CUYAMA BASIN GROUNDWATER SUSTAINABILITY AGENCY

PUBLIC DRAFT

Groundwater Sustainability Plan

APRIL 2019

WOODARD & CURRAN

EXECUTIVE SUMMARY

Introduction

In 2014, the California legislature enacted the Sustainable Groundwater Management Act (SGMA) in response to continued overdraft of California's groundwater resources. The Cuyama Groundwater Basin (Basin) is one of 21 basins and subbasins identified by the California Department of Water Resources (DWR) as being in a state of critical overdraft. SGMA requires preparation of a Groundwater Sustainability Plan (GSP) to address measures necessary to attain sustainable conditions in the Basin. Within the framework of SGMA, sustainability is generally defined as the conditions that result in long-term reliability of groundwater supply, and the absence of undesirable results.

Critical Dates for the Cuyama Basin

- 2020 By January 31: submit GSP to DWR
- 2025 Review and update GSP
- 2030 Review and update GSP
- 2035 Review and update GSP
- 2040 Achieve sustainability for the Basin

In 2017, in response to SGMA, the Cuyama Basin Groundwater Sustainability Agency (CBGSA) was formed. The CBGSA is a joint-powers agency that is comprised of Kern, Santa Barbara, San Luis Obispo and Ventura counties, plus the Cuyama Community Services District and the Cuyama Basin Water District. The CBGSA is governed by an 11-member Board of Directors, with one representative from Kern, San Luis Obispo and Ventura counties, two representatives from Santa Barbara County, one member from the Cuyama Community Services District, and five members from the Cuyama Basin Water District.

The Draft Cuyama Basin GSP has been prepared and is now available for public review and comment. SGMA requires the CBGSA develop a GSP that achieves groundwater sustainability in the Basin by 2040. Although SGMA references 2015 as a basis for groundwater planning, SGMA does not require a GSP to address undesirable results that occurred before 2015. The Draft GSP outlines the need for significant reduction in pumping in the central portion of the Basin and has identified two projects for potential development that could help offset the projected reductions in pumping. Although current analysis indicates groundwater pumping reductions on the order of 50 to 67 percent may be required to achieve sustainability, additional efforts are required to confirm the level of pumping reduction required to achieve sustainability. These efforts include collecting additional data and a review of the Basin model, along with other efforts as outlined in the Draft GSP.

Plan Area

The CBGSA's jurisdictional area is defined by DWR's 2013 Bulletin 118, and in the 2016 Interim Update. The Basin generally underlies the Cuyama Valley, as shown in Figure ES-1.

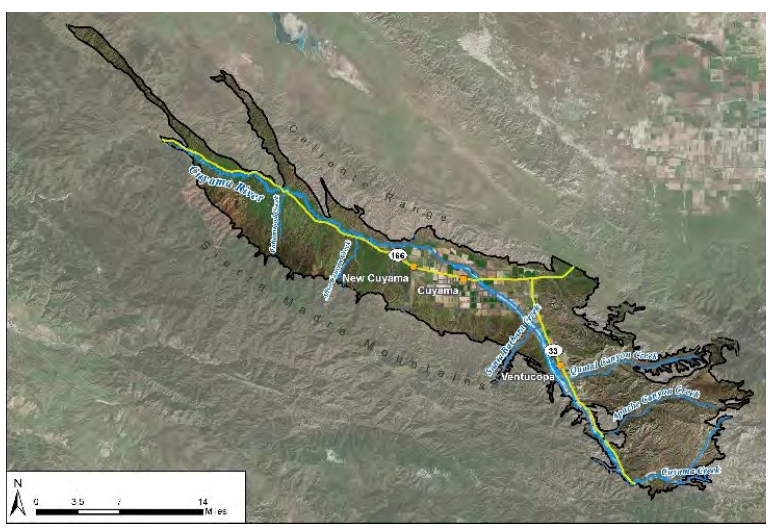

Figure ES-1: GSP Plan Area

Outreach Efforts

Figure ES 2 - Community Workshops

A stakeholder engagement strategy was developed to ensure that the interests of all beneficial users of groundwater in the Basin were considered. The strategy incorporated monthly CBGSA Standing Advisory Committee (SAC) meetings, monthly CBGSA Board meetings, quarterly community workshops, and information distribution to all property owners and residents in the Basin. Figure ES-2 shows attendees at one of the community workshops conducted during development of the GSP.

The SAC was established to encourage active involvement from diverse social, cultural, and economic elements of the population in the Basin. The SAC members represent large and small landowners and growers from different geographic locations in the Basin, longtime residents including Hispanic community members, and a manager of an environmentally-centric non-profit organization. The community workshops were conducted in both English and Spanish, creating an opportunity for local individuals to engage in the GSP development process.

Public Meeting	Number
Cuyama Basin GSA Board Meetings	20
Cuyama Basin GSA Standing Advisory Committee Meetings	18
Joint Meetings of Cuyama Basin GSA Board and Standing Advisory Committee	7
Community Workshops	5

Basin Setting

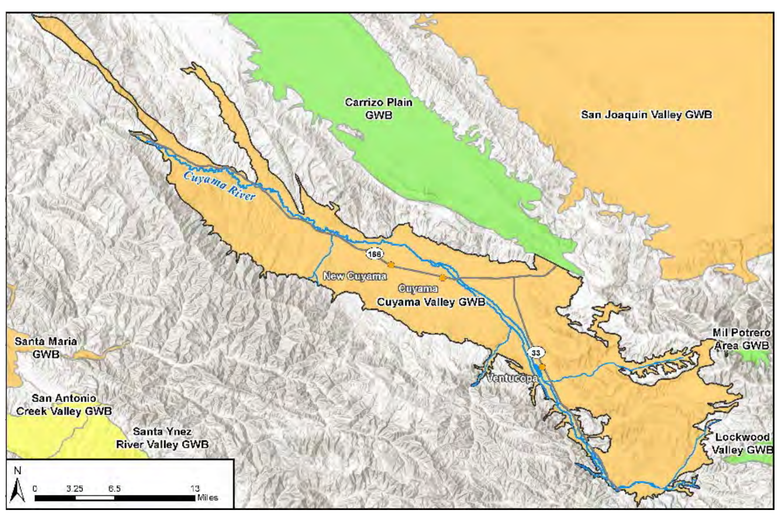

Figure ES-3: Basin Setting

The Basin is located at the southeastern end of the California Coast Ranges, near the San Andreas and Santa Maria River fault zones and bounded on the north and south by faults. These faults create several constraints on groundwater flow through the Basin. Groundwater flows from the eastern portions of the Basin toward the western most portion of the Basin. Surface water flows in the same direction, with the major surface stream being the Cuyama River. Multiple smaller streams flow into the Cuyama River, and the Cuyama River flows to the west and eventually joins with the Santa Maria River. The location of the Basin is shown in Figure ES-3.

Existing Groundwater Conditions

Groundwater levels in some portions of the Basin have been declining for many years while other areas of the Basin have experienced no significant change in groundwater levels. The change in groundwater levels varies across the Basin, with the greatest declines occurring in the central portion of the Basin where the greatest concentration of irrigated agriculture is practiced. The western and eastern portions of the Basin have experienced significantly less change in groundwater levels. However, additional irrigated agricultural acreage has been developed recently in the western portion of the Basin, warranting additional levels of monitoring to determine if there are any impacts to long-term groundwater levels and sustainability.

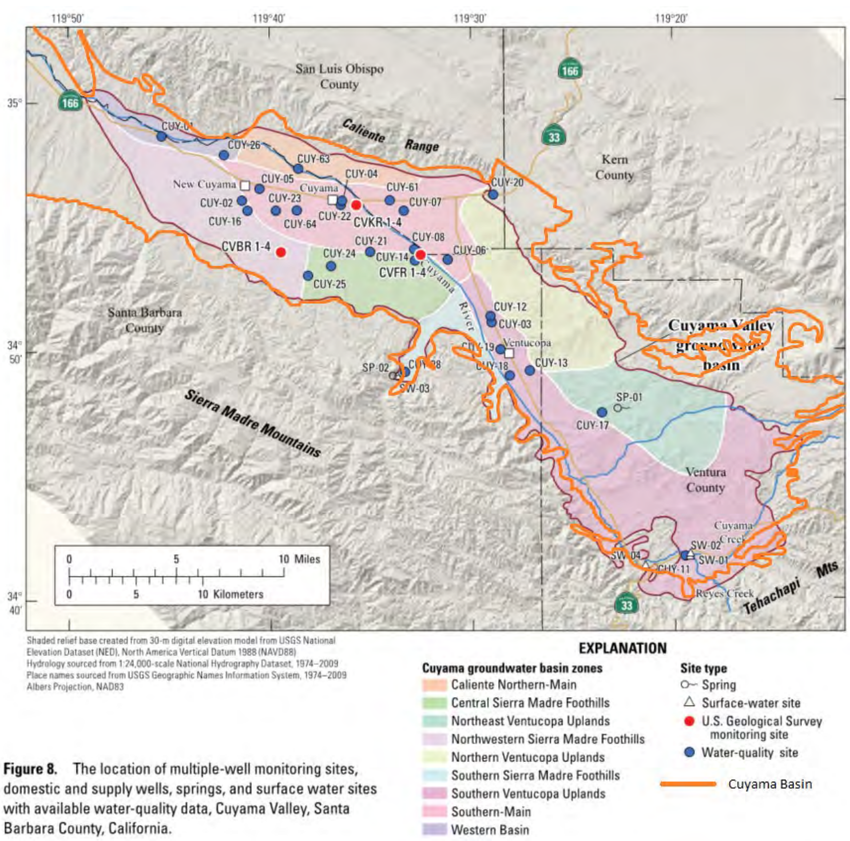

Figure 8. The location of multiple-well monitoring sites, domestic and supply wells, springs, and surface water sites with available water-quality data, Cuyama Valley, Santa Barbara County, California.

Figure ES-4: USGS Water Quality Sampling Locations

Groundwater quality in the Basin is variable, particularly along the periphery. Water quality in the Basin has historically had high levels of total dissolved solids (TDS) and sulfates. The United States Geologocal Survey (USGS) has conducted several water quality studies; areas where USGS has evaluated groundwater quality are shown in Figure ES-4. High concentrations of other constituents, such as nitrate, arsenic, sodium, boron, and hexavalent chromium are generally localized and not wide-spread. Groundwater ranges from hard to very hard and is predominantly of the calcium-magnesium-sulfate type. Average TDS concentrations across the Basin are as high as 1,500 to 6,000 milligrams per liter (mg/L) along portions of the Basin's southern boundary. These values exceed the California recommended maximum contaminant level (MCL) of 500 mg/L. Concentrations of boron at up to 15 mg/L have been observed along the southern Basin boundary, with concentrations of chloride at levels up to 1,000 mg/L in the same area.

Along the southern boundary, the groundwater quality reflects recharge from springs and runoff from the Sierra Madre Mountains. TDS concentrations in this part of the Basin range from 400 to 700 mg/L. Along the eastern edge of the Basin, near the Caliente Range, groundwater quality declines as concentrations of sodium, chloride, TDS, and boron increase. Concentrations of boron range up to 15 mg/L, concentrations of chloride increase up to 1,000 mg/L, and TDS concentrations range from 3,000 to 6,000 mg/L.

Undesirable Results

Undesirable results are defined as those conditions that cause significant and unreasonable reduction in the long-term viability of domestic, agricultural, municipal, or environmental uses of the Basin's groundwater. SGMA identifies six defined areas for classification of undesirable results, as shown in the adjacent callout. The one undesirable result that does not impact the Basin is seawater intrusion. Water quality in the Basin is generally not good due to high TDS and other constituents, and there is some limited subsidence in the Basin, but the major areas of undesirable results are associated with the following:

- Chronic lowering of groundwater levels
- Significant and unreasonable reduction in groundwater storage
- Depletions of interconnected surface water

Figure ES-5 is a graph showing the annual and cumulative long-term reduction in groundwater storage in the Basin. This reduction in groundwater storage coincides with the lowering of groundwater levels.

Categories of Undesirable Results

- Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon
- Significant and unreasonable reduction of groundwater storage
- Significant and unreasonable seawater intrusion
- Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies
- Significant and unreasonable land subsidence that substantially interferes with surface land uses
- Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water

The lowering of groundwater levels has corresponded with degradation of groundwater quality, and particularly levels of TDS. Additionally, lowering of groundwater levels has contributed to some minor but measurable levels of subsidence in the central portion of the Basin, and has contributed to depletions in interconnections of surface and groundwater systems.

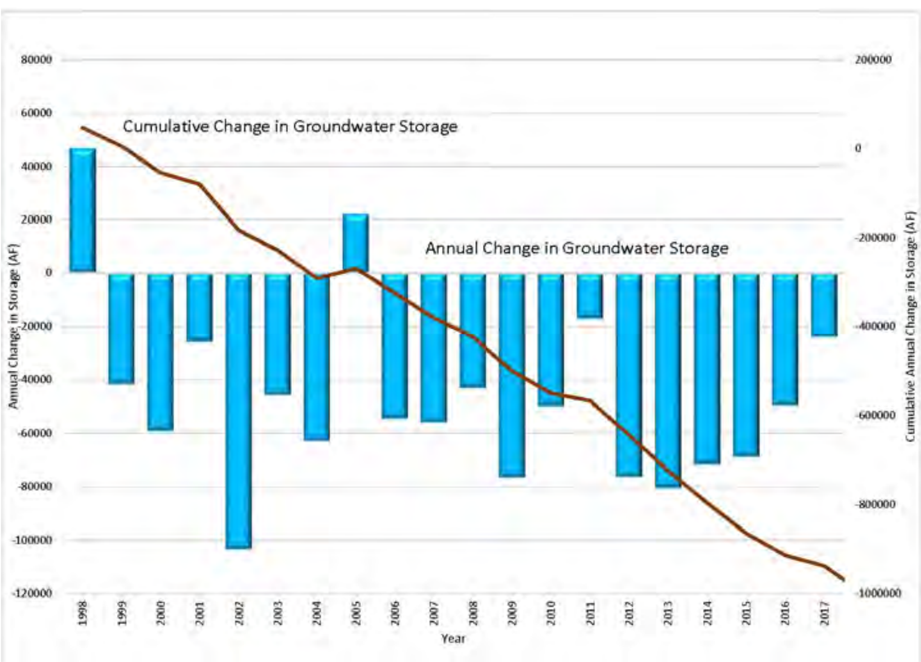

Figure ES-5: Annual and Cumulative Changes in Groundwater Storage

Sustainability

SGMA introduces several terms to measure sustainability, including:

- **Sustainability Goals** – These goals are the culmination of conditions reulting in an absence of undesirable results within 20 years.
- **Undesirable Results** – Undesirable results are the significant and unreasonable occurrence of conditions that adversely affect groundwater use in the Basin.
- **Sustainability Indicators** – Sustanability indicators refer to any of the adverse effects caused by groundwater conditions occurring throughout the Basin that, when significant and unreasonable, cause undesirable results, including the following:
  - — Lowering groundwater levels
  - — Reduction of groundwater storage
  - — Seawater intrusion
  - — Degraded water quality
  - — Land subsidence
  - — Depletion of interconnected surface water
- **Minimum Thresholds** – Minimum thresholds are a numeric value for each sustainability indicator, and are used to define when undesirable results occur, if minimum thresholds are exceeded in a percentage of sites in the Basin's monitoring network.
- **Measurable Objectives** – Measurable objectives are a specific set of quantifiable goals for the maintenance or improvement of groundwater conditions. They will be included in the adopted GSP, and will help the CBGSA achieve their sustainability goal for the Basin.

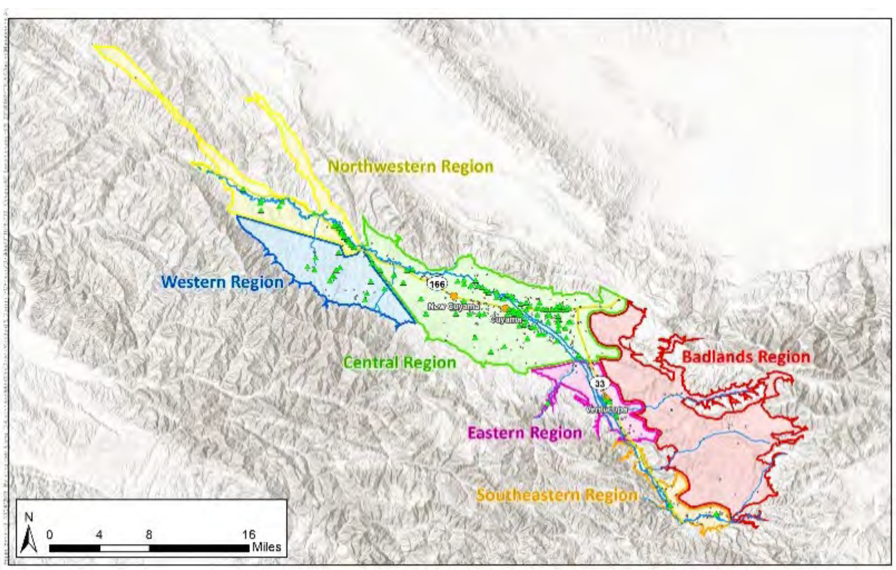

Figure ES-6: Threshold Regions

The method prescribed by SGMA to measure undesirable results involves setting minimum thresholds and measurable objectives for a series of representative wells. Geologic conditions and land use vary across the Basin. These varying conditions also cause groundwater conditions to vary across the Basin. The CBGSA Board of Directors concluded that one set of minimum thresholds for the entire Basin may not provide the appropriate degree of refinement needed to effectively manage Basin-wide sustainability. As a result, threshold regions were created to establish the appropriate sustainability criteria for each area of the Basin. The threshold regions are shown in Figure ES-6.

Representative wells were identified to provide a basis for measuring groundwater conditions throughout the Basin without having to measure each well, which would be cost prohibitive. Representative wells were selected based on availability and their history of recorded groundwater levels, and their potential to effectively represent the groundwater conditions surrounding the identified well, and consent of the well owner to utilize the identified well for monitoring purposes.

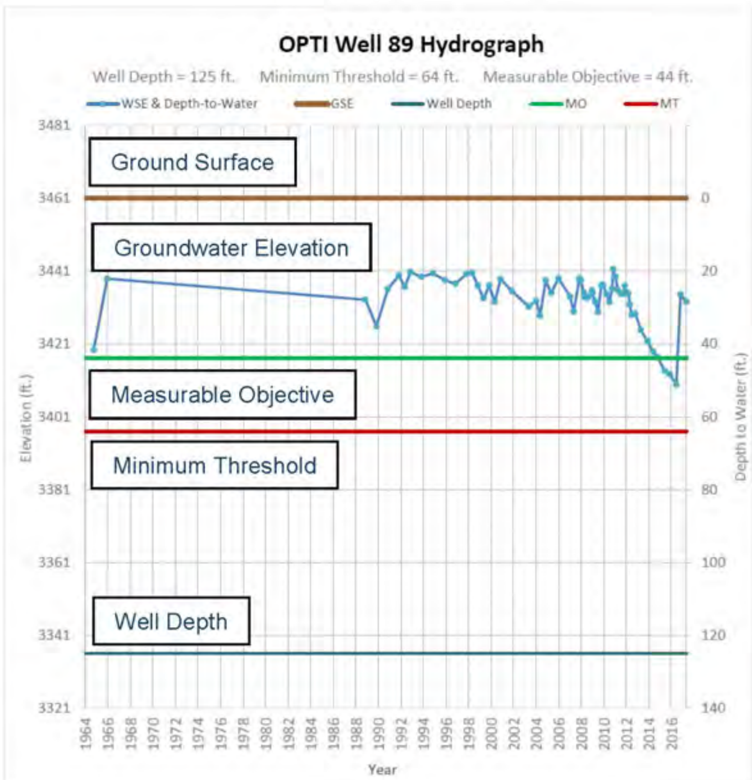

Figure ES-7: Sample Relationship Between Minimum Threshold and Measurable Objective

A total of 61 representative wells have been identified for measurement of groundwater levels in the Basin, and 64 representative wells have been identified for groundwater quality monitoring. There are five selected ground surface subsidence monitoring stations. Using groundwater level data as the basis for measuring change in groundwater storage, these representative wells and subsidence monitoring stations provide the basis for measuring the five potential undesirable results across the Basin.

Minimum thresholds and measurable objectives were developed for each of the identified representative wells. Figure ES-7 shows a typical relatonship of the minimum thresholds, measurable objectives, and other data for a sample well.

Thresholds were developed with reference to 2015 groundwater levels. In general, measurable objectives were established based on providing a 5-year drought buffer above the minimum threshold. The opposite approach was taken in the southeastern region where the measurable objective was established based on 2015 groundwater levels and the minimum threshold was determined by providing a 5-year drought buffer below the established measurable objective.

A table summarizing minimum thresholds and measurable objectives is included in the GSP. Graphs showing the minimum threshold and measurable objective for each of the representative wells are contained in an appendix to the GSP.

Water Budgets

The Basin has been in an overdraft condition for many years. Overdraft conditions in the Basin were first documented in the 1950s. Since then, groundwater pumping has increased in response to increased levels of agricultural production, leading to increased levels of groundwater overdraft.

The groundwater evaluations conducted as a part of GSP development have provided estimates of the historical, current and future groundwater budget conditions.

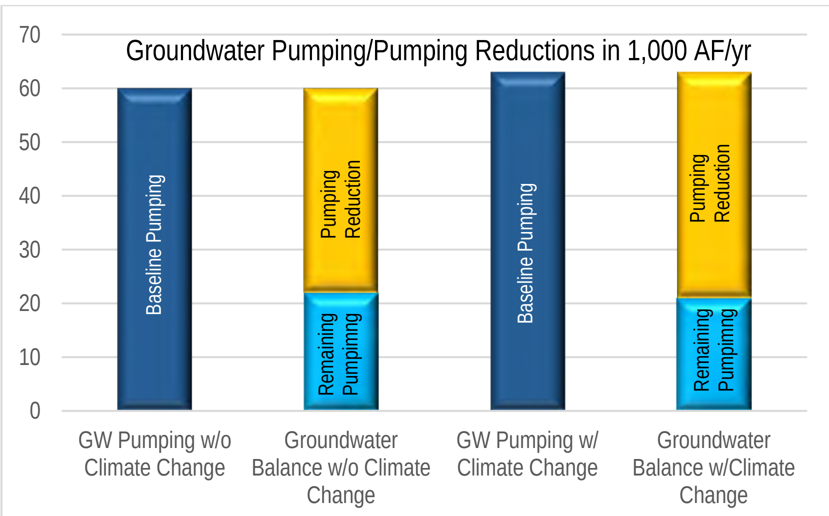

Figure ES-8: Basin-Wide Groundwater Pumping and Reductions Required to Achieve Sustainability

These analyses show that at current groundwater pumping levels, the average annual overdraft is estimated to be approximately 26,000 acre-feet, and the reduction in groundwater pumping required to achieve sustainability is approximately 40,000 acre-feet per year. Future groundwater conditions in the Basin will continue to show decreased groundwater levels based on projections of current land and water uses. Since there are no projected changes in land use or population in the Basin, the projected annual decline in groundwater storage is estimated to be the same as under current conditions.

The projected Basin water budget was also evaluated under climate change conditions. Under the intermediate climate change scenario prescribed by DWR, the annual groundwater overdraft is projected to increase to approximately 27,000 acre-feet, requiring an approximate 42,000 acre-feet per year reduction in groundwater pumping to achieve sustainability. These changes are shown in Figure ES-8.

The current analysis was prepared using the best available information and through development of a new groundwater modeling tool. Although the Basin has been studied for many years, the available data are not as robust in areas outside the center of the Basin as compared to many other basins, thus leading to some level of uncertainty in the analyses. A data collection program has been designed to augment existing information, and is included in the GSP. It is anticipated that as additional information becomes available, the new model can be updated, and more refined estimates of annual pumping and overdraft can be developed.

Analysis of the Basin as a whole shows that much of the Basin is in hydrologic balance. Existing and projected groundwater levels in the western portions of the Basin, along with the Southeastern Region, show those areas to be sustainable under current and projected conditions. However, the Central Threshold Region shows an annual water budget of approximately minus 25,000 acre-feet per year.

Monitoring Networks

The Draft GSP outlines the monitoring networks for the five sustainability indicators that apply to the Basin. The objective of these monitoring networks is to monitor conditions across the Basin and to detect trends toward undesirable results. Specifically, the monitoring network was developed to do the following:

Five Sustainability Indicators Applicable to the Cuyama Groundwater Basin

- Chronic lowering of groundwater levels
- Reduction in groundwater storage
- Degraded water quality
- Land subsidence
- Depletions of interconnected surface water

- Monitor impacts to the beneficial uses or users of groundwater
- Monitor changes in groundwater conditions relative to measurable objectives and minimum thresholds
- Demonstrate progress toward achieving measurable objectives described in the GSP

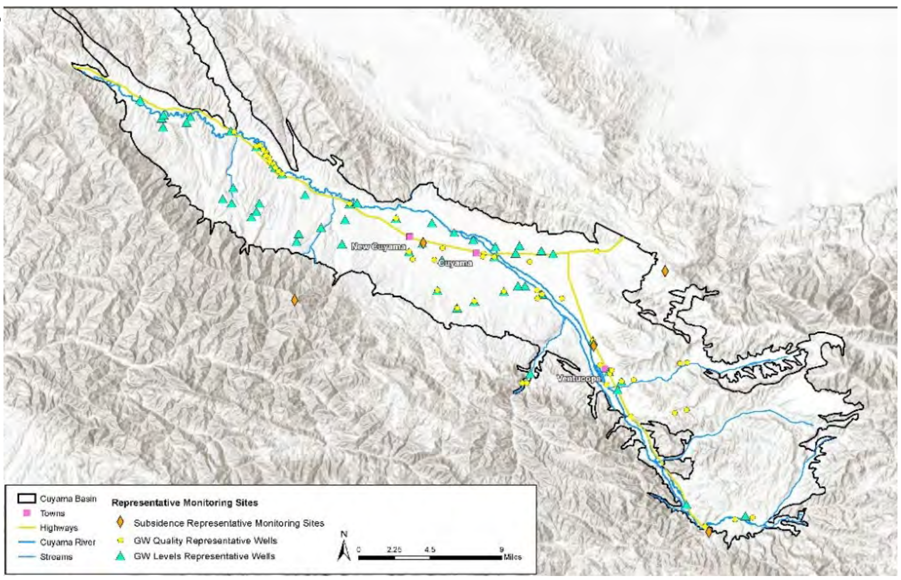

Figure ES-9: Groundwater Monitoring Wells

The monitoring networks were designed by evaluating data sources provided by DWR, including the California Statewide Groundwater Elevation Monitoring (CASGEM) Program, the USGS, participating counties, and private landowners. The monitoring network consists of wells that are already being used for monitoring in the Basin. Additional wells are being added, and there is the potential for installing new dedicated monitoring wells through DWR's Technical Support Services program.

Summary of Existing Monitoring Wells	
Number of CASGEM wells	6
Number of voluntary wells	107
Total number of DWR and CASGEM wells	222
Earliest measurement year	1946
Longest period of record	68 years
Median period of record	12

Most wells in the monitoring network are measured on either a semi-annual or annual schedule. Historical measurements have been entered into the Basin Data Management System (DMS), and future data will also be stored in the Basin DMS.

A summary of the existing monitoring wells is shown in the adjacent table.

Data Management System

The Basin DMS was built on a flexible, open software platform that uses familiar Google maps and charting tools for analysis and visualization. The Basin DMS serves as a data-sharing portal that enables use of the same data and tools for visualization and analysis. These tools support sustainable groundwater management and create transparent reporting about collected data and analysis results.

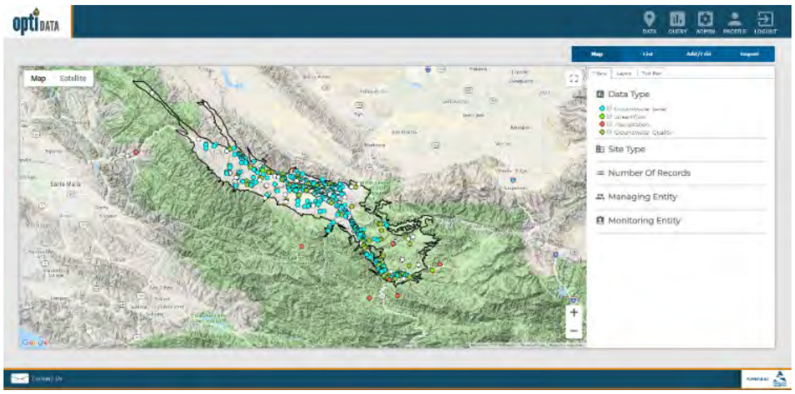

Figure ES-10: Opti DMS Screenshot

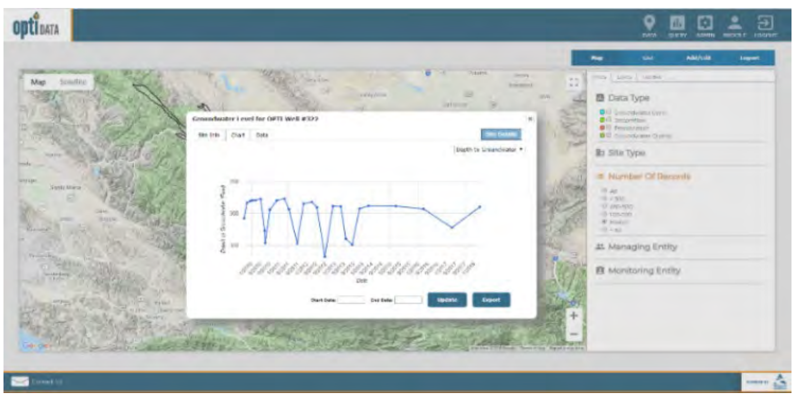

Figure ES-11: Typical DMS Data Display

The Basin DMS is web-based; the public can easily access this portal using common web browsers such as Google Chrome, Firefox, and Microsoft Edge. The Basin DMS is currently populated with available historical data. Additional data will be entered into the system as it is collected.

The Basin DMS portal provides easy access and the ability to query information stored in the system. Groundwater data can be plotted for any of the available data points, providing a pictorial view of historical and current data.

The DMS can be accessed https://opti.woodardcurran.com/cuyama/login.php.

Projects and Management Actions

Achieving sustainability in the Basin requires implementation of management actions and, if demonstrated to be feasible, projects that will increase water supply. One management action, which is reductions in groundwater pumping, is required to achieve sustainability irrespective of the feasibility of any other water supply projects. The exact amount of required reduction in groundwater pumping will be reevaluated after additional data are collected and analyzed. Based on current information, groundwater pumping in the Basin may have to be reduced by as much as 50 to 67 percent. Additional evaluations of pumping reductions required to achieve sustainability are planned over the next several years. These additional evaluations may lead to modification of levels of pumping reduction associated with the attainment of reliability.

Additional management actions included in the Draft GSP include the following:

- Monitoring and recording of groundwater levels, groundwater quality, and subsidence data
- Maintaining and updating the Basin DMS with newly collected data
- Monitoring of groundwater use through use of satellite imagery
- Annual monitoring of progress toward sustainability
- Annual reporting of Basin conditions to DWR as required by SGMA

Several alternative projects to potentially increase water supply availability in the Basin were identified and considered. The initial set of alternatives were reviewed with the Basin SAC and the CBGSA Board of Directors, resulting in two potential water supply projects included in the Draft GSP. These projects require further analysis and permitting to determine feasibility and cost effectiveness. These projects are described below.

The first project is rainfall enhancement through what is commonly referred to a cloud seeding. Cloud seeding is a type of weather modification with the objective to increase the amount of precipitation that would fall in the Basin watershed. The concept is to introduce silver iodide, or similar substance, into the clouds to induce greater rainfall. Cloud seeding has been used in numerous areas throughout California and other western states. Preliminary estimates suggest up to approximately 5,000 acre-feet per year of additional water supply could be added to the Basin. The target area for rainfall enhancement is shown in Figure ES-12.

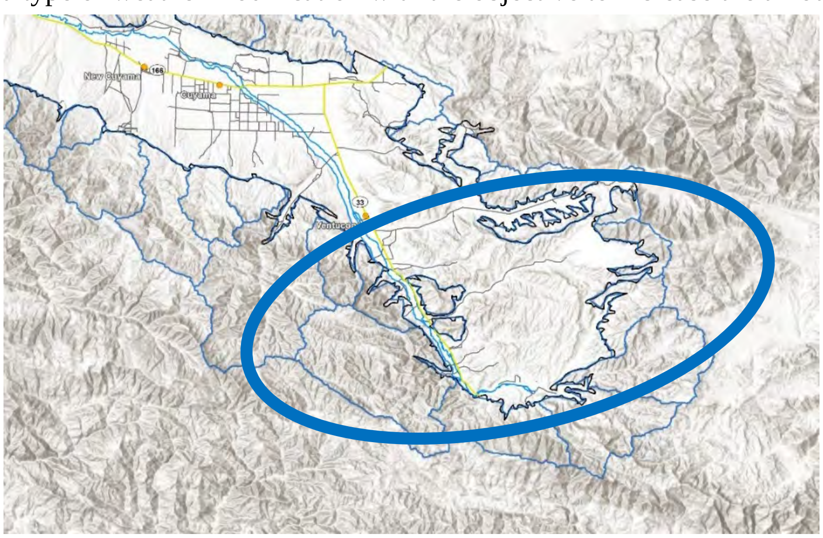

Figure ES-12: Target Area for Potential Rainfall Enhancement

The next step toward implementation of this water supply project is to refine the analysis to better determine the potential increase in precipitation that could be achieved, and to refine the estimated cost of implementation. The project would require completion of an environmental document consistent with the requirements of the California Environmental Quality Act (CEQA).

The second potential project is capture of high stormwater flows in the Cuyama River, and diversion into recharge basins that would be sited in the Central Area of the Basin. The captured stormwater flows would percolate into the groundwater basin resulting in increased recharge of groundwater. The potential stormwater recharge project has several challenges associated with it, including ensuring water rights availability, managing sediment that will be present in any diverted stormwater flows, and obtaining lands for construction of the recharge basins. Preliminary estimates suggest that up to 4,000 acre-feet per year of additional water supply could be added to the Basin. The general location of the potential recharge basins are shown in Figure ES-13.

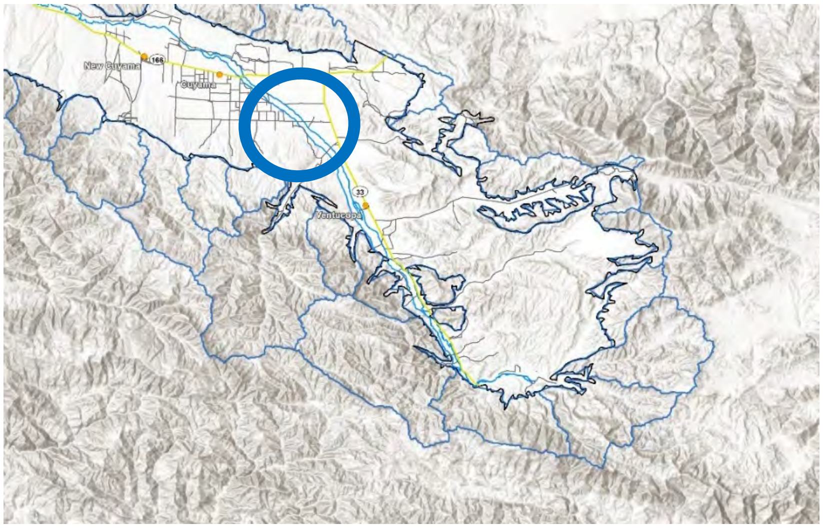

Figure ES-13: General Location of Potential Recharge Basins

The next step toward implementation of this potential project is to evaluate each of these areas of uncertainty and to develop more refined estimates of potential water supply benefit and cost.

The Draft GSP also includes projects specific to the domestic water systems in Ventucopa, Cuyama, and New Cuyama. These projects include installing new wells to secure reliability of water supply to residents of these communities. Implementation of these community well projects would be the responsibility of each of the three communities, as the projects address reliability of available supply for each community.

GSP Implementation

Achieving sustainability in the Basin requires implementation of management actions and, if demonstrated to be feasible, projects that will increase water supply. One management action, which is reductions in groundwater pumping, is required to achieve sustainability irrespective of the feasibility of any other water supply projects. Implementing project and management actions can best be achieved through development of Basin Management Areas to focus necessary activities on the areas of the Basin with projected long-term overdraft.

Two Management Areas have been established in the Basin to aid in administering projects and management actions, as shown in Figure ES-14. The Central and Ventucopa Management Areas were identified based on projected groundwater levels decreasing at a rate of 2 feet or more per year over the next 20 years.

Figure ES-15 depicts the general boundaries of the proposed Management Areas. The highlighted colors show the projected annual change in groundwater levels, with clear and green indicating no change to less than 2 feet of projected annual decline in groundwater levels, and the yellow, orange and red areas indicating areas of increasing projections of annual declines in groundwater levels, ranging from more than 2 feet per year up to more than 4 feet per year.

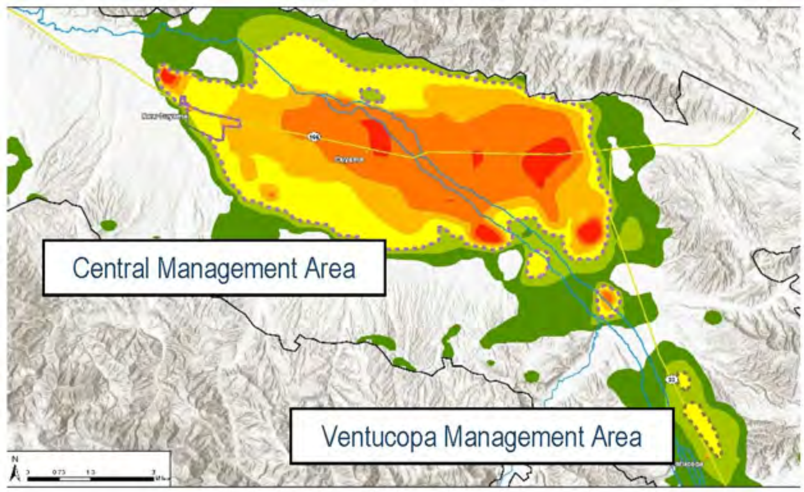

Figure ES-14: Location of Central and Ventucopa Management Areas

Overdraft conditions in the Central Management Area requires reductions in groundwater pumping. The exact amount of required reduction in groundwater pumping will be reevaluated after additional data are collected and analyzed. However, based on current information, total Basin-wide groundwater pumping may have to be reduced by as much as 50 to 67 percent, with the major proportion or reduction required in the Central Management Area.

Both Management Areas will be administered by the CBGSA. However, the CBGSA may elect to delegate administrative responsibility to another party such as the Cuyama Basin Water District, since all wells supplying the affected lands are within the Cuyama Basin Water District boundary.

Implementing the GSP will require numerous management activities that will be undertaken by the CBGSA, including the following:

- Preparing annual reports summarizing the conditions of the Basin and progress towards sustainability and submitting them to DWR
- Monitoring groundwater conditions for all five sustainability indicators twice each year
- Entering updated groundwater data into the Basn DMS
- Monitoring basin-wide groundwater use using satellite imagery
- Updating the GSP once every five years

The CBGSA Board adopted a preliminary schedule for reduction of groundwater pumping in the Central Management Area.

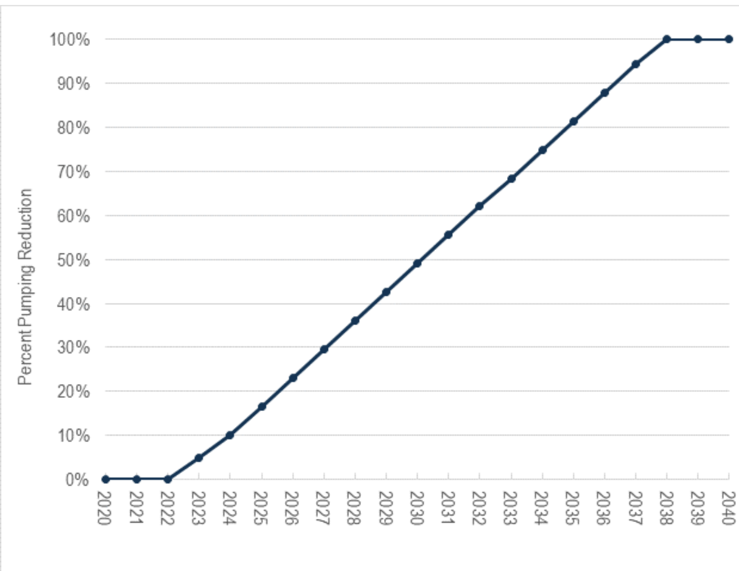

Figure ES-15: Schedule for Proposed Reductions in Groundwater Pumping

For the Central Management Area, pumping reductions are scheduled to begin in 2023 with full implementation by 2040, as shown in Figure ES-15. This approach provides adequate time to put into place methods necessary to monitor groundwater use and reductions. The specific methods for monitoring and reporting will be developed beginning in 2021, with the target of methods being in place by the end of 2022 to allow effective monitoring to beginning in 2023. In 2023, monitoring in 2023 will demonstrate achievement of the proposed levels of pumping reduction by the end of that year.

Pumping reductions are not currently recommended for the Ventucopa Area. The recommendation is to undertake additional monitoring, incorporate new monitoring wells, and further evaluate groundwater conditions in the area over the next two to five years. Once additional data are obtained and evaluated, the need for any reductions in pumping will be determined.

Evaluation and possible implementation of the two identified projects will also be initiated between 2020 and 2025. Further evaluation of the two projects is necessary to determine technical, economic, and institutional feasibility. A critical aspect of feasibility for the stormwater diversion project will be confirmation of water rights availability. Downstream water right holders will have to be maintained whole for the project to be feasible, requiring a more in-depth analysis of water flows and availability. As a result, the first step in determining feasibility will be to evaluate the potential for obtaining a right for diversion from the Cuyama River.

Figure ES-16 presents the overall schedule of activities over the next 20 years

2020 – 2025	2025 – 2030	2030 – 2035	2035 – 2040
Set up and Initiate Monitoring and Pumping Allocation Programs	**Project Implementation and GSP Evaluation/Update**	**Project Implementation and GSP Evaluation/Update**	**Achieve Groundwater Basin Sustainability**
• Establish monitoring network and initiate monitoring and reporting • Evaluate/refine thresholds and monitoring network • Install new wells • Develop pumping monitoring program* • Set up and initiate pumping allocation program* • Project analysis and feasibility • Public outreach	• **GSA conducts 5-year evaluation/update** • Monitoring and reporting continues • Evaluate/refine thresholds and monitoring network • Refine water budget • Pumping monitoring program continues* • Continue implementation of pumping allocation program* • Plan/design/construct small to medium sized projects* • Outreach continues	• **GSA conducts 5-year evaluation/update** • Monitoring and reporting continues • Evaluate/refine thresholds and monitoring network • Refine water budget • Pumping monitoring program continues* • Continue implementation of pumping allocation program* • Plan/design/construct larger projects* • Outreach continues	• **GSA conducts 5-year evaluation/update** • Monitoring and reporting continues • Evaluate/refine thresholds and monitoring network • Refine water budget • Pumping monitoring program continues* • Pumping allocation program fully implemented* • Project implementation completed* • Outreach continues

Figure ES-16: Implementation Plan Schedule of Activities
* Represents Management Area activities

Funding

Implementation of the GSP requires funding sources. To the degree they become available, outside grants will be sought to assist in reducing cost of implementation to residents and landowners of the Basin. However, there will be a need to collect funds to support implementation.

The areas associated with GSA-wide management and GSP implementation will be borne by the landowners across the Basin. These costs include:

- GSA administration
- Groundwater level monitoring and reporting
- Groundwater quality monitoring and reporting
- Ground surface subsidence monitoring and reporting
- Water use estimation
- Data management
- Stakeholder engagement
- Annual report preparation and submittal to DWR
- Developing and implementing a funding mechanism
- Grant applications
- GSP updates (every five years)

For budgetary purposes, the estimated initial cost of these activities is on the order $800,000 to $1.2 million per year. The CBGSA Board of Directors will evaluate options for securing the needed funding. Options for funding include fees based on groundwater pumping, acreage, or combinations of these, and pursuit of any available grant funds.

Activities associated with the two Management Areas will be borne by the landowners and water users within the two Management Areas.

For the Ventucopa Management Area, the costs include monitoring of groundwater level data and evaluation of the need for additional or new representative wells and potential need for pumping allocations. The estimated initial cost of these activities is on the order $40,000 to $80,000 per year.

For the Central Management Area, costs include the following:

- Developing and implementing a system for pumping allocations, tracking, and management
- Developing and implementing a funding mechanism
- Evaluation and implementing water supply projects

The estimated initial cost of these activities is on the order $200,000 to $500,000 per year, plus costs associated with evaluating and implementing either of the two potential water supply projects. Depending on feasibility, the annual costs of the rainfall enhancement project would be on the order of $150,000 per year. The stormwater water capture project cost could be on the order of $3 to $4 million per year to amortize the capital cost of the project and to provide funds for annual operations and maintenance.

The CBGSA Board of Directors will evaluate options for securing the needed funding. Similar to the funding options for the GSA-wide activities, options for funding include fees based on groundwater pumping, acreage, or combinations of these, and pursuit of any available grant funds. The CBGSA Board of Directors will evaluate options for securing the needed funding.

Funding for new community wells or well improvements is the responsibility of the three Basin communities. There are potential opportunities for grant funds, depending on timing and state and federal grant funding availability.

Cuyama Valley
Groundwater Basin

Draft Groundwater Sustainability Plan: Agency Information, Plan Area, and Communication

Prepared by:

Cuyama Basin Groundwater Sustainability Agency

Woodard & Curran

April 2019

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Acronyms

Basin	Cuyama Valley Groundwater Basin
CASGEM	California Statewide Groundwater Elevation Monitoring
CBGSA	Cuyama Basin Groundwater Sustainability Agency
CBWD	Cuyama Basin Water District
CCSD	Cuyama Community Services District
CDFW	California Department of Fish and Wildlife
DWR	California Department of Water Resources
GAMA	Groundwater Ambient Monitoring and Assessment
GICIMA	Groundwater Information Center Interactive Map
GSP	Groundwater Sustainability Plan
IRWM	Integrated Regional Water Management
LID	Low Impact Development
NMFS	National Marine Fisheries Service
PBO	Plate Boundary Observatory
RCD	Resource Conservation District
RWQCB	Regional Water Quality Control Board
SBCWA	Santa Barbara County Water Agency
SGMA	Sustainable Groundwater Management Act
SLOCFC&WCD	San Luis Obispo County Flood Control & Water Conservation District
SR	State Route
TDS	total dissolved solids
UNAVCO	University NAVSTAR Consortium
USGS	United States Geological Survey
VCWPD	Ventura County Watershed Protection District
WDL	Water Data Library
WMP	Water Management Plan

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1. AGENCY INFORMATION, PLAN AREA, AND COMMUNICATION

1.1 Introduction and Agency Information

This section describes the Cuyama Basin Groundwater Sustainability Agency (CBGSA), its authority in relation to the Sustainable Groundwater Management Act (SGMA), and the purpose of this Groundwater Sustainability Plan (GSP).

This GSP meets regulatory requirements established by the California Department of Water Resources (DWR) as shown in the completed *Preparation Checklist for GSP Submittal* (Appendix A). The CBGSA's Notification of Intent to Develop a Groundwater Sustainable Plan is in Appendix B.

On June 6, 2016, Santa Barbara County Water Agency (SBCWA) sent DWR a notice of intent to form a Groundwater Sustainability Agency (GSA). Following this submittal, the CBGSA Board of Directors was organized, and now includes the following individuals:

- Derek Yurosek – Chairperson, Cuyama Basin Water District (CBWD)
- Lynn Compton – Vice Chairperson, County of San Luis Obispo
- Byron Albano – CBWD
- Cory Bantilan – SBCWA
- Tom Bracken – CBWD
- George Cappello – CBWD
- Paul Chounet – Cuyama Community Services District (CCSD)
- Zack Scrivner – County of Kern
- Glenn Shephard – County of Ventura
- Das Williams – SBCWA
- Jane Wooster – CBWD

During development of this GSP, board meetings were held on the first Wednesday of every month at 4 pm in the Cuyama Family Resource Center, at 4689 California State Route 166, in New Cuyama, California.

The CBGSA's established boundary corresponds to DWR's *California's Groundwater Bulletin 118 – Update 2003* (Bulletin 118) groundwater basin boundary for the Cuyama Valley Groundwater Basin (Basin) (DWR, 2003). No additional areas were incorporated.

1.1.1 Contact Information

Contact information for the CBGSA is shown below.

- Cuyama Basin General Manager/CBGSA Director: Jim Beck
- Phone Number: (661) 447-3385
- Email: tblakslee@hgcpm.com
- Physical and Mailing Address: 4900 California Avenue, Tower B, 2nd Floor, Bakersfield, CA. 93309
- Website: http://cuyamabasin.org/index.html

1.1.2 Management Structure

The CBGSA is governed by an 11-member Board of Directors that meets monthly. The General Manager manages day-to-day operations of the CBWD, while Board Members vote on actions of the CBGSA; the Board is the CBGSA's decision-making body.

During GSP development, an Advisory Committee was formed to act in an advisory capacity to the CBGSA Board of Directors. The Advisory Committee includes the following individuals:

- Roberta Jaffe – Chairperson
- Brenton Kelly – Vice Chairperson
- Brad DeBranch
- Louise Draucker
- Jake Furstenfeld
- Joe Haslett
- Mike Post
- Hilda Leticia Valenzuela

1.1.3 Legal Authority

Per Section 10723.8(a) of the California Water Code, SBCWA gave notice on behalf of the CBGSA of its decision to form a GSA, which is Basin 3-013, per DWR's Bulletin 118 (Appendix C).

1.2 Plan Area

This section describes the Basin, including major streams and creeks, institutional entities, agricultural and urban land uses locations of groundwater production wells, locations of state lands and geographic boundaries of surface water runoff areas. This section also describes existing surface water and groundwater monitoring programs, existing water management programs, and general plans in the Basin. The information contained in this section reflects information from publicly available sources, and may not reflect all information that will be used for GSP technical analysis.

This section of the GSP satisfies Section 354.8 of the SGMA regulations.

1.2.1 Plan Area Definition

The Basin is in California's Central Coast Hydrologic Region. It is beneath the Cuyama Valley, which is bounded by the Caliente Range to the northwest and the Sierra Madre Mountains to the southeast. The Basin was initially defined in Bulletin 118. The boundaries of the Cuyama Basin were delineated by DWR because they were the boundary between permeable sedimentary materials and impermeable bedrock. DWR defines this boundary as "impermeable bedrock with lower water yielding capacity. These include consolidated rocks of continental and marine origin and crystalline/or metamorphic rock."

1.2.2 Plan Area Setting

Figure 1-1 shows the Basin and its key geographic features. The Basin encompasses an area of about 378 square miles and includes the communities of New Cuyama and Cuyama, which are located along State Route (SR) 166 and Ventucopa, which is located along SR 33. The Basin encompasses an approximately 55-mile stretch of the Cuyama River, which runs through the Basin for much of its extent before leaving the Basin to the northwest and flowing towards the Pacific Ocean. The Basin also encompasses stretches of Wells Creek in its north-central area, Santa Barbara Creek in the south-central area, the Quatal Canyon drainage and Cuyama Creek in the southern area of the Basin. Most of the agriculture in the Basin occurs in the central portion east of New Cuyama, and along the Cuyama River near SR 33 through Ventucopa.

Figure 1-2 shows the CBGSA boundary. The CBGSA boundary covers all of Cuyama Basin. The CBGSA was created by a Joint Exercise of Powers Agreement among the following agencies:

- Counties of Kern, San Luis Obispo, and Ventura
- SBCWA, representing the County of Santa Barbara
- CBWD
- CCSD

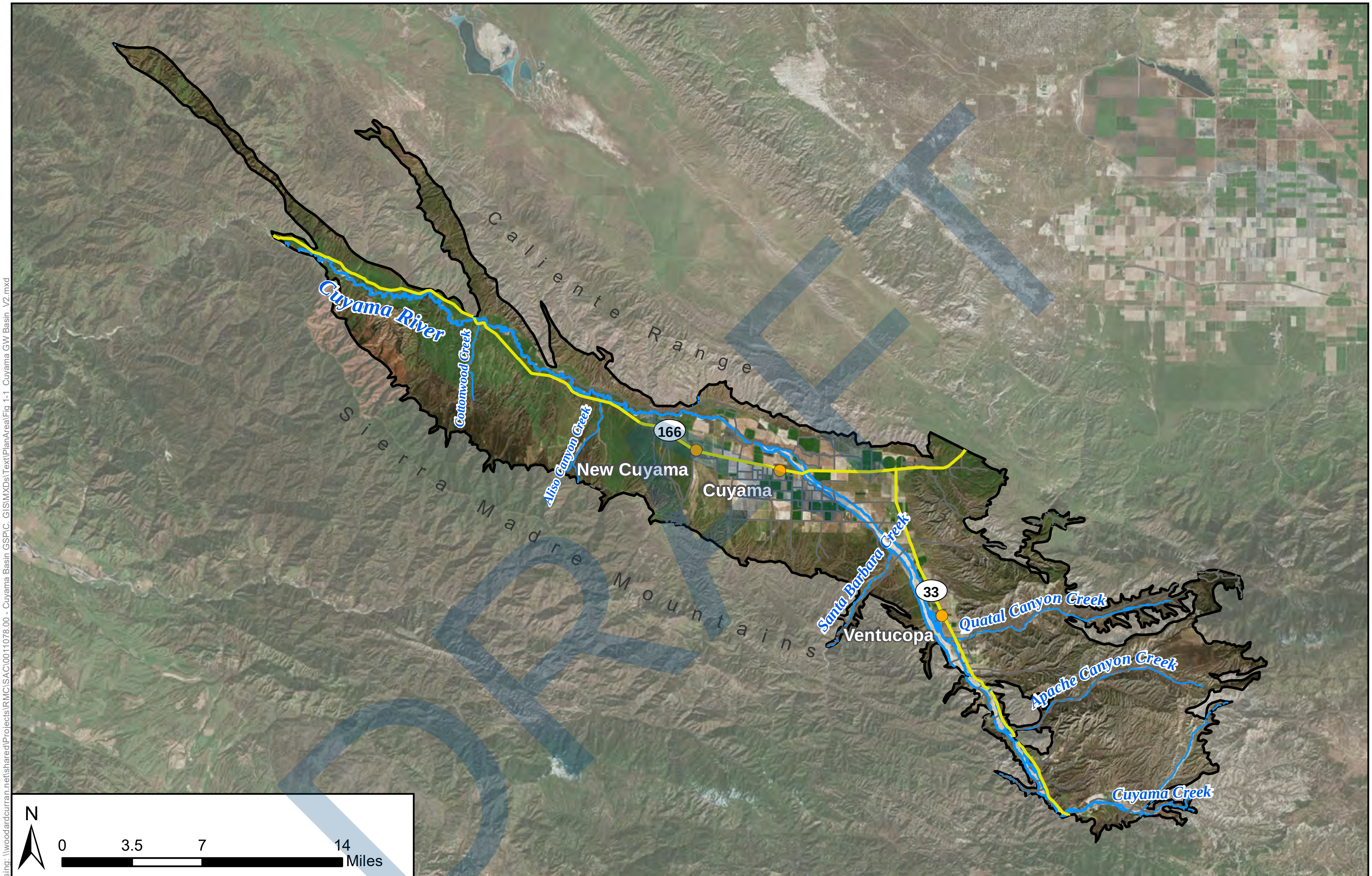

Figure 1-1 - Cuyama Valley Groundwater Basin

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

April 2019

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Legend

- Towns
- Cuyama Basin
- Highways
- Local Roads
- Cuyama River
- Streams/Creeks

Figure Exported: 7/9/2018 By: mwicks Using: \\woodardcurran.net\shared\Projects\RMC\SAC\0011078.00 - Cuyama Basin GSP\C. GIS\MXDs\Text\PlanArea\Fig 1-1 Cuyama GW Basin V2.mxd

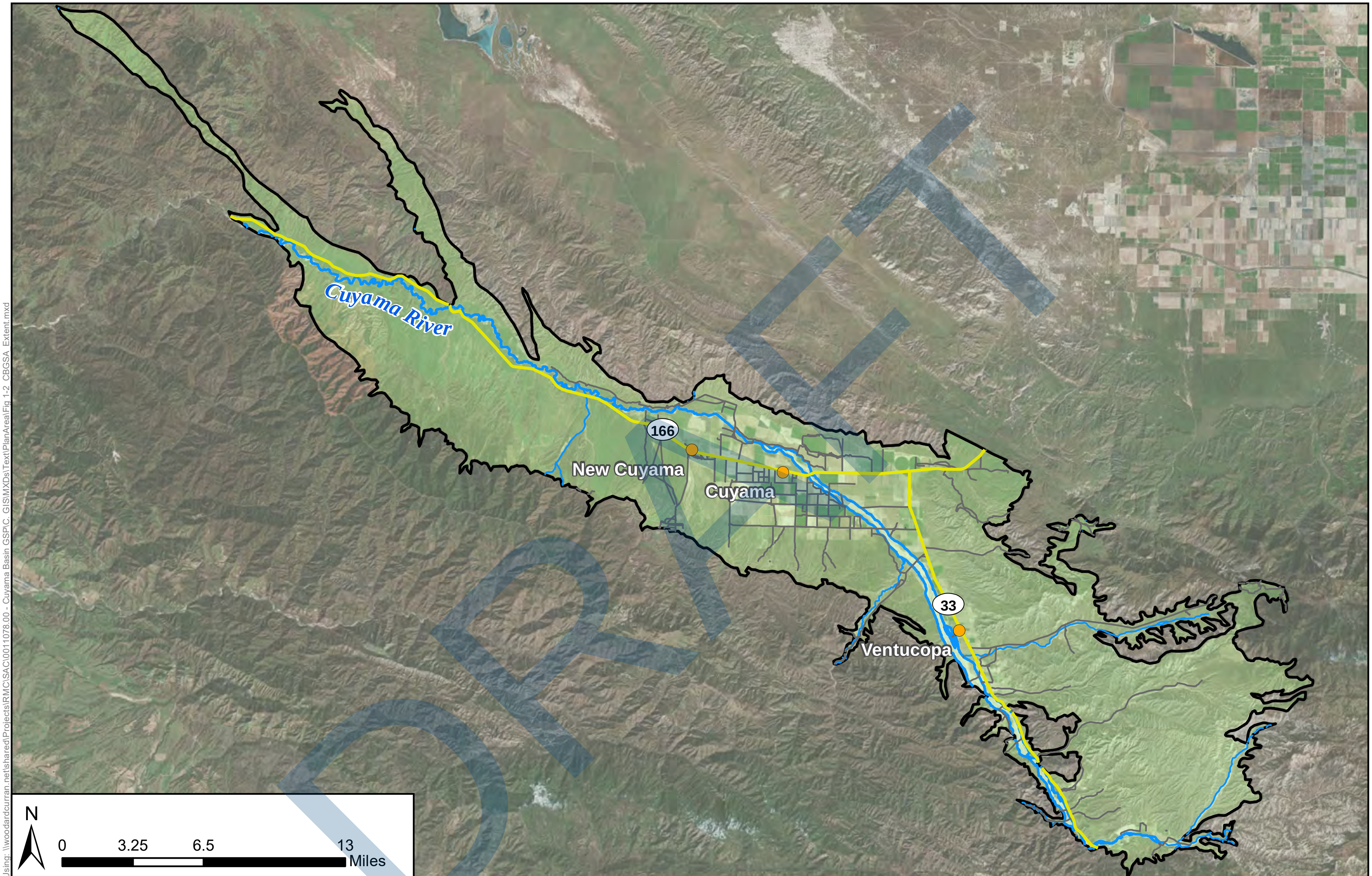

Figure 1-2 - Cuyama Valley Groundwater Sustainability Agency Boundary

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

April 2019

WOODARD & CURRAN

Legend

- Towns
- Cuyama Basin GSA
- Highways
- Local Roads
- Cuyama River
- Streams/Creeks

Figure Exported: 6/19/2018 By: mwicks Using: \\woodardcurran.net\shared\Projects\RMC\SAC\0011078.00 - Cuyama Basin GSP\C_GIS\MXDs\Text\PlanArea\Fig 1-2_CBGSA_Extent.mxd

Figure 1-3 shows the Basin and neighboring groundwater basins. The Carrizo Plain Basin is located immediately northeast of the Cuyama Basin and they share a boundary at a location about 5 miles east of the intersection of SR 166 and SR 133. The San Joaquin Valley Basin is located just east of the Carrizo Plain Basin. The Basin also shares a boundary with the Mil Potrero Area Basin, which is located just east of one of the Basin's southeastern tips, and the Lockwood Valley Basin is located close to the Basin's southern area but does not share a boundary with it. To the southwest, and more distant from the Basin, are the Santa Maria, San Antonio Creek Valley and Santa Ynez River Valley basins, which are located about 30 to 40 miles southwest of the Cuyama Basin.

Figure 1-4 depicts the Basin's extent relative to the boundaries of the various counties that overlie the Basin. Santa Barbara County has jurisdiction over the largest portion of the Basin (168 square miles), covering most of the area south of the Cuyama River, as well as Ventucopa and a small area to the north of that community. San Luis Obispo County has jurisdiction over areas north of the Cuyama River (covering 77 square miles). The Cuyama River marks the boundary between San Luis Obispo County and Santa Barbara County. Kern County has jurisdiction over the smallest extent of Cuyama Basin area compared to the other counties (13 square miles). Its jurisdictional coverage is located just east of the SR 166 and SR 33 intersection, as well as tips of the Basin in the Quatal Canyon area. Ventura County has jurisdiction over the southeastern area of the Basin (covering 120 square miles), including the area east of Ventucopa.

Figure 1-5 shows the non-county jurisdictional boundaries in the Basin. The CBWD was formed in 2016 and covers a large area of the Basin (about 130 square miles), from a location about 5 miles west of Wells Creek to 2 miles east of the intersection of SR 166 and SR 33, and south of Ventucopa along SR 33. The CCSD was formed in 1977 and covers a small area of the Basin (about 0.5 square miles) located along SR 166 in the community of New Cuyama.

Figures 1-6 through 1-13 show the agricultural and urban land uses in the Cuyama Basin for the years 1996, 2000, 2003, 2006, 2009, 2012, 2014 and 2016, respectively. The 1996 land use data are from historical DWR county land use surveys[1] while the 2014 and 2016 land use data were developed for DWR using remote sensing data.[2] Data for the remaining years were developed by the CBGSA using the same remote sensing method that DWR used for 2014 and 2016. Agricultural land is located primarily in the New Cuyama and Ventucopa areas, and along the SR 166 and SR 33 corridors between those communities. There is a regular rotation of crops with between 9,000 and 15,000 acres of agricultural area left idle each year between 2000 and 2016 (the 1996 dataset does not include records of idle land). Areas that are in active agricultural use primarily produce miscellaneous truck crops, carrots, potatoes and sweet potatoes, miscellaneous grains and hay, and grapes. Various other crop types are produced in the Basin as well, such as fruit and nut trees, though at smaller production scales.

[1] https://www.water.ca.gov/Programs/Water-Use-And-Efficiency/Land-And-Water-Use/Land-Use-Surveys

[2] https://gis.water.ca.gov/app/CADWRLandUseViewer/

In addition to the crop types shown on the maps, much of the land area in the Basin, particularly in the western and eastern areas, consists of non-irrigated pasture. These are not present on the map because they are not detected by the remote sensing approach. Some recently planted crops are also not shown on the maps because they were either not detected by the remote sensing approach or were planted subsequent to the most recently mapped year of 2016. These include a new vineyard along SR 166 in the western part of the basin (which the remote sensing approach identifies as "idle" in 2016) and new olive orchards along SR 33. These additional land uses will be accounted for in the numerical modeling used to develop water budgets for the GSP.

Figure 1-14 shows 2016 land use by water source in the Basin. Almost all of the water use in the Basin is served by groundwater. There are 37 surface water rights permits in the Basin that allow up to 116 acre-feet per year. Much of the surface water use is for stockwatering of pasture land, which may not be included in the land use dataset shown in the figure.

Figure 1-15 shows the number of domestic wells per square mile and the average depth of domestic wells in each square mile in the Basin. Figure 1-15 shows a grid pattern where each block on the grid is a section that covers 1 square mile of land. The number in each square represents the average depth of the well(s) in the section. Most of the sections in the Basin that have domestic wells contain only one well, while twelve sections contain two wells each, three sections contain three wells each, four sections contain four wells each, and one section contains six wells. Wells range in depth broadly across the Basin, from as shallow as 120 feet below ground surface in the southeast portion of the Basin to 1,000 feet below ground surface in the central portion of the Basin.

Figure 1-16 shows the density and average depth of production wells in the Basin per square mile. There is a wide distribution of production well density in the Basin (between 1 and 11 wells per square mile). Depths of production wells range from 50 feet below ground surface (bgs) on the outer edges of the Basin, to over 1,200 feet bgs in the central portion of the Basin.

Figure 1-17 shows the density and average depth of public wells in the Cuyama Basin. The Basin contains three public wells, one just south of New Cuyama, one east of Ventucopa and one at the southern tip of the Basin. These wells have depths of 855, 280 and 800 feet, respectively.

Information presented in Figures 1-15 through 1-17 reflect information contained in DWR's well completion report database, which contains information about the majority of wells drilled after 1947. However, some wells may not have been reported to DWR (potentially up to 30 percent of the total), and therefore are not included in the database or in these figures. Furthermore, designations of each well as a domestic, production, or public well were developed by DWR based on information contained in the well completion reports and have not been modified for this document.

Figure 1-18 shows the public lands in and around the Basin. Some portions of the land that overlies the Cuyama Basin, and most of the areas immediately surrounding the Basin, have a federal or State jurisdictional designation. The Los Padres National Forest covers most of the Basin's northwestern arm, then runs just outside the Basin's western boundary until the Forest boundary turns east at about Ventucopa where it covers the southern part of the basin. The balance of the northwestern arm consists of private holdings and the state-owned Carrizo Plains Ecological Reserve which extends into the basin to the Santa Barbara County-San Luis Obispo County line at the Cuyama River. A portion of the Basin north of Ventucopa, as well as an area nearby that is immediately outside the Basin, is designated as the Bitter Creek National Wildlife Refuge. The Bureau of Land Management has jurisdiction over a large area outside the Basin, and along the Basin's northern boundary, including small parts of the Basin north of the Cuyama River. Most of the northeastern arm of the Basin is designated as State Lands.

Figure 1-19 shows that the Basin is located within the Cuyama Watershed, which lies within the larger Santa Maria watershed, with the Basin occupying roughly the entirety of the Santa Maria Basin's eastern contributing watershed, and a small part of the Cuyama Basin's northeastern arm that flows into the Estrella River Basin due to the topography present in this area. Figure 1-19 illustrates the Cuyama Watershed's location in the Santa Maria Basin, as well as the larger Basin's major receiving water bodies, which include the Santa Maria River, the Cuyama River, Aliso Canyon Creek, Cottonwood Creek, Apache Canyon Creek, Santa Barbara Creek, the Quatal Canyon drainage, and Cuyama Creek.

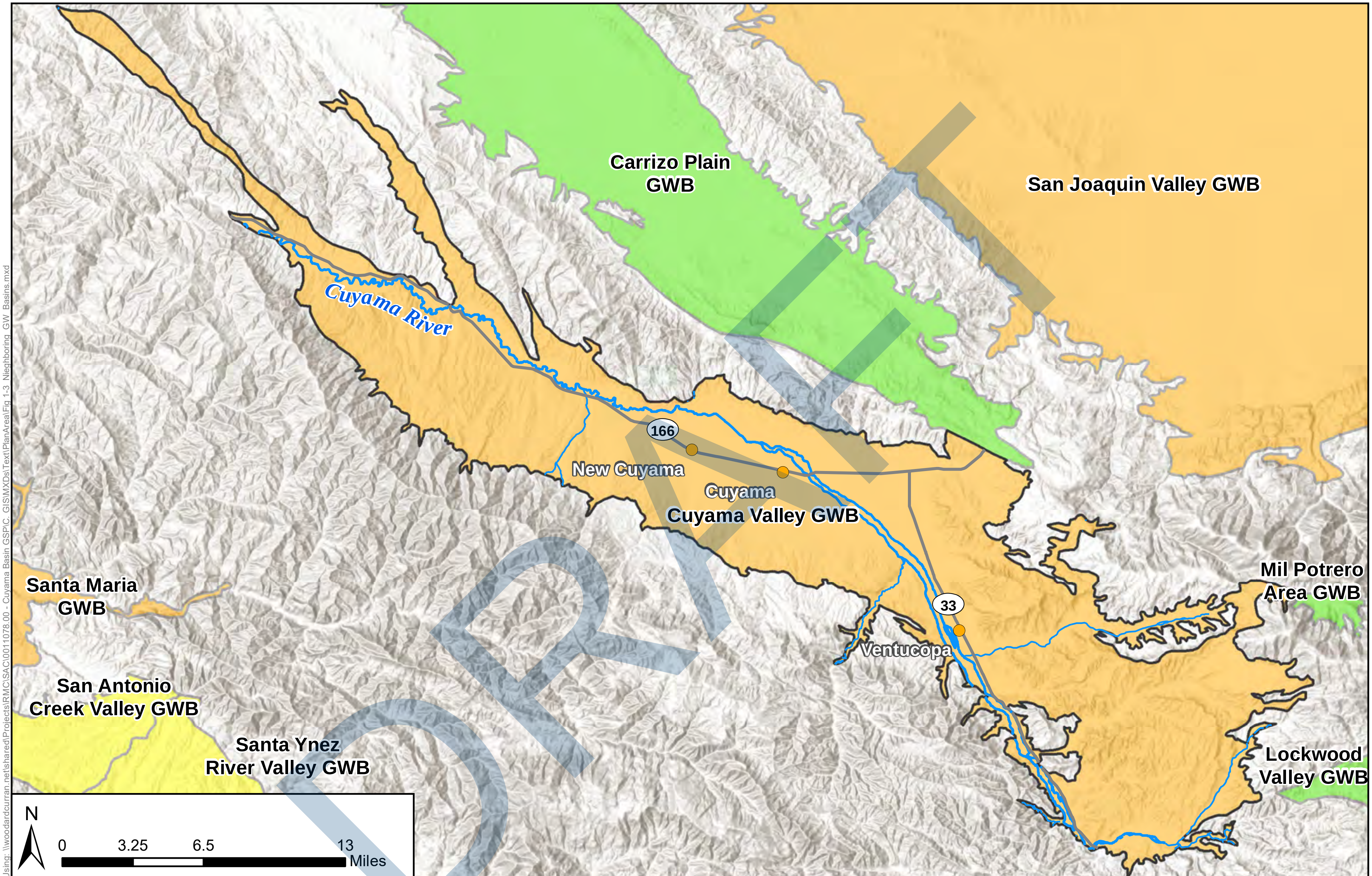

Figure 1-3 - Neighboring Groundwater Basins

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

April 2019

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Legend

- Towns
- Cuyama Basin
- Highways
- Cuyama River
- Streams/Creeks

Basin Priority

- High Priority
- Medium Priority
- Low Priority
- Very Low Priority

Figure Exported: 6/19/2018 By: mwicks Using: \\woodardcurran.net\shared\Projects\RMC\SAC\0011078.00 - Cuyama Basin GSP\C_GIS\MXDs\Text\PlanArea\Fig 1-3 Neighboring GW Basins.mxd

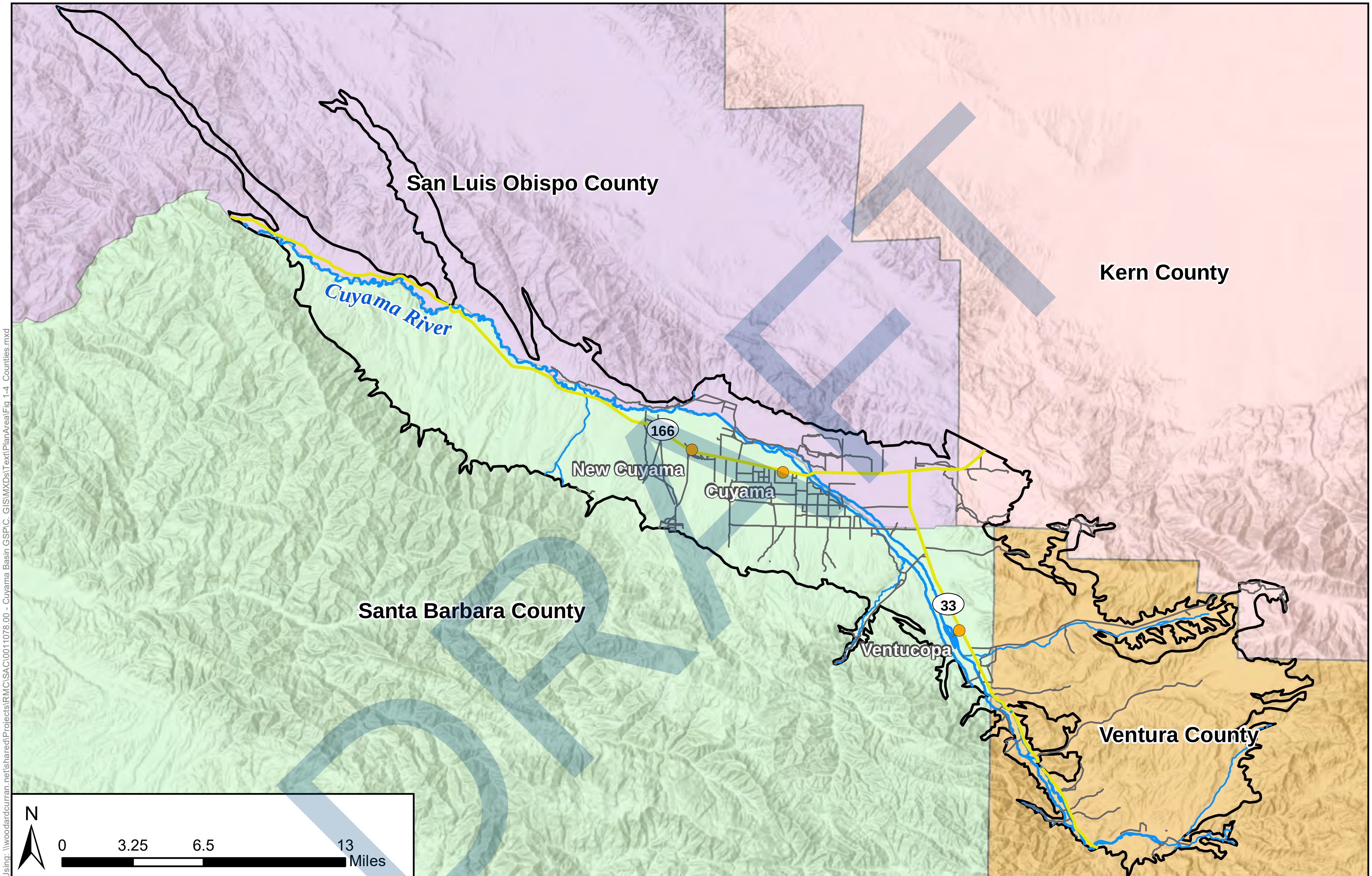

Figure 1-4 - Counties Overlying Cuyama Basin

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

April 2019

Legend

- Towns
- Cuyama Basin
- Highways
- Local Roads
- Cuyama River
- Streams/Creeks

County

- Kern County
- San Luis Obispo County
- Santa Barbara County
- Ventura County

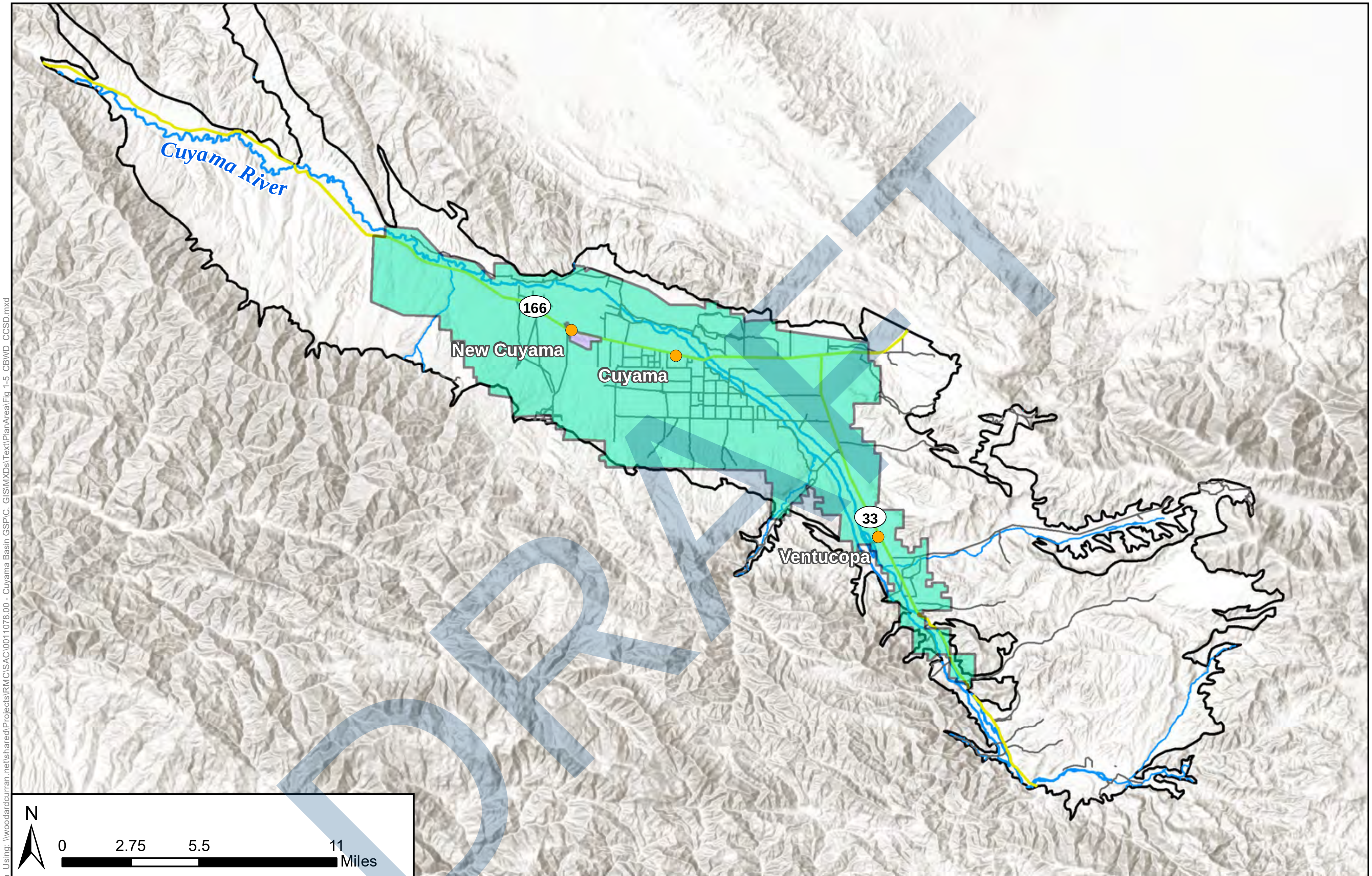

Figure 1-5 - Non-County Jurisdictional Boundaries

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

April 2019

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Legend

- Cuyama Basin
- Towns
- Cuyama Community Service District
- Cuyama Basin Water District
- Highways
- Local Roads
- Cuyama River
- Streams/Creeks

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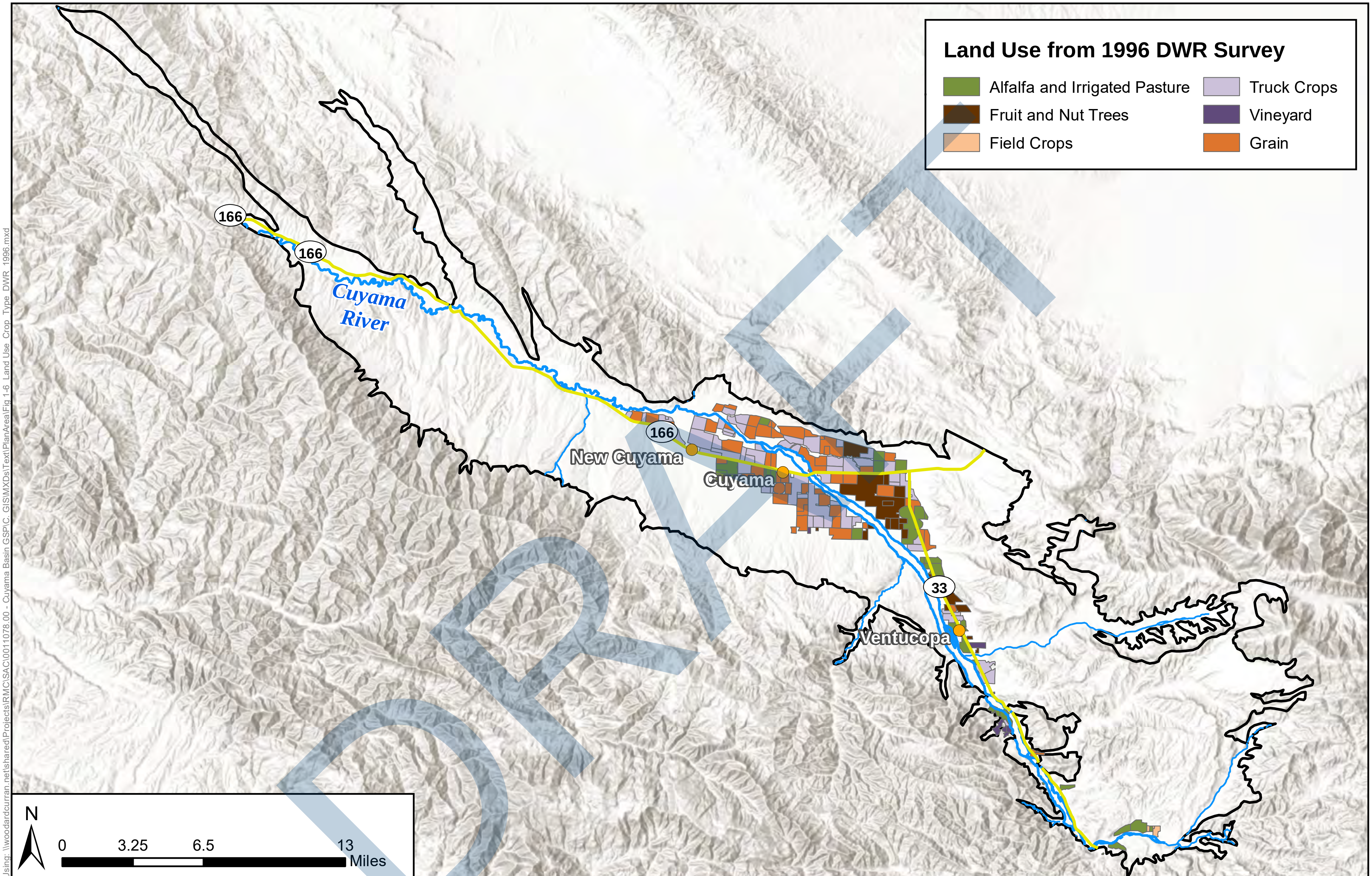

Figure 1-6 - 1996 Land Use

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- Towns
- Highways
- Cuyama River
- Streams/Creeks

Source: California Department of Water Resources County Land Use Surveys, 1996 dataset.
https://www.water.ca.gov/Programs/Water-Use-And-Efficiency/Land-And-Water-Use/Land-Use-Surveys

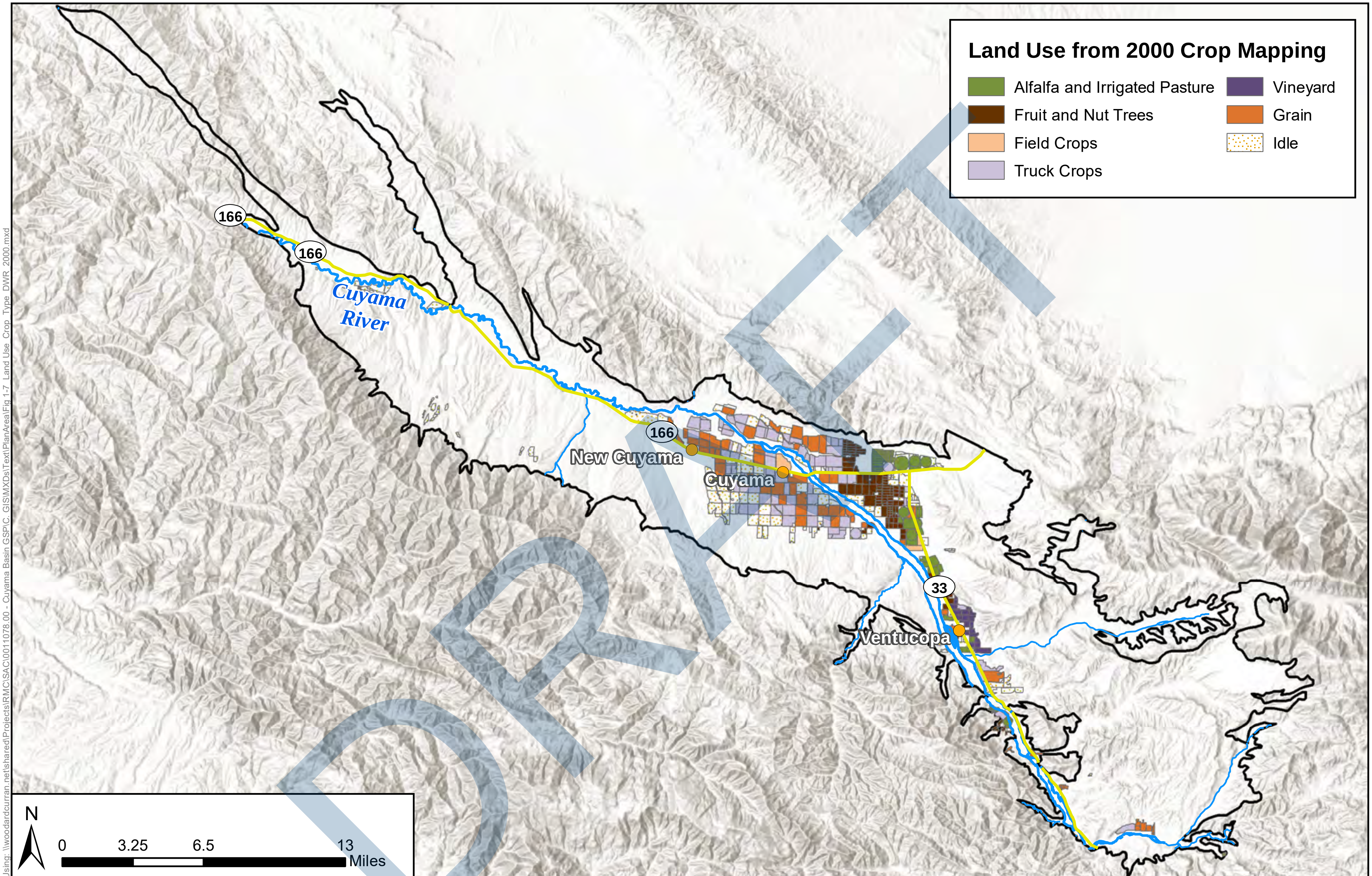

Figure 1-7 - 2000 Land Use

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

April 2019

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Legend

Cuyama Basin
Towns
Highways
Cuyama River
Streams/Creeks

Source: Crop Mapping developed by LandIQ for the Cuyama Basin GSA, 2000 dataset

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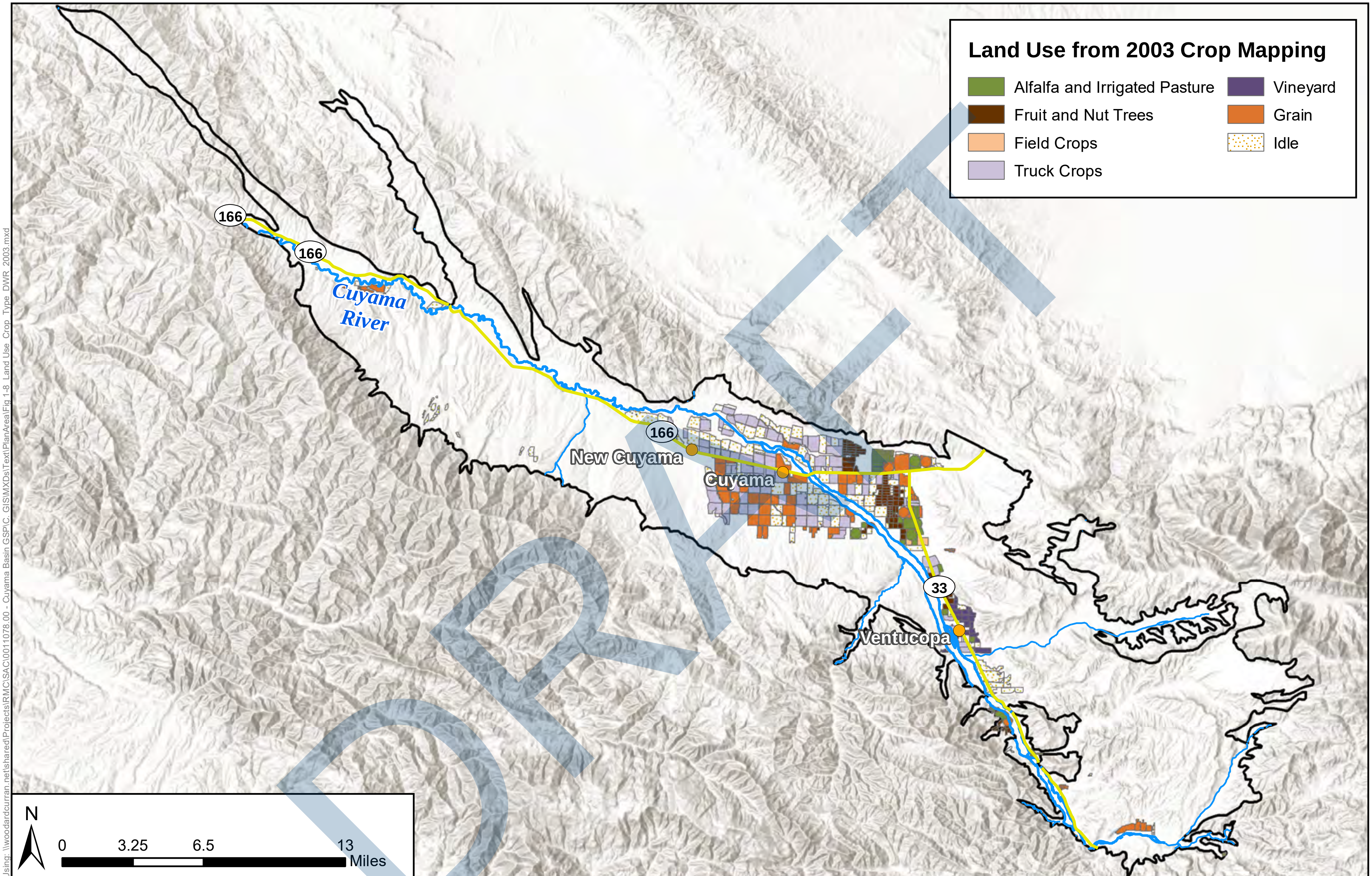

Figure 1-8 - 2003 Land Use

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

Cuyama Basin
Towns
Highways
Cuyama River
Streams/Creeks

Source: Crop Mapping developed by LandIQ for the Cuyama Basin GSA, 2003 dataset.

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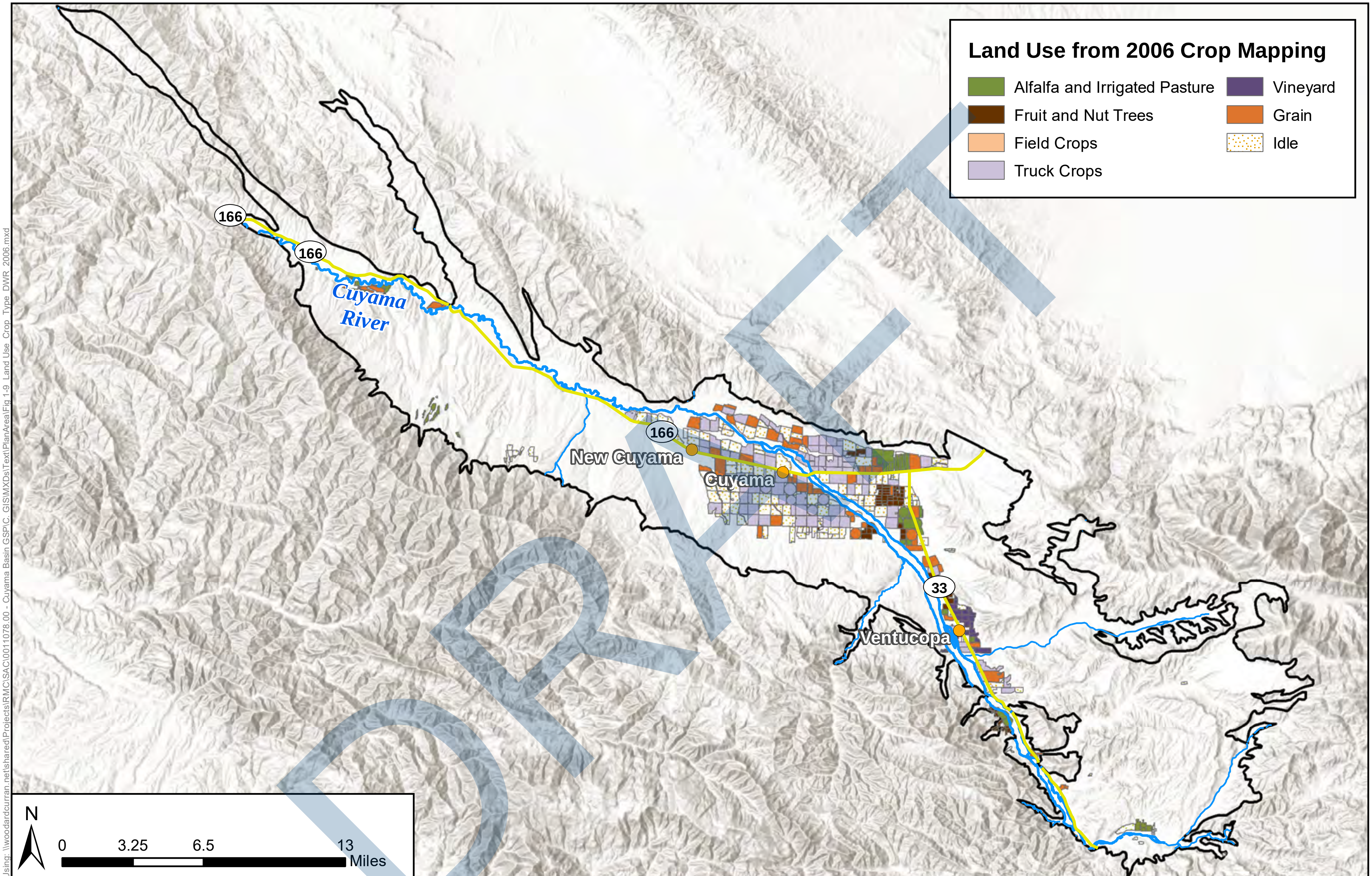

Figure 1-9 - 2006 Land Use

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- Towns
- Highways
- Cuyama River
- Streams/Creeks

Source: Crop Mapping developed by LandIQ for the Cuyama Basin GSA, 2006 dataset.

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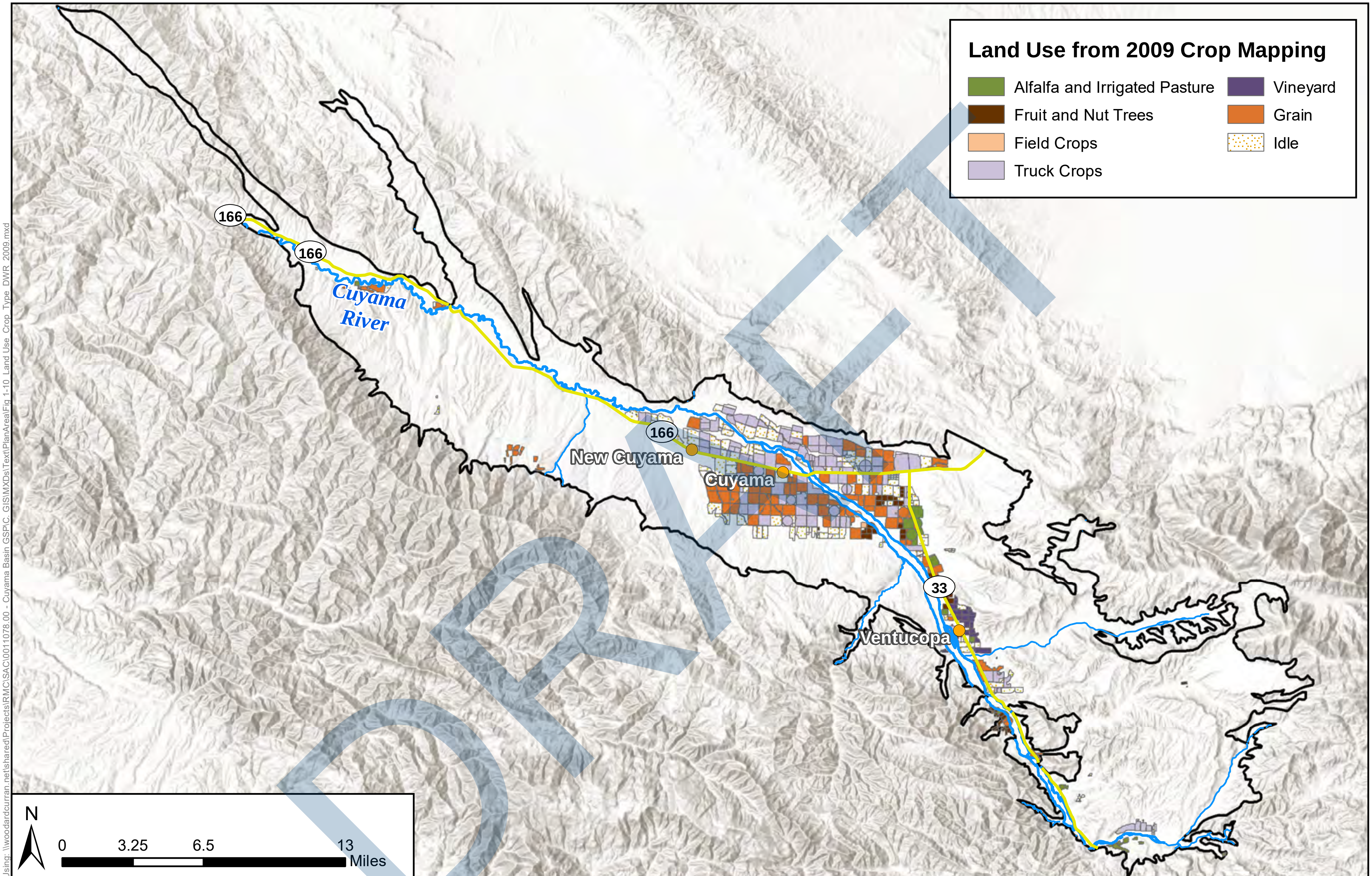

Figure 1-10 - 2009 Land Use

Cuyama Basin Groundwater Sustainability Agency

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Legend

- Cuyama Basin
- Towns
- Highways
- Cuyama River
- Streams/Creeks

Source: Crop Mapping developed by LandIQ for the Cuyama Basin GSA, 2009 dataset.

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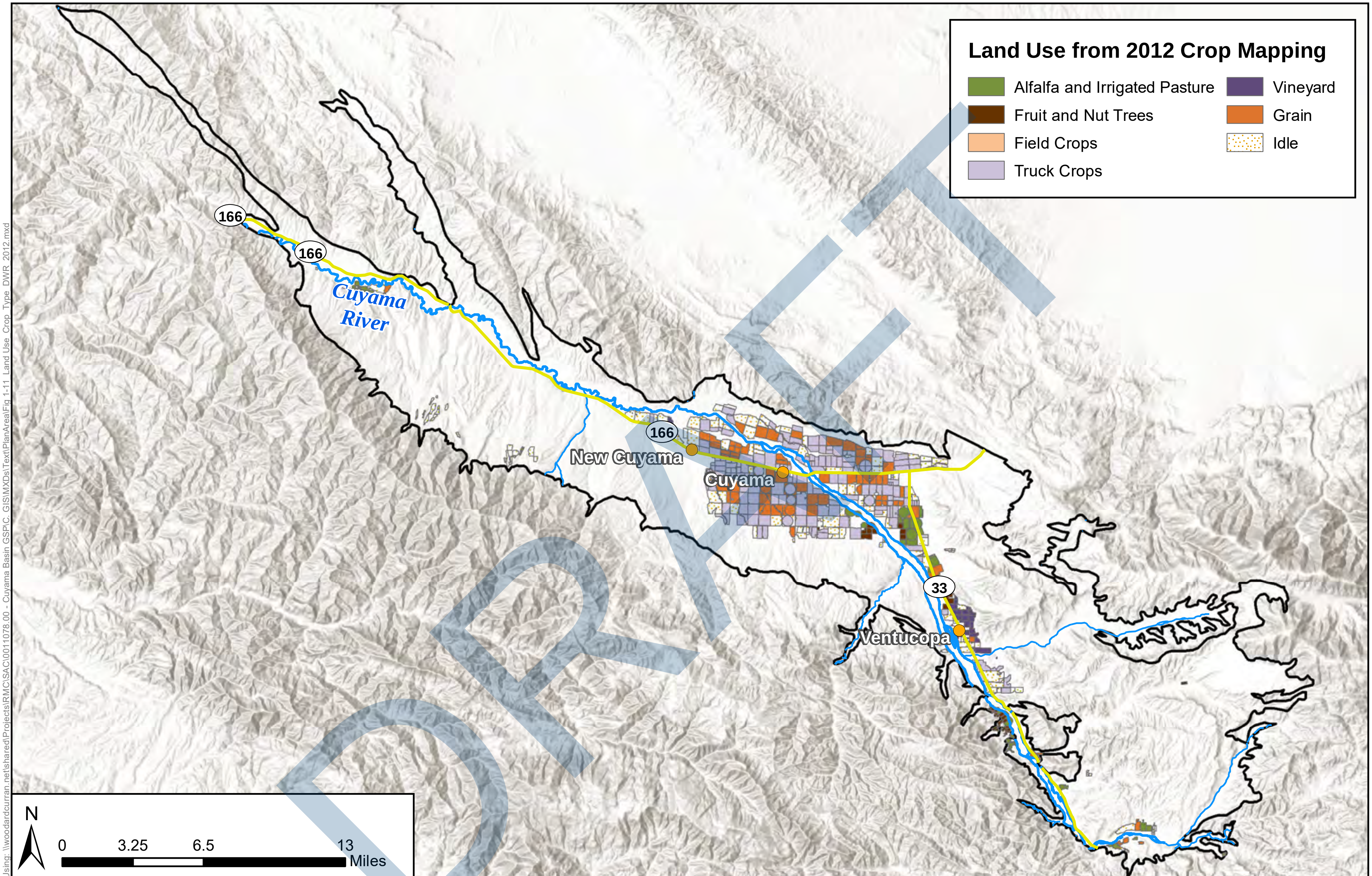

Figure 1-11 - 2012 Land Use

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- Towns
- Highways
- Cuyama River
- Streams/Creeks

Source: Crop Mapping developed by LandIQ for the Cuyama Basin GSA, 2012 dataset.

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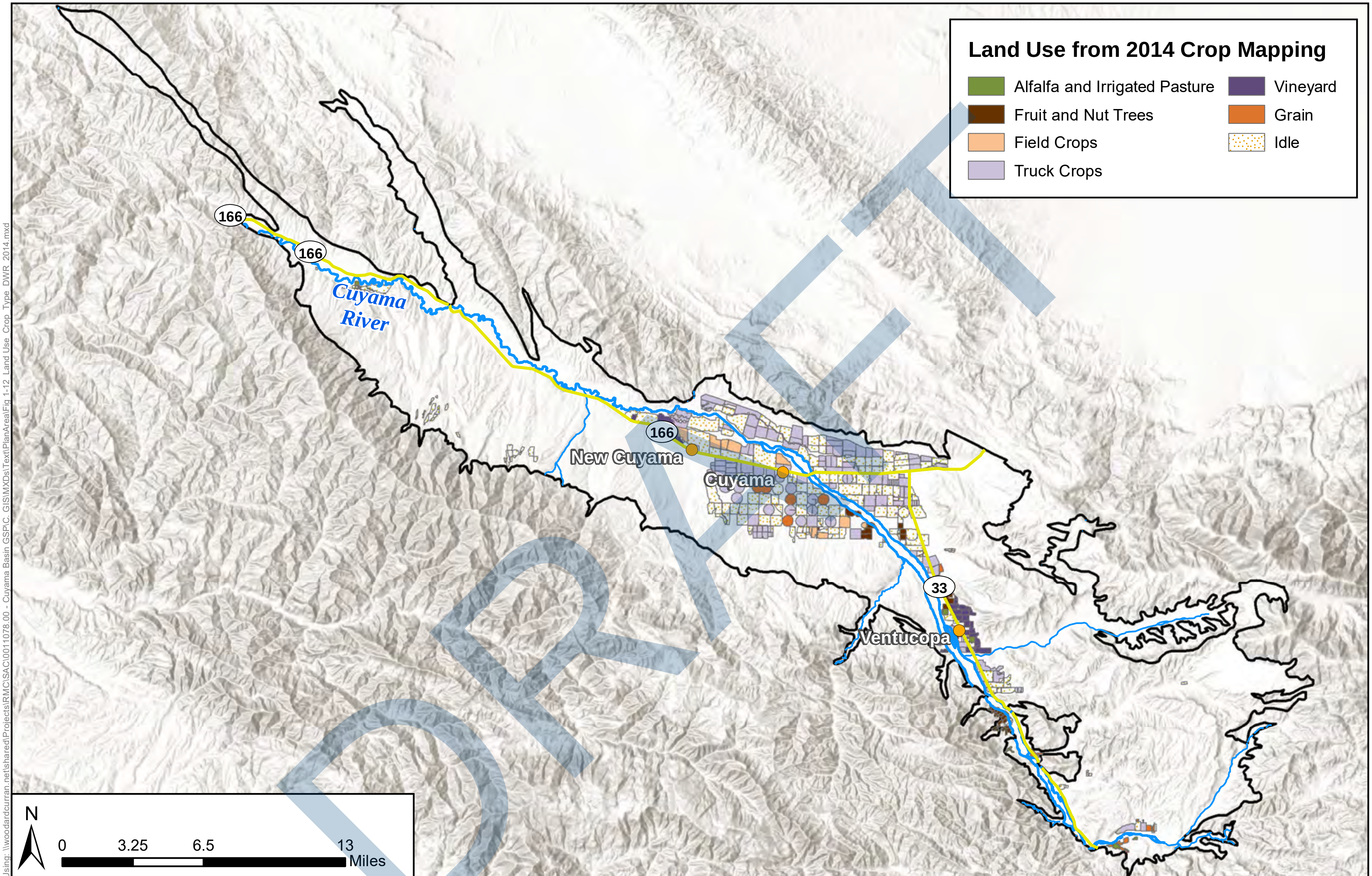

Figure 1-12 - 2014 Land Use

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

Cuyama Basin
Towns
Highways
Cuyama River
Streams/Creeks

Source: California Department of Water Resources County Land Use Surveys, 2014 dataset.
https://gis.water.ca.gov/app/CADWRLandUseViewer/

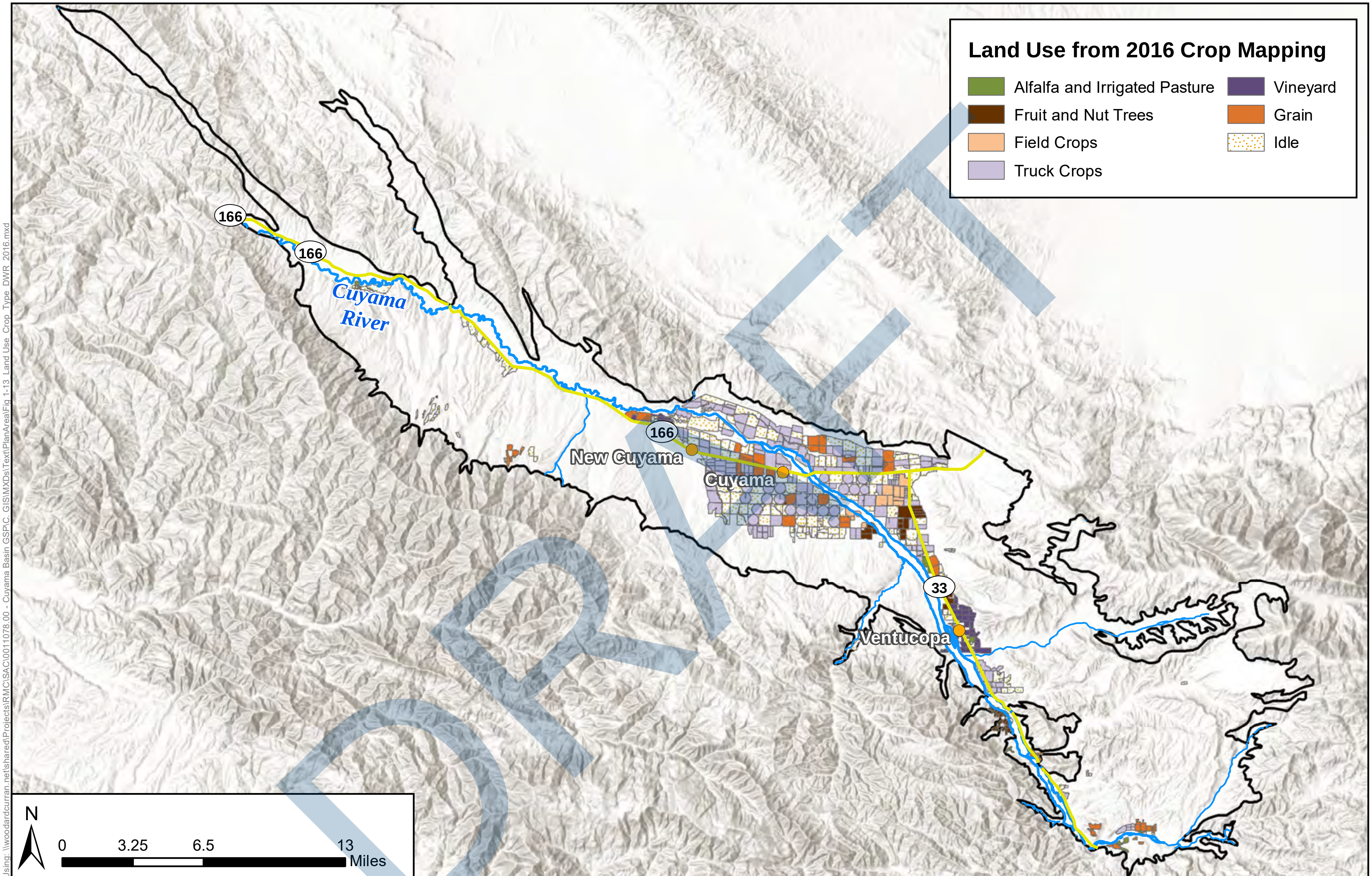

Figure 1-13 - 2016 Land Use

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

Cuyama Basin
Towns
Highways
Cuyama River
Streams/Creeks

Source: California Department of Water Resources County Land Use Surveys, 2016 dataset. https://gis.water.ca.gov/app/CADWRLandUseViewer/

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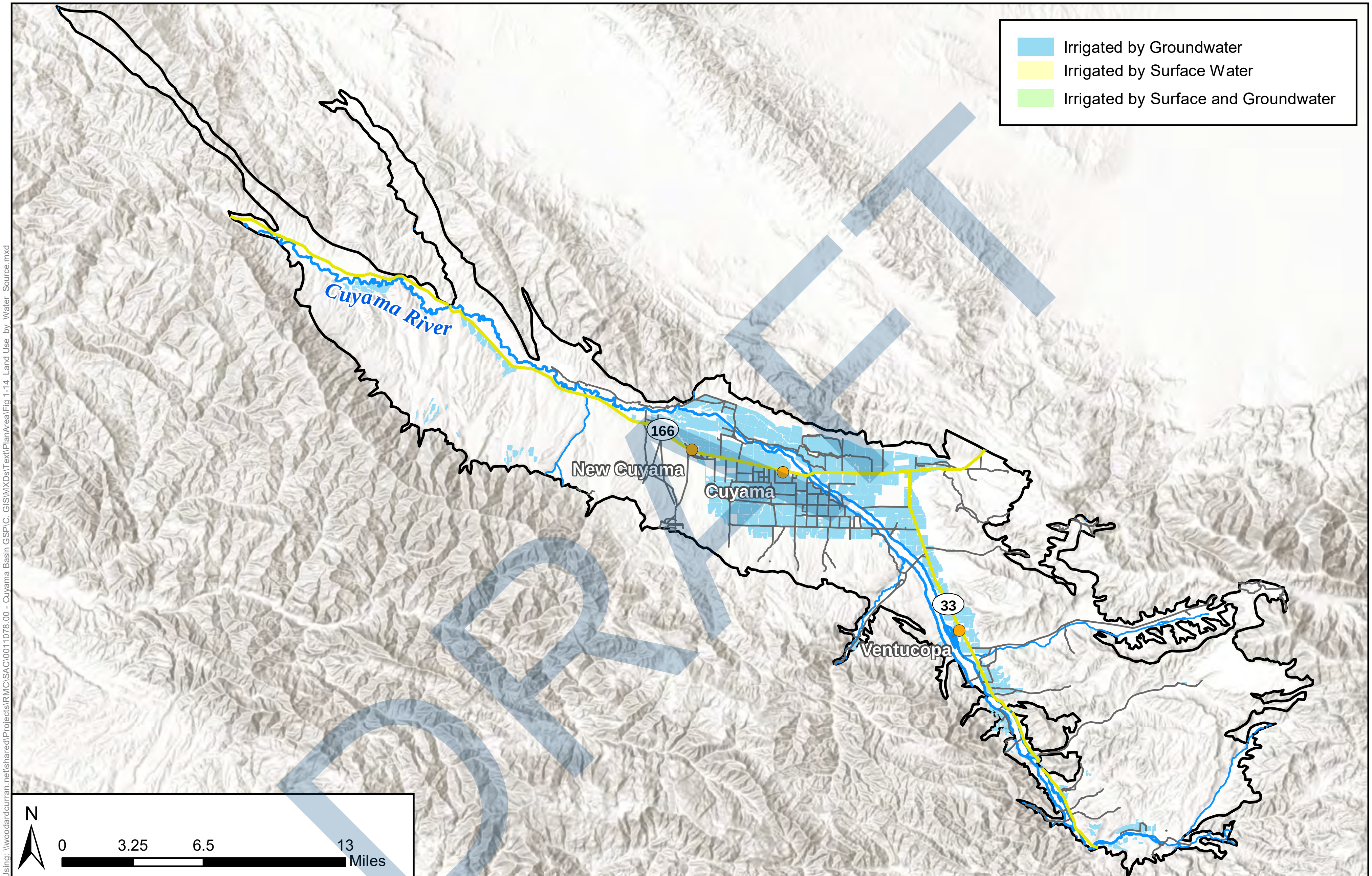

Figure 1-14 - Land Use by Water Source

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

April 2019

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Legend

Cuyama Basin
Towns
Highways
Local Roads
Cuyama River
Streams/Creeks

Source: California Department of Water Resources Statewide Crop Mapping, 2016 dataset. https://gis.water.ca.gov/app/CADWRLandUseViewer/

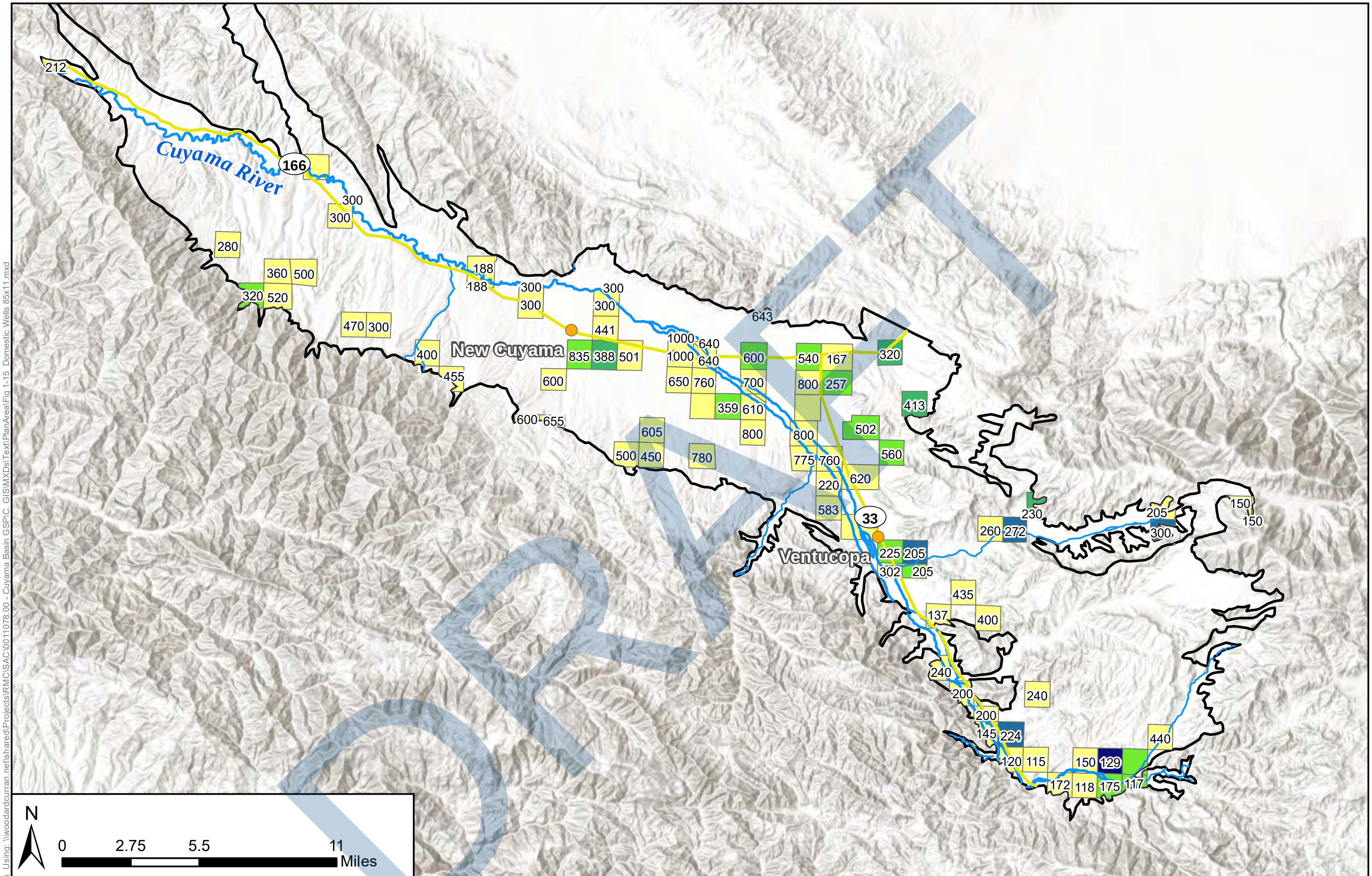

Figure 1-15 - Domestic Well Density and Average Depths

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

April 2019

WOODARD &CURRAN

Legend

- Cuyama Basin
- Towns
- Highways
- Cuyama River
- Streams/Creeks

Number of Domestic Wells by Township & Range

- 1 Well
- 2 Wells
- 3 Wells
- 4 Wells
- 6 Wells

Numbers in the township and range grid correspond to the average depth of the wells within that grid. Grids with no number have no associated well depth data. Average well depth is given in feet below the ground surface.

Source: Department of Water Resources, Well Completion Report Map Application. Downloaded on February 6, 2018. <https://dwr.maps.arcgis.com/apps/webappviewer/index.html?id=181078580a214c0986e2da28f8623b37>

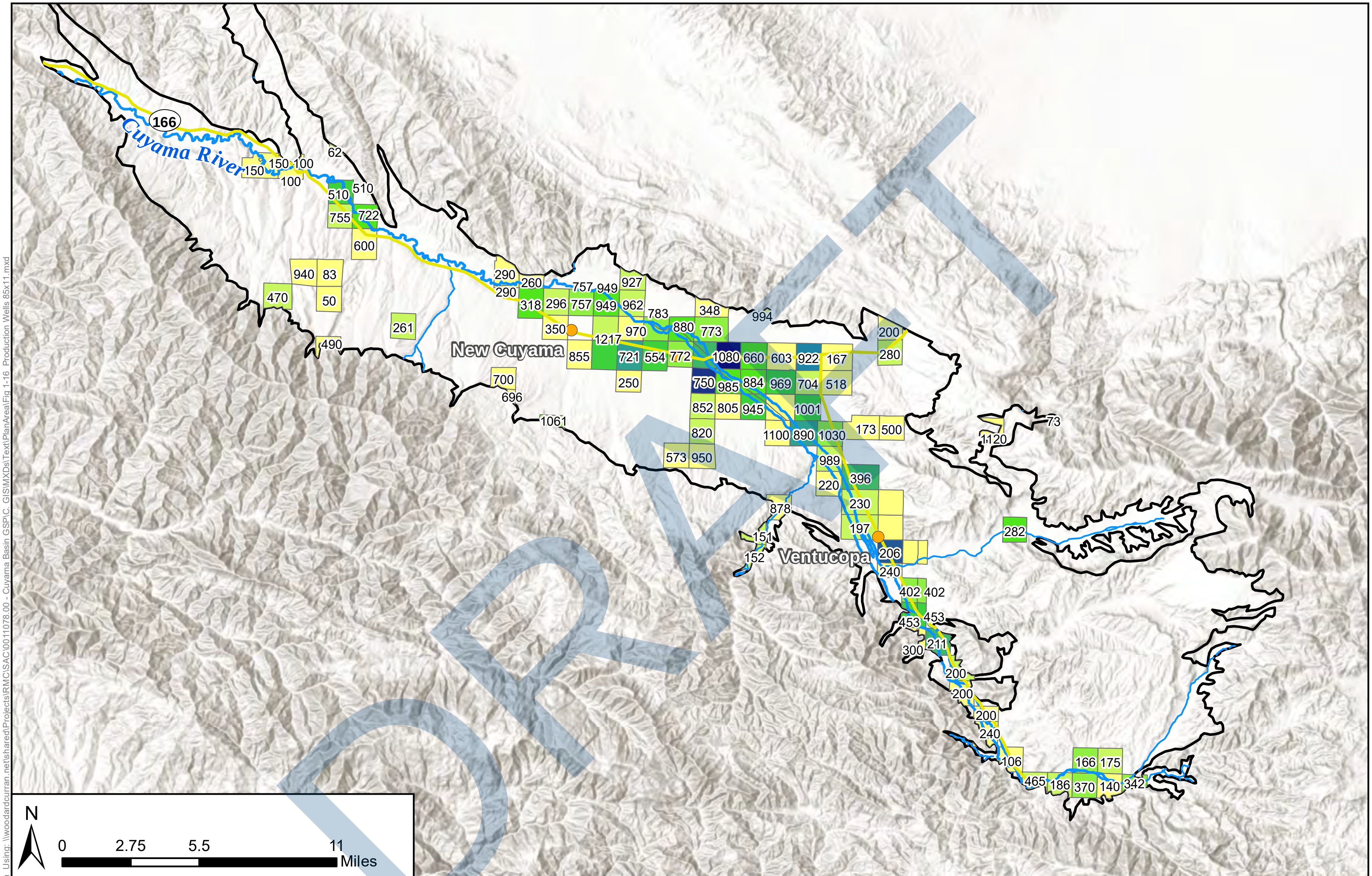

Figure 1-16 - Production Well Density and Average Depths

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

April 2019

WOODARD & CURRAN

Legend

- Cuyama Basin
- Towns
- Highways
- Cuyama River
- Streams/Creeks

Number of Production Wells by Township & Range

1 Well	5 Wells	9 Wells
2 Wells	6 Wells	10 Wells
3 Wells	7 Wells	11 Wells
4 Wells	8 Wells	

Numbers in the township and range grid correspond to the average depth of the wells within that grid. Grids with no number have no associated well depth data. Average well depth is given in feet below the ground surface.

Source: Department of Water Resources, Well Completion Report Map Application. Downloaded on February 6, 2018. <https://dwr.maps.arcgis.com/apps/webappviewer/index.html?id=181078580a214c0986e2da28f8623b37>

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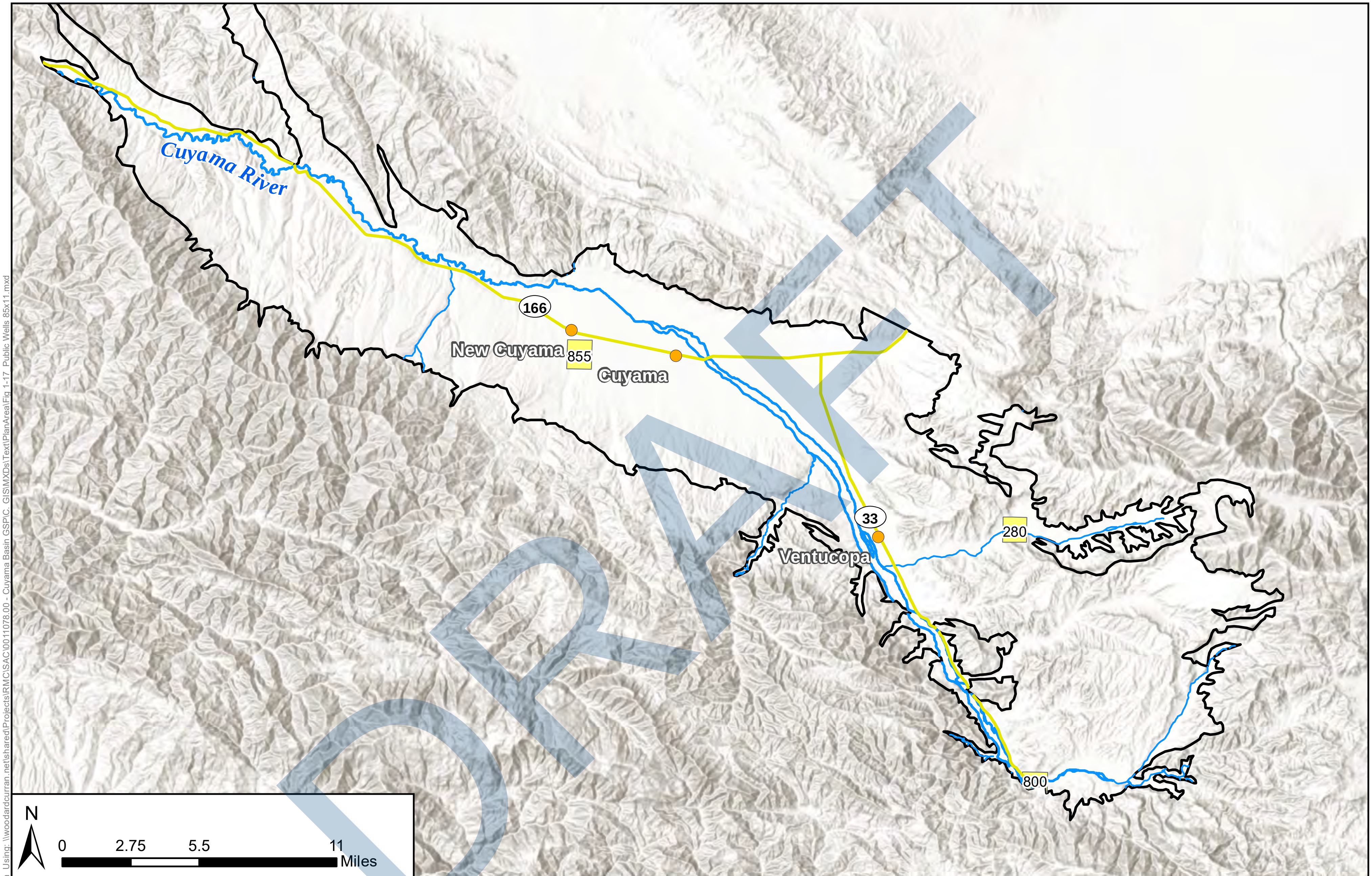

Figure 1-17 - Public Well Density and Average Depths

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

April 2019

WOODARD &CURRAN

Legend

- Cuyama Basin
- Towns
- Highways
- Cuyama River
- Streams/Creeks

Number of Public Wells by Township & Range

- 1 Well

Numbers in the township and range grid correspond to the average depth of the wells within that grid. Grids with no number have no associated well depth data. Average well depth is given in feet below the ground surface.

Source: Department of Water Resources, Well Completion Report Map Application. Downloaded on February 6, 2018. <https://dwr.maps.arcgis.com/apps/webappviewer/index.html?id=181078580a214c0986e2da28f8623b37>

Figure Exported: 6/14/2018 By: ceggleton Using: \\woodardcurran.net\shared\Projects\RMC\SAC\0011078.00 - Cuyama Basin GSP\C_GIS\MXDs\Text\PlanArea\Fig 1-17_Public Wells 85x11.mxd

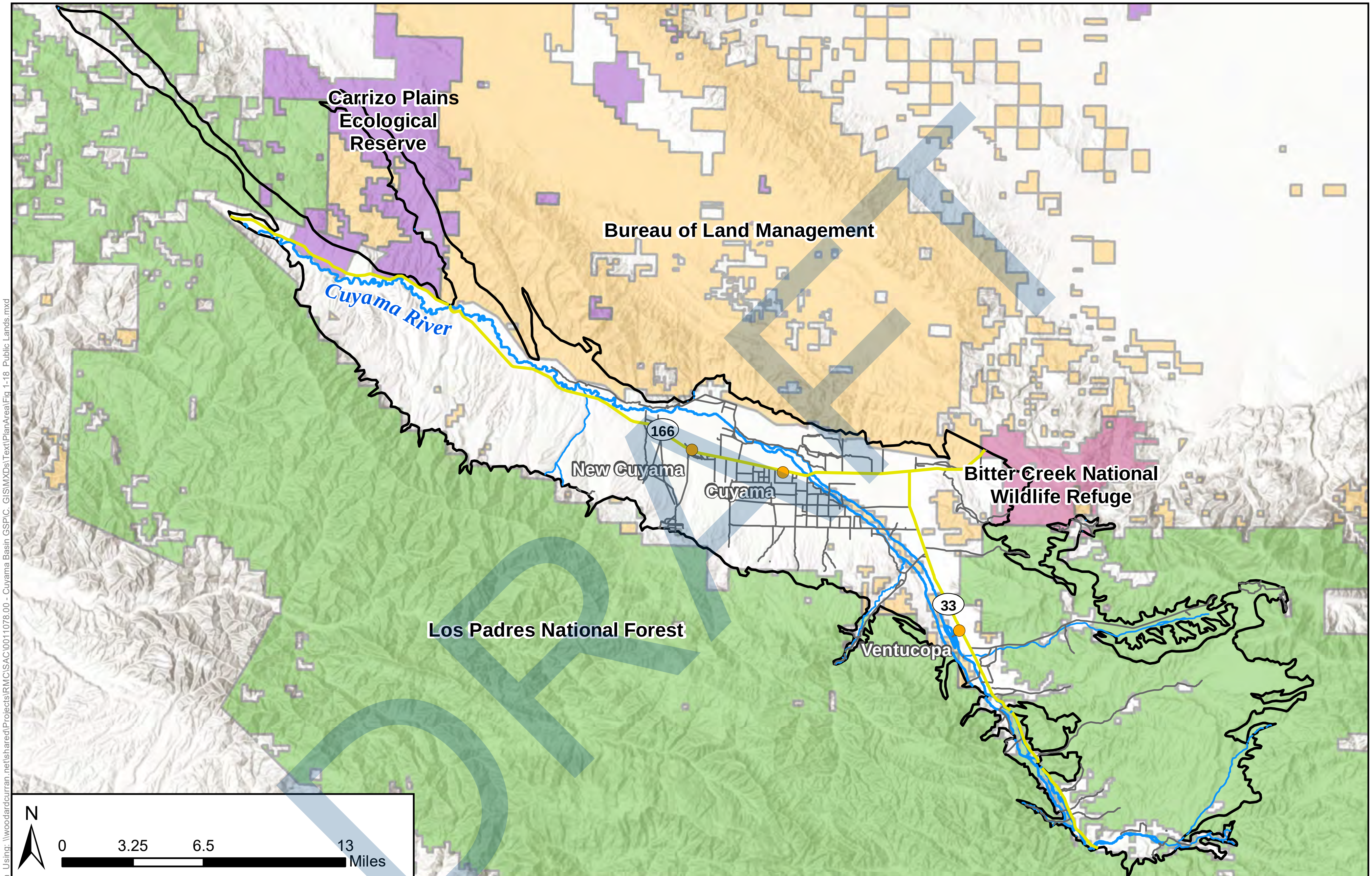

Figure 1-18 - Federal and State Lands

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

April 2019

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Legend

- Cuyama Basin
- Towns
- Highways
- Local Roads
- Cuyama River
- Streams/Creeks
- Bureau of Land Management
- US Forest Service
- US Fish and Wildlife
- State Lands

Figure Exported: 6/19/2018 By: ceggleton Using: \\woodardcurran.net\shared\Projects\RMC\SAC\0011078.00 - Cuyama Basin GSP\C_GIS\MXDs\Text\PlanArea\Fig 1-18 Public Lands.mxd

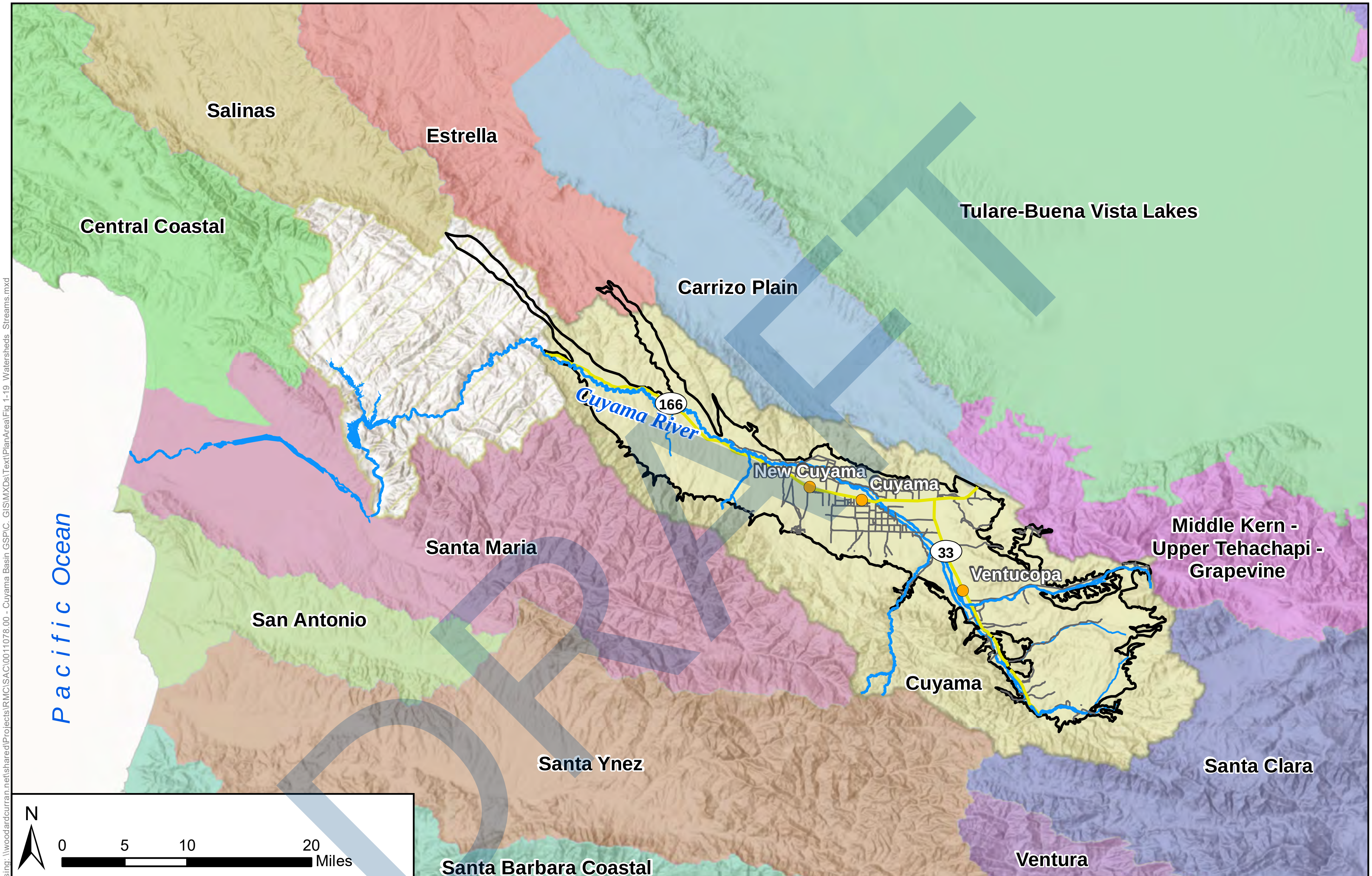

Figure 1-19 - Regional Watersheds

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Figure Exported: 7/4/2018 By: mwicks Using: \\woodardcurran.net\shared\Projects\RMC\SAC\0011078.00 - Cuyama Basin GSP\C_GIS\MXDs\Text\PlanArea\Fig 1-19 Watersheds Streams.mxd

1.2.3 Existing Surface Water Monitoring Programs

Existing surface water monitoring in the Cuyama Basin is extremely limited. Surface water monitoring in the basin is limited to DWR's California Data Exchange Center program, and monitoring performed by the United States Geological Survey (USGS). The only California Data Exchange Center gage in the Cuyama River watershed is at Lake Twitchell, which is downstream of the Cuyama Basin. The USGS has two active gages that capture flows in the Cuyama River watershed upstream of Lake Twitchell, as well as four deactivated gages (Figure 1-20). Table 1-1 lists the active and deactivated gages in the Basin.

Table 1-1. USGS Surface Flow Gages in the Cuyama Basin

Gage Number	Location	Status	Years of Record
11136800	Cuyama River below Buckhorn Canyon near Santa Maria	Active	1959-2017
11136650	Aliso Canyon Creek near New Cuyama	Deactivated	1963-1972
11136600	Santa Barbara Canyon Creek near Ventucopa	Active	2009-2017
11136500	Cuyama River near Ventucopa	Deactivated	1945-1958; 2009-2014
11136480	Reyes Creek near Ventucopa	Deactivated	1972-1978
11136400	Wagon Road Creek near Stauffer	Deactivated	1972-1978

The two active gages include one gage on the Cuyama River downstream of the Basin (ID 11136800), which is located just upstream of Lake Twitchell. This gage has 58 recorded years of streamflow measurements from 1959 to 2017. The other active gage is south of the city of Ventucopa along Santa Barbara Canyon Creek (ID 11136600) and has seven recorded years of streamflow measurements ranging from 2010 to 2017. Although neither of these stream gages provide a comprehensive picture of surface water flows in the Cuyama Basin, they can be used to help monitor the inflow and outflow of surface water through the Basin.

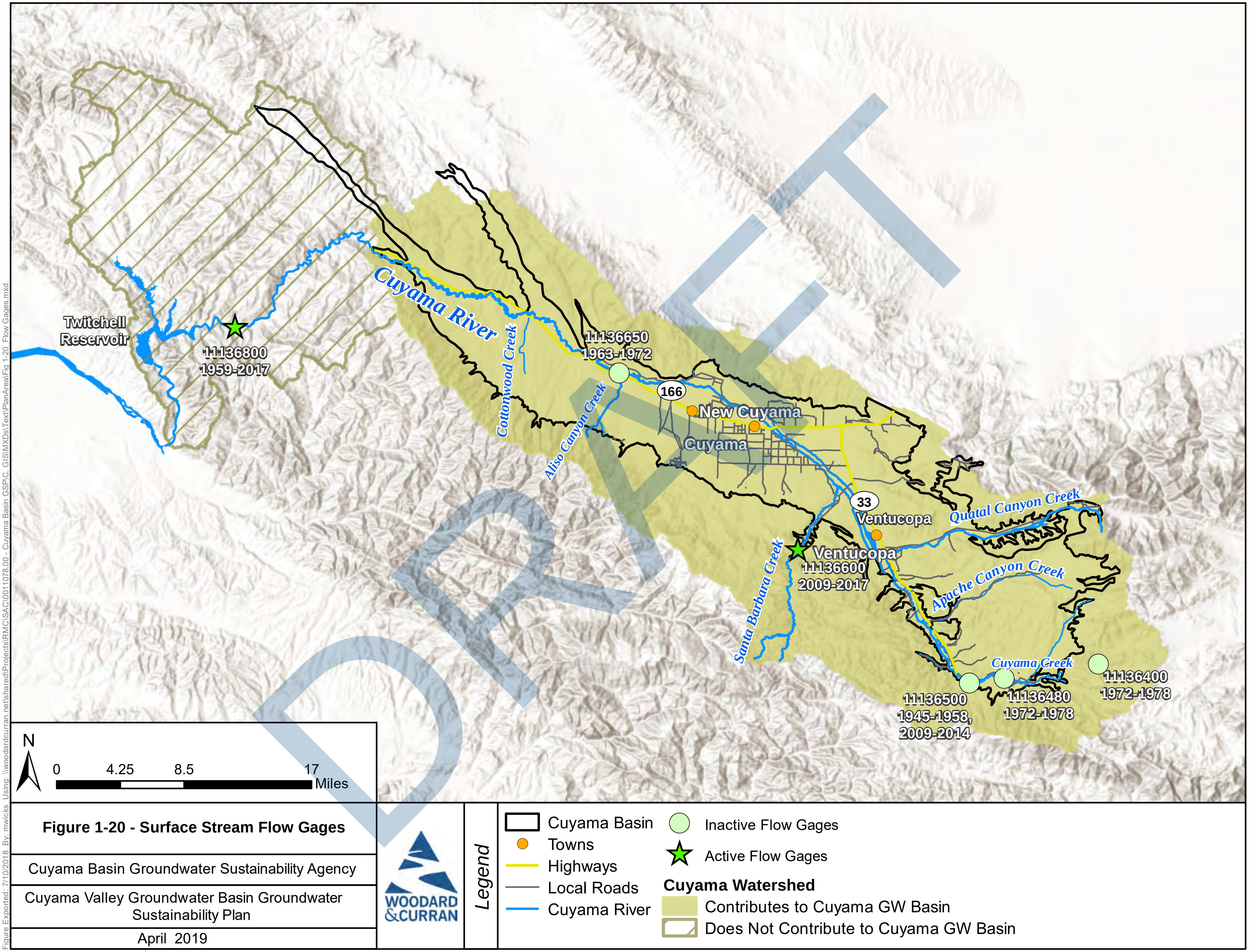

Figure 1-20 - Surface Stream Flow Gages

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

April 2019

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Figure Exported: 7/10/2018 By: mwicks Using: \\woodardcurran.net\shared\Projects\RMC\SAC\0011078.00 - Cuyama Basin GSP\C. GIS\MXDs\Text\PlanArea\Fig 1-20 Flow Gages.mxd

1.2.4 Existing Groundwater Monitoring Programs

Existing groundwater monitoring programs in the Basin are primarily operated by regional, state and federal agencies. Local agencies such as the CCSD and CBWD do not conduct routine monitoring. Existing groundwater monitoring programs in the Basin collect data on groundwater elevation, groundwater quality and subsidence at varying temporal frequencies. Each groundwater monitoring program in the Basin is described below, and additional information is provided in Chapter 4.

Groundwater Elevation Monitoring

DWR Water Data Library

DWR's Water Data Library (WDL) is a database that stores groundwater elevation measurements from wells in the Basin measured from 1946 through the present. Data contained in the WDL are from several different monitoring entities, including the Ventura County Watershed Protection District (VCWPD), SBCWA, Santa Barbara County Flood Control and Water Conservation District, and San Luis Obispo County Flood Control and Water Conservation District (SLOCFC&WCD).

USGS – National Water Information System

The USGS's National Water Information System contains extensive water data, including manual measurements of depth to water in wells throughout California. Wells are monitored by the USGS in the Santa Barbara County Flood Control and Water Conservation District's jurisdictional area. Most of the wells that were monitored in 2017 have been monitored since 2008, although a few have measurements dating back to 1983. Groundwater level measurements at these wells are taken approximately once per quarter.

California Statewide Groundwater Elevation Monitoring Program

The California Statewide Groundwater Elevation Monitoring (CASGEM) Program monitors seasonal and long-term groundwater elevation trends in dedicated groundwater basins throughout California. Monitoring entities establish CASGEM dedicated monitoring wells and report seasonal groundwater levels to CASGEM's database. The information below describes sources where CASGEM data can be retrieved.

DWR Groundwater Information Center Interactive Map

DWR's Groundwater Information Center Interactive Map (GICIMA) is a database that collects and stores groundwater elevations and depth-to-water measurements. Groundwater elevations are measured biannually in the spring and fall by local monitoring agencies. Depth-to-water and groundwater elevation data are submitted to the GICIMA by the various monitoring entities including the SLOCFC&WCD, SBCWA, and VCWPD.

SBCWA CASGEM Monitoring Plan

The SBCWA's CASGEM Monitoring Plan discusses the SBCWA's 19-well monitoring network, which includes 16 actively monitored wells and three inactive wells no longer monitored due to accessibility and permission issues. Initially, SBCWA was the sole monitoring entity for the entire Basin, but in 2014 SBCWA reapplied to CASGEM as a partial monitoring entity to reduce their monitoring activities and grant permission for neighboring counties (San Luis Obispo and Ventura) to monitor their portions of the Basin.

Of the 16 active wells in SBCWA's monitoring network, three are CASGEM dedicated monitoring wells and 13 are voluntary. Wells are monitored by either SBCWA staff or USGS staff. The three CASGEM dedicated monitoring wells are measured biannually in April and October, whereas the 13 voluntary wells are measured annually. All wells are single completion. CASGEM dedicated wells have known Well Completion Reports and perforated intervals.

SLOCFC&WCD CASGEM Monitoring Plan

The SLOCFC&WCD's CASGEM Monitoring Plan identifies two wells in their CASGEM monitoring network. Upon recognition as a CASGEM monitoring entity in 2014, San Luis Obispo County Department of Public Works staff monitored these wells biannually. Static water level measurements are obtained biannually in April and October (corresponding to seasonal highs and low groundwater elevations).

VCWPD CASGEM Monitoring Plan

The VCWPD CASGEM Monitoring Plan identifies the two wells in their CASGEM monitoring network. Upon recognition as a CASGEM monitoring entity in 2014, VCWPD staff have monitored the two wells biannually. Static water level measurements are obtained biannually, due to the remoteness of the area, in April and October (corresponding to seasonal highs and low groundwater elevations). The two wells are in the southernmost portion of the Basin.

VCWPD does not have information beyond location and water elevation measurements for the two wells. There are no well completion reports for either well, and the perforation intervals are unknown. VCWPD identifies the southeastern portion of the Basin as a spatial data gap, given that the area contains no monitoring wells.

Groundwater Quality Monitoring

DWR WDL

DWR's WDL monitors groundwater quality data. Samples are collected from a variety of well types including irrigation, stock, domestic, and some public supply wells. Wells are not regularly sampled, and most wells have only one- or two-days' worth of sampling measurements and large temporal gaps between the results. Constituents most frequently monitored include dissolved chloride, sodium, calcium, boron, magnesium, and sulfate. Measurements taken include conductance, pH, total alkalinity and hardness (more than 1,000 total samples per parameter). Additional dissolved nutrients, metals, and total dissolved solids (TDS) are also sampled but have fewer sample results available (one to 1,000 samples per parameter).

GeoTracker Groundwater Ambient Monitoring and Assessment Program

Established in 2000, the Groundwater Ambient Monitoring and Assessment (GAMA) Program monitors groundwater quality throughout the state of California. The GAMA Program will create a comprehensive groundwater monitoring program throughout California and increase public availability and access to groundwater quality and contamination information. The GAMA Program receives data from a variety of monitoring entities including DWR, USGS, and the State Water Resources Control Board. In the Basin, three agencies submit data from monitoring wells for a suite of constituents including TDS, nitrates and nitrites, arsenic, and manganese.

National Water Information System

The USGS's National Water Information System monitors groundwater for chemical, physical, and biological properties in water supply wells throughout the Basin and data are updated to GeoTracker on a quarterly basis. The majority of wells with groundwater quality data were monitored prior to 2015.

Irrigated Lands Regulatory Program

The Irrigated Lands Regulatory Program, established in 2003, regulates discharges from irrigated agriculture to surface and ground waters and establishes waste discharge orders for selected regions. The Irrigated Lands Regulatory Program focuses on priority water quality issues, such as pesticides and toxicity, nutrients, and sediments. Wells are sampled biannually, once between March and June, and once between September and December.

Division of Drinking Water

The State Water Resources Control Board's Division of Drinking Water, (formerly the Department of Health Services) monitors public water system wells per the requirements of Title 22 of the California Code of Regulations relative to levels of organic and inorganic compounds such as metals, microbial compounds and radiological analytes. Data are available for active and inactive drinking water sources, for water systems that serve the public, and wells defined as serving 15 or more connections, or more than 25 people per day. In the Basin, Division of Drinking Water wells were monitored for Title 22 requirements, including pH, alkalinity, bicarbonate, calcium, magnesium, potassium, sulfate, barium, copper, iron, zinc, and nitrate.

Subsidence Monitoring

In the Basin, subsidence monitoring is performed using continuous global positioning system (CGPS) stations monitored by the University NAVSTAR Consortium's (UNAVCO) Plate Boundary Observatory (PBO) program. There are no known extensometers in the Basin.

UNAVCO PBO

The UNAVCO PBO network consists of a network of about 1,100 CGPS and meteorology stations in the western United States used to monitor multiple pieces of information, including subsidence. There are two stations in the Cuyama Basin: CUHS, located near the city of New Cuyama, and VCST, located south of the city of Ventucopa. The CUHS station has subsidence data from 2000 through 2017, and the VCST station has subsidence data from 2001 through 2017.

1.2.5 Existing Water Management Programs

Santa Barbara County Integrated Regional Water Management Plan 2013

The *Santa Barbara County Integrated Regional Water Management Plan 2013* (IRWM Plan 2013) is the main integrated regional water management planning document for the Santa Barbara County IRWM Region (County of Santa Barbara, 2013). IRWM Plan 2013 emphasizes multi-agency collaboration, stakeholder involvement and collaboration, regional approaches to water management, water management involvement in land use decisions, and project monitoring to evaluate results of current practices. IRWM Plan 2013 identifies regionally and locally focused projects that help achieve regional objectives and targets while working to address water-related challenges in the region.

The following IRWM Plan 2013 objectives related to groundwater use would potentially influence implementation of the GSP:

- Protect, conserve, and augment water supplies
- Protect, manage, and increase groundwater supplies
- Practice balanced natural resource stewardship
- Protect and improve water quality
- Maintain and enhance water and wastewater infrastructure efficiency and reliability

IRWM Plan 2013 provides valuable resources related to potential concepts, projects and monitoring strategies that can be incorporated into the CBGSA GSP.

San Luis Obispo County 2014 IRWM Plan

The San Luis Obispo 2014 IRWM Plan presents a comprehensive water resources management approach to managing the region's water resources, focusing on strategies to improve the sustainability of current and future needs of San Luis Obispo County (County of San Luis Obispo, 2014). Much of the IRWM Plan was based on the San Luis Obispo County Water Master Report (SLOCFC&WCD, 2012)

The following 2014 IRWM Plan goals related to groundwater use would potentially influence implementation of the GSP:

- **Water Supply Goal:** Maintain or improve water supply quantity and quality for potable water, fire protection, ecosystem health, and agricultural production needs; as well as to cooperatively address limitations, vulnerabilities, conjunctive-use, and water-use efficiency.
- **Ecosystem and Watershed Goal:** Maintain or improve the health of the Region's watersheds, ecosystems, and natural resources through collaborative and cooperative actions, with a focus on assessment, protection, and restoration/enhancement of ecosystem and resource needs and vulnerabilities.
- **Groundwater Monitoring and Management (Groundwater) Goal:** Achieve sustainable use of the region's water supply in groundwater basins through collaborative and cooperative actions.
- **Water Resources Management and Communications (Water Management) Goal:** Promote open communications and regional cooperation in the protection and management of water resources, including education and outreach related to water resources conditions, conservation/water use efficiency, water rights, water allocations, and other regional water resource management efforts.

The 2014 IRWM Plan provides valuable resources related to potential concepts, projects, and monitoring strategies that can be incorporated into the CBGSA GSP.

Ventura County 2014 IRWM Plan

The Ventura County 2014 IRWM Plan reflects the unique needs of a diverse region in Ventura County, which encompasses three major watersheds, 10 cities, portions of the Los Padres National Forest, a thriving agricultural economy, and is home to more than 823,000 people (County of Ventura, 2014). The 2014 IRWM Plan is a comprehensive document that primarily addresses region-wide water management and related issues.

The following 2014 IRWM Plan goals related to groundwater use would potentially influence implementation of the GSP:

- Reduce dependence on imported water and protect, conserve and augment water supplies
- Protect and improve water quality
- Protect and restore habitat and ecosystems in watersheds

The 2014 IRWM Plan provides valuable resources related to potential concepts, projects and monitoring strategies that can be incorporated into the CBGSA GSP.

Kern County 2011 IRWM Plan

The Kern County 2011 IRWM Plan covers most of Kern County but does not include the portion of the county that includes the Cuyama Basin (Kern County Water Agency, 2011). Therefore, the IRWM Plan is not relevant to the Cuyama GSP and is not addressed here.

1.2.6 General Plans in Plan Area

As illustrated in Figure 2-4, the Cuyama Basin is located within the geographic boundaries of four counties, including Kern, San Luis Obispo, Santa Barbara and Ventura. Implementation of the CBGSA GSP would be affected by the policies and regulations outlined in the General Plans of these counties, given that the Cuyama Basin, and long-term land use planning decisions that would affect the Basin, are under the jurisdiction of these counties.

This section describes how implementation of the various General Plans may change water demands in the Basin, for example due to population growth and development of the built environment, how the General Plans may influence the GSP's ability to achieve sustainable groundwater use, and how the GSP may affect implementation of General Plan land use policies.

Santa Barbara County Comprehensive Plan

The Santa Barbara County Comprehensive Plan is a means by which more orderly development and consistent decision making in the county can be accomplished. The Plan involves a continuing process of research, analysis, goal-setting and citizen participation, the major purpose of which is to enable the County Board of Supervisors and Planning Commission to more effectively determine matters of priority in the allocation of resources, and to achieve the physical, social and economic goals of the communities in the county (County of Santa Barbara, 2016).

Relevant Santa Barbara County Comprehensive Plan Principles and Policies

The following Santa Barbara County Comprehensive Plan Land Use Element policies related to groundwater use would potentially influence implementation of the GSP:

- **Land Use Development Policy 4:** Prior to issuance of a development permit, the County shall make the finding, based on information provided by environmental documents, staff analysis, and the applicant, that adequate public or private services and resources (i.e., water, sewer, roads, etc.) are available to serve the proposed development.
- **Hillside and Watershed Protection Policy 7:** Degradation of the water quality of groundwater basins, nearby streams, or wetlands shall not result from development of the site. Pollutants, such as chemicals, fuels, lubricants, raw sewage, and other harmful waste, shall not be discharged into or alongside coastal streams or wetlands either during or after construction.

The following Santa Barbara County Comprehensive Plan Conservation Element, Groundwater Resources Section goals and policies related to groundwater use would potentially influence implementation of the GSP:

- **Goal 1:** To ensure adequate quality and quantity of groundwater for present and future county residents, and to eliminate prolonged overdraft of any groundwater basins.

- **Policy 1.1:** The County shall encourage and assist all of the county's water purveyors and other groundwater users in the conservation and management, on a perennial yield basis, of all groundwater resources.
- **Policy 1.2:** The County shall encourage innovative and/or appropriate, voluntary water conservation activities for increasing the efficiency of agricultural water use in the county.
- **Policy 1.3:** The County shall act within its powers and financial abilities to promote and achieve the enhancement of groundwater basin yield.
- **Goal 2:** To improve existing groundwater quality, where feasible, and to preclude further permanent or long-term degradation in groundwater quality.
- **Policy 2.1:** Where feasible, in cooperation with local purveyors and other groundwater users, the County shall act to protect groundwater quality where quality is acceptable, improve quality where degraded, and discourage degradation of quality below acceptable levels.
- **Policy 2.2:** The County shall support the study of adverse groundwater quality effects which may be due to agricultural, domestic, environmental and industrial uses and practices.
- **Goal 3:** To coordinate County land use planning decisions and water resources planning and supply availability.
- **Policy 3.1:** The County shall support the efforts of the local water purveyors to adopt and implement groundwater management plans pursuant to the Groundwater Management Act and other applicable law.
- **Policy 3.2:** The County shall conduct its land use planning and permitting activities in a manner which promotes and encourages the cooperative management of groundwater resources by local agencies and other affected parties, consistent with the Groundwater Management Act and other applicable law.
- **Policy 3.3:** The County shall use groundwater management plans, as accepted by the Board of Supervisors, in its land use planning and permitting decisions and other relevant activities.
- **Policy 3.4:** The County's land use planning decisions shall be consistent with the ability of any affected water purveyor(s) to provide adequate services and resources to their existing customers, in coordination with any applicable groundwater management plan.
- **Policy 3.5:** In coordination with any applicable groundwater management plan(s), the County shall not allow, through its land use permitting decisions, any basin to become seriously over drafted on a prolonged basis.
- **Policy 3.6:** The County shall not make land use decisions which would lead to the substantial over commitment of any groundwater basin.
- **Policy 3.7:** New urban development shall maximize the use of effective and appropriate natural and engineered recharge measures in project design, as defined in design guidelines to be prepared by the Santa Barbara County Flood Control and Water Conservation District in cooperation with P&D.
- **Policy 3.8:** Water-conserving plumbing, as well as water-conserving landscaping, shall be incorporated into all new development projects, where appropriate, effective, and consistent with applicable law.

- **Policy 3.9:** The County shall support and encourage private and public efforts to maximize efficiency in the pre-existing consumptive M&I use of groundwater resources.
- **Policy 3.10:** The County, in consultation with the cities, affected water purveyors, and other interested parties, shall promote the use of consistent "significance thresholds" by all appropriate agencies with regard to groundwater resource impact analysis.
- **Goal 4:** To maintain accurate and current information on groundwater conditions throughout the county.
- **Policy 4.1:** The County shall act within its powers and financial abilities to collect, update, refine, and disseminate information on local groundwater conditions.

The following Santa Barbara County Comprehensive Plan Agricultural Element goal and policy related to groundwater use would potentially influence implementation of the GSP:

- **Goal 1:** Santa Barbara County shall assure and enhance the continuation of agriculture as a major viable production industry in Santa Barbara Country. Agriculture shall be encouraged. Where conditions allow, (taking into account environmental impacts) expansion and intensification shall be supported.
- **Policy 1F:** The quality and availability of water, air, and soil resources shall be protected through provisions including but not limited to, the stability of Urban/Rural Boundary Lines, maintenance of buffer areas around agricultural areas, and the promotion of conservation practices.

Santa Barbara County Comprehensive Plan's Influence on Water Demand and Groundwater Sustainability Plan's Goals

Review of relevant *Santa Barbara County Comprehensive Plan* goals and policies reveals that the County's goals and policies relative to future land use development and conservation complement the use and conservation of groundwater resources goals anticipated to be included in the CBGSA GSP. The Comprehensive Plan explicitly states as a goal ensuring that adequate quality and quantity of groundwater will be available for present and future county residents, as well as the elimination of prolonged overdraft of any groundwater basins through land use planning decisions and water resources planning.

The county is expected to grow from 428,600 to 520,000 residents between 2015 and 2040 (Santa Barbara County Association of Governments, 2012). These growth estimates are County-wide, and the General Plan does not specify how much growth, if any, is expected to occur within the Basin. Ensuring sustainable management of the Basin through implementation of the GSP will be critical in terms of supporting projected population growth in the county while maintaining sustainable groundwater levels in the Basin.

GSP's Influence on Santa Barbara County Comprehensive Plan's Goals and Policies

Successful implementation of the GSP will help to ensure that the Cuyama Basin's groundwater supply is managed in a sustainable manner. Given the amount of population growth projected in the county in the coming years, it is possible that changes in groundwater management by the GSP will result in changes to the pace, location and type of development that will occur in the county in the future. It is anticipated that

GSP implementation will be consistent with the Comprehensive Plan's goals related to sustainable land use development in the county.

San Luis Obispo County General Plan

The *San Luis Obispo County General Plan* describes official County policy on the location of land uses and their orderly growth and development. It is the foundation upon which all land use decisions are based, guides action the County takes to assure a vital economy, ensures a sufficient and adequate housing supply, and protects agricultural and natural resources (County of San Luis Obispo, 2015).

Relevant San Luis Obispo General Plan Principles and Policies

The following San Luis Obispo General Plan Land Use Element principles and policies related to groundwater use would potentially influence implementation of the GSP:

- **Principle 1:** Preserve open space, scenic natural beauty and natural resources. Conserve energy resources. Protect agricultural land and resources.
- **Policy 1.2:** Keep the amount, location and rate of growth allowed by the Land Use Element within the sustainable capacity of resources, public services and facilities.
- **Policy 1.3:** Preserve and sustain important water resources, watersheds and riparian habitats.

The following San Luis Obispo General Plan Conservation and Open Space Element goals and policies related to groundwater use would potentially influence implementation of the GSP:

- **Goal WR 1:** The county will have a reliable and secure regional water supply.
- **Policy WR 1.2:** Conserve Water Resources. Water conservation is acknowledged to be the primary method to serve the county's increasing population. Water conservation programs should be implemented countywide before more expensive and environmentally costly forms of new water are secured.
- **Policy WR 1.3:** New Water Supply. Development of new water supplies should focus on efficient use of our existing resources. Use of reclaimed water, interagency cooperative projects, desalination of contaminated groundwater supplies, and groundwater recharge projects should be considered prior to using imported sources of water or seawater desalination, or dams and on-stream reservoirs.
- **Policy WR 1.7:** Agricultural Operations. Groundwater management strategies will give priority to agricultural operations. Protect agricultural water supplies from competition by incompatible development through land use controls.
- **Policy WR 1.12:** Impacts of New Development. Accurately assess and mitigate the impacts of new development on water supply. At a minimum, comply with the provisions of Senate Bills 610 and 221.
- **Policy WR 1.14:** Avoid Net Increase in Water Use. Avoid a net increase in non-agricultural water use in groundwater basins that are recommended or certified as Level of Severity II or III for water supply. Place limitations on further land divisions in these areas until plans are in place and funded to ensure that the safe yield will not be exceeded.

- **Goal WR 2:** The County will collaboratively manage groundwater resources to ensure sustainable supplies for all beneficial uses.
- **Policy WR 2.1:** Groundwater quality assessments Prepare groundwater quality assessments, including recommended monitoring, and management measures.
- **Policy WR 2.2:** Groundwater Basin Reporting Programs. Support monitoring and reporting programs for groundwater basins in the region.
- **Policy WR 2.3:** Well Permits. Require all well permits to be consistent with the adopted groundwater management plans.
- **Policy WR 2.4:** Groundwater Recharge. Where conditions are appropriate, promote groundwater recharge with high-quality water.
- **Policy WR 2.5:** Groundwater Banking Programs. Encourage groundwater-banking programs.
- **Goal WR 3:** Excellent water quality will be maintained for the health of the people and natural communities.
- **Policy WR 3.2:** Protect Watersheds. Protect watersheds, groundwater and aquifer recharge areas, and natural drainage systems from potential adverse impacts of development projects.
- **Policy WR 3.3:** Improve Groundwater Quality. Protect and improve groundwater quality from point and non-point source pollution, including nitrate contamination; MTBE and other industrial, agricultural, and commercial sources of contamination; naturally occurring mineralization, boron, radionuclides, geothermal contamination; and seawater intrusion and salts.
- **Policy WR 3.4:** Water Quality Restoration. Pursue opportunities to participate in programs or projects for water quality restoration and remediation with agencies and organizations such as the Regional Water Quality Control Board (RWQCB), California Department of Fish and Wildlife (CDFW), National Marine Fisheries Service (NMFS), and Resource Conservation Districts (RCDs) in areas where water quality is impaired.
- **Goal 4:** Per capita water use in the county will decline by 20% by 2020.
- **Policy WR 4.1:** Reduce Water Use. Employ water conservation programs to achieve an overall 20% reduction in per capita residential and commercial water use in the unincorporated area by 2020. Continue to improve agricultural water use efficiency consistent with Policy AGP 10 in the Agricultural Element.
- **Policy WR 4.2:** Water Pricing Structures. Support water-pricing structures to encourage conservation by individual water users and seek to expand the use of conservation rate structures in areas with Levels of Severity II and III for water supply.
- **Policy WR 4.3:** Water conservation The County will be a leader in water conservation efforts.
- **Policy WR 4.5:** Water for Recharge. Promote the use of supplemental water such as reclaimed sewage effluent and water from existing impoundments to prevent overdraft of groundwater. Consider new ways to recharge underground basins and to expand the use of reclaimed water. Encourage the eventual abandonment of ocean outfalls.

- **Policy WR 4.6:** Graywater. Encourage the use of graywater systems, rainwater catchments, and other water reuse methods in new development and renovation projects, consistent with state and local water quality regulations.
- **Policy WR 4.7:** Low Impact Development. Require Low Impact Development (LID) practices in all discretionary and land division projects and public projects to reduce, treat, infiltrate, and manage urban runoff.
- **Policy WR 4.8:** Efficient Irrigation. Support efforts of the resource conservation districts, California Polytechnic State University, the University of California Cooperative Extension, and others to research, develop, and implement more efficient irrigation techniques.
- **Goal 5:** The best possible tools and methods available will be used to manage water resources.
- **Policy WR 5.1:** Watershed Approach. The County will consider watersheds and groundwater basins in its approach to managing water resources in order to include ecological values and economic factors in water resources development.

The following San Luis Obispo General Plan Agriculture Element goals and policies related to groundwater use would potentially influence implementation of the GSP:

- **Policy AGP10a:** Encourage water conservation through feasible and appropriate "best management practices." Emphasize efficient water application techniques; the use of properly designed irrigation systems; and the control of runoff from croplands, rangelands, and agricultural roads.
- **Policy AGP10b:** Encourage the U.C. Cooperative Extension to continue its public information and research program describing water conservation techniques that may be appropriate for agricultural practices in this county. Encourage landowners to participate in programs that conserve water.
- **Policy AGP11b:** Do not approve proposed general plan amendments or re-zonings that result in increased residential density or urban expansion if the subsequent development would adversely affect: (1) water supplies and quality, or (2) groundwater recharge capability needed for agricultural use.
- **Policy AGP11c:** Do not approve facilities to move groundwater from areas of overdraft to any other area, as determined by the Resource Management System in the Land Use Element.

San Luis Obispo County General Plan's Influence on Water Demand and Groundwater Sustainability Plan

The semi-arid climate in the county is subject to limited amounts of rainfall and recharge of groundwater basins and surface reservoirs. A focus of the County General Plan is that future development should take place recognizing that the dependable supply of some county groundwater basins is already being exceeded. If mining of groundwater continues in those areas without allowing aquifers to recharge, water supply and water quality problems will eventually result, which may be costly to correct and could become irreversible.

The General Plan explicitly encourages preservation of the county's natural resources, and states that future growth should be accommodated only while ensuring that this growth occurs within the sustainable capacity of these resources.

The county was expected to grow between 0.44 and 1 percent per year from 2013 through 2018, an increase of approximately 12,000 persons over the five-year period and is expected to grow by over 41,000 from 2010 to 2030 (County of San Luis Obispo, 2014). These growth estimates are County-wide and the General Plan does not specify how much growth, if any, is expected to occur within the Basin. Ensuring sustainable management of the basin through implementation of the GSP will be critical in terms of supporting projected population growth in the county while maintaining sustainable groundwater levels in the basin.

GSP's Influence on San Luis Obispo County General Plan's Goals and Policies

Successful implementation of the GSP will help to ensure that the Cuyama Basin's groundwater supply is managed in a sustainable manner. Given the amount of population growth projected in the county in the coming years, it is possible that changes in groundwater management by the GSP will impact the location and type of development that will occur in the Basin in the future. It is anticipated that GSP implementation will reinforce the General Plan's goals related to sustainable land use development in the county.

Ventura County General Plan

The Ventura County General Plan consists of the following:

- County-wide Goals, Policies and Programs containing four chapters (Resources, Hazards, Land Use, and Public Facilities and Services)
- Four appendices (Resources, Hazards, Land Use, and Public Facilities and Services), which contain background information and data in support of the Countywide Goals, Policies and Programs
- Several Area Plans which contain specific goals, policies and programs for specific geographical areas of the county

Relevant Ventura County General Plan Principles and Policies

The following Ventura County General Plan (Resources Chapter, Water Resources Section, 1.3.1 Goals, 1.3.2 Policies) goals and policies related to groundwater use would potentially influence implementation of the GSP:

- **Goal 1:** Inventory and monitor the quantity and quality of the county's water resources.
- **Goal 2:** Effectively manage the water resources of the county by adequately planning for the development, conservation and protection of water resources for present and future generations.
- **Goal 3:** Maintain and, where feasible, restore the chemical, physical and biological integrity of surface and groundwater resources.
- **Goal 4:** Ensure that the demand for water does not exceed available water resources.

- **Goal 5:** Protect and, where feasible, enhance watersheds and aquifer recharge areas.
- **Goal 6:** Promote reclamation and reuse of wastewater for recreation, irrigation and to recharge aquifers.
- **Goal 7:** Promote efficient use of water resources through water conservation.
- **Policy 1:** Discretionary development which is inconsistent with the goals and policies of the County's Water Management Plan (WMP) shall be prohibited, unless overriding considerations are cited by the decision-making body.
- **Policy 2:** Discretionary development shall comply with all applicable County and State water regulations.
- **Policy 3:** The installation of on-site septic systems shall meet all applicable State and County regulations.
- **Policy 4:** Discretionary development shall not significantly impact the quantity or quality of water resources in watersheds, groundwater recharge areas or groundwater basins.
- **Policy 5:** Landscape plans for discretionary development shall incorporate water conservation measures as prescribed by the County's Guide to Landscape Plans, including use of low water usage landscape plants and irrigation systems and/or low water usage plumbing fixtures and other measures designed to reduce water usage.
- **Policy 10:** All new golf courses shall be conditioned to prohibit landscape irrigation with water from groundwater basins or inland surface waters identified as Municipal and Domestic Supply or Agricultural Supply in the California Regional Water Quality Control Board's Water Quality Control Plan unless either: a) the existing and planned water supplies for a Hydrologic Area, including interrelated Hydrologic Areas and Subareas, are shown to be adequate to meet the projected demands for existing uses as well as reasonably foreseeable probable future uses in the area, or b) it is demonstrated that the total groundwater extraction/recharge for the golf course will be equal to or less than the historic groundwater extraction/recharge (as defined in the Ventura County Initial Study Assessment Guidelines) for the site. Where feasible, reclaimed water shall be utilized for new golf courses.

The following Ventura County General Plan (Land Use Chapter, 3.1.1 Goals) goal related to groundwater use would potentially influence implementation of the GSP:

- **Goal 1:** Ensure that the county can accommodate anticipated future growth and development while maintaining a safe and healthful environment by preserving valuable natural resources, guiding development away from hazardous areas, and planning for adequate public facilities and services. Promote planned, well-ordered and efficient land use and development patterns.

The following Ventura County General Plan (Public Facilities Chapter, Water Supply Facilities section 4.3.1 Goals and 4.3.2 Policies) goals and policies related to groundwater use would potentially influence implementation of the GSP:

- **Goal 1:** Ensure the provision of water in quantities sufficient to satisfy current and projected demand.

- **Goal 2:** Encourage the employment of water conservation measures in new and existing development.
- **Goal 3:** Encourage the continued cooperation among water suppliers in the county in meeting the water needs of the county as a whole.
- **Policy 1:** Development that requires potable water shall be provided a permanent potable water supply of adequate quantity and quality that complies with applicable County and State water regulations. Water systems operated by or receiving water from Casitas Municipal Water District, the Calleguas Municipal Water District or the United Water Conservation District will be considered permanent supplies unless an Urban Water Management Plan (prepared pursuant to Part 2.6 of Division 6 of the Water Code) or a water supply and demand assessment (prepared pursuant to Part 2.10 of Division 6 of the Water Code) demonstrates that there is insufficient water supply to serve cumulative development in the district's service area. When the proposed water supply is to be drawn exclusively from wells in areas where groundwater supplies have been determined by the Environmental Health Division or the Public Works Agency to be questionable or inadequate, the developer shall be required to demonstrate the availability of a permanent potable water supply for the life of the project.
- **Policy 2:** Discretionary development as defined in section 10912 of the Water Code shall comply with the water supply and demand assessment requirements of Part 2.10 of Division 6 of the Water Code.
- **Policy 3:** Discretionary development shall be conditioned to incorporate water conservation techniques and the use of drought resistant native plants pursuant to the County's Guide to Landscape Plans.

Ventura County Plan's Influence on Water Demand and Groundwater Sustainability Plan's Goals

Review of relevant Ventura County General Plan goals and policies reveals that the County's goals and policies relative to future land use development and conservation complement the use and conservation of groundwater resources goals included in the CBGSA GSP. The General Plan explicitly states as a goal ensuring that adequate quality and quantity of groundwater will be available for present and future county residents, as well as accommodating anticipated future growth and development while maintaining a safe and healthful environment by preserving valuable natural resources, including groundwater.

The county is expected to grow from 865,090 to 969,271 residents between 2018 and 2040 (Caltrans, 2015). These growth estimates are County-wide and the General Plan does not specify how much growth, if any, is expected to occur within the Basin. Ensuring sustainable management of the basin through implementation of the GSP will be critical in terms of supporting projected population growth in the county while maintaining sustainable groundwater levels in the Basin.

GSP's Influence on Ventura County General Plan's Goals and Policies

Successful implementation of the GSP will help to ensure that the Cuyama Basin's groundwater supply is managed in a sustainable manner. Given the amount of population growth projected in the county in the coming years, it is possible that changes in groundwater management by the GSP will result in changes to the pace, location and type of development that will occur in the county in the future. It is anticipated that GSP implementation will reinforce the General Plan's goals related to sustainable land use development in the county.

Kern County General Plan

Because of the close interrelationship between water supplies, land use, conservation, and open space issues, the Land Use, Conservation, and Open Space Element sections of the Kern County General Plan are the most relevant elements for development of the GSP. These elements provide for a variety of land uses for future economic growth while also assuring the conservation of Kern County's agricultural, natural, and resource attributes (County of Kern, 2009).

Relevant Kern County General Plan Goals and Policies

The following Land Use, Conservation, and Open Space Element goals and policies related to groundwater use would potentially influence implementation of the GSP:

- **Goal 1.4.5:** Ensure that adequate supplies of quality water (appropriate for intended use) are available to residential, industrial, and agricultural users in Kern County.
- **Policy 1.4.2:** The efficient and cost-effective delivery of public services and facilities will be promoted by designating areas for urban development which occur in or adjacent to areas with adequate public service and facility capacity.
- **Policy 1.4.2.a:** Ensure that water quality standards are met for existing users and future development.
- **Goal 1.6.6:** Promote the conservation of water quantity and quality in Kern County.
- **Goal 1.6.7:** Minimize land use conflicts between residential and resource, commercial, and industrial land uses.
- **Policy 1.6.11:** Provide for an orderly outward expansion of new urban development so that it maintains continuity of existing development, allows for the incremental expansion of infrastructure and public service, minimizes impacts on natural environmental resources, and provides a high-quality environment for residents and businesses.
- **Policy 1.9.10:** To encourage effective groundwater resource management for the long-term economic benefit of the county, the following shall be considered:
- **Policy 1.9.10.a:** Promote groundwater recharge activities in various zone districts.
- **Policy 1.9.10.c:** Support the development of groundwater management plans.
- **Policy 1.9.10.d:** Support the development of future sources of additional surface water and groundwater, including conjunctive use, recycled water, conservation, additional storage of surface water and groundwater and desalination.
- **Goal 1.10.1:** Ensure that the county can accommodate anticipated future growth and development while maintaining a safe and healthful environment and a prosperous economy by preserving valuable natural resources, guiding development away from hazardous areas, and assuring the provision of adequate public services.

- **Policy 1.10.6.39:** Encourage the development of the county's groundwater supply to sustain and ensure water quality and quantity for existing users, planned growth, and maintenance of the natural environment.
- **Policy 1.10.6.40:** Encourage utilization of community water systems rather than the reliance on individual wells.
- **Policy 1.10.6.41:** Review development proposals to ensure adequate water is available to accommodate projected growth.

Kern County General Plan's Influence on Water Demand and Groundwater Sustainability Plan's Goals

Review of relevant Kern County General Plan goals and policies reveals that the County's goals and policies relative to future land use development and conservation complement the use and conservation of groundwater resources goals that are anticipated to be included in the CBGSA GSP. The General Plan explicitly encourages development of the county's groundwater supply to ensure that existing users have access to high quality water, and states that future growth should be accommodated only while ensuring that adequate high-quality water supplies are available to existing and future users.

GSP's Influence on Kern County General Plan's Goals and Policies

Successful implementation of the GSP will help to ensure that the Cuyama Basin's groundwater supply is managed in a sustainable manner. Given the small portion of the Cuyama Basin that lies in Kern County, it is anticipated that GSP implementation will have little to no effects on the General Plan's goals related to sustainable land use development in the county.

1.2.7 Plan Elements from CWC Section 10727.4

The plan elements from California Water Code Section 10727.4 require GSPs to address or coordinate the addressing of the components listed in Table 1-1. As noted in the table, several components of California Water Code Section 10727.4 address issues that are not within the CBGSA's authority, and are coordinated with local agencies.

Table 1-2. Plan Elements from CWC Section 10727.4

Element	Location
(a) Control of saline water intrusion	Not applicable
(b) Wellhead protection areas and recharge areas.	To be coordinated with counties
(c) Migration of contaminated groundwater.	Coordinated with Regional Water Quality Control Board (RWQCB)
(d) A well abandonment and well destruction program.	To be coordinated with counties
(e) Replenishment of groundwater extractions.	Chapter 7, Projects and Management Actions
(f) Activities implementing, opportunities for, and removing impediments to, conjunctive use or underground storage.	Chapter 7, Projects and Management Actions
(g) Well construction policies.	To be coordinated with counties
(h) Measures addressing groundwater contamination cleanup, groundwater recharge, in-lieu use, diversions to storage, conservation, water recycling, conveyance, and extraction projects.	Chapter 7, Projects and Management Actions, and coordinated with RWQCB
(i) Efficient water management practices, as defined in Section 10902, for the delivery of water and water conservation methods to improve the efficiency of water use.	Coordinated with Cuyama Basin Irrigation District
(j) Efforts to develop relationships with state and federal regulatory agencies.	Chapter 8, Plan Implementation
(k) Processes to review land use plans and efforts to coordinate with land use planning agencies to assess activities that potentially create risks to groundwater quality or quantity.	To be coordinated with counties
(l) Impacts on groundwater dependent ecosystems.	Chapter 2, Basin Settings, Section 2.2. Groundwater Conditions

1.3 Notice and Communication

In accordance with the SGMA regulations in Section 354.10, Notice and Communication, this section provides the following information:

- Description of the beneficial uses and users of groundwater in the Basin, including the land uses and property interests potentially affected by the use of groundwater in the Basin, the types of parties representing those interests, and the nature of consultation with those parties.
- List of public meetings at which the GSP was discussed or considered by the CBGSA.
- Comments regarding the GSP received by the CBGSA and a summary of any responses made by the CBGSA (Appendix D).
- Explanation of the CBGSAs decision-making process.
- Identification of opportunities for public engagement and a discussion of how public input and response will be used.
- Description of how the CBGSA encourages the active involvement of diverse social, cultural, and economic elements of the population within the Basin.
- Methods the CBGSA used to inform the public about progress implementing the GSP, including the status of projects and actions.

1.3.1 Description of Beneficial Uses and Users of Groundwater

Beneficial uses and users of groundwater in the Basin include the following interests (as listed in California Water Code Section 10723.2):

- Holders of overlying groundwater rights, including agricultural users and domestic well owners. There are approximately 475 agricultural and domestic wells identified to date in the Basin.
- Public water systems/municipal well operators are CCSD, the Cuyama Mutual Water Company, and the Ventucopa Water Supply Company.
- Disadvantaged communities: There are two disadvantaged communities in the Cuyama Basin, Cuyama and New Cuyama. The census block groups for the Santa Barbara and San Luis Obispo county portions of the Basin are considered disadvantaged.
- Local land use planning agencies are San Luis Obispo, Santa Barbara, Ventura, and Kern counties.
- Entities that monitor and report groundwater elevations are CCSD, San Luis Obispo County, SBCWA, and Ventura County.

Potential interests (listed in California Water Code Section 10723.2) that are not present in the Cuyama Basin include:

- Environmental users of groundwater
- Surface water users, if there is a hydrologic connection between surface and groundwater bodies
- Federal government, including, the military and managers of federal lands
- California Native American tribes

The types of parties representing Cuyama Basin interests and the nature of consultations with these parties are summarized below.

Standing Advisory Committee

The Standing Advisory Committee (SAC) was established in September 2017 to encourage active involvement from diverse social, cultural, and economic elements of the population within the Basin. The SAC membership reflects this diversity. The members represent large and small landowners and growers from different geographic locations in the Basin, longtime residents of New Cuyama including Hispanic community members, and a manager of an environmentally-centric non-profit organization. SAC's role is described in Section 1.3.4.

Technical Forum

A technical forum was established to allow for technical input from interested parties within the Cuyama Basin. The forum had no decision-making authority. Monthly conference calls were held with representatives from the following organizations to review and seek input on technical matters:

- CBWD and consultants EKI and Provost & Pritchard
- CCSD and consultants Dudek
- Grapevine Capital Partners, North Fork Vineyard and consultants Cleath-Harris Geologists
- San Luis Obispo County
- Santa Barbara Pistachio Company
- SBCWA

Additional Consultations

The GSP team conducted additional consultations regarding GSP matters via email, telephone, or via in-person meetings with representatives from the following groups:

- Bolthouse Farms
- Community representatives from the Family Resource Center and Blue Sky Center
- Duncan Family Farms

- DWR
- Grimmway Farms
- Individual landowners in the Cuyama Basin
- Kern County
- Santa Barbara County Fire Department, New Cuyama Station
- Santa Barbara County Public Works Department
- Santa Barbara IRWM Program
- United States Department of Agriculture's Forest Service Mount Pinos Ranger District, Los Padres National Forest
- University of California at Santa Barbara
- USGS
- Ventura County
- Wellntel Network

The following agencies and organizations were notified by mail about GSA-hosted community workshops:

- Cachuma Resource Conservation District in Santa Maria, CA 93454
- California Department of Fish and Wildlife, Headquarters in Sacramento, CA 94244
- California Natural Resources Agency in Sacramento, CA 95814
- California Wildlife Conservation Board in Sacramento, CA 95814
- Kern County, Cooperative Extension in Bakersfield, CA 93307
- Leadership Council for Justice and Accountability in Bakersfield, CA 93301
- Los Padres Forest Watch in Santa Barbara, CA, 93102
- Morro Coast Audubon Society in Morro Bay, CA 93443
- San Luis Obispo County, Cooperative Extension in San Luis Obispo, CA 93401
- United States Department of Agriculture's Natural Resource Conservation Service in Fresno, CA 93711
- United States Fish and Wildlife Service in Ventura, CA 93003
- United States Fish and Wildlife Service, Attention Friends of California Condors Wild and Free in Ventura, CA 93003
- United States Forest Service, Bitter Creek National Wildlife Refuge, Refuge Manager, Debora Kirkland in Ventura, CA 93003
- United States Forest Service, Los Padres National Forest, Headquarters in Goleta, CA 93117
- Ventura County Audubon Society Chapter in Ventura, California 93002
- Ventura County, Cooperative Extension in Ventura, CA 93003

The CBGSA developed a stakeholder engagement strategy to ensure that the interests of all beneficial uses and users of groundwater in the Basin were considered. Multi-organization planning processes can be complex. It can be challenging for community members to understand required decision-making steps, and where and how stakeholder issues and concerns are considered. Groundwater management as a practice is also complex. Educating and engaging groundwater stakeholders and the community about complex issues while simultaneously meeting deadlines established by SGMA, required an organized stakeholder engagement strategy.

An additional challenge to the engagement strategy is that the Basin area is rural, and has no news media outlets serving the area. The combined population per the 2010 Census of the three disadvantaged communities is 666 (Ventucopa 92, Cuyama 57, and New Cuyama 517). The engagement strategy relied primarily on mail and email communications about community workshop and GSA meetings. Mailings were sent to 675 parcel owners. Additionally, the CBGSA sent 185 emails stakeholders, engaged with counters who distributed notices, and word of mouth.

In January 2018, and to inform development of stakeholder engagement strategy, the CBGSA conducted 22 phone interviews with members of the CBGSA Board of Directors, SAC, CBGSA staff, staff from each of the four counties, and community representatives from the New Cuyama Family Resource Center and the Blue Sky Center, which are both located in New Cuyama. Several common themes emerged, which were used to form the basis for constructive stakeholder engagement and planning for the GSP. The prevailing ideas expressed included the following outreach and planning objectives:

- Provide a fair, balanced, and transparent public process that builds trust and understanding towards the common goal of a GSP that can best benefit everyone in the Basin.
- Provide a public meeting environment that is inclusive of all perspectives and all stakeholders.
- Provide education on a range of topics, at key milestones throughout the planning process, beginning with education about SGMA and what a GSP includes.
- Provide education and outreach specifically inclusive of smaller farmers/ranchers and the Hispanic community.
- Develop a GSP that is fair for all stakeholders in the Basin.

The stakeholder engagement strategy was developed to support the themes listed above, and in March 2018, the strategy was approved by the CBGSA Board. The strategy can be found online at: http://cuyamabasin.org/assets/pdf/CBGSP-Engagement-Strategy_May2018.pdf

1.3.2 List of Public Meetings Where the GSP was Discussed

Below is a list of the public meetings where the GSP was discussed. The following includes the public meetings held from June 2017 through April 2019.

CBGSA Board Meetings

In 2017, meetings were held on June 30, August 2, September 6, September 27, October 4, October 9, November 1, and December 6.

In 2018, meetings were held on January 3, January 10, April 4, May 2, July 11, August 1, September 5, October 3, and November 7.

In 2019, meetings were held on January 9, February 6, and April 3.

Joint Meetings of CBGSA Board and Standing Advisory Committee

In 2018, joint meetings were held on February 7, March 7, June 6, September 5, and December 3.

In 2019, one joint meeting was held on March 6.

CBGSA Standing Advisory Committee Meetings

In 2017, standing Advisory Committee meetings were held on October 16, and November 30.

In 2018, standing Advisory Committee meetings were held on January 4, February 1, March 1, March 29, April 26, May 31, June 28, July 26, August 30, September 27, November 1, and November 29.

In 2019, standing Advisory Committee meetings were held on January 8, January 31, February 28, and March 28.

Community Workshops

In 2018, community workshops conducted in both English and Spanish were held on March 7, June 6, September 5, and December 3.

In 2019, an additional community workshop, also conducted in English and in Spanish, was held March 6.

1.3.3 Comments Regarding the GSP Received by the CBGSA, Response Summary

Public comments received and CBGSA responses provided are in Appendix D.

1.3.4 1.3.4 GSA Decision Making Process

On June 30, 2017, the CBGSA Board of Directors met for the first time. The 11-member board is the designated decision-making entity for GSP development, and is subject to the Brown Act.[1] According to the requirements of the act, all meetings were noticed 72 hours in advance, were open to the public and included a public comment period. Board membership and meeting agendas, minutes, and materials are available online at http://cuyamabasin.org/cuyama-gsa-board.html. Meeting agendas were also posted at the meeting location, the Family Resource Center, in New Cuyama.

In September 2017, the CBGSA Board appointed the seven-member SAC as the primary body for providing advice and input to the CBGSA Board on GSP development and implementation, and assisting with stakeholder engagement throughout the Cuyama Basin. In March 2018, the CBGSA Board expanded the SAC membership to nine members, including representatives from the Hispanic community in the Basin. One member resigned in March 2019, and the CBGSA Board of Directors is currently considering a replacement process. According to the requirements of the Brown Act, all SAC meetings were noticed 72 hours in advance and were open to the public. SAC membership, agendas, minutes, and meeting materials are available at http://cuyamabasin.org/standing-advisory-committee.html.

The CBGSA decision-making process included developing agenda for each meeting of the CBGSA Board and for each SAC meeting. The CBGSA Executive Director developed the agendas in concert with the technical team, outreach team, and the respective chairs of the CBGSA Board and SAC. Agenda items were either educational, informational, or required direction or decision. Agenda items were presented to the SAC, and then the SAC chair would provide an overview of SAC discussion and recommendations at the subsequent CBGSA Board meeting. Figure 2-21 depicts the overall topics and decision process for developing the GSP.

[1] http://ag.ca.gov/publications/2003_Intro_BrownAct.pdf

Figure 1-21. Topics and Decision Process for GSP Development

1.3.5 Opportunities for Public Engagement and How Public Input was Used

Community input was encouraged and received at all CBGSA Board meetings, SAC meetings, and community workshops. This GSP was shaped by community input, SAC input, and CBGSA Board direction and decisions.

Opportunities for Public Engagement

Regular opportunities for public engagement were available throughout GSP development. The CBGSA Board, SAC, and CBGSA staff encouraged public input throughout the development of the GSP in the following ways described below.

Meetings and Direct Engagement

- Public meetings and community workshops (detailed in Section 1.3.2)
- Direct contact with CBGSA staff. The public was encouraged to contact the CBGSA staff by phone, email, or mail with questions and comments. CBGSA contact information was distributed at all meetings and is available on the CBGSA website at http://cuyamabasin.org/contact-us.html.
- An informal briefing was hosted by the technical team at The Place, a restaurant in Ventucopa. The technical team met with interested growers and residents to update them and answer questions about the GSP.

GSP Section Review and Comment Periods

When draft sections of the GSP section became available for review and comment, the CBGSA Board, SAC members, stakeholders were notified. A list of the dates drafts were available online are listed below. Draft GSP sections are available online at: http://cuyamabasin.org/resources.html#gsp.

- February 21, 2019: Chapter 5, Sustainability
- February 21, 2019: Chapter 2, Water Budget
- November 28, 2018: Chapter 2, Groundwater Conditions Draft
- November 28, 2018: Chapter 2, Groundwater Conditions Draft: Appendix X Hydrographs
- November 28, 2018: Chapter 2, Groundwater Conditions Draft: Appendix Y – Groundwater Contours
- November 28, 2018: Chapter 2, Groundwater Conditions Draft: Appendix Z – Subsidence White Paper
- November 16, 2018: Chapter 6, Data Management System Chapter Draft
- October 3, 2018: Chapter 2, Updated Hydrogeologic Conceptual Model Draft
- September 24, 2018: Chapter 4, Monitoring Networks Section Draft
- September 24, 2018: Chapter 4, Monitoring Networks Section - Appendices
- September 21, 2018: Chapter 2, Updated Hydrogeologic Conceptual Model Draft
- August 24, 2018: Chapter 2, Groundwater Conditions Draft
- August 24, 2018: Chapter 2, Groundwater Conditions Draft: Appendix X – Hydrographs
- August 24, 2018: Chapter 2, Groundwater Conditions Draft: Appendix Y – Groundwater Contours
- August 24, 2018: Chapter 2, Groundwater Conditions Draft: Appendix Z – Subsidence White Paper
- July 27, 2018: Draft Undesirable Results Narrative
- July 27, 2018: Management Framework Matrix
- June 22, 2018: Draft Hydrogeologic Conceptual Model
- April 20, 2018: Draft Description of Plan Area

How Public Input and Response was Used in the Development of the GSP

Public input was used to help shape the GSP development. The input was also used to develop context and content for CBGSA meetings, SAC meetings, community workshops, CBGSA newsletters, and for contend posted to the CBGSA website.

All CBGSA-hosted public meetings were designed to encourage input, discussion, and questions from both the CBGSA Board of Directors and SAC members as well as public audience members. The minutes of CBGSA Board and SAC meetings reflect the questions and comments raised by members and the general public. For each community workshop, public comments were summarized and provided to the CBGSA staff and technical team, the CBGSA Board of Directors, and SAC for further consideration.

Examples of how public input helped shape the GSP are described below.

During the development of the GSP, community input was valuable in identifying and closing groundwater data gaps. Residents and agricultural businesses provided additional data about groundwater levels, historical pumping, and cropping patterns.

During discussion of projects and management actions, several community members and CBGSA Board members expressed concern about unreliable community water supplies in New Cuyama, Cuyama, and Ventucopa. The GSP's list of projects was revised to include construction of new wells for these communities.

Community input also shaped other actions carried forward for further analysis in the GSP. Two projects to improve water resources in the basin came from public input: cloud seeding and rangeland management. The technical team evaluated each approach and discussed benefits and impacts with the CBGSA Board, SAC, and the community. Cloud seeding as a project is included in the GSP for further evaluation. Rangeland management was not carried forward in the GSP due to concerns about the potential impacts of vegetation management, and institutional concerns about coordination with the United States Forest Service.

Appendix D includes a summary of public comments and responses.

1.3.6 How GSA Encourages Active Involvement

Establishment of the SAC in September 2017 was a intended to encourage active involvement from diverse social, cultural, and economic elements of the population in the Basin. All meetings of the CGBSA Board and SAC were open to the public and included a public comment period. Community members participated in the public meetings. Community workshops were held in both English and Spanish, provided time for discussion of each topic presented, and provided comment forms for written comments. Workshop materials were also available in English and Spanish. The quarterly CBGSA newsletter was available in English and Spanish and described GSP planning status and opportunities for participation. Notices for community workshops were available in both English and Spanish. Distribution channels included email, hand-delivered postings throughout the Cuyama Valley, and postcard mailings to parcel owners within Basin boundaries. A website (www.cuyamabasin.org) was designed and made available early in the GSP process to assist in keeping stakeholders informed and up to date.

1.3.7 Method of Informing the Public

To inform the public about GSP progress and to seek public input, the following methods were used:

- Notice of public meetings, including CBGSA Board meetings, SAC meetings, and community workshops (in both English and Spanish)
- Website (www.cuyamabasin.org)
- Email distribution via a stakeholder email list was maintained throughout the process and grew to 185 contacts

- Postcards were mailed to 675 parcel owners in the Basin to announce community workshops and provide a link to the website to follow the progress of GSP development
- A quarterly, four-page CBGSA newsletter was mailed to all New Cuyama, CA post office box holders as a part of the Cuyama Recreation District Newsletter. The newsletter was also distributed via the stakeholder email list.
- Volunteers at the Family Resource Center distributed community workshop notices to locations throughout the Cuyama Basin.
- A member of the SAC posted community workshop notices in some of the finger areas in the west part of the Cuyama Basin.

The development of the mailing list and email list was informed by SGMA Section 10723.2, which calls for consideration of interests for all beneficial uses and users of groundwater. The initial email list of approximately 80 stakeholders grew to 185 stakeholders by March 2019. Additionally, a conventional mailing list was used that included 675 parcel owners in the Cuyama Basin identified by each of the four counties and the 17 agencies and organizations listed above in Section 1.3.1.

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Appendix A

Preparation Checklist
for Groundwater Sustainability Plan Submittal

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Cuyama Basin Groundwater Sustainability Plan - Preparation Checklist for GSP Submittal

GSP Regulations Section	Water Code Section	Requirement	Description	GSP Section and Status
Article 3. Technical and Reporting Standards				
352.2		Monitoring Protocols	• Monitoring protocols adopted by the GSA for data collection and management • Monitoring protocols that are designed to detect changes in groundwater levels, groundwater quality, inelastic surface subsidence for basins for which subsidence has been identified as a potential problem, and flow and quality of surface water that directly affect groundwater levels or quality or are caused by groundwater extraction in the basin	Chapter 4 *Monitoring Networks - Appendix A*
Article 5. Plan Contents, Subarticle 1. Administrative Information				
354.4		General Information	• Executive Summary • List of references and technical studies	*Executive Summary*
354.6		Agency Information	• GSA mailing address • Organization and management structure • Contact information of Plan Manager • Legal authority of GSA • Estimate of implementation costs	Chapter 1 Section 1.1 *Introduction and Agency Information*
354.8(a)	10727.2(a)(4)	Map(s)	• Area covered by GSP • Adjudicated areas, other agencies within the basin, and areas covered by an Alternative • Jurisdictional boundaries of federal or State land • Existing land use designations • Density of wells per square mile	Chapter 1 Section 1.2 *Plan Area*

GSP Regulations Section	Water Code Section	Requirement	Description	GSP Section and Status
Article 5. Plan Contents, Subarticle 1. Administrative Information (Continued)				
354.8(b)		Description of the Plan Area	• Summary of jurisdictional areas and other features	Chapter 1 Section 1.2 *Plan Area*
354.8(c) 354.8(d) 354.8(e)	10727.2(g)	Water Resource Monitoring and Management Programs	• Description of water resources monitoring and management programs • Description of how the monitoring networks of those plans will be incorporated into the GSP • Description of how those plans may limit operational flexibility in the basin • Description of conjunctive use programs	Chapter 4 *Monitoring Networks*
354.8(f)	10727.2(g)	Land Use Elements or Topic Categories of Applicable General Plans	• Summary of general plans and other land use plans • Description of how implementation of the GSP may change water demands or affect achievement of sustainability and how the GSP addresses those effects • Description of how implementation of the GSP may affect the water supply assumptions of relevant land use plans • Summary of the process for permitting new or replacement wells in the basin • Information regarding the implementation of land use plans outside the basin that could affect the ability of the Agency to achieve sustainable groundwater management	Chapter 1 Section 1.2 *Plan Area*

GSP Regulations Section	Water Code Section	Requirement	Description	GSP Section and Status
Article 5. Plan Contents, Subarticle 1. Administrative Information (Continued)				
354.8(g)	10727.4	Additional GSP Contents	**Description of Actions related to:** • Control of saline water intrusion • Wellhead protection • Migration of contaminated groundwater • Well abandonment and well destruction program • Replenishment of groundwater extractions • Conjunctive use and underground storage • Well construction policies • Addressing groundwater contamination cleanup, recharge, diversions to storage, conservation, water recycling, conveyance, and extraction projects • Efficient water management practices • Relationships with State and federal regulatory agencies • Review of land use plans and efforts to coordinate with land use planning agencies to assess activities that potentially create risks to groundwater quality or quantity • Impacts on groundwater dependent ecosystems	Chapter 8. *Implementation Plan*
354.10		Notice and Communication	• Description of beneficial uses and users • List of public meetings • GSP comments and responses • Decision-making process • Public engagement • Encouraging active involvement • Informing the public on GSP implementation progress	Chapter 8 *Implementation Plan*

GSP Regulations Section	Water Code Section	Requirement	Description	GSP Section and Status
Article 5. Plan Contents, Subarticle 2. Basin Setting				
354.14		Hydrogeologic Conceptual Model	• Description of the Hydrogeologic Conceptual Model • Two scaled cross-sections • Map(s) of physical characteristics: topographic information, surficial geology, soil characteristics, surface water bodies, source and point of delivery for imported water supplies	Chapter 2 *Basin Settings* Section 2.1 *Hydrogeologic Conceptual Model*
354.14(c)(4)	10727.2(a)(5)	Map of Recharge Areas	• Map delineating existing recharge areas that substantially contribute to the replenishment of the basin, potential recharge areas, and discharge areas	Chapter 2 *Basin Settings* Section 2.3 *Water Budget*
	10727.2(d)(4)	Recharge Areas	• Description of how recharge areas identified in the plan substantially contribute to the replenishment of the basin	Chapter 2 *Basin Settings* Section 2.3 *Water Budget*
354.16	10727.2(a)(1) 10727.2(a)(2)	Current and Historical Groundwater Conditions	• Groundwater elevation data • Estimate of groundwater storage • Seawater intrusion conditions • Groundwater quality issues • Land subsidence conditions • Identification of interconnected surface water systems • Identification of groundwater-dependent ecosystems	Chapter 2 *Basin Settings* Section 2.2 *Groundwater Conditions*
354.18	10727.2(a)(3)	Water Budget Information	• Description of inflows, outflows, and change in storage • Quantification of overdraft • Estimate of sustainable yield • Quantification of current, historical, and projected water budgets	Chapter 2 *Basin Settings* Section 2.3 *Water Budget*
	10727.2(d)(5)	Surface Water Supply	• Description of surface water supply used or available for use for groundwater recharge or in-lieu use	Chapter 2 *Basin Settings* Section 2.3 *Water Budget*

GSP Regulations Section	Water Code Section	Requirement	Description	GSP Section and Status
Article 5. Plan Contents, Subarticle 2. Basin Setting (Continued)				
354.20		Management Areas	• Reason for creation of each management area • Minimum thresholds and measurable objectives for each management area • Level of monitoring and analysis • Explanation of how management of management areas will not cause undesirable results outside the management area • Description of management areas	Chapter 7 *Projects and Management Actions* Section 7.2 *Management Areas*
Article 5. Plan Contents, Subarticle 3. Sustainable Management Criteria				
354.24		Sustainability Goal	• Description of the sustainability goal	Chapter 3 *Undesirable Results* Section 3.1 *Sustainability Goal*
354.26		Undesirable Results	• Description of undesirable results • Cause of groundwater conditions that would lead to undesirable results • Criteria used to define undesirable results for each sustainability indicator • Potential effects of undesirable results on beneficial uses and users of groundwater	Chapter 3 *Undesirable Results*

354.28	10727.2(d)(1) 10727.2(d)(2)	Minimum Thresholds	• Description of each minimum threshold and how they were established for each sustainability indicator • Relationship for each sustainability indicator • Description of how selection of the minimum threshold may affect beneficial uses and users of groundwater • Standards related to sustainability indicators • How each minimum threshold will be quantitatively measured	Chapter 5 *Minimum Thresholds, Measurable Objectives, and Interim Milestones*

GSP Regulations Section	Water Code Section	Requirement	Description	GSP Section and Status
Article 5. Plan Contents, Subarticle 3. Sustainable Management Criteria (Continued)				
354.30	10727.2(b)(1) 10727.2(b)(2) 10727.2(d)(1) 10727.2(d)(2)	Measurable Objectives	• Description of establishment of the measureable objectives for each sustainability indicator • Description of how a reasonable margin of safety was established for each measureable objective • Description of a reasonable path to achieve and maintain the sustainability goal, including a description of interim milestones	Chapter 5 *Minimum Thresholds, Measurable Objectives, and Interim Milestones*
Article 5. Plan Contents, Subarticle 4. Monitoring Networks				
354.34	10727.2(d)(1) 10727.2(d)(2) 10727.2(e) 10727.2(f)	Monitoring Networks	• Description of monitoring network • Description of monitoring network objectives • Description of how the monitoring network is designed to: demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers and surface water features; estimate the change in annual groundwater in storage; monitor seawater intrusion; determine groundwater quality trends; identify the rate and extent of land subsidence; and calculate depletions of surface water caused by groundwater extractions • Description of how the monitoring network provides adequate coverage of Sustainability Indicators • Density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends • Scientific rational (or reason) for site selection • Consistency with data and reporting standards • Corresponding sustainability indicator, minimum threshold, measureable objective, and interim milestone	Chapter 4 *Monitoring Networks*

GSP Regulations Section	Water Code Section	Requirement	Description	GSP Section and Status
			(Monitoring Networks Continued) • Location and type of each monitoring site within the basin displayed on a map, and reported in tabular format, including information regarding the monitoring site type, frequency of measurement, and the purposes for which the monitoring site is being used • Description of technical standards, data collection methods, and other procedures or protocols to ensure comparable data and methodologies	
354.36		Representative Monitoring	• Description of representative sites • Demonstration of adequacy of using groundwater elevations as proxy for other sustainability indicators • Adequate evidence demonstrating site reflects general conditions in the area	Chapter 4 *Monitoring Networks*
354.38		Assessment and Improvement of Monitoring Network	• Review and evaluation of the monitoring network • Identification and description of data gaps • Description of steps to fill data gaps • Description of monitoring frequency and density of sites	Chapter 4 *Monitoring Networks*

GSP Regulations Section	Water Code Section	Requirement	Description	GSP Section and Status
Article 5. Plan Contents, Subarticle 5. Projects and Management Actions				
354.44		Projects and Management Actions	• Description of projects and management actions that will help achieve the basin's sustainability goal • Measureable objective that is expected to benefit from each project and management action • Circumstances for implementation • Public noticing • Permitting and regulatory process • Time-table for initiation and completion, and the accrual of expected benefits • Expected benefits and how they will be evaluated • How the project or management action will be accomplished. If the projects or management actions rely on water from outside the jurisdiction of the Agency, an explanation of the source and reliability of that water shall be included. • Legal authority required • Estimated costs and plans to meet those costs • Management of groundwater extractions and recharge	Chapter 7 *Projects and Management Actions*
354.44(b)(2)	10727.2(d)(3)		• Overdraft mitigation projects and management actions	Chapter 7 *Projects and Management Actions*

GSP Regulations Section	Water Code Section	Requirement	Description	GSP Section and Status
Article 8. Interagency Agreements				
357.4	10727.6	Coordination Agreements - Shall be submitted to the Department together with the GSPs for the basin and, if approved, shall become part of the GSP for each participating Agency.	**Coordination Agreements shall describe the following:** • A point of contact • Responsibilities of each Agency • Procedures for the timely exchange of information between Agencies • Procedures for resolving conflicts between Agencies • How the Agencies have used the same data and methodologies to coordinate GSPs • How the GSPs implemented together satisfy the requirements of SGMA • Process for submitting all Plans, Plan amendments, supporting information, all monitoring data and other pertinent information, along with annual reports and periodic evaluations • A coordinated data management system for the basin • Coordination agreements shall identify adjudicated areas within the basin, and any local agencies that have adopted an Alternative that has been accepted by the Department	The Cuyama Basin does not need a coordination agreement because the basin is using a single GSP

Appendix B

Notification of Intent to Develop a Groundwater Sustainability Plan

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CUYAMA BASIN GROUNDWATER SUSTAINABILITY AGENCY

1901 Royal Oaks Drive, Suite 200 Sacramento, California 95815
December 1, 2017

Trevor Joseph, GGM Section Chief
STATE OF CALIFORNIA
Department of Water Resources
P.O. Box 94236
Sacramento, CA 94236

Subject: Notification of Intent to Develop a Groundwater Sustainable Plan (GSP)

Dear Mr. Joseph:

Pursuant to California Water Code Section 10727.8 and California Code of Regulations Section 353.6, the Department of Water Resources (DWR) is hereby given notice that the Cuyama Basin Groundwater Sustainability Agency (CBGSA) intends to commence with the development of a Groundwater Sustainability Plan (GSP). The CBGSA will have a single coordination agreement compliant with Section 10727.6.

The CBGSA Board of Directors (BOD) meetings are held regularly the first Wednesday of every month at the Family Resource Center, 4689 CA-166, New Cuyama, CA 93254. Special Board meetings will be held as needed and noticed through the website and local posting. The public is encouraged to attend and participate in the GSP development and implementation process.

Additionally, the CBGSA has formed a Standing Advisory Committee (SAC) comprised of members falling within the categories of interested persons or representatives of interested entities as described in the Sustainable Groundwater Management Act (SGMA). The SAC will specifically engage on issues related to GSP preparation and implementation. The SAC may also be involved in other outreach efforts to encourage participation from diverse social, cultural, and economic elements of the population in development and implementation of a GSP. The SAC is a public meeting and interested parties are encouraged to attend. The SAC meetings are held the Thursday immediately before the Board of Directors monthly session.

Meeting notices and materials are posted online on the Santa Barbara County website at http://www.countyofsb.org/pwd/gsa.sbc and at the Family Resource Center, 4689 CA-166, New Cuyama, CA 93254.

The CBGSA looks forward to working collaboratively with DWR on developing and implementing a GSP. Should DWR have any questions about this notice, please contact Jim Beck by email at jbeck@hgcpm.com or by phone at (661) 333-7091.

Sincerely,

J. M. Beck

Jim Beck, CBGSA Executive Director

Appendix C

Notice of Decision to Form a Groundwater Sustainability Agency

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RESOLUTION OF THE
BOARD OF DIRECTORS OF
THE CUYAMA BASIN WATER DISTRICT

RESOLUTION TO PARTICIPATE IN THE FORMATION OF A GROUNDWATER SUSTAINABILITY AGENCY PURSUANT TO THE SUSTAINABLE GROUNDWATER MANAGEMENT ACT FOR THE CUYAMA VALLEY GROUNDWATER BASIN

RESOLUTION NO. <u>2017-003</u>

WHEREAS, the California legislature passed a statewide framework for sustainable groundwater management, known as the Sustainable Groundwater Management Act (California Water Code § 10720 *et seq.)* as amended, which became effective January 1, 2015; and

WHEREAS, pursuant to the Sustainable Groundwater Management Act (SGMA), sustainable groundwater management is intended to occur pursuant to Groundwater Sustainability Plans (GSP) that are created and adopted by local Groundwater Sustainability Agencies (GSA); and

WHEREAS, pursuant to Water Code §10723(a), a Local Agency or combination of Local Agencies, as defined in Water Code §10721(n), may decide to become or form a Groundwater Sustainably Agency; and

WHEREAS, the Cuyama Basin Water District, Santa Barbara County Water Agency, the County of San Luis Obispo, the County of Ventura, the County of Kern, and Cuyama Community Services District are "Local Agencies" as defined in Water Code §10721(n), and collectively include all of the lands within the Basin; and

WHEREAS, the Cuyama Basin Water District was formed in part to provide a vehicle for landowners in the Cuyama Valley Groundwater Basin to directly participate in the SGMA process; and

WHEREAS, the District desires to form a Groundwater Sustainability Agency in conjunction with the Cuyama Basin Water District, the County of San Luis Obispo, the County of Ventura, the County of Kern, and Cuyama Community Services District, and which may include at a later time other Local Agencies and other legally authorized entities; and

WHEREAS, a notice of a public hearing to consider whether the District should elect to become a GSA for the basin in conjunction with the Local Agencies listed above was timely published in the Santa Barbara News Press, San Luis Obispo Star and Ventura County Star pursuant to California Government Code §6066; and

WHEREAS, the District held a public hearing on May 22, 2017, in Ventura, San Luis

Obispo and Santa Barbara Counties, to consider election to become a GSA for a portion of the Basin; and

NOW, THEREFORE, BE IT RESOLVED AS FOLLOWS: that the Board of Directors of the Cuyama Basin Water District declares and directs as follows:

1. That the Board of Directors of the District herein decides to form a Groundwater Sustainability Agency in conjunction with the County of Santa Barbara, the County of San Luis Obispo, the County of Ventura, the County of Kern and Cuyama Community Services District known as the Cuyama Basin Groundwater Sustainability Agency (Agency), and which shall have all the powers granted to a groundwater sustainability agency pursuant to the Sustainable Groundwater Management Act.

2. That the Agency hereby created shall consider the interests of all beneficial uses and users of groundwater, as well as those responsible for implementing groundwater sustainability plans, as required by California Water Code §10723.2.

3. That the Agency hereby created shall establish and maintain a list of persons interested in receiving notices regarding plan preparation, meeting announcements, and availability of draft plans, maps,. and other relevant documents, as required by California Water Code §10723.4.

4. That the President of the Board of Directors of the District shall be authorized to execute a Joint Exercise of Powers Agreement with the County of Santa Barbara, the County of San Luis Obispo, the County of Ventura, the County of Kern, and Cuyama Community Services District, and cause notice to be given to the California Department of Water Resources of the decision of the Board of Directors of the District in conjunction with the County of Santa Barbara, County of San Luis Obispo, the County of Ventura, the County of Kern, and Cuyama Community Services District to create the above referenced Groundwater Sustainability Agency.

5. As provided by said Joint Exercise of Powers Agreement, each of the Directors of the District are designated as a Director of the Agency, and General Manager, Matt Klinchuch is hereby appointed as an alternate, if any Director is absent from a meeting of the Agency, and Board Secretary, Brad DeBranch is appointed as a second alternate, if any Director is absent from a meeting of the Agency, subject to modification by the Board of Directors from time to time.

PASSED, APPROVED, AND ADOPTED by the Board of Directors of the Cuyama Basin Water District, on this 22nd day of May, 2017, by the following vote:

AYES: Directors Albano, Bracken, Cappello, Wooster & Yurosek

NAYS: None

ABSENT: None

ABSTAIN: None

SECRETARY'S CERTIFICATE

I, BRAD DEBRANCH, Secretary of the Cuyama Basin Water District, do hereby certify that the foregoing is a full, true and correct copy of the Resolution of the Board of Directors of the Cuyama Basin Water District, duly and regularly adopted by the Board of Directors of the Cuyama Basin Water District in all respects as required by law and the Bylaws of the Cuyama Basin Water District, on this 22nd day of May, 2017, by the consent in writing of all members of the Board of Directors of the Cuyama Basin Water District to the adoption of said resolution.

BRAD DEBRANCH, Secretary

A RESOLUTION OF THE BOARD OF DIRECTORS OF THE CUYAMA COMMUNITY SERVICES DISTRICT TOWN SITE OF NEW CUYAMA STATE OF CALIFORNIA

RESOLUTION TO PARTICIPATE IN THE FORMATION OF A GROUNDWATER SUSTAINABILITY AGENCY PURSUANT TO THE SUSTAINABLE GROUNDWATER MANAGEMENT ACT FOR THE CUYAMA COMMUNITY SERVICES DISTRICT AREA OF THE CUYAMA VALLEY GROUNDWATER BASIN	**RESOLUTION NO. 17-2**

WHEREAS, the California legislature passed a statewide framework for sustainable groundwater management, known as the Sustainable Groundwater Management Act (California Water Code § 10720 *et seq.*) as amended, which became effective January 1, 2015; and

WHEREAS, pursuant to the Sustainable Groundwater Management Act (SGMA), sustainable groundwater management is intended to occur pursuant to Groundwater Sustainability Plans (GSP) that are created and adopted by local Groundwater Sustainability Agencies (GSA); and

WHEREAS, pursuant to Water Code §10723(a), a Local Agency or combination of Local Agencies, as defined in Water Code §10721(n), may decide to become or form a Groundwater Sustainability Agency; and

WHEREAS, the Santa Barbara County Water Agency, the Cuyama Basin Water District, the Cuyama Community Services District, the County of San Luis Obispo, the County of Ventura, and the County of Kern are "Local Agencies" as defined in Water Code §10721(n), and collectively include all of the lands within the Basin; and

WHEREAS, the Cuyama Community Services District desires to form a Groundwater Sustainability Agency in conjunction with the Cuyama Basin Water District, the Santa Barbara County Water Agency, the County of San Luis Obispo, the County of Ventura, and the County of Kern, and which may include at a later time other Local Agencies and other legally authorized entities; and

WHEREAS, a notice of a public hearing to consider whether the District should elect to become a GSA for a portion of the basin was published in the Santa Maria Times and Bakersfield Californian press pursuant to California Government Code §6066; and

WHEREAS, the Cuyama Community Services District held a public hearing on May 23, 2017 to consider election to become a GSA for a portion of the basin; and

NOW, THEREFORE, BE IT RESOLVED AS FOLLOWS: that the Board of Directors of the Cuyama Community Services District declares and directs as follows:

1. That the Board of Directors of the Cuyama Community Services District herein decides to form a Groundwater Sustainability Agency in conjunction with the Cuyama Basin Water District, the Santa Barbara County Water Agency, the County of San Luis Obispo, the County of Ventura, and the County of Kern, known as the Cuyama Basin Groundwater Sustainability Agency (Agency), and which shall have all the powers granted to a groundwater sustainability agency pursuant to the Sustainable Groundwater Management Act.

2. That the Agency hereby created shall consider the interests of all beneficial uses and users of groundwater, as well as those responsible for implementing groundwater sustainability plans, as required by California Water Code §10723.2.

3. That the Agency hereby created shall establish and maintain a list of persons interested in receiving notices regarding plan preparation, meeting announcements, and availability of draft plans, maps, and other relevant documents, as required by California Water Code §10723.4.

4. That the Chair of the Board of Directors of the Cuyama Community Services District shall be authorized to execute a Joint Exercise of Powers Agreement with the Cuyama Basin Water District, the Santa Barbara County Water Agency, the County of San Luis Obispo, the County of Ventura, and the County of Kern, and cause notice to be given to the California Department of Water Resources of the decision of the Board of Directors of the Cuyama Community Services District in conjunction with the Cuyama Basin Water District, Santa Barbara County Water Agency, the County of San Luis Obispo, the County of Ventura, and the County of Kern to create the above referenced Groundwater Sustainability Agency.

PASSED, APPROVED, AND ADOPTED by the Board of Directors of the Cuyama Community Services District, Town Site of New Cuyama, State of California, on this 23rd day of May, 2017 by the following vote:

AYES:	F. Paul Chounet John Coats Malcolm Ricci Deborah Williams
NAYS:	None
ABSENT:	Linda Proeber

ABSTAIN: None

ACCEPTED AND AGREED:
CUYAMA COMMUNITY SERVICES DISTRICT

By:______________________________
Malcolm Ricci, Chair, Board of Directors

By:______________________________
F. Paul Chounet, Vice Chair, Board of Directors

ATTEST:
VIVIAN VICKERY,
OFFICE ADMINISTRATOR/BOARD SECRETARY
Cuyama Community Services District

CUYAMA COMMUNITY SERVICES DISTRICT ESTABLISHED CCSD DECEMBER 8, 1977

By:______________________________
Board Secretary

County of Santa Barbara
BOARD OF SUPERVISORS
Minute Order

May 9, 2017

Present: 5 - Supervisor Williams, Supervisor Wolf, Supervisor Hartmann, Supervisor Adam, and Supervisor Lavagnino

PUBLIC WORKS, BOARD OF DIRECTORS, WATER AGENCY — File Reference No. 17-00341

RE: HEARING - Consider recommendations regarding Cuyama Valley Groundwater Basin Groundwater Sustainability Agency Formation, First and Fifth Districts, as follows:
(EST. TIME: 1 HR.)

Acting as the Board of Directors, Water Agency:

a) Approve and authorize the Chair to execute the "Joint Exercise of Powers Agreement, Cuyama Basin Groundwater Sustainability Agency" to form a Groundwater Sustainability Agency in the Cuyama Valley Groundwater Basin;

b) Adopt the Resolution entitled "Resolution to Participate in the Formation of a Groundwater Sustainability Agency Pursuant to the Sustainable Groundwater Management Act for the Cuyama Valley Groundwater Basin";

c) Appoint by Resolution Supervisor Das Williams as a Director of the Groundwater Sustainability Agency, with Chief of Staff Darcel Elliot as an alternate;

d) Appoint by Resolution Fifth District Chief of Staff Cory Bantilan as a Director of the Groundwater Sustainability Agency, with an alternate to be designated by Mr. Bantilan; and

e) Determine that the proposed actions are not a project under the California Environmental Quality Act, pursuant to Guidelines Section 15378(b) (5), organization or administrative activities that will not result in a direct or indirect physical change in the environment.

COUNTY EXECUTIVE OFFICER'S RECOMMENDATION: APPROVE

County of Santa Barbara

BOARD OF SUPERVISORS

Minute Order

May 9, 2017

Received and filed staff presentation and conducted public hearing.

A motion was made by Supervisor Williams, seconded by Supervisor Lavagnino, that this matter be acted on as follows:

a) Approved; Chair to execute;

b) Adopted;

RESOLUTION NO. 17-97

c) and d) Adopted, amended as follows:

Appoint by Resolution Fifth District Chief of Staff Cory Bantilan as a Director of the Groundwater Sustainability Agency, with Supervisor Lavagnino as an alternate.

RESOLUTION NO. 17-98

e) Approved.

The motion carried by the following vote:

Ayes:	4 -	Supervisor Williams, Supervisor Wolf, Supervisor Hartmann, and Supervisor Lavagnino
Recused:	1 -	Supervisor Adam

RESOLUTION OF THE
BOARD OF DIRECTORS OF THE SANTA BARBARA COUNTY WATER AGENCY
STATE OF CALIFORNIA

RESOLUTION TO PARTICIPATE IN THE FORMATION OF A GROUNDWATER SUSTAINABILITY AGENCY PURSUANT TO THE SUSTAINABLE GROUNDWATER MANAGEMENT ACT FOR THE CUYAMA VALLEY GROUNDWATER BASIN	**RESOLUTION NO.** 17-97

WHEREAS, the California legislature passed a statewide framework for sustainable groundwater management, known as the Sustainable Groundwater Management Act (California Water Code § 10720 *et seq.*) as amended, which became effective January 1, 2015; and

WHEREAS, pursuant to the Sustainable Groundwater Management Act (SGMA), sustainable groundwater management is intended to occur pursuant to Groundwater Sustainability Plans (GSP) that are created and adopted by local Groundwater Sustainability Agencies (GSA); and

WHEREAS, pursuant to Water Code §10723(a), a Local Agency or combination of Local Agencies, as defined in Water Code §10721(n), may decide to become or form a Groundwater Sustainably Agency; and

WHEREAS, the Santa Barbara County Water Agency, the Cuyama Basin Water District, Cuyama Community Services District, the County of San Luis Obispo, the County of Ventura, and the County of Kern are "Local Agencies" as defined in Water Code §10721(n), and collectively include all of the lands within the Basin; and

WHEREAS, the Santa Barbara County Water Agency desires to form a Groundwater Sustainability Agency in conjunction with the Cuyama Basin Water District, Cuyama Community Services District, the County of San Luis Obispo, the County of Ventura, and the County of Kern, and which may include at a later time other Local Agencies and other legally authorized entities; and

WHEREAS, a notice of a public hearing to consider whether the County should elect to become a GSA for the basin in conjunction with the Local Agencies listed above was published in the Santa Maria Times and Santa Barbara News Press pursuant to California Government Code §6066; and

WHEREAS, the County Water Agency held a public hearing on May 9, 2017 to consider election to become a GSA for a portion of the basin; and

NOW, THEREFORE, BE IT RESOLVED AS FOLLOWS: that the Board of Directors of the Santa Barbara County Water Agency declares and directs as follows:

1. That the Board of Directors of the Santa Barbara County Water Agency herein decides to form a Groundwater Sustainability Agency in conjunction with the Cuyama Basin Water District, Cuyama Community Services District, the County of San Luis Obispo, the County of Ventura, and the County of Kern, known as the Cuyama Basin Groundwater Sustainability Agency (Agency), and which shall have all the powers granted to a groundwater sustainability agency pursuant to the Sustainable Groundwater Management Act.

2. That the Agency hereby created shall consider the interests of all beneficial uses and users of groundwater, as well as those responsible for implementing groundwater sustainability plans, as required by California Water Code §10723.2.

3. That the Agency hereby created shall establish and maintain a list of persons interested in receiving notices regarding plan preparation, meeting announcements, and availability of draft plans, maps, and other relevant documents, as required by California Water Code §10723.4.

4. That the Chair of the Board of Directors of the Santa Barbara County Water Agency shall be authorized to execute a Joint Exercise of Powers Agreement with the Cuyama Basin Water District, Cuyama Community Services District, the County of San Luis Obispo, the County of Ventura, and the County of Kern, and cause notice to be given to the California Department of Water Resources of the decision of the Board of Directors of the Santa Barbara County Water Agency in conjunction with the Cuyama Basin Water District, Cuyama Community Services District, the County of San Luis Obispo, the County of Ventura, and the County of Kern to create the above referenced Groundwater Sustainability Agency.

PASSED, APPROVED, AND ADOPTED by the Board of Directors of the Santa Barbara County Water Agency, State of California, on this 9th day of May, 2017 by the following vote:

AYES: Supervisors Williams, Wolf, Hartmann, and Lavagnino

NAYS: None

ABSENT: None

ABSTAIN: None

RECUSED: Supervisor Adam

ATTEST:
MONA MIYASATO,
COUNTY EXECUTIVE OFFICER
Ex Officio Clerk of the Board Directors
of the Santa Barbara County Water Agency

By: ______________________
Deputy

ACCEPTED AND AGREED:
SANTA BARBARA COUNTY WATER AGENCY

By: ______________________
Joan Hartmann, Chair, Board of Directors

APPROVED AS TO FORM:
MICHAEL C. GHIZZONI
COUNTY COUNSEL

By: ______________________
Deputy

#1

RESOLUTION OF THE
BOARD OF DIRECTORS OF THE SANTA BARBARA COUNTY WATER AGENCY
STATE OF CALIFORNIA

RESOLUTION TO APPOINT DIRECTORS AND ALTERNATES TO THE CUYAMA BASIN GROUNDWATER SUSTAINABILITY AGENCY BOARD OF DIRECTORS PURSUANT TO THE SUSTAINABLE GROUNDWATER MANAGEMENT ACT FOR THE CUYAMA VALLEY GROUNDWATER BASIN	)))))))))	**RESOLUTION NO.** 17-98

WHEREAS, the California legislature passed a statewide framework for sustainable groundwater management, known as the Sustainable Groundwater Management Act (California Water Code § 10720 *et seq.*) as amended, which became effective January 1, 2015; and

WHEREAS, the Santa Barbara County Water Agency (County Water Agency) is entering into a Joint Powers Agreement to form the Cuyama Basin Groundwater Sustainability Agency in conjunction with the Cuyama Basin Water District, Cuyama Community Services District, the County of San Luis Obispo, the County of Ventura, and the County of Kern, and which may include at a later time other Local Agencies and other legally authorized entities; and

WHEREAS, the Joint Powers Agreement for the Cuyama Basin Groundwater Sustainability Agency specifies that the County Water Agency shall appoint two Directors and their two alternates, each of whom shall be an elected official or member of management; and

WHEREAS, the Cuyama Valley Groundwater Basin lies within the County of Santa Barbara's First and Fifth Supervisorial Districts; and

NOW, THEREFORE, BE IT RESOLVED AS FOLLOWS: that the Board of Directors of the Santa Barbara County Water Agency declares and directs as follows:

1. That the Board of Directors of the Santa Barbara County Water Agency hereby appoints First District Supervisor Das Williams as a Director of the Cuyama Basin Groundwater Sustainability Agency, and appoints First District Chief of Staff Darcel Elliot as an Alternate Director.

2. That the Board of Directors of the Santa Barbara County Water Agency hereby appoints Fifth District Chief of Staff Cory Bantilan as a Director of the Cuyama Basin Groundwater Sustainability Agency, and appoints Fifth District Supervisor Steve Lavagnino as an Alternate Director of the Cuyama Basin Groundwater Sustainability Agency.

PASSED, APPROVED, AND ADOPTED by the Board of Directors of the Santa Barbara County Water Agency, State of California, on this 9th day of May, 2017 by the following vote:

AYES: Supervisors Williams, Wolf, Hartmann, and Lavagnino

NAYS: None

ABSENT: None

ABSTAIN: None

RECUSED: None

ATTEST:
MONA MIYASATO,
COUNTY EXECUTIVE OFFICER
Ex Officio Clerk of the Board Directors
of the Santa Barbara County Water Agency

By: ______________________
Deputy

ACCEPTED AND AGREED:
SANTA BARBARA COUNTY WATER AGENCY

By: ______________________
Joan Hartmann, Chair, Board of Directors

APPROVED AS TO FORM:
MICHAEL C. GHIZZONI
COUNTY COUNSEL

By: ______________________
Deputy

IN THE BOARD OF SUPERVISORS

County of San Luis Obispo, State of California

Tuesday, May 23, 2017

PRESENT: Supervisors Bruce S. Gibson, Adam Hill, Lynn Compton, Debbie Arnold, and Chairperson John Peschong

ABSENT: None

RESOLUTION NO. 2017-145

RESOLUTION APPROVING THE JOINT EXERCISE OF POWERS AGREEMENT CREATING A JOINT POWERS AGENCY (JPA) TO SERVE AS THE CUYAMA BASIN GROUNDWATER SUSTAINABILITY AGENCY, APPOINTING THE DIRECTOR AND ALTERNATE DIRECTOR REPRESENTING THE COUNTY OF SAN LUIS OBISPO TO THE JPA BOARD OF DIRECTORS, AND FINDING THAT THE PROJECT IS EXEMPT FROM SECTION 21000 *ET SEQ.* OF THE CALIFORNIA PUBLIC RESOURCES CODE (CEQA)

The following Resolution is hereby offered and read:

WHEREAS, in 2014, the California Legislature adopted, and the Governor signed into law, three bills (SB 1168, AB 1739, and SB 1319) collectively referred to as the Sustainable Groundwater Management Act (SGMA) (Water Code §§ 10720 *et seq.*), that became effective on January 1, 2015, and that have been subsequently amended; and

WHEREAS, the intent of SGMA, as set forth in Water Code Section 10720.1, is to provide for the sustainable management of groundwater basins at a local level by providing local groundwater agencies with the authority, and technical and financial assistance necessary, to sustainably manage groundwater; and

WHEREAS, SGMA requires the formation of Groundwater Sustainability Agencies (GSAs) for the purpose of achieving groundwater sustainability through the adoption and implementation of Groundwater Sustainability Plans (GSPs) for all medium and high priority basins as designated by the California Department of Water Resources (DWR); and

WHEREAS, SGMA requires that a local agency or a collection of agencies through a joint powers agreement or memorandum of agreement decide to become a single GSA or that multiple local agencies decide to each become a GSA for all medium and high priority basins on or before June 30, 2017 and that the GSA or GSAs for basins DWR has designated as "subject to critical conditions of overdraft" develop a GSP or coordinated GSPs on or before January 31, 2020; and

WHEREAS, the Cuyama Valley Groundwater Basin (Basin) has been designated by DWR as a medium priority basin subject to critical conditions of overdraft; and

WHEREAS, the County of San Luis Obispo, the Santa Barbara County Water Agency, the County of Ventura, the County of Kern, the Cuyama Basin Water District, and the Cuyama Community Services District are each a "local agency" within the Basin as defined in Water Code Section 10721(n), and thus are eligible to collectively form a GSA for the Basin through a joint powers agreement under the authority of Water Code Section 10723.6(a) (collectively, Local Agencies or Members); and

WHEREAS, the Local Agencies have determined that management of the Basin will best be achieved through the creation of a joint powers agency (JPA) to serve as the GSA for the Basin pursuant to the terms and conditions set forth in the Joint Exercise of Powers Agreement attached hereto as Exhibit A and incorporated herein (Joint Powers Agreement); and

WHEREAS, Article 3.1 of the Joint Powers Agreement provides that the JPA is a public entity separate from the Members and shall be known as the Cuyama Basin Groundwater Sustainability Agency; and

WHEREAS, Article 7.1 of the Joint Powers Agreement provides that the JPA shall be governed by a board of eleven (11) directors (JPA Board) comprised of representatives from each of the six (6) Members; and

WHEREAS, Article 7.2 of the Joint Powers Agreement provides that the directors and alternate directors representing each Member shall be appointed by the governing body of the Member with the exception that all five (5) Cuyama Basin Water District Board members shall serve as directors on the JPA Board; and

WHEREAS, the Members are committed to the sustainable management of groundwater within the Basin and intend to consider the interests of all beneficial users and uses of groundwater within the Basin through establishment of an advisory committee as more specifically set forth in Article 8 of the Joint Powers Agreement; and

WHEREAS, Article 5.2 of the Joint Powers Agreement acknowledges that SGMA expressly reserves certain powers and authorities to and preserves certain powers and authorities of cities and counties, including, without limitation, the issuance of permits for the construction, modification or abandonment of groundwater wells, land use planning and groundwater management pursuant to city and county police powers in a manner that is not in conflict with the GSP; and

WHEREAS, the County of San Luis Obispo published a notice of public hearing consistent with the requirements contained within Water Code Section 10723(b); and

WHEREAS, the Board of Supervisors conducted such a public hearing on May 23, 2017.

NOW, THEREFORE, BE IT RESOLVED AND ORDERED by the Board of Supervisors of the County of San Luis Obispo, State of California, that:

Section 1: The foregoing recitals are true and correct and are incorporated herein by reference.

Section 2: The County of San Luis Obispo hereby decides to participate in and jointly form the JPA known as the Cuyama Basin Groundwater Sustainability Agency, the boundaries of which are depicted in Exhibit B attached hereto and incorporated herein, to serve as the GSA for the Basin by approving and authorizing the Chairperson of the Board of Supervisors to execute the Joint Powers Agreement.

Section 3: The Director of Public Works of the County of San Luis Obispo, or designee, is hereby authorized and directed to submit notice of adoption of this Resolution in addition to all other information required by SGMA, including but not limited to, all information required by Water Code Section 10723.8, to the Santa Barbara County Water Agency in accordance with Article 3.2 of the Joint Powers Agreement and/or to DWR, and to support the JPA's development and maintenance of an interested persons list as described in Water Code Section 10723.4 and a list of interested parties as described in Water Code Section 10723.8(a)(4).

Section 4: The Director of Public Works of the County of San Luis Obispo, or designee, is hereby authorized to take such other and further actions as may be necessary to administer the County of San Luis Obispo's participation in the Joint Powers Agreement as set forth therein.

Section 5: The Board of Supervisors finds that the adoption of this Resolution is exempt from the requirements of the California Environmental Quality Act (Public Resources Code §§ 21000 et seq.) (CEQA) pursuant to Section 15061(b)(3) of the CEQA Guidelines.

Section 6: The Environmental Coordinator of the County of San Luis Obispo is hereby directed to file a Notice of Exemption in accordance with the provisions of CEQA.

Section 7: The Board of Supervisors hereby appoints the District 4 Supervisor, Lynn Compton, as the director and the District 5 Supervisor, Debbie Arnold, as the alternate director to represent the County on the JPA Board.

Upon motion of Supervisor Compton, seconded by Supervisor Arnold, and on the following roll call vote, to wit:

AYES: Supervisor Compton, Arnold, Gibson, Hill and Chairperson Peschong
NOES: None
ABSENT: None
ABSTAINING: None

the foregoing Resolution is hereby adopted on the 23rd day of May, 2017.

John Peschong
Chairperson of the Board of Supervisors

ATTEST:

TOMMY GONG
Clerk of the Board of Supervisors

By: Annette Ramirez
Deputy Clerk

[SEAL]

APPROVED AS TO FORM AND LEGAL EFFECT:

RITA L. NEAL
County Counsel

By: /s/ Erica Stuckey
Deputy County Counsel

Dated: May 10, 2017

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STATE OF CALIFORNIA,)
) **ss.**
COUNTY OF SAN LUIS OBISPO)

I, Tommy Gong, County Clerk and ex-officio Clerk of the Board of Supervisors, in and for the County of San Luis Obispo, State of California, do hereby certify the foregoing to be a full, true and correct copy of an order made by the Board of Supervisors, as the same appears spread upon their minute book.

WITNESS my hand and the seal of said Board of Supervisors, affixed this 23rd day of May, 2017.

Tommy Gong
County Clerk and Ex-Officio Clerk
of the Board of Supervisors

(SEAL)

By: [signature]
Deputy Clerk

JOINT EXERCISE OF POWERS AGREEMENT
CUYAMA BASIN GROUNDWATER SUSTAINABILITY AGENCY

This Joint Exercise of Powers Agreement ("Agreement") is made and entered into as of MAY 23, 2017 ("Effective Date"), by and between the Cuyama Basin Water District ("CBWD"), the Cuyama Community Services District ("CCSD"), the County of Kern ("Kern"), the County of San Luis Obispo ("San Luis Obispo"), the Santa Barbara County Water Agency ("Santa Barbara"), and the County of Ventura ("Ventura"), also each referred to individually as "Member" and collectively as "Members," for the purposes of forming a joint powers agency to serve as the groundwater sustainability agency for the Cuyama Valley Groundwater Basin. This joint powers agency shall hereinafter be known as the Cuyama Basin Groundwater Sustainability Agency ("CBGSA" or "GSA").

RECITALS

A. WHEREAS, the Sustainable Groundwater Management Act of 2014 ("SGMA"), Water Code §§ 10720 *et seq.*, requires the formation of groundwater sustainability agencies to manage medium and high priority basins by June 30, 2017, and the adoption of groundwater sustainability plans ("GSP") by January 31, 2020 for high and medium priority basins that are subject to conditions of critical overdraft; and

B. WHEREAS, the Cuyama Valley Groundwater Basin (also referred to as the "Cuyama Groundwater Basin"), as identified and defined by the California Department of Water Resources (DWR) in Bulletin 118 (as Basin 3-13), has been designated by DWR as a medium priority basin subject to conditions of critical overdraft; and

C. WHEREAS, all Members to this Agreement are local agencies, as defined in SGMA, located within the Cuyama Groundwater Basin and duly organized and existing under the laws of the State of California; and

D. WHEREAS, pursuant to SGMA, specifically Water Code § 10723.6, and the Joint Exercise of Powers Act, Government Code §§ 6500 *et seq.*, the Members are authorized to create a joint powers agency to jointly exercise any power common to the Members together with such powers as are expressly set forth in the Joint Exercise of Powers Act and in SGMA upon successfully becoming a GSA for the Cuyama Groundwater Basin; and

E. WHEREAS, in accordance with Water Code § 10723(b), all members have held a public hearing regarding entering into this Agreement and complied with the noticing provisions in SGMA; and

F. WHEREAS, the Members desire to create a joint powers authority to sustainably manage the Cuyama Groundwater Basin as required by SGMA.

NOW, THEREFORE, in consideration of the terms, conditions, and covenants contained herein, the Members hereby agree as follows:

ARTICLE 1
INCORPORATION OF RECITALS

1.1 The foregoing recitals are true and correct and are incorporated herein by reference.

ARTICLE 2
DEFINITIONS

The following terms shall have the following meanings for purposes of this Agreement:

2.1 "Agreement" means this Joint Exercise of Powers Agreement forming the Cuyama Basin Groundwater Sustainability Agency over the Cuyama Valley Groundwater Basin.

2.2 "Basin" means the Cuyama Valley Groundwater Basin, also referred to as the Cuyama Groundwater Basin, as identified and defined by DWR in Bulletin 118 (as Basin 3-13) as of the Effective Date or as modified pursuant to Water Code Section 10722.2.

2.3 "Bulletin 118" means DWR's report entitled "California Groundwater: Bulletin 118" updated in 2016, and as it may be subsequently updated or revised in accordance with Water Code § 12924.

2.4 "Board of Directors" or "Board" means the governing body of the GSA as established by Article 7 (Board of Directors) of this Agreement.

2.5 "CBGSA" or "GSA" means the Cuyama Basin Groundwater Sustainability Agency formed as a separate entity through this Agreement.

2.6 "Director(s)" and "Alternate Director(s)" means a director or alternate director appointed by a Member pursuant to Articles 7.2 (Appointment of Directors) and 7.3 (Alternate Directors) of this Agreement.

2.7 "DWR" means the California Department of Water Resources.

2.8 "GSP" means a Groundwater Sustainability Plan, as defined by SGMA in Water Code §§ 10727 *et seq.*

2.9 "Joint Exercise of Powers Act" means Government Code §§ 6500, *et seq.*, as may be amended from time to time.

2.10 "Member(s)" means a local agency eligible under SGMA to be a groundwater sustainability agency and included in Article 6.1 (Members) of this Agreement or any local agency that becomes a new member pursuant to Article 6.2 (New Members) of this Agreement.

2.11 "Officer(s)" means the Chair, Vice Chair, Secretary, Auditor or Treasurer of the GSA to be appointed by the Board of Directors pursuant to Article 9.2 (Appointment of Officers) of this Agreement.

2.12 "SGMA" means the Sustainable Groundwater Management Act, Water Code §§ 10720 *et seq.*, as may be amended from time to time.

2.13 "State" means the State of California.

ARTICLE 3
CREATION OF THE GSA

3.1 Creation of a Joint Powers Agency. There is hereby created pursuant to the Joint Exercise of Powers Act, Government Code §§ 6500 *et seq.*, and SGMA, Water Code §§ 10720 *et seq.*, a joint powers agency, which will be a public entity separate from the Members to this Agreement, and shall be known as the Cuyama Basin Groundwater Sustainability Agency ("CBGSA" or "GSA"). The boundaries of the CBGSA shall be coterminous with the boundaries of the Basin as determined by DWR in Bulletin 118 or as modified by DWR pursuant to Water Code Section 10722.2.

3.2 Notices. Within 30 days after the Effective Date of this Agreement, and after any amendment hereto, Santa Barbara, on behalf of the GSA, or the GSA, shall cause a notice of this Agreement or amendment to be prepared and filed with the office of the California Secretary of State containing the information required by Government Code § 6503.5. Within 30 days after the Effective Date of this Agreement, Santa Barbara, on behalf of the GSA, shall cause a statement of the information concerning the GSA, required by Government Code § 53051, to be filed with the office of the California Secretary of State and with the County Clerk for the County of Santa Barbara, and any other County in which the GSA maintains an office, setting forth the facts required to be stated pursuant to Government Code § 53051(a). Within 30 days after the Effective Date of this Agreement, Santa Barbara, on behalf of the GSA, shall inform DWR of each Parties' decision and intent to undertake sustainable groundwater management within the Basin through the GSA in accordance with Water Code § 10723.8.

3.3 Purpose of the CBGSA. The purpose of the CBGSA is to implement and comply with SGMA in the Cuyama Valley Groundwater Basin by serving as the Basin's groundwater sustainability agency, developing, adopting, and implementing a GSP for the Basin, and sustainably managing the Basin pursuant to SGMA.

ARTICLE 4
TERM

4.1 This Agreement shall become effective on the date on which the last Member listed in Article 6.1 (Members) signs this Agreement ("Effective Date"), after which notices shall be filed in accordance with Article 3.2 (Notices). This Agreement shall remain in effect until terminated pursuant to the provisions of Article 17 (Withdrawal of Members) of this Agreement.

ARTICLE 5
POWERS

5.1 The GSA shall possess the power in its own name to exercise any and all common powers of its Members reasonably necessary for the GSA to implement the purposes of SGMA and for no other purpose, together with such other powers as are expressly set forth in the Joint Exercise of Powers Act and in SGMA subject to the limitations set forth therein.

5.2 SGMA expressly reserves certain powers and authorities to and preserves certain powers and authorities of cities and counties, including, without limitation, the issuance of permits for the construction, modification or abandonment of groundwater wells, land use planning and groundwater management pursuant to city and county police powers in a manner that is not in conflict with the GSP. The Directors representing the counties of San Luis Obispo, Kern and Ventura do not have the ability to authorize the GSA to exercise or infringe upon any such reserved powers and authorities, without the GSA first seeking and receiving authorization by formal action of the Boards of Supervisors. Furthermore, this Agreement shall not be interpreted as limiting or ceding any such reserved or preserved powers and authorities. In addition, to the extent that a Member other than a county independently possesses any of the powers or authorities expressly preserved by SGMA, the GSA does not have the ability or authority to exercise or infringe on such preserved powers and/or authorities of such Member without the GSA first seeking and receiving authorization from such Member's governing board, unless specifically enumerated in this Agreement.

5.3 For purposes of Government Code § 6509, the powers of the GSA shall be exercised subject to the restrictions upon the manner of exercising such powers as are imposed on the Cuyama Basin Water District, and in the event of the withdrawal of the Cuyama Basin Water District as a Member under this Agreement, then the manner of exercising the GSA's powers shall be exercised subject to those restrictions imposed on the Cuyama Community Services District.

5.4 As required by Water Code § 10723.2, the GSA shall consider the interests of all beneficial uses and users of groundwater in the Basin, as well as those responsible for implementing the GSP. Additionally, as set forth in Water Code § 10720.5(a), any GSP adopted pursuant to this Agreement shall be consistent with

Section 2 of Article X of the California Constitution. Nothing in this Agreement modifies the rights or priorities to use or store groundwater consistent with Section 2 of Article X of the California Constitution, with the exception that no extraction of groundwater between January 1, 2015 and the date the GSP is adopted may be used as evidence of, or to establish or defend against, any claim of prescription. Likewise, as set forth in Water Code § 10720.5(b), nothing in this Agreement or any GSP adopted pursuant to this Agreement determines or alters surface water rights or groundwater rights under common law or any provision of law that determines or grants surface water rights.

5.5 The GSA may define within the GSP one or more management areas within the Basin in accordance with 23 CCR § 354.20.

ARTICLE 6
MEMBERSHIP

6.1 Members. The Members of the GSA shall be:

(a) Cuyama Basin Water District;

(b) Cuyama Community Services District;

(c) County of Kern;

(d) County of San Luis Obispo;

(e) Santa Barbara County Water Agency; and

(f) County of Ventura

as long as they have not, pursuant to the provisions hereof, withdrawn from this Agreement.

6.2 New Members. Any local agency, as defined by SGMA, that is not a Member on the Effective Date of this Agreement may become a Member upon all of the following:

(a) The approval of the Board of Directors as specified in Article 12.3 (Decisions of the Board);

(b) Amendment of the Agreement in accordance with Article 18.2 (Amendments to Agreement); and

(c) Payment of a pro rata share of all previously incurred costs that the Board of Directors determines have resulted in benefit to the local agency, and are appropriate for assessment on the local agency.

ARTICLE 7
BOARD OF DIRECTORS

7.1 Formation of the Board of Directors. The GSA shall be governed by a Board of Directors ("Board"). The Board shall consist of eleven (11) Directors consisting of representatives from each of the Members identified in Article 6.1 (Members) as follows:

(a) Five (5) Directors representing CBWD;

(b) One (1) Director representing CCSD;

(c) One (1) Director representing Kern;

(d) One (1) Director representing San Luis Obispo;

(e) Two (2) Directors representing Santa Barbara; and

(f) One (1) Director representing Ventura.

7.2 Appointment of Directors. The Directors shall be appointed by the governing body of the Members as follows:

(a) The Directors representing CBWD shall be the Directors of CBWD's Board of Directors, provided if the CBWD Board is ever expanded, then CBWD's Board will appoint the five Directors from CBWD's Board representing CBWD by resolution of CBWD's Board.

(b) The Director representing CCSD shall be appointed by resolution of the CCSD's Board of Directors.

(c) The Director representing Kern shall be appointed by resolution of Kern's Board of Supervisors.

(d) The Director representing San Luis Obispo shall be appointed by resolution of San Luis Obispo's Board of Supervisors.

(e) The Directors representing Santa Barbara shall be appointed by resolution of Santa Barbara's Board of Directors.

(f) The Director representing Ventura shall be appointed by resolution of Ventura's Board of Supervisors.

Subject to Article 7.2 each Director shall be an elected official or member of management of the Member.

7.3 Alternate Directors. Each Director shall have one Alternate to act as a substitute Director for that Director. All Alternates shall be appointed in the same manner as set forth in Article 7.2 (Appointment of Directors). Alternate Directors shall not vote or participate in any deliberations of the Board unless appearing as a substitute for a Director due to absence or conflict of interest. If the Director is not present, or if the Director has a conflict of interest which precludes participation by the Director in any decision-making process of the Board, the Alternate Director appointed to act in his/her place shall assume all rights of the Director, and shall have the authority to act in his/her absence, including casting votes on matters before the Board. An Alternate Director shall be an elected official or member of management of the Member.

7.4 Requirements. Each Director and Alternate Director shall be appointed by resolution as noted in Article 7.2 (Appointment of Directors). Directors and Alternate Directors shall serve at the pleasure of the governing body of the Member that appointed him/her. No individual Director may be removed except by the vote of the governing body of the Member that appointed him/her.

7.5 Vacancies. Upon the vacancy of a Director, the Alternate Director shall serve as Director until a new Director is appointed as set forth in Article 7.2 (Appointment of Directors). Members shall submit any changes in Director or Alternate Director positions to the Board or Executive Director by providing a copy of the executed resolution.

7.6 Duties of the Board of Directors. The business and affairs of the GSA, and all of its powers, including without limitation all powers set forth in Article 5 (Powers), are reserved to and shall be exercised by and through the Board of Directors, except as may be expressly delegated to the Executive Director or others pursuant to this Agreement, Bylaws, GSP, or by specific action of the Board of Directors.

7.7 Director Compensation. No Director shall be compensated by the GSA for preparation for or attendance at meetings of the Board or meetings of any committee created by the Board. Nothing in this Article is intended to prohibit a Member from compensating its representatives on the Board or on a committee for attending such meetings.

ARTICLE 8
ADVISORY COMMITTEES

8.1 Standing Advisory Committee. A Standing Advisory Committee is hereby established as a group of representatives to advise the GSA, and shall be appointed by the Board.

(a) Purpose. The Standing Advisory Committee shall advise the Board concerning, where legally appropriate, implementation of SGMA in the Basin and review the GSP before it is approved by the Board.

(b) Membership. The composition of and appointments to the Standing Advisory Committee shall be determined by the Board.

(c) Brown Act. All Meetings of the Standing Advisory Committee, including special meetings, shall be noticed, held, and conducted in accordance with the Ralph M. Brown Act (Government Code §§ 54950 *et seq.*).

(d) Compensation. No Advisory Committee member shall be compensated by the GSA for preparation for or attendance at meetings of the Board or at any committee created by the Board.

8.2 Additional Advisory Committees. The Board may from time to time appoint one or more additional advisory committees or establish standing or ad hoc committees to assist in carrying out the purposes and objectives of the GSA. The Board shall determine the purpose and need for such committees and the necessary qualifications for individuals appointed to them. No committee member shall be compensated by the GSA for preparation for or attendance at meetings of the Board or at any committee created by the Board.

ARTICLE 9
OFFICERS

9.1 Officers. Officers of the GSA shall be a Chair, Vice Chair, Secretary, Auditor and Treasurer. Additional officers may be appointed by the Board as it deems necessary.

(a) Chair. The Chair shall preside at all meetings of the Board of Directors.

(b) Vice Chair. The Vice Chair shall exercise all powers of the Chair in the Chair's absence or inability to act.

(c) Secretary. The Secretary shall keep minutes of the Board of Director meetings.

(d) Auditor and Treasurer. The Treasurer and Auditor shall perform such duties and responsibilities specified in Government Code §§ 6505.5 and 6505.6.

9.2 Appointment of Officers. Officers shall be elected annually by, and serve at the pleasure of, the Board of Directors. Officers shall be elected at the first Board meeting, and thereafter at the first Board meeting following January 1st of each year. A Director appointed by Santa Barbara shall be designated as the Chair Pro Tem to preside at the initial meeting of the Board until a Chair is elected by the Board. An Officer may serve for multiple consecutive terms, with no term limit. Any Officer may resign at any time upon written notice to the Board, and may be removed and replaced by the Board. Notwithstanding the foregoing, the Treasurer and Auditor shall be appointed in the manner specified in Government Code §§ 6505.5 and 6505.6. Until such time as the Board determines otherwise, the GSA's Treasurer shall be the Treasurer of Santa Barbara.

9.3 Principal Office. The principal office of the GSA shall be established by the Board of Directors, and may thereafter be changed by the Board.

ARTICLE 10
EXECUTIVE DIRECTOR

10.1 Appointment. The Board may appoint an Executive Director or other designated manager ("Executive Director") of the GSA, who may, but need not be, an officer, employee, or representative of one of the Members.

10.2 Compensation. The Executive Director's compensation shall be determined by the Board.

10.3 Duties. The Executive Director shall serve at the pleasure of the Board and shall be responsible to the Board for the property and efficient administration of the GSA. The Executive Director shall have the powers designated by the Board, or otherwise as set forth in the Bylaws.

10.4 Termination. The Executive Director shall serve until he/she resigns or the Board terminates his/her appointment.

ARTICLE 11
GSA DIRECTOR MEETINGS

11.1 Initial Meeting. The initial meeting of the GSA Board of Directors shall be called by Santa Barbara and held within the boundaries of the Basin, within sixty (60) days of the Effective Date of this Agreement.

11.2 Time and Place. The Board of Directors shall meet at least quarterly, at a date, time and place set by the Board within the Basin, and at such other times as may be determined by the Board. Meetings may be held via teleconferencing to the extent allowed by law and teleconferenced meetings shall be conducted in accordance with the Ralph M. Brown Act (Government Code §§ 54950 *et seq.*).

11.3 Special Meetings. Special meetings of the Board of Directors may be called by the Chair or by a simple majority of Directors, in accordance with the Ralph M. Brown Act (Government Code §§ 54950 *et seq.*).

11.4 Conduct. All meetings of the Board of Directors, including special meetings, shall be noticed, held, and conducted in accordance with the Ralph M. Brown Act (Government Code §§ 54950 *et seq.*).

11.5 Local Conflict of Interest Code. The Board of Directors shall adopt a local conflict of interest code pursuant to the provisions of the Political Reform Act of 1974 (Government Code §§ 81000 *et seq.*).

ARTICLE 12
VOTING

12.1 Quorum. A quorum of any meeting of the Board of Directors shall consist of a majority of the Directors. In the absence of a quorum, any meeting of the Directors may be adjourned by a vote of the simple majority of Directors present, but no other business may be transacted.

12.2 Director Votes. Voting by the Board of Directors shall be made on the basis of one vote for each Director weighted as follows:

(a) Directors representing CBWD- each Director's vote shall be weighted by 6.667%;

(b) Director representing CCSD- Director's vote shall be weighted by 11.111%;

(c) Director representing Kern- Director's vote shall be weighted by 11.111%;

(d) Director representing San Luis Obispo- Director's vote shall be weighted by 11.111%;

(e) Directors representing Santa Barbara- each Director's vote shall be weighted by 11.111%; and

(f) Director representing Ventura- Director's vote shall be weighted by 11.111%.

A Director, or an Alternate Director when acting in the absence of his/her Director, may vote on all matters of GSA business unless disqualified.

12.3 Decisions of the Board.

(a) Majority Approval. Except as otherwise specified in this Agreement, all decisions of the Board of Directors shall require the affirmative vote of more than 50% of the weighted vote total in accordance with Article 12.2, provided that if a Director is disqualified from voting on a matter before the Board because of a conflict of interest and no Alternate Director is present in the Director's place or if the Alternate Director is also disqualified because of a conflict of interest, that Director shall be excluded from the calculation of the total number of Directors that constitute a majority.

(b) Supermajority Approval. Notwithstanding the foregoing, 75% of the weighted vote total in accordance with Article 12.2 shall be required to approve any of the following: (i) the annual budget; (ii) the GSP for the Basin and any substantive amendment thereto; (iii) any stipulation to resolve litigation; (iv) addition of new Members pursuant to Article 6.2 (New Members); (v) establishment and levying any fee, charge or assessment; (vi) adoption or amendment of Bylaws; or (vii) selection of consultant to prepare the GSP.

ARTICLE 13
BYLAWS

13.1 The Board of Directors may approve and amend, as needed, bylaws for the GSA.

ARTICLE 14
ACCOUNTING PRACTICES

14.1 General. The Board of Directors shall establish and maintain such funds and accounts as may be required by generally accepted public agency accounting practices. The GSA shall maintain strict accountability of all funds and a report of all receipts and disbursements of the GSA. The GSA shall hire an independent auditor to audit its funds and accounts as required by law.

14.2 Fiscal Year. Unless the Board of Directors decides otherwise, the fiscal year for the GSA shall run from July 1^{st} to June 30^{th}.

14.3 Records. The books and records of the GSA shall be open to inspection by the Members.

ARTICLE 15
BUDGET AND EXPENSES

15.1 Budget. The Board of Directors shall adopt an annual budget for the GSA.

15.2 GSA Funding and Contributions.

(a) For the purpose of funding the expenses and ongoing operations of the GSA, the Board of Directors shall maintain a funding account in connection with the annual budget process.

(b) The GSA shall pursue and apply for grants and/or loans to fund a portion of the cost of developing and implementing the GSP as the Board shall direct.

(c) The Board of Directors may fund the GSA and the GSP as provided in SGMA at Water Code § 10730 *et seq.*, from voluntary Member contributions, and/or from any other means allowable by law.

15.3 Return of Contributions. In accordance with Government Code § 6512.1, repayment or return to the Members of all or any part of any contributions made by Members and any revenues by the GSA may be directed by the Board of Directors at such time and upon such terms as the Board of Directors may decide; provided that (1) any return of contributions shall be made in proportion to the contributions paid by each Member to the GSA, and (2) any capital contribution paid by a Member voluntarily, and without obligation to make such capital contribution pursuant to Article 15.2 (GSA Funding and Contributions), shall be returned to the contributing Member, together with accrued interest at the annual rate published as the yield of the Local Agency Investment Fund administered by the California State Treasurer, before any other return of contributions to the Members is made. The GSA shall hold title to all funds and property acquired by the GSA during the term of this Agreement.

15.4 Issuance of Indebtedness. The GSA may issue bonds, notes or other forms of indebtedness, provided such issuance is approved at a meeting of the Board of Directors by 100% of the weighted vote total in accordance with Article 12.2.

ARTICLE 16
LIABILITIES

16.1 Liability. In accordance with Government Code § 6507, the debts, liabilities and obligations of the GSA shall be the debts, liabilities and obligations of the GSA alone, and not the Members.

16.2 Indemnity. The GSA, and those persons, agencies and instrumentalities used by it to perform the function authorized herein, whether by contract, employment or otherwise shall be exclusively liable for any injuries, costs, claims, liabilities, damages or whatever kind arising from or related to activities of the GSA. The GSA agrees to indemnify, defend and hold harmless each Member, their respective governing boards, officers, officials, representatives, agents and employees from and against any and all claims, suits, actions, arbitration proceedings, administrative proceedings, regulatory proceedings, losses, damages, judgments, expenses or costs, including but not limited to attorney's fees, and/or liabilities arising out of or attributable to the GSA or this Agreement ("Claims").

Funds of the GSA may be used to defend, indemnify, and hold harmless the GSA, each Member, each Director and Alternate Director, and any officers, officials, agents or employees of the GSA for their actions taken within the course and scope of their duties while acting on behalf of the GSA against any such Claims.

The Members do not intend hereby to be obligated either jointly or severally for the debts, liabilities, obligations or Claims of the GSA, except as may be specifically provided for in Government Code § 895.2. Provided, however, if any Member(s) of the GSA are, under such applicable law, held liable for the acts or omissions of the GSA, such parties shall be entitled to contribution from the other Members so that after said contributions each Member shall bear an equal share of such liability.

16.3 Insurance. The GSA shall procure appropriate policies of insurance providing coverage to the GSA and its Directors, officers and employees for general liability, errors and omissions, property, workers compensation, and any other coverage the Board deems appropriate. Such policies shall name the Members as additional insureds.

ARTICLE 17
WITHDRAWAL OF MEMBERS

17.1 Unilateral Withdrawal. Any Member may unilaterally withdraw from this Agreement without causing or requiring termination of this Agreement, effective upon sixty (60) days written notice to the Executive Director and all other Members.

17.2 Rescission or Termination of GSA. This Agreement may be rescinded and the GSA terminated by unanimous written consent of all Members, except during the outstanding term of any GSA indebtedness.

17.3 Effect of Withdrawal or Termination. Upon termination of this Agreement or unilateral withdrawal, a Member shall remain obligated to pay its share of all liabilities and obligations of the GSA required of the Member pursuant to terms of this Agreement, but only to the extent that the liabilities and obligations were incurred or accrued prior to the effective date of such termination or withdrawal and are the individual Member's liabilities and obligations as opposed to the GSA's obligation and liabilities in accordance with Article 16. Any Member who withdraws from the GSA shall have no right to participate in the business and affairs of the GSA or to exercise any rights of a Member under this Agreement or the Joint Exercise of Powers Act, and shall not share in distributions from the GSA. Notwithstanding the foregoing, nothing contained in this Article 17.3 shall be construed as prohibiting a Member that has withdrawn from the GSA to become a separate groundwater sustainability agency within its jurisdiction.

17.4 Return of Contribution. Upon termination of this Agreement, where there will be a successor public entity which will carry on the functions of the GSA and assume its assets, the assets of the GSA shall be transferred to the successor public entity. If there is no successor public entity which will carry on the functions of the GSA, then any surplus money on-hand shall be returned to the Members in proportion to their contributions made. The Board of Directors shall first offer any property, works, rights and interests of the GSA for sale to the Members on terms and conditions determined by the Board of Directors. If no such sale to Members is consummated, the Board of

Directors shall offer the property, works, rights, and interest of the GSA for sale to any non-member for good and adequate consideration. The net proceeds from any sale shall be distributed among the Members in proportion to their contributions made.

ARTICLE 18
MISCELLANEOUS PROVISIONS

18.1 Notices. Notices to a Member shall be sufficient if delivered to the clerk or secretary of the respective Member's governing board or at such other address or to such other person that the Member may designate in accordance with this Article. Delivery may be accomplished by personal delivery or with postage prepaid by first class mail, registered or certified mail or express courier.

18.2 Amendments to Agreement. This Agreement may be amended or modified at any time only by subsequent written agreement approved and executed by all of the Members.

18.3 Agreement Complete. The foregoing constitutes the full and complete Agreement of the Members. This Agreement supersedes all prior agreements and understandings, whether in writing or oral, related to the subject matter of this Agreement that are not set forth in writing herein.

18.4 Severability. Should any part, term or provision of this Agreement be decided by a court of competent jurisdiction to be illegal or in conflict with any applicable federal law or any law of the State of California, or otherwise be rendered unenforceable or ineffectual, the validity of the remaining parts, terms, or provisions hereof shall not be affected thereby, provided however, that if the remaining parts, terms, or provisions do not comply with the Joint Exercise of Powers Act, this Agreement shall terminate.

18.5 Withdrawal by Operation of Law. Should the participation of any Member to this Agreement be decided by the courts to be illegal or in excess of that Member's authority or in conflict with any law, the validity of the Agreement as to the remaining Members shall not be affected thereby.

18.6 Assignment. The rights and duties of the Members may not be assigned or delegated without the written consent of all other Members. Any attempt to assign or delegate such rights or duties in contravention of this Agreement shall be null and void.

18.7 Binding on Successors. This Agreement shall inure to the benefit of, and be binding upon, the successors of the Members.

18.8 Dispute Resolution. In the event that any dispute arises among the Members relating to this Agreement, the Members shall attempt in good faith to resolve the controversy through informal means. If the Members cannot agree upon a resolution of the controversy, the dispute may be submitted to mediation prior to commencement of any legal action, if agreed to by all Members. The mediation shall be no more than a full day (unless agreed otherwise among the Members) and the cost of mediation shall be paid in equal proportion among the Members.

18.9 Counterparts. This Agreement may be executed in counterparts, each of which shall be deemed an original and together shall constitute one and the same instrument.

18.10 Singular Includes Plural. Whenever used in this Agreement, the singular form of any term includes the plural form and the plural form includes the singular form.

18.11 Member Authorization. The governing bodies of the Members have each authorized execution of this Agreement and all signatories to this Agreement warrant and represent that they have the power and authority to enter into this Agreement in the names, titles and capacities stated herein and on behalf of the Members.

18.12 No Third Party Beneficiary. Except as expressly set forth herein, this Agreement is not intended to benefit any person or entity not a party hereto.

IN WITNESS WHEREOF, the Members have executed this Agreement to be effective on the date executed by the last Member as noted on Page 1.

ATTEST:
Clerk of the District

By: ______________________
Deputy Clerk

Address:

CUYAMA BASIN WATER DISTRICT:

By: ______________________
Chair, Board of Directors

Date: ______________________

ATTEST:
Clerk of the Board

By: ______________________
Deputy Clerk

Address:

CUYAMA COMMUNITY SERVICE DISTRICT:

By: ______________________
Chair, Board of Directors

Date: ______________________

ATTEST:
Clerk of the Board

By: ______________________
Secretary

Address:

COUNTY OF KERN:

By: ______________________
Chair, Board of Supervisors

Date: ______________________

ATTEST:
Clerk of the Board

By: ______________________
Deputy Clerk

Address:

COUNTY OF SAN LUIS OBISPO:

By: ______________________
Chair, Board of Supervisors

Date: ______________________

APPROVED AS TO LEGAL FORM AND EFFECT
Rita L. Neal
County Counsel

By: ______________________ 5-2-2017
Deputy County Counsel

ATTEST:
Mona Miyasato
County Executive Officer
Clerk of the Board, Ex Officio Clerk of
the Santa Barbara County Water Agency

By: ______________________________
Deputy Clerk

Address:

SANTA BARBARA COUNTY WATER AGENCY:

By: ______________________________
Joan Hartmann, Chair
Board of Directors

Date: ______________________________

RECOMMENDED FOR APPROVAL:
Santa Barbara County Water Agency

By: ______________________________
Scott D. McGolpin
Public Works Director

APPROVED AS TO FORM:
Risk Management
Ray Aromatorio, ARM, AIC

By: ______________________________
Risk Management

APPROVED AS TO FORM:

Michael C. Ghizzoni
County Counsel

By: ______________________________
Deputy County Counsel

APPROVED AS TO ACCOUNTING FORM:
Theodore A. Fallati, CPA
Auditor-Controller

By: ______________________________
Deputy

ATTEST:
Clerk of the Board

By: ______________________________
Secretary

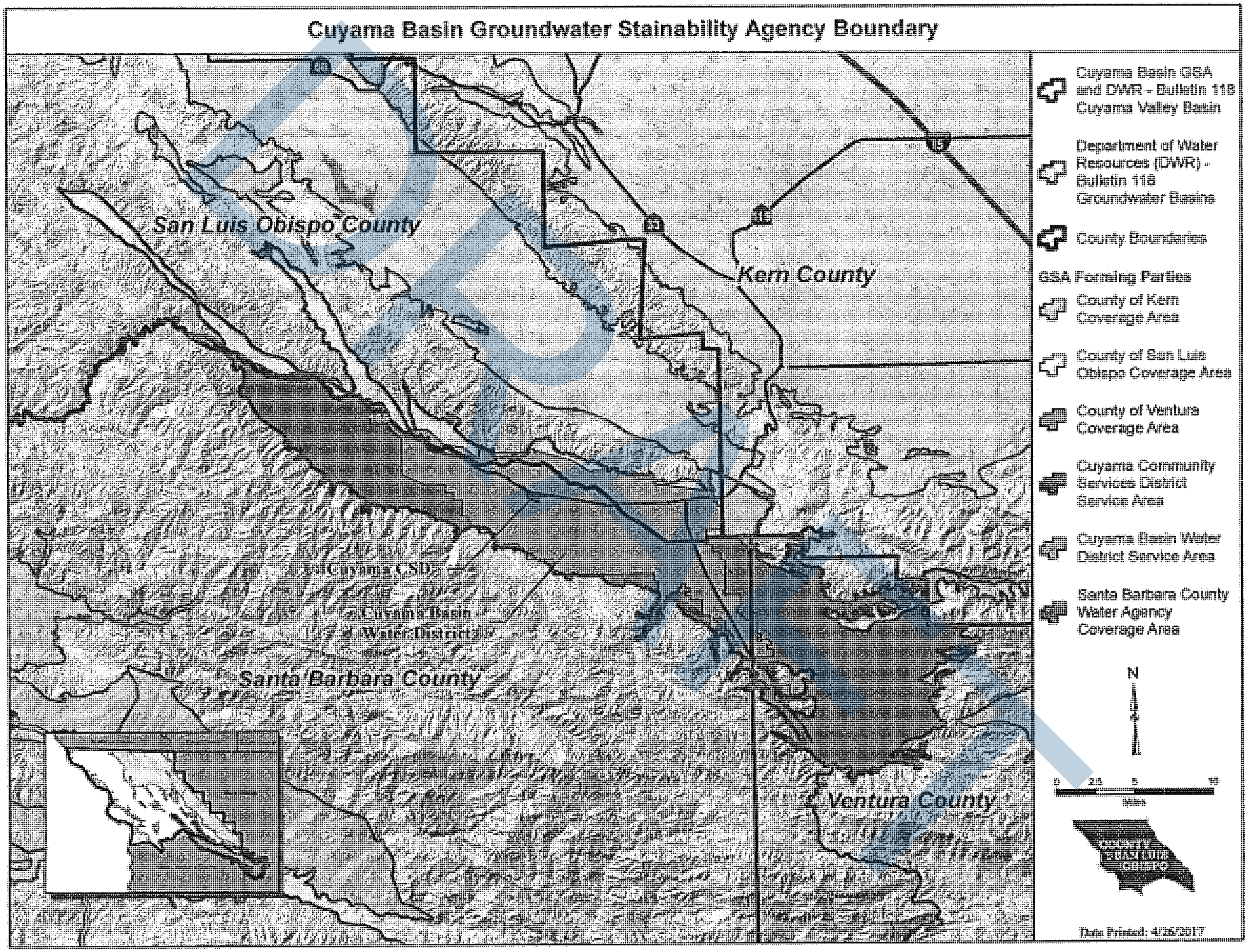
Address:

COUNTY OF VENTURA:

By: ______________________________
Chair, Board of Supervisors

Date: ______________________________

EXHIBIT B


Cuyama Basin Groundwater Stainability Agency Boundary
San Luis Obispo County
Kern County
Cuyama CSD
Cuyama Basin Water District
Santa Barbara County
Ventura County
Cuyama Basin GSA and DWR - Bulletin 118 Cuyama Valley Basin
Department of Water Resources (DWR) - Bulletin 118 Groundwater Basins
County Boundaries
GSA Forming Parties
County of Kern Coverage Area
County of San Luis Obispo Coverage Area
County of Ventura Coverage Area
Cuyama Community Services District Service Area
Cuyama Basin Water District Service Area
Santa Barbara County Water Agency Coverage Area
N
0 2.5 5 10
Miles
COUNTY OF SAN LUIS OBISPO
Date Printed: 4/26/2017
DRAFT

BOARD MINUTES
BOARD OF SUPERVISORS, COUNTY OF VENTURA, STATE OF CALIFORNIA

SUPERVISORS STEVE BENNETT, LINDA PARKS, KELLY LONG, PETER C. FOY AND JOHN C. ZARAGOZA
June 6, 2017 at 2:30 p.m.

Public Hearing Regarding a Joint Powers Agreement to Form a Groundwater Sustainability Agency to Manage the Cuyama Valley Groundwater Basin; Adoption of the Resolution Authorizing the County to Enter a Joint Powers Agreement Creating the Cuyama Basin Groundwater Sustainability Agency and Appointment of a Director and Alternate Director of the Cuyama Basin Groundwater Sustainability Agency. (Public Works Agency)

(X) All Board members are present.

(X) The Board holds a public hearing.

(X) The following persons are heard: Glenn Shephard, Byron Albano, and Jeff Pratt.

(X) The following document is submitted to the Board for consideration:
(X) Exhibit 2 - Cuyama Valley Basin Maps

(X) Upon motion of Supervisor Bennett, seconded by Supervisor Parks, and duly carried, the Board hereby approves recommendations and appoints Glenn Shephard as the Director and Arne Anselm as the Alternate Director.

I hereby certify that the annexed instrument is a true and correct copy of the document which is on file in this office.
Dated: 6/7/17
MICHAEL POWERS
Clerk of the Board of Supervisors
County of Ventura, State of California

By: Lori Gains
Deputy Clerk of the Board

By: [signature]
Brian Palmer
Chief Deputy Clerk of the Board

RESOLUTION NO. 17-060

RESOLUTION OF THE BOARD OF SUPERVISORS OF THE COUNTY OF VENTURA AUTHORIZING EXECUTION OF JOINT POWERS AGREEMENT TO CREATE THE CUYAMA BASIN GROUNDWATER SUSTAINABILITY AGENCY AND APPOINTING DIRECTOR(S) TO CBGSA BOARD

WHEREAS, California enacted the Sustainable Groundwater Management Act of 2014 (California Water Code § 10720 et seq., SGMA), which authorizes local agencies to manage groundwater in a sustainable fashion; and

WHEREAS, pursuant to the SGMA, sustainable groundwater management is intended to occur pursuant to Groundwater Sustainability Plans (GSP) that are created and adopted by local Groundwater Sustainability Agencies (GSA); and

WHEREAS, pursuant to Water Code §10723(a), a Local Agency or combination of Local Agencies, as defined in Water Code §10721(n), may decide to become or form a Groundwater Sustainably Agency; and

WHEREAS, the Cuyama Basin Water District, the Cuyama Community Services District, the County of Kern, the County of San Luis Obispo, the Santa Barbara County Water Agency, and the County of Ventura (Member Agencies) are Local Agencies as defined by the Water Code and wish to enter into the attached proposed Joint Exercise of P owers Agreement (JPA) to create the Cuyama Basin Groundwater Sustainability Agency (CBGSA or GSA) to manage all of the Cuyama Valley Groundwater Basin (basin number 4-3-13 in the California Department of Water Resources CASGEM groundwater basin system (Basin);

WHEREAS, the JPA requires the governing board of the County of Ventura to appoint a Director to the CBGSA Board of Directors;

WHEREAS, a notice of a public hearing to consider whether the County should enter into this JPA Agreement to form the Cuyama Basin Groundwater Sustainability Agency to manage this Basin was duly published pursuant to the requirements of California Government Code §6066; and

WHEREAS, the County held a public hearing on June 6, 2017 to consider whether to enter into the JPA to form the Cuyama Basin GSA to manage all of this Basin;

NOW, THEREFORE, BE IT RESOLVED that the Ventura County Board of Supervisors hereby:

1. Approves the attached JPA to form the Cuyama Basin GSA (Exhibit 1) and authorizes the Chair to execute the JPA on behalf of the County of Ventura;

2. Declares the County's commitment, as a Member Agency to the GSA, to assist the GSA in considering the interests of all beneficial uses and users

of groundwater, as well as those responsible for implementing groundwater sustainability plans, as required by California Water Code §10723.2.

3. Declares the County's commitment, as a Member Agency to the GSA, to assist the GSA in establishing and maintaining a list of persons interested in receiving notices regarding plan preparation, meeting announcements, and availability of draft plans, maps, and other relevant documents, as required by California Water Code §10723.4; and

4. Hereby appoints Glenn Shephard as a Director, and appoints Arne Anselm as an Alternate Director, to the Cuyama Groundwater Sustainability Agency Board of Directors to represent the interests of the County of Ventura on the CBGSA Board.

Upon motion of Supervisor Bennett, seconded by Supervisor Parks, and duly carried, the Board hereby approves and adopts this resolution on the 6th day of June, 2017.

Chair, Board of Supervisors
County of Ventura

ATTEST:

Michael Powers,
Clerk of the Board of Supervisors
County of Ventura, State of California.

By: ______________________
Deputy Clerk of the Board

COUNTY OF VENTURA * CALIFORNIA *

BEFORE THE BOARD OF SUPERVISORS
COUNTY OF KERN, STATE OF CALIFORNIA

In the matter of: Resolution No. 2017-108

RESOLUTION ELECTING TO BECOME A GROUNDWATER SUSTAINABILITY AGENCY FOR A PORTION OF THE CUYAMA GROUNDWATER BASIN

I, KATHLEEN KRAUSE, Clerk of the Board of Supervisors of the County of Kern, do certify that the following resolution, on motion of Supervisor Couch, seconded by Supervisor Gleason, was duly passed and adopted by the Board of Supervisors at an official meeting this 23rd day of May, 2017, by the following vote:

AYES: Gleason, Scrivner, Maggard, Couch, Perez

NOES: None

ABSENT: None

BOARD OF SUPERVISORS KERN COUNTY, CA

KATHLEEN KRAUSE
Clerk of the Board of Supervisors
County of Kern, State of California

Deputy Clerk

RESOLUTION

Section 1. WHEREAS:

(a) The comprehensive groundwater legislation referred to as the "Sustainable Groundwater Management Act" (SGMA) was signed into law on September 16, 2014 with an effective date of January 1, 2015, and codified at California Water Code sections 10720 *et seq.*; and

(b) The stated purpose of SGMA, as set forth in California Water Code Section 10720.1, is to provide for the sustainable management of groundwater basins, and subbasins, as defined by the California Department of Water Resources at a local level by providing local water supply, water management and land use agencies with the authority and technical and financial assistance necessary to sustainably manage groundwater; and

(c) SGMA further provides for and anticipates that eligible local agencies overlying basins that are designated by California Department of Water Resources (DWR) as "high or medium priority" will form Groundwater Sustainable Agencies ("GSAs") for the purpose of achieving groundwater sustainability through the adoption and implementation of Groundwater Sustainability Plans ("GSPs"); and

(d) Water Code section 10723(a) authorizes local agencies with water supply, water management or local land use responsibilities, or a combination of those local agencies, overlying a groundwater basin to elect to become a GSA; and

(e) The County of Kern falls within the SGMA definition of local agency and it overlies the entirety of the unadjudicated groundwater subbasin known as Cuyama Groundwater Basin (Basin).

(f) The Basin, which is defined in DWR Bulletin 118 as Basin No. 3-13, has been designated as a high priority basin in critical overdraft; and

(g) Many of the express powers set forth in SGMA were previously held exclusively by the County through its constitutionally granted policy power over groundwater and as such the ability of a local water purveyor to now also exercise these powers through the formation of a GSA is a significant expansion of the authorities granted to local water purveyors. Prior to SGMA, the powers and authorities afforded to a of a local water purveyor were expressly set forth, and limited by, the purveyor's enabling act; and

(h) SGMA anticipates and expressly provides the statutory authorities for GSAs to operate as enterprise funds through the imposition of fees on those that are benefited by the GSA's operations. As such, any initial outlay of general funds by the County may be recouped once the GSA is formed; and

(i) SGMA does not allow a local agency to impose fees or regulatory requirements on activities that are outside of the boundaries of the local agency and therefore in order to ensure uniformity in the implementation of SGMA and its effects on all lands within the Basin the County of Kern should elect to become a GSA or be a member of all GSA's in the Basin; and

(j) Water Code section 10735.2(a) provides that the State Board may designate the Basin as probationary if any portion of the Basin is not covered by a GSA before June 30, 2017; and

(k) Staff has reviewed this matter and determined that this matter is exempt from further CEQA review pursuant CEQA Guideline section 15061(b)(3) because it can be seen with certainty that there is no possibility that the activity in question may have a significant effect on the environment and CEQA Guideline section 15378(b)(5) because the matter is an organizational activity that will not result in a direct or indirect physical change in the environment; and

(l) As required by Water Code section 10723(b), the notice of public hearing to consider this election to become a GSA for the Basin was published pursuant to Government Code section 6066 in the Bakersfield Californian; and

(m) On May 9, 2017, the Board of Supervisors approved a Joint Powers Authority (JPA) Agreement with the Cuyama Basin Groundwater Sustainability Agency; and

(n) All members to the JPA Agreement are local agencies, as defined in SMGA, located within the Basin and duly organized and existing under the laws of the State of California; and

(o) On May 23, 2017, the Board of Supervisors properly held the noticed public hearing required by Water Code section 10723(b) at 2:00 p.m. in the Board of Supervisors Chambers.

Section 2. IT IS RESOLVED by the Board of Supervisors of the County of Kern, State of California, as follows:

1. This Board finds that the recited facts are true and that it has the jurisdiction to consider, approve, and adopt this Resolution.

2. This Board incorporates and makes all the findings recommended by staff, whether verbally or in their written reports.

3. This Board finds and determines that the applicable provisions of the California Environmental Quality Act of 1970 ("CEQA"), the State CEQA Guidelines, and the Kern County Guidelines have been observed in conjunction with the hearing and the considerations of this matter and it is exempt from further CEQA review pursuant Sections 15061(b)(3) and 15378(b)(5).

4. As set forth in the DWR's Groundwater Sustainability Agency Frequently Asked Questions dated January 7, 2016, the GSA formed by the County of Kern shall consider the desires of other eligible agencies to join this GSA or form other GSA's with the participation and membership of the County of Kern.

5. As required by Water Code section 10723.2, the GSA formed by the County of Kern shall consider the interests of all beneficial uses and users of groundwater, as well as those that are responsible for implementing groundwater sustainability plans.

6. As required by Water Code section 10723.4, the GSA shall establish and maintain a list of all persons interested in receiving notices regarding the GSP preparation, meetings, announcements, and the availability of draft plans, maps and other relevant documents.

7. Staff is directed to ensure that the notice of GSA formation, and all supporting documentation, is submitted to California Department of Water Resources by no later than June 30, 2017.

8. Staff is further authorized and directed to engage in discussions with other qualified local agencies that wish to be a part of the GSA established herein.

9. The Clerk of this Board shall cause a Notice of Exemption to be filed with the County Clerk.

10. The Clerk of this Board shall transmit copies of this Resolution to the following:

Planning and Natural Resources
County Counsel

Cuyama Basin Water District
c/o Cuyama Valley Family Resources Center
4689 Hwy 166
New Cuyama, CA 93254

COPIES FURNISHED:
See above
6/2/2017 (TN)

Appendix D

Groundwater Sustainability Plan Summary of Public Comments and Responses

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APPENDIX D
GROUNDWATER SUSTAINABILITY PLAN COMMENTS AND RESPONSES

This appendix documents public input about the Cuyama Basin Groundwater Sustainability Agency's (CBGSA's) Groundwater Sustainability Plan (GSP) and their responses. Input was received in the following ways:

- At CBGSA Board and Standing Advisory Committee (SAC) meetings
- At community workshops
- Comments sent directly to the CBGSA
- Comments made on the draft GSP chapters or sections that were provided for public comment prior to release of the public draft GSP. These are shown in Attachment 1.
- Comments made by technical staff and consultants on Technical Forum conference calls. These are shown in Attachment 2.

Public Comments and Responses at CBGSA and SAC Meetings

Questions and responses noted below are from the minutes of the CBGSA Board meetings, joint meetings of the CBGSA Board and SAC meetings. Complete minutes for these meetings are available online at www.cuyamabasin.org.

CBGSA Board Meetings

Questions and answers recorded in the minutes for CBGSA Board meetings are listed below in chronological order, from oldest to newest.

April 4, 2018

Question: How recent is the collected data? Why do we not go back to the USGS sites for data?

Answer: Woodard & Curran have all of the data that the Santa Barbara County Water Resources Agency and USGS had.

Question: Has someone been hired to go out and collect that data proactively?

Answer: The more data received, the better.

Question: What about data consistency? How will it be vetted for accuracy?

Answer: A request for data was sent out to the four counties, CBWD, and CCSD. Wells on different sides of a geological fault will be looked at to determine if that data is valid.

Question: Will Woodard & Curran report the data that is not used?

Answer: Woodard & Curran plan on doing that.

May 2, 2018

The minutes for this meeting included no questions from the public.

July 11, 2018

Question: Clarify the review period of the GSA plans by DWR?

Answer: DWR will begin reviewing the plans in 2020, and it may take up to two years to complete the review period.

Question: What will the GSAs be doing while the GPSs are being reviewed?

Answer: The GSAs may begin implementing GSP programs.

Question: Can Woodard & Curran identify who is making comments from the technical forum?

Answer: Woodard & Curran can do this.

August 1, 2018

Question: How do the groundwater level maps correlate to the USGS studies since they do not show the same drops (in groundwater levels).

Answer: The graph represents a different time frame.

Question: How well does the USGS data compare?

Answer: It compares very well and is represented in the model. The current integrated water flow model (IWFM) that Woodard & Curran are using is very good.

Question: Will the stakeholders be informed of the Board and SACs definition of sustainability?

Answer: This information is coming. The sustainability goals and criteria will be developed and available in the September to November time period. The CBGSA Board has not been presented with the criteria for drafting their definition of sustainability, and this composition will be drafted in the fall.

September 5, 2018

Question: Will the public comments made on parts of the draft GSP sections be seen by the SAC.

Answer: All of the comments received by Woodard & Curran will be compiled so the SAC will see everyone's comments.

October 3, 2018

Question: When will the Groundwater Dependent Ecosystems (GDE) be developed?

Answer: In a month or two.

Question: If the CBGSA chose not to have management areas, would they still need boundaries for thresholds?

Answer: Boundaries would still be required.

November 7, 2018

Question: If some wells exceed their thresholds in the same area but are less than the required percentage triggering State intervention, will this trigger anything.

Answer: No.

Question: Are there enough monitoring wells in each area to set thresholds?

Answer: We are working with the data we have. Splitting up the western area will reduce the amount of data and will result in dubious results.

January 9, 2019

The minutes for this meeting included no questions from the public.

February 6, 2019

The minutes for this meeting included no questions from the public.

Joint Meetings of the CBGSA Board and SAC

Questions and answers recorded in the minutes at joint meetings of the CBGSA Board and SAC are listed below in chronological order, from oldest to newest.

February 7, 2018

The minutes for this meeting included no questions from the public.

March 7, 2018

The minutes for this meeting included no questions from the public.

June 6, 2018

The minutes for this meeting included no questions from the public.

February 13, 2018

Question: How can you set minimum thresholds and measurable objectives without the water budget as you would have to go back and redo those numbers if they do not match with the water budget.

Answer: You do not have to resubmit the GSP but update the annual report.

March 6, 2018

Minutes for this meeting were not available as of this writing.

SAC Meetings

Questions and answers recorded in the minutes for SAC meetings are listed below in chronological order, from oldest to newest.

March 1, 2018

Question: Will the GSP team stay until the conclusion of the Spanish workshop at 8:30 pm?

Answer: The GSP consultants will remain for both the English and Spanish language workshops.

Question: Why is an efficient surface interface option a benefit with the IWFM model when Cuyama Valley does not have surface water.

Answer: The Cuyama Valley does have surface water in different forms. The groundwater basin is recharged through surface streams (and upstream fingerlings), as well as irrigation percolation.

March 29, 2018

Question: Is the data going into the model going to be shared publicly?

Answer: Yes, either on the CBGSA website or through DWR's SGMA portal website.

Question: When are the minimum thresholds and measurable objectives determined.

Answer: They will be determined after the conceptual model is developed.

April 26, 2018

Question: Is ground truthing is being done on the data.

Answer: The technical team confirmed that they are spending significant time to do this.

May 31, 2018

Question: Is the GSA aware of the IRWM grant to the Cuyama Community Services District (CCSD)?

Answer: The GSA is aware of the grant.

Question: Will reports be available on the GSA website for public review?

Answer: Yes.

Question: Why is the baseline shown as January 1, 2015?

Answer: The baseline is the ending point for data collection that was provided by DWR.

Question: What is the timeframe for deciding WMAs?

Answer: By the end of summer. The modeling results will assist in determining if WMAs exist.

Question: Who will determine the financial component of achieving measurable objectives.

Answer: The SAC will determine the financial component, and Woodard & Curran will develop a portfolio of options to achieve the measurable objectives the group decides on. Potential projects and management actions for meeting measurable objectives will be discussed in the near future.

Question: Why doesn't the SAC have data for pumping levels?

Answer: Landowners do not always like to provide pumping levels. Woodard & Curran will estimate pumping levels. The lack of pumping data could be a data gap that is identified in the GSP and that the GSA should formulate ways to improve this data going forward.

Question: Will climate change be factored into the GSP?

Answer: Yes, DWR will provide climate data for this variable.

June 28, 2018

Question: Aren't groundwater pumping numbers a critical component of verifying the model?

Answer: The GSA can decide pumping limits, but DWR does not require any pumping data.

Question: If groundwater dependent vegetation is negatively impacted by water diversions, these areas should be monitored. Can the SAC put a caveat in the GSP to add monitoring areas that are not currently monitored if changes in the water use occur?

Answer: This is something that can be updated during the 5-year update cycle or during the annual review of the monitoring data.

Question: Can the next CBGSA newsletter explain the difference between monitoring wells and the monitoring network.

Answer: Yes.

Question: Are community members unaware of their current pumping rates, how will they know if they go over their limit?

Answer: It will be determined how landowners will report on their data.

Question: How will the definition of sustainability be decided?

Answer: The CBGSA Board will develop the definition with stakeholder input.

July 26, 2018

Question: Where will the water budgets for the ten recent years be coming from and when will they be available?

Answer: The water budgets will be developed by the numerical model, and the initial results are anticipated to be available at the September 5, 2018 meeting.

Question: Under SGMA, does the water budget take climate change into account?

Answer: Yes, it will.

Question: How big of an area will be reported on?

Answer: Woodard & Curran will report potentially on four areas. The CBGSA Board will determine this number.

Question: What is the typical range that the regional scale is based on? Is there a standard range?

Answer: It is based on irrigation efficiency. It is a general range, but the number will be updated in the model to be specific for Cuyama.

Question: Will there ever be a number on all the wells detailing what is being pumped or will it be estimated?

Answer: That decision will be made as the implementation plan is developed. There are several ways to calculate future use, one way being satellite imagery like evapotranspiration. The California DWR will accept pump meters and satellite imagery that can calibrate appropriately. If pumping meters are used, they will need to be installed during the implementation period starting in 2020.

Question: If in five years from now, if the GSP is not being achieved, how precise is the data to point out where we are missing the mark, and can it be pinpointed to the 40-acre grid.

Answer: The actual evapotranspiration modeling is on a 30 meter by 30-meter pixel; therefore the cropping pattern should be fairly visible and accurate.

Question: Will the urban demand estimate factors in the efficiency and age of the system?

Answer: It will.

Question: Will the data from the 12 wells provided by Grapevine Capital be included?

Answer: Woodard & Curran will confirm this.

Question: Will Woodard & Curran study storage loss based on subsidence? Do11 inches equate to lost storage? Does the model does not incorporate subsidence?

Answer: Not sure. We need to get further information.

August 30, 2018

Question: For domestic water use, how would the model be used for areas not in the Cuyama Community Services District.

Answer: The model will be based on estimated using recent census information that is being developed.

Question: Can you clarify the1967-2017 date range for the model, is the model going to go back that far?

Answer: The model is looking at 50 years of data for precipitation and resulting runoff and recharge.

Question: Has Woodard & Curran looked into moving groundwater from plentiful areas to areas that are lacking?

Answer: We will investigate this.

Question: Are some of the wells are drilled below the groundwater basin as Grapevine Capital said they have drilled their wells to bedrock.

Answer: This question will need to be answered by Grapevine Capital.

September 27, 2018

Question: Why is the Cuyama Community Services District (CCSD) was listed as a management area?

Answer: It is shown for jurisdictional reasons.

Question: Who makes the final decision on management areas. Will the interests of New Cuyama be impacted?

Answer: The CBGSA Board.

Question: Can subsidence can affect storage differently in areas that are a mixture of sand and clay?

Answer: There is not a lot of space being lost in those areas.

November 1, 2018

Question: Does Woodard & Curran think Tritium and the age of water is an issue?

Answer: No, since the Sustainable Groundwater Management Act (SGMA) is about regional water management and the Tritium study focuses on a few localized wells. The presence of Tritium does not mean deep well percolation is not occurring.

Question: Is the Vadose zone being tracked?

Answer: Woodard & Curran has not tracked the Vadose zone because it is very expensive, and those costs could be avoided by tracking groundwater levels.

Question: Why was five years of storage was chosen for the Margin of Operational Flexibility?

Answer: Five years is the approximate length of a drought period; however, this is a

subjective value that can be changed.

Question: Is the same rationale is needed for every representative well?

Answer: No and that is why they are looking at suggesting the use of management areas.

Question: Can the minimum threshold be set based on how much water is in each well?

Answer: That is possible. Using the "shallowest well method" for setting minimum thresholds does not work as well in canyons or areas with elevation changes.

Question: Is there a potential that the GSP can be produced by 2020 without management actions?

Answer: Management actions will be addressed in the GSP.

Question: What minimum thresholds will be applied to each representative well?

Answer: Woodard & Curran will present recommended thresholds for the SAC to review, which will ultimately go to the CBGSA Board for approval.

November 29, 2018

Question: When discussing minimum threshold numbers, how was the 20% number was decided on for the range? Is it an industry standard?

Answer: It is a value based on professional experience.

Question: Would the California DWR approve a minimum threshold of 100% of range.

Answer: Yes, because it does not cause undesirable results and it would not dewater wells in that area.

Question: Was this (rational options for the central region of the basin) applied to some wells that have a steeper drop.

Answer: The example (Opti Well 421) is actually a fairly steep drop but does not appear that way due to the hydrograph scaling.

Question: How does setting thresholds in the Cuyama Basin affect overdraft?

Answer: Regardless of where the minimum thresholds are set, they must not go down and need to flatten out. In explaining the differences between the threshold options, if you believe there are no undesirable results in the central region, you likely want to keep the minimum threshold low, however, if you think there have been, you likely want to keep it higher.

Question: When can minimum thresholds be changed?

Answer: DWR requires updates every five years, but the GSA can update yearly.

January 8, 2019

No questions from the public were noted in the minutes for this meeting.

January 31, 2019

Question: Has Woodard & Curran discussed implementing mini rainfall models in the different regions (of the Cuyama Basin)?

Answer: Woodard & Curran are using 30-40 sub-watersheds, and each one simulates the inflows and outflows for each section of the Cuyama Basin.

Question: Did the average annual precipitation come from a database or the model?

Answer: It came from the PRISM database which is actual data that is extrapolated.

Question: How did the applied water value change from the December 3, 2018 community workshop?

Answer: The December 3 value was a very rough first cut and improvements have been made to the model since them.

Question: What do the terms appropriative and correlative rights relate to?

Answer: They apply to surface water and groundwater rights. Appropriative rights are based on historic use, and correlative rights determine rights in groundwater based on ownership of land. Prescriptive rights are obtained through the adverse possession of someone else's water rights.

Question: Has the option to only allocate pumping in the problem areas been considered?

Answer: This can be done, but it can be difficult to determine the fringe of impacts. More than one allocation can be created.

Public Input and Response Received at Community Workshop

From March 2018 through March 2019, five community workshops were held in both English and Spanish. At the request of the Spanish-speaking community, the Spanish language workshops were held in a separate room at the same time and location as the English language workshops. The following summarizes the questions asked and the responses provided at each workshop.

March 7, 2018, Community Workshops

Two community workshops, one in English and one in Spanish, were held on March 7, 2018, in New Cuyama, CA. Questions received, and the responses provided are grouped below by workshop topic.

Topic 1 – Sustainable Groundwater Management Act and Groundwater Sustainability Plan

Question: Aren't the solutions for the Cuyama Basin groundwater problem simply more rain and less use? What other options do we have?

Answer: The GSP will include projects and management actions to assist the Cuyama Basin in reaching sustainability by 2040. The projects and management actions will potentially include actions to reduce pumping and projects to increase water supplies.

Question: How many aquifers are there in the Cuyama Basin?

Answer: The available data from the USGS indicated that the Basin included three aquifers.

Question: What do the concepts of Measurable Objectives, Minimum Thresholds, and Interim Milestones mean?

Answer: Each of these SGMA-related terms were further clarified in accordance with SGMA definitions.

Question: What is the difference between Minimum Threshold and Measurable Objective?

Answer: The minimum threshold is the value below which undesirable results occur. The Measurable objective is a specific, quantifiable goal for Basin conditions.

Question: Under SGMA, is there a timetable requirement for meeting the Minimum Threshold?

Answer: By 2040.

Question: If we create a reasonable GSP that is accepted by DWR, what happens if there are droughts that result in failure to meet the objective?

Answer: The GSP includes an implementation plan that will drive the monitoring program. Every five years update to the GSP is required. The monitoring for undesirable results will allow the GSA to know if the GSP is on track or not and can work with the GSA Board and DWR to make adjustments to the GSP as needed. The intent is to look at long-term sustainability and set minimum thresholds that allow for fluctuations that may occur as a result of droughts.

Question: There are naturally occurring calcium and magnesium levels in the water; how are these addressed under SGMA?

Answer: The GSP address constituents that are shown to have a causal nexus between potential GSP actions and constituent concentrations.

Question: Who evaluates the GSP and who reports to DWR?

Answer: DWR will evaluate the GSP. The GSA staff will respond to inquiries about the GSP from DWR.

Question: If the GSP is a “living” document, with interim reporting milestones, then can the plan be adjusted or changed?

Answer: Yes. The GSP will be updated every five years. Adjustments will be proposed as needed.

Question: SGMA requires the identification of projects and management actions; most of the examples shown won't work; what options will be available for the Cuyama Basin?

Answer: In a few months, the GSP team will have more information to present workable projects and management actions for consideration for inclusion in the GSP.

Topic 2 – Data for Use in the Hydrologic Model

Question: What public data are being used to develop the plan?

Answer: Public data is being accessed from the four counties with jurisdiction in the Cuyama Basin, U.S. Geological Survey, California Data Exchange Center, National Oceanic and Atmospheric Administration, California Statewide Groundwater Elevation Monitoring, and others.

Question: What data will the team use from private wells?

Answer: Well construction information and historical groundwater levels

Question: How will the team be filling in the data gaps?

Answer: The team is collecting any available data from wells in the basin and developing a proposed plan for establishing a robust monitoring network to fill data gaps.

Question: How will the team validate the data?

Answer: A comparison will be made between private landowner data and publicly available data.

Question: How will the team address discrepancies?

Answer: Data that appears to be anomalous when compared to the overall dataset will be removed for purposes of the technical analysis.

Question: What does relevant timeframe mean (referring to a statement that the team is collecting data for the relevant timeframe)?

Answer: The team is using the period from 1995 to 2015 to validate the groundwater model.

Question: What will future pumping allocations be based on, a 20- to 30-year historical amount?

Answer: There are several approaches for allocating groundwater pumping, which will be discussed as part of projects and management actions.

Question: What is the difference, for the effectiveness of the model, if the team receives generic water data versus specific data from basin growers/farmers/ranchers (referring to a prior statement about the availability of data from private sources)?

Answer: Specific numeral data is more useful for model development.

Question: Will the team accept water data from growers/farmers/ranchers that USGS did not include in their study?

Answer: Yes.

Question: Will the team use the monitoring data that USGS is still gathering?

Answer: Yes. All data that is provided by June 2018 will be used in development of the GSP.

Question: Does the team know the pumping capacity for the production wells identified?

Answer: No. Groundwater pumping is estimated based on crop types and water demand for those crops, rather than on pumping capacity.

Topic 3 – Cuyama Basin Plan Area Description Elements

Question: For the geology, will the team use core samples to validate the geology?

Answer: No, that would be costly. The team is using available published geologic reports.

Question: Can the team get the changes in land use from satellite imagery? For land use changes since 2014, Sunrise Olive Ranch, on the road to Ventucopa, should be included. Since 2014, more than the normal amount of land has been fallowed due to drought conditions.

Answer: Yes. Data that was provided on current land uses will be incorporated into modeling analyses for current and projected conditions.

Question: Will the team refer to the same geographic zones as USGS did: Ventucopa Uplands Zone, Main Basin Zone, and Foothill Zone?

Answer: Geographic regions will be developed for relevancy to the GSP.

Question: Has there been subsidence from oil pumping? USGS says there has been no subsidence at Russell Ranch.

Answer: There is no evidence of subsidence in that area.

Question: Is there a different evapotranspiration rate for the valley portion of the basin?

Answer: The model calculates the evapotranspiration based on the data provided by the Irrigation Training & Research Center at Cal Poly San Luis Obispo.

Question: Who is paying for this?

Answer: Funds from the four counties that have jurisdiction in the Cuyama Basin along with state grant funds.

Question: On the CBGSA Board of Directors, there are five representatives from the Cuyama Basin Water District (CBWD) and only one from the Cuyama Community Services District. Does CBWD pay more?

Answer: Yes, the CBGSA Board has developed a cost allocation formula for the participating entities.

Question: What can New Cuyama residents do to stop the decline in groundwater use? Water consumption is minimal now with people using bottled water; irrigation is limited. People are doing their part. What else could the community do?

Answer: Continue to provide input to the development and implementation of a balanced GSP for the Cuyama Basin.

Question: Water bills are very high; how will this project affect the water bills?

Answer: The GSP does not address the cost of water for the community. The GSP will consider projects, such as a new well for New Cuyama.

Question: What will be the economic impact on agriculture and jobs in the community? What are the impacts of potential changes in water use?

Answer: The economic impacts on agriculture are not yet known. As the GSP development progresses, more information about the pumping allocations will better inform options for sustainability.

Discussion about Existing Basin Conditions

The workshop included an interactive discussion that focused on individual ranchers/farmers talking about their observations and experiences with water in different geographic areas in the Cuyama Basin. Attendees discussed their experience with water in distinct geographic areas of the Cuyama Basin including Upper Ventucopa (Apache Canyon), Lower Ventucopa, the foothills of the central portion of the basin, the valley floor, and Cottonwood Canyon/northwest basin. The information provided a better understanding of the changes in water levels and pumping capacities over time as well as the importance of understanding the influence of fault lines on the aquifer.

June 6, 2018, Community Workshops

Two community workshops, one in English and one in Spanish, were held on June 6, 2018, in New Cuyama, CA. Questions received, and the responses provided are grouped below by workshop topic.

Topic 1 – Overview of Physical Conditions of the Cuyama Basin

Question: What happens if the Cuyama Basin does not reach the minimum threshold by 2040?

Answer: The Cuyama Basin GSP is reviewed every five years, from 2020 to 2040, and adjustments to the GSP would be made if progress toward the minimum threshold is not occurring.

Question: How will the existing water quality contamination, specifically from salinity and arsenic, be addressed in the GSP?

Answer: These are described in the groundwater conditions section of the GSP.

Question: How can water quality help understand the flows and barriers of groundwater and help with the geologic modeling?

Answer: Water quality can be significantly different on one side or another of a groundwater barrier that impedes or diverts groundwater flows, so water quality analyses can help identify barriers and how groundwater flows. However, water quality testing can be expensive, so it should be considered carefully.

Question: Can you define groundwater plumes?

Answer: Plumes are areas of contamination that can move through and spread in groundwater. Plume fronts determine the direction and speed of spreading contamination.

Question: What is the depth to groundwater levels on the three Cuyama Basin hydrogeology layers?

Answer: In the center of the Cuyama Basin, the deepest groundwater level is at 1,000 feet; followed by the middle layer at 800 feet; followed by the top layer at 600 feet.

Question: Regarding the two faults (Russell Fault and Rehoboth Fault), why are they of such interest?

Answer: The two faults are of interest because there is less recorded data regarding the faults and how these faults generally affect groundwater flows. The published studies are not consistent regarding the impact of faults on water flow.

Question: Is more research going to be done on Santa Barbara Canyon fault and its effect on the aquifer?

Answer: The existing published data is consistent for Santa Barbara Canyon fault, so it is a low priority for further research at this time.

Question: What is the significance of "basement" rock?

Answer: Basement rock is a catch-all term for rock formations that generally do not hold water and are a barrier to water movement. If you consider the basin a bathtub filled with sand and water, the basement rock is the porcelain bathtub. In some cases, the rock can be fractured, which allows some movement of water through basement rock.

Question: Do we know if the "bathtub" or basement rock leaks?

Answer: Most basement rock in most basins does leak, but that cannot be measured. The model includes this as an estimate.

Question: On the ground surface and groundwater elevation profile, does it consider the sides of the river as opposed to just the river end-to-end? Have you done anything to look at the sides of the Cuyama Valley? Are you identifying water-bearing layers of wells?

Answer: The groundwater conditions section of the GSP considers the sides of the river, i.e., how the groundwater levels change from the edges of the Cuyama Basin to the Cuyama River. The next phase of work looks at the data to estimate the elevation contours and use existing reports to understand groundwater movement. USGS looked at groundwater layers. They found them not to be consistent from well to well. Over time, the Cuyama River has deposited fine sand and coarse rocks in varied ways in the Cuyama Valley.

Question: Have you given thought to water management areas based on the hydrology and geology?

Answer: Water management areas are a possible consideration, based on the hydrology and geology. However, there is no decision at this time; there is more work to be done. Management areas are going to be discussed at future meetings.

Question: Are you looking at well logs to identify geologic layers?

Answer: Yes, if provided.

Question: When was the last USGS study done?

Answer: The latest data from the USGS study was 2014. More recent data is being used to understand current conditions.

Question: How and when will data gaps be addressed? Before and after the draft plan?

Answer: While developing the GSP, the unknowns are documented. Moving forward, data gaps are addressed as more data is gathered. Activities to address data gaps and reduce uncertainty will be included in the GSP and used to refine the GSP at the 5-year updates.

Topic 2 – Sustainability and Role of Water in the Future of Cuyama Basin

Following a general introduction about sustainability and what it means in SGMA, the following question asked of participants *What does sustainability of the Cuyama Valley mean for you?* The responses are summarized below:

Balanced Water Use: Balance water use among all water users to allow everyone (farms and residential) to remain in the Cuyama Basin. Water needs to be balanced, and water needs to be used wisely by all users. The water table is replenished and fills to levels that do not fall to dangerous levels even in drought.

Economic Productivity and Stability: Current Perspectives: Without water, how can we survive and maintain our livelihood? The community is already subject to greater impacts now with the high cost of water ($160 to $200 per household per month) and the water contamination (salinity and arsenic) that has come as a result of the increase in farming. The farmers/ranchers can pack up and leave the area if they want to, leaving the community with no jobs and no community; the people in the community can't just pick up and leave.

Future Perspectives: Water and jobs are directly connected. The Cuyama economy should continue to grow. Economic productivity and quality of life are necessary. Solutions to water issues have to be economical. Cuyama needs an economy that keeps people employed. Water use by homes is negligible compared to agriculture. Access to affordable quality water is the only thing that can support people and the economy in the Cuyama Valley.

Water Equality: Need to fix the current water inequality in the future. (people have bad water with salinity and arsenic, and farmers pump all day). Regulate the amount of farming and irrigating so that residents can have clean water, affordable water. Water needs to be used wisely by all users. All water users must evaluate their use and determine where they can cut back – individuals must have enough water to maintain good health, and large and small farms must evaluate their use and change their practices to be more conservation oriented.

Local Ecology: We would like to see more plant growth along the riverbed and improvement to local ecology (e.g., trees). Utilize trees for windbreaks. Restore habitats for migratory birds as well as insects and wild animals.

Farming Management Practices: Farms have to change how they do business. Consider crop shift and value-added processing. Grow crops that are more permanent to reduce tilling and soil drying. Maintain the dry rangeland that is sustainable in parts of the valley. Farmers need to change what they are growing to use water more wisely. Use hedge-rows around fields. Rebuilding soil for moisture retention (no-till and cover crop).

Water Delivery Infrastructure: The Community Services District pumps break, the wells go down now; this didn't happen 5 to 10 years ago.

Water Quality: The water has not been drinkable for at least 28 years (number of years the speaker has lived near the intersection of 166 and 33). The water is better at Maricopa, so they go there to get water. Three to four times per year the water is brown. The salinity has gotten worse. The people need better water sources in the future, with no salinity. Better drinking water, some wells not drinkable, total dissolved solids. Increased salinity from overdrafting on large farms leads to more overdrafting to remediate the problem which leads to dust and poor air quality.

Groundwater Depth: 10 years ago, when there were fewer farms, the depth to water was okay. Now with more farms, the water depths are worse – have to drill deeper now to find water. Depth to water was bad during the drought, but it is even worse now since even more farming (North Fork Vineyard) has come into the Valley. Need to stop wells from going dry.

Additional Comments: Sustainability means the return of environmental and groundwater conditions to rates that were previous to the adverse effects taking place. Sustainability means improving water quality, the reverse of land subsidence, and decreasing well depths. Sustainability is maximizing resources and increasing quality of life for members of the community. Sustainability is not just water, rebuild soils in the area. Sustainability means survival of the community and wildlife through drought periods, that mega-farming is not expanded beyond current levels, and no additional residential development. Sustainability means that people, animals, and crops must be able to survive without using more water than is replenished in an average year; this requires re-evaluation of current practices. The water connection to the natural and human environment is essential – e.g., water retention can support natural and human communities. The future has to be different – we are at a change point. Consider that there are longer cycles of wet and dry in the future. Re-establish reservoirs. Use a 60-year cycle to accommodate for a full wet and dry cycle of the Pacific Decadal Oscillation (we entered a wet cycle in 2014).

The next question asked of participants was, Water is important for the future of the Cuyama Valley. What do you see as important challenges or undesirable effects for the future of water in the Cuyama Valley for the following:

- Water and Jobs
- Water and Community/Households
- Water and Small Farms
- Water and Large Farms
- Water and Natural Resources
- Water and the Economy

Water and Jobs: The water used for farming is okay, but the water for the community is still bad. Jobs go if the water goes. We want water for all – a balanced approach. We want to keep jobs in the Valley for people that live here. For homeowners, the value of the homes will drop drastically if there is no water and no jobs. With most farms, worker housing has been removed causing families with children to move away, which has impacted the schools. Family housing needs to be addressed. Affordable, quality water supports jobs. The only jobs are farming jobs, so some people live here, but don't work here. Need increased population to work at both small and large farms – keep the money in the Valley.

Water and Community: Water of good quality must be available for people and animals at an affordable price. Cuyama Community Services District (CCSD) needs to provide safe and affordable water. Are the problems with the town water (low pressure, salinity, brown color at times, arsenic, unreliable delivery system) because of the nearby over-pumping? Can there be a way not to pump at all within a certain proximity to the town? We want water for the community pool, for community recreation. Grimmway should pay the CCSD water bills, which are between $160 and $200 a month. Increasing arsenic, salinity, and carcinogens. The town well is drying, need functioning wells in town. Don't want to have to decide between washing clothes or taking a shower like it is now in New Cuyama. Need to educate children now about how to use water wisely, how to conserve water. With most farms, worker housing has been removed causing families with children to move away which has impacted the schools. Family housing needs to be addressed. Groundwater pumping could turn the Cuyama Basin into a desert, making homes impossible to sell, making it impossible to move elsewhere.

Water and Small Farms: Many small farms are gone now. Generational farming is phasing out. Small farms have been and continue to be affected because as the water is deeper; farmers can't afford to drill deeper while the big farms can. Deeper wells to reach water makes more expense for the small farmer; this is not sustainable. A bad impact would be that the community and small farms are unfairly punished for the negligence of the responsible parties of the negative effects. Small farms need to be protected from wells going dry and crops going dry.

Water and Big Farms: No Water = No Jobs. Bad water quality impacts crops negatively – the crops will not be as good. Big farms should operate sustainably with the amount of water to keep water use balanced for everyone. Farming needs to reevaluate water use and crop choice. Can farmers grow crops that use less water? Regulate the water, so farmers change what they are growing. Big farms don't care about how much water they use, and they don't care about the community. They have the money to drill new wells. They have the money to pick up and leave; the people don't. Large farms operated by industrial ag-corporations appear to be blind to the damage that they do to the environment and the community. Shrink industrial agriculture by at least 50%. Wells are going dry, crops going dry. Agriculture must pay for water based on the actual amount that they use.

Water and Natural Resources: Chemicals are being sprayed onto the crops and then going into the groundwater. If there is no water, big agriculture leaves, and they leave a polluted dustbowl full of the sprayed chemicals. Air quality is bad because of big agriculture operations. Animals like deer and rabbits will be left with no water. There are fewer deer and rabbits now probably because they've been eating and drinking the sprayed chemicals. If there is no clean water for animals, then there will be no animals. Need diversity of species. Build organic matter into the soil. Forty-five years ago, streams ran year-round, not just as torrents after rains. With a sustainable water table, the streams could run again. Over pumping has already destroyed much of the natural environment that drew people here years ago. Sustaining riparian areas, supporting wildlife habitat.

Water and Economy: Cost of water needs to be affordable. Economic stability through boom and bust. We want affordable water. Affordability of well drilling to depth. Economic impact: agriculture and urban – need to connect with uses. It is undesirable for long-term management if the whole valley is treated the same. We need a diversified economy; we are over-reliant on certain industries. Changes in farming practices are important to the economy. If the GSP fails, there will be no economic stability.

General Undesirable Results: Everyone will get less water. It is a closed system. What if the Groundwater Sustainability Plan doesn't get the outcomes we want? Well infrastructure is old and falling apart, which contributes to poor water quality. Groundwater pumping could limit access to water for the community. Land subsidence could be a problem that leads to infrastructure issues, less recharge for children to take on business and have a positive experience in Cuyama.

September 5, 2018, Community Workshops

Two community workshops (English and Spanish), were held on September 5, 2018, in New Cuyama, CA. Questions received, and the responses provided are grouped below by workshop topic.

Topic 1 – Modeling Cuyama Basin Groundwater Conditions

Question: Explain primary and secondary axes and what are the Average Annual Volume numbers on slide 26, Groundwater Budget: Basin-Wide.

Answer: The left axis shows the groundwater gains (e.g., recharge) and losses (e.g., pumping) each year. The right axis depicts the cumulative change in groundwater storage, as shown with the black line on the graph. The average annual volumes are the estimated average annual gains or losses from the groundwater basin, as calculated by the model.

Question: The numbers shown as model results today are not calibrated, right? The community should not assume the numbers fully depict the historical conditions or trends.

Answer: Yes, the model is not yet fully calibrated; the numbers are preliminary and are likely to change.

Question: When mentioning domestic use, the population you used was in the thousands?

Answer: No, the estimated population for the Community Services District is approximately 800. This estimate will be updated with new information when available.

Question: The point is there is a downward trend in groundwater storage, and the point is to figure out how to get it not to go down? It looks like we are down 200 feet, but the water budget graph makes it look like there is the same amount of water coming in as is going out.

Answer: The annual water budget is balanced on the graph by the amount of change in water storage (purple). Most years, there is a decline in water storage.

Question: What is the definition of “developed land?”

Answer: Anything with agricultural and urban use on it.

Question: Why is evapotranspiration the only thing used to estimate pumping demand and not direct evaporation from spray irrigation or ponded water?

Answer: Evapotranspiration includes estimates for direct evaporation.

Question: Is there a way to measure/monitor deep percolation?

Answer: There is no easy way to measure that.

Question: On most of the graphs on slide 28, the actual groundwater levels look like they are deeper than what the model has estimated.

Answer: Yes, the model still needs to be calibrated to develop closer alignment between modeled results and actual measurements. The team is working in the next several months to understand local irrigation practices better and calibrate the model.

Question: There may be different depths of screens in wells that could affect the well depth monitoring that the model has not captured. How hard is it to go back in and add layers for well?

Answer: If we have data on it, then it can be added, but we do not want to break up existing layers into sublayers just to “brute force” the model.

Question: How is the pumping value calculated when the pumps do not have meters on them?

Answer: We estimate the pumping demand based on domestic and agricultural uses and calculate pumping amounts based on those needs.

Question: Plants need water in the ground, and there is water above ground, puddling, etc. How is this water considered in the model calculations?

Answer: We capture the total irrigation water demand through the evapotranspiration calculations, which included direct evaporation.

Question: How is climate change incorporated into this model?

Answer: The CBGSP team will include scenarios that estimate future changes resulting from climate change (e.g., changing rainfall patterns, increased irrigation demand).

Question: Does the model take into account the changes in the basin as it narrows? It may be more than the model currently covers.

Answer: We have implemented what the USGS implemented in their model for the shape of the basin, based on well logs (water and oil) and satellite data.

Question: Recently the Government proposed selling leases for oil drilling (federal land in the foothills). Oil operations could use additional groundwater, particularly if fracking is involved. How would that be considered?

Answer: Future water demands in the Cuyama Basin can be considered. We can look into how likely additional pumping from the Cuyama Basin would be.

Question: Is 90% irrigation efficiency realistic?

Answer: Irrigation efficiency is based on evapotranspiration and not on other irrigation practices. The CBGSP team will further clarify these calculations.

Question: How do subsidence and the loss of storage due to subsidence fit into the model?

Answer: There are no simple, cost-effective ways to model subsidence. Subsidence and the potential loss of storage are discussed and addressed in the GSP.

Question: How do you estimate and calibrate surface water flows if there are no good surface water gauges in the basin.

Answer: The land surface component of the model simulates surface water flows based on available precipitation, soil, and land use datasets. Then we compare the results with the available streamflow observations to make adjustments.

Question: Did the USGS study include surface flow in their model?

Answer: USGS has limited information about surface flows, which the team is reviewing and comparing.

Question: How are you looking at groundwater dependent ecosystems (GDEs) and all the wildlife that depends on that.

Answer: We have a biologist who is reviewing and checking available data regarding groundwater dependent ecosystems in the basin. A memo summarizing the findings will be prepared.

Question: How does the model take into consideration how some wells have declined, and others have remained relatively stable?

Answer: The model calculates water budget and elevation levels for each cell in the model based on the conditions in that cell. The calibration effort is getting the calculations to replicate real-world measurement.

Question: With so many factors calculated in the model, it is important to understand the level of certainty that underlies the factors and model results. Can that uncertainty be quantified?

Answer: The GSP includes a discussion of uncertainty and recommendations for reducing uncertainty in the future.

Question: The presenter asked for information about the causes for the Cuyama Community Services District groundwater levels to drop after 2011. The commenter noted that this was the year that Duncan Family Farms started farming irrigated land near the CCSD well – could there be a correlation?

Answer: There may be a connection. This will be investigated as part of numerical model calibration.

Question: I'd like to know the implications of water being removed from the older alluvium (beneath the aquitard) and being put into the newer alluvium (above the aquitard)? It is called "deep percolation" in the model but it different/distinct from that water not being pumped and remaining in the deep alluvium.

Answer: This is not likely to significantly affect the overall groundwater budget.

Question: How does the pumping in one area affect others (cone of depression)? Does the heavy agricultural pumping make domestic wells have to be deeper? Who should bear these consequences if this occurs?

Answer: If groundwater levels fall below minimum thresholds, the Board will determine the proper action to make in response.

Question: Cuyama Community Services District had two wells. One went out of service a couple of years ago. I am wondering if your model is using data from two different wells?

Answer: The numerical model assumes that pumping for the CCSD is taken from the remaining well.

Question: What sustainable options are you exploring? How can the options you are currently presenting be viable? Are you addressing a model for "sustainability" by proposing a pipeline? How does that make sense?

Answer: A pipeline is an example of a project that might be considered to help the Cuyama Basin become sustainable by 2040. Some projects and management actions will be presented later in the GSP development process for further consideration and evaluation.

Question: Are there underground river flows (data) available?

Answer: This type of data is not available. However, subsurface flows are estimated by the numerical model.

Topic 2 – Potential Management Actions and Projects for the Cuyama Basin

Question: Are cattle positive or negative in terms of water use? Can they be used to manage vegetation in rangeland?

Answer: This is not likely to have a significant effect on the overall Basin water budget.

Question: How do we evaluate the sustainability of whatever project(s) we consider when some options may draw water from other basins?

Answer: The options considered should help sustain the Cuyama Basin; the CBGSA Board and Standing Advisory Committee may consider many factors in evaluating options.

Question: Do the projects need to be suggested now? And implemented by 2020? Or do they get implemented later?

Answer: The GSP includes an evaluation of potential actions and an implementation plan for the most viable approaches. The projects and management actions do not have to be implemented by 2020.

Question: Are we trying to reach 2015 levels? Or are we leveling off whenever we level off in 2040?

Answer: There is no mandate to meet 2015 levels. The thresholds and objectives will define what the projects and management actions need to achieve.

Question: Given that we are in critical overdraft, have we been in contact with DWR? They implied that levels could not change from now.

Answer: The Cuyama Basin is not required to return to 2015 groundwater levels. The requirement is that the basin achieves sustainability, which the GSP will define for this basin.

Question: Explain the glide path. How is it used; is this to help predict the future?

Answer: The glide path is included to establish a predictable plan for how and when the basin might achieve more sustainable conditions.

Question: Is there a way, when considering purchasing water, to evaluate how demands and supplies and price may change over time? Can price changes be accounted for in a 20-year purchase plan?

Answer: Evaluation for the inclusion in the GSP includes estimated costs for the projects and management actions considered.

Question: How would funds would be raised to buy that water?

Answer: The GSP implementation plan will describe how management actions and projects could be funded.

Question: What can be learned from other GSAs?

Answer: The team is reviewing ideas being considered by other GSAs.

Question: What can we do as a community to counter these changes (climate change, loss of EPA regulations, changes in government and legislation) to allow ourselves to flourish?

Answer: The GSP will include modeling for climate change.

Question: The options (for management actions and projects) do not make sense in terms of what is sustainable. What options are you considering that are regenerative options for water supply?

Answer: Reuse options may be considered by local landowners in response to pumping allocations.

Topic 3 – Concepts for Management Areas

Question: Can we use a combination of those management areas?

Answer: Yes. The GSA could decide to combine concepts or use a different approach not developed yet.

Question: The blue areas shown (high groundwater levels) are traditionally grazing lands that use very little water, so why manage them?

Answer: The Board could decide to establish management areas only in areas where groundwater management is needed.

Question: Why do we have so much area that is outside of the main part of the basin? Why don't we change the basin boundary?

Answer: Boundary modifications could be considered, but the rules specify when DWR will consider changes.

Question: Do we need management areas? It's hard to set them if we don't know what they can and cannot do.

Answer: This presentation is a preliminary presentation of concepts. Having no management areas is also an option. The GSP team will provide additional information about what can and can't be accomplished with management areas at a future workshop.

Question: Could the GSP set management areas based on data gaps, with the purpose of not necessarily setting thresholds and just trying to figure out what to do there?

Answer: It is possible, but generally, management areas are to help set thresholds and to organize and implement management actions and projects.

Question: Another data point would be rainfall in the foothills, can you establish management areas by rainfall patterns?

Answer: It is possible, but generally, management areas are to help set thresholds and to organize and implement management actions and projects.

Question: What standard are federal lands under in terms of water use? Are there regulations they must comply with?

Answer: The federal government is not bound by state law.

Question: If there have been grapes planted at the west end of the basin and the basin was in overdraft before that, who decides for final water cutbacks.

Answer: The GSA Board will decide on the management actions, projects, and implementation plan.

Question: Can you accomplish results without management areas?

Answer: Yes, management areas are not required. The GSA is the managing and implementing agency, with or without management areas.

December 3, 2018, Community Workshops

Two community workshops (English and Spanish), were held on December 3, 2018, in New Cuyama, CA. Questions received, and the responses provided are grouped below by workshop topic.

Topic 1 – Sustainability Thresholds

Question: How does the water budget relate to the minimum thresholds?

Answer: The water budget and minimum thresholds are not directly related. The water budget doesn't influence what is established as minimum thresholds. The water budget and numerical model are used to guide projects and management actions so that the Cuyama Basin will be sustainable within 20 years and be above the minimum thresholds.

Question: When in the water budget analysis are the topography of the Cuyama Basin and recharge areas considered?

Answer: The topography of the Cuyama Basin is considered in the water budget and numerical model, which considers the collection of surface water and infiltration to the groundwater. The identification of potential recharge areas is a part of the development of projects and management actions to increase water supplies in the basin.

Question: When setting minimum thresholds, why allow further decline of the groundwater levels? How is that sustainability? If minimum thresholds are set below 2015 levels and allow further decline, then how do we get balance? Don't we have to get the water budget in balance?

Answer: The setting of minimum thresholds is designed so that, as a whole, the Cuyama Basin avoids undesirable results. Undesirable results adversely affect beneficial uses of groundwater – in some portions of the basins, groundwater levels can decline without causing further undesirable results, and the minimum thresholds reflect this.

Question: Are there actual undesirable results that can be related to the proposed minimum thresholds in the different threshold regions? What are we trying to prevent the setting of the minimum thresholds? Have the undesirable results that are to be avoided been defined for each region?

Answer: Part of the rationale for setting minimum thresholds by regions within the basin is to indicate when a given threshold region might be approaching an undesirable result. Potential undesirable results have not been identified by region at this time. Five undesirable results apply in the Cuyama Basin as defined by SGMA: reduction of groundwater storage, land subsidence, chronic lowering of groundwater levels, depletion of interconnected surface water, degraded water quality).

Question: How connected is the groundwater between the threshold regions?

Answer: Groundwater flow varies among the threshold regions based on the geology, but generally, the groundwater is connected between the regions.

Question: Are additional monitoring wells planned?

Answer: Yes, a monitoring network is established that includes new monitoring wells in areas that require additional data.

Question: Explain what you mean by "establish range of operation in the groundwater basin."

Answer: On slide #30, "Why Minimum Thresholds" three reasons were given: Required by SGMA, establish range of operation in the groundwater basin, and protect other groundwater pumpers. The second reason "establish range of operation in the groundwater basin" is referring to setting a range of groundwater levels to allow for groundwater pumping through wet and dry periods.

Question: Did the technical team working on the model consult with other agencies and surrounding counties for data?

Answer: Yes, data was collected from several agencies including DWR, U.S. Geological Survey, the counties of Kern, Santa Barbara, San Luis Obispo, and Ventura, and others.

Question: What do you mean when you say, "protect access to groundwater for the Cuyama Community Services District?"

Answer: This is a good example of how minimum thresholds can help identify when an undesirable result might occur, such as dewatering the CCSD well. The CCSD access to groundwater should be protected as it is an existing groundwater user.

Question: When will there be a new well for the Cuyama Community Services District (CCSD)?

Answer: A new CCSD well will be evaluated as a possible project in the GSP. It will be up to the CBGSA Board to decide on the actions that protect groundwater users.

Question: Does the CBGSA submit the GSP and then find funding for projects and management actions such as a new well for the CCSD?

Answer: Part of the evaluation of projects and management actions will be identifying potential funding sources for projects, including grants and/or local funding by the GSA and groundwater pumpers.

Question: Isn’t it a contradiction to say that we can allow wells to be drilled deeper such a new CCSD well while working to achieve sustainability in the Cuyama Basin?

Answer: Interim period between 2020 to 2040, while projects and management actions are being implemented, it is possible that groundwater levels will continue to decline, which may warrant new wells to maintain access for groundwater pumpers.

Question: Do other GSPs have more or less monitoring wells than in the Cuyama Basin?

Answer: It varies. Each groundwater basin is developing monitoring wells and the right number to provide a basin-wide measurement of sustainability.

Question: How do you update the GSP every 5-years; what does that look like?

Answer: During the five years, everything is monitored and assessed. The update is a chance to relook at conditions with new and better information, refine and update sustainability thresholds, check-in on how project and management actions are doing, and determine if new projects or actions are justified or needed.

Question: What is an example of a management action that is implemented, and then needs to be changed or modified during the 5-year GSP update process?

Answer: For example, new monitoring wells will be installed around the faults. During the 5-year update, it may be learned that more monitoring wells are needed to further understand the conditions. Another example would be where a recharge project was implemented with good results, and a decision might be made to expand it.

Question: If a goal is to increase water supplies, how will that be done?

Answer: The team will be evaluating projects and management actions, which is a topic for future workshops.

Question: As the GSP is updated every 5-years, will the actions get stricter to achieve sustainability by 2040?

Answer: The GSP contemplates phased implementation of projects and management actions as well as water allocations. The 5-year updates may show that more projects and management actions are needed if progress toward sustainability by 2040 is not matching expectations.

Question: For the rationale that sets the minimum threshold at 2015, is the idea then that the well doesn't go below that level even without undesirable results?

Answer: This is still to be determined. The team will use rationales selected with input from the community, SAC, and the CBGSA Board to develop specific minimum thresholds for each threshold region and interim milestones. In some cases, the interim milestones may go below 2015 levels with the goal of recovering by 2040.

Question: How do threshold regions or rationales relate to the existing 30% overdraft?

Answer: The rationales are intended to develop the minimum thresholds to monitor against undesirable results. 30% represents the over-pumping across the entire basin. Projects and management actions are developed to address over-pumping.

Question: 20 thousand acre-feet (TAF) must be cut back, but how can that happen if we keep declining groundwater levels?

Answer: There will be a transition period between now and 2040, during this time there may be further lowering of groundwater levels, but the overall intent of the plan is to get the basin in balance by 2040 and beyond. Beyond 2040, inputs have to match the outputs.

Question: Groundwater levels must flatten completely to be sustainable; is that rationale correct?

Answer: Sustainability boils down to two things: inputs must match outputs, and undesirable results must be avoided. The inputs must match the outputs on a long-term average, not each year, so there may still be fluctuations in groundwater levels.

Topic 2 – Numerical Model Update and Initial Water Budgets

Question: What direction does groundwater flow?

Answer: Like surface water, groundwater movement in an unconfined aquifer is dictated by gravity – it flows downhill. Groundwater flows from areas of higher hydraulic head to areas of lower hydraulic head. In the Cuyama Basin, that is generally from the south to the north, and from the east to the west.

Question: How much water is an acre-foot?

Answer: An acre-foot of water is 43,560 cubic feet, or to 325,851 U.S. gallons, enough water to cover a football field with a foot of water.

Question: How does the model calculate deep percolation?

Answer: The model calculates deep percolation as the potential quantity of recharge to an aquifer. Recharge is the amount of water leaving the active root zone (deep percolation). Recharge is derived from precipitation, irrigation, evapotranspiration, and soil hydraulic properties.

Question: How does the water budget change in different parts of the Cuyama Basin?

Answer: The water budget is developed for the entire Cuyama Basin.

Question: What is the total groundwater depletion in the Cuyama Basin over the past 20 years?

Answer: Since 1995, the total decline in basin storage is approximately 400,000 acre-feet.

Question: Was the age of the wells recorded?

Answer: The monitoring well data that was collected had a wide variation in its level of detail. Some wells had an installation date, and some did not.

Question: How does the plugging of well screens affect groundwater level readings?

Answer: If monitoring well screens are plugged, it is less likely that measurements in the well will represent conditions near the well.

Question: Is the model developed enough to depict the size of storage or what is left in storage?

Answer: The total amount of storage in the basin is unknown because there is uncertainty about the depth of the groundwater basin throughout the whole area.

Question: How does the model calculate evapotranspiration?

Answer: The model calculates the evapotranspiration based on the data provided by the Irrigation Training & Research Center at Cal Poly San Luis Obispo.

Question: How much water is nature using?

Answer: Native vegetation consumptive use is approximately 182,000 acre-feet per year out of a basin-wide total of about 223,000 acre-feet.

Question: How much water is left after native plants and agriculture?

Answer: Deep percolation to the groundwater is approximately 32,000 acre-feet per year and 11,000 acre-feet per year is runoff.

Question: Have you forecasted full groundwater depletion?

Answer: No. The GSP is looking at how to get the basin back in balance, not how long it would take to use all the water in the basin.

Question: What about groundwater dependent ecosystems, are they taken into account in the model?

Answer: Groundwater dependent ecosystems are not represented directly in the model; instead their water consumption is lumped in with other native vegetation.

Question: What influences the groundwater ranges?

Answer: Location, geologic conditions, topography, precipitation, and several other factors.

Question: What about groundwater quality, is that addressed in the GSP?

Answer: Salinity is included in the GSP.

Question: Is climate change included in the model?

Answer: There will be projected hydrologic conditions under a climate change scenario provided by DWR.

Question: What does "reconstructed stream flows" mean? Isn't it an estimate?

Answer: Streamflows leaving the Cuyama Basin are estimated using the reconstructed historical precipitation data.

Question: When looking at earlier studies conducted in the Cuyama Basin, how do they compare with the model and the resulting water budgets?

Answer: The results are not directly comparable because no previous model covered the entire Cuyama Basin.

Question: If the model can calculate storage loss, how much is left, how close to empty are we?

Answer: The total amount of water stored in the basin is unknown due to uncertainties in the depth of the basin. The GSP is looking at how to get the basin back in balance, not how long it would take to use all the water in the basin.

Question: What science can show what happens to deep percolation when the vadose zone is 500 feet of empty, de-watered dry zone above the groundwater level but below the land use? Where in California has this ever been studied? What procedure can predict this? What certainty exists as to whether the deep percolation ever makes it back down to usable groundwater?

Answer: The lowering of groundwater levels at very high rates has a significant impact on the recharge of deeper aquifers when a thick clay layer exists. As a result of lower pressures, the pore space between the clay particles get smaller and slow the vertical flow. Without such thick clay layers, the most significant impact is the delay in time for the recharge occurrence to reach saturated groundwater level rather than the volume.

Community Workshops March 6, 2019

Two community workshops, one in English and one in Spanish, were held on March 6, 2019, in New Cuyama, CA. Questions received, and the responses provided are grouped below by workshop topic.

Topic 1 – SGMA Background and GSP Development Overview

There were no questions.

Topic 2 – Cuyama Basin Water Budget

Question: What is the sustainable yield of the Cuyama Basin?

Answer: Total sustainable yield in the Basin is about 21 thousand-acre-feet (taf)

Question: The concept of regions is confusing because the conceptual model is detailed while the defined regions are fairly blocky. How defined will be boundaries of these regions be?

Answer: The CBGSA previously approved regions to be used for developing groundwater level thresholds; however, these regions will not be used as Management Areas. As determined by the CBGSA Board, management area boundaries will be estimated using numerical modeling results.

Question: Is the Ventucopa Management Area set in the town? What is the Ventucopa Area?

Answer: On March 6, 2019, the Board approved using preliminary Management Areas defined by groundwater level changes estimated by the Cuyama Basin numerical model of greater than 2 feet per year.

Question: When will the model runs that include Climate Change be available?

Answer: Modeling results that incorporate climate change will be shown at the April CBGSA Board meeting.

Question: Is climate change included in the model?

Answer: Not yet, but the model will be run with climate change assumptions provided by DWR.

Question: Why is the word "draft" on a number of the slides?

Answer: The analysis is not quite completed so the word draft was added where appropriate.

Question: What is the "Woodward & Curran technical team"?

Answer: This is the consultant team developing the GSP for the Cuyama Basin under contract with the CBGSA.

Question: In New Cuyama, how far down is the water?

Answer: The well is about 800 feet deep and the groundwater level is around 200 feet deep.

Question: Will the water quality improve if the aquifer is recharged?

Answer: We don't know.

Topic 3 – Projects and Management Actions

Question: The pumping reduction numbers seem high? I am not convinced by the pumping reductions-only scenario. There are roughly 16,000 irrigated acres, 3 feet = 8,000 acres. Half of those taken out = balanced.

Answer: The projected pumping reductions needed to reach sustainability reflect the best estimate of the numerical model given the current available information. The model is not perfect as there are data gaps. It should be noted that the required pumping reduction will be greater than the projected overdraft. Need to take into consideration the reduction from deep percolation.

Question: Will taking crops out of production (fallowing land) be a primary tool to become sustainable?

Answer: Yes.

Question: If the Department of Water Resources (DWR) will take 2 years to review the GSP, what happens in those 2 years?

Answer: The assumption is that the Cuyama Basin GSP will be implemented on the schedule submitted with the GSP. The DWR will have to review annual reports as well.

Question: Who is paying to implement projects?

Answer: The CBGSA Board will have to determine this and the funding strategy is likely to be reflective of a philosophy that the costs should be paid by the beneficiaries.

Question: Has cloud seeding been tried over the Cuyama Basin?

Answer: No, but it has been used in Santa Barbara County and other locations.

Question: Is there a risk of toxicity for fruits and nuts that are being grown?

Answer: There is no significant toxic effects as measured thus far.

Question: What is the history of cloud seeding? How long has this technique been used and monitored for toxicity? Has toxicity been measured?

Answer: Cloud seeding has been performed over many decades in many watersheds across California. For example, cloud seeding has been utilized in the Kern River area for over 30 years. These other basins have not experienced major issues with toxicity.

Question: How to test effectiveness (of cloud seeding)?

Answer: Once cloud seeding is implemented, it is difficult to estimate exactly how much additional precipitation results because there is no opportunity to test with and without conditions for the same year.

Question: Someone did a master's thesis on Cottonwood Canyon runoff potential. Did Woodward & Curran use information from canyons that run when there is over 1 inch of rain?

Answer: The model simulates water flows from the canyons. The Woodward and Curran team would be glad to look at the person's master's thesis.

Question: Do cost estimates include annual costs?

Answer: The cost estimates include both implementation and annual costs.

Question: Since the Central Region is so overdrafted, would those in the Central Region pay for potential projects?

Answer: Most likely project costs would be paid by those landowners who derive the greatest benefit.

Question: Silting has shutdown projects in Ventucopa, could this be a big issue here?

Answer: Yes.

Question: Have you considered streambed restoration to slow water? Sounds like the natural function of a stream is being described.

Answer: There is a component of natural recharge, but the concept of stormwater capture is to divert water than would otherwise be lost downstream due to high flows in the river.

Question: Can you increase seepage in the river bottom?

Answer: This would need to be studied to assess the benefits and whether there would be any negative environmental impacts.

Questions: Do you have to do projects?

Answer: SGMA requires that sustainability be reached, and projects can help bring the Cuyama Basin into balance by 2040. You don't have to do projects, but it is prudent because every acre of farming that you lose has an economic impact associated with it.

Question: If pumping increases outside of the Central Region and Ventucopa Area, could more management areas be created?

Answer: Yes.

Question: Currently, there is not much requirement to measure your water use, with the GSP will there be required metering?

Answer: Not for those with private wells using less than 2 acre-feet per year, but metering may be required in other locations—the exact mechanism for tracking water use still needs to be determined by the CBGSA Board.

Question: Why are the groundwater conditions in the Central region and the Ventucopa area so different.

Answer: The Central Region has more pumping and the Ventucopa area has more recharge; additionally, wells in Ventucopa are much shallower than those in the Central region.

Question: How will the new community wells be paid for?

Answer: We hope to get grant funds.

Question: With cloud seeding, how do you measure for toxicity?

Answer: Toxicity has not been a problem in other areas using cloud seeding.

Question: If the projects proposed do not work, then what happens?

Answer: Pumping would have to be further reduced.

Question: Which is implemented first, is it projects followed by pumping reductions?

Answer: Pumping reductions would be implemented first followed by projects.

Question: Is there information on every well in the Cuyama Basin? If not, why not?

Answer: No. Not every well was added to the State's database.

Question: How soon will monitoring start, is there a deadline for when it must begin?

Answer: There is not a specific schedule. Developing the detailed monitoring network and monitoring plan will be part of the initial work to be done.

Question: The Cuyama Community Services District (CCSD) well is not impacting the Cuyama Basin like agricultural pumping is, right?

Answer: Correct.

Topic 4 – GSP Implementation Plan

Question: Do less aggressive pumping reductions mean lower levels of groundwater?

Answer: Yes, less aggressive pumping reductions would result in lower groundwater levels initially; however, the CBGSA will need to bring levels above the minimum thresholds approved by the CBGSA Board by 2040.

Question: Are the monitoring wells new wells or converted ag production wells?

Answer: Both.

Question: What is an assessment?

Answer: SGMA gives GSA's the authority to implement assessments which will likely be property assessments based on acreage, or they could be based on something else. The CBGSA Board of Directors will decide the strategy. An assessment that includes pumping is a likely component of any future assessment.

Question: How are the socio-economic impacts being evaluated? With pumping reductions by the large ag growers, looking at the socio-economic impacts is crucial.

Answer: An economic assessment will be performed prior to any project or pumping allocation implementation.

Question: Can the CBGSA staff talk to the large employers in the Cuyama Basin and ask them to encourage their employees to be involved as this process continues to go forward over the coming years? The employees don't seem to know about what is needed to achieve sustainability in the Cuyama Basin. The employers and employees need to be encouraged to talk about what is coming.

Answer: The GSA has an active outreach process that is designed to try to include as many local residents in the process as possible.

Written Comments Received at March 6 Workshops

- It seems that an aggressive implementation of pumping reductions would be best for keeping the native ecological balance in the riparian areas with the least loss of the rich natural areas that provide quality of life for the inhabitants of the region.
- The pumping reductions might mean financial loss for some, but most of the financial gain from the use of the valley's water does not stay in the valley to provide benefits for the local population, but rather it goes to communities outside of the valley.
- Can a program to educate/provide more efficient irrigation systems like improved water delivery equipment or means to reduce evaporation be developed?
- Is there a way to use a little less technical language and simplify things by using more general terms with more diagrams? Some of the text slides need simplification.

Comments Made Directly to the CBGSA

The following letter was received by the CBGSA via email on March 3, 2019, and is quoted below.

OPEN LETTER TO CBGSA

If any entity was to craft a responsible long term business plan which relied on one key input or commodity naturally present but limited, in the region of operation, common sense would stress the *fact*, if the key commodity, commonly called a resource, was limited and would maintain it at the highest possible level to insure a viable business. If responsibly envisioned, this would require, among other things, taking into account patterns and trends regarding the limitation, continual degradation, and increased extraction expense of that input. It would make less sense to argue over the fine points of the remaining commodity and one's allotment within a narrow speculative margin than to plan and do everything possible to use with greatest efficiency and to augment through whatever means possible that key commodity. One must ask, to be blunt, what are the real objectives and contradictions behind CBGSP word play, and actual resource conservation and business as usual?

In the present example, there is a consortium of interests (Cuyama Basin Water District) determined to implement a probable short-to-medium-range plan that prefers to maximize output (capital) at the expense of adequate or perhaps even minimum maintenance of the commodity. This is at odds with the stated purpose of the GSP. This convoluted approach is justified by a perception of a-right-by-law of the dominant users, without acknowledgement of any responsibility to maintain the commodity and the fact that the depletion of it has had considerable adverse impacts on the region's character and potential long term availability for other users.

The science of and historical concern with the issue of water extraction in the Cuyama Valley Basin point to ongoing degradation by agricultural industry on a scale beyond the available water commodity in this basin. The patterns of verifiable depletion were just beginning to be noted in the 1951 USGS study. The basin had been essentially in equilibrium until 1946, a date that coincided with the arrival of electricity to the valley. By 1970, USGS reported that the estimated cumulative dewatering was in the range of 400,000 acre feet for the Basin.

The County of Santa Barbara's own studies at ten year intervals indicated by 1987 the total annual water demand in the basin was between 48,882 and 48,982 acre feet. Beyond a number of recommendations for grower conservation and a tax incentive proposal that never materialized, nothing more was done by agency action and the can was kicked further down the road. By the inception of the most recent USGS study in 2008, the county's water agency, taking all previous reports as more or less accurate, determined that the basin had already irrecoverably lost an estimated 1,500,000 acre feet in addition to the ongoing overdraft per year.

Pumping cost has motivated increased irrigation efficiency and production of less demanding crops since the late 1980's, and diminished the annual deficit to the 30,000 range that is currently being debated as the Groundwater "Sustainability" Plan is being formed. Still, and most importantly, every partisan in this issue does acknowledge a significant annual water deficit, yet among the consortium of major extractors there is no intention to diminish pumping to a level that would stabilize the water commodity in the basin. Instead the intention appears to be to drag out the maximum possible output (pursuing maximum capital return on basically "free" water). Thus the real preferred plan and expectation is to misrepresent the situation as much as the current legislation allows. This, at least in theory, is poor business practice from any perspective. In the short term, the major extractor beneficiaries seek to avoid full responsibility and continue production to the fullest possible extent while the irreversible desertification of the valley continues.

This myopic misuse of the groundwater of California is what SGMA intends to counter. Each of the groundwater basins in the State has unique conditions that require real and forthright solutions. In the Cuyama Basin, the excessive extraction of a sole source commodity is particularly irresponsible and damaging to the individuals and communities that call the valley's basin their home, to the future generations who will have to live with less of that much-needed commodity, and to the grace and modest bounty of a natural landscape that has already suffered irreparable damage from agriculture. It is long past time for a groundwater recovery plan that runs counter to the normal business bottom line, and takes an honest look at a bigger reality.

Most Sincerely,

John Mackenzie

Former Vice-Chairman CCSD

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Attachment D-1

Pre-Public Draft
Comments and Responses

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Cuyama Basin Description of Plan Area - April Draft
Summary of Comments and Responses
June 22, 2018

Comment #	Section	Section Paragraph #	Paragraph's Sentence #	Sentence Starts with, "...	Comment	Proposed Response
1	1.1	2	1	This document will...	Comment: Would imagine this sentence isn't necessary in the final GSP?	This is correct, the sentence will be removed from final GSP
2	1.3	1	3	The Basin also encompasses...	Comment: Since referencing the creeks, it would be helpful to label creeks like Fig 1-14	Creek labels will be added to Figure 1-1
3	1.3	3	4	The San Joaquin Valley Basin...	Comment: Figure spells 'Potero'	Spelling will be corrected in the Figure
4	1.3	5	1	Figure 1-5 shows...	Comment: Why is [Figure 1-5] this map at a differentn scale than the others?	The scale of Figure 1-5 will be modified to show full basin.
5	1.3	5	1	The CBWD covers...	Insert: "...west of Wells Creek to # miles east of the intersection of...."	Comment accepted.
6	1.3	6	1	Figure 1-6 and 1-7...	Comment "Figure 1-6": If data in this figure is all from the Counties, why say DWR land survey?	The figure depicts land use resulting from surveys performed by DWR
7	1.3	6	1	Figure 1-6 and 1-7...	Comment "... 2014...": How is the Grapevine Capital land use going to be included in this effort?	These figures depict historical land use from before the Grapevine Capital development. For modeling purposes, assumptions about current and future land use will include the Grapevine Capital development as well as other recent changes in land use.
8	1.3	6	---	Crops are generally...	Text Edits ". Crops are generally rotated regularly, and some agricultural area is idle. ~~, but a~~Areas that are in active agricultural use produce are primarily miscellaneous truck crops, carrots, potatoes and sweet potatoes, miscellaneous grains and hay, and grapes. Various other crop types are produced in the Basin as well, such as fruit and nut trees, though at smaller production scales.	Comment accepted.
9	1.3	7	4	Much of the surface water...	Comment "figure.": Color scheme between the legend and map appear to be different. Some irrigated lands appear to not have a water use	The current background map shows land uses that were not present in 2014. The background map will be replaced to avoid color confusion.
10	1.3	8	1	Figure 1-9...	Comment "average depth": Would median be a better indicator per square mile?	DWR provides average values, and average is the common statistical representation of groundwater depths
11	1.3	9	1	Figure 1-10...	Comment "10": Is there potential for this figure to change if more data comes in by 5/31? Legend in figure still says 'Domestic' instead of Production	Applicable data provided on or before 5/31/2018 will be incorporated, if possible, in to the groundwater model. However, this data may not be incorporated into this Plan Area figure. The figure's legend will be updated to say "Domestic" in place of "Production".
12	1.3	9	1	Figure 1-10...	Comment "density": Suggest using a different color spectrum, i.e. 'cool to hot' as the density goes up	Comment accepted.
13	1.3	9	1	Figure 1-10...	Comment "average depth": Would median be a better metric?	DWR provides average values, and average is the common statistical representation of groundwater depths
14	1.3	10	2	The Basin contains...	Comment "three": Really only 3? CCSD only has 1 well?	The information represented in Figure 1-11 is what is included in DWR's well completion report database, which contains information on the majority of wells drilled after 1947. However, some wells may not have been reported to DWR (potentially up to 30%), and therefore are not included in the database or this summary.
15	1.3	11	3	The Los Padres National...	Insert: "... then runs outside the Basin's western and southern boundary...	Comment accepted
16	1.3	12	1	Figure 1-13...	Comment "13": Why is Santa Maria watershed more prominent than Cuyama?	The Figure will be modified to make the Cuyama watershed more prominent.
17	1.3	12	1	Figure 1-13...	Comment "part of the Cuyama Basin's northeastern arm located in the Estrella River Basin.": Should add some discussion/explanation why Cuyama Basin doesn't receive water from watersheds on the west side	A sentence will be added to the paragraph that explains why this area does not flow into the Cuyama Basin.
18	1.3	12	3	The figure also identifies...	Comment "... figure also identifies the various other groundwater basins...": Seval of these aren't shown in the map	This sentence will be removed as this figure is not intended to show groundwater basins.
19	1.4	1	4	The USGS has two active...	Comment "deactivated gages": Discuss history coverage of deactivated gages	The text will be modified to discuss the deactivated USGS gages
20	1.4	2	4	and another gage...	Comment "and another gage downstream of the watershed but above Twitchell reservoir on the Cuyama River.": What?	This sentence will be revised for clarity
21	1.5	1	2	Existing groundwater monitoring...	Comment "Existing groundwater monitoring programs in the Basin collect data on groundwater elevation, groundwater quality and subsidence at varying temporal frequencies": Should have a figure(s) to help with the discussion in this section and following sub-sections. Figures may also help identify data gaps	Figures depicting existing groundwater monitoring wells will be included in the Monitoring Network section of the GSP.
22	1.5.1	8	5	Full construction information...	Comment "Full construction information is not available for voluntary wells because SBCWA does not have permission to release available construction information.": Is this still valid? Thought there were on-going conversations on these.	W&C will follow up with Matt Young of Santa Barbara County to verify this information
23	1.5.1	8	6	This known data gap...	Comment "Monitoring Plan": SBCWA's monitorng plan?	This discussion of data gaps will be removed from this section of the GSP and added to the Monitoring Network section of the GSP
24	1.5.1	8	bullets	Spatial gaps...	Comment "• Spatial gaps in the northwestern and southeastern areas of the Santa Barbara County portion of the Basin. • Data gaps in the area north of Highway 166 and in the center of the Basin between Bell and Kirschenmann Roads. ": Figures would be helpful	This discussion of data gaps will be removed from this section of the GSP and added to the Monitoring Network section of the GSP
25	1.5.1	9	bullet	Horizontal spatial gap...	Comment "at least one well per 10 square miles": Should focus on this more and or earlier. Could help develop gaps and projects for monitoring wells going forward	This discussion of data gaps will be removed from this section of the GSP and added to the Monitoring Network section of the GSP
26	1.5.2	0	heading		Comment on heading 1.5.2: Figures showing the temporal and spatial availability of the data would help facilitate discussion and also highlight the gaps and needs moving forward	A figure showing this information will be inlcuded in the Monitoring Network section of the GSP

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27	1.5.2	5	3	In the Cuyama basin…	Comment ", six DDW": Are these not public? That would be more than three portrayed earlier	W&C will review the information and determine if any of these wells need to be categorized as public wells
28	1.5.3	1	2	There are no known…	Comment "no known extensometers": Are these different than the stations mentioned in the following paragraph?	Yes, all current subsidence monitoring stations within the basin use GPS.
29	1.5.7	0	heading		Comment on heading 1.7: Recommend discussing in same order from section to section. Previous section went SB, SLO, Ventura, Kern. This section goes Kern, SLO, SB, Ventura.	The order of the subsections in 1.7 will be reordered and corrected
30	1.8	1	bullet (g)	Well Construction policies	Comment: Will this cover how well permits are granted or denied for new or replacement wells going forward?	No, this section of the GSP documents current well permitting programs. Potential changes to these programs could be considered in the Project and Management Actions section of the GSP.
31	1.9	0	heading		Comment on heading: Are these all cited in text?	Yes
32	1.3	3	4	To the southwest…	Comment "To the southwest, and more distant from the Cuyama Basin, are the Santa Maria, San Antonio Creek Valley and Santa Ynez River Valley Basins, which are located about 10 to 15 miles southwest of the Cuyama Basin.": The distance to these other basins is not accurate. San Antonio Creek is at least 35 miles away as the crow flies, and much futher by highway. The Santa Ynez basin is even further.	Text will be modified for clarity
33	1.3	6	1	Figure 1-6 and 1-7…	Comment on whole paragraph: - These maps do not show range land which dominate the western area of the valley and should be included as an agricultural land use. - Recent agricultural land development is not included which are significant increases in relation to groundwater use in the Basin: specifically the 870 acres of vineyard planted in the western portion of the Basin; and the intensive olive cropping along Hwy 33 are not included. If the map cannot be updated to 2016, then these additions/changes should at least be mentioned in the narrative. - Potatoes and sweet potatoes are not grown at any scale any longer, making it pretty clear that the crop types the report refers to are based on old data. Hay, which is a rain-fed crop, is hardly farmed anymore. However, alfalfa, which is an intensively irrigated crop, and was a cause of the early overdrafting, is still grown along Highway 33. A drive across the Valley today shows large plantings of beets, broccoli, garlic and salad greens, along with carrots.	Land use for additional years, including 2016, is currently being processed and will be shown in the next revision of the Plan Area document. These land use datasets only show irrigated agricultural lands and therefore do not include non-irrigated range and pasture land. However, water use from these other land areas will be accounted for in the numerical model and water budget as part of the GSP.
34	1.3	11	3	The Los Padres National…	Comment "The Los Padres National Forest covers most of the Basin's northwestern arm, then runs outside the Basin's western boundary, where it enters the Basin again and covers most of the Basin east of Ventucopa": Los Padres National Forest also is the boudanry and part of the watershed for the entire southern component of the Basin. A watershed focus should be used since these arms, even though they are located outside the physical basin itself, are feeder streams into the basin.	Comment noted. Figure 1-13 shows the portions of the Los Padres National Forest that run off into the Cuyama Basin.
35	1.4	1-2	3	The Only CDEC gages…	Comment "The only CDEC gages in the Cuyama River watershed are at Lake Twitchell which is downstream of the Cuyama Basin. The USGS has two active gages that capture flows in the Cuyama River watershed upstream of Lake Twitchell… Although neither of these stream gages is located within the Cuyama Basin, they can be used to monitor the inflow and outflow of surface water through the Basin.": The gages located near Twitchell Reservoir are only partially fed by stream flow from the upper basin. Multiple tributaries flow into the Cuyama River to the west of the Basin. Some of these streams include: Miranda Pines Creek, Alamo Creek, and many other smaller creeks. A drive along Highway 166 from the western end of the Basin at Rock Creek to Twitchell Reservoir shows multiple cases of creeks or washes with riparian vegetation (Sycamore, Cottonwood, Willows, etc.) leading into the Cuyama River, all indications of significant groundwater movement. Thus, we question how accurate a reading these gages would provide for stream flow exiting the Cuyama Basin as defined by Bulletin 118.	Comment noted. Figure 1-14 shows the portion of the watershed upstream of Twitchell Reservoir that flows into the Cuyama River within and downstream of the Cuyama Groundwater Basin, as well as the location of gage 1136800. As part of developing the water budget, W&C will estimate the portion of the gage 1136800 flow that originated from the Cuyama Basin area.
36	General Comment				Comment: Is this the section where past studies of groundwater in the Cuyama Basin would be mentioned? If so, we recommend including this summary chart of past studies prepared by Dennis Gibbs, Yulalona Hydrology, as part of a report for Santa Barbara Pistachio Company, December 7, 2017. We feel that the Plan Description should more clearly summarize the historic overdraft of the groundwater in the Basin that has been documented for many decades. This really should be the starting point for any future management plan. (summary chart below)	These will be discussed in the Water Budget section of the GSP

Summary of all modern Hydrologic Analyses of the Cuyama Groundwater Basin

Year	Agency	Overdraft*	Method
2014	USGS-SBCWA	34,500 AF/y	Finite Difference Model
2009	UCSB Bren School	30,500 AF/y	Mass Balance
1998	CDWR	14,600 AF/y	Specific Yield
1992	SBCWA	28,000 AF/y	Mass Balance
1988	CRCD	30,300 AF/y	Mass Balance
1977	SBCWA	38,000 AF/y	Mass Balance
1970	USGS	21,000 AF/y	Mass Balance
1951	USGS	"Steady State"	Observations

*terminology; overdraft has been replaced with "usage greater than replenishment"

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37	General Comment				Comment: We also question if oil wells and pumping have been examined in terms of potential water use. It is known that water must be injected into some oils wells to aid in the oil extraction process. Is there any of this going on, have water wells been drilled to supply this water, and if so, how much water is being used?	This will be addressed in the Water Budget section of the GSP. No information has been provided for the water use for oil production.
38	General Comment				Comment: We also believe that the report should include a list of all the new water wells that have been drilled and put into operation in the Basin since the passage of SGMA, including where they are, how much water they can pump, and for what crops they will be used. A lot of water development and water use changes have occurred in the Basin in the past 3-4 years.	Recently installed groundwater wells will be included in the well database developed for the GSP if information is provided for them. However, these will not be identified separately.
39	1.2	1	2	It is beneath the Cuyama...	Comment "It is beneath the Cuyama Valley, which is bounded by the Caliente Range to the northwest and the Sierra Madre Mountains to the southeast": these 2 ranges should be shown on the figure.	Labels for these ranges will be added to Figure 1-1.
40	1.3	1	4	The Basin also encompasses...	Comment "Wells Creek": not labeled on figure	Creek labels will be added to Figure 1-1
41	1.3	1	4	The Basin also encompasses...	Comment "Quatal Canyon drainage": not labeled on figure	Creek labels will be added to Figure 1-1
42	1.3	1	4	The Basin also encompasses...	Comment "Cuyama Creek": not labeled on figure	Creek labels will be added to Figure 1-1
43	1.3	2	1	Figure 1-2...	Comment "CBGSA": not mentioned in legend	The legend will be updated to note the CBGSA boundary
44	1.3	4	7	Its jurisdictional coverage...	Edits "Ventura County ~~encompasses~~ has jurisdiction over the southeastern area of the Basin (covering 120 square miles), including the area east of Ventucopa."	Comment accepted
45	1.3	6	3	Crops are generally...	Edits "~~Crops are generally generally~~ there is regular rotation of crops~~ rotated regularly, and~~with some agricultural area ~~is~~ left idle~~, but~~. ~~areas~~ Areas that are in active agricultural use produce primarily miscellaneous truck crops, carrots, potatoes and sweet potatoes, miscellaneous grains and hay, and grapes. Various other crop types are produced in the Basin as well, though at smaller production scales.	Comment accepted
46	1.3	10	Figure 1-10		Comment on Figure: Legend has Township & Range with Domestic Wells but figure is production wells density	The legend will be updated to say "Domestic" in place of "Production"
47	1.3	10	1	Figure 1-10...	Comment: define production well	Definition will be added to the text for "Production", "Domestic" and "Public" wells
48	1.3	11	Figure 1-11		Comment on Figure: Legend has Township & Range with Domestic Wells but figure is production wells density	The legend will be updated to say "Domestic" in place of "Public"
49	1.3	11	2	The Basin contains...	Comment: Which well is this? Our database does not show a municpal well in Cuyama Basin	DWR's well completion database shows a public well at this location. Initial research suggests that this well is located at a fire station, but this has not been confirmed.
50	1.3	12	3	The Los Padres National...	Edits: The Los Padres National Forest covers most of the Basin's northwestern arm, then runs just outside the Basin's western boundary~~, where it enters the Basin again and covers most of the Basin~~ until the Forest boundary turns east at about~~east of~~ Ventucopa where it covers the southern part of the basin. A portion of the Basin north of Ventucopa, as well as an area nearby that is immediately outside the Basin, is designated as the Bitter Creek National Wildlife Refuge. The Bureau of Land Management (BLM) has jurisdiction over a large area ~~that runs~~ outside the Basin, and along the Basin's northern boundary~~, and covers~~including small parts of the Basin north of the Cuyama River. Most of the northeastern arm of the Basin is designated as State Lands.	Comment accepted
51	1.3	13	1	Figure 1-13...	Comment on figure: Where is the Cuyama Watershed on the figure? Needs to be more obvious. It would also be helpful if the areas of different colors were included in the legend	The Figure will be modified to make the Cuyama watershed more prominent.
52	1.3	13	after 2		Comment on last comment/insertion: Figure would be more helpful if it did not include all the extra basins. Also, are they basins or watersheds. Ventura is labeled at the bottom but that's not the county boundary or the Cuyama basin boundary)	This sentence will be removed as this figure is not intended to show groundwater basins.
53	1.4	1	1	Existing groundwater monitoring...	Edits: "Existing surface water monitoring in the Cuyama Basin is extremely limited. ~~Existing s~~Surface water monitoring in the basin is limited to DWR's California Data Exchange Center (CDEC) program, and monitoring performed by the United States Geological Survey (USGS). The only CDEC gage~~s~~ in the Cuyama River watershed ~~are~~ is at Lake Twitchell which is downstream of the Cuyama Basin . The USGS has two active gages that capture flows in the Cuyama River watershed upstream of Lake Twitchell, as well as four deactivated gages (Figure 1-14). "	Comment accepted
54	1.4	1			Comment on Figure showing Twitchell: Not clear where this is on the map	A label will be added for Twitchell Reservoir on Figure 1-14
55	1.4	1			Comment on Figure 1-14: Are the gages that are labeled on the figure only the USGS gages? What is the area with the diagonal lines?	Yes, the figure only shows USGS gages. There are no other surface flow gages within the basin. As described in the legend, the hatched area shows the portion of the Cuyama River Watershed that contributes to the Cuyama River downstream of the Cuyama Valley Groundwater Basin

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56	1.4	2			Edits: "The two active gages include one gage on the Cuyama River downstream of the Basin (ID #11136800), which is located just upstream of Lake Twitchell. This gage has 58 years ~~recorded years~~ of recorded streamflow measurements from 1959 to 2017. The other active gage is south of the city of Ventucopa along Santa Barbara Canyon Creek (ID #11136600) and has seven ~~recorded~~ years of recorded streamflow measurements ranging from 2010 to 2017. and another gage downstream of the watershed but above Twitchell reservoir on the Cuyama River. Although neither of these stream gages is located within the Cuyama Basin, they can be used to monitor the inflow and outflow of surface water through the Basin.	Comments accepted
57	1.4	2			Comment "The two active gages...": USGS?	Yes, the document will be clarified to be clear that these are USGS gages
58	1.4	2			Comment "The other active gage is south of the city of Ventucopa...": town not labeled on map. Also Ventucopa has been called a community, a town and not a city in this report	A label will be added for Ventucopa to Figure 1-14. The document will be update to consistently refer to Ventucopa as a "town"
59	1.4	2			Comment "and another gage downstream of the watershed but above Twitchell reservoir on the Cuyama River.": ???	Text will be modified for clarity
60	1.5.1	1	2	Data is submitted...	Comment: What is SBCWA?	SBCWA was previously spelled out in Section 1.3
61	1.5.1	3	4	Wells were montiored...	Edits "~~Wells were monitored in 2017, with most~~ Most of the wells that were monitored in ~~being~~ 2017 have been monitored since 2008, although a few have measurements dating back to 1983.	Comment accepted
62	1.5.1	7	6	Full Construction information...	Comment: construction information is no longer confidential	W&C will follow up with Matt Young of Santa Barbara County to verify this information
63	1.7			Addition, last paragraph of 1.7	Insertion "**Ventura County Plan's Update** The County of Ventura is working on a comprehensive update to its General Plan for the first time in almost 30 years. The County's current General Plan expires in 2020 and it has not been comprehensively updated since 1988. Since that time, there have been many important changes to state law that dictate what issues must be included in a general plan. As a part of the General Plan Update, the existing elements may be reorganized and the County will develop three additional elements to address issues related to agriculture, economic development, and water. The General Plan Update will also incorporate the topics of health and climate change. "	Insertion accepted
64				Figure 1-11	Comment: Figure 1-11 shows public wells with a public well at the south end of the basin. We don't have a municipal well in Cuyama Basin in our database.	DWR's well completion database shows a public well at this location. Initial research suggests that this well is located at a fire station, but this has not been confirmed.
65					Comment: • The two wells that are being reported to the CASGEM program are not the two described in section 1.5.1 Groundwater Elevation Monitoring, Ventura County Watershed Protection District CASGEM Monitoring Plan (page 20). The well Ventura reports are: o 07N24W13C03S has been monitored since at least April 1989, and we have a well completion report on it so we do have construction information. o 07N23W16R01S has been monitored since at least March 1972. We do not have a well completion report so no well construction information. Our database has the well depth as 73 feet but I don't know where the information came from. Casing diameter is 10 inches.	This section will be reviewed and clarified
66					Comment: There is not map that shows the wells they are using for water elevation or water quality data.	This information will be provided in the Monitoring Network section of the GSP
67					Comment on Figure 1-12, Fed and state lands: The state lands in the n/w should be labeled "Carrizo plain ecological reserve" as the wildlife sustainability issues will be important.	Carrizo Plains Ecological Reserve will be added to Figure 1-12 where the map label "State Lands" is currently located
68	1.6.2				Comment: The San Luis Obispo 2014 IRWM Plan presents a comprehensive water resources management approach to managing the region's water resources, focusing on strategies to improve the sustainability of current and future needs of San Luis Obispo County (County of San Luis Obispo, 2014), see note below. • Note that the IRWM Plan was heavily based on the 2012 Master Water Report -- https://slocountywater.org/site/Frequent%20Downloads/Master%20Water%20Plan/	A sentence will be added to Section 1.6.2 to note that the IRWM Plan Update was based on the 2012 Master Water Report.
69	1.2				Comment: Add labels on figure for Caliente Range and Sierra Madre Mountains	Labels for these ranges will ba added to Figure 1-1.
70	1.3				Comment: combine Figure 1-1 and 1-2?	Creek labels will be added to Figure 1-1
71	1.3				Label Wells Creek, Santa Barbara Creek, Quatal Canyon, and Cuyama Creek on Figure 1-1	Creek labels will be added to Figure 1-1
72	1.3	2	3	The CBGSA was created..	Edit: Remove "E" from "JEPA"	W&C will confirm the correct acryonym.

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73	1.3				Comment on Figure 1-2: Figure 1-4 shows County Boundaries? Figure 1-2 Not Needed Combined w/ Figure 1-1.	The Figures have been organized to clearly show compliance with SGMA requirements and therefore, the contents and numbering of each figure will not change.
74	1.3	3		Figure 1-3 shows...	Comment on entire paragraph: P. 3 coss draft 2018 SGMA Prioritization. High Priority	Figure 1-3 will be updated to reflect the new prioritization of the Cuyama Valley Groundwater Basin
75	1.3	4			Comment on Figure 1-4: Move to Figure 1-2A	The Figures have been organized to clearly show compliance with SGMA requirements and therefore, the contents and numbering of each figure will not change.
76	1.3	5			Comment on Figure 1-5: Figure 1-2b	The Figures have been organized to clearly show compliance with SGMA requirements and therefore, the contents and numbering of each figure will not change.
77	1.3	6			Comment on Figure 1-6 and 1-7: Show all Ag? Cattle Grazing, pastures, and federal and state land. From Landuse. New Figure?	These land use datasets only show irrigated agricultural lands and therefore do not include non-irrigated range and pasture land. However, water use from these other land areas will be accounted for in the numerical model and water budget as part of the GSP. Federal and State Lands are shown in Figure 1-12.
78	1.3	7		Figure 1-8 shows...	Comment on whole paragraph: Capture all ag? Any diminimis users?	These land use datasets only show irrigated agricultural lands and therefore do not include non-irrigated range and pasture land. However, water use from these other land areas will be accounted for in the numerical model and water budget as part of the GSP.
79	1.3	7		Figure 1-8 shows...	Comment "Pastureland, which may not be...": Can you add this infor? New figure?	These land use datasets only show irrigated agricultural lands and therefore do not include non-irrigated range and pasture land. However, water use from these other land areas will be accounted for in the numerical model and water budget as part of the GSP.
80	1.3	8		The number in each...	Comment at end of paragraph": Add table QAQC discuss. This data is the Figure 13 head to follow	A table is not necessary to represent this information
81	1.3	between 8 and 9			Comment: Geology and well screen level?	Geology information will be provided in the HCM section of the GSP. Screen interval data is not widely available.
82	1.3	9		Figure 1-10 shows...	Comment on paragraph: QAQC discuss	Language will be added to describe the reliablility and completeness of DWR well information.
83	1.3			Figure 1-1	Comments: - add "creeks" to make the label "streams/creeks" - label from page 1 - if showing parcels/ ag areas show the entire basin.	Creek labels will be added to Figure 1-1. Background imagery will be revised to provide more clarity.
84	1.3			Figure 1-2...	Comment: - Combine w/ Figure 1-1 - Too busy w/ all the roads	Background imagery will be revised to provide more clarity. The Figures have been organized to clearly show compliance with SGMA requirements and therefore, the contents and numbering of each figure will not change.
85	1.3			Figure 1-4	Comment: Figure 1-2?	The Figures have been organized to clearly show compliance with SGMA requirements and therefore, the contents and numbering of each figure will not change.
86	1.3			Figure 1-5	Comment: Suggest using entire Basin Scale? Instead of 200 median	The scale of Figure 1-5 will be modified to show full basin.
87	1.3			Figure 1-3	Comment on Medium or all Priorities: Still correct> Draft 2018 SGMA Plan is High	Figure 1-3 will be updated to reflect the new prioritization of the Cuyama Valley Groundwater Basin
88	1.3			Figure 1-6	Comment: Does this include Harvard? All ag?	Land use for additional years, including 2016, is currently being processed and will be shown in the next revision of the plan area document. These land use datasets only show irrigated agricultural lands and therefore do not include non-irrigated range and pasture land. However, water use from these other land areas will be accounted for in the numerical model and water budget as part of the GSP.
89	1.3			Figure 1-7	Comments: - Move state and federal land use figures to ag land use to another figure - show all ag?	Figure 1-12 does not show land use but rather the boundaries of State and Federal lands. Land use for additional years, including 2016, is currently being processed and will be shown in the next revision of the plan area document. These land use datasets only show irrigated agricultural lands and therefore do not include non-irrigated range and pasture land. However, water use from these other land areas will be accounted for in the numerical model and water budget as part of the GSP.

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90	1.3			Figure 1-8	Comments: - show all ag? - Any de minimis users?	Land use for additional years, including 2016, is currently being processed and will be shown in the next revision of the plan area document. These land use datasets only show irrigated agricultural lands and therefore do not include non-irrigated range and pasture land. However, water use from these other land areas will be accounted for in the numerical model and water budget as part of the GSP. De minimis user data is not availble.
91	1.3			Figure 1-9	Edit to legend: Remove "Township & Range with" to just make it "Domestic Wells"	"Number of Domestic Wells by Township and Range" will be used in Figure 1-9, and similar changes will be made to Figures 1-10 and 1-11.
92	1.3			Figure 1-10	Edit to legend: Remove "Township & Range with" and change to "Production" to just make it "Production Wells"	"Number of Domestic Wells by Township and Range" will be used in Figure 1-9, and similar changes will be made to Figures 1-10 and 1-11.
93	1.3			Figure 1-11	Comment: - Google show all ag? - Cicled well with "280" and called it "Strange"	Background imagery will be revised to provide more clarity. The Figures have been organized to clearly show compliance with SGMA requirements and therefore, the contents and numbering of each figure will not change.
94	1.3			Figure 1-11	Edit to legend: Remove "Township & Range with" to just make it "Domestic Wells"	"Number of Domestic Wells by Township and Range" will be used in Figure 1-9, and similar changes will be made to Figures 1-10 and 1-11.
95	1.3				General comment, might be for Figure 1-10 and 1-11?: Well Screen level? Geology?	Geology information will be provided in the HCM section of the GSP. Screen interval data is not widely availble. Screen interaval information is not currently availble for most wells. Text will be updated to reflecty why screen levels are not included
96	1.3			Figure 1-12 and 1-13	Comment: Suggest move up ahead or behind Ag land use on or before.	The Figures have been organized to clearly show compliance with SGMA requirements and therefore, the contents and numbering of each figure will not change.
97	1.4	1			Comment: Approximate amount?	This is described in the subsequent paragraph.
98	1.4	2			Comment: How is this data QA/QC?	The USGS performs QA/QC on their data prior to posting.
99	1.5	1			Comment: When was the CCSD and CBWD formed?	This information will be added to the paragraph that references Figure 1-5
100	1.5	1			Comment "There are 101 wells...: Approximate?	References to the numbers of wells will be removed from this seciton and discussed in the Monitoring Network section of the GSP along with appropriate figures
101	1.5	1			Comment: Figures?	Figures will be added to the Monitroing Network section of the GSP
102	1.5.1	2	1	SLOFC&WCD has...	Insertion: "has two CASGEM wells in the service area..."	Comment accepted
103	1.5.1	4	4	Wells were monitored in 2017...	Comment on "with most being monitored isnce 2008.": Revise, awkward.	Sentence will be revised for clarity
104	1.5.1	4			Comment: Tables/figures?	This section of the GSP describes the program in general terms. More details will be provided in the Monitoring Network section of the GSP
105	1.5.1	5			Comment: Table/figures.	This section of the GSP describes the program in general terms. More detailes will be provided in the Monitoring Network section of the GSP
106	1.5.1	6			Comment: SLO County so the well is mentioned previously and these wells are voluntary	Monitoring programs often overlap which is why the wells are mentioned multiple times
107	1.5.1	9			Comment on paragraph header: Volunteer Program for SLO	Comment noted. No change needed
108	1.5.1	9			Comment on "One well is screened in the Younger Alluvium....": Go over Geolog of Basin. Does not fit?	Geology references will be removed from this section of the GSP and will be included in the HCM section of the GSP
109	1.5.2	1	5 and 6	Constituents most frequently...	Comment: General minerals? Nitrates?	Comment noted. No change needed
110	1.5.2	5			Comment on whole paragraph: Add new requirement for ILRP order. Title I to Title III	Comment noted. This level of detail is not needed in the GSP document.
111	1.5.3				Comment on Placeholder for other USGS Subsidence Monitoring: CORS stations if in area?	This will be updated during the development of the Monitoring Network section of the GSP.
112	1.7				Comment on Section: Need to State GSA's goal then how each Plan Aligns w/ them.	The text will be modified so as to not state or imply that the GSA is adopting goals from the General Plan.
113	1.7.1	1			Comment: GSA Board should decide?	The text will be modified so as to not state or imply that the GSA is adopting goals from the General Plan.
114	1.7.1	3			Comment/edit: Remove last sentence starting with "Due to the complementary nature...." GSA decides. Should b a combo of all General Plans	The text will be modified so as to not state or imply that the GSA is adopting goals from the General Plan.
115	1.7.1	4	2	Given the small portion of the...	Comment/edit: Remove "...and the GSP's alignment wit hthe Genral Plan's goals" Goals need to be vbetted with GSA Board and Public.	The text will be modified so as to not state or imply that the GSA is adopting goals from the General Plan.
116	1.7.2.	3rd to last Paragraph			Comment on last sentence: Need to vett goasl w/ GSA Board and Public	The text will be modified so as to not state or imply that the GSA is adopting goals from the General Plan.

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Comment #	Section	Section Paragraph #	Paragraph's Sentence #	Sentence Starts with, "...	Comment	Proposed Response
117	1.3				Comment: This section uses a variety of indexes to describe the Basin but misses others. Numerous secondary streams flow into the valley and contribute to the flow of the Cuyama River but only a couple are mentioned. What about Cottonwood, Aliso, Branch, Salisbury, Ballenger, Burgees, Apache and Reyes Creeks. And what can be done to monitor the sometimes significant contribution these creeks have to the basin. The lack of surface water flow monitoring on any of these secondary stream is a potentially problem for developing a water budget or model. Also no mention is made about the variety of surface water features other then streams and rivers. Cuyama is notorious for its Seeps, Springs, Wetland meadows and Cienegas. There are Federal and State agencies which have wetland tracking maps for these Groundwater Dependent Ecosystems and they characterize a significant portion of the valley. There should be a map representing these wetlands and a monitoring program to understand their conditions.	The streams and other surface water features shown on the figures will be revisited when the surface water modeling approach for the GSP is developed. A map will be developed that shows the wetlands contained in state and federal databases.
118	1.3			Figure 1-5	Comment: Figure 1-5 is at an unnecessarily odd scale and it would be helpful to see it combined with Figure 1-4 so as to see which county is responsible for the parts of the Basin which are outside of the Water District.	The scale of Figure 1-5 will be modified to show full basin. The Figures have been organized to clearly show compliance with SGMA requirements and therefore, the contents and numbering of each figure will not change.
119	1.3			Figures 1-6 and 1-7	Comment: Figures 1-6 & 1-7 regard land use changes up to 2014, however significant changes have happened across the valley with regards to land use and crop changes. How can the changes at Harvard Vineyard, Sunridge Nursery, Duncan Farm, Sunrise Olive, the Solar Farm and others be accounted for as they all are recent major land use changes on a large portion of the valley?	Land use for additional years, including 2016, is currently being processed and will be shown in the next revision of the Plan Area document. These land use datasets only show irrigated agricultural lands and therefore do not include non-irrigated range and pasture land. However, water use from these other land areas will be accounted for in the numerical model and water budget as part of the GSP.
120	1.3			Figure 1-8	Comment: Figure 1-8 is incorrect or miss-keyed. Some Irrigated lands are unmarked and no lands are irrigated by surface water as appear to be indicated on the map by the wrong color key.	The current background map shows land uses that were not present in 2014. The background map will be replaced to avoid color confusion.
121	1.5				Comment: The section on existing monitoring of surface water is telling in its brevity. There are not enough flow gauges to make real measurements. This will be a critical issue with the water budget and model development.	Comment noted. For the water budget development, flows will be estimated using precipitation records
122	General Comment				Comment: No mention is made of historic Groundwater use or of the many studies made of the Basin. It seems relevant to present the history of peer reviewed studies and the commonality of all their conclusions; mainly historic & chronic overdraft. Summary of all modern Hydrologic Analyses of the Cuyama Groundwater Basin Year Agency Overdraft Method 2014 USGS-SBCWA 34,500 AF/y Finite Difference Model 2009 UCSB Bren School 30,500 AF/y Mass Balance 1998 CDWR 14,600 AF/y Specific Yield 1992 SBCWA 28,000 AF/y Mass Balance 1988 CRCD 30,300 AF/y Mass Balance 1977 SBCWA 38,000 AF/y Mass Balance 1970 USGS 21,000 AF/y Mass Balance 1951 USGS "Steady State" Observations	These will be discussed in the Water Budget section of the GSP
123	1.4	2	4	and another gage...	Comment: Sentence structure issue	The text will be modified for clarity
124	1.4	2	5	Although neither of...	Comment: 11136600 is within the DWR GW Basin Boundary	The text will be modified for clarity
125	1.4	2	5	Although neither of...	Comment: May be misleading when considering the development of a GSP and monitoring inflow and outflow from Basin. 11136800 is 15 miles downstream with a fairly large contributing watershed above it and outside the basin. Then again, suppose it's better than nothing at all.	The usefulness of this gage for monitoring will be assessed when the surface water monitoring approach is developed. No change needed for this document.
126	1.5	1		There are 101 wells...	Comment: A general NWIS datapull has double this number of wells with historic data. Possible referring to active program?	Groundwater level data is currently being assessed and the records of wells with historical data will be confirmed. References to the numbers of wells will be removed from this seciton and discussed in the Monitoring Network section of the GSP.
127	1.5	1		There are 101 wells...	Comment: Monitored by whom? USGS and SBCWA and the water district?	The agencies that perform the monitoring are described in the sections below.
128	1.5.1	1	1	Data is submitted to the WDL from ... Santa Barba County Flood Contrl and Water Conservation District...	Comment: Not that I'm aware of. We (WA) do provide data to DWR for the CASGEM program only. Probably what they're referring to here.-although there's a CASGEM section below. I have a feeling that DWR may mine data from the NWIS webpage.	The discussion on the entities who perform monitoring will be reviewed and clarified
129	1.5.1	3	2	The USGS provides historical data for 48 wells from 1946 to 2009...	Comment: ????????????? Also what makes me think DWR pulled data out of NWIS. Discrete values in NWIS are coded CA042 for for Flood Control. The WA submits CASGEM and voluntary CASGEM data for wells to DWR. USGS has never directly provided data to DWR.	The discussion on the entities who perform monitoring will be reviewed and clarified

Cuyama Basin Description of Plan Area - April Draft
Summary of Comments and Responses
June 22, 2018

Comment #	Section	Section Paragraph #	Paragraph's Sentence #	Sentence Starts with, "...	Comment	Proposed Response
130	1.5.1	4	2	In the Cuyama Basin, there are 23 wells…	Comment: ?? Historically there are 200+	Groundwater level data is currently being assessed and the records of wells with historical data will be confirmed. References to the numbers of wells will be removed from this seciton and discussed in the Monitoring Network section of the GSP.
131	1.5.1	4	3	Wells are monitored by the USGS in SBFC&WCD's…	Comment: Water Agency Program	The discussion on the entities who perform monitoring will be reviewed and clarified
132	1.5.1	4	3	…with most being monitored since 2008…	Comment: Ignoring historic data set	Groundwater level data is currently being assessed and the records of wells with historical data will be confirmed.
133	1.5.1	4	3	…back to 1983	Comment: And earlier	Groundwater level data is currently being assessed and the records of wells with historical data will be confirmed.
134	1.5.1	4	3	Groundwater level measurements at these wells are taken approximately once per quarter	Comment: Only during the study	Groundwater level data is currently being assessed and the records of wells with historical data will be confirmed.

Cuyama Basin Hydrogeologic Conceptual Model - June Draft
Summary of Public Comments and Responses
September 19, 2018

Comment #	Section	Section Paragraph #	Paragraph's Sentence #	Sentence Starts with, "...	Comment	Response to Comment
1	2.1	Global			I understand that this draft does not yet constitute the complete Basin Setting Description, but of the three requirements of an HCM by CDWR, I find this draft addresses only the first item comprehensively. 1. An understanding of the general physical characteristics related to regional hydrology, land use, geology and geologic structure, water quality, principal aquifers, and principal aquitards of the basin setting; 2. A context to develop water budgets, mathematical (analytical or numerical) models, and monitoring networks; 3. A tool for stakeholder outreach and communication.	The GSP will use the HCM for guiding water budget development and HCM components will be elaborated upon during outreach activities.
2	2.1	Global			In order to facilitate and serve as the basis for the development, construction, and application of a mathematical (analytical or numerical) model and water budget, more narrative would be needed regarding the sources of recharge, and the consumptive use by existing native rangeland and phreatophyte vegetation, as well as a better description of the complexity of the "cascading basin" that results from hydrogeologic barriers that separate the Ventucopa Uplands from the Main Zone, the Main Zone from the Cottonwood subarea and the Cottonwood subarea from the Santa Maria Groundwater Basin. The suggested base period does not span one or more of the major climatic cycles know as the Pacific Decadal Oscillation (PDO), nor does it include the major period of dewatering of the basin in the 1970's & 1980's when much of the groundwater storage was lost. (see USGS, Cuyama Valley, California Hydrologic Study: An Assessment of Water Availability)	This will be addressed in later chapters.
3	2.1	Global			In order to better serve as a tool for stakeholder outreach and communication it would be necessary to more adequately "provide often highly-technical information in a format more easily understood to aid in stakeholder outreach and communication of the basin characteristics to local water users" (DWR). This should include a graphic three dimensional interpretation of the Basin characteristics. "The breadth and level of detail of the basin conditions should be sufficient to capture long-term changes in groundwater behavior" (DWR). I find there to be a deficiency of detail in this regard. I will provide examples in the specific comments below.	3D graphic will be included in the Basin Model and Water Budget section. There is a general deficiency in detail about Cuyama geology.
4	2.1	Global			Data Gaps that are not mentioned include information about: - Santa Barbara Canyon Fault - pumpage data - Stream-flow gauge on the Cuyama River - Seasonal land use practices like frost protection and drench leaching for salinity, varieties of irrigation methods, multiple cropping's in the same year on the same field - Discrepancies between where water is extracted and where it is applied such as the well at Bell and Foothill roads that pumps groundwater for several miles eastward across the Rehoboth Fault	The Data Gaps section of the HCM has been updated. Some of these items will be addressed in the Groundwater Conditions section.
5	2.1	Global			Subsidence data is not mentioned	Subsidence will be discussed in the Groundwater Conditions Section
6	2.1	Global			There is no Groundwater Elevation Contour Map	Groundwater elevation contour maps will be presented in the Groundwater Conditions Section
7	2.1.10	Global			Not all of these citations are from published sources that are considered Peer Reviewed Journals. There should be a consistent citation format that could make that distinction. How will QC/QA be addressed? Some USGS citations are incorrect. The format is inconsistent and some citations are missing. Here are a few examples: Deeds, D.A., Kulongoski, J.T., Mühle, J., Weiss, R.F., 2015, Tectonic activity as a significant source of crustal tetrafluoromethane emissions to the atmosphere: Observations in groundwaters along the San Andreas Fault: Earth and Planetary Science Letters, Vol. 15, pp. 163-172. (https://doi.org/10.1016/j.epsl.2014.12.016) Everett. R.R., Hanson, R.T., and Sweetkind, D.S., 2011, Kirschenmann Road multi-well monitoring site, Cuyama Valley, California Hydrologic Study: An Assessment of Water Availability, Fact Sheet 2014-3075, 2014 Cuyama Valley, Santa Barbara County, California: U.S. Geological Survey Open-File Report 2011-1292, 4 p. (http://pubs.usgs.gov/of/2011/1292/) Everett, R.R., Gibbs, D.R., Hanson, R.T., Sweetkind, D.S., Brandt, J.T., Falk, S.E. and Harich, C.R., 2013, Geology, water-quality, hydrology, and geomechanics of the Cuyama Valley groundwater basin, California, 2008–12: U.S. Geological Survey Scientific Investigations Report 2013–5108, 62 p. Gibbs, D., 2010, Cuyama Groundwater Basin: Department of Public Works, Santa Barbara County, 8 p. Hanson, R.T., Flint, L.E., Faunt, C.C., Gibbs, D.R., and Schmid, W., 2014, Hydrologic models and analysis of water availability in Cuyama Valley, California: U.S Geological Survey Scientific Investigations Report 2014–5150, 150 p., http://dx.doi.org/10.3133/sir20145150. Hanson, R.T., and Sweetkind, D.S., 2014, Water Availability in Cuyama Valley, California: U.S. Geological Survey Fact Sheet FS2014-3075 4p. Hanson, R.T., Boyce, S.E., Schmid, Wolfgang, Hughes, J.D., Mehl, S.M., Leake, S.A., Maddock, Thomas, III, and Niswonger, R.G., 2014, MODFLOW-One-Water Hydrologic Flow Model (OWHM): U.S. Geological Survey Techniques and Methods 6-A51, 122 p. (http://pubs.usgs.gov/tm/tm6a51/) Parsons, M.C., Kulongoski, J.T., and Belitz, Kenneth 2014, Status and understanding of groundwater quality in the South Coast Interior groundwater basins, 2008—California GAMA Priority Basin Project: U.S. Geological Survey Scientific Investigations Report 2014–5023, 68 p., http://dx.doi.org/10.3133/sir20145023. Mathany, T.M., Kulongski, J.T., Ray, M.C., and Belitz, Kenneth, 2009, Groundwater-quality data in the South Coast Interior Basins study unit, 2008: Results from the California GAMA program: U.S. Geological Survey Data Series 463, 82 p. Available at http://pubs.usgs.gov/ds/463. Sweetkind, D.S., Faunt, C.C., and Hanson, R.T., 2013, Construction of 3-D geologic framework and textural models for Cuyama Valley groundwater basin, California: U.S. Geological Survey Scientific Investigations Report 2013–5127, 46 p.	The reference list was reviewed and updated.

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Comment #	Section	Section Paragraph #	Paragraph's Sentence #	Sentence Starts with, "...	Comment	Response to Comment
8	2.1.10				I understand the great pressure that the Woodard & Curran team is under to satisfy the statutory deadlines presented by SGMA. This is a complex and convoluted Basin a long way from Sacramento and under these circumstances information is hard to acquire and verify with ground truthing given the time constraints. For those of us living and working in Cuyama this is more than a little frustrating. However, this document is meant to provide a current and historical picture of groundwater dynamics in a conceptual framework that can be used to understand the issues as they relate to a sustainable future. As such it needs some additional data and narratives. A 3D graphic is missing. A description of the changes to GDEs, water quality & availability due to groundwater extraction in recent history is needed. How, why and for how long has Cuyama been considered a critically over-drafted basin?	Please note that this is only one section of many that is devoted to describing groundwater conditions in the Basin. The 3D graphic (and model) will be discussed in Section 4 (Basin Model and Water Budget) The Groundwater Conditions Section will discuss: GDEs Water quality Groundwater availability Historical groundwater storage & use
9	2.1.3	Global			It would be very helpful to maintain some consistent descriptive format. Some formation descriptions lack important information that is provided for the others. In particular their water bearing relevance to the Basin or its boundaries and to the model itself would be good to include in each formation description. Some do, some don't.	The inconsistency in description formats, particularly for the faults, is a result of the discrepancies in the amount of data and reports. Some faults are well studied and have numerous resources to cite while others (like the Morales fault) lack information.
10	2.1.4	3	6	The syncline has folded water and non-water bearing formations...	Descriptions of structural features (i.e. faults & synclines) should be more consistent in format with more reference to their relevance to the hydrology in general. For example if the Cuyama Syncline "is favorable to the transmission of water from the southeast end of the valley" why would it then have "no pronounced effect on the occurrence of groundwater in the basin"? The syncline near Santa Barbara Canyon Fault has little or no description of its relevance to groundwater movement. If its occurrence is significant but its relevance is unknown this should be noted as a data gap for further investigation.	Noted. Will discuss details of tectonic features in Data Gap section.
11	2.1.4	10	1	Due to the lack of a consensus as to	I appreciate the last paragraph of the Russell Fault description for its acknowledgment of the known-unknowns of this formation with respect to its permeability to groundwater flow. This honesty is refreshing and should be encouraged elsewhere. It is at least as important to identify what we don't know as to acknowledge what we do.	Noted.
12	2.1.4	18	5	The fault is considered a barrier to	What is the significance of the Santa Barbara Canyon Fault being a barrier to groundwater flow? "The SBCF was not represented as a barrier to flow in the younger alluvium in the model cells that represent the Cuyama River channel in the CUVHM"(D.Gibbs). How might this impact the Model or Budget? What more would we need to know about the fault to adequately address the management decisions to come? How can we discover what it is we need to know?	The USGS in 2013 also concluded that the SBCF was a barrier to groundwater flow: "Relatively small amount of vertical offset in the SBCF indicates changes in water levels across the fault documented in previous studies are perhaps the result of distinct fault-zone properties rather than juxtaposition of units of differing water-transmitting ability" (USGS, 2013a).
13	2.1.4	20	1	The Morales fault is a 30-mile....	The Morales Fault is used as the northern boundary of the Basin but very little is mentioned as to its type, or hydrologic permeability. Is its only relevance and justification for being a boundary that it was used as such in the bulletin 118?	Because the Morales Fault bounds the basin sediments and basement rocks. Basement rocks are impermeable. Impermeable rocks are a basin boundary.
14	2.1.4	last paragraph	4	The presence of these non-aquifer materials in this area....	As for the outcrops of bed rock in the western part of the Basin; how can we quantify that the outcrops "likely restricts groundwater movement by limiting the extent of permeable materials in this portion of the basin"? Again, how can we learn what we need to know to understand this impact on the model and water budget as a whole?	The characteristics of the formations in the outcrops indicate that they are non-water bearing. They could be further studied with well installation and pump testing to improve understanding of their permeability.
15	2.1.5	2			Not all of the faults being used to set the Basin's Lateral Boundaries have been described as impermeable to groundwater flow. Is it important to provide any supporting science behind the Bulletin 118 delineation? Might there be some issues here like the fingers that are in the Basin but outside of the watershed and boundary faults that may or may not constitute barriers to groundwater flow?	Because the faults bound the basin sediments and basement rocks. Basement rocks are impermeable. Impermeable rocks are a basin boundary.
16	2.1.5	5	1	The bottom of the Cuyama Basin...	Please cite the claim "the bottom of the Cuyama Basin is generally defined by the base of the upper member of the Morales Formation".	A citation has been added.
17	2.1.5	Global			Be consistent when referring to the aquifer. It is defined as ending at the upper member of the Morales Formation but throughout the section the entire Morales Formation is referenced as the aquifer	A sentence has been added at the beginning of the section clarifying that when referring to the aquifer, we are referring to alluvium layers through the top of the Morales Formation.
18	2.1.6	1	5	There are no major stratigraphic....	How can you claim "There are no major stratigraphic aquitards or barriers to groundwater movement, amongst the alluvium and the Morales Formation", and then describe those formations as "consisting of interbedded layers of sand and gravel and thick beds [of] clay ranging from 1 to 36 ft."? That 2nd description defines an aquitard and is evidenced by the many "exceptions of locally perched aquifers resulting from clays in the formations." These clays and aquitards have profound effects on the lateral and vertical movement of groundwater within the Aquifers. I cannot believe that "the aquifer is considered to be continuous and unconfined" in the presence of so many thick clay layers! How can this inconsistence be reconciled?	There are no continuous clay layers that cover a large area of the Basin in the reviewed literature. Individual clay lenses are not considered a regional aquitard. The extent and nature of clay lenses is not well understood in Cuyama and could be investigated as a data gap.
19	2.1.6	9	3	Using aquifer tests from 63 wells...	This is also evidenced by the "estimates of horizontal hydraulic conductivity ranging from 1.5 to 28 feet per day (ft/d)". That's quite a range to be considered unconfined, and would render the average and/or median values to be statistically irrelevant. The wide ranges in the estimates for all the Aquifer Properties show the great variability of groundwater movement within the aquifers due to these aquitards. How will the mathematical model and the budget handle this kind of spatial differentiation?	Discussion of model and water budget methodology will be discussed in the Water Budget & Basin Model Sections
20	2.1.6	Figure 2-12			This map shows that there are no Aquifer Test Wells anywhere in the Ventucopa Uplands south of the SBCF. This data gap contributes to a lack of understanding of the Ventucopa area, the region responsible for most of the groundwater recharge into the main basin. Similar data gaps exist for Cottonwood area west of the Russell Fault. How will these gaps be addressed before developing the Model and Budget?	How aquifer tests (or lack thereof) will be used in the groundwater model will be described in the Basin Model section. The limited amount of conductivity data will be identified as a data gap that can potentially filled by studies at the direction of the GSA in the future.
21	2.1.6	Figures 2-8 to 2-11			These cross sections need a legend and should trace the current & historic groundwater levels similar to the way the USGS did with their cross sections. The cross sections should also indicate where one intersects another and should show the locations of the major faults and synclines as they intersect these sections as shown in the USGS charts of the same cross sections. If these cross sections are from the USGS Study why are they redacted and without citations?	The cross sections have been updated.
22	2.1.7				No reference is made of the USGS GAMA reports and related sampling. No discussion of age dating, tritium isotopes, or trace metals. Can the historical data from Singer and Swarzenski (1970) be compared to the more current data by Hanson et al (2013) as part of the USGS Cuyama studies and the GAMA project to provide the relevant water quality trends? Why is the age dating data ignored as it relates to poor water quality and the lack of recent recharge?	Additional discussion of water quality (including historical water quality and age dating) is discussed in the Groundwater Conditions section.

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Comment #	Section	Section Paragraph #	Paragraph's Sentence #	Sentence Starts with, "...	Comment	Response to Comment
23	2.1.8	3			The USGS Geochemistry and isotope dating indicate little to no recharge in the Cuyama Main Basin. Deep percolation of artificial recharge from inefficient irrigation practices is additionally hampered by clay layers, distance to the zone of saturation and compaction due to dewatering and subsidence. Consequently looking at soil properties from the SAGBI database may not be representative of the subsurface properties that potentially control recharge and runoff. How can this potentially high margin of error be verified?	If a groundwater recharge program is selected by the GSA, further study will need to be conducted as part of the program.
24	2.1.8	3			No mention is made of the many Groundwater Dependent Ecosystems; springs, seeps and wetland meadows. Historical evidence should be presented and current conditions quantified for these groundwater discharge areas. How or where will they be presented?	GDEs will be discussed in the Groundwater Conditions section. Available spring reference material was presented in Figure 2-16.
25	2.1.8	3 & 4		Surface Water Bodies & Areas of Recharge	A more complete description of the surface water activities, with regards to runoff & recharge throughout the basin is needed.	Surface water (including runoff and recharge) will be discussed in further detail in the Water Budget section.
26	2.1.8	3 & 4		Surface Water Bodies & Areas of Recharge	How can we evaluate and determine the volume or rate of surface water depletion as it relates to groundwater extraction? An evaluation of the uncertainties and the margins of error within the data sets and HCM components will be needed before any assumptions can be made by using them in the Model or Budget.	Surface water will be discussed in further detail in the Water Budget section.
27	2.1.8	Figure 2-16			This map does not reflect the "approximately 25 miles of the eastern portion of the Cuyama River [that] is categorized as a wetland by the U.S. Fish & Wildlife Service's National Wetlands Inventory". Where is that data being presented? What about the remaining 75% of the valley including the river channel and rangelands? How will recharge be calculated for the majority of the Basin?	Recharge will be discussed in the Water Budget Section. Wetlands will be further discussed in Groundwater Conditions.
28	2.1.8	Figure 2-15			This map and the supporting text do not include many of the major contributing drainages that we have been talking about: Apache Canyon, Ballinger Canyon, Salisbury Creek, Branch Canyon, Alisos Canyon and Cottonwood Canyon. There are also many artificial standing bodies of water pumped from the groundwater that are used for irrigation, frost protection and salinity abatement. They should be adequately described as part of the HCM. How will these surface waters be routed into the groundwater Model and the Water Budget?	A location map will be developed, surface water is a part of the water budget.
29	2.1	Global			Does is meet the requirements for SGMA and help address the DWR BMP's: https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/BMP_HCM_Final_2016-12-23.pdf	The GSP will be compliant with Regulations and will consider the BMPs, as appropriate.
30	2.1.1				Suggestion labeling all the faults mentioned or approximate location on a separate figure. Cuyama is complex and a visual map would help.	Please see Figure 2-6
31	2.1.2				Suggestion labeling all the faults mentioned or approximate location on a separate figure. Cuyama is complex and a visual map would help.	Please see Figure 2-6
32	2.1.2				Label ranges that are mentioned in the text.	Please see Figure 2-1
33	2.1.6	Figure 2-12			I suggested adding another figure and showing the location of the areas with Bulletin 118	The Basin boundary has been overlain over the USGS map
34	2.1.3	Figure 2-3			Add timeline scale under Epoch, such as Holocene approx. 11,700 years	A timeline scale has been added to Figure 2-3
35	2.1.6	Figures 2-9 to Figure 2-11			Figures 2-9 to 2-11: Add legend: formation type, location markers to help the public, fault names, etc.... Please discuss what these figures mean.	These cross sections have been removed. Revised versions will be included in a later draft.
36	2.1.3	4	4	The older alluvium is	Label on map (TTRF & GRF)	Please see Figure 2-6
37	2.1.3	6	8	The Morales Formation	Label on map - Cuyama Badlands	Please see Figure 2-2
38	2.1.3	8	2	Layers of volcanic ash	Label on map - Caliente	Follow-up. May consider labeling geologic units on the figure.
39	2.1.3	Figure 2-2			Label on map - La Panza and Sierra Madre ranges	No change made to map because these ranges are located outside of the Basin.
40	2.1.3	Figure 2-2			Label on map - Cuyama Badlands and La Panza Range	No change made to map because these ranges are located outside of the Basin.
41	2.1.4	22	3	Outcrops of basement	Suggest to add a footnote to help explain to the public what this is.	The text has been revised.
42	2.1.4	8	1	The highest yielding wells	Not sure if this is for the main basin or basin wide, I suggest clarifying it up front. If basin -wide add the methodology and/or assumptions of how this is projected to the entire basin, such as hydraulic conductivity is from 63 wells in one basin section, so how does this reflect the entire basin with all of the differing geology: faults, formations, and etc...	A description of conductivity that is available currently has been added.
43	2.1.4	12	2	Using aquifer tests from 63 wells...	How was this determine, maybe showing the formula to explain in a footnote?	This is referenced from USGS, 2013c who did not reference their calculations
44	2.1.4	12	6	Wells screened in both	Similar to older alluvium, I suggest adding an explanation for the similarity.	This is a USGS, 2013c interpretation and was made by them, based on their work.
45	2.1.4	12	7	Using groundwater level	values are highest in the central portion of the valley and decline to the west because (geology/faults, etc.....)	The text has been revised for clarification
46	2.1.7	4	2	In 2013, the USGS	Suggest adding a footnote to define the primary and secondary MCL's for the public.	The text has been revised for clarification
47	2.1.8	Figure 2-15			Add recharge and discharge map with labels, seeps, and etc.	Springs and seeps are mapped in Figure 2-16
48	2.1.8	5	Global	Areas of Recharge	Add water budget	This will be discussed in the Water Budget section
49	2.1.3	Figure 2-2			So, essentially the only map we have of the basin formations is from T. Dibblee?	No. Multiple maps were reviewed during HCM development. The Dibblee map was selected for the figure due to its robust detail.

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Comment #	Section	Section Paragraph #	Paragraph's Sentence #	Sentence Starts with, "...	Comment	Response to Comment
50	2.1.4	8	3	Water bearing units on the western	What does this mean: "Water bearing units on the western (upthrown) side of the Russell fault are thinner than the water bearing units to the east of the Russell fault due to this uplift"?	The fault has offset deposits so that one side is thicker than the other.
51	2.1.4	14	6	Evidence of the faults and their no-flow boundaries	The Singer reported that water was slow to replenish along the faults - was based on what?	The Singer report did not state why.
52	2.1.4	Figure 2-6			Will consideration be given to minor faults?	Where data is available regarding the nature of faults, they are/will be considered in the GSP.
53	2.1.5	Figure 2-8			Yes, this map was released in June 2012 but some notation should be made of when it was drawn. So this is the best map you have? What do the colors represent? It is highly likely that this map was drawn even before the basin boundaries were established. So this is the best information and most recent info available?	Multiple maps were reviewed during HCM development. The Dibblee map was selected for figure use due to its robust detail. The legend from Figure 2-2 was added to Figure 2-8.
54	2.1.5	Figures 2-9 - 2-11			Are these maps a continuation of Figure 2-8? It is unclear how these maps relate.	These cross sections have been removed. Revised versions will be included in a later draft.
55	2.1.8	6	3	SAGBI provides an index for groundwater recharge for….	The info from the Soil Ag Groundwater Banking Index seem rather unnecessary in an area where an annual rainfall rarely is enough to reach past plant roots, unless you plan on collecting flood water which I thought had already been examined by Twitchell.	Aquifer recharge options will be considered as part of the Actions and Projects evaluation.
56	2.1.4	20	2	The Morales thrust fault *as* a dip of approximately	I know what a dip is - does this mean 30 degrees?	Text is revised to state "The Morales thrust fault has a dip of approximately 30 degrees."
57	Global				We already have subsidence, which means that certain areas will not recharge. So how is water getting below those compacted levels to recharge the aquifers the deep wells are drawing from? It would seem that the water that does not run off the surface or is absorbed by the plants would run downhill on top of the impermeable layers, i.e. in a generally westward pattern away from Cuyama Valley, NOT down into the aquifer.	Noted. No change needed to HCM.
58	Global				What is the definition of "successful implementation of the GSP." Population growth in the rest of the county has nothing to do with population growth in Cuyama Valley unless some small, non-polluting company decided to move here and create employment for local people. That appears to be unlikely unless the county has a plan to attract people who want to live here, rather than extractive Big Ag commuters. With 35 students in the high school this coming year, we're certainly not going to attract families any time soon.	Successful implementation of the GSP is determined by the GSA with input from the stakeholder advisory committee and local stakeholders.
59	pg. 5				pg. 5 - Does Old Cuyama no longer have a well?	Unknown.
60	2	2	1	Hydrogeologic Conceptual Model	The "Best Management Practices (BMP) for the Sustainable Management of Groundwater: Hydrological Conceptual Model" document fundamentals indicate that a HCM can be used for "stakeholder outreach and communication". Without clear explanations, a glossary, definitions, clear citations, the document in its current form has limited use in stakeholder outreach and communication. Further, the BMP document recommends that the HCM for a basin's GSP should include a 3-D model of the basin. The draft HCM for the Cuyama Basin does not include such a model.	The GSP will be compliant with Regulations and will consider the BMPs, as appropriate.
61	2.1	Global			All data submitted by non-public entities should be noted as such and flagged in the HCM and throughout the final GSP. Their contributions (data, input, maps, quotes) to the GSP should be noted as provided by entities that are affiliated with a private interest in the valley. Further, the HCM and the GSP should contain a list of all non-public agencies that have submitted data, with notations on their affiliations. Specifically, Cleath-Harris is affiliated with the North Fork property; EKI is affiliated with the Cuyama Basin Water District.	Data and knowledge about the geology in this Basin is deficient in details. Any available data or reports were reviewed and formally cited if used.
62	2.1	Global			All maps and charts that do not include data from the current 850 acres of North Fork planting should be flagged and noted as not including the current planting and wells drilled.	The HCM is limited to geology. Comment noted for other sections.
63	2.1.4	4	1	There is a syncline in the western	It should be noted that this information has not been verified through independent review and has been provided by an entity affiliated with a grower that has vested interest in outcomes that may result from including this information in the HCM and the GSP.	Comment noted. A link to the referenced document has been provided in the references section of the HCM section.
64	2.1.4	6	1	The Russell fault is a subsurface	According to Sweetkind et al., the Russell Oil Field is located at the western edge of the valley, not "in the center of the main basin". If the location is referring to "center" on a north-south axis, please state as such.	The text has been revised.
65	2.1.4	21	1	A fault located southwest of the Russell	Refer to #1 above. This material appears to have been provided by Cleath-Harris. Please include citation, and flag that this information has not been verified by an independent, public entity.	Comment noted. A link to the referenced document has been provided in the references section of the HCM section.
66	2.1.5	4	2	The lower member of the Morales Formation is composed of clay..	As noted in 2.1.10 References of the Draft HCM, the Cleath-Harris study "Groundwater Investigations and Development, North Fork Ranch, Cuyama, California" did not appear to address the main basin. Is this citation correct? Or should an earlier reference be cited?	Citation has been revised.
67	2.1.6	10	3	The dewatered alluvium has an average specific yield of 15 percent	The wide ranges of specific yield appear to be problematic in estimating an average specific yield of 15%. Please note how these wide range will be addressed.	How conductivity reference information will be used in the groundwater model will be described in the Basin Model section.
68	2.1.6	10	3	The dewatered alluvium has an average specific yield of 15 percent	Please explain why the HCM refers to a specific yield cited in 1970, yet, as written, seems to imply that the average specific yield is correlated to data noted by the USGS 35 years later. If this is a sound hydrogeological practice, please elaborate	Properties of the subsurface geology do not change over time, because subsurface materials (sand, silt, rock) do not move.

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69	2.1.7	4	1	In 2013, the USGS collected groundwater from 39 wells and two...	Before submitting the GSP, these readings should be updated at minimum to 2018, five years following the initial readings, and that these readings should be taken at regular intervals going forward. Please state in the text how and when these readings will be updated.	Additional groundwater quality information will be included in the Groundwater Conditions section. A field study on groundwater quality could be chosen by the GSA as a plan action. GSP development does not include field work due to budget and time constraints.
70	2.1.7	5		Groundwater is used primarily for irrigation.	This statement should be updated to include the North Fork plantings. Further, in section 4€ of the GSP emergency Regulations (https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/GSP_Emergency_Regulations.pdf), pg. 14 states that the HCM shall include the following regarding the aquifer/aquitards: "Identification of the primary use or uses of each aquifer, such as domestic, irrigation, or municipal water supply." While not 'primary' use, the description above does not include domestic and municipal use by the CCSD.	The statement has been revised to also discuss domestic and municipal uses and add a statement regarding irrigation in the west, along the river.
71	2.1.10				An additional suggested reference is "Tertiary Tectonics and Sedimentation in the Cuyama Basin, San Luis Obispo, Santa Barbara, and Ventura Counties, California, Book 59, April 1988" http://www.worldcat.org/title/tertiary-tectonics-and-sedimentation-in-the-cuyama-basin-san-luis-obispo-santa-barbara-and-ventura-counties-california/oclc/19296307	Noted. We will review this document.
72	2.1.2	Figure 2-1			This figure states that faults were obtained from the Dept of Conservation webpage yet there are many faults on the figure which are not part of the interactive map. If there are other sources for the faults they should be listed.	Second source of fault information was added to figure.
73	2.1.4	9	4	In 2015, the USGS identified the Russell fault as a barrier to flow...	This is not accurate. The fault was used as a no-flow boundary for the sake of model computation. It was never identified as a barrier; in fact, it is identified in the publications as not being a barrier to groundwater flow. The wording in this instance is misleading needs to be reconsidered.	The USGS has contradicted itself in its characterization of the Russell fault across multiple reports.
74	2.1.4	9	5	Based on the conclusions of the...	My observation is that this ["Standing moisture near the fault.."] is all Green Canyon flow from Caliente Ranch	Noted. No change needed to HCM.
75	2.1.4	9	6	In addition, Cleath-Harris....	This document should be made available for review by members of the Technical Forum	Comment noted. A link to the referenced document has been provided in the references section of the HCM section.
76	2.1.4	9	1		Is this illustrated in Figure 2-6?	Yes, the fault is shown in Figure 2-6.
77	2.1.6	4	2	The recent and younger alluvium is the primary source of groundwater...	Appears to be referencing much older publications when younger alluvium actually was the primary source of groundwater on the western side of the basin. Now there are 850 acres of vineyard and wells as deep as 900 feet. (primary pumping wells ranging from 450 to 730 feet).	Noted. No change needed to HCM.
78	2.1.6	Figures 2-9 to 2-11			Figures 2-9 through 2-11 need a legend, showing what formation each unit represents.	These cross sections have been removed. Revised versions will be included in a later draft.
79	2.1.8	3	5	Peak flows through the Cuyama River	Reference to peak flows. What gage and where is it? Upstream Ventucopa gage (period of record?) or downstream Buckhorn gage 15+ miles outside of the basin?	Gages were shown in the Plan Area section and more surface water data will be part of the Water Budget Section.
80	2.1.4	Global			This looks very good to me. I applaud the choice to verify fault barriers to water flow by well monitoring and not to rely on theoretical modelling of the geology. The modelling that has been done is understandably biased by the interests of a major user who has also employed two of the consultant firms listed as having modelled these faults and their impacts. This needs to be publicly disclosed in the interest of transparency.	Noted. No change needed to HCM.
81	2.1.4	Figure 2-6			Fault maps on pages 6 and 16 show the Whiterock/Russell Fault zone as a broken line, which does not match the continuous lines used on the maps.conservation.ca.gov (referenced source) or the map on page 13 or Dibblee's map on page 20.	The Russell fault line on a map is indicative of the fault's general area. The figure is revised to show a continuous line.
82	2.1.6	Figures 2-9 to 2-11			Pages 24 and 25: Cross-section A-A' crosses the bedrock high's mapped by Dibblee and DeLong, which are shown on page 20. The page 25 interpretation incorrectly leaves bedrock far below the surface. If this cross section was meant to cross the river bed, it is not based on available data as permeable sediments average only the top 50 feet below the surface across this section of the fault zone.	These cross sections have been removed. Revised versions will be included in a later draft.
83	2.1.3	2	6	The deposits thicken to the east; typically ranging from 5 to 50 feet...	The younger and recent alluvium are the principal water-bearing formations in the Cuyama Basin. Since the alluvium is so much thinner on the western portion of the valley, would this not imply that the actual amount of stored groundwater would be much less, and that any calculations (for example the estimate of the amount of water in the Cottonwood sub-area where Harvard's vineyard is located) of how much actual groundwater is available needs to be verified?	Water budget details will be prepared in the Water Budget Section.
84	2.1.3	6	7	In 1970, Singer and Swarzenski reported the Morales Formation....	It is unclear to what extent and which faults are being called into question as limiting the lateral extent of the Morales Formation. For some faults there is good data on this limiting effect, and on others it is unclear or disputed (for example the Russell Fault), and for others, how much depth of the Morales Formation there might be over some of the more inactive faults.	Noted. No change needed to HCM.
85	2.1.3	12	3	To the east, the Vaqueros Formation grades into the lower	What about the so-called Vaqueros outcrop near the confluence of Cottonwood Creek? There is no evidence that this outcrop is part of a continuous below-ground formation, or an isolated uplifted portion of the formation that is now independent of the below ground material.	Noted. No change needed to HCM.
86	2.1.3	Figure 2-3			The figure seems to represent the upper member of the Morales Formation to only be made up of gravel conglomerate. Our understanding is that it is actually layered sediments that include gravel, but also layers of silt, clay, and sand, more like the lower member. Is this true?	Noted. Sedimentary rock is typically deposited in layers.

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87	2.1.4	5	1	There is a syncline in the western portion of the basin…….	This citation is from unpublished, non-peer reviewed work produced for a stakeholder with specific interests. If this information is to be part of the HCM it needs to be made publicly available and peer reviewed, or stated that it is not.	Comment noted. A link to the referenced document has been provided in the references section of the HCM section.
88	2.1.4	5	2	The full extent of this syncline….	Presence or absence of this extension needs to be ground-truthed.	Field study could be chosen by the GSA as a plan action to fill data gaps. GSP development does not include field work due to budget and time constraints.
89	2.1.4	9	5	Based on the conclusions of the USGS, Dudek stated that the fault…	It should be noted that DWR rejected the boundary modification based on conflicting scientific evidence that claims that the Russell Fault is buried under at least 1000 feet of Lower and Upper Alluvium and Morales Formation, all of which are water bearing and probably allowing permeability at the Fault. This should be mentioned in the HCM draft.	Discussion of the DWR's rejection of the basin boundary modification has been added to the text.
90	2.1.4	9	6	In addition, Cleath-Harris determined that the..	For all information submitted by Cleath-Harris: This is cited from unpublished, non-peer reviewed work produced for a stakeholder with specific interests. It is also in conflict with the previous comment we make above.	Comment noted. A link to the referenced document has been provided in the references section of the HCM section.
91	2.1.4	9	1	The Russell fault has been analyzed	Further comment on Russell Fault: The fault has been inactive for 4 million years and since then has had 1000 feet of deposition of Morales formation on top of it of which several strata are water bearing. Agricultural wells on both sides of the fault are less than 1000 feet deep. Hence, there is a high likelihood of water movement in both directions above the fault. (Citation: Yeats, R.S., J.A. Calhoun, B.B. Nevins, H.F. Schwing, and H.M. Spitz. 1989. Russell Fault: Early Strike-Slip Fault of the California Coast Ranges. The American Association of Petroleum Geologists Bulletin. Vol. 73 (9): 1089-1102.) Therefore we agree with the conclusion for further investigating that needs to include the strata on top of the Fault. This could be an appropriate area for more test wells.	Noted. We will review this document.
92	2.1.4	21	1	A fault located southwest of the Russell fault runs southeast….	This is lacking a citation.	Text as been revised to include a citation
93	2.1.4	21	1	A fault located southwest of the Russell fault runs southeast….	Please include: There is no evidence that this Fault is a barrier of water flow from south to north and no evidence that it prevents water use in the north from impacting wells to the south, especially in the Cottonwood Canyon area.	Preexisting reports disagree about the fault's nature and the fault's characteristics to flow are considered a data gap.
94	2.1.4	Figure 2-7			Is this figure included in the draft? What is the source of this figure?	Yes, Figure 2-7 is included in the draft - data sources are listed in the top left corner.
95	2.1.4	last paragraph	4	The presence of these non-aquifer materials in this area….	There is no hydrologic data to back this up, so it is important to not infer any attributes of permeability.	The characteristics of the formations in the outcrops indicate that they are non-water bearing. They could be further studied with well installation and pump testing to improve understanding of their permeability.
96	2.1.5	5	2	The lower member of the Morales Formation is composed of clay….	If Cleath-Harris is citing work done by other authors, those authors should be cited as the original source of the information. Also, since the cited Cleath-Harris study is an unpublished, private report prepared for stakeholders with interests in access to water in the Cuyama Valley, it needs public vetting and validation from other experts in the field before being given any weight in the HCM.	Noted. This document will be made publicly available.
97	2.1.5	5	4	The top of the Morales Formation…	This infers that everything above 750 feet at a minimum is potentially water bearing sediments. Is this correct?	The Morales Formation thickness is variable.
98	2.1.6	9	3	Using aquifer tests from 63 wells…	Does this vary seasonally and/or from wet year to dry year?	Conductivity is not connected to above ground seasons.
99	2.1.6	10	4	The USGS estimated the specific…	It is not clear what these yield numbers mean. Are they a percent? Why is the value for dewatered alluvium a percentage, and the ranges for recent alluvium not listed as percentages? How does the dewatered yield relate to these ranges?	Text has been revised for consistency.
100	2.1.6	Figures 2-9 to 2-11			Comment: What is A-A', B-B', C-C'. It would be helpful for the figures to have captions. Where are the faults on these sections and the differentiation between upper and lower Morales?	These cross sections have been removed. Revised versions will be included in a later draft.
101	2.1.6	Global			Within this section there is no mention of aquitards. It is important to know about aquitard presence especially clay layers in the Morales since they can significantly restrict water movement.	There are no continuous clay layers that cover a large area of the Basin in the reviewed literature. Individual clay lenses are not considered a regional aquitard. The extent and nature of clay lenses is not well understood in Cuyama and could be investigated as a data gap.
102	2.1.6 & 2.1.7	Figures 2-12 & 2-13			It would be helpful to clarify what the boundary line is in these figures. It appears to exclude the western portion of the Basin. If the drawn boundaries are not aligned with Bulletin 118 boundaries, can that be overlayed?	Basin boundary has been overlain over the USGS map
103	2.1.6 & 2.1.7	Figures 2-12 & 2-13			Water quality sites appear to be lacking in both the western and eastern portion of the Basin.	Noted. There is very limited data in these areas.

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104	2.1.7	4	1	In 2013, the USGS collected groundwater from 39 wells and two…	All of these constituents need to be monitored over time, especially nitrates. Since one of the proposals for increasing recharge rates is through percolation through ag land use, these soils which will most likely continue to increase nitrate levels even from organic farming.	Additional groundwater quality information will be included in the Groundwater Conditions section. A field study on groundwater quality could be chosen by the GSA as a plan action. GSP development does not include field work due to budget and time constraints.
105	2.1.7	5	2	The majority of agricultural activity	This statement does not take into account the new intensive viticulture in the western portion of the Basin.	The text has been revised to include western area.
106	2.1.8	3	3	The river is perennial with most dry seasons	Based on historic records of streamflow we know that year-round surface flow has become rare, especially in dry years. Even in normal years, the Cuyama River no longer has surface flow all year. The loss of riparian vegetation is a good indication of the reduction of perennial streamflow. We think this change should be mentioned.	Surface water flows will be discussed as part of the historical Water Budget.
107	2.1.8	3	5	There are approximately four main….	Wells Creek should be changed to Aliso Creek	Wells Creek has been renamed Aliso Canyon Creek
108	2.1.8	4	2	Downstream on the Cuyama River	Twitchell Reservoir is completely dry in most summers and completely dry all year during drought years, demonstrating how limited surface stream flow is for the entire Cuyama River. This should also be included.	Surface water flows will be discussed as part of the historical Water Budget.
109	2.1.8	Figure 2-15			Wells Creek should be changed to Aliso Creek	Wells Creek has been renamed Aliso Canyon Creek
110	2.1.2	4	5	Thrust and compression continued..	Comment: Thrusting reactivated older faults, particularly in the western basin. The upper and lower Morales are unconformable (percom with E&B Natural Resources and Ellis 1994), visible in seismic lines available in Ellis 1994 thesis. Lower Morales is fine grained, and generally predates or dates to very early compressive stage. The low gradient in the system leads to deposition of finer grain size material. As compression begins/continues you get first uplift and erosion (the unconformity) followed by coarser-grained deposition of Upper Morales as slopes increase (mountain range rise). Upper Morales often shows some degree of angular unconformity as well. Studies have also looked at composition and sources of gravels in Morales (Ellis 1993,???) which help firm up this timing. The western valley shows extensive Morales deformation, particularly echelon folding as was noted by Nevins, 1983, Schwing 1984, Calhoun 1985.	Comment noted. Thank you. No change needed in HCM.
111	2.1.3	4	5	Older alluvium is typically 400…	Comment: Western area is more gypsiferous than east of Russell. Add citation/description from DeLong of this unit for western area as cited paper does not address this area. See also Hill 1958.	Comment accepted. Description from DeLong and Hill, etc. has been reviewed and incorporated as appropriate.
112	2.1.3	6	4	The contact between the upper…	Comment: Older alluvium is much thinner than this in the Western Valley (much less than 100' typically). The USGS 2013a report did not address the western valley. When using this report to address generalized conditions for the valley, generalizations are often not applicable west of the Russell fault (out of the report study area). This means that if this source is used, western valley needs to be addressed separately.	Comment accepted.
113	2.1.3	6	4	The Morales is massively bedded…	Comment: This paper is East of the Russell fault only. There are areas in the western basin where Morales is less than this, particularly near the western boundary.	Comment accepted. Text has been revised per the USGS report extent.
114	2.1.3	9	6	The formation underlies the….	Comment: Unconformably underlies the Morales Formation (unconformity reported by Hill et al. 1958). Other marine units unconformably underlie Morales Fm. in the western area as well based on Dibblee, Hill, DeLong, etc..	Comment accepted. Description from DeLong and Hill, etc. has been reviewed and incorporated as appropriate.
115	2.1.3	--	Figure 2-3	--	Comment: Should be an unconformity between Upper and Lower Morales. In most of the valley this unconformity is buried. It is not highly apparent in well logs, but is very obvious in seismic sections. As most papers have addressed only well log data, this is not widely reported. See seismic sections for the Eastern Valley (in Ellis 1994).	Comment accepted. Description of upper/lower Morales unconformity and reference has been added to the text per Ellis 1994.
116	2.1.4	4	2	The full extent of this syncline….	Comment: Dibblee mapped back in the 1940's and 1950's in this area, John Minch did the editing and digitization around and after Dibblee's death in 2004. Minch is the editor, not the mapper.	Comment accepted. Citation has been edited to refer only to Dibblee.
117	2.1.4	8	3	The USGS in 2013 studied the fault…	Comment: InSAR report notes that deformation did not extend far enough west to be truncated by fault (insufficient data). They concluded without data. This is an important caveat to this statement.	Comment noted. Thank you. No change needed in HCM.
118	2.1.4	23	3	Figure 2-7 shows an overlay….	Edit: "Figure 2-7shows an overlay.." (space needed)	Comment accepted.
119	2.1.4	12	4	The Whiterock fault is a barrier…	Comment: This fault forms part of the boundary to the basin but also extends under the basin (under the Cuyama River and Highway 166) (see Yates et al 1989, Calhoun 1985, Schwing 1984, Nevins 1983. This portion of the white rock (along with the TTRF and GRF) help to impede N-S infiltration of river water into the main (central) basin east of the Russell fault. This should not be neglected in either the HCM or the groundwater model.	Comment noted. References have been reviewed regarding Whiterock fault.
120	2.1.4	23	5	As shown in Figure 2-7, Outcrops	Comment: It is important to note that these outcrops occur west of the area in Figure 2-7 as well (See mouth of Cottonwood Canyon, and other areas mapped by Dibblee). They are very common in the entire western basin, but have not been well mapped or well structurally constrained. The focus has been in the area terrace mapped by DeLong as this is pretty much the best data available. It is not comprehensive.	Comment noted. Thank you. No change needed in HCM.
121	2.1.4	17	6	The USGS in 2013 also concluded…	Comment: Oil well data across this fault (See Ellis 1994 and others) addresses this as well including structure and offset.	Comment accepted.
122	2.1.4	8	7	EKI reviewed the USGS's work in…	Comment: Except at the river, alluvium is above the water table along the fault. This can clearly be seen in mapping of the area. Only the Morales Formation need be truncated for this to be a barrier to flow. The river channel is a spill point between the east and west subbasins.	Comment noted. Thank you. No change needed in HCM.

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123	2.1.4	--	Figure 2-6	--	Comment: This map does not show the Russell fault as continuous across the Valley. To my knowledge, every published geologic map of the area does: USGS 2013, Dibblee, DeLong, Smith and Jennings, Jennings and Strand, Yates et al, Vedder and Repenning, English, Singer and Swarzenski, Upson and Worts. 18 miles of offset along this fault does not occur without a continuous fault plane. When one of the key issues in the valley is both the continuity and offset of this fault to ignore well established maps on the continuity of the fault (all the way across the valley, no gaps) will lead to a LOT of misunderstandings. I realize this is likely a GIS translation issue, but another GIS shapefile which shows the continuous fault across the valley should to be used.	Comment accepted. Data from Ellis 1994 has been reviewed and incorporated as appropriate.
124	2.1.4	--	Figure 2-6	--	Comment: Work in Ellis 1994 pulls the SBCF into Ballinger Canyon and establishes a minimum degree of offset. This line should extend further east.	comment accepted
125	2.1.4	4	Heading	Syncline in the Northwestern....	Formatting Edit: Move header onto next page	comment accepted
126	2.1.6	10	7	The highest values in the Morales...	Comment: Most of the fault discussions in the technical forums have suggested to dealing with faults using a reduction in conductivity. How will this by resolved both in the model and in the conceptual model given that the values would be expected to deviate significantly from average, and given limited pump test data. Hydraulic conductivity across fault zones is an important issue.	Model development will be discussed in the Basin Model section.
127	2.1.6	--	Figure 2-9	--	Comment: There is a major difference between surface mapping (Dibblee and others) and this section line. See annotation (below).	The figure has been reviewed and updated.
128	2.1.7	2	7	Along the eastern edge of the...	Comment: Again, this does not reflect TDS conditions in the western basin which show a sharp change across the Russell fault based on historic data (the USGS water quality series that was used to develop Singer and Swarzenski circa 1965-1970). If you are going to cite this study then you should look at the data the USGS collected in the western area (same time span) that shows the quality shift and address both the cross fault quality change and more broadly conditions in the west. Water quality (both historic and current) across the Russell fault is a KEY discussion point in the basin as it is a metric for helping to define both potential subbasins and management areas.	Comment noted. Groundwater quality will be discussed further in the Geologic Conditions section.
129	2.1.1	1	1	The basin is located at the south...	Edit: "...north of the Western Transverse Ranges (Figure 2-1~~Figure2-1~~)	Comment accepted
130	2.1.2	5	1	Following a period of orogeny...	Comment: Suggest adding general ranges of time in Ma after epoch names	Noted. Text has been revised to include ranges of time in Ma.
131	2.1.2	5	2	This period also correlated...	Edit: "This period also correlated with two transgressive-regressive cycles, when the sea advanced and retreated over the area that is now Cuyama Basin".	Comment accepted
132	2.1.2	6	3	The transition to a predominately...	Edit: "The transition to a predominantely...."	Comment accepted
133	2.1.3	1	5	The Cuyama Valley Groundwater...	Edit: "....nonmarine deposits of Pliocene to Pleistocene age unconformably over~~laying~~ consolidated marine and nonmarine sedimentary rocks of late Cretaceous to middle Cenozoic age on top of ~~overlaying~~ Mesozoic....."	Comment accepted
134	2.1.3	5	1	The Paso Robles Formation part...	Edit: The Paso Robles Formation is part of the Quaternary....	Comment accepted
135	2.1.3	2	2	Recent alluvium is active fluvial...	Edit: "Recent alluvium is active fluvial channel deposits associated with the Cuyama River and other active channels." Suggest header "Stratigraphic Units Within the Main Cuyama Basin Aquifer"	Comment accepted
136	2.1.3	5	2	It is identified by an unconformity...	Comment: How identified? Unconformity is at top of unit? Bottom of unit?	Comment accepted
137	2.1.3	5	3	The Paso Roble Formation is a gray..	Edit: The Paso Robles Formation is a gray, crudely bedded alluvial gravel derived from Miocene rocks and basement rocks of western San Emigdio Mountains east of the San Andreas Fault	Comment accepted
138	2.1.3	1	5	A generalized stratigraphic...	Edit: "...of the Valley is ~~mapped in~~ shown on Figure 2-3."(space needed)	Comment accepted
139	2.1.3	6	--	Morales Formation	Comment: Suggest breaking Morales into separate paragraphs for Upper Morales and Lower Morales, then separate by header "Stratigraphic Units Below the Main Cuyama Basin Aquifer"	Comment accepted.
140	2.1.3	--	Figure 2-2	--	Comments on Figure: - Suggest marking intervals of young alluvium - Morales Formation as "Cuyama Basin aquifer" or something similar and everything below the Morales Formation as "Bedrock (below groundwater basin" or similar - Younger Alluvium - Pliocene highlighted - confirm the unconformity is Pliocene aged	Comment accepted.
141	2.1.3	--	Figure 2-4	--	Comments on Figure: - A-A' does not match USGS (2013a) - B-B' is not discussed in text - Confusing. "Study Area boundary is not the same as the Basin Boundary - the basin is the focus of the study."	Comment noted. Bulletin 118 Basin boundary has been added for context.
142	2.1.4	5	1	There is a syncline in the western...	Edit: "...that roughly follows a west-northwest (WNW)	Text has been edited to remove (NW) acronym after west-northwest and move to the first instance of northwest.
143	2.1.4	etween 14 & 1	1	The South Cuyama Fault.....	Comment: Missing header format: South Cuyama Fault	Comment accepted
144	2.1.4	1	2	Major Faults and synclines are...	Edit: Major ~~F~~faults and synclines are...	Comment accepted
145	2.1.4	13	2	The fault dips southwest by north...	Comment: Wide variation in orientation? Or does it just dip mostly NE?	The text has been revised.

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Comment #	Section	Section Paragraph #	Paragraph's Sentence #	Sentence Starts with, "...	Comment	Response to Comment
146	2.1.4	19	2	The Morales fault is a 30-mile....	Comment & Edit: The Morales thrust has a dip of approximately 30 degrees and has a large amount of offset." Unclear. Suggest "...dips approximately 30 degrees north, and has been mapped with offsets of approximately XXXX feet (reference, date)..."	Comment accepted.
147	2.1.4	14	5	Both faults are considered to be....	Comment on Figure: Turkey Trap Ridge, Graveyard Ridge, and Santa Barbara Canyon Faults should be clearly differentiated as likely barriers to GW flow on the structural map.	Comment noted. Thank you. No change needed in HCM.
148	2.1.4	9	7	EKI reviewed the USGS's work in...	Comment: EKI (2017) concluded that the Russell Fault as implemented in the CUVHM was not consistent with its characterization in the USGS study. We did not make the conclusion you stated. Instead, we recommended further investigation of the hydraulic properties of the fault.	Comment accepted.
149	2.1.4	--	Figure 2-6	--	Comments on Figure: In the Legend - - Remove "reverse faults"; no reverse faults shown in map - Explain SBCF, TTRF, GRF - Show plunge direction on syncline - Use different linetype, halo, or other graphic means to represent faults considered to be GW flow barriers.	Comment accepted.
150	2.1.5	5	3	The top of the Morales Formation...	Comment: Suggest a map of depth to basin bottom or basin/aquifer thickness	Comment noted. Thank you. No change needed in HCM.
151	2.1.6	2	6	Cross sections were created...	Comment: Need better description of the relationship between basin & model layering.	Model layering is described in the model development portion of the report
152	2.1.6	4	3	In the west, younger alluvium...	Edit: "...thick beds ~~up~~ of clay (ranging from 1 to 36 ft. thick)..." Comment: 36-ft thick beds of clay sounds like at least a local aquitard, which contradicts assertion of no aquitards on previous page.	There are no continuous clay layers that cover a large area of the Basin in the reviewed literature. Individual clay lenses are not considered a regional aquitard. The extent and nature of clay lenses is not well understood in Cuyama and could be investigated as a data gap.
153	2.1.6	6	5	In most regions of the basin, the....	Comment: "...of the basin, the top of the saturated zone (the water table) is either..." (or just use water table alone)	Comment accepted. Text is revised to "...of the basin, the top of the saturated zone (the water table) is either..."
154	2.1.6	7	5	In the east and southeastern...	Comment: This section is the first time water transmitting properties are mentioned. It seems contradictory to state properties are "not well defined," yet the hydraulic conductivity "varies greatly laterally and with depth."	Comment noted. Thank you. No change needed in HCM.
155	2.1.6	12	2	Using aquifer tests from 63 wells...	Comment: The distribution of test locations is limited, and wells with data are not located "across the valley."	Comment accepted. Text is revised to state "Using aquifer tests from 63 wells ~~across~~ located primarily in the central portion of the valley."
156	2.1.6	12	6	Data from the 51 wells were not....	Comment: What 51 wells? Different from the 63 wells discussed above?	Comment accepted. The text is revised to "63 wells."
157	2.1.6	12	7	Using groundwater level contours...	Comment: Transmissivity exhibits spatial variability. "Fluctuate" conveys oscillation with time.	Comment accepted.
158	2.1.6	--	--	--	Comments on Figure: - Absolutely nothing on east side? So no hydraulic data for Morales Fm? Or are wells available W of Russell Fault with P/T data? - Need to show data from west of Russell Fault. - Show DWR Basin Boundary as overlay on all maps to avoid confusion. Especially maps from USGS (2013).	The DWR Boundary has been overlayed on the figure. Detailed data on this Basin is not widely available and not widely, spatially distributed.
159	2.1.7	--	--	--	Comment: Suggest point or post maps of WQ data for TDS, Cl, B, NO3. Include symbolization to identify shallow, moderate, deep well data where available. May help to identify both horizontal and vertical data gaps.	Comment noted. Groundwater quality is further discussed in Groundwater Conditions.
160	2.1.8	3	5	Peak flows through the Cuyama...	Comment: suggest mentioning the period of record.	Comment accepted
161	2.1.8	5	2	The basin is comprised mostly of...	Edit: "...comprised mostly of fine- to coa~~u~~rse-loamy soils..."	Comment accepted
162	2.1.8	7	2	Approximately 25 miles of the...	Comment: Wetlands are typically discharge areas - they are GW fed. What is going on here (what is feeding the wetland - perennial SW flows)? The wetlands should be shown on a map.	Citation from US Fish & Wildlife wass incorrectly located and has been removed.
163	2.1.8	8	5	SAGBI data shown in figure Figure...	Edit: "SAGBI data shown in ~~figure~~ Figure 2-16~~8: Recharge Areas, Seeps, and Springs~~..."	Comment accepted
164	2.1.8	9	3	Figure 2-18 shows the location of....	Edit: "Figure 2-1~~8~~6 shows the location..."	Comment accepted
165	2.1.8	9	3	The springs shown in Figure 2-18...	Edit: "The springs shown in Figure 2-1~~8~~6 shows the location..."	Comment accepted
166	2.1.8	9	3	The springs shown in Figure 2-18...	Comments on Areas of Recharge Section: - Where is the discussion of inflows and outflows and system dynamics? - Conceptual 3-D block diagram is needed, in fact it is critical for supporting outreach activities. - Missing land use - processing it is part of IDC work and is surely available. - Groundwater Elevation map - USGS provides for part of the basin.	Comment noted. These items will be discussed in the Groundwater Conditions and Water Budget sections.
167	2.1.8	--	--	--	Comment: Section describes topography, surface water, soil, and recharge potential but not sources of recharge....Include description of sources of recharge?	Comment noted. The amount of recharge will discussed in the Water Budget section.
168	2.1.8	--	Figure 2-16	--	Comment on Figure: Incomplete per 23 CCR §354.14 (d) - need to graphically show recharge areas in addition to these SAGBI soil data. More data available at https://gis.water.ca.gov/app/NCDatasetViewer/	Comment noted. The link is to GDE data, which is discussed in Groundwater Conditions section.
169	General Comment				Comment: Need to develop 3D cartoon diagram, conceptual components of water budget. Not all water budget components are identified, e.g. river relationship to GW, others.	Comment noted. Water Budget components are discussed in the Water Budget section.
170	General Comment				Comment: Need to mention uses of GW, inflows, outflows; main basin outflow is pumping.	Comment noted. Water Budget components are discussed in the Water Budget section.

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171	General Comment				Comment: Spatial component of hydraulic properties is not presented. Same for water level measurement density and water quality data density. Suggest maps showing these data densities or gaps.	Comment noted. Groundwater Conditions components are discussed in the Groundwater Conditions section.
172	General Comment				Comment: Statement re no imported water?	Comment accepted.
173	2.1.2	5	5	The Paso Robles Formation is sandwiched…	Edit: "….it rests ~~uncomforably~~ unconformably below the older alluvium…."	Comment accepted.
174	2.1.2	--	Figure 2-1	--	Comments on Figure: The label for the Santa Ynez Fault appears to have been misspelled ("Yenez"), "Transerverse Ranges" is misspelled (Transverse)	Comment accepted. Figure 2-2 has been revised.
175	2.1.4	11	4	The USGS determined the fault to…	Comment: Subsidence is mentioned in discussion of the Rehoboth Fault as a barrier to GW flow, then it is never mentioned again. Has subsidence been documented in the Basin? Is it potentially problematic? Consider including a brief paragraph discussing subsidence later in the GW conditions discussion.	Comment noted. Subsidence will be discussed further in the Groundwater Conditions section of the GSP.
176	2.1.4	last paragraph	6	The presence of these non-aquifer…	Comment: "The presence of these non-aquifer materials in this area likely *restricts GW movement…*". I'm not sure I agree with this statement. Does an island of bedrock in an alluvial aquifer restrict GW flow? The GW flows around it, correct? When I think restricting flow, I think of faults, barriers, etc. This seems to include a debatable statement where it isn't necessary. Consider simplifying to the "presence of these non-aquifer materials in this area limits the extent of permeable materials in this portion of the basin."	Comment accepted.
177	2.1.4	--	Figure 2-6	--	Comment: If possible, provide direction arrows for strike-slip faults and up/down symbols for normal faults.	Comment accepted
178	2.1.5	3	2	The Cuyama and Carrizo Plain…	Comment: Consider including the neighboring basins (Carrizo Plain too) on one of the figures.	Comment noted. A map of the Cuyama Basin and neighboring subbasins was developed and included in the Plan Area section, please see Figure 1-3.
179	2.1.6	8	5	In the east and southeastern parts of…	Edit: "…where the Morales Formation ~~outcrops~~ crops out, the formation…"	Comment accepted
180	2.1.6	--	Figure 2-9 Figure 2-10 Figure 2-11	--	Comment: Include legend identifying strata depicted in cross sections.	Comment accepted.
181	2.1.7	2	3	With the exception of spikes in nitrate..	Comment: This is an overly broad statement: "…groundwater quality is…typical of alluvial basins." What is typical of alluvial basins? TDS here is pretty high, not typical of the alluvial basins I have worked in to date.	Comment accepted.
182	2.1.7	3	2	Marine rocks produce brackish water…	Comment: This is an overly broad statement: "Marine rocks produce brackish water…" Maybe these marine rocks produce brackish water, and if so, identify the specific formations that produce brackish water here, but there are plenty of marine rocks that don't produce brackish water.	Comment noted. Citation is a direct quote from author.
183	2.1.7	4	7	Nitrate concentrations ranged from…	Edit: "….to 45.3 mg/L, exceeding the SMCL (10 mg/L) in…." Nitrate is a primary standard with an MCL, not a secondary standard with SMCL.	Comment accepted.
184	2.1.7	#1 -3	--	--	Comment: Strongly suggest including a map with groundwater level hydrographs, along the lines of the attached figure for SLO Basin. You discuss historic groundwater quality, but no historic groundwater levels. This is the crux of the biscuit and why the basin is in critical overdraft. A figure with hydrographs can communicate at a glance areas that have significant declines and areas that do not.	Comment noted. Groundwater levels are discussed in the Groundwater Conditions section.
185	2.1.4	9	1	The Russell fault has been…	The InSAR data is only an indicator that a combination of factors were not present to create differential deformation across the fault. These factors include large enough water-level declines to cause deformation along with a fault the can truncate the transmission of those declines across the fault. Although the InSAR images show no obvious differential deformation there is no evidence that it is still not a barrier to or partial barrier to groundwater flow and that the water level declines in proximity to the fault and on either side of the fault were enough to cause a signal of 10mm or more of deformation to be seen in InSAR image (which is the lower resolution when differencing radar reflection images as InSAR). The Russell Fault was treated as a no flow boundary in all layers except for just one cell in the youngest alluvium (layer 1) and a pair of cells in the Morales and Older alluvium directly below the Cuyama River in the Greek Ranch. So the Russell Fault was treated as a flow boundary in the CUVHM model with the concept of potential re-incised channels that could allow some groundwater underflow directly beneath the Cuyama River. "MiniVibe" seismic profiles across the fault on both sides of the River with short receiver spacing's (<1 meter spacing) would probably be needed to better determine the structural integrity and geometry of this potential flow barrier and fault in all three geologic units. The truncation of the geologic units is also indicated by Sweetkind and others (2013). The EKI conclusion is suspect as the hydraulic gradients are generally unknown in the recent alluvium and may well be closer to perpendicular to the river except near the river channel.	Comment noted. Reference provided was inaccurate, correct reference is USGS, 2013c. On pg. 55 the USGS states "Similar to the other faults, the Russell fault did not appear to be acting as a barrier to groundwater flow. " The text has been updated to include this statement.

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186	2.1.4	11	4	The USGS determined the fault to...	Comment: The Rehoboth Fault was treated as an HFB barrier in the younger, older alluvium and Morales in the CUVHM.	Comment noted. Will review CUVHM literature regarding Rehoboth Fault.
187	2.1.4	18	5	The fault is considered a barrier...	Comment: The Santa Barbara Canyon Fault was not represented as a barrier to flow in the younger alluvium in the model cells that represented the Cuyama River channel in the CUVHM.	Comment accepted. Data from Ellis 1994 will be reviewed and incorporated as appropriate.
188	2.1.4				Comment: The entire Cottonwood area is poorly defined including potential faults that could be groundwater flow barriers that are not shown on maps, described, and are not implemented in the new model.	Comment noted. Data and reports on this area are sparse, and details in this area will be noted as a data gap.
189	2.1.4		Figure 2-6		Comment on Figure: Missing faults such as Russell and Santa Barbara Canyon Faults as well as others in the Cottonwood area. These are likely transform faults that create flow barriers along with the other normal and thrust faults in the Cuyama Valley.	Comment noted. Russell fault and Santa Barbara Canyon Fault (SBCF) are shown on Figure 2-6. acronyms have been defined on this figure
190	2.1.5	2	1	The Cuyama Basin is geologically..	Comment: Lateral boundaries lack information from USGS studies and research drilling in Cuyama Valley	Comment noted. Thank you. No change needed in HCM.
191	2.1.6	1			Comment: What aquitards? There is no mention of them or physical data to support such a discussion	Comment noted, The 5th sentence of Section 2.1.6 notes that "There are no major stratigraphic aquitards or barriers to groundwater movement..."
192	2.1.6	3	2	Rocks older than the upper....	Comment: Need citation on "rocks older than the Morales...."	Comment accepted. Text has been revised to include reference to USGS, 2013a.
193	2.1.6	8	5	In the east and southeastern...	Comment: Most of it is far above the zone of saturation	Comment noted. Thank you. No change needed in HCM.
194	2.1.6	11	7	The highest values in the Morales...	Comment: Not sure the statement about yields on the west end is accurate...perhaps different in 1970 when there was more saturated thickness.	Comment noted. Thank you. No change needed in HCM.
195	2.1.6	11	3	The dewatered alluvium has an....	Comment: Specific yields from the 1998 CDWR work states 10-15% used in calibration. Please reference properly. USGS had additional estimates from their Tech files and was published in Everett and others (2013).	Comment noted. Text has been revised
196	2.1.6				Comment: Do not use information from USGS studies	Comment noted. Thank you. No change needed in HCM.
197	2.1.7	5	1	The Cuyama Valley is known for...	Comment: Aquifer use section does not give reference for claim that this is one of the most productive agricultural regions in Southern California. Groundwater has also been used in support of oil-well drilling and secondary recovery techniques.	Comment accepted.
198	2.1.7	#1-4			Comment: Water quality section did not reference the USGS GAMA reports and related sampling. No discussion of age dating, tritium isotopes, trace metals. The citations from Singer & Swarzenski (1970) are interesting] but the section Recent Groundwater Quality uses little to none of the water chemistry, water quality or isotope geochemistry published by the USGS as part of the Cuyama studies and the GAMA project.	Comment noted. Groundwater quality, including discussion of GAMA data will be further discussed in the Groundwater Conditions section.
199	2.1.8	3	5	There are approximately four main..	Comment: Missing/misstating major drainages: should have Upper Cuyama, Rancho Nuevo, Apache Canyon, Berges Canyon, Quatal Canyon, Ballinger Canyon, Santa Barbara Canyon, Branch Canyon, Alisos Canyon, and Cottonwood, as well as the Cuyama River	Comment noted. The GSP identifies the main sources that feed the Cuyama River, only select streams were listed.
200	2.1.8	4	1	No standing bodies of water....	Comment: Surface water bodies section does not catalogue the man-made ponds used as storage for irrigation water	Comment noted. Man-made ponds could be inventoried as a GSP implementation action item.
201	2.1.9	1	1	HCM data gaps are present in the...	Comment: Several Data Gaps not mentioned including pumpage data, annual-seasonal land use and irrigation methods, linkages between where water is extracted and where it is applied for irrigation such as the well at Bell and Foothill roads that pumps groundwater which is transported miles eastward to the main zone across the Rehoboth Fault. Subsidence data is not mentioned and additional streamflow data such as reactivating the gage on the Cuyama River is a huge data gap.	Comment noted. Water Budget components are discussed in the Water Budget section.
202	General Comment				General comment: The report seems more like a compendium of compiled information rather than a "conceptual model." There is no discussion of routing surface waters into the Cuyama GW Basin nor a discussion of how the different components of the Integrated Water Flow Model will work together to synthesize accurate output numbers	Comment noted. Groundater conditions components, water budget components, and the groundwater model will be discussed in the appropriate upcoming sections.
203	General Comment				Comment: Use of Kellogg should be done with caution as our understanding is that this work was largely a compilation of previous studies and had limited field verifications. We recommend that you check with Kellogg before using any of his maps.	Comment noted. Thank you. No change needed in HCM.
204	General Comment				Comment: HCM report uses and cites old reports such as Upson et al. and Singer et al a lot but does not use much of the information from any of the USGS reports Hanson et al. and somare are not even cited such as the USGS Kirschenmann Road Monitoring well site Open File Report.	Comment noted. Thank you. No change needed in HCM.
205	References				Comment: Some USGS citations are incorrect, the format is inconsistent and some references are missing.	The references have been reviewed and updated.

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Comment #	Section	Section Paragraph #	Paragraph's Sentence #	Sentence Starts with, "...	Comment	Response to Comment
1	General	N/A	N/A	N/A	The text is overtly understated regarding significante conditions depicted with conclusive data sets & trends.There is a need to "state the obvious" when viewing conclusive data sets.	Comment noted. No change required in document.
2	General	N/A	N/A	N/A	No historical baseline is established for the discussion of measurable objectives. The contextual perspective of past or current conditions is not generally available. The uncertainty of this will not be helped when a algorithm generates it in the model.	Comment noted. No change required in document.
3	General	N/A	N/A	N/A	Data Gaps are recognized as a significant challenge to fully understanding the groundwater conditions and drive a higher degree of uncertainty when making assumptions & conclusions	
4	2.2	1	N/A	Bullets # 4,5 & 6 of 7	Three intended objectives outlined in the first paragraph of section 2.2, have not been addressed	As noted in the document, these sections are under development and will be available in a future version of this section.
5	2.2.1	N/A	N/A	Fig. 2.2-1	Landmarks - Caliente Range - Ventucopa Uplands (Badlands) - Apache Canyon	Caliente Range and Apache Canyon have been added to Figure 2.2-1. Ventucopa Uplands are not specifically discussed in this section.
6	2.2.3	N/A	N/A	Fig. 2.2-16 to18	If the screening intervals and perforation depths of these three multi completion wells are know and presented here, then why are they not in the Opti DMS?	This information will be added to the Opti DMS for these well locations
7	2.2.3	N/A	N/A	Fig. 2.2-19	Text should explain that the blue arrows indicate the direction of the downward horizontal groundwater flow. These arrows are helpful and should be used in other Groundwater Contour maps.	The text referring to this figure has been updated. There are no other figures in this section for which these arrows would be appropriate.
8	2.2.3	N/A	N/A	Fig. 2.2-20	Illustrates a classic example of a Bullseye depression. Speak to the significance of these conditions. Speak also to the Data Gaps representing the missing northeast area, near the intersections of 166 & 33. How big or deep is the zone of depression?	Comment noted. The document notes that the depth to water is up to 600 feet deep.
9	2.2.4	1	N/A	Bullet #1	Storage loss is a significant groundwater condition that should be measurable, but we are going to model it first. The cart is before the horse!	While changes in groundwater storage can be inferred from changes in groundwater levels, storage quantities cannot be directly measured with the available data. The numerical model will provide the best available estimate of groundwater storage.
10	2.2.6	2	1	Subsidence	Subsidence at a rate of > 0.5" / year should not be dismissed or diminished by comparison to the collapse of the San Joaquin. This is a critical Data Gap with only one monitor site in the central basin. It may or may not be anomalous without anything to compare it to	Comment noted. The need for additional subsidence monitoring is discussed in the Monitoring Networks section.
11	2.2.7 Literature Review	8	1	The USGS reported the following	The USGS, SBCWA & the GAMA data files all indicate constituante levels (TDS, Nitrate, Sulfate, & Arsenic) above MCL in the central basin implicating a causal nexus with localized excessive groundwater extraction.	Comment noted. The data is insufficient to make a definitive conclusion about the relationship between groundwater extraction and water quality.
12	2.2.7	5	2	Toward the northeast end of the basin...	The available data is inconclusive in establishing any trends in conditions over time, stable or otherwise. How can we quantify a minimum threshold and how can we monitor this causal nexus between groundwater extraction & groundwater quality degradation?	Comment noted. The data is insufficient to make a definitive conclusion about the relationship between groundwater extraction and water quality.
13	2.2.7	N/A	N/A	Groundwater Quality	Available groundwater age & temperature data should be used to help determine flow rates over faults, intermixing of aquifer layers, and recharge rates of deep percolation.The response to this same comment on the Draft HCM was that it would be presented in this section of the GSP. What section will it be in next?	As discussed at the November 1 SAC meeting,
14	2.2.8	N/A	N/A	InterconnectedSurface Water Systems	When this section is developed it should additionally include the following: 1.)Consideration of the causal nexus between declines in ephemeral and intermittent streams, and SGMA related activities. 2.)Estimates of the ecological services and emergent benefits of interconnected surface water systems. 3.)Literature Review of the historic loss of the riparian habitats through the valley. 4.)Consider potentials for river channel modification to slow, spread & sink stream discharge for enhanced recharge.	Comment noted. This will be taken into consideration when this section is developed.
15	2.2.9	N/A	N/A	Groundwater Dependent Ecosystems	When this section is developed it should additionally include the following: 1.)Estimates of Evapotranspiration needs of existing GDEs and the stream discharge requirements to satisfy their dependance. 2.)Assessment of the Beneficial Uses and emergent benefits of the biology associated with the GDEs. 3) Consider the causal nexus of desertification and the loss of native wetland habitats due to SGMA related activities. 4)Consideration of enhancing GDEs to facilitate stormwater capture and recharge by the reduction of flash runoff	Comment noted. This will be taken into consideration when this section is developed.
16	2.2.10	N/A	N/A	Data Gaps	Recognised Data Gaps include: 1) Recent groundwater level & quality data in the Ventucopa upland & river corridor, 2) Historical groundwater data from the Cottonwood subarea. 3) More multi-completion wells in the main basin to better understand the zone of depression. 4) Data for Groundwater elevations in the north and west of the basin. 5) Well Completion Data with perforation intervals. Available from down hole video logging. 6) More CGPS Subsidence monitors in the main basin. 7) Current Groundwater quality data basin wide. 8) Surface water flow gauges on the Cuyama in the Basin, at bridges on Hwy 33 in Ventucopa uplands and Hwy 166 in the central basin. 9) Data concerning GDEs in the basin.	Comment noted. This will be taken into consideration when this section is developed.
17	2.2.10	N/A	N/A	Data Gaps	Major Data Gaps continue to generate the concern for the uncertainty of any conclusions made from the assumptions needed to develop a numerical model. Greater uncertainty requires a more conservative approach to model assumptions.	Comment noted. No change required in document.
18	General	N/A	N/A	N/A	In its current form, the draft GWC chapter is incomplete relative to 23 CCR §354.16 because several GWC elements identified above (groundwater storage changes, interconnected surface water systems, and groundwater dependent ecosystems) are included in the chapter only as placeholders and are not complete	Comment noted. No change required in document.
19	2.2.2 GW Hydrographs 2.2.3 GW Contours	N/A	N/A	N/A	The GWC chapter does not adequately reference the hydrogeologic conceptual model (HCM). The discussion of groundwater contour figures lacks any mention of the hydraulic effect of faults. For instance, the HCM documents that SBCF is a barrier to groundwater flow. This significant fact should be used to interpret water level observations ("Groundwater Hydrographs" [2.2.2]; "Groundwater Contours" [2.2.3]).	Comment noted. No change required in document.
20	2.2.2 GW Hydrographs 2.2.3 Vertical Gradients 2.2.3 GW Contours	N/A	N/A	N/A	The GWC chapter does not adequately reference the hydrogeologic conceptual model (HCM). Similarly, the HCM discusses varying hydraulic conductivities between the younger alluvium, older alluvium, and Morales Formation. The effects of hydrostratigraphy should be considered in discussions of vertical gradients, hydrograph comparisons, and groundwater elevation contours ("Groundwater Hydrographs" [2.2.2]; "Vertical Gradients" [2.2.3]; "Groundwater Contours" [2.2.3]).	Comment noted. No change required in document.
21	2.2.3			1947 to 1966 Groundwater Trends	The chapter cites results from the outdated CUVHM model. Cited CUVHM results ("1947 to 1966 Groundwater Trends" [2.2.3]) may be unreliable and obsolete given that WC is developing a new model.	Comment noted. Even after development of the updated model, data from the USGS study will still be a primary source of information for the earlier period from 1947-1966.

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22	Figures 2.2-11 to 2.2-15				Hydrograph figures lack organization and their interpretation is insufficiently clear (2.2-11 to - 15). Partial overlap and repetition of hydrographs make the figures confusing. Figures should be revised so that each one exclusively covers a portion of the basin with unique hydrographs. Well 620 should be discussed under "central portion" because it is north of SBCF and follows the pattern of decline in that region. South of the fault to the Ventucopa area is showing a largely consistent picture of long-term steady elevations (Wells 40, 41, 85) with the exception of decline in Well 62 since the 1990s. The area of decline in the western portion of the basin extends to Well 70, just west of Bitter Creek. Regarding the statement that "all monitoring wells in [the central portion of the basin] show consistent declines, consider that Well 28 has elevations leveling off in the 1990s and then starting to recover in the 2000s.	The figure and text have been made consistent. Title corrected.
23	2.2.3				Referenced hydrographs are missing, or more useful selections are available. Hydrographs for Wells 40, 316, and 640 are discussed in the text but not included in the figures. Consider adding hydrographs for Wells 70, 107, 110, 112, and 114, because they have significantly long data records, fill spatial gaps, and preserve the variation in water level trends observed in the basin. Consider removing hydrographs for Wells 108, 121, 571, 830, 840, and 846 because their data records are too short to reveal much about water level trends.	The figure and text have been made consistent. Title corrected.
24	2.2.3 GW Hydrographs			Groundwater levels followed	The GWC chapter contains unsupported statements. The statement, "Groundwater levels followed climactic patterns" ("Groundwater Hydrographs" [2.2.3]) is ambiguous. If it refers to cycles of wet and dry years, a hyetograph of monthly or annual rainfall totals should be included to support it.	Comment noted. No change required in document.
25	2.2.7 Data Analysis			The spikes of TDS	The GWC chapter contains unsupported statements. The statement, "The spikes of TDS increases correspond with Cuyama River flow events" ("Data Analysis" [(2.2.7]) should be supported by showing a river hydrograph on the same plot.	Figures showing the climactic variability will be included in the Water Budgets section.
26	2.2.1 Useful Terminology 2.2.3 Vertical Gradients				Wells that are screened in different intervals are not differentiated. In two mentions of wells having different depths ("Useful Terminology" [2.2.1], "Vertical Gradients" [2.2.3]), language should be precise that perforations are at different depth intervals.	Comment noted. No change required in document.
27	2.2.3 Vertical Gradients				Improvements are needed in vertical gradient hydrographs and interpretation ("Vertical Gradients" [2.2.3]). The hydrographs should have finer x-axis label resolution than annual, because seasonality is discussed in the document. Regarding their interpretation, hydrographs that behave similarly lend themselves into being grouped by geographic subareas when possible. This type of grouping is one consideration when defining potential groundwater management areas. It is therefore important that these assessments accurately represent the data. Uncertainty must be clearly communicated by (for example) use of hydrographs which reflect the variability observed in a spatial grouping. Some specific examples include:	The scale of the hydrographs have been modified to show greater vertical detail
28	2.2.3 Vertical Gradients				a. (CVFR) "There is no vertical gradient." At the scale of the hydrograph figure, we cannot discern whether there is no gradient or a small gradient.	The scale of the hydrographs have been modified to show greater vertical detail
29	2.2.3 Vertical Gradients				b. (CVBR) We cannot dismiss the contribution of horizontal recharge; the CVFR site shows the basin is not vertically driven, at least not everywhere. Also, given the depth to water it is speculative to conclude vertical recharge exceeds horizontal. Furthermore, the hydrographs show "shallow" wells are influenced by seasonal conditions just as much as "deep" wells.	The text has been revised for clarity.
30	2.2.3 Vertical Gradients				c. (CVKR) "The hydrograph of the four completions shows that at the deeper completions are slightly lower than the shallower completions in the spring at each completion, and deeper completions are generally lower in the summer and fall." This statement seems to say groundwater levels decrease with depth in the in the spring, summer, and fall. Why is winter excluded—no measurements?	The text has been revised for clarity.
31	2.2.3 Vertical Gradients				d.(CVKR) "This likely indicates that...the vertical gradient is significantly smaller at this location in the spring measurements." Or does it indicate that there is no vertical gradient during unpumped conditions?	The text has been revised for clarity.
32	2.2.3 Appendix Y				Errors and overgeneralizations exist in the mapped groundwater elevation contours (including Appendix Y). The text analyzing the contour figures (including in the appendices) contains interpretive errors ("Groundwater Contours" [2.2.3]). For instance, "In the southeastern portion of the basin near Ventucopa, groundwater is mostly between 100 and 150 feet bgs" should be "between 150 and 200 feet bgs."	The text has been revised for clarity.
33	2.2.3 Appendix Y				The same discussions of contour maps in Appendix Y seem to be reused for each season/map, ignoring or smoothing over distinctions between them. For example, an area of low groundwater elevation is described as "northeast of...Cuyama" for Figures Y-1, -3, -5, and -7, yet the figures show that area shifting between the north and northwest of Cuyama.	The text has been revised for clarity.
34	2.2.3 Appendix Y				In several instances, "groundwater levels rising" should be replaced with "depth to water decreasing" because the topic is DTW contours. Contour labels on Figure Y-4 neither match values posted on wells nor represent a 50-ft contour interval.	Figure Y-4 has been corrected.
35	2.2.3 Appendix Y				Explanation of the maps should specify that they "improve understanding of recent horizontal trends in the basin." The inferred contours are unnecessary, speculative, and often seem to be physically unreasonable. The small contour interval relative to low well density causes several occurrences of a "target" effect, where a single well drives the appearance of a dramatic groundwater mound (like a "bullseye"). In some cases, the actual cause of the large head differential appears to be the SBCF. Larger contour intervals would decrease this effect.	Due to the regional nature and large topographic and groundwater depth ranges in the Cuyama Basin, the 50 foot contour interval was chosen to capture trends while not ignoring conditions that are shallower than 100 feet. Like many presentation figure decisions, this one is a compromise. No change made to contour maps.
36	2.2.7 Data Analysis				Explanation of water quality constituents is needed. An explanation of why TDS, nitrate, and arsenic are selected for mapping and discussion would be helpful ("Data Analysis" [2.2.7]).	These consituents were selected because they were identified as being of interest during the stakeholder process. Very limited data is available for analysis of other constituents.
37	2.2.7 Data Analysis				An incorrect Nitrate MCL is cited. The nitrate MCL is cited as 5 mg/L ("Data Analysis" [2.2.7]). It actually is 10 mg/L as N.	The MCL value has been corrected
38	Figure 2.2-25				Consistent time scales in Figure 2.2-25 should be used for clarity. The plot time scales are inconsistent, which makes interpretation unnecessarily difficult.	The time scales on the plots have been set to allow readers to clearly see the data.

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39	Appendix X				The hydrograph appendix contains errors and omissions. Many wells are symbolized in the map but not labeled. Many wells labeled in the map do not have hydrographs included. Data axis label intervals are inconsistent (one year vs. three years). For Wells 90 and 639, the y-axis minimum is too high.	Wells symbolized in the maps incorporated into Appendix X incorporate all "OPTI Wells." These includes both groundwater level monitoring and groundwater quality wells that are included in the source datasets. This means that some wells on the map will not have a hydrograph associated with them. Additionally, some of the wells may overlap one another so closely that GIS is unable to automate every well number label on the map. These limitations are not affected in the online DMS, but Appendix X is intended to provide as much information as reasonable in print form. Hydrograph label axis intervals are automated. Labels still effectively show GWE and DTW. The Y-axis in the hydrographs have been adjusted to show all data in wells 90 and 639.
40	Appendix Z			This loss of aquifer	The subsidence appendix requires further explanation. Regarding the statement, "This loss of aquifer is limited to the water that was stored in the compressed clays, and storage capacity lost is limited to the water that was stored in clays that were compressed" ("How Subsidence Occurs"), what does WC intend to communicate regarding the difference between loss of aquifer and loss of storage capacity? Aren't they effectively the same thing?	The text has been revised for clarity.
41	2.2 GW Conditions	1	1	The groundwater conditions section	Chapter scope. The statement, "The groundwater conditions section is intended to…Define measurable objectives to maintain or improve specified groundwater conditions" ("Groundwater Conditions" [2.2]) is more accurately worded in the following paragraph: "The groundwater conditions described in this section…are used elsewhere in the GSP to define measurable objectives."	The text has been revised for clarity.
42	2.2.1 Useful Terminology				Terms not used in the document. Two defined terms ("Useful Terminology" [2.2.1]) are not used elsewhere in the document, and their purposes should be stated: "historical high groundwater elevation" and "historical low groundwater elevation."	These definitions have been removed from the section.
43	Figures 2.2-1 & 2.2-2				Map symbology. Figure 2.2-1 has non-intuitive and inconsistent symbology. Purple lines and points represent an eclectic set of "landmarks". All the canyons are labeled, but most of the creeks are not. Bitter Creek is referenced many times in this document, but it is not shown on any subsequent figures. In Figure 2.2-2, Bitter Creek and SBCF are mentioned in the text discussion but not shown on the figure.	Comment noted. The purpose of Figure 2.2-1 is to show the locations of elected landmarks in the Basin to assist in discussion of conditions in the section. It is not necessary to repeat each landmark in subsequent figures.
44	2.2.3 GW Hydrographs			In the western area	Unclear sentences. There are several incomplete and/or confusing sentences in the document. "In the western area west of Bitter Creek are near the surface near the Cuyama river, and deeper below ground to the south, uphill from the river, and have been generally stable since 1966" ("Groundwater Hydrographs" [2.2.3]).	The text has been revised for clarity.
45	2.2.3 Vertical Gradients			The hydrograph of the four completions	Unclear sentences. There are several incomplete and/or confusing sentences in the document. "The hydrograph of the four completions shows that at the deeper completions are slightly lower than the shallower completions in the spring at each completion, and deeper completions are generally lower in the summer and fall" ("Vertical Gradients" [2.2.3]).	The text has been revised for clarity.
46	2.2.3 GW Countours			Measurements from wells of different	Unclear sentences. There are several incomplete and/or confusing sentences in the document. "Measurements from wells of different depths are representative of conditions at that location and there are no vertical gradients" should say "…assumes there are no vertical gradients" ("Groundwater Contours" [2.2.3]).	The text has been revised for clarity.
47	2.2.7 Data Analysis			TDS in the central portion	Unclear sentences. There are several incomplete and/or confusing sentences in the document. "TDS in the central portion of the basin" ("Data Analysis" [2.2.7]).	The text has been revised for clarity.
48	2.2.7 Data Analysis			The chart for Well 85	Unclear sentences. There are several incomplete and/or confusing sentences in the document. "The chart for Well 85 at the intersection of Quatal Canyon and the Cuyama River is generally below 800 mg/L TDS with spikes of TDS increases" ("Data Analysis" [2.2.7]).	The text has been revised for clarity.
49	Appendix Z			[Subsidence is] not restricted	Unclear sentences. There are several incomplete and/or confusing sentences in the document. "[Subsidence is] not restricted in rate, magnitude, or area involved" (Appendix Z).	The text has been revised for clarity.
50	2.2.7 Reference and Data Collection				Links and sources identical. Two different DWR data source links ("Reference and Data Collection" [(2.2.7]) share the same web address.	The link for the CNRA dataset has been updated.
51	General	N/A	N/A	N/A	It seems that there has been no examination of faults/aquitards down stream (West) from the basin border. While it is acknowledged that the GSA has no authority beyond the defined basin, it would seem that knowing what the further extent of pooled ground water is present and where/why that water is held back would be important for making management decisions in that segment of the basin. It may well be that the basin's western limit was drawn for exactly to account for this but that does not seem to be clearly spelled out.	Comment noted. This is outside of the scope of the GSP.
52	Figure 2.2-1				On Figure 2.2-1 the location of the Russell Ranch Oil Field is not too accurate….it is also wrong on OPTI ID (Jane to send Brian a map).	Russell Ranch Oil Field has been removed from the figure.
53	Appendix X				In the hydrographs (appendix X), many of the wells on our place are no longer there. It is misleading because some wells were drilled, tested once and that was it. I guess they give info about water depth.	The maps and data in Appendix X are intended to show the groundwater level information that is available historically in the Basin. Because of this, many wells that no longer exist will be included.
54	Figures Y-4 & Y-6				Just based on what I know the stats were on our wells, it looks like Figures Y-4 and Y-6 are over-generalized. Some places we saw differences and some places the Wells didn't fluctuate all.	Comment noted. The contour maps represent estimates based on the available information in each period.
55	General				On all maps, in every section, please show the major faults and major streams as landmarks for easier location of what is being shown on the specific map.	This represents too much detail for most maps in the section. Figure 2.2-1 is intended to provide geographic locations of features for reference.

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56	General				Age dating of water is an important component of groundwater conditions since it indicates sources and recharge. Any claim for surface recharge of the groundwater needs to be validated by tritium analysis.	This is incorrect. Tritium analysis can provide some useful information about groundwater recharge, but is not a conclusive method for determining whether surface recharge has occurred.
57	General				The Cuyama Basin needs dedicated test wells at critical locations in order to better understand groundwater availability and movement	Comment noted. Potential locations of new monitoring wells is discussed in the Monitoring Networks section.
58	2.2.3 GW Trends				While the maps clearly show the decades-long downward trend of the central basin (Figure 2.2-7), the narrative just mentions specifics and does not give enough of a full watershed overview of how there are records since 1950 of extraction without replenishment which has created a record of a severe downward trend of approximately 500 feet over 6+ decades. This overview is key to establishing minimum thresholds for the GSP since this downward trend needs to stop with no continued depletion. We recommend adding a summation overview to this section.	Comment noted. This level of detail is not needed in this section.
59	2.2.4 Change in GW Storage				The determination of groundwater storage from the model seems backwards, since the model is highly dependent on how much water there is to pump. Isn't there data available to inform the groundwater storage available in certain areas? Without such data the accuracy of the model seems much more uncertain.	The model provides the best estimate currently available of the quantity of groundwater storage available.
60	2.2.6 Land Subsidence				Any subsidence can negatively affect groundwater storage. The very limited measurements to date don't adequately determine if current subsidence has been occurring for a long period of time or is just beginning. This creates a data gap that adds more uncertainty to the model and therefore more monitoring sites are needed to determine both rates and extent of subsidence.	Comment noted. The need for additional subsidence monitoring is discussed in the Monitoring Networks section.
61	2.2.7 GW Quality				This section on groundwater quality reports on various constituents' historical conditions, but does not develop a foundation for a baseline for future monitoring nor identify what constituents are recommended for monitoring.	Monitoring is addressed in the Monitoring Networks section. There is not enough existing historical data to 'establish a baseline' in this basin.
62	2.2.7 GW Quality				In reviewing the information in this section, plus in discussing this in meetings as well as with the CCSD and other hydrologists involved in monitoring wells in the Cuyama Basin, we would recommend that current baselines be established for TDS, nitrate levels, and specific heavy metals such as arsenic relevant to different areas of the basin	What is a 'baseline' for TDS, arsenic, nitrates and metals? This is not a term typically used in conjunction with water quality
63	2.2.7 GW Quality				Monitoring be established that relates depth of groundwater extraction to constituents present and monitors for changes over time. Water quality analysis should also include tritium analysis to determine the age dating of water and verify if recharge from the surface is occurring.	The relationship between depth to groundwater and the concentration of water quality constituents is not known in this basin due to limited groundwater quality monitoring information - therefore - the relation between depth and constituent concentration cannot be developed accurately, and is a data gap that should be filled during GSP implementation
64	2.2.7 GW Quality				How will nitrogen loading from both agricultural applications and groundwater use be monitored?	GSAs do not have authority toregulate agricultural fertilizer practices - therefore, the GSA will not be monitoring them.
65	2.2.7 GW Quality				How will arsenic induction by extraction of ancient water be monitored?	It won't be performed as a part of the initial GSP - the relationship between depth to groundwater and the concentration of water quality consituents (like arsenic) is not known at this time. The GSA board may decide to establish an arsenic monitoring program as part of GSP implementation and expansion of the water quality monitoring grid, but existing monitoring is erratic, spatially inaedquate and not useful for this purpose.
66	2.2.7 GW Quality				Does CCSD have a time series of arsenic level in their wells to see if changes have occurred?	The CCSD has not provided water quality data
67	2.2.8 Interconnected Surface Water Systems				This section will also need a historical component of surface water loss through looking at riparian habitats.	Comment noted. Historical information on surface water loss is not available except through model estimates.
68	2.2.9 GDE				A response to the study being conducted by a consulting biologist: this study should be done when GDEs are most biologically active and engage ground-truthing by accessing local knowledge of the different areas of the Basin.	Comment noted.
69	2.2.10 Data Gaps				Throughout this section data gaps are referred to, but are not listed here. The fact that there are so many data gaps in this section is very disconcerting, since most of these gaps provide critical data to inform the model. Not having these data introduces greater uncertainty in the validity of the model.	Comment noted. The model will be developed based on the best available information that is currently available, but can be updated in the future.
70	Ch 2 Intro	1	1	This document includes the	It looks like some the GSP regulations for § 354.8 is missing or maybe part of another chapter. Other GSP Regulations seem to be included but not listed.	As noted, this is just one section that will satisfy the requirements of § 354.8
71	2.2.1 Useful Terminology	N/A	N/A	MCL – Maximum Contaminant	Suggest defining the Primary and Secondary MCL which is discussed in the document, but not defined.	These terms are not used in the document.
72	2.2.2 GW Elevation Data Processing	Bullet list	N/A	N/A	Please verify if any wells are duplicates and/or reported to multiple agencies?	This was performed prior to development of the section.

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73	2.2.2 GW Elevation Data Processing	2	2	Data collected also included	Please clarify the meaning of "questionable measurement code"	This information is provided by monitoring agencies to indicate when conditions at a well effect the quality of a measurement. This level of detail is not needed in this document.
74	Figure 2.2-2 & 2.2-4	N/A	N/A	N/A	Please label [Bitter Creek] on figure.	The location of Bitter Creek is shown in Figure 2.2-1
75	2.2.1 Useful Terminology	N/A	N/A	Figure 2.2-1	Add faults to acronym list (missing GRF and TTRF)	These have been added to the acronyms list
76	Figure 2.2-2	N/A	N/A	N/A	Suggest removing the word Earlier from figure and adding actual years, if possible	This change is not needed as the purpose of this figure is to highlight wells with recently measured data.
77	General	N/A	N/A	N/A	Suggest showing State and Federal lands on all of the figures. This may help the public understand why some areas have no wells or water quality data.	These are shown on the figures in the Plan Area section.
78	General	N/A	N/A	N/A	Suggest adding stream/creek names to all figures that mentioned streams/creeks in the description of the figure.	The stream names have been added to Figure 2.2-1
79	Figure 2.2-3	N/A	N/A		Suggest adding on figure abbrev. or defining terms in the description of Figure 2.2-3 for CVKR, CVFR, CVBR	These are names that are provided for the wells. We assume they are abreviations, but have not come across definitions, and thus cannot provide that information.
80	Figure 2.2-5	N/A	N/A		Suggest - Label on figure (Russell Ranch Oilfields, Cottonwood Canyon, & Aliso Canyon)	These are labeled on Figure 2.2-1
81	Figure 2.2-11	Bullet list	N/A		Round Springs Canyon, near Ozena Fire Station & Springs Canyon, near Ozena Fire Station - Please label on figures.	These are labeled on Figure 2.2-1
82	2.2.3 GW Hydrographs			Figure 2.2-12 shows	Suggest stating your interpretation of why this area is having a quick recovery (for example - stream influence provides recharge to this basin area / fault/ etc.), if known or is additional investigation required?	Comment noted. This is beyond the scope of this section.
83	2.2.3 GW Hydrographs			Near Ventucopa, hydrographs for Wells 85	Suggest defining climatic patterns.	Figures showing the climactic variability will be included in the Water Budgets section.
84	Figure 2.2-12			The hydrograph for Well 40	Missing: Suggest adding well hydrograph to the Figure 2.2-12. (for wells 40 & 316)	The text has been revised for clarity.
85	2.2.3 GW Hydrographs	9	2	The hydrographs in this area show consistent	Suggest adding your interpretation of why this area shows consistent decline and little to no responses, if known or is additional investigation required?	Comment noted. This is beyond the scope of this section.
86	Figure 2.2-14	10	3	Levels remain lowered along	Missing: Suggest adding well hydrograph to the Figure 2.2-14. (well 640)	The text has been revised for clarity.
87	2.2.3 GW Hydrographs	10	4	Groundwater levels are higher to the west	Suggest adding your interpretation of why this area shows consistent decline, if known or is additional investigation required?	Comment noted. This is beyond the scope of this section.
88	Figure 2.2-15	N/A	N/A		Please define GSE and WSE – located on hydrographs	These have been added to the acronyms list
89	2.2.3 Vertical Gradients	Bullet list	N/A	CVFR is comprosed of four completion	Please clarify term "completion". Is this a cluster of monitoring wells?	A sentence has been added to the section to define "multiple completion well"
90	2.2.3 Vertical Gradients	Bullet lists	N/A	N/A	Suggest showing the map location for CVFR, CVBR, and CVKR if possible.	The locations of these wells are shown in Figure 2.2-3
91	2.2.3 GW Countours	Bullet List	N/A	Due to the limited spatial amount	Please explain more of the process to generate the contours in this section or in an appendix, number of wells used, etc.	Comment noted. Additional information is not needed.
92	2.2.3 GW Countours			The contour maps are not indicative	Suggest adding: do not account for topography ***or faults*** . A short discussion on faults would be helpful to the public with the groundwater contours.	The faults are discussed in detail in the GCM section.
93	Figure 2.2-20				Bitter Creek - Place label on figure	This is labeled on Figure 2.2-1
94	2.2.3 GW Countours			Contour maps for spring 2017	Suggest explaining the difference between the years from all of these figures, to help the public understand what they are reviewing.	The text has been added to the document.
95	Figure Y-1, Y-3, Y-5, Y-7				Suggest adding groundwater flow arrows to the figure	Groundwater flow arrows have been added to these figures
96	Figure Y-1				Ozena fire station - place label on figure	This is labeled on Figure 2.2-1
97	2.2.3 GW Countours			The contour map shows a steep	The contour map shows a steep gradient ***north*** of - Suggest verifying the direction	The text has been revised for clarity.
98	2.2.6 Land Subsidence	N/A	N/A	N/A	Suggest showing and discussing the entire basin area, as well as showing the three stations (P521, OZST, and BCWR) on a figure with graphs, if possible.	The current figure shows all 3 station locations. The data for P521 is shown because it is the most relevant.
99	2.2.7 Data Analysis	2	2	In 1966, TDS was above the MCL	Please list and discuss all of the secondary MCL standards for TDS (500 mg/L; 1,000 mg/L and 1,500 mg/L) and why 1,500 mg/L is being recommended.	Comment noted. No change needed.
100	Figure 2.2-23	N/A	N/A	N/A	Place label on figure (Ozena Fire Station, Santa Barbara Canyon, and upper Quatal Canyon)	These are labeled on Figure 2.2-1
101	2.2.7 Data Analysis			In the 2011-2018 period, TDS was	In the 2011-2018 period, TDS was above the **MCL** in over 50% of measurements. - Suggest listing which MCL standard?	Comment noted. No change needed.
102	Figure 2.2-24	N/A	N/A		Place label on figure (Quatal Canyon, and along the Cuyama River between Cottonwood Canyon and Schoolhouse Canyon)	These are labeled on Figure 2.2-1
103	Figure 2.2-25	N/A	N/A		Place label on figure (Quatal Canyon)	This is labeled on Figure 2.2-1

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104	2.2.7 Data Analysis			Figure 2.2-26 shows that the	Figure 2.2 26 shows that data collected in 1966 was below the MCL of 5 mg/L throughout the basin, with **some measurements** above the **MCL** in the central portion of the basin where irrigated agriculture was operating Suggest adding number of samples: ## samples out of ### total samples & Suggest adding the primary MCL for nitrates to be consistent with the rest of the page	Nitrate MCL has been corrected to 10 mg/L
105	2.2.7 Data Analysis			Figure 2.2-27 shows that the	Figure 2.2 27 shows that data collected over this period **was generally** below the **MCL**, with two measurements that were over 20 mg/L. Suggest adding number of samples: ## samples out of ### total samples & Suggest adding the primary MCL for nitrates to be consistent with the rest of the page	Nitrate MCL has been corrected to 10 mg/L
106	2.2.7 Data Analysis			Figure 2.2-28 shows that the	Figure 2.2 28 shows arsenic measurements from 2008-2018. Data was not available prior to this time period in significant amounts. Figure 2.2 28 shows arsenic measurements **were below** the MCL of 10 ug/L where data was available. Suggest adding number of samples, ## samples out of ### total samples	Text has been revised for clarity.
107	Figure 2.2-31				Place label on figure (Ballinger, Quatal, and Apache Canyons)	These are labeled on Figure 2.2-1
108	2.2.7 Literature Review	Bullet List		97% of samples had concentrations greater than	Is this the MCL for each concentration? If so, please add the MCL in the bullet point	These are not the MCL. No change needed.
109	General				This section as a whole requires significant revision. The description of wells needs to be revised to be clear what entity conducted the monitoring, not what database W&C gathered the data from. For a discussion of SBCWA monitoring programs in the basin, the SBCWA contract with the USGS, and its relationship to CASGEM, please contact Matt Scrudato. This section contains minimal analysis of groundwater conditions, just reporting of selected hydrographs, with little explanation or interpretation. The water quality section is confusingly structured and incomplete. Finally, although we understand the time sensitivities in preparing the GSP by spring 2019, it would save reviewers quite a bit of time if a technical editor or senior W&C staff member reviewed these sections prior to distribution.	The section has been revised for clarity.
110	General				Most of the wells in the basin are not dedicated monitoring wells, but are frequently described in this section as such.	Text has been revised for clarity.
111	2.2.1 Useful Terminology	Bullet list		There are two versions of contour maps	Consider breaking identification of gw elevation and depth to water info out into a separate bullet point. GW elevation and depth to water are not just used on contour maps, they are used in hydrographs as well.	Text has been revised for clarity.
112	General				Please change "collected" to "compiled" throughout this section. It is potentially confusing to the reader to describe gathering data from various sources as collecting data. Typically collecting well data refers to taking measurements	Text has been revised for clarity.
113	2.2.2 GW Elevation Data Processing	1	1	Groundwater well information and	"collected from **local stakeholders**" - These appear to be included in the 8 major sources.	Text has been revised for clarity.
114	2.2.2 GW Elevation Data Processing	Bullet List		Well and groundwater elevation data were	Was data collected from the CSD? If so, include in list.	No data was collected from the CSD
115	2.2.2 GW Elevation Data Processing	Bullet List		list of data	Include references for publically available data sources; Any available info on data validation, and collection would be useful for these.	References are included in the Data Management GSP section
116	2.2.2 GW Elevation Data Processing			Data collected included well information	Data accuracy section is needed. What standards/protocols are each of these data collection entities following? How is ground surface elevation being determined. DGPS like the original USGS model? Off a map with +/-20 foot accuracy? Please elaborate.	This has been addressed in a footnote.
117	Figure 2.2-2 & 2.2-3				Figures should be titled differently. These are not DWR wells. They are wells with data pulled from the DWR database. The DWR database I assume is CASGEM, which was ultimately collected by SBCWA/USGS. The database that Woodard and Curran compiled the data from is ultimately less important than how it was gathered. Need to make distinction in the title (which is different on the actual figure) of what this is supposed to show. Where they got the data and/or who collected it? Actual title on figure says "DWR Wells" which is not an accurate statement.	Figure titles have been revised for clarity.
118	2.2.2 GW Elevation Data Processing			Roughly half of the wells from DWR's database	Please provide context for why this is important in the text. "measured in 17-18 is mentioned throughout without context. This is a plan that will be issued in 2020. Why 17-18 is the focus needs to be explained.	Text has been revised for clarity.
119	2.2.2 GW Elevation Data Processing			Data collected from the DWR	This is confusing. Data was perhaps collected by Woddard and Curren from DWR, but the data was not collected by DWR. Clarify data received (how / where did they locate the data) vs collected (who and how collected.	Text has been revised for clarity.
120	2.2.2 GW Elevation Data Processing			Data collected from the DWR	"one measurement in the spring, and one measurement in the fall " - If this refers to the CASGEM wells this is not entirely true – most wells monitored 1xyear with a few 2xyear	Text has been revised for clarity.
121	Figure 2.2-3				This list of wells is mostly accurate, but is missing some wells like Spanish Ranch on far west end.	Wells included in Figure 2.2-3 have been reviewed and it has been confirmed that the Figure includes all well data provided by the USGS
122	2.2.2 GW Elevation Data Processing			Data collected from USGS has been typically measured bi-annually	Not entirely true. And there is data overlap here with CASGEM program. Again, describe SBCWA/USGS monitoring program.	Text has been revised for clarity.

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123	2.2.2 GW Elevation Data Processing			Santa Barbara wells are concentrated in the western portion	This does not include all wells monitored by the County. The County does not own these wells, and monitors far more than just these wells.	The maps show the wells and data that had been provided as of June 2018.
124	2.2.2 GW Elevation Data Processing			Data collected from the counties	"measured bi-annually" - Currently making quarterly measurements. Appear to be missing wells. Were a few select wells chosen?	Text has been revised for clarity.
125	Figure 2.2-4				Missing a few. Difficult to determine how many. At some point need to should describe why/how these are different from DWR/CASGEM and USGS program. For example, Matt Scrudato is monitoring in the west end because there is a lack of data in that area – something SBCWA agreed to do to help with GSP development.	The maps show the wells and data that had been provided as of June 2018.
126	2.2.2 GW Elevation Data Processing				Need to add a section somewhere that describes QA/QC process, who does it (USGS, SBCWA), who doesn't (Bolthouse/Grimmway/Grapevine), and why.	This has been addressed in a footnote.
127	2.2.2 GW Elevation Data Processing			The locations of SBCWA well data are located	What is the difference between these wells and the wells referenced in Figure 2.2-4? SBCWA should be taken off Figure 2.2-5 for several reasons (we don't own the wells shown, we're not a private company, we're not ag, etc). All of wells measured by Matt Scrudato should be in Figure 2,2-4	Wells included in these figures have been reviewed and it has been confirmed that the Figure 2.2-4 includes all well data provided by the SBCWA and that Figure 2.2-5 includes all well data provided by private landowners.
128	2.2.2 GW Elevation Data Processing			The locations of SBCWA	"The locations of SBCWA well data are located **west of Cottonwood Canyon**" - West of Aliso Canyon would be more accurate	Text has been revised for clarity.
129	2.2.2 GW Elevation Data Processing			The date of measurement varies significantly by year.	Explain why this is important as context for the reader.	Text has been revised for clarity.
130	2.2.2 GW Elevation Data Processing				"Data provided by Grapevine Capital Partners is **bi-annual** " - quarterly	Text has been revised for clarity.
131	Figure 2.2-7				This graph is more confusing than helpful. Please reomve. Well locations are already identified previously and hydrographs are better described in later sections. The need for this statement and graph appears to be validation for the quality of water level data provided by Grimway and Bolthouse. This should be done in a separate data validation section. Please remove the statement "accurate measurements" from this paragraph. At best, the statement can note that data "match ing tracking historical trends within a 4-mile area", but in no way should refer to these data as "accurate measurements". Then again, what is the definition of an "accurate measurement"? The USGS states that discrete water level measurements made with graduated steel or electric tapes are accurate to 0.01 foot. What standard is Woodard & Curran using? If this graph is kept in the document, the graph should start in about year 1977 when there is a comparison between the data sets. The data prior to this is irrelevant. It is not clear which well relates to which line on the graph. 1. Were there any wells which were monitored by BOTH Grimway/Bolthouse and the USGS where data can be compared for a single location? Are these all the Grimway/Bolthouse wells where data are available or only a select few? 2. DWR are not collecting well data in Cuyama	The figure is included because of interest expressed during public meetings regarding how data provided by private landowners compares with data provided by public agencies. The text describing the figure has been revised for clarity.
132	2.2.2 GW Elevation Data Processing			Figure 2.2-7 shows a comparison of data	Need context to explain why this comparison is being done.	Text has been revised for clarity.
133	2.2.2 GW Elevation Data Processing			Figure 2.2-8 shows a comparison of data	Need context to explain why this comparison is being done.	Text has been revised for clarity.
134	Figure 2.2-8				The need for this statement and graph appears to be validation for the quality of water level data provided by Grapevine Capital Partners. Please remove both the discussion (page 2.2-11) and the graph as these data illustrates nothing at all. 1. Two of the Santa Barbara County wells are not even part of the network. I don't even think these wells exist in the Valley. It is unclear where these data came from. 2. You appear to be comparing very shallow wells to a 6 of the 12 deep production wells. 3. Are these discrete static water level measurements used for the Grapevine data or select points from the continuous 5-minute data sets? SBCWA has been making periodic discrete water level measurements at the 12 productions wells on the Harvard property. A comparison of 26 measurements shows differences between discrete water level and computed water levels ranging from -47.9 feet to 150.36 feet. These are large outliers when compared to all the measurements, but would be a better indication of the data quality (see chart below). SBCWA has measurements from 9/2018 to compare as well. There would be some variation of only a few feet in this comparison based on equipment PSI (most likely higher PSI being used due to large level changes and therefor reduced accuracy), MP elevation choice, computation procedures, etc. Please contact Matt Scrudato to discuss specifics.	The figure is included because of interest expressed during public meetings regarding how data provided by private landowners compares with data provided by public agencies. The text describing the figure has been revised for clarity.
135	2.2.2 GW Elevation Data Processing			A long term comparison is not possible	The wells are in different locations, what value does this provide?	The figure is included because of interest expressed during public meetings regarding how data provided by private landowners compares with data provided by public agencies. The text describing the figure has been revised for clarity.

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136	Figure 2.2-5				Again, misleading title here vs. actual figure which states "Owners and Operating Entities" SBCWA does not own or operate the wells assigned to us in this graph. We only own and maintain CVFR, CVKR, and CVBR. Further this map does not include most of the wells measured by the SBCWA	The figure title has been revised for clarity
137	2.2.3 GW Trends				This section needs major reorganization. There is a time based section, then a number of other sections without a designated timeframe. Also, the wording in this section needs a thorough review by a technical editor.	The text has been revised for clarity.
138	2.2.3 1947 to 1966 GW Trends			1947 to 1966 Groundwater Trends	Hydrographs illustrated are all through 2018. Are you trying to differentiate between times or is the next section a separate concept? If so, there needs to be discussion on more current trends following 1966.	The text has been revised for clarity.
139	2.2.3 GW Hydrographs			Groundwater Hydrographs	This is confusing. The previous section is about a specific time period. If this is 1966-present you should say so.	The text has been revised for clarity.
140	2.2.3 GW Hydrographs			Groundwater hydrographs were developed to provide indicators	What indicators? Don't the hydrographs just show trends?	The text has been revised for clarity.
141	2.2.3 GW Hydrographs			Hydrographs for all monitoring wells with elevation	There can be a big difference between a monitoring well and a well that is being monitored. Be more clear.	The text has been revised for clarity.
142	Appendix X				Comments on Appendix X: 1) Some graphs extrapolate off the hydrograph – is this in error or is there a data point(s) not shown? 2) Similarly, some graphs don't show any data points. 3) Scale issues 4) No need for one per page, consider 4 5) Hydrographs don't identify data source, who and how collected and whether data has been QA/QC. Consider adding an index of all wells, like a lookup table, with OPTI number, USGS number, and well number owner/operator uses, etc.	1) This has been fixed by increasing vertical scale 2) Some OPTI wells only have groundwater quality data associated with them. Because there are so many wells, a hydrograph was made for every OPTI well; therefore some do not have level data. 3) This has been addressed in #1. The graph scales were selected to show the depth to water of all wells on the same scale. 4)One figure per page allows greate detail to be seen in the graphs, as some have a significant amount of data points. 5) This information is available through OPTI for those who would like to review it.
143	2.2.3 GW Hydrographs			Figure 2.2-11 shows Hydrographs in different portions	Please describe in the text why these wells were chosen. Are they representative of the areas?	The text and figure have been revised for clarity.
144	2.2.3 GW Hydrographs	Bullet list		In the area southeast of Round Springs Canyon	Please edit for clarity and grammar. Also, if you are going to describe the hydrographs, you should describe all of them If they want to generalize then make the graph mimic these areas, pick 5 representative hydrographs. Right now there are 7 on the Figure which looks cluttered.	The text has been revised for clarity.
145	Figure 2.2-11				Bitter Creek area - Illustrate on map as a reference	This is labeled on Figure 2.2-1
146	2.2.3 GW Hydrographs			Figure 2.2-12 shows selected hydrographs	Why is this section in a different format than the previous. Please make consistent.	Comment noted. No change needed.
147	Figure 2.2-12				Well 40 & 316 - where? Not shown in map	The text has been revised for clarity.
148	2.2.3 GW Hydrographs			Figure 2.2-13 shows hydrographs of discontinued monitoring wells	Then need to explain why they were selected.	The text has been revised for clarity.
149	General				Stick with one descriptor – either elevation or depth to water. Mixing elevation and depth to water is confusing to the reader.	The section consistently discusses depth to water
150	Figure 2.2-14				Well 640 - where? Not shown in map	The text has been revised for clarity.
151	2.2.3 GW Hydrographs			Figure 2.2-15 shows hydrographs of monitoring wells	The discussion on west end hydrographs and the related Figure 2.2-15 is misleading. Continuous data sets from the 12 wells indicate water levels drops as large as 100 feet in CHG-14 since data collection started in June 2017. This well is the extreme, where other production wells on Harvard vineyard property show water level drops of 25-50 feet. The trends indicate the yearly hydrologic minimum continues to drop.	Wells shown in Figure 2.2-15 show a range of conditions in the western edge of the Basin. OPTI Well 840 shows conditions see in part of the Basin.

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152	2.2.3 GW Hydrographs			Hydrographs for wells 571 and 108	Earlier discrete data located in NWIS.	Well 571 (USGS Code 345847119534901) only has two measurements as shown in the hydrograph (https://groundwaterwatch.usgs.gov/AWLSites.asp?S=345847119534901&ncd=) Well 108 has 8 measurements. Individual points are difficult to destinguish due to hydrograph size, but the hydrograph is correct.
153	Figure 2.2-11				Suggest illustrating hydrographs using same scale / minimize white space for all Figures in this section	All hydrographs on each figure are the same scale
154	Figure 2.2-12 & 2.2-13				Actual Figure has typo in title Also for all Figures in this section, suggest only showing hydrographs referred to in text.	The figure and text have been made consistent. Title corrected.
155	2.2.3 Vertical Gradients			Knowledge about vertical gradients is required by regulation	Please cite the regulation for the reader.	The text has been revised for clarity.
156	2.2.3 Vertical Gradients			Figure 2.2-16 shows the combined hydrograph	State that these wells were installed by USGS as part of the Cuyama Valley Water Availability Study in cooperation with the SBCWA. Multiple completion wells are owned by SBCWA.	This text has been added.
157	Figure 2.2-16, 2.2-17, 2.2-18				The data used to determine there is no vertical gradient as illustrated in the figure 2.2-16 (page 2.2-27) appear to be discrete measurements. At times, there were only two discrete measurements in a year with the remainder of the year interpolated. This is not enough data for an elevation comparison. The USGS used continuous 15-minute unit value data for this nested well and concluded the following (from page 39, Scientific Investigations Report 2013-5108) CVFR.....did show similar seasonal and longer-term changes. Similar to CVKR and CVBR, the vertical hydraulic gradients were upward during the winter months and reversed to downward gradients during the irrigation season; however the gradients at the CVFR site were notably smaller. USGS conclusion supported by water chemistry samples showing increased tritium with depth which may result from younger water from shallow sytem. Woodard & Curran should review the full continuous data set prior to making a conclusion about vertical gradients. Data are available on NWIS. This is data for 3B2- https://nwis.waterdata.usgs.gov/ca/nwis/uv?cb_72019=on&format=gif_default&site_no=345351119323102&period=&begin_date=2010-09-04&end_date=2012-09-01 1.The scale used in these graphs (2.2-16, 17 and 18) mask the trends and makes any analysis impossible. Please change the graph scale for all three graphs (2.2-16-18). 2.The x-axis date scale for Figures 2.2-16 and 17 follow an unusual interval. Is this done for any specific reason (see figure below)? A graph with a scale that masks everything that is happening. A 600 ft axis for a graph with an 80 ft range.	Available Continuous Data has been added. Continuous data is only available from 7/21/201 through 11/28/2012 as it has been "Approved." All other "Provisional" data is only available in summary form, which is the data that was being shown in the hydrograph. Newly added continuous data follows the trend that was already shown on hydrograph.
158	2.2.3 GW Countours			Groundwater contour maps were prepared for	Where is 2016	The hydrograph periods were selected to show the change over the most recent period of 3 years for which data was available in the Spring (from 2015 to 2018) and from the Fall (from 2014 to 2017). Therefore, a figure for 2016 was not necessary.
159	2.2.3 GW Countours			These years were selected	Explain in the text the importance of this date in relation to SGMA. Why? Explain. I may have missed this in earlier sections but are they choosing Jan 1 2015 as their baseline?	The text has been revised for clarity.
160	2.2.3 GW Countours			Each contour map is contoured at	Labels and symbols should be obvious on the map without having to describe in the text	Comment noted. No change needed.
161	2.2.3 GW Countours			Due to the limited temporal amount	Non-pumping and static measurements? What was the selection of wells based on? It appears wells are missing.	The maps are based on available data during the period in question.
162	2.2.3 GW Countours			These assumptions make the contours	Explain in the text which wells aree used and why? Howe was data interpolated?	The maps are based on available data during the period in question.
163	Figure 2.2-19				Correct typo in text on lower right of map - "limitated"	The figure has been corrected.
164	Appendix Y				Where are contour maps for 2016?	The hydrograph periods were selected to show the change over the most recent period of 3 years for which data was available in the Spring (from 2015 to 2018) and from the Fall (from 2014 to 2017). Therefore, a figure for 2016 was not necessary.
165	2.2.3 GW Countours				These descriptions are not useful with the maps in the appendix. The descriptions should be with the maps, either here in the text or back in the appendix.	Comment noted. No change needed.

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166	2.2.3 GW Countours			Figure Y-1 through Figure Y-8	Explain reason for changes in seasonal contours.	Comment noted. No change needed.
167	2.2.4 Change in GW Storage			Change in groundwater storage for the last 10 years	Why 10?	SGMA requires 10 years of data for historical water budgets
168	2.2.6 Land Subsidence				The paper mentions that the USGS determined 0.2 feet of subsidence in 10 years. This appears to be the change in daily land surface elevation starting in about May 2007 (0.00 mm) and ending in April 2012 (-68mm). This would be a 5-year period of record for analysis. The full 12 year period of record from 2000-2012 is 0.4 feet of subsidence and the 10-years mentioned in the W&C paper (2000-2010) is 0.26 feet of subsidence. Woodard&Curran used data from 1999 to 2018 to determine 1 foot of subsidence. The brief and general summary of the USGS data and analysis from SIR 2013-5108 does not seem to correlate to what is written in this paper. Please expand on the first paragraph related to the USGS data. This will help the reader determine what was completed prior to your analysis of these data.	The subsidence estimate in the first paragraph has been corrected.
169	Appendix Z				Appendix Z adds little value to the document, appears to be at least partly taken directly from Wikipedia, only focuses on subsidence effects on agriculture, and appears to have been written prior to W&C contracting with the GSA. It is unclear why this was included in the document. Background educational materials data on, e.g., water level data collection, water quality, and other topics is not provided, so why provide this for subsidence. Please delete.	Comment noted. The appendix is included because some readers are interested in this content.
170	2.2.7 GW Quality				A summary of the conclusions drawn about water quality would be very useful. As written, the section is quite disjointed. There is a smattering of data analysis, and review of other studies, but no conclusions about what groundwater quality conditions are in various regions of the basin. There is no explanation of why constituents were selected for analysis. The literature review might be better placed before the data analysis to provide context.	Some additional explanation has been added, including an explanation has been added for why these constituents were included.
171	2.2.7 Reference and Data Collection				Why was age dating data not considered in this analysis and discussion? Why no data from the CSD? Does this (USGS) include NWIS?	The CSD did not provide water quality data. Age dating does not provide information on water quality conditions in the data. The USGS data does include NWIS.
172	2.2.7 Reference and Data Collection			Data used in reference studies was not generally available	This is not correct. ALL data used in USGS and SBCWA studies (3 out of the 4 referenced in this section) are available and are therefore represented in the data.	The text has been revised for clarity.
173	2.2.7 Data Analysis			Collected data was analyzed for TDS, nitrate, and arsenic	Explain in the text why only these constituents were selected. Explain for the lay reader what the possible sources of these constituents are	The text has been revised for clarity.
174	2.2.7 Data Analysis			Figure 2.2-24 shows TDS of groundwater	Note: Additional data for west end collected July 2018 will be available soon.	Comment noted. Due to budget and schedule constraints, data provided after June 2018 will not be incorporated into the current version of the plan.
175	2.2.7 Data Analysis			Multiple years of collected data were used	Where is the comparison? Figure 2.2-23 (1966 data) shows high (>2000mgL) TDS for wells on west end N of river. These are very shallow and recharged by the river. Figure 2.2-24 shows wells directly S of river with low TDS. These are new deep wells. They shouldn't be compared as the same unit. The map aludes to the fact that they are. That possibly the quality has improved	The text does not make a direct comparison because there is insufficient data to make specific conclusions regarding how TDS may have changed over time.
176	Figure 2.2-25				Include a line showing the MCL on the figure	MCL lines have been added to the figure.
177	2.2.7 Data Analysis			Figure 2.2 28 shows arsenic measurements	USGS data indicate 4 of the 33 wells were >10 Only 25 wells used in this study. Why the discrepancy and why were the 4 wells with >10 not used? Please elaborate on data selection used for this analysis.	The text and figure have been reviewed and updated.
178	2.2.7 Data Analysis			Figure 2.2-28 shows arsenic measurements	What about the CSD? They treat for arsenic.	The CSD did not provide any arsenic data.
179	2.2.7 Data Analysis			Figure 2.2-29 shows that most of these sites	Describe for the reader what this means – leaks from storage tanks?	The text has been revised for clarity.
180	2.2.7 Literature Review	1	1	In 1970, Singer and Swarzenski reported	"TDS was as high as 1,500 to 1,800 mg/L TDS" - contradicts following sentence; "and higher (3,000-6,000 mg/L) in wells " - This is much higher than the first sentence says.	The text has been revised for clarity.
181	2.2.7 Literature Review	1		They state that the high TDS is generated	"water from marine rocks" - Confusing if you don't identify them geologically	Comment noted. No change needed.
182	2.2.7 Literature Review	2		The study identified that specific conductance	In the text, please provide context for why this is important and what this means in the context of groundwater quality.	The text has been revised for clarity.
183	2.2.7 Literature Review			In 2013, USGS reported	Please discuss any vertical gradients in constituent concentrations in the multicompletion wells.	The text and figure have been reviewed and updated.

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1	General				The Monitoring Networks spatial density around the faults of interest is insufficient.	Comment noted. These areas have been included in the groundwater level data gaps.
2	General - Well Data with Completion reports				The insufficient Quality Control / Quality Assurance compounds the uncertainty due to the scarcity of data.	Comment noted. Monitoring protocols will be set up to ensure consistent QA/QC for monitoring in the future.
3	General (Well ID #)				Will any cross reference table for well ID#s be made available?	This can be provided separate from the document.
4	Global (Salinity)				Please use the term TDS	The text has been changed to note at first usage that salinity is measured in TDS
5	General				The MN must asses all causal nexus between groundwater quality and groundwater extraction, such as constituents migrating into areas with lower pressure heads due to heavy groundwater extraction.	Comment noted. This can be accomplished in the implementation phase by filling in the monitoring data gaps.
6	4.2 Basin Conditions (Pg. 4-11)			Fig 4-2 Combined Hydrograph	The text should clearly articulate that groundwater elevations have declined consistently over 500' since pumping started in 1947.	The text has been revised for clarity.
7	4.3 Existing Monitoring Used (Pg. 4-13)				Other wells that have been monitored by DWR - CASGEM, USGS and/or The Ventura County Watershed Protection District (VCWPD) in the Ventucopa Uplands river corridor should be reconcidered for selection as a monitoring site for the GSP.	Comment noted. Additional wells can be added during the GSP implementation phase.
8	Table 4-5: Cuyama Basin VCWPD Wells (Pg. 4-22)				Table is mislabeled as; Number of SLOCFC&WCD wells	The table has been corrected.
9	Table 4-9: Cuyama Basin NWQMC, USGS, IRLP Water Quality Monitoring Sites (Pg. 4-29)				The texts suggests "The NWQMC database provides data on 47 water quality monitoring sites", but the table indicated there are 176 sites.	The text has been revised for clarity.
10	GAMA / DWR (Pg. 4-31)			age dating and groundwater movement trending	If freshwater recharge is assumed to be happening, then where is it going if not into the productive wells of the area?	Comment noted. This is not relevant to the Monitoring Network section.
11	4.3.5 Surface Water Monitoring (Pg. 4-37)			Fig 4-14	Not one stream gauge exists on the Cuyama River within the basin. Can we get a Plan to fill this Data Gap? Flow Gauges at the 3 bridges over the Cuyama?	This will be discussed in Section 4.10 when it is developed.
12	4.5.5 Representative Monitoring (Fig 4-16 thru Fig 4-18)				The major Data Gaps area in Fig 4-18 are also the fault zones of interest and the likely boundaries to proposed Management Areas (or Threshold Regions). What is the plan to solve this uncertainty?	This will need to be addressed during the GSP implementation phase.
13	4.6 Groundwater Storage Monitoring Network (Pg. 4-53)				All of the data gaps for the groundwater level monitoring network will now compound the uncertainty of the Groundwater Storage calculations. How will calculations made from uncertain data be verfied for QA/QC?	Monitoring protocols will be set up to ensure consistent procedures for monitoring in the future.
14	4.8 Degraded Groundwater Quality Monitoring Network (Pg. 4-53)				The best available science suggests a causal nexus between SGMA related activities like groundwater extraction and the migrations of constituents into areas with lower pressure heads due to unsustainable extraction.(See Appendix A, page 21-29) Boron, Arsenic & Nitrites should be monitored along with age dating to determine the movement of bodies of groundwater and the rates of any freshwater recharge.	The text has been revised to describe the rationale for establishing the monitoring network only for salinity.
15	4.9 Land Subsidence Monitoring Network (Pg. 4-60)				Is it possible to use other avaliable technologies (like InSAR to match the USGS data set) while we wait for more CGPS installations to come online?	The can be explored by the GSA during the GSP implementation phase.
16	4.9.5 Monitoring Protocols (Pg. 4-62)			"New stations will require downloading the data as equipment storage..."	Garbled english!	The text has been revised for clarity.
17	4.10 Depletions of Interconnected Surface Water Monitoring Network (Pg. 4-64)				The last of the Cuyama River Cottonwood trees stand as testament to the depletion of interconnected surface waters. Try to count them before their dead limbs crack and fall to the dry sands of their former wetlands.	Comment noted. No change needed in the Monitoring Network section.
18	Pg. 4-22				On page 4-22 the first line of the table is incorrect (not SLOCFC&WCD)). It should read VCWPD wells.	The table has been corrected.
19	Figure 4-7				The map in Figure 4-7 the title for VC wells in the legend for VCWPD should be more descriptive - Ventura County Watershed Protection District database wells to be consistent with the other maps.	The figure title has been changed.

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20	Intro			This section was prepared to meet the requirements	Consider listing the GSP regulations for this chapter	The regulation has been added.
21	4.2 Monitoring Networks Obj.	1	1	This section describes the Cuyama	Consider adding a comment or footnote on seawater intrusion to reinforce why it is not being monitored.	This is discussed in the Undesirable Results GSP Section.
22	4.2.1 Basin Conditions Relevant	2	3	There are no major stratigraphic aquitards or	Suggest clarifying this sentence. The basin has faults, maybe adding a figure of the Morales Formation.	The text has been revised for clarity. A figure of the Morales Formation is shown in the HCM Section.
23	4.2.1 Basin Conditions Relevant	2	4	The aquifer ranges from	Consider adding the top and bottom basin range.	The text has been revised for clarity.
24	4.2.1 Basin Conditions Relevant	3	1	The largest groundwater	Suggest adding a table of the entire basin for land use, square miles, and percentage, such urban, rural, open space, and etc.	This is discussed in the Plan Area section.
25	4.2.1 Basin Conditions Relevant	4	2	Generally, groundwater elevations	Consider quantifying the decrease in years, such as ... decreasing by approximately XX ft from the 1940s and 1950s to the present	The text has been revised for clarity.
26	4.2.1 Basin Conditions Relevant	4	2	Generally, groundwater elevations	Suggest verifying if the figure is missing.	The figure is included in the GSP section.
27	4.3.1 Groundwater Level Monitoring	4	1	CASGEM allows locally	Editorial: "CASGEM allows ~~locally~~ local agencies to be designated"	The text has been revised for clarity.
28	4.3.1 Groundwater Level Monitoring			There are currently six CASGEM	Clarification - The two SLO County CASGEM wells are volunteer wells (County agreement with private owner)	The text has been revised for clarity.
29	Figure 4-3			Cuyama Basin DWR/CASGEM Wells	Suggest adding the Federal and State areas to the monitoring network to help show why groundwater wells are not located in several basin areas.	These are shown in the Plan Area section and are not needed in this section.
30	Table 4-2			Cuyama Basin USGS Well Statistics	Suggest verifying if duplicate wells exist between all agencies, such as County, DWR, and USGS.	This is addressed in Section 4.3.2
31	Figure 4-4			Cuyama Basin USGS Wells	Suggest adding the Federal and State areas to the monitoring network to help show why groundwater wells are not located in several basin areas.	These are shown in the Plan Area section and are not needed in this section.
32	Table 4-3			Cuyama Basin SBCWA Well Statistics	Suggest verifying if duplicate wells exist between all agencies, such as County, DWR, and USGS.	This is addressed in Section 4.3.2
33	Figure 4-5			Cuyama Basin SBCWA Managed Wells	Suggest adding the Federal and State areas to the monitoring network to help show why groundwater wells are not located in several basin areas.	These are shown in the Plan Area section and are not needed in this section.
34	4.3.1 GW Level Monitoring - SLO	1	2	SLOCFC&WCD also reports the data for	SLO County – the two CASGEM wells are in the County's volunteer program (agreement between the County and owner). If using these 2 wells in the GSP, the CBGSA will need agreements with the owners.	Comment noted. Agreements can be sought during the GSP implementation phase.
35	Figure 4-6			Cuyama Basin SLOCFC&WCD Wells	Suggest adding the Federal and State areas to the monitoring network to help show why groundwater wells are not located in several basin areas.	This is addressed in Section 4.3.2
36	Figure 4-7			Cuyama Basin VCWPD Wells	Suggest adding the Federal and State areas to the monitoring network to help show why groundwater wells are not located in several basin areas.	This is addressed in Section 4.3.2
37	Figure 4-8			Cuyama Basin Community Services District Wells	Suggest adding the Federal and State areas to the monitoring network to help show why groundwater wells are not located in several basin areas.	This is addressed in Section 4.3.2
38	Figure 4-9			Cuyama Basin Private Landowner Wells	Suggest adding the Federal and State areas to the monitoring network to help show why groundwater wells are not located in several basin areas.	This is addressed in Section 4.3.2
39	4.3.3 GW Quality Monitoring - NWQMC	2	3	Initial water quality data for the Cuyama	Could this data be leveraged for the GSP? If so, please add the regulations pertaining to the IIRLP, such as water quality sampling.	This is included in the monitoring network. Regulations for IRLP progam can be found here: https://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/
40	Multiple figures			Cuyama Basin NWQMC, USGS, IRLP Water Quality Monitoring Sites	Suggest adding the Federal and State areas to the monitoring network to help show why groundwater wells are not located in several basin areas.	These are shown in the Plan Area section and are not needed in this section.
41	4.3.3 GW Quality Monitoring - Private Landowners	1	1	Private landowners within the	Consider verifying if these owners are in the IRLP, included in GAMA?	Comment noted. This can be done during the GSP implementation phase.

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42	4.4 Monitoring Rationales	1	2	Monitoring networks in the Cuyama GSP	Suggest adding – "Cuyama Basin GSP"	The text has been revised for clarity.
43	4.4 Monitoring Rationales	3	2	The schedule and costs associated	Suggest adding –a period "GSP."	The text has been revised for clarity.
44	Table 4.13			Number of Wells Selected for Monitoring Network	SBCWA - Suggesting verifying that well are not being counted twice between agencies and verifying that the programs are continuing, if leverage existing programs	The table has been updated to note that the total does not equal the sum of the rows due to wells being duplicated in multiple databases.
45	Table 4.13			Number of Wells Selected for Monitoring Network	SLOCFC&WCD - Clarification - The two SLO County CASGEM wells are volunteer wells (County agreement with owner), not monitoring wells. The CBGSA will need agreements with the well owners for additional sampling beyond CASGEM	Comment noted. No change needed to text.
46	4.5.3 Monitoring Frequency	5	1	The Basin is an unconfined aquifer	Where did the 5 inches per year come from?	"5-inches" is based on values provided in Table 4-14, which is from the *Monitoring Networks and Identification of Data Gaps Best Mangement Practices.* "5-inches" refers to the quantitative value of annual recharge. This value is output from the model, which currently models an annual recharge of # inches. Although this value is subject to change based on model calibration efforts, it is not expect to increase above 5-inches per year.
47	4.5.3 Monitoring Frequency	5	2	Based on the data in Table 4-14	Suggest that the CBGSA Board review the consultant economic benefit cost analysis on monthly, quarterly, and semi-annual groundwater sampling to determine what is feasible? Suggest the Consultant reviews the sampling timeframe with the CBGSA Board.	Comment noted. The specific time frame will need to be selected by the CBGSA Board going forward.
48	4.5.4 Spatial Density	3		Based on Hopkins well density	Suggest adding reference	The reference has been added to the text.
49	4.5.4 Spatial Density	3		Based on Heath	Suggest adding reference	The reference has been added to the text in the section and to the references at the end of the section.
50	4.5.6 GW Level Monitoring Network	1	1	The Groundwater Level Monitoring Network	Suggesting verifying that well are not being counted twice between agencies and verifying that the programs are continuing, if leverage existing programs.	Entities with current monitoring programs were attempted to be contacted. Of those that responded to our inqueries, most were non-committal with the continuation of their programs, however, this non-committal response was a result of not knowing specifics about the wells in Cuyama and not wanting to be responsible for missinformation. This is also why criteria for inclusion in the monitoring network is so broad. In the event some wells are discontinued, it is the hope that other wells will be able to provide sufficient data. If this is not the case, the GSA will have to determine if additional wells will need to be constructed. A review of the monitoirng network was conducted and no duplicates were found. Wells that appear in Figure 4-17: Cuyama GW Basin Groundwater level and Storage Monitoring Network Wells that have multiple labels for what appears to be the same site are actually multi-completion (aka multi-depth) wells. Each individual casing is considered an independent well due to the output of GWL measurements. Note: Due to revisions to the Monitoring Network and Representative Wells through Board direction, the Table and List of wells has been updated.
51	4.5.6 GW Level Monitoring Network	1	1	The Groundwater Level Monitoring Network	Does the CBGSA have to form agreements with the well owners for volunteer programs?	Yes, this will need to be done going forward during the GSP implementation phase.
52	4.5.6 GW Level Monitoring Network	3	1	The proposed monitoring frequency	Suggest that the CBGSA Board review the consultant economic benefit cost analysis on monthly, quarterly, and semi-annual groundwater sampling to determine what is feasible? Suggest the Consultant reviews the sampling timeframe with the CBGSA Board.	Comment noted. The specific time frame will need to be selected by the CBGSA Board going forward.
53	Appendix K	1	1	General	Suggesting verifying that this follows SGMA GSP protocols.	Appendix K is *Best Management Practices for the Sustainable Management of Groundwater Monitoring Protocols, Standards, and Sites* published by DWR and provided on the SGMA website.

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Comment #	Section	Section Paragraph #	Paragraph's Sentence #	Sentence Starts with, "...	Comment	Response to Comment
54	4.5.8 Data Gaps	3	1	Well construction information is not	Suggesting verifying if there is a SGMA GSP standard for well construction. If so, does this monitoring network meet these standards?	Article 3, Section 352.4, (c) describes the standards to apply to the wells. Although it outlines the information that should be included under Part (1), Part (2) states that either the GSA create a schedule for acquiring the necessary information, or describe why the information is not necessary to undersand and manage groundwater in the basin. Due to the extremely limited amount of data within the Cuyama Basin, an attempt to use all valuable data was made. To understand the limitations of the data, the Tiering System was utlized and discussed within the section. Additionally, within Project and Management Actions, there will be additional information about pursuing projects to obtain additional well information.
55	4.5.9 Plan to fill data gaps	3	3	New wells drilled by DWR's	Suggest updating this section when DWR approves the TSS for new wells	Comment noted. This will be considered if DWR approves the TSS before completion of the GSP.
56	4.8 Degraded GW Quality	1	1	Due to the relationship of undesirable	This needs to be vetted by the CBGSA Board for any constituent to be monitored and sampled. Is sampling for salinity meeting SGMA GSP regulations? Suggest providing a discuss of why other constituent are not being monitored	The text has been revised to describe the rationale for establishing the monitoring network only for salinity.
57	4.8.2 Monitoring Sites Selected	1	4	Note that due to duplication of wells	Consider updating the table (4-17) with the correct values.	The table has been updated.
58	4.8.3 Monitoring Frequency	2	3	The Basin, in coordination	This needs to be vetted by the CBGSA Board for any constituent to be monitored, sampled, and frequency of sampling.	Comment noted. The specific time frame will need to be selected by the CBGSA Board going forward.
59	4.8.6 GW Quality Monitoring Network	1	3	All 64 wells are representative	Suggest verifying if these are duplicate wells and if leveraging data from existing programs to verify that the program is continuing.	Comment noted. This will be done during the implementation phase going forward.
60	4.8.8 Data Gaps	4	3	All management entities are	Suggest verifying that this assumption is true	The text has been revised for clarity.
61	4.8.9 Plan to fill data gaps	3	2	Downhole video logging	Suggest verifying that you can perform downhole video logging in existing wells with casings.	This will be verified as specific wells are identified for video logging by the DWR TSS.
62	4.9.7 Plan to fill data gaps	1	3	Although there are multiple	Suggest reviewing the pros/cons and cost associated with recommendation	The rationale for this recommendation is provided in the text.
63	General				It is quite difficult to determine the appropriateness of the proposed monitoring network without know what the management areas will be. Suggest revising/recirculating once they have been identified.	Comment noted. This can be considered by the GSA Board.
64	Figure 4.1			Well completion diagram	Depth to Bottom of Well should/could be reworded to match the what is written under useful terms - Total Well Depth	Updated Figure
65	4.1 Useful Terms			Subsidence (refer to appendix Z	Suggest deleting appendix Z for reasons described in comments to Groundwater Conditions Section	Comment noted. The appendix is included because some readers are interested in this content.
66	4.2.1 Basin Conditions Relevant	2	3	There are no major stratigraphic aquitards	Fault lines?	The text has been revised for clarity.
67	4.2.1 Basin Conditions Relevant	2		The aquifer ranges from 10's to 100's of feet	Not a very useful, give #s.	Specific values are unavailble in this summary sentence. Therefore, numbers have been removed. For details on aquifer thickness, refer to the HCM section.
68	4.2.1 Basin Conditions Relevant	2		Median reported hydraulic	Median or a range?	Median, as shown in Table 2.1-1.
69	4.2.1 Basin Conditions Relevant	2		Figure 2.1-2 shows the extent	Do we have that?	This figure is in the HCM section.
70	4.2.1 Basin Conditions Relevant	3		Based on the most recent data from 2016,	Sentence is somewhat confusing.	The text has been revised for clarity.
71	Figure 4-2			Central Basin with Combined	Label wells on map	The figure has too many wells to effectively label them.
72	4.3 Existing Monitoring Used	1	1	This section discusses current groundwater	As mentioned in comments to the groundwater conditions section, this is a list of databases from which W&C pulled data, it is not a list of monitoring programs.	The text has been revised for clarity.
73	4.3.1 Groundwater Level Monitoring				I like how each monitoring entity is mentioned in a separate section below. A general summary of how these data were collected should be included for each entitry to include information such as: 1-protocols 2-accuracy 3-equipment used 4-QA/QC	Users can refer to the metadata provided by each data source for this information. This level of detail is not needed in this GSP section.

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74	4.3.1 Groundwater Level Monitoring - DWR, Statewide...			CASGEM Wells – Wells with well	Many of the voluntary wells have publically available well construction info. This distinction is not correct.	The text has been revised for clarity.
75	4.3.1 Groundwater Level Monitoring - DWR, Statewide...			Most wells were measured on a semi-annual	This is not correct, most wells are measured annually. Some were measured semi-annually during the USGS study.	The text has been revised for clarity.
76	Table 4-1			Summary Statistics for CASGEM Wells	No CASGEM program in 1946. It started in 2000. No big deal. These wells are now CASGEM.	The table header has been revised for clarity.
77	Figure 4-3			Cuyama Basin DWR/CASGEM	As commented on the groundwater conditions section, these are not DWR wells.	The figure title has been changed.
78	4.3.1 Groundwater Level Monitoring - USGS	5	1	USGS has approximately 25 approved	Needs to be much clearer. USGS doesn't "have" these wells. They happen to appear in the USGS database.	The text has been revised for clarity.
79	Table 4.2			Cuyama Basin USGS Well Statistics	# of provisional wells - This is unclear. There may be some provisional data from the last few months that re currently not approved. Standard to approve data within 150 days. This statement leads one to believe that these data are not useable.	The distinction between provisional and approved USGS wells has been removed.
80	Figure 4-4			Cuyama Basin USGS Wells	These are not USGS wells. They are wells that are in the USGS database.	The text has been revised for clarity.
81	4.3.1 Groundwater Level Monitoring - SBCWA	1	1	The Santa Barbara County Water Agency (SBCWA) manages	Summary of SBCWA monitoring programs: USGS network for entire basin was 32 wells. •About 14 of these 32 wells are overlapped on the west-end with our quarterly network. •Our quarterly network is 36 wells but could be considered as large as 47 if we want to count the Harvard production wells which they self-monitor and we periodically verify. •Mandatory CASGEM is 3 and Voluntary CASGEM is 13. These are also part of the USGS total of 32 wells. • The USGS has stopped monitoring wells in the basin.The entire network we will start to monitor will be about 52 in total (or 63 if we want to consider the 11 Harvard production wells).	Text and Table has been updated
82	4.3.1 Groundwater Level Monitoring - SBCWA	1	3	Many of these wells are included in the DWR	I didn't see any in the DWR database. Some are in NWIS. Important to clarify that wells may be in database and maps, but our data for the last couple of years is not located in the database.	Unecessary detail removed from document
83	Table 4-3			Number of SBCWA-wells	29 should be 55	Numbers reflect data provided by SBCWA. Numbers have been updated to reflect this.
84	Table 4-3			Number of SBCWA wells included in the Monitoring Network	30 is ?	Numbers have been updated.
85	Figure 4-5			Cuyama Basin SBCWA	As mentioned, this does not include all the wells monitored by SBCWA	Figure has been updated
86	4.3.1 Groundwater Level Monitoring - Private Landowners	1	1	Private landowners within the Basin	Nearly all the wells mentioned previously are owned and "managed" by private landowners. The terminology is very confusing.	The text has been revised for clarity.
87	4.3.1 Groundwater Level Monitoring - Private Landowners	1	3	Summary statistics for these	Are these private wells that are measured by USGS, Ventura, SLO, and SBCWA? Or are these overlap wells found in separate databases? Hard to tell without shapefiles. If there are 99 wells measured by private landowners, there would a serious issue with data quality and accuracy and should not be the foundation of the model.	The text has been clarified to note that these are additional wells beyond those included in the previously described datasets.
88	4.3.2 Overlapping and Duplicate Data	2	1	Duplicates were identified and then	Were similar MP elevations, accuracy standards, and methodology used?	Well data was not altered during this duplicate identification processing. Sources were either combined (i.e. one source had GSE and another had RPE) or the source with the more accurate information was utilized (i.e. once dsource only had ID and general coordinates whereas another may have had well construction info and general coordinates). Sources where there were conflicting data, such as Well Depth, were addressed one by one and researched and professional determination was made. All elevation values were ultimately corrected using a singular DEM dataset to standardize all elevation values.

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89	Table 4-8			MSC column	Explain how Local Name is different from Name? Explain how is USGS ID different from MSC?	Some wells had two names. For example, OPTI Well 834 has a state well number, a well name of "Mustang Production" and local well name of "Spanish WM-1". In an effort to include as much well information as possible "two" well name categories were included. The USGS ID and MSC are two unique identification serial numbers. For example, OPTI well 134 has a SWN of 07N23W20M001S and a USGS Site Code of 344115119202001.
90	Table 4-8			SBCWA row	The table needs to include all SBCWA-monitored wells, which includes all of the CASGEM Wells in the basin within SB County.	Data provided by the SBCWA in indivudal spreadsheets did not include CASGEM ID, and thus a check mark was not included in the CASGEM ID column for the SBCWA row in Table 4-8. Table 4-8 is intended to show what information was included in the orginal data provided to W&C to illistrate the necessity of finding duplicates and data processing. Although those wells may have CASGEM IDs, these were associated with the wells during data processing.
91	Table 4-8			Managing Entity column	Change heading to Database	The heading has been changed to "Data Maintaining Entity"
92	4.3.3 GW Quality Monitoring	1	1	This section discusses existing groundwater	Confusingly worded – the programs were "collected"?	The text has been revised for clarity.
93	4.3.3 GW Quality Monitoring - NWQMC				Why is NWIS not mentioned?extensive water quality data available.	The data downloaded form the NWQMC includes NWIS data. The text has been revised for clarification.
94	4.3.3 GW Quality Monitoring - NWQMC				What sample constituents and parameters?	Text has been editted for clarity.
95	4.3.3 GW Quality Monitoring - NWQMC	2	3	IRLP was initiated in 2003	Are these data collected by the landowner? Explain in text who does this data collection?	Who collects this data is unknown and not included in the data provided by the management enetities
96	Table 4-9			Median period of record	Is this accurate?	Yes. A considereable number of sites only took 1-2 samples during a single year.
97	4.3.3 GW Quality Monitoring - GAMA/DWR				Explain in text what sample constituents and parameters.	Clarification has been added to the text, detail about consituents was not added due to nexus of causality in water qualty result.
98	4.3.3 GW Quality Monitoring - GAMA/DWR			Earliest measurement date year	GAMA started in 2000 Many of these data are historic USGS data from NWIS. The database W&C pulled the data from is not indicative of what program or agency collected the data.	While this comment is correct, the intent of this section is to summarize the data that is available, and was downloaded, and could be downloaded, from each of these sources and to show the processes W&C took to processes and collect data for the Cuyama Basin.
99	4.3.3 GW Quality Monitoring - Ventura County Watershed				Need to add a section on the CSD.	A new section has been added to include data provided by the CSD.
100	4.3.3 GW Quality Monitoring - Ventura County Watershed				What sample constituents and parameters?	Clarification has been added to the text, detail about consituents was not added due to nexus of causality in water qualty result.
101	4.3.3 GW Quality Monitoring - Private Landowners				What sample constituents and parameters?	The text addresses that only TDS is utlized by this data source.
102	4.3.4 Subsidence Monitoring			Appendix Z, a subsidence white	As commented on groundwater conditions section, suggest deleting this white paper.	Comment noted. The appendix is included because some readers are interested in this content.
103	4.3.5 Surface Water Monitoring				Perhaps assess whether there is more needed? Where?	This will be addressed in Section 4.10
104	4.4 Monitoring Rationales	2	1	The monitoring networks were	Be specific - levels? Storage?	The text has been revised for clarity.
105	4.5.2 Monitoring Wells Selected for Monitoring Network				SBCWA knows of currently available wells to fill these data gaps for monitoring. Also, a few wells, which are also currently available, should be monitored in the Ventucopa Uplands and east uplands. We don't need the network density here, but maintaining a baseline dataset is important. It is unwise to completely overlook these areas because there's currently little to no and use. Please contact Matt Scrudato for information on wells available	Comment noted. In the GSP implementation phase, the GSA should coordinate with SBCWA staff to identify appropriate wells to fill data gaps.

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106	4.5.2 Monitoring Wells Selected for Monitoring Network	2	1	Tier 1 encompasses wells with the most	Are there any in the Basin? None show up on the figure	No, there are no Tier 1 wells in the Basin.
107	4.5.2 Monitoring Wells Selected for Monitoring Network			Table 4-13 & following paragraph	This is not useful and unnecessarily confusing due to the overlap between the top three monitoring groups. The database that W&C found the well in is irrelevant.	The paragraph has been removed.
108	Figure 4-16			Cuyama Basin Groundwater Level and Storage Monitoring	No Tier 1 Wells?	No, there are no Tier 1 wells in the Basin.
109	4.5.3 Monitoring Frequency	5	1	The Basin is an unconfined aquifer	Large withdrawals are not consistent across the basin. Mention where the large withdrawals occur.	The text has been revised for clarity.
110	4.5.3 Monitoring Frequency	5	2	Based on the data in Table 4-14	If there are management areas, may not need monthly monitoring this across all areas. A good reason to wait until MAs jave been decided.	Comment noted. This can potentially be updated in the Public Draft if the GSA Board provides direction on management areas.
111	4.5.4 Spatial Density				Should be done by management area.	The monitoring wells correspond to the wells used to develop threholds, which have been selected by threshold region.
112	4.5.4 Spatial Density	1	5	Monitoring wells in close proximity	Many of the wells in the basin are themselves pumped. There are very few dedicated monitoring wells.	Comment noted. No change needed to text.
113	4.5.5 Representative Monitoring				The GSA will need access agreements with private landowners to monitor nearly all of these wells. These ability to get these agreements may drastically alter which wells are selected.	Comment noted. No change needed to text.
114	4.5.5 Representative Monitoring			Monitoring Well – Other wells are	"Supplemental wells" may be a less confusing description.	The text has been changed accordingly.
115	4.5.5 Representative Monitoring			Adequate Spatial Distribution – Representative monitoring	Awkward phrasing, please restate for clarity	The text has been revised for clarity.
116	4.5.6 GW Level Monitoring Network	1	1	The Groundwater Level Monitoring Network is comprised	Sum of Table 4.13 is 151 wells. Not useful.	Paragraph was removed.
117	Table 4-16			Column: Managing Agency as of 2018	These are not the managing agency. This is the database W&C pulled the data from	The column has been renamed "Data Mantaining Agency"
118	Table 4-16			OPTI ID	Add Bittercreek. Appears to be a discrepancy between managing agency mentioned here and monitoring agency mentioned on the OPTI webpage.	We are unclear what "Add Bittercreek" means. With more clarification, we can make a change in the Public Draft.
119	Table 4-16			2* SB County	This well appears to be located in Ventura in OPTI	Table has been updated
120	Table 4-16			105 - confidential	This data is published in NWIS. Not confidential. Depth of well 600 feet. Depth of hole 750 feet.	The table has been updated.
121	Table 4-16			109	Plots in the ocean near Channel Islands.	Data provided to W&C was plotted in the Ocean. This well has been removed, and and the correct well/lat/long was added to the network as OPTI Well 833
122	Table 4-16			120	Collapsed well. Not a good choice.	Data provided to W&C did not indicate the well was collapsed. Instances like recent collapses that happened after data collection will be addressed in the GSP implementation phase.
123	Figure 4-17			Groundwater Level and Storage Representative	Big data gaps in this map. SBCWA can assist in providing better spatial coverage.	Comment noted. In the GSP implementation phase, the GSA should coordinate with SBCWA staff to identify appropriate wells to fill data gaps.
124	4.5.7 Monitoring Protocols	1	1		LSD accuracy standard? What is the required accuracy for the WL data? May want to refer to USGS publication Groundwater Technical Procedures of the USGS if this is the required standard. https://pubs.er.usgs.gov/publication/tm1A1	As mentioned before about Appendix K (*Best Management Practices for the Sustainable Management of Groundwater Monitoring Protocols, Standards, and Sites)* the GSP cites DWRs published material for sampling protocols.
125	4.5.7 Monitoring Protocols	1	1	Monitoring protocols for the groundwater	The attached appendix is titled Appendix A.	The text has been revised for clarity.
126	4.5.8 Data Gaps	1	1	Groundwater levels monitoring data gaps	awk - delete sentence and 2 bullet points below	The text has been revised for clarity.
127	4.5.9 Plan to fill data gaps	2	1	The CBGSA has already been	Provide context (Proposition 1, etc)	The text has been revised for clarity.

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128	4.5.9 Plan to fill data gaps	2	2	This task includes identification	Explain where? Why? What will this illustrate and how will it help? Better than discrete monthly measurements?	The text has been revised for clarity.
129	4.5.9 Plan to fill data gaps	3	1	DWR provides Technical Support Services (TSS) to	This needs context and has no basin-specific info.	The text has been revised for clarity.
130	Figure 4-18			Groundwater Levels Monitoring Network	See Figures 4.10 and 4-4. There appear to be wells available to fill data gaps. CVCR6 RRU1 and 2	Comment noted. W&C will coordinate with SBCWA staff to identify appropriate wells to fill data gaps.
131	4.8 Degraded GW Quality	1	1	Due to the relationship of undesirable	Elaborate. This need a lot more justification. Why only salinity? What is the standard? What would cause this to change? No other parameters needed at all?	The text has been revised to describe the rationale for establishing the monitoring network only for salinity.
132	4.8.2 Monitoring Sites Selected				Too many in North Fork. Large data gaps. No west end monitoring? Poor distribution when other wells are available.	The monitoring network identified in the document only includes wells that are currently being monitored for salinity. Wells for filling the data gaps identified in the document will be idenfied in the future during GSP implementation.
133	4.8.2 Monitoring Sites Selected	1	4	Note that due to duplication of wells	Why show this if there are overlaps? What value does it add?	It identifies the role that these entities currently play in managing and maintaining water quality data in the Basin.
134	4.8.3 Monitoring Frequency	1	1	Monitoring agencies such the USGS	USGS always in July, except during the recent basin study. They collect these samples for the SBCWA. The SBCWA will likely discontinue this program once the GSP is submitted.	Text has been editted for clarity. Text reflects the conversation with USGS staff and W&C.
135	4.8.3 Monitoring Frequency	1		Monitoring agencies such the USGS (entire paragraph)	This is irrelevant. Explain what the GSA is going to do first, then explain how it will leverage samples collected by other agencies.	The text has been revised for clarity.
136	4.8.3 Monitoring Frequency	2	2	The Basin, in coordination with partnering	This should come first	The text has been revised for clarity.
137	4.8.3 Monitoring Frequency	2	2	Representative wells, those with sufficient	Not necessary, it was already stated that all are representative wells.	The text has been revised for clarity.
138	Table 4-18			Managing Agency as of 2018	See previous comment.	The text has been revised for clarity.
139	Table 4-18			Department of Water Resources	Wells 710-758 are DWR. This managing agency should stay consistent and use DWR.	The table has been revised for clarity.
140	Table 4-18			Last Measurement Date	Many of these are from the USGS Study, not part of a regular monitoring program. There is no "managing entity as of 2018".	"Managing entity" has been changed to "Data Maintaining Agency"
141	4.8.7 Monitoring Protocols			Existing groundwater quality monitoring	Irrelevant. GSA will be establishing its own network and using its own protocols. Existing programs may not continue.	The text has been revised for clarity.
142	4.8.8 Data Gaps	3		Additional information about how	Use the three wells completed at different depths.	Comment noted. This can be considered during the GSP implementation phase.
143	4.8.8 Data Gaps	4	1	The entire Basin is identified as	??? The basin is the data gap?? Please restate to explain what data is missing.	The text has been revised for clarity.
144	4.8.9 Plan to fill data gaps	1	1	The CBGSA will fill the temporal	Explain (DWR's TSS program. to perform downhole logging....)	The text has been revised for clarity.
145	Figure 4-20				Wells are available. SBCWA can help find them. SBCWA are actually measuring them and collecting water quality samples.	Comment noted. The GSA can coordinate with SBCWA to incorporate these wells during the GSP implementation phase.
146	4.9.3 Monitoring Frequency	1	1	Subsidence monitoring frequencies should capture	State clearly in the beginning of the section what the GSA will do.	The text has been revised for clarity.
147	4.9.4 Spatial Density	1	1	The current spatial density of subsidence	With 2 stations within the basin as mentioned in 4.9-2?	Yes, this is based on the 2 stations currently in the Basin.
148	Figure 4-21			Current Subsidence Monitoring	Legend does not include symbols for the sites.	Stations are labeled on map, and thus are not needed in the legend.

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149	4.9.5 Monitoring Protocols				Is there equipment calibration needed? There needs to be a written standard. This needs to be elaborated on. There are some standards already developed which may be useful as a guide and reference. These are as follows: (for GNSS surveys) USGS- https://pubs.usgs.gov/tm/11d1/tm11-D1.pdf NOAA https://www.ngs.noaa.gov/PUBS_LIB/NGS-58.html https://www.ngs.noaa.gov/PUBS_LIB/NGS592008069FINAL2.pdf USGS reports have information about "future monitoring" which may be a useful reference when establishing the standards and protocols. Here's an example: https://pubs.usgs.gov/sir/2014/5075/pdf/sir2014-5075.pdf	Comment noted. This can be considered during the GSP implementation phase.
150	4.9.5 Monitoring Protocols	2	1	Data should be saved on	Where? Central databse?	The text has been revised for clarity.
151	4.9.7 Plan to fill data gaps				Should we create a baseline dataset set now since it may take time to establish permanent sites? DGPS biannually?	Comment noted. This can be considered during the GSP implementation phase.
152	4.9.7 Plan to fill data gaps	2	1	Theses stations can be managed	Why USGS? Are they running the current stations or have we determined that they will do this monitoring? If so, M Sneed (USGS) should elaborate on the protocols and methodology.	Comment noted. This can be considered during the GSP implementation phase.
153	General				Representativeness of wells for water level monitoring. Wells used within a monitoring network must not only meet standards for sufficient well construction and monitoring data, they also must be representative of local hydrogeologic conditions. "The designation of a representative monitoring site shall be supported by adequate evidence demonstrating that the site reflects general conditions in the area." [§ 354.36(c)]. The process for selecting candidate wells for the water level Monitoring Network is explained based on well construction and monitoring frequency criteria, but the chapter is unclear on how selected wells were determined to be representative of certain areas of the basin.	Comment noted. These factors can be considered when the monitoring network is finalized during the GSP implementation phase.
154	General				Representativeness of wells for water quality monitoring. The process used to select wells as representative for water quality monitoring also is not transparent. All available wells apparently were included in the water quality Monitoring Network, but this section (e.g., Page 4-54) lacks discussion of basin groundwater quality characteristics. A Piper diagram with data from all wells, or maps with well-by-well Stiff diagrams could highlight spatial differences (and redundancies) in water quality. If only TDS data are available, a figure showing side-by-side historical TDS data boxplots for all wells would allow identification of wells with statistically-distinct (or redundant) historical data.	Comment noted. The available water quality data is discussed in the Groundwater Conditions chapter. This level of detail is not needed in this chapter.
155	General				General determination process. In general, a systematic process for selecting representative wells is not discussed. The basis used to identify the various wells as representative is not clear.	The criteria used to select representative monitoring wells are given in Section 4.5.5
156	General				Optimization. It also is unclear whether an effort was made to simplify the network to increase efficiency, and reduce cost (i.e., have the same wells be used for water levels, water quality monitoring, etc). The chapter needs a discussion of network optimization, including (a) coordination of monitoring with other agencies or entities to potentially share costs and eliminate redundant monitoring, and (b) identification of clustering and spatial redundancy within the network, via comparison of water level, well construction, and water quality data (see preceding comment #2), to eliminate wells that are not both unique and representative.	Comment noted. This can be addressed when the monitoring network is finalized during the GSP implementation phase.

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157	General				Clustering effects. The potential effect of data clustering on conclusions drawn from parts of the network with very high well densities also is not discussed. The well density discussion needs to consider the potential effects of data clustering on conclusions drawn from aggregation of water level data. For example, if Undesirable Results are defined as a certain percentage of monitoring network wells experiencing water levels below their Minimum Thresholds, clustering of wells through intentional "selection of additional wells in heavily pumped areas" may artificially magnify the apparent portion of the basin affected, increasing the likelihood of it being judged as out of compliance with sustainability criteria.	Comment noted. This can be addressed when the monitoring network is finalized during the GSP implementation phase.
158	General				Sustainability Criteria. The Monitoring Network section does not include "quantitative values for the minimum threshold, measurable objective, and interim milestones that will be measured at each monitoring site", as required [§354.34 (g)(3)]. We understand that these sustainability criteria are currently under development, and anticipate that, when final, the appropriate values will be incorporated into this chapter.	This will be provided in the Sustainability Thresholds GSP chapter.
159	General				Data gaps. Discussion of plans to fill data gaps is very general, with no description of "steps that will be taken to fill data gaps before the next five-year assessment, including the location and purpose of newly added or installed monitoring sites." [§354.38 (d)]. Regulations specify that each GSA identify data gaps wherever the basin does not contain (a) a sufficient number of monitoring sites, (b) does not monitor sites at a sufficient frequency, or (c) utilizes monitoring sites that are unreliable, including those that do not satisfy minimum standards of the monitoring network adopted by the agency. There is no reason therefore to create minimum well acceptance standards to match what is currently available, and instead criteria should emphasize the capacity to reliably monitor and track basin efforts to maintain sustainability.	Comment noted. The specific plan to fill data gaps will be developed during the GSP implementation phase.
160	General				Acquisition of wells to meet network deficiencies. Regulations regarding minimum requirements for monitoring network wells state "If an Agency relies on wells that lack casing perforations, borehole depth, or total well depth information to monitor groundwater conditions as part of a Plan, the Agency shall describe a schedule for acquiring monitoring wells with the necessary information, or demonstrate to the Department that such information is not necessary to understand and manage groundwater in the basin." [§352.4]. Additionally, DWR's Best Management Practices #2 – Monitoring Networks & Identification of Data Gaps states that agricultural or municipal wells may be used in place of monitoring wells, but that "If not using a dedicated monitoring well, the GSA must provide a rationale and a schedule for acquiring one." The Monitoring Network section does not assert that the information available for existing wells is adequate to understand the basin, nor does it support or refute the need for a rationale and schedule for acquiring monitoring wells.	Comment noted. This can be addressed when the monitoring network is finalized during the GSP implementation phase.
161	General				Access for future monitoring. DWR's Best Management Practices #2 – Monitoring Networks & Identification of Data Gaps also states, "Monitoring wells should be secured by a long-term access agreement to ensure year-round site access." No discussion is provided in the Monitoring Network section regarding negotiation goals or procedures to ensure access to wells on private property for monitoring in the future.	Comment noted. This can be addressed when the monitoring network is finalized during the GSP implementation phase.
162	General				Implementation. Explanation of how the Monitoring Network will be developed and implemented is deferred to a later GSP section (Projects and Management Actions), although it is required in the Monitoring Network section [§354.34(b)].	This can be revisited for the Public Draft version of this section when the implentation section is available

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163	General				Areas with known data gaps. Very few wells were selected for the Monitoring Network within the southeastern part of the basin (near and upstream of Ventucopa). Ventura County Watershed Protection District maintains 51 wells in the area (Table 4-11, Figure 4-12), and private landowners have indicated they provided data to WC for additional wells in this area. It may be useful to reconsider inclusion of some of these wells into the network, to obtain better representation in this area of the basin. A pre-existing well with known construction data and some measurements is preferable to nothing, as long as the well is in acceptable condition.	Additional wells have been added to the monitoring network in these region.
164	General				Field confirmation of selected Network wells. Anecdotally, some older historically gauged wells under consideration for inclusion within the network may have failed, allowing annular or aquifer materials into the casing, and altering their effective screened intervals. We recommend field-confirmation of total depths and general condition of wells selected for the network, particularly in areas of sparse well data density where each well represents large areas of the basin.	Comment noted. This can be addressed when the monitoring network is finalized during the GSP implementation phase.
165	General				Surface water monitoring. Discussion of interconnected surface water monitoring is deferred until after numerical modeling is complete.	Comment noted.
166	Pg. 4-14				Places where the relationships between sets of wells and databases is confusing: The distinction between California State Groundwater Elevation Monitoring (CASGEM) and other Department of Water Resources (DWR) wells is confusing. The text refers to Figure 4-3 as CASGEM wells, but the map labels say "DWR Database Wells." There appear to be 222 wells on the map, not 113. Terminology between text, table, and figure is inconsistent.	The text has been revised for clarity.
167	Pg. 4-28				Places where the relationships between sets of wells and databases is confusing: "IRLP [sic] water quality measurements are sampled from surface locations." Why are Irrigated Lands Regulatory Program (ILRP) sites included in the groundwater quality database (see label and caption for Figure 4-10)? It is unclear whether all the sites in Table 4-9 are groundwater sites.	ILRP stations were utlized in the quality monitoring because surface flows within the basin, except during signifincantly high flow events, percolate into the groundwater system. These water qulaity measurements may be useful to provide information to the GSA as to the quality of water that enters the groundwater system.
168	Pg. 4-29				Places where the relationships between sets of wells and databases is confusing: The relationship between databases from ILRP, California Environmental Data Exchange Network (CEDEN), U.S. Geological Survey (USGS), and National Water Quality Monitoring Council (NWQMC) is confusing. We suggest clarifying this point, perhaps using a Venn diagram or a similar graphic.	The text has been revised for clarity.
169	Pg. 4-40				Monitoring network selection issues: Proposed Monitoring Network tiers reflect priorities in the following order: (i) recent data, (ii) frequent data, (iii) known construction information. This is reasonable if monitoring is limited only to acquisition of data from existing programs. However, if the network is selected to meet SGMA requirements and monitor specifically for the GSA, then construction information and future well access is more important than frequency of past measurements and (to an extent) more important than the date of the most recent measurement. Additionally, no discussion was provided of data by which the wells were determined to be representative of the basin.	There is not adequate information on well construction and well access to base well selection on these criteria. These will need to be considered as the monitoring program is developed during the GSP implementation phase.
170	Pg. 4-35				Monitoring network selection issues: How were private landowner TDS values obtained? What was the context of the monitoring? Will landowners be enlisted to continue monitoring? How will this be accomplished if so?	Comment noted. This can be addressed when the monitoring network is finalized during the GSP implementation phase.
171	Pg. 4-45				Monitoring network selection issues: "Wells with multiple depths..." The vertical distribution of representative wells is not discussed. It appears here as a goal, but there is no indication of the depth distribution of the representative network.	Criteria Updated.
172	Pg. 4-53				Monitoring network selection issues: "...Established to monitor for salinity." What about other constituents from the groundwater conditions GSP chapter?	The text has been revised to describe the rationale for establishing the monitoring network only for salinity.

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173	Pg. 4-53				Monitoring network selection issues: "…Unlikely to be monitored again by that monitoring agency." Will the GSA rely on the agencies to continue monitoring? Will the GSA attempt to share monitoring activity with the agency, ensure the network is monitored through their own funding?	Comment noted. This can be addressed when the monitoring network is finalized during the GSP implementation phase.
174	Pg. 4-58				Monitoring network selection issues: "Well/measurement depths for three-dimensional constituent mapping." Was this considered in the section discussing groundwater level data gaps?	Not directly. We anticipate that the GSA will first need to focus on filling spatial data gaps in the monitoring network.
175	Pg. 4-37				Text issues: Section 4.3.4 discusses CGPS stations on Figure 2.2-22. The Monitoring Networks section needs its own figure showing subsidence monitoring stations, including CGPS stations. Also, on the same page an unreferenced "subsidence white paper" is attributed to Appendix Z, which likely is a placeholder. The paper needs a complete reference.	The figure in Chapter 2 is sufficient. The white paper is an appendix to the Groundwater Conditions chapter - the reference has been revised for clarity.
176	Pg. 4-39				Text issues: Section 4.5.1, discussing Management Areas, may be out of date. Several other sections discussing Management Areas also may no longer be accurate.	This section will be developed when the Board provides direction on management areas in the Basin.
177	Pg. 4-62				Text issues: The subsidence monitoring network section should at least mention critical or subcritical infrastructure likely to be affected by subsidence. If none exists, it may be helpful to state this and cite as the reason that limited subsidence monitoring will be required.	The data gaps section identifies areas that may be critically affected by subsidence.
178	Pg. 4-18				Table issues: Shouldn't "Number of SBCWA wells included in the Monitoring Network" be less than "Number of SBCWA wells"? The distinction between these categories is unclear. There is no discussion of why some are included, and others are not.	The text has been revised for clarity.
179	Pg. 4-24				Table issues: CCSD well table shows two wells with longest period of record 37 years and median 11 years. This is not possible given only two wells.	Table has been updated
180	Pg. 4-47 - 4-49				Table issues: Suggest adding a table number and identification on each page of the multi-page table.	The table format has been revised
181	General				Figure issues: When map figure discussions in the text name geographic features, those features should be shown and labeled on the map (e.g., Pages 4-14, 4-18).	The text has been revised for clarity.
182	Figure 4-2				Figure issues: Are all the hydrograph wells within this oval? Why focus on such a small part of the basin? This cannot be the extent of agriculture. Wells shown on hydrographs should be labeled on the map.	Yes. A single area was selected for presentation purposes as using all wells within the central basin would create a hydrograph that would not be useful or legible.
183	Figure 4-15				Figure issues: As discussed above, the selection scheme values a monthly monitoring record over knowledge of critical well construction data (screened or perforated interval). We rather suggest swapping the criteria for Tier 2 and Tier 3. Also, text explaining the criteria for each tier needs to be increased in size for readability.	Suggestion noted but not included. Every well with data from 2017-2018 was included in the montioring network regaurdless of well construciton information or frequency of measurement.
184	Figure 4-17				Figure issues: Faults should be included on this figure (and on most if not all water level monitoring network figures), especially since they were discussed in the monitoring well selection rationale.	Faults have been added to 4-16 and 4-17
185	Figure 4-19				Figure issues: What are "Non-Groundwater Quality Monitoring Network Wells"? This should be explained in the text.	Wells have been removed from figure.
186	Figure 4-20				Figure issues: This map distinguishes between Representative Wells and Active Groundwater Quality Monitoring Network Wells. The text says that all water quality network wells are representative wells.	Figurue and text has been updated.
187	Pg. 4-20				Misc/Minor: "East of Highway 33" should be "west of Highway 33."	This has been fixed.
188	Figure 4-2				Misc/Minor: Data series labels on the plot should be clearer or larger.	This has been fixed.
189	Pg. 4-26				Misc/Minor: "Landowners have provided data on 99 wells." Needs discussion of how the data were requested and obtained.	The text has been revised for clarity.
190	Pg. 4-28				Misc/Minor: Throughout the document, Irrigated Lands Regulatory Program is abbreviated as "IRLP" rather than "ILRP."	This has been fixed.
191	Pg. 4-44				Misc/Minor: "Proximity to other prominent features such as faults…" Based on this statement it is unclear - should monitoring wells be near or far from faults?	The text has been revised for clarity.

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Comment #	Section	Section Paragraph #	Paragraph's Sentence #	Sentence Starts with, "...	Comment	Response to Comment
	Comments on DMS Section					
1	General				The GSP chapter and DMS appear to fulfill the basic requirements of GSP Regulation § 352.6 - Data Management System.	Comment noted. No change required in document.
2	Table 6-2				All data types within the DMS are listed in Table 6-2, but it is unclear which data are minimum required information (e.g., latitude and longitude) and which are optional parameters (e.g., casing perforations).	The table and text have been revised to indicate required fields.
3	6.3	3	2	In many cases ...	The chapter states "In many cases, there were discrepancies between ground surface elevation (GSE) of the well from different sources. In these cases, the ground surface elevation of the well was updated using the USGS digital elevation model." This might cause problems with calculation of water-level elevations, as the USGS DEM is less precise than surveyed GSE values, and based on a 30 meter by 30 meter horizontal resolution. DEM elevation values are interpolated and averaged within each model element. The use of DEM elevation data could affect assumed groundwater flow directions in areas with shallow groundwater gradients. More information should be provided to demonstrate the adequacy of this approach over evaluating and selecting the most likely of the elevations published in original data sources for the wells. At the least, wells with groundwater elevations calculated using DEM values should be flagged clearly in hydrographs, piezometric surface maps, and other interpretations.	Comment noted. The data used in the model can be re-evaulated in the future as the monitoring network is implemented and more data is available.
4	General				For "more detailed" instructions on DMS use, the user is referred to a sparse one-page user guide. Some pertinent details of user interaction and function limits could be provided, for example restrictions on data downloads for review of well construction details.	Comment noted. The Opti User Guide is a 17 page user manual for data managers and is provided separately from the 1 page Opti Quick Start Guide. The User Guide will be linked to the DMS Section upon finalization.
5	6.2.1 User and Data Access...			Private data is monitoring data...	Please clarify, it is unclear if private data can be edited by ANY private user. Also, how is this performed? For example, is the private data associated to the user type with parcel/well id	The text has been revised for clarity. Sites (wells, gages, etc.) and their associated data (whether private, shared, or published) may only be edited by Administrators and Power Users associated with the Managing Entity.
6	6.2.2 Data Entry and Validation	1	3	The data is validated using...	Please clarify -Who is performing and verifying the quality control checks?	The text has been revised for clarity. The system runs some validation checks to alert users to potential data quality issues. The data is validated by the Managing Entity's Administrators or Power Users.
7	6.2.2 Data Entry and Validation - Data Collection...	1	2	In the Data Entry tool, new sites may be added by...	Please explain who is verify the data entry? Is the data being flagged as new, so it can be reviewed later by the GSA Board?	The text has been revised for clarity to match the existing conditions. If process changes are required for GSA Board review, the DMS can be configured to meet those needs during the implementation phase.
8	6.2.2 Data Entry and Validation - Monitoring Data...			Quality Flag	Please explain the term "Quality Flag" and how is it used and by whom	The text has been revised for clarity. Quality flags are associated with individual measurements and include quality assurance descriptions (e.g., "Pumping", "Can't get tape in casing", etc.). The quality flags should be documented by the person taking the measurement.
9	6.2.2 Data Entry and Validation - Data Validation	3	2	Users may access partially completed...	Consider adding a note to the bottom of the page to reference that this is a partially completed import validation, in case of data discrepancies.	The text has been revised for clarity. Partially completed logs are currently identified as incomplete in the DMS import logs.
10	6.3 Data Included in the Data...	2		Groundwater Elevation (2 parameters)...	Please list these parameters. The GSA Board may need this information to resolve any data discrepancies. Can the list of parameters grow?	The text has been revised to list parameters. The list of parameters can grow as the needs of the GSA change over time.
11	6.2 Functionality of the Data...	2	3	For more detailed instructions on ...	Provide a hyperlink to the user's guide here	Comment noted. Hyperlink will be included upon finalizing and posting the User Guide.
12	6.2.2 Data Entry and Validation	1	1	To encourage agency and user participation...	This possibly helps maintain consistency but how do these tools improve data quality? Data quality is a function of training, following protocols, and equipment calibrations combined to create defensible data. It even mentions below in Data Validation that these data may not be accurate.	Comment noted. The text has been revised for clarity.
	Comments on topics separate from the DMS Section					
13	General				Clustering effects. The potential effect of data clustering on conclusions drawn from parts of the network with very high well densities also is not discussed. The well density discussion needs to consider the potential effects of data clustering on conclusions drawn from aggregation of water level data. For example, if Undesirable Results are defined as a certain percentage of monitoring network wells experiencing water levels below their Minimum Thresholds, clustering of wells through intentional "selection of additional wells in heavily pumped areas" may artificially magnify the apparent portion of the basin affected, increasing the likelihood of it being judged as out of compliance with sustainability criteria.	This was accounted for in the selection of wells included in the Representative Monitoring Network, and will be addressed in the Sustainability Thresholds GSP section.
14	General				A number of properties including well construction details and measuring-point (MP) and ground surface (GS) elevations cannot be queried in the public "Opti" interface. Some of the data can be viewed on a well-by-well basis, but the use of tables and queries is very limited. This lack of transparency makes quantitative evaluation by outside parties difficult.	Comment noted. No change required in document. Will evaluate as enhancements to Opti query tool during implementation phase.
15	General				Queries seem to hang without producing consistent results depending on the browser used to access the website. For example, the Opti system seems to produce better results using Google Chrome than Mozilla Firefox, and Microsoft Internet Explorer is stated as not compatible at all.	Comment noted. No change required in document. Will evaluate Opti query tool performance.

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16	General				A few queries to test the site's functions revealed some potential structural problems with the DMS. In one example, a query for all wells with Managing Agency = Cuyama Basin GSA returns an extensive list of wells but when the data are downloaded to an Excel format file, only subsidence data for two sites (not wells, apparently) are produced. In another example, a query for Reference ET > 0 appears to be coded into the menu system but running the query produces no records.	Could not reproduce results described. A query for all wells with Managing Entity = "Cuyama Basin GSA" and subsequent Excel export produced expected results. More information is needed to try and identify the issue described. The system is coded for more data types (e.g., Reference ET) than are currently collected for future expansion of data efforts.
17	6.2 Functionality of the Data...				Please clarify - Does the GSA need agreements with well owner for the information they are supplying? For example, if someone is adding a new well to the DMS, can the board use the well data in their monitoring network? What is the GSA process to approve a new groundwater well for the DMS?	These issues will be addressed during the GSP implementation phase.
18	6.2.1 User and Data Access...				Please clarify - Does the DMS track what data was changed and by what user?	The data record and user associated with measurement data entry/modification is stored in the DMS but not currently viewable in the tabular data output.
19	6.2.1 User and Data Access...			System Administrator users manage,,,	Please clarify - Who is the system administrator? Does the GSA need to designate someone?	Currently, the Consultant team is the System Administrator. The GSA can designate a System Administrator as desired.
20	6.2.1 User and Data Access...			The Cuyama Basin GSA is...	Please clarify term "Cuyama Basin GSA" – Do you mean GSA Board members, Executive Director, or both? Do you need the Board to address this and list who is the managing entity(ies)?	It is currently the Executive Director and GSA consultants. The GSA Board will decide on the appropriate party for managing the DMS in the future.
21	Table 6-2			Data Collection Site Information	Is there a way to rank the groundwater well locations/elevations on accuracy? For example, rank (1) – accurate with little risk to location/ elevation to rank 3 – not as accurate, considering surveying the groundwater well to verify location/elevation	That ranking does not currently exist in the DMS, but can be added is needed during the implementation phase.
22	6.2.2 Data Entry and Validation - Monitoring Data...	1	1	Monitoring data including but not limited to...	Would Land Use data be included in this data set?	Land use is currently not included in this dataset. Additional data needs can be evaluated and potentially included during the implementation phase.
23	6.2.2 Data Entry and Validation - Data Validation				To help address data questions, is there a column to note who revised or entered the data?	The data record and user associated with measurement data entry/modification is stored in the DMS but not currently viewable in the tabular data output.
24	6.2.2 Data Entry and Validation - Data Validation	1	2	The entities that maintain the monitoring data...	Who will keep the DMS maintained and updated?	DMS maintenance and update will be determined by the Cuyama Subbasin GSA Board.
25	6.2.2 Data Entry and Validation - Data Validation	1	2	The entities that maintain the monitoring data...	Please list all assumptions made for the database, such as locations of each well and how they were verified, such as by a GPS survey, lats/logs, google maps, and etc. Consider approaching the GSA Board with a disclaimer on the DMS for data and accuracy.	Comment noted. A disclaimer window has been added upon logging into the DMS.
26	6.2.2 Data Entry and Validation - Data Validation	2	1	Upon saving the data in the data entry interface...	Can the GSA Board increase the list of data validation checks?	Comment noted. No change required in document. Will work with Cuyama Subbasin GSA to evaluate need for additional data validation checks during implementation phase.
27	6.2.3 Visualization and Analysis	1	1	Transparent visualization and analysis	Can it be incorporated into their own DMS system?	There are many options for integrating different DMS systems and functionalities. These options and the exact requirement would need to be identified and evaluated for inclusion during the implementation phase.
28	6.3 Data Included in the Data...	5	2	Using the DMS data viewing capabilities...	Consider asking the GSA Board, if they would like a list of recommendations to this chapter, such as below. 6.4 RECOMMENDATIONS Recommendation to survey each groundwater well, as discussed on Page 7 of the DWR BMP Groundwater Monitoring Protocols, Standards, and Sites Best Management Practice, December 2016. • The elevation of the Reference Point (RP) on the well casing of each well must be surveyed to the North American Vertical Datum of 1988 (NAVD88), or a local datum that can be converted to NAVD88. The elevation of the RP must be accurate to within 0.5 foot. It is preferable for the RP elevation to be accurate to 0.1 foot or less.	Comment noted. This can be addressed by the GSA Board during the implementation phase.
29	General				The Data Management System has been developing with steady improvements being made over time. However, several issues with functionality and the need for more complete data inputs still persist. The wells in the Monitoring Network are not in a viewable layer. And a search by State ID #s is not cross referenced with the Opti ID #s, challenging the users ability to find a particular well.	Comment noted. The DMS will be updated to display wells in the Monitoring Network once the Monitoring Network has been finalized. State Well Numbers and Opti IDs (Site Name) are cross referenced in the Site List. Consultant team will evaluate updating the Query tool to reflect the cross reference and update functionality as needed during the implementation phase.

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30	6.2.2 Data Entry and Validation, page 6-2				Although some of the critically important data has be entered, many of the data parameters on table 6-2 are completely blank throughout the DMS. The fields that are most important to understanding the aquifer a particular well might represent is the depth and casing perforation intervals. None of this is available in Opti, yet. I'm told much of this data is in W&C's hands, but are not able to be input due to time & budget. Why can't the wells selected for the Groundwater Level Monitoring Network be viewed as a subset or a seperate layer? Same for any of the other sites in the Monitoring Network? Which wells are the representative Groundwater Quality Monitoring wells? If "The data is validated using a number of quality control checks prior to inclusion in the DMS." What are the QC/QA checks? As we move forward, in order to help promote user confidence in the data stored and published in the DMS, some ground truthing and well site canvassing will be required by a licensed hydrogeologist to verify and complete the understanding of the Monitoring Network wells and their data.	Comments noted. Additional data may be added during the implementation phase. The DMS will be updated to display wells in the Monitoring Network once the Monitoring Network has been finalized. The QC/QA checks performed by the DMS are listed in Section 6.2.2 and include: • Duplicate measurements: The database checks for duplicate entries based on the unique combination of site, data type, date, and measurement value. • Inaccurate measurements: The database compares data measurements against historical data for the site and flags entries that are outside the historical minimum and maximum values. • Incorrect data entry: Data field entries are checked for correct data type, e.g., number fields do not include text, date fields contain dates, etc.
31	6.2.4 Query and Reporting, page 6-5				The query tool does not allow a well to be searched by the various other ID#s like the State Well ID, USGS Code, or CASGEM ID, even when this data is present. This is unnecessarily cumbersome. A cross reference table should be made available if the DMS can't search for it. The Analysis Tools and the toolbox mentioned sounds very helpful but it is not part of the DMS. Will the DMS ever actually offer any of these analysis tools, including contouring, total water budget visualization, and management area tracking?	Enhancements to the Query tool will be evaluated and implemented as needed during the plan implementation phase. The tools discussed in the DMS section of the GSP are currently available for non-public users. Access will be granted for Monitoring Entities and their associated users to these tools. Additional tools will be made available as needed during the implementation phase.
32	6.1 Overview of the Cuyama Basin….	2	3	The site may be accessed here:	Where will this site ultimately reside? It shouldn't be in the system of W&C, nor should their name be part of this URL. Does the GSA own the DMS and will it have access once W&C's contract ends?	To be determined by the Cuyama Subbasin GSA Board. W&C can direct the DMS to a domain of the GSA's choosing.
33	6.2.2 Data Entry and Validation - Data Collection…	1	2	In the Data Entry tool, new sites may be added by…	May not want to provide access to create new sites to too many users. This could create issues with overlap.	Comment noted. Access will be determined by Cuyama Subbasin GSA Board.
34	6.2.2 Data Entry and Validation - Data Collection…	1	3	Existing sites may be updated using the Edit Site…	A feature should be added (similar to the CASGEM portal) which automatically tracks ALL edits to data and site information to include date/time/user/edit.	Comment noted. Will evaluate feasibility and address during implementation phase.
35	6.2.2 Data Entry and Validation - Data Collection…	2	1	The information that is collected for sites…	Many of these items could use additional clarification for the user and entity inputting these data. Examples include………. 1)-Lat/Long-accuracy and how was the information obtained. Cell phone, GPS, DGPS, etc. NAD27 or NAD83, or…….? 2)-Accuracy of GSE and how was the information obtained? NAVD29 or NAVD88 or….?	Comment noted. Will evaluate feasibility and address during implementation phase.
36	6.2.2 Data Entry and Validation - Monitoring Data…				Can we add a function to upload photos and measurement field notes? Storing this original data and viewing changes to the well head over many years will be useful. I can't tell if these are options, but additional things to add to this list are…… 1)-Time of measurement. 2)-Status (pumping, nearby pumping, dry, flowing, etc) 3)-Accuracy of measurement 4)-Equipment used to make the measurement (steel tape, electric tape, etc.) and was this equipment calibrated? Calibration paperwork should be loaded to this data portal for reference. 5)-Things noted in Supplemental Info are mentioned in Table 6.2 and linked to the well. These shouldn't be changed during measurements unless the reference point changed as a result of breaking or modification.	Comment noted. Will evaluate feasibility and address during implementation phase.
37	6.2.2 Data Entry and Validation - Data Validation	1	1	Quality control helps ensure the integrity….	Data validation is a huge issue in the basin, but we understand this section is strictly related to the DMS. Possibly a footnote explaining this issue with data quality should be provided to the user. Possibly verification/statement that certain protocols were followed when making the measurement? Additionally, data quality can be better verified by adding entries which………. 1)-indicate data accuracy (0.01 ft, 0.1 ft, 0.5 ft, to the nearest foot, etc). 2)-equipment calibration 3)-where two consecutive measurements completed? 4)-availability of field notes	Comment noted. Will evaluate feasibility and address during implementation phase.
38	6.2.2 Data Entry and Validation - Data Validation	2		Inaccurate measurements: The database…	Many of the historical data were collected by private entities with no QA/Q processes in place. In addition, in a declining basin, one would expect to continually see entries outside the historical minimum values.	Comment noted. No change required in document.
39	6.2.2 Data Entry and Validation - Data Validation	3	3	This allows a second person to also access the…	There should be confirmation that 2 individuals reviewed these data. Possibly an option for a second user to login and initial that the data have been visually confirmed.	Comment noted. Will evaluate feasibility and address during implementation phase.
40	General				Where there are multiple data sources for one site that the most negative data be assumed as the most accurate pending implementation of the monitoring system	Comment noted. Will evaluate feasibility and address during implementation phase.

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Comment #	Section	Section Paragraph #	Paragraph's Sentence #	Sentence Starts with, "...	Comment	Response to Comment
1	2.3.4 Water Budget…Current and Projected	1		Because there is no basis to assume any changes in Cuyama Basin	Consider adding projects to the projected water budget.	The Water Budget section on sustainable yield now includes an analyses that incorporates potential projects.
2	General Comments				"As defined by the Groundwater Sustainability Plan (GSP) regulations promulgated by the California Department of Water Resources (DWR), the water budgets section is intended to quantify the following: (5) If overdraft conditions occur, a quantification of overdraft over a period of years during which water year and water supply conditions approximate average conditions." These are the only two times the word "overdraft" is used in this whole chapter, yet the data indicates that of the 60 TAF extracted every year from the Cuyama Groundwater Basin for agriculture, 23 to 26 TAF of it is in excess of available recharge, otherwise known as "overdraft". That's 44% overdraft, almost ½ the amount that is being extracted. That is before climate change or GDEs are factored into the budget. Yet there is not one mention of the word overdraft! Change in Storage is an unclear euphemism that must be qualified with another disassociating term, such as positive/negative or gain/loss. In a basin that is designated by DWR as critically overdrafted, the GSP should not be hiding the problem behind misleading terminology that downplays the issue. Call it by its real name; Overdraft.	A note has been added that reduction in storage is overdraft.
3	2.3.5 Water Budget Estimates				The terms used for the components of the surface and groundwater budgets should be clearly defined in a Useful Terms section. What is specifically meant by these terms and how are they calculated,estimated or measured; Evapotranspiration, Deep Percolation, Applied Water, Runoff, Stream Seepage, Subsurface inflow, Reduction in storage	A Useful Terms section has been added
4	2.3.6 Historical Water Budget			The Basin average annual historical groundwater budget has greater	This sounds like chronic overdraft. To accurately quantify it would be to compare it to the total pumping demand. 23 TAF/Y has no reference to the basin as a whole. 44% overdraft is a quantification. The decision makers who are charged with balancing this basin are not well served when the problem is not clearly stated.	Required pumping reductions to eliminate overdraft are now quantified in the sustainable yield section.
5	2.3.7 Current and Projected Water Budget				The water budget considers native vegetation within the surface water system of the water budget. Native vegetation evapotranspiration (174,000 AFY) is a significant portion (60%) of the average annual surface water budget. Because the section of the report related to Groundwater Dependent Ecosystems is not yet available for review, it is unknown if some portion of the native vegetation could be utilizing groundwater as its water source. It is also recognized that this is one of the many real data gaps, as this Basin's hydrologic connection to the native ecosystems is poorly understood. The Project of Rangeland Management fits in here with a possible win/win between ecological services and a water Budget. Fire, as a management strategy for maintaining a more mature natural ecosystem, can augment groundwater recharge in the main basin. Where is the Data Gap section to help refine this understanding to help improving these Thresholds into the future.	GDEs are now discussed in the Groundwater Conditions section. The rangeland management project is not included in the GSP per direction from the Board
6	2.3.7 Current and Projected Water Budget				The text incorrectly identifies Figure 2.3-9 and Figure 2.3-10 as historical when they are current and projected numbers. The text also fails to quantify the overdraft of 42% by only stating that the "budget has greater outflows than inflows, leading to an average annual decrease in groundwater storage of 25,000 AF" By presenting only the value of the imbalance, the degree of overdraft is not conveyed and the severity of the situation is avoided and misrepresented. This is an unacceptable disservice to contextual understanding, which misleads and decontextualized the situation to decision-makers and stakeholders.	The text has been corrected. Required pumping reductions to eliminate overdraft are now quantified in the sustainable yield section.
7	Table 2.3-4: Current and Projected				What is meant by these Water Year Types? How many inches of rain per type of water year? This table could be informative if it had more reference or context. What is the % of normal or average?	Water year types were developed for the Cuyama Basin based on historical Basin precipitation.
8	2.3.8 Sustainable Yield Estimate				DWR requires an estimate of sustainable yield for the basin. Why is this incomplete? This section can be developed without the projects and management actions modeling analysis. Why not estimate the Sustainable Yield for the baseline condition before projects and management actions? Some amount less than the sum of Deep Percolation + Stream Seepage + Subsurface Inflow would be a Sustainable Yield. That's < 35,000 AF or 56% of currant pumping. Quantify what we do already know.	Sustainable yield information is now included in the section.
9	General Comments				It is disingenuous to present alarming data without reference or context for the understanding of its severity. DWR requires the quantification of the overdraft. W&C has not only failed to clearly quantify the degree of overdraft, but they refrained from even using the term at all. For the sake of stakeholder understanding and effective decision making it is critical that all information is presented in full context. Complex issues need their significance and their implications explained clearly.	A note has been added that reduction in storage is overdraft.
10	2.3.1 Water Budget Information	3			It would be useful to be more specific which regulations are binding than the entire California Code of Regulations.	A footnote has been added as suggested below.
11	Figure 2.3-2				Please double-check the cumulative departure calculations. Based on visual inspection, the calculations appears to be off in places (e.g., 2003 received 12 inches below average precip, but the cumulative departure only drops about 8 inches)	The figure has been updated
12	2.3.4 Water Budget…Current and Projected	1		This baseline uses current land and water use	This is not accurate based on previously presented information in the Technical Forum. It was previously understood that you are varying assumed land use going forward to match historical changes in annual crops.	The text has been revised for clarity.
13	General Comments				There does not appear to be a placeholder for a projected groundwater budget considering climate change.	A section on climate change has been added.
14	2.3.1 Water Budget Information	3		In this document, consistent with the	Suggest citing in footnote: California Code of Regulations, Title 23. Waters, Division 2. Department of Water Resources, Chapter 1.5. Groundwater Management, Subchapter 2. Groundwater Sustainability Plans	This has been added.
15	Figure 2.3-2				Align and standardize vertical scales to allow direct comparison for a given year or set of years.	The figure has been updated

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16	General Comments				The IWFM was calibrated for the period 1995-2015. The historical budget is for the period 1998-2017. Presumably the 2016 and 2017 periods are predicted by the model. Where is the post audit of those results?	These can be made available to the Tech Forum members
17	2.3.4 Water Budget…Historical	1	2	The hydrologic period of 1998	This results in cumulative removal of 18 inches of water relative to the long-term average.	Comment noted. No change required in document.
18	2.3.5 Water Budget Estimates			The following components are included in the groundwater budget	Are spring flows negligible/ignored?	Spring flows are negligible compared to the overall water budget.
19	Table 2.3-2			Average Annual Land Surface Water Budget	Incorporate "20-yr" and "50-yr" in table title	These have been added as footnotes to the table
20	Table 2.3-3			Average Annual Land Surface Water Budget	Move tables closer to text where they are discussed.	The section has been re-formatted
21	Table 2.3-4			"Runoff" cell	Is this flow out of the basin?	Yes
22	Table 2.3-3			Cell with 25,000 value in 3rd column for Deep Percolation	Rounding error? Why not 26,000 AFY as with land surface deep percolation?	Yes, this difference is due to ronding.
23	Figure 2.3.4			Historical Land Surface Water Budget	Need to be rigorous about land surface and groundwater budgets; do not refer to basin budget components.	The text has been revised as recommended.
24	2.3.6 Historical Water Budget			The Basin experiences about 285,000 AF	"Basin" - The unsaturated soil zone, not the basin; groundwater is part of the basin water budget.	The text has been revised as recommended.
25	2.3.6 Historical Water Budget			The Basin experiences about 285,000 AF	"inflows" - Land surface inflows	The text has been revised as recommended.
26	2.3.6 Historical Water Budget			About 225,000 AFY is consumed as evapotranspiration	These amounts make sense?	Yes, the evapotranspiration estimates are reasonable given the available land use data. The stream seepage and deep percolation estimates are reasonable given the data that is available.

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Comment #	Section	Section Paragraph #	Paragraph's Sentence #	Sentence Starts with, "...	Comment	Response to Comment
1	5.1 Useful Terms			Sustainability Goals – The culmination	The definitions are almost verbatim from the regs but could use some translation for a general audience, esp Sustainability Goals	To make sure that we are consistent with the Regulations, we have kept the definitions as is.
2	5.2.1 Threshold Regions…Southeastern Threshold			The northern boundary of this region is the narrows at the Cuyama river,	"and the eastern boundary" - You mean western boundary?	Although correct, the intention was to say the "eastern" because to the west of the boundary of the Basin and to the west is the Badlands Management Area. The intention was to destinguish the boundary between the two management areas.
3	5.2.1 Threshold Regions…Eastern Threshold			The Eastern Threshold Region lies just east of the central part of the	…lies just southeast?	Text has been updated
4	5.2.1 Threshold Regions…Eastern Threshold			Hydrographs in this region indicate that groundwater	Mention other aspects of Eastern Region: More variability in water levels? Locally important shallow production wells?	Text has been updated to provide more clarity to destinguish this region from the Central Region by discussing differences in water level. Also mentioned in this section is the Santa Barabara Canyon Fault, which is discussed in more detail in the HCM.
5	5.2.1 Threshold Regions…Western Threshold			The eastern boundary is defined by the Russell Fault,	Brief explanation of which land uses are differentiated	Text has been updated
6	5.2.1 Threshold Regions…Northwestern Threshold			The southeastern border was drawn to differentiate between the	Suggest "southern border" or border with the western region"; also, which land uses differentiated?	Text has been updated
7	Figure 5-1: Cuyama GW Basin Level			Map	Suggest text callout labels on the map to make it easier to tell which region is which	The figure has been updated
8	Figure 5-1: Cuyama GW Basin Level			Map	Change Legend to say "Representative well with OPTI well ID number"	The figure is clear enough without this change.
9	5.2.2 Minimum Thresholds…Southeastern Threshold			Placeholder for IM calculation	Show and reference example hydrograph (use real one) with example of trend and MT & MO calculation	Since the document has been changed to make all IMs equal to MTs, this is not needed
10	5.2.2 Minimum Thresholds…Southeastern Threshold			Levels will be measured using	An embedded table to summarize monitoring frequency would be useful	Monitoring frequency is discussed in the Monitoring Networks chapter
11	5.2.2 Minimum Thresholds…Eastern Threshold			The MT for this region intends to protect	Suggest combined hydrograph with multiple wells to illustrate trend	Hydrographs with thresholds are provided in an appendix
12	5.2.2 Minimum Thresholds…Eastern Threshold			This 20% of the range was then added below	State period of historical range used (1995-2014, or entire range of data?)	Updated text for clarity
13	5.2.2 Minimum Thresholds…Eastern Threshold			The MT values calculated by the two methods were then compared, and	Update method of setting MT & MO per 3/6/2019 GSA Board Meeting	Text has been updated. Board provided final approval for update to MTs and MOs at the 4/5/2019 meeting
14	5.2.2 Minimum Thresholds…Central Threshold			If no measurement was taken during this 4-month period	State period used to evaluate range	Updated text for clarity
15	5.2.2 Minimum Thresholds…Western Threshold			The MT was calculated by taking the difference between the total well depth and the value closest to mid-February, 2018	2018 or 2015? Explain reason for change in assumed baseline	Updated text for clarity
16	5.2.2 Minimum Thresholds…Northwestern Threshold			This value was then set as the MT.	In other words, an allowable loss of 15% of the estimated saturated thickness of the aquifer was proposed.	This is correct.

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17	Table 5-1 - Representative Monitoring			2030 IM	IM???	IM = Interim Milestone
18	Table 5-1 - Representative Monitoring	OPTI well 77, Final MO 400			How do the MT's agree across the Basin? Table shows significant difference in parameter ranges in different Threshold Regions. Are we going to have some agreement across the Basin or will it bust? The Central Region has a range of 600 feet, Western 130 feet, and Eastern 70 feet.	Thresholds have been calculated to be protective of certain areas of the Basin and the conditions within those portions of the Basin while also considering beneficial uses of GW. In other regions, they have been calculated to achieve sustainability over the planning horizon. While threshold levels may differ across regions, these thresholds will 1) help move the
19	Table 5-1 - Representative Monitoring	OPTI well 324, Final MT 311			Suggest using a contour or symbolic post map to illustrate overall basin MTs and MOs. May show some discontinuities that you will want to address in the text.	Spatial density of wells may not be sufficient to provide a map that is accurate to represent the MOs across the entire basin. When more data is available, this may be an option.
20	5.3 Reduction in Groundwater	2	1	Reduction of groundwater storage is not a concern for the Basin	I kinda thought this was the main concern, actually. Might want to re-word this a little. Maybe something like "Separate monitoring of groundwater storage changes apart from groundwater levels is not proposed..."	Text has been updated for clarity
21	5.3 Reduction in Groundwater	3	1	Second, because the primary aquifer in the Basin is not confined	Storage also is linear with water levels in confined systems, you just have a much smaller storage coefficient.	Comment noted. No change needed.
22	5.5 Degraded Water Quality	3	1	Because the undesirable result for degraded water quality	Suggest clarifying this. Maybe "Because undesirable water quality results are defined under SGMA only as those chemical constituents which are influenced by SGMA-related groundwater management activities, not all chemicals of concern in Cuyama Basin groundwater will be monitored or regulated by the GSA. Total dissolved solids (TDS) will..."	Text has been updated for clarity
23	Table 5-2: MOs	Table		MO column	Suggest making a symbolic post map, color "heat map" or contours to illustrate the basin as a whole, or maybe by threshold region, even though you aren't using those for WQ. Still people have gotten used to them and now think along those lines.	Spatial density of wells may not be sufficient to provide a map that is accurate to represent the MOs across the entire basin. When more data is available, this may be an option.
24	5.6.3 Minimum Thresholds	1	1	Because current subsidence rates are not believed to be significant and	P521 is outside the basin. VCST is in the basin.	Updated text for clarity
25	5.6.3 Minimum Thresholds	2	2	Thus, the MO for subsidence is set for zero	Isn't CUHS subsidence ~11 inches? More than zero...	Text has been updated for clarity. Although approximatly 295 mm of subsidence has occurred in the last 14.5 years (estimated by taking -5mm around mid 2002 ti -300 around Jan 2017), the rate of subisdence has been about 0.8 inches per year.
26	5.7 Depletions of Interconnected	2	2	In January 1, 2015 surface flows infiltrated into the groundwater	Are you talking about a single 1-day flood event? This sentence is unclear if you are describing general conditions or a specific event.	Updated the text for clarity
27	5.7 Depletions of Interconnected	2		Conditions have not changed since January 1, 2015	How does this correspond to the water budget showing significant surface water outflows?	Updated the text for clarity
28	General Comment				No explanation is offered for the absence of Interim Milestones. How and when will these be calculated? Placeholders for these important sustainability goals represent a critical gap in this chapter and need some explanation as to the timing and process for their completion.	The updated draft sets all IMs for water levels and water qualities to equal MTs
29	General Comment				Minimum Thresholds for the Eastern Region are being reconsidered and adjusted by the GSA and are not accurately reflected in this draft for review.	Text has been updated. Board provided final approval for update to MTs and MOs at the 4/5/2019 meeting
30	General Comment				The sustainability criteria of subsidence, loss of storage, water quality and the depletion of interconnected surface waters are underemphasized to the point of misrepresenting the undesirable results that are currently being experienced by beneficial users and uses other than agriculture in the basin.	Comment noted. No change needed.
31	General Comment				There is a dismissive approach to addressing the undesirable results of the Sustainability Criteria and to the setting of MTs. All the available data indicates conditions of overdraft in the basin but many MTs allow for continued declines in groundwater elevations and groundwater quality. The perspective towards sustainability appears to be coming from the viewpoint of the commercial agricultural beneficial user and dismissive of the needs of others, such as domestic and environmental users. Many water quality issues are avoided, such as arsenic and nitrates and domestic supply needs. Subsidence is dismissed and increasingly tolerated. Interconnected surface waters and GDEs are assumed to be irrelevant without the responsibility for protection. This is unexceptable to this stakeholder and I would hope and expect that the DWR would agree	Comment noted. No change needed.
32	5.2 Chronic Lowering				Of the six Threshold Regions that were defined for specific MT/MO/IMs, only two specifically note protection of environmental uses: Southeastern Threshold Region, and Eastern Threshold Region. However, W&C has defined likely GDEs in the Northwestern region and parts of the Central region. Without the associated maps and GDE report, it was unclear if these wells with MTs and MOs are protective of these likely GDEs. Most MTs/MOs in these wells (Table 5-1) are really deep; a few wells have MTs < 100ft and MOs <50 ft. It would be important for be able see where those wells overlay with the potential GDEs (both original NC dataset potential GDEs and the W&C likely GDEs). How is it demonstrated that the lowering of groundwater levels with these thresholds won't adversely impact these beneficial uses?	Well locations relative to GDEs can be assessed when Monitoring Network data gaps are addressed during the GSP implementation phase.

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33	5.2.1 Threshold Regions				This subsection does not discuss the strategies used to calculate the MOs, MTs, and Milestones for each Threshold Region, as stated in the text, but only describe the characteristics and location of the regions. Strategies are presented in subsection 5.2.2.	Text has been updated for clarity
34	5.2.2 Minimum Thresholds…Southeastern Threshold				The MT is intended to be "protective of domestic, private, public, and environmental uses", yet for one of the only two monitoring wells in this region the MT is set only one foot above the bottom of the well (Opti well #2). How is that being protective?	MT is set at levels determined and approved by the GSA Board. If levels drop below MTs, the Board can take action in the future.
35	5.2.2 Minimum Thresholds…Eastern Threshold				It has been noted that these rationales do not work well for this region and that the monitoring wells are not representative of the wells in this region. The rationales for this region need to be reconsidered by the GSA and then this subsection rewritten before review.	Text has been updated. Board provided final approval for update to MTs and MOs at the 4/5/2019 meeting
36	5.2.2 Minimum Thresholds…Western Threshold				This sentence makes no sense; "This would allow users in this Threshold Region to utilize their groundwater supply without increasing the risk of running a dry well beyond acceptable limits, and this methodology is responsive to the variety of conditions and well depths in this region." A well running dry would surely constitute an Undesirable Result.	Text has been updated for clarity
37	5.2.2 Minimum Thresholds…Western Threshold				OPTI Well 474 is not in this region, why is it mentioned here?	Well 474 is in the western region
38	5.2.2 Minimum Thresholds…Northwestern Threshold				Very little publicly verified information is available for this region which until recently had never been developed for irrigation. Only two years of data exists from the new wells in the region. How was the "total average saturated thickness for the primary storage area of the region" determined with any validity? With such limited historical data available, how was 50 feet determined to be 5 years of storage? Local landowner input is suspect to be biased in the interest of their recent commercial development and is therefore questionable at best. In the case of such uncertainty it seems imprudent and risky to set MTs so far below current conditions in a critically overdrafted basin. Were the "Far-west Northwestern" wells put into a newly designated Threshold Region, moved into the "Western" region, or just "reclassified" because the rational is inappropriate? Is this an appropriate solution? This was never discussed by the SAC or GSA.	Information about this region was provided in two memorandums emailed to the Cuyama mailing list on 12/13/2018. The GSA Board was able to take this information into account when setting MTs for this region.
39	5.3 Reduction in Groundwater				Reduction of groundwater storage is certainly a concern for the Basin for obvious reasons. A lack of sufficient monitoring data in several areas of the Basin (western, northwestern, far west northwestern, eastern, and southeastern) inadequately represent conditions of groundwater storage. Chronic groundwater elevation declines in many areas of the Basin indicate significant reduction in storage. The historic and current condition of overdraft (-26 TAF/Y) has reduced groundwater storage in the basin by well over 1,000,000 AF, and is projected to continue until some substantial changes are made to the management of this resource. The reduction of groundwater storage caused by continued overdraft is an undesirable result experienced by every beneficial user in the basin	The text has been revised to just note that direct measurement of storage is not needed, while removing reference to storage not being a concern.
40	5.5 Degraded Water Quality				Because of the causal nexus between excessive groundwater extraction and degrading groundwater quality, the GSA is responsible for monitoring the changes in concentrations of any constituent that would represent an undesirable degradation of water quality due to groundwater extraction. These include Arsenic, Nitrates and TDS. Limiting the GSP to monitoring TDS alone is not sufficient and does not satisfy the requirements of SGMA with regards to monitoring groundwater quality.	Direction was provided by the GSA Board (through approval of the Monitoring Networks GSP section) to only include TDS for monitoring and sustainability in the GSP. As stated in the text, other contamination sites are regulated by the RWQC, nitrates are unde the jurisdiction of the ILRP, and the GSA does not possess land use authroity to incluence fertlizer use. Additionally, Arsenic occurs at specific depths in the Basin and is not managed a the GSA regional scale.
41	5.5.3 Minimum Thresholds				TDS levels in the groundwater detrimentally impact the agricultural economy of the Basin because crops like potatoes, beets and leafy greens, formerly a much larger part of local production, are no longer commercially viable. Carrots may tolerate the high TDS, but they suffer in quality, taste and sweetness. It should be noted that to defend poor water quality and tasteless produce does not serve the local agricultural economy well and the GSP should not include this sort of language. Further, there is no mention made of the undesirable effect experienced by domestic and livestock users due to the poor water quality. It should be noted that carrot production is not the only beneficial user of groundwater in the basin. Disadvantaged communities in the valley are not well resourced to treat drinking water sources or redrill domestic wells.	High TDS in the Basin, as stated in the text (Sustainability Thresholds Sectio nand Groundwater Conditions) is naturally occuring within the Basin. The GSA has voted to monitor TDS, but may only influece TDS concentrations through groundwater levels, through additional inputs. These inputs travel through highly saline rock, contributing to additional TDS in the groundwater. Per SGMA regulations, the GSA is also only required to maintain water quality conditions that exist as of January 1, 2015. The GSA may choose to refine these thresholds later as more data is collected.
42	Table 5-2: MOs				How is it that all the Interim Milestones set for TDS have progressively higher concentrations over time? For example Opti well 99, with a MT of 1562, has an IM of 1490 - 1508 mg/L for 2025, 1490 - 1526 mg/L for 2030, and 1490 - 1544 mg/L for 2035. This appears to be getting worse not better! Why is it that many wells in the table (all of the last 17) have MO the same as the MTs, with IMs that have no range or change? For example; Opti well 845 has an MO of 1250 and an MT of 1250, and all three IMs are 1250 - 1250 mg/L. This data table implies worsening TDS concentrations over time and needs further clarification.	Interim Milestone calculations have been updated such that IMs equal the MTs at all intervals.
43	5.6 Subsidence				With the current accelerating rate of subsidence of approximately 0.5 inches per year, what is the rationale of a MT of 2 inches per year? This is far too permissive and clearly allows for up to 10 inches of collapse in 5 years at four time the current rate. Ground surface instability and associated storage loss of this caliber is not achieving sustainability and would constitute a significant undesirable result. There needs to be a clearer explanation of why this undesirable result is allowable	No undesirable result has been identified for subsidence of up to 2 inches per year
44	5.7 Depletions of Interconnected				Riparian habitat and phreatophytes in the Cuyama River have been drying up and dying since long before January 1, 2015, as groundwater levels decline and the river bank storage is lost. Conditions continue to degrade with the depletion of interconnected surface water as less of the river experiences surface flows due to declining groundwater elevations. Deforestation and riparian habitat loss is an undesirable result due to the adverse effects of continued overdraft. Groundwater dependent ecosystems are similarly adversely impacted by this undesirable result. SGMA requires GSAs to identify, quantify and manage these beneficial uses to avoid any undesirable results. This GSP fails to recognize that requirement or manage for these undesirable results.	Comment noted. Please review the GDE report for additoinaly information.
45	5.7 Depletions of Interconnected				Without the baseline information in the Groundwater Conditions, especially in the newly developed Northwestern region, it is difficult to justify the decision to allow for the continued decline of groundwater levels with these MT/MO.	Comment noted. The MTs and MOs reflect the values approved by the Board.

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46	5.2.1 Threshold Region... Southeastern Threshold				I believe it is inaccurate to describe this Region as having groundwater levels that are “generally high in this area, with levels around 50 feet or less below the ground surface which indicates that this region is likely in a ‘full’ condition.” If the GSP is going to characterize this region like that, then it needs to point out that it is based on limited history from two wells in the southern headlands half of the region, and that little or no data exists for the areas north toward the narrows. Data does, however, exist, and I think it should inform our understanding and description of the region. At the request of staff, I have twice sent 3rd party documentation in the form of various well drilling reports as well as additional information about the significant fluctuations in static water levels that have occurred historically within this region. Those documents , well videos and air-line measurements show that static water levels in this region have fluctuated significantly during drought periods to at least as low as 108’ bgs. I believe there needs to be a recognition of the historical fluctuation of water levels in this region, and that this section should include something like the following wording: “Groundwater is generally high in this area with levels around 100 feet or less below ground surface. Groundwater levels in this region are subject to significant declines during drought periods but have typically recovered to within 50’ or less of ground surface during historically wet periods.”	Text has been updated to add additional language.
47	5.2.1 Threshold Region...Eastern Threshold				The Eastern Threshold Region description should include a little more information: It only mentions conditions during the past 20 years, whereas our understanding of the reliability and availability of water in this region relates to a much longer time horizon. Our historical modeling is informed by 50 years of data, and I think we should at least descriptively recognize what’s happened in this region over a longer history. I think we should include wording to the effect that “Hydrographs in this region indicate that groundwater levels have ranged widely and repeatedly over the past 50 years. Hydrographs in the Ventucopa area indicate that groundwater levels have been, in general, declining for the past 20 years.	Example is OPTI Well 85. Text has been updated for clarity.
48	5.2.2 Minimum Thresholds…Southeastern Threshold				Although the charts and thresholds are all good, I believe the threshold description rationale is in error. It reverses the use of the terms MO and MT.	Text has been updated to correct this error.
49	5.2.2 Minimum Thresholds…Southeastern Threshold	2	1	The MT for the Southeastern Threshold Region…	It should read: “The MO for Southeastern Region….”	Text has been edited
50	5.2.2 Minimum Thresholds…Southeastern Threshold	3	1	To provide an operational flexibility range, the…	Sentence should read “To provide an operational flexibility range, the MT was calculated by adding 5-years of groundwater storage to the MO.”	Text has been edited
51	5.5.3 Minimum Thresholds				The section seems to say that the TDS levels in the water need to be better measured and understood, and that we can’t do much about them, and they’re not necessarily impacting the economy that much, but then goes on to set Minimum Thresholds at very strict levels sometimes just above a recent historical level. At least some of the OPTI wells in the DMS have very limited data associated with the TDS, or even just two data points, sometimes with the same date (OPTI 83) and have a falsely narrow range of readings. Under the MT formula, this results in an exceptionally strict MT such as in OPTI 83 where the MT is set at just 6 ppm over the only reading on the well which was August of 2011. TDS levels vary broadly over short distances, and can vary significantly from year to year. My own sampling results show TDS results varying by as much as 800 ppm from one well to the next and by similar amounts on an individual well over time. If water quality readings that violate MTs will be an issue, then I believe the proposed MTs should be rethought and not expressed in terms of historical ranges, but rather as a percentage factor over recent values.	Comment noted. The Board can reassess the thresholds in the future as more data is collected.
52	5.1 Useful Terms	Final			Typo in use of MI instead of IM.	Text has been updated
53	5.2.1 Threshold Regions	1		These conditions are influenced by geographic…	This sentence is confusing and needs revision	Text has been updated
54	5.2.1 Threshold Regions…Southeastern Threshold				Typo “southeaster”	Text has been updated
55	5.2.1 Threshold Regions…Southeastern Threshold				Describing groundwater levels is sufficient, no need to editorialize about “full” condition”, or at least state that it is currently in a full condition.	Text has been updated
56	5.2.1 Threshold Regions….Central Threshold			Hydrographs in this region indicate that groundwater levels have been…	Should note that the levels have been substantially declining, or give a sense of the average rate of decline.	Comment noted. This is shown in the Groundwater Conditions section.
57	5.2.1 Threshold Regions…Western Threshold				Mention types of land use to distinguish it from NW Region Also, describing groundwater levels is sufficient, no need to editorialize about “full” condition”, or at least state that it is currently in a full condition.	Text has been updated

Cuyama Basin Sustainability Section
Summary of Public Comments and Responses
April 22, 2019

Comment #	Section	Section Paragraph #	Paragraph's Sentence #	Sentence Starts with, "…	Comment	Response to Comment
58	5.2.1 Threshold Regions…Northwestern Threshold			The Northwestern Threshold Region is the bottom of the Cuyama…	Please be more specific and revise to something like: " The Northwestern Threshold Region is at the western edge of the Cuyama Basin and has undergone changes in land use from grazing to irrigated crops over the past 4 years." Also, describing groundwater levels is sufficient, no need to editorialize about "full" condition", or at least state that it is currently in a full condition.	Text has been updated
59	5.2.1 Threshold Regions…Badlands Threshold			There is no monitoring in this region, and this	Revise to "… and no sustainability criteria were developed for this region."	Text has been updated
60	5.2.2 Minimum Thresholds	General Comment			MTs were established for wells, not regions. So the text should state that MTs were calculated for wells in a given region.	Text has been updated
61	5.2.2 Minimum Thresholds	General Comment			Include additional reasoning why the various threshold rationales were chosen.	Comment noted. This will be included in the Undesirable Results Narrative.
62	5.2.2 Minimum Thresholds…Central Threshold			The MT for the Central Threshold Region	Typo "The MT for the Central Threshold Region was calculated by taking finding…"	Text has been updated
63	5.2.2 Minimum Thresholds…Central Threshold			OPTI Wells 74, 103, 114, 568, 609, and	Please explain the reason for this in the text (e.g., "Because OPTI Wells 74, 103, 114, 568, 609, and 615 did not have sufficient measurements…")	The text has been updated. These wells did not have measurements to within the specified time range to represent January 1, 2015 conditions and thus utlized a linear trendline to extroplate and estimated value.
64	5.2.2 Minimum Thresholds…Western Threshold			OPTI Well 474 utilizes a modified MO calculation	Please explain why in the text.	Text has been updated
65	5.3 Reduction in Groundwater	2		Reduction of groundwater storage is not a concern for the Basin for two reasons.	Reduction of groundwater storage may be able to measured using levels as a proxy, but it is inaccurate to say that it is not a concern. Even areas that may be currently "full" may suffer reductions in groundwater storage going forward. Suggest deleting this discussion.	The text has been revised to just note that direct measurement of storage is not needed, while removing reference to storage not being a concern.
66	5.5 Degraded Water Quality	3		Because the undesirable result for degraded	Explain in text why TDS will be monitored. Current discussion is only about constituents not to be monitored.	Text has been updated
67	5.5 Degraded Water Quality	3		Arsenic occurs at specific depths in the basin, but the location	If arsenic increases with depth, then managing declines in groundwater levels would manage arsenic concentrations.	Text has been updated
68	5.5.3 Minimum Thresholds	3	1	Due to these factors the MT for representative well sites are set	Please give an example of how this is calculated with an example well for clarity in the text. Also provide the calculations in Table 5.2 or in an appendix. Columns with the total range and the 90th percentile of measurements would be useful.	Text and Table has been updated
69	Table 5-2: MOs				Table should state that these concentrations are for TDS. Include units for MO and MT as they are for the IMs. For ease of table reading, could move units to the header.	Table has been updated
70	5.6.2 Representative Monitoring				It's not just water-related infrastructure that is impacted by land subsidence. It can be roads, bridges, etc.	Text has been updated
71	Figure 5-4				Needs to be referenced	Text has been updated
72	5.7 Depletions of Interconnected	2	2	In January 1, 2015 surface flows infiltrated into the groundwater	This statement, and this whole section is confusing and should be revised. I think that the intent is to say that there has been no change in surface water depletion since 2015, but the wording is quite awkward and would not be coherent to a reader without significant background knowledge.	Text has been updated
73	General Comment				In general, the Central Coast Water Board recommends that the number of chemical constituents included in the Minimum Thresholds (MT), Measurable Objectives (MO), and Interim Milestones (IM) be increased. The Central Coast Water Board agrees that MTs, MOs and IMs should be established for total dissolved solids (TDS), however, including only that single constituent is insufficient for determining whether a groundwater basin is being managed sustainably with respect to water quality or for determining if undesirable results are being addressed. Land use in the Cuyama Valley is dominated by commercial agriculture, an industry that utilizes a variety of chemicals and practices that pose threats to groundwater quality. Therefore, the Central Coast Water Board recommends expanding the list of chemical constituents in the MT, MO, and IM to include nitrate, arsenic, and major dissolved ions. The reasoning for this recommendation is described in detail below.	Direction was provided by the GSA Board (through approval of the Monitoring Networks GSP section) to only include TDS for monitoring and sustainability in the GSP. Therefore, this Section will only include water quality sustainability indicators for TDS, unless alternate direction is provided by the Board.

Cuyama Basin Sustainability Section
Summary of Public Comments and Responses
April 22, 2019

Comment #	Section	Section Paragraph #	Paragraph's Sentence #	Sentence Starts with, "...	Comment	Response to Comment
74	General Comment				Nitrate: Nitrate contamination of groundwater from agricultural activities is widely documented in the Central Coast region, including within the Cuyama Valley. Approximately 9% of on-farm domestic wells in the Cuyama Valley exceed the human health standard for nitrate concentration in drinking water1. The draft chapter states that the Cuyama Valley groundwater sustainability agency (GSA) does not have the authority to influence fertilizer use, and we are not suggesting the GSA should undertake such a regulatory role. However, the GSPs are required to implement thresholds and monitoring that can identify when undesirable results are occurring. Given the current impairment from nitrate in the basin and ongoing agricultural activity, it is appropriate to require thresholds and monitoring for nitrate in the Cuyama Valley groundwater basin. Nitrate monitoring is not unusual in agriculturally-dominated basins; for example, the Salinas Valley GSA is recommending an expanded suite of chemical constituents for its thresholds and monitoring. The recommendation in their most recent draft includes up to 25 different chemical constituents, including nitrate and arsenic. Finally, we recommend that nitrate be reported as nitrogen (nitrate as N), because this convention allows for easy comparison and summation (e.g., calculation of total nitrogen).	Direction was provided by the GSA Board (through approval of the Monitoring Networks GSP section) to only include TDS for monitoring and sustainability in the GSP. Therefore, this Section will only include water quality sustainability indicators for TDS, unless alternate direction is provided by the Board.
75	General Comment				Arsenic: Arsenic is a toxic chemical compound that occurs naturally in relatively high concentrations in many of the sediments that form California groundwater basins, including those of the Central Coast. Groundwater data from the Water Board's GeoTracker GAMA website indicates that 12% of the wells in the Cuyama Valley groundwater basin exceed the maximum contaminant level (MCL) for arsenic in drinking water. The highest concentration recorded in the basin occurred in 2011 and was more than six times greater than the MCL. Furthermore, recent studies in the Central Valley of California and the Mekong Delta in Thailand have demonstrated that ground subsidence associated with groundwater over-pumping can mobilize arsenic by 'squeezing' it out of subsurface clay layers. The resulting mobilized arsenic can then enter groundwater and increase arsenic concentrations in nearby water supply wells. Because there is documented overdraft and subsidence in the Cuyama Valley, there is the potential risk of anthropogenically-induced arsenic contamination of groundwater due to arsenic mobilization from clay layers in the Cuyama Valley basin. Lastly, in addition to sediment related sources, arsenic is a component in many pesticides commonly used on various crops. These factors suggest that arsenic should be included in the MTs, MOs, and IMs for the Cuyama Valley basin.	Direction was provided by the GSA Board (through approval of the Monitoring Networks GSP section) to only include TDS for monitoring and sustainability in the GSP. Therefore, this Section will only include water quality sustainability indicators for TDS, unless alternate direction is provided by the Board.
76	General Comment				Major Dissolved Ions: Major dissolved cation and anion composition in groundwater reflects the source of recharge water, lithological and hydrological properties of the aquifer, groundwater residence time, and chemical processes within the aquifer. As such, major dissolved ions are valuable for identifying different groundwater types (via Piper or Stiff diagrams) and for "fingerprinting" source water from individual wells. In addition, ionic charge balance provides quality assurance that all the major ions are actually included in the analysis and that TDS concentrations are accurate. Finally, collection and analysis of major dissolved ion samples is easy and inexpensive, and the cost of the analysis is well worth the data provided, particularly if the well is already being sampled for other constituents.	Direction was provided by the GSA Board (through approval of the Monitoring Networks GSP section) to only include TDS for monitoring and sustainability in the GSP. Therefore, this Section will only include water quality sustainability indicators for TDS, unless alternate direction is provided by the Board.
77	5.1 Useful Terms				Suggest that the GSA Board is aware that the representative wells are theoretical until an agreement between the GSA and well owner is executed. Does the Consultant have a list of other potential representative wells in case a well is not operational, or an agreement cannot be executed?	All the wells that could be used as representatives wells are included, and thus no alternative list is available. The text has been updated for clarity
78	5.2.1 Threshold Regions…Southeastern Threshold	1	1	The Southeaster Threshold Region	Spelling	Text has been updated
79	5.2.1 Threshold Regions…Southeastern Threshold	1	2	Groundwater is generally high	Consider adding a timeframe or date to when this area was defined as full.	Text has been edited for clarity
80	5.2.1 Threshold Regions…Southeastern Threshold	1	3	The northern boundary of this region is the	Consider defining all four boundary directions for the Southeastern Threshold Region.	Text has been updated
81	5.2.1 Threshold Regions…Eastern Threshold	1	4	The northern boundary of this region	Consider defining all four boundary directions for the Eastern Threshold Region.	Text has been updated
82	5.2.1 Threshold Regions…Central Threshold	1	3	The south-eastern boundary is defined by	Consider defining all four boundary directions for the Central Threshold Region.	Text has been updated
83	5.2.1 Threshold Regions…Western Threshold	1	1	The Western Threshold Region is characterized	Consider adding a timeframe or date to when this area was defined as full.	The text has been updated.
84	5.2.1 Threshold Regions…Western Threshold	1	3	The eastern boundary is defined by	Consider defining all four boundary directions for the Western Threshold Region.	Text has been updated
85	5.2.1 Threshold Regions…Northwestern Threshold	1	2	Hydrographs in this portion of the	Consider adding a timeframe or date to when this area was defined as full.	The text has been updated.
86	5.2.1 Threshold Regions…Northwestern Threshold	1	3	The southeastern border was drawn to	Consider defining all four boundary directions for the Northwestern Threshold Region.	Text has been updated
87	5.2.1 Threshold Regions…Eastern Threshold	1	3	The northern boundary of this region is	Consider defining all four boundary directions for the Eastern Threshold Region.	Text has been updated

Cuyama Basin Sustainability Section
Summary of Public Comments and Responses
April 22, 2019

Comment #	Section	Section Paragraph #	Paragraph's Sentence #	Sentence Starts with, "...	Comment	Response to Comment
88	5.2.1 Threshold Regions…Central Threshold	1	3	The south-eastern boundary	Consider defining all four boundary directions for the Central Threshold Region.	Text has been updated
89	5.2.1 Threshold Regions…Western Threshold			The Western Threshold Region is characterized	Consider adding a timeframe or date to when this area was defined as full.	The text has been updated.
90	5.2.1 Threshold Regions…Western Threshold			The eastern boundary is defined by the	Consider defining all four boundary directions for the Western Threshold Region.	Text has been updated
91	5.2.1 Threshold Regions…Northwestern Threshold	1	2	Hydrographs in this portion of the Basin	Consider adding a timeframe or date to when this area was defined as full.	The text has been updated.
92	5.2.1 Threshold Regions…Northwestern Threshold	1	3	The southeastern border	Consider defining all four boundary directions for the Northwestern Threshold Region.	Text has been updated
93	5.2.1 Threshold Regions…Badlands Threshold	1	2	There are few active wells and little	Consider removing the word little and adding an estimated value of groundwater from the groundwater model.	The text has been edited.
94	5.2.1 Threshold Regions…Badlands Threshold	1	3	There is no monitoring in this region	Consider defining the geology of the Badlands area, such as adding Ballinger, Quatal, and Apache Canyons. This will help explain why this area has few active wells	This is in the HCM section.
95	5.2.2 Minimum Threhsolds	1	1		Consider adding a summary of why each region may have a different MT and MO.	This information is provided in the text
96	5.2.2 Minimum Thresholds…Southeastern Threshold				Consider adding a hydrograph figure to help explain each threshold region for MO & MT.	Hydrographs with thresholds are provided in an appendix
97	5.2.2 Minimum Thresholds…Eastern Threshold				Consider adding a hydrograph figure to help explain each threshold region for MO & MT.	Hydrographs with thresholds are provided in an appendix
98	5.2.2 Minimum Thresholds…Central Threshold				Consider adding a hydrograph figure to help explain each threshold region for MO & MT.	Hydrographs with thresholds are provided in an appendix
99	5.2.2 Minimum Thresholds…Western Threshold				Consider adding a hydrograph figure to help explain each threshold region for MO & MT.	Hydrographs with thresholds are provided in an appendix
100	5.2.2 Minimum Thresholds…Northwestern Threshold				Consider adding a hydrograph figure to help explain each threshold region for MO & MT.	Hydrographs with thresholds are provided in an appendix
101	5.2.2 Minimum Thresholds…Badlands Threshold			The Badlands Threshold Region has no	Page 5-8 states that the area has few active wells, please clarify or correct.	Text has been updated
102	5.2.3 Selected Minimum Thresholds				Consider adding a summary table for MO / MT, such as the one shown in the GSA Board agenda packet on March 6th.	Summary table is provided - Table 5-1
103	5.5.3 Minimum Thresholds	2	3	Much of the crops grown	Consider referencing the crop types or adding a figure on crop types to support this statement.	This information would be inlcuded in the plan in the Basin Settings section
104	General Comment				Consider adding adaptive management as a section in this chapter to provide flexibility to the GSA Board for MO, MT, and interim milestones. Revisions to the MO, MT, and interim milestones could be based on the data collected and analyzed from the GSP monitoring and overall plan effectiveness.	Addaptive management will be included in the Projects and managmeent action section.
105	Refernces			California Department of Water Resources (DWR),	Wrong agency?	Text has been updated
106	Refernces			rrigated Land Regulatory Program (IRLP),	Correction - ILRP	Text has been updated

Cuyama Basin Placeholder Sections
Summary of Public Comments and Responses
April 22, 2019

Comment #	Section	Section Paragraph #	Paragraph's Sentence #	Sentence Starts with, "...	Comment	Response to Comment
1	1.2.8 Plan Elements from CWC Section 10727.4	1	1	The plan elements from...	Suggest revising language in 1.2.8 - first sentence	The text has been revised
2	2.2.4 Change in Groundwater Storage	1	5	The color of bar...	Consider revising the river name	The year type index has been clarified.
3	2.2.10 Data Gaps	1			Consider adding a table on all the data gaps mentioned below in 2.2.10, including data gaps required by DWR GSP regulations.	This is not needed
5	General				Overdraft continues to be hidden within confusing language. Clarity with this issue is paramount and should not be at all ambiguous.	The text has been revised to note that negative change in storage is overdraft
6	General				Some shake up in classifying GDEs has made two unrealistic elimination of either 56% or 82% potential GDEs.	Comment noted. A more detailed analysis of GDEs can be performed during implementation if the Board chooses to do so.
7	General				Additional Data Gaps for the Groundwater Conditions we noted.	The data gaps section has been edited.
8	General				Due to the absence of any stream gauges in the Cuyama in the basin the model is calculating all the amounts and the relationships between the surface and groundwater. This interpreted Interconnectivity of surface waters with the groundwater in not well reflected from the model onto the Figure. More inter-relativity in the presentation is needed.	Comment noted.
9	2.1.10 Hydrogeologic Conceptual Model Data Gaps				It has been recognized that the interconnectivity between Groundwater and surface water is poorly understood, and represents a significant Data Gap in the HCM and throughout this GSP. Many historic seeps, springs and wetlands indicate a complex cascading basin in the three main aquifers with perched groundwater elevations on top of clay layered aquitards. This affects the Groundwater Dependent Ecosystems across the basin and needs further understanding.	Comment noted. A more detailed analysis of GDEs can be performed during implementation if the Board chooses to do so.
10	2.2.4 Change in Groundwater Storage	1	4	Average annual use over the twenty-year period was...	The text does not express the degree or severity of the overdraft. The sentence is incorrect and misinforming. It does not even use the euphemism "change in storage", the word "use" should read "overdraft".	The text has been revised to note that negative change in storage is overdraft
11	2.2.4 Change in Groundwater Storage	1	1	Historical change in storage in the Cuyama Basin...	The text does not express the degree or severity of the overdraft. In this sentence, at least the first "change in storage" could be replaced for clarity with "overdraft". At the very least quantify it as "negative change in storage".	The text has been revised to note that negative change in storage is overdraft
12	2.2.4 Change in Groundwater Storage				The water year type should be correlated to a Cuyama Basin type of water year, not the central valley. Please define what is designated by the water year type as a percent of deviation from an average or normal year.	The year type index has been clarified.
13	2.2.8 Interconnected Surface Water Systems				Is this the same Appendix X as the GDE Report Appendix X?	The text has been revised to clarify that this is referring to the IWFM model appendix.
14	2.2.8 Interconnected Surface Water Systems				Presumably, the Cuyama Basin IWFM Model can be used to analyze groundwater interactions between all the surface water flows in the Basin. Figure 2.2 only represents the Cuyama River, and four of the creeks. Are these the only reaches being analyzed from the model? And can we get more analysis of this data? Show amounts and percentages of gain and loss by reach.	While runoff from all watersheds is simulated in the model, these are the only reaches explicitly simulated as creeks in the model.
15	2.2.8 Interconnected Surface Water Systems				As is noted in the Section 4-10 below, this modeling is being done without any stream gauge data points, because there are no stream gauges, yet.	Comment noted.
16	Table 2-1				This table needs a couple of additional rows on the bottom for Totals & Averages by Reach. This would illustrate the patterns better than the Total column does and it would be helpful to overlay on Figure 2-2 (which needs relabeling). Range of data and the % of Total would also be informative additional rows to this chart	An average annual row has been added.
17	2.2.9 Groundwater Dependent Ecosystems				How and why did we go from reducing to 497 acres from the 2700 acres of GDEs in the DWR's Natural Communities Commonly Associated with Groundwater (NCCAG) dataset, to these 123 "probable GDEs" and 275 "probable non-GDEs"? What happened to acreage? It is not reasonable to eliminate such a large % (82% & 56% respectively) of possible GDE acres from a desktop analysis of aerial imagery and such little field study (1 & ½ days and only six discreet sites). All of the GDEs up Santa Barbara Canyon are on public land and are full of seeps, springs & wetlands. You just have to walk in to verify them, not drive. Why are they classified as non-GDEs? Figure 2-5 misspelled "Likely Wetlands" and shows no discernable wetlands at all. This report drastically underrepresents the remaining GDEs and risks the continued loss of this important beneficial use of the groundwater resources.	Comment noted. A more detailed analysis of GDEs can be performed during implementation if the Board chooses to do so.
18	2.2.9 Groundwater Dependent Ecosystems	2	2	The NCCAG dataset was compiled by the Nature Conservancy...	Is this true? I thought it was CWDR. The text and Figure 2-3 should credit DWR, not The Nature Conservancy. And that is all the more reason to ground truth verify the data before tossing it out	The text has been revised.
19	2.2.10 Data Gaps				Additional Data Gaps in the Groundwater Conditions include the following: All the major faults are not well understood with regard to the degree they represent a barrier to flow and at what depth below the surface.	The data gaps section has been edited.
20	2.2.10 Data Gaps				Additional Data Gaps in the Groundwater Conditions include the following: The wells in the database and in the Monitoring Network are not well known and must be canvassed to verify well depth, perforation interval and current status.	The data gaps section has been edited.
21	2.2.10 Data Gaps				Additional Data Gaps in the Groundwater Conditions include the following: The size of the Basin with regard to groundwater in storage is not well known and after 40 years of chronic overdraft and the loss of over 1 MAF, what remains in storage?	The data gaps section has been edited.

Cuyama Basin Placeholder Sections
Summary of Public Comments and Responses
April 22, 2019

Comment #	Section	Section Paragraph #	Paragraph's Sentence #	Sentence Starts with, "...	Comment	Response to Comment
22	4.10 Depletions of Interconnected Surface Water Monitoring Network			Monitoring Networks for depletions of surface water cannot ...	It is appreciated by this reviewer that the lack of any surface water gage stations on the Cuyama River in the Basin is recognized as an impediment to accurate modeling. No amount of numeric estimating can make up for the lack of real data points. When can we see these new stream gages installed?	Comment noted.
23	Appendix X				This Technical Memorandum could have been more informative with a brief Publication Review. Historical reference with field verification and local experience would have yielded different conclusions. With only six actual field sites visited, this was not a significant field verification and the aerial imagery analysis was inadequate to identify the many existing GDEs that were disqualified in this report.	Comment noted. A more detailed analysis of GDEs can be performed during implementation if the Board chooses to do so.

Attachment D-2

Technical Forum
Meeting Memoranda

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MEETING MEMORANDUM

PROJECT: Cuyama Basin Groundwater Sustainability Plan Development

MEETING DATE: 5/4/2018

MEETING: Technical Forum Conference Call

ATTENDEES: Matt Young (Santa Barbara County Water Agency)
Cathy Martin (San Luis Obispo County)
Matt Klinchuch (Cuyama Basin Water District)
Dennis Gibbs (Santa Barbara Pistachio Company)
Jeff Shaw (EKI)
Neil Currie (Cleath-Harris Geologists)
John Fio (HydroFocus)
Brian Van Lienden, Lyndel Melton, Ali Taghavi, John Ayres & Sercan Ceyhan (Woodard & Curran)

1. AGENDA

- Model grid update
- Hydrogeology
- Hydrology
- Land and water use
- Data collection update
- Next steps

2. DISCUSSION ITEMS

The following table summarizes discussion items raised at the meeting and the plans for resolution identified for each item.

Item No.	Discussion Item	Plan for Resolution
1	The updated model grid was provided for review on April 19, 2018.	Since no comments were provided, the W&C team is moving forward with the current grid.
2	The technical analysis needs to account for an unnamed fault near Cottonwood Canyon.	Neil Currie will provide information related to this fault. W&C will review this information and incorporate it into the hydrogeologic conceptual model (HCM). No change needed to the model grid as it appears to be of sufficient resolution to allow incorporation, as appropriate, into the model.

3	The HCM should use Delong's mapping of terrace outcrops.	W&C will review this information and incorporate it into the HCM.
4	We need to make clear in reporting where data came from, how it was validated and how it was used	Once the data collection effort is complete, W&C will report to the CBGSA and Technical Forum the sources of data and the approach used for data validation..
5	Materials should be sent out for review prior to the call. Technical forum members would like to see a draft HCM document prior to the next call.	Presentation materials will be sent out prior to each call, with documents provided as available. The W&C team will attempt to provide a draft HCM document prior to the next call.
6	Why has work begun on the numerical model before completion of the HCM? Don't we need a water budget before we can develop the numerical model?	Work on the numerical model needs to be done in parallel with the HCM to meet the aggressive project schedule. Information from the HCM will still be incorporated into the numerical model. W&C will develop a rough water budget for review; however, the numerical model will be the primary source of water budget information.
7	The upper and lower Morales formations have different anisotropy and need to be treated differently in the HCM and numerical model	This is consistent with the W&C team's understanding. Assessment of these formations will be primarily based on the USGS representation.
8	How is daily precipitation data developed? How are PRISM block data mapped to the numerical model grid?	PRISM includes daily data back to 1981; prior to that daily data will be developed by matching similar years. PRISM block data will be mapped to the model grid using spatial interpolation.
9	Will stakeholders be able to review groundwater level and hydrograph information?	Groundwater level information will be provided as part of the Groundwater Conditions portion of the GSP. Additional groundwater level information will be accessible to stakeholders through the Opti data management system once it is developed.

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MEETING MEMORANDUM

PROJECT: Cuyama Basin Groundwater Sustainability Plan Development

MEETING DATE: 6/8/2018

MEETING: Technical Forum Conference Call

ATTENDEES: Matt Young (Santa Barbara County Water Agency)
Matt Scrudato (Santa Barbara County Water Agency)
Matt Klinchuch (Cuyama Basin Water District)
Dennis Gibbs (Santa Barbara Pistachio Company)
Jeff Shaw (EKI)
Neil Currie (Cleath-Harris Geologists)
John Fio (HydroFocus)
Brian Van Lienden (Woodard & Curran)
Ali Taghavi (Woodard & Curran)
John Ayres (Woodard & Curran)
Sercan Ceyhan (Woodard & Curran)

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1. AGENDA

- Hydrogeologic Conceptual Model (HCM) Development Update
- Groundwater Level Monitoring
- Next steps

2. DISCUSSION ITEMS

The following table summarizes discussion items raised prior to and during the conference call and the plans for resolution identified for each item.

Item No.	Discussion Item	Plan for Resolution
1	The draft HCM GSP section is under development and will be provided to the Technical Forum members for review	A draft HCM document will be provided to the Forum members on Wed June 13, with comments due by Mon June 18.
2	What is the role of the Technical Forum in the GSP development process – is its purpose to provide an update on progress or a more robust "Technical Advisory Committee" that provides formal input?	The Technical Forum was formed to provide information and receive feedback on the development of technical products to technical experts representing different parties within the Basin. While the feedback provided by Technical Forum members is valuable and will be incorporated when possible, the Technical Forum does not have a formal role in the GSP development process.
3	We should show a cross-section along the Cuyama River that shows the Santa Barbara County fault.	This will be developed and considered for inclusion in the HCM document.

4	We should consider extending the model calibration period earlier than the mid-1990's so as to not exclude extensive dewatering in the 1970's and 1980's and to capture historic climatic cycles	The current calibration period of 1996-2015 was set based primarily on the availability of historical data, particularly related to land use and groundwater elevations. W&C will review the data and extend the calibration period further back if the data warrants it. For current and future level runs, the plan is to incorporate hydrology back to October 1959, corresponding with available data from USGS gage 11136800.
5	The figures of the model layering do not show the small outcrops in the vicinity of the Russell Fault.	Aquifer hydraulic conductivities at model nodes in these areas will be adjusted to account for outcrops as part of the development of the model.
6	Are there enough model nodes to adequately represent the White Rock and Rehoboth faults?	The model grid has been reviewed and the model nodes provide reasonable density to represent those faults, as necessary.
7	We should develop maps showing faults compared to monitoring points and to the model grid.	These figures will be considered during development of the model.
8	Is the SAGBI data shown during the presentation from the modified or unmodified dataset?	This figure has been modified to note that it is showing the modified dataset.
9	Questions raised regarding the modeling approach: (a) The model is planned to have large areas of very small model-element discretization (gridding). The model elements generally are on a much finer scale than the available input data. This presents an issue of false precision, where the model runs the risk of producing easily-misinterpreted output on a cell-by-cell basis. (b) The model is planned to run at a daily time-step, which contrasts with the available input data for pumping, streamflow, and other factors that will have nowhere near that level of detail. (c) The combination of fine grid dimensions and short time-steps will greatly increase the model run time, potentially adding significant time and expense to each iteration. This will limit the overall time available to calibrate the model and quantify its deficiencies, and generally reduce the usefulness of the model as a management tool.	The model grid elements have been developed so as to adequately represent important characteristics of the groundwater basin including the Cuyama River, irrigated areas and faults and to ensure a numerical representation of the physical system, to the extent that the data allows. Similarly, the daily time step was selected to adequately capture the hydrologic variability of Cuyama river streamflow and tributaries runoff within the Basin. While developing the spatial and temporal discretization, maintaining a reasonable model runtime was a criteria that was considered. Based on our experience developing and using IWFM models throughout the state, it is not anticipated that the spatial and/or temporal scales would be a barrier to successfully calibrating and applying the model for the GSP. When reporting model outputs, presentations of data will be developed to report data at appropriate spatial and temporal scales for understanding and interpreting the results.

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MEETING MEMORANDUM

PROJECT: Cuyama Basin Groundwater Sustainability Plan Development

MEETING DATE: 7/13/2018

MEETING: Technical Forum Conference Call

ATTENDEES: Matt Young (Santa Barbara County Water Agency)
Matt Scrudato (Santa Barbara County Water Agency)
Matt Klinchuch (Cuyama Basin Water District)
Dennis Gibbs (Santa Barbara Pistachio Company)
Anona Dutton (EKI)
Neil Currie (Cleath-Harris Geologists)
John Fio (HydroFocus)
Matt Naftaly (Dudek)
Brian Van Lienden (Woodard & Curran)
Ali Taghavi (Woodard & Curran)
John Ayres (Woodard & Curran)
Sercan Ceyhan (Woodard & Curran)

1. AGENDA

- Review and Comparison of Data Received
- Discussion on Undesirable Results and Minimum Thresholds
- Next steps

2. DISCUSSION ITEMS

The following table summarizes comments raised during the conference call and the response and plan for resolution (if appropriate) identified for each item.

Item No.	Comment	Commenter	Response/Plan for Resolution
1	What is the basis for saying that there is a 90% concurrence between DWR/LandIQ land use and Boltouse/Grimmway data	John Fio	This is based on a parcel by parcel comparison of the available data
2	Can the comparison between DWR/LandIQ and Bolthouse/Grimmway land use data be used to improve the data available for the GSP	Anona Dutton	The LandIQ data will be used to supplement parcels/years where data is not available from Bolthouse/Grimmway. The data in the common land areas will be reviewed to confirm if any adjustments are warranted.

3	When we are doing the modeling, do we assume that pumping locations are the same going back in time (i.e. the current snapshot of well locations) or will they change over time?	Anona Dutton	The W&C team is open to ideas on this question. The data that we have doesn't have a timestamp, so we would need to have information on when new wells came on line historically. We can also see if changes in well depths provide an indication during calibration.
4	Will the model assume point well locations or use a distributed pumping approach	Anona Dutton	The current plan is to use the specific well locations for Bothouse and Grimmway wells (where we have a higher confidence in the available data) and to use a distributed pumping approach in other areas of the Basin.
5	Did we receive any historical pumping data?	Anona Dutton	Very little pumping data is available; therefore pumping amounts will need to be estimated by the model.

3. FEEDBACK ON UNDESIRABLE RESULTS AND MINIMUM THRESHOLDS

The Technical Forum members discussed potential ideas for undesirable results and minimum thresholds. These are summarized below for each sustainability indicator.

Lowering of Groundwater Levels

- The effects on domestic and municipal use should be a high priority
- The historical low value is considered a reasonable starting point in other basins
- We could also look at the levels in recent years (i.e. 2015 and 2017) and also compare those to the historical drought in 1992

Reduction in Groundwater Storage

- The SGMA regulations call for extractions to be compared to sustainable yields, but that isn't an effective approach in the Cuyama Basin
- It is not possible to measure groundwater storage – this can only be done with a numerical model. It would be especially difficult in the Western portion of the Basin because of it's tectonically shaped nature

Degraded Water Quality

- The Western portion of the Basin has salinity levels significantly below other parts of the Basin
- We should consider looking at changes in current quality levels as compared to historical levels
- We should look at whether other constituents besides salt are above MCL levels
- We should look at whether we can discuss constituent migration

Land Subsidence

- Oil operations will affect subsidence in the Western portion of the Basin
- Subsidence data will be provided in the Groundwater Conditions section
- The W&C team is open to ideas, especially on what is being done in other basins

Surface Water Depletions

- We have a poor understanding of current conditions due to the lack of stream gages
- We could potentially satisfy this requirement by saying that effects on surface flows would be minimal due to an absence of groundwater-surface water connection
- We may want to consider the effect on springs – the USGS model utilized boundary conditions to represent springs. But a lot of in-basin springs are related to fault conditions

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MEETING MEMORANDUM

PROJECT: Cuyama Basin Groundwater Sustainability Plan Development

MEETING DATE: 8/3/2018

MEETING: Technical Forum Conference Call

ATTENDEES: Matt Young (Santa Barbara County Water Agency)
Matt Scrudato (Santa Barbara County Water Agency)
Matt Klinchuch (Cuyama Basin Water District)
Dennis Gibbs (Santa Barbara Pistachio Company)
Neil Currie (Cleath-Harris Geologists)
John Fio (EKI)
Matt Naftaly (Dudek)
Jeff Shaw (EKI)
John Ayres (Woodard & Curran)
Sercan Ceyhan (Woodard & Curran)
Micah Eggleton (Woodard & Curran)

1. AGENDA

- Current Basin Water Conditions
- Numerical Model Development Update
- Next steps

2. DISCUSSION ITEMS

The following table summarizes comments raised during the conference call and the response and plan for resolution (if appropriate) identified for each item.

Item No.	Comment	Commenter	Response/Plan for Resolution
1	The well at the intersection of the Cuyama River and Cottonwood Canyon Creek may be picking up water from the basin finger just North of the well	Neil Currie	This will be kept in mind when evaluating data from this well.
2	Data may be easier to interpret if wells form a common area are clustered and plotted on the same graph	Jeff Shaw	The W&C team will review the presentation of data and improve where appropriate.

3	Were discontinuities due to faults considered when creating groundwater elevation and depth-to-water maps?	Neil Currie	Due to limitations in the amount and spatial distribution of data and to large changes in elevation in many areas, it is difficult to identify and locate discontinuities that can be attributed to faults.
4	There is potentially more groundwater elevation data out in the west by the Spanish Ranch property.	Neil Currie	The W&C team will incorporate any additional data that is provided.
5	Why is the numerical model's agricultural pumping estimate different from its ETAW estimate?	Jeff Shaw	The agricultural pumping estimate reflects ETAW plus related inefficiencies and losses.
6	What is the time schedule for OPTI to be made available for review?	Jeff Shaw	An initial version of OPTI should be available for review prior to the September Workshop.
7	When will model simulation results be available for review?	Jeff Shaw	Preliminary model simulation results will be presented at the September Workshop and Technical Forum call.
8	Is the agricultural efficiency currently shown by the model reasonable?	John Fio	The model is still undergoing calibration and the data shown were preliminary estimates. It may be refined as the calibration is completed.

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MEETING MEMORANDUM

PROJECT: Cuyama Basin Groundwater Sustainability Plan Development

MEETING DATE: 8/31/2018

MEETING: Technical Forum Conference Call

ATTENDEES: Matt Young (Santa Barbara County Water Agency)
Matt Scrudato (Santa Barbara County Water Agency)
Matt Klinchuch (Cuyama Basin Water District)
Dennis Gibbs (Santa Barbara Pistachio Company)
Neil Currie (Cleath-Harris Geologists)
John Fio (EKI)
Jeff Shaw (EKI)
Anona Dutton (EKI)
Brian Van Lienden (Woodard & Curran)
Sercan Ceyhan (Woodard & Curran)
Ali Taghavi (Woodard & Curran)
Byron Clark (Davids Engineering)

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1. AGENDA

- Approach for Cuyama Basin model development
- Preliminary modeling results for Cuyama Basin groundwater conditions
- Next steps

2. DISCUSSION ITEMS

The following table summarizes comments raised during the conference call and the response and plan for resolution (if appropriate) identified for each item.

Item No.	Comment	Commenter	Response/Plan for Resolution
1	Will you make the IDC and IWFM model files available for review?	Jeff Shaw	Model files will be made available once the model is fully calibrated. Calibration is still ongoing for both the IDC and IWFM, and will be refined based on stakeholder feedback
2	What is the status of the IDC calibration?	Jeff Shaw	As mentioned above, IDC calibration continues to be refined; however, the model is currently reasonable enough to move forward with groundwater model calibration. Additional back and forth with IDC and IWFM will take place during the full model calibration.
3	What factors/parameters are most sensitive to agricultural efficiency levels in the model?	John Fio	There are many factors that affect agricultural efficiency; the target soil moisture fraction is one of the last factors to be refined as part of the calibration.

4	There are some years (e.g. 2002) where the model currently shows small net loss from the groundwater aquifer to the stream. Is this correct?	John Fio	This is a preliminary result, which is subject to ongoing revisions, refinement, and correction.
5	Some wells are at the edge of the Upper and Lower Morales formations; this could explain why groundwater levels in those wells are dipping recently	Neil Currie	This will be considered as model refinement continues.
6	Are calibration results available for the western portion of the basin?	Neil Currie	Results for this area are not yet complete because model calibration is being done from upstream to downstream.
7	Is the drop in CSD well levels related to subsidence?	Jeff Shaw	There may be a relationship, but subsidence is likely to have a small effect on aquifer storage
8	Reductions in CSD well levels may be related to development of the nearby Duncan Family Farms in the late 1990's	Dennis Gibbs	This will be investigated and considered as part of the model refinement.
9	A deep percolation estimate of 38 taf/year is concerning because tests have shown water in the aquifer to be very old	Dennis Gibbs	The deep percolation value will be refined as the model calibration is completed
10	Does the model have a time lag in deep percolation to the aquifer?	John Fio	Yes, there is a time lag because the model includes an unsaturated zone between the root zone and the groundwater zone.
11	What are the model's initial conditions?	John Fio	Initial conditions are based on observed historical data at the beginning of the calibration period in 1994
12	Does the model represent discontinuities near Santa Barbara Fault as part of the initial conditions? This could improve run-time.	John Fio	The available data does not have the resolution necessary to do so. The model solves for the discontinuities as part of its solution.
13	Is the Santa Barbara Fault keyed into bedrock at its east end?	John Fio	Yes
14	Are you comparing the model to the USGS model?	Anona Dutton	The USGS model is used for reference and for comparison, but their model data is not used directly with the exception of the geologic layering in the center of the basin. There are tables comparing water budgets in last Technical Forum Call.

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MEETING MEMORANDUM

PROJECT: Cuyama Basin Groundwater Sustainability Plan Development

MEETING DATE: 9/21/2018

MEETING: Technical Forum Conference Call

ATTENDEES: Matt Young (Santa Barbara County Water Agency)
Matt Scrudato (Santa Barbara County Water Agency)
Matt Klinchuch (Cuyama Basin Water District)
Dennis Gibbs (Santa Barbara Pistachio Company)
Neil Currie (Cleath-Harris Geologists)
John Fio (EKI)
Jeff Shaw (EKI)
Anona Dutton (EKI)
Brian Van Lienden (Woodard & Curran)
Sercan Ceyhan (Woodard & Curran)
Ali Taghavi (Woodard & Curran)
Micah Eggleton (Woodard & Curran)
John Ayres (Woodard & Curran)
Byron Clark (Davids Engineering)
Bryan Thoreson (Davids Engineering)

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1. AGENDA

- Monitoring Networks
- Update on Numerical Model Development
- Management Areas
- DWR Technical Services Program Update
- Next steps

2. DISCUSSION ITEMS

The following table summarizes comments raised during the conference call and the response and plan for resolution (if appropriate) identified for each item.

Item No.	Comment	Commenter	Response/Plan for Resolution
1	How does the monitoring well network for groundwater levels prioritize screen interval information vs measurement frequency?	Jeff Shaw	Higher measurement frequency is given higher priority over having screen interval information in monitoring well prioritization

2	How was prioritization performed for water quality monitoring wells?	Jeff Shaw	There's not a lot of water quality data available, so prioritization is focused on the number of water quality measurements at each well
3	Can we apply a tiering scheme to water quality, similar to levels?	Jeff Shaw	That's something that could be considered in the future, but we're finding in general that the quality of water quality data is low, which is why we need a plan to fill that data gap.
4	SBCWA provided us with an email with additional Western basin water quality data	Matt Scrudato	This will be considered as model refinement continues.
5	How are we separating out the effects of water vs oil for subsidence?	Neil Currie	The GSP propose that the GSA explore adding more subsidence data sensors, which will provide additional data to make this assessment.
6	How much of the available water level data was provided by private landowners and what is the quality of that data?	Dennis Gibbs	Data was provided by Grapevine, Bolthouse, and Grimmway. Their data was from pressure transducers or from their monitoring program. This data filled in data gaps for areas where we wouldn't have data otherwise. In the Groundwater Conditions section we compared historical level data between private and DWR/USGS and found that they were consistent with each other.
7	Are there any active monitoring sites in Ventura County?	Dennis Gibbs	There are 2 along the river at the South end of the Basin. The W&C team coordinated directly with Ventura County to obtain the available data.
8	Why does the top tier in the level prioritization require a monthly frequency? Wouldn't quarterly be sufficient?	Dennis Gibbs	DWR guidance materials clearly indicate that the Cuyama Basin needs to do monthly monitoring based on its quantity of groundwater use and recharge. We recommend that the entire monitoring network be monthly for the first few years and then quarterly after that.
9	A significant portion of the wells in the monitoring network are private landowners. Do they have consistent protocols for how they collect data?	Jeff Shaw	They are not consistent in how they do monitoring currently. The GSP will set up consistent protocols for future monitoring.
10	Water is currently moving east and west across the middle of the Basin	Dennis Gibbs	This is being represented in the IWFM model.
11	W&C requested assistance from the CBWD regarding production well locations. What is the status of that effort?	Brian Van Lienden	Matt Klinchuch has reached out to landowners and has acquired some data. Additional data should be provided by the end of next week, although he may not get a response from some landowners.

12	Can you share the IDC and PEST outputs from the model development?	John Fio and Jeff Shaw	While preliminary versions of these modules are complete, they continue to be refined as the IWFM model is calibrated. This data can be provided once the model calibration is complete.
13	How did you determine how much acreage is idle during the period of record?	Jeff Shaw	Idle land uses were included in the land use data provided by Bolthouse and Grimmway, and in the land use estimates developed by LandIQ. These were refined using Landsat satellite imagery to detect the actual presence of green vegetation each year.
14	What does a 2% difference in irrigated area translate to in terms of change in water demand?	Anona Dutton	For the CBWD ag area – 2% of ~57 TAF/year total demand equates to about 1,100-1,200 AF/year.
15	Are fallowed fields included in the remote sensing model?	Jeff Shaw	Yes
16	Would improving efficiency in lower efficiency areas improve the Basin water budget?	Jeff Shaw	Given the very low river flows in this Basin, it is assumed that the water that's not consumed is returned to the groundwater. Therefore, an improvement in efficiency won't have an appreciable effect on the overall water budget.
17	Looking at data density for the proposed southeast management area, there's not a lot of information to help understand conditions in that part of the Basin	Jeff Shaw	This is a critical data gaps area. But in some of these areas, there's not a lot of need for data monitoring.
18	The recommended management areas look really good. In east of Ventucopa area, there's a finger that should be in Southeast Basin Area.	Dennis Gibbs	The delineations of the management areas will be reviewed and refined.
19	Do we need to have a calibrated model before setting management areas?	Jeff Shaw	We need to set the sustainability thresholds very soon. While modeling results are useful, we need to move forward, and we can adjust down the road. Modeling results probably won't change the management area delineations drastically.

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MEETING MEMORANDUM

PROJECT: Cuyama Basin Groundwater Sustainability Plan Development

MEETING DATE: 10/23/2018

MEETING: Technical Forum Conference Call

ATTENDEES: Matt Young (Santa Barbara County Water Agency)
Fray Crease (Santa Barbara County Water Agency)
Matt Klinchuch (Cuyama Basin Water District)
Neil Currie (Cleath-Harris Geologists)
Tim Cleath (Cleath-Harris Geologists)
John Fio (EKI)
Jeff Shaw (EKI)
Anona Dutton (EKI)
Matt Naftaly (Dudek)
Brian Van Lienden (Woodard & Curran)
Sercan Ceyhan (Woodard & Curran)
Ali Taghavi (Woodard & Curran)
Micah Eggleton (Woodard & Curran)

1. AGENDA

- GSP Development Process and GSP Outline Update
- Update on Management Areas
- Sustainability Thresholds Overview
- Numerical Model Development Update
- Next Steps

2. DISCUSSION ITEMS

The following table summarizes comments raised during the conference call and the response and plan for resolution (if appropriate) identified for each item.

Item No.	Comment	Commenter	Response/Plan for Resolution
1	Would the rationale used for sustainability indicators be similar with each threshold region?	Jeff Shaw	The intent is to use the threshold regions to help identify rationales used to set the sustainability indicators in each region.
2	Using the term “threshold regions” as opposed to “management areas” may be confusing	Matt Young	Comment noted. The terminology used will need to be clarified going forward.

3	Why a straight line instead of using a hydrogeologic barrier in Northeast boundary?	Neil Currie	The intent of the boundary is just to separate out wells in different regions. The exact boundary line can be adjusted in the future.
4	We should separate out all of the undeveloped area in the eastern basin into a separate region.	Multiple	This proposal has been included in the options to be presented to the SAC and Board.
5	In the central basin, we should consider using the 2015 levels as the measurable objective rather than the minimum threshold.	Anona Dutton	This will be considered as an option as the proposed thresholds are developed.
6	The shallowest well rationale is limited because we don't have good data on which wells are still active.	Anona Dutton	This limitation has been added to the presentation materials for the SAC and Board.
7	Undesirable results for each sustainability indicator need to be clearly defined.	Tim Cleath	Comment noted. These will be described in the relevant GSP section.
8	We should describe the reasoning behind each rationale in the presentations to the SAC and Board	Anona Dutton	Descriptions for each rationale will be added to the SAC and Board presentations.
9	Why were the wells in the presentation selected?	Jeff Shaw	The wells used in the presentation are just example wells selected to demonstrate how each potential rationale would work.
10	Instead of using a different rationale in each region, W&C should use a step function to implement the criteria that can be applied throughout the Basin.	Jeff Shaw and Anona Dutton	It would be very difficult to develop a single function that can be applied basin-wide. Using different rationales in each region provides more flexibility to define thresholds and objectives for each well in a reasonable way. The reasoning for why rationales were selected in each region will be described in the relevant GSP section.

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MEETING MEMORANDUM

PROJECT: Cuyama Basin Groundwater Sustainability Plan Development

MEETING DATE: 11/28/2018

MEETING: Technical Forum Conference Call

ATTENDEES: Matt Young (Santa Barbara County Water Agency)
Matt Klinchuch (Cuyama Basin Water District)
Neil Currie (Cleath-Harris Geologists)
Spencer Harris (Cleath-Harris Geologists)
John Fio (EKI)
Jeff Shaw (EKI)
Dennis Gibbs (Santa Barbara Pistachio Company)
Brian Van Lienden (Woodard & Curran)
Sercan Ceyhan (Woodard & Curran)
Micah Eggleton (Woodard & Curran)
John Ayres (Woodard & Curran)
Mesut Cayar (Woodard & Curran)

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1. AGENDA

- Detailed Monitoring Analysis in Schoolhouse Canyon
- Review of Preliminary Thresholds
- Numerical Model Development Update
- Next Steps

2. DISCUSSION ITEMS

The following table summarizes comments raised during the conference call and the response and plan for resolution (if appropriate) identified for each item.

Item No.	Comment	Commenter	Response/Plan for Resolution
1	Spikes similar to what was seen in Schoolhouse Canyon in 2017 may happen in many in wet years, and in other wells in the Basin as well.	Jeff Shaw	Comment noted. 2017 is the only year where data is currently available to see this pattern in the western basin.
2	Are the representative wells that were selected in the Western Basin typical of stakeholder wells?	Dennis Gibbs	Most of the representative wells that were selected in the western basin are stakeholder wells. These wells reflect the available range of well depths in the region.

3	How do minimum thresholds relate to the undesirable results?	Spencer Harris	Minimum thresholds and undesirable results are directly related as the minimum threshold is the level below which an undesirable result is occurring.
4	Can the model help developing some of these thresholds, including how sustainable they might be?	Spencer Harris	Once the model has been developed it can be used to look at how variable groundwater levels may be when pumping is at long-term sustainable levels.
5	The levels proposed for wells in the western basin may not be representative of how the wells in that part of the basin will be used.	Spencer Harris	Greater buffers for operational flexibility can be considered.
6	Why assume that going below 2015 or 2018 levels would result in unreasonable consequences? What would happen if these thresholds are being crossed?	Spencer Harris	Using 2015 or 2018 levels may be reasonable in some areas but not others. We would need to consider the physical characteristics of each part of the aquifer.
7	In the northwestern region, there has been a change in land use and the representative wells are active pumping wells – when you develop a new area, there's a drawdown that occurs. It is unreasonable to set a threshold based on current levels when you know that the levels will be drawn below that due to the current operation of the wells. We would like a rationale that reflects this while avoiding undesirable results in the region.	Spencer Harris	An additional approach for the Western region will be added for discussion at the SAC meeting.
8	Greater flexibility can be a good thing in establishing the thresholds and objectives, especially in areas where future operations may differ from what we've seen historically. Physically-based criteria in the western basin are worthy of consideration.	Jeff Shaw	Comment noted. Operational flexibility will be taken into consideration when developing the sustainability thresholds.
9	The BMPs say that we should consider GDE. Have we looked at that?	Matt Young	A biologist is currently doing an assessment; when it is complete, the results will be reported to the Tech Forum and SAC
10	How are we verifying the numerical model?	John Fio	Checking water levels and mass balances for a period outside the calibration period (e.g. 2016/2017)

11	Given that you've divided the Basin into regions, it would be useful to lay out the case for why we think each region behaves similarly.	Jeff Shaw	This is something we can address in future presentations.
12	Do we have an estimate of the total groundwater storage? Will we quantify it?	Multiple	The model gives an estimate, but its based on the stratigraphy and storage coefficients. Storage estimates have a lot of uncertainty with respect to the depth of the basin and storage properties.

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MEETING MEMORANDUM

PROJECT: Cuyama Basin Groundwater Sustainability Plan Development

MEETING DATE: 12/14/2018

MEETING: Technical Forum Conference Call

ATTENDEES: Matt Young (Santa Barbara County Water Agency)
Fay Crease (Santa Barbara County Water Agency)
Tim Cleath (Cleath-Harris Geologists)
John Fio (EKI)
Jeff Shaw (EKI)
Dennis Gibbs (Santa Barbara Pistachio Company)
Matt Naftaly (Dudek)
Brian Van Lienden (Woodard & Curran)
Sercan Ceyhan (Woodard & Curran)
Micah Eggleton (Woodard & Curran)
John Ayres (Woodard & Curran)
Ali Taghavi (Woodard & Curran)

1. AGENDA

- Numerical Model Development Update
- Review of Preliminary Thresholds Presentation

2. DISCUSSION ITEMS

The following table summarizes comments raised during the conference call and the response and plan for resolution (if appropriate) identified for each item.

Item No.	Comment	Commenter	Response/Plan for Resolution
1	What drives the model boundary flows to be higher in recent years?	Matt Young	The boundary flows are still being reviewed as part of model calibration. The cause of this difference will be investigated.
2	Can you provide the projected land use for review along with more information on the ARMA model for projecting land use?	Jeff Shaw	These will be provided to the Technical Forum members.
3	Can you talk about how and why you make an assumption about improved agricultural efficiency? How much of the decline in agricultural pumping is due to improved efficiency versus change in cropping pattern?	Matt Young	Irrigation efficiencies in the model are based on the rationale that improved irrigation practices have been applied in the field. The actual change in agricultural water use in the model is due to both the change in cropping patterns and the change in irrigation efficiency. W&C will review the data to assess how much change is due to each factor.

4	The shallowest well may not be the most important factor to use to determine thresholds. It would be better to look at the bottom of basin.	Tim Cleath	The shallowest nearby well is not a sole factor that is used, but it is an indicator of aquifer conditions. There is not a lot of good information on the bottom of the aquifer in many parts of the basin
5	You should look at a longer period of record – focusing on just 2010 to present is focusing just on a single drought and could be misleading.	Tim Cleath	For the most part, the data doesn't really go further back on wells that are currently monitored.
6	Isolating the Badlands region on the eastern part of basin is a good improvement	Tim Cleath	Comment noted.
7	Many wells only have monitoring measurements once per year – the frequency of data makes it hard to understand trends	Tim Cleath	A number of the wells in the monitoring network are from private landowners, and they only measured once a year. We have to work with the data we have now, but can change the frequency of monitoring going forward.
8	In wells with no fluctuations, the five years of storage approach doesn't work very well; we should consider a different approach in these regions	Jeff Shaw & Tim Cleath	We may need to consider other ideas; Technical Forum members are welcome to submit ideas for how to develop thresholds in these areas.
9	We should include a buffer in the thresholds so that we don't trigger an "undesirable result" if we go below the minimum threshold.	Jeff Shaw	Going below the minimum threshold initially triggers an investigation by the GSA to determine the cause. The GSA will need to consider the available information and determine how to respond.
10	Using 2015 as an operational level is not a good approach in the western basin. Thresholds should be based on quantitative estimates of undesirable results, similar to what we have provided the Board	Tim Cleath	The proposal from Grapevine provided to the Board will be included for discussion in the slides on the northwestern region at the Dec 18 Board meeting.
11	The Caliente Hills fingers should be treated like the eastern Badlands (i.e. put into their own region) because there is no development in those areas.	Tim Cleath	This is something that could be considered by the Board.
12	The distribution of wells to be used for management should be more restrictive than those to be used for thresholds	Tim Cleath	We are restricted by the available data and available time to develop the GSP. The monitoring network and thresholds will need to be adjusted as more information is available in the future.

13	You should do a statistical analysis of which strategies work in each region.	Jeff Shaw	Comment noted. We will have a table available with summary information at the meeting on December 18.
14	If you're going to propose a saturated-thickness method option for calculating sustainability criteria in one of the Threshold Regions, you should examine that method for all of them. It's a technically defensible method (vs. subtracting some arbitrary value from 2015, for example), and it may help create more MoOF.	Jeff Shaw	This can be considered, however, data may not available to do this type of analysis in all parts of the basin.

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MEETING MEMORANDUM

PROJECT: Cuyama Basin Groundwater Sustainability Plan Development

MEETING DATE: 1/25/2019

MEETING: Technical Forum Conference Call

ATTENDEES: Matt Young (Santa Barbara County Water Agency)
Matt Scrudato (Santa Barbara County Water Agency)
Catherine Martin (San Luis Obispo County)
Neil Currie (Cleath-Harris Geologists)
John Fio (EKI)
Jeff Shaw (EKI)
Dave Leighton (EKI)
Dennis Gibbs (Santa Barbara Pistachio Company)
Brian Van Lienden (Woodard & Curran)
Sercan Ceyhan (Woodard & Curran)
Micah Eggleton (Woodard & Curran)
John Ayres (Woodard & Curran)
Ali Taghavi (Woodard & Curran)
Sebastien Poore (Woodard & Curran)

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1. AGENDA

- Numerical Model and Water Budget Update
- Projects and Management Actions
- Groundwater Dependent Ecosystems

2. DISCUSSION ITEMS

The following table summarizes comments raised during the conference call and the response and plan for resolution (if appropriate) identified for each item.

Item No.	Comment	Commenter	Response/Plan for Resolution
1	When will you release the model input and output files?	Jeff Shaw	Model files will be released subsequent to the release of the draft Water Budgets GSP section.
2	It may make sense to subdivide the Central Basin into developed and undeveloped areas. I can provide input on where it makes sense to draw a line.	Dennis Gibbs	Dennis can mark up the pdf map provided to the Tech Forum and send it back to us with his ideas.
3	The rationale for separating the two areas in CB for water budget accounting is not clear.	John Fio	Comment noted. This separation has not been included in material to be presented to the SAC and Board

4	There was discussion about potentially drawing a different line between the Northwest and Western boundaries for purposes of water budgets. The new boundary would better reflect geology in that part of the Basin.	Multiple	Technical Forum members responded that these changes could be reasonable, for purposes of discussing water budgets. However, we would need to be careful that we are still adequately reflecting the relationship between the regions and the threshold wells. The original boundary has been retained for the SAC/Board presentations.
5	What was the modeling assumption for pumping going forward?	Jeff Shaw	W&C took the 2017 land use conditions, and assumed a variable pattern going forward that approximated recent agricultural land use.
6	There are localized pumping depressions in the Ventucopa corridor.	Dennis Gibbs	Comment noted. This may need to be considered when looking at model performance in the Ventucopa region.
7	I can give you some ideas for good locations for monitoring wells in the Ventucopa area.	Dennis Gibbs	W&C will contact Dennis and others fior ideas for where new wells can be added in the Category 1 task.
8	What iss the largest avg annual decline in the Basin?	Dennis Gibbs	The largest decline in the Basin is about 10 feet/year.
9	Twitchell Reservoir has a sedimentation problem – the GSA should engage Twitchell operators when considering a potential stormwater capture project.	Dennis Gibbs	Comment noted. This should be considered if the GSA does a more detailed study during the implementation phase.
10	Controlled burning would be a hard sell. If you ran a burn on areas where there is a flat slope it could work, but it often doesn't go according to plan.	Jeff Shaw	Comment noted. The pros and cons of this option will need to be considered by the Board.
11	Through controlled prescription burning, you don't necessarily increase sedimentation. A program that runs appropriately will reduce ET and sediment won't necessarily go down the valley	Dennis Gibbs	Comment noted. The pros and cons of this option will need to be considered by the Board.
12	You should consider cloud seeding as a potential action. A study has been performed for this action in the Cuyama Basin.	Matt Scrudato	Matt will provide W&C with the study report. This action will be added to the SAC/Board presentation for consideration.
13	Materials developed for Paso Robles GSP development may be useful for Cuyama Basin discussions with the SAC/Board.	Cathy Martin	Cathy will provide W&C with the materials and these will be taken into consideration for future SAC/Board presentations.

14	It would be better to use example numbers rather than actual numbers when discussing the potential pumping allocation options.	Multiple	This change has been made to the SAC/Board presentations.

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MEETING MEMORANDUM

PROJECT: Cuyama Basin Groundwater Sustainability Plan Development

MEETING DATE: 2/22/2019

MEETING: Technical Forum Conference Call

ATTENDEES: Matt Young (Santa Barbara County Water Agency)
Fray Crease (Santa Barbara County Water Agency)
Spencer Harris (Cleath-Harris Geologists)
Neil Currie (Cleath-Harris Geologists)
John Fio (EKI)
Jeff Shaw (EKI)
Dave Leighton (EKI)
Matt Klinchuch (Provost & Pritchard)
Dennis Gibbs (Santa Barbara Pistachio Company)
Brian Van Lienden (Woodard & Curran)
Sercan Ceyhan (Woodard & Curran)
Micah Eggleton (Woodard & Curran)
Ali Taghavi (Woodard & Curran)
Sebastien Poore (Woodard & Curran)

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1. AGENDA

- Numerical Model and Water Budget Update
- Projects and Management Actions
- Groundwater Dependent Ecosystems

2. DISCUSSION ITEMS

The following table summarizes comments raised during the conference call and the response and plan for resolution (if appropriate) identified for each item.

Item No.	Comment	Commenter	Response/Plan for Resolution
1	The model input and output files were provided to the Technical Forum members earlier this week.	W&C	The Technical Forum members did not have any questions or comments on them at the time of the call.
2	How does the integrated model account for precipitation onto upper watershed areas that would flow into the Basin area?	Spencer Harris	Areas outside of the groundwater basin are simulated in the model based on precipitation and assumed land cover to estimate runoff and subsurface inflow from each upper watershed area.
3	Can you add an accounting of the water flows in the upper watershed areas?	Spencer Harris	W&C will provide the Technical Forum members with the model data files for the upper watersheds.

4	Do the sustainability runs maintain the same crop mix as current conditions?	Dennis Gibbs	For modeling purposes, the sustainability runs assumed that annual crops would be reduced proportionally while perennial crops would be unchanged.
5	It is not appropriate to make a distinction between annual and perennial crops in implementing pumping reductions.	Multiple	This assumption was used for modeling purposes and does not reflect a recommendation for implementation. To avoid confusion, the language used in the SAC and Board slides has been modified to remove the distinction.
6	Is there any opportunity to switch to less water intensive crops to reduce the financial impact?	Spencer Harris	This is something that could be evaluated using economic analysis, most likely during the GSP implementation phase.
7	It would be helpful to see some error bars – have you done any sensitivity analysis on model inputs?	Jeff Shaw	This has not been done yet for Cuyama GSP, but it could be considered in future analysis.
8	The assumptions used for cloud seeding probably overestimate the benefit because in practice cloud seeding would typically be applied only on a subset of storms throughout the year.	Matt Young	The current analysis is only intended to provide an initial estimate of the benefits that may be accrued. However, to improve this initial analysis, W&C has requested additional information from Santa Barbara Co staff on the timing of when cloud seeding would be applied.
9	On the North side of Highway 166 where the river is the widest, that is the historical channel. There are areas there that are prime for detention storage.	Dennis	Alternative areas for recharge of stormwater can be considered in a future study.
10	The estimates of benefits for the three water supply projects are reasonably accurate for use in the GSP.	Dennis	Comment noted.
11	Has climate change analysis been applied to any of these scenarios?	Jeff	Climate change has not yet been evaluated for the GSP. An analysis will be developed for inclusion in the Public Draft.

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MEETING MEMORANDUM

PROJECT: Cuyama Basin Groundwater Sustainability Plan Development

MEETING DATE: 3/25/2019

MEETING: Technical Forum Conference Call

ATTENDEES: Matt Young (Santa Barbara County Water Agency)
Cathy Martin (San Luis Obispo County)
Neil Currie (Cleath-Harris Geologists)
John Fio (EKI)
Jeff Shaw (EKI)
Dave Leighton (EKI)
Matt Klinchuch (Provost & Pritchard)
Dennis Gibbs (Santa Barbara Pistachio Company)
Brian Van Lienden (Woodard & Curran)
Sercan Ceyhan (Woodard & Curran)

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1. AGENDA

- Numerical Model and Water Budget Update
- Projects and Management Actions
- Groundwater Dependent Ecosystems

2. DISCUSSION ITEMS

The following table summarizes comments raised during the conference call and the response and plan for resolution (if appropriate) identified for each item.

Item No.	Comment	Commenter	Response/Plan for Resolution
1	There are ancillary issues that could affect the CCSD production area. If groundwater levels adjacent to the CCSD are drawn down, it would affect the CCSD.	Dennis Gibbs	The groundwater levels monitoring network will be used to measure if levels in the vicinity of the CCSD are being drawn down.
2	If the CCSD is not part of a management area, then how can it be limited to historical pumping levels?	Matt Young	This will be clarified during the SAC discussion.
3	The CCSD well is outside the CCSD service area.	Matt Klinchuch	This will need to be accounted for in designating management areas.
4	The pumping allocation approach could be the subject of potential litigation. The GSA should seek legal counsel in developing the approach.	Matt Young	CBGSA and/or CBWD legal counsel will be consulted in development of the policy.

5	What is the methodology for developing the climate change scenarios?	Dennis Gibbs	The climate change scenarios include modified precipitation and crop evapotranspiration (ET) that are adjusted using data and methods provided by the California Department of Water Resources.
6	You should consider presenting the more variability in modeling results, including looking at drier and wetter climate scenarios instead of just the central tendency projection.	Jeff Shaw	This will be considered for future analyses, most likely during the GSP implementation phase.
7	Looking at just the 1967-2016 hydrology does not capture the full climatic cycle.	Dennis Gibbs	A 50-year period was selected to comply with SGMA requirements.
8	Why does climate change result in higher crop ET but lower native vegetation ET?	Matt Klinchuch	Whereas the model will pump water to meet crop ET, the native vegetation ET is limited by the availability of precipitation. Therefore, actual native vegetation ET is less under climate change.
9	Can other pumping reduction schedules be considered outside of the ones shown?	Jeff Shaw	Yes – the Board can select an appropriate glide path for pumping reductions.
10	Will economics be considered prior to pumping reductions are implemented?	Multiple	Economic analysis can be performed in the GSP implementation phase prior to implementation of projects or pumping allocations.
11	Another approach for tracking pumping could be to use crop acreage with a factor for each crop.	Matt Young	Alternate methods can be considered for implementation by the Board.
12	A footnote should be added to note whether pumping fees would be applied to de minimis users	Cathy Martin	The presentation slides will be clarified prior to the GSA Board meeting
12	Another option to consider for GSA financing is to have a fee for each well with an additional charge for each unit of pumping	Matt Young	Alternate methods can be considered for implementation by the Board.
13	Fox Canyon in Ventura County could be reviewed for potential implementation approaches	Jeff Shaw	This can be considered during the GSP implementation phase.

Cuyama Valley Groundwater Basin

Draft Groundwater Sustainability Plan: Basin Settings

Prepared by:

Cuyama Basin Groundwater Sustainability Agency
Woodard & Curran

April 2019

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Table of Contents

Tables

Figures

Appendices

Acronyms

µg/L	micrograms per liter
µS/cm	microsiemens per centimeter
AF	acre-feet (foot)
AFY	acre-feet per year
Basin	Cuyama Valley Groundwater Basin
CALSIMETAW	California Simulation of Evapotranspiration of Applied Water
CBGSA	Cuyama Basin Groundwater Sustainability Agency
CBWRM	Cuyama Basin Water Resources Model
CUVHM	Cuyama Valley Hydrologic Model
DWR	California Department of Water Resources
EKI	EKI Environment & Water, Inc.
GAMA	California Groundwater Ambient Monitoring and Assessment Program
GDE	groundwater dependent ecosystem
GPS	global positioning system
GSP	*Groundwater Sustainability Plan*
HCM	hydrogeologic conceptual model
InSAR	interferometric synthetic-aperture radar
Ma	million years
MCL	maximum contaminant level
METRIC	Mapping Evapotranspiration at High Resolution and Internalized Calibration
Navstar	A network of United States that provide global positioning system services
NCCAG	Natural Communities Commonly Associated with Groundwater
NRCS	Natural Resources Conservation Service
NWIS	National Watershed Information System
PG&E	Pacific Gas & Electric
PRISM	Parameter-Elevation Regressions on Independent Slopes Model
RWQCB	Regional Water Quality Control Board
SAGBI	Soil Agricultural Groundwater Banking Index

Acronyms

SBCF	Santa Barbara Canyon Fault
SBCWA	Santa Barbara County Water Agency
SGMA	Sustainable Groundwater Management Act
SR	State Route
TDS	total dissolved solids
UNAVCO	A non-profit university-governed consortium facilitating geoscience research and education using geodesy
USGS	United States Geological Survey

2. Basin Settings: Overview

This Cuyama Valley Groundwater Basin (Basin) Settings chapter contains three main sections as follows:

- **Hydrogeologic Conceptual Model (HCM)** – The HCM section (Section 2.1) provides the geologic information needed to understand the framework that water moves through in the Basin. It focuses on geologic formations, aquifers, structural features, and topography.
- **Groundwater Conditions** – The Groundwater Conditions section (Section 2.2) describes and presents groundwater trends, levels, hydrographs and level contour maps, estimates changes in groundwater storage, identifies groundwater quality issues, addresses subsidence, and addresses surface water interconnection.
- **Water Budget –** The Water Budget section (Section 2.3) describes the data used to develop the water budget. Additionally, this section discusses how the budget was calculated, provides water budget estimates for historical conditions, and current conditions and projected conditions.

2.1 Basin Settings: HCM

This section of Chapter 2 describes the HCM for the Basin. Additionally, this HCM section satisfies Section 354.8 of the Sustainable Groundwater Management Act (SGMA) regulations. As defined in the regulations promulgated by the Department of Water Resources (DWR), the HCM:

1. "Provides an understanding of the general physical characteristics related to regional hydrology, land use, geology geologic structure, water quality, *principal aquifers*, and principal aquitards of the *basin setting;*
2. Provides the context to develop water budgets, mathematical (analytical or numerical) models, and monitoring networks, and
3. Provides a tool for stakeholder outreach and communication."

This HCM was developed to understand and then convey information about the physical conditions by which water moves through the Basin. This information is also used to support development of water budgets (Section 2.3).

2.1.1 Useful Terms

This chapter includes descriptions of geologic formations and structures, aquifers, and properties of geology related to groundwater, among other related components.

A glossary of technical terms is below. The terms listed here are intended as a guide for readers, and are not a definitive definition of any term.

- **Formation –** A formation, or geologic formation, is a unit of rock of similar properties, such as grain size, mineral composition, or depositional environmental. Geologic formations are distinct from surrounding rock types and are large enough to be mapped regionally. If the formation contains a dominant rock type, such as sandstone, it may be included in the name of the formation.
- **Basement rocks –** Basement rocks are the oldest and deepest rocks in the subsurface. Basement rocks are typically crystalline and metamorphic or igneous in origin, and groundwater generally only moves through fractures in the rock instead of pore spaces like in sedimentary rocks. No sedimentary layers are found below the basement rocks.
- **Water bearing formation –** A water bearing formation is a rock formation that is saturated and contains water within the pores or fractures of the unit. One or more water bearing formations compose an aquifer.
- **Aquifer –** An aquifer is an underground reservoir of water stored within the pores and fractures of rocks and sediments.
- **Unconfined aquifer –** An unconfined aquifer is an aquifer that does not have an impermeable layer above it (such as a clay layer). With an unconfined aquifer, the upper water surface is defined as the water table and is at atmospheric pressure. Water seeps from the ground surface directly into the aquifer, as there are not impermeable layers to prevent the water from entering the aquifer.
- **Cross section –** A cross section is a diagram that identifies subsurface layers located beneath a surficial trend. Stratigraphic cross sections depict geologic formations in the subsurface in relation to elevation. Cross sections are useful tools to interpret geology in the subsurface and visualize the relative thickness and distribution of geologic formations. Cross sections are often presented with an accompanying map that acts as a reference to spatially locate the trend of the cross section at the surface. To read cross sections, use the location and trend of the surficial lines on the location map as a key. For instance, where A-A' is marked on the map represents where the cross section named A-A' is located spatially
- **Hydraulic conductivity** – Hydraulic conductivity is defined as the "measure of a rock or sediment's ability to transmit water," typically measured in feet or meters per unit of time (day, hour, minute) (DWR, 2003). Rocks and sediments with high values of conductivity, such as gravels or coarse sands, are able to sustain groundwater flow better than rocks and sediments with low values of conductivity. Rocks and sediments with near zero values of hydraulic conductivity, such as very fine-grained sandstones, shale, or granites, do not transmit groundwater and are barriers to flow. Values of conductivity are used in the groundwater model to determine how quickly formations transmit groundwater and where barriers to groundwater flow (i.e., formations with very low values of conductivity) exist.
- **Hydrogeology** – The study of groundwater and aquifers.

- **Primary aquifer –** According to SGMA regulations, primary aquifers must be identified. In the Goundwater Sustainability Plan (GSP), aquifers requiring specific monitoring and management must also be identified. Primary aquifers are regionally extensive and are sources of groundwater used for beneficial uses.
- **Aquitard –** An aquitard is a layer of strata that has a low conductivity that groundwater flows very slowly through. Aquitards can be regional, such as the Corcoran Clay in the Cuyama Valley, where it prevents flow from upper strata to lower strata across the western side of the valley, or it can be localized, which is common in most alluvial settings. Localized aquitards restrict vertical flows in a small region of an aquifer, and water will generally move laterally around localized aquitards as it flows by gravity toward the bottom of the aquifer.
- **Piper diagrams** – A Piper diagram is used to characterize the chemical quality of a water sample, and involves plotting the relative proportions of major ions. Piper diagrams show the relative abundance of major cations (e.g., sodium, potassium, calcium, magnesium) and anions (e.g., bicarbonate, carbonate, sulfate, chloride, fluoride) commonly found in water on a charge equivalent basis, as a percentage of the total ion content of the water. Piper diagrams are useful for understanding what kind of salts make up the total dissolve solids (TDS) in a location.

2.1.2 Regional Geologic and Structural Setting

The Basin is located at the southeastern end of the California Coast Ranges and north of the Western Transverse Ranges (Figure 2-1), and is in an area of high tectonic activity. The Basin is bounded on the north and south by faults, and is located near major fault zones such as the San Andreas and Santa Maria River fault zones. Because the Basin is located in a mountainous region with high tectonic activity, it has a number of structural features generated by this activity. The Basin has been deformed by this tectonic activity, and is generally a synclinal basin, with multiple synclines that are oriented to the northwest and a number of faults that cross the Basin.

Tectonic activity from the northwest movement of the San Andreas Fault system has led to the development of a fold and thrust belt, which has driven the deformation of the Cuyama Valley for the past four million years (United States Geological Survey [USGS], 2013c). The Cuyama Valley was formed by a downfaulted block of the earth's crust called a graben. This block is bordered on the north by the Morales and Whiterock faults and on the south by the South Cuyama and Ozena faults. Along these borders the faults have thrust older rocks of pre-Pliocene age over the rocks of Pliocene age and younger. In the eastern part of the valley the north-bordering faults approach the San Andreas Fault zone and the south-bordering faults approach the Big Pine Fault. (Singer and Swarzenski, 1970)

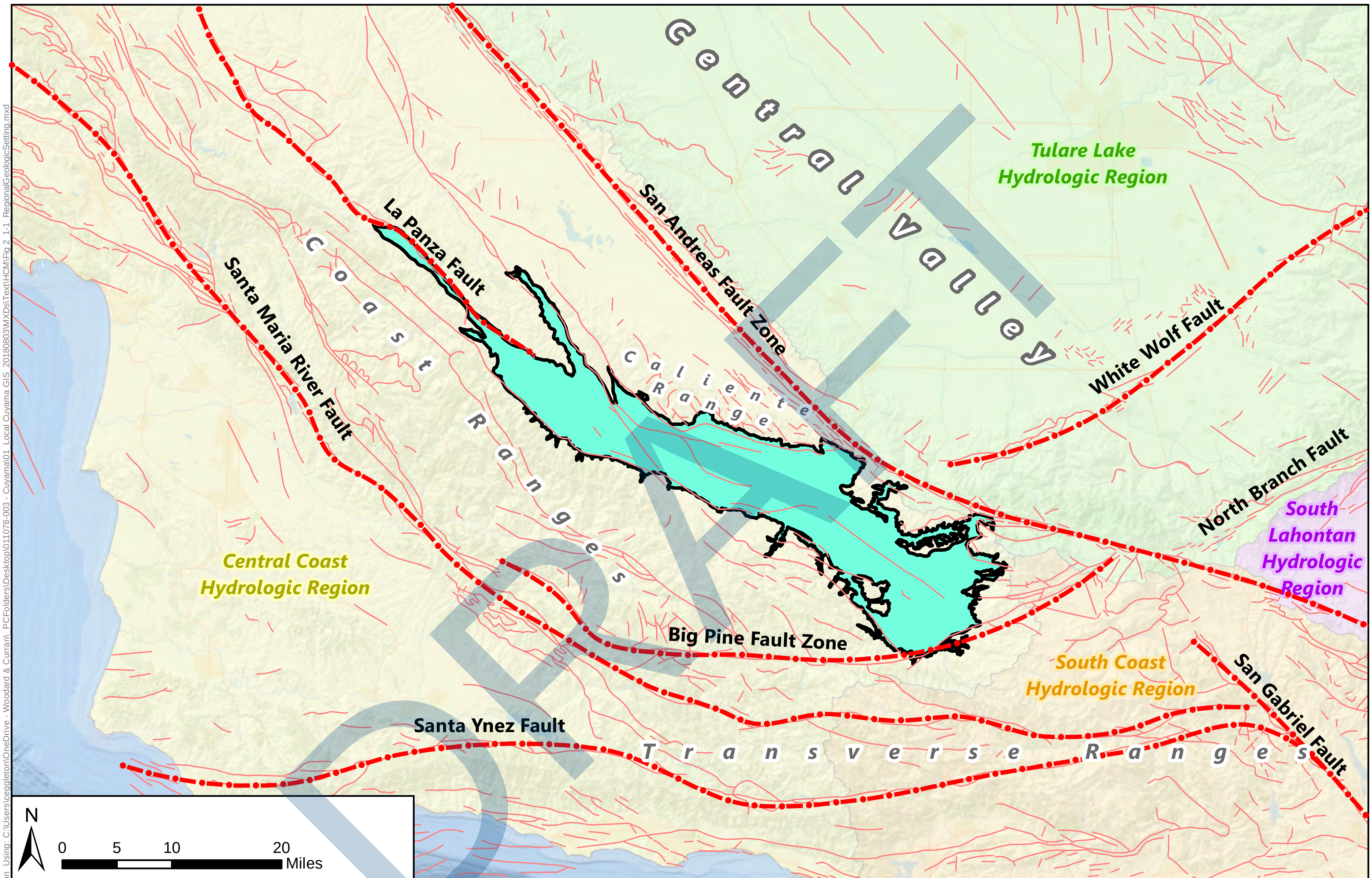

Figure 2-1: Regional Geologic Setting

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

Cuyama Basin

Faults

Fault Data Sources:
Fault Activity Map of California (2010) from the California Department of Conservation. Retrieved 6/13/2018.
<http://maps.conservation.ca.gov/cgs/fam/>
California Geologic Map Data from United States Geologic Survey. Retrieved 2/8/2018.
<https://mrdata.usgs.gov/geology/state/state.php?state=CA>

2.1.3 Geologic History

The Basin has a long history of deformation and deposition, most of this influenced by tectonic activity and cycles of marine transgression and regression. Formations in the Basin reflect variable depositional environments, from the middle bathyal shales and siltstones to the nonmarine sandstone, conglomerate, and mudstones. Marine rocks are dominant in the western part of the Basin and interfinger to the east with nonmarine rocks (Ellis, 1994).

A major late Eocene/early Oligocene (38 to 28 million years (Ma)) unconformity affected all regions south of the San Andreas Fault, shown in the geologic record by nonmarine Oligocene (23 Ma) rocks overlying a thick section (i.e., several kilometers) of upper Eocene (56 Ma) marine rocks (Kellogg et al., 2008; Ellis, 1994). This unconformity is a result of the Ynezian orogeny (around 30 Ma) during which pre-Oligocene marine rocks were folded and uplifted above younger, Oligocene-age sediments (Kellogg et al., 2008).

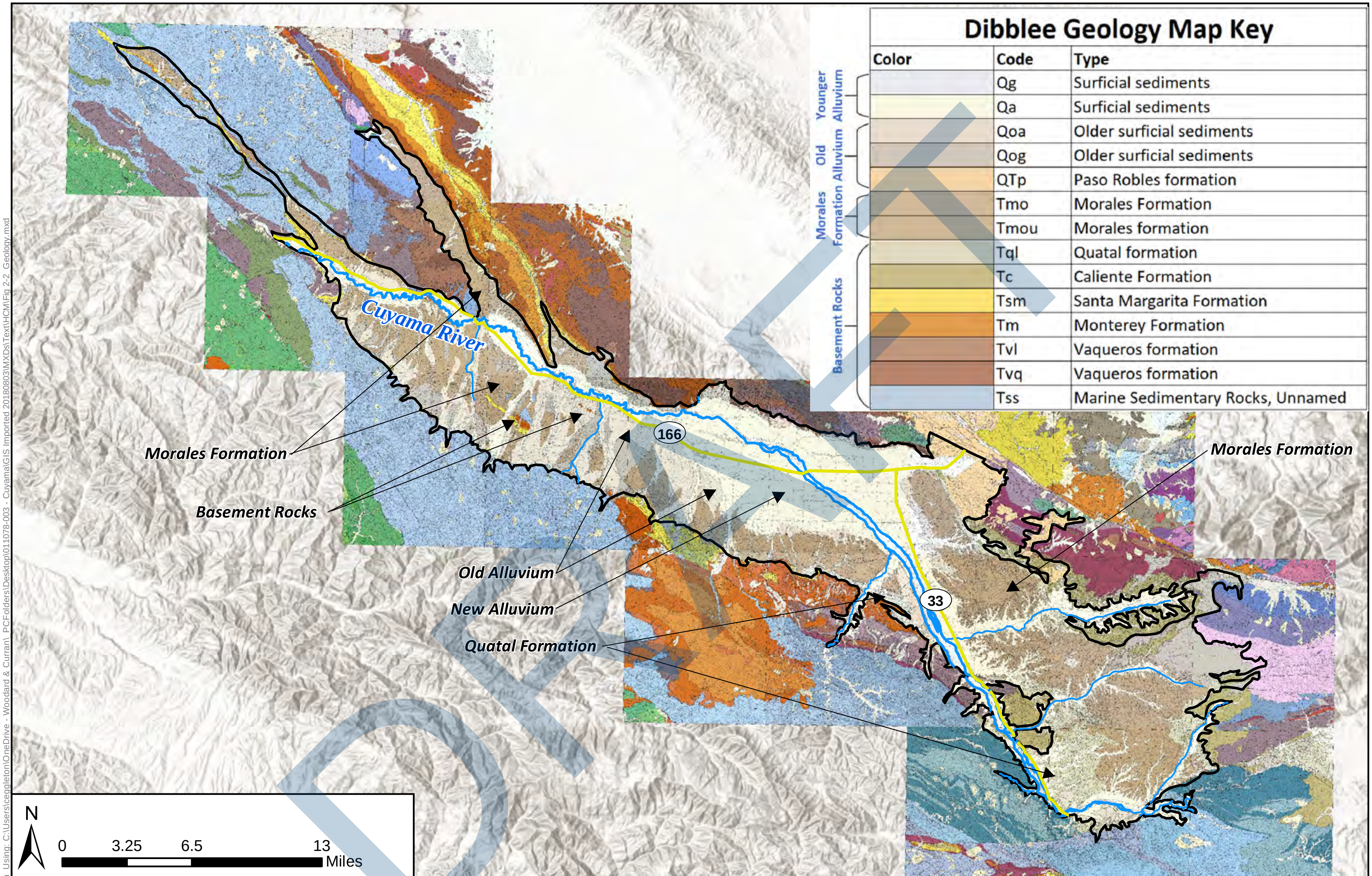
Following a period of orogeny, deformation changed to extension from the late Oligocene and early Miocene (around 23 Ma) and the Basin became a major extensional basin (Ellis, 1994). This period also correlated with two transgressive-regressive cycles, where the sea advanced and retreated over geologic time over the sediments now in the Basin due to tectonic subsidence (Bazeley, 1988). Sediments deposited during this period reflect the cyclical nature of sea-level rise and are generally categorized by marine strata in the west and nonmarine strata to the east. Formations deposited during ocean transgression are thick marine sediments, including the Vaqueros Formation, Monterey Formation, Branch Canyon Sandstone, and Santa Margarita Sandstone (Kellogg et al., 2008; Lagoe, 1981). Many of the marine units interfinger with terrestrial units and eventually pinch out to zero thickness in the east. During the late Miocene (8 Ma), the sea regressed from the western part of the region, evident in the geologic record where the nonmarine Caliente Formation interfingers with the similarly aged marine Santa Margarita Sandstone and unconformably overlies the Branch Canyon Sandstone (Kellogg et al., 2008). By the middle Miocene (15 Ma), the eastern Cuyama Valley area was characterized by a shelf and nonmarine deposition. Deformation by the middle Miocene changed from extension to right-lateral strike slip motion, resulting in the development of the Russell fault.

Deformation from Oligocene extension and Miocene strike-slip faulting regimes was buried by the folding, uplift, and thrust faulting during the Pliocene through Pleistocene compression (beginning around 4 Ma) (Ellis, 1994). Compression led to the uplift of the Coast and Transverse mountain ranges surrounding the current topographic valley and the converging thrust faults that surround the present day topographic basin, including the Whiterock, Morales, and South Cuyama faults (USGS, 2013b). The transition to a predominantly compressional system led to the development of a thrust system across the older extensional basin and began thrusting older sediments above younger sediments through the Cuyama Valley (Davis et al., 1988). Older, inactive faults and rocks were buried by the deposition of the younger Morales Formation, Older Alluvium, and Younger Alluvium. Thrust and compression continued into the Quaternary (3 to 2.5 Ma) and uplifted the Caliente Range and thrusted Miocene-aged rocks of the Caliente Range southward over Quaternary alluvium on the Morales fault (USGS, 2013b; Ellis, 1994).

The Morales Formation and Older Alluvium are folded into synclines along the north and south margins of the valley near the bounding thrust faults (USGS, 2013b). The end of the Pliocene (around 2 Ma) marks the complete withdrawal of the sea from the area and the final sea regression marks the change in deposition of marine sediments to the continental clay, silt, sand, and gravel of the Morales Formation and alluvium (Singer and Swarzenski, 1970; Ellis, 1994). Fluvial deposits of claystone, sandstone, and conglomerate became the primary forms of sedimentation.

2.1.4 Geologic Formations/Stratigraphy

The Basin is composed of a sequence of unconsolidated to partly consolidated nonmarine deposits of Pliocene to Pleistocene age unconformably overly consolidated marine and nonmarine sedimentary rocks of late Cretaceous to middle Cenozoic age on top of Mesozoic crystalline granitic and gneissic bedrock (Davis et al., 1988). The unconsolidated to partly consolidated nonmarine deposits are the primary water-bearing units in the Basin and are described in further detail in Section 2.1.7. Individual geologic units found in the Basin are described in detail below, in order of youngest to oldest in deposition. Geologic units mapped at the surface are shown in Figure 2-2. A generalized stratigraphic column of the Cuyama Valley is shown in Figure 2-3.



Dibblee Geology Map Key

Color	Code	Type
	Qg	Surficial sediments
	Qa	Surficial sediments
	Qoa	Older surficial sediments
	Qog	Older surficial sediments
	QTp	Paso Robles formation
	Tmo	Morales Formation
	Tmou	Morales formation
	Tql	Quatal formation
	Tc	Caliente Formation
	Tsm	Santa Margarita Formation
	Tm	Monterey Formation
	Tvl	Vaqueros formation
	Tvq	Vaqueros formation
	Tss	Marine Sedimentary Rocks, Unnamed

Figure 2-2: Geologic Map

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- Cuyama River
- Streams
- Highways

Data Source: Thomas W. Dibblee, Jr., Dibblee Foundation Relased in June 2012, Purchased from AAPG as GeoTIF 28 March 2018.

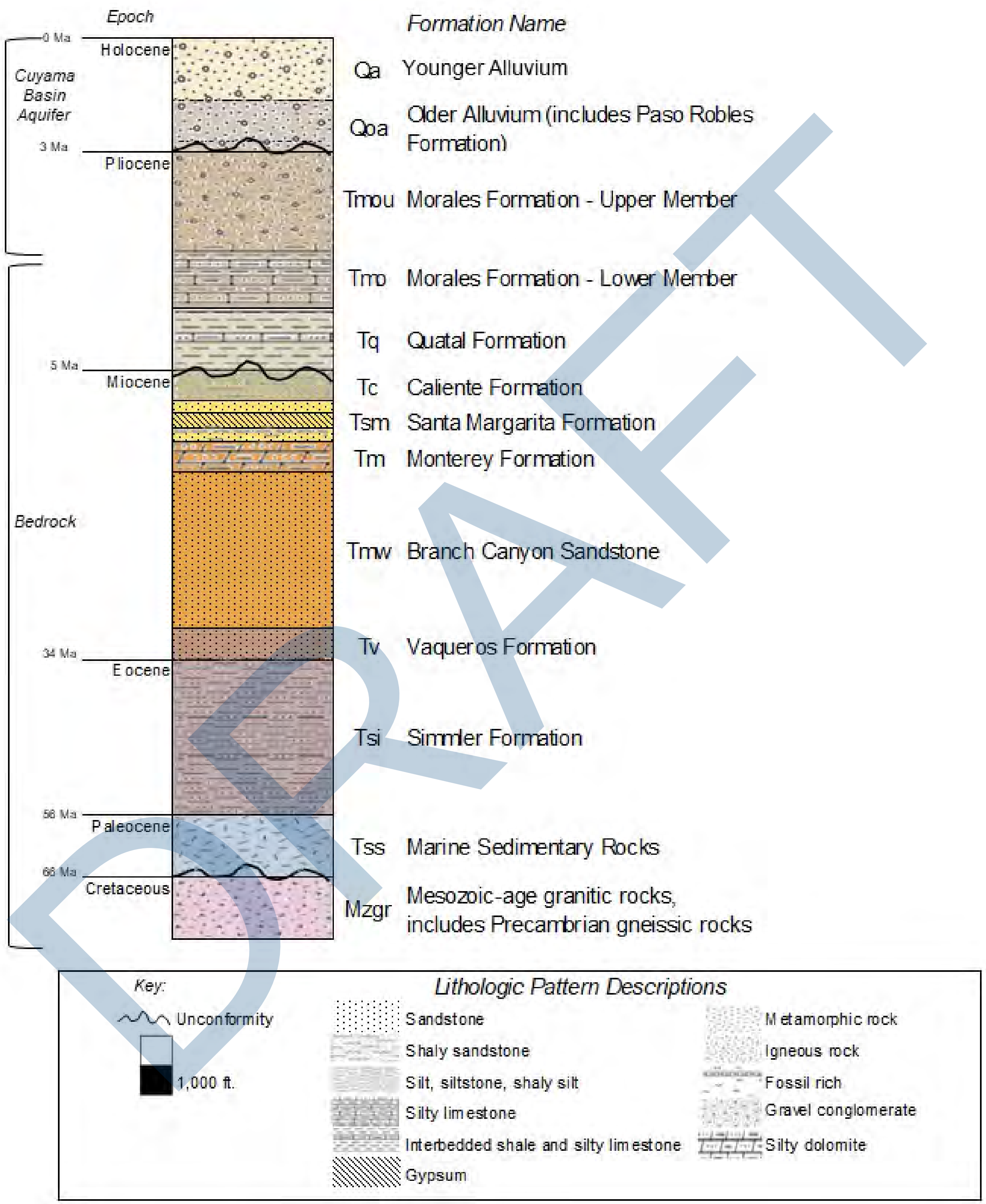
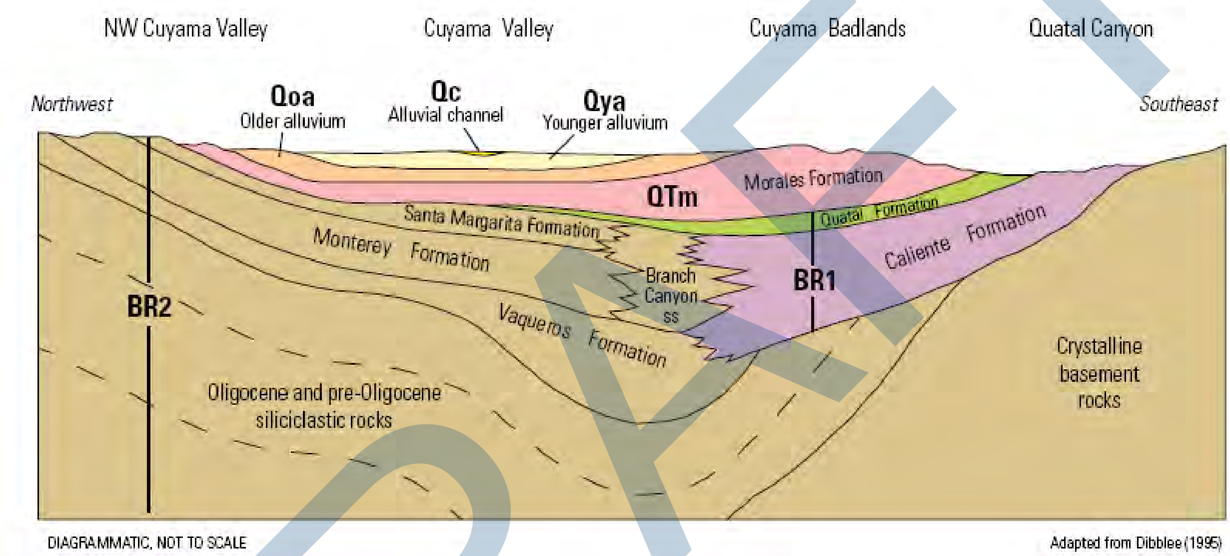


Figure 2-3: Generalized Stratigraphic Column of the Cuyama Valley

Stratigraphic Units of the Cuyama Basin Aquifer

Stratigraphic units in this section are presented in order from youngest to oldest. The USGS prepared a generalized stratigraphic diagram of the Basin and surrounding area in 2013 (Figure 2-4). The diagram shows the relationship of the Young Alluvium, Older Alluvium, Morales Formation, and basement rocks in and near the Basin. The diagram shows that the Morales formation is thicker to the east, and that the Caliente Formation is interfingered with a number of other basement rock formations (Santa Margarita, Monterey, Vaqueros) beneath the Basin (USGS 2013a). This diagram shows the general relationship of formations in the Cuyama area and is not a precise representation of unit thickness.



Source: USGS, 2013a.

Figure 2-4. Generalized Stratigraphic Diagram

Recent and Younger Alluvium

The youngest deposit of the Basin is the Recent and Young alluvium. Recent alluvium is made up of active fluvial channel deposits associated with the Cuyama River and other active channels. Deposits include river-bed gravels and grain sizes range from silt to boulder size and are found along active fluvial channels in the Basin. The Younger Alluvium is inactive fluvial deposits consisting of unconsolidated to partly consolidated sand, gravel, and boulders, with some clay deposited as part of stream channels, floodplains, alluvial fans, or stream terraces (USGS, 2013c). Younger Alluvium is exposed throughout the central portion of the Central Valley and along the active channels and flood plains of the Cuyama River and other streams. The deposits thicken to the east, typically ranging from 5 to 50 feet in the west and thickening from 630 to 1,100 feet in the east (Singer and Swarzenski, 1970). Recent and Younger alluvium are primarily Holocene in age, but the Younger alluvium can date back to the Pleistocene (USGS, 2013c). The Younger and Recent alluvium are the principal water-bearing formations in the Basin.

Older studies do not distinguish Younger Alluvium from Older Alluvium (Upson and Worts, 1951; Singer and Swarzenski, 1970), but more recent studies (Kellogg et al., 2008) mapped the two alluvium units as distinguishable mappable units at the surface, and in 2013, the USGS identified differences in the two units using electric log signatures. A greater degree of consolidation, dissection, and local deformation distinguishes the Older Alluvium deposits from the Younger alluvium.

Older Alluvium

Older Alluvium is primarily Pleistocene in age and is composed of unconsolidated to partly consolidated sand, gravel, and boulders with some clay (USGS, 2013a). The percentage of clay increases in the western part of the Cuyama Valley. Older Alluvium deposits are typically more consolidated and deformed than Younger alluvium deposits and contain a higher clay content. The Older alluvium is dissected alluvial fans, colluvial deposits and sediments on multiple terraces and alluvial surfaces and is found exposed on uplifted alluvial surfaces along the south side of the Cuyama Valley and on the caps of the Turkey Trap and Graveyard ridges (USGS, 2013a). Older Alluvium is typically 400 to 600 feet thick, but increases in thickness up to 1,000 feet near the axis of the Cuyama Valley and decreases in thickness west of the Russell fault (USGS, 2013a; Cleath-Harris, 2018). The Older Alluvium overlies the Morales Formation unconformably, west of the Cuyama Badlands (Ellis, 1994).

Paso Robles Formation

The Paso Robles Formation is part of the Quaternary alluvium series and is commonly grouped with the Older Alluvium. The Paso Robles Formation is a gray, crudely bedded alluvial gravel derived from Miocene rocks and basement rocks of western San Emigdio Mountains east of San Andreas Fault (Davis et al., 1988). The Formation is composed of pebbles, gravel, sand, and some cobbles. The Paso Robles Formation is sandwiched between two unconformities; it rests uncomformably below the Older Alluvium and with angular discordance above the Morales Formation (Davis et al., 1988; Ellis, 1994). The Paso Robles Formation is present only in a small northeastern portion of the Basin.

Morales Formation

The Pliocene to Pleistocene-aged Morales Formation (Morales) is divided into two members, the upper and lower. The Morales Formation is the oldest formation to respond to the modern topography of the Basin, indicating its deposition simultaneous to acceleration of tectonic-driven subsidence (Yeats et al., 1989). The contact between the upper and lower members of the Morales is used to define the base of water-bearing units of the Basin (USGS, 2013a).

The Morales is massively bedded and ranges from 1,000 to 5,000 feet in thickness east of the Russell fault and up to 1,200 feet thick west of the Russell fault (USGS, 2013a; Cleath-Harris, 2018). Thickness of the Morales Formation is disputed amongst published references. In 1970, Singer and Swarzenski reported the Morales Formation to be up to 10,000 feet in thickness along the northern margin of the Valley (Singer and Swarzenski, 1970). The Morales Formation is found throughout the Valley and is widely exposed to the east of the Cuyama River near Ventucopa and the Cuyama Badlands. Its lateral extent is generally limited by faults. The Morales Formation is overlain unconformably by the older and Younger Alluvium (Hill, 1958).

Upper Morales

The upper member of the Morales is composed of partly consolidated, poorly sorted deposits of gravelly arkosic sand, pebbles, cobbles, siltstone, and clay of Pleistocene age (Davis et al., 1988). The upper Morales is a water-bearing unit and the base of this member marks the base of aquifer materials in the Basin. The upper Morales is thickest to the east near the Cuyama Badlands, approximately 2,200 feet, and shallows to the west, less than 800 feet west of the Russell fault (Hill, 1958; Cleath-Harris, 2018). In the central portion of the Basin, south of the Cuyama River, the upper Morales is around 1,500 feet thick (Ellis, 1994). In some areas, such as near Ballinger Canyon, the Morales shows some degree of angular unconformity (Ellis, 1994).

Stratigraphic Units Below the Basin Aquifer

Lower Morales

The lower member of the Morales consists of clay, shale, and limestone with lacustrine clay beds with distinct coarse-grained intervals, boulder trains, and gravelly channel deposits (USGS, 2013a). The lower member of the Morales finer grained than the upper Morales and is less permeable. The lower Morales is not considered a water bearing unit. South of the Cuyama River, the lower part of the Morales consists of about 1,300 feet of gray, gypsiferous, lacustrine claystones (Hill, 1958). The lower Morales lies conformably on the Quatal Formation and, in western areas of the Basin, unconformably on other marine units (Ellis, 1994).

Quatal Formation

The Quatal Formation is a sequence of fluvial and lacustrine claystone, siltstone, and sandstone which unconformably underlies the Morales Formation. Near the Cuyama Badlands, the formation is up to 820 feet of gypsiferous claystone while in other areas the unit is nonmarine sandstones interbedded with the claystone (USGS, 2013a). The Quatal Formation thins to the west and pinches out to zero in thickness near the town of Cuyama. In the eastern and central parts of the Basin, the Quatal Formation is a distinct stratigraphic marker that defines the bottom of the Morales Formation (USGS, 2013a). The Quatal Formation is not a water bearing unit and is not considered a part of the Basin groundwater system.

Caliente Formation

The Caliente Formation is composed of nonmarine sandstones, claystones, and conglomerates of Miocene age (Davis et al., 1988). Layers of volcanic ash and basalt sills and dikes are commonly found in the formation and tertiary basalt is found interbedded with the formation in the Caliente Range (Davis, 1988; Dudek, 2016). The formation is exposed on the eastern half the Valley, along the Basin edge in the Caliente Ranges and in a footwall block of the Pine Mountain fault (Kellogg et al., 2008). The fluvial Caliente Formation was deposited in the east at the same time the marine Branch Canyon Sandstone and Santa Margarita Formation were being deposited to the west (Ellis, 1994). The Caliente Formation conformably overlies and interfingers with the marine sedimentary rocks of the Santa Margarita Formation and pinches out to zero thickness to the west (Kellogg et al., 2008; Davis et al., 1988).

Santa Margarita Formation

The Santa Margarita Formation is composed of shallow-marine, consolidated sandstones from the middle to late Miocene (USGS, 2013b). The formation contains a gypsum member and a sandstone-mudstone member. The gypsum member consists of a greenish-gray, medium to thin bedded gypsum, up to 82 feet thick (Kellogg et al., 2008). The sandstone and mudstone member consists of interbedded layers of arkosic sandstone, mudstone, and siltstone, up to 400 feet thick (Kellogg et al., 2008). The sandstone sequence is rich in shallow marine molluscan fossils. The formation unconformably underlies the Morales Formation in the northwest of the Valley and grades into the Caliente Formation to the east (Hill, 1958). Locally, the formation contains layers of volcanic ash, basalt sills, dikes and flow units (Davis et al., 1988). The Santa Margarita Formation is the youngest marine unit in the Basin and marks the final phase of marine sedimentation and sea transgression (Lagoe, 1981).

Monterey Formation

The Monterey Formation consists of intervals of dolomitic marine shale, mudstone, and siltstone. The formation is subdivided into two members: the upper Whiterock Bluff Shale member and the lower Saltos Shale member (Davis et al., 1988). The Whiterock Bluff Shale is a calcareous in the lower two-thirds and becomes gradually siliceous in the upper one-third and is found up to 1,200 feet in thickness (Bazeley, 1988; Hill, 1958). The Saltos Shale member is a calcareous shale with turbiditic sandstones and was deposited at the same time as the fluvial Caliente Formation, but in the western, bathyal portion of the Basin (Davis et al., 1988; USGS, 2013b). The Saltos Shale member is found up to 2,250 feet thick (Hill, 1958). The formation is middle Miocene in age and is cut with layers of volcanic ash and Miocene-age basalt sills (Davis et al., 1988). In the Caliente Mountain Range, tertiary basalt is found interbedded with the Monterey Formation (Davis et al., 1988). To the east, the Monterey Formation grades into the Branch Canyon Sandstone. The formation is conformably overlain by the Santa Margarita Formation.

Branch Canyon Sandstone

The Branch Canyon Sandstone is Middle Miocene in age and is a shallow marine sandstone (Davis et al., 1988). Like the Monterey and Santa Margarita formations, the Branch Canyon Sandstone contains layers of volcanic ash and is cut by basalt sills and dikes (Davis et al., 1988). The sandstone grades into the Caliente Formation to the east and is up to 2,500 feet thick (Kellogg et al., 2008). The easternmost extent of the Branch Canyon Sandstone represents an early Miocene wave-dominated shoreline and is defined by the gradational change into the nonmarine Caliente Formation to the east (Davis et al., 1988; Bazeley, 1988).

Vaqueros Formation

Most of the oil produced in the Basin comes from the Vaqueros Formation. The formation is late Oligocene to early Miocene in age and is a marine clastic unit that is subdivided into three members: the upper, shallow-marine Painted Rock Sandstone member, the middle, bathyal Soda Lake Shale member, and the lower, shallow-marine Quail Canyon Sandstone member (Davis et al., 1988). The Vaqueros Formation represents a shallow-marine, high-energy, shoreface environment where the lower half represents a transgressive environment and the upper half represents a regressive environment (Bazeley, 1988). To the east, the Vaqueros Formation grades into the lower part of the nonmarine Caliente Formation. In the Cuyama Badlands, the Vaqueros Formation rests on the Simmler Formation and crystalline basement rocks, while in the central portion of the Basin, the Vaqueros Formation rests on Paleogene sedimentary rocks (Ellis, 1994). The Branch Canyon Sandstone and Monterey Formation are conformably above the Vaqueros Formation (Davis et al., 1988).

Simmler Formation

The Simmler Formation is a terrestrial sandstone, siltstone, and conglomerate of the Oligocene epoch (Davis et al., 1988). The Simmler Formation contains a shale member containing intervals of claystones and siltstones interbedded with coarse sandstones and a sandstone member containing sandstones interbedded with siltstones and claystones (Kellogg et al., 2008). The formation is as thick as 2,800 feet and overlies the Eocene-Oligocene unconformity (Kellogg et al., 2008). To the east, the Simmler Formation interfingers with a thin section of the marine Vaqueros Formation, marking the beginning of marine regression in the early to middle Miocene (Kellogg et al., 2008). Sediments of the Simmler Formation were sourced from the erosion of the Santa Barbara Canyon area and were deposited on a wide, delta plain (Bazeley, 1988). Though rare, the Simmler Formation can contain interbedded mafic volcanics (Yeats et al., 1989).

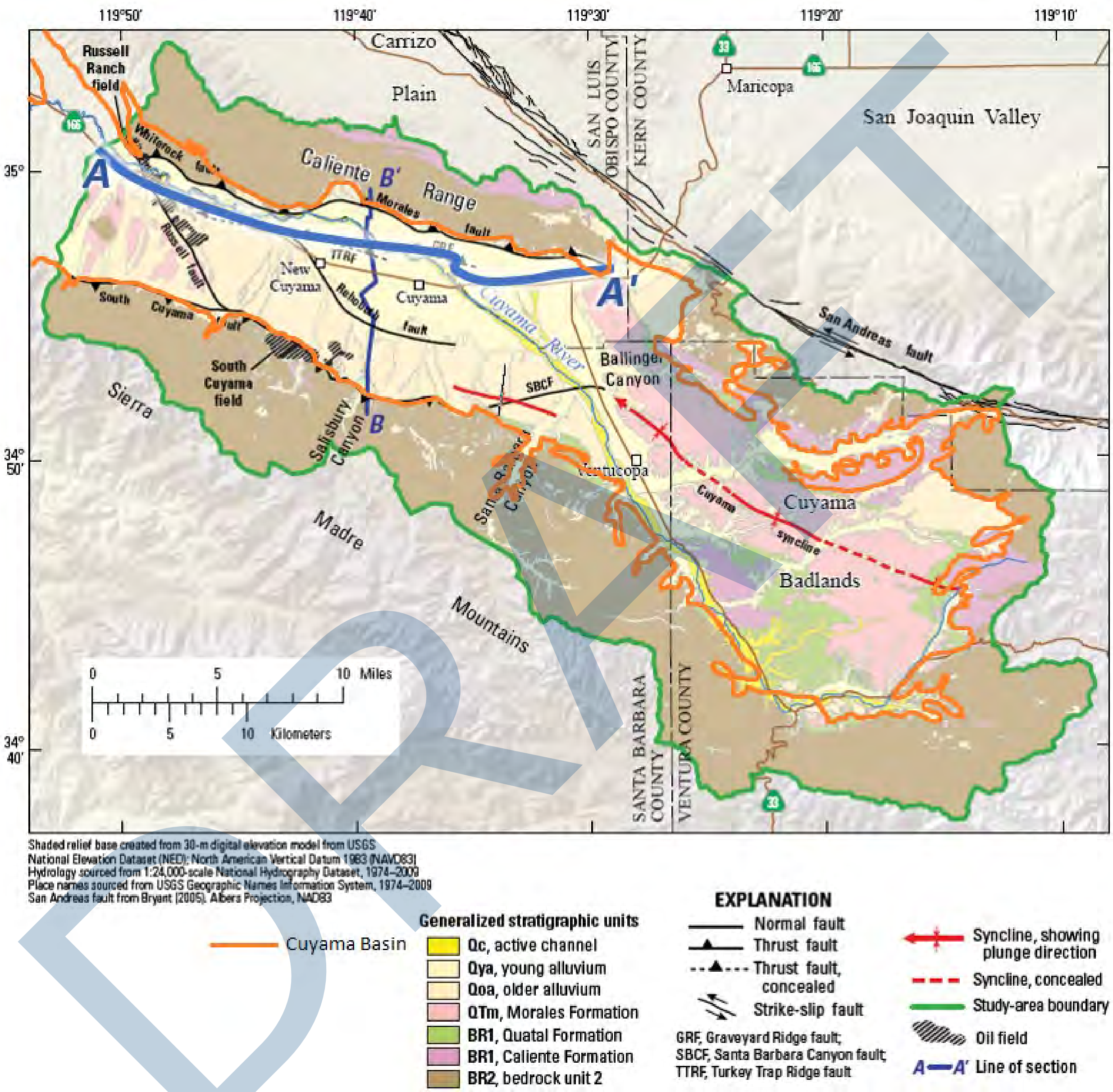
Marine Sedimentary Rocks

Late Cretaceous to Eocene marine rocks are unnamed but are part of the crystalline basement of the Cuyama Valley (Davis et al., 1988). The strata are unconformably overlain by a thick section of middle and upper Cenozoic rocks and are primarily exposed in the La Panza and Sierra Madres ranges and the hanging walls of the South Cuyama, La Panza, and Ozena faults (Davis et al., 1988).

Formations Older Than Marine Sedimentary Rocks

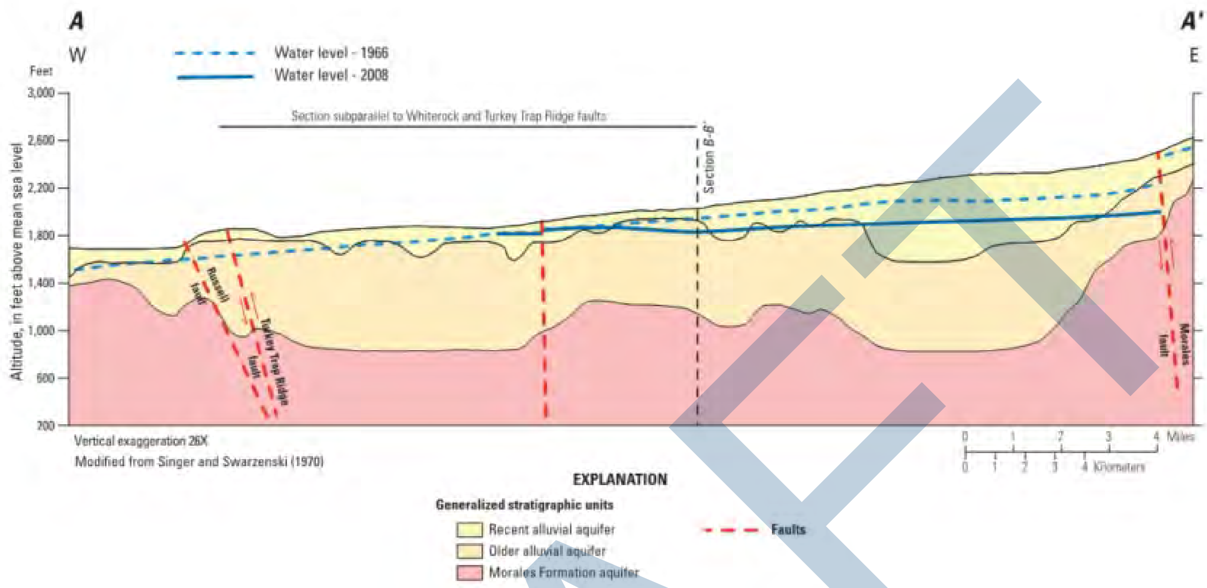
The crystalline rocks of the Cuyama Valley are composed of Mesozoic age granitic rocks and Precambrian age gneissic rocks (Davis et al., 1988). Cretaceous granitic rocks are exposed in the La Panza Range and near the San Andreas Fault, 12 to 18 miles southeast of the Cuyama Valley (USGS, 2013b). Precambrian granitic gneissic rocks outcrop east of the Cuyama Badlands and the La Panza Range (USGS, 2013b). Total thickness is unknown.

Figure 2-5 shows the locations of cross sections across the central portion of the Basin prepared by USGS in 2013. Figure 2-5 shows a west-east cross section that runs near the towns of New Cuyama and Cuyama labeled A-A’, and a south-north cross section labeled B-B’. Figure 2-6 shows the A-A’ cross section and Figure 2-7 shows the B-B’ cross section. Cross-section A-A’ shows the layering of Recent and Old alluvial aquifers and the Morales Formation aquifer. It also shows where the Russell Fault and Turkey Trap Ridge Fault cross the cross section, and shows groundwater elevation. Figure 2-7 shows cross section B-B’, which shows layering of the aquifers and the locations where the Rehoboth and Graveyard Ridge fault cross the cross section.



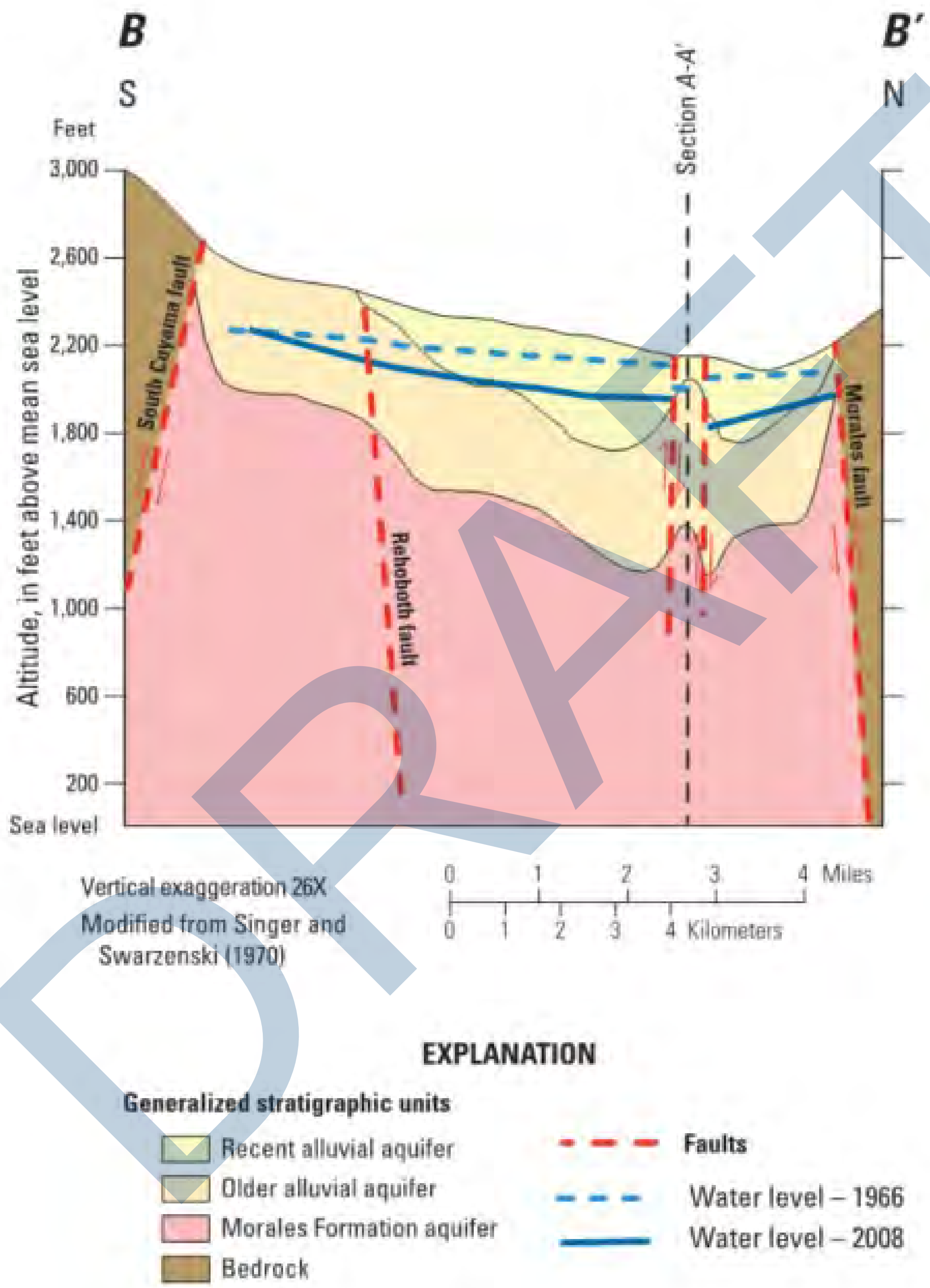
Source: USGS, 2015.

Figure 2-5: Location of USGS 2015 Cross Sections



Source: USGS, 2015

Figure 2-6: USGS Cross Section A-A'



Source: USGS, 2015

Figure 2-7: USGS Cross Section B-B'

2.1.5 Faults and Structural Features

The Basin is bounded by faults and contains a number of tectonic features including synclines, faults, and outcrops of basement rocks in the Basin. Major faults and synclines are shown in

Figure 2-8. Outcrops of basement rocks are shown on the geologic maps (Figure 2-2 and Figure 2-5).

Synclines

There are a number of synclines in the Basin; they are generally oriented to the northwest/southeast consistent with how the majority of the Basin is oriented.

Cuyama Syncline

The Cuyama Syncline is located in the southeastern portion of the Basin. It stretches from the Ballinger Canyon south into the Cuyama Badlands, ending along the Cuyama River. The Cuyama Syncline plunges from the Ventucopa area northwestward to beneath the valley from the Ventucopa area to the southeast. The syncline is known from subsurface data from oil exploration wells beneath the valley and exposed near the town of Ventucopa and in the Cuyama Badlands. (USGS, 2013a). The axis of the syncline strikes roughly parallel to the San Andreas Fault (N50ºW) and plunges to the northwest (13ºNW) (Singer and Swarzenski, 1970; Ellis, 1994). The Cuyama syncline was a depocenter (a site of sediment accumulation) during the deposition of the Morales Formation (Ellis, 1994). The syncline has folded water and non-water bearing formations and is favorable to the transmission of water from the southeast end of the valley but otherwise has no pronounced effect on the occurrence of groundwater (Upson and Worts, 1951).

Syncline Near the Santa Barbara Canyon Fault

Near the Santa Barbara Canyon Fault, A syncline is indicated by the USGS. The syncline runs generally east-west and is roughly 5 miles long. It ends near the southern edge of the South Cuyama fault (USGS, 2013a).

Syncline in the Northwestern Portion of the Basin

There is a syncline in the western portion of the Basin that roughly follows a west-northwest direction near the southern border of the Basin, located southwest of the Russel fault, near an outcrop of the Santa Margarita formation (Cleath-Harris, 2018). The full extent of this syncline, and its length are not documented at this time, but likely extends 5 to 10 miles, which is the length of documented faults in the area, as mapped by Dibblee. (Dibblee, 2005)

Major Faults

There are a number of faults within the Basin, many of which take the form of ‘fault zones’ where there are multiple individual faults close together oriented in the same direction. This section describes each major fault individually, with consideration that there are often additional small faults near each major fault. Major faults are shown in Figure 2-8.

Russell Fault

The Russell fault is a subsurface, right lateral, strike-slip fault that is 7 miles long and runs roughly parallel to the Russell Ranch oil field through the western portion of the Basin.

The Russell fault offsets the top of bedrock by as much as 1,500 feet (Nevins, 1982), and has had approximately 18 miles of right-lateral offset documented on the NW-striking Russell fault in the northwestern part of the Cuyama Valley have occurred between 23 and 4 Ma (USGS, 2013a; Ellis, 1994). The fault is referred to as strike-slip by several authors, and normal fault by others, and is sometimes referred to as both strike slip and normal within the same document (USGS, 2013a). Water bearing units on the western (upthrown) side of the Russell fault become thinner to the west of the Russell Fault and become thicker to the east of the Russel Fault due to this uplift. Alluvium is generally limited to stream channels and the Cuyama River bed on the western side of the fault.

The Russell fault has been analyzed by a number of authors who have come to differing conclusions regarding the fault's potential to be a barrier to groundwater flow. In 1989, Yeats stated that "the base of the Morales Formation is not cut by the fault" (Yeats et al., 1989). Using tectonic activity and decreasing offset of younger beds, Yeats concluded that the Vaqueros Formation is primarily impacted as it was deposited during the fault's most active period and that by the time the Morales Formation was deposited 19 million years later, activity on the fault had ceased (Yeats et al., 1989). The USGS in 2008 initially concluded that the fault was not a barrier to flow (USGS, 2013c). The USGS in 2013 studied the fault using interferometric synthetic-aperture radar (InSAR) data and concluded that "the Russell fault did not appear to be acting as a barrier to groundwater flow" (USGS, 2013c). In 2015 the USGS identified the Russell fault as a barrier to flow and used it as a no flow boundary in the Cuyama Valley Hydrologic Model (CUVHM) (USGS, 2015). Based on the conclusions of the USGS, Dudek stated that the fault has indicators that it obstructs groundwater flow due to truncation of older geologic formations and standing moisture near the fault and prepared a basin boundary modification request based on the conclusion that the fault is a barrier to flow (Dudek, 2016). In addition, Cleath-Harris determined that the fault is a barrier to flow and prepared a technical memorandum to document their study of the fault's behavior (Cleath-Harris, 2018). In 2016, DWR denied a request for a basin boundary modification motivated by claims that the Russell Fault is a barrier to groundwater flow and divides groundwater in the central portion of the Basin from groundwater in the west. DWR rejected the Basin boundary modification request, citing a lack of hydrogeologic data that supported evidence of barrier. EKI Environment & Water, Inc. (EKI) reviewed the USGS's work in 2017 and concluded the fault potential to be a barrier is not understood and recommended additional study to refine the fault's properties (EKI, 2017).

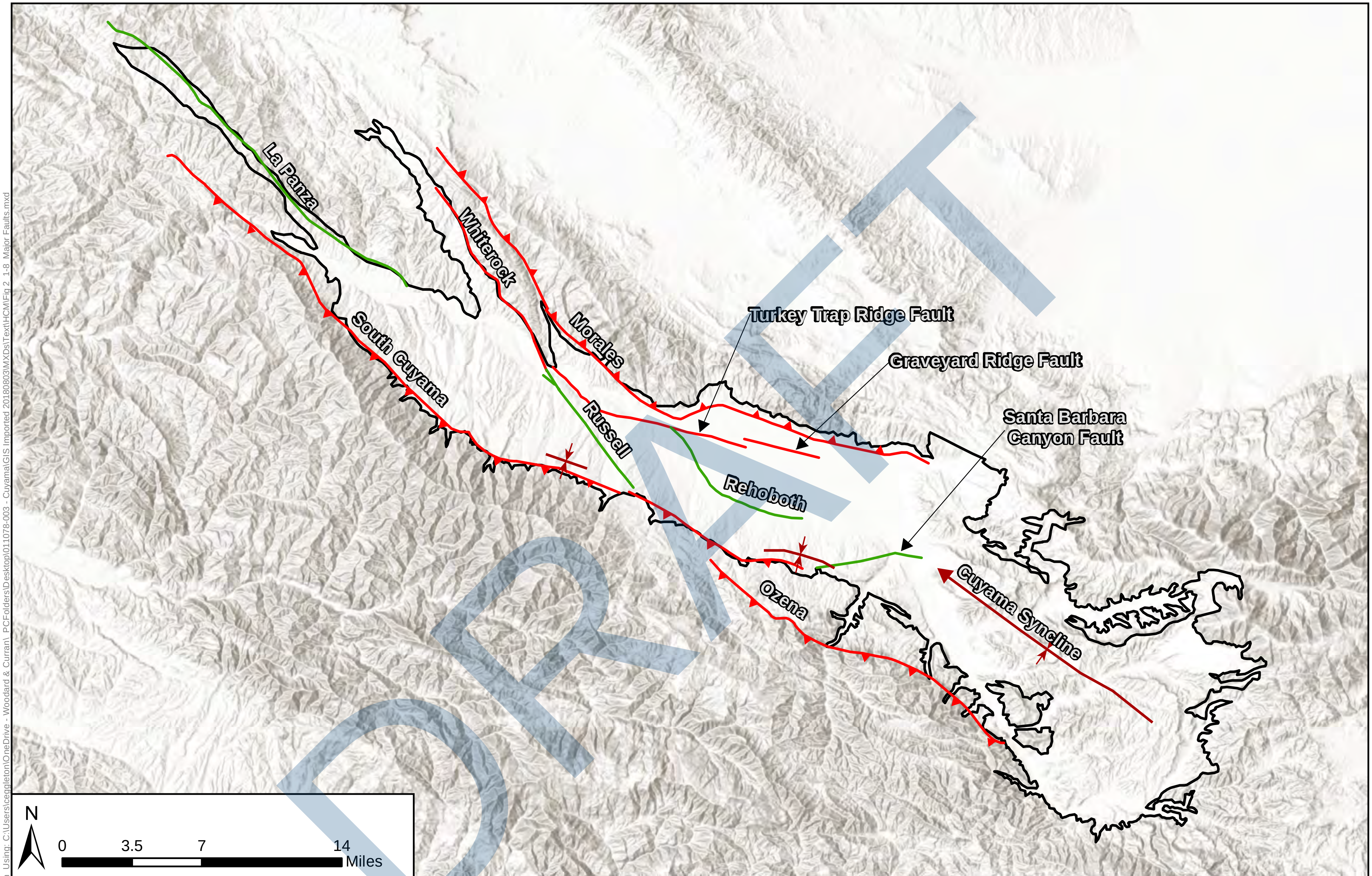


Figure 2-8: Major Faults

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Legend

Fault Types

- Normal
- Syncline
- Thrust
- Thrust Fault, Concealed

Cuyama Basin

Rehoboth Fault

The Rehoboth fault is a normal, subsurface fault that bisects the central portion of the Basin. The fault is approximately 8 miles long and trends to the southeast. The USGS concluded that evidence of the fault is inferred based on water level-changes in the west-central part of the valley and offset of the Morales Formation (USGS, 2013b; USGS, 2013a). The top of the Morales Formation is offset 160 feet on the northeast side of the fault and the offset increases with depth (USGS, 2013a). Surface exposures of the Older Alluvium do not appear to be offset along the trace of the fault, indicating the motion of the Rehoboth fault ceased prior to the deposition of the older and Younger Alluvium (USGS, 2013a).

Despite stating that the Rehoboth fault does not "have a discernible effect on the elevation" of the Older Alluvium and Younger Alluvium and that the fault was "not a significant barrier to groundwater flow" as symmetrical subsidence and uplift was observed on both sides of the fault, the USGS included the Rehoboth fault as a leaky, horizontal barrier to groundwater flow in the CUVHM (USGS, 2013a; USGS, 2013b; USGS, 2015). In the CUVHM, the Rehoboth fault impedes underflow in the Older Alluvium and Morales Formation along the Sierra Madre Foothills region (USGS, 2015). The USGS also listed the Rehoboth fault as affecting the younger and Older Alluviums and the Morales Formation in a summary table of "Geologic Units affected by Cuyama Valley faults" (USGS, 2013a).

Whiterock Fault

The Whiterock fault is a surface and subsurface thrust fault that runs along the northern finger of the Cuyama Basin. The fault can be traced further south under the Basin near the Cuyama River and State Route (SR) 166, though it is subsurface (Calhoun, 1985). The fault dips northeast and is late Oligocene to early Miocene in age (Davis et al., 1988). The Whiterock fault is exposed at the surface where it thrusts the Monterey Formation over the Morales Formation (Davis et al., 1988). Activity along the fault began after movement ceased on the Russell fault and tectonically overrides the Russell fault (Nevins, 1982; Calhoun, 1985). The fault cuts the Morales Formation south of the Cuyama River but does not affect the younger or Older Alluviums (DeLong et al., 2011; Nevins, 1982).

Turkey Trap Ridge Fault and Graveyard Ridge Fault

The Turkey Trap Ridge fault and the Graveyard Ridge fault are normal, subsurface faults that trend slightly north of west in the center of the Cuyama Valley (USGS, 2013a). The primary difference between the two faults is that the Turkey Trap Ridge fault is 11 miles long and located southwest of the Graveyard Ridge fault; the Graveyard Ridge fault is 4 miles long. Both faults are located north of SR 166 and are oriented in a "left-stepping, echelon pattern" (USGS, 2013a). Seismic reflection profiles collected along the ridges indicate they are bounded by north-dipping, south-directed, reverse faults along the south sides (USGS, 2013a). Both faults are considered to be barriers to groundwater. Evidence of the faults and their no-flow zones include springs and seeps along the base of the faults in the 1940-50s and water-level changes across the faults of 80 to 100 feet in the area near these ridges (Upson and Worts, 1951; Singer and Swarzenski, 1970).

In 1970, Singer and Swarzenski reported that water removed by pumping from this region was slow to replenish because faults restrict movement of water from neighboring areas. The impediment to flow could be related to the hydraulic properties of the faults themselves or fault juxtaposition of older, slightly less permeable Older Alluvium to the north against Younger Alluvium to the south of the faults (USGS, 2013a).

South Cuyama Fault

The South Cuyama fault is a surficial, thrust fault that defines a 39-mile stretch of the Basin's southwestern boundary. The fault thrusts the Eocene-Cretaceous aged marine sediments against the Older Alluvium and Morales Formation and impedes groundwater flow across the fault zone.

Ozena Fault

The Ozena fault is a 17-mile long surficial, thrust fault located 3 miles south of the Cuyama Basin and locally cuts through the southeastern canyons of the Basin. Less than 1 mile of the Ozena fault is within the Cuyama Basin boundary. The fault trends west to northwest and runs parallel to the Basin boundary.

Santa Barbara Canyon Fault

The Santa Barbara Canyon fault is a normal, subsurface fault that runs 5 miles perpendicular to the Santa Barbara Canyon. The fault is east-west striking and offsets basin deposits with impermeable Eocene-Cretaceous marine rocks (typically the Simmler and Vaqueros Formations) (Bazeley, 1988). Evidence of the fault comes from reported seasonal springs, a steep hydraulic gradient in the southeastern part of the Cuyama Valley near the fault, and the truncation of distinct gravel beds (Singer and Swarzenski, 1970). Water levels in the Ventucopa area have been reported 98 feet higher than water levels to the north (Singer and Swarzenski, 1970). The fault is considered a barrier to groundwater flow as it prevents groundwater flow from moving across the boundary bounded by the marine rocks (USGS, 2015). The USGS in 2013 also concluded that the Santa Barbara Canyon fault was a barrier to groundwater flow: "Relatively small amount of vertical offset in the Santa Barbara Canyon fault indicates changes in water levels across the fault documented in previous studies are perhaps the result of distinct fault-zone properties rather than juxtaposition of units of differing water-transmitting ability" (USGS, 2013a).

La Panza Fault

The La Panza fault is a surficial thrust fault that trends west to northwest along 22 miles of the western margin of the Basin (USGS, 2013b). The present day thrust fault is a reactivated Oligocene extensional fault that was once part of the same system with the Ozena fault (USGS, 2013b; Yeats et al., 1989). The fault defines the west-central margin of the Basin as it juxtaposes older non-water bearing Eocene to Cretaceous marine rocks and the Simmler Formation against the younger, water bearing alluvium and Morales Formation, impeding groundwater flow across the fault.

Morales Fault

The Morales fault is a 30-mile-long thrust fault that forms the boundary along the north central portion of the Basin. The Morales thrust fault has a dip of approximately 30 degrees (Davis et al., 1988).

Unnamed Fault Near Outcrop of Santa Margarita Formation

A fault located southwest of the Russell fault runs southeast to northwest and is located next to an outcrop of the Santa Margarita formation inside the Basin (Dibblee, 2005). The fault runs parallel to the long side of the outcrop and bounds the syncline that is to the south of the outcrop. The fault's extent is not well documented, and its surficial exposure is roughly 5 miles long.

Outcrops of Bedrock Inside the Basin

There are a number of outcrops of non-aquifer material within the Basin. The outcrops occur primarily in the eastern upland portion of the Basin and the western portion, near and to the west of the Russell Fault. Outcrops of basement rock in the western portion of the Basin occur in a different manner than those in the eastern portion, outcrops in the eastern portion are likely depositional contacts with the Morales Formation that were missed during basin delineation by DWR.[1] Outcrops in the western portion are likely tied to tectonic activity and faulting.

Outcrops of basement rock in the eastern upland portion of the Basin are shown in Figure 2-2. The Quatal Formation, and the Caliente Formation are present within the Basin boundary near the edges of the Basin. The Quatal formation is exposed at the surface near the Cuyama River, and in the higher elevation portions of the Basin, and in a band near the Quatal Canyon. The Caliente Formation is exposed at the surface within the Basin in the northeast portion of the Basin, near and along the Quatal Canyon. Another outcrop of Caliente Formation is present near the Cuyama River, but that outcrop has been excluded from the Basin during the Basin's delineation by DWR and is visible in Figure 2-2.

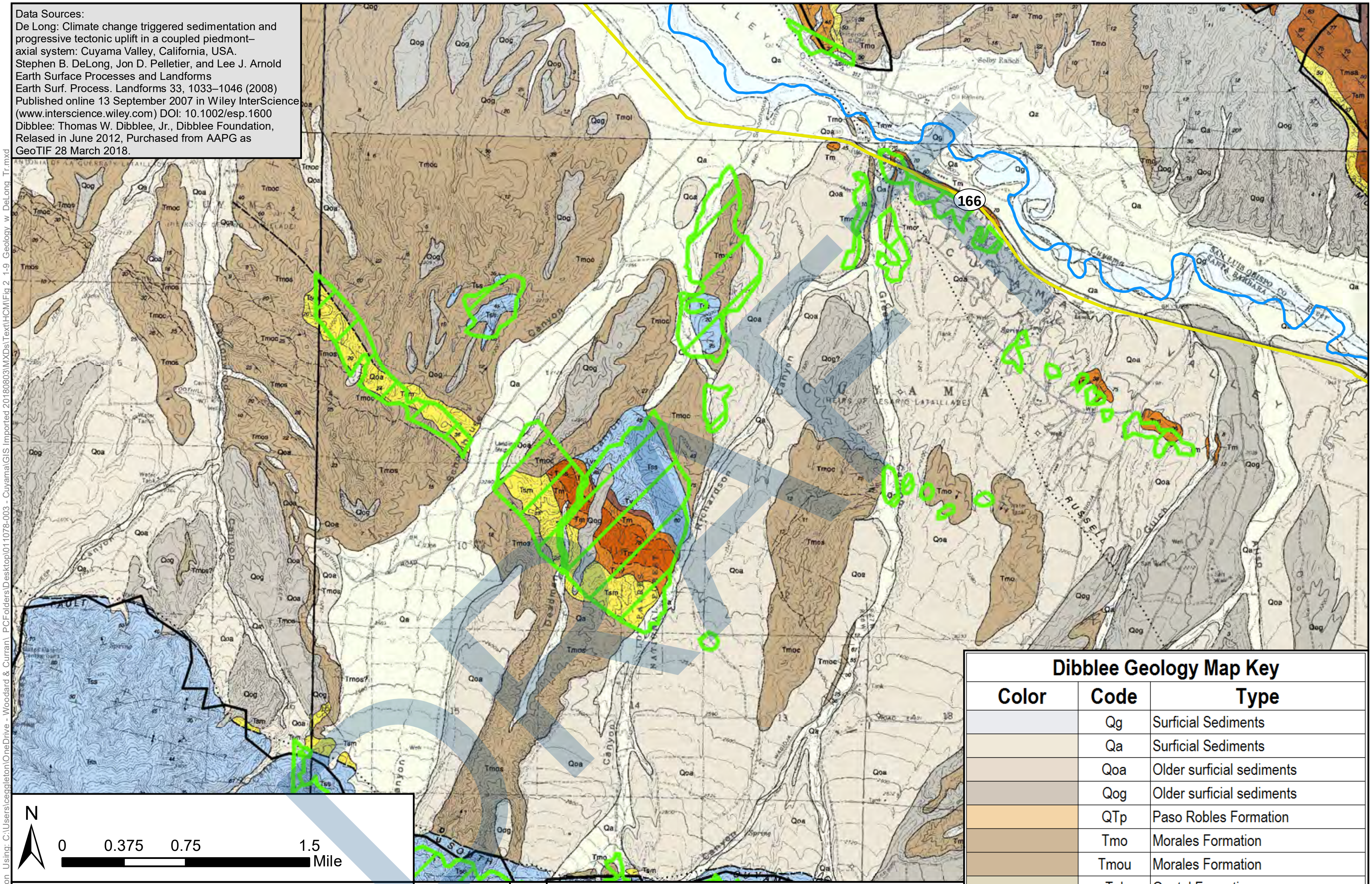
Outcrops of basement rock in the western portion of the Basin are exposed at the surface in limited areas and are tied to tectonic activity in the area.

shows the outcrops of bedrock near the Russell Fault with an overlay of areas identified by DeLong as "Tr," or out of basin bedrock, overlain on the geologic mapping performed by Dibblee. In general, the outcrops identified by DeLong and Dibblee largely overlap and indicate that in separate field study efforts, the outcrops were identified independently by different geologists. As shown in

[1] DWR delineates basins based on the type of restrictions to groundwater flow. The boundaries of the Cuyama Basin were delineated by DWR because they were the boundary between permeable sedimentary materials (within the Basin) and impermeable bedrock (outside the Basin). DWR defines this boundary as "Impermeable bedrock with lower water yielding capacity. These include consolidated rocks of continental and marine origin and crystalline/or metamorphic rock."

Figure 2-9, outcrops of non-aquifer materials are present near the Russell Fault, next to the Cuyama River, as well as to the south of the Cuyama River, both in small outcrops that are partially linear in nature, and larger outcrops that are located next to faults, such as where the Santa Margarita, Monterey and Marine Sedimentary Formations are present. The presence of these non-aquifer materials in this area likely restricts groundwater movement by limiting the extent of permeable materials in this portion of the Basin.

Data Sources:
De Long: Climate change triggered sedimentation and progressive tectonic uplift in a coupled piedmont–axial system: Cuyama Valley, California, USA.
Stephen B. DeLong, Jon D. Pelletier, and Lee J. Arnold
Earth Surface Processes and Landforms
Earth Surf. Process. Landforms 33, 1033–1046 (2008)
Published online 13 September 2007 in Wiley InterScience (www.interscience.wiley.com) DOI: 10.1002/esp.1600
Dibblee: Thomas W. Dibblee, Jr., Dibblee Foundation, Relased in June 2012, Purchased from AAPG as GeoTIF 28 March 2018.



Dibblee Geology Map Key		
Color	Code	Type
	Qg	Surficial Sediments
	Qa	Surficial Sediments
	Qoa	Older surficial sediments
	Qog	Older surficial sediments
	QTp	Paso Robles Formation
	Tmo	Morales Formation
	Tmou	Morales Formation
	Tql	Quatal Formation
	Tc	Caliente Formation
	Tsm	Santa Margarita Formation
	Tm	Monterey Formation
	Tvl	Vaqueros Formation
	Tvq	Vaqueros Formation
	Tss	Marine Sedimentary Rocks,

Figure 2-9: Geology with De Long "Tr" Overlay

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Legend

- Cuyama Basin
- De Long Geology "Tr" - Out of Basin Bedrock
- Highways
- Cuyama River

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2.1.6 Basin Boundaries

The Basin has multiple types of basin boundaries. The majority of the boundaries are in contact with impermeable bedrock and faults, and a small portion is bounded by a groundwater divide between this Basin and the Carrizo Plain groundwater basin.

Lateral Boundaries

The Cuyama Basin is geologically and topographically bounded; to the north by the Morales and Whiterock faults and the Caliente Range, to the west by the South Cuyama and Ozena faults and the Sierra Madre Range, to the east within the Los Padres National Forest and Caliente Range, and to the south by the surface outcrops of Pliocene and younger lithologies, which are surrounded by Miocene and older consolidated rocks (Dudek, 2016). The boundaries of the Cuyama Basin were delineated by DWR in Bulletin 118 because they were the boundary between permeable sedimentary materials and impermeable bedrock. DWR defines this type boundary as: "Impermeable bedrock with lower water yielding capacity. These include consolidated rocks of continental and marine origin and crystalline/or metamorphic rock" (DWR, 2003). The thrust faults bounding the Cuyama Basin juxtapose younger, water-bearing lithologies against older, impermeable rocks. The consolidated continental and marine rocks and shales of the bordering mountain ranges mark a transition from the permeable aquifer sediments to impermeable bedrock.

Boundaries with Neighboring Subbasins

The Cuyama Basin shares a boundary to the east with the Carrizo Plain Groundwater Basin (Carrizo Plain Basin) and the Mil Potrero Area Groundwater Basin, as shown in Figure 1-3. The Cuyama and Carrizo Plain basins share a 4-mile boundary along Caliente Ranges, which is a groundwater divide basin boundary. DWR defines this type of boundary as "A groundwater divide is generally considered a barrier to groundwater movement from one basin to another for practical purposes. Groundwater divides have noticeably divergent groundwater flow directions on either side of the divide with the water table sloping away from the divide" (DWR, 2003).

The Cuyama and Mil Potrero basins are share a less than 1 mile boundary along the San Emigdio Canyon. The division between the Cuyama and Mil Potrero basins is also a groundwater divide basin boundary.

Bottom of the Cuyama Basin

The bottom of the Basin is generally defined by the base of the upper member of the Morales Formation (USGS, 2015). The lower member of the Morales Formation is composed of clay, shale, and limestone and is less permeable than the upper member of the Morales Formation (USGS, 2013a). The USGS describes the Morales Formation (both the upper and lower member combined) as up to 5,000 feet thick (USGS, 2013a). The top of the Morales Formation is generally encountered 750 feet below ground surface (bgs) but ranges up to 1,750 feet bgs in the Sierra Madre Foothills (USGS, 2013a). When referring to the Morales Formation in the context of the Cuyama aquifer, this is a reference to only the upper member of the Morales Formation.

2.1.7 Principal Aquifers and Aquitards

There is one principal aquifer in the Basin composed of the Younger Alluvium, Older Alluvium, and the Morales Formation. DWR's *Groundwater Glossary* defines an aquifer as "a body of rock or sediment that is sufficiently porous and permeable to store, transmit, and yield significant or economic quantities of groundwater to wells and springs." Most of the water pumped in the valley is contained in the younger and Older Alluviums. These two units are indistinguishable in the subsurface and are considered, hydrologically, one unit. There are no major stratigraphic aquitards or barriers to groundwater movement, amongst the alluvium and the Morales Formation. The aquifer is considered to be continuous and unconfined with the exception of locally perched aquifers resulting from clays in the formations.

Aquifers

The aquifers making up the principal aquifer in the Cuyama Basin are Younger Alluvium, Older Alluvium, and the Upper Member of the Morales Formation. These units consist of unconsolidated to partly consolidated sand, gravel, silt, clay, and cobbles within alluvial fan and fluvial deposits and in total range from 3,000 to 4,000 feet in thickness (Upson and Worts, 1951). Rocks older than the upper Morales Formation are generally considered either non-water bearing or contain water, but the water is released too slowly or of quality that is too poor for domestic and irrigation uses (USGS, 2013a). Historically, most of the water pumped in the Cuyama Valley has been extracted from the Younger and Older alluvium.

Recent and Younger Alluvium

Historically, most of the water pumped in the Cuyama Basin was sourced from the saturated portions of the Younger and Older alluvium (Singer and Swarzenski, 1970). Groundwater is found in the permeable Holocene alluvial fill and in the underlying, less permeable, Pliocene-Pleistocene continental deposits. Younger Alluvium deposits thicken to the east, typically ranging from 5 to 50 feet in the west and thicken from 630 to 1,100 feet in the east (Singer and Swarzenski, 1970).

The Younger Alluvium varies compositionally across the Basin (Upson and Worts, 1951). The Recent and Younger alluvium is the primary source of groundwater on the western side of the Basin. In the west, Younger Alluvium consists of interbedded layers of sand and gravel and thick beds up clay (ranging from 1 to 36 feet thick) (Upson and Worts, 1951). Clay beds, found 100 to 150 feet bgs, define the base of the Younger Alluvium (Upson and Worts, 1951). Wells in the western part of the Basin that are screened in the Younger Alluvium are shallow but have moderately large yields, as the sands and gravels have high permeabilities (Singer and Swarzenski, 1970).

In the south-central part of the Basin, the alluvium contains more gravel and is less fine grained compared to western alluvium. The alluvium is predominantly sand and silt with some beds of gravel and clay, though no continuous layers of any material exist (Upson and Worts, 1951).

Older Alluvium

Older Alluvium consists of unconsolidated to partly consolidated sand, gravel, boulders, and some clay. Similar to the Younger Alluvium, clay content increases to the west (Upson and Worts, 1951). Like the Younger Alluvium, historically most of the water pumped in the Cuyama Basin was sourced from the saturated portions of the younger and Older Alluvium (Singer and Swarzenski, 1970). More wells are perforated in the Older Alluvium in the western portion of the Basin than to the east (USGS, 2013c). In most regions of the Basin, the top of the saturated zone (the water table) is either deep in the alluvium or below its base (Upson and Worts, 1951).

Upper Morales Formation

The Pliocene to Pleistocene-aged Morales Formation is divided into two members, the upper and lower. The upper member of the Morales Formation is composed of partly consolidated, poorly sorted deposits of gravelly arkosic sand, pebbles, cobbles, siltstone, and clay and is considered water bearing (USGS, 2013a). Water bearing properties of the Morales Formation are not well defined, but available data indicate that the hydraulic conductivity of the formation varies greatly laterally and with depth (USGS, 2013c). Permeabilities of the upper Morales Formation vary greatly laterally and with depth; the highest values occur in the syncline beneath the central part of the valley and decrease to the west (Singer and Swarzenski, 1970). In the east and southeastern parts of the valley where the Morales Formation crops out, the formation is coarse grained and moderately permeable, but land is topographically unsuited to agricultural development and few wells have been installed.

Aquifer Properties

The highest yielding wells are screened in the alluvium and located in the north-central portion of the Basin. Pumping in the alluvium also occurs in the eastern part of the Cuyama Valley, along the Cuyama River and its tributary canyon as far as a few miles upstream from Ozena (Singer and Swarzenski, 1970).

Hydraulic Conductivity

DWR defines hydraulic conductivity as the "measure of a rock or sediment's ability to transmit water" (DWR, 2003). The hydraulic conductivity is variable within the principal aquifer, varying laterally, vertically, and amongst the three aquifer formations. In general, conductivity is highest near the center of the Basin and decreases to the west and east with the highest values associated with the Younger Alluvium and the Morales Formation with the lowest. Conductivity data are widely available for the central portion of the Basin (near the towns of New Cuyama and Cuyama) and near the western vineyards; data are sparse elsewhere.

Available data from field tests (including pump and slug tests) were reviewed from the following sources:

- 3 multi-completion USGS wells (USGS, 2013c)
- 51 PG&E wells (USGS, 2013c)
- 66 private landowner wells in the central portion of the Basin
- 2 private landowner wells in the western portion of the Basin

Figure 2-10 shows the locations of these wells. Dates of field tests range from 1942 (PG&E tests) to 2018 (Grapevine Capital tests), and wells are screened in all three of the main aquifer formations, including the Younger Alluvium, Older Alluvium, and Morales Formation. Additional sources include the USGS's 2015 *Hydrologic Models and Analysis of Water Availability in Cuyama Valley, California,* which describes conductivity values used in the CUVHM, along with Singer and Swarzenski (1970) and a 2011 USGS study. The CUVHM characterizes the recent and Younger Alluvium as having the highest hydraulic conductivity of all aquifer units (USGS, 2015). Conductivity values calculated from field tests for the wells are used to characterize each aquifer formation, as described below and summarized in Table 2-1.

Recent and Younger Alluvium – As shown in Table 2-1, wells screened exclusively in the Younger Alluvium in the central portion of the Basin have hydraulic conductivities ranging from 1 to 31.9 feet per day and a median conductivity of 9.5 feet per day. Wells screened in both the younger and Older Alluvium in the central portion of the Basin had a higher median conductivity of 10.1 feet per day. Field tests are lower than those reported by the USGS in 2015 which reported hydraulic conductivity for the recent and Younger Alluvium ranged from 5.2 to 85 feet per day (USGS, 2015). Within the Recent and Younger Alluvium, the highest horizontal conductivity is near the Cuyama River. Vertical conductivity ranges from 0.2 feet per day in tributaries crossing the alluvium in areas west of the Russell fault up to 49 feet per day in the Cuyama River in the Ventucopa Uplands (USGS, 2015).

Older Alluvium – In the central portion of the Basin, hydraulic conductivity in the Older Alluvium ranges from 0 to 81.2 feet per day, with a median conductivity of 16 feet per day. Field tests are higher than those reported by the USGS in 2015, which reported conductivity for the Older Alluvium ranges from 0.3 to 28 feet per day in the central Basin (USGS, 2015; USGS, 2011). West of the Russell fault, conductivity ranges from 0.77 to 1.79 feet per day with a median value of 1.24 feet per day in areas west of the Russell Fault, near the vineyards. Conductivity generally decreases with depth. Field data show that while the range in hydraulic conductivity for wells screened in both the Older Alluvium and Morales Formation is lower than wells screened exclusively in the Older Alluvium (ranging from 0 to 61.2 feet per day), the median value is higher at 21.4 feet per day. The USGS calculated the median hydraulic conductivity for the Older Alluvium (15 feet per day) to be about five times the estimated value for the Morales Formation (i.e., 3.1 feet per day) (USGS, 2013c).

Morales Formation – The Morales Formation has the lowest hydraulic conductivity of all aquifer units. In the central portion of the Basin, conductivity for wells exclusively screened in the Morales Formation range from 1.6 to 9.9 feet per day, with a median value of 3.15 feet per day. Two wells were interpreted to be screened exclusively in the Morales Formation west of the Russell fault; hydraulic conductivity for these wells ranges from 1.6 – 1.98 feet per day. The hydraulic conductivity of the Morales Formation decreases with depth and the lower member of the formation (the clay and limestone unit) has a lower conductivity than the upper member (sandstone). The highest values in the Morales Formation occur in the central portion of the valley and decrease west (Singer and Swarzenski, 1970).

Table 2-1: Summary of Hydraulic Conductivities in Aquifer Formations

Well Owner	Number of Wells	Formation(s) Well is Screened In	Conductivity Range (feet/day)	Median Conductivity (feet/day)
USGS	6[a]	Older Alluvium	1.5 – 18.1	15
	6[a]	Upper Morales Formation	1.6 – 9.9	3.15
PG&E[b]	22	Younger Alluvium	1 - 30	9
	19	Younger and Older Alluvium	0.1 - 37	4.5
	8	Older Alluvium	0.1 – 17	4
	2	Older Alluvium and Upper Morales Formation	0.1 – 4	2
Private Landowners, Central Portion of the Basin[c]	2	Younger Alluvium	28.9 – 31.9	30.4
	19	Younger Alluvium and Older Alluvium	3.9 – 68.6	17.1
	6	Younger Alluvium and Upper Morales Formation	1 – 21.3	12
	16	Older Alluvium	3.2 – 81.2	17.15
	23	Older Alluvium and Upper Morales Formation	3.6 – 61.2	23
Private Landowners, Western Portion of the Basin[c]	4	Older Alluvium	0.77 – 1.79	1.47
	6	Older Alluvium and Upper Morales Formation	0.64 – 1.59	1.22
	2	Upper Morales Formation	1.6 – 1.98	1.79

Notes:
[a]Three wells with four completions each; each well completion is reported as a single well.
[b]Conductivity estimated using transmissivity field tests.
[c]Conductivity estimated using specific capacity field tests.

Specific Yield

DWR defines specific yield as the "amount of water that would drain freely from rocks or sediments due to gravity and describes the portion of groundwater that could actually be available for extraction" (DWR, 2003). Specific yield is a measurement specific to unconfined aquifers, such as the primary aquifer in the Cuyama Basin.[2] The dewatered alluvium has an average specific yield of 0.15 (Singer and Swarzenski, 1970). The USGS estimated the specific yields of the three aquifer formations during CUVHM calibration, calculating that the recent alluvium had the lowest specific yield ranging from 0.02 to 0.14, the Older Alluvium has a specific yield ranging from 0.05 to 0.19, and the Morales Formation has the highest specific yield ranging from 0.06 to 0.25 (USGS, 2015).

Specific Capacity

Specific capacity is defined as "the yield of the well, in gallons per minute, divided by the pumping drawdown, in feet" (Singer and Swarzenski, 1970). Specific capacity in the aquifer varies laterally and vertically but is typically highest in the Younger Alluvium and lowest in the Morales Formation. Wells perforated in the Younger Alluvium have a median specific capacity of 60 gallons per minute (gpm) per foot (USGS, 2013c). Wells perforated in both the Younger and Older alluvium have a median specific capacity of 40 gpm per foot (USGS, 2013c). Wells perforated in the Older Alluvium have a median specific capacity of 20 gpm per foot (USGS, 2013c). The silt and clay content of the Older Alluvium increases to the west and corresponds to a decrease in specific capacity in the alluvium; specific capacities are less on the western half of the valley compared to the eastern half. However, a greater percentage of wells in the western part are perforated in the Older Alluvium (USGS, 2013c). The specific capacity of the Morales Formation varies laterally but is generally less than the specific capacity of the younger and Older Alluvium. In the western part of the valley, the Morales Formation has a specific capacity ranging from 5 to 25 gpm per foot. In the north north-central portion of the Basin the specific capacity increases to 25 to 50 gpm per foot (Singer and Swarzenski, 1970).

Transmissivity

DWR defines transmissivity as the "aquifer's ability to transmit groundwater through its entire saturated thickness" (DWR, 2003). Using aquifer tests from 63 wells (shown in Figure 2-10), estimates of transmissivity ranged from 560 to 163,400 gallons per day per foot (gpd/foot) and decreased with depth (USGS, 2013c). Among the aquifer units, wells screened in the Younger Alluvium had the highest transmissivity, with a median value of 15,700 gpd/foot (USGS, 2013c). Wells screened in Older Alluvium had a transmissivity three times less than the Younger Alluvium wells, at a median value of 5,000 gpd/foot (USGS, 2013c). Wells screened in both the younger and alluvium had a median transmissivity of 11,300 gpd/foot (USGS, 2013c). Data from the 61 wells were not available for the Morales Formation, but a transmissivity estimate from two wells screened in both the Older Alluvium and Morales Formation averaged 4,900 gpd/foot (USGS, 2013c). Using groundwater level contours, Singer and Swarzenski determined the range of transmissivity values in the Morales Formation to change much

[2] For confined aquifers, the measurement of "storativity" is used instead of specific yield.

more than the transmissivity values of the younger and Older Alluvium; in general, values are highest in the central portion of the valley and decline to the west as the thicknesses of the younger and Older Alluvium become more shallow.

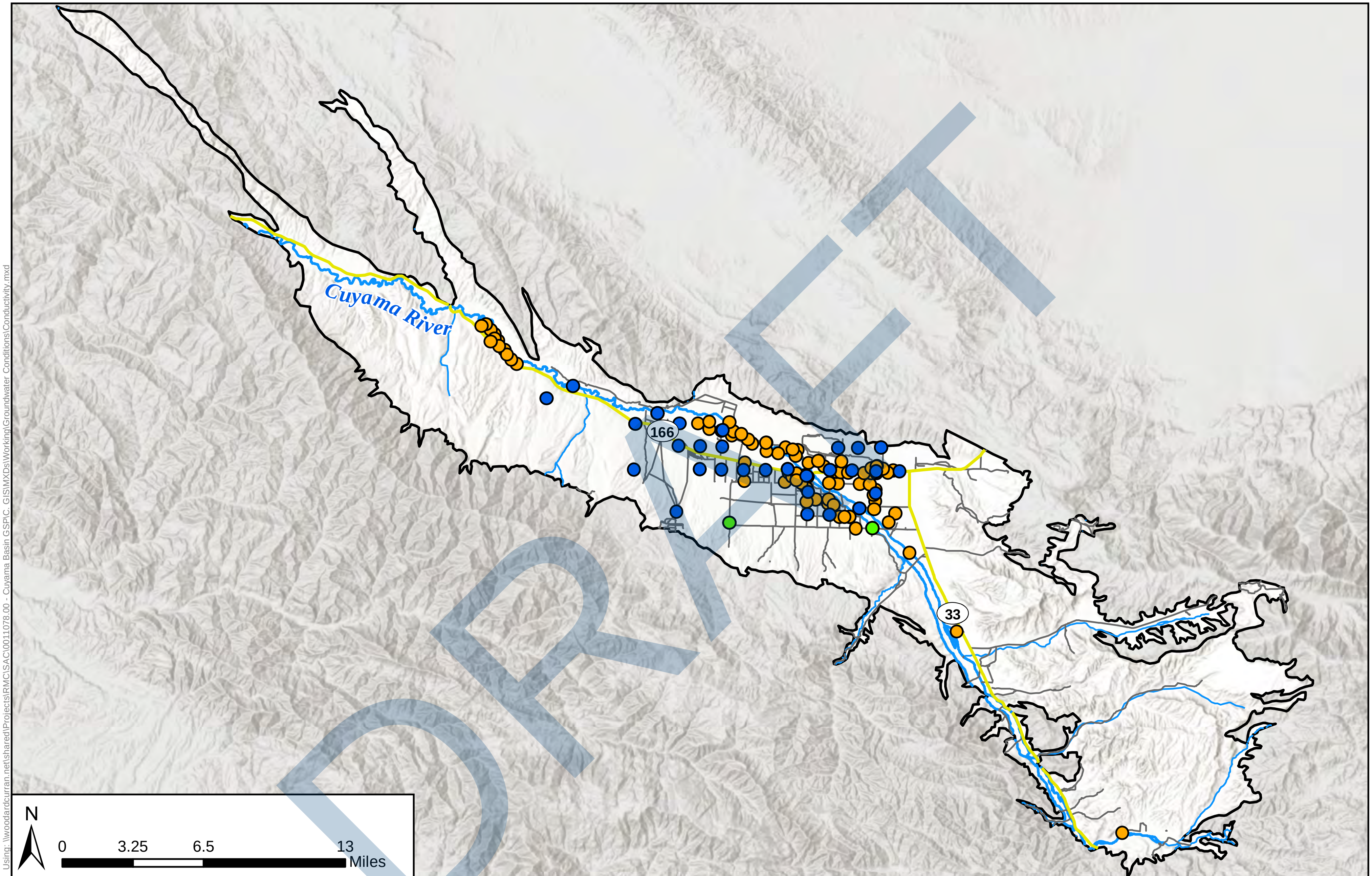

Figure 2-10: Location of Aquifer Testing Wells

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Legend

Highways
Local Roads
Cuyama River
Streams
Cuyama Basin

Well Owner

Private Landowners
PG&E
USGS

Figure Exported: 9/11/2018 By: ccongleton Using: \\woodardcurran.net\shared\Projects\RMC\SAC\0011078.00 - Cuyama Basin GSP\GIS\MXDs\Working\Groundwater Conditions\Conductivity.mxd

2.1.8 Natural Water Quality Characterization

Water quality in the Basin has historically had a high level of TDS and sulfates. High concentrations of other constituents, such as nitrate, arsenic, sodium, boron, and hexavalent chromium are localized (USGS, 2013c). Locations where water quality measurements were taken by the USGS are shown in Figure 2-11.

Singer and Swarzenski studied groundwater in the Basin in 1970. Groundwater ranged from hard to very hard and is predominantly of the calcium-magnesium-sulfate type (Singer and Swarzenski, 1970). Averages of concentrations include 30 milligrams per liter (mg/L) chloride, 0.20 mg/L of boron, and 1,500 to 1,800 mg/L TDS (Singer and Swarzenski, 1970). Along the periphery of the Basin, groundwater quality is variable. Along the southern boundary and near the eastern badlands, the groundwater quality reflects the recharge from springs and runoff from the Sierra Madre Mountains; TDS concentrations range from 400 to 700 mg/L and most of the water is sodium calcium bicarbonate (Singer and Swarzenski, 1970). Along the eastern edge of the valley, near the Caliente Range, water quality declines as concentrations of sodium, chloride, TDS, and boron increase. Concentrations of boron range up to 15 mg/L, concentrations of chloride increase up to 1,000 mg/L, and TDS concentrations range from 3,000 to 6,000 mg/L (Singer and Swarzenski, 1970).

Singer and Swarzenski in 1970 also concluded that the Basin's water quality potentially results from the mixing of water from the marine rocks: "This water quality presumably results from the mixing of water from the marine rocks of Miocene age with the more typical water from the alluvium and is characterized by increased sodium, chloride, and boron. Although chloride and boron concentrations commonly are less than 30 and 0.20 mg/L, respectively, in the central part of the valley, the water from many wells is close to the Caliente Range contains several hundred to nearly 1,000 mg/L of chloride and as much as 15 mg/L of boron." (Singer and Swarzenski, 1970). Singer and Swarzenski did not provide a map showing their sampling locations.

In 2011, the USGS published the *Kirschenmann Road Monitoring Well Site Open File Report* (USGS, 2011), which included analysis of major-ion composition for samples collected from the multiple-well monitoring site CVKR, and samples from selected water supply and irrigation wells in the Cuyama Valley. Figure 2-12 shows a Piper diagram of the major-ion analysis. Figure 2-12 shows that groundwater in the central portion of the Basin shares similar major-ions, and is largely chloride, fluoride, sulfate and calcium magnesium type water. Figure 2-13 shows the locations USGS sampled to perform this analysis.

In 2017 EKI compiled water quality data contained in the appendices of the USGS report *Geology, Water-Quality, Hydrology, and Geomechanics of the Cuyama Valley Groundwater Basin, California, 2008-12* (USGS 2013c). and prepared a Piper diagram with the data (Figure 2-14). The locations of the data used in this Piper diagram are shown in Figure 2-15. The Piper diagram shows the majority of samples indicate that water in the Basin can be characterized as calcium-magnesium sulfate waters, which agrees with conclusions made by USGS in 2013.

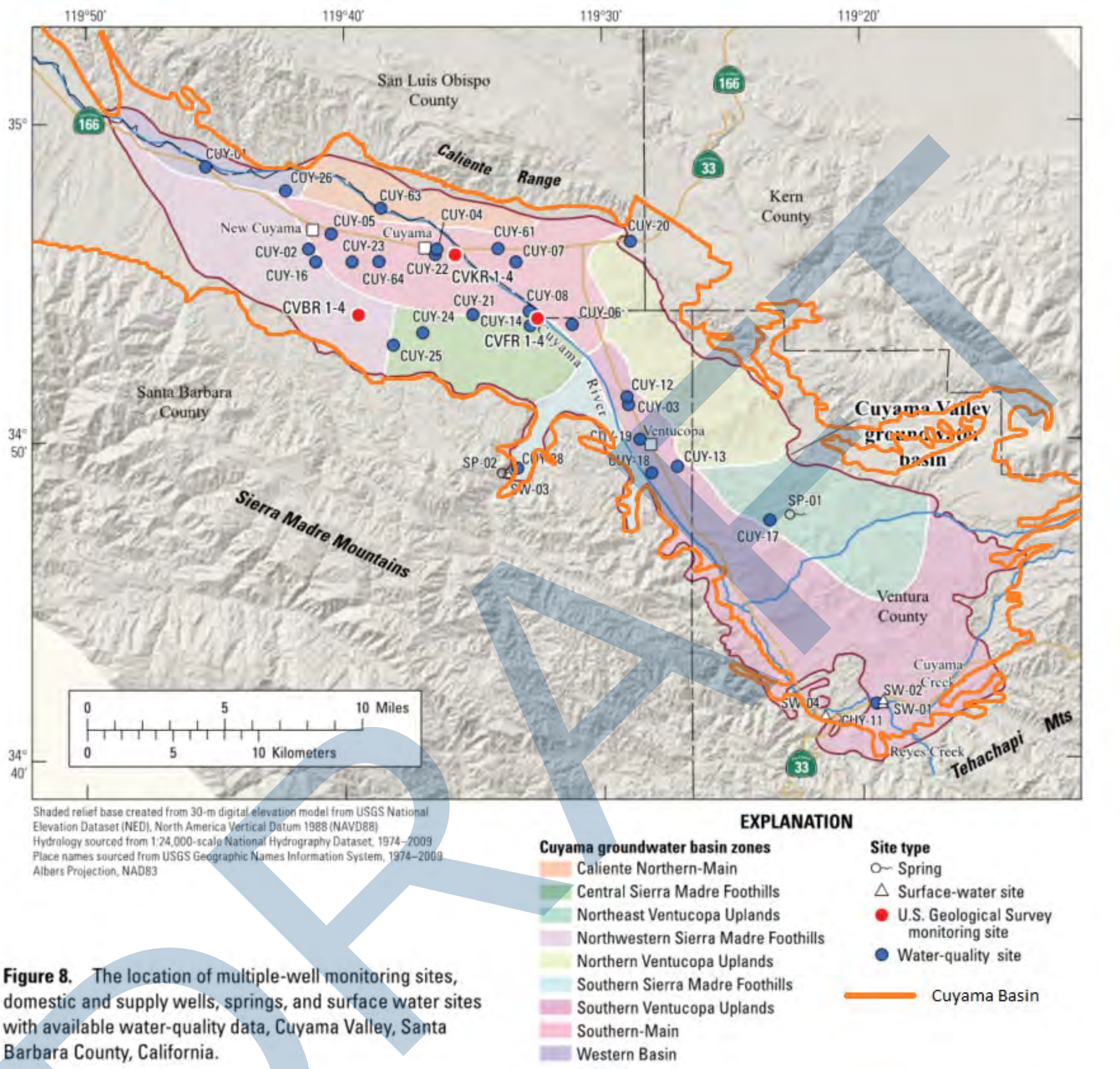

Figure 8. The location of multiple-well monitoring sites, domestic and supply wells, springs, and surface water sites with available water-quality data, Cuyama Valley, Santa Barbara County, California.

Source: USGS, 2013c.

Figure 2-11: Location of USGS 2013 Groundwater Quality Sampling Sites

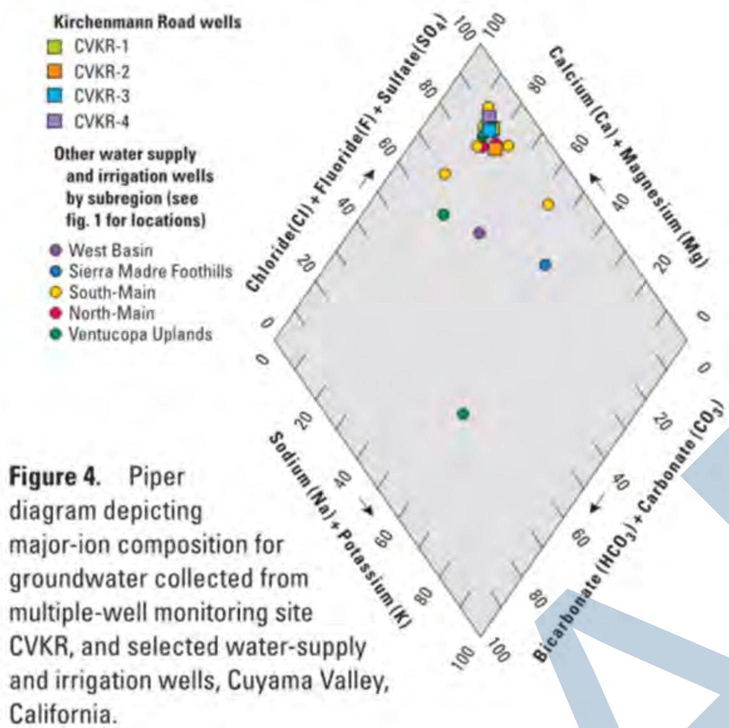

Figure 2-12: Piper Diagram for Well CVKR1-4

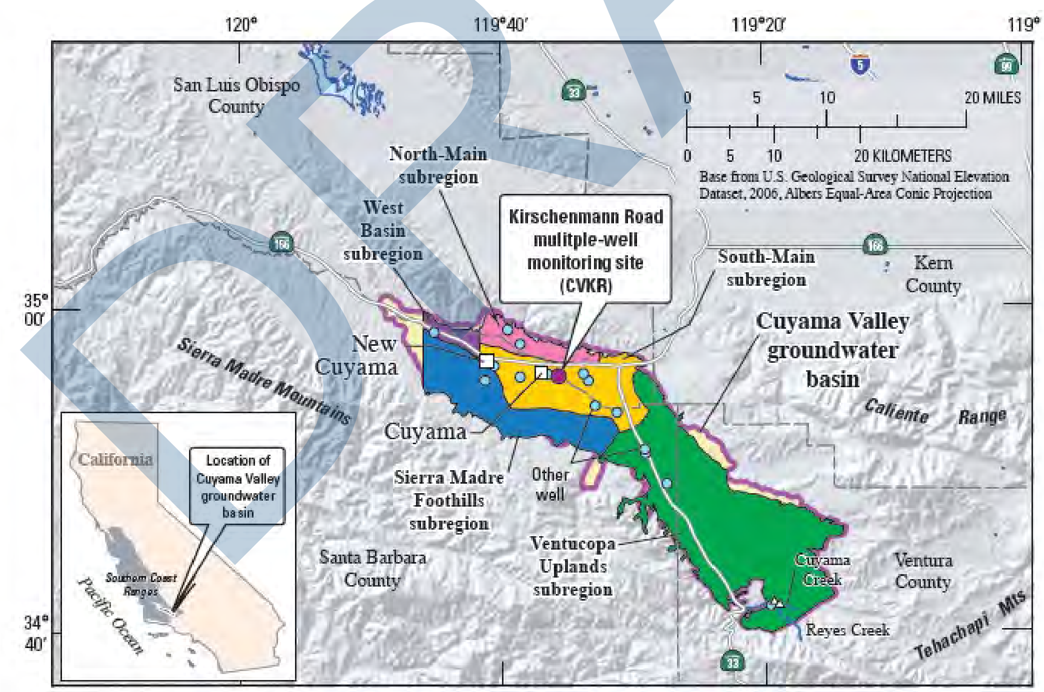

Figure 2-13: Location Map for Samples Used in Figure 2-12

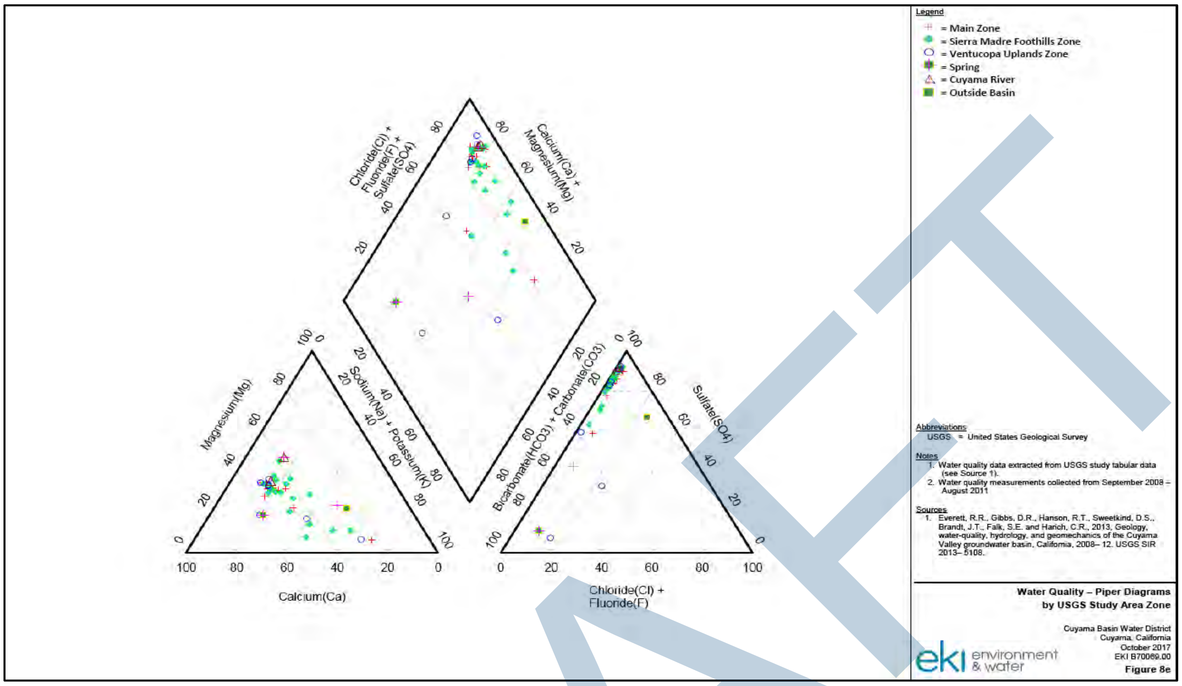

Figure 2-14: Piper Diagram of USGS 2013 Water Quality Sampling

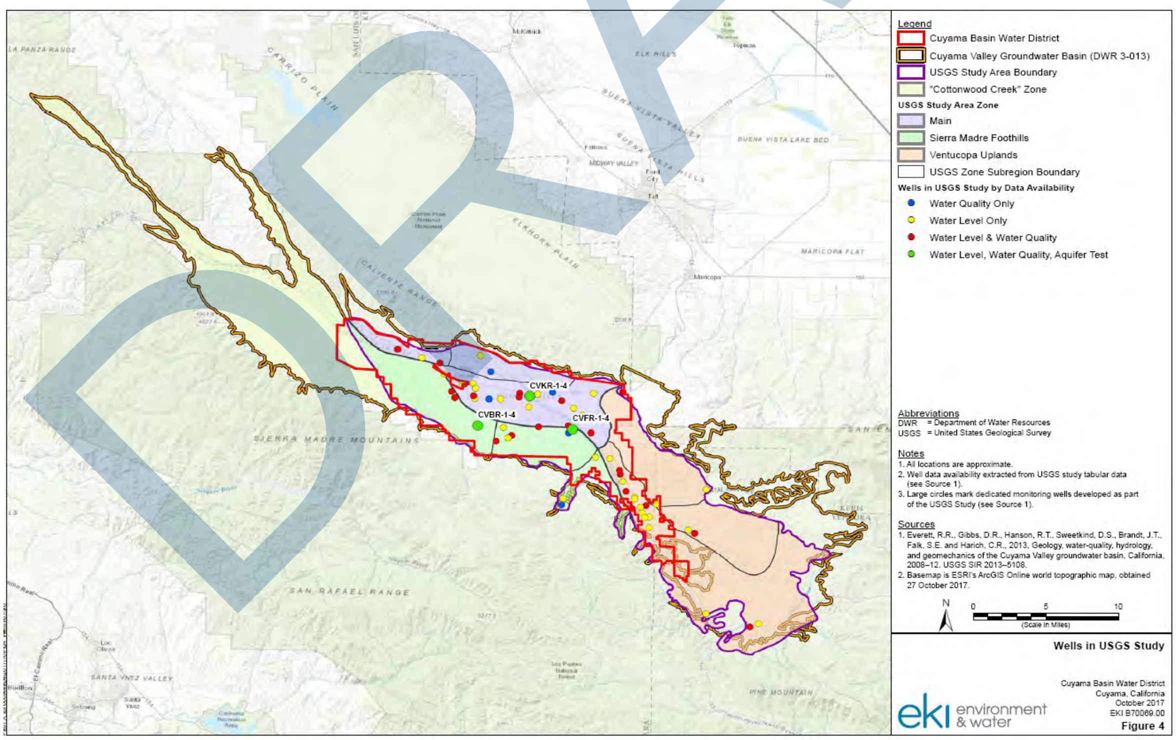

Figure 2-15: Location Map of USGS 2013 Sampling

Aquifer Use

The Cuyama Valley is dependent on groundwater as its sole source of supply. Groundwater is used for irrigation, domestic and municipal use (USGS, 2013c). The majority of agricultural activity occurs between the New Cuyama and Ventucopa areas, and west of the Russell fault near the north fork.

2.1.9 Topography, Surface Water and Recharge

This section describes the topography, surface water, soils, and groundwater recharge potential in the Basin. There are no imported water supplies to the Cuyama Basin and are not discussed in this section.

Topography

The Basin is lowest in the northwest, and highest in the southeast. The lowest elevation in the Basin is located at the west edge where the Cuyama River exits at approximately 1,300 feet, while the highest point is approximately 7,250 feet on the eastern boundary. Figure 2-16 shows the topographic characteristics of the Basin. The south facing northern slopes of the valley are generally steeper than the north facing south slopes. The eastern portion of the Basin along the valley walls becomes steep, characterized by mountainous runoff-cut topography.

Surface Water Bodies

The Cuyama River is the primary surface water feature in the valley and flows from an elevation of 3,800 feet on the eastern side to the west of the Basin to 1,300 feet at the western outlet of the Basin. The Cuyama River travels approximately 55 miles through the Basin and has a slope ratio of approximately 1:125. The river is perennial, with most dry seasons seeing little to no flows. Large flows usually occur in flashes due to the small watershed and storms that provide precipitation onto the surrounding Coastal Range Mountains. Peak flows through the Cuyama River, dated between 1929 and 2017, range from approximately 6,000 cubic feet per second to the highest recorded flow of 15,500 cubic feet per second on February 18, 2017 (National Watershed Information System [NWIS], 2018). There are approximately four main perennial streams that feed the Cuyama River: Aliso Creek, Santa Barbara Creek, Quatal Canyon Creek, and Cuyama Creek. However, during precipitation events many more smaller streams flow from the valley walls and surrounding mountains. Figure 2-17 shows the locations of surface water bodies in the Basin.

Downstream on the Cuyama River lies Twitchell Reservoir, however this is an artificial body of water outside of the Basin.

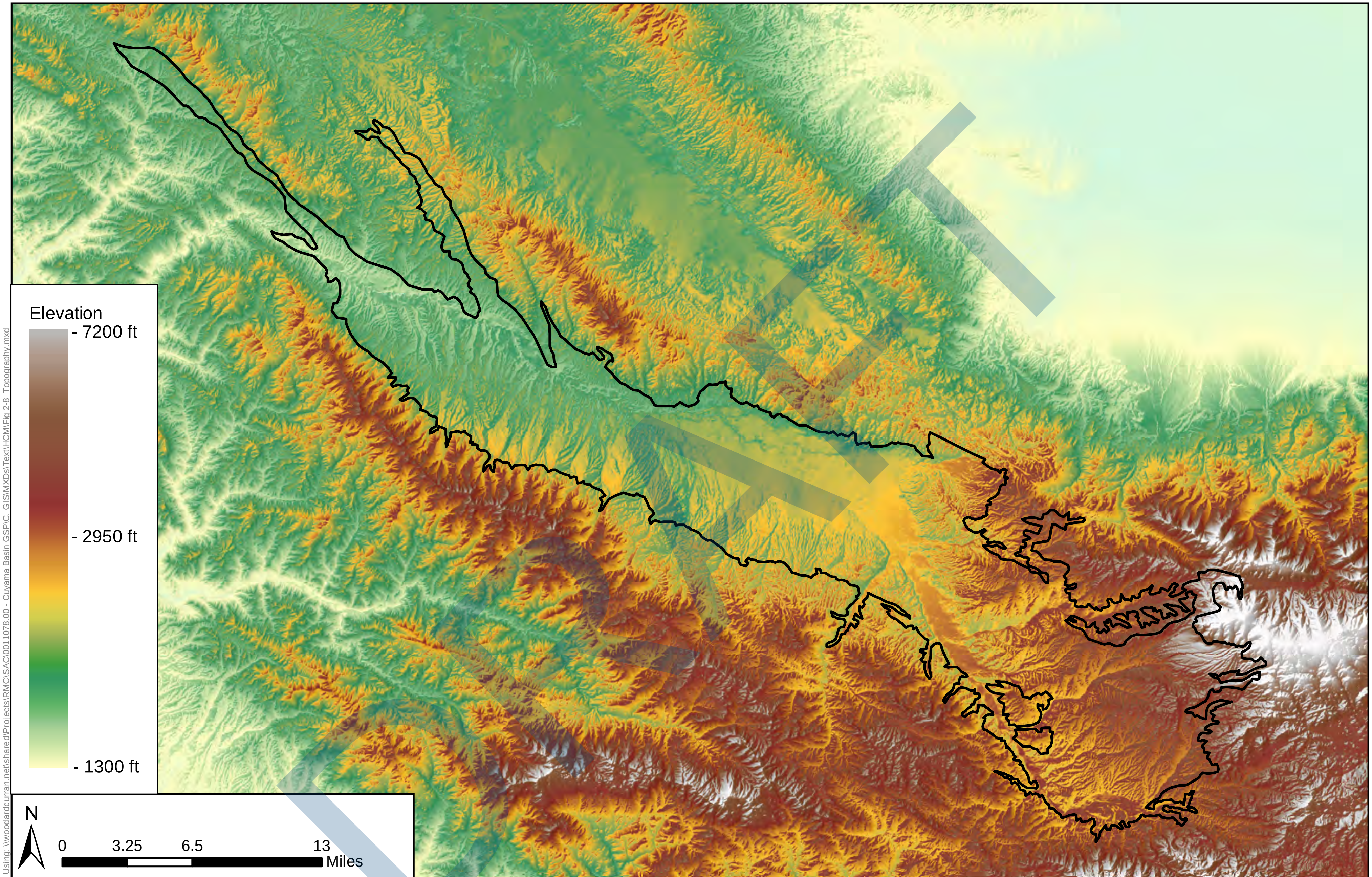

Figure 2-16: Topography

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Cuyama Basin

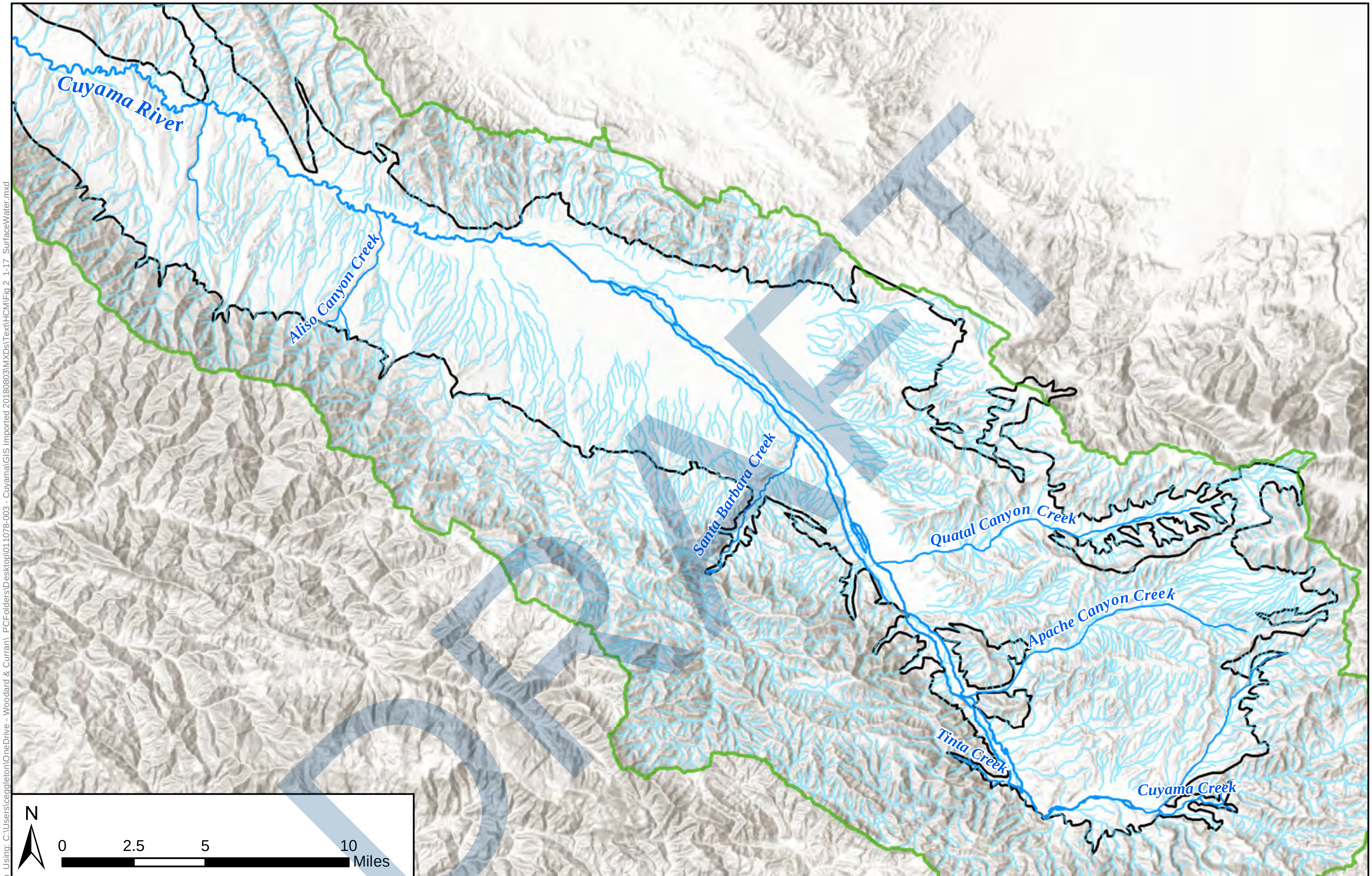

Figure 2-17: Surface Water

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- Cuyama Basin
- Cuyama Watershed
- Cuyama River
- Major Cuyama GW Basin Streams
- All Other NHD Flow Lines, Creeks, and Streams in the Cuyama Watershed

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Areas of Recharge, Potential Recharge, and Groundwater Discharge Areas

Areas of recharge and potential recharge lie primarily within the central and low-lying areas of the Cuyama Valley. Agricultural and open space lands are considered areas of potential recharge. Figure 2-18 shows areas with their potential for groundwater recharge, as identified by the Soil Agricultural Groundwater Banking Index (SAGBI). SAGBI provides an index for the groundwater recharge for agricultural lands by considering deep percolation, root zone residence time, topography, chemical limitations, and soil surface condition. SAGBI data categorizes 22,675 acres out of 37,568 acres (60 percent) of agricultural and grazing land within the Basin as moderately good, good, or excellent for groundwater recharge (University of California, Davis, 2018). SAGBI data shown in

Figure 2-18 is derived from “modified” SAGBI data. “Modified” SAGBI data show higher potential for recharge than unmodified SAGBI data because the modified data assume that the soils have been or will be ripped to a depth of 6 feet, which can break up fine grained materials at the surface to improve percolation.

Groundwater discharge areas are identified as springs located within the Basin.

Figure 2-18 shows the location of historical springs identified by the USGS (NWIS, 2018). The springs shown in represent a dataset collected by the USGS and are not a comprehensive map of springs in the Basin.

Soils

Soils in the Basin were categorized by the National Resource Conservation Service (NRCS). The Basin is comprised mostly of fine- to coarse-loamy soils (NRCS STATSGO2, 2018). As shown in Figure 2-19, the valley bottom and primary soil surrounding the Cuyama River and its tributaries is primarily fine-loamy soils, while the northern boundary of the Basin has coarse-loamy soils.

Figure 2-20 shows soils by hydrologic soil group. Hydrologic soil groups were calculated by the NRCS on a by-county basis. As shown in Figure 2-20, interpretations of soil groups varied by county in each study. In general, hydrologic soil groups are sorted by permeability, with class A being the most permeable and class D being the least permeable. Figure 2-20 shows that in general most of the soils in the Basin have lower permeabilities and are listed as class C or D, with higher permeabilities being located near streams and rivers.

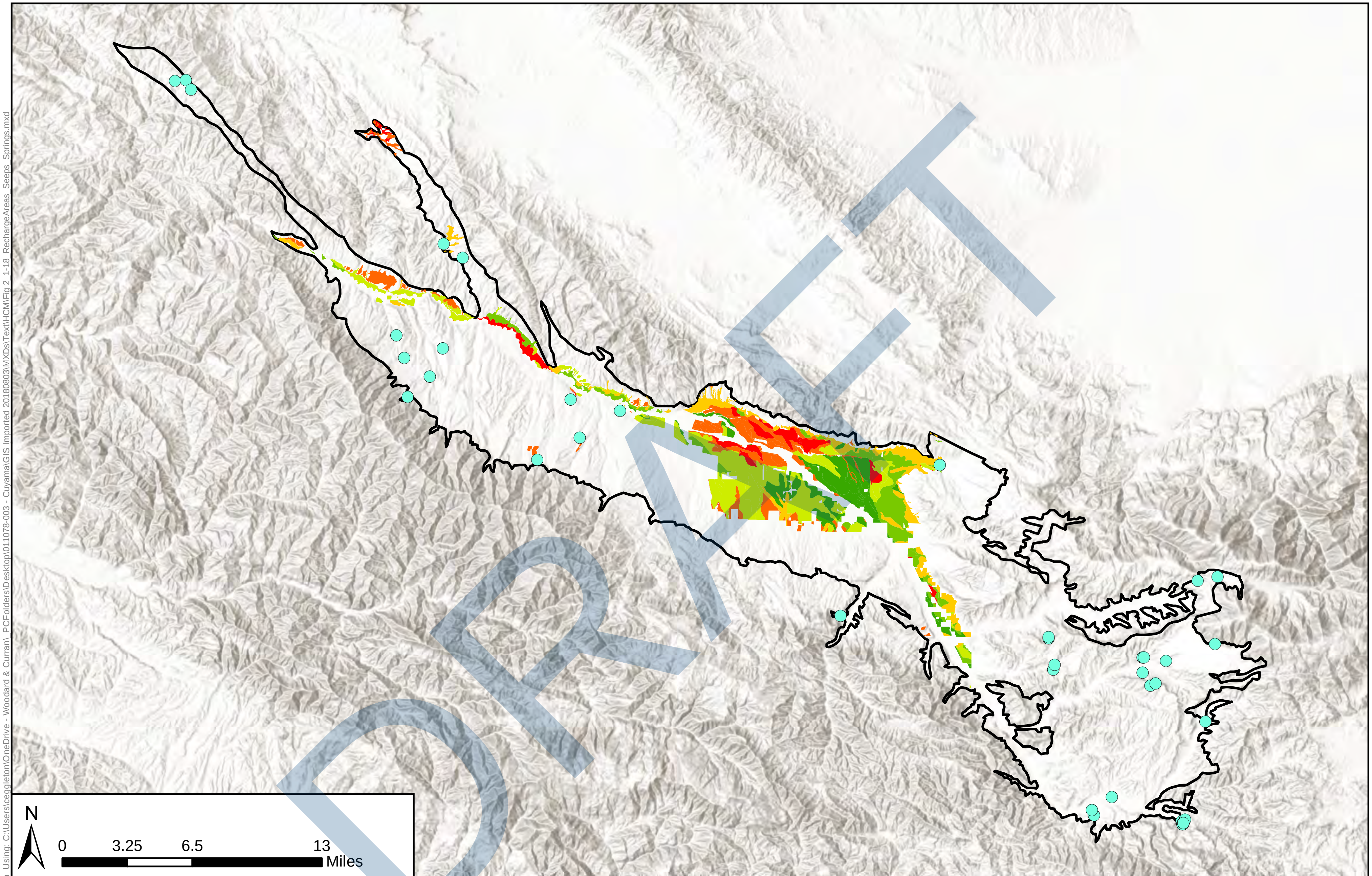

Figure 2-18: Recharge Areas, Seeps, and Springs

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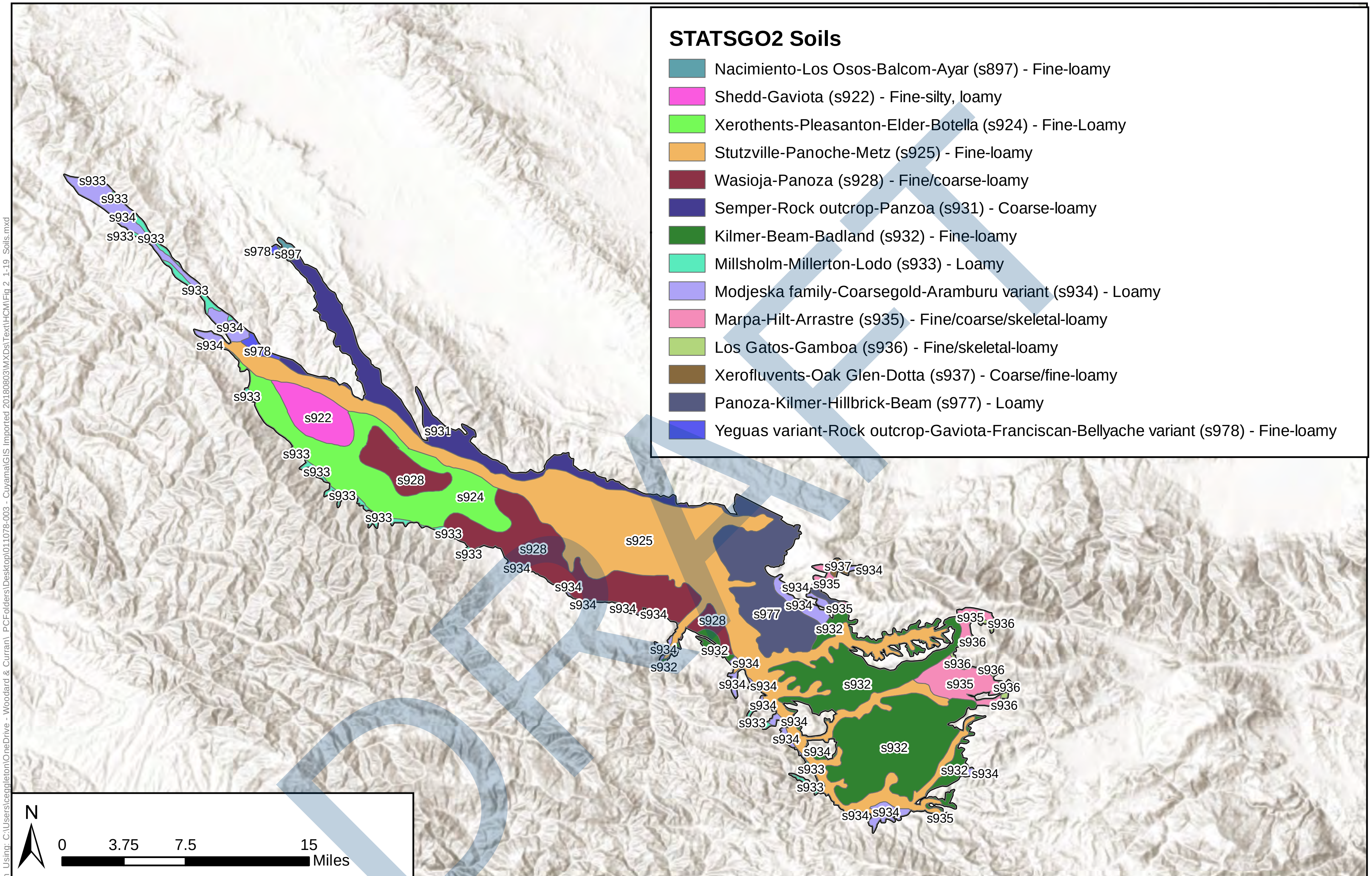

Figure 2-19: Soils

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Cuyama Basin

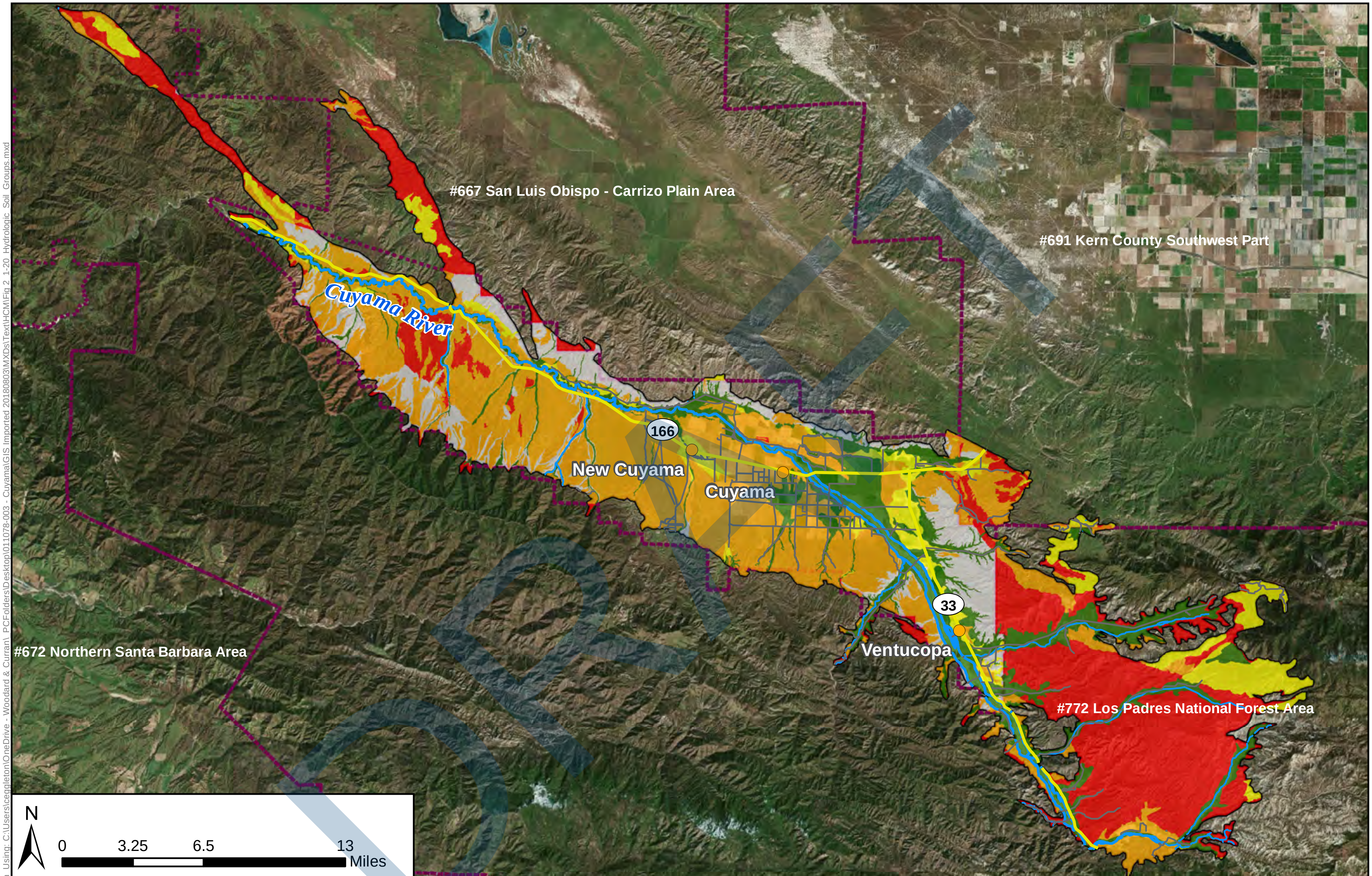

Figure 2-20: Hydrologic Soil Groups

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Cuyama Basin
Cuyama River
Streams
Towns
Highways

Hydrologic Soil Group
A
B
C
D
Not classified

Soil Survey Boundary

Soil Survey Key:
#772 Los Padres National Forest Area
Soil Survey Number
Survey Name

2.1.10 Hydrogeologic Conceptual Model Data Gaps

The following are the HCM data gaps that were identified during the development of this GSP. There is no consensus about whether faults are barriers to flow in the Basin, and if so, at what depth are they a barrier to flow. There is also confusion about whether smaller faults and fault splays are barriers to flow. Aquifer properties in areas where aquifer testing has not been conducted are not well defined, and are estimated. The connection between groundwater levels upstream of Ventucopa and in the Ventucopa region are not well understood; additionally, it is not well understood if groundwater flows are channelized in the Ventucopa and upland regions. Lastly, connectivity between the alluvium west of the Russel Fault and areas in upland areas is not agreed upon. Other data gaps may be discovered during implementation of the GSP.

2.2 Basin Settings: Groundwater Conditions

This section of Chapter 2 satisfies Section 354.8 of the SGMA regulations, and describes the historical and current groundwater conditions in the Basin. Water budget components follow in Section 2.3.

As defined by the SGMA regulations, this section does the following:

- Defines current and historical groundwater conditions in the Basin
- Describes the distribution, availability, and quality of groundwater
- Identifies interactions between groundwater, surface water, groundwater-dependent ecosystems, and subsidence
- Establishes a baseline of groundwater quality and quantity conditions that will be used to monitor changes in the groundwater conditions relative to measurable objectives and minimum thresholds
- Provides information to be used for defining measurable objectives to maintain or improve specified groundwater conditions
- Supports development of a monitoring network to demonstrate that the Cuyama Basin Groundwater Sustainability Agency (CBGSA) is achieving Basin sustainability goals

The majority of published information about groundwater in the Basin is focused on the central part of the Basin, roughly from an area a few miles west of New Cuyama to roughly Ventucopa. The eastern uplands and western portion of the Basin have been studied less, and consequentially, fewer publications have been written about those areas, and less historical information is available in those areas.

The groundwater conditions described in this section are intended to convey the present and historical availability, quality, and distribution of groundwater and are used elsewhere in the GSP to define measurable objectives, identify sustainability indicators, and establish undesirable results.

Groundwater conditions in the Basin vary by location. To assist in discussion of the location of specific groundwater conditions, Figure 2-21 shows selected landmarks in the Basin to assist discussion of the location of specific groundwater conditions. Figure 2-22 shows major faults in the Basin in red, highways in yellow, towns as orange dots, and canyons and Bitter Creek in purple lines that show their location.

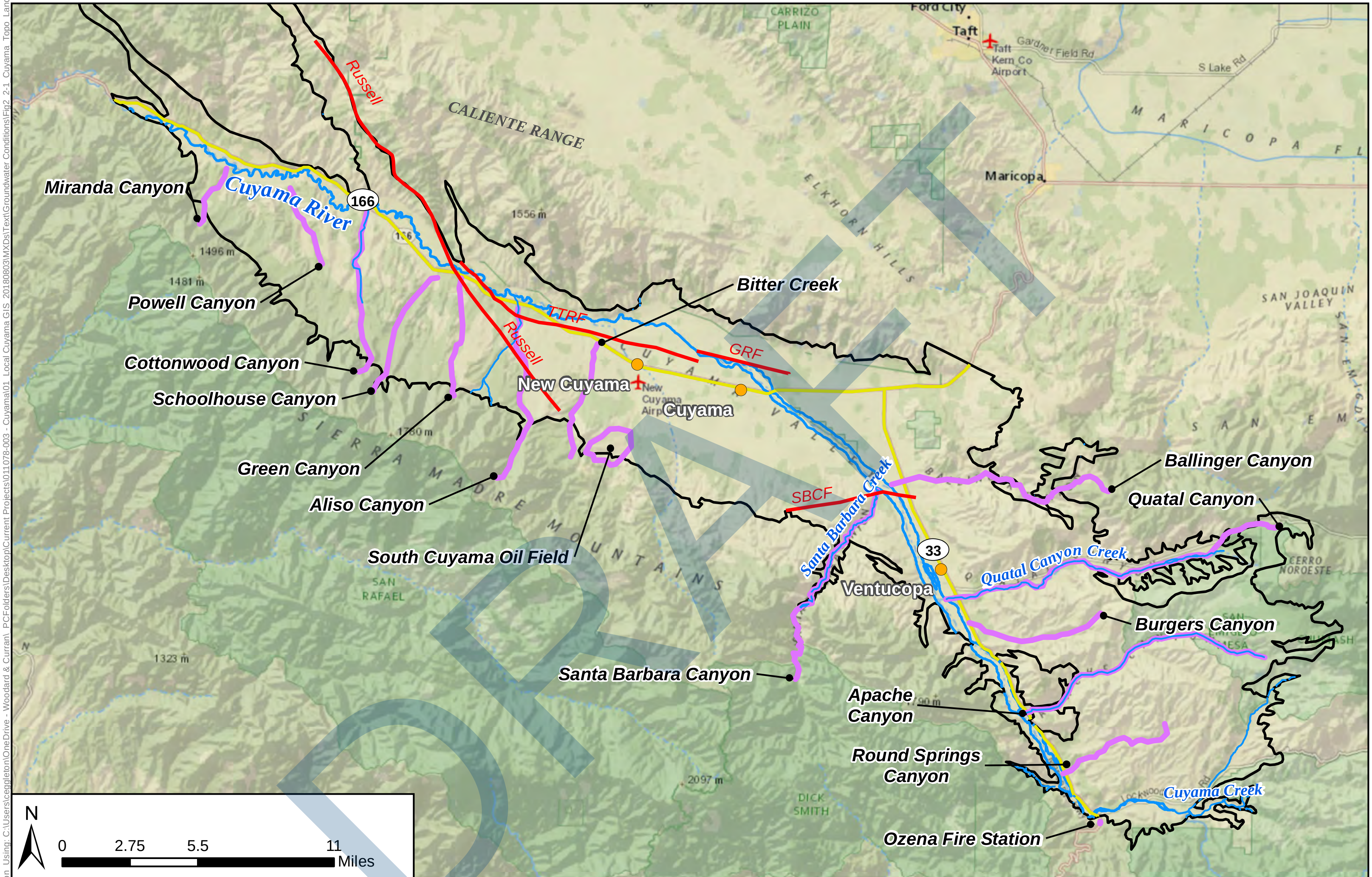

Figure 2-21 - Cuyama Basin Landmarks

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- Cuyama Basin
- Cuyama River
- Streams
- Faults
- Highways
- Landmarks
- Towns

2.2.1 Useful Terms

This section of Chapter 2 includes descriptions of the amounts, quality, and movement of groundwater, among other related components. A list of technical terms and their definitions are below. These definitions are given to guide readers through the section and are not a definitive definition of any term.

- **Depth to groundwater –** This is the distance from the ground surface to groundwater, typically reported at a well.
- **Horizontal gradient** – The horizontal gradient is the slope of groundwater from one location to another when one location is higher, or lower than the other. The horizontal gradient is shown on maps with an arrow showing the direction of groundwater flow in a horizontal direction.
- **Vertical gradient** – A vertical gradient describes the movement of groundwater perpendicular to the ground surface. Vertical gradient is measured by comparing the elevations of groundwater in wells that are of different depths. A downward gradient is one where groundwater is moving down into the ground, and an upward gradient is one where groundwater is upwelling towards the surface.
- **Contour map –** A contour map shows changes in groundwater elevations by interpolating groundwater elevations between monitoring sites. The elevations are shown on the map with the use of a contour line, which indicates that at all locations that line is drawn, it represents groundwater being at the elevation indicated. There are two versions of contour maps shown in this section as follows:
  - Elevation of groundwater above mean sea level, which is useful because it can help identify the horizontal gradients of groundwater, and
  - Depth to water (i.e. the distance from the ground surface to groundwater), which is useful because it can help identify areas of shallow or deep groundwater.
- **Hydrograph –** A hydrograph is a graph that shows the changes in groundwater elevation over time for each monitoring well. Hydrographs show how groundwater elevations change over the years and indicate whether groundwater is rising or descending over time.
- **Maximum contaminant level (MCL)** – An MCL is a standard set by the State of California regarding drinking water quality. An MCL is the legal threshold on the amount of a substance that may appear in public water systems. MCLs are different for different constituents in drinking water.
- **Elastic land subsidence** – Elastic land subsidence is the reversible and temporary fluctuation in the earth's surface in response to seasonal periods of groundwater extraction and recharge.
- **Inelastic land subsidence** – Inelastic land subsidence is the irreversible and permanent decline in the earth's surface resulting from the collapse or compaction of the pore structure within the fine-grained portions of an aquifer system.

2.2.2 Groundwater Elevation Data Processing

Groundwater well information and groundwater level monitoring data were compiled from four public sources, with additional data compiled from private landowners. These include the following:

- USGS
- DWR
- Santa Barbara County Water Agency (SBCWA)
- San Luis Obispo County
- Private landowners

Data provided by these sources included well information such as location, well construction, well owner, ground surface elevation and other related components, as well as groundwater elevation data including information such as date measured, depth to water, groundwater surface elevation, questionable measurement code, and comments. At the time that this analysis was performed, groundwater elevation data was available for the time period from 1949 to June 2018.[3] There are many wells with monitoring data from some time in the past, but no recent data, while a small number of wells have monitoring data recorded for periods of greater than 50 years. Figure 2-22 through Figure 2-25 show well locations with available monitoring data, and the entity that maintains monitoring records at each well. These figures also show in a larger, darker symbol if the monitoring well has been measured in 2017 or 2018.

Figure 2-22 shows the locations of well data received from the DWR database. As an assessment of which wells have been monitored recently, the wells with monitoring data collected between January 2017 and June 2018 were identified. Roughly half of the wells from DWR's database contain monitoring data in 2017-18, with roughly half the wells having no monitoring data during this period. Wells in DWR's database are concentrated in the central portion of the Basin, east of Bitter Creek and north of the Santa Barbara Canyon Fault (SBCF). Many wells in DWR's database have been typically measured bi-annually, with one measurement in the spring, and one measurement in the fall.

Figure 2-23 shows the locations of well data received from the USGS database. Many of these wells are duplicative of wells contained in the DWR database. The majority of wells from the USGS database were not monitored in 2017-18. Wells that were monitored in 2017-18 are concentrated in the western portion of the Basin, west of New Cuyama, with a small number of monitoring wells in the central portion of the Basin and near Ventucopa. Many wells in the USGS database haves been typically measured bi-annually, with one measurement in the spring, and one measurement in the fall.

[3] The analysis shown in this section was performed in the summer of 2018 and does not reflect data that may have been collected after June 2018. In addition, the analysis reflects the available data as provided by each entity - an assessment has not been performed on the standards and protocols followed by each entity that compiles and maintains the available datasets.

Figure 2-24 shows the locations of well data received from Santa Barbara and San Luis Obispo counties. Wells from both counties were monitored in 2017-18. Wells monitored by Santa Barbara County are concentrated in the western portion of the Basin west of Bitter Creek. The two wells monitored by San Luis Obispo County are in the central portion of the Basin; these wells also appear in the USGS database. Data are collected in many of these wells on a bi-annual basis, with one measurement in the spring, and one measurement in the fall, with some measurements at some wells occurring on a quarterly basis.

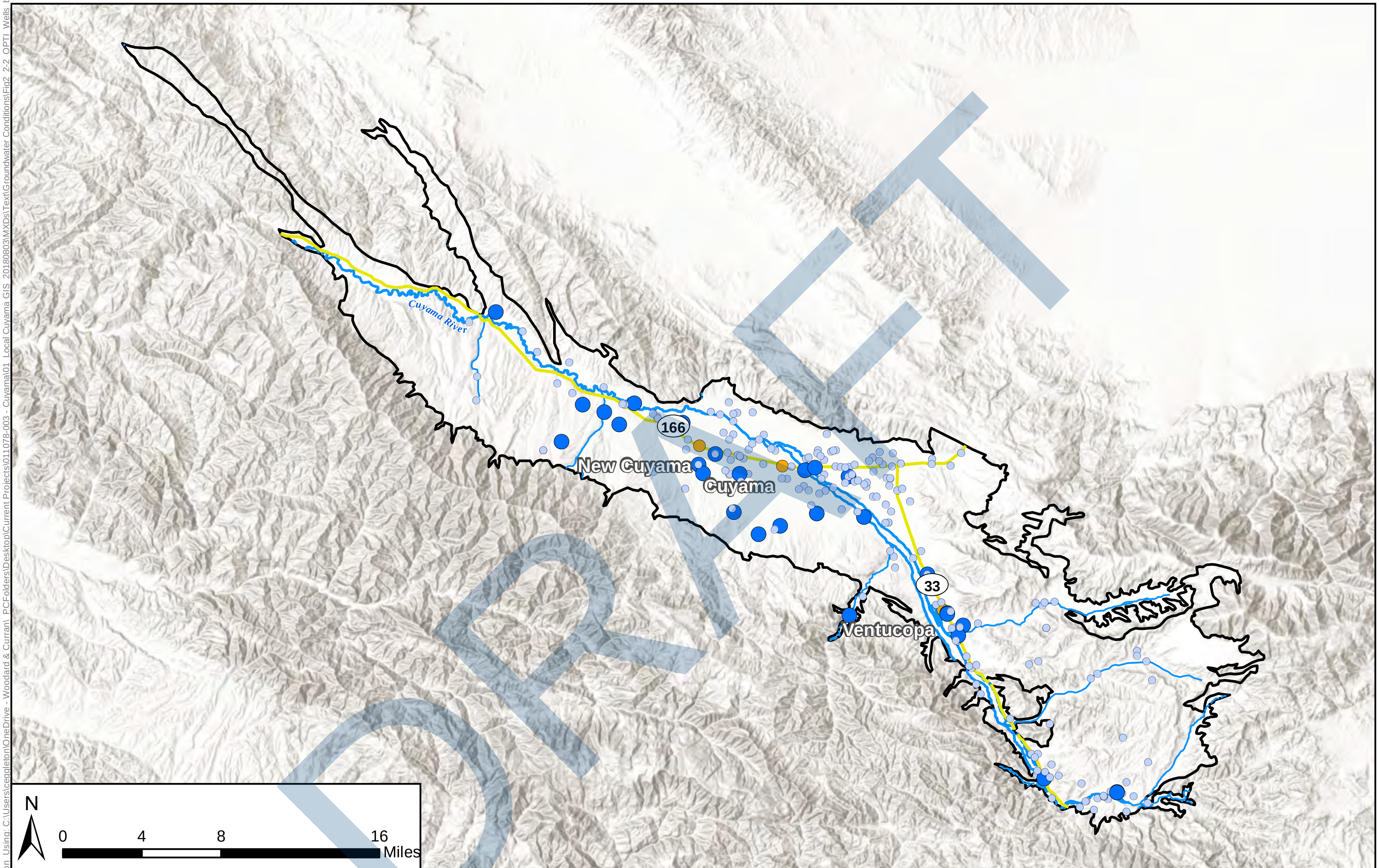


Figure 2-22: Cuyama GW Basin Wells with Monitoring Data Provided by DWR

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

April 2019

Legend

- Cuyama Basin
- Towns
- Highways
- Cuyama River
- Streams
- DWR Database Wells Last Measured in 2017-2018
- DWR Database Wells Last Measured 2016 and Earlier

Figure Exported: 11/13/2018 By: ceggleton Using: C:\Users\ceggleton\OneDrive - Woodard & Curran_PCFolders\Desktop\Current Projects\011078-003 - Cuyama\01_Local Cuyama GIS_20180803\MXDs\Text\Groundwater Conditions\Fig2_2-2_OPTI_Wells_by_Agency

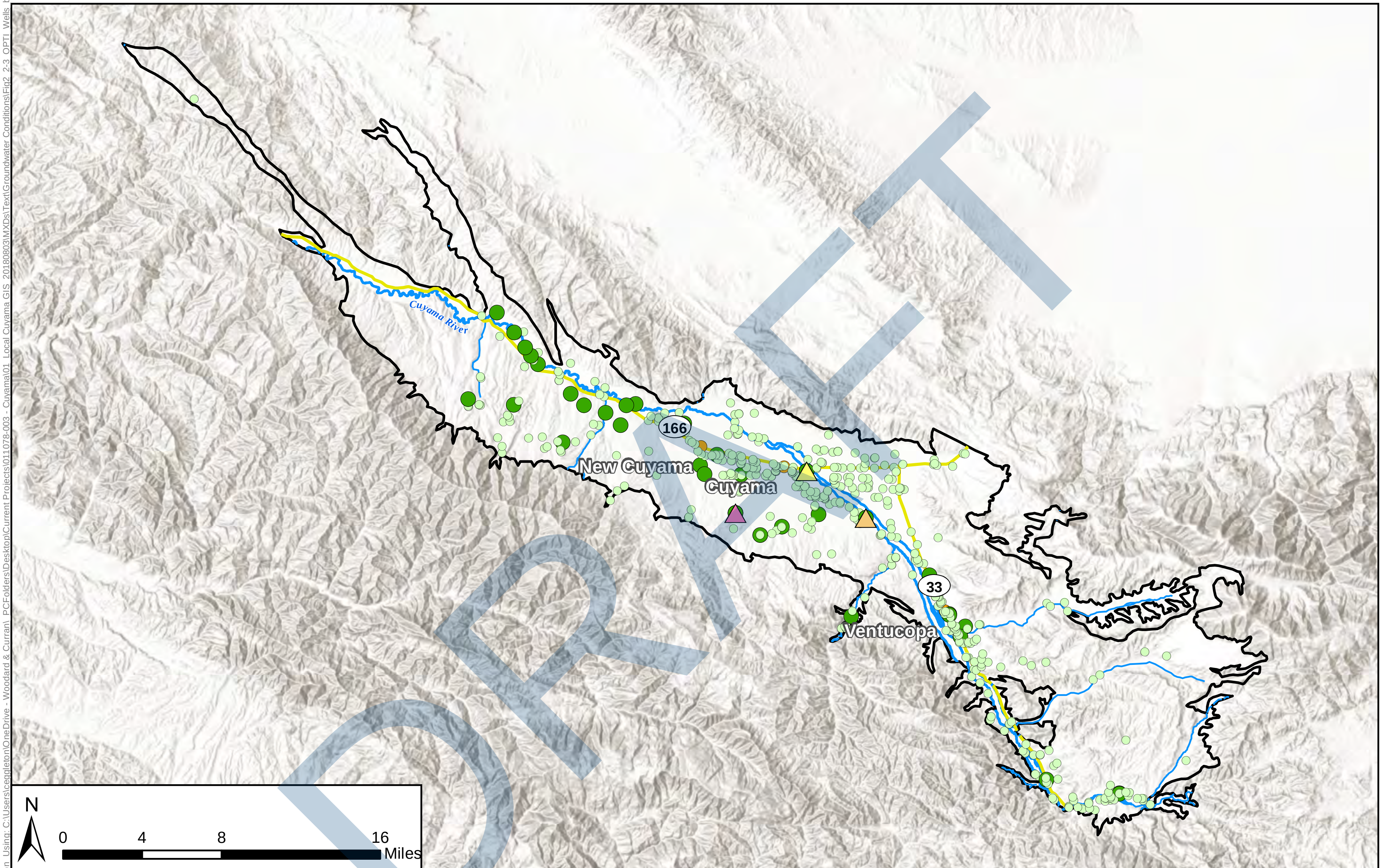


Figure 2-23: Cuyama GW Basin Wells with Monitoring Data Provided by USGS

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

April 2019

WOODARD & CURRAN

Legend

- Cuyama Basin
- Towns
- Highways
- Cuyama River
- Streams
- USGS Database Wells Last Measured in 2017-2018
- USGS Database Wells Last Measured 2016 or Earlier
- CVBR Multi-Completion Well
- CVFR Multi-Completion Well
- CVKR Multi-Completion Well

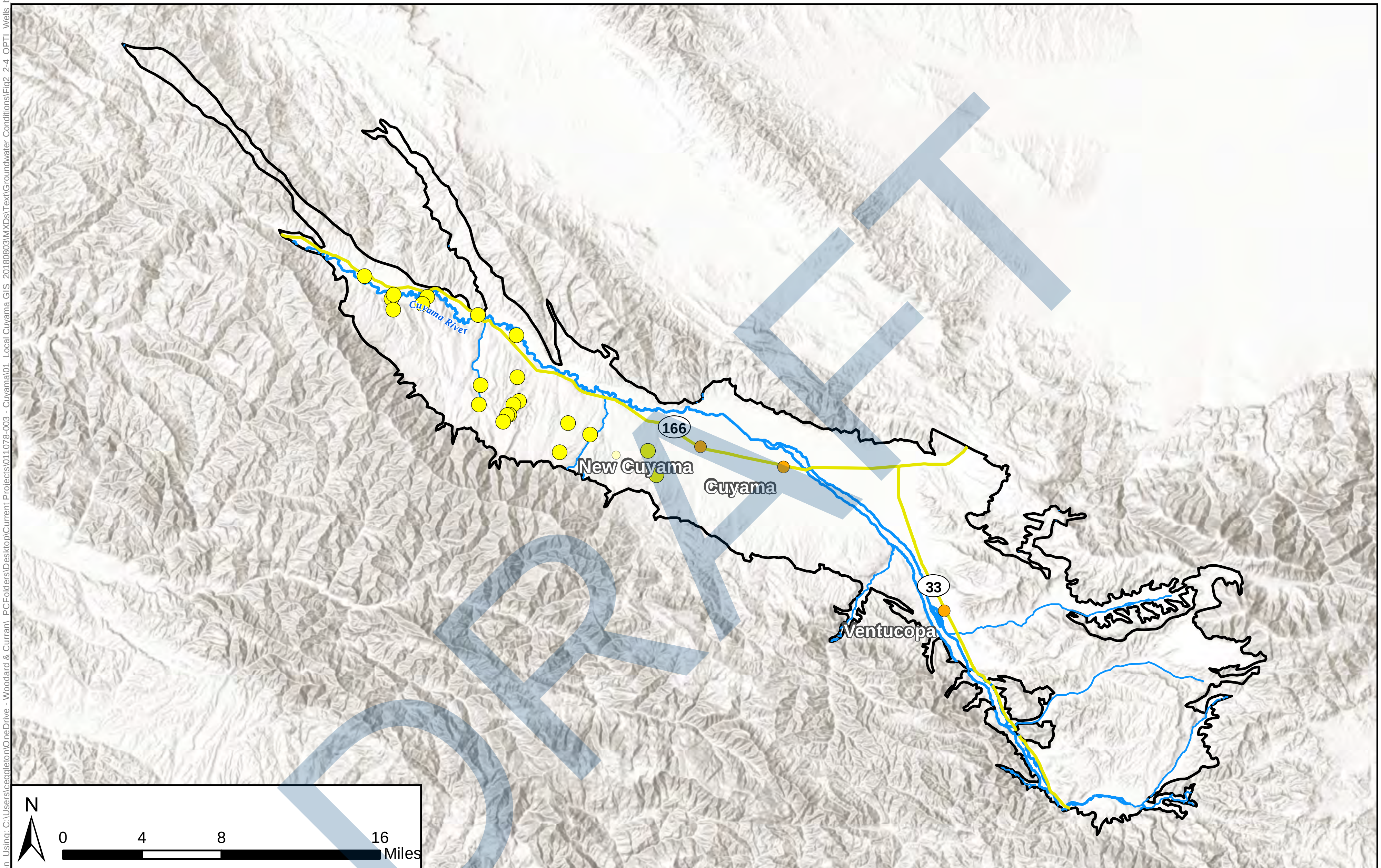


Figure 2-24: Cuyama GW Basin Wells with Monitoring Data Provided by Local Agencies

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

April 2019

WOODARD & CURRAN

Legend

- Cuyama Basin
- Towns
- Highways
- Cuyama River
- Streams
- County Database Wells Last Measured in 2017-2018
- County Database Wells Last Measured 2016 or Earlier

Figure 2-25 shows the locations of well data received from private landowners. The majority of wells provided by private landowners are located in the central portion of the Basin, between the Cuyama River and Highway 33, generally running along SR 166. Additional wells provided by private landowners are located along the Cuyama River and SR 166, near the Russell Ranch Oilfields. Associated data provided with private landowners varies by source. Some data and measurements were taken annually, while other well owners were taken biannually or quarterly.

Figure 2-26 shows the locations of collected data from all entities by their last measured date. Wells with monitoring data in 2017-2018 are shown in bright green triangles. There are recent measurements in many different parts of the Basin as follows:

- Near the Cuyama River in the eastern uplands and near Ventucopa
- In the central portion of the Basin, especially north of SR 166 but with some wells located in the southern portion of the central basin
- In the western portion of the Basin east of Aliso Canyon. An additional concentration of recent monitoring points is present along the Cuyama River near the Russell Ranch Oilfields.

Figure 2-27 shows a comparison of data provided by private landowners and data compiled from the DWR and the USGS databases in the central portion of the Basin. This figure was developed to provide information on the consistency between data from these differing sources. The figure shows the location of compared wells, and the measurements on those wells by source. The measurements of groundwater elevation among the measured wells indicate that the monitoring by the private landowners and agencies approximately match in tracking historical trends from the public databases.

Figure 2-28 shows a comparison of data collected from other private landowners, and data collected from SBCWA. This figure was developed to provide information on the consistency between data from these differing sources. The figure shows the location of compared wells, and the measurements on those wells by source. A long-term comparison is not possible due to the shorter measurement period of the Santa Barbara County wells, but the measurements of groundwater elevation among the measured wells indicate that the monitoring by private landowners in the western portion of the Basin and the county are similar in elevation, with the county's data showing slightly higher elevations.

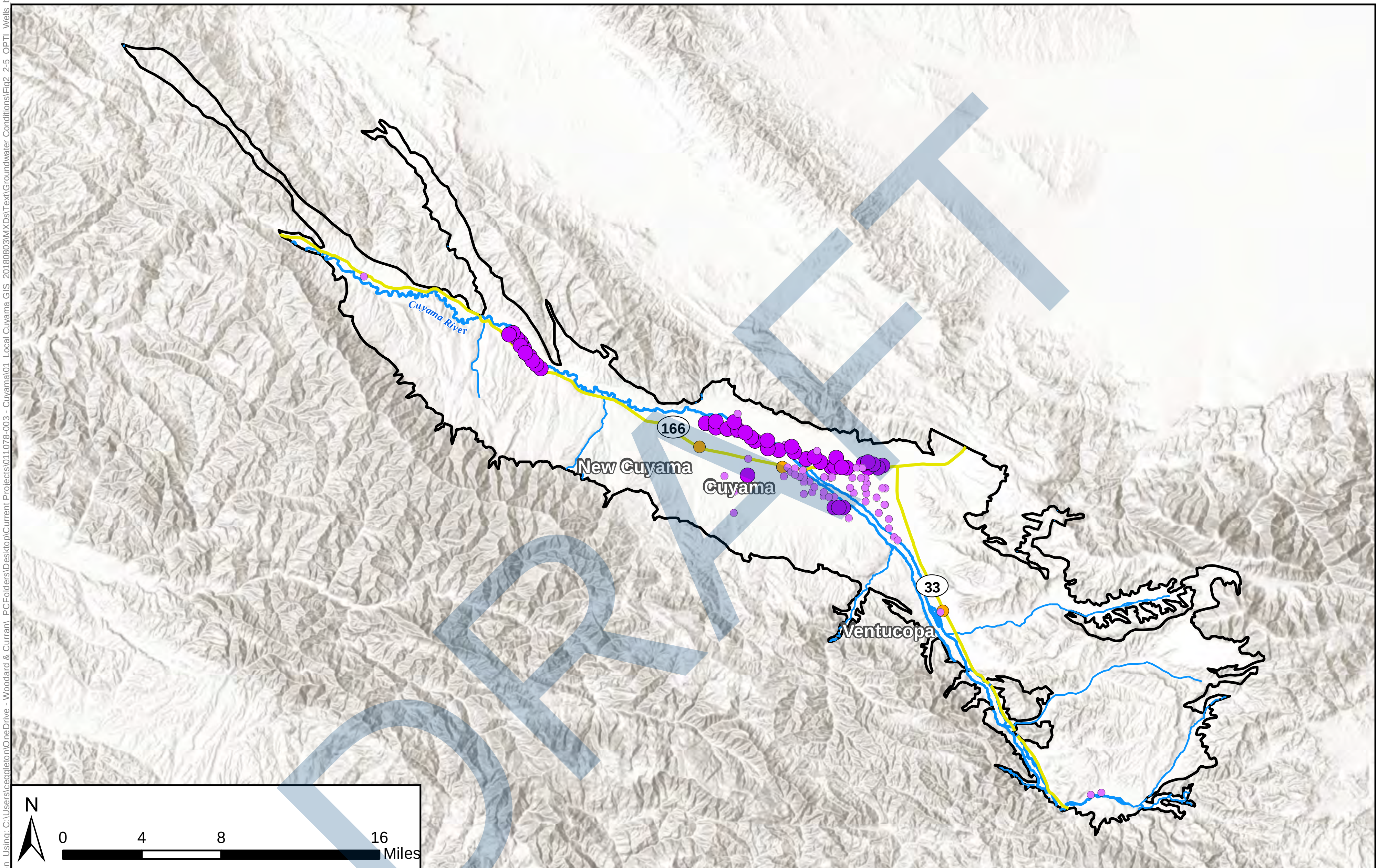


Figure 2-25: Cuyama GW Basin Wells with Monitoring Data Provided by Private Landowners

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

April 2019

WOODARD & CURRAN

Legend

- Cuyama Basin
- Towns
- Highways
- Cuyama River
- Streams
- Private Landowners Reported Wells Last Measured in 2017-2018
- Private Landowners Reported Wells Last Measured 2016 and Earlier

DRAFT

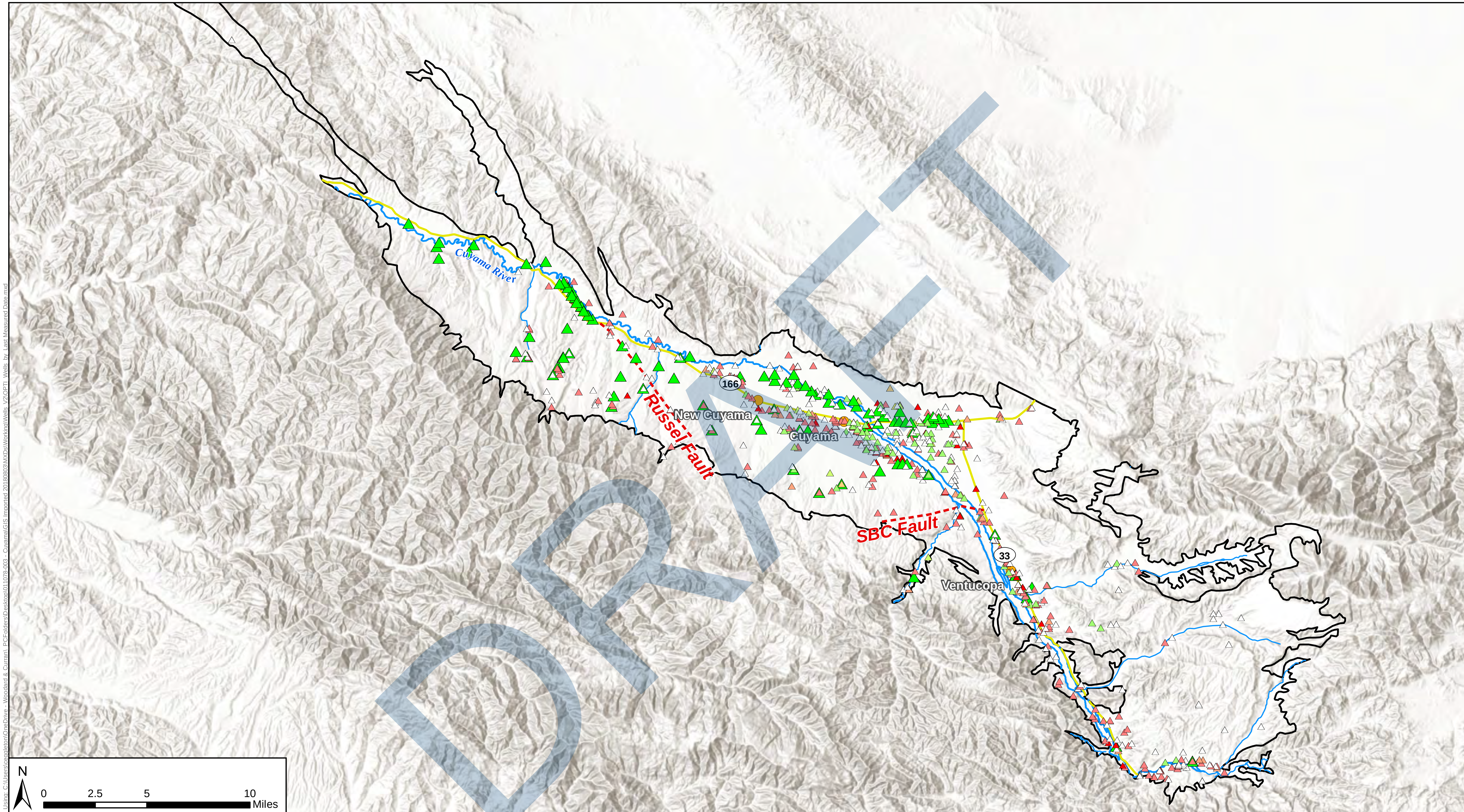


Figure 2-26: Cuyama GW Basin Wells by Last Measurement Date

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

April 2019

WOODARD & CURRAN

Legend

Cuyama Basin
Towns
Highways
Cuyama River
Streams
Fault

Most Recent Year with Measurements

2017 - 2018
2010 - 2016
2000 - 2009
1990 - 1999
1980 - 1989
1970 - 1979
1960 - 1969
1950 - 1959
Pre-1950
No Measurment Data

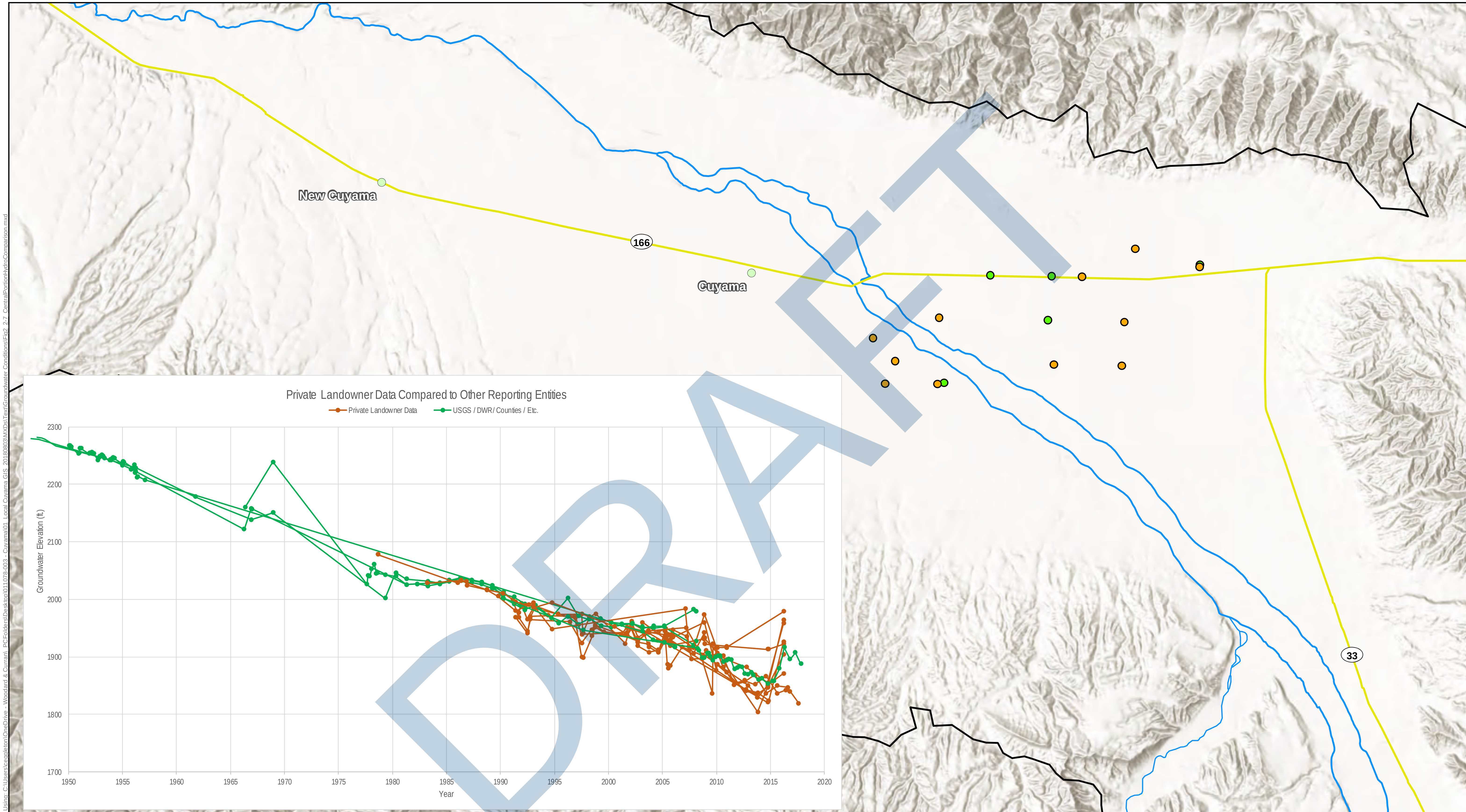


Figure 2-27: Central Cuyama GW Basin Wells and Hydrographs by Data Source

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

April 2019

WOODARD & CURRAN

Legend

- Cuyama Basin
- Towns
- Highways
- Cuyama River
- Streams
- USGS, DWR, County, Etc., Wells
- Private Landowners

N

0 0.5 1 2 Miles

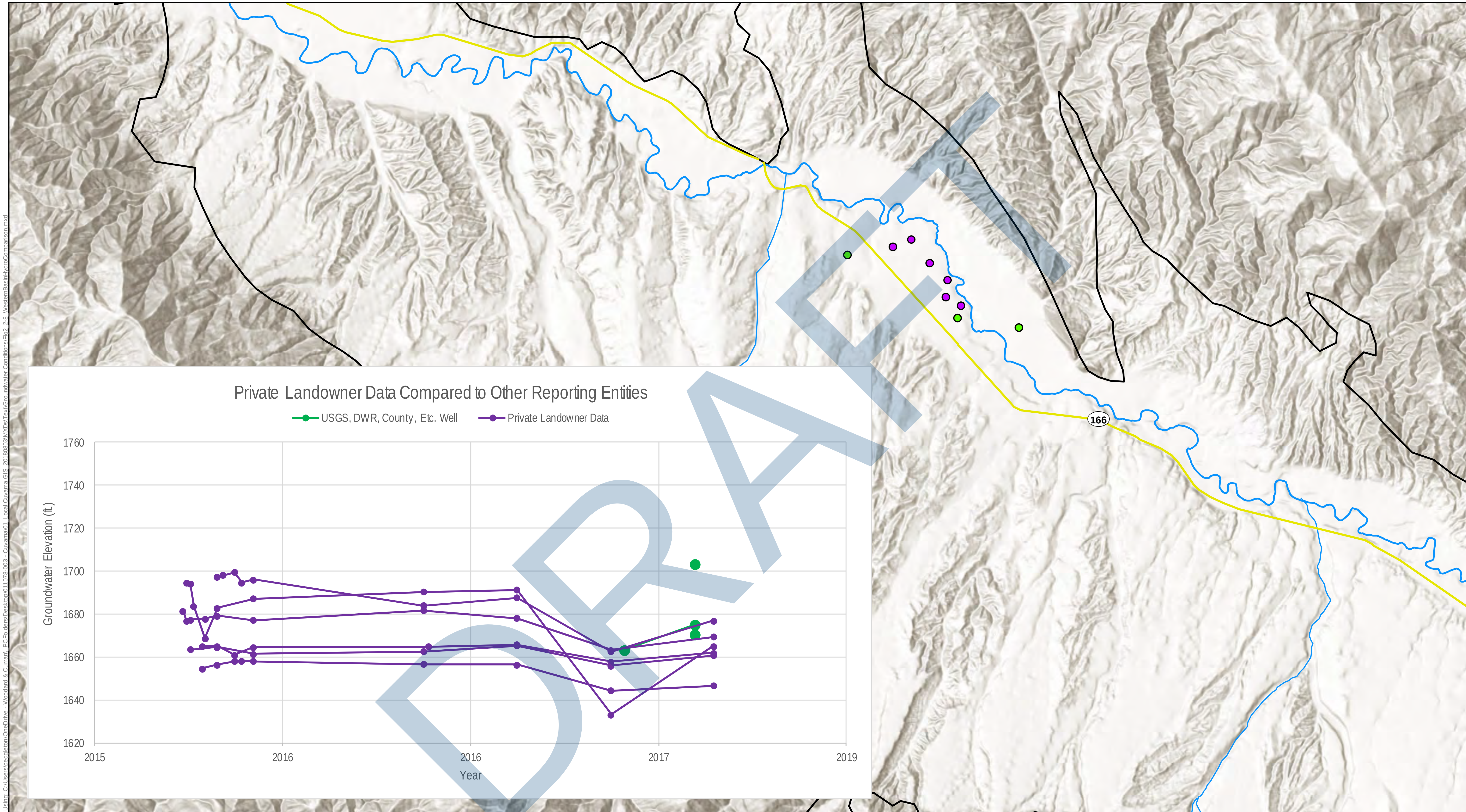


Figure 2-28: Western Cuyama GW Basin Wells and Hydrographs by Data Source

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

April 2019

WOODARD & CURRAN

Legend

- Cuyama Basin
- Highways
- Cuyama River
- Streams
- USGS, DWR, County, Etc. Wells
- Private Landowner Wells

N

0 0.5 1 2 Miles

2.2.3 Groundwater Trends

This section describes groundwater trends in the Basin generally from the oldest available studies and data to the most recent. Groundwater conditions vary widely across the Basin. In the following sections, historical context is provided by summarizing information from relevant studies about conditions from 1947 to 1966, followed by discussion of how groundwater conditions have changed based on available historical groundwater level monitoring data.

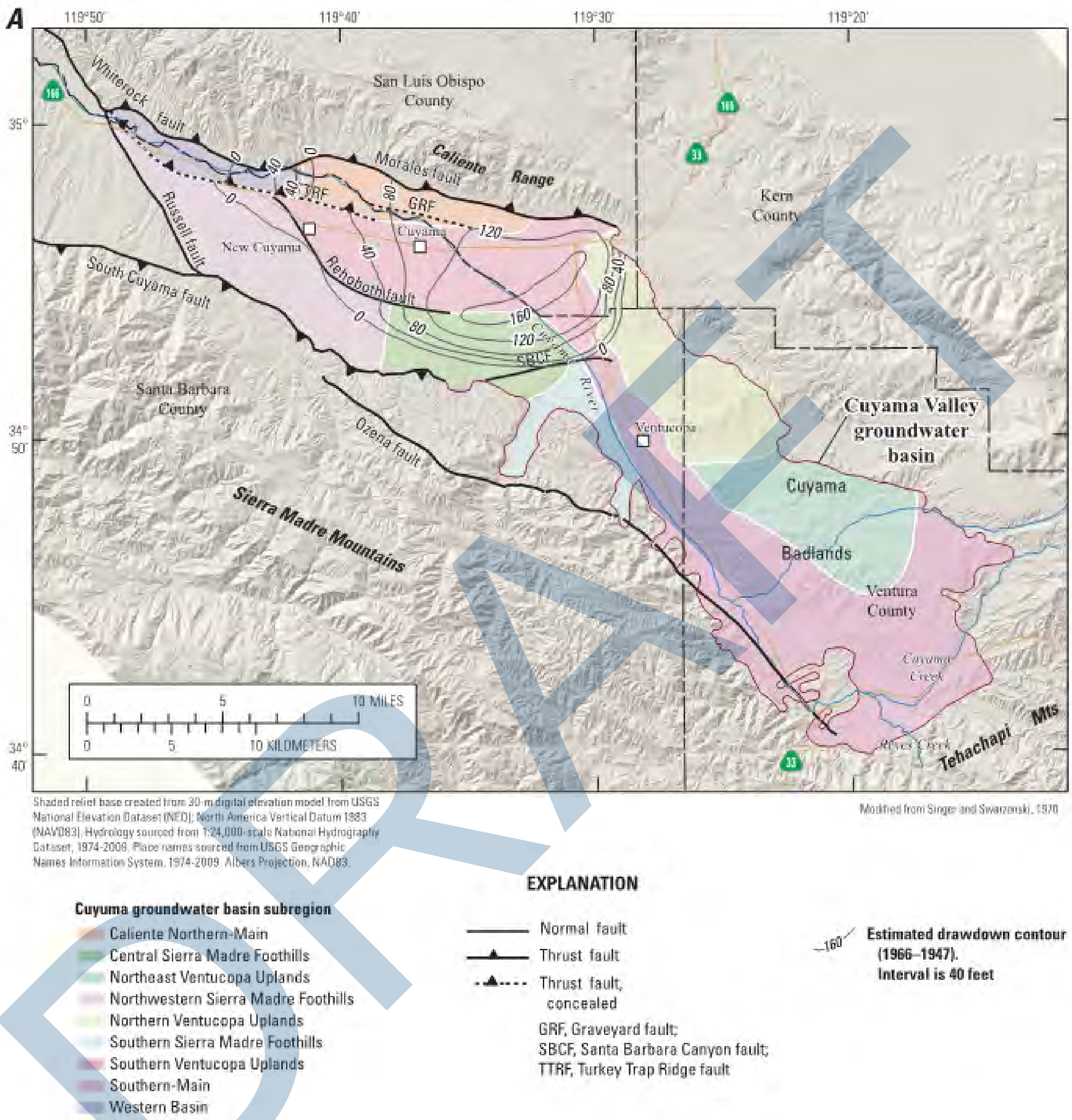
Historical Context – 1947 to 1966 Groundwater Trends

This section discusses public reports about conditions from 1947 to 1966. Information about groundwater conditions in the Basin during this period are limited to reports that discuss the central portion of the Basin and scattered groundwater elevation measurements in monitoring wells.

A USGS report titled *Water Levels in Observation Wells in Santa Barbara County, California* (USGS, 1956) discussed groundwater elevation monitoring in the Basin. The report states that ,prior to 1946, there was no electric power in the Cuyama Valley, which restricted intensive irrigation, and that groundwater levels in the central portion of the Basin remained fairly static until 1946. The report states that: "Declines in groundwater began after 1946," and that groundwater declined "as much as 8.8 feet from the spring of 1955 to 1956; the average decline was 5.2 feet. The decline of water levels at the lower and upper ends of the valley during this period was not so great as in the middle portion and averaged 1.7 and 2.2 feet respectively. Since 1946, water levels in observation wells have decline on the average about 27 feet" (USGS, 1956).

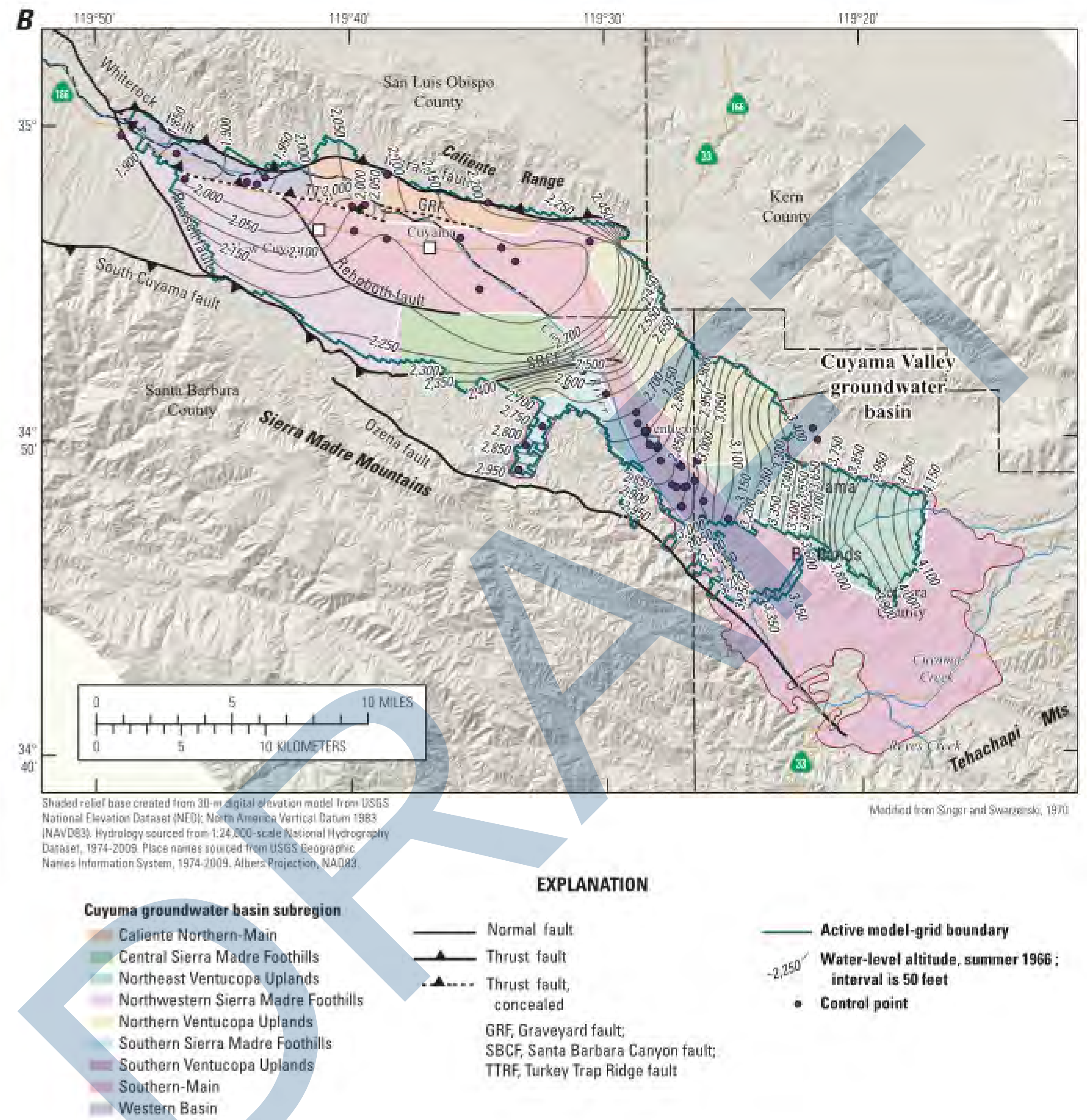
A USGS report titled *Hydrologic Models and Analysis of Water Availability in the Cuyama Valley, California* (USGS, 2015) presents two maps generated by using CUVHM simulated data. Figure 2-29 shows the estimated drawdown in the central portion of the Basin from 1947 to 1966. Figure 2-29 shows that estimated drawdown ranged from zero at the edges of the central basin to over 160 feet in the southeastern portion of the central Basin.

Figure 2-30 shows the estimated contours of groundwater elevation for September 1966. These contours show a low area in the central portion of the central Basin, and a steep groundwater gradient in the southeast near Ventucopa and in the highlands. A gentle groundwater gradient occurs in the southwestern portion of the central Basin, generally matching topography.



Source: USGS, 2015

Figure 2-29: Water Level Drawdown Contours, 1966 to 1947



Source: USGS, 2015

Figure 2-30: 1966 Water Level Contours

Groundwater Trends According to Available Monitoring Data

To understand how groundwater conditions have changed in the Basin in recent decades, analysts developed and analyzed groundwater hydrographs, vertical gradients and contours, which are discussed below.

Groundwater Hydrographs

Groundwater hydrographs were developed to provide indicators of groundwater trends throughout the Basin. Measurements from each well with historical monitoring data were compiled into one hydrograph for each well. These hydrographs are presented in Appendix A.

In many cases, changes in historical groundwater conditions at particular wells have been influenced by climactic patterns in the Basin (Section 2.3). Historical precipitation is highly variable, with several relatively wet years and some multi-year droughts.

Groundwater conditions generally vary in different parts of the Basin. Figure 2-31 shows hydrographs in select wells in different portions of the Basin. These wells were selected they broadly represent Basin conditions in their areas. More information about conditions is below.

- In the area southeast of Round Springs Canyon, near Ozena Fire Station (Well 89), groundwater levels have stayed relatively stable with a small decline during the 2012 to 2015 drought, and showed quick recovery.
- In the vicinity of Ventucopa (at Well 62), groundwater levels have followed climactic patterns and have generally been declining since 1995.
- Just south of the SBCF (at Well 101), groundwater levels have been fairly stable and are closer to the surface than levels in Ventucopa.
- North of the SBCF and east of Bitter Creek in the central portion of the Basin (at Wells 55 and 615), groundwater levels have been declining consistently since 1950.
- In the area west of Bitter Creek (at Wells 119 and 830), groundwater levels are near ground surface near the Cuyama River, and are below ground in the area to the south, uphill from the river. Levels have been generally stable since 1966.

Figure 2-32 shows selected hydrographs for wells in the area near Ventucopa. Near Ventucopa, hydrographs for Wells 85 and 62 show the same patterns and conditions from 1995 to the present and show that groundwater levels in this area respond to climactic patterns, but also have been in decline since 1995 and are currently at historic low elevations. The hydrograph for Well 85 shows that prior to 1985 groundwater levels responded to drought conditions but recovered during wetter years. Well 40 is located just south of the SBCF and its hydrograph indicates that groundwater levels in this location have remained stable from 1951 to 2013, when monitoring ceased. Wells 91 and 620 are north of the SBCF and their hydrographs show more recent conditions, where depth to water has declined consistently and is below 580 feet below ground surface (bgs).

Figures 2-33 and 2-34 show hydrographs of discontinued and currently monitored wells in the central portion of the Basin, north of the SBCF and east of Bitter Creek. The hydrographs of discontinued wells in this area are shown in Figure 2-33. These hydrographs show consistent declines of groundwater levels and little to no response to either droughts or wetter periods. The hydrograph for Well 35 shows a consistent decline from 1955 to 2008, from 30 feet bgs to approximately 150 feet bgs. Well 472 shows a decline from approximately 5 feet bgs in 1949 to approximately 85 feet bgs in 1978.

Figure 2-34 shows hydrographs of currently monitored wells in the central portion of the Basin. In general, these hydrographs show that groundwater levels are decreasing, with the lowest levels in the southeast portion of the area just northwest of the SBCF, as shown in the Well 610 hydrograph, where groundwater levels were below 600 feet bgs. Levels remain lowered along the Cuyama River, as shown in the hydrographs for Wells 604 and 618, which are currently approximately 500 feet bgs. Groundwater levels are higher to the west (Well 72) and towards the southern end of the area (Well 96). However, almost all monitoring wells in this area show consistent declines in elevation.

Figure 2-35 shows hydrographs of monitoring wells in the western portion of the Basin, west of Bitter Creek. Hydrographs in this area show that generally, groundwater levels are near the surface near the Cuyama River, and further from the surface to the south, which is uphill from the river. The hydrograph for Well 119 shows a few measurements from 1953 to 1969, and three more recent measurements. All measurements for Well 119 show a depth to water of 60 feet bgs. The hydrograph for Well 846 shows that in 2015 depth to water was slightly above 40 feet and is slightly below 40 feet in 2018. The hydrograph for Well 840 shows a groundwater level near ground surface in 2015, and a decline to 40 feet bgs in 2018. Hydrographs for wells uphill from the river (Wells 573 and 121) show that groundwater is roughly 70 feet bgs in this area. Hydrographs for Wells 571 and 108, at the edge of the Basin have recent measurements, and show groundwater levels that range from 120 to 140 feet bgs.

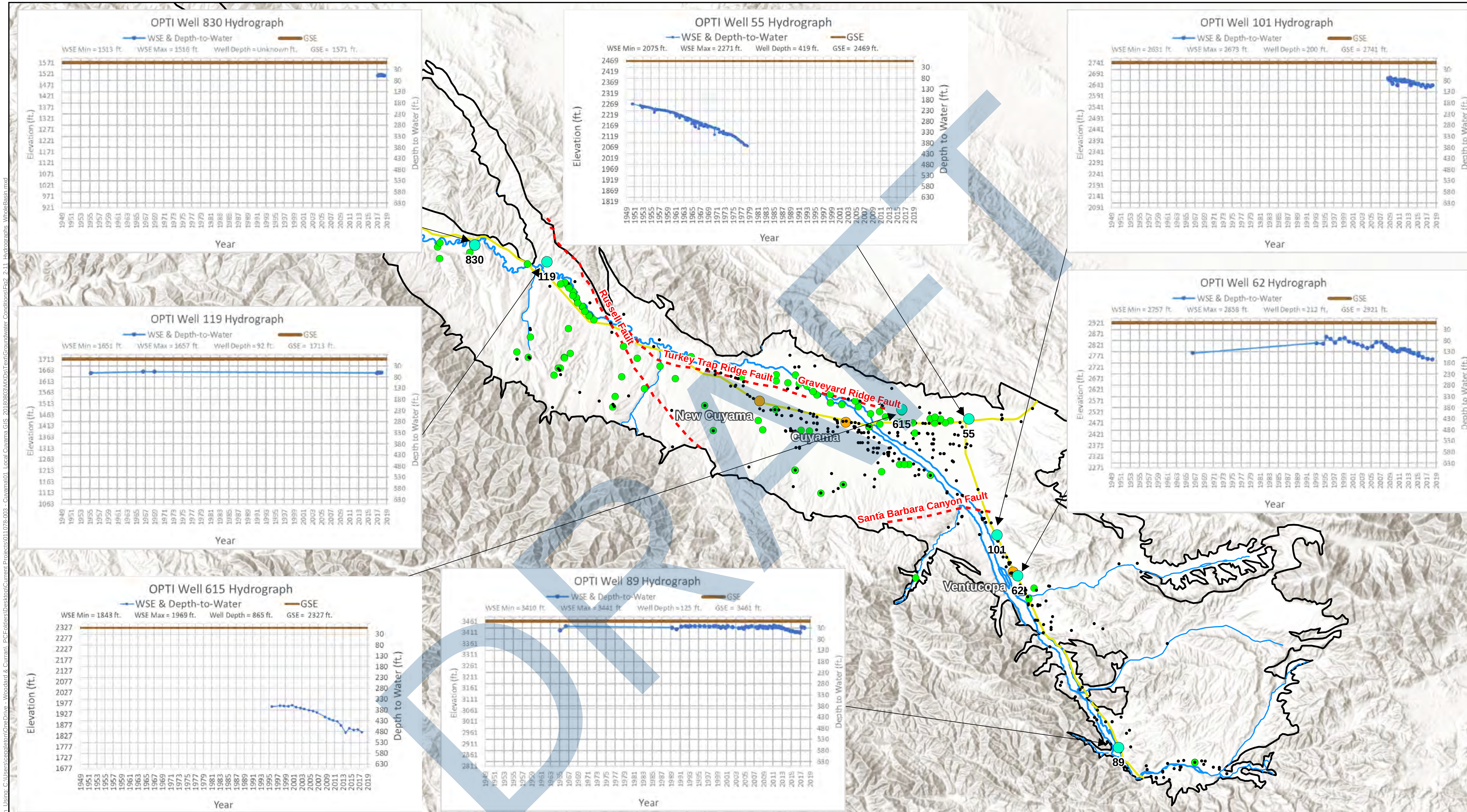


Figure 2-31: Cuyama GW Basin Hydrographs

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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WOODARD & CURRAN

Legend

- Cuyama Basin
- Towns
- Highways
- Cuyama River
- Streams
- Faults
- Hydrographed Wells
- Currently Monitored Wells
- Not Currently Monitored

N

0 2.5 5 10 Miles

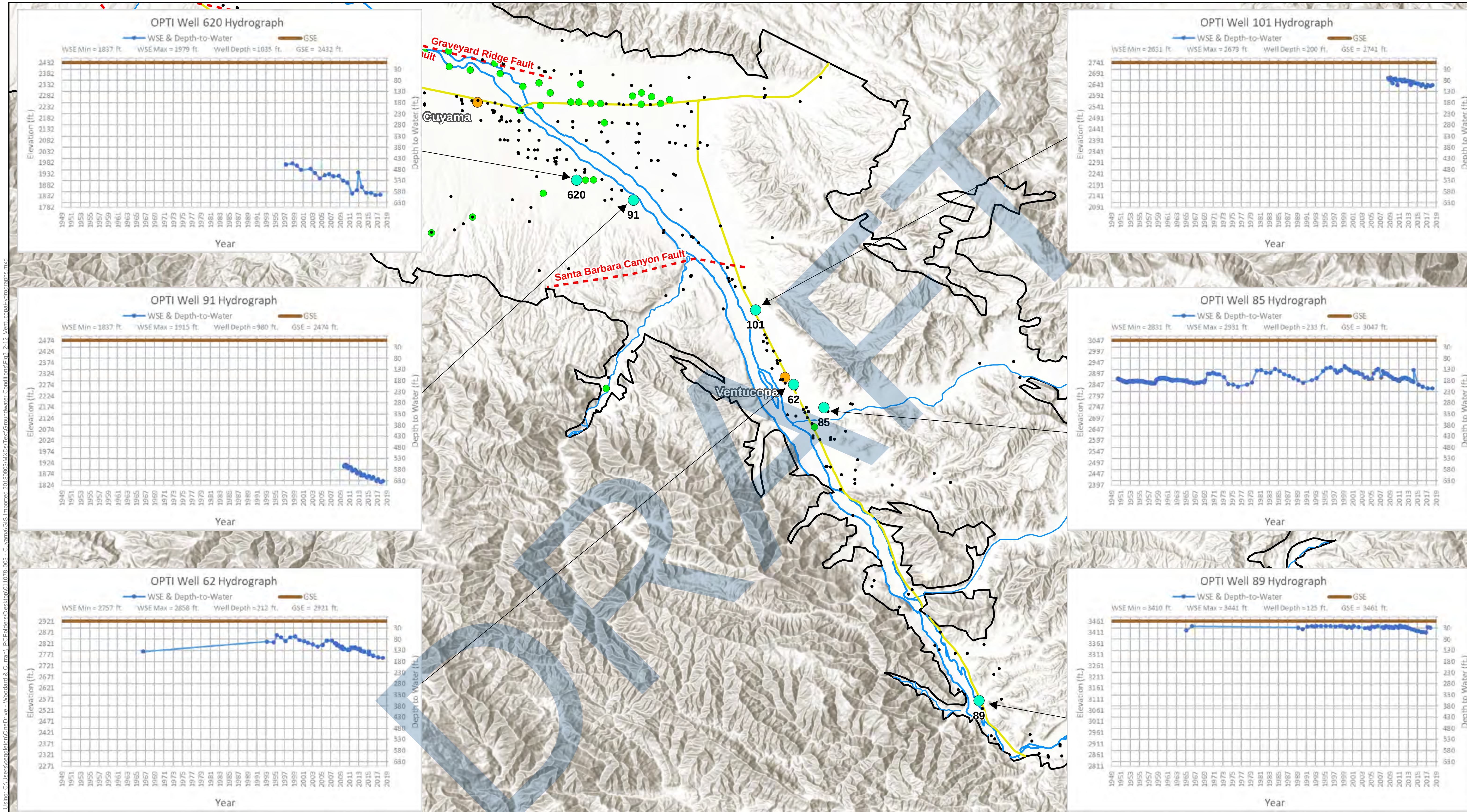

Figure 2-32: Cuyama GW Basin Hydrographs for the Ventucopa Area of the Basin

Cuyama Basin Groundwater Sustainability Agency

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WOODARD & CURRAN

Legend

- Cuyama Basin
- Towns
- Highways
- Cuyama River
- Streams
- Faults
- Hydrographed Wells
- Currently Monitored Wells
- Not Currently Monitored

N

0 1.25 2.5 5 Miles

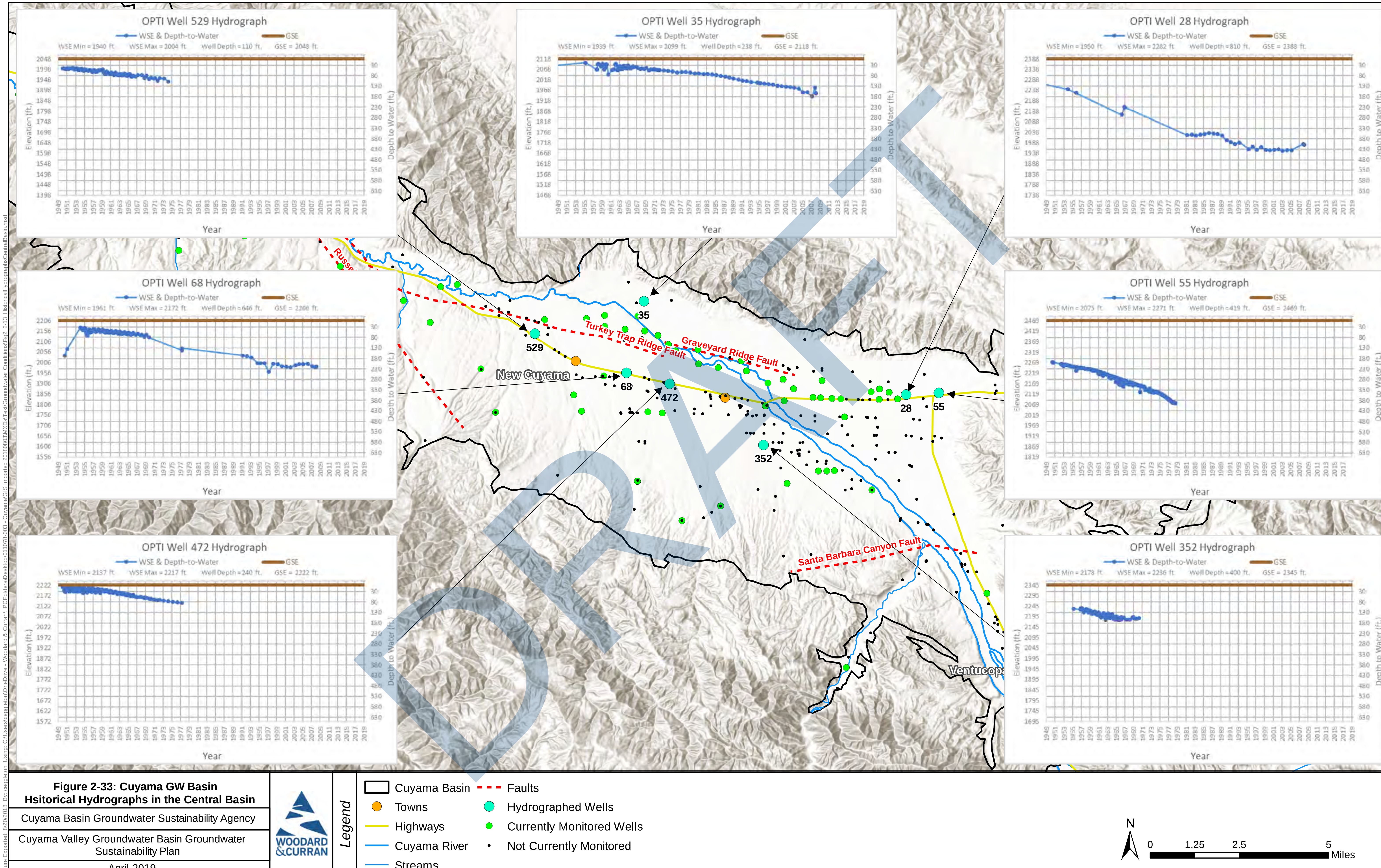

Figure 2-33: Cuyama GW Basin Hsitorical Hydrographs in the Central Basin

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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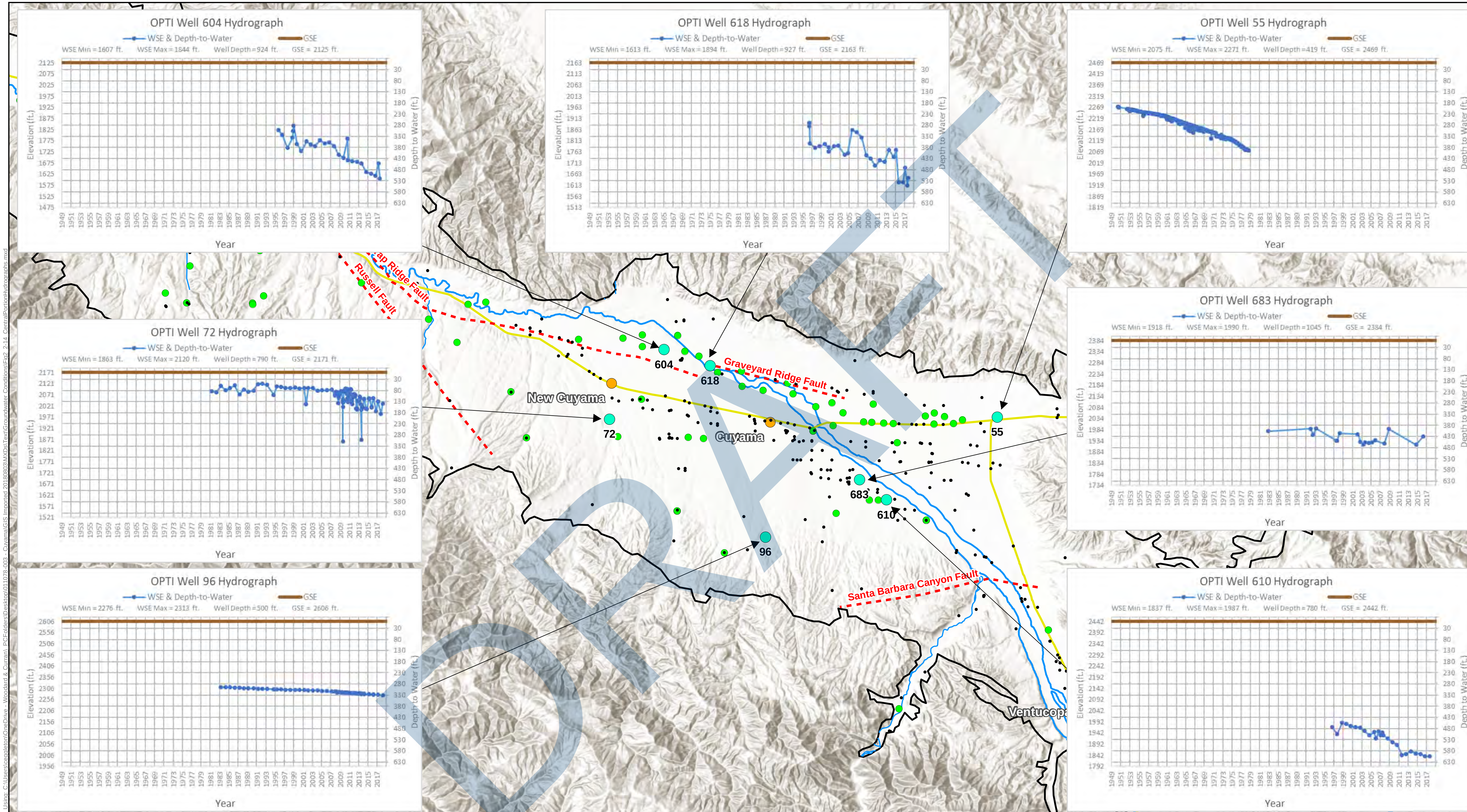

Figure 2-34: Cuyama GW Basin Hydrographs for the Central Portion of the Basin

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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WOODARD & CURRAN

Legend

- Cuyama Basin
- Towns
- Highways
- Cuyama River
- Streams
- Faults
- Hydrographed Wells
- Currently Monitored Wells
- Not Currently Monitored

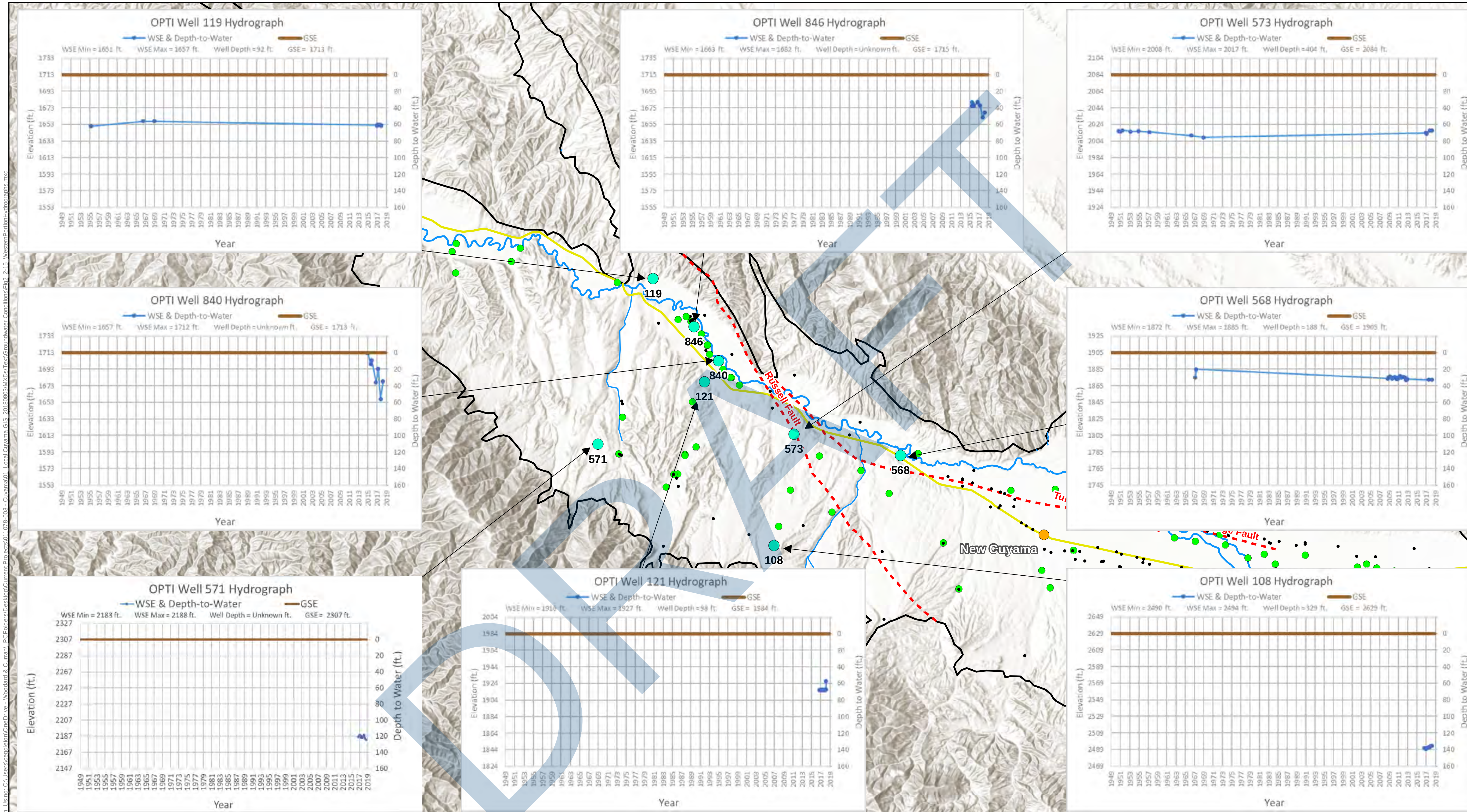

Figure 2-35: Cuyama GW Basin Hydrographs for the Westside Area of the Basin

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

April 2019

WOODARD & CURRAN

Legend

- Cuyama Basin
- Towns
- Highways
- Cuyama River
- Streams
- Faults
- Hydrographed Wells
- Currently Monitored Wells
- Not Currently Monitored

N

0 1.25 2.5 5 Miles

Vertical Gradients

A vertical gradient describes the movement of groundwater perpendicular to the ground surface. A vertical gradient is typically measured by comparing the elevations of groundwater in a well with multiple completions that are of different depths. If groundwater elevations in the shallower completions are higher than in the deeper completions, the gradient is identified as a downward gradient. A downward gradient is one where groundwater is moving down into the ground. If groundwater elevations in the shallower completions are lower than in the deeper completions, the gradient is identified as an upward gradient. An upward gradient is one where groundwater is upwelling towards the surface. If groundwater elevations are similar throughout the completions, there is no vertical gradient to identify. An understanding of the Basin's vertical gradients is required by Section 354.16(a) of the SGMA regulations, and this understanding further describes how groundwater moves in the Basin.

There are three multiple completion wells in the Basin. A multiple completion well includes perforations at multiple intervals, and therefore provides information at multiple depths in the well. Figure 2-23 shows the locations of the multiple completion wells in the Basin, and are located in the central portion of the Basin, north of the SBCF and east of Bitter Creek.

Figure 2-36 shows the combined hydrograph for the multiple completion well CVFR, which was installed by USGS.[4] CVFR is comprised of four completions, each at different depths as follows:

- CVFR-1 is the deepest completion with a screened interval from 960 to 980 feet bgs
- CVFR-2 is the second deepest completion with a screened interval from 810 to 830 feet bgs
- CVFR-3 is the third deepest completion with a screened interval from 680 to 700 feet bgs
- CVFR-4 is the shallowest completion with a screened interval from 590 to 610 feet bgs

The hydrograph of the four completions shows that they are close to the same elevation at each completion, and therefore it is unlikely that there is any vertical gradient at this location.

Figure 2-37 shows the combined hydrograph for the multiple completion well CVBR, which was installed by USGS. CVBR is comprised of four completions, each at different depths as follows:

- CVBR-1 is the deepest completion with a screened interval from 830 to 850 feet bgs
- CVBR-2 is the second deepest completion with a screened interval from 730 to 750 feet bgs
- CVBR-3 is the third deepest completion with a screened interval from 540 to 560 feet bgs
- CVBR-4 is the shallowest completion with a screened interval from 360 to 380 feet bgs

The hydrograph of the four completions shows that at the deeper completions, groundwater elevations are slightly lower than the shallower completions in the winter and spring, and deeper completions are

[4] All three multiple completion wells were installed by the USGS as part of the Cuyama Valley Water Availability Study in cooperation with SBCWA

generally lower than the shallower completion in the summer and fall. This indicates that during the irrigation season, the deeper portions of the aquifer are likely to be where pumping occurs. This pumping removes water from the deeper portion of the aquifer, creating a vertical gradient during the summer and fall. By the spring, enough water has moved down or horizontally to replace removed water, and the vertical gradient is significantly smaller at this location in the spring measurements.

Figure 2-38 shows the combined hydrograph for the multiple completion well CVKR, which was installed by the USGS. CVKR is comprised of four completions, each at different depths as follows:

- CVKR-1 is the deepest completion with a screened interval from 960 to 980 feet bgs
- CVKR-2 is the second deepest completion with a screened interval from 760 to 780 feet bgs
- CVKR-3 is the third deepest completion with a screened interval from 600 to 620 feet bgs
- CVKR-4 is the shallowest completion with a screened interval from 440 to 460 feet bgs

The hydrograph of the four completions shows that at the deeper completions are slightly lower than the shallower completions in the spring at each completion, and deeper completions are generally lower in the summer and fall. This indicates that during the irrigation season, the deeper portions of the aquifer are likely to be where pumping occurs. This pumping removes water from the deeper portion of the aquifer, creating a vertical gradient during the summer and fall. By the winter and spring, enough water has moved down to replace removed water, and the vertical gradient is very small at this location in the spring measurements.

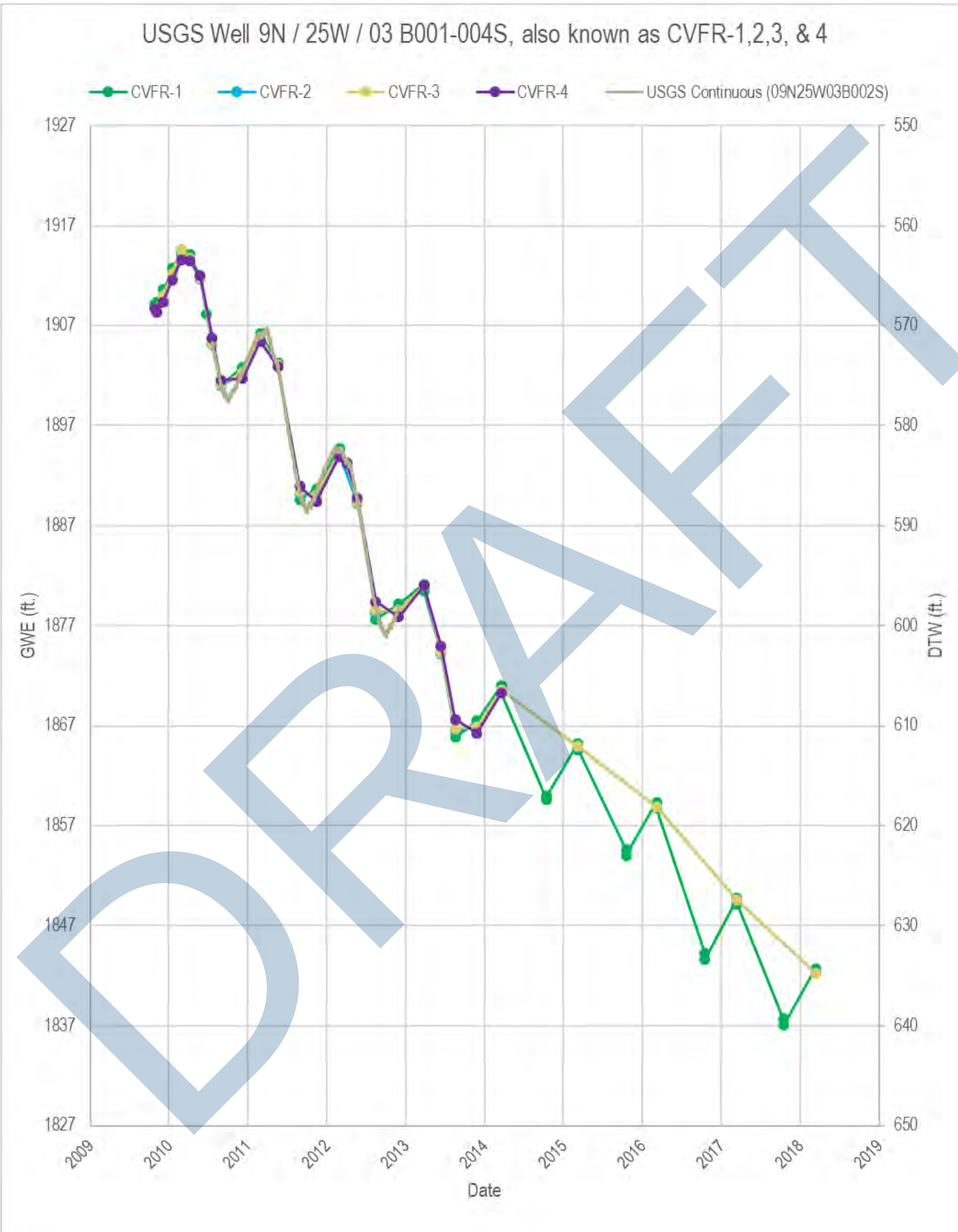

Figure 2-36: Hydrographs of CVFR1-4

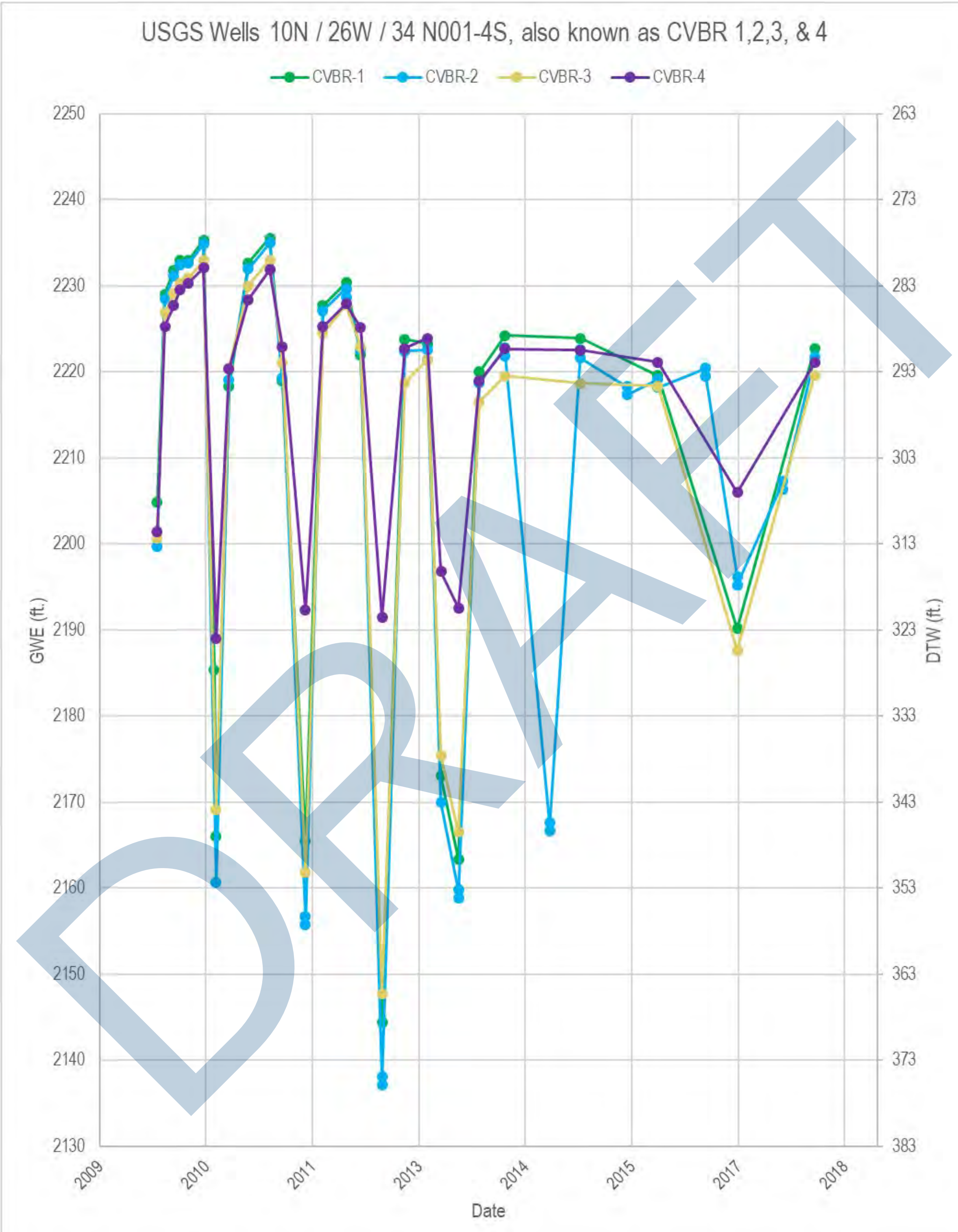

Figure 2-37: Hydrographs of CVBR1-4

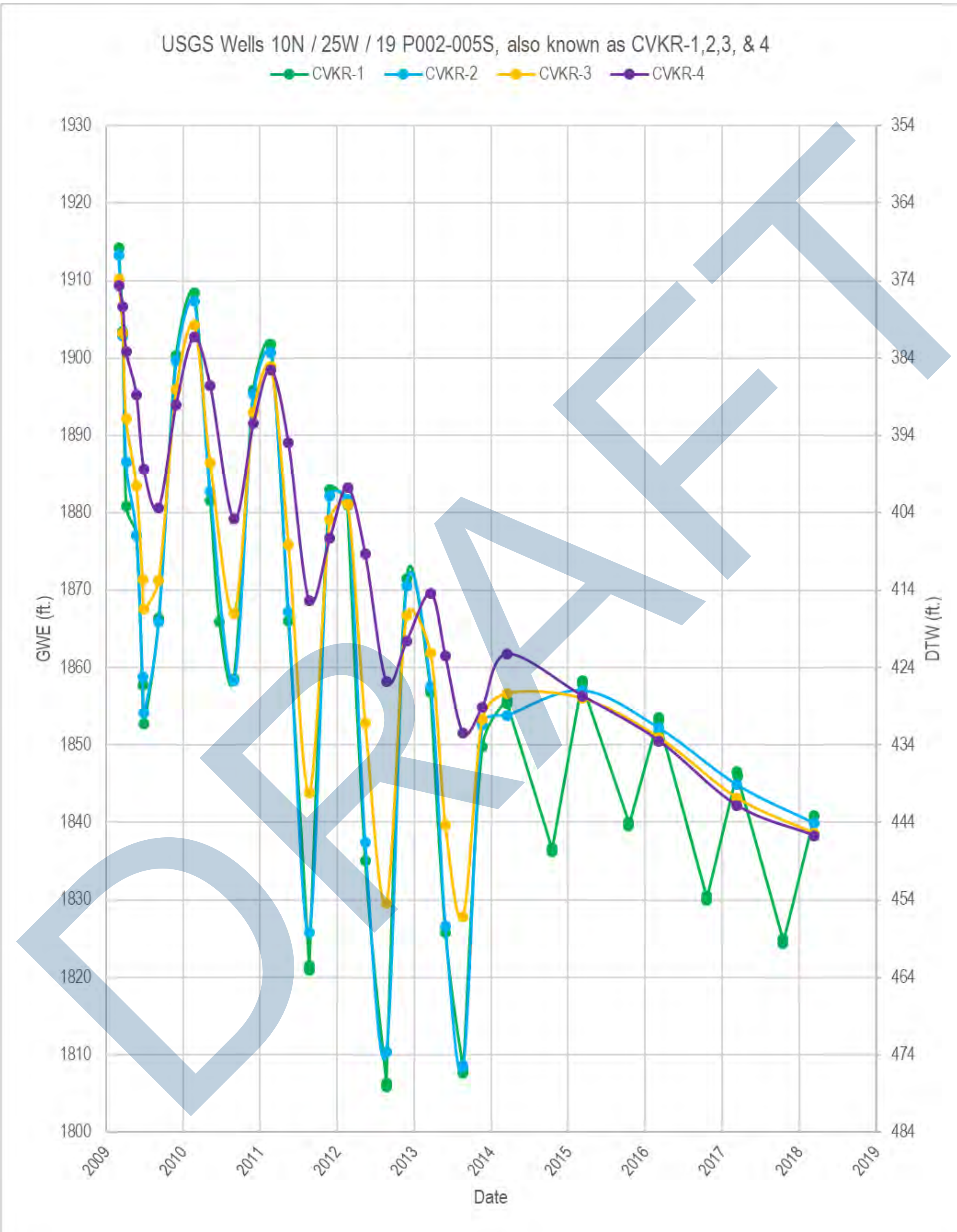

Figure 2-38: Hydrographs of CVKR1-4

Groundwater Contours

Analysts prepared groundwater contour maps to improve understanding of recent groundwater trends in the Basin. Analysts used the data collected and described in Section 2.2.2 to develop these maps. A contour map shows changes in groundwater elevations by interpolating groundwater elevations between monitoring sites. The elevations are shown on the map with the use of a contour line, which indicates that at all locations that line is drawn, the line represents groundwater at the elevation indicated. There are two versions of contour maps used in this section: one that shows the elevation of groundwater above mean sea level, which is useful because it can be used to identify the horizontal gradients of groundwater, and one that shows contours of depth to water, the distance from the ground surface to groundwater, which is useful because it can identify areas of shallow or deep groundwater.

Analysts prepared groundwater contour maps for both groundwater elevation and depth to water for the following periods:

- Spring 2018
- Fall 2017
- Spring 2017
- Spring 2015
- Fall 2014

These years were selected for contours because they are representative of current conditions, and because these years identify conditions near January 1, 2015, when SGMA came into effect. The contour maps are described below.

Each contour map follows the same general format. Each contour map is contoured at a 50-foot contour interval, with contour elevations indicated in white numeric labels, and measurements at individual monitoring points indicated in black numeric labels. Areas where the contours are dashed and not colored in are inferred contours that extend elevations beyond data availability and are included for reference only. The groundwater contours were also based on assumptions in order to accumulate enough data points to generate useful contour maps. Assumptions are as follows:

- Measurements from wells of different depths are representative of conditions at that location and there are no vertical gradients. Due to the limited spatial amount of monitoring points, data from wells of a wide variety of depths were used to generate the contours.
- Measurements from dates that may be as far apart temporally as three months are representative of conditions during the spring or fall season, and conditions have not changed substantially from the time of the earliest measurement used to the latest. Due to the limited temporal amount of measurements in the Basin, data from a wide variety of measurement dates were used to generate the contours.

These assumptions generate contours that are useful at the planning level for understanding groundwater levels across the Basin, and to identify general horizontal gradients and regional groundwater level trends. The contour maps are not indicative of exact values across the Basin because groundwater contour maps approximate conditions between measurement points, and do not account for topography. Therefore, a well on a ridge may be farther from groundwater than one in a canyon, and the contour map will not reflect that level of detail.

Expansion and improvement of the monitoring network to generate a more accurate understanding of groundwater trends in the Basin is discussed in Chapter 4.

Figure 2-39 shows groundwater elevation contours for spring of 2018, along with arrows showing the direction of groundwater flow. In the southeastern portion of the Basin near Ventucopa, groundwater has a horizontal gradient to the northwest. The gradient increases in the vicinity of the SBCF and flows to an area of lowered groundwater elevation southeast of the town of Cuyama. From the town of New Cuyama to the west, groundwater has a horizontal gradient that generally flows to the northeast, from areas with higher elevation topography towards areas with lower elevation topography where the Cuyama River is located.

Figure 2-40 shows depth to groundwater contours for spring of 2018. Just south the SBCF, groundwater is near 100 feet bgs. North of the SBCF, depth to groundwater declines rapidly and is over 600 feet bgs. Depth to groundwater reduces to the west towards New Cuyama, where groundwater is around 150 feet bgs. West of Bitter Creek, groundwater is shallower than 100 feet bgs in most locations, and is shallower than 50 feet bgs in the far west and along the Cuyama River.

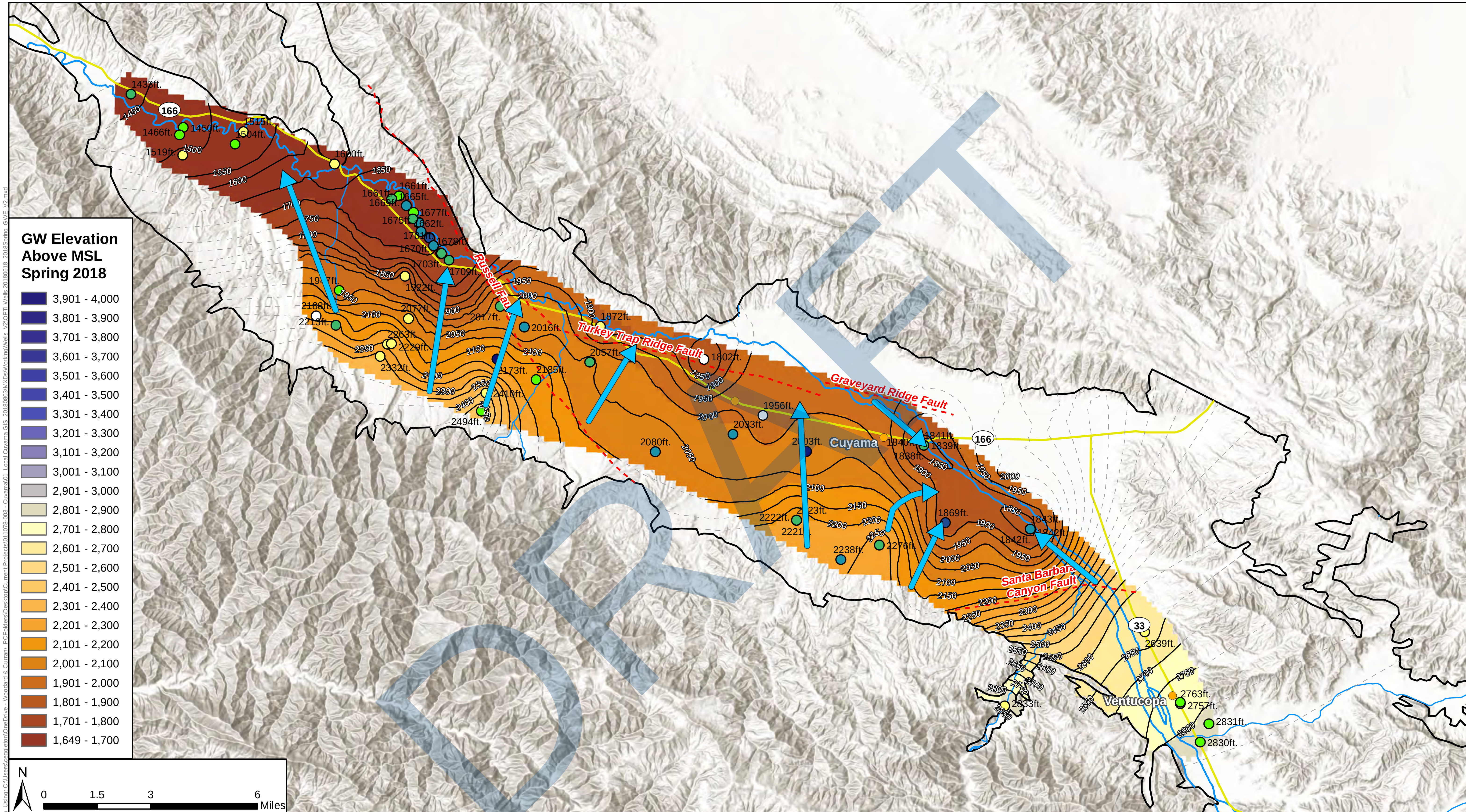

Figure 2-39: Cuyama GW Basin Wells by Groundwater Surface Elevation

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

April 2019

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Legend

- Cuyama Basin
- Cuyama River
- Faults
- Groundwater Elevation Above MSL
- Inferred Groundwater Elevation Above MSL
- Groundwater Flow Direction

Well Depth Below GSE

- Unknown
- 0 - 200 ft
- 200 - 400 ft
- 400 - 600 ft
- 600 - 800 ft
- 800 - 1,000 ft
- 1,000 - 1,200 ft

Contours were interpolated using data measured from 2/1/2018 - 4/30/2018 due to limited data availability.

Contours Interval: 50 ft.

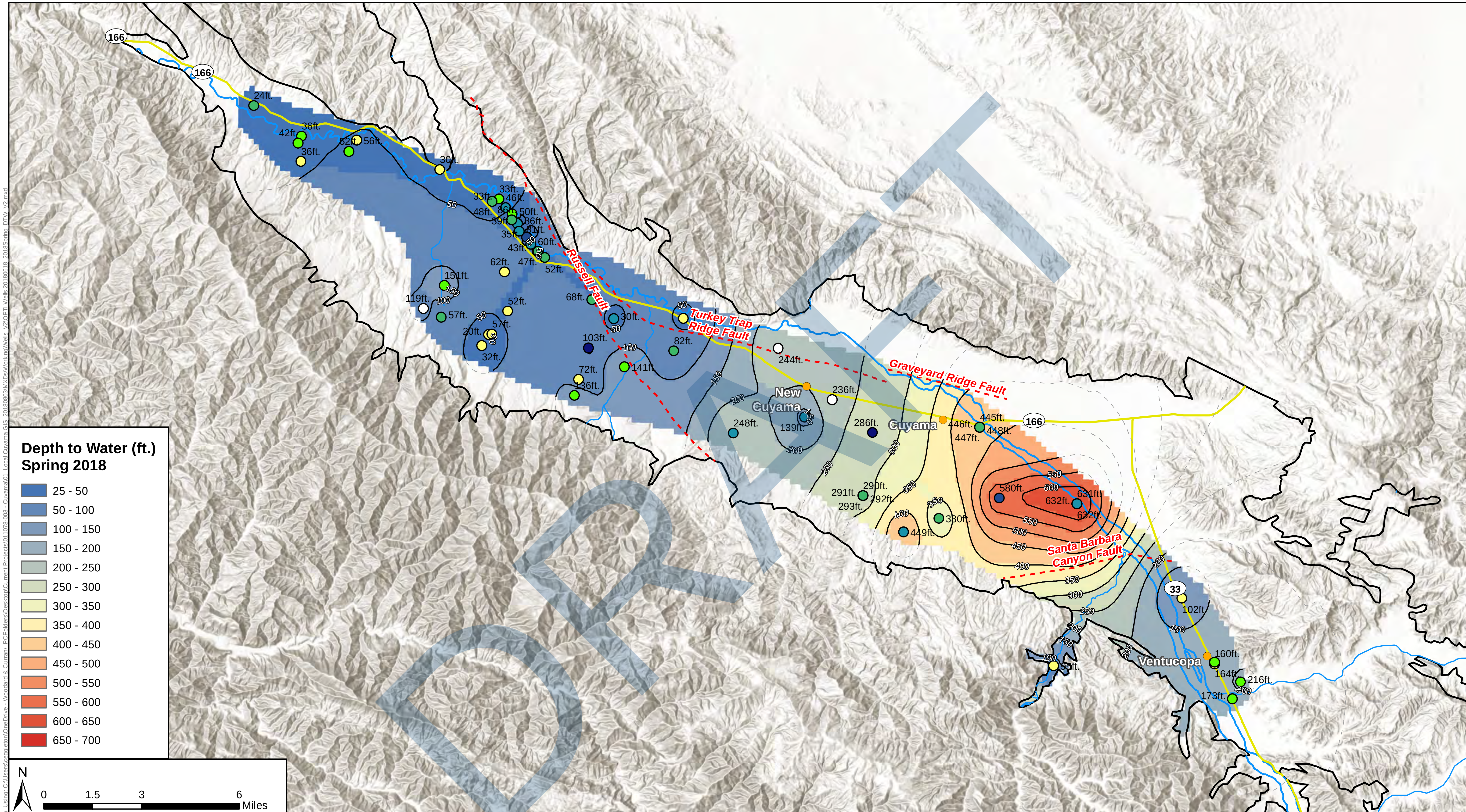

Figure 2-40: Cuyama GW Basin Wells by Depth to Water

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

April 2019

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Legend

- Cuyama Basin
- Cuyama River
- Faults
- Groundwater Depth-to-Water Contours below Groundsurface
- Inferred Groundwater Depth-to-Water Contours below Groundsurface

Well Depth Below GSE

- Unknown
- 0 - 200 ft
- 200 - 400 ft
- 400 - 600 ft
- 600 - 800 ft
- 800 - 1,000 ft
- 1,000 - 1,200 ft

Contours were interpolated using data measured from 2/1/2018 - 4/30/2018 due to limitated data availability.

Contours Interval: 50 ft.

The remaining contour maps for spring 2017, fall 2017, spring 2015, and fall 2014 are shown below. These dates were selected to show the changes over the most recent period of three years for which data were available in the spring (from 2015 to 2018) and from the fall (from 2014 to 2017).

Figure 2-41 shows groundwater elevation contours for fall of 2017. Because more data were available in this time frame, the contour map shows increased detail in some areas. In the southeastern portion of the Basin near the Ozena fire station, groundwater gradients appear to indicate flows that follow the Cuyama River. The contour map shows a steep gradient across the SBCF and flows to an area of lowered groundwater elevation northeast of the town of Cuyama. From the town of New Cuyama to the west, groundwater has a horizontal gradient that generally flows to the northeast, from areas with higher elevation topography towards areas with lower elevation topography where the Cuyama River is located.

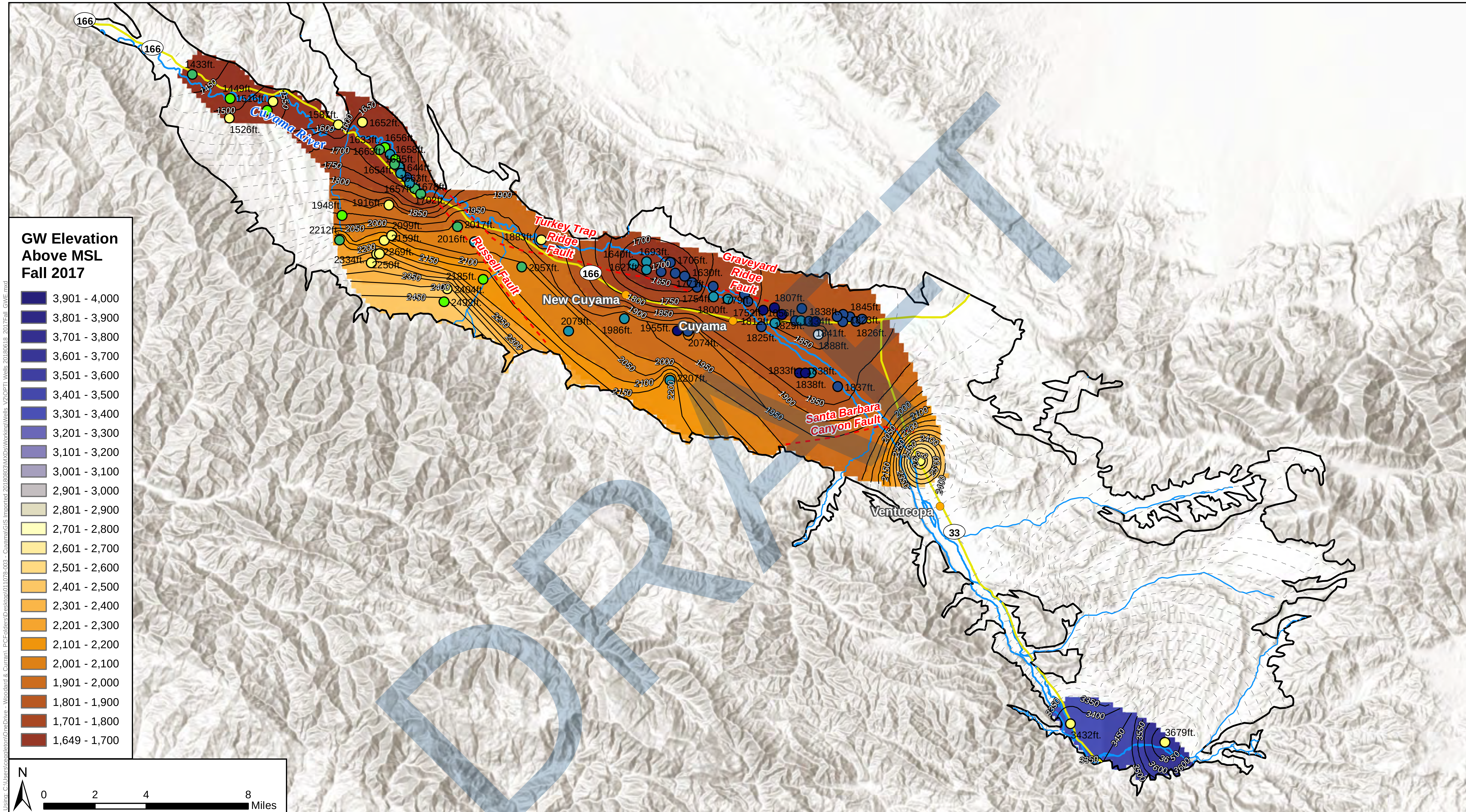

Figure 2-41: Fall 2017 Groundwater Elevation

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- Cuyama River
- Faults
- Groundwater Elevation Above MSL
- Inferred Groundwater Elevation Above MSL

Well Depth Below GSE

- Unknown
- 0 - 200 ft
- 200 - 400 ft
- 400 - 600 ft
- 600 - 800 ft
- 800 - 1,000 ft
- 1,000 - 1,200 ft

Contours were interpolated using data measured from 8/1/2017 - 11/30/2017 due to limitaed data availbility.

Contours Interval: 50 ft.

Figure 2-42 shows depth to water contours for fall of 2017. Because more data were available in this time frame, the contour map has increased detail in some areas. In the southeastern portion of the Basin near the Ozena fire station, depth to water is under 50 feet bgs. There is a steep gradient near the SBCF, and groundwater is below 600 feet bgs immediately northwest of the SBCF. The central portion of the Basin generally has a depth to water between 400 and 500 feet bgs, with depth to groundwater decreasing to the west of New Cuyama. West of Bitter Creek, groundwater is generally shallower than 100 feet below bgs, and is shallower than 50 feet bgs along the Cuyama River in most cases.

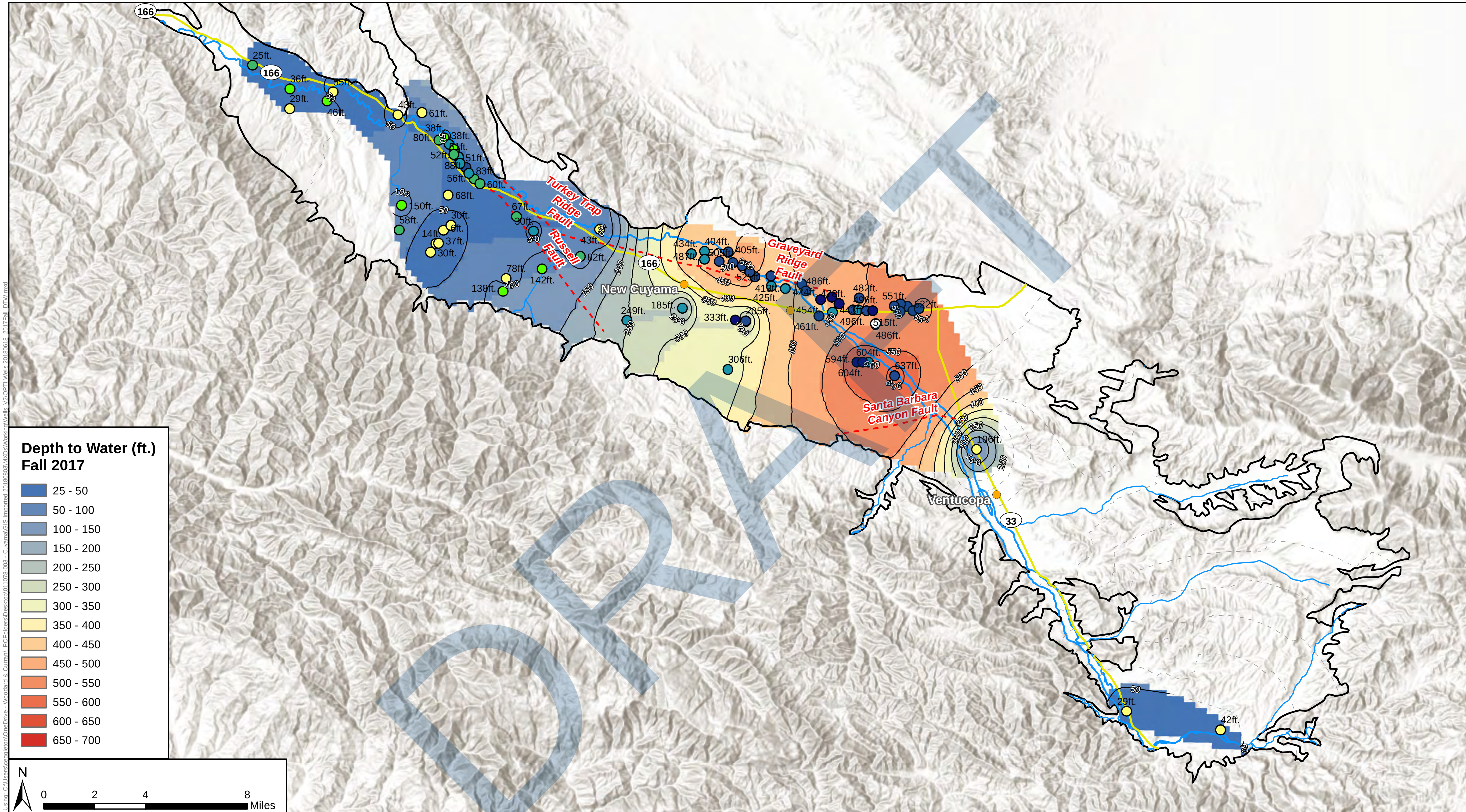

Figure 2-42: Fall 2017
Depth to Water

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

April 2019

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Legend

- Cuyama Basin
- Cuyama River
- Faults
- Groundwater Depth-to-Water Contours below Groundsurface
- Inferred Groundwater Depth-to-Water Contours Below Groundsuface

Well Depth Below GSE

- Unknown
- 0 - 200 ft
- 200 - 400 ft
- 400 - 600 ft
- 600 - 800 ft
- 800 - 1,000 ft
- 1,000 - 1,200 ft

Contours were interpolated using data measured from 8/1/2017 - 11/30/2017 due to limitated data availability.

Contours Interval: 50 ft.

Figure 2-43 shows groundwater elevation contours for spring of 2017. Because more data were available in this time frame, the contour map has increased detail in some areas. In the southeastern portion of the Basin near the Ozena fire station, groundwater gradients appear to indicate flows that follow the Cuyama River. The contour map shows a steep gradient across the SBCF and flows to an area of lowered groundwater elevation northeast of the town of Cuyama. From the town of New Cuyama to the west, groundwater has a horizontal gradient that generally flows to the northeast, from areas with higher elevation topography towards areas with lower elevation topography where the Cuyama River is located.

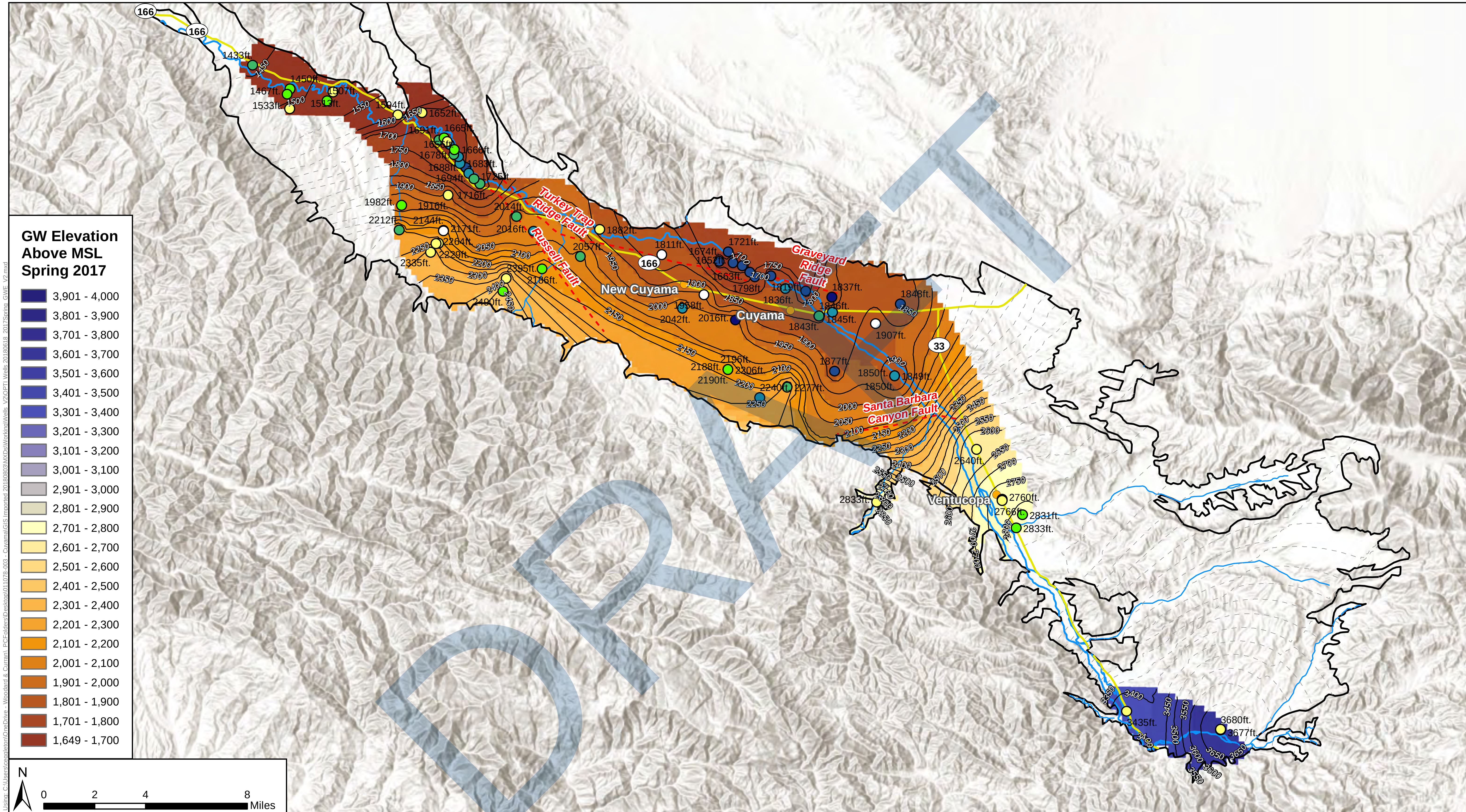

Figure 2-43: Spring 2017 Groundwater Elevation

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- Cuyama River
- Faults
- Groundwater Elevation Above MSL
- Inferred Groundwater Elevation Above MSL

Well Depth Below GSE

- Unknown
- 0 - 200 ft
- 200 - 400 ft
- 400 - 600 ft
- 600 - 800 ft
- 800 - 1,000 ft
- 1,000 - 1,200 ft

Contours were interpolated using data measured from 1/1/2017 - 4/30/2017 due to limitated data availability.

Contours Interval: 50 ft.

Figure 2-44 shows depth to water contours for spring of 2017. In the southeastern portion of the Basin near the Ozena fire station, depth to water is under 50 feet bgs. Depth to groundwater near Ventucopa is between 150 and 200 feet bgs. There is a steep gradient near the SBCF, and groundwater is below 600 feet bgs immediately northwest of the SBCF. The central portion of the Basin generally has a depth to water between 350 and 500 feet bgs, with depth to groundwater decreasing to the west of New Cuyama. West of Bitter Creek, groundwater is generally shallower than 100 feet below bgs, and is shallower than 50 feet bgs along the Cuyama River in most cases.

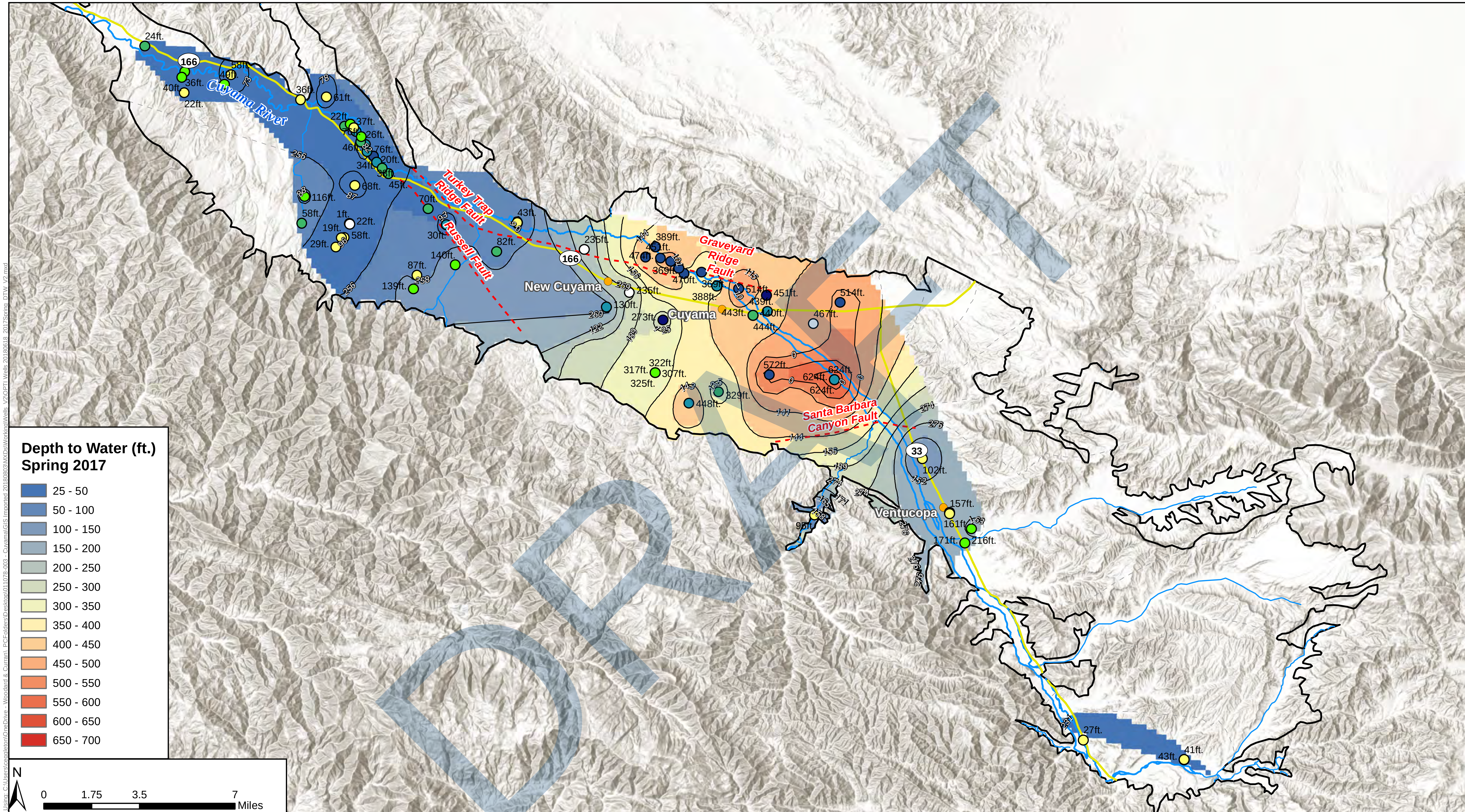

Figure 2-44: Spring 2017
Depth to Water

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- Cuyama River
- Faults
- Groundwater Depth-to-Water Contours Below Groundsurface
- Inferred Groundwater Depth-to-Water Contours Below Groundsurface

Well Depth Below GSE

- Unknown
- 0 - 200 ft
- 200 - 400 ft
- 400 - 600 ft
- 600 - 800 ft
- 800 - 1,000 ft
- 1,000 - 1,200 ft

Contours were interpolated using data measured from 1/1/2017 - 4/30/2017 due to limitated data availability.

Contours Interval: 50 ft.

Figure 2-45 shows groundwater elevation contours for spring of 2015. In the southeastern portion of the Basin near the Ozena fire station, groundwater gradients appear to indicate flows that follow the Cuyama River. The contour map shows a steep gradient across the SBCF and flows to an area of lowered groundwater elevation northeast of the town of Cuyama. From the town of New Cuyama to the west, the limited number of data points restrict strong interpretation of the gradient, which is to the northwest.

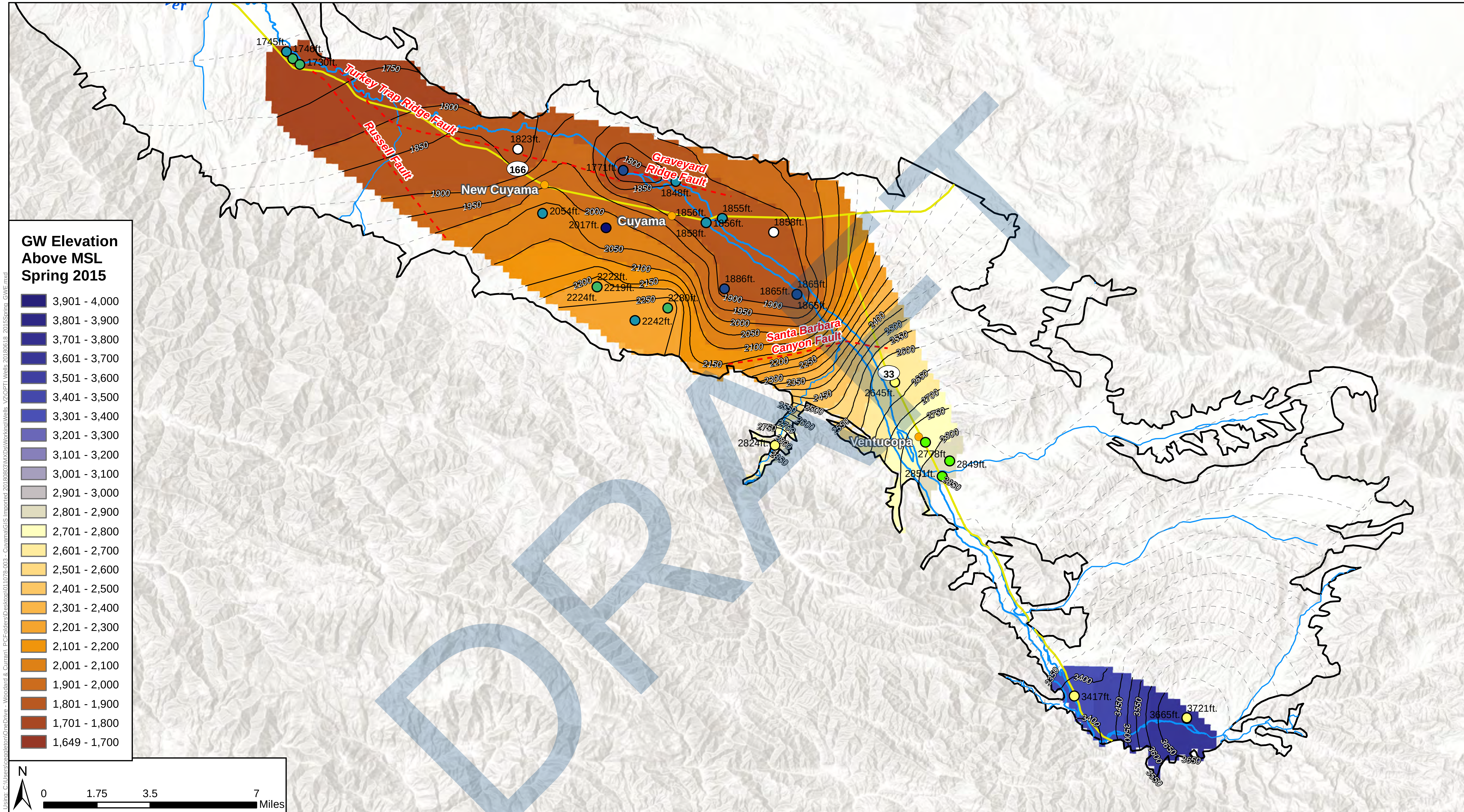

Figure 2-45: *Spring 2015 Groundwater Elevation*

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- Cuyama River
- Faults
- Groundwater Elevation Above MSL
- Inferred Groundwater Elevation Above MSL

Well Depth Below GSE

- Unknown
- 0 - 200 ft
- 200 - 400 ft
- 400 - 600 ft
- 600 - 800 ft
- 800 - 1,000 ft
- 1,000 - 1,200 ft

Contours were interpolated using data measured from 2/1/2015 - 4/30/2015 due to limitated data availability.

Contours Interval: 50 ft.

Figure 2-46 shows depth to water contours for spring of 2015. In the southeastern portion of the Basin near the Ozena fire station, depth to water is under 50 feet bgs. Depth to groundwater near Ventucopa is between 150 and 200 feet bgs. There is a steep gradient near the SBCF, and groundwater is below 600 feet bgs immediately northwest of the SBCF. The central portion of the Basin generally has a depth to water between 350 and 450 feet bgs, with groundwater levels rising to the west of New Cuyama. These depths are in general less severe than those shown for the spring of 2017, reflecting deepening depth to groundwater conditions in the central portion of the Basin. Interpretation from New Cuyama to monitoring points in the northwest is hampered by a limited set of data points.

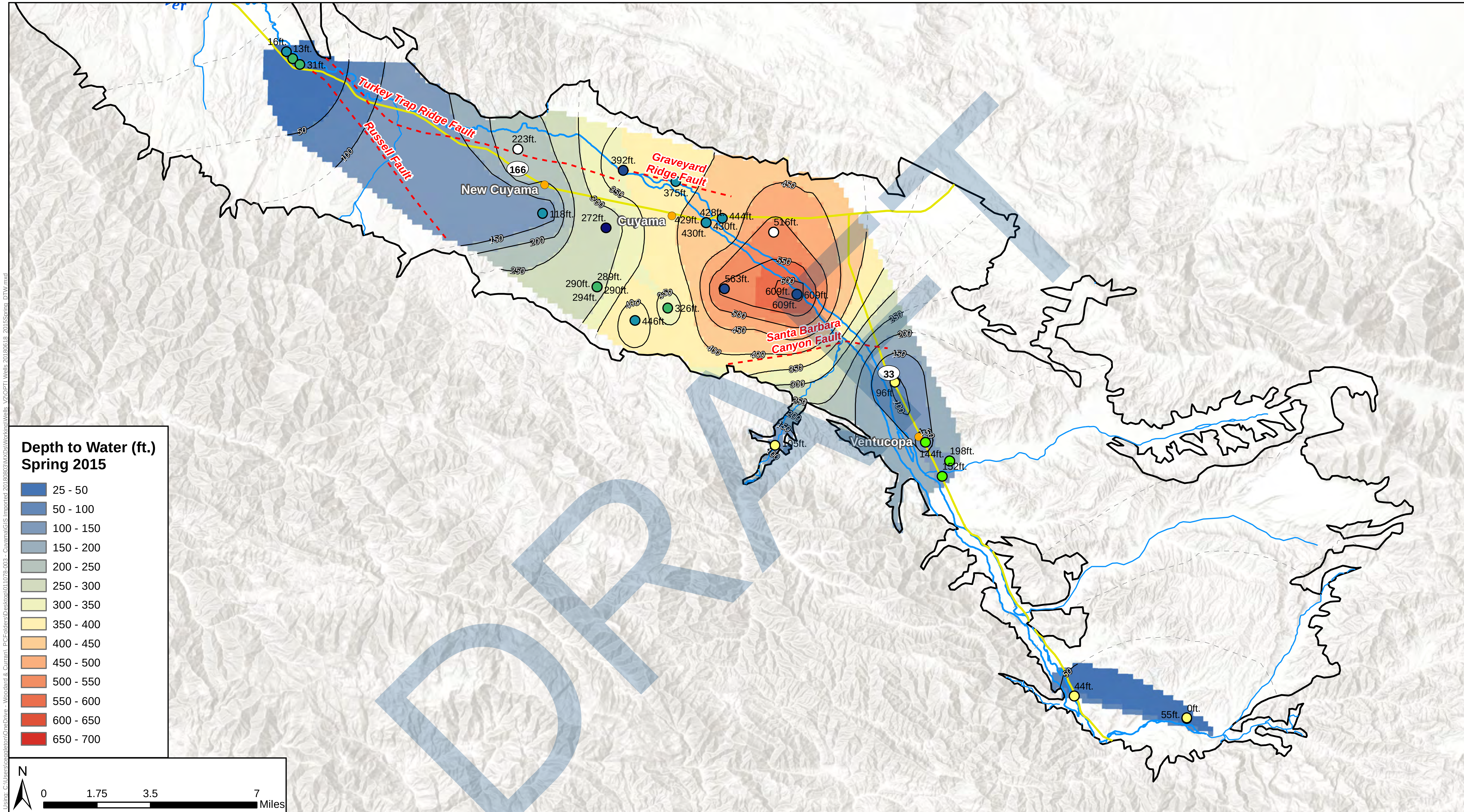

Figure 2-46: Spring 2015
Depth to Water

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- Cuyama River
- Faults
- Groundwater Depth-to-Water Contours below Groundsurface
- Inferred Groundwater Depth-to-Water Contours below Groundsurface

Well Depth Below GSE

- Unknown
- 0 - 200 ft
- 200 - 400 ft
- 400 - 600 ft
- 600 - 800 ft
- 800 - 1,000 ft
- 1,000 - 1,200 ft

Contours were interpolated using data measured from 2/1/2015 - 4/30/2015 due to limitated data availability.

Contours Interval: 50 ft.

Figure 2-47 shows groundwater elevation contours for fall of 2014. In the southeastern portion of the Basin near the Ozena fire station, groundwater gradients appear to indicate flows that follow the Cuyama River. The contour map shows a steep gradient across the SBCF and flows to an area of lowered groundwater elevation northeast of the town of Cuyama.

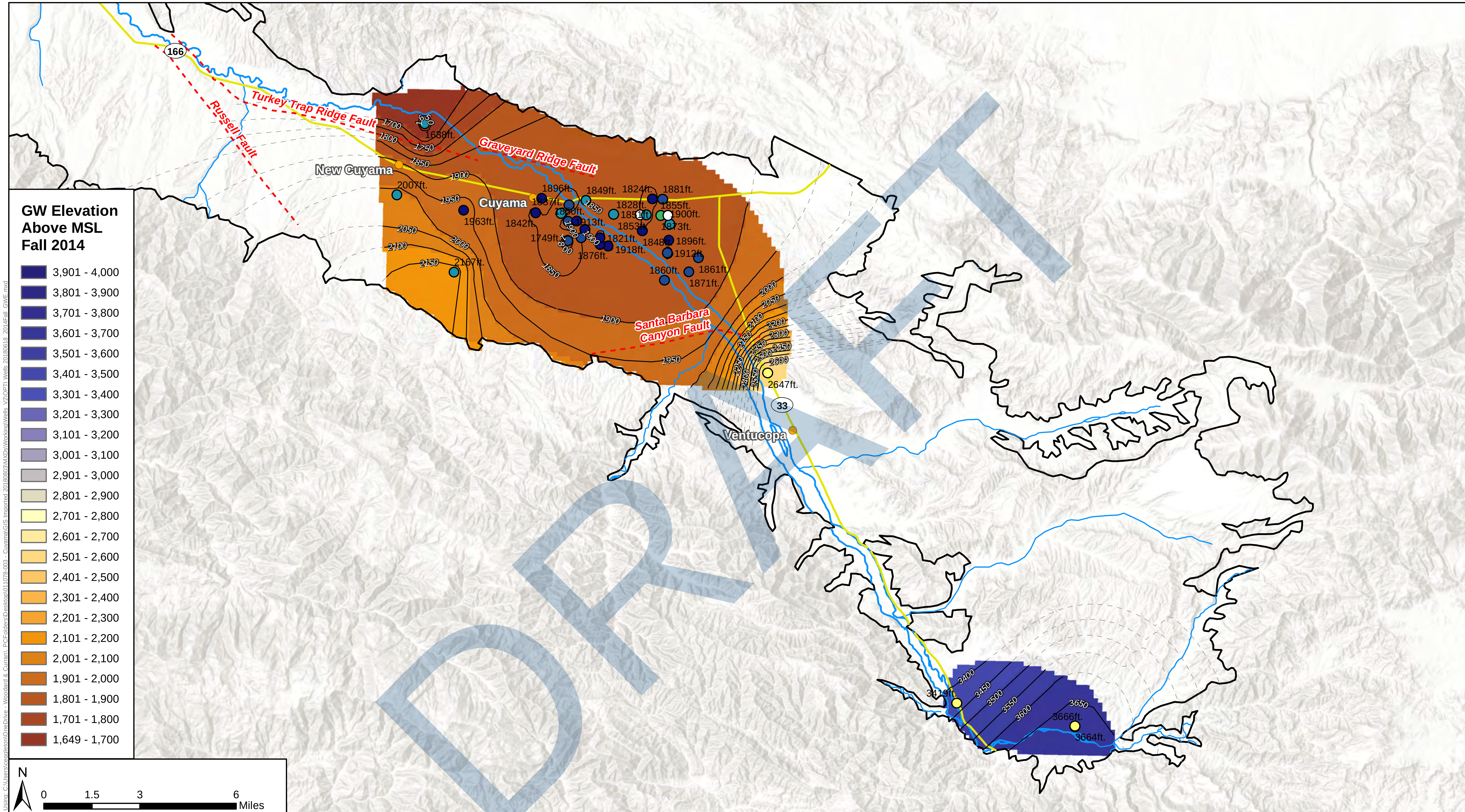

Figure 2-47: *Fall 2014 Groundwater Elevation*

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- Cuyama River
- Faults
- Groundwater Elevation Above MSL
- Inferred Groundwater Elevation Above MSL

Well Depth Below GSE

- Unknown
- 0 - 200 ft
- 200 - 400 ft
- 400 - 600 ft
- 600 - 800 ft
- 800 - 1000 ft
- 1,000 - 1,200 ft

Contours were interpolated using data measured from 9/1/2014 - 11/30/2014 due to limitated data availability.

Contours Interval: 50 ft.

Figure 2-48 shows depth to water contours for fall of 2014. In the southeastern portion of the Basin near the Ozena fire station, depth to water is under 50 feet bgs. There is a steep gradient near the SBCF, and groundwater is below 600 feet bgs immediately northwest of the SBCF. The central portion of the Basin generally has a depth to water between 350 and 500 feet bgs, with groundwater levels rising to the west of New Cuyama. These depths are in general less severe than those shown for the fall of 2017, reflecting depth to groundwater conditions in the central portion of the Basin. Interpretation from New Cuyama to monitoring points in the northwest is hampered by a limited set of data points.

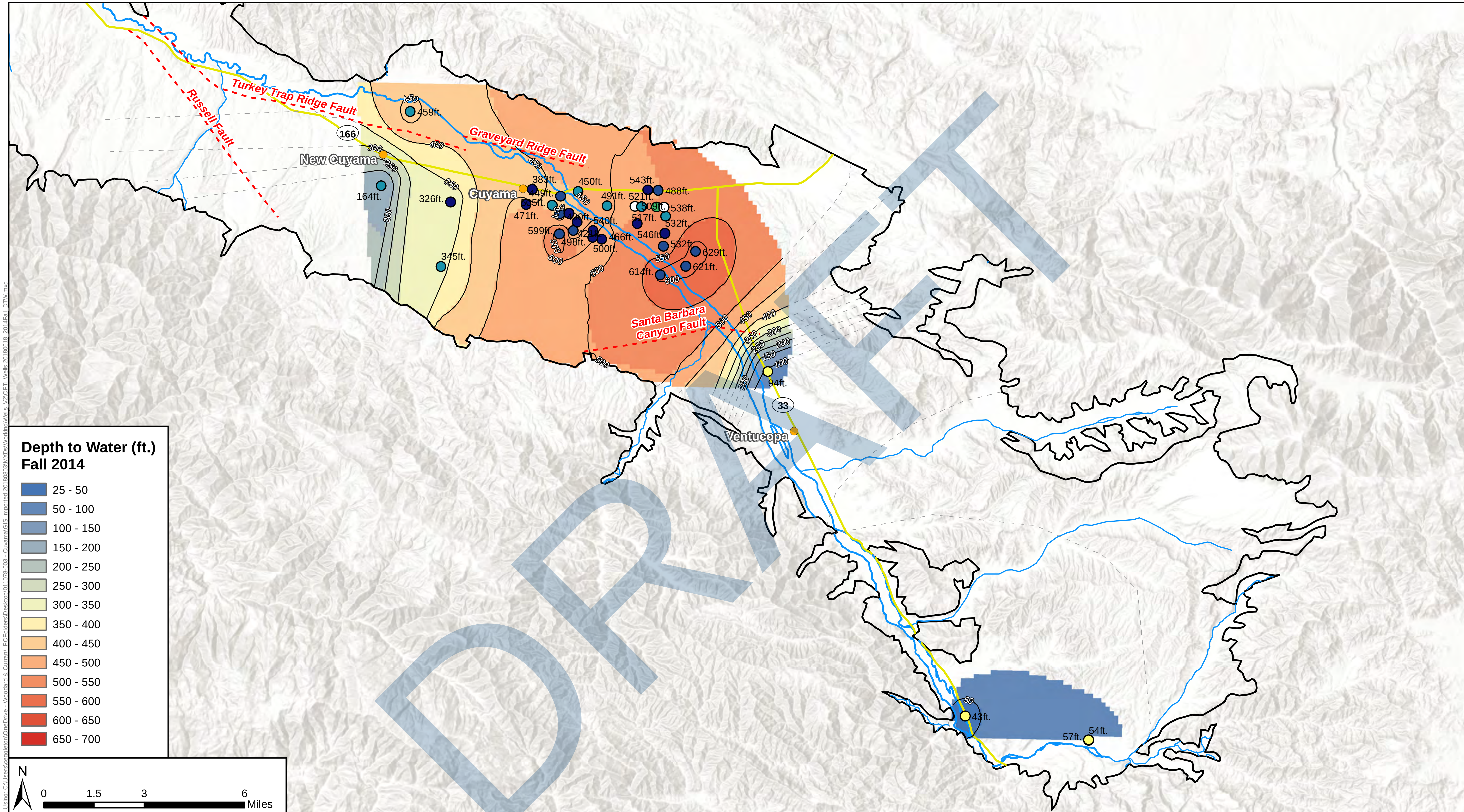

Figure 2-48: Fall 2014 Depth to Water

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- Cuyama River
- Faults
- Groundwater Depth-to-Water Contours below Groundsurface
- Inferred Groundwater Depth-to-Water Contours below Groundsurface

Well Depth Below GSE

- Unknown
- 0 - 200 ft
- 200 - 400 ft
- 400 - 600 ft
- 600 - 800 ft
- 800 - 1000 ft
- 1,000 - 1,200 ft

Contours were interpolated using data measured from 9/1/2014 - 11/30/2014 due to limitated data availability.

Contours Interval: 50 ft.

2.2.4 Change in Groundwater Storage

Historical change in Basin groundwater storage has shown a consistent decline. Figure 2-49 shows change in storage by year, water year type,[5] and cumulative water volume for the last 20 years. Change in storage was calculated using the Cuyama Basin Water Resources Model (CBWRM). Average annual use over the 20-year period was -23,076 acre-feet. The color of bar for each year of change in storage correlates a water year type defined by Basin precipitation. Change in storage is negative in 18 of the 20 years, and was negative during two of three wet years, as designated by the water year type.

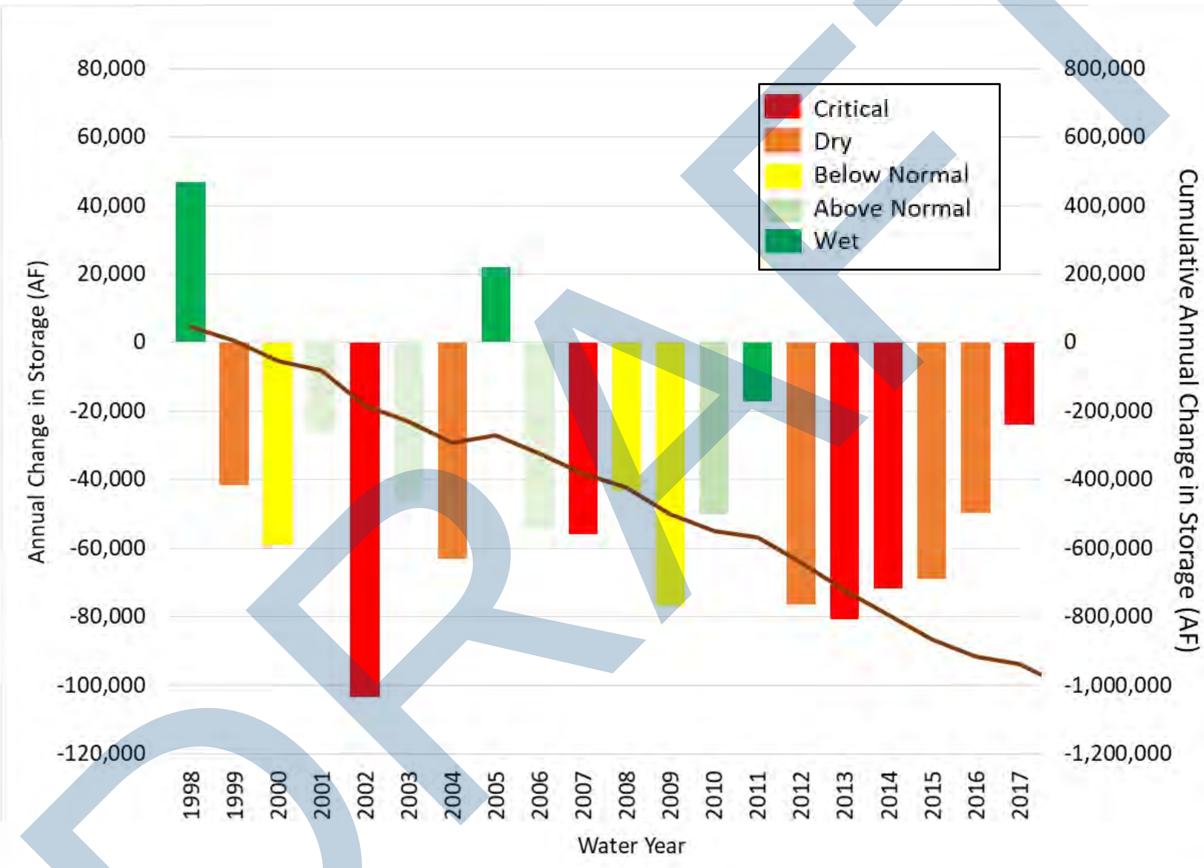

Figure 2-49. Cuyama Groundwater Storage by Year, Water Year Type, and Cumulative Water Volume

[5] Water year types are customized for the Basin watershed based on annual precipitation as follows:

- Wet year = more than 19.6 inches
- Above normal year = 13.1 to 19.6 inches
- Below normal year = 9.85 to 13.1 inches
- Dry year = 6.6 to 9.85 inches
- Critical year = less than 6.6 inches.

2.2.5 Seawater Intrusion

Seawater intrusion is not an applicable sustainability indicator, because seawater intrusion is not present in the Basin and is not likely to occur due to the distance between the Basin and the Pacific Ocean, its bays, deltas, or inlets.

2.2.6 Land Subsidence

In 2015, USGS measured land subsidence as part of its technical analysis of the Cuyama Valley. USGS used two continuous global positioning systems (GPS) sites and five reference point InSAR sites, shown in Figure 2-50 (USGS, 2015). There are 308 monthly observations from 2000 to 2012, and total subsidence from 2000 to 2012 ranged from 0.0 to 0.4 feet. USGS simulated subsidence using the CUVHM, and estimated that inelastic subsidence began in the late 1970s (USGS, 2015).

Subsidence data were collected from the University NAVSTAR Consortium (UNAVCO) database. UNAVCO maintains data on five GPS monitoring stations in the area in and around the Basin. Figure 2-43 shows the monitoring stations and their measurements since 1999. Three stations (P521, OZST, and BCWR) are located just outside the Basin. The three stations' measurements show ground surface level as either staying constant or slightly increasing. The increase is potentially due to tectonic activity in the region. Two stations (VCST and CUHS) are located within the Basin. Station VCST is located near Ventucopa and indicates that subsidence is not occurring in that area. Station CUHS indicates that 300 millimeters (approximately 12 inches) of subsidence have occurred in the vicinity of New Cuyama over the 19 years that were monitored. The subsidence at this station increases in magnitude following 2010, and generally follows a seasonal pattern. The seasonal pattern is possibly related to water level drawdowns during the summer, and elastic rebound occurring during winter periods.

A white paper that provides information about subsidence and subsidence monitoring techniques is in Appendix B.

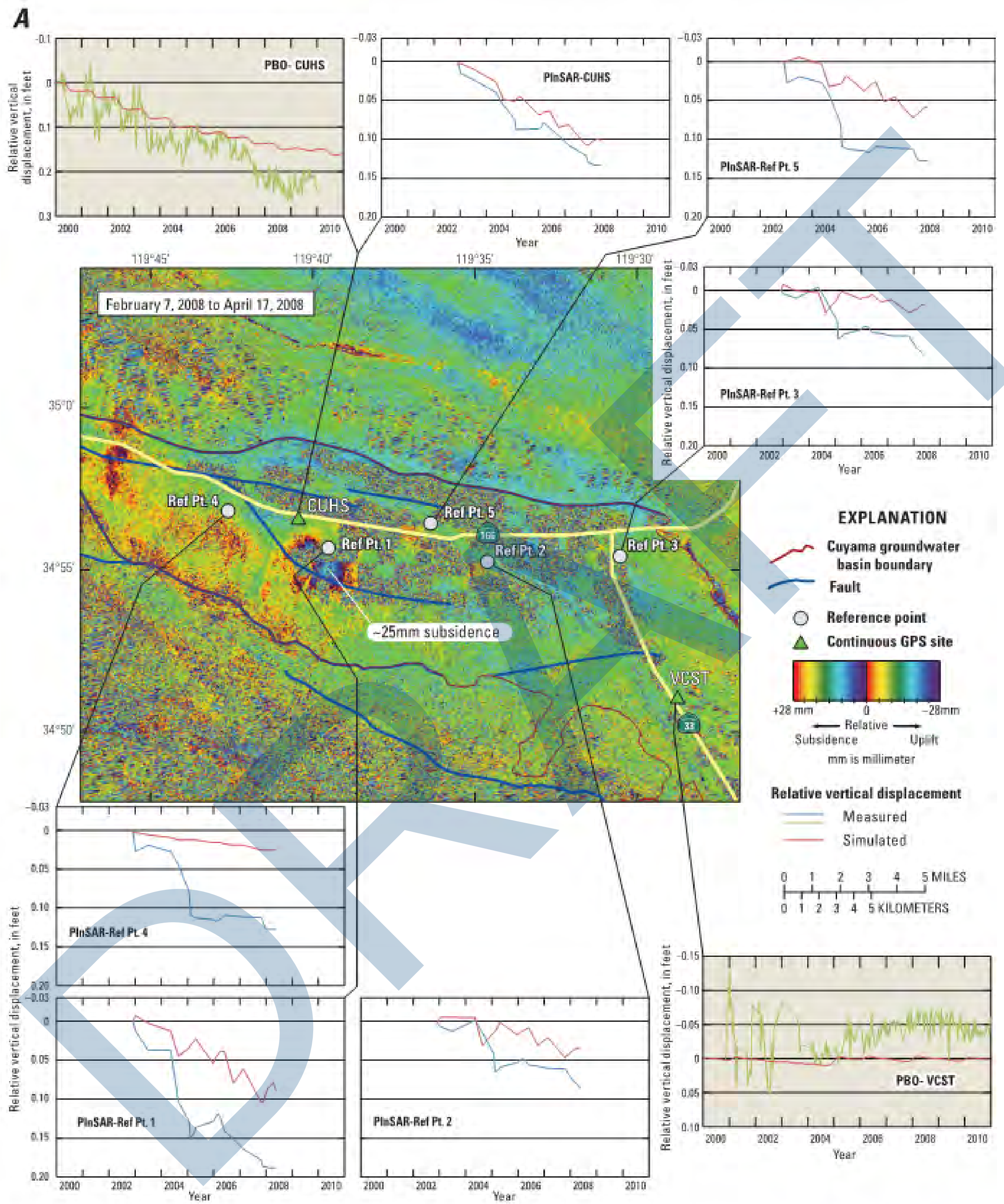

Figure 29. Historical subsidence as *A*, map of seasonal InSAR with graphs of simulated and measured time series for selected locations of relative land-surface deformation from Plate-Boundary Observation (PBO) sites and Point InSAR targets, and *B*, simulated total subsidence 1950–2010 for the calibrated hydrologic flow model, Cuyama Valley, California.

Source: USGS, 2015

Figure 2-50: Locations of Continuous GPS and Reference InSAR Sites in the Cuyama Valley

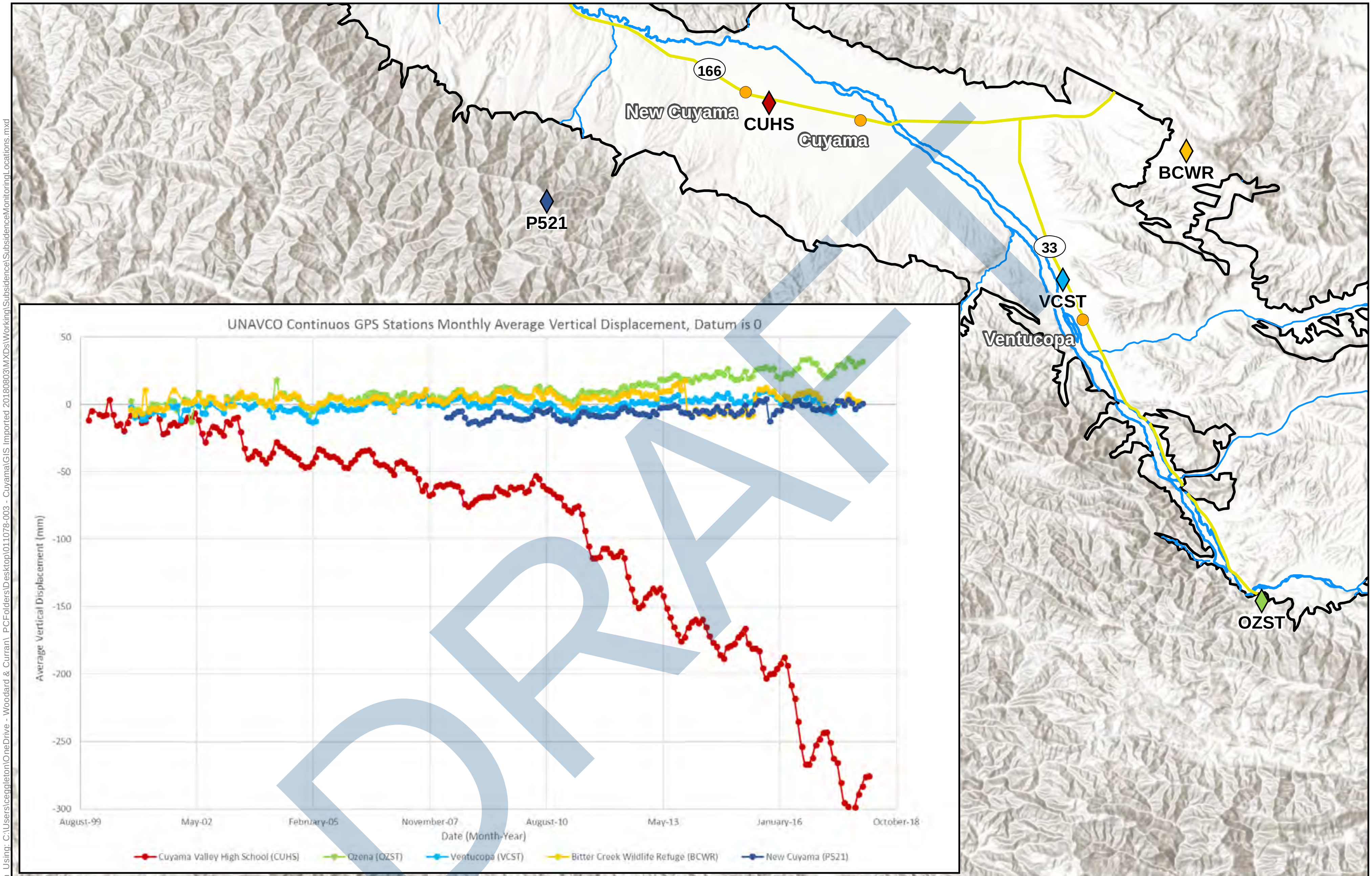

Figure 2-51: Subsidence Monitoring Locations

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Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- Towns
- Highways
- Cuyama River
- Streams

0 2.5 5 10 Miles

N

2.2.7 Groundwater Quality

This section presents Basin groundwater quality information, including a discussion of available water quality data and references, results of water quality data analysis performed for the GSP, and a literature review of previous studies about water quality in the Basin.

Reference and Data Collection

References and data related to groundwater quality were collected from the following sources:

- USGS National Water Quality Monitoring Council. Downloaded data from June 1, 2018 from https://www.waterqualitydata.us/portal/
- DWR GeoTracker California Groundwater Ambient Monitoring and Assessment (GAMA) Program. Downloaded data on June 5, 2018 for each county, from http://geotracker.waterboards.ca.gov/gama/datadownload
- DWR California Natural Resources Agency data. Downloaded on June 14, 2018 from https://data.cnra.ca.gov/dataset/periodic-groundwater-level-measurements
- County of Ventura
- Private landowners

Data were then compiled into a database for analysis.

Analysts also compiled references containing groundwater quality information. The information included in these references were used to enhance understanding of groundwater quality conditions beyond available data. References used in this section include the following:

- Singer and Swarzensky. 1970. *Pumpage and Ground-Water Storage Depletion in Cuyama Valley, 1947-1966.* This report focuses on groundwater depletion, but also includes information about groundwater quality.
- USGS. 2008 *Groundwater-Quality Data in the South Coast Interior Basins Study Unit, 2008: Results from the California Groundwater Ambient Monitoring and Assessment (GAMA) Program*. This study summarizes water quality testing on 12 wells in the Cuyama Valley; wells were tested for a variety of constituents.
- SBCWA. 2011. *Santa Barbara County 2011 Groundwater Report.* This report provides groundwater conditions from throughout the county, and provides water quality information for the Cuyama Valley.
- USGS. 2013c. *Geology, Water-Quality, Hydrology, and Geomechanics of the Cuyama Valley Groundwater Basin, California, 2008-12*. This report investigates a wide variety of groundwater components in the Cuyama Valley, including water quality.

Data Analysis

Collected data were analyzed for TDS, nitrate, and arsenic. These three constituents were included in analysis because they were cited in previous studies of the Basin, and they were discussed during public meetings as being of concern to stakeholders in the Basin.

Figure 2-52 shows TDS of groundwater measured in wells in 1966. In 1966, TDS was above the MCL of 1,500 micrograms per liter (mg/L) in over 50 percent of measurements. TDS was over 2,000 mg/L near the Cuyama River in the southeast portion of the Basin near the Ozena Fire Station, Santa Barbara Canyon, and upper Quatal Canyon, indicating that high TDS water was entering the Basin from the watershed above these measurement points. TDS measurements were over the MCL throughout the central portion of the Basin, where irrigated agriculture was operating, near the towns of Cuyama and New Cuyama, and along the Cuyama River to the northwest of New Cuyama. TDS was less than 500 mg/L in a number of measurements between Bitter Creek and Cottonwood Canyon, indicating that lower TDS water was entering the Basin from the watersheds in this area.

Figure 2-53 shows TDS of groundwater measured in wells between 2011 and 2018. Multiple years of collected data were used to generate enough mapped data density for comparison to 1966 data. From 2011 to 2018 period, TDS was above the MCL in over 50 percent of measurements. TDS was over 1,500 mg/L near the Cuyama River in the southeast portion of the Basin near the Ozena Fire Station, and in Santa Barbara Canyon, indicating that high TDS water was entering the Basin from the watershed above these measurement points. TDS measurements were over the MCL throughout the central portion of the Basin where irrigated agriculture was operating. A number of 500 to 1,000 mg/L TDS concentrations were measured near New Cuyama and in upper Quatal Canyon, and along the Cuyama River between Cottonwood Canyon and Schoolhouse Canyon.

Figure 2-54 shows measurements of TDS for selected monitoring points over time. Monitoring points were selected by the number of measurements, with higher counts of measurements selected to be plotted. The charts indicate that TDS in the vicinity of New Cuyama has been over 800 mg/L TDS throughout the period of record, and that TDS has either slightly increased or stayed stable over the period of record. The chart for Well 85 at the intersection of Quatal Canyon and the Cuyama River is generally below 800 mg/L TDS with rapid spikes of TDS increases above that level. The timing of rapid increases in measured TDS correspond with Cuyama River flow events, indicating a connection between rainfall and stream flow and an increase in TDS. This is the only location where this trend was detected.

Figure 2-55 shows measurements of nitrate in 1966. This figure also shows that data collected in 1966 shows the Basin was below the MCL of 10 mg/L throughout, with some measurements above the MCL in the central portion of the Basin where irrigated agriculture was operating.

Figure 2-56 shows measurements of nitrate in groundwater measured in wells between 2011 and 2018. Multiple years of collected data were used to generate enough mapped data density for comparison to 1966 data. This figure also shows that data collected over this period show the Basin was generally below the MCL, with two measurements that were over 20 mg/L.

Figure 2-57 shows arsenic measurements from 2008 to 2018. Data were not available prior to this time in significant amounts.

Figure 2-57 also shows that arsenic measurements were below the MCL of 10 micrograms per liter (µg/L) in the majority of the Basin where data was available. However, high arsenic values exceeding 20 µg/L were recorded at three well locations in the area south of New Cuyama; all of these high concentration samples were taken at depths of 700 feet or greater, and readings in the same area taken at shallower depths were below the MCL.

Figure 2-58 shows the results of a query using the Regional Water Quality Control Board (RWQCB)'s GeoTracker website. GeoTracker documents RWQCB contaminant concerns and mitigation projects. As shown in the figure, most GeoTracker sites show that gasoline, oil and/or diesel fuel have been cited as the contaminant of concern.

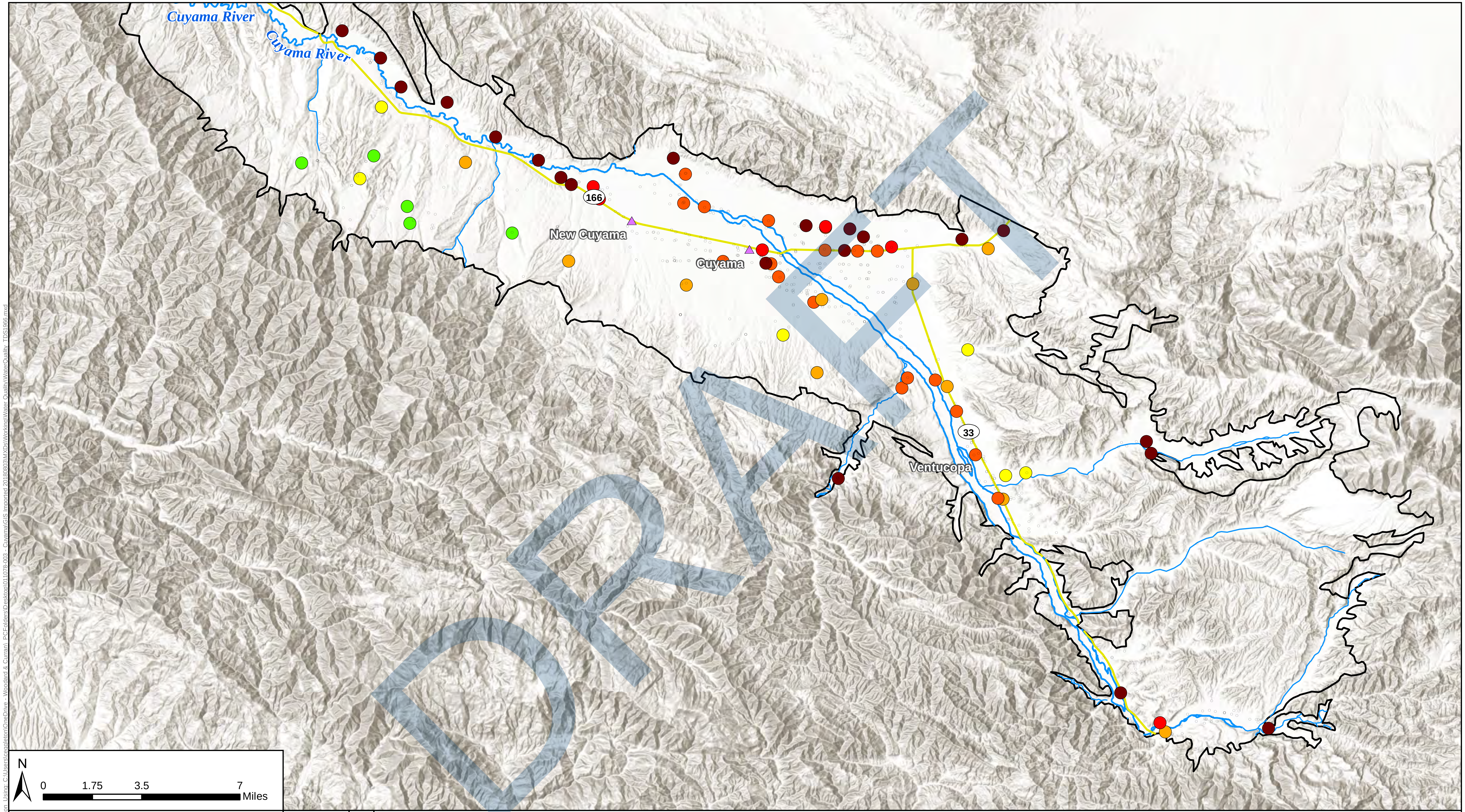

Figure 2-52: 1966 Average Well Measurements of Total Dissolved Solids, mg/L

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Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

April 2019

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Legend

TDS, mg/L

- No Measurements
- < 500 mg/L
- 500 - 1,000 mg/L
- 1,000 - 1,500 mg/L
- 1,500 - 1,750 mg/L
- 1,750 - 2,000 mg/L
- >2,000 mg/L

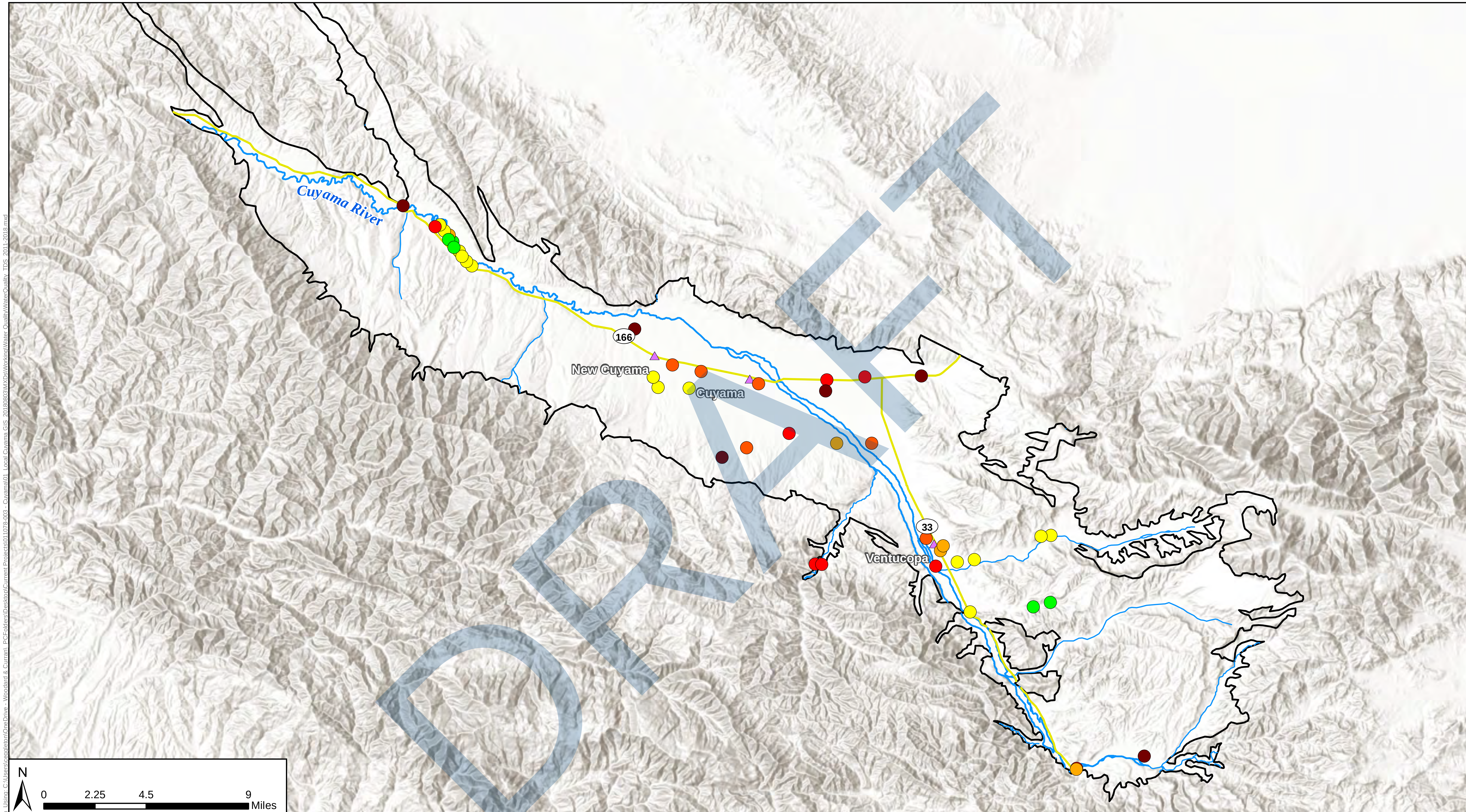

Figure 2-53: 2011-2018 Average Well Measurements of Total Dissolved Solids, mg/L

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

TDS, mg/L

Average_Re

- < 500 mg/L
- 500 - 1,000 mg/L
- 1,000 - 1,500 mg/L
- 1,500 - 1,750 mg/L
- 1,750 - 2,000 mg/L
- > 2,000 mg/L

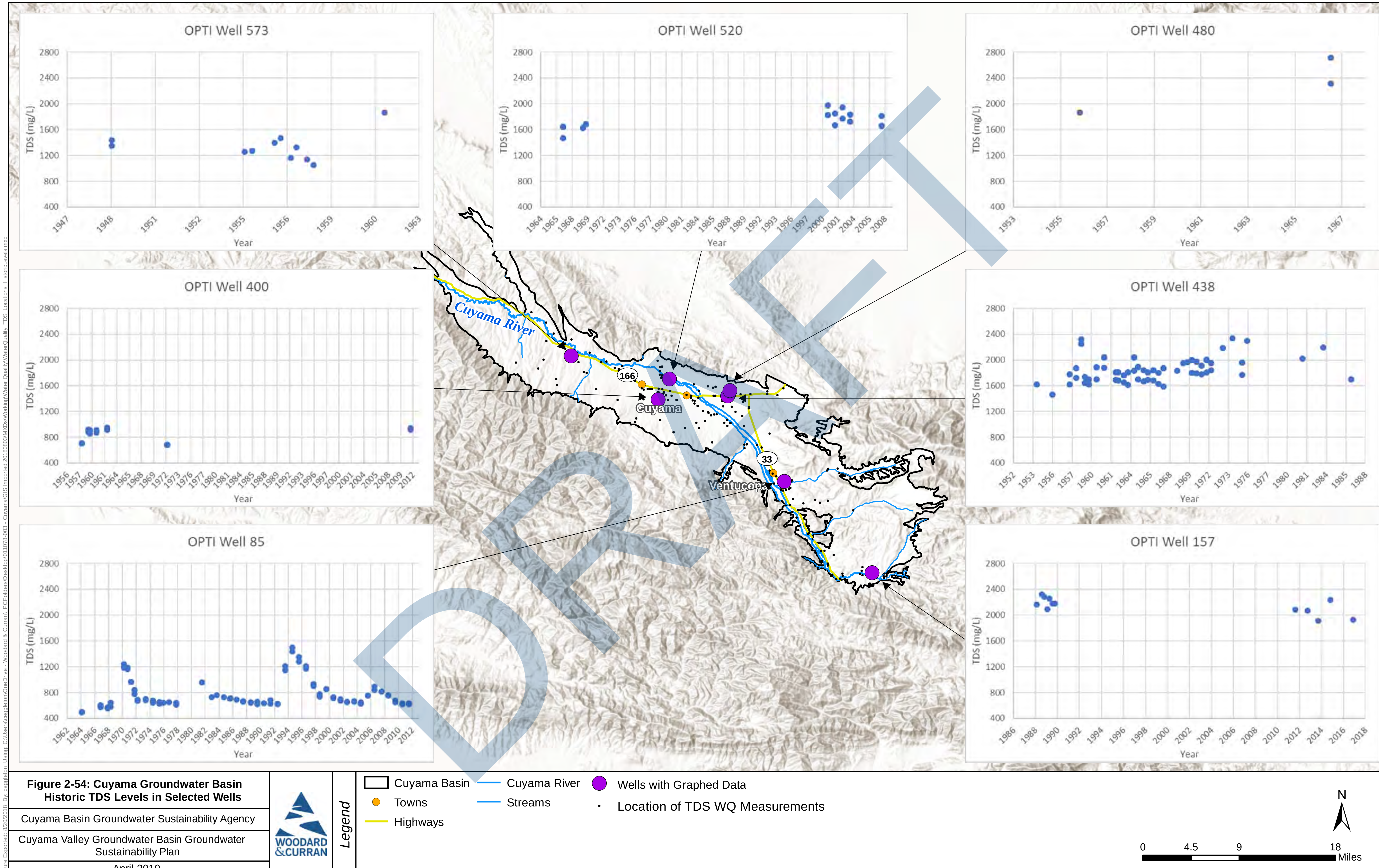

Figure 2-54: Cuyama Groundwater Basin Historic TDS Levels in Selected Wells

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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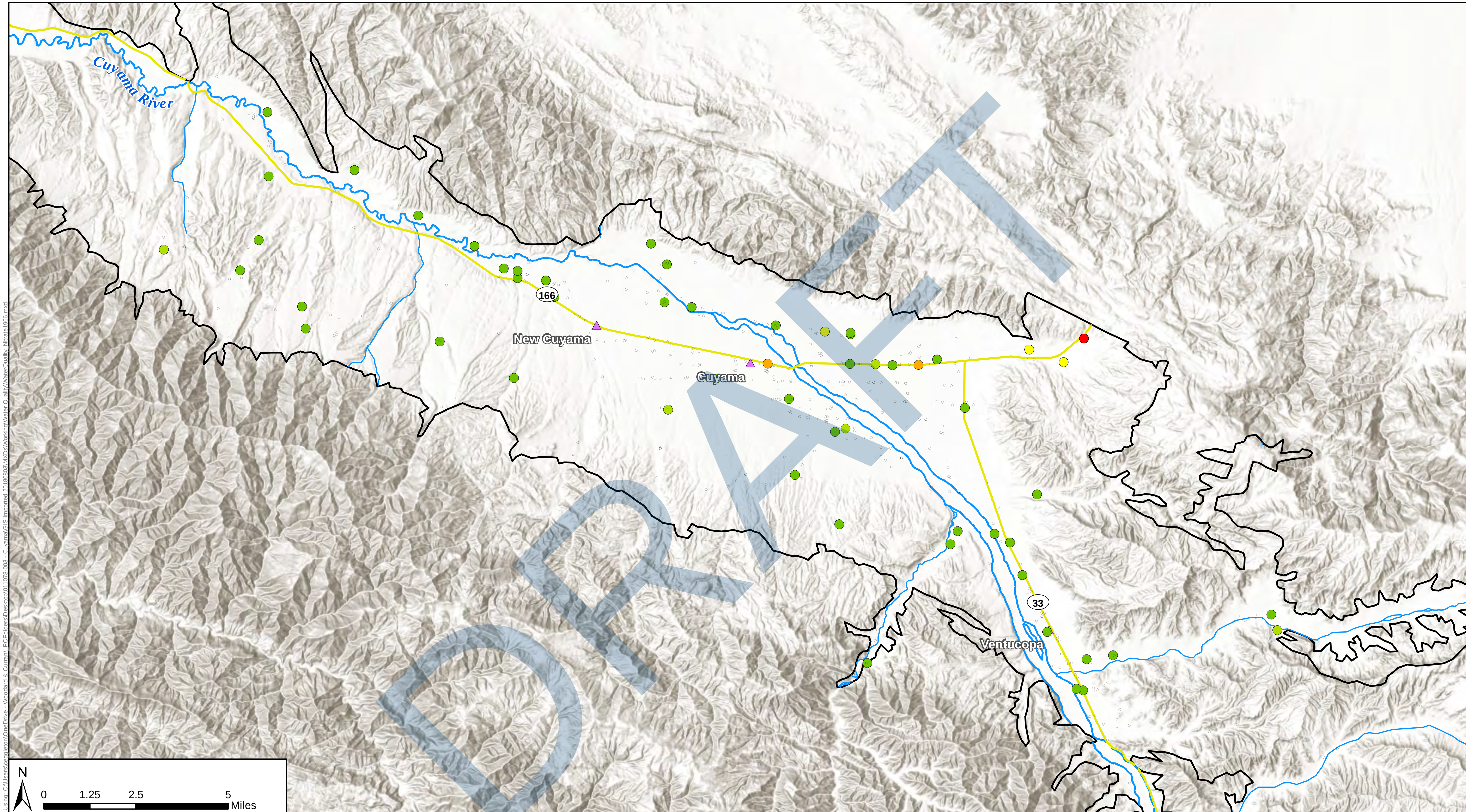

Figure 2-55: 1966 Average Well Measurements of Nitrate (NO3) as Nitrogen

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Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

Nitrate (NO3) as N, mg/L

- No Measurements
- < 5 mg/L
- 5 - 8 mg/L
- 8 - 10 mg/L
- 10 - 15 mg/L
- 15 - 20 mg/L
- > 20 mg/L

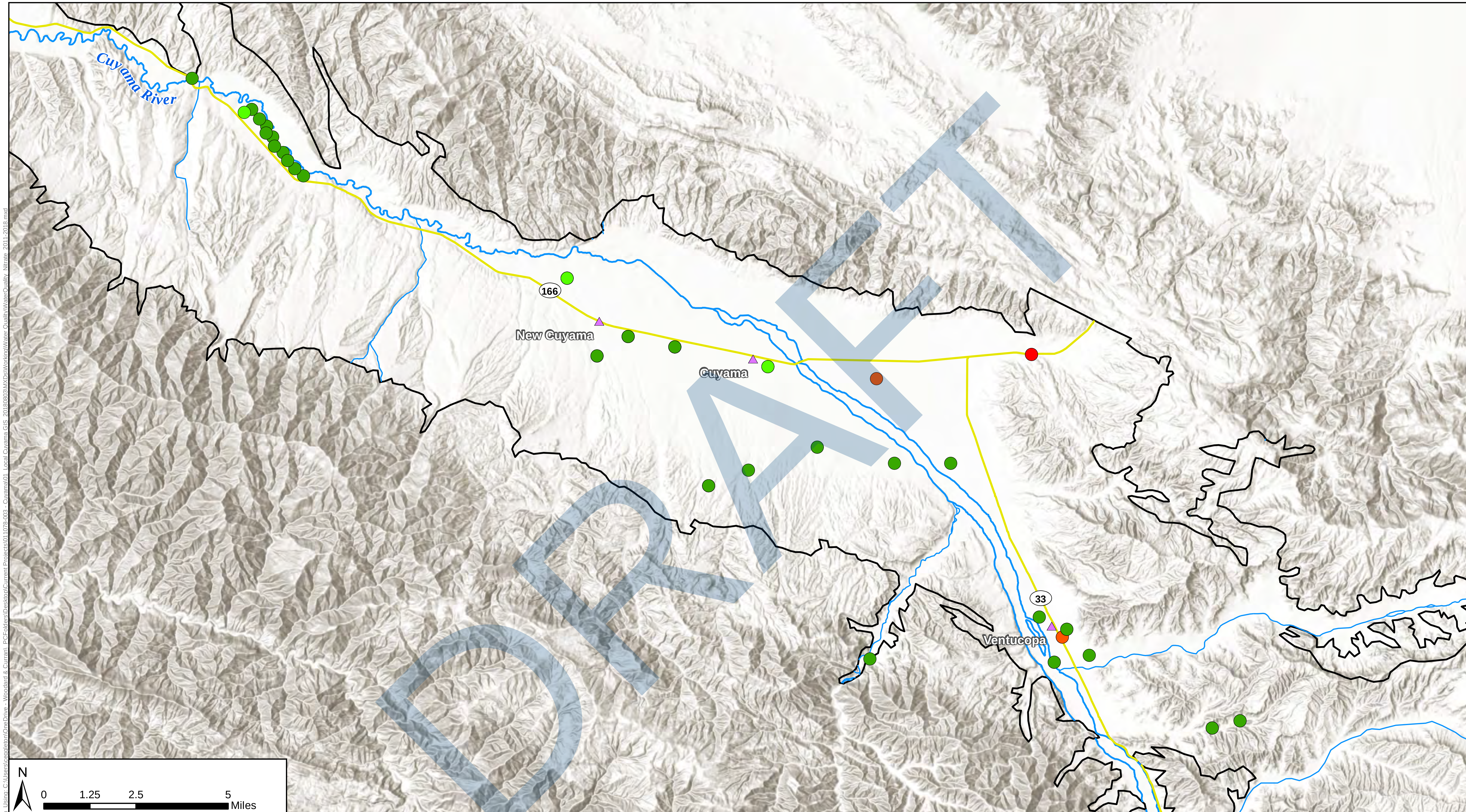

Figure 2-56: 2011-2018 Average Well Measurements of Nitrate (NO3) as Nitrogen

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Nitrate (NO3) as N, mg/L

- < 5 mg/L
- 5 - 8 mg/L
- 8 - 10 mg/L
- 10 - 15 mg/L
- 15 - 20 mg/L
- > 20 mg/L

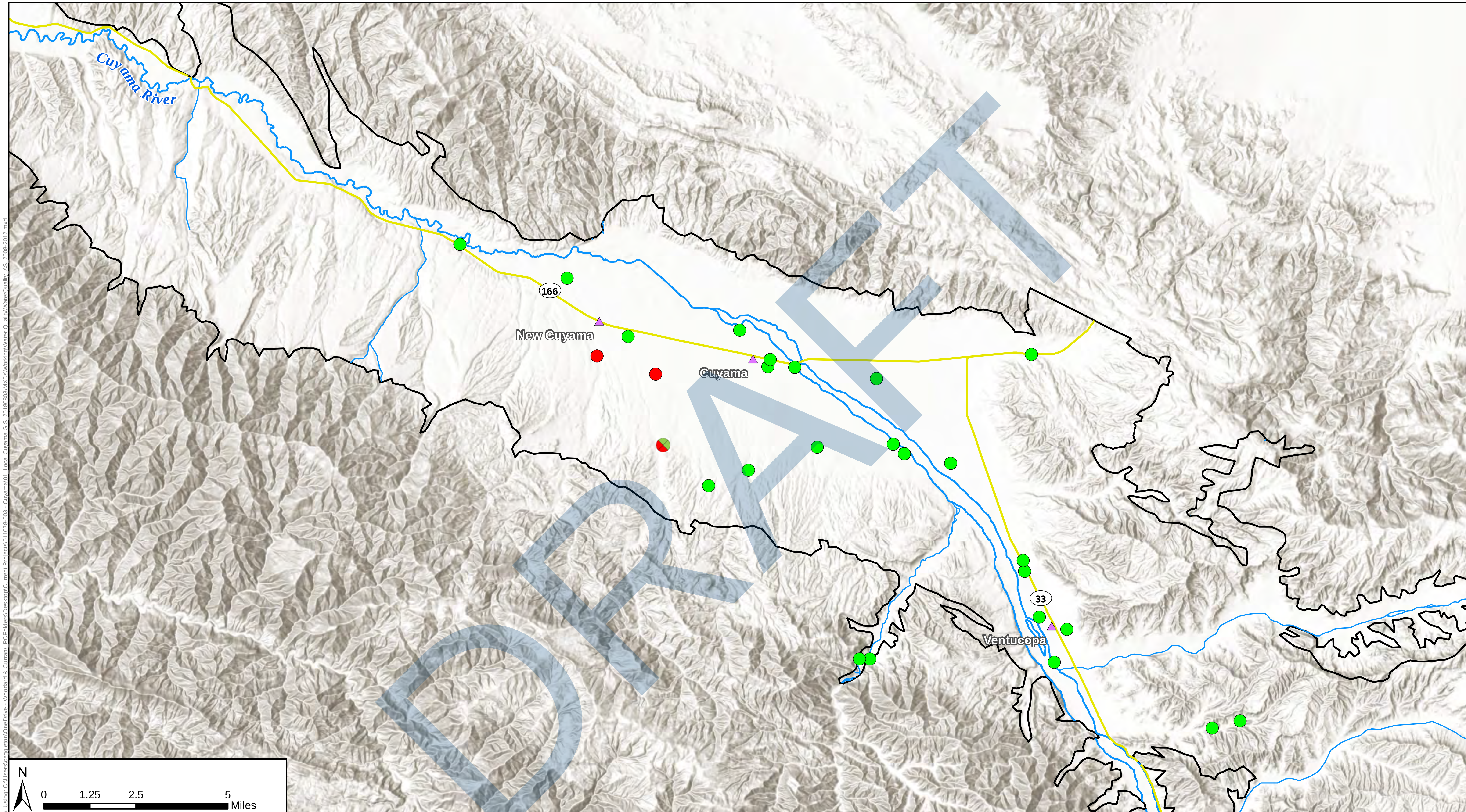

Figure 2-57: 2008-2018 Average Well Measurements of Arsenic, ug/L

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Aresenic (As), ug/L

- < 5 ug/L
- 5 - 10 ug/L
- 10 - 20 ug/L
- > 20 ug/L

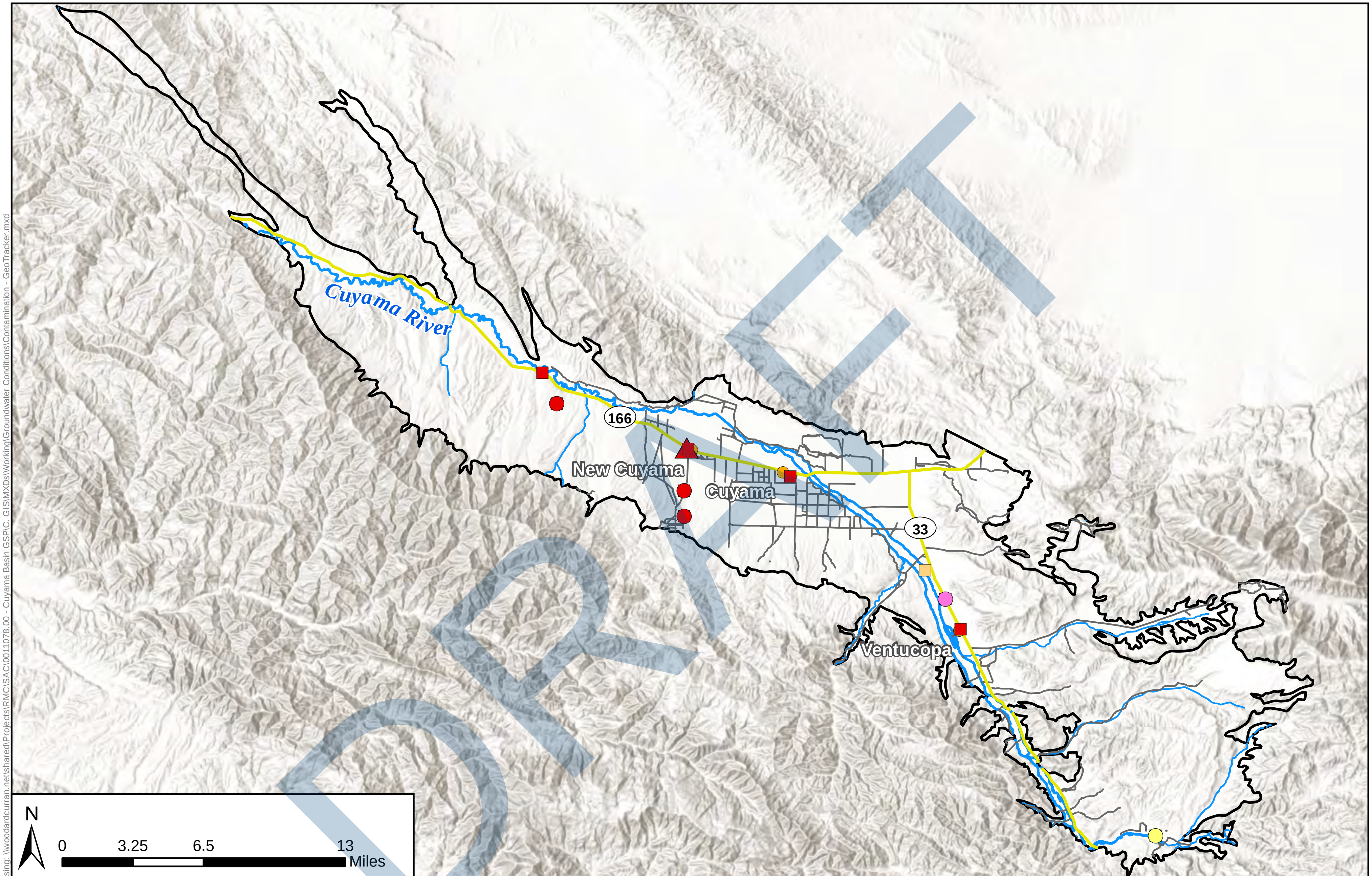

Figure 2-58 - Sites with Water Quality Concerns

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Cuyama Basin
Towns
Highways
Local Roads
Cuyama River
Streams

Site Status
Open Sites
Closed Sites
Permitted UST

Contaminant of Concern
Gas, Oil &/or Diesel
TPH & Lead
VOCs
Alcohols

Figure Exported: 8/7/2018 By: lsalberg Using: \\woodardcurran.net\shared\Projects\RMC\SAC\0011078.00 - Cuyama Basin GSP\C. GIS\MXDs\Working\Groundwater Conditions\Contamination - GeoTracker.mxd

Literature Review

In 1970, Singer and Swarzenski reported that TDS in the central basin was in the range of 1,500 to 1,800 mg/L TDS, and that the cations that contributed to the TDS and the amount of TDS varied by location in the Basin. They also reported that TDS was lower (i.e., from 400 to 700 mg/L) in areas downstream from the Sierra Madre Mountains where TDS was made up of sodium or calcium bicarbonate, and higher (i.e., from 3,000 to 6,000 mg/L) in wells close to the Caliente Range and in the northeastern part of the valley. Singer and Swarzenski stated that the high TDS was generated by mixing of water from marine rocks with more recent water from alluvium. They determined that groundwater movement favors movement of brackish water from the north of the Cuyama River toward areas of groundwater depletion, and that return of some water applied during irrigation and needed for leaching the soil carries dissolved salts with it to the water table (Singer and Swarzensky, 1970).

In 2008, USGS reported GAMA Program results. The GAMA Program sampled 12 Basin wells for a wide variety of constituents. Figure 2-59 shows the location of GAMA Program wells. The GAMA Program identified that specific conductance, which provides an indication of salinity, ranged from 637 to 2,380 microsiemens per centimeter (µS/cm) across the study's 12 wells. The GAMA Program study reported that the following constituents were not detected at levels above the MCL for each constituent in any samples for the following constituents:

- Pesticides or pesticide degradates
- Gasoline and refrigerants
- Aluminum, antimony, barium, beryllium, boron, cadmium, copper, iron, and lead
- Ammonia and phosphate
- Lithium, molybdenum, nickel, selenium, strontium, thallium, tungsten, uranium, vanadium, and zinc
- Bromide, calcium, chloride, fluoride, iodide, magnesium, potassium, silica, and sodium

The GAMA Program reported that there were detections at levels above the MCL for the following constituents:

- Manganese exceeded its MCL in two wells
- Arsenic exceeded the MCL in one well
- Nitrate exceeded the MCL in two wells
- Sulfate exceeded its MCL in eight wells
- TDS exceeded its MCL in seven wells
- VOCs detected in one well

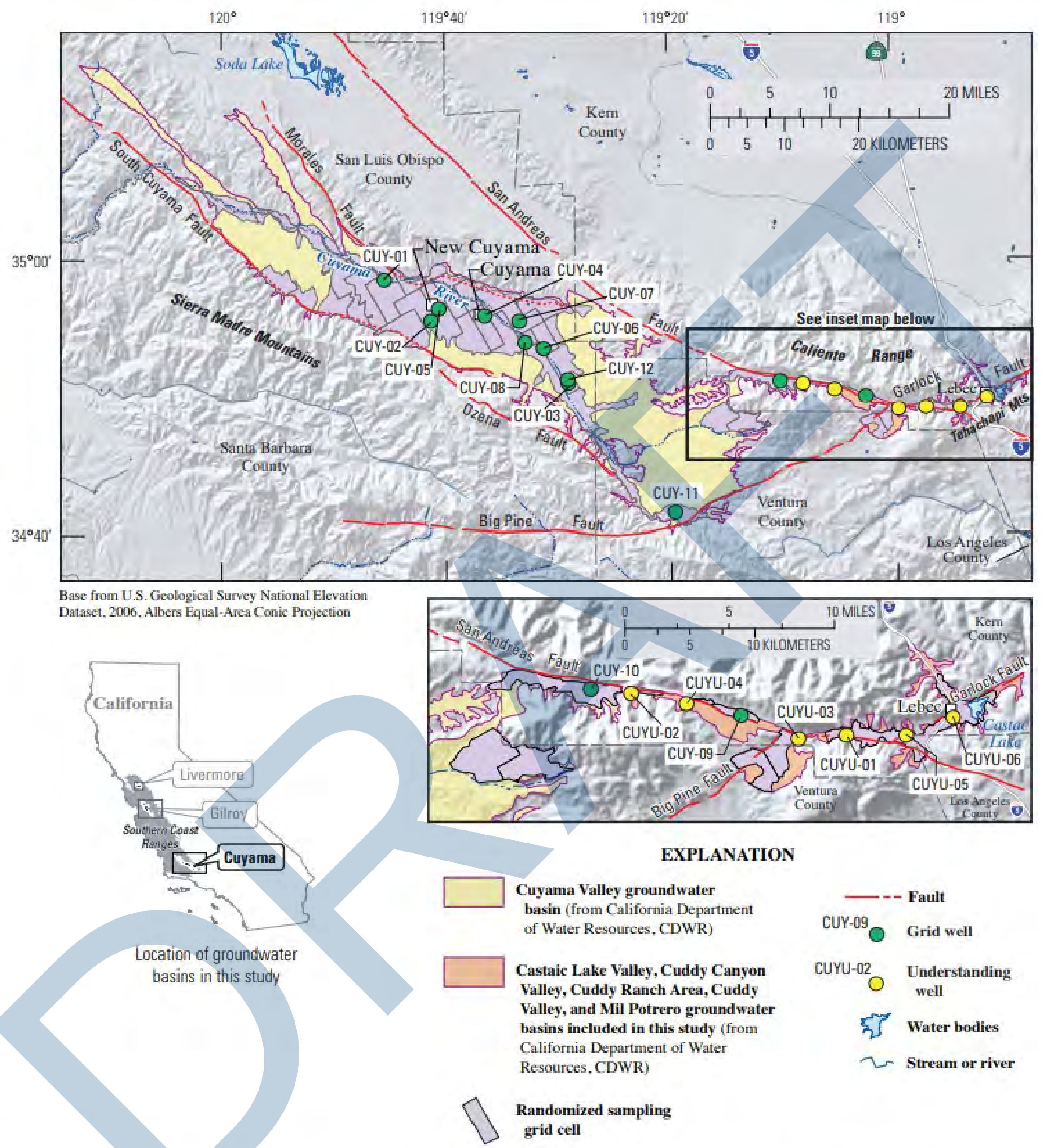


Figure 5. The South Coast Interior Basins Groundwater Ambient Monitoring and Assessment (GAMA) study unit showing the distribution of the Cuyama study-area grid cells, the location of sampled grid wells and understanding wells, the Cuyama Valley, Castaic Lake Valley, Cuddy Canyon Valley, Cuddy Ranch Area, Cuddy Valley, and Mil Potrero groundwater-basin boundaries (as defined by the California Department of Water Resources, CDWR), major cities, major roads, topographic features, and hydrologic features. Alphanumeric identification numbers for grid wells

Source: USGS, 2008

Figure 2-59: Locations of GAMA Sample Locations

In 2011, SBCWA reported that TDS in the Basin typically ranged from 1,500 to 1,800 mg/L in the main part of the Basin, while the eastern portion of the Cuyama Badlands near Ballinger, Quatal, and Apache Canyons had better water quality with TDS typically ranging rom 400 to 700 mg/L. SBCWA noted spikes in TDS in the Badlands Well following the wet rainfall years of 1969 and 1994 and stated that the spikes are attributable to overland flow from rainfall which is flushing the upper part of the Basin after dry periods.

SBCWA reported that boron is generally higher in the upper part of the Basin and is of higher concentration in the uplands than in the deeper wells in the central part of the Basin. Toward the northeast end of the Basin at extreme depth there exists poor quality water, perhaps connate (trapped in rocks during deposition) from rocks of marine origin.

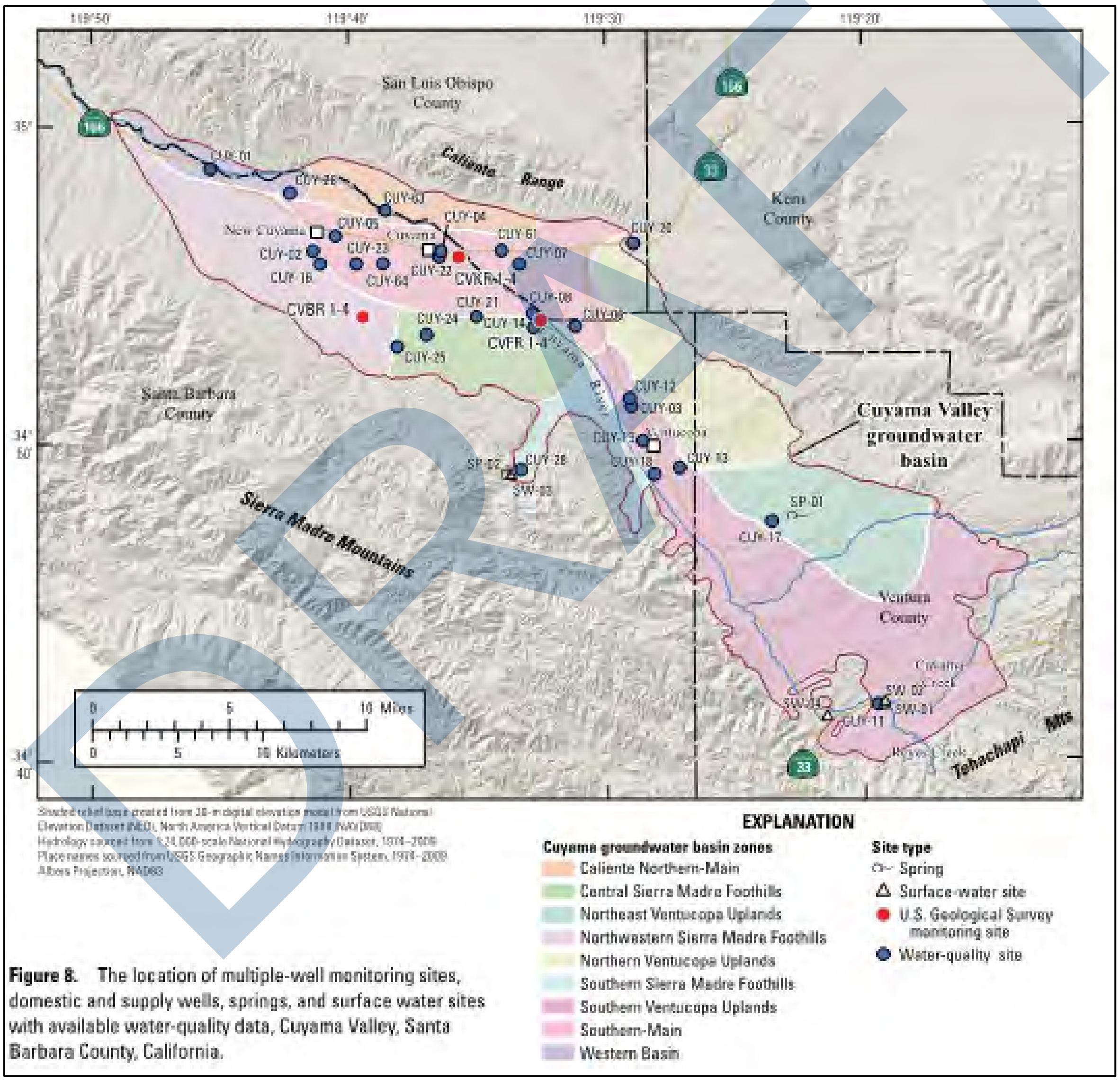
SBCWA also reported: "There was little change in TDS, calcium, magnesium, nitrates and sulfates during the 2009- 2011 period. In some cases, concentrations of these nutrients actually fell during the period, most likely due to a lack of rainfall, recharge and flushing of the watershed. As the Cuyama watershed is mostly dry, water quality data must be examined with caution as sometimes overland flow from rainfall events "flushes" the watershed and inorganic mineral concentrations actually peak during storm flows. Typically, in other areas of Santa Barbara County mineral concentrations are diluted during widespread storm runoff out of natural watersheds."

In 2013, USGS reported that they collected groundwater quality samples at 12 monitoring wells, 27 domestic wells, and 2 springs for 53 constituents including: field parameters (water temperature, specific conductance, pH, DO, alkalinity), major and minor ions, nitrate, trace elements, stable isotopes of hydrogen and oxygen, tritium and carbon-14 activities, arsenic, iron, and chromium. Figure 2-60 shows the USGS sampling locations, which were presented in a figure from their report. The USGS reported sampling result as follows:

- Groundwater in the alluvial aquifer system has high concentrations of TDS and sulfate
- 97 percent of samples had concentrations greater than 500 mg/L for TDS
- 95 percent of samples had concentrations greater than 250 mg./L for sulfate
- 13 percent of samples had concentrations greater than 10 mg/L for nitrate
- 12 percent of samples had concentrations greater than 10 ug/L for arsenic
- One sample had concentrations greater than the MCL for fluoride
- Five samples had concentrations greater than 50 mg/L for manganese
- One sample had concentration of iron greater than 300 mg/L for iron
- One sample had concentration of aluminum greater than 50 mg/L

USGS reported that nitrate was detected in five locations above the MCL of 10 mg/L. Four wells where nitrate levels were greater than the MCL were in the vicinity of the center of agricultural land-use area. Irrigation return flows are possible source of high nitrate concentrations. There was a decrease in concentrations with depth in the agricultural land use area which indicated the source of higher nitrate concentrations likely to be near the surface. The lowest nitrate levels were outside the agricultural use area, and low concentrations of nitrate (less than 0.02 mg/L) in surface water samples indicated surface water recharge was not a source of high nitrate

The USGS reported that arsenic was found in greater concentration than the MCL of 10 ug/L in four of the 33 wells sampled, and samples of total chromium ranged from no detections to 2.2 ug/L, which is less than the MCL of 50 ug/L. Hexavalent chromium ranged from 0.1 to 1.7 ug/L which is less than the MCL of 50 ug/L.



USGS 2013c

Figure 2-60: USGS 2013c Water Quality Monitoring Sites

2.2.8 Interconnected Surface Water Systems

The CBWRM, described in Appendix C, was used to analyze interactions between surface water flows in the Basin. Surface water flows were assigned reaches, five on the Cuyama River, and four for creeks. Figure 2-61 shows these reaches are shown in Figure 2-51; each reach was assigned a number. Results of the analysis are shown in Table 2-X in AF for each reach. Seven years had higher total depletions than 2017, which had a depletion estimate of 5,016 AF. Reach characteristics are listed below.

- **Reach 1 – Alamo Creek:** This reach was gaining in each year analyzed, with an average gain of 380 AF per year. The highest gain of 692 AF was in 1998, and the lowest gain was 192 AF in 2016.
- **Reach 2 – Cuyama River, from edge of basin to Alamo Creek**: This reach was losing in each year analyzed, with an average loss of 26 AF. The smallest loss was 1 AF in 2007, and the largest loss was -109 AF in 2005.
- **Reach 3 – Cuyama River from Alamo Creek, to Quatal Canyon Creek:** This reach was mostly gaining in each year, and lost in one year. The average of gains and losses was a gain of 931 AF. The highest gain of 2,781 was in 1998, and the loss of 300 AF occurred in 2017.
- **Reach 4 – Quatal Canyon Creek:** This reach was losing in each year analyzed, with an average loss of 83 AF. The smallest loss was 1 AF in 2007, and the largest loss was -347 AF in 1998.
- **Reach 5 – Cuyama River from Quatal Canyon Creek to Santa Barbara Canyon Creek:** This reach was losing in each year analyzed, with an average loss of 926 AF. The smallest loss was 180 AF in 2013, and the largest loss was 2,394 AF in 2005.
- **Reach 6 – Santa Barbara Canyon Creek:** This reach was gaining in each year analyzed, with an average gain of 95 AF per year. The highest gain of 222 AF was in 1999, and the lowest gain was 222 AF in 2016.
- **Reach 7 – Cuyama River from Santa Barbara Canyon Creek to Schoolhouse Canyon Creek:** This reach was losing in each year analyzed, with an average loss of 5,218 AF. The smallest loss was 797 AF in 2013, and the largest loss was 16,472 AF in 1998
- **Reach 8 – Schoolhouse Canyon Creek:** This reach was gaining in each year analyzed, with an average gain of 175 AF/year. The highest gain of 249 AF was in 1998, and the lowest gain was 134 AF in 2017.
- **Reach 9 – Cuyama River west of Schoolhouse Canyon Creek:** This reach was gaining in each year analyzed, with an average gain of 1,333 AF/year. The highest gain of 2,743 AF was in 1998, and the lowest gain was 750 AF in 2015.

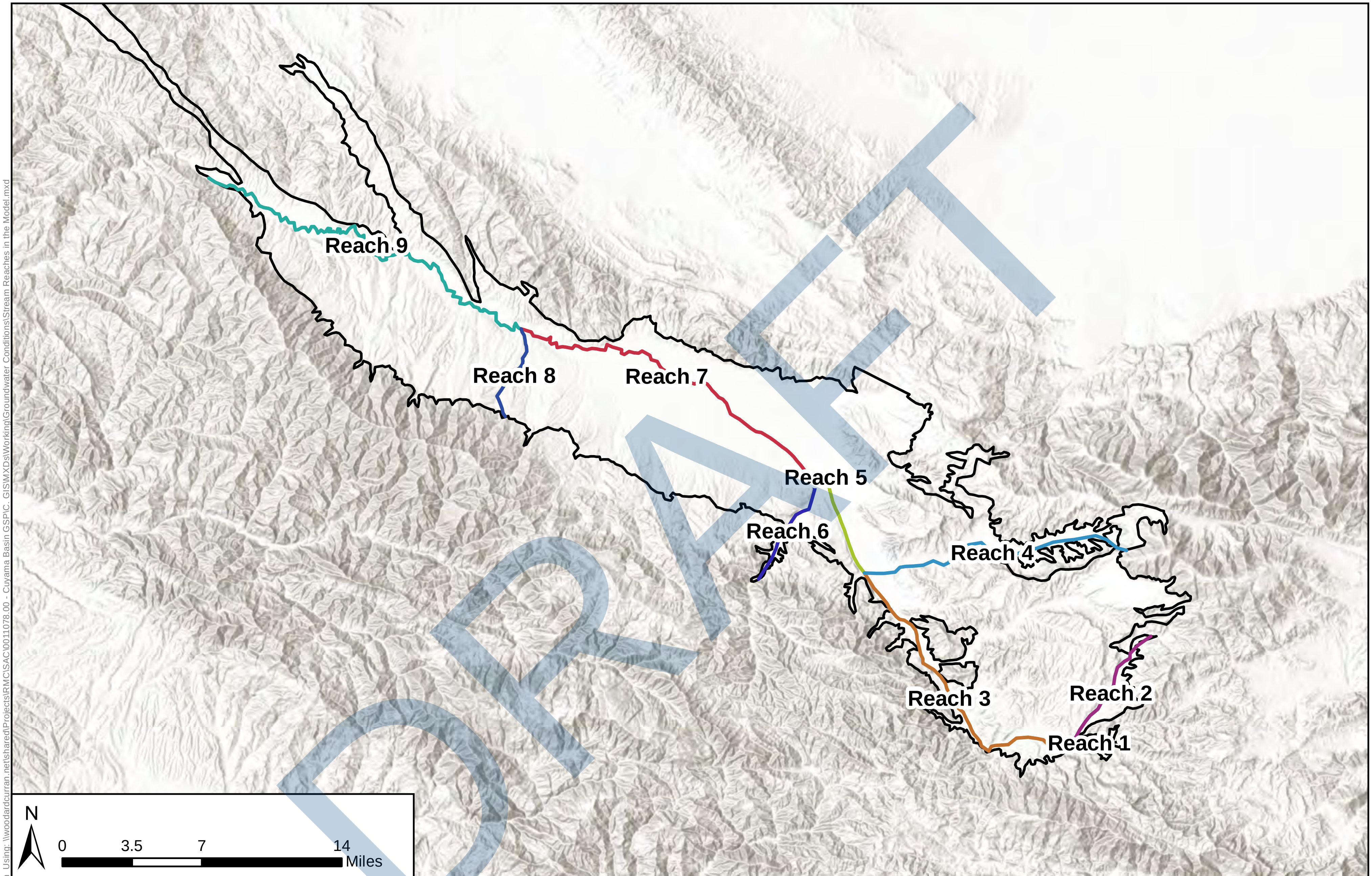


Figure 2-61: Stream Reaches Used in Cuyama Groundwater Model

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Cuyama Basin

Stream Reach

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9

Table 2-2: Stream Depletion by Reach

Year	Reach 1 (AF)	Reach 2 (AF)	Reach 3 (AF)	Reach 4 (AF)	Reach 5 (AF)	Reach 6 (AF)	Reach 7 (AF)	Reach 8 (AF)	Reach 9 (AF)	Total (AF)
1998	692.9	-100.7	2780.8	-346.8	-2182.5	164	-16471.5	249.3	2742.9	-12471.6
1999	547.1	-4.3	2636.1	-15.1	-561.3	222.1	-3060.8	234.1	2383.5	2381.4
2000	492.6	-19.3	1915.6	-60.8	-973.6	150	-4602.7	218.3	2152.4	-727.5
2001	460.6	-55.1	1300.5	-194.6	-1369.1	134	-7776	197.8	1906.3	-5395.6
2002	376.6	-1.2	1519.8	-2	-268.8	99.3	-1215.9	198.7	1783.1	2489.6
2003	340	-25.8	463.2	-78	-1247.9	75.8	-6156.6	189.6	1320.9	-5118.8
2004	293	-13.5	706.4	-37.2	-711.3	61.6	-3370.3	183.1	1447.5	-1440.7
2005	525.5	-109	668.7	-254.7	-2394	152.8	-14950.5	178	1115.9	-15067.3
2006	583.8	-23	1112.7	-106.3	-1302.3	155.6	-7026.4	172.2	1089.5	-5344.2
2007	455.6	-0.7	1542.1	-0.8	-269.9	114.1	-1327.9	172.3	1328.8	2013.6
2008	426.3	-26.6	797.8	-92.4	-1204.7	103.2	-5902.4	160.6	1105.7	-4632.5
2009	361.8	-8.3	956.6	-33.7	-540.2	77.5	-3191.7	164.2	997.3	-1216.5
2010	347.2	-29.4	294.2	-74.9	-1091.6	72.6	-5843.1	158.2	836	-5330.8
2011	332.3	-48.6	397.4	-191.5	-1518.5	79.5	-7937.3	143.2	899.7	-7843.8
2012	274.1	-7.7	650.6	-28.2	-457.8	60.6	-2720.4	153.9	1091.8	-983.1
2013	244.9	-0.9	768.7	-4.7	-180.2	46.9	-797.2	150.9	1169	1397.4
2014	226.4	-11	183.1	-31.2	-548	37	-2429.6	147.9	971.8	-1453.6
2015	211.9	-7.7	211.7	-16.5	-350.6	30.2	-1968.7	143.9	749.5	-996.3
2016	191.5	-8.6	16.8	-23	-447.1	27.1	-2713	141.1	766.7	-2048.5
2017	208.2	-19.9	-300.4	-67.8	-906	34.5	-4900.3	133.7	801.8	-5016.2
Annual Average	379.6	-26.1	931.1	-83.0	-926.3	94.9	-5218.1	174.6	1333.0	-3340.3

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2.2.9 Groundwater Dependent Ecosystems

A groundwater dependent ecosystem (GDE) is defined by SGMA emergency regulations in Section 351(m) as referring "to ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface." Section 354.16(g) of the same regulations requires identification of GDEs in the Basin using data available from DWR, or the best available information. GDEs are not mentioned elsewhere in the emergency regulations. Because the Natural Communities Commonly Associated with Groundwater (NCCAG) dataset includes a number of estimates, DWR recommends the verification of NCCAG-identified locations by a licensed biologist.

DWR provided the NCCAG dataset through the SGMA data portal at https://gis.water.ca.gov/app/NCDatasetViewer/ . The NCCAG dataset was compiled using a set of six pre-existing dataset sources, and is explained in detail at: https://gis.water.ca.gov/app/NCDatasetViewer/sitedocs/# . Figure 2-61 shows the locations of areas identified as NCCAG in the dataset.

A Woodard & Curran licensed wetlands biologist verified the NCCAG dataset using remote sensing techniques supported by in-person field verification. This work is documented in a Technical Memorandum (Appendix D). The analysis was performed by groupings, and the results of analysis at the groupings level is shown in Figure 2-62. Analysis concluded that there were 123 probable GDEs and 275 probable non-GDEs in the Basin, as shown in Figure 2-63.

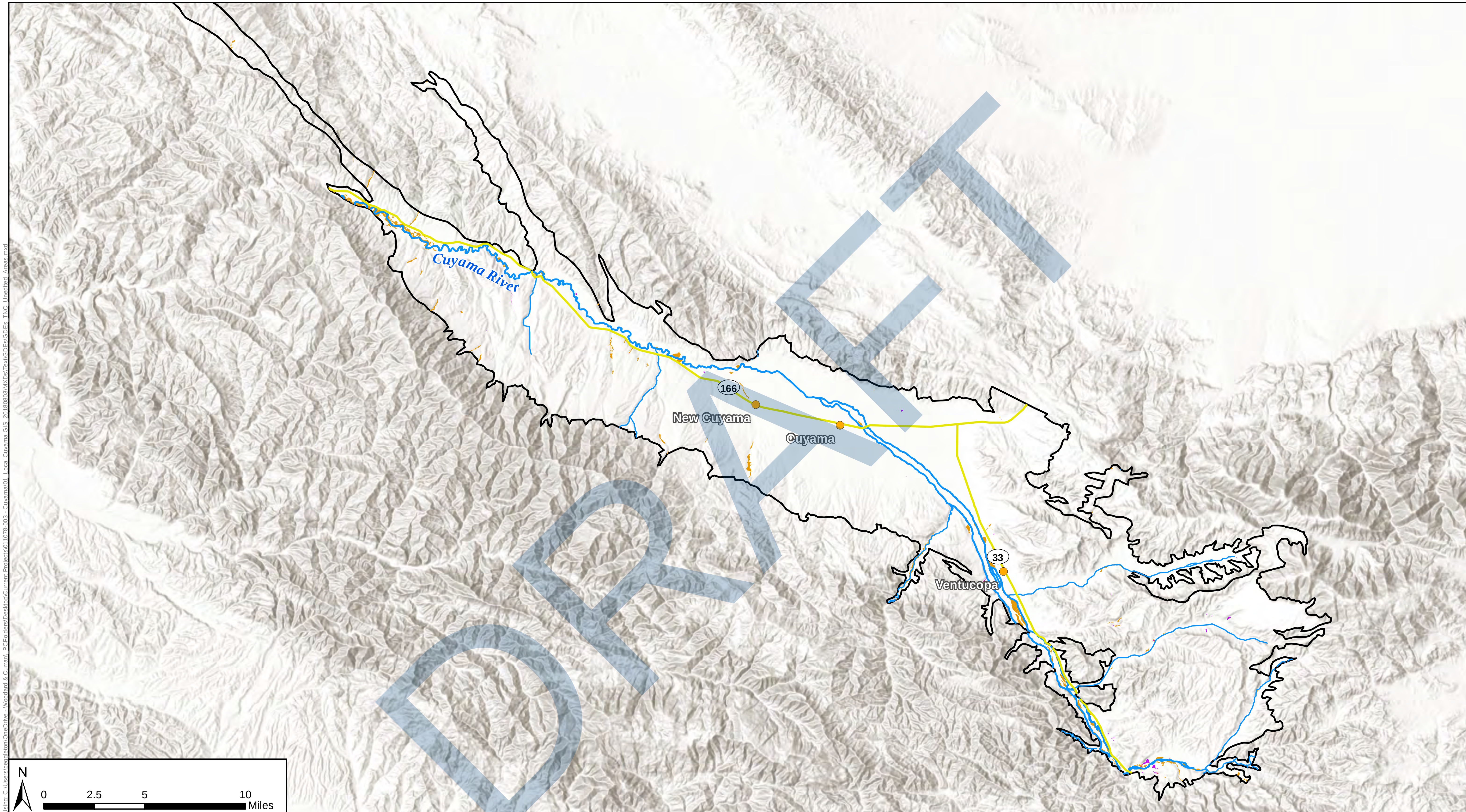

Figure 2-62 - Cuyama Basin TNC Identified NCCAG Dataset

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Legend

- Cuyama Basin
- TNC Identified Potential GDE Wetland
- TNC Identified Potential GDE Vegetation
- Towns
- Cuyama River
- Streams
- Highways

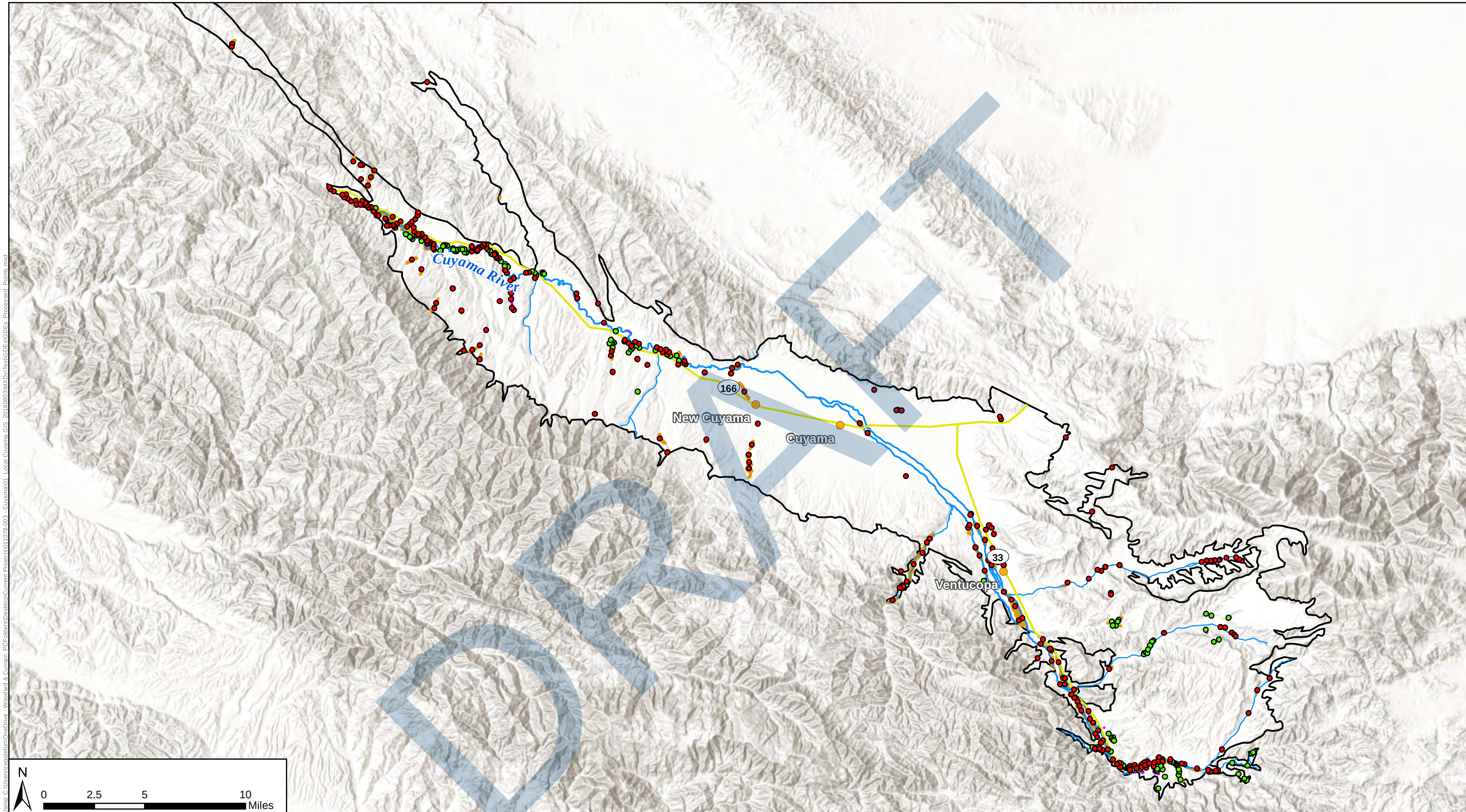

Figure 2-63 - Cuyama Basin NCAG GDE Point Analysis

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Legend

- Cuyama Basin
- TNC Identified Potential GDE Wetland
- TNC Identified Potential GDE Vegetation
- Cuyama NCAG Probable Non-GDEs
- Cuyama NCAG Probable GDEs
- Towns
- Cuyama River
- Streams
- Highways

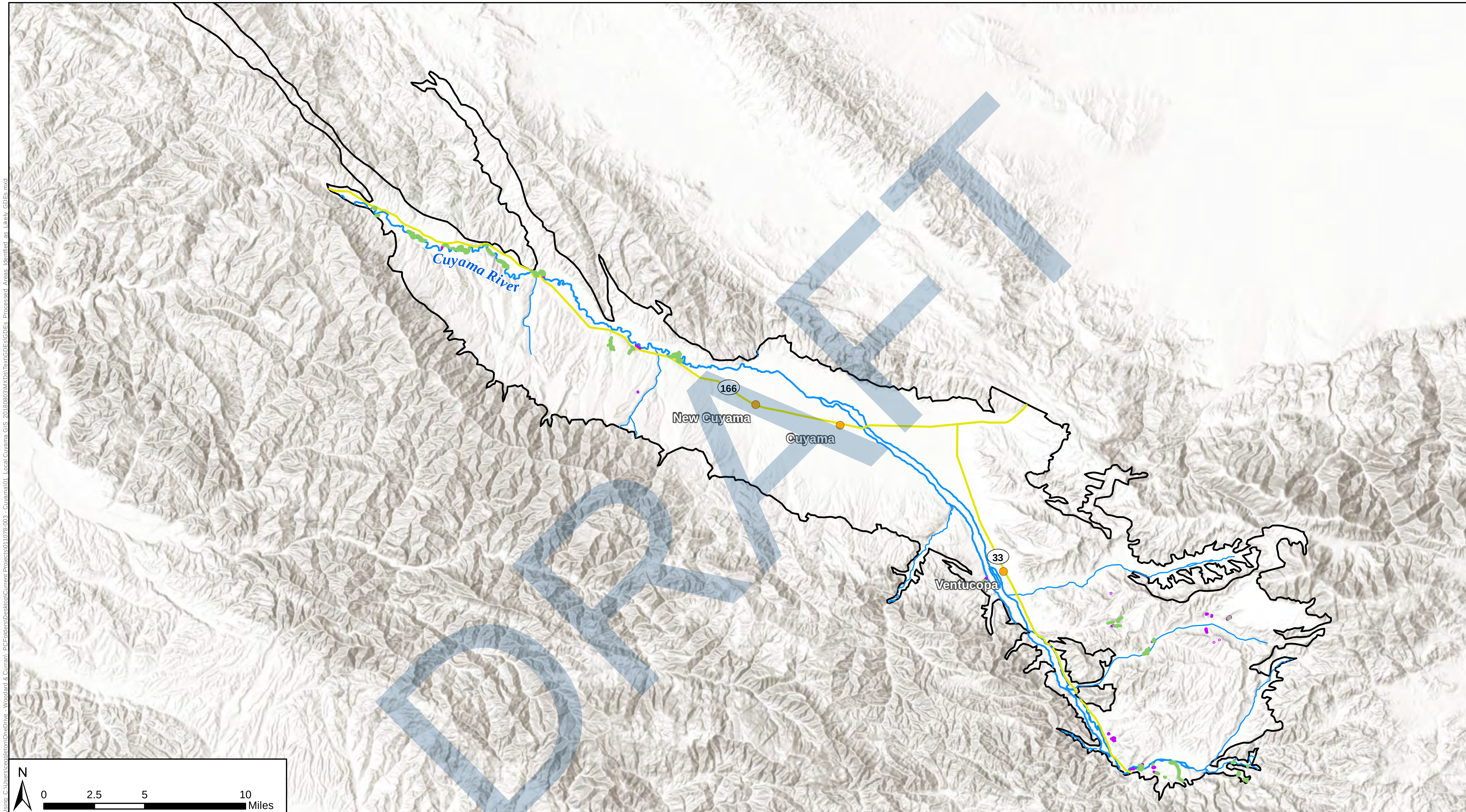

Figure 2-64 - Cuyama Basin Probable GDEs Based on Analysis

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Legend

- Cuyama Basin
- Towns
- Cuyama River
- Streams
- Highways
- Likely GDE Vegetation
- Liley GDE Weltlands

2.2.10 Data Gaps

Groundwater conditions data gaps were identified during the development of this GSP, and when additional questions were asked by stakeholders during GSP development. Data gaps are summarized below.

- Due to sporadic monitoring by a variety of monitoring entities, a long period of record of monitoring for groundwater levels does not exist in many areas in the Basin
- The depths where arsenic occurs are not known, making setting sustainability thresholds for arsenic not feasible
- The Cuyama River is not gaged inside the Cuyama Basin, so flows of the river in the Basin have been estimated based on measurements at downstream gages
- Subsidence in the central portion of the Basin where groundwater levels are lowest is not monitored nor understood
- Vertical gradients in the majority of the Basin are not understood due to the lack of wells with completions of different depths near located near each other
- Salinity in groundwater in the Basin has a number of natural sources, but are not discretely identified
- GDEs could be evaluated in greater detail
- Faults are not well understood with regard to the degree they represent a barrier to flow and at what depth below the surface.
- The size of the Basin regarding groundwater in storage is not well understood.
- Information about many of the wells in the Basin is incomplete, and additional information is needed regarding well depths, perforation intervals and current status

As the CBGSA develops its monitoring networks and implements the GSP, these data gaps will be revisited and re-evaluated for importance during the five-year update of the GSP.

2.3 Basin Settings: Water Budget

This section describes the historical, current and projected water budgets for the Basin. As defined by SGMA regulations, this section quantifies the following:

- Total surface water entering and leaving a basin by water source type
- Inflow to the groundwater system by water source type
- Outflows from the groundwater system by water use sector
- The change in the annual volume of groundwater in storage between seasonal high conditions
- If overdraft conditions occur, a quantification of overdraft over a period of years during which water year and water supply conditions approximate average conditions
- The water year type associated with the annual supply, demand, and change in groundwater stored

- An estimate of sustainable yield for the Basin

Useful Terms

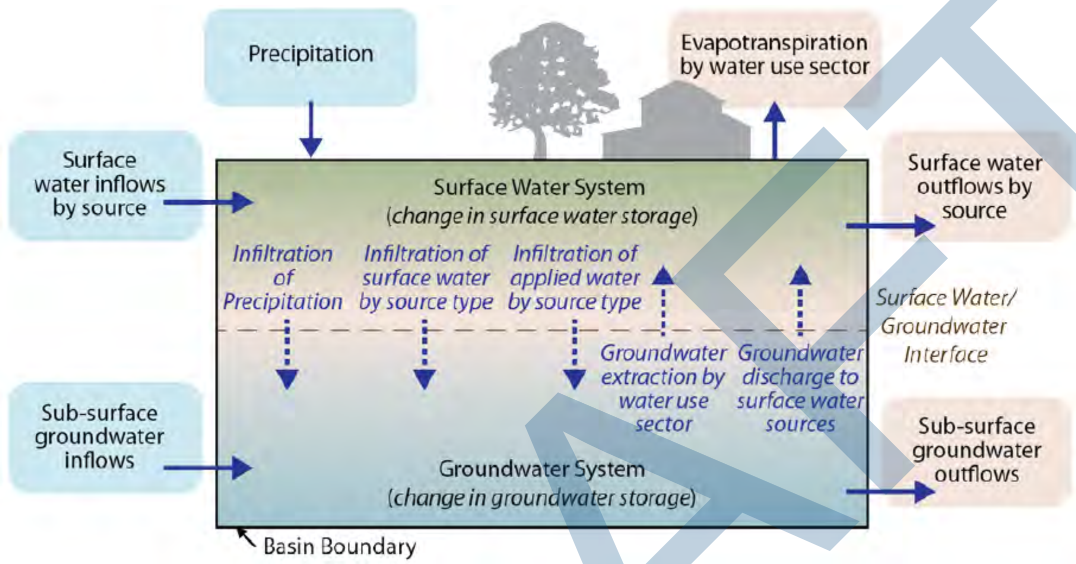
This section of Chapter 2 describe components of water budgets in the Basin. The terms listed here are intended as a guide for readers, and are not a definitive definition of any term.

- **Precipitation** – Precipitation is the volume of rainfall that travels from the soil zone to the unsaturated (vadose) zone of the groundwater aquifer.
- **Applied Water** – Applied water is the volume of water that is applied by an irrigation system to assist crop and pasture growth.
- **Evapotranspiration** – Evapotranspiration is the volume of water entering the atmospheric system through the combined process of evaporation from soil and plant surfaces and transpiration from plants.
- **Domestic Water Use** – Domestic water use is the volume of water used for indoor household purposes, including potable and non-potable water provided to households by a public water supplier (domestic deliveries) and self-supplied water.
- **Deep Percolation** – Deep percolation is the volume of applied water and precipitation that travels from the soil zone to the unsaturated (vadose) zone of the groundwater aquifer.
- **Runoff** – Runoff is the volume of water flowing into the surface water system in a water budget zone from precipitation over the land surface.
- **Stream Seepage** – Stream seepage is the volume of water entering the groundwater system from rivers and streams.
- **Subsurface Inflow** – Subsurface inflow is the volume of water entering as groundwater into the groundwater system through its subsurface boundaries.
- **Change in Storage** – Change in storage is the net change in the volume of groundwater stored in the underlying aquifer.
- **Overdraft –** Overdraft is the long-term negative net change in volume of groundwater stored in the underlying aquifer.
- **Sustainable Yield** – Sustainable yield is the average annual groundwater pumping that can be sustained without any long-term negative net change in groundwater storage.

Water Budget Information

This water budget was developed to provide a quantitative accounting of water entering and leaving the Basin. Water entering the Basin includes water entering at the surface and entering through the subsurface. Similarly, water leaving the Basin leaves at the surface and through the subsurface. Water enters and leaves naturally, such as through precipitation and streamflow, and through human activities, such as pumping and recharge from irrigation. Figure 2-64 presents a vertical slice through the land surface and aquifer to summarize the water balance components used during analysis.

The values presented in the water budget provide information about historical, current, and projected conditions as they relate to hydrology, water demand, water supply, land use, population, climate change, sea-level rise (which is not applicable in the Basin), groundwater and surface water interaction, and subsurface groundwater flow. This information can help manage groundwater om the Basin by identifying the scale of different uses, highlighting potential risks, and identifying potential opportunities to improve water supply conditions, among other elements.



(Source: DWR)

Figure 2-65:. Generalized Water Budget Diagram

Water budgets can be developed on different spatial scales. In agricultural use, water budgets may be limited to the root zone in soil, improving irrigation techniques by estimating the inflows and outflows of water from the upper portion of the soil accessible to plants through their roots. In a strictly groundwater study, water budgets may be limited to water flow in the subsurface, helping analysts understand how water flows beneath the surface. Global climate models simulate water budgets that incorporate atmospheric water, allowing for simulation of climate change conditions. In this document, consistent with the SGMA regulations, water budgets investigate the combined surface water and groundwater system in the Basin.

Water budgets can also be developed at different temporal scales. Daily water budgets may be used to demonstrate how evaporation and transpiration increase during the day and decrease at night. Monthly water budgets may be used to demonstrate how groundwater pumping increases in the dry, hot summer months and decreases in the cool, wet winter months. In this section, and consistent with SGMA regulations, this water budget focuses on the full water year (i.e., the 12 months spanning from October of the previous year to September of the current year), with some consideration to monthly variability.

The SGMA regulations require that annual water budgets are based on three different conditions: historical, current, and projected. Water budgets are developed to capture typical conditions during these time periods. Typical conditions are developed through averaging over hydrologic conditions that incorporate droughts, wet periods, and normal periods. By incorporating these varied conditions in the budgets, an analysis of the water system under certain hydrologic conditions such as drought can be performed along with an analysis of long-term average conditions. Information is provided below about the hydrology dataset used to identify time periods for budget analysis, the use of the CBWRM and associated data in water budget development, and about budget estimates.

Identification of Hydrologic Periods

Hydrologic periods were selected to meet the needs of developing historical, current, and projected water budgets. The SGMA regulations require that the projected water budget reflect 50 years of historical hydrology to reflect long-term average hydrologic conditions. Historical precipitation data for the Basin was used to identify hydrologic periods that would provide a representation of wet and dry periods and long-term average conditions needed for budget analyses. Analysis of a long-term historical period time provides information that is expected to be representative of long-term future conditions.

Figure 2-65 shows annual precipitation in the Basin for water years 1968 to 2017. The chart includes bars displaying annual precipitation for each water year and a horizontal line representing the mean precipitation of 13.1 inches. Rainfall data for the Basin are derived from the Parameter-Elevation Regressions on Independent Slopes Model (PRISM) dataset of DWR's California Simulation of Evapotranspiration of Applied Water (CALSIMETAW) model. Analysts identified periods with a balance of wet and dry periods using the cumulative departure from mean precipitation method. Under this method, the long-term average precipitation is subtracted from annual precipitation in each water year to develop the departure from mean precipitation for each water year. Wet years have a positive departure and dry years have a negative departure; a year with exactly average precipitation would have zero departure. Starting at the first year analyzed, departures are added cumulatively for each year. So, if the departure for Year 1 is 5 inches and the departure for Year 2 is -2 inches, the cumulative departure would be 5 inches for Year 1 and 3 inches (i.e., 5 plus -2) for Year 2. The cumulative departure of the spatially averaged of the rainfall in the Basin is shown on Figure 2-65. The cumulative departure from mean precipitation is based on these data sets, and is displayed as a line that starts at zero and highlights wet periods with upward slopes and dry periods with downward slopes. More severe events are shown by steeper slopes and greater changes. The period from 2013 to 2014 illustrates a short period with dramatically dry conditions (i.e., a 16-inch decline in cumulative departure over two years).

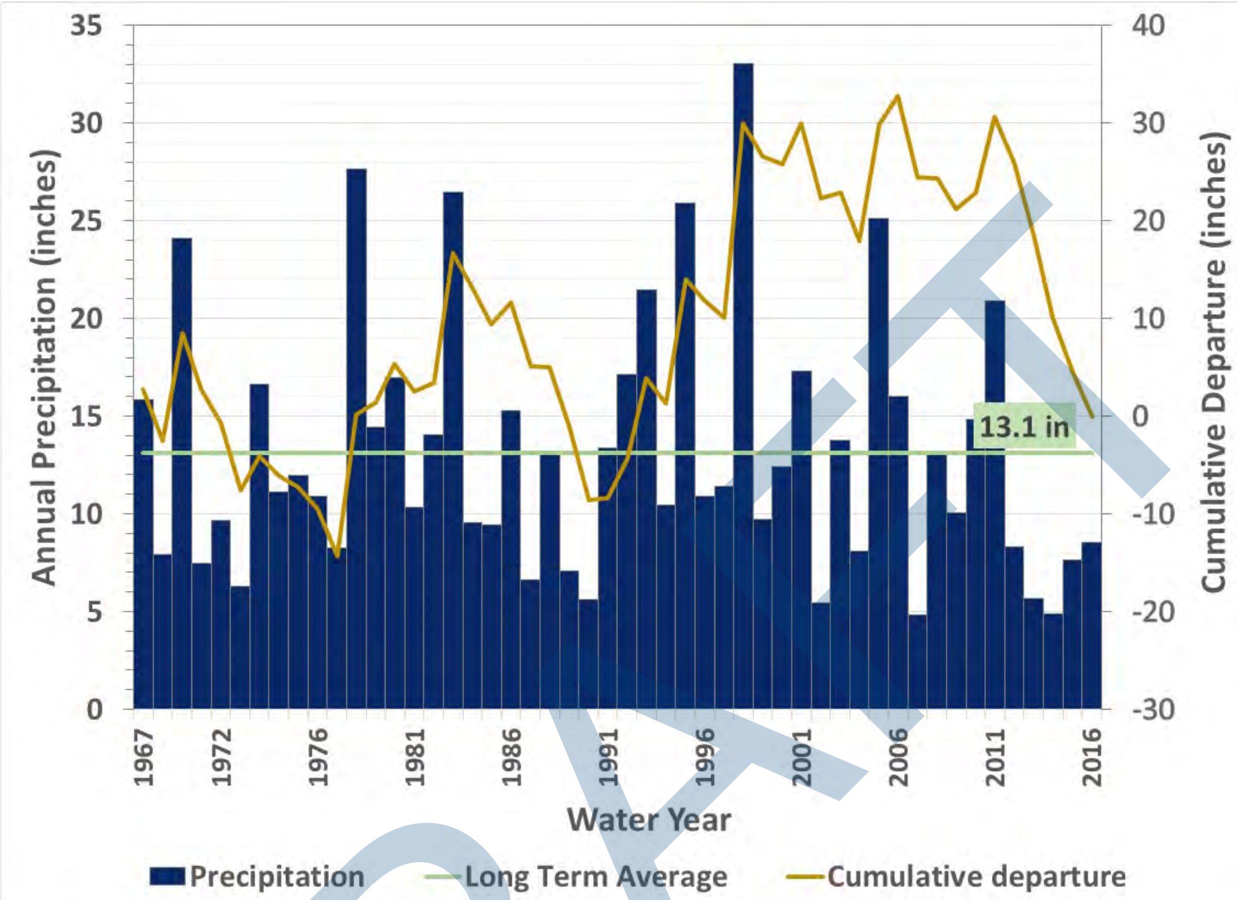


Figure 2-66: 50-Year Historical Precipitation and Cumulative Departure from Mean Precipitation

CBWRM Model Use and Associated Data for Water Budget Development

Water budgets were developed using the CBWRM model, which is a fully integrated surface and groundwater flow model covering the Basin. The CBWRM was developed in consultation with members of the Technical Forum, which includes technical staff and consultants representing a range of public and private entities in the Basin. Participants on the Technical Forum are shown in Chapter 1 Section 1.3. The Technical Forum held 14 monthly conference calls over the course of model development. These calls provided opportunities for Technical Forum members to review and comment on all major aspects of model development.

The CBWRM integrates the groundwater aquifer with the surface hydrologic system and land surface processes and operations. The CBWRM was calibrated for the hydrologic period of October 1995 to September 2015 by comparing simulated evapotranspiration, groundwater levels, and streamflow records with historical observed records. Development of the model involved study and analysis of hydrogeologic conditions, agricultural and urban water demands, agricultural and urban water supplies, and an evaluation of regional water quality conditions. The model was developed based on the best available data and information as of June 2018. It is expected that the model will be refined in the future as improved and updated monitoring information becomes available for the Basin. These refinements may result in changes in the estimated water budgets described in this section.

Additional information on the development and calibration of the CBWRM is included in Appendix C.

CBWRM simulations were developed to allow for the estimation of water budgets. Model simulations were used to develop the water budgets for historical, current, and projected conditions, which are discussed in detail below:

- The **historical water budget** was based on a simulation of historical conditions in the Basin.
- The **current water budget** was based on a simulation of current (2017) land and water use over historical hydrologic conditions, assuming no other changes in population, water demands, land use, or other conditions.
- The **projected water budget** was based on a simulation of future land and water use over the historical hydrologic conditions. Since future land and water use in the Cuyama Basin is assumed to be the same as current conditions, the projected water budget is the same as the current water budget.

Water Budget Definitions and Assumptions

Definitions and assumptions for the historical, current, and projected water budgets are provided below. Table 2-2 summarizes these assumptions.

Historical Water Budget

The historical water budget is intended to evaluate availability and reliability of past surface water supply deliveries, aquifer response to water supply, and demand trends relative to water year type. The hydrologic period of 1998 through 2017 was selected for the historical water budget to provide a period of representative hydrology while capturing recent Basin operations. The period 1998 through 2017 has an average annual precipitation of 12.2 inches, nearly the same as the long-term average of 13.1 inches and includes the recent 2012 to 2017 drought, the wet years of 1998 and 2005, and periods of normal precipitation.

Current and Projected Water Budget

While a budget indicative of current conditions could be developed using the historical calibration model, like the historical water budget, such an analysis would be difficult to interpret due to the extreme weather conditions of the past several years and its effect on local agricultural operations. Instead, to analyze the effects of current land and water use on groundwater conditions, and to accurately estimate current inflows and outflows for the Basin, a current and projected conditions baseline scenario was developed using the IWFM. This baseline uses current land and water use conditions approximating year 2017 conditions with a historical precipitation sequence and a year-to-year variance in cropping patterns that matches the historical variability. Because there is no basis to assume any changes in Basin population or land use in the future as compared to current conditions (in the absence of projects or actions), a single baseline has been developed that reflects both current and projected conditions.

The current and projected conditions baseline includes the following conditions:

- Hydrologic period:
  - Water years 1968 to 2017 (i.e., a 50-year hydrology)
- Precipitation is based on:
  - PRISM dataset for the period from 1968 to 2017
- Land use is based on:
  - Land use estimates developed by DWR and the CBGSA using remote sensing data
  - Land use information for historical years provided by private landowners
- Domestic water use is based on:
  - Current population estimates
  - Cuyama Community Services District delivery records
- Agricultural water demand is based on:
  - The IWFM Demand Calculator in conjunction with historical remote sensing technology, Mapping Evapotranspiration at High Resolution and Internalized Calibration (METRIC)

Table 2-3: Summary of Groundwater Budget Assumptions

Water Budget Criteria	Historical	Current and Projected
Scenario	Historical simulation	Current and projected conditions baseline
Hydrologic Years	Water years 1998 to 2017	Water years 1968 to 2017
Development	Historical	Current
Agricultural Demand	Historical land use	Current conditions
Domestic Use	Historical records	Current conditions

Projected Water Budget with Climate Change

A second projected level water budget has been developed that incorporates the projected effects of climate change. The projected conditions with climate change baseline are the same as the current and projected conditions baseline, except that adjustments have been made to estimated precipitation and agricultural and native vegetation evapotranspiration during the 50-year hydrologic period. The estimated precipitation and evapotranspiration from 1968 to 2017 were adjusted using perturbation factors developed from the Central Tendency climate scenario data provided by DWR. On average, the perturbation factors for this scenario result in an increase in precipitation of about 1.4 percent and in an increase in crop evapotranspiration of about 5.4 percent. Additional information about how precipitation and evapotranspiration were adjusted for climate change can be found in the IWFM documentation in Appendix C.

Water Budget Estimates

Land surface and groundwater budgets are reported for the historical period, for current and projected conditions, and for projected conditions with climate change.

The following components are included in the land surface water budget:

- Inflows:
  - Precipitation
  - Applied Water
- Outflows:
  - Evapotranspiration
    - Agriculture
    - Native vegetation
  - Domestic water use
  - Deep percolation
    - From precipitation
    - From applied water
  - Runoff
    - Stream seepage to groundwater
    - Flow out of Basin

The following components are included in the groundwater budget:

- Inflows:
  - Deep percolation
  - Stream seepage
  - Subsurface inflow
- Outflows:
  - Groundwater pumping
- Change in storage (where negative values reflect overdraft conditions)

The estimated average annual water budgets are provided in Tables 2-3 and 2-4 for the historical period and for current and projected conditions. The following sections provide additional information regarding each water budget.

Table 2-4: Average Annual Land Surface Water Budget			
Component	**Historical Water Volume[a] (AFY)**	**Current and Projected Water Volume[b] (AFY)**	**Projected Water Volume With Climate Change[b] (AFY)**
Inflows			
Precipitation	226,000	230,000	233,000
Applied water	58,000	59,000	63,000
Total Inflow	**285,000**	**289,000**	**296,000**
Outflows			
Evapotranspiration			
Agriculture	58,000	63,000	66,000
Native vegetation	167,000	174,000	174,000
Domestic water use	300	400	400
Deep Percolation			
Precipitation	18,000	15,000	15,000
Applied water	10,000	11,000	11,000
Runoff	32,000	26,000	29,000
Total Outflow	**285,000**	**289,000**	**296,000**

Notes:
AFY = acre-feet per year
[a]From water years 1998 to 2017
[b]Based on 50-year hydrology

Table 2-5: Average Annual Groundwater Budget			
Component	**Historical Water Volume[a] (AFY)**	**Current and Projected Water Volume[b] (AFY)**	**Projected Water Volume with Climate Change[b] (AFY)**
Inflows			
Deep percolation	28,000	25,000	26,000
Stream seepage	3,000	5,000	6,000
Subsurface inflow	5,000	5,000	5,000
Total Inflow	**36,000**	**35,000**	**37,000**
Outflows			
Groundwater pumping	59,000	60,000	64,000
Total Outflow	**59,000**	**60,000**	**64,000**
Change in Storage	**(23,000)**	**(25,000)**	**(27,000)**

Notes:
AFY = acre-feet per year
[a]From water years 1998 to 2017
[b]Based on 50-year hydrology

Historical Water Budget

The historical water budget is a quantitative evaluation of the historical surface and groundwater supply covering the 20-year period from 1998 to 2017. This period was selected as the representative hydrologic period to calibrate and reduce the uncertainty of the IWFM. Proper analysis and calibration of water budgets within IWFM ensures the hydrologic characteristics of the groundwater basin are accurately represented. The goal of the water budget analysis is to characterize the supply and demand, while summarizing the hydrologic flow within the Basin, including the movement of all primary sources of water such as rainfall, irrigation, streamflow, and subsurface flows.

Figure 2-67 summarizes the average annual historical land surface inflows and outflows in the Basin. Figure 2-68 shows the annual time series of historical land surface inflows and outflows.

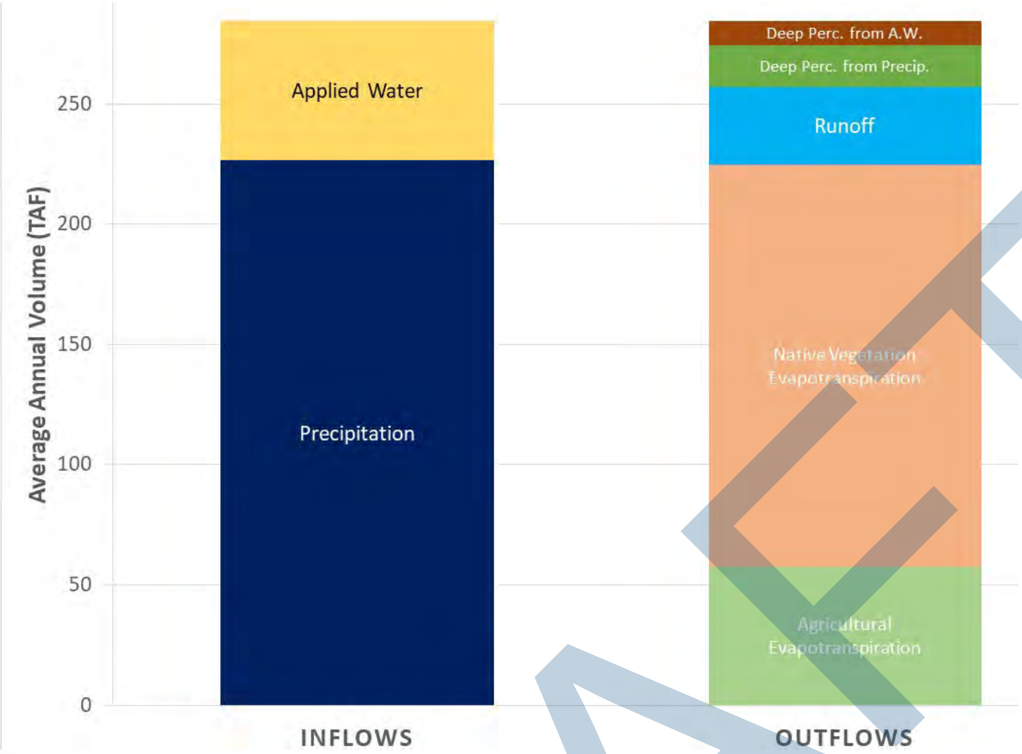


Figure 2-67: Historical Average Annual Land Surface Water Budget

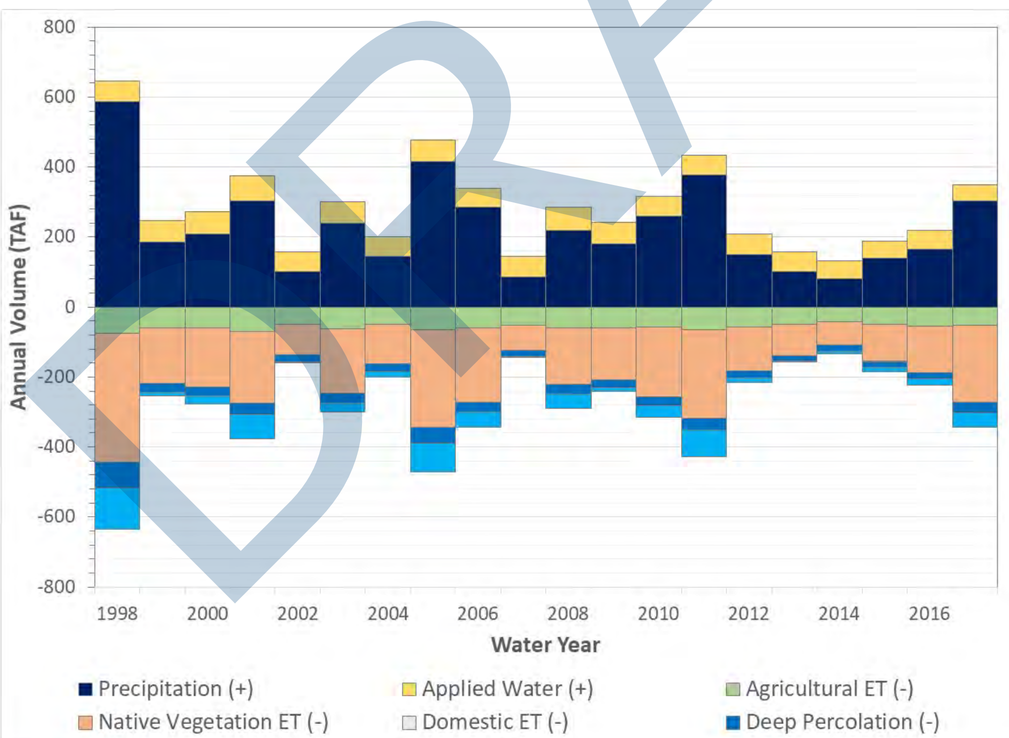


Figure 2-68: Historical Land Surface Water Budget Annual Time Series

The Basin experiences about 285,000 AF of land surface inflows each year, of which 226,000 AF is from precipitation and the remainder is from applied water. About 225,000 acre-feet per year (AFY) is consumed as evapotranspiration or domestic use, with the remainder either recharging the groundwater aquifer as deep percolation or stream seepage or leaving the Basin as river flow.

The annual time series shows large year-to-year variability in the availability of water, with land surface inflows ranging from a low of about 132,000 AF to a high of 645,000 AF. These year-to-year changes in inflows result in corresponding differences in outflows, with total annual agricultural, native vegetation and domestic evapotranspiration ranging from 108,000 to 444,000 AF.

Figure 2-69 summarizes the average annual historical groundwater inflows and outflows in the Basin. Figure 2-70 shows the annual time series of historical groundwater inflows and outflows. The Basin average annual historical groundwater budget has greater outflows than inflows, leading to an average annual decrease in groundwater storage (i.e. overdraft) of 23,000 AF. The groundwater storage decreases consistently over time, despite year-to-year variability in groundwater inflows.

Figure 2-69: Historical Average Annual Groundwater Budget

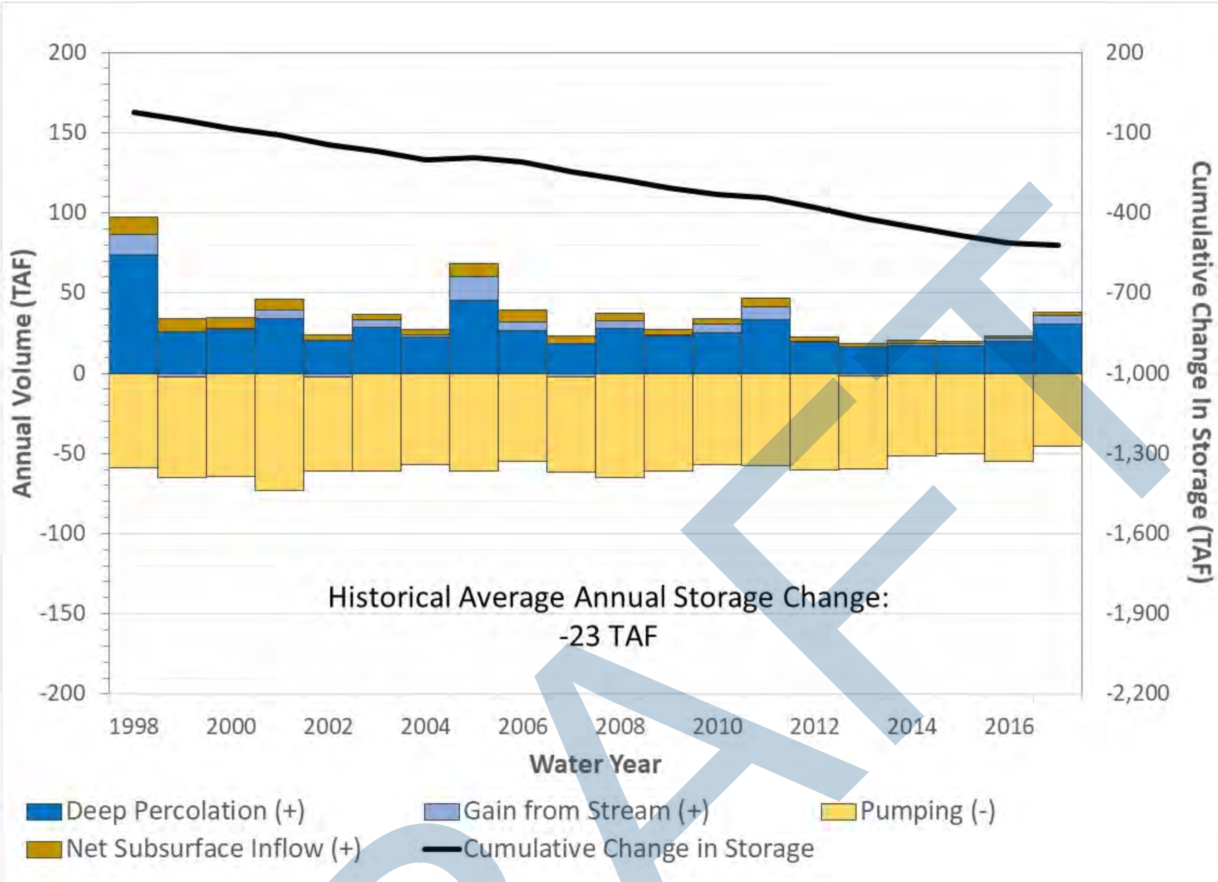


Figure 2-70: Historical Groundwater Budget Annual Time Series

Current and Projected Water Budget

The current and projected water budget quantifies inflows to and outflows from the Basin using 50 years of hydrology in conjunction with 2017 population, water use, and land use information.

Figure 2-71 summarizes the average annual current and projected land surface inflows and outflows in the Basin. Figure 2-72 shows the annual time series of current and projected land surface inflows and outflows.

Figure 2-71: Current and Projected Average Annual Land Surface Water Budget

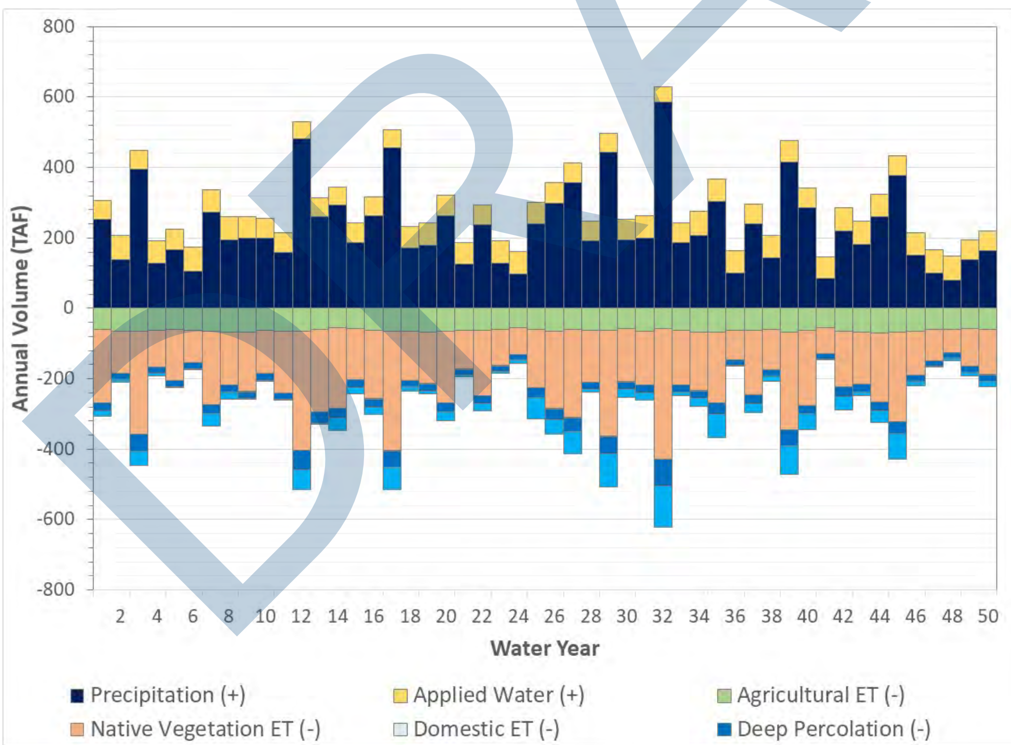


Figure 2-72: Current and Projected Land Surface Water Budget Annual Time Series

Under current and projected conditions, the Basin experiences about 290,000 AF of land surface inflows each year, of which 230,000 AF is from precipitation and the remainder is from applied water. About 238,000 AFY is consumed as evapotranspiration or domestic use, with the remainder either recharging the groundwater aquifer as deep percolation or stream seepage or leaving the Basin as river flow.

The annual time series shows the year-to-year variability in the availability of water, with land surface inflows ranging from a low of about 147,000 AF to a high of 628,000 AF. These year-to-year changes in inflows result in corresponding differences in outflows, with total annual agricultural, native vegetation and domestic evapotranspiration ranging from 127,000 to 429,000 AF.

Figure 2-73 summarizes the average annual current and projected groundwater inflows and outflows in the Basin. Figure 2-74 shows the annual time series of current and projected groundwater inflows and outflows. The Basin average annual current and projected groundwater budget has greater outflows than inflows, leading to an average annual decrease in groundwater storage (i.e. overdraft) of 25,000 AF. As with the historical conditions, the groundwater storage decreases consistently over time, despite year-to-year variability in groundwater inflows.

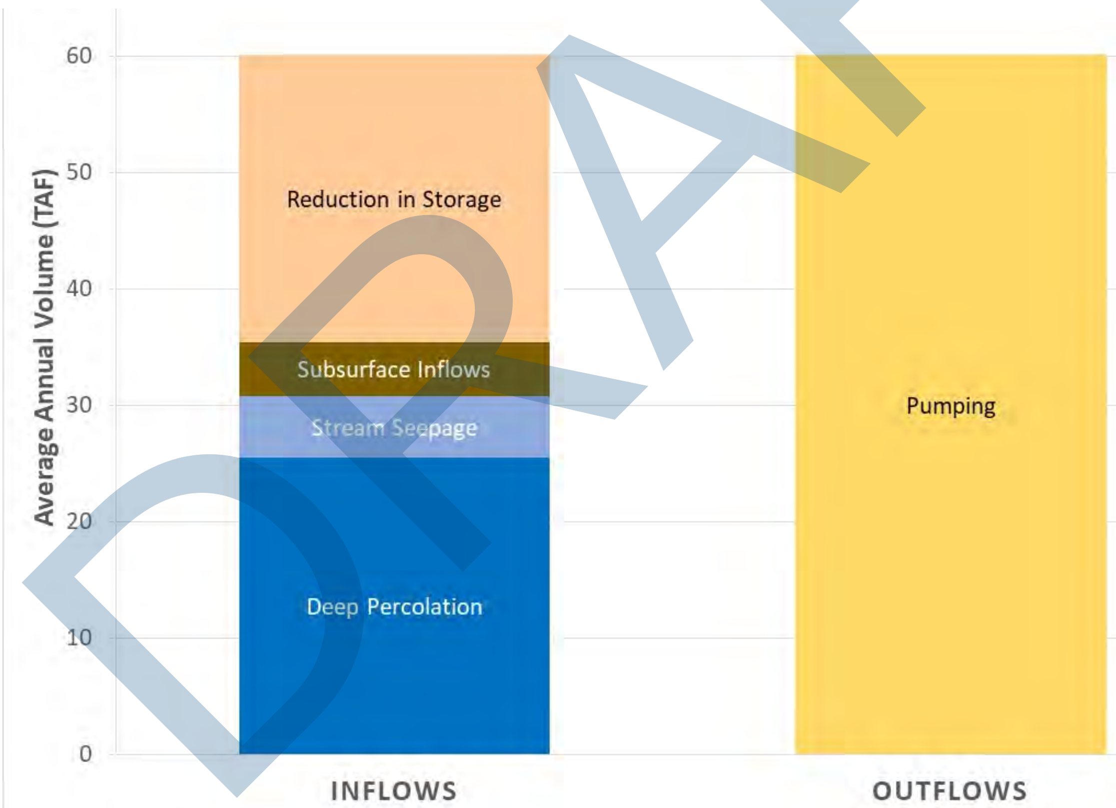


Figure 2-73: Current and Projected Average Annual Groundwater Budget

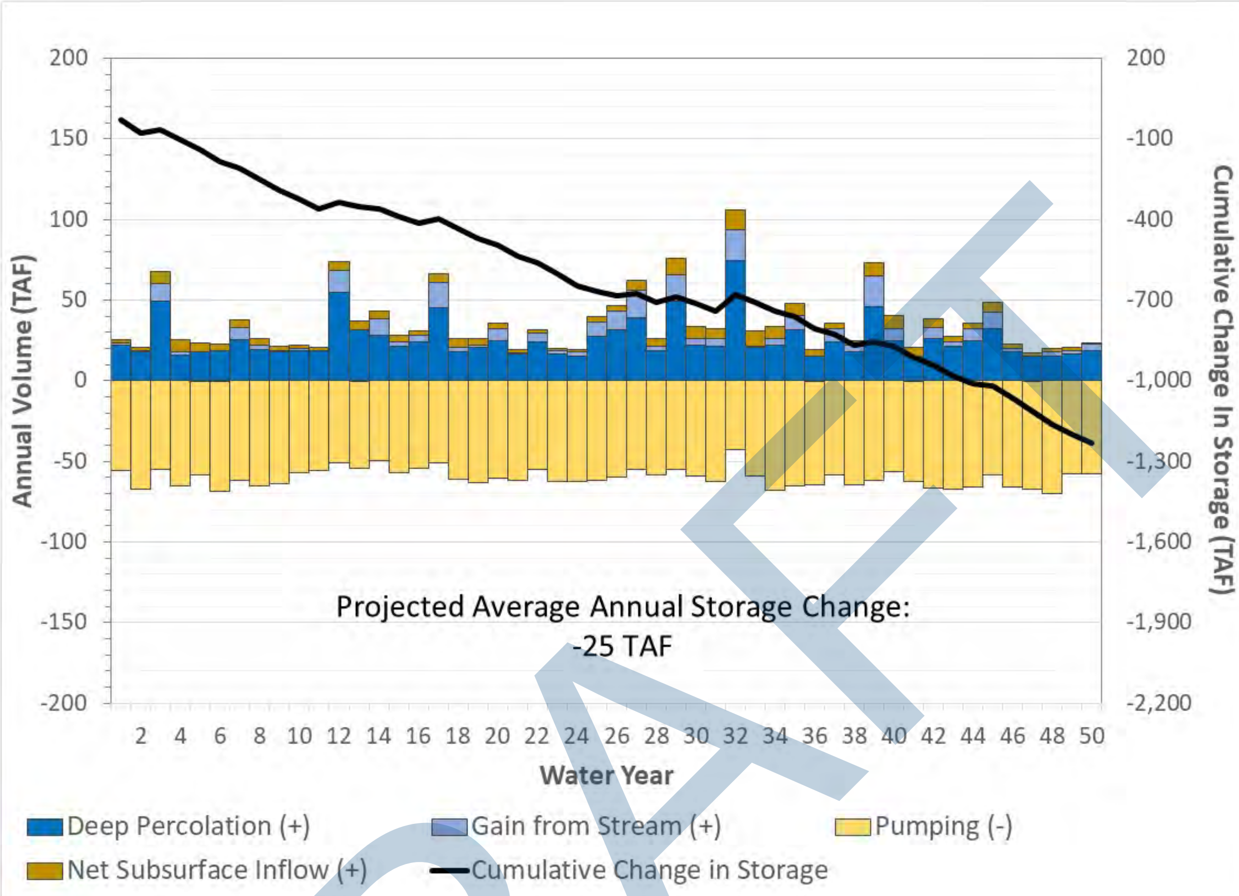


Figure 2-74: Current and Projected Groundwater Budget Annual Time Series

The current and projected water demand, water supply, and change in groundwater storage vary by water year type[6], as shown in Table 2-6. In wet years, precipitation meets a relative high proportion of the water demand, which reduces the need for groundwater. By contrast, in drier years more groundwater pumping is required to meet the agricultural demand not met by precipitation. This leads to an increase in groundwater storage in wet years and a decrease in the other year types.

[6] Water year types are customized for the Basin watershed based on annual precipitation as follows:

- Wet year = more than 19.6 inches
- Above normal year = 13.1 to 19.6 inches
- Below normal year = 9.85 to 13.1 inches
- Dry year = 6.6 to 9.85 inches
- Critical year = less than 6.6 inches

Table 2-6: Current and Projected Average Annual Supply, Demand, and Change in Groundwater Storage by Water Year Type

Component	Water Year Type				
	Wet	Above Normal	Below Normal	Dry	Critical
Water Demand					
Agricultural Evapotranspiration (AFY)	64,000	63,000	64,000	63,000	60,000
Domestic Use (AFY)	500	400	400	300	200
Total Demand	**64,000**	**63,000**	**64,000**	**63,000**	**60,000**
Water Supply					
Groundwater Pumping (AFY)	54,000	59,000	62,000	61,000	66,000
Total Supply	**54,000**	**59,000**	**62,000**	**61,000**	**66,000**
Change in Storage	**18,000**	**(21,000)**	**(34,000)**	**(37,000)**	**(46,000)**

Projected Water Budget with Climate Change

The projected water budget with climate change quantifies inflows to and outflows from the Basin using 50-years of hydrology in conjunction with 2017 population, water use, and land use information, with historical precipitation and evapotranspiration values modified for climate change.

Figure 2-75 summarizes the average annual current and projected land surface inflows and outflows in the Basin. Figure 2-76 shows the annual time series of current and projected land surface inflows and outflows.

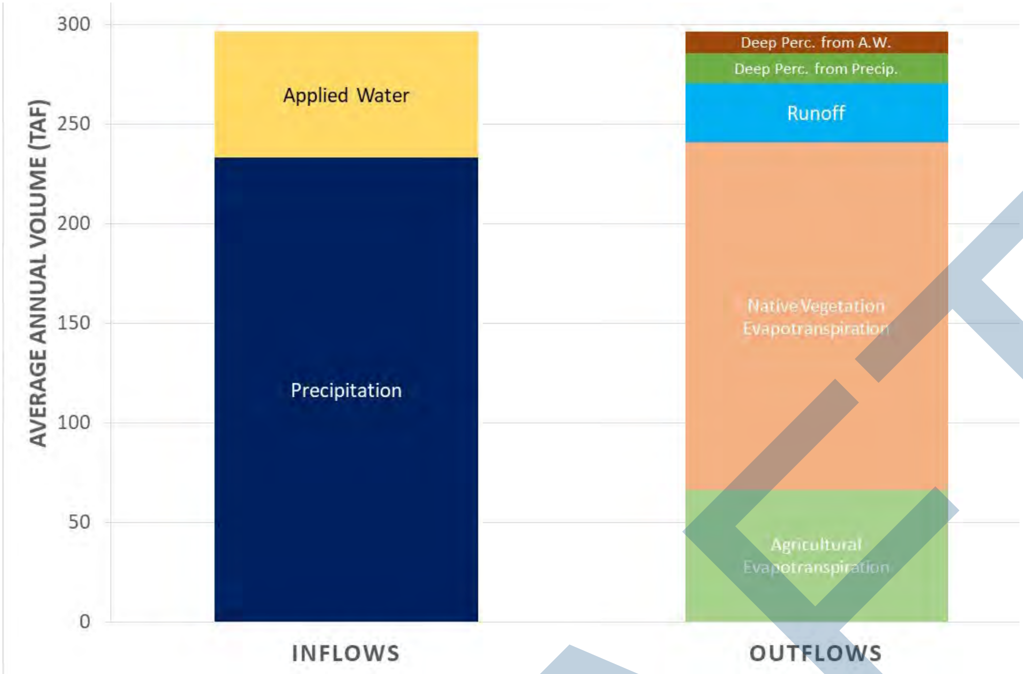


Figure 2-75: Projected Average Annual Land Surface Water Budget with Climate Change

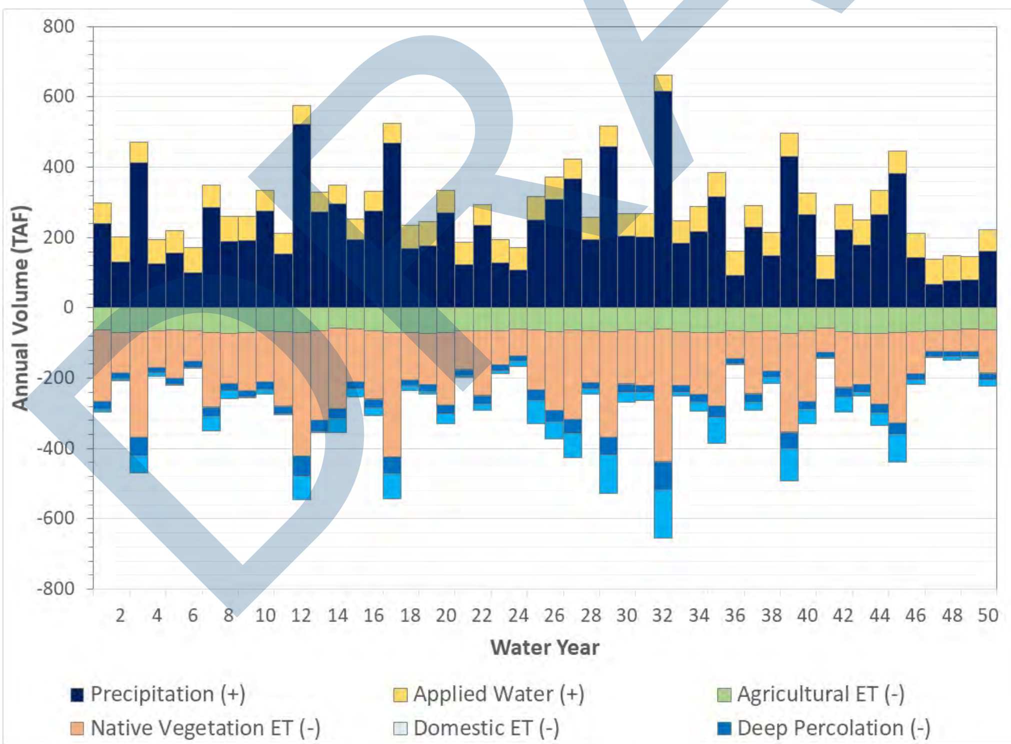


Figure 2-76: Projected Land Surface Water Budget with Climate Change Annual Time Series

Under projected conditions with climate change, the Basin experiences about 296,000 AF of land surface inflows each year, of which 233,000 AF is from precipitation and the remainder is from applied water. About 241,000 AFY is consumed as evapotranspiration or domestic use, with the remainder either recharging the groundwater aquifer as deep percolation or stream seepage or leaving the Basin as river flow.

The annual time series shows the year-to-year variability in the availability of water, with land surface inflows ranging from a low of about 138,000 AF to a high of 663,000 AF. These year-to-year changes in inflows result in corresponding differences in outflows, with total annual agricultural, native vegetation and domestic evapotranspiration ranging from 123,000 AF to 438,000 AF.

Figure 2-77 summarizes the average annual projected groundwater inflows and outflows with climate change in the Basin. Figure 2-78 shows the annual time series of projected groundwater inflows and outflows with climate change. The Basin average annual current and projected groundwater budget has greater outflows than inflows, leading to an average annual decrease in groundwater storage (i.e., overdraft) of 27,000 AF. As with the historical conditions, the groundwater storage decreases consistently over time, despite year-to-year variability in groundwater inflows.

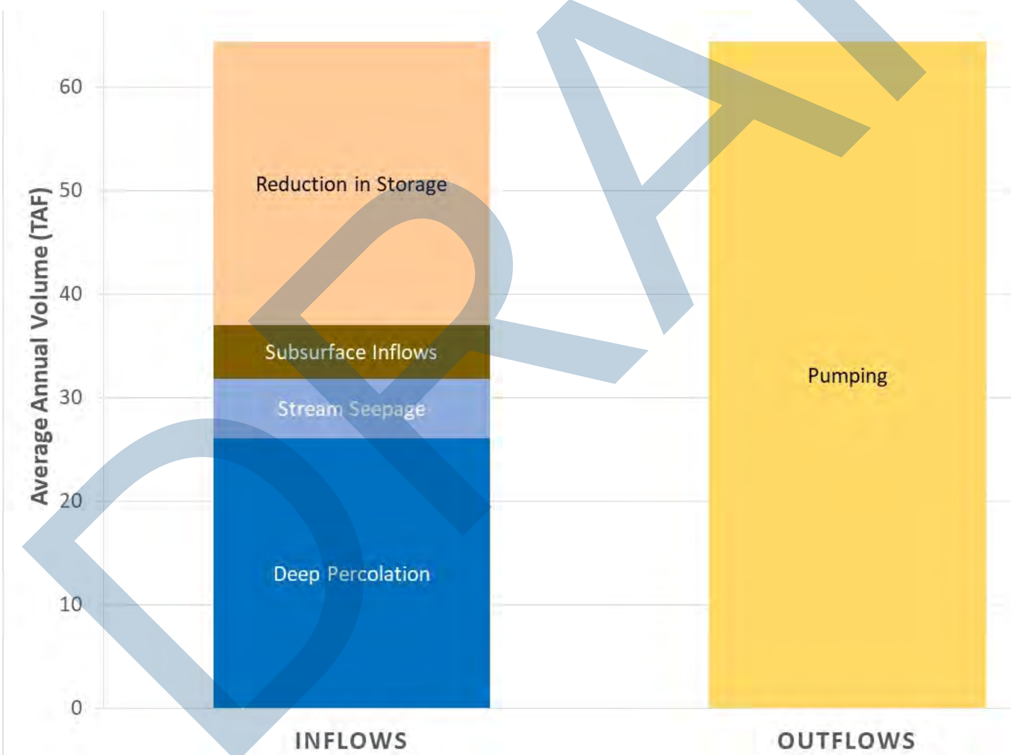


Figure 2-77: Current and Projected Average Annual Groundwater Budget

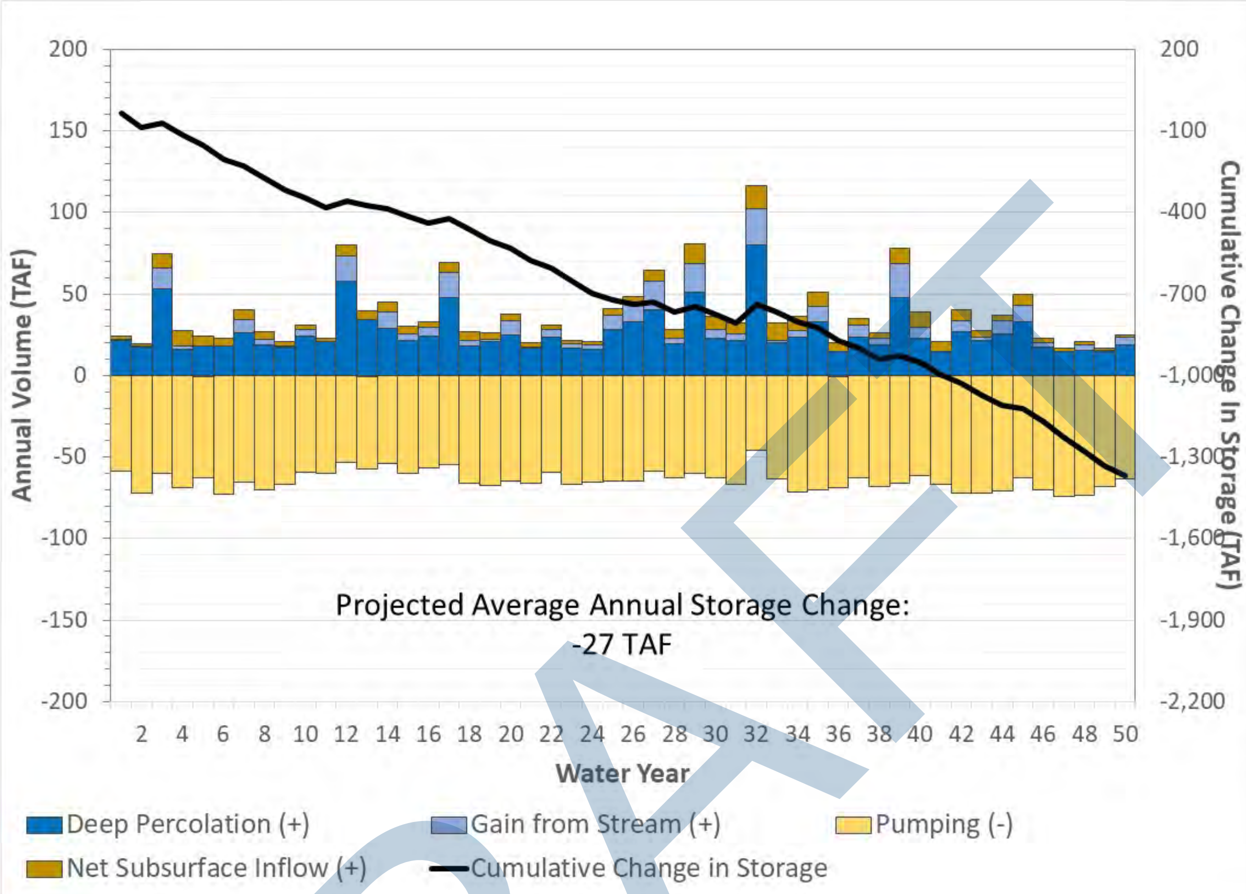


Figure 2-78: Current and Projected Groundwater Budget Annual Time Series

Sustainable Yield Estimates

Four simulations were performed to estimate the sustainable yield in the Basin as follows:

- Current and projected conditions sustainability with pumping reductions only
- Current and projected conditions sustainability with pumping reductions and water supply projects
- Projected sustainability with climate change with pumping reductions only
- Projected sustainability with climate change with pumping reductions and water supply projects

These simulations were performed using the current and projected conditions and projected conditions with climate change baselines described above, with projects and pumping reductions implemented so as to achieve an exact balance between supplies and demands in the Basin-wide groundwater budget on average over the 50-year simulation period.

Each simulation incorporating water supply projects was performed using example projects intended to estimate the potential water supply benefits from those projects. It is anticipated that these projects will be further evaluated and refined in the future prior to potential implementation. The analyses included the following water supply projects:

- **Flood and stormwater capture –** it was assumed that facilities would be developed to capture stormwater flows and recharge them into the groundwater aquifer in the central basin area. It was assumed that approximately 2,500 AF per year could be captured and recharged.
- **Precipitation enhancement –** it was assumed that cloud seeding would be performed to increase precipitation in the upper watershed areas. Based on previous studies of potential cloud seeding programs, it was assumed that precipitation would increase by 10% on average.

Chapter 7 of this GSP describes these potential water supply projects in greater detail. Chapter 7 also describes potential mechanisms to reduce groundwater pumping.

As noted above, these simulations were performed using the best available data and information as of June 2018. It is expected that the model will be refined in the future as improved and updated monitoring information becomes available in the Basin. These refinements will result in changes in the sustainable yield estimates described in this section.

Table 2-7 shows the groundwater budget for each sustainability scenario. Because there is no long-term average change in groundwater storage in these scenarios, the groundwater pumping represents the overall estimated sustainable yield in each scenario. The Basin sustainable yield is estimated to be about 20,000 to 21,000 AFY without water supply projects (i.e., a 67 percent reduction in groundwater pumping compared to baseline) and about 27,000 AFY with water supply projects (i.e., a 55 to 63 percent reduction in groundwater pumping compared to baseline).

Table 2-7: Average Annual Groundwater Budget for Sustainability Scenarios				
Component	**Current and Projected Conditions with Pumping Reductions Only (AFY)**	**Projected Conditions with Climate Change with Pumping Reductions Only (AFY)**	**Current and Projected Conditions with Pumping Reductions and Water Supply Projects (AFY)**	**Projected Conditions with Climate Change with Pumping Reductions and Water Supply Projects (AFY)**
Inflows				
Deep percolation	12,000	11,000	18,000	18,000
Stream seepage	4,000	5,000	4,000	4,000
Subsurface inflow	4,000	5,000	5,000	5,000
Total Inflow	**20,000**	**21,000**	**27,000**	**27,000**
Outflows				
Groundwater pumping	20,000	21,000	27,000	27,000
Total Outflow	20,000	21,000	27,000	27,000
Change in Storage	**(0)**	**(0)**	**(0)**	**(0)**
Reduction in groundwater pumping relative to Baseline	**(40,000)**	**(43,000)**	**(33,000)**	**(37,000)**
Percent reduction	**-67%**	**-67%**	**-55%**	**-63%**
Notes: All sustainability scenarios are simulated using the 1968 to 2017 hydrologic period.				

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Appendix A

Cuyama Valley Groundwater Basin Hydrographs

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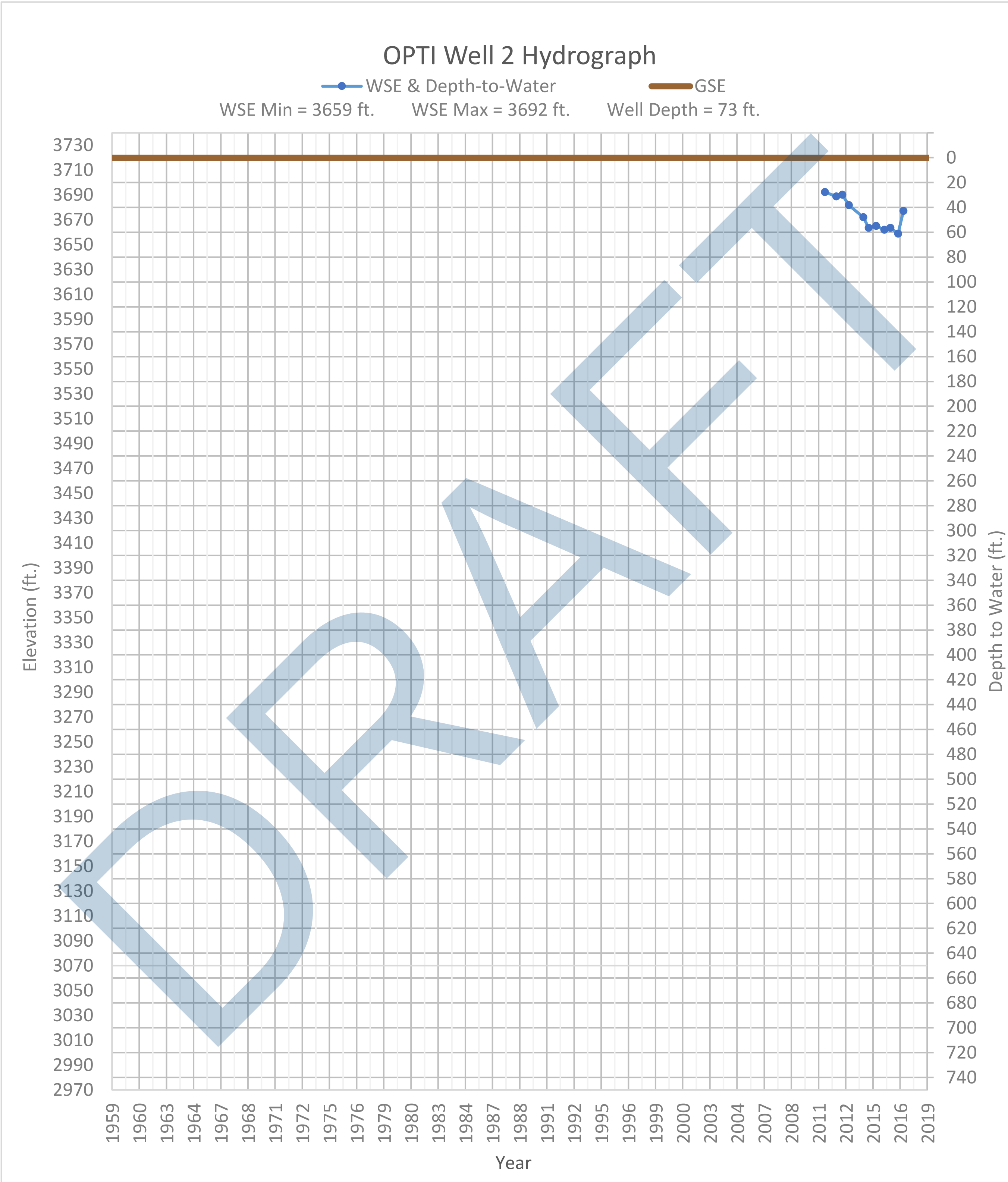
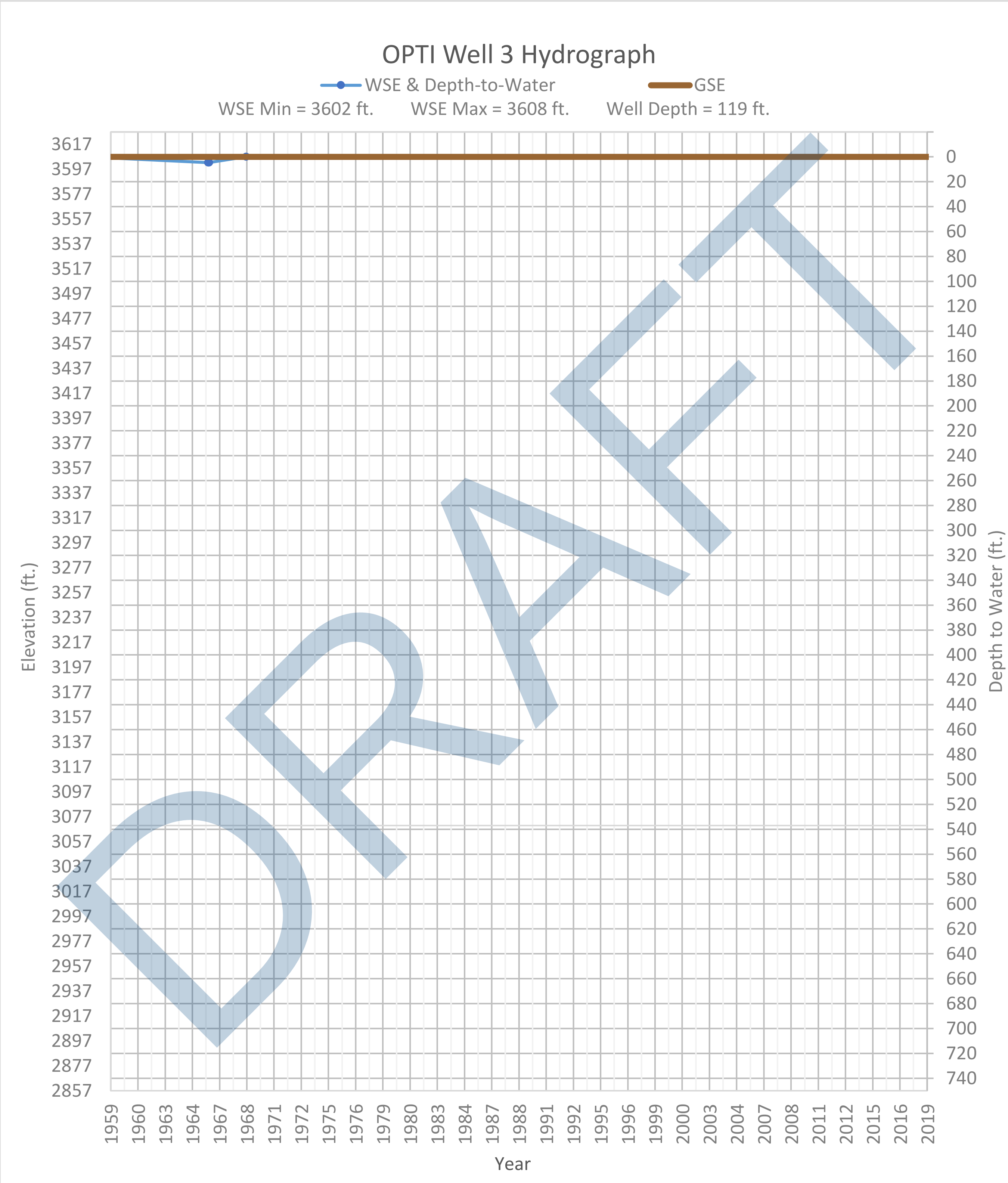
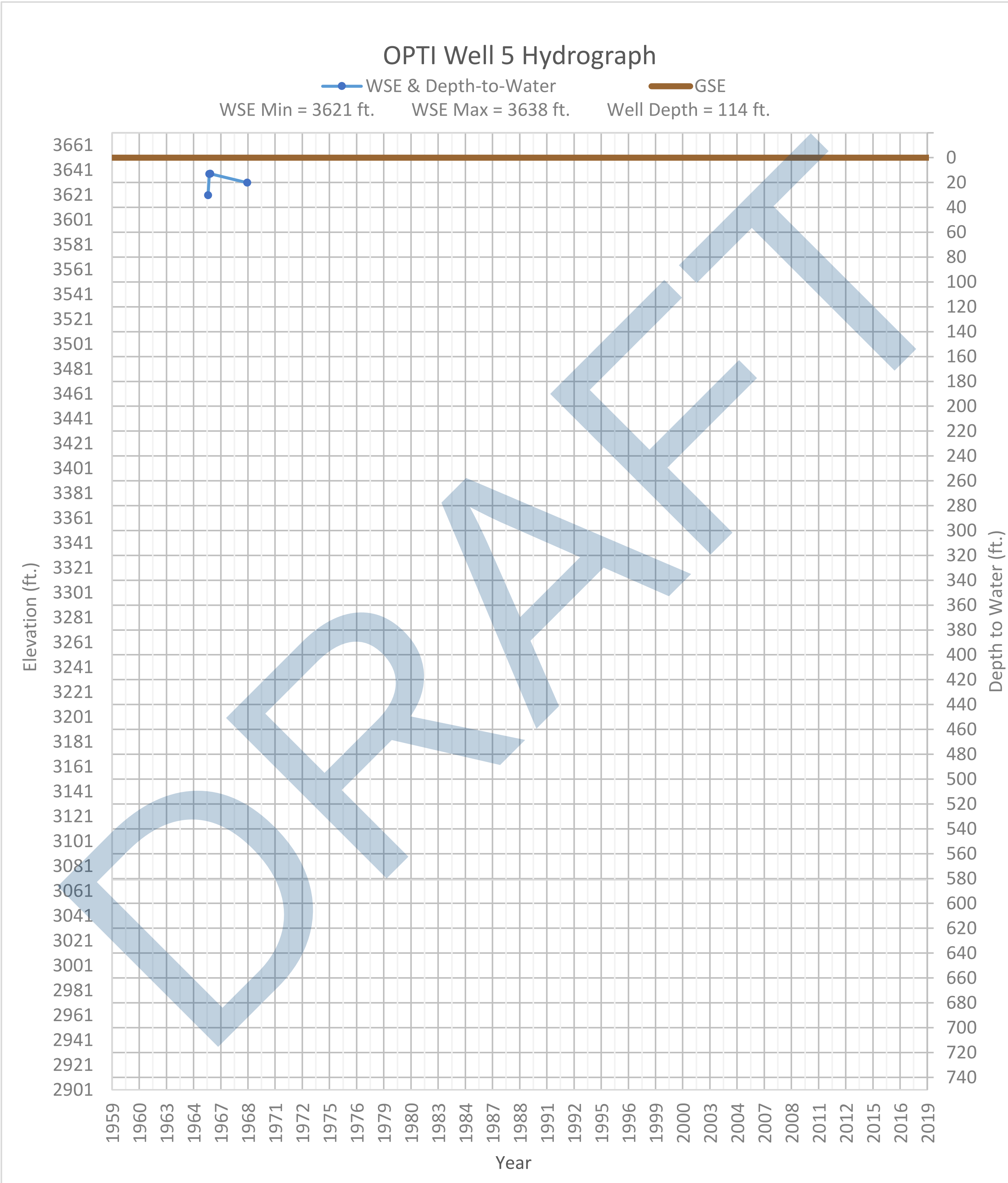


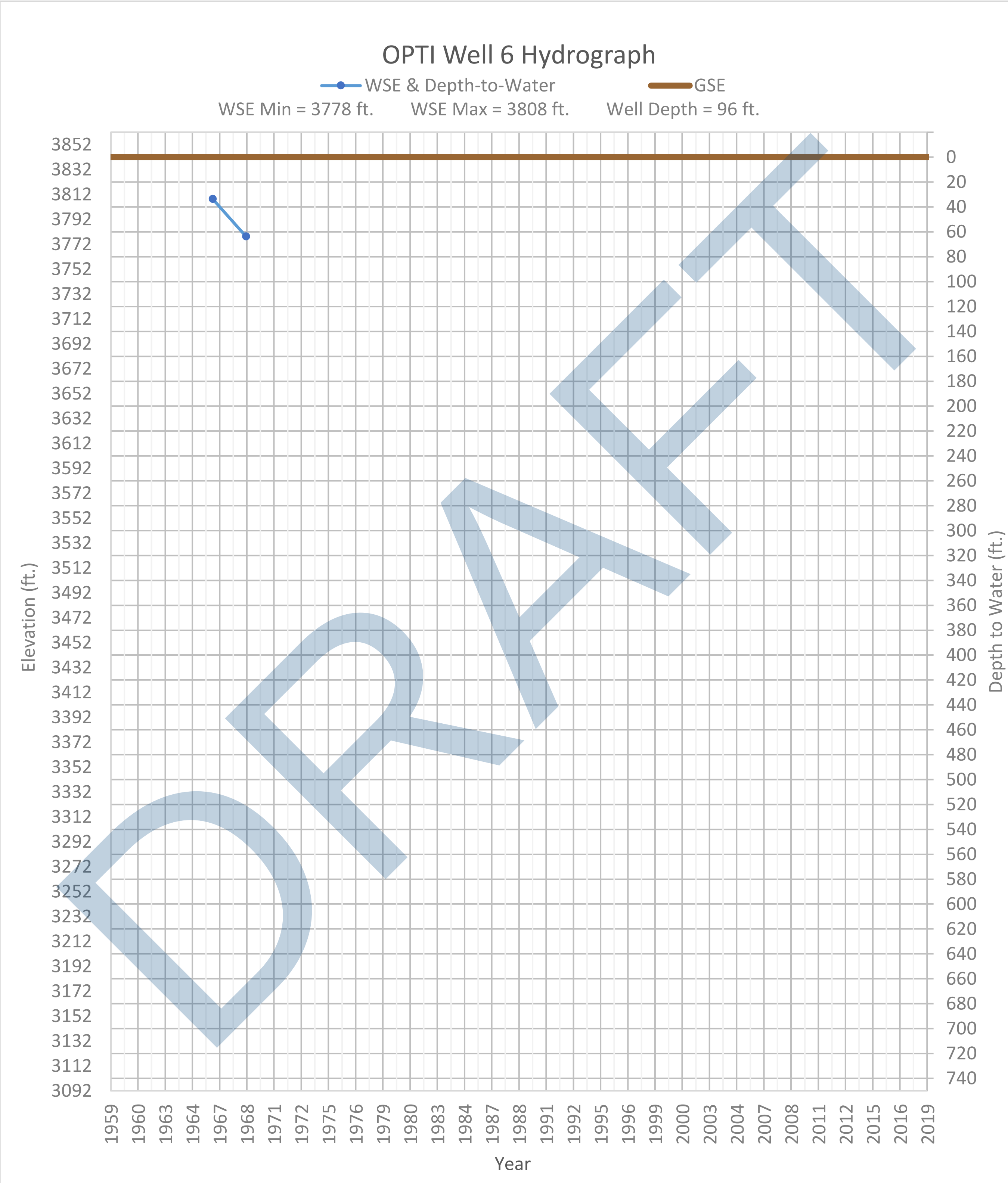
OPTI Well 2 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3659 ft.
WSE Max = 3692 ft.
Well Depth = 73 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 3 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3602 ft.
WSE Max = 3608 ft.
Well Depth = 119 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 5 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3621 ft.
WSE Max = 3638 ft.
Well Depth = 114 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 6 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3778 ft.
WSE Max = 3808 ft.
Well Depth = 96 ft.
Elevation (ft.)
3852
3832
3812
3792
3772
3752
3732
3712
3692
3672
3652
3632
3612
3592
3572
3552
3532
3512
3492
3472
3452
3432
3412
3392
3372
3352
3332
3312
3292
3272
3252
3232
3212
3192
3172
3152
3132
3112
3092
Depth to Water (ft.)
0
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40
60
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100
120
140
160
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2019
Year
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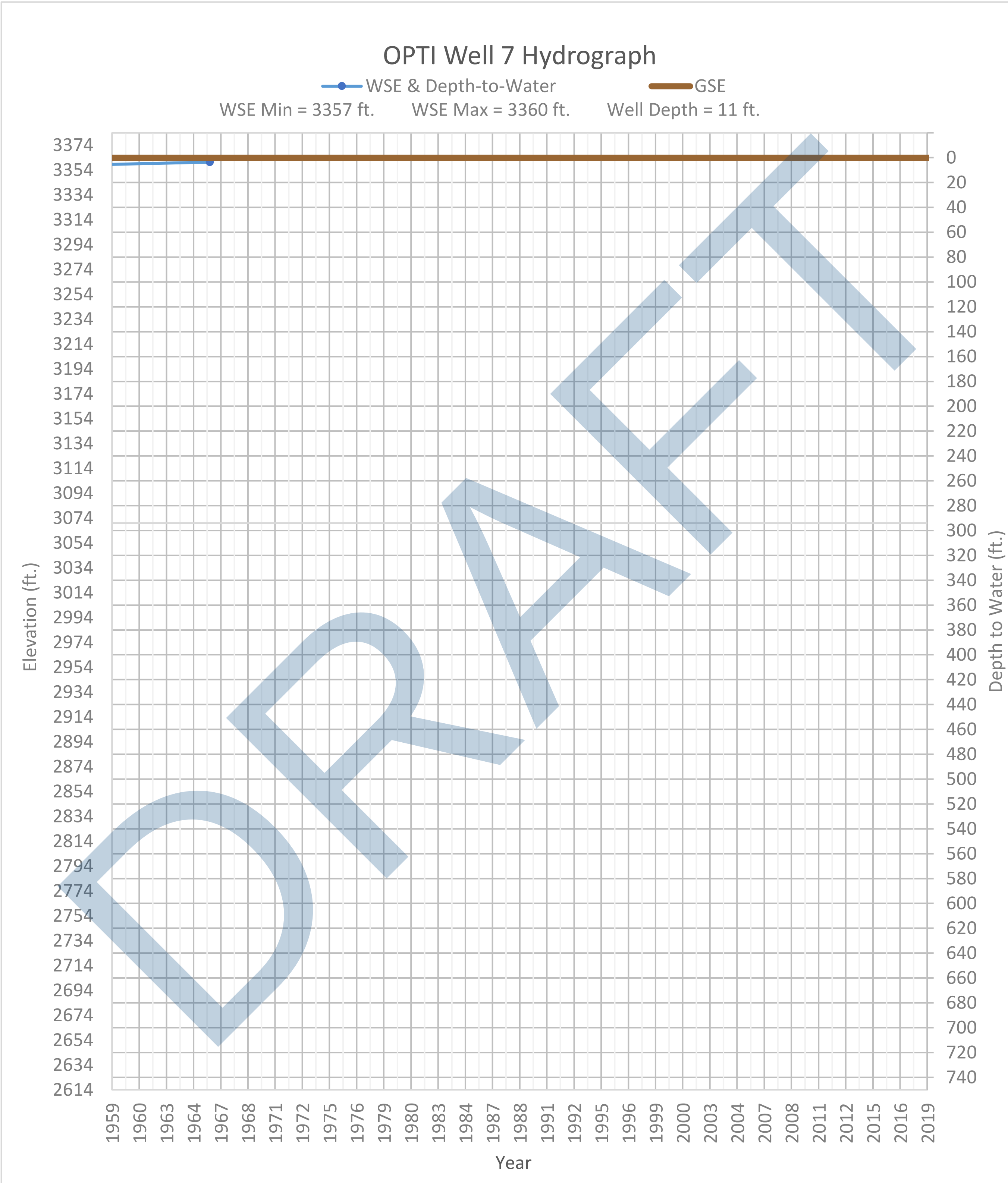

OPTI Well 7 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3357 ft.
WSE Max = 3360 ft.
Well Depth = 11 ft.
Elevation (ft.)
3374
3354
3334
3314
3294
3274
3254
3234
3214
3194
3174
3154
3134
3114
3094
3074
3054
3034
3014
2994
2974
2954
2934
2914
2894
2874
2854
2834
2814
2794
2774
2754
2734
2714
2694
2674
2654
2634
2614
Depth to Water (ft.)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
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300
320
340
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380
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Year
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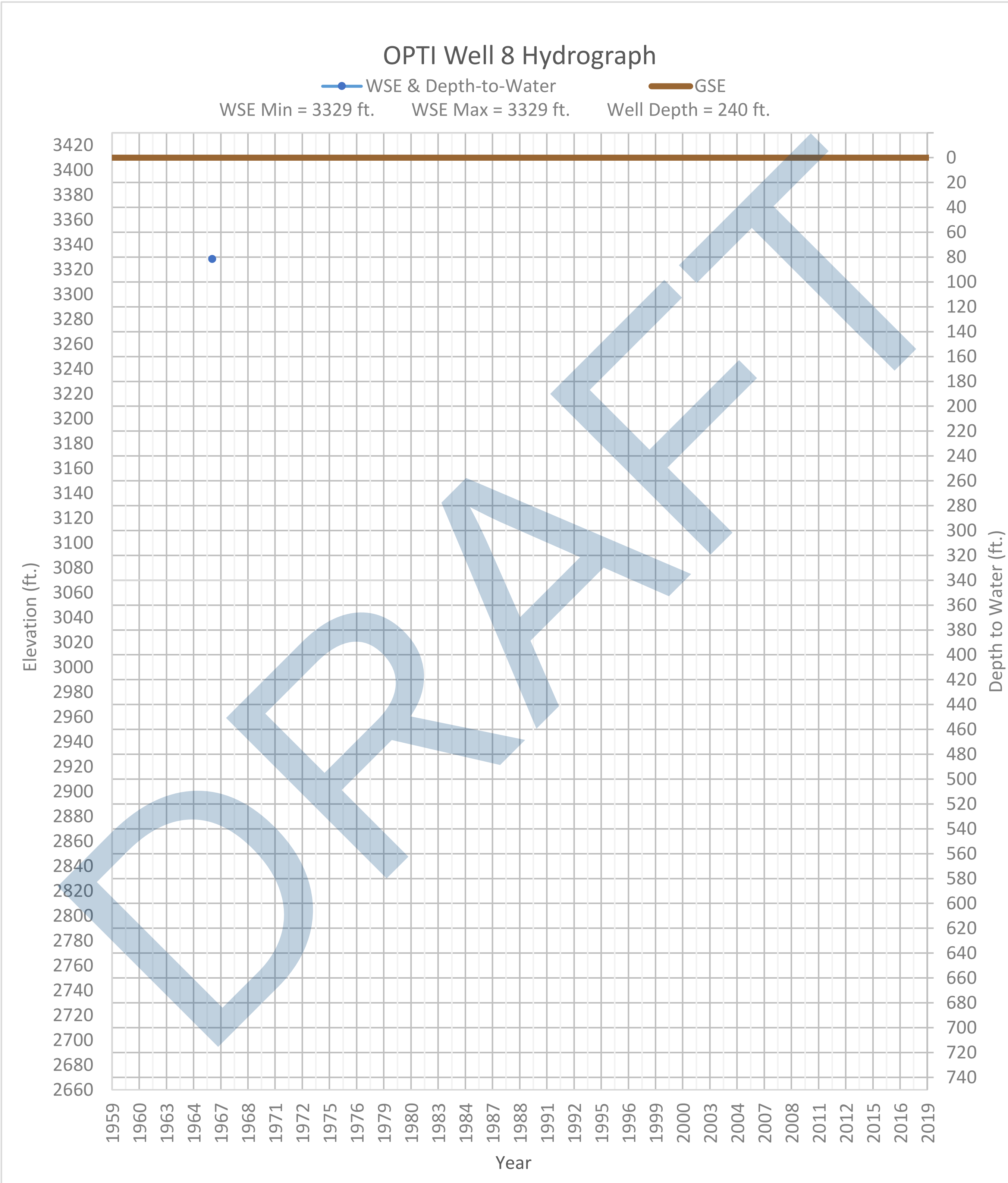
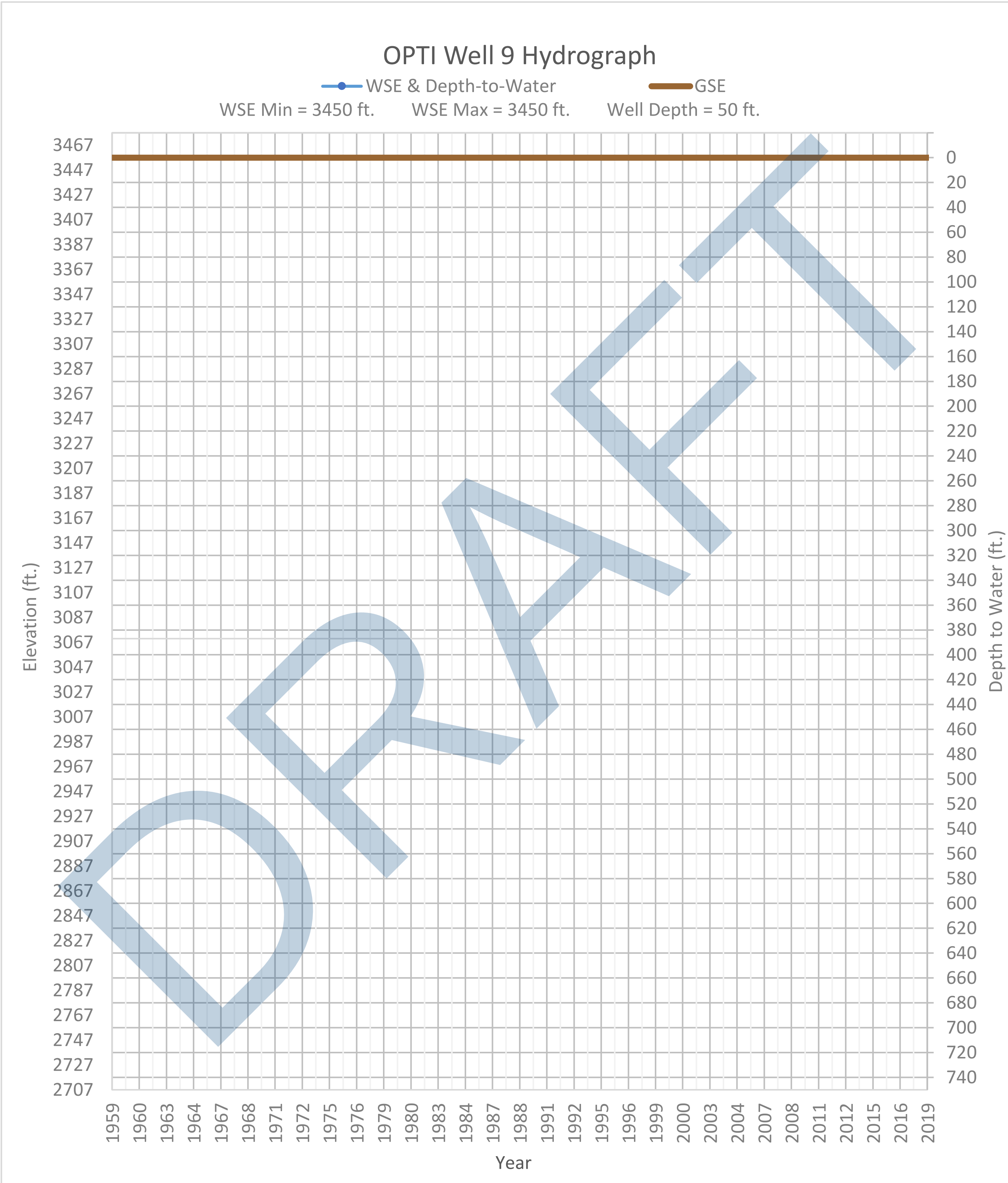


OPTI Well 8 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3329 ft.
WSE Max = 3329 ft.
Well Depth = 240 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 9 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3450 ft.
WSE Max = 3450 ft.
Well Depth = 50 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
3467
3447
3427
3407
3387
3367
3347
3327
3307
3287
3267
3247
3227
3207
3187
3167
3147
3127
3107
3087
3067
3047
3027
3007
2987
2967
2947
2927
2907
2887
2867
2847
2827
2807
2787
2767
2747
2727
2707
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140
160
180
200
220
240
260
280
300
320
340
360
380
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460
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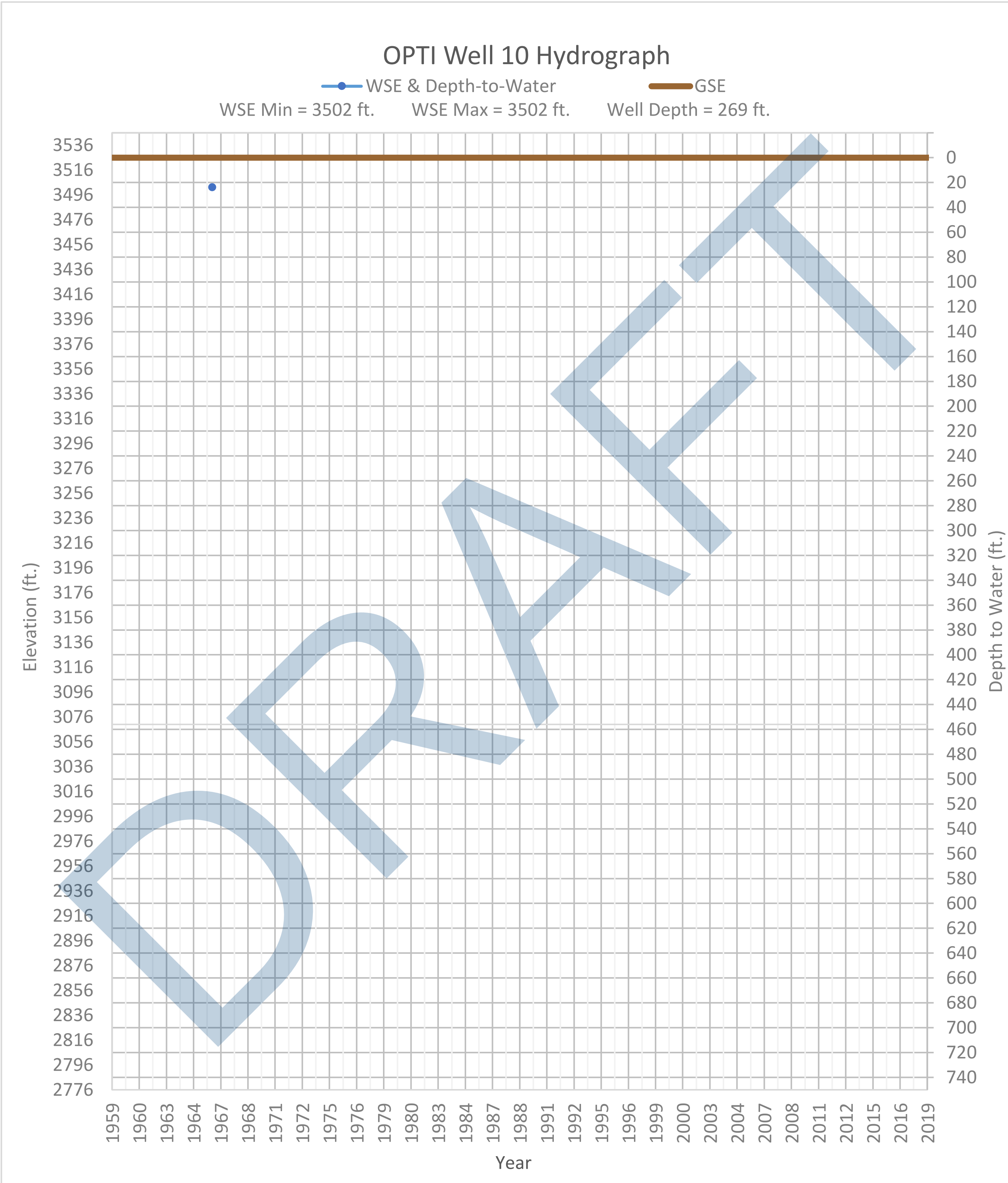

OPTI Well 10 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3502 ft.
WSE Max = 3502 ft.
Well Depth = 269 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
3536
3516
3496
3476
3456
3436
3416
3396
3376
3356
3336
3316
3296
3276
3256
3236
3216
3196
3176
3156
3136
3116
3096
3076
3056
3036
3016
2996
2976
2956
2936
2916
2896
2876
2856
2836
2816
2796
2776
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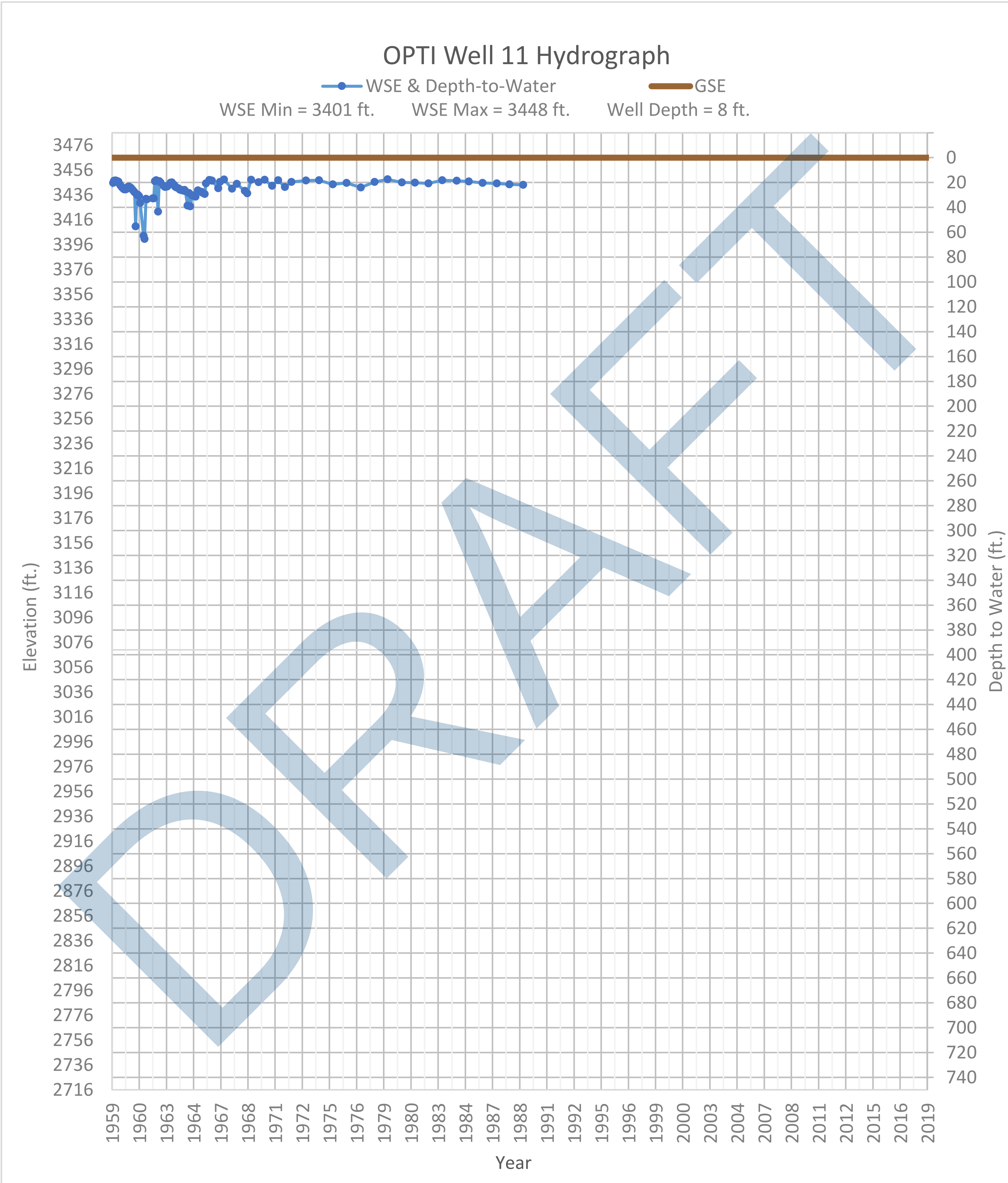
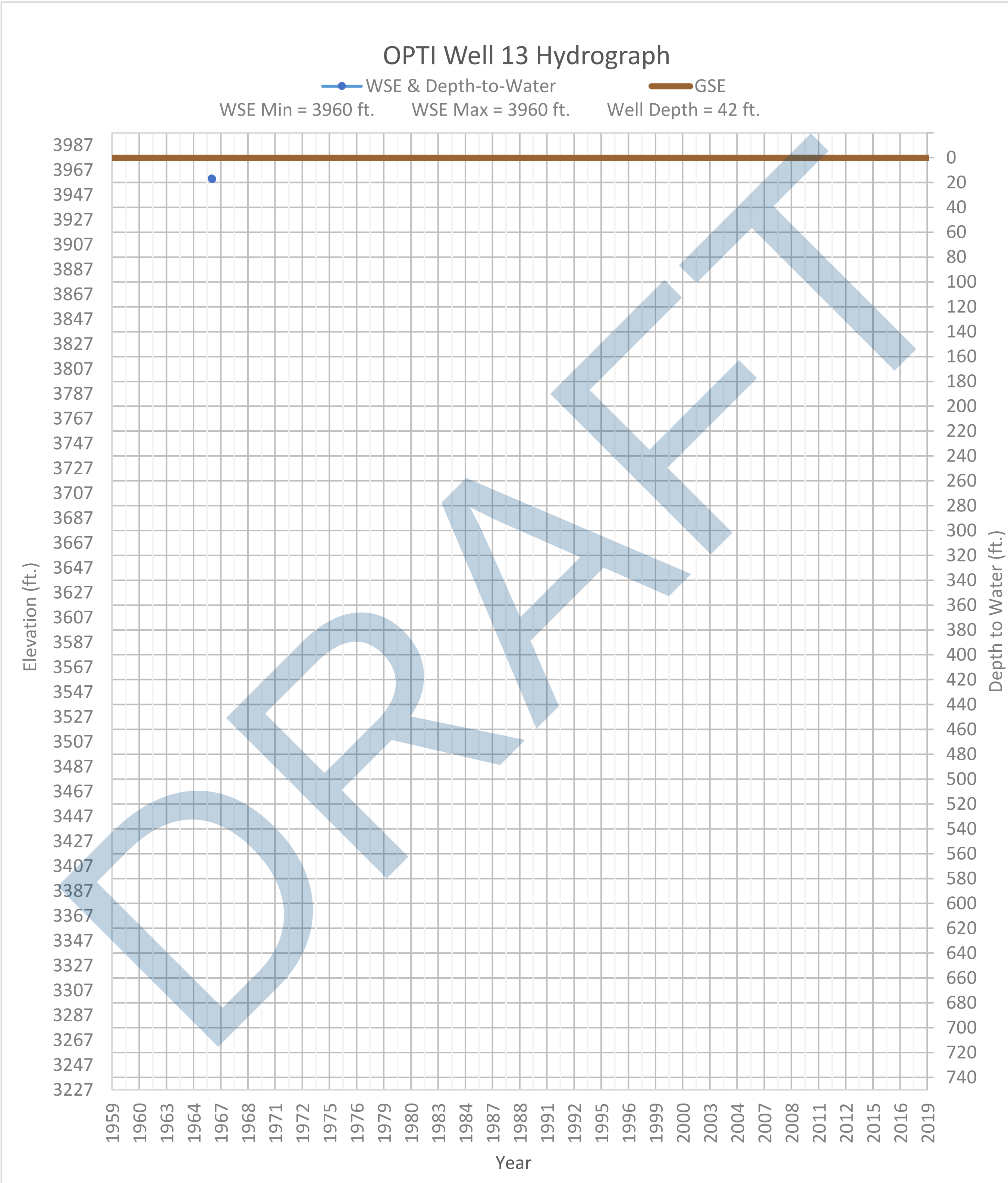
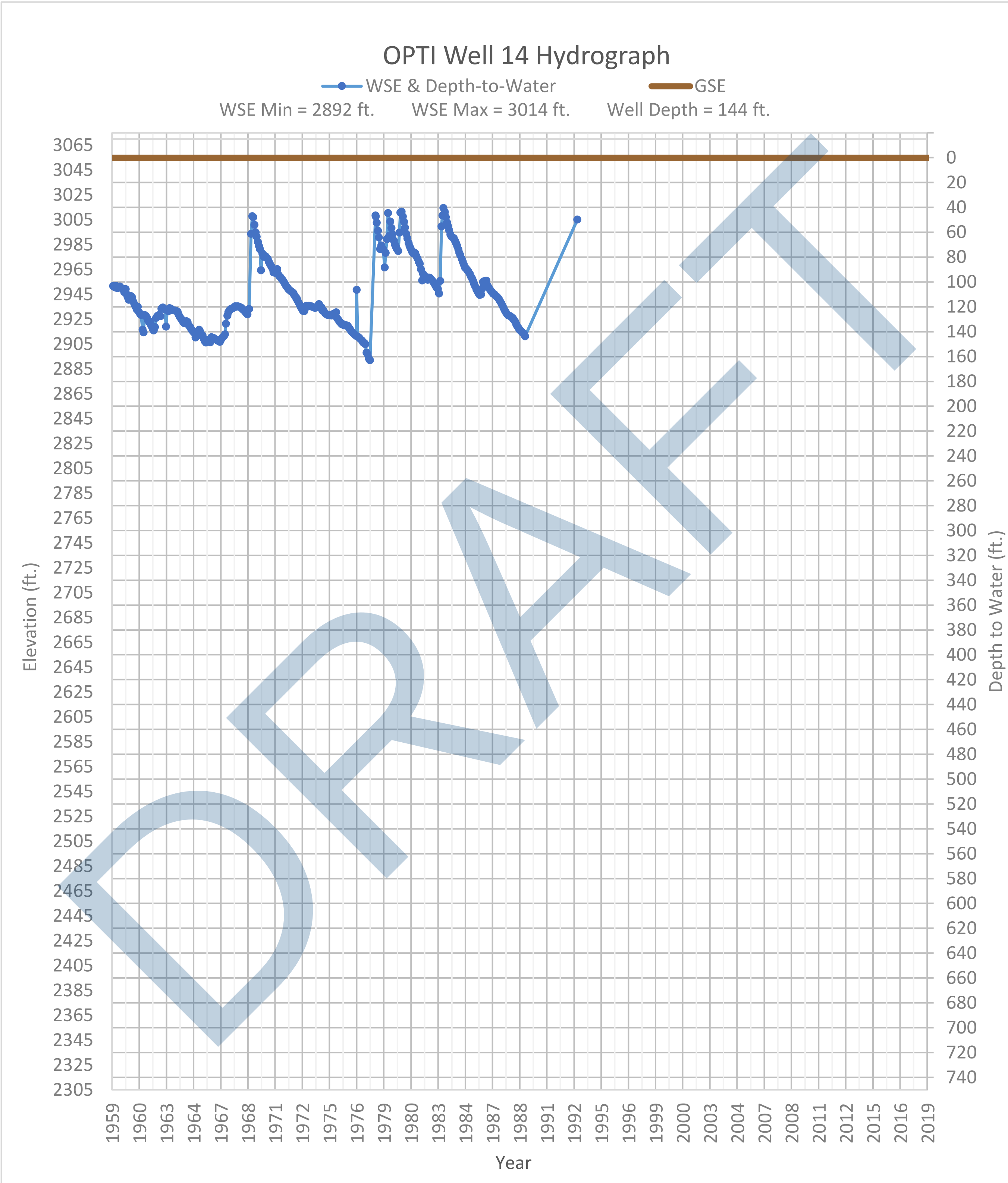


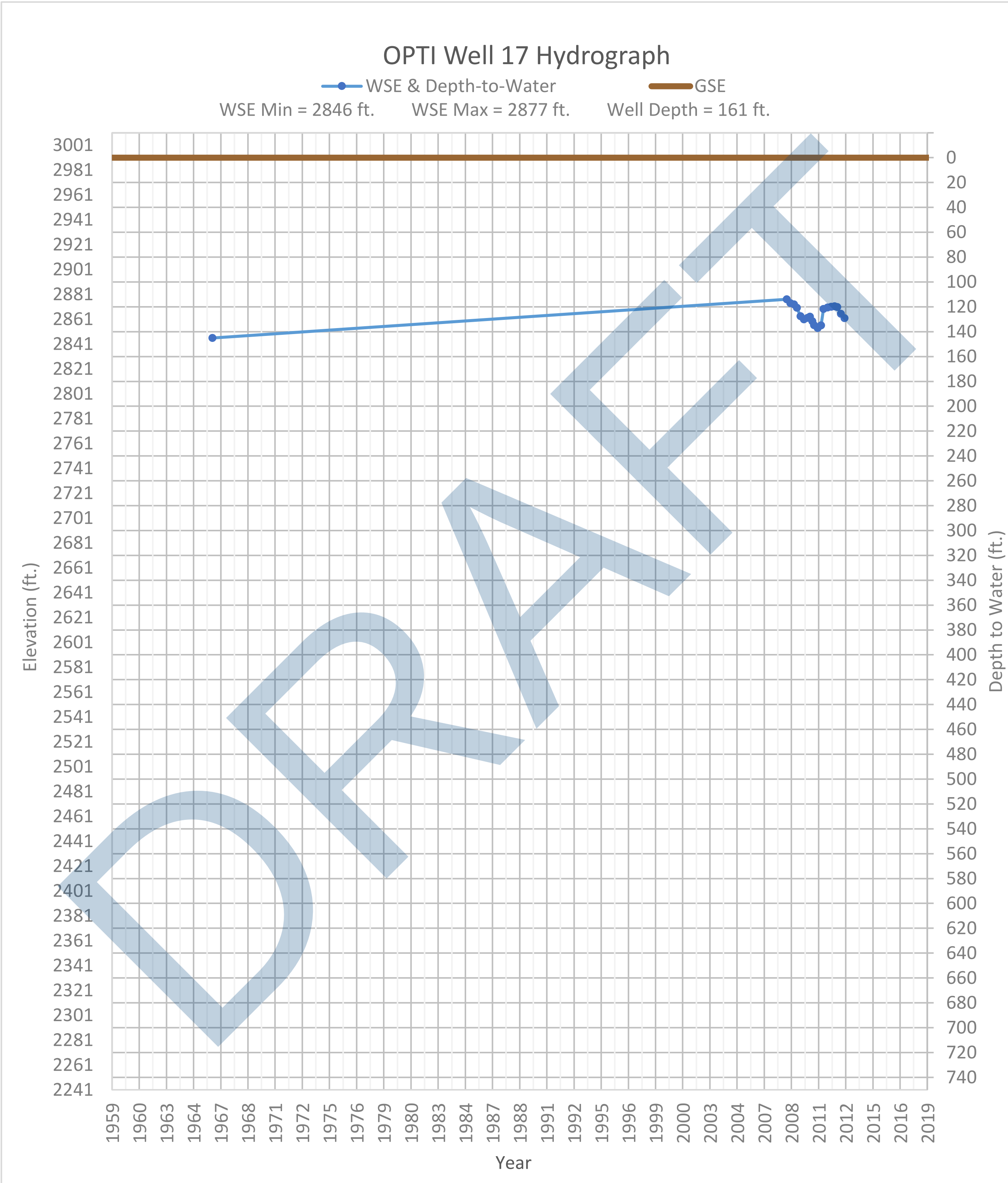
OPTI Well 11 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3401 ft.
WSE Max = 3448 ft.
Well Depth = 8 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



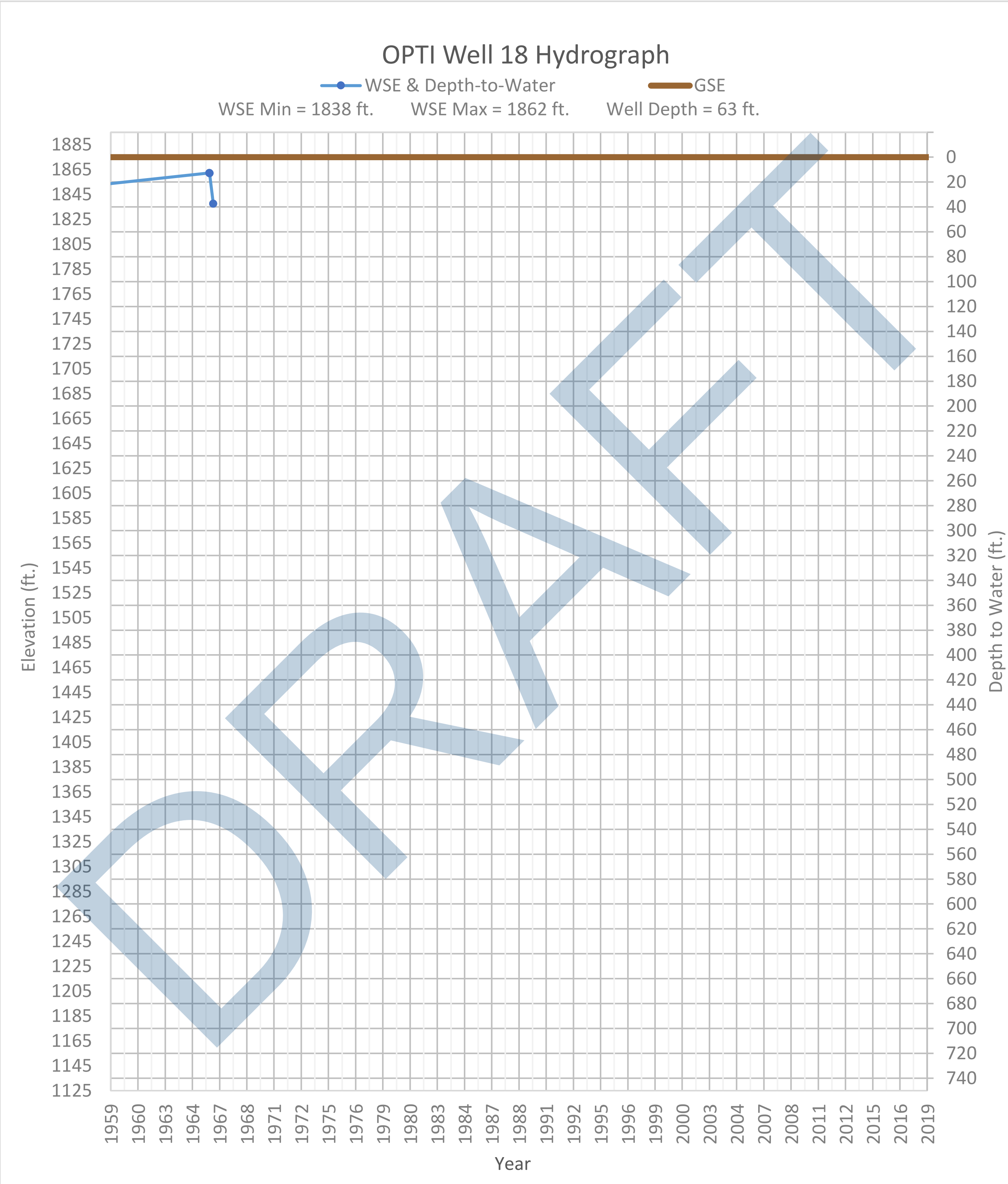
OPTI Well 13 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3960 ft.
WSE Max = 3960 ft.
Well Depth = 42 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 14 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2892 ft.
WSE Max = 3014 ft.
Well Depth = 144 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 17 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2846 ft.
WSE Max = 2877 ft.
Well Depth = 161 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 18 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1838 ft.
WSE Max = 1862 ft.
Well Depth = 63 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
1885
1865
1845
1825
1805
1785
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1745
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1705
1685
1665
1645
1625
1605
1585
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1125
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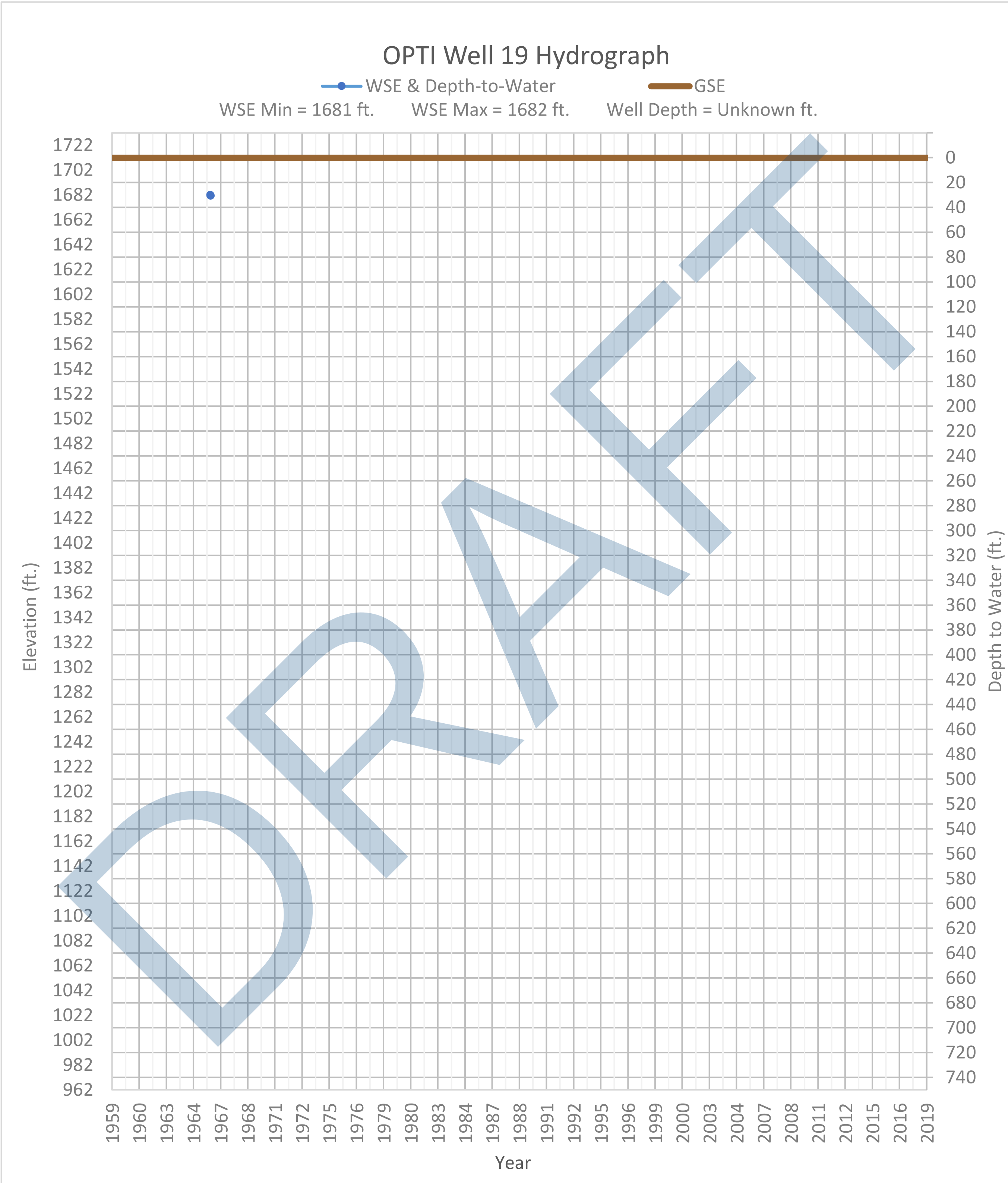
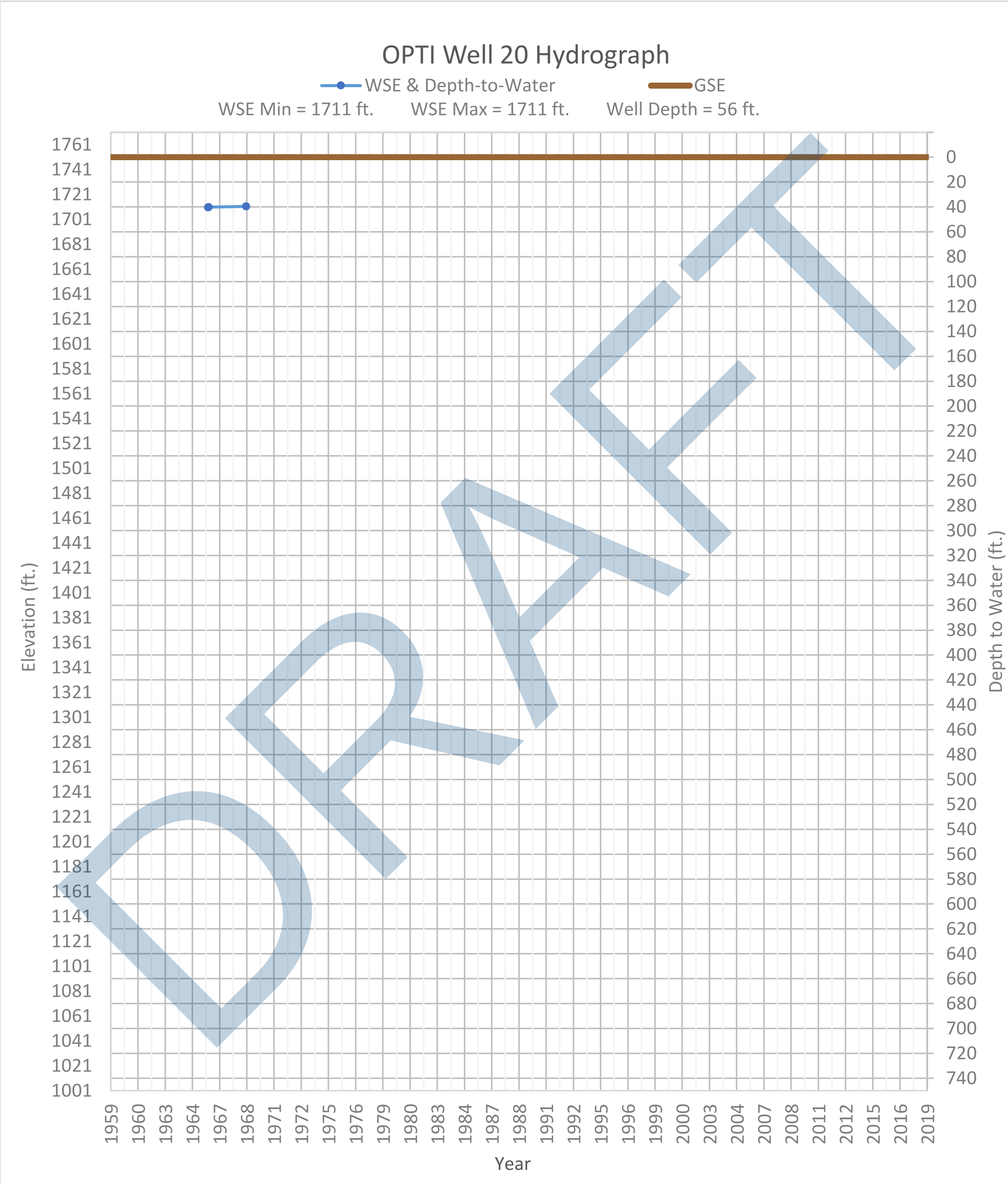
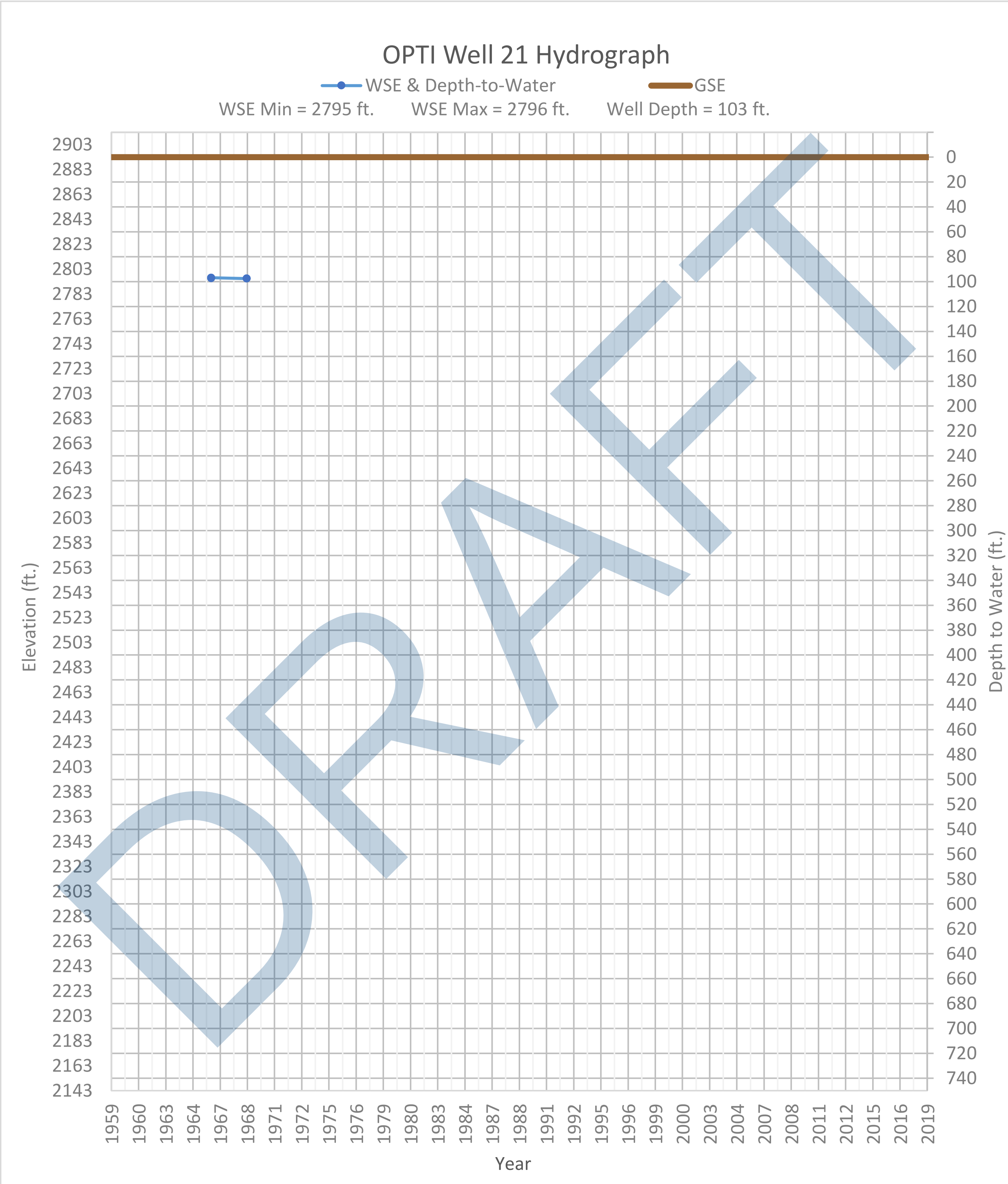
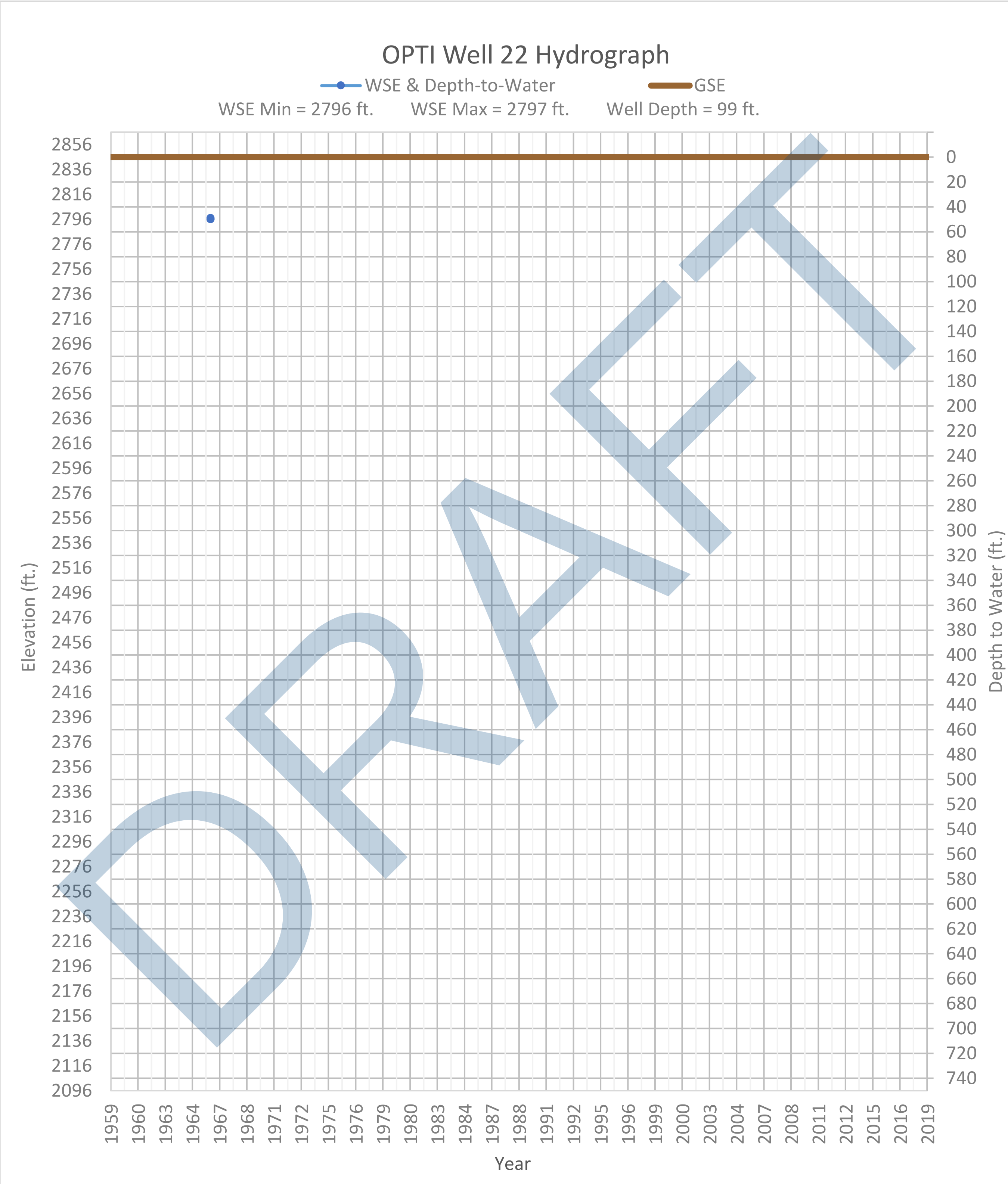


OPTI Well 19 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1681 ft.
WSE Max = 1682 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

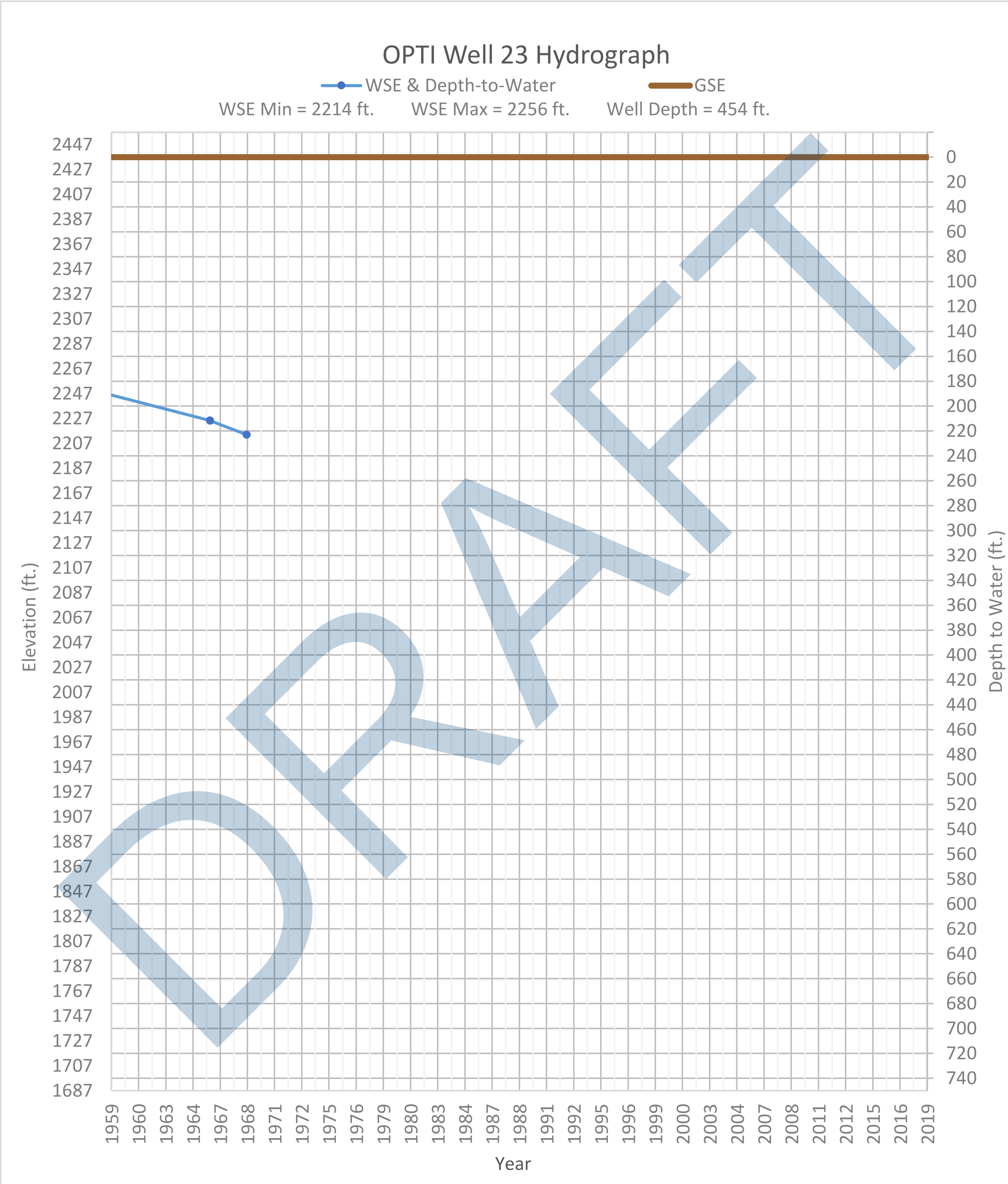


OPTI Well 20 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1711 ft.
WSE Max = 1711 ft.
Well Depth = 56 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

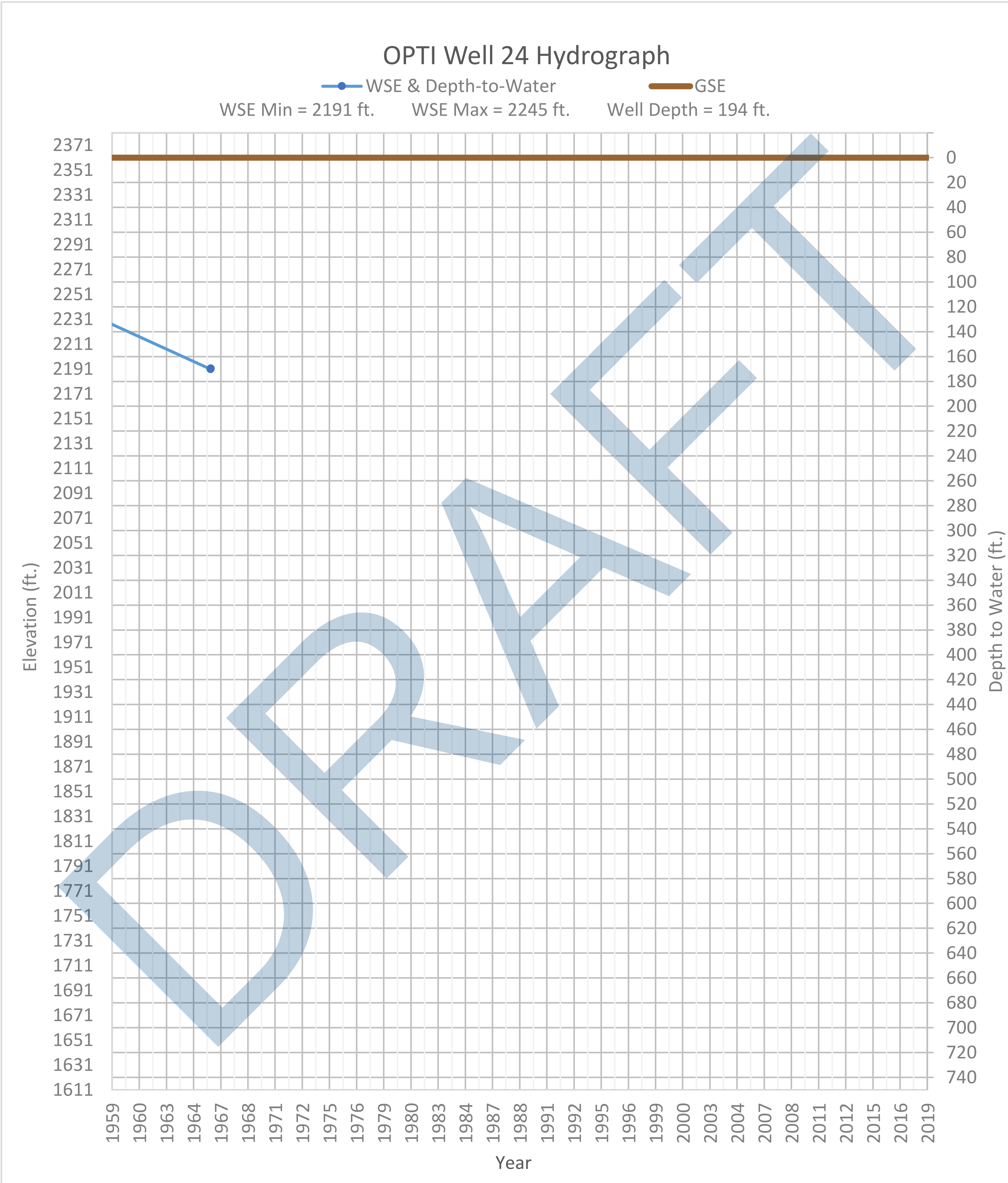

OPTI Well 21 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2795 ft.
WSE Max = 2796 ft.
Well Depth = 103 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



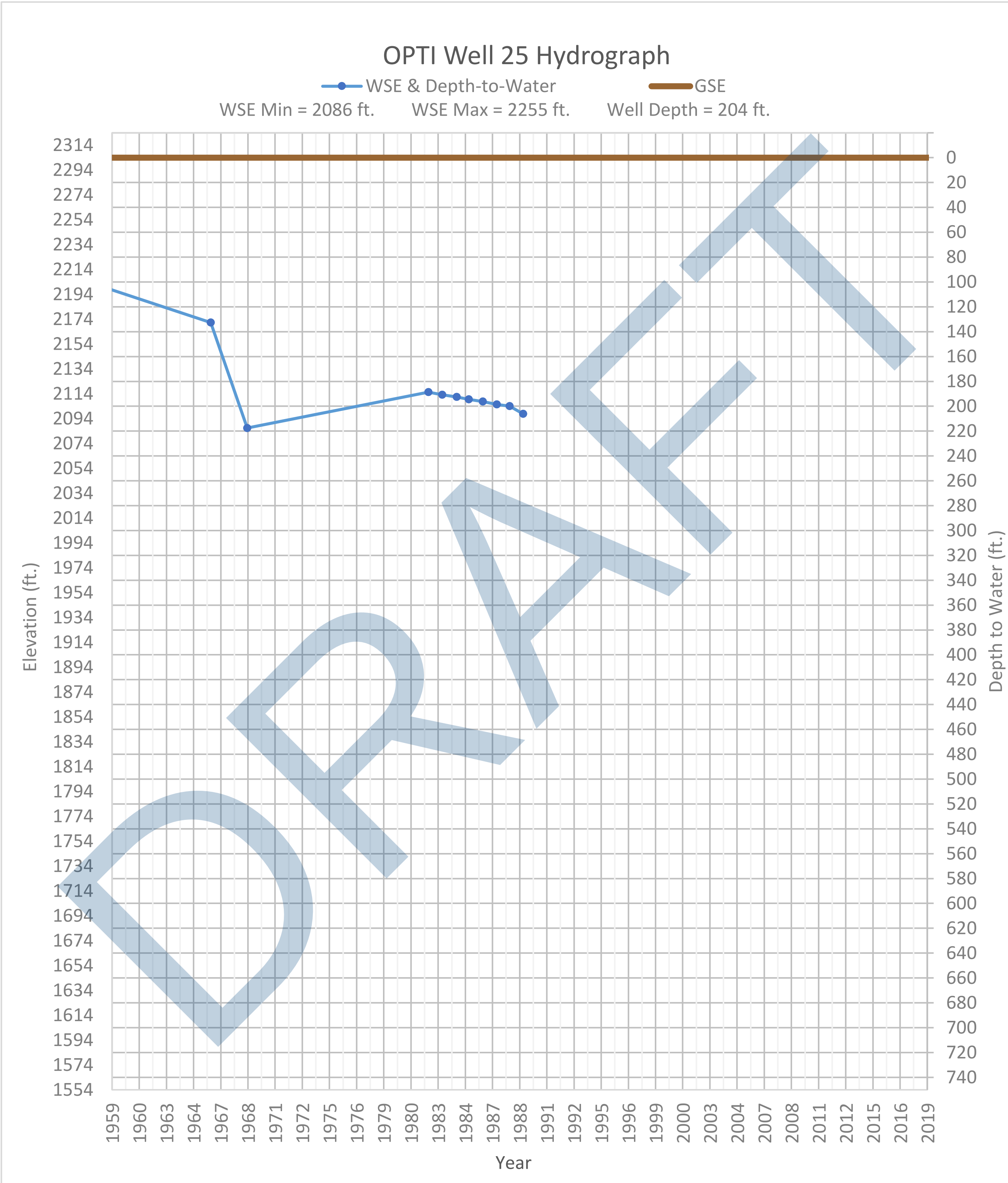
OPTI Well 22 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2796 ft.
WSE Max = 2797 ft.
Well Depth = 99 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



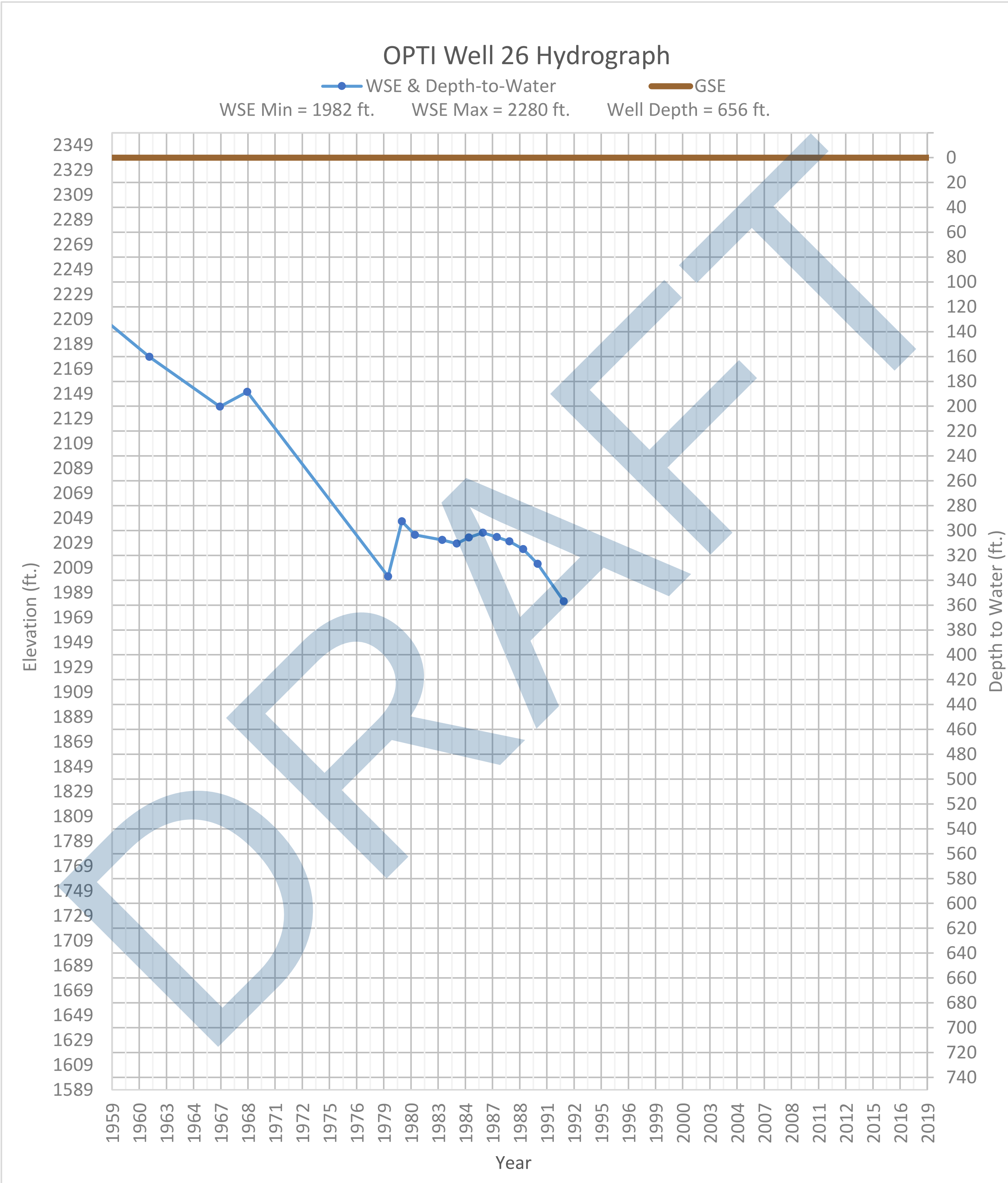
OPTI Well 23 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2214 ft.
WSE Max = 2256 ft.
Well Depth = 454 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



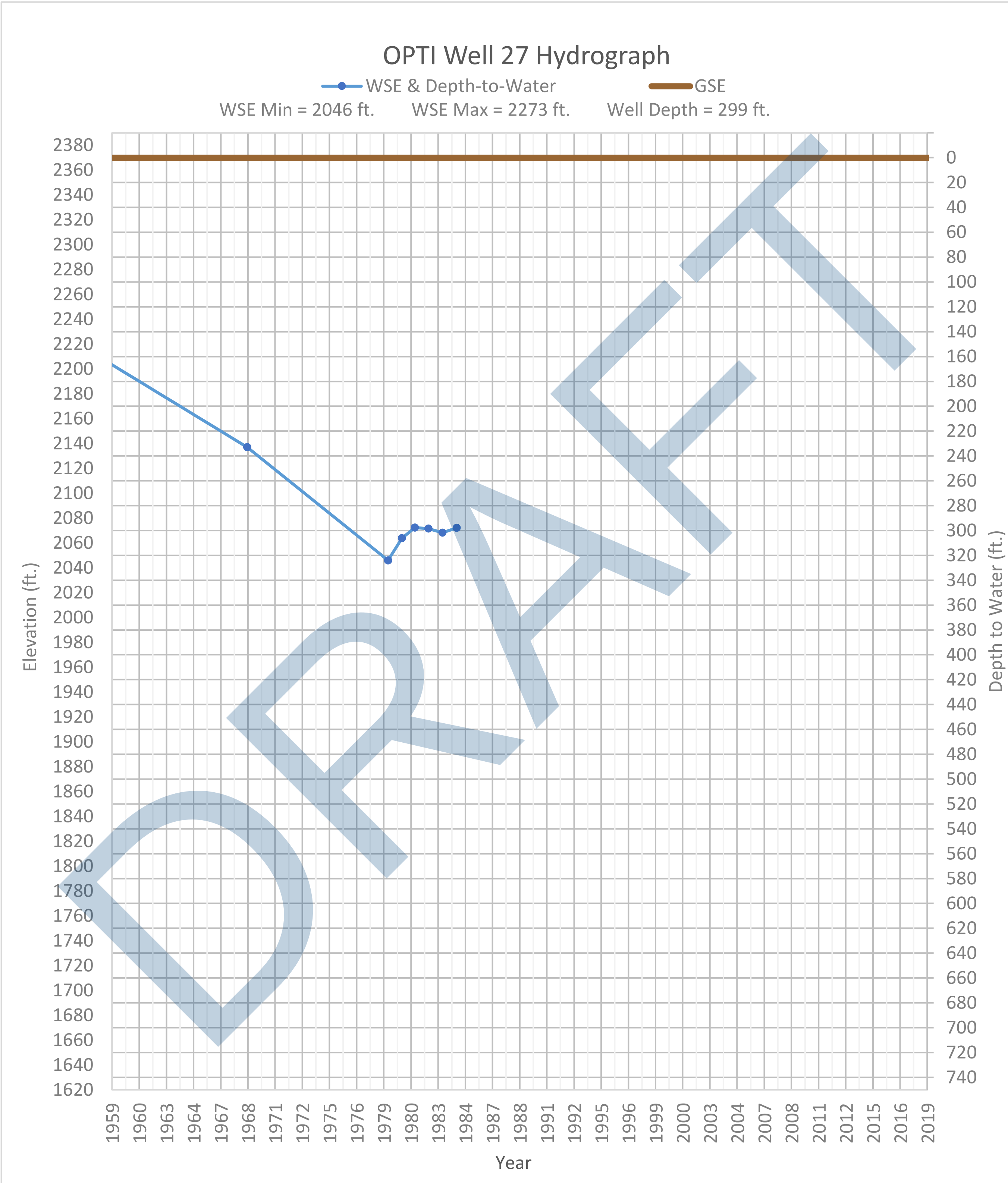
OPTI Well 24 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2191 ft.
WSE Max = 2245 ft.
Well Depth = 194 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



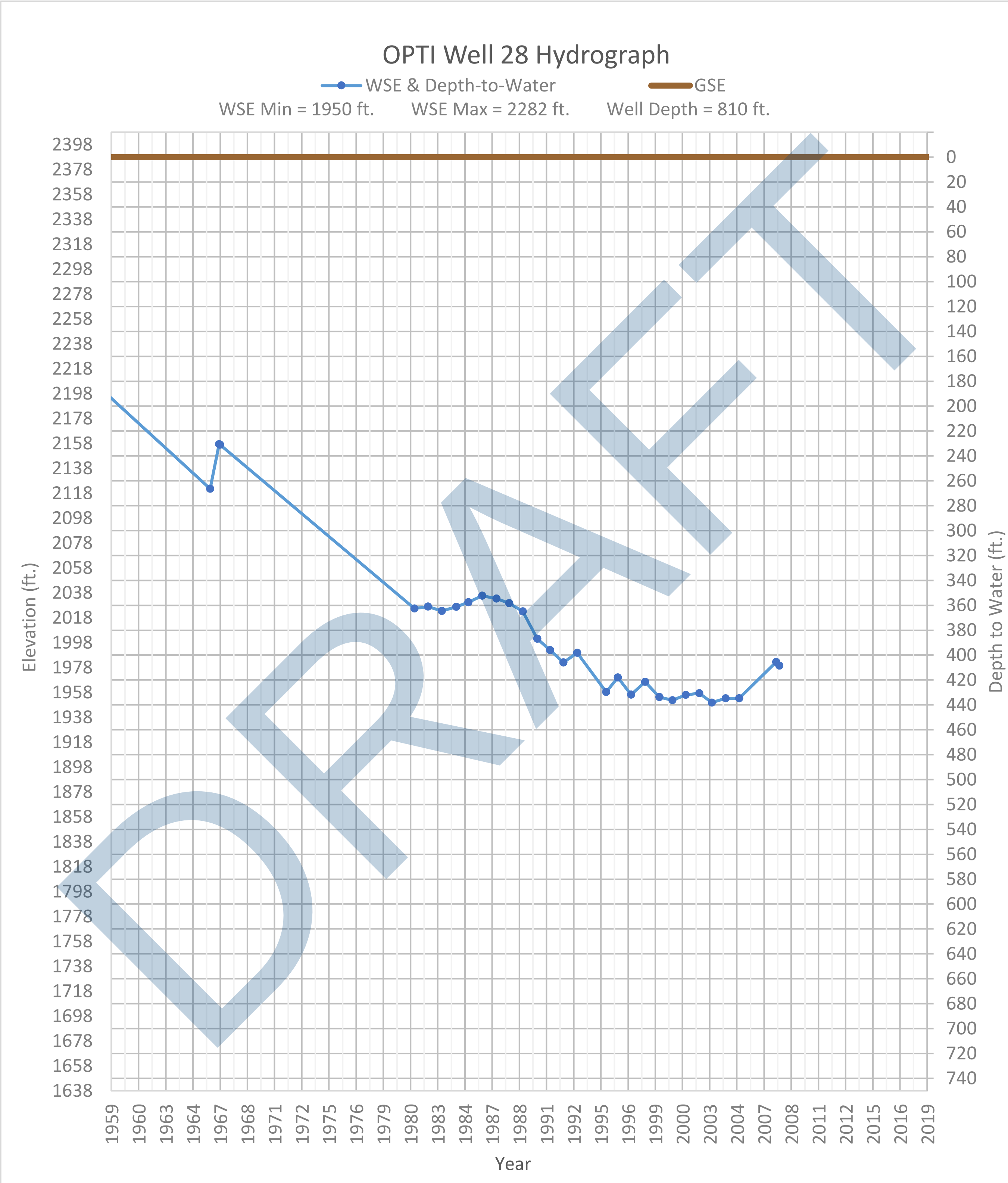
OPTI Well 25 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2086 ft.
WSE Max = 2255 ft.
Well Depth = 204 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2314 2294 2274 2254 2234 2214 2194 2174 2154 2134 2114 2094 2074 2054 2034 2014 1994 1974 1954 1934 1914 1894 1874 1854 1834 1814 1794 1774 1754 1734 1714 1694 1674 1654 1634 1614 1594 1574 1554
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720 740
1959 1960 1963 1964 1967 1968 1971 1972 1975 1976 1979 1980 1983 1984 1987 1988 1991 1992 1995 1996 1999 2000 2003 2004 2007 2008 2011 2012 2015 2016 2019
DRAFT

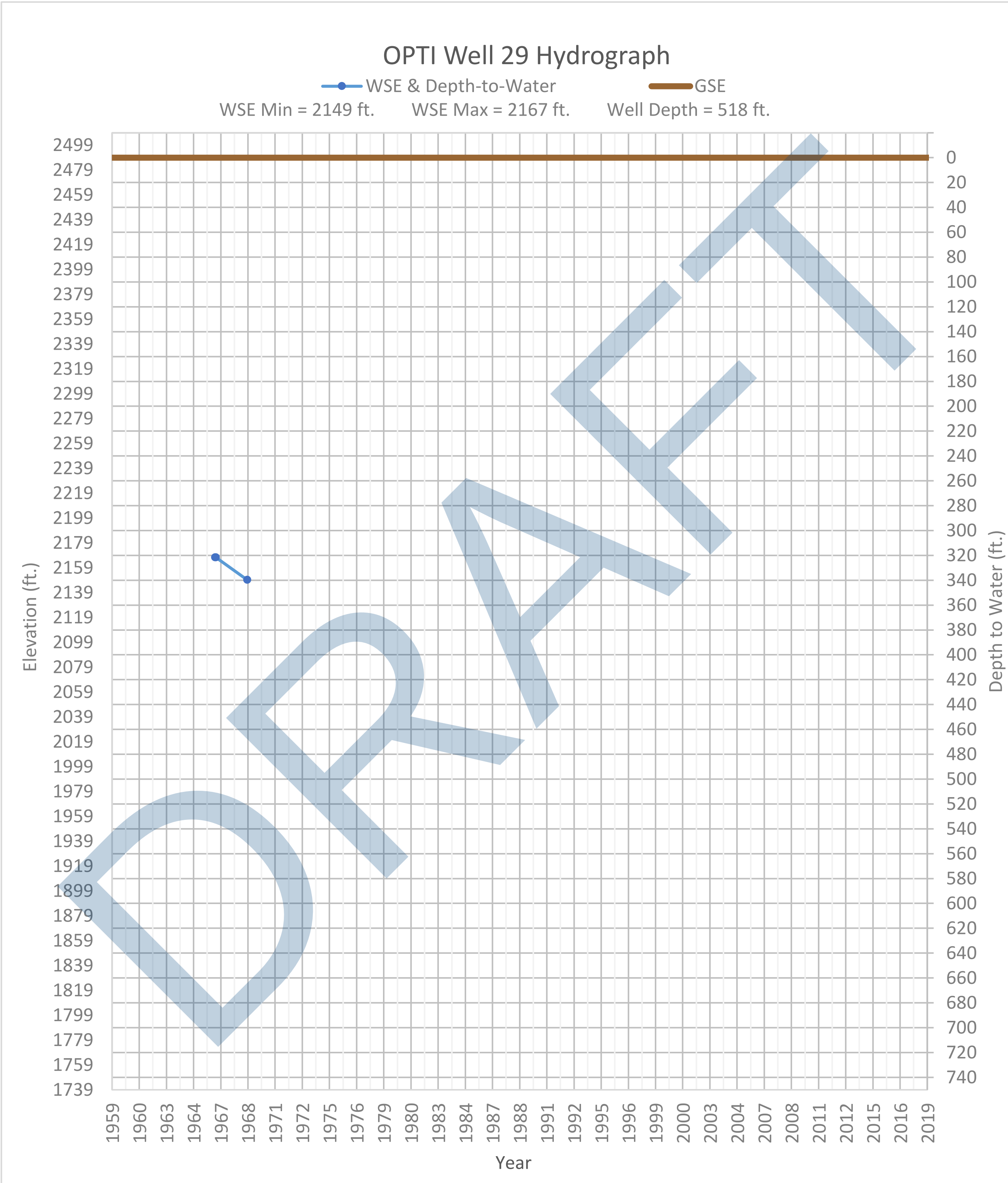


OPTI Well 26 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1982 ft.
WSE Max = 2280 ft.
Well Depth = 656 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

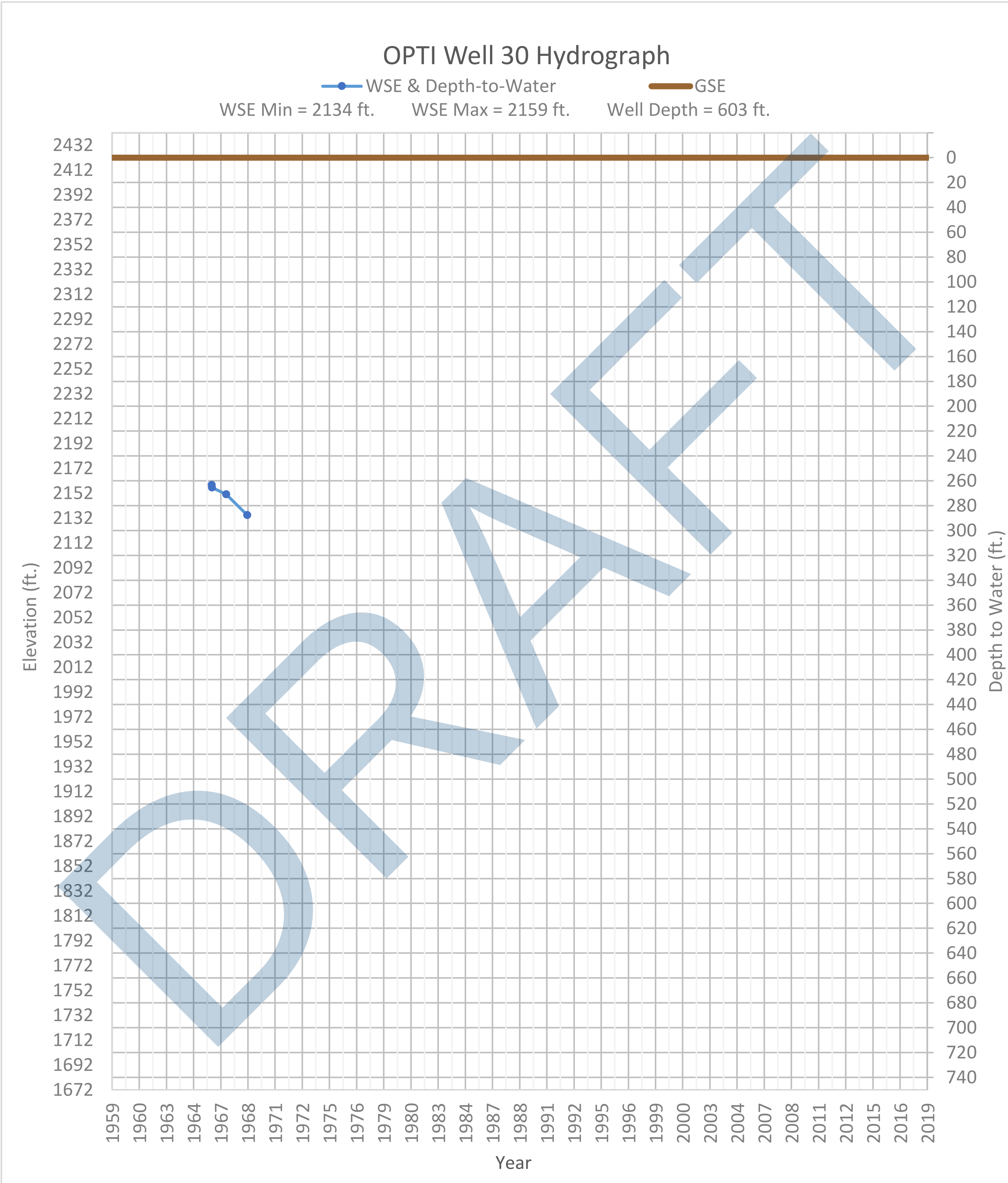


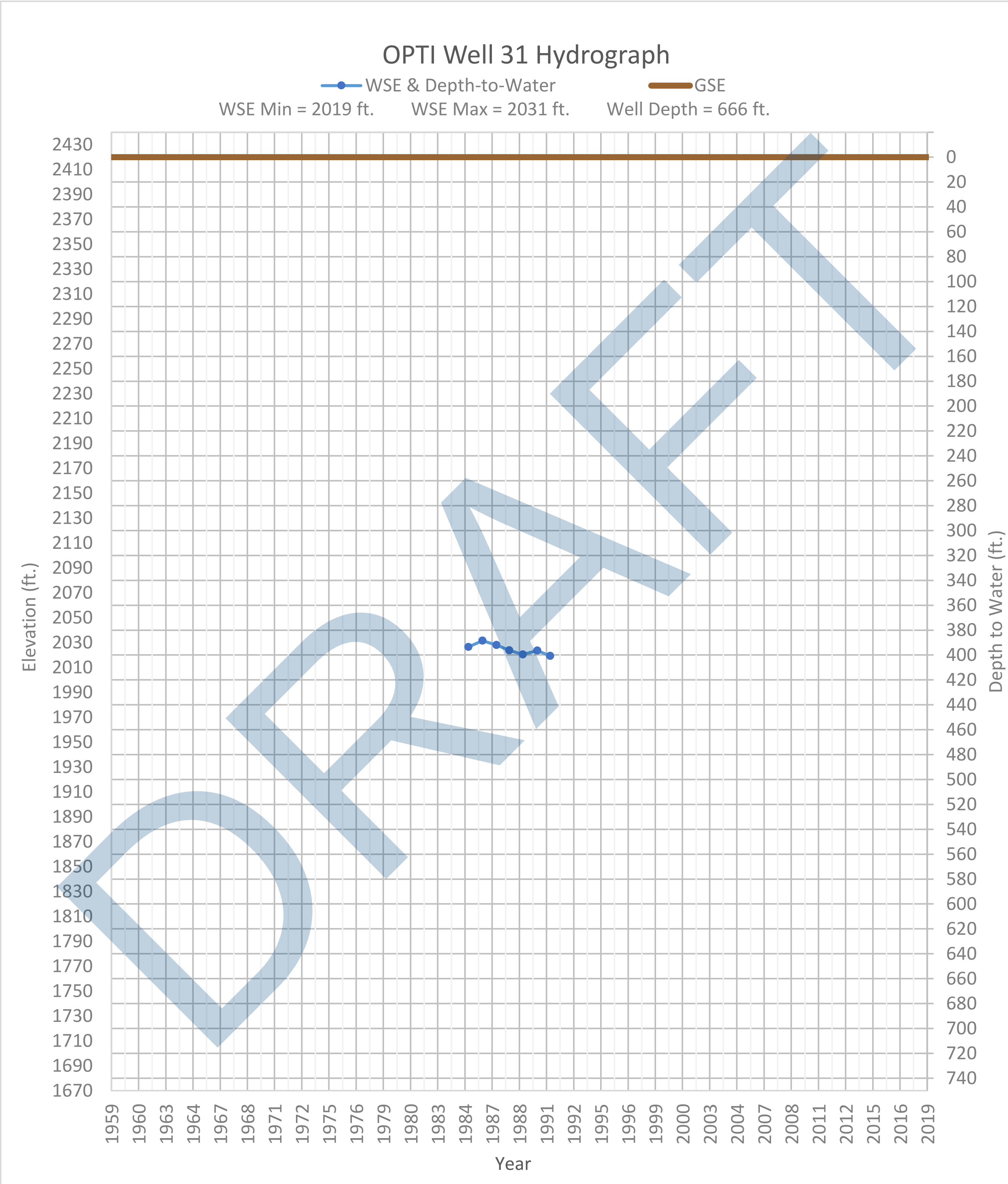
OPTI Well 27 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2046 ft.
WSE Max = 2273 ft.
Well Depth = 299 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

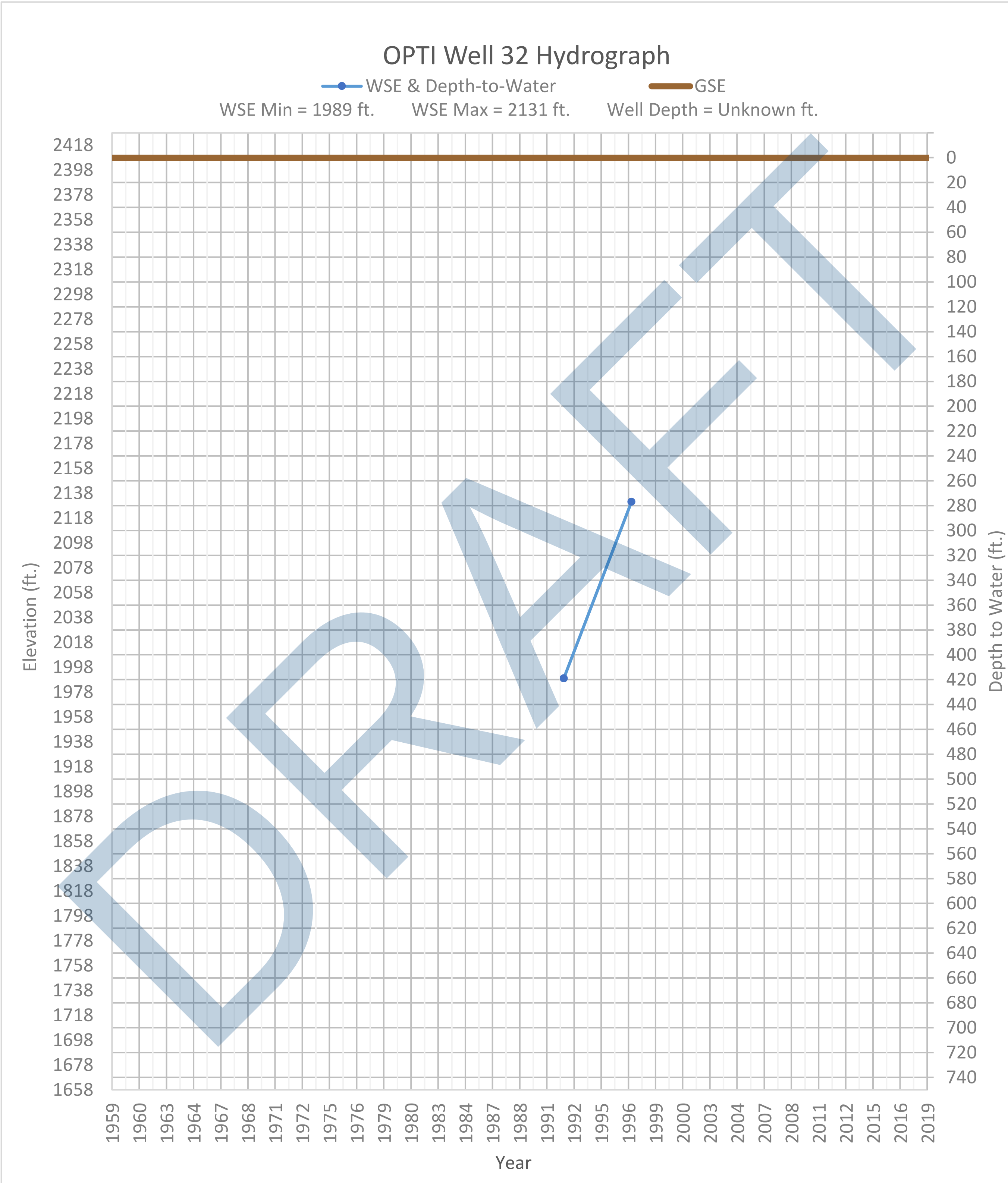

OPTI Well 28 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1950 ft.
WSE Max = 2282 ft.
Well Depth = 810 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



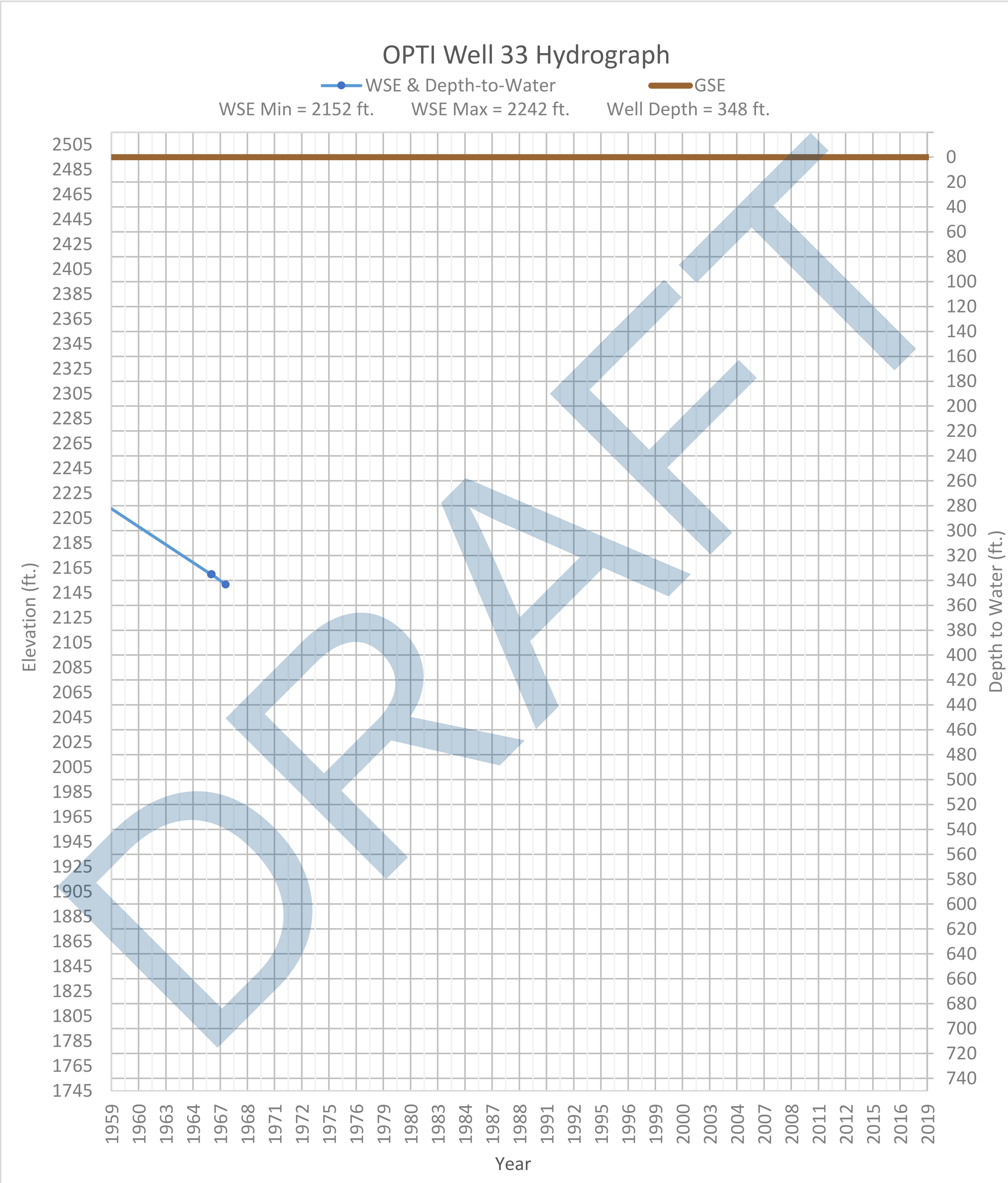
OPTI Well 29 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2149 ft.
WSE Max = 2167 ft.
Well Depth = 518 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 30 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2134 ft.
WSE Max = 2159 ft.
Well Depth = 603 ft.
Elevation (ft.)
Depth to Water (ft.)
Year

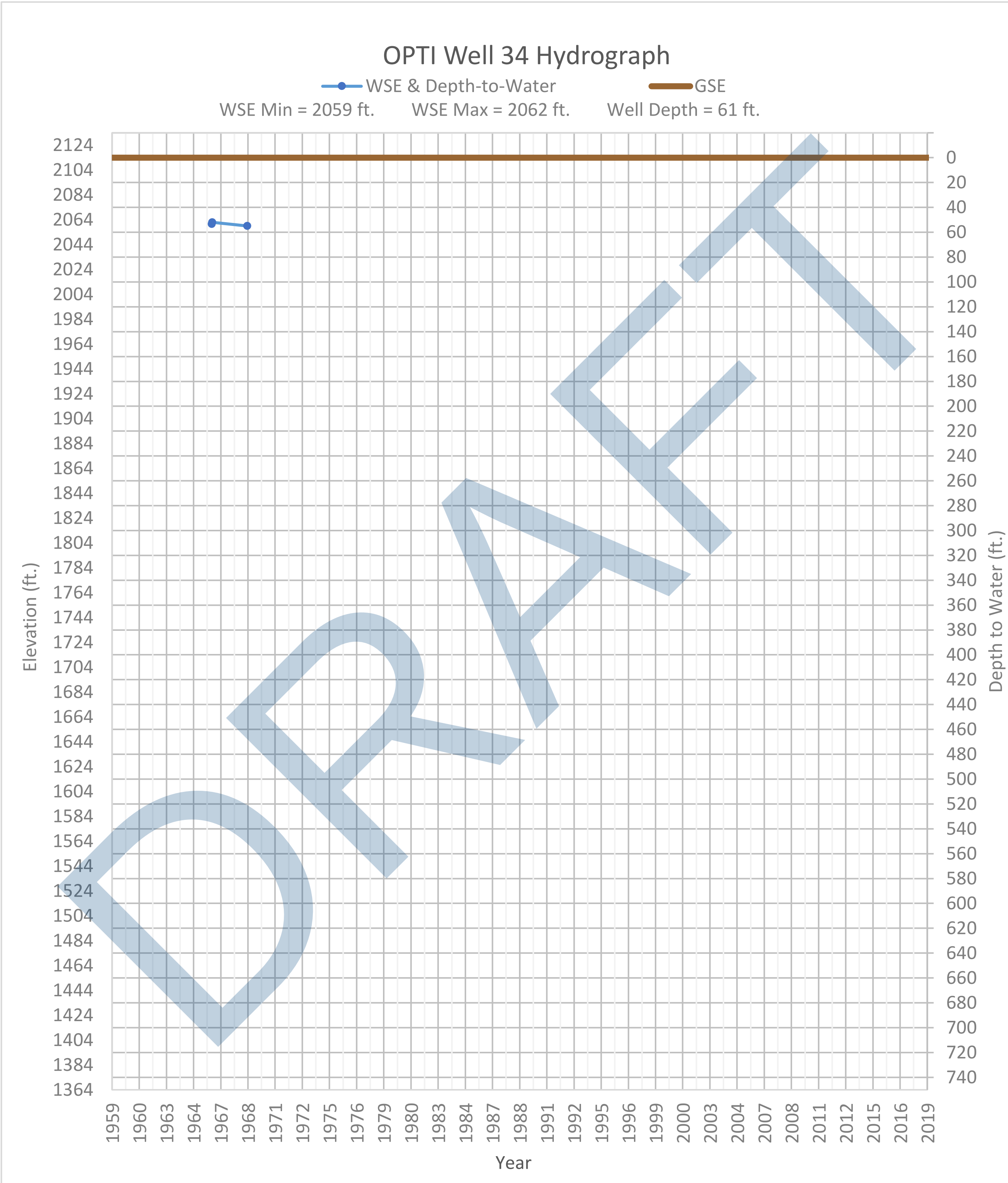

OPTI Well 31 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2019 ft.
WSE Max = 2031 ft.
Well Depth = 666 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



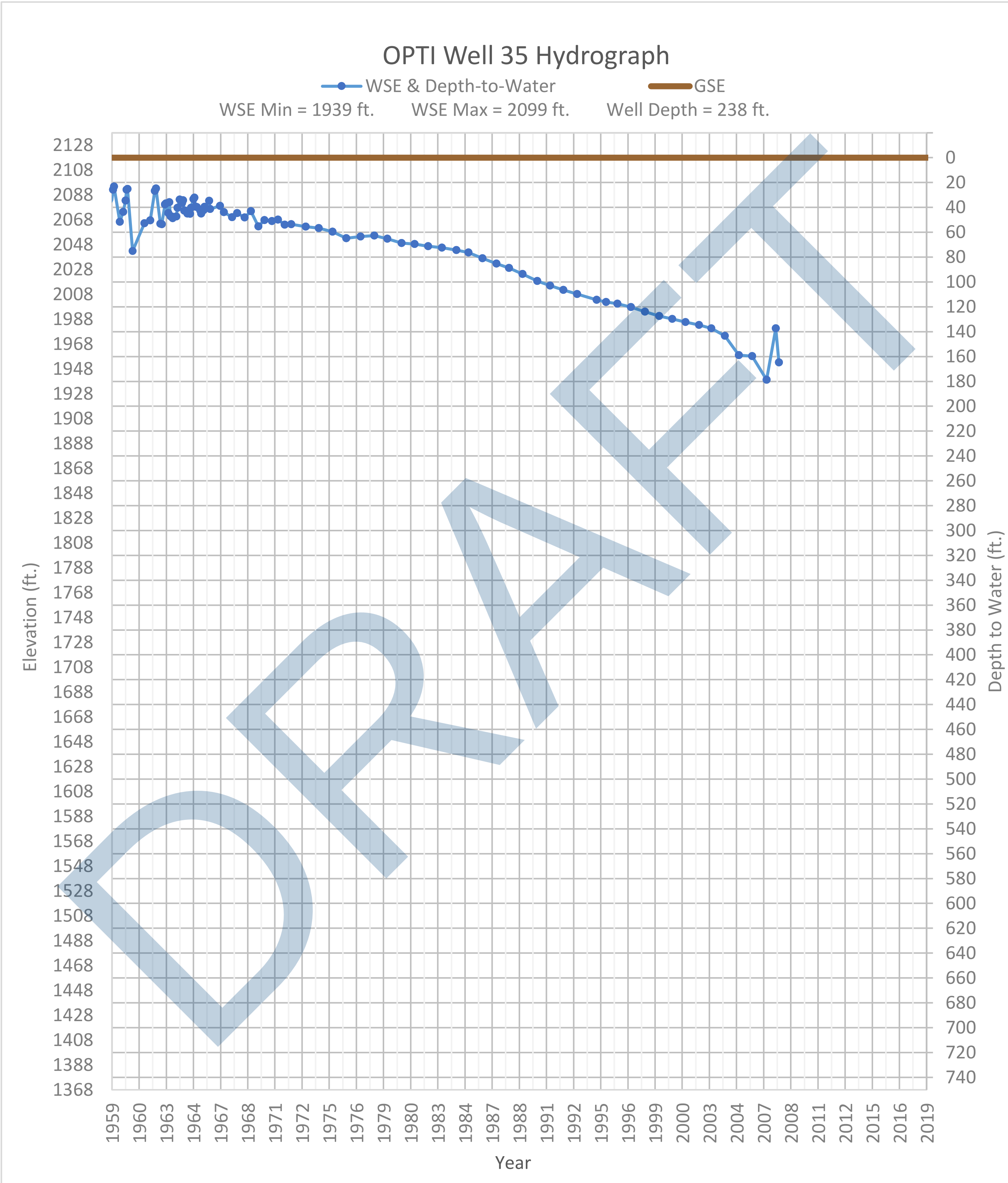
OPTI Well 32 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1989 ft.
WSE Max = 2131 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



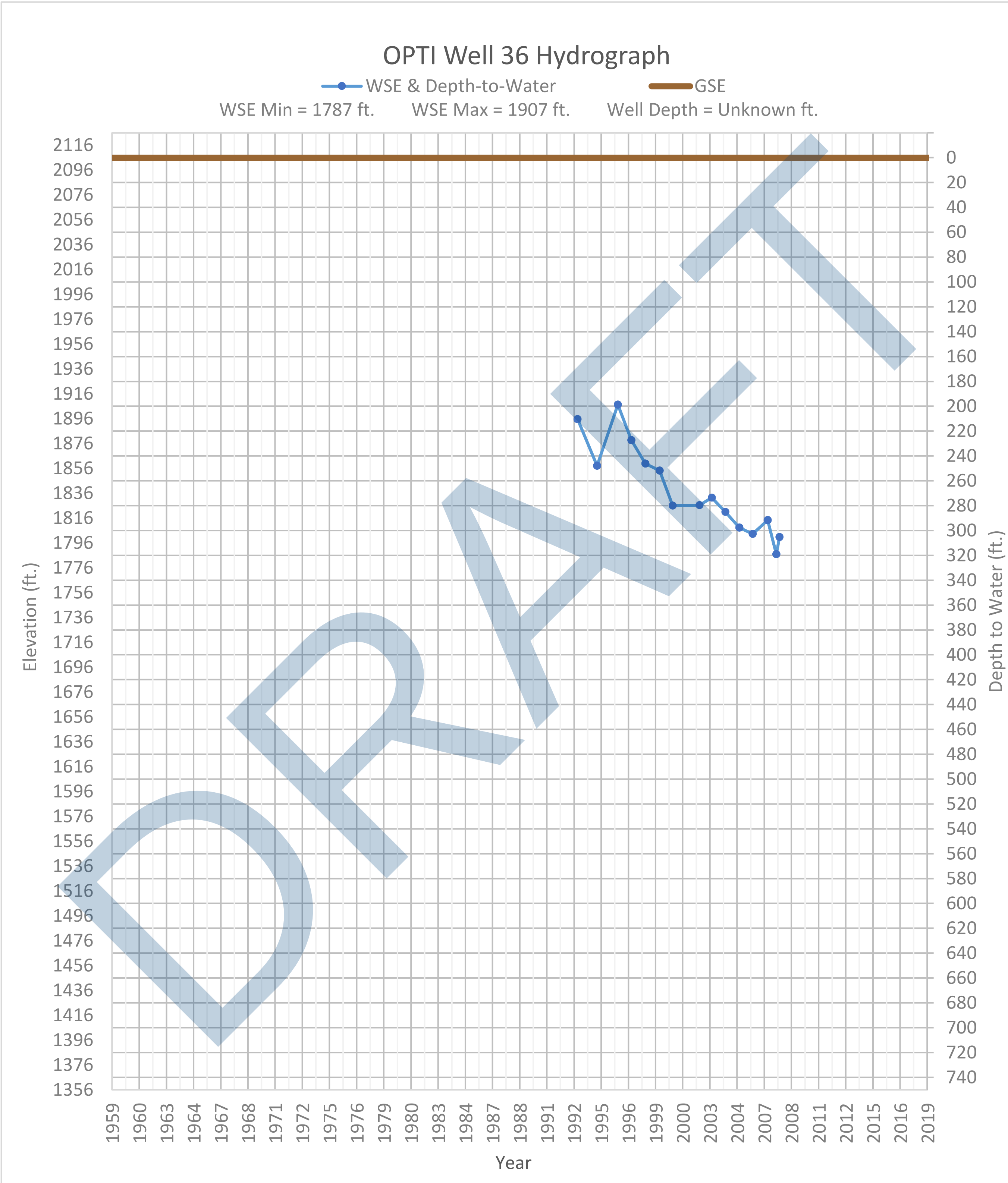
OPTI Well 33 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2152 ft.
WSE Max = 2242 ft.
Well Depth = 348 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



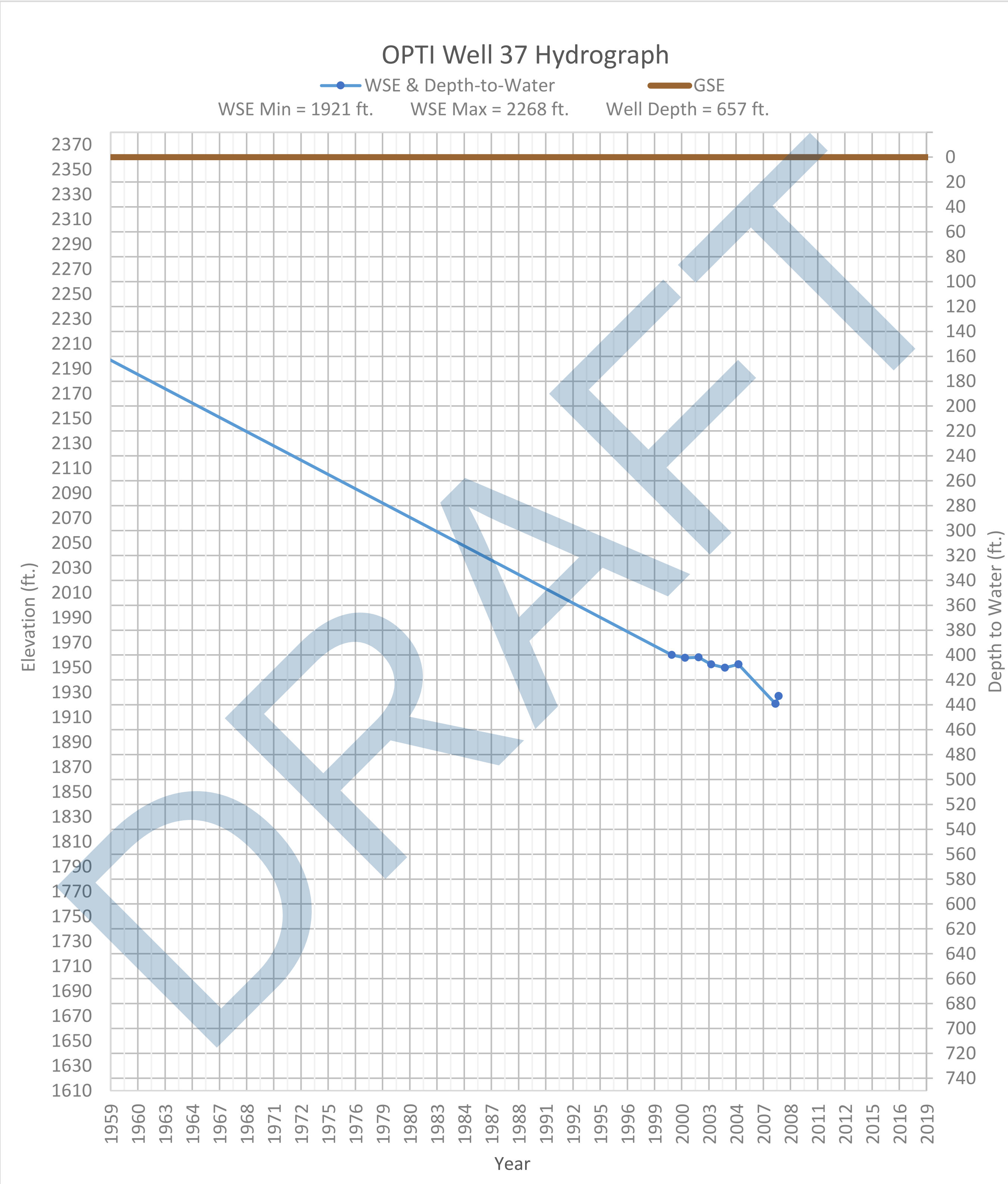
OPTI Well 34 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2059 ft.
WSE Max = 2062 ft.
Well Depth = 61 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



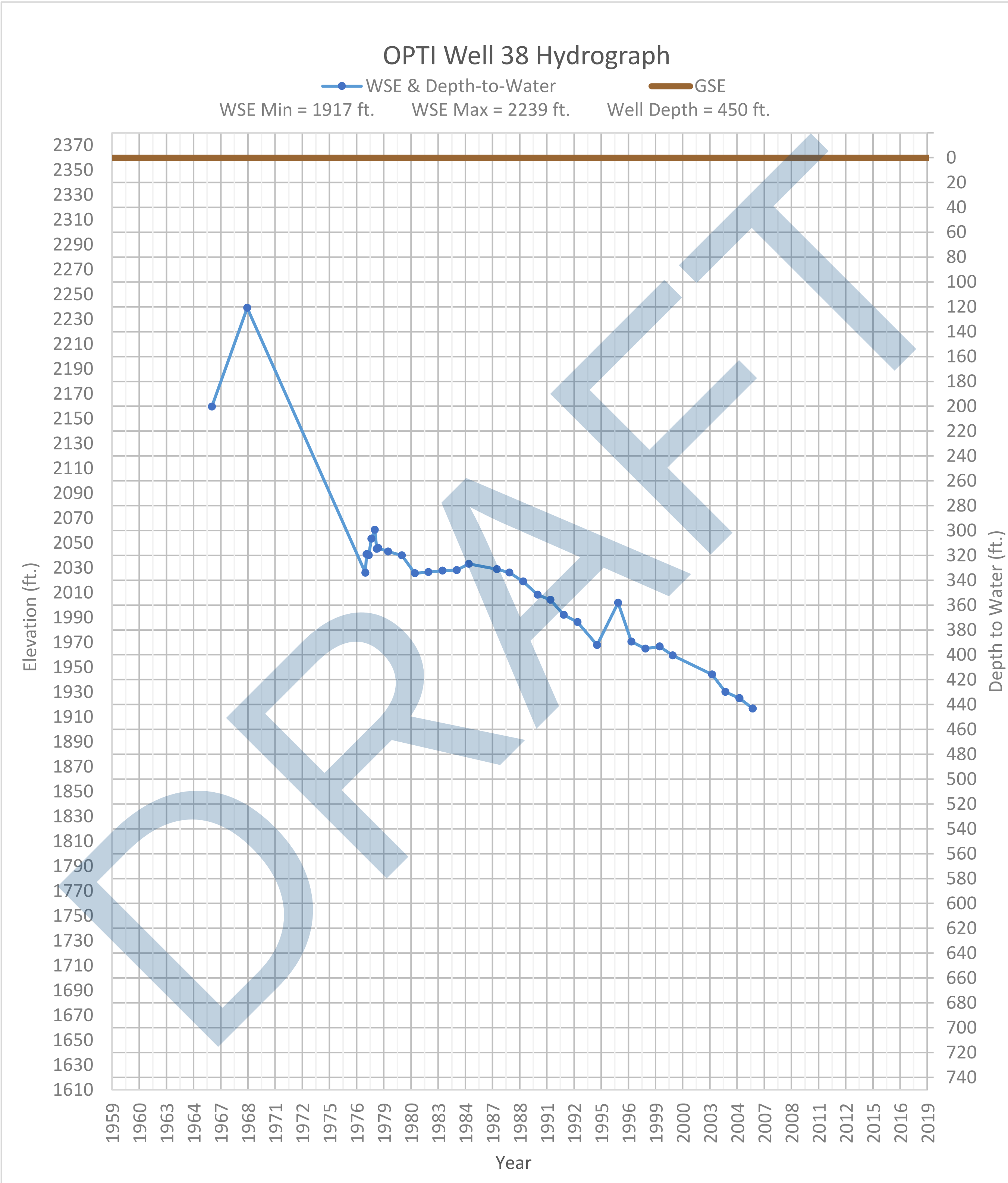
OPTI Well 35 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1939 ft.
WSE Max = 2099 ft.
Well Depth = 238 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



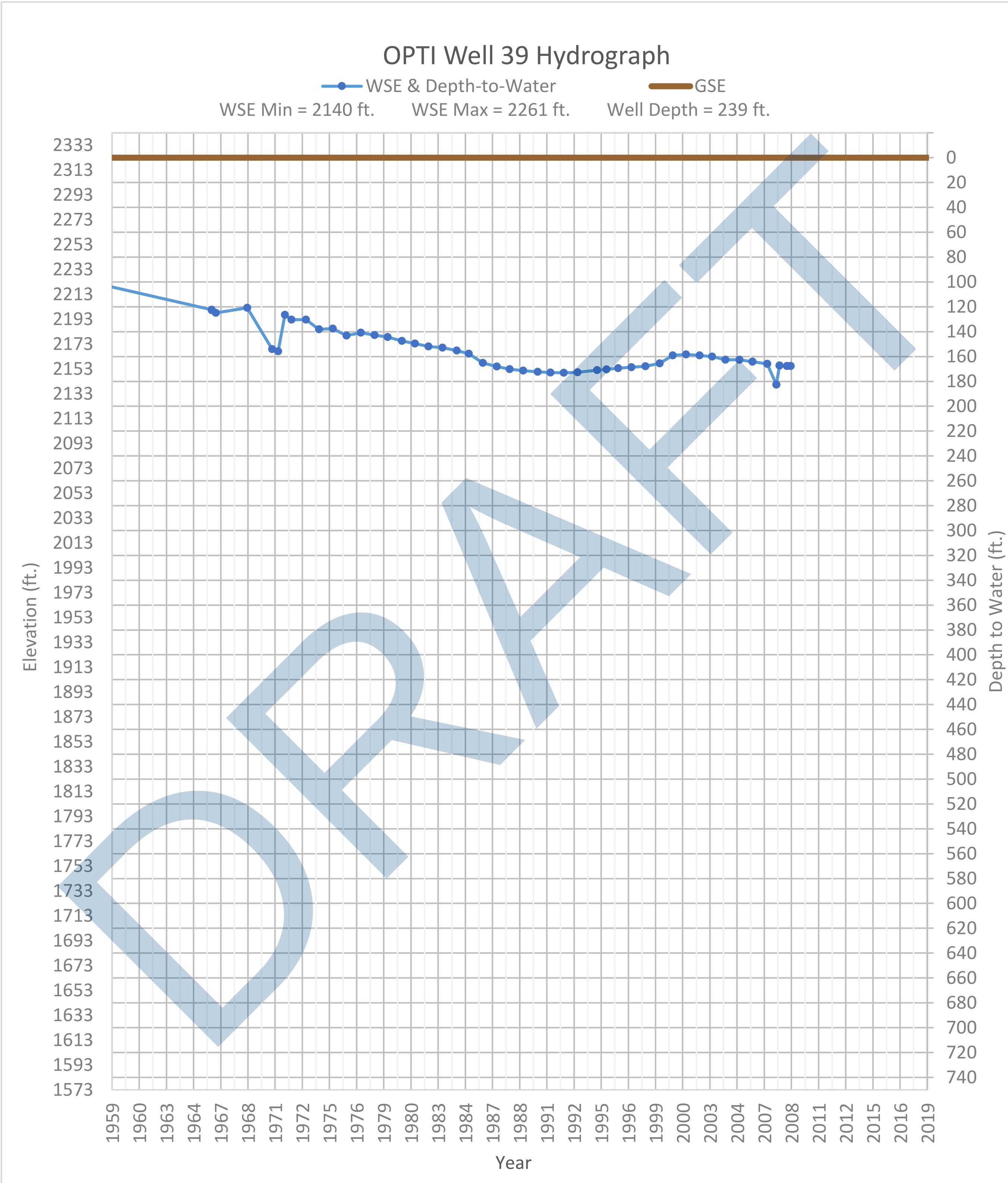
OPTI Well 36 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1787 ft.
WSE Max = 1907 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



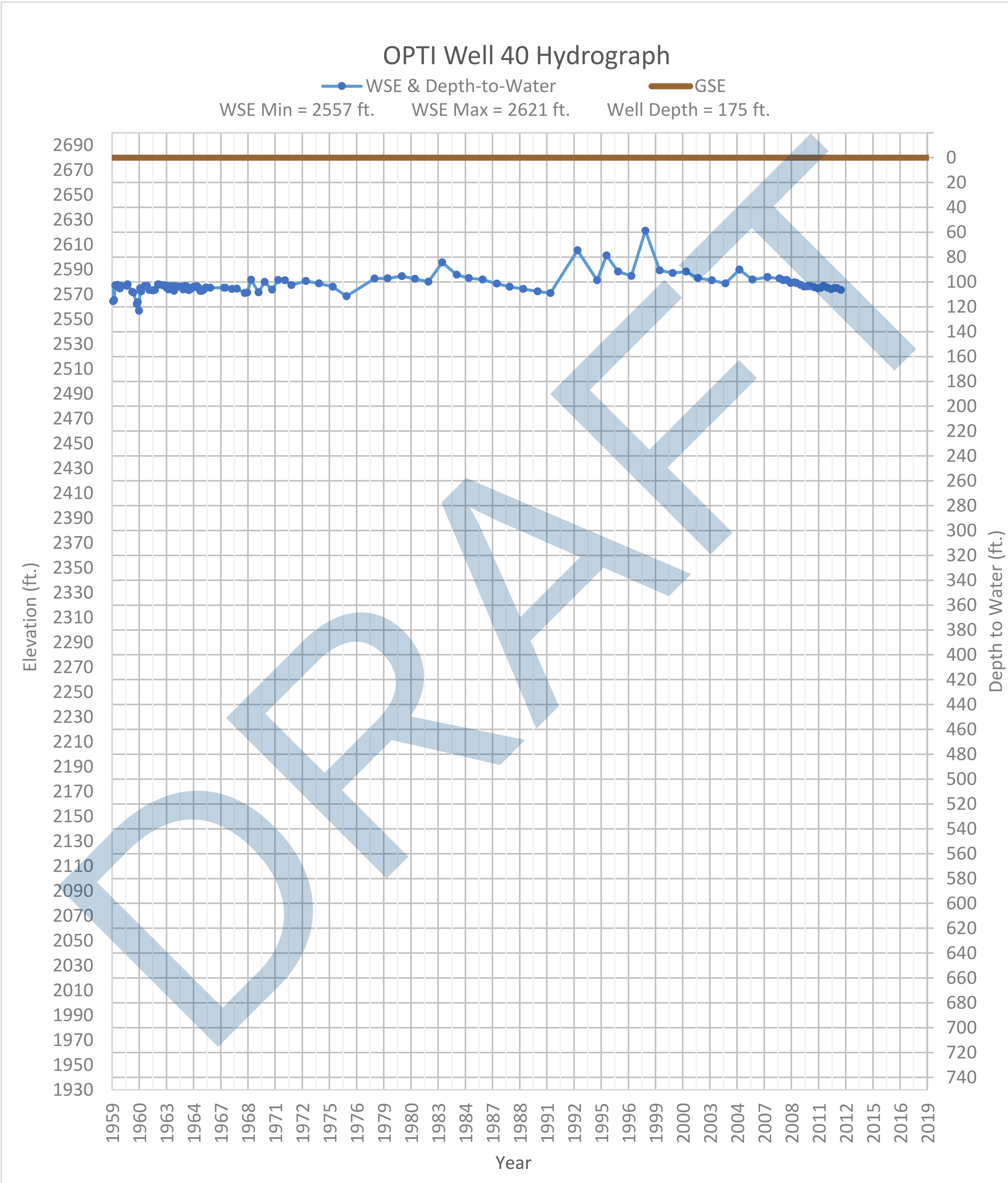
OPTI Well 37 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1921 ft.
WSE Max = 2268 ft.
Well Depth = 657 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



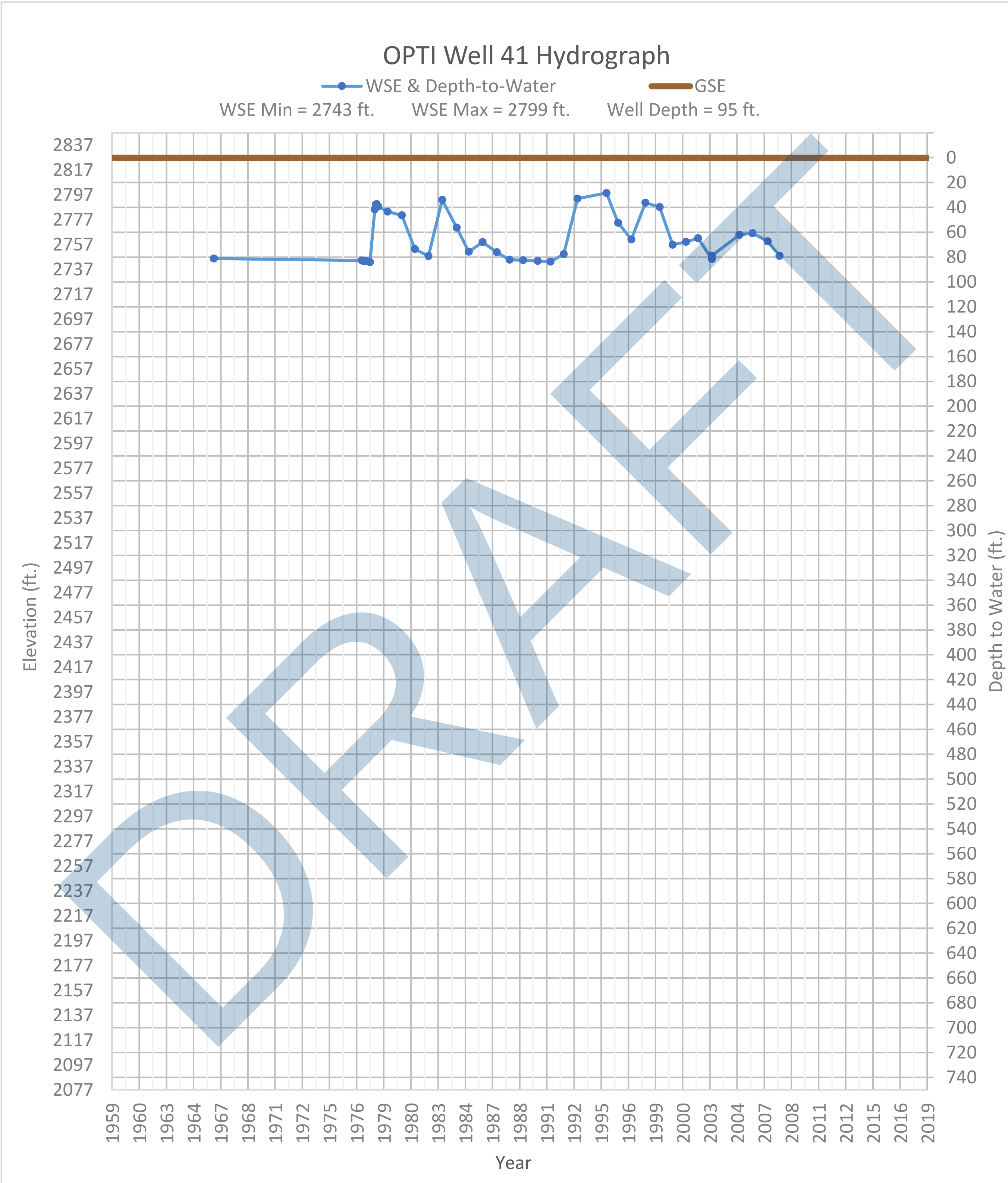
OPTI Well 38 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1917 ft.
WSE Max = 2239 ft.
Well Depth = 450 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



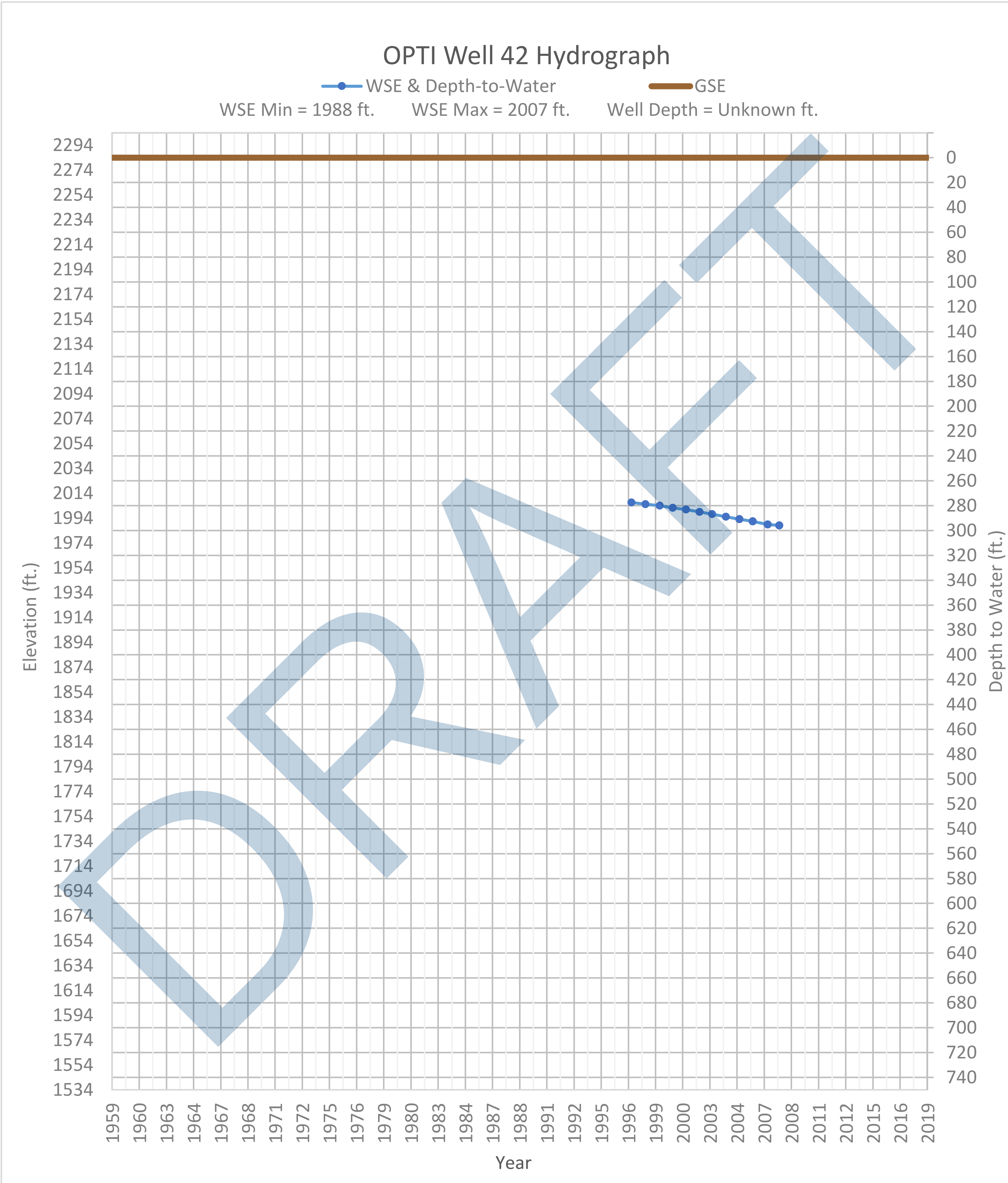
OPTI Well 39 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2140 ft.
WSE Max = 2261 ft.
Well Depth = 239 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

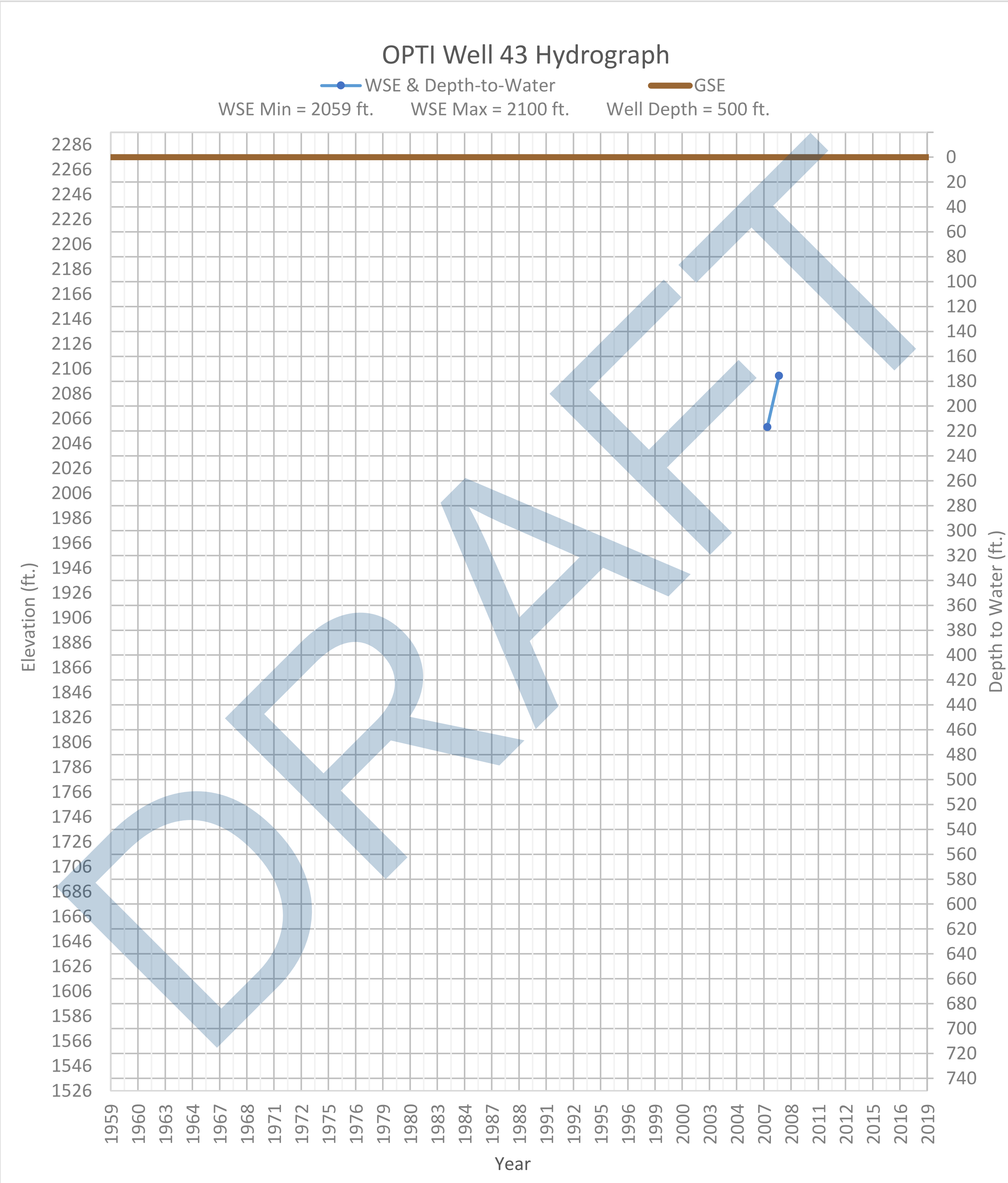


OPTI Well 40 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2557 ft.
WSE Max = 2621 ft.
Well Depth = 175 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 41 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2743 ft.
WSE Max = 2799 ft.
Well Depth = 95 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 42 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1988 ft.
WSE Max = 2007 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2294 2274 2254 2234 2214 2194 2174 2154 2134 2114 2094 2074 2054 2034 2014 1994 1974 1954 1934 1914 1894 1874 1854 1834 1814 1794 1774 1754 1734 1714 1694 1674 1654 1634 1614 1594 1574 1554 1534
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720 740
1959 1960 1963 1964 1967 1968 1971 1972 1975 1976 1979 1980 1983 1984 1987 1988 1991 1992 1995 1996 1999 2000 2003 2004 2007 2008 2011 2012 2015 2016 2019
DRAFT



OPTI Well 43 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2059 ft.
WSE Max = 2100 ft.
Well Depth = 500 ft.
Elevation (ft.)
2286
2266
2246
2226
2206
2186
2166
2146
2126
2106
2086
2066
2046
2026
2006
1986
1966
1946
1926
1906
1886
1866
1846
1826
1806
1786
1766
1746
1726
1706
1686
1666
1646
1626
1606
1586
1566
1546
1526
Depth to Water (ft.)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
680
700
720
740
Year
1959
1960
1963
1964
1967
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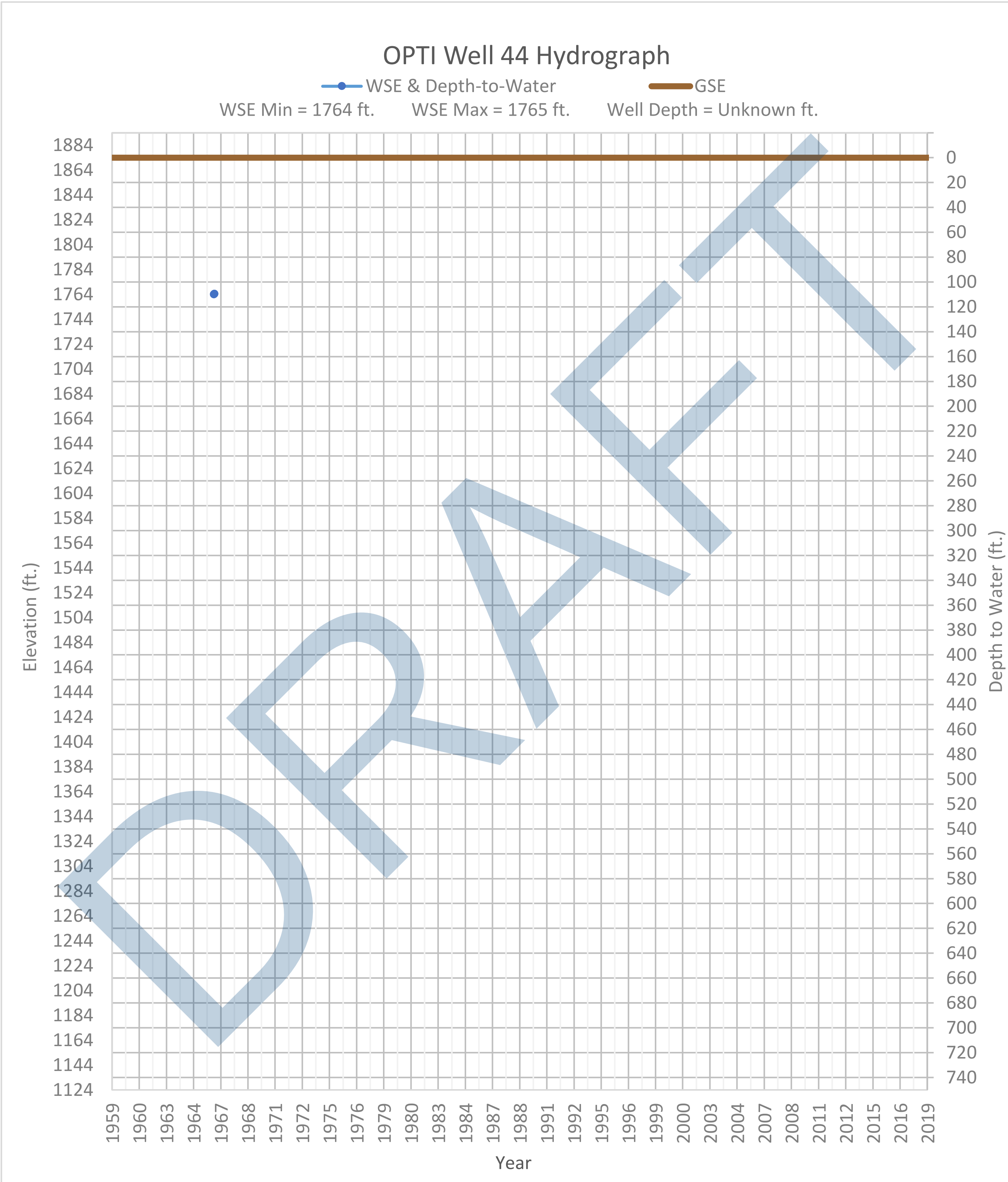
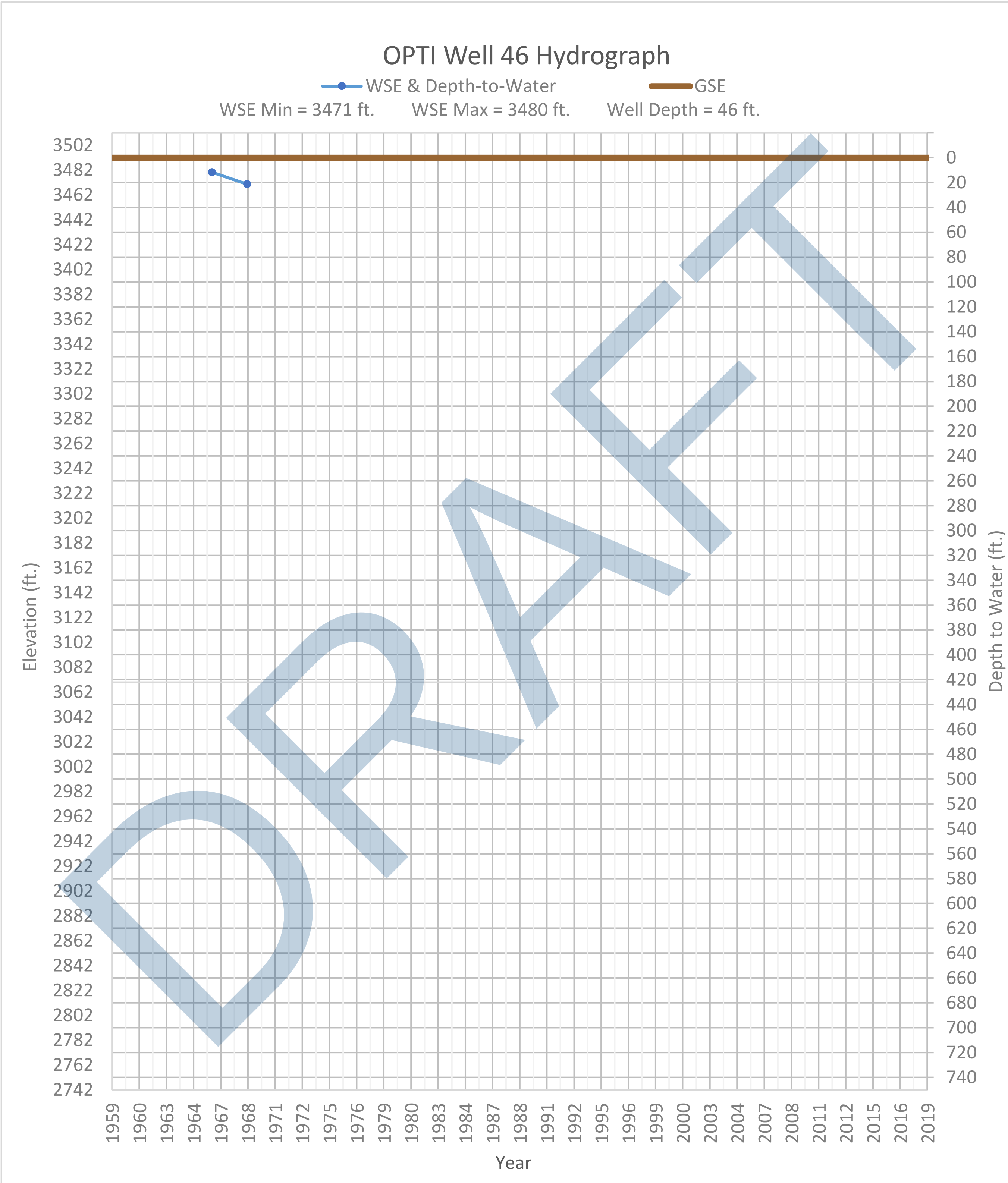
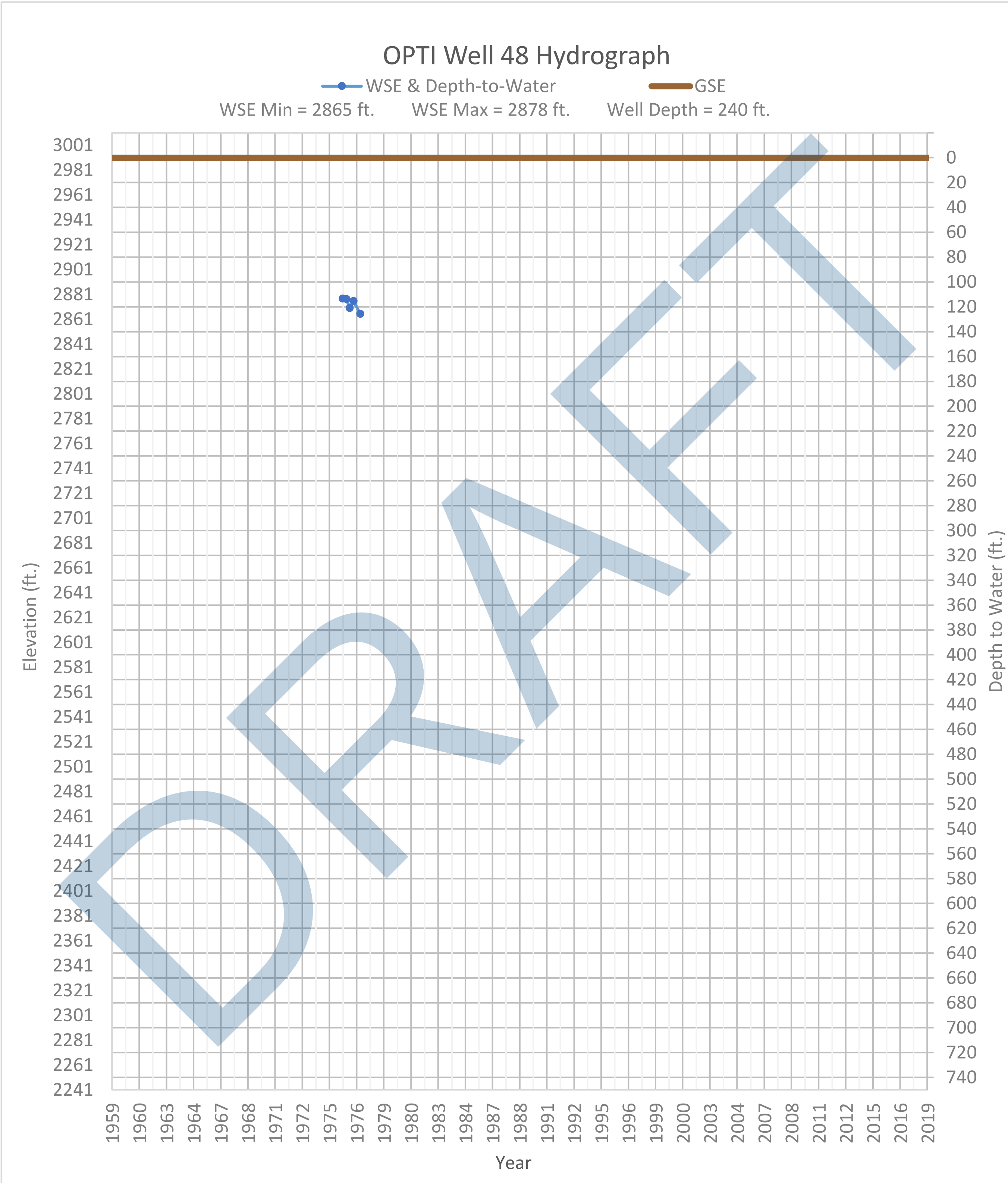
2007
2008
2011
2012
2015
2016
2019
DRAFT

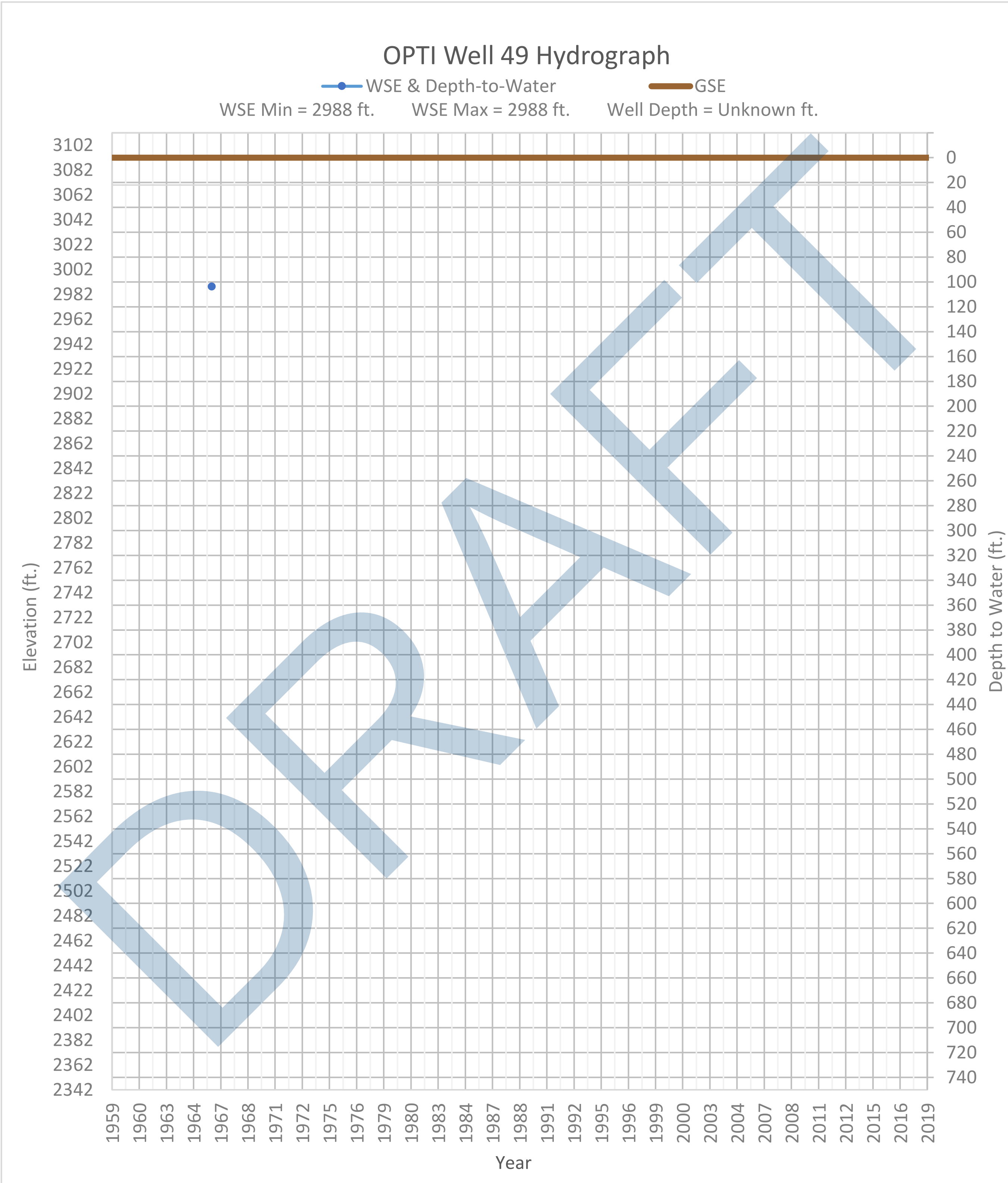


OPTI Well 44 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1764 ft.
WSE Max = 1765 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

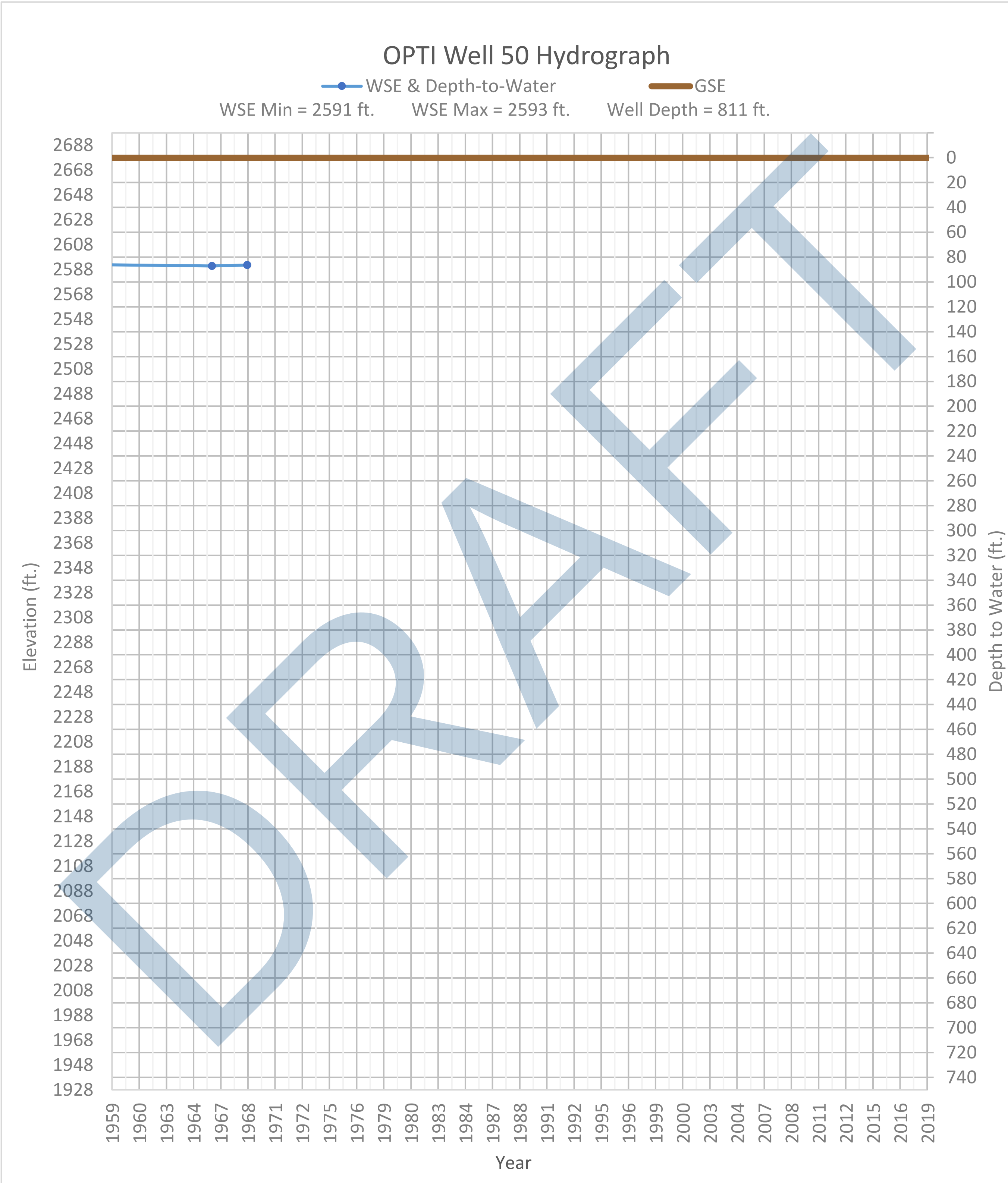


OPTI Well 46 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3471 ft.
WSE Max = 3480 ft.
Well Depth = 46 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

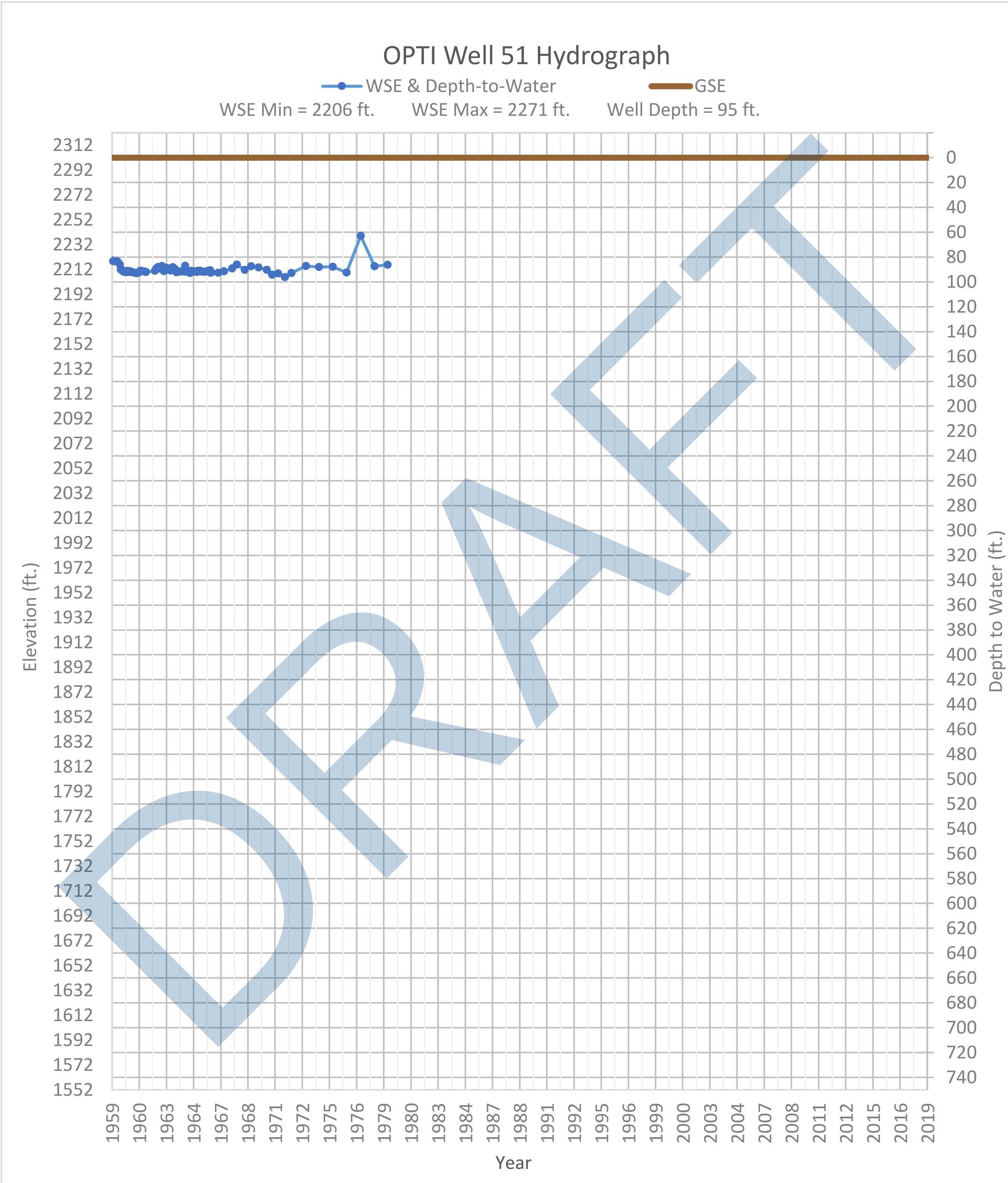

OPTI Well 48 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2865 ft.
WSE Max = 2878 ft.
Well Depth = 240 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 49 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2988 ft.
WSE Max = 2988 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 50 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2591 ft.
WSE Max = 2593 ft.
Well Depth = 811 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 51 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2206 ft.
WSE Max = 2271 ft.
Well Depth = 95 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2312
2292
2272
2252
2232
2212
2192
2172
2152
2132
2112
2092
2072
2052
2032
2012
1992
1972
1952
1932
1912
1892
1872
1852
1832
1812
1792
1772
1752
1732
1712
1692
1672
1652
1632
1612
1592
1572
1552
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
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580
600
620
640
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680
700
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1959
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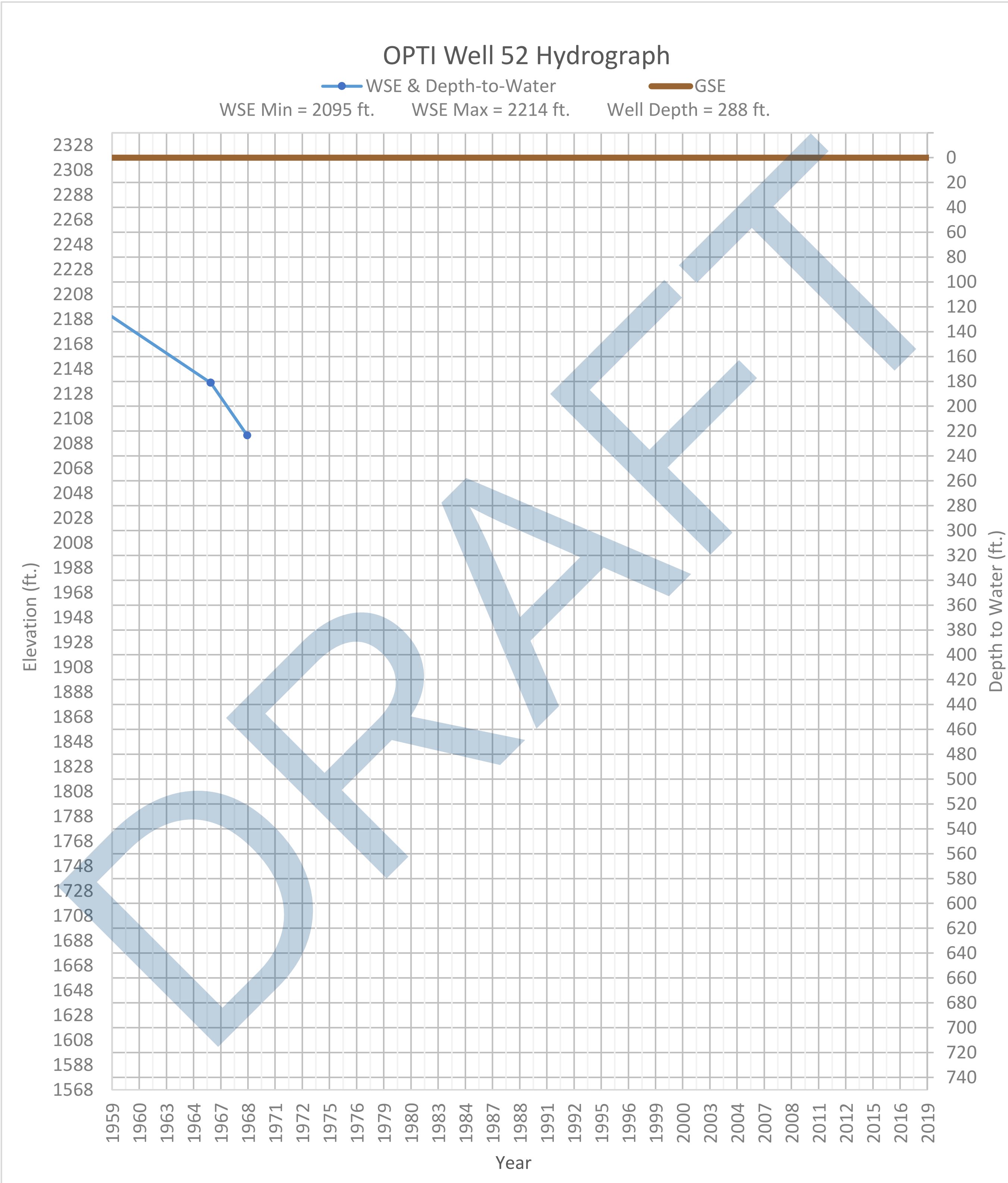
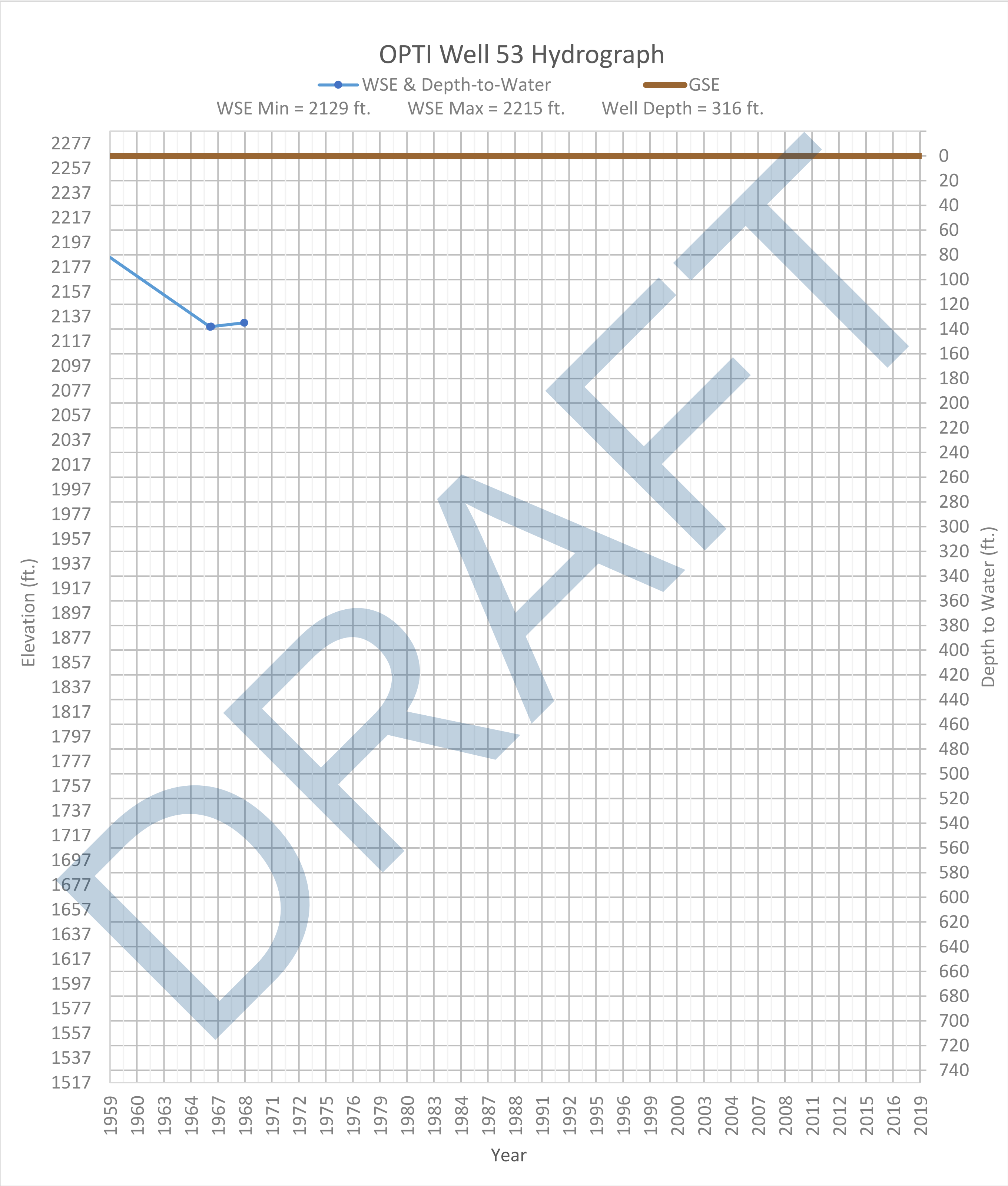
DRAFT



OPTI Well 52 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2095 ft.
WSE Max = 2214 ft.
Well Depth = 288 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 53 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2129 ft.
WSE Max = 2215 ft.
Well Depth = 316 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2277
2257
2237
2217
2197
2177
2157
2137
2117
2097
2077
2057
2037
2017
1997
1977
1957
1937
1917
1897
1877
1857
1837
1817
1797
1777
1757
1737
1717
1697
1677
1657
1637
1617
1597
1577
1557
1537
1517
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
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520
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660
680
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740
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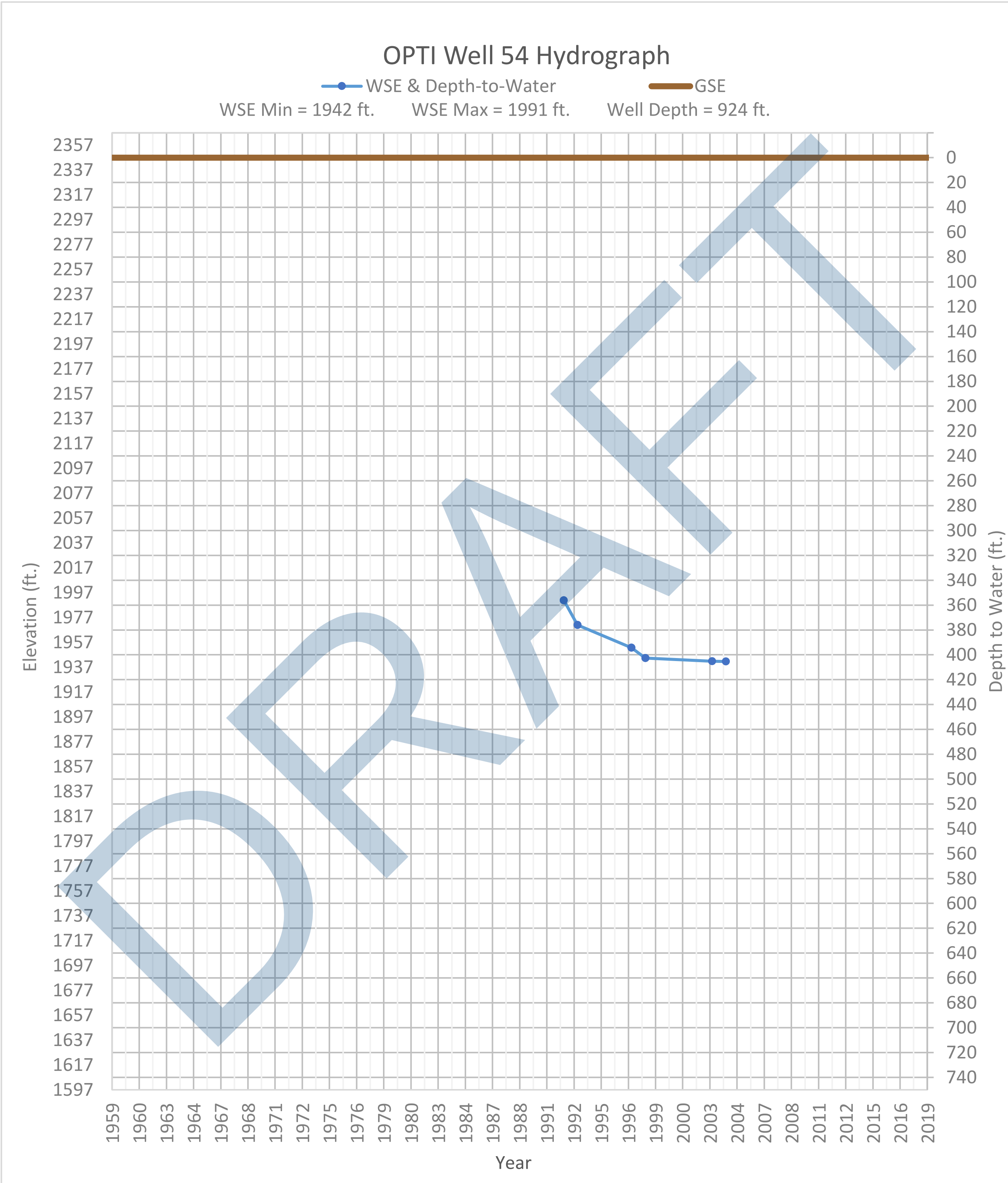
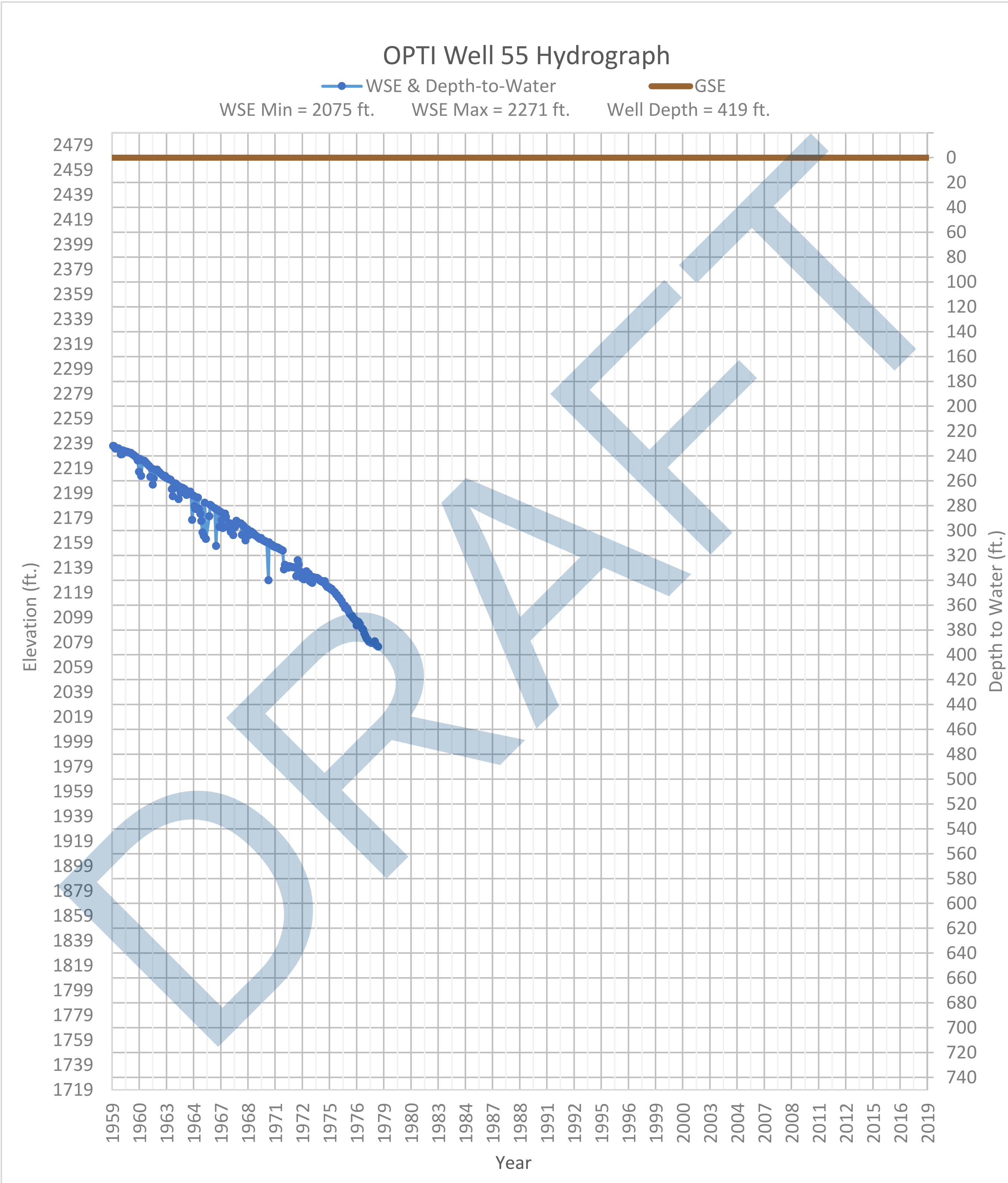
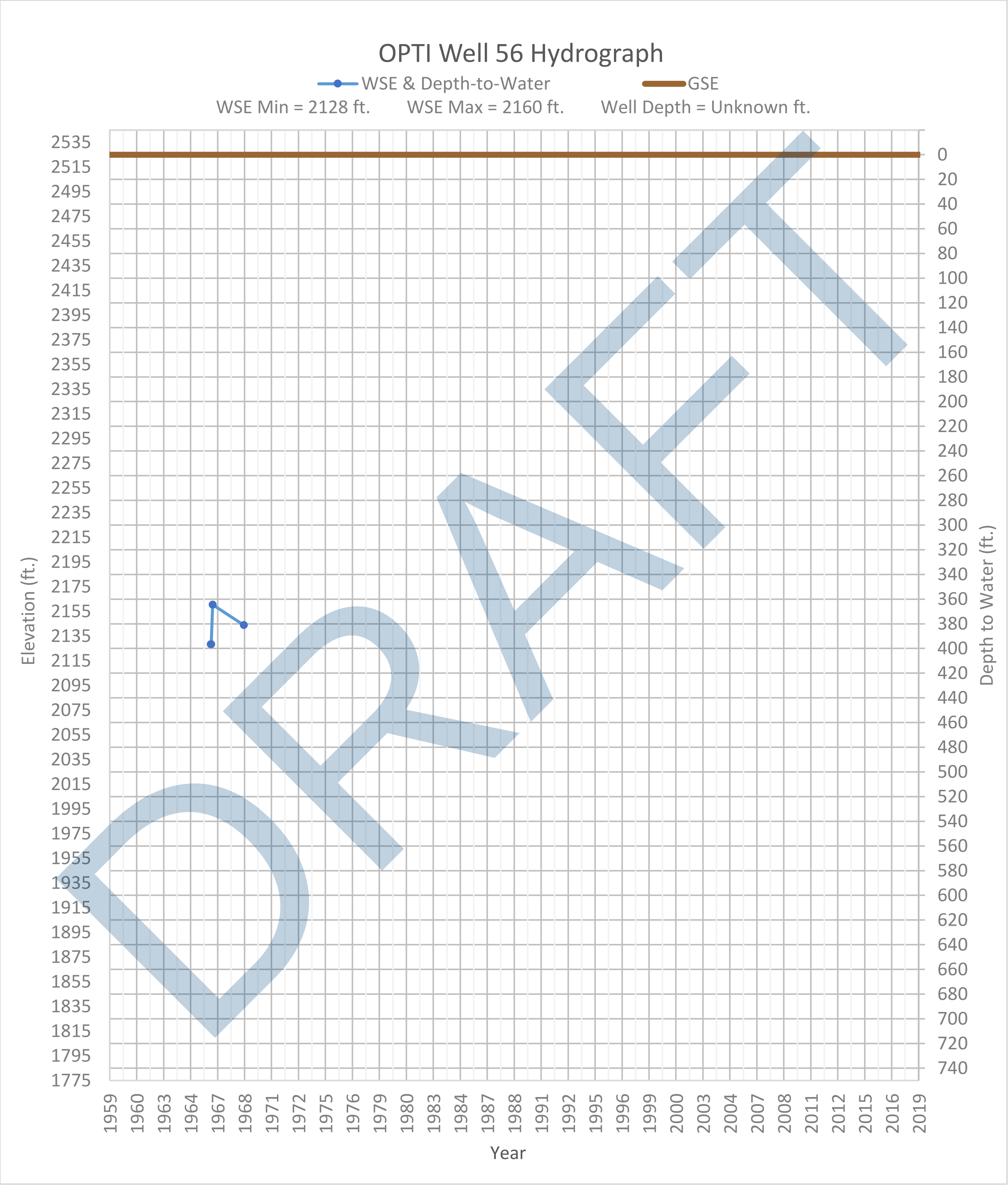
2019
DRAFT

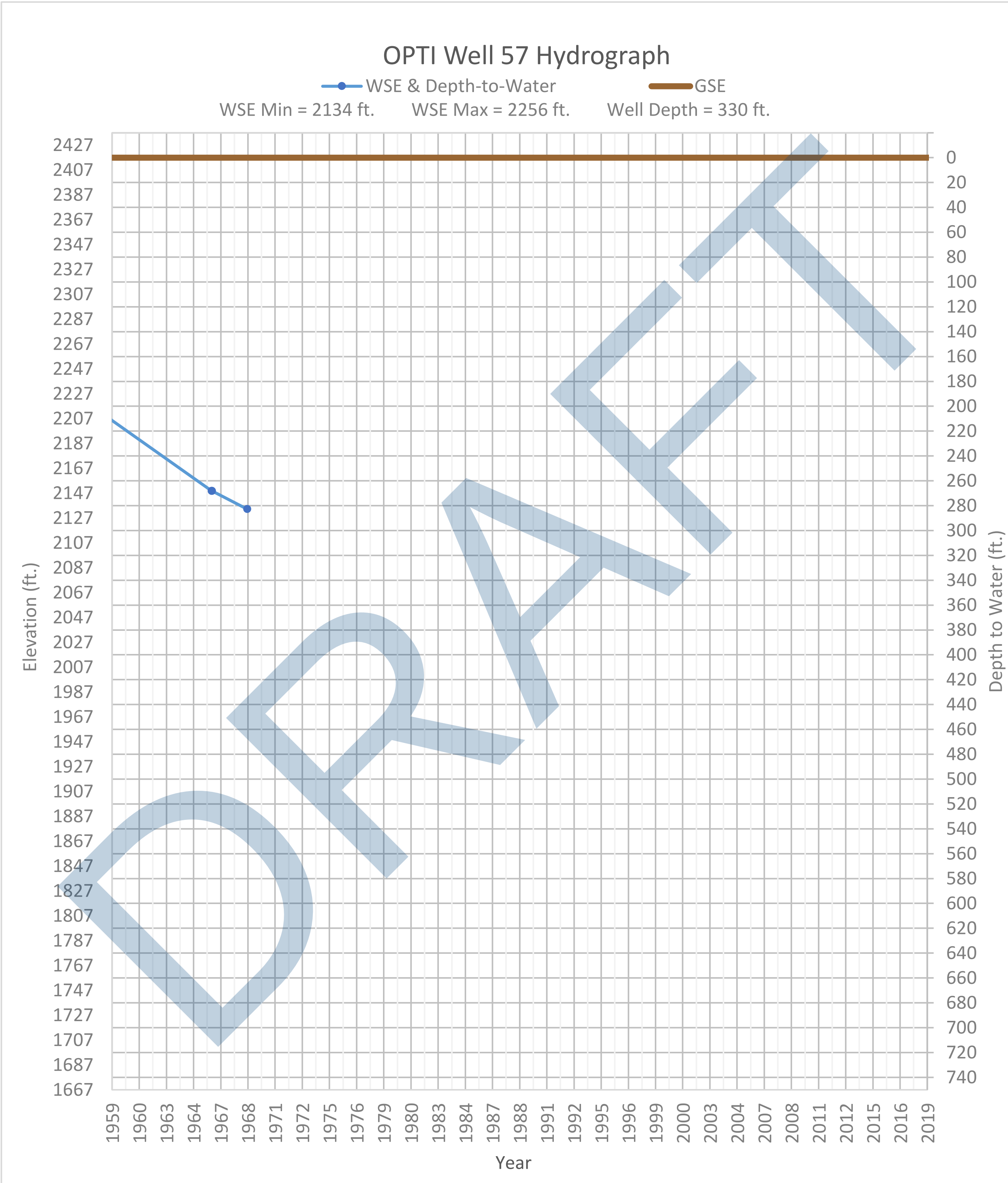


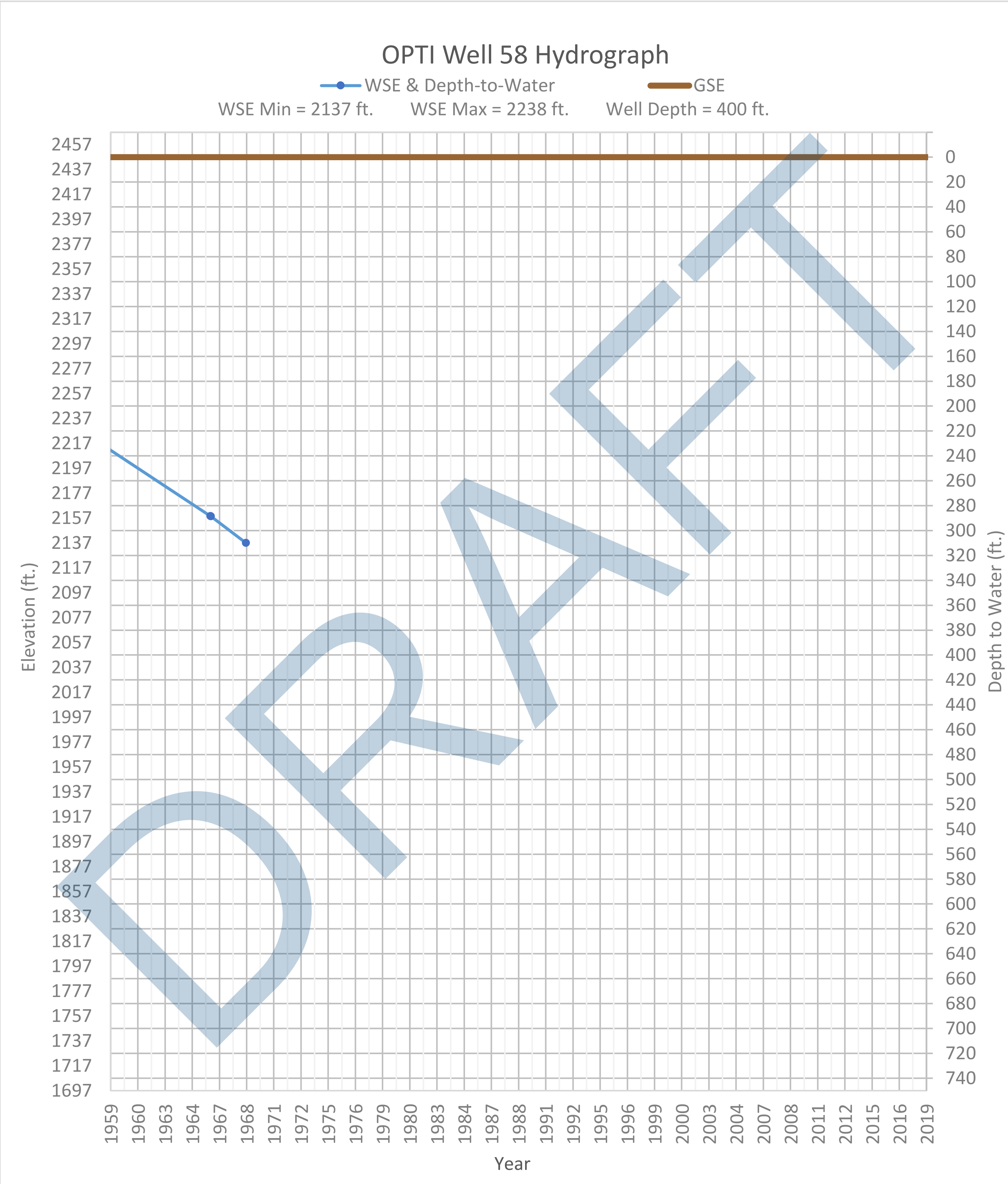
OPTI Well 54 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1942 ft.
WSE Max = 1991 ft.
Well Depth = 924 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 55 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2075 ft.
WSE Max = 2271 ft.
Well Depth = 419 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

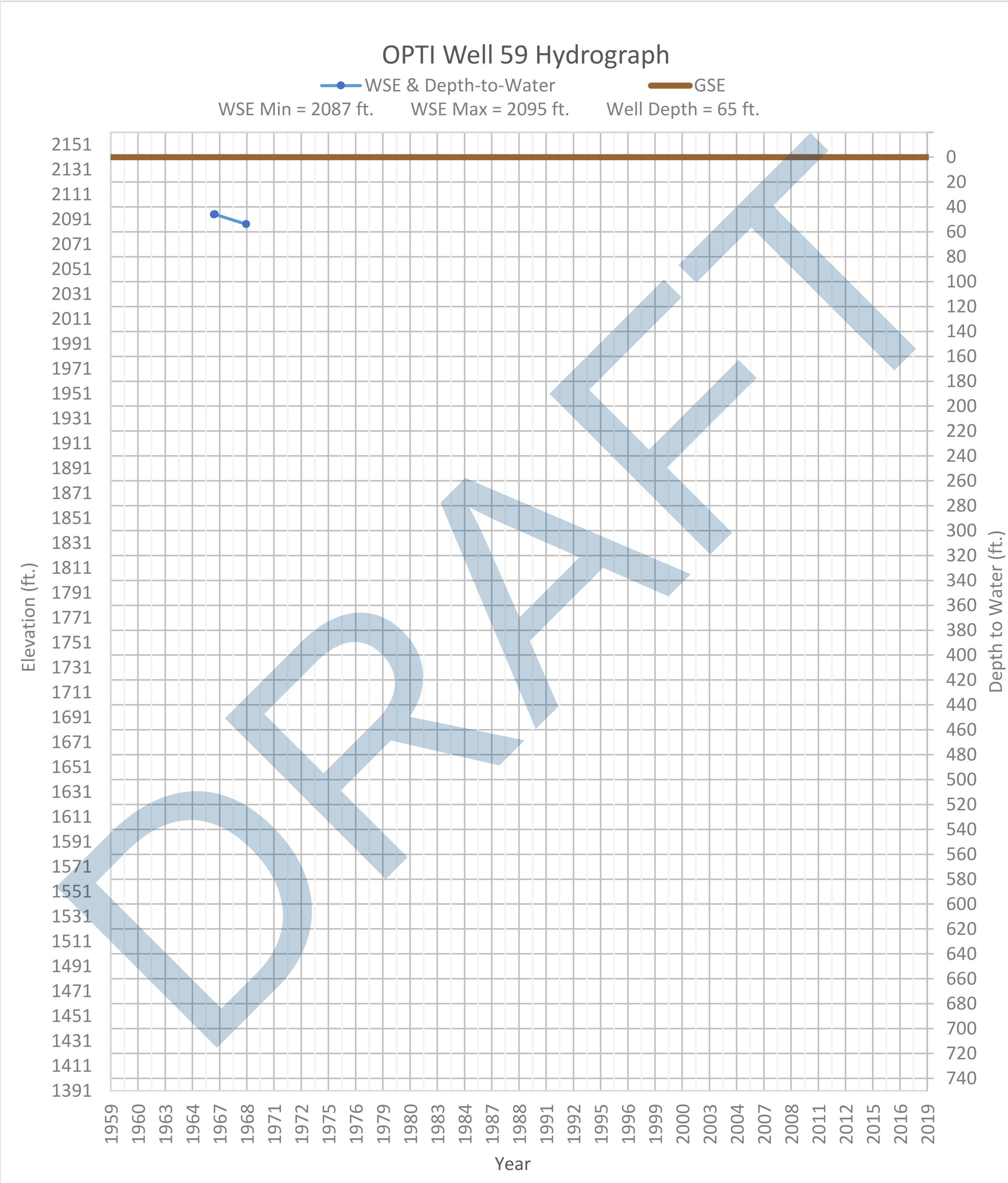


OPTI Well 56 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2128 ft.
WSE Max = 2160 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

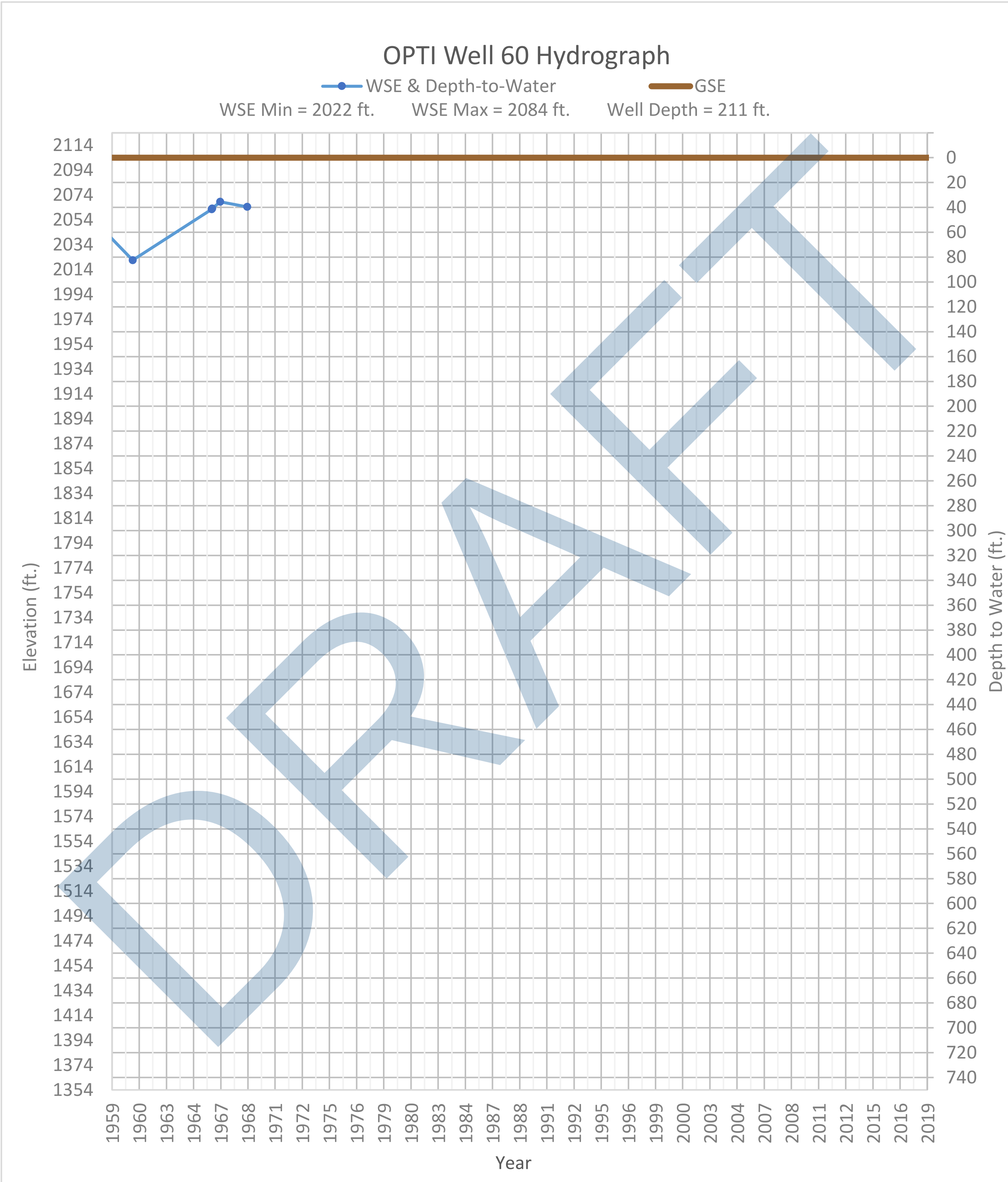

OPTI Well 57 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2134 ft.
WSE Max = 2256 ft.
Well Depth = 330 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

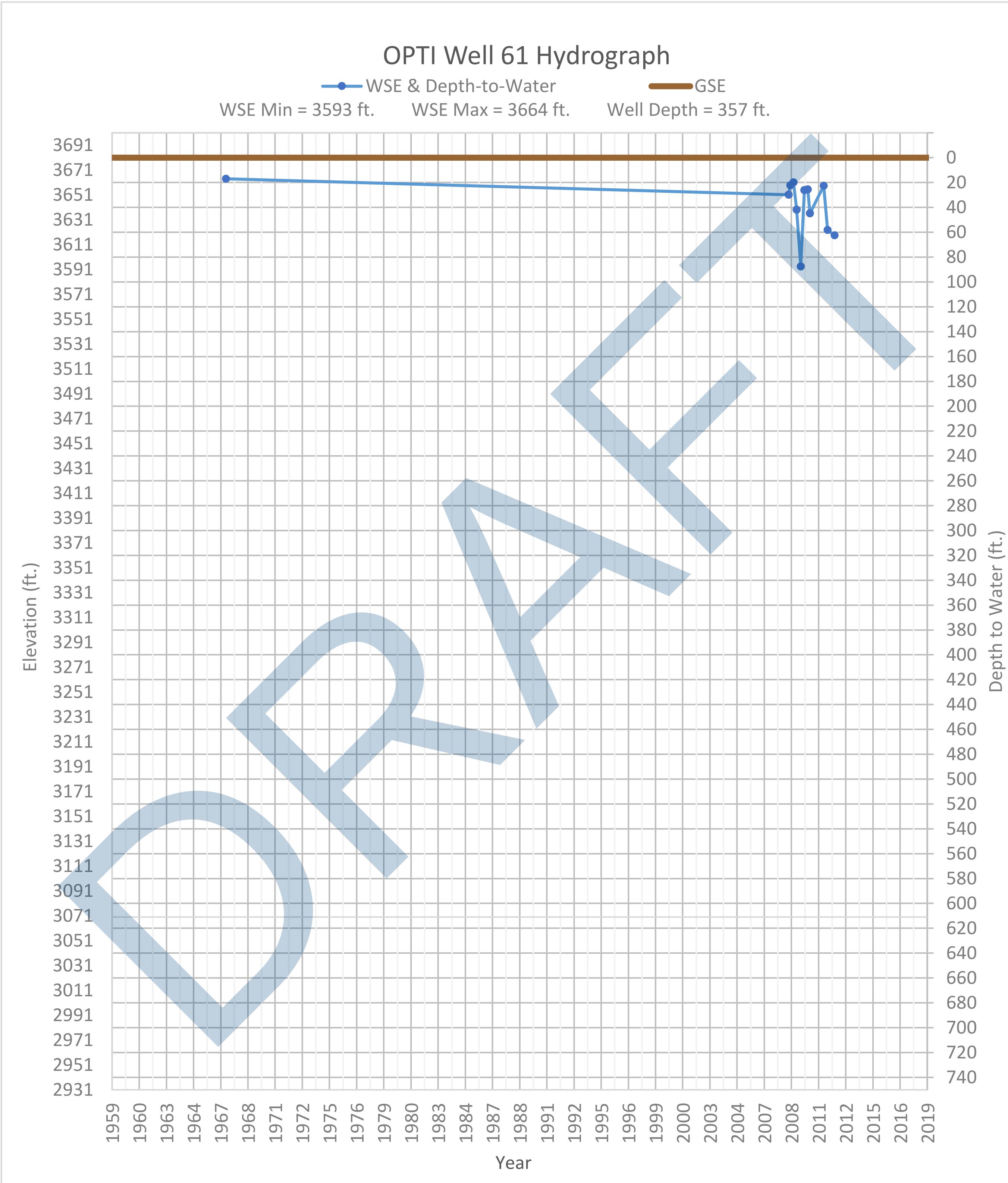


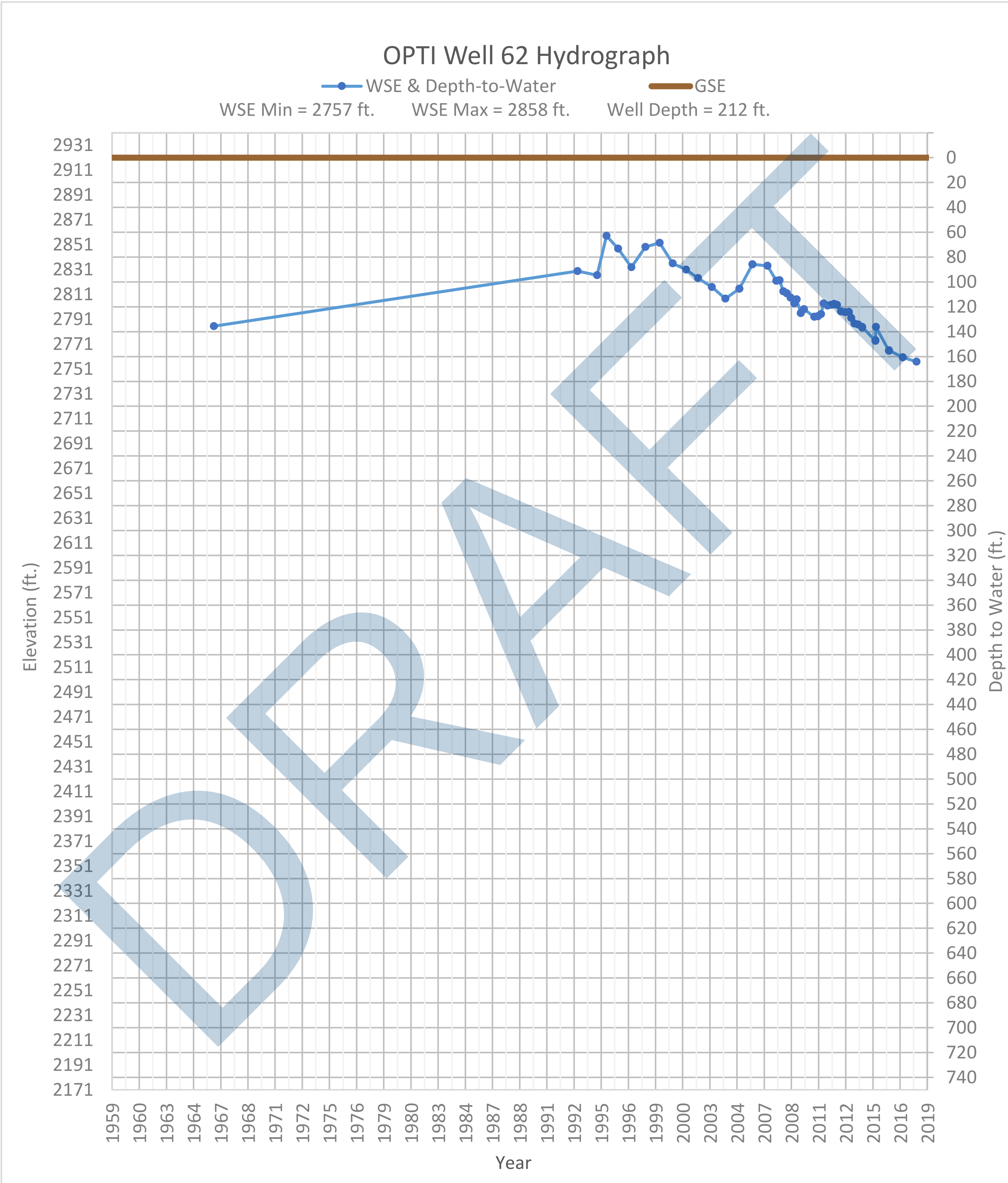
OPTI Well 58 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2137 ft.
WSE Max = 2238 ft.
Well Depth = 400 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

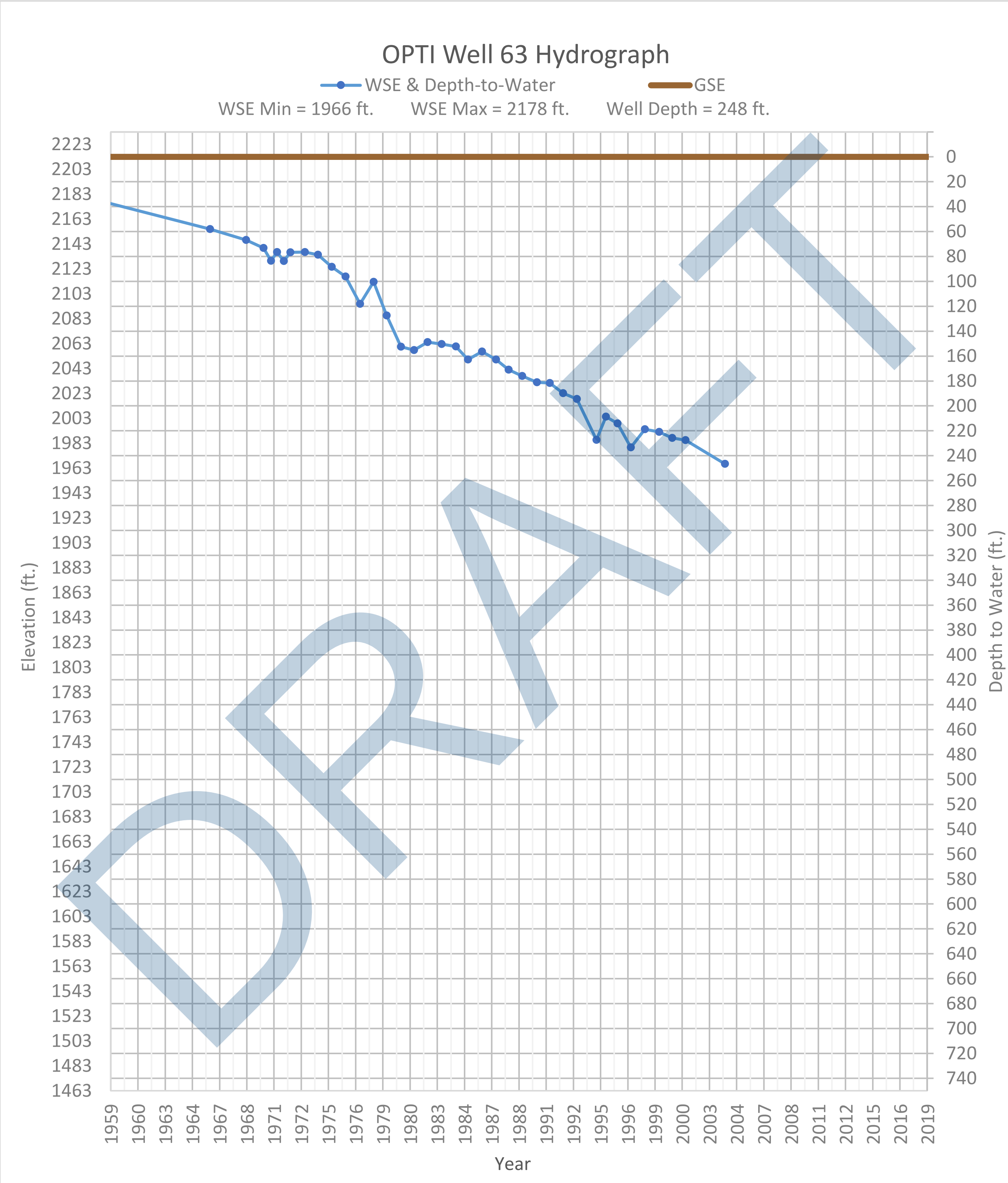


OPTI Well 59 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2087 ft.
WSE Max = 2095 ft.
Well Depth = 65 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

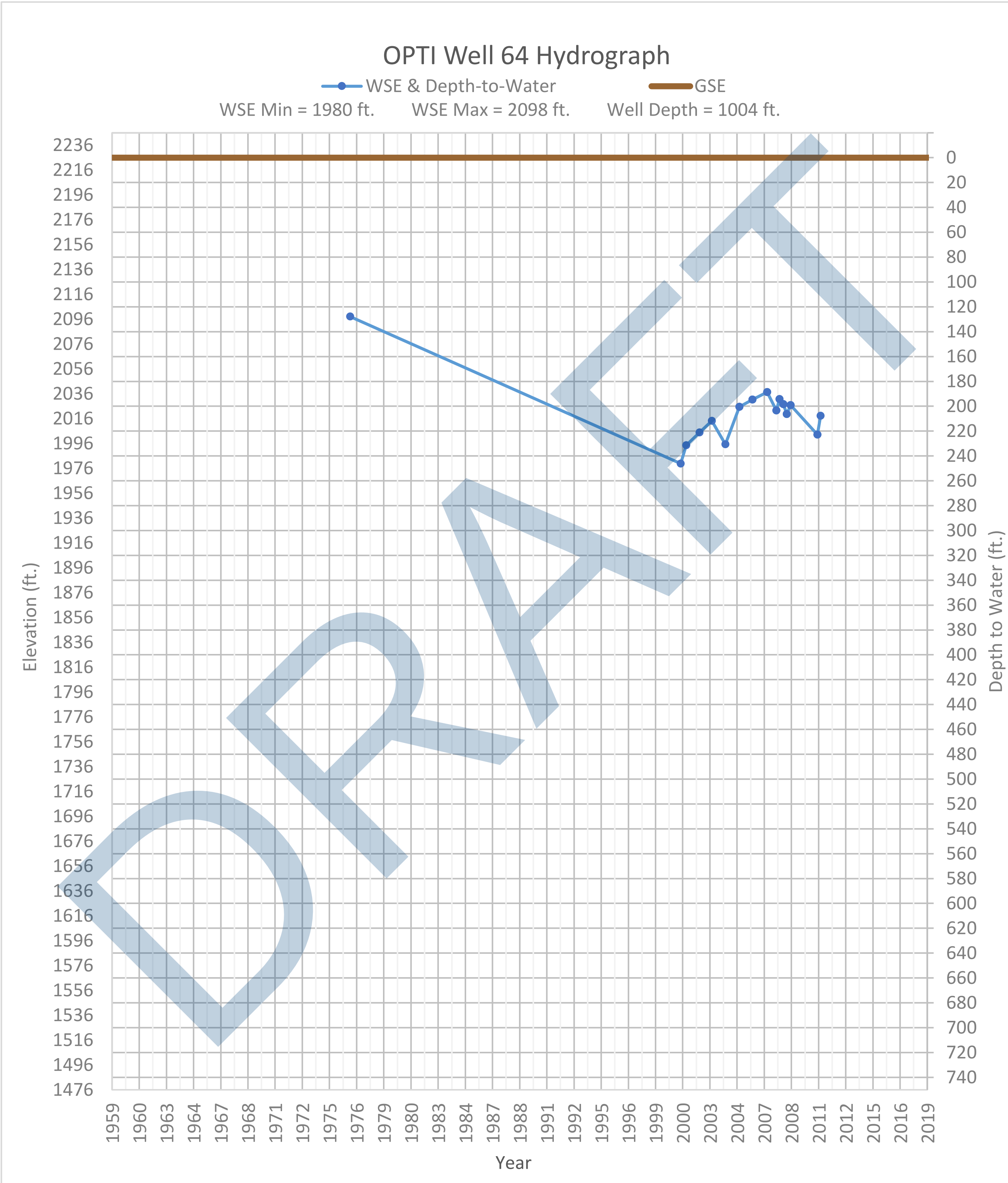

OPTI Well 60 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2022 ft.
WSE Max = 2084 ft.
Well Depth = 211 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 61 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3593 ft.
WSE Max = 3664 ft.
Well Depth = 357 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

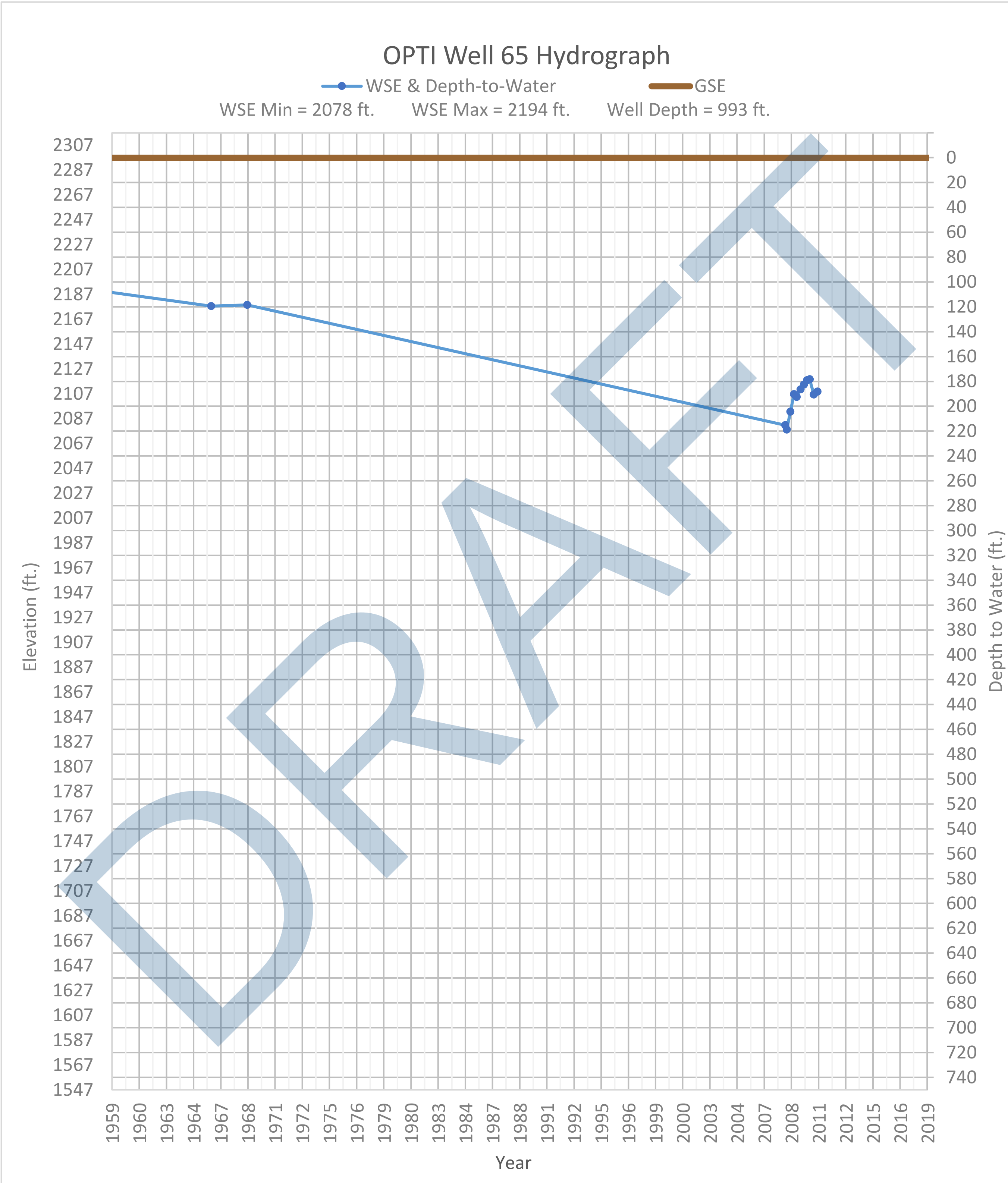

OPTI Well 62 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2757 ft.
WSE Max = 2858 ft.
Well Depth = 212 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



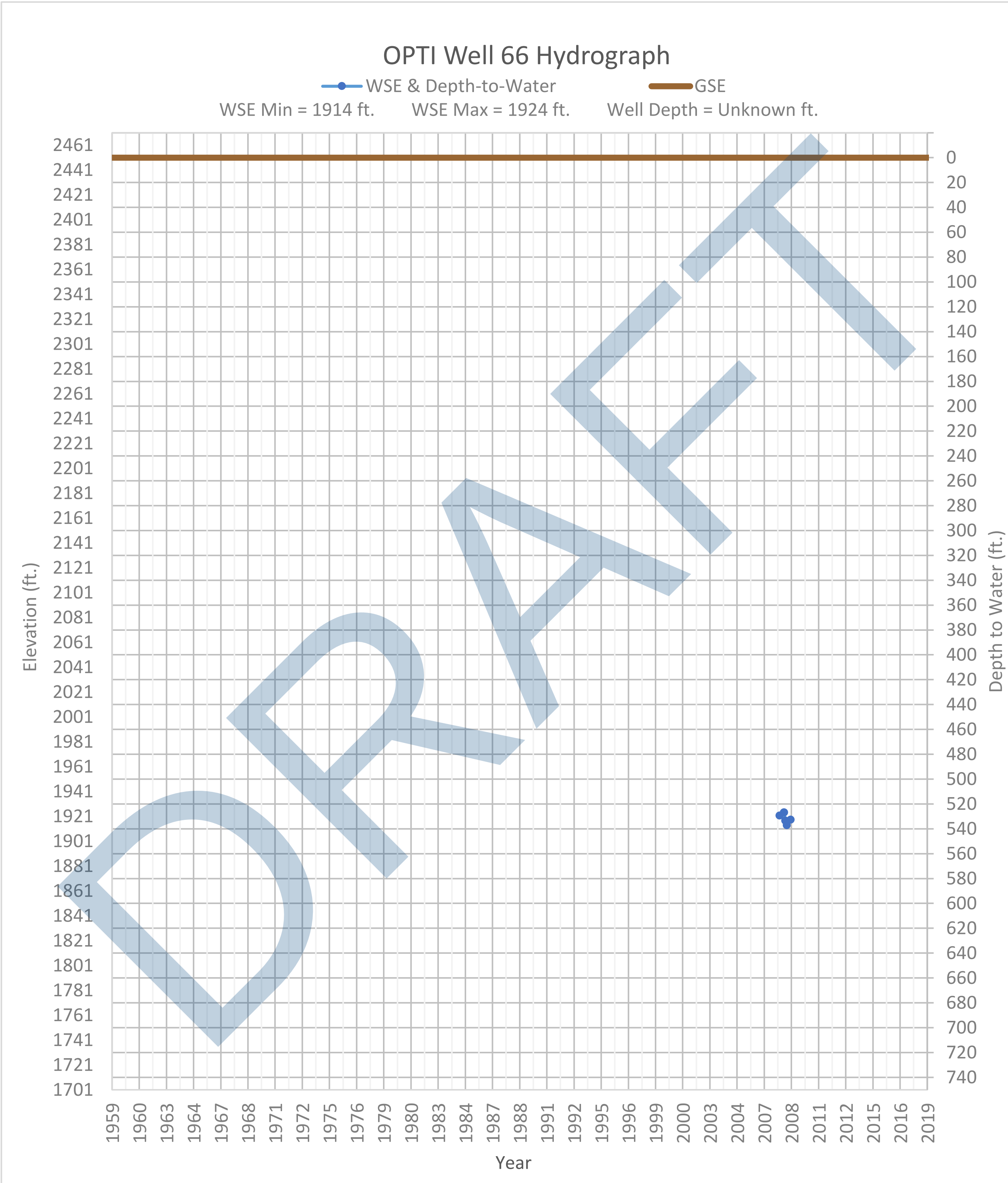
OPTI Well 63 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1966 ft.
WSE Max = 2178 ft.
Well Depth = 248 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

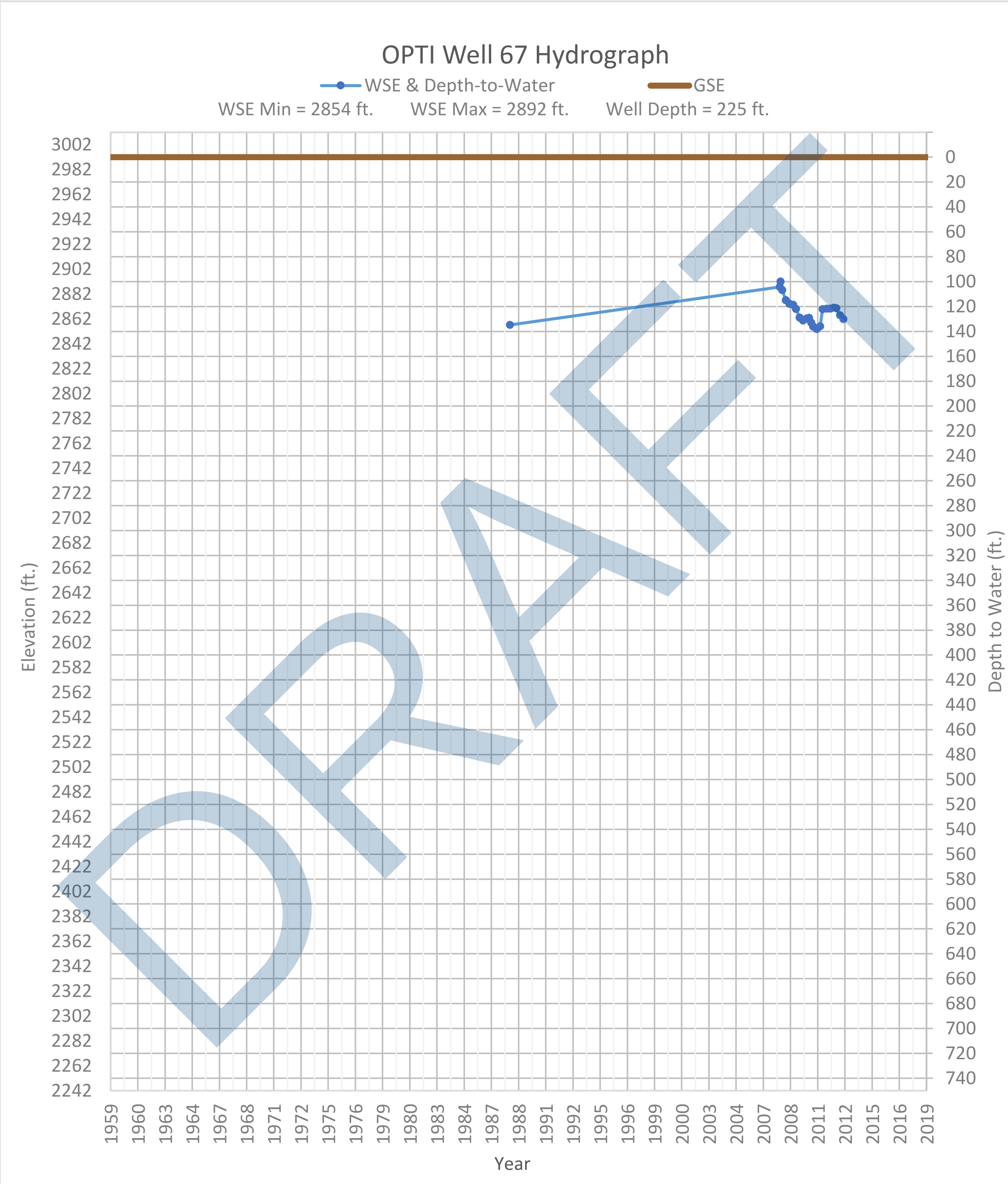


OPTI Well 64 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1980 ft.
WSE Max = 2098 ft.
Well Depth = 1004 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2236 2216 2196 2176 2156 2136 2116 2096 2076 2056 2036 2016 1996 1976 1956 1936 1916 1896 1876 1856 1836 1816 1796 1776 1756 1736 1716 1696 1676 1656 1636 1616 1596 1576 1556 1536 1516 1496 1476
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720 740
1959 1960 1963 1964 1967 1968 1971 1972 1975 1976 1979 1980 1983 1984 1987 1988 1991 1992 1995 1996 1999 2000 2003 2004 2007 2008 2011 2012 2015 2016 2019
DRAFT

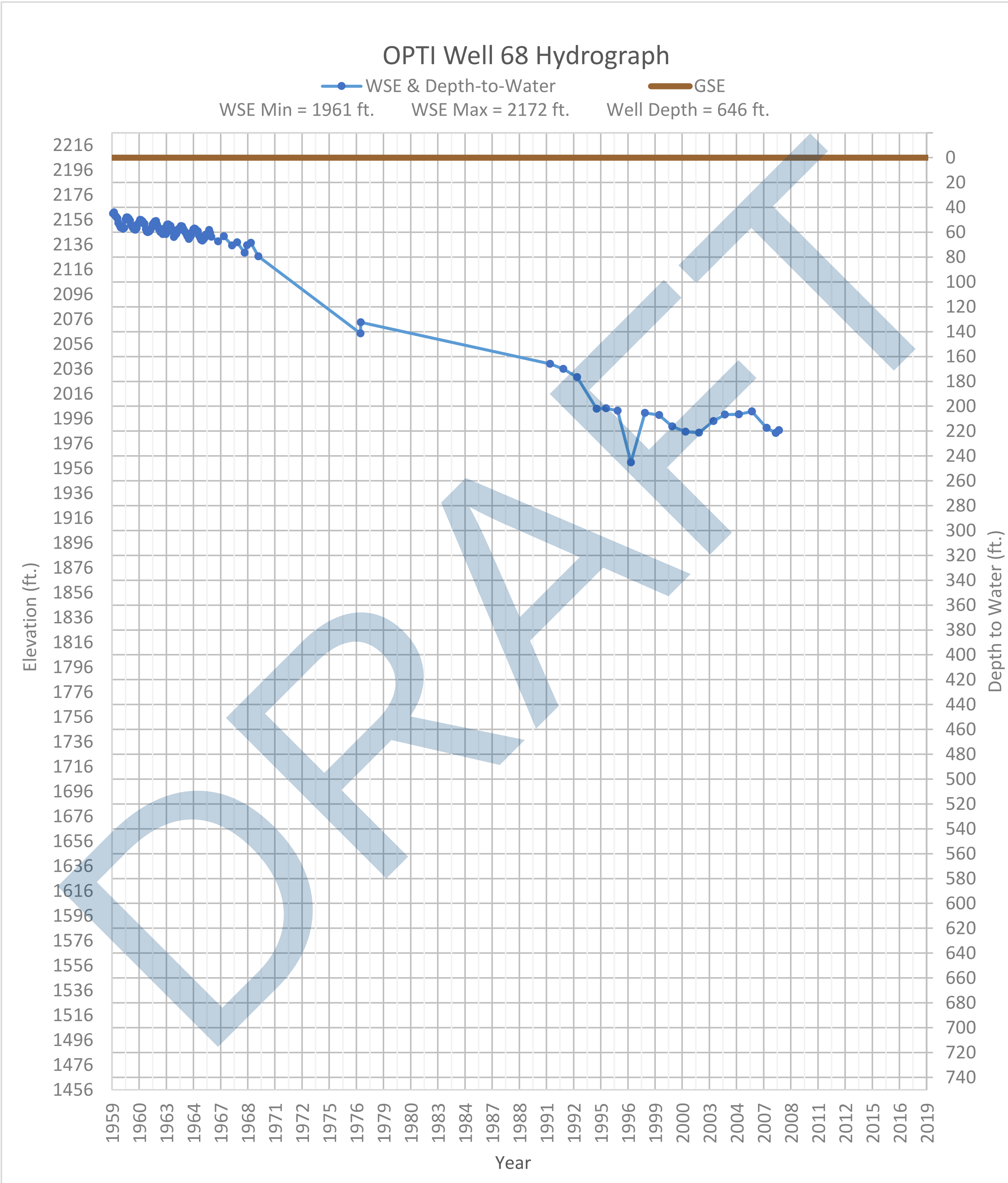


OPTI Well 65 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2078 ft.
WSE Max = 2194 ft.
Well Depth = 993 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

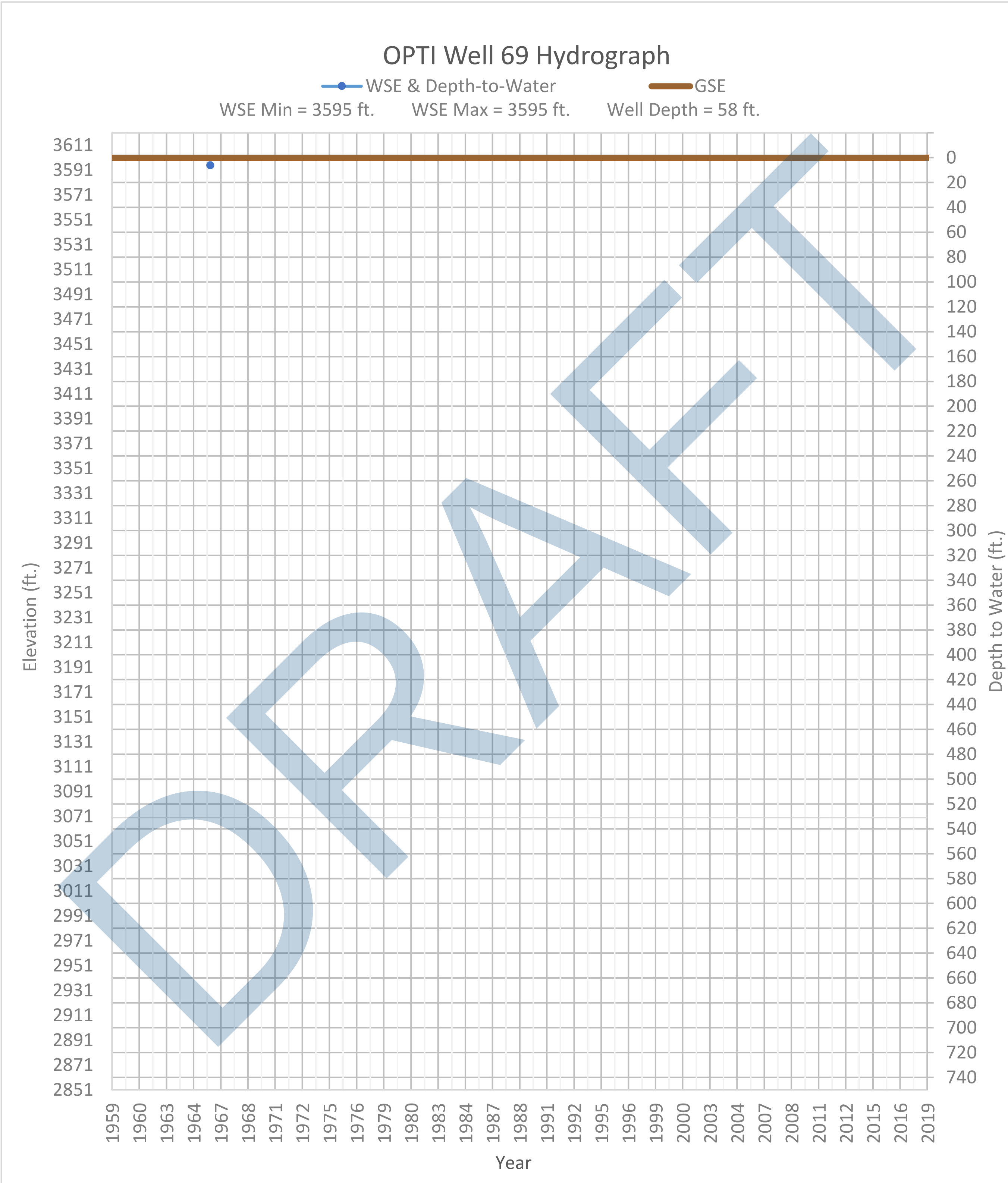

OPTI Well 66 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1914 ft.
WSE Max = 1924 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 67 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2854 ft.
WSE Max = 2892 ft.
Well Depth = 225 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 68 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1961 ft.
WSE Max = 2172 ft.
Well Depth = 646 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 69 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3595 ft.
WSE Max = 3595 ft.
Well Depth = 58 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
3611
3591
3571
3551
3531
3511
3491
3471
3451
3431
3411
3391
3371
3351
3331
3311
3291
3271
3251
3231
3211
3191
3171
3151
3131
3111
3091
3071
3051
3031
3011
2991
2971
2951
2931
2911
2891
2871
2851
0
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180
200
220
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260
280
300
320
340
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460
480
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560
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620
640
660
680
700
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1959
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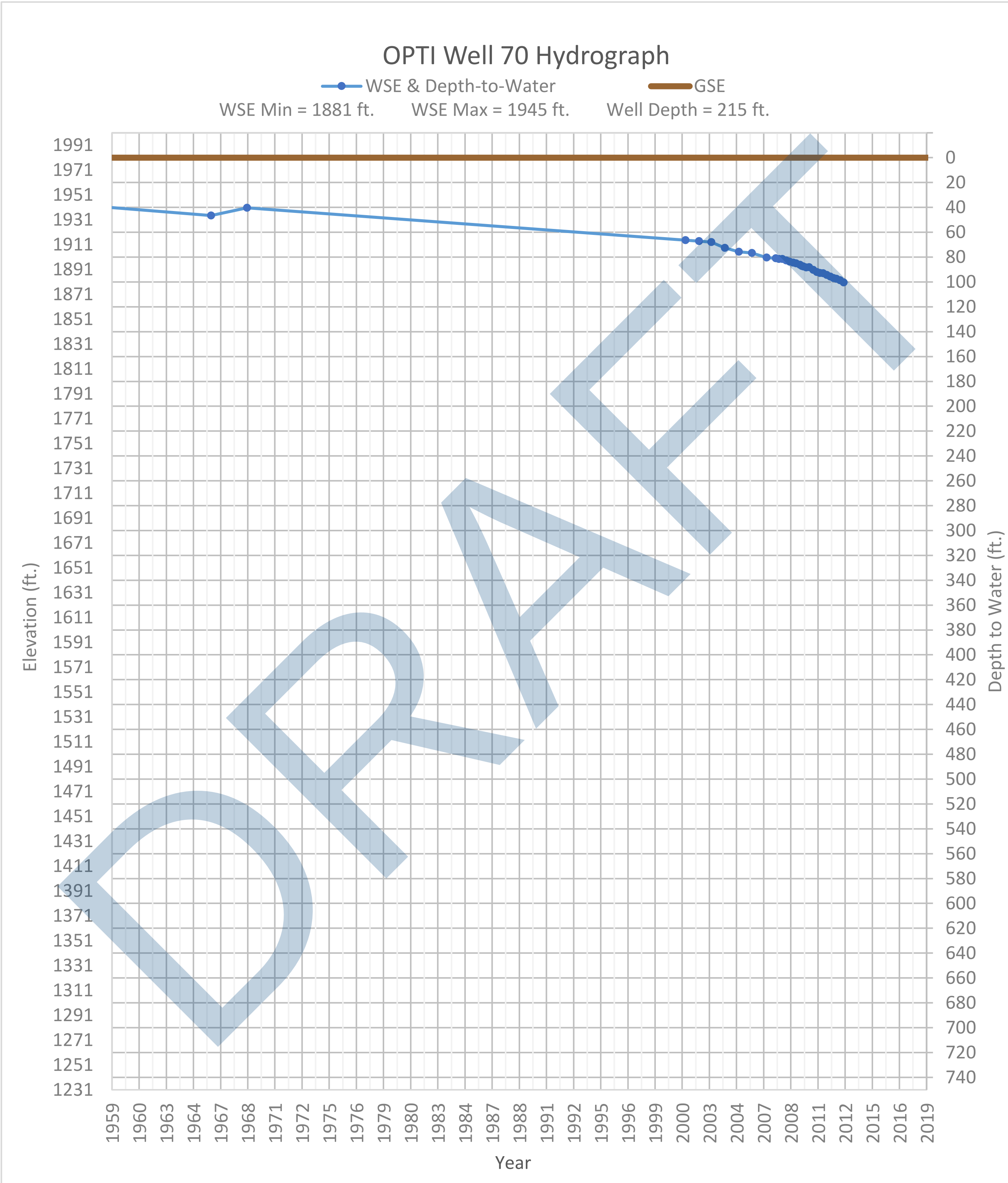
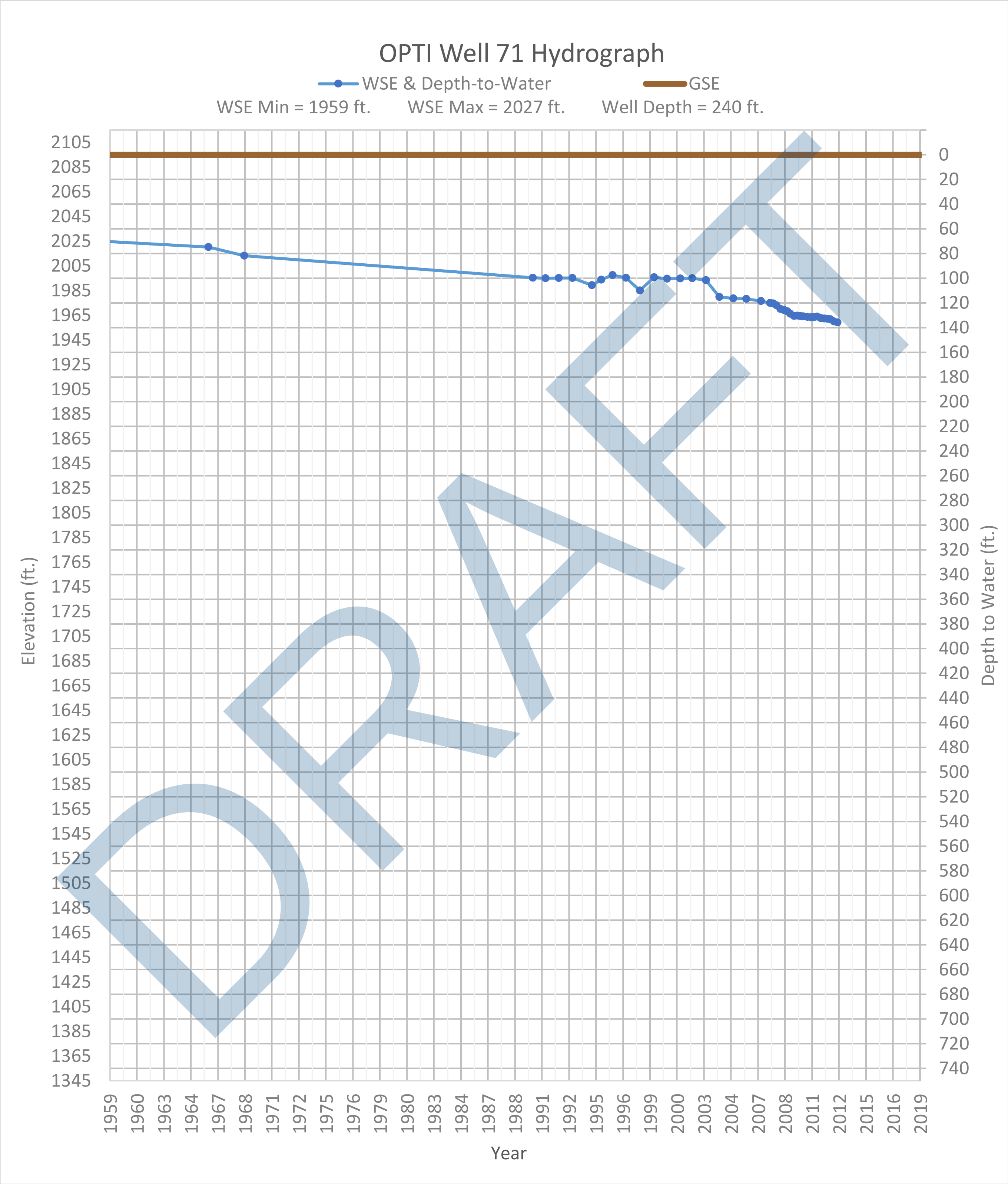
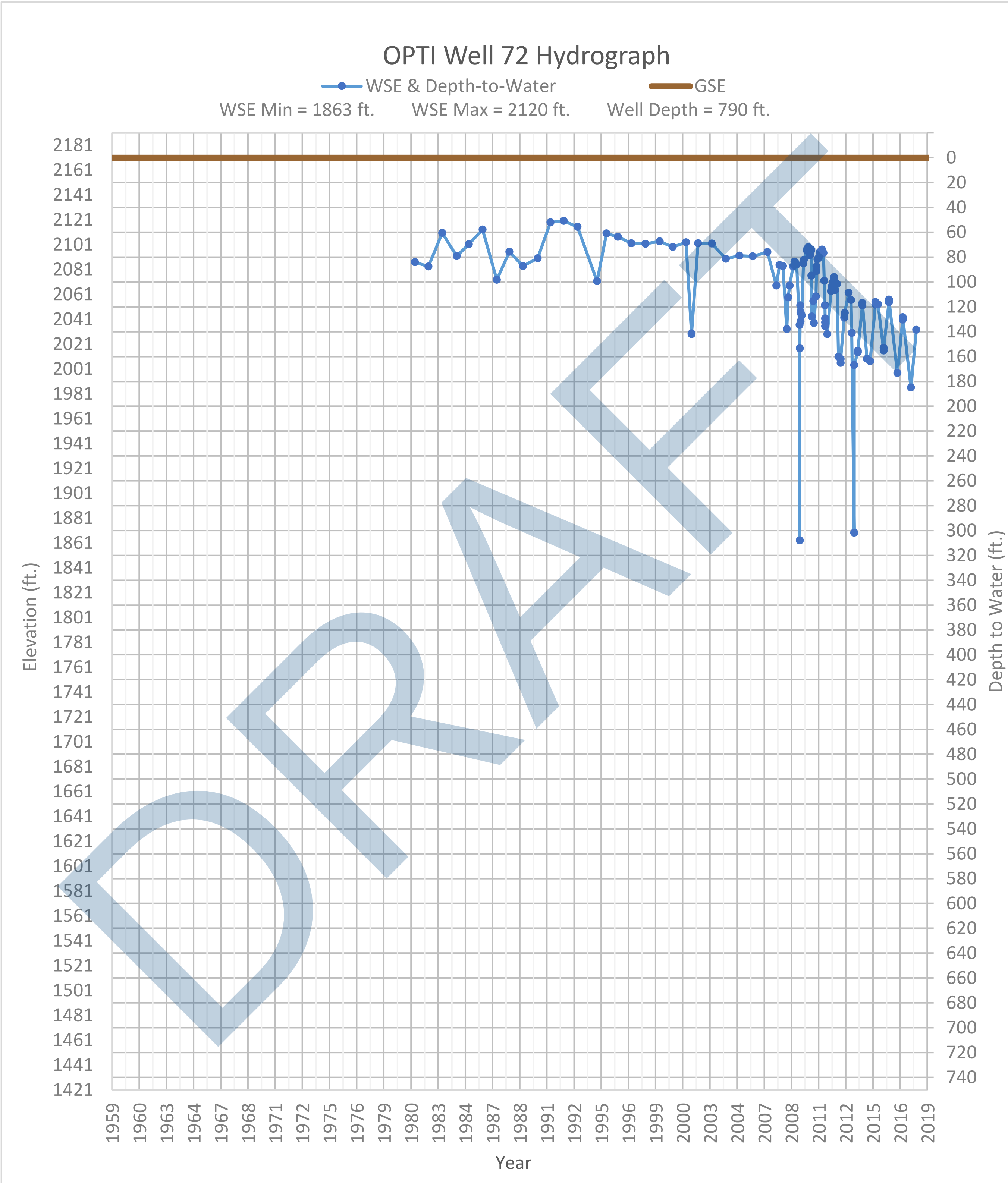
2016
2019
DRAFT



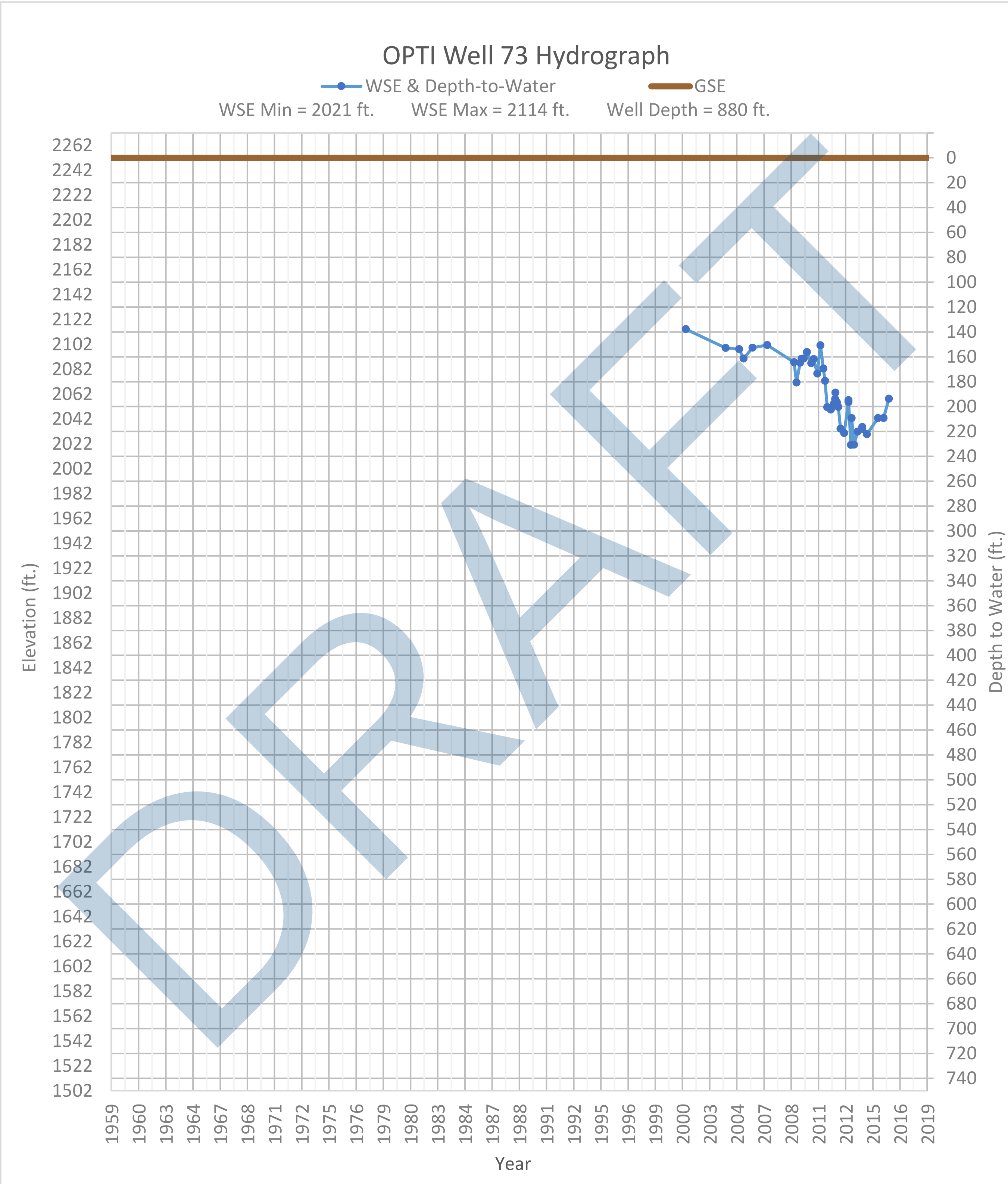
OPTI Well 70 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1881 ft.
WSE Max = 1945 ft.
Well Depth = 215 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



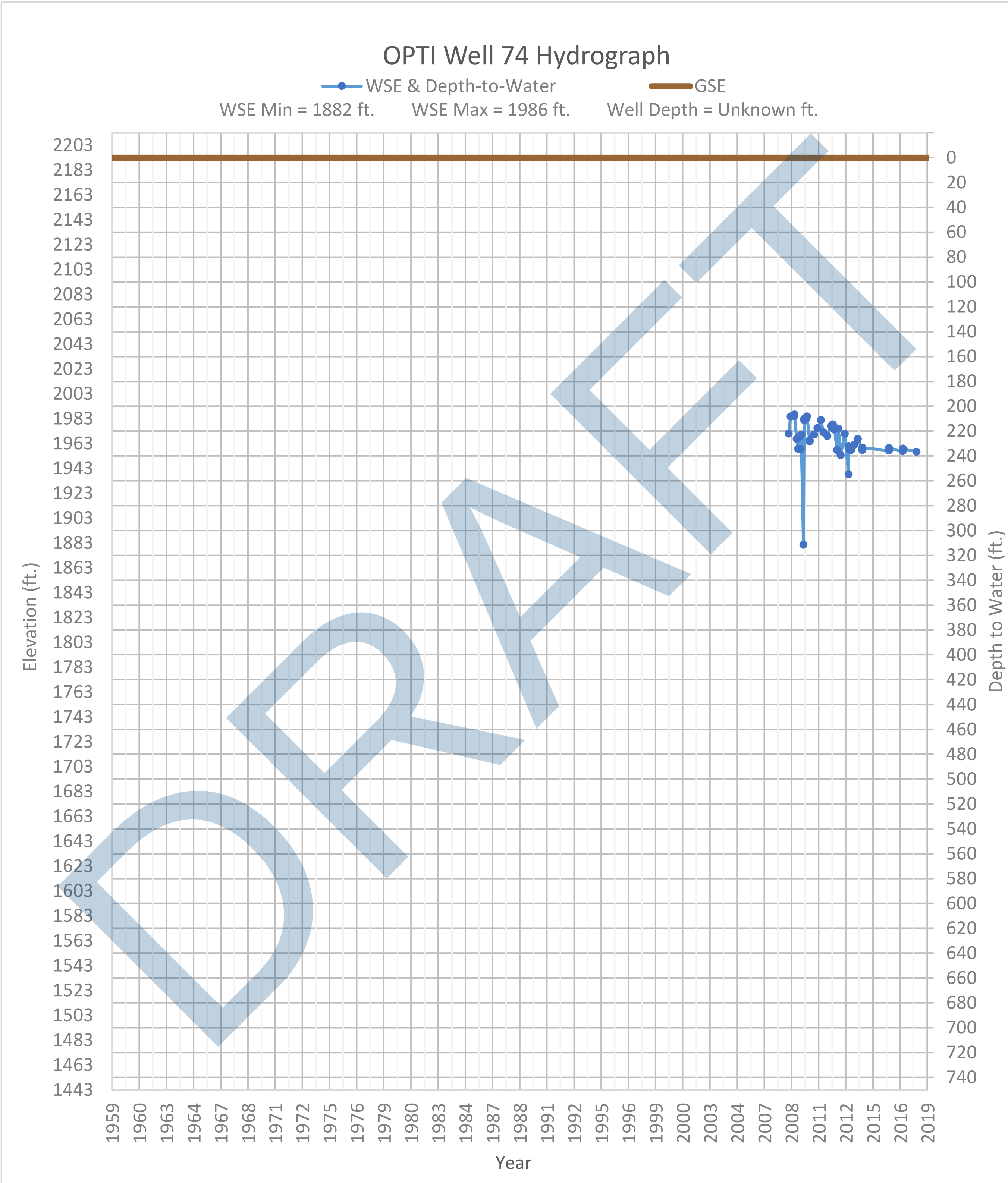
OPTI Well 71 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1959 ft.
WSE Max = 2027 ft.
Well Depth = 240 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 72 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1863 ft.
WSE Max = 2120 ft.
Well Depth = 790 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 73 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2021 ft.
WSE Max = 2114 ft.
Well Depth = 880 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 74 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1882 ft.
WSE Max = 1986 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2203
2183
2163
2143
2123
2103
2083
2063
2043
2023
2003
1983
1963
1943
1923
1903
1883
1863
1843
1823
1803
1783
1763
1743
1723
1703
1683
1663
1643
1623
1603
1583
1563
1543
1523
1503
1483
1463
1443
0
20
40
60
80
100
120
140
160
180
200
220
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260
280
300
320
340
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380
400
420
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460
480
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560
580
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620
640
660
680
700
720
740
1959
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1992
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2000
2003
2004
2007
2008
2011
2012
2015
2016
2019
DRAFT


OPTI Well 75 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1912 ft.
WSE Max = 2089 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2305
2285
2265
2245
2225
2205
2185
2165
2145
2125
2105
2085
2065
2045
2025
2005
1985
1965
1945
1925
1905
1885
1865
1845
1825
1805
1785
1765
1745
1725
1705
1685
1665
1645
1625
1605
1585
1565
1545
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
680
700
720
740
1959
1960
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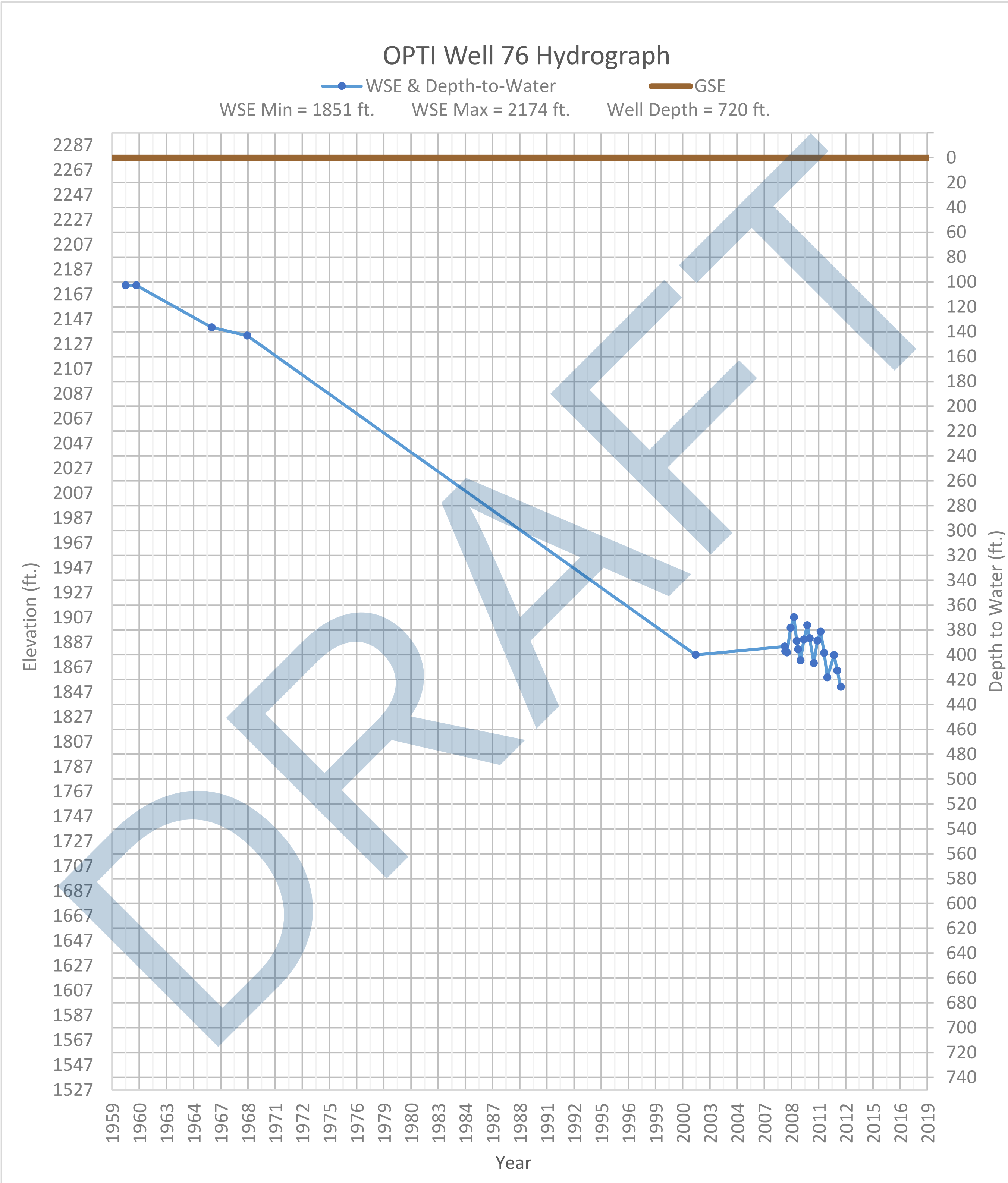
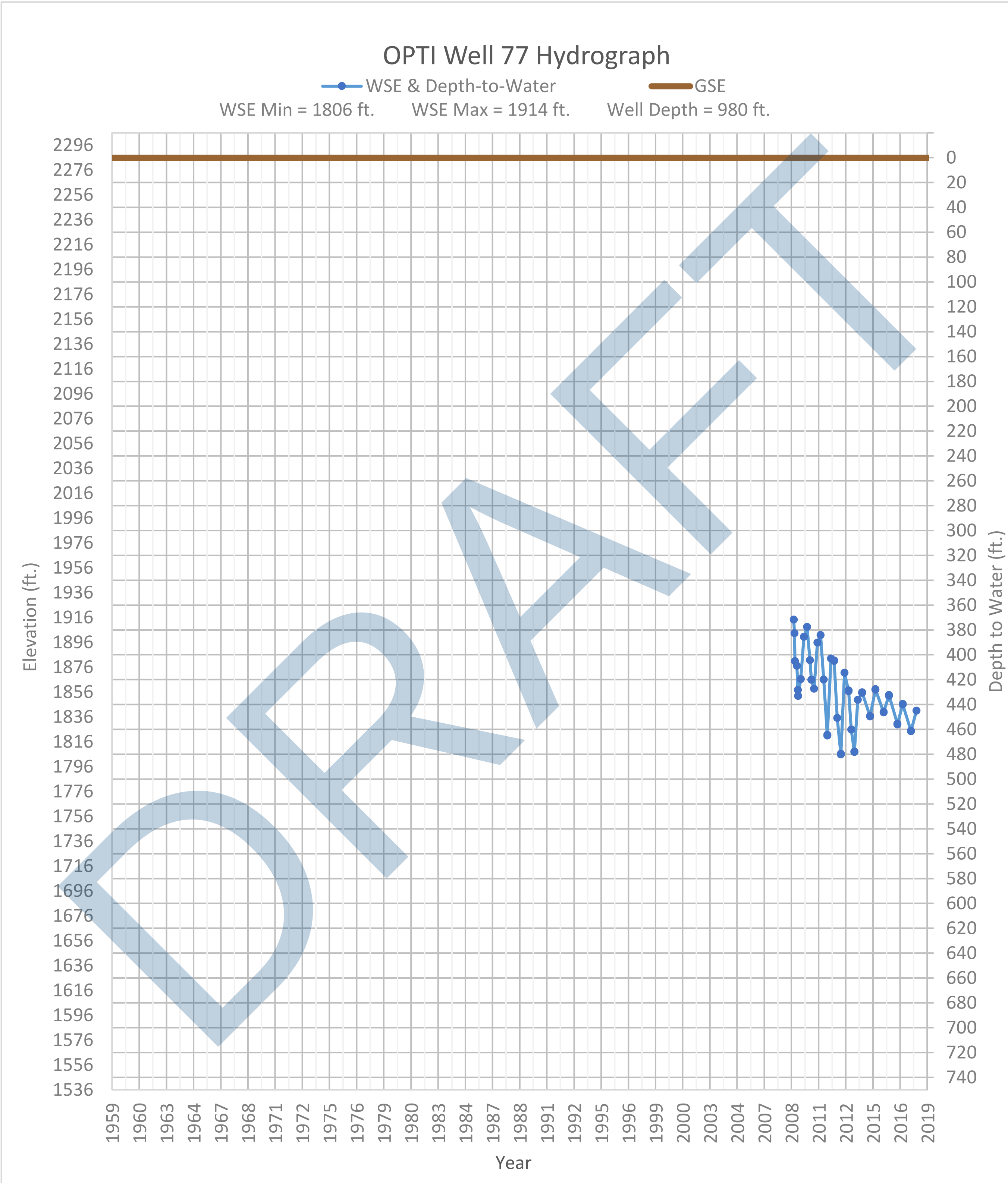
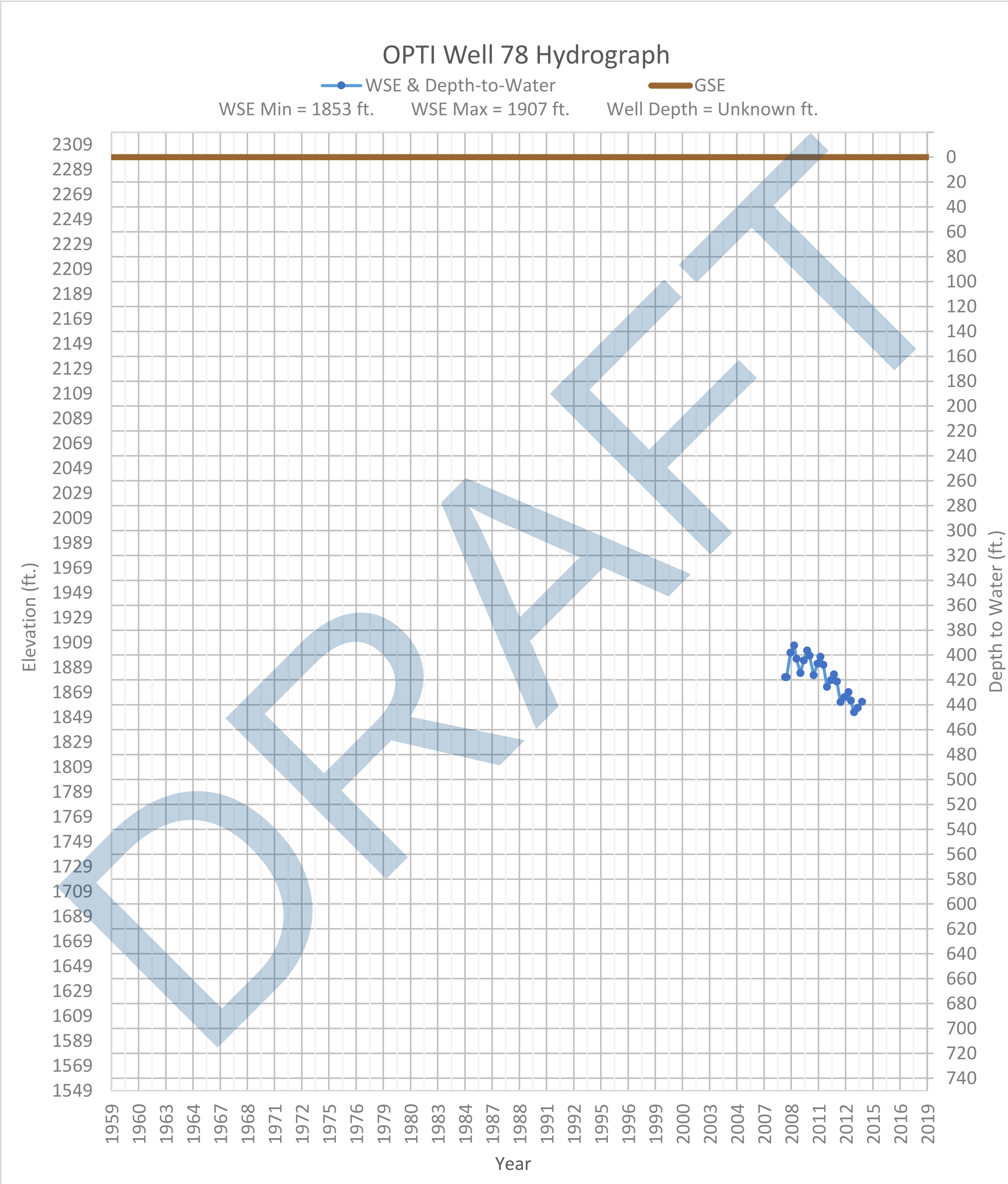
2019
DRAFT

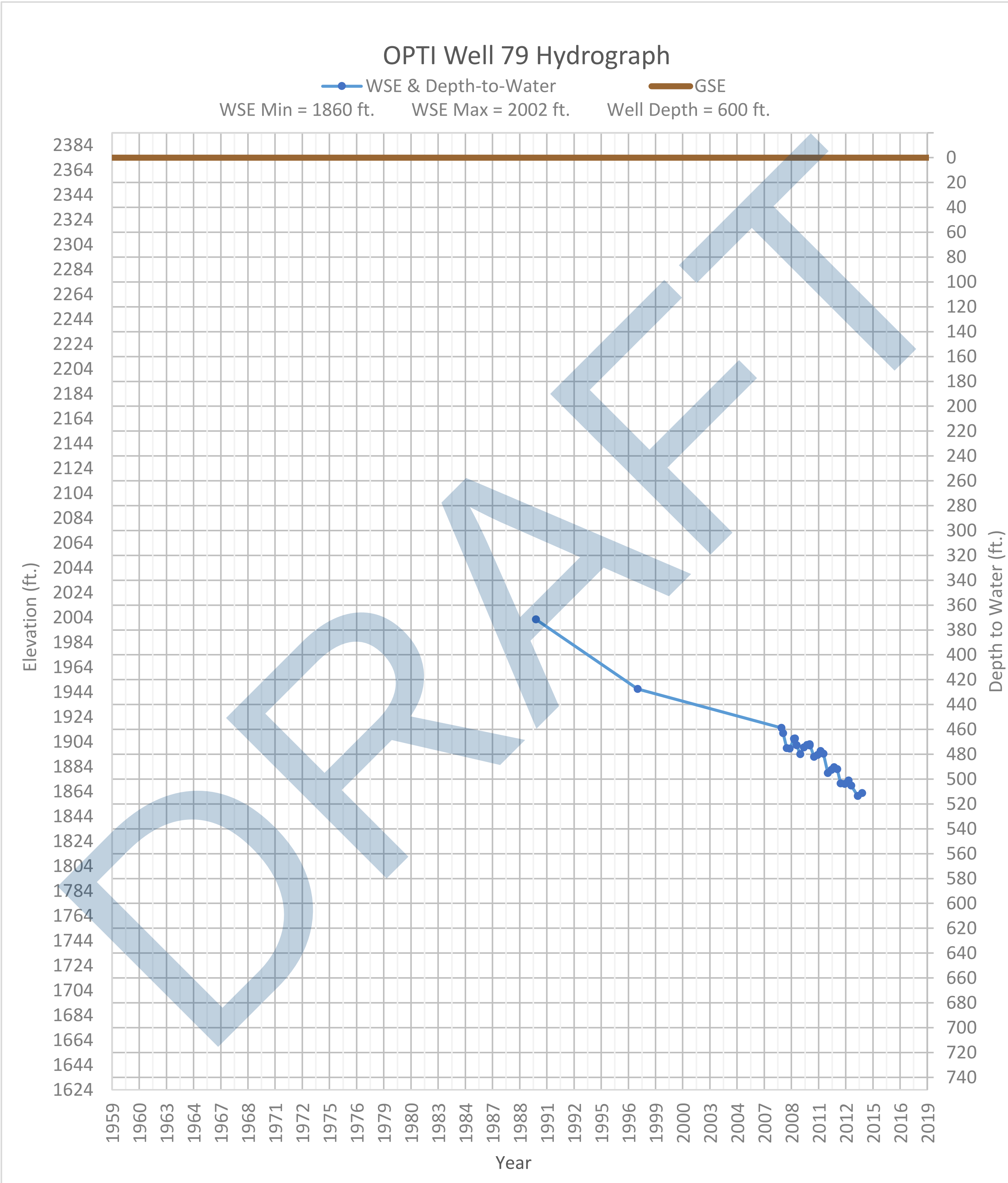


OPTI Well 76 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1851 ft.
WSE Max = 2174 ft.
Well Depth = 720 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

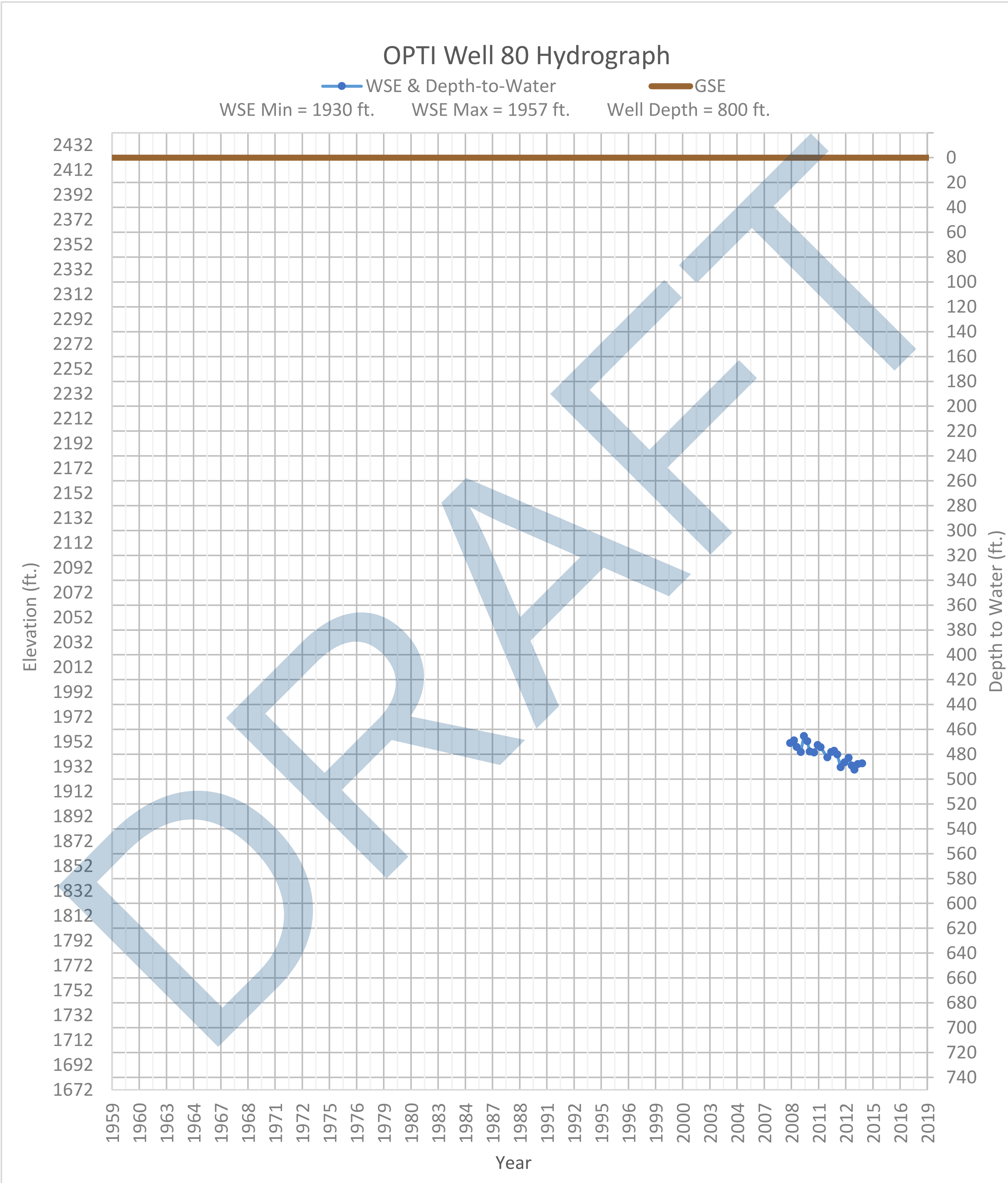

OPTI Well 77 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1806 ft.
WSE Max = 1914 ft.
Well Depth = 980 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

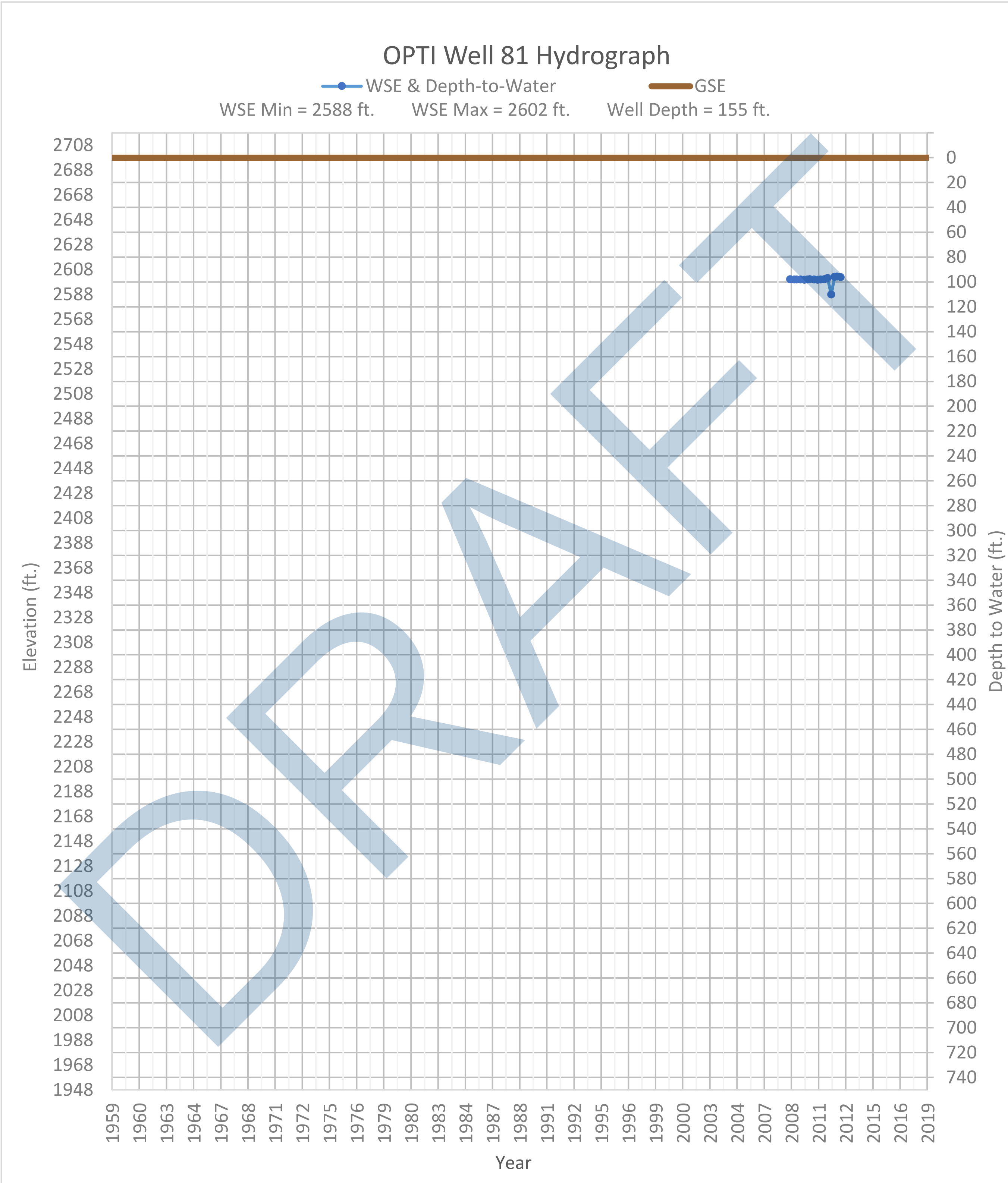


OPTI Well 78 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1853 ft.
WSE Max = 1907 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 79 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1860 ft.
WSE Max = 2002 ft.
Well Depth = 600 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 80 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1930 ft.
WSE Max = 1957 ft.
Well Depth = 800 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 81 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2588 ft.
WSE Max = 2602 ft.
Well Depth = 155 ft.
Elevation (ft.)
2708
2688
2668
2648
2628
2608
2588
2568
2548
2528
2508
2488
2468
2448
2428
2408
2388
2368
2348
2328
2308
2288
2268
2248
2228
2208
2188
2168
2148
2128
2108
2088
2068
2048
2028
2008
1988
1968
1948
Depth to Water (ft.)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
680
700
720
740
1959
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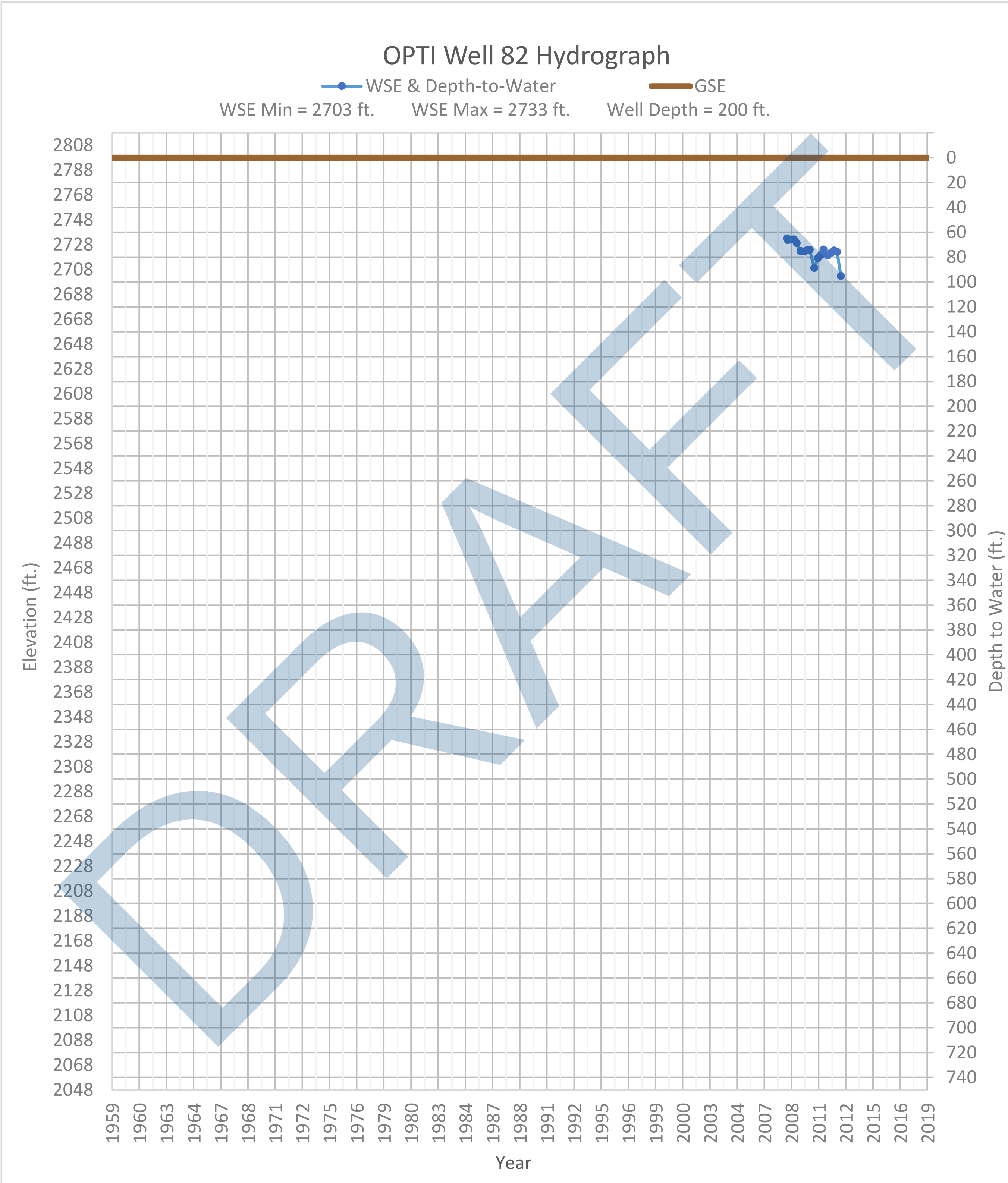
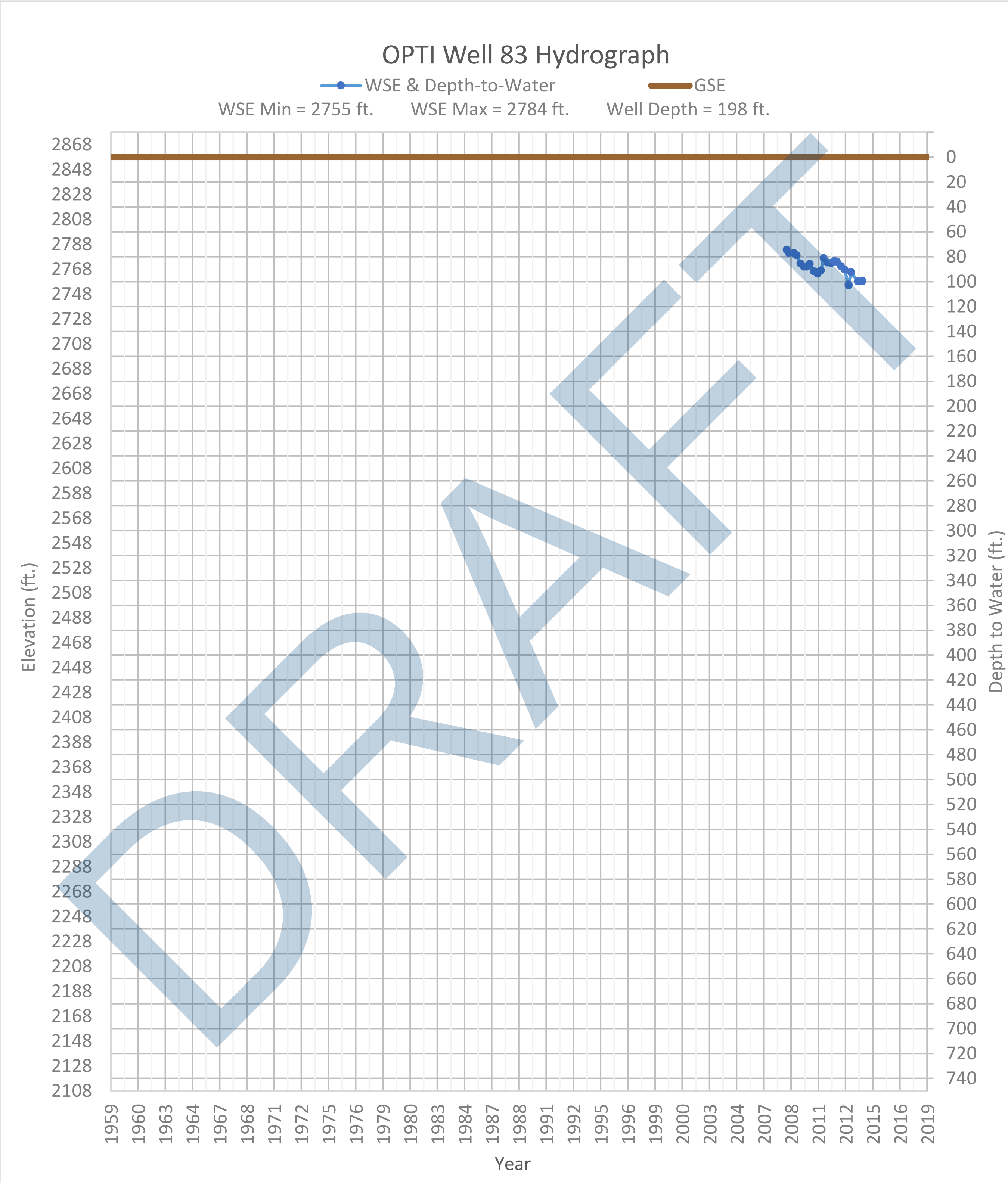
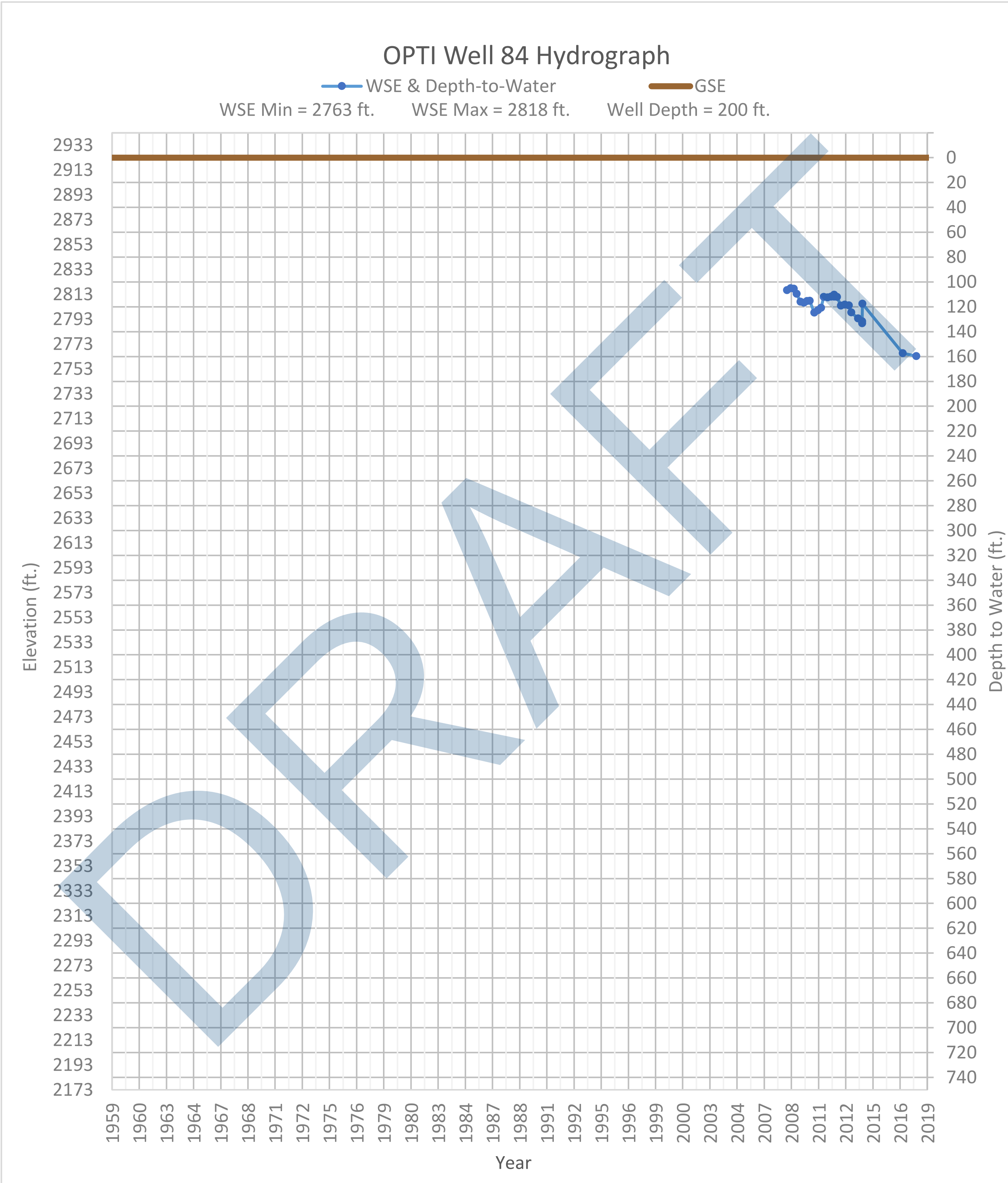
2016
2019
Year
DRAFT



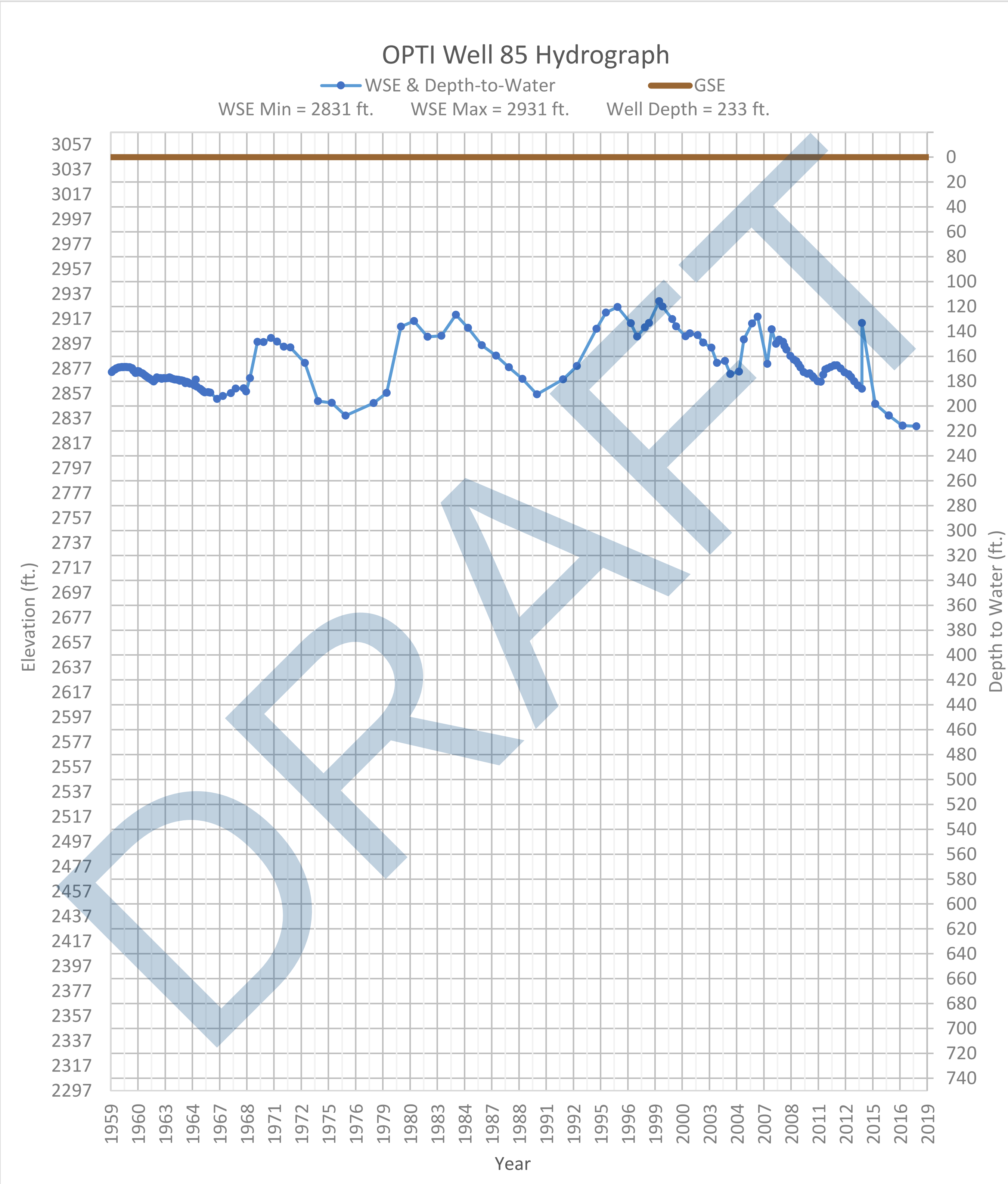
OPTI Well 82 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2703 ft.
WSE Max = 2733 ft.
Well Depth = 200 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



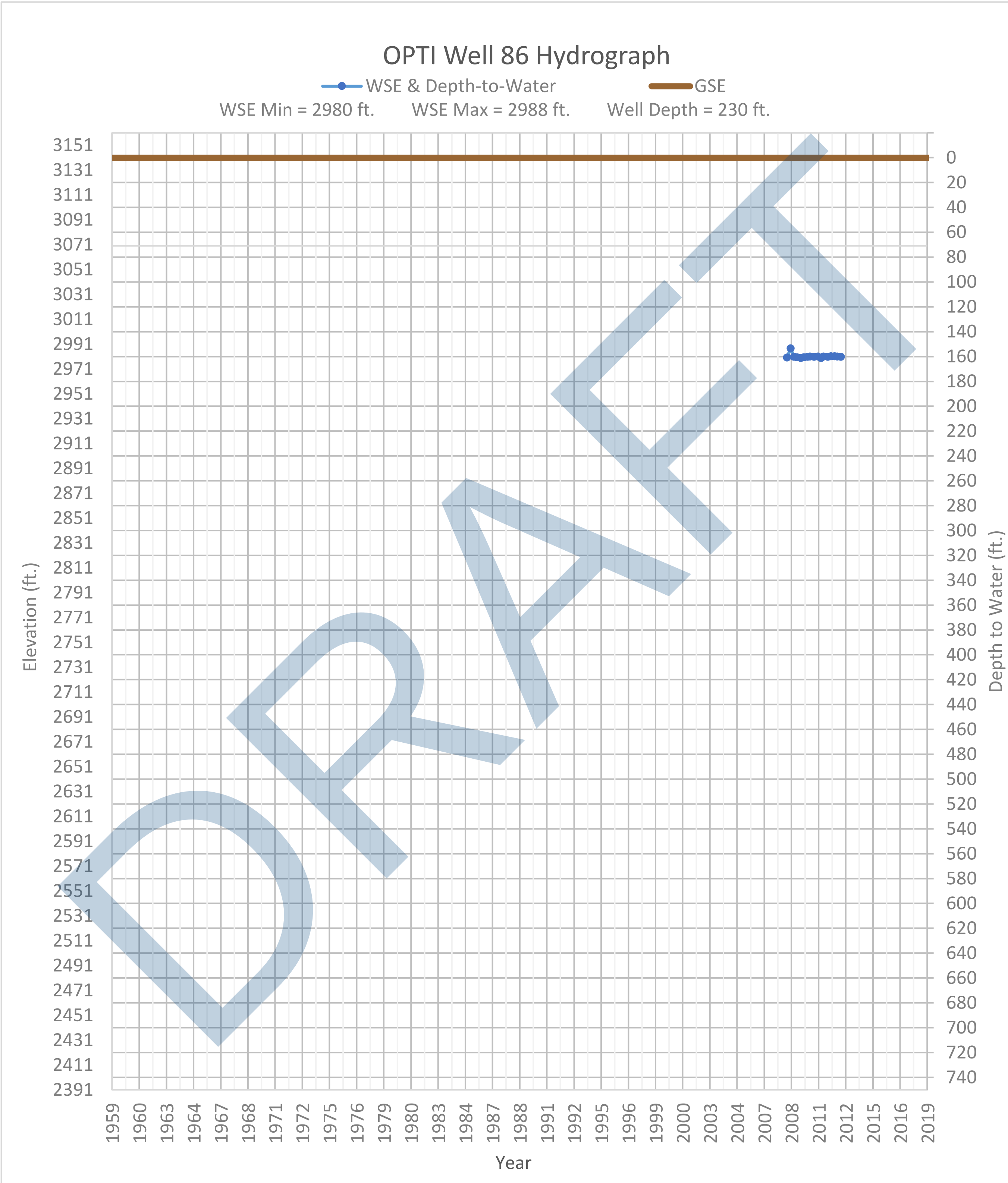
OPTI Well 83 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2755 ft.
WSE Max = 2784 ft.
Well Depth = 198 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



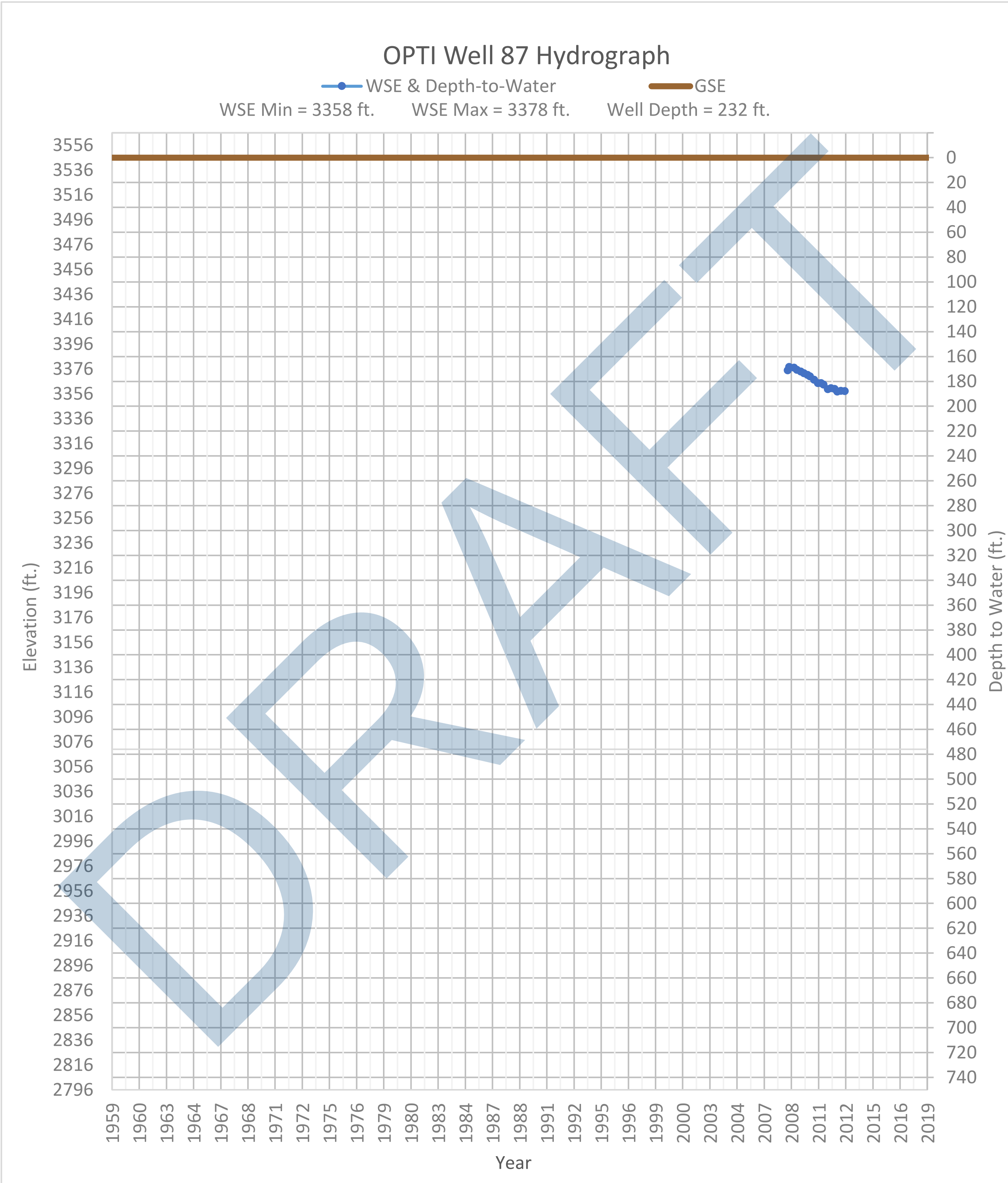
OPTI Well 84 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2763 ft.
WSE Max = 2818 ft.
Well Depth = 200 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



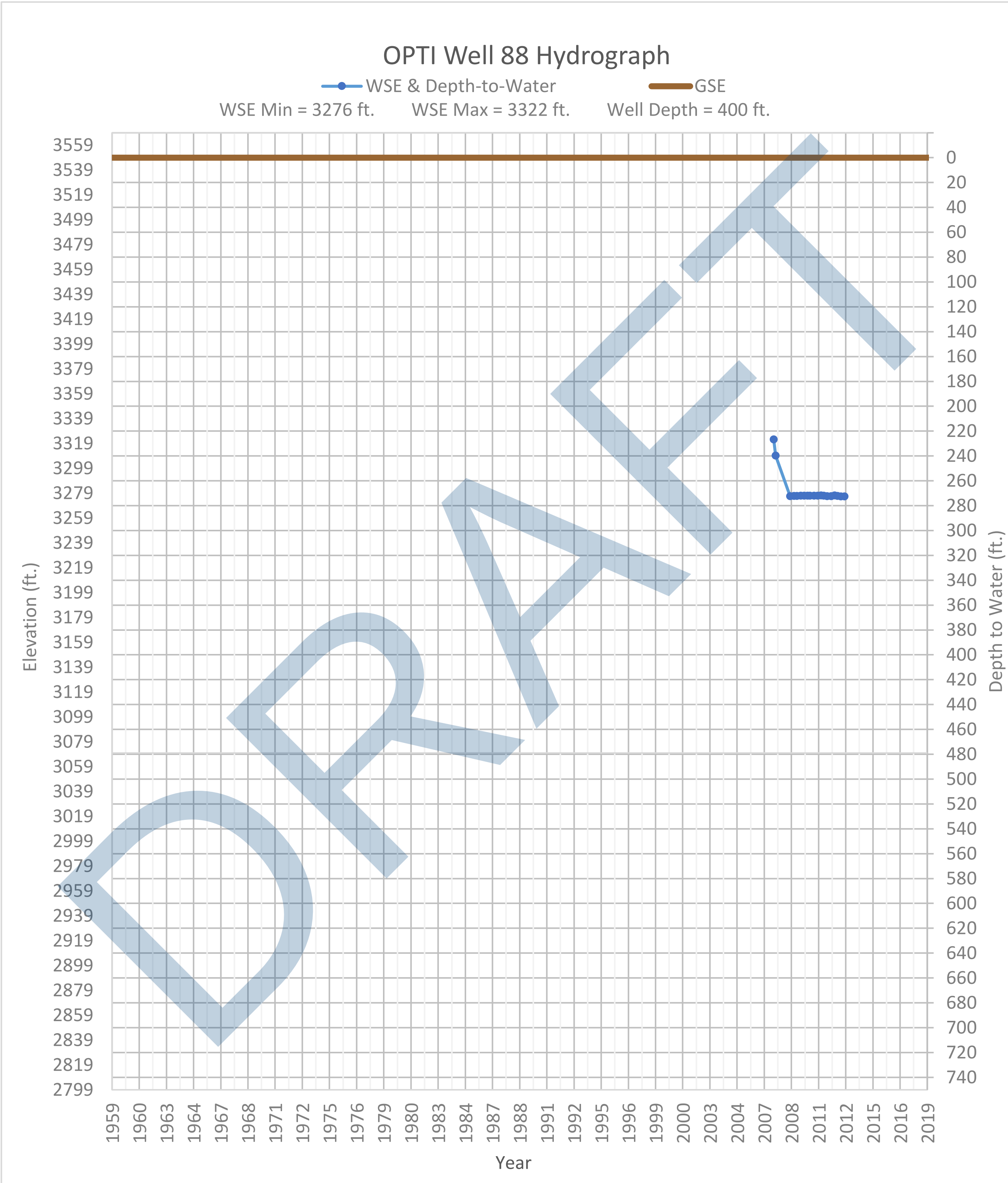
OPTI Well 85 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2831 ft.
WSE Max = 2931 ft.
Well Depth = 233 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



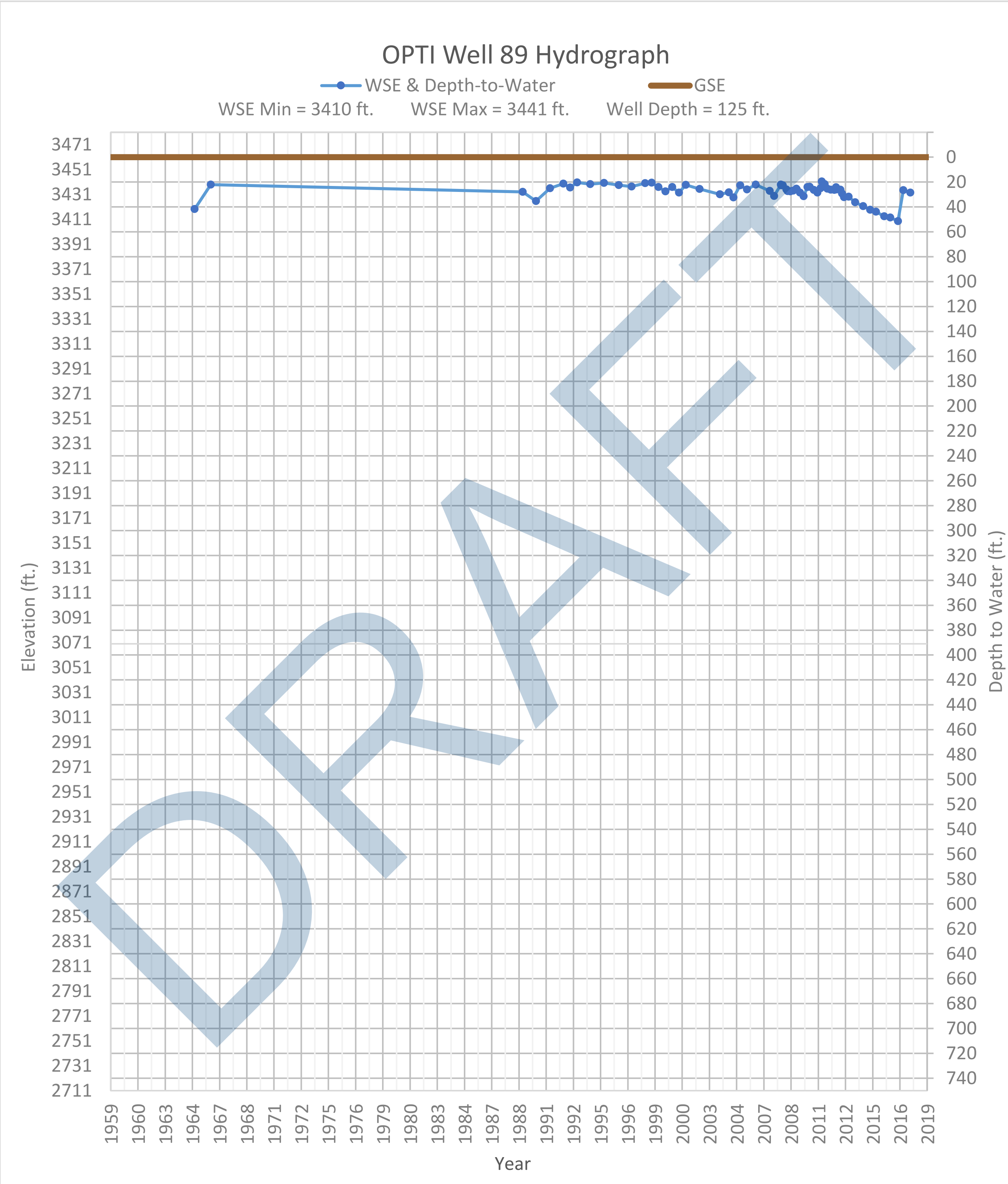
OPTI Well 86 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2980 ft.
WSE Max = 2988 ft.
Well Depth = 230 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



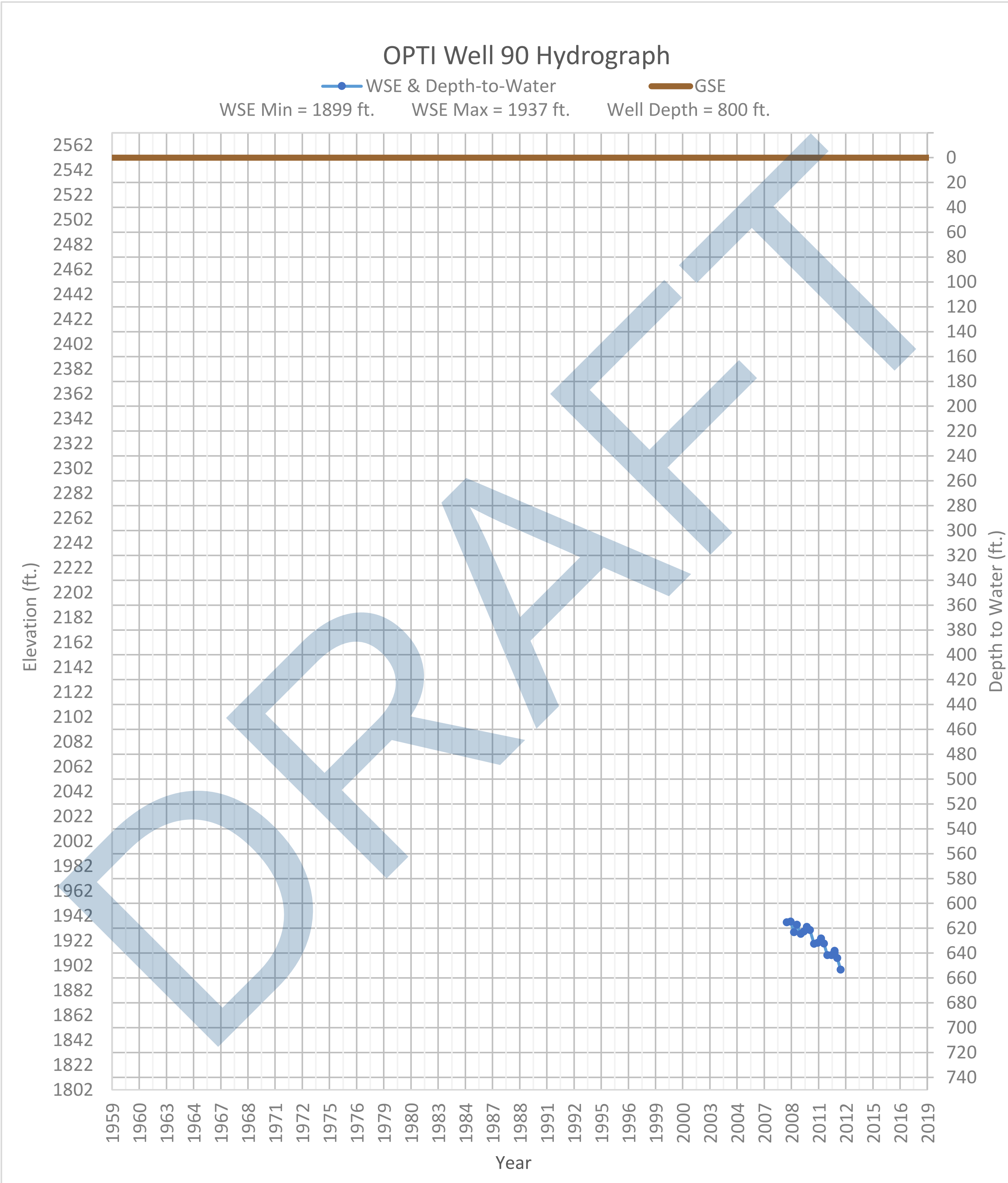
OPTI Well 87 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3358 ft.
WSE Max = 3378 ft.
Well Depth = 232 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
3556 3536 3516 3496 3476 3456 3436 3416 3396 3376 3356 3336 3316 3296 3276 3256 3236 3216 3196 3176 3156 3136 3116 3096 3076 3056 3036 3016 2996 2976 2956 2936 2916 2896 2876 2856 2836 2816 2796
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720 740
1959 1960 1963 1964 1967 1968 1971 1972 1975 1976 1979 1980 1983 1984 1987 1988 1991 1992 1995 1996 1999 2000 2003 2004 2007 2008 2011 2012 2015 2016 2019
DRAFT



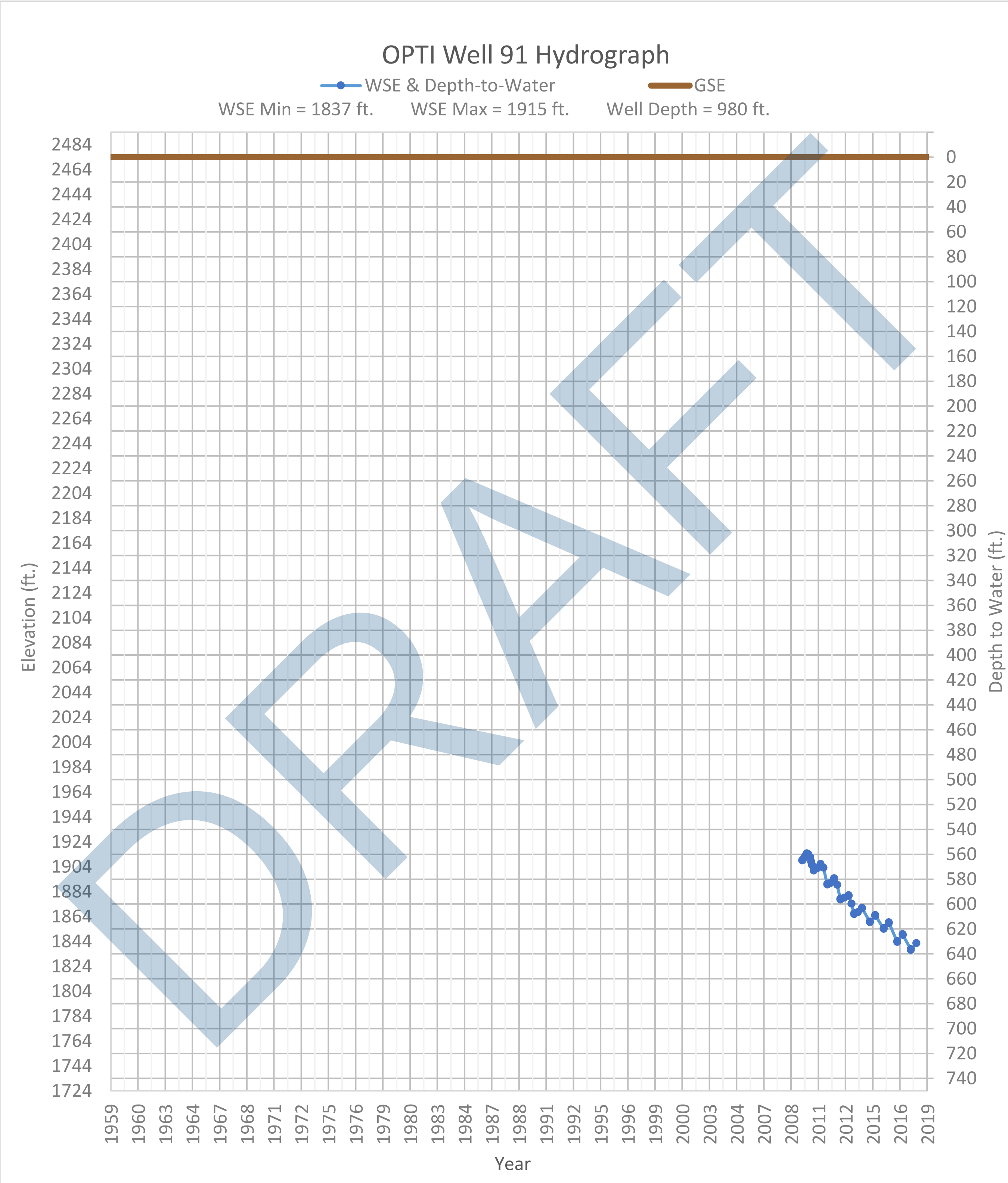
OPTI Well 88 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3276 ft.
WSE Max = 3322 ft.
Well Depth = 400 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



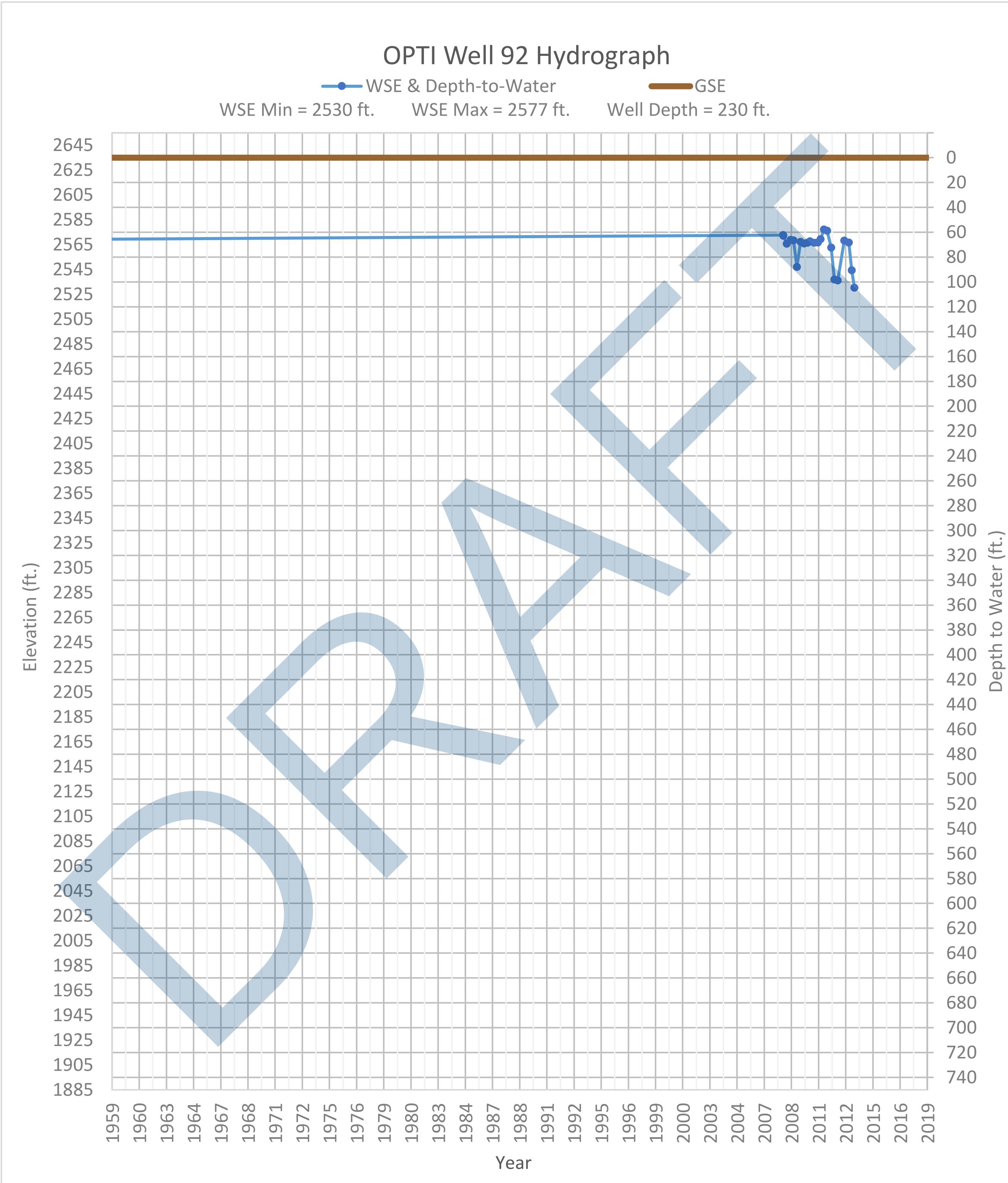
OPTI Well 89 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3410 ft.
WSE Max = 3441 ft.
Well Depth = 125 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



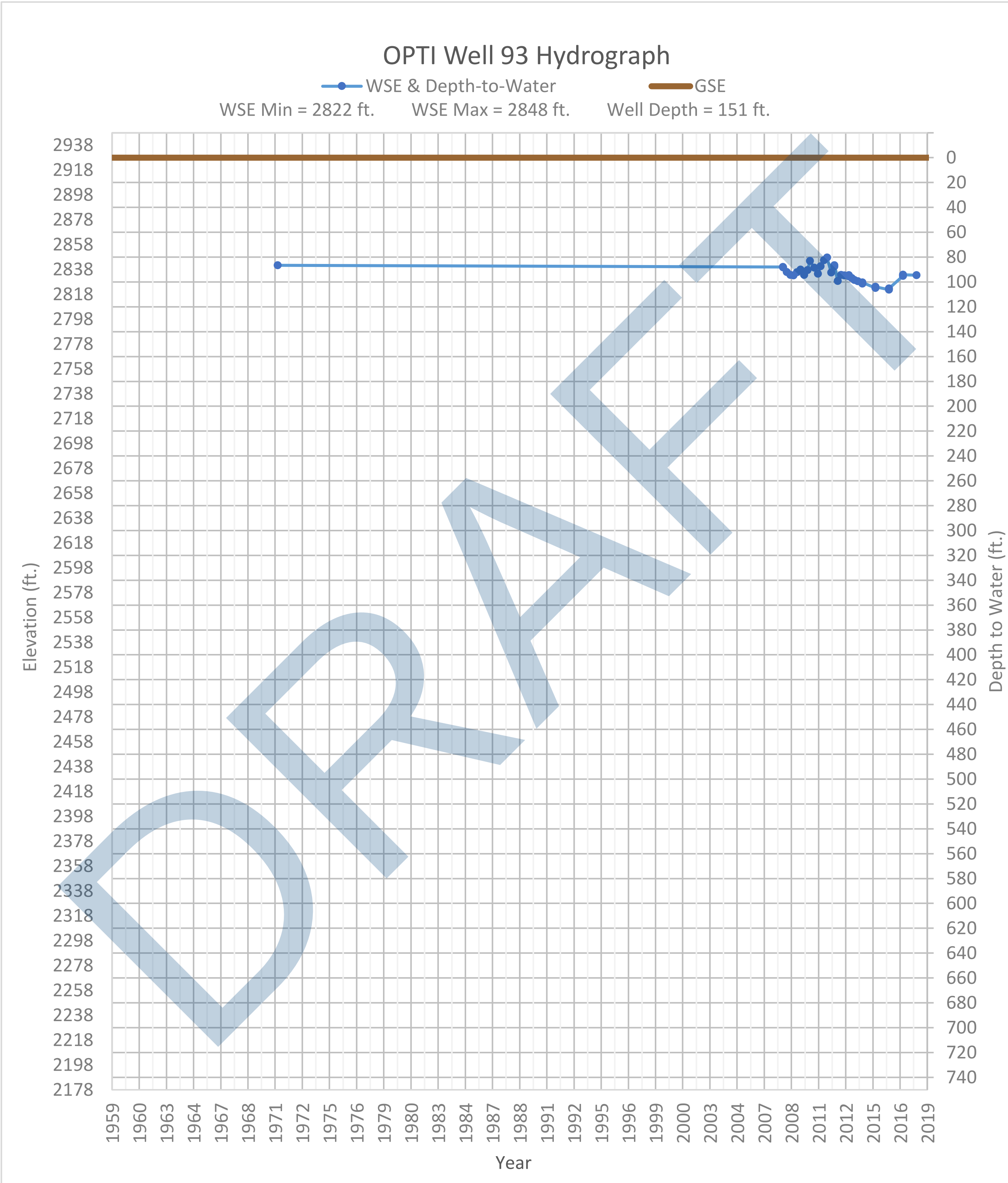
OPTI Well 90 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1899 ft.
WSE Max = 1937 ft.
Well Depth = 800 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



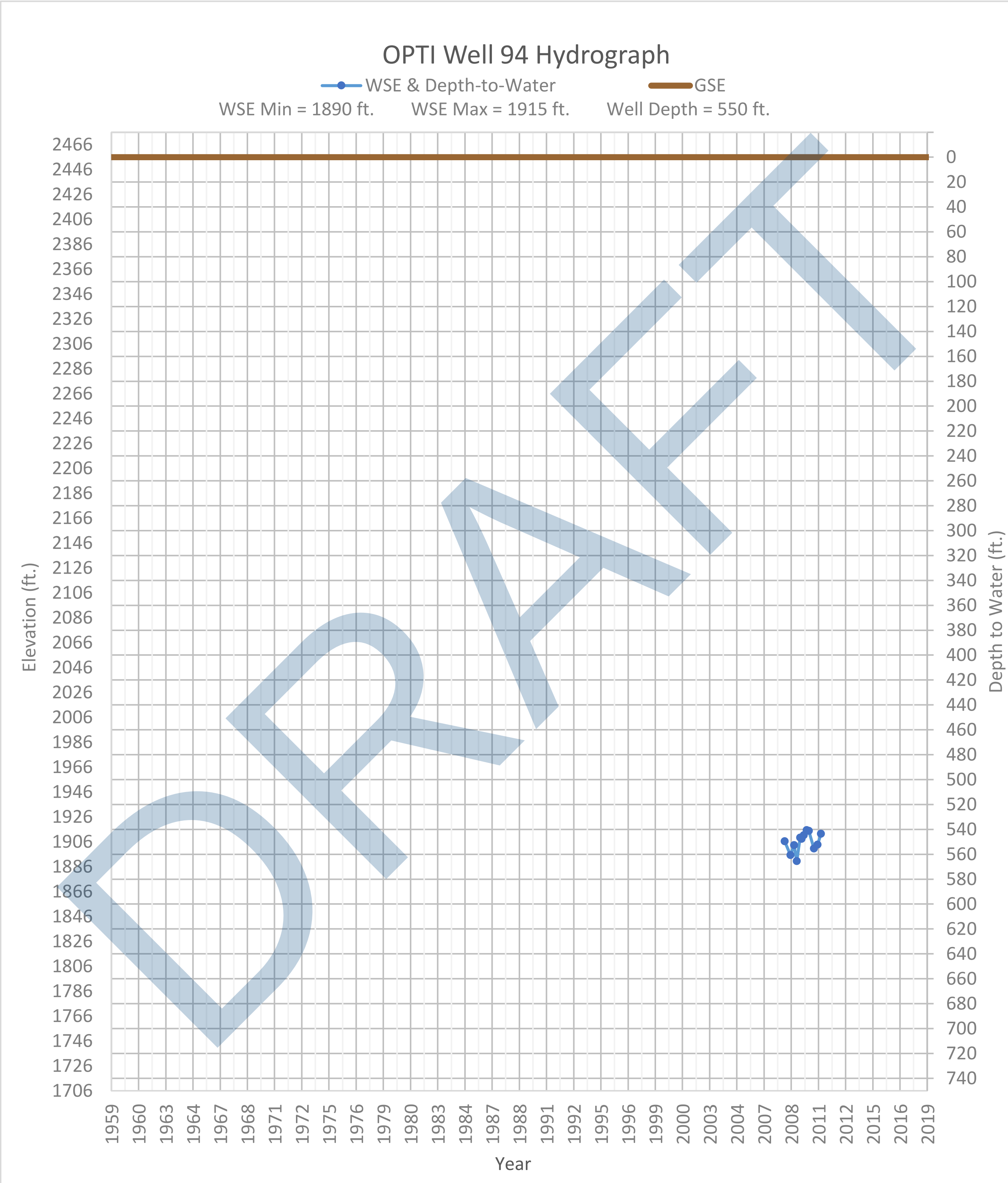
OPTI Well 91 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1837 ft.
WSE Max = 1915 ft.
Well Depth = 980 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



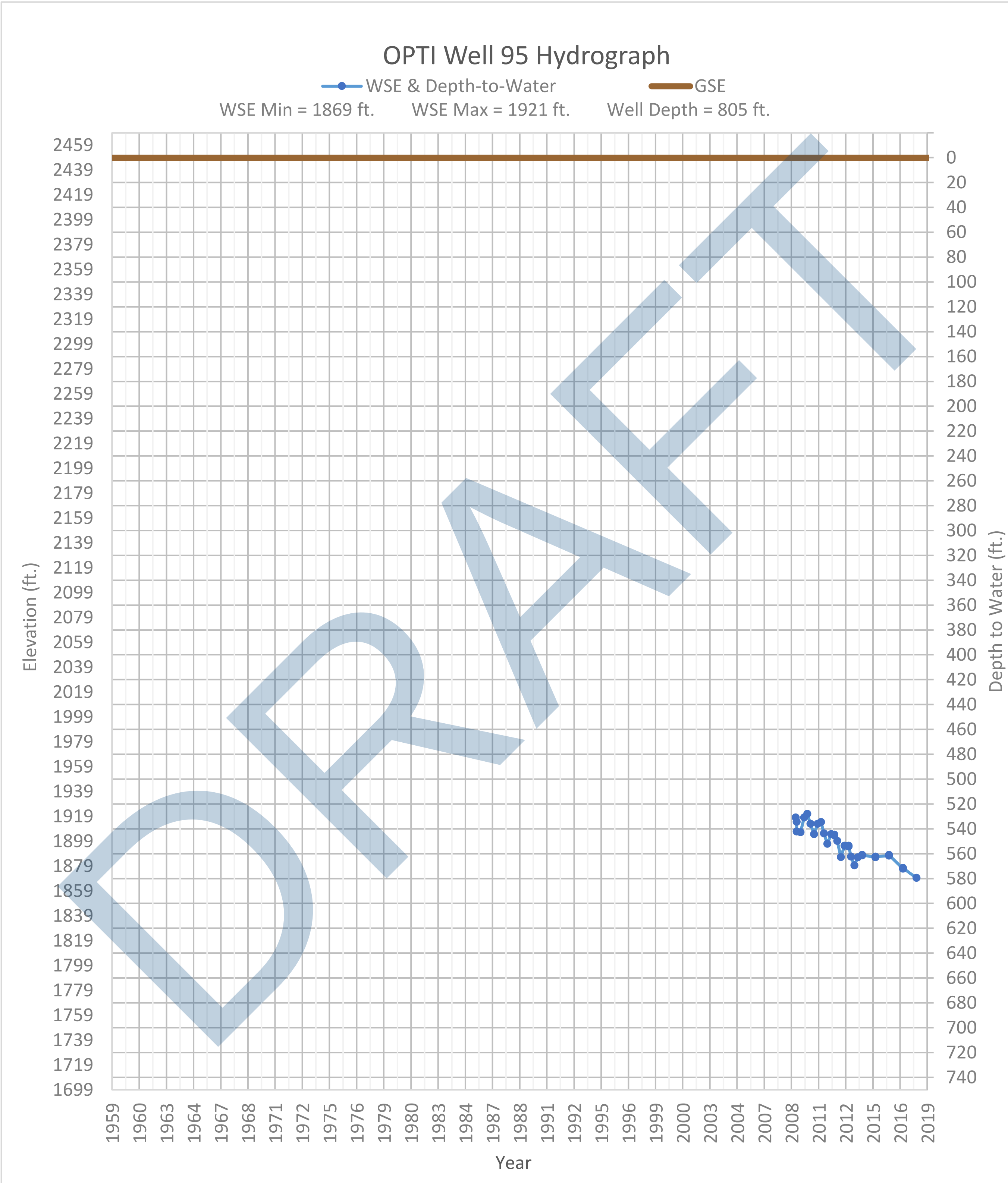
OPTI Well 92 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2530 ft.
WSE Max = 2577 ft.
Well Depth = 230 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



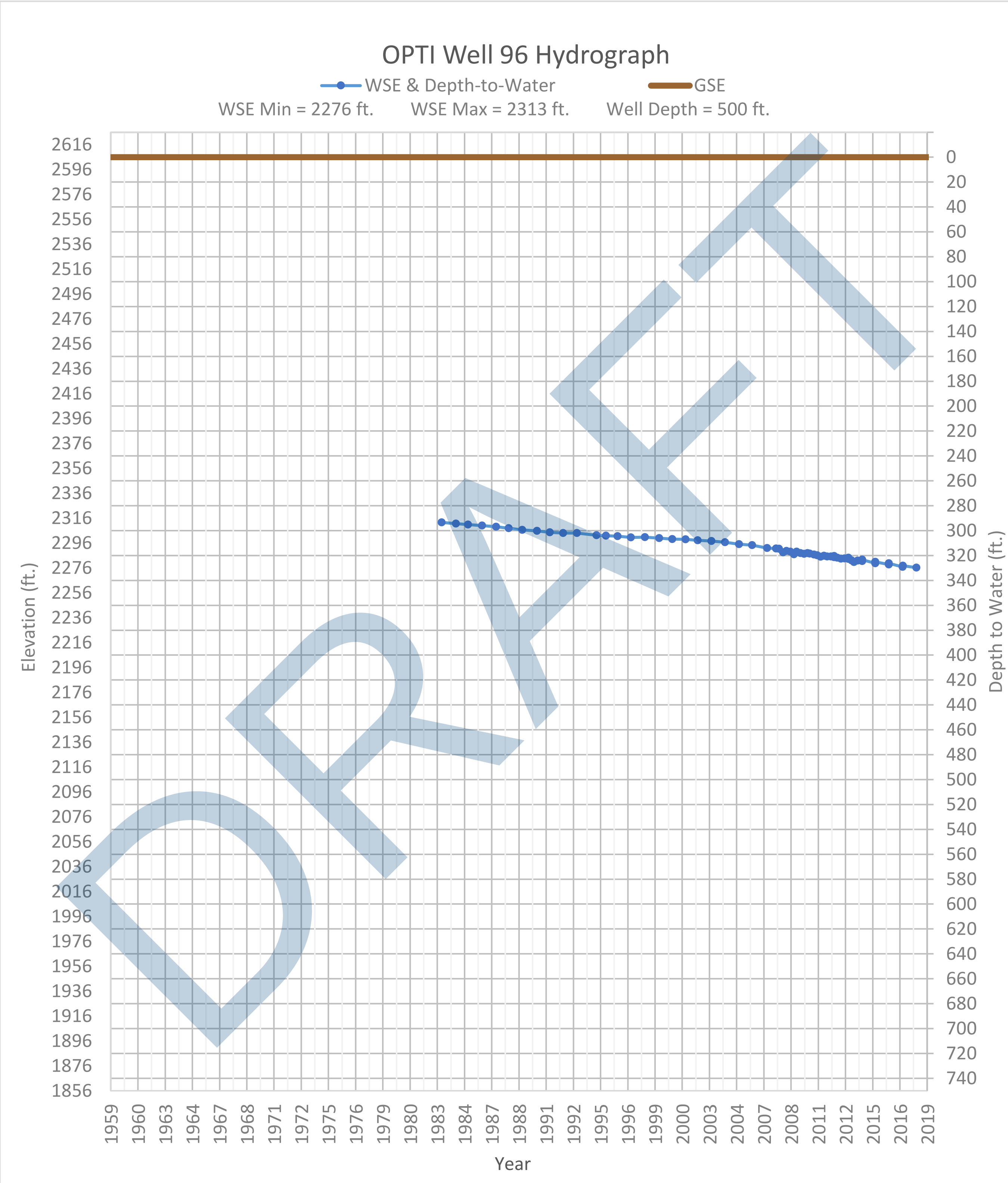
OPTI Well 93 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2822 ft.
WSE Max = 2848 ft.
Well Depth = 151 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 94 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1890 ft.
WSE Max = 1915 ft.
Well Depth = 550 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 95 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1869 ft.
WSE Max = 1921 ft.
Well Depth = 805 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 96 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2276 ft.
WSE Max = 2313 ft.
Well Depth = 500 ft.
Elevation (ft.)
2616
2596
2576
2556
2536
2516
2496
2476
2456
2436
2416
2396
2376
2356
2336
2316
2296
2276
2256
2236
2216
2196
2176
2156
2136
2116
2096
2076
2056
2036
2016
1996
1976
1956
1936
1916
1896
1876
1856
Depth to Water (ft.)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
680
700
720
740
Year
1959
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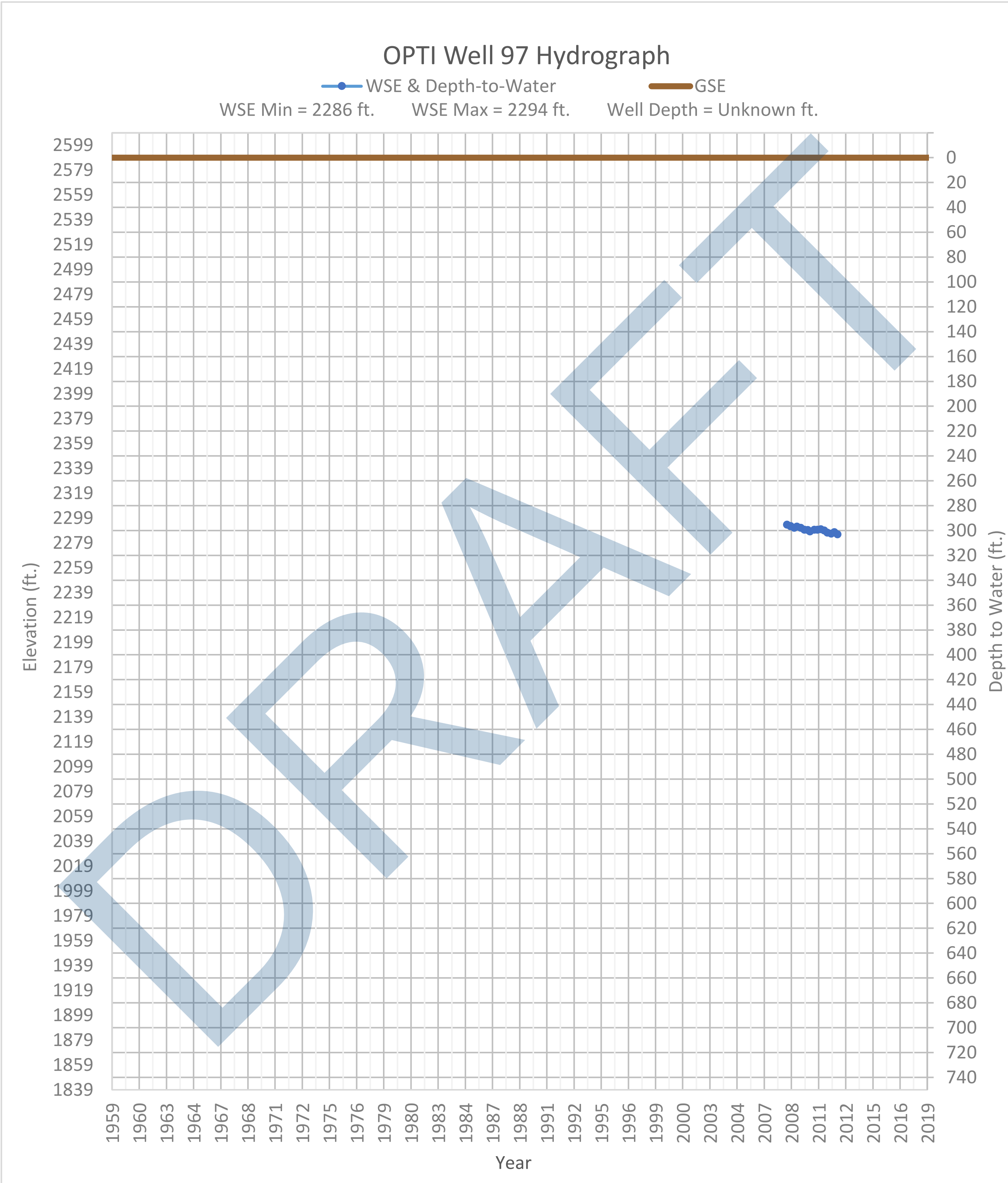
2015
2016
2019
DRAFT



OPTI Well 97 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2286 ft.
WSE Max = 2294 ft.
Well Depth = Unknown ft.
Elevation (ft.)
2599
2579
2559
2539
2519
2499
2479
2459
2439
2419
2399
2379
2359
2339
2319
2299
2279
2259
2239
2219
2199
2179
2159
2139
2119
2099
2079
2059
2039
2019
1999
1979
1959
1939
1919
1899
1879
1859
1839
Depth to Water (ft.)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
680
700
720
740
Year
1959
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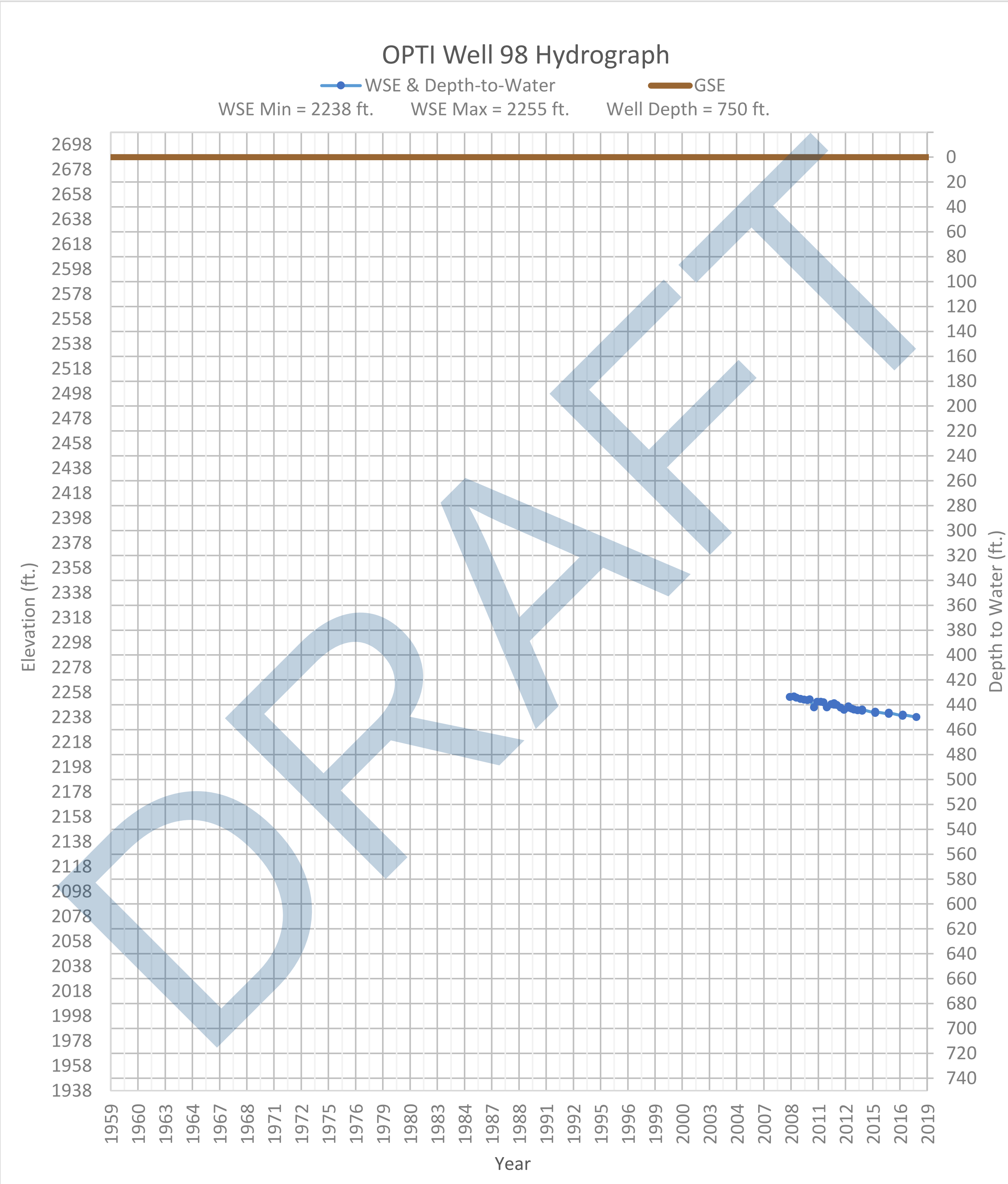
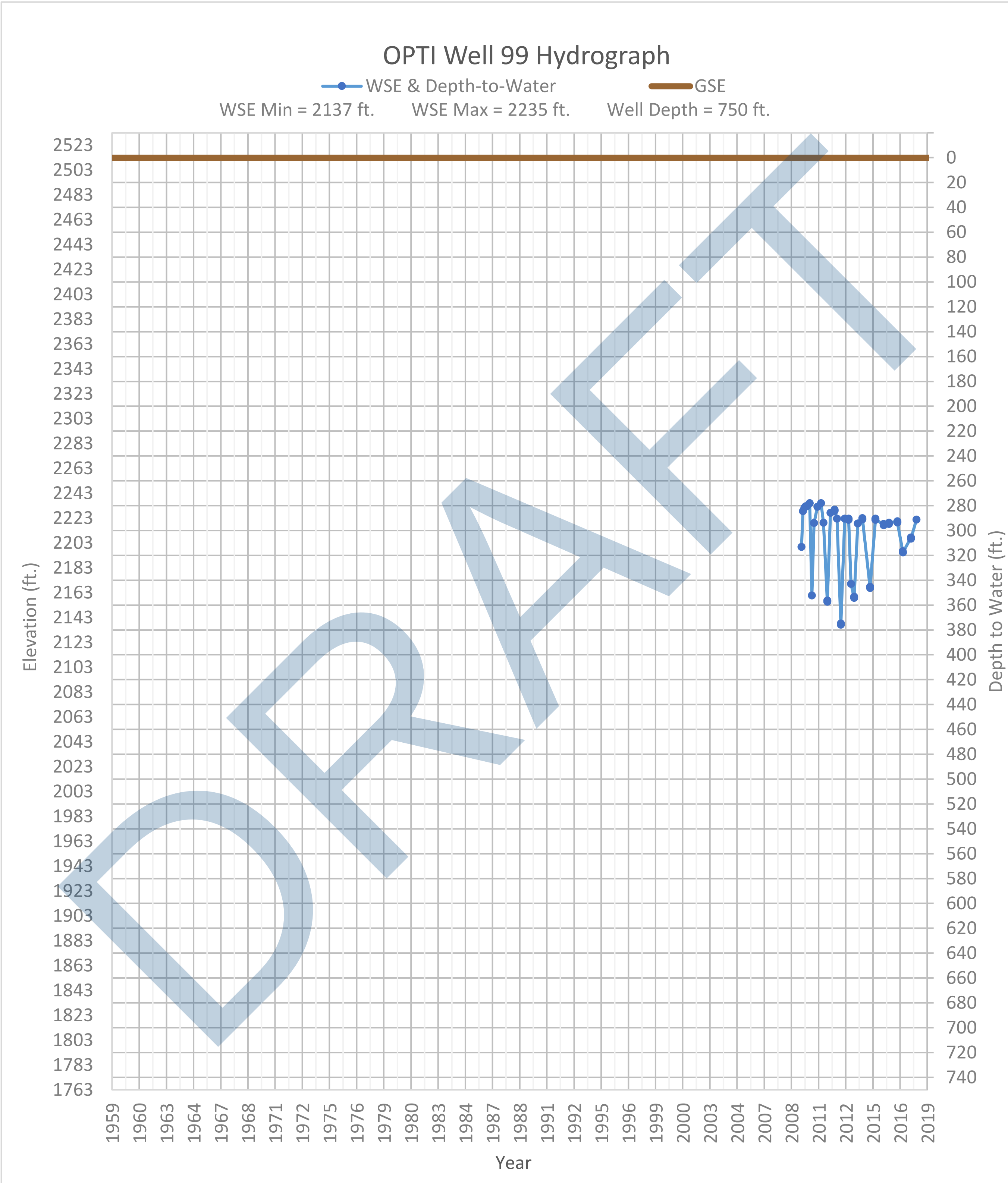
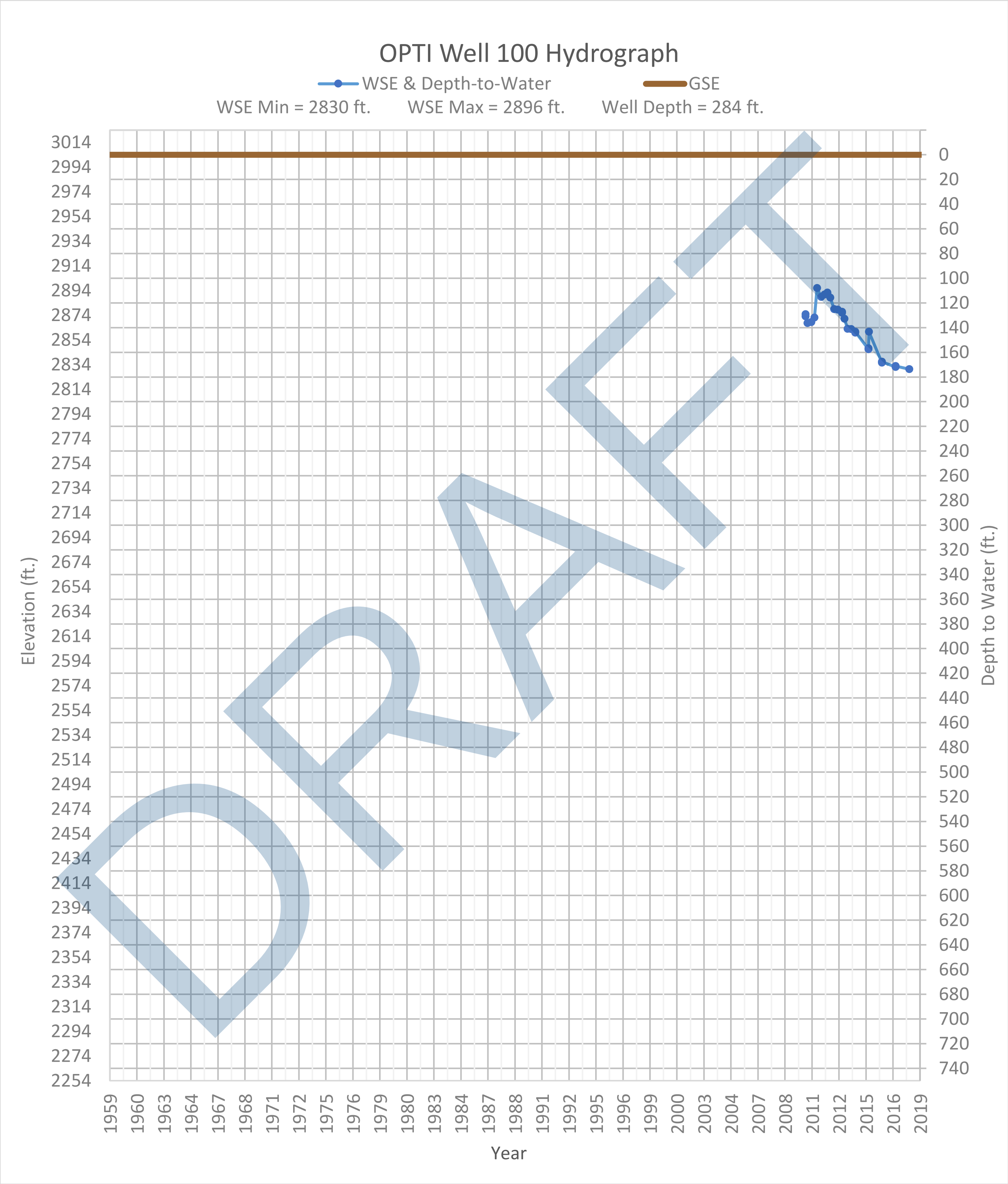
DRAFT



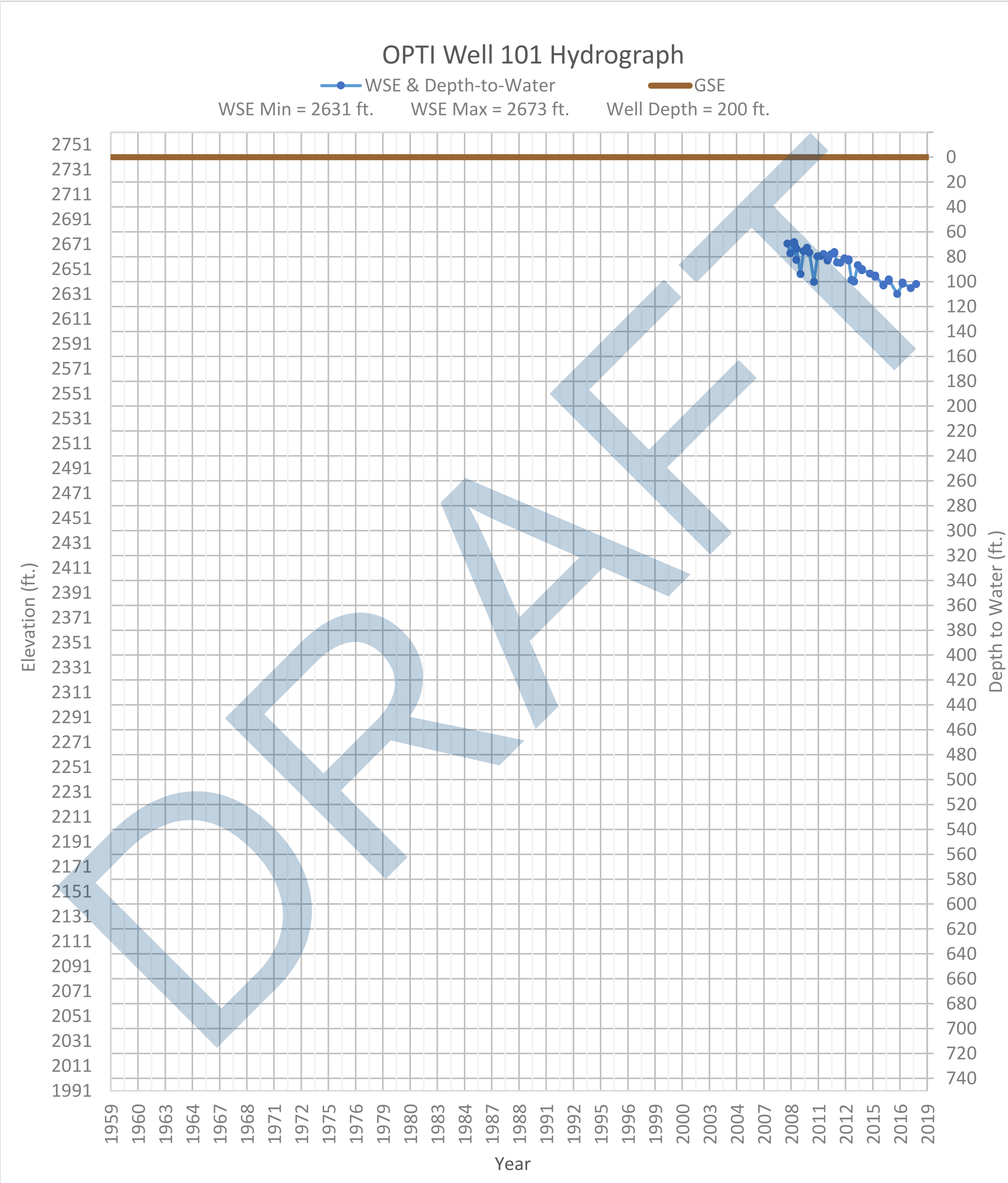
OPTI Well 98 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2238 ft.
WSE Max = 2255 ft.
Well Depth = 750 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 99 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2137 ft.
WSE Max = 2235 ft.
Well Depth = 750 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

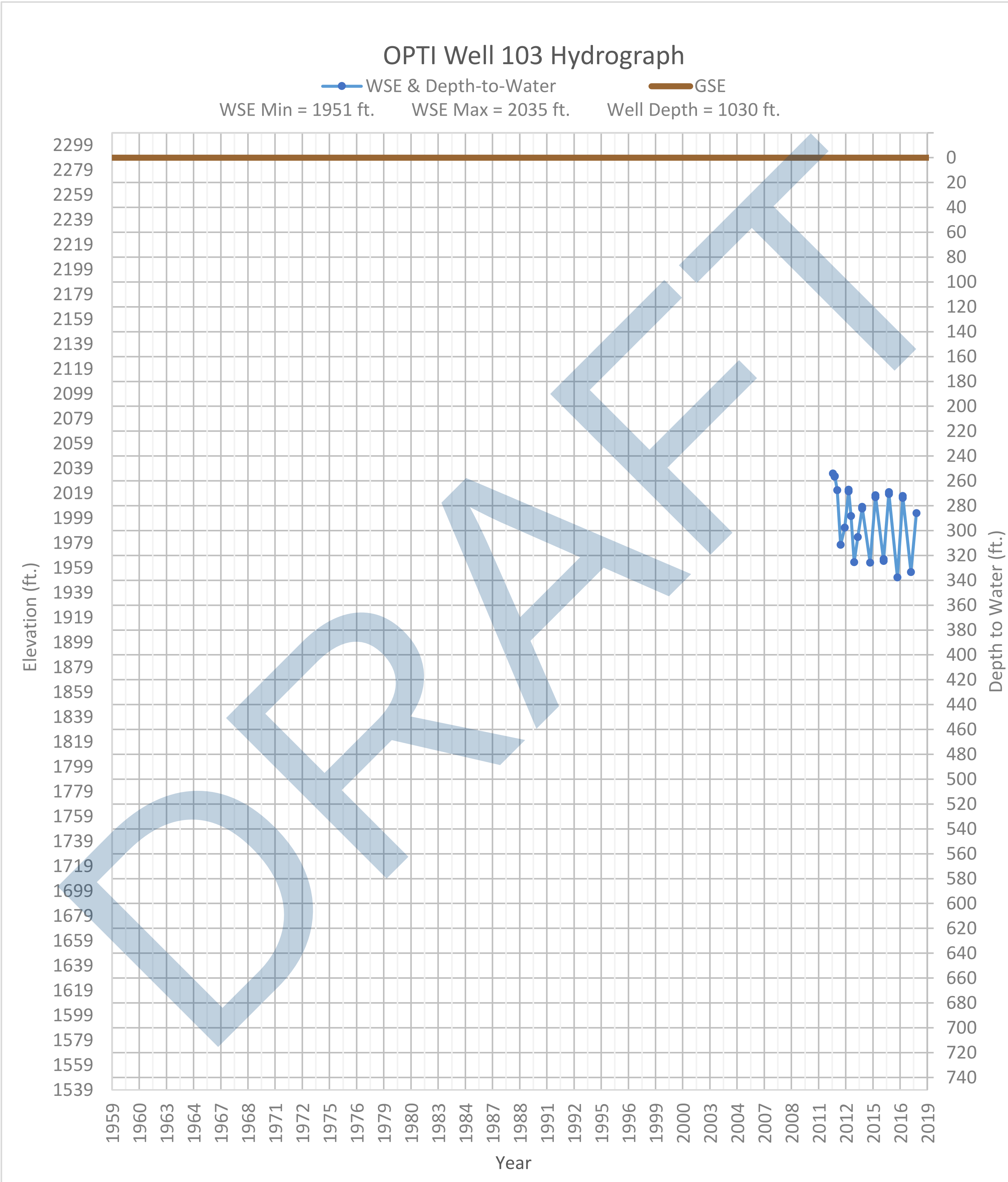


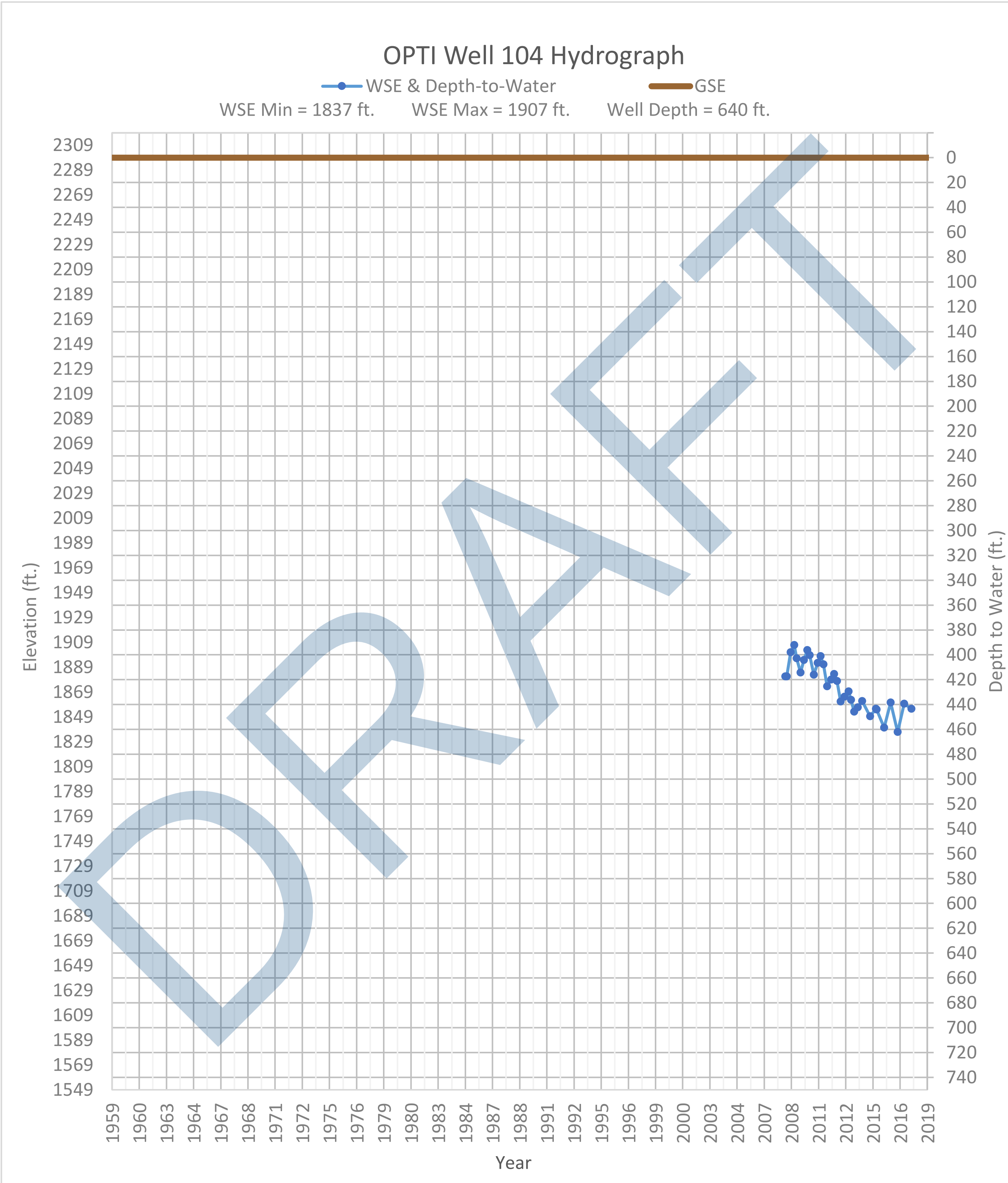
OPTI Well 100 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2830 ft.
WSE Max = 2896 ft.
Well Depth = 284 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

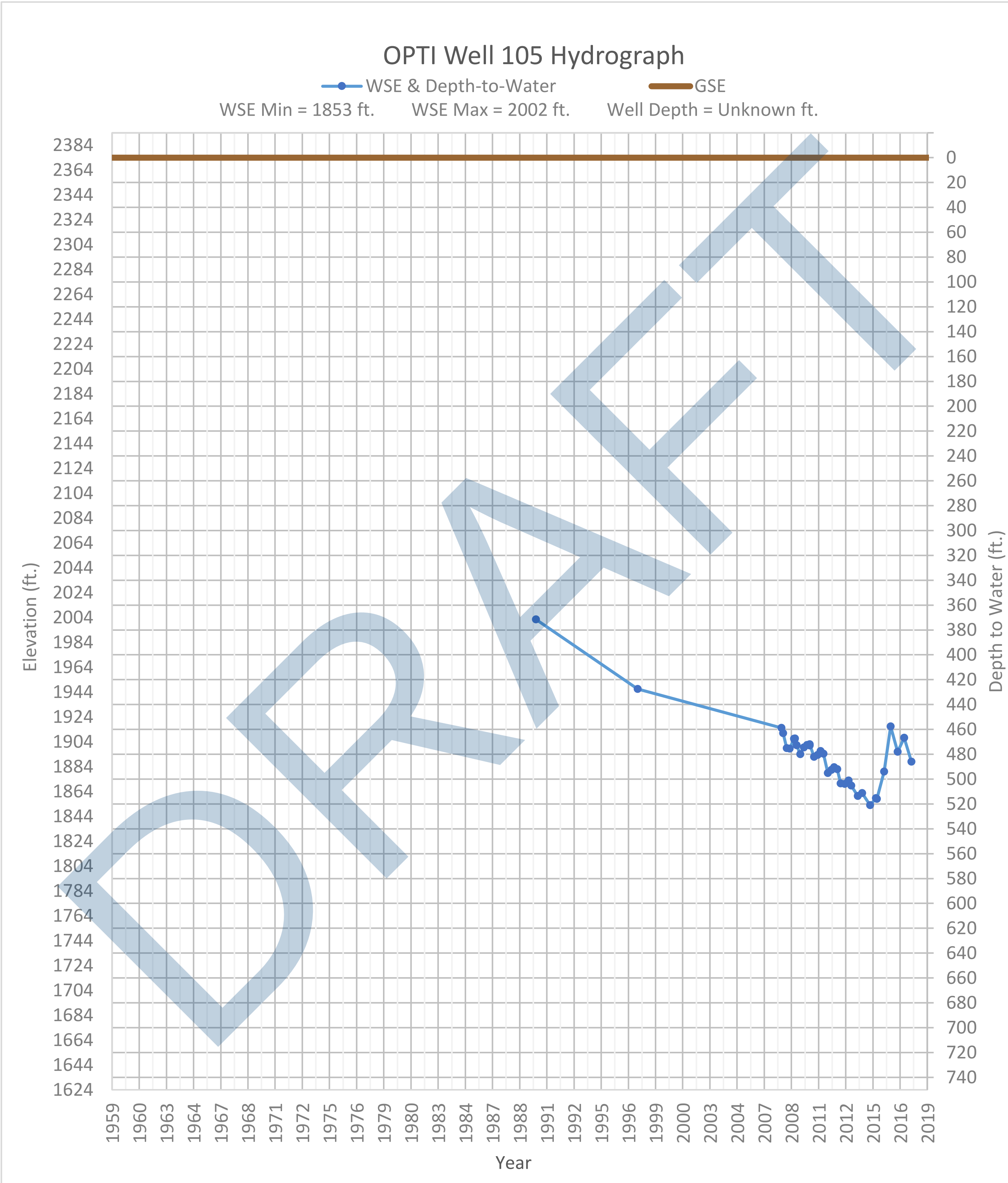


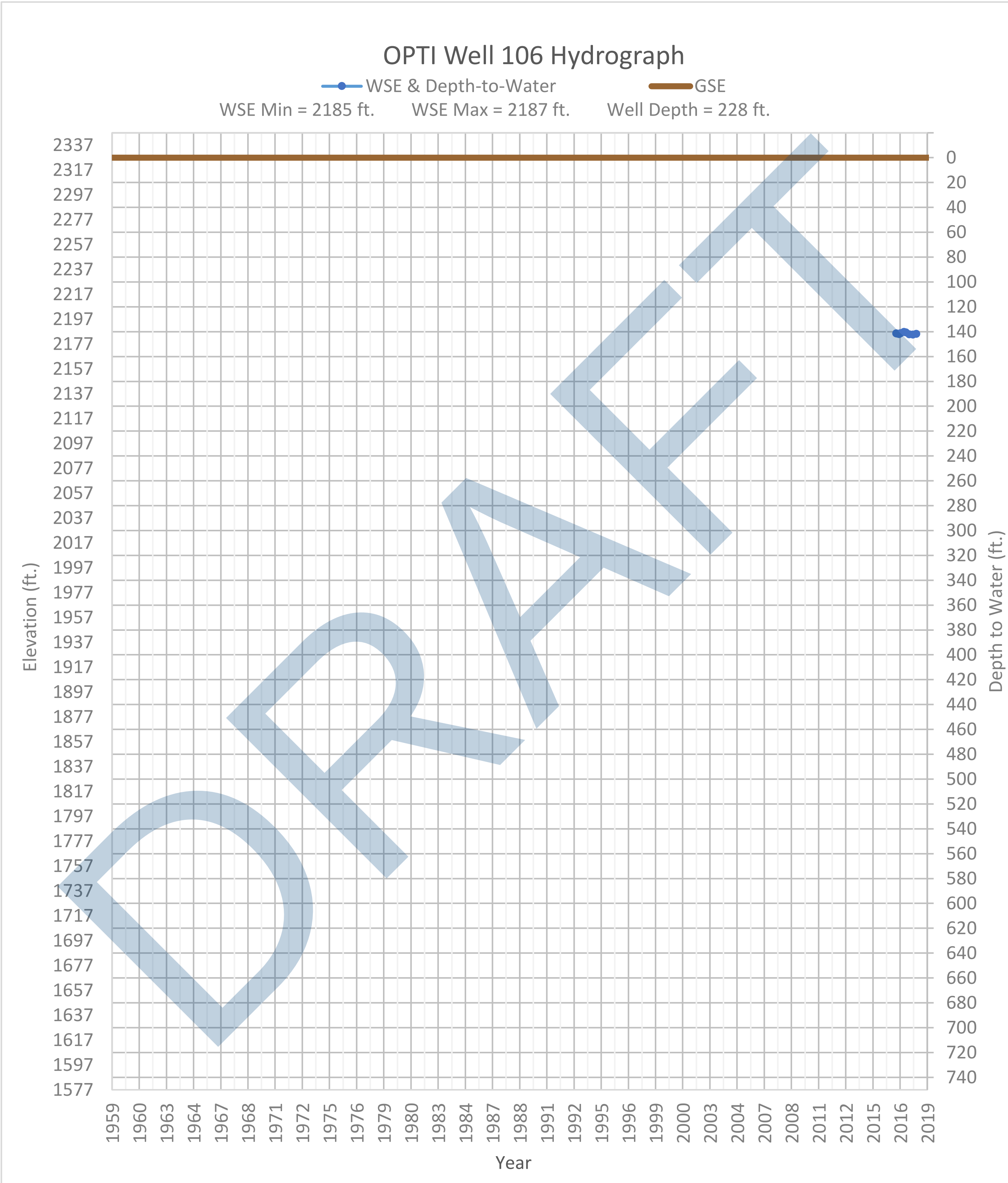
OPTI Well 101 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2631 ft.
WSE Max = 2673 ft.
Well Depth = 200 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

OPTI Well 102 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1802 ft.
WSE Max = 1861 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 103 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1951 ft.
WSE Max = 2035 ft.
Well Depth = 1030 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 104 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1837 ft.
WSE Max = 1907 ft.
Well Depth = 640 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 105 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1853 ft.
WSE Max = 2002 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 106 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2185 ft.
WSE Max = 2187 ft.
Well Depth = 228 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2337
2317
2297
2277
2257
2237
2217
2197
2177
2157
2137
2117
2097
2077
2057
2037
2017
1997
1977
1957
1937
1917
1897
1877
1857
1837
1817
1797
1777
1757
1737
1717
1697
1677
1657
1637
1617
1597
1577
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
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640
660
680
700
720
740
1959
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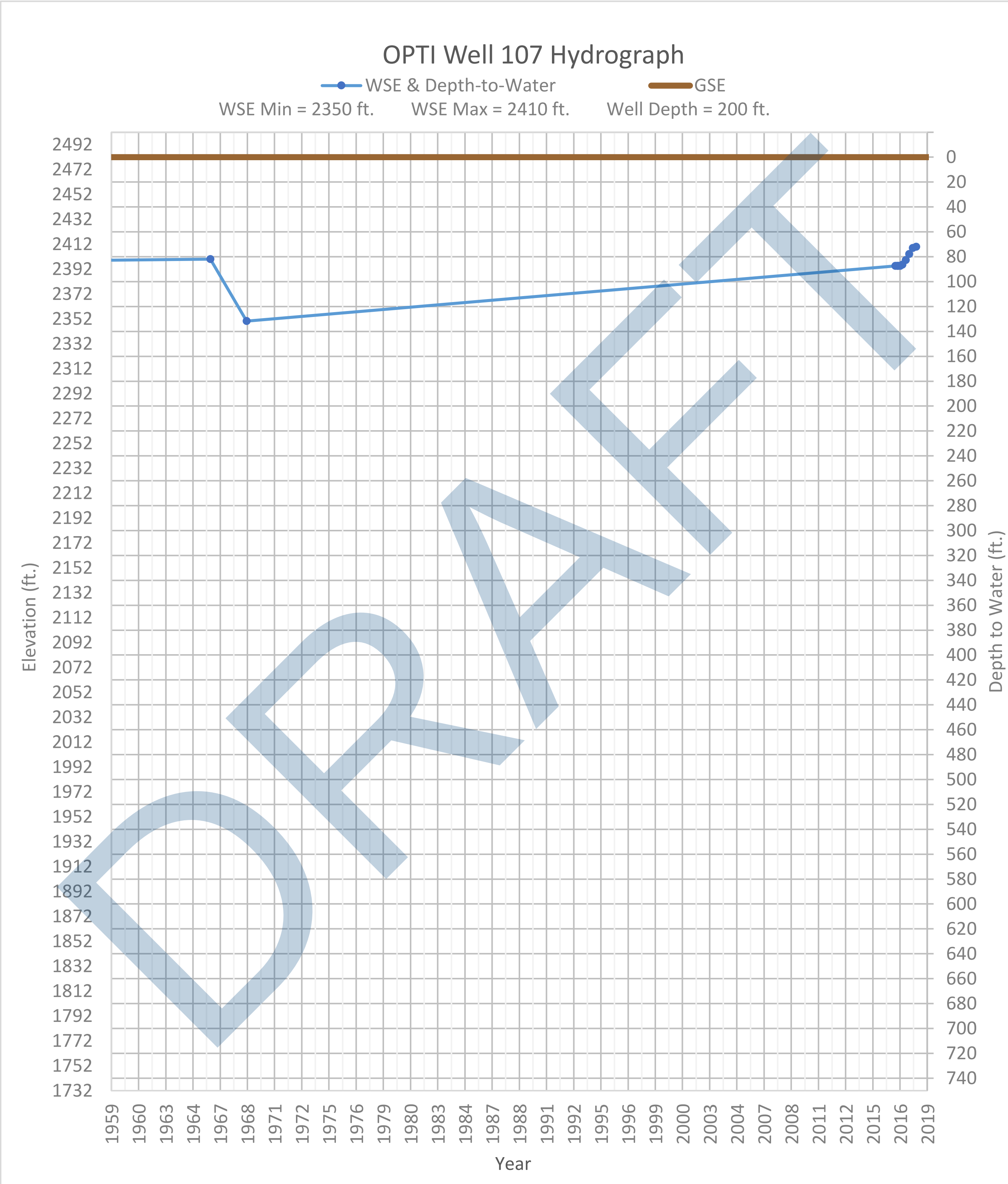
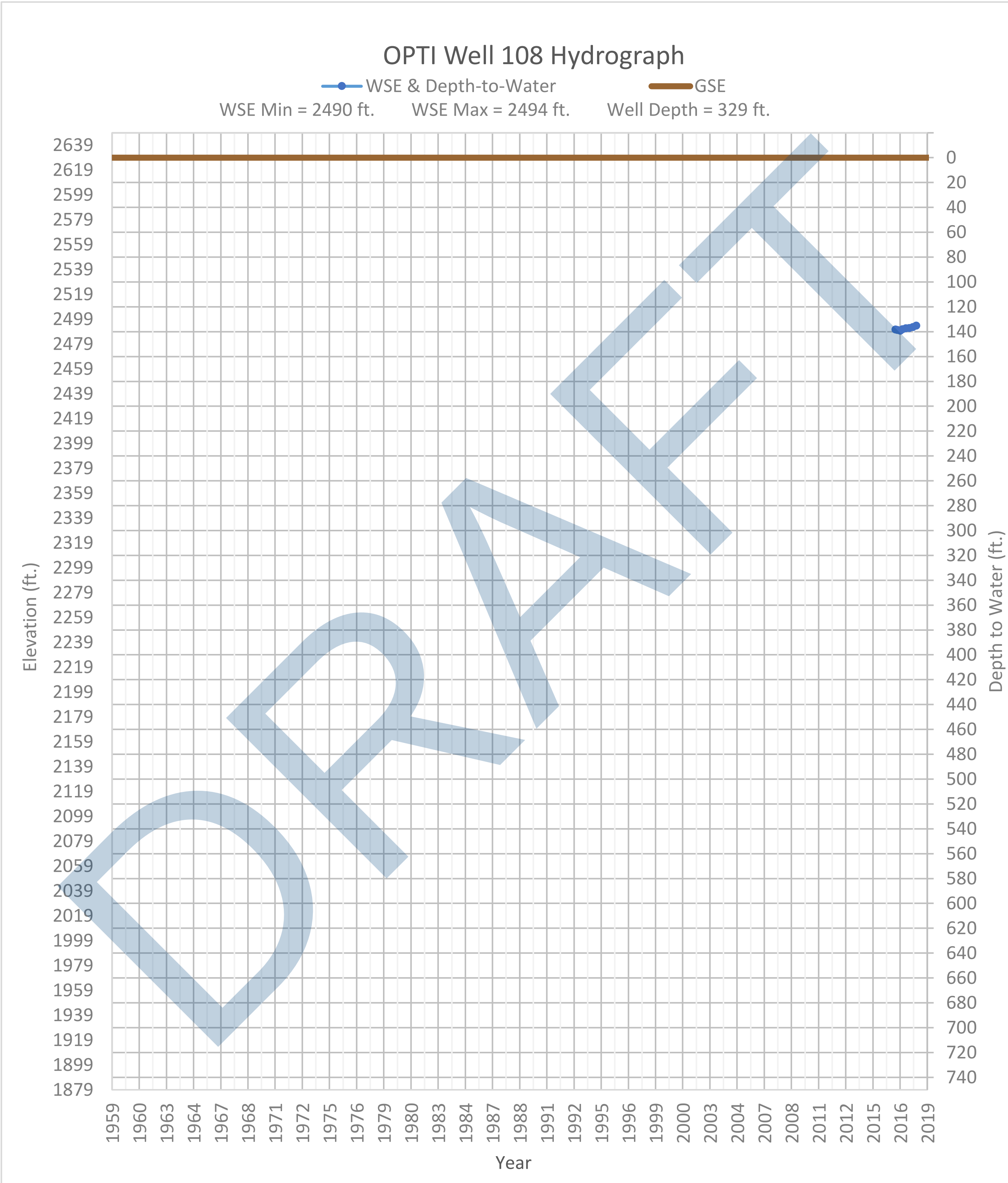
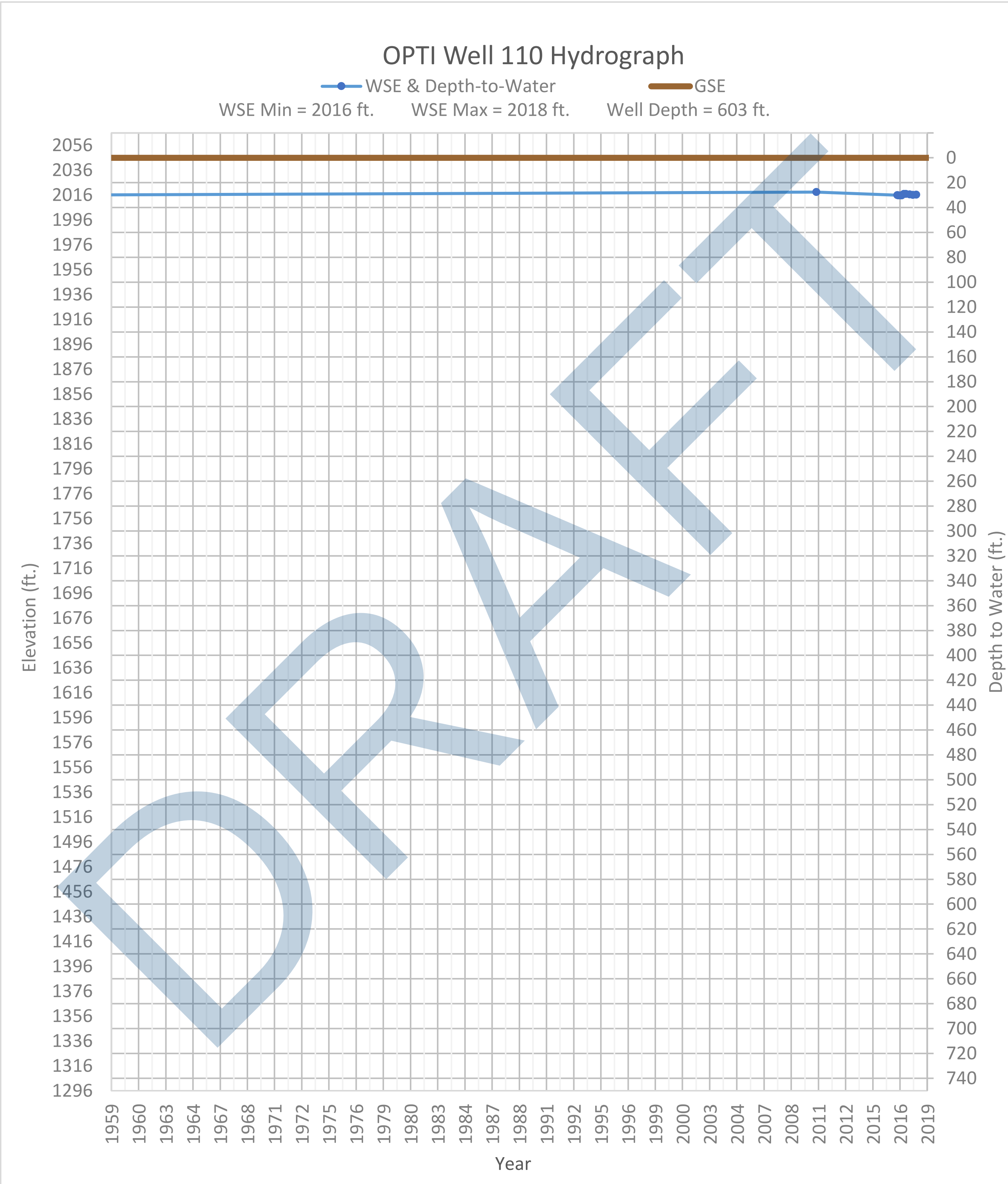
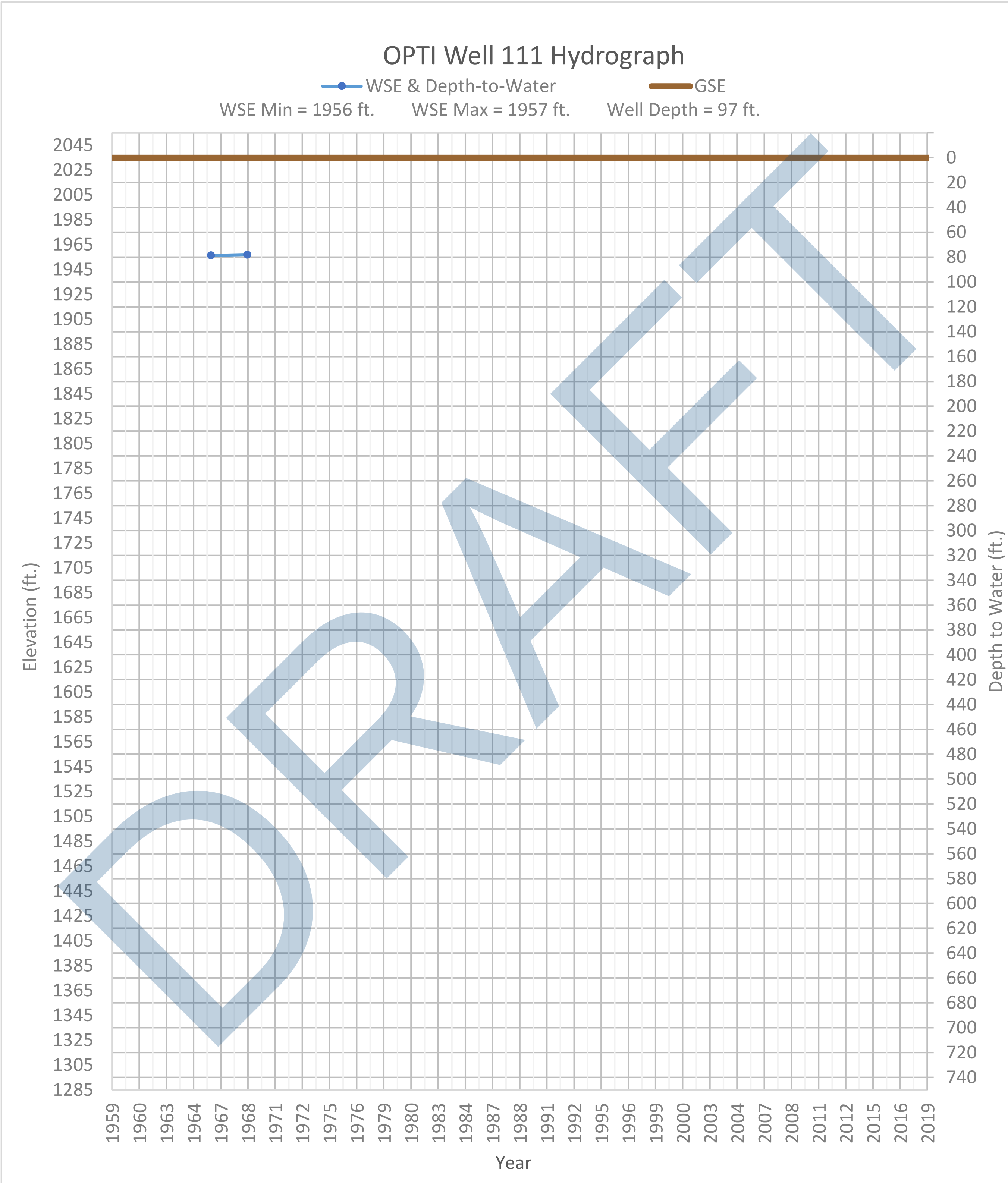


OPTI Well 107 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2350 ft.
WSE Max = 2410 ft.
Well Depth = 200 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

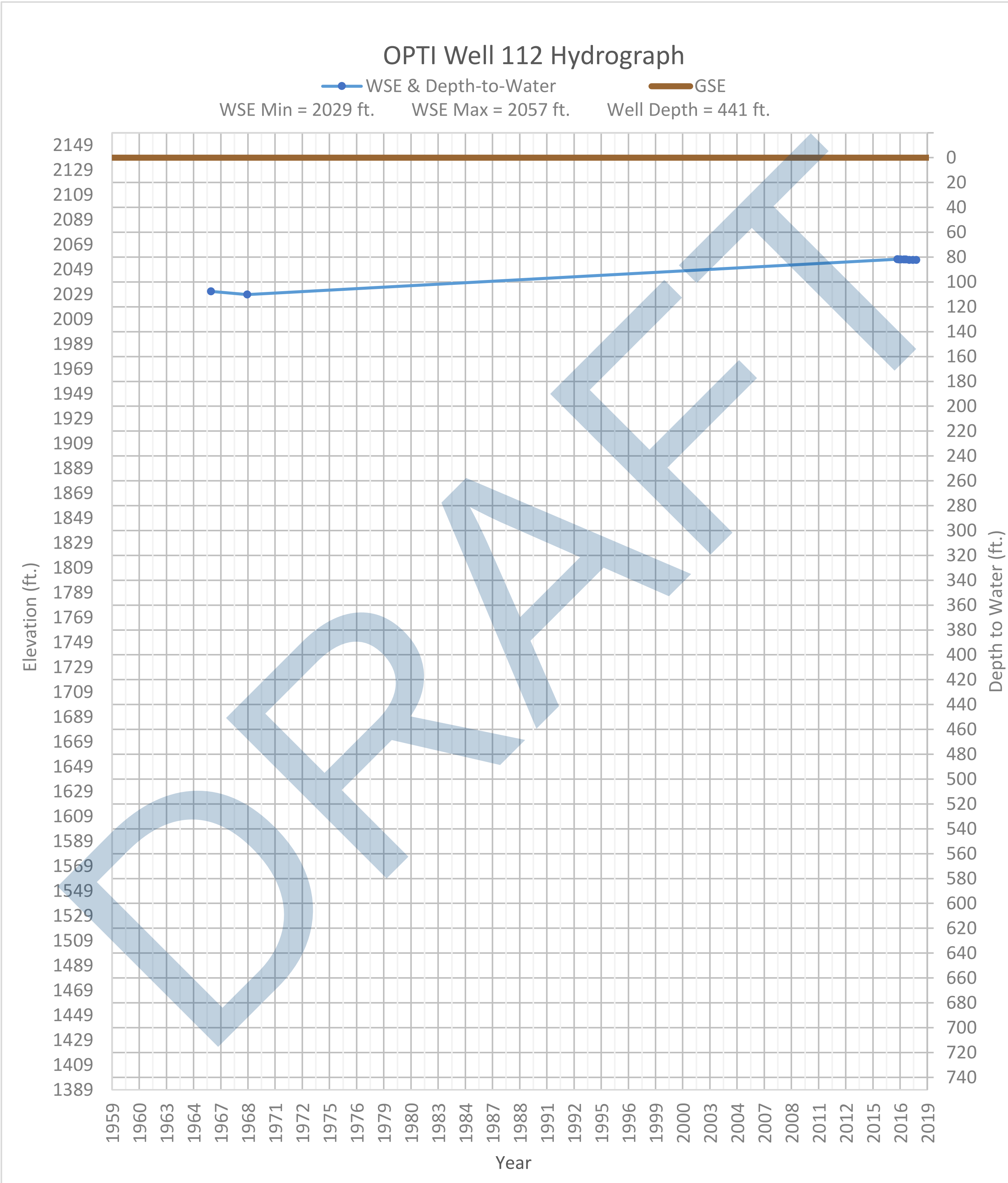

OPTI Well 108 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2490 ft.
WSE Max = 2494 ft.
Well Depth = 329 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

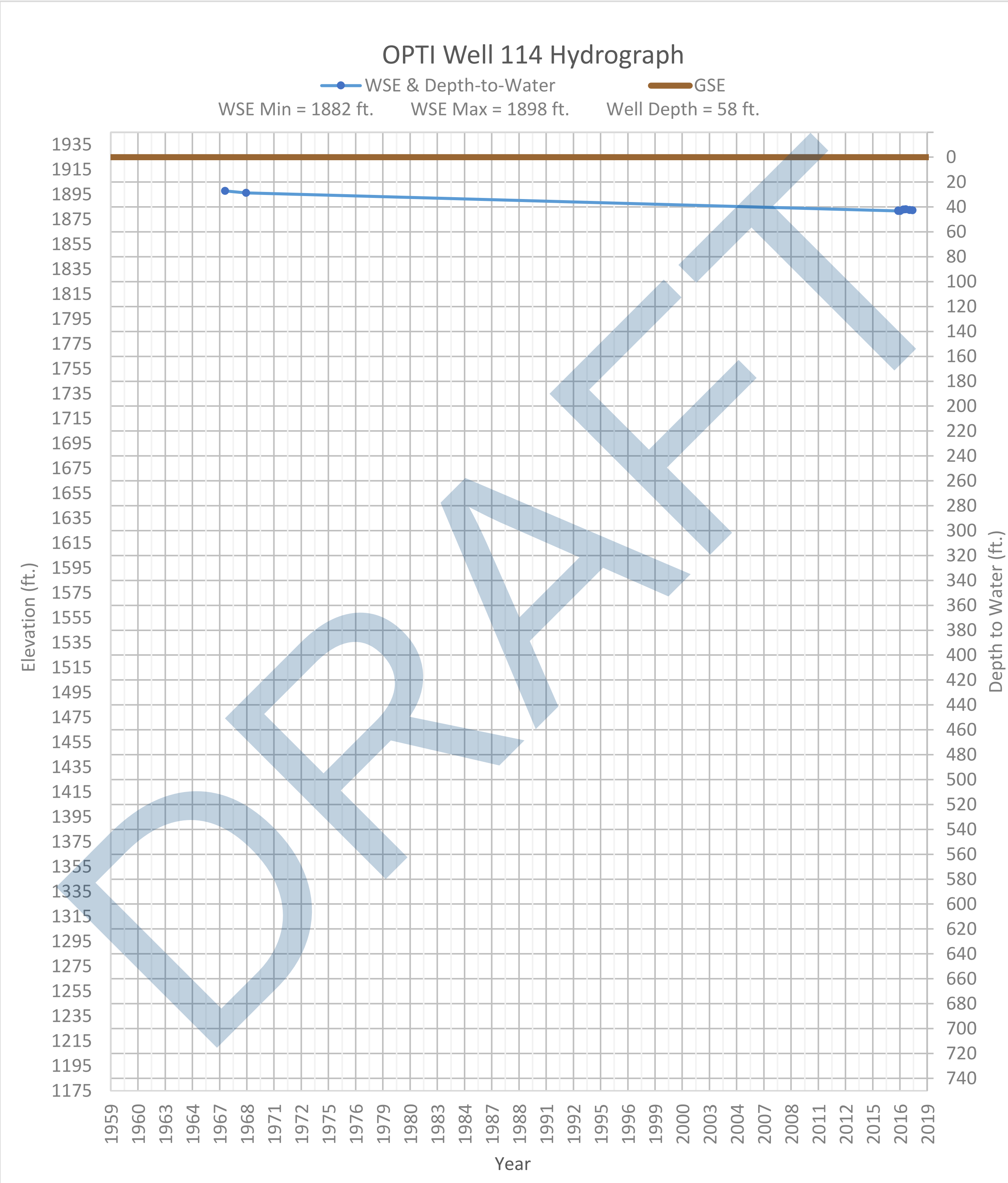


OPTI Well 110 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2016 ft.
WSE Max = 2018 ft.
Well Depth = 603 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

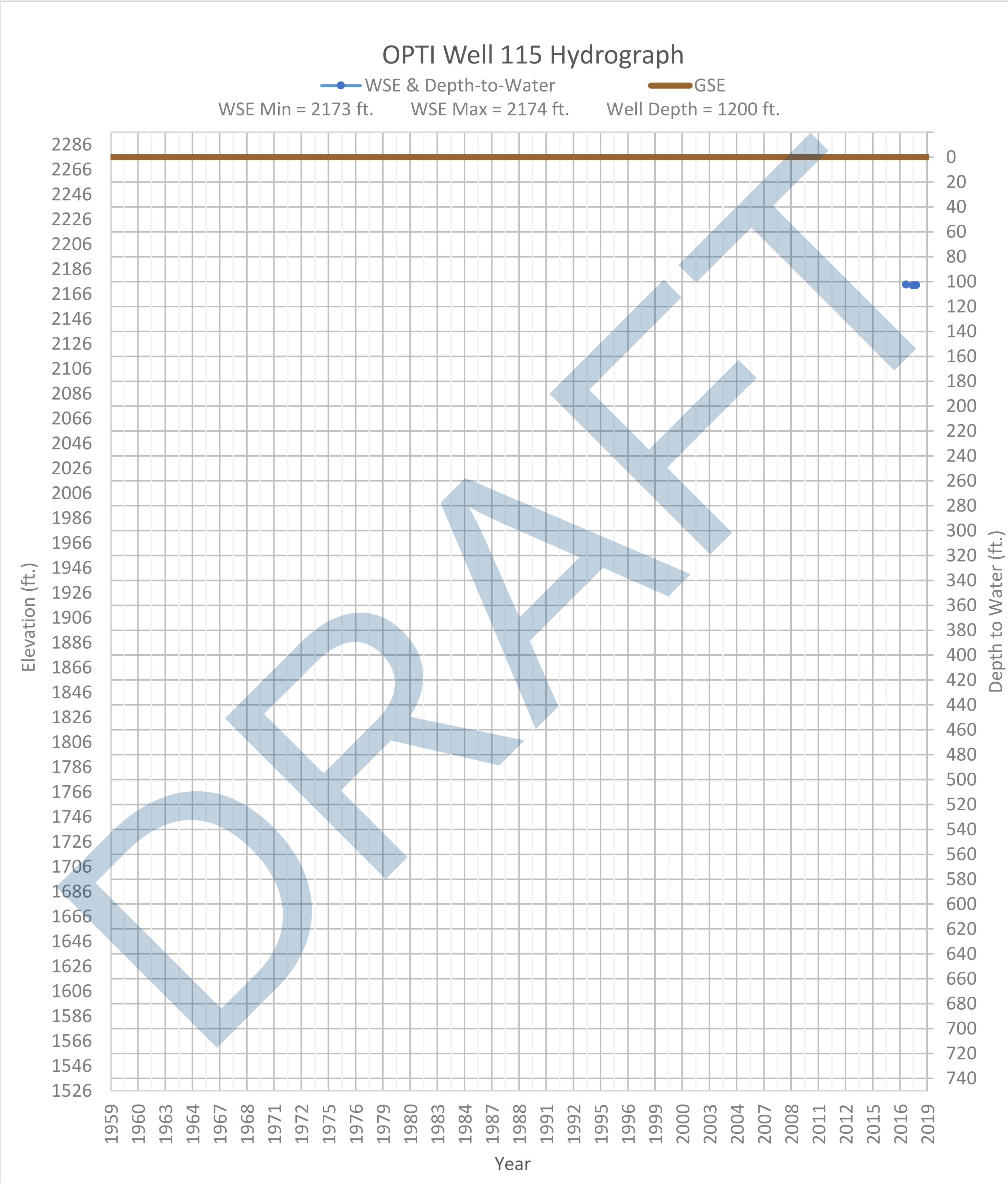


OPTI Well 111 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1956 ft.
WSE Max = 1957 ft.
Well Depth = 97 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

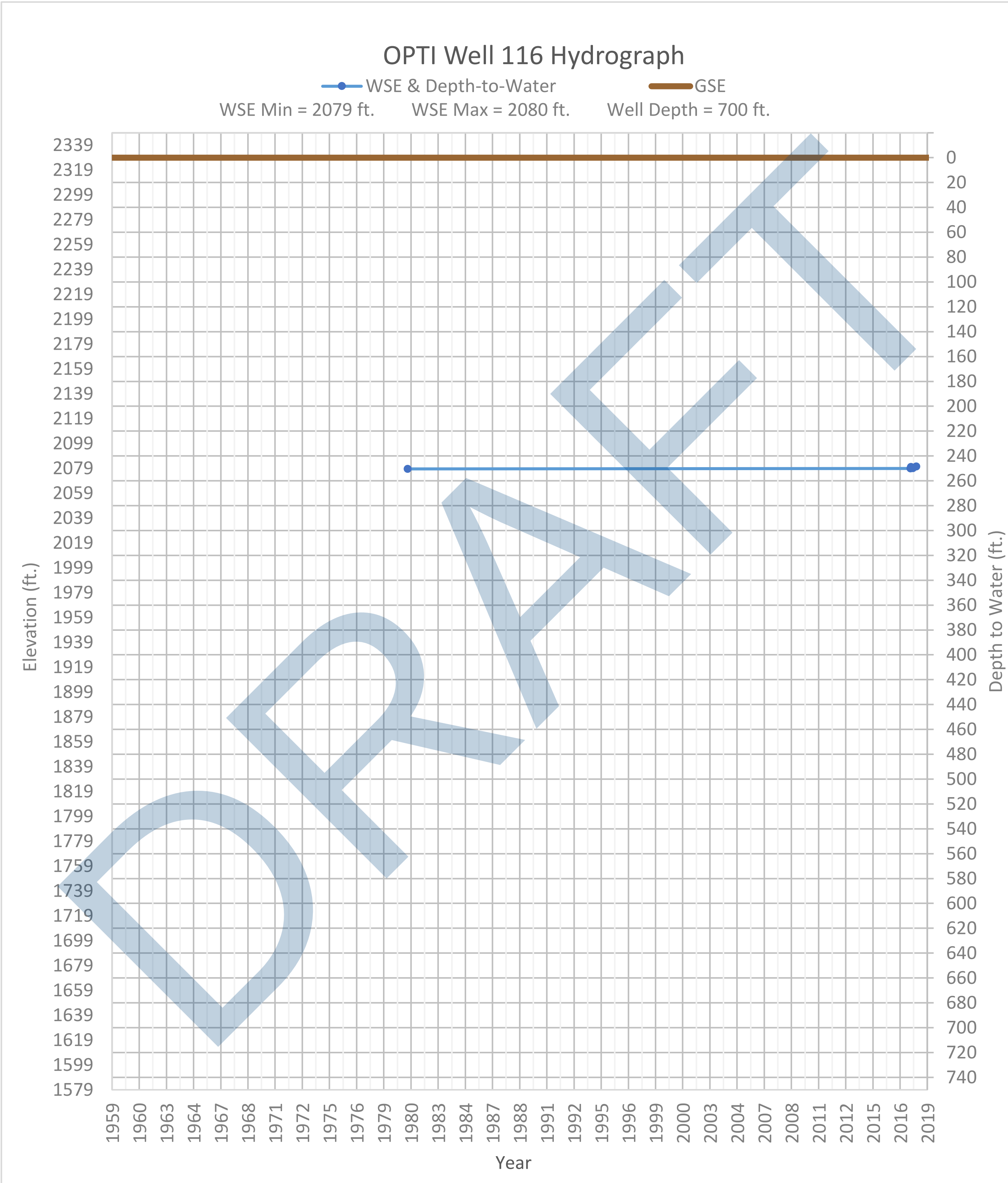

OPTI Well 112 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2029 ft.
WSE Max = 2057 ft.
Well Depth = 441 ft.
Elevation (ft.)
2149 2129 2109 2089 2069 2049 2029 2009 1989 1969 1949 1929 1909 1889 1869 1849 1829 1809 1789 1769 1749 1729 1709 1689 1669 1649 1629 1609 1589 1569 1549 1529 1509 1489 1469 1449 1429 1409 1389
Depth to Water (ft.)
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720 740
Year
1959 1960 1963 1964 1967 1968 1971 1972 1975 1976 1979 1980 1983 1984 1987 1988 1991 1992 1995 1996 1999 2000 2003 2004 2007 2008 2011 2012 2015 2016 2019
DRAFT



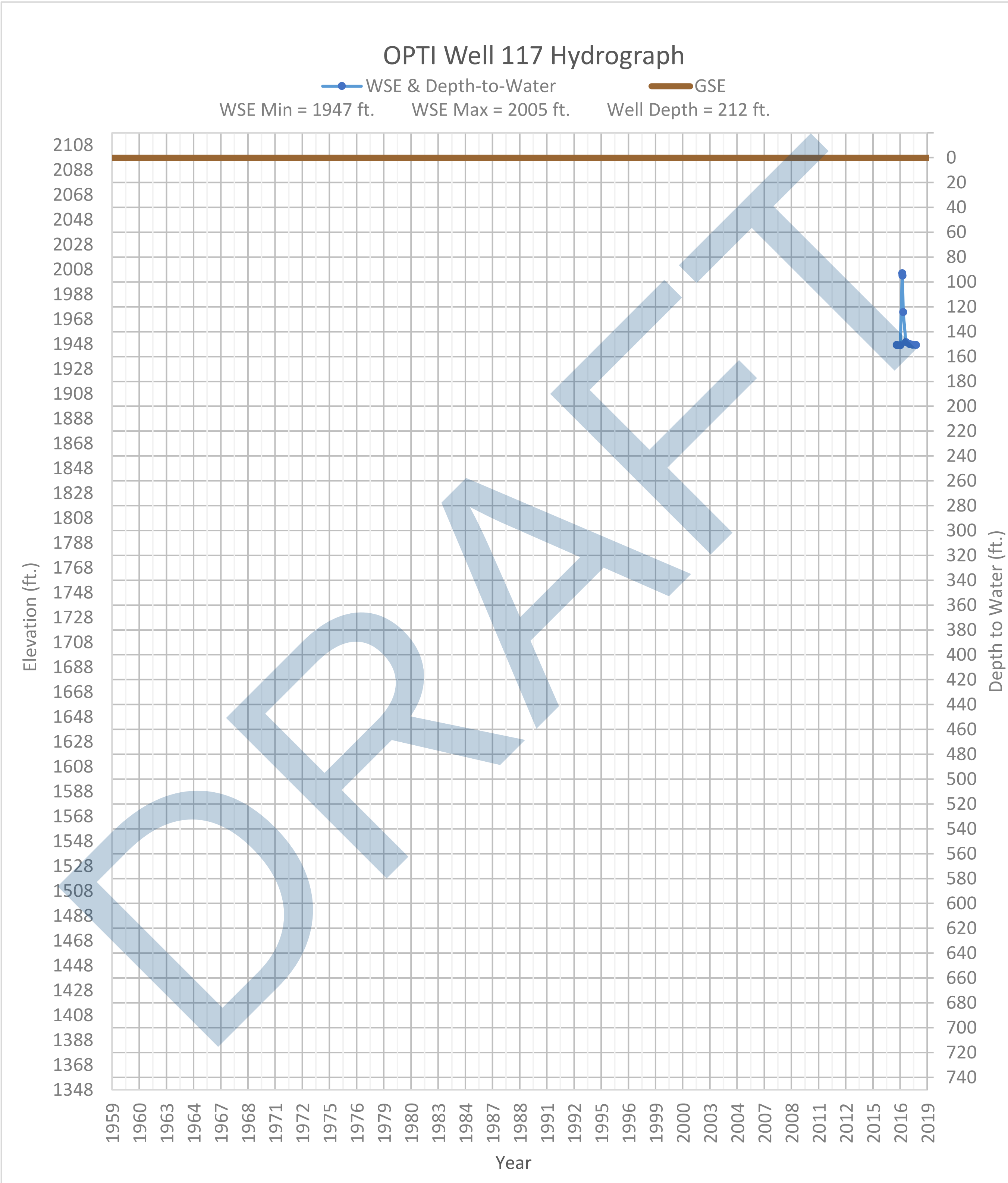
OPTI Well 114 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1882 ft.
WSE Max = 1898 ft.
Well Depth = 58 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



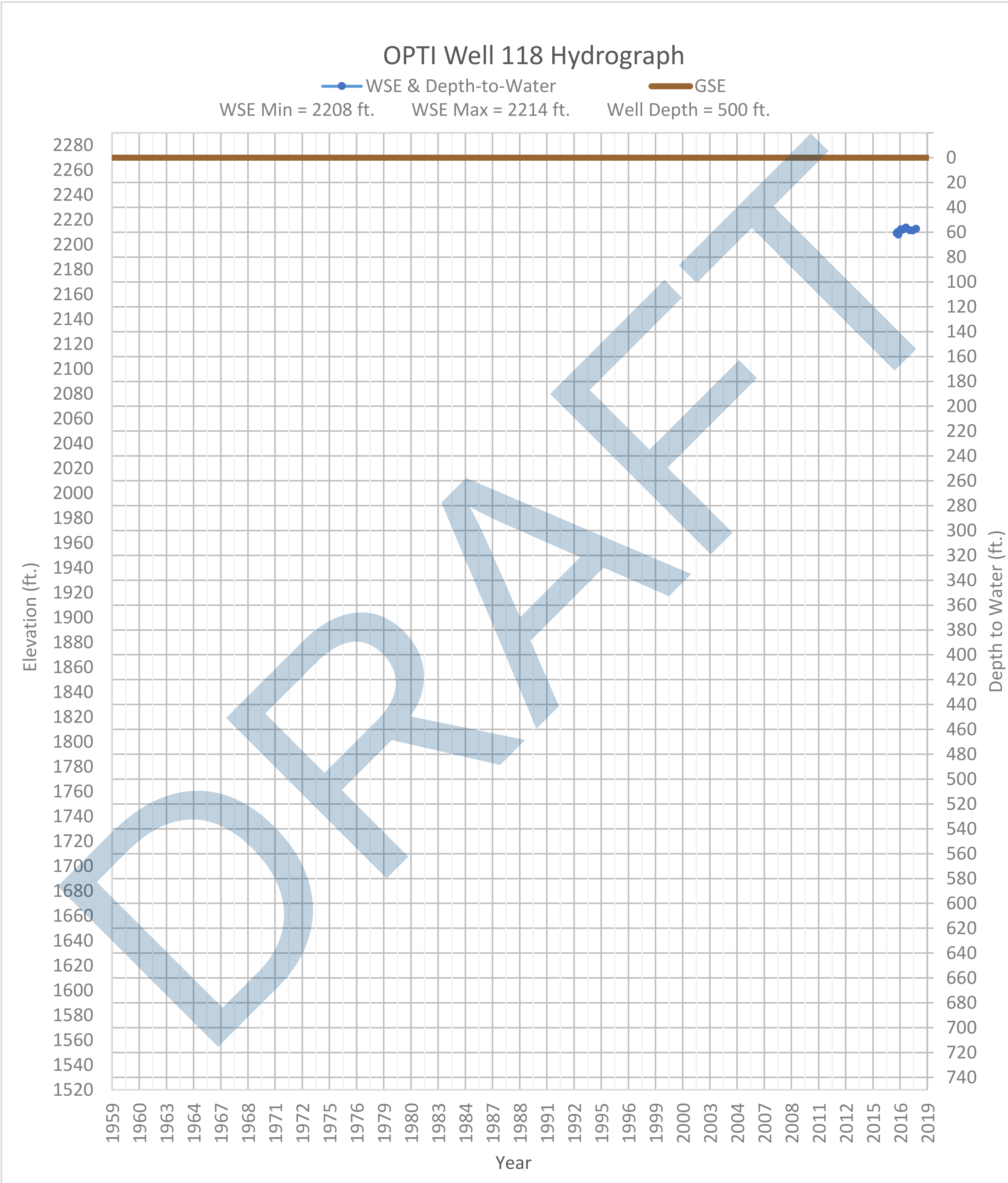
OPTI Well 115 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2173 ft.
WSE Max = 2174 ft.
Well Depth = 1200 ft.
Elevation (ft.)
Depth to Water (ft.)
Year

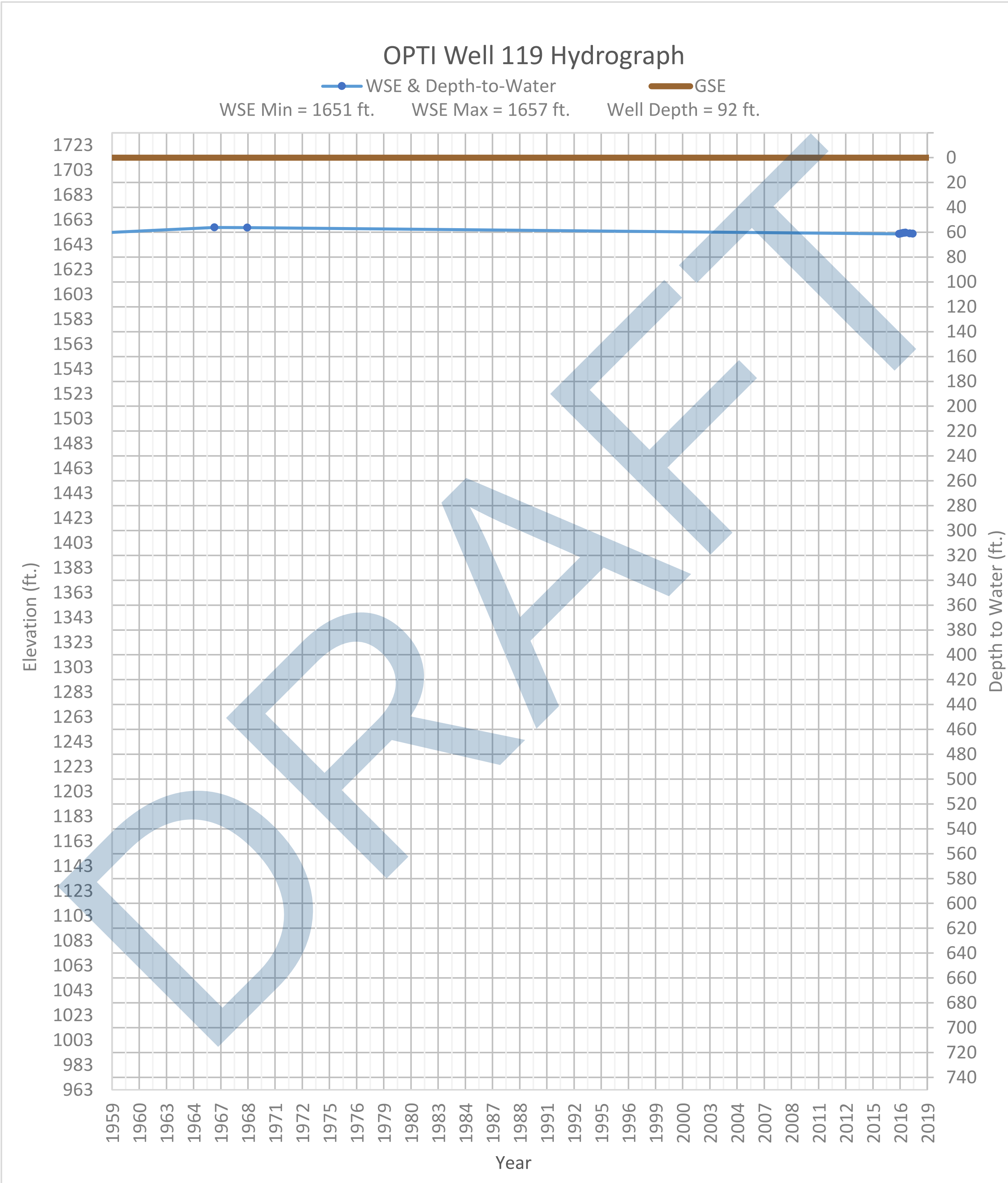


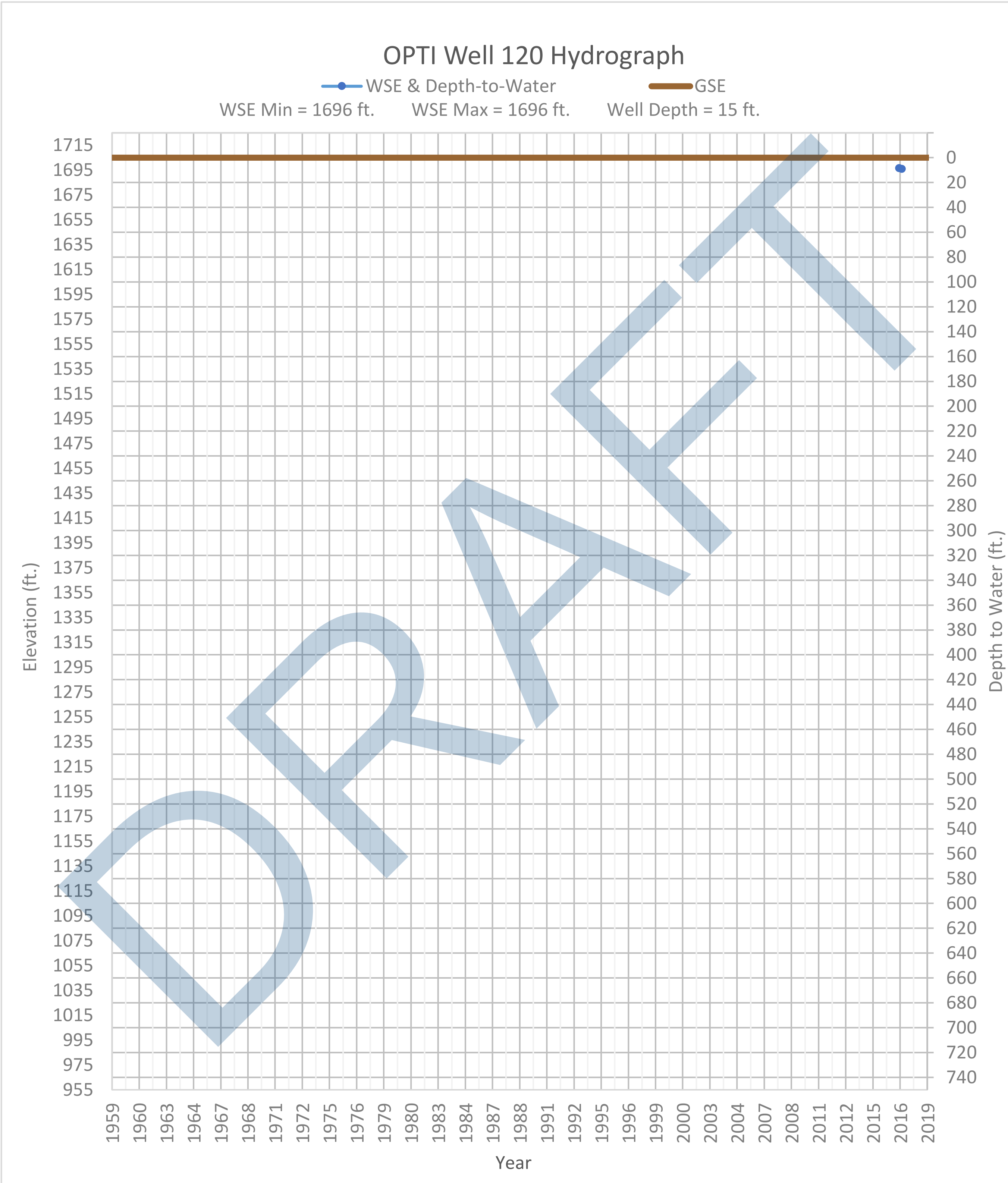
OPTI Well 116 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2079 ft.
WSE Max = 2080 ft.
Well Depth = 700 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 117 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1947 ft.
WSE Max = 2005 ft.
Well Depth = 212 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 118 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2208 ft.
WSE Max = 2214 ft.
Well Depth = 500 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 119 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1651 ft.
WSE Max = 1657 ft.
Well Depth = 92 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 120 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1696 ft.
WSE Max = 1696 ft.
Well Depth = 15 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
1715
1695
1675
1655
1635
1615
1595
1575
1555
1535
1515
1495
1475
1455
1435
1415
1395
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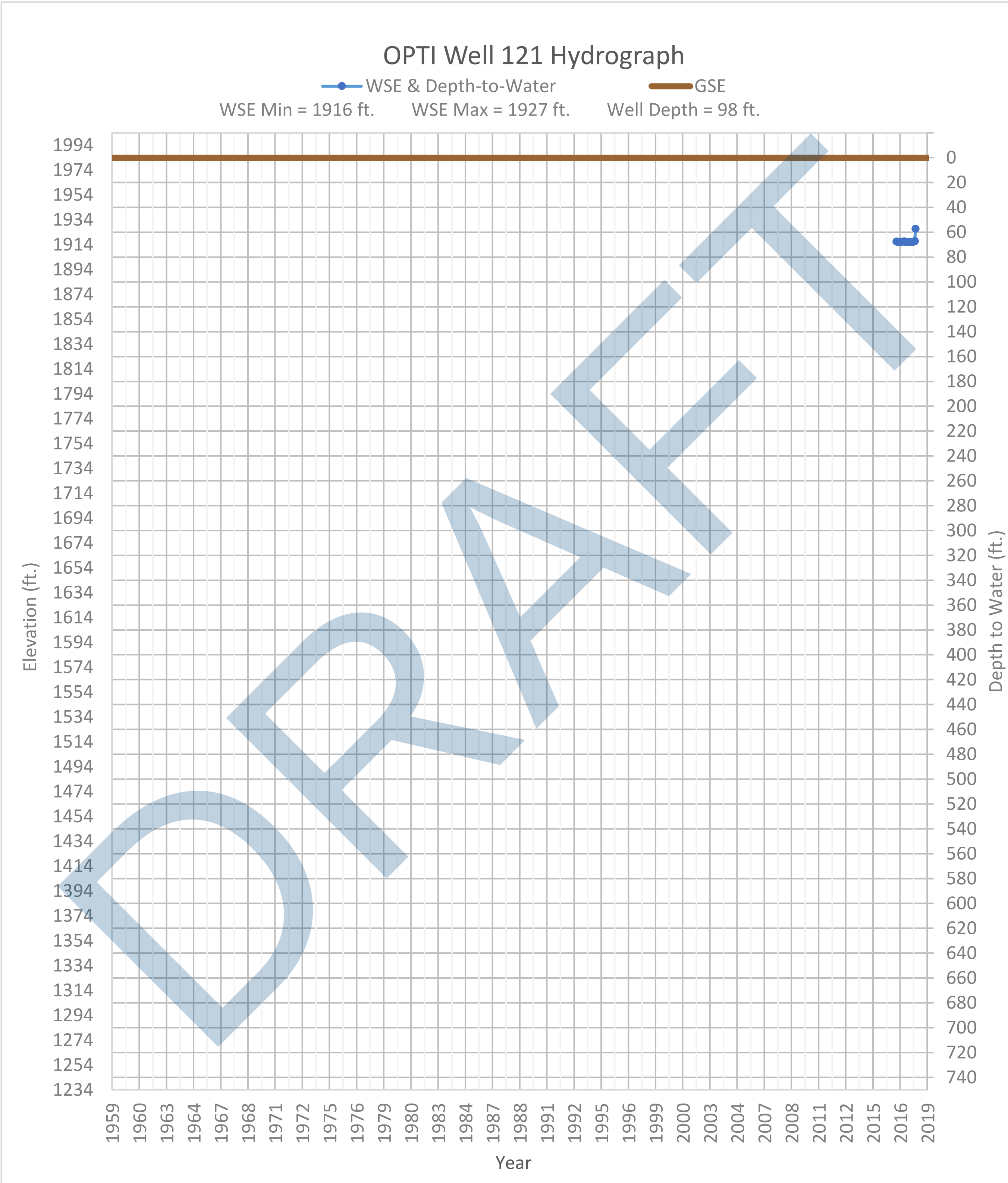

OPTI Well 121 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1916 ft.
WSE Max = 1927 ft.
Well Depth = 98 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
1994
1974
1954
1934
1914
1894
1874
1854
1834
1814
1794
1774
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1734
1714
1694
1674
1654
1634
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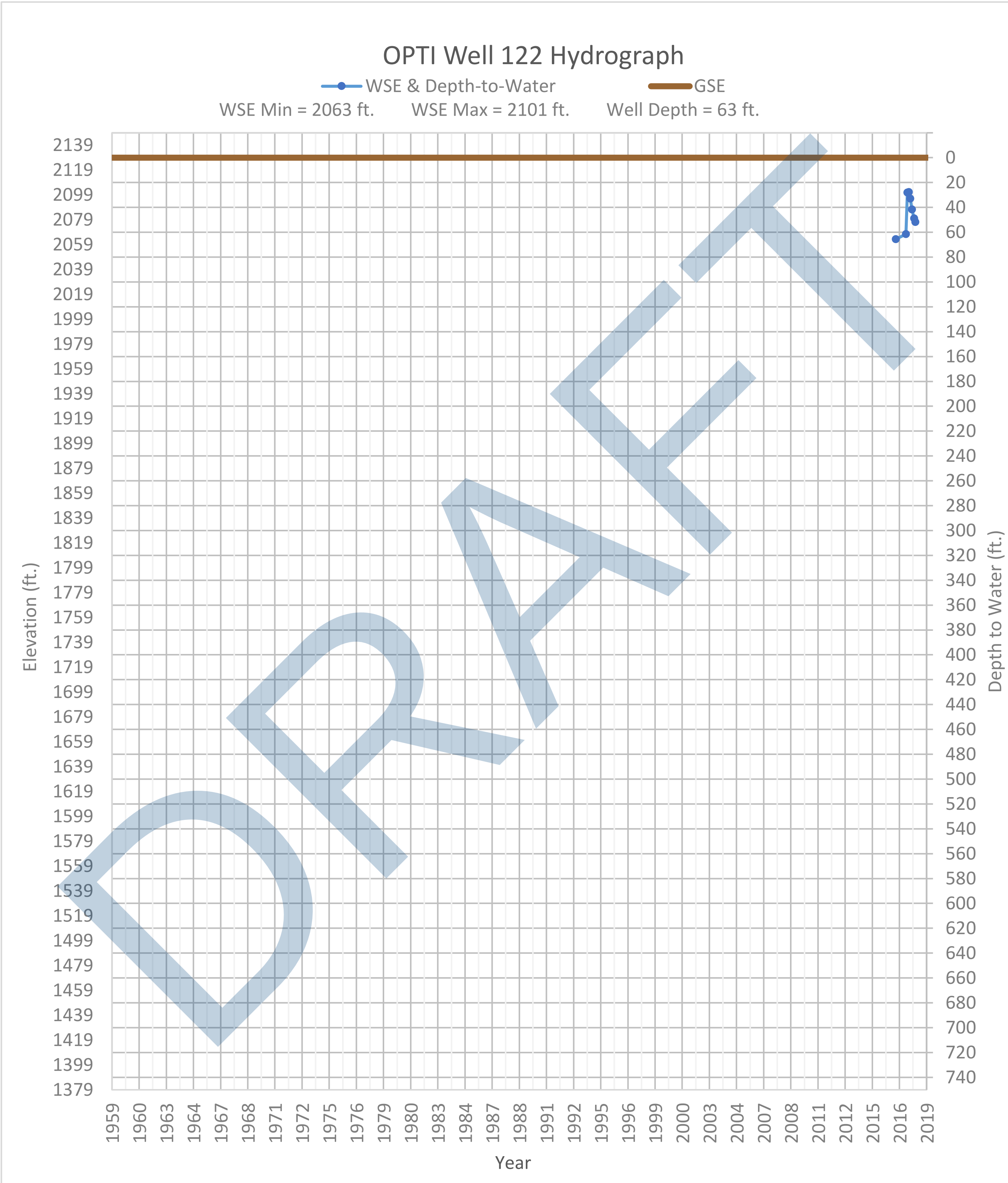
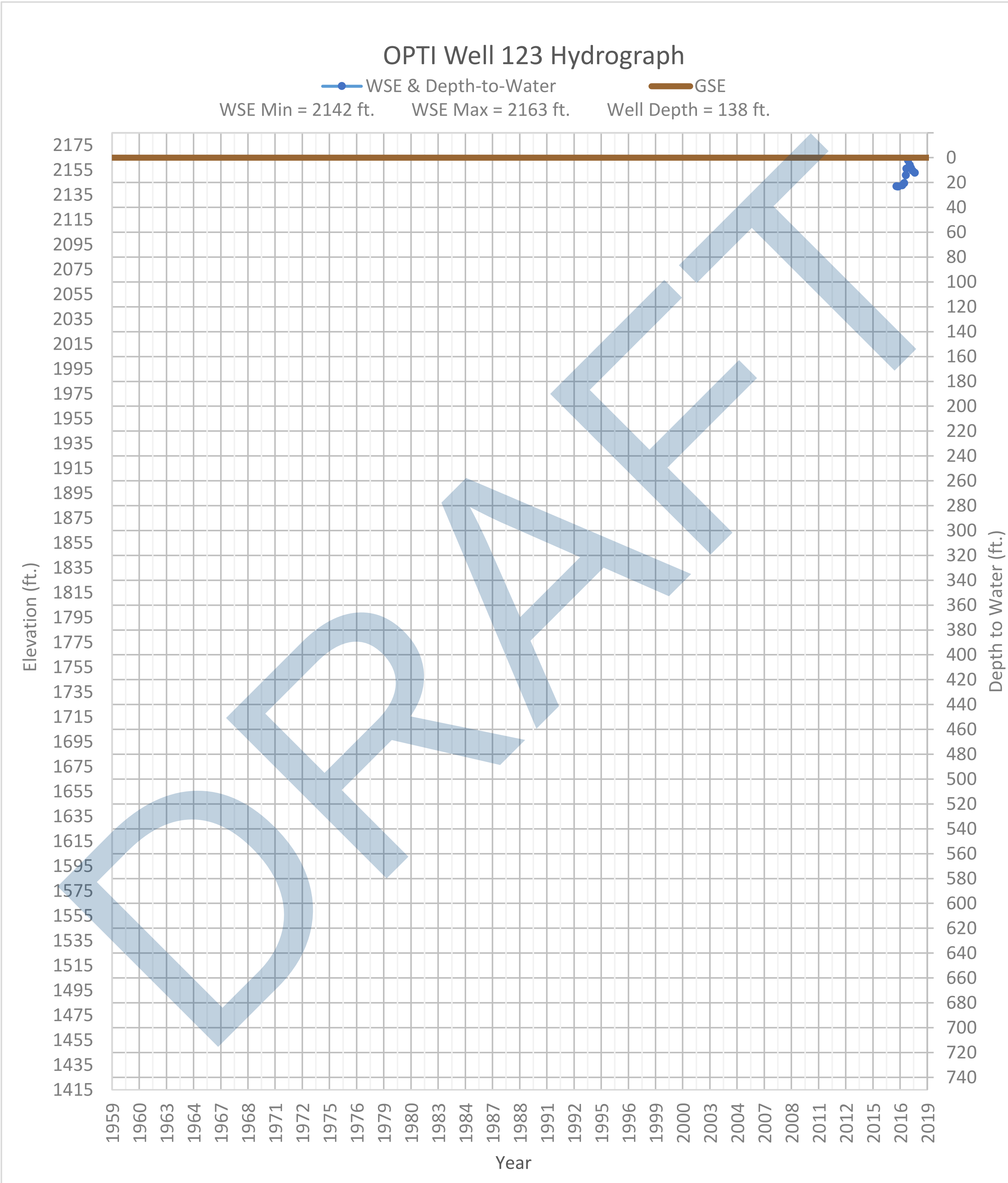
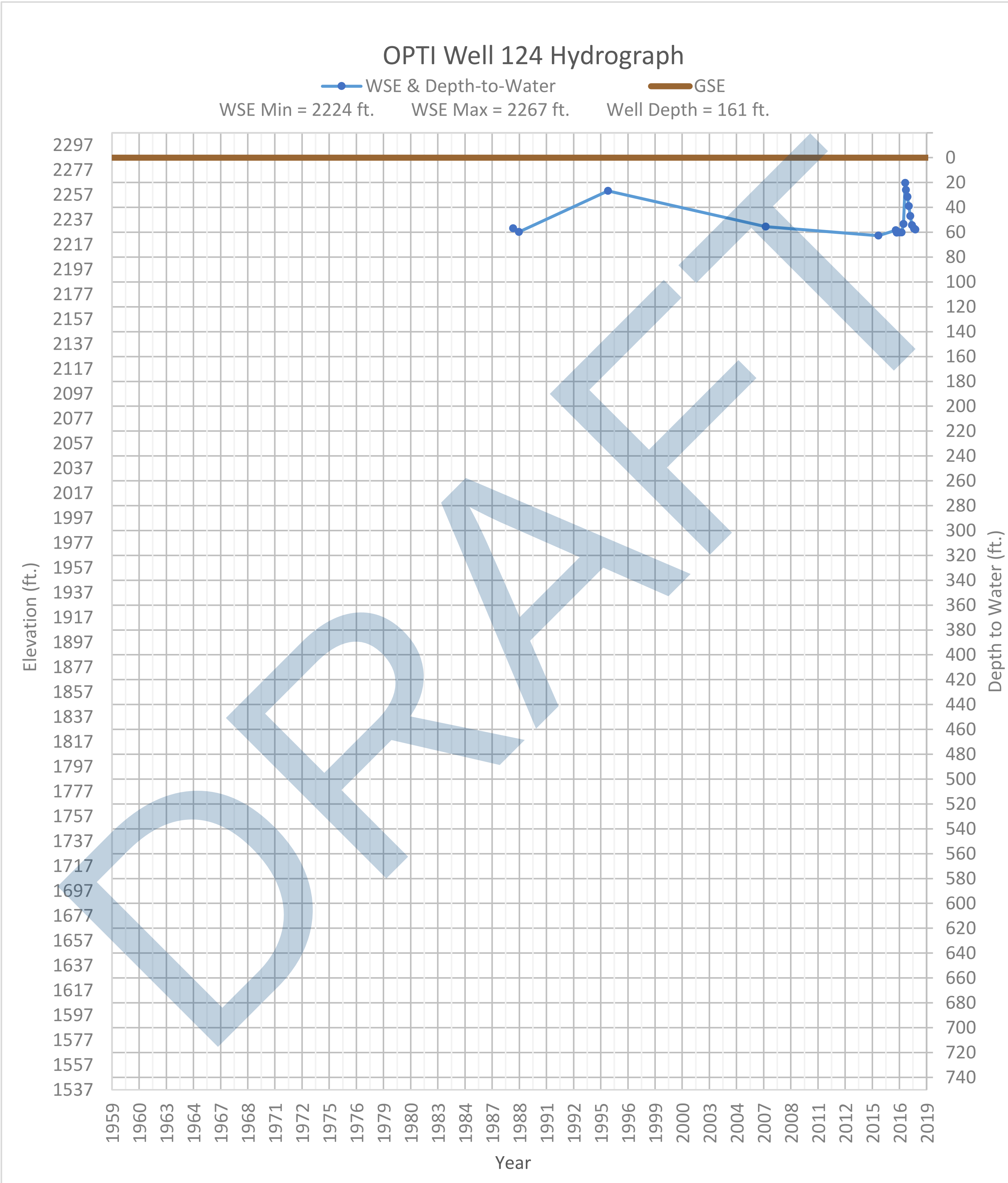
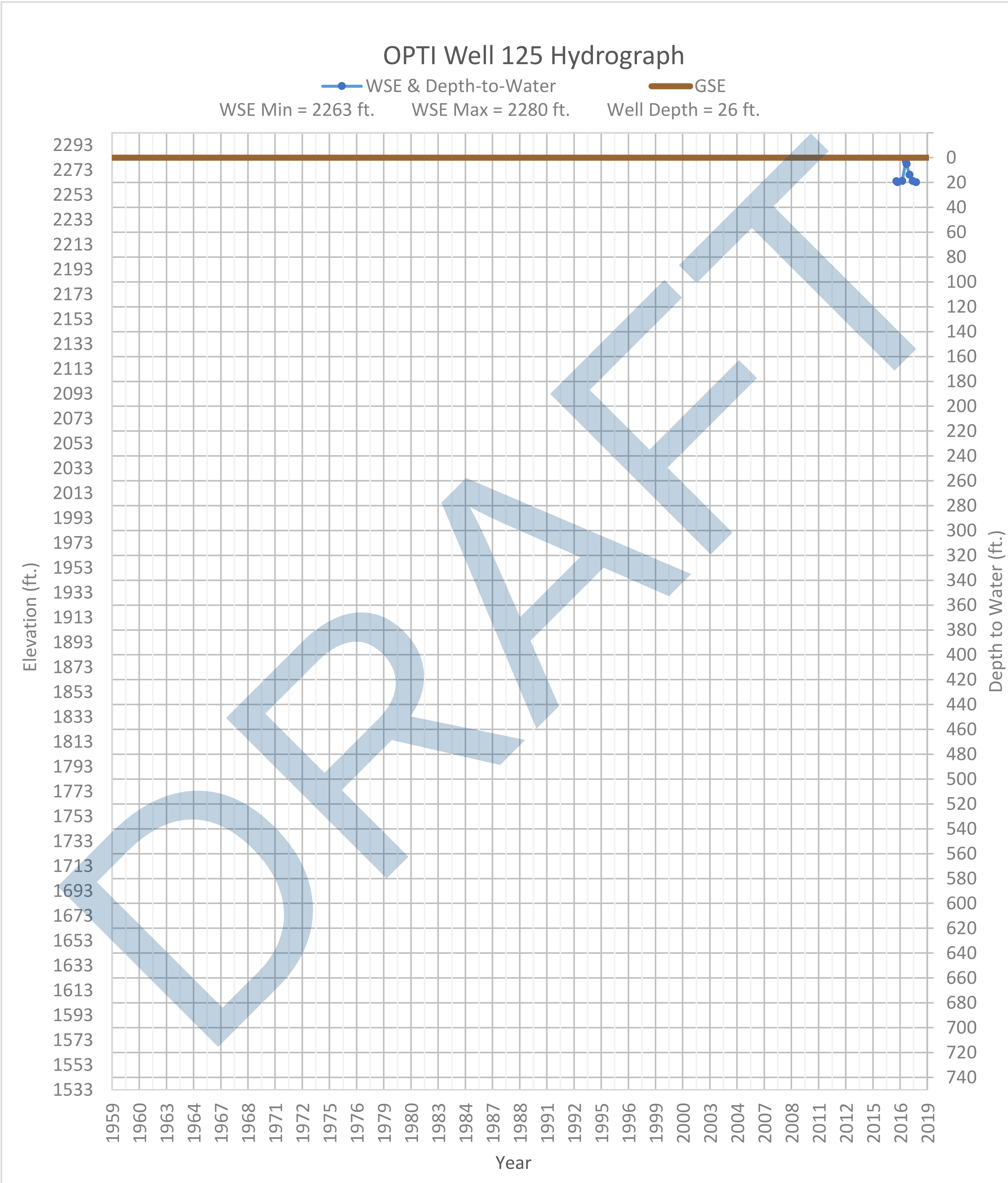


OPTI Well 122 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2063 ft.
WSE Max = 2101 ft.
Well Depth = 63 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

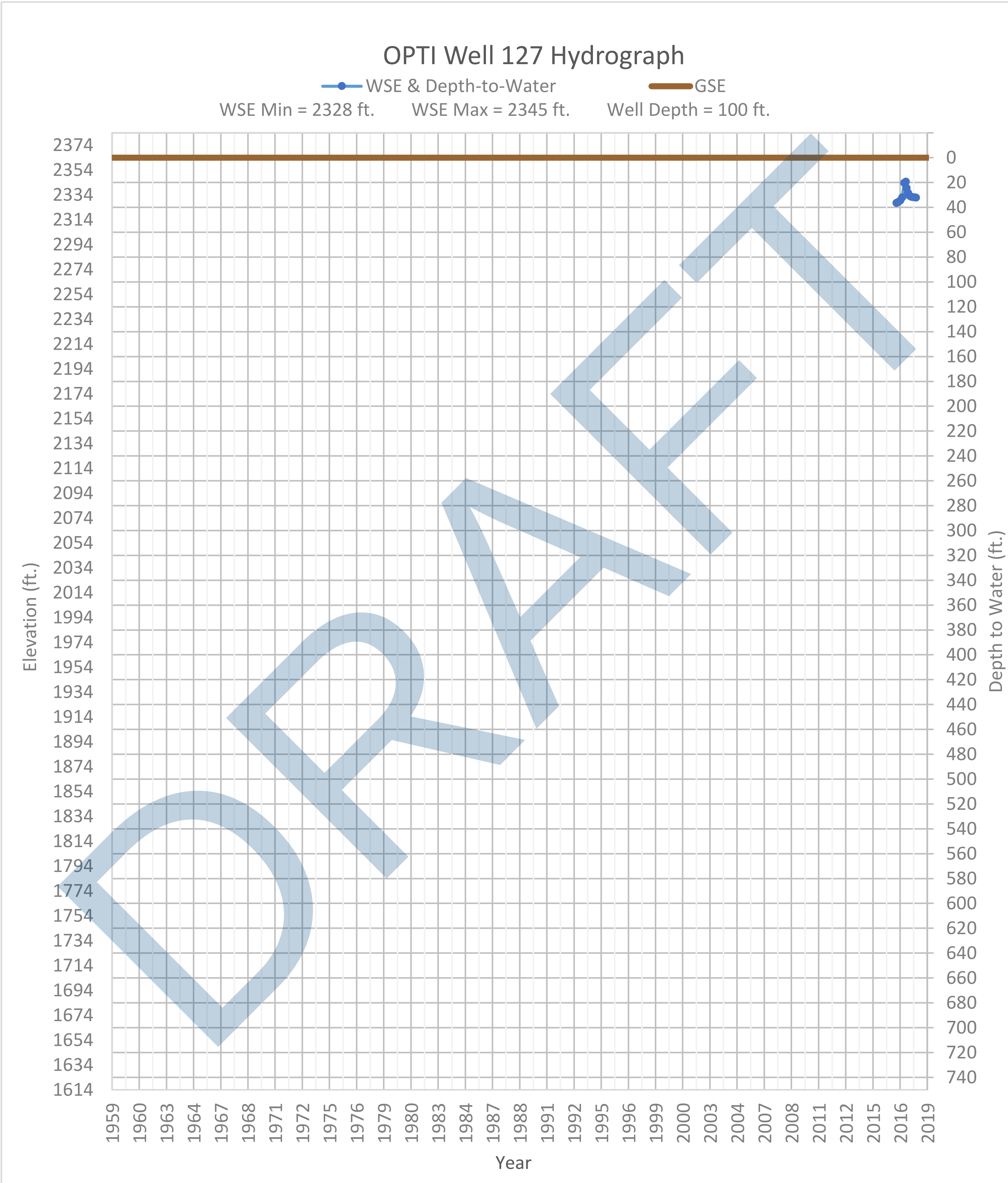

OPTI Well 123 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2142 ft.
WSE Max = 2163 ft.
Well Depth = 138 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



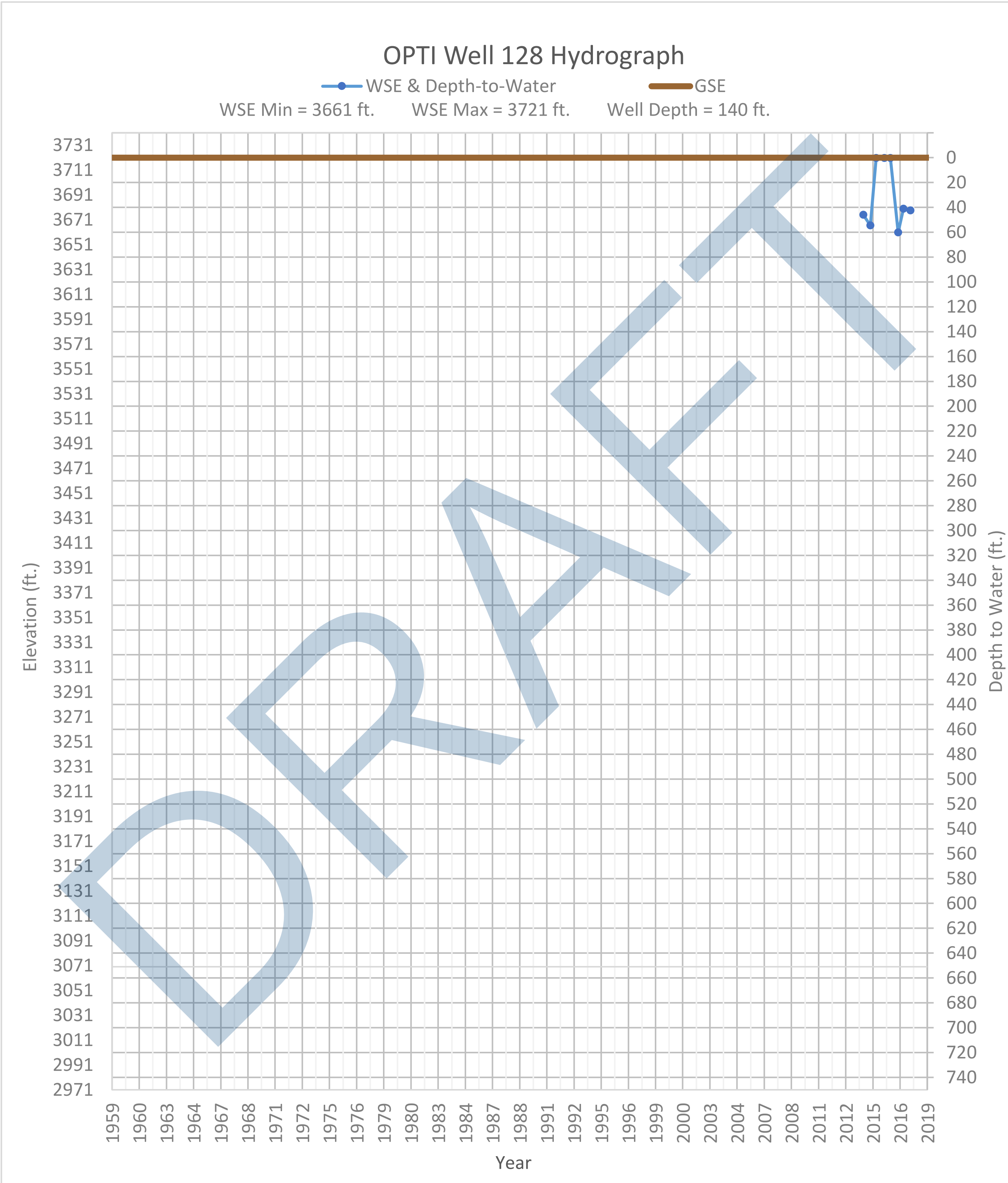
OPTI Well 124 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2224 ft.
WSE Max = 2267 ft.
Well Depth = 161 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



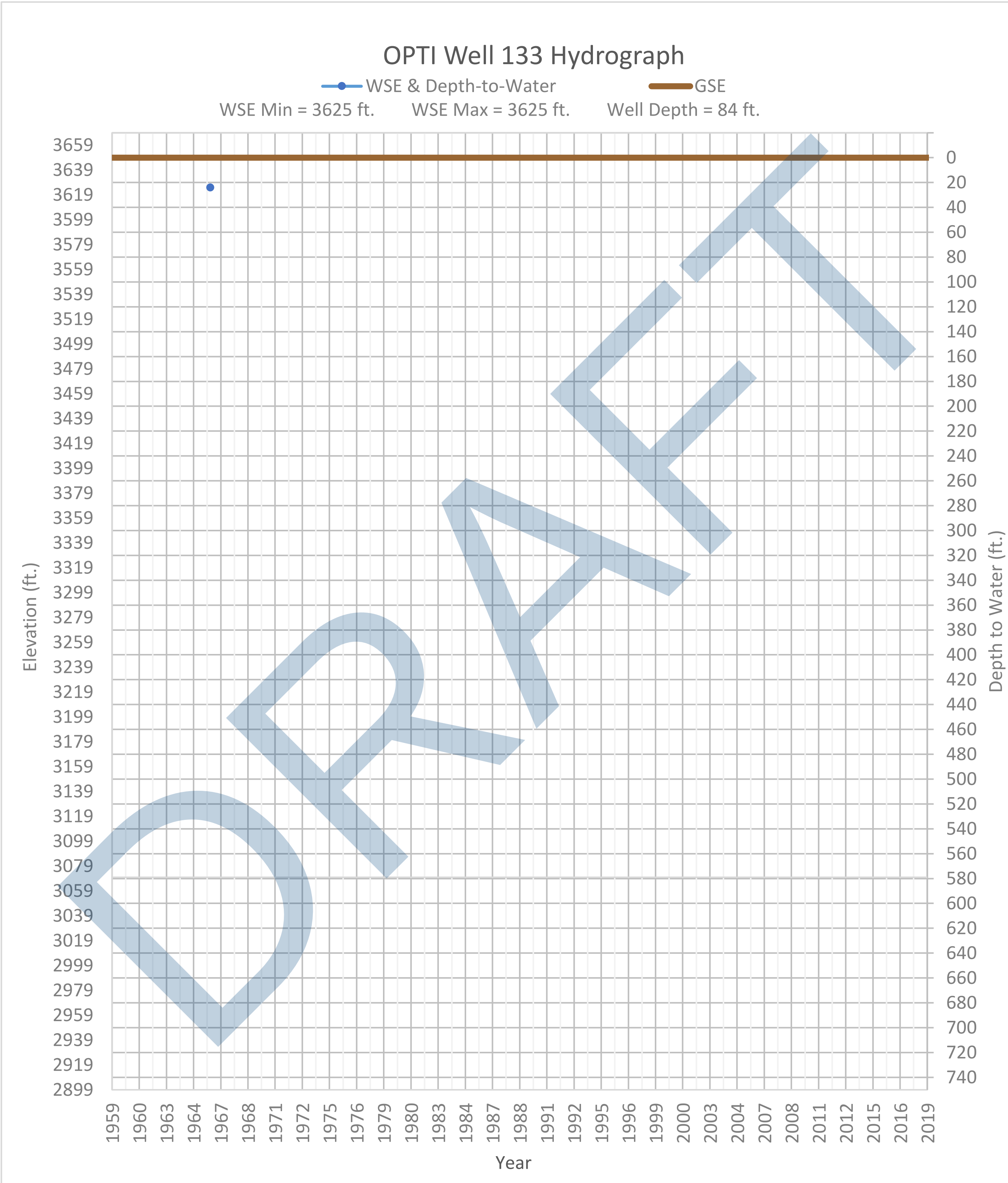
OPTI Well 125 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2263 ft.
WSE Max = 2280 ft.
Well Depth = 26 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



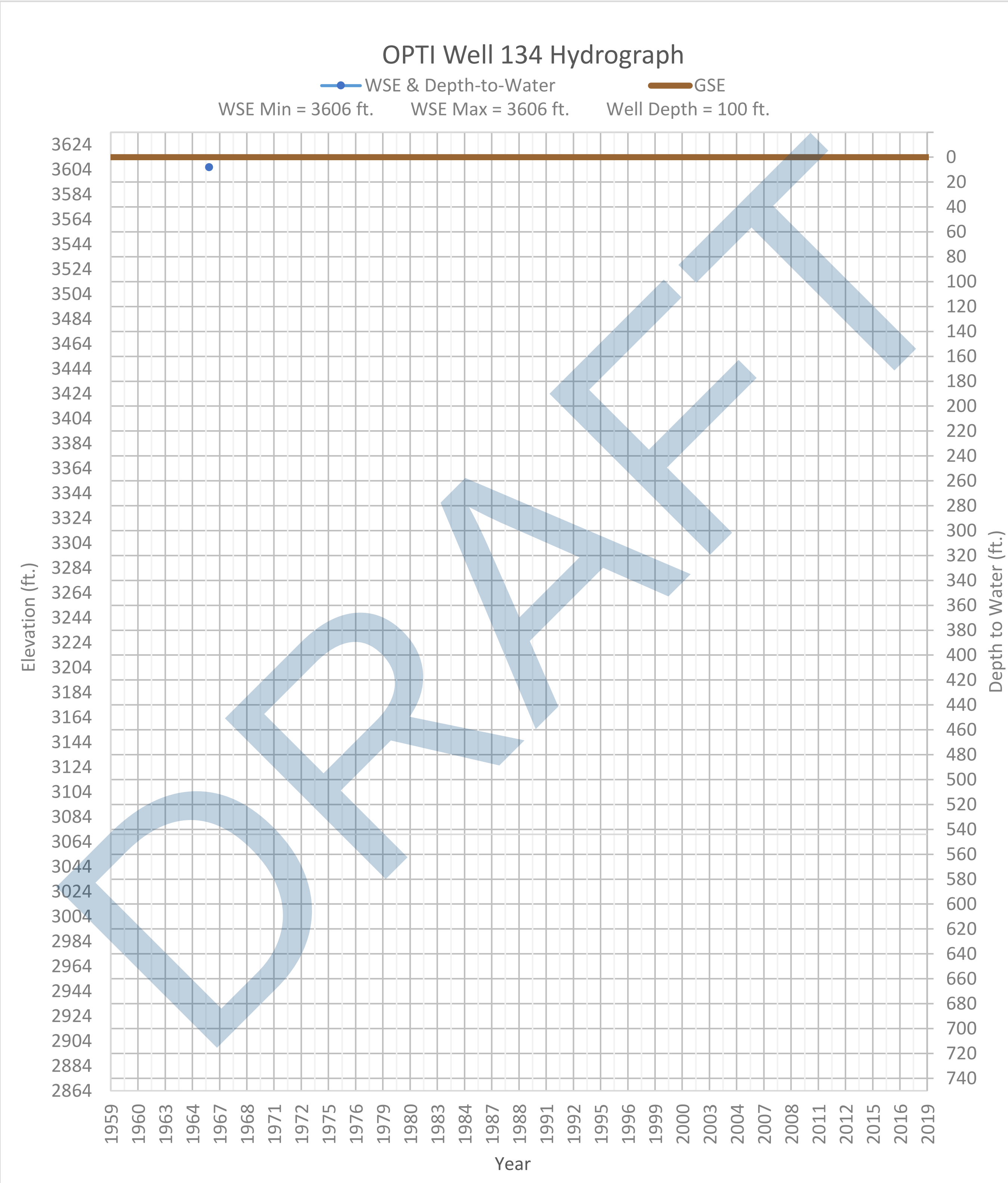
OPTI Well 127 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2328 ft.
WSE Max = 2345 ft.
Well Depth = 100 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



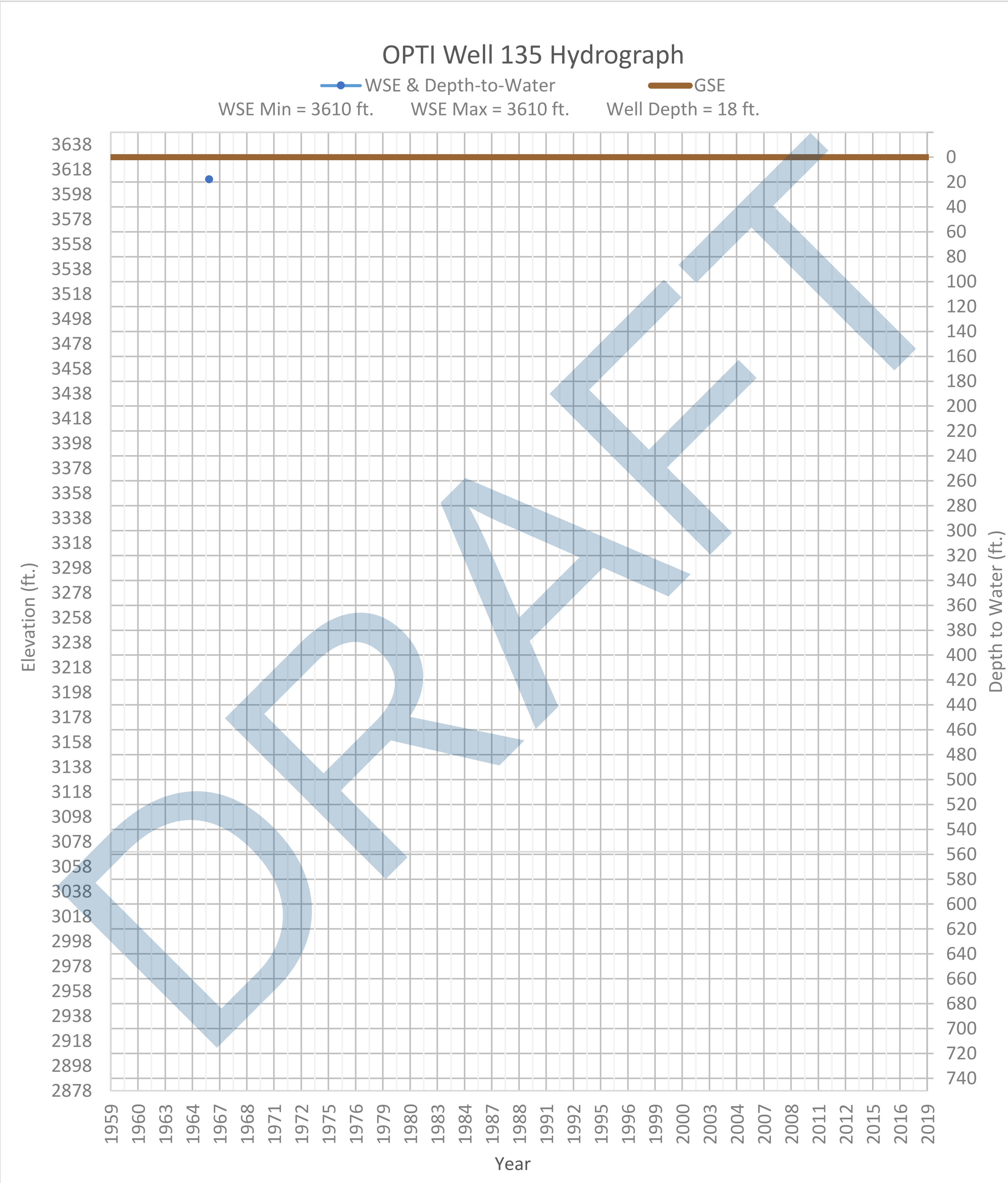
OPTI Well 128 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3661 ft.
WSE Max = 3721 ft.
Well Depth = 140 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



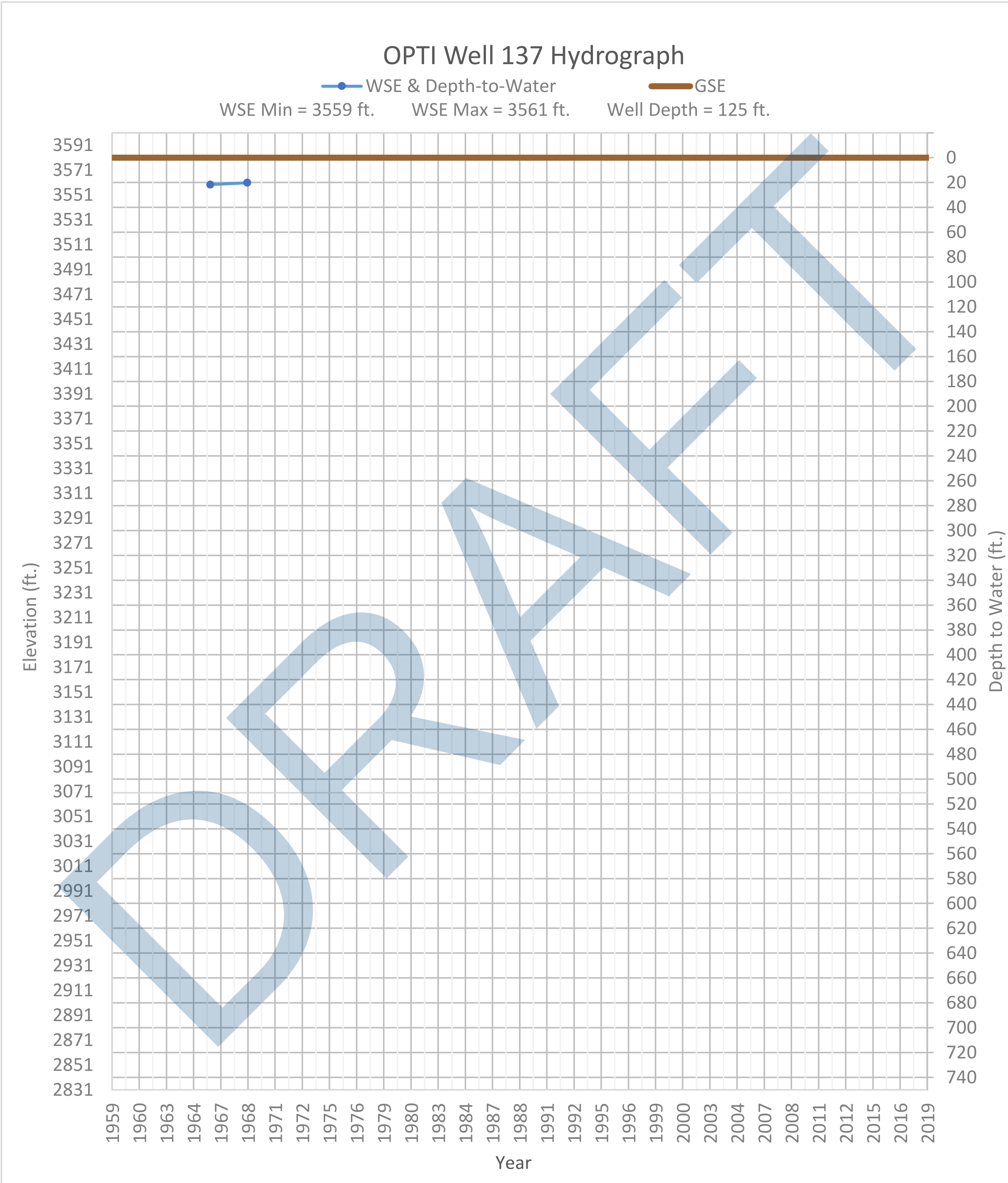
OPTI Well 133 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3625 ft.
WSE Max = 3625 ft.
Well Depth = 84 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 134 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3606 ft.
WSE Max = 3606 ft.
Well Depth = 100 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 135 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3610 ft.
WSE Max = 3610 ft.
Well Depth = 18 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 137 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3559 ft.
WSE Max = 3561 ft.
Well Depth = 125 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
3591
3571
3551
3531
3511
3491
3471
3451
3431
3411
3391
3371
3351
3331
3311
3291
3271
3251
3231
3211
3191
3171
3151
3131
3111
3091
3071
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3031
3011
2991
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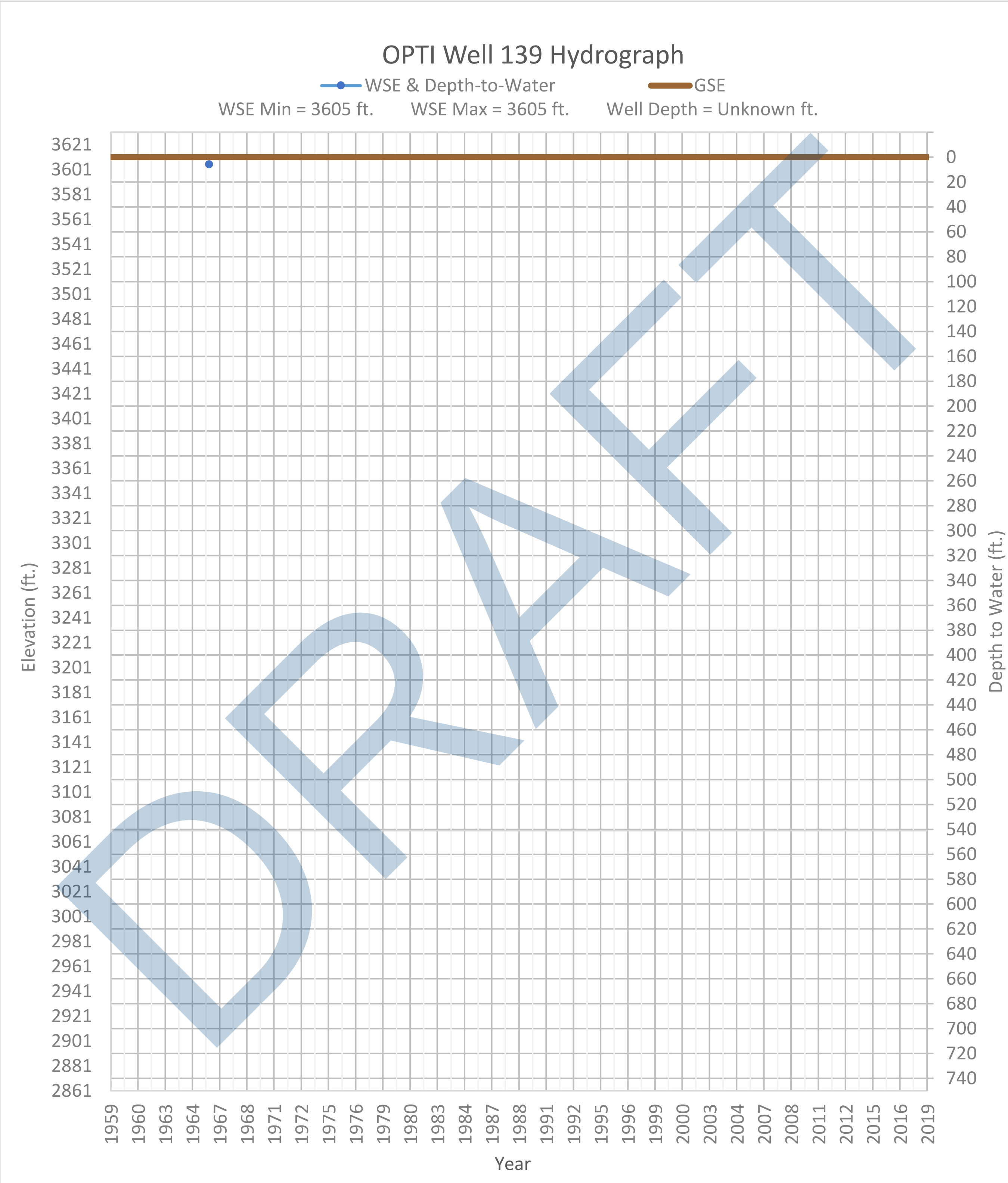
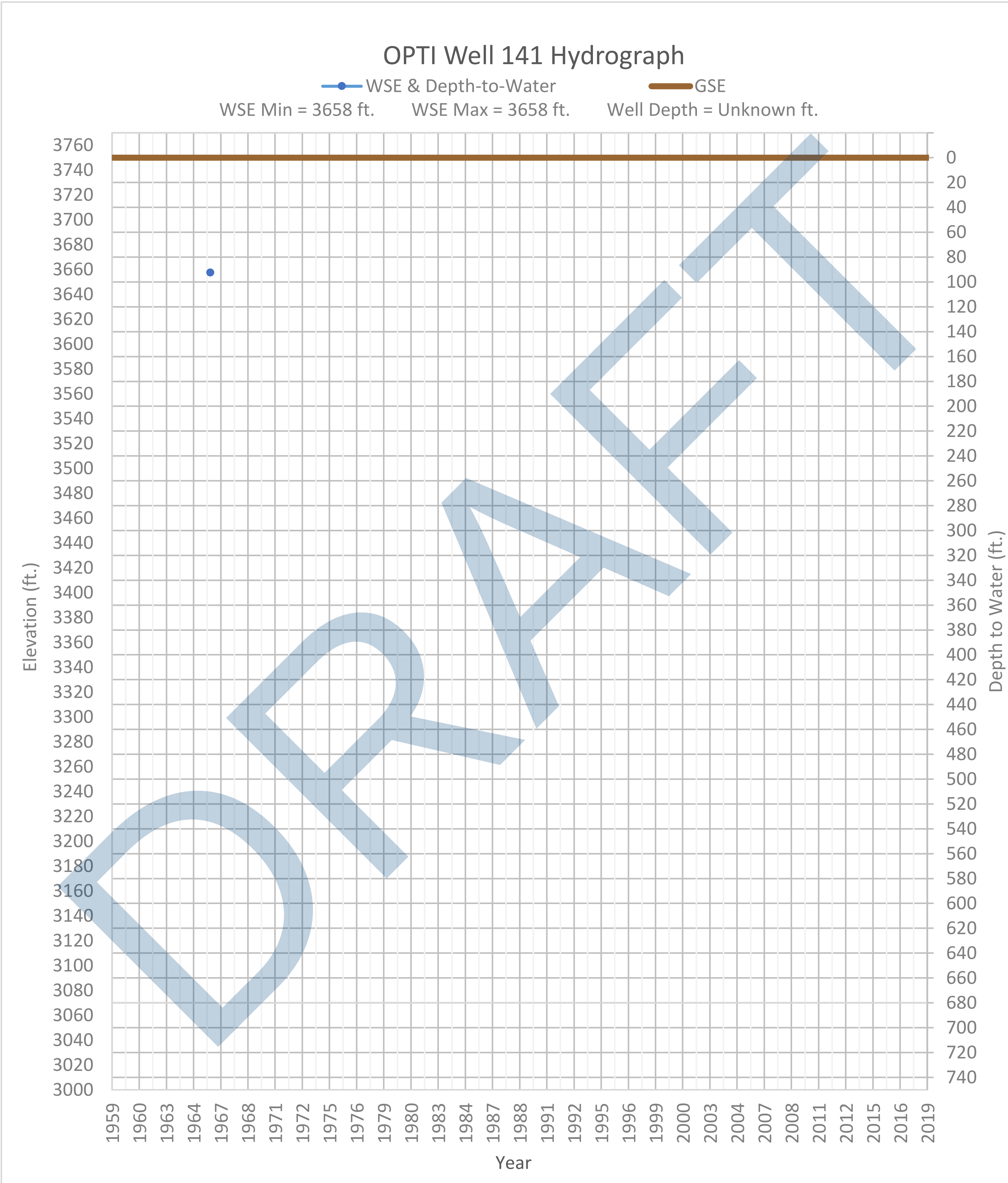
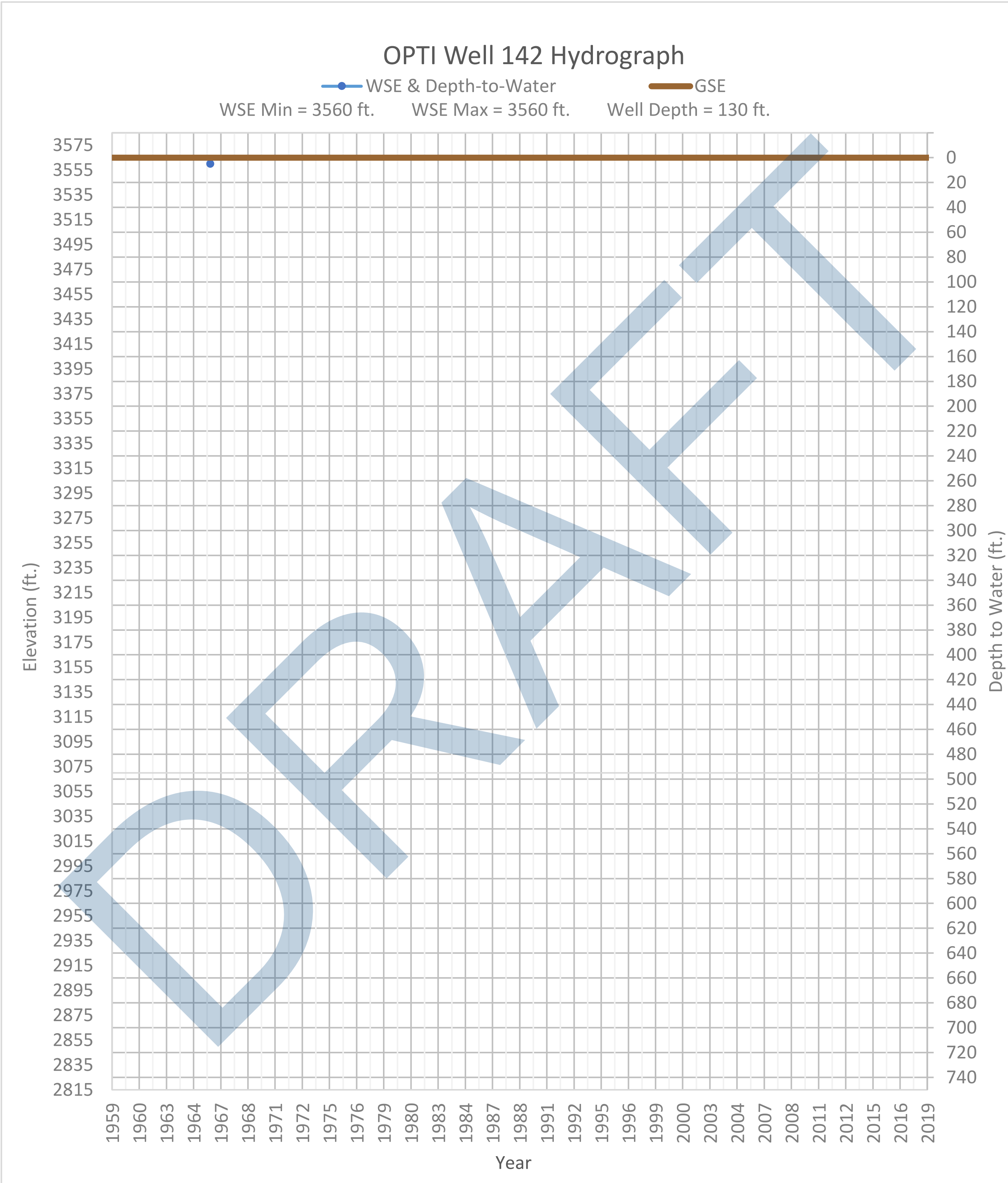
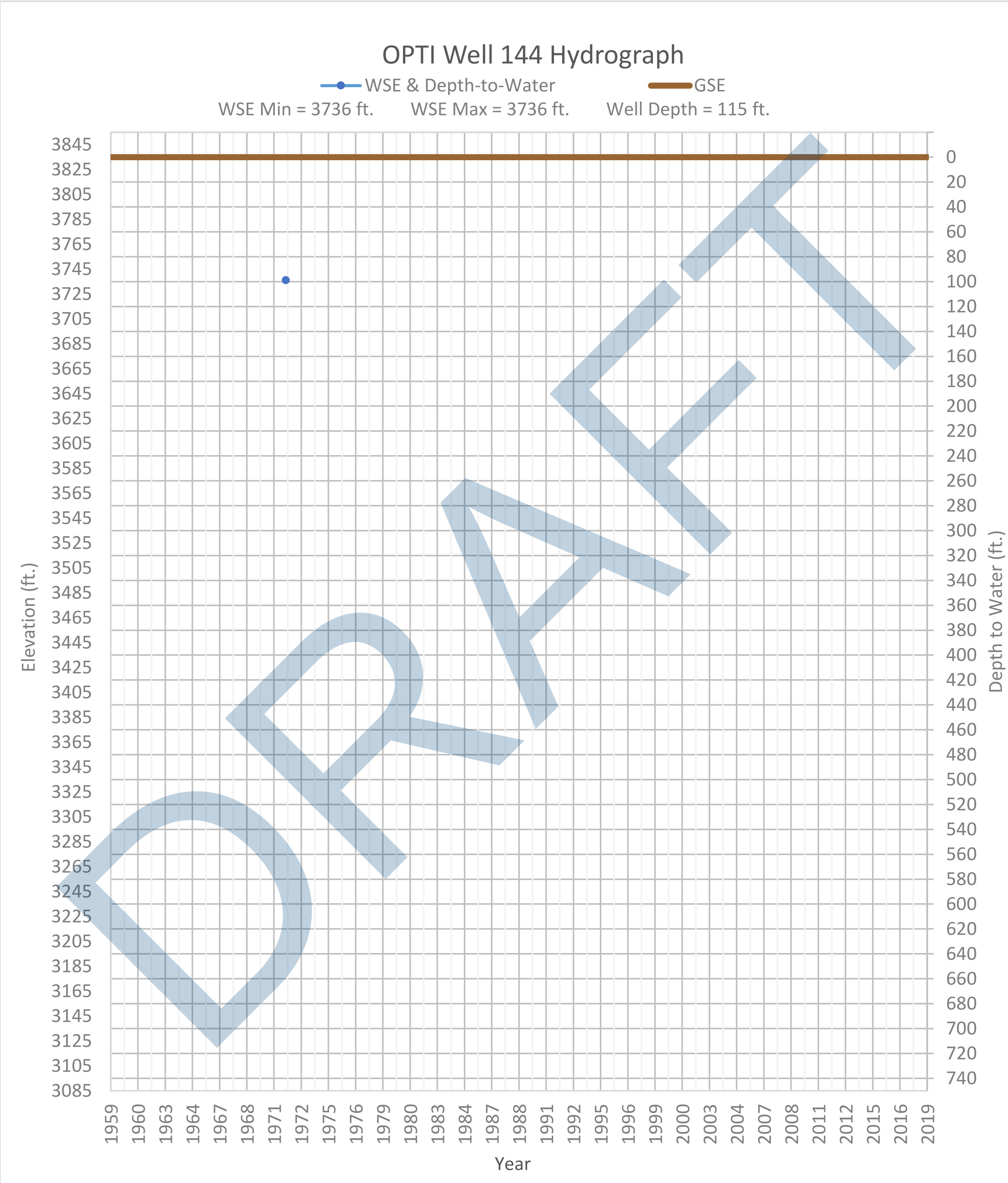


OPTI Well 139 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3605 ft.
WSE Max = 3605 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

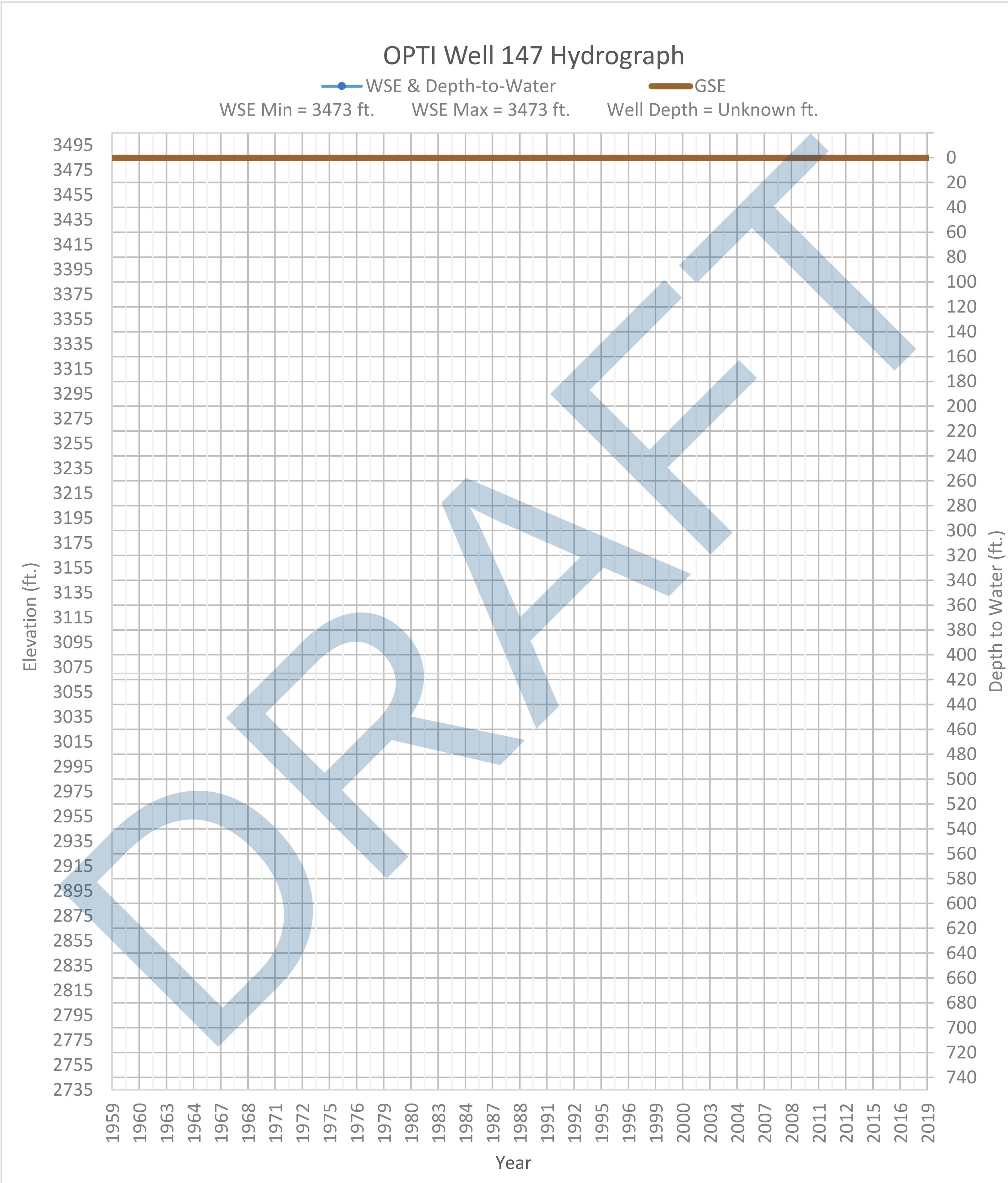


OPTI Well 141 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3658 ft.
WSE Max = 3658 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

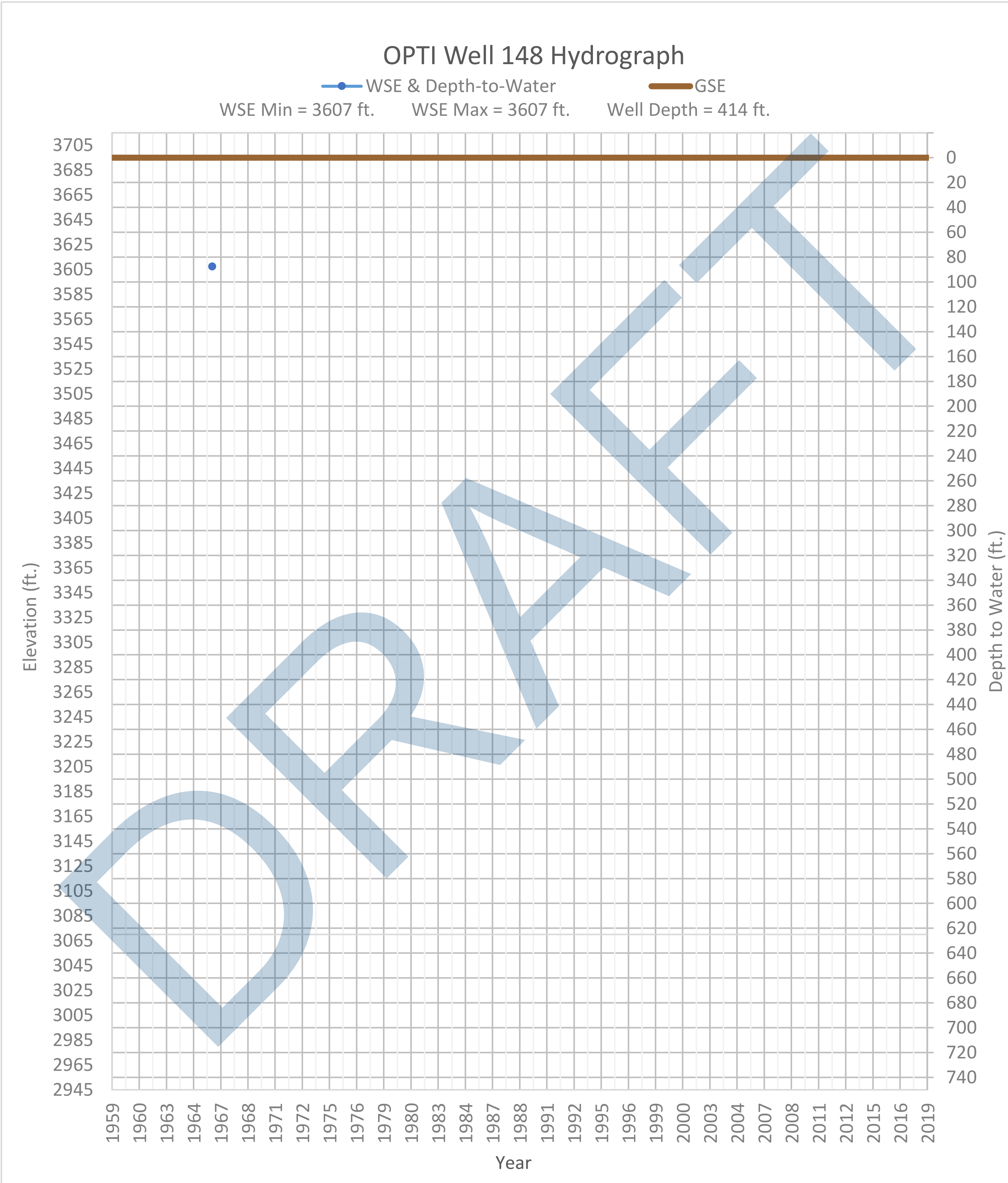

OPTI Well 142 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3560 ft.
WSE Max = 3560 ft.
Well Depth = 130 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



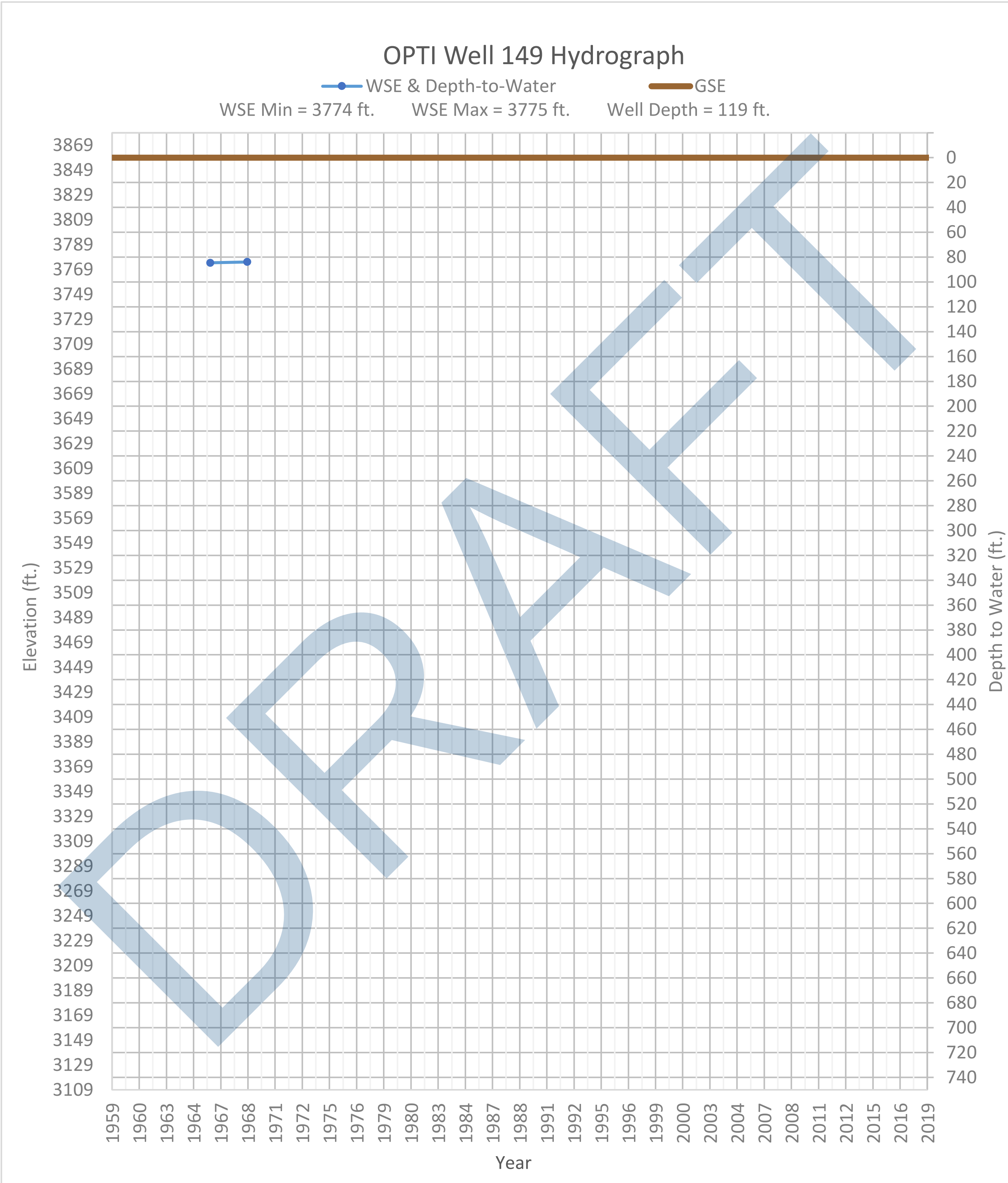
OPTI Well 144 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3736 ft.
WSE Max = 3736 ft.
Well Depth = 115 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

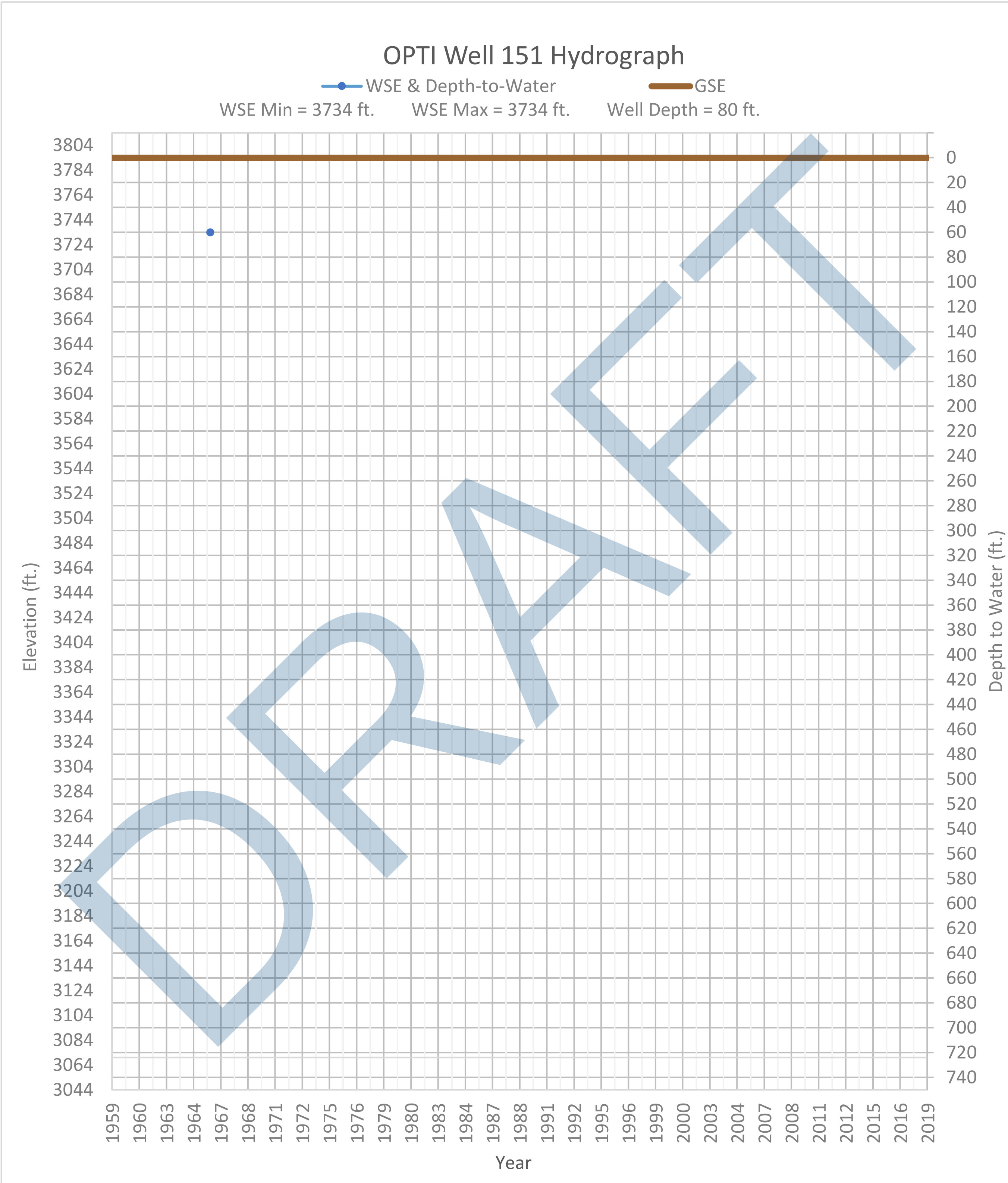


OPTI Well 147 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3473 ft.
WSE Max = 3473 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

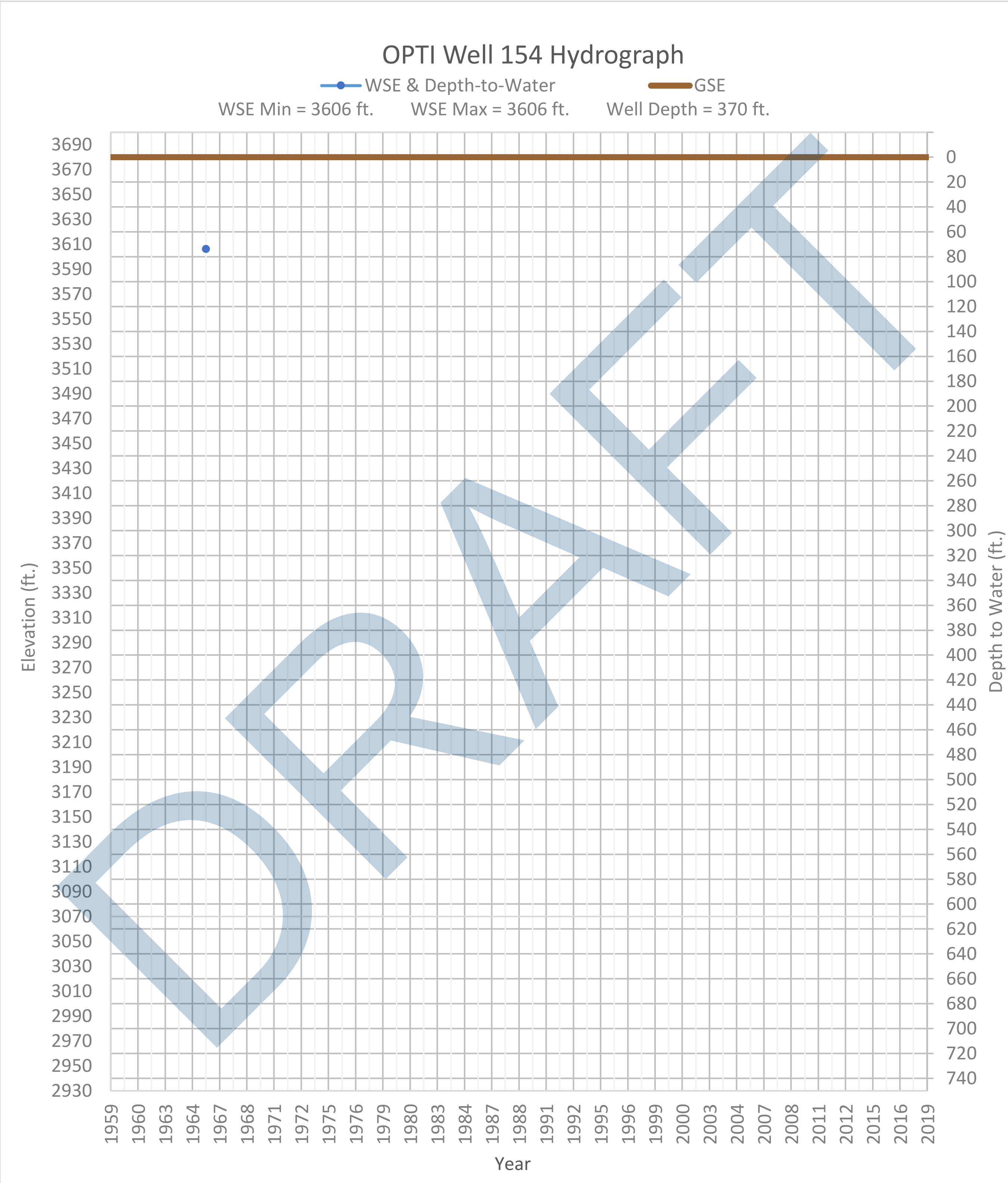


OPTI Well 148 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3607 ft.
WSE Max = 3607 ft.
Well Depth = 414 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

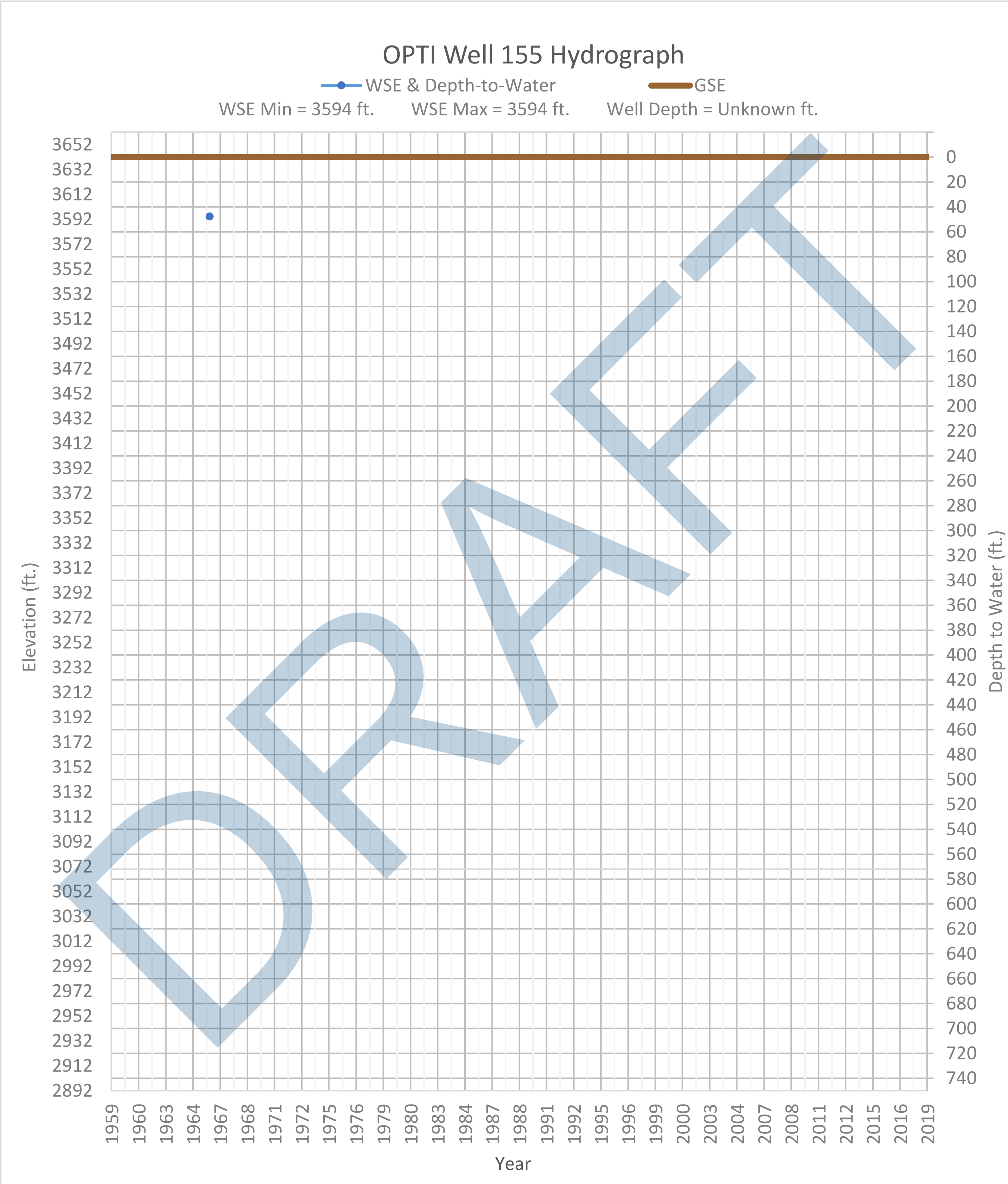

OPTI Well 149 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3774 ft.
WSE Max = 3775 ft.
Well Depth = 119 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



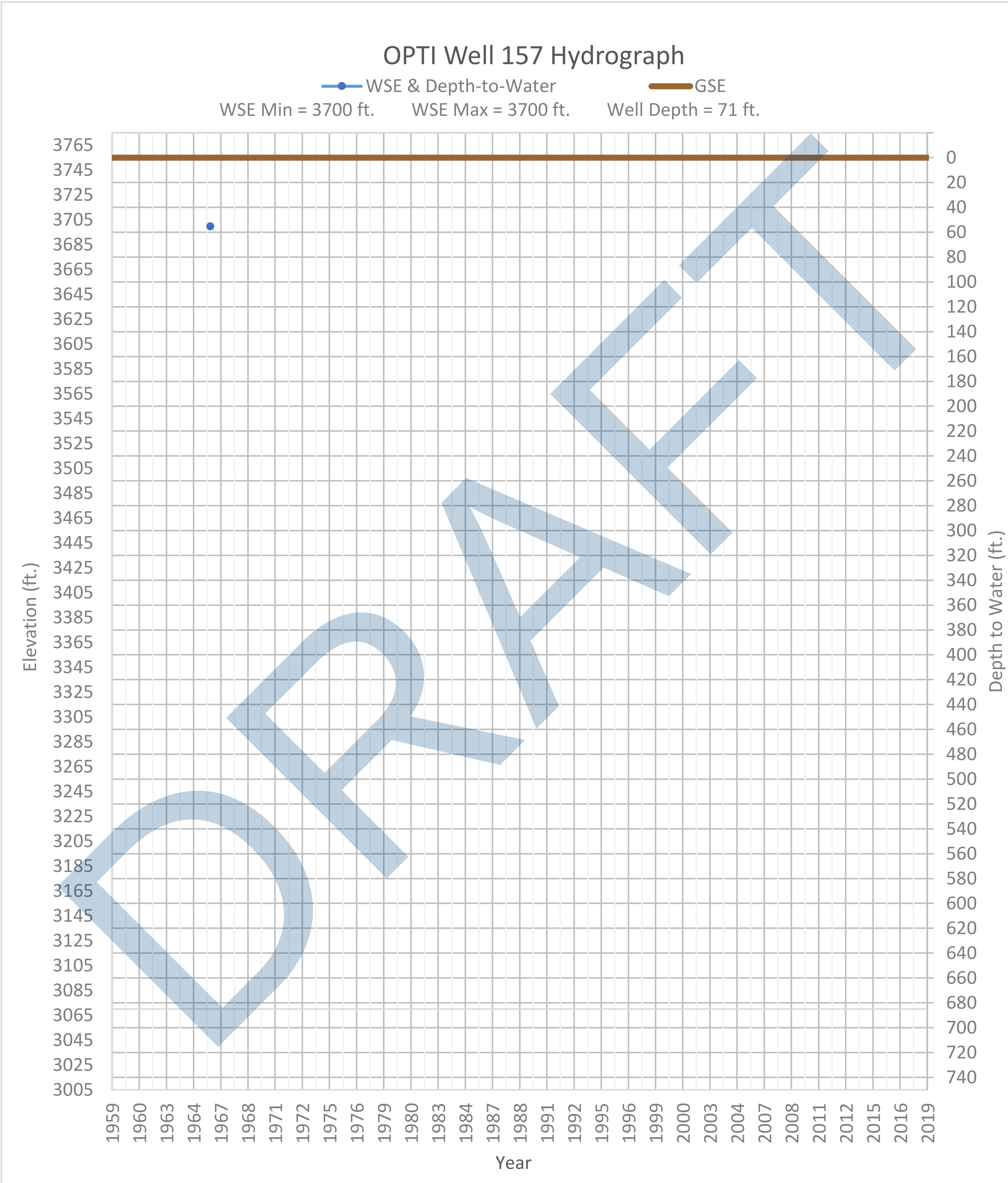
OPTI Well 151 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3734 ft.
WSE Max = 3734 ft.
Well Depth = 80 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 154 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3606 ft.
WSE Max = 3606 ft.
Well Depth = 370 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 155 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3594 ft.
WSE Max = 3594 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 157 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3700 ft.
WSE Max = 3700 ft.
Well Depth = 71 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
3765
3745
3725
3705
3685
3665
3645
3625
3605
3585
3565
3545
3525
3505
3485
3465
3445
3425
3405
3385
3365
3345
3325
3305
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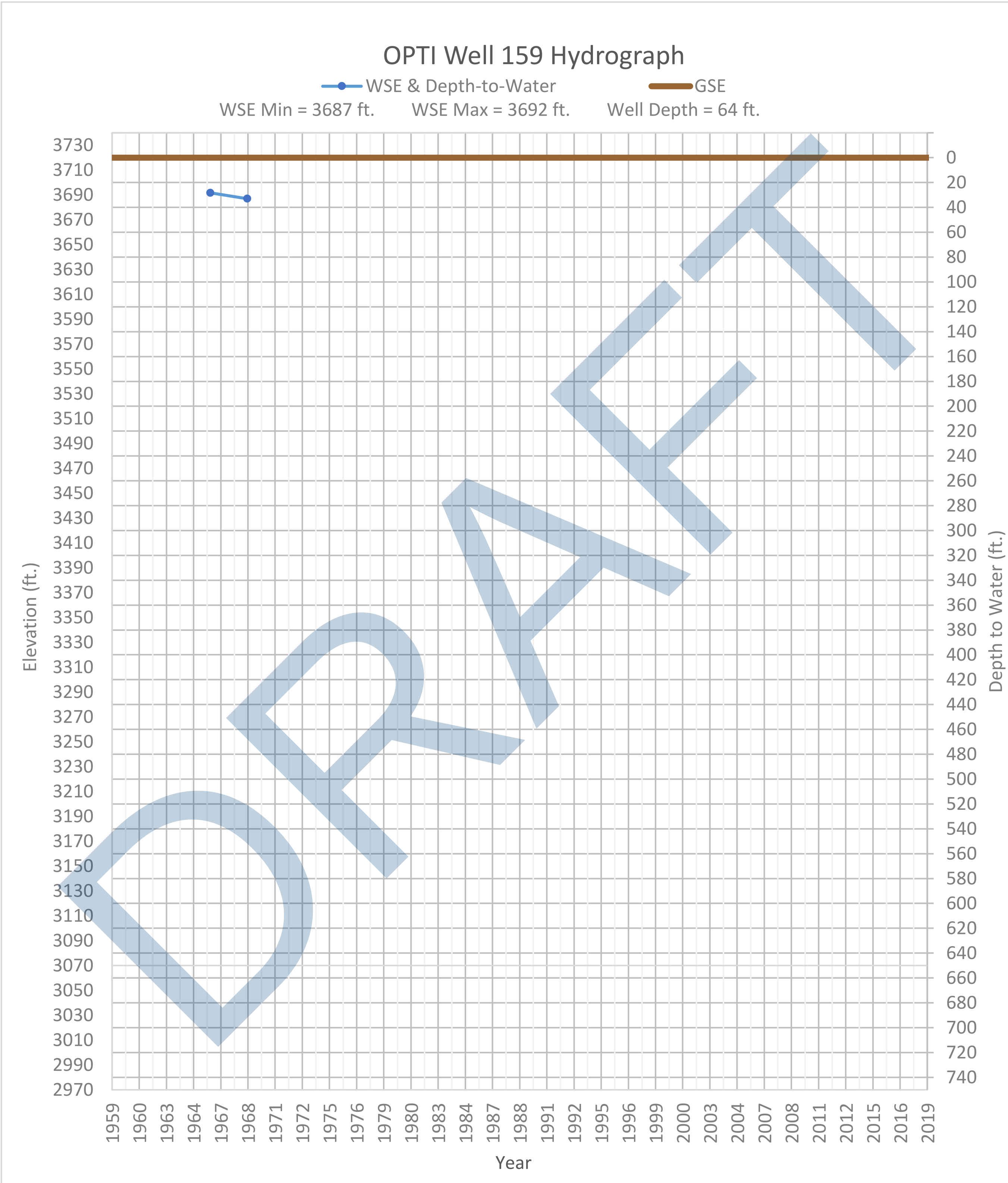
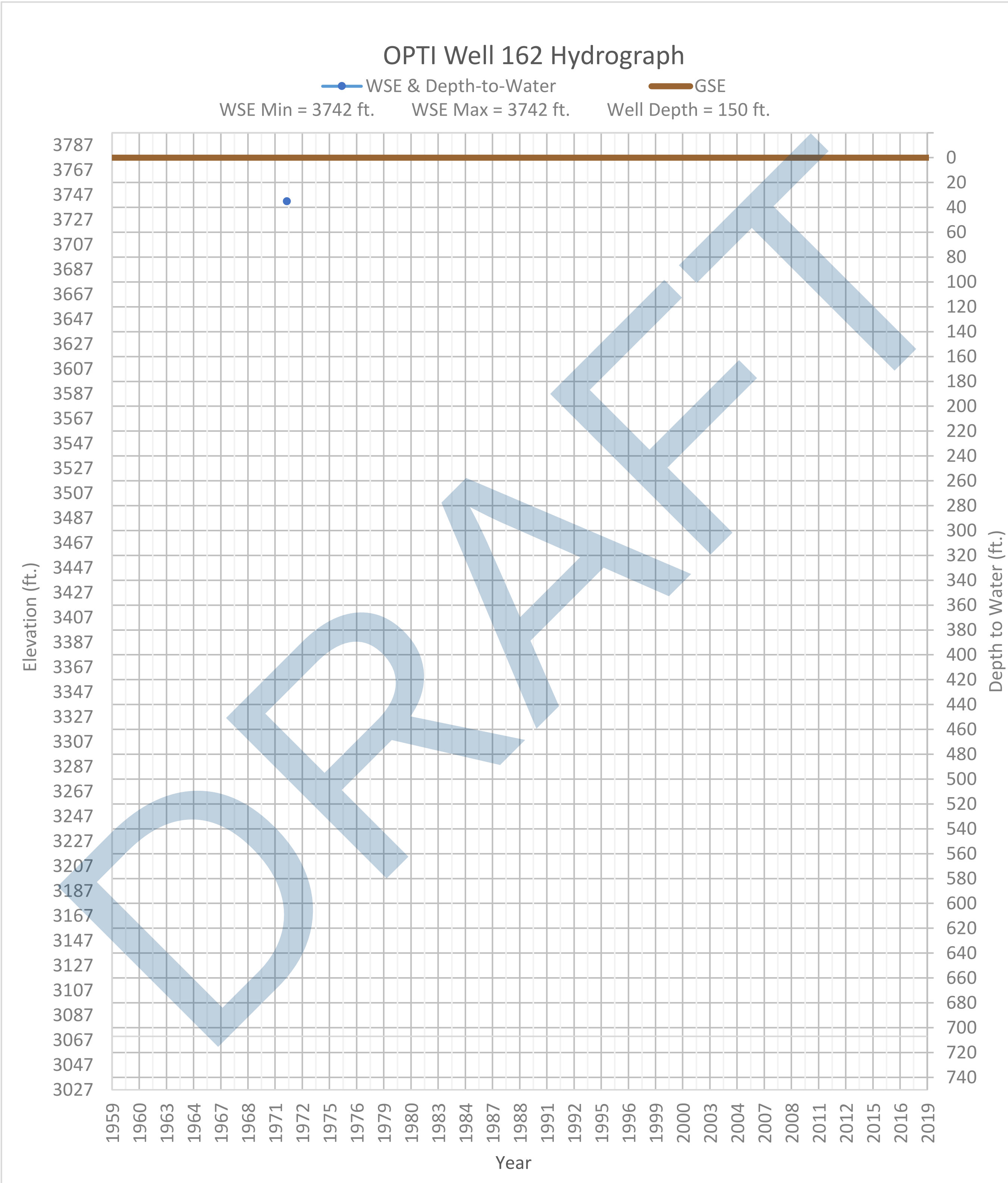


OPTI Well 159 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3687 ft.
WSE Max = 3692 ft.
Well Depth = 64 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 162 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3742 ft.
WSE Max = 3742 ft.
Well Depth = 150 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
3787
3767
3747
3727
3707
3687
3667
3647
3627
3607
3587
3567
3547
3527
3507
3487
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3407
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3167
3147
3127
3107
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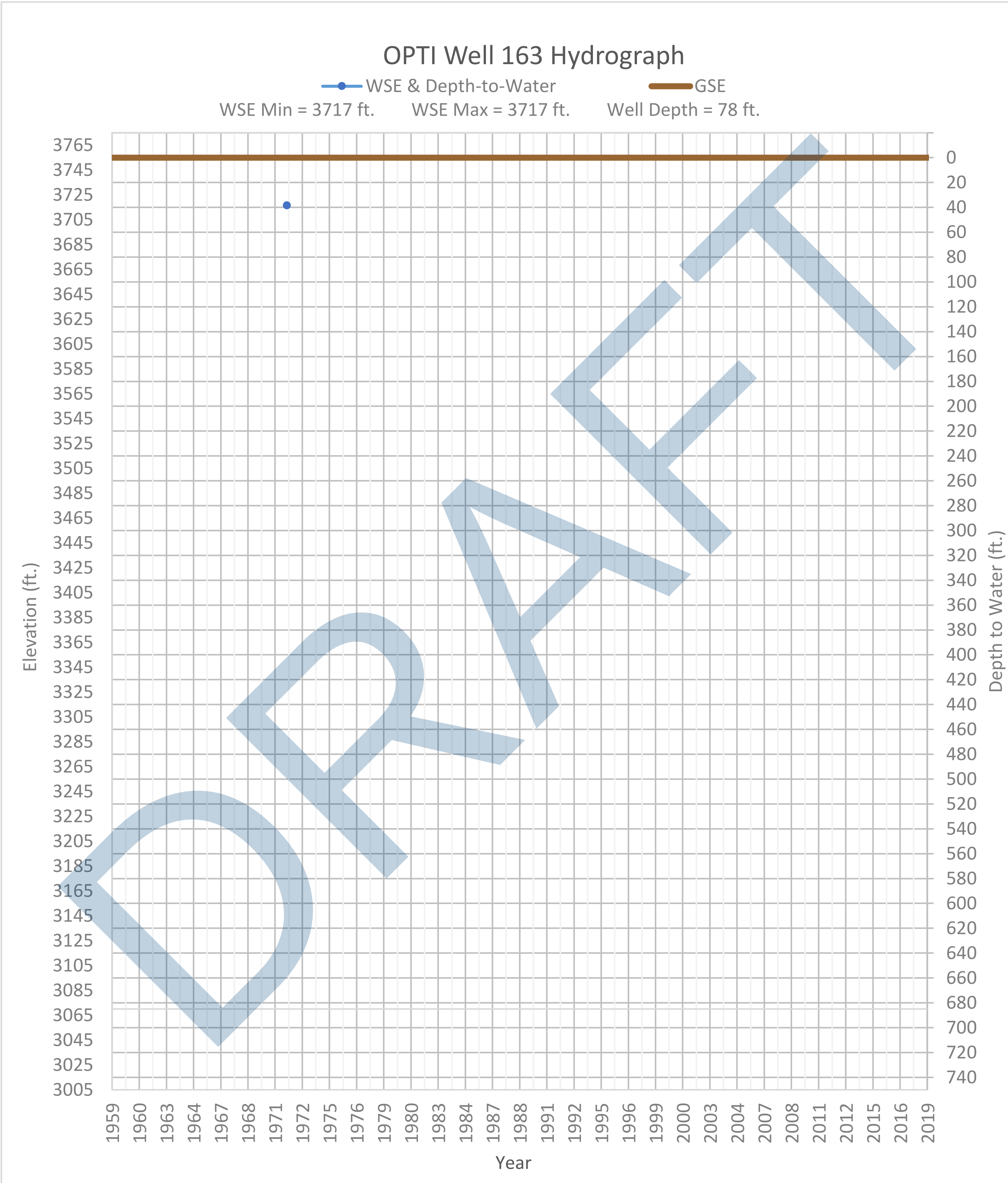
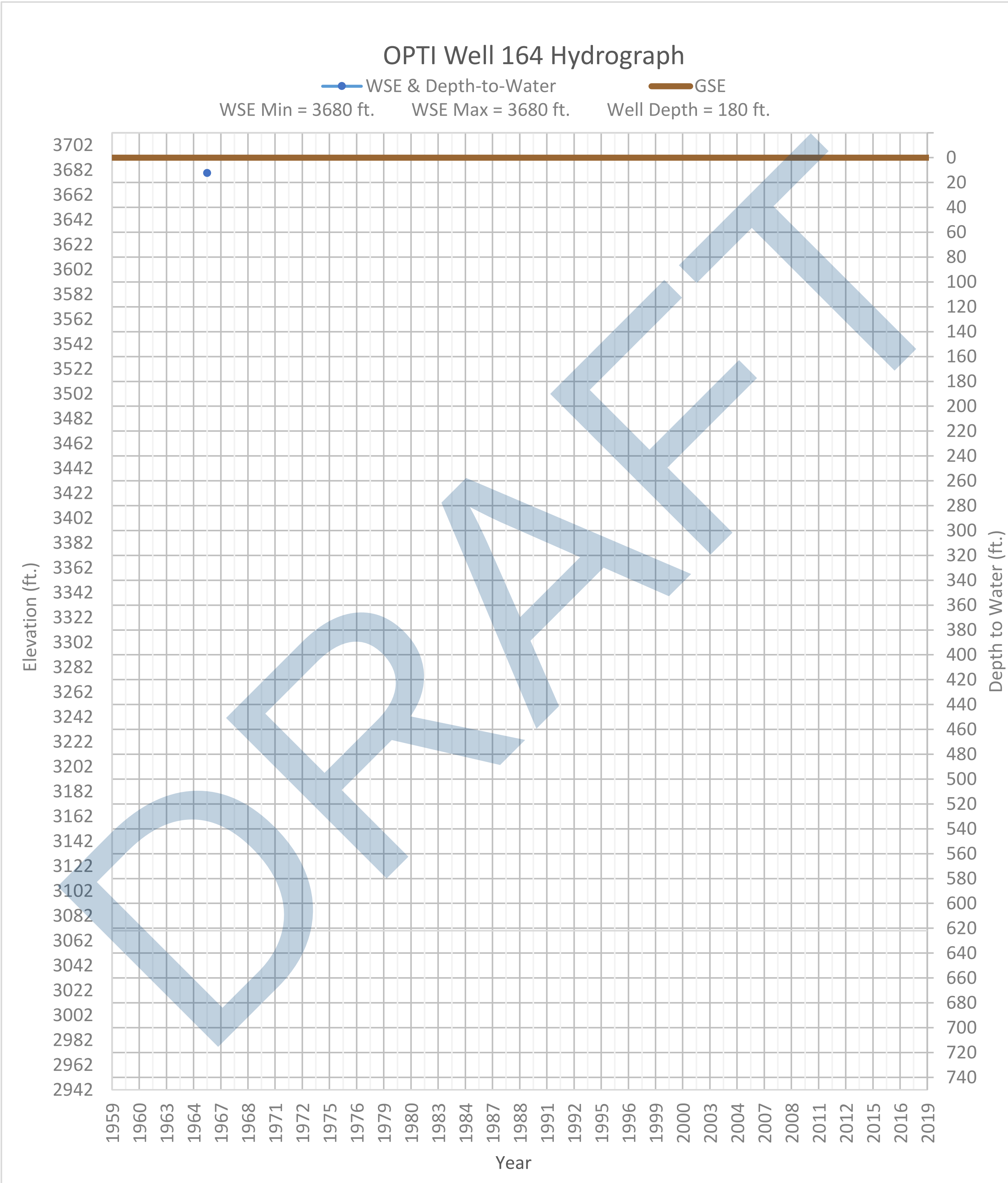
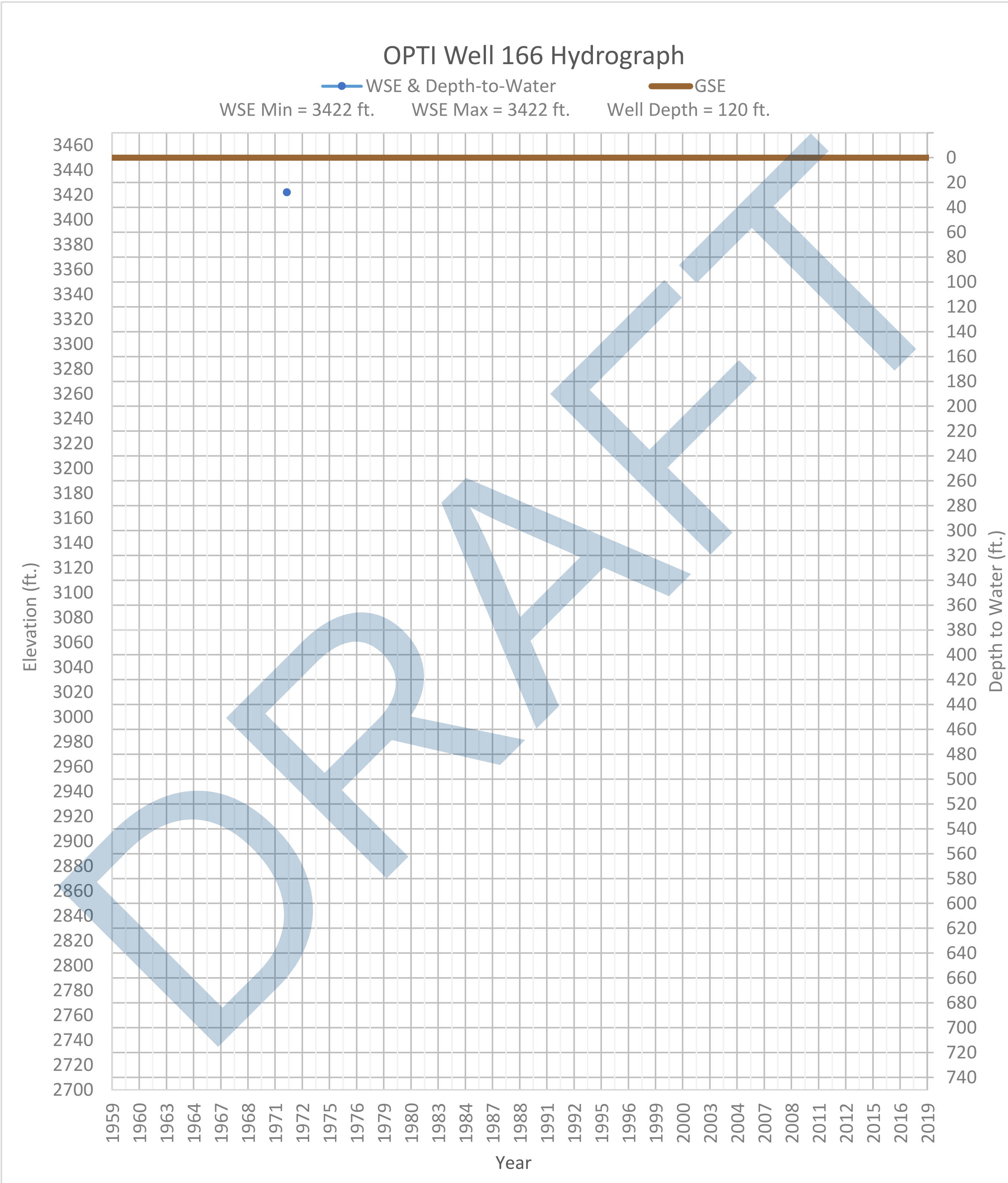
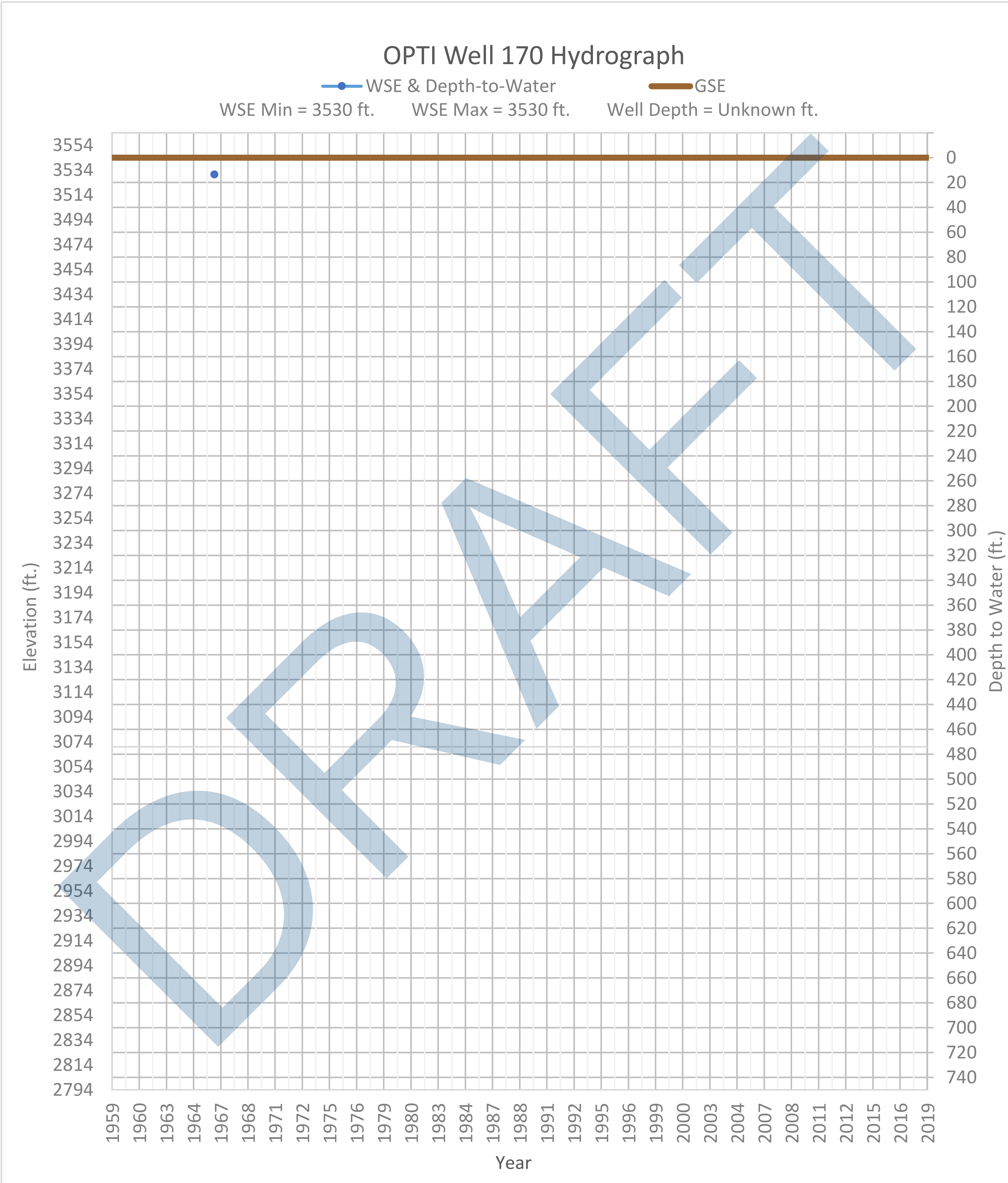

OPTI Well 163 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3717 ft.
WSE Max = 3717 ft.
Well Depth = 78 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



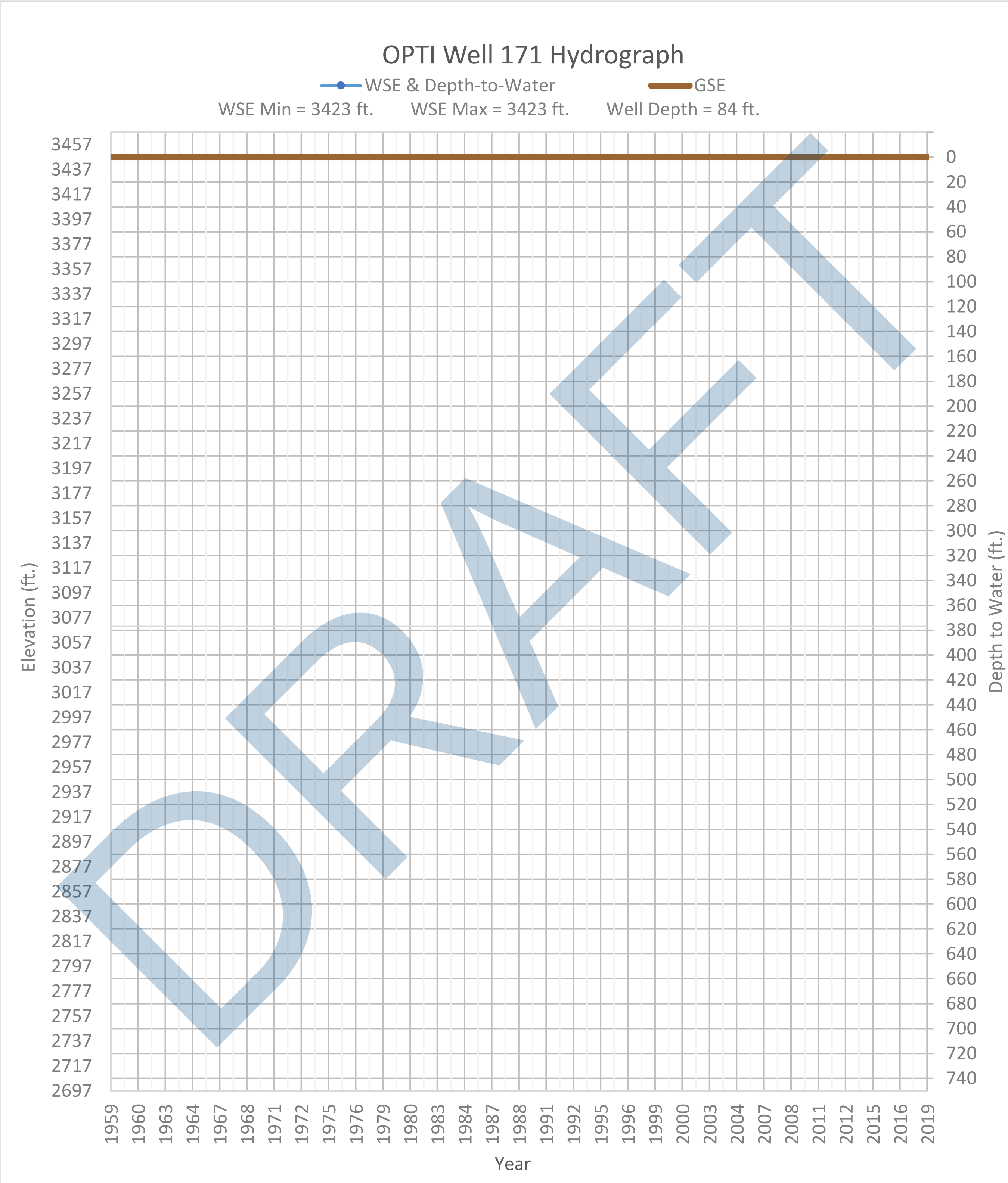
OPTI Well 164 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3680 ft.
WSE Max = 3680 ft.
Well Depth = 180 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



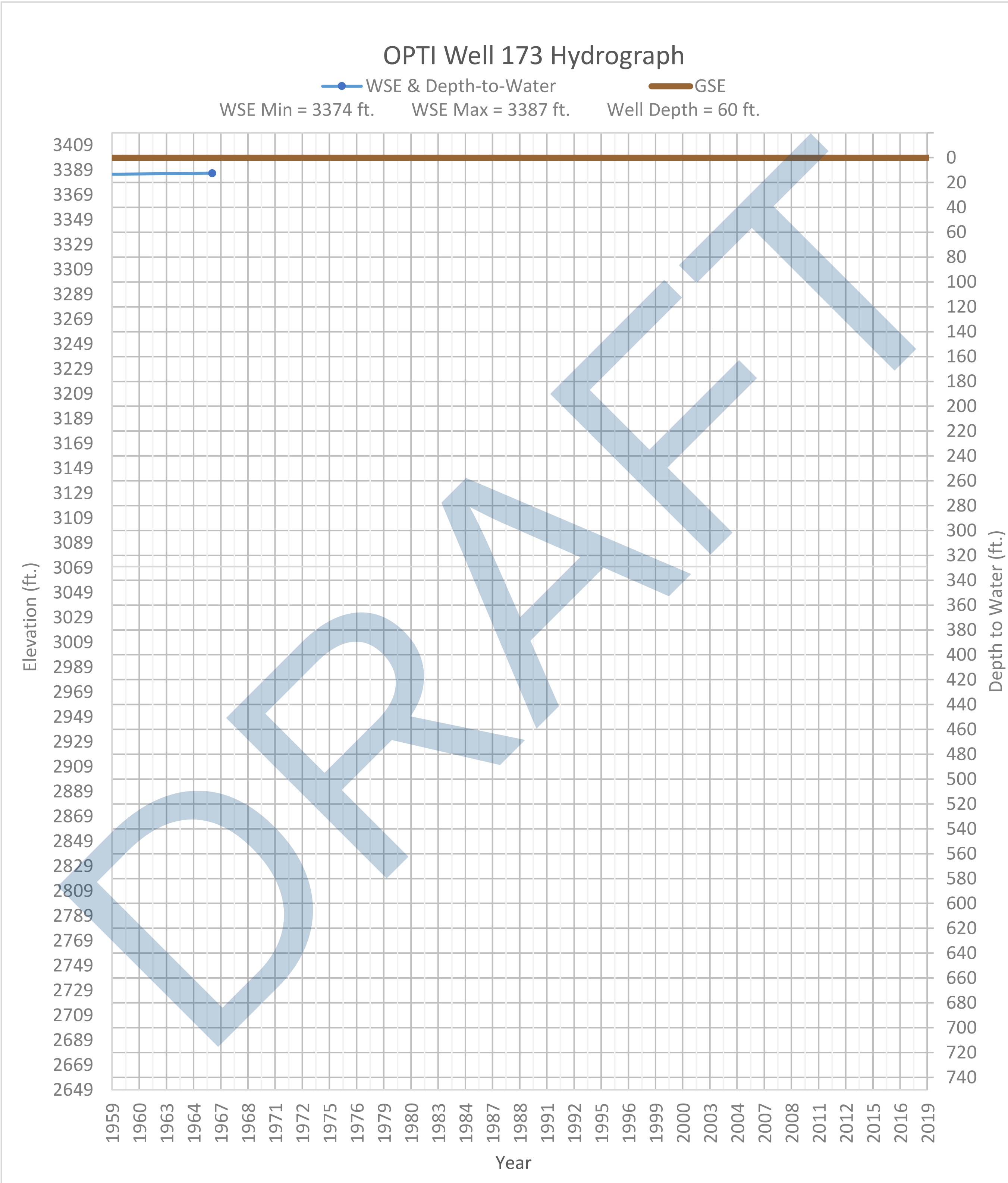
OPTI Well 166 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3422 ft.
WSE Max = 3422 ft.
Well Depth = 120 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



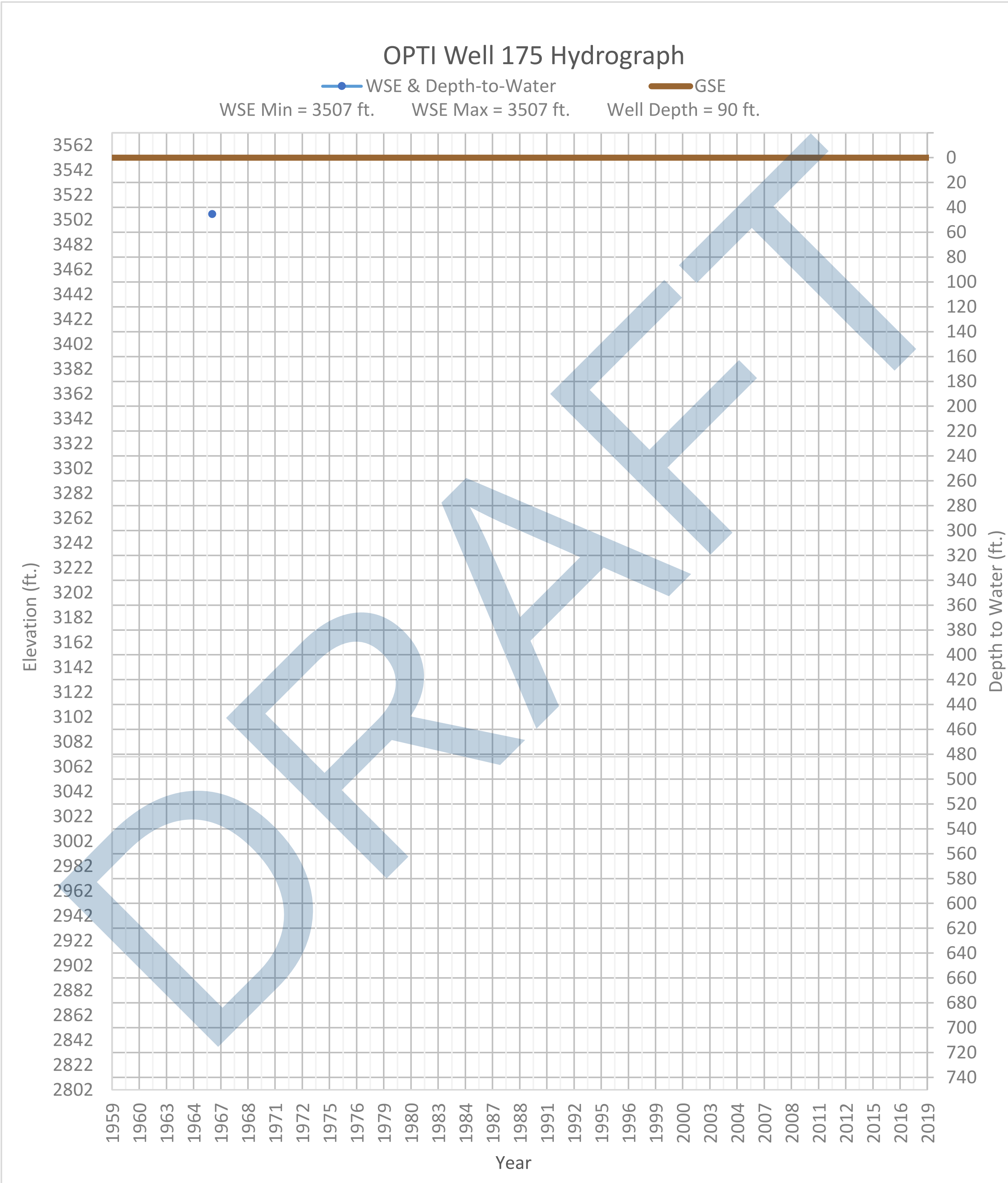
OPTI Well 170 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3530 ft.
WSE Max = 3530 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



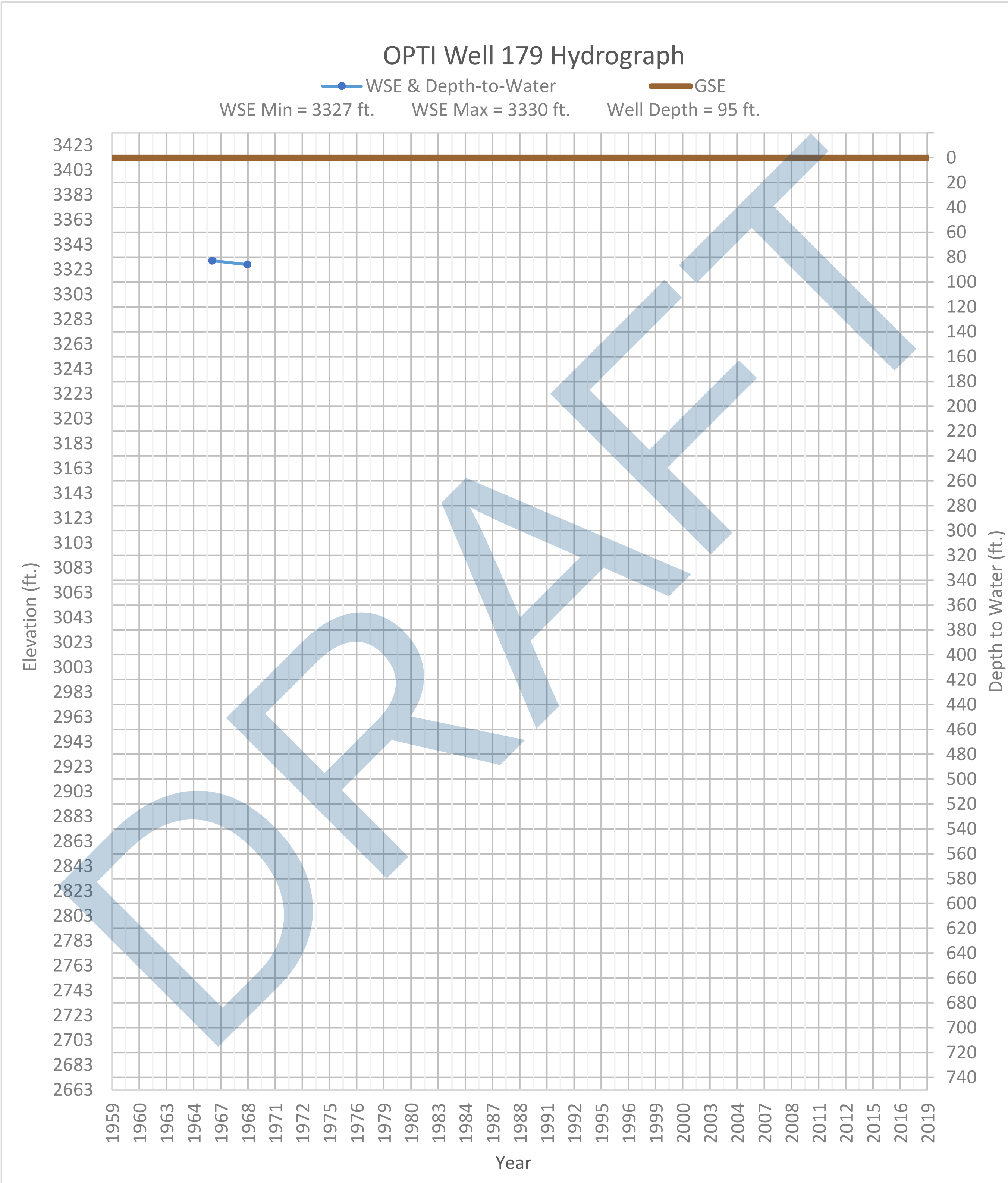
OPTI Well 171 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3423 ft.
WSE Max = 3423 ft.
Well Depth = 84 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



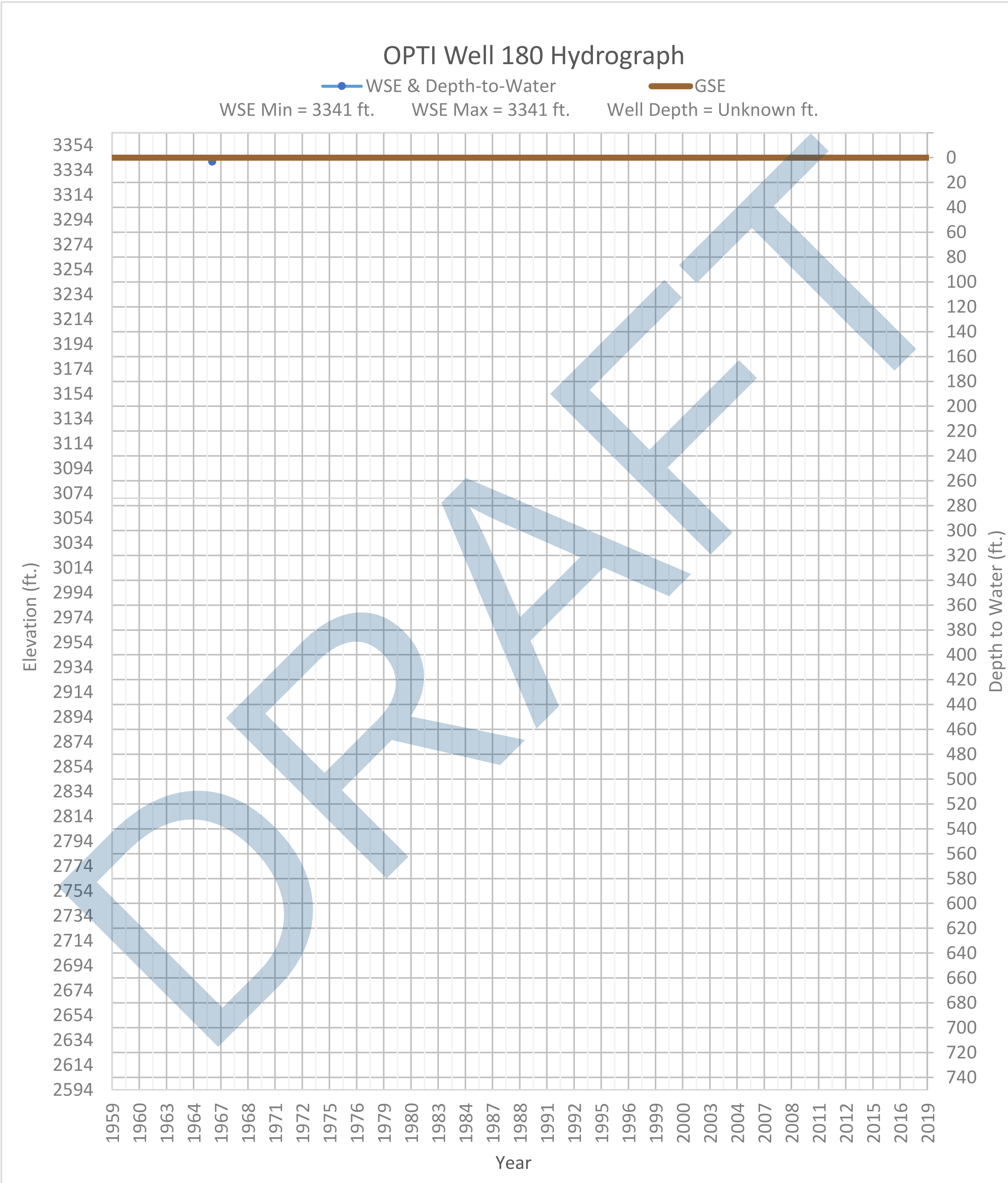
OPTI Well 173 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3374 ft.
WSE Max = 3387 ft.
Well Depth = 60 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 175 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3507 ft.
WSE Max = 3507 ft.
Well Depth = 90 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 179 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3327 ft.
WSE Max = 3330 ft.
Well Depth = 95 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 180 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3341 ft.
WSE Max = 3341 ft.
Well Depth = Unknown ft.
Elevation (ft.)
3354
3334
3314
3294
3274
3254
3234
3214
3194
3174
3154
3134
3114
3094
3074
3054
3034
3014
2994
2974
2954
2934
2914
2894
2874
2854
2834
2814
2794
2774
2754
2734
2714
2694
2674
2654
2634
2614
2594
Depth to Water (ft.)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
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Year
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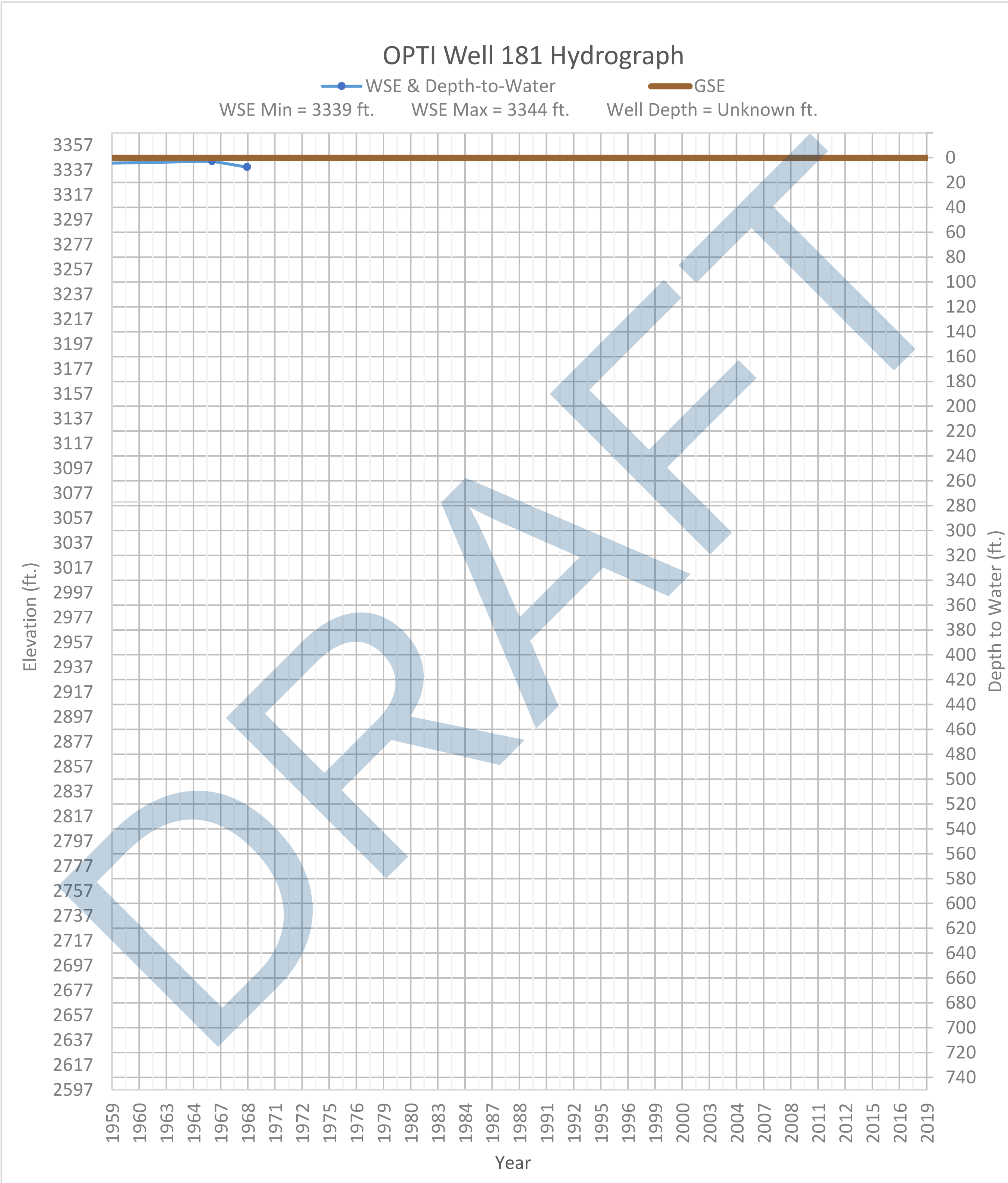
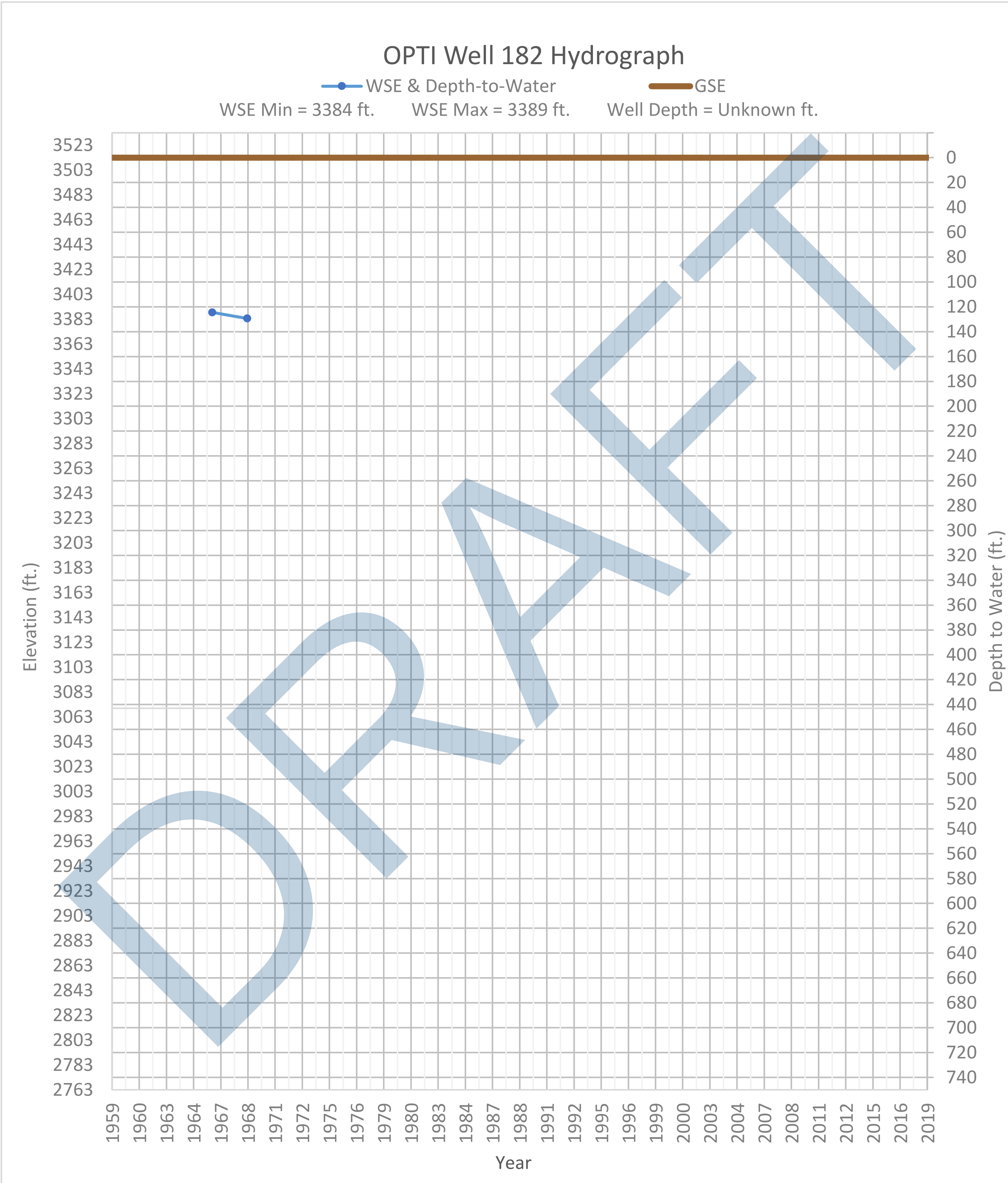
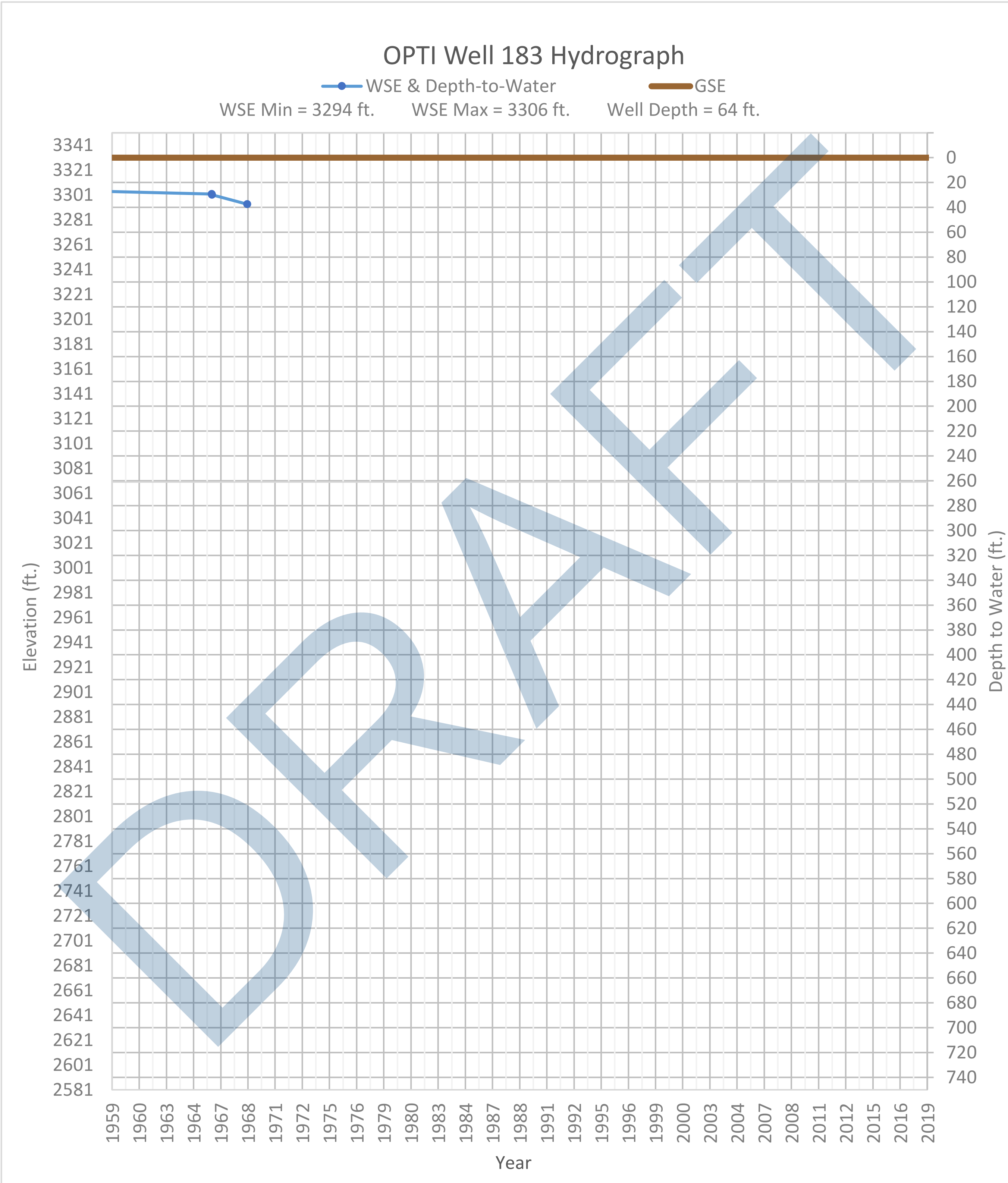
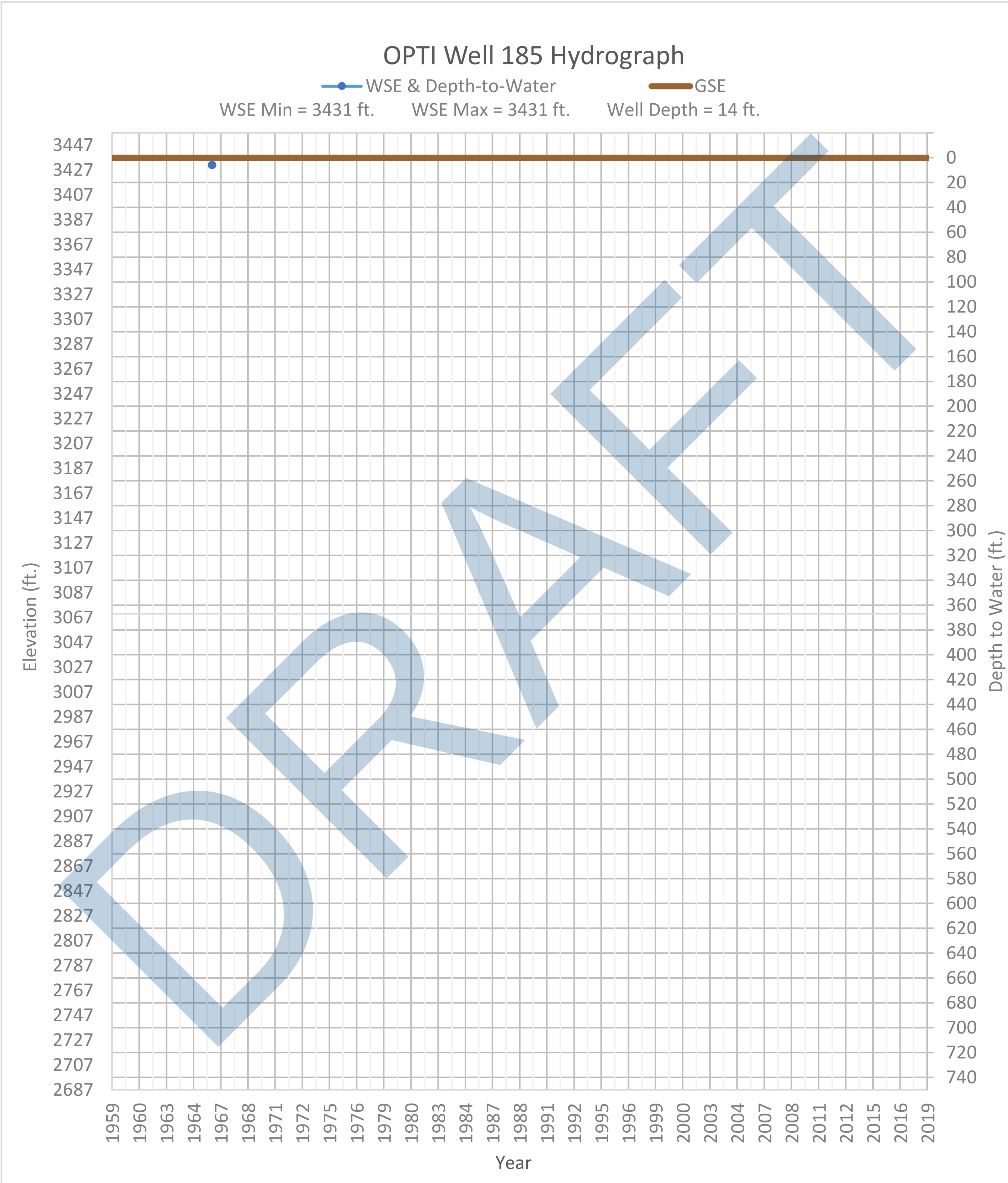


OPTI Well 181 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3339 ft.
WSE Max = 3344 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

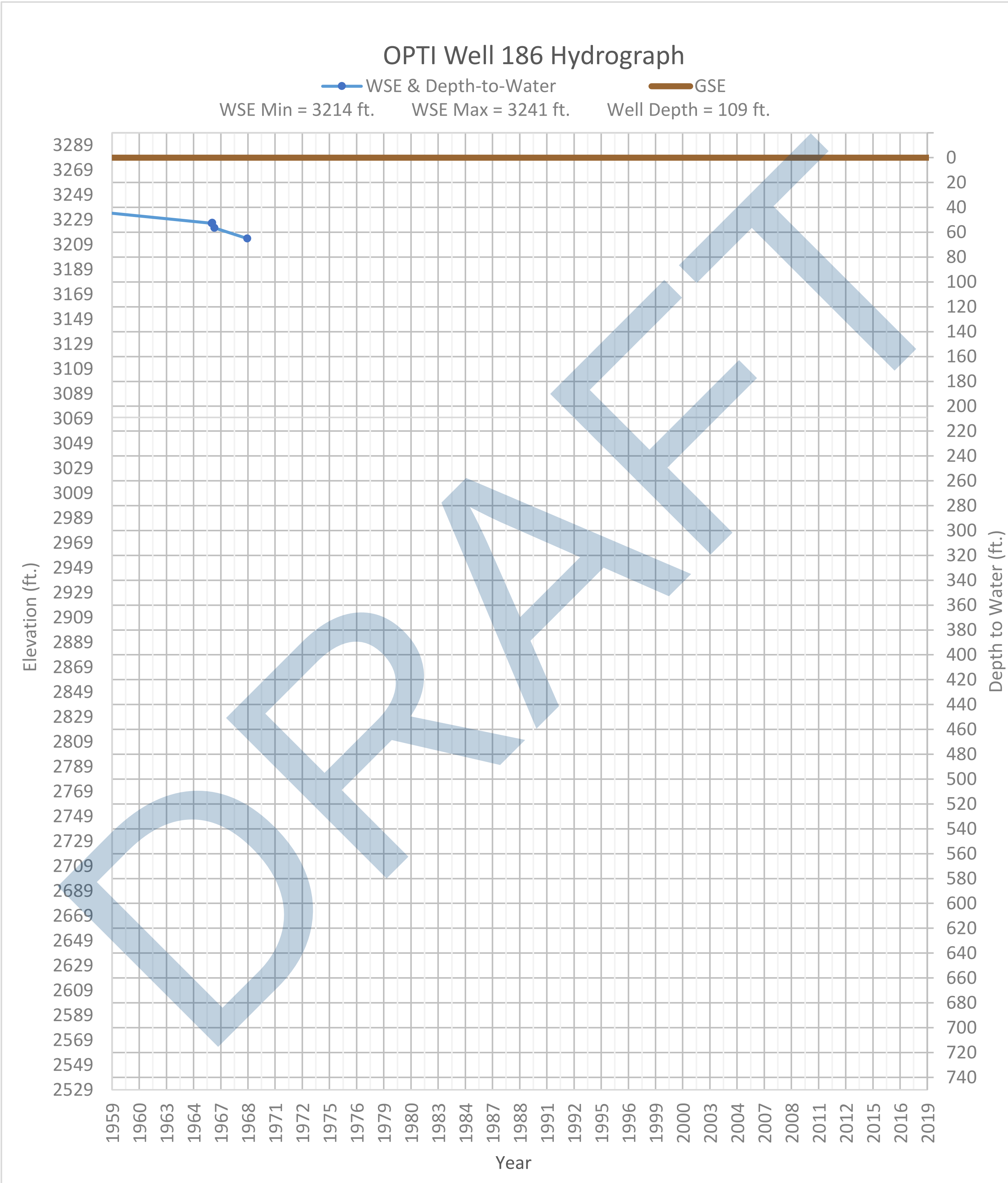

OPTI Well 182 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3384 ft.
WSE Max = 3389 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

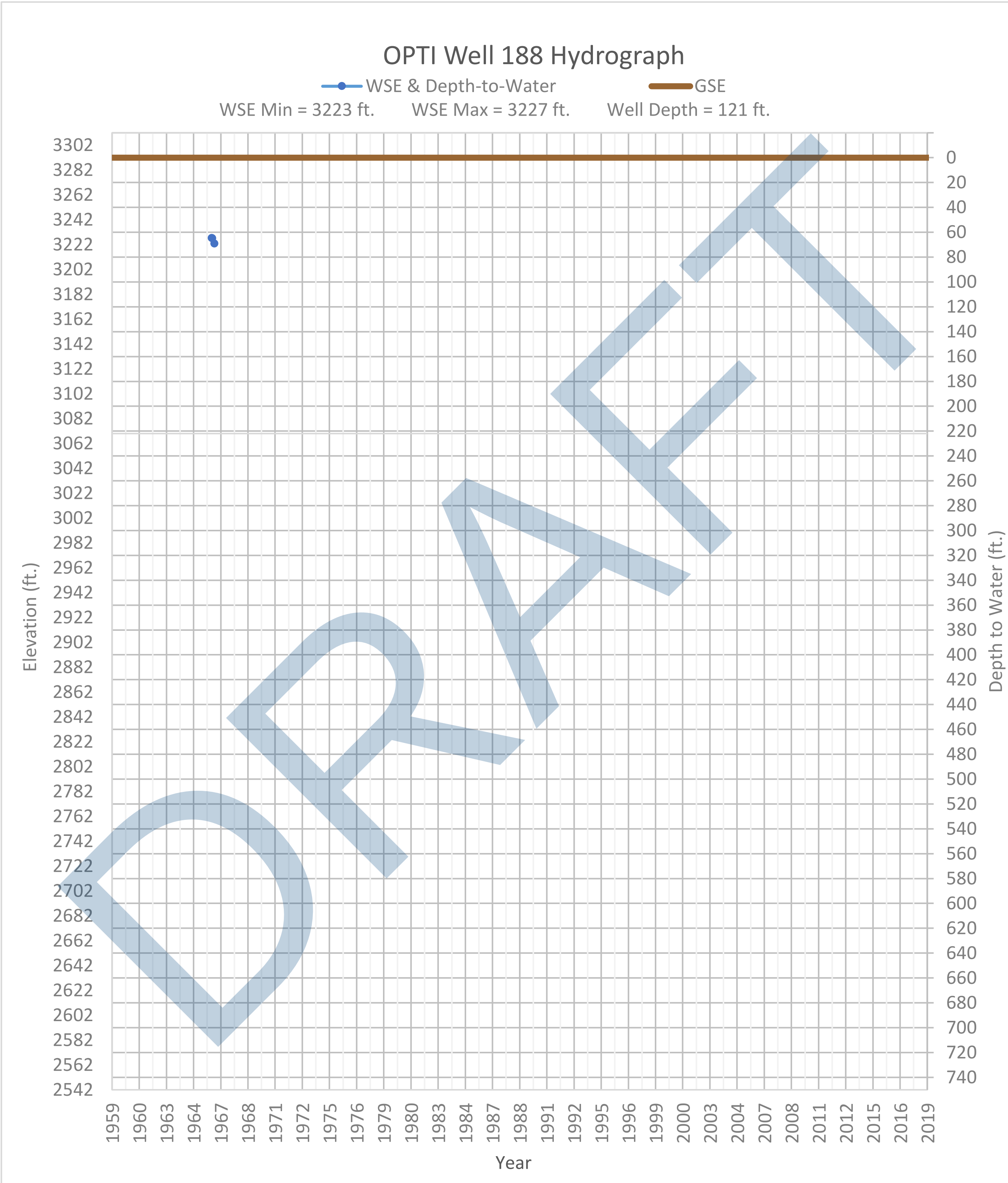


OPTI Well 183 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3294 ft.
WSE Max = 3306 ft.
Well Depth = 64 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

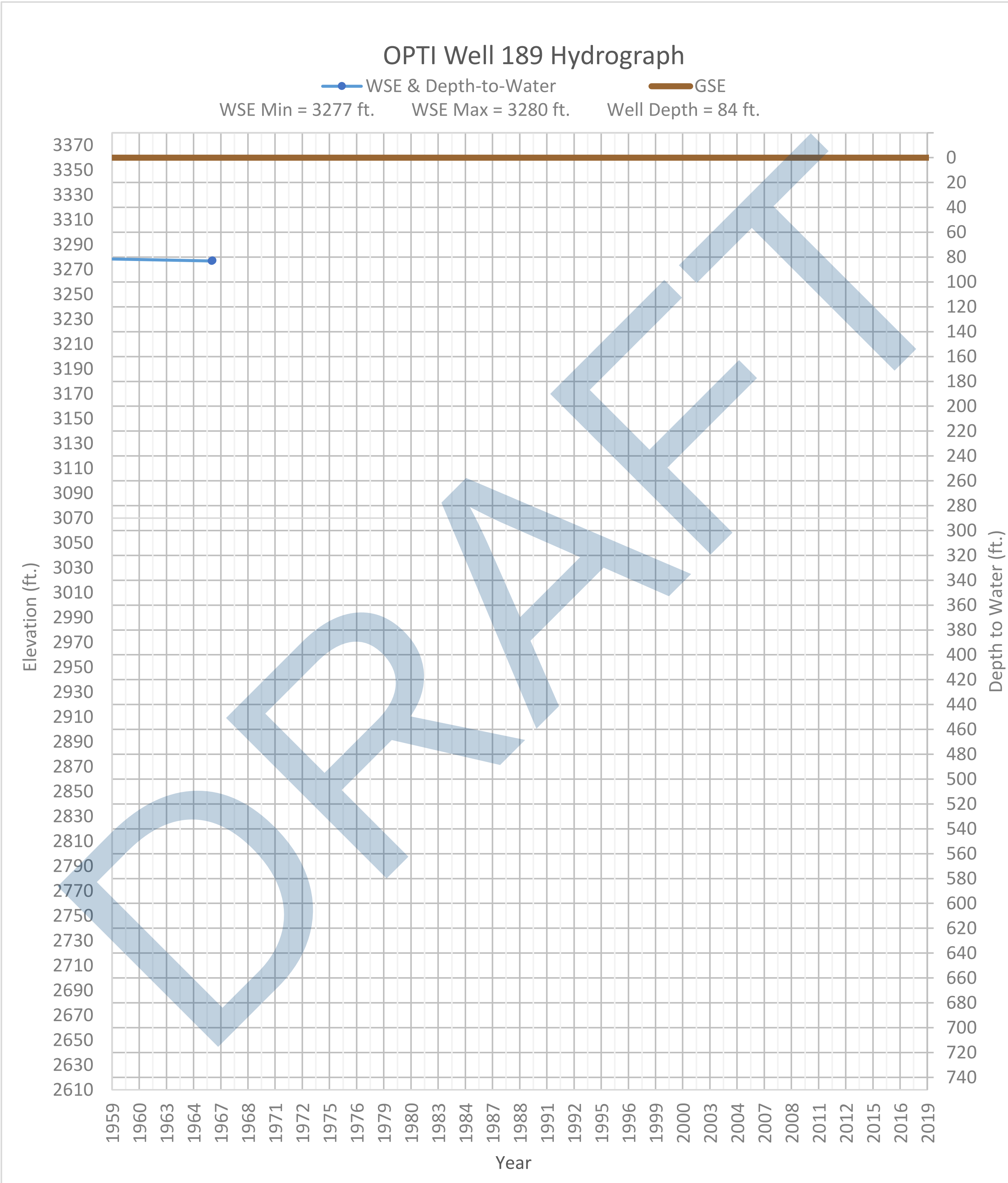


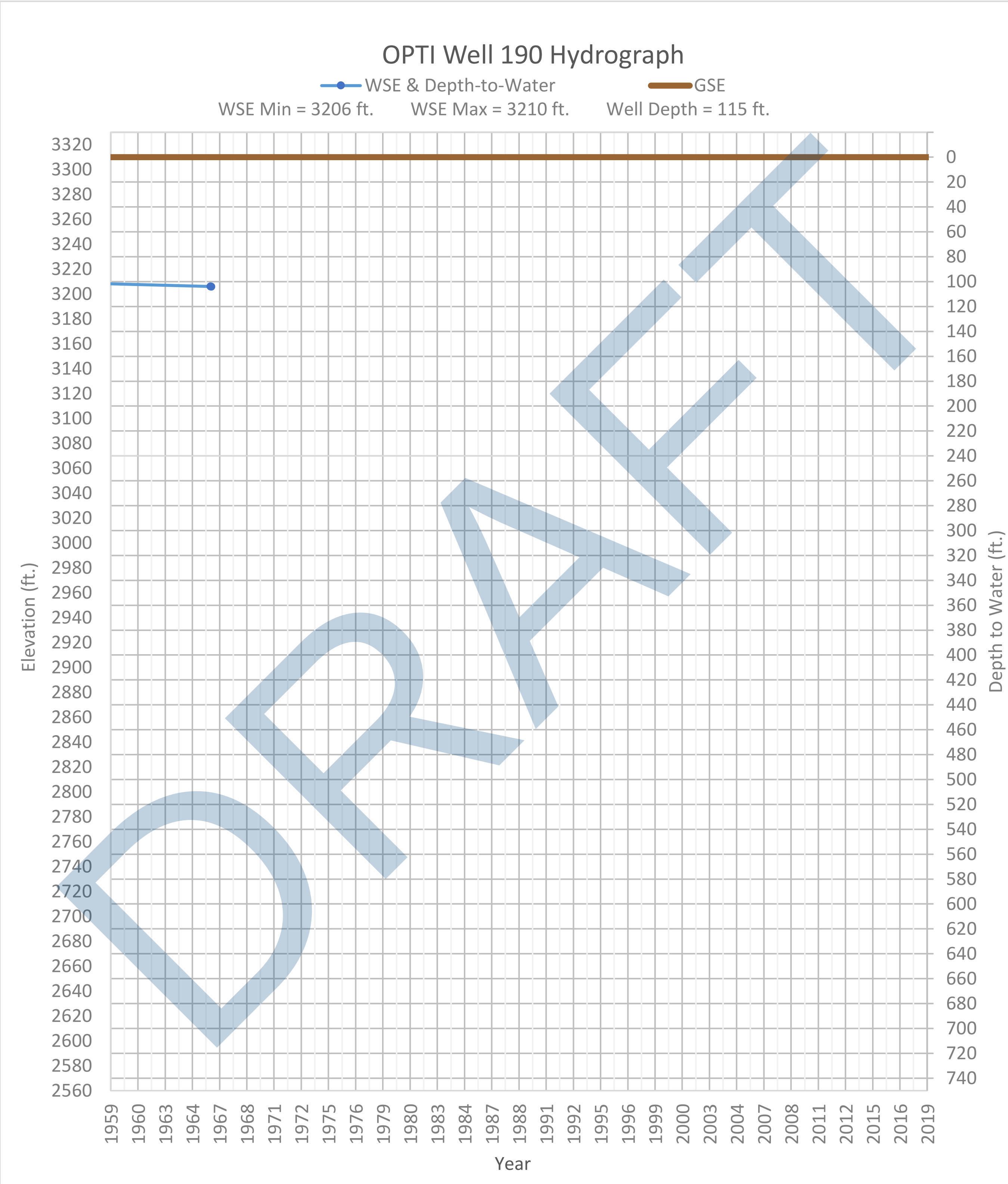
OPTI Well 185 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3431 ft.
WSE Max = 3431 ft.
Well Depth = 14 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 186 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3214 ft.
WSE Max = 3241 ft.
Well Depth = 109 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

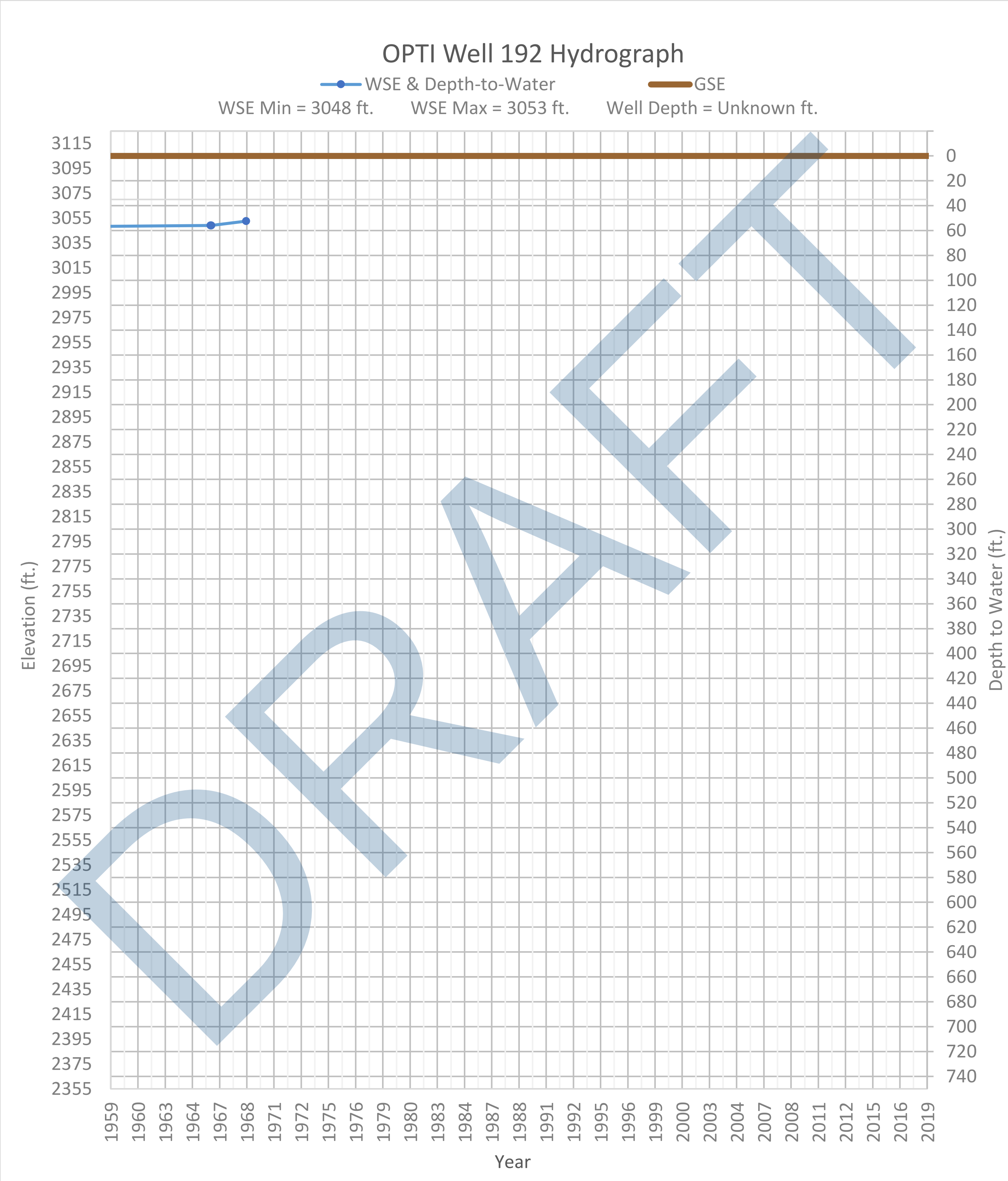


OPTI Well 188 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3223 ft.
WSE Max = 3227 ft.
Well Depth = 121 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

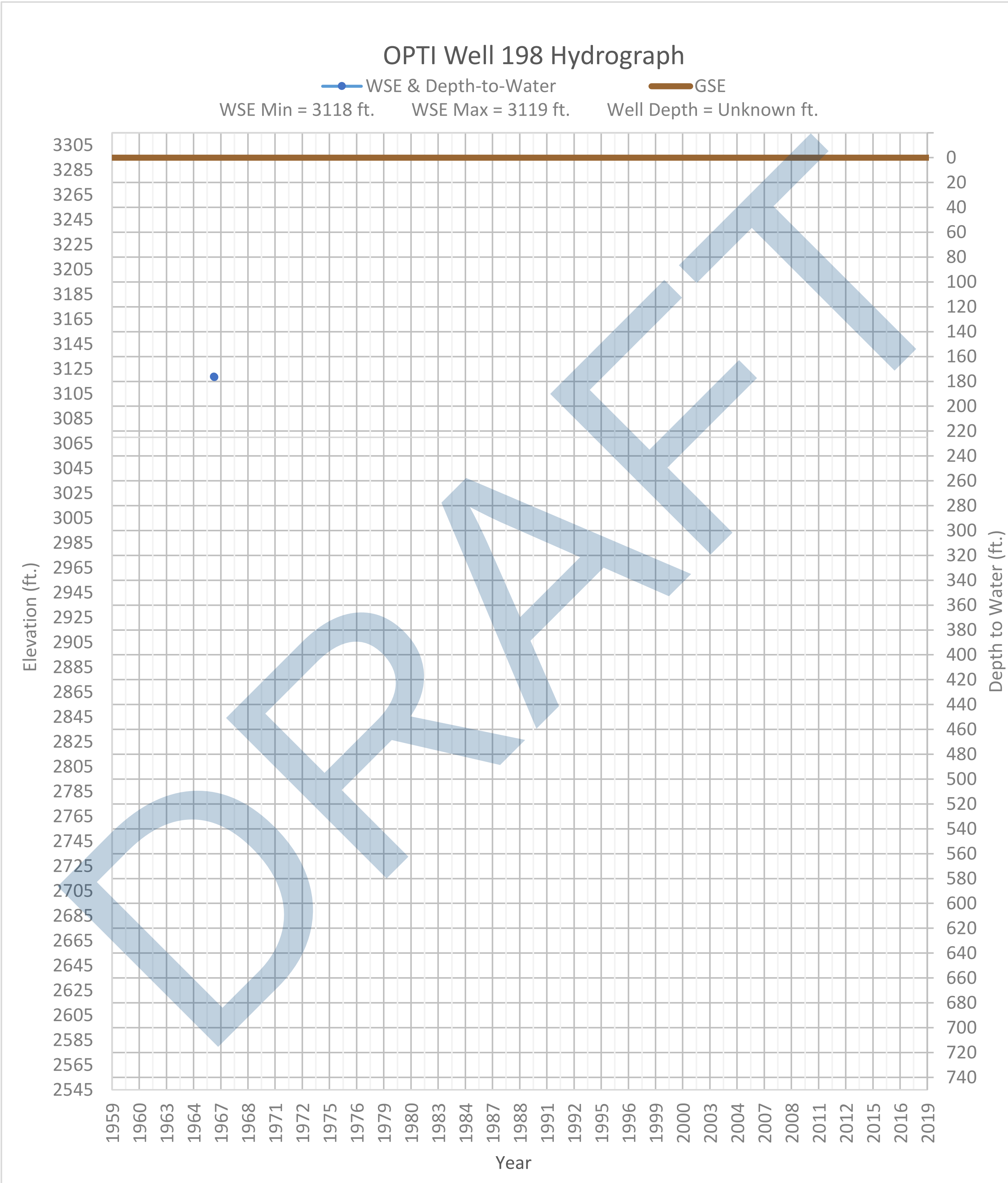

OPTI Well 189 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3277 ft.
WSE Max = 3280 ft.
Well Depth = 84 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 190 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3206 ft.
WSE Max = 3210 ft.
Well Depth = 115 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 192 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3048 ft.
WSE Max = 3053 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 198 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3118 ft.
WSE Max = 3119 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
3305
3285
3265
3245
3225
3205
3185
3165
3145
3125
3105
3085
3065
3045
3025
3005
2985
2965
2945
2925
2905
2885
2865
2845
2825
2805
2785
2765
2745
2725
2705
2685
2665
2645
2625
2605
2585
2565
2545
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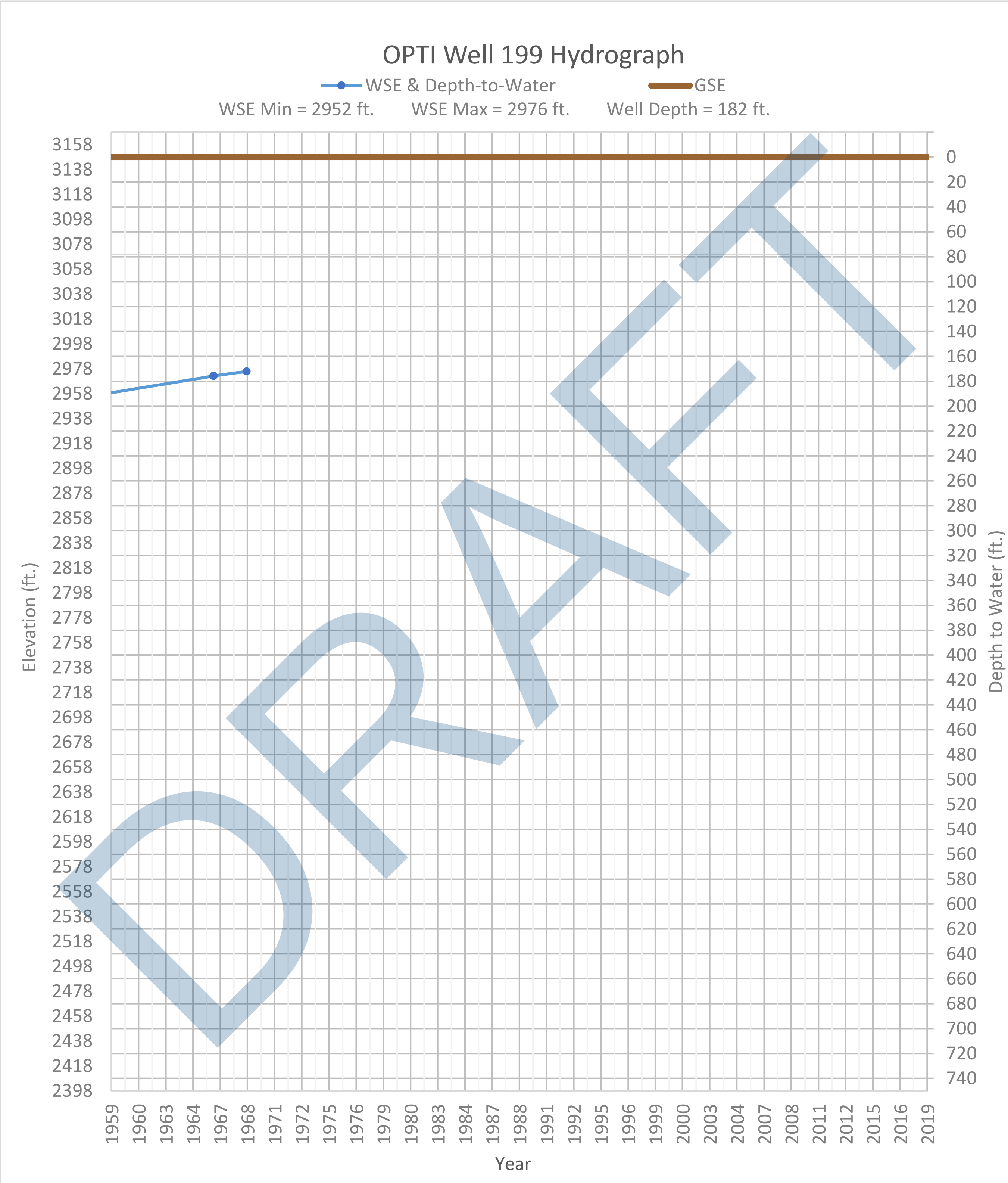
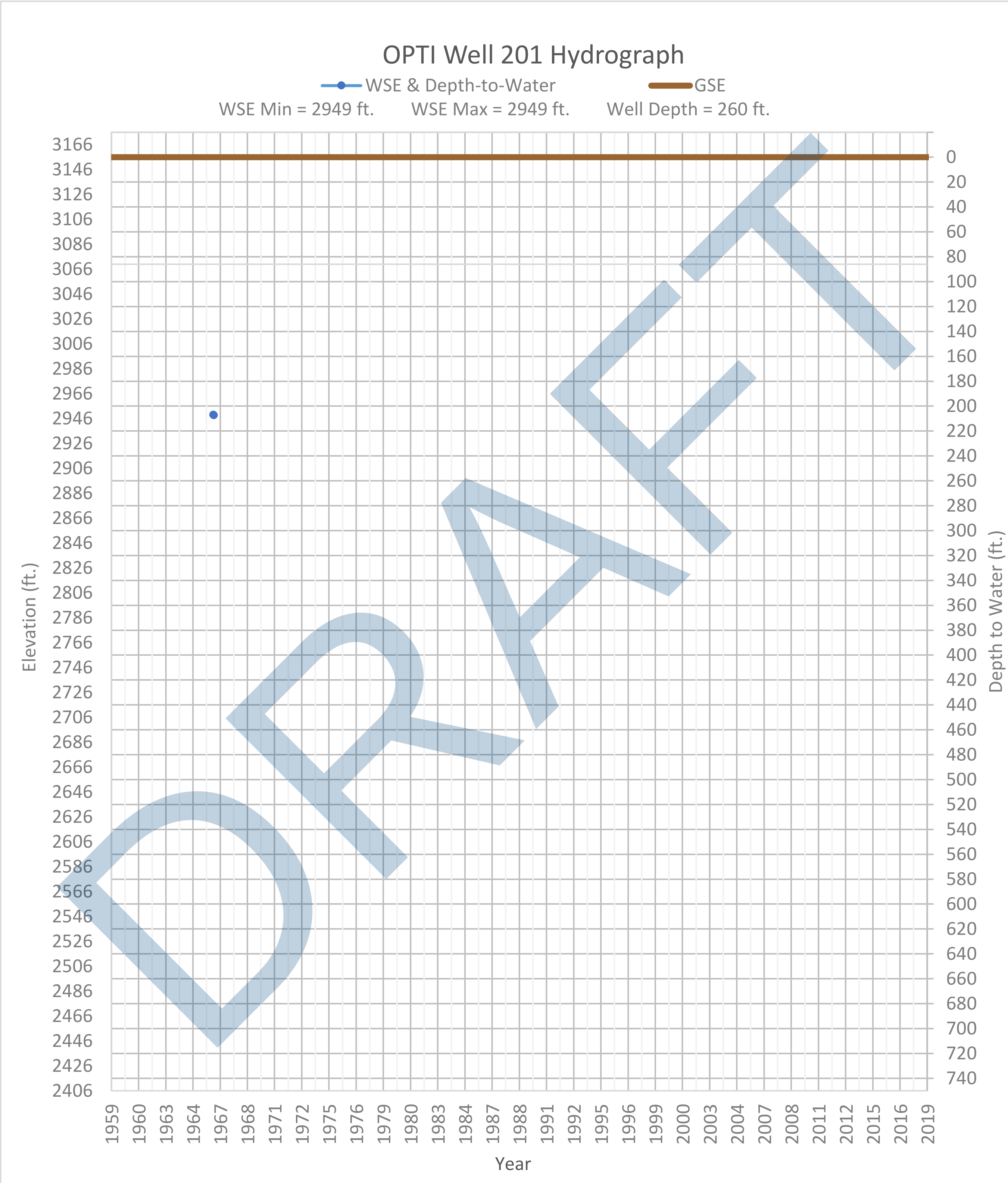
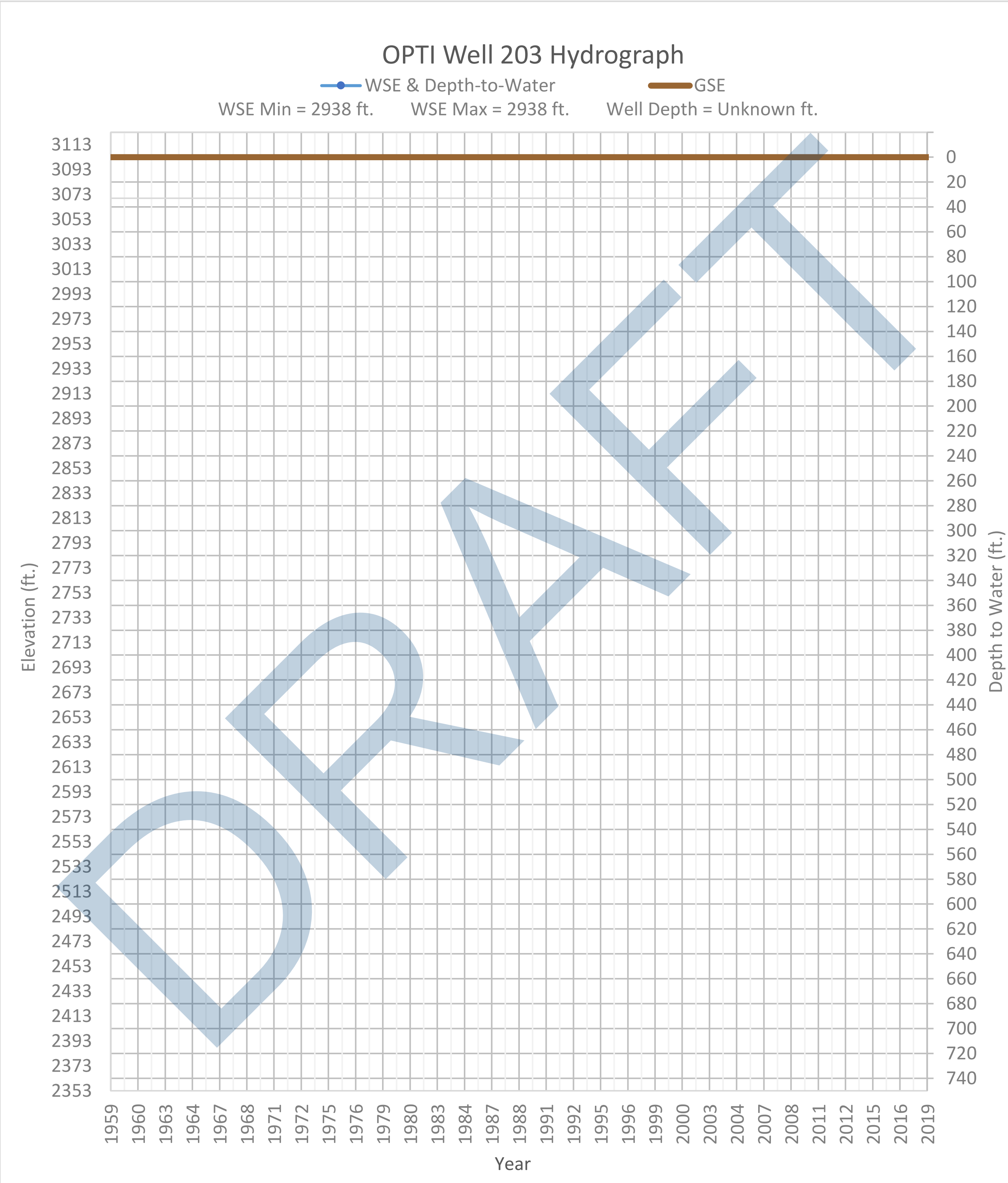

OPTI Well 199 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2952 ft.
WSE Max = 2976 ft.
Well Depth = 182 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 201 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2949 ft.
WSE Max = 2949 ft.
Well Depth = 260 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 203 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2938 ft.
WSE Max = 2938 ft.
Well Depth = Unknown ft.
Elevation (ft.)
3113
3093
3073
3053
3033
3013
2993
2973
2953
2933
2913
2893
2873
2853
2833
2813
2793
2773
2753
2733
2713
2693
2673
2653
2633
2613
2593
2573
2553
2533
2513
2493
2473
2453
2433
2413
2393
2373
2353
Depth to Water (ft.)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
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Year
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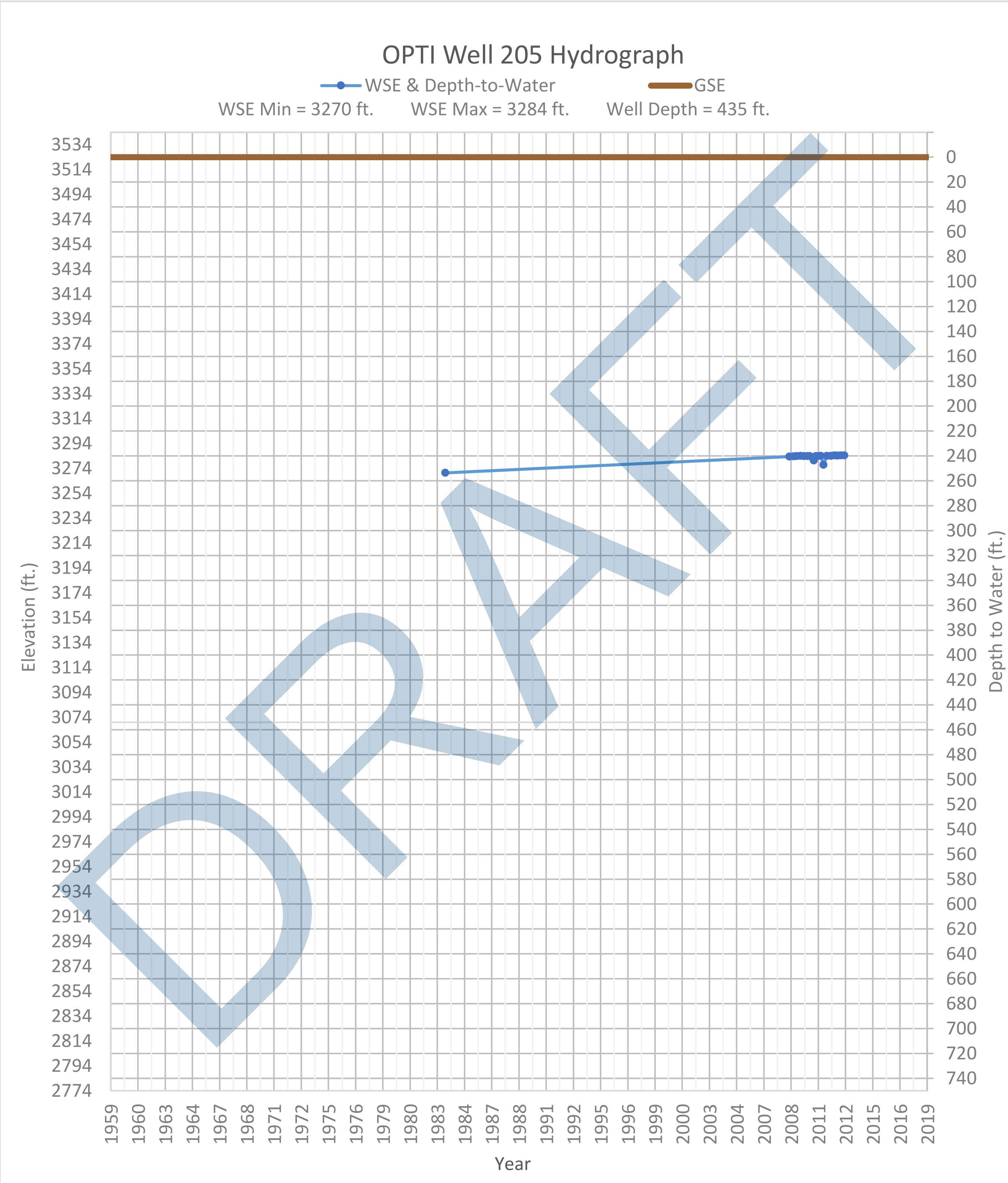
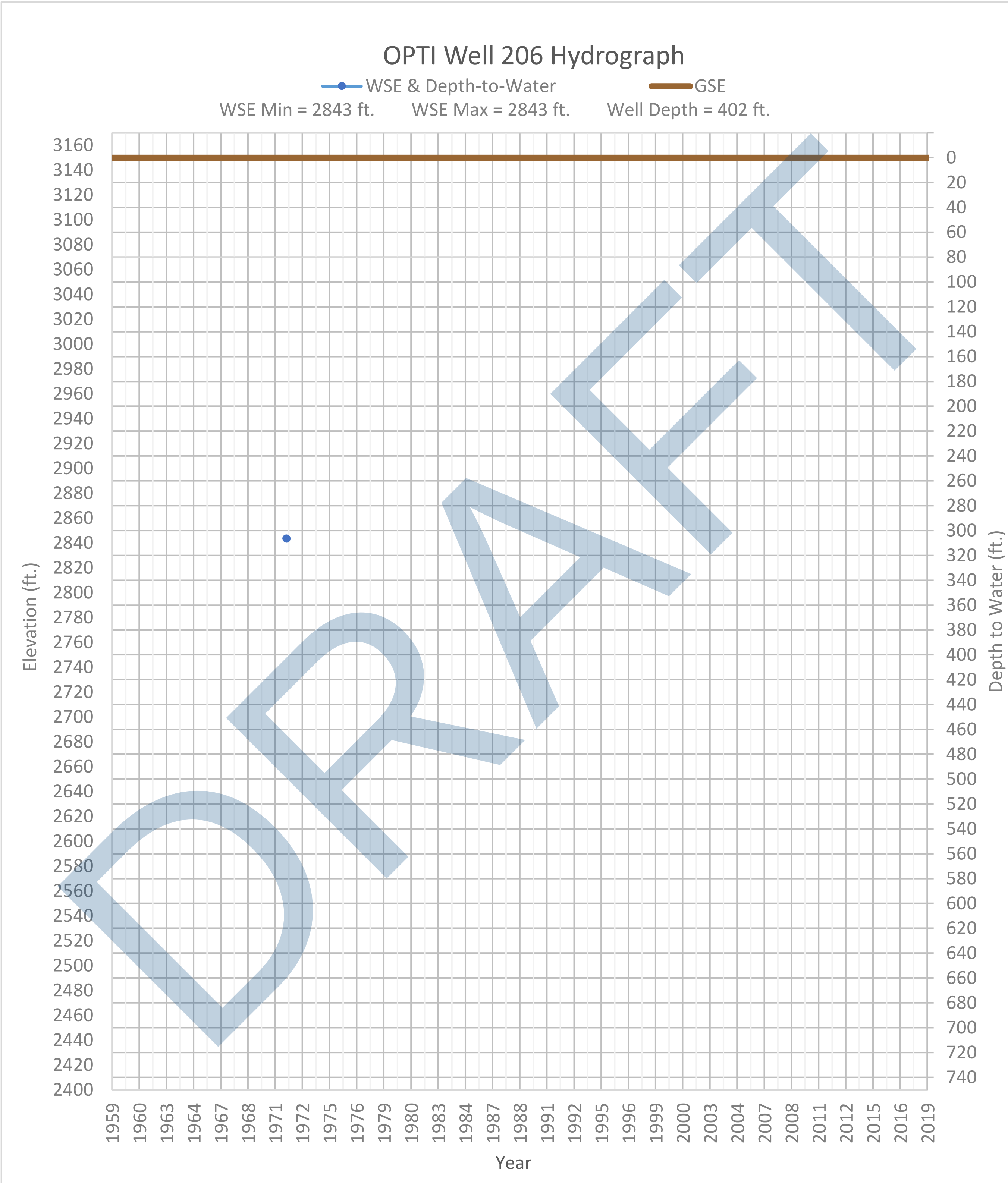
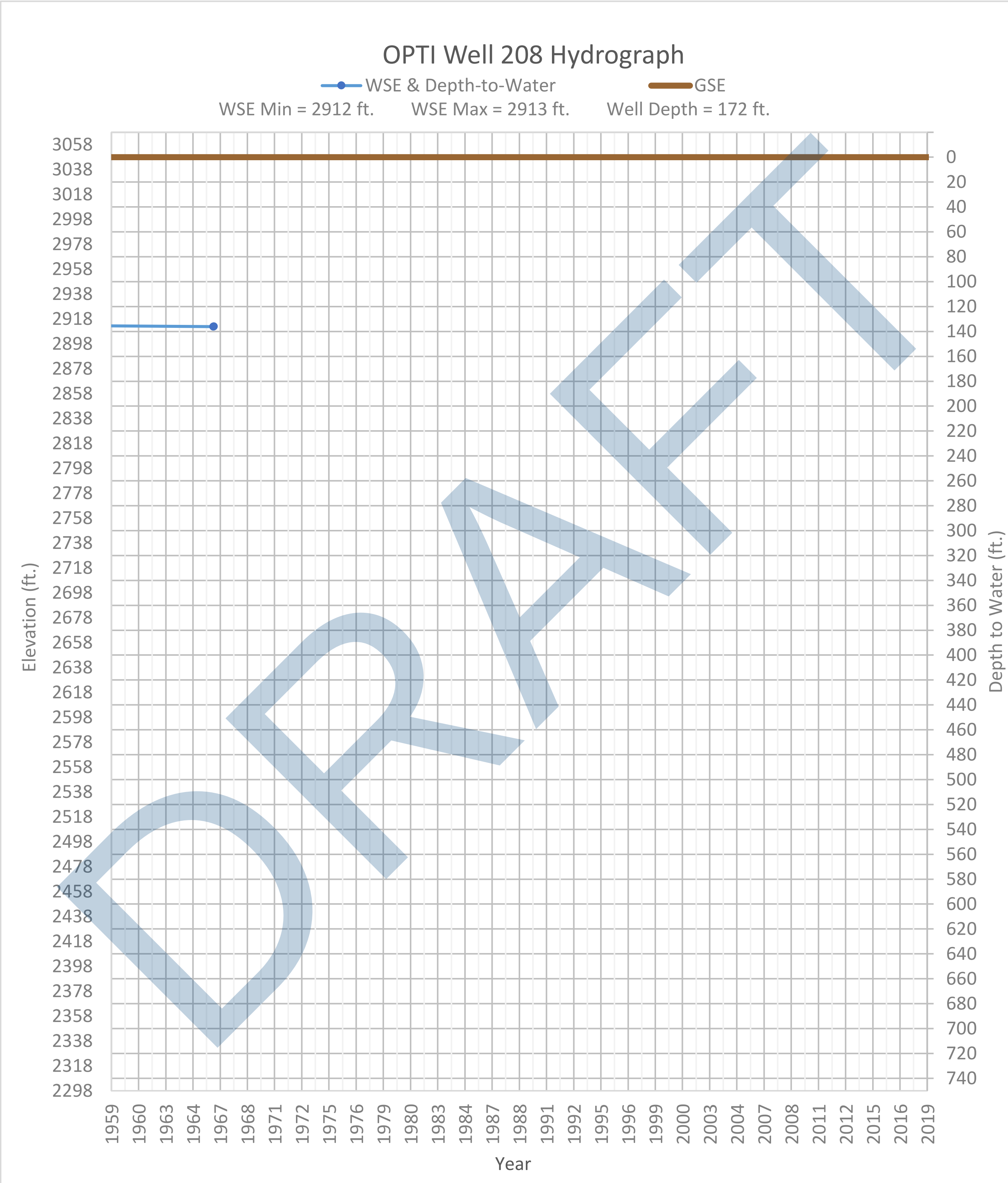


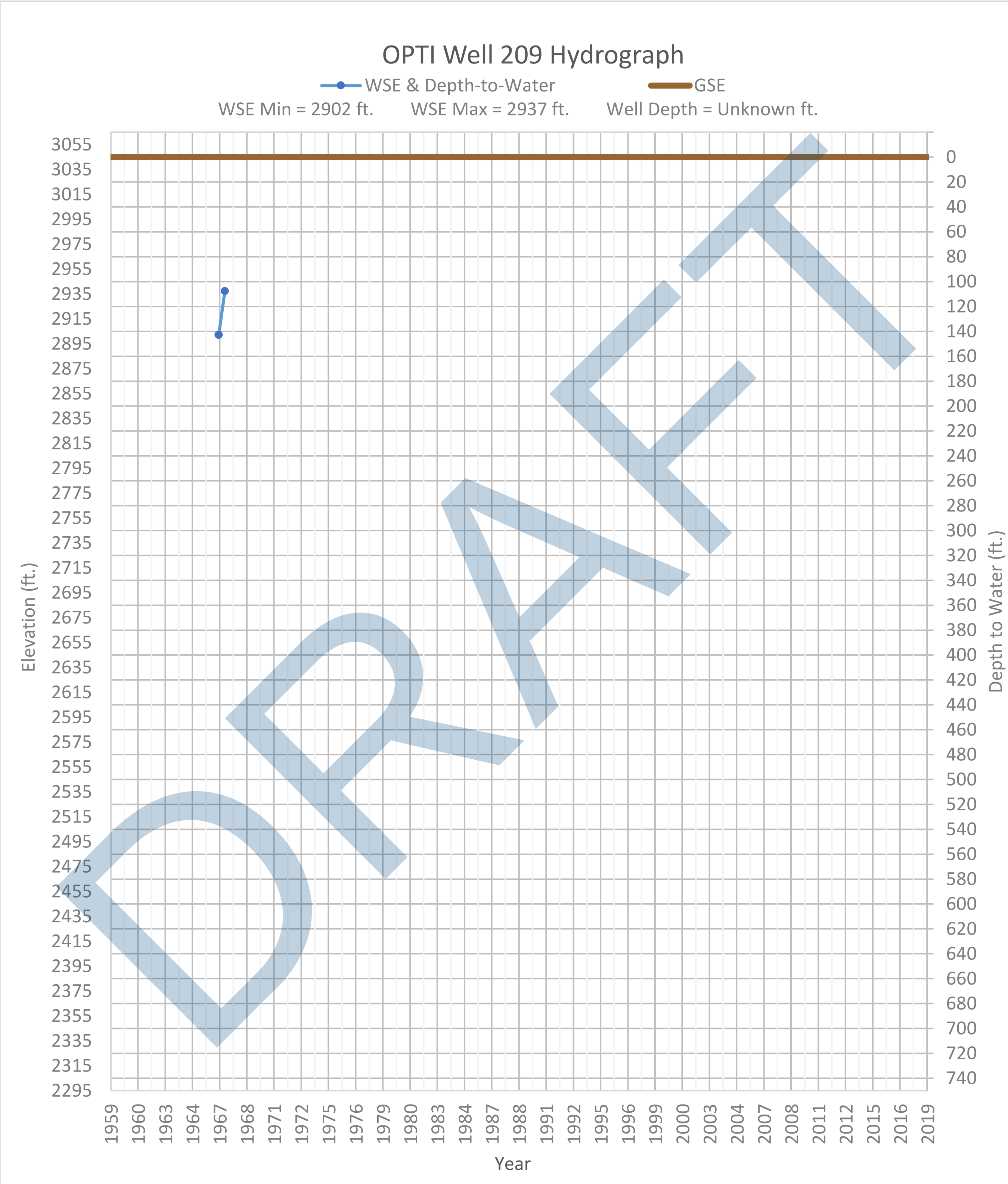
OPTI Well 205 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3270 ft.
WSE Max = 3284 ft.
Well Depth = 435 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

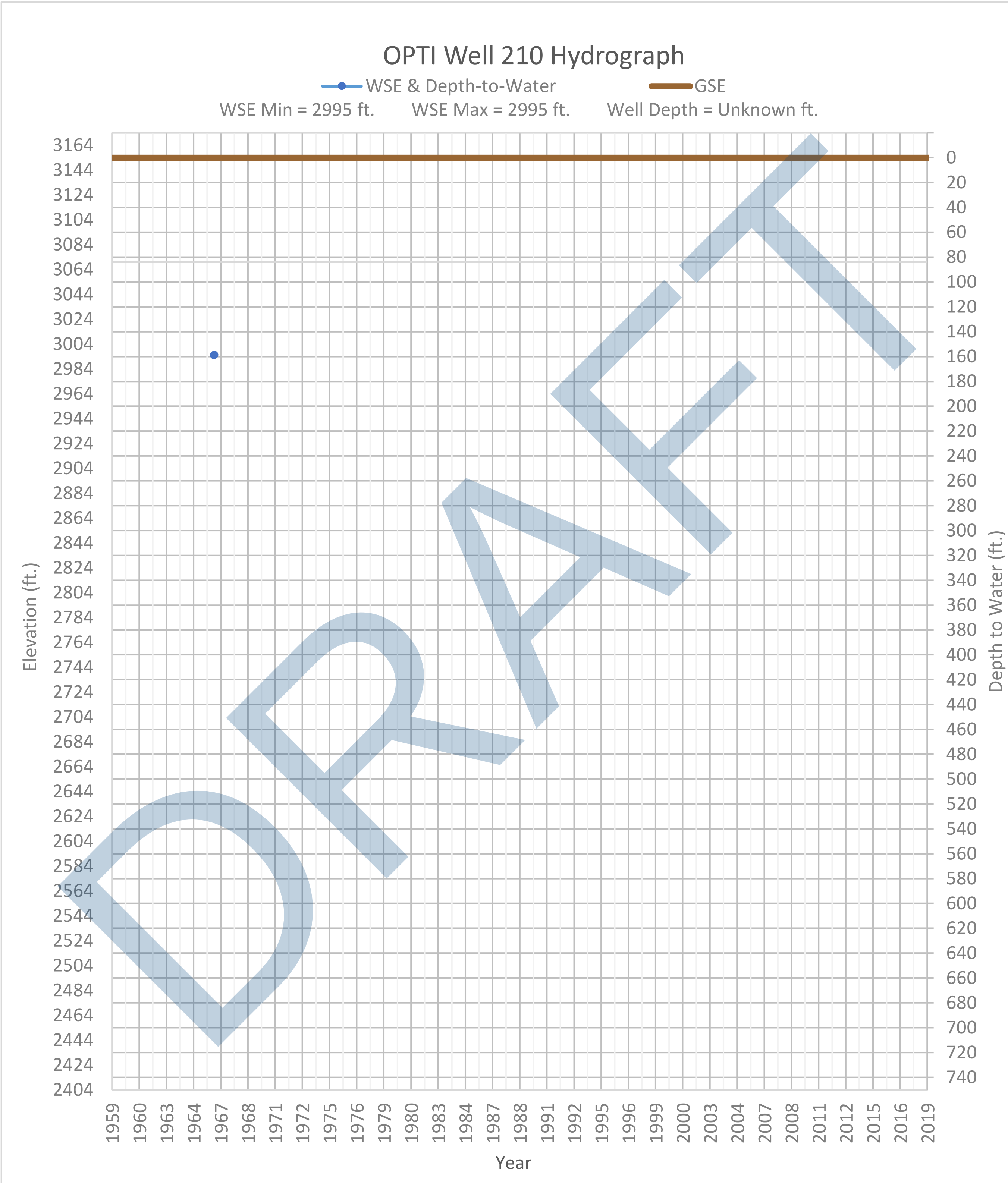


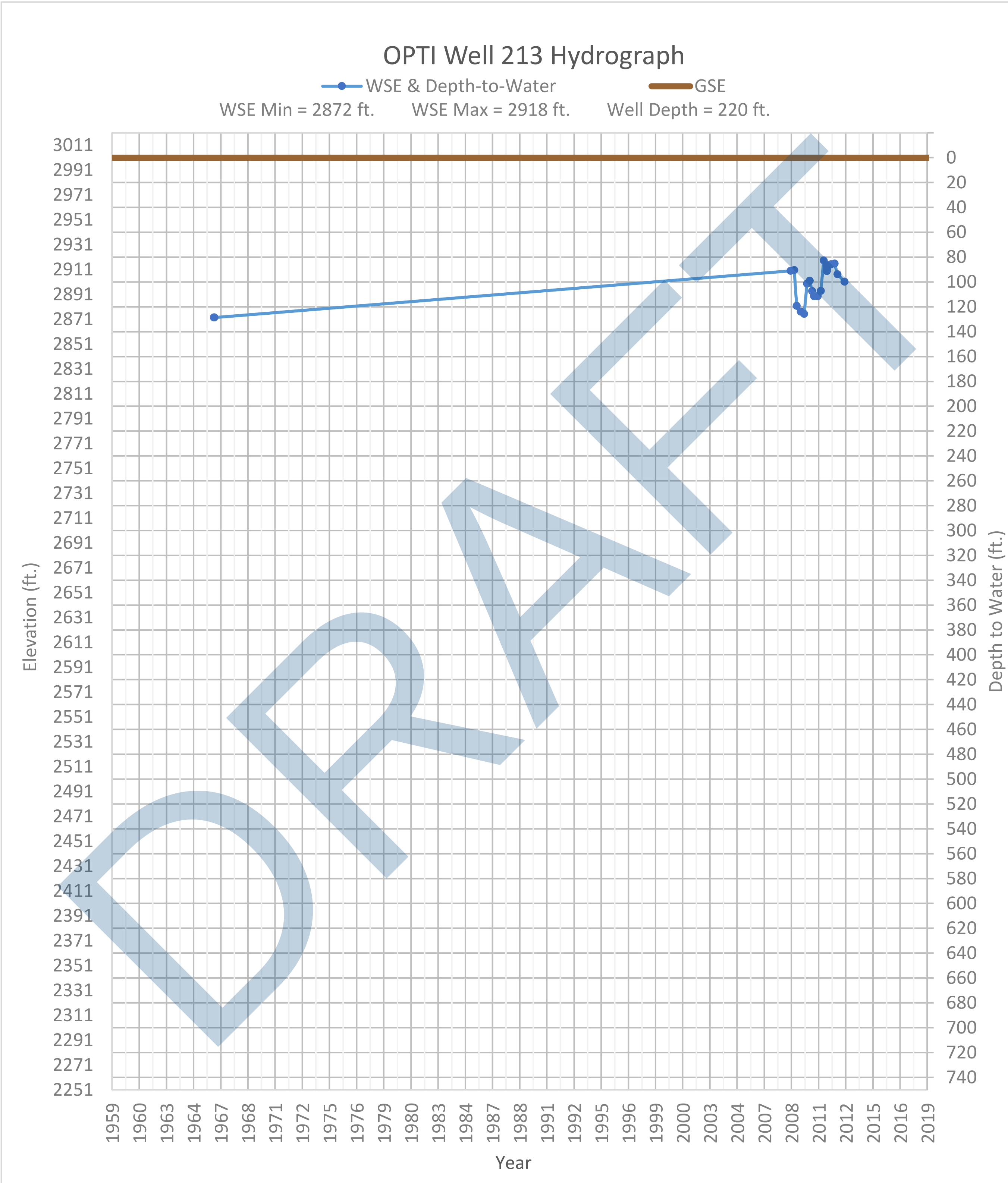
OPTI Well 206 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2843 ft.
WSE Max = 2843 ft.
Well Depth = 402 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 208 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2912 ft.
WSE Max = 2913 ft.
Well Depth = 172 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 209 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2902 ft.
WSE Max = 2937 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 210 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2995 ft.
WSE Max = 2995 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 213 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2872 ft.
WSE Max = 2918 ft.
Well Depth = 220 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
3011
2991
2971
2951
2931
2911
2891
2871
2851
2831
2811
2791
2771
2751
2731
2711
2691
2671
2651
2631
2611
2591
2571
2551
2531
2511
2491
2471
2451
2431
2411
2391
2371
2351
2331
2311
2291
2271
2251
0
20
40
60
80
100
120
140
160
180
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220
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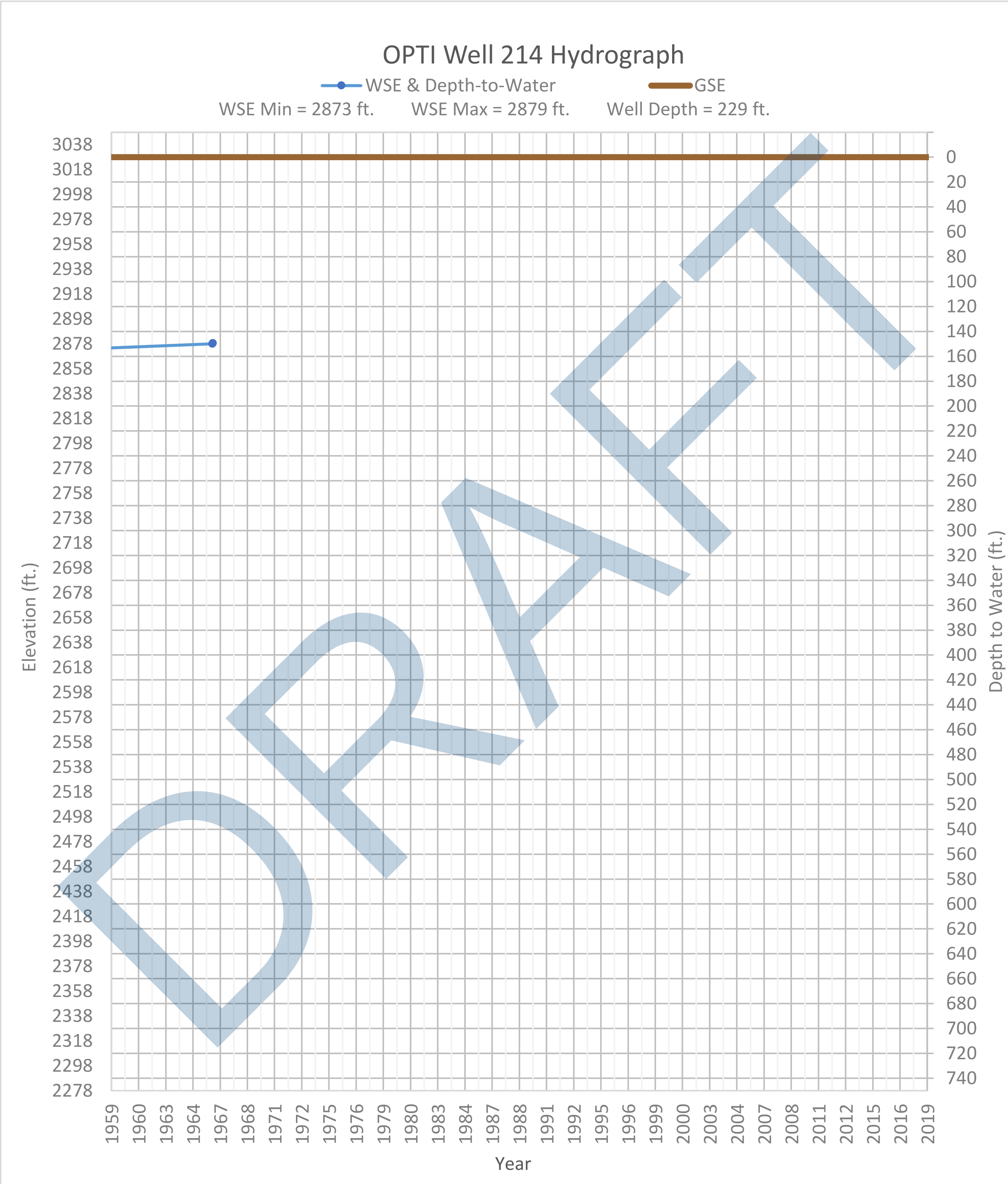
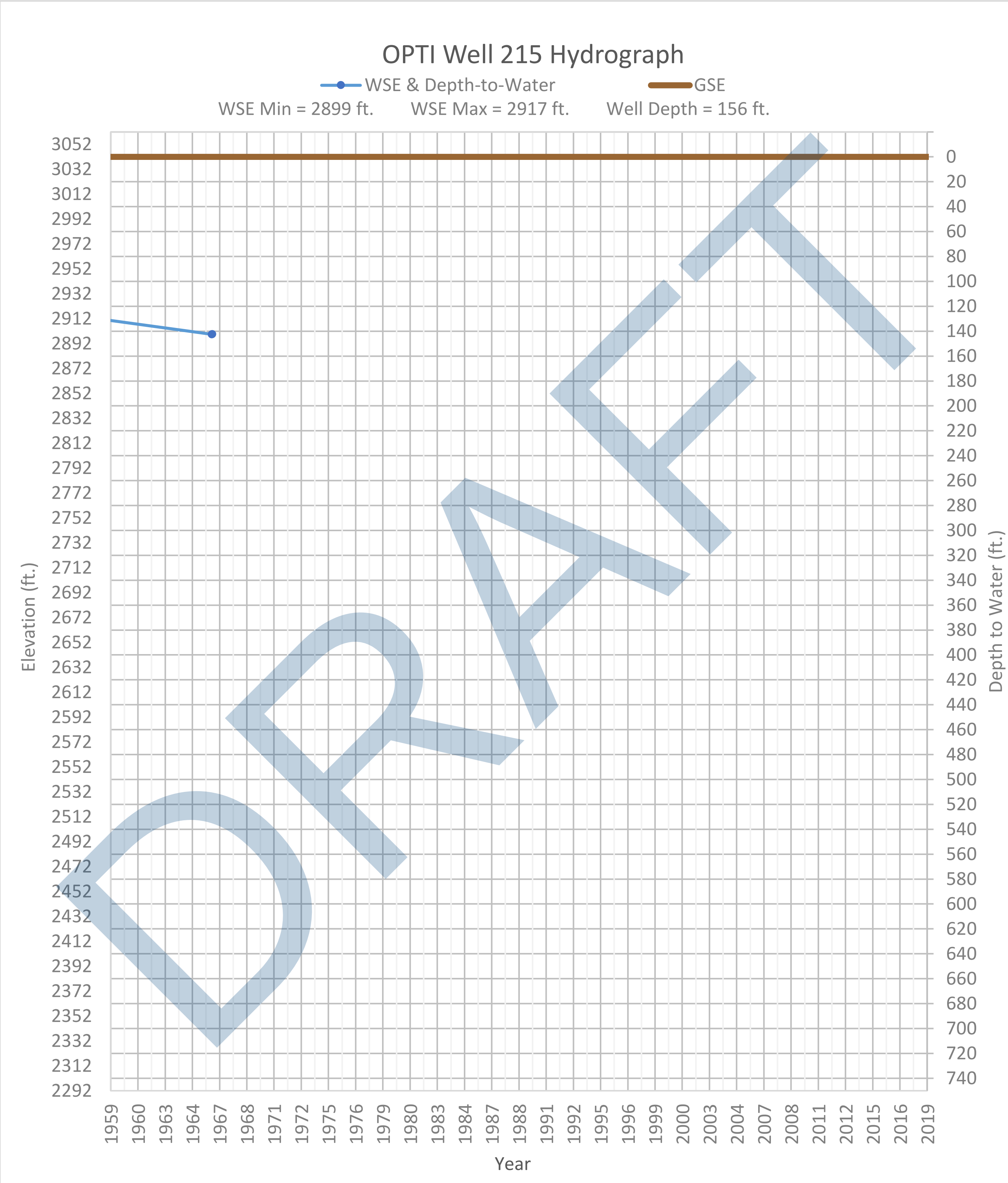
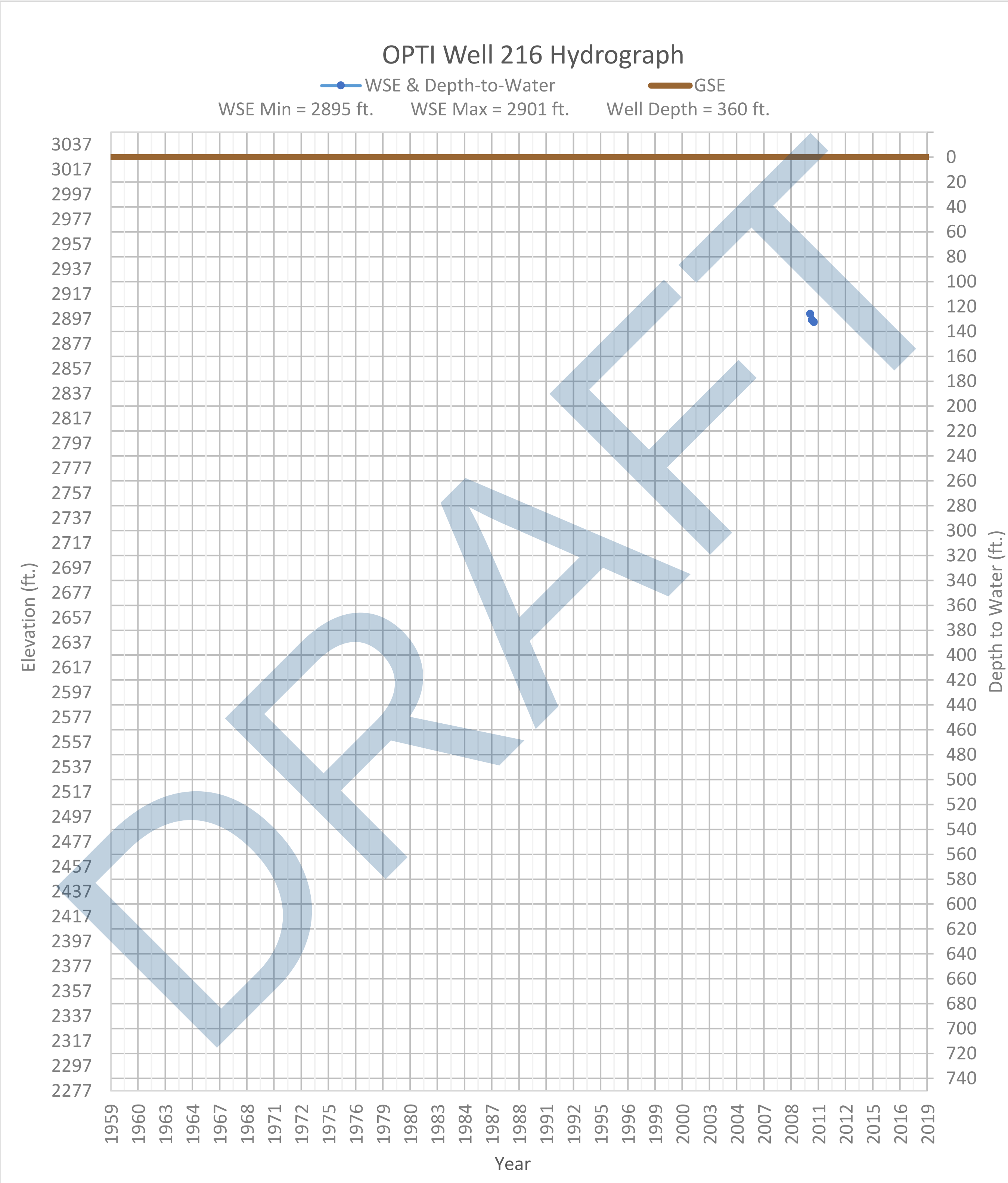
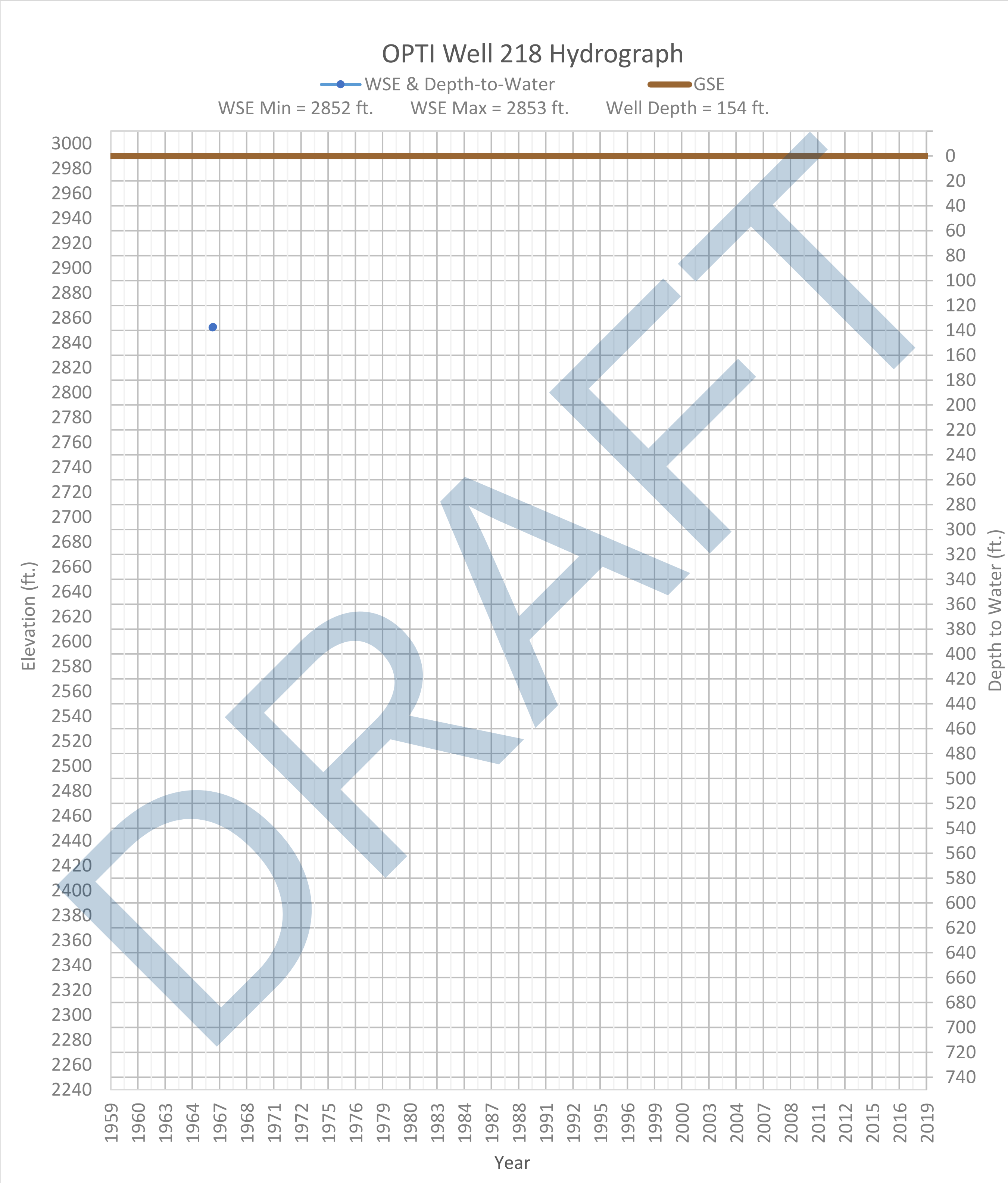

OPTI Well 214 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2873 ft.
WSE Max = 2879 ft.
Well Depth = 229 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



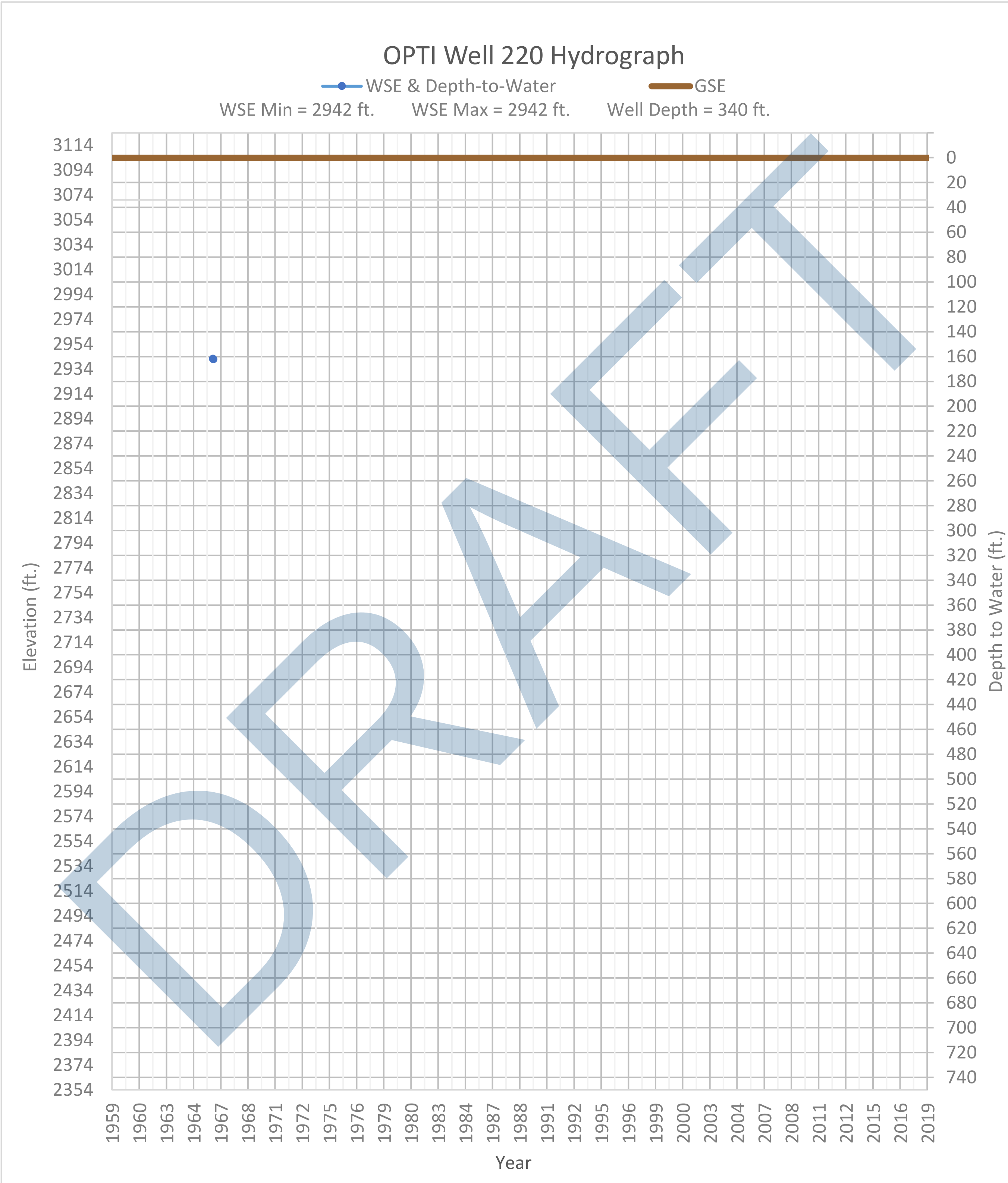
OPTI Well 215 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2899 ft.
WSE Max = 2917 ft.
Well Depth = 156 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



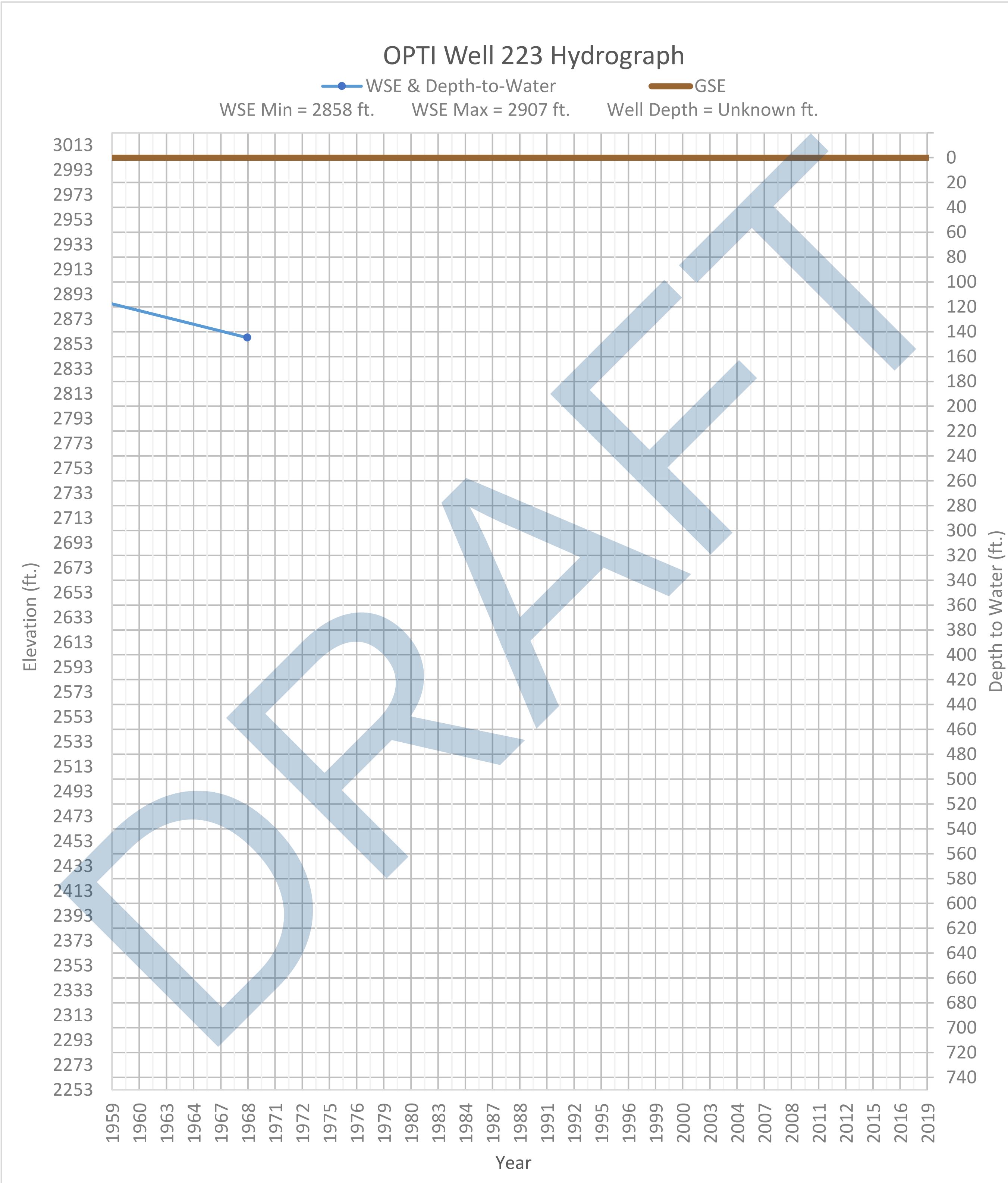
OPTI Well 216 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2895 ft.
WSE Max = 2901 ft.
Well Depth = 360 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



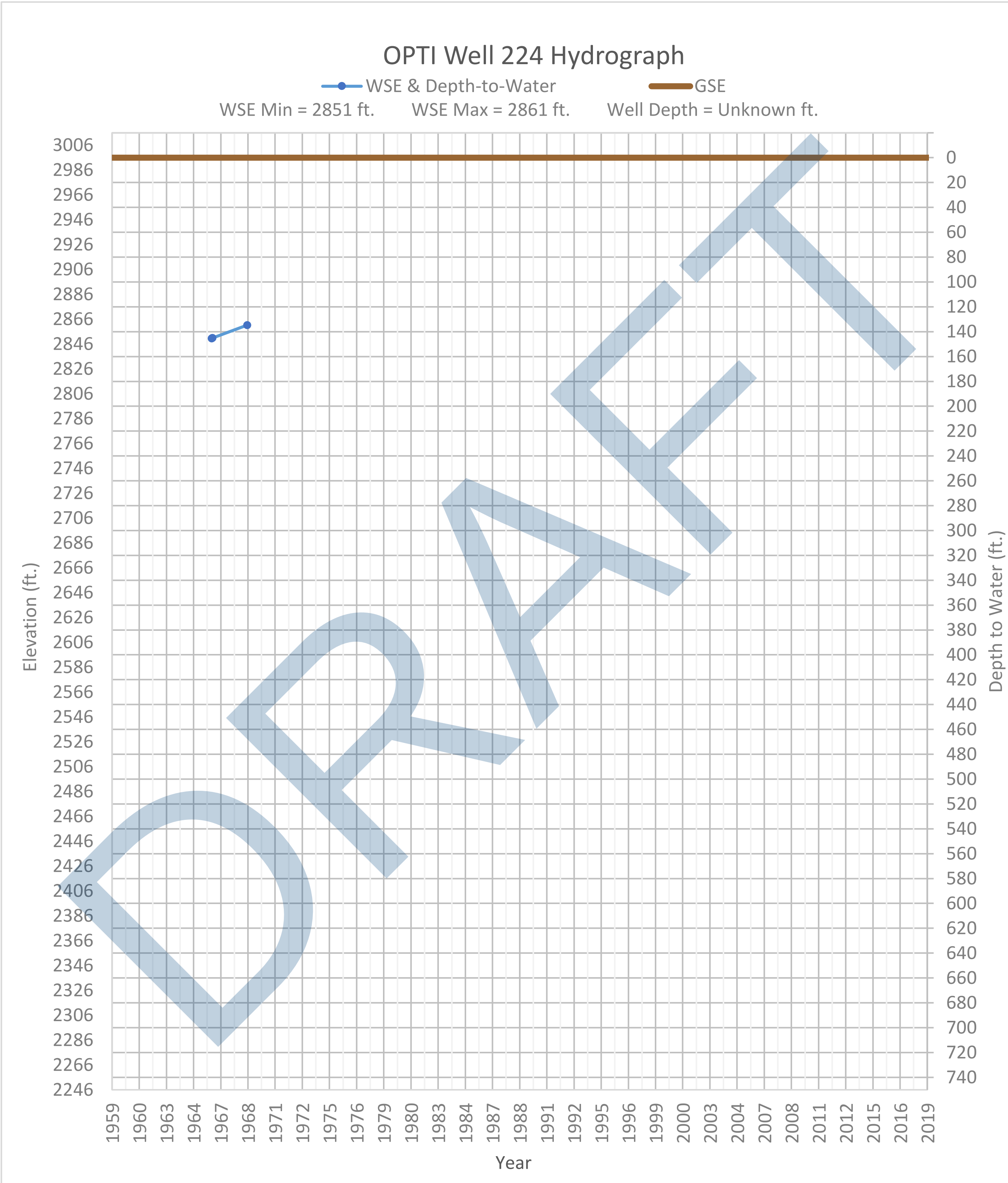
OPTI Well 218 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2852 ft.
WSE Max = 2853 ft.
Well Depth = 154 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



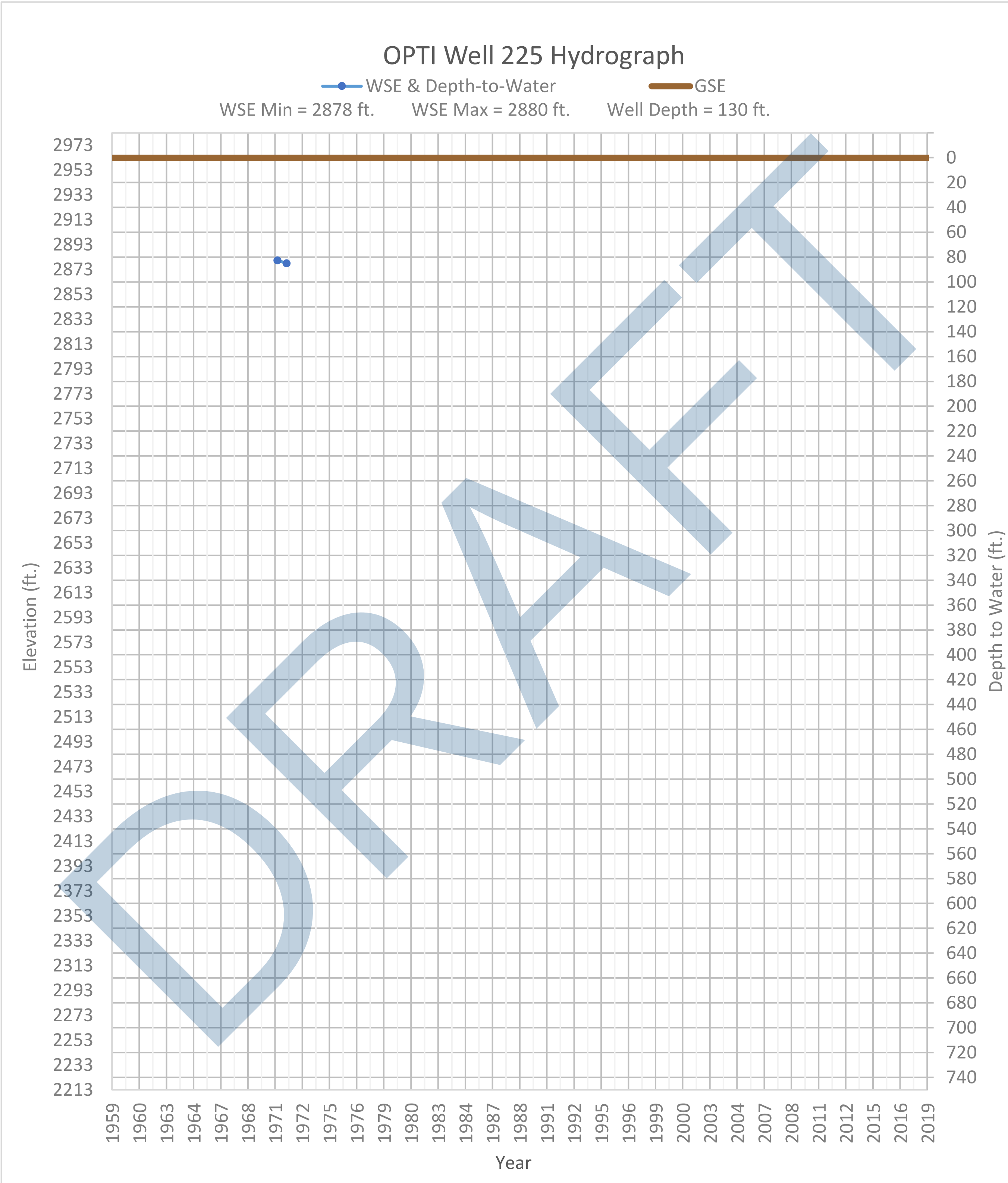
OPTI Well 220 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2942 ft.
WSE Max = 2942 ft.
Well Depth = 340 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



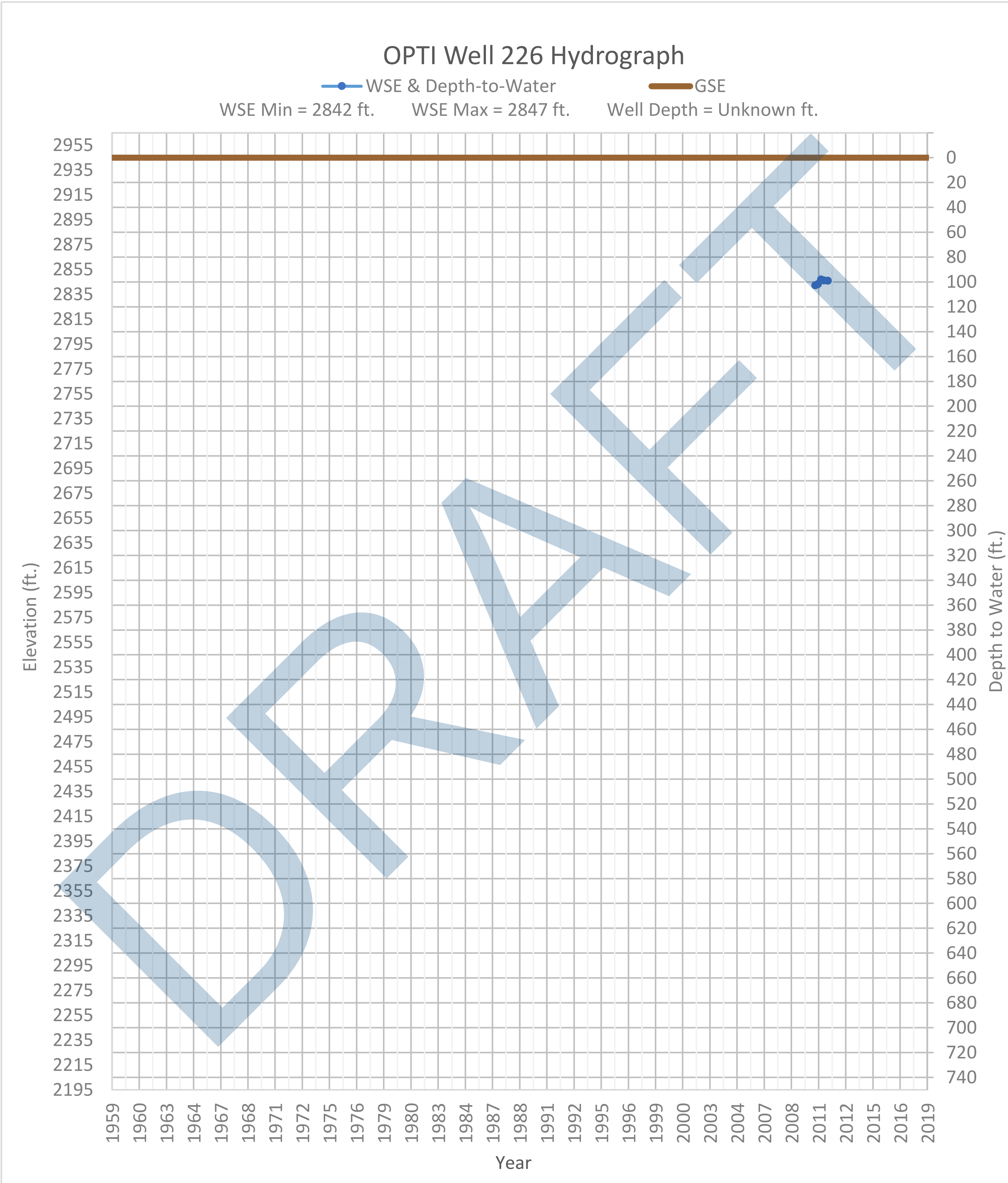
OPTI Well 223 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2858 ft.
WSE Max = 2907 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 224 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2851 ft.
WSE Max = 2861 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 225 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2878 ft.
WSE Max = 2880 ft.
Well Depth = 130 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 226 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2842 ft.
WSE Max = 2847 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2955
2935
2915
2895
2875
2855
2835
2815
2795
2775
2755
2735
2715
2695
2675
2655
2635
2615
2595
2575
2555
2535
2515
2495
2475
2455
2435
2415
2395
2375
2355
2335
2315
2295
2275
2255
2235
2215
2195
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
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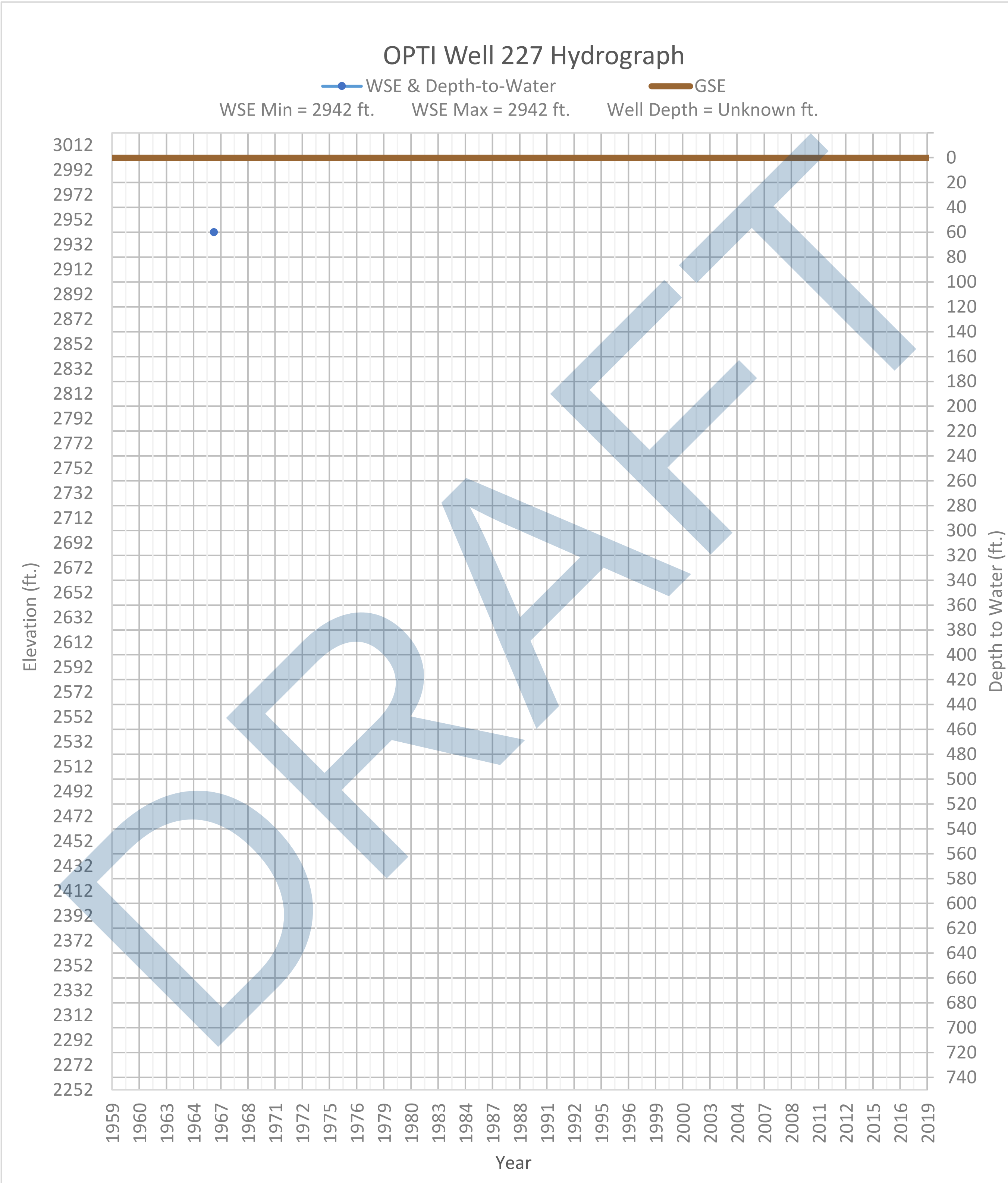
DRAFT



OPTI Well 227 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2942 ft.
WSE Max = 2942 ft.
Well Depth = Unknown ft.
Elevation (ft.)
3012
2992
2972
2952
2932
2912
2892
2872
2852
2832
2812
2792
2772
2752
2732
2712
2692
2672
2652
2632
2612
2592
2572
2552
2532
2512
2492
2472
2452
2432
2412
2392
2372
2352
2332
2312
2292
2272
2252
Depth to Water (ft.)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
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Year
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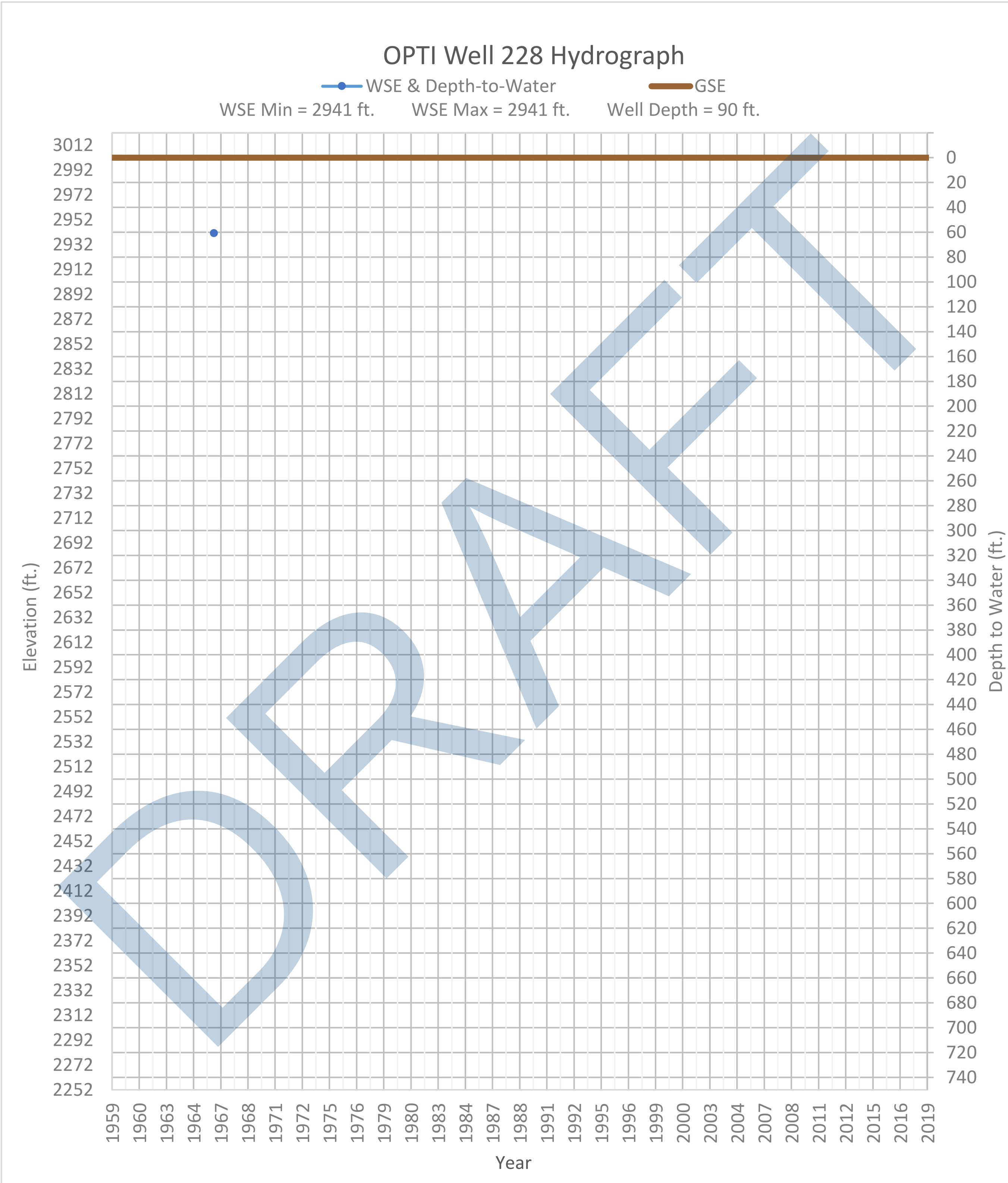
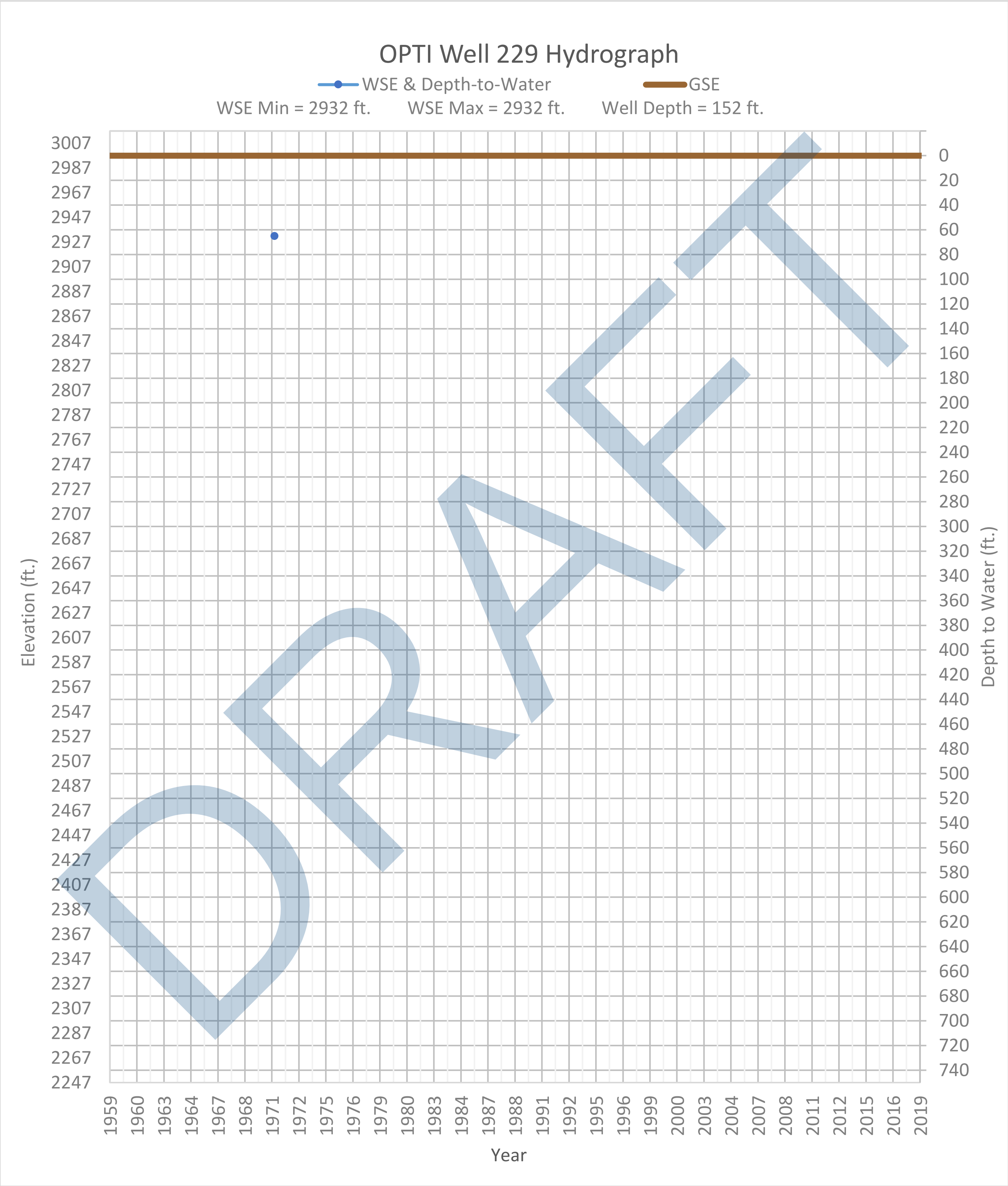
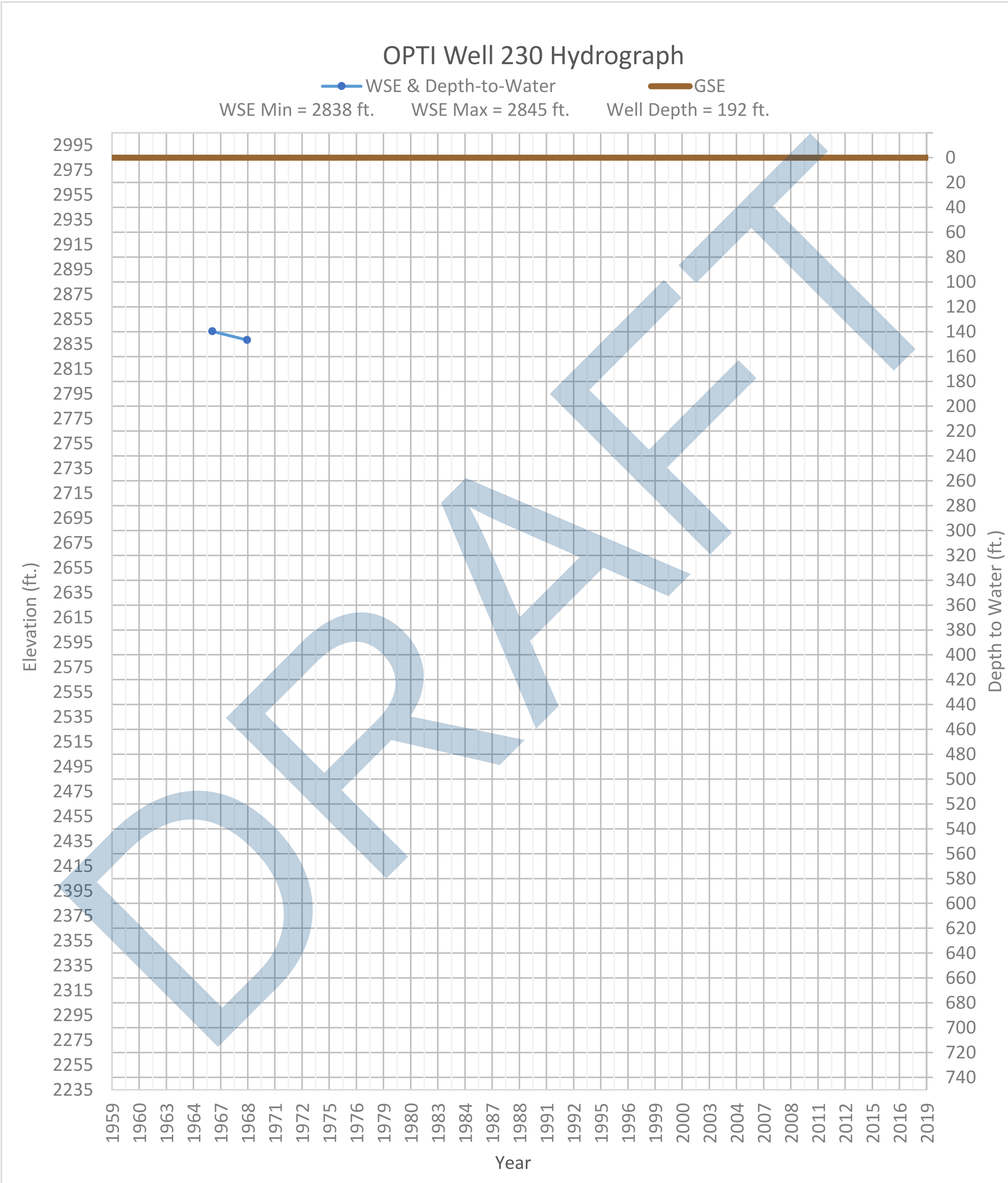


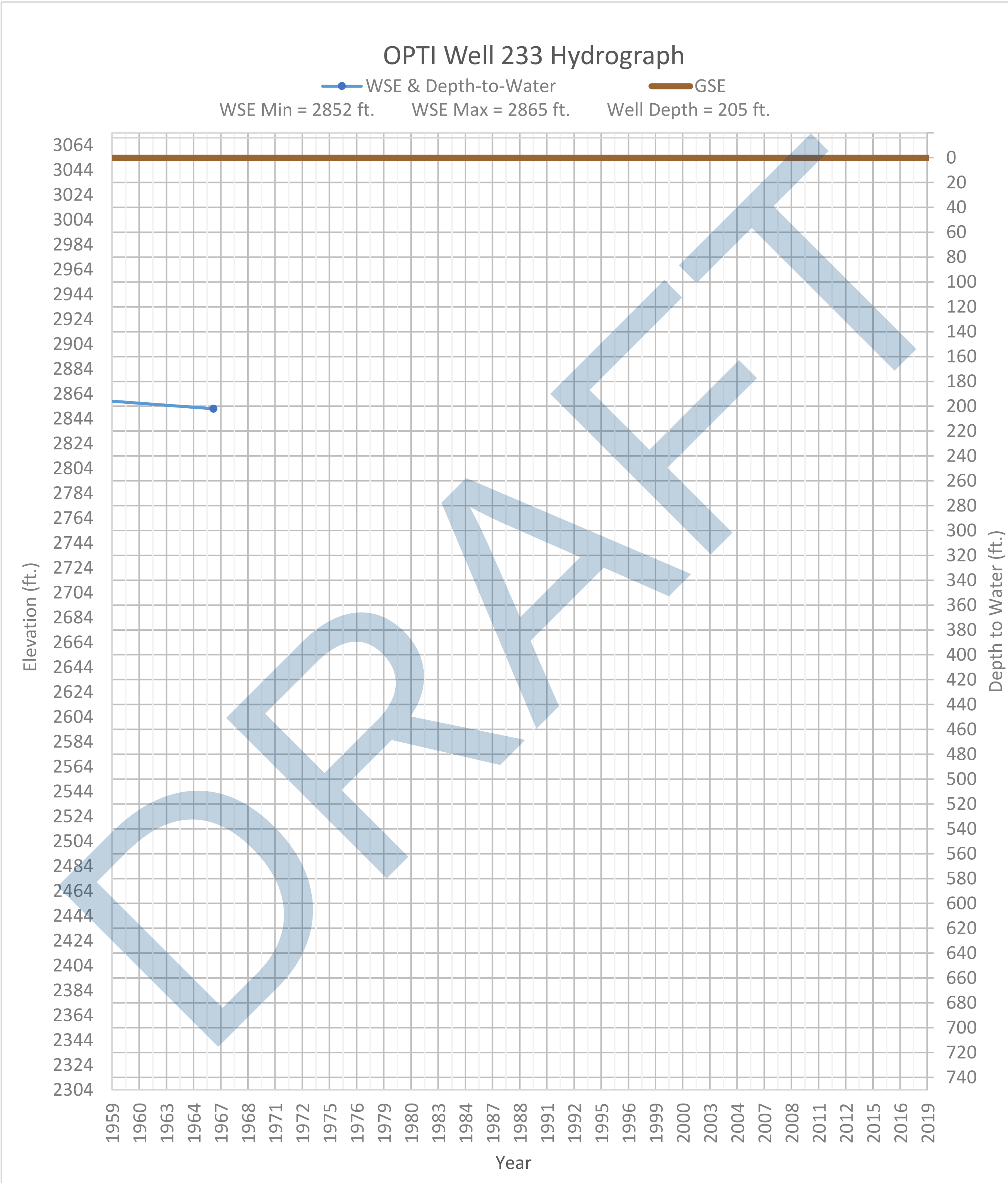
OPTI Well 228 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2941 ft.
WSE Max = 2941 ft.
Well Depth = 90 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



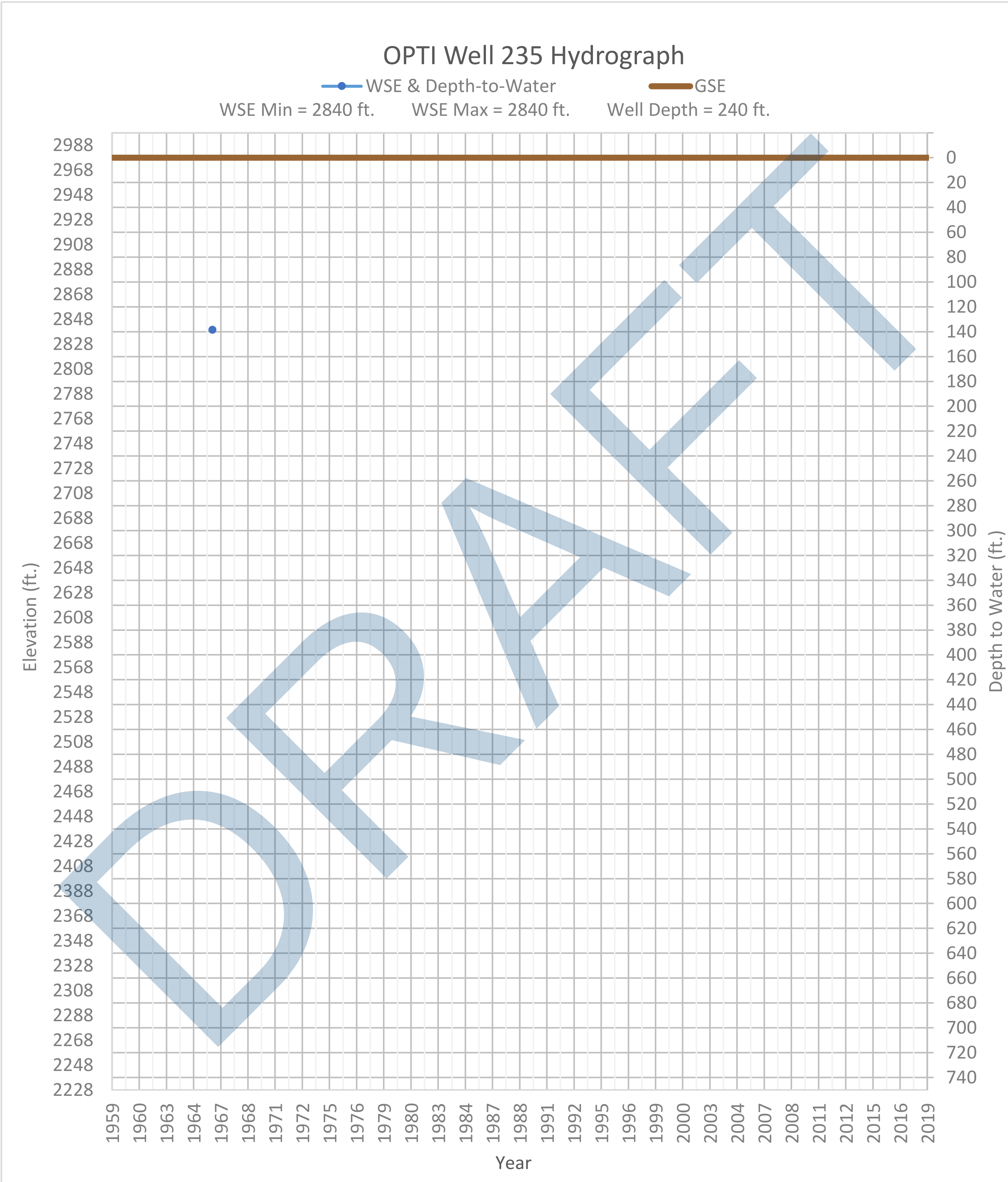
OPTI Well 229 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2932 ft.
WSE Max = 2932 ft.
Well Depth = 152 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



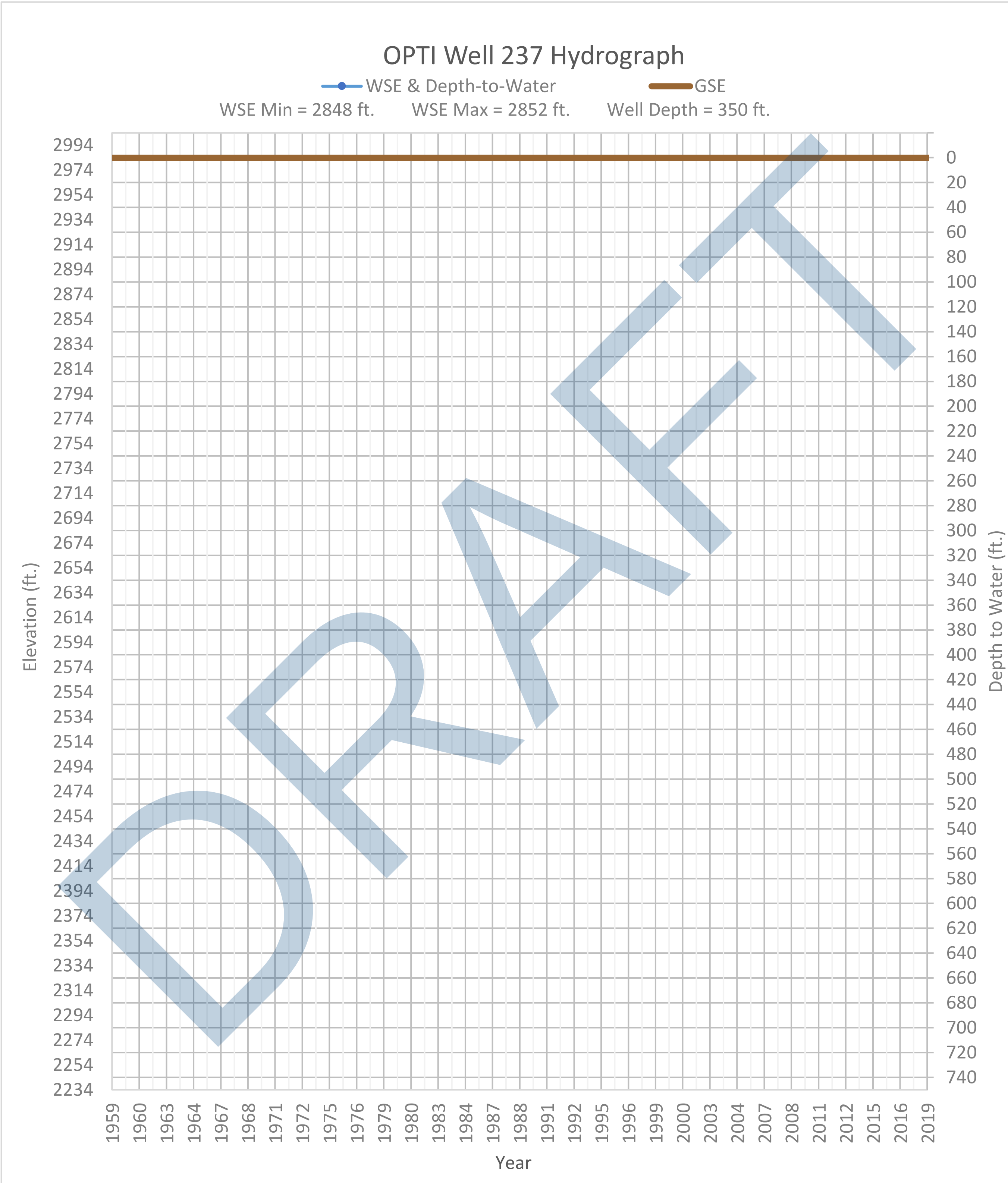
OPTI Well 230 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2838 ft.
WSE Max = 2845 ft.
Well Depth = 192 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



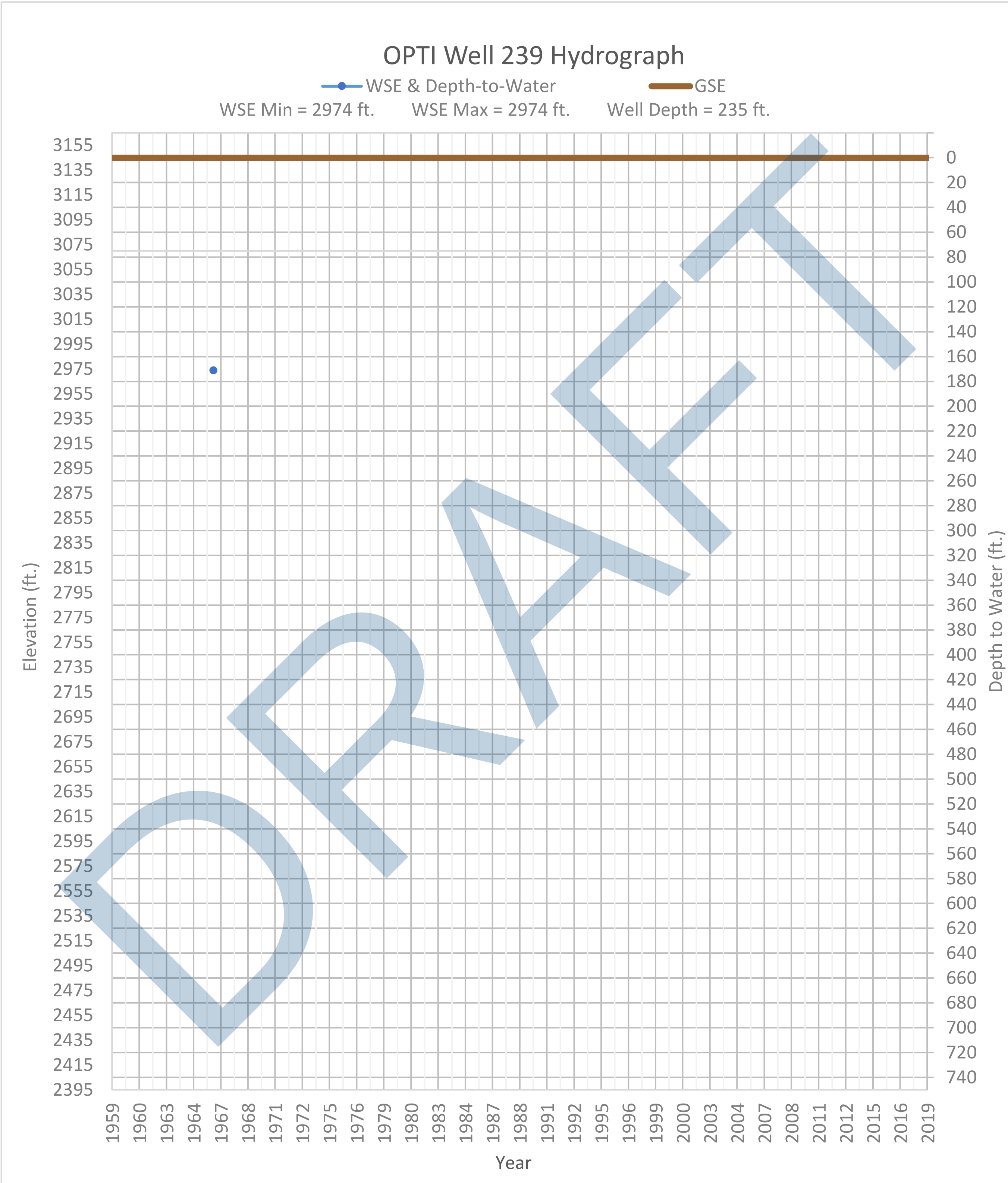
OPTI Well 233 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2852 ft.
WSE Max = 2865 ft.
Well Depth = 205 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



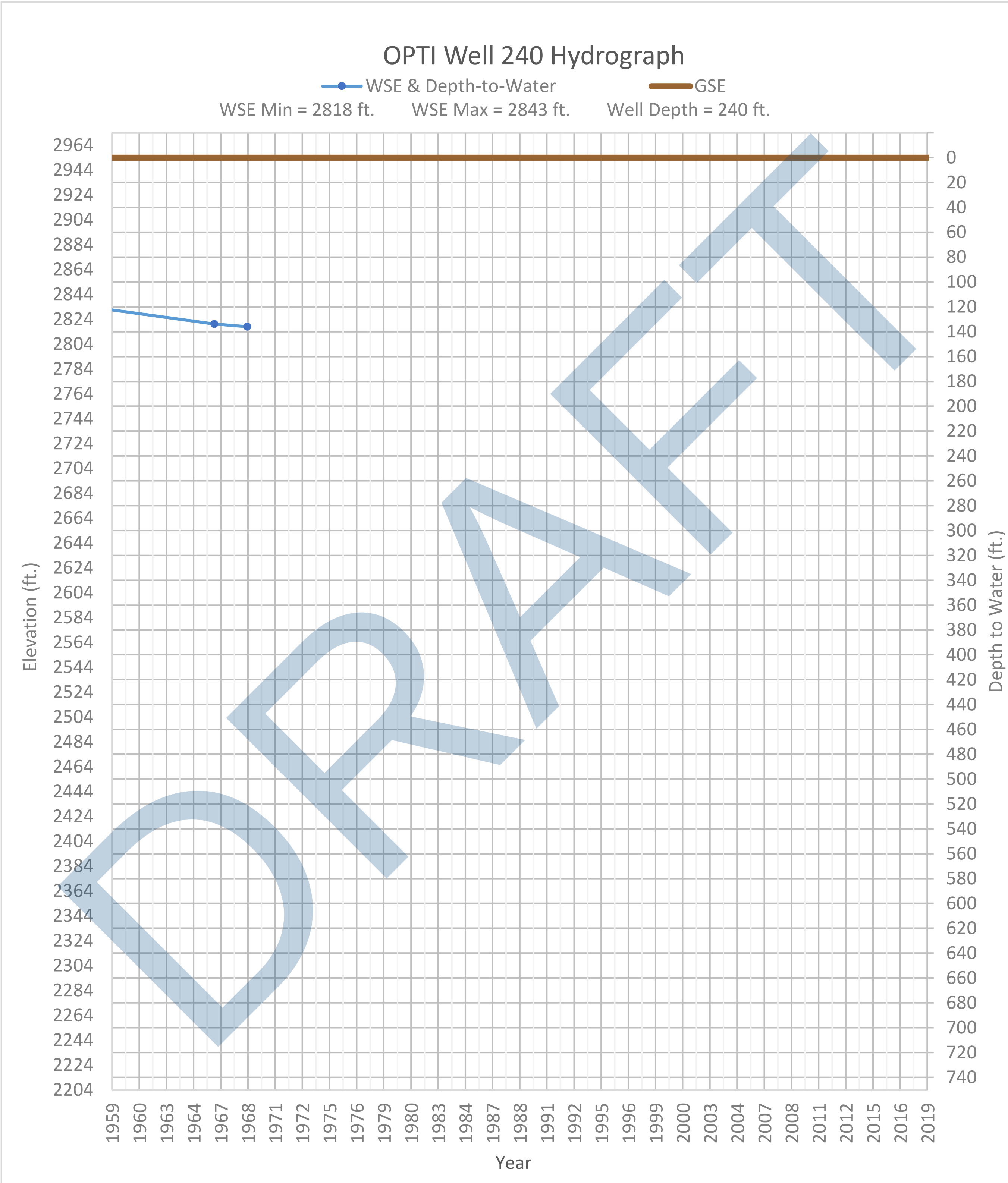
OPTI Well 235 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2840 ft.
WSE Max = 2840 ft.
Well Depth = 240 ft.
Elevation (ft.)
Depth to Water (ft.)
Year



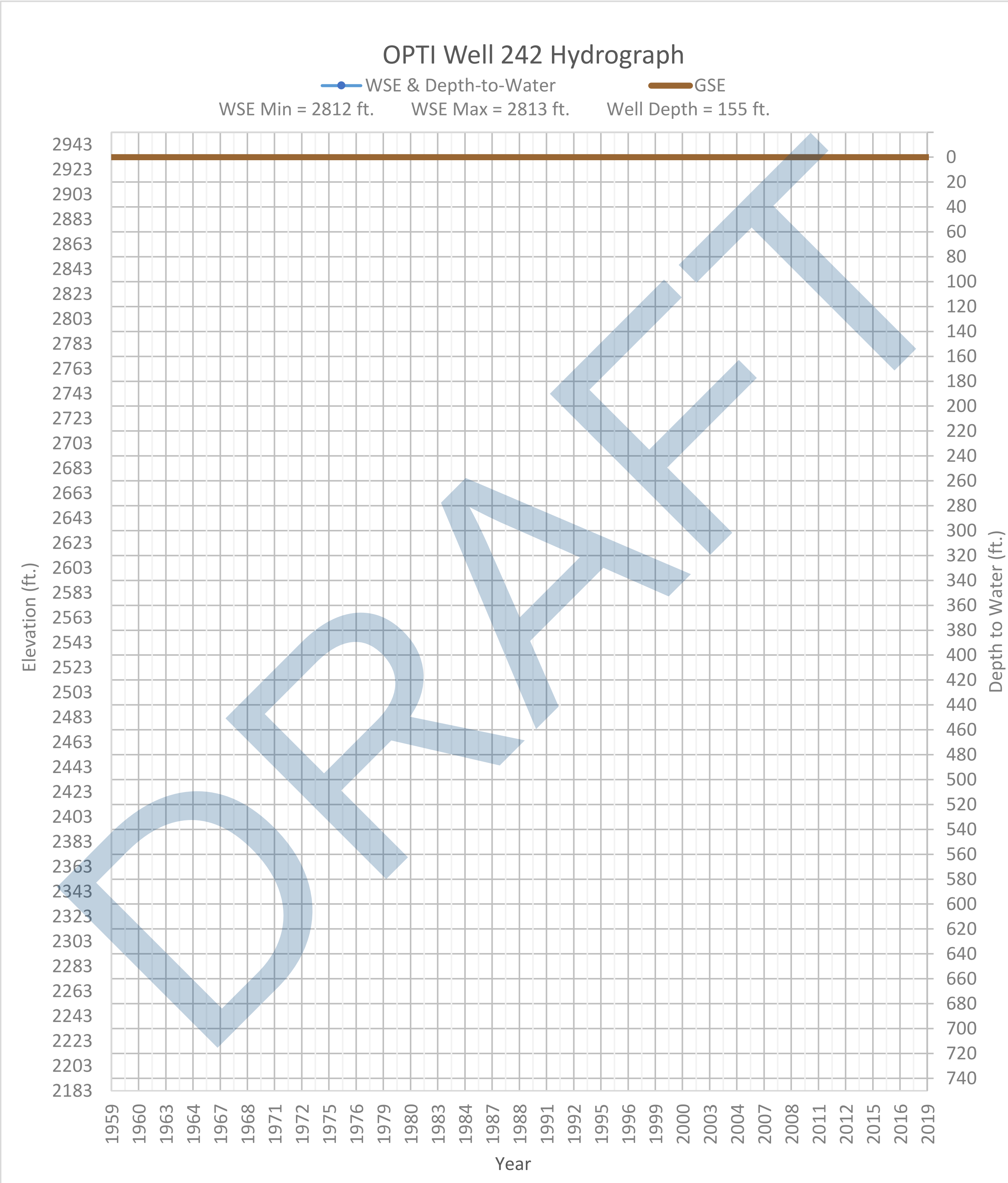
OPTI Well 237 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2848 ft.
WSE Max = 2852 ft.
Well Depth = 350 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 239 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2974 ft.
WSE Max = 2974 ft.
Well Depth = 235 ft.
Elevation (ft.)
3155 3135 3115 3095 3075 3055 3035 3015 2995 2975 2955 2935 2915 2895 2875 2855 2835 2815 2795 2775 2755 2735 2715 2695 2675 2655 2635 2615 2595 2575 2555 2535 2515 2495 2475 2455 2435 2415 2395
Depth to Water (ft.)
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720 740
Year
1959 1960 1963 1964 1967 1968 1971 1972 1975 1976 1979 1980 1983 1984 1987 1988 1991 1992 1995 1996 1999 2000 2003 2004 2007 2008 2011 2012 2015 2016 2019
DRAFT



OPTI Well 240 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2818 ft.
WSE Max = 2843 ft.
Well Depth = 240 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 242 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2812 ft.
WSE Max = 2813 ft.
Well Depth = 155 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2943
2923
2903
2883
2863
2843
2823
2803
2783
2763
2743
2723
2703
2683
2663
2643
2623
2603
2583
2563
2543
2523
2503
2483
2463
2443
2423
2403
2383
2363
2343
2323
2303
2283
2263
2243
2223
2203
2183
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
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2016
2019
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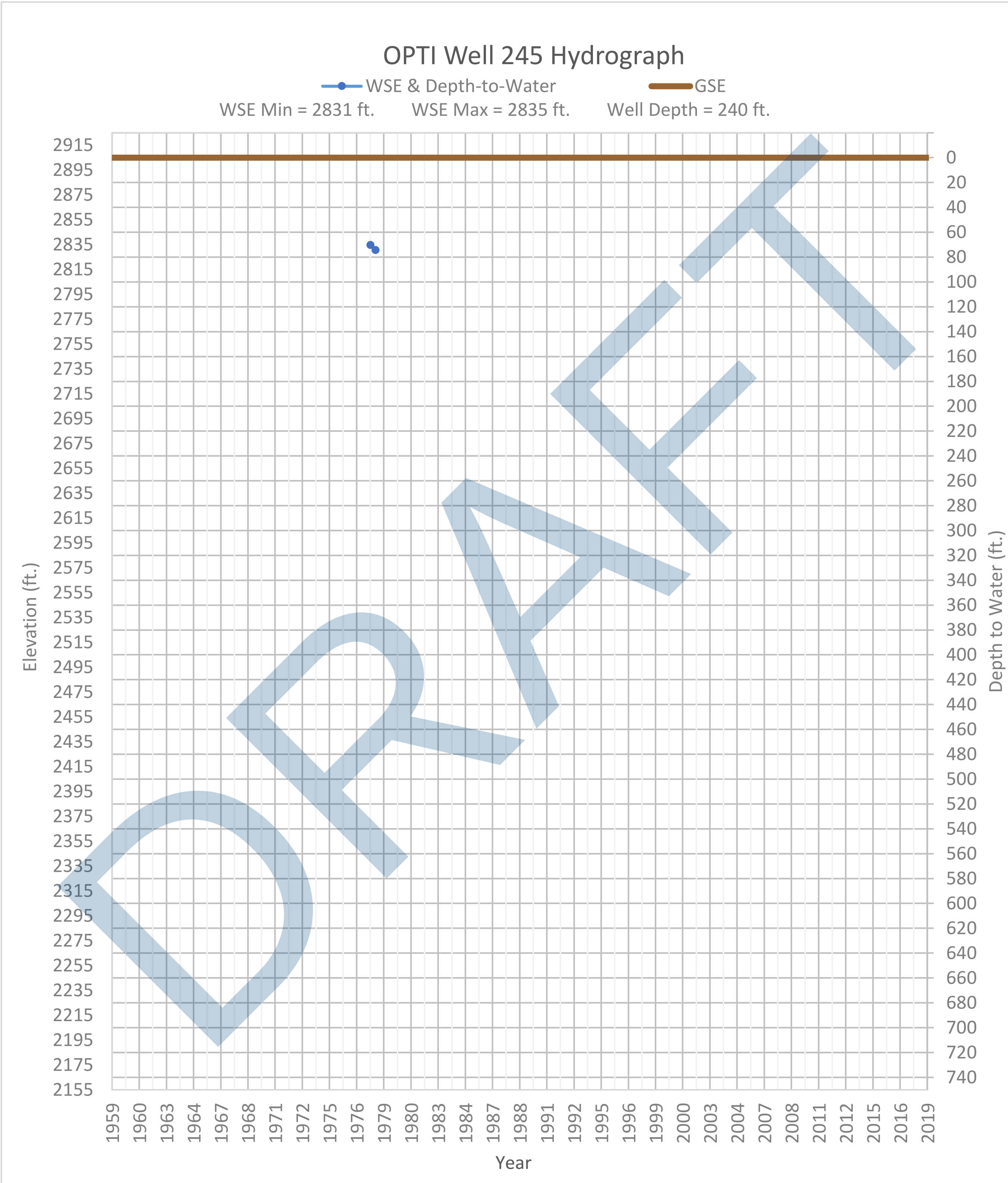
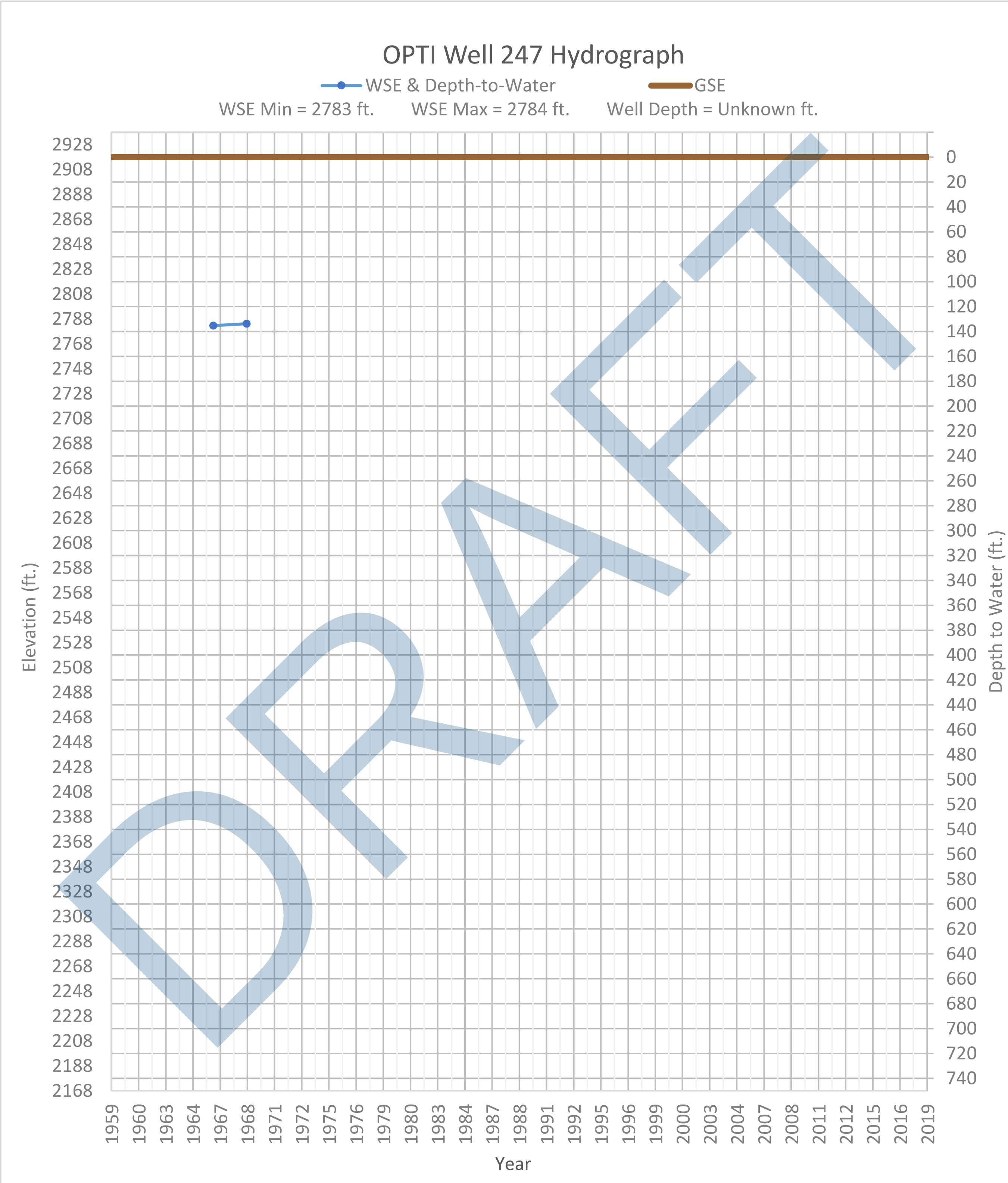
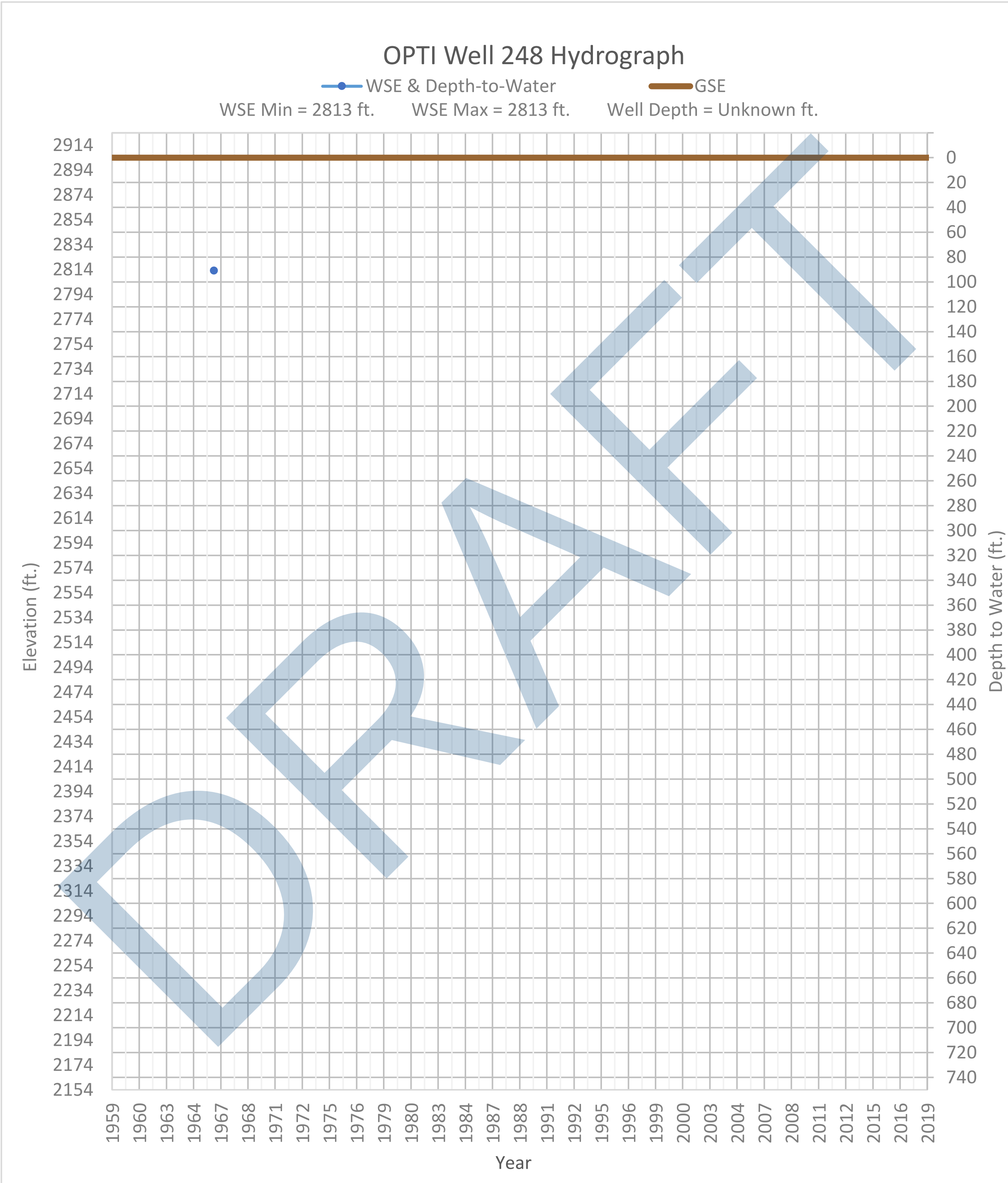
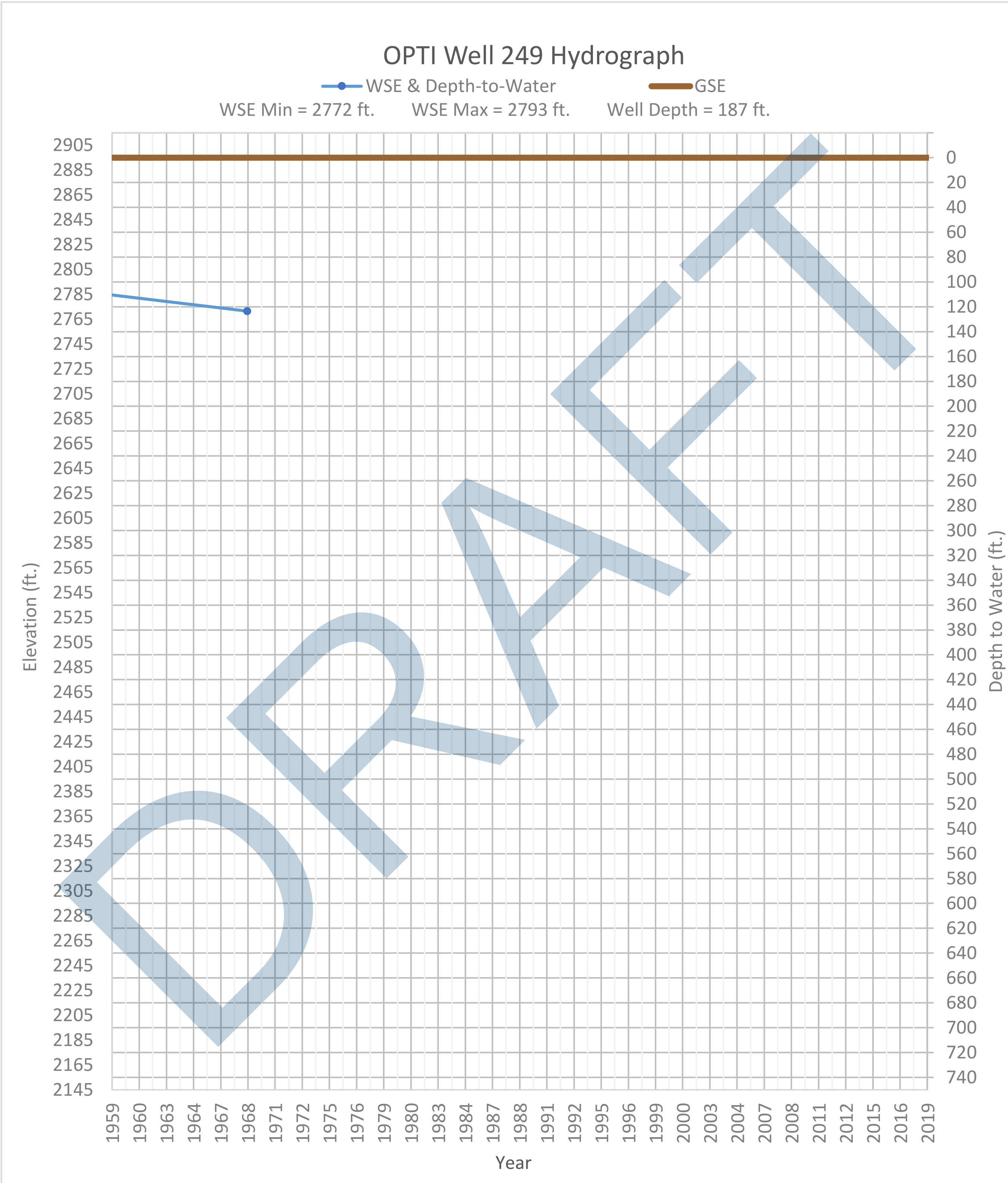


OPTI Well 245 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2831 ft.
WSE Max = 2835 ft.
Well Depth = 240 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

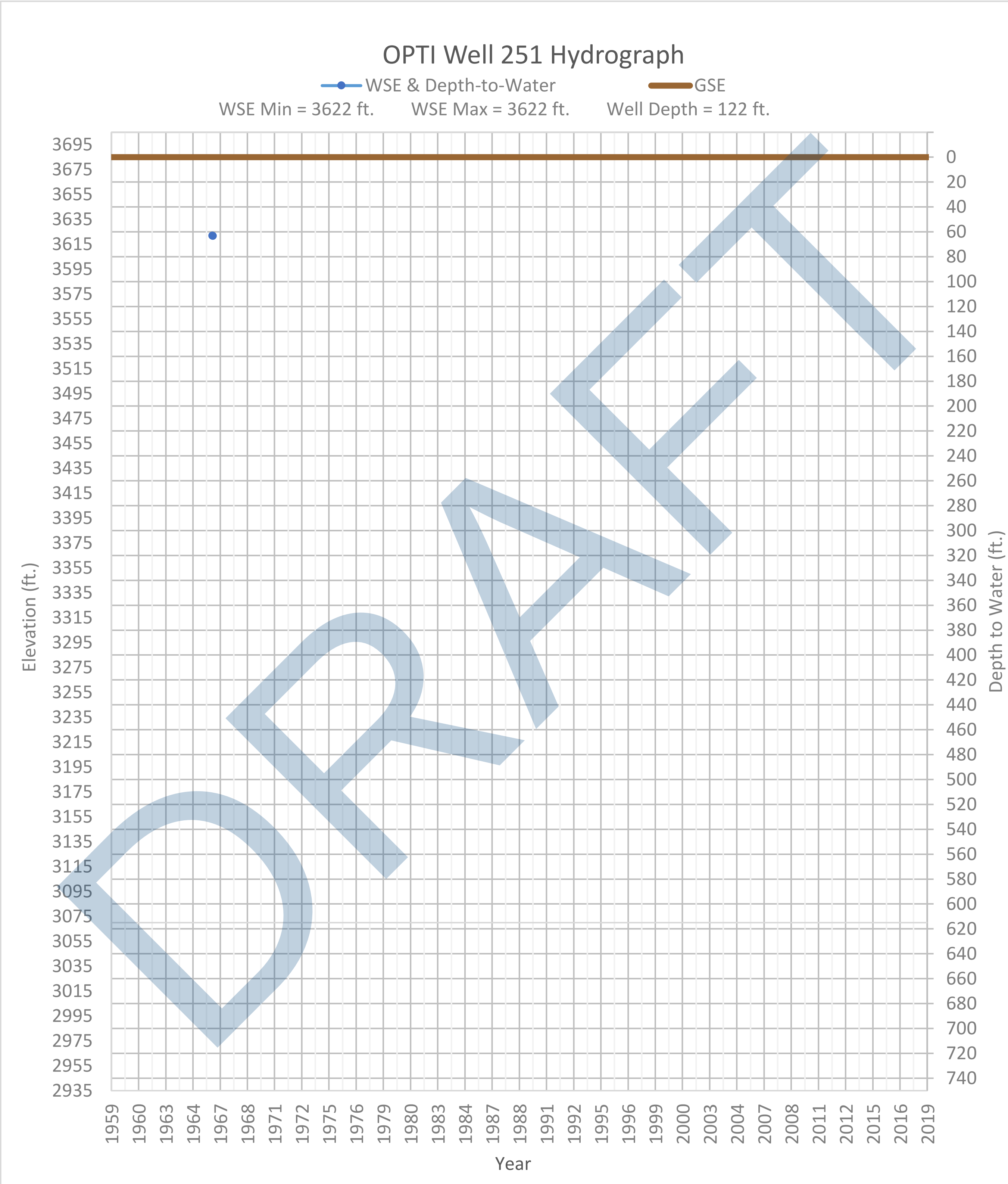

OPTI Well 247 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2783 ft.
WSE Max = 2784 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



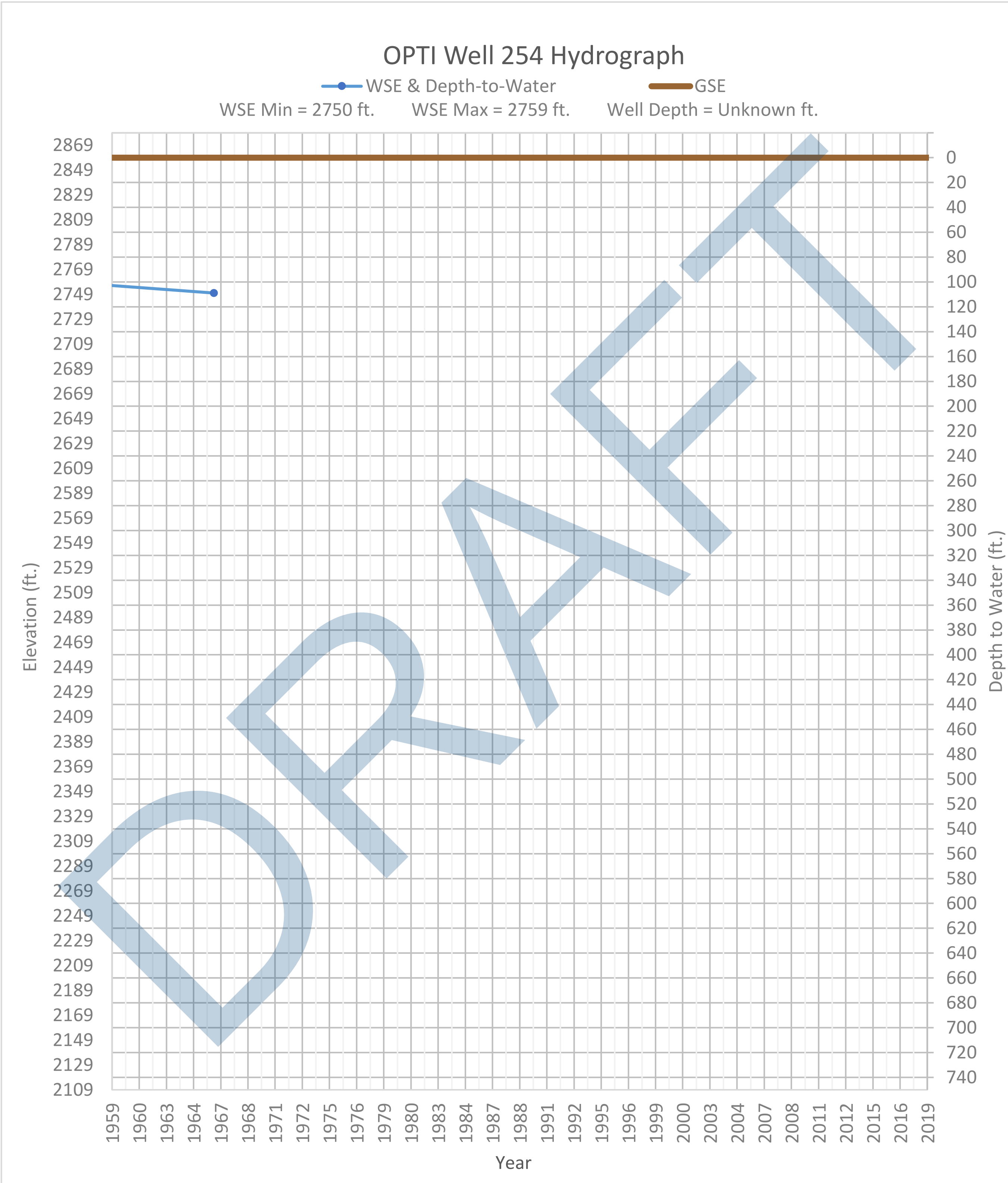
OPTI Well 248 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2813 ft.
WSE Max = 2813 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 249 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2772 ft.
WSE Max = 2793 ft.
Well Depth = 187 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 251 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3622 ft.
WSE Max = 3622 ft.
Well Depth = 122 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 254 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2750 ft.
WSE Max = 2759 ft.
Well Depth = Unknown ft.
Elevation (ft.)
2869
2849
2829
2809
2789
2769
2749
2729
2709
2689
2669
2649
2629
2609
2589
2569
2549
2529
2509
2489
2469
2449
2429
2409
2389
2369
2349
2329
2309
2289
2269
2249
2229
2209
2189
2169
2149
2129
2109
Depth to Water (ft.)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
680
700
720
740
Year
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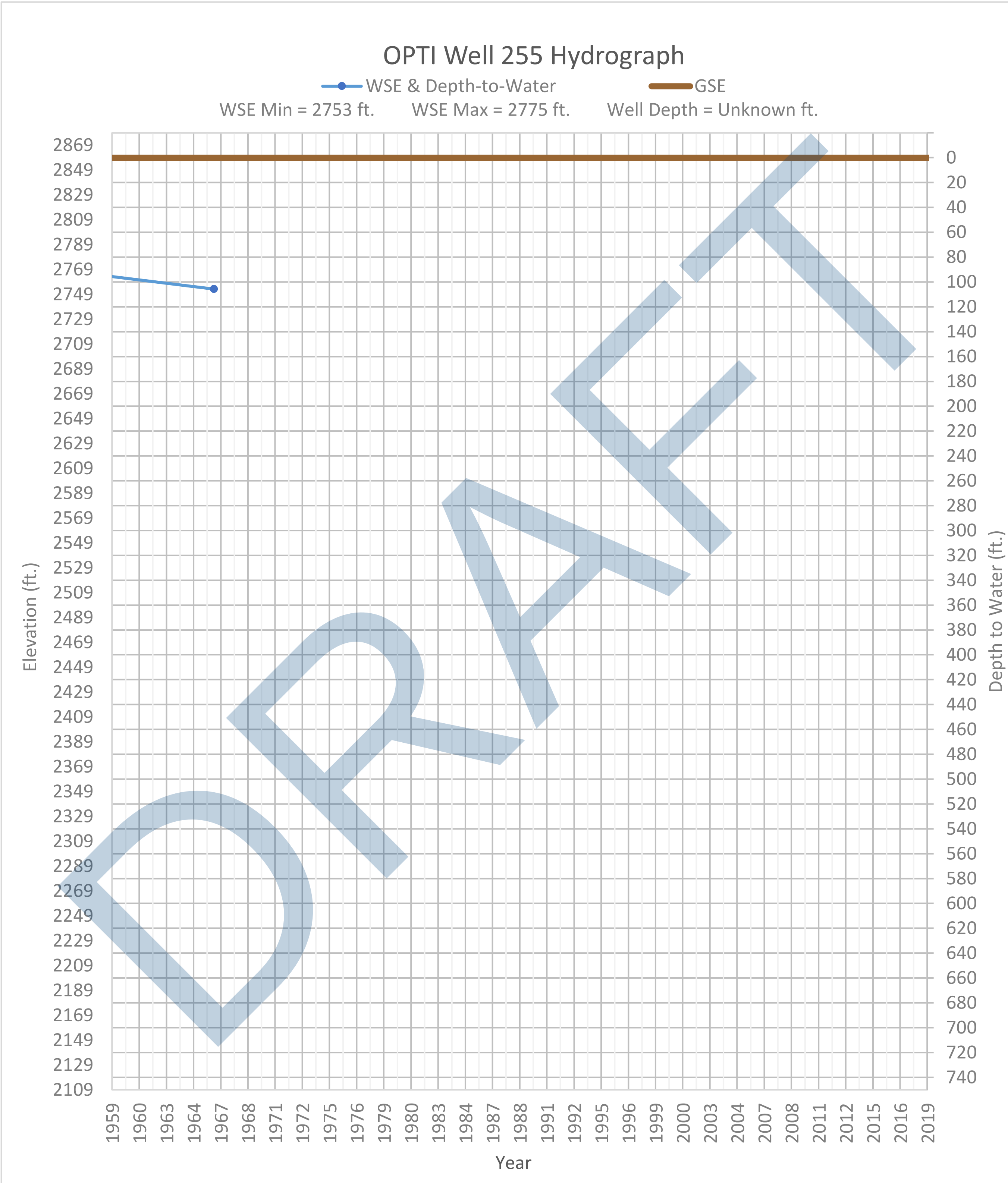
2016
2019
DRAFT



OPTI Well 255 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2753 ft.
WSE Max = 2775 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2869
2849
2829
2809
2789
2769
2749
2729
2709
2689
2669
2649
2629
2609
2589
2569
2549
2529
2509
2489
2469
2449
2429
2409
2389
2369
2349
2329
2309
2289
2269
2249
2229
2209
2189
2169
2149
2129
2109
0
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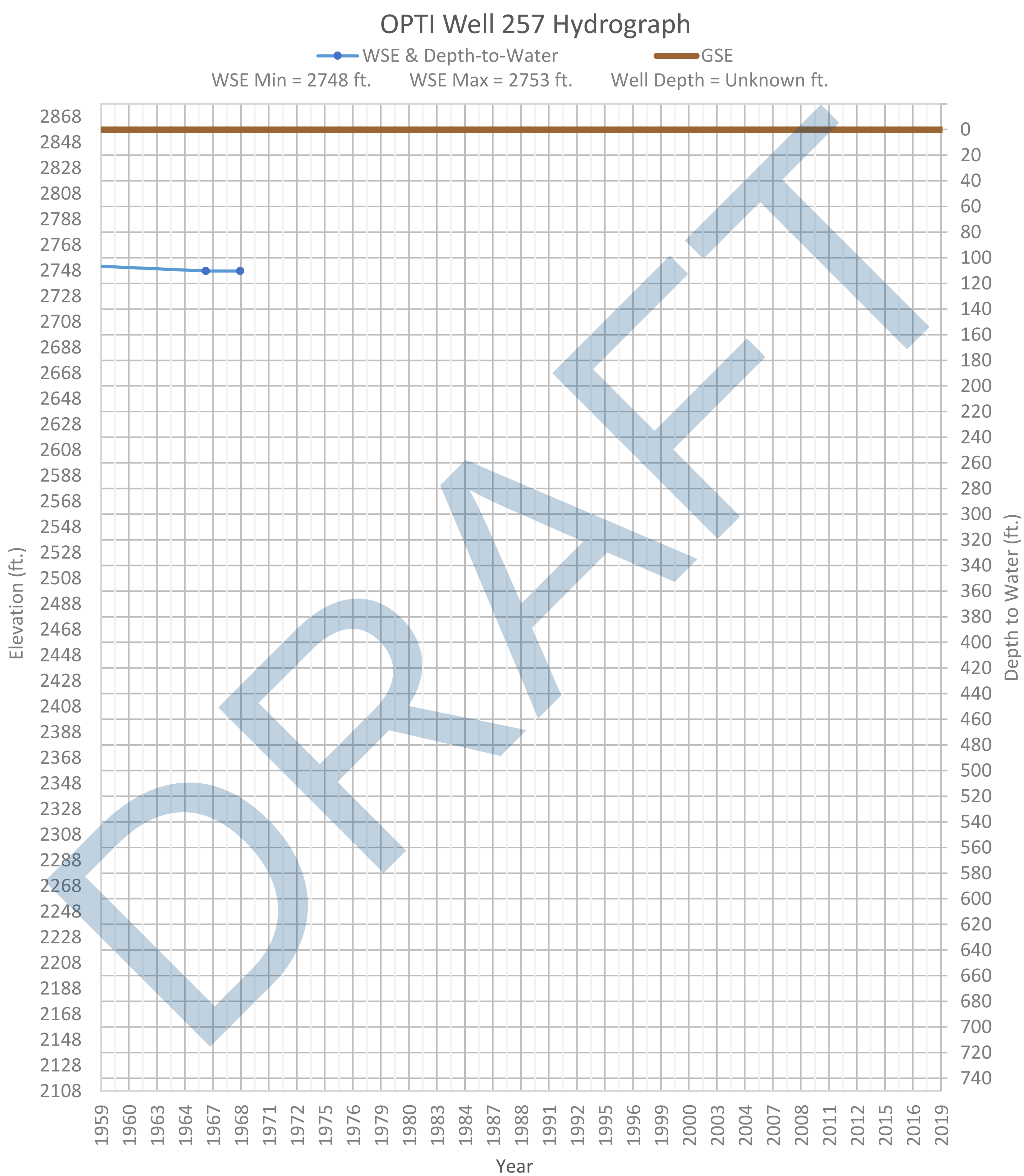
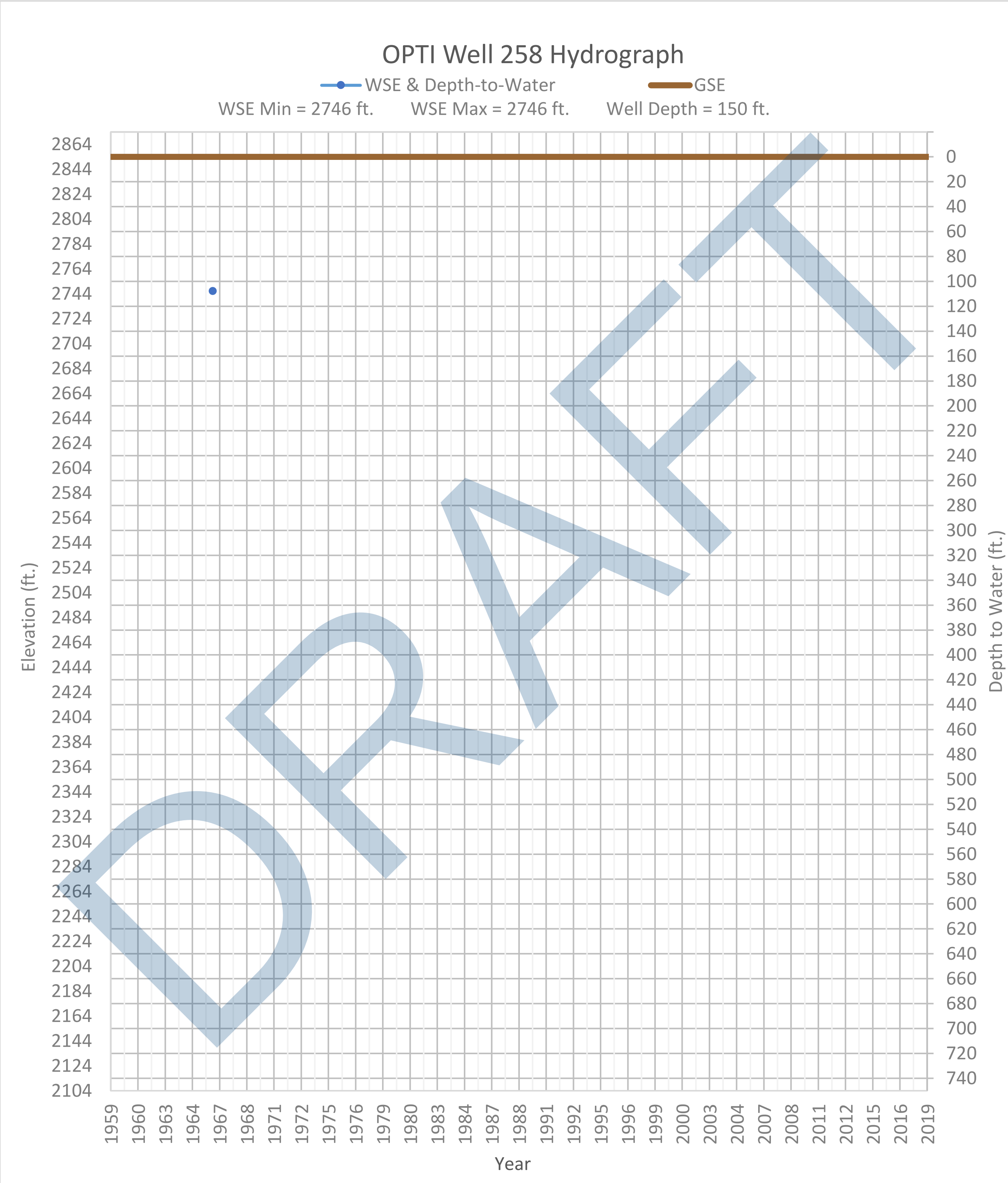
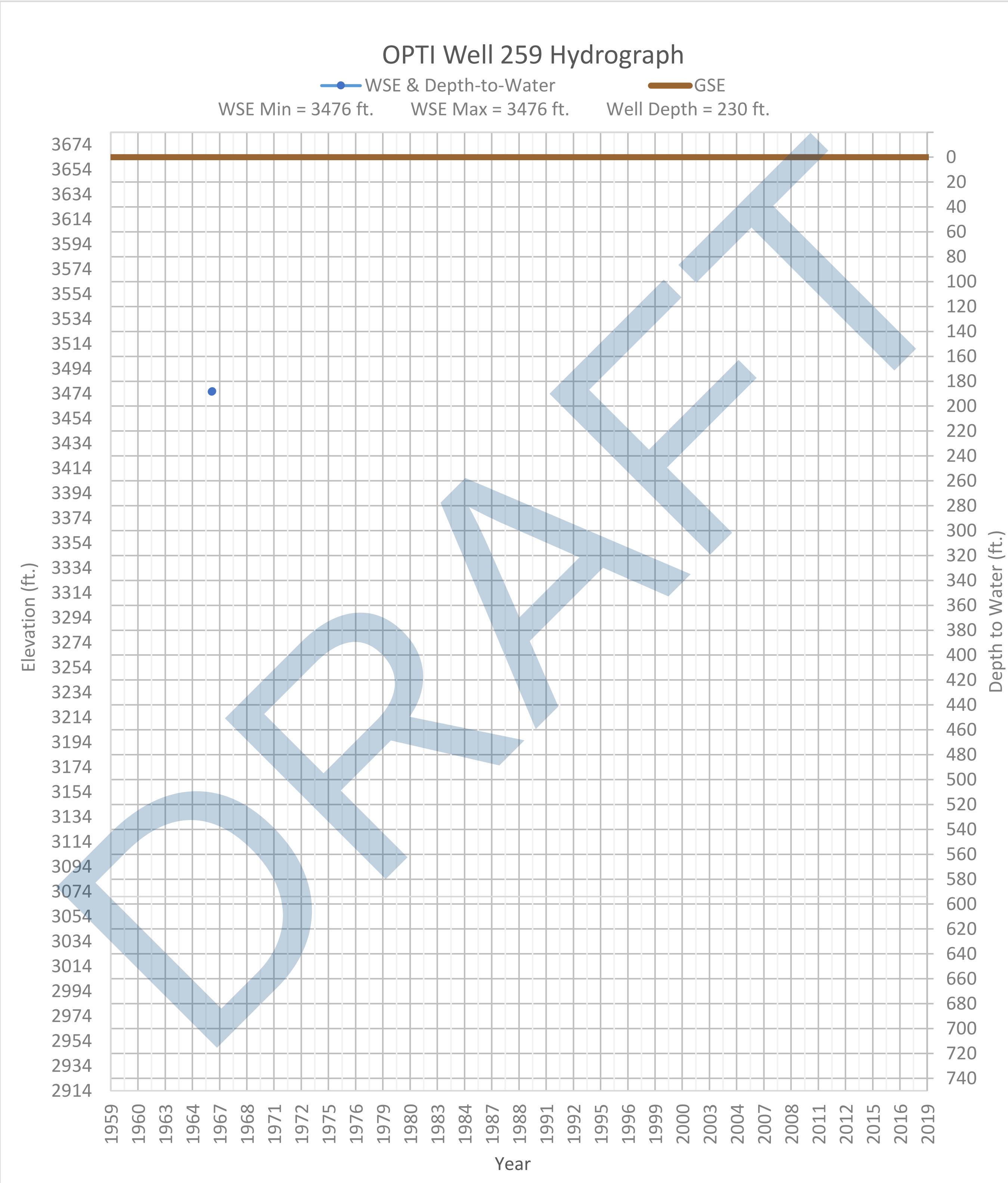
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
680
700
720
740
1959 1960 1963 1964 1967 1968 1971 1972 1975 1976 1979 1980 1983 1984 1987 1988 1991 1992 1995 1996 1999 2000 2003 2004 2007 2008 2011 2012 2015 2016 2019
DRAFT



OPTI Well 257 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2748 ft.
WSE Max = 2753 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 258 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2746 ft.
WSE Max = 2746 ft.
Well Depth = 150 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 259 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3476 ft.
WSE Max = 3476 ft.
Well Depth = 230 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
3674
3654
3634
3614
3594
3574
3554
3534
3514
3494
3474
3454
3434
3414
3394
3374
3354
3334
3314
3294
3274
3254
3234
3214
3194
3174
3154
3134
3114
3094
3074
3054
3034
3014
2994
2974
2954
2934
2914
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
680
700
720
740
1959
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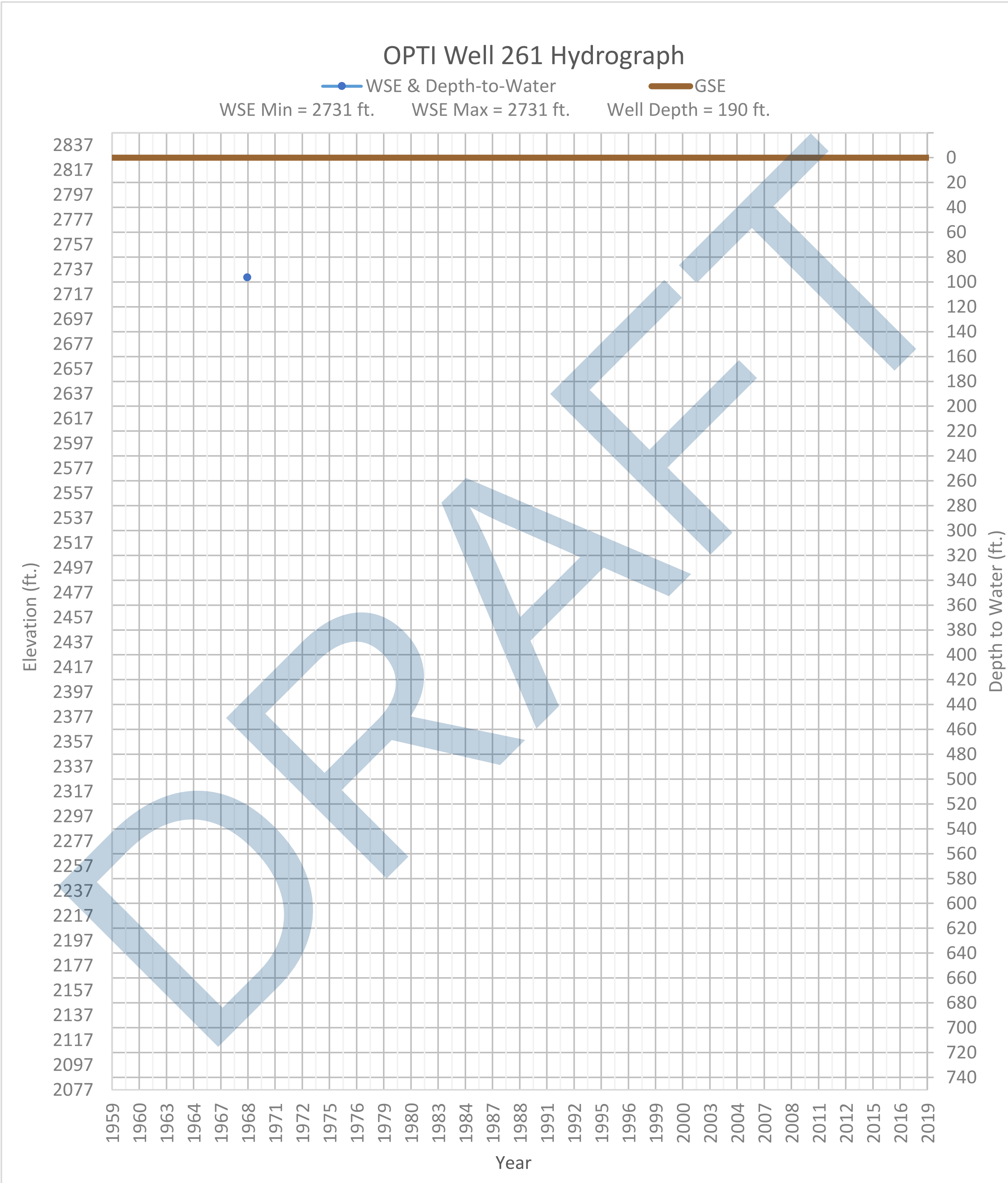
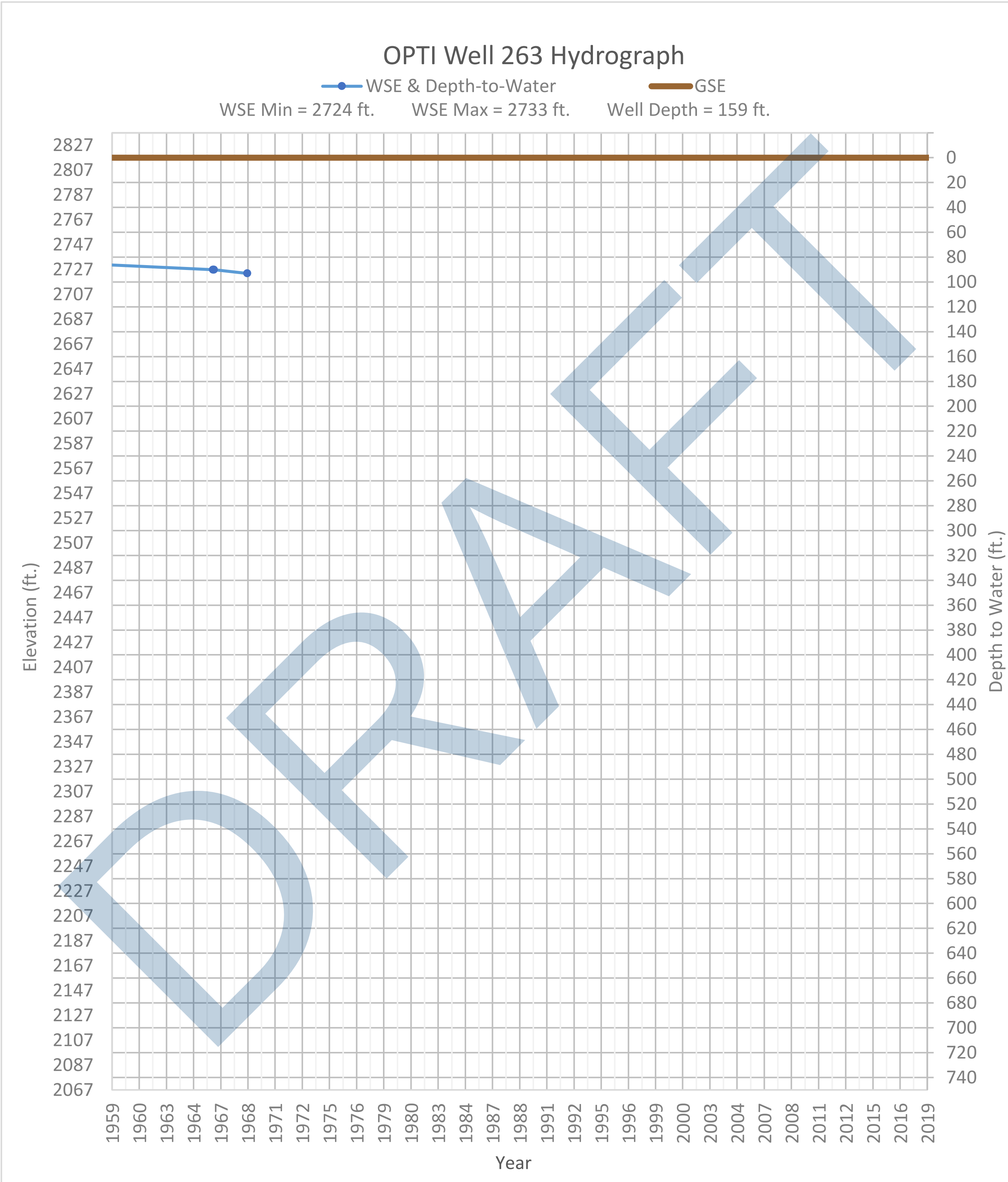
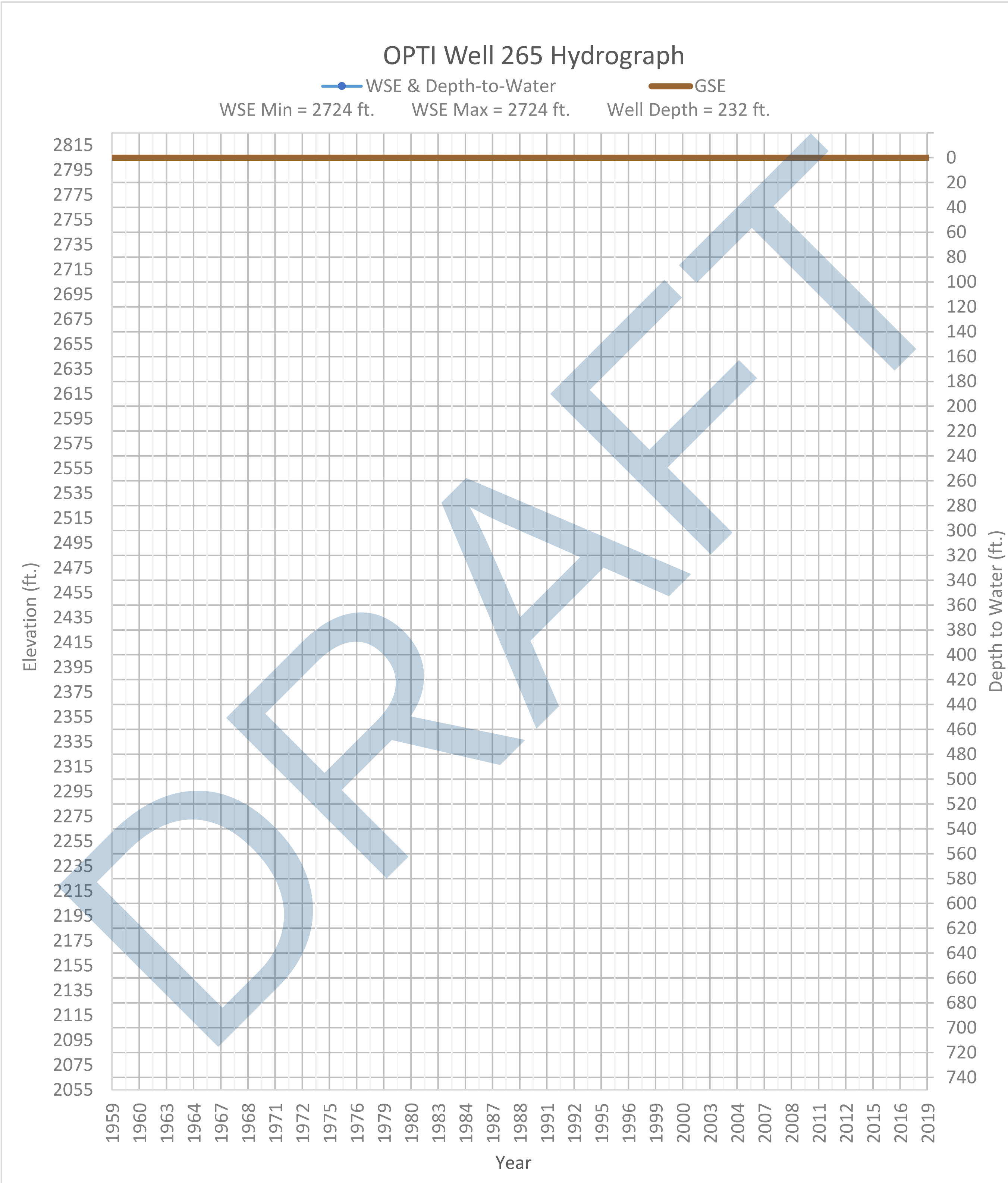
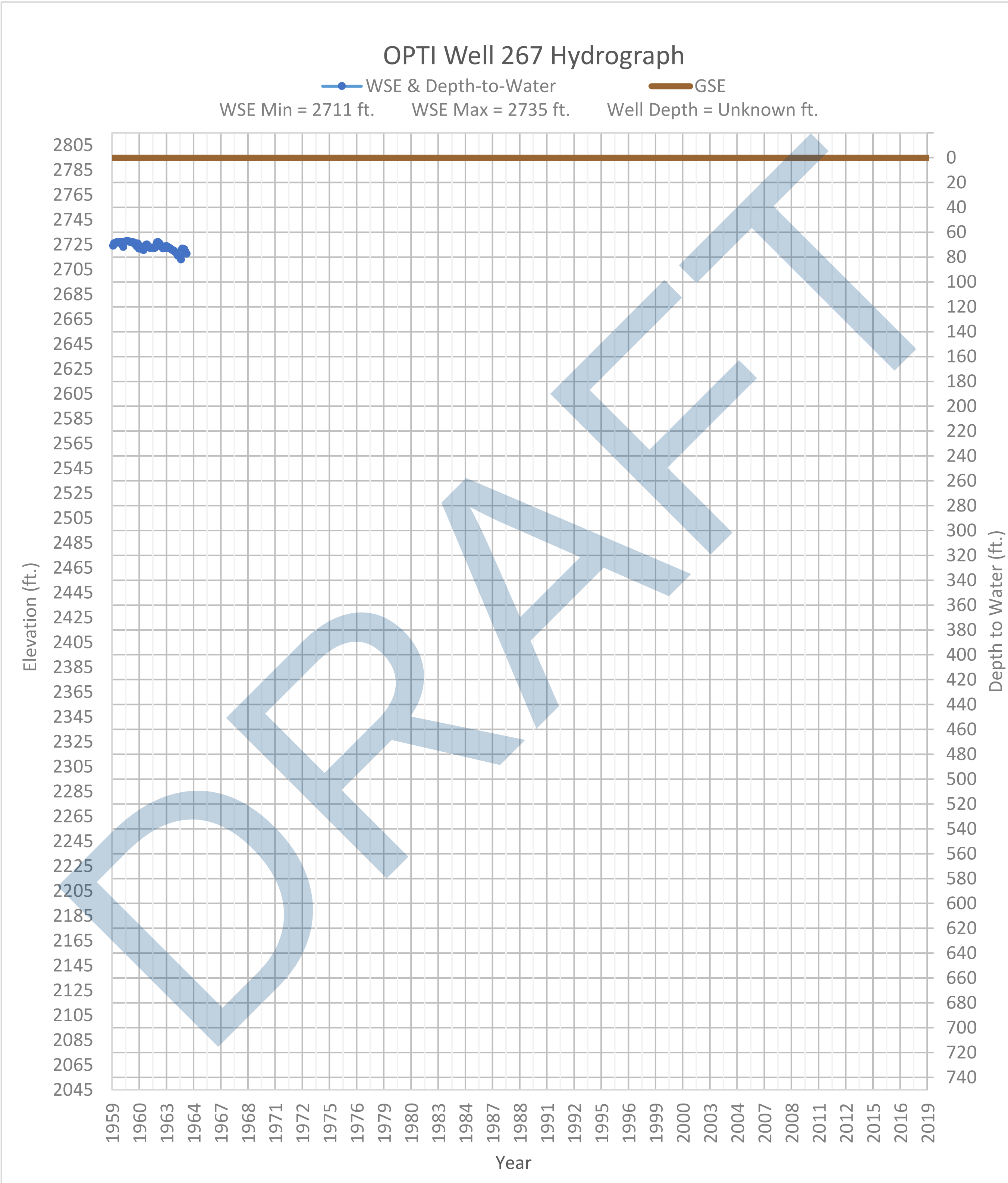

OPTI Well 261 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2731 ft.
WSE Max = 2731 ft.
Well Depth = 190 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

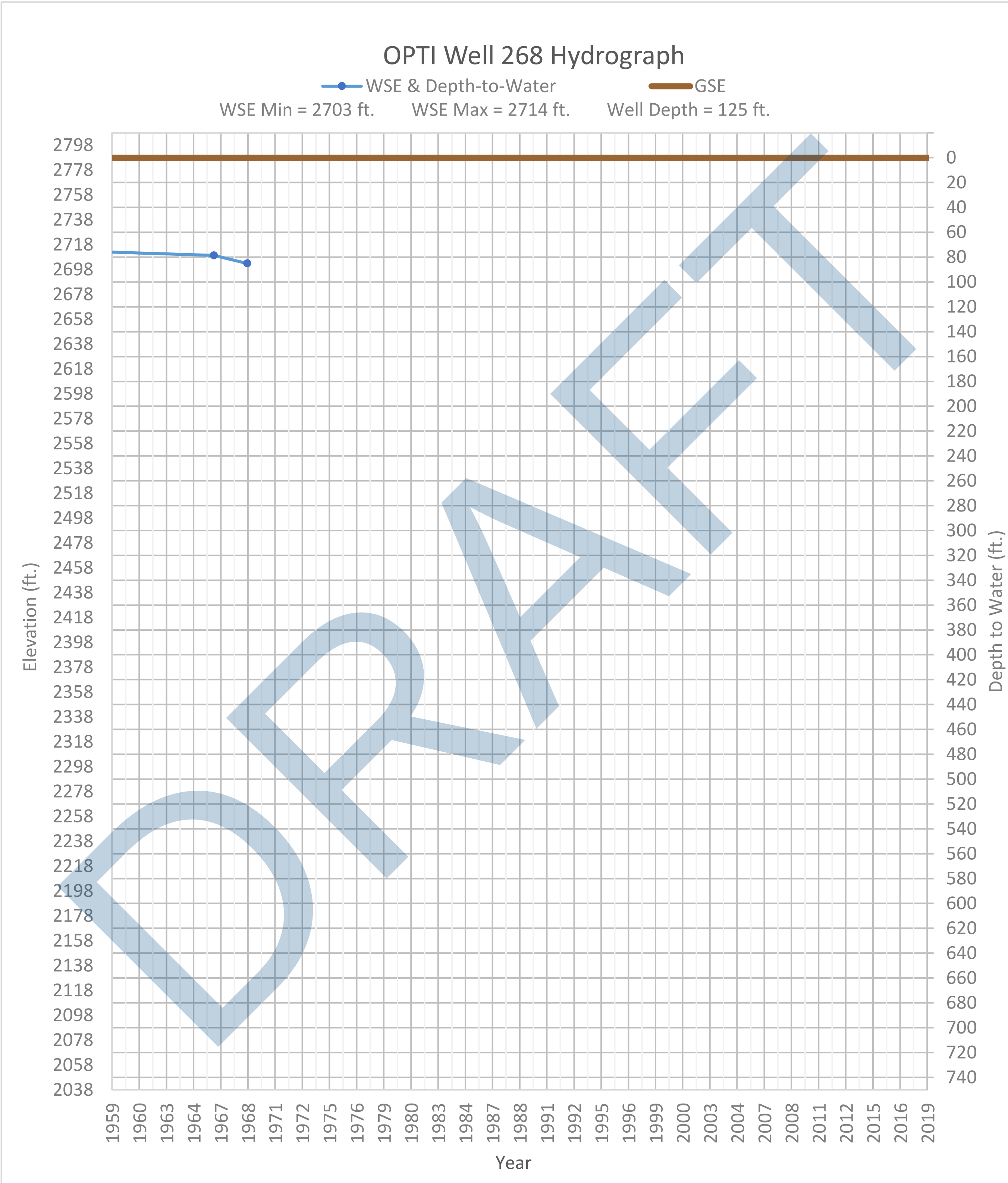


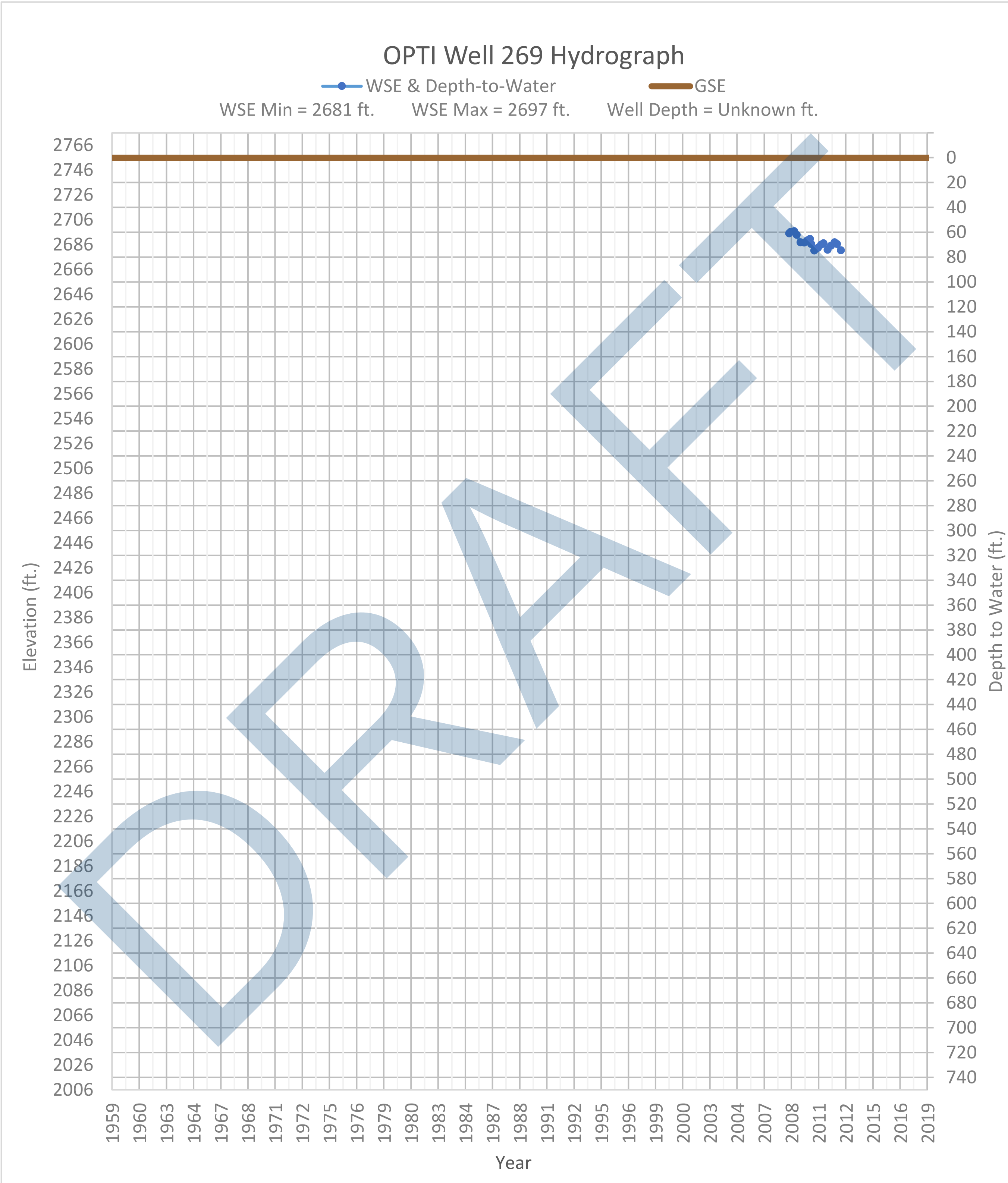
OPTI Well 263 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2724 ft.
WSE Max = 2733 ft.
Well Depth = 159 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 265 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2724 ft.
WSE Max = 2724 ft.
Well Depth = 232 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

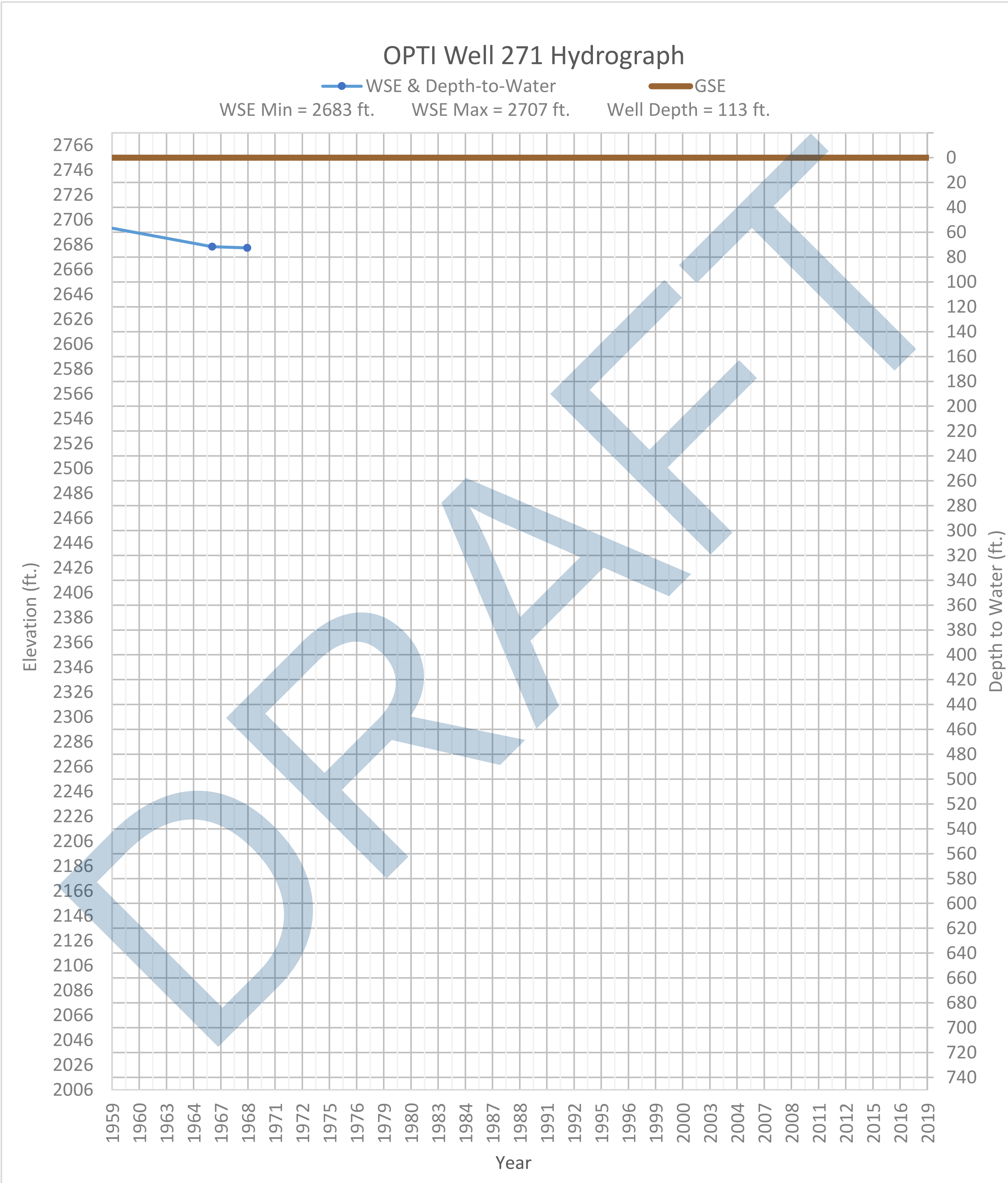


OPTI Well 267 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2711 ft.
WSE Max = 2735 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 268 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2703 ft.
WSE Max = 2714 ft.
Well Depth = 125 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 269 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2681 ft.
WSE Max = 2697 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 271 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2683 ft.
WSE Max = 2707 ft.
Well Depth = 113 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2766
2746
2726
2706
2686
2666
2646
2626
2606
2586
2566
2546
2526
2506
2486
2466
2446
2426
2406
2386
2366
2346
2326
2306
2286
2266
2246
2226
2206
2186
2166
2146
2126
2106
2086
2066
2046
2026
2006
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
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1959
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2019
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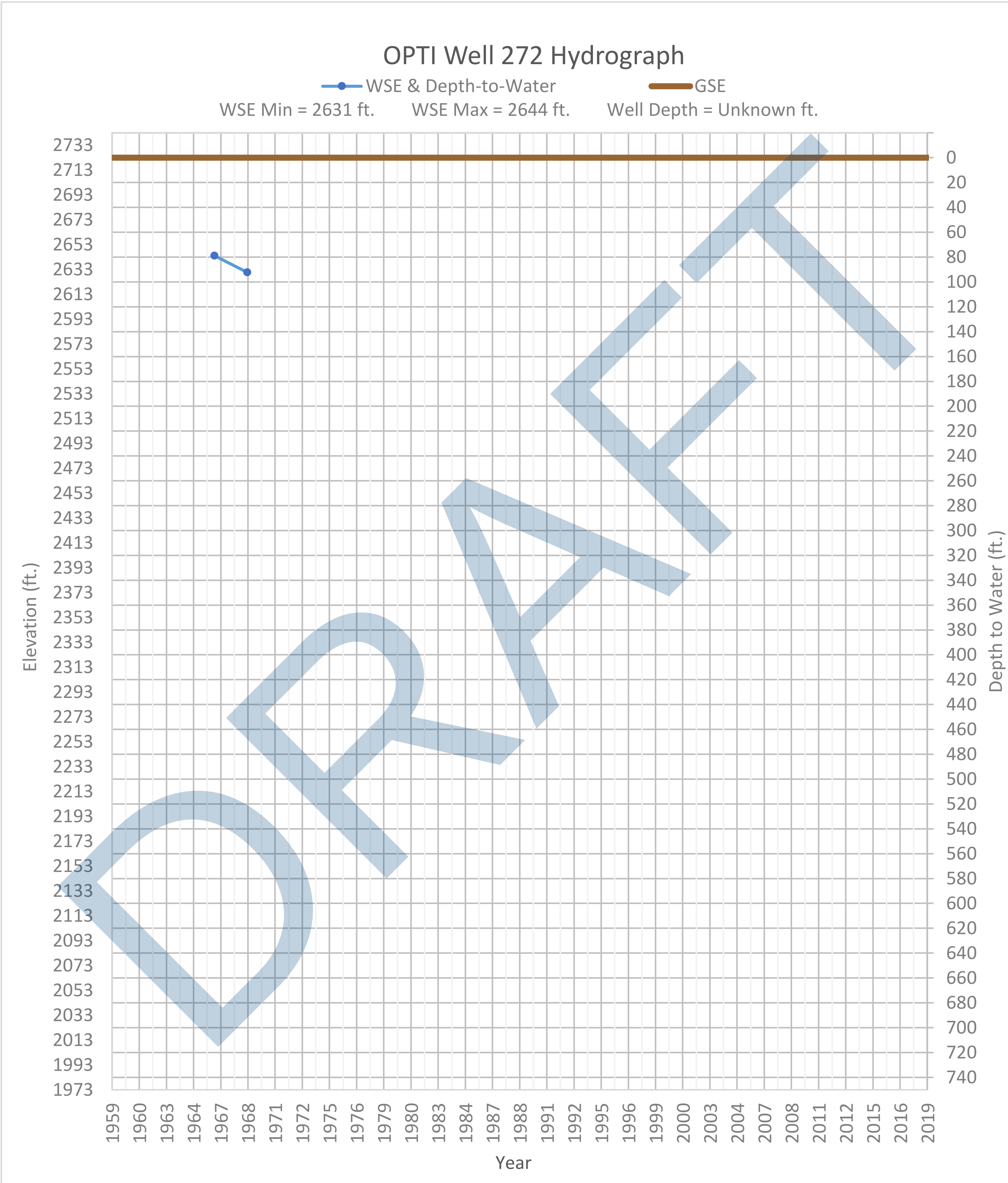
OPTI Well 272 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2631 ft.
WSE Max = 2644 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2733
2713
2693
2673
2653
2633
2613
2593
2573
2553
2533
2513
2493
2473
2453
2433
2413
2393
2373
2353
2333
2313
2293
2273
2253
2233
2213
2193
2173
2153
2133
2113
2093
2073
2053
2033
2013
1993
1973
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
680
700
720
740
1959
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1963
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1967
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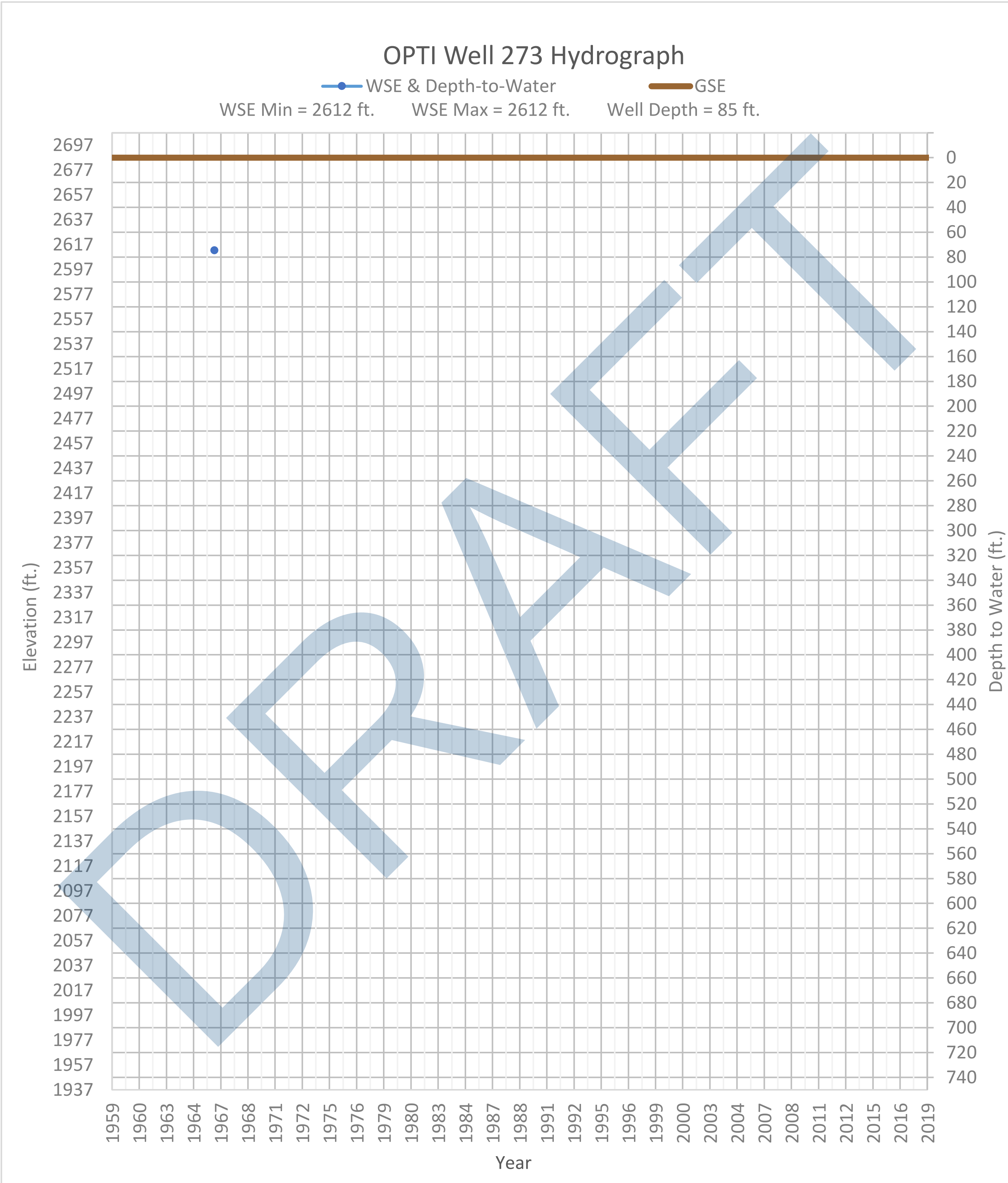
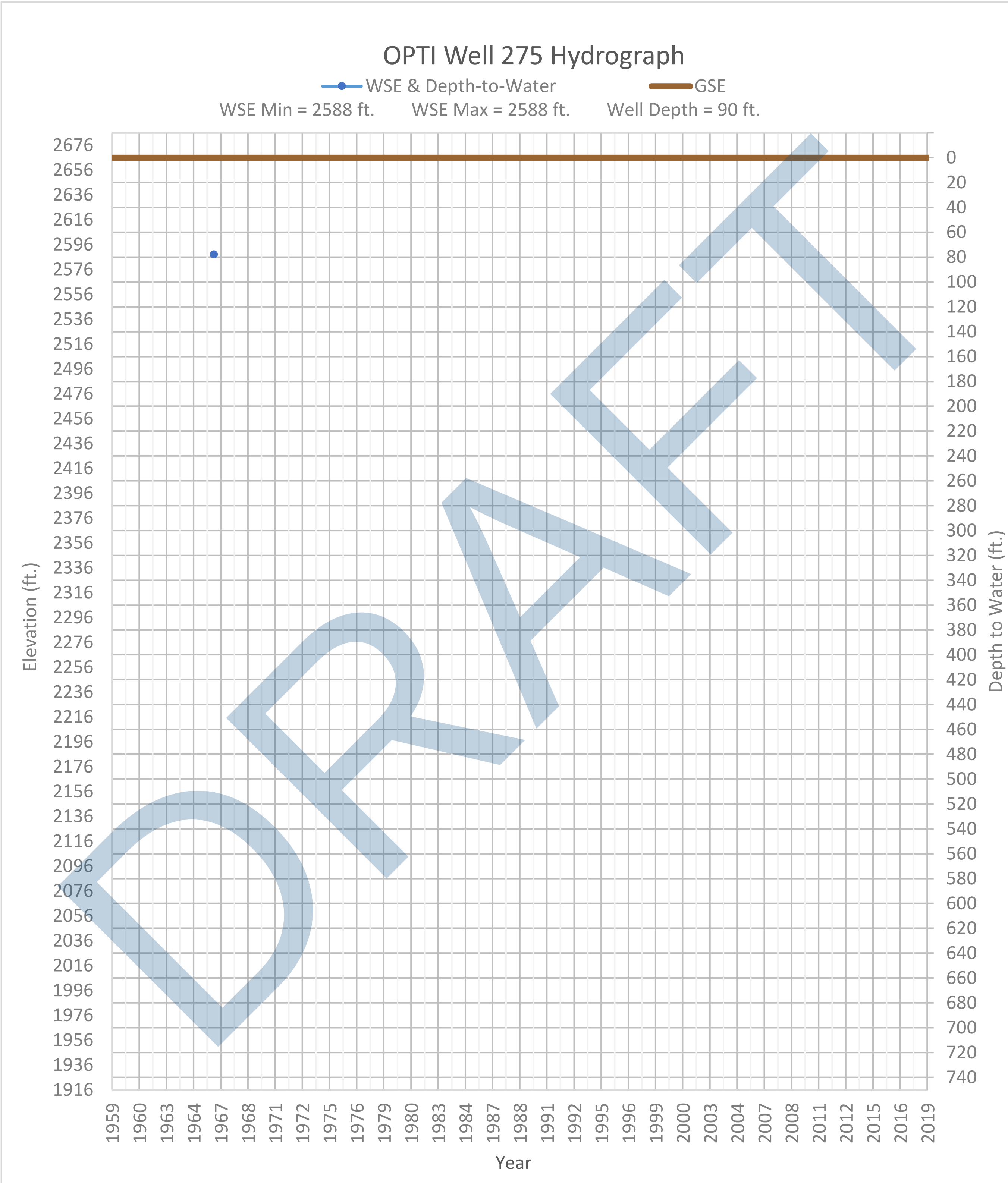
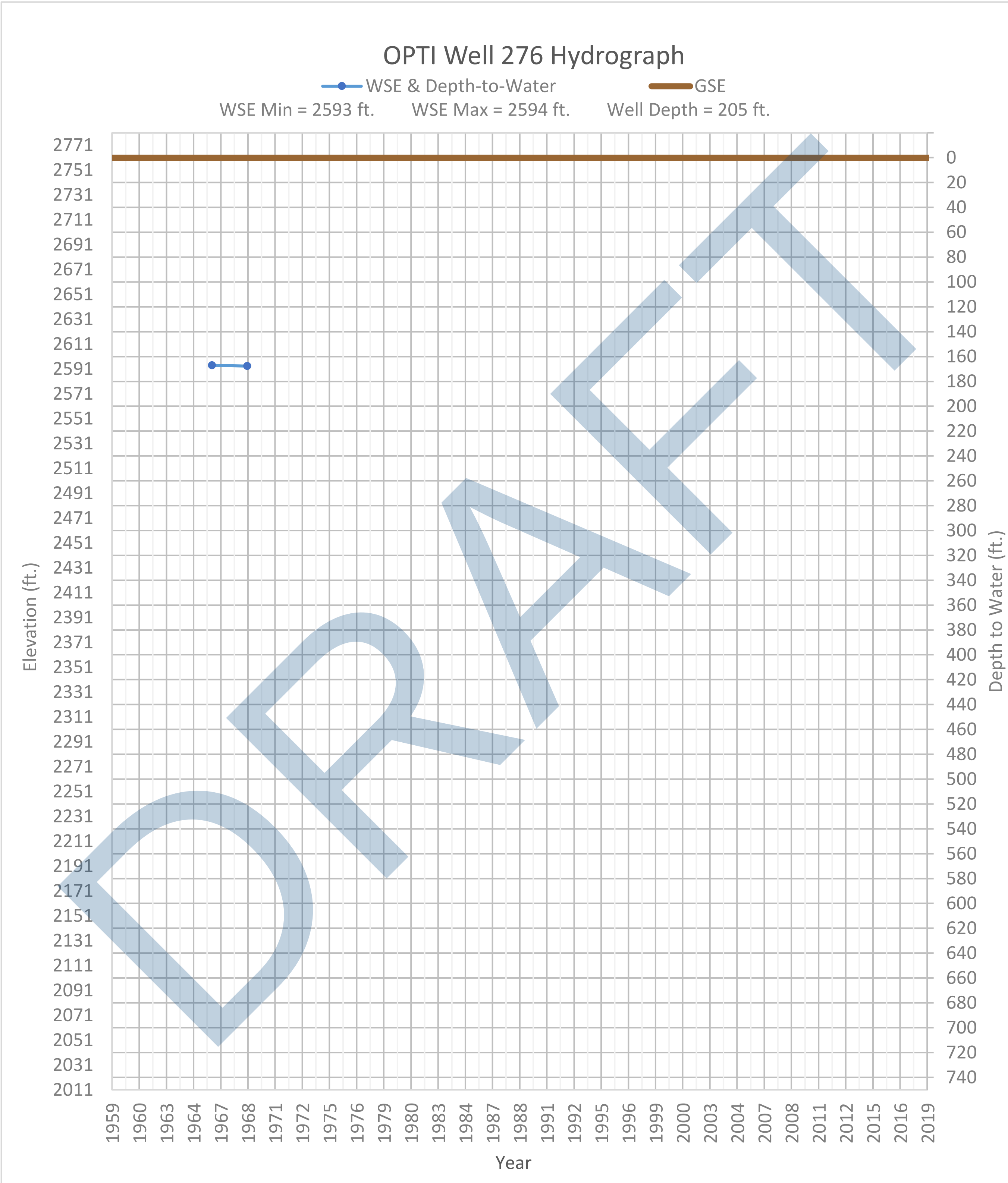
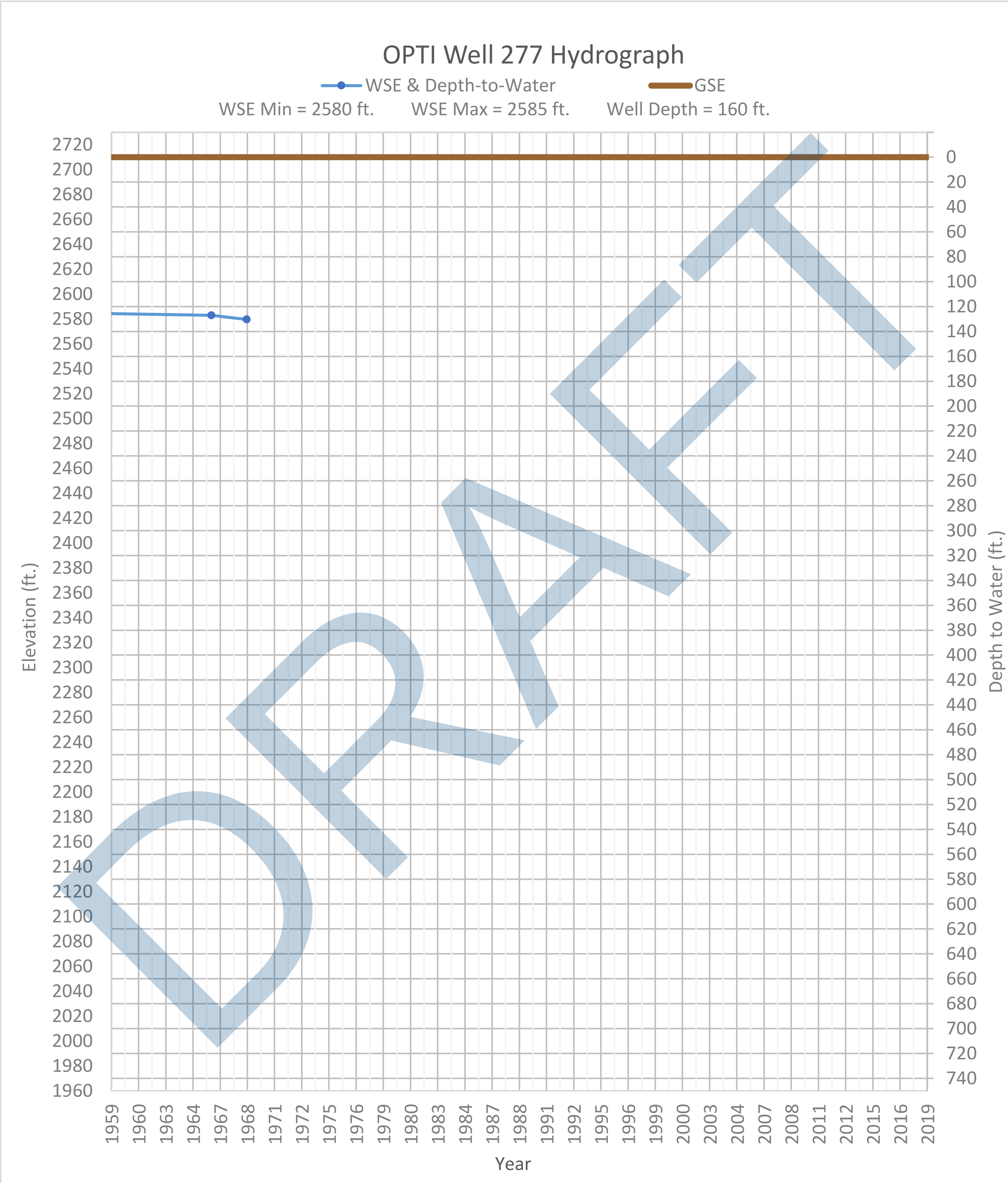
2016
2019
DRAFT


OPTI Well 273 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2612 ft.
WSE Max = 2612 ft.
Well Depth = 85 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

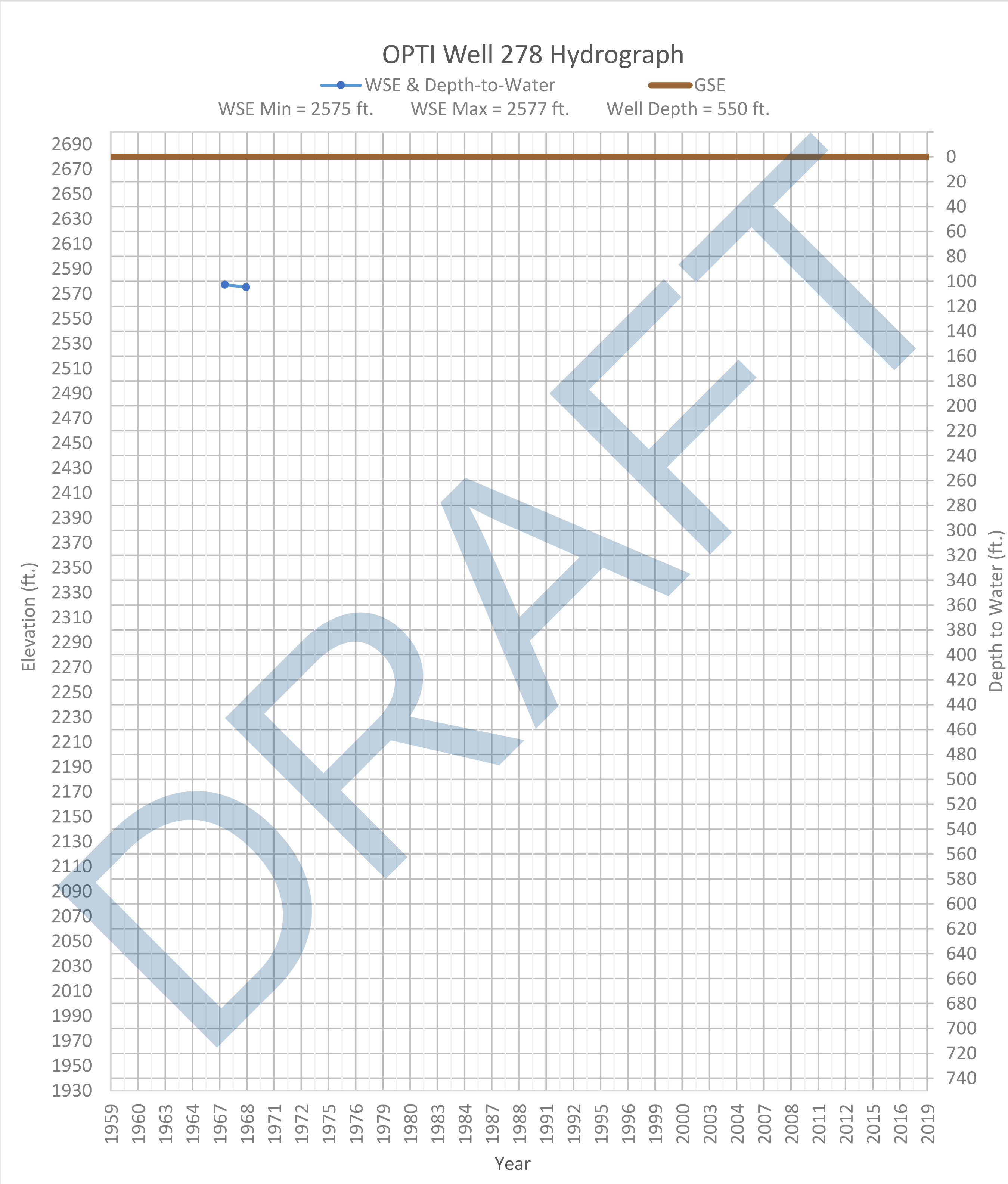


OPTI Well 275 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2588 ft.
WSE Max = 2588 ft.
Well Depth = 90 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

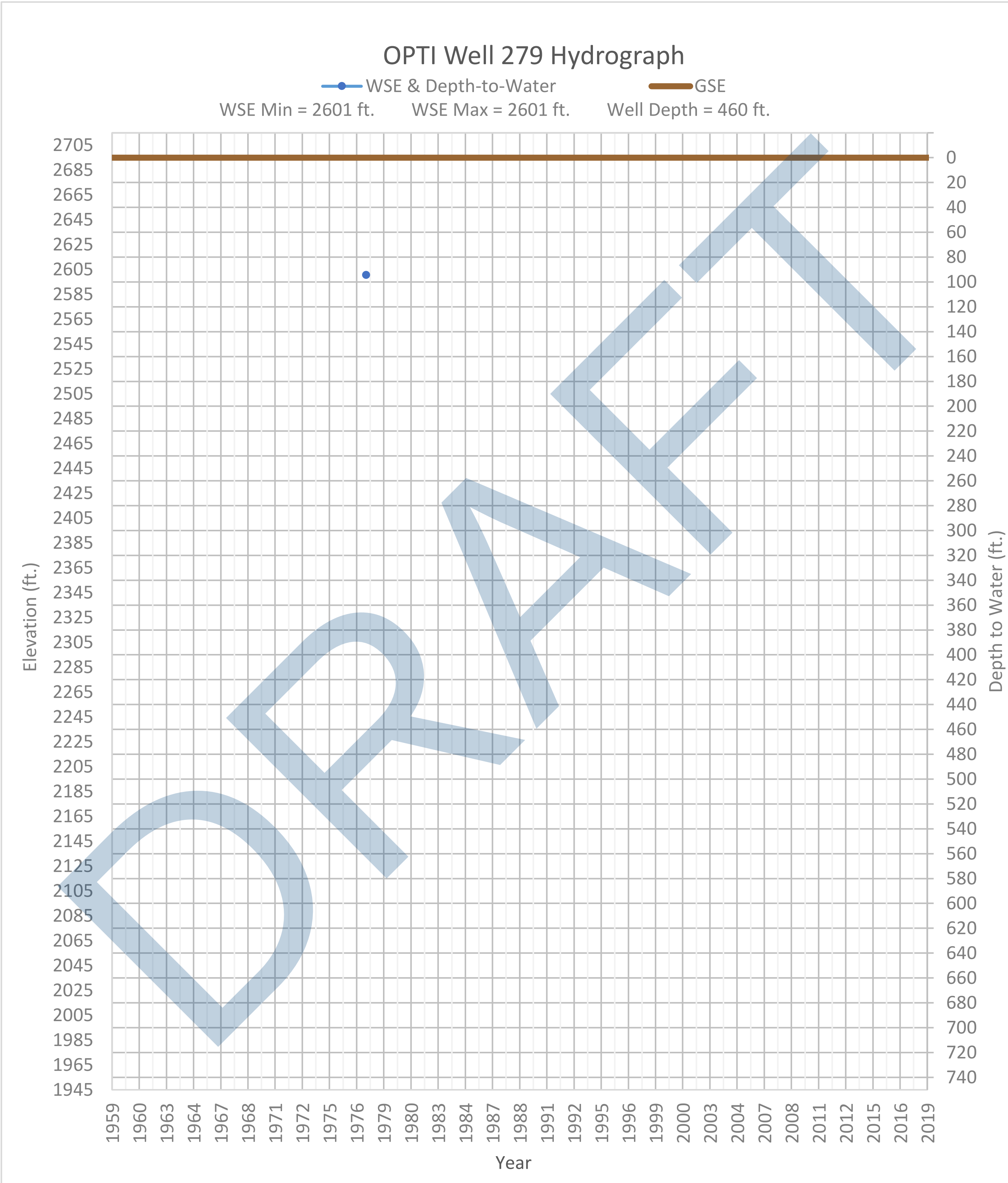

OPTI Well 276 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2593 ft.
WSE Max = 2594 ft.
Well Depth = 205 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



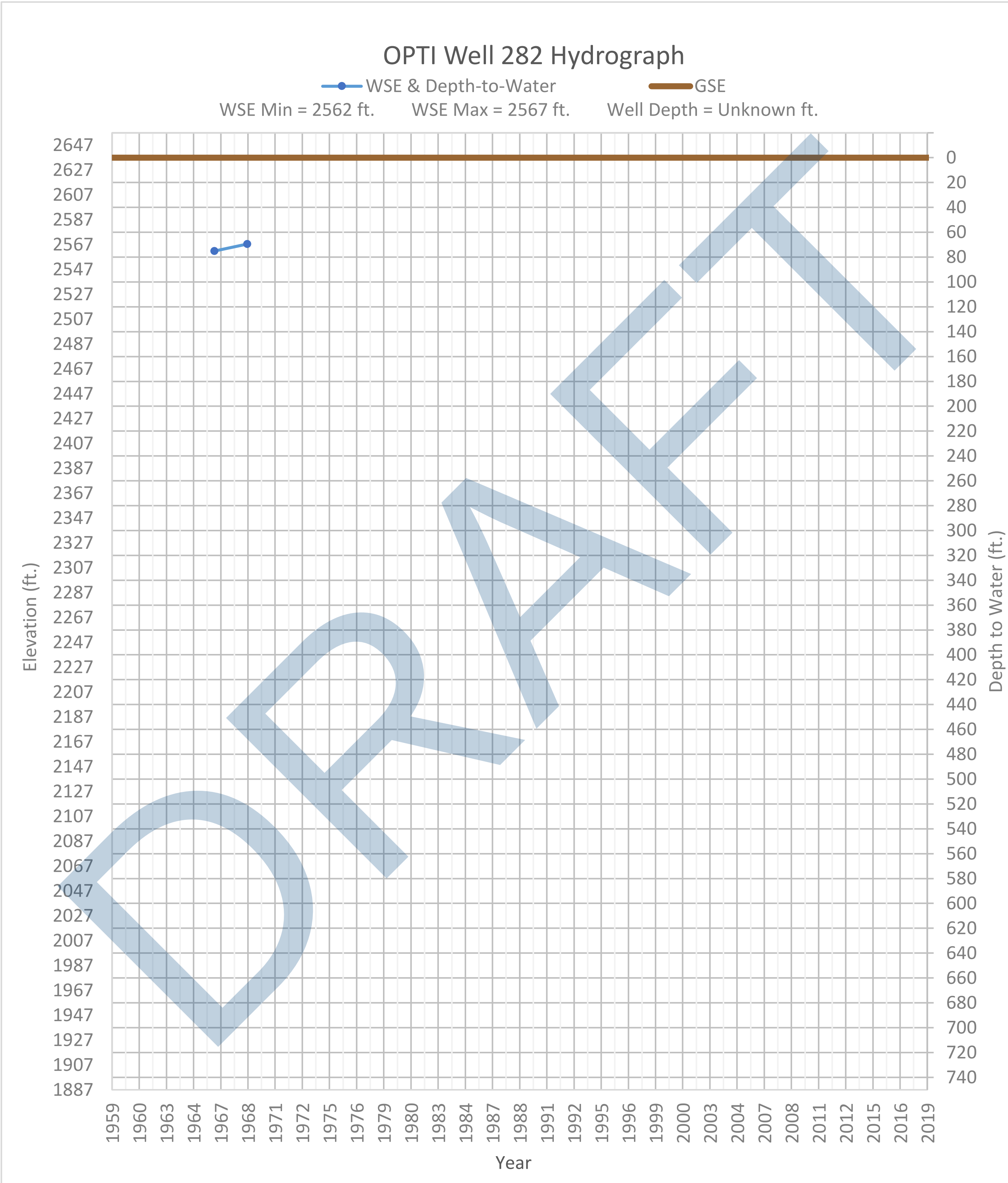
OPTI Well 277 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2580 ft.
WSE Max = 2585 ft.
Well Depth = 160 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



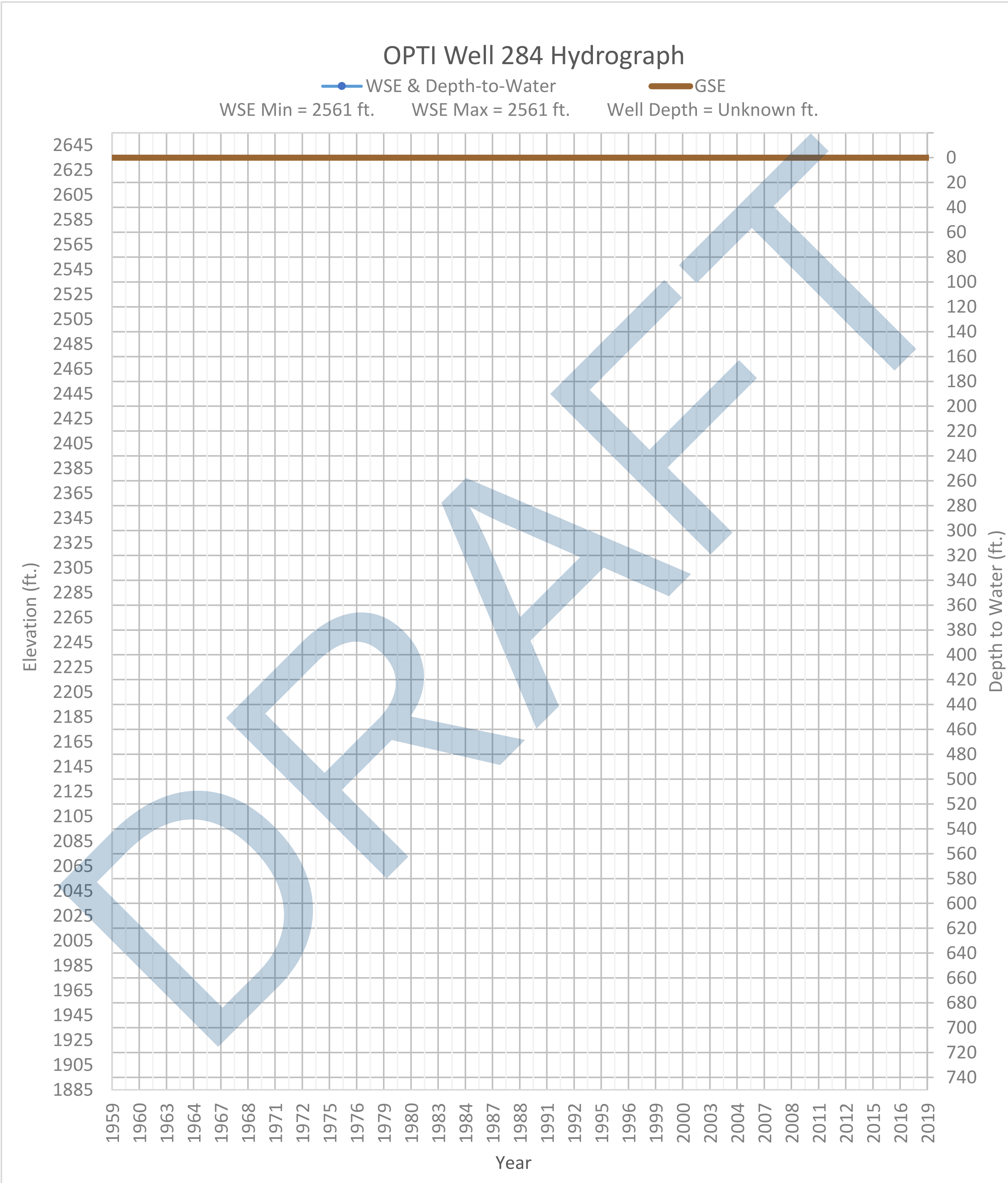
OPTI Well 278 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2575 ft.
WSE Max = 2577 ft.
Well Depth = 550 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 279 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2601 ft.
WSE Max = 2601 ft.
Well Depth = 460 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 282 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2562 ft.
WSE Max = 2567 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 284 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2561 ft.
WSE Max = 2561 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2645
2625
2605
2585
2565
2545
2525
2505
2485
2465
2445
2425
2405
2385
2365
2345
2325
2305
2285
2265
2245
2225
2205
2185
2165
2145
2125
2105
2085
2065
2045
2025
2005
1985
1965
1945
1925
1905
1885
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
680
700
720
740
1959
1960
1963
1964
1967
1968
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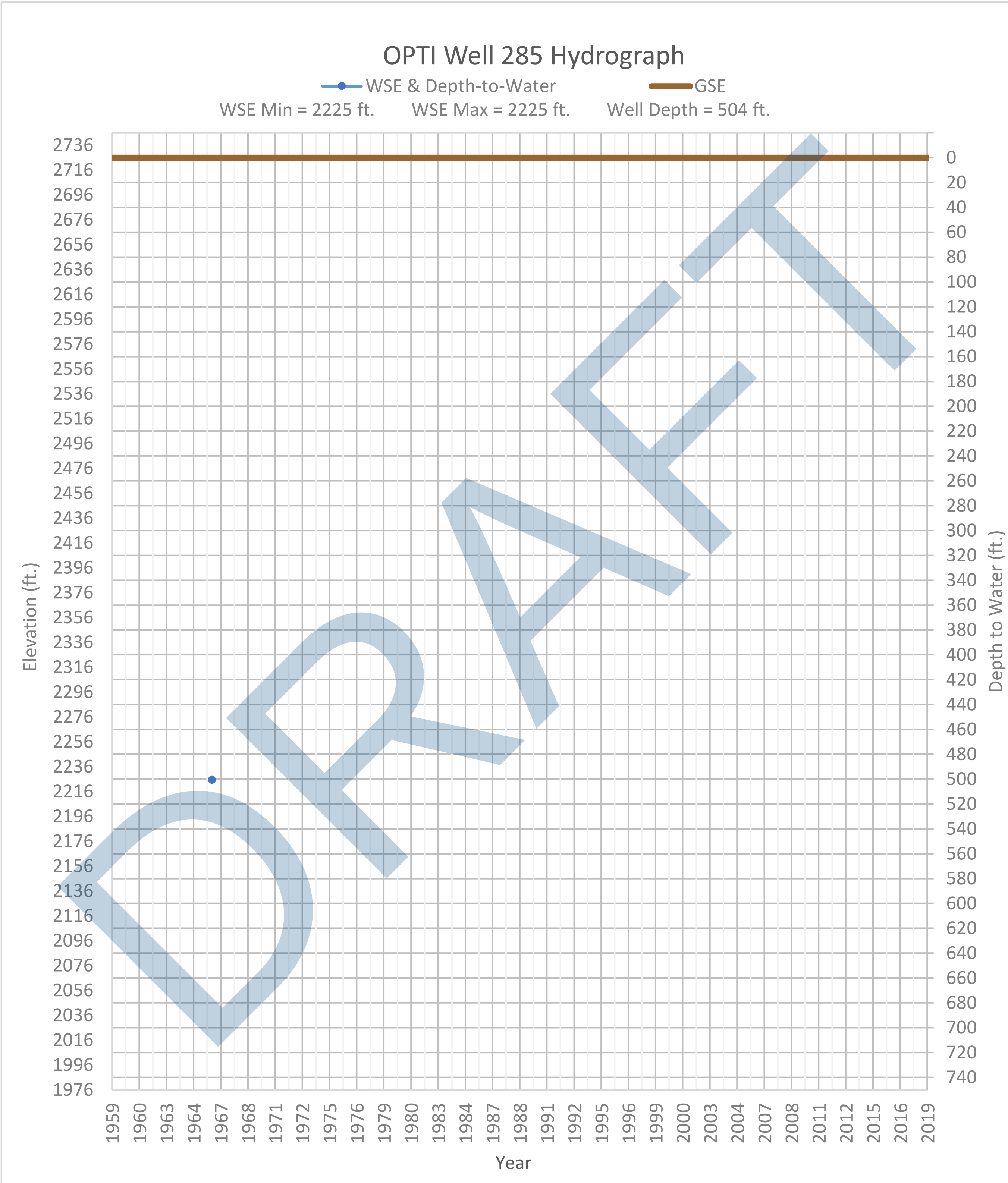
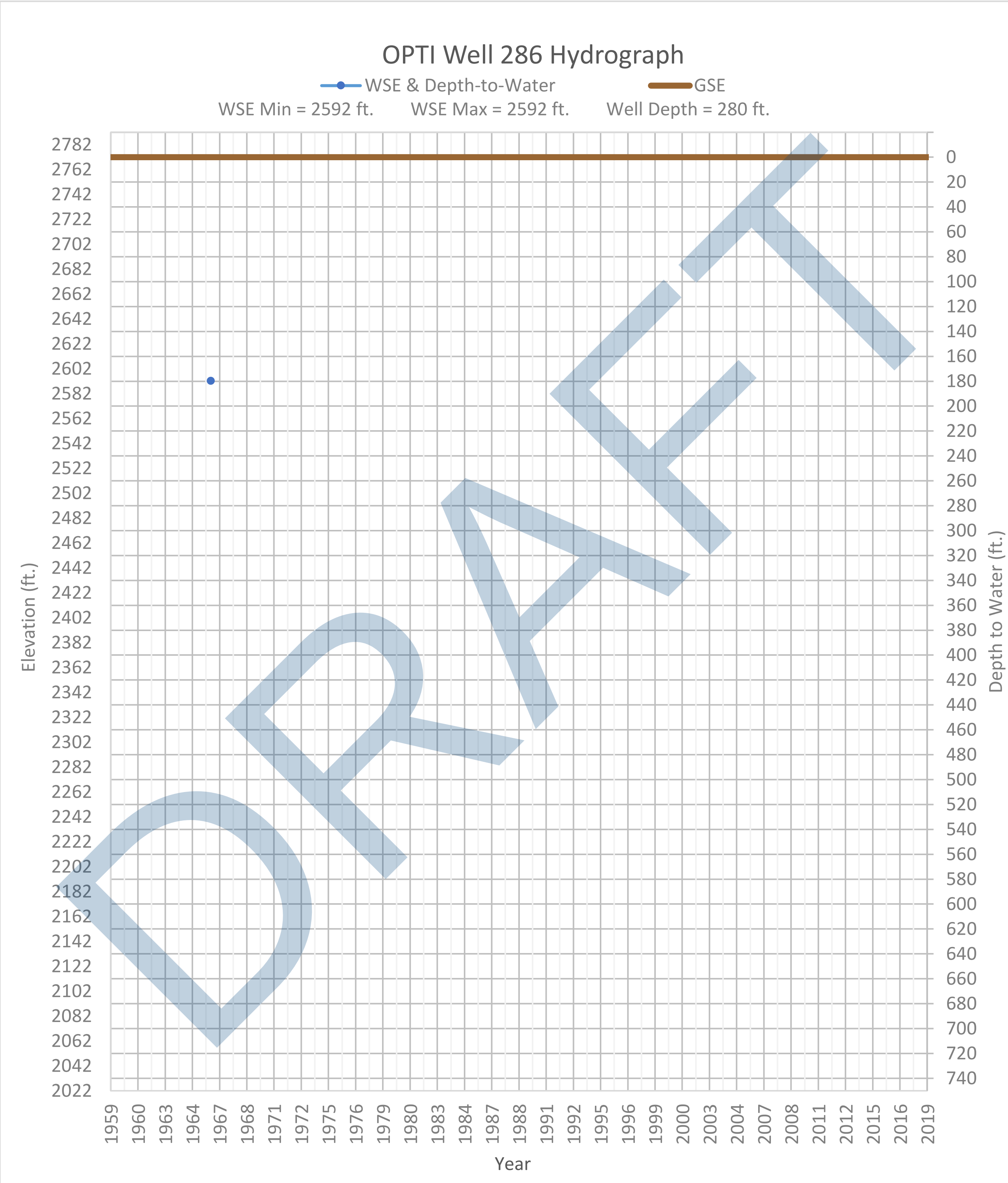
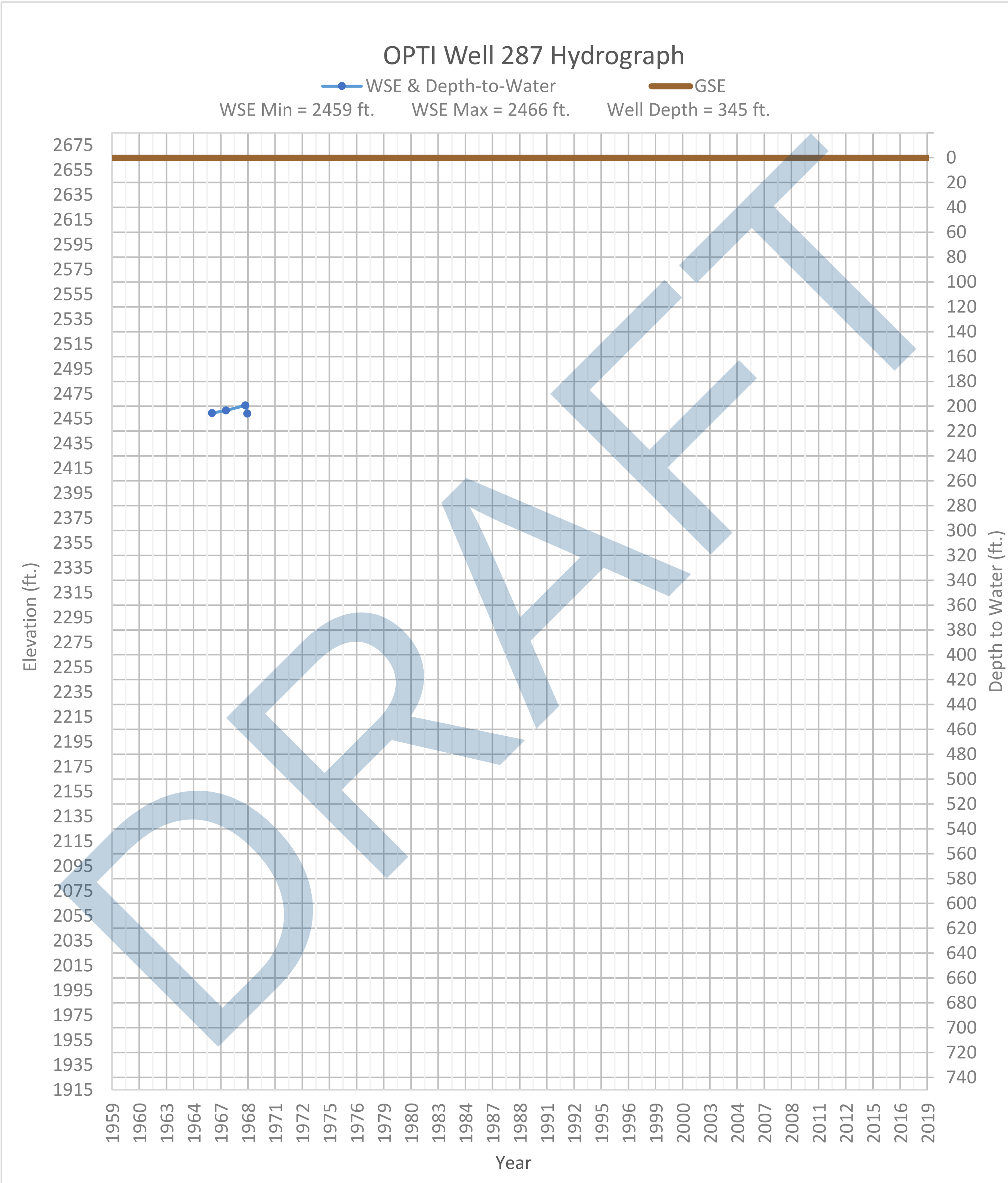
2016
2019
DRAFT



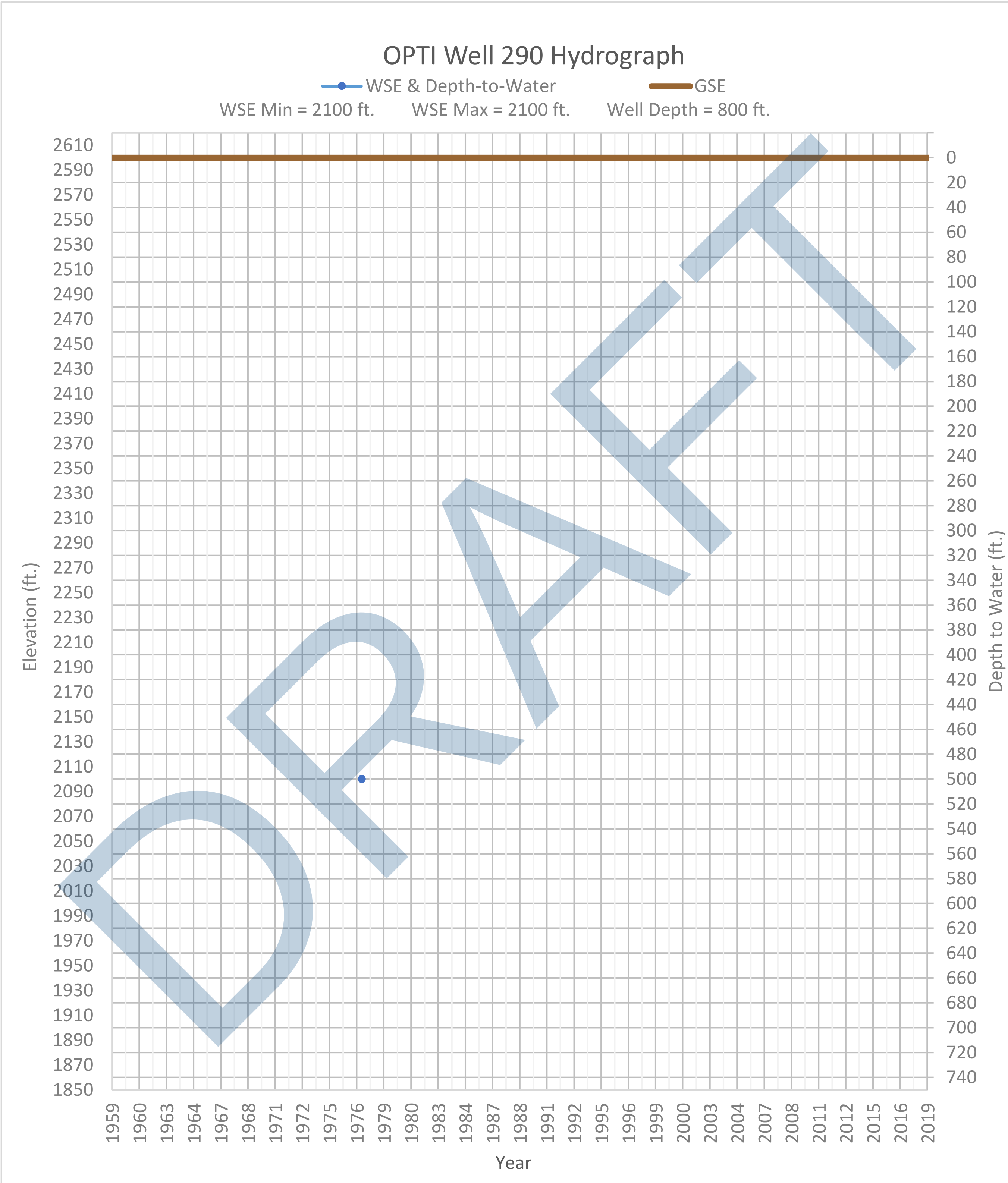
OPTI Well 285 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2225 ft.
WSE Max = 2225 ft.
Well Depth = 504 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



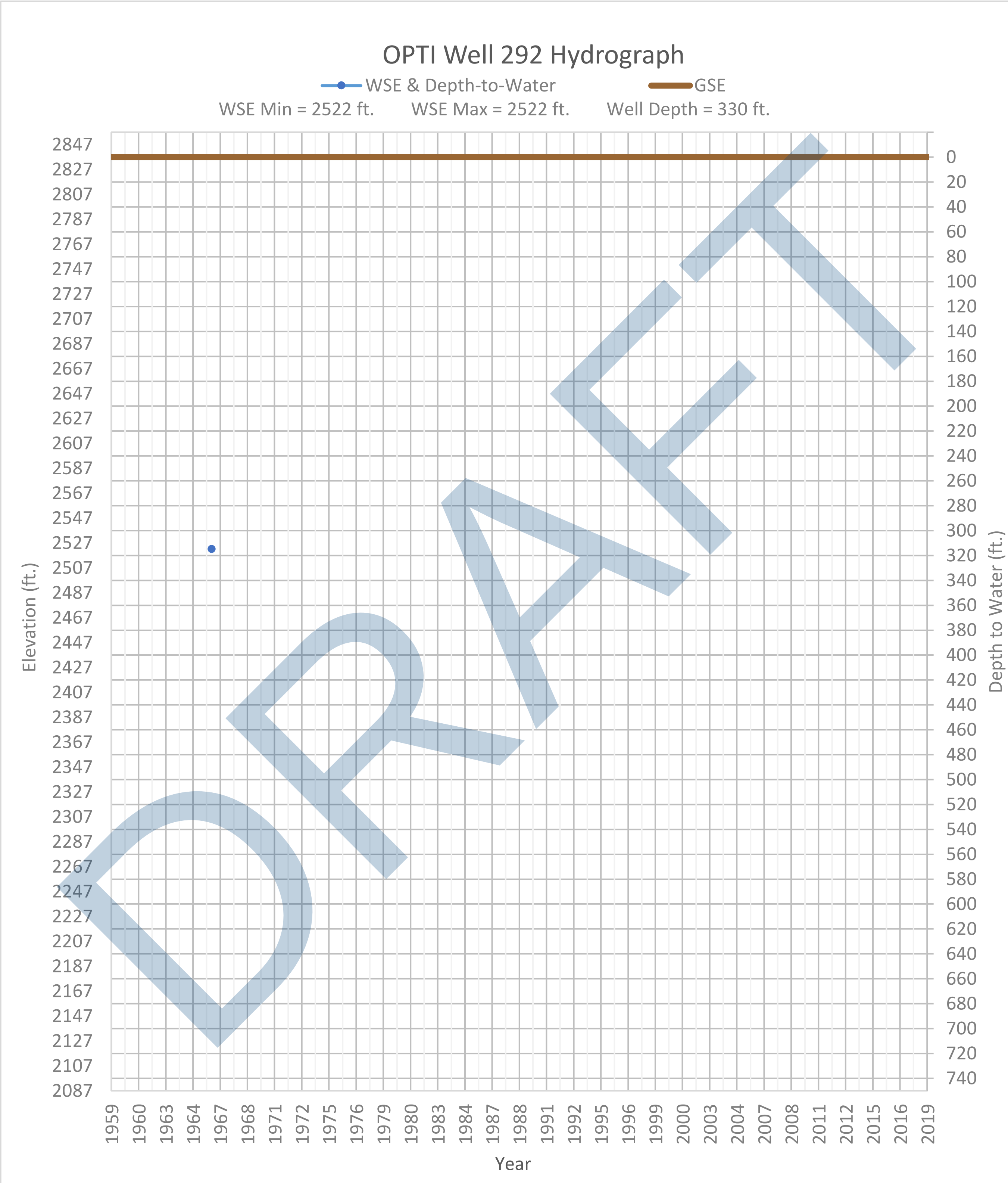
OPTI Well 286 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2592 ft.
WSE Max = 2592 ft.
Well Depth = 280 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



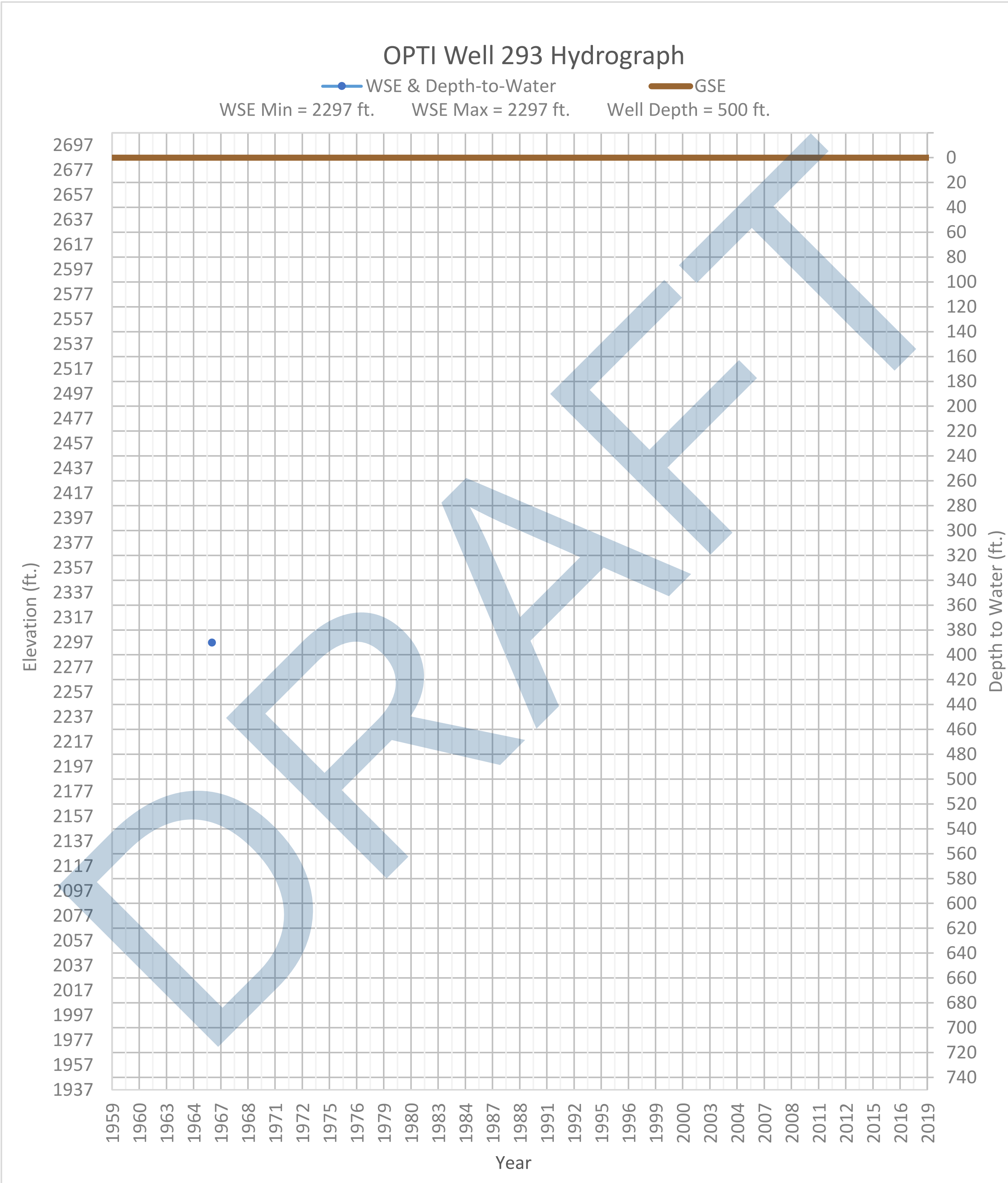
OPTI Well 287 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2459 ft.
WSE Max = 2466 ft.
Well Depth = 345 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



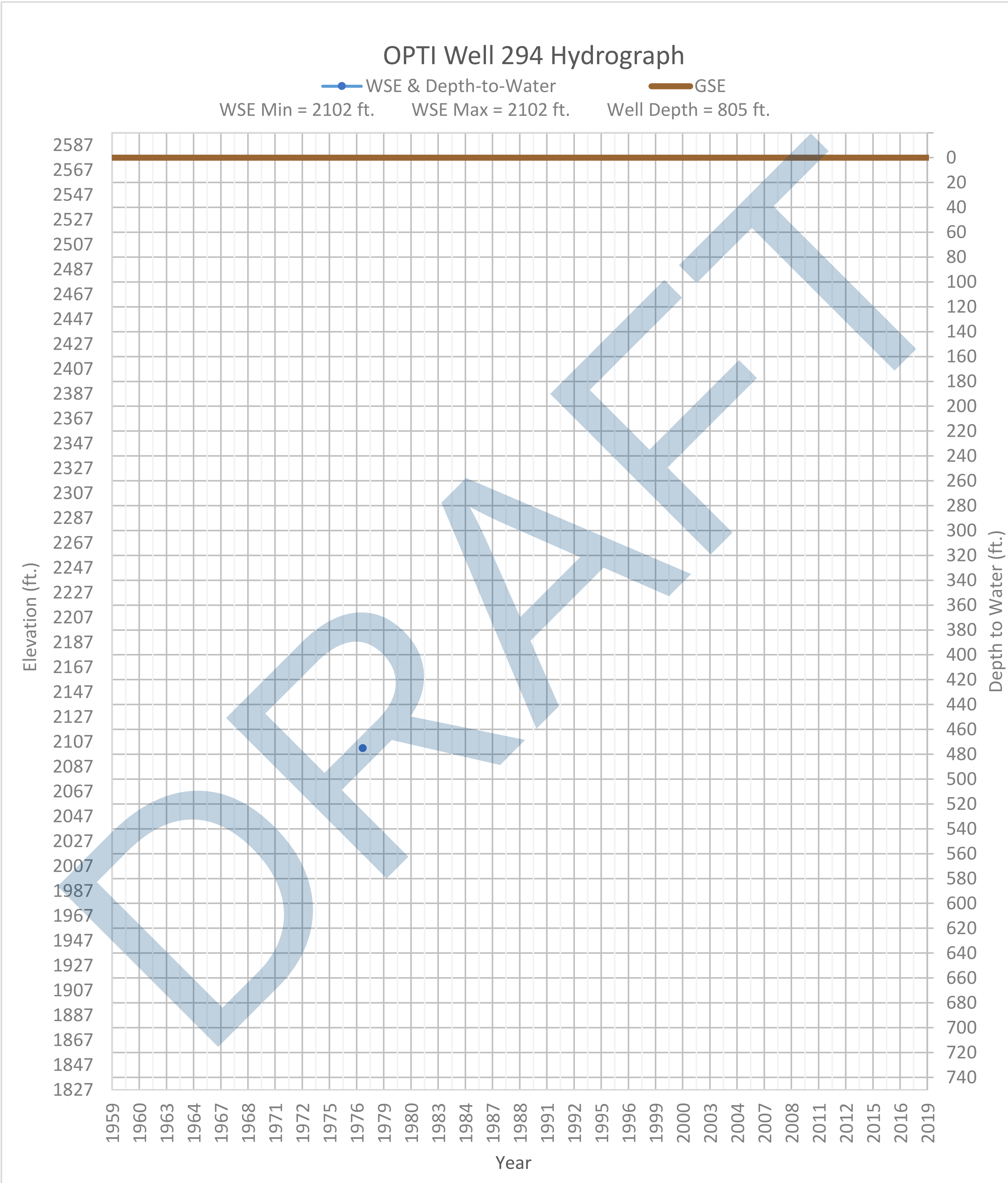
OPTI Well 290 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2100 ft.
WSE Max = 2100 ft.
Well Depth = 800 ft.
Elevation (ft.)
2610 2590 2570 2550 2530 2510 2490 2470 2450 2430 2410 2390 2370 2350 2330 2310 2290 2270 2250 2230 2210 2190 2170 2150 2130 2110 2090 2070 2050 2030 2010 1990 1970 1950 1930 1910 1890 1870 1850
Depth to Water (ft.)
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720 740
1959 1960 1963 1964 1967 1968 1971 1972 1975 1976 1979 1980 1983 1984 1987 1988 1991 1992 1995 1996 1999 2000 2003 2004 2007 2008 2011 2012 2015 2016 2019
Year
DRAFT

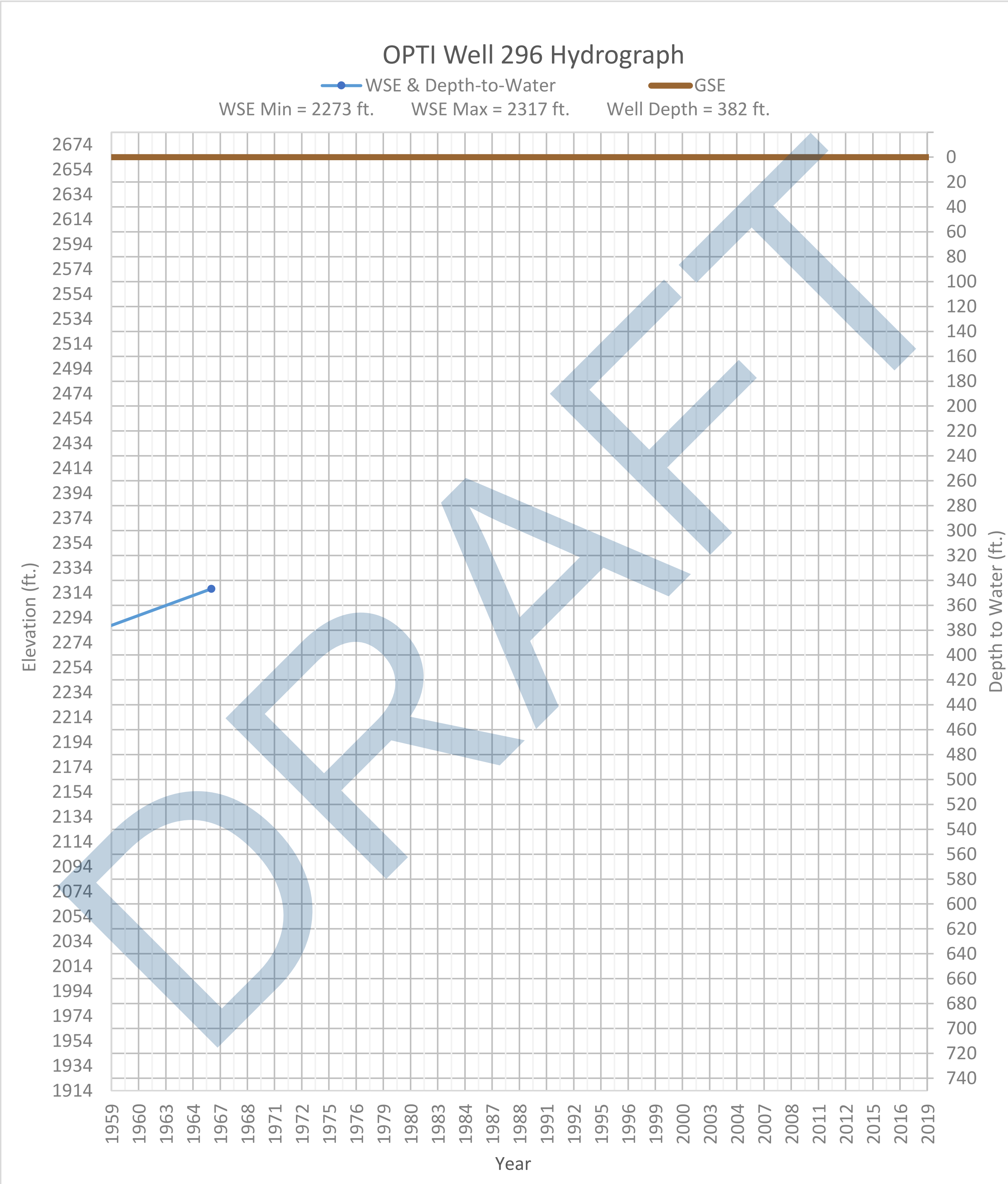


OPTI Well 292 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2522 ft.
WSE Max = 2522 ft.
Well Depth = 330 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

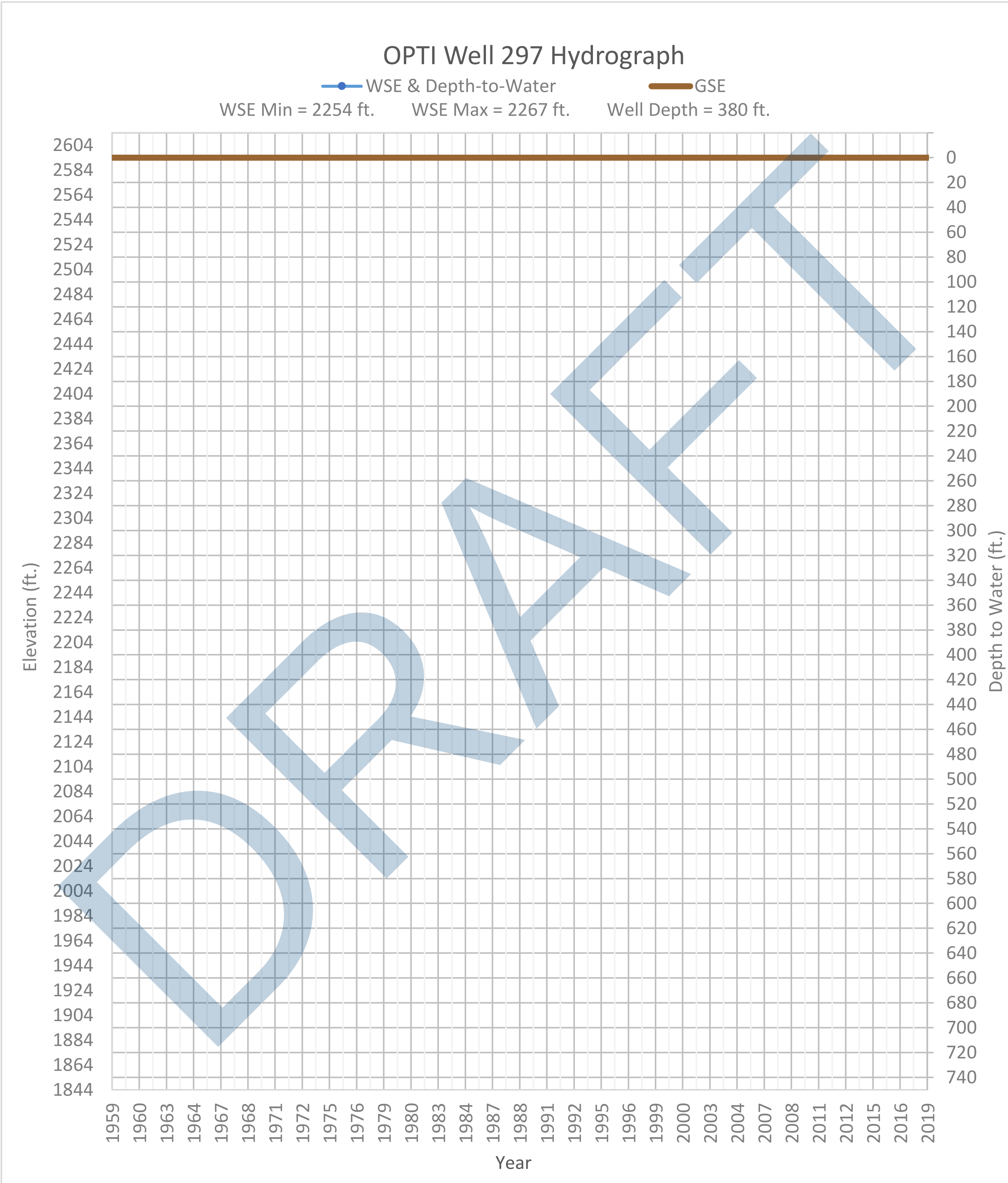


OPTI Well 293 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2297 ft.
WSE Max = 2297 ft.
Well Depth = 500 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

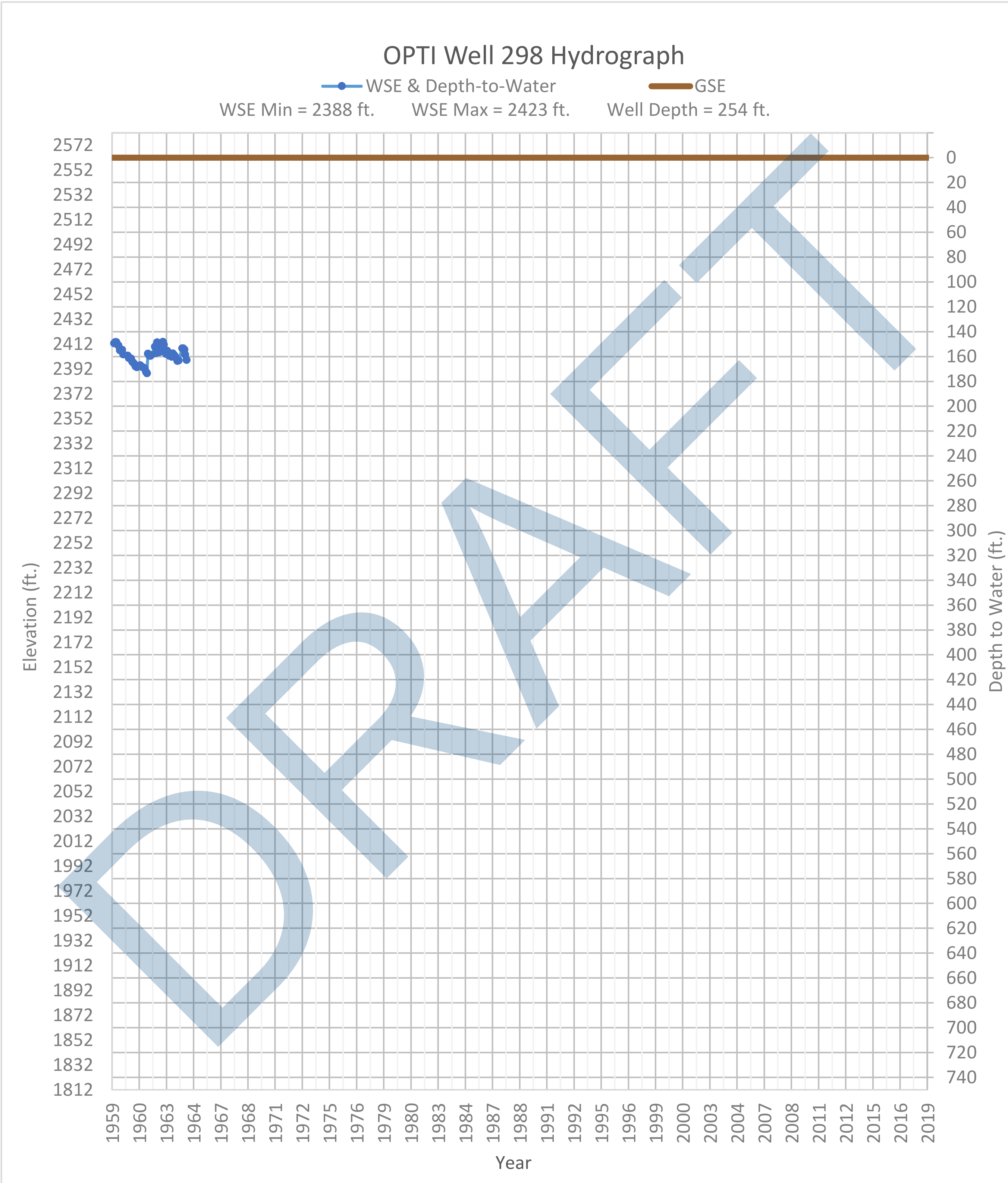

OPTI Well 294 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2102 ft.
WSE Max = 2102 ft.
Well Depth = 805 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



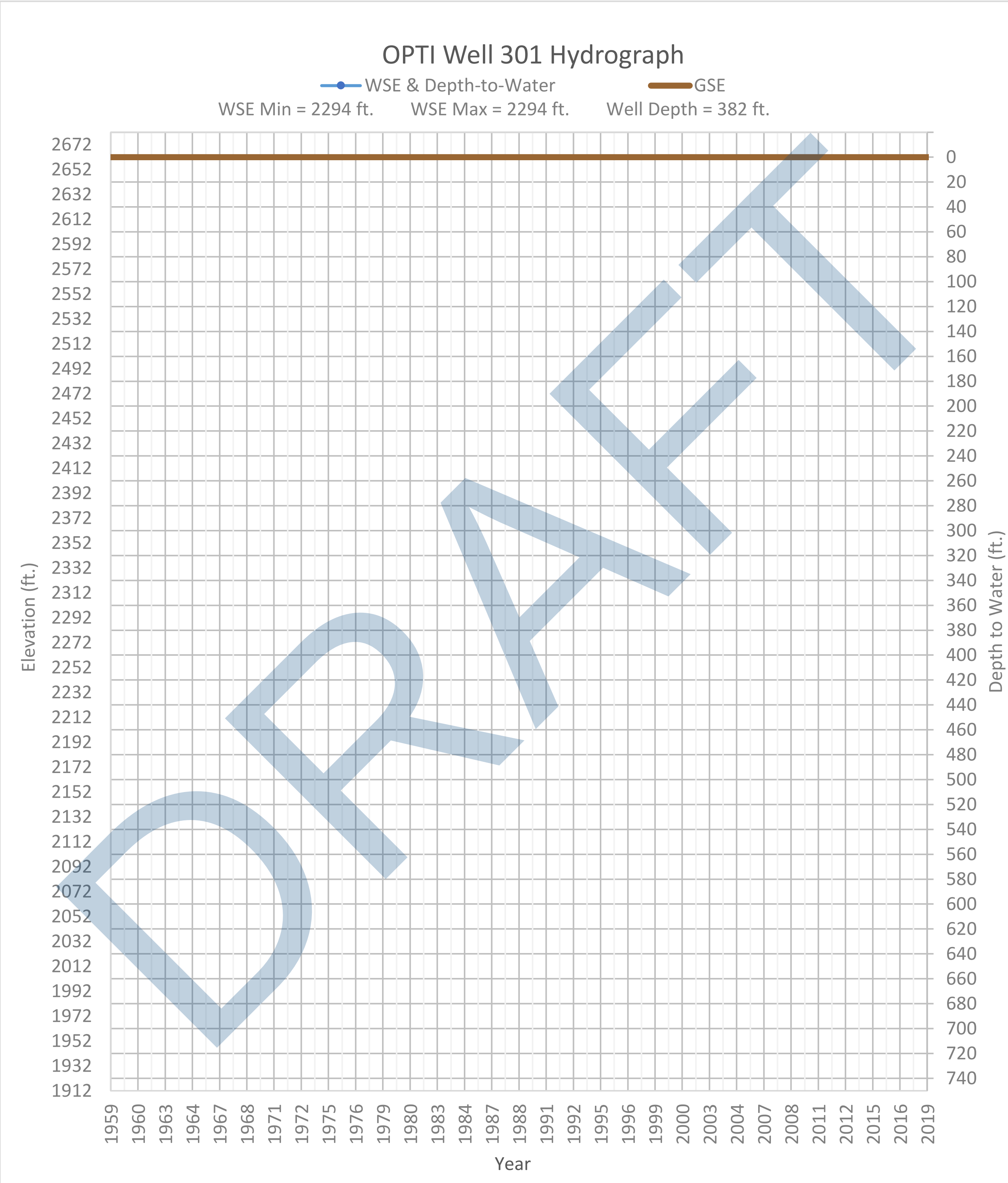
OPTI Well 296 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2273 ft.
WSE Max = 2317 ft.
Well Depth = 382 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



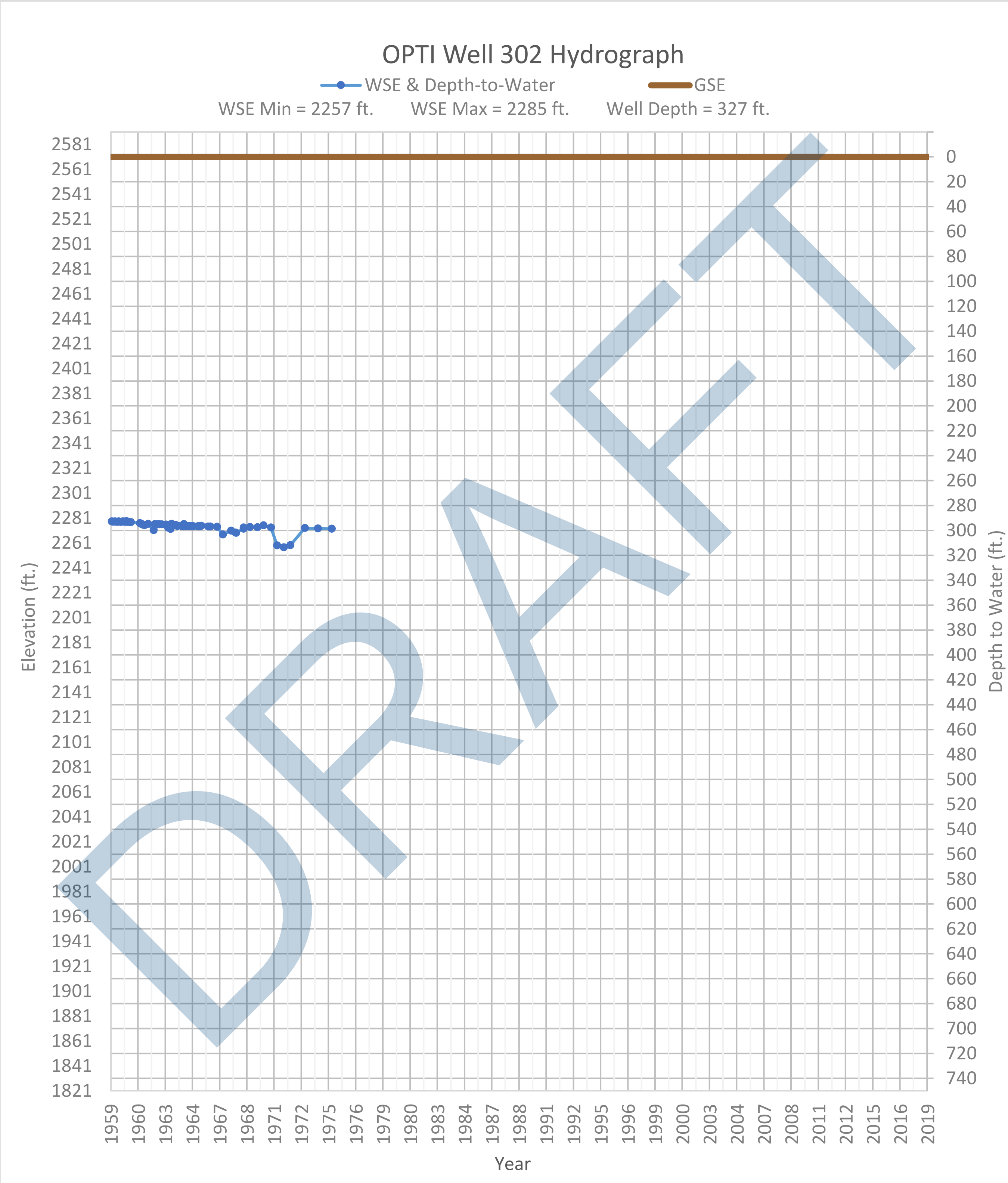
OPTI Well 297 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2254 ft.
WSE Max = 2267 ft.
Well Depth = 380 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



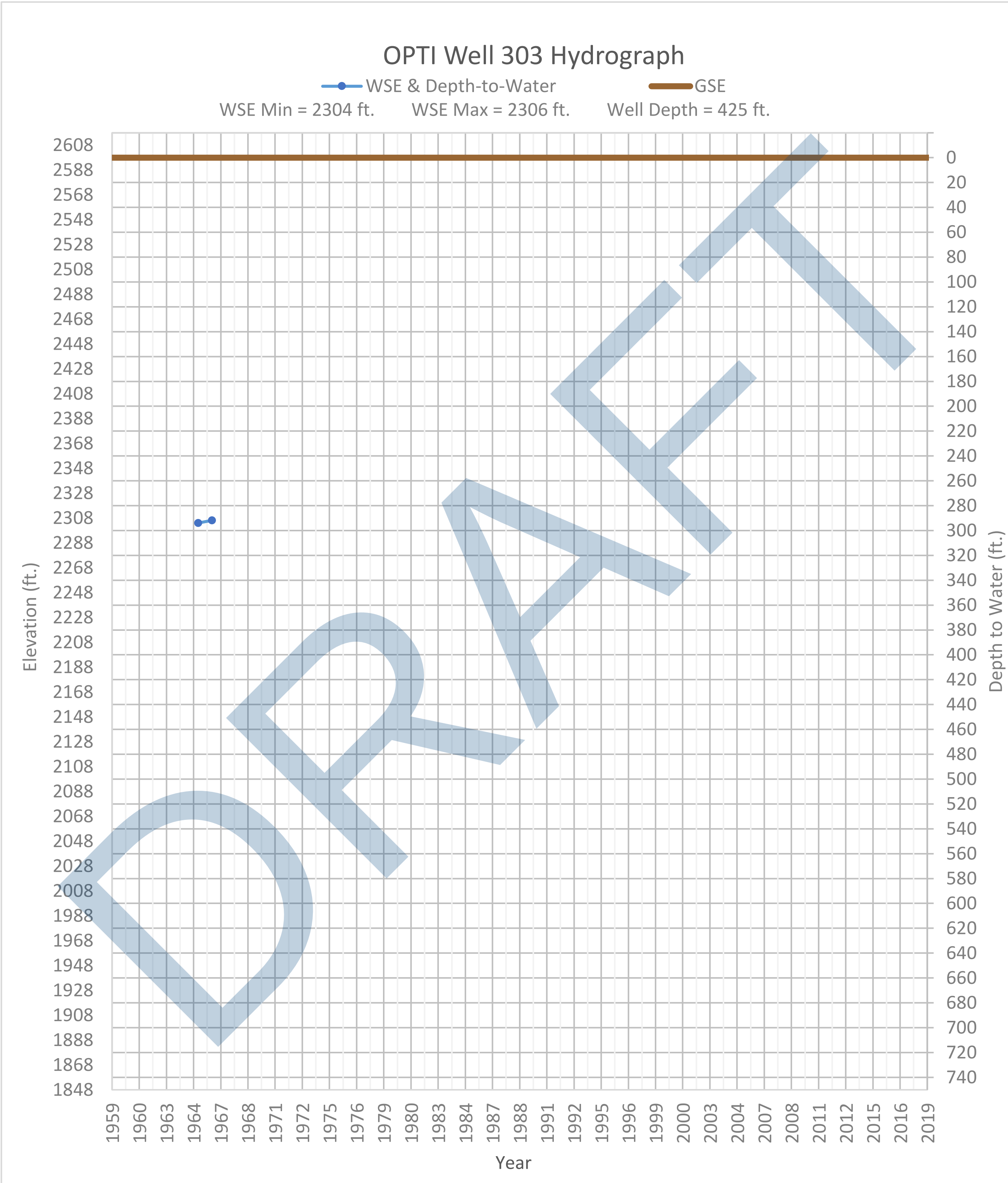
OPTI Well 298 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2388 ft.
WSE Max = 2423 ft.
Well Depth = 254 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 301 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2294 ft.
WSE Max = 2294 ft.
Well Depth = 382 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 302 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2257 ft.
WSE Max = 2285 ft.
Well Depth = 327 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 303 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2304 ft.
WSE Max = 2306 ft.
Well Depth = 425 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2608
2588
2568
2548
2528
2508
2488
2468
2448
2428
2408
2388
2368
2348
2328
2308
2288
2268
2248
2228
2208
2188
2168
2148
2128
2108
2088
2068
2048
2028
2008
1988
1968
1948
1928
1908
1888
1868
1848
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
680
700
720
740
1959
1960
1963
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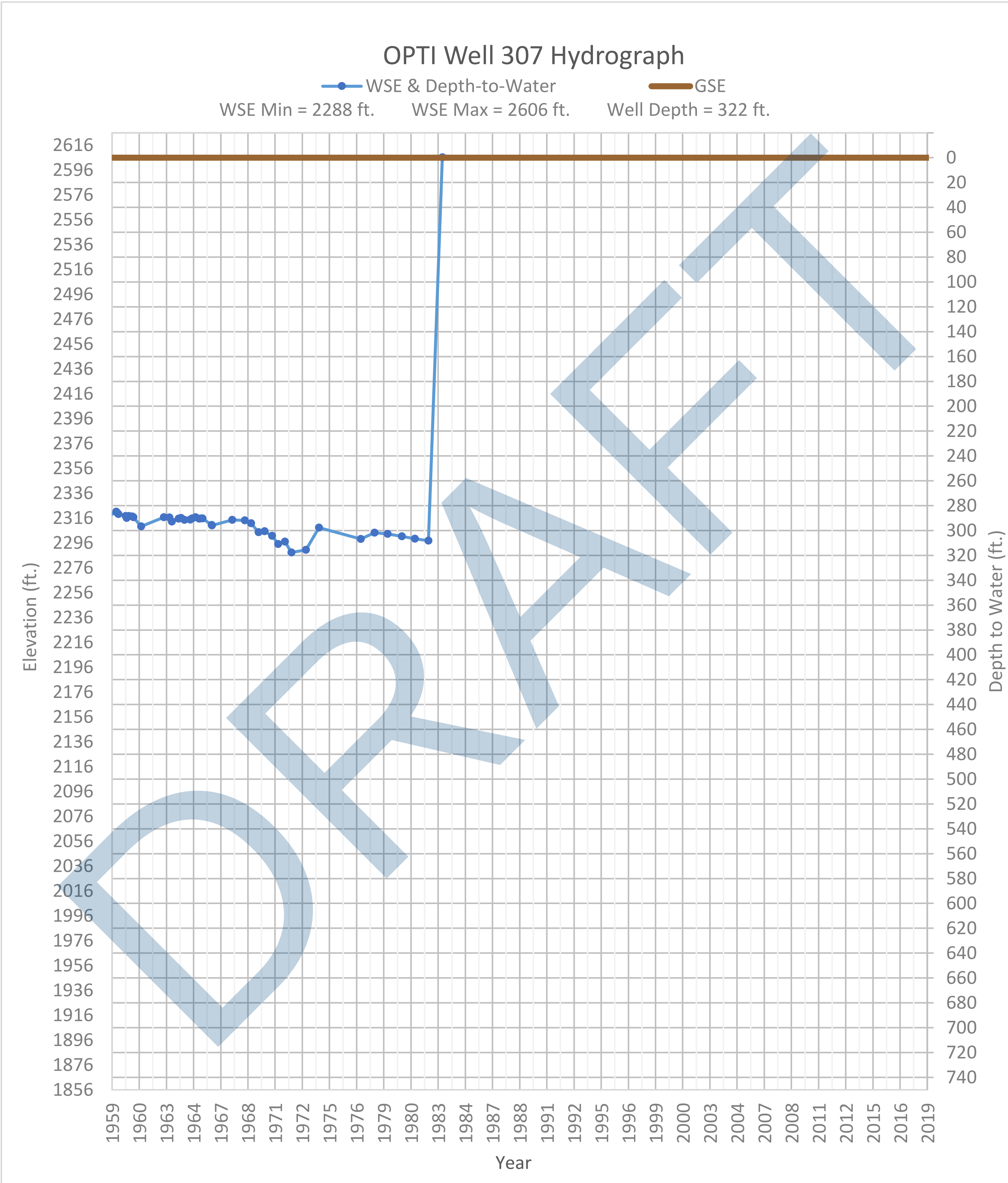
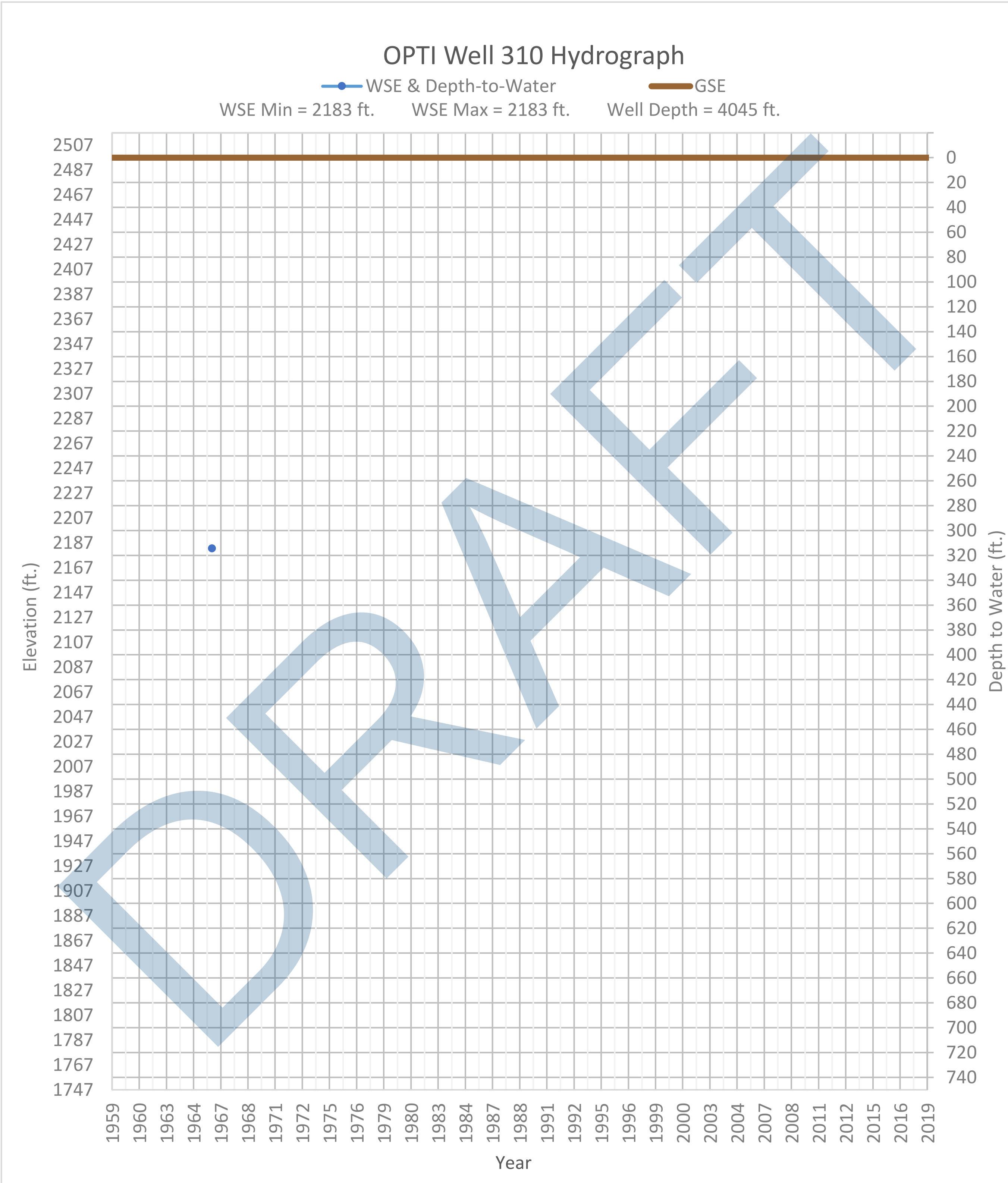
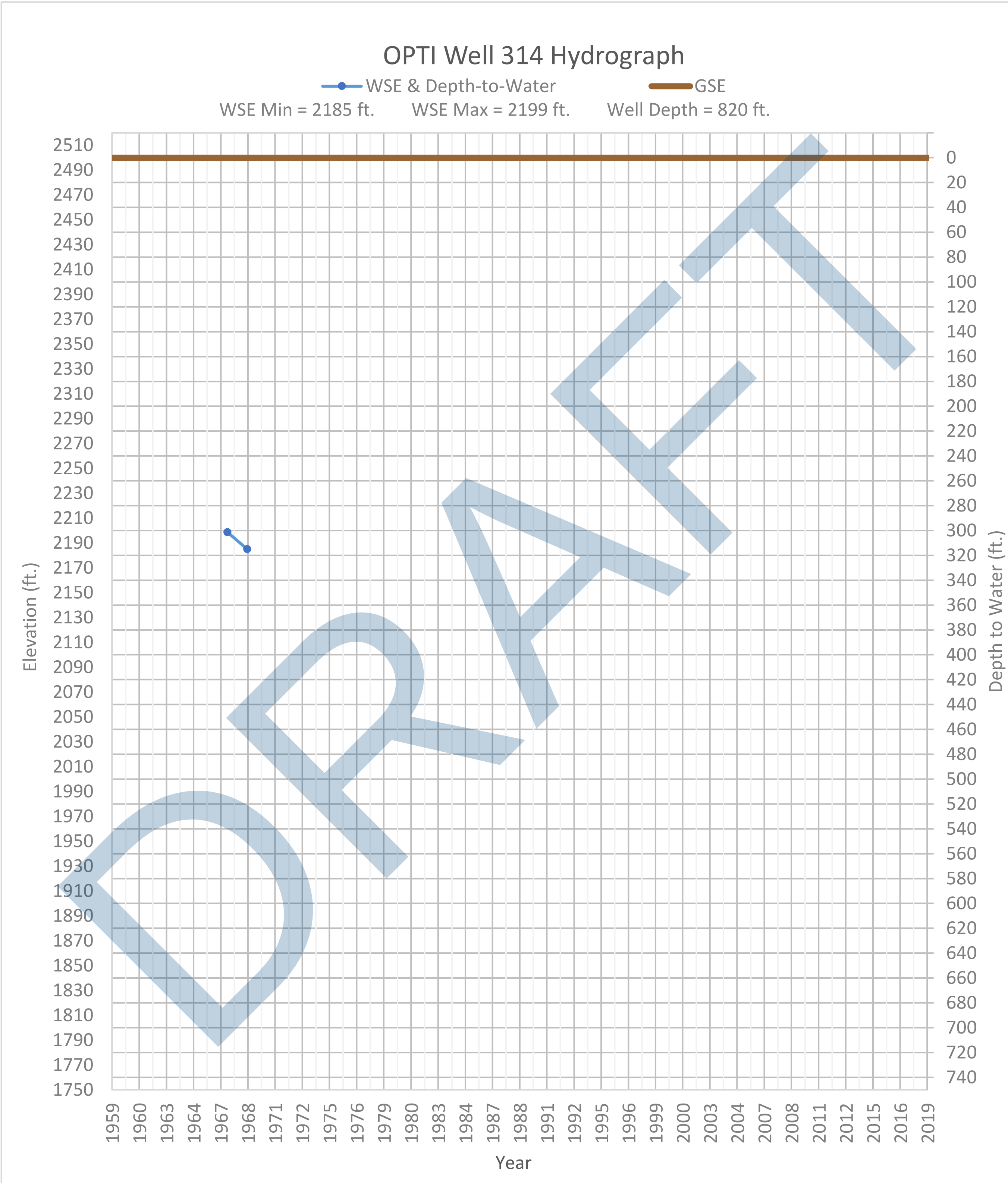
2016
2019
DRAFT

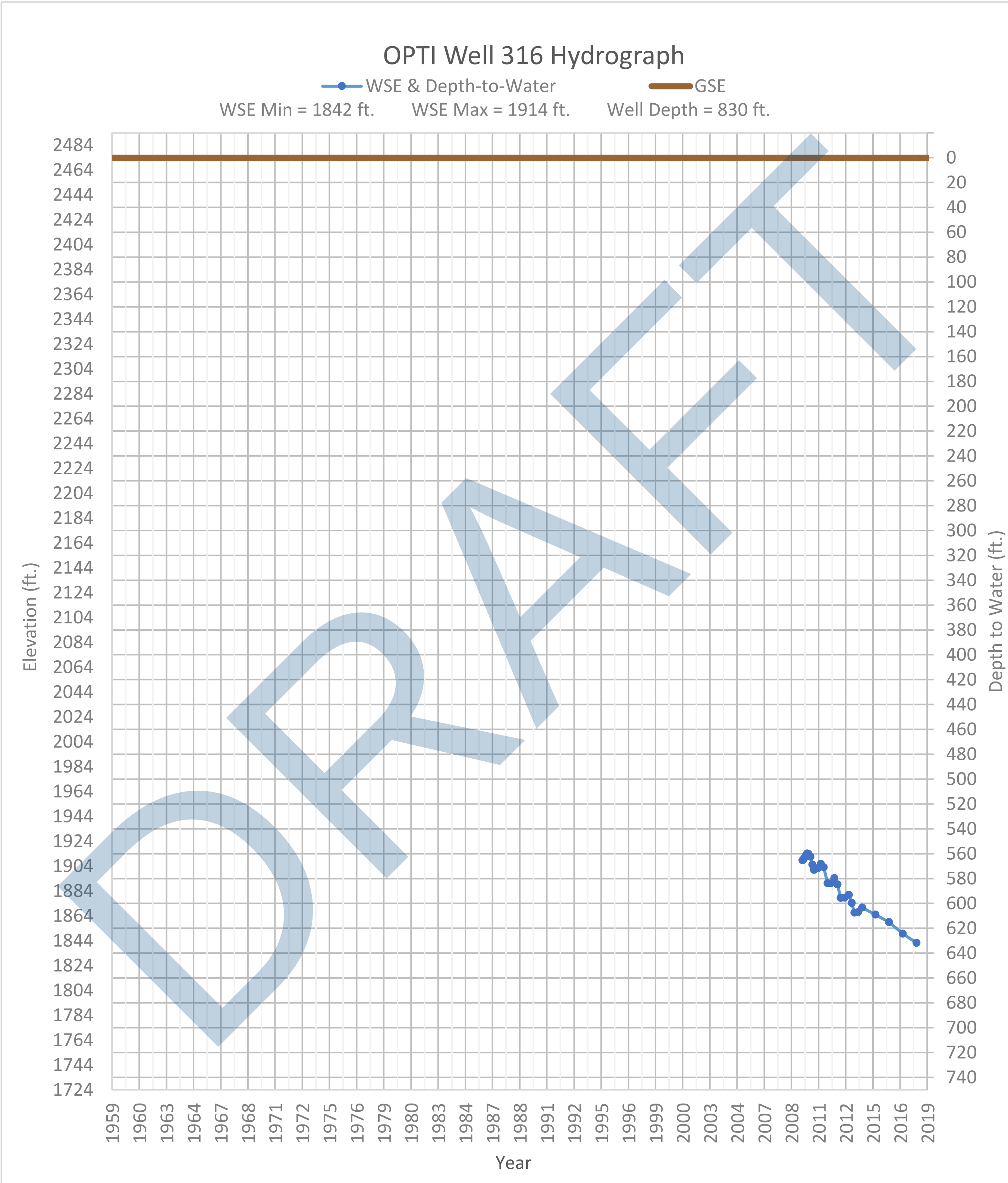

OPTI Well 307 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2288 ft.
WSE Max = 2606 ft.
Well Depth = 322 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

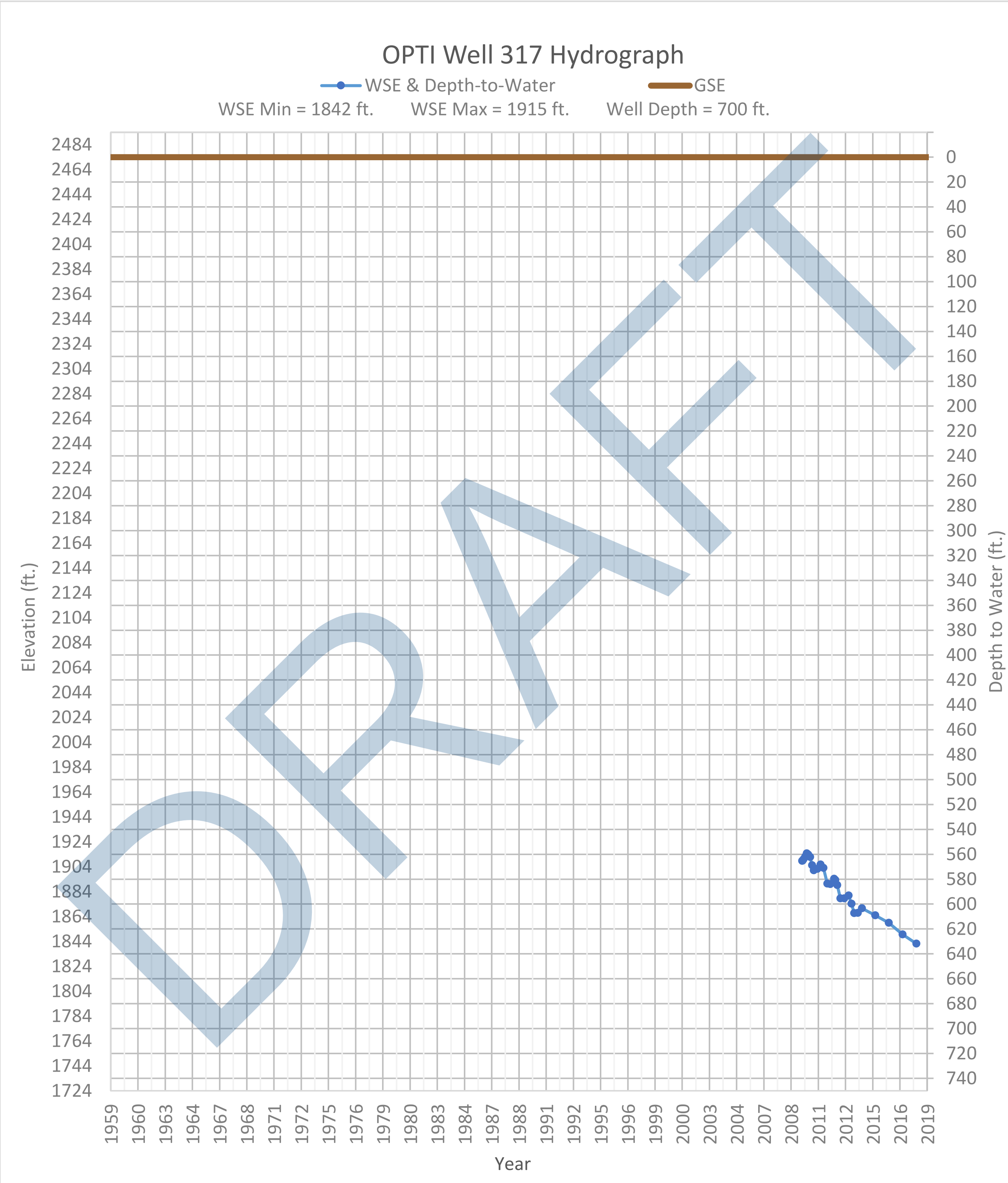


OPTI Well 310 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2183 ft.
WSE Max = 2183 ft.
Well Depth = 4045 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

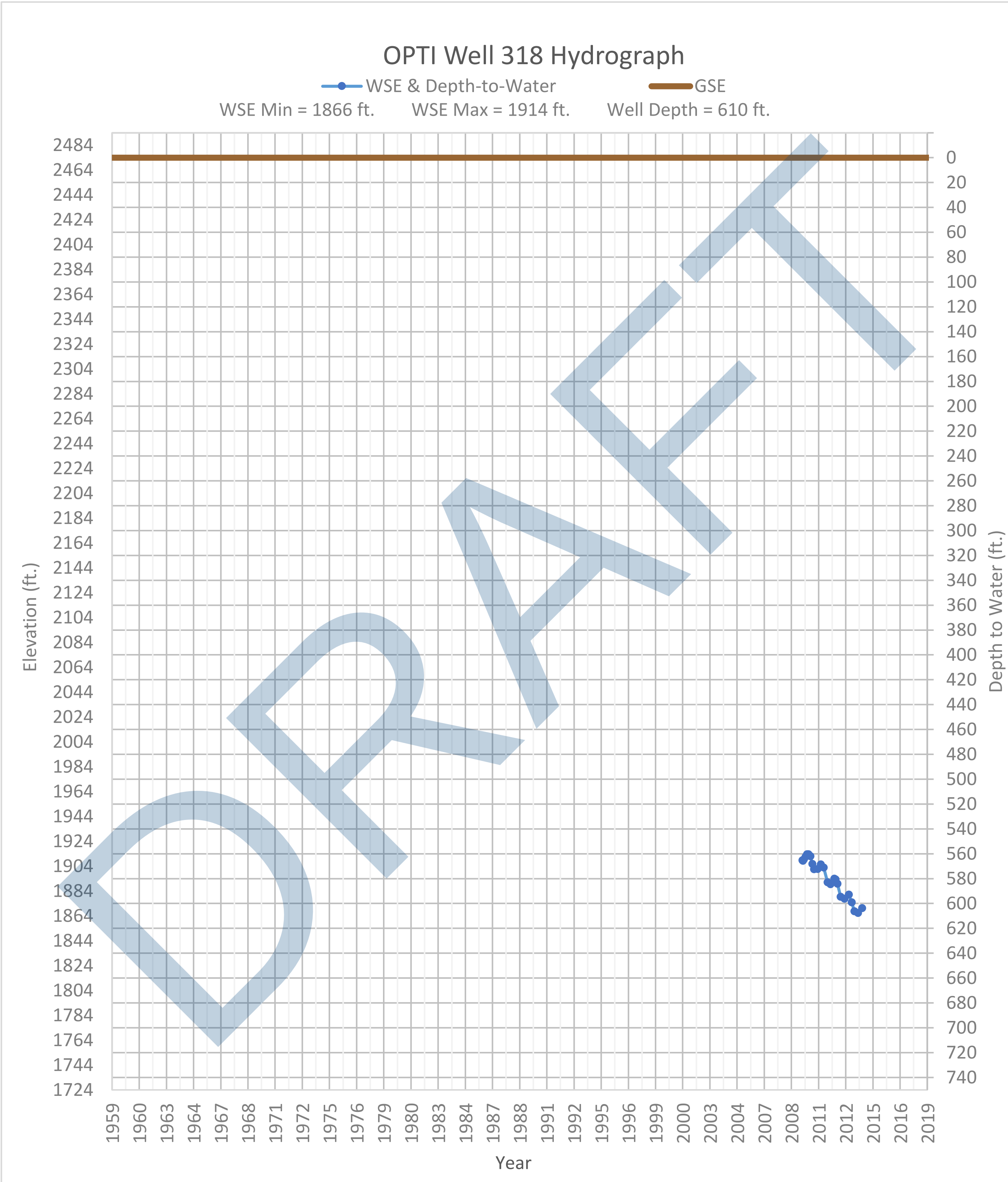


OPTI Well 314 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2185 ft.
WSE Max = 2199 ft.
Well Depth = 820 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

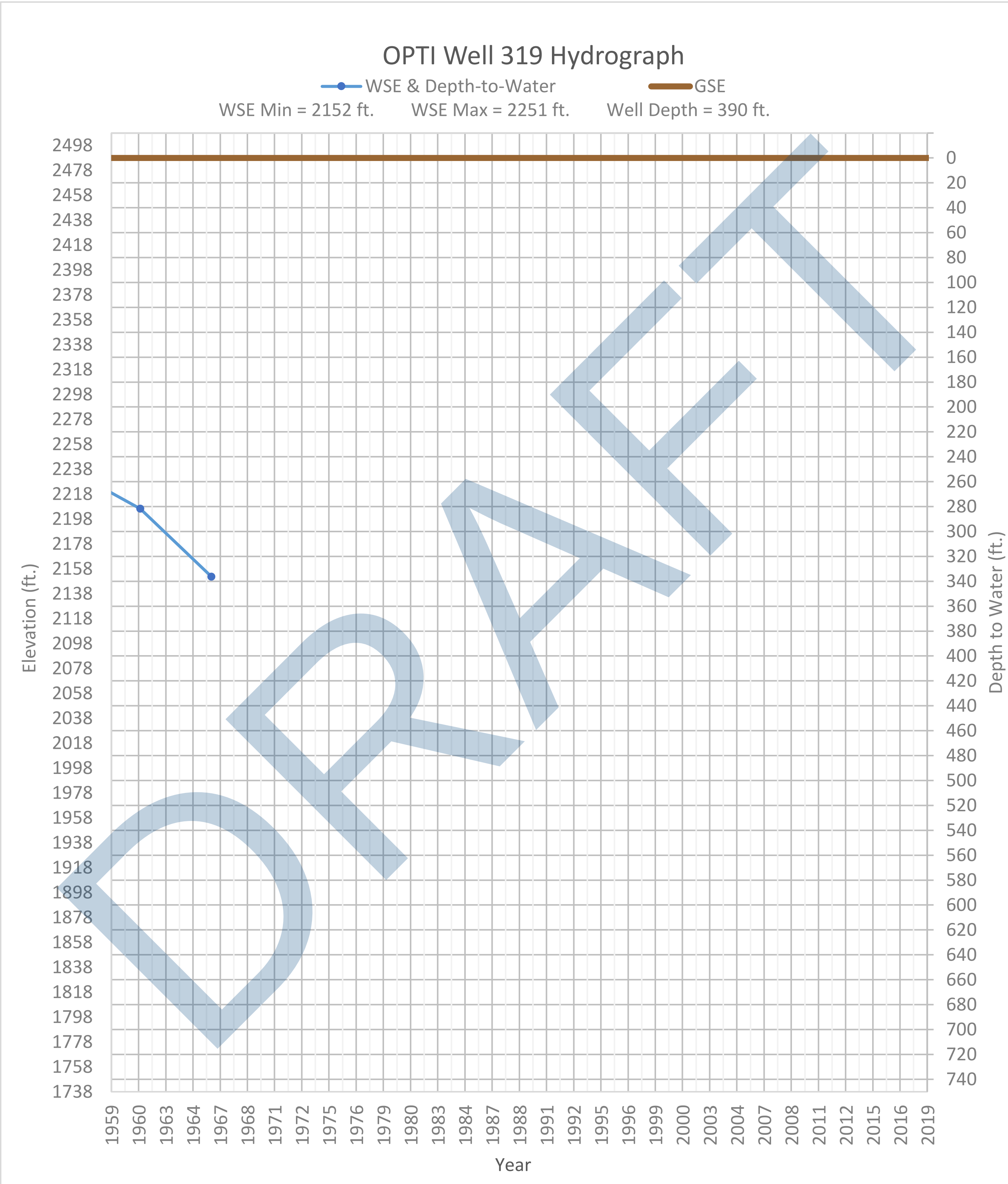

OPTI Well 316 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1842 ft.
WSE Max = 1914 ft.
Well Depth = 830 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



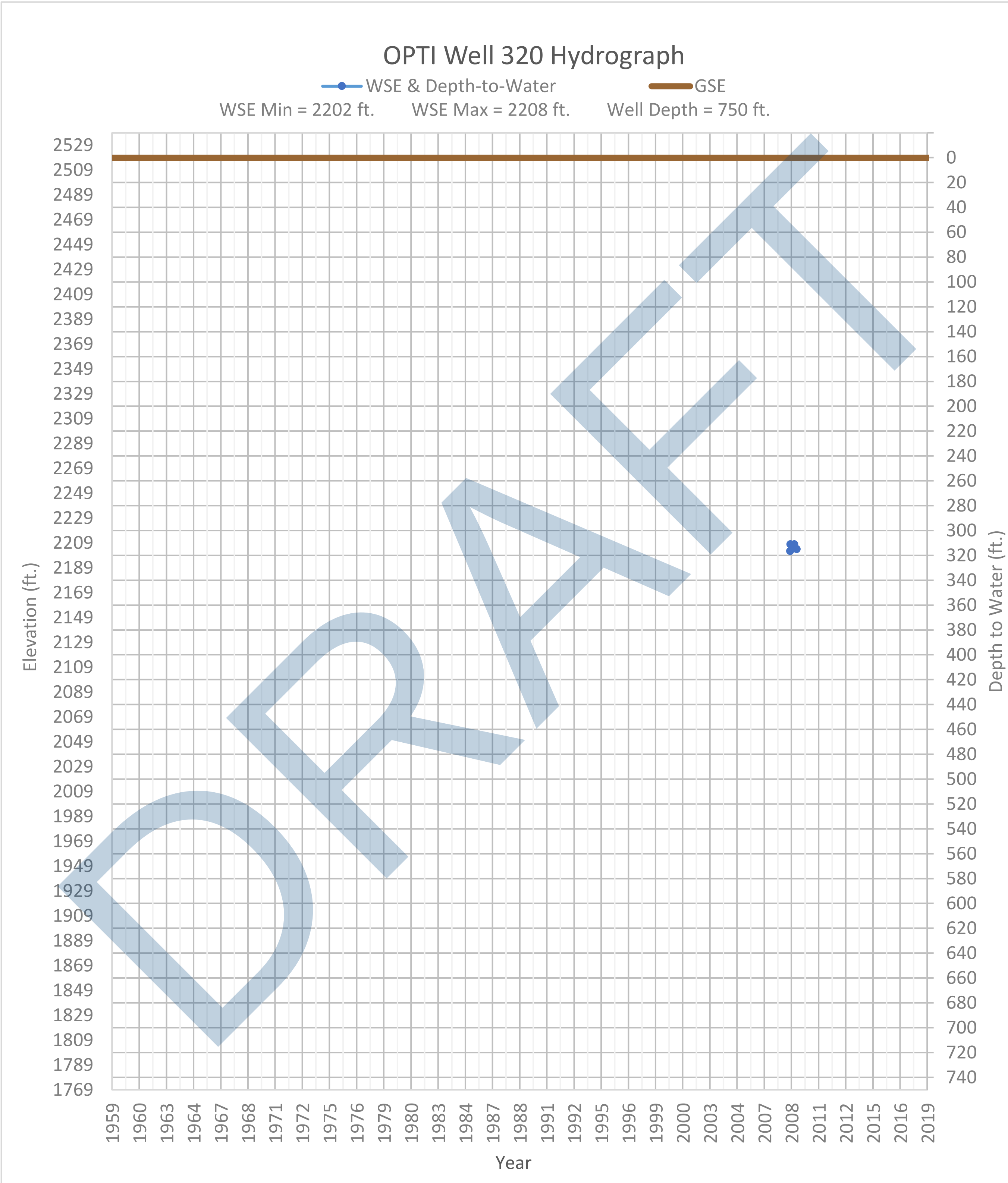
OPTI Well 317 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1842 ft.
WSE Max = 1915 ft.
Well Depth = 700 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



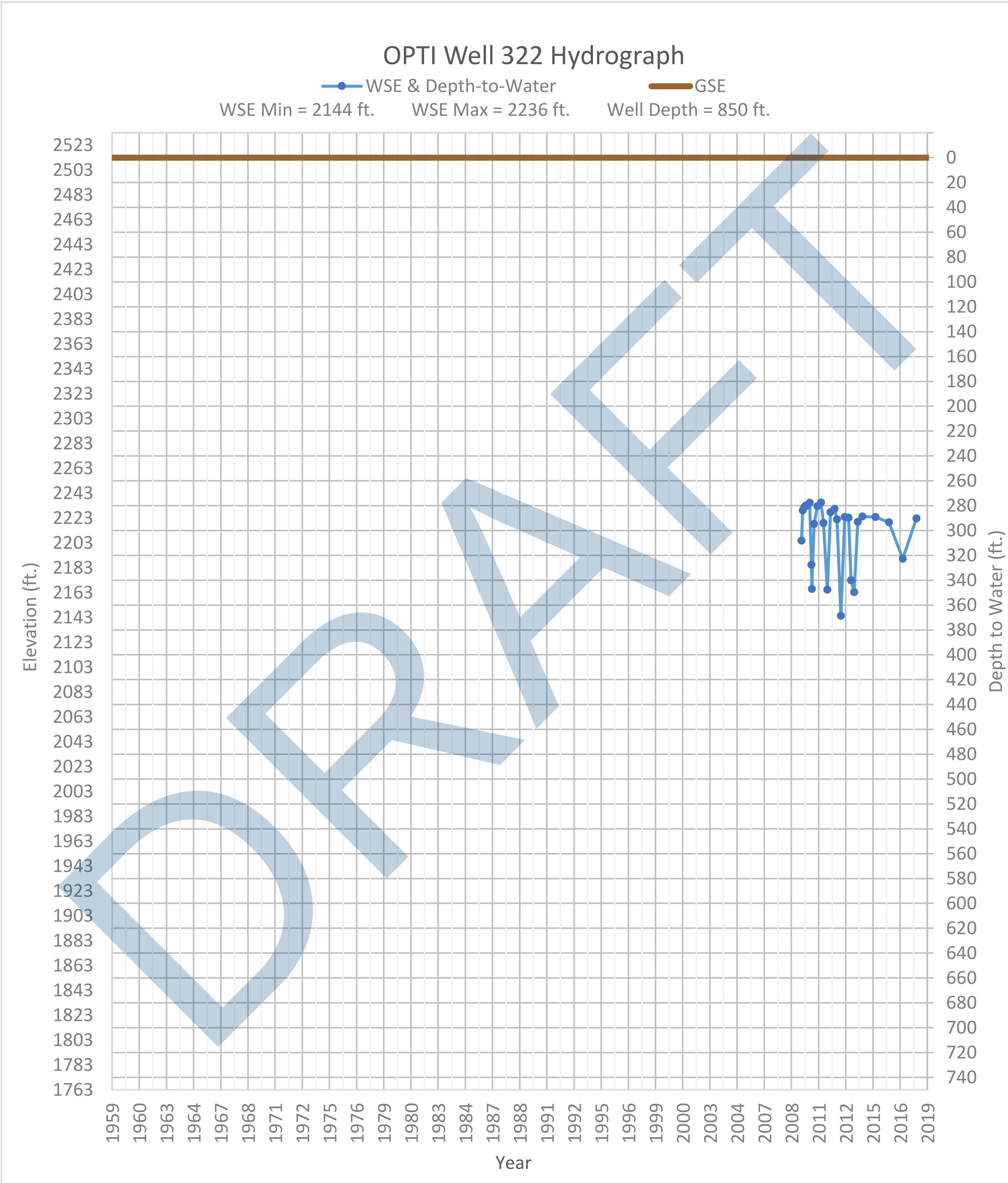
OPTI Well 318 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1866 ft.
WSE Max = 1914 ft.
Well Depth = 610 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

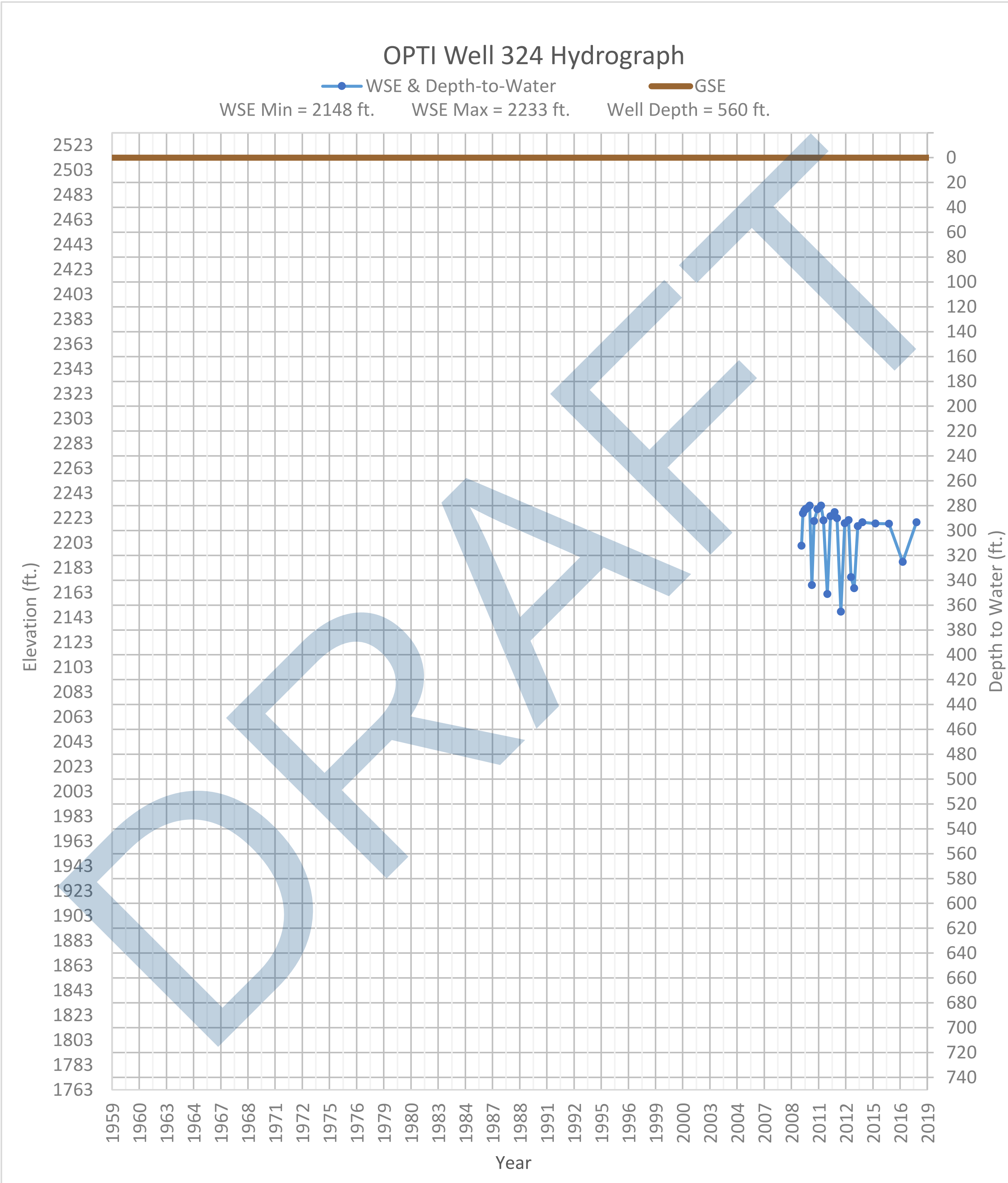


OPTI Well 319 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2152 ft.
WSE Max = 2251 ft.
Well Depth = 390 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

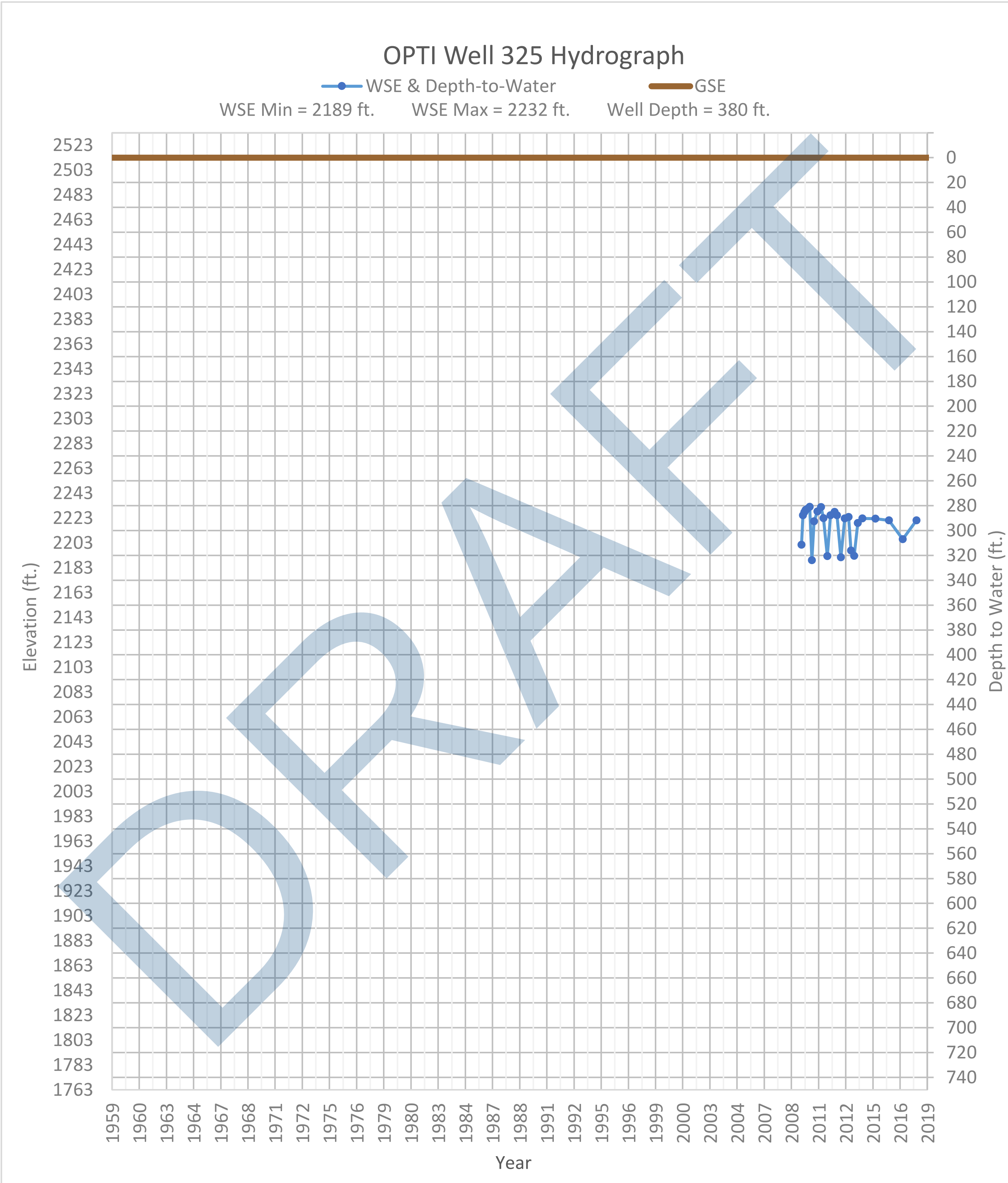


OPTI Well 320 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2202 ft.
WSE Max = 2208 ft.
Well Depth = 750 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

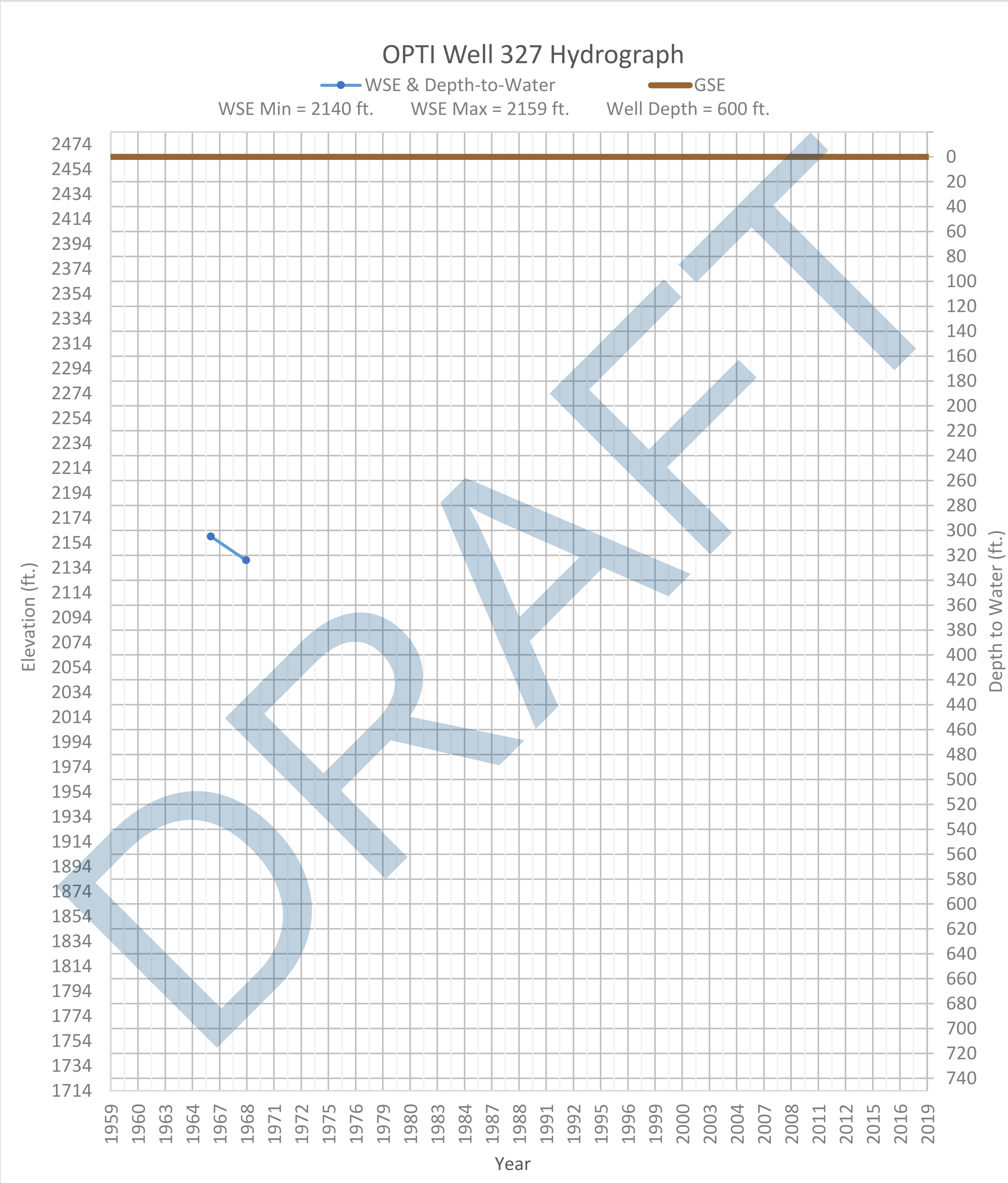

OPTI Well 322 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2144 ft.
WSE Max = 2236 ft.
Well Depth = 850 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



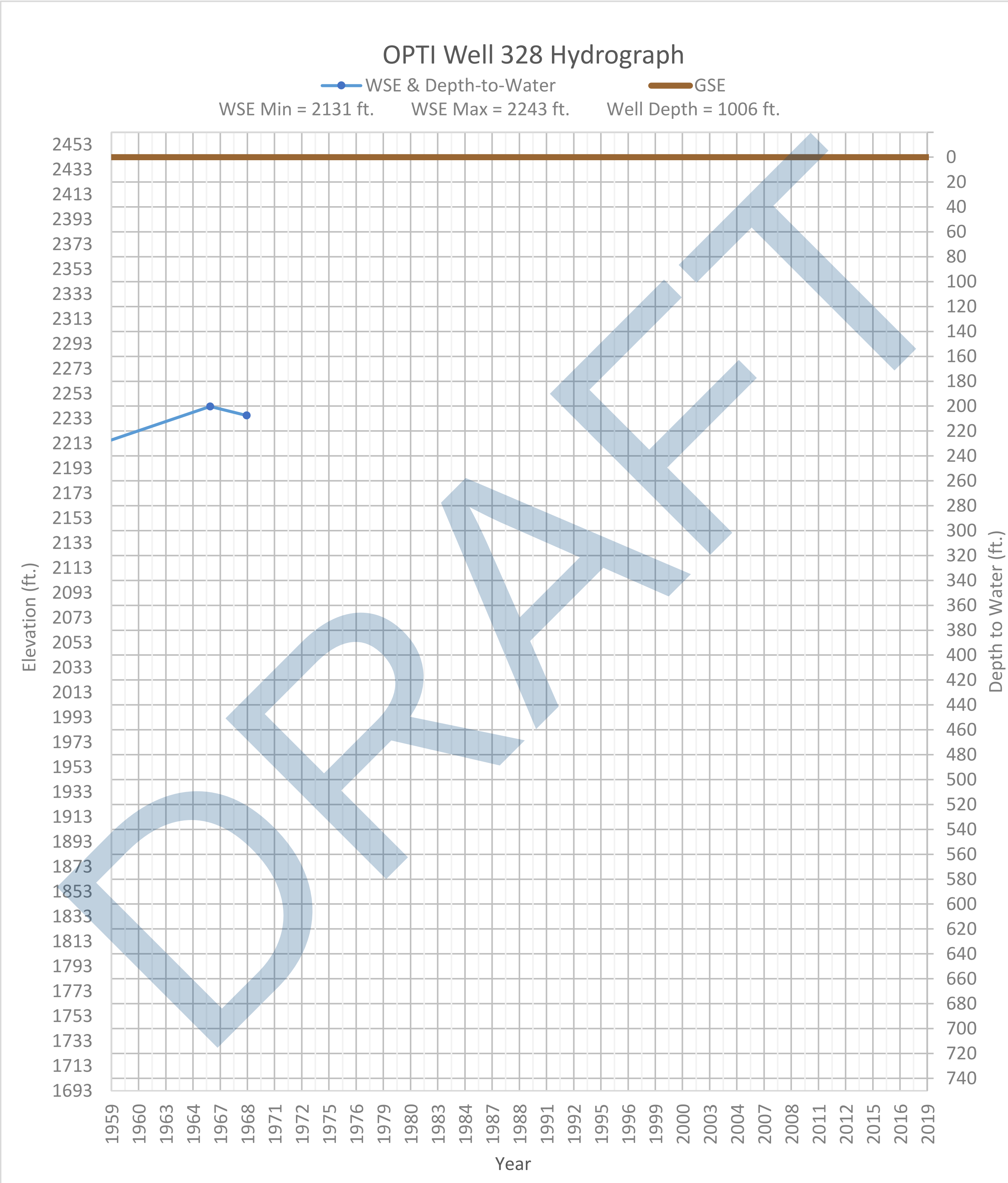
OPTI Well 324 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2148 ft.
WSE Max = 2233 ft.
Well Depth = 560 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



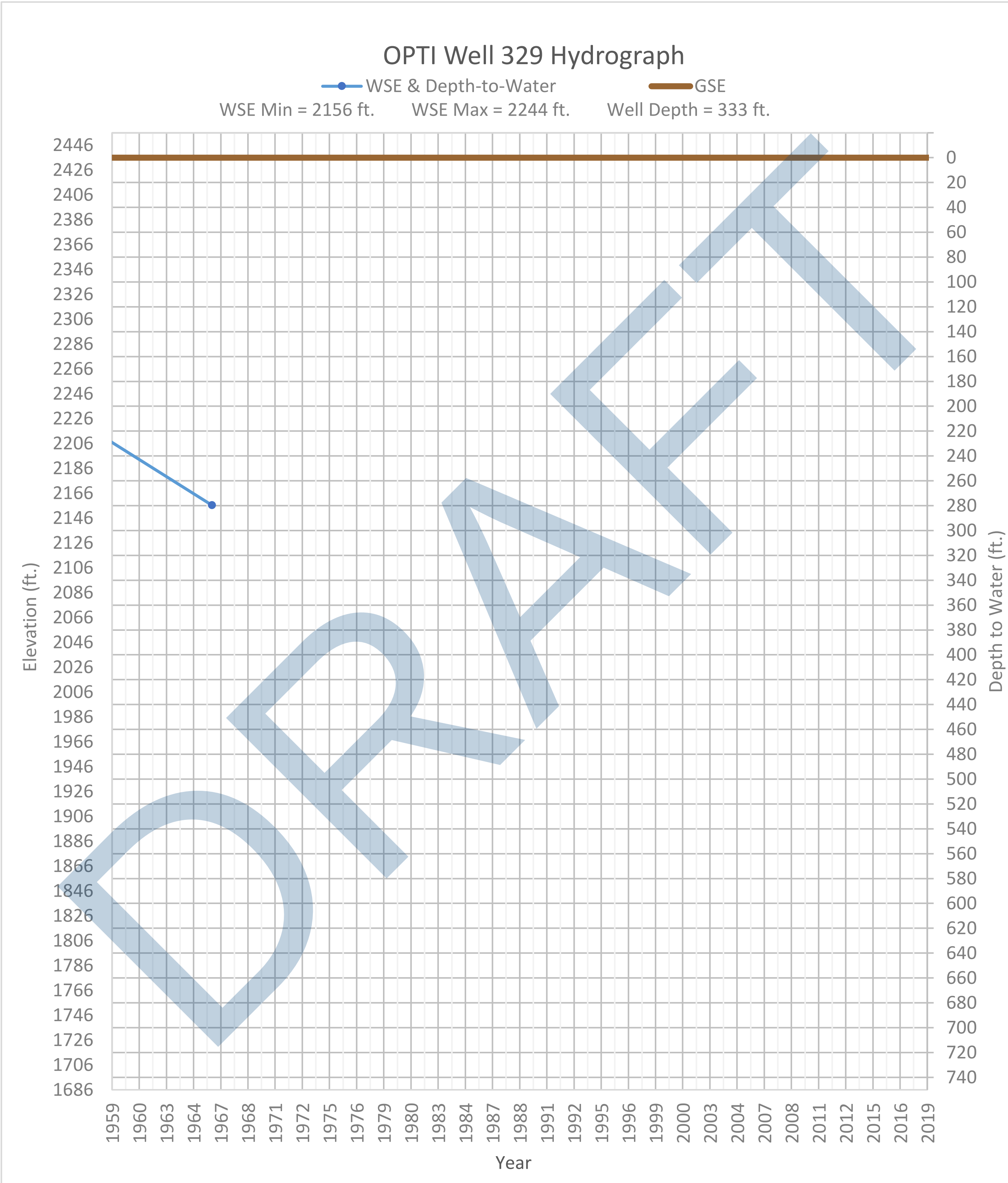
OPTI Well 325 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2189 ft.
WSE Max = 2232 ft.
Well Depth = 380 ft.
Elevation (ft.)
Depth to Water (ft.)
Year



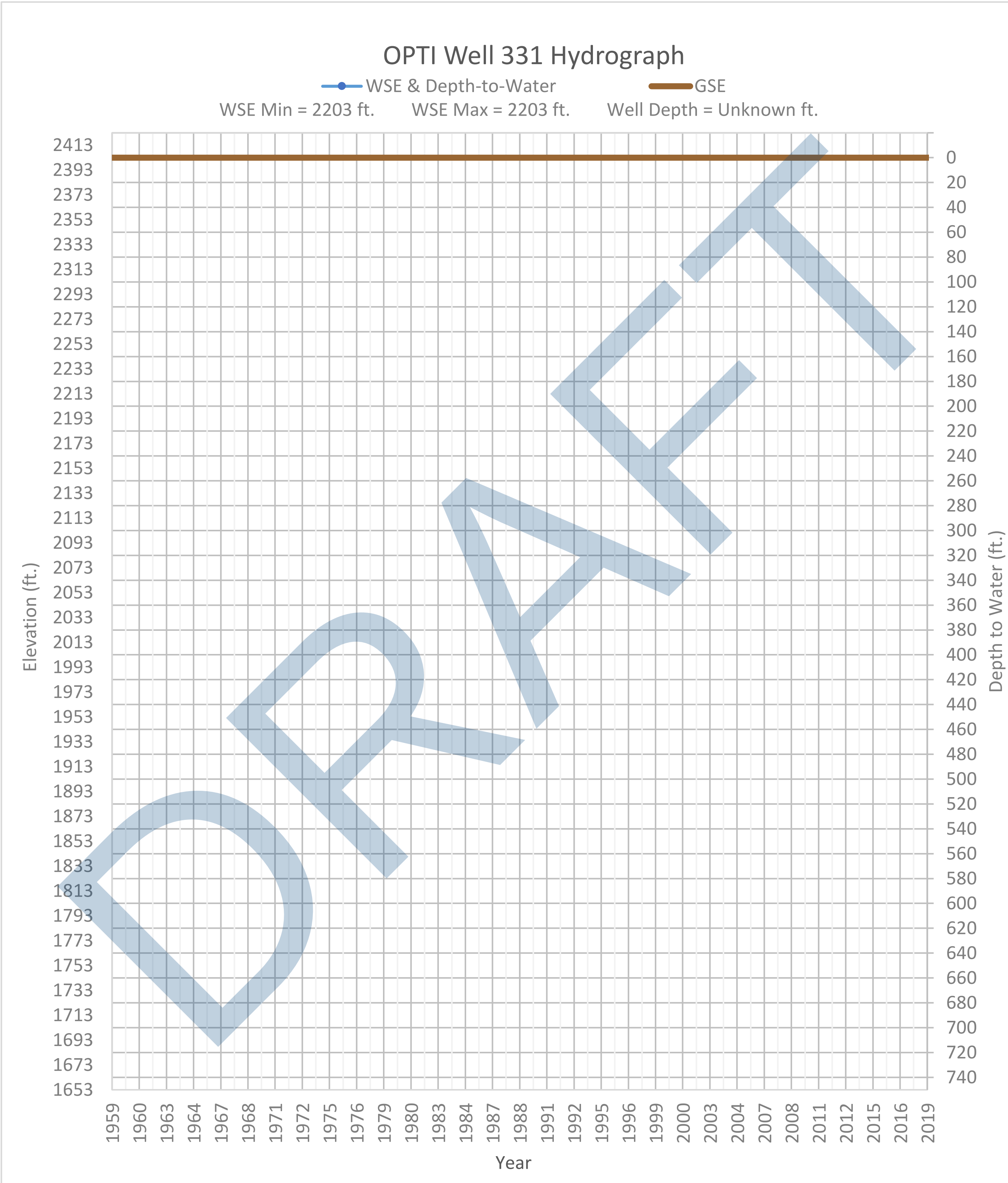
OPTI Well 327 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2140 ft.
WSE Max = 2159 ft.
Well Depth = 600 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



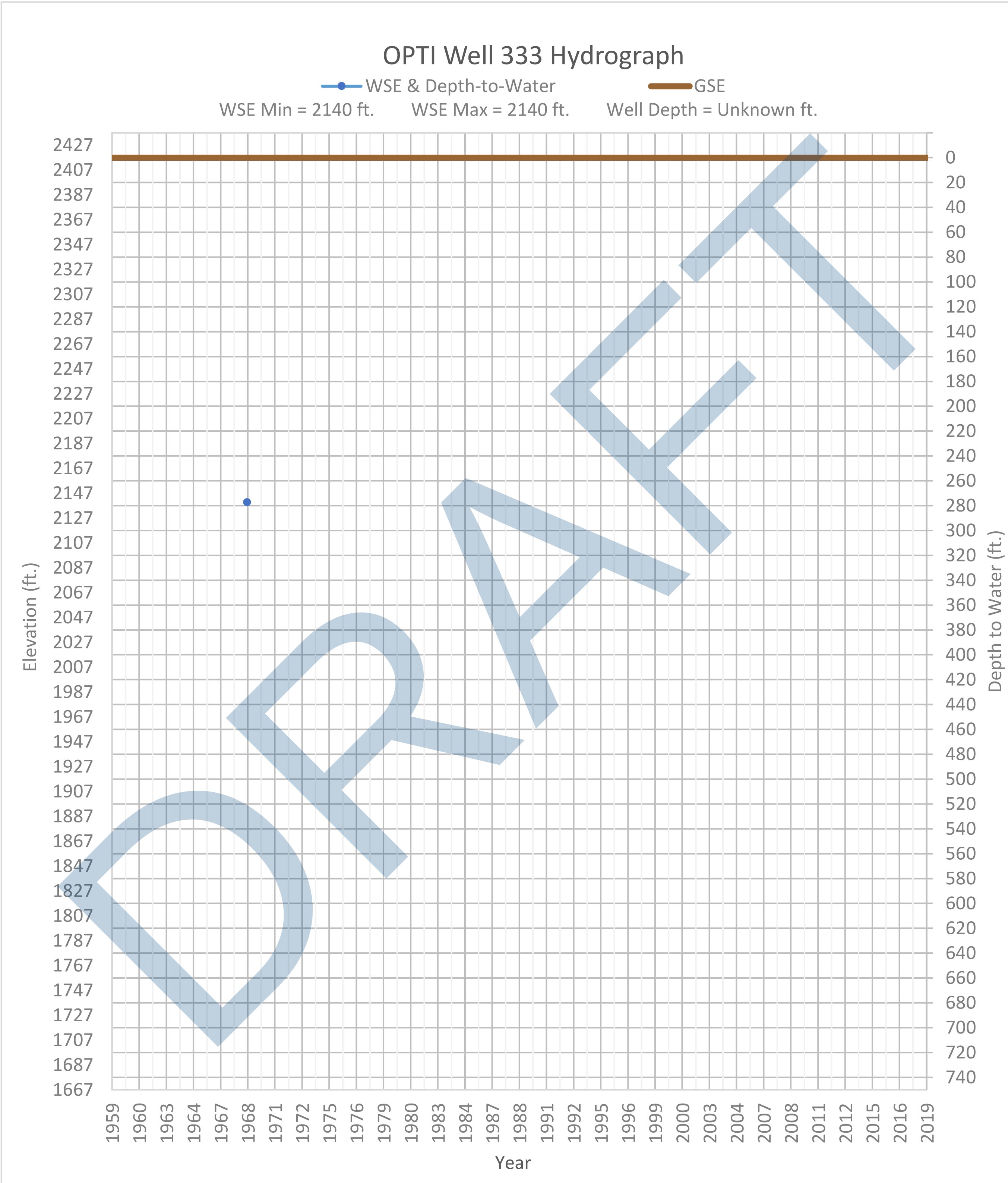
OPTI Well 328 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2131 ft.
WSE Max = 2243 ft.
Well Depth = 1006 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



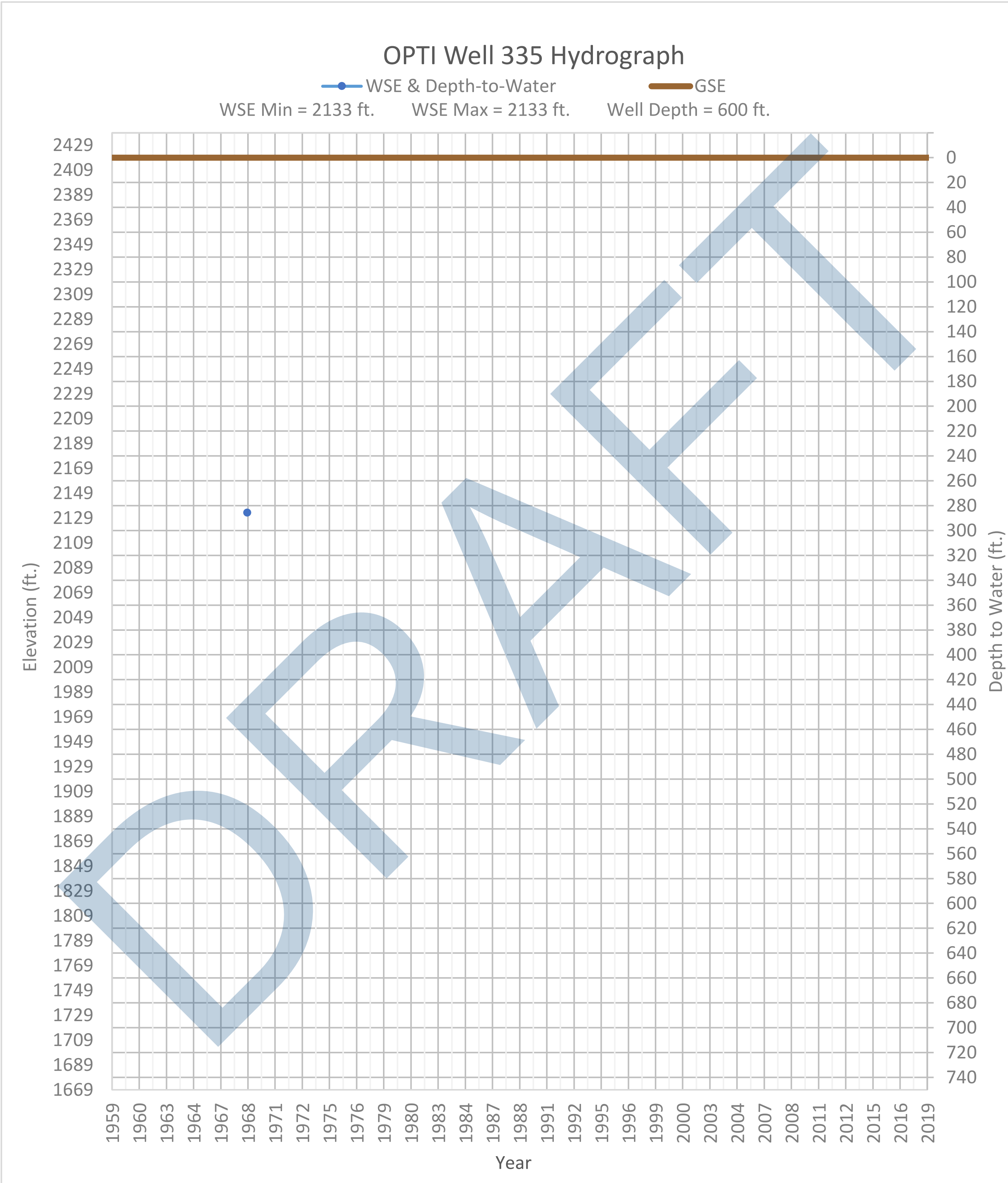
OPTI Well 329 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2156 ft.
WSE Max = 2244 ft.
Well Depth = 333 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



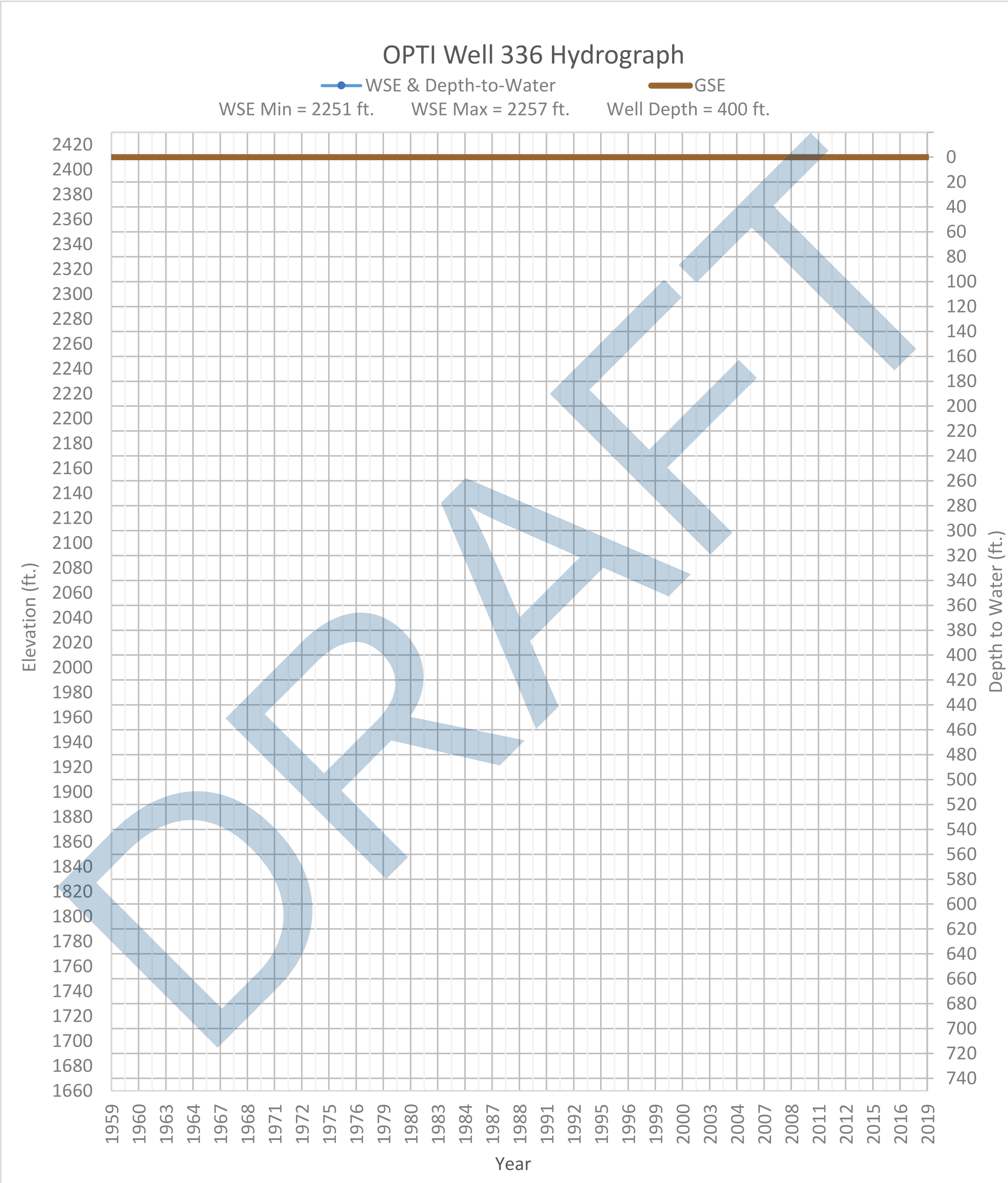
OPTI Well 331 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2203 ft.
WSE Max = 2203 ft.
Well Depth = Unknown ft.
Elevation (ft.)
2413 2393 2373 2353 2333 2313 2293 2273 2253 2233 2213 2193 2173 2153 2133 2113 2093 2073 2053 2033 2013 1993 1973 1953 1933 1913 1893 1873 1853 1833 1813 1793 1773 1753 1733 1713 1693 1673 1653
Depth to Water (ft.)
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720 740
1959 1960 1963 1964 1967 1968 1971 1972 1975 1976 1979 1980 1983 1984 1987 1988 1991 1992 1995 1996 1999 2000 2003 2004 2007 2008 2011 2012 2015 2016 2019
Year
DRAFT



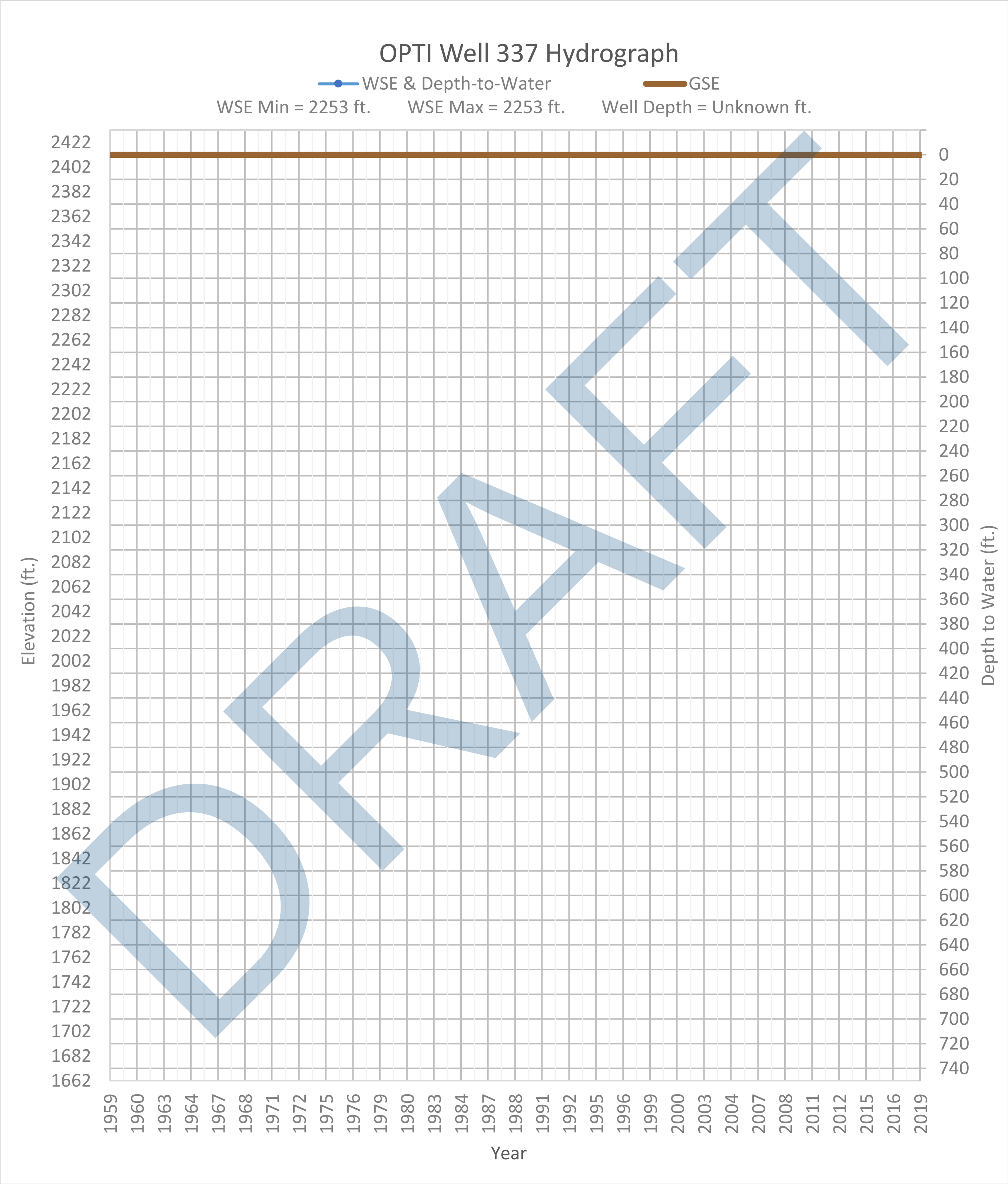
OPTI Well 333 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2140 ft.
WSE Max = 2140 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

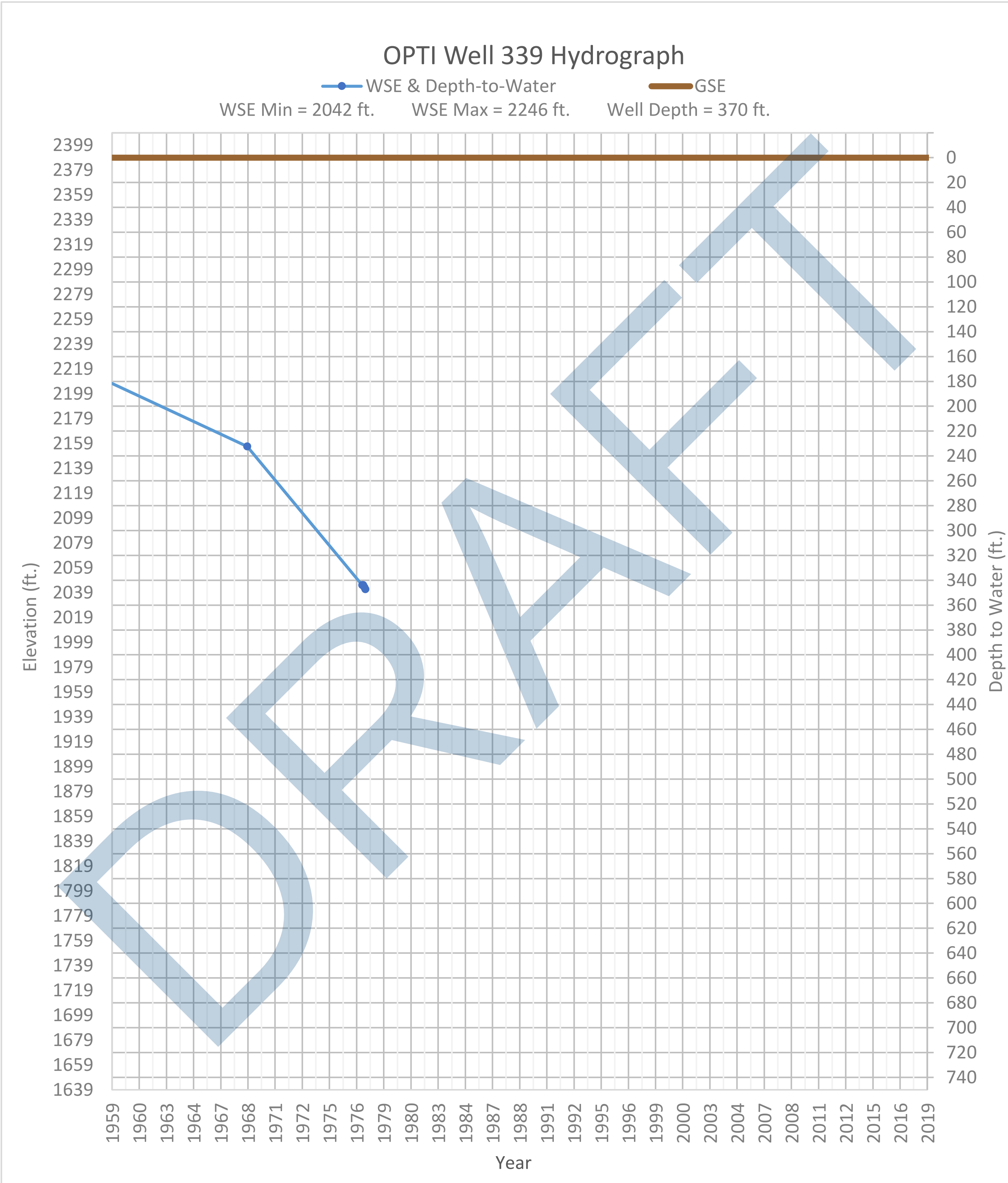


OPTI Well 335 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2133 ft.
WSE Max = 2133 ft.
Well Depth = 600 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

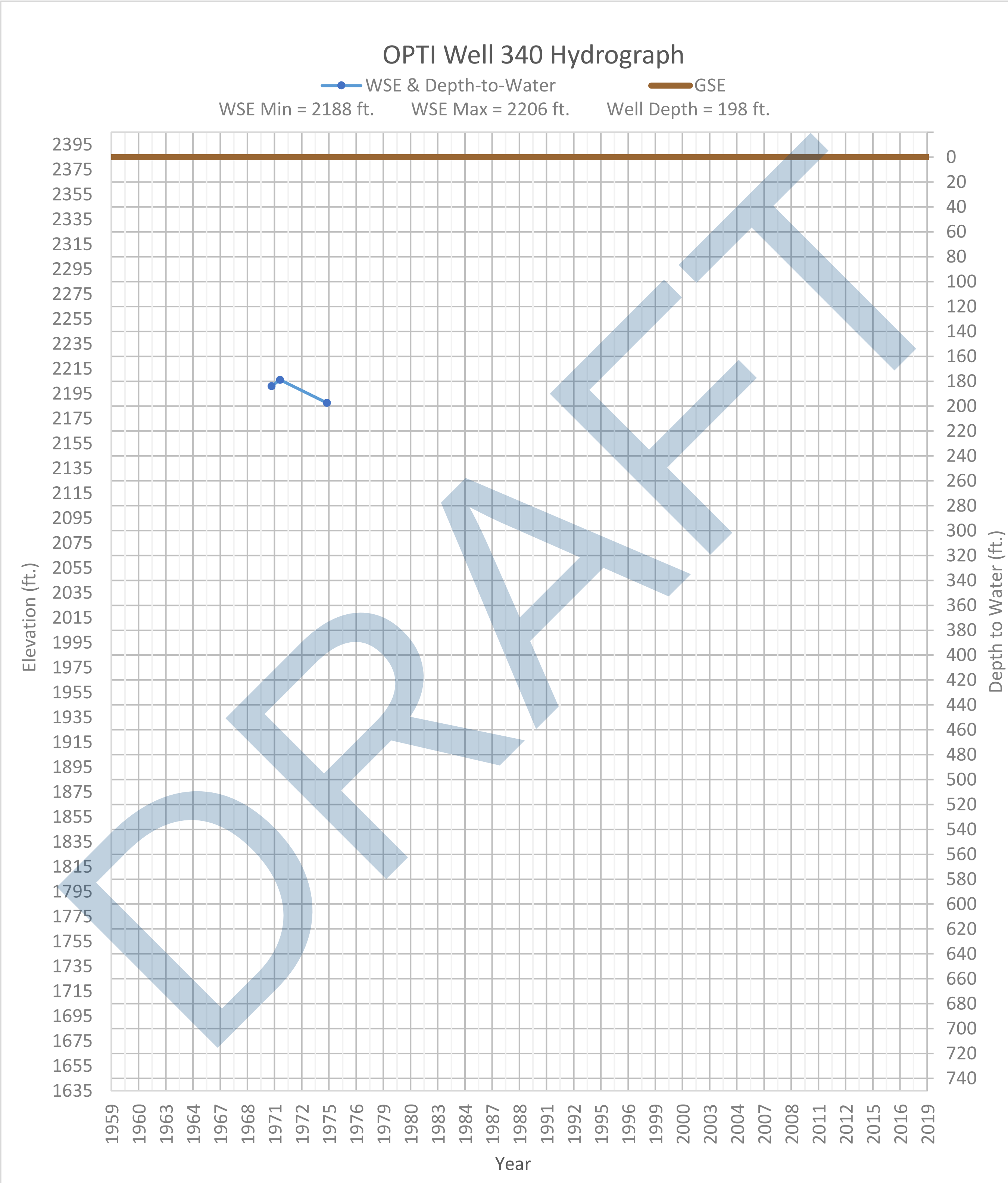


OPTI Well 336 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2251 ft.
WSE Max = 2257 ft.
Well Depth = 400 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

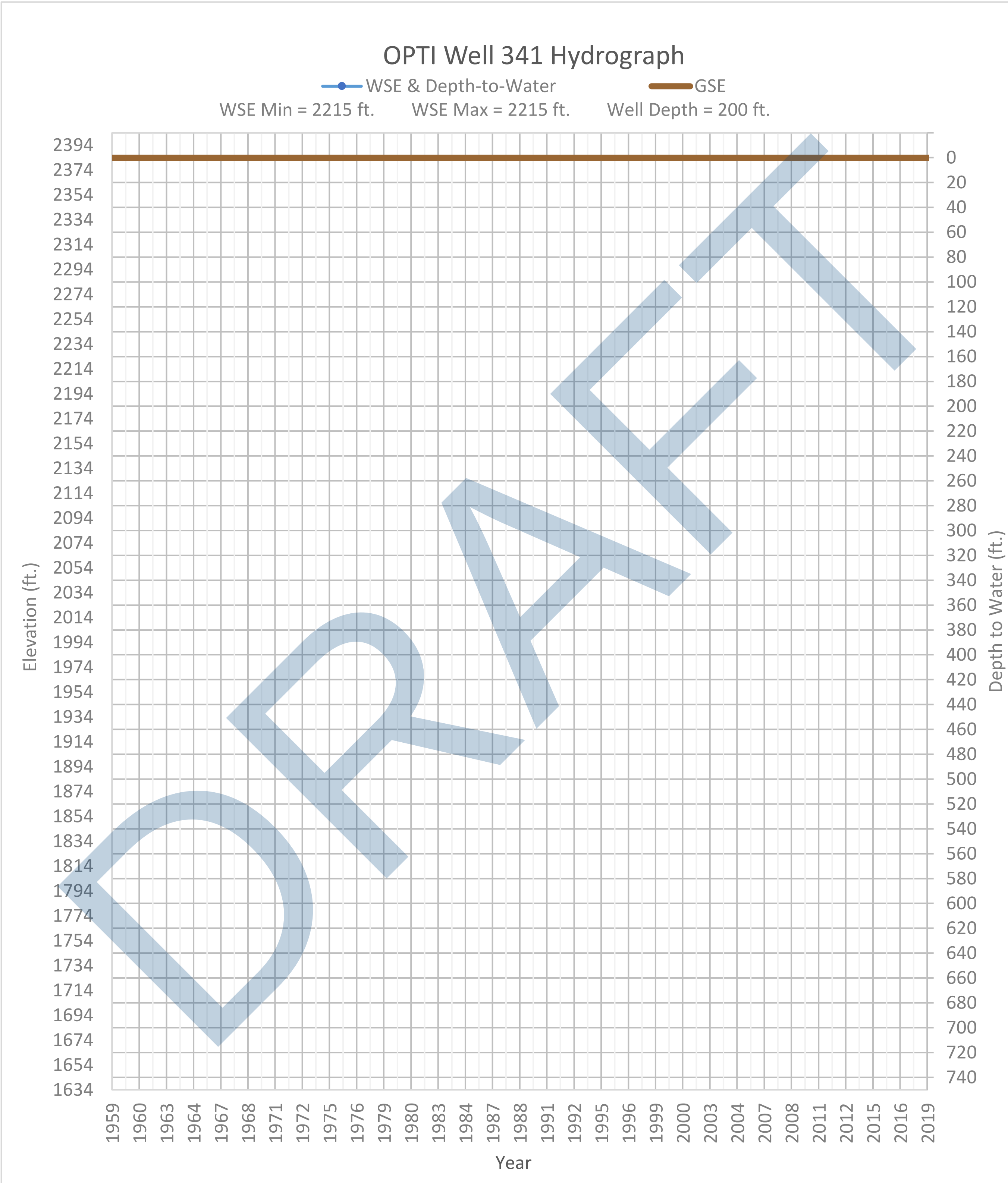

OPTI Well 337 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2253 ft.
WSE Max = 2253 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

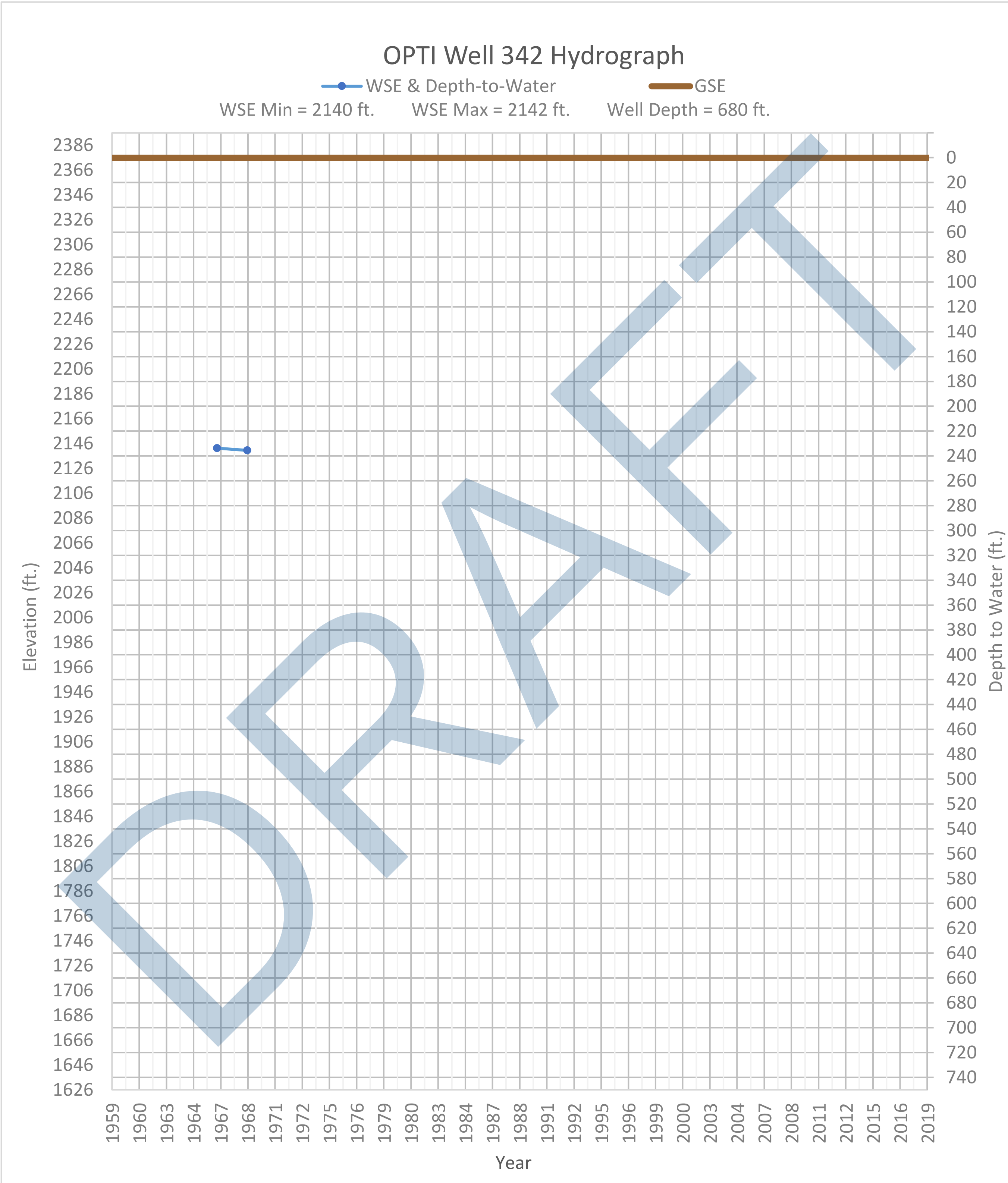


OPTI Well 339 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2042 ft.
WSE Max = 2246 ft.
Well Depth = 370 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 340 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2188 ft.
WSE Max = 2206 ft.
Well Depth = 198 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 341 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2215 ft.
WSE Max = 2215 ft.
Well Depth = 200 ft.
Elevation (ft.)
2394 2374 2354 2334 2314 2294 2274 2254 2234 2214 2194 2174 2154 2134 2114 2094 2074 2054 2034 2014 1994 1974 1954 1934 1914 1894 1874 1854 1834 1814 1794 1774 1754 1734 1714 1694 1674 1654 1634
Depth to Water (ft.)
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720 740
Year
1959 1960 1963 1964 1967 1968 1971 1972 1975 1976 1979 1980 1983 1984 1987 1988 1991 1992 1995 1996 1999 2000 2003 2004 2007 2008 2011 2012 2015 2016 2019
DRAFT



OPTI Well 342 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2140 ft.
WSE Max = 2142 ft.
Well Depth = 680 ft.
Elevation (ft.)
2386
2366
2346
2326
2306
2286
2266
2246
2226
2206
2186
2166
2146
2126
2106
2086
2066
2046
2026
2006
1986
1966
1946
1926
1906
1886
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1826
1806
1786
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1746
1726
1706
1686
1666
1646
1626
Depth to Water (ft.)
0
20
40
60
80
100
120
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160
180
200
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Year
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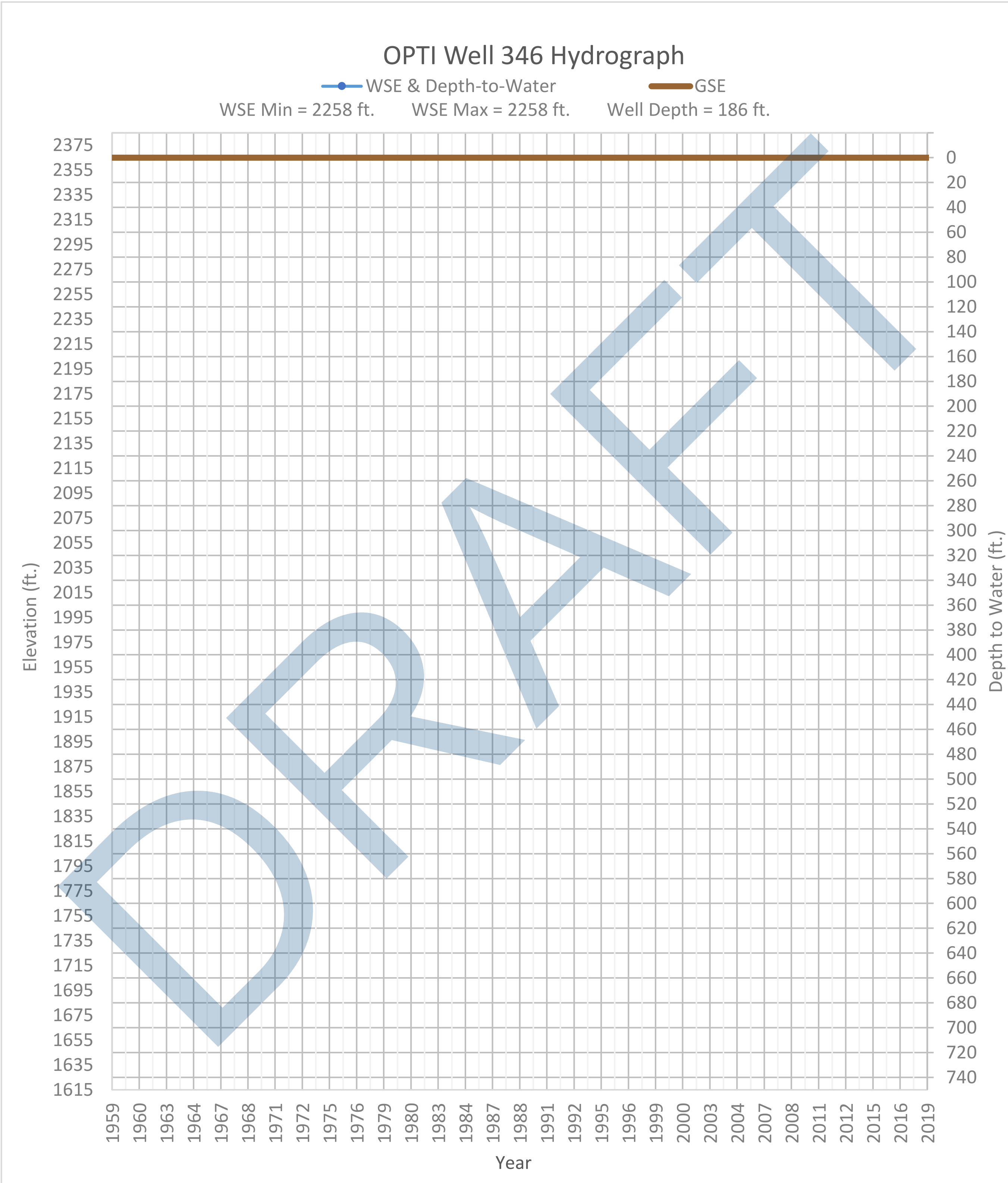

OPTI Well 346 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2258 ft.
WSE Max = 2258 ft.
Well Depth = 186 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2375
2355
2335
2315
2295
2275
2255
2235
2215
2195
2175
2155
2135
2115
2095
2075
2055
2035
2015
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1975
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1935
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1675
1655
1635
1615
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160
180
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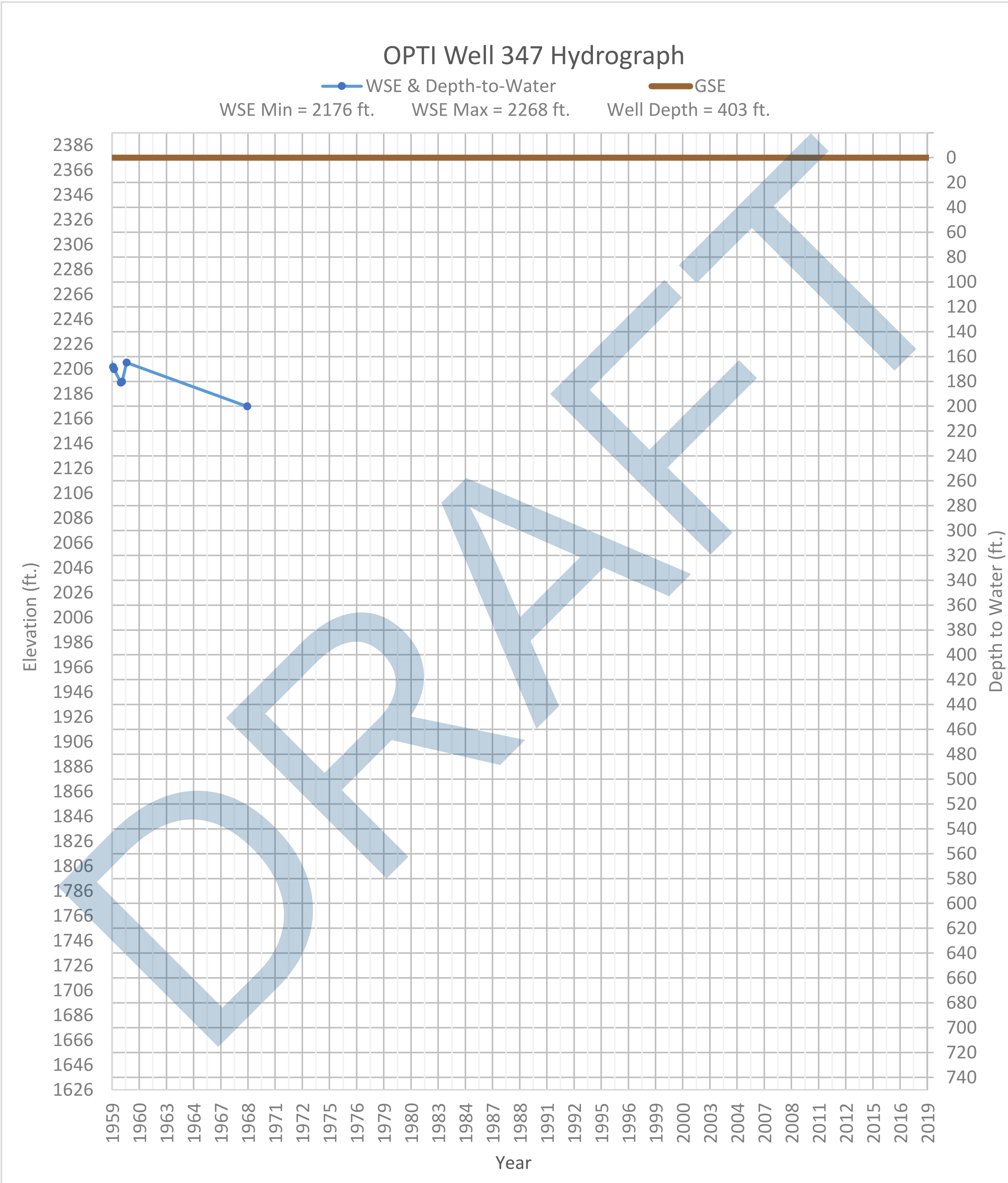
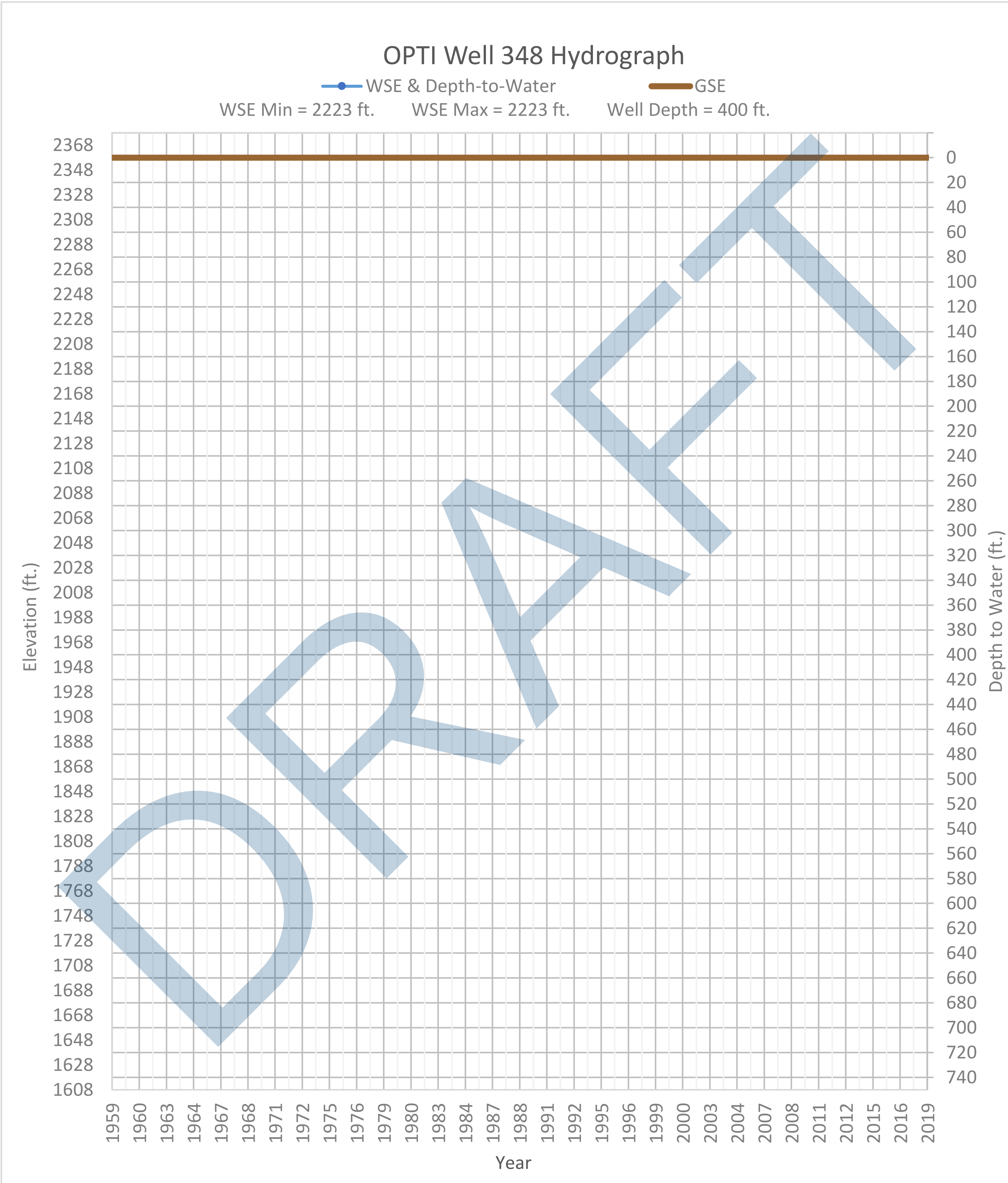
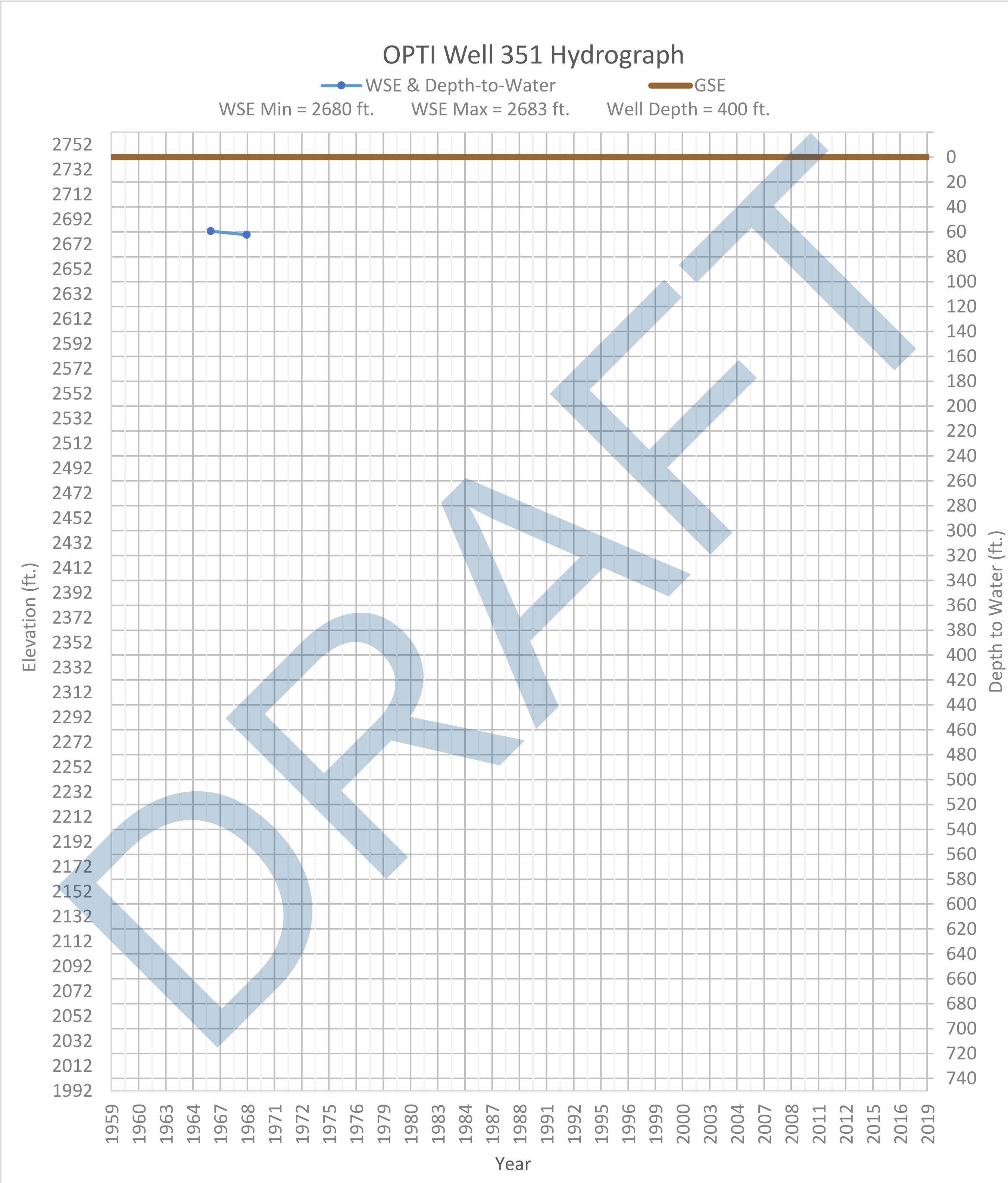
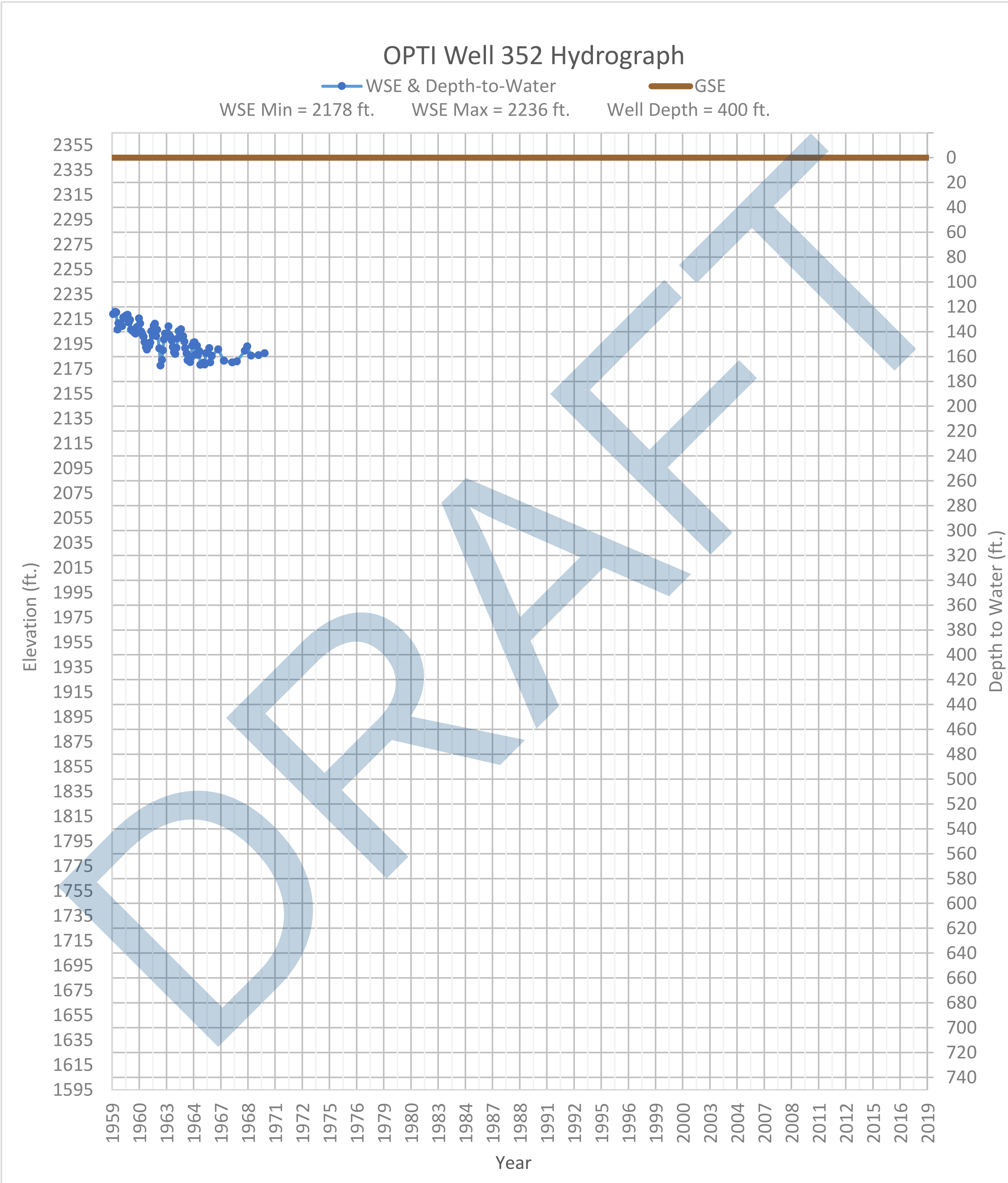


OPTI Well 347 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2176 ft.
WSE Max = 2268 ft.
Well Depth = 403 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

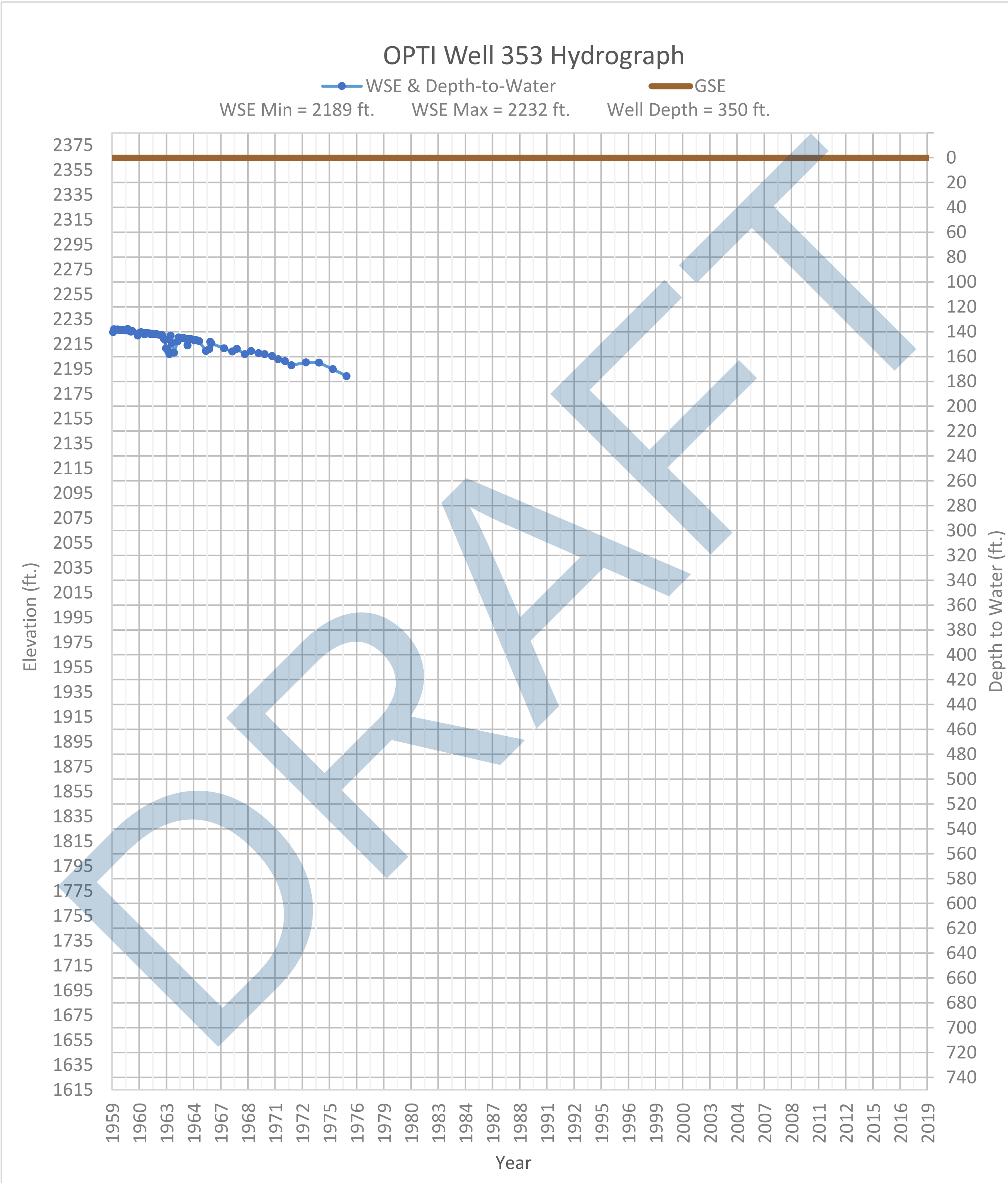

OPTI Well 348 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2223 ft.
WSE Max = 2223 ft.
Well Depth = 400 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



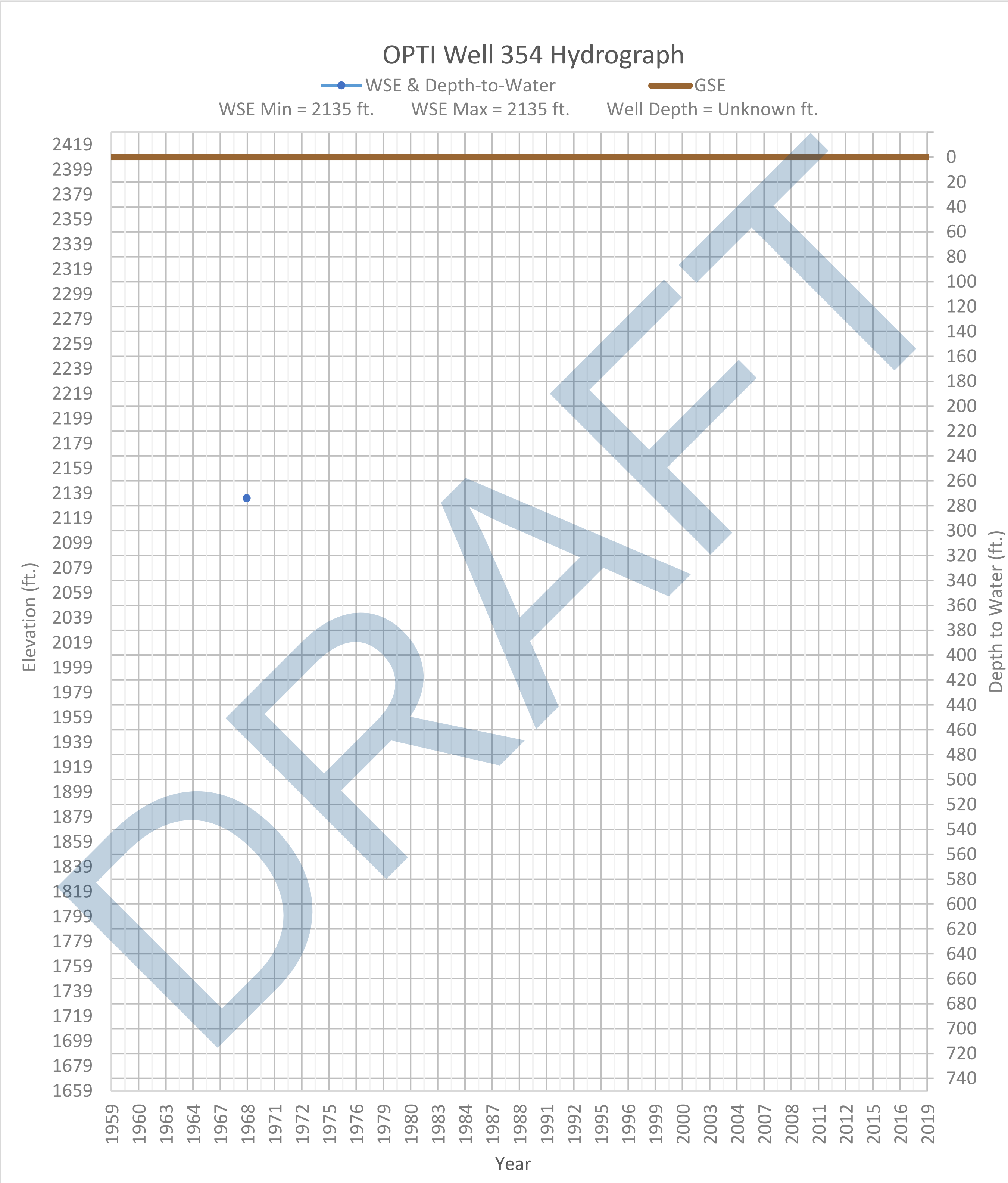
OPTI Well 351 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2680 ft.
WSE Max = 2683 ft.
Well Depth = 400 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



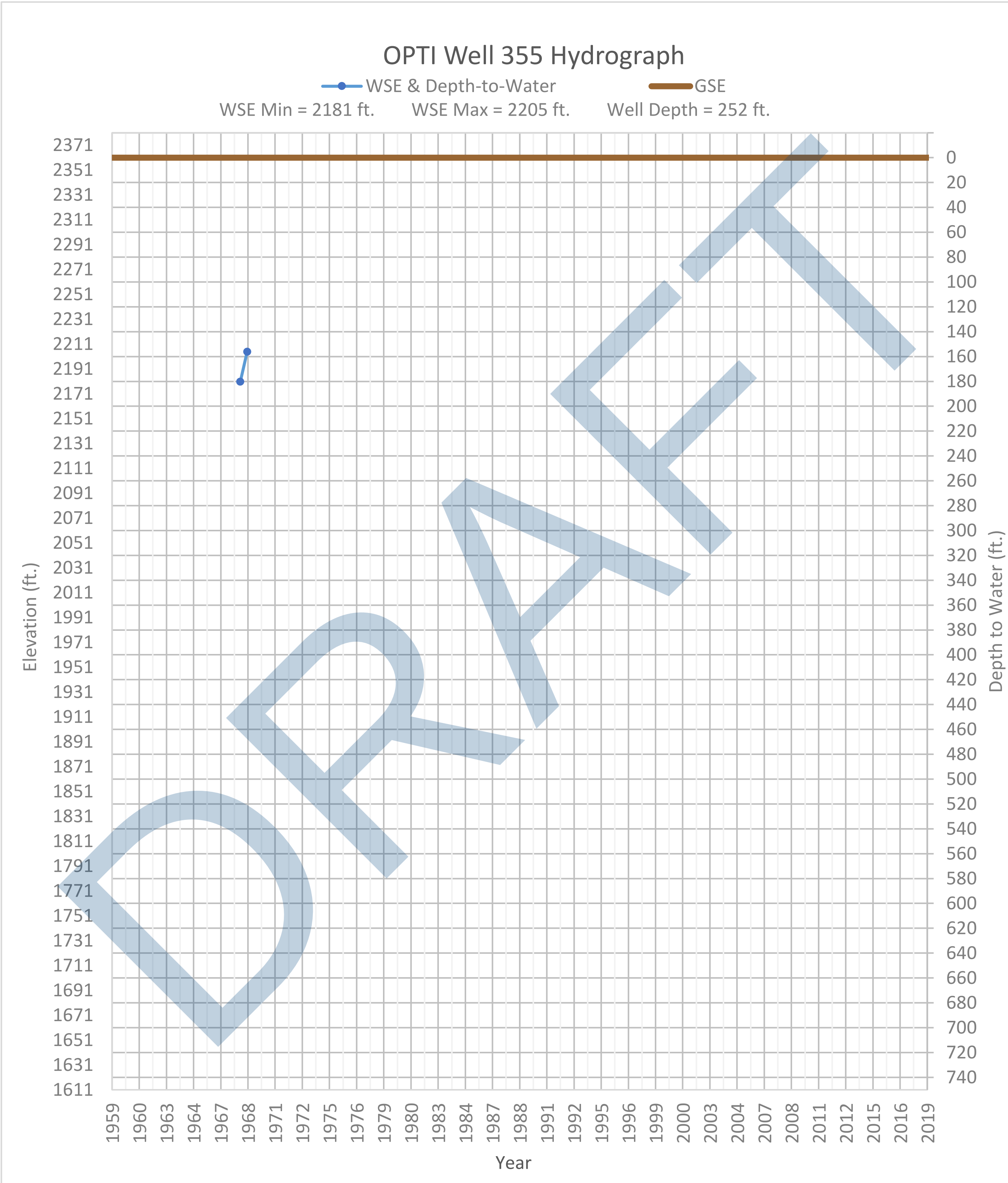
OPTI Well 352 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2178 ft.
WSE Max = 2236 ft.
Well Depth = 400 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



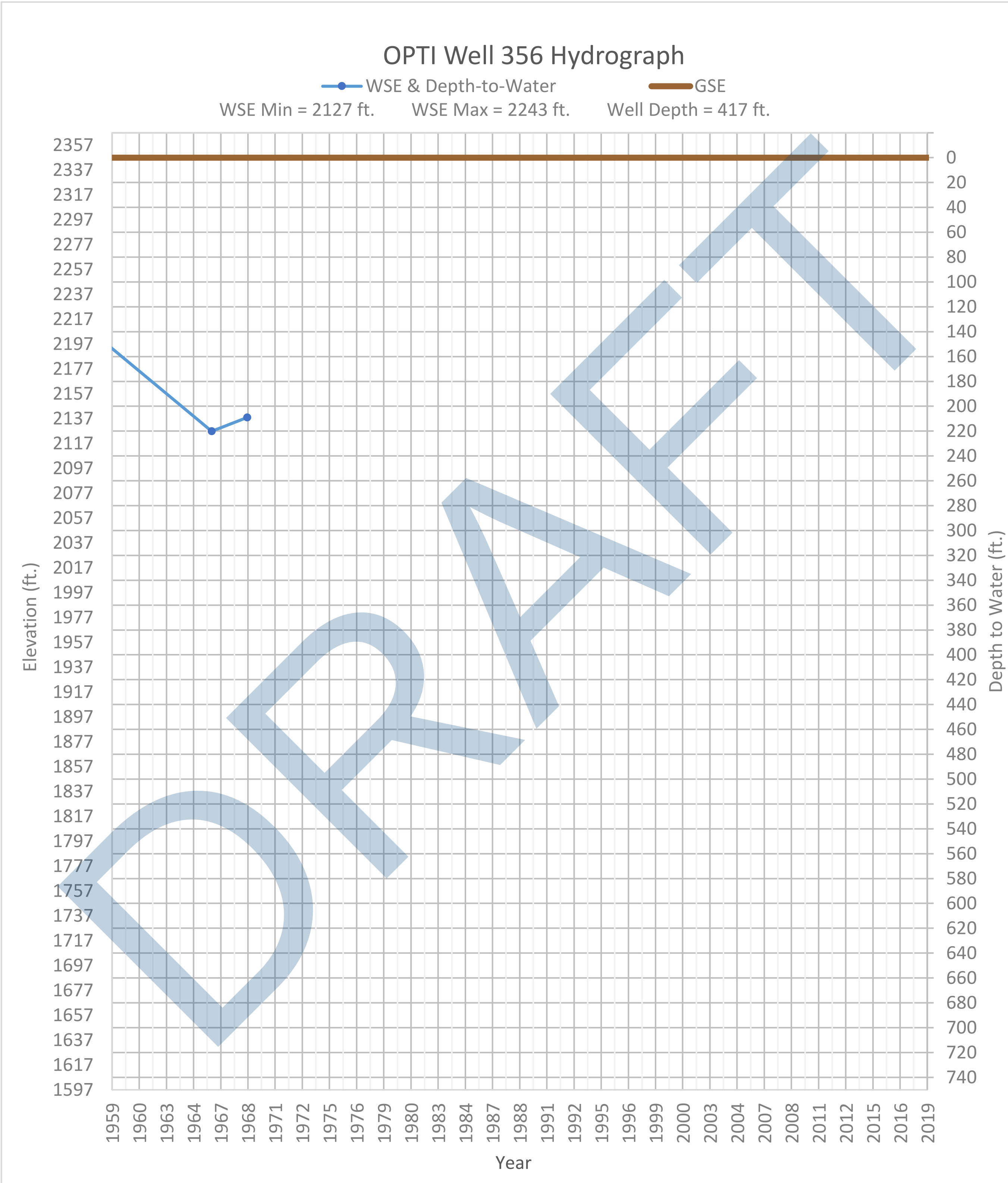
OPTI Well 353 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2189 ft.
WSE Max = 2232 ft.
Well Depth = 350 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

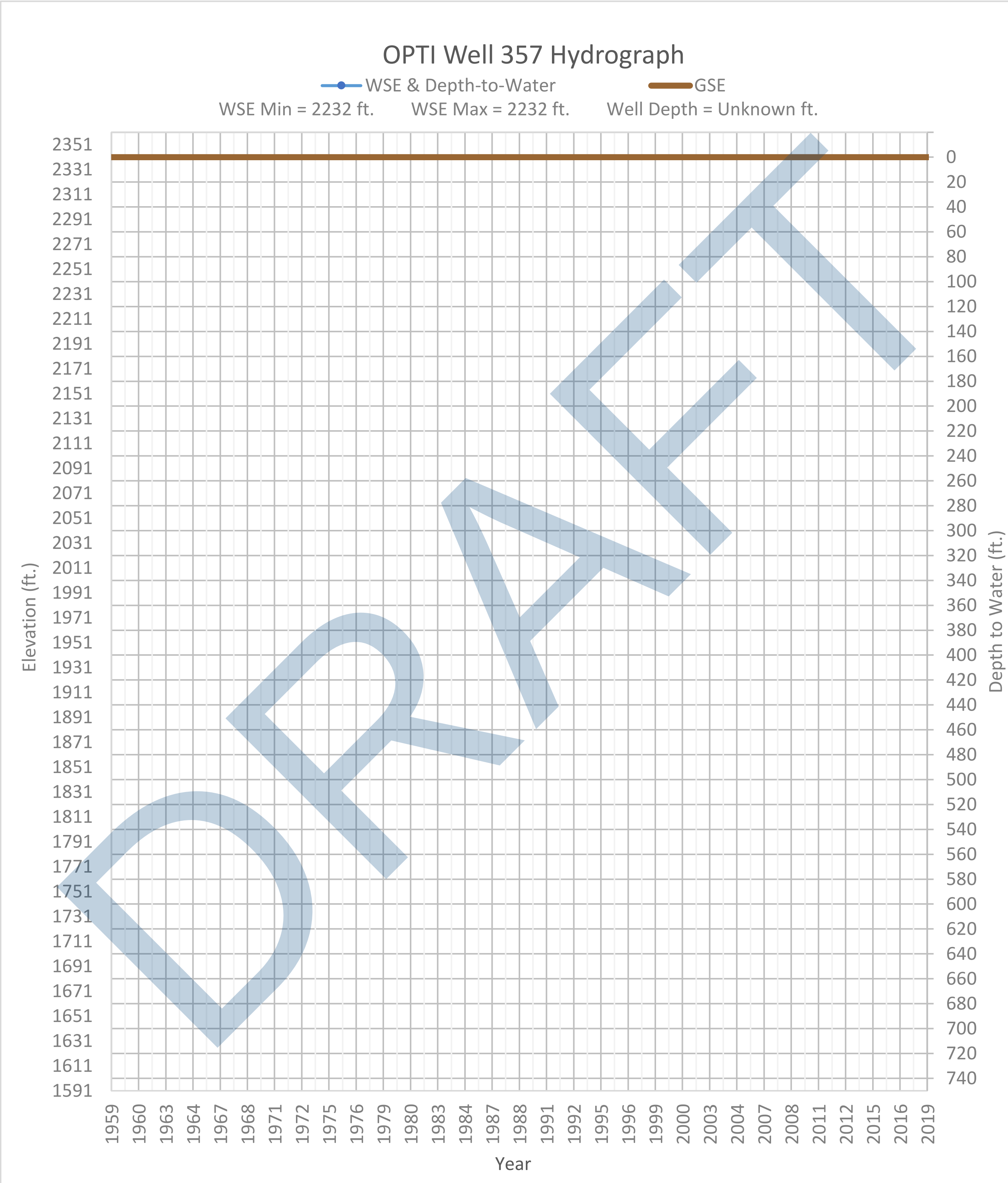


OPTI Well 354 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2135 ft.
WSE Max = 2135 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

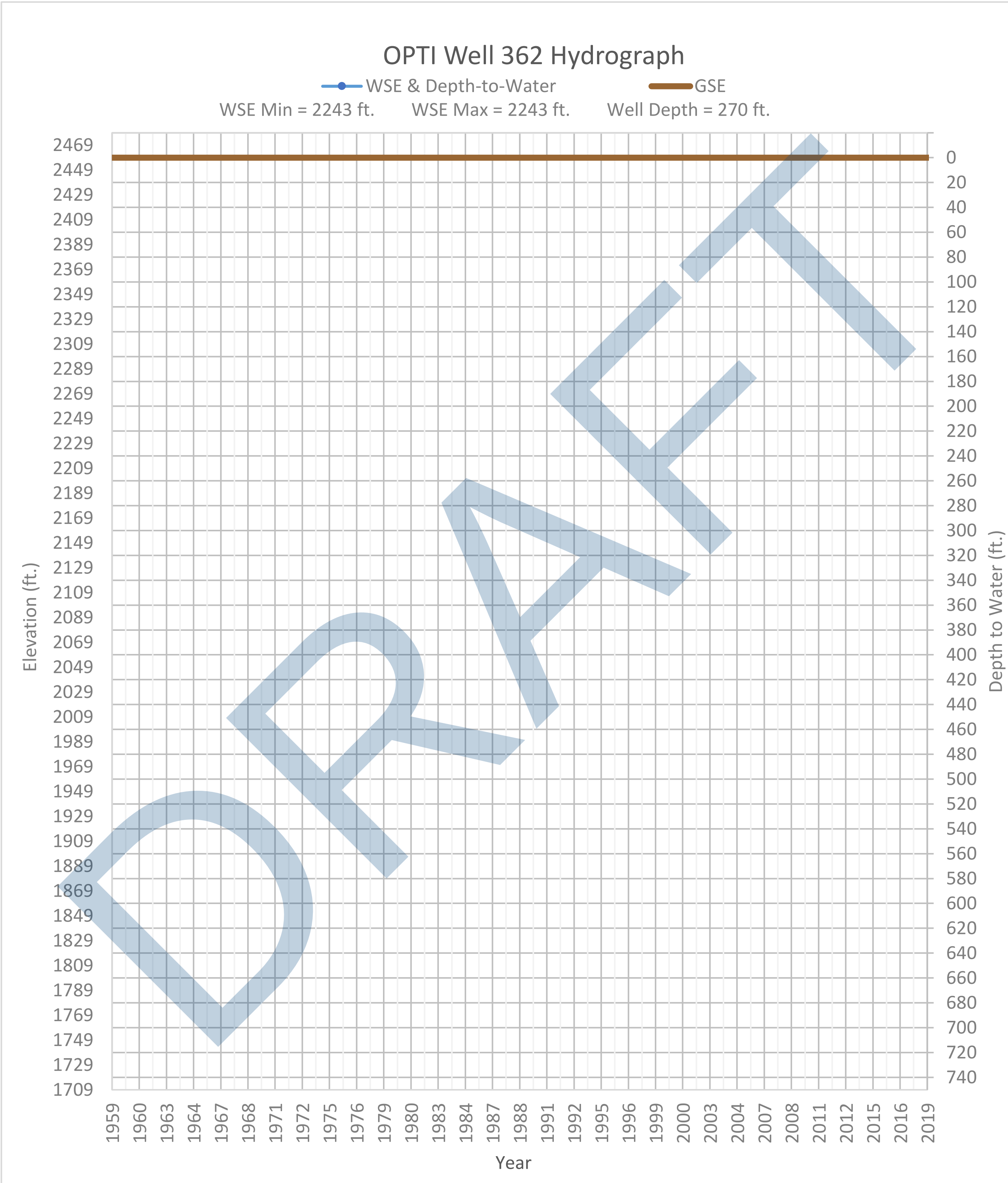


OPTI Well 355 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2181 ft.
WSE Max = 2205 ft.
Well Depth = 252 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 356 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2127 ft.
WSE Max = 2243 ft.
Well Depth = 417 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 357 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2232 ft.
WSE Max = 2232 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2351 2331 2311 2291 2271 2251 2231 2211 2191 2171 2151 2131 2111 2091 2071 2051 2031 2011 1991 1971 1951 1931 1911 1891 1871 1851 1831 1811 1791 1771 1751 1731 1711 1691 1671 1651 1631 1611 1591
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720 740
1959 1960 1963 1964 1967 1968 1971 1972 1975 1976 1979 1980 1983 1984 1987 1988 1991 1992 1995 1996 1999 2000 2003 2004 2007 2008 2011 2012 2015 2016 2019
DRAFT



OPTI Well 362 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2243 ft.
WSE Max = 2243 ft.
Well Depth = 270 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2469
2449
2429
2409
2389
2369
2349
2329
2309
2289
2269
2249
2229
2209
2189
2169
2149
2129
2109
2089
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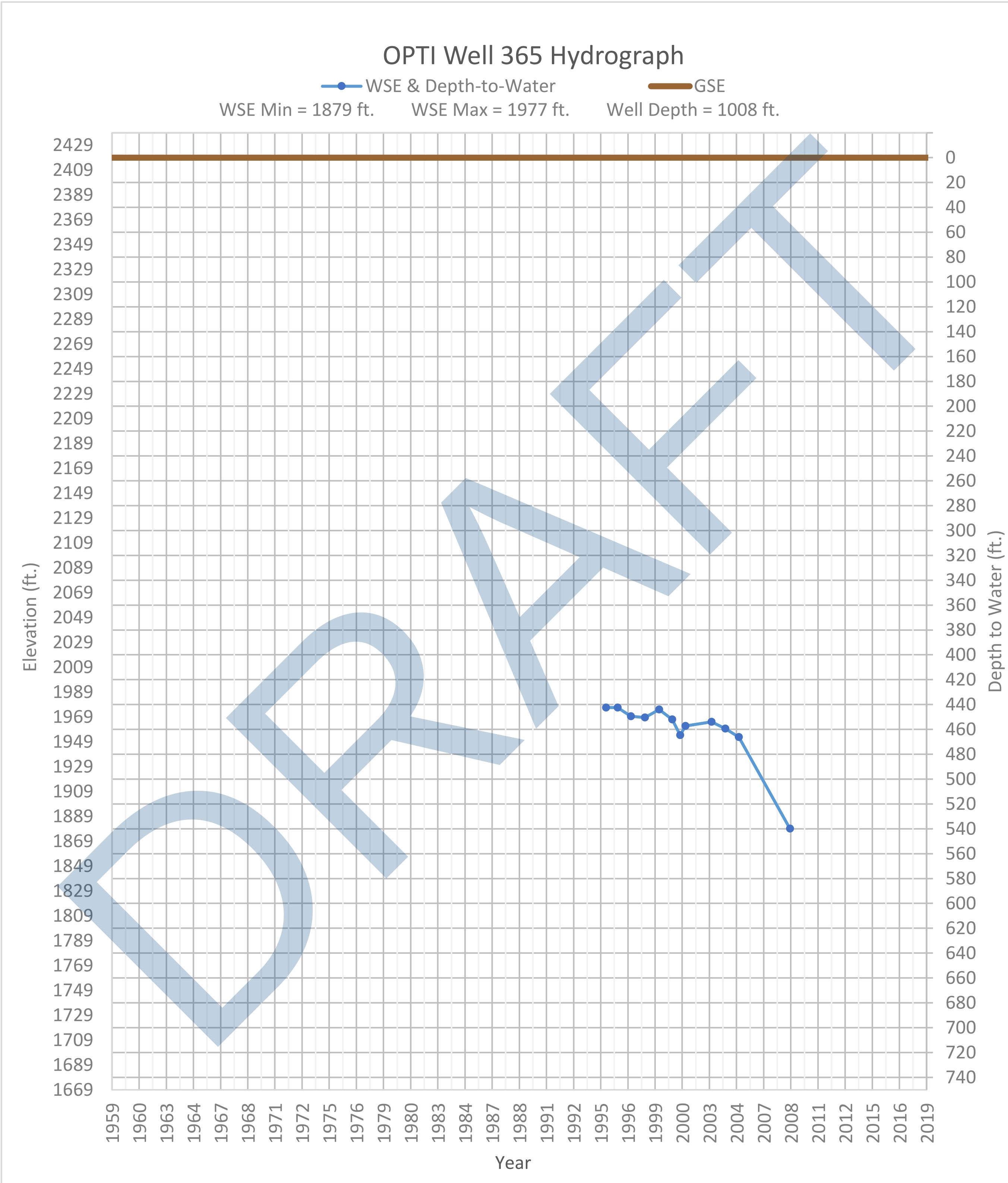
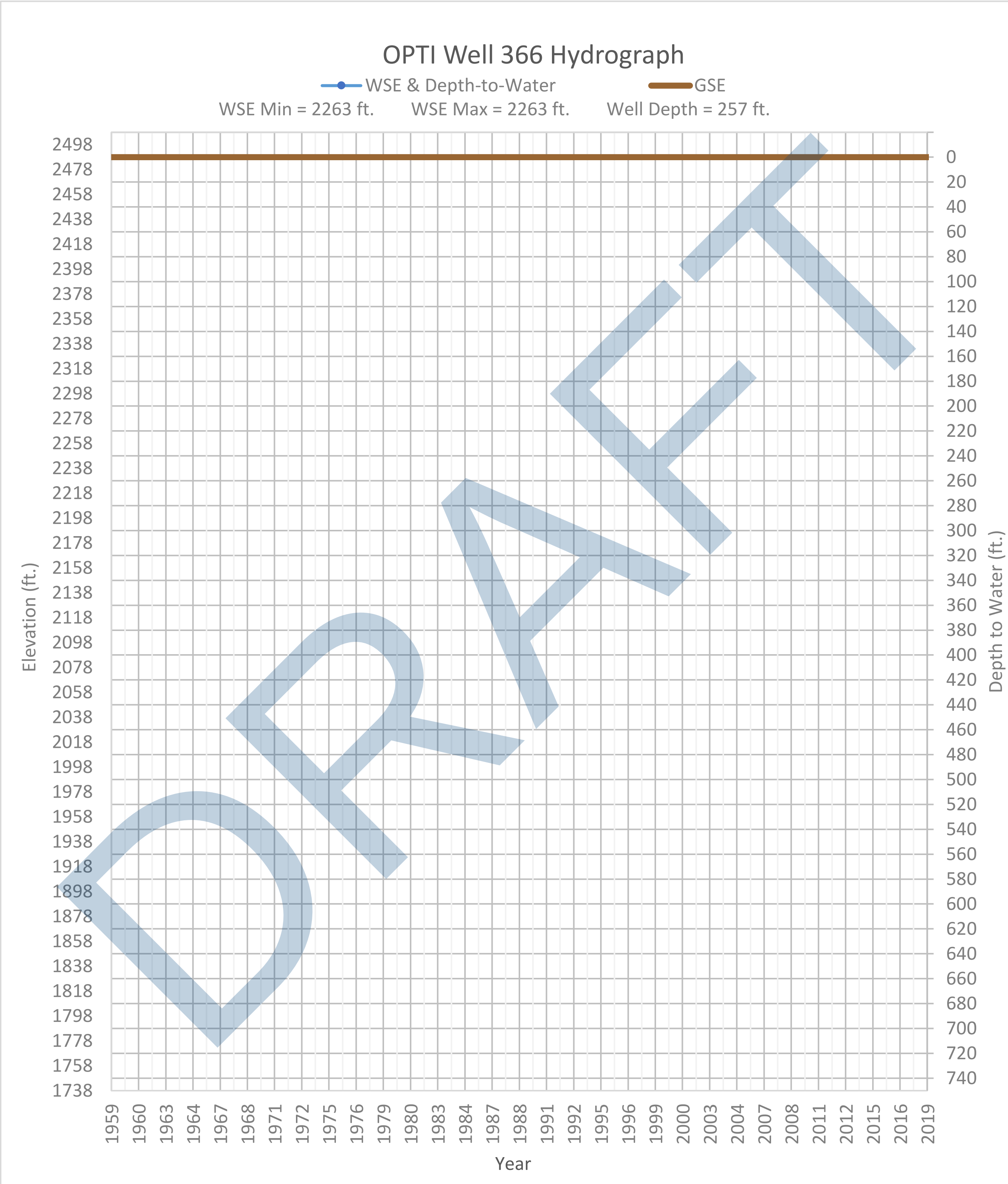
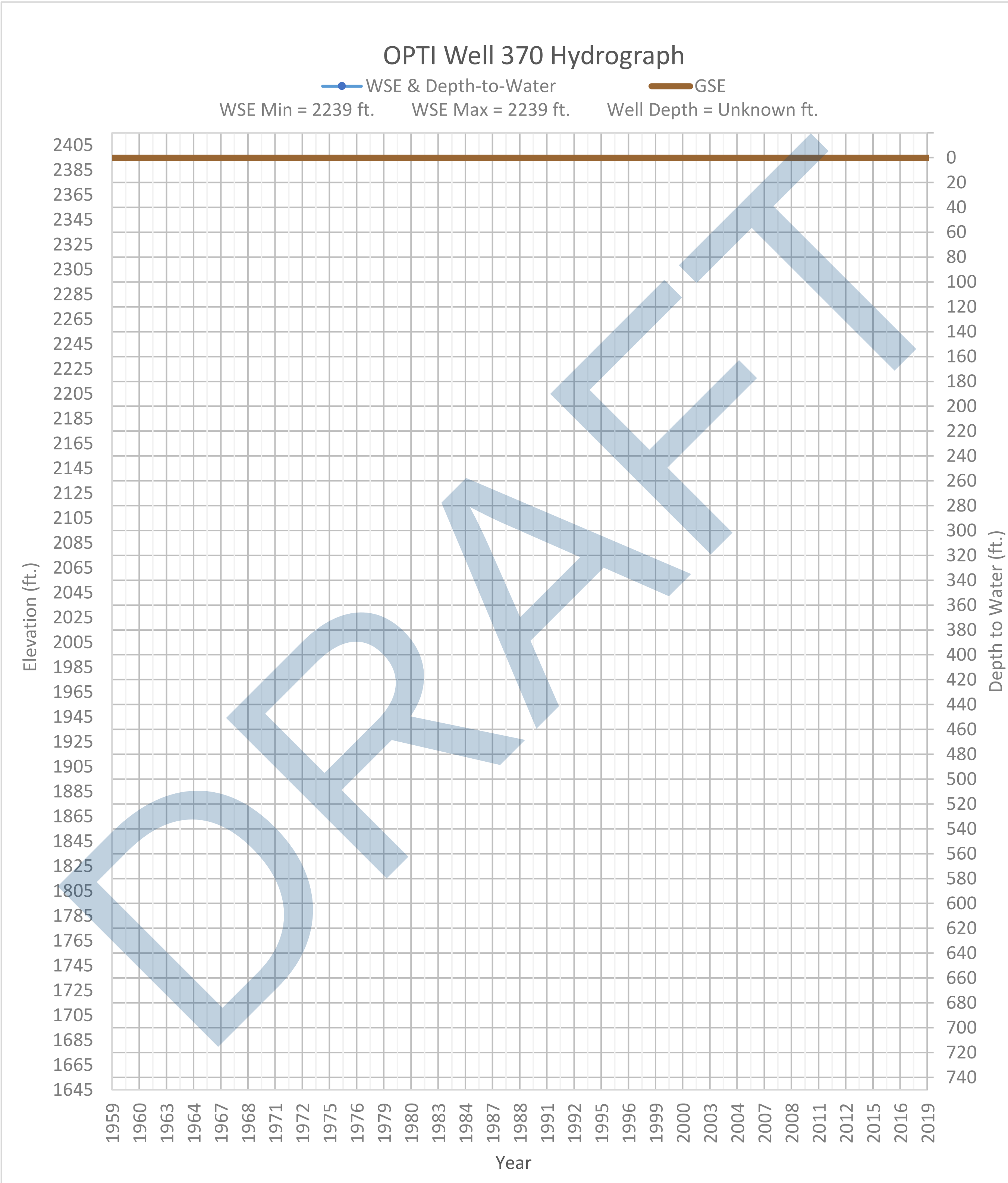
DRAFT



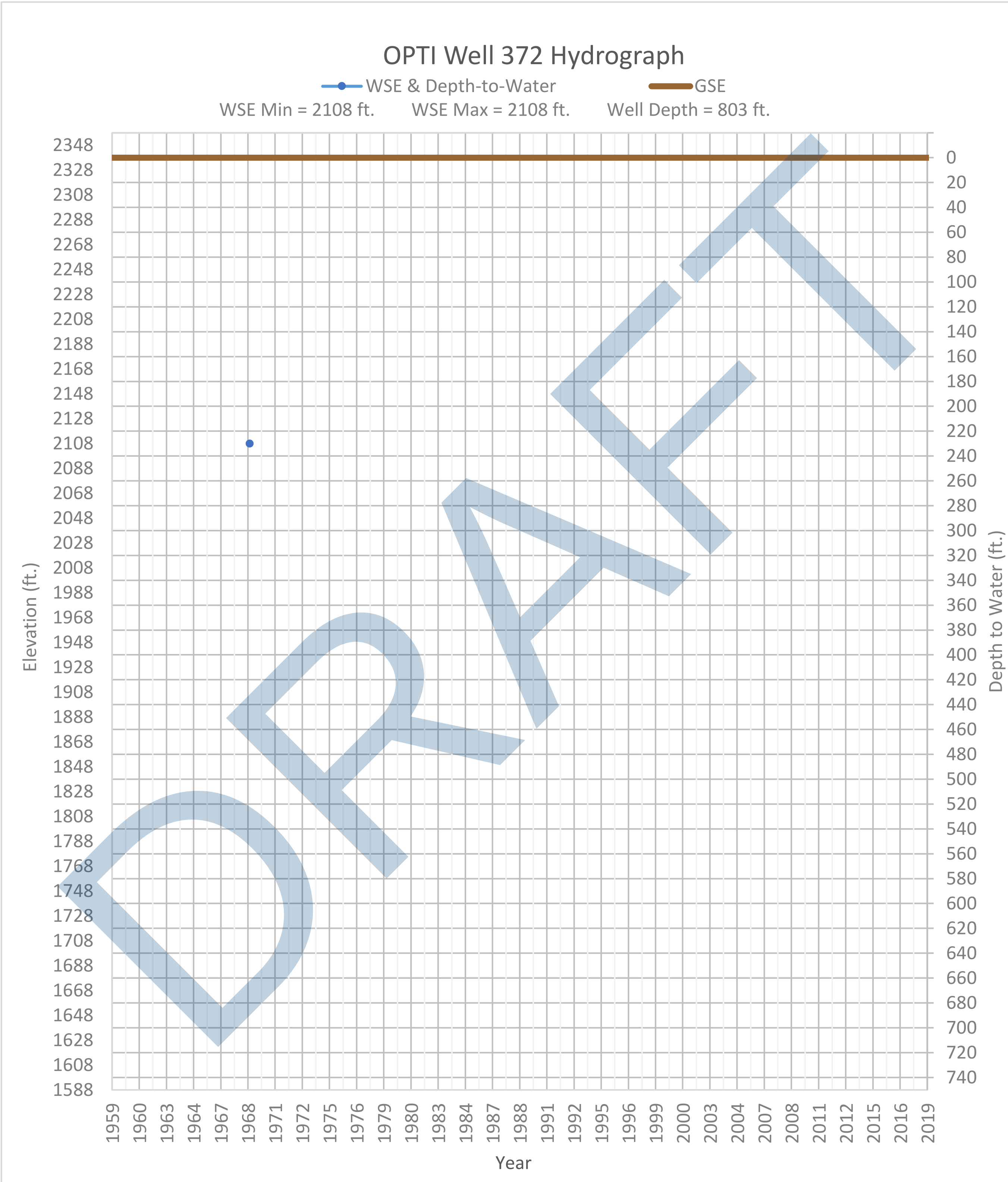
OPTI Well 365 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1879 ft.
WSE Max = 1977 ft.
Well Depth = 1008 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



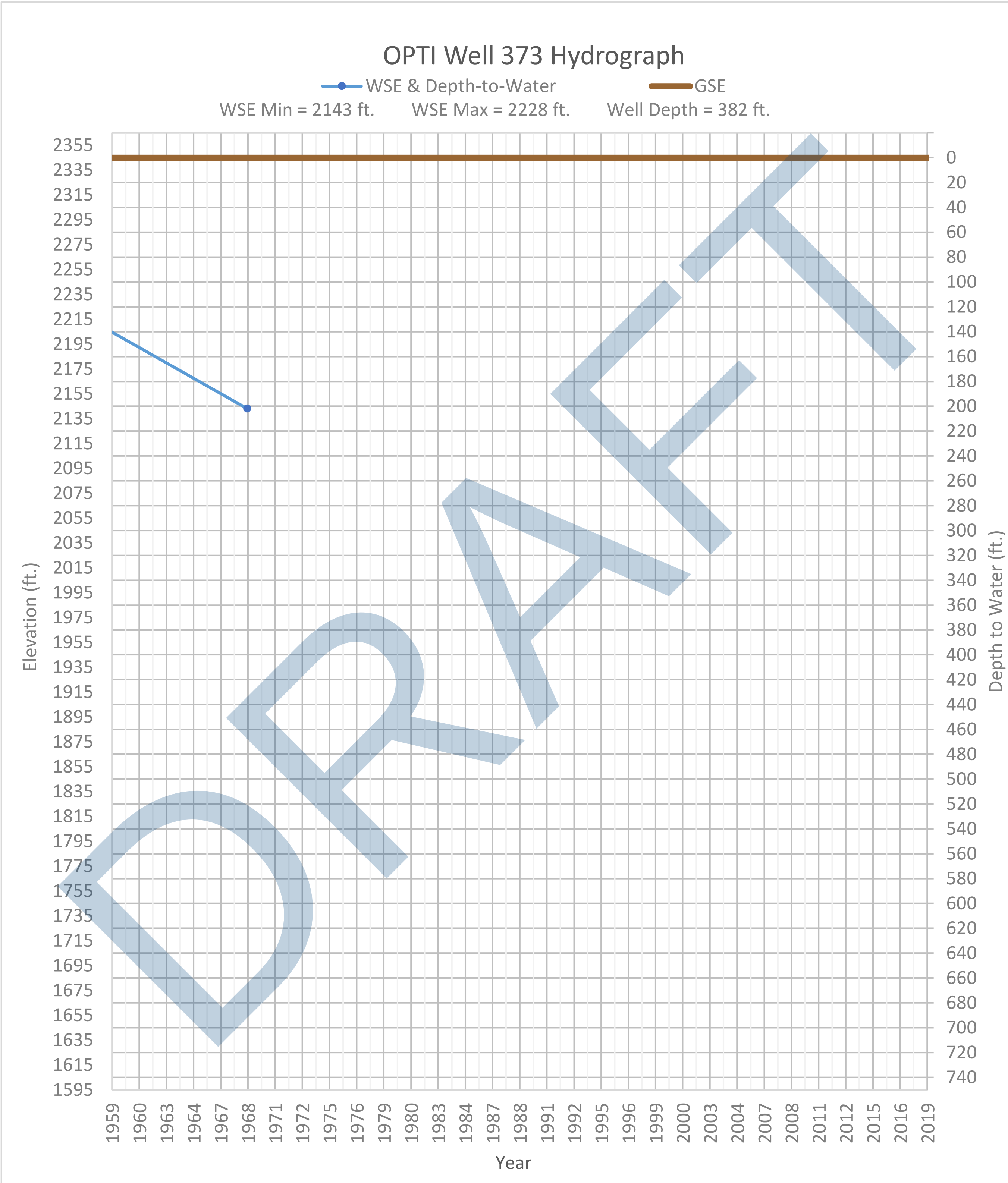
OPTI Well 366 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2263 ft.
WSE Max = 2263 ft.
Well Depth = 257 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



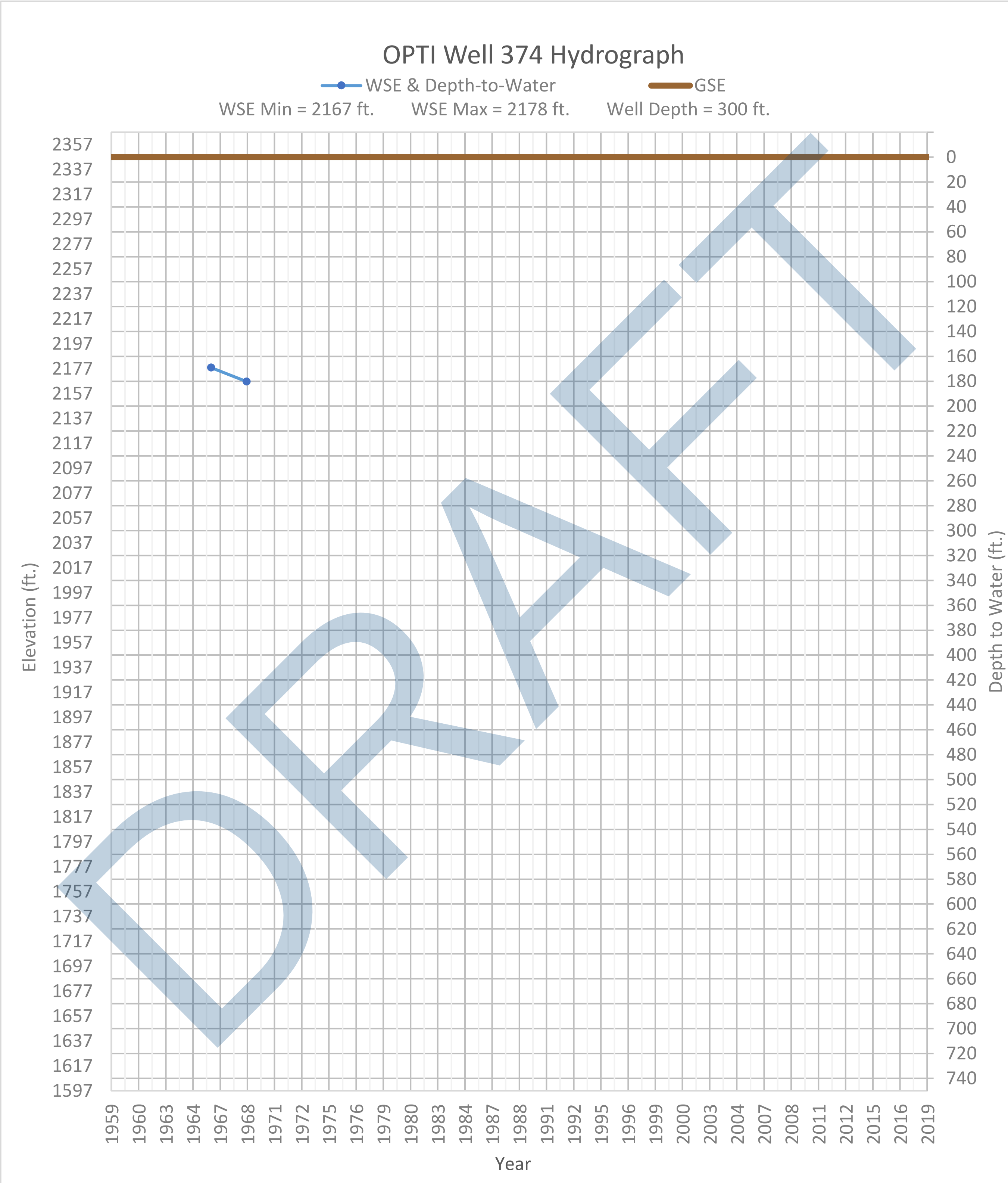
OPTI Well 370 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2239 ft.
WSE Max = 2239 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



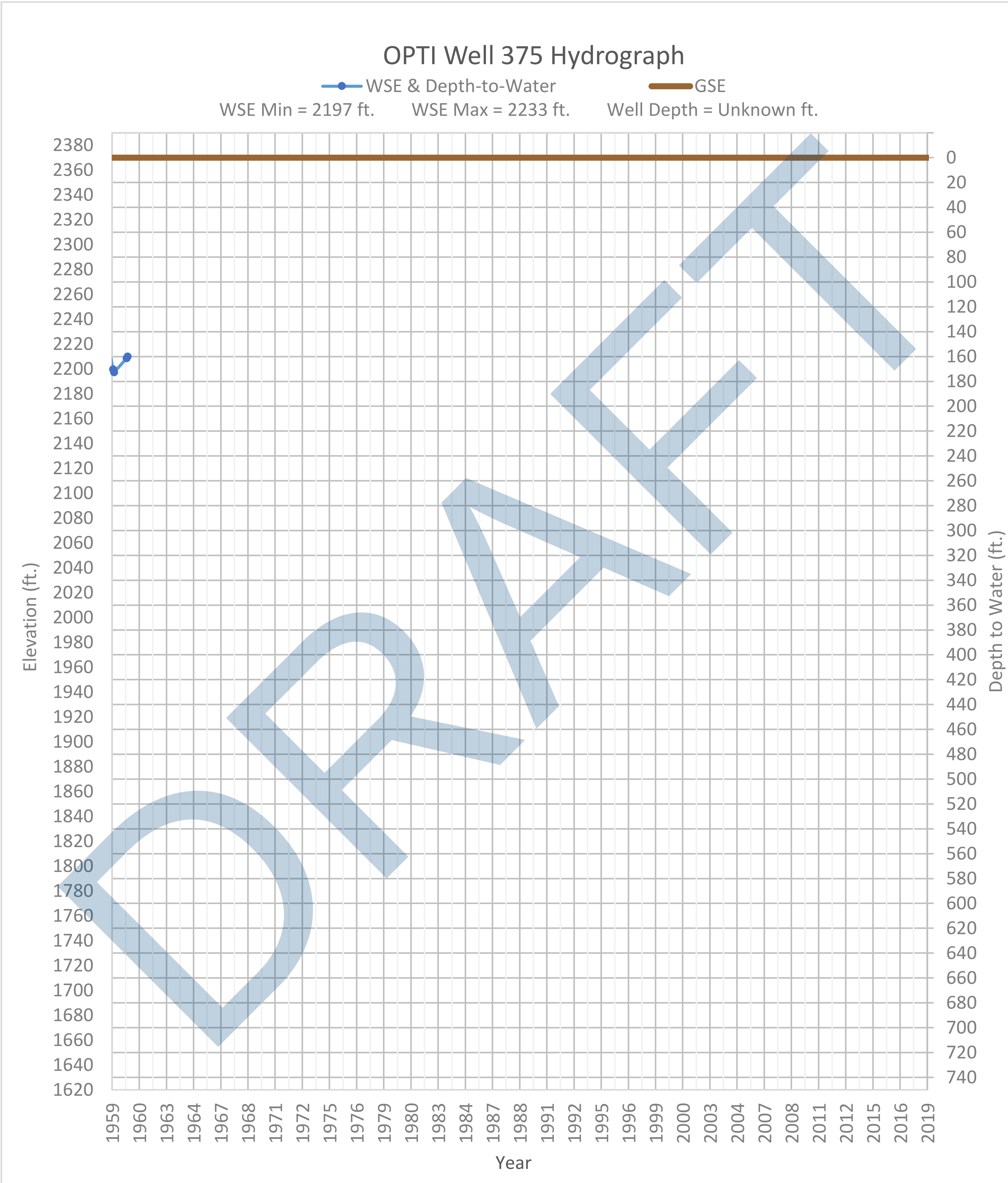
OPTI Well 372 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2108 ft.
WSE Max = 2108 ft.
Well Depth = 803 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

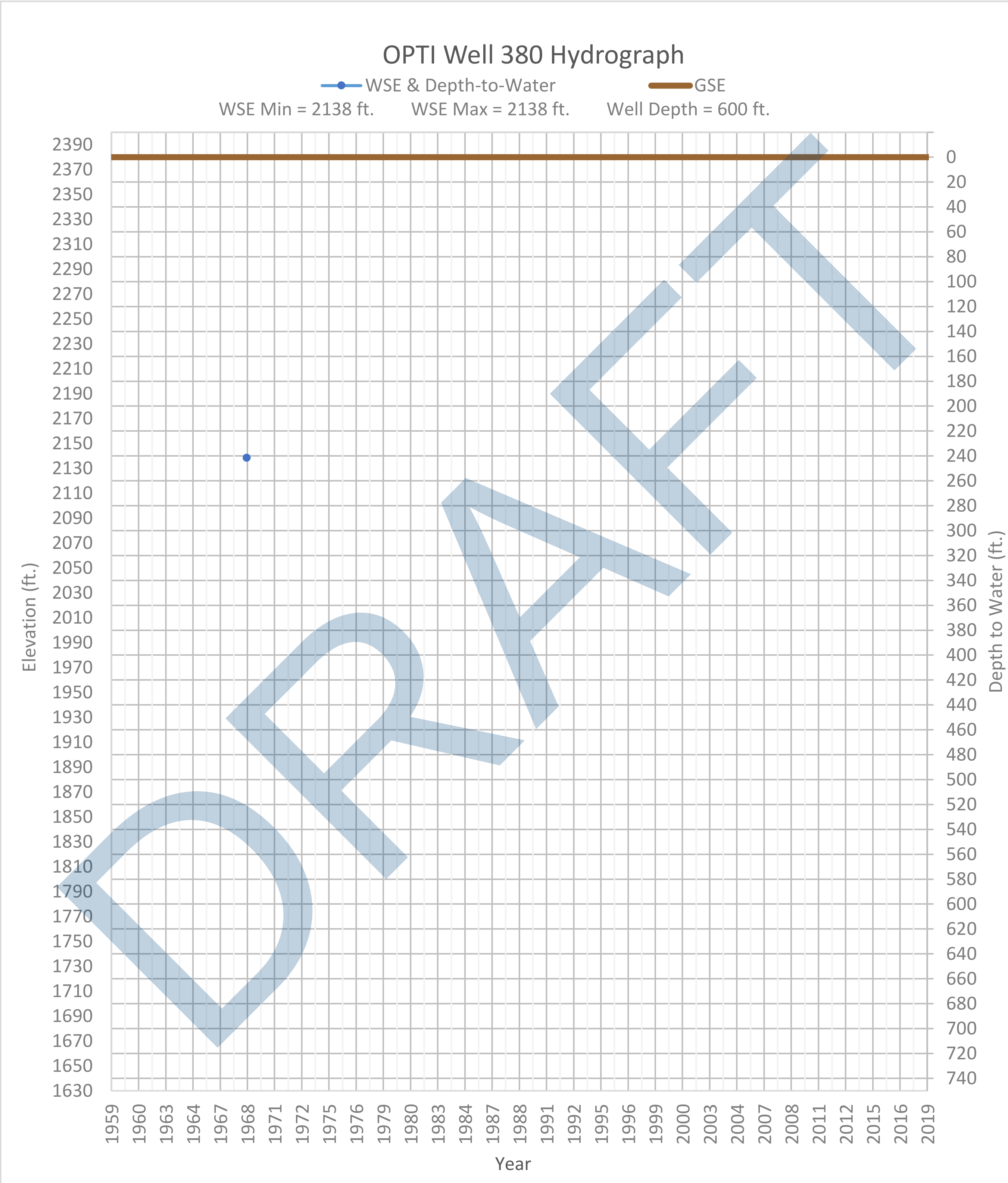


OPTI Well 373 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2143 ft.
WSE Max = 2228 ft.
Well Depth = 382 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

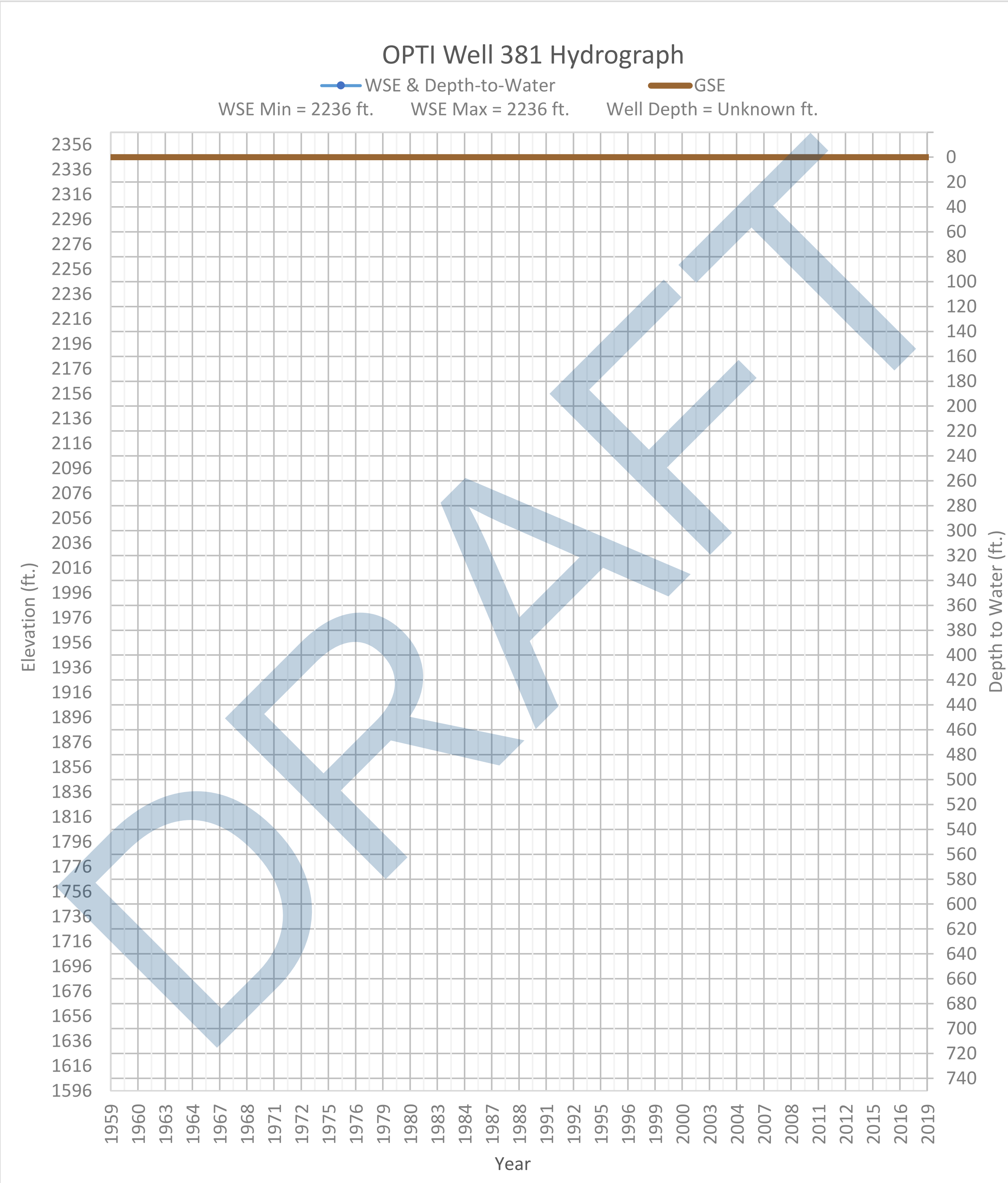


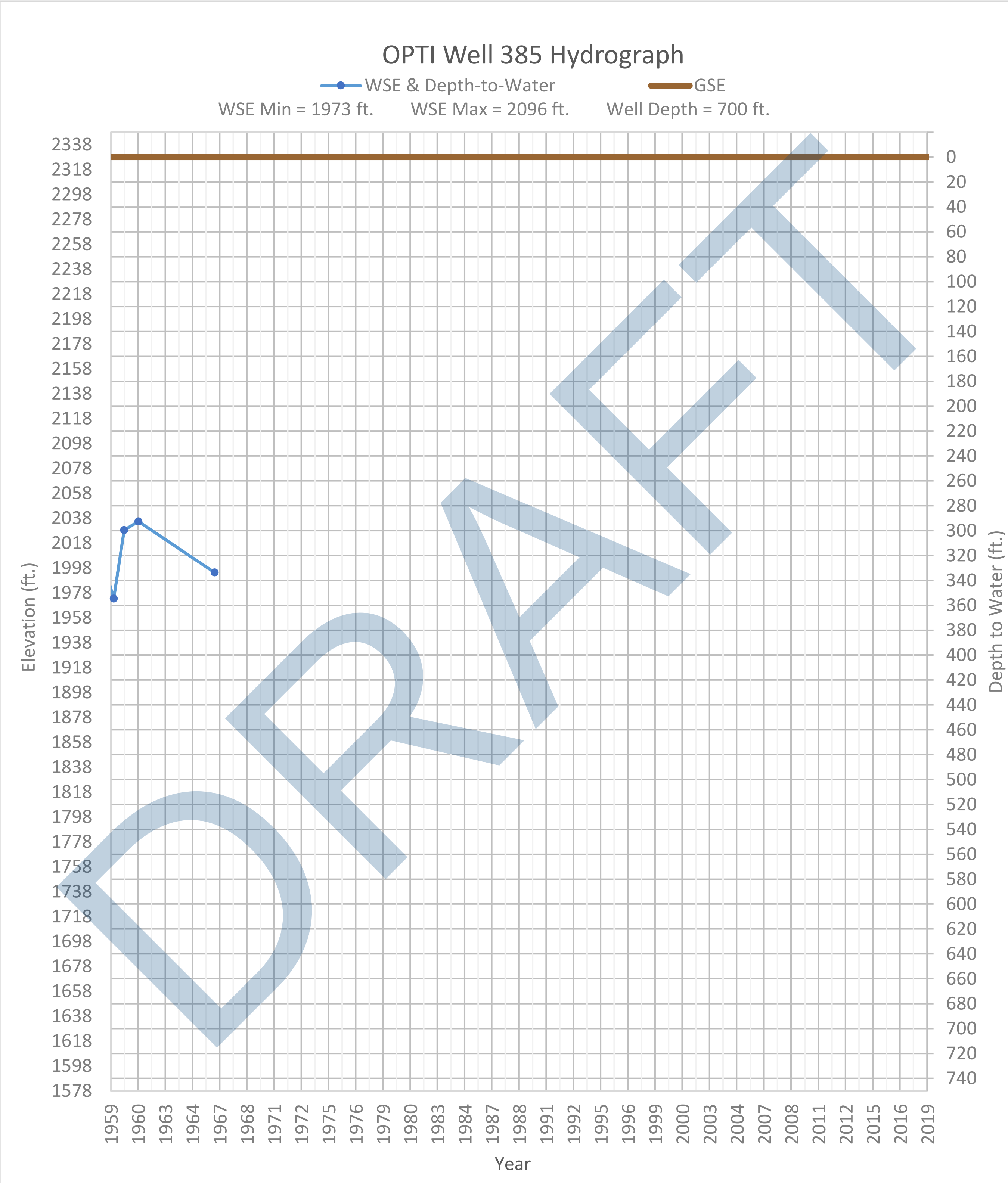
OPTI Well 374 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2167 ft.
WSE Max = 2178 ft.
Well Depth = 300 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2357 2337 2317 2297 2277 2257 2237 2217 2197 2177 2157 2137 2117 2097 2077 2057 2037 2017 1997 1977 1957 1937 1917 1897 1877 1857 1837 1817 1797 1777 1757 1737 1717 1697 1677 1657 1637 1617 1597
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720 740
1959 1960 1963 1964 1967 1968 1971 1972 1975 1976 1979 1980 1983 1984 1987 1988 1991 1992 1995 1996 1999 2000 2003 2004 2007 2008 2011 2012 2015 2016 2019
DRAFT


OPTI Well 375 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2197 ft.
WSE Max = 2233 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

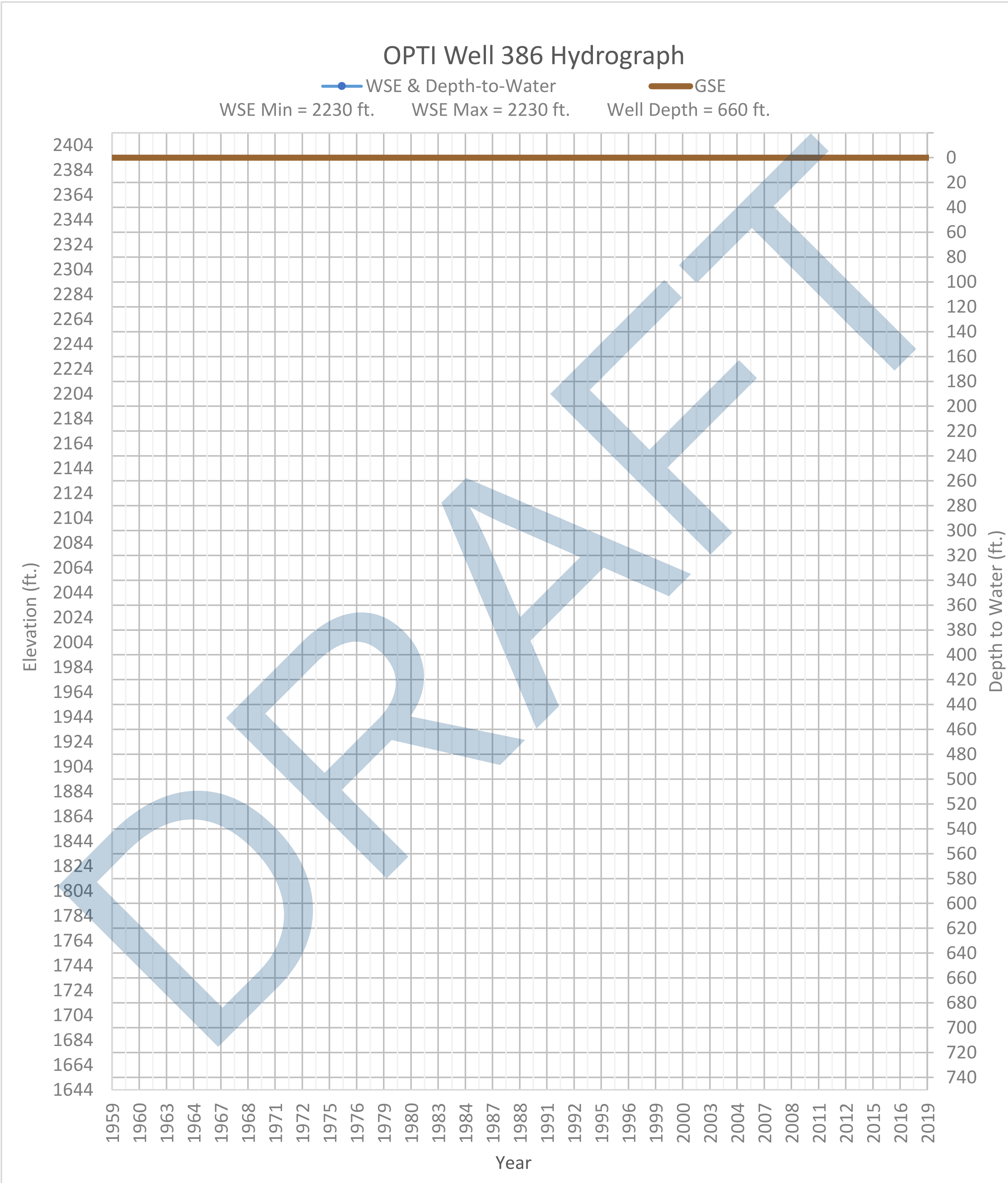


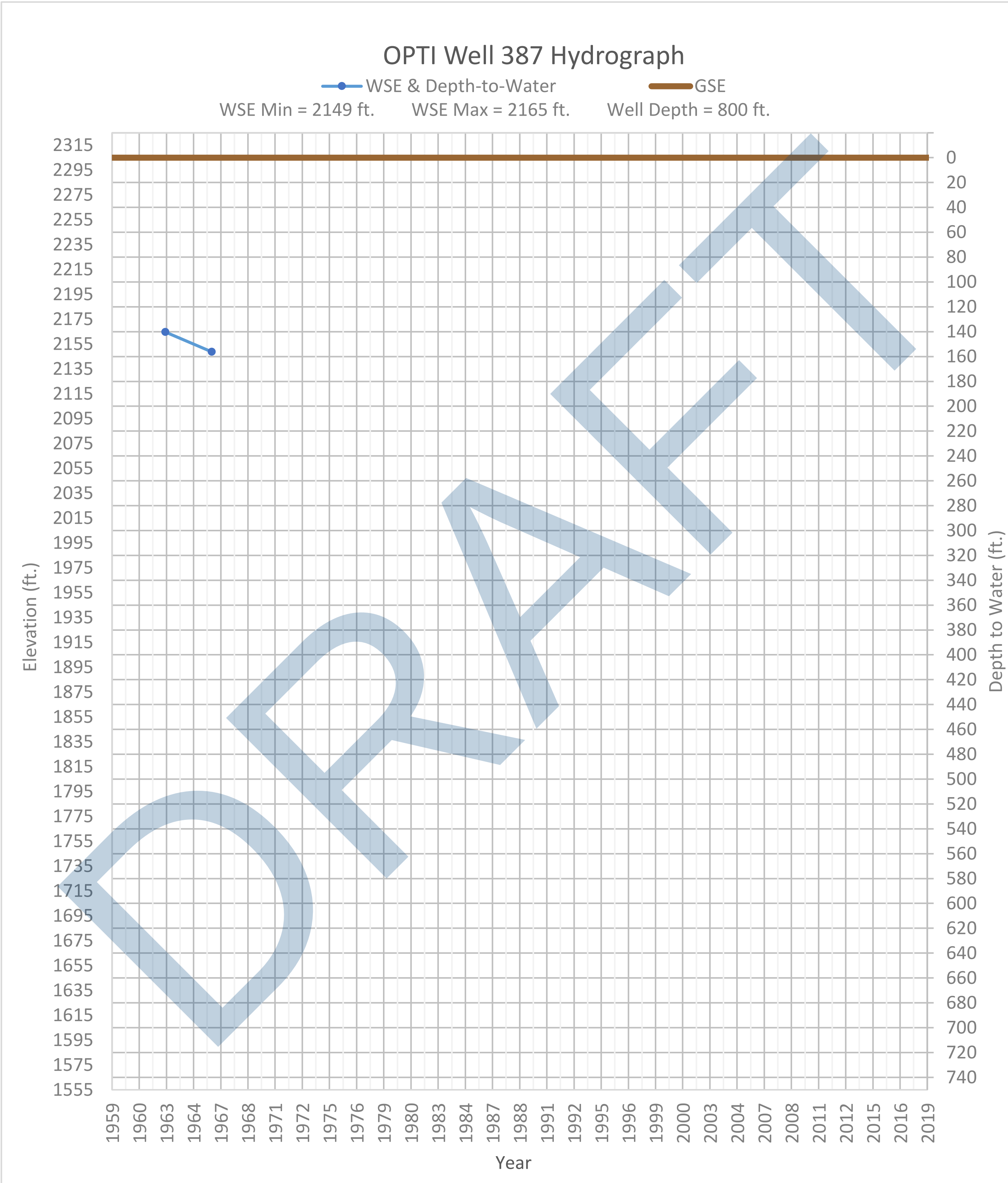
OPTI Well 380 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2138 ft.
WSE Max = 2138 ft.
Well Depth = 600 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 381 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2236 ft.
WSE Max = 2236 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

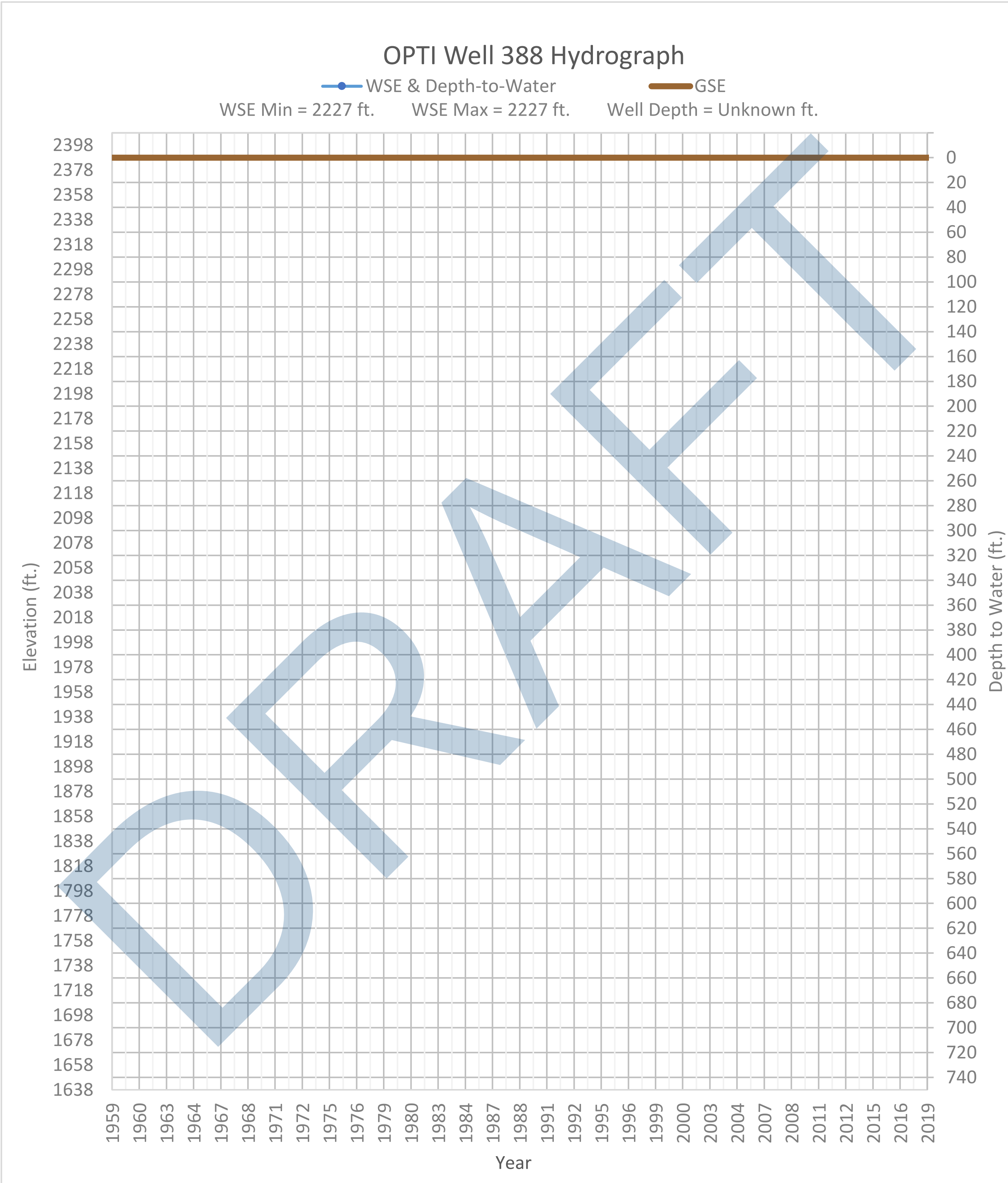


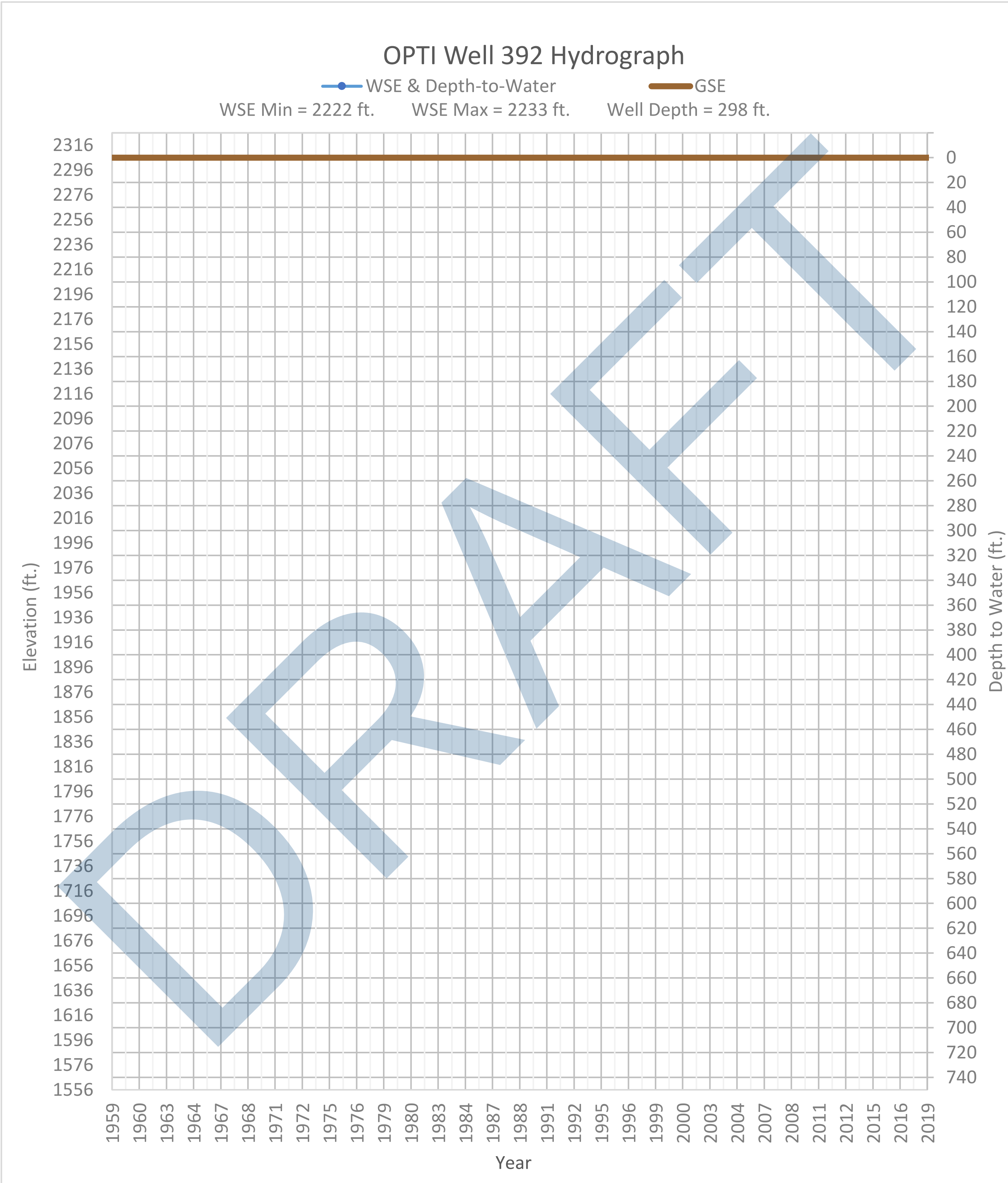
OPTI Well 385 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1973 ft.
WSE Max = 2096 ft.
Well Depth = 700 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

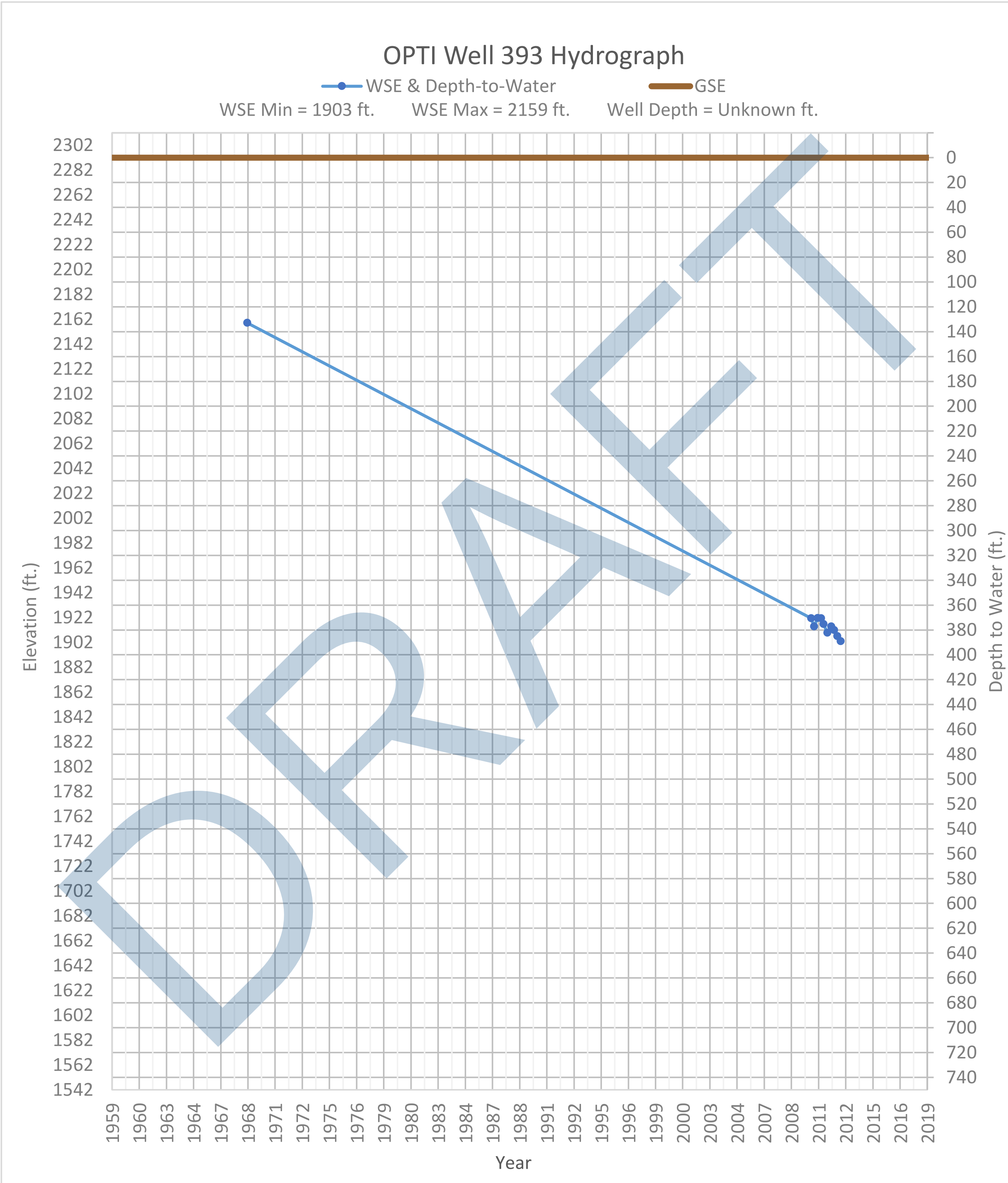

OPTI Well 386 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2230 ft.
WSE Max = 2230 ft.
Well Depth = 660 ft.
Elevation (ft.)
2404 2384 2364 2344 2324 2304 2284 2264 2244 2224 2204 2184 2164 2144 2124 2104 2084 2064 2044 2024 2004 1984 1964 1944 1924 1904 1884 1864 1844 1824 1804 1784 1764 1744 1724 1704 1684 1664 1644
Depth to Water (ft.)
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720 740
Year
1959 1960 1963 1964 1967 1968 1971 1972 1975 1976 1979 1980 1983 1984 1987 1988 1991 1992 1995 1996 1999 2000 2003 2004 2007 2008 2011 2012 2015 2016 2019
DRAFT



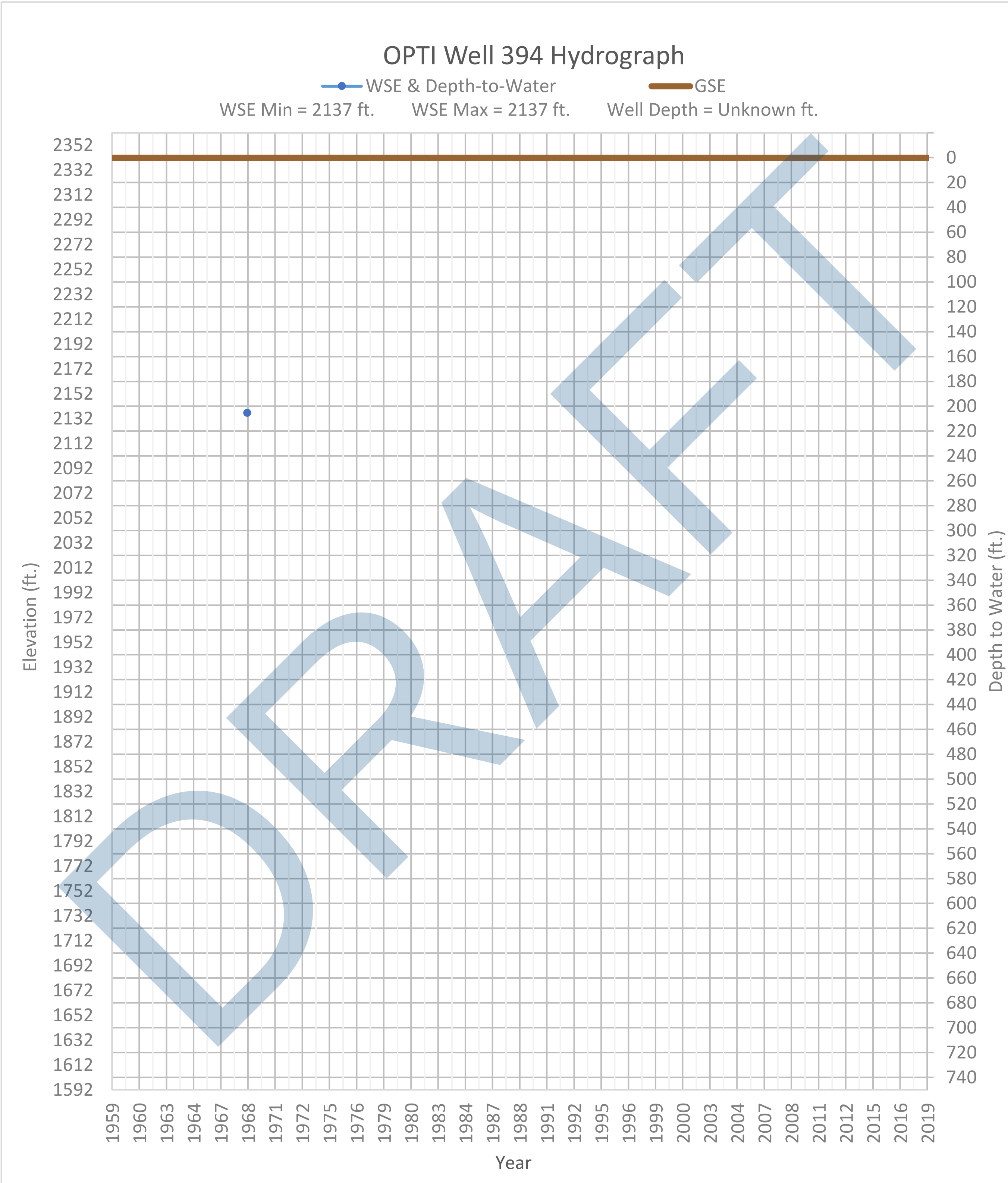
OPTI Well 387 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2149 ft.
WSE Max = 2165 ft.
Well Depth = 800 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 388 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2227 ft.
WSE Max = 2227 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

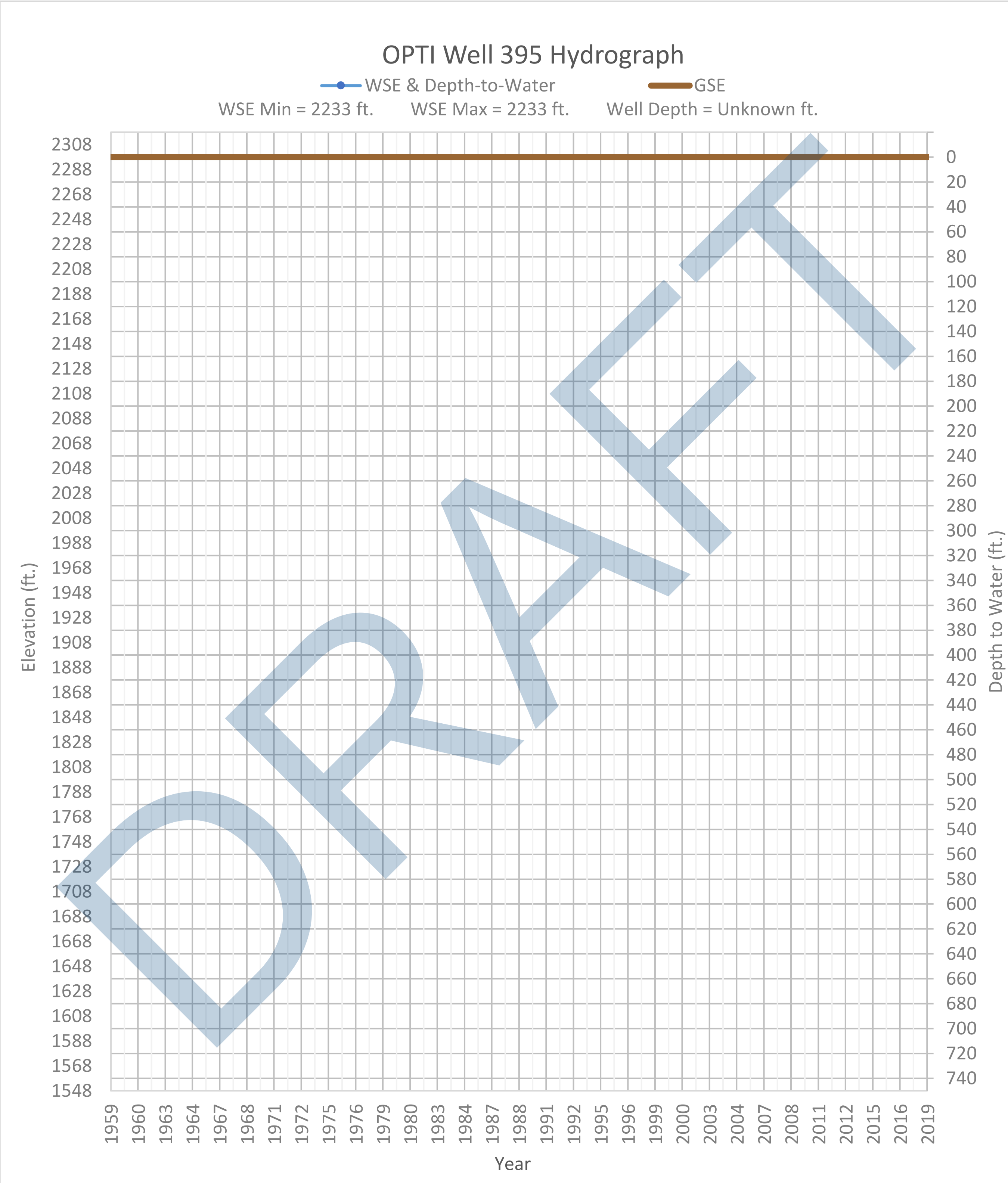

OPTI Well 392 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2222 ft.
WSE Max = 2233 ft.
Well Depth = 298 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 393 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1903 ft.
WSE Max = 2159 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 394 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2137 ft.
WSE Max = 2137 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 395 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2233 ft.
WSE Max = 2233 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2308
2288
2268
2248
2228
2208
2188
2168
2148
2128
2108
2088
2068
2048
2028
2008
1988
1968
1948
1928
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2016
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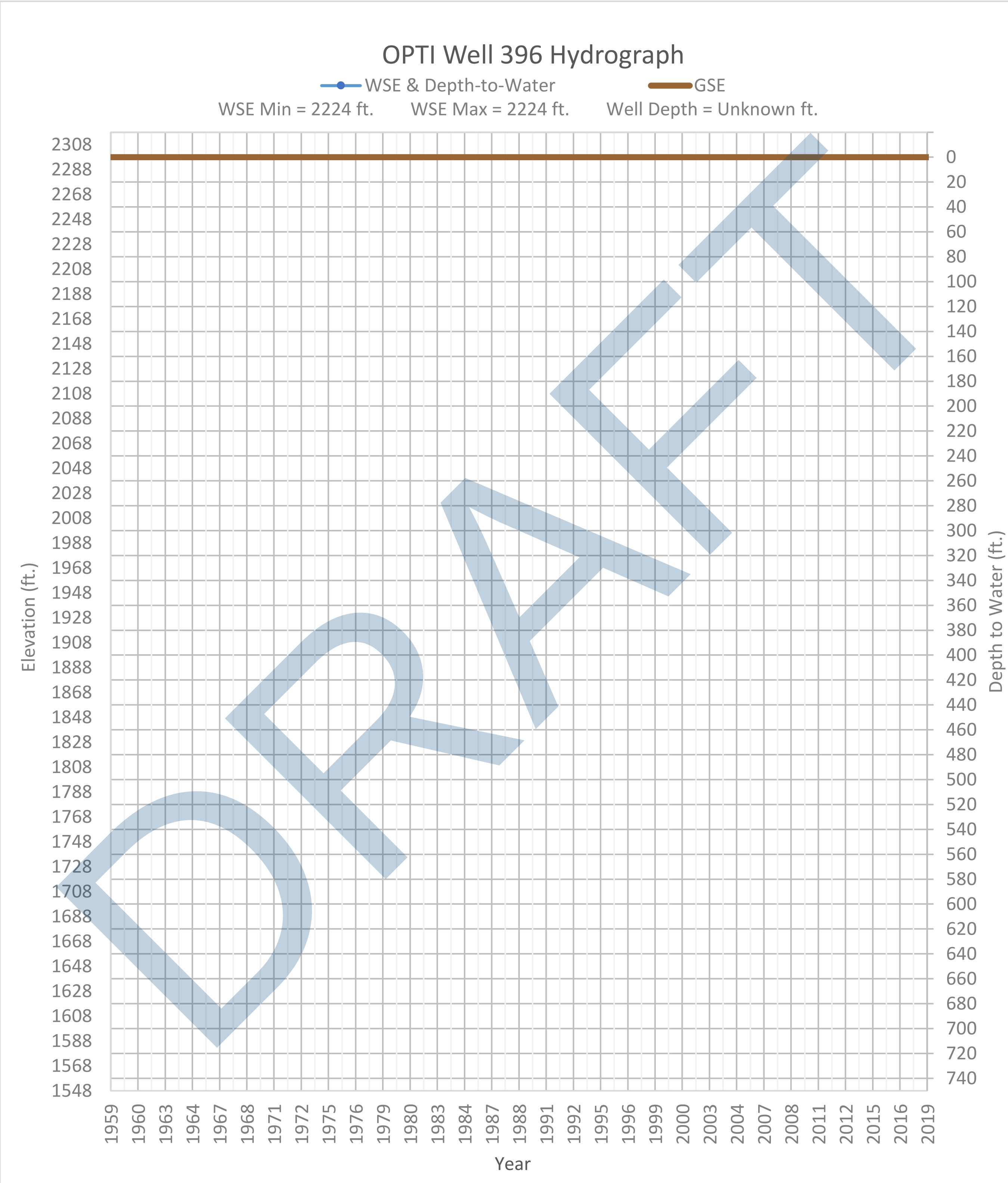

OPTI Well 396 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2224 ft.
WSE Max = 2224 ft.
Well Depth = Unknown ft.
Elevation (ft.)
2308
2288
2268
2248
2228
2208
2188
2168
2148
2128
2108
2088
2068
2048
2028
2008
1988
1968
1948
1928
1908
1888
1868
1848
1828
1808
1788
1768
1748
1728
1708
1688
1668
1648
1628
1608
1588
1568
1548
Depth to Water (ft.)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
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Year
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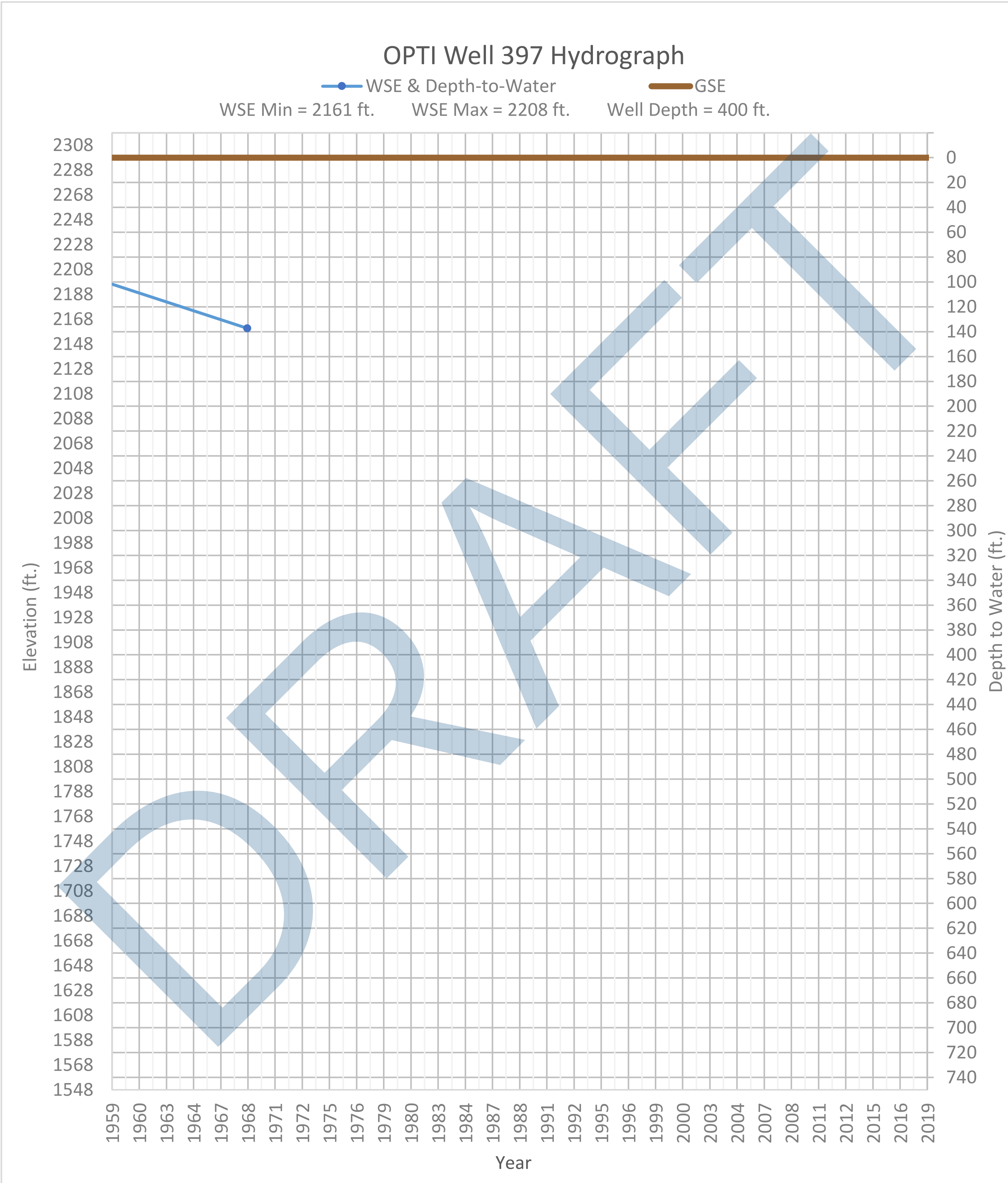

OPTI Well 397 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2161 ft.
WSE Max = 2208 ft.
Well Depth = 400 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2308
2288
2268
2248
2228
2208
2188
2168
2148
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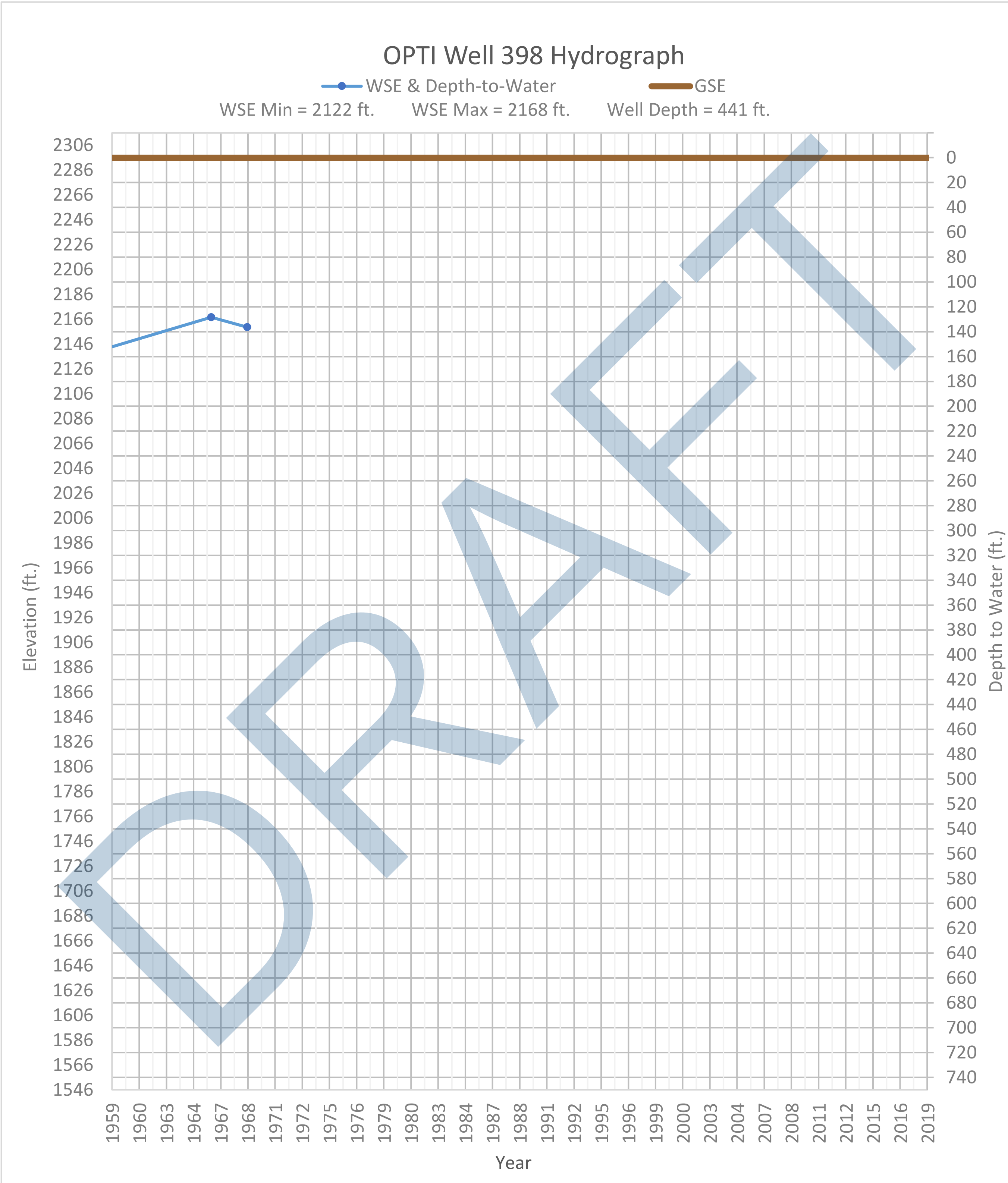
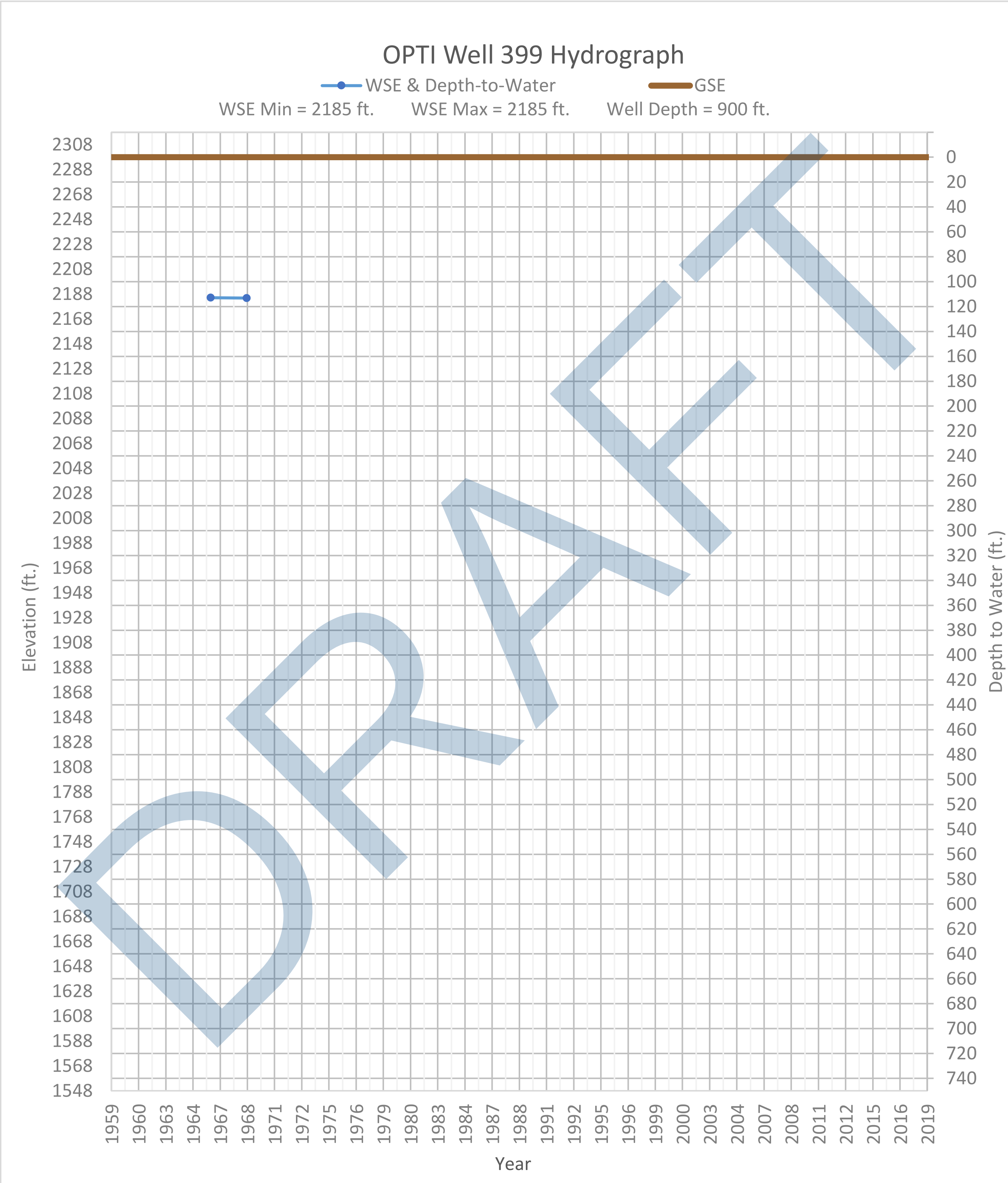
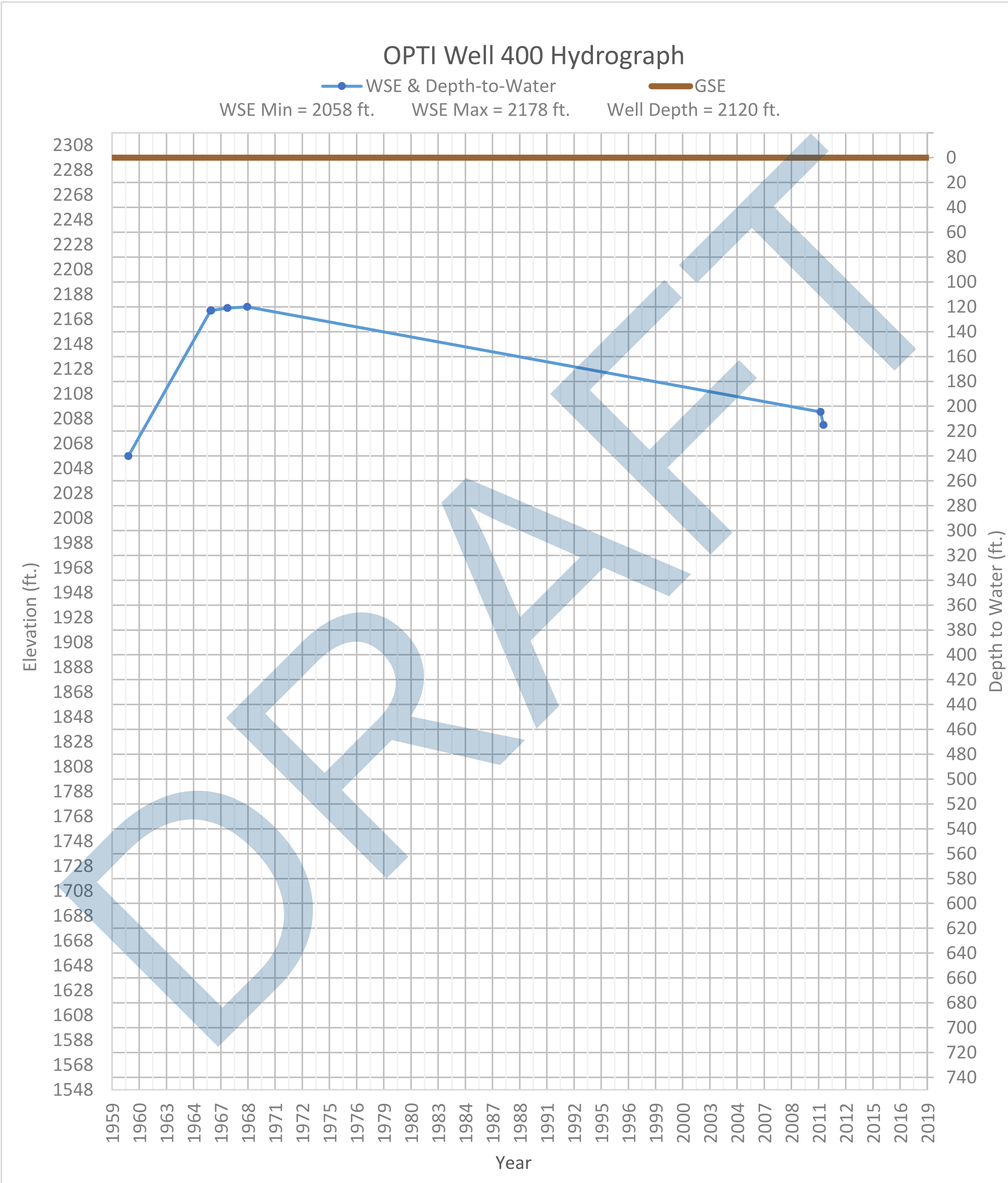


OPTI Well 398 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2122 ft.
WSE Max = 2168 ft.
Well Depth = 441 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 399 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2185 ft.
WSE Max = 2185 ft.
Well Depth = 900 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 400 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2058 ft.
WSE Max = 2178 ft.
Well Depth = 2120 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2308
2288
2268
2248
2228
2208
2188
2168
2148
2128
2108
2088
2068
2048
2028
2008
1988
1968
1948
1928
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1648
1628
1608
1588
1568
1548
0
20
40
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100
120
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160
180
200
220
240
260
280
300
320
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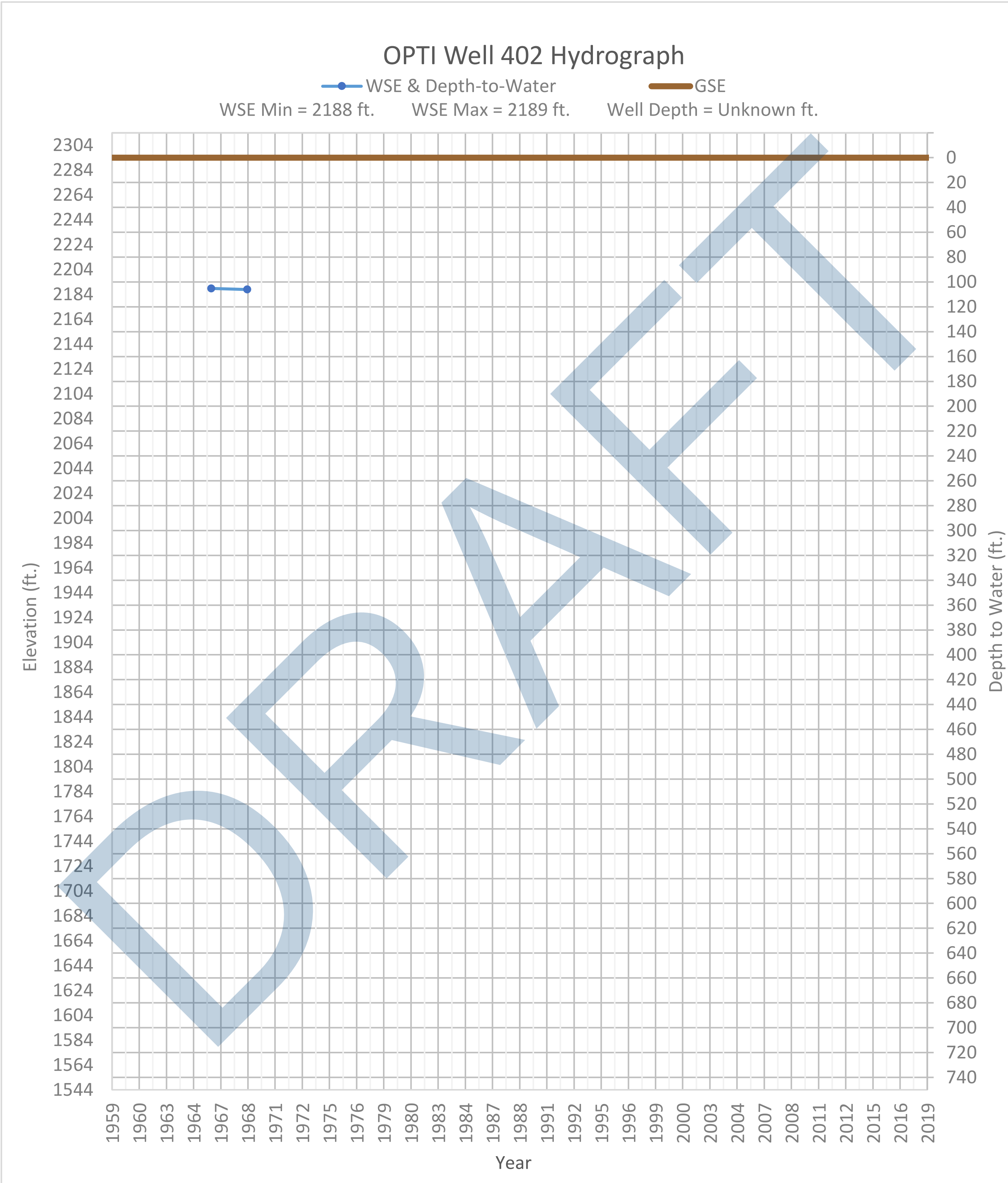
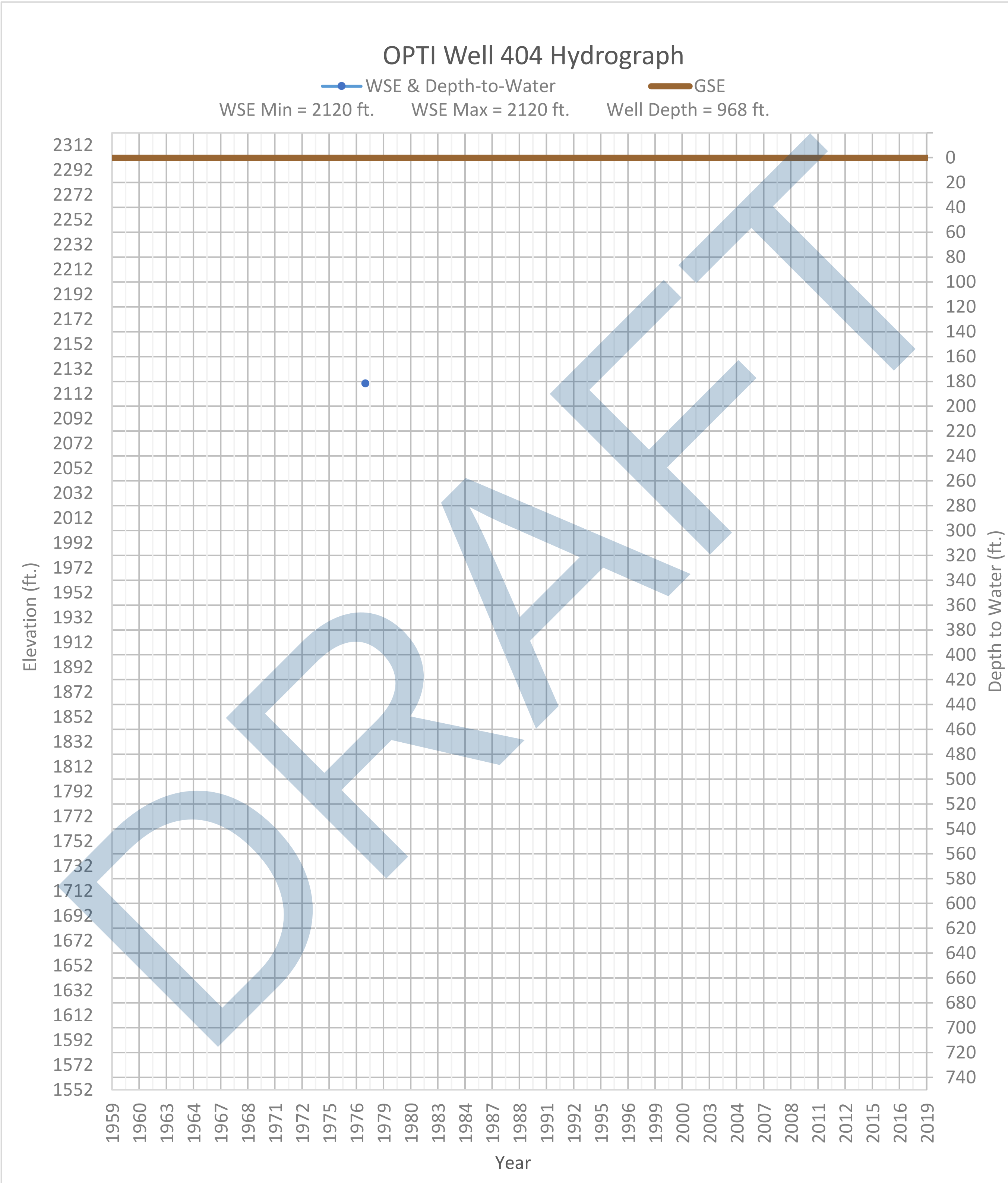
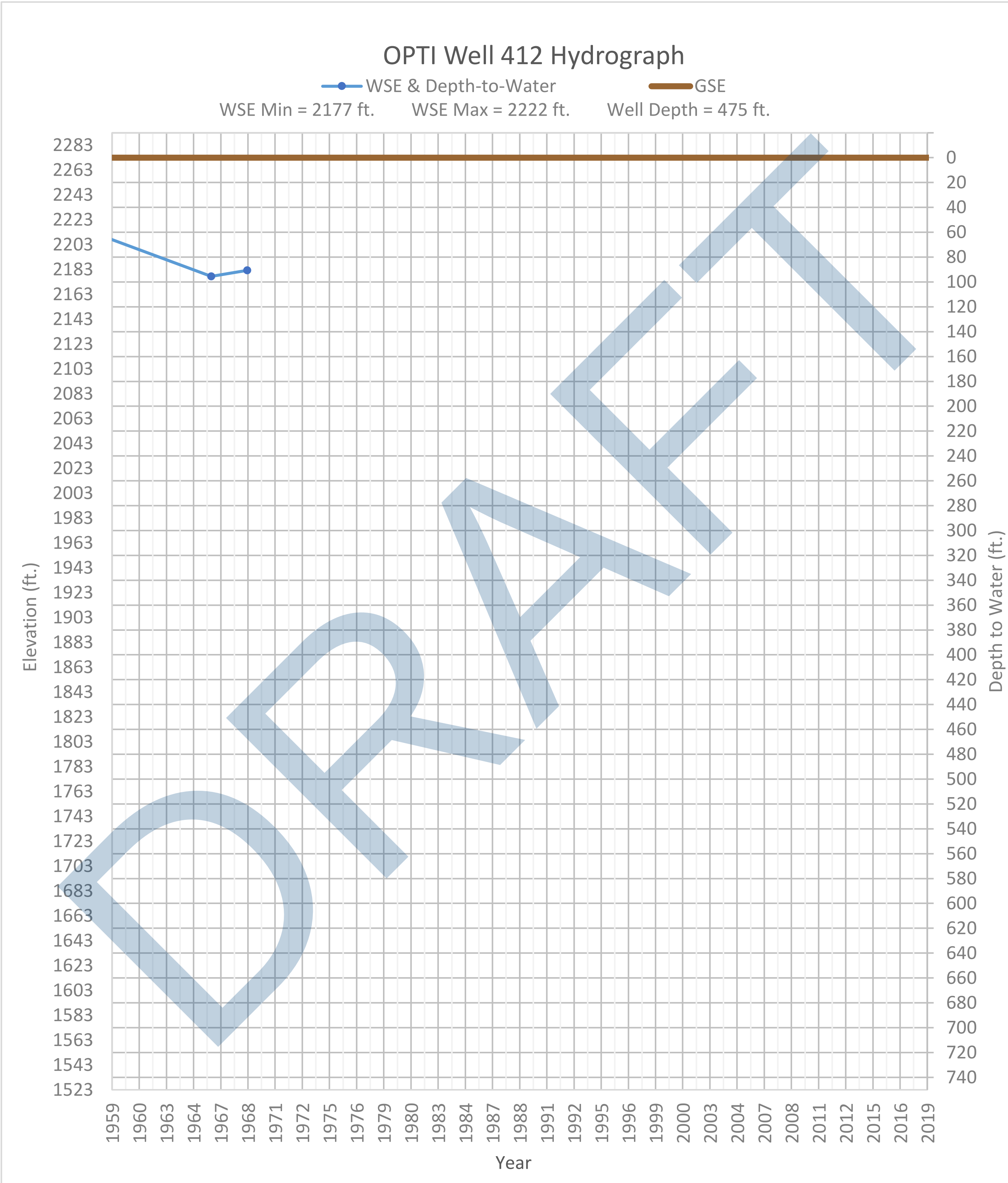
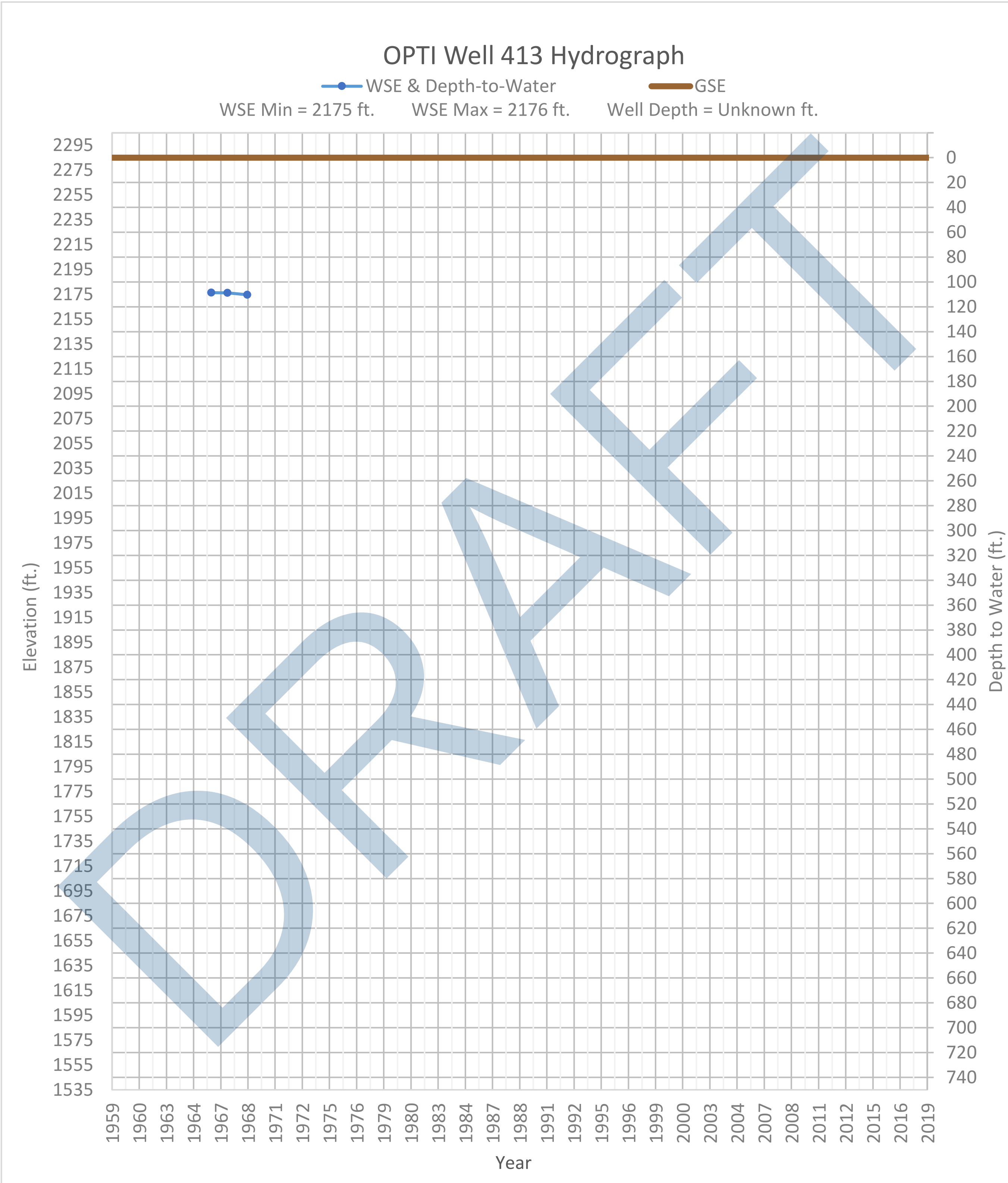


OPTI Well 402 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2188 ft.
WSE Max = 2189 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year

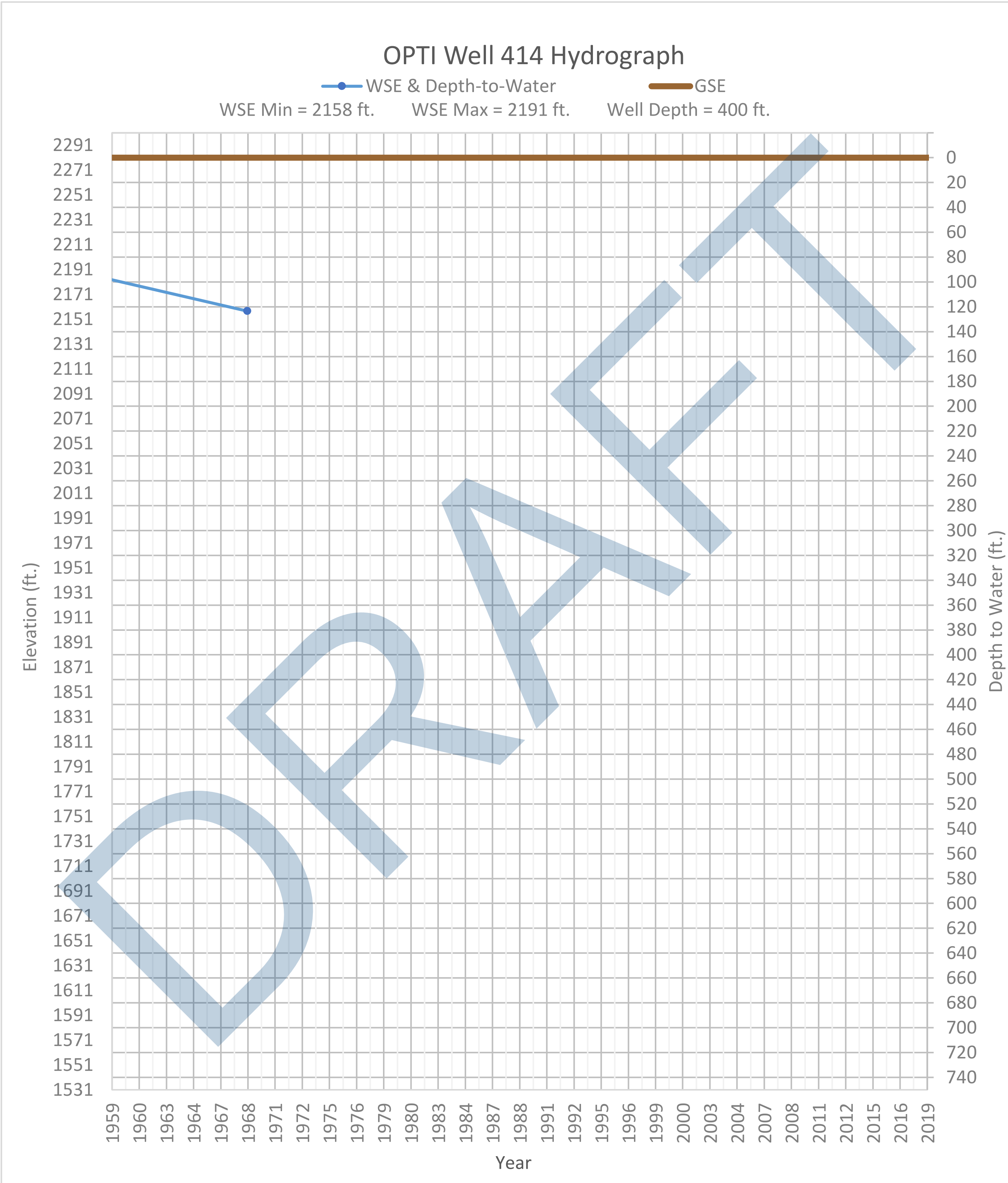

OPTI Well 404 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2120 ft.
WSE Max = 2120 ft.
Well Depth = 968 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

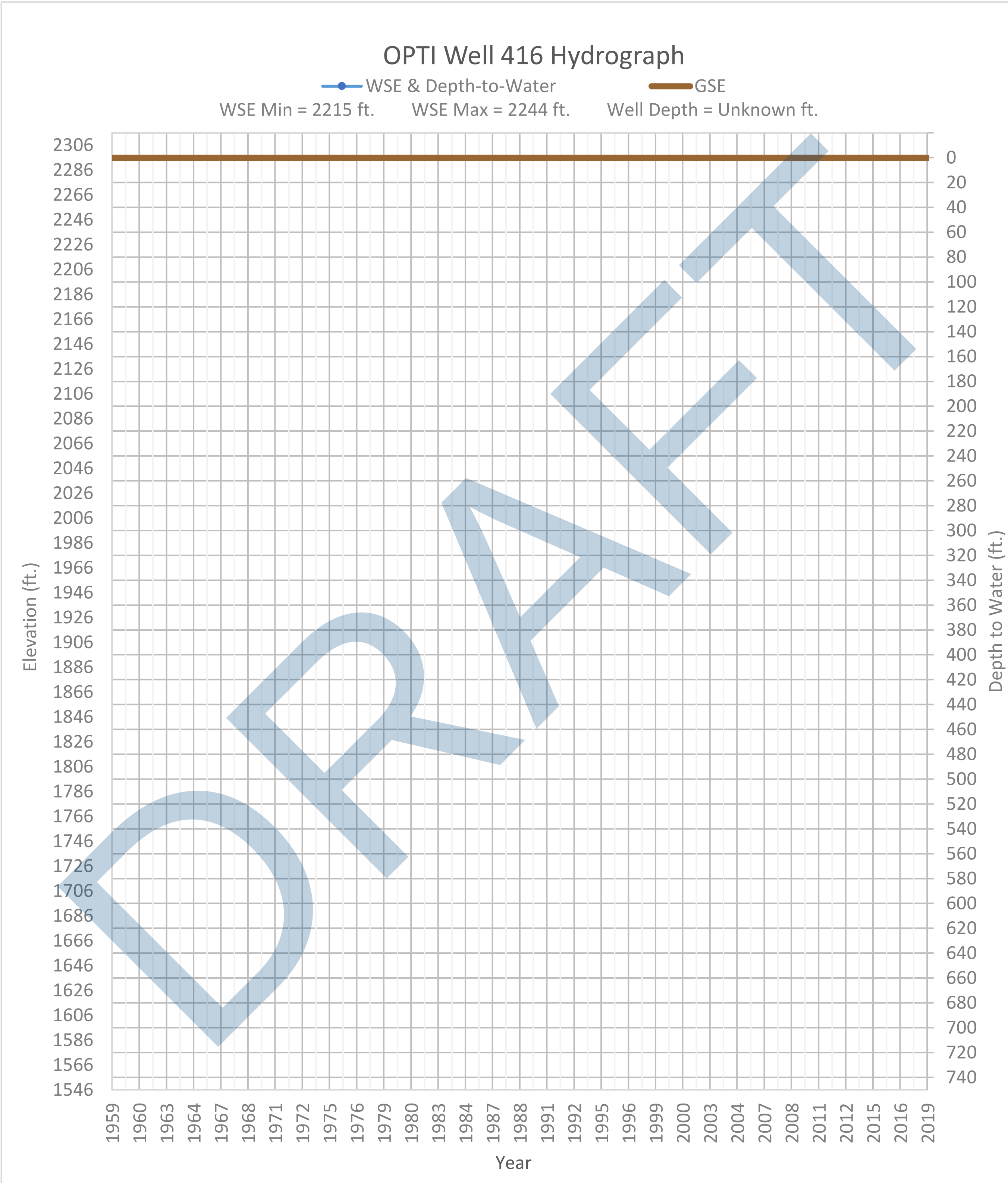


OPTI Well 412 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2177 ft.
WSE Max = 2222 ft.
Well Depth = 475 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

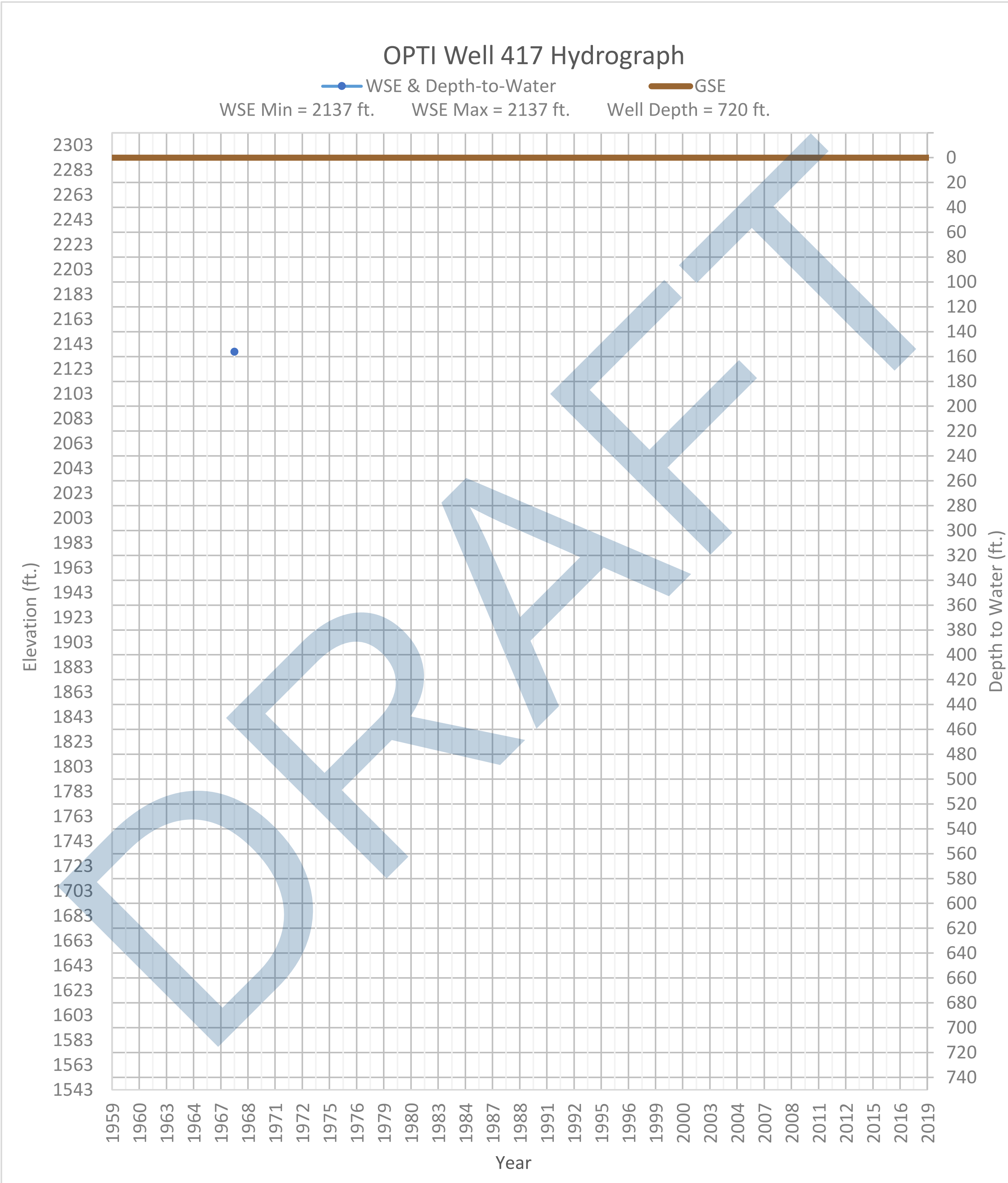


OPTI Well 413 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2175 ft.
WSE Max = 2176 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 414 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2158 ft.
WSE Max = 2191 ft.
Well Depth = 400 ft.
Elevation (ft.)
Depth to Water (ft.)
Year



OPTI Well 416 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2215 ft.
WSE Max = 2244 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 417 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2137 ft.
WSE Max = 2137 ft.
Well Depth = 720 ft.
Elevation (ft.)
2303
2283
2263
2243
2223
2203
2183
2163
2143
2123
2103
2083
2063
2043
2023
2003
1983
1963
1943
1923
1903
1883
1863
1843
1823
1803
1783
1763
1743
1723
1703
1683
1663
1643
1623
1603
1583
1563
1543
Depth to Water (ft.)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
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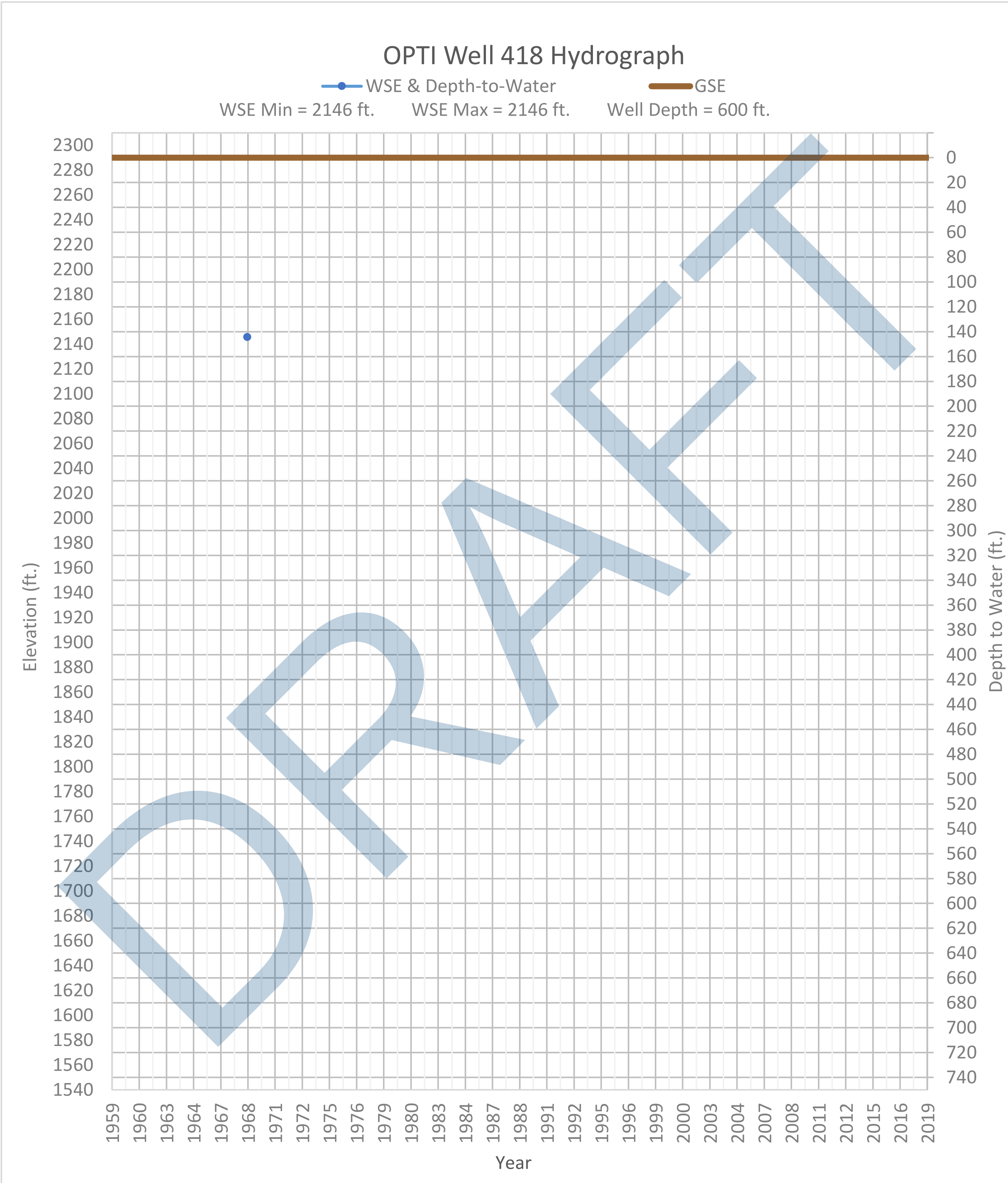
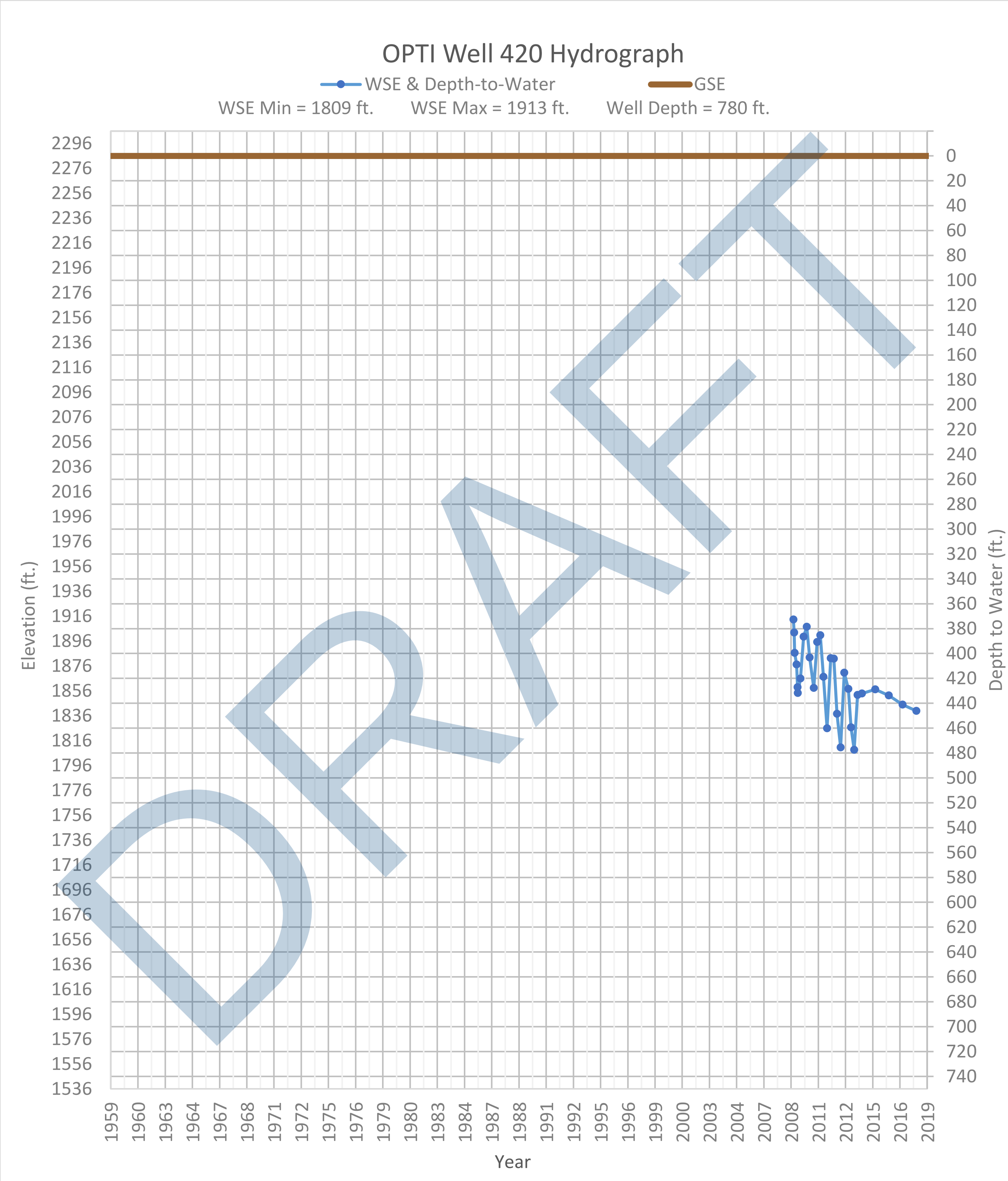
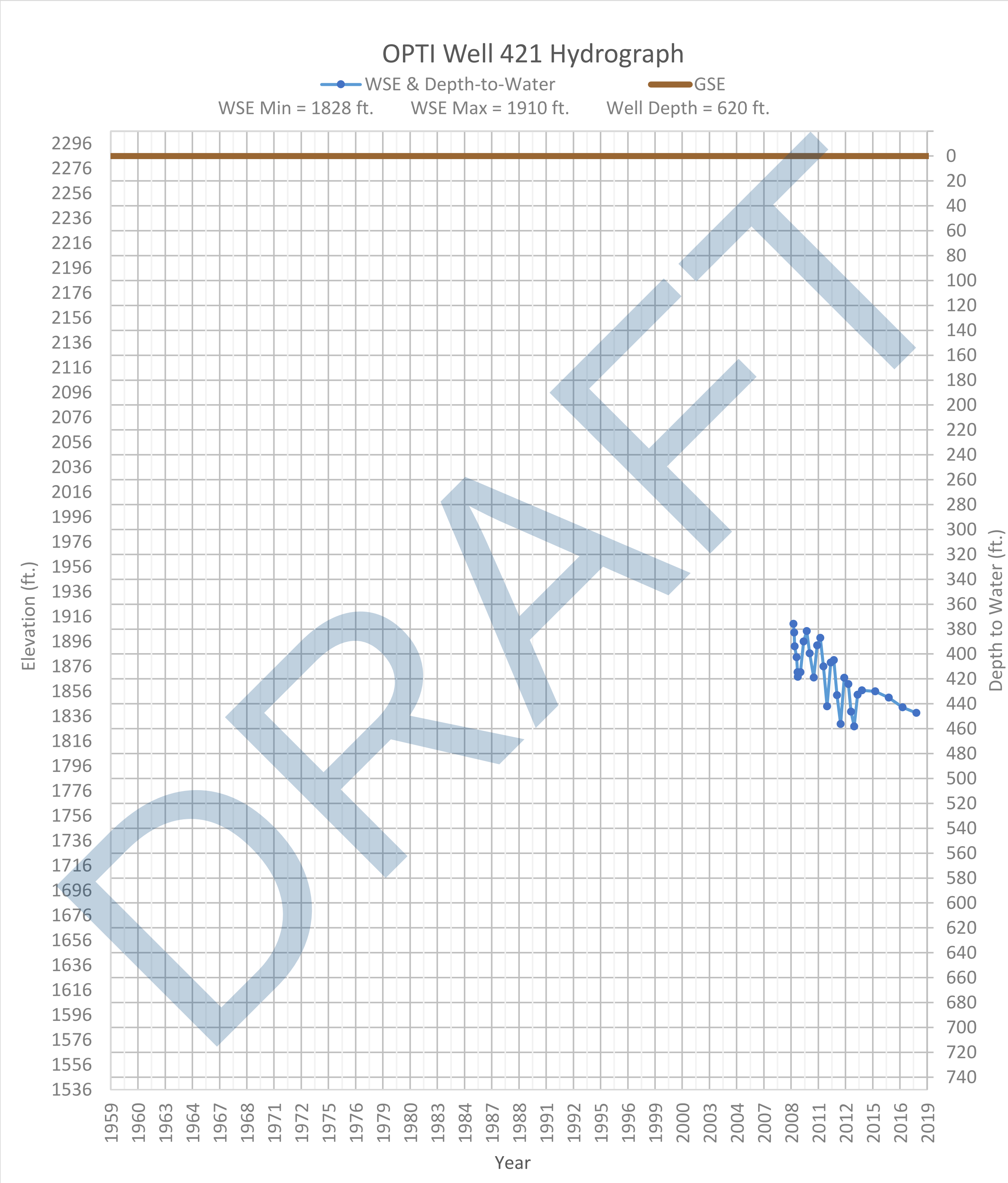
Year
DRAFT



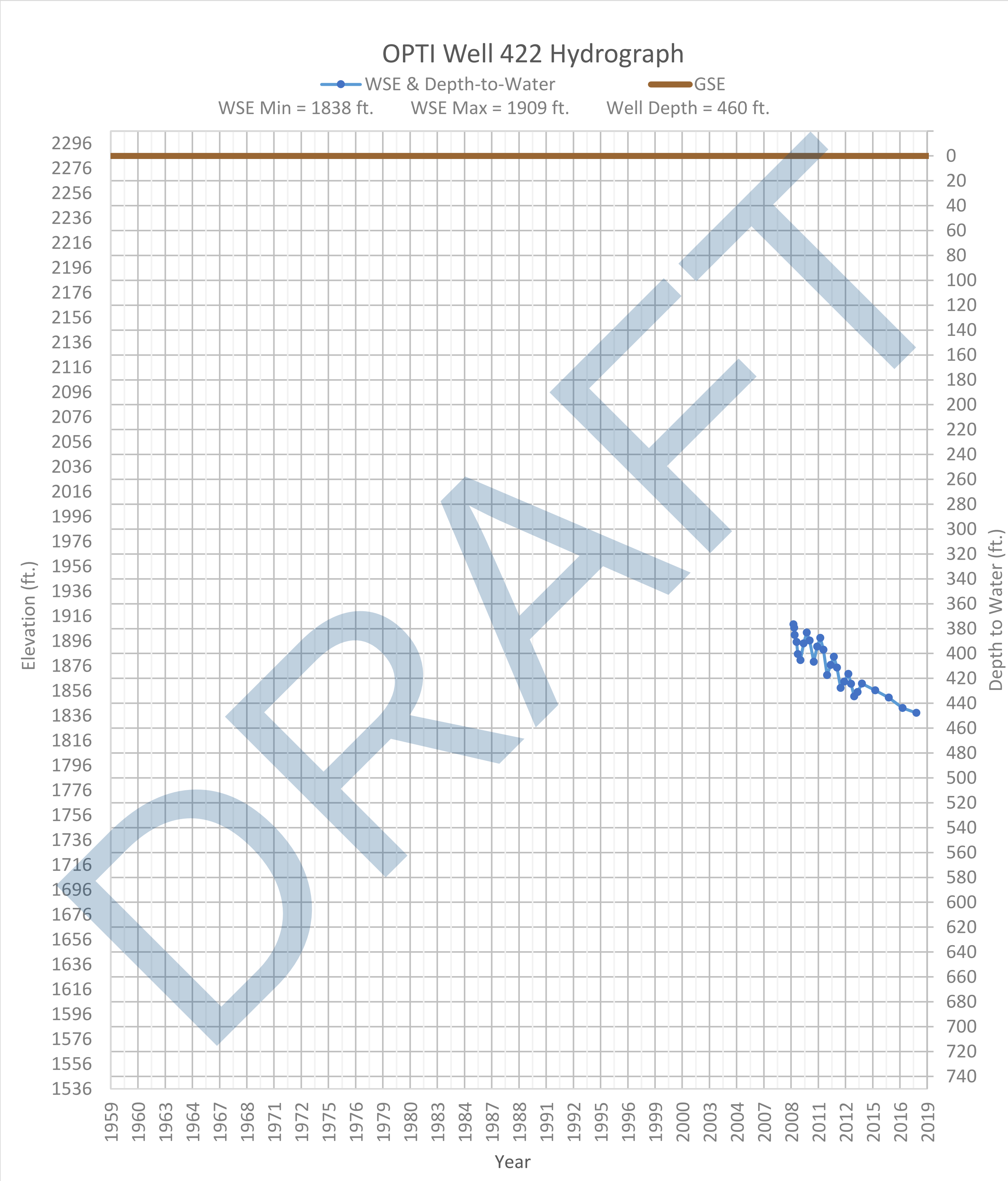
OPTI Well 418 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2146 ft.
WSE Max = 2146 ft.
Well Depth = 600 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



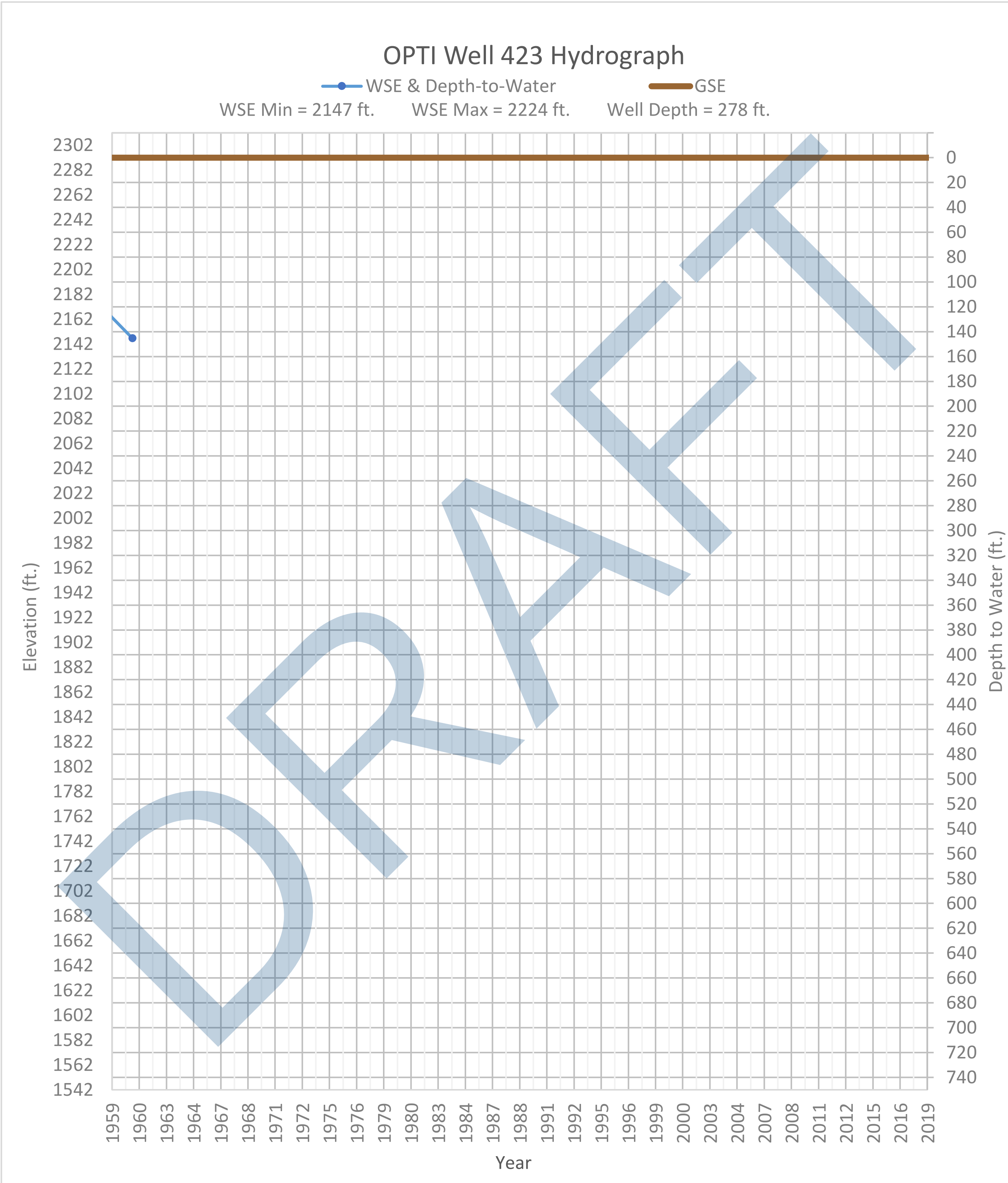
OPTI Well 420 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1809 ft.
WSE Max = 1913 ft.
Well Depth = 780 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



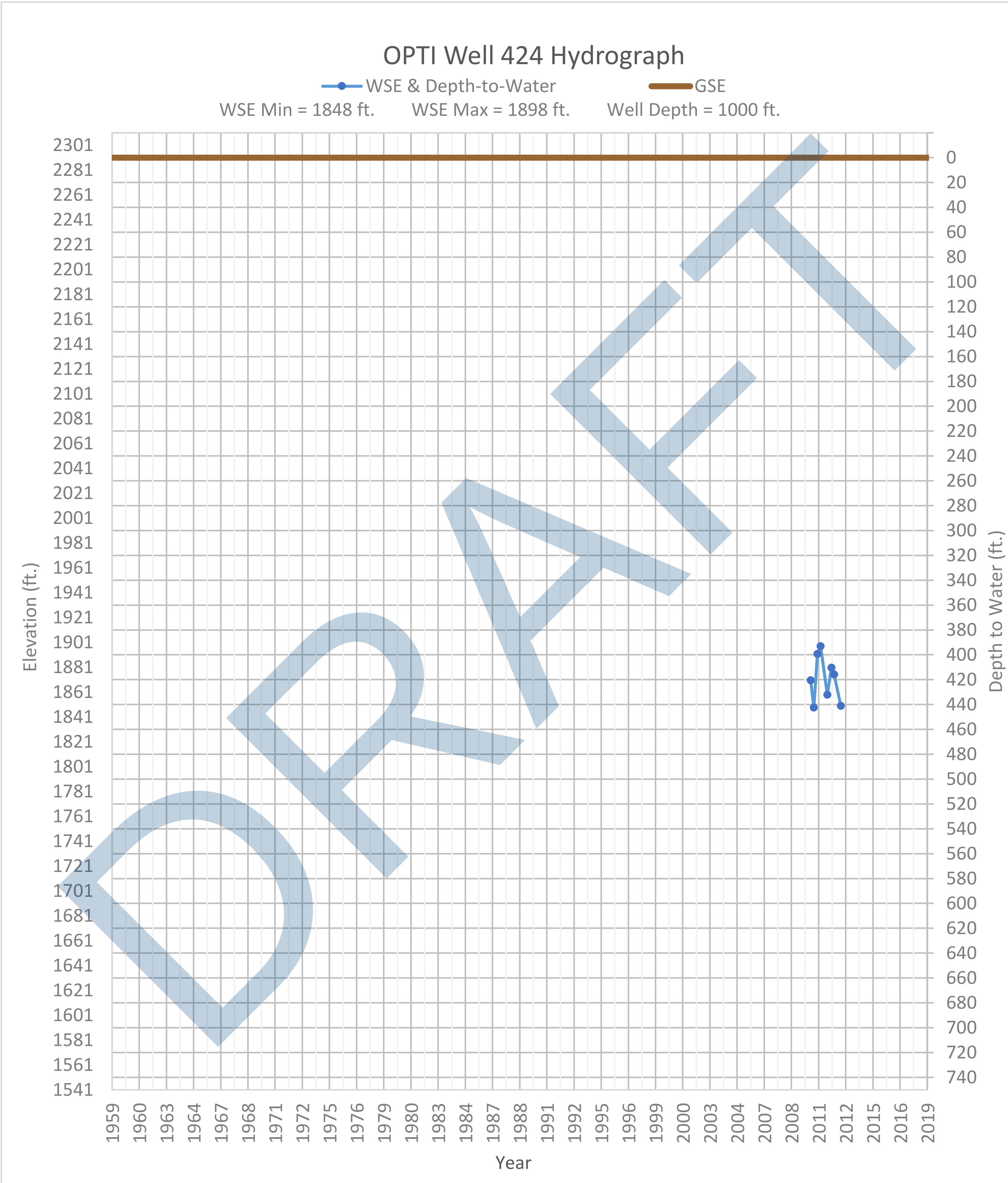
OPTI Well 421 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1828 ft.
WSE Max = 1910 ft.
Well Depth = 620 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



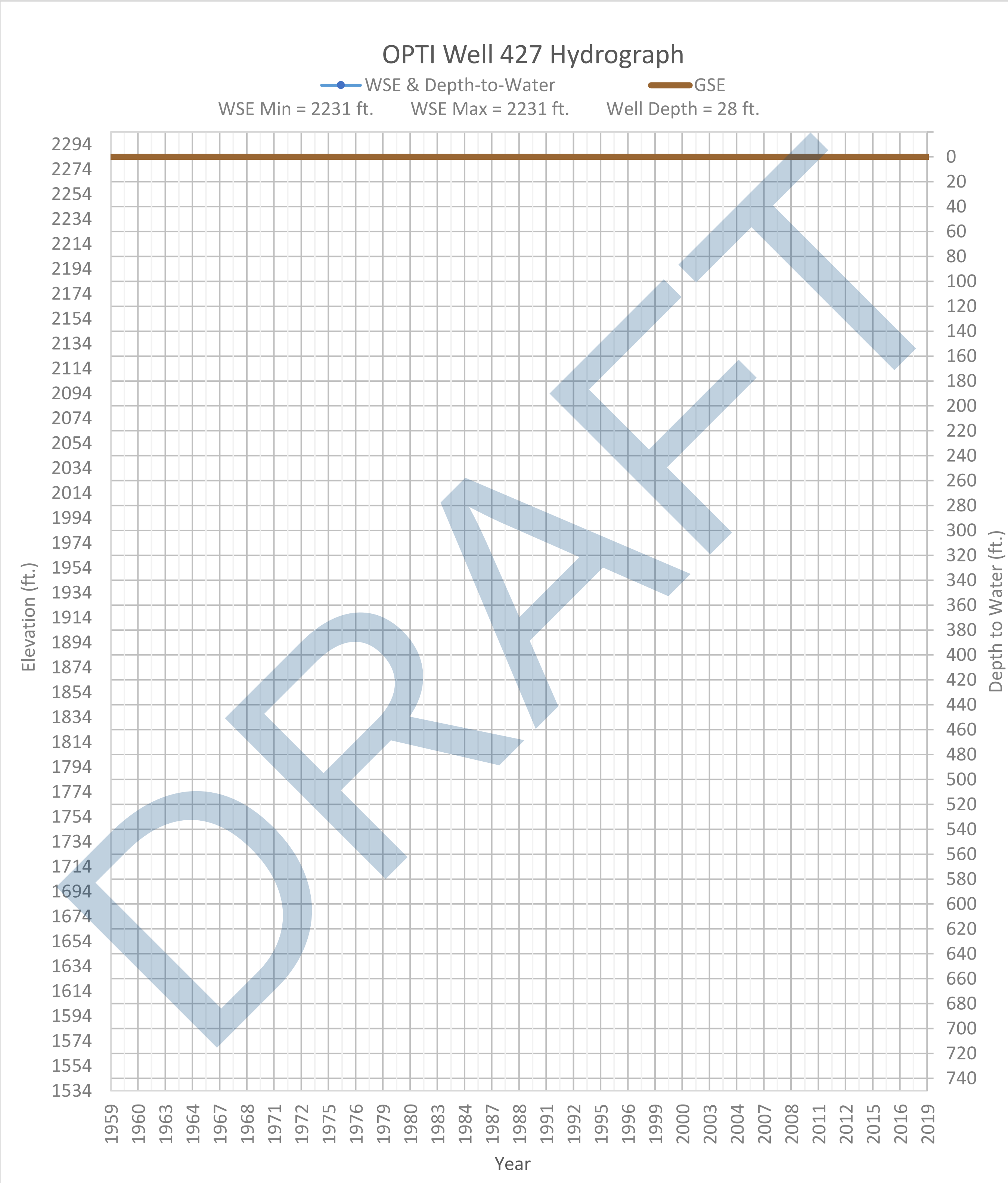
OPTI Well 422 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1838 ft.
WSE Max = 1909 ft.
Well Depth = 460 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 423 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2147 ft.
WSE Max = 2224 ft.
Well Depth = 278 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 424 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1848 ft.
WSE Max = 1898 ft.
Well Depth = 1000 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 427 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2231 ft.
WSE Max = 2231 ft.
Well Depth = 28 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2294
2274
2254
2234
2214
2194
2174
2154
2134
2114
2094
2074
2054
2034
2014
1994
1974
1954
1934
1914
1894
1874
1854
1834
1814
1794
1774
1754
1734
1714
1694
1674
1654
1634
1614
1594
1574
1554
1534
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120
140
160
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220
240
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280
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320
340
360
380
400
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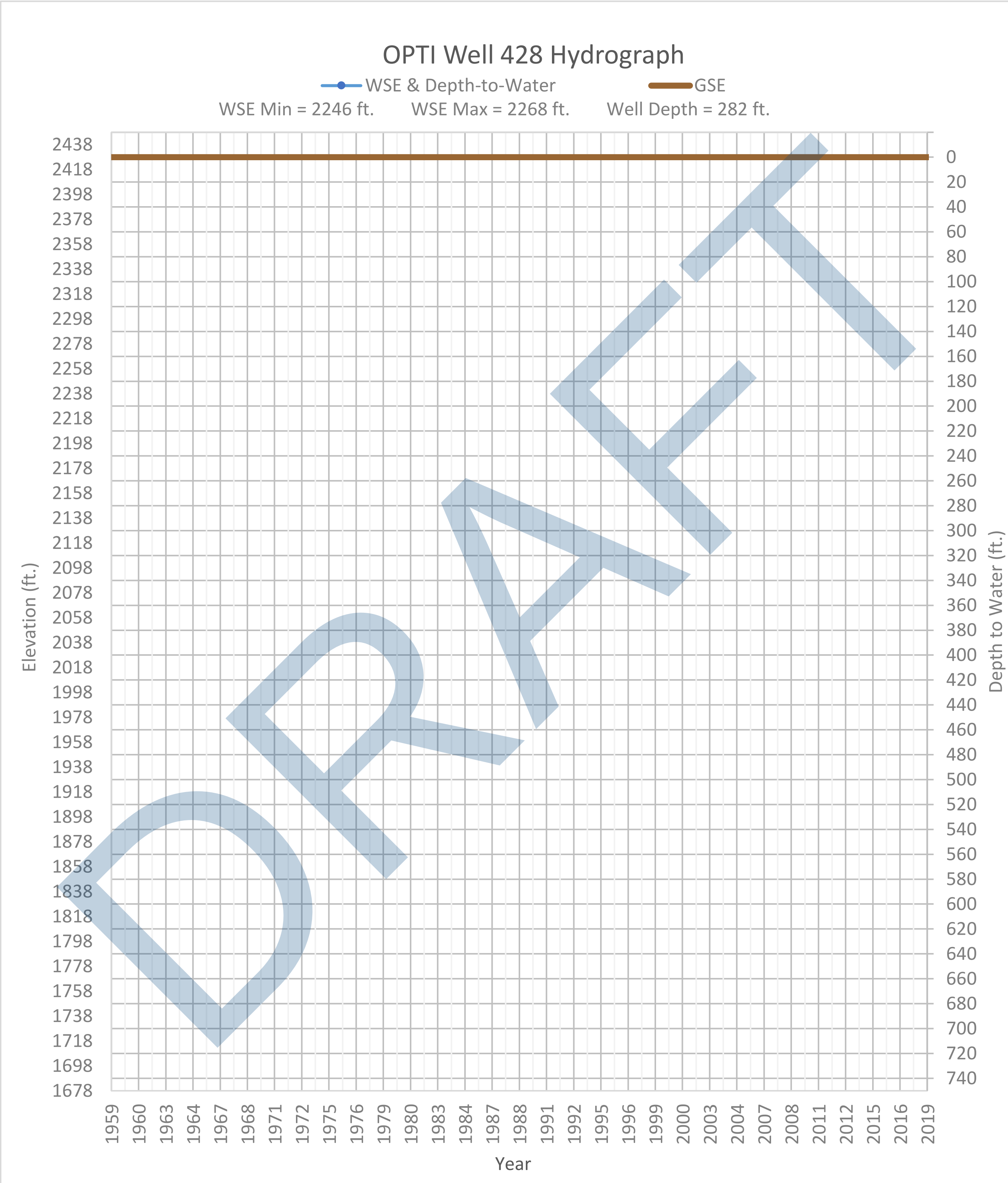
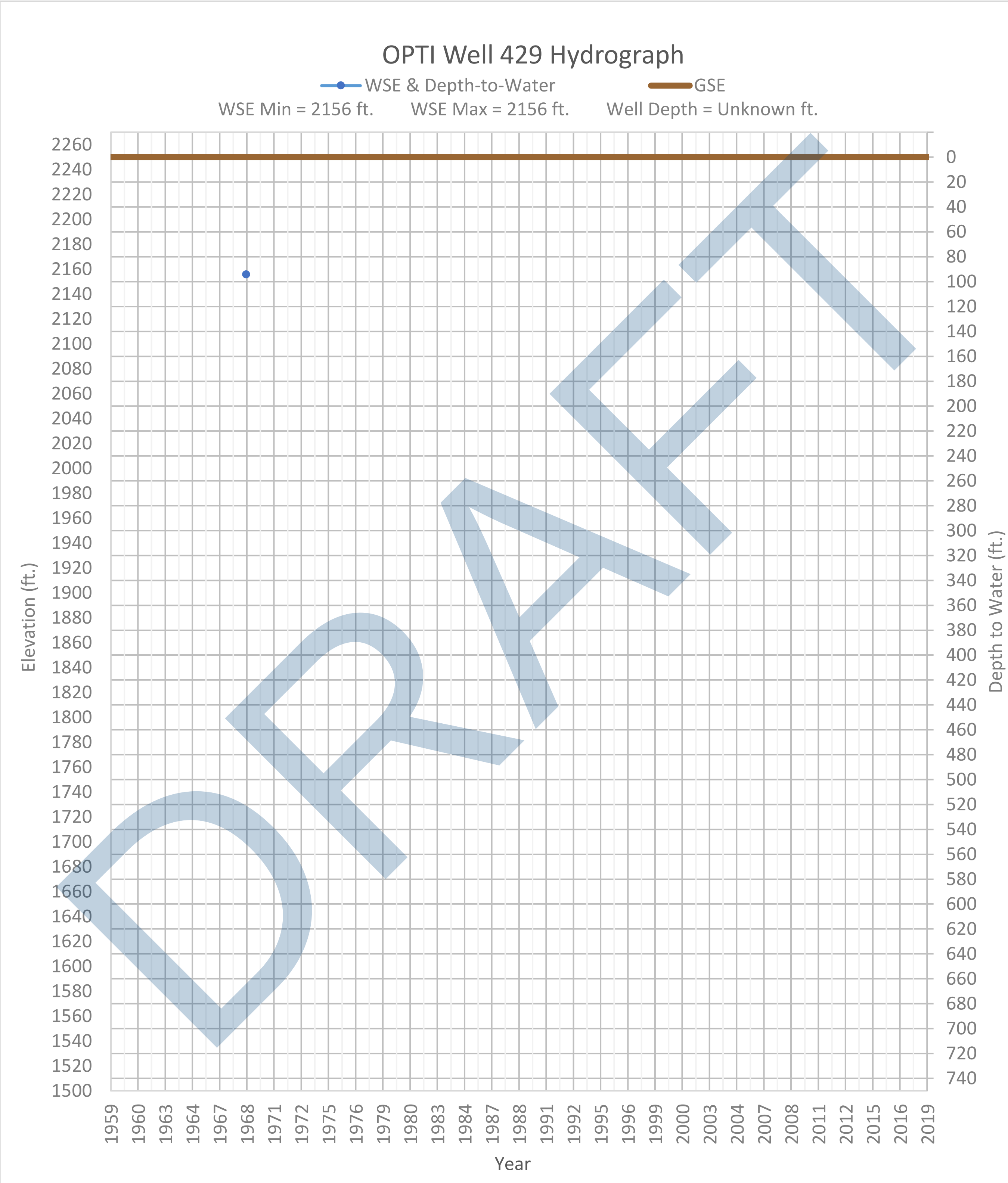
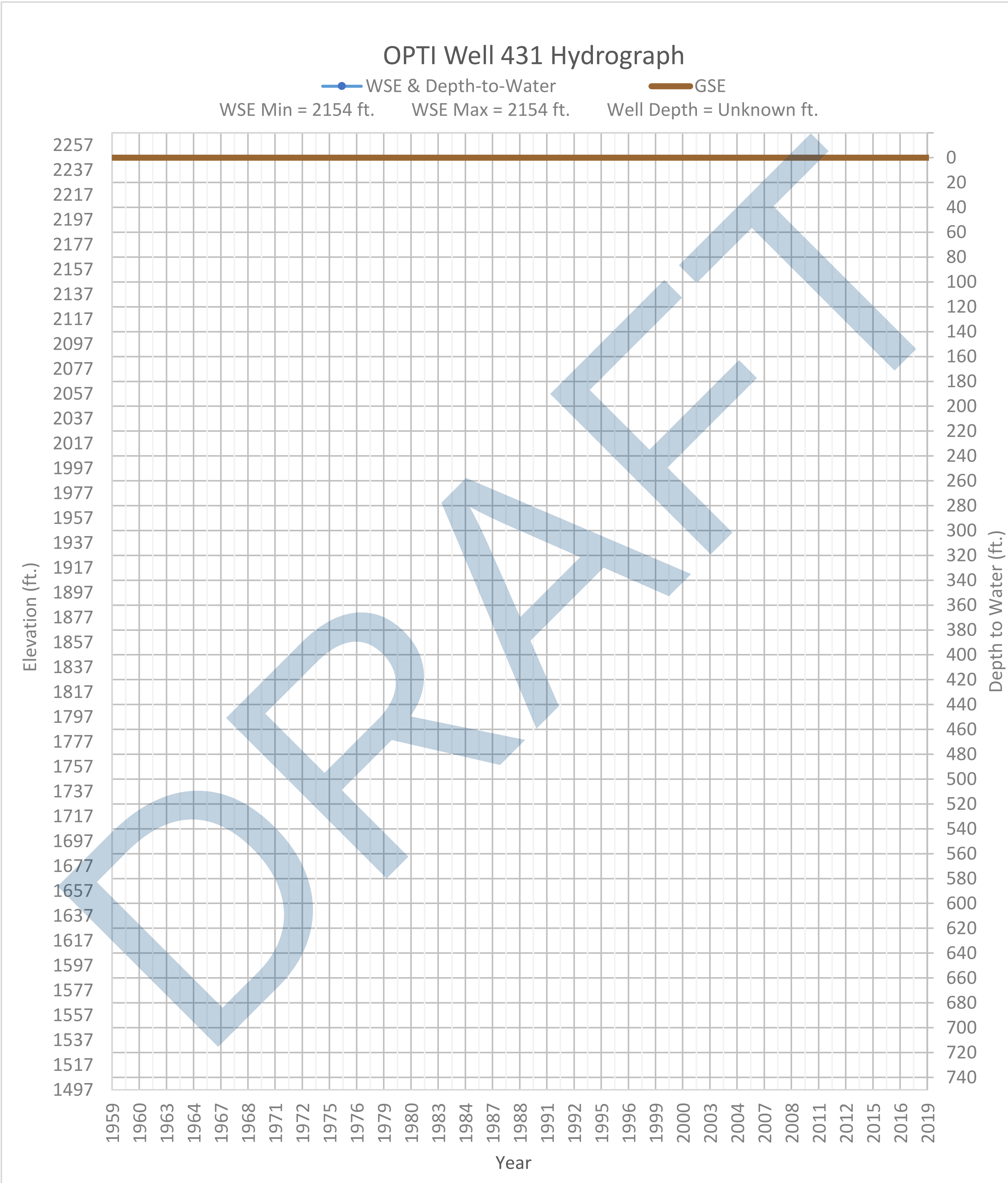
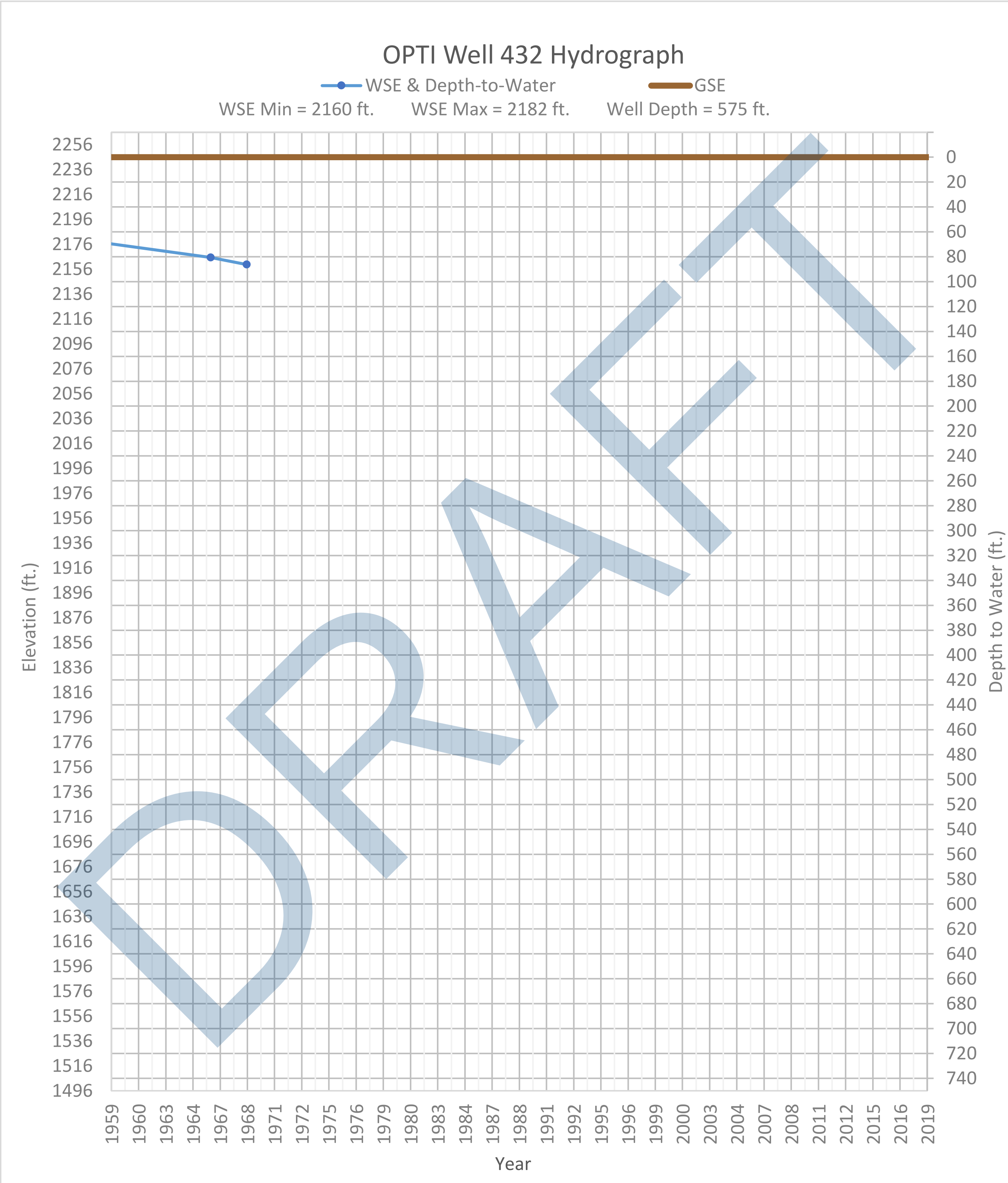


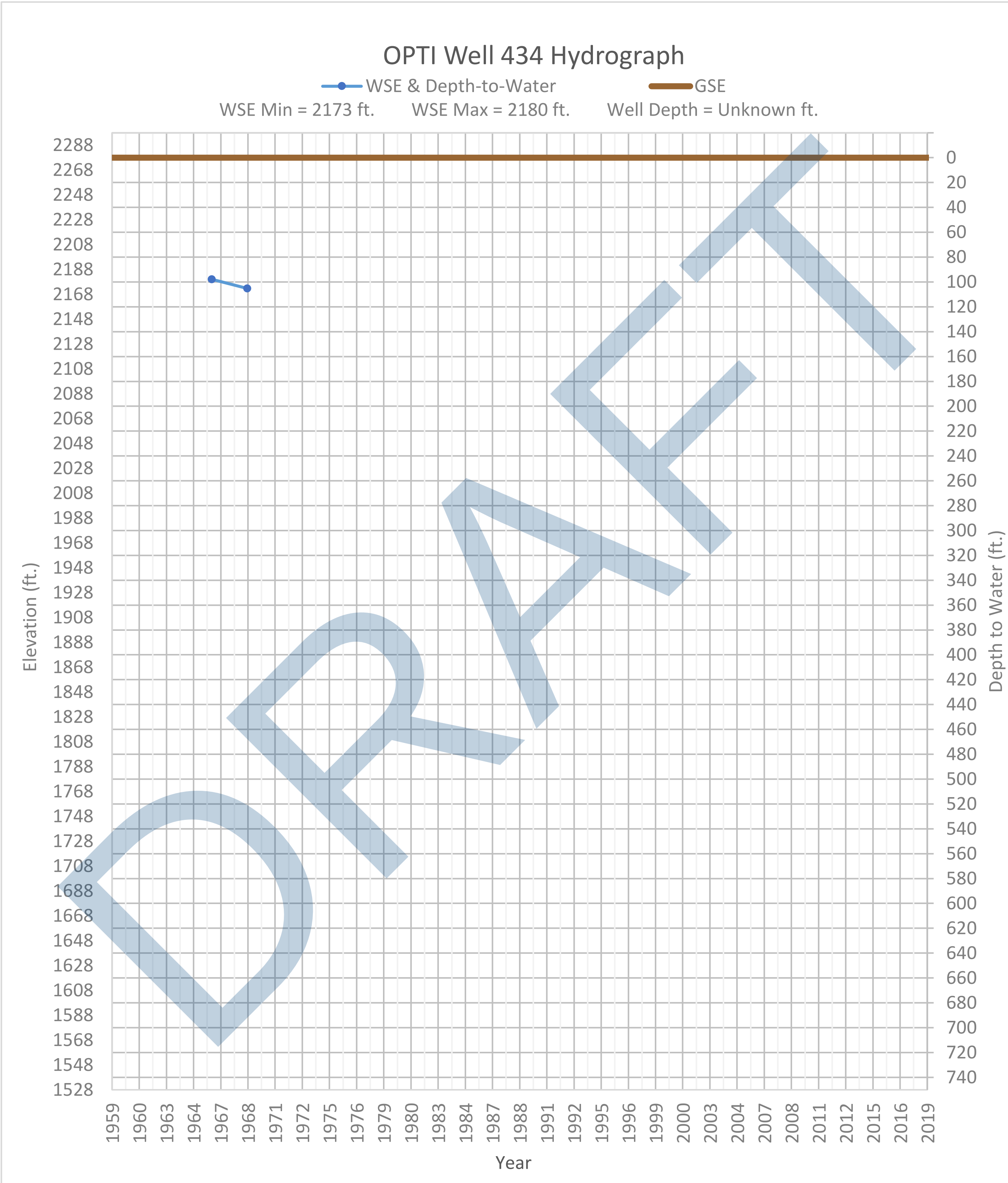
OPTI Well 428 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2246 ft.
WSE Max = 2268 ft.
Well Depth = 282 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 429 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2156 ft.
WSE Max = 2156 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 431 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2154 ft.
WSE Max = 2154 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 432 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2160 ft.
WSE Max = 2182 ft.
Well Depth = 575 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 434 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2173 ft.
WSE Max = 2180 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2288
2268
2248
2228
2208
2188
2168
2148
2128
2108
2088
2068
2048
2028
2008
1988
1968
1948
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2019
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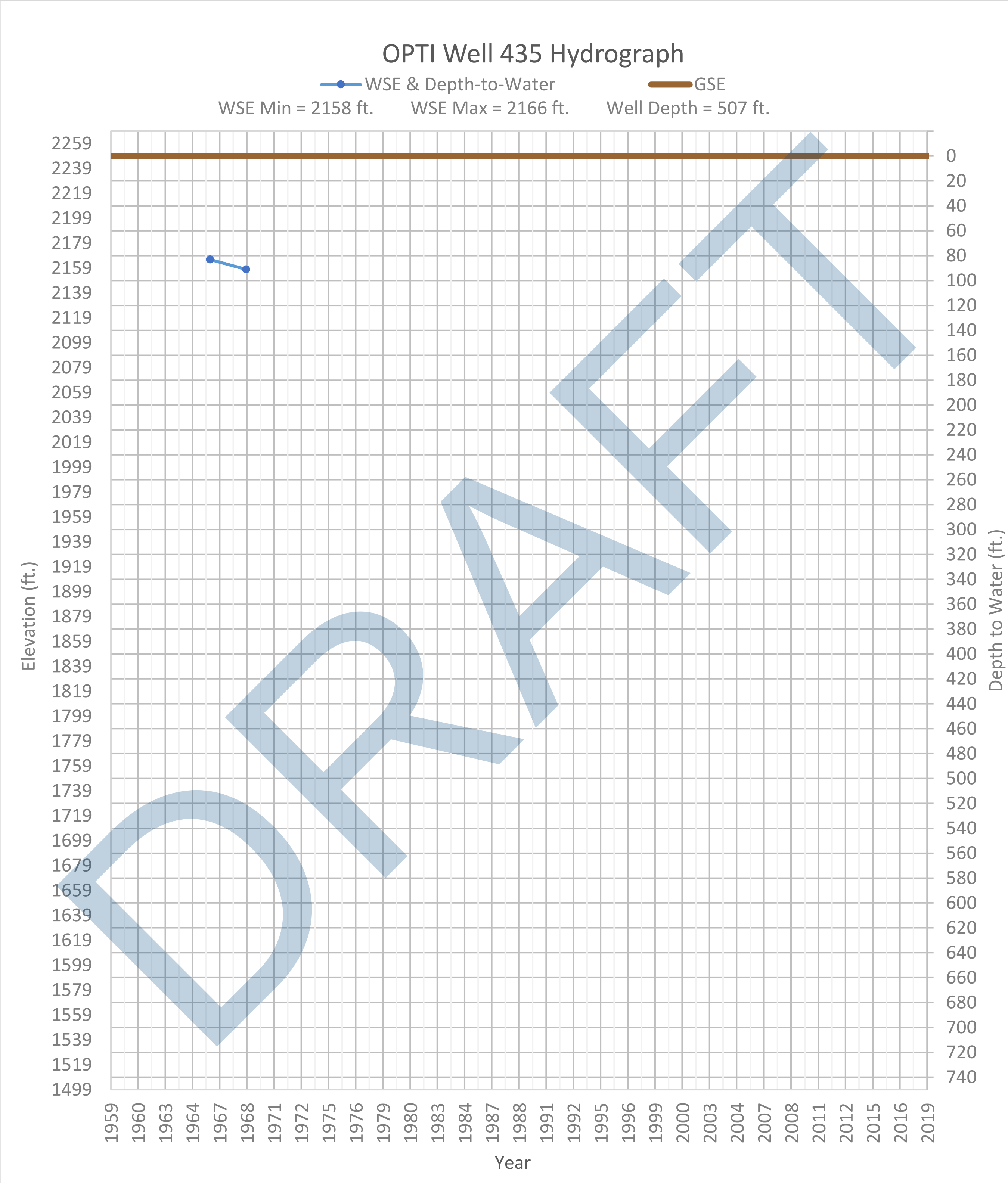
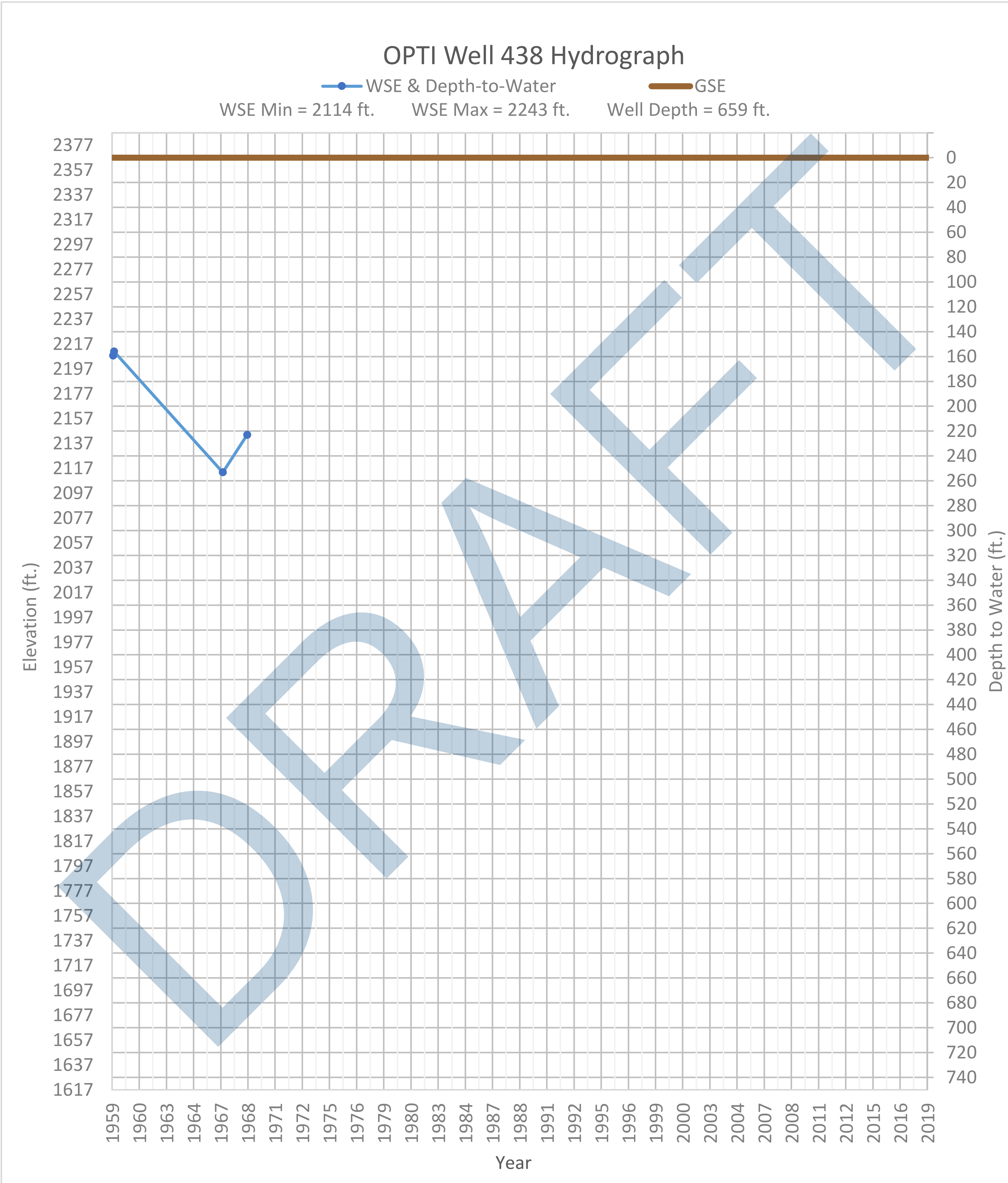
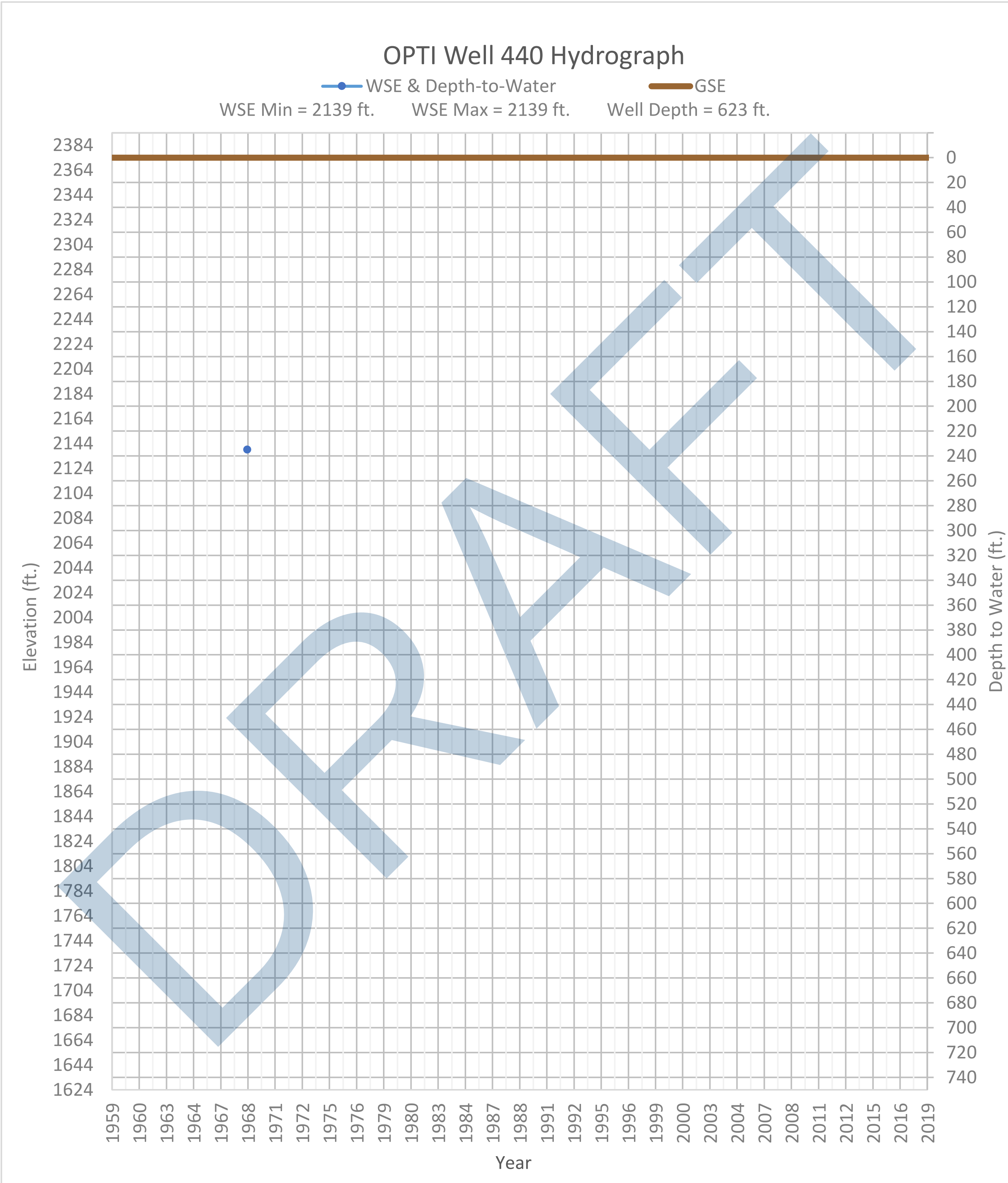


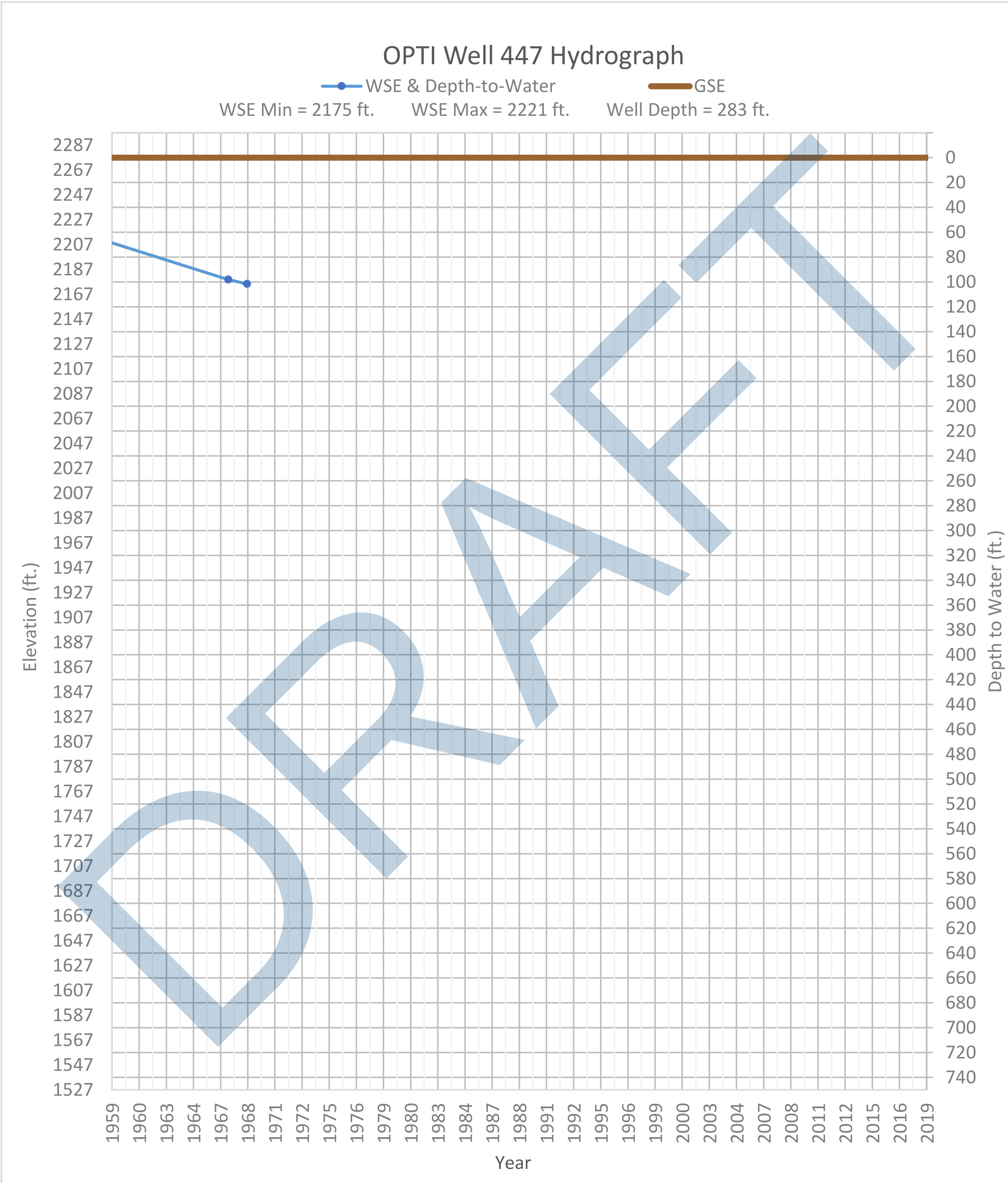
OPTI Well 435 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2158 ft.
WSE Max = 2166 ft.
Well Depth = 507 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



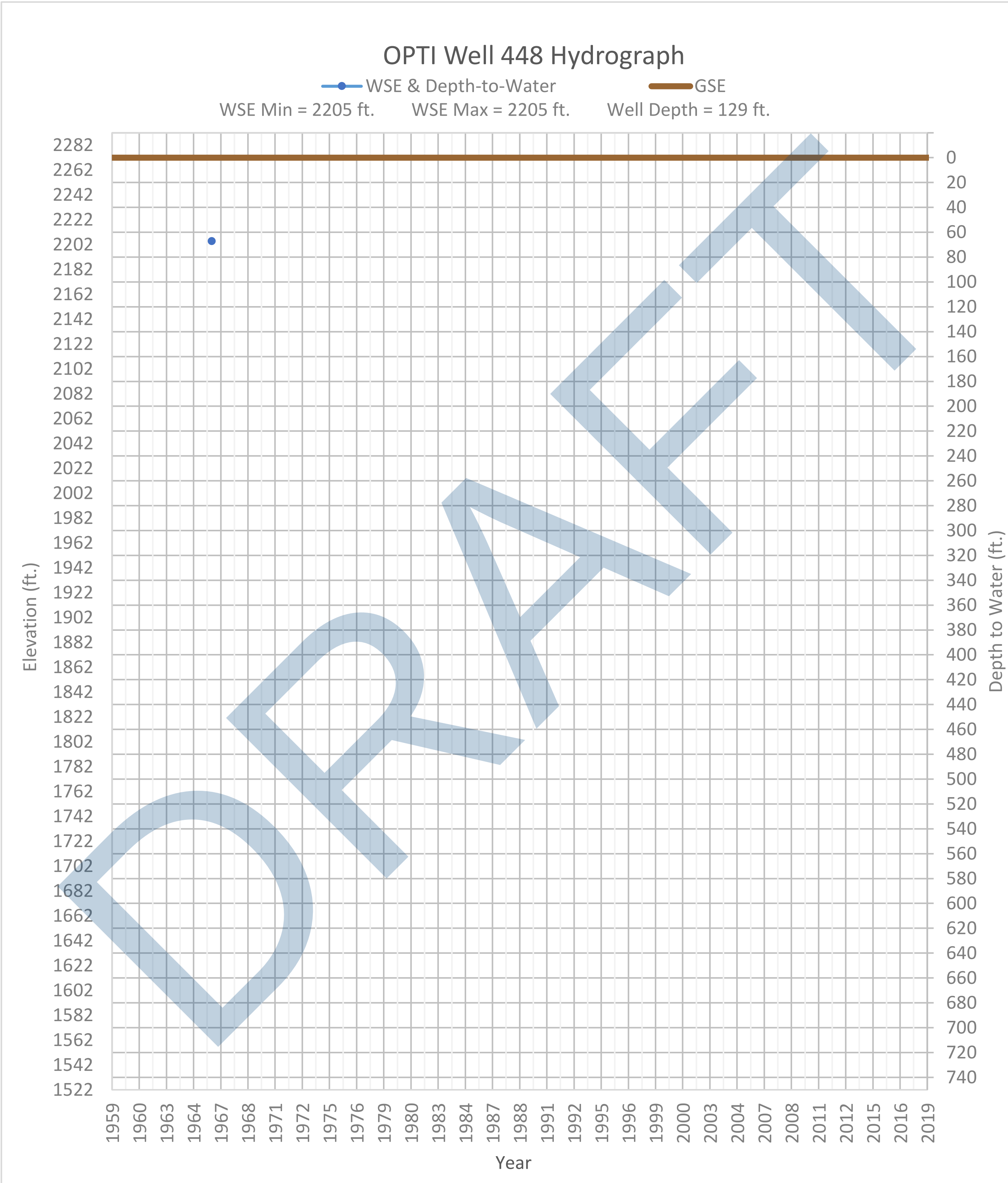
OPTI Well 438 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2114 ft.
WSE Max = 2243 ft.
Well Depth = 659 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



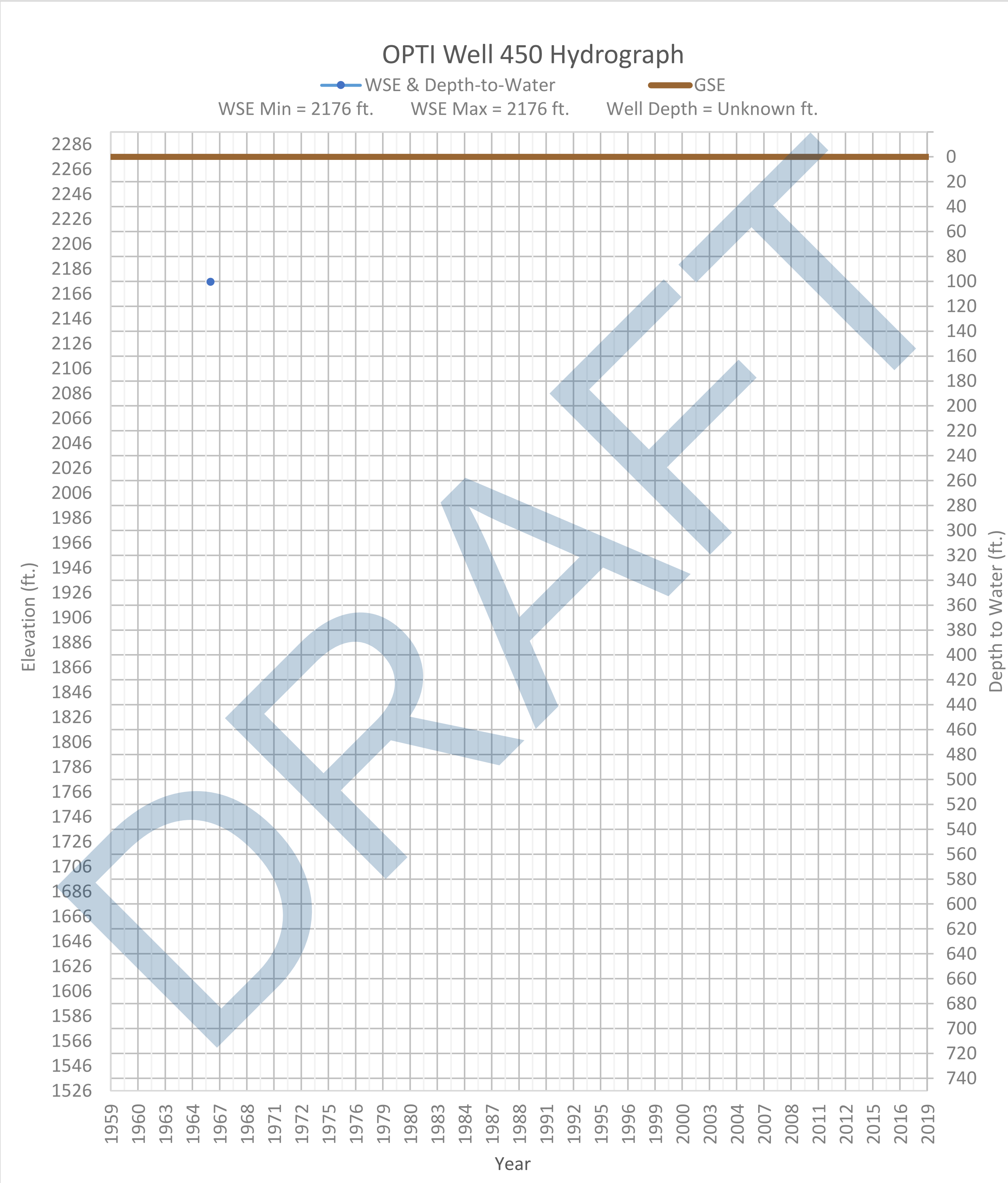
OPTI Well 440 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2139 ft.
WSE Max = 2139 ft.
Well Depth = 623 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



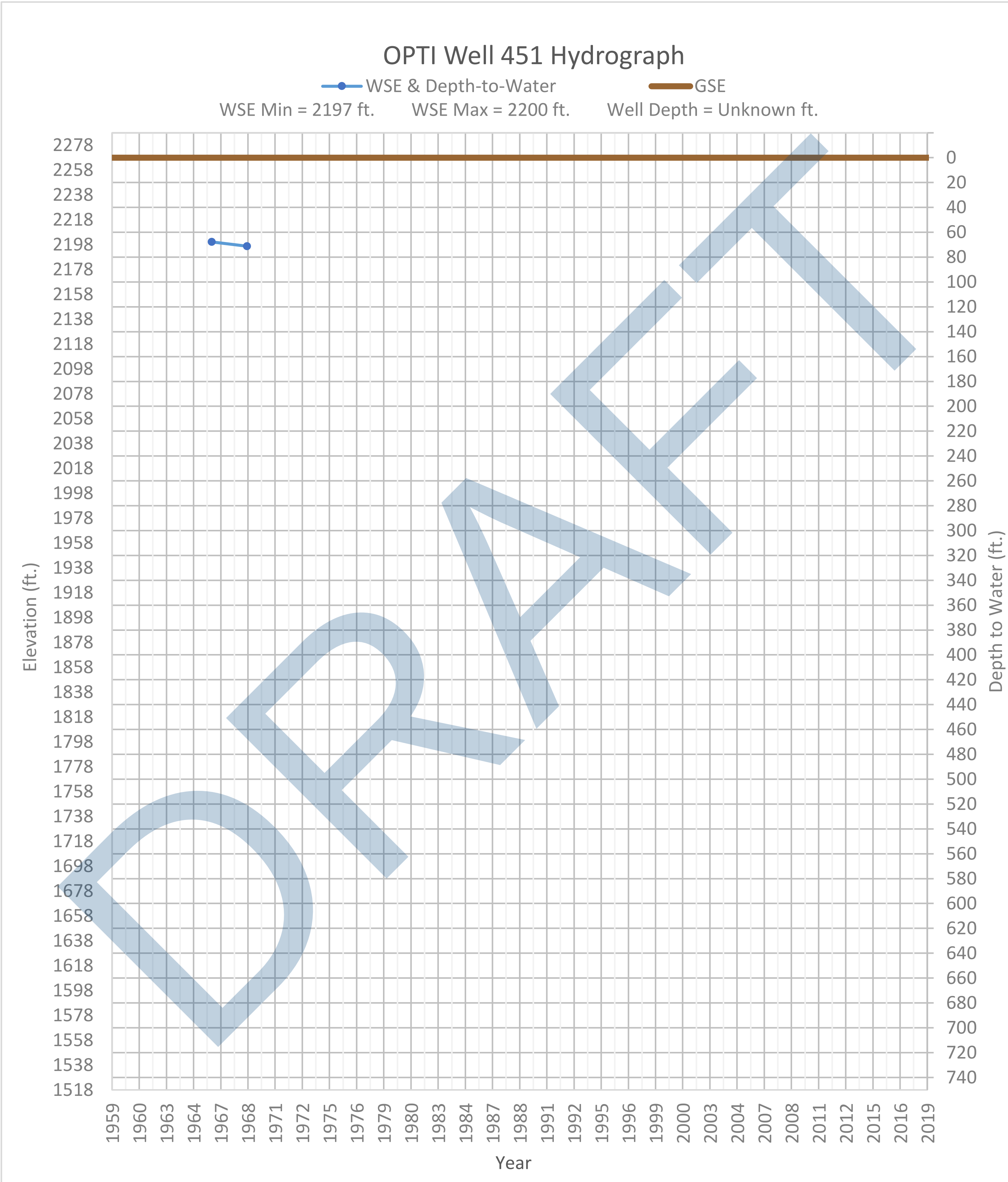
OPTI Well 447 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2175 ft.
WSE Max = 2221 ft.
Well Depth = 283 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



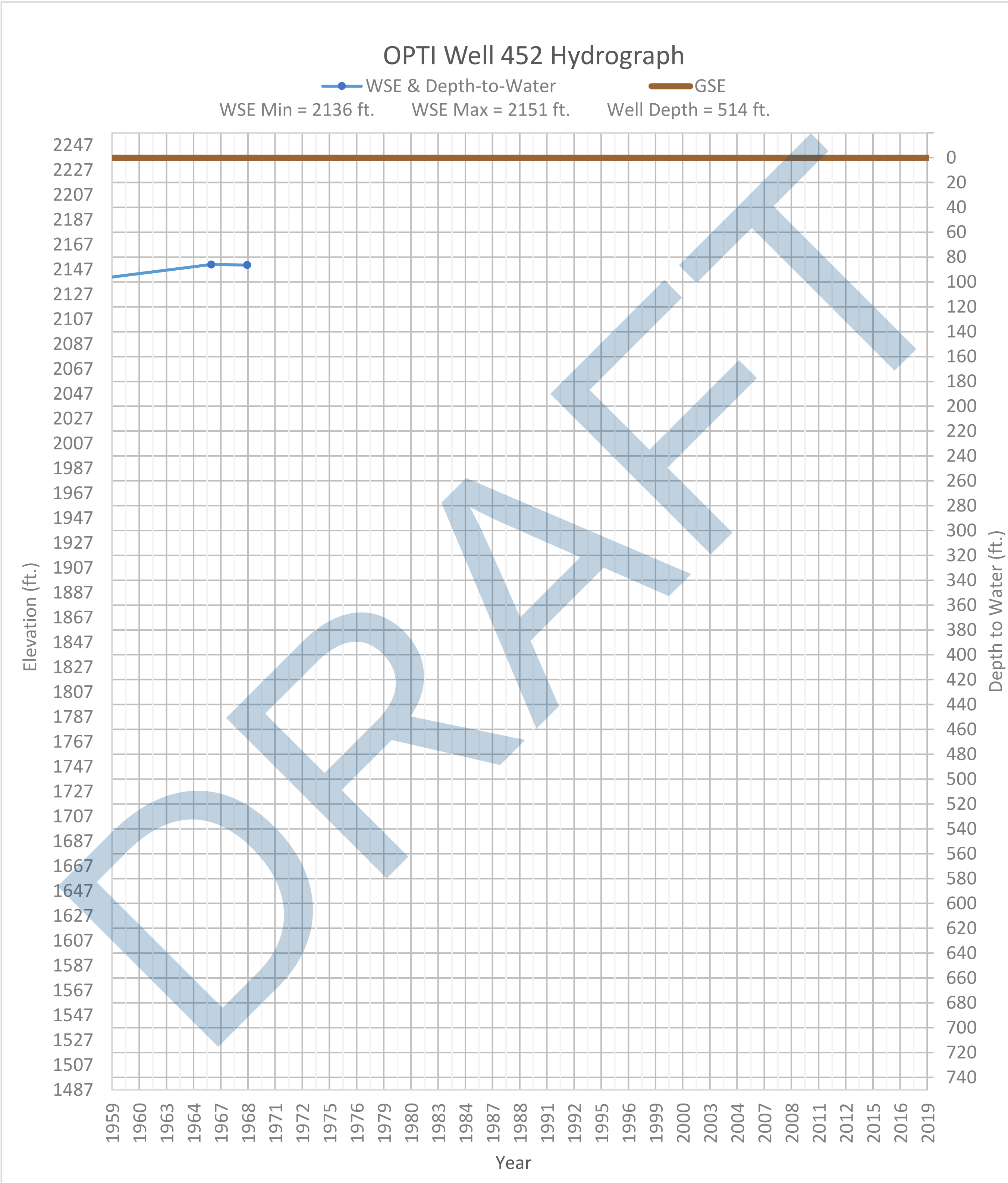
OPTI Well 448 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2205 ft.
WSE Max = 2205 ft.
Well Depth = 129 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 450 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2176 ft.
WSE Max = 2176 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 451 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2197 ft.
WSE Max = 2200 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

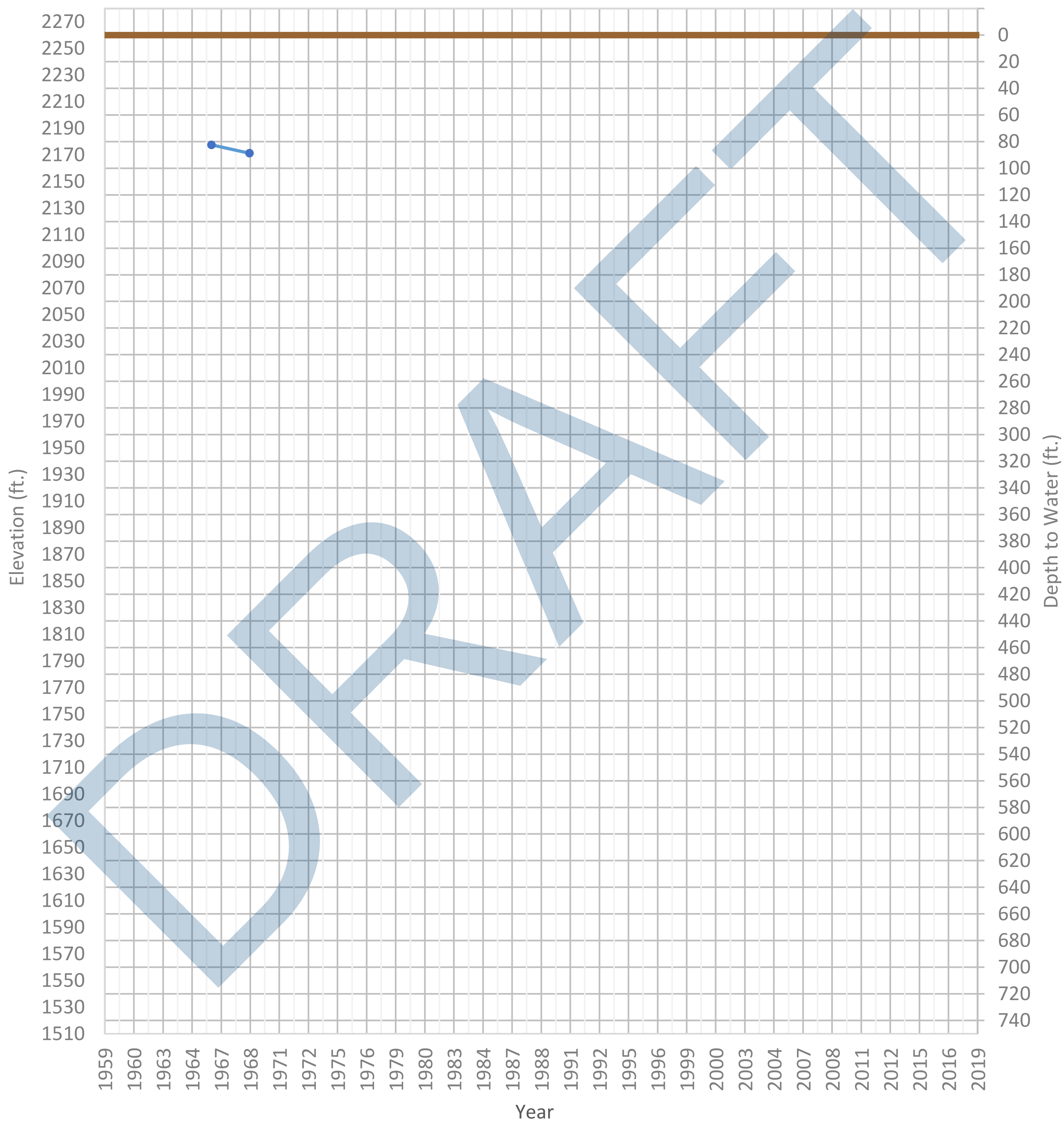


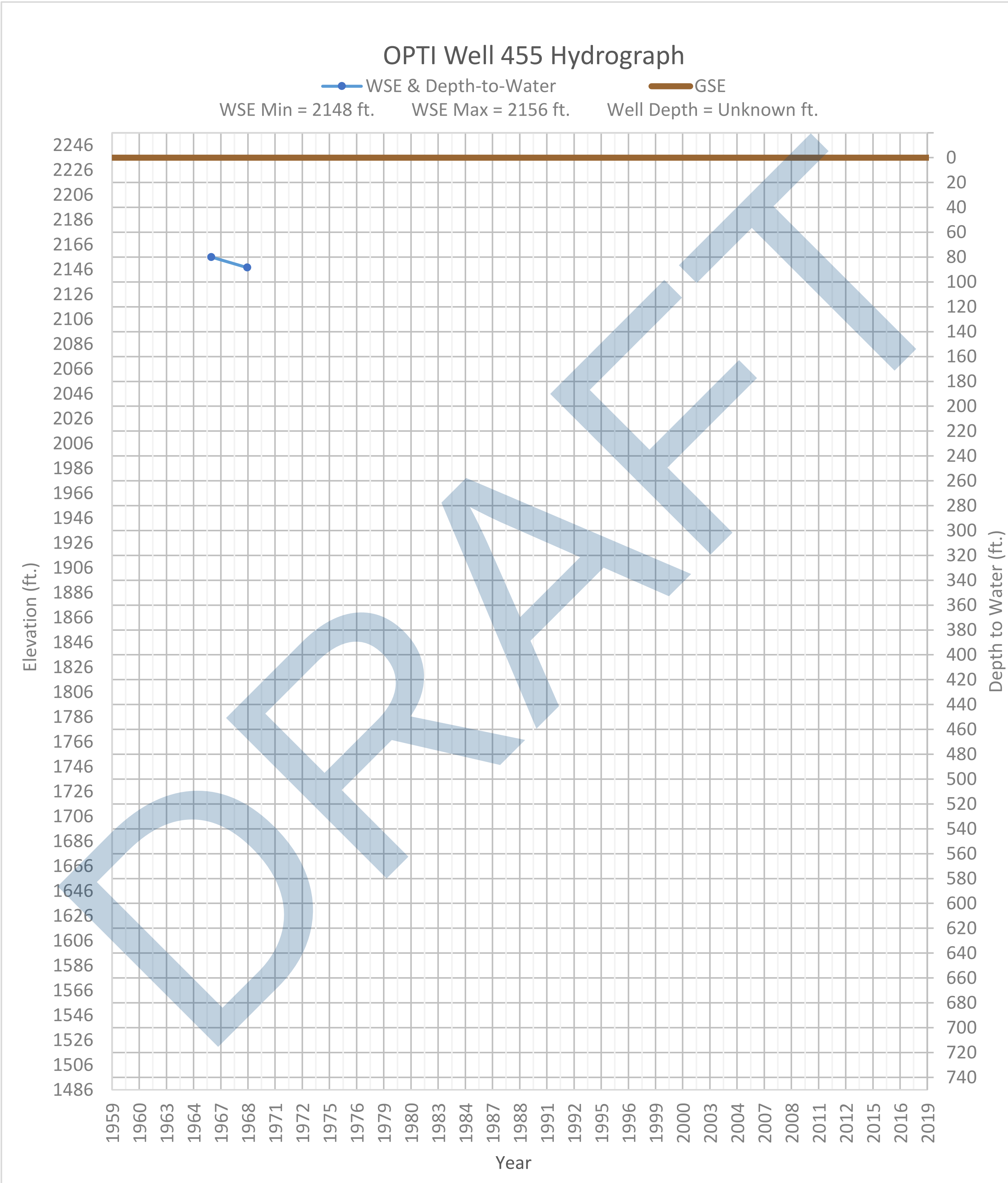
OPTI Well 452 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2136 ft.
WSE Max = 2151 ft.
Well Depth = 514 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

OPTI Well 454 Hydrograph

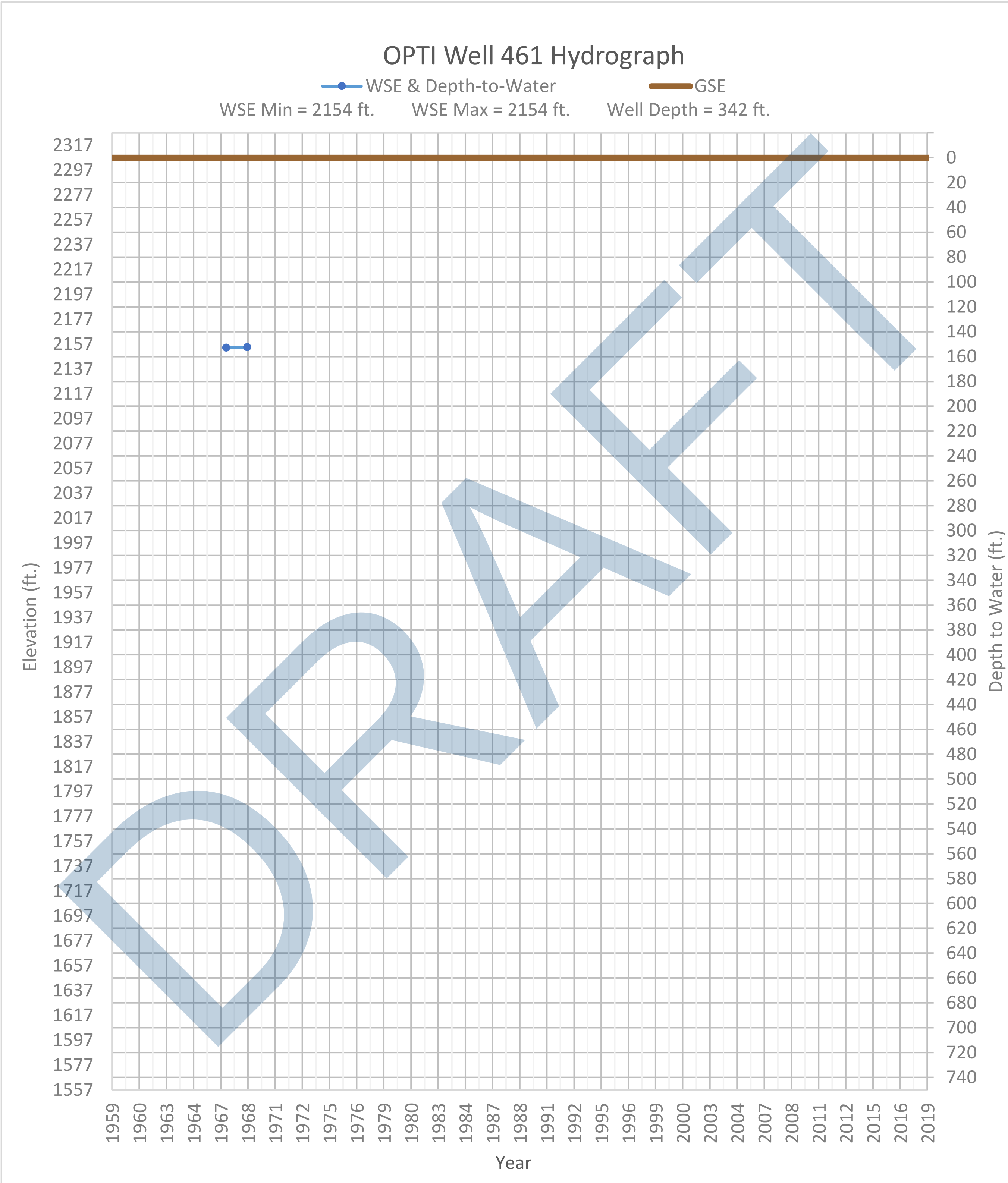
WSE & Depth-to-Water GSE

WSE Min = 2171 ft. WSE Max = 2178 ft. Well Depth = Unknown ft.

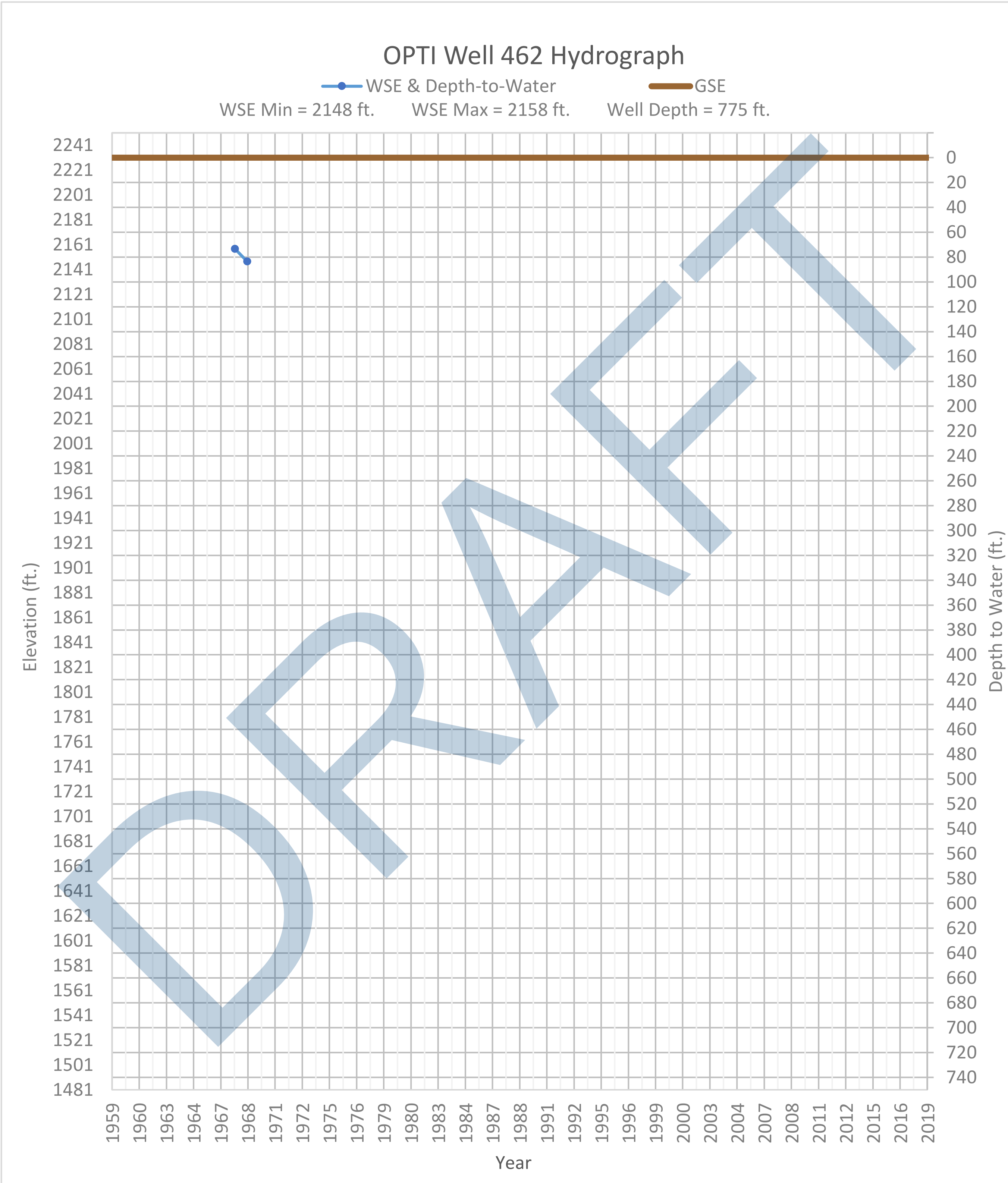


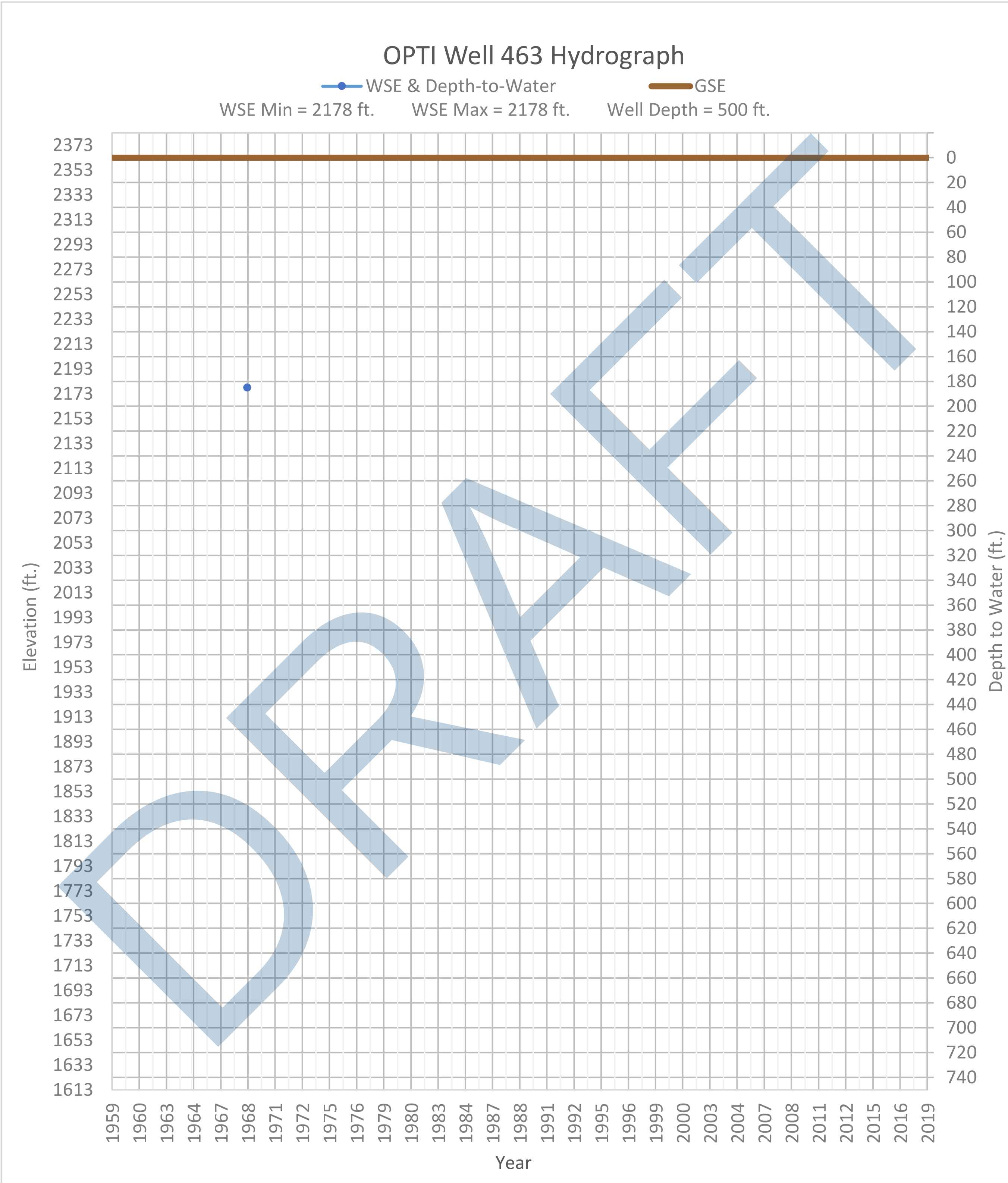


OPTI Well 455 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2148 ft.
WSE Max = 2156 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

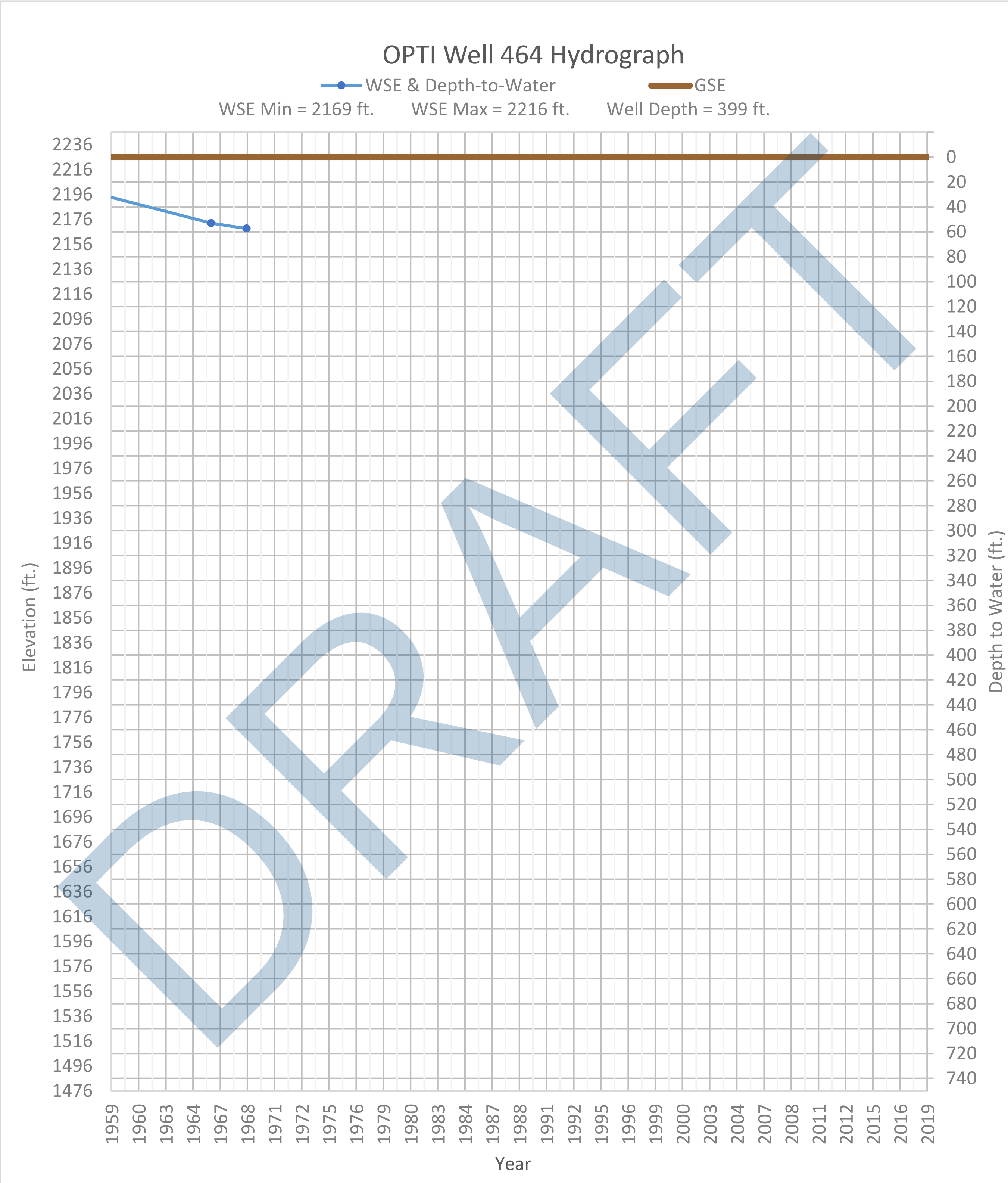


OPTI Well 461 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2154 ft.
WSE Max = 2154 ft.
Well Depth = 342 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 462 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2148 ft.
WSE Max = 2158 ft.
Well Depth = 775 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 463 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2178 ft.
WSE Max = 2178 ft.
Well Depth = 500 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 464 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2169 ft.
WSE Max = 2216 ft.
Well Depth = 399 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2236
2216
2196
2176
2156
2136
2116
2096
2076
2056
2036
2016
1996
1976
1956
1936
1916
1896
1876
1856
1836
1816
1796
1776
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1476
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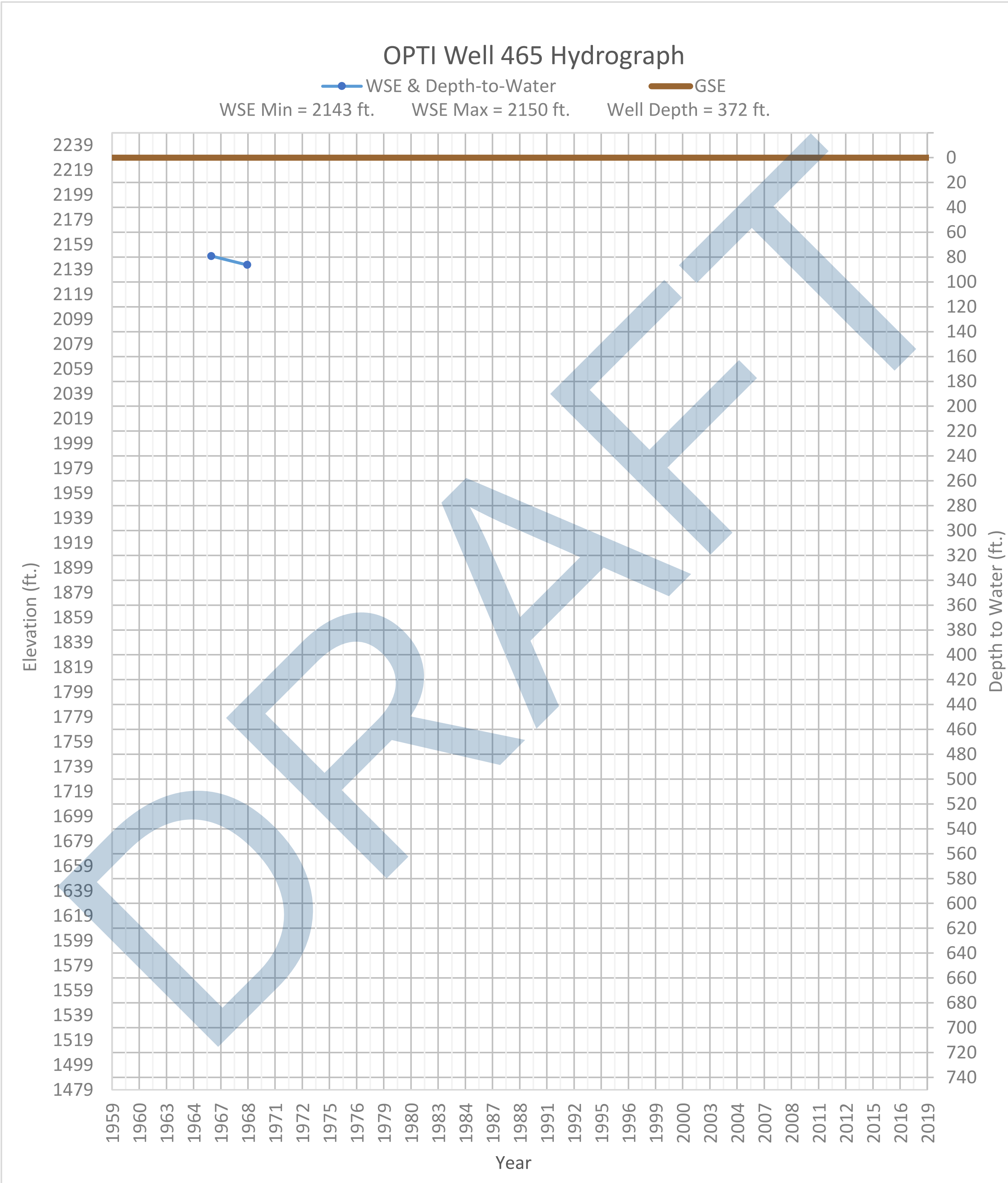
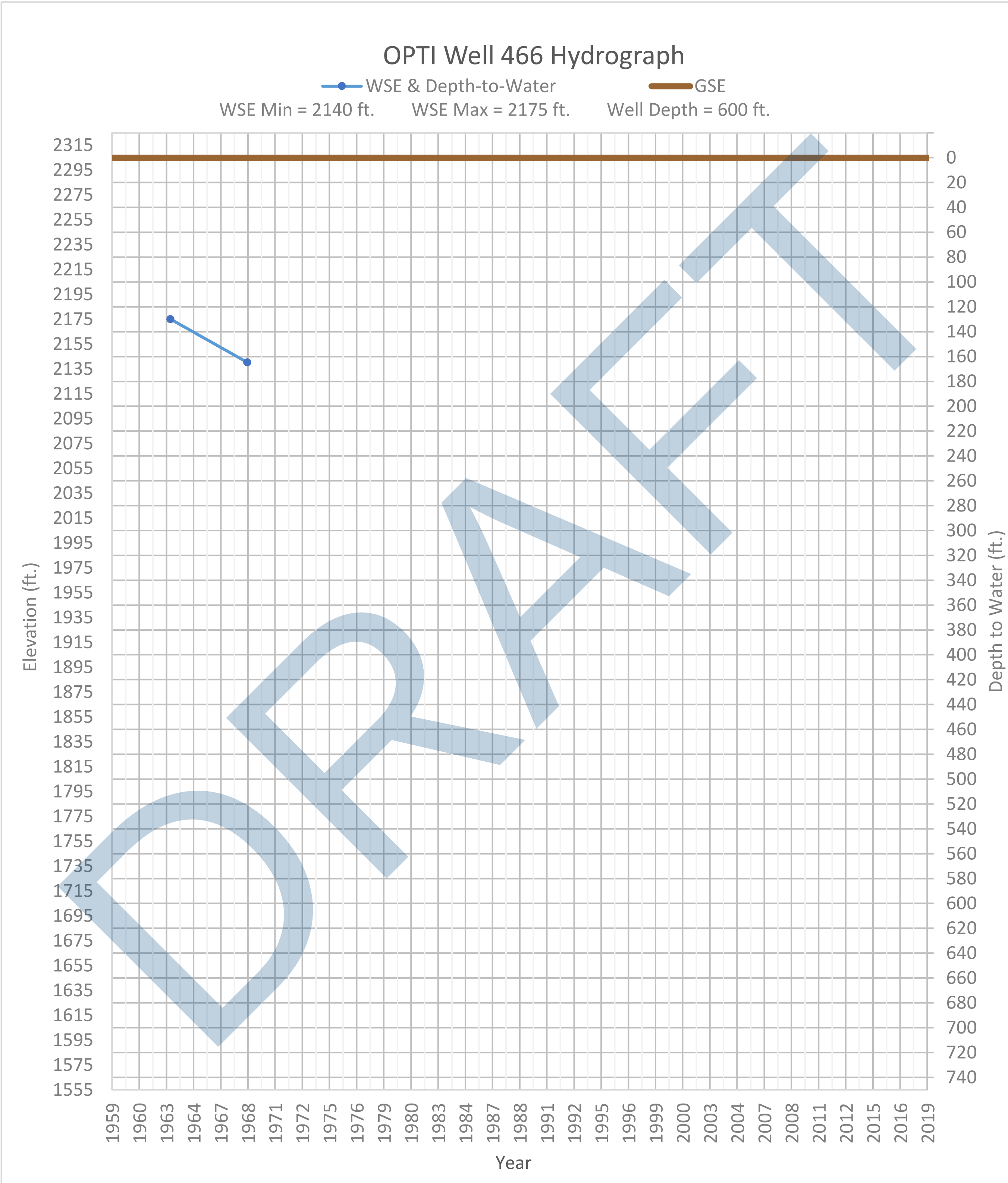
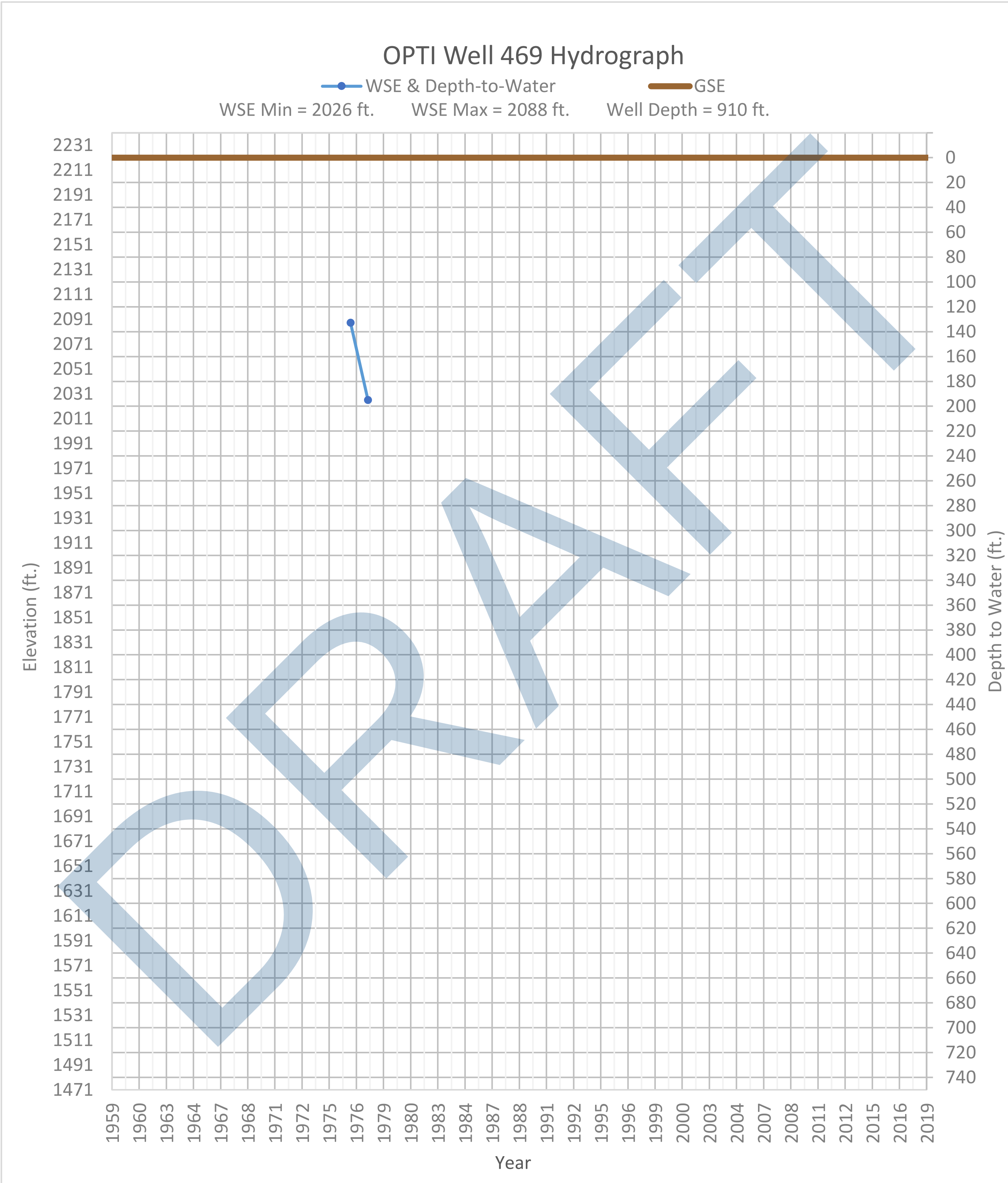
DRAFT

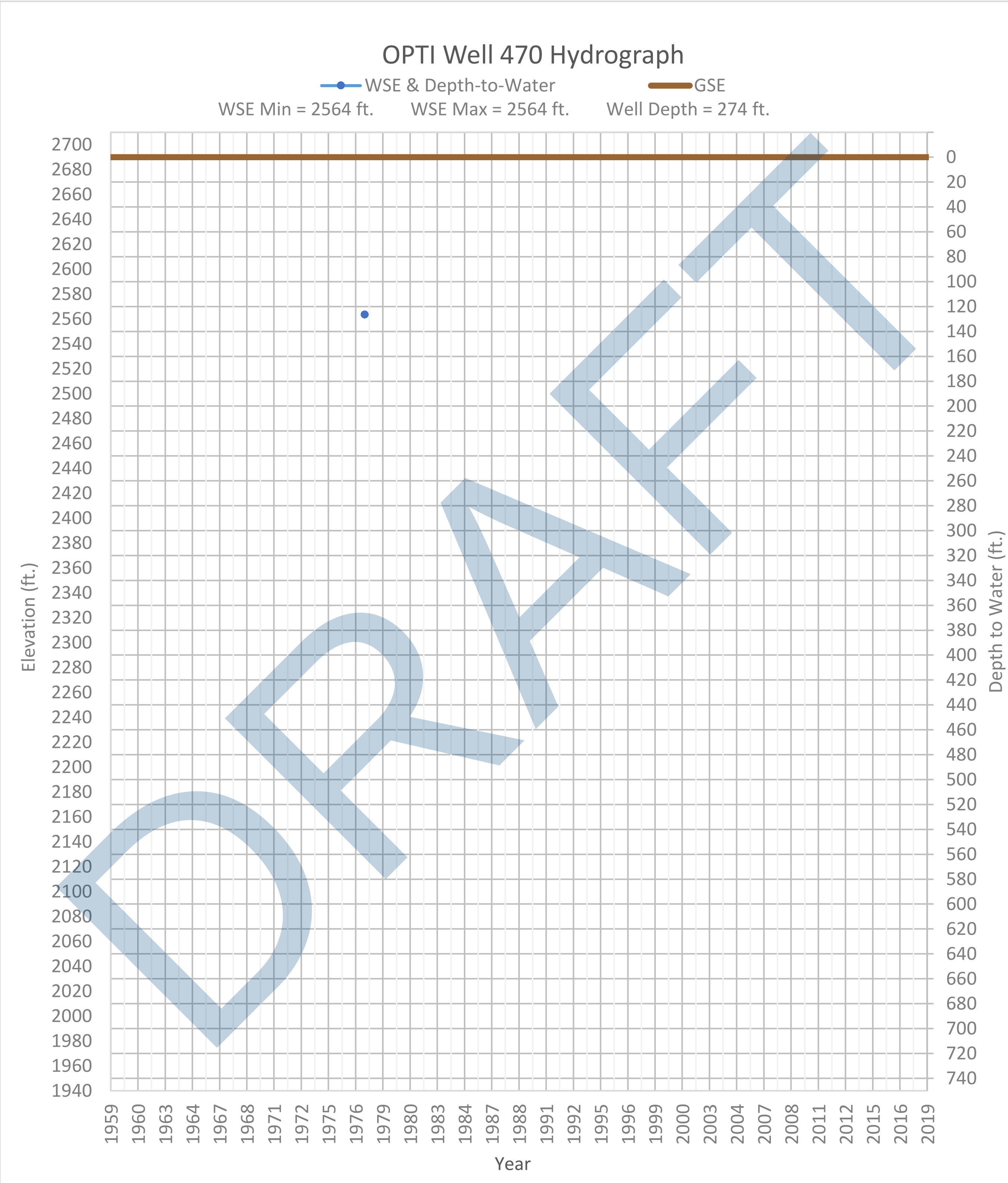

OPTI Well 465 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2143 ft.
WSE Max = 2150 ft.
Well Depth = 372 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



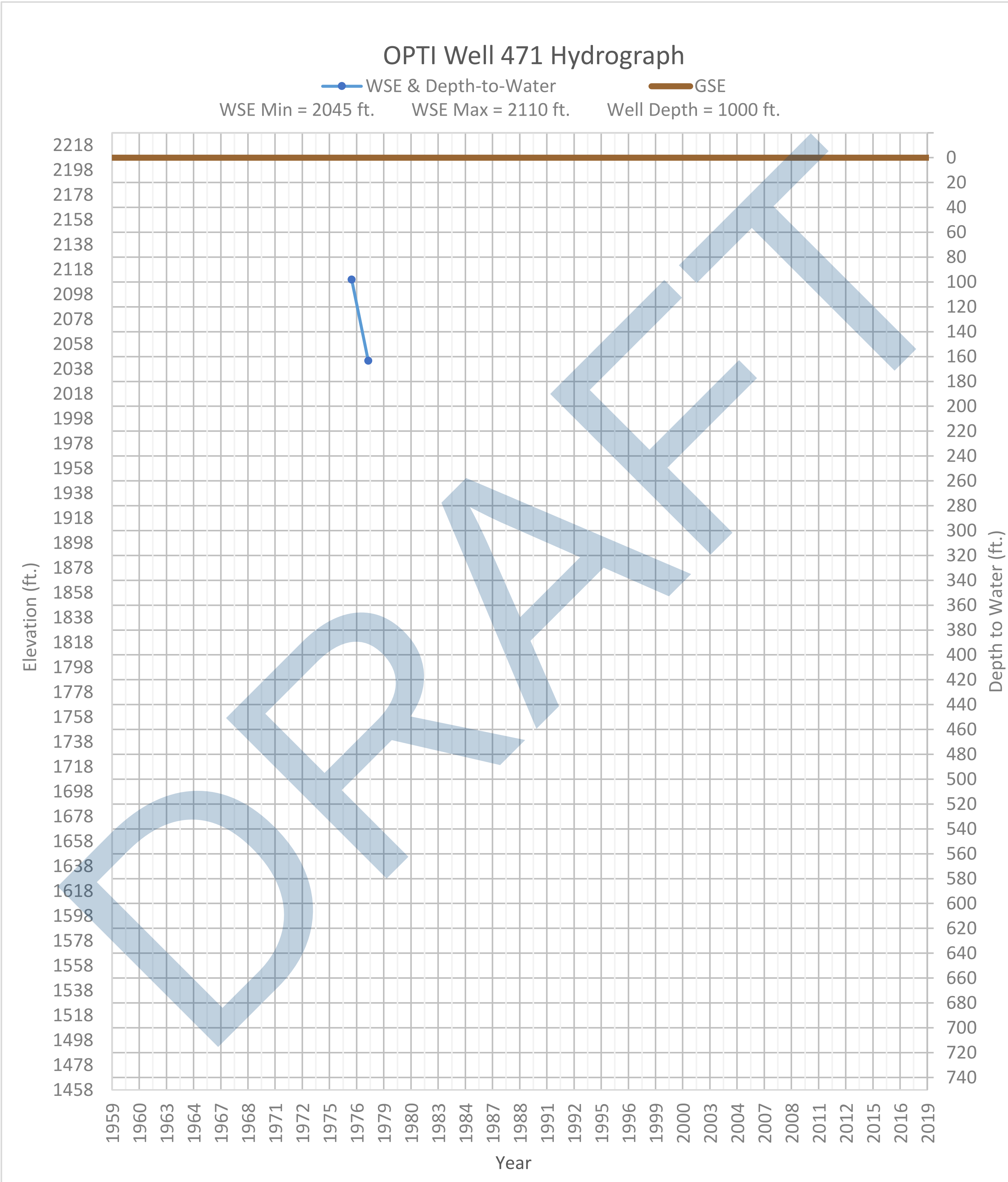
OPTI Well 466 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2140 ft.
WSE Max = 2175 ft.
Well Depth = 600 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

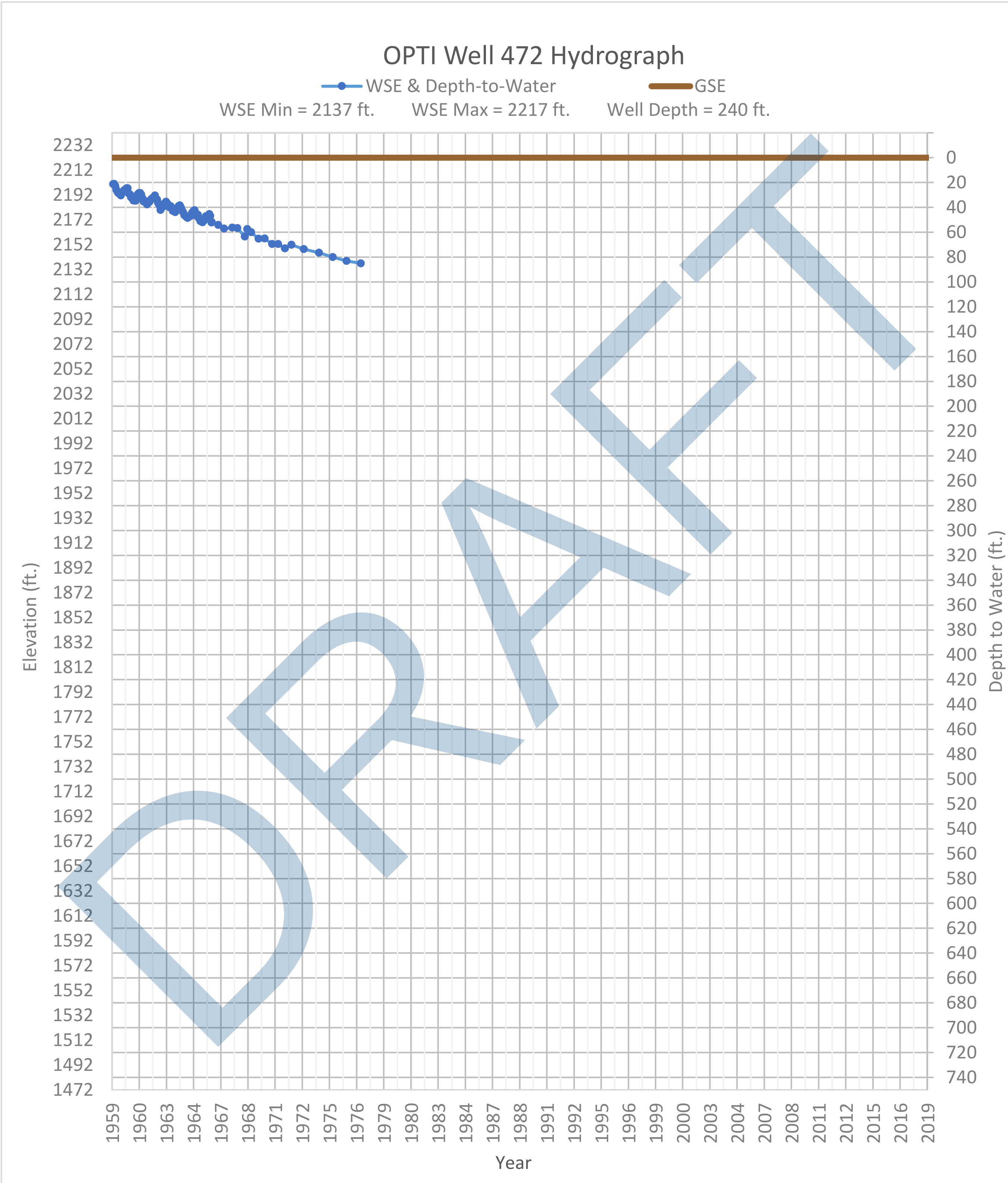


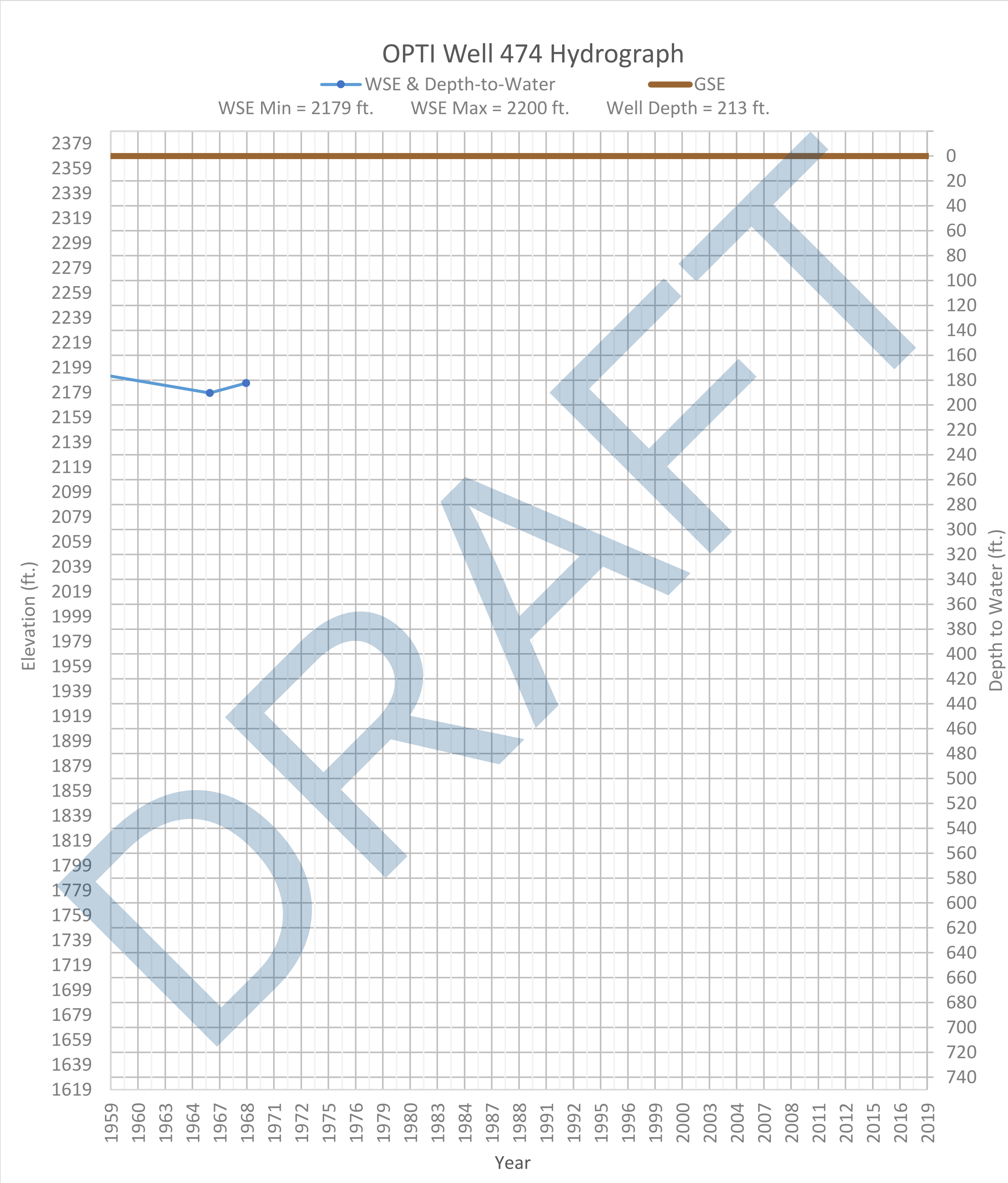
OPTI Well 469 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2026 ft.
WSE Max = 2088 ft.
Well Depth = 910 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



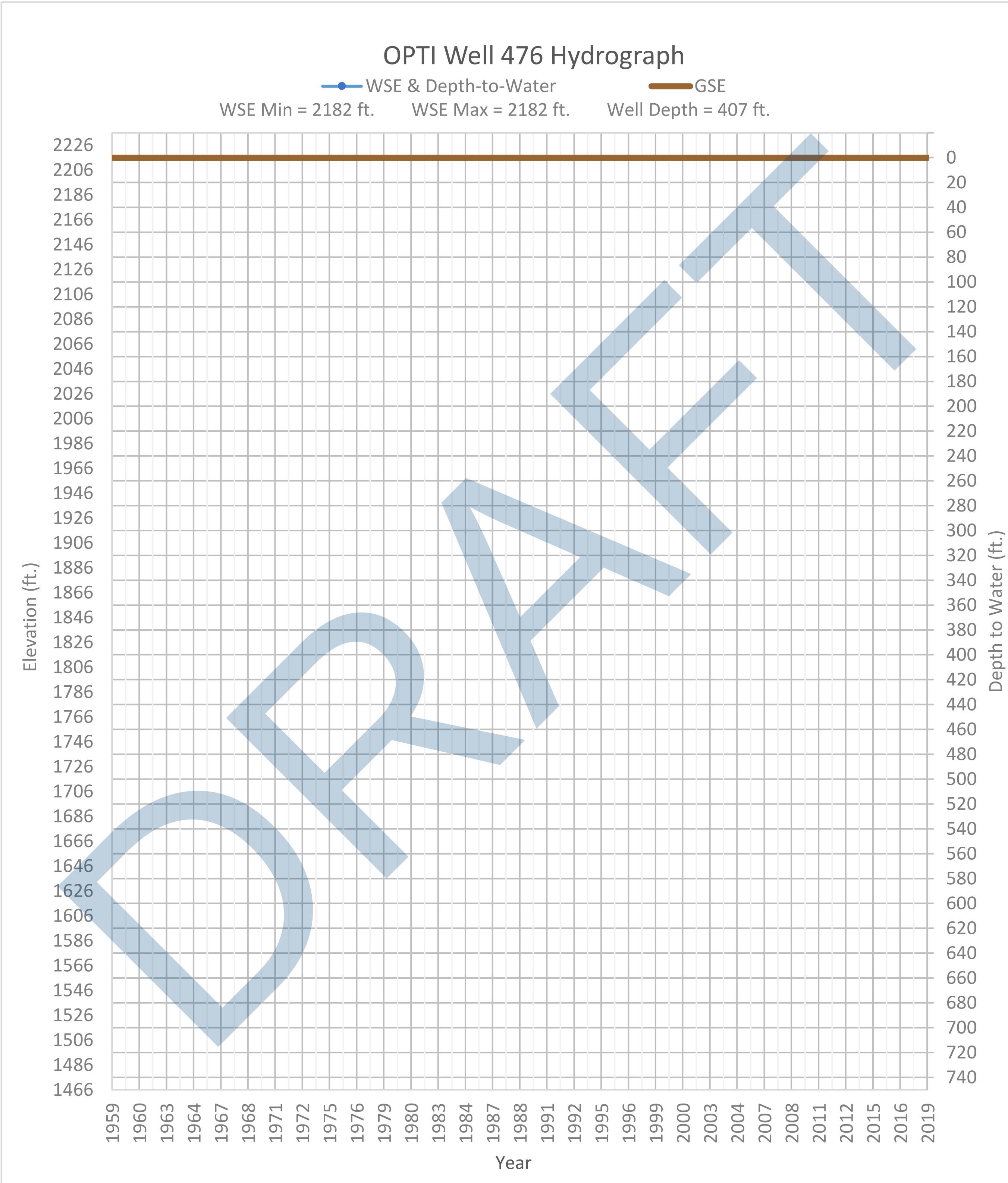
OPTI Well 470 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2564 ft.
WSE Max = 2564 ft.
Well Depth = 274 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 471 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2045 ft.
WSE Max = 2110 ft.
Well Depth = 1000 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 472 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2137 ft.
WSE Max = 2217 ft.
Well Depth = 240 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 474 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2179 ft.
WSE Max = 2200 ft.
Well Depth = 213 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 476 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2182 ft.
WSE Max = 2182 ft.
Well Depth = 407 ft.
Elevation (ft.)
2226
2206
2186
2166
2146
2126
2106
2086
2066
2046
2026
2006
1986
1966
1946
1926
1906
1886
1866
1846
1826
1806
1786
1766
1746
1726
1706
1686
1666
1646
1626
1606
1586
1566
1546
1526
1506
1486
1466
Depth to Water (ft.)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
680
700
720
740
Year
1959
1960
1963
1964
1967
1968
1971
1972
1975
1976
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1980
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2003
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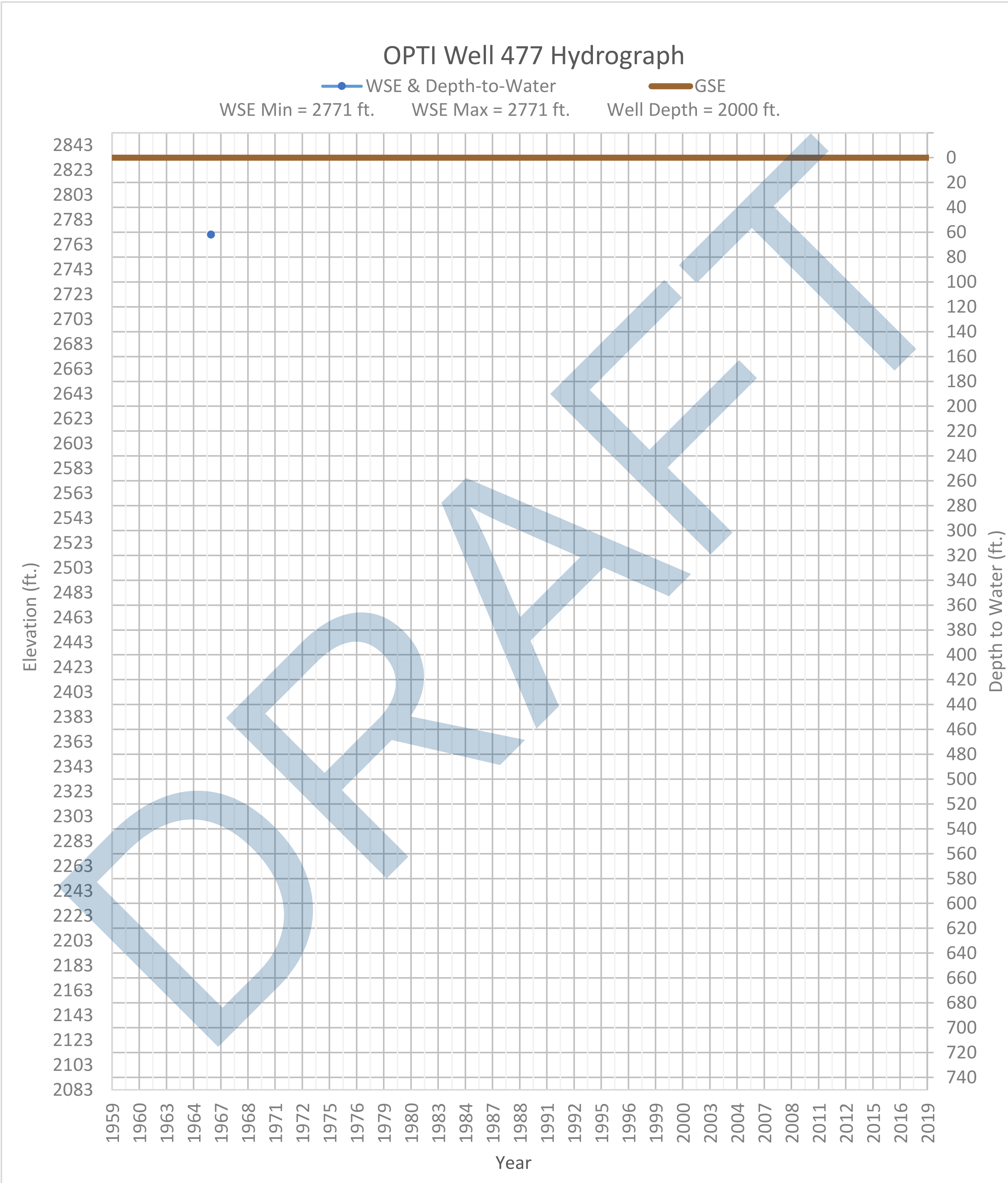
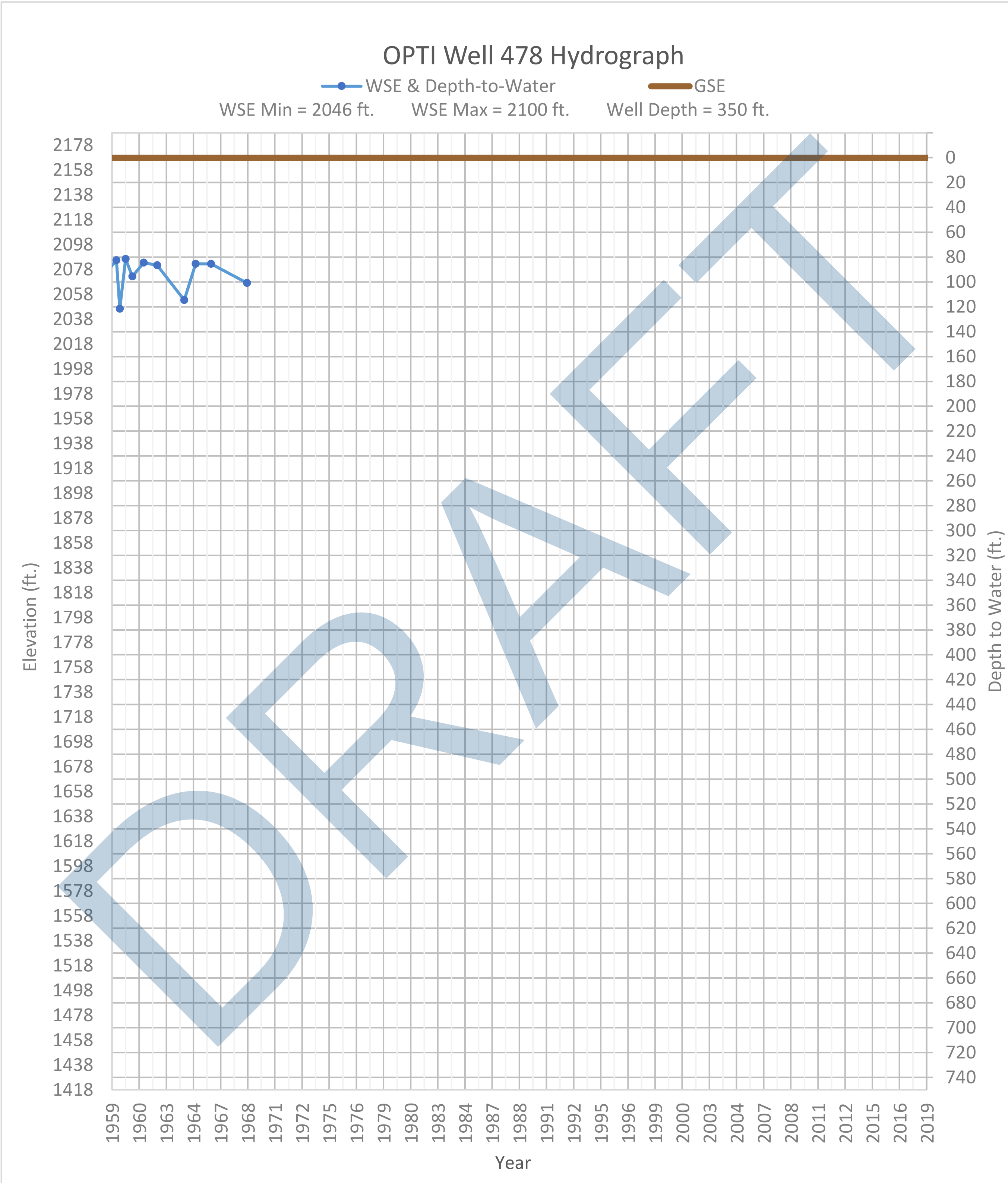
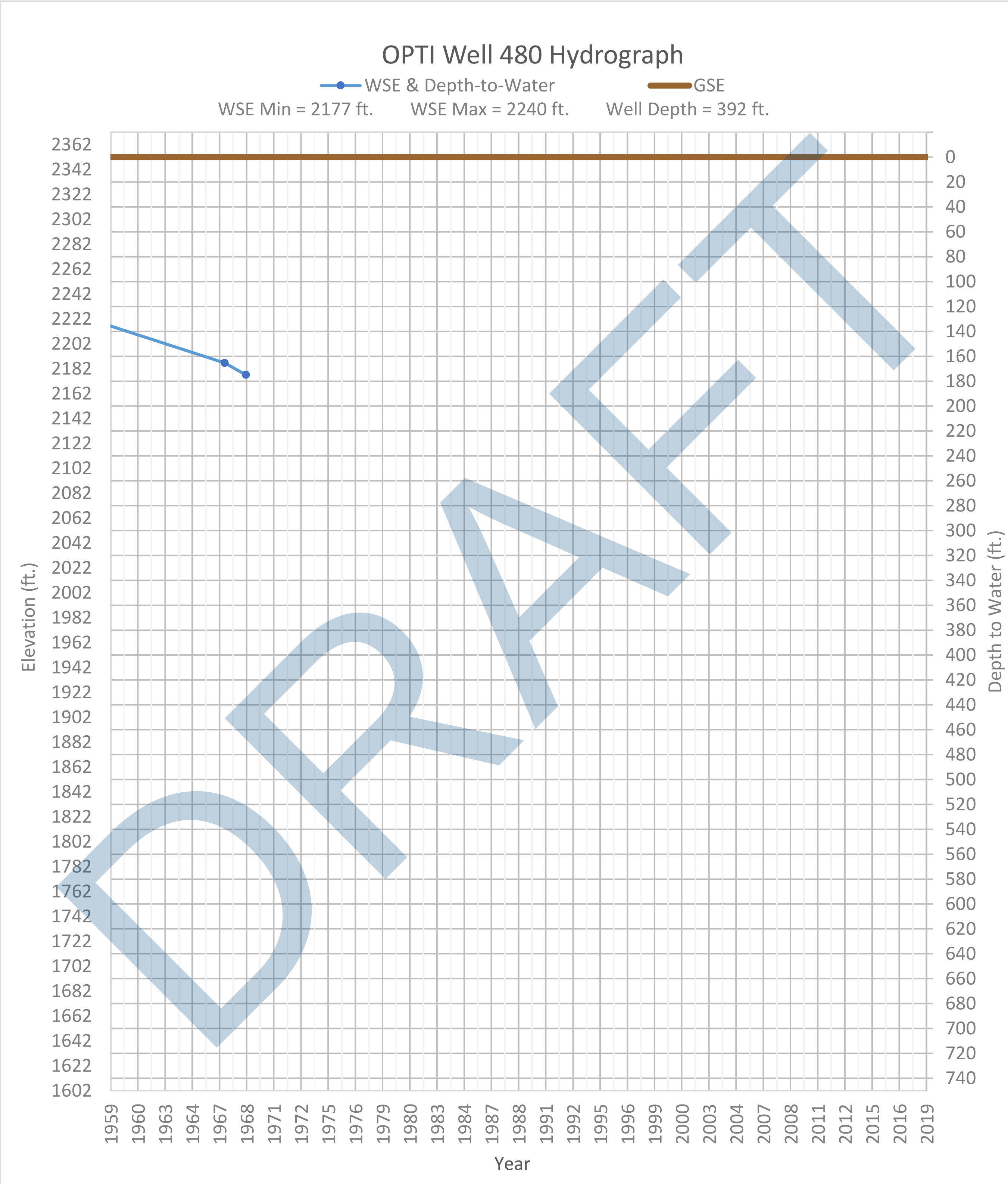
2011
2012
2015
2016
2019
DRAFT

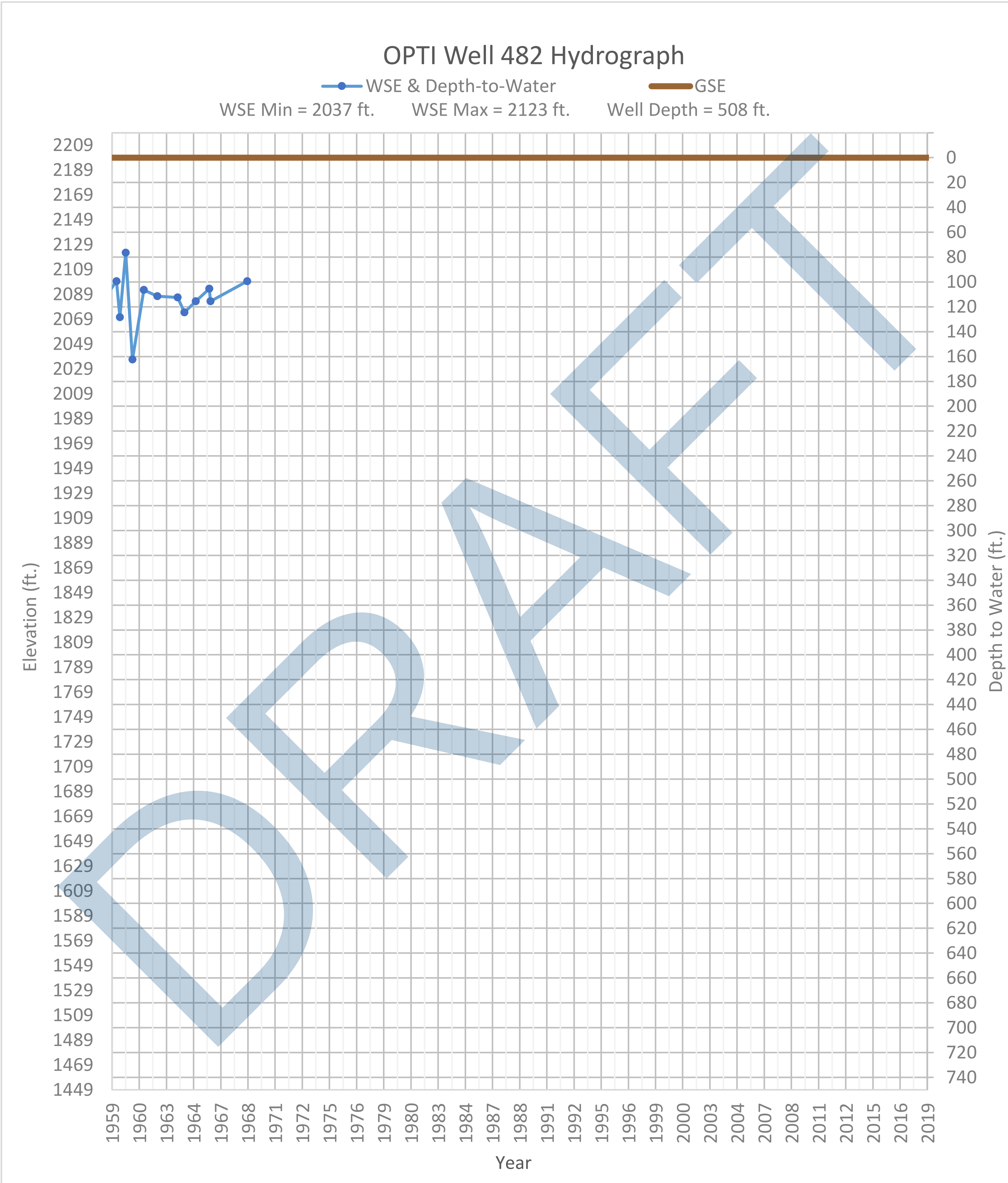

OPTI Well 477 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2771 ft.
WSE Max = 2771 ft.
Well Depth = 2000 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



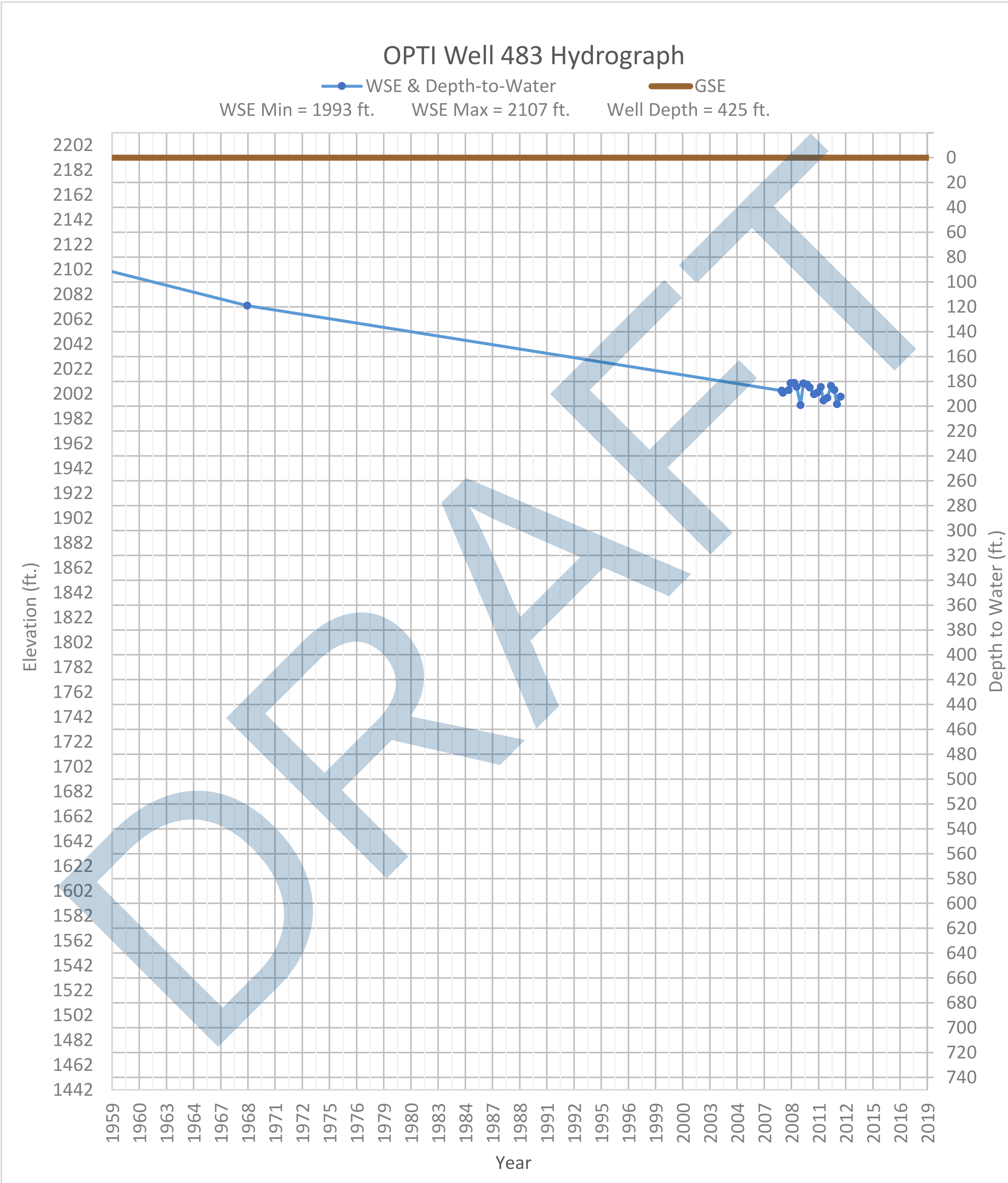
OPTI Well 478 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2046 ft.
WSE Max = 2100 ft.
Well Depth = 350 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



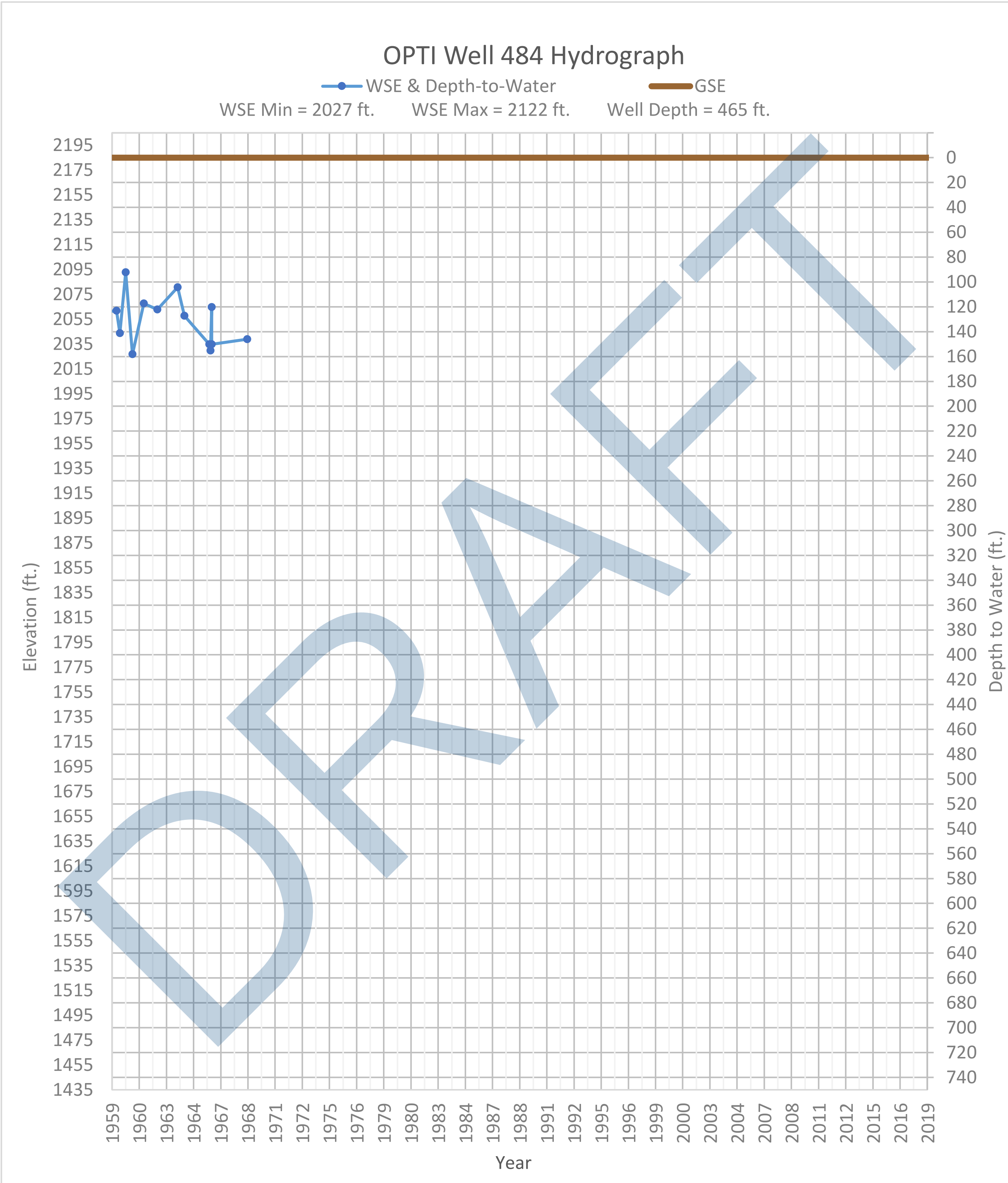
OPTI Well 480 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2177 ft.
WSE Max = 2240 ft.
Well Depth = 392 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



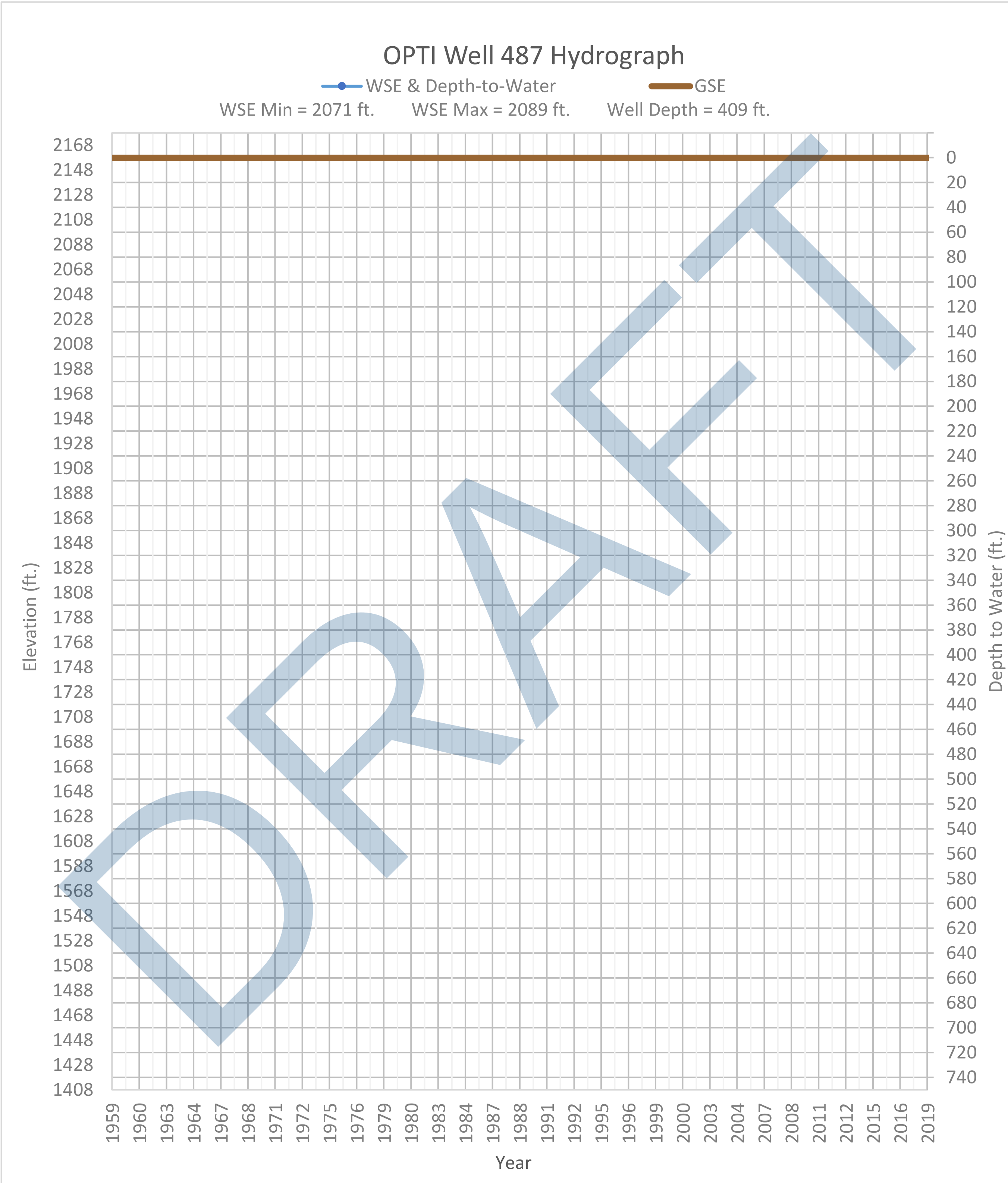
OPTI Well 482 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2037 ft.
WSE Max = 2123 ft.
Well Depth = 508 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



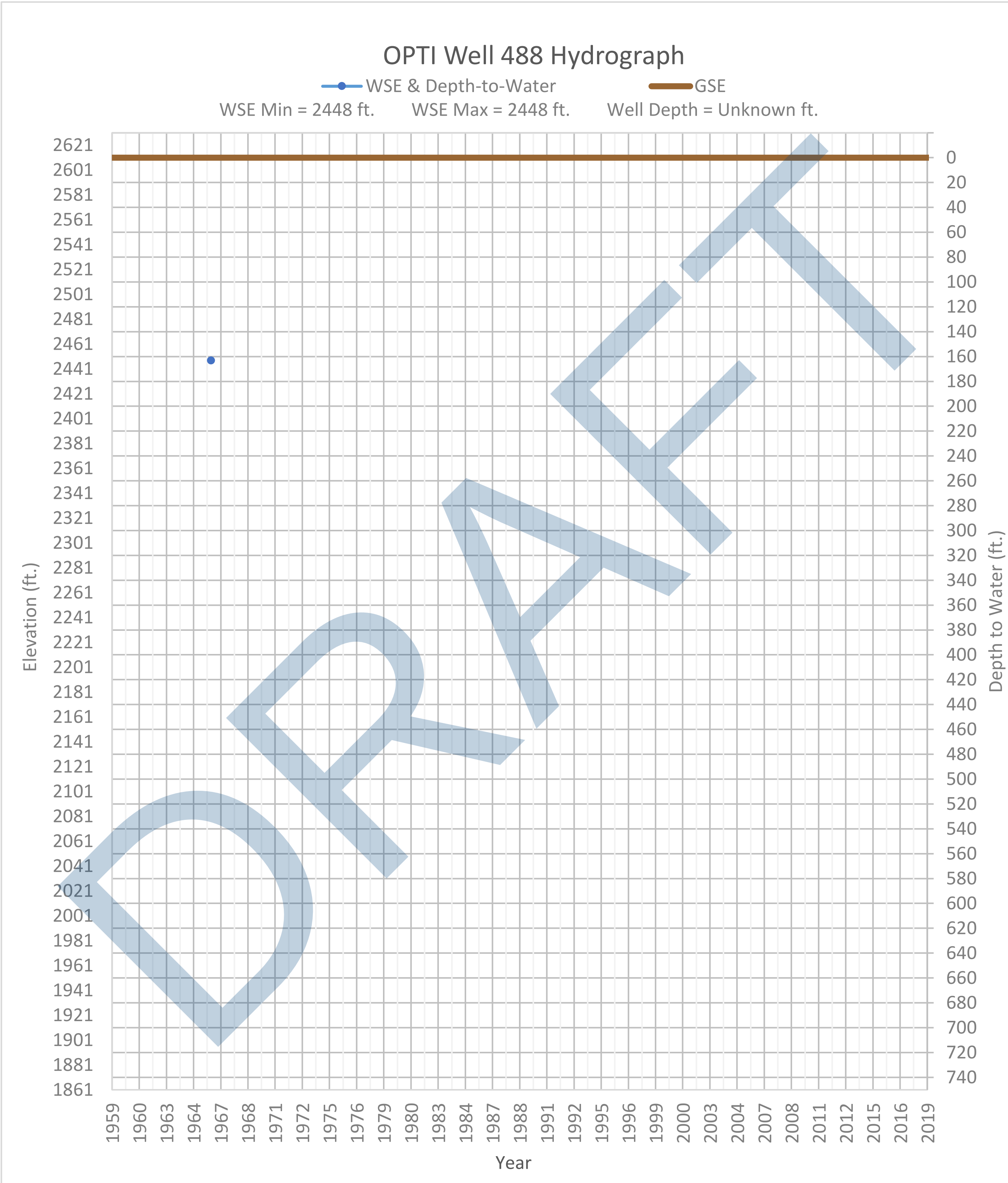
OPTI Well 483 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1993 ft.
WSE Max = 2107 ft.
Well Depth = 425 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



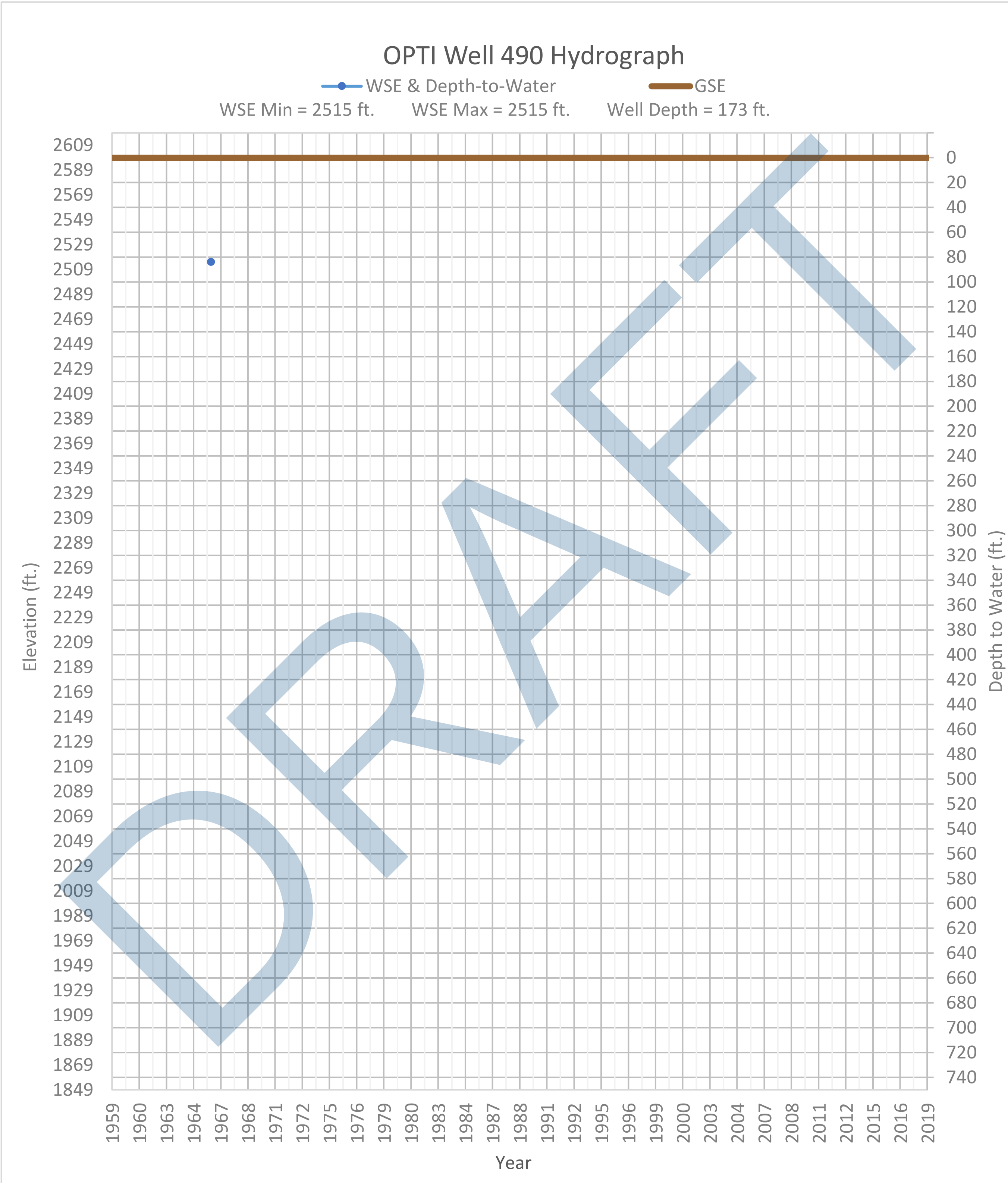
OPTI Well 484 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2027 ft.
WSE Max = 2122 ft.
Well Depth = 465 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



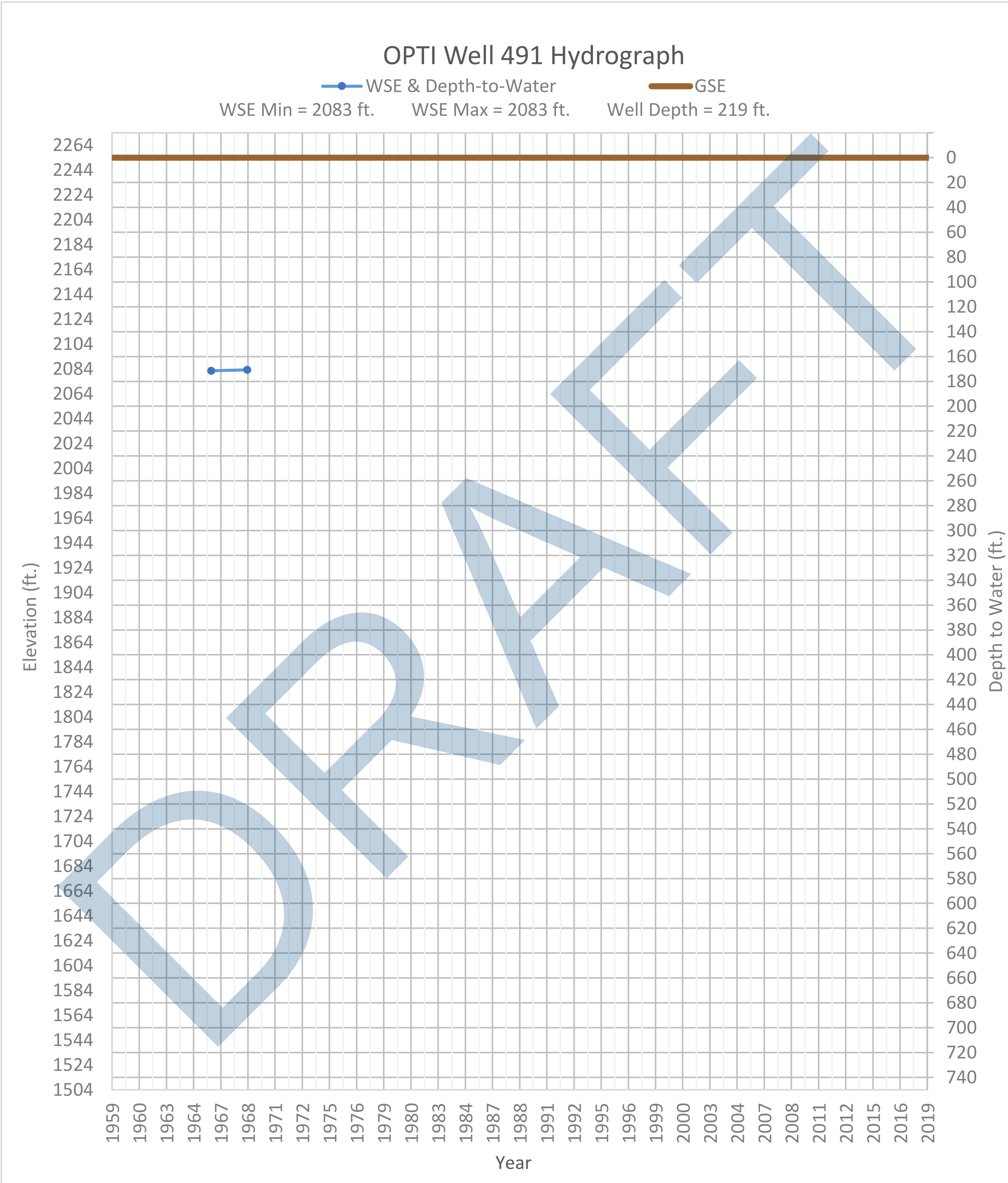
OPTI Well 487 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2071 ft.
WSE Max = 2089 ft.
Well Depth = 409 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

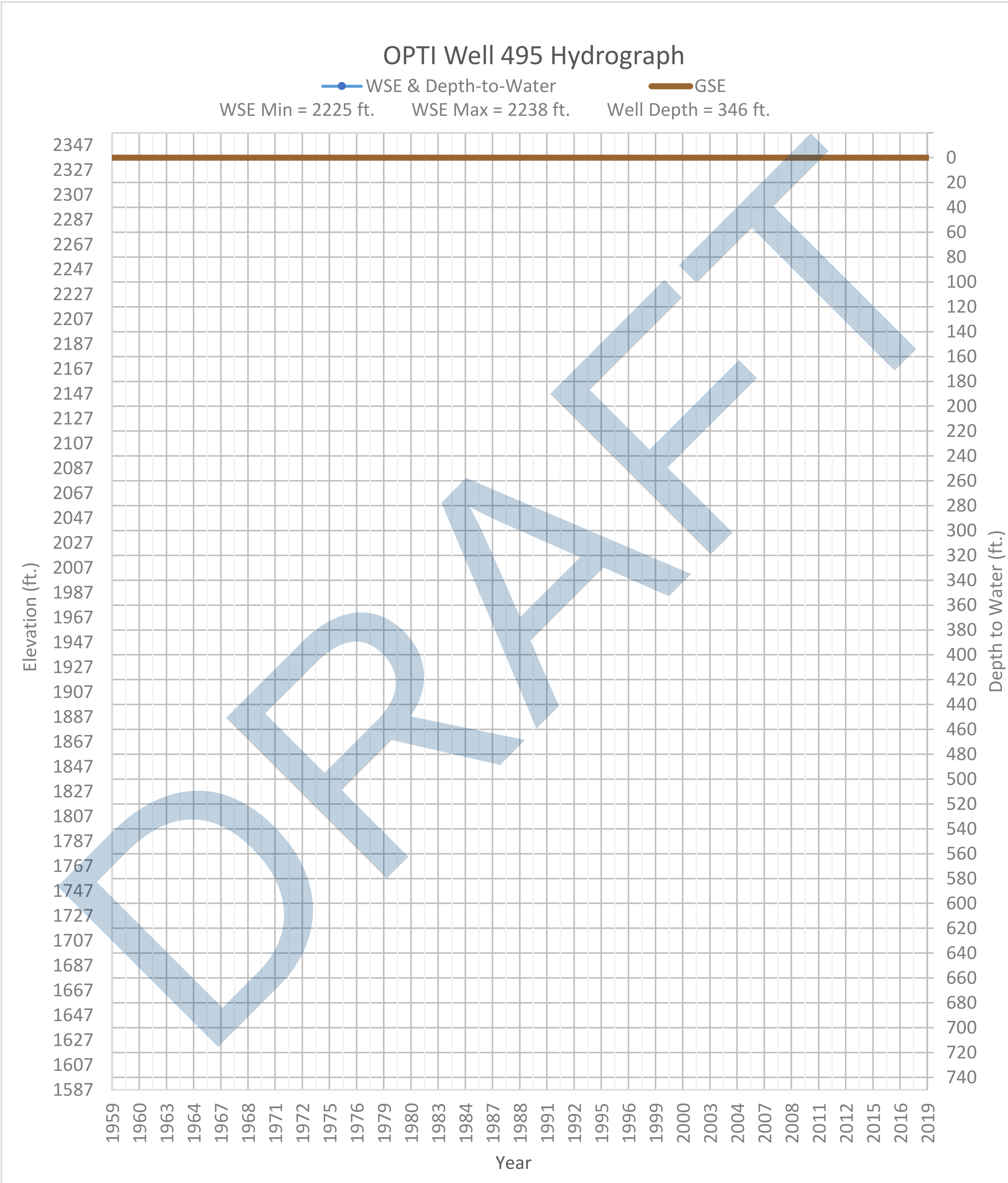


OPTI Well 488 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2448 ft.
WSE Max = 2448 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

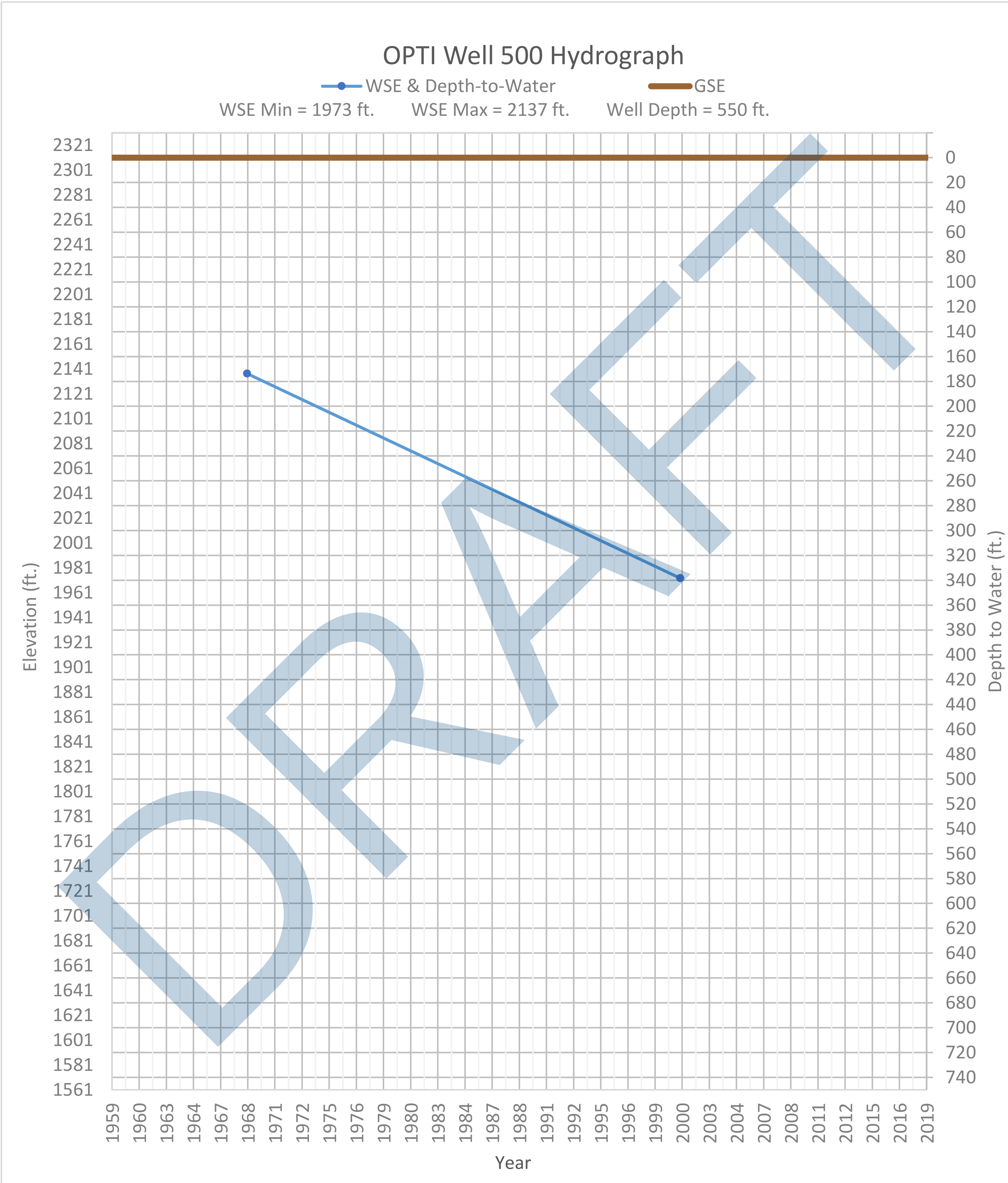


OPTI Well 490 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2515 ft.
WSE Max = 2515 ft.
Well Depth = 173 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

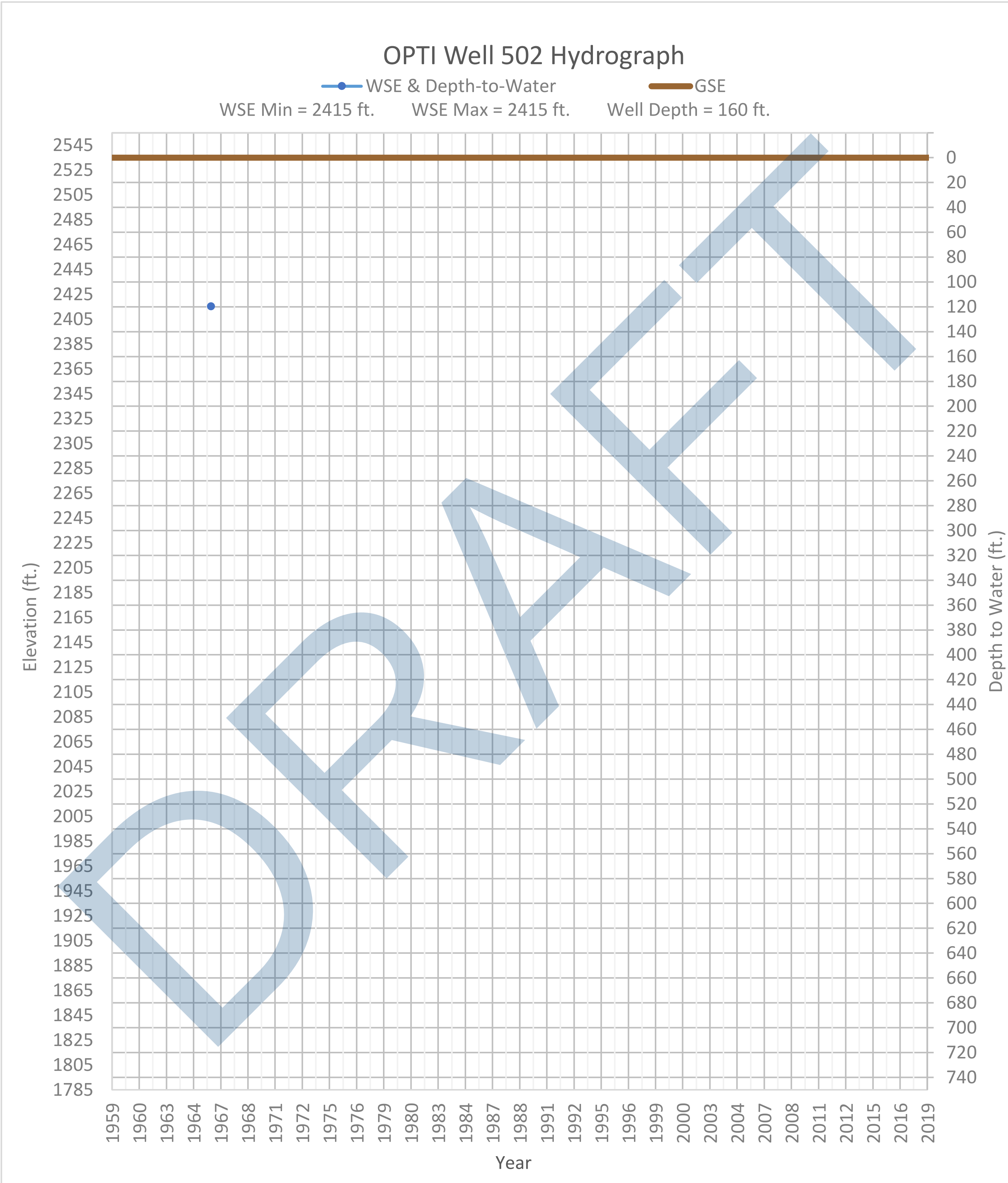

OPTI Well 491 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2083 ft.
WSE Max = 2083 ft.
Well Depth = 219 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



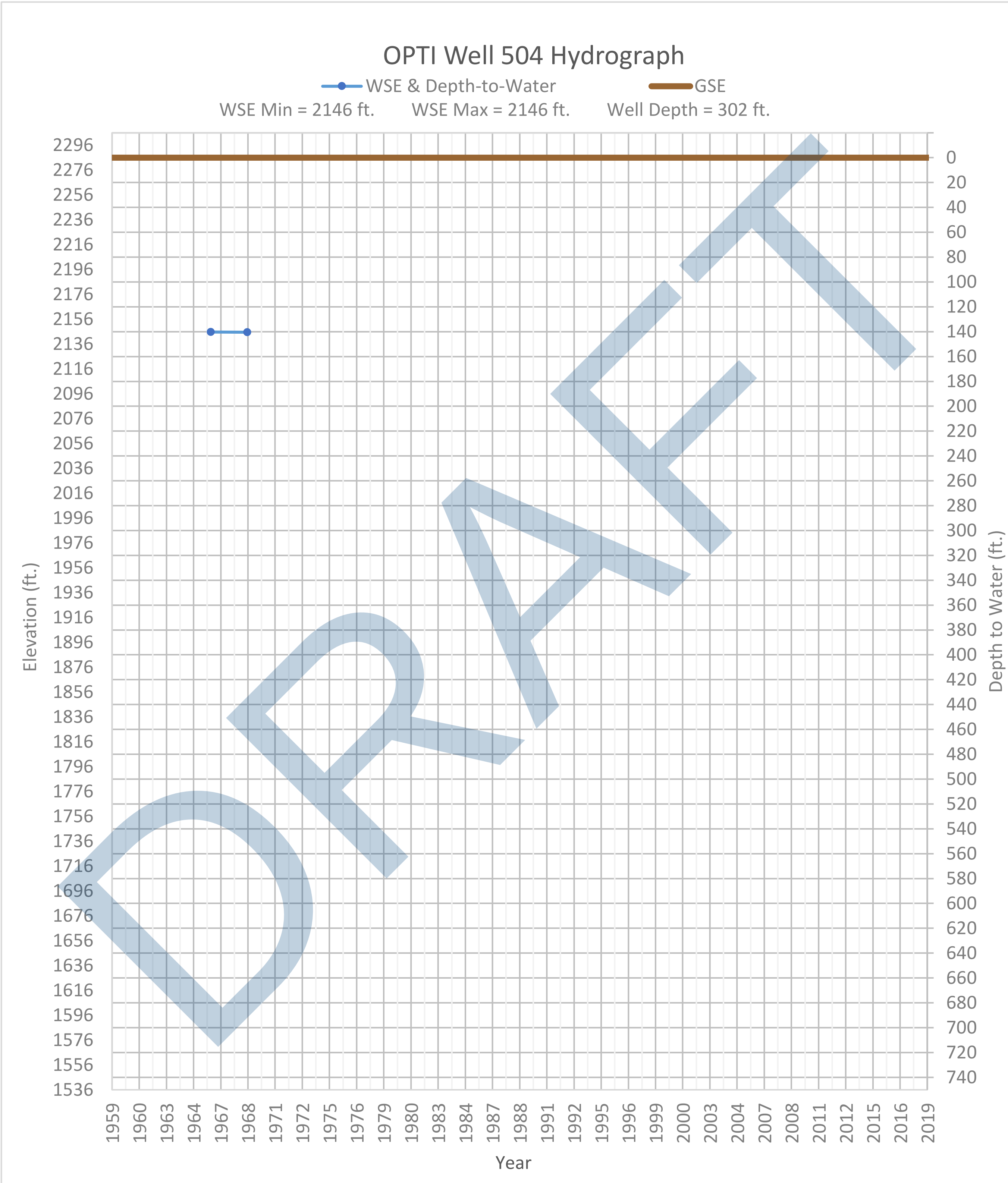
OPTI Well 495 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2225 ft.
WSE Max = 2238 ft.
Well Depth = 346 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



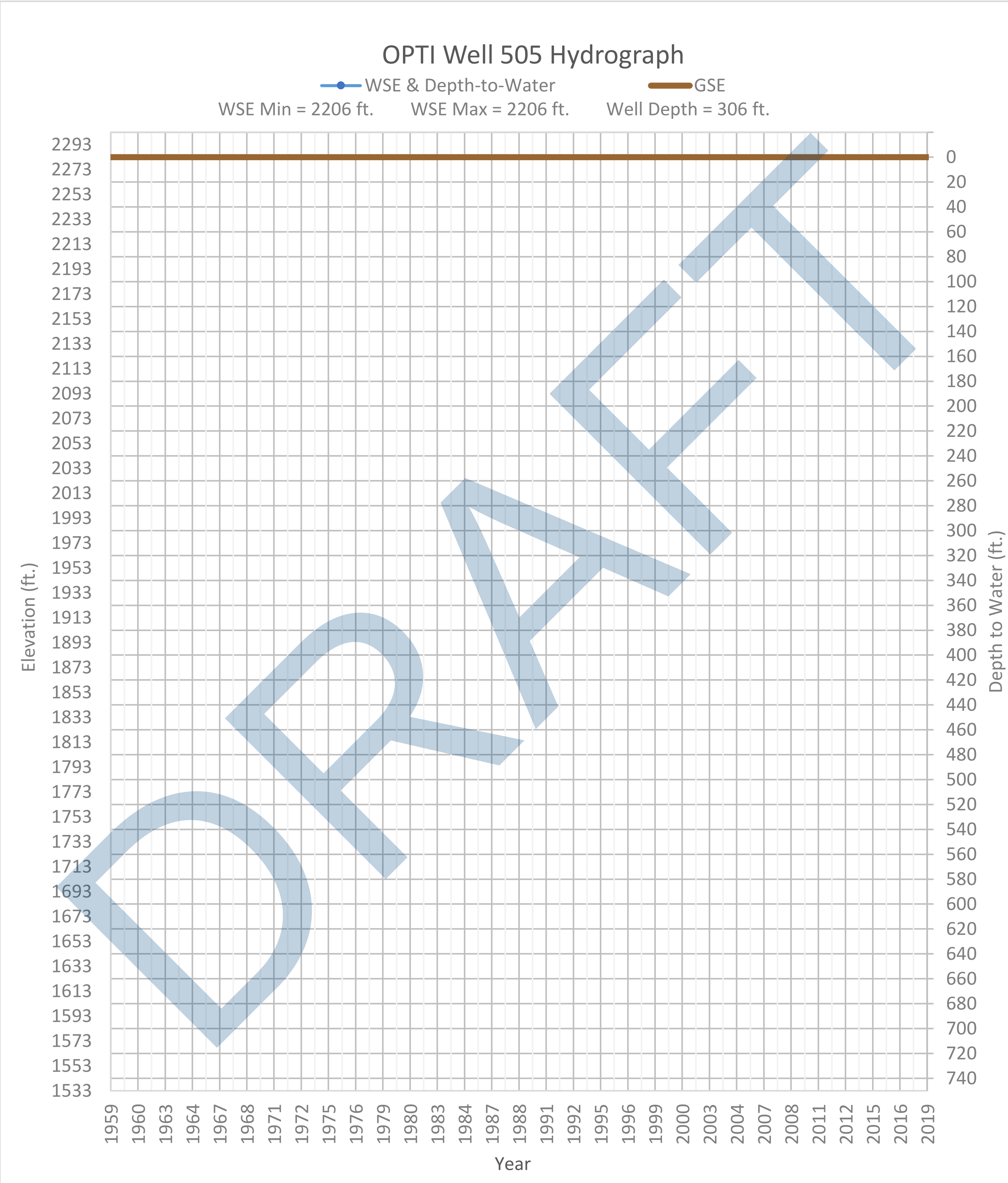
OPTI Well 500 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1973 ft.
WSE Max = 2137 ft.
Well Depth = 550 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



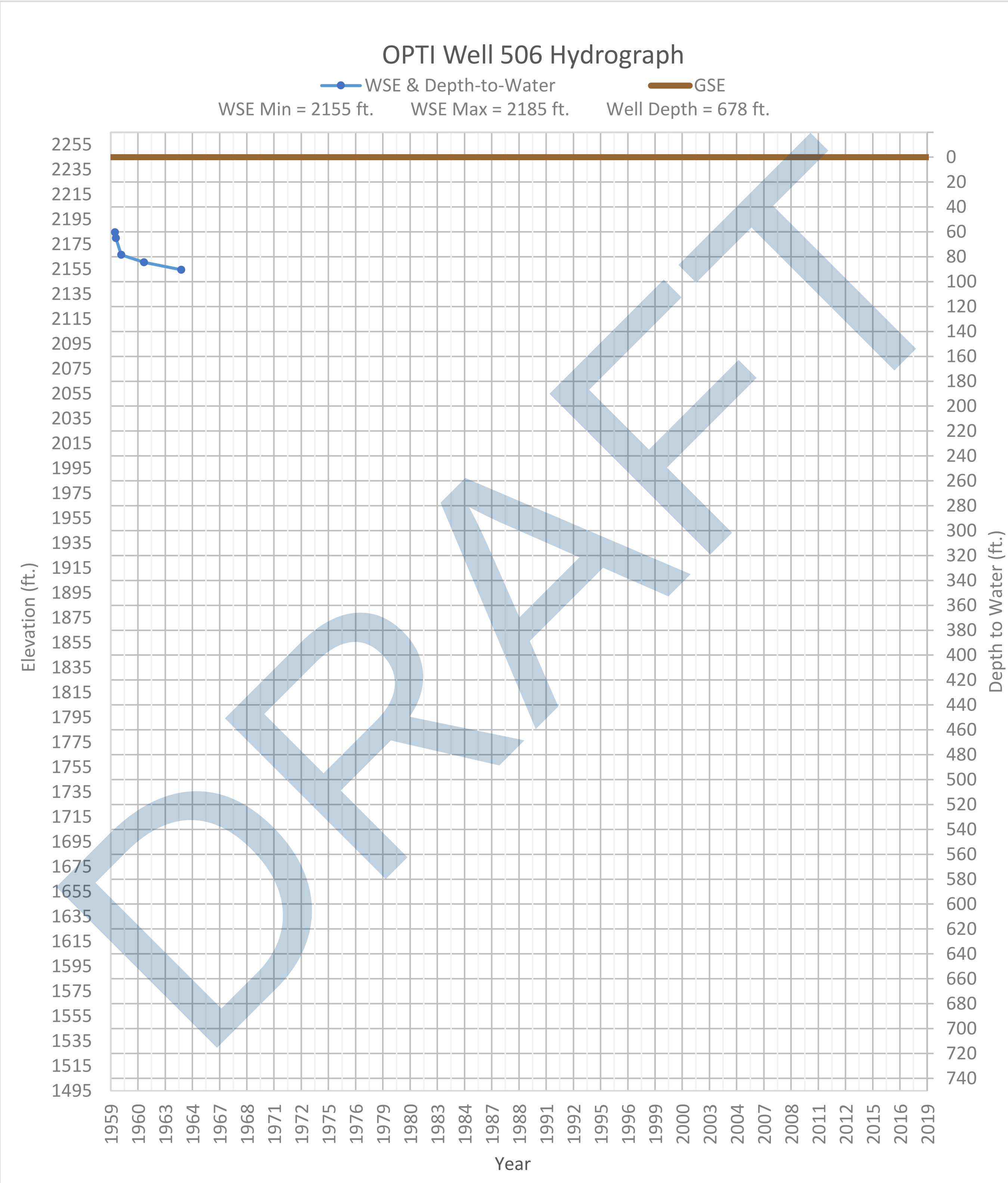
OPTI Well 502 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2415 ft.
WSE Max = 2415 ft.
Well Depth = 160 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

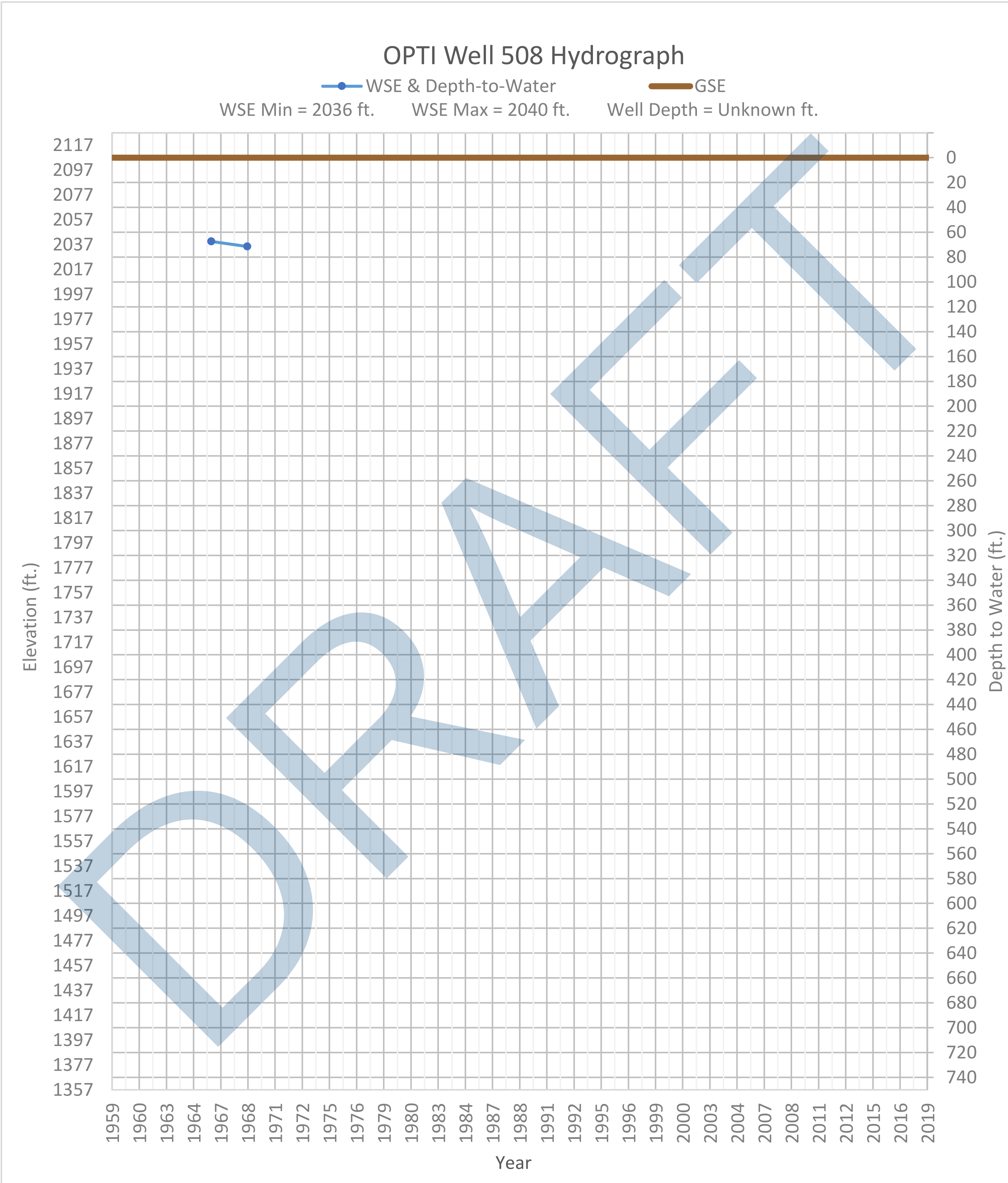


OPTI Well 504 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2146 ft.
WSE Max = 2146 ft.
Well Depth = 302 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

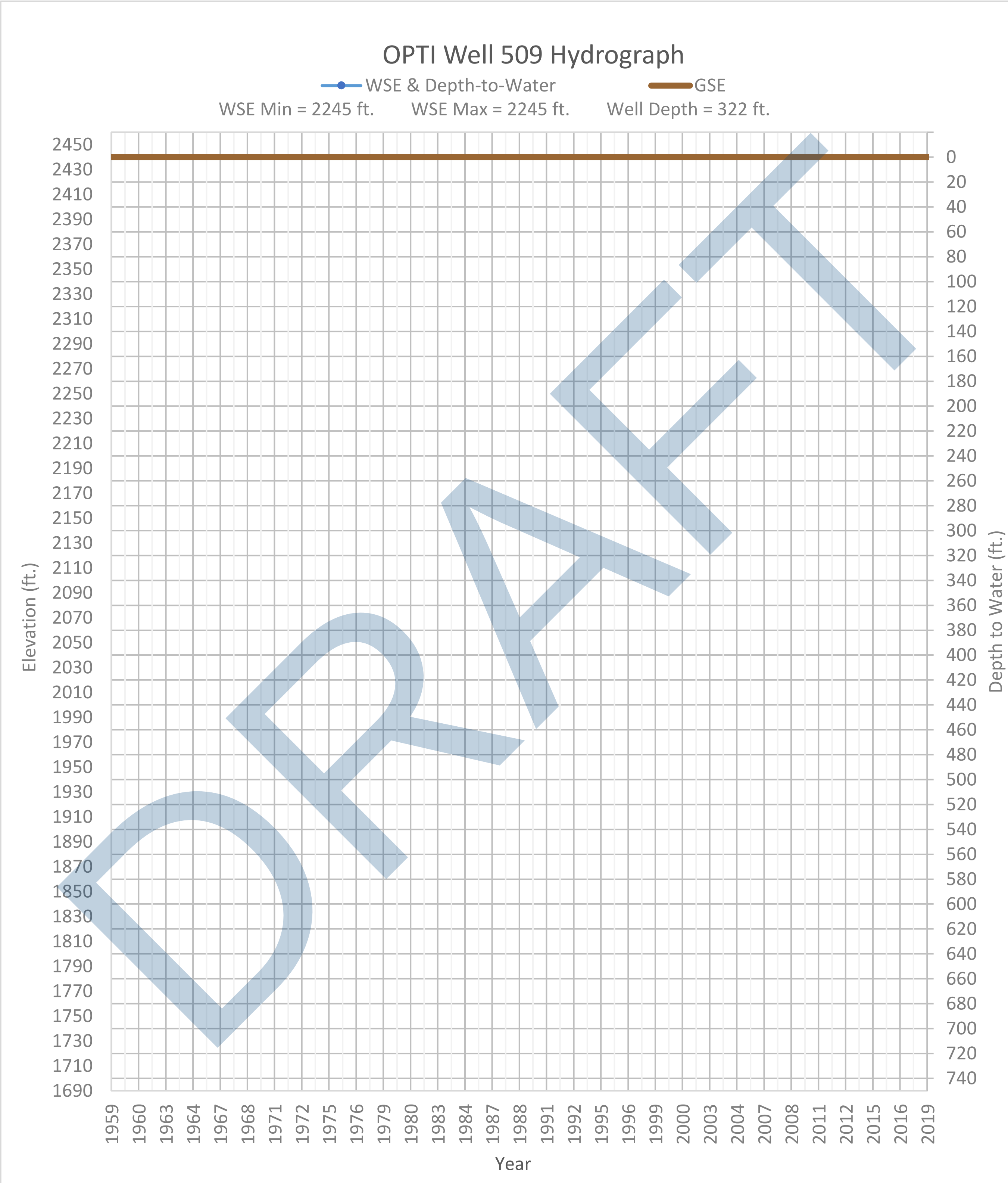


OPTI Well 505 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2206 ft.
WSE Max = 2206 ft.
Well Depth = 306 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

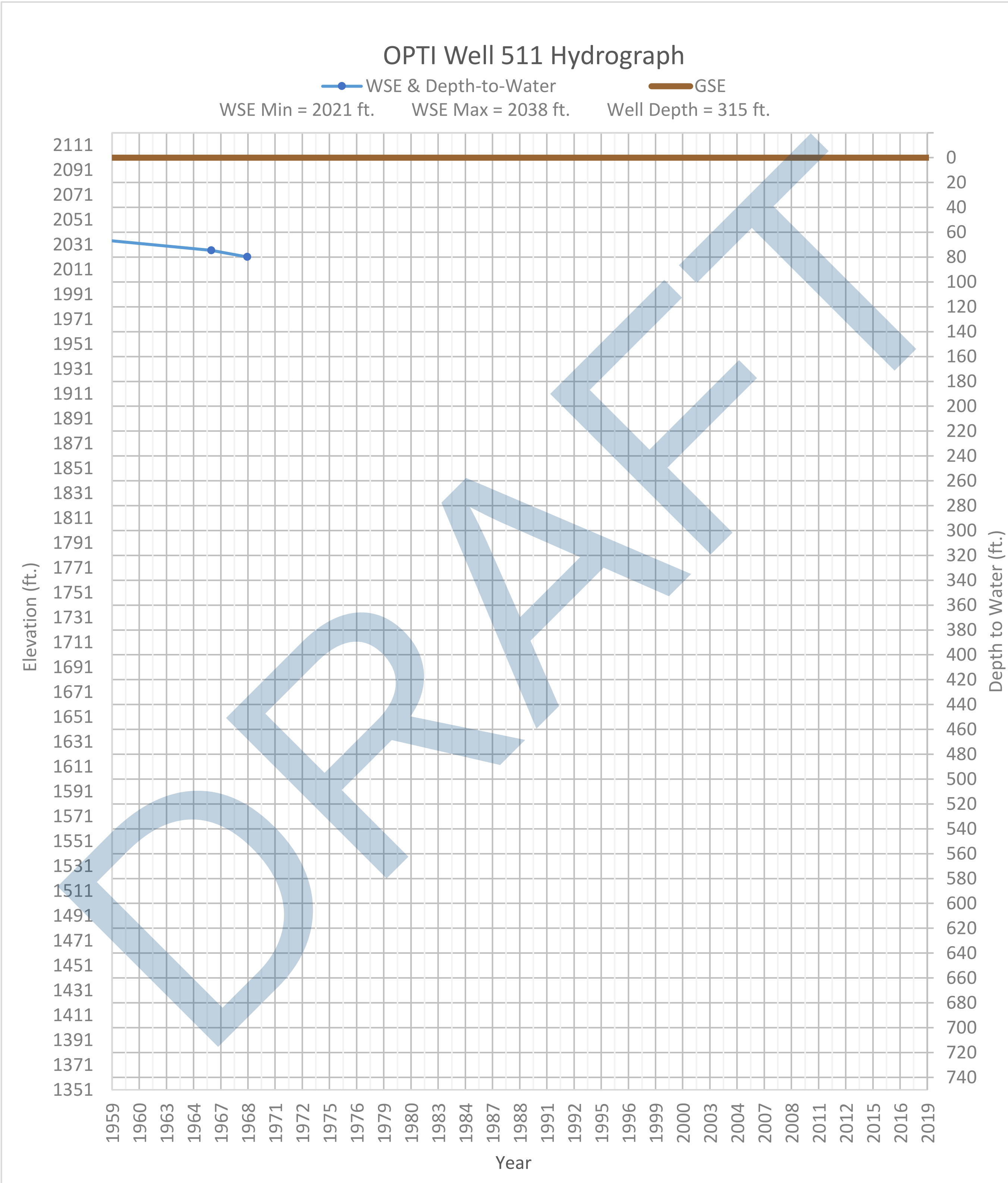

OPTI Well 506 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2155 ft.
WSE Max = 2185 ft.
Well Depth = 678 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



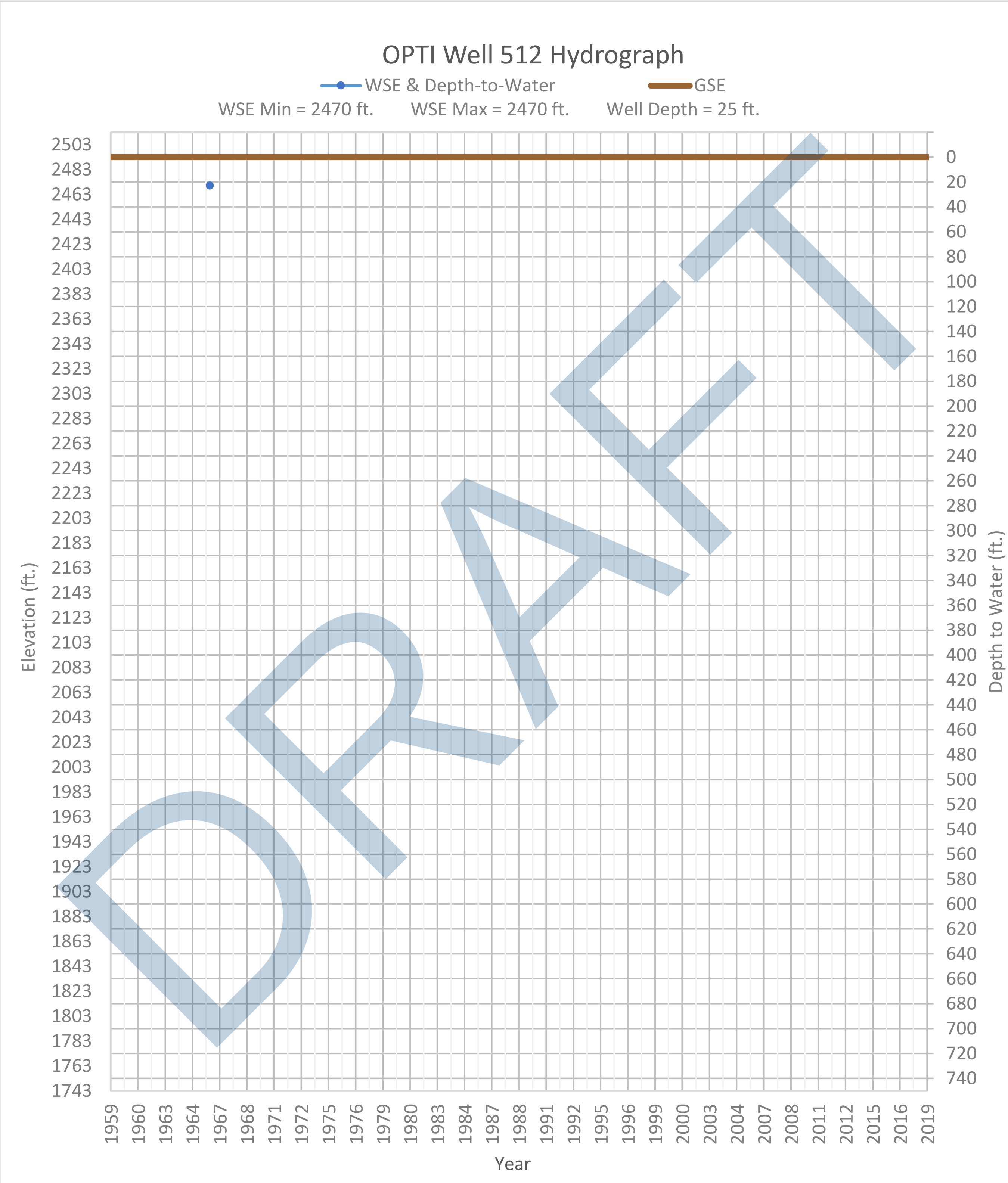
OPTI Well 508 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2036 ft.
WSE Max = 2040 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 509 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2245 ft.
WSE Max = 2245 ft.
Well Depth = 322 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 511 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2021 ft.
WSE Max = 2038 ft.
Well Depth = 315 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 512 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2470 ft.
WSE Max = 2470 ft.
Well Depth = 25 ft.
Elevation (ft.)
2503
2483
2463
2443
2423
2403
2383
2363
2343
2323
2303
2283
2263
2243
2223
2203
2183
2163
2143
2123
2103
2083
2063
2043
2023
2003
1983
1963
1943
1923
1903
1883
1863
1843
1823
1803
1783
1763
1743
Depth to Water (ft.)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
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520
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680
700
720
740
1959
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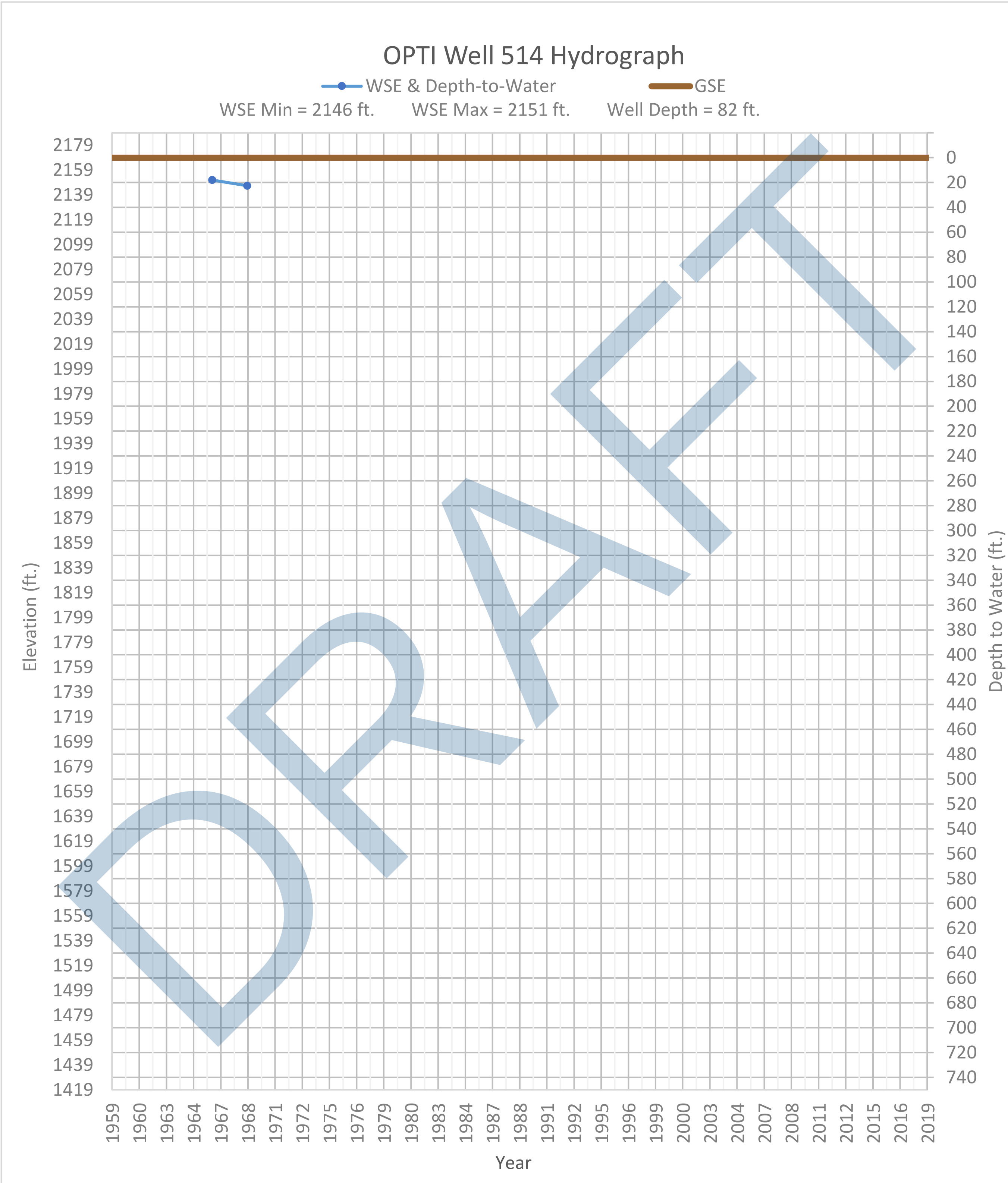
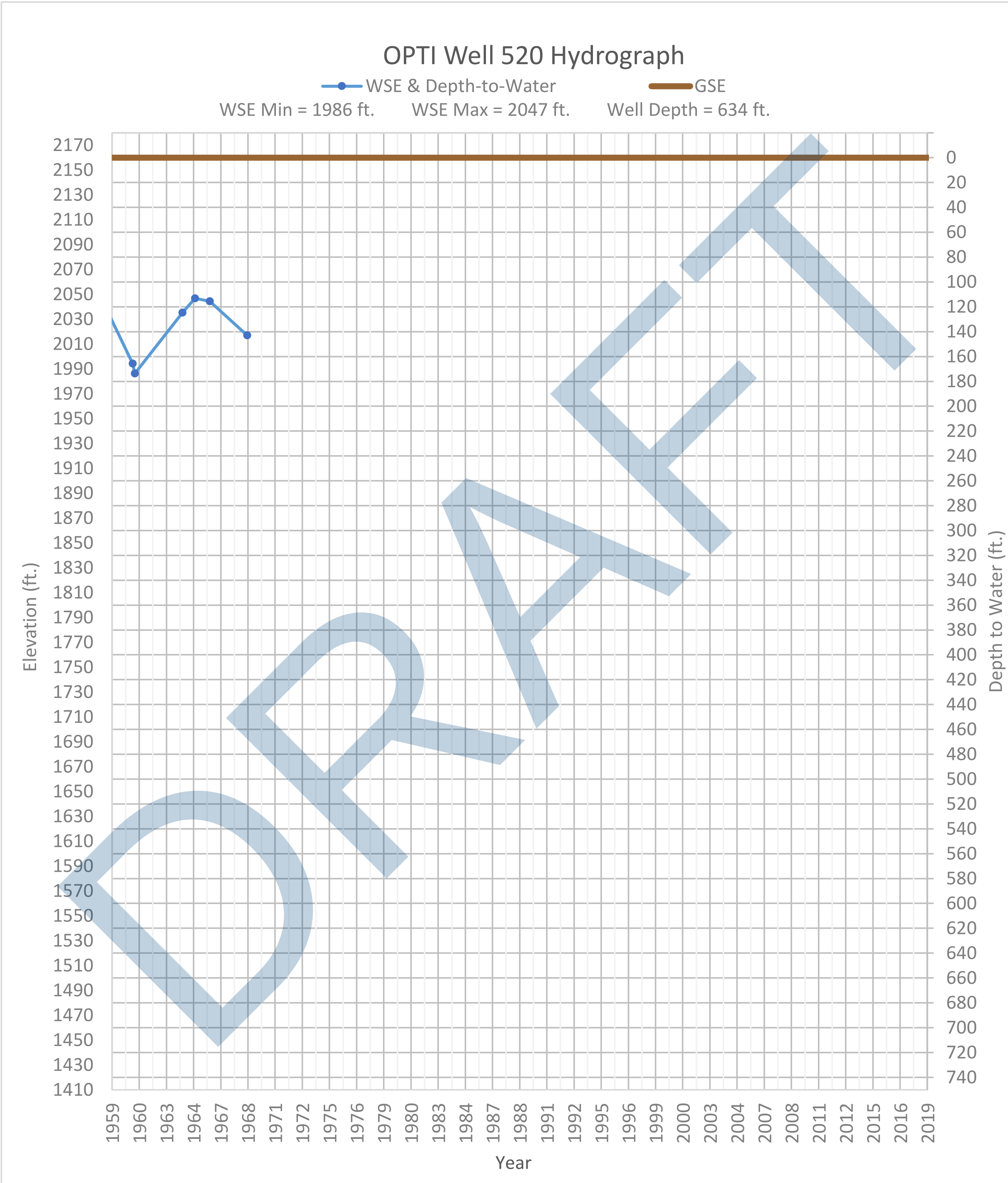
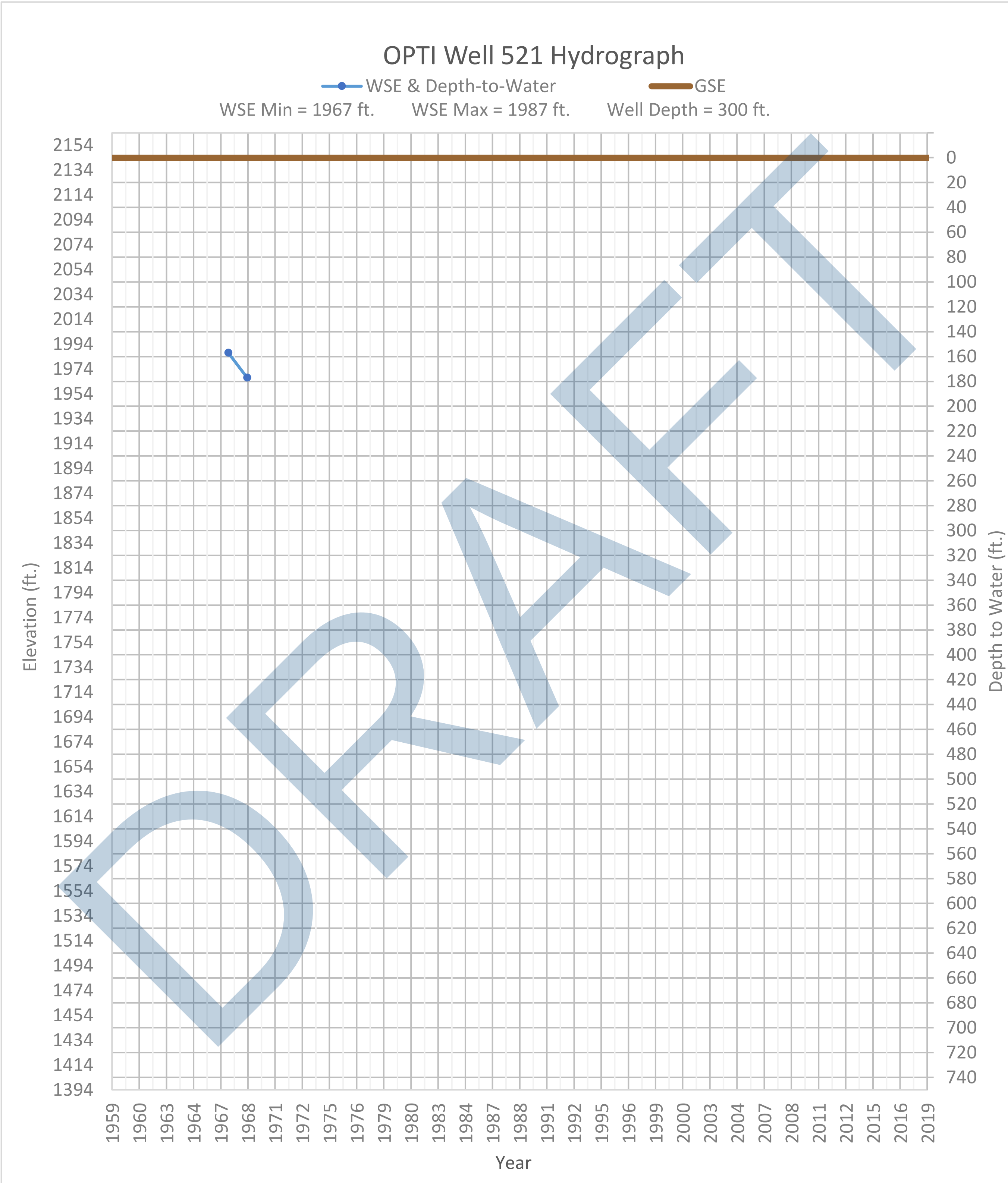
2019
Year
DRAFT

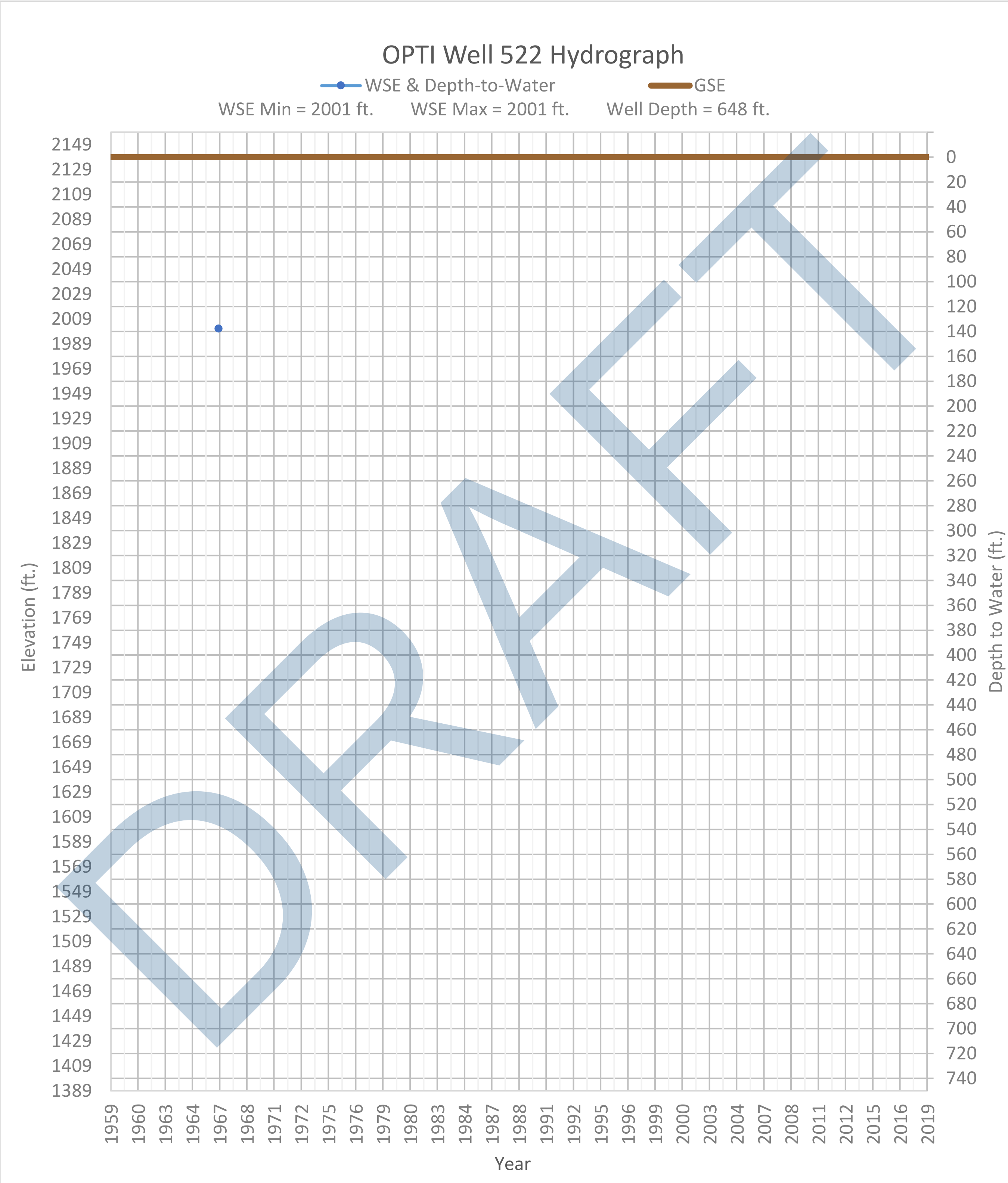


OPTI Well 514 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2146 ft.
WSE Max = 2151 ft.
Well Depth = 82 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

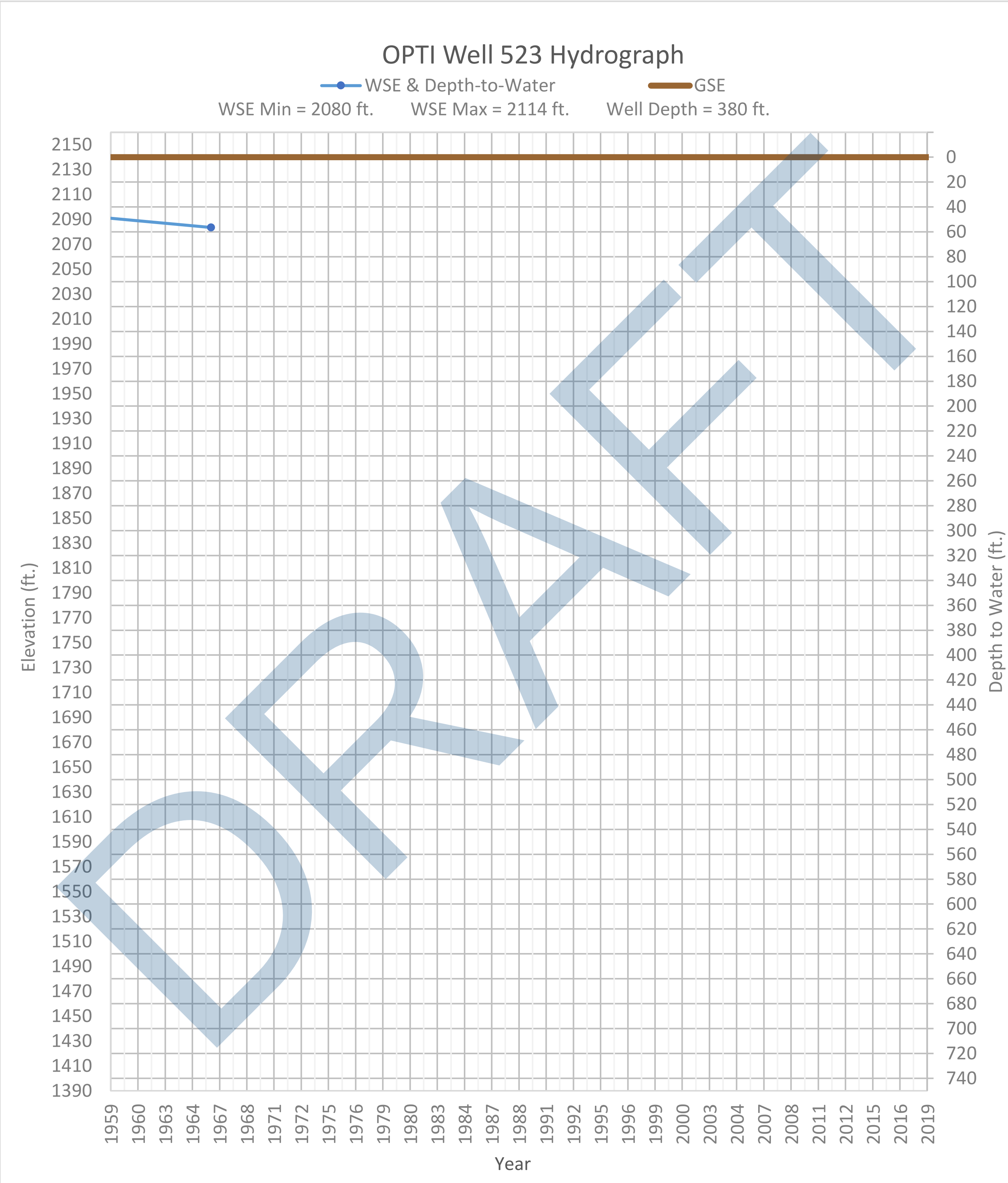

OPTI Well 520 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1986 ft.
WSE Max = 2047 ft.
Well Depth = 634 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 521 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1967 ft.
WSE Max = 1987 ft.
Well Depth = 300 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 522 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2001 ft.
WSE Max = 2001 ft.
Well Depth = 648 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 523 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2080 ft.
WSE Max = 2114 ft.
Well Depth = 380 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2150
2130
2110
2090
2070
2050
2030
2010
1990
1970
1950
1930
1910
1890
1870
1850
1830
1810
1790
1770
1750
1730
1710
1690
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1610
1590
1570
1550
1530
1510
1490
1470
1450
1430
1410
1390
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
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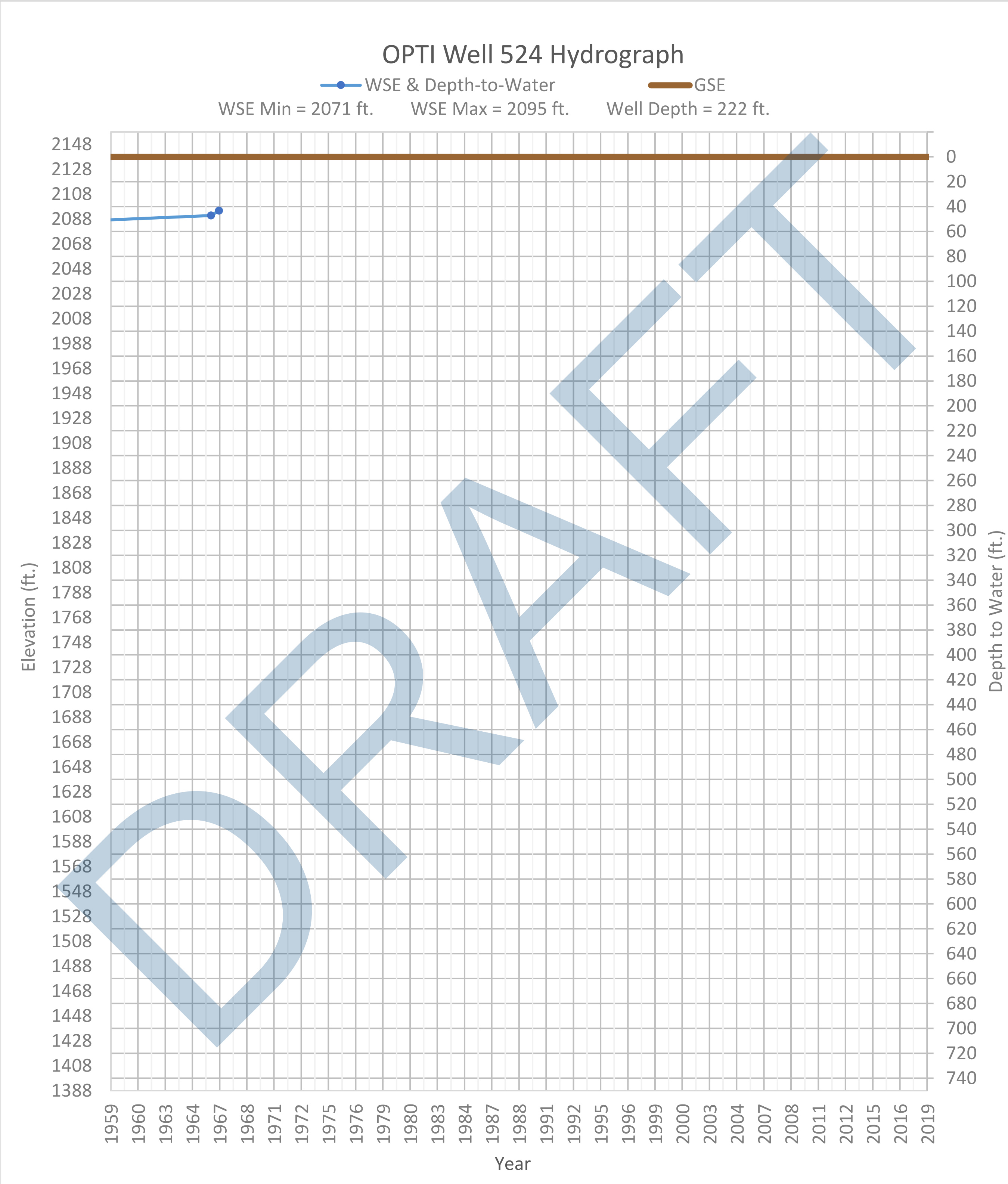
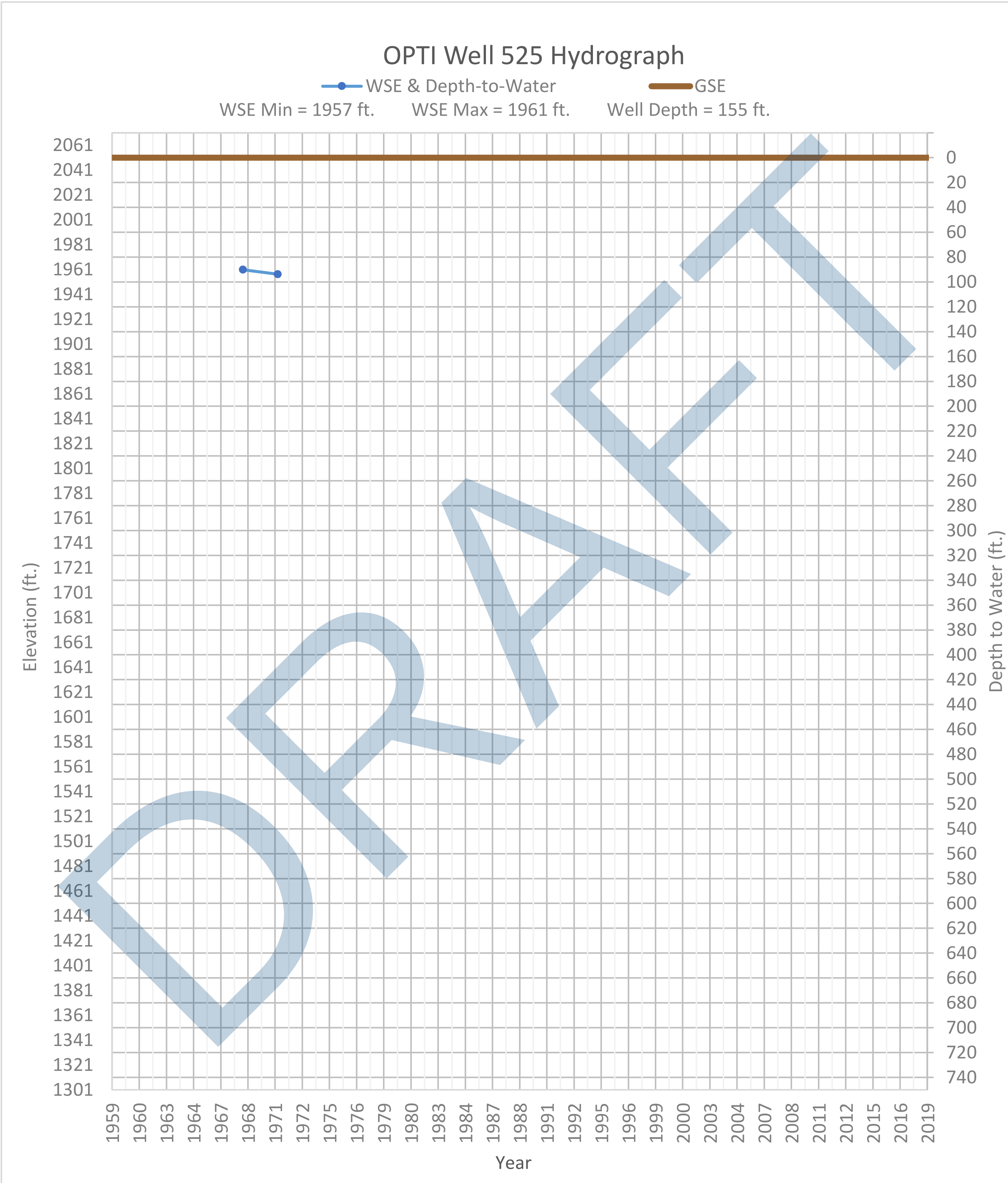
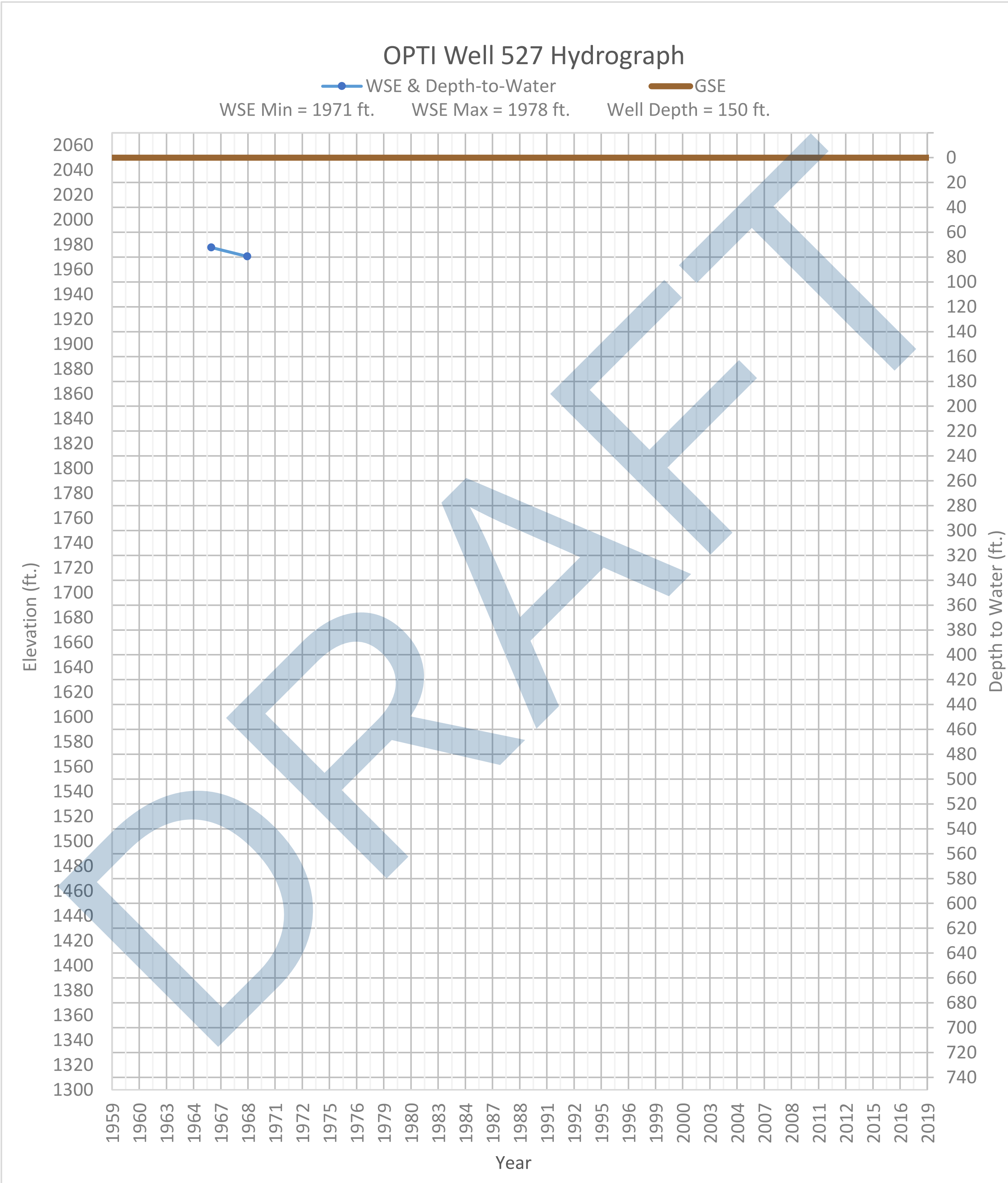
DRAFT

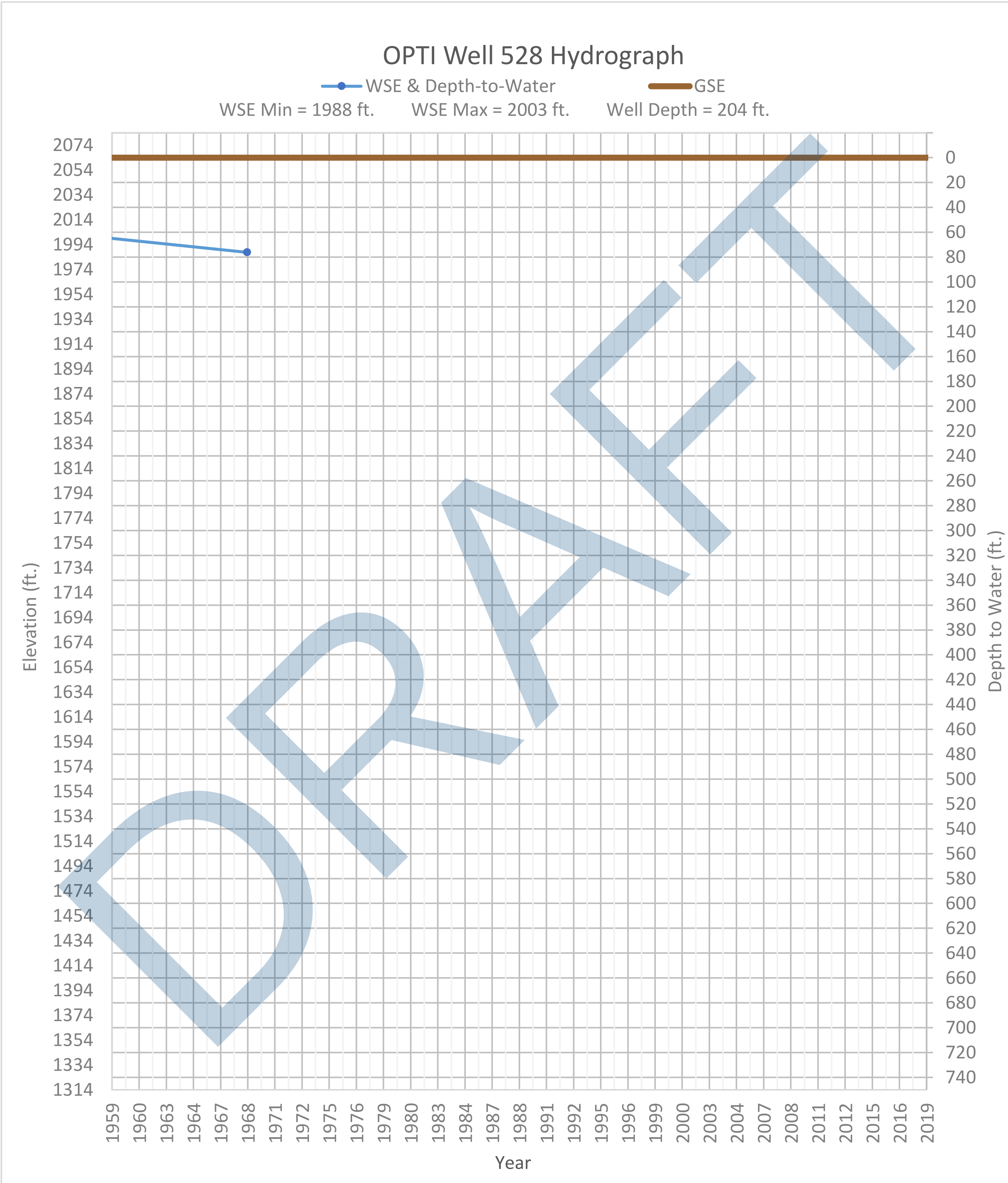


OPTI Well 524 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2071 ft.
WSE Max = 2095 ft.
Well Depth = 222 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

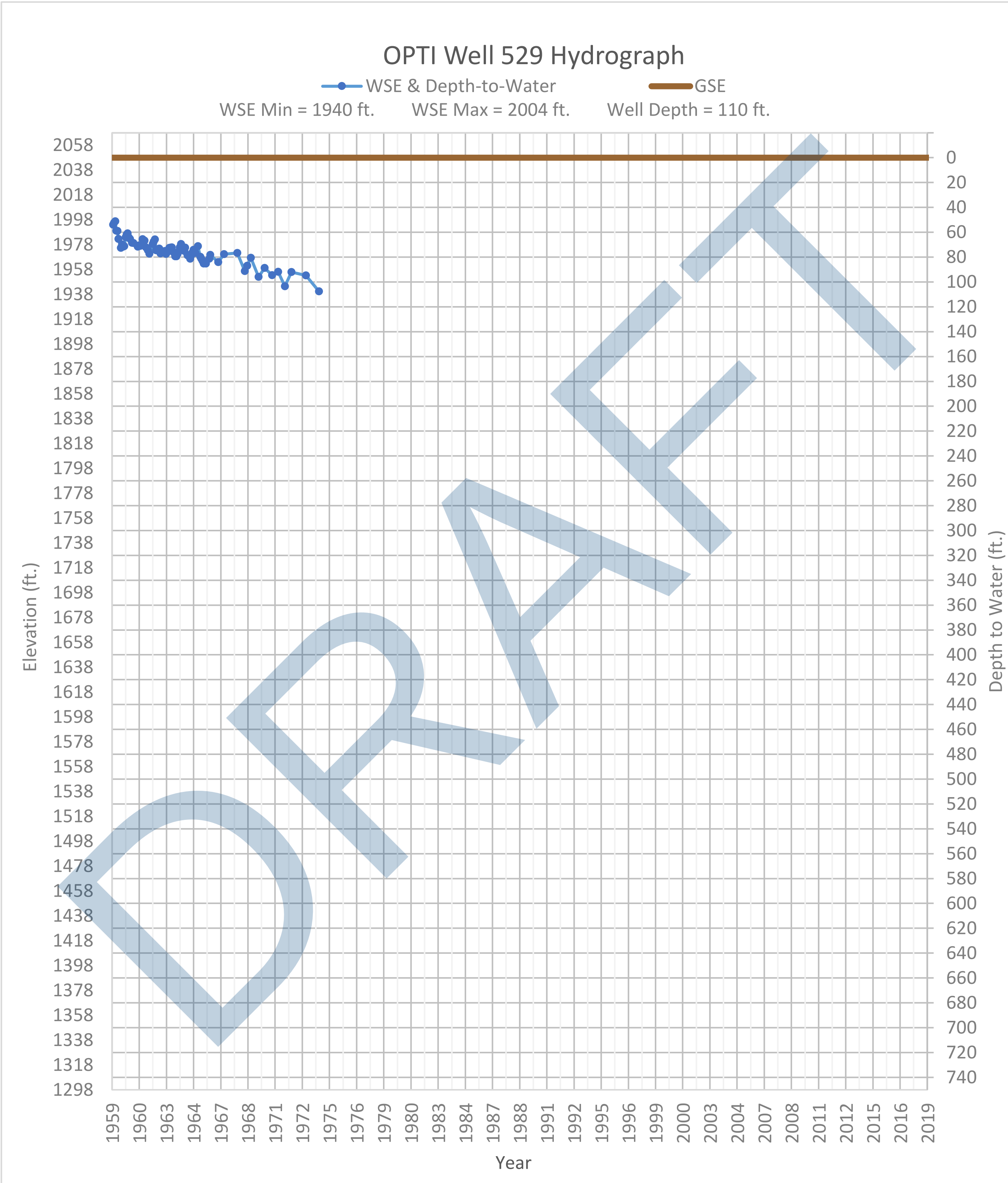

OPTI Well 525 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1957 ft.
WSE Max = 1961 ft.
Well Depth = 155 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2061 2041 2021 2001 1981 1961 1941 1921 1901 1881 1861 1841 1821 1801 1781 1761 1741 1721 1701 1681 1661 1641 1621 1601 1581 1561 1541 1521 1501 1481 1461 1441 1421 1401 1381 1361 1341 1321 1301
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720 740
1959 1960 1963 1964 1967 1968 1971 1972 1975 1976 1979 1980 1983 1984 1987 1988 1991 1992 1995 1996 1999 2000 2003 2004 2007 2008 2011 2012 2015 2016 2019
DRAFT

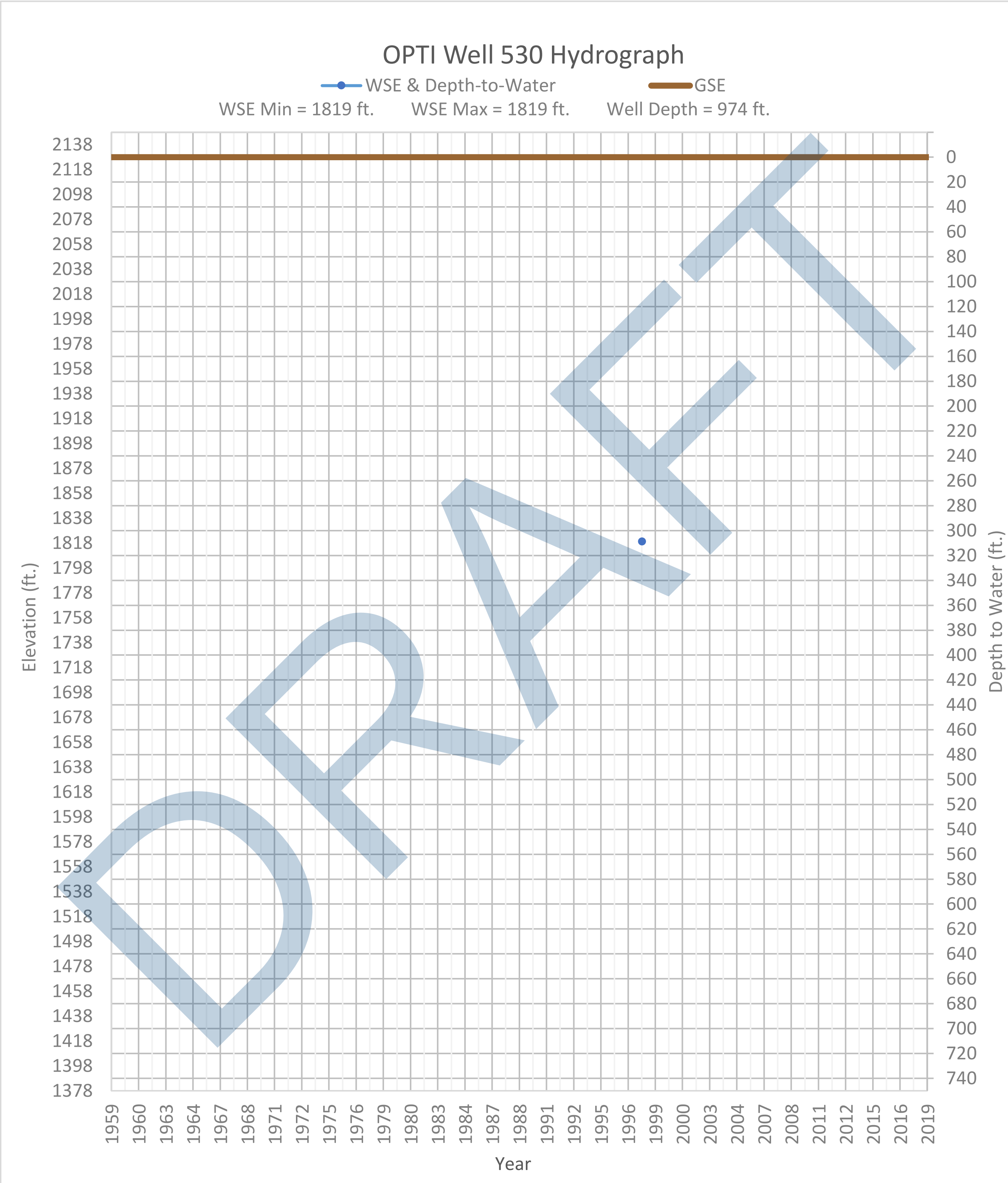


OPTI Well 527 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1971 ft.
WSE Max = 1978 ft.
Well Depth = 150 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

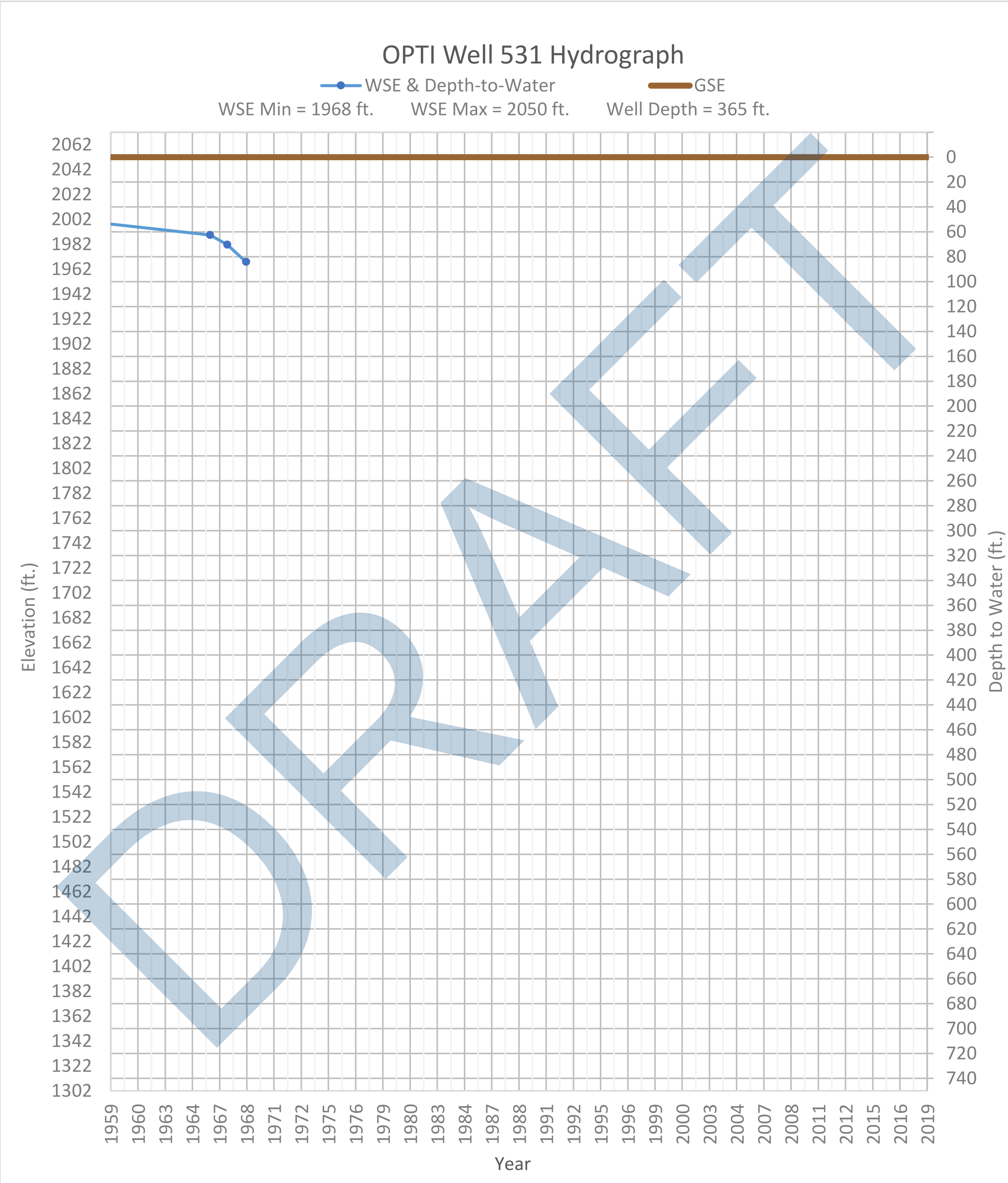


OPTI Well 528 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1988 ft.
WSE Max = 2003 ft.
Well Depth = 204 ft.
Elevation (ft.)
Depth to Water (ft.)
Year


OPTI Well 529 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1940 ft.
WSE Max = 2004 ft.
Well Depth = 110 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 530 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1819 ft.
WSE Max = 1819 ft.
Well Depth = 974 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2138 2118 2098 2078 2058 2038 2018 1998 1978 1958 1938 1918 1898 1878 1858 1838 1818 1798 1778 1758 1738 1718 1698 1678 1658 1638 1618 1598 1578 1558 1538 1518 1498 1478 1458 1438 1418 1398 1378
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720 740
1959 1960 1963 1964 1967 1968 1971 1972 1975 1976 1979 1980 1983 1984 1987 1988 1991 1992 1995 1996 1999 2000 2003 2004 2007 2008 2011 2012 2015 2016 2019
DRAFT



OPTI Well 531 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1968 ft.
WSE Max = 2050 ft.
Well Depth = 365 ft.
Elevation (ft.)
2062
2042
2022
2002
1982
1962
1942
1922
1902
1882
1862
1842
1822
1802
1782
1762
1742
1722
1702
1682
1662
1642
1622
1602
1582
1562
1542
1522
1502
1482
1462
1442
1422
1402
1382
1362
1342
1322
1302
Depth to Water (ft.)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
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560
580
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2016
2019
Year
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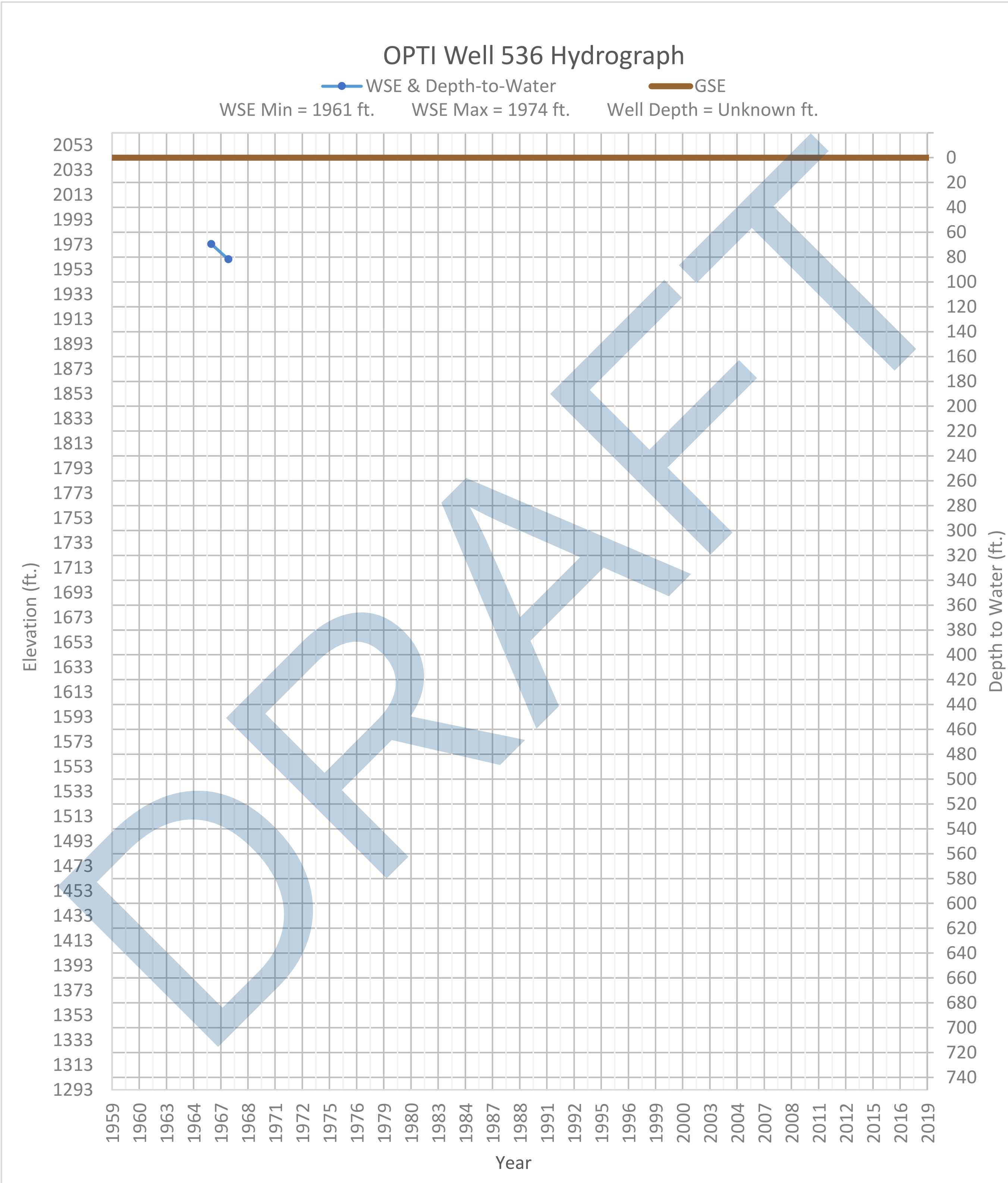
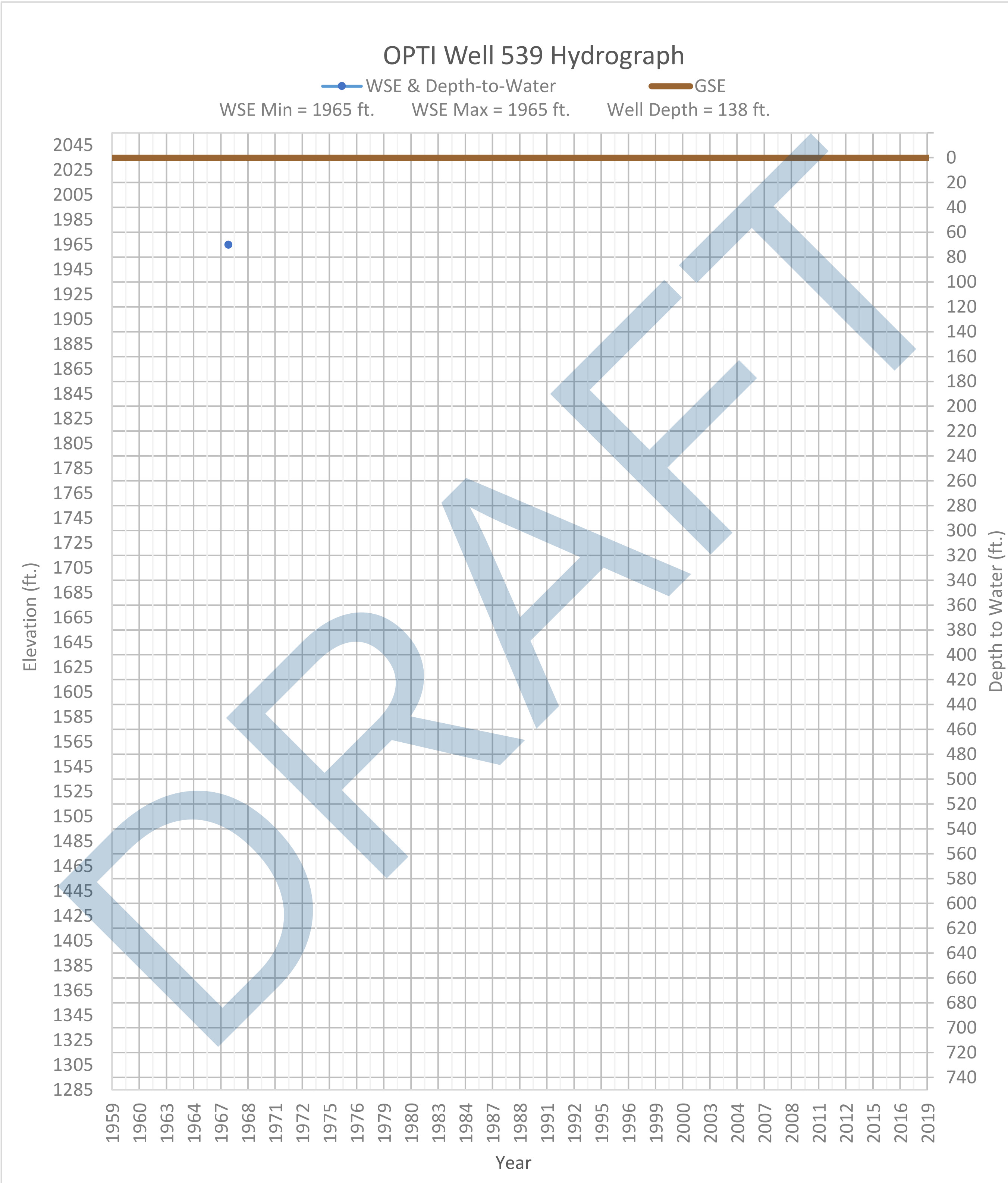
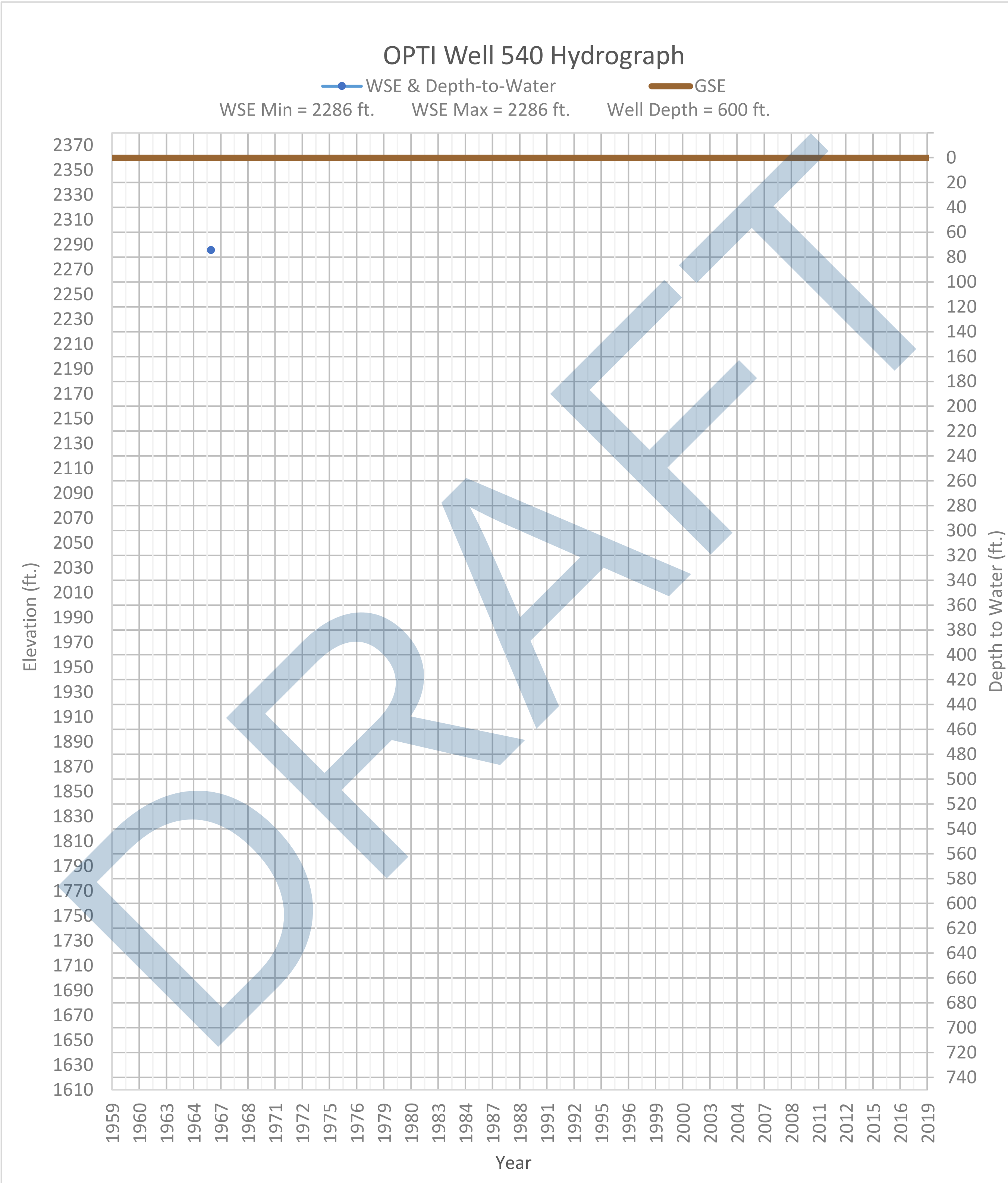
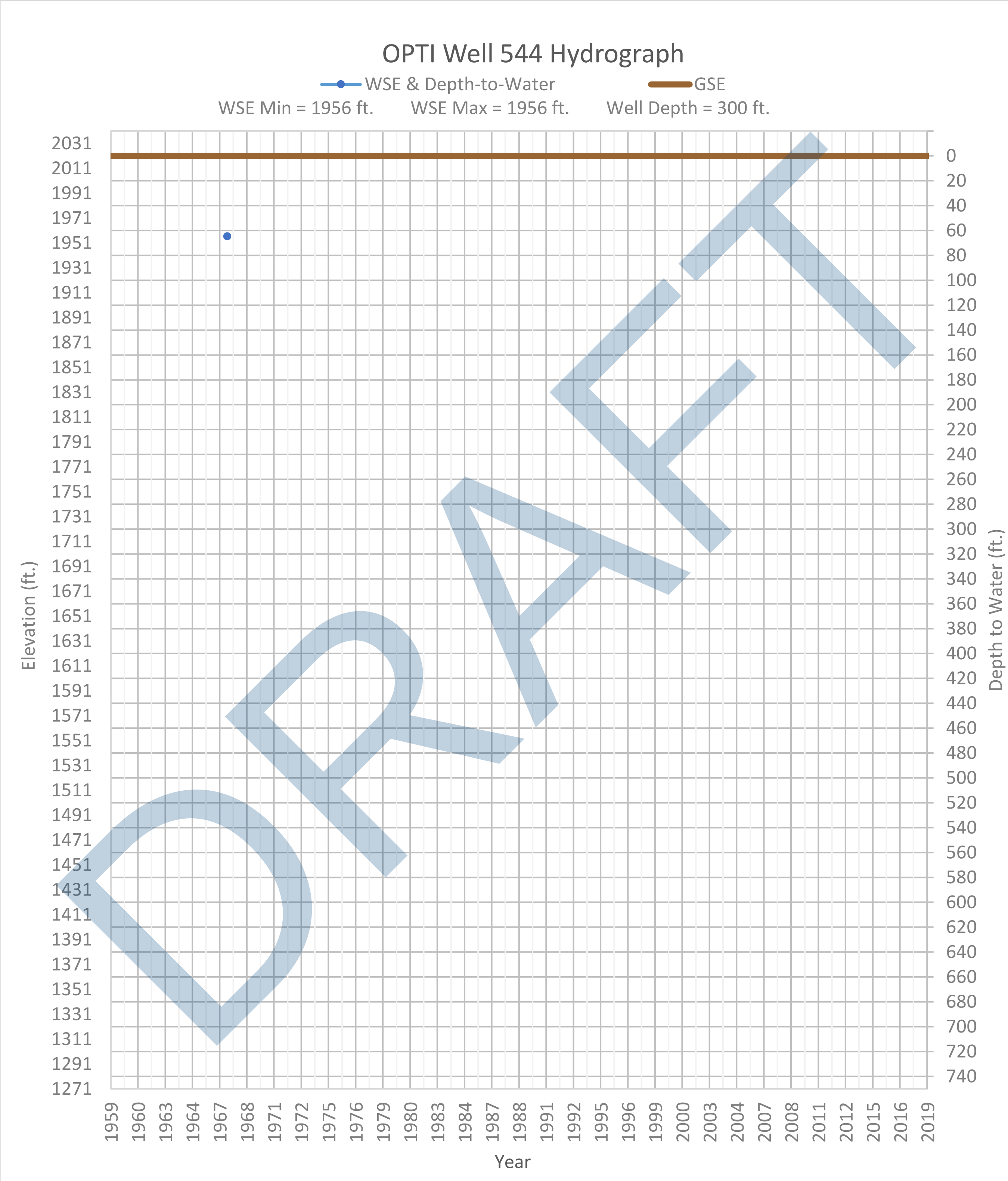


OPTI Well 536 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1961 ft.
WSE Max = 1974 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

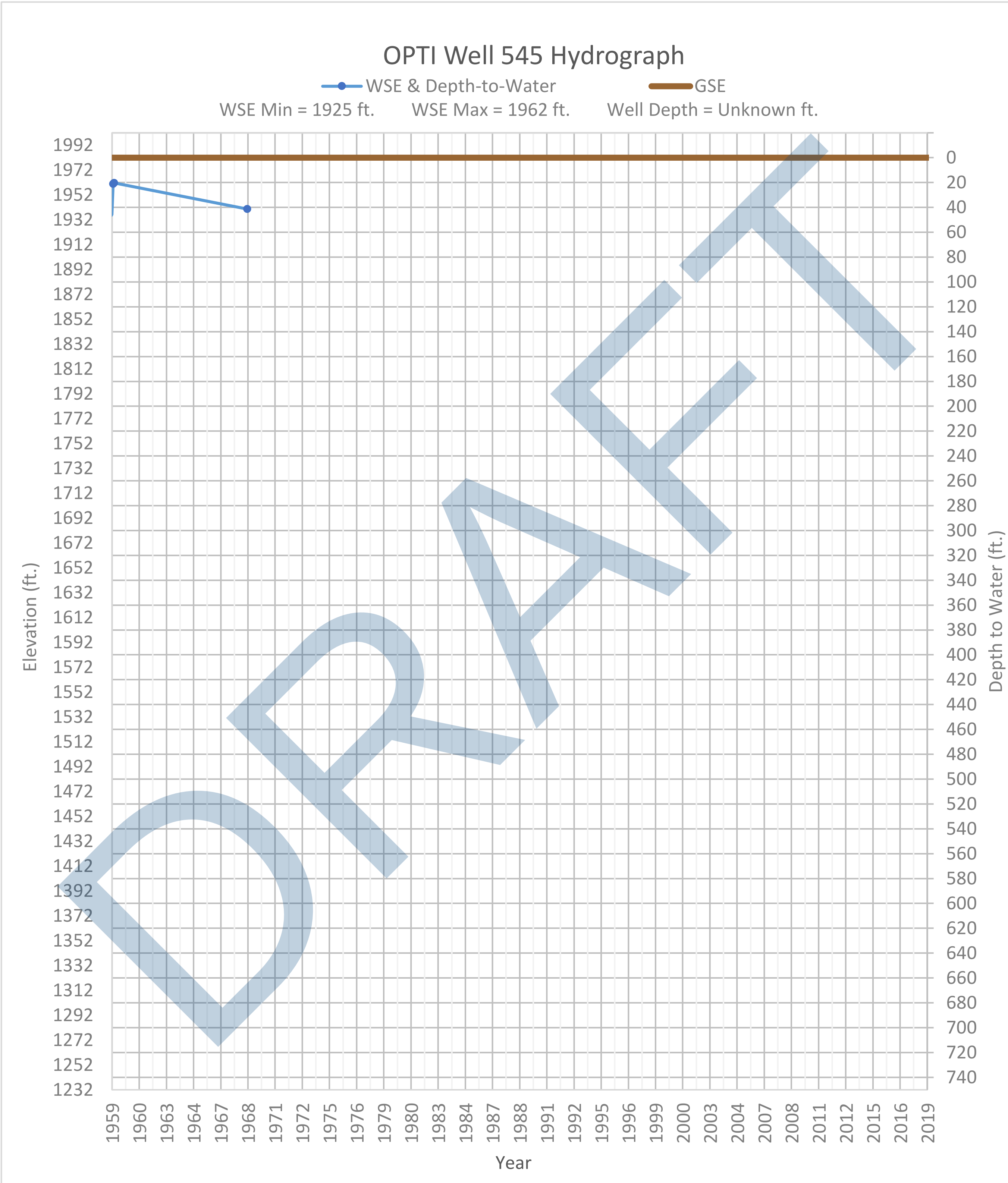

OPTI Well 539 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1965 ft.
WSE Max = 1965 ft.
Well Depth = 138 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



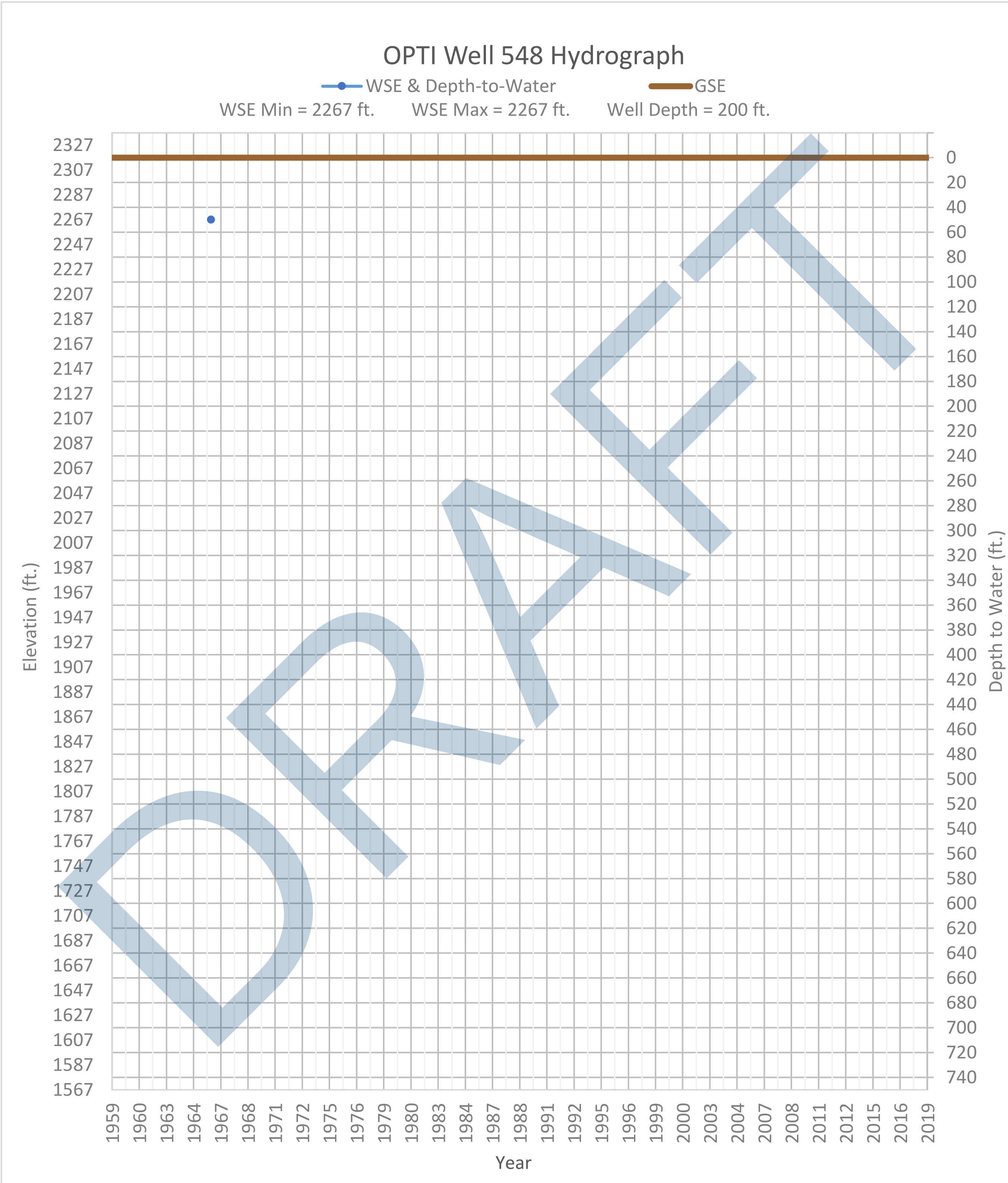
OPTI Well 540 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2286 ft.
WSE Max = 2286 ft.
Well Depth = 600 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



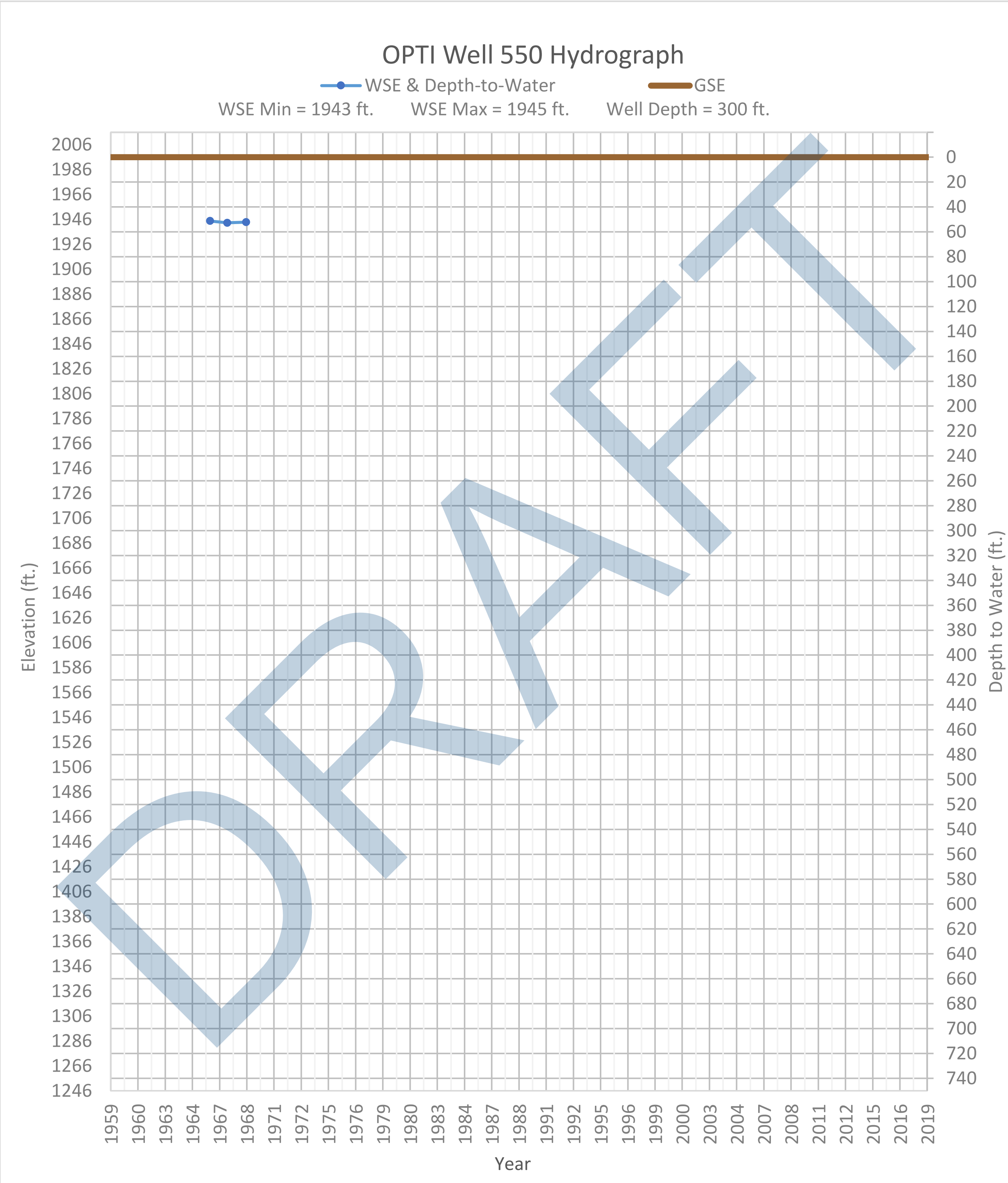
OPTI Well 544 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1956 ft.
WSE Max = 1956 ft.
Well Depth = 300 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 545 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1925 ft.
WSE Max = 1962 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 548 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2267 ft.
WSE Max = 2267 ft.
Well Depth = 200 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 550 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1943 ft.
WSE Max = 1945 ft.
Well Depth = 300 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2006
1986
1966
1946
1926
1906
1886
1866
1846
1826
1806
1786
1766
1746
1726
1706
1686
1666
1646
1626
1606
1586
1566
1546
1526
1506
1486
1466
1446
1426
1406
1386
1366
1346
1326
1306
1286
1266
1246
0
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60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
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420
440
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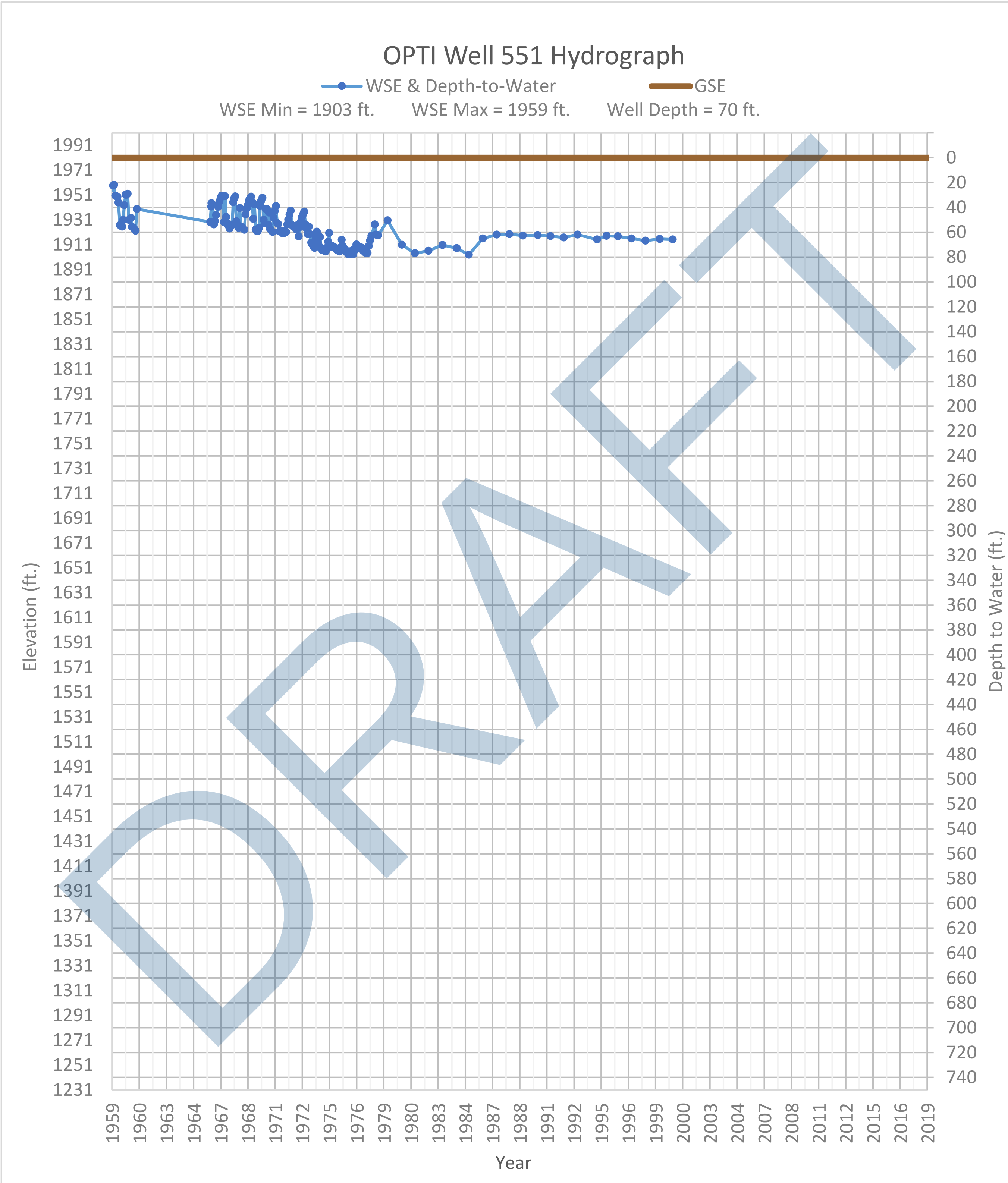
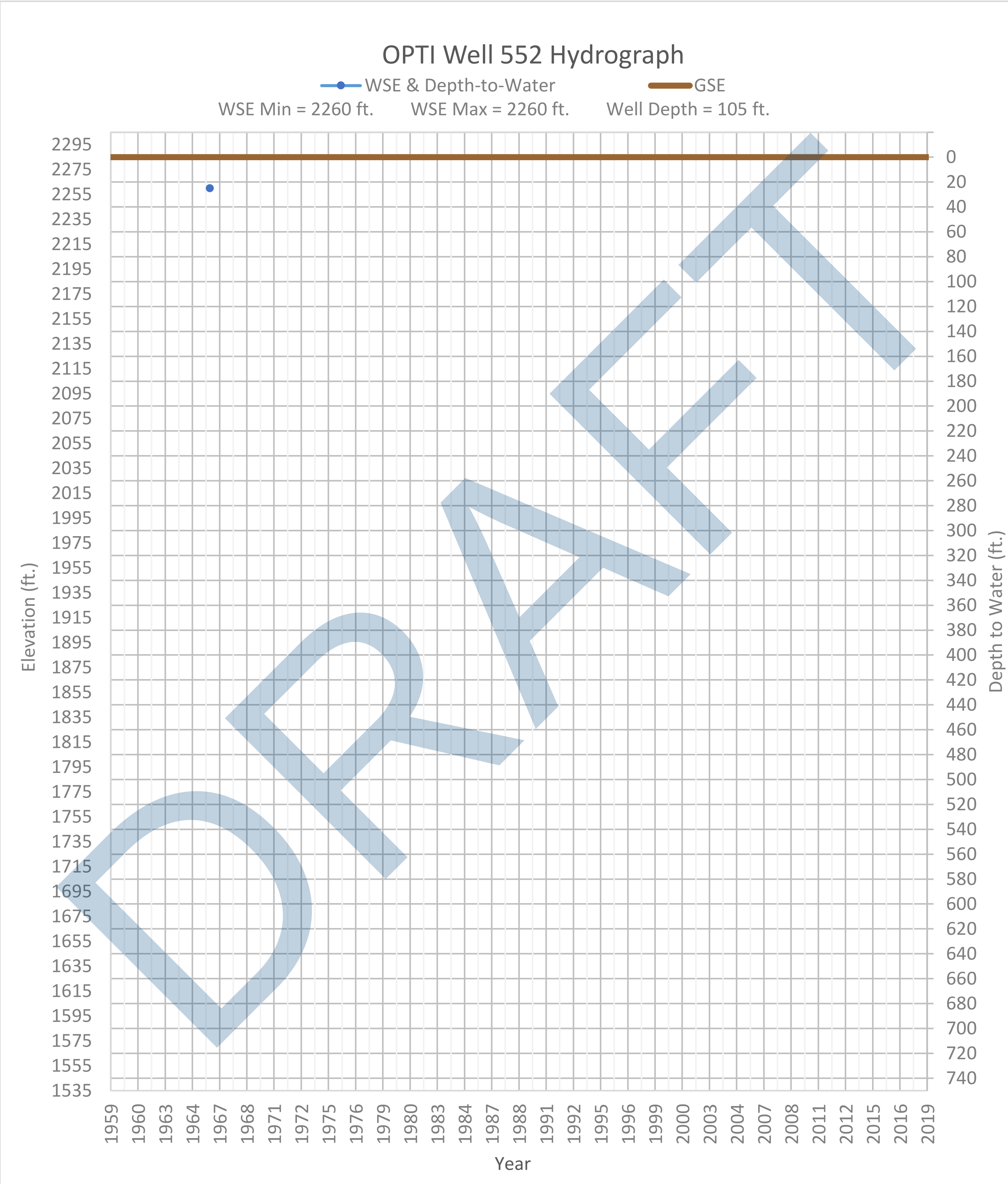
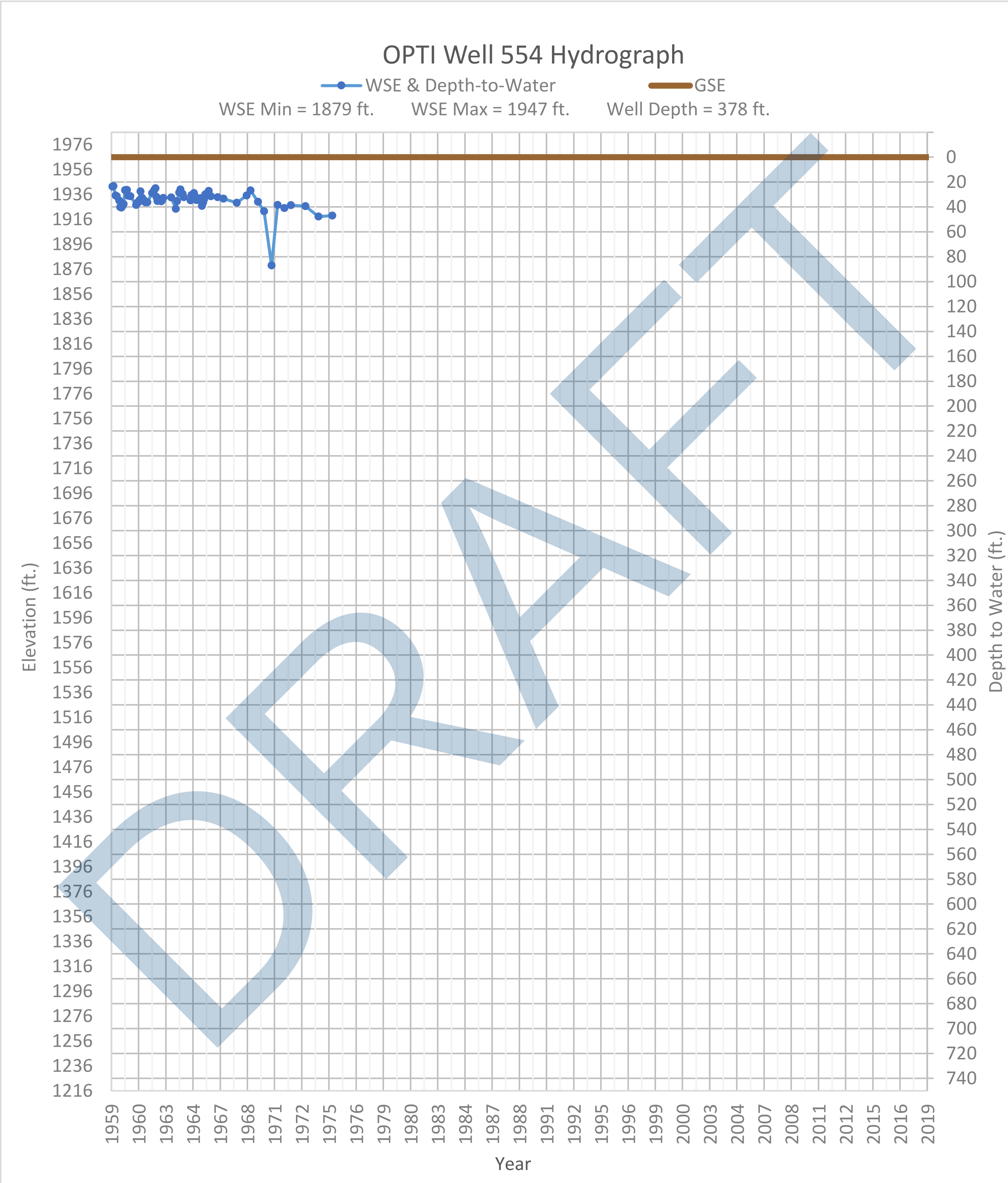
2019
DRAFT

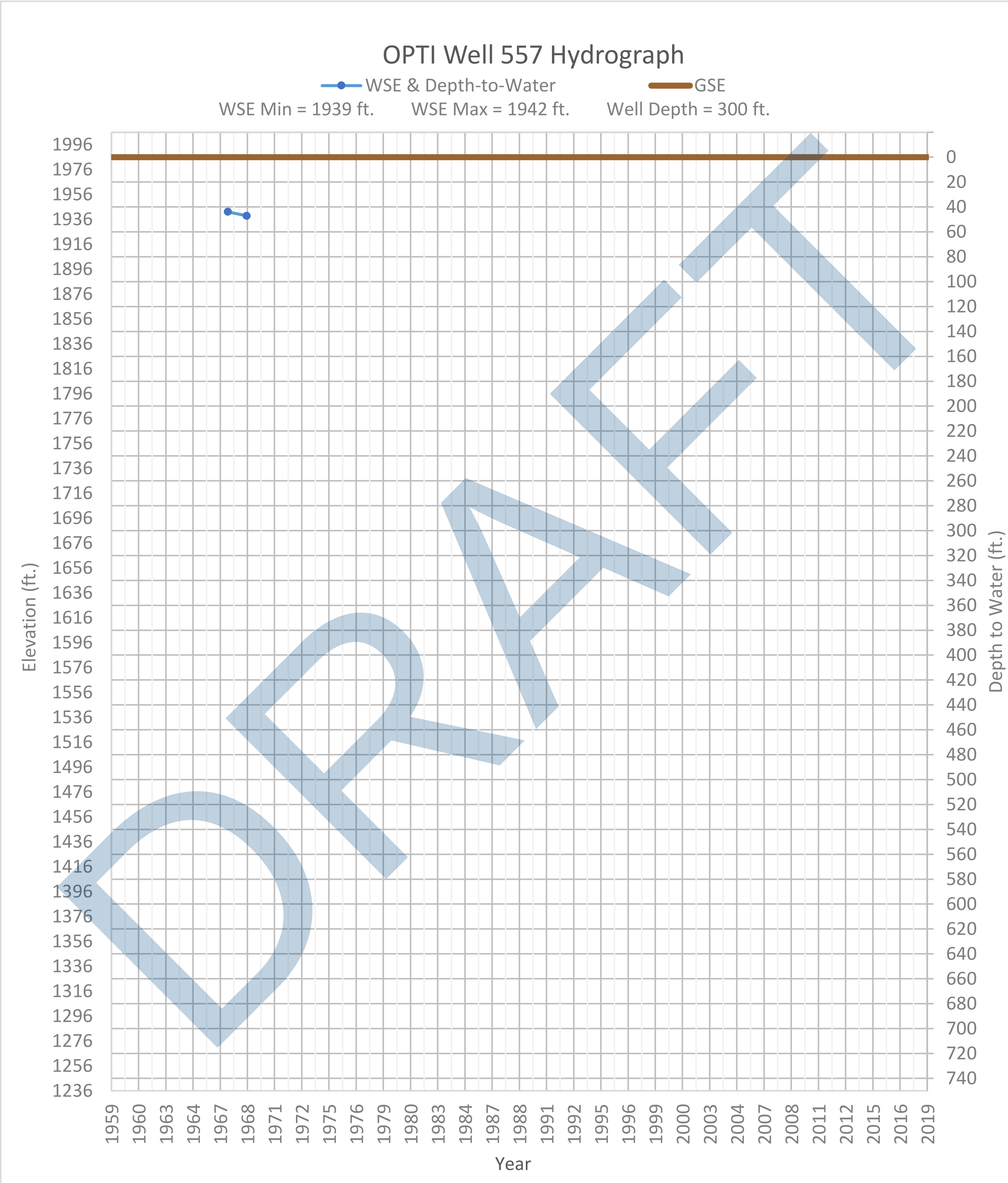

OPTI Well 551 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1903 ft.
WSE Max = 1959 ft.
Well Depth = 70 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 552 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2260 ft.
WSE Max = 2260 ft.
Well Depth = 105 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 554 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1879 ft.
WSE Max = 1947 ft.
Well Depth = 378 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 557 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1939 ft.
WSE Max = 1942 ft.
Well Depth = 300 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
1996
1976
1956
1936
1916
1896
1876
1856
1836
1816
1796
1776
1756
1736
1716
1696
1676
1656
1636
1616
1596
1576
1556
1536
1516
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1476
1456
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1416
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1356
1336
1316
1296
1276
1256
1236
0
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80
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180
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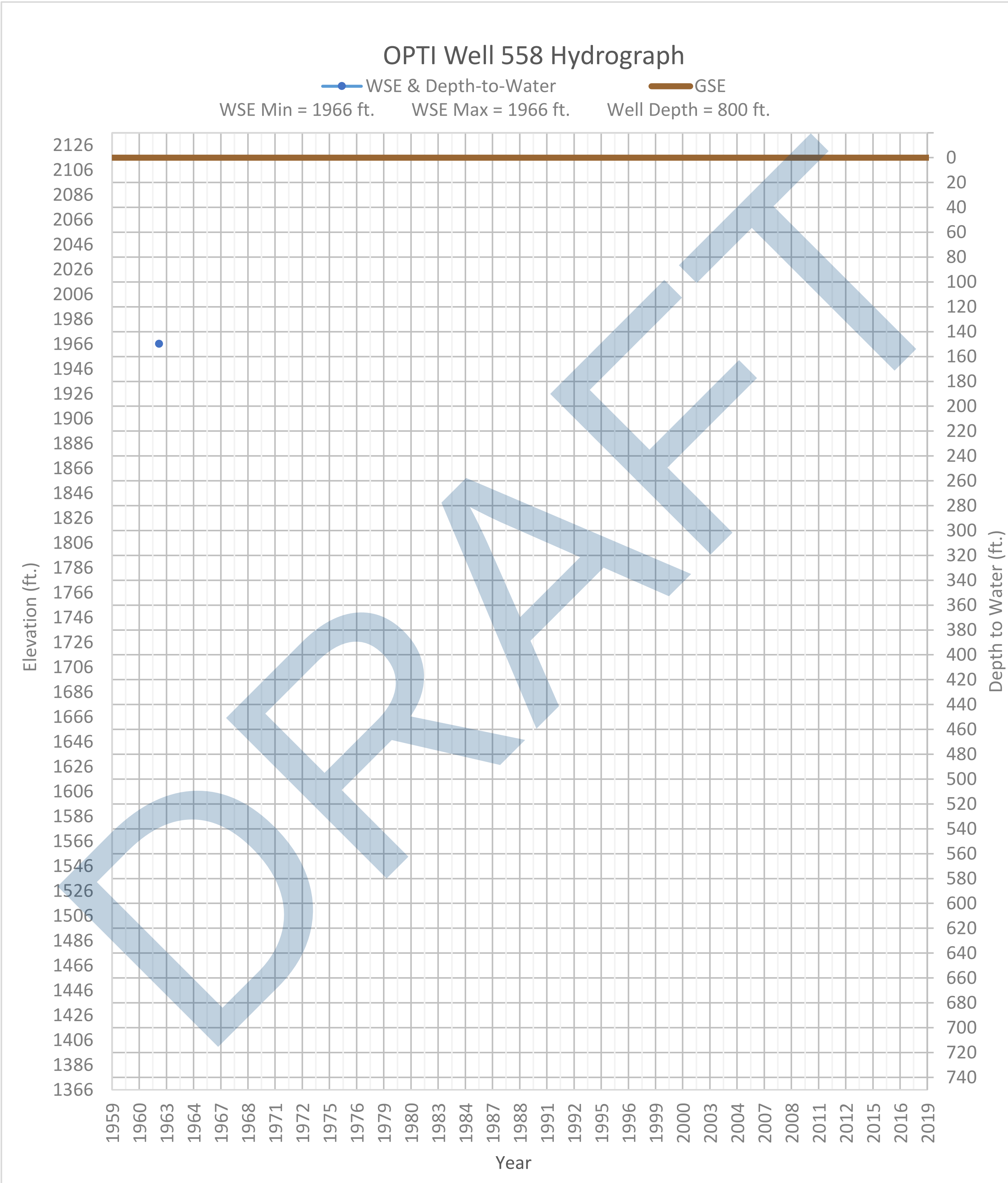
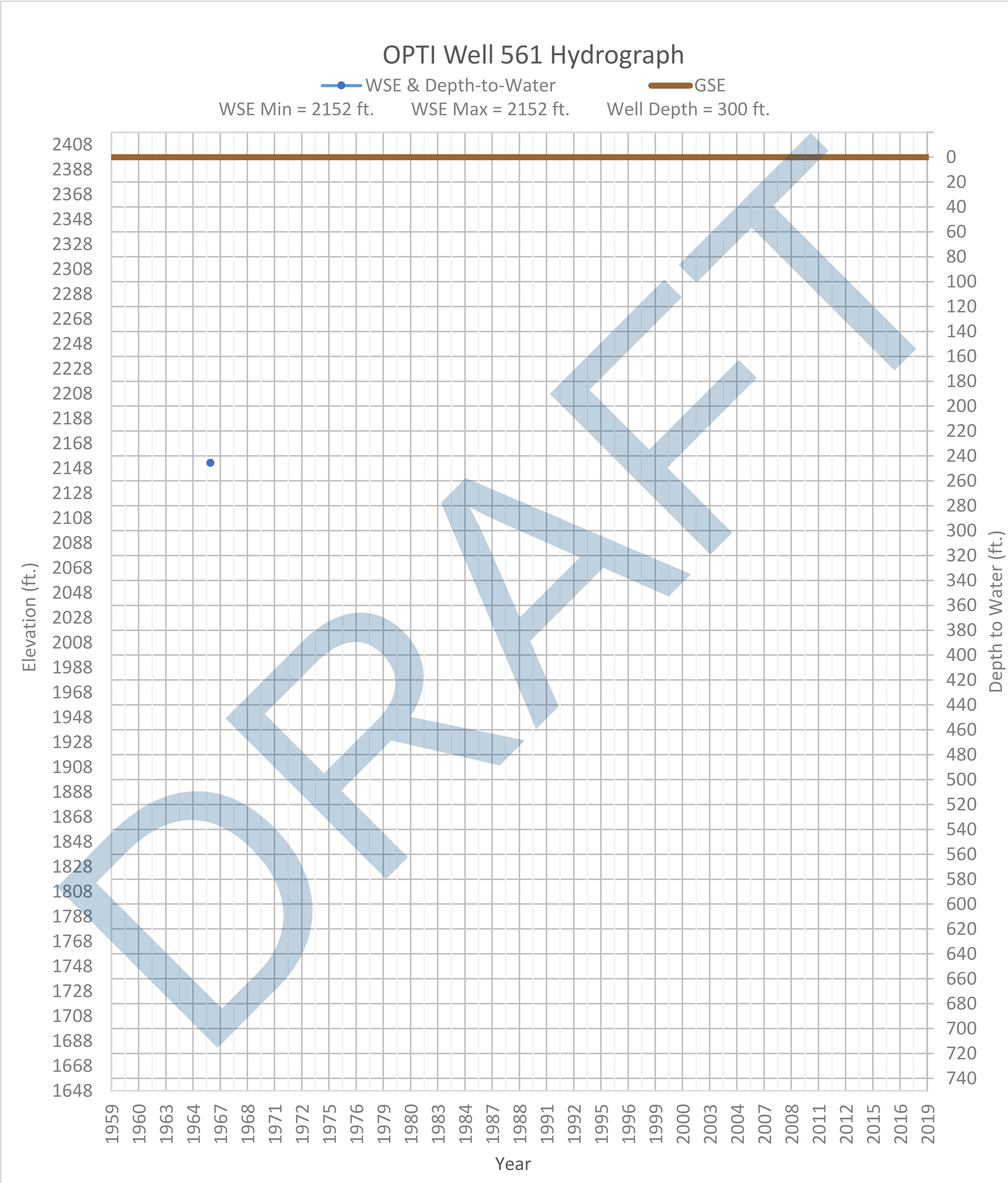
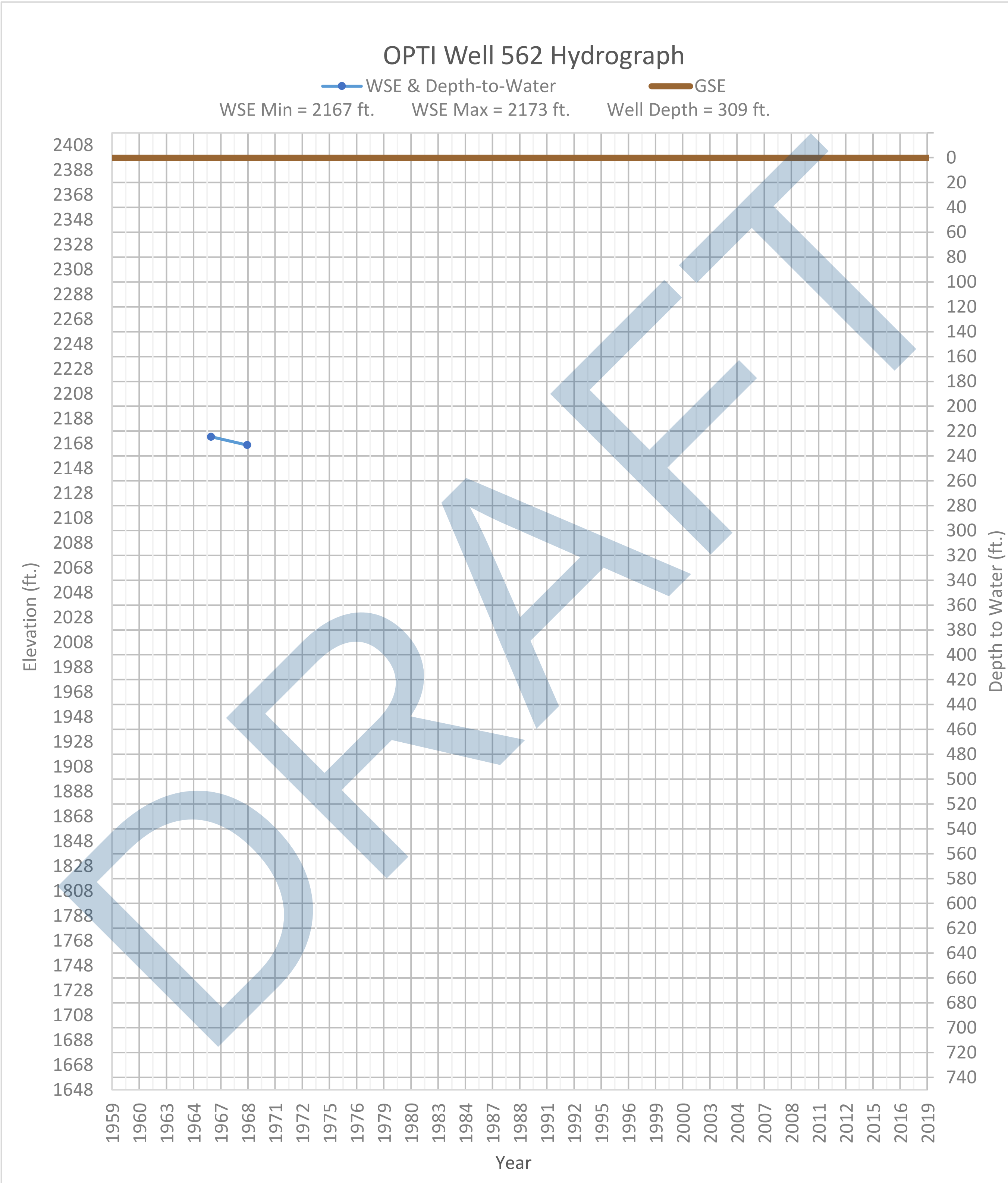
DRAFT



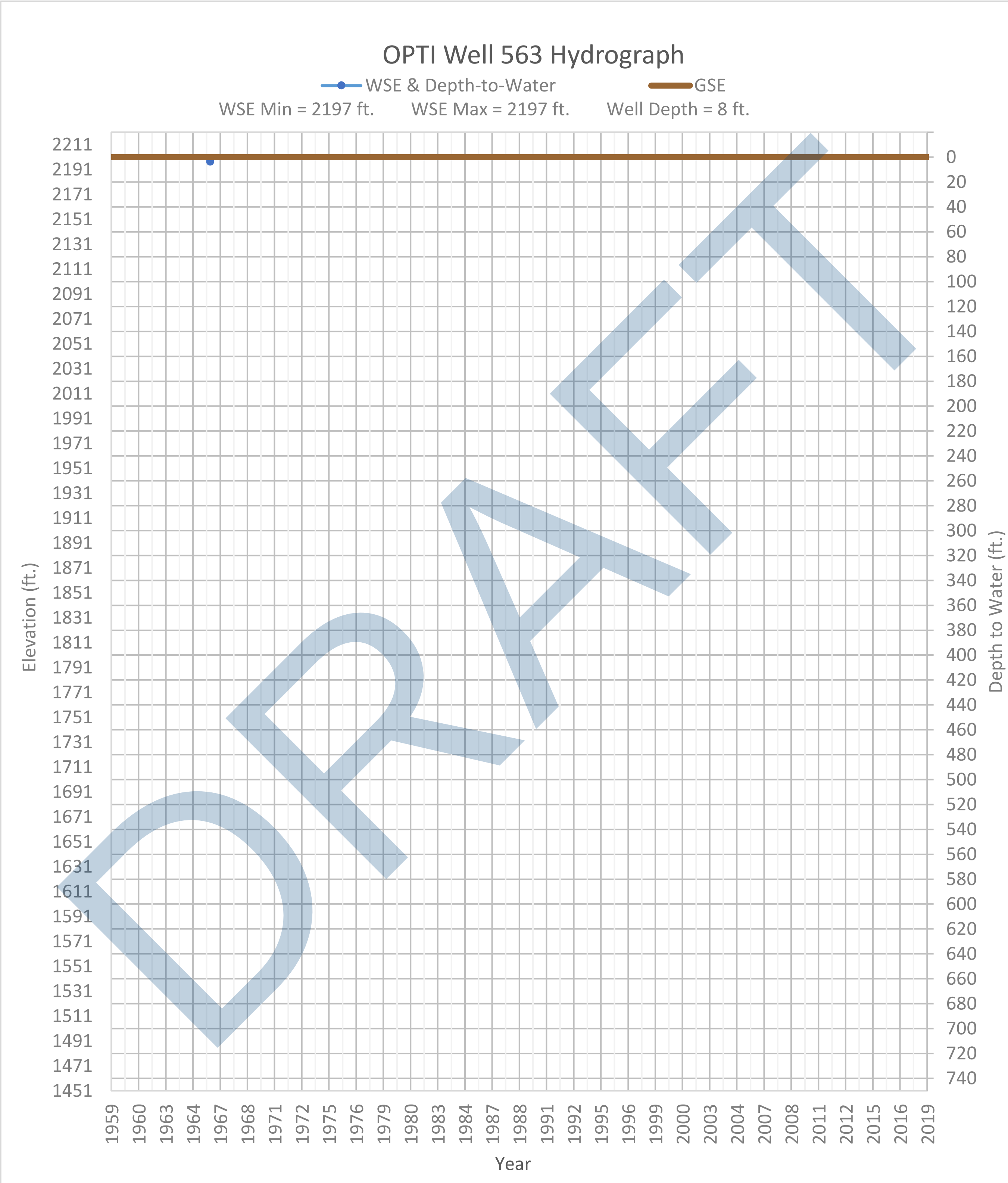
OPTI Well 558 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1966 ft.
WSE Max = 1966 ft.
Well Depth = 800 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

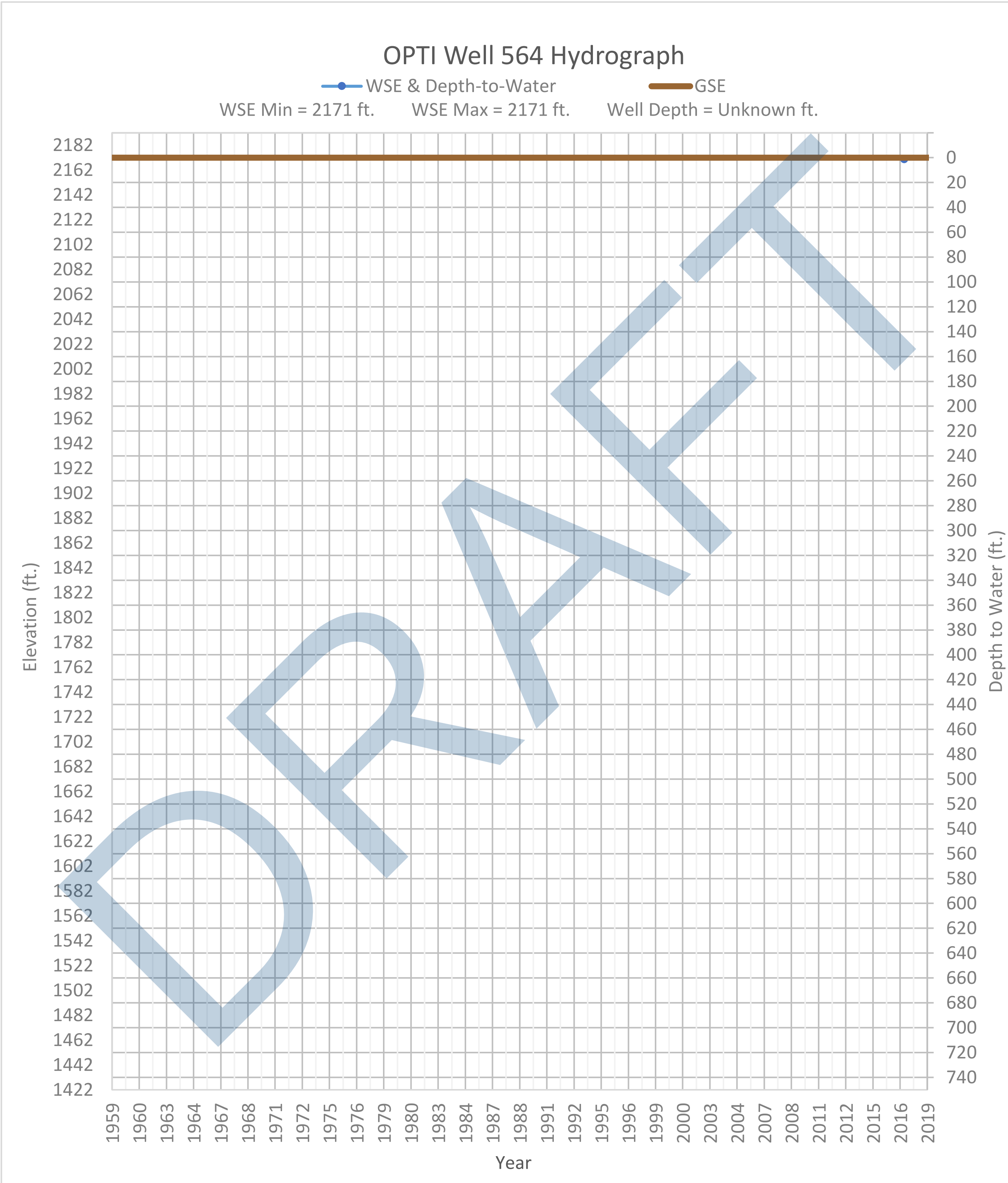


OPTI Well 561 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2152 ft.
WSE Max = 2152 ft.
Well Depth = 300 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

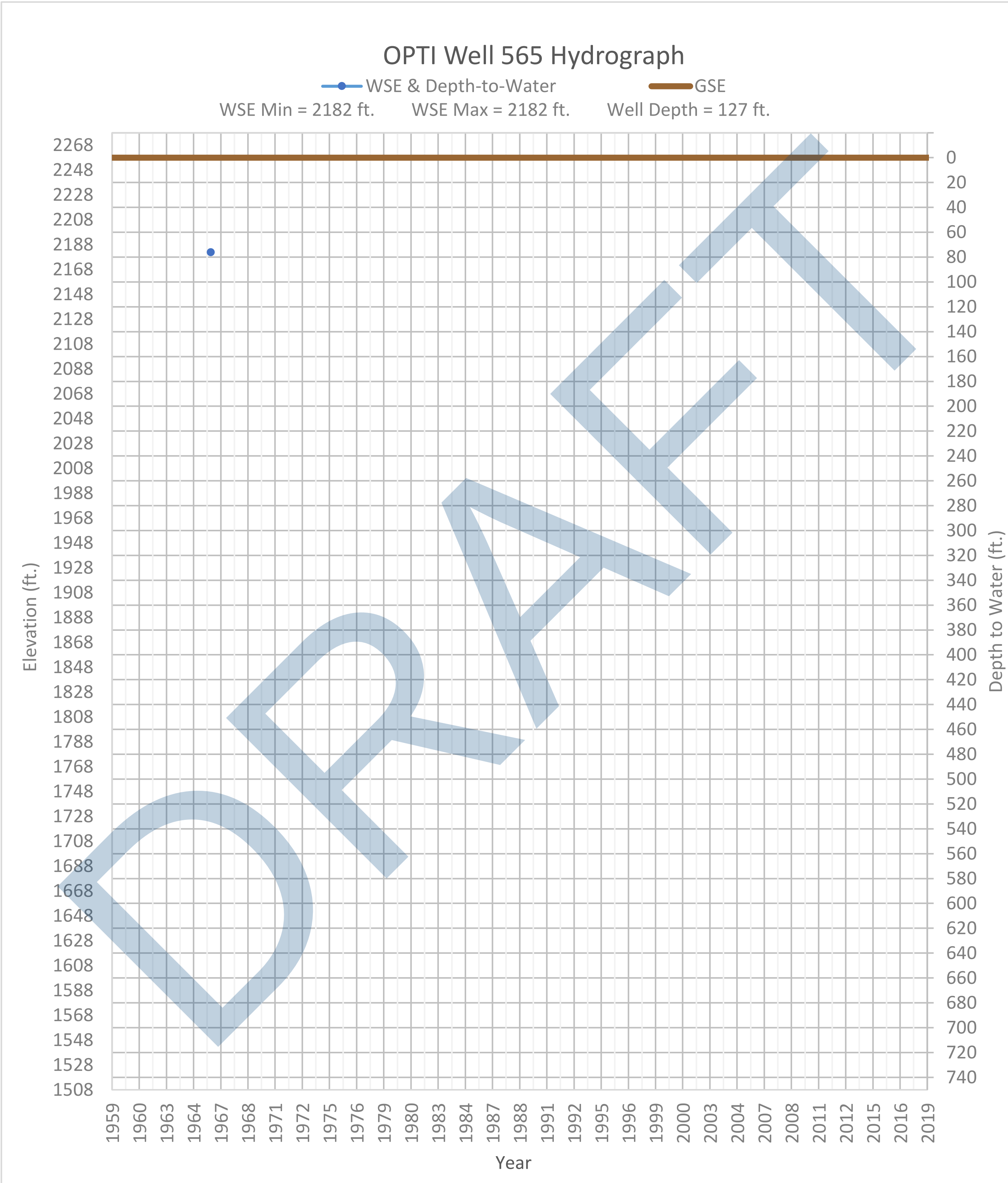


OPTI Well 562 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2167 ft.
WSE Max = 2173 ft.
Well Depth = 309 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

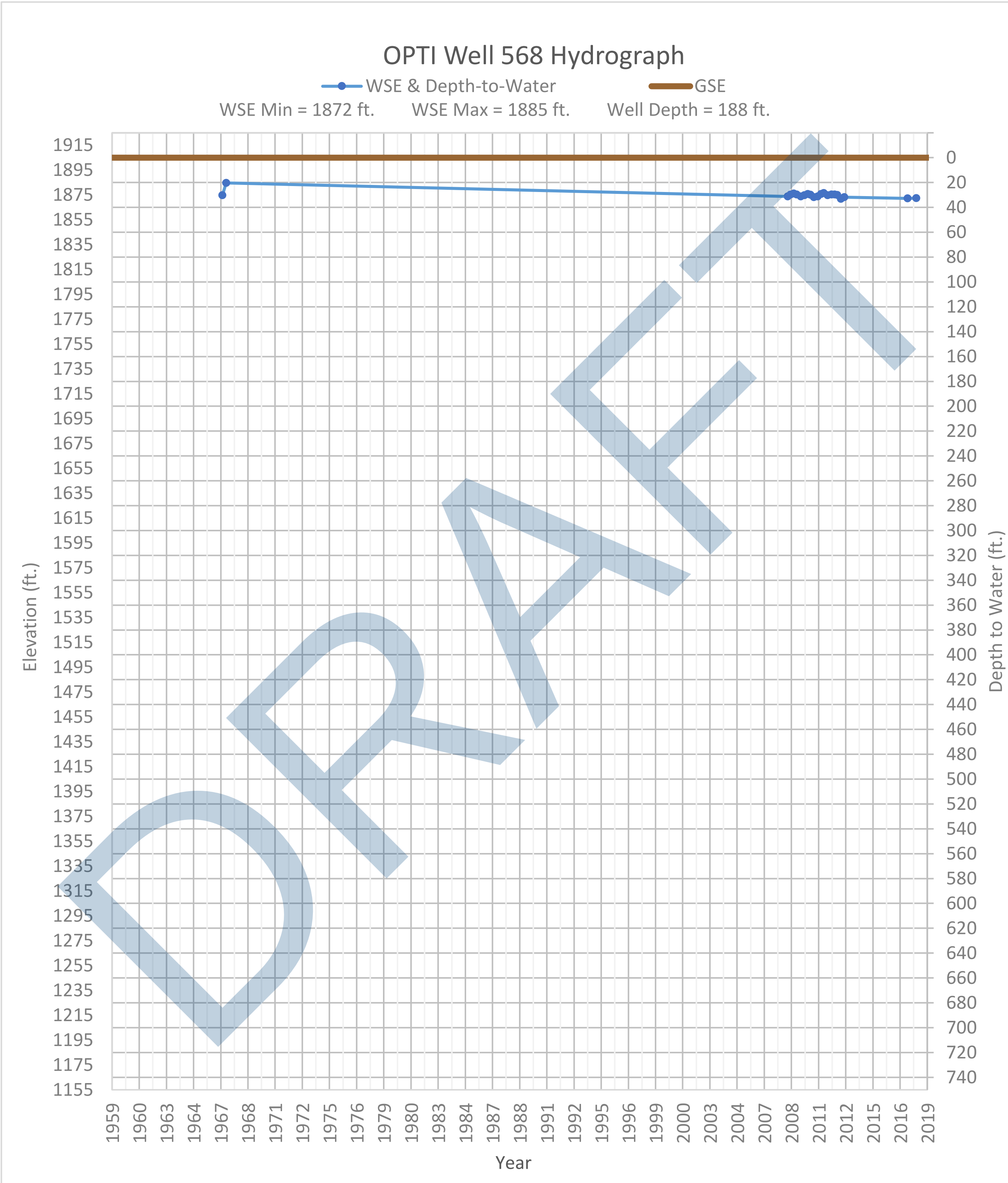

OPTI Well 563 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2197 ft.
WSE Max = 2197 ft.
Well Depth = 8 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT
2211 2191 2171 2151 2131 2111 2091 2071 2051 2031 2011 1991 1971 1951 1931 1911 1891 1871 1851 1831 1811 1791 1771 1751 1731 1711 1691 1671 1651 1631 1611 1591 1571 1551 1531 1511 1491 1471 1451
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720 740
1959 1960 1963 1964 1967 1968 1971 1972 1975 1976 1979 1980 1983 1984 1987 1988 1991 1992 1995 1996 1999 2000 2003 2004 2007 2008 2011 2012 2015 2016 2019



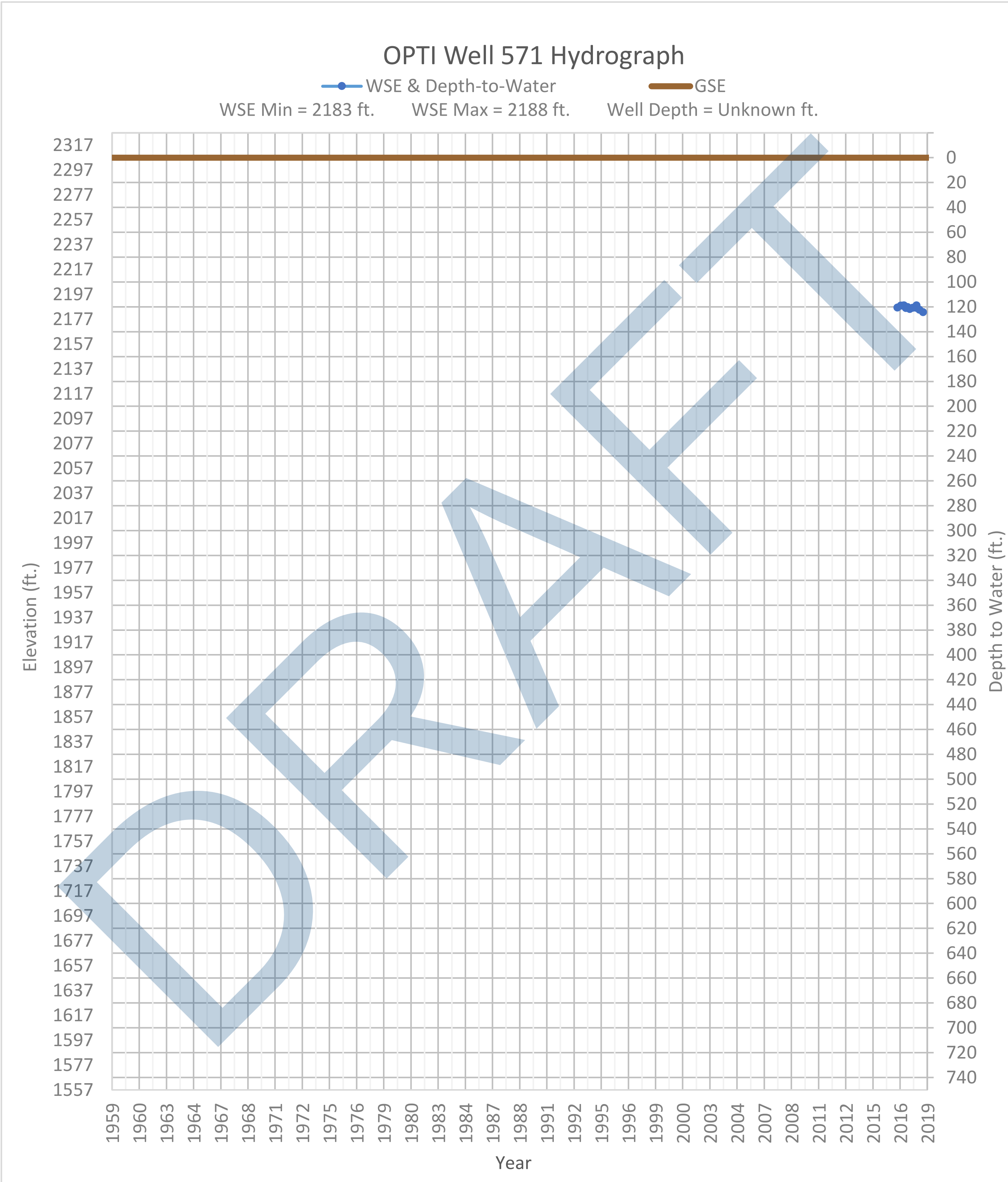
OPTI Well 564 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2171 ft.
WSE Max = 2171 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



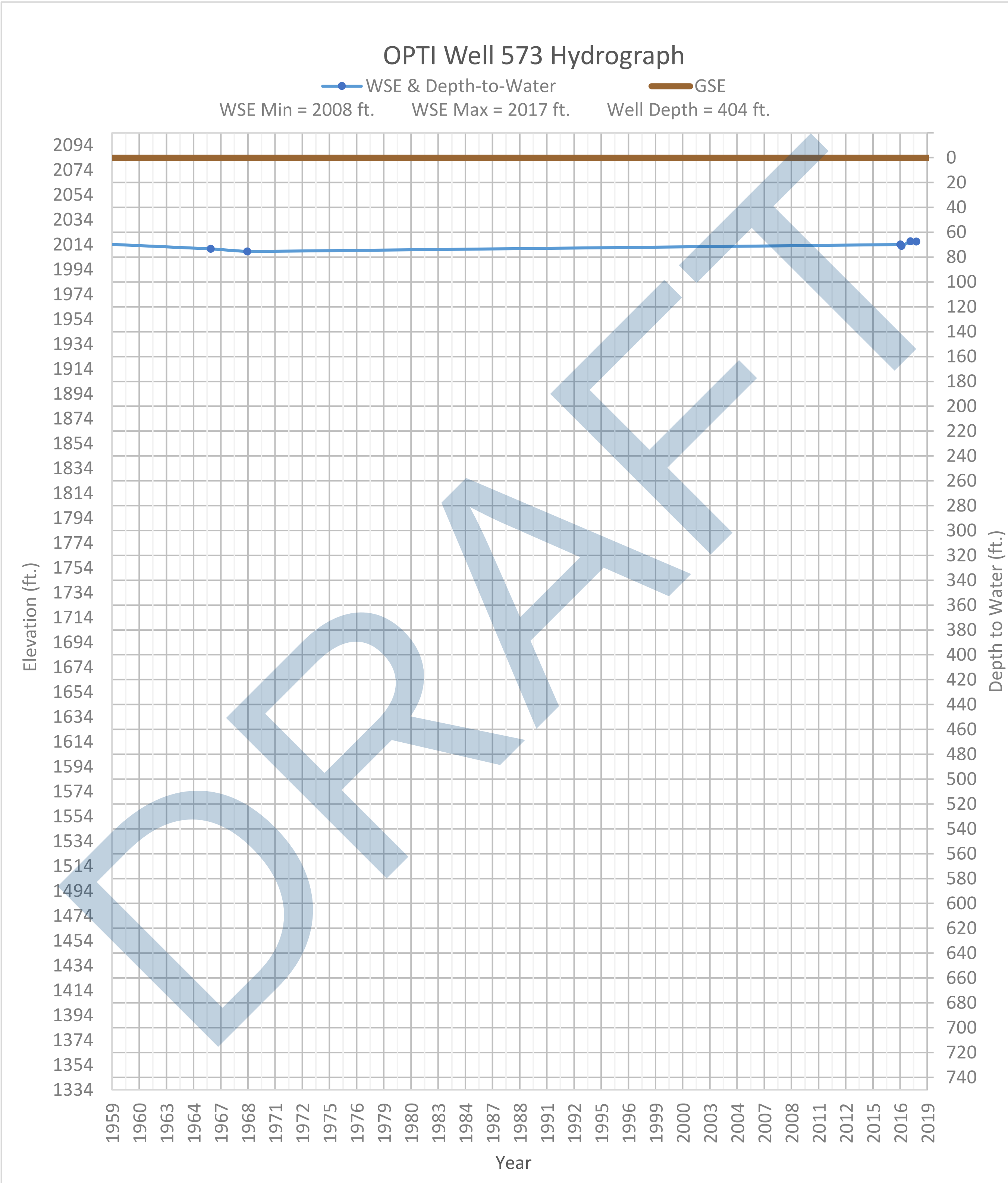
OPTI Well 565 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2182 ft.
WSE Max = 2182 ft.
Well Depth = 127 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



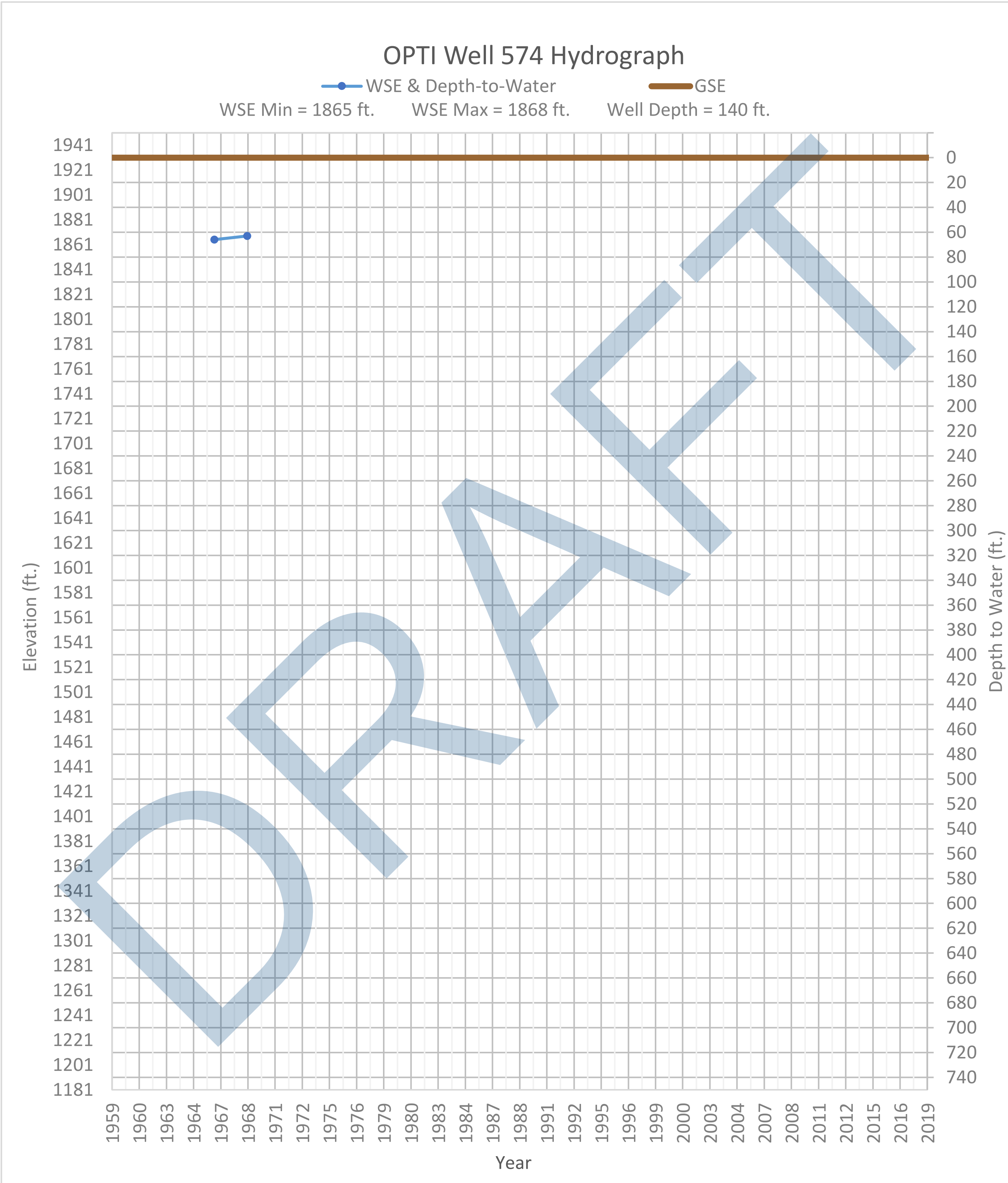
OPTI Well 568 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1872 ft.
WSE Max = 1885 ft.
Well Depth = 188 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 571 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2183 ft.
WSE Max = 2188 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 573 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2008 ft.
WSE Max = 2017 ft.
Well Depth = 404 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 574 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1865 ft.
WSE Max = 1868 ft.
Well Depth = 140 ft.
Elevation (ft.)
1941
1921
1901
1881
1861
1841
1821
1801
1781
1761
1741
1721
1701
1681
1661
1641
1621
1601
1581
1561
1541
1521
1501
1481
1461
1441
1421
1401
1381
1361
1341
1321
1301
1281
1261
1241
1221
1201
1181
Depth to Water (ft.)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
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680
700
720
740
Year
1959
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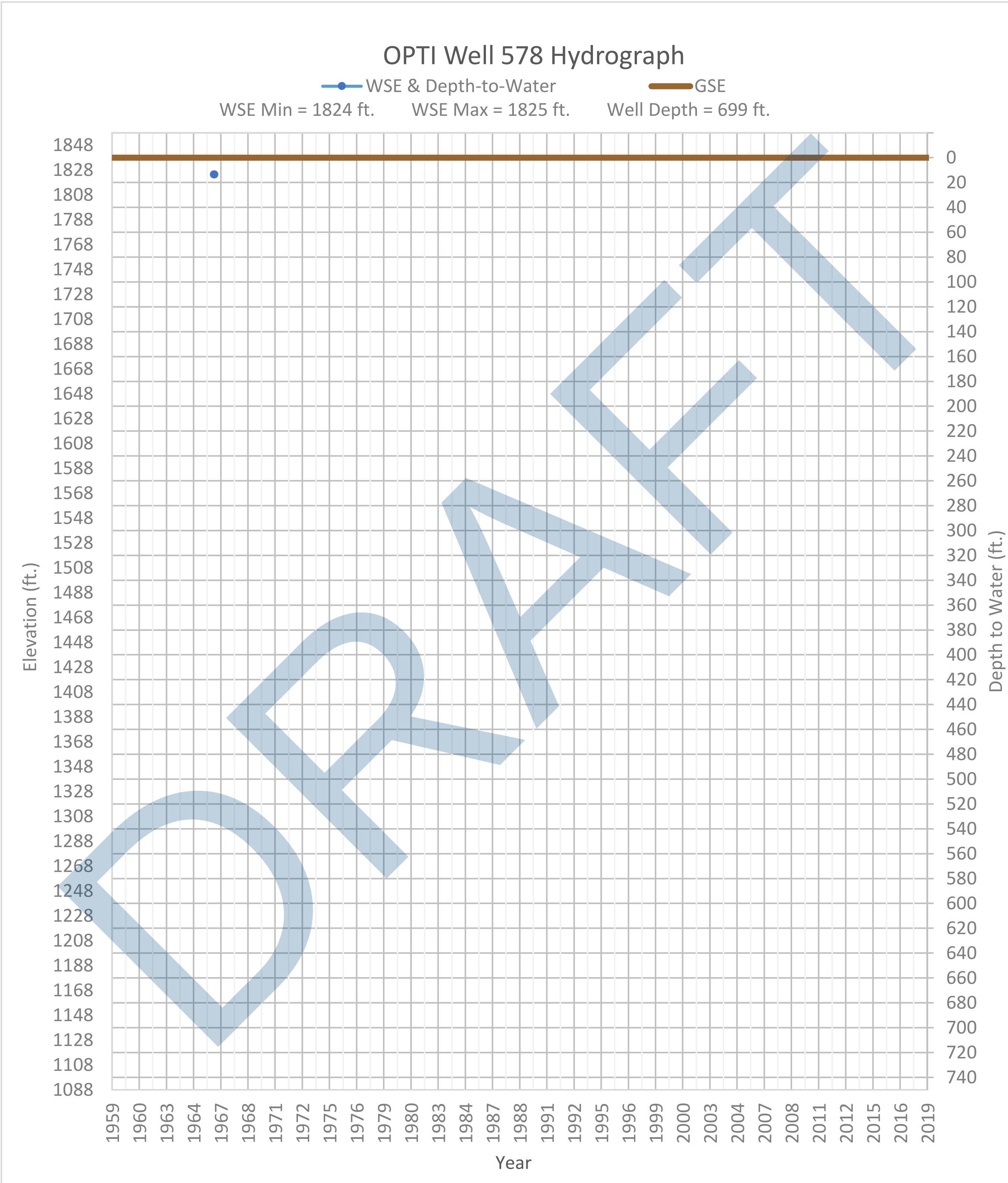
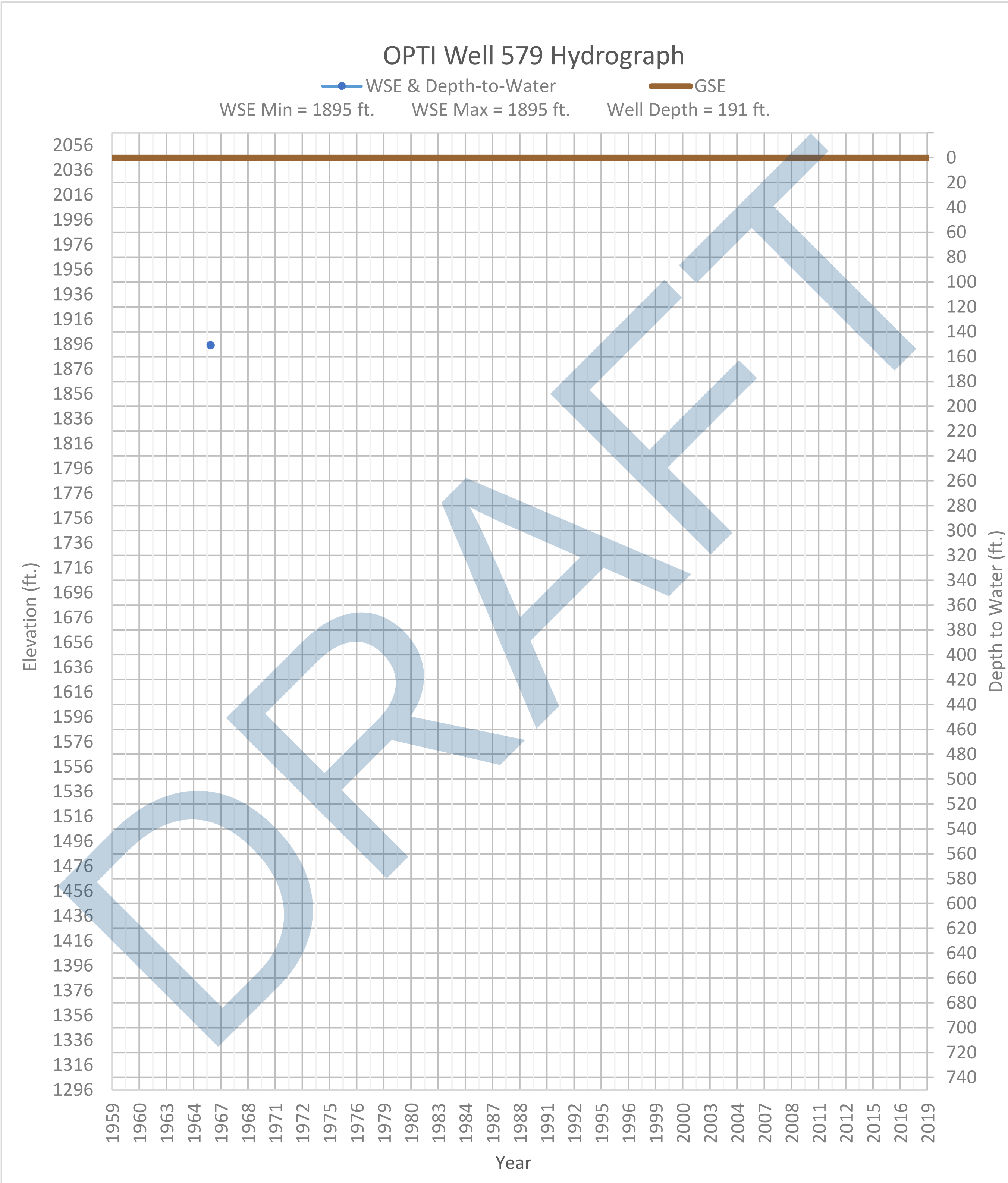
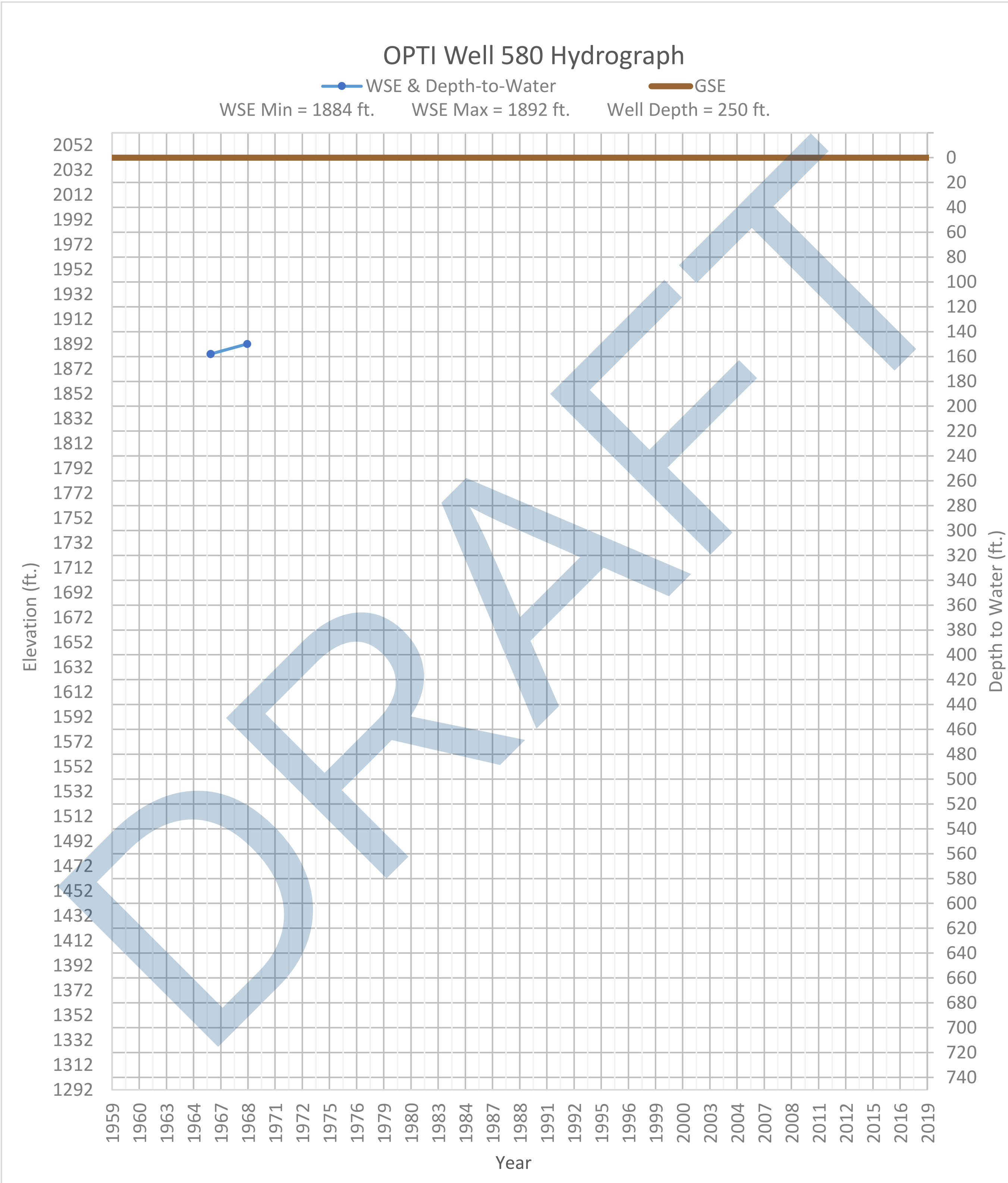
DRAFT



OPTI Well 578 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1824 ft.
WSE Max = 1825 ft.
Well Depth = 699 ft.
Elevation (ft.)
1848
1828
1808
1788
1768
1748
1728
1708
1688
1668
1648
1628
1608
1588
1568
1548
1528
1508
1488
1468
1448
1428
1408
1388
1368
1348
1328
1308
1288
1268
1248
1228
1208
1188
1168
1148
1128
1108
1088
Depth to Water (ft.)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
680
700
720
740
Year
1959 1960 1963 1964 1967 1968 1971 1972 1975 1976 1979 1980 1983 1984 1987 1988 1991 1992 1995 1996 1999 2000 2003 2004 2007 2008 2011 2012 2015 2016 2019
DRAFT



OPTI Well 579 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1895 ft.
WSE Max = 1895 ft.
Well Depth = 191 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2056 2036 2016 1996 1976 1956 1936 1916 1896 1876 1856 1836 1816 1796 1776 1756 1736 1716 1696 1676 1656 1636 1616 1596 1576 1556 1536 1516 1496 1476 1456 1436 1416 1396 1376 1356 1336 1316 1296
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720 740
1959 1960 1963 1964 1967 1968 1971 1972 1975 1976 1979 1980 1983 1984 1987 1988 1991 1992 1995 1996 1999 2000 2003 2004 2007 2008 2011 2012 2015 2016 2019



OPTI Well 580 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1884 ft.
WSE Max = 1892 ft.
Well Depth = 250 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2052
2032
2012
1992
1972
1952
1932
1912
1892
1872
1852
1832
1812
1792
1772
1752
1732
1712
1692
1672
1652
1632
1612
1592
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1532
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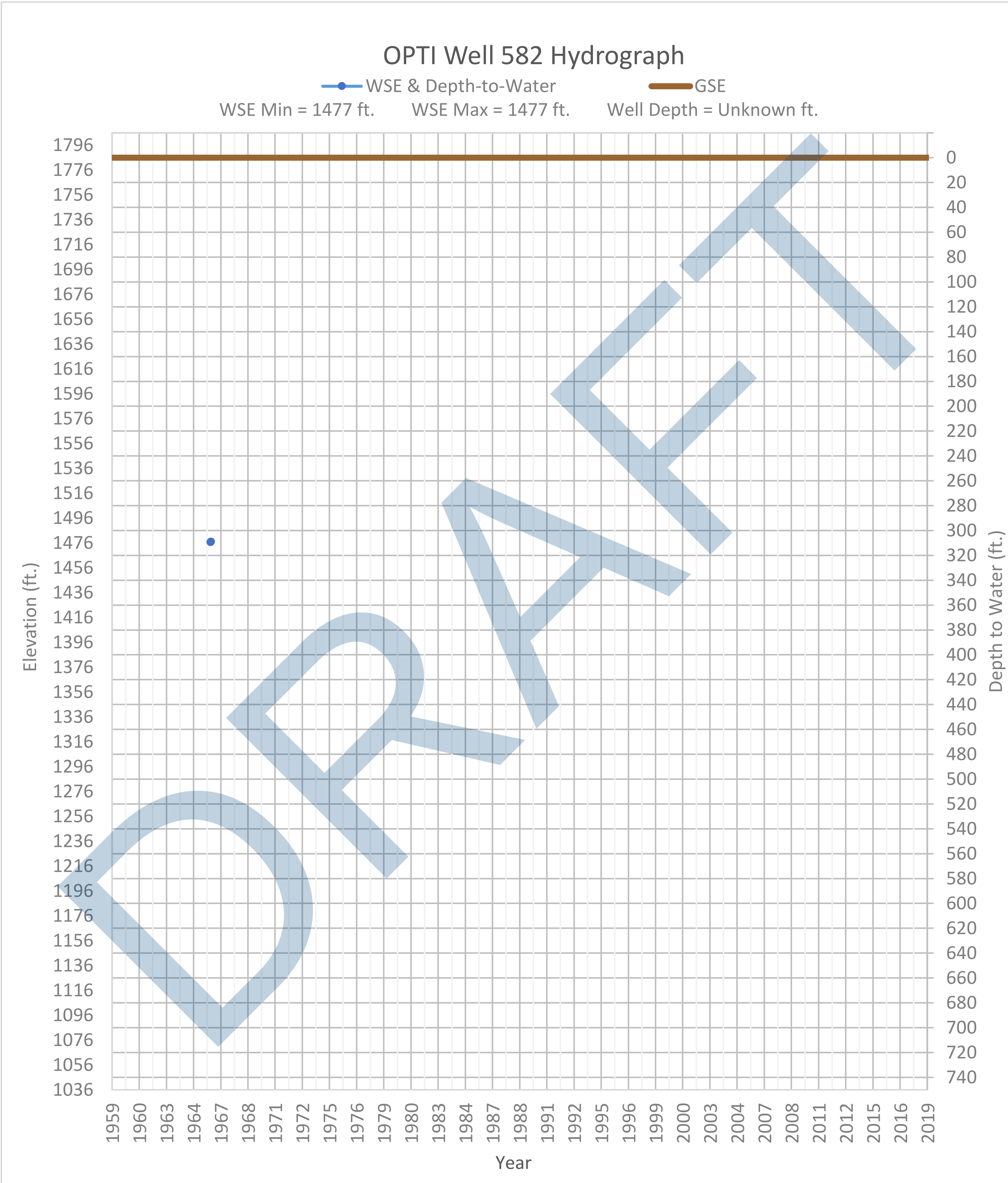
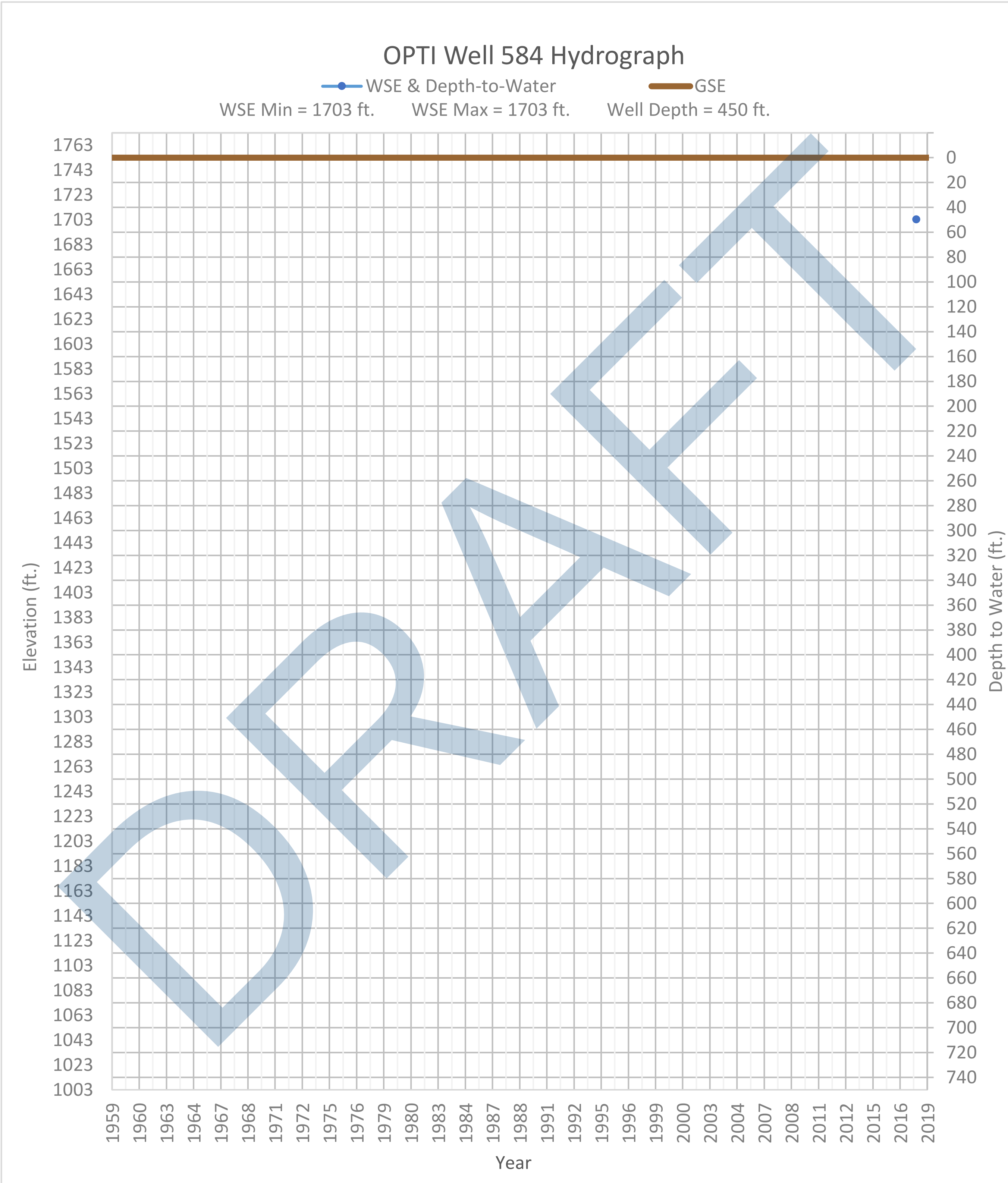
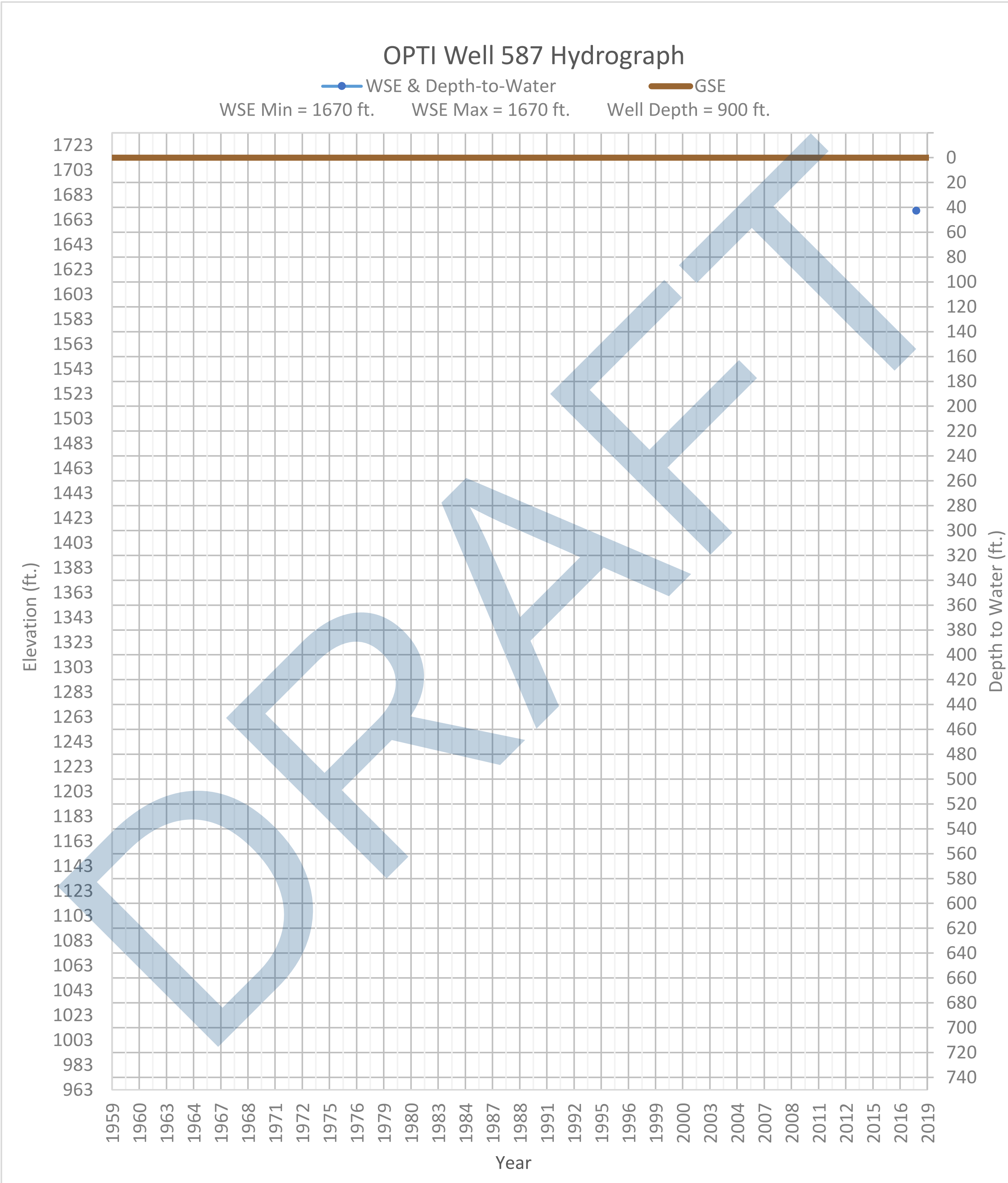
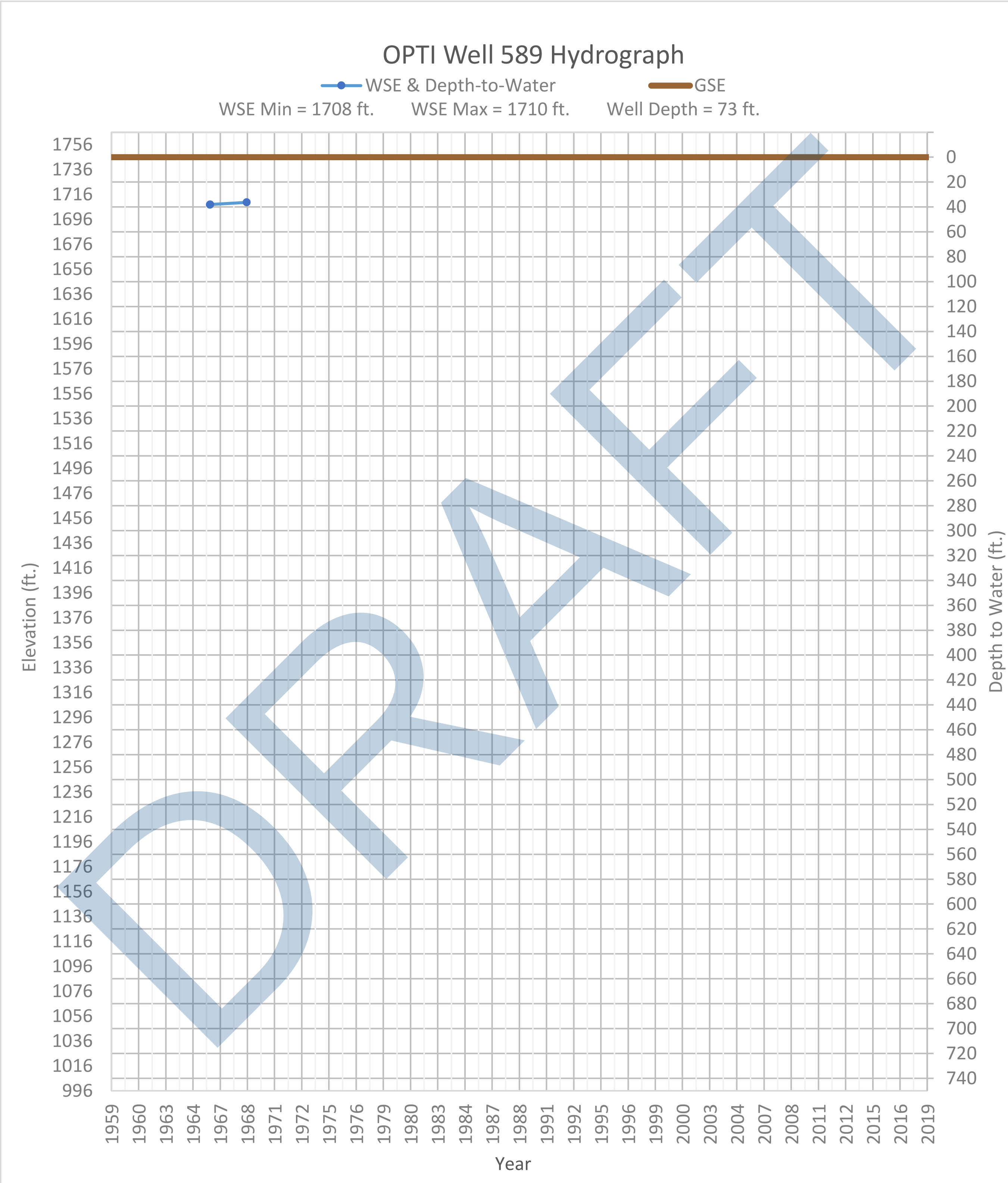


OPTI Well 582 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1477 ft.
WSE Max = 1477 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

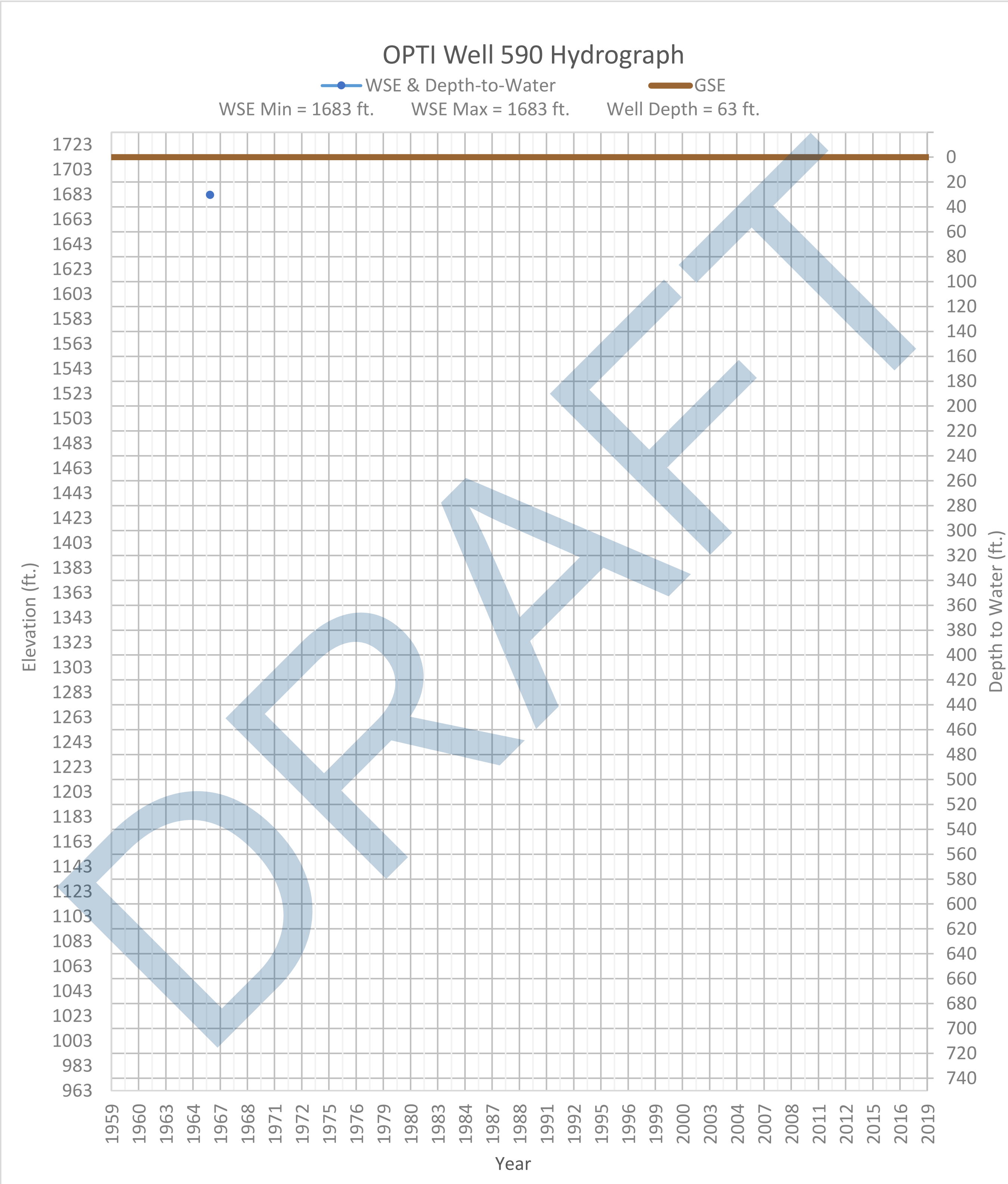


OPTI Well 584 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1703 ft.
WSE Max = 1703 ft.
Well Depth = 450 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 587 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1670 ft.
WSE Max = 1670 ft.
Well Depth = 900 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 589 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1708 ft.
WSE Max = 1710 ft.
Well Depth = 73 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 590 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1683 ft.
WSE Max = 1683 ft.
Well Depth = 63 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
1723
1703
1683
1663
1643
1623
1603
1583
1563
1543
1523
1503
1483
1463
1443
1423
1403
1383
1363
1343
1323
1303
1283
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1143
1123
1103
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1063
1043
1023
1003
983
963
0
20
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60
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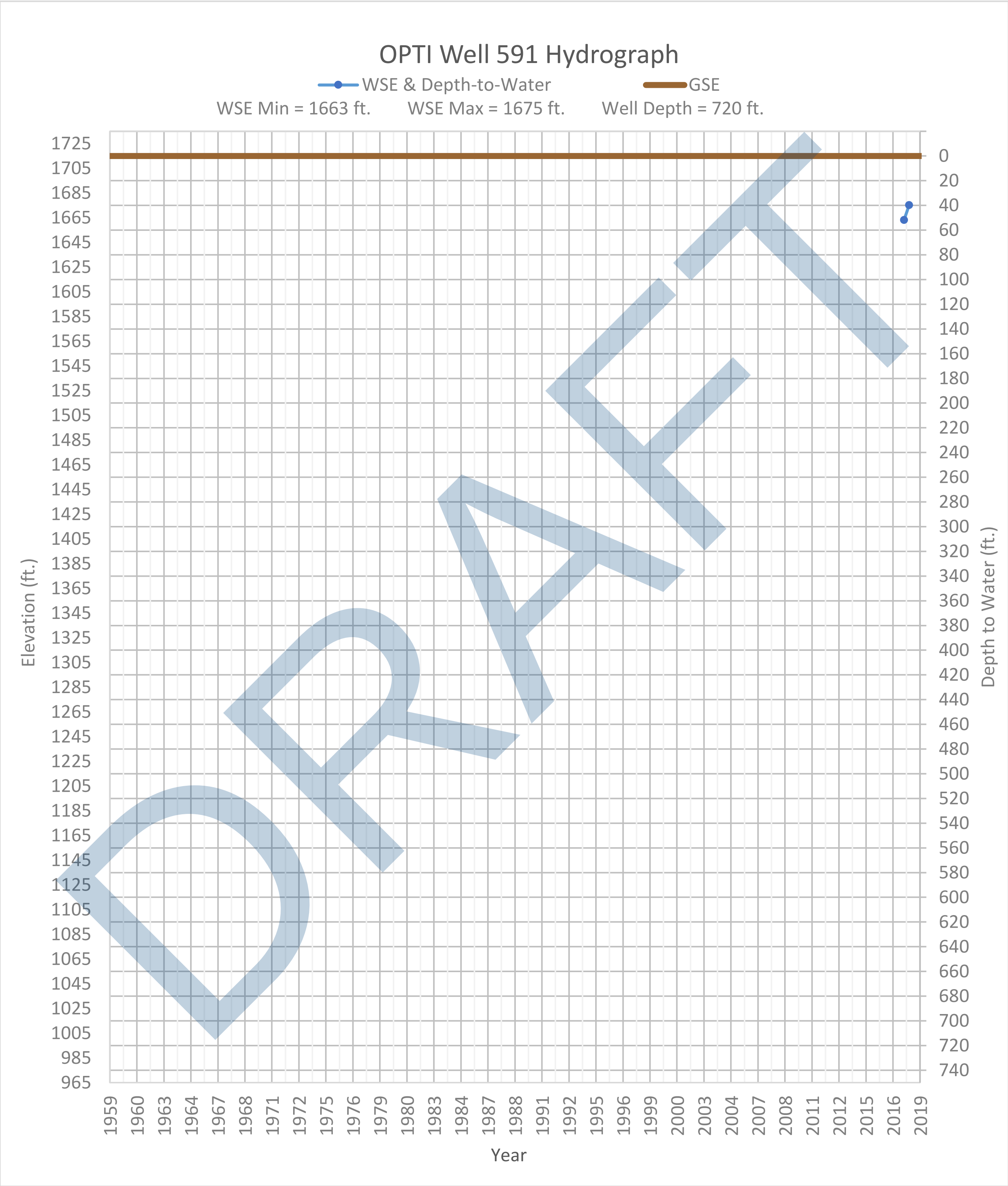
2007
2008
2011
2012
2015
2016
2019
DRAFT



OPTI Well 591 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1663 ft.
WSE Max = 1675 ft.
Well Depth = 720 ft.
Elevation (ft.)
1725
1705
1685
1665
1645
1625
1605
1585
1565
1545
1525
1505
1485
1465
1445
1425
1405
1385
1365
1345
1325
1305
1285
1265
1245
1225
1205
1185
1165
1145
1125
1105
1085
1065
1045
1025
1005
985
965
Depth to Water (ft.)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
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560
580
600
620
640
660
680
700
720
740
Year
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2016
2019
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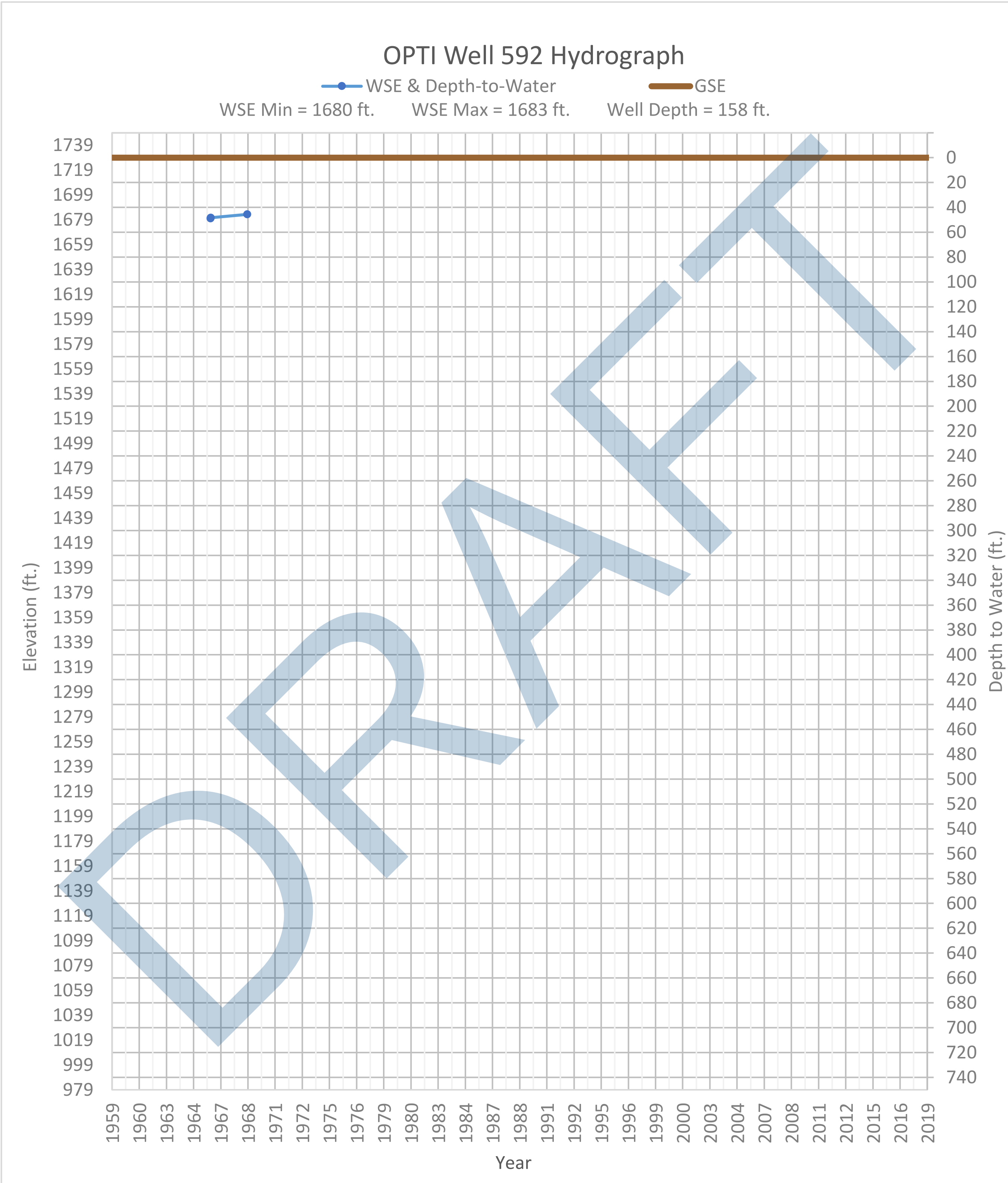
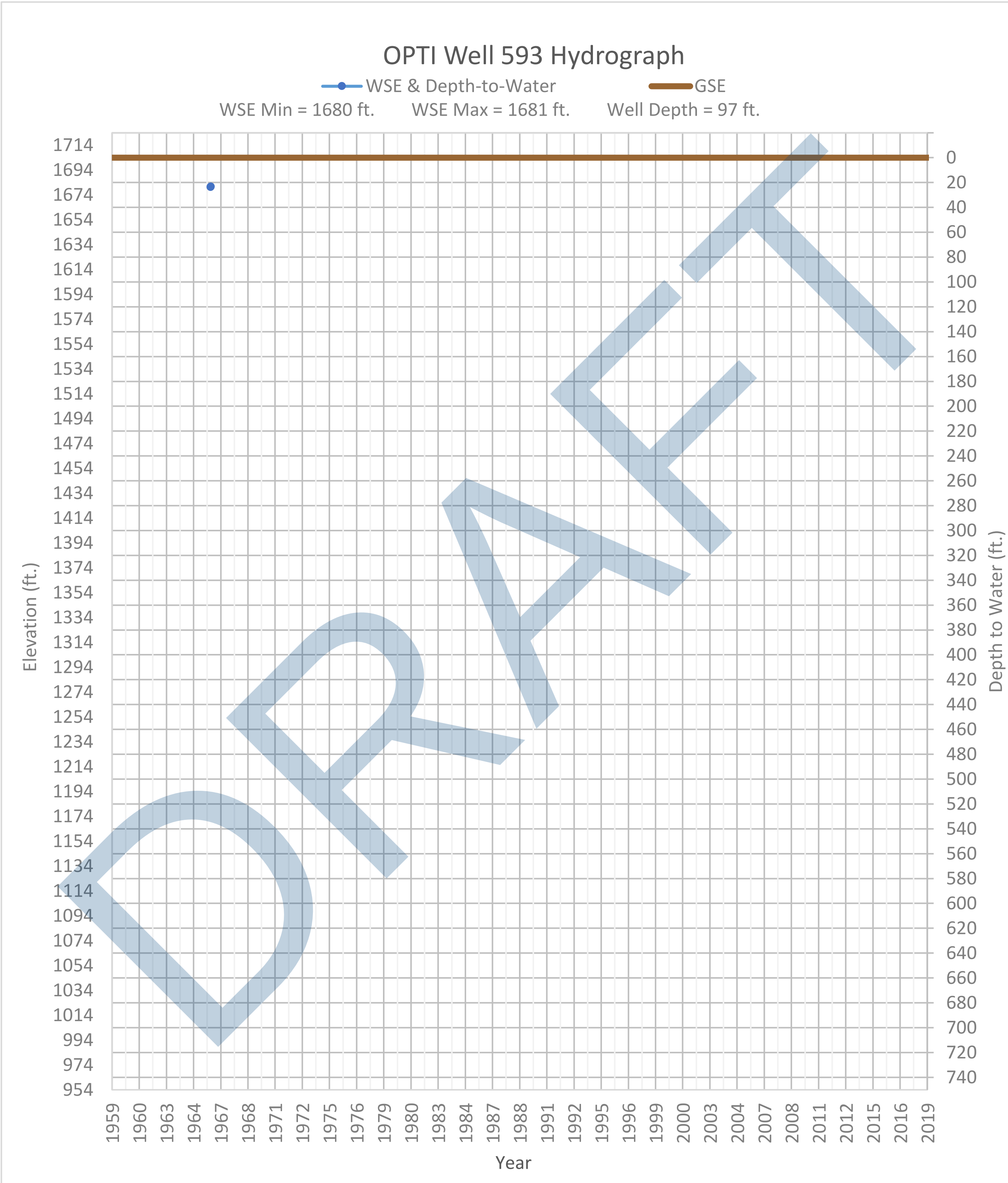

OPTI Well 592 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1680 ft.
WSE Max = 1683 ft.
Well Depth = 158 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 593 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1680 ft.
WSE Max = 1681 ft.
Well Depth = 97 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
1714
1694
1674
1654
1634
1614
1594
1574
1554
1534
1514
1494
1474
1454
1434
1414
1394
1374
1354
1334
1314
1294
1274
1254
1234
1214
1194
1174
1154
1134
1114
1094
1074
1054
1034
1014
994
974
954
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
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620
640
660
680
700
720
740
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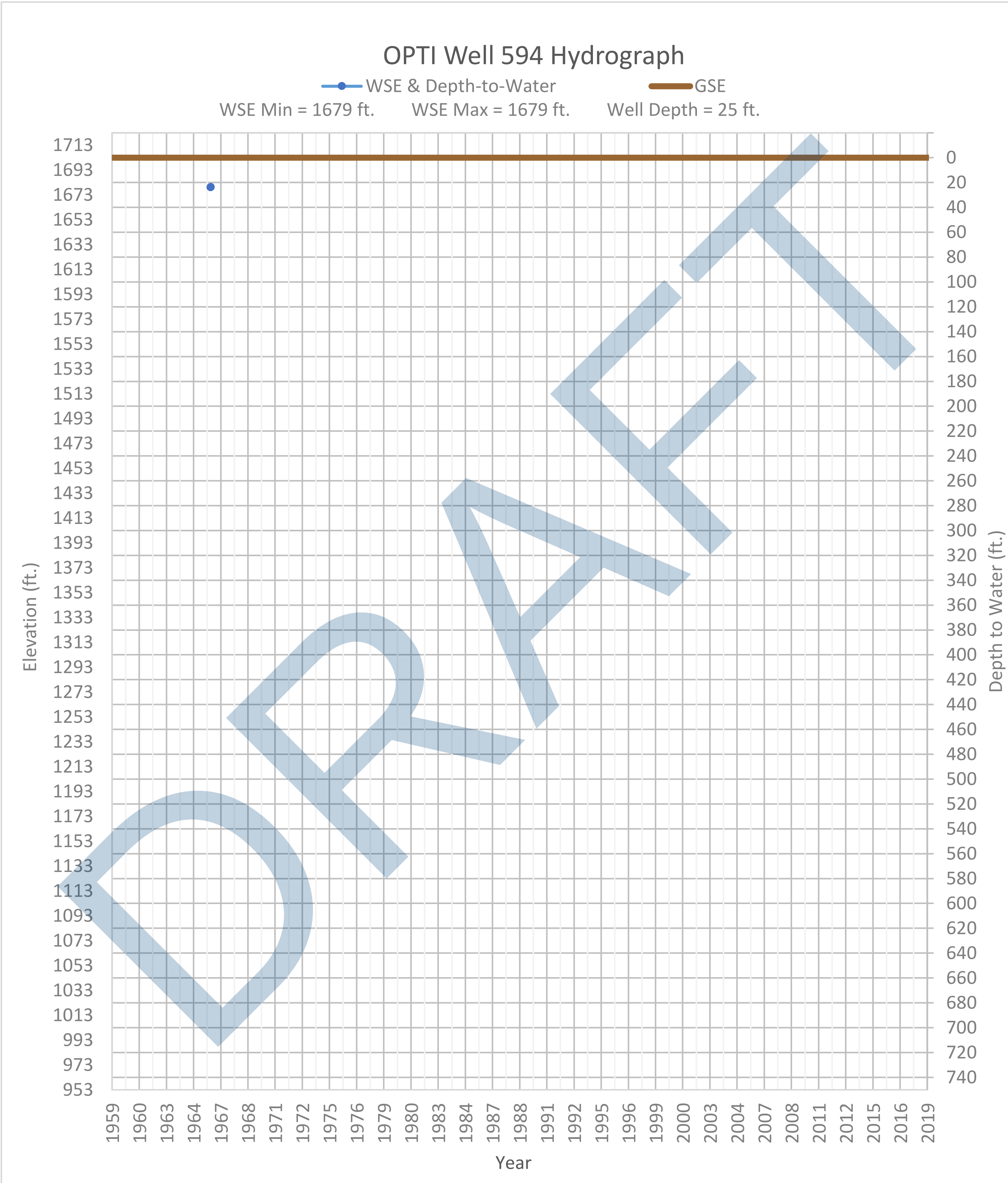
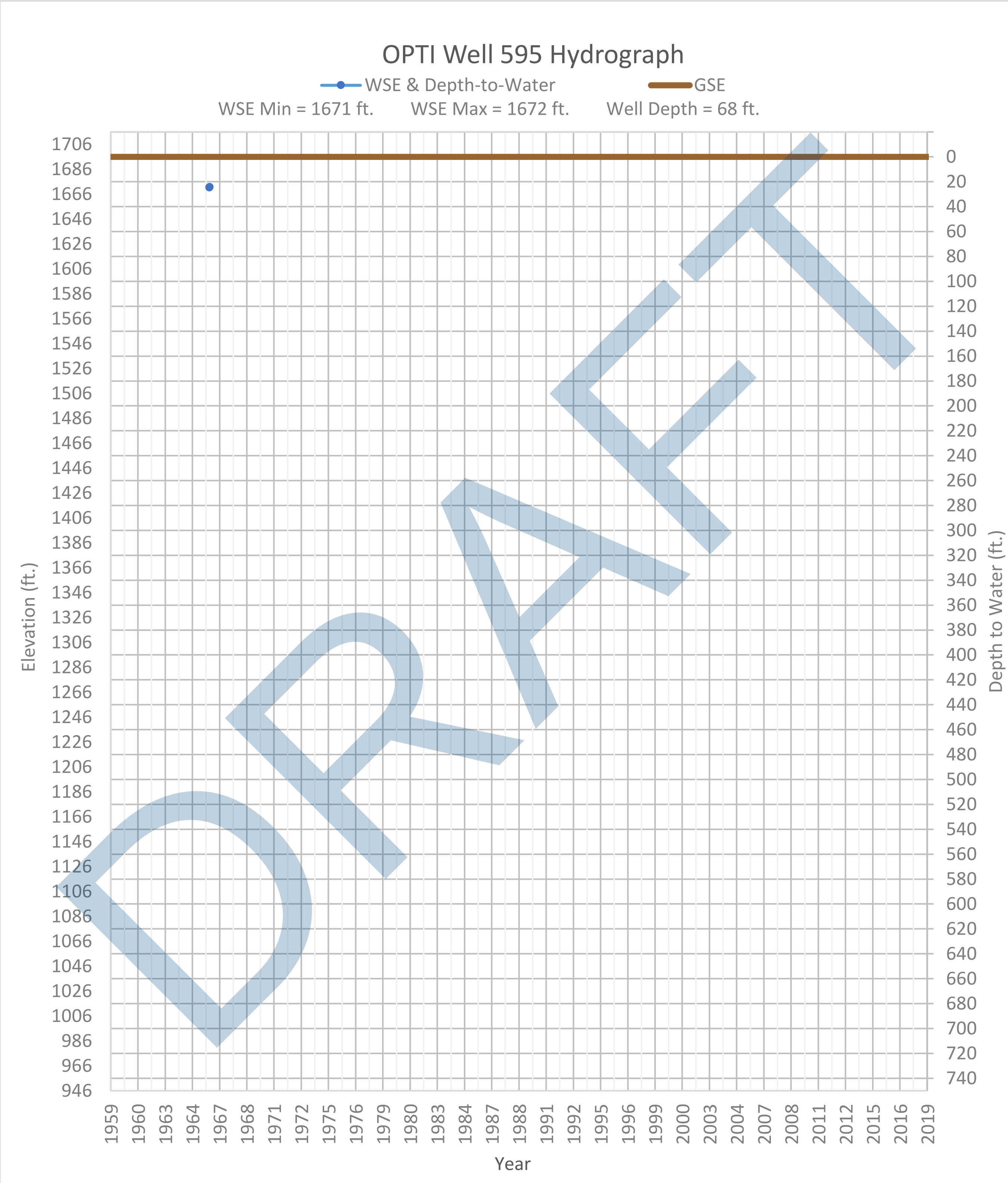
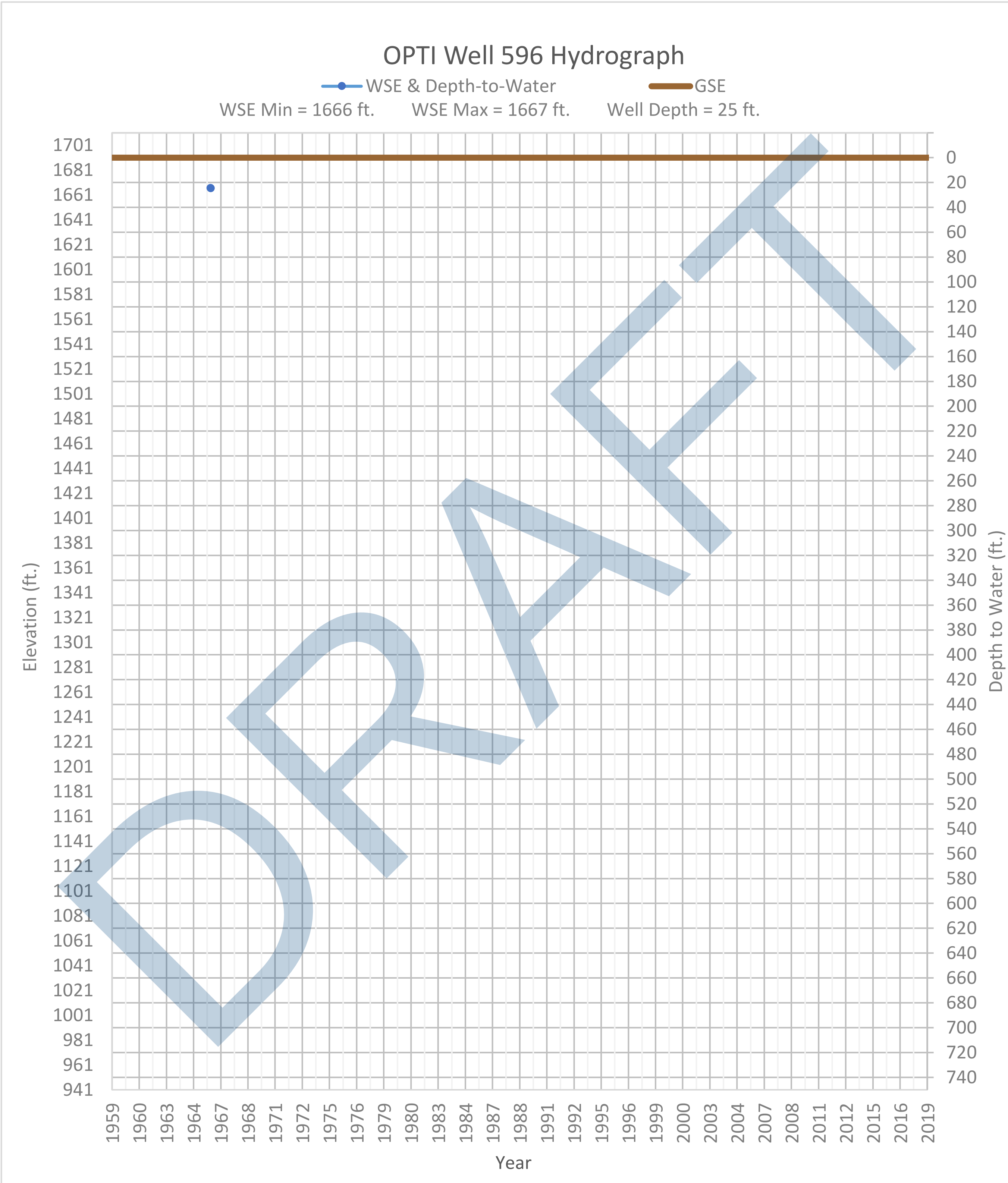
2016
2019
DRAFT



OPTI Well 594 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1679 ft.
WSE Max = 1679 ft.
Well Depth = 25 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 595 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1671 ft.
WSE Max = 1672 ft.
Well Depth = 68 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 596 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1666 ft.
WSE Max = 1667 ft.
Well Depth = 25 ft.
Elevation (ft.)
1701
1681
1661
1641
1621
1601
1581
1561
1541
1521
1501
1481
1461
1441
1421
1401
1381
1361
1341
1321
1301
1281
1261
1241
1221
1201
1181
1161
1141
1121
1101
1081
1061
1041
1021
1001
981
961
941
Depth to Water (ft.)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
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560
580
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660
680
700
720
740
Year
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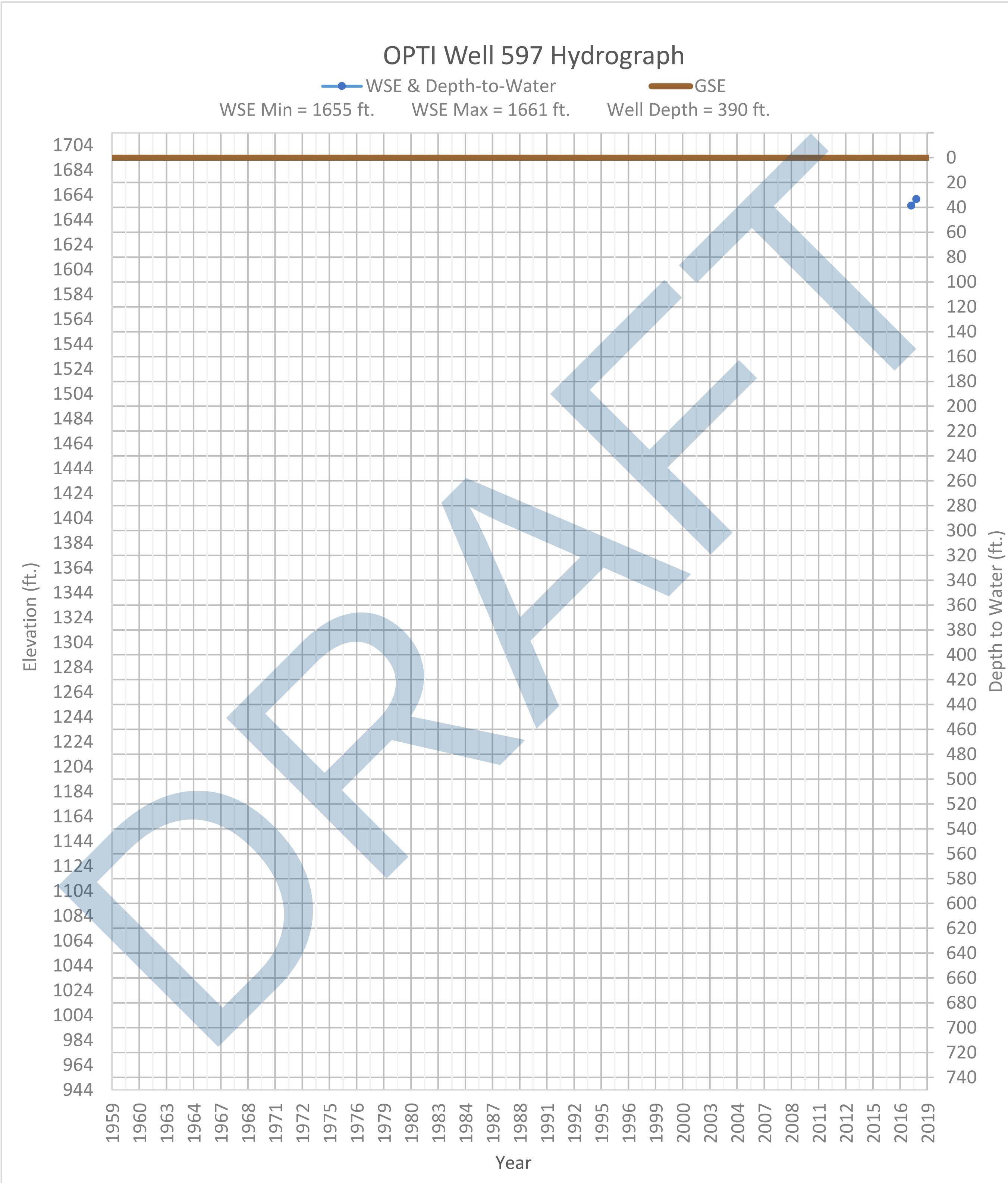
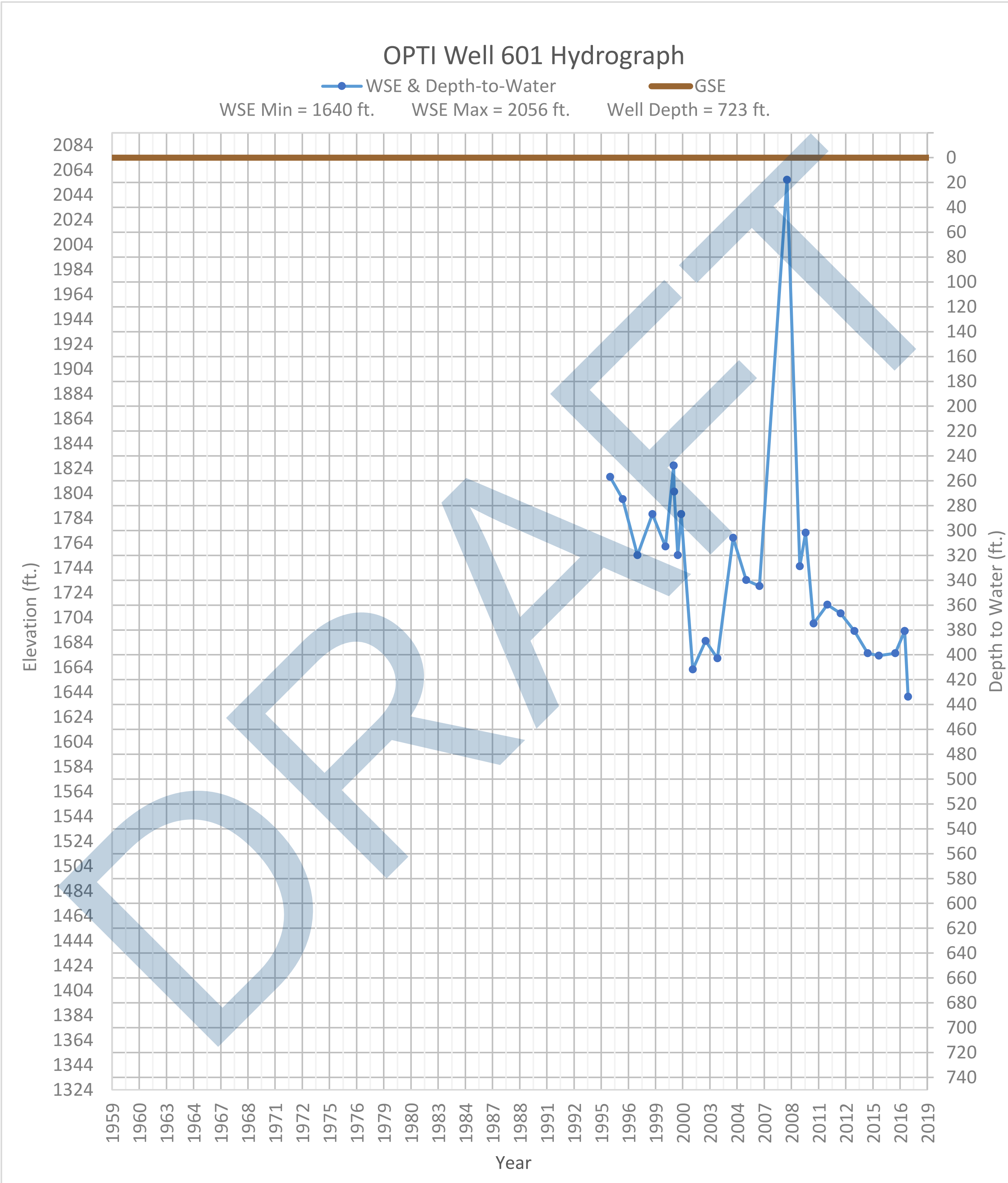
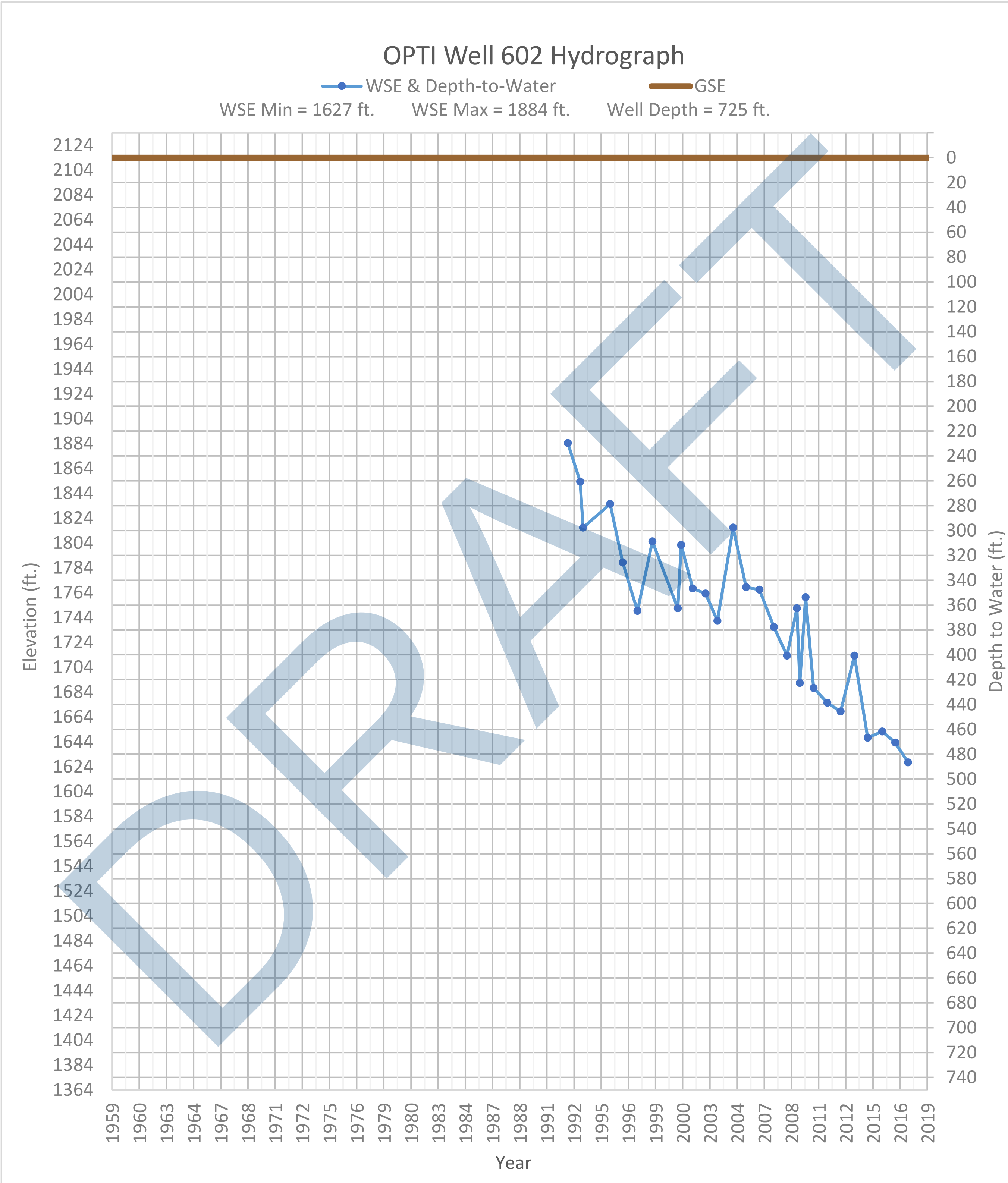


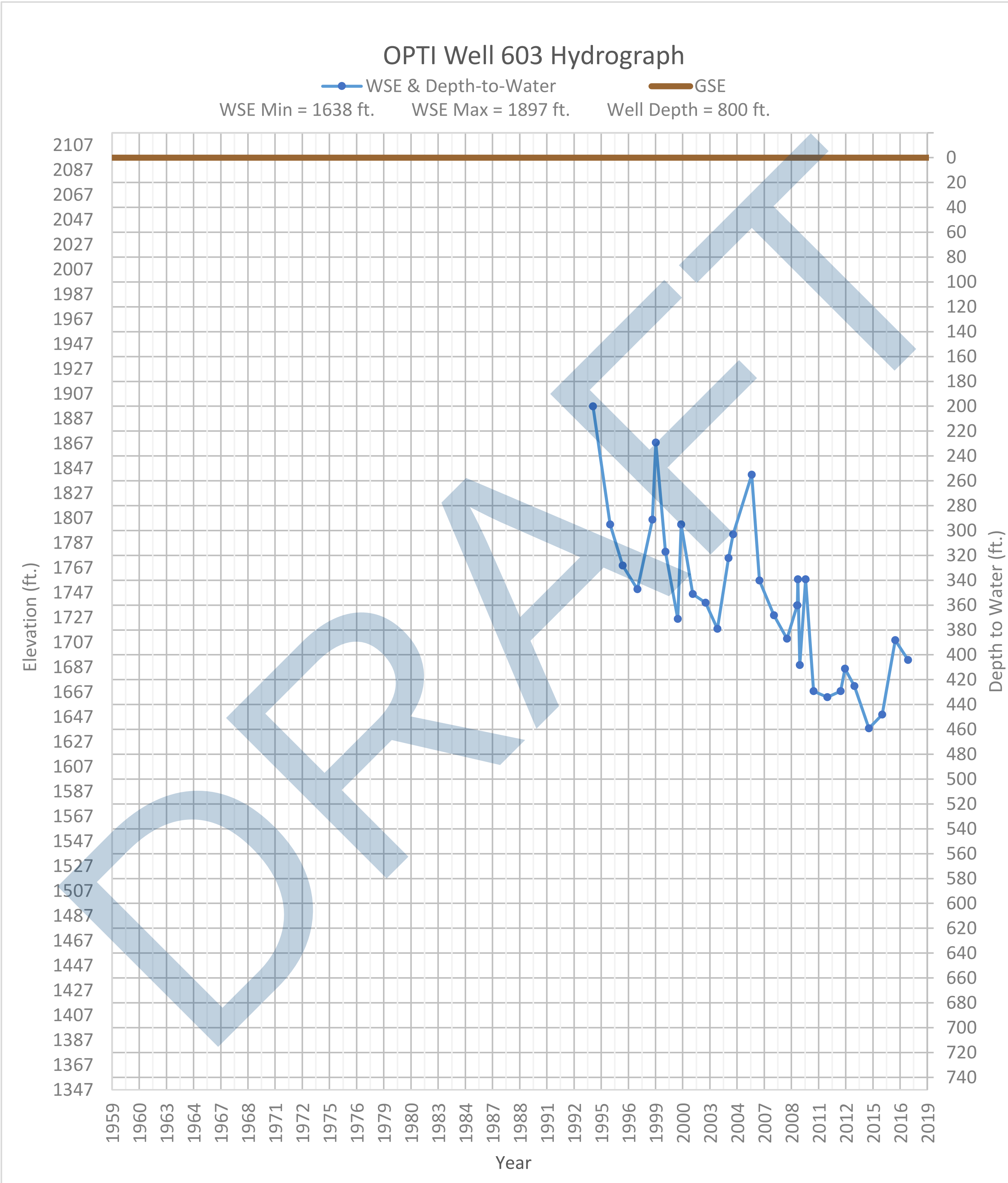
OPTI Well 597 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1655 ft.
WSE Max = 1661 ft.
Well Depth = 390 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



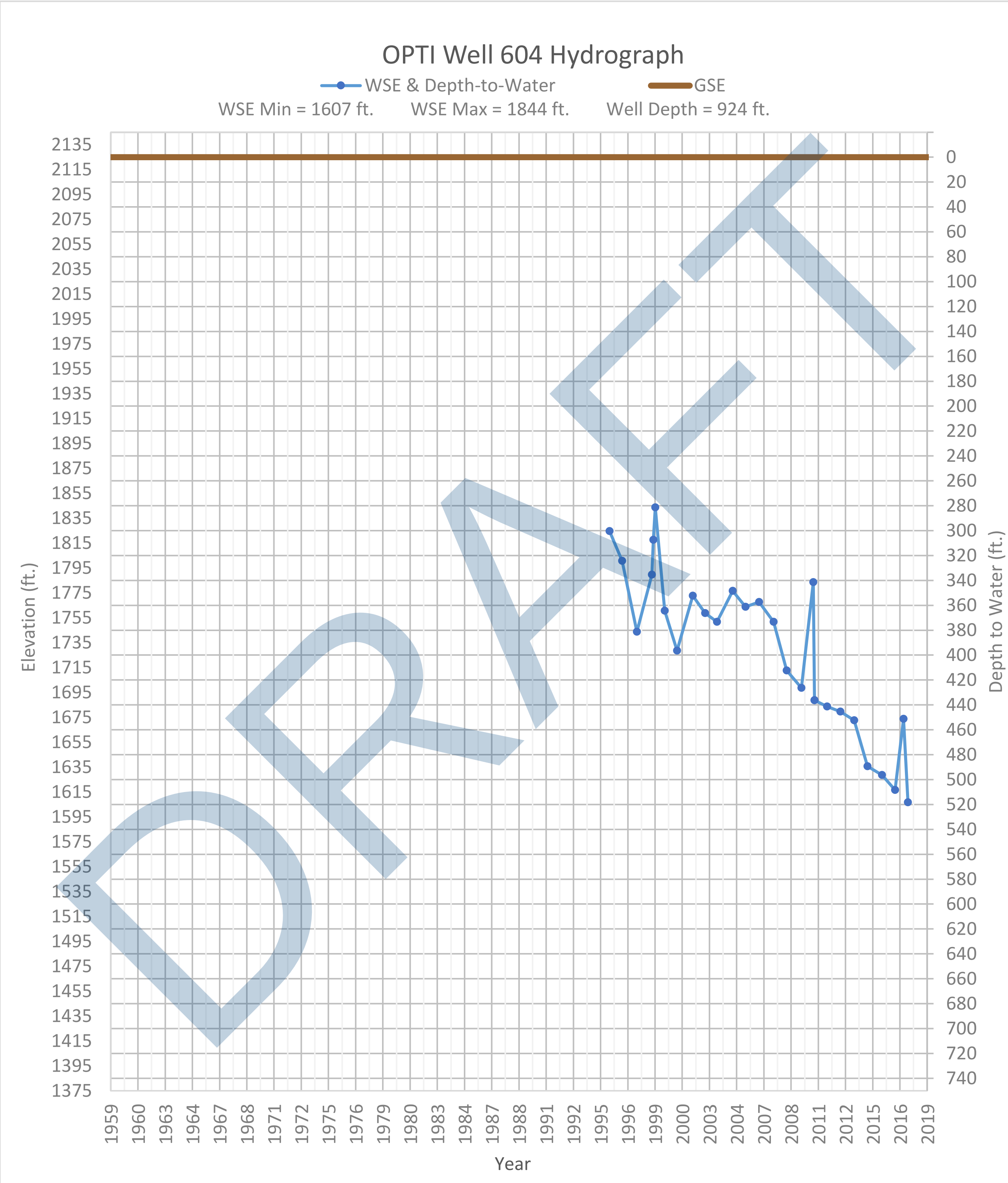
OPTI Well 601 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1640 ft.
WSE Max = 2056 ft.
Well Depth = 723 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 602 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1627 ft.
WSE Max = 1884 ft.
Well Depth = 725 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 603 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1638 ft.
WSE Max = 1897 ft.
Well Depth = 800 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 604 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1607 ft.
WSE Max = 1844 ft.
Well Depth = 924 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2135
2115
2095
2075
2055
2035
2015
1995
1975
1955
1935
1915
1895
1875
1855
1835
1815
1795
1775
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1375
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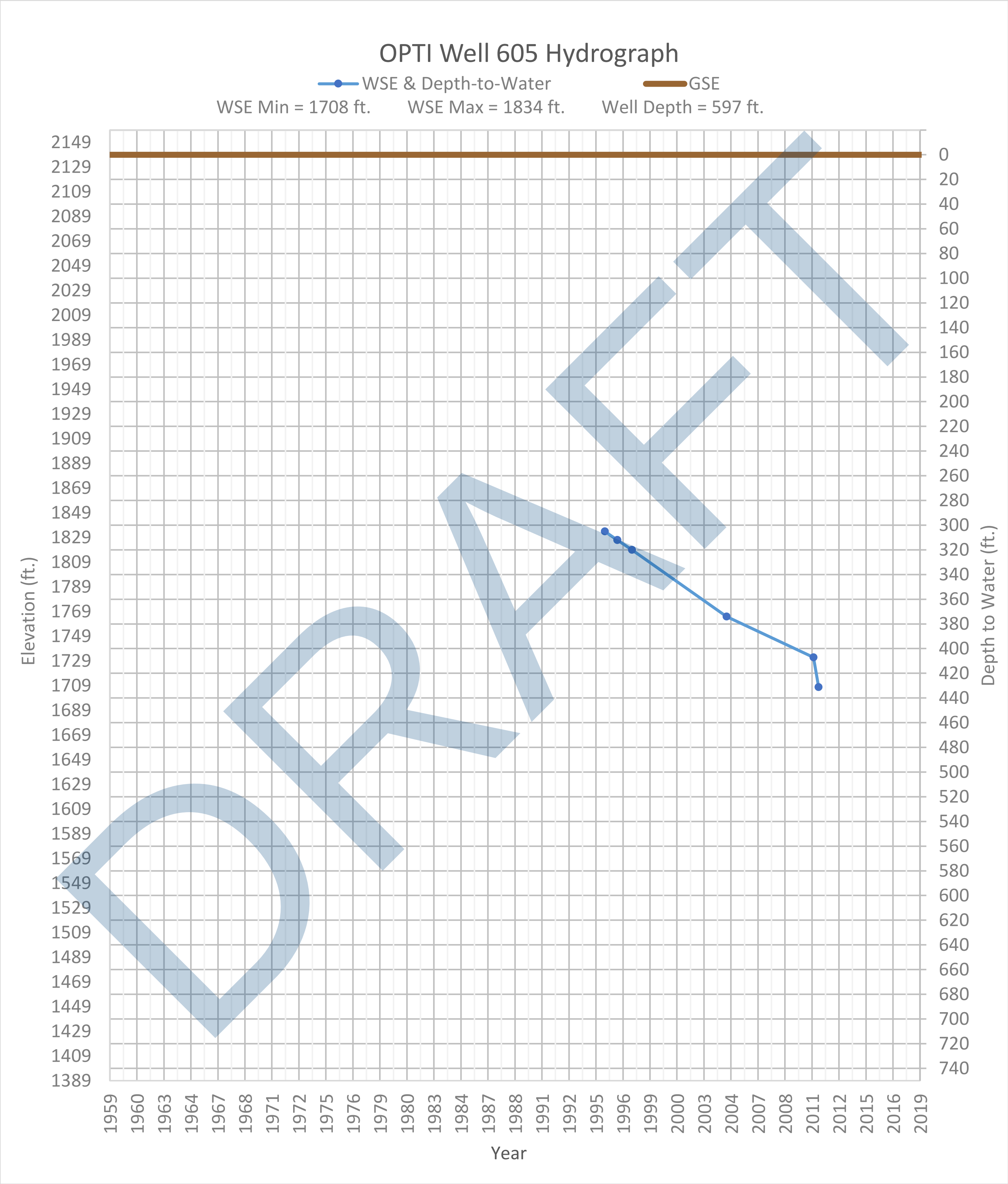
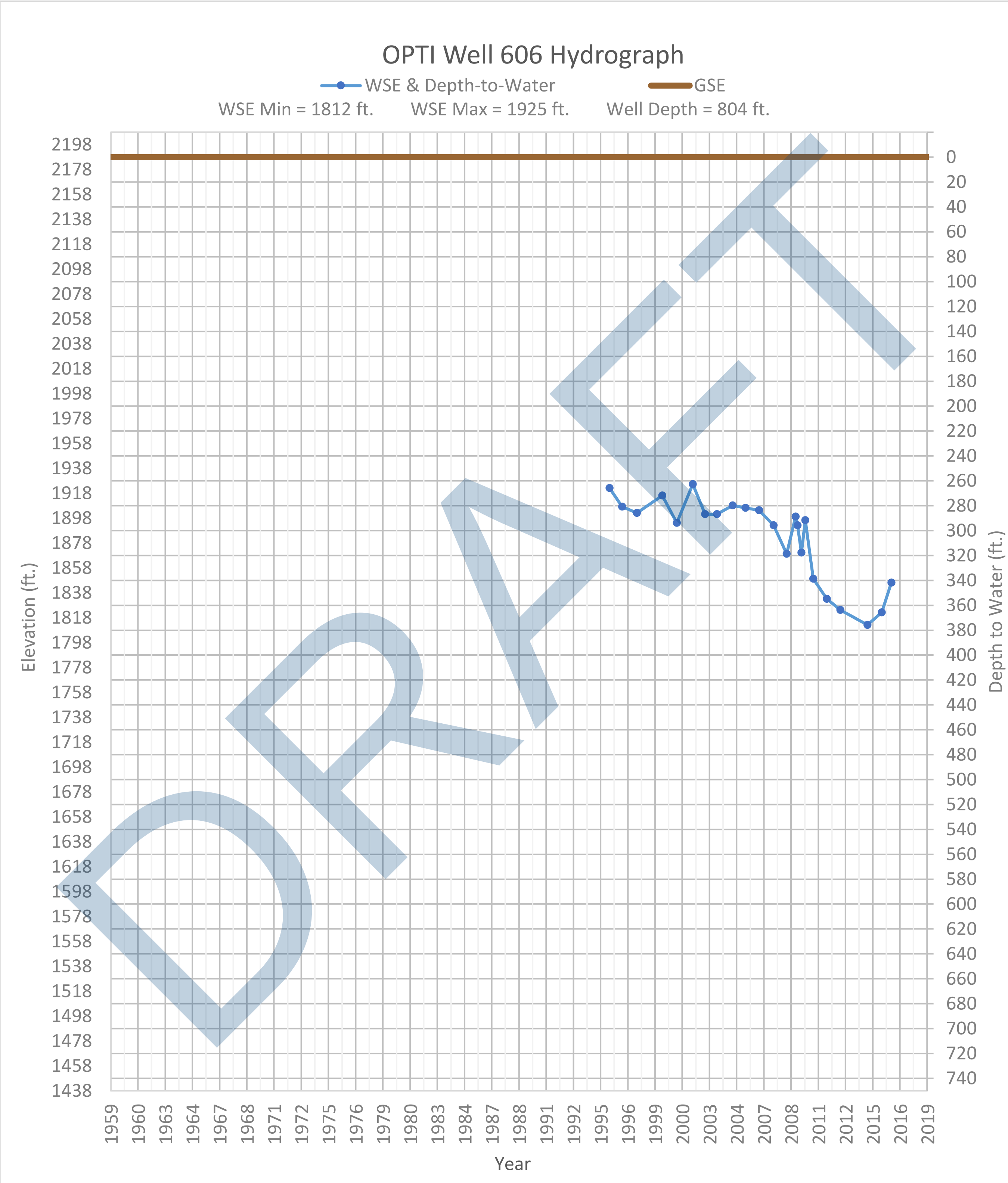
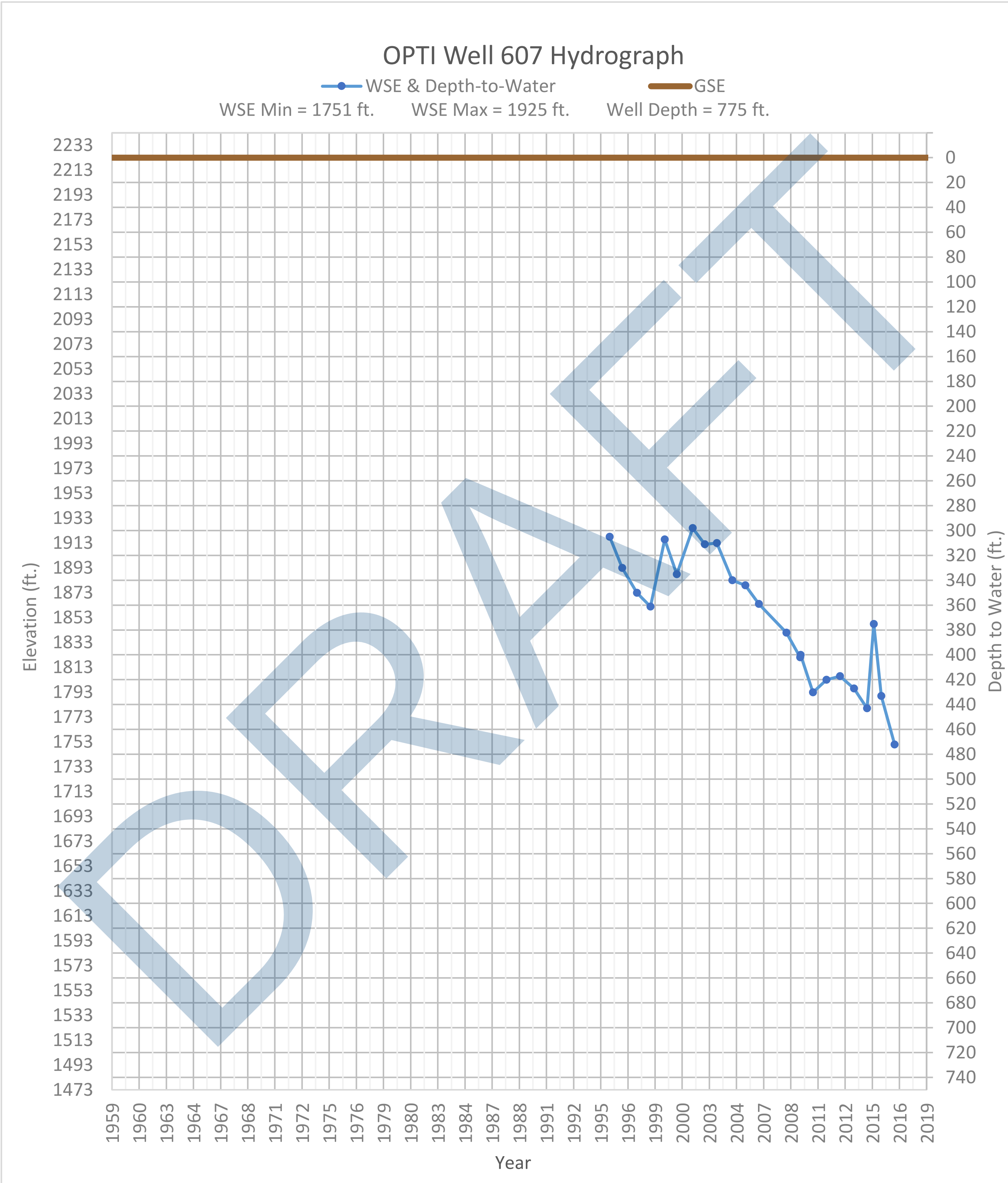
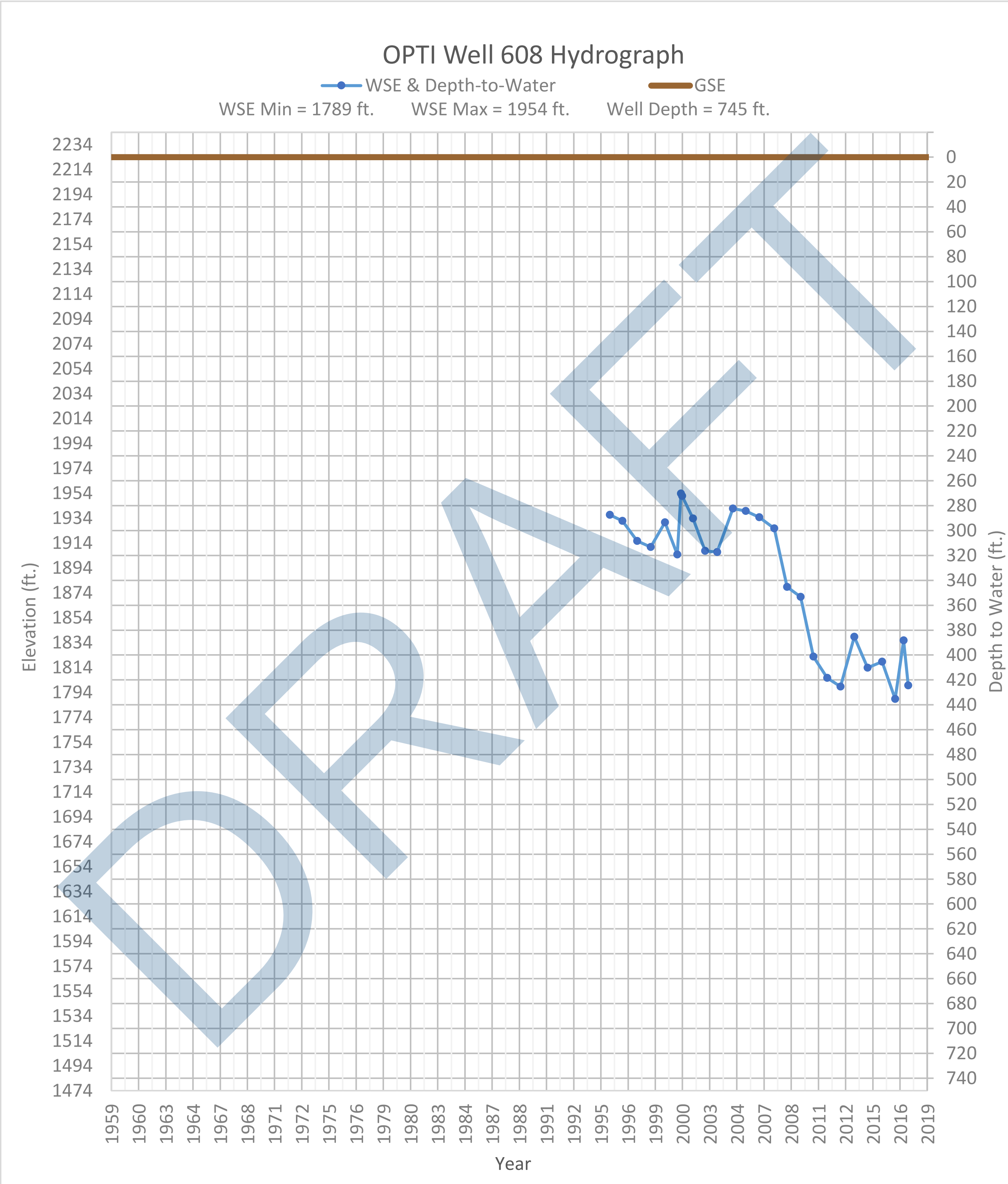


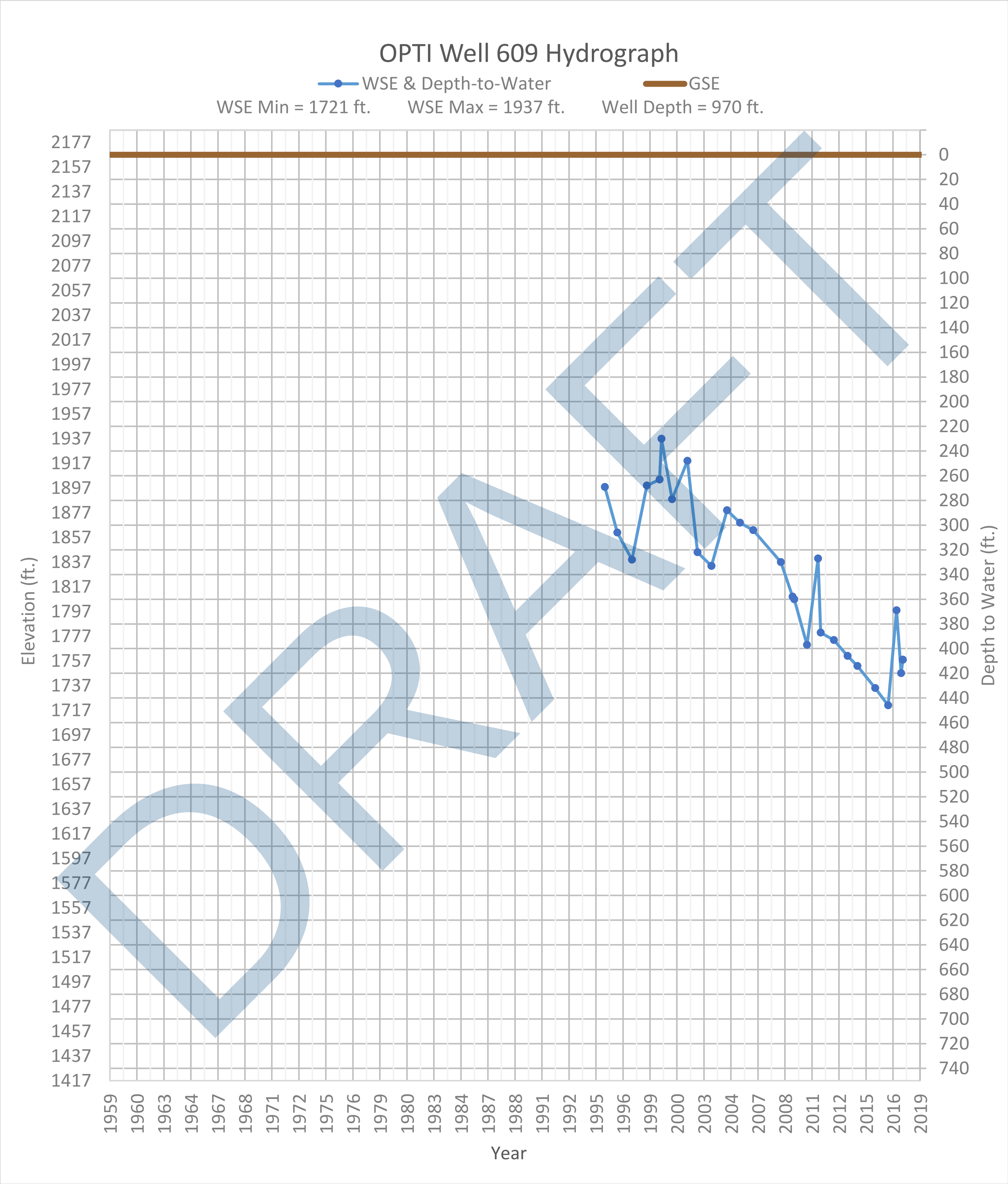
OPTI Well 605 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1708 ft.
WSE Max = 1834 ft.
Well Depth = 597 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

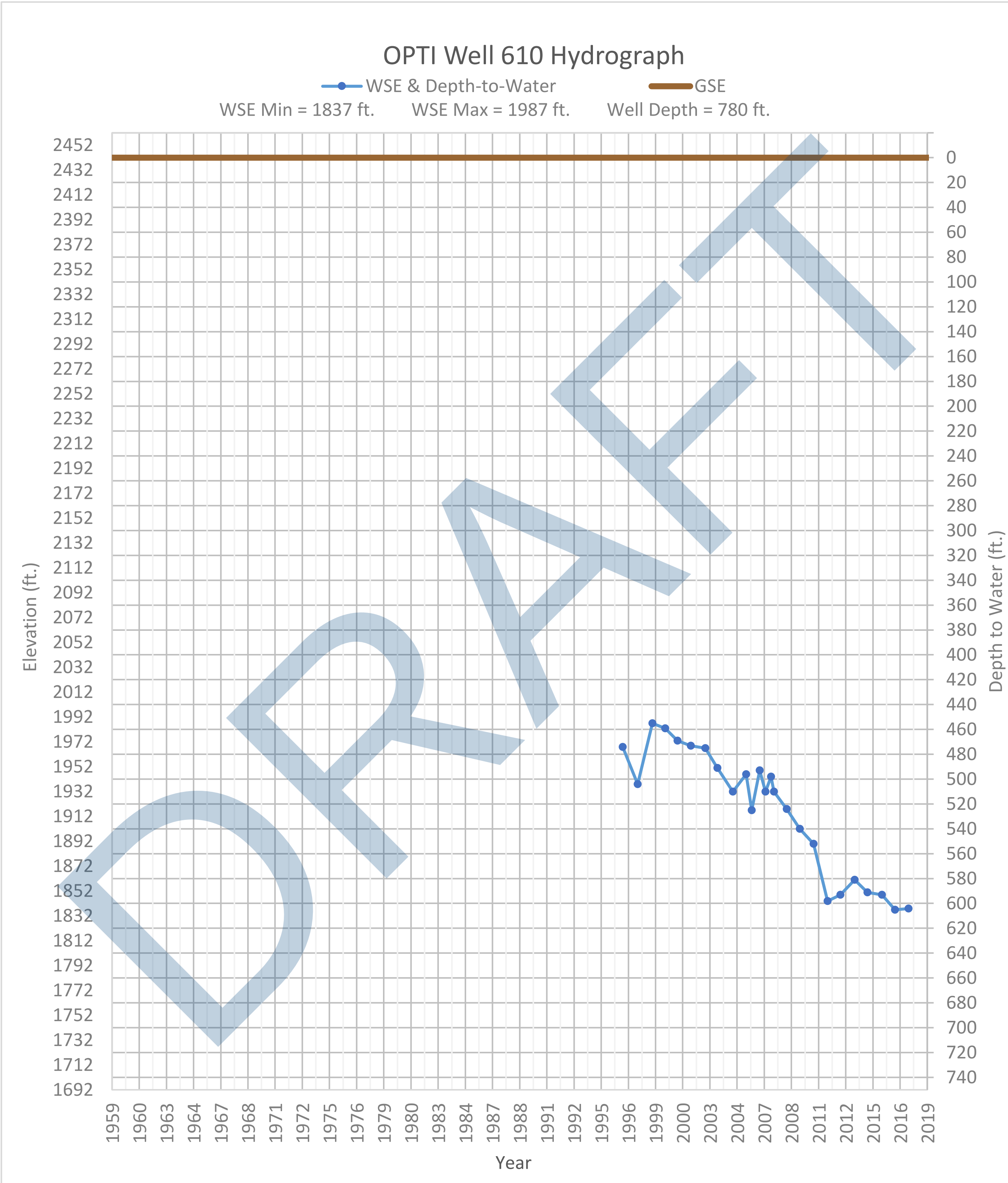

OPTI Well 606 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1812 ft.
WSE Max = 1925 ft.
Well Depth = 804 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



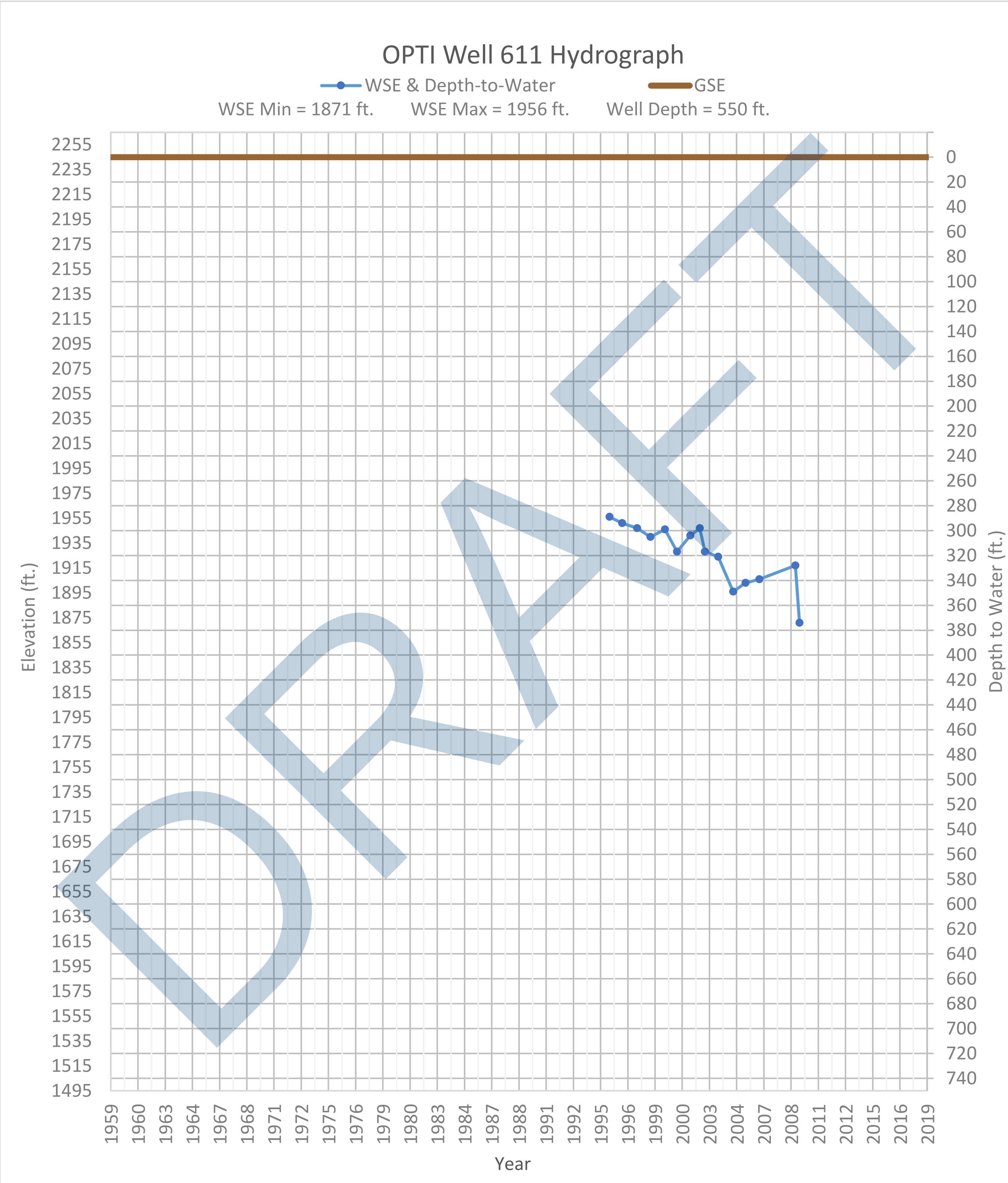
OPTI Well 607 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1751 ft.
WSE Max = 1925 ft.
Well Depth = 775 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 608 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1789 ft.
WSE Max = 1954 ft.
Well Depth = 745 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

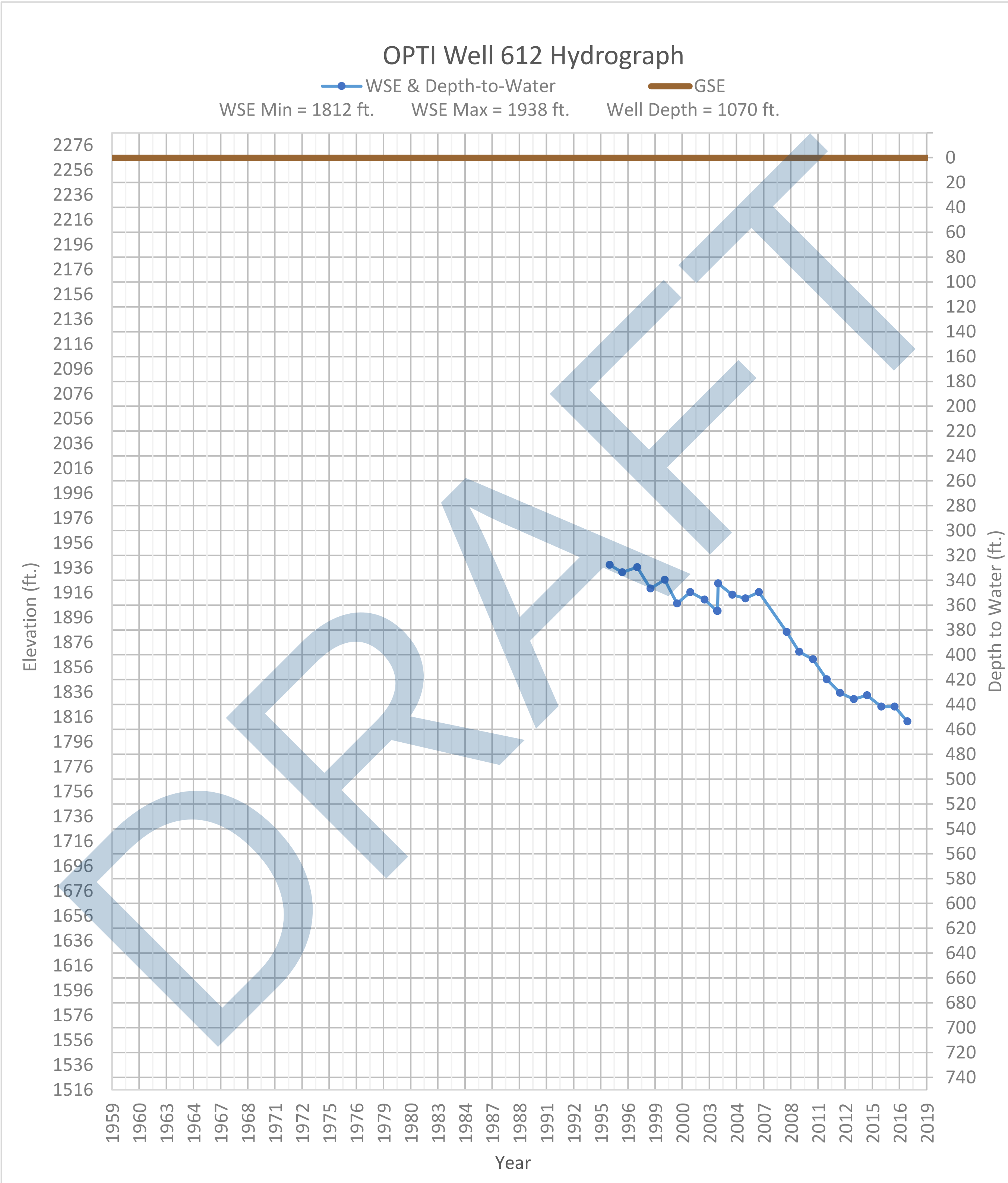

OPTI Well 609 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1721 ft.
WSE Max = 1937 ft.
Well Depth = 970 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



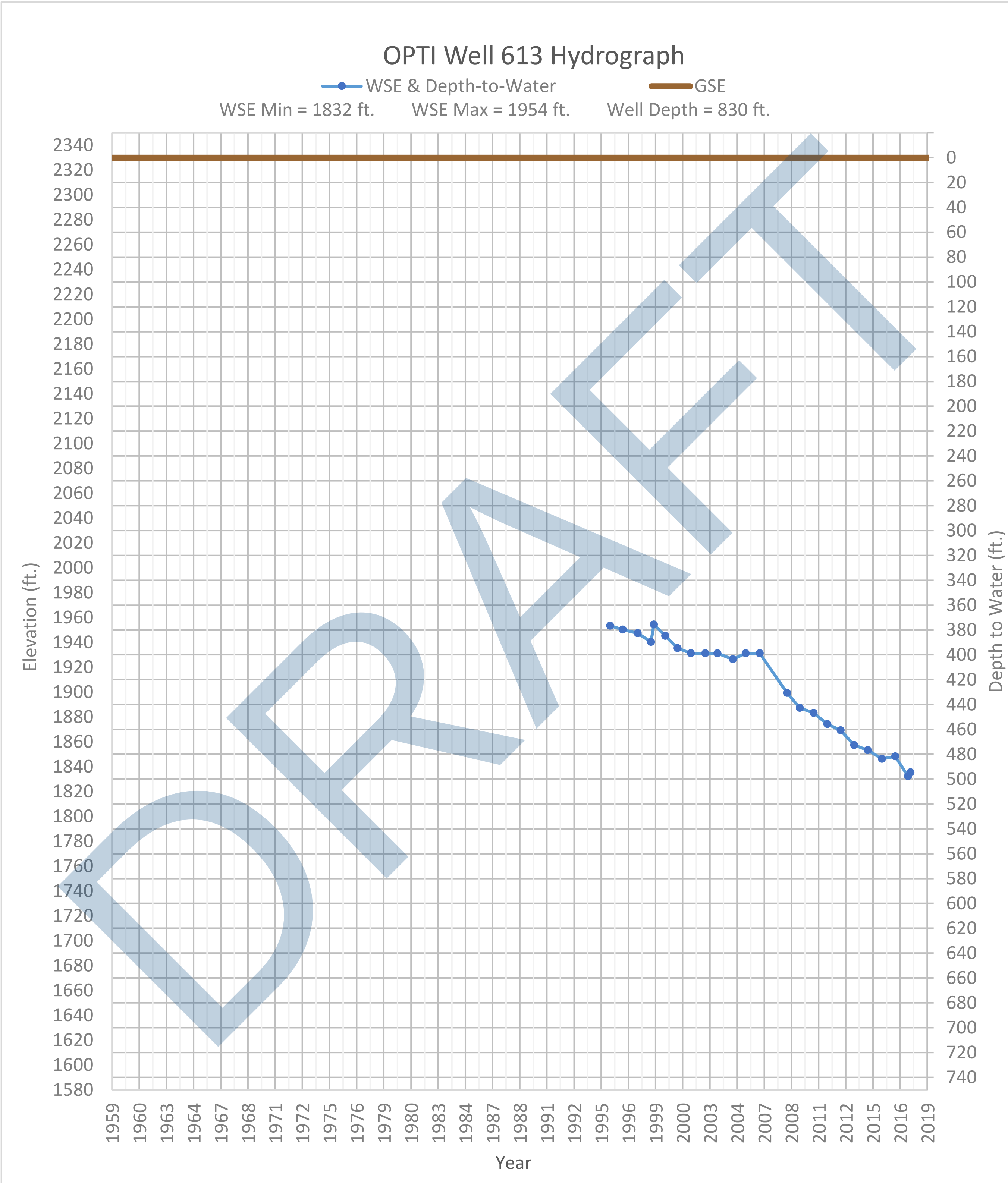
OPTI Well 610 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1837 ft.
WSE Max = 1987 ft.
Well Depth = 780 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

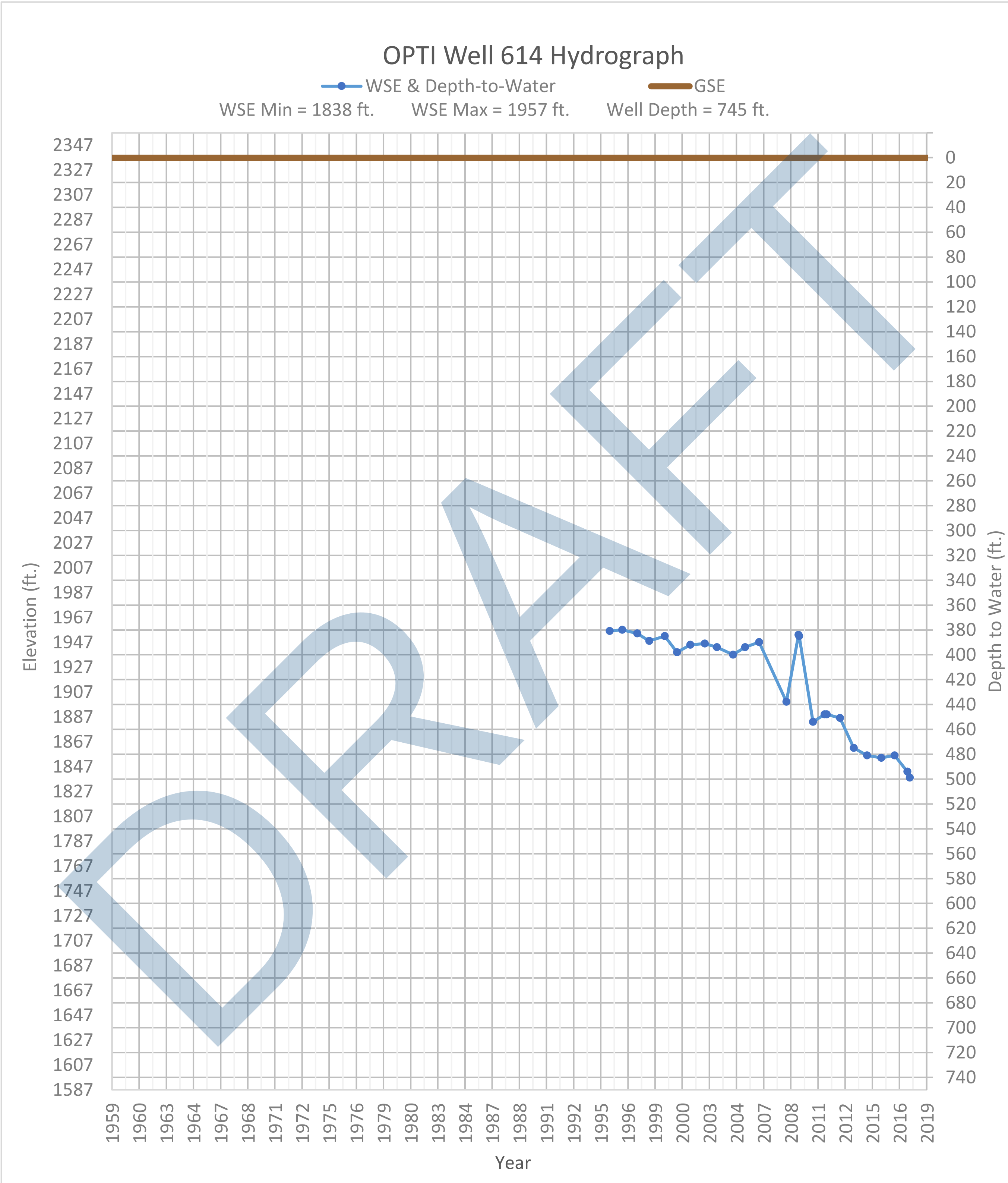


OPTI Well 611 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1871 ft.
WSE Max = 1956 ft.
Well Depth = 550 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

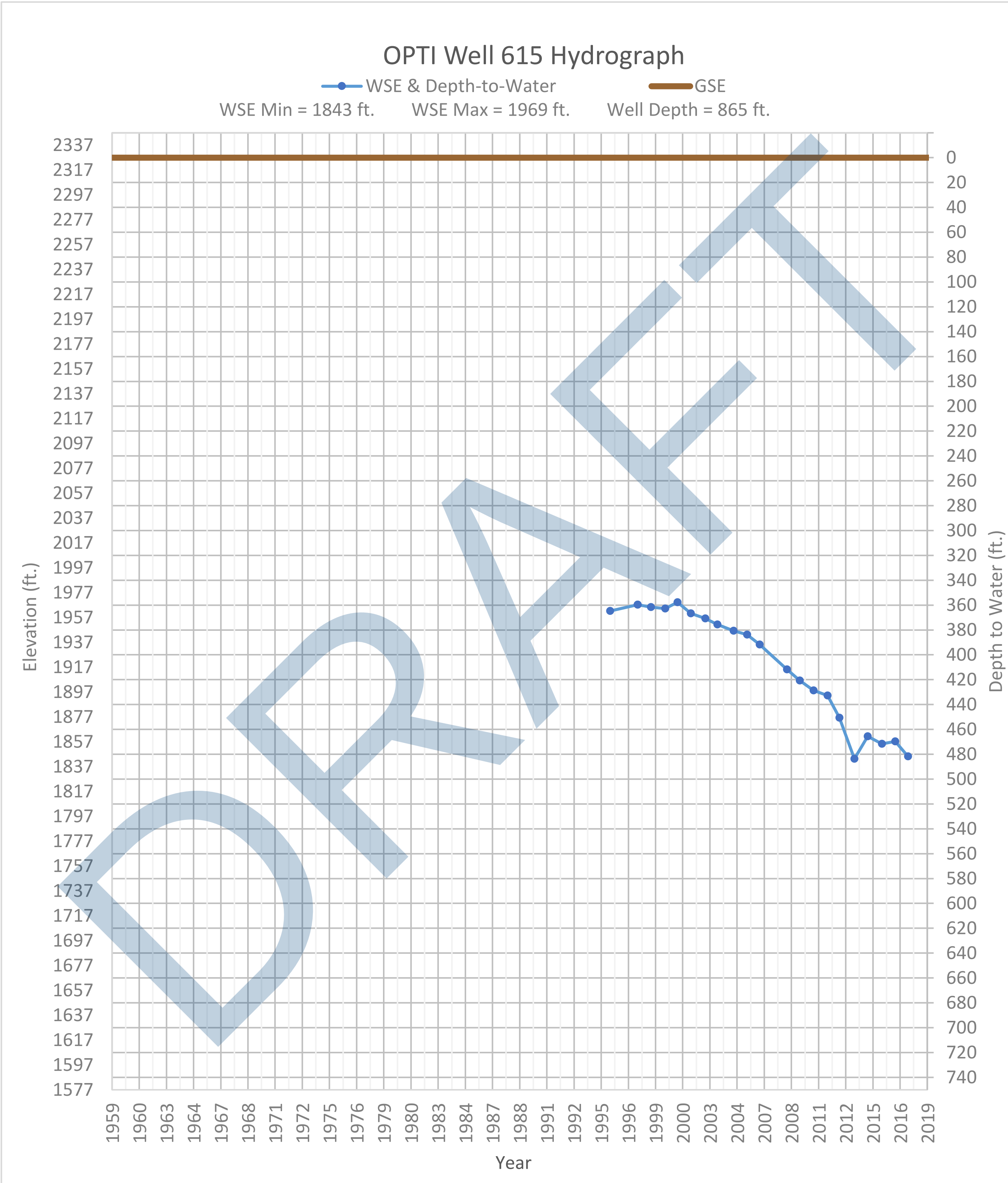


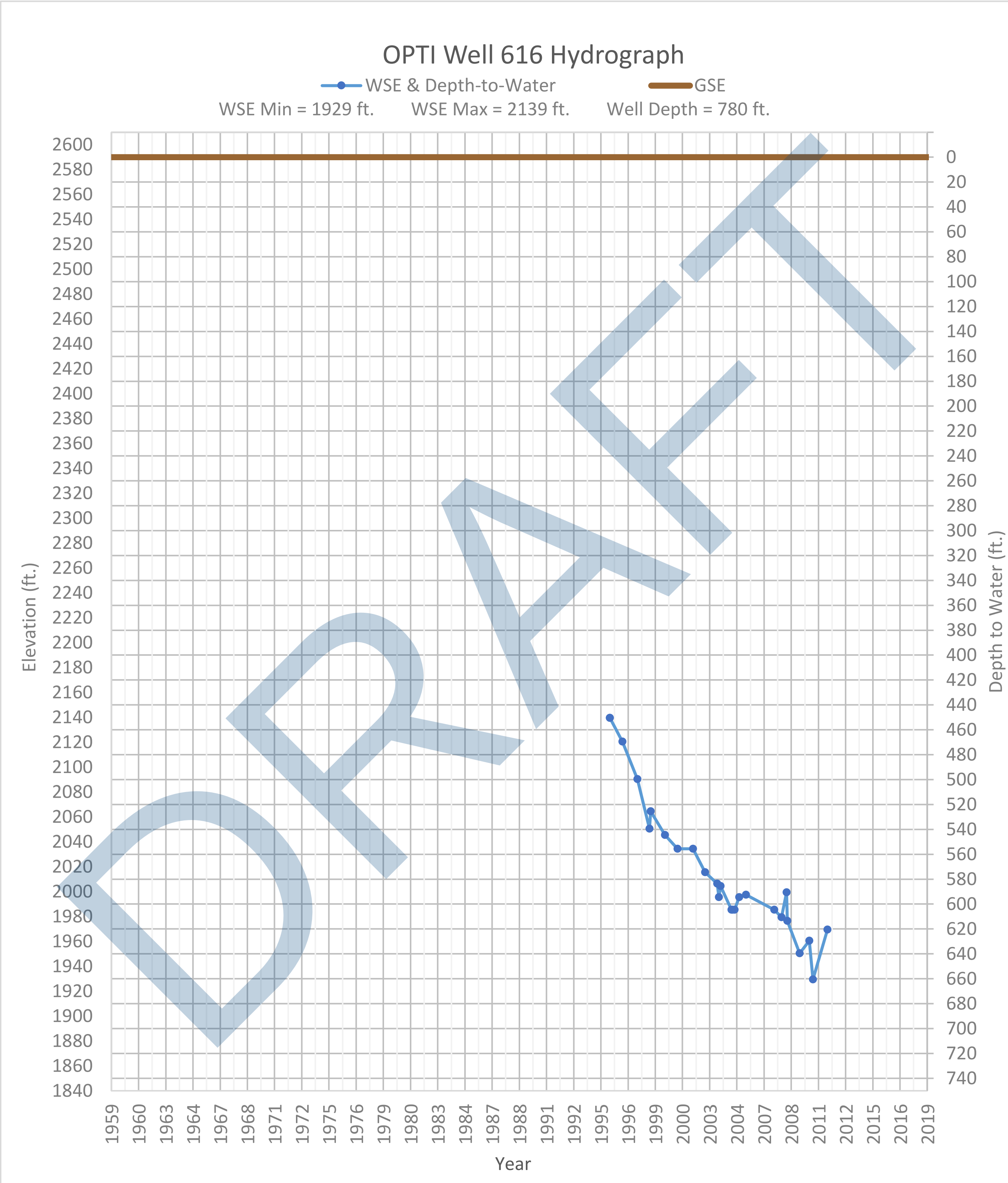
OPTI Well 612 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1812 ft.
WSE Max = 1938 ft.
Well Depth = 1070 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 613 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1832 ft.
WSE Max = 1954 ft.
Well Depth = 830 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 614 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1838 ft.
WSE Max = 1957 ft.
Well Depth = 745 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 615 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1843 ft.
WSE Max = 1969 ft.
Well Depth = 865 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 616 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1929 ft.
WSE Max = 2139 ft.
Well Depth = 780 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2600
2580
2560
2540
2520
2500
2480
2460
2440
2420
2400
2380
2360
2340
2320
2300
2280
2260
2240
2220
2200
2180
2160
2140
2120
2100
2080
2060
2040
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2000
1980
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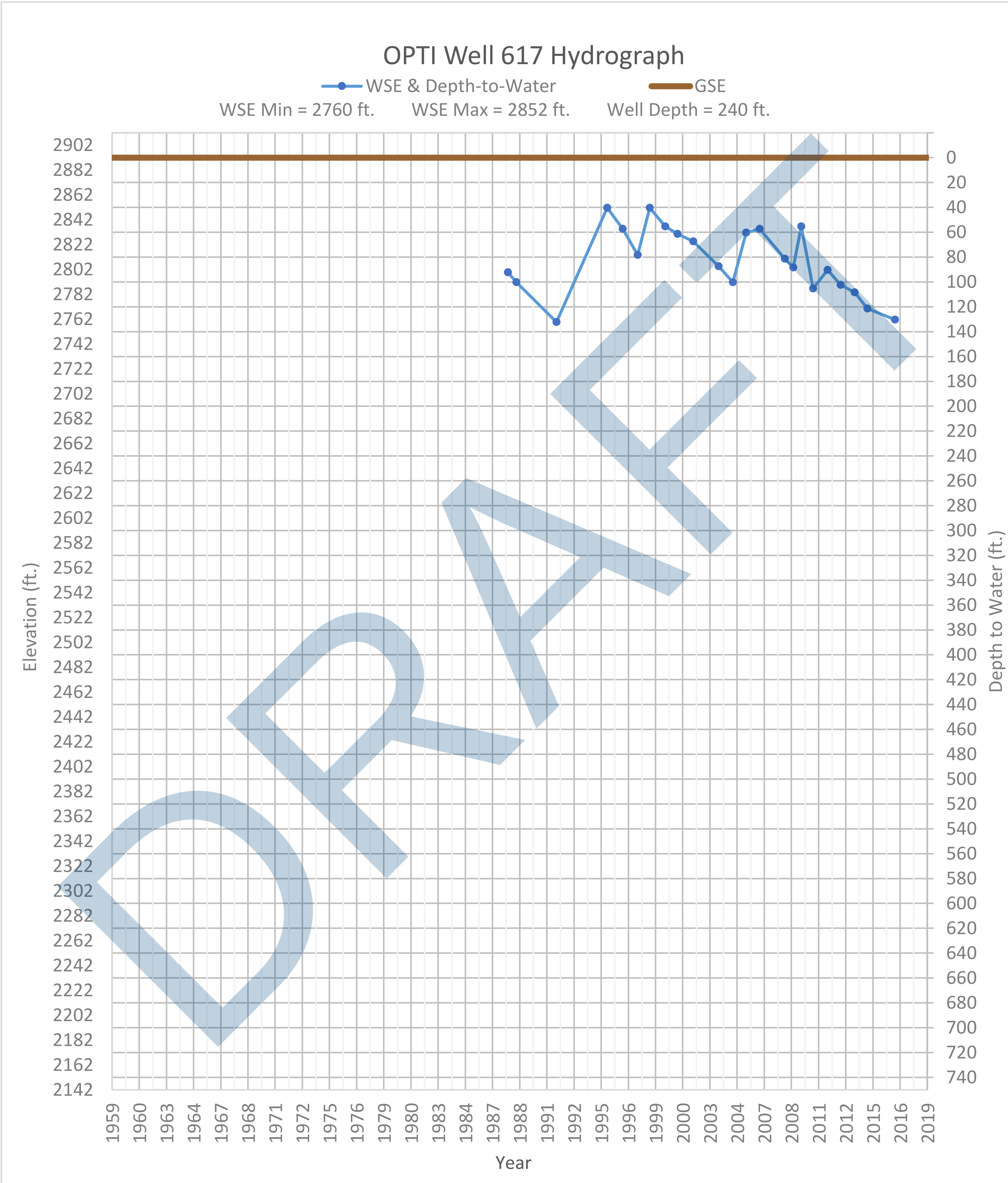
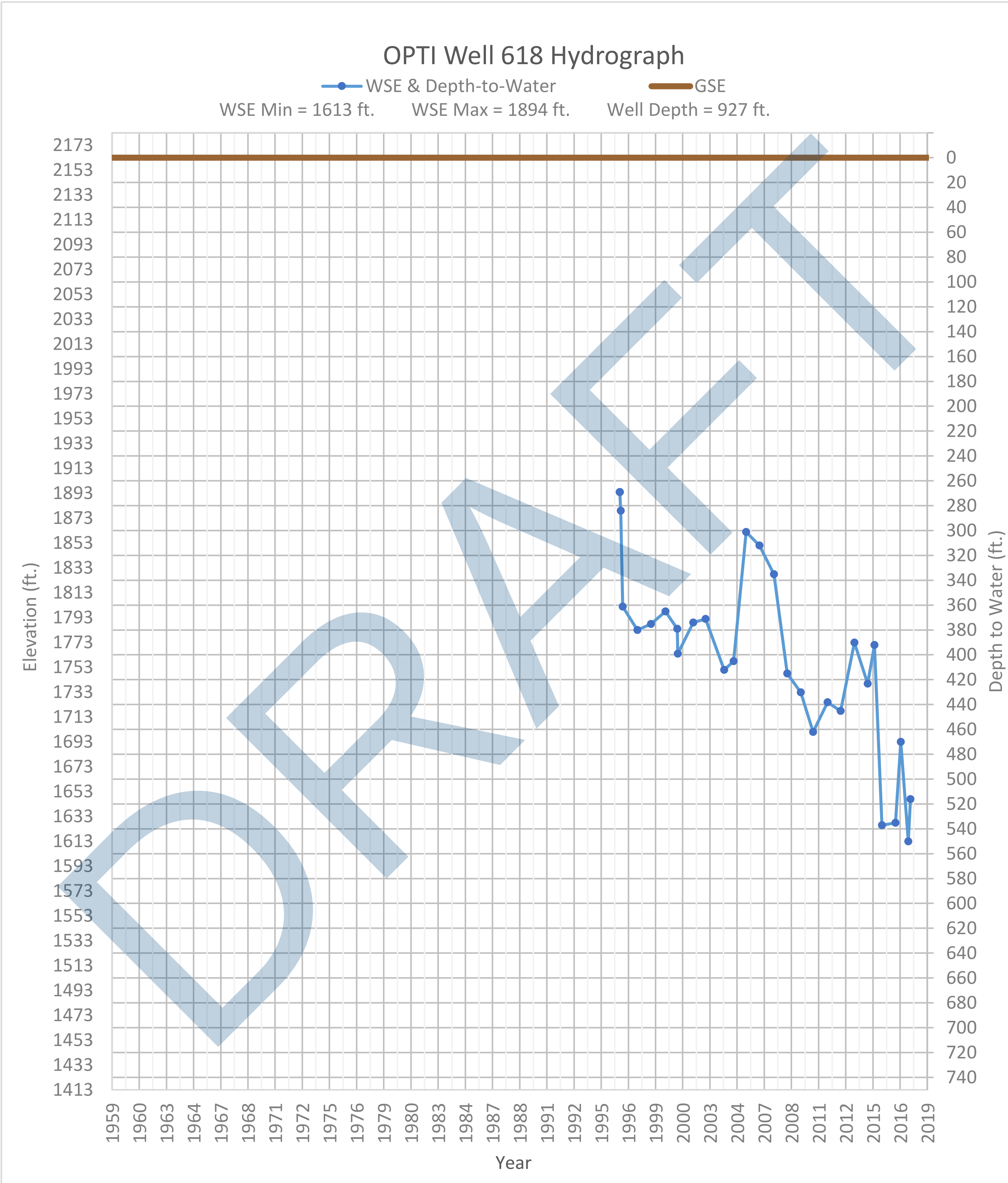
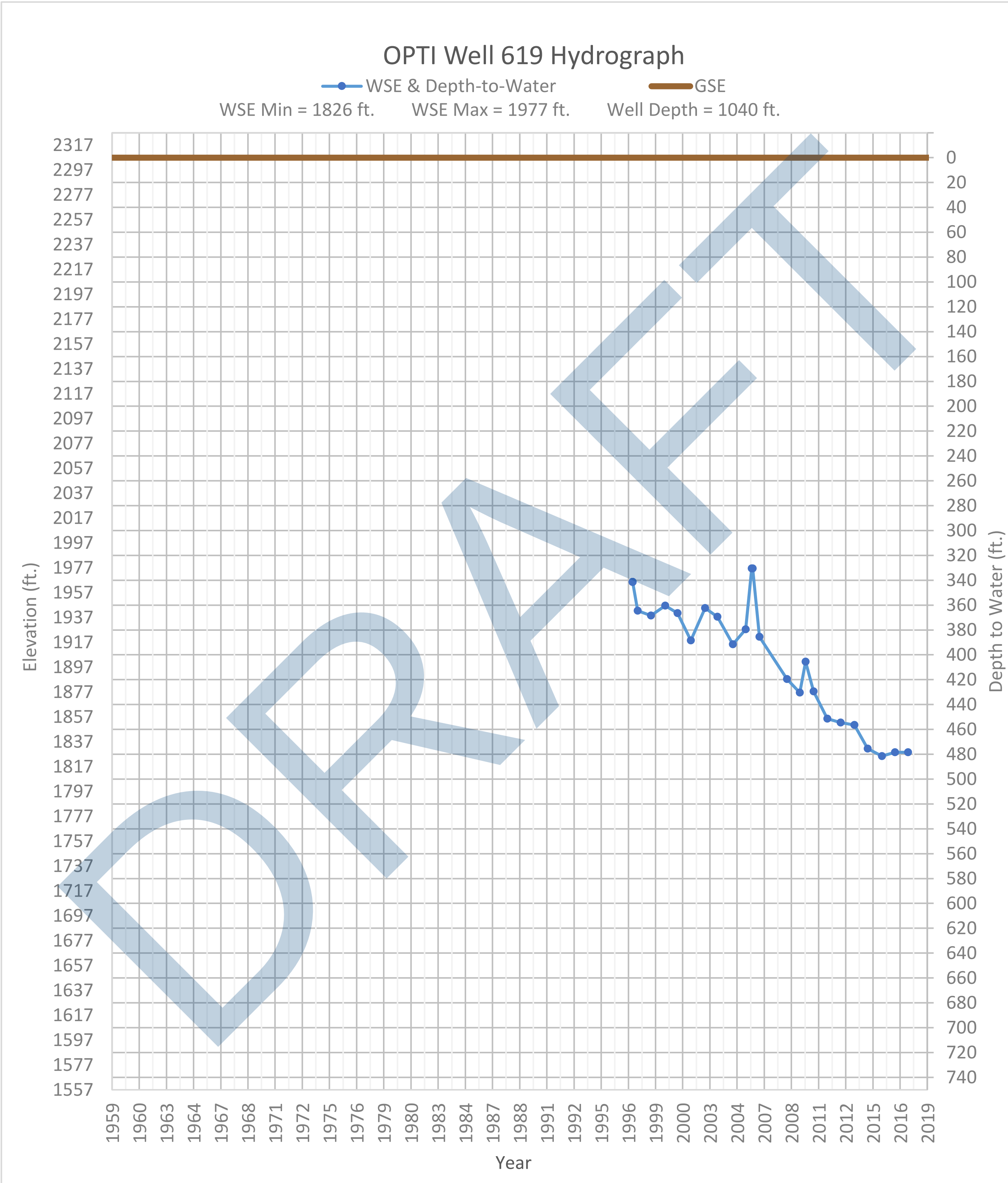
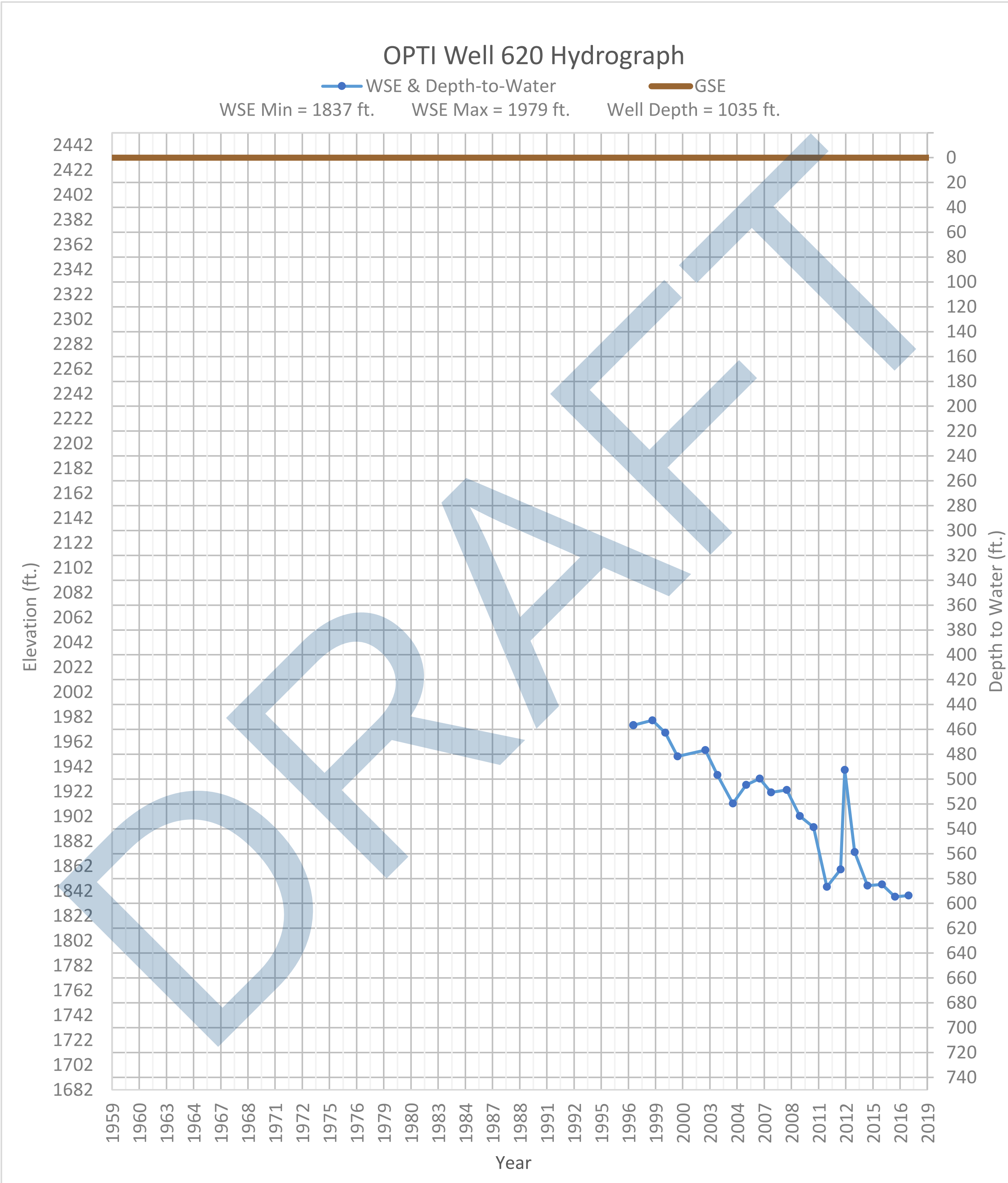


OPTI Well 617 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2760 ft.
WSE Max = 2852 ft.
Well Depth = 240 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

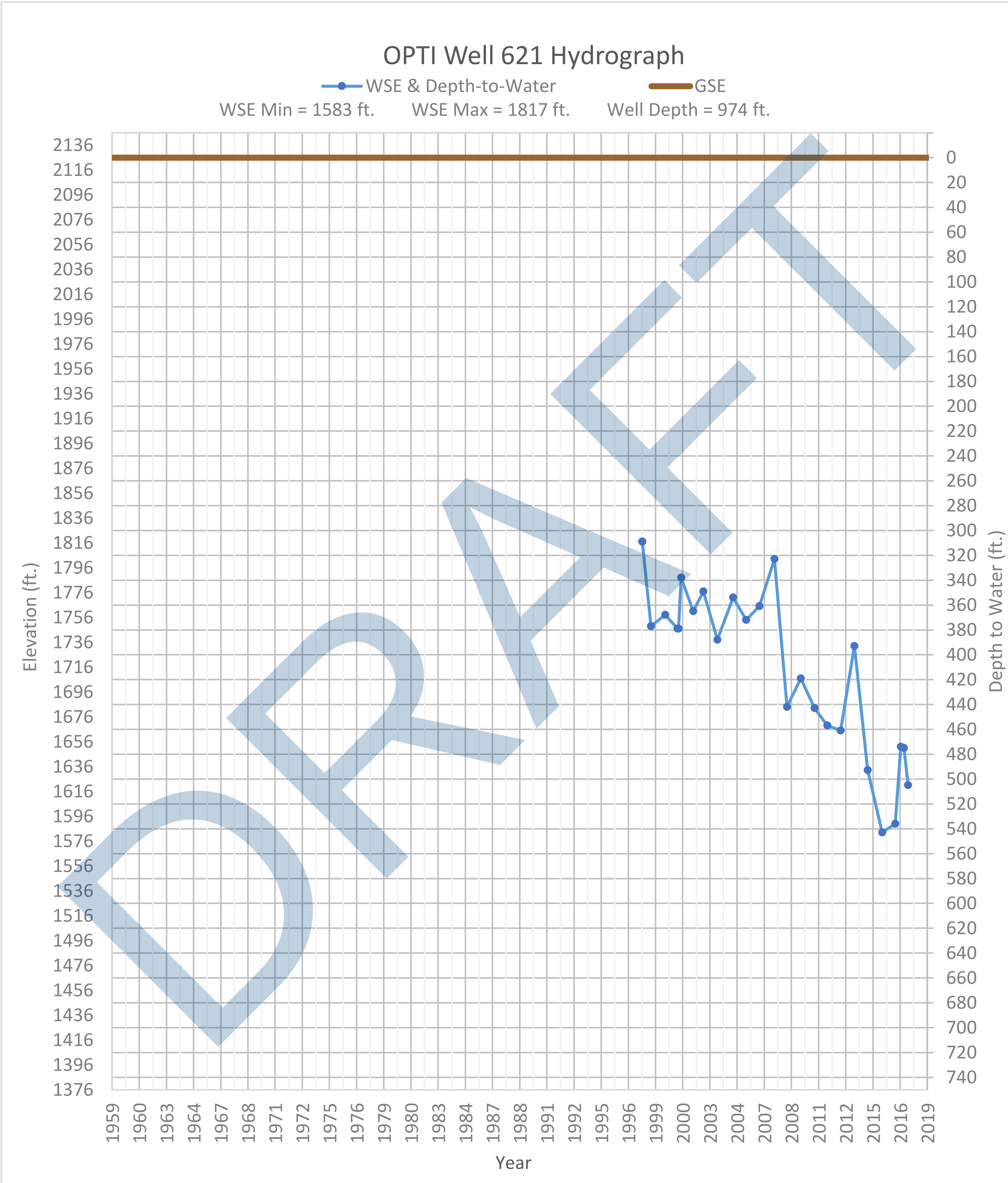

OPTI Well 618 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1613 ft.
WSE Max = 1894 ft.
Well Depth = 927 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



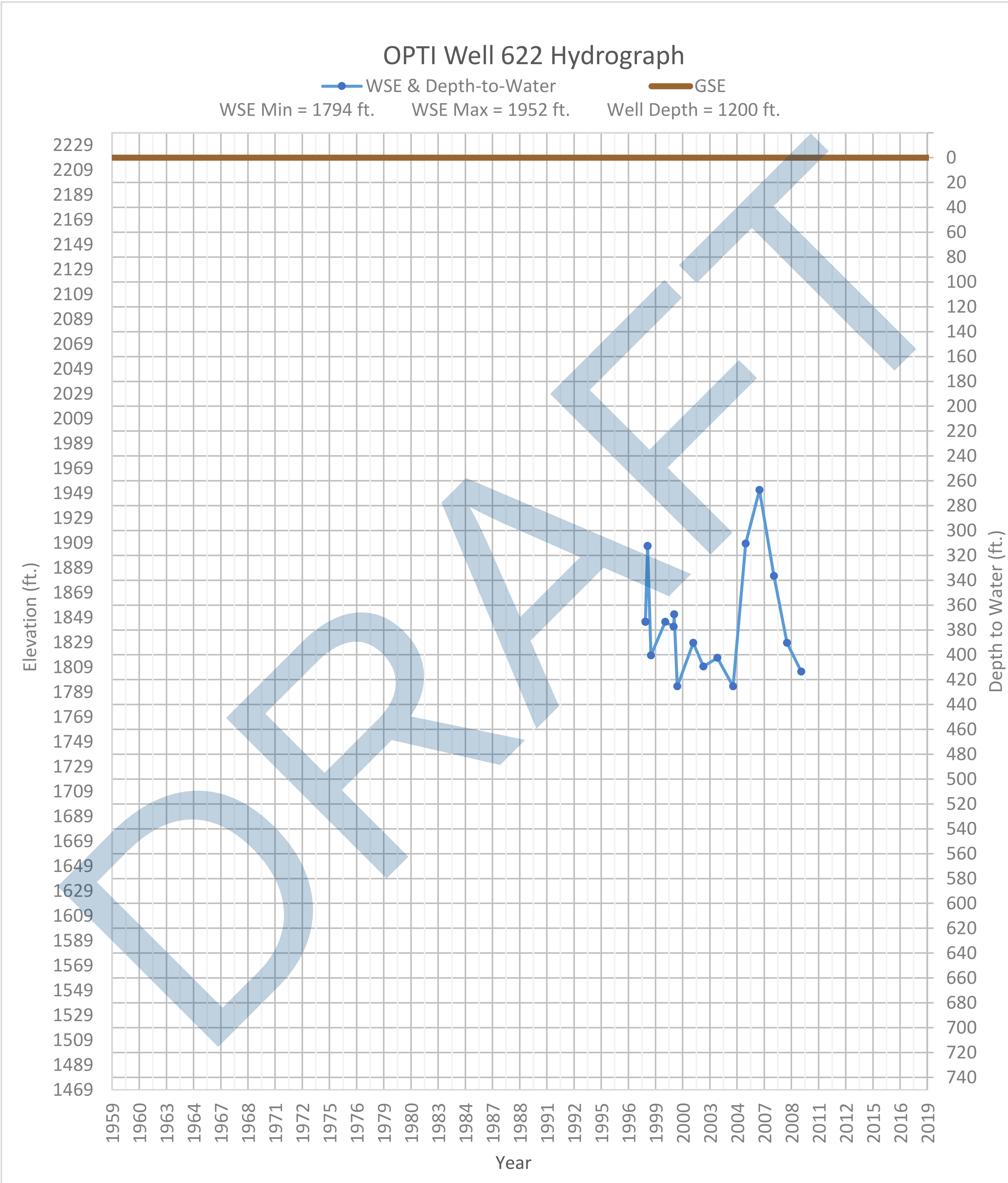
OPTI Well 619 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1826 ft.
WSE Max = 1977 ft.
Well Depth = 1040 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



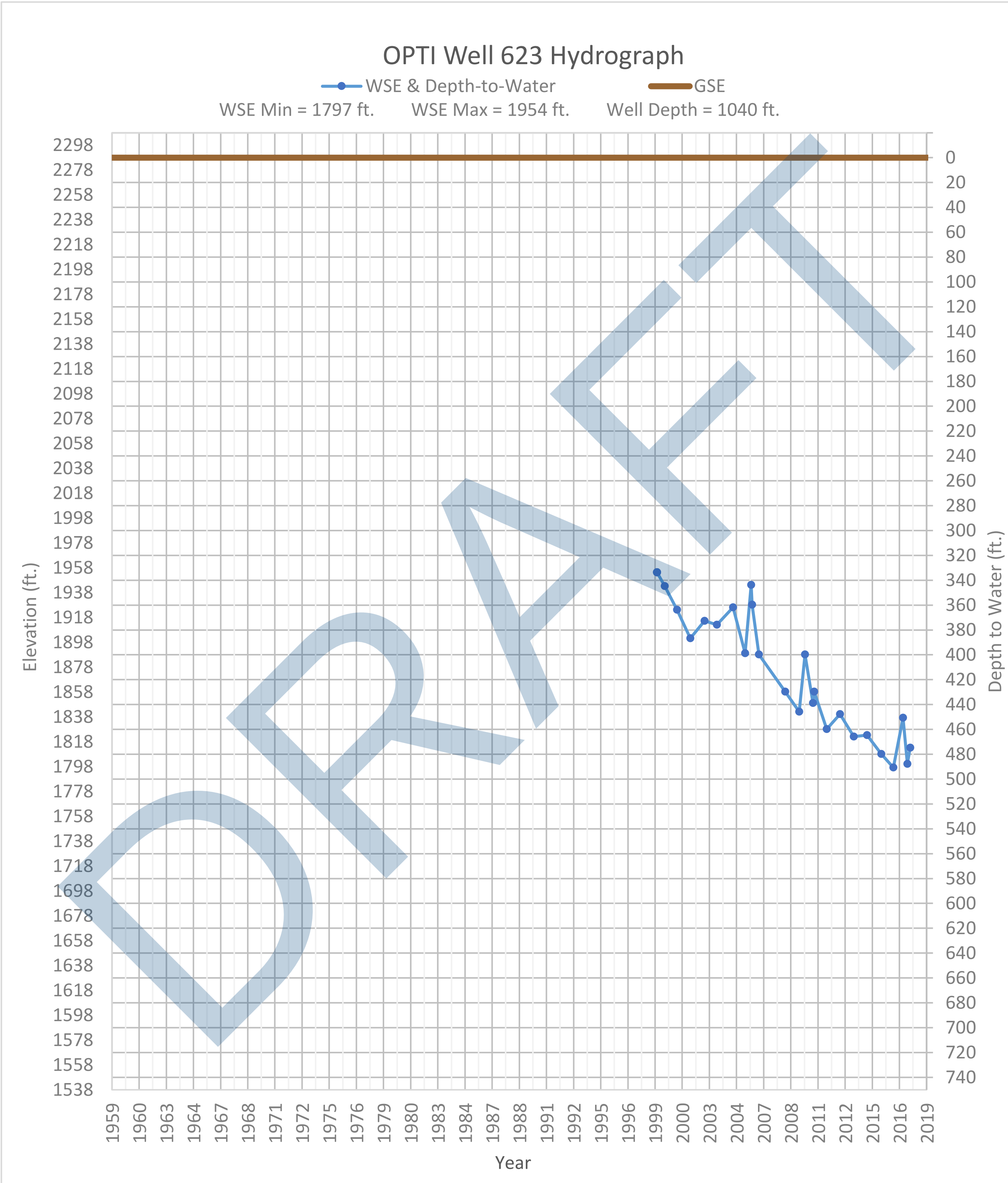
OPTI Well 620 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1837 ft.
WSE Max = 1979 ft.
Well Depth = 1035 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



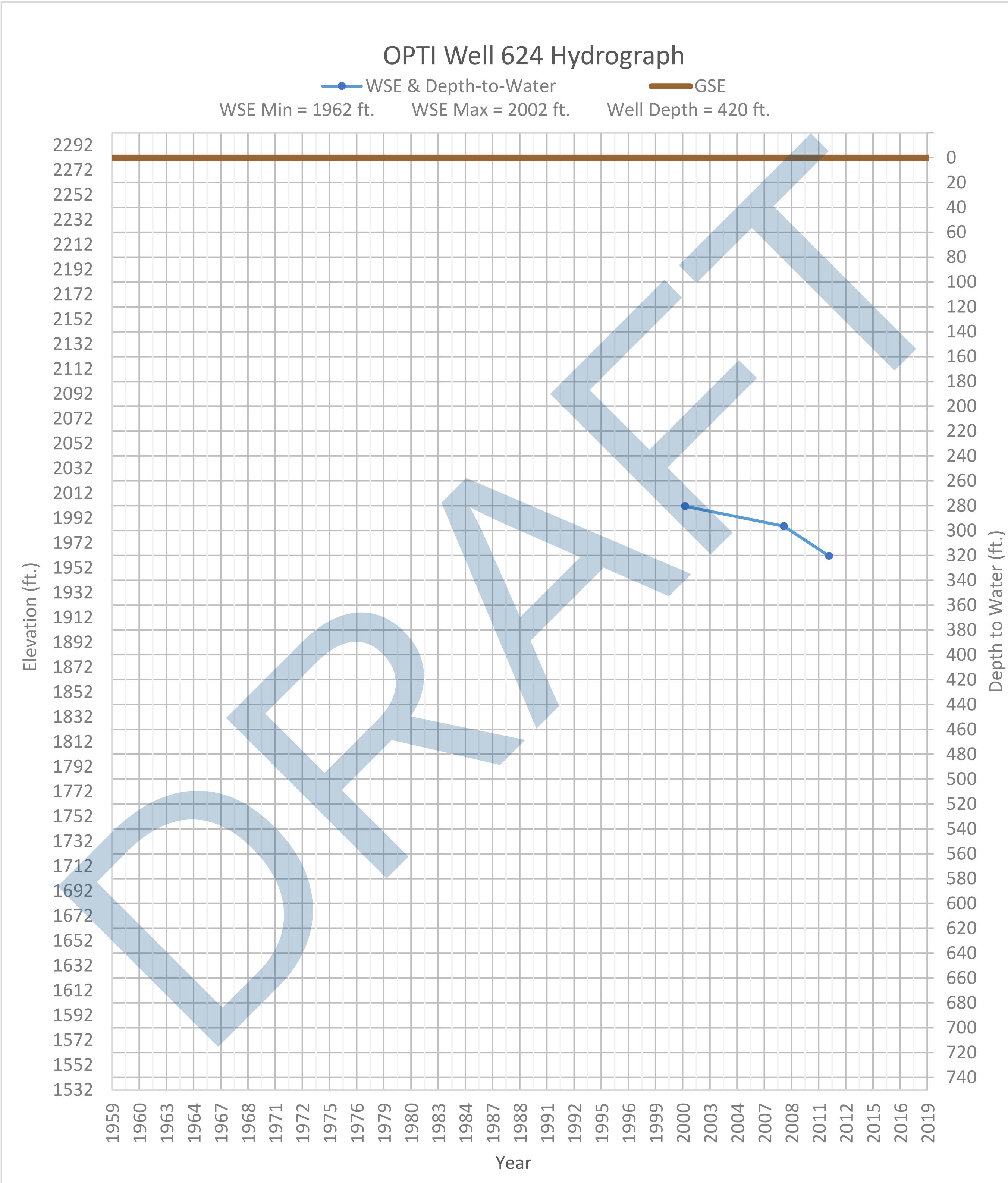
OPTI Well 621 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1583 ft.
WSE Max = 1817 ft.
Well Depth = 974 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



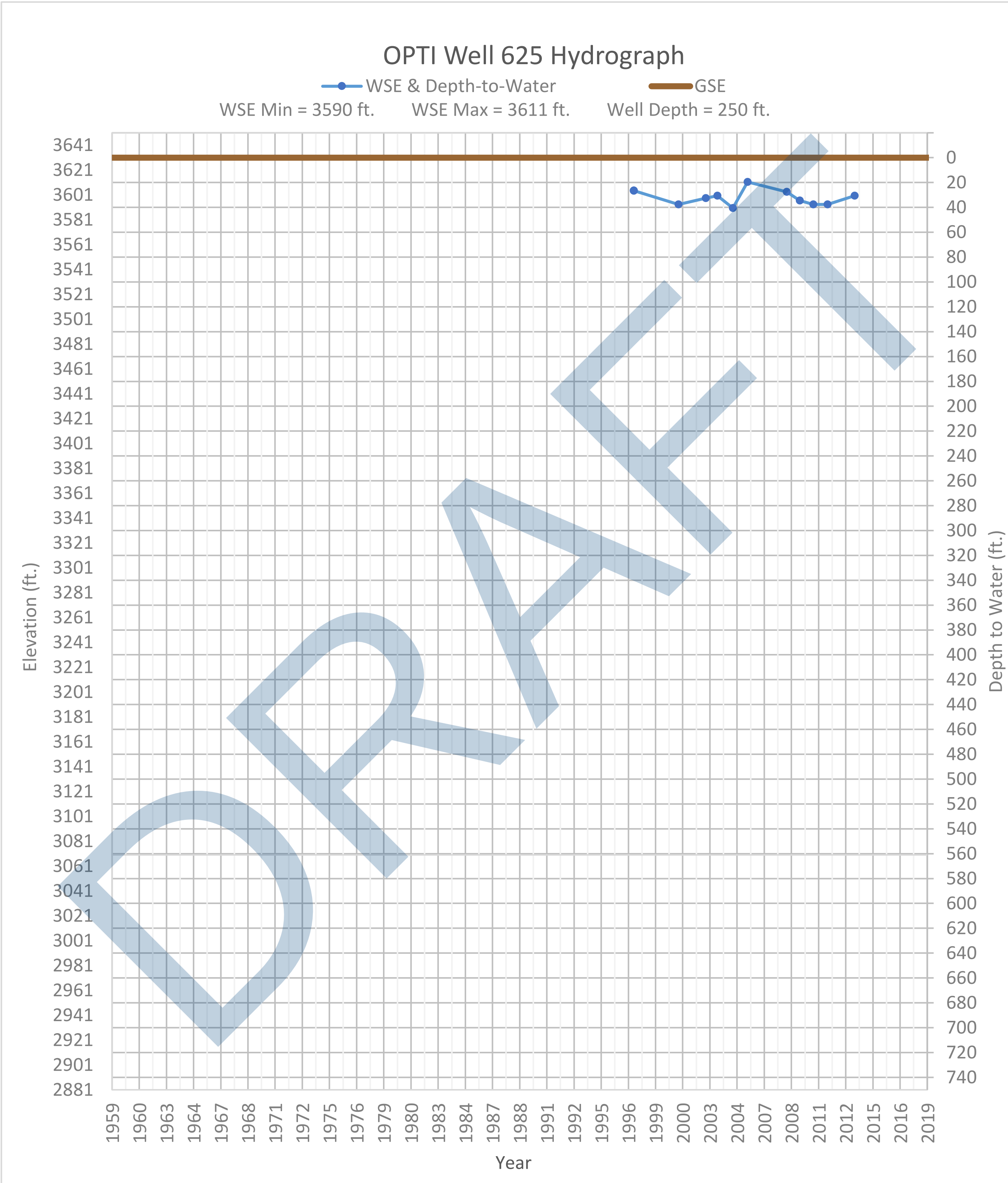
OPTI Well 622 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1794 ft.
WSE Max = 1952 ft.
Well Depth = 1200 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



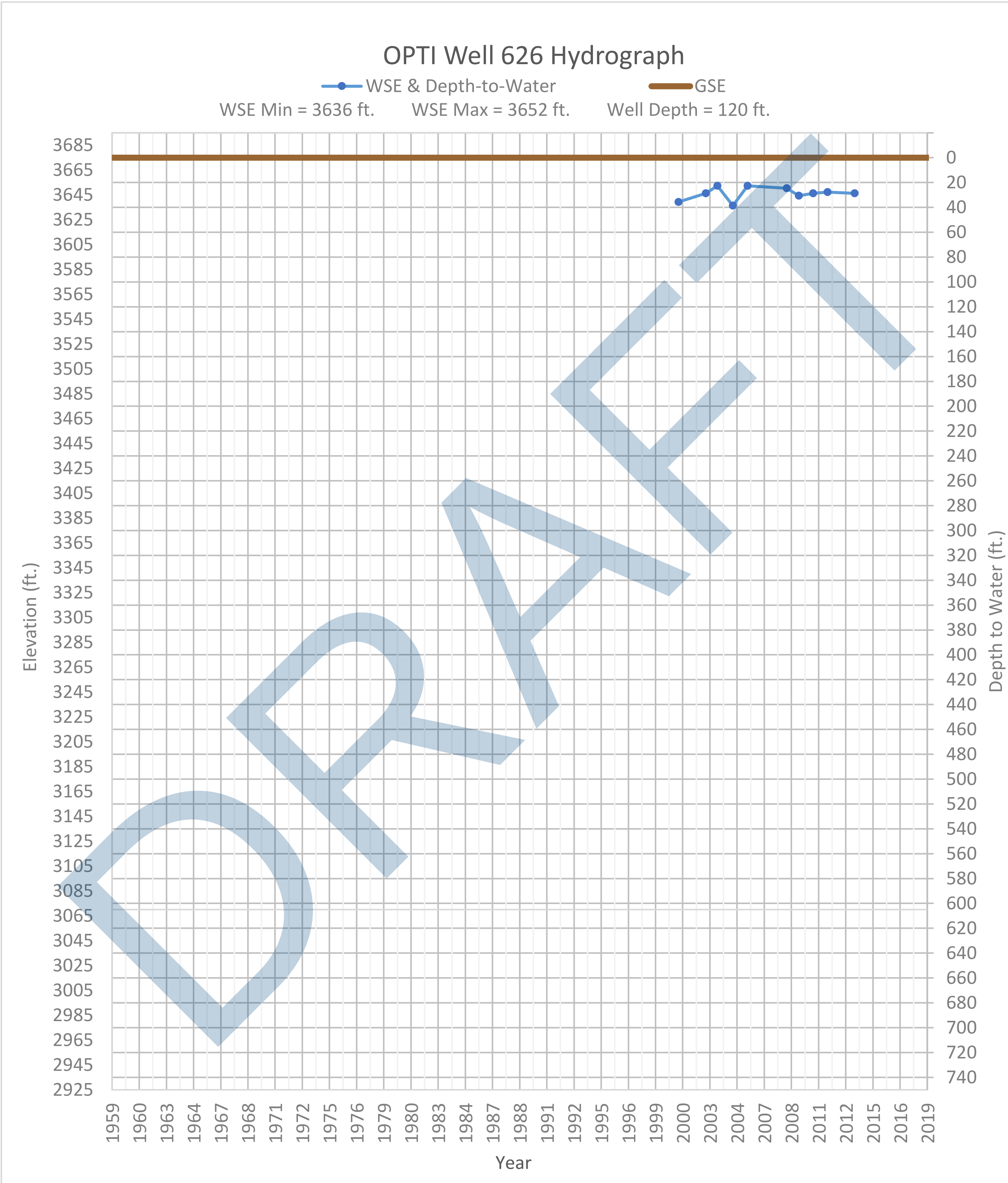
OPTI Well 623 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1797 ft.
WSE Max = 1954 ft.
Well Depth = 1040 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



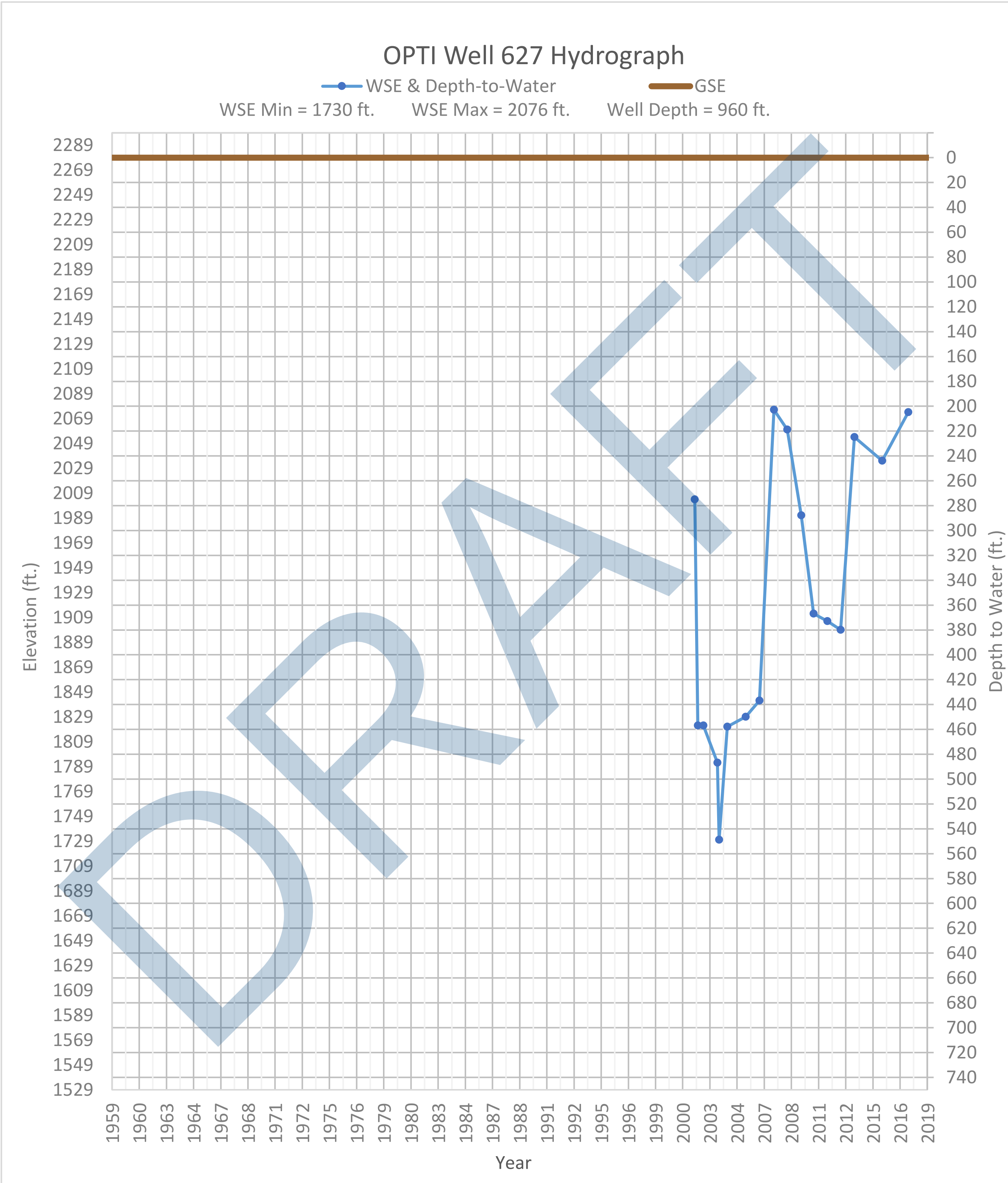
OPTI Well 624 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1962 ft.
WSE Max = 2002 ft.
Well Depth = 420 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 625 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3590 ft.
WSE Max = 3611 ft.
Well Depth = 250 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

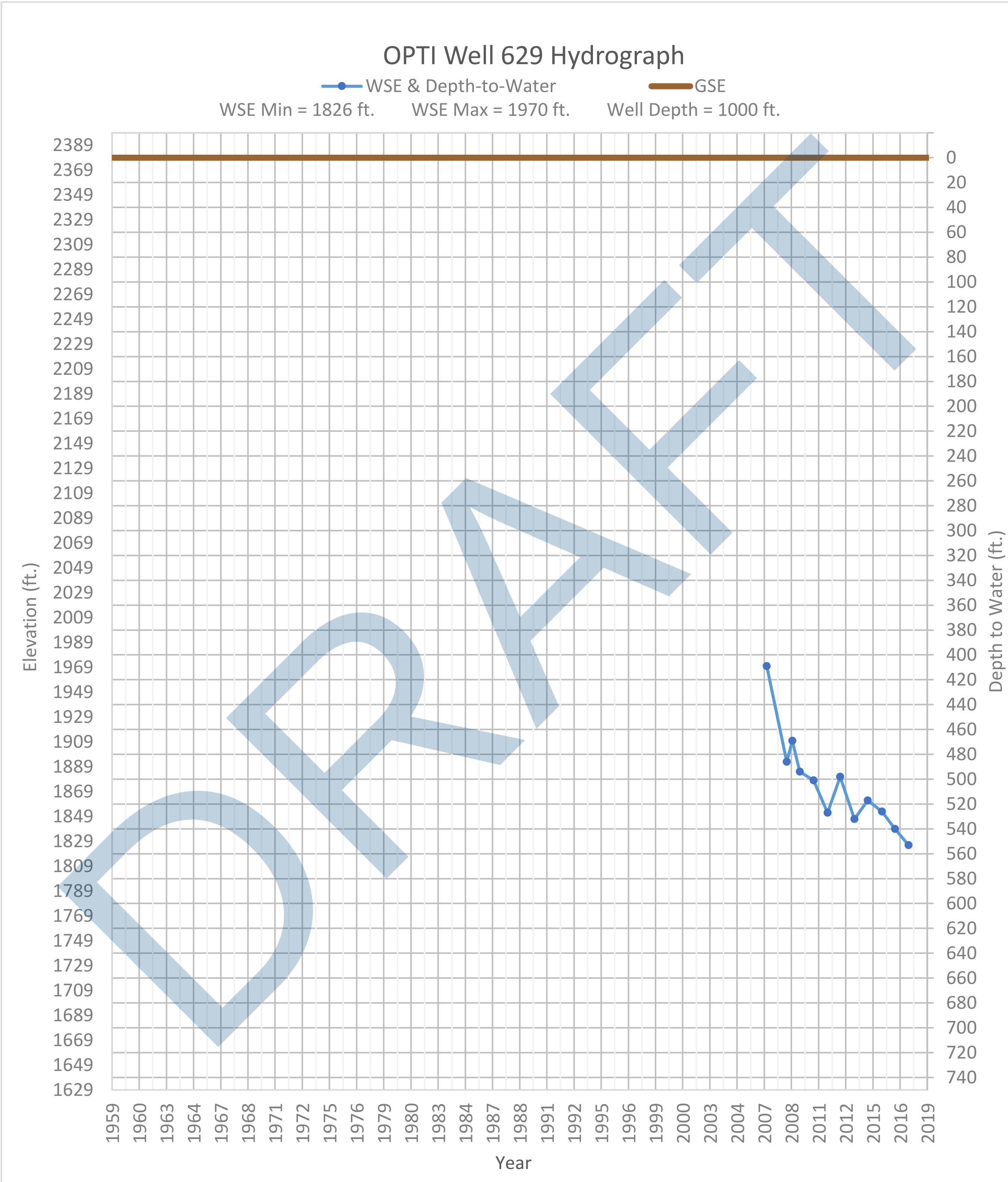


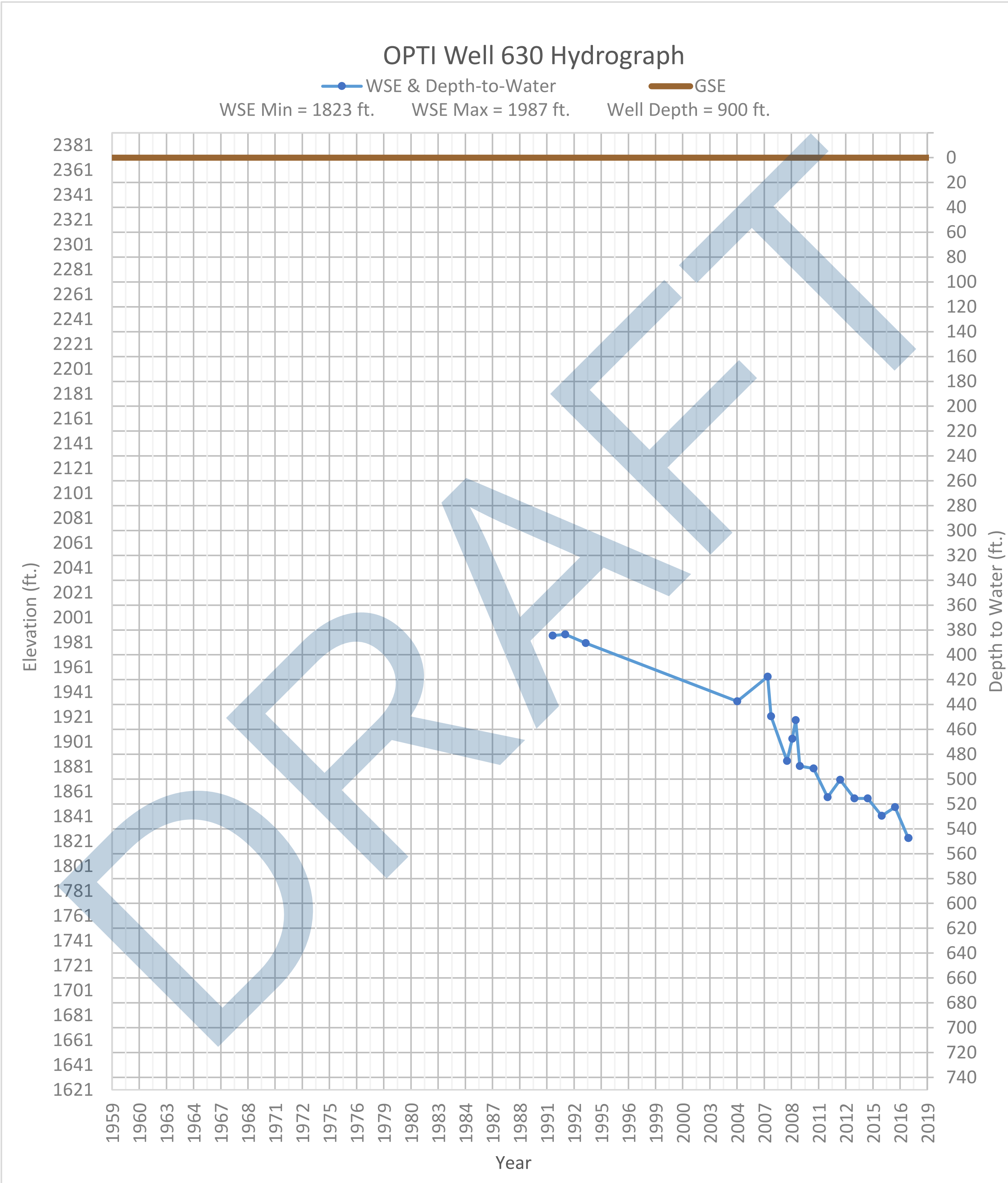
OPTI Well 626 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 3636 ft.
WSE Max = 3652 ft.
Well Depth = 120 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



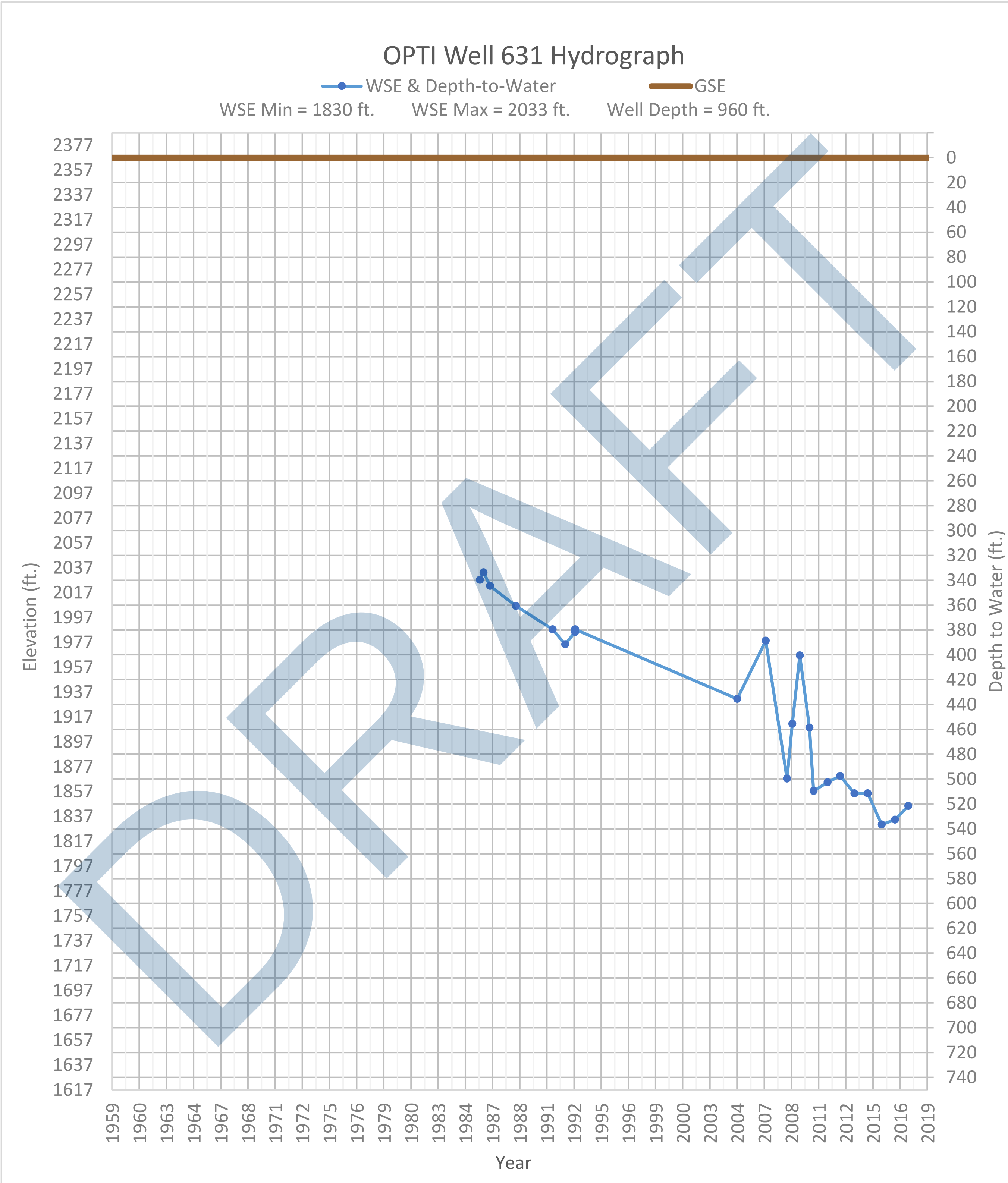
OPTI Well 627 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1730 ft.
WSE Max = 2076 ft.
Well Depth = 960 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

OPTI Well 628 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1792 ft.
WSE Max = 2078 ft.
Well Depth = 941 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

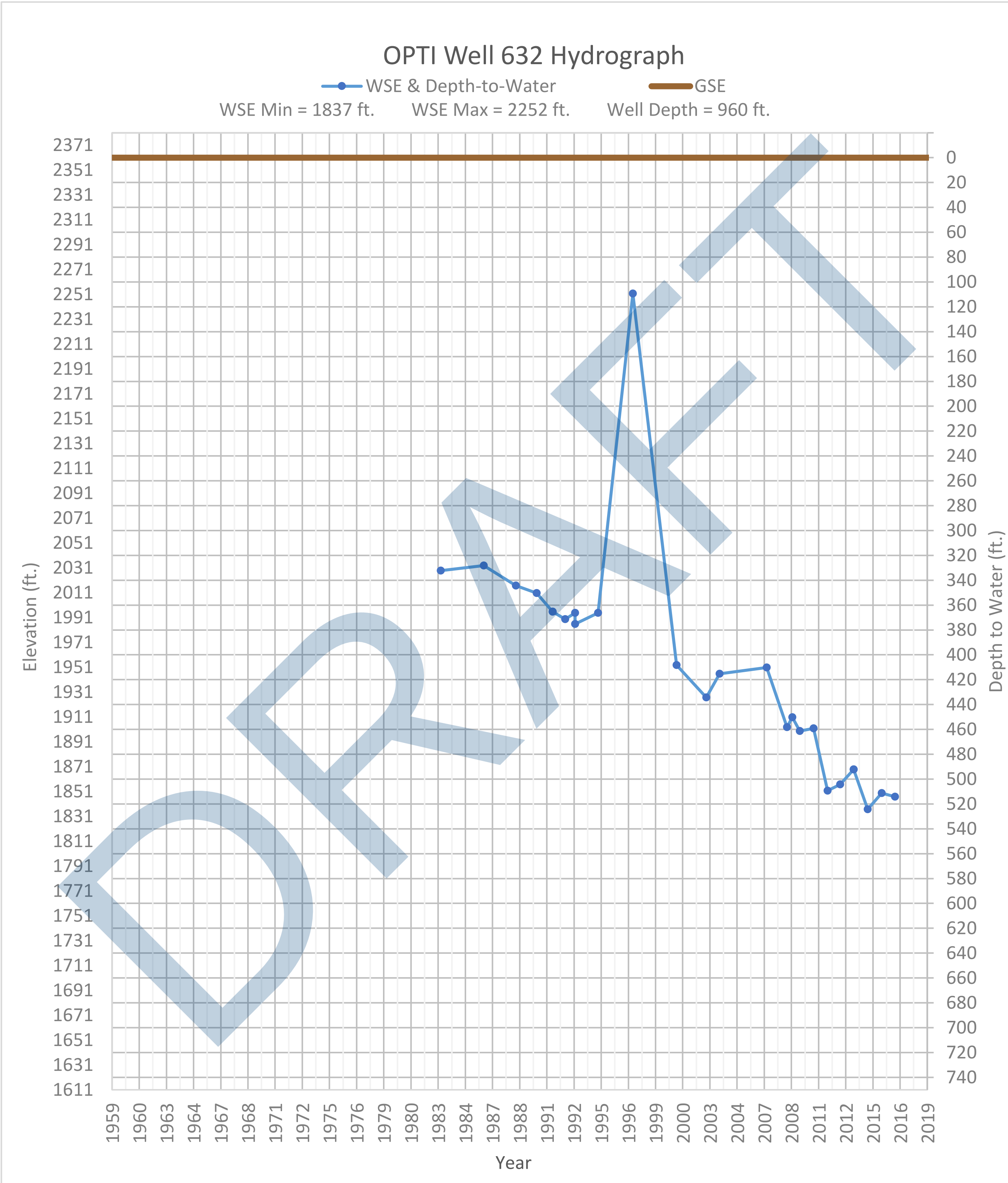

OPTI Well 629 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1826 ft.
WSE Max = 1970 ft.
Well Depth = 1000 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



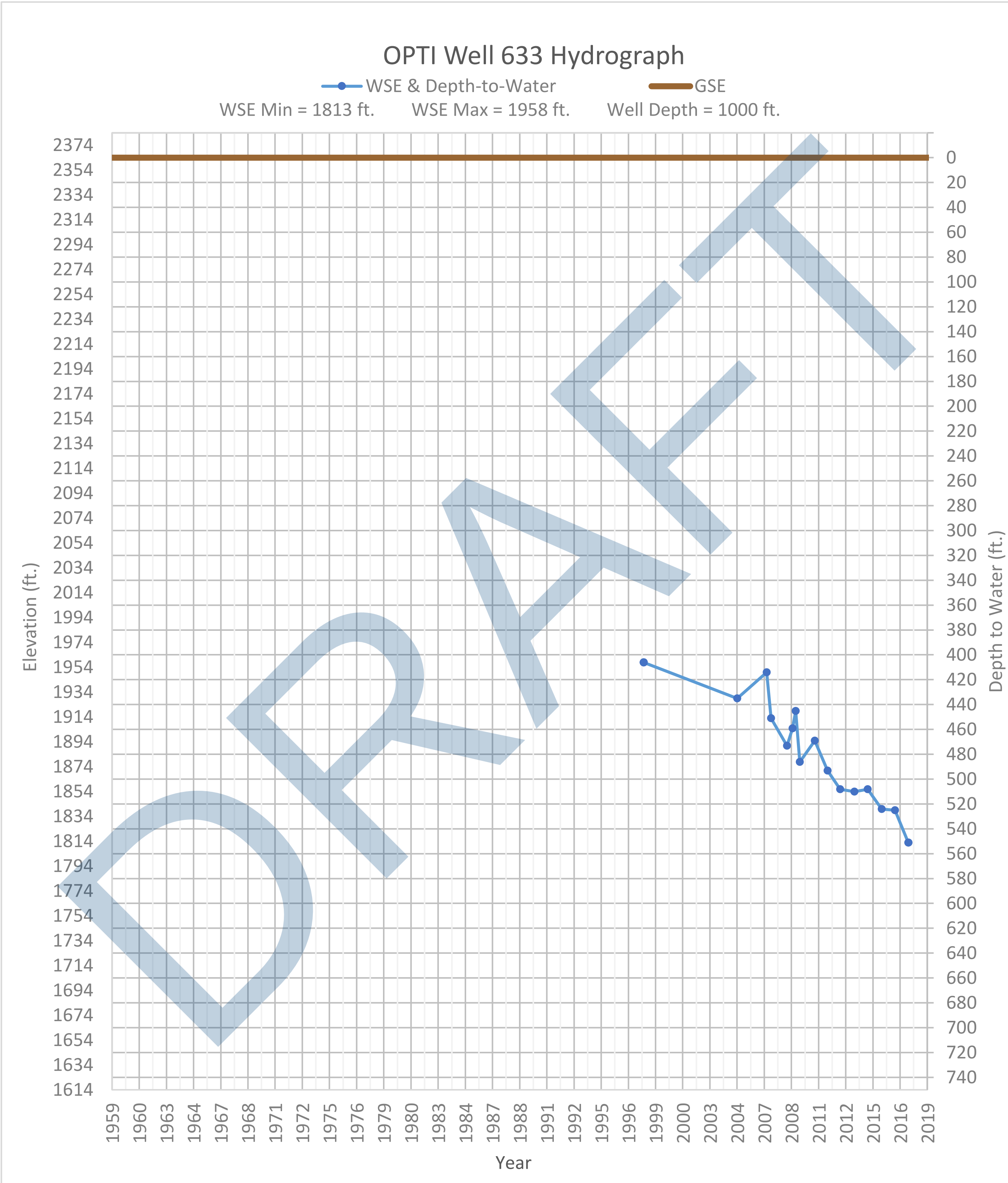
OPTI Well 630 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1823 ft.
WSE Max = 1987 ft.
Well Depth = 900 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

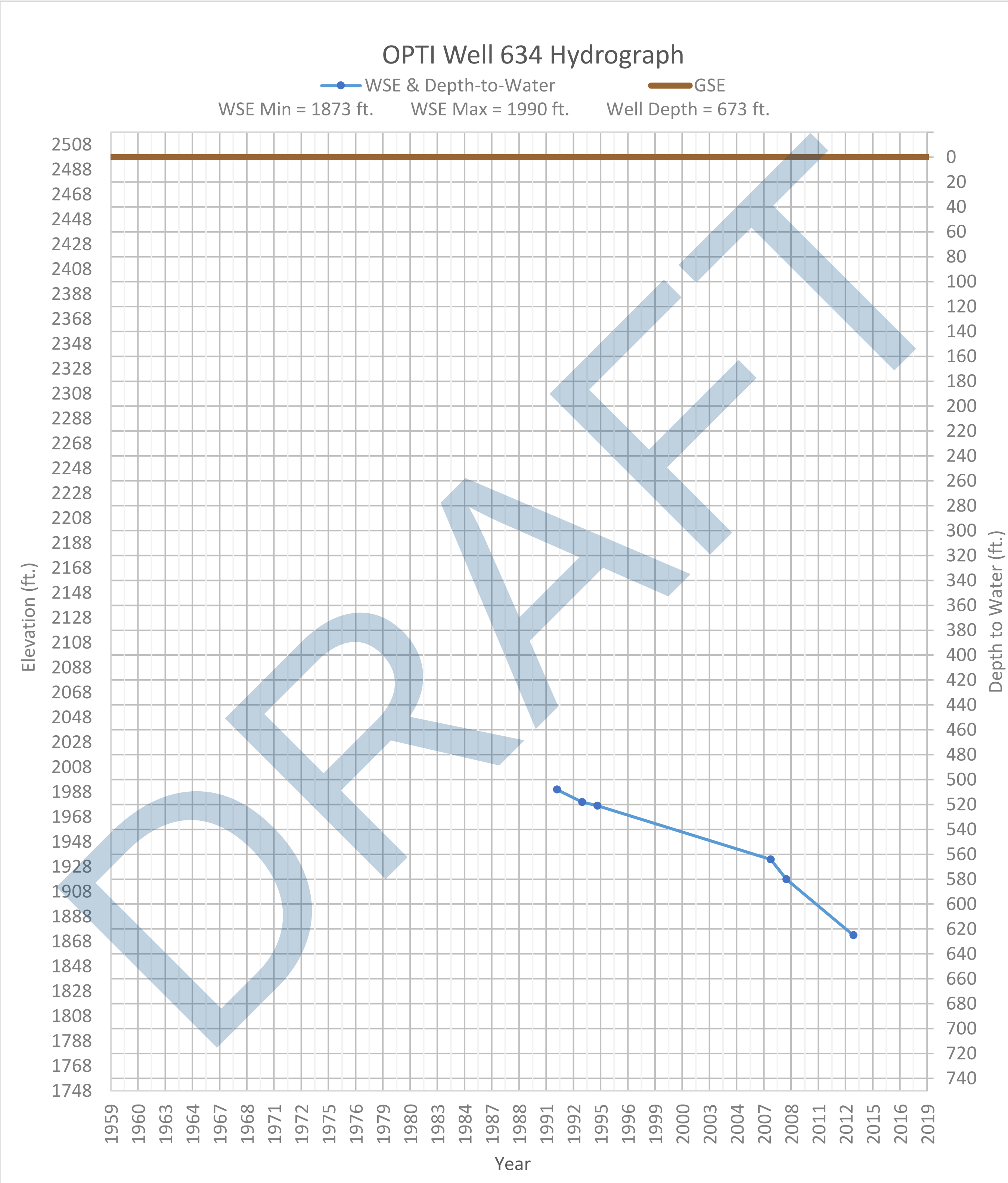


OPTI Well 631 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1830 ft.
WSE Max = 2033 ft.
Well Depth = 960 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

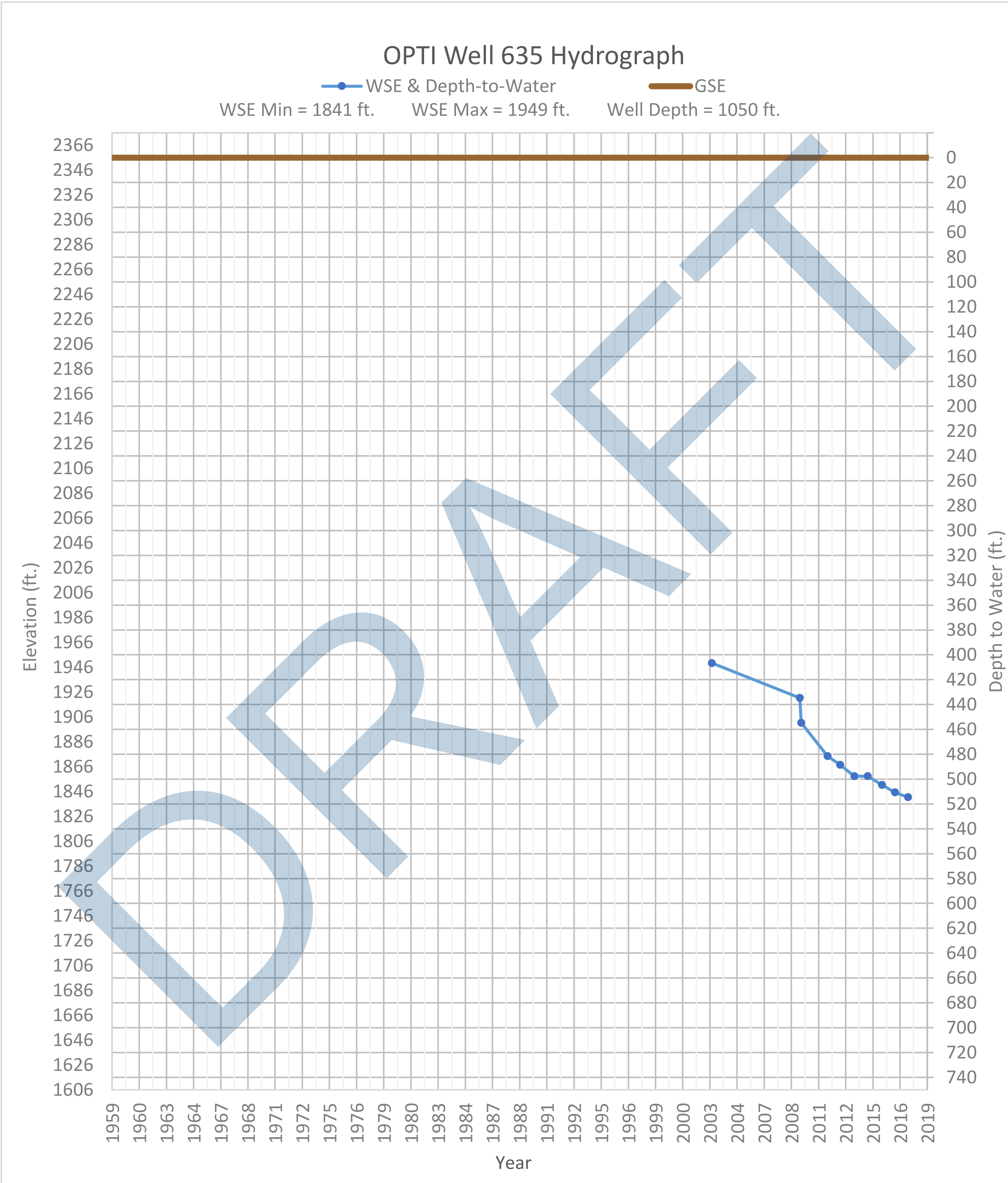


OPTI Well 632 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1837 ft.
WSE Max = 2252 ft.
Well Depth = 960 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

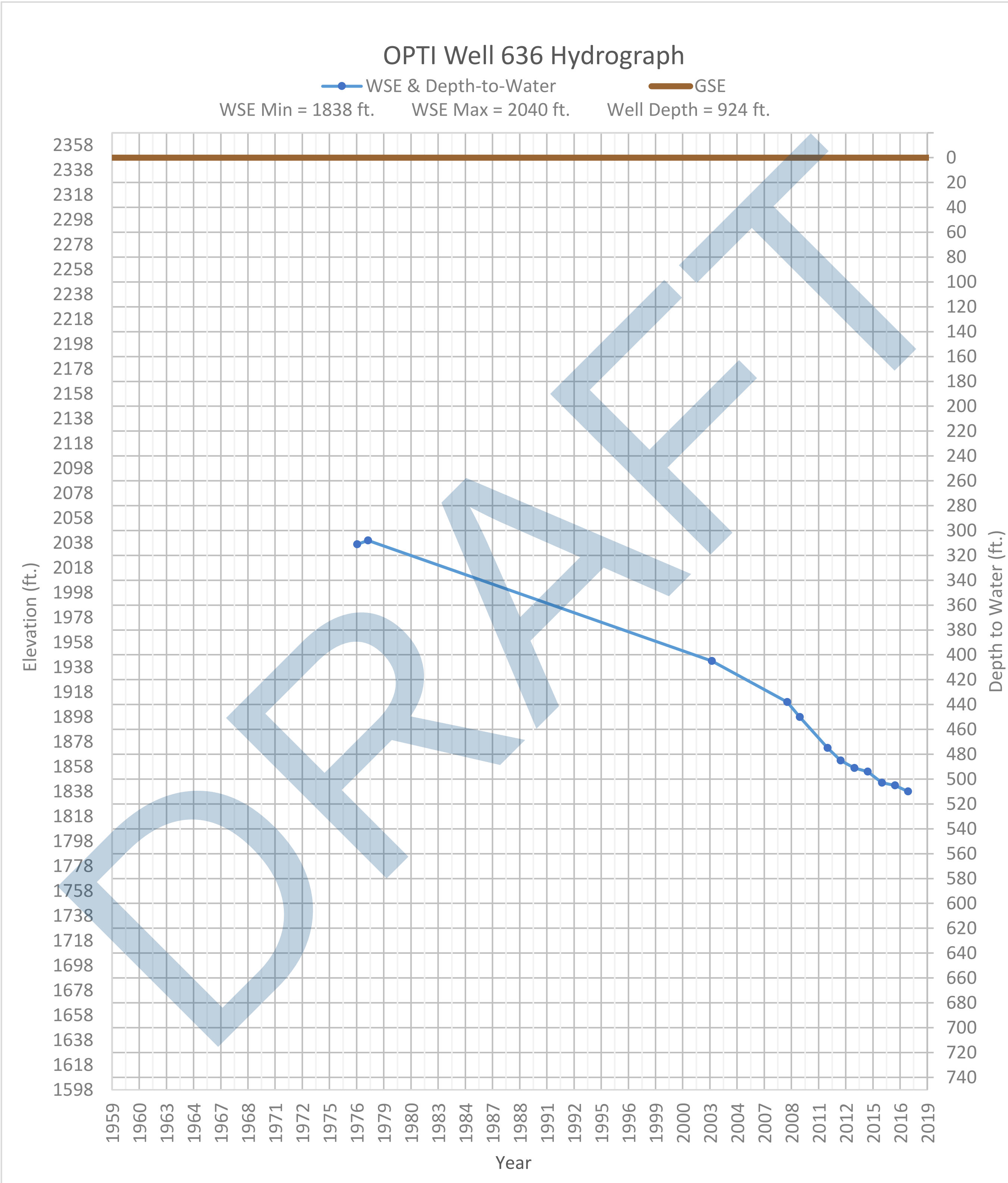

OPTI Well 633 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1813 ft.
WSE Max = 1958 ft.
Well Depth = 1000 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

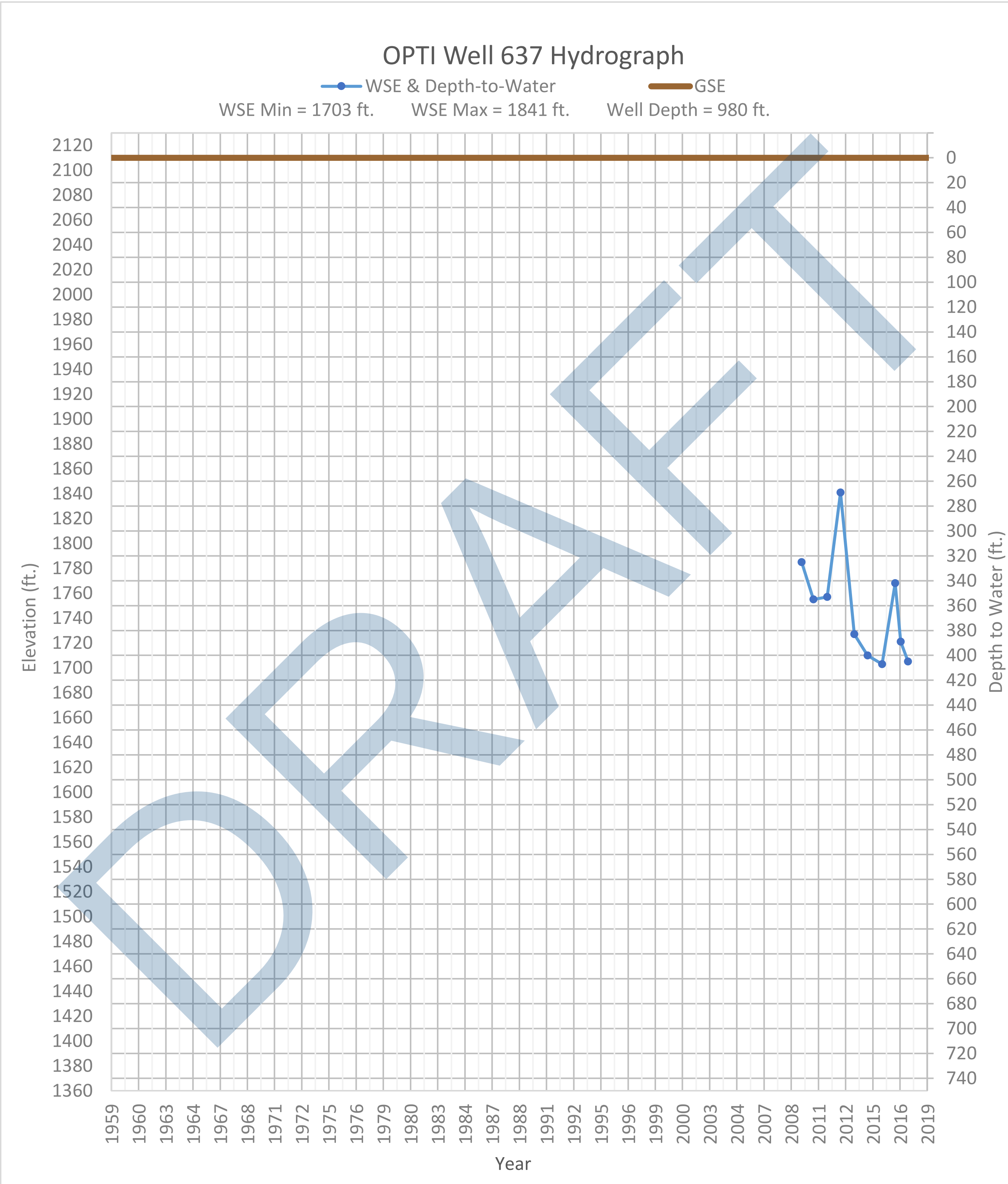


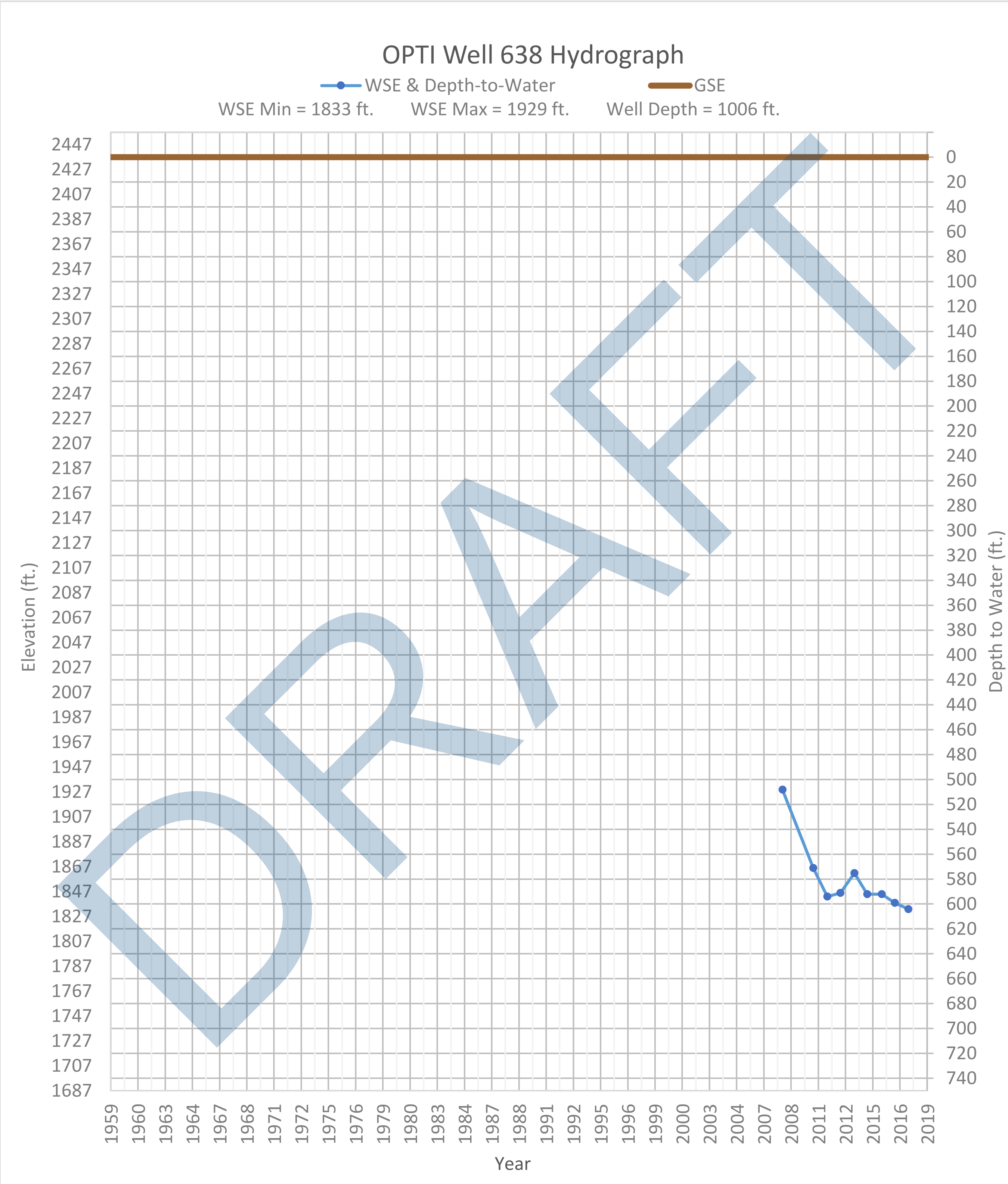
OPTI Well 634 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1873 ft.
WSE Max = 1990 ft.
Well Depth = 673 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



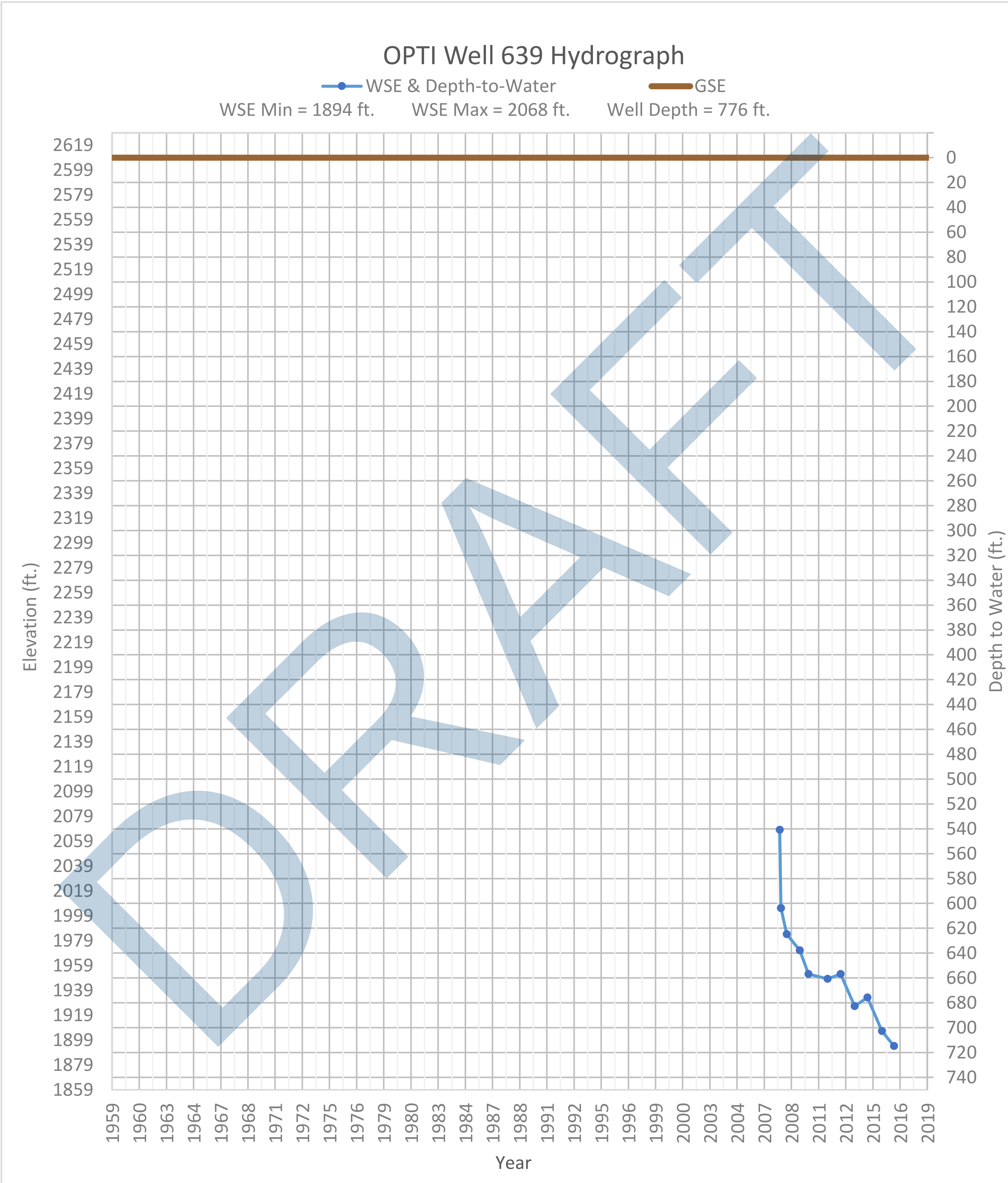
OPTI Well 635 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1841 ft.
WSE Max = 1949 ft.
Well Depth = 1050 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 636 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1838 ft.
WSE Max = 2040 ft.
Well Depth = 924 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

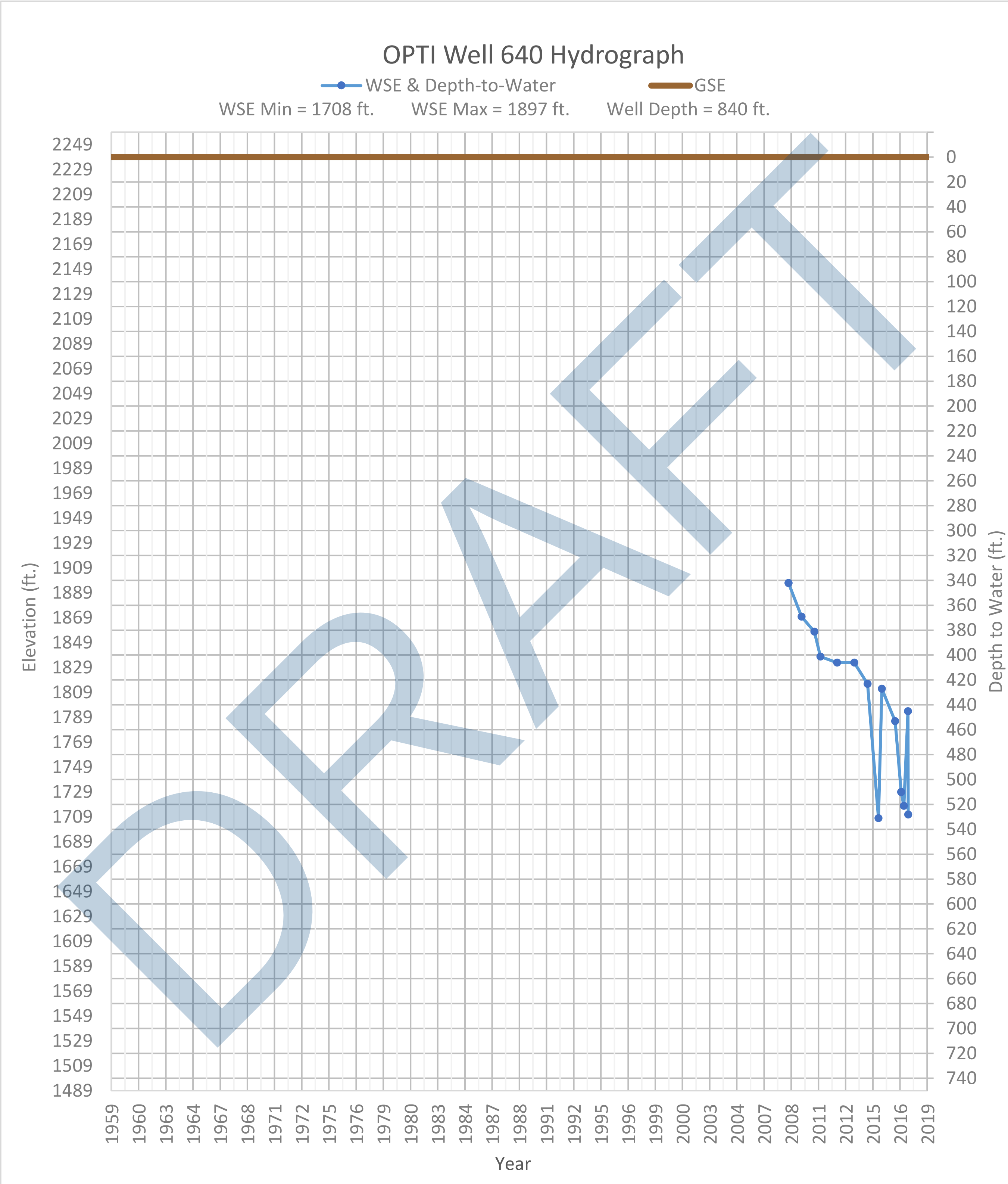

OPTI Well 637 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1703 ft.
WSE Max = 1841 ft.
Well Depth = 980 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



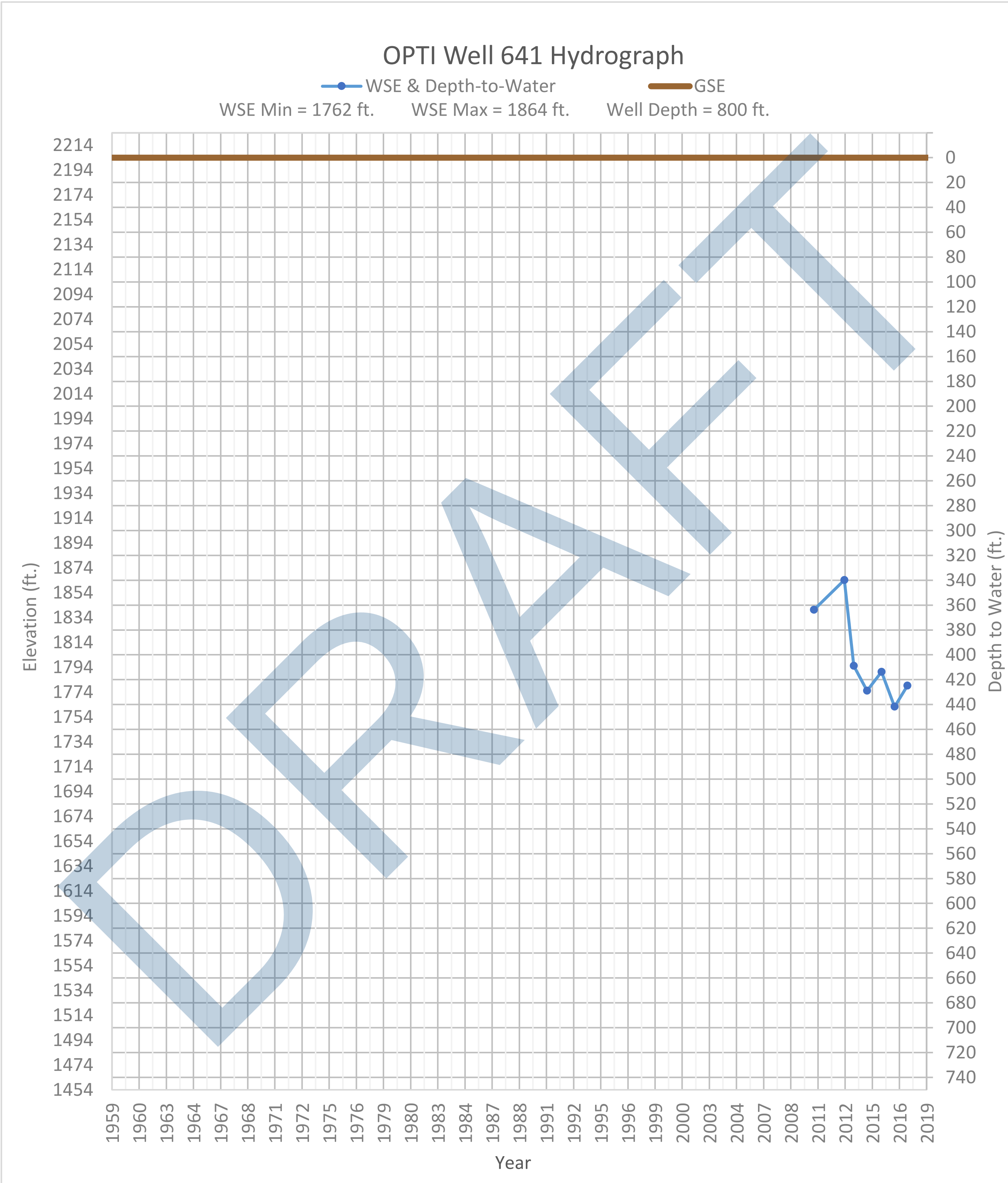
OPTI Well 638 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1833 ft.
WSE Max = 1929 ft.
Well Depth = 1006 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



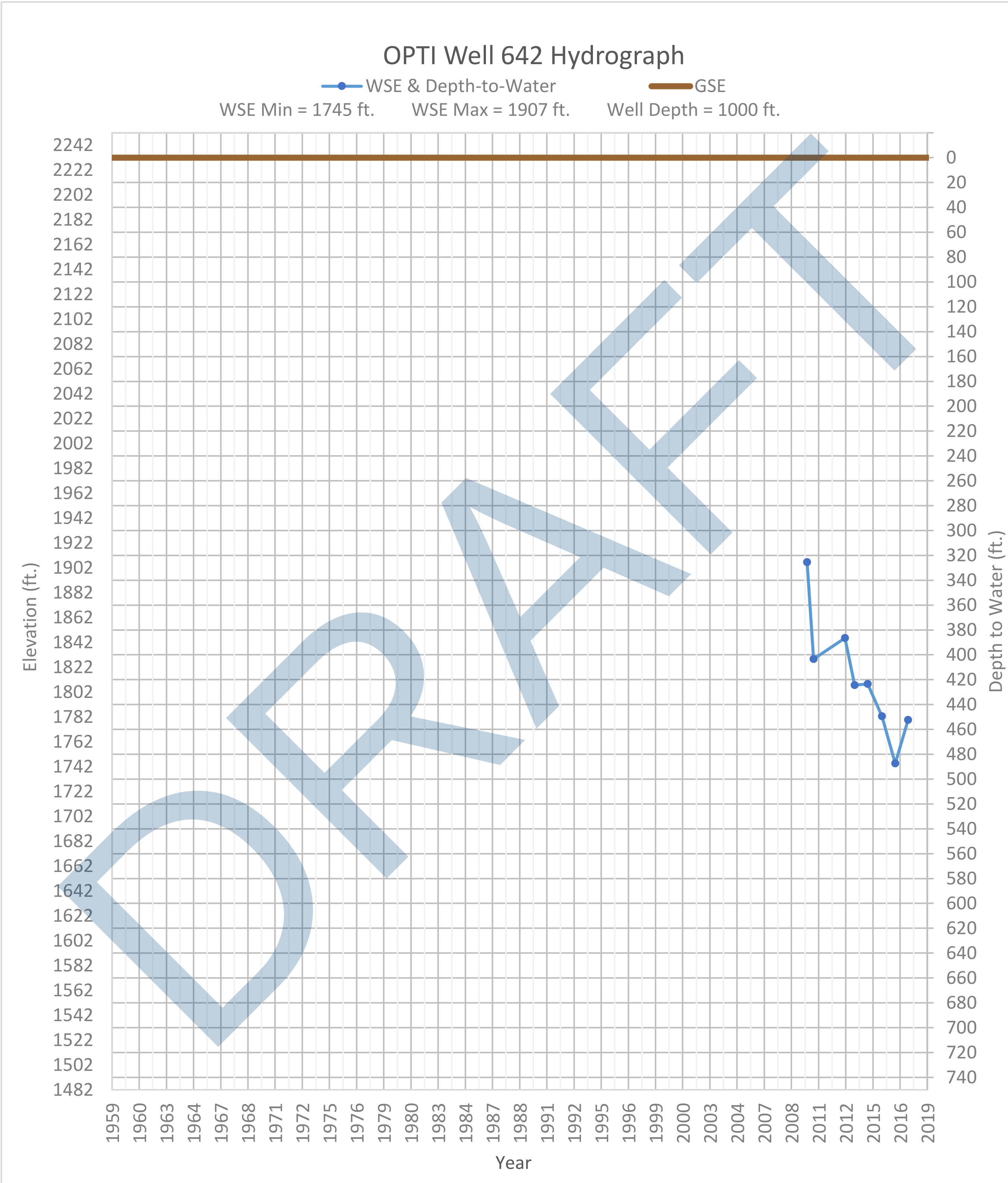
OPTI Well 639 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1894 ft.
WSE Max = 2068 ft.
Well Depth = 776 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



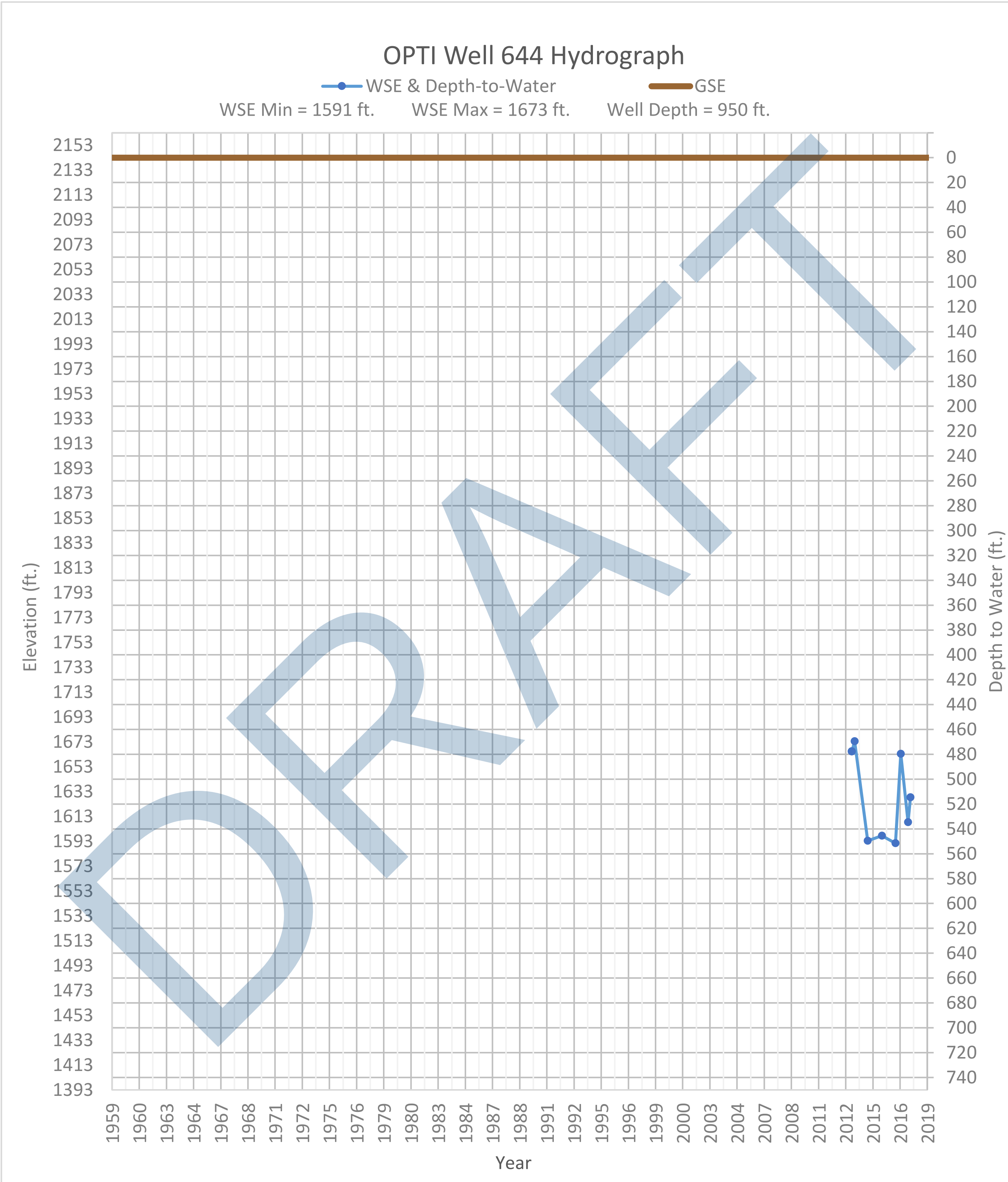
OPTI Well 640 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1708 ft.
WSE Max = 1897 ft.
Well Depth = 840 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



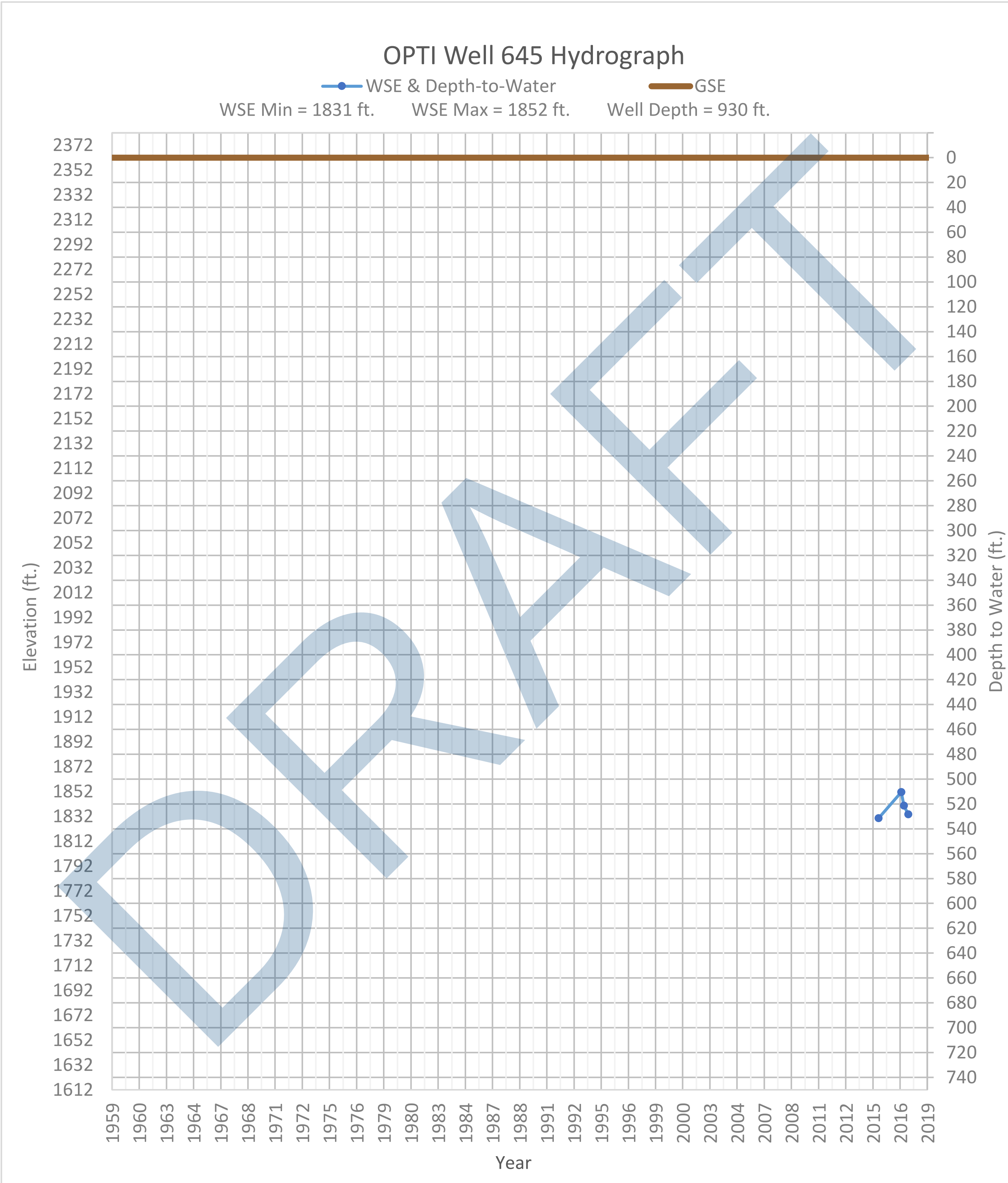
OPTI Well 641 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1762 ft.
WSE Max = 1864 ft.
Well Depth = 800 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



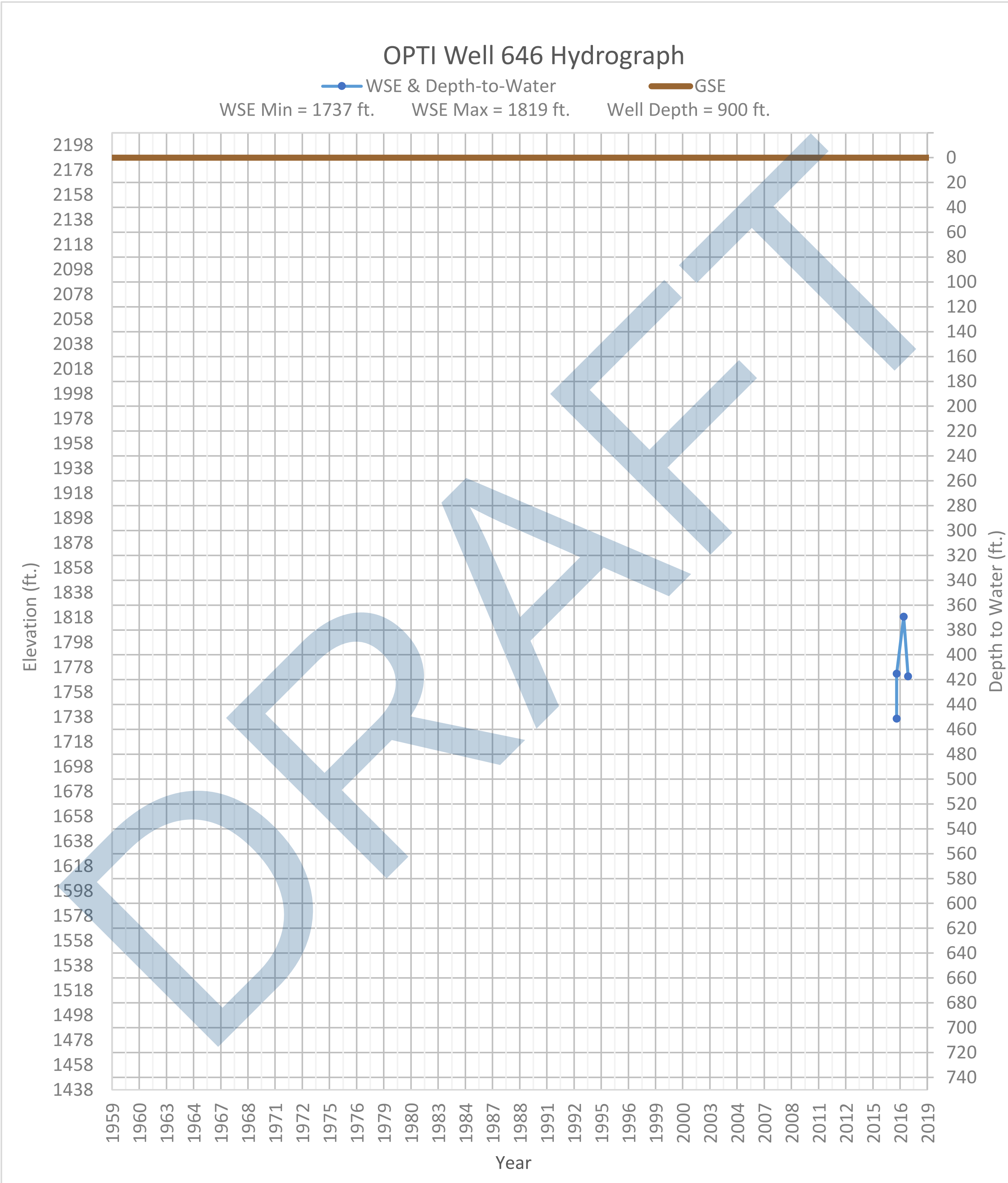
OPTI Well 642 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1745 ft.
WSE Max = 1907 ft.
Well Depth = 1000 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



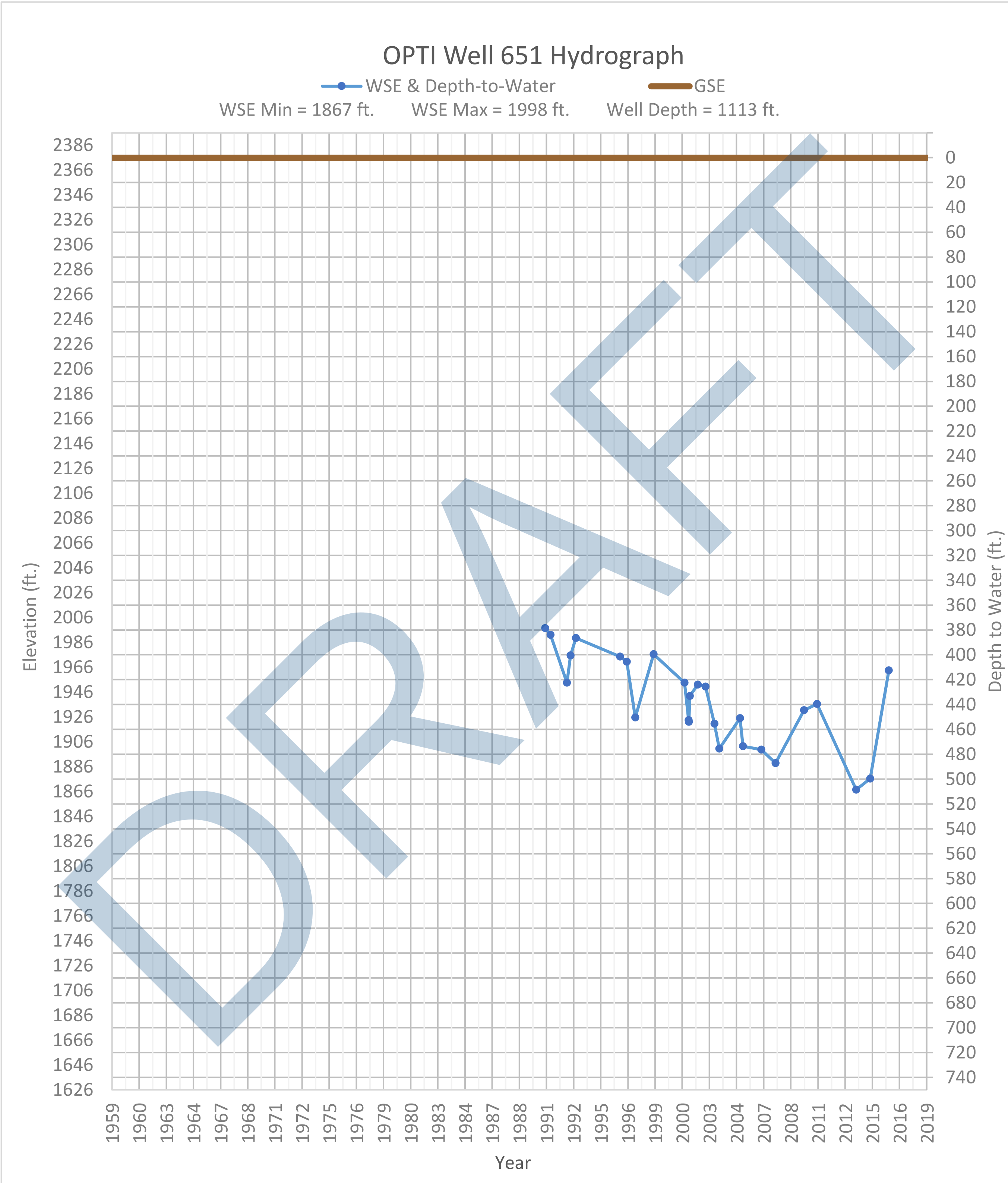
OPTI Well 644 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1591 ft.
WSE Max = 1673 ft.
Well Depth = 950 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



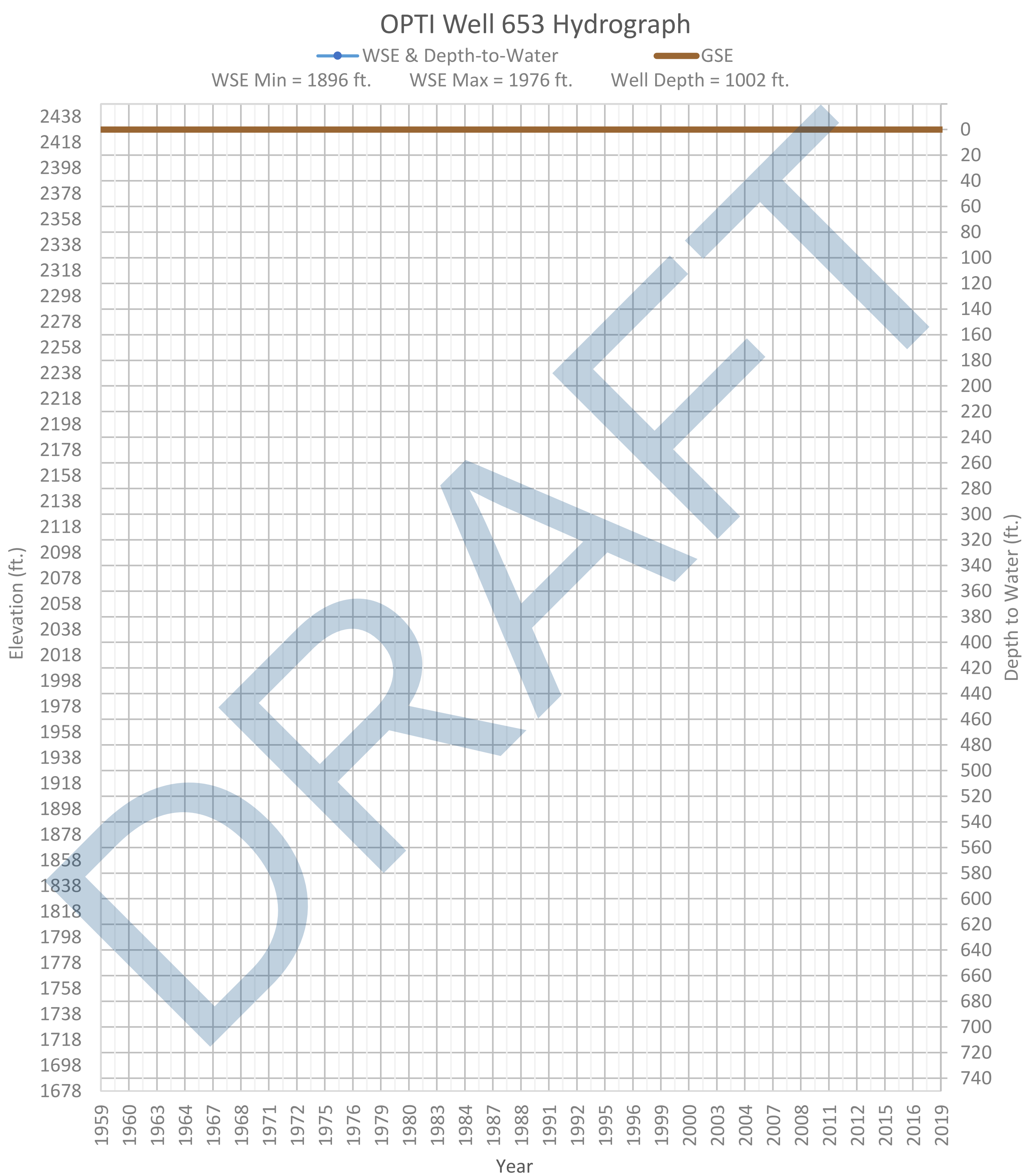
OPTI Well 645 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1831 ft.
WSE Max = 1852 ft.
Well Depth = 930 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



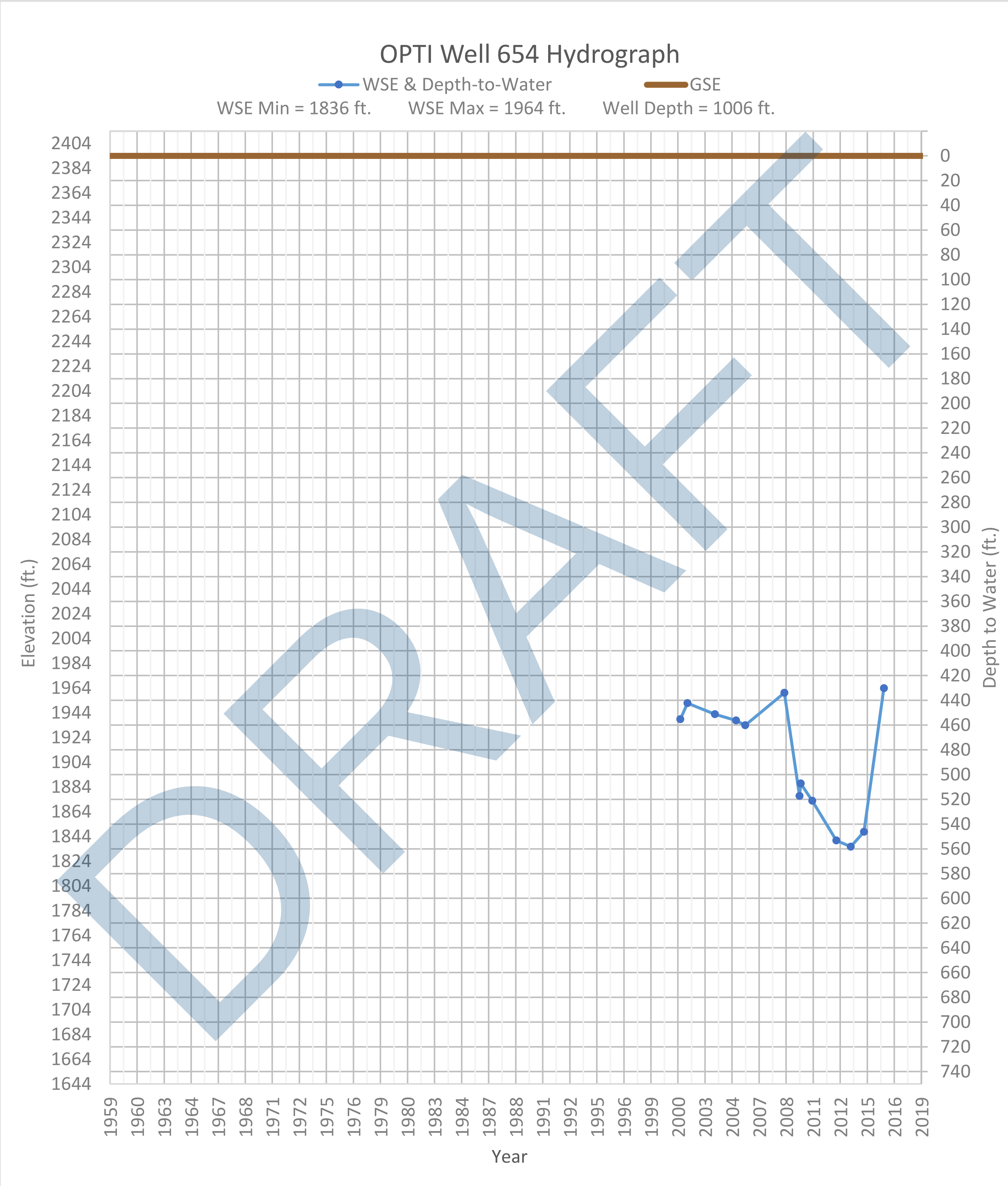
OPTI Well 646 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1737 ft.
WSE Max = 1819 ft.
Well Depth = 900 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



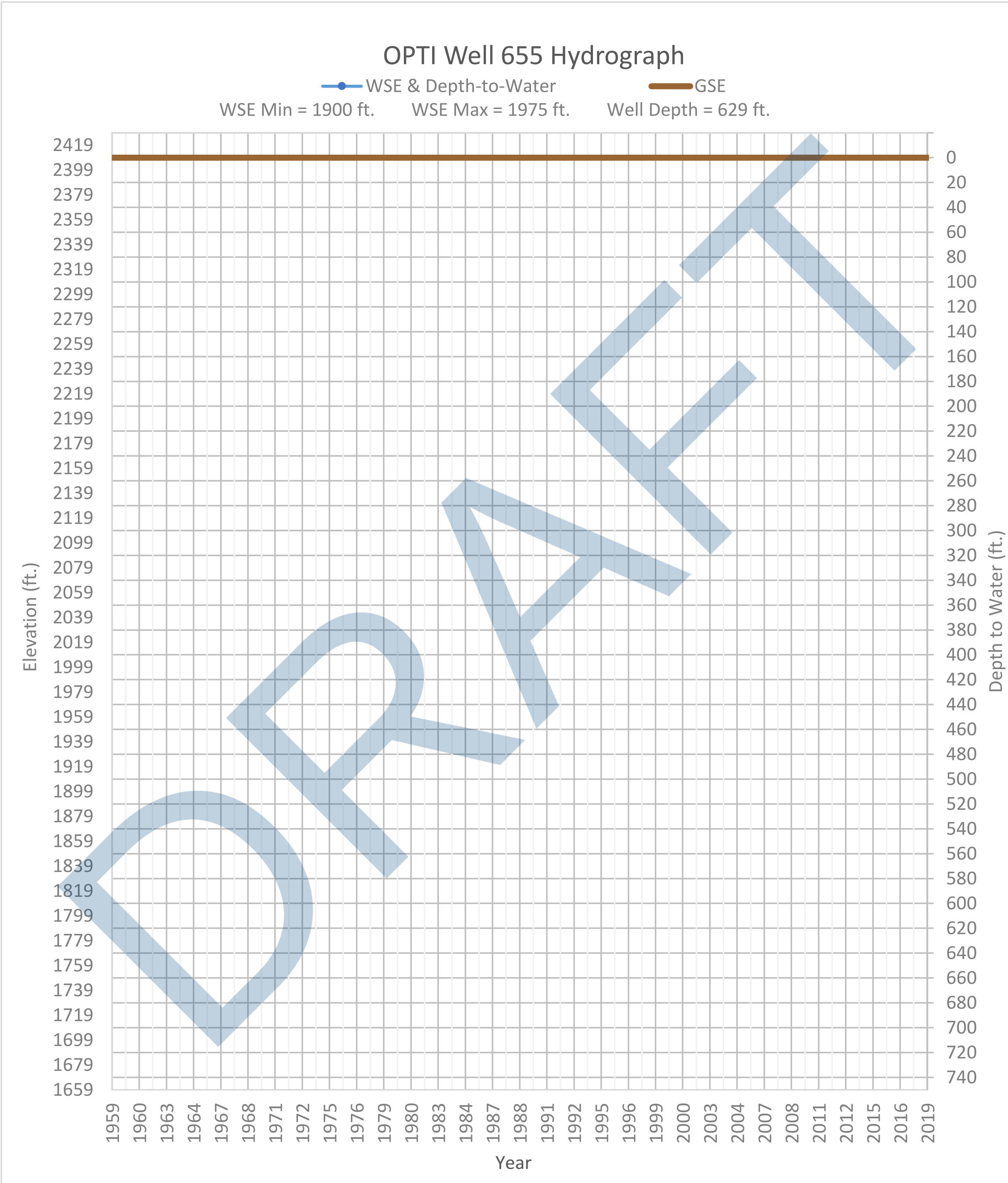
OPTI Well 651 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1867 ft.
WSE Max = 1998 ft.
Well Depth = 1113 ft.
Elevation (ft.)
2386
2366
2346
2326
2306
2286
2266
2246
2226
2206
2186
2166
2146
2126
2106
2086
2066
2046
2026
2006
1986
1966
1946
1926
1906
1886
1866
1846
1826
1806
1786
1766
1746
1726
1706
1686
1666
1646
1626
Depth to Water (ft.)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
680
700
720
740
Year
1959
1960
1963
1964
1967
1968
1971
1972
1975
1976
1979
1980
1983
1984
1987
1988
1991
1992
1995
1996
1999
2000
2003
2004
2007
2008
2011
2012
2015
2016
2019
DRAFT



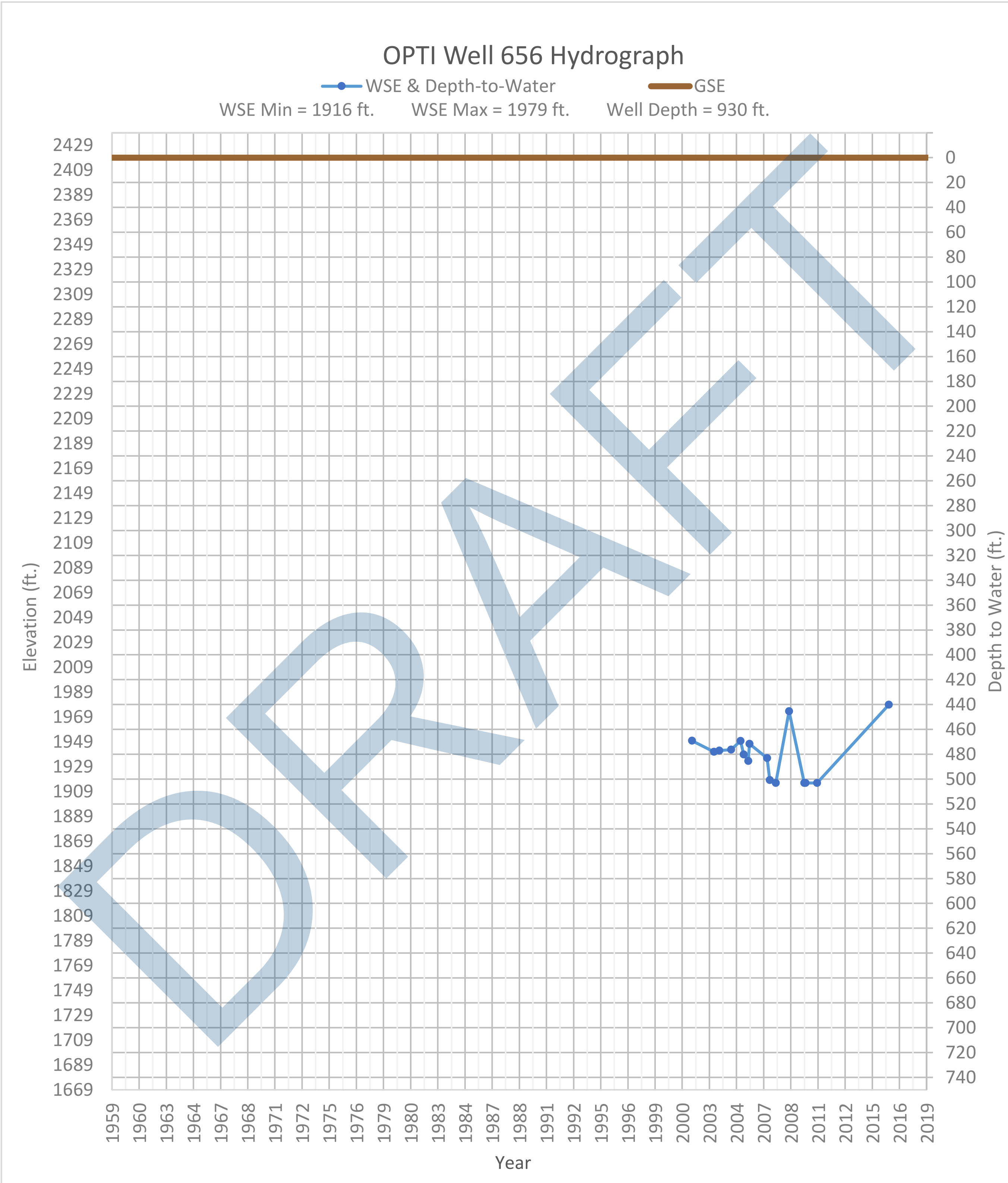
OPTI Well 653 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1896 ft.
WSE Max = 1976 ft.
Well Depth = 1002 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



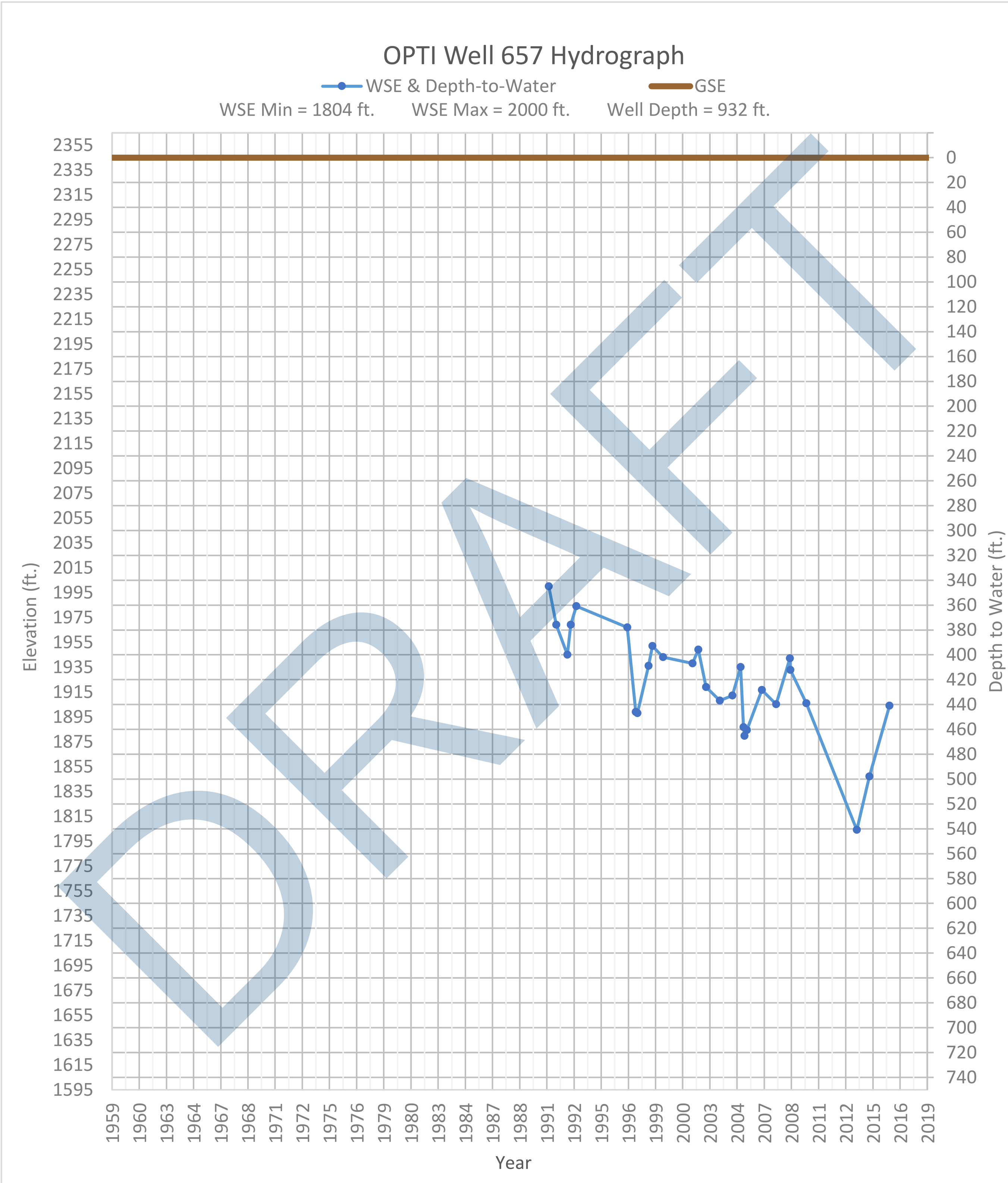
OPTI Well 654 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1836 ft.
WSE Max = 1964 ft.
Well Depth = 1006 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



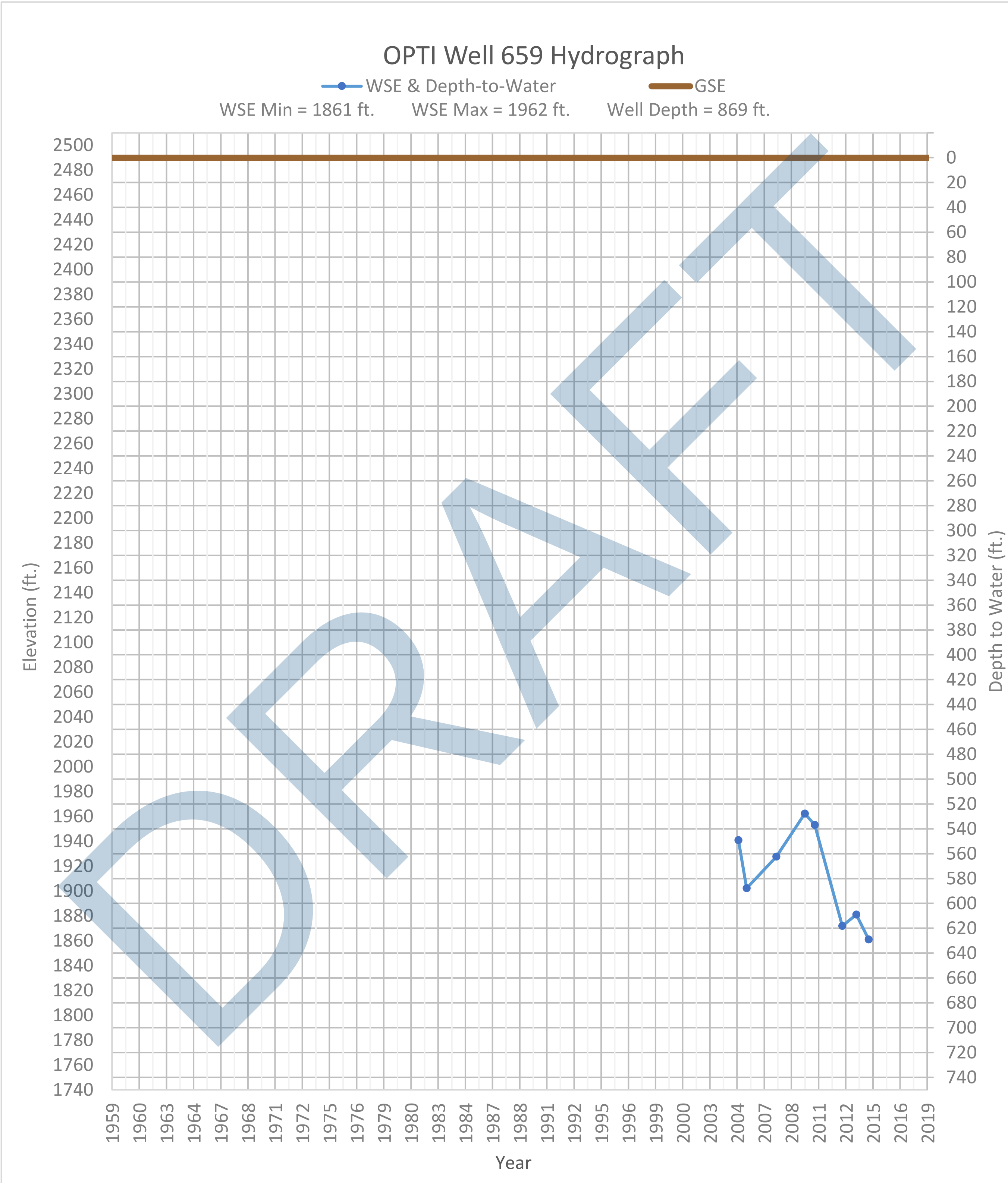
OPTI Well 655 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1900 ft.
WSE Max = 1975 ft.
Well Depth = 629 ft.
Elevation (ft.)
2419
2399
2379
2359
2339
2319
2299
2279
2259
2239
2219
2199
2179
2159
2139
2119
2099
2079
2059
2039
2019
1999
1979
1959
1939
1919
1899
1879
1859
1839
1819
1799
1779
1759
1739
1719
1699
1679
1659
Depth to Water (ft.)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
680
700
720
740
Year
1959
1960
1963
1964
1967
1968
1971
1972
1975
1976
1979
1980
1983
1984
1987
1988
1991
1992
1995
1996
1999
2000
2003
2004
2007
2008
2011
2012
2015
2016
2019
DRAFT



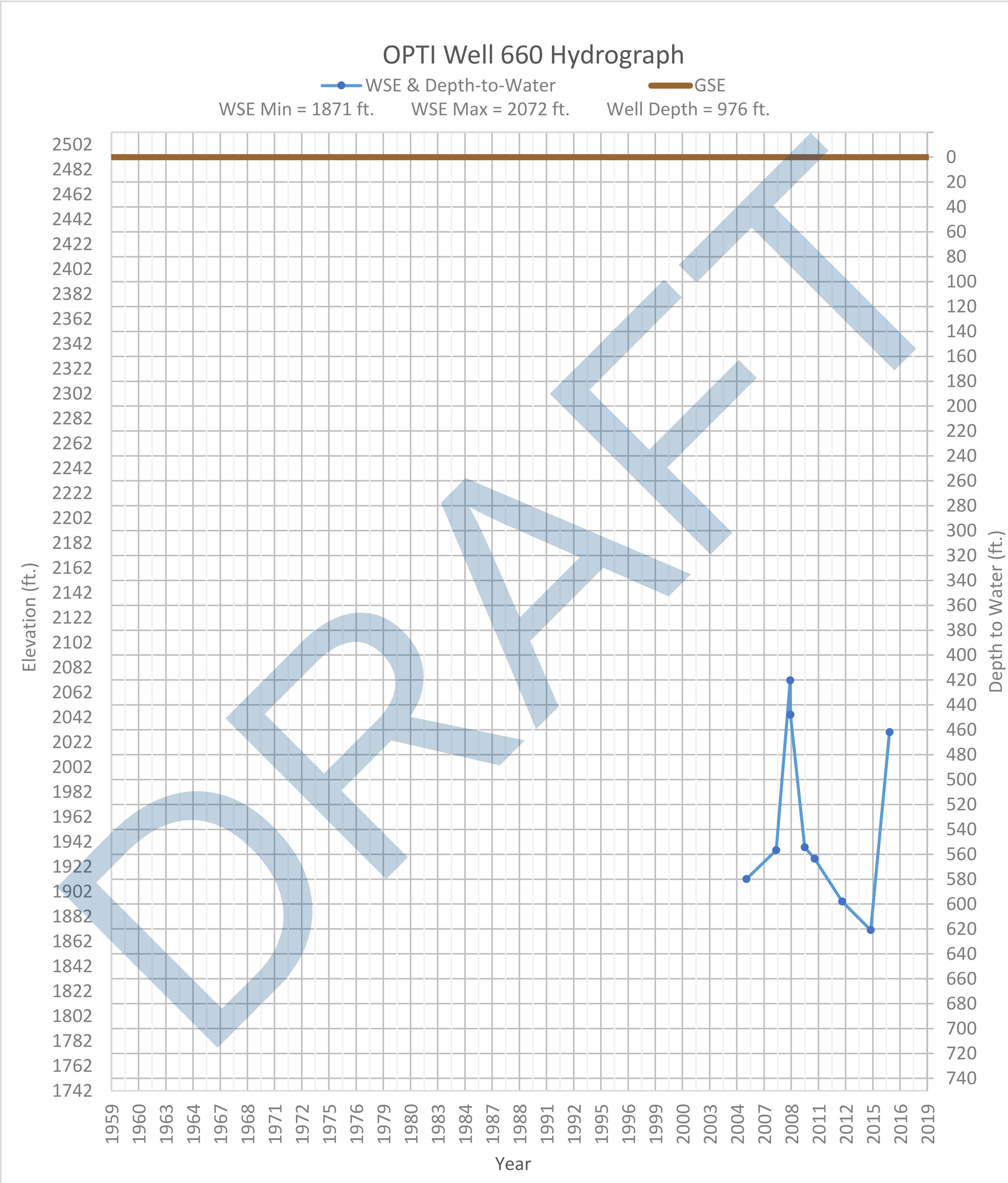
OPTI Well 656 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1916 ft.
WSE Max = 1979 ft.
Well Depth = 930 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



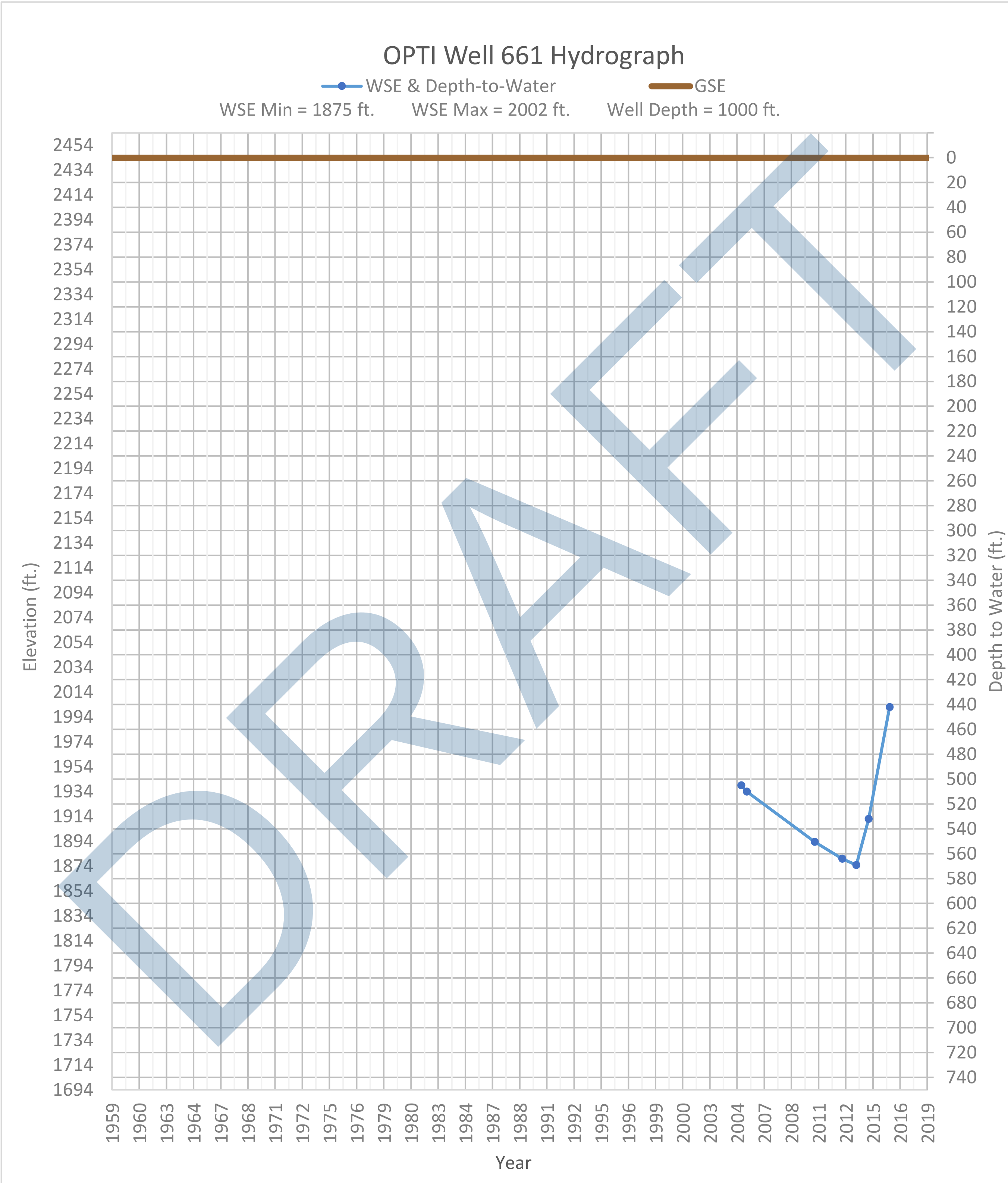
OPTI Well 657 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1804 ft.
WSE Max = 2000 ft.
Well Depth = 932 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



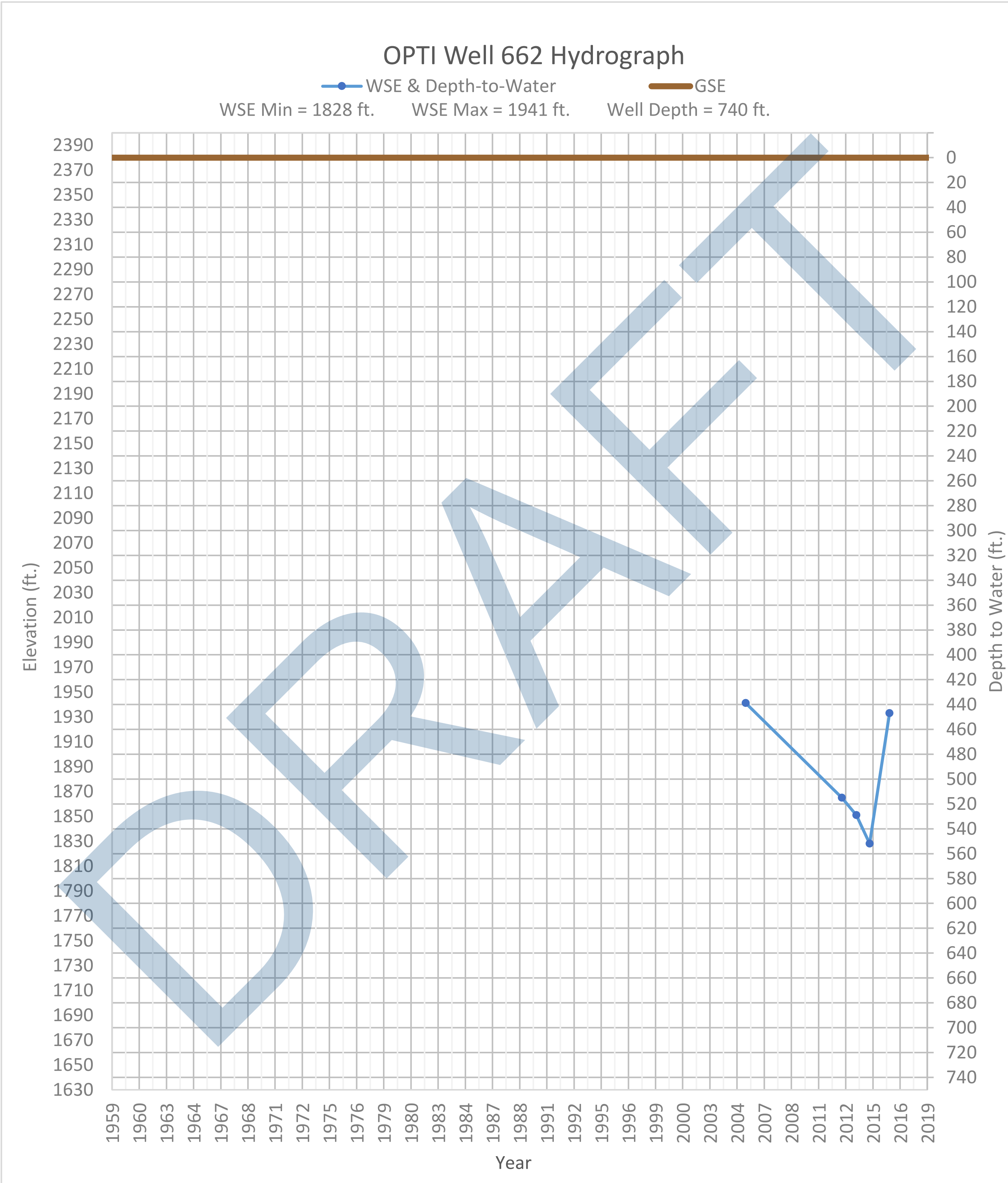
OPTI Well 659 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1861 ft.
WSE Max = 1962 ft.
Well Depth = 869 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

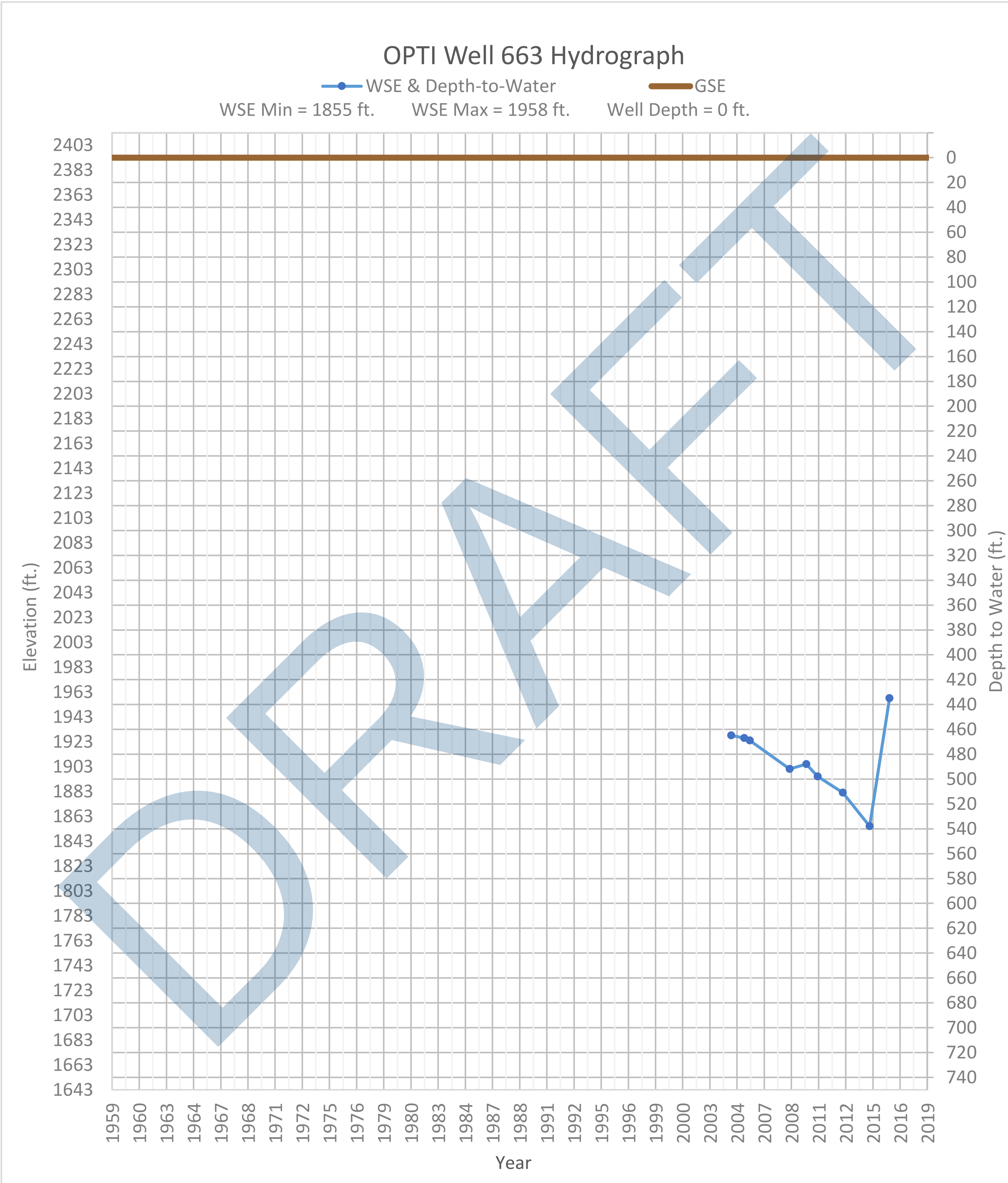


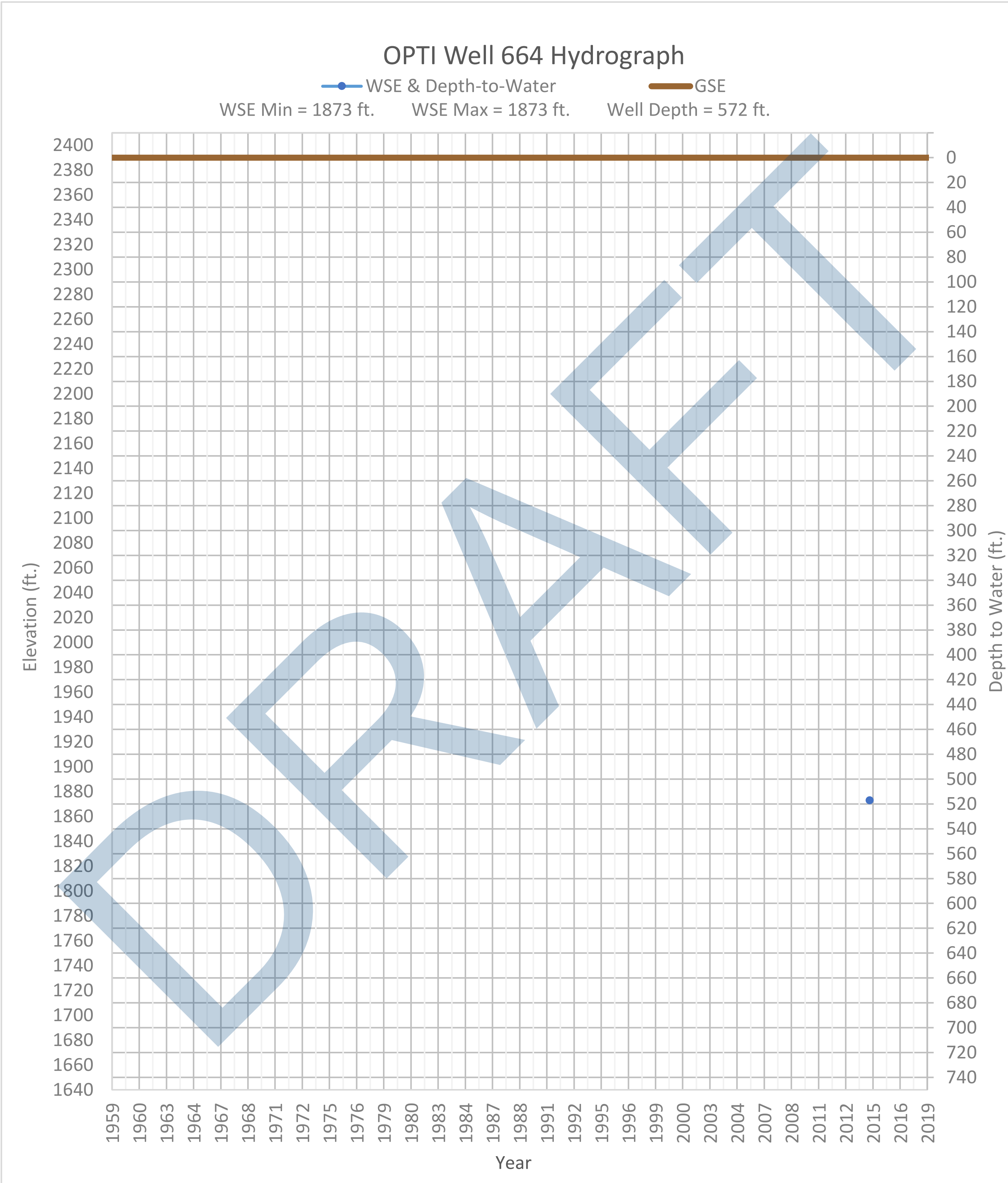
OPTI Well 660 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1871 ft.
WSE Max = 2072 ft.
Well Depth = 976 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

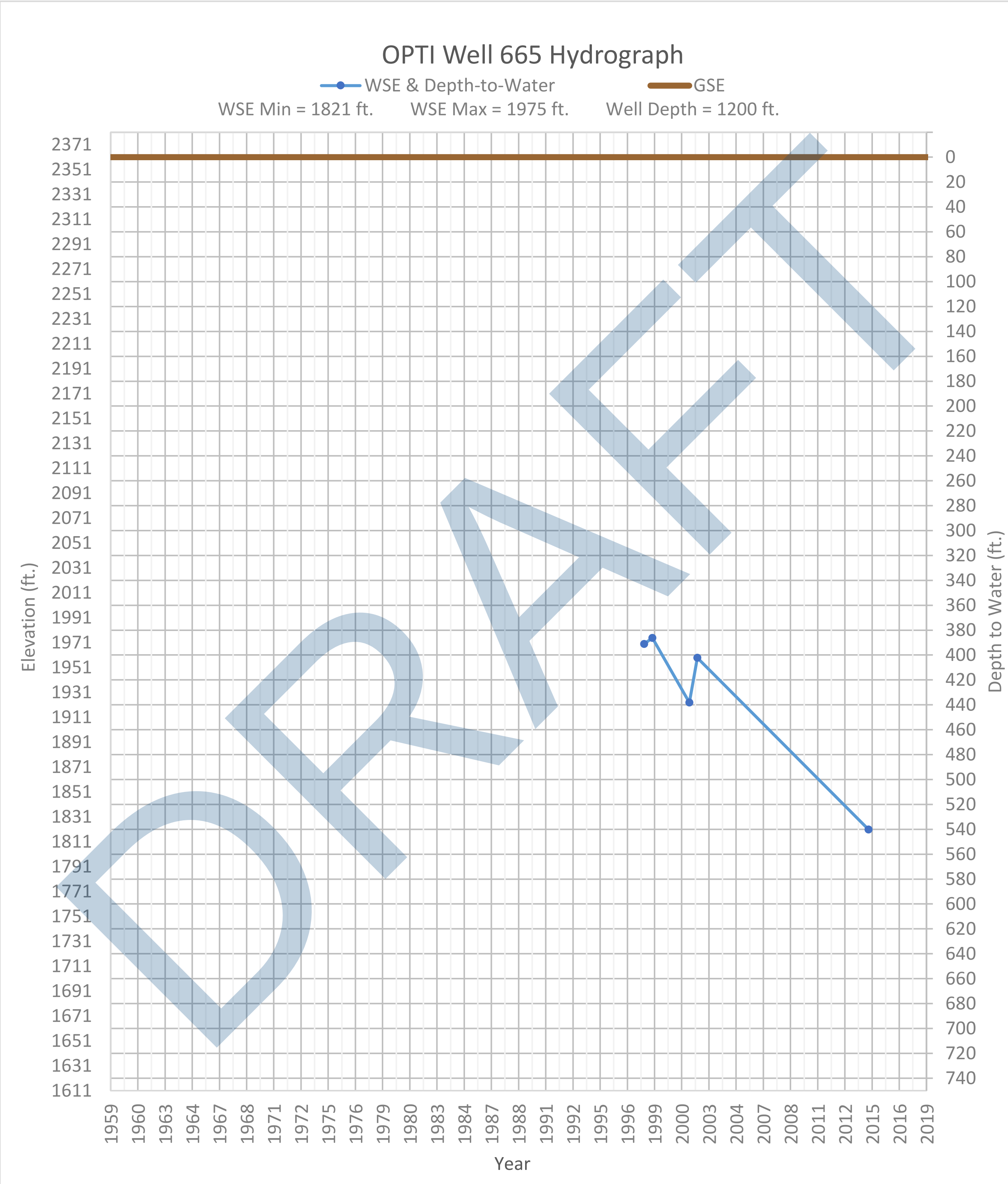


OPTI Well 661 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1875 ft.
WSE Max = 2002 ft.
Well Depth = 1000 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

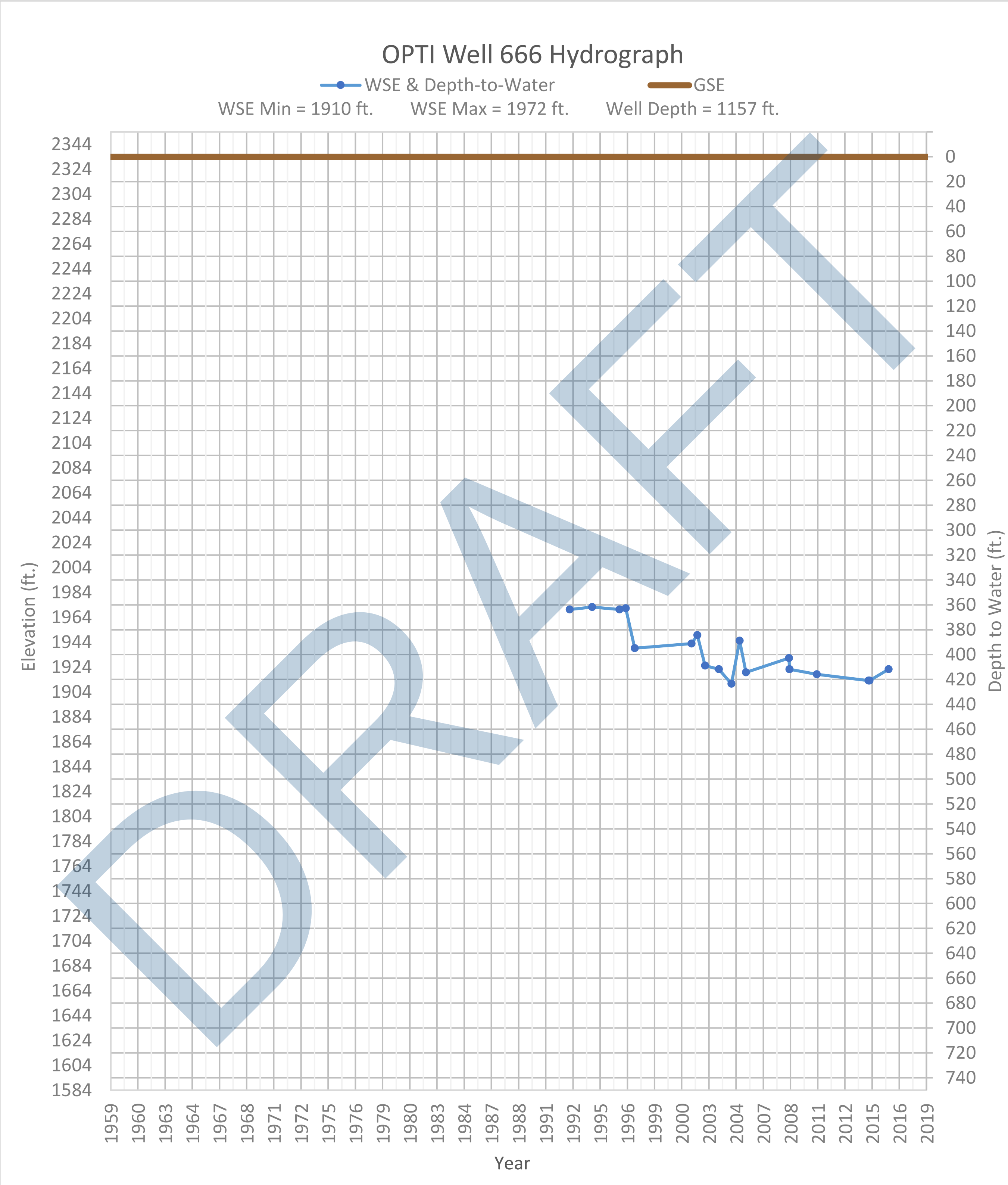

OPTI Well 662 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1828 ft.
WSE Max = 1941 ft.
Well Depth = 740 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 663 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1855 ft.
WSE Max = 1958 ft.
Well Depth = 0 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

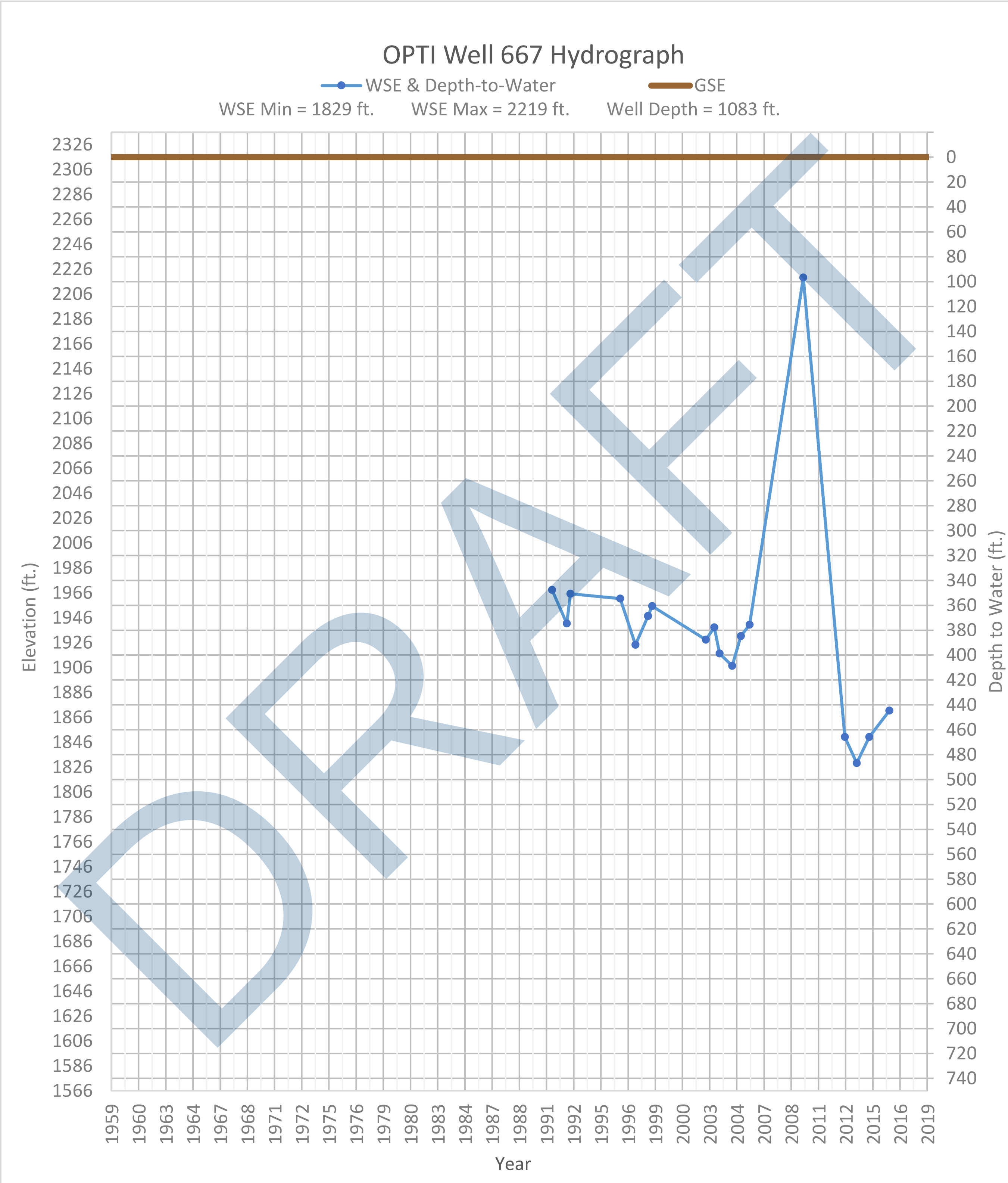

OPTI Well 664 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1873 ft.
WSE Max = 1873 ft.
Well Depth = 572 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



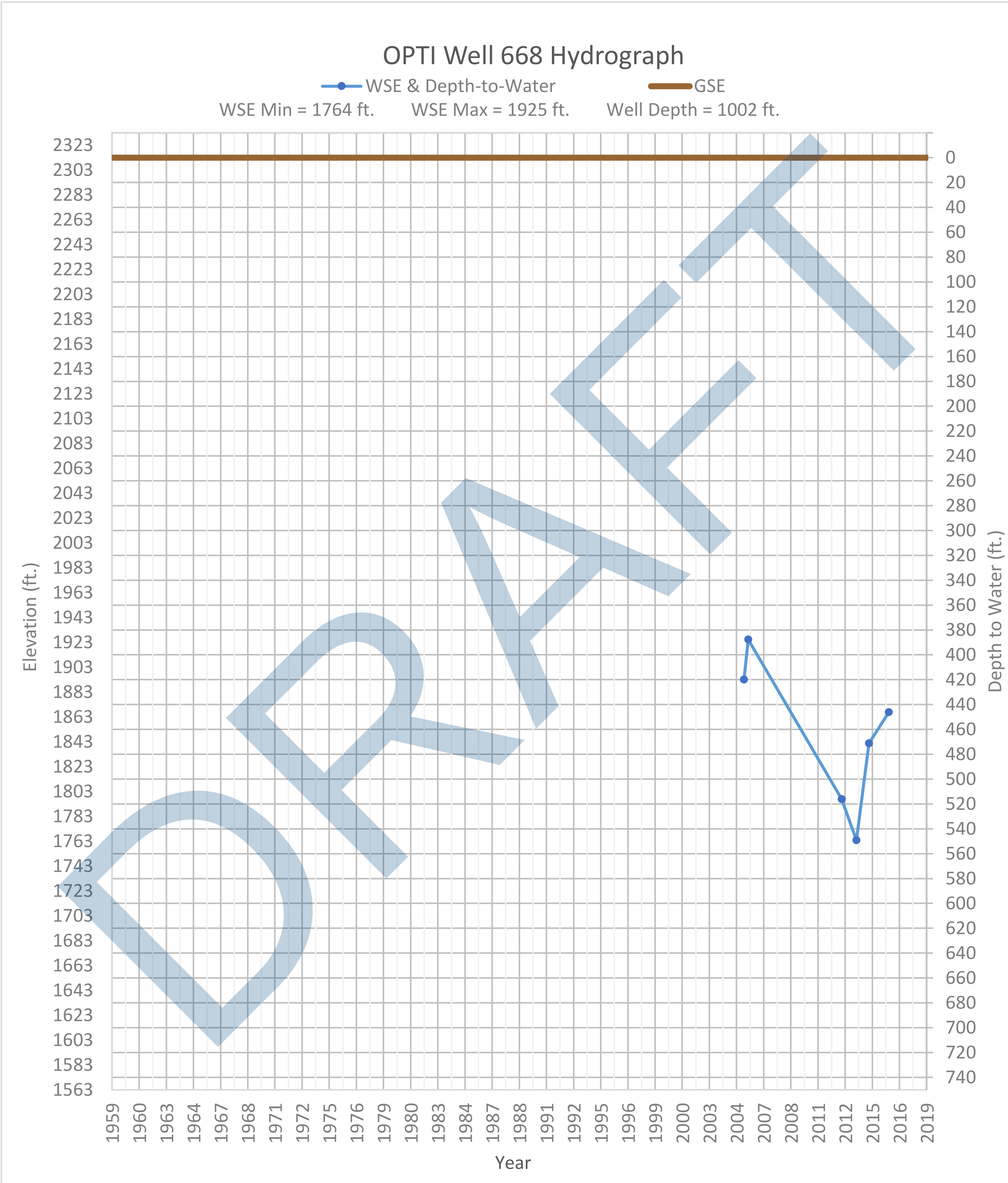
OPTI Well 665 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1821 ft.
WSE Max = 1975 ft.
Well Depth = 1200 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



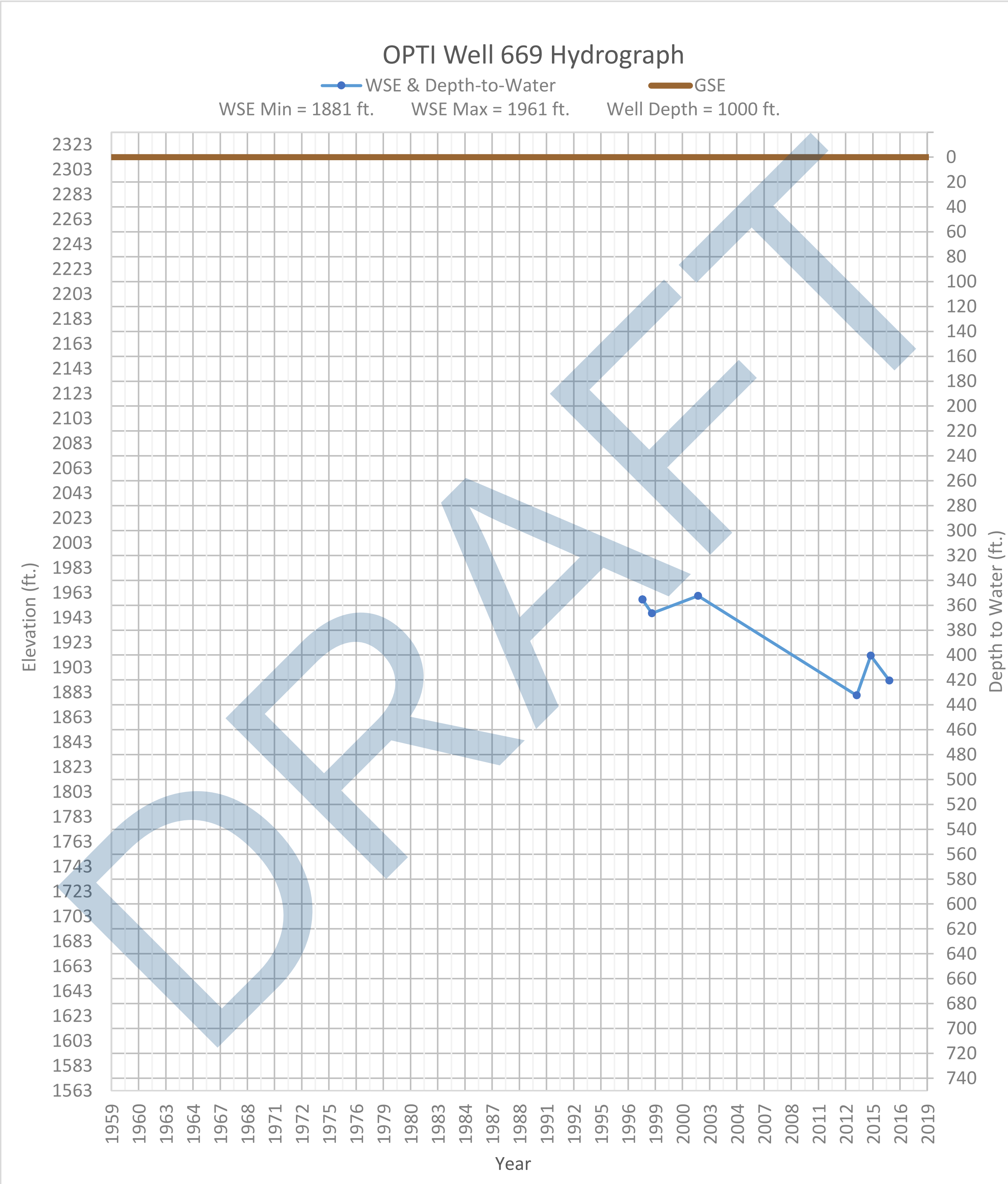
OPTI Well 666 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1910 ft.
WSE Max = 1972 ft.
Well Depth = 1157 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



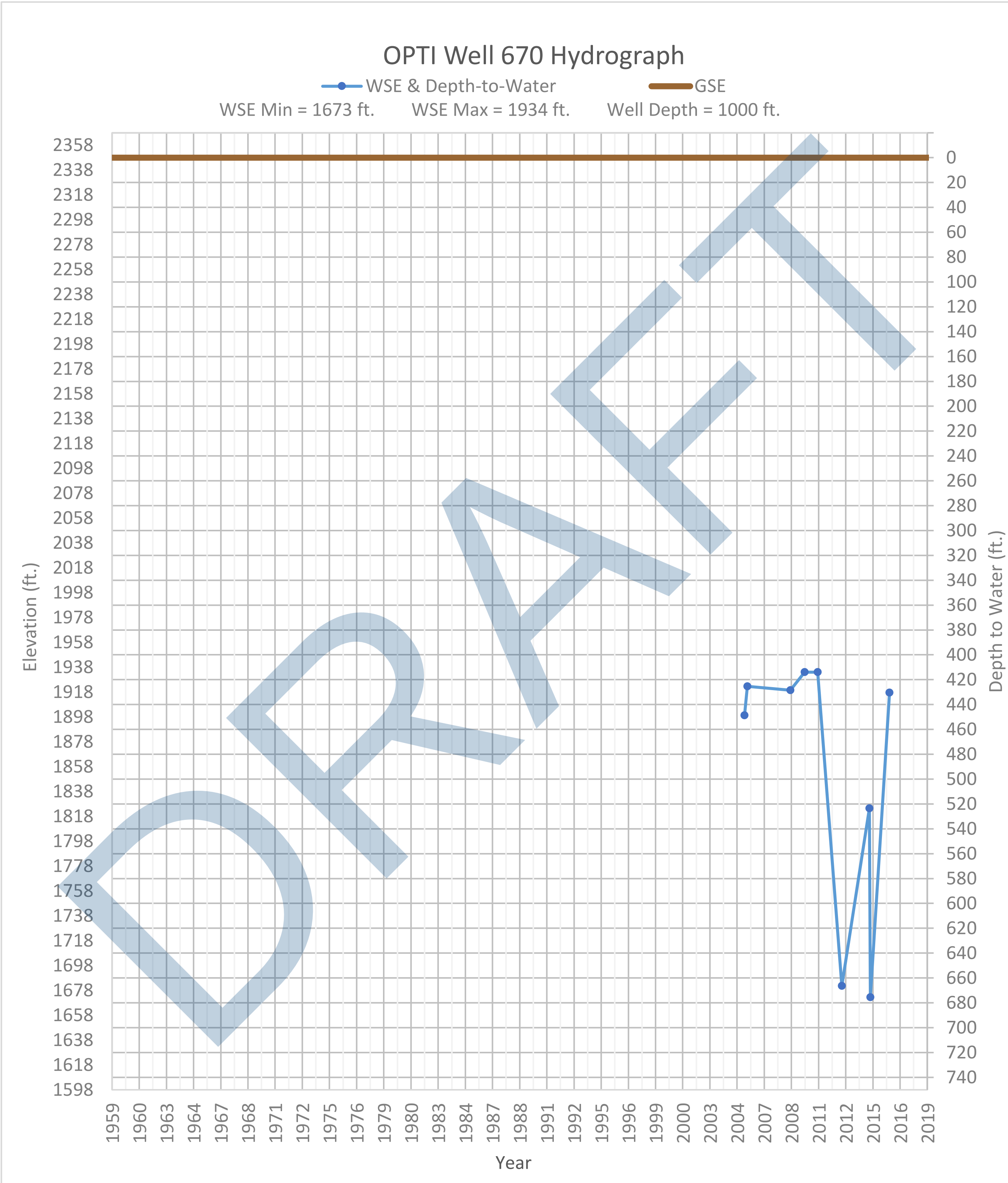
OPTI Well 667 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1829 ft.
WSE Max = 2219 ft.
Well Depth = 1083 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



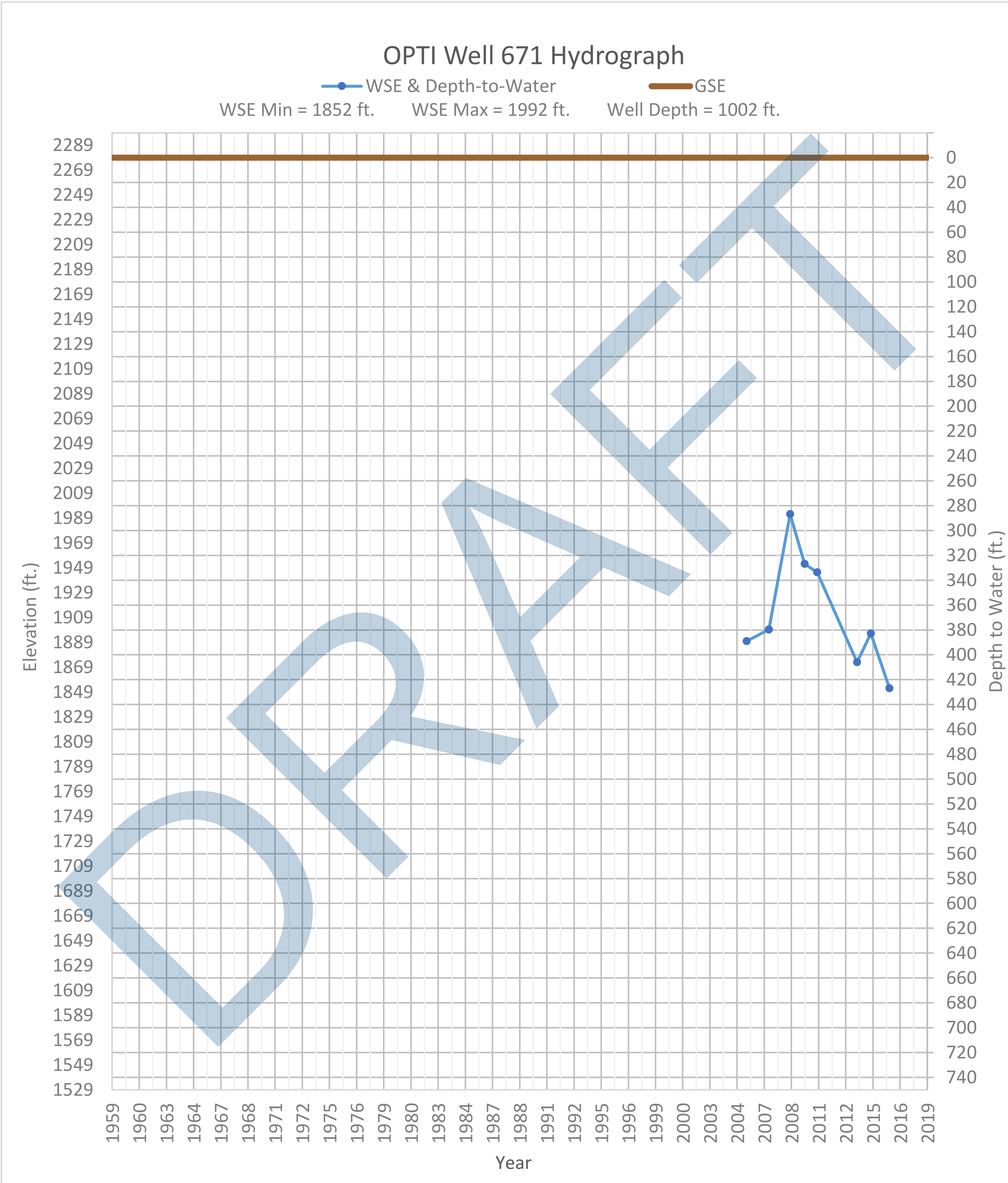
OPTI Well 668 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1764 ft.
WSE Max = 1925 ft.
Well Depth = 1002 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



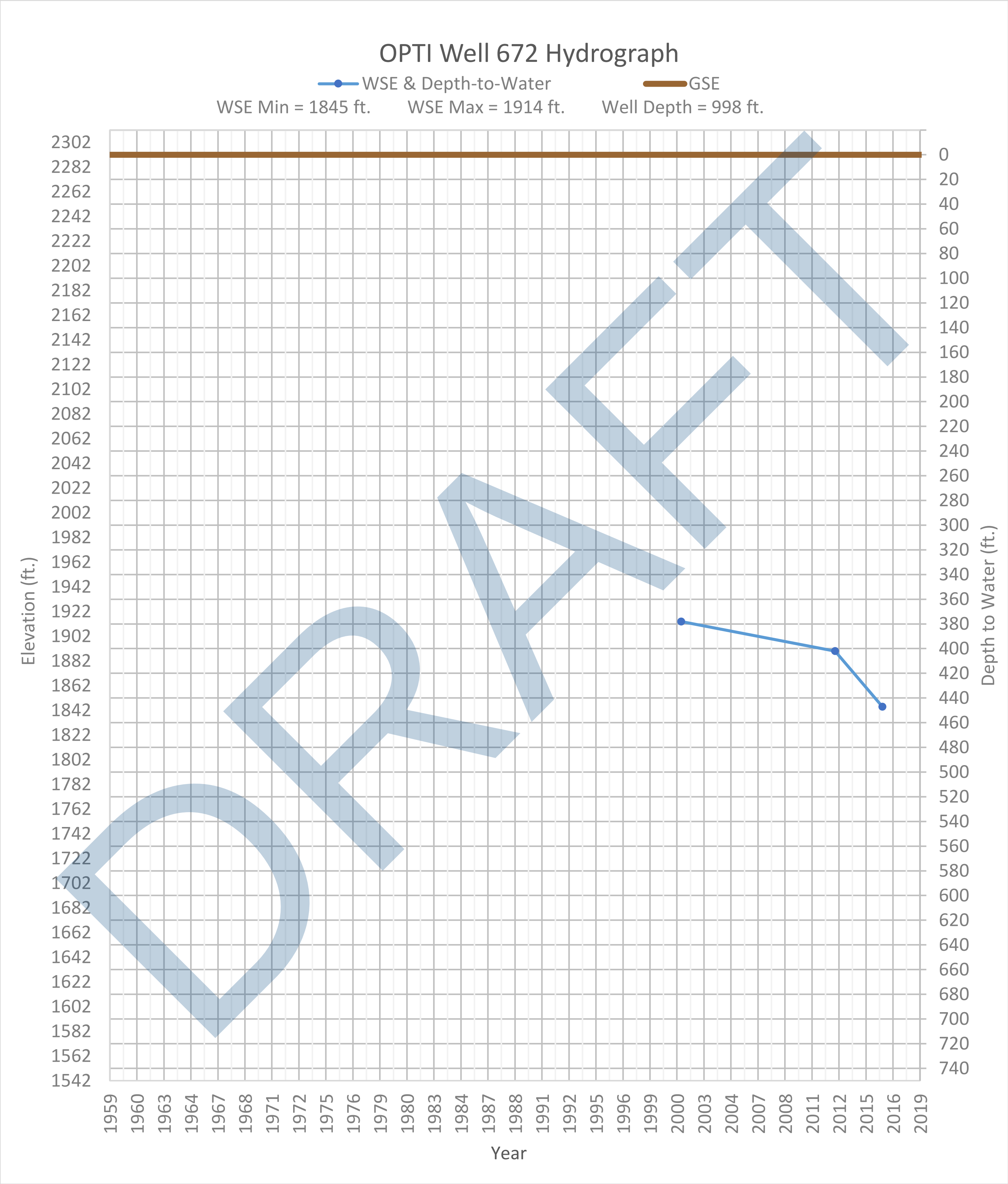
OPTI Well 669 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1881 ft.
WSE Max = 1961 ft.
Well Depth = 1000 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



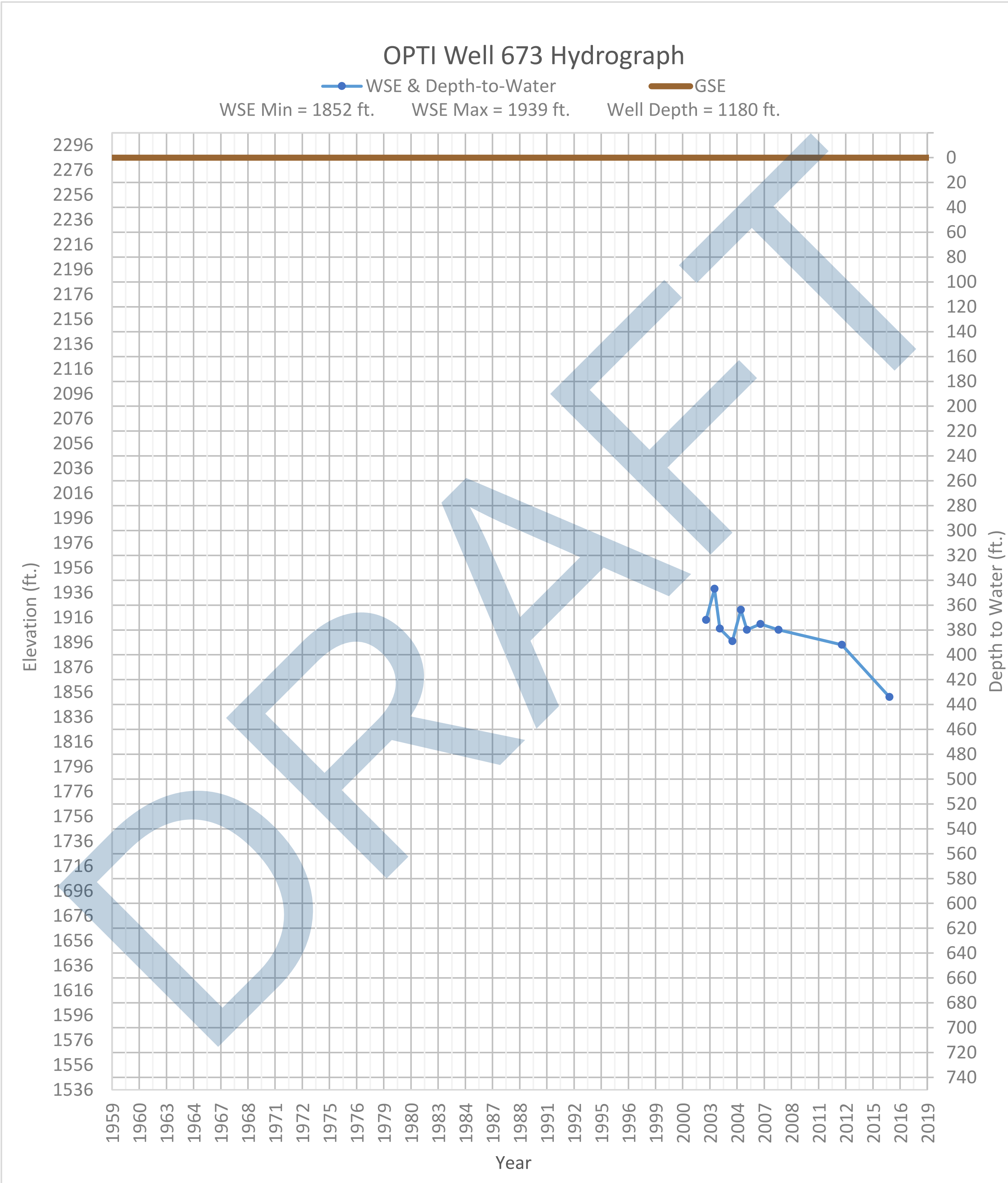
OPTI Well 670 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1673 ft.
WSE Max = 1934 ft.
Well Depth = 1000 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



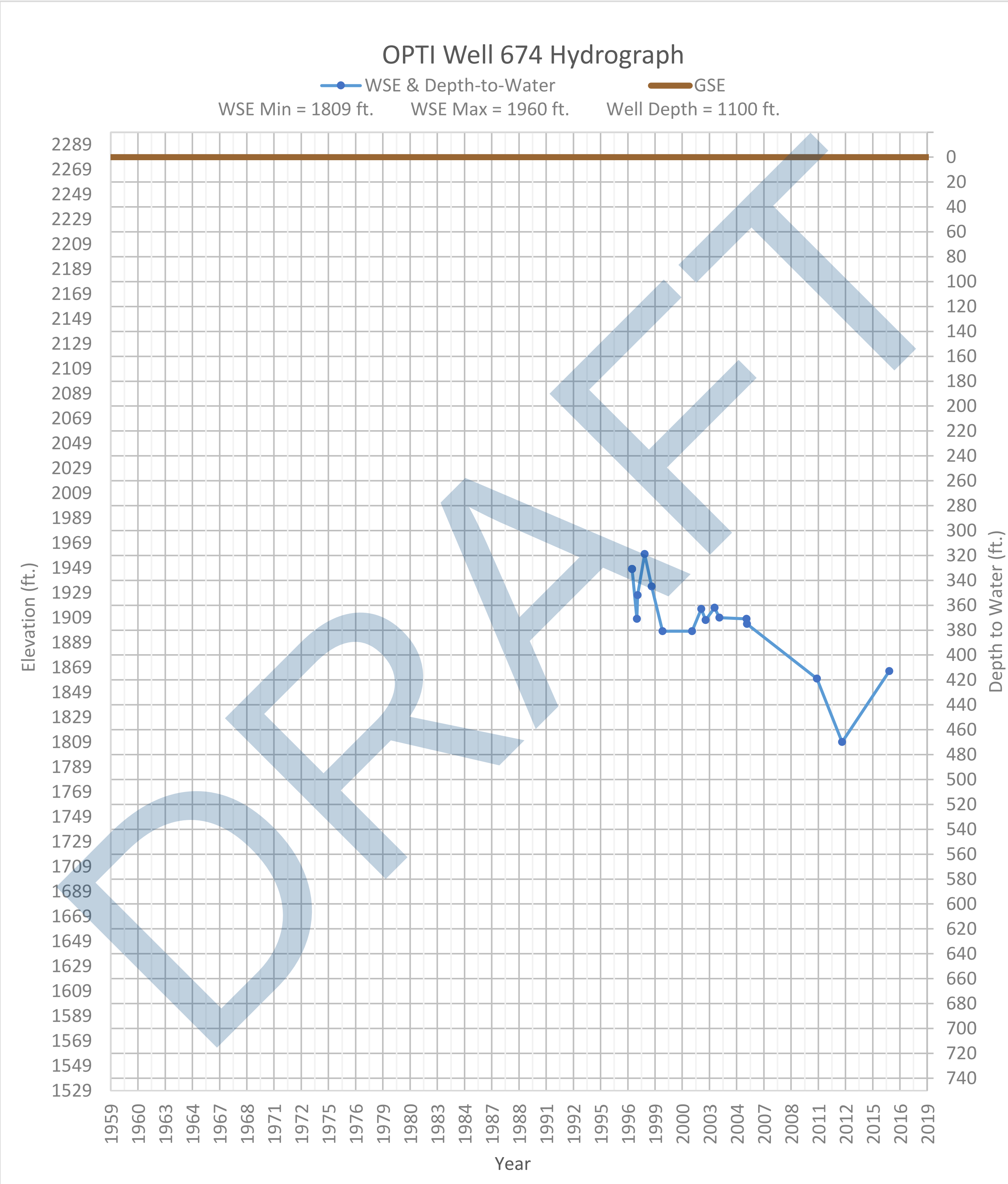
OPTI Well 671 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1852 ft.
WSE Max = 1992 ft.
Well Depth = 1002 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



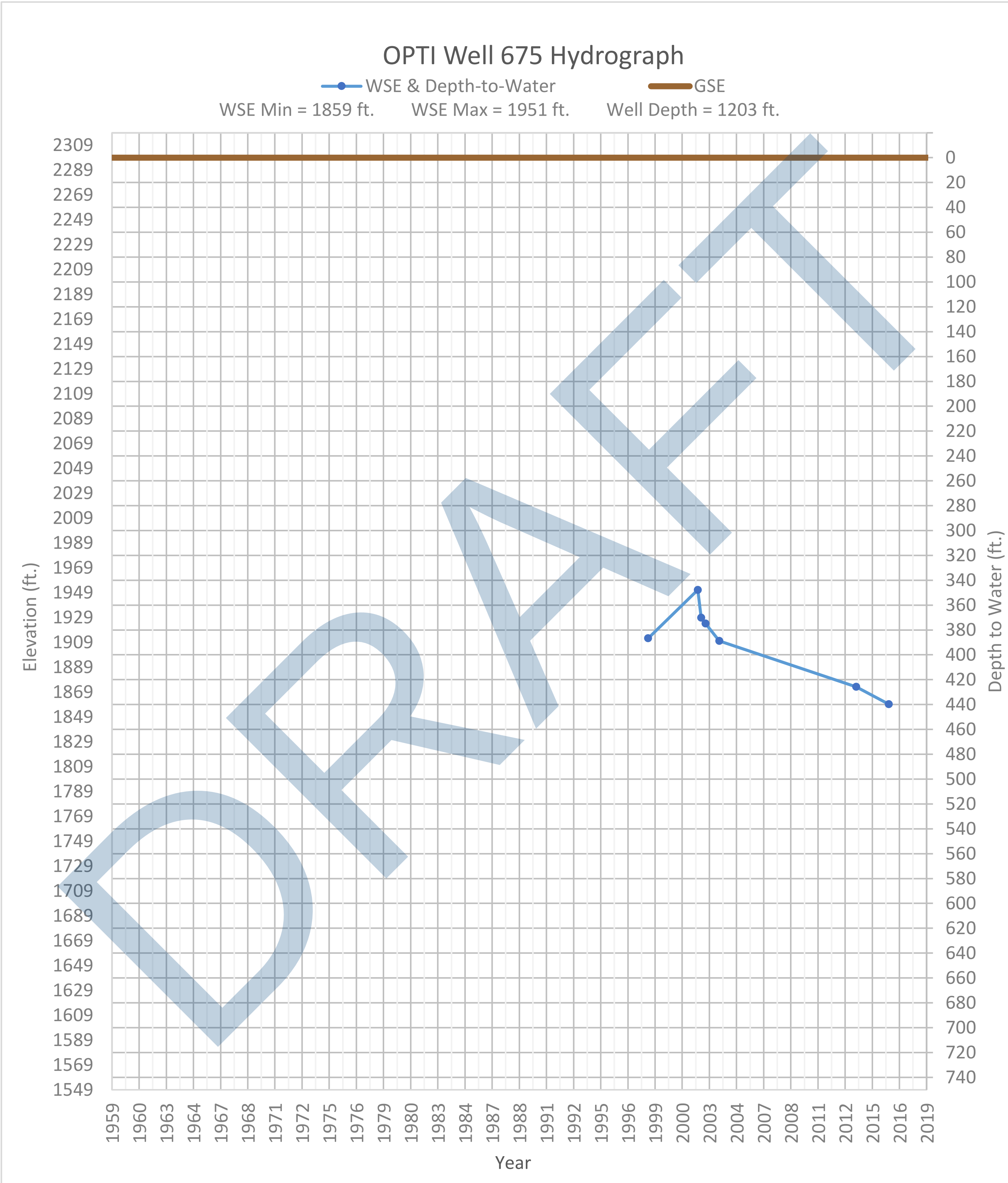
OPTI Well 672 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1845 ft.
WSE Max = 1914 ft.
Well Depth = 998 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



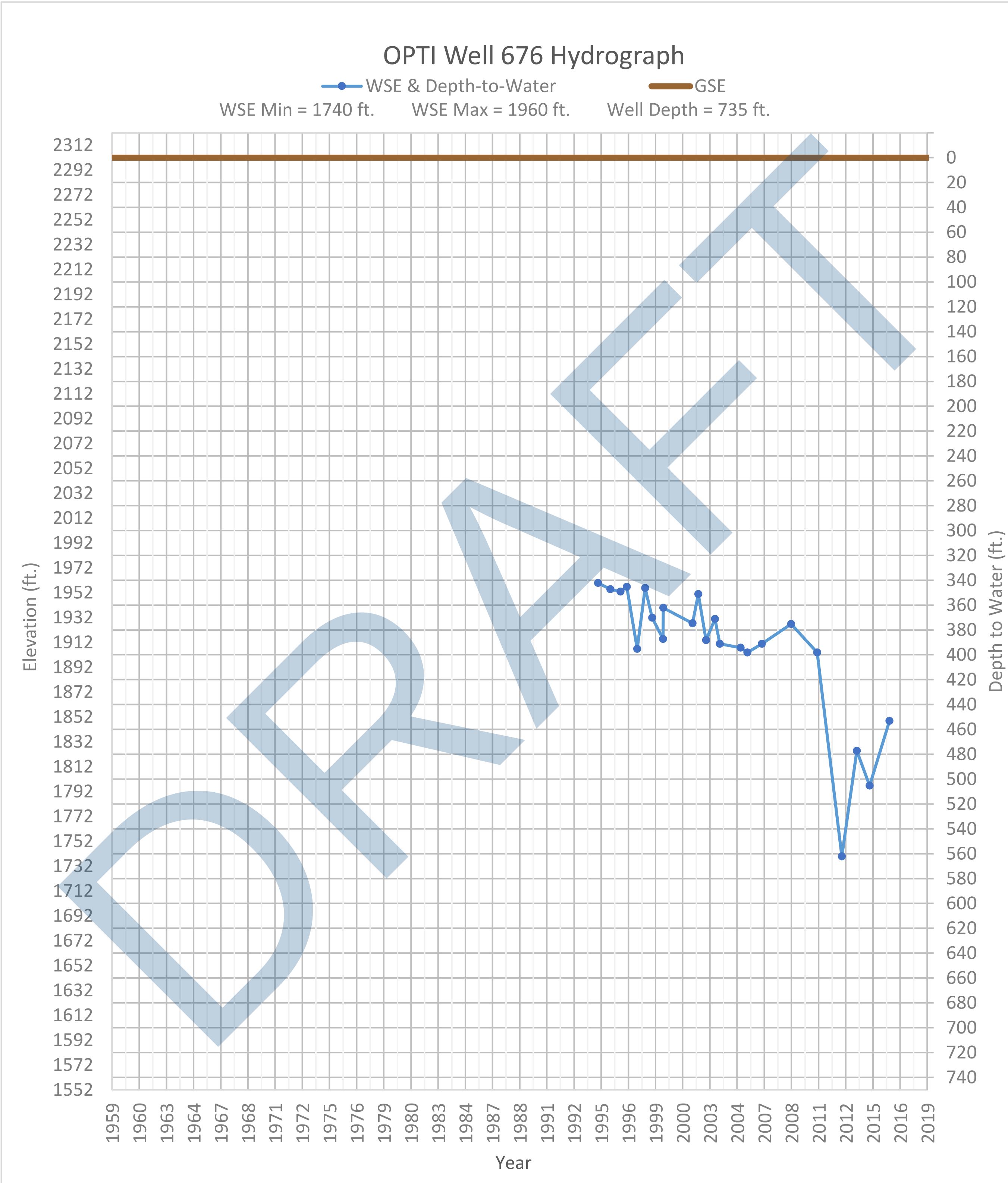
OPTI Well 673 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1852 ft.
WSE Max = 1939 ft.
Well Depth = 1180 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 674 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1809 ft.
WSE Max = 1960 ft.
Well Depth = 1100 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 675 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1859 ft.
WSE Max = 1951 ft.
Well Depth = 1203 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 676 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1740 ft.
WSE Max = 1960 ft.
Well Depth = 735 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
2312
2292
2272
2252
2232
2212
2192
2172
2152
2132
2112
2092
2072
2052
2032
2012
1992
1972
1952
1932
1912
1892
1872
1852
1832
1812
1792
1772
1752
1732
1712
1692
1672
1652
1632
1612
1592
1572
1552
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
680
700
720
740
1959
1960
1963
1964
1967
1968
1971
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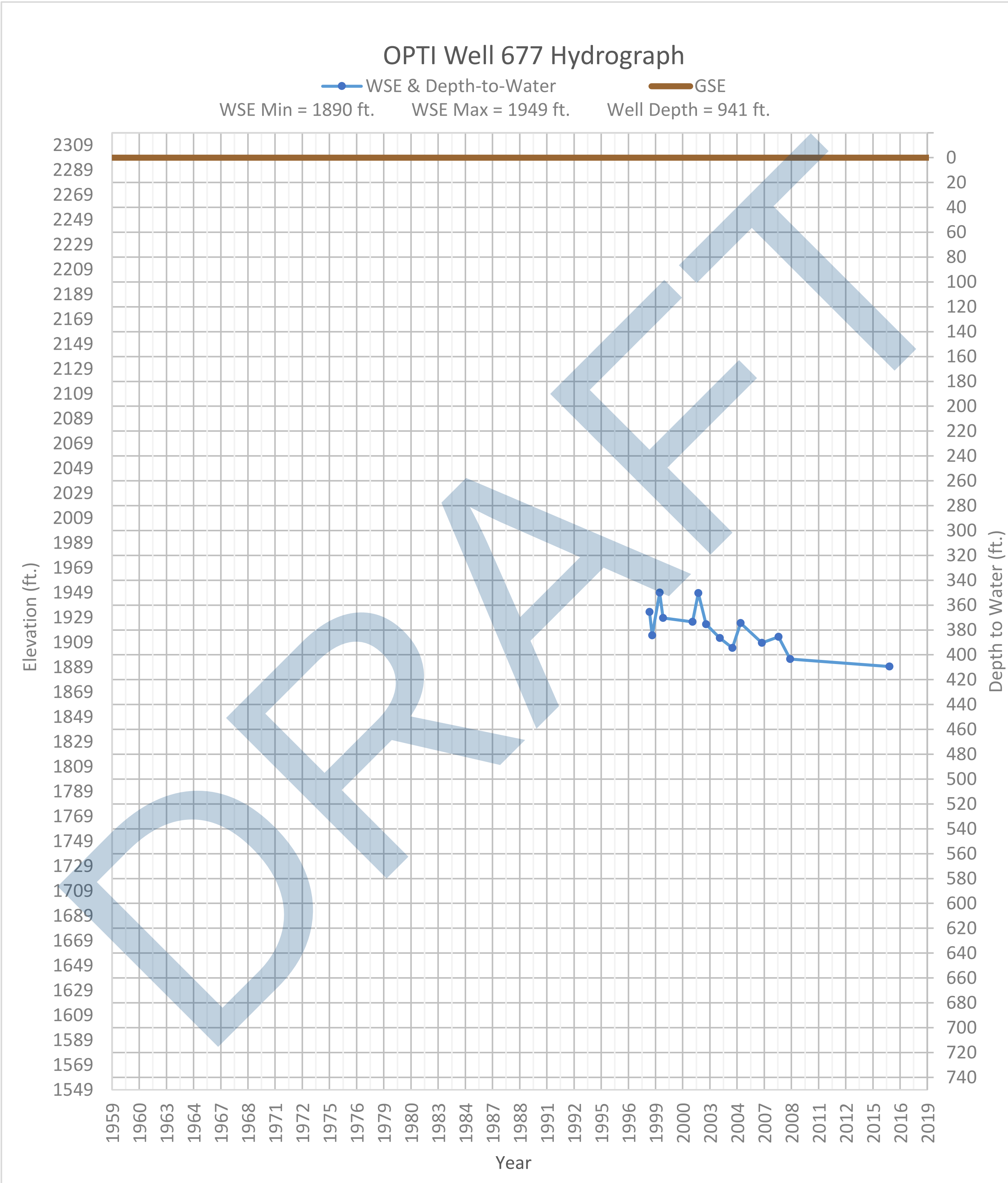
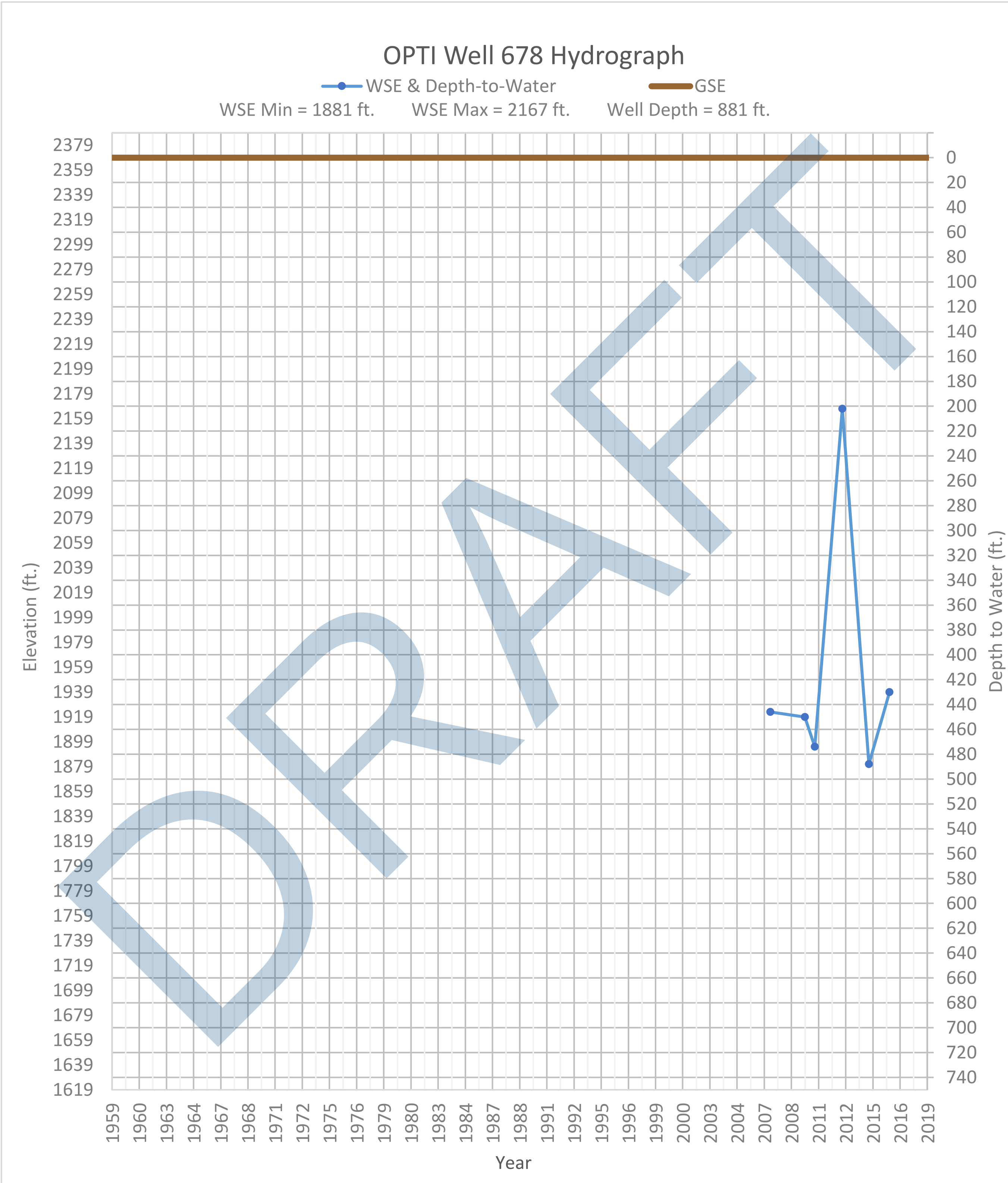
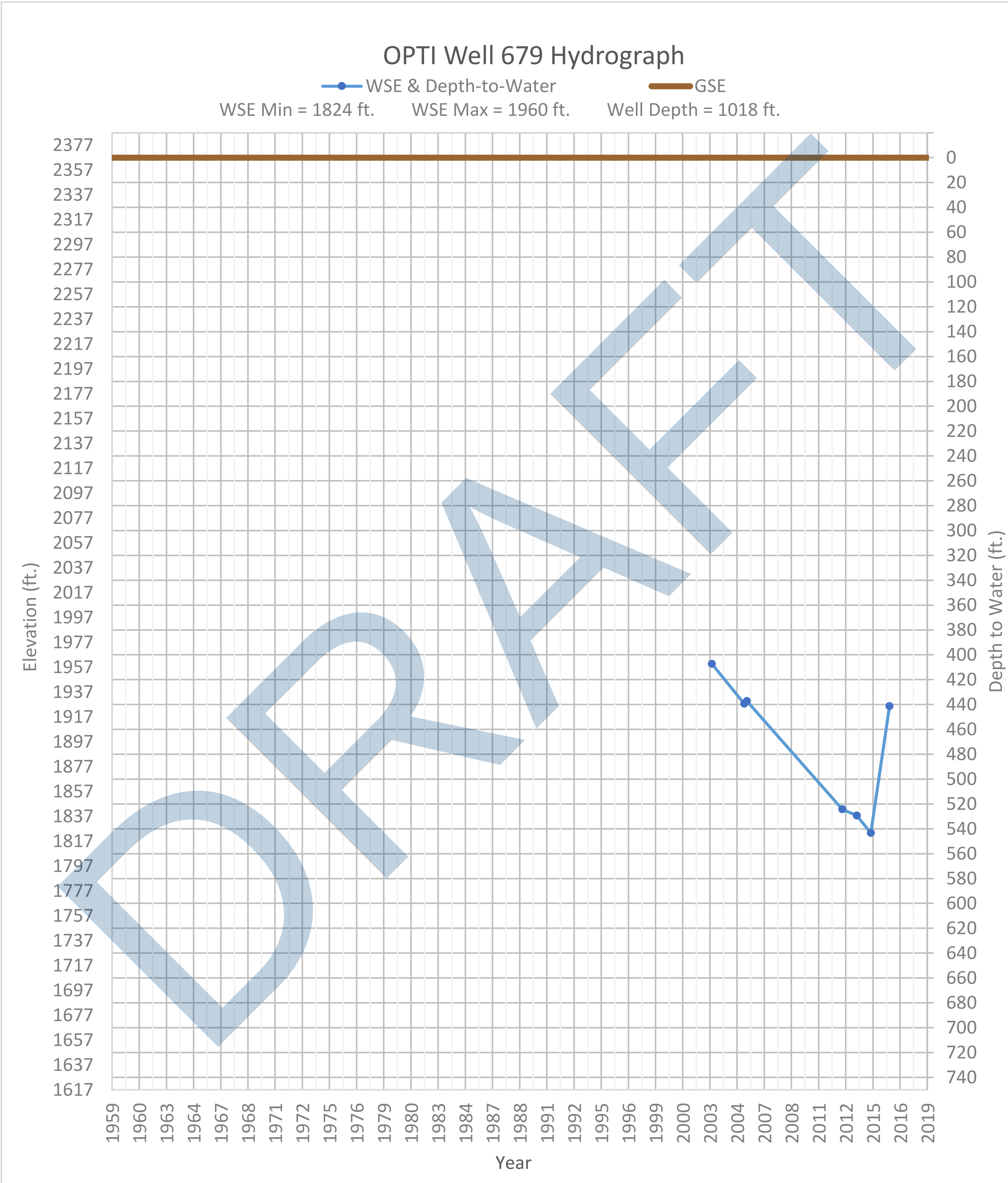
2019
DRAFT



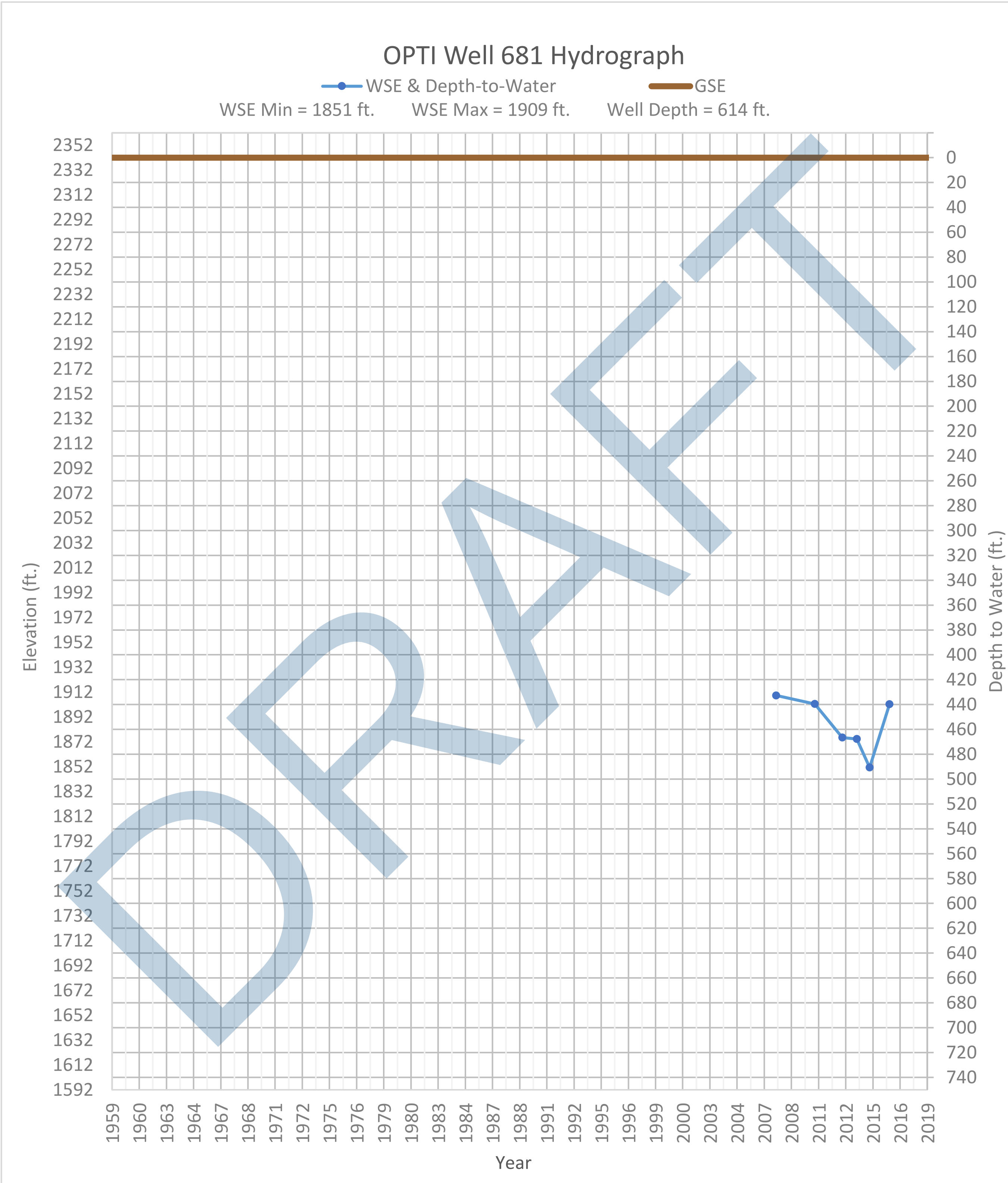
OPTI Well 677 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1890 ft.
WSE Max = 1949 ft.
Well Depth = 941 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



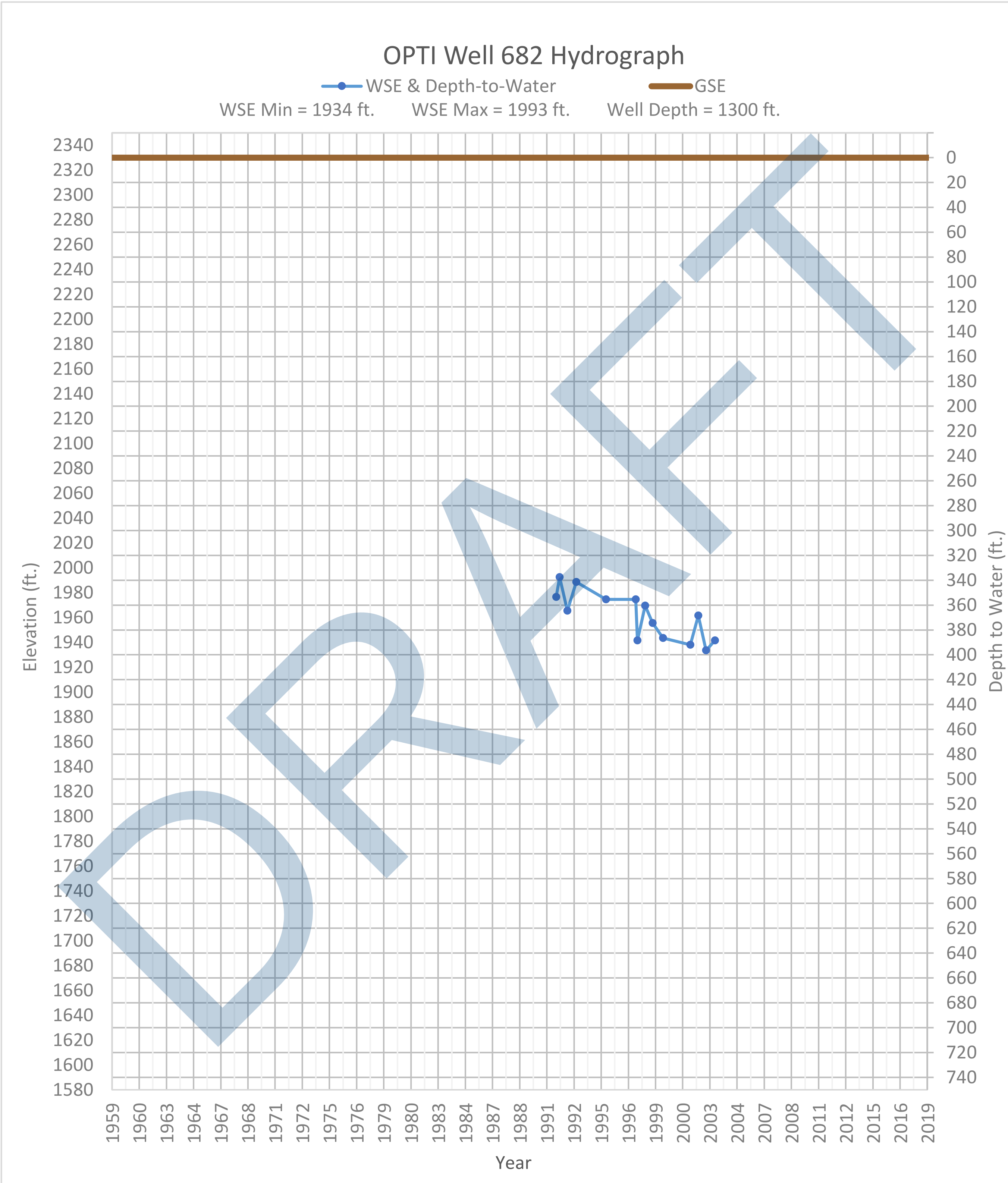
OPTI Well 678 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1881 ft.
WSE Max = 2167 ft.
Well Depth = 881 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



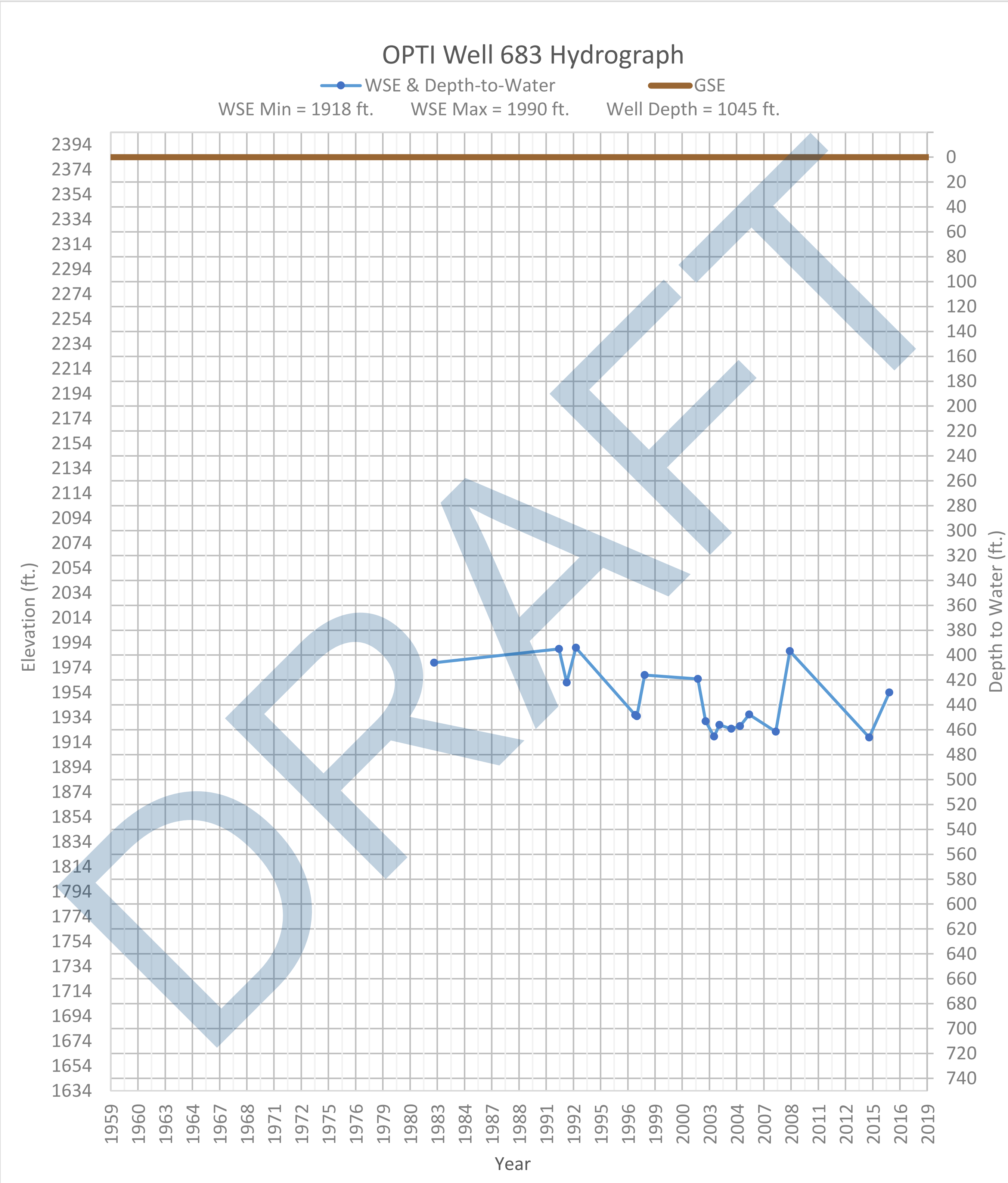
OPTI Well 679 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1824 ft.
WSE Max = 1960 ft.
Well Depth = 1018 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



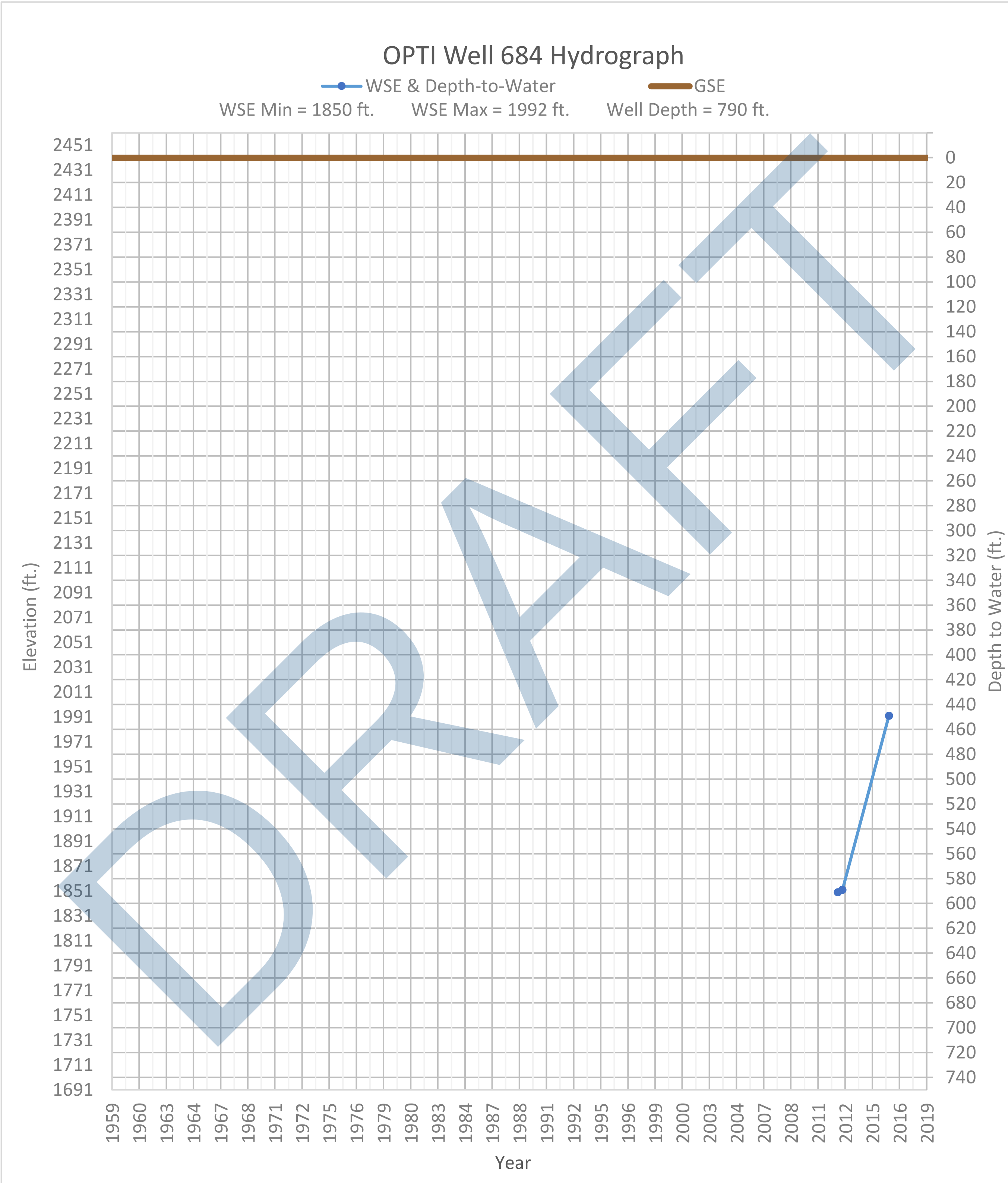
OPTI Well 681 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1851 ft.
WSE Max = 1909 ft.
Well Depth = 614 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



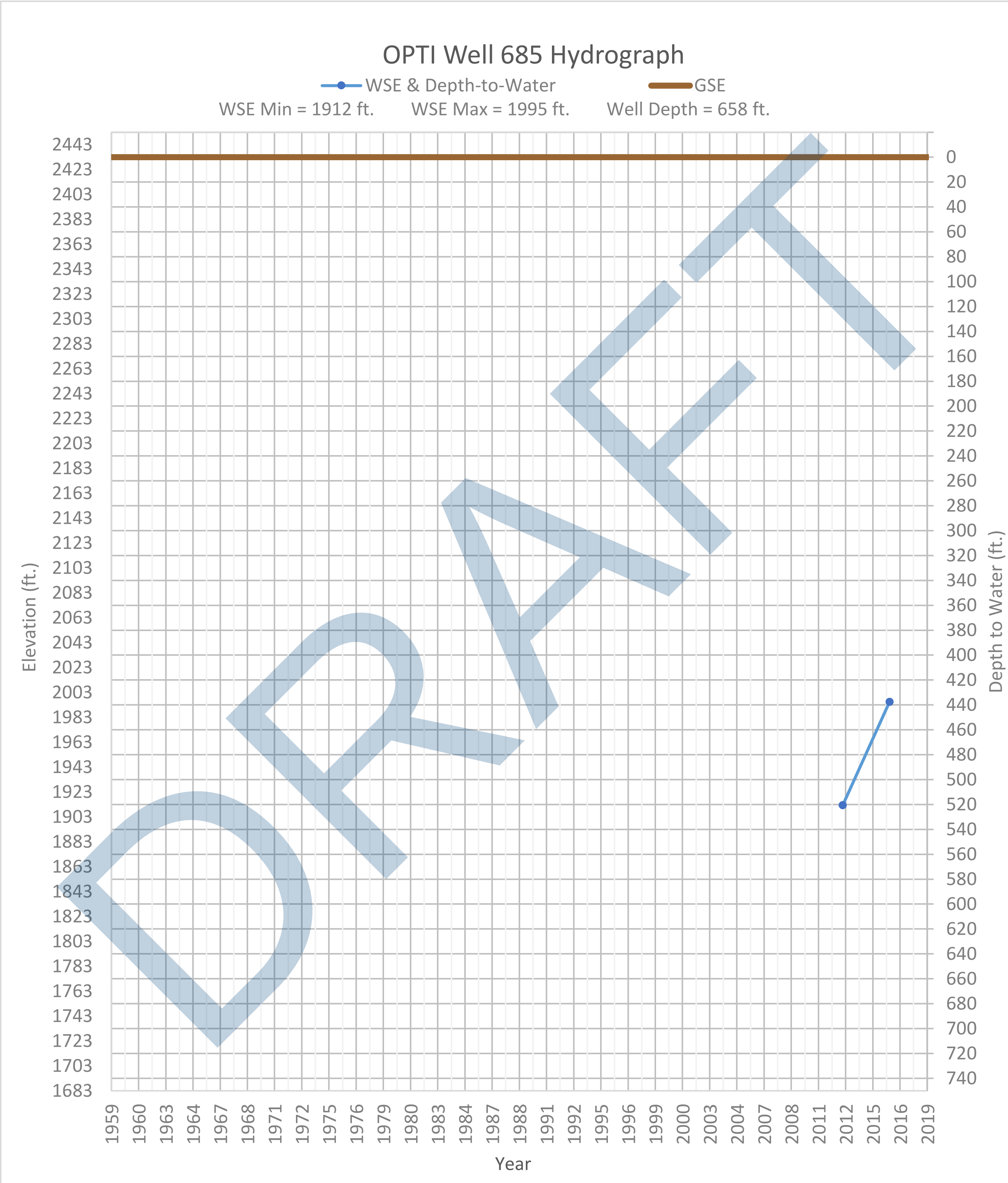
OPTI Well 682 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1934 ft.
WSE Max = 1993 ft.
Well Depth = 1300 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



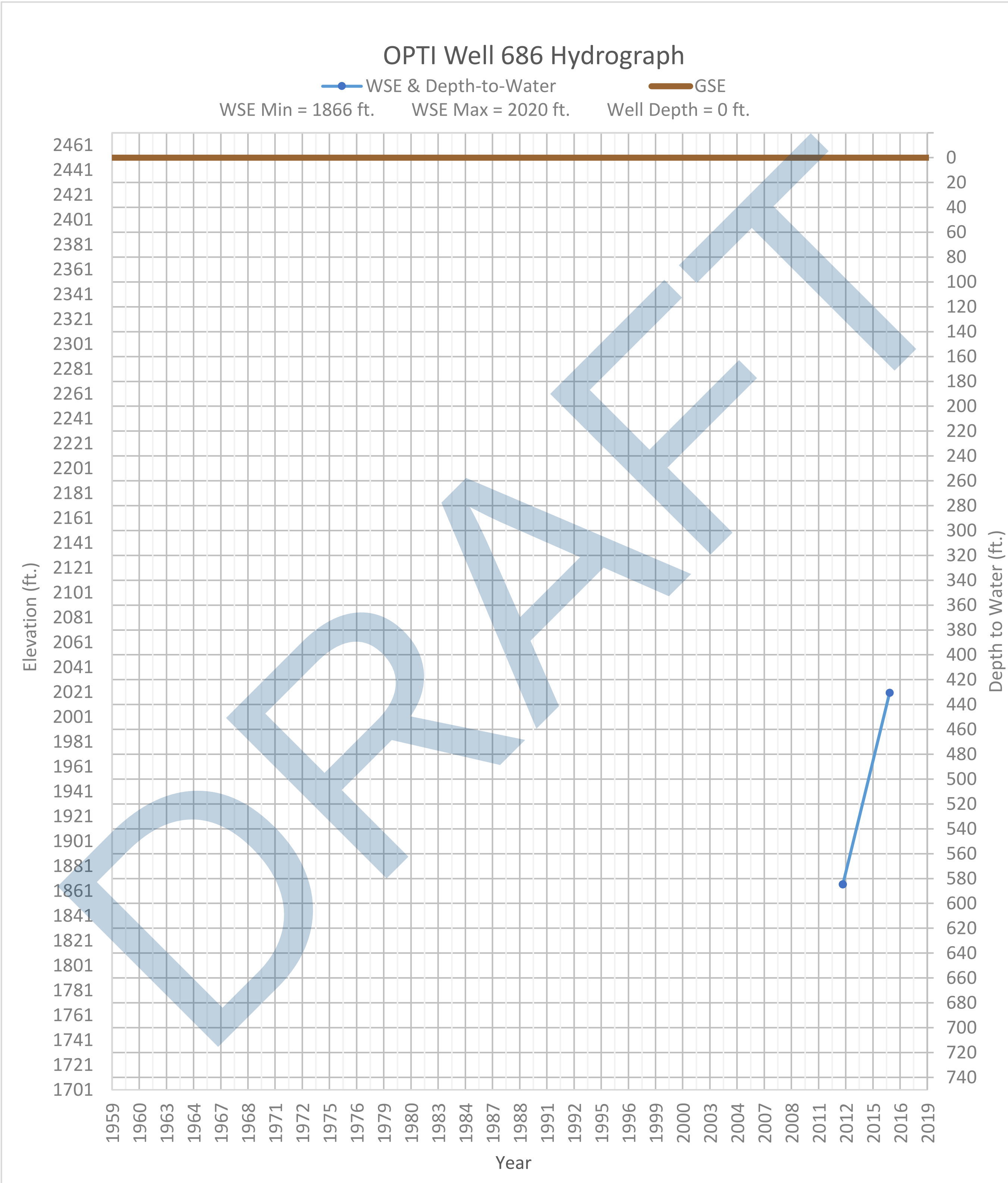
OPTI Well 683 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1918 ft.
WSE Max = 1990 ft.
Well Depth = 1045 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 684 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1850 ft.
WSE Max = 1992 ft.
Well Depth = 790 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

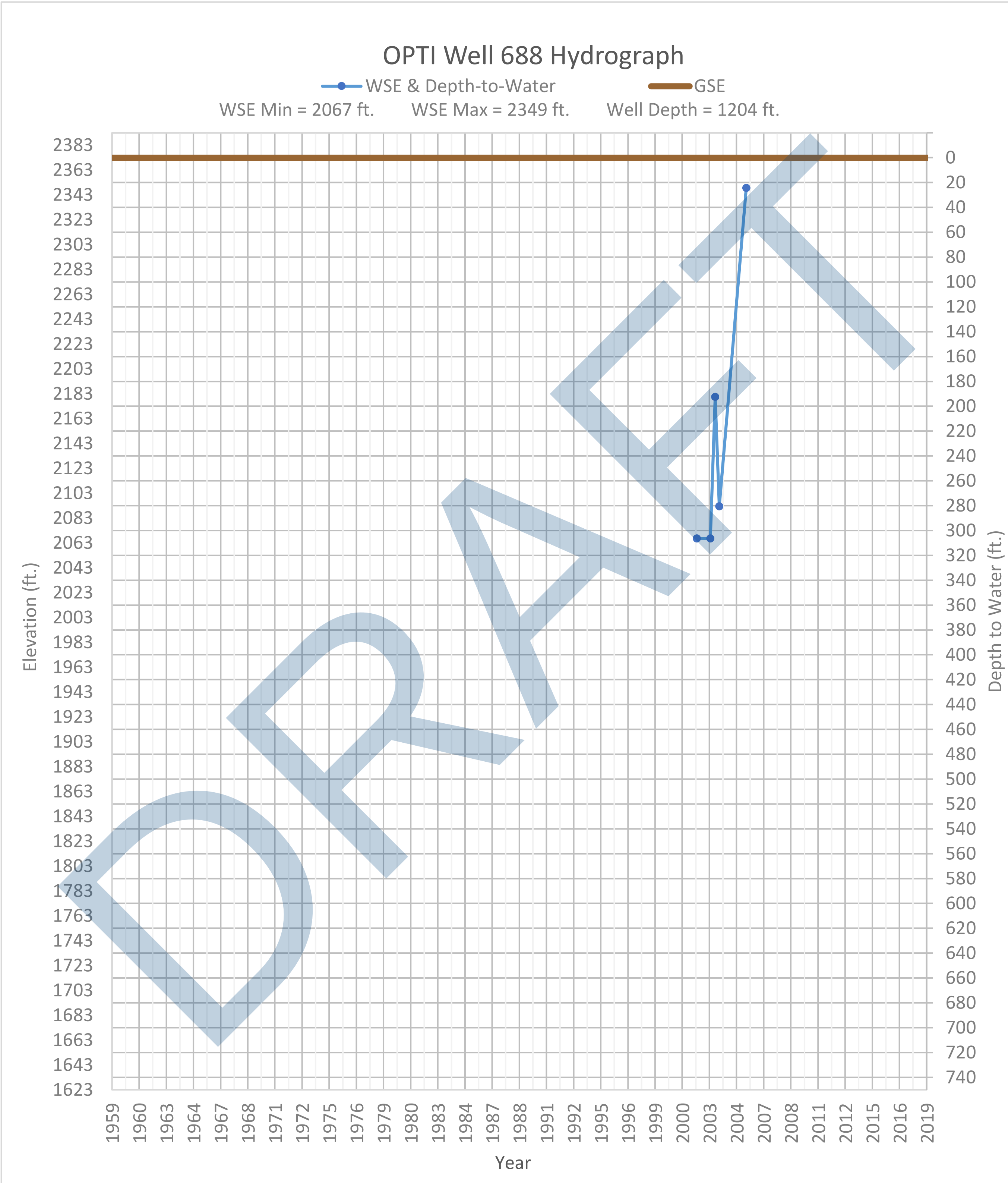


OPTI Well 685 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1912 ft.
WSE Max = 1995 ft.
Well Depth = 658 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

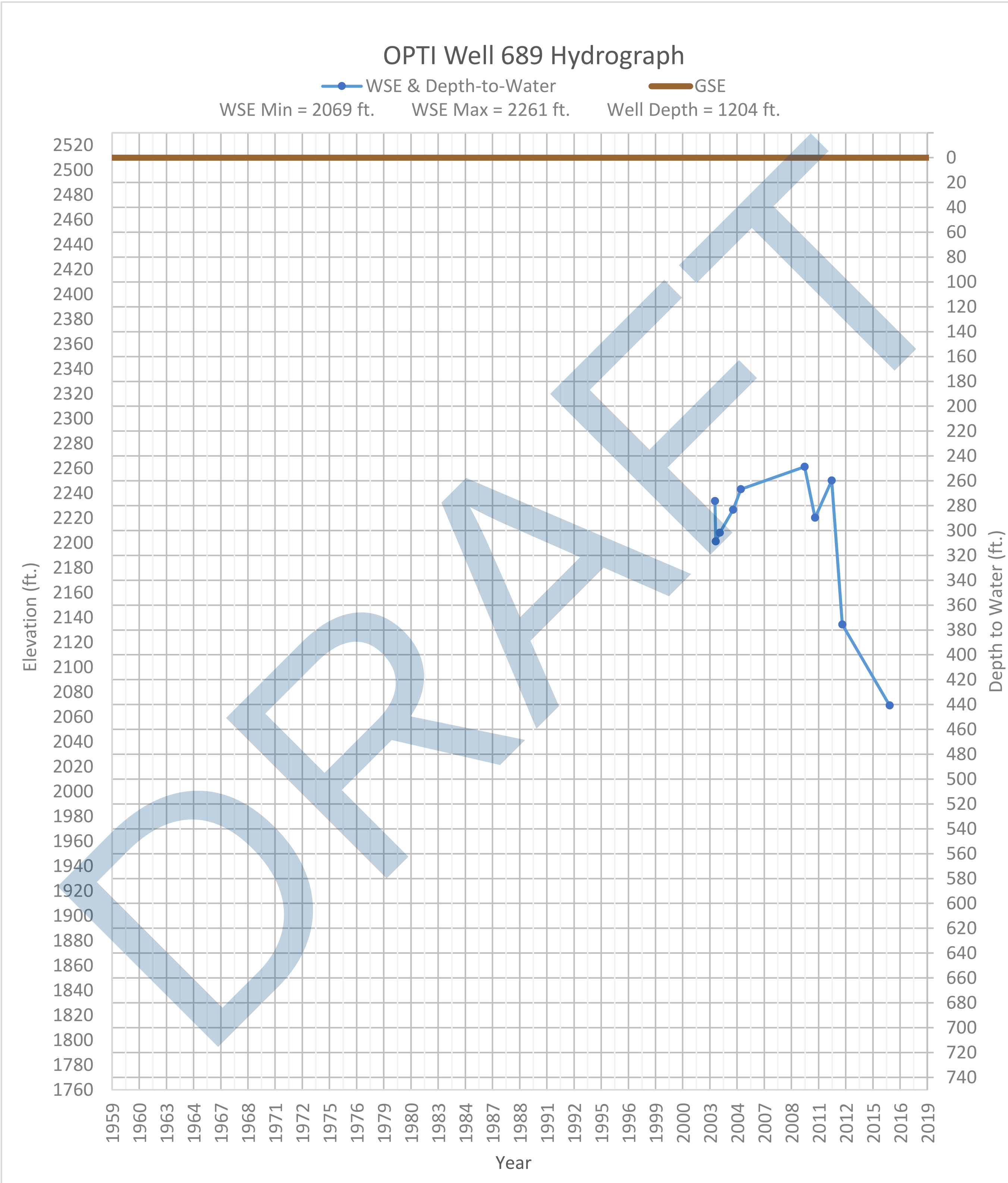


OPTI Well 686 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1866 ft.
WSE Max = 2020 ft.
Well Depth = 0 ft.
Elevation (ft.)
2461 2441 2421 2401 2381 2361 2341 2321 2301 2281 2261 2241 2221 2201 2181 2161 2141 2121 2101 2081 2061 2041 2021 2001 1981 1961 1941 1921 1901 1881 1861 1841 1821 1801 1781 1761 1741 1721 1701
Depth to Water (ft.)
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720 740
Year
1959 1960 1963 1964 1967 1968 1971 1972 1975 1976 1979 1980 1983 1984 1987 1988 1991 1992 1995 1996 1999 2000 2003 2004 2007 2008 2011 2012 2015 2016 2019
DRAFT

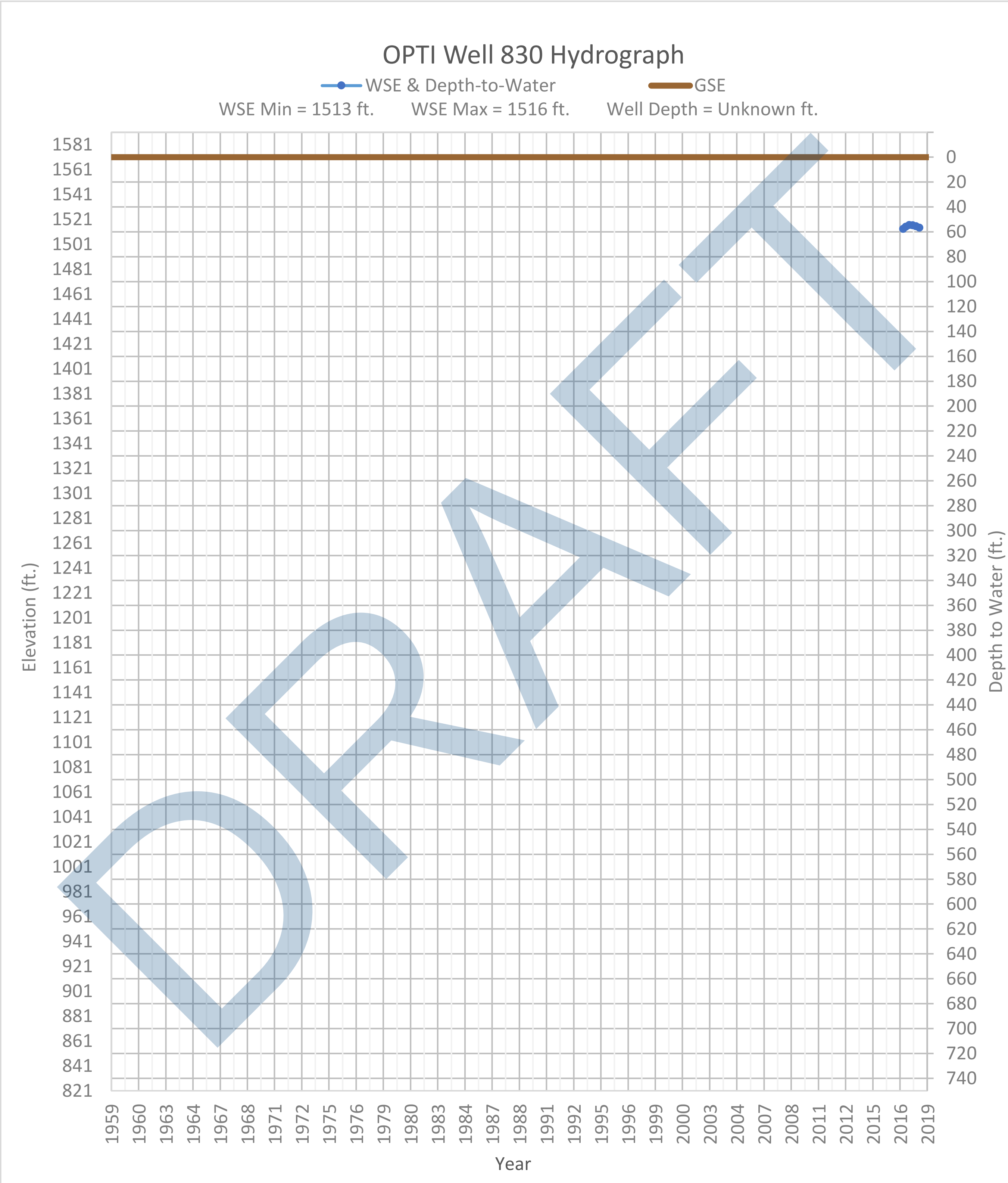
OPTI Well 687 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1781 ft.
WSE Max = 2101 ft.
Well Depth = 1195 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

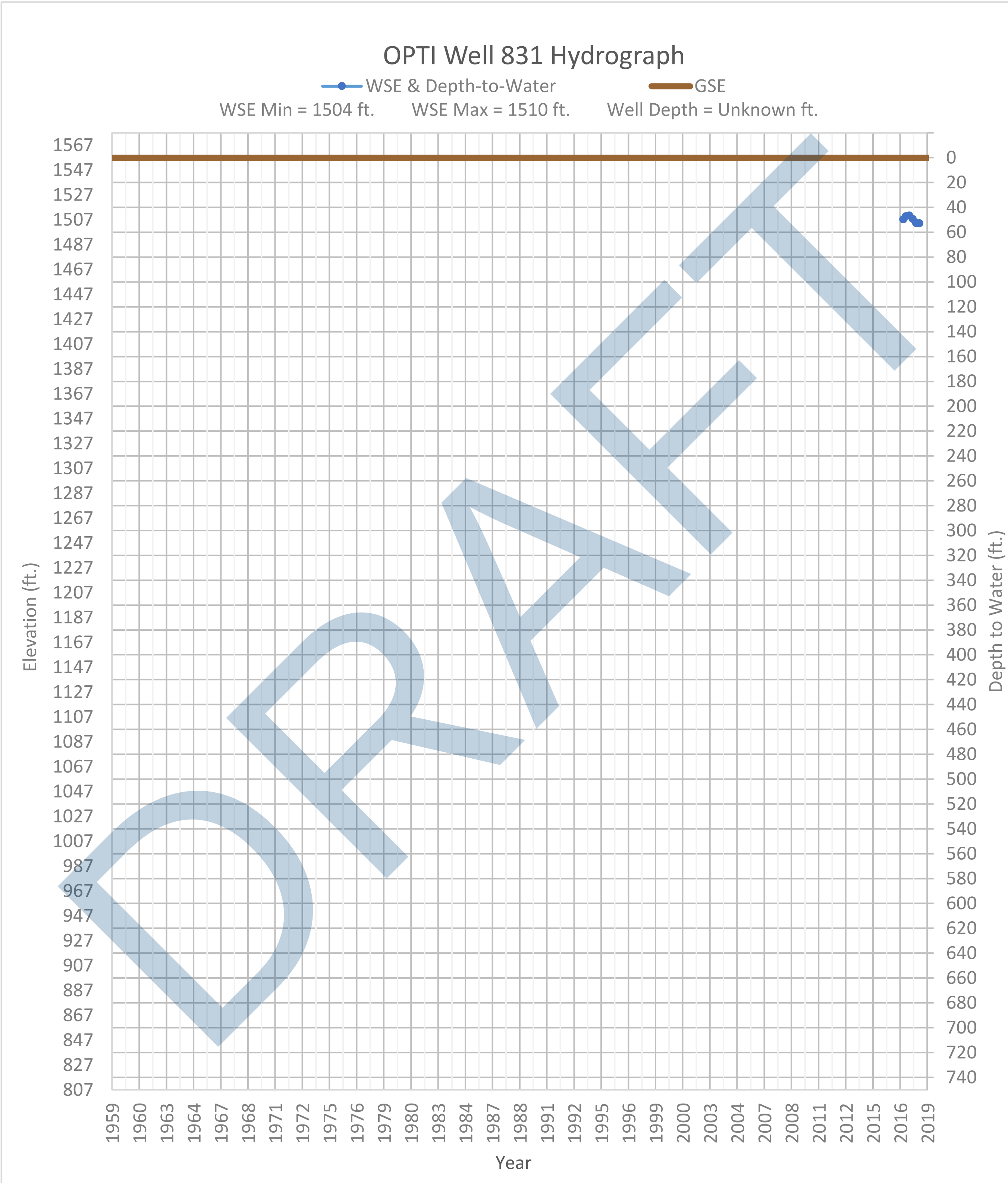


OPTI Well 688 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2067 ft.
WSE Max = 2349 ft.
Well Depth = 1204 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 689 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 2069 ft.
WSE Max = 2261 ft.
Well Depth = 1204 ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 830 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1513 ft.
WSE Max = 1516 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 831 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1504 ft.
WSE Max = 1510 ft.
Well Depth = Unknown ft.
Elevation (ft.)
1567
1547
1527
1507
1487
1467
1447
1427
1407
1387
1367
1347
1327
1307
1287
1267
1247
1227
1207
1187
1167
1147
1127
1107
1087
1067
1047
1027
1007
987
967
947
927
907
887
867
847
827
807
Depth to Water (ft.)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
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420
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680
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720
740
Year
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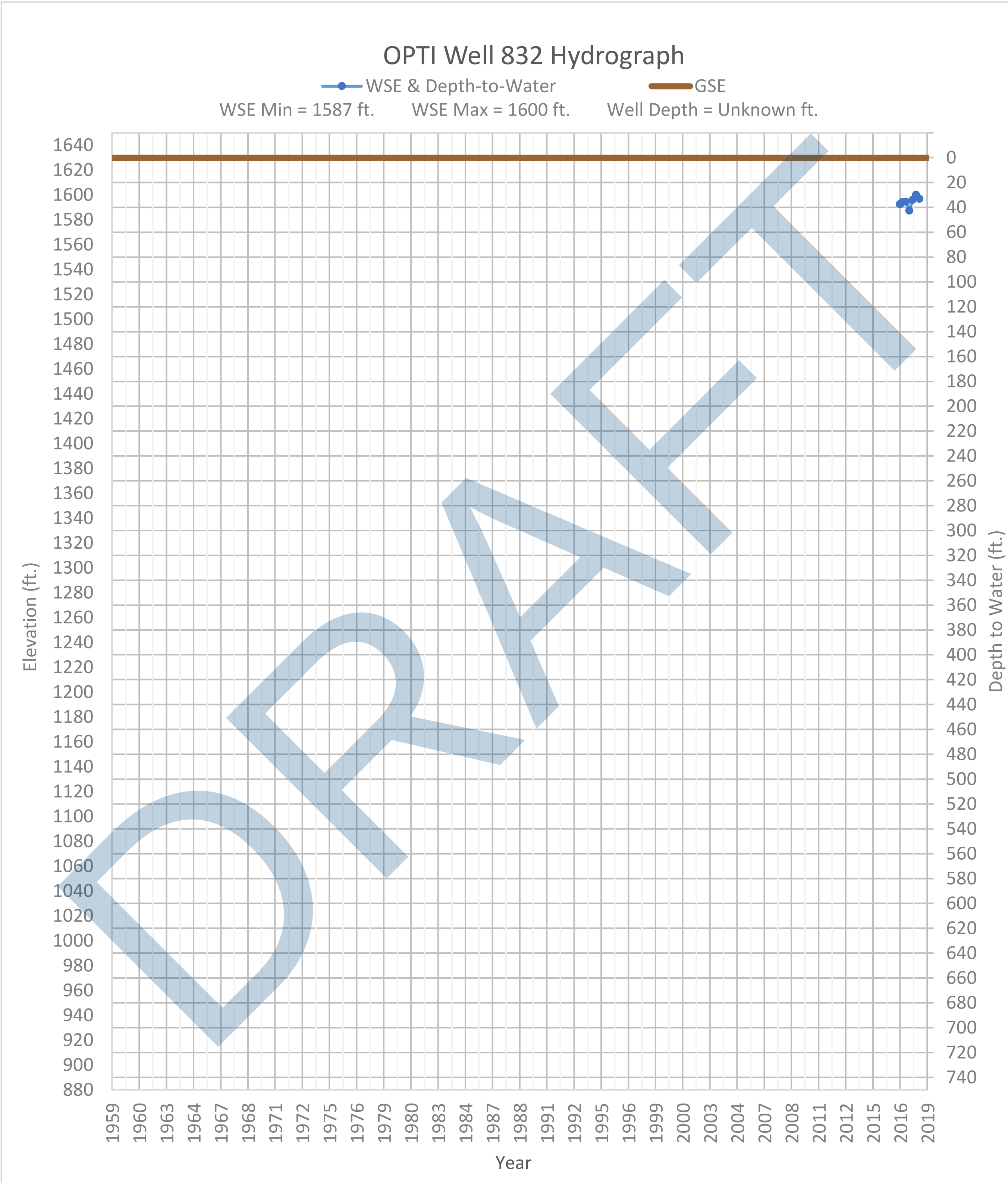
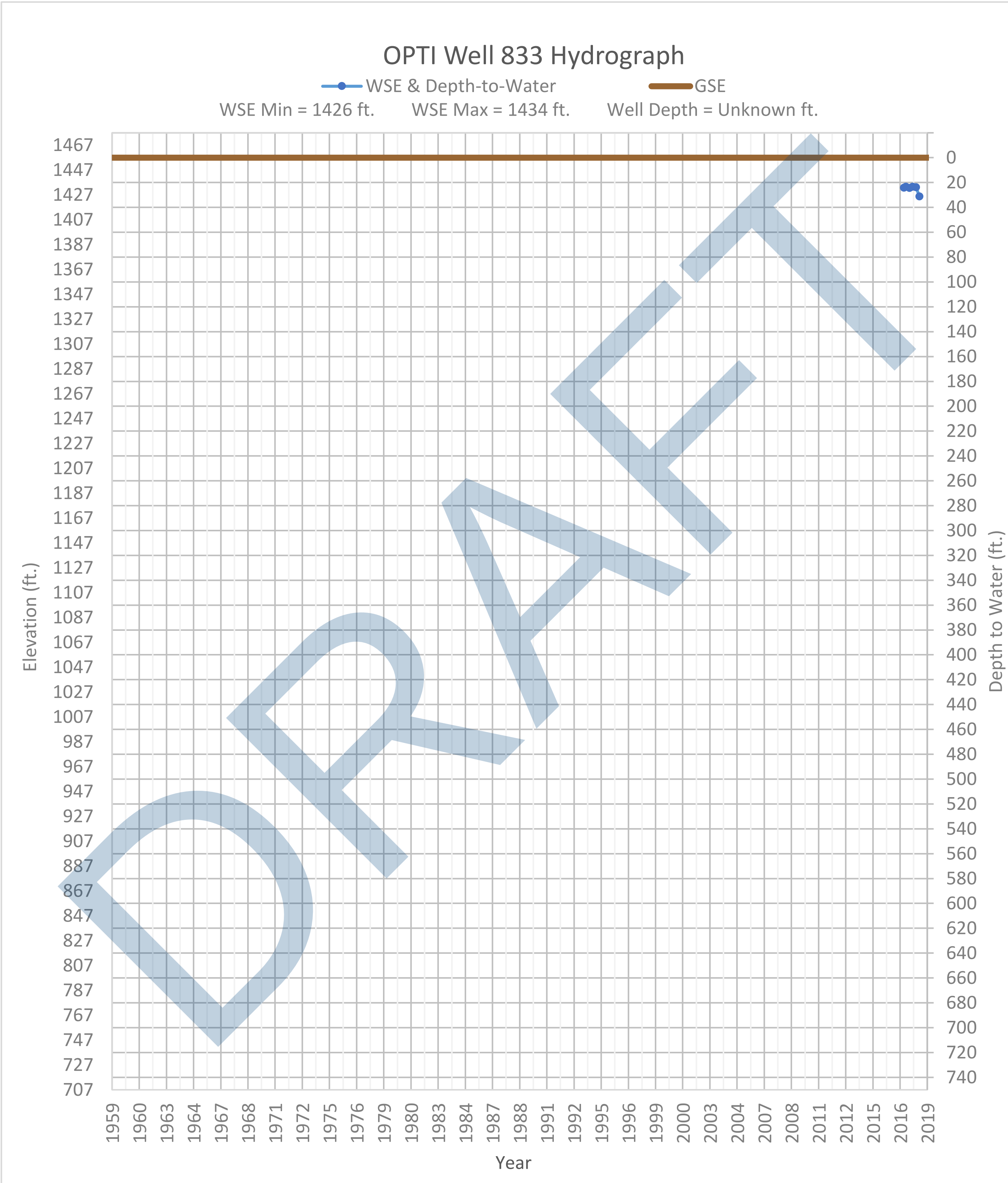
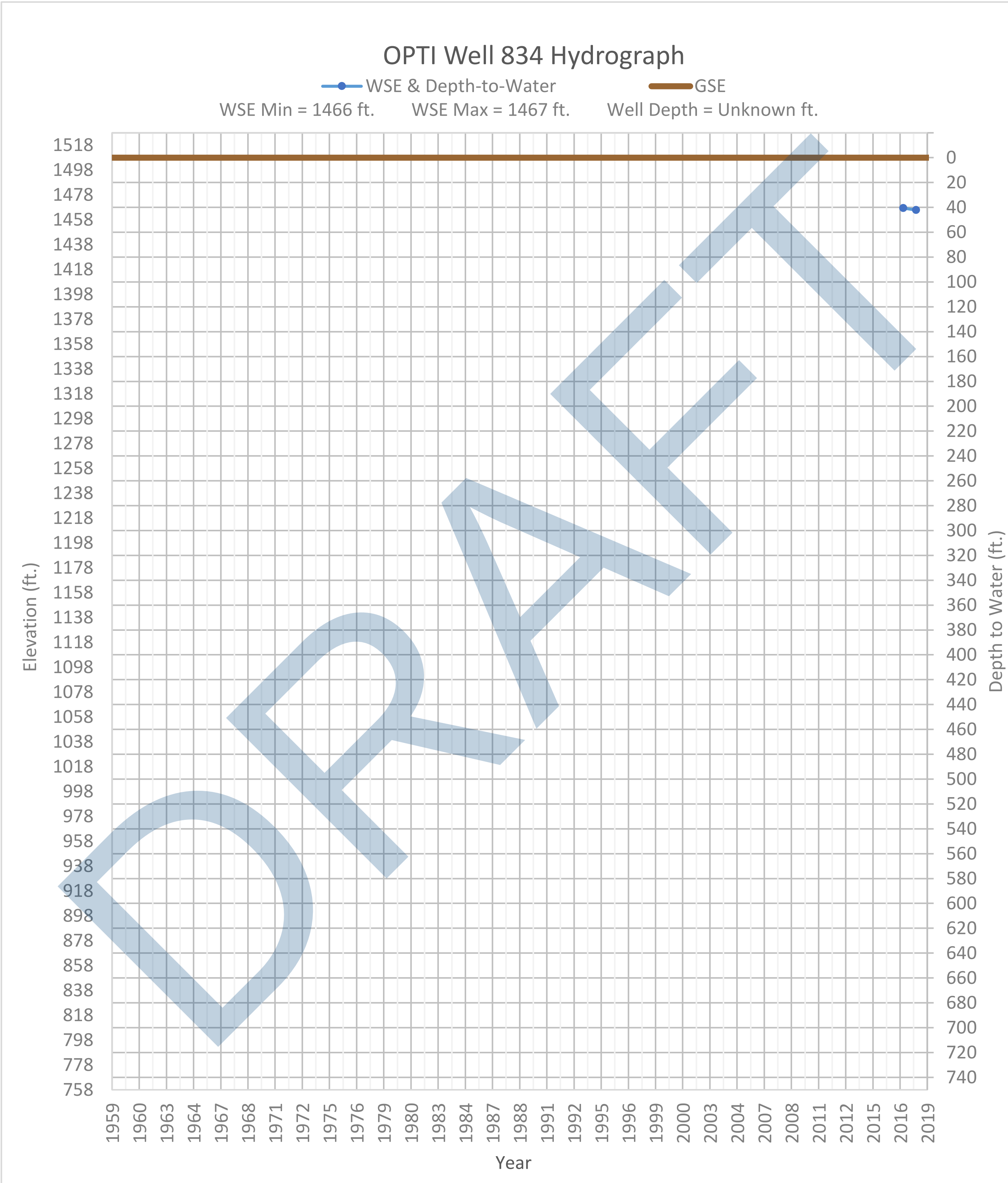
2016
2019
DRAFT



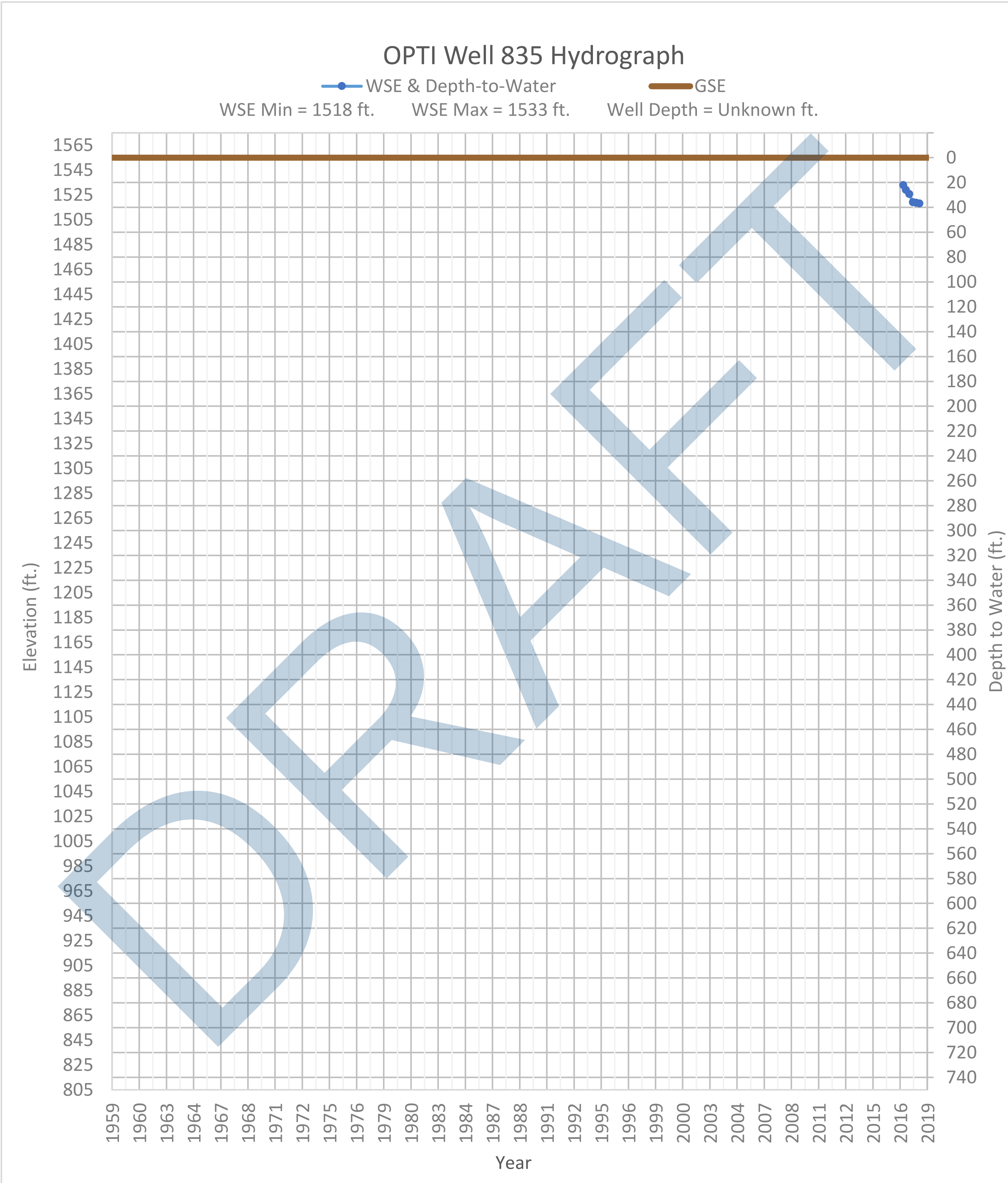
OPTI Well 832 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1587 ft.
WSE Max = 1600 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

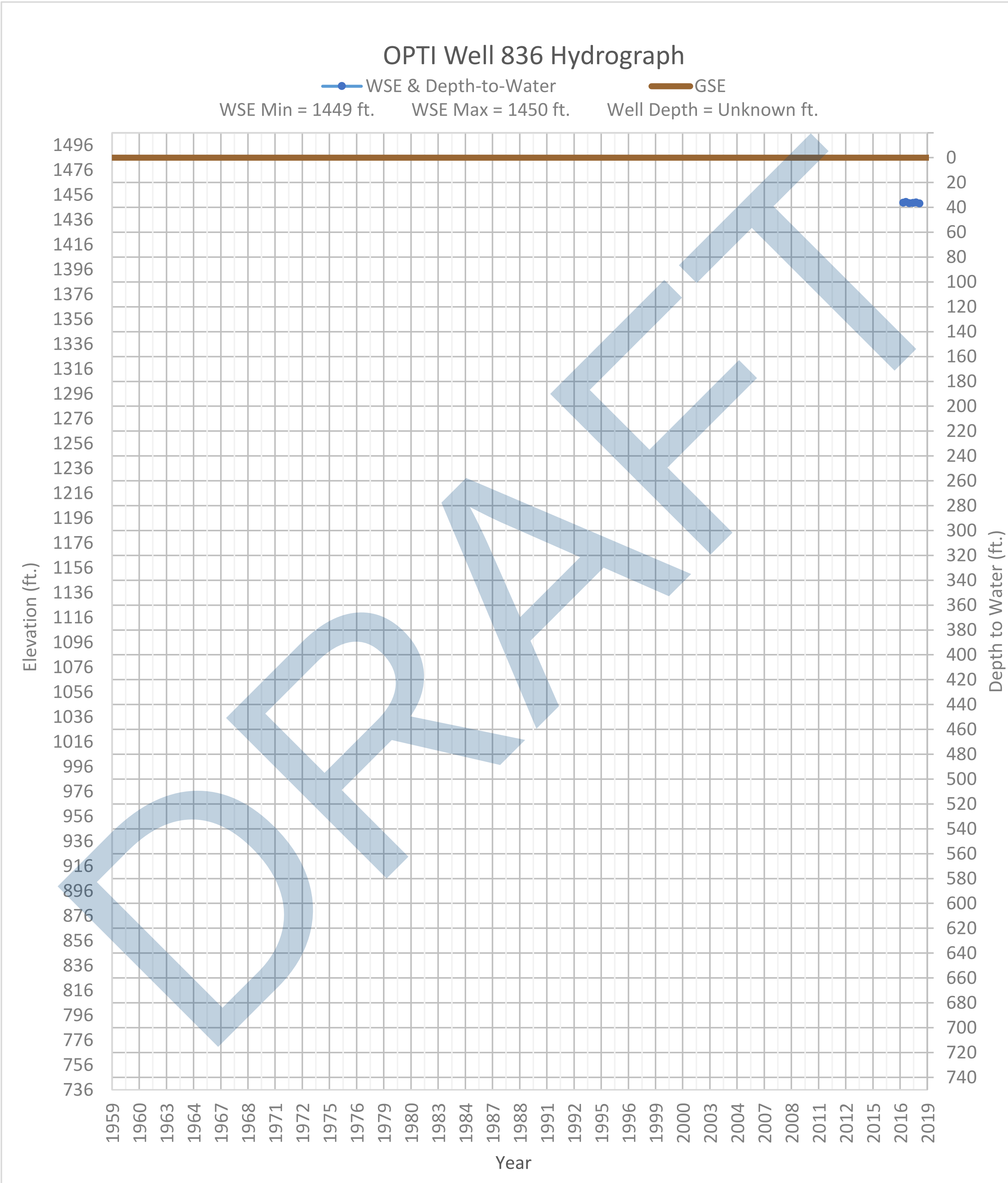


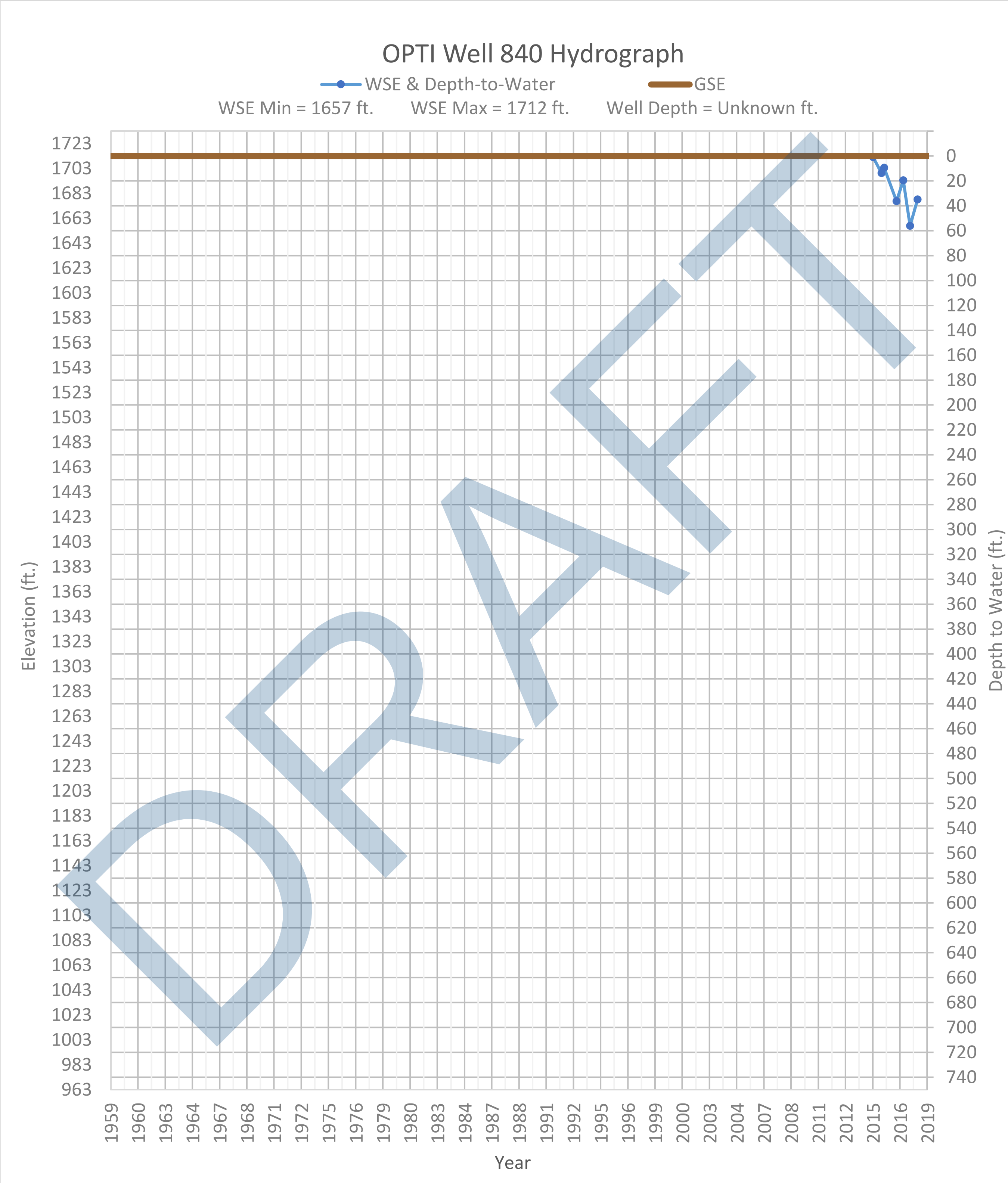
OPTI Well 833 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1426 ft.
WSE Max = 1434 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



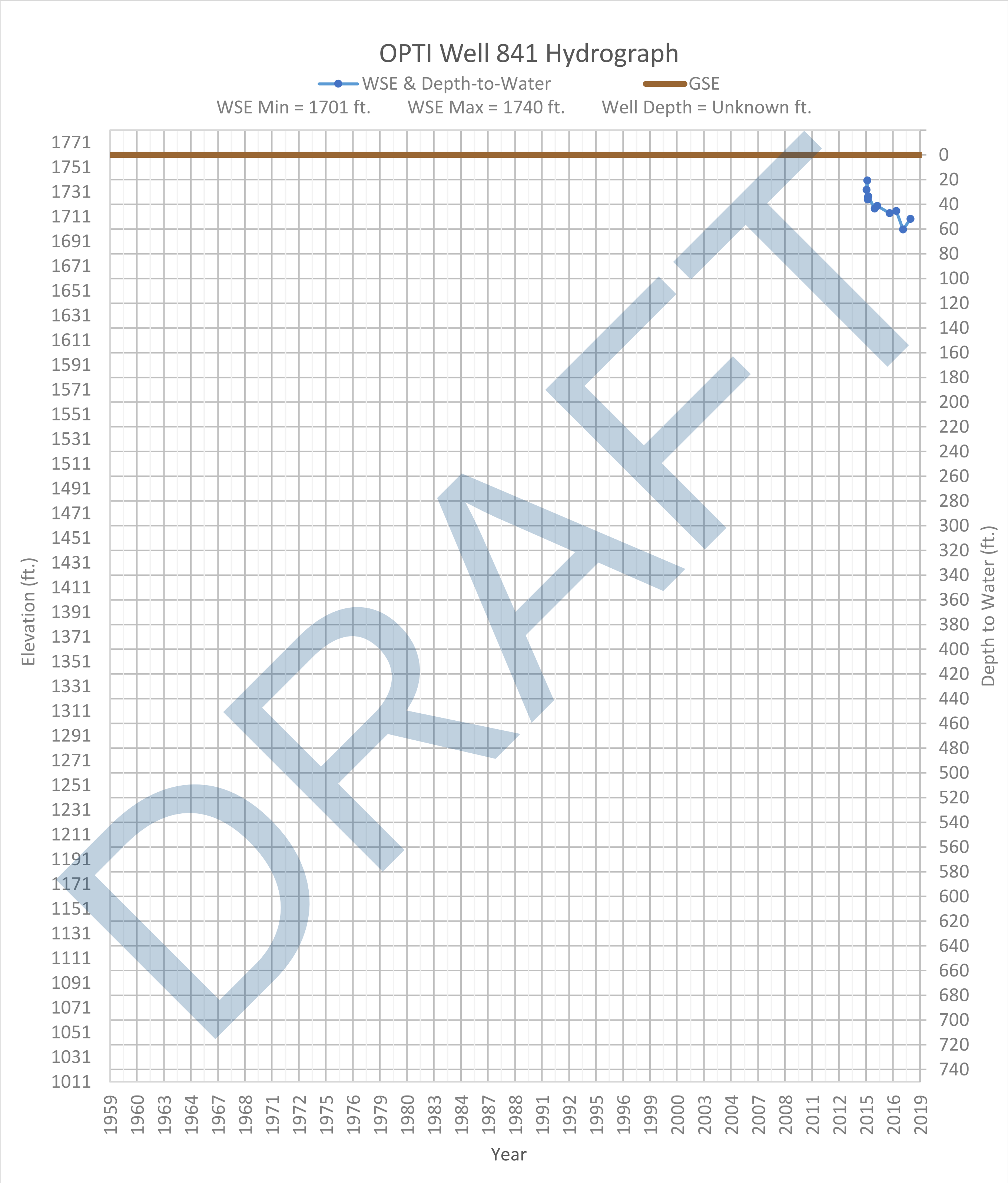
OPTI Well 834 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1466 ft.
WSE Max = 1467 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

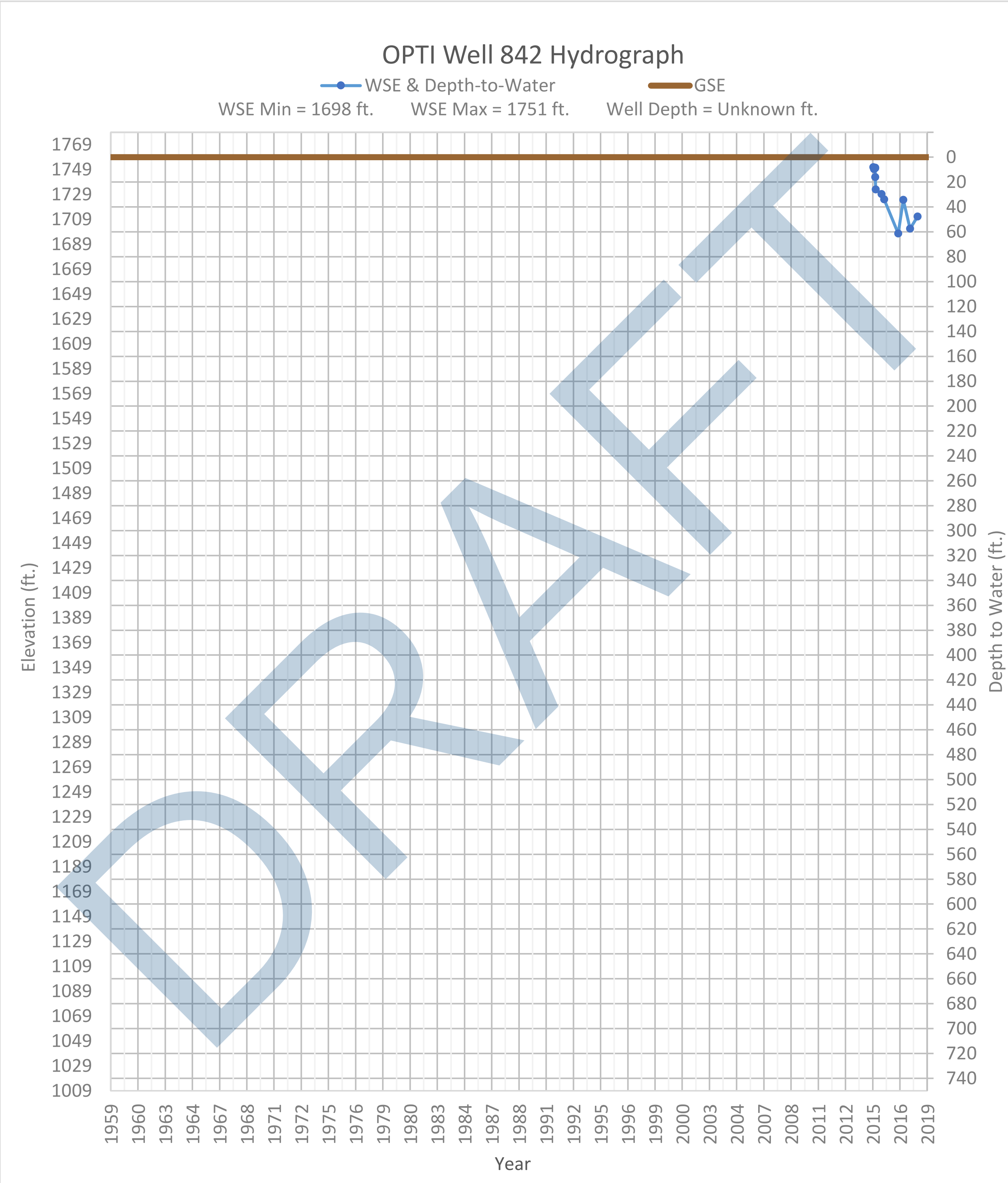

OPTI Well 835 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1518 ft.
WSE Max = 1533 ft.
Well Depth = Unknown ft.
Elevation (ft.)
1565 1545 1525 1505 1485 1465 1445 1425 1405 1385 1365 1345 1325 1305 1285 1265 1245 1225 1205 1185 1165 1145 1125 1105 1085 1065 1045 1025 1005 985 965 945 925 905 885 865 845 825 805
Depth to Water (ft.)
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720 740
Year
1959 1960 1963 1964 1967 1968 1971 1972 1975 1976 1979 1980 1983 1984 1987 1988 1991 1992 1995 1996 1999 2000 2003 2004 2007 2008 2011 2012 2015 2016 2019
DRAFT


OPTI Well 836 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1449 ft.
WSE Max = 1450 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

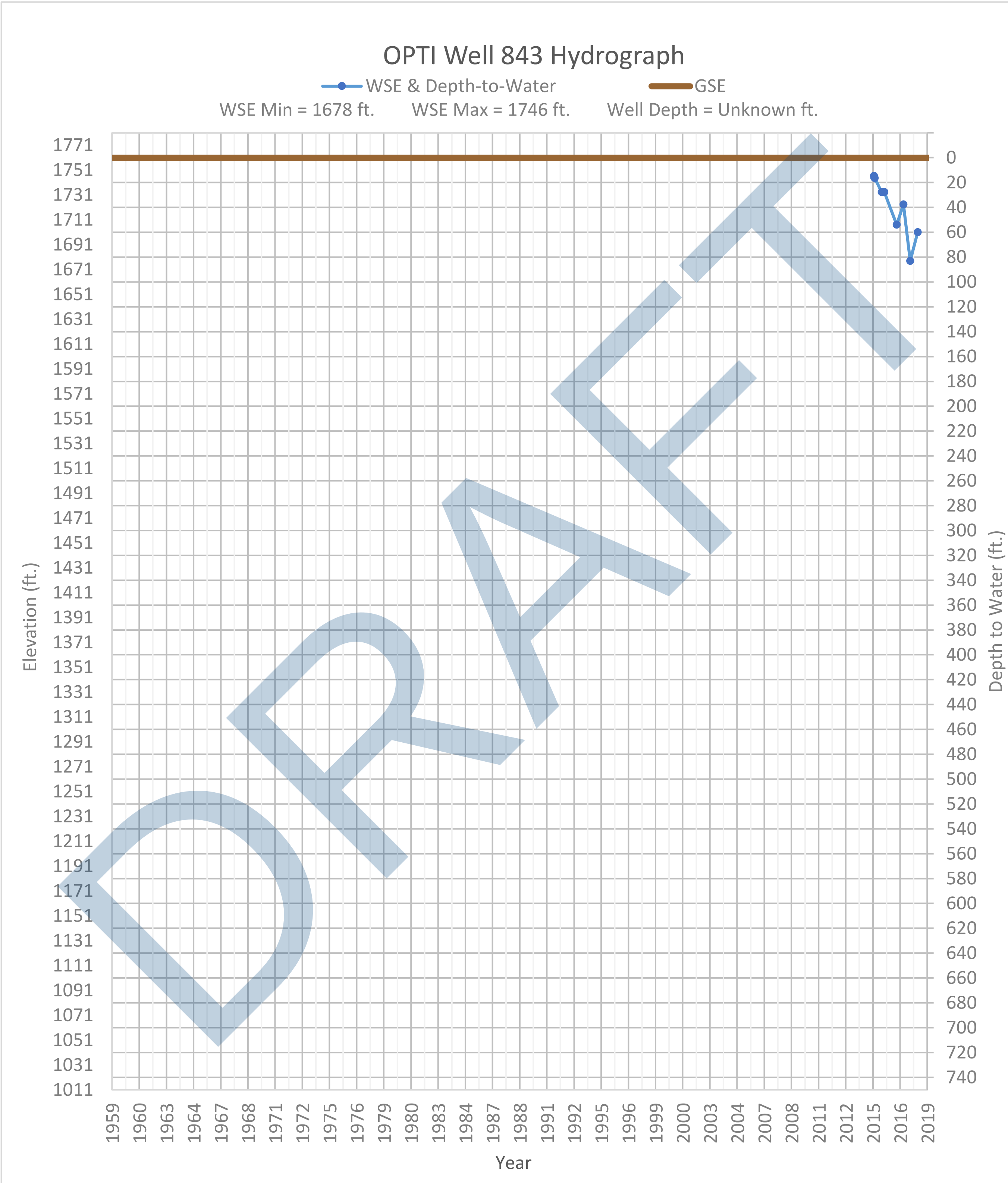


OPTI Well 840 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1657 ft.
WSE Max = 1712 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 841 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1701 ft.
WSE Max = 1740 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 842 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1698 ft.
WSE Max = 1751 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 843 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1678 ft.
WSE Max = 1746 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
1771
1751
1731
1711
1691
1671
1651
1631
1611
1591
1571
1551
1531
1511
1491
1471
1451
1431
1411
1391
1371
1351
1331
1311
1291
1271
1251
1231
1211
1191
1171
1151
1131
1111
1091
1071
1051
1031
1011
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
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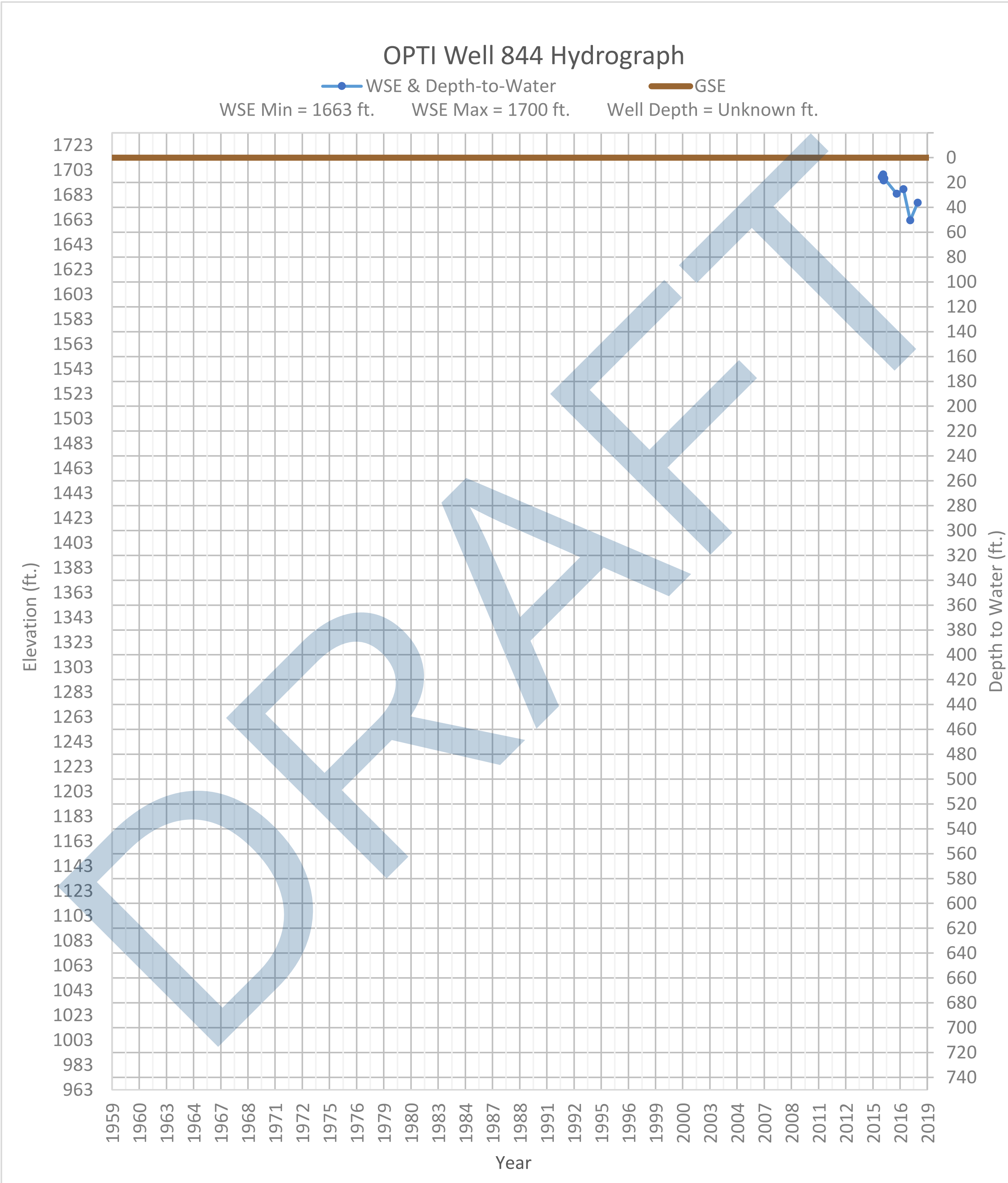
2015
2016
2019
DRAFT



OPTI Well 844 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1663 ft.
WSE Max = 1700 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
1723
1703
1683
1663
1643
1623
1603
1583
1563
1543
1523
1503
1483
1463
1443
1423
1403
1383
1363
1343
1323
1303
1283
1263
1243
1223
1203
1183
1163
1143
1123
1103
1083
1063
1043
1023
1003
983
963
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
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620
640
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680
700
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1959
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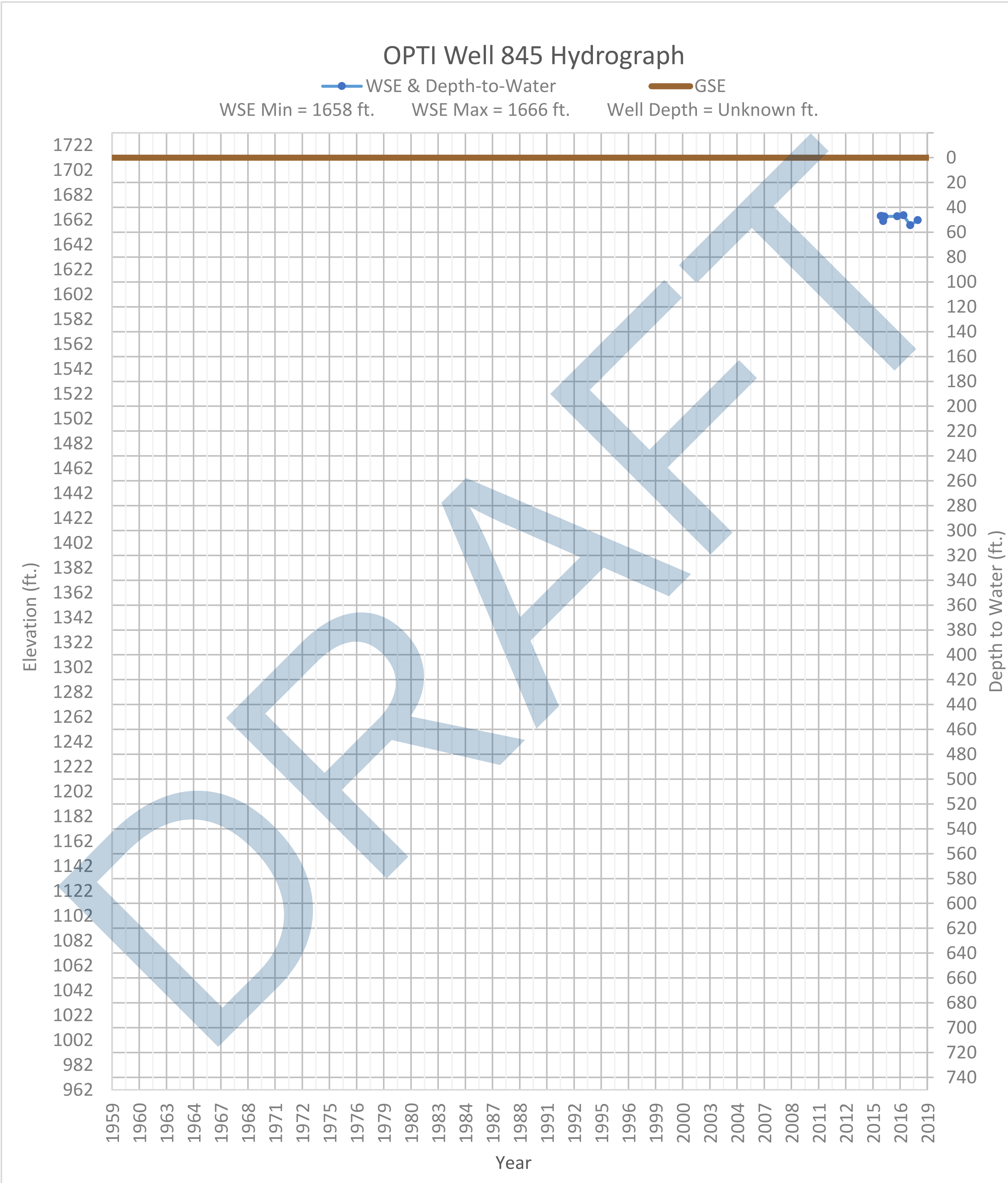
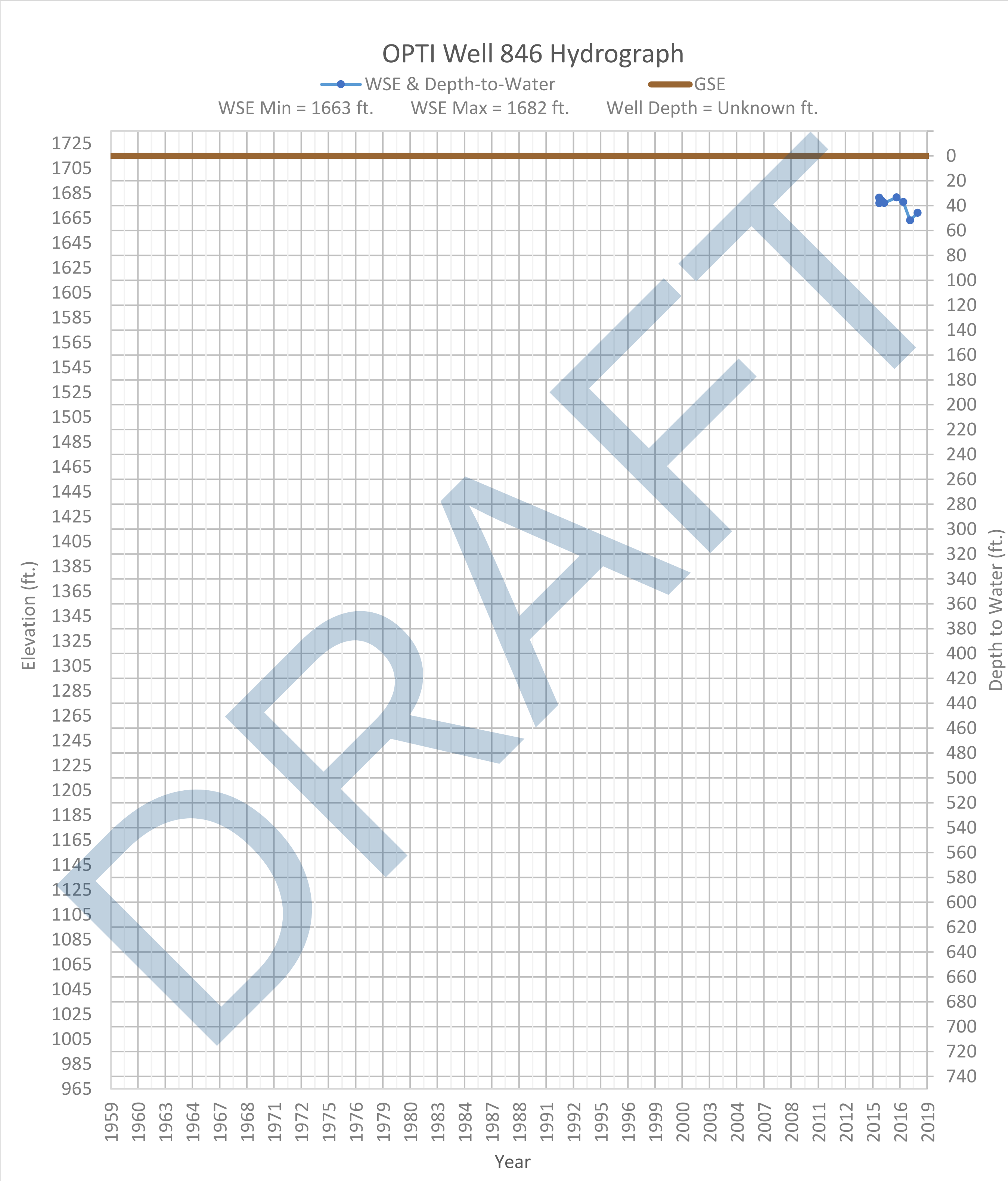
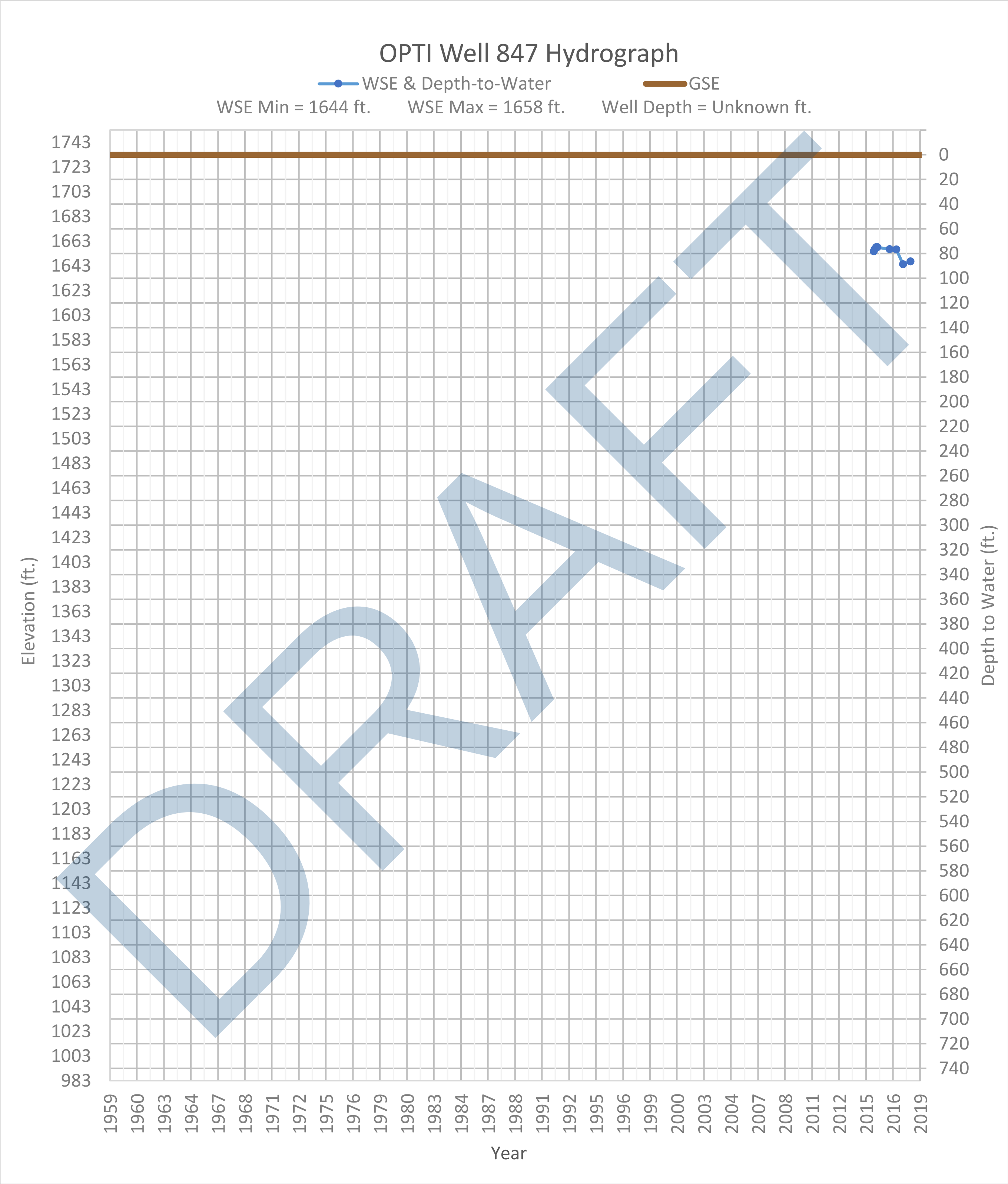
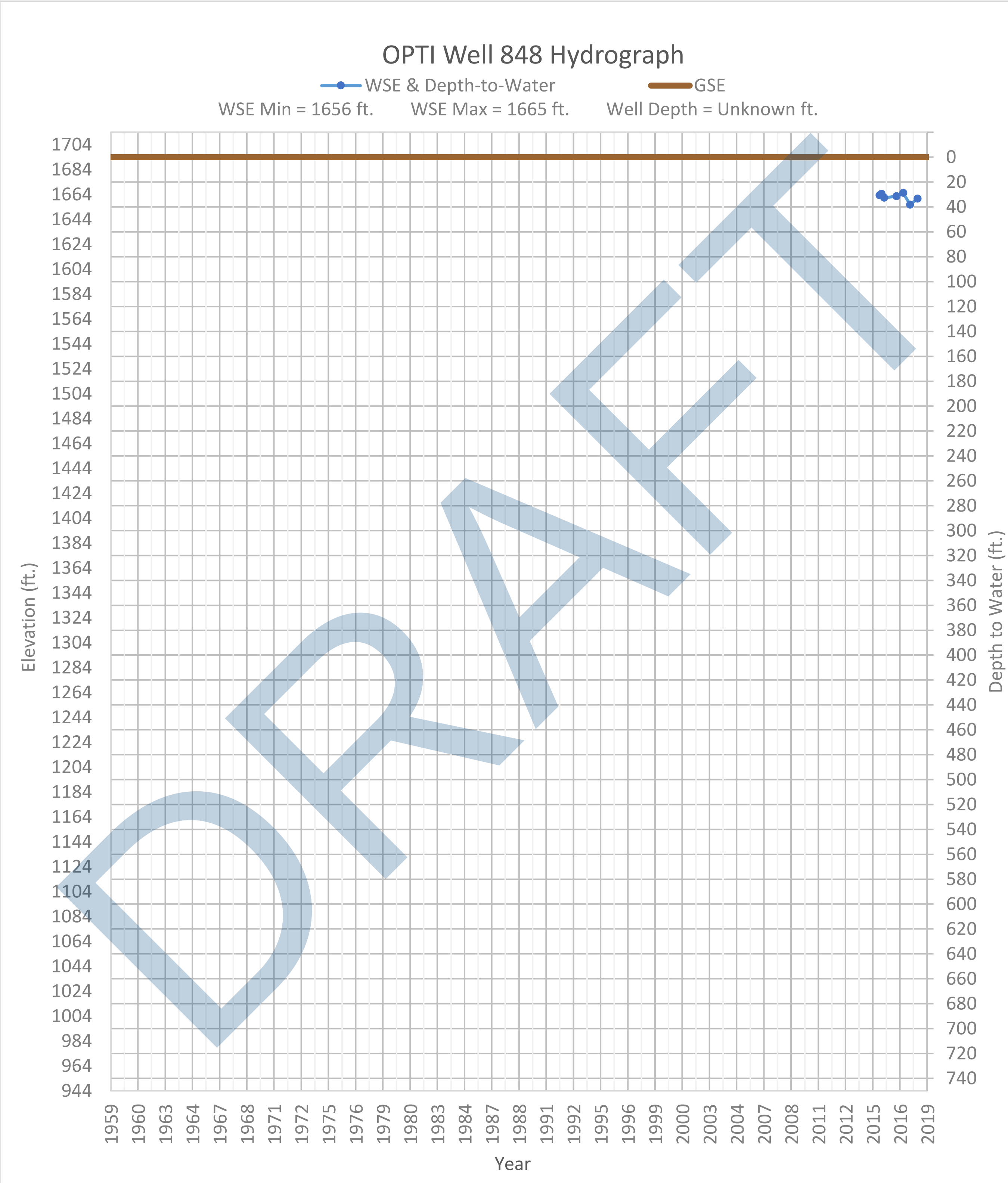
2016
2019
DRAFT


OPTI Well 845 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1658 ft.
WSE Max = 1666 ft.
Well Depth = Unknown ft.
Elevation (ft.)
1722 1702 1682 1662 1642 1622 1602 1582 1562 1542 1522 1502 1482 1462 1442 1422 1402 1382 1362 1342 1322 1302 1282 1262 1242 1222 1202 1182 1162 1142 1122 1102 1082 1062 1042 1022 1002 982 962
Depth to Water (ft.)
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720 740
Year
1959 1960 1963 1964 1967 1968 1971 1972 1975 1976 1979 1980 1983 1984 1987 1988 1991 1992 1995 1996 1999 2000 2003 2004 2007 2008 2011 2012 2015 2016 2019
DRAFT

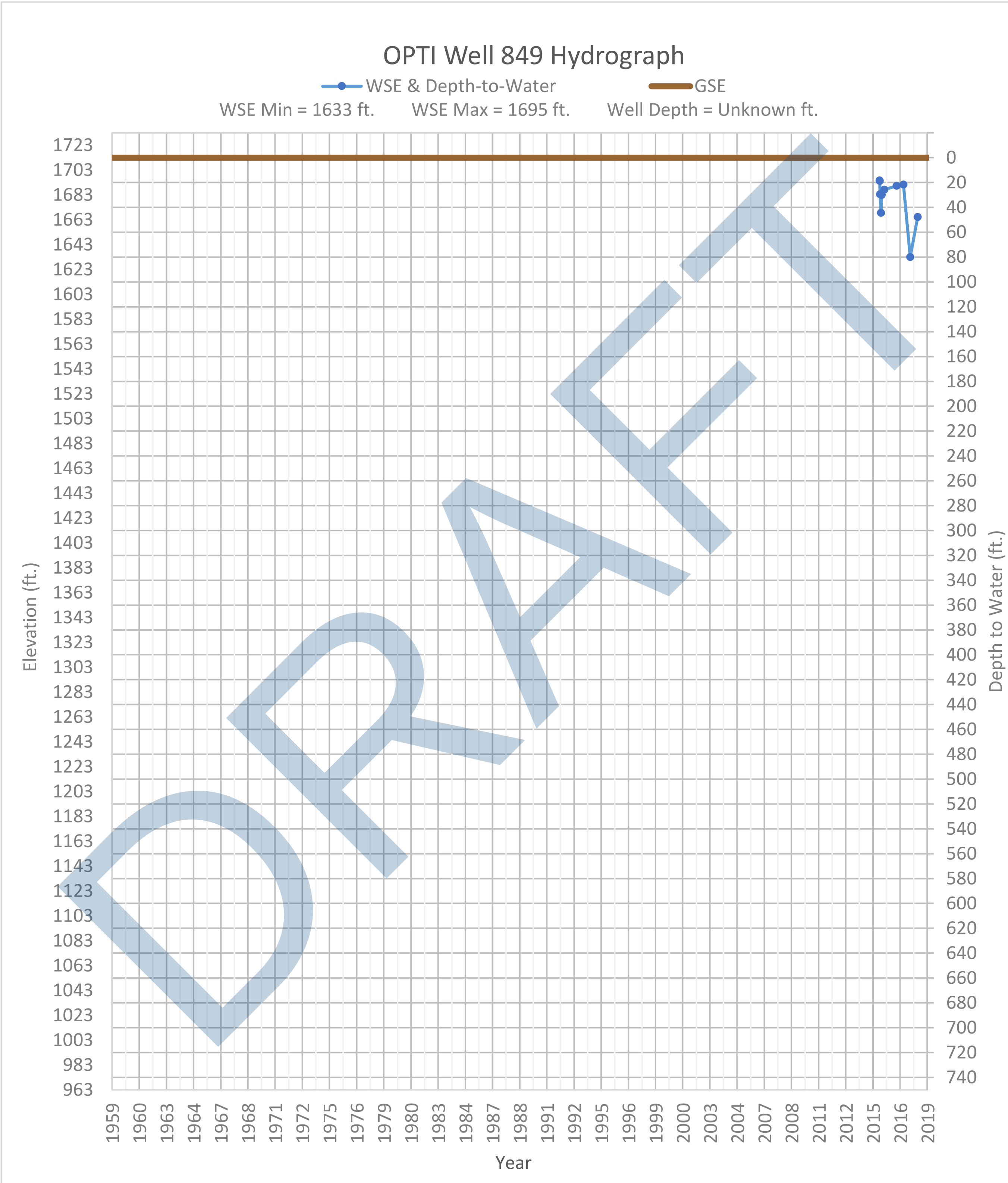


OPTI Well 846 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1663 ft.
WSE Max = 1682 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

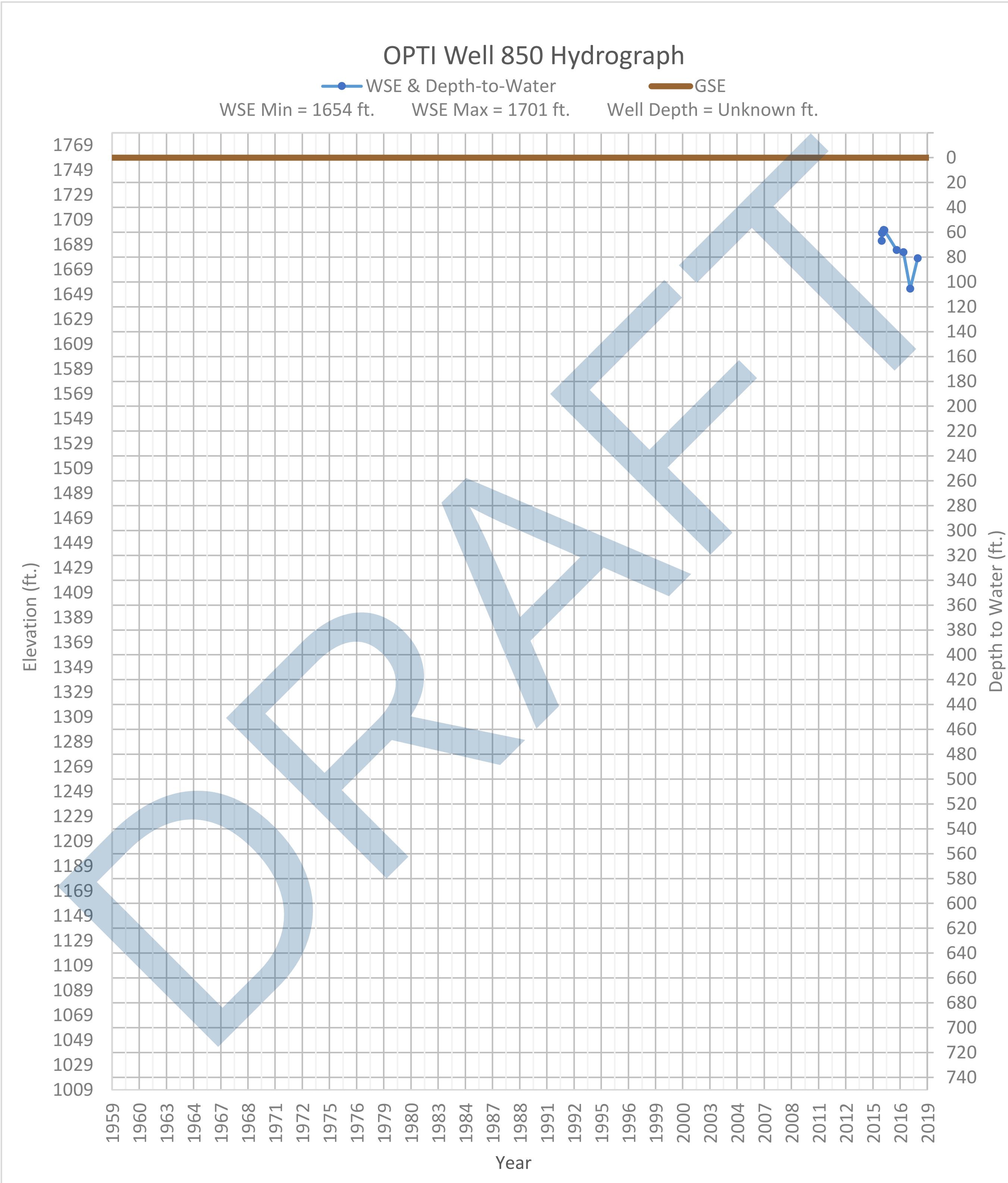

OPTI Well 847 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1644 ft.
WSE Max = 1658 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 848 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1656 ft.
WSE Max = 1665 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 849 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1633 ft.
WSE Max = 1695 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 850 Hydrograph
WSE & Depth-to-Water
GSE
WSE Min = 1654 ft.
WSE Max = 1701 ft.
Well Depth = Unknown ft.
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

Appendix B

White Paper: Subsidence and Subsidence Monitoring Techniques

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Subsidence White Paper

Author: C. Micah Eggleton - *Environmental Planner* at Woodard & Curran, September 19, 2017.
meggleton@woodardcurran.com

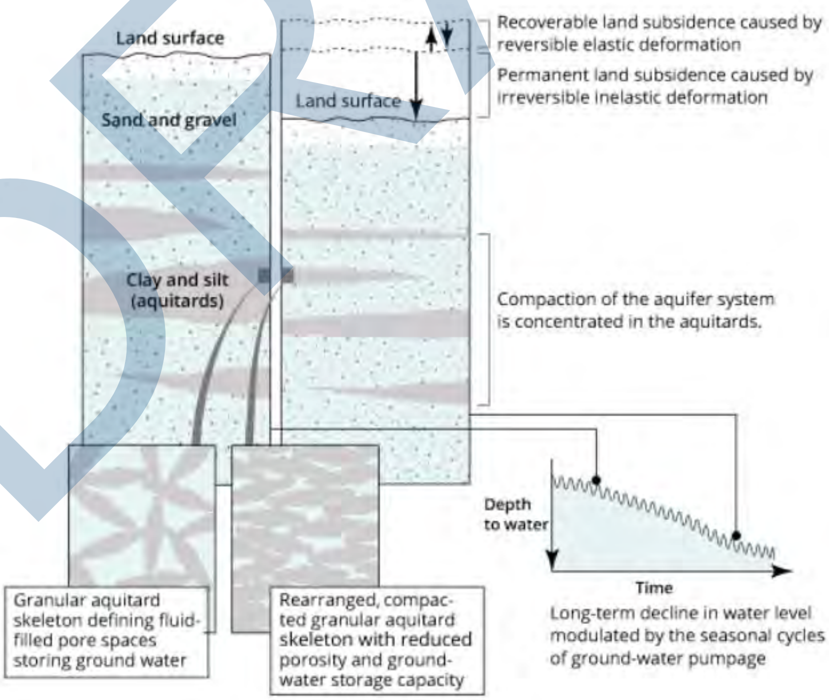
What is Subsidence?

Land subsidence is the sinking or downward settling of the earth's surface, not restricted in rate, magnitude, or area involved. Subsidence is often a result of over-extraction of subsurface water. In these cases, subsidence generally occurs over a large to very large area (10's to 100's of km^2) and may happen over several years.

How Subsidence Occurs

Groundwater saturates the sediments in the subsurface where groundwater is present. Sediments in water bearing units are commonly made up of sands, gravels, silts, and clays. Aquitards are composed of clay materials, and may have multiple thin layers or larger extensive, and/or thicker layers. Groundwater in these materials fills the pore spaces and supports the material's structure. As groundwater levels decline, the sands, gravels, silts, and clays in water bearing units are dewatered, and the water's support of the structure of the materials is removed. Clays in particular rearrange when dewatered and clay grains orient in a similar direction, which reduces the amount of pore space and thus, the clay compacts. As the clays compact, ground surface elevation begins to drop.

Figure 1: Subsidence and Compaction Process



Source: USGS, Ladn Subsidence: Cause and Effect. 9/17/2017. https://ca.water.usgs.gov/land_subsidence/california-subsidence-cause-effect.html#pumping

This is problematic all over the world but is of particular concern in California agricultural communities such as the Cuyama Basin. Cuyama Basin subsidence may have effects on agriculture in a few ways.

1. Water delivery systems that may deliver irrigation water can be affected by land subsidence. Surface canals or gravity lines may not have enough elevation gradient to transport water or may even have reverse flows due to changes in ground surface elevation.
2. Infrastructure such as buildings and roads may be de-leveled and need repair

Figure 2: Subsidence Visualized

Source: USGS, https://ca.water.usgs.gov/land_subsidence/

Not all groundwater pumping results in permanent subsidence. Groundwater reservoirs have an *elastic* and *inelastic* range of stress. Within the elastic range of stress, water levels in a groundwater storage unit can fluctuate without damaging the storage unit's ability to recharge to its original capacity. If water levels in a storage system dip into the inelastic range, the clays compact and cause inelastic land subsidence.

Clays and silts, such as those present in the Younger Alluvium, Older Alluvium, and Upper Morales Formations, generally have lower elastic capabilities, meaning they are not able to recover to their original volume once water has been removed. Once clays and silts are heavily compacted, they often cannot return to their previous saturation capacity even if groundwater levels are increased; this permanently reduces the storage capacity of the aquifer. This loss of aquifer is limited to the water that was stored in the compressed clays, and storage capacity lost is limited to the water that was stored in clays that were compressed, which is reflected in the amount of subsidence measured. Water stored in clay materials is generally not available for use by wells.

Methods of Measuring Land Subsidence

Measurements of elevations, aquifer-system compaction, and water levels are used to improve our understanding of the processes responsible for land-surface elevation changes. Elevation or elevation-change measurements are fundamental to monitoring land subsidence and have been measured by using interferometric synthetic aperture radar (InSAR), continuous GPS (CGPS) measurements, extensometers, and spirit-leveling surveying.

<u>Interferometric Synthetic Aperture Radar (InSAR)</u>

InSAR is a method and product of remote sensing imagery that measure changes in land-surface altitude by sending radar signals (historically C-band but new equipment often uses L- or X-band) to the land surface and measuring the return time of that signal. Changes in land surface elevation are calculated by taking the difference between two SAR images of the same area taken at different times. The difference between the two shows the ground-surface displacement (range change) between the two time periods.

The spatial resolution of InSAR is dependent on the location and resolution of the remote imagery, and whether it is taken from a plane or by orbiting satellite. At its finest resolution, InSAR has a sampling pixel of approximately 25' by 25' from satellites. The resolution of vertical displacement is dependent upon meteorological, observational, and other conditions, but is typically within a few centimeters to millimeters.

Raw InSAR data requires specialized computer programs to process and view. Some agencies and organizations, such as the California Water Science Center, provide InSAR imagery online. Direct data downloads are possible, but require registration approved with UNAVCO as an affiliate with an institution engaged in SAR research to download data. Data is available for anyone to browse online, and there are several agencies/institutes that publish data for specific regions.

Currently, InSAR imagery is obtained via specialized radar equipment on an aircraft and managed by NASA's Jet Propulsion Laboratory (JPL). In December 2021, the satellite NISAR is scheduled to launch; NISAR will provide coverage every 12 days and all NASA data will be free.

Continuous Global Positing System (CGPS)

CGPS stations continuously measure the three-dimensional position of a sensor. There are more than 1,000 sensors in Western North America, with hundreds in California. Most sensors are managed by the Plate Boundary Observatory/UNAVCO and by Scripps Orbit and Permanent Arrary Center (SOPAC), but other groups such as Caltrans also operate sensors. These monitoring stations help measure tectonic movements as well as subsidence, which means data is taken in the X, Y, and Z axis.

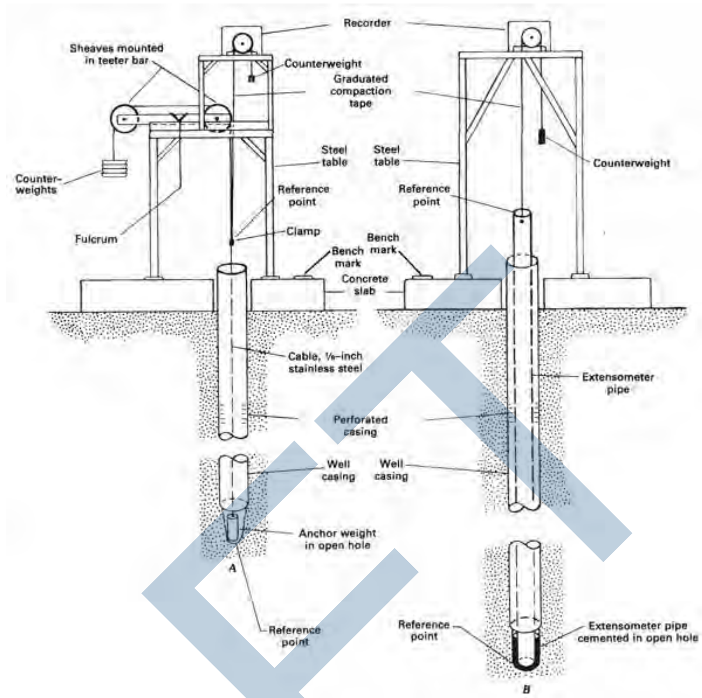
Measurements are typically taken every 15 seconds and are processed to produce a daily position. The CGPS system has data/information published online, however, some use is limited and registration is required for certain data access.

Currently, subsidence measurements in and immediately around the Cuyama Basin are taken through CGPS instrumentation.

Spirit Leveling

This is the oldest method of measuring subsidence and was used long before electronic aids such as GPS. The primary tool is a Spirit Level in combination with a telescope and graduated vertical rods. Measurements are based on one reference point. This technique is best used for smaller survey areas (5 miles or less) and areas where high spatial density is desired. This is a good option for localized surveying and where cost is a priority.

<u>Extensometers</u>



Extensometers are *one dimensional* indicators of change in a specified depth. In regards to land subsidence, they often measure the change in an aquifer system within a specific depth range – that is to say, if the extensometer extends 20 meters into the ground, it can only measure the change in compaction (or expansion) within those 20m. It is also important to understand that extensometers measure compaction/expansion, *not* elevation.

Between the 1950s and 1970s, more than two dozen extensometers were installed in California's Central Valley by the USGS, with additional units installed since then.

Most extensometers are constructed as cable or pipe borehole extensometers (see the figure to the right above). They function by having a cable or pipe extend to the bottom of a drilled hole to the measuring depth at a specific reference point. At the top of this cable or pipe is a reference point, and attached to the reference point is another cable that extends to the top of a platform near the ground surface, around a wheel, and to a counter weight which maintains tension on all cables. As the ground elevation and bottom reference point change in relation to one another, the wheel turns as the counter weight either drops or rises. This change in the position of the counter weight is equal to the amount of compaction between the two reference points.

Although simple in theory, extensometers can be costly to install due to the drilling that is required and robust equipment needed. In addition, multiple extensometers are often needed to measure compaction across a range of depths and to determine which portion of the subsurface is compacting.

<u>Piezometers</u>

Piezometers measure the hydraulic pressure in a groundwater system. Piezometers are paired with extensometers or CGPS data to analyze stress-strain characteristics of a groundwater system. These systems allow for the calculation of the *skeletal storage coefficient*, which is the standard measure of an aquifer's storage directly related to the compressibility of the soil/storage system. This is what largely controls how "recoverable" an aquifer system is when it is recharged with water.

If water levels continue to decline into the inelastic range of stress, it can become possible to compute the *inelastic storage coefficient* that governs the permanent compaction of the aquifer system. If water levels fluctuate into both of these ranges seasonally or annually, it may be possible to calculate both.

Appendix C

Cuyama Basin Integrated Water Flow Model

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Tables

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Attachments

Appendix C — Cuyama Basin Water Resources Model Documentation

Introduction

Goals of Model Development

The Cuyama Basin Water Resources Model (CBWRM) was developed to evaluate the recent historical, current, and projected surface water and groundwater conditions in the Cuyama Groundwater Basin (Basin), and simulate various scenarios as part of the Basin's *Groundwater Sustainability Plan* (GSP). The fine temporal and spatial scale of the CBRWM allows the Cuyama Basin Groundwater Sustainability Agency (CBGSA) and its stakeholders to evaluate the effect of changing groundwater conditions in different parts of the Basin.

The CBWRM was developed in consultation with members of the Technical Forum, which includes technical staff and consultants representing a range of public and private entities in the Basin. Technical Forum members are listed in Chapter 1, Section 1.3. The Technical Forum held 14 monthly conference calls over the course of CBWRM development, and model data and outputs were provided to Technical Forum members to facilitate review and feedback on model development. This allowed Technical Forum members to review and comment on all major aspects of CBWRM development.

Basin Overview

The Basin encompasses an area of approximately 378 square miles, and includes the communities of New Cuyama and Cuyama, which are located along State Route (SR) 166 and Ventucopa, which is located along SR 33. Figure C-1 shows the Cuyama Basin and its key geographic features. The Basin encompasses an approximately 55-mile stretch of the Cuyama River, which runs through the Basin for much of its extent before leaving the Basin to the northwest and flowing toward the Pacific Ocean. The Basin also encompasses reaches of Wells Creek in its north-central area, Santa Barbara Creek in the south-central area, and the Quatal Canyon drainage and Cuyama Creek in the southern area of the Basin. Primary land use and development in the Basin is agricultural use, which mostly occurs in the central portion east of New Cuyama, and along the Cuyama River near SR 33 through Ventucopa. Additionally, there has recently been new agricultural development in the western part of the Basin.

CBRWM Platform

The CBWRM was developed based on the Integrated Water Flow Model (IWFM) software platform. The IWFM is an open-source, finite element simulation code that supports triangular and quadrilateral elements (Dogrul et al., 2017b). IWFM was specifically designated in the Sustainable Groundwater Management Act (SGMA) regulations as a model supported by the California Department of Water Resources (DWR) for evaluation of the integrated surface water and groundwater resources a basin, including detailed water budget development that meets SGMA requirements. IWFM has been used throughout California for planning and management of water resources, including GSP development. IWFM is also used for DWR's California Central Valley Groundwater-Surface Water Simulation Model

(C2VSim), which is the fine-grid version that is being refined and enhanced by DWR to support SGMA activities throughout the Central Valley at the regional scale (DWR, 2018).

The IWFM Demand Calculator (IDC) is the stand-alone root zone component of IWFM that simulates land surface and root zone flow processes (Dogrul et al., 2017b). It calculates agricultural and urban water demands using inputs including climatic conditions, soil hydrologic conditions, and land use types and cropping patterns. The IDC can be used as a stand-alone model, or it can be combined with IWFM. When combined, the full IWFM model simulates the integrated system of land surface processes and groundwater system and the stream system, as well as interaction among these systems.

CBWRM Development

Model Input Data

The CBWRM historical model simulates Basin hydrologic conditions on a daily time step from water year 1995 through water year 2017 (i.e., October 1, 1994 through September 30, 2017). Table C-1 lists CBWRM files and corresponding major data sources.

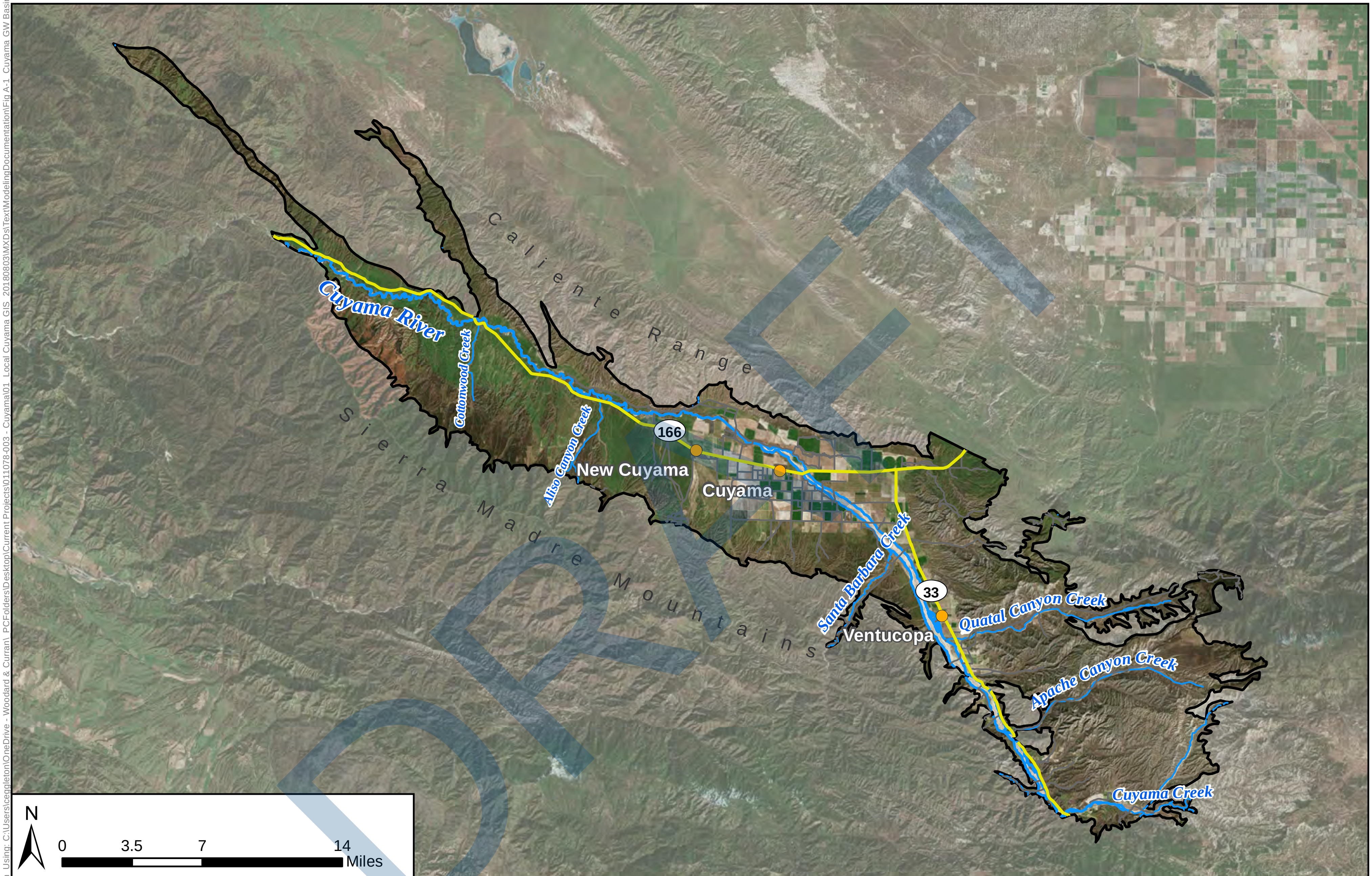

Figure C-1 - Cuyama Valley Groundwater Basin

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Towns
- Cuyama Basin
- Highways
- Local Roads
- Cuyama River
- Streams/Creeks

Figure Exported: 4/15/2019 By: ceggleton Using: C:\Users\ceggleton\OneDrive - Woodard & Curran\PCFolders\Desktop\Current Projects\011078-003 - Cuyama\01_Local Cuyama GIS_20180803\MXDs\Text\ModelingDocumentation\Fig A-1_Cuyama GW Basin_V1.m

Table C-1: CBWRM Major Model Data

Major Data Category	Minor Data Category	Data Source
Hydrogeological Data	Geologic Stratification	Diblee Maps and Cuyama Valley Hydrologic Model (CUVHM)
Stream Data	Stream Configuration	National Hydrography Dataset (NHD)
	Streamflow Records	United States Geological Survey (USGS) and California Data Exchange Center (CDEC) Stream Gages
Hydrological Data	Precipitation	Parameter-Elevation Relationships on Independent Slopes Model (PRISM)
Agricultural Water Demand	Land Use and Cropping Patterns	• DWR • Private Landowners • CBGSA-developed data
	Evapotranspiration	California Irrigation Management Information System (CIMIS)
	Soil Properties	Natural Resources Conservation Service (NRCS) Soil Survey Geographic Database (SSURGO)
Urban Water Demand	Population	United States Census Bureau
	Per Capita Water Use	Cuyama Community Services District (CCSD) Local Information
Water Supply	Groundwater Pumping	CCSD
Other	Initial GW Level Conditions	• DWR Water Data Library • Private landowners
	Small Watersheds	NHD
	GW Level Records for Calibration Wells	• DWR Water Data Library • Private landowners

Analysts developed the 50-year hydrologic period of water years 1968 through 2017 for use in CBWRM to meet SGMA requirements for long-term water budget representation for current and projected Basin conditions.

CBWRM Grid

Analysts developed the finite element grid using the Groundwater Modeling System (GMS) software' the grid development module. The model grid network is composed of a combination of quadrilateral and triangular elements, which allows a detailed representation of various hydrologic, geologic, and jurisdictional features required for development of information about land and water use, water supply, groundwater conditions, and water budget. The CBWRM grid and the specific features used in grid development are shown in Figure C-2. These features include the following:

- The Basin boundary as defined in DWR's Bulletin 118 (DWR, 2004)
- Hydrologic and hydrogeologic features (i.e., Cuyama River and minor streams, faults, and outcroppings)
- The Cuyama Community Services District (CCSD) boundary
- Cuyama Water District boundary

The CBWRM grid contains 6,582 elements with an average element area of 36.8 acres. Primary objectives during grid development were to maintain a manageable number of elements and nodes for model computational performance, to optimize resolution for data analysis, and to contain relatively finer resolution along rivers, which allows for better simulation of stream-aquifer interaction to optimize the model run time and to streamline model output.

Stream Configuration and Watersheds

The CBWRM surface hydrology is represented by nine model stream reaches, representing the Cuyama River. The USGS has two active gages that record flows in the Cuyama River watershed upstream of Lake Twitchell. These include one gage on the Cuyama River downstream of the Basin (ID 11136800), which is located just upstream of Lake Twitchell. This gage has 58 recorded years of streamflow measurements from 1959 to 2017. The other active gage is south of the city of Ventucopa along Santa Barbara Canyon Creek (ID 11136600), and this partial record is limited to seven years (i.e., from 2010 to 2017).

The inflow from upper watershed areas originates from ungaged watersheds. Figure C-3 shows the upper watershed areas included in the model. Flows from ungaged watersheds surrounding the Basin are estimated using a simplified rainfall runoff module incorporated in the small watersheds module of the CBWRM. This module simulates the surface water and groundwater contributions from the small watersheds using daily precipitation rates and runoff and infiltration characteristics assigned to each ungaged watershed. The portion of flow from the small watershed that enters the model domain as surface runoff is directed to drain into simulated streams. The portion of flow from small watersheds that infiltrates to ground contributes to the main groundwater system as boundary flows.

All subsurface inflows from these small watersheds are routed to model Layer 1 along specified groundwater nodes, with a user-defined maximum percolation rate at each node. Excess flows that do not infiltrate to groundwater enter the simulated streams at user-specified locations. The hydrologic conditions of these small watersheds used to estimate the subsurface and surface flows are represented using parameters (e.g., precipitation, surface layer soil parameters, runoff coefficient) for each watershed.

Precipitation

Rainfall data for the CBWRM area are derived from the PRISM database (PRISM Climate Group, 2018). The database contains monthly precipitation data starting from 1895 and daily precipitation data from December 1, 1981 on a 4-kilometer grid throughout the model area. To develop data for the daily time step of the CBWRM, monthly precipitation data for the 1968 to 1981 time period was downscaled to daily temporal resolution with a similar water year type analysis using the recorded Cuyama River flows. Each of the model elements was mapped to the nearest PRISM reference node, which are uniformly distributed across the model domain. The resulting average annual precipitation is shown in Figure C-4.

Figure C-5 shows the Basin averaged annual rainfall in the model area and the cumulative departure from mean, which is an indication of long-term rainfall trends in the area. The average annual precipitation during the 50-year hydrologic sequence from October 1967 to September 2017 was 13.1 inches, which ranges from an annual average of 11.4 inches in the valley floor to 14.8 inches in the upper watershed areas.

Attachment 1 describes the climate change scenarios analyzed for projected future conditions, and the modifications made to the precipitation data to reflect the effects of climate change.

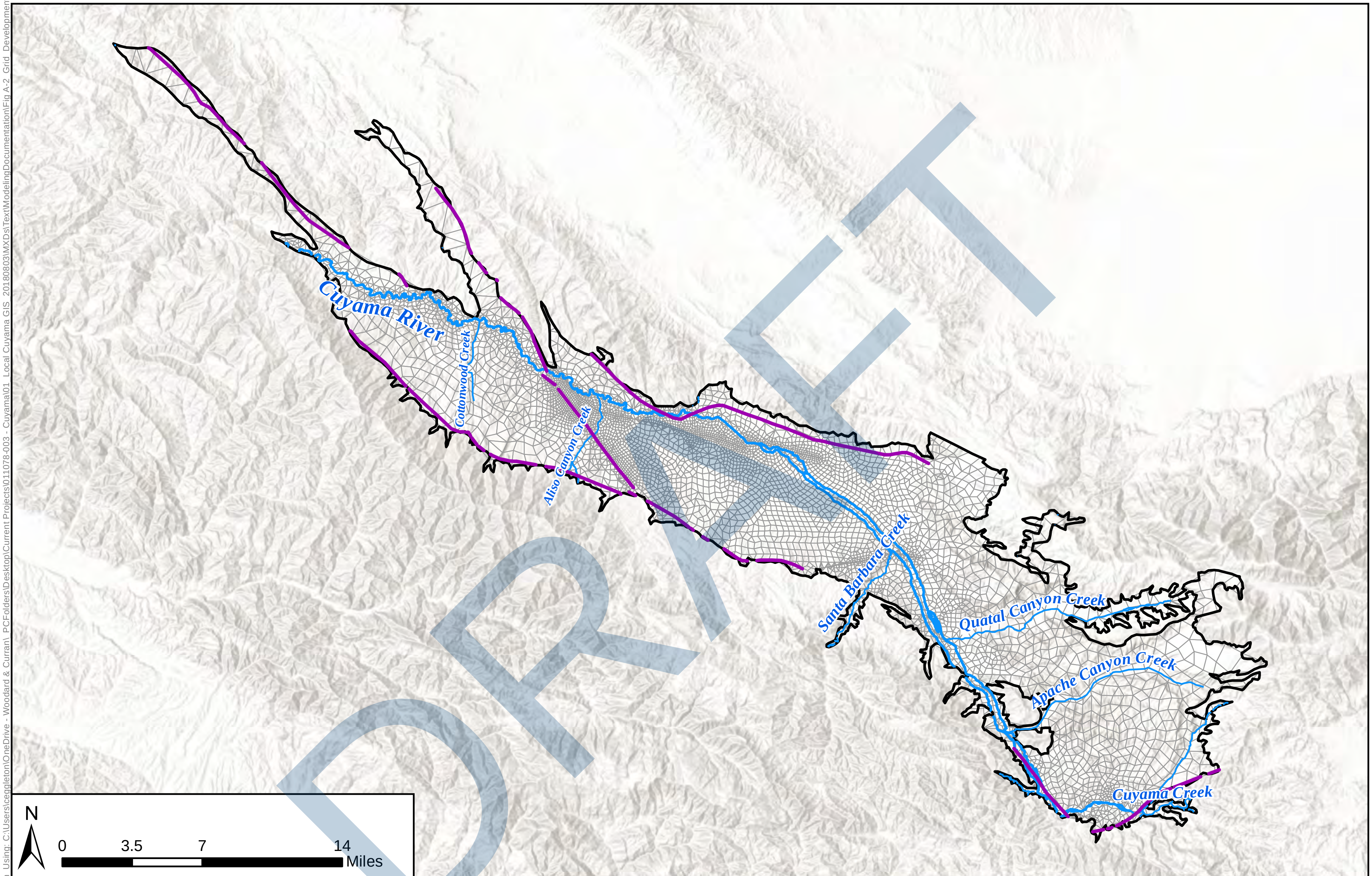

Figure C-2 - Cuyama Valley Groundwater Basin IWFM Grid Development Features

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- IWFM Grid Development Features
- Cuyama Faults
- Cuyama River
- Streams/Creeks

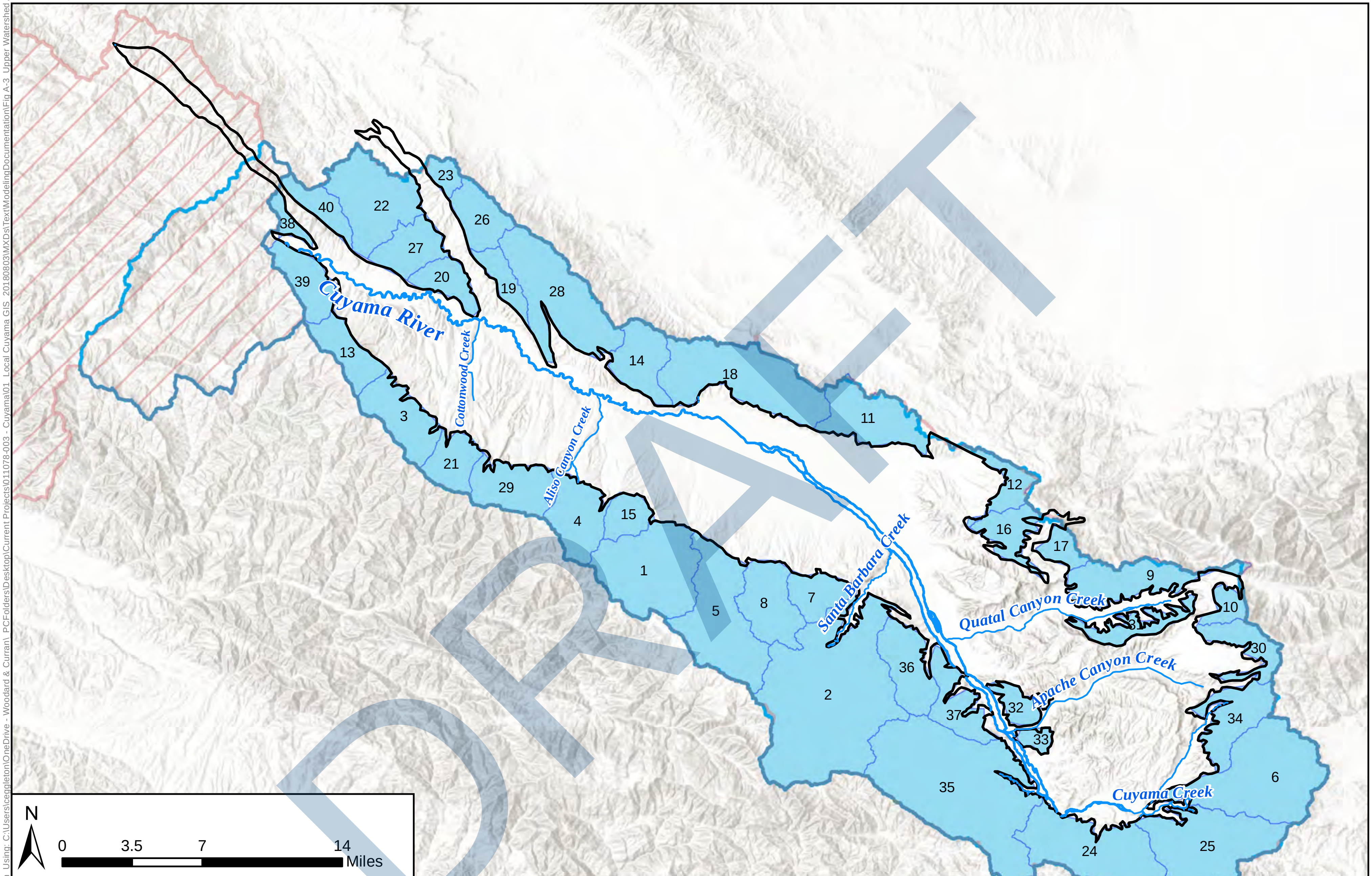

Figure C-3 - Cuyama Valley Groundwater Basin Upper Watershed Areas in the IWFM Model

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- Cuyama River
- Streams/Creeks
- Contributes to Cuyama GW Basin
- Does Not Contribute to Cuyama GW Basin
- Watershed
- Small Watersheds (HUC 12)

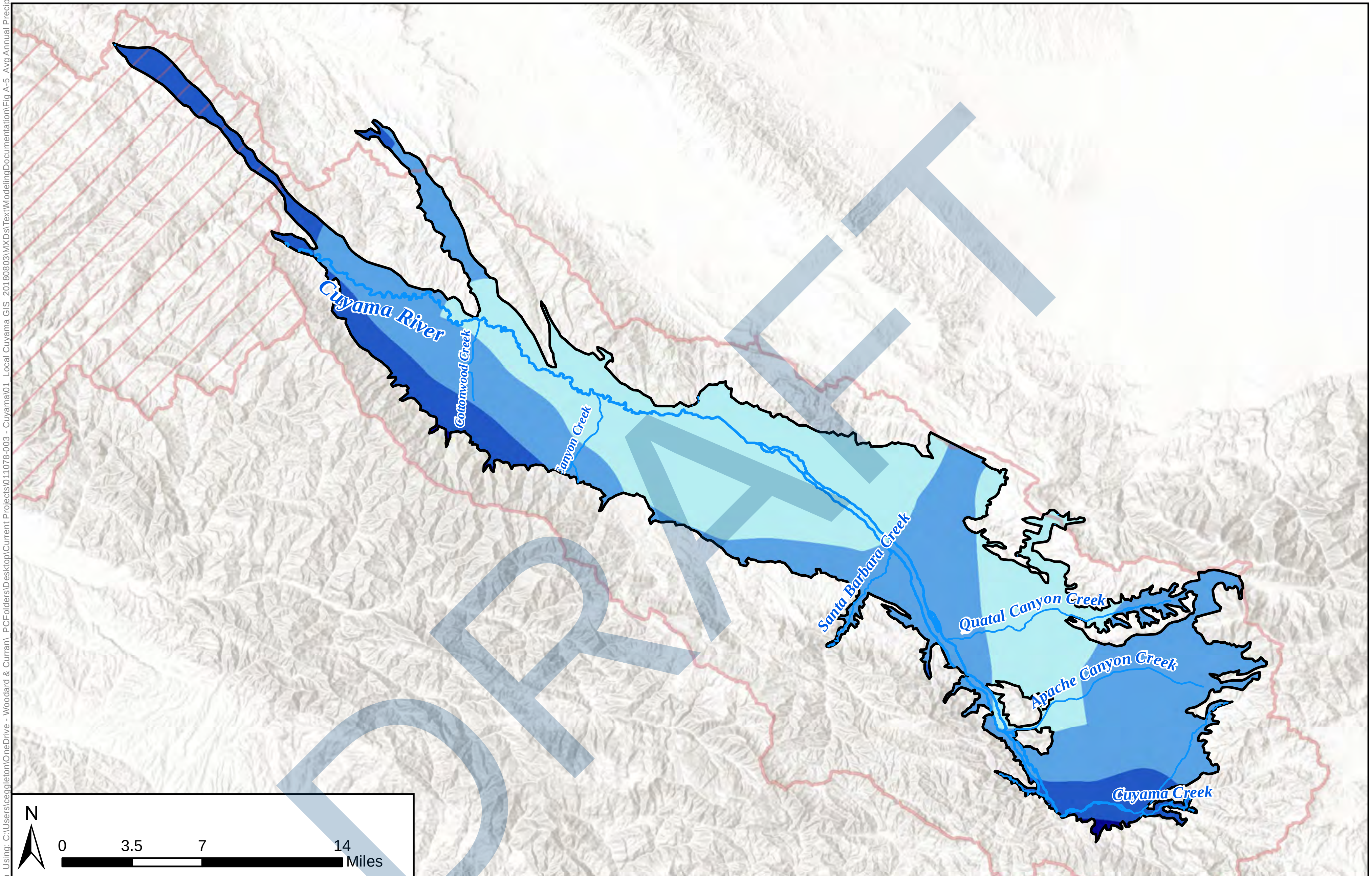

Figure C-4 - Cuyama Valley Groundwater Basin Average Annual Precipitation

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- Cuyama River
- Streams/Creeks
- Contributes to Cuyama GW Basin
- Does Not Contribute to Cuyama GW Basin

Average Annual Precipitation (.in)

- 5.1 - 10
- 11 - 15
- 16 - 20
- 21 - 25

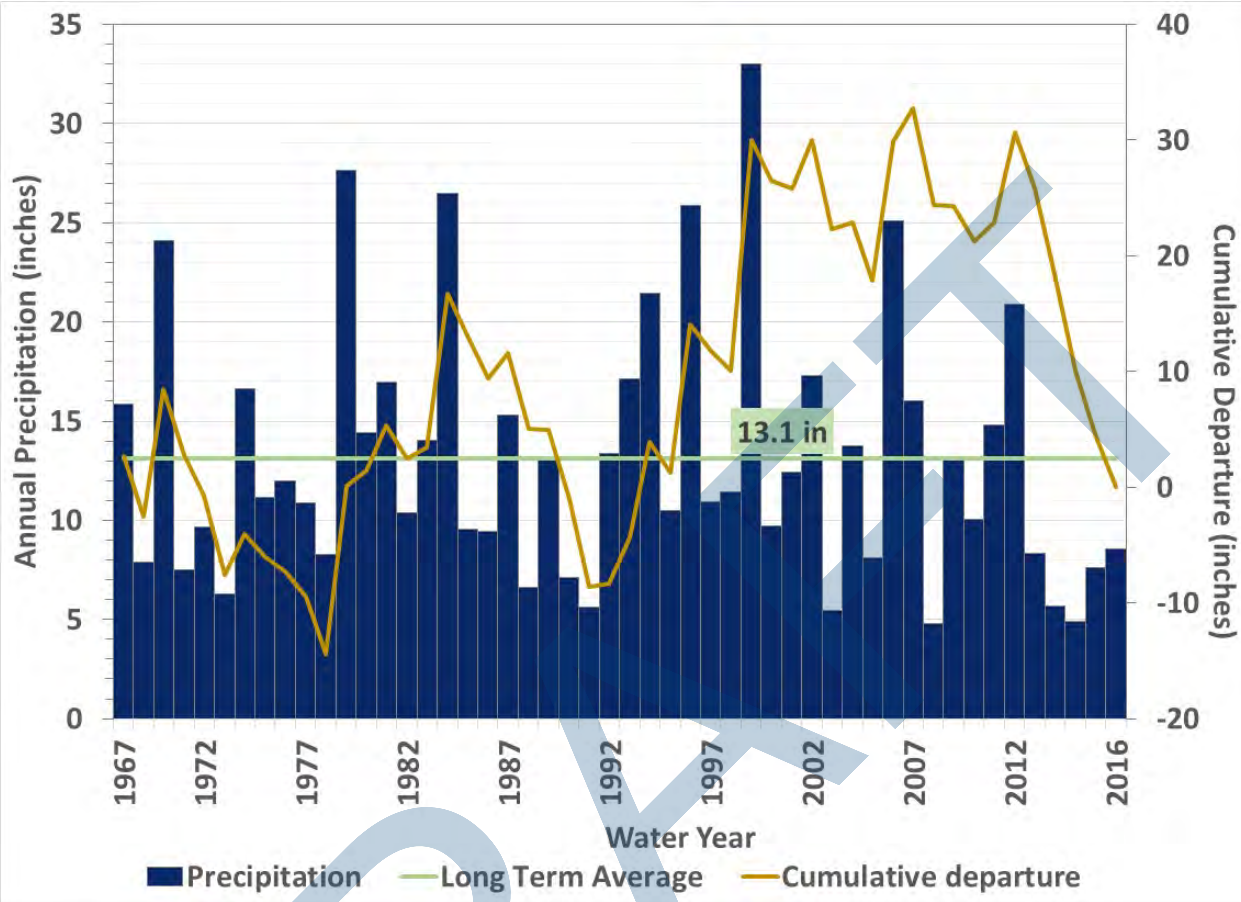

Figure C-5: 50-Year Historical Precipitation and Cumulative Departure from Mean Precipitation

Root Zone Soil Parameters

Soil properties specified in the CBWRM are field capacity, wilting point, total porosity, saturated hydraulic conductivity, and pore size distribution index. These soil properties are specified for each model element, and were used to calculate runoff and infiltration from both rainfall and applied water at each model time step.

DWR's IWFM Soil Data Builder (DWR, 2017) was used in conjunction with the SSURGO (USDA, 2017a) soil data to determine the five soil parameters for each model element. The IWFM Soil Data Builder extracts the SSURGO data relevant to the model area and associates it with each model grid element. For the elements where SSURGO data was incomplete, analysts used the USDA's Digital General Soil Map of the United States (STATSGO2) data (USDA, 2017b) to complement SSURGO parameters.

CBRWM elements are associated with the four hydrologic soil groups according to their runoff potential and infiltration characteristics. NRCS defines these hydrological soil groups as follows (NRCS, 2009):

- **Group A** – Soils in this group have low runoff potential when thoroughly wet. Water is transmitted freely through the soil. Group A soils typically have less than 10 percent clay and more than 90 percent sand or gravel and have gravel or sand textures. Some soils having loamy sand, sandy loam, loam or silt loam textures may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.
- **Group B** – Soils in this group have moderately low runoff potential when thoroughly wet. Water transmission through the soil is unimpeded. Group B soils typically have between 10 and 20 percent clay and 50 to 90 percent sand and have loamy sand or sandy loam textures. Some soils having loam, silt loam, silt, or sandy clay loam textures may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.
- **Group C** – Soils in this group have moderately high runoff potential when thoroughly wet. Water transmission through the soil is somewhat restricted. Group C soils typically have between 20 and 40 percent clay and less than 50 percent sand and have loam, silt loam, sandy clay loam, clay loam, and silty clay loam textures. Some soils having clay, silty clay, or sandy clay textures may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.
- **Group D** – Soils in this group have high runoff potential when thoroughly wet. Water movement through the soil is restricted or very restricted. Group D soils typically have greater than 40 percent clay, less than 50 percent sand, and have clayey textures. In some areas, they also have high shrink-swell potential.

Land Use and Cropping Patterns

Land use and cropping patterns are key data sets that support estimation of monthly agricultural water requirements over the period of model simulation. Consistent with the DWR's C2VSim, the CBWRM includes 23 irrigated crop categories and four general land use categories. The general land use categories include urban landscape (e.g., residential areas, school fields, roads, etc.), water surface (e.g., streams, lakes, and reservoirs), riparian vegetation (e.g., native vegetation in the vicinity of surface water), and native vegetation. The 23 irrigated crop categories are combined into six summary-level crop group with similar water use and/or irrigation practices, which also provides a simpler representation of crop group types for planning and policy purposes. Table C-2 lists the land use categories.

Table C-2: Land Use Categories

Land Use Type	Model Category	Grouped Categories
Irrigated Crops	• Apple • Berry • Citrus • Olive • Pistachio • Misc. Deciduous • Misc. Subtropical Fruits	Fruit and Nut Trees
	Vineyards	Vineyards
	• Alfalfa • Mixed Pasture	Alfalfa and Irrigated Pasture
	• Misc. Grain • Misc. Grass • Wheat	Grain
	• Dry Beans • Corn • Misc. Field Crops • Safflowers	Field Crops
	• Carrot • Cole • Mixed Greens • Lettuce • Melons • Onion • Potatoes • Misc. Truck Crops	Truck Crops
	Idle and Fallow Lands	Idle
Other Land Use	• Urban Landscape • Water Surface • Riparian Vegetation • Native Vegetation	

Spatial land use data were used to specify land use types and crop acreages for each model element for each year of simulation. The following data sources were used:

- 1996 data from historical DWR county land use surveys[1]
- 2014 and 2016 data that were developed for DWR using remote sensing data by LandIQ[2]
- 2000, 2003, 2006, 2009, 2012 data that were developed for the CBGSA using remote sensing data; development of these datasets is documented in Attachment 2.
- Data provided by private landowners for portions of the Basin between 1992 and 2017

Figure C-6 shows the spatial distribution of the major land use categories in the Basin for 2016.[3] Estimated land use in 2016 includes approximately 36,500 acres of irrigated land use. Figure C-7 shows the historical trend of land use categories in the Basin and the projected assumed annual land use pattern for the 50-year hydrologic period used for the projected condition model scenario. The projected annual land use categories are developed based on the 2017 crop categories as the basis, with annual variability developed based on an autoregressive moving average model that uses the historical land use data sets.

[1] https://www.water.ca.gov/Programs/Water-Use-And-Efficiency/Land-And-Water-Use/Land-Use-Surveys
[2] https://gis.water.ca.gov/app/CADWRLandUseViewer/
[3] Figures for other years can be found in Chapter 1

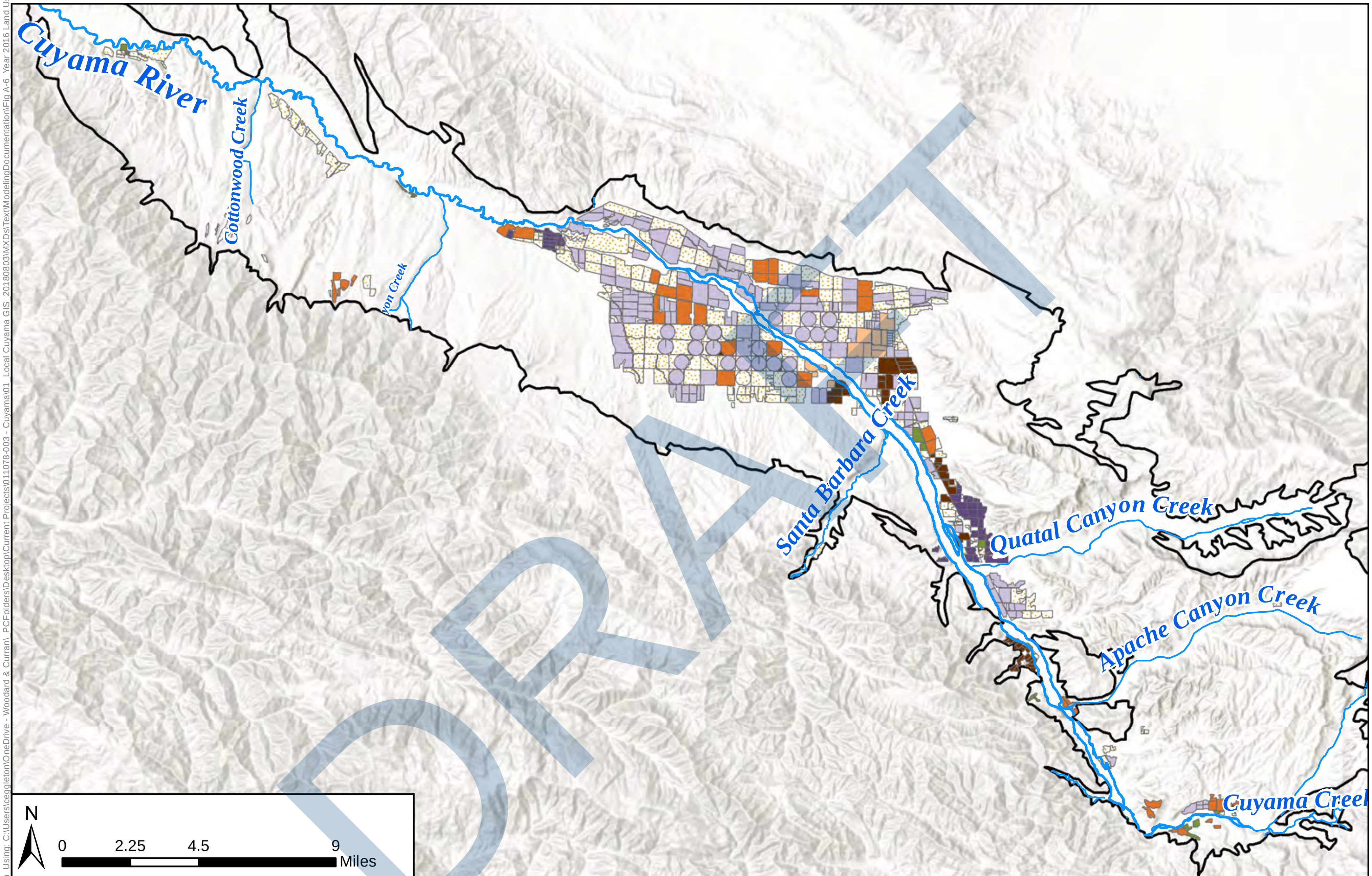

Figure C-6 - Cuyama Valley Groundwater Basin Year 2016 Land Use

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- Cuyama River
- Streams/Creeks

Land Use from 2016 Crop Mapping

- Alfalfa and Irrigated Pasture
- Fruit and Nut Trees
- Field Crops
- Truck Crops
- Vineyard
- Grain
- Idle

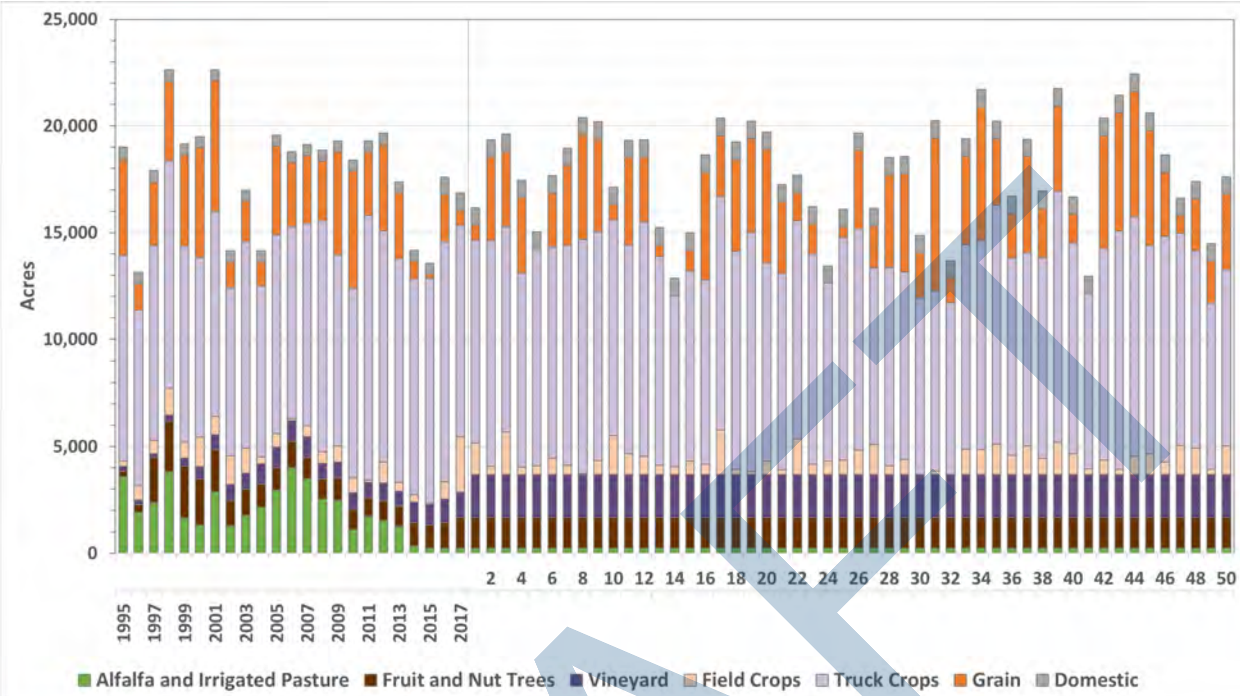


Figure C-7: Historical and Projected Land Use in the Basin

Evapotranspiration

The crop evapotranspiration (ET) requirement is an important factor in agricultural demand estimation. Every land use category must have evapotranspiration assigned for the simulation period. Due to changes in cropping patterns and irrigation practices over time during the historical calibration period, the ET data are specified as a time series during the entire calibration period. ET values are based on the reference evapotranspiration data from Cuyama CIMIS Station. The reference evapotranspiration was converted to crop evapotranspiration using crop coefficients, supplemented by information developed using the Mapping EvapoTranspiration at High Resolution with Internalized Calibration (METRIC) methodology (as described in Attachment 3). Crop coefficients for each land use category were developed using the Remote Sensing Root Zone (RSRZ) model. The RSRZ Model is driven by the Landsat Normalized Difference Vegetation Index (NDVI) data set, which was originally developed for the Kaweah Delta Water Conservation District in Tulare and Kings counties. The RSRZ model simulates the rootzone processes on a daily time step, and using remote sensing data, it can capture changes in the timing and intensity of cropping over time.

In the CBWRM, ET represents the net vertical water flux from the land surface and root zone through the upper model layer. Figure C-8 shows the range in annual evapotranspiration rates for each crop category. For climate change scenarios analyzed for projected future conditions, evapotranspiration rates were modified to reflect the effects of anticipated temperature change (Attachment 3).

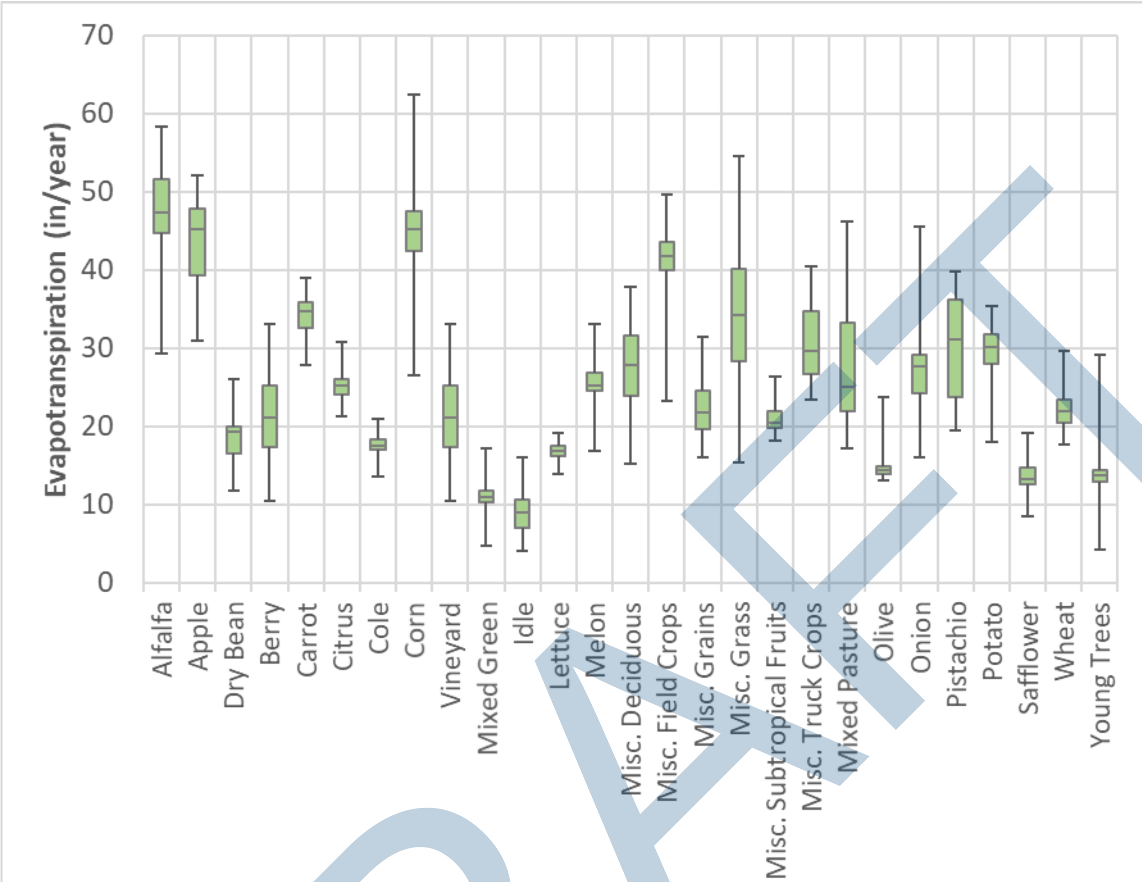


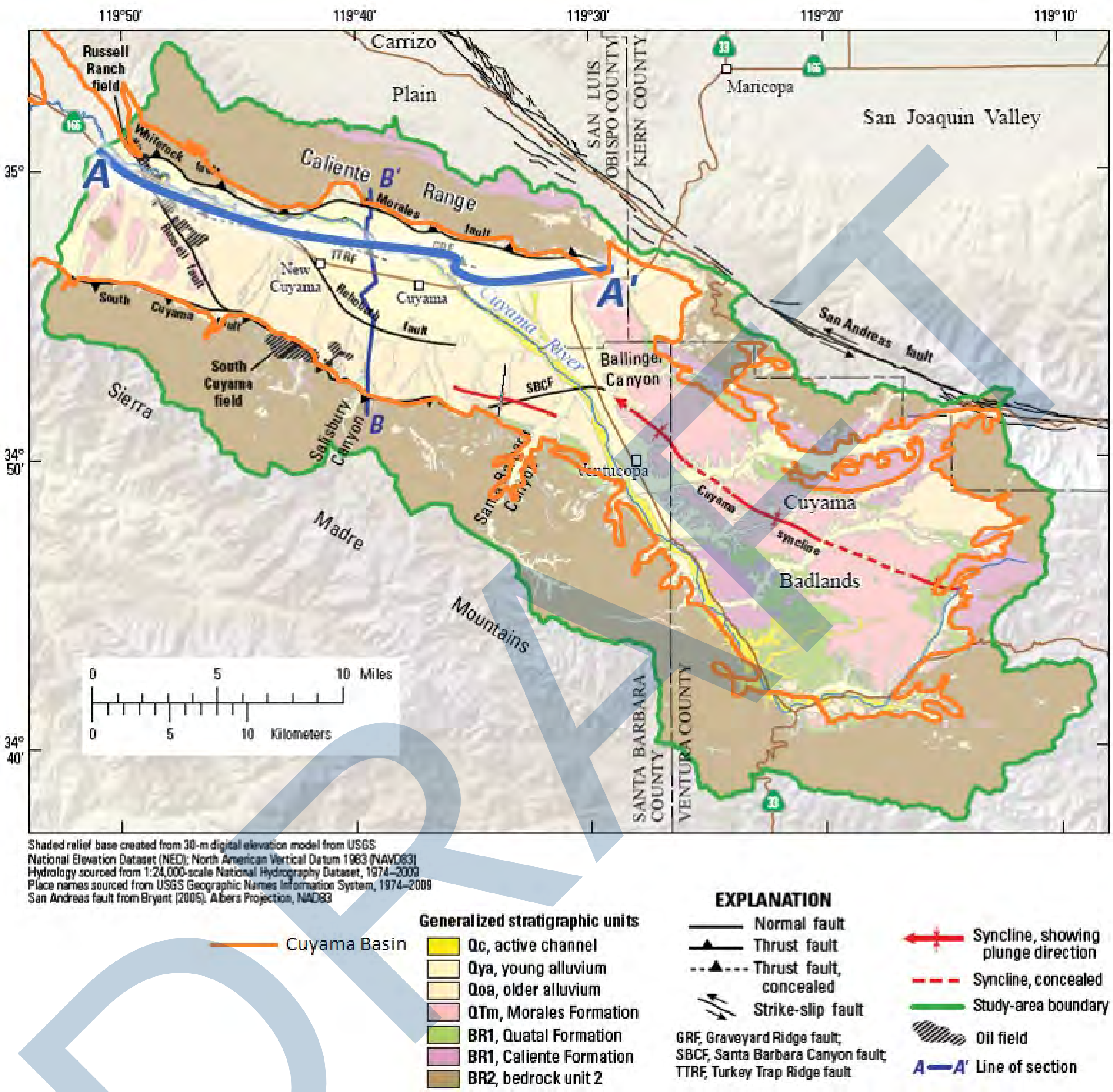
Figure C-8: Annual Evapotranspiration for Each Land Use Type

CBWRM Layering

The CBWRM subsurface zone is characterized by the following three model layers, representing geologic stratification from ground surface to bedrock (listed from top to bottom below) as follows:

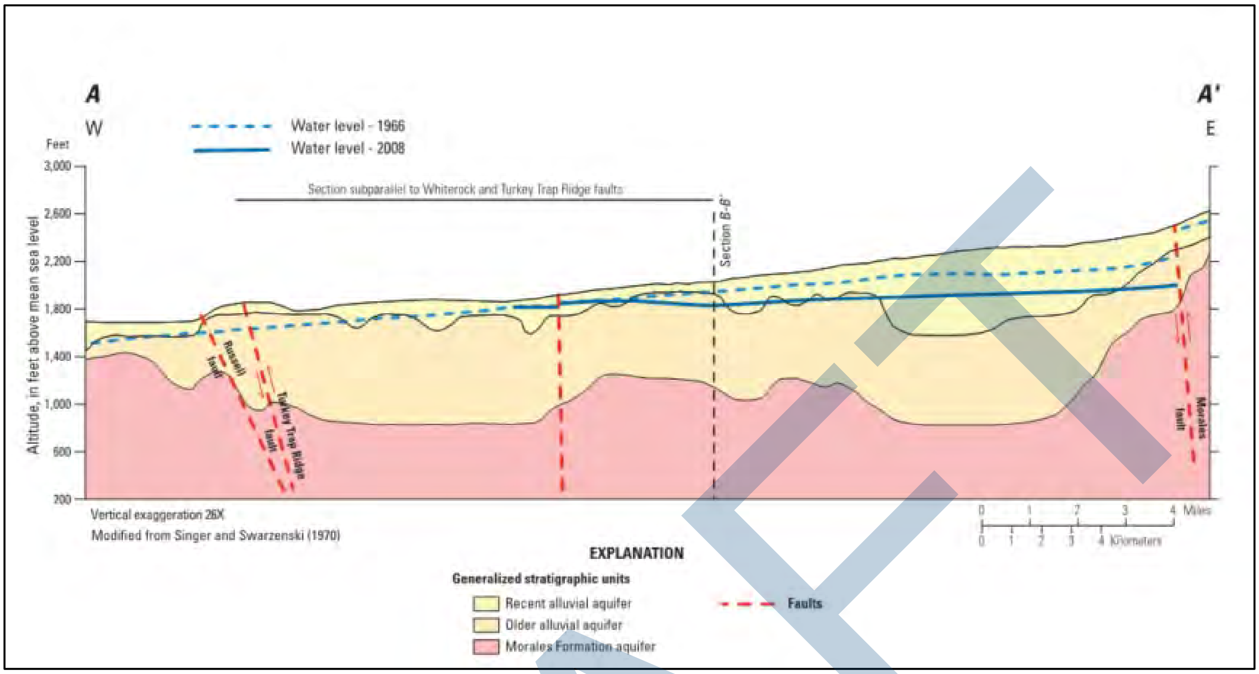
- Layer 1: Recent Alluvial aquifer
- Layer 2: Older Alluvial aquifer
- Layer 3: Morales Formation aquifer

These layers are primarily based on geologic stratification as defined by the USGS (USGS, 2015). They were refined using additional data sets as described in Chapter 2, Section 2.1 of the GSP. Figure C-9 shows the locations of cross sections across the central portion of the Basin as prepared by the USGS in 2013 (USGS, 2013). Figure C-10 shows a west-east cross section that runs near the towns of New Cuyama and Cuyama labeled A-A’ (Figure C-11), and a south-north cross section labeled B-B’ (Figure C-12).



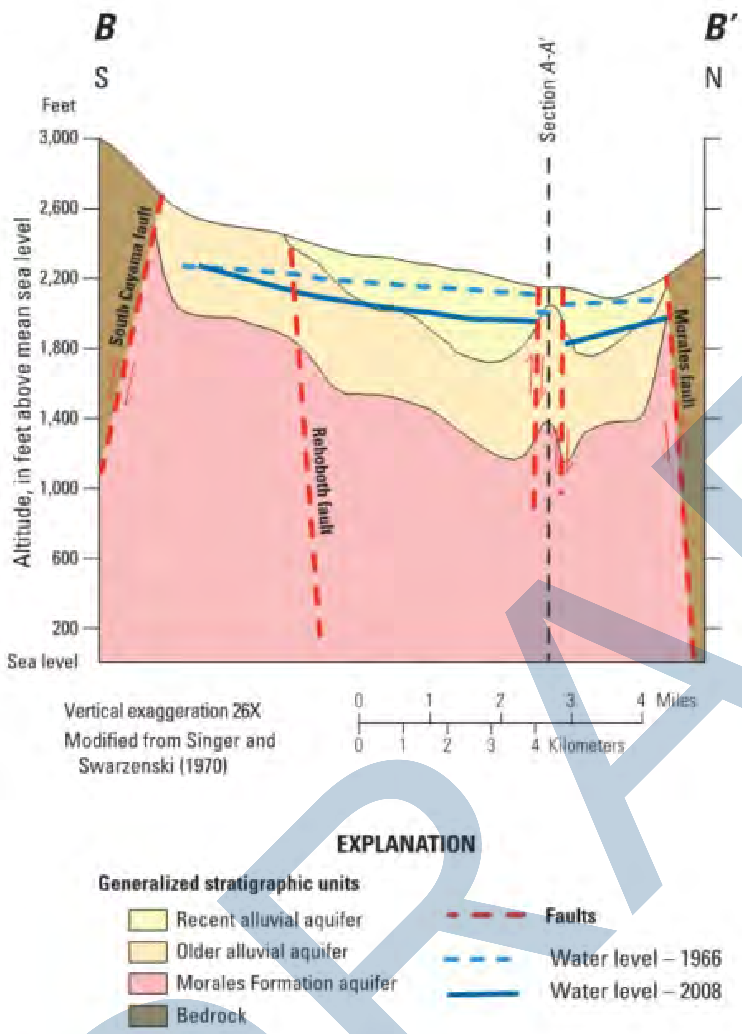
Source: USGS, 2015.

Figure C-9: Location of USGS 2015 Cross Sections



Source: USGS, 2015

Figure C-10: USGS Cross Section A-A'



Source: USGS, 2015

Figure C-11: USGS Cross Section B-B'

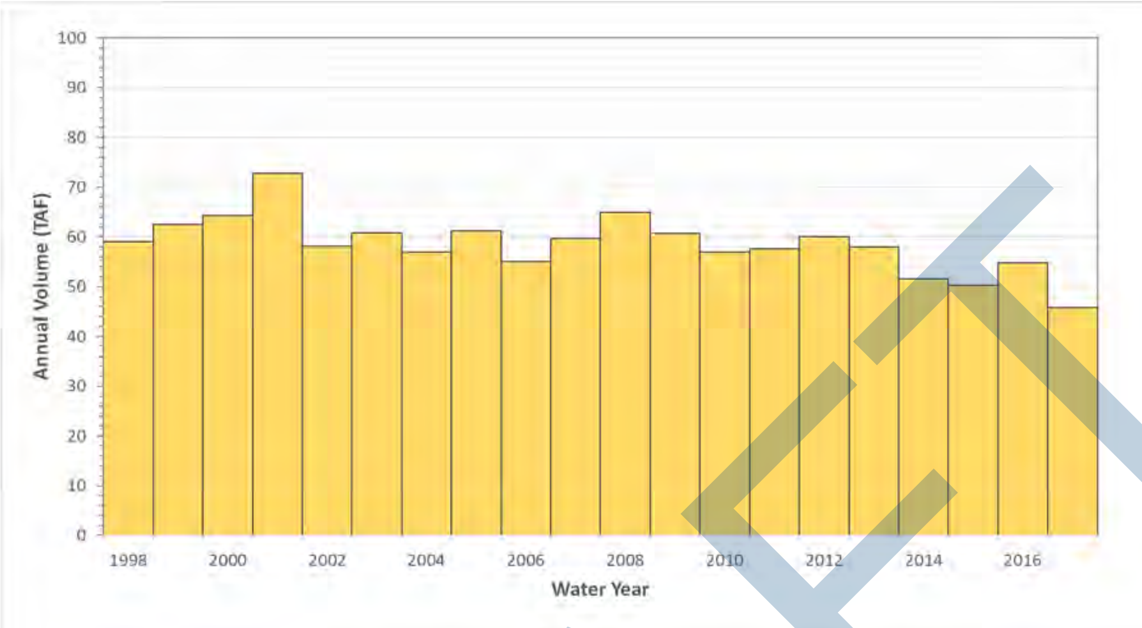


Figure C-12: Annual Agricultural Water Demand

Boundary Conditions

As discussed in the previous section, both surface and subsurface inflows within the ungaged watershed areas tributary to the main Basin are simulated using small watersheds module of the CBWRM. No flow boundary conditions were assumed for the rest of the domain boundary.

Initial Conditions

Groundwater heads for each model node and each layer at the beginning of the historical simulation (i.e., October 1, 1994) were developed using groundwater level data described in Chapter 2, Section 2.2. Due to the lack of information on well depth and/or perforation for many of the wells used, groundwater heads for each model layer are assumed to be the same. During the calibration process, some refinements were made by layer, as needed. This assumption, however, results in the use of first few years of simulation for start-up period to stabilize the simulated groundwater levels. Therefore, the model calibration period effectively ends up to be the 18-year period of water years 1998 through 2015.

Water Supply and Demand Data

The following sections describe the data and methodology for the CBWRM water demand and supply calculations. Agricultural water demands were calculated in the IDC portion of IWFM. Agricultural and domestic supplies are specified in the CBWRM's groundwater pumping data.

Agricultural Water Demand

Agricultural water demand is the amount of irrigation water that is required to satisfy the crops' evapotranspiration requirement after rainfall. The IDC is designed to estimate the agricultural water demand for each model element through consumptive use methodology. The IDC calculations rely on model input data for historical crop acreage, irrigation practices, soil moisture requirements, effective rainfall (the portion of rainfall available for crop consumptive use), crop evapotranspiration, and localized soil parameters. This data was compiled, analyzed, synthesized, and processed for input into CBWRM.

Domestic Water Use

IDC calculates urban water demand based on population and per capita water use, and the breakdown of indoor versus outdoor water use by month. For the Basin, the per capita water use was estimated using historical pumping estimates provided by the CCSD (CCSD 2010 to 2017) and population records published for the CCSD service area. Domestic water use during the historical period ranges between 100 and 200 acre-feet per year (AFY).

CBRWM Calibration

The goals of CBRWM calibration were as follows:

- Achieve a reasonable water budget for each component of the hydrologic cycle modeled (i.e., land and water use, soil moisture, stream flow, and groundwater) that is acceptable by the stakeholders to support the development of the GSP
- Maximize the agreement between simulated and observed groundwater levels at select well locations, and simulated and observed streamflow hydrographs at select gaging stations

These objectives are achieved through verification of model input data and adjustment of model parameters.

CBRWM calibration begins after data analysis and input data file development are completed. The calibration effort can be broken down into subsets that align with packages within the IWFM platform. As an integrated surface water and groundwater model, the results of each part of the simulation are dependent on one another. The model calibration can be considered a systematic process that includes the following activities:

- Calibrate water demand estimates for agricultural and urban sectors
- Calibrate surface water features, including the small watershed runoff, boundary flows, and streamflows
- Calibrate overall water budgets for the model area, and model subregions
- Calibrate simulated groundwater levels to observed groundwater levels
- Compare calibration performance with the calibration targets
- Conduct additional refinements to model as necessary

The CBWRM was calibrated to historical groundwater elevation data, with the calibration informed by local data provided by private landowners and other stakeholders.

Due to uncertainty in the initial conditions, a one-year warm-up period was included to allow groundwater levels to stabilize. Thus, the model calibration period for the CBWRM is October 1995 through September 2015, or water years 1996 through 2015 (i.e., 20 years).

Calibration of IDC and Root-Zone Parameters

The goal of IDC calibration is to estimate a reasonable urban and agricultural demand and develop the components of a balanced root zone budget. IDC calibration serves as the foundation of IWFM calibration as demand estimates directly affect the estimates of groundwater pumping. This part of the calibration effort focused primarily on refining individual budget items, while maintaining reasonable root zone parameters.

The calibrated IDC was used to estimate monthly agricultural water demand at each model element during the model hydrologic period. To adjust agricultural demand, elemental root zone parameters were adjusted in accordance with the hydrologic soil group. Figure C-12 shows estimates of annual agricultural water demand in the Basin from water year 1998 to water year 2017. The average annual agricultural water demand during these years is estimated to be approximately 59,000 AFY. The year-to-year variability in estimated agricultural demand reflects the variabilities in land use, precipitation, and temperature experienced historically in the Basin.

Calibration of Surface Water Features

As discussed above, small watersheds were used to simulate inflows into the model from ungaged watersheds. The small watershed were split between surface water runoff that enters the stream system, percolation that occurs during transport to the streams, and baseflow entering the groundwater system at the model boundary.

As discussed above, limited streamflow data are available to perform calibration on surface water flows in the model. One USGS gage is available on the Cuyama River downstream of the Basin (ID 11136800), which is located just upstream of Lake Twitchell. The flows from this gage were adjusted to estimate flows at the downstream boundary of the Basin. These adjusted flows were then compared to the flows resulting from the model calibration process.

Calibration of Water Budgets

The aim of the calibration process is to ensure an accurate representation of the hydrologic characteristics of the Basin, confirmed through the analysis of the resulting water budgets. A water budget balances all supplies, demands, and any subsequent change in storage occurring within that specific portion of the hydrologic cycle. IWFM automatically outputs budgets at the subregion scale for processes involving groundwater, the surface layer, streams, the root zone, and small watersheds. IWFM can output select budget information down to a single element or any specific grouping of elements. This feature was used during the calibration process to prepare water budget information by certain geographic areas for planning and comparison purposes.

During this step of the calibration process, CBRWM results are reviewed and summarized into monthly and annual (by water year) budgets. Two key hydrologic components that were reviewed most frequently during the calibration process were the groundwater budget and the land and water use budget. During extensive analysis of water budgets, key model datasets and parameters were adjusted (including parameters related to soil and root zone, small watershed and boundary flows, stream system, and aquifer system), to better match the conceptual understanding of the Basin. CBWRM water budget results are summarized in the following sections.

Land Surface Water Budget

The following components are included in the land surface water budget:

- Inflows:
  - Precipitation
  - Applied Water
- Outflows:
  - Evapotranspiration (Agricultural and Native Vegetation)
  - Domestic Water Use
  - Deep Percolation
  - Runoff

Figure C-13 shows the annual time series of historical land surface inflows and outflows during the calibration period. The Basin experienced about 282,000 AF of inflows each year, of which 223,000 AF is from precipitation and the remainder is from applied water. About 223,000 AFY was consumed as evapotranspiration and domestic use, with the remainder either recharging the groundwater aquifer as deep percolation, stream seepage or leaving the Basin as river flow.

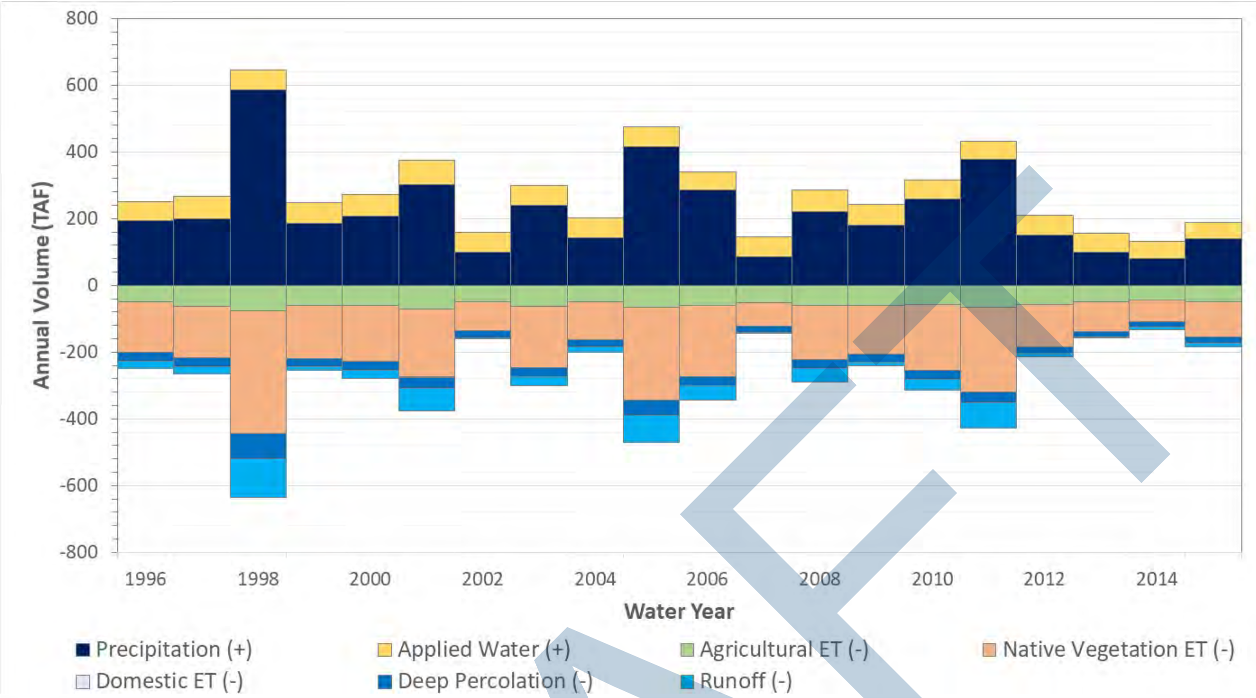


Figure C-13: Land Surface Water Budget Annual Time Series in the Calibration Period

Groundwater Budget

The following components are included in the groundwater water budget:

- Inflows:
  - Deep percolation
  - Stream seepage
  - Subsurface inflow
- Outflows:
  - Groundwater pumping

Figure C-14 shows the annual time series of groundwater inflows and outflows during the calibration period. The Basin average annual historical groundwater budget has greater outflows than inflows, leading to an average annual deficit in groundwater storage of 23,000 AF. The groundwater storage decreases consistently over time, despite year-to-year variability in groundwater inflows.

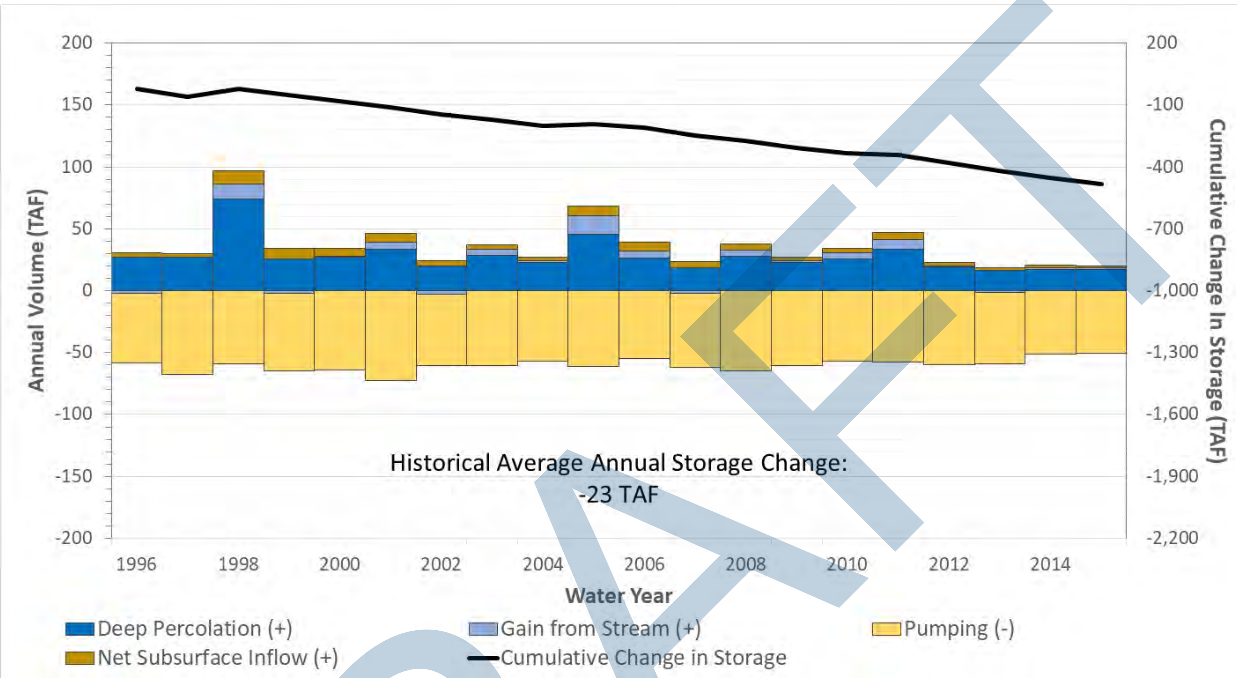


Figure C-14. Groundwater Budget Annual Time Series in the Calibration Period

Groundwater Level Calibration

The goal of groundwater level calibration is to achieve reasonable agreement between the simulated and observed values (in this case, groundwater levels at the calibration wells). Within the CBWRM, 139 wells were used to evaluate the model calibration at both a regional and local scale. These wells are included in the CBGSA's Opti data management system. The calibration wells were selected based on their period of record and availability of observation data, spatial distribution across the model, and trends of nearby wells. These calibration wells are shown in Figure C-15.

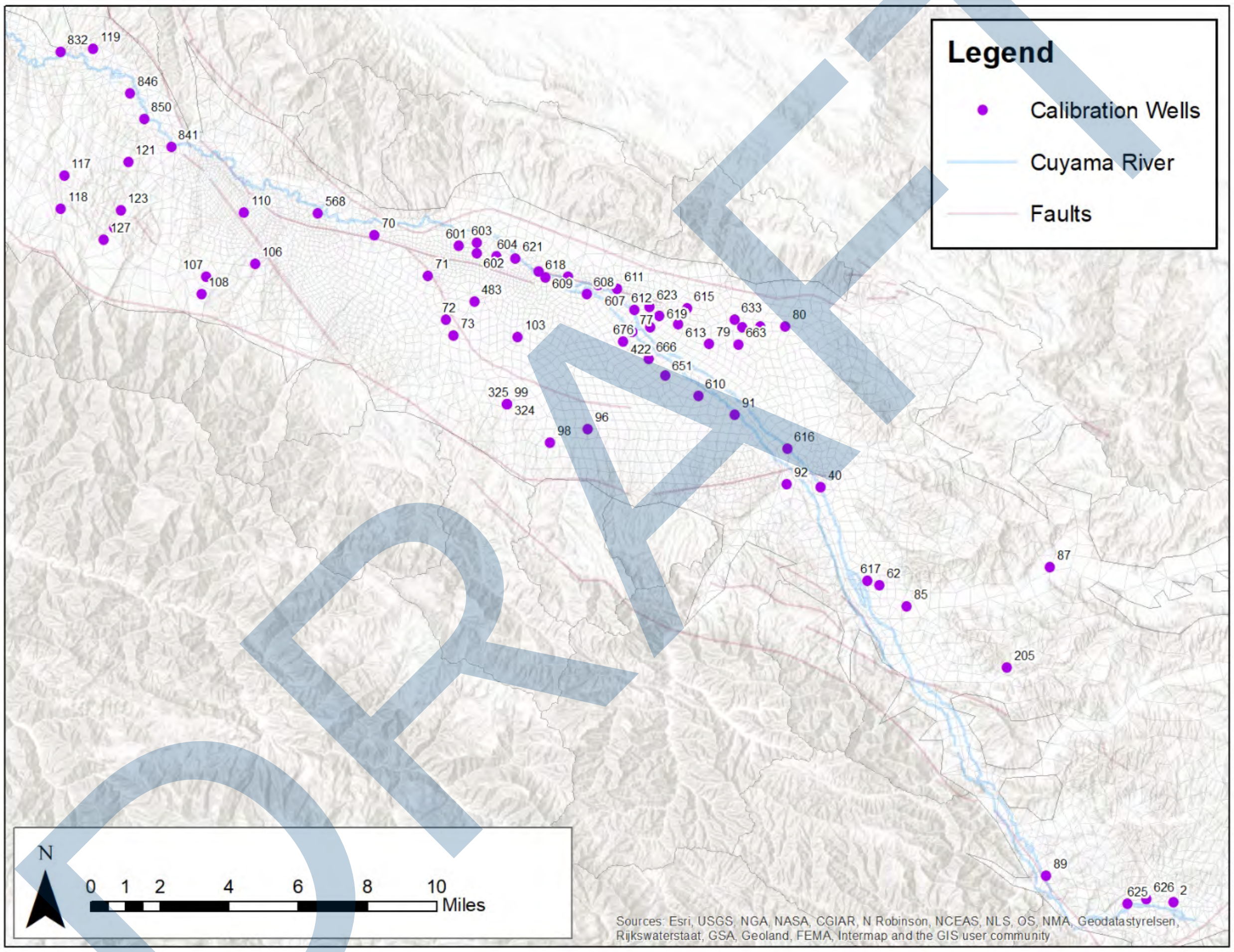


Figure C-15. Location of Calibration Wells

Simulated groundwater levels were calibrated to observed levels through systematic adjustments to aquifer parameters including hydraulic conductivity, specific storage, and specific yield. The goal of groundwater level calibration is to achieve the maximum agreement between simulated and observed groundwater elevations at calibration wells while maintaining aquifer parameters within reasonable range. The groundwater level calibration is performed in two stages as follows:

- The initial calibration effort is focused on the regional scale to verify hydrogeological assumptions made during model data development and confirm the accuracy of general groundwater flow directions. During this stage, simulated groundwater elevation trends, flow directions, and groundwater gradients are compared to those that can be synthesized form the reported data.
- The second stage of calibration of groundwater levels is to compare the simulated and observed groundwater levels at each calibration well. This comparison provides information on the overall model performance during the simulation period. The simulated groundwater elevations at the calibration wells were compared with corresponding observed values for concurrence in long-term trends as well as seasonal fluctuations.

The results of the groundwater level calibration indicate that CBWRM reasonably simulates long-term hydrologic responses under various hydrologic conditions, and the short-term monthly or seasonal fluctuations. Attachment 3 shows a selection of calibration wells with their resulting groundwater level hydrographs.

Figures C-16 and C-17 show a statistical comparison of the final simulated and observed groundwater levels across the entire Basin. As shown in these figures, the model results show a strong correlation with the observed data.

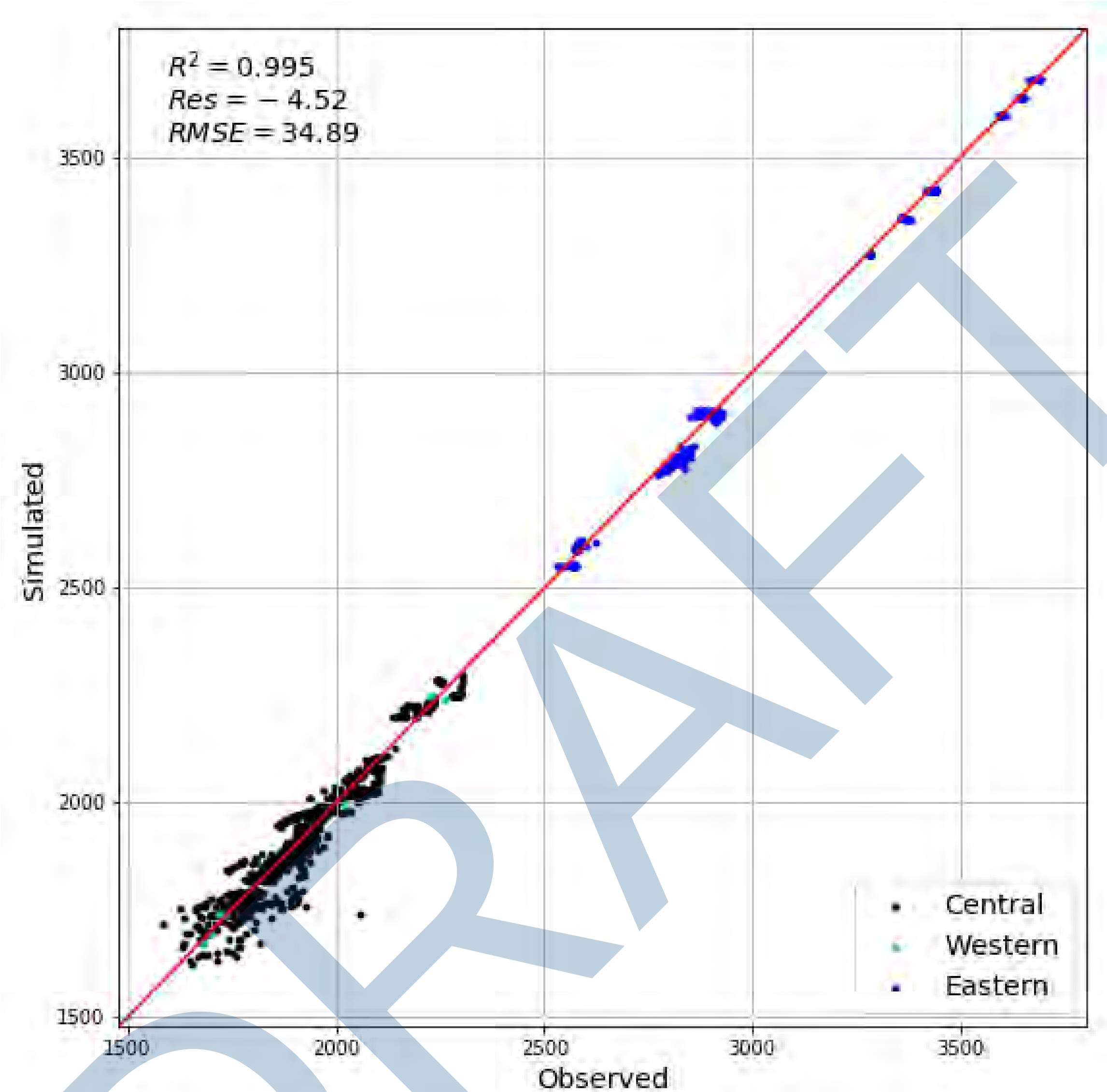


Figure C-16: Comparison of Simulated and Observed Groundwater Levels

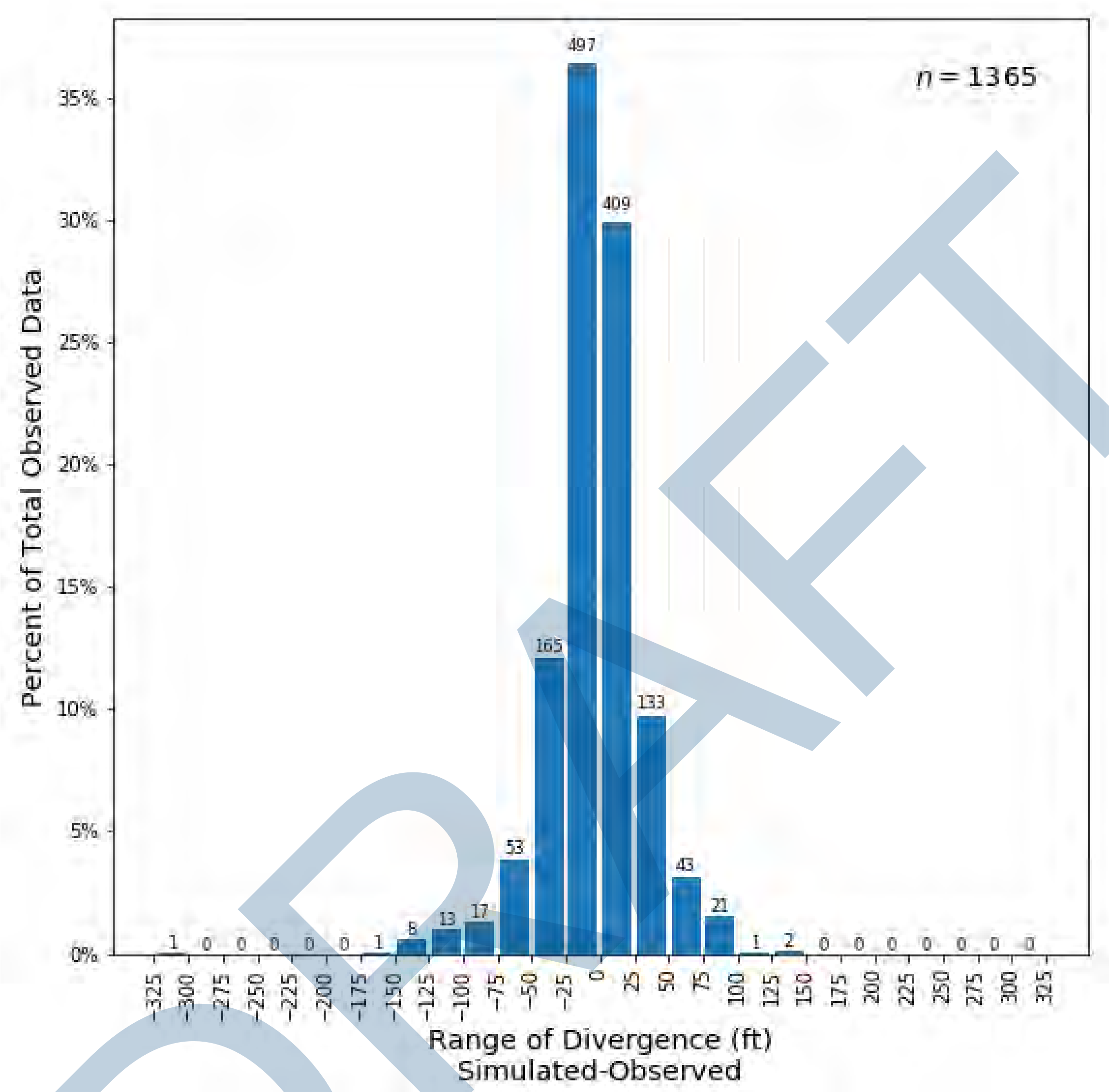


Figure C-17: Histogram of Divergence of Simulated Groundwater Levels from Observed Data

Uncertainty Assessment

To incorporate the uncertainty that originates from various model inputs such as hydraulic parameters, land use, irrigation practices and agricultural demand, an ensemble of perturbed simulation results were analyzed to quantify the overall effect on the groundwater storage change over the historical simulation period.

Accounting for these uncertainties, the upper and lower bounds for the cumulative groundwater storage change are presented in Figure C-18 below. The upper and lower bounds for the average groundwater storage change were estimated to range from 21,000 to 26,000 AFY.

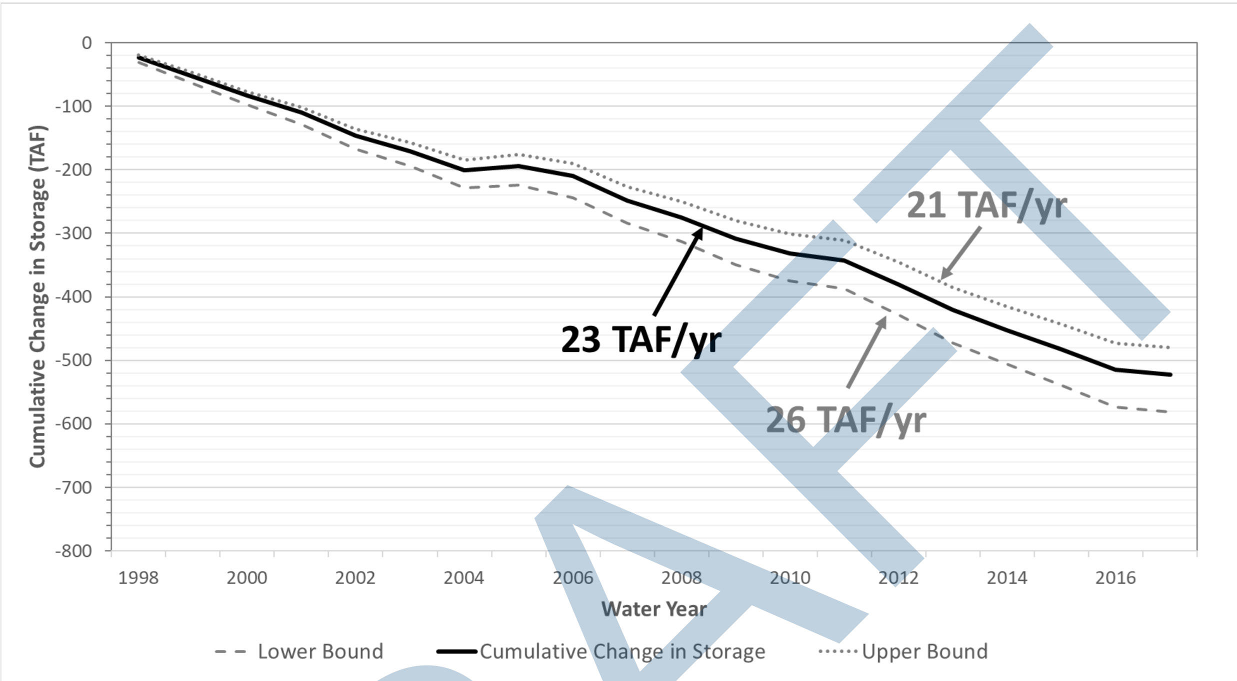


Figure C-18: Lower and Upper Bounds for the Groundwater Storage Change

Conclusions and Recommendations

The CBWRM is the latest analytical model based on DWR's state-of-the science modeling platform, IWFM. The CBWRM has relied on data sets from various sources, and was developed to support GSP development with the primary purpose of assessing hydrologic and groundwater conditions in the Basin during the recent historical period from water 1998 to water year 2017. CBWRM also assesses hydrologic and groundwater conditions under the Basin's current level of development and under projected conditions.

Based on analysis, the following conclusions are made:

1- CBRWM is reasonably calibrated, and reflects a reasonable representation of the Basin's hydrologic and hydrogeologic conditions

2- CBRWM calibration meets the intended need to support GSP development

3- GSP stakeholders and the Technical Forum have reviewed model development and calibration results, and have agreed that the CBWRM, as it stands, is a strong analytical tool to be used for assessment of and planning for sustainable groundwater conditions in the Basin.

The following recommended actions would support future model updates:

- **Continue engagement with local stakeholders**. Continue working with local agencies and groundwater users in the Basin to further understand the local operations of the groundwater system and improve representation of groundwater users in the model by collecting additional data. Specific data to be considered are irrigation practices outside the main District areas, groundwater level data, information on the well profiles and characteristics.
- **Perform additional hydrogeological conceptualization.** Specific areas can benefit from additional hydrogeologic investigations. These include eastern art of the basin in the vicinity of the Ventucopa area, as well as the western part of the model, downgradient from the Russel Fault. In addition, data about effectiveness of the fault system in the area are very sparse. Additional targeted groundwater exploration and/or groundwater level monitoring should focus on the areas near the fault systems.
- **Improve streamflow record collection.** Currently, there are no long-term streamflow gaging stations within the CBWRM. As part of GSP implementation, at least two streamflow gaging stations should be installed and monitored regularly, so that Basin inflows and outflows are properly monitored.
- **Improve representation of small watersheds.** Surface water flow from and evapotranspiration losses in the ungaged watersheds represent a relatively large portion of the Basin water budgets. Additional investigations on the native vegetation ET, and runoff conditions in the ungaged watersheds can improve model representation of this feature.
- **Develop groundwater pumping estimates.** As groundwater pumping is the primary outflow from the groundwater system, an accurate representation of outflow significantly improve CBWRM performance. A pilot project is recommended to monitor and measure groundwater use and well discharge for select parcels based on cropping patterns and geographic location relative to the river and relative to other hydrologic features, such as faults.
- **Incorporate future data into model calibration.** Data will be collected using the CBGSA's groundwater monitoring network, and should be used to re-assess and improve CBWRM calibration, especially in areas of the Basin where little or no data exist currently.

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Attachment C-1

Land Use and Consumptive Water Use of Cuyama Groundwater Basin for Water Years 1996 Through 2016

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TECHNICAL MEMORANDUM – DRAFT

LAND USE AND CONSUMPTIVE WATER USE OF CUYAMA GROUNDWATER BASIN FOR WATER YEARS 1996 THROUGH 2016

To: Woodard & Curran

From: Land IQ

Date: July 27, 2018

INTRODUCTION

Accurate and current information on constantly changing consumptive water use for crops is critical not only to water rights administration, but also to sustainable groundwater management, agricultural irrigation management, and to environmental and water quality protection. Land IQ has been contracted by Woodard & Curran to analyze consumptive water use in the Cuyama Groundwater Basin for these purposes and overall Groundwater Sustainability Plan (GSP) development data resources.

This memorandum provides methods and results of crop type identification for selected water years (1996, 2000, 2003, 2006, 2009, 2012, 2014 & 2016) during the 20 year time period. Multiple sources of data are used in the identification of each field. These sources include aerial imagery, satellite photography, DWR land use surveys and ground survey information.

This documentation also provides estimates of crop evapotranspiration (ET) for the 1996 and 2016 water years (10/1/1995 – 9/30/1996, 10/1/2015 – 9/30/2016). The surface energy balance model, METRIC (Mapping Evapotranspiration with high Resolution and Internalized Calibration), is applied to estimate monthly and annual evapotranspiration. The input data include CIMIS weather station data and USGS Landsat 5 & 8 satellite images.

DETERMINING LAND USE

Land use is one of the most influential inputs to a consumptive use or groundwater model. The most common land use in the Cuyama Groundwater Basin is agriculture production. Crop type information optimizes estimations of evapotranspiration, applied water, deep percolation return flows and other water balance input data requirements.

LAND USE DATA SOURCES

Available resources for crop mapping in recent years are more refined and accurate than in past years. Table 1 shows the types of aerial/satellite imagery as well as data availability for each year. Taking this into account, the accuracy and specificity of crop identification is greatest in the most recent mapping years (2014 & 2016). In more recent years, data allows individual crop types to be identified, instead of a more general category (e.g. Miscellaneous Truck Crops).

TABLE 1. SUMMARY OF DATA SOURCES AVAILABLE FOR EACH ANALYSIS YEAR

Year	Land Use Survey Data	Google Earth	NAIP Imagery	Landsat
2016	✔	✔	✔	✔
2014	✔	✔	✔	✔
2012	-	✔	✔	✔
2009	-	✔	✔	✔
2006	-	✔	✔	✔
2003	-	-	✔	✔
2000	-	-	-	✔
1996	✔	-	-	✔

LAND USE SURVEY DATA

The California Department of Water Resources (DWR) publishes land use data for regions on a rotating schedule for all or portions of each California County (DWR, 2018). The Cuyama Valley was last surveyed by DWR in 1996, including >90% of the fields in the Valley. Since then, Land IQ has completed statewide crop mapping for DWR in 2014 and 2016, encompassing the entire Cuyama Valley. In these three years, this data was used as a base layer and updated as needed.

GOOGLE EARTH

Google Earth provides high resolution satellite imagery with some temporal variation. Currently, most Google Earth data is provided by DigitalGlobe's WorldView-3 satellite, providing sub-meter resolution (Digital Globe, 2010). The street view function is also very helpful when identifying past years' crops. The street view in this area is very limited, however, and only available in 2008.

NAIP AERIAL IMAGERY

The National Agriculture Imagery Program (NAIP) captures aerial imagery during the growing season for public use (USDA, 2017). The imagery for the Cuyama Valley was available starting in 2003. NAIP imagery has a fairly high resolution of one meter. This imagery is used to update the field boundary layer for each year because the high resolution allows for the identification of fields that have split or have a different footprint. The drawback to NAIP imagery is that it is only a snapshot in time, with no temporal variation. Figure 1 shows 2009 NAIP imagery of the Cuyama Valley at two different scales to show detail.

FIGURE 1. NATURAL COLOR COMPOSITE OF NAIP IMAGE, FOR 05/05/2012; 1:300,000 SCALE ON LEFT; 1:9,000 SCALE ON RIGHT.

LANDSAT SATELLITE IMAGERY

Landsat satellite imagery is a joint project between the USGS and NASA that collects imagery for public use. Landsat provides lower resolution imagery (30 x 30 meter pixels) but at a much higher frequency than NAIP (USGS, 2007). Depending on year and cloud cover, imagery for an area could be as frequent as every 8 days. This frequency allows for the observation of the crop in all stages of development. All imagery dates during the growing season are used to identify the color and texture changes, to support the crop type identification.

The Cuyama Valley is within Landsat reference system path 42 and row 36. Landsat 5, 7, and 8 were used for appropriate years. All available growing season images were utilized, except those that had cloud contamination. Figure 2 is an example of the agriculture area in Landsat 5 on June 26, 2009.

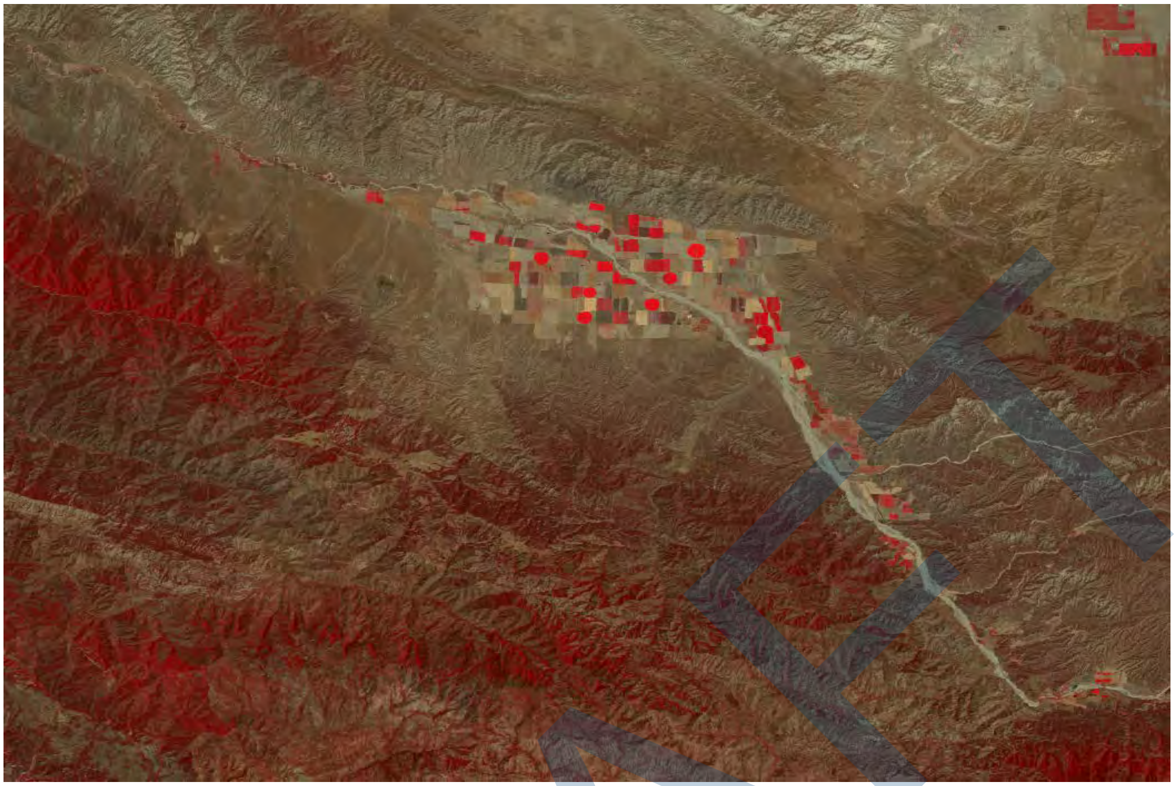

FIGURE 2. FALSE COLOR COMPOSITE OF LANDSAT 5 IMAGE, PATH 42 ROW 36, FOR 06/26/2009. AGRICULTURE IS IN THE MIDDLE OF THE IMAGE.

LAND USE RESULTS

Classification and field boundary updates were completed for each year, using the data sources available. Table 2 summarizes the results of the classification and boundaries. The top 5 crop classes during the 20 year period (excluding idle) were miscellaneous truck, miscellaneous grain and hay, carrots, alfalfa and alfalfa mixtures, and apples.

TABLE 2. SUMMARY OF CROP MAPPING RESULTS

DWR Crop	1996	2000	2003	2006	2009	2012	2014	2016
Alfalfa & alfalfa mixtures	3,574	2,586	1,950	2,201	935	1,356	168	235
Apples	2,475	2,478	1,417	773	518	282	307	331
Beans (dry)	-	259	-	-	-	-	1,064	-
Bush berries	-	-	-	-	-	-	-	21
Carrots	4,698	843	307	566	5,582	6,654	2,302	5,572
Citrus	-	2	2	2	4	4	2	2
Cole crops	-	-	107	137	292	236	182	383
Corn, sorghum and sudan	-	185	209	-	74	-	32	173
Grapes	357	794	768	768	765	853	1,303	1,241
Greenhouses	-	-	-	-	-	-	-	5
Idle	-	8,286	9,971	12,247	9,139	8,449	15,352	13,572
Lettuce/leafy greens	-	-	-	271	212	171	-	612
Melons, squash, and cucumbers	12	-	-	-	-	-	562	50
Miscellaneous deciduous	12	10	10	16	41	35	10	6
Miscellaneous field crops	114	-	-	-	-	-	-	-
Miscellaneous grain and hay	7,462	5,756	5,580	4,712	8,767	6,367	851	3,198
Miscellaneous grasses	-	192	485	192	111	14	22	-
Miscellaneous subtropical fruit and nut	-	-	-	-	-	-	-	7
Miscellaneous truck	3,723	6,842	8,083	9,380	3,451	4,078	6,100	3,322
Mixed pasture	737	104	91	398	273	392	97	142
Native	-	-	-	-	-	166	-	-
Olives	-	4	4	4	4	4	4	517
Onions and garlic	313	10	315	527	983	1,231	615	2,190
Peaches/nectarines	413	348	284	213	75	-	-	-
Pistachios	676	604	604	757	757	722	802	722

DETERMINING CONSUMPTIVE USE

Traditional methods of calculating evapotranspiration can be done quite accurately using weighing lysimeters and eddy correlation monitoring techniques. These methods are limited, however, because they provide point values of ET for a specific location and fail to provide the ET on a regional scale. This limitation has motivated the development of using remotely sensed (RS) data from satellites to evaluate ET over vast areas. Satellite data are ideally suited for deriving spatially continuous ET surfaces that can be pared down to the field scale because of their temporal and spatial characteristics. However, the most accurate use of RS models require calibration to surface measurements.

SURFACE ENERGY BALANCE CONSUMPTIVE USE ANALYSIS – METRIC MODEL

METRIC estimates surface evapotranspiration (ET) based on the evaluation of the energy balance at the earth's surface. METRIC model processes instantaneous remotely-sensed images and weather data, and estimates the partitioning of energy into net incoming radiation (R_n), heat flux into the ground (G), sensible heat flux to the air (H), and latent heat flux (LE). The latent heat flux is computed as a residual in the energy balance, representing the energy consumed by ET. The main advantage of using the energy balance is that the actual ET is computed, rather than a potential ET. A disadvantage of the energy balance approach is in the complexity of calculations and the need for human oversight during calibration. Figure 3 shows a general workflow of the METRIC process.

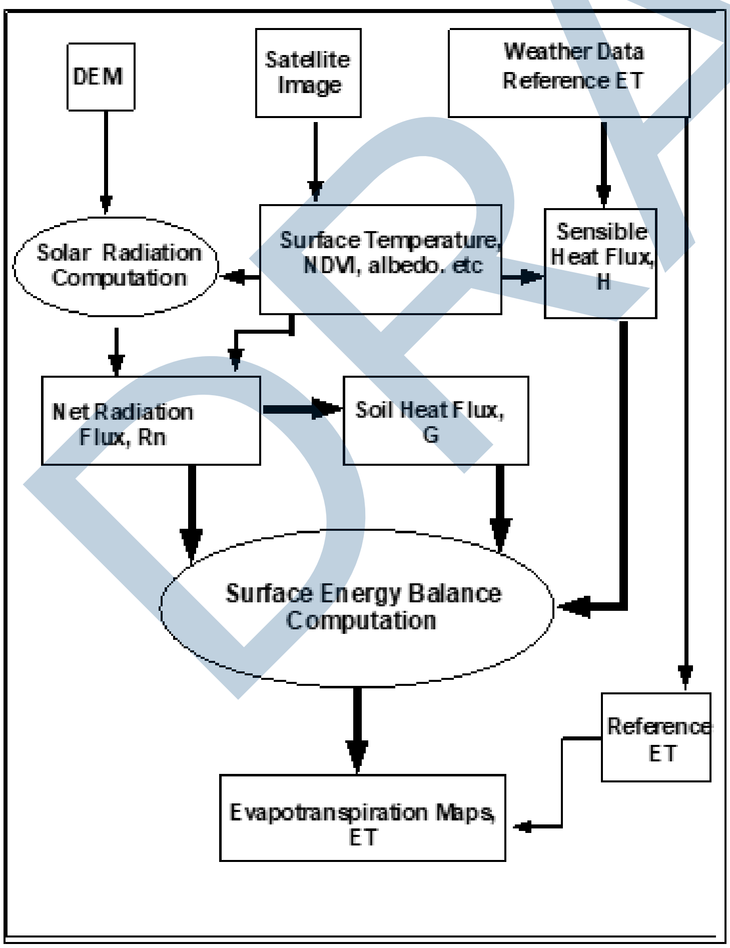

FIGURE 3. GENERAL WORKFLOW OF THE METRIC PROCESS

For the Cuyama Groundwater Basin METRIC application, the Cuyama station (CIMIS station #88) was selected to produce the reference ET (ETo) during calibration. During the internal calibration of sensible heat flux in METRIC, multiple pairs of hot and cold pixels are selected for the model, the one with relative stable result is selected for final calibration. A detailed description of METRIC can be found in Allen et al. (2007a, b; 2008).

METRIC Input Data – Satellite Images

The Cuyama Groundwater Basin is within Landsat reference system path 42 and row 36. For the 1996 water year, Landsat 5 images were used, and for the 2016 water year, Landsat 8 images were used. All available images were utilized, except those that had cloud contamination.

Tables 3 and 4 provide a list of the images used for each water year. A total of 14 Landsat 5 images were modeled by METRIC for the 1996 water year, and a total of 16 Landsat 8 images were modeled for the 2016 water year. For each image, the METRIC model was used to estimate actual daily ET. Linear interpolation was then used to calculate monthly and annual ET.

TABLE 3. DATES OF THE LANDSAT 5 SATELLITE IMAGES USED FOR METRIC PROCESSING IN 1996 WATER YEAR

#	Date of Landsat	Image Type
1	9/24/1995	Landsat 5
2	10/10/1995	Landsat 5
3	11/11/1995	Landsat 5
4	11/27/1995	Landsat 5
5	1/14/1996	Landsat 5
6	5/21/1996	Landsat 5
7	6/6/1996	Landsat 5
8	6/22/1996	Landsat 5
9	7/8/1996	Landsat 5
10	7/24/1996	Landsat 5
11	8/9/1996	Landsat 5
12	8/25/1996	Landsat 5
13	9/10/1996	Landsat 5
14	9/26/1996	Landsat 5

TABLE 4. DATES OF THE LANDSAT 8 SATELLITE IMAGES USED FOR METRIC PROCESSING IN 2016 WATER YEAR

#	Date of Landsat	Image Type
1	10/1/2015	Landsat 8
2	11/18/2015	Landsat 8
3	1/21/2016	Landsat 8
4	2/6/2016	Landsat 8
5	3/9/2016	Landsat 8
6	3/25/2016	Landsat 8
7	4/26/2016	Landsat 8
8	5/12/2016	Landsat 8
9	6/13/2016	Landsat 8
10	6/29/2016	Landsat 8
11	7/15/2016	Landsat 8
12	7/31/2016	Landsat 8
13	8/16/2016	Landsat 8
14	9/1/2016	Landsat 8
15	9/17/2016	Landsat 8
16	10/3/2016	Landsat 8

METRIC Input Data – Weather Data

METRIC utilizes reference ET as calculated by the ASCE standardized Penman-Monteith equation (ASCE-EWRI 2005) for calibration of the energy balance process. For our study, grass reference ET (ETo) is used in the modeling process. Hourly weather data time steps are needed to represent ETo at the time of the Landsat overpass for calibration of the METRIC energy balance estimation process. ETo was calculated using the RefET software from the University of Idaho (Allen, 2013). California Irrigation Management Information System (CIMIS) weather station #88 at Cuyama was used to provide hourly weather data for ETo calculation. Figure 4 is an example of weather data for May 21st, 1996. Figure 5 shows the annual reference ETo for 1996 and 2016 water years calculated from the CIMIS Cuyama weather station using RefET software.

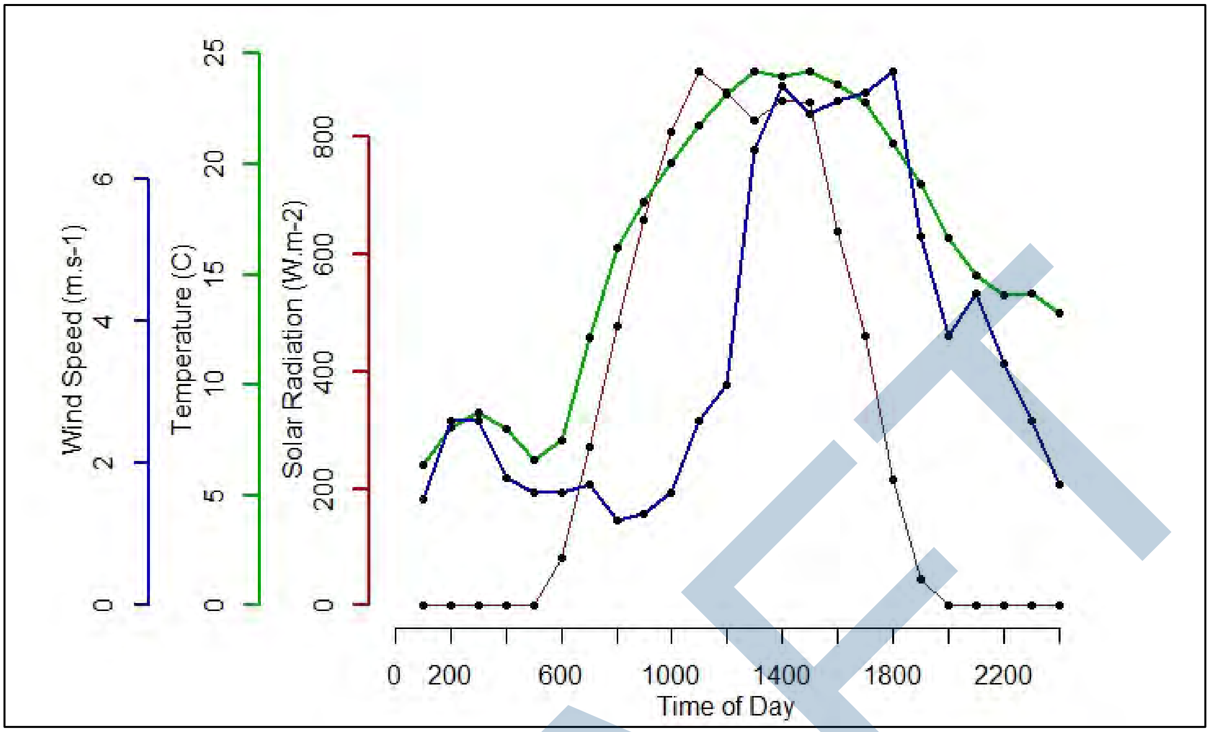

FIGURE 4. CIMIS CUYAMA #88 STATION WEATHER DATA ON MAY 21ST, 1996.

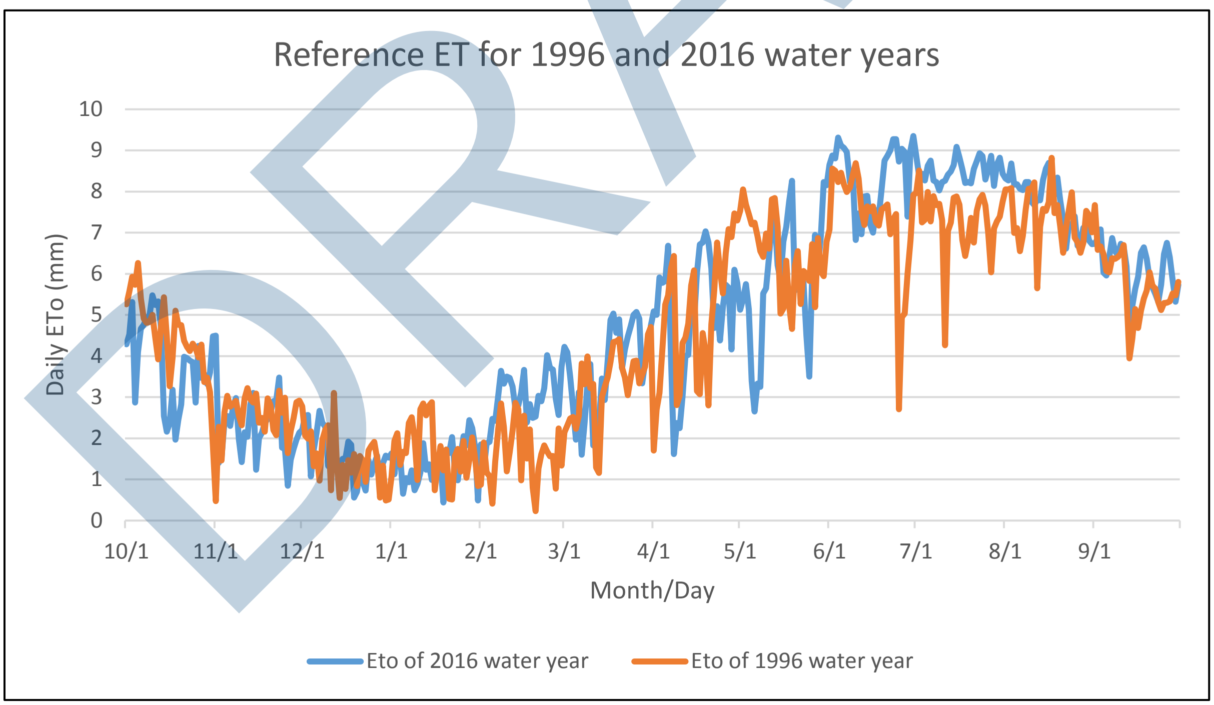

FIGURE 5. REFERENCE EVAPOTRANSPIRATION FOR 1996 AND 2016 WATER YEARS.

CONSUMPTIVE USE RESULTS

The annual ET data for the 1996 and 2016 water years are summarized by major crop types within each year. Tables 5 and 6 show the results of average crop actual ET. Major crops, such as alfalfa, apples, and carrots, have relative higher annual ET in 2016 than 1996, and these could be attributed to a number of factors:

- 2016 total annual ETo is higher than 1996 total annual ETo. As shown in Figure 5, during the month of June and July, ETo is consistently higher in 2016.
- The underlying crop layers used for generating the statistics are created differently. 2016 crop layer is created by Land IQ while 1996 crop layer is created by DWR.
- The field boundary of 2016 is more accurate, compared with 1996 field boundary. And this could cause differences in ET stats.
- Crop variety and irrigation methods are different in those 2 years, making crops evaporate more water in 2016.

Figure 6 shows the overview of 2016 water year ET over the whole Cuyama Basin. The focus and calibration area for METRIC ET evaluations was the agricultural growing region (valley floor) itself. The surrounding mountains with different elevations and aspects may have differing results.

TABLE 5. SUMMARY OF CROP EVAPOTRANSPIRATION OF 1996 WATER YEAR

Crop Types	1996 Water Year ET (mm)	1996 Crop Acres
Alfalfa and Alfalfa Mixtures	1124	3576
Apples	875	2477
Carrots	713	4702
Grapes	749	357
Miscellaneous Grain and Hay	483	7468
Miscellaneous Truck Crops	519	3726
Mixed Pasture	721	737
Onions and Garlic	447	313
Peaches/nectarines	764	414
Pistachios	584	677

TABLE 6. SUMMARY OF CROP EVAPOTRANSPIRATION OF 2016 WATER YEAR

Crop Types	2016 Water Year ET (mm)	2016 Crop Acres
Alfalfa and Alfalfa Mixtures	1366	235
Apples	1224	331
Carrots	1018	5572
Grapes	727	1242
Miscellaneous Grain and Hay	782	3198
Miscellaneous Truck Crops	723	3322

Mixed Pasture	555	142
Onions and Garlic	897	2190
Pistachios	1253	722
Lettuce/Leafy Greens	700	613
Olives	617	517
Safflower	590	810

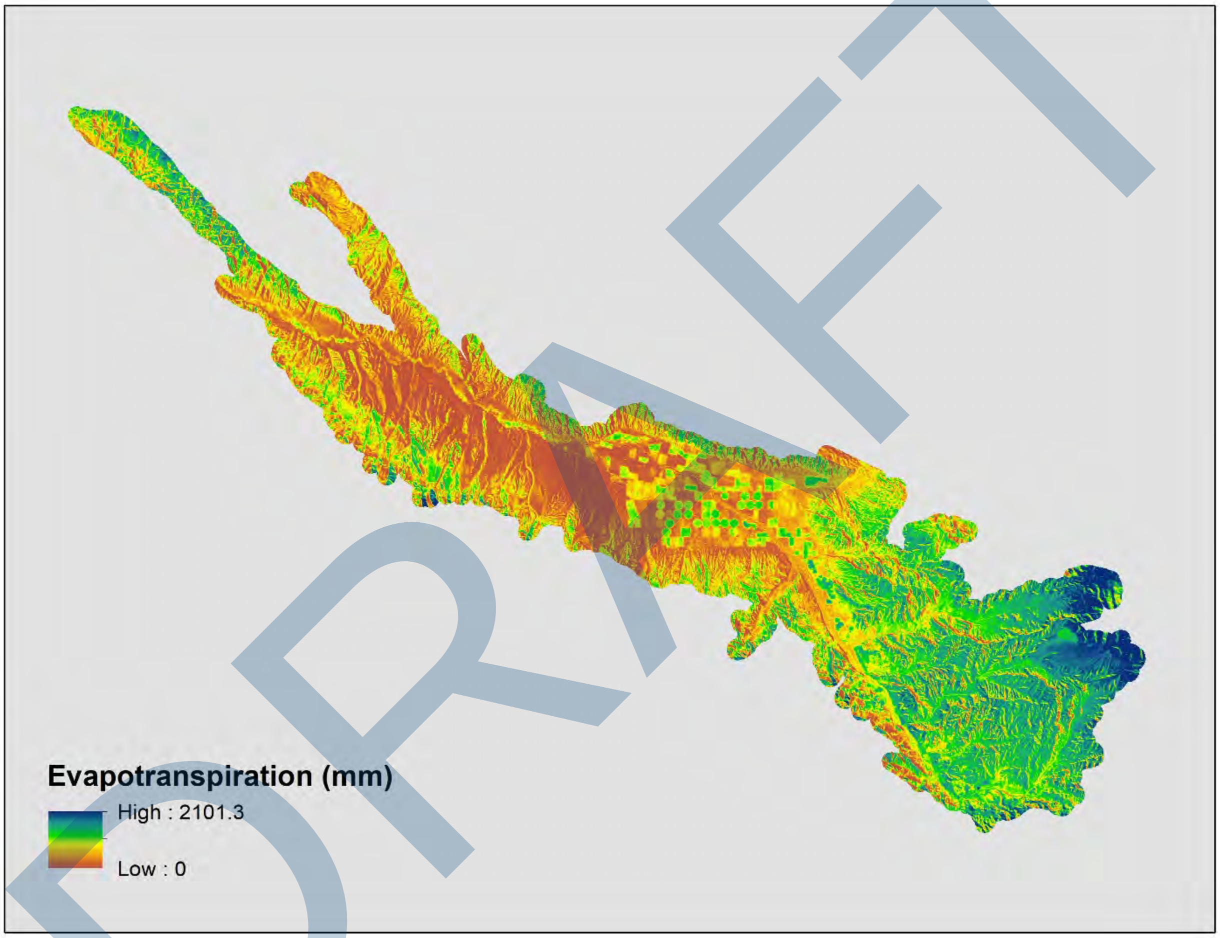

FIGURE 6. 2016 WATER YEAR EVAPOTRANSPIRATION OF THE CUYMA BASIN.

DATA DELIVERABLES

Data delivered as part of the consumptive water analysis efforts are summarized in Table 7.

TABLE 7. SUMMARY OF CROP MAPPING DATA DELIVERABLES

#	File Name	Description
1	CuyamaValley_2016_LandUse_Classification.shp	Crop classification for 2016 water year (attribute: Crop2016)
2	CuyamaValley_2014_LandUse_Classification.shp	Crop classification for 2014 water year (attribute: Crop2014)
3	CuyamaValley_2012_LandUse_Classification.shp	Crop classification for 2012 water year (attribute: Crop2012)
4	CuyamaValley_2009_LandUse.shp	Crop classification for 2009 water year (attribute: Crop2009)
5	CuyamaValley_2006_LandUse.shp	Crop classification for 2006 water year (attribute: Crop2006)
6	CuyamaValley_2003_LandUse.shp	Crop classification for 2003 water year (attribute: Crop2003)
7	CuyamaValley_2000_LandUse.shp	Crop classification for 2000 water year (attribute: Crop2000)
8	CuyamaValley_1996_LandUse.shp	Crop classification for 1996 water year (attribute: Crop1996)
9	1995-10_ETa.tif	Raster image of total evapotranspiration (unit: mm) for October 1995
10	1995-11_ETa.tif	Raster image of total evapotranspiration (unit: mm) for November 1995
11	1995-12_ETa.tif	Raster image of total evapotranspiration (unit: mm) for December 1995
12	1996-01_ETa.tif	Raster image of total evapotranspiration (unit: mm) for January 1996
13	1996-02_ETa.tif	Raster image of total evapotranspiration (unit: mm) for February 1996
14	1996-03_ETa.tif	Raster image of total evapotranspiration (unit: mm) for March 1996
15	1996-04_ETa.tif	Raster image of total evapotranspiration (unit: mm) for April 1996
16	1996-05_ETa.tif	Raster image of total evapotranspiration (unit: mm) for May 1996
17	1996-06_ETa.tif	Raster image of total evapotranspiration (unit: mm) for June 1996
18	1996-07_ETa.tif	Raster image of total evapotranspiration (unit: mm) for July 1996
19	1996-08_ETa.tif	Raster image of total evapotranspiration (unit: mm) for August 1996
20	1996-09_ETa.tif	Raster image of total evapotranspiration (unit: mm) for September 1996

#	File Name	Description
21	1996_total_ETa_mm.tif	Raster image of total evapotranspiration (unit: mm) for 1996 water year
22	2015-10_ETa.tif	Raster image of total evapotranspiration (unit: mm) for October 2015
23	2015-11_ETa.tif	Raster image of total evapotranspiration (unit: mm) for November 2015
24	2015-12_ETa.tif	Raster image of total evapotranspiration (unit: mm) for December 2015
25	2016-01_ETa.tif	Raster image of total evapotranspiration (unit: mm) for January 2016
26	2016-02_ETa.tif	Raster image of total evapotranspiration (unit: mm) for February 2016
27	2016-03_ETa.tif	Raster image of total evapotranspiration (unit: mm) for March 2016
28	2016-04_ETa.tif	Raster image of total evapotranspiration (unit: mm) for April 2016
29	2016-05_ETa.tif	Raster image of total evapotranspiration (unit: mm) for May 2016
30	2016-06_ETa.tif	Raster image of total evapotranspiration (unit: mm) for June 2016
31	2016-07_ETa.tif	Raster image of total evapotranspiration (unit: mm) for July 2016
32	2016-08_ETa.tif	Raster image of total evapotranspiration (unit: mm) for August 2016
33	2016-09_ETa.tif	Raster image of total evapotranspiration (unit: mm) for September 2016
34	2016_total_ETa_mm.tif	Raster image of total evapotranspiration (unit: mm) for 2016 water year
35	Reference_ETo	Reference ET for 1996 and 2016 water years
36	Cuyama Consumptive Use Report	Memorandum summarizing consumptive use efforts (this document)

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Attachment C-2

Climate Change Scenario Development

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1. CLIMATE CHANGE SCENARIO DEVELOPMENT

1.1 Regulatory Background

As prescribed in Section 354.18(d)(3) and Section 354.18(e) of the GSP Regulations, climate change conditions were incorporated into the projected water budgets for the Eastern San Joaquin Groundwater Sustainability Plan.

Section 354.18(d)(3) states:

"*(d) The Agency shall utilize the following information provided, as available, by the Department pursuant to Section 353.2, or other data of comparable quality, to develop the water budget:*

> *(1) Historical water budget information for mean annual temperature, mean annual precipitation, water year type, and land use.*
> *(2) Current water budget information for temperature, water year type, evapotranspiration, and land use.*
> *(3) Projected water budget information for population, population growth, **climate change**, and sea level rise.***"**

Section 354.18(e) states:

"*(e) Each Plan shall rely on the best available information and best available science to quantify the water budget for the basin in order to provide an understanding of historical and projected hydrology, water demand, water supply, land use, population, **climate change**, sea level rise, groundwater and surface water interaction, and subsurface groundwater flow. If a numerical groundwater and surface water model is not used to quantify and evaluate the projected water budget conditions and the potential impacts to beneficial uses and users of groundwater, the Plan shall identify and describe an equally effective method, tool, or analytical model to evaluate projected water budget conditions.***"**

Climate change analysis is an area with continued evolution in terms of methods, tools, forecasted datasets, and the predictions of actual greenhouse gas concentrations in the atmosphere. There is a large number of available combinations of these elements that result in many potential ways to evaluate climate change impacts. For the purposes of this GSP, the method proposed by DWR as a valid method of evaluation in its guidance document was considered adequate (DWR, 2018). Similarly, the "best available information" was deemed the information provided by DWR, customized for the method proposed. The following resources from DWR were used to carry out the climate change analysis:

- SGMA Data Viewer
- Guidance for Climate Change Data Use During
- Sustainability Plan Development and Appendices (Guidance Document)
- Water Budget BMP
- Desktop IWFM Tools

SGMA Data Viewer provides the location for which the climate change forecasts datasets[1] were downloaded for the Cuyama subbasin (DWR, 2019). The guidance document details the approach, development, applications, and limitations of the datasets available from the SGMA Data Viewer (DWR, 2018). The Water Budget BMP describes in more granular detail how projected water budgets should be computed (DWR, 2016). The Desktop IWFM Tools are available to calculate the projected precipitation and evapotranspiration inputs under climate change conditions (DWR, 2018).

Generally, the methods suggested by DWR in the above resources were used, with a few exceptions to ensure the resolution and scale matched that of the historical and current water budgets. Figure C-2-1 shows the overall process consistent with the Climate Change Resource Guide (DWR, 2018) that describes workflow beginning with baseline historical conditions to perturbed 2070 conditions for the projected model run.

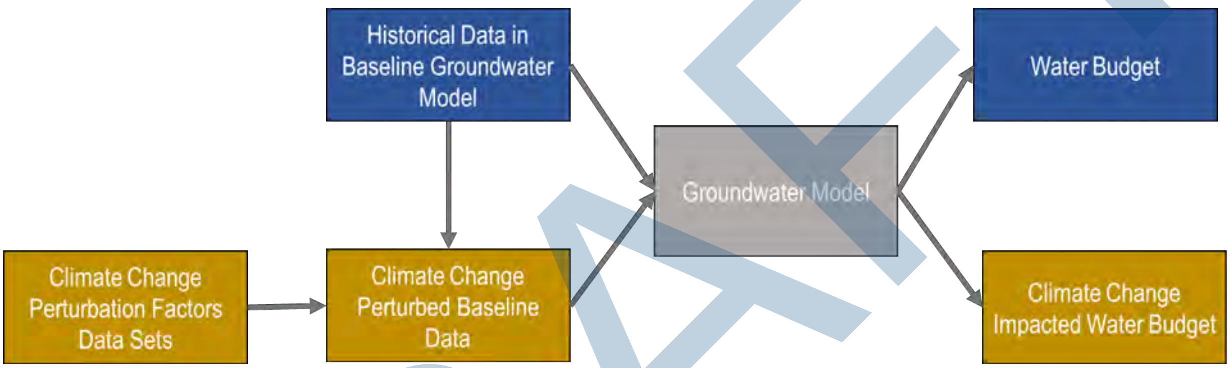

Figure C-2-1

Table C-2-1 below summarizes the forecasted variable datasets provided by DWR that were used to carry out the climate change analysis (DWR, 2019).

Table C-2-1.

Input Variable	DWR Provided Dataset
Precipitation	**Change Factors:** VIC model-generated GIS grid with associated change factor time series for each cell
Reference ET	**Change Factors:** VIC model-generated GIS grid with associated change factor time series for each cell

[1] In the industry, climate change impacted variable forecasts are sometimes referred to as "data" and their collections are called "datasets." Calling forecasted variable values "data" can be misleading so this document tries to be explicit about when we are referring to data (historical data) vs. forecasts or model outputs.

1.2 Climate Change Analysis Methodology

For climate change impacts on groundwater, accepted methods include the assessment of the impacts on the individual water resource system elements that are impacted and directly link to groundwater. These elements include precipitation, streamflow, evapotranspiration and, for coastal aquifers, sea level rise as a boundary condition. For Cuyama, sea level is not relevant. Additionally, in the Cuyama model does not have any stream inflows. For this reason, streamflow under climate change was not perturbed in this analysis.

The methods for perturbing the precipitation and evapotranspiration input files is described in the following sections. Two future scenarios were evaluated in this analysis, according to DWR guidance (DWR, 2018):

- Water Budget under 2030 central tendency conditions to assess near-future impacts of climate change.
- Water Budget under 2070 central tendency conditions to assess impacts of climate change over the long-term planning and implementation period.

Perturbed Precipitation under Climate Change

Projected precipitation change (perturbation) factors are provided by DWR, calculated using a climate period analysis based on historical precipitation from January 1915 to December 2011 (DWR, 2018). Change factors provided by DWR were calculated as a ratio of the value of a variable under a “future scenario” divided by a baseline. DWR used a macroscale hydrologic model that solves the full water and balance in a watershed, called the Variable Infiltration Capacity (VIC) Model. The baseline data corresponds to the 1995 historical template detrended scenario by the VIC model through global circulation model (GCM) downscaling. The “future scenario” corresponds to VIC outputs of the simulation of future conditions using GCM forecasted hydroclimatic variables as inputs. These change factors are thus a simple perturbation factor that corresponds to the ratio of a future with climate change divided by the past without it. Change factors are available on a monthly time step and spatially defined by the VIC model grid. Supplemental tables with the time series of perturbation factors are available by DWR for each grid cell.

Because the Cuyama model has a daily time step, the historical baseline time series (WY 1960-WY 2017) was aggregated monthly. DWR change factors, or perturbation factors, were then multiplied by historical baseline precipitation to generate projected precipitation under 2030 and 2070 central tendency future scenarios using the Desktop IWFM GIS tool (DWR, 2018). The tool calculates an area weighted precipitation change factor for each model grid geometry. This model grid geometry was generated based on polygons generated around the PRISM nodes that are within the model region.

However, the DWR tool only includes change factors through 2011. The remaining 5 years of the time series were synthesized according to historically comparable water years. The perturbation factor from the corresponding month of the comparable year was applied to the baseline of the missing years (2012-2017) to generate projected values. Months with no precipitation in the baseline were assumed a monthly precipitation of 1mm under climate change to account for increased precipitation that cannot be calculated from a baseline of 0 mm for these synthesized years. Table C-2-2 below shows the comparable water years assigned for each missing year.

Table C-2-2

WY with Missing Change Factors	Comparable WY on Record	
	April - Sept	Oct - March
2012	1987	2009
2013	1990	1990
2014	1990	1989
2015	2001	1990
2016	1990	1989
2017	1990	1990

Applying Change Factors to Precipitation and ET

DWR datasets include scenarios for 2030 and 2070 timeframes and for conditions similar to historical in terms of precipitation forecasted (central tendency) and conditions wetter and drier. All scenarios available present higher future temperatures. The team selected the 2070 central tendency forecasted conditions for the analysis.

After applying the change factor to the model simulation period (baseline) we obtained the precipitation and evapotranspiration under climate change. The resulting perturbed precipitation values and the baseline precipitation values can be found in Figure C-2-2 below. The exceedance plot for these two times series can be found in Figure C-2-3.

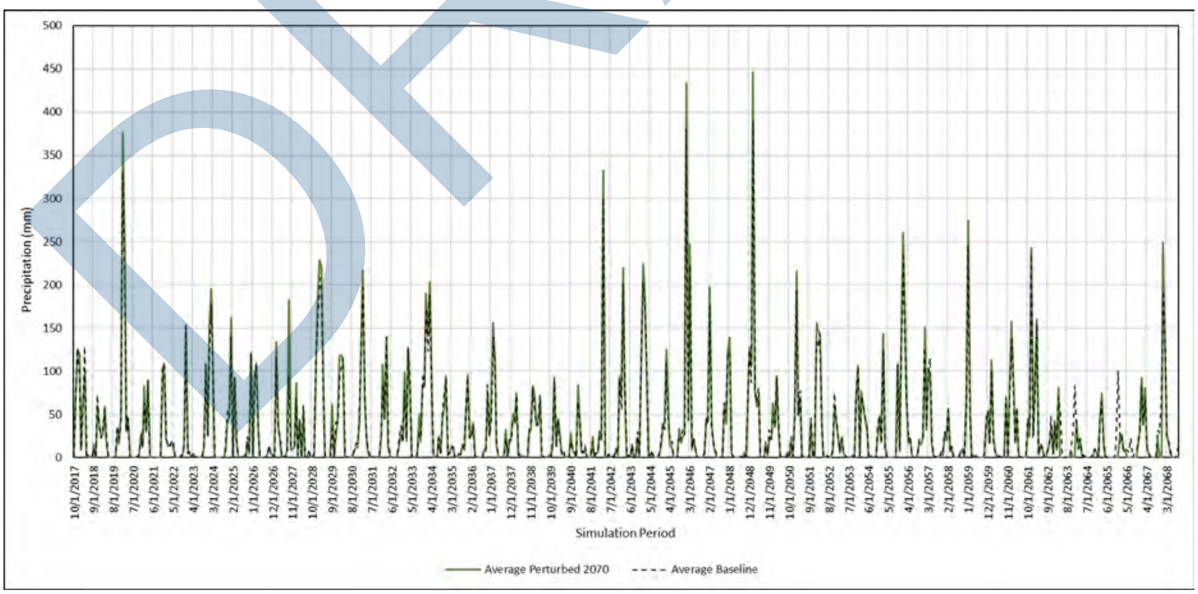

Figure C-2-2. Precipitation Perturbation Factors as Compared to Baseline Values

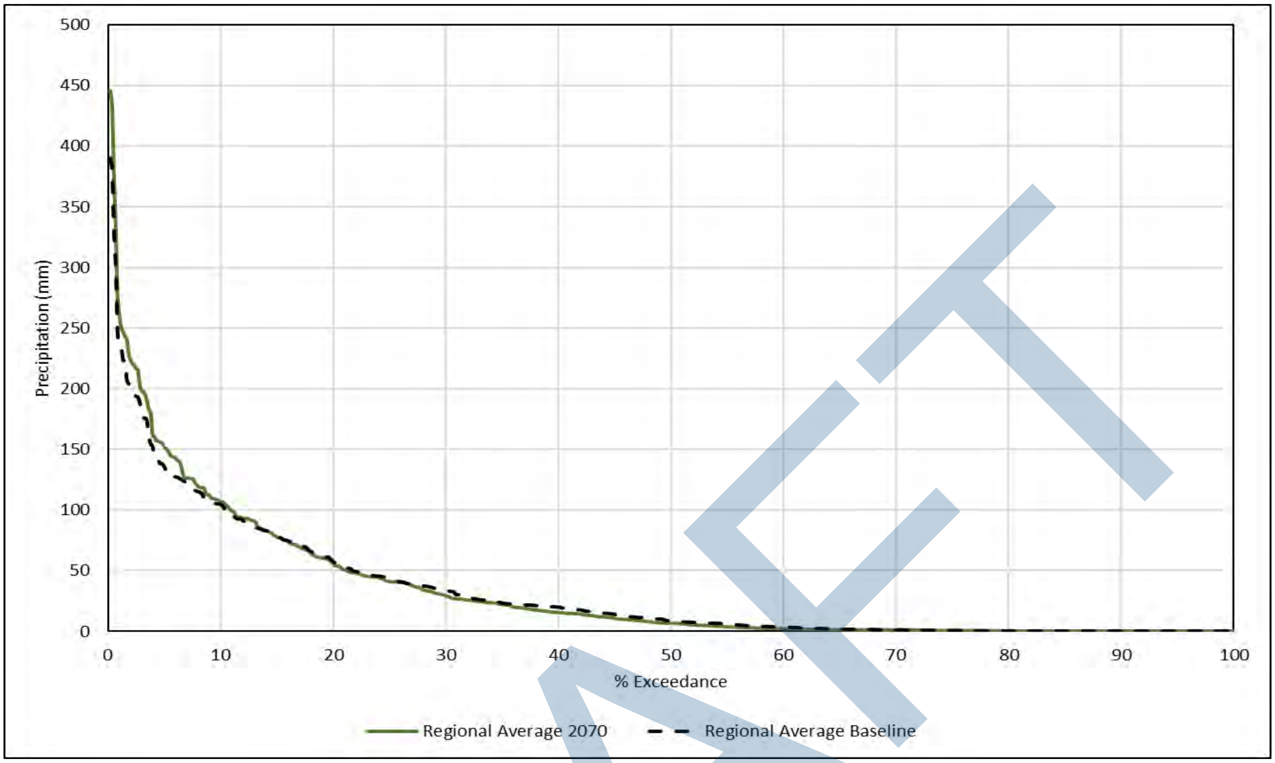

Figure C-2-3. Exceedance of Precipitation Perturbation Factors as Compared to Baseline Values

Figure C-2-4 shows the difference between the regional average under 2070 climate change conditions and the regional average under historical baseline conditions plotted against different amounts of projected monthly precipitation.

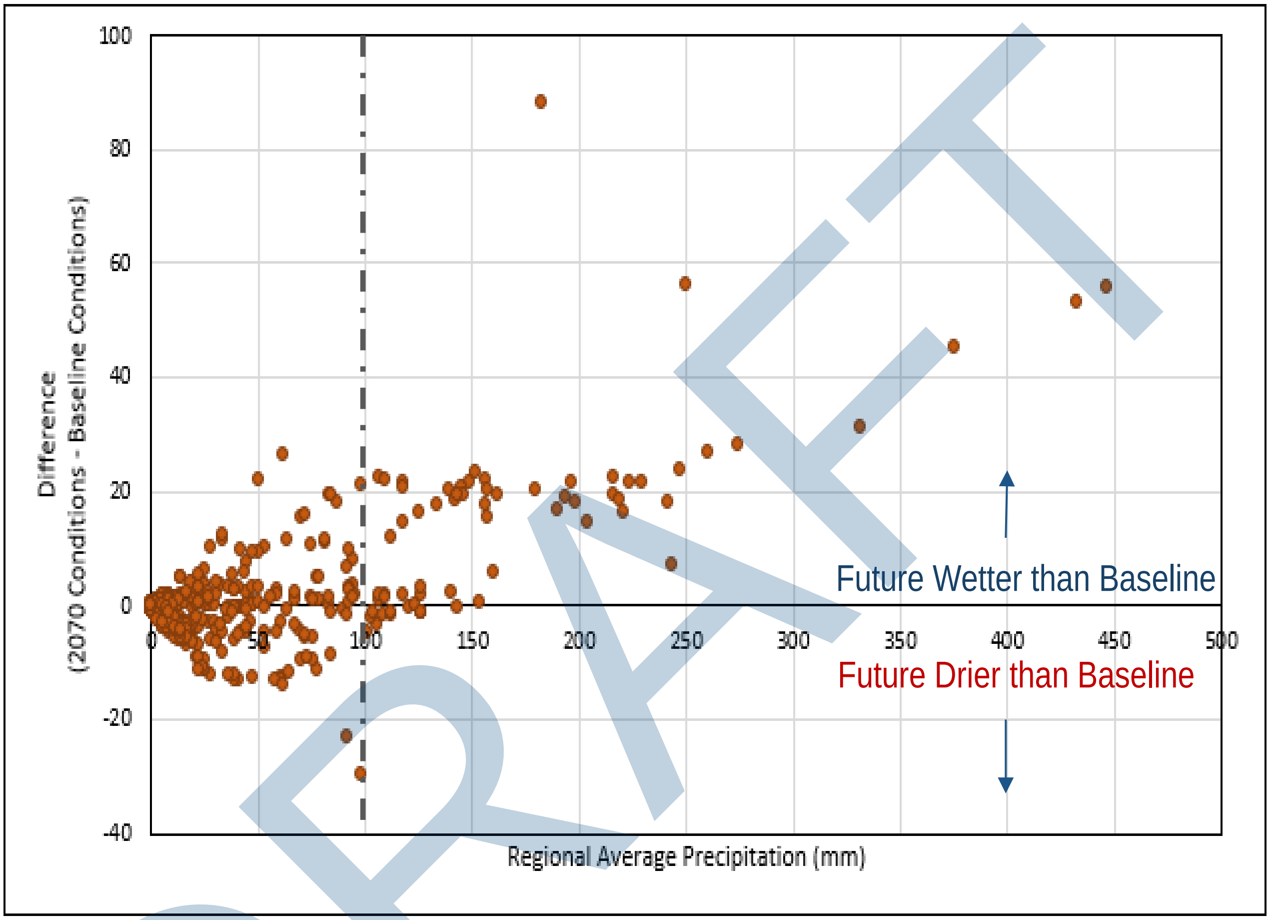

Figure C-2-4. Difference in Monthly Precipitation Estimates as Compared to Baseline Values

This plot demonstrates that in 2070 with climate change added, in low precipitation months, there is approximately equal probability that the month will be wetter or drier than historical conditions. However, under climate change, the 2070 conditions will be always wetter on average in months with precipitation above approximately 100mm. Therefore, under climate change conditions, we can see that the occurrence of low precipitation months will likely not change, but the higher precipitation months will be wetter overall than the baseline.

It is important to note that, while the central tendency scenario shows limited changes in future precipitation compared to historical record, the drier and wetter scenarios do show more variability. Figure 5 shows the exceedance curve for the wet scenario and it shows a larger difference to baseline compared to the central tendency. The use of other scenarios can be explored in future GSP updates.

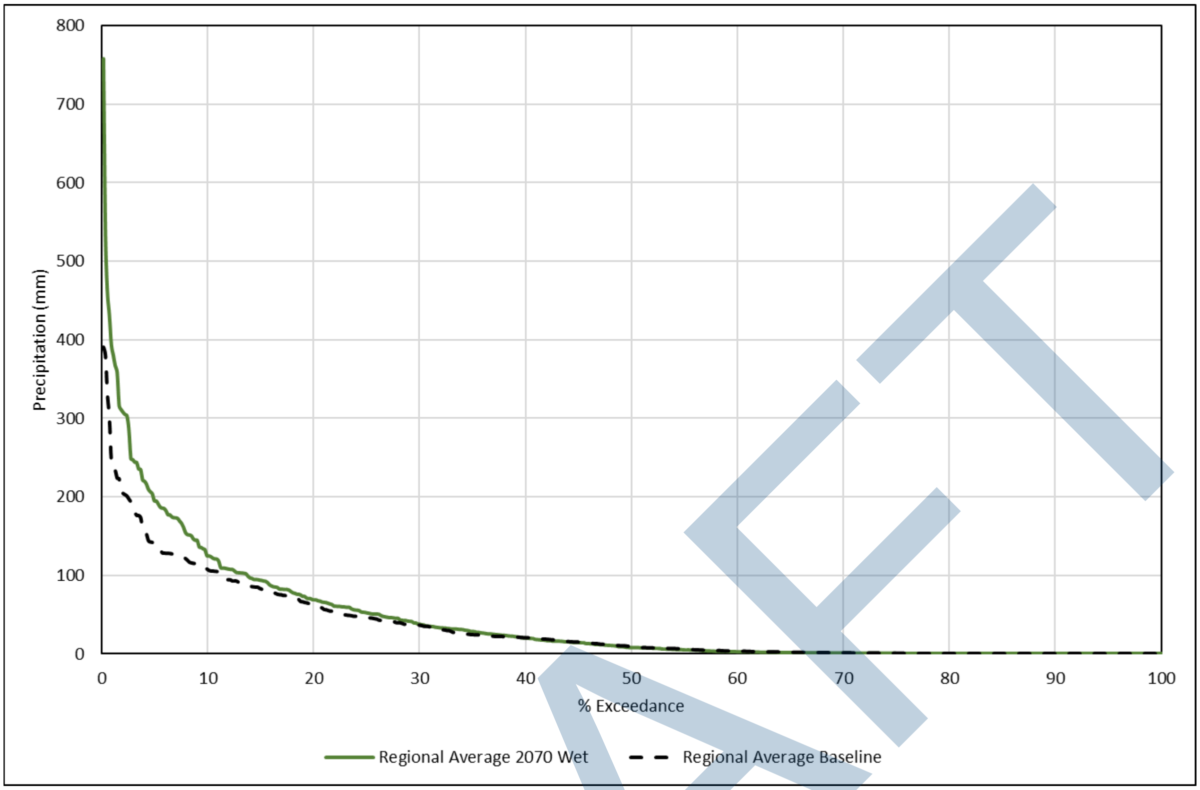

Figure C-2- 5. Exceedance of Wet Scemario Precipitation Estimates as Compared to Baseline Values

Perturbed Evapotranspiration under Climate Change

Reference evapotranspiration (ET) is differentiated only by crop in the Cuyama model. However, because there is no spatial component to ET, the same crop in a different part of the basin is modeled with the same ET. Change factors for ET are available in the same spatially distributed manner as precipitation, as described above. However, to match the level of discretization with the Cuyama model, an average ET change factor was calculated across all VIC grid cells within the Cuyama Subbasin boundary. Therefore, the tool to process ET provided by DWR was not needed or used. Change factors provided by DWR for WY 1964 through December 1, 2011 were averaged. This average ET change factor was then applied to the baseline ET time series for each crop type. Because the same ET change factor was applied over the entire baseline time series, no synthesis was required in this analysis.

- For 2030, average change factor is: **1.03**
- For 2070, average change factor is: **1.07**

To better show the impact of climate change, a sample of years (1994 & 1995) for one crop (Melons) is included in Figure C-2-6. Figure C-2-7 shows the exceedance curve for these estimates.

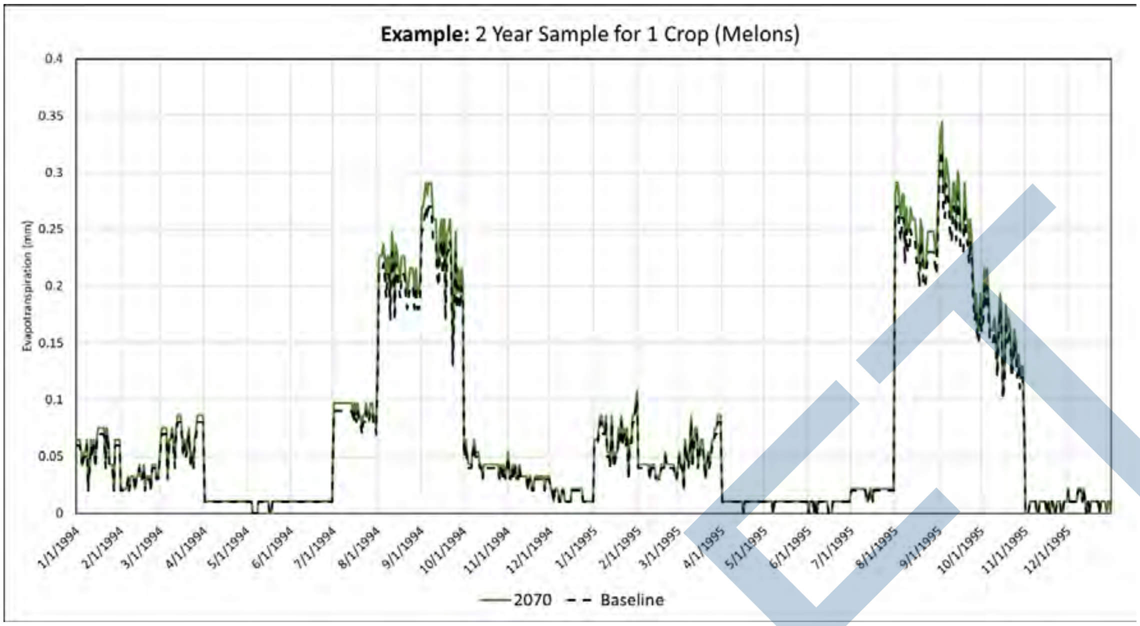

Figure C-2-6. Changes in Melon Evapotranspiration in 1994 & 1995 as Compared to Baseline Values

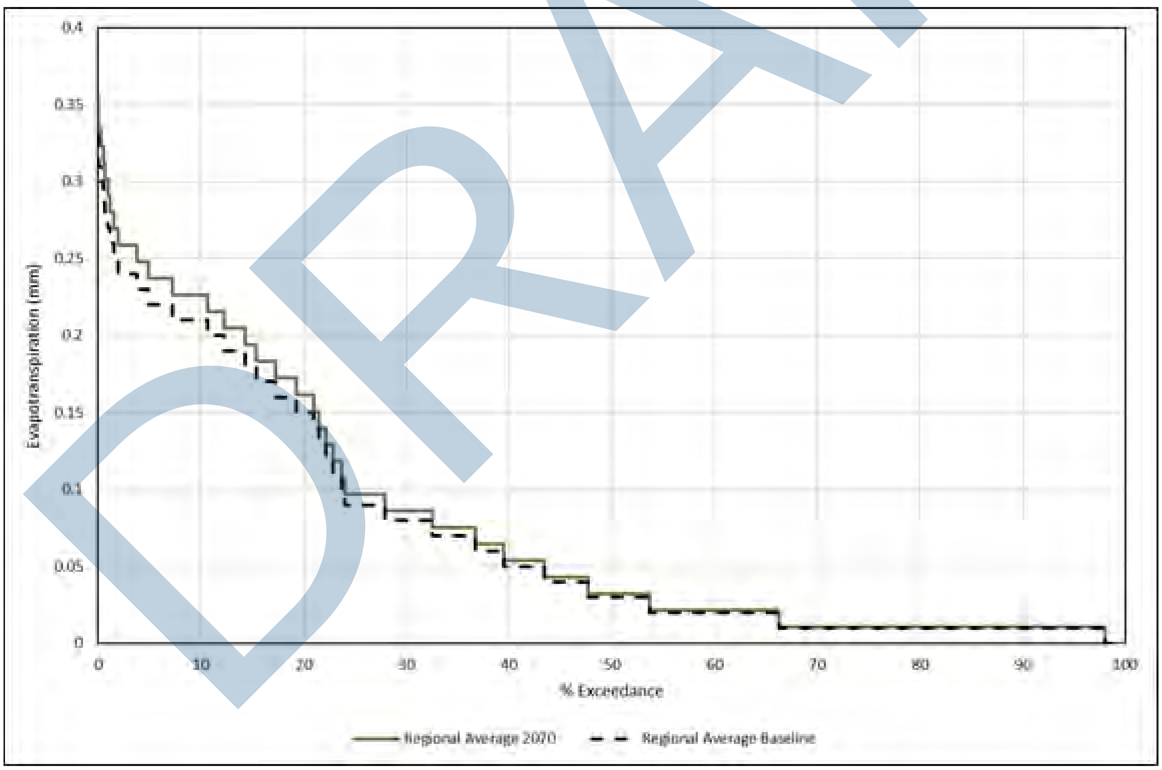

Figure C-2-7. Exceedance of Melon Evapotranspiration in 1994 & 1995 as Compared to Baseline Values

Considerations for this Analysis

By using DWR's climate change datasets, this GSP has chosen to use a climate period analysis. A "period of analysis" method is what DWR proposes since it provides an intuitive way to compare the past and future conditions, preserving historical temporal trends. Under a period of analysis (sometimes referred to as the "delta method") precipitation and Crop ET patterns from the past are mirrored into the future and shifted either higher or lower in magnitude (DWR, 2018). When using a period of analysis method, any difference between the baseline historical conditions and the projected conditions can be attributed only to climate change.

Using a climate period analysis in contrast to a transient analysis, however, brings also some disadvantages. While a significant advantage of this method is that the climate change signal can be isolated from signals of other impacts, temporal changes in the water resources system are ignored in favor of adopting the temporal trends of the past. In a continuously changing and variable climate in California, this approach incurs significant disadvantages. Inter-annual variability in the climate period analysis follows the exact patterns of the historical period it references. Shifting seasonality of precipitation, peak snowmelt, and temperature, are important climate impacts expected through the GSP planning horizon that are not captured in the projected water budget (Langridge, Sepaniak, Fencl, & Mendez, 2018) (PPIC, 2019). Longer drought period than have been recorded historically are also expected according to many climate experts (PPIC, 2019). These changes are also not captured.

Opportunities for Future Refinement

The regulations dictate that GSPs reflect the best available science to make climate change projections. For future GSP updates, climate change analysis incorporation should build off of this baseline work to continually improve projections into the future. Some refinements or modifications may include:

- Use other scenarios (dry and wet) in addition to the central tendency scenario
- Use a transient method as opposed to a period of record method
- Incorporate paleohydrology observations and make inferences about the impacts of longer droughts captured in the paleorecord

1.3 References

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Attachment C-3

Groundwater Level Hydrographs for Calibration Wells

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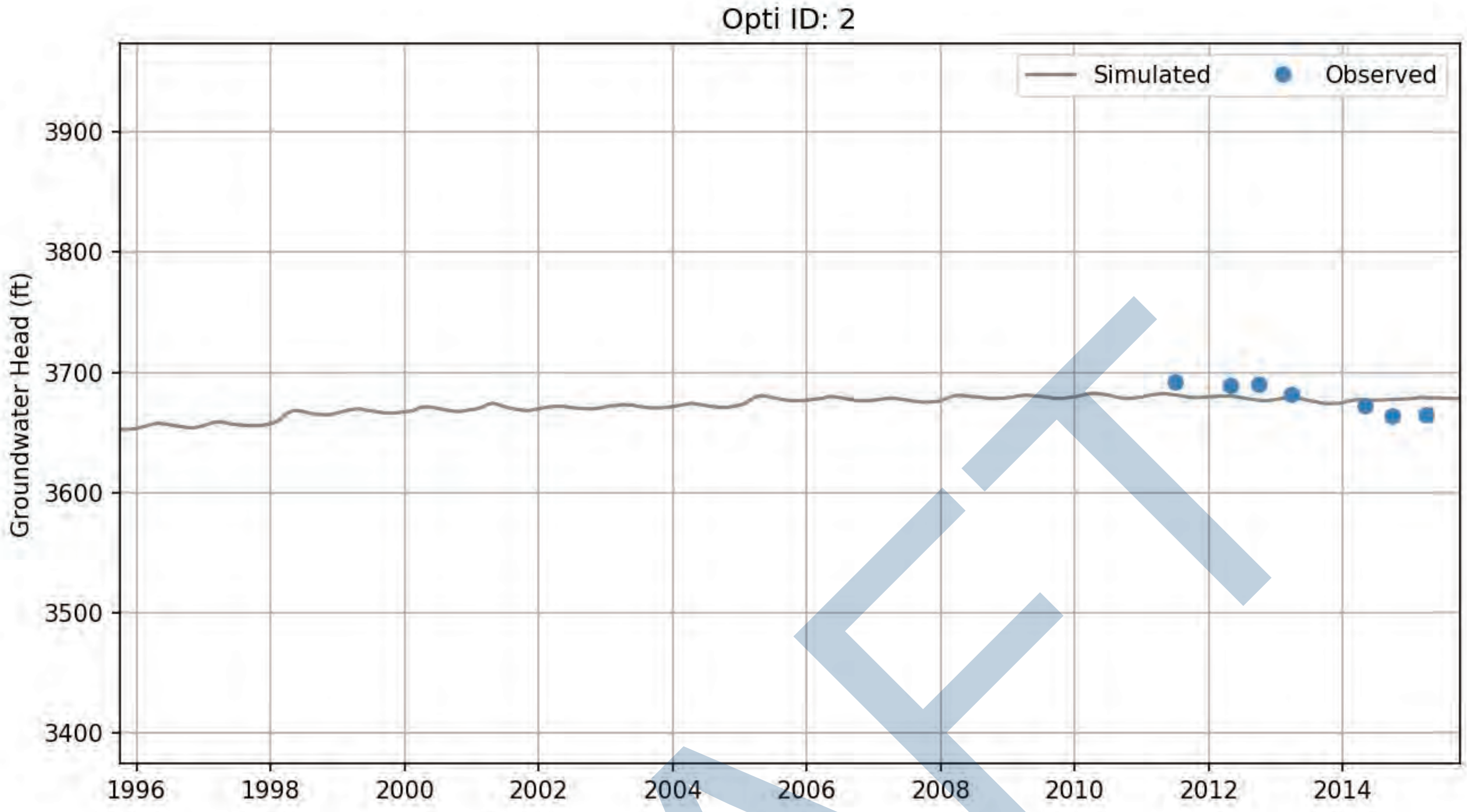

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Observed
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3600
3500
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1998
2000
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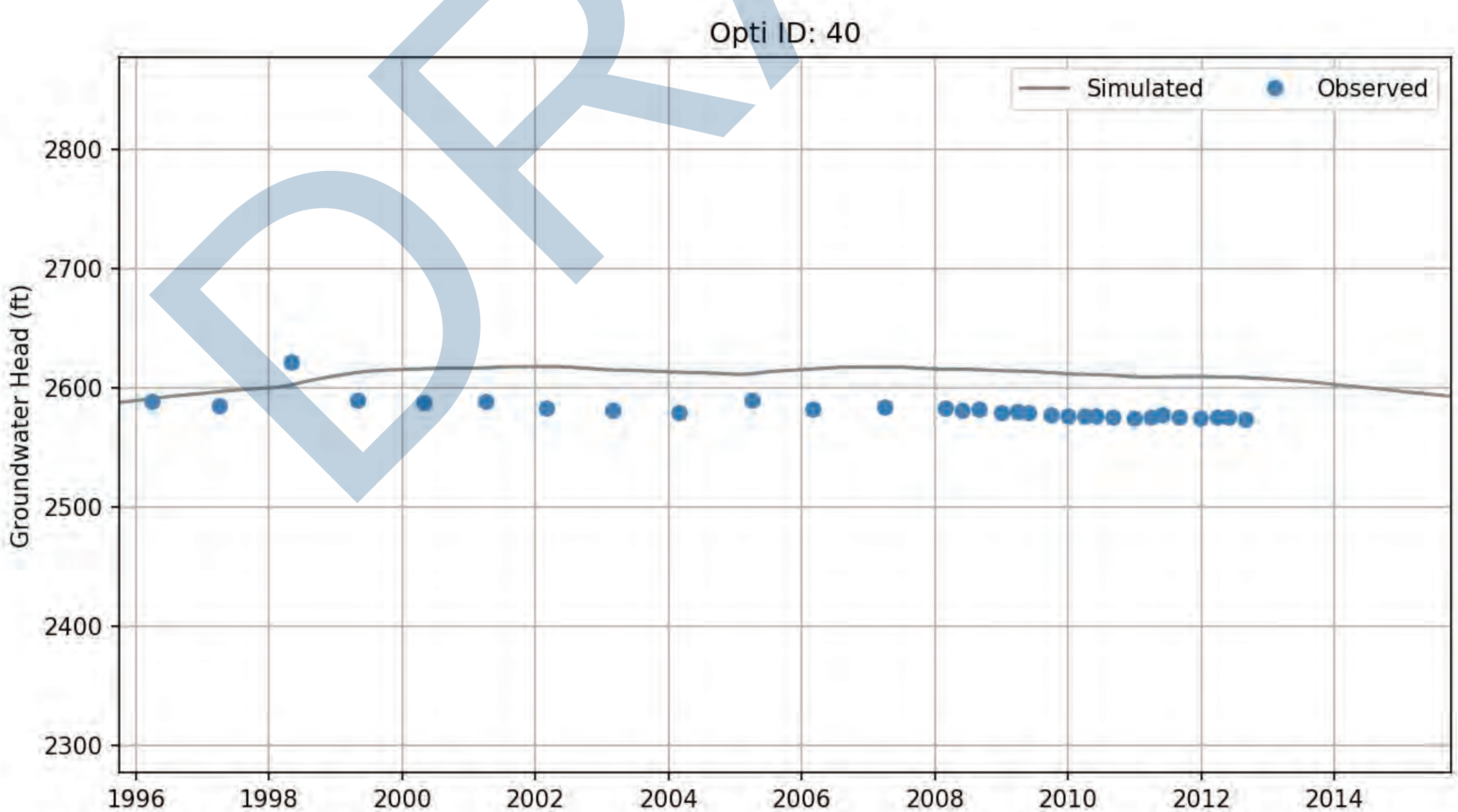
2006
2008
2010
2012
2014



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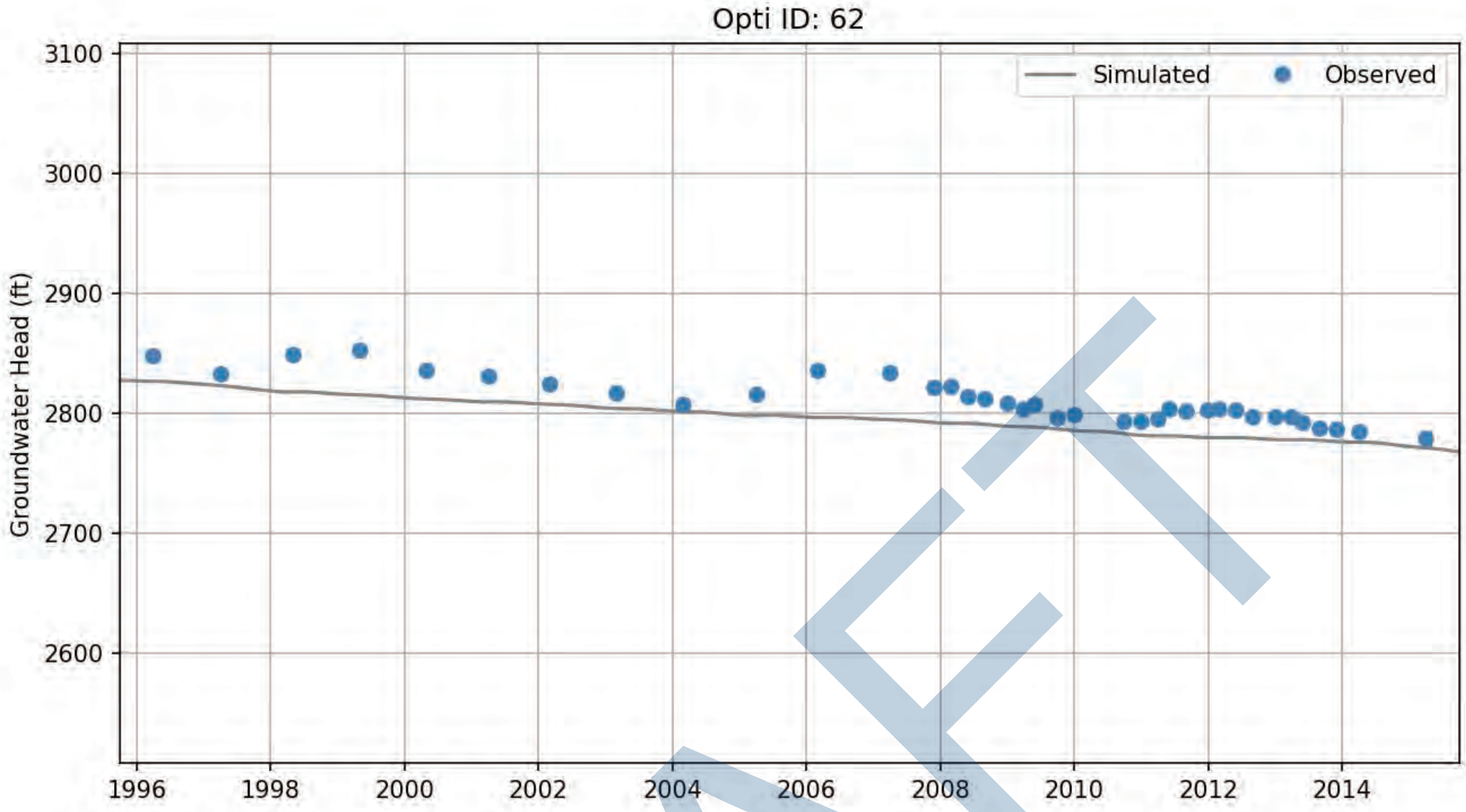
2600
2500
2400
2300
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014



Opti ID: 62
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Groundwater Head (ft)
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3000
2900
2800
2700
2600
1996
1998
2000
2002
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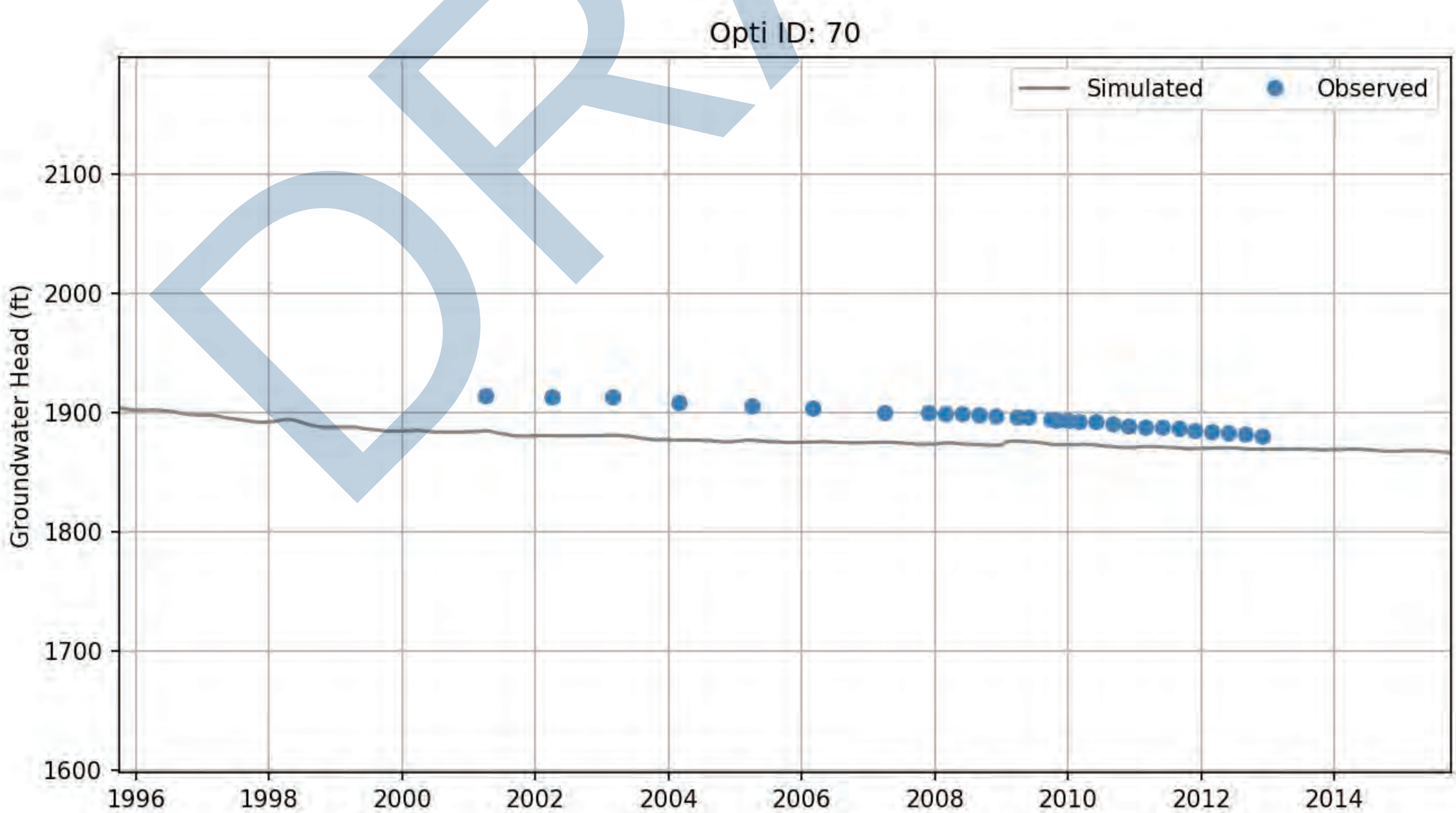
2006
2008
2010
2012
2014



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Observed
Groundwater Head (ft)
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1900
1800
1700
1600
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2000
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2006
2008
2010
2012
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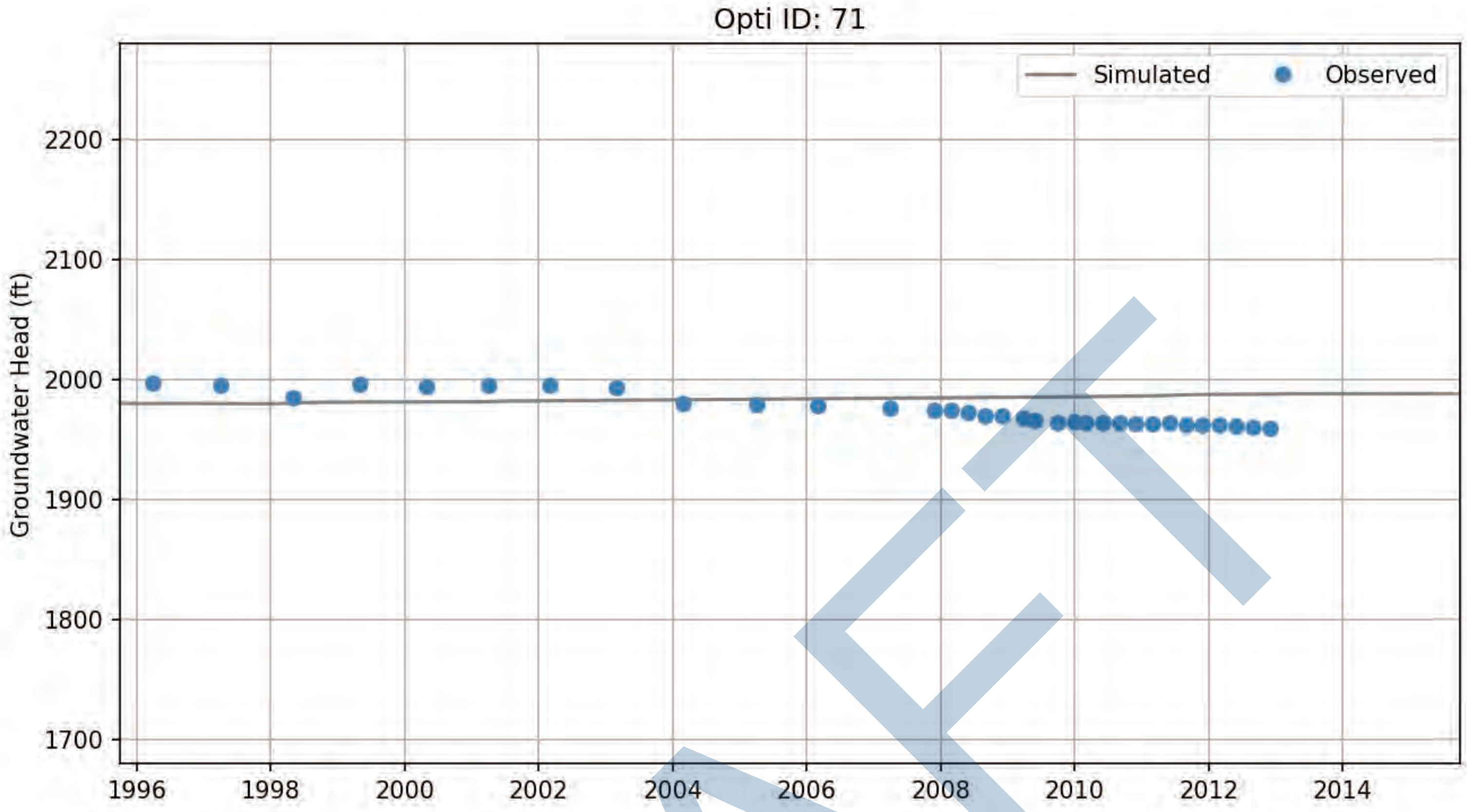

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1800
1700
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2000
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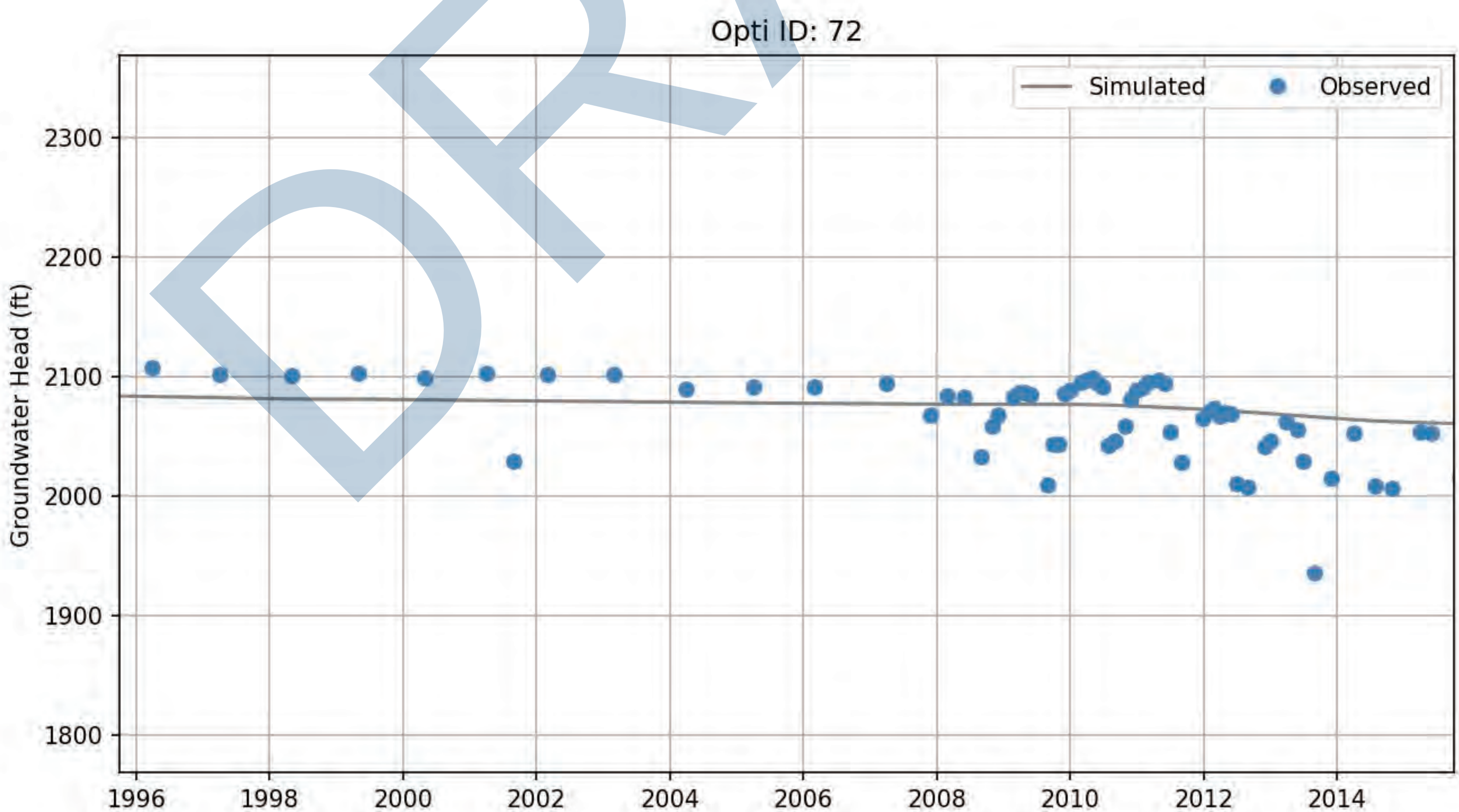
2006
2008
2010
2012
2014



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Groundwater Head (ft)
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2000
1900
1800
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2006
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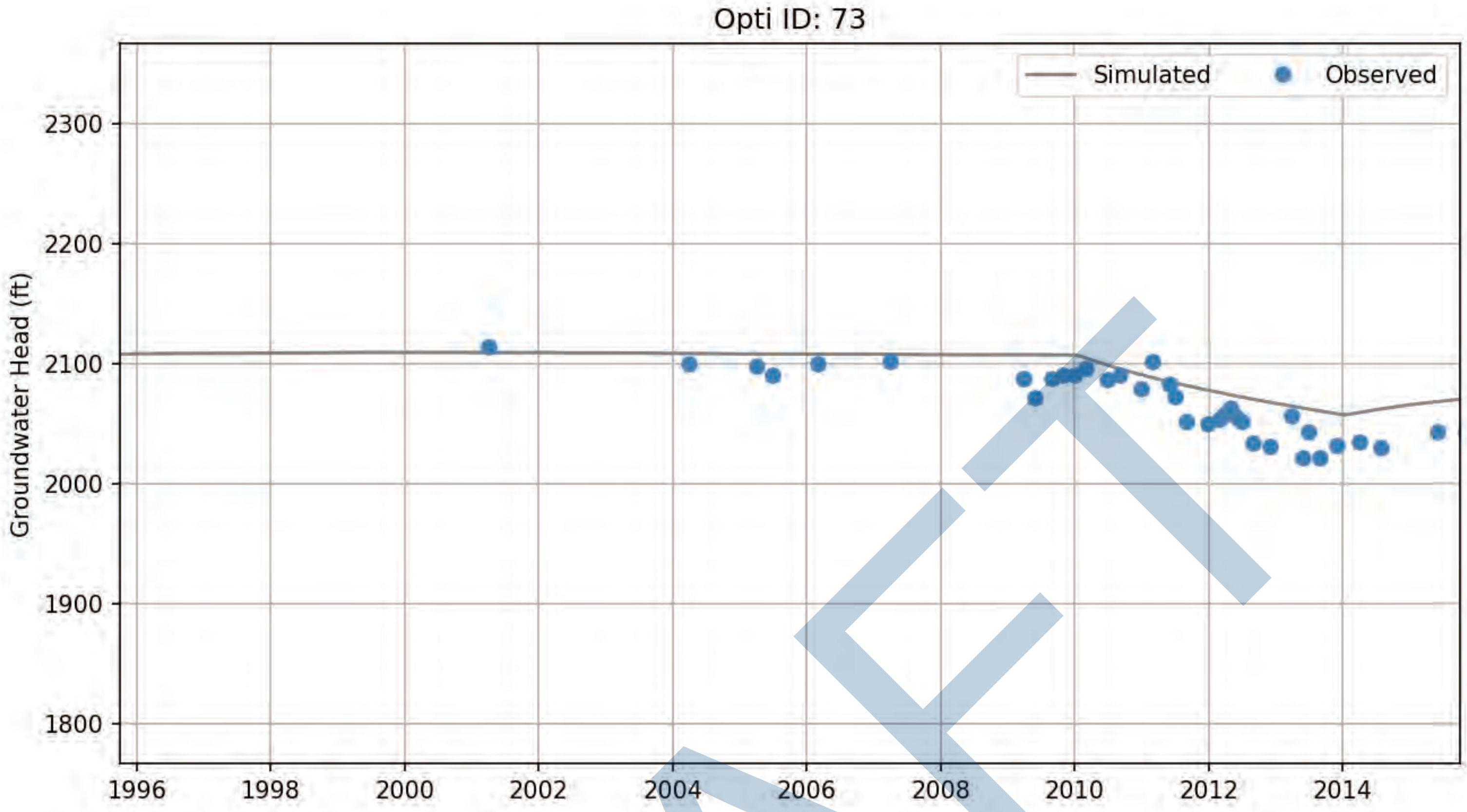
2010
2012
2014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Groundwater Head (ft)
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1800
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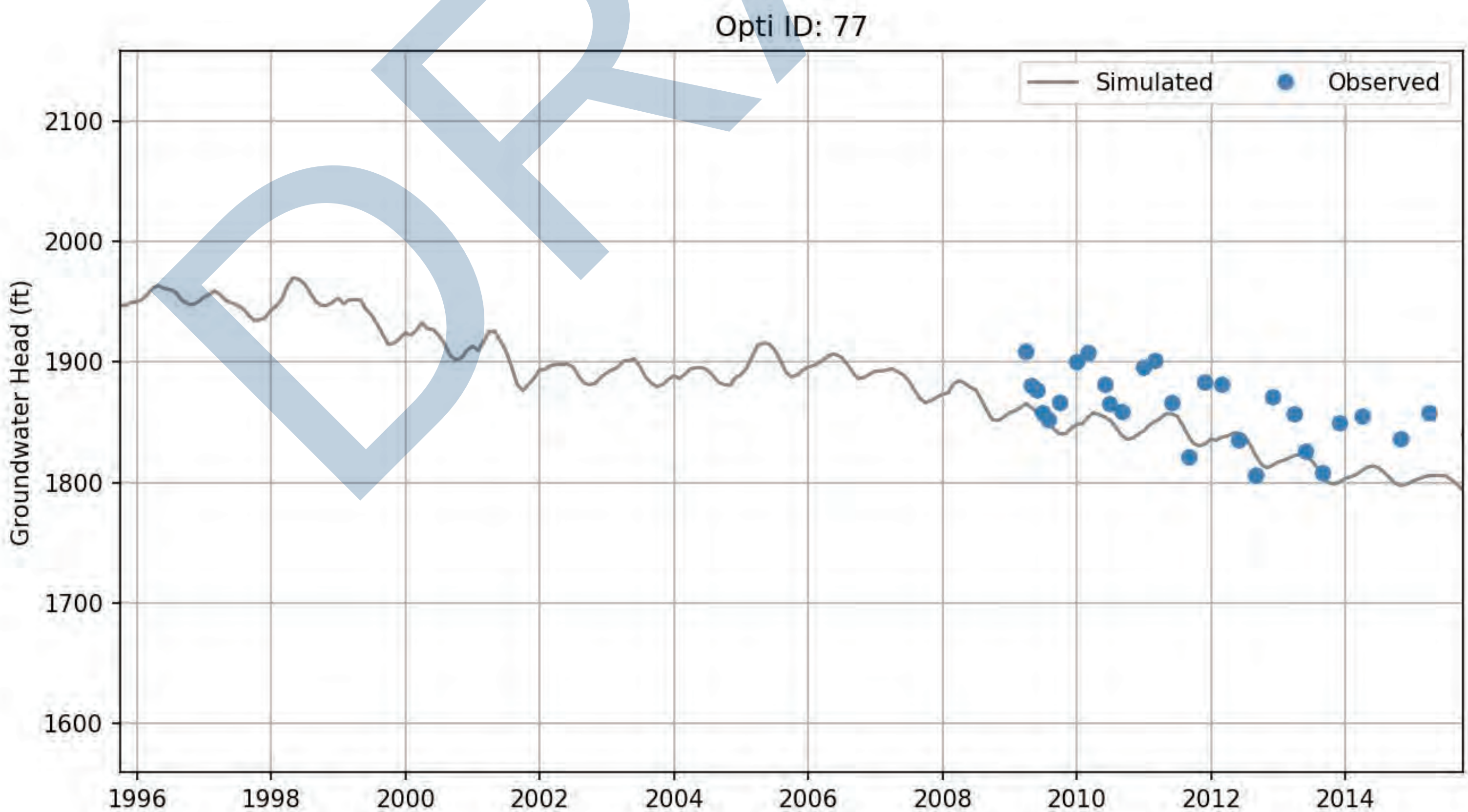
2012
2014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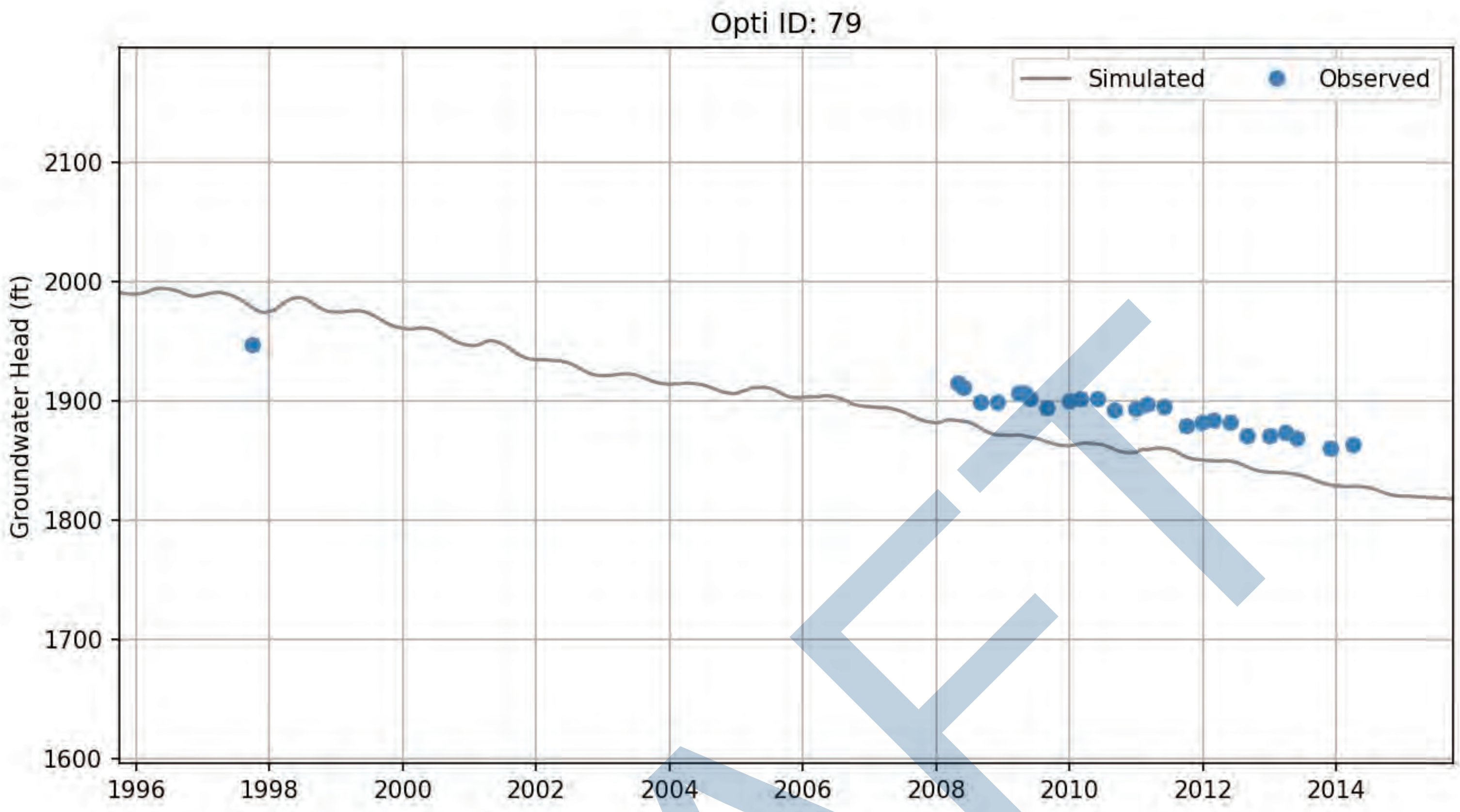
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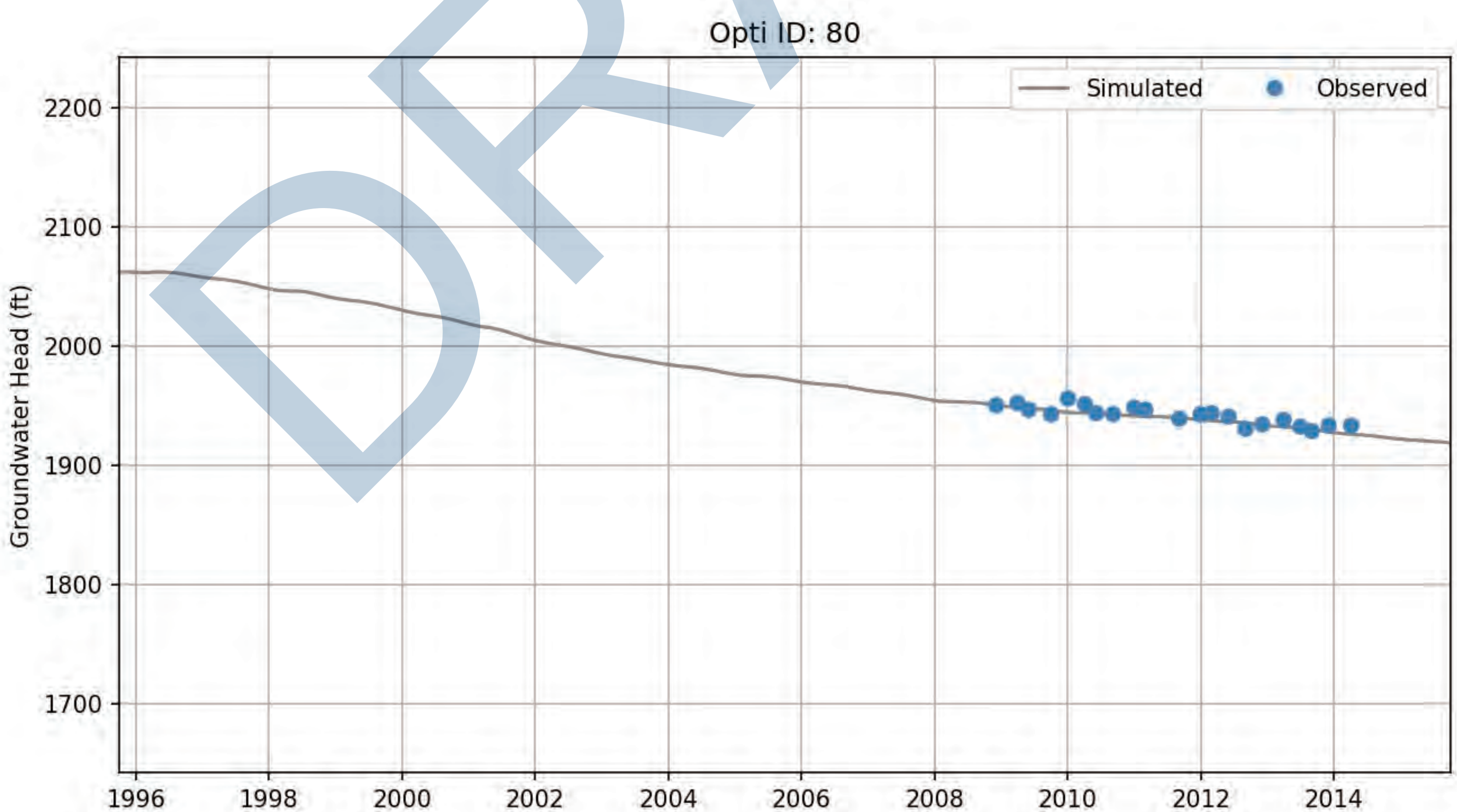
2014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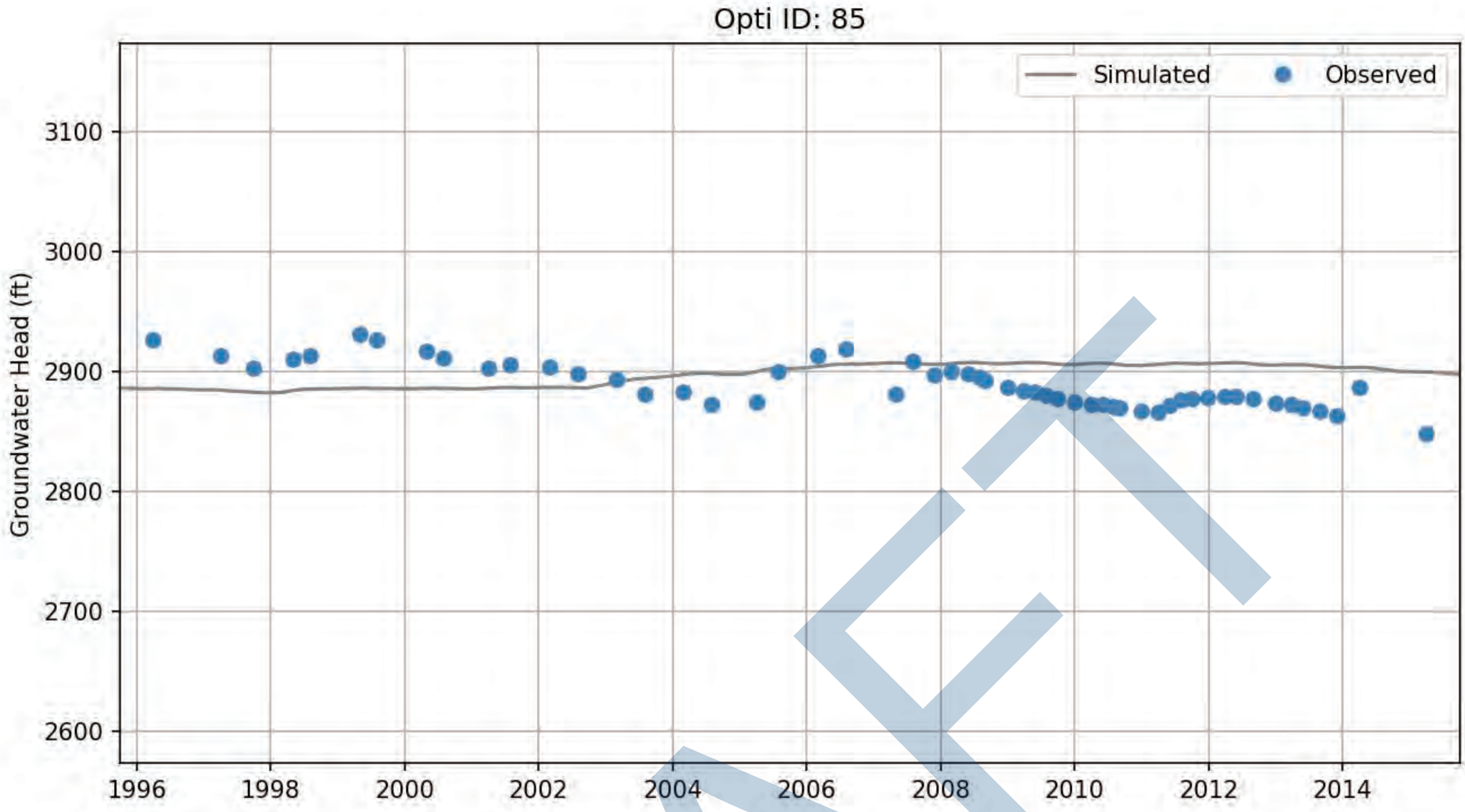
2010
2012
2014



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Observed
Groundwater Head (ft)
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2900
2800
2700
2600
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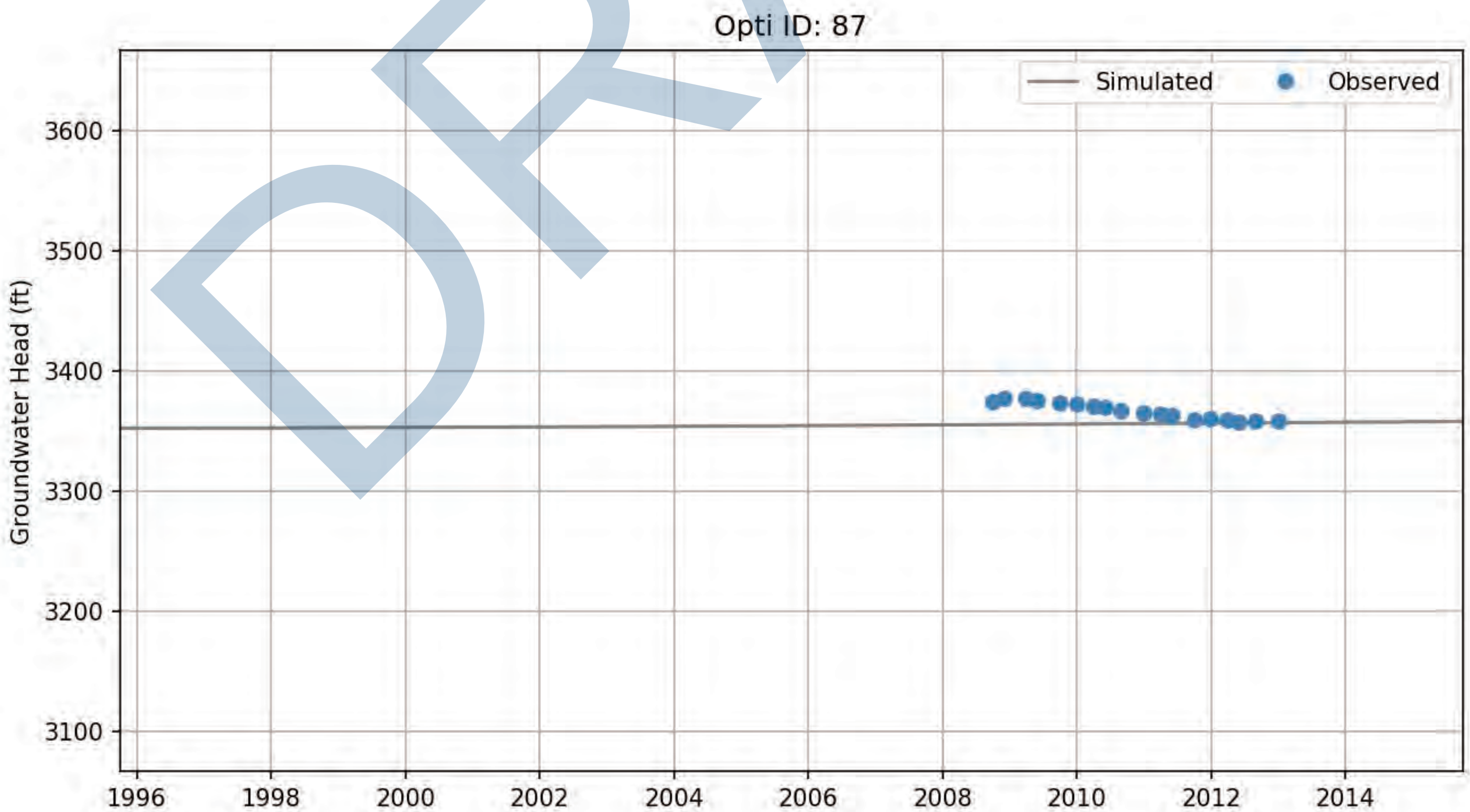
1998
2000
2002
2004
2006
2008
2010
2012
2014



Opti ID: 87
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Groundwater Head (ft)
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3500
3400
3300
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3100
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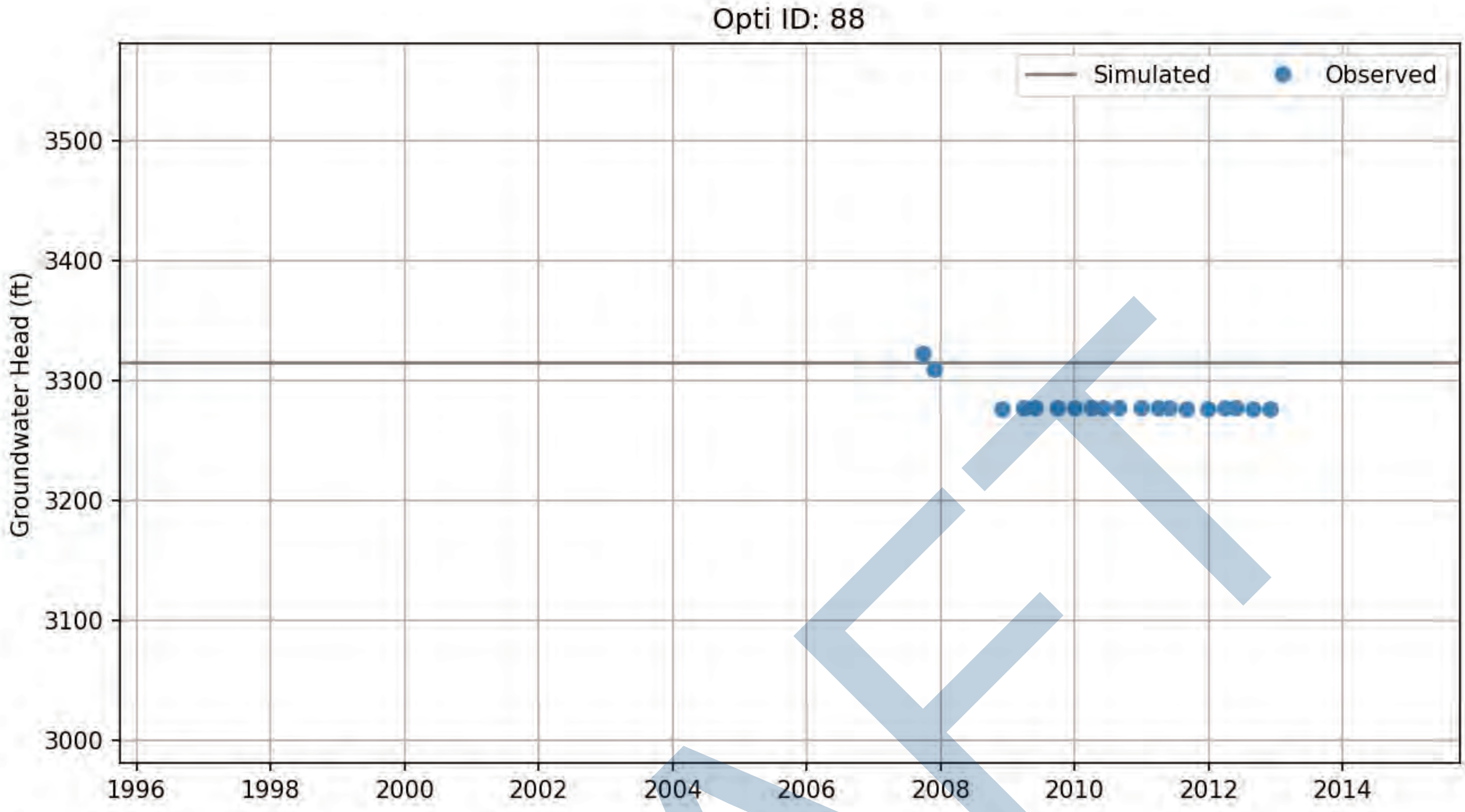
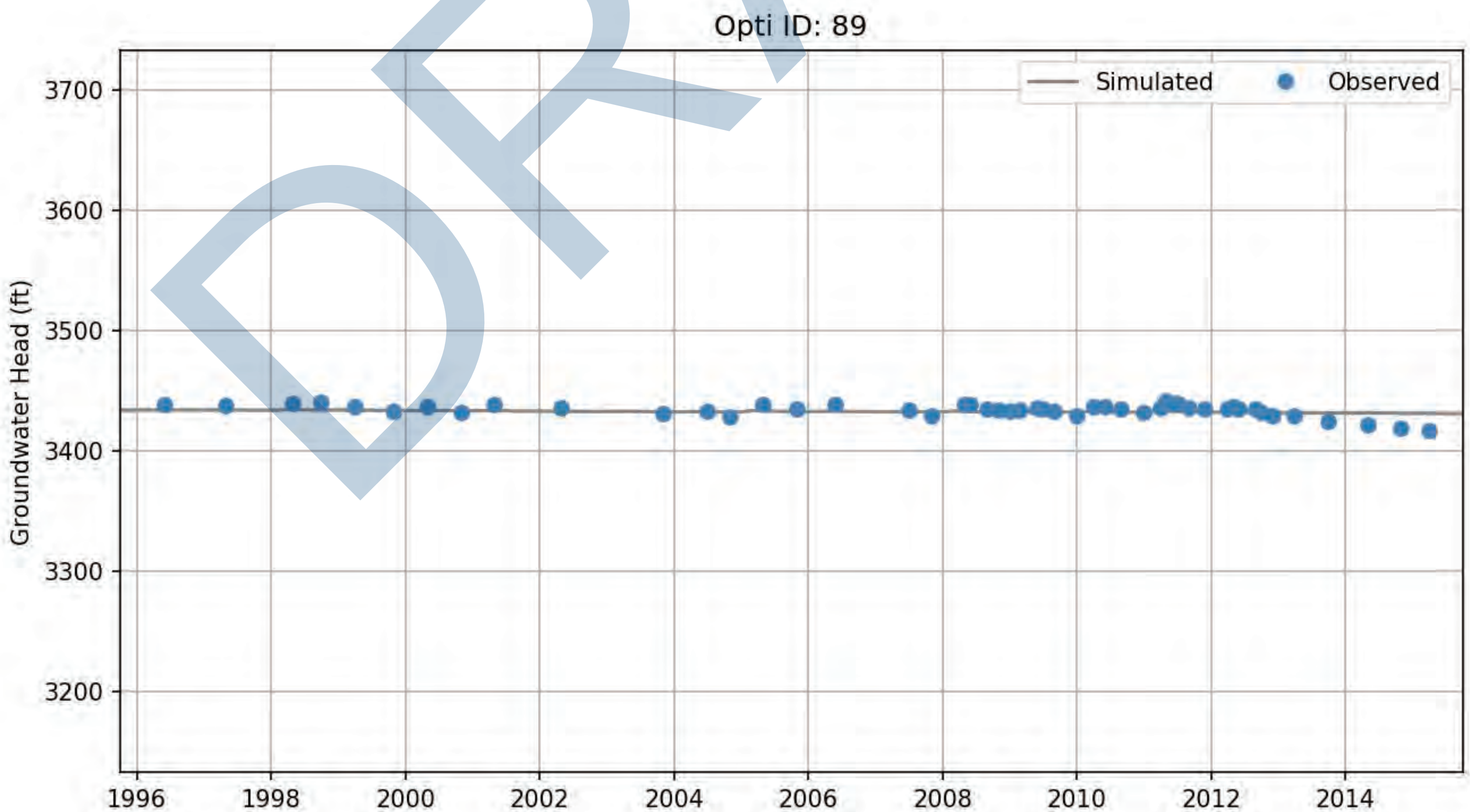
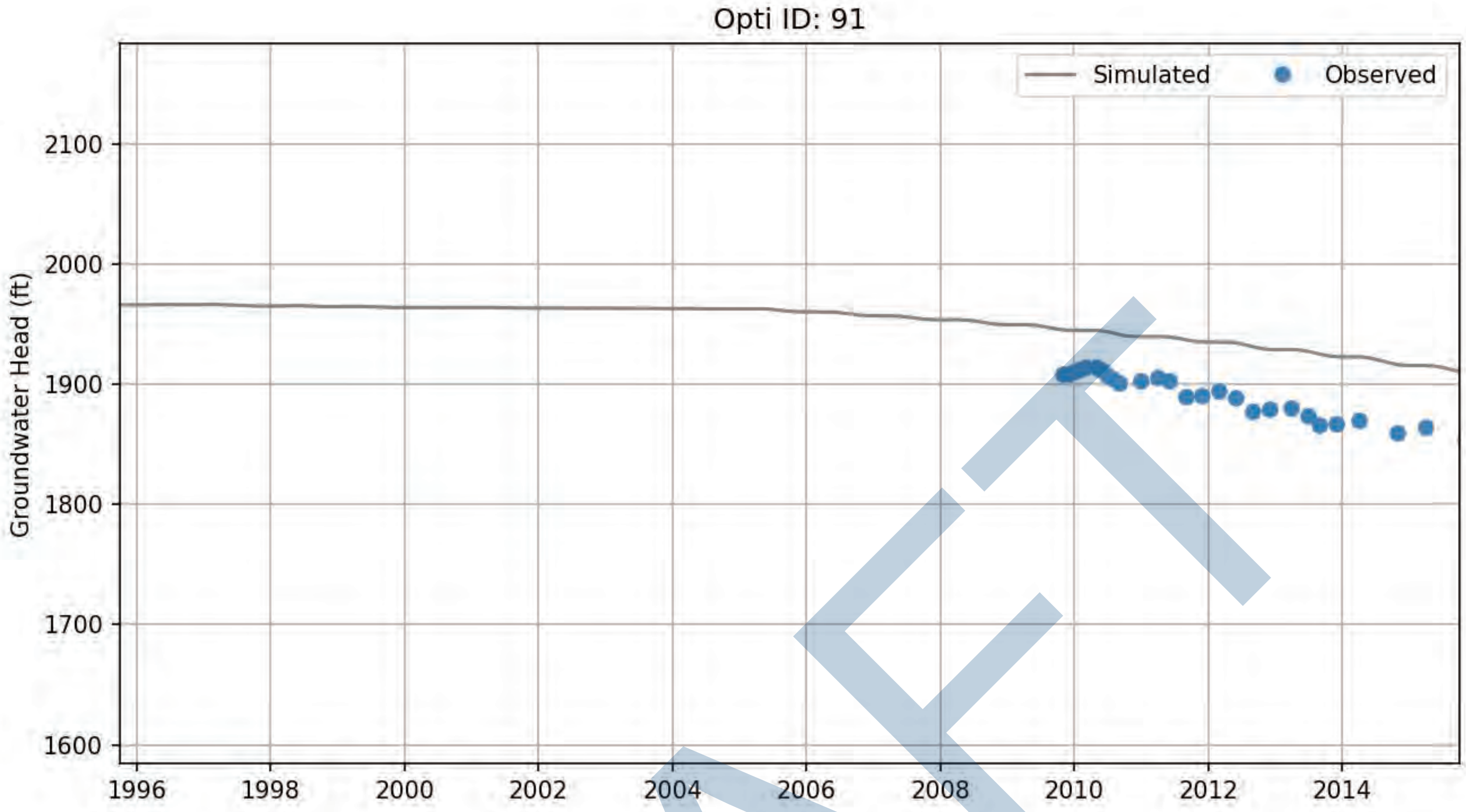
1998
2000
2002
2004
2006
2008
2010
2012
2014

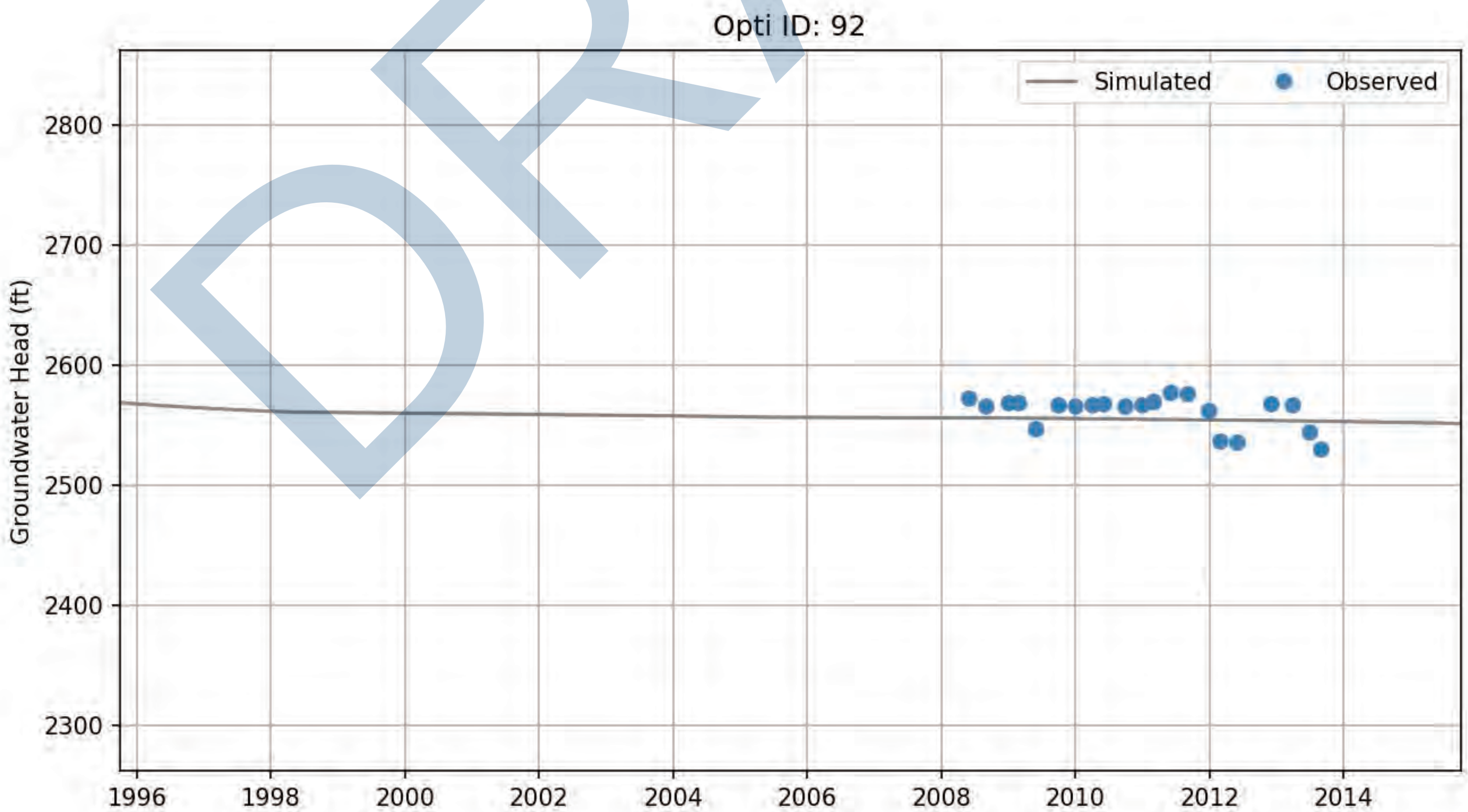


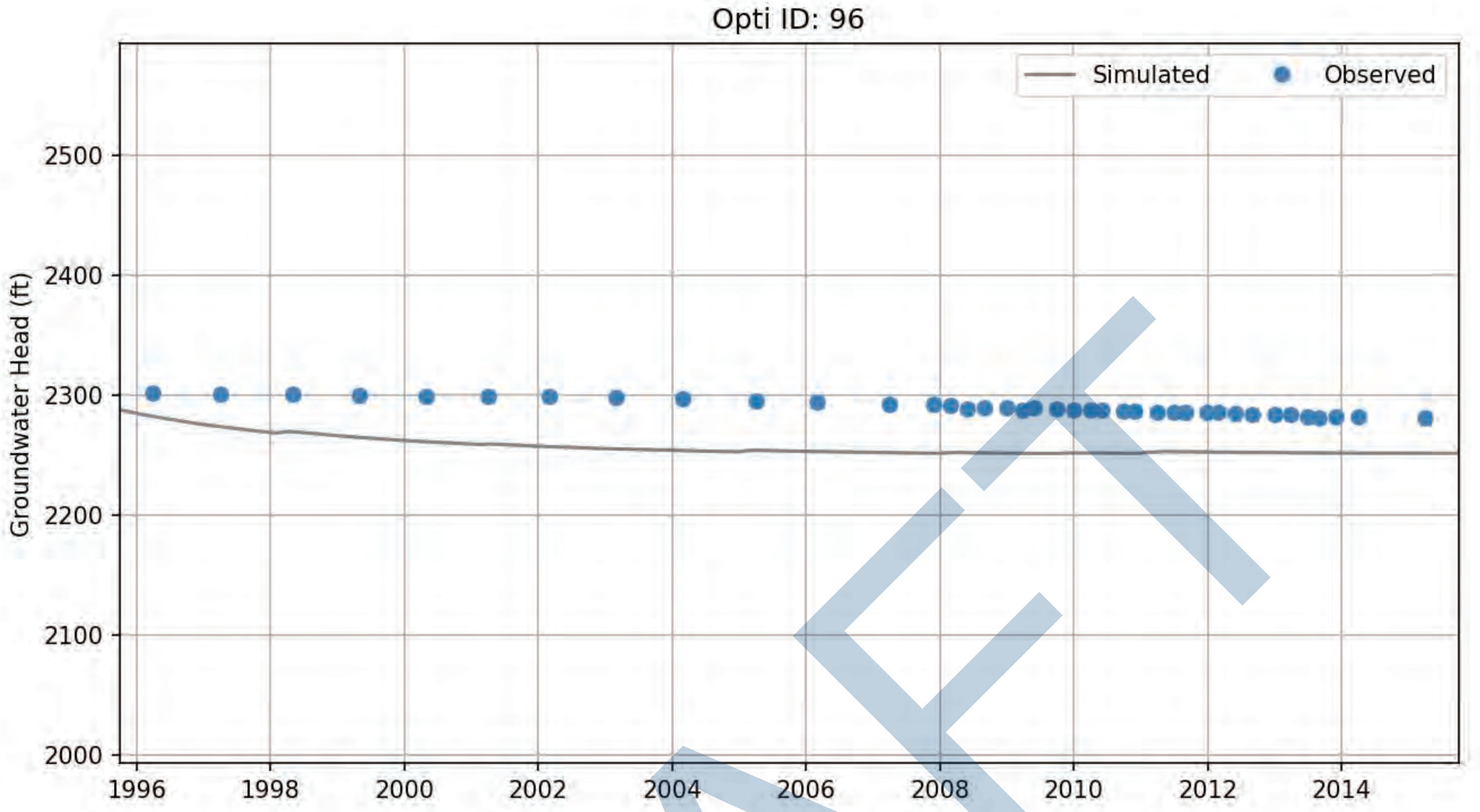
Opti ID: 88
Simulated
Observed
Groundwater Head (ft)
3500
3400
3300
3200
3100
3000
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

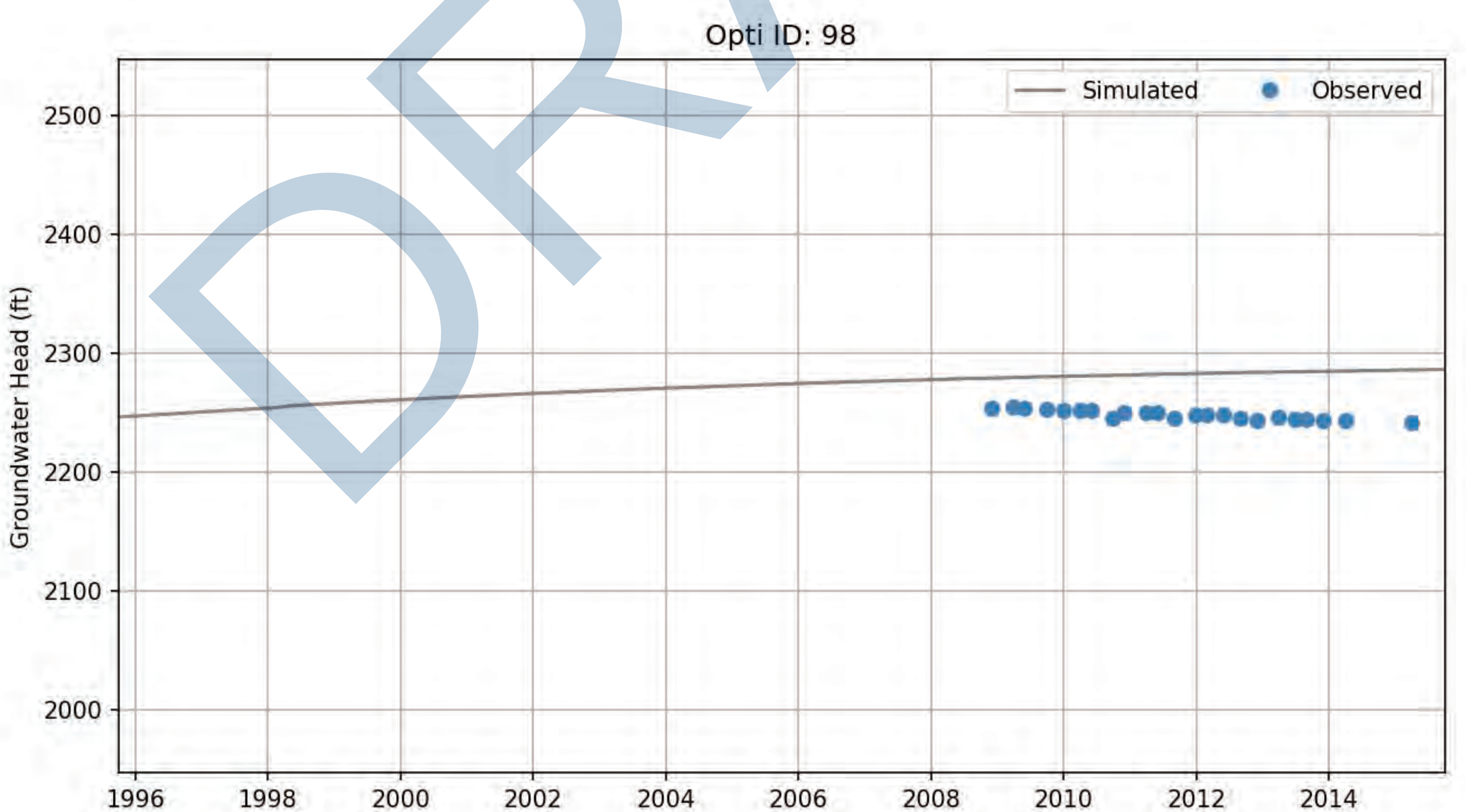


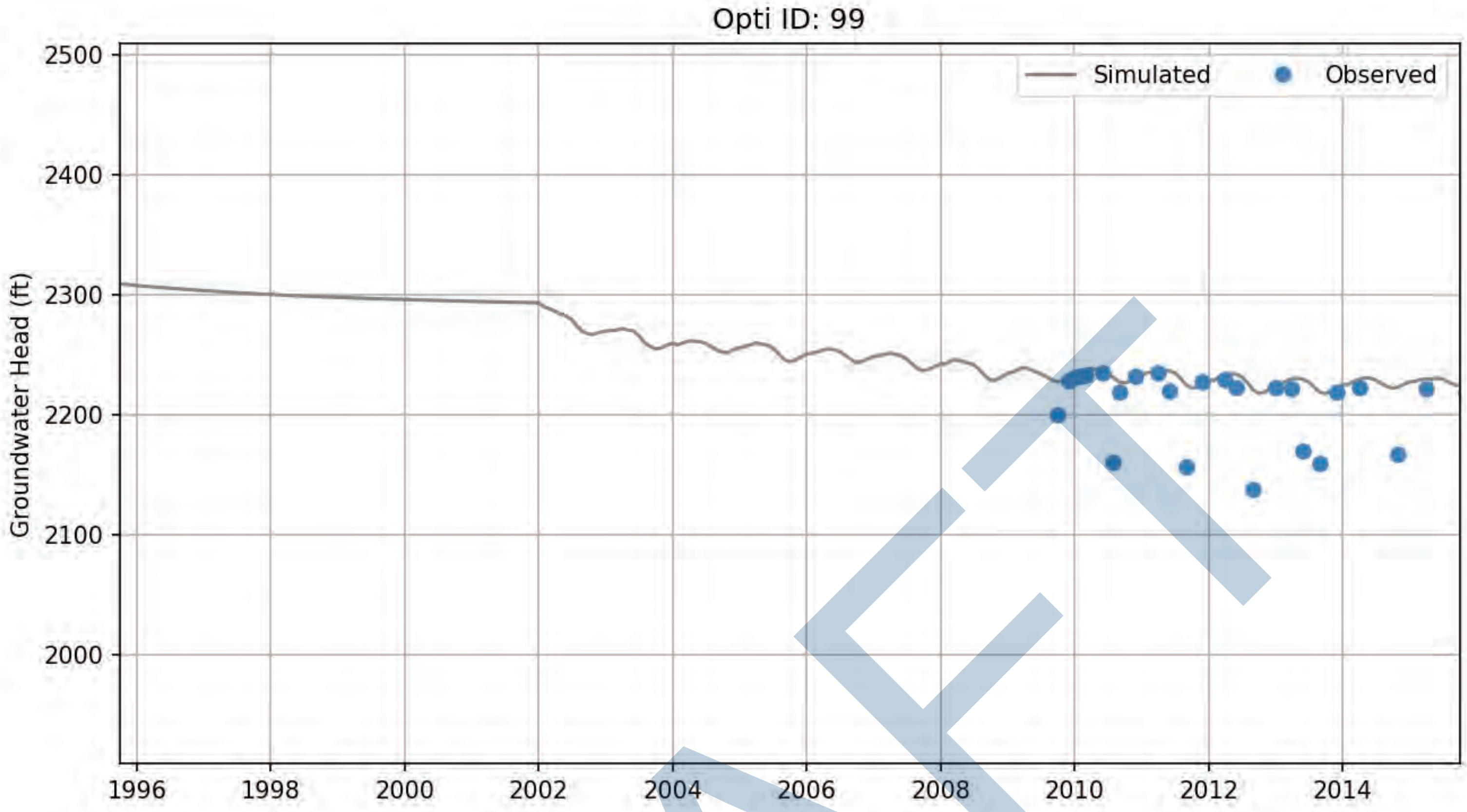
Opti ID: 89
Simulated
Observed
Groundwater Head (ft)
3700
3600
3500
3400
3300
3200
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

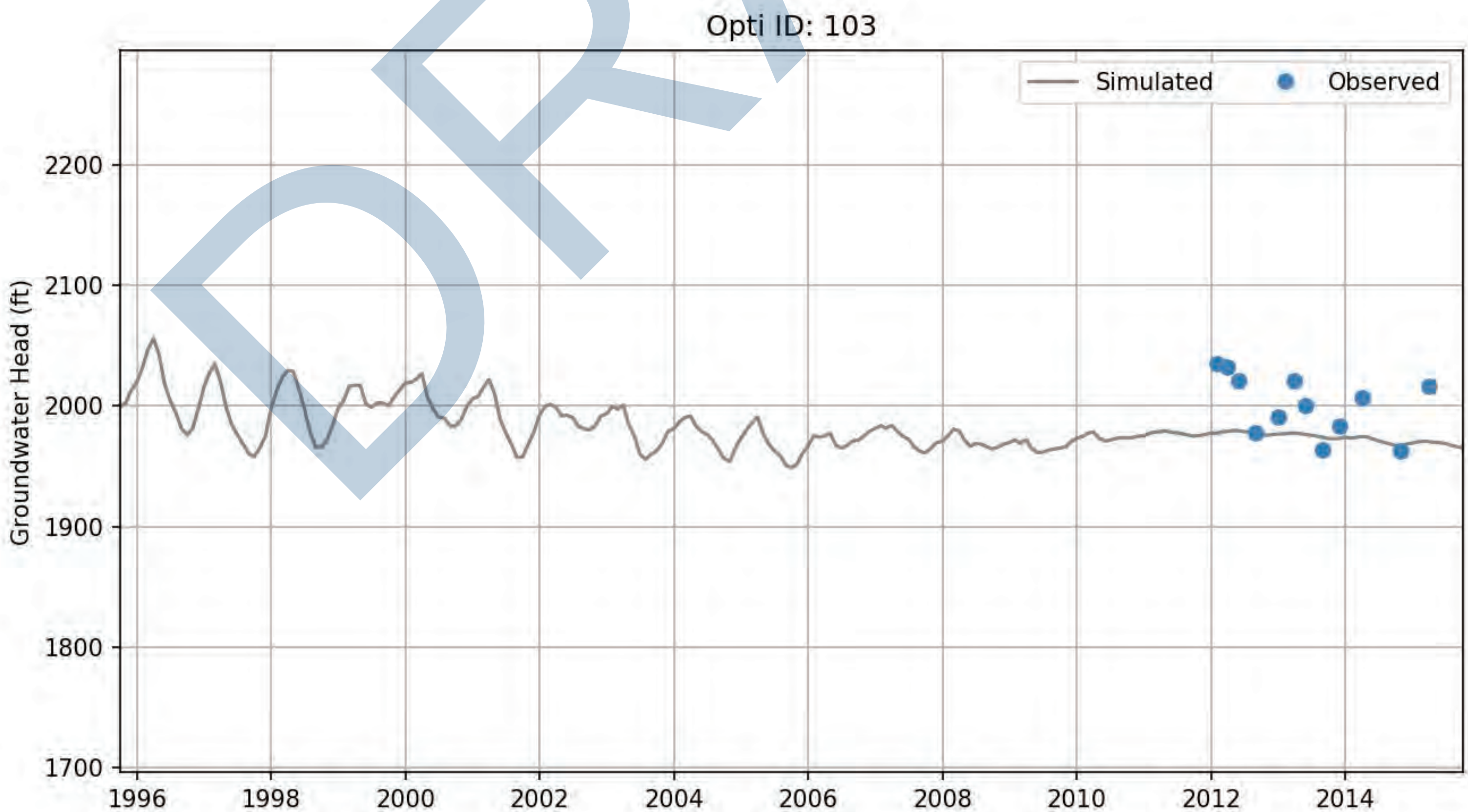

Opti ID: 91
Simulated
Observed
Groundwater Head (ft)
2100
2000
1900
1800
1700
1600
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

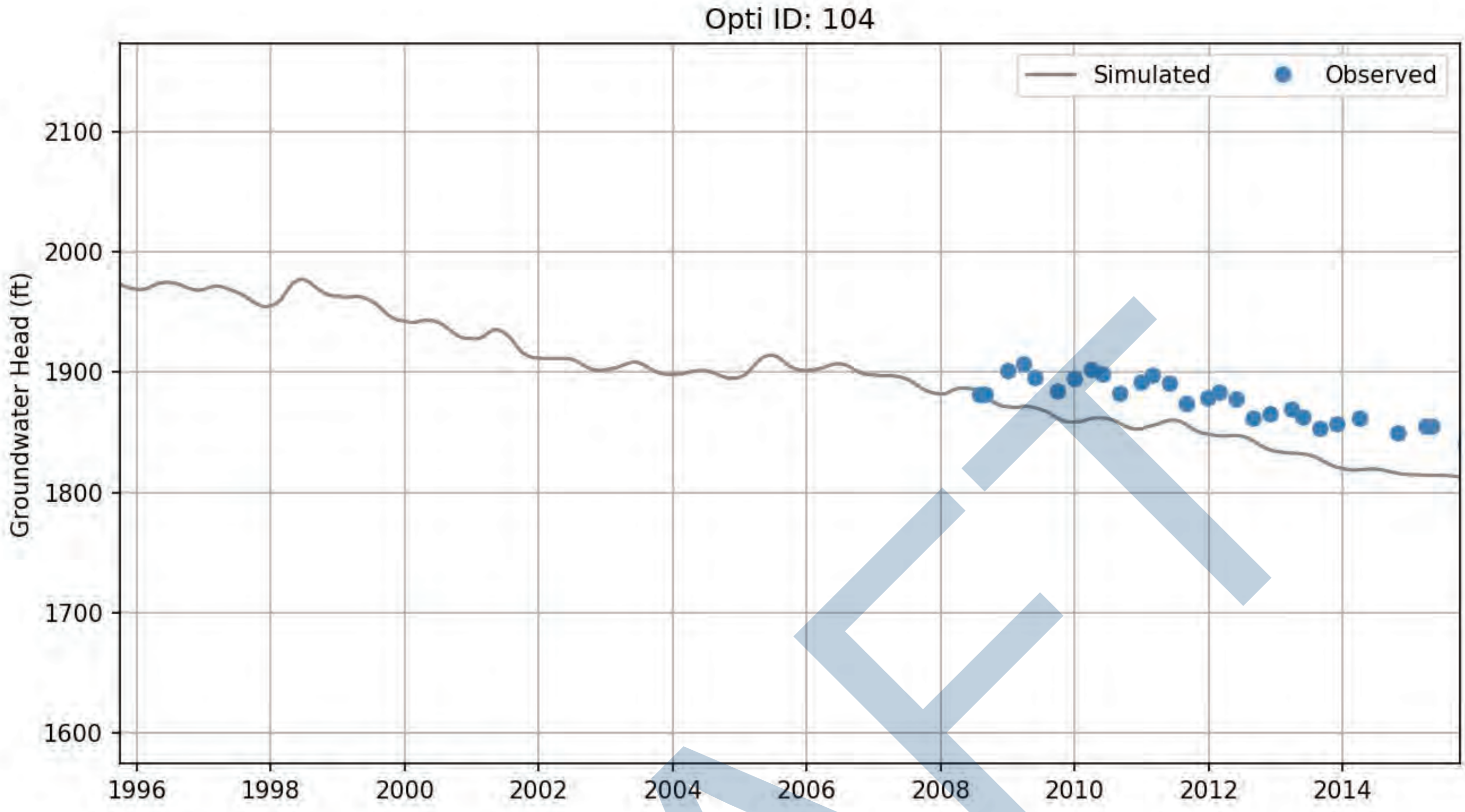

Opti ID: 92
Simulated
Observed
Groundwater Head (ft)
2800
2700
2600
2500
2400
2300
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

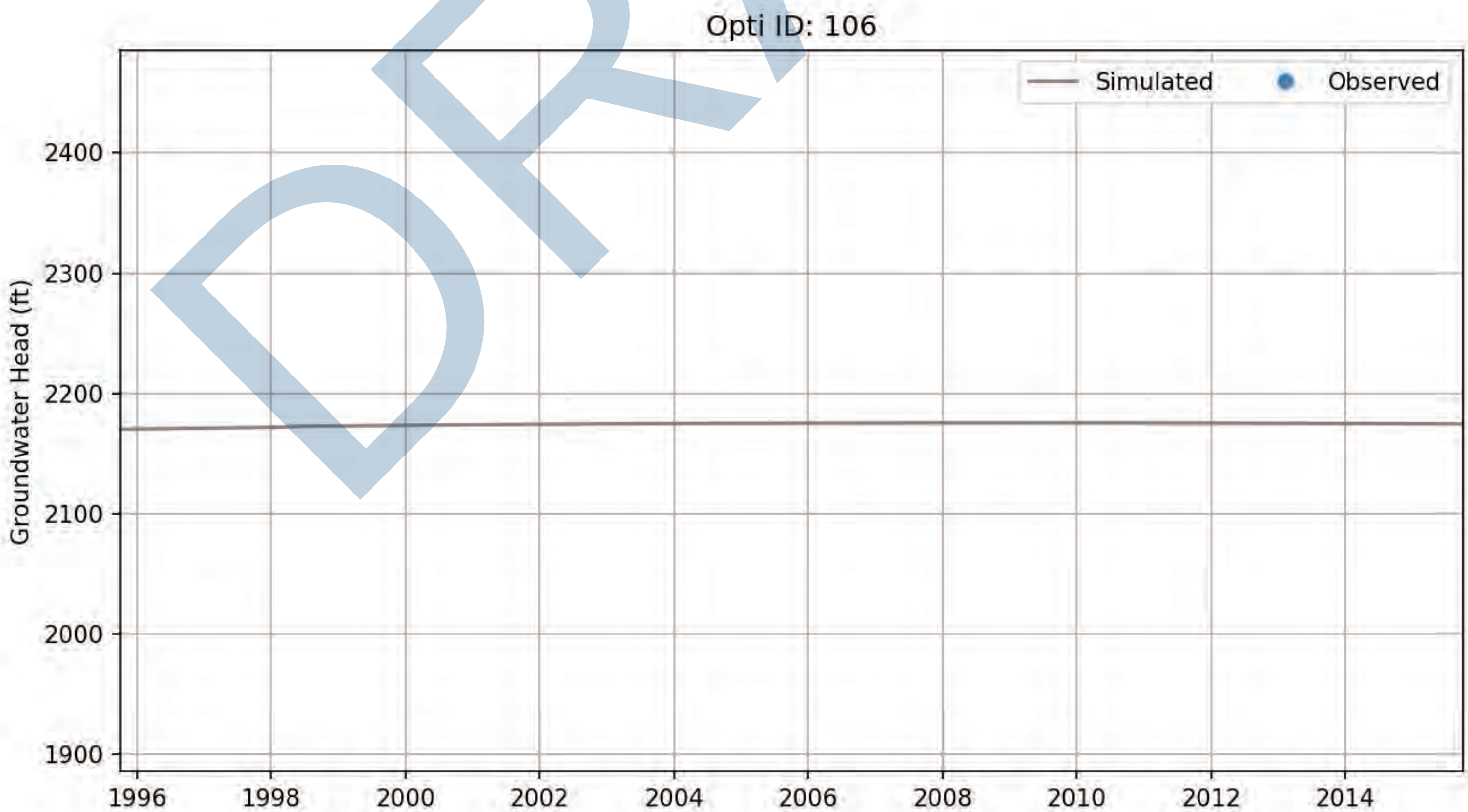

Opti ID: 96
Simulated
Observed
Groundwater Head (ft)
2500
2400
2300
2200
2100
2000
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

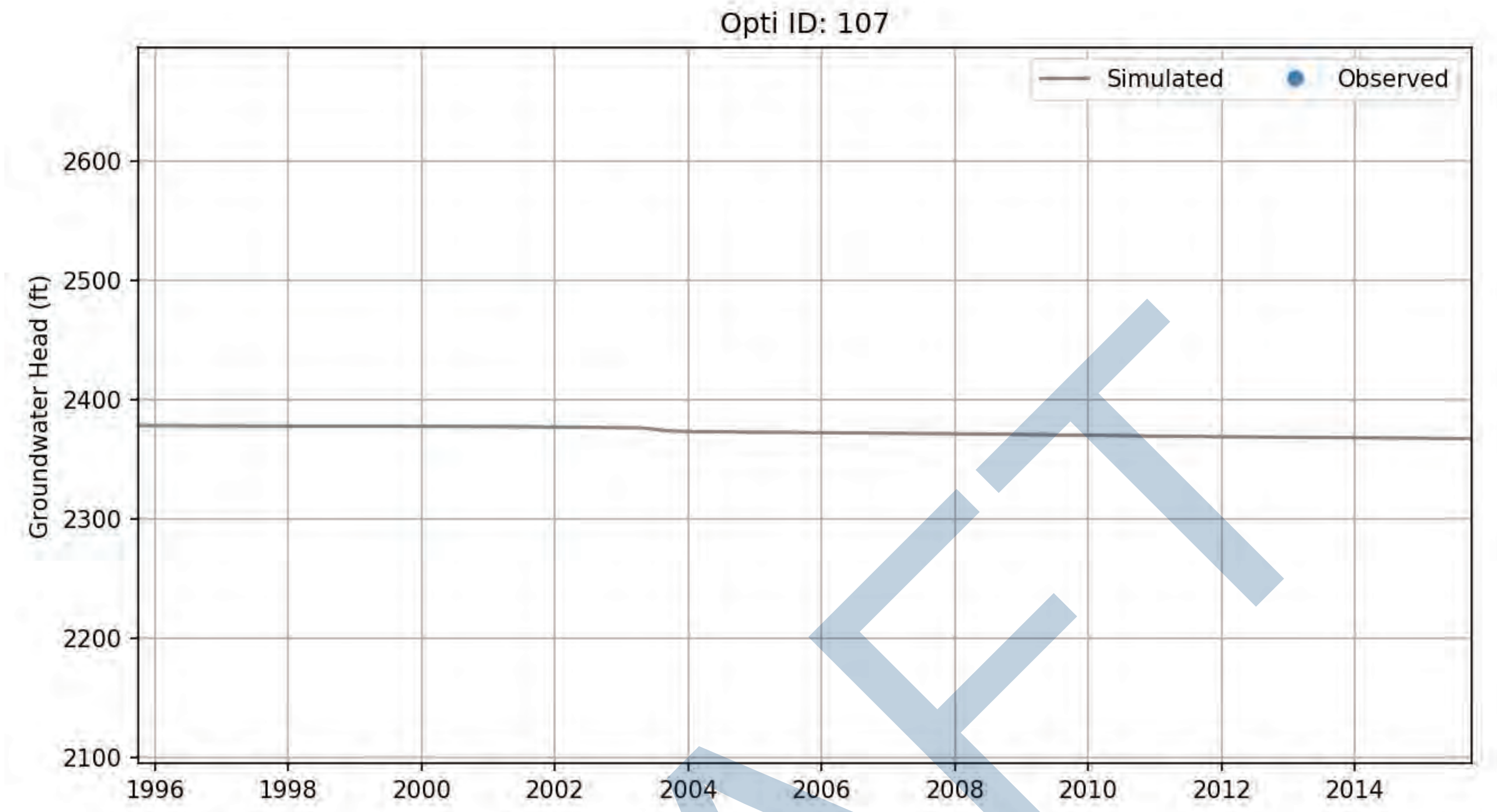

Opti ID: 98
Simulated
Observed
Groundwater Head (ft)
2500
2400
2300
2200
2100
2000
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

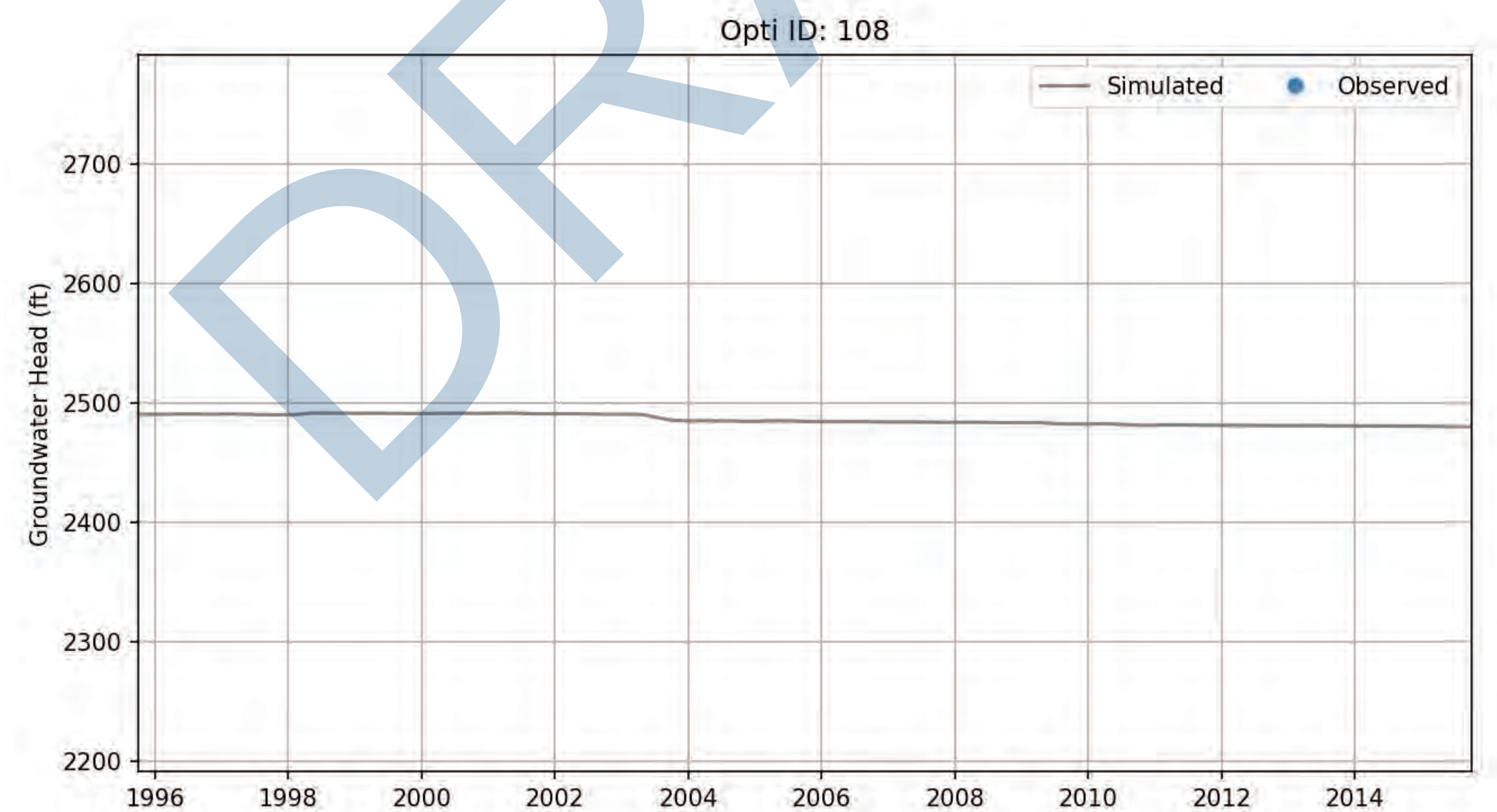

Opti ID: 99
Simulated
Observed
Groundwater Head (ft)
2500
2400
2300
2200
2100
2000
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

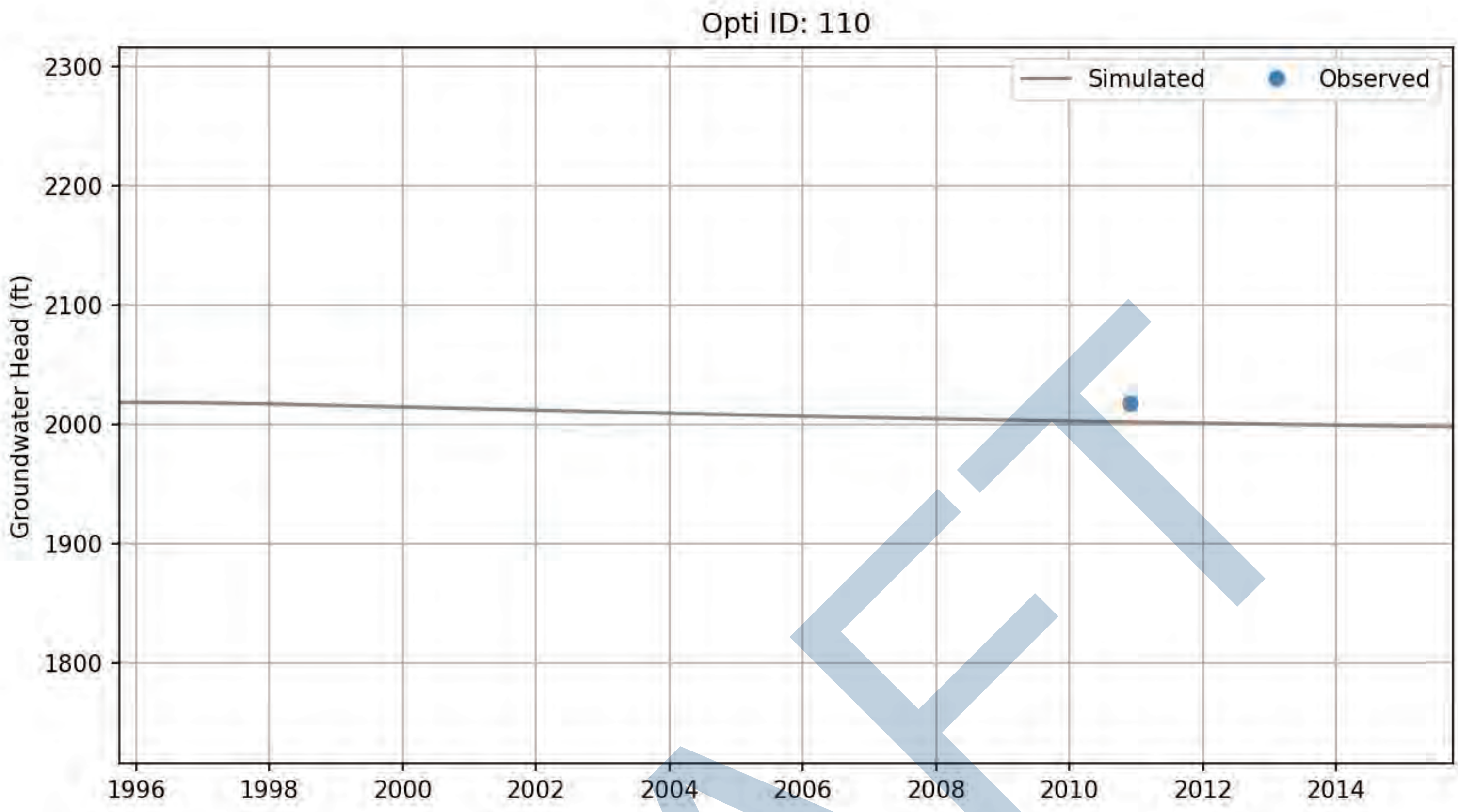

Opti ID: 103
Simulated
Observed
Groundwater Head (ft)
2200
2100
2000
1900
1800
1700
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014


Opti ID: 104
Simulated
Observed
Groundwater Head (ft)
2100
2000
1900
1800
1700
1600
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

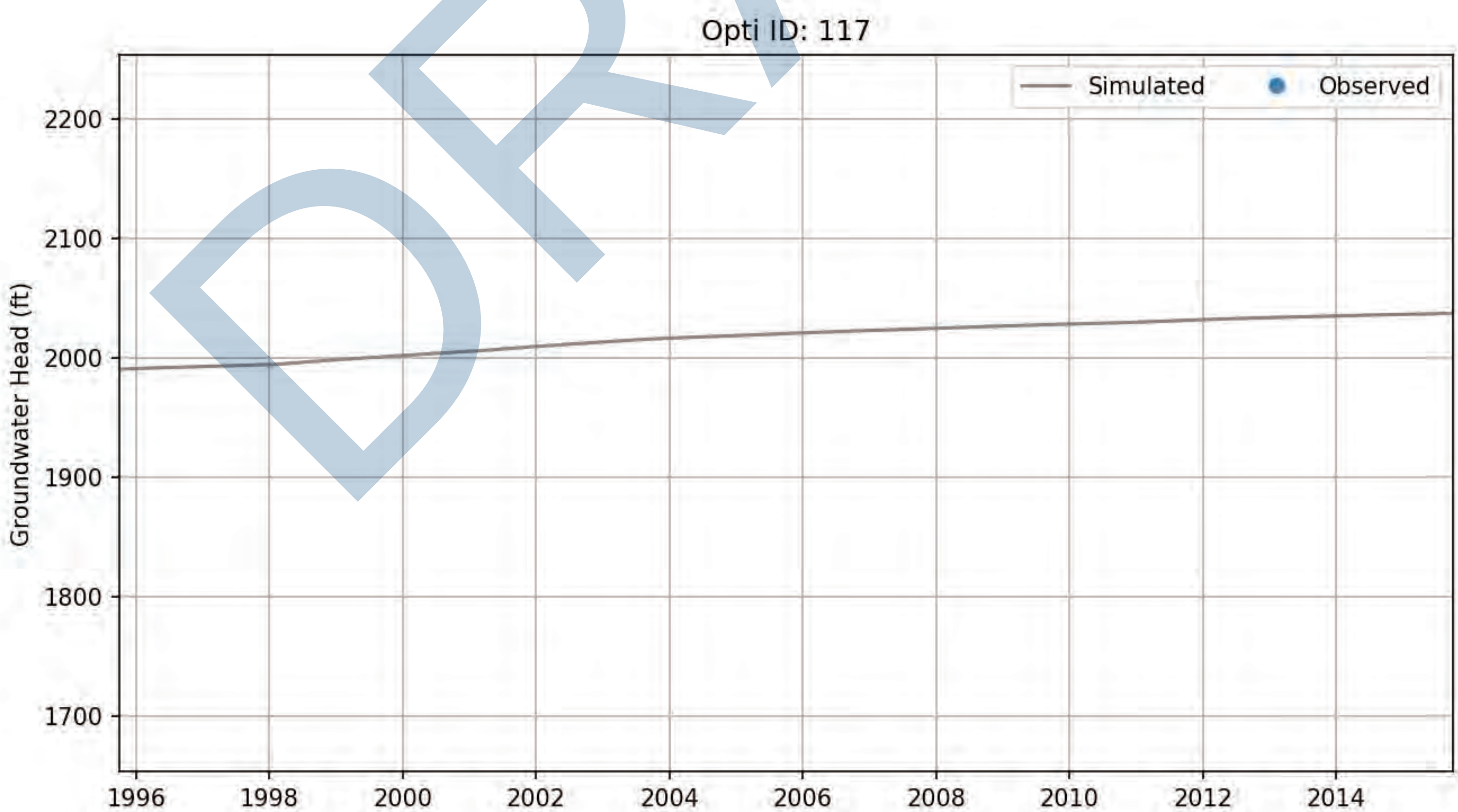

Opti ID: 106
Simulated
Observed
Groundwater Head (ft)
2400
2300
2200
2100
2000
1900
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014


Opti ID: 107
Simulated
Observed
Groundwater Head (ft)
2600
2500
2400
2300
2200
2100
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

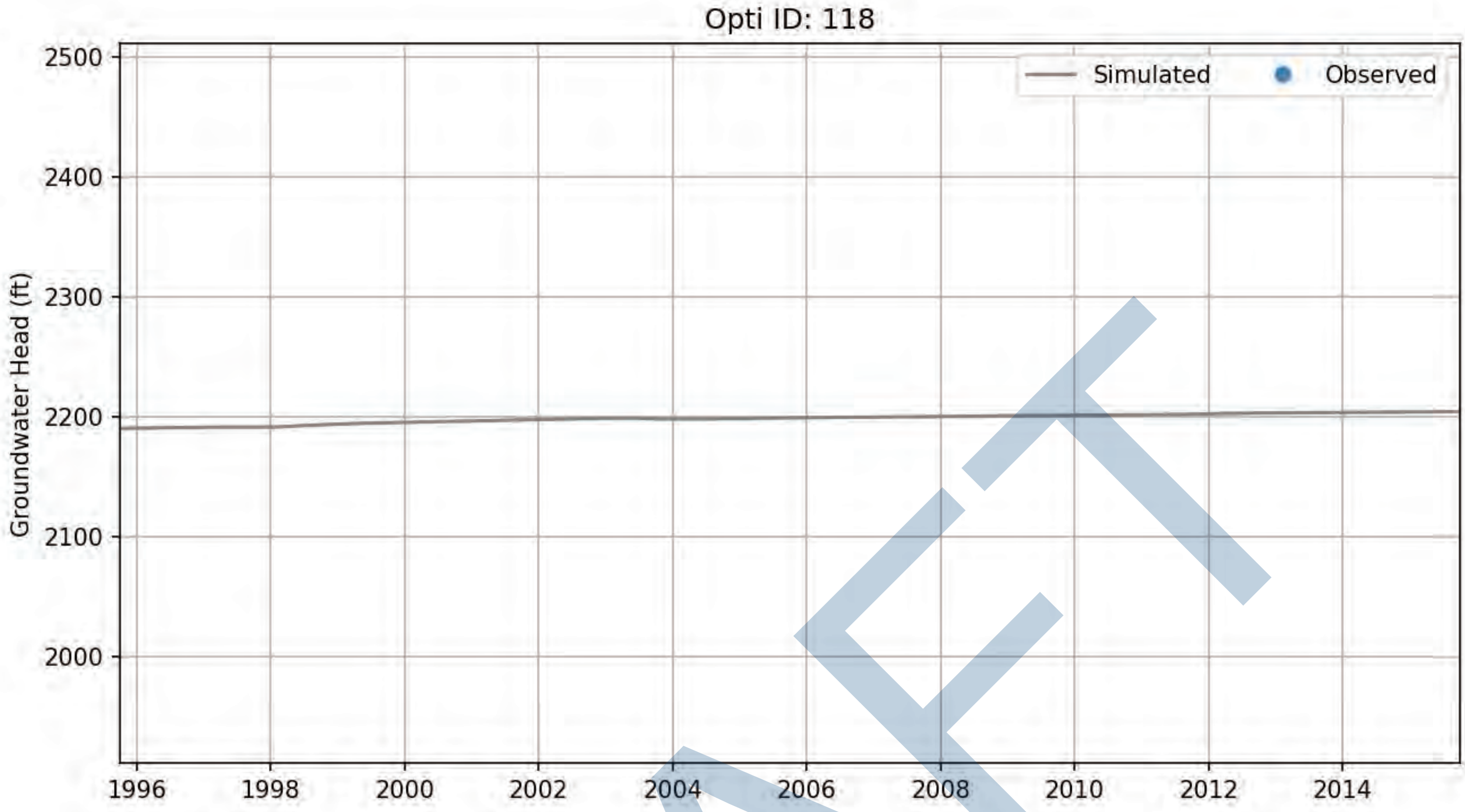

Opti ID: 108
Simulated
Observed
Groundwater Head (ft)
2700
2600
2500
2400
2300
2200
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

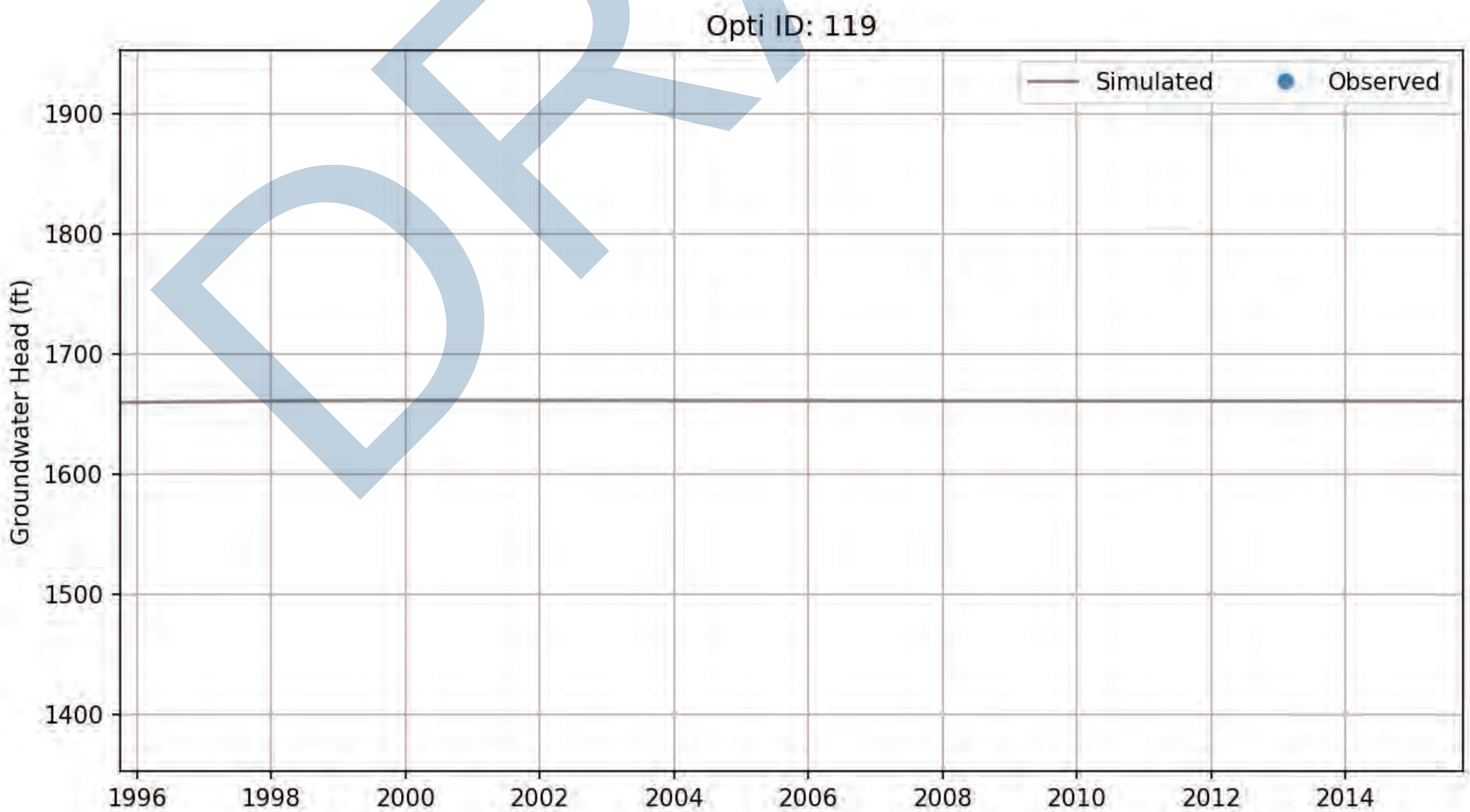


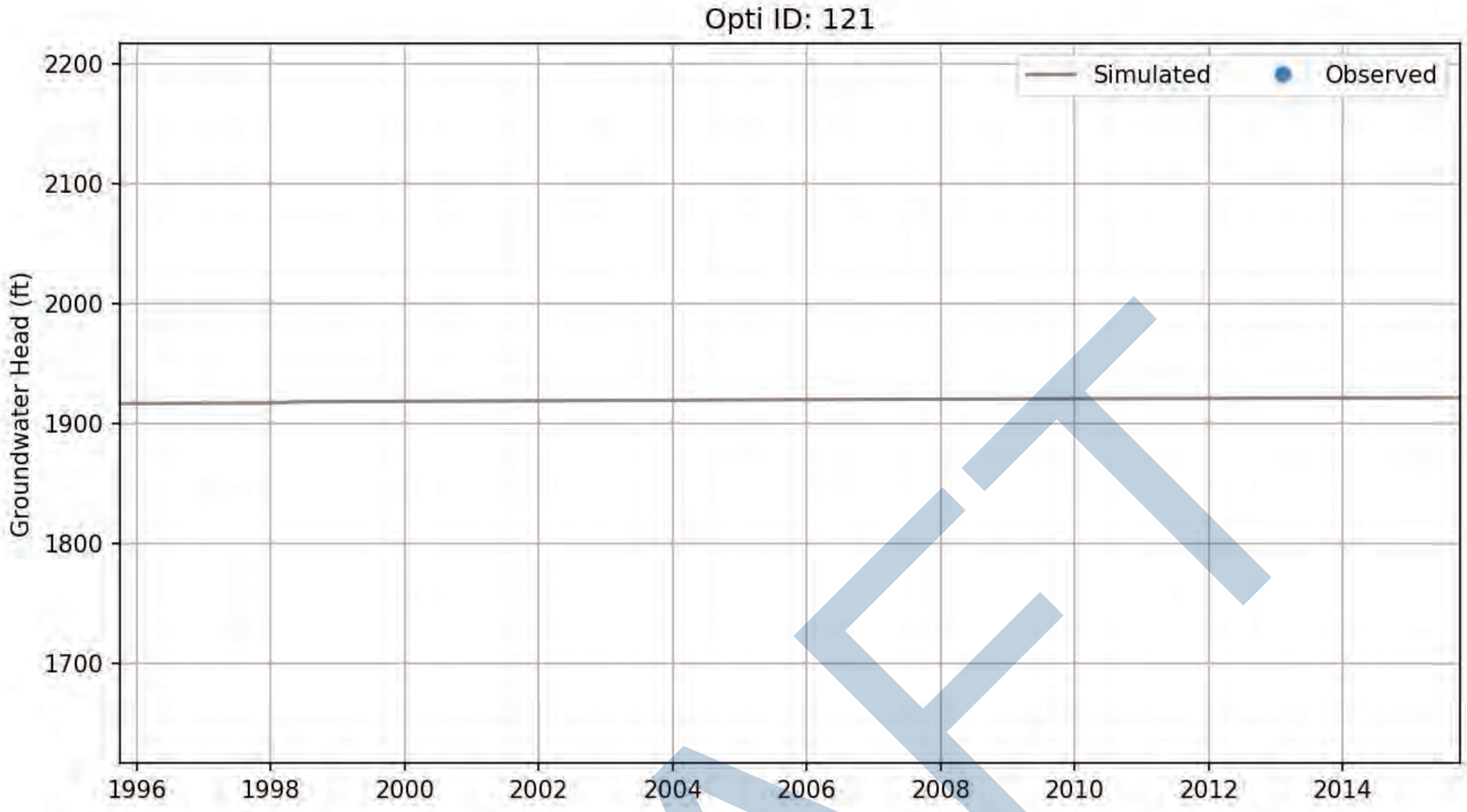
Opti ID: 110
Simulated
Observed
Groundwater Head (ft)
2300
2200
2100
2000
1900
1800
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

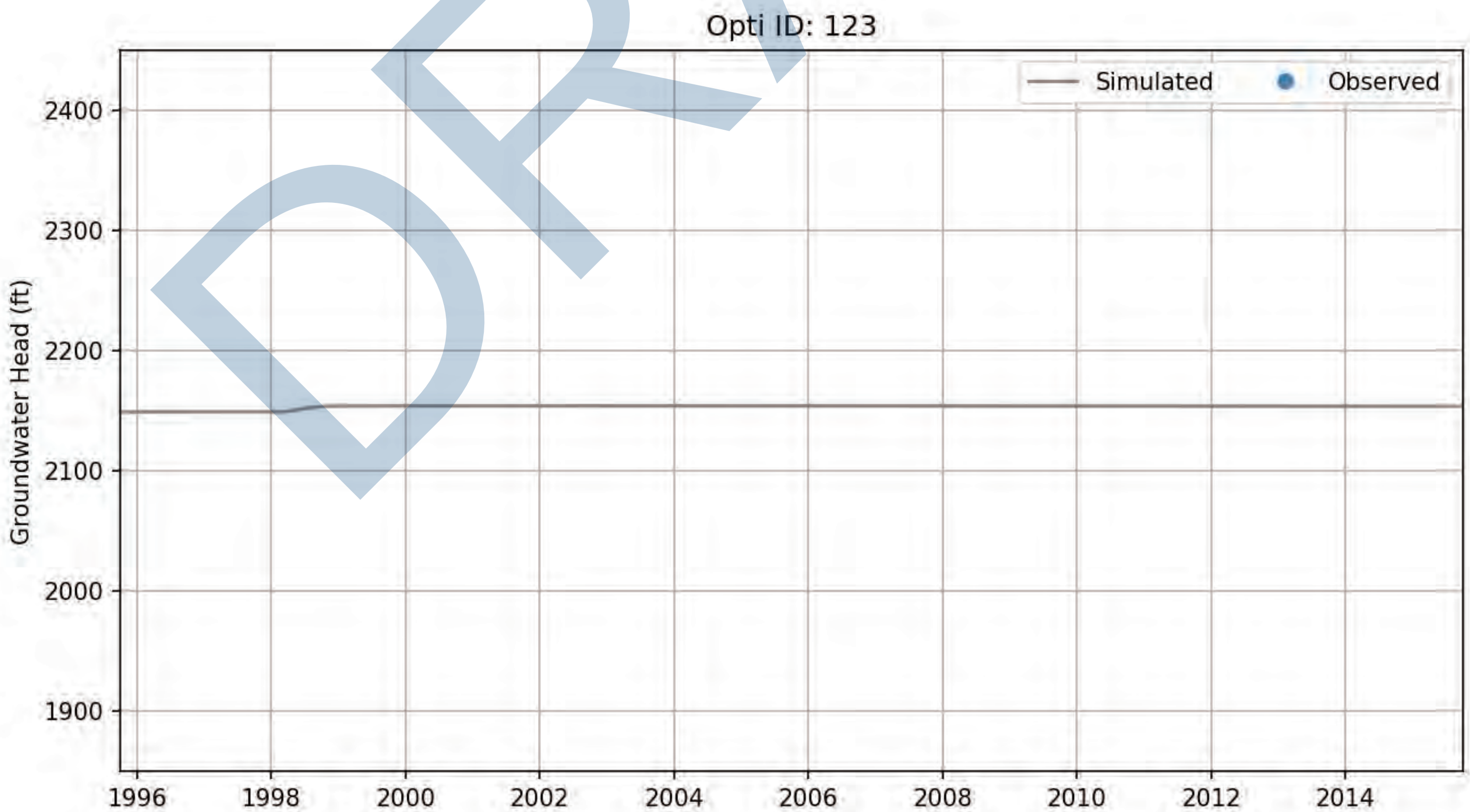


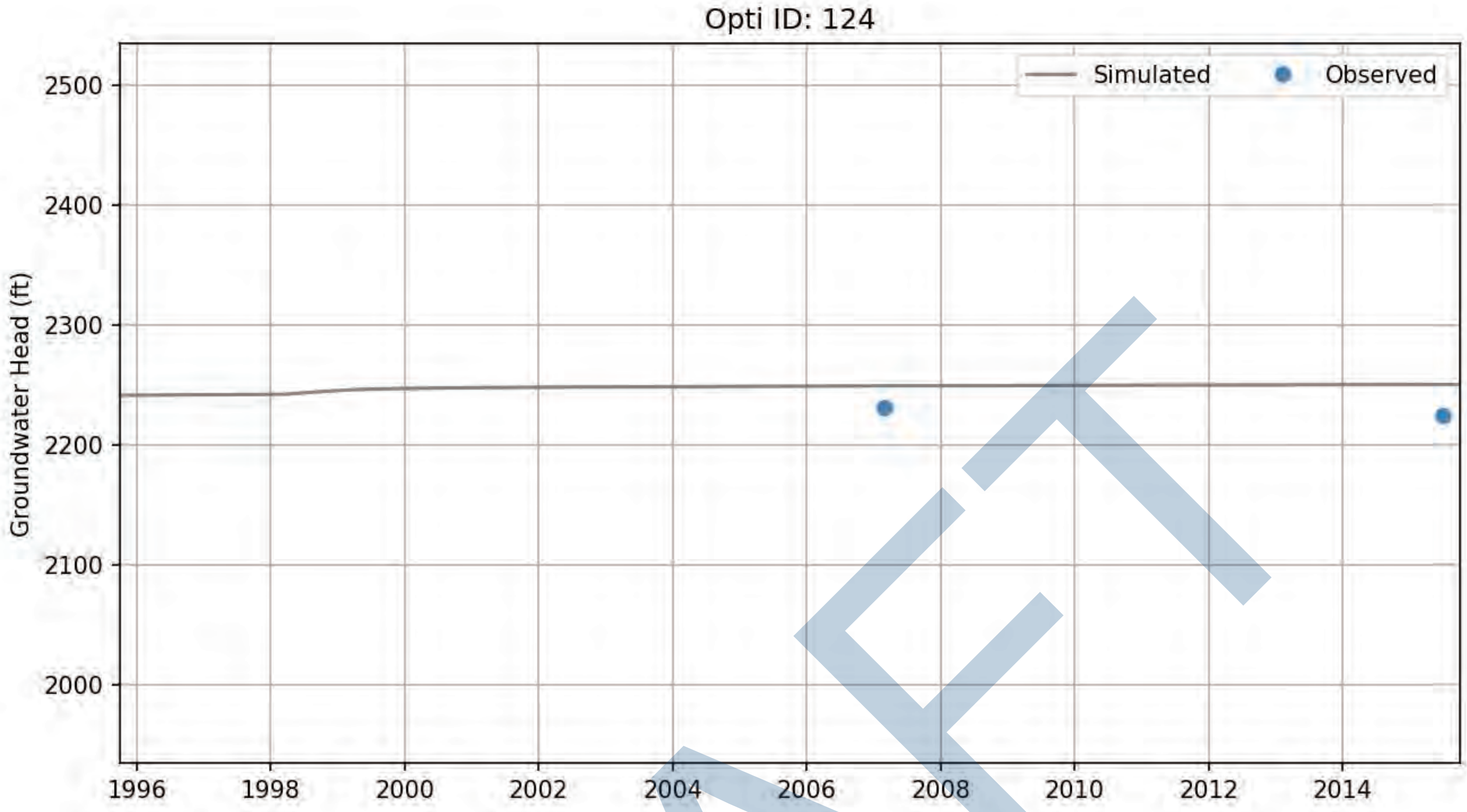
Opti ID: 117
Simulated
Observed
Groundwater Head (ft)
2200
2100
2000
1900
1800
1700
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014


Opti ID: 118
Simulated
Observed
Groundwater Head (ft)
2500
2400
2300
2200
2100
2000
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

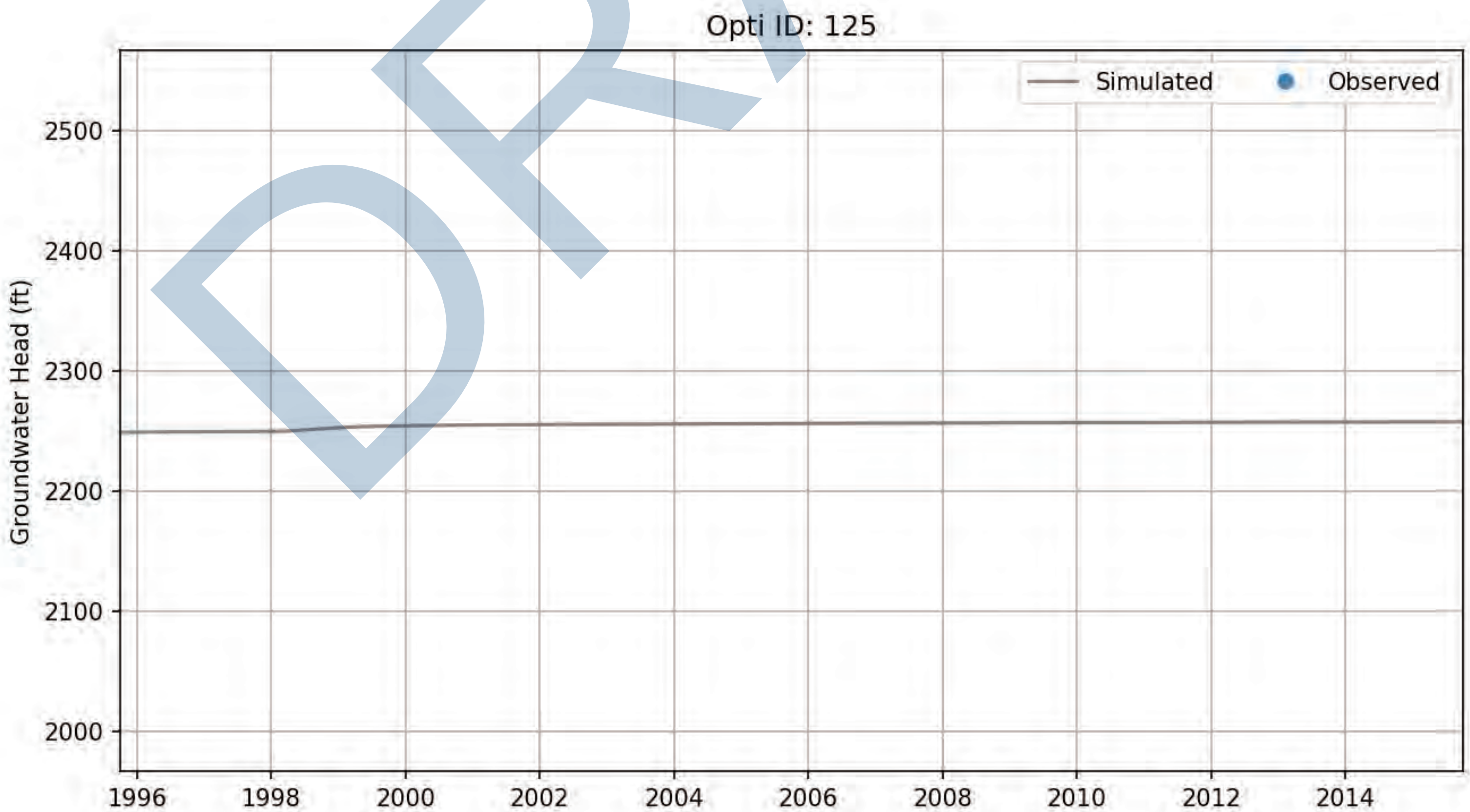

Opti ID: 119
Simulated
Observed
Groundwater Head (ft)
1900
1800
1700
1600
1500
1400
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014


Opti ID: 121
Simulated
Observed
Groundwater Head (ft)
2200
2100
2000
1900
1800
1700
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

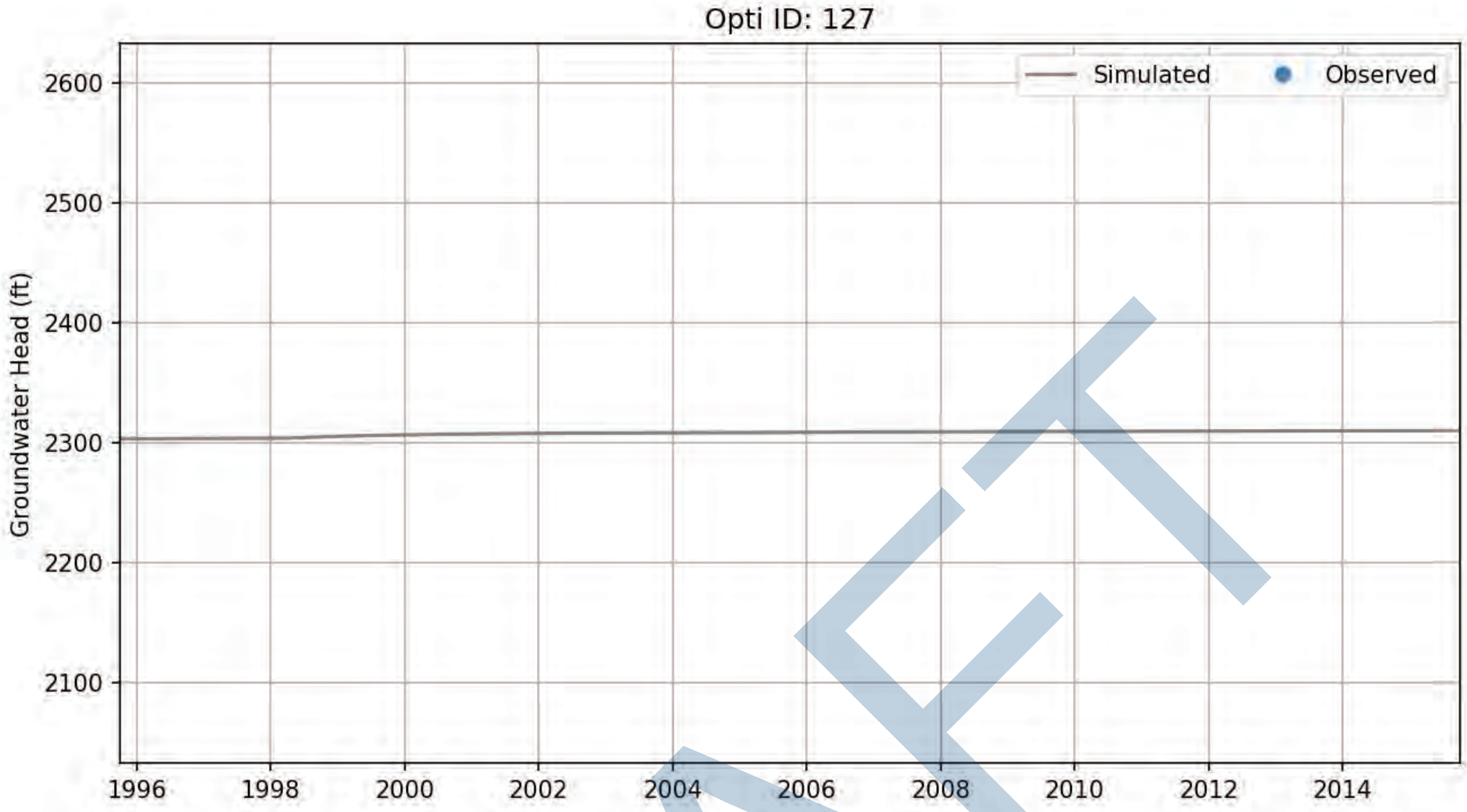

Opti ID: 123
Simulated
Observed
Groundwater Head (ft)
2400
2300
2200
2100
2000
1900
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

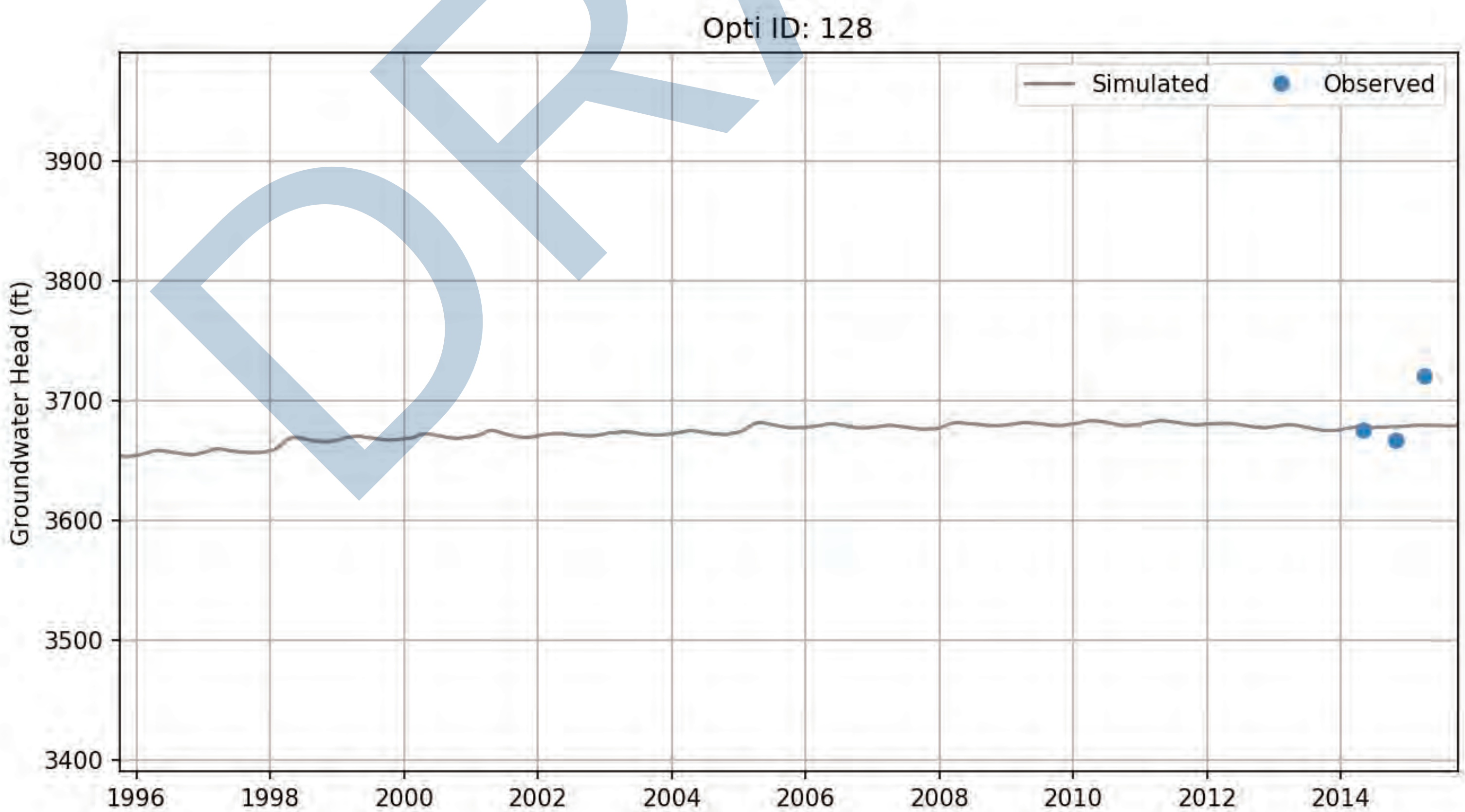


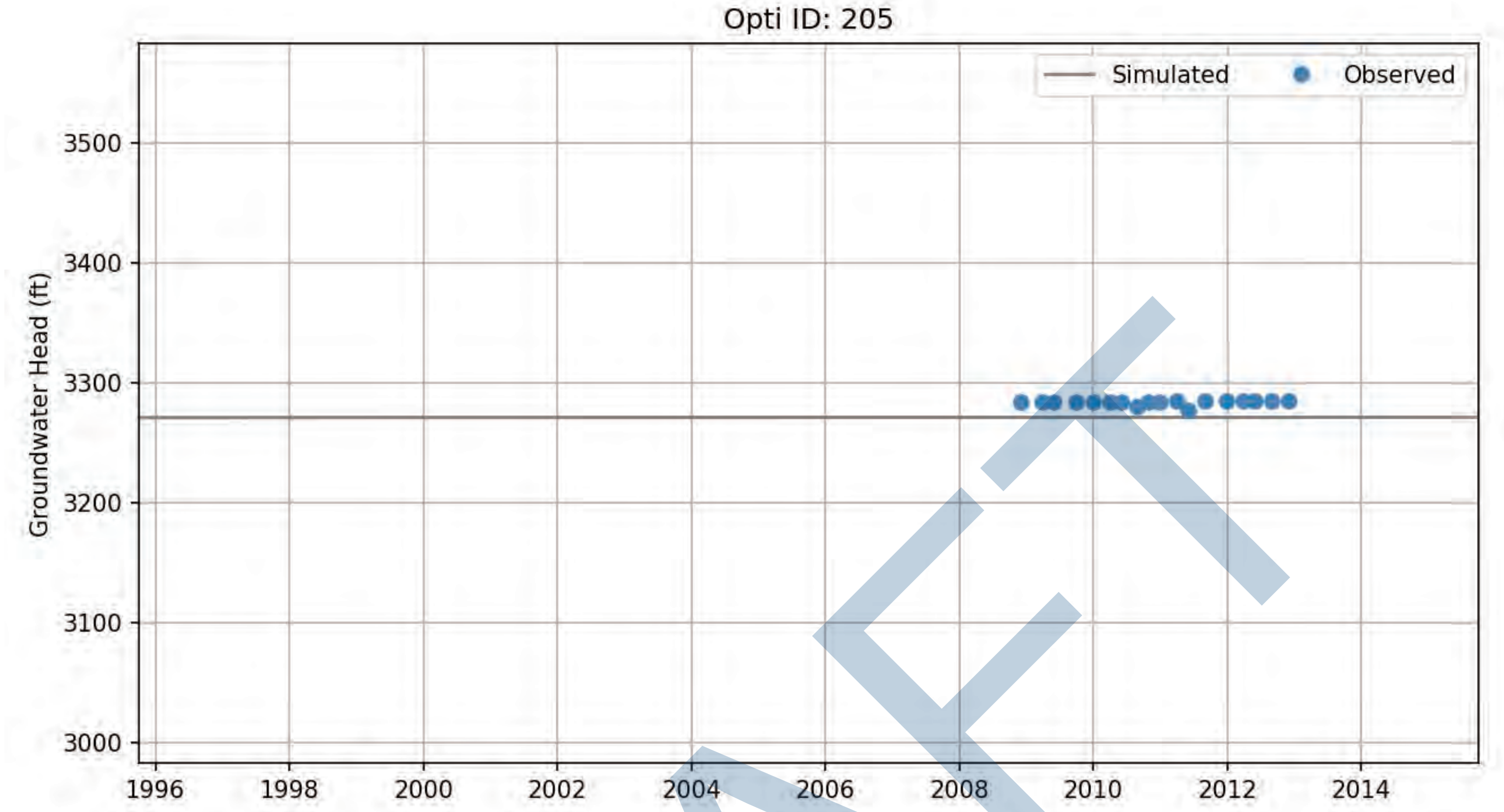
Opti ID: 124
Simulated
Observed
Groundwater Head (ft)
2500
2400
2300
2200
2100
2000
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

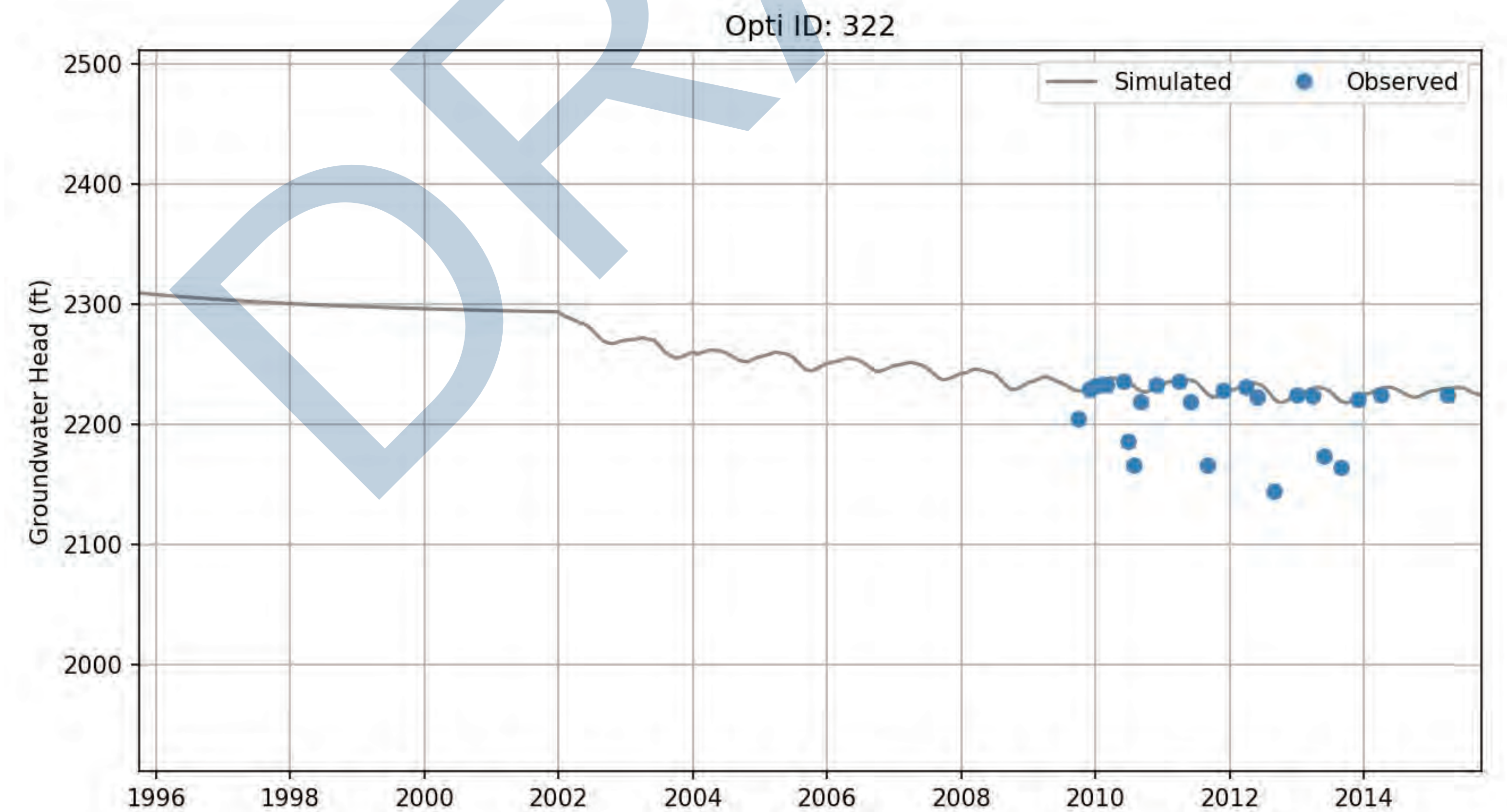


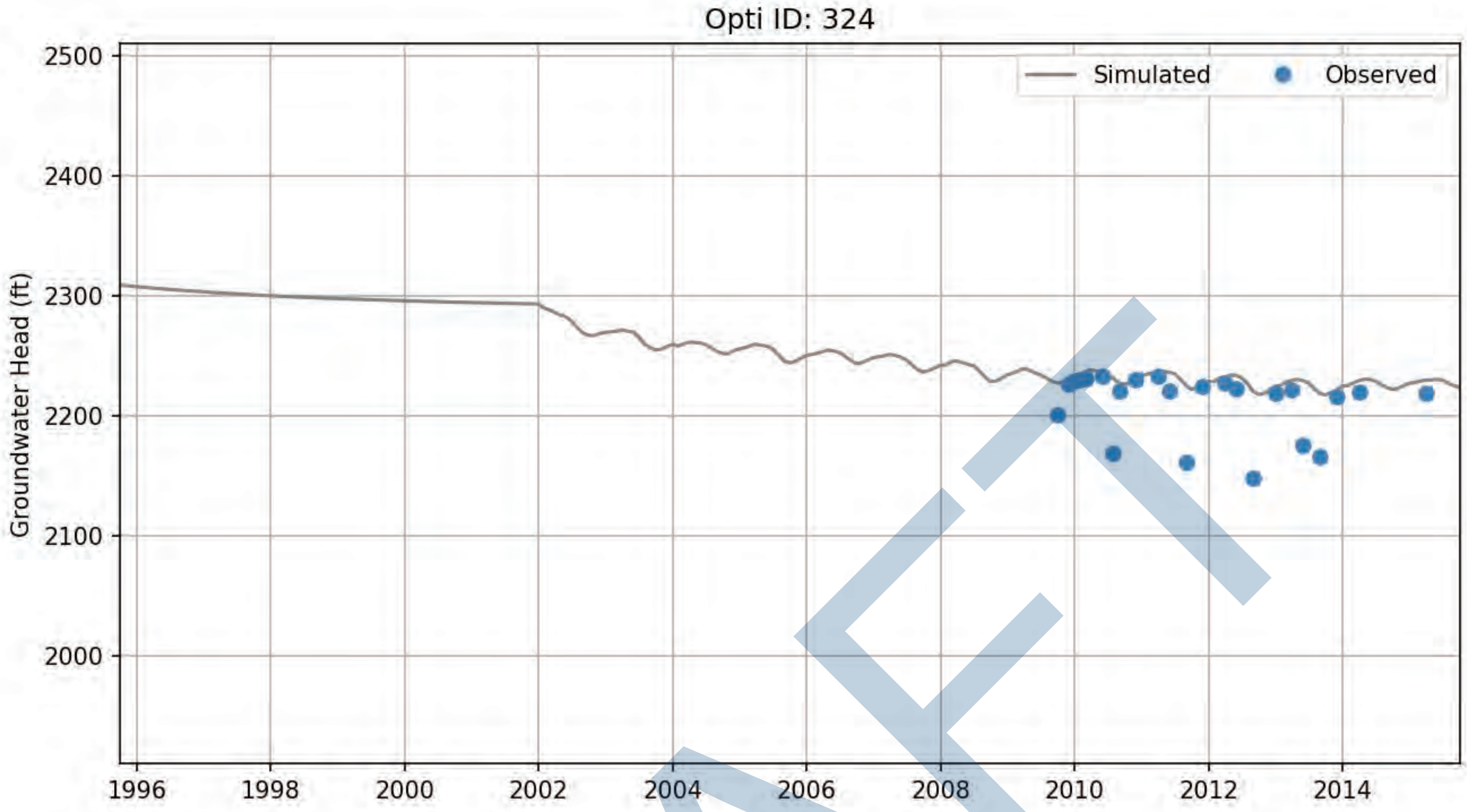
Opti ID: 125
Simulated
Observed
Groundwater Head (ft)
2500
2400
2300
2200
2100
2000
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

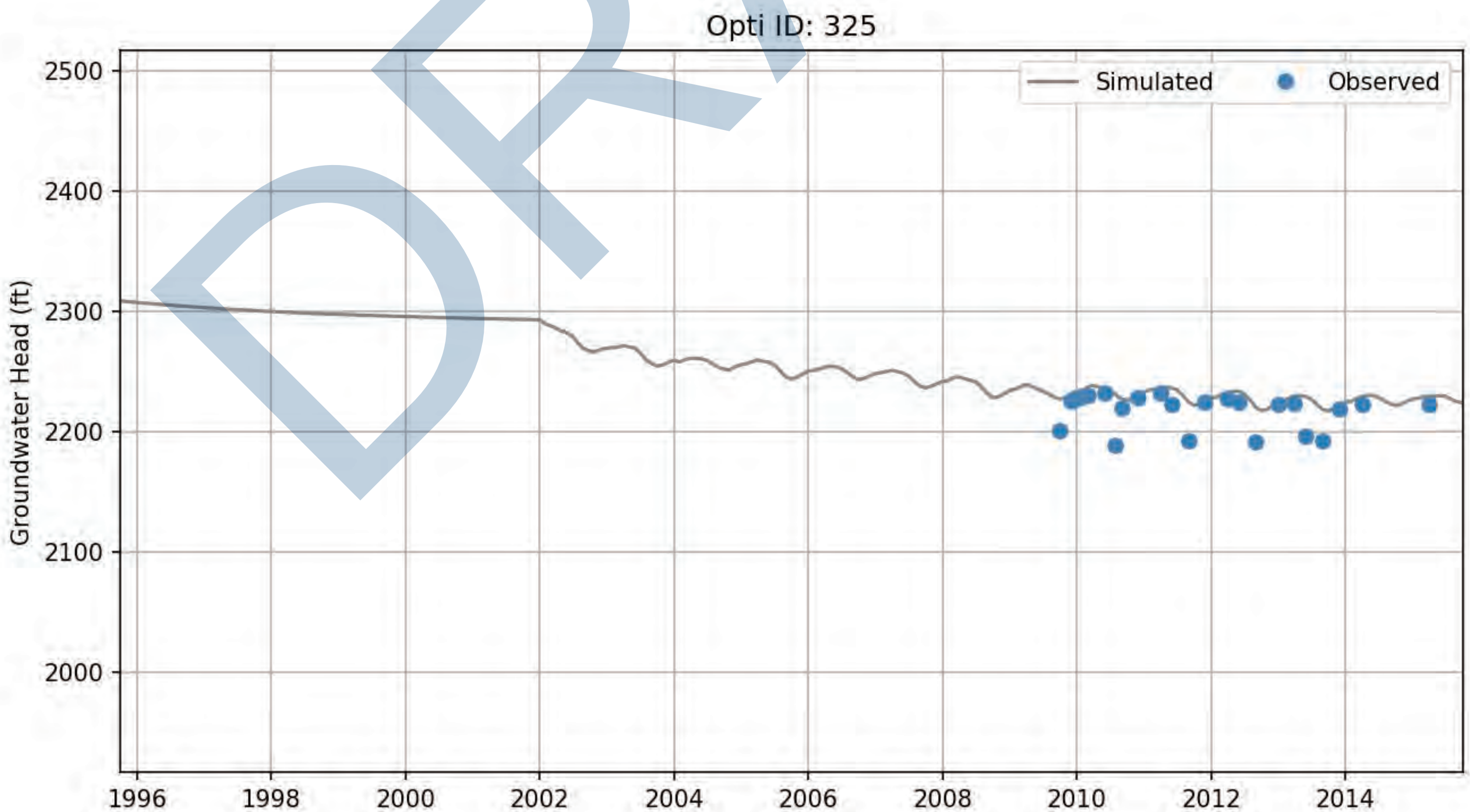

Opti ID: 127
Simulated
Observed
Groundwater Head (ft)
2600
2500
2400
2300
2200
2100
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

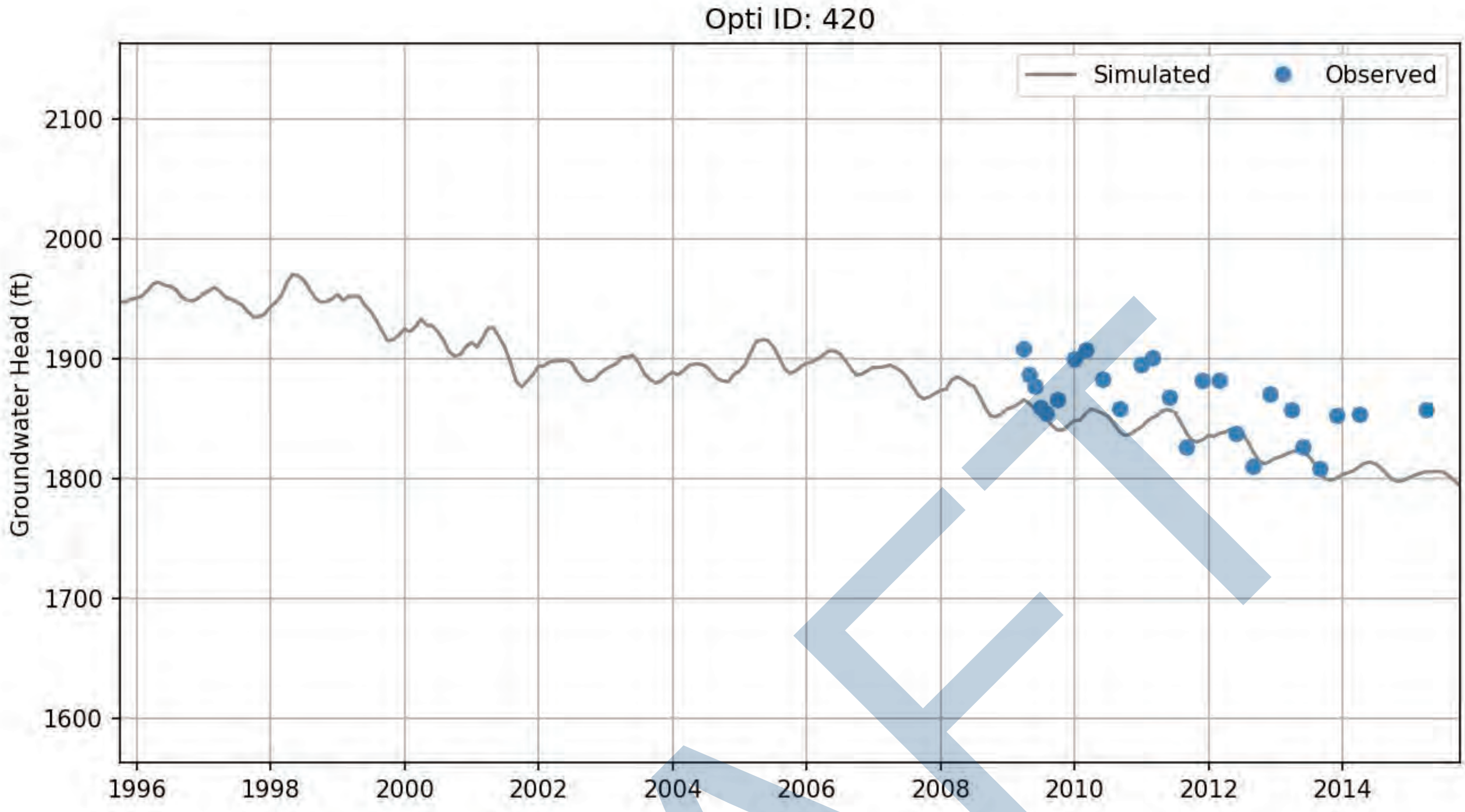

Opti ID: 128
Simulated
Observed
Groundwater Head (ft)
3900
3800
3700
3600
3500
3400
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

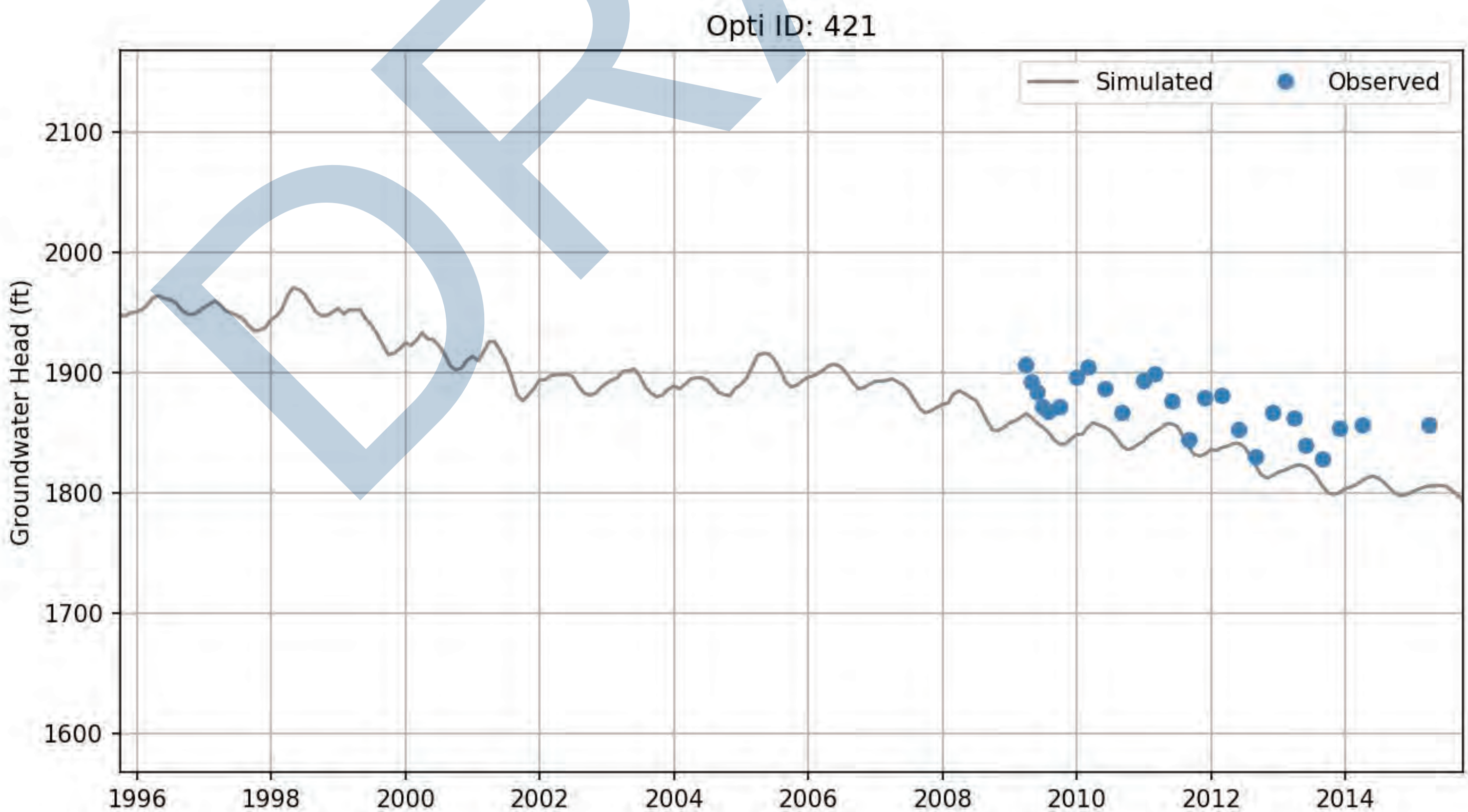

Opti ID: 205
Simulated
Observed
Groundwater Head (ft)
3500
3400
3300
3200
3100
3000
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

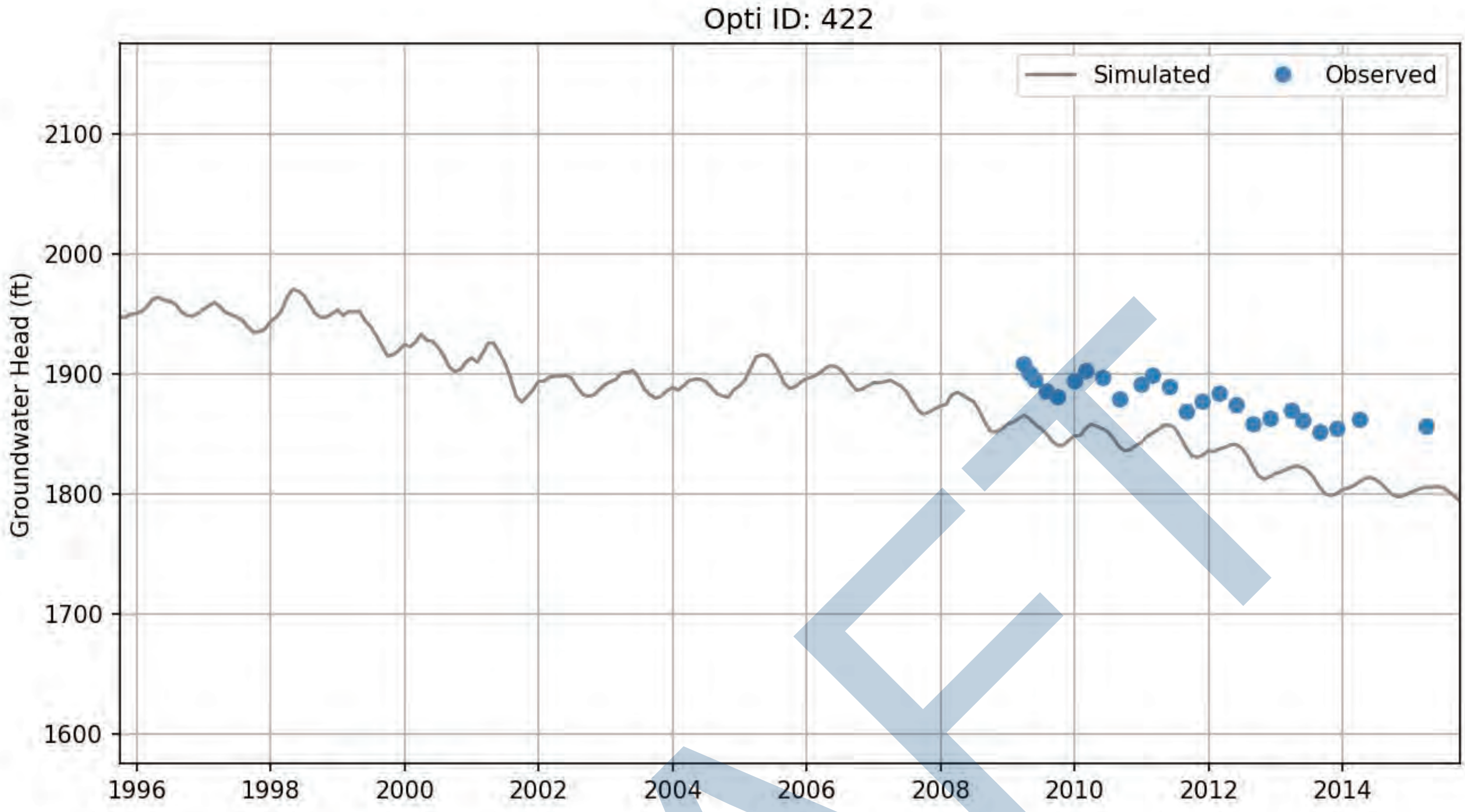

Opti ID: 322
Simulated
Observed
Groundwater Head (ft)
2500
2400
2300
2200
2100
2000
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

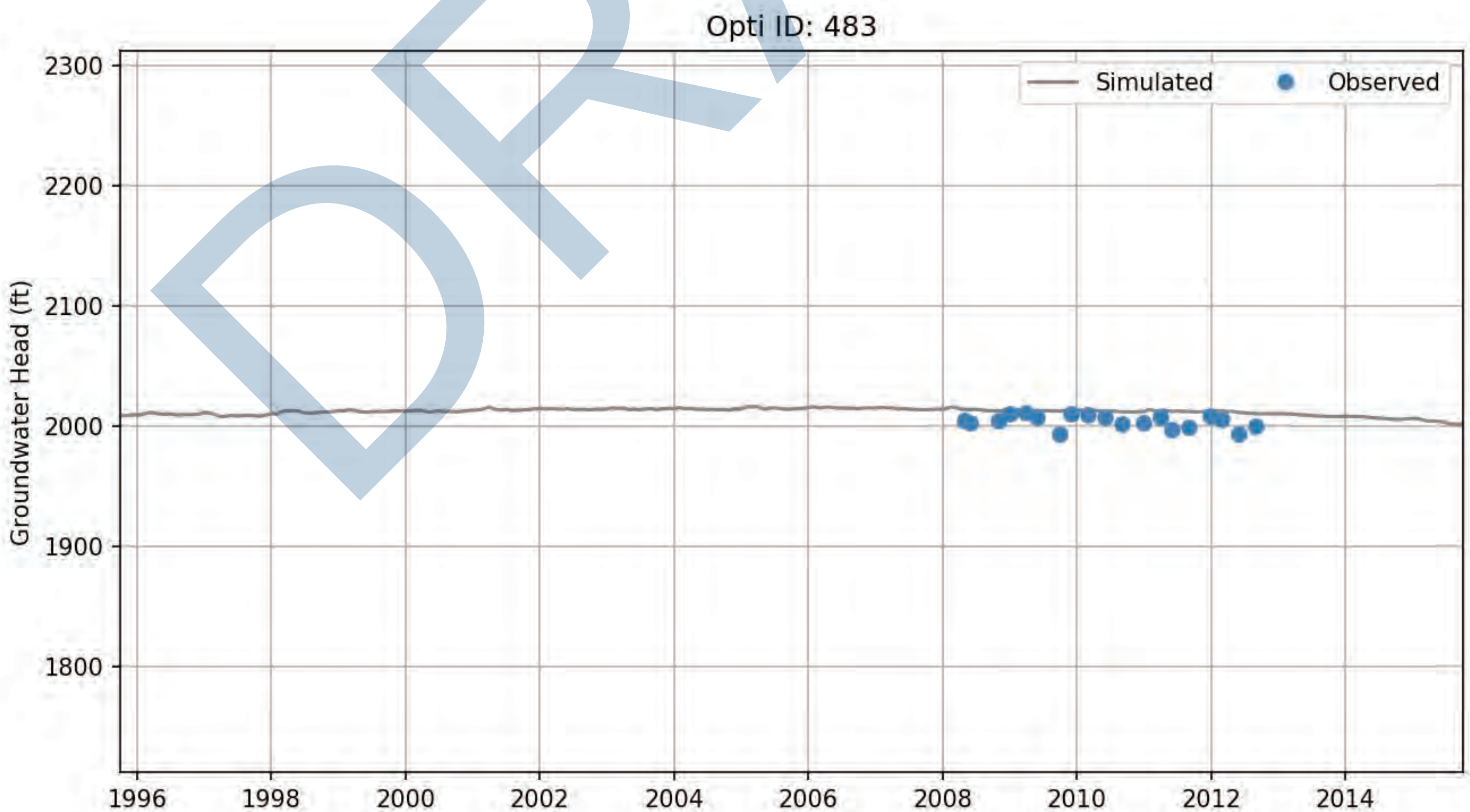

Opti ID: 324
Simulated
Observed
Groundwater Head (ft)
2500
2400
2300
2200
2100
2000
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

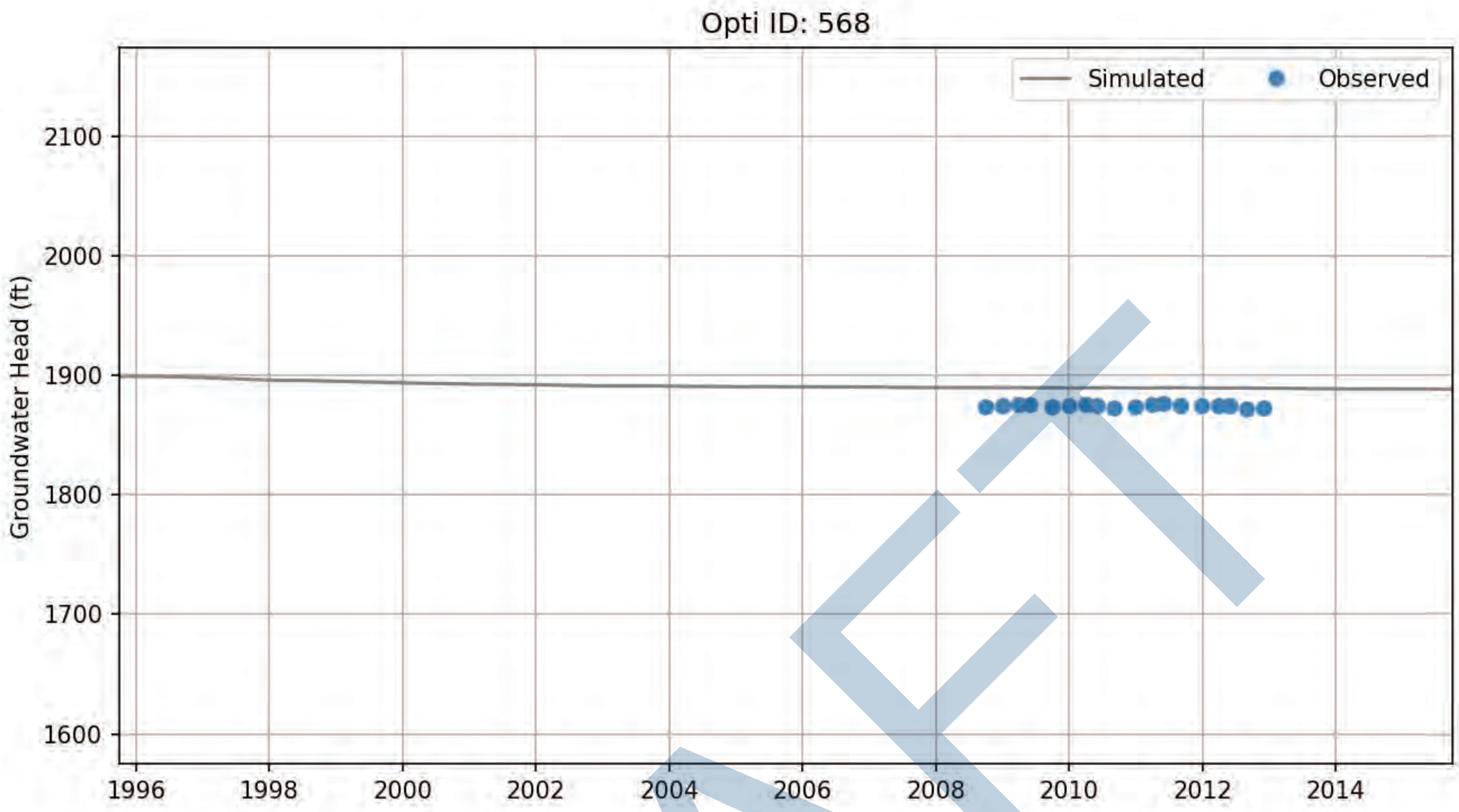

Opti ID: 325
Simulated
Observed
Groundwater Head (ft)
2500
2400
2300
2200
2100
2000
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

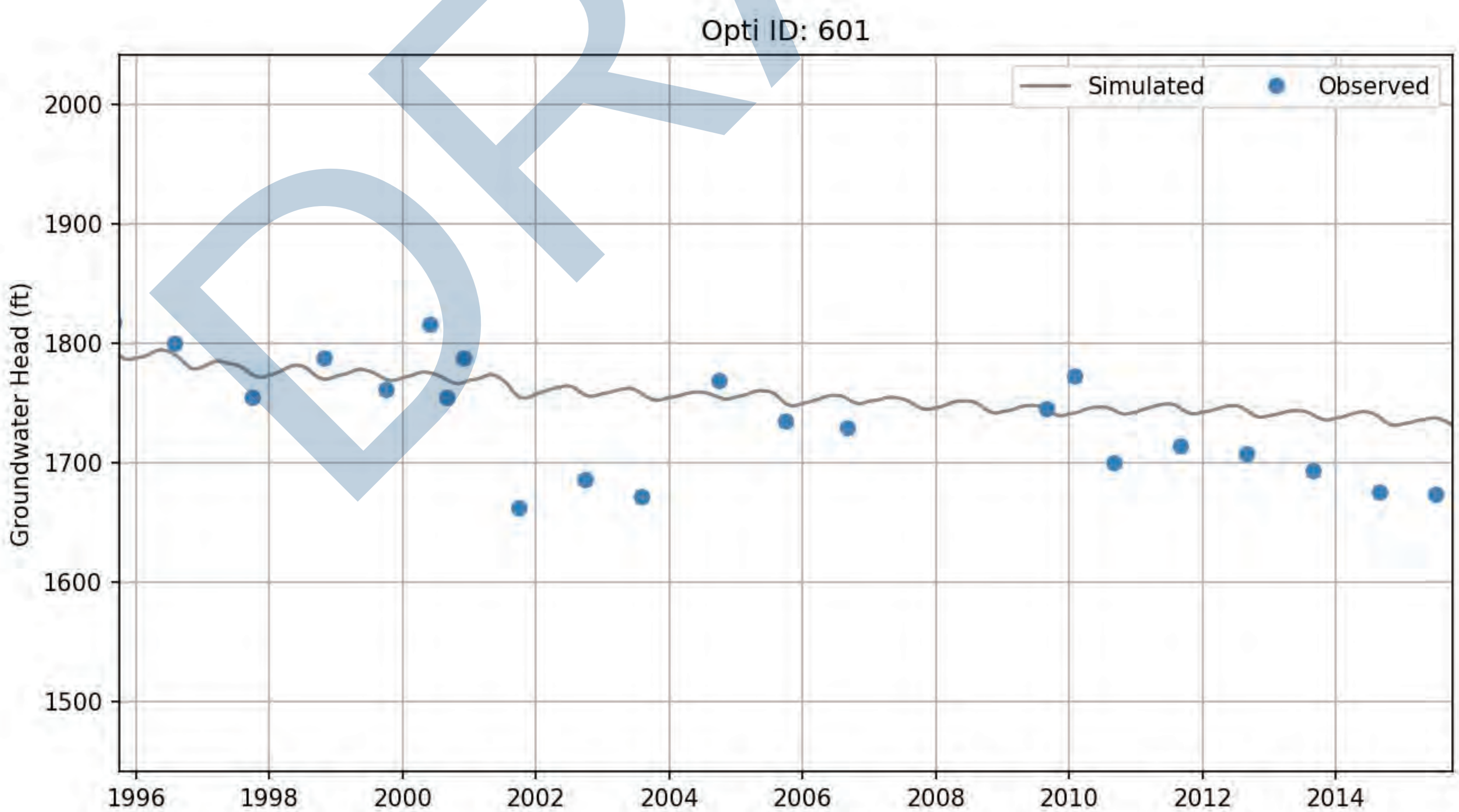

Opti ID: 420
Simulated
Observed
Groundwater Head (ft)
2100
2000
1900
1800
1700
1600
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

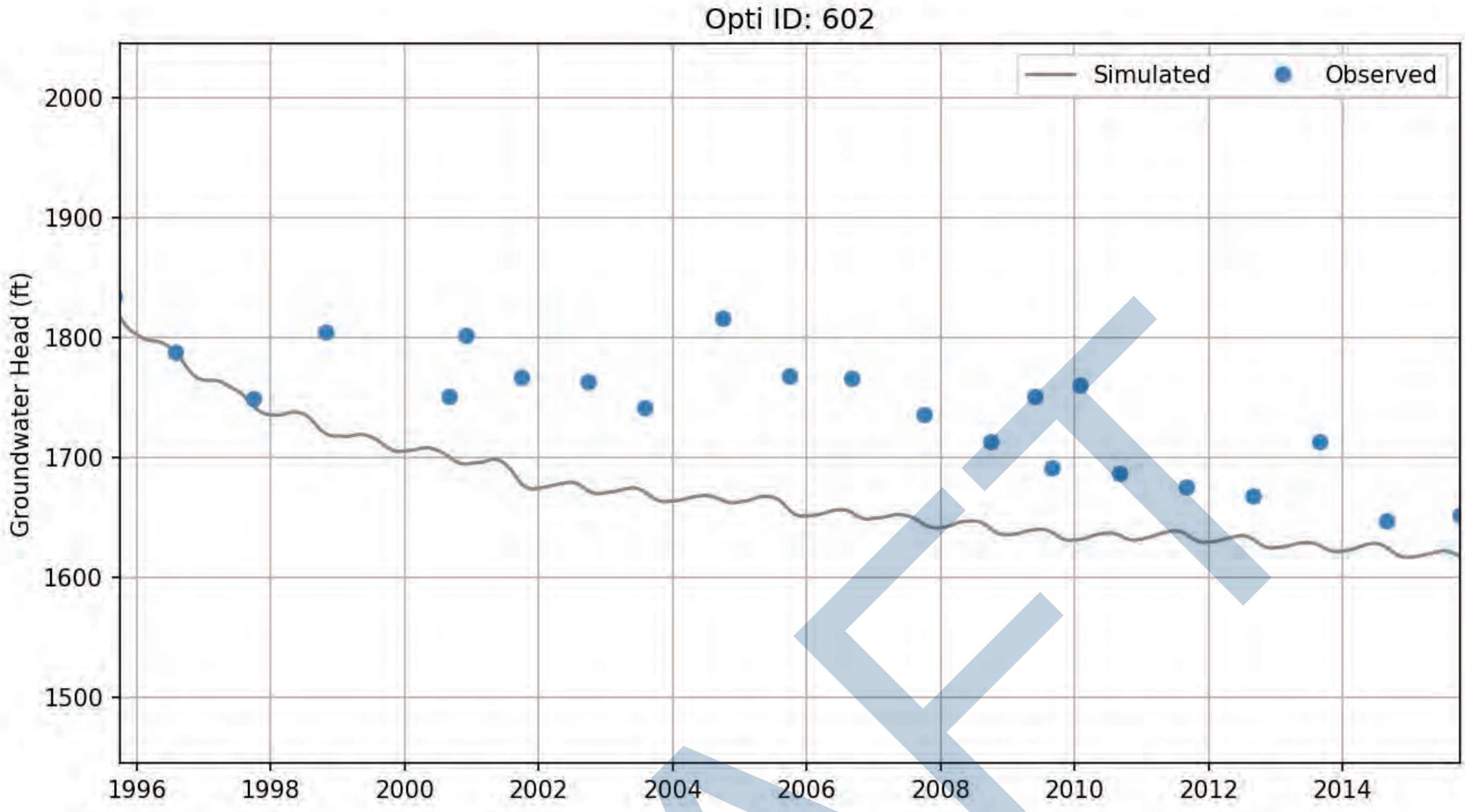

Opti ID: 421
Simulated
Observed
Groundwater Head (ft)
2100
2000
1900
1800
1700
1600
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

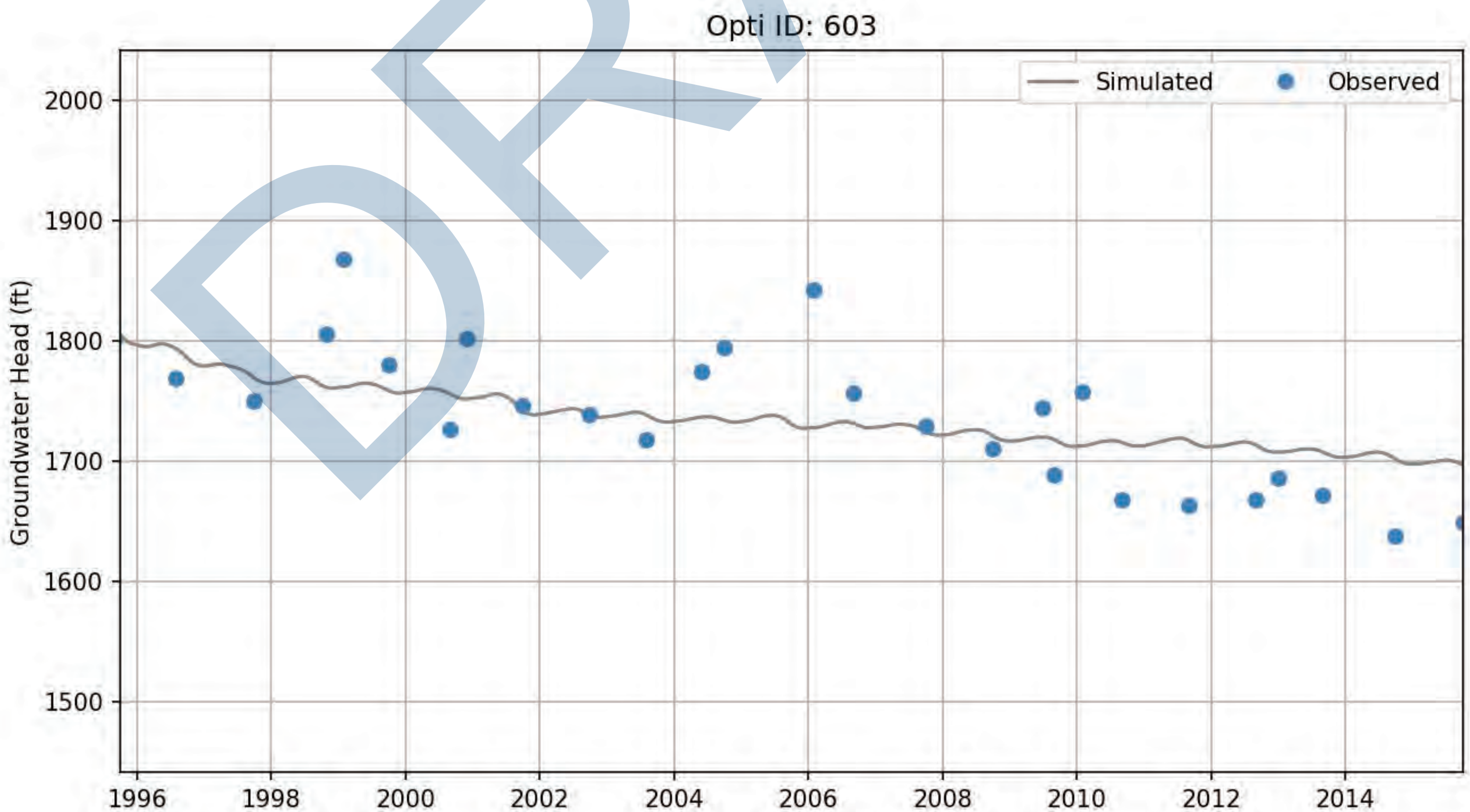

Opti ID: 422
Simulated
Observed
Groundwater Head (ft)
2100
2000
1900
1800
1700
1600
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

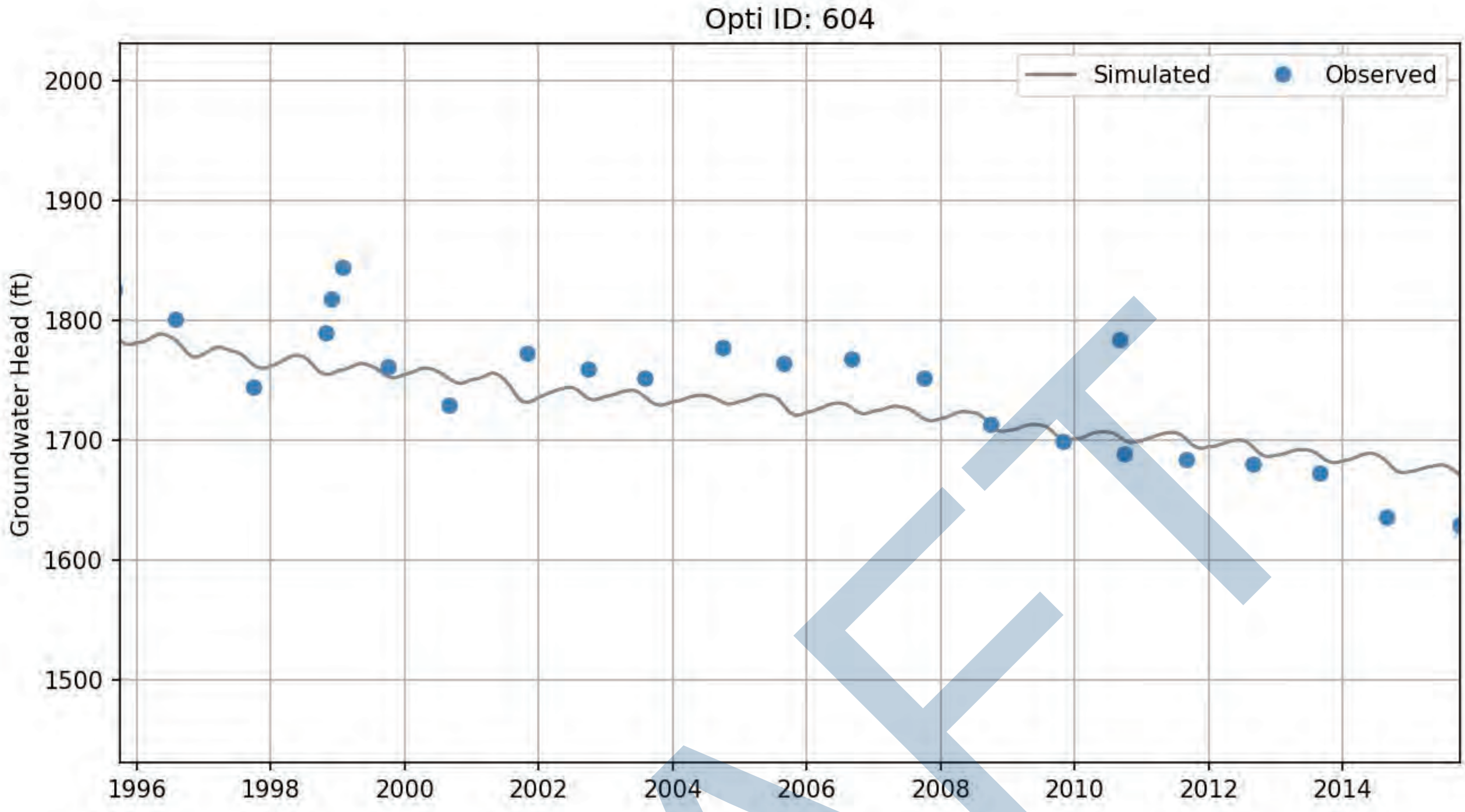

Opti ID: 483
Simulated
Observed
Groundwater Head (ft)
2300
2200
2100
2000
1900
1800
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

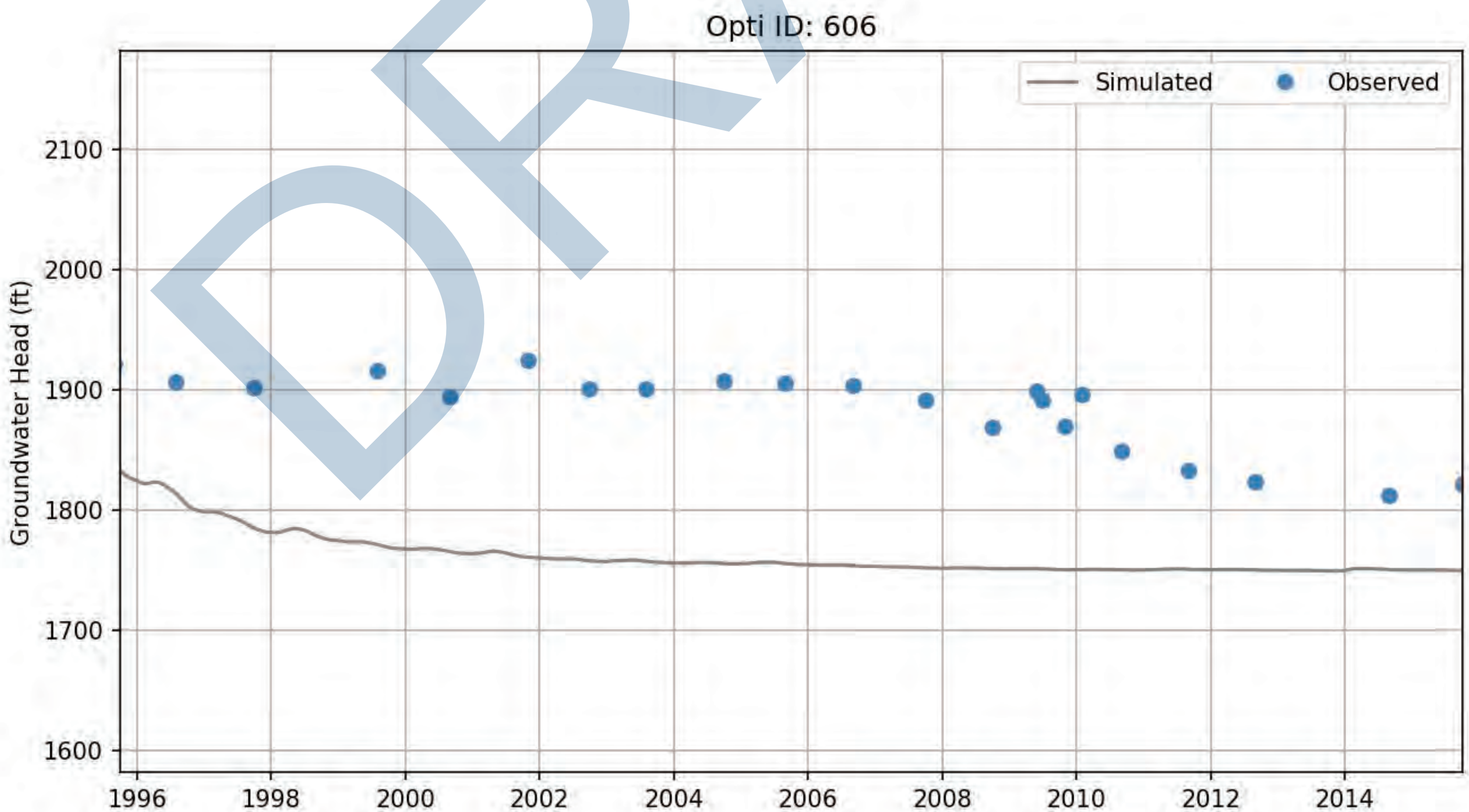

Opti ID: 568
Simulated
Observed
Groundwater Head (ft)
2100
2000
1900
1800
1700
1600
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

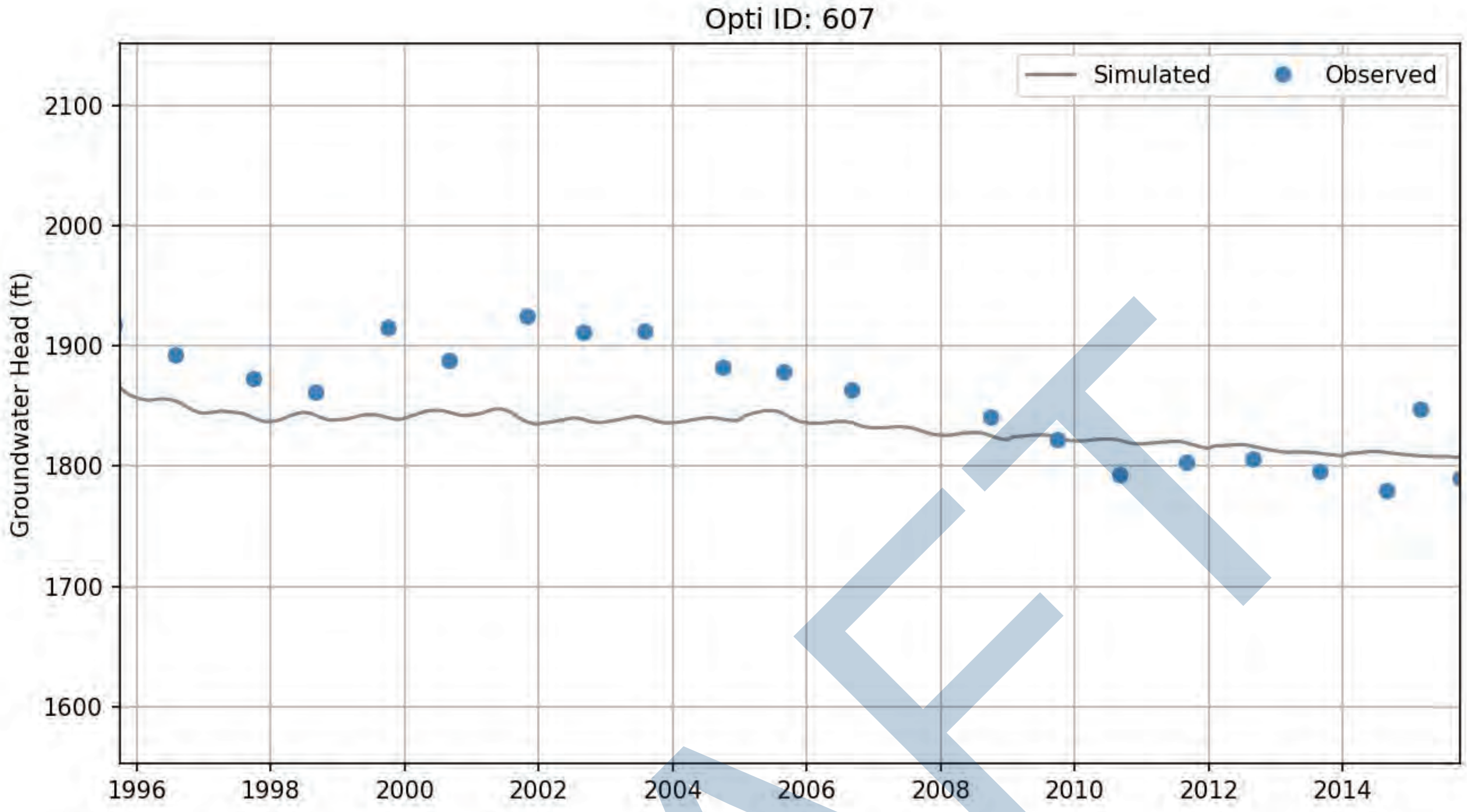

Opti ID: 601
Simulated
Observed
Groundwater Head (ft)
2000
1900
1800
1700
1600
1500
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

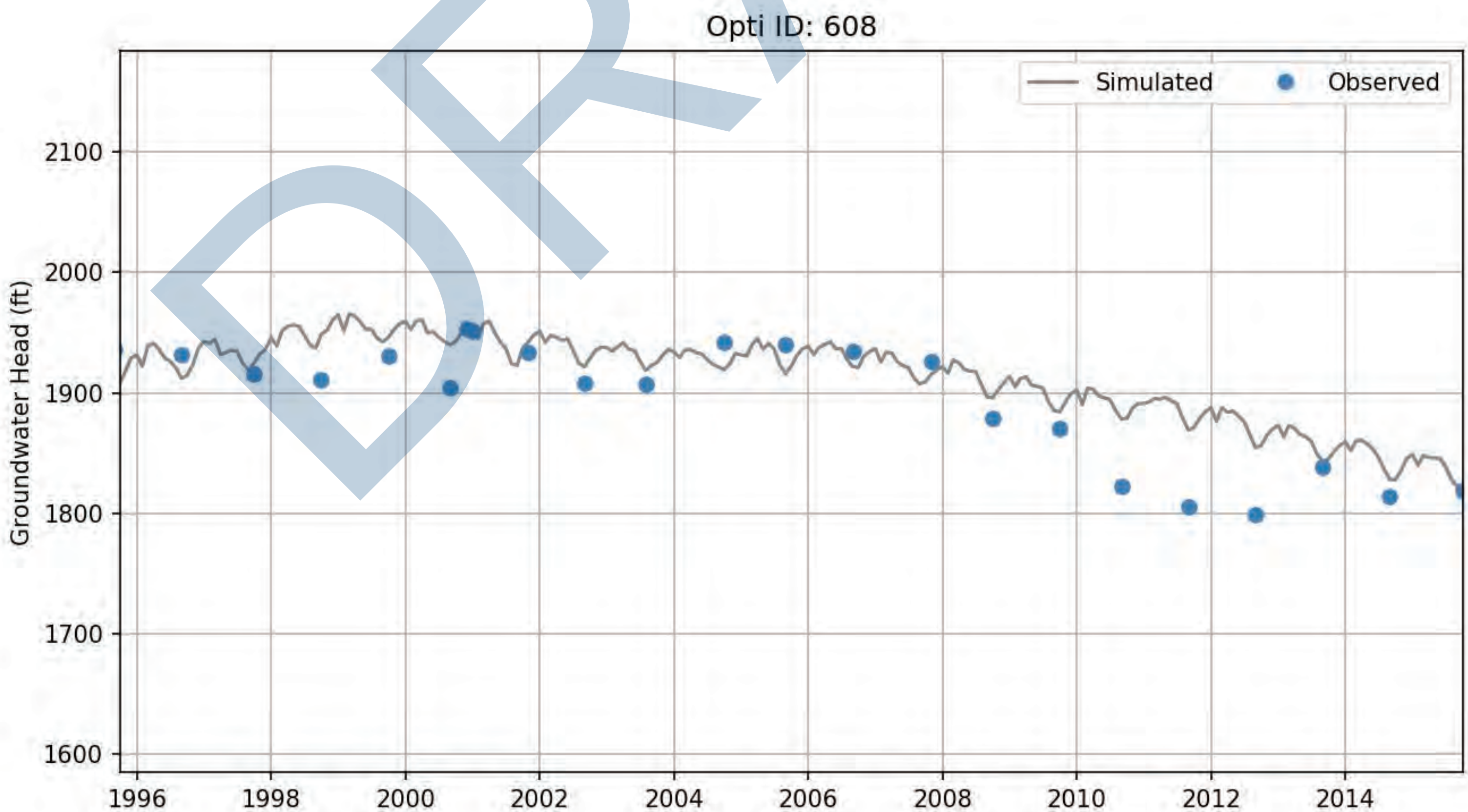

Opti ID: 602
Simulated
Observed
Groundwater Head (ft)
2000
1900
1800
1700
1600
1500
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

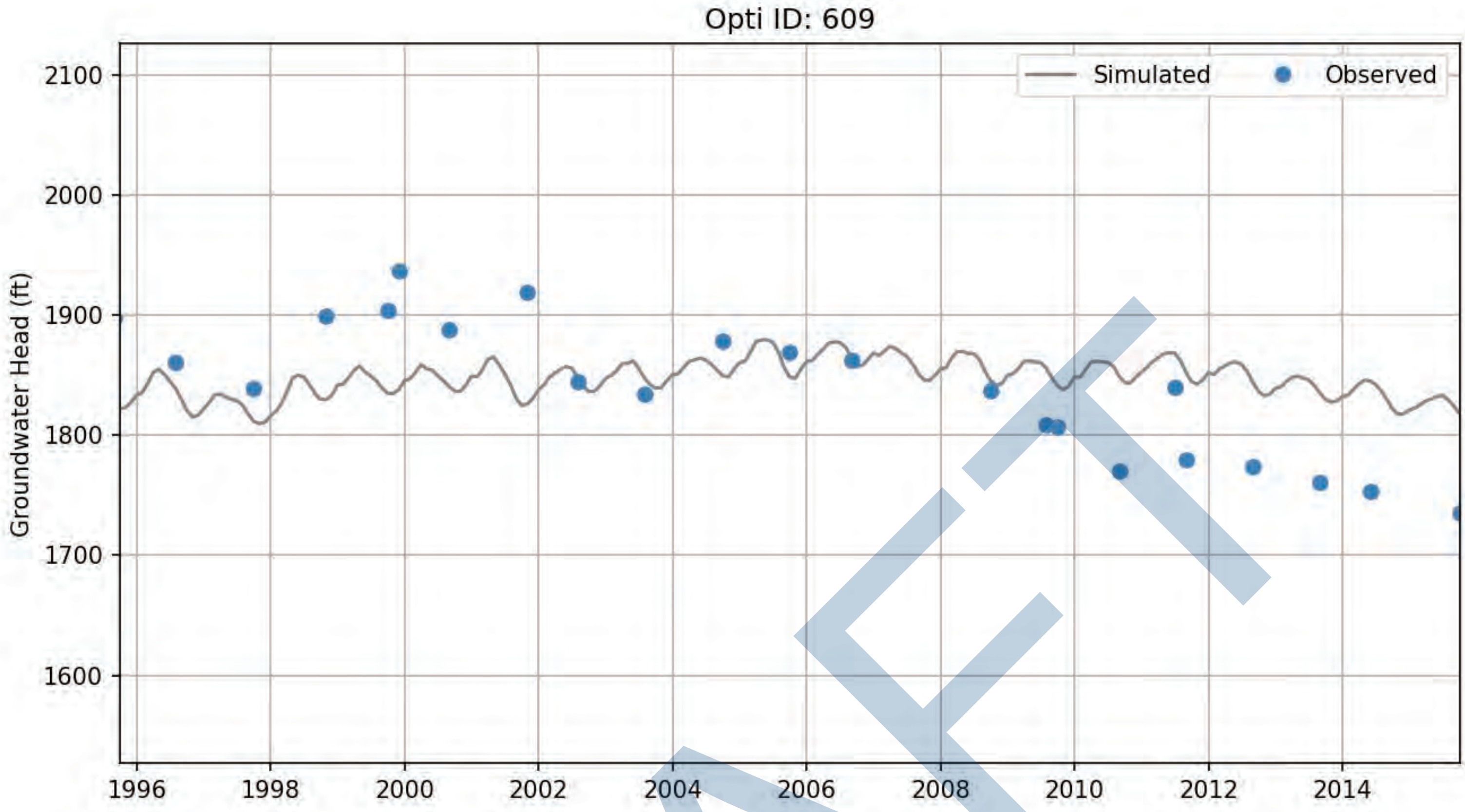

Opti ID: 603
Simulated
Observed
Groundwater Head (ft)
2000
1900
1800
1700
1600
1500
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

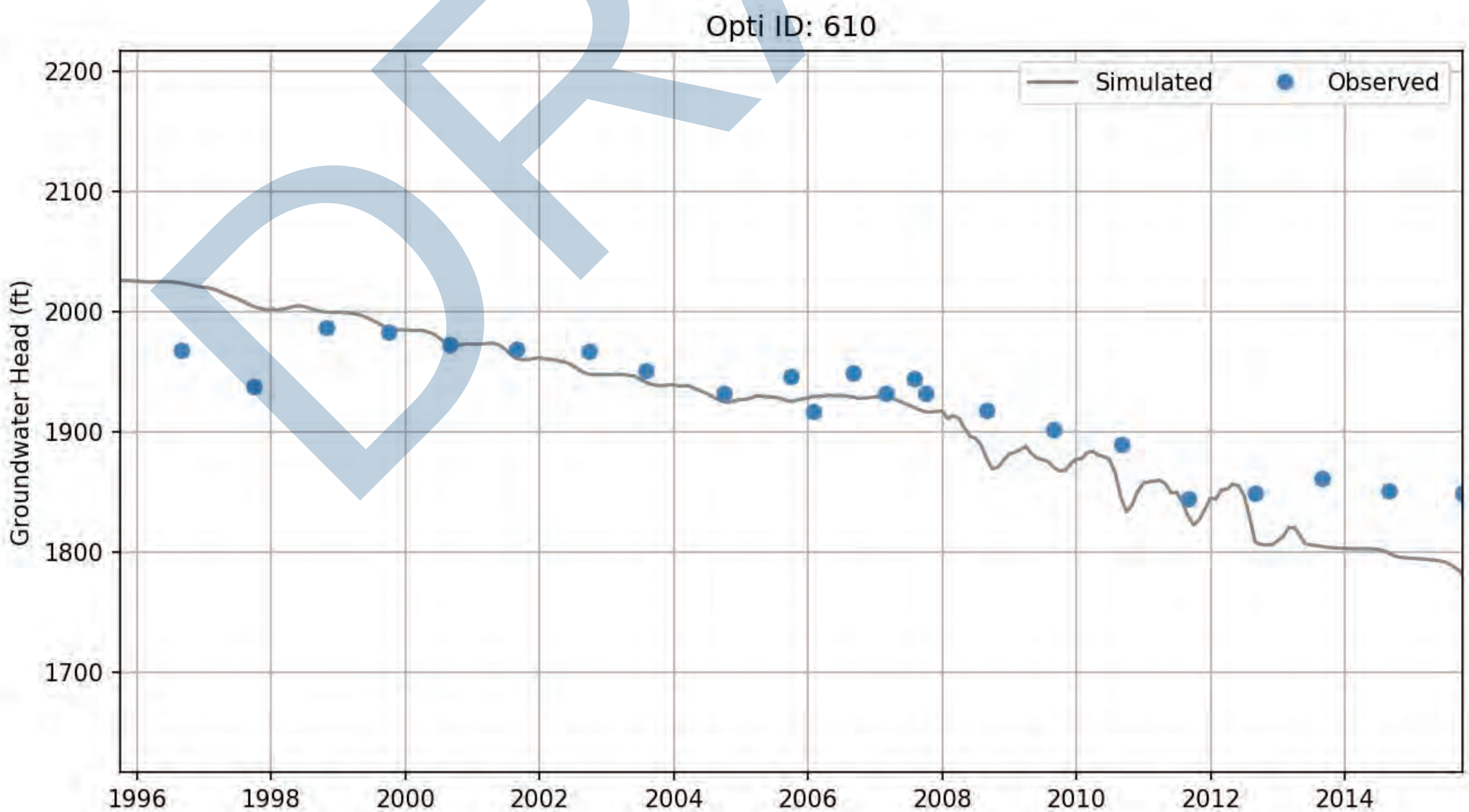

Opti ID: 604
Simulated
Observed
Groundwater Head (ft)
2000
1900
1800
1700
1600
1500
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

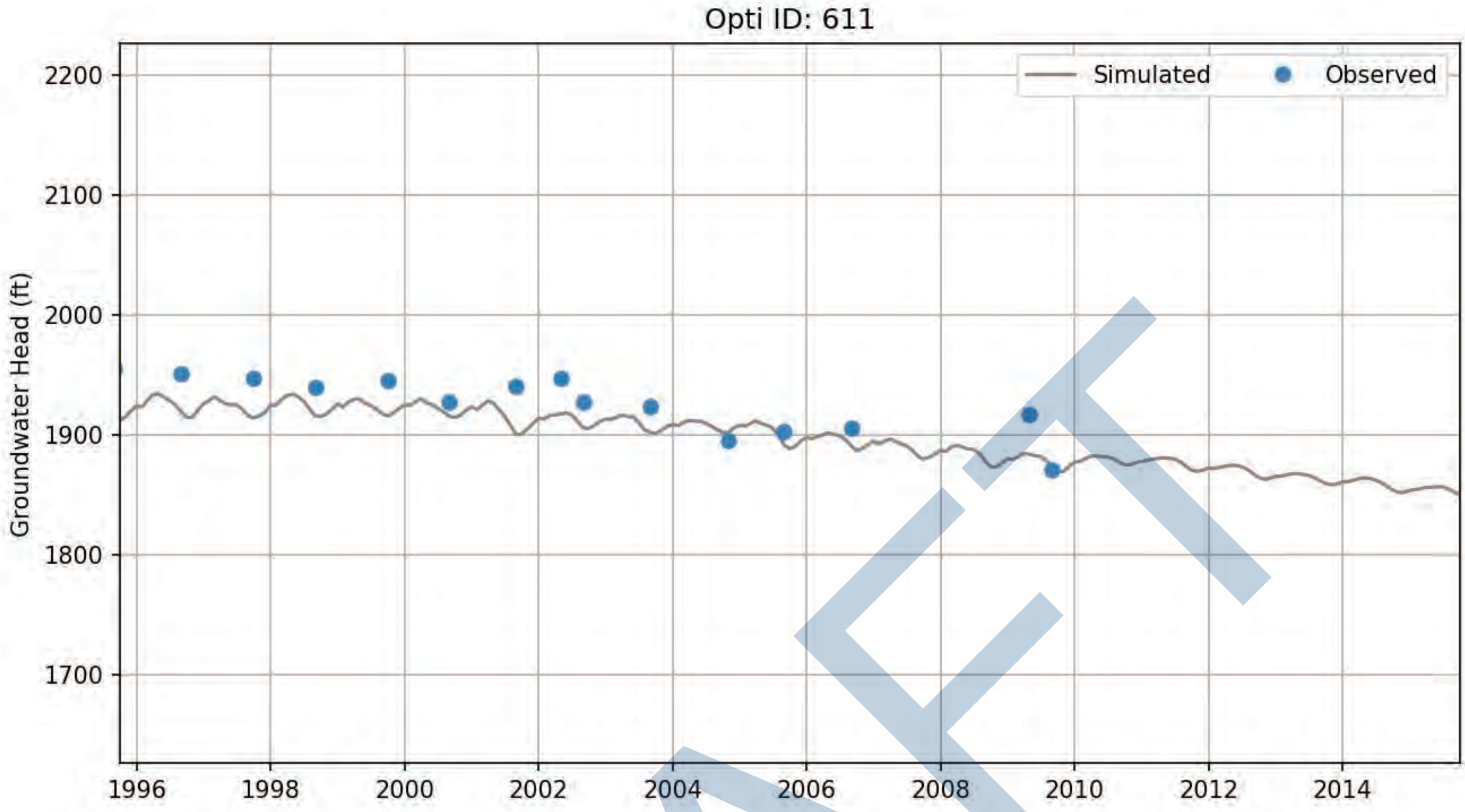

Opti ID: 606
Simulated
Observed
Groundwater Head (ft)
2100
2000
1900
1800
1700
1600
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

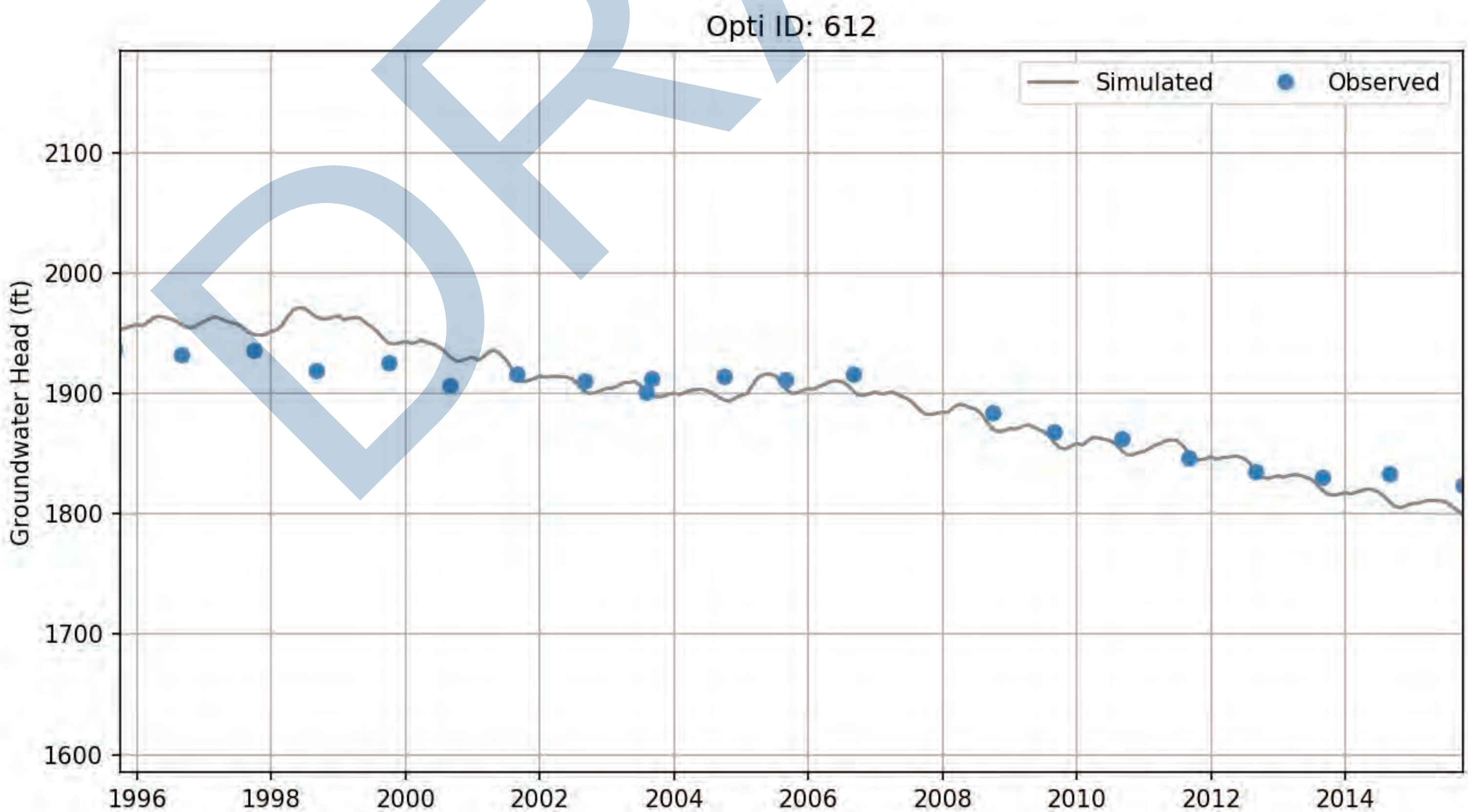

Opti ID: 607
Simulated
Observed
Groundwater Head (ft)
2100
2000
1900
1800
1700
1600
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

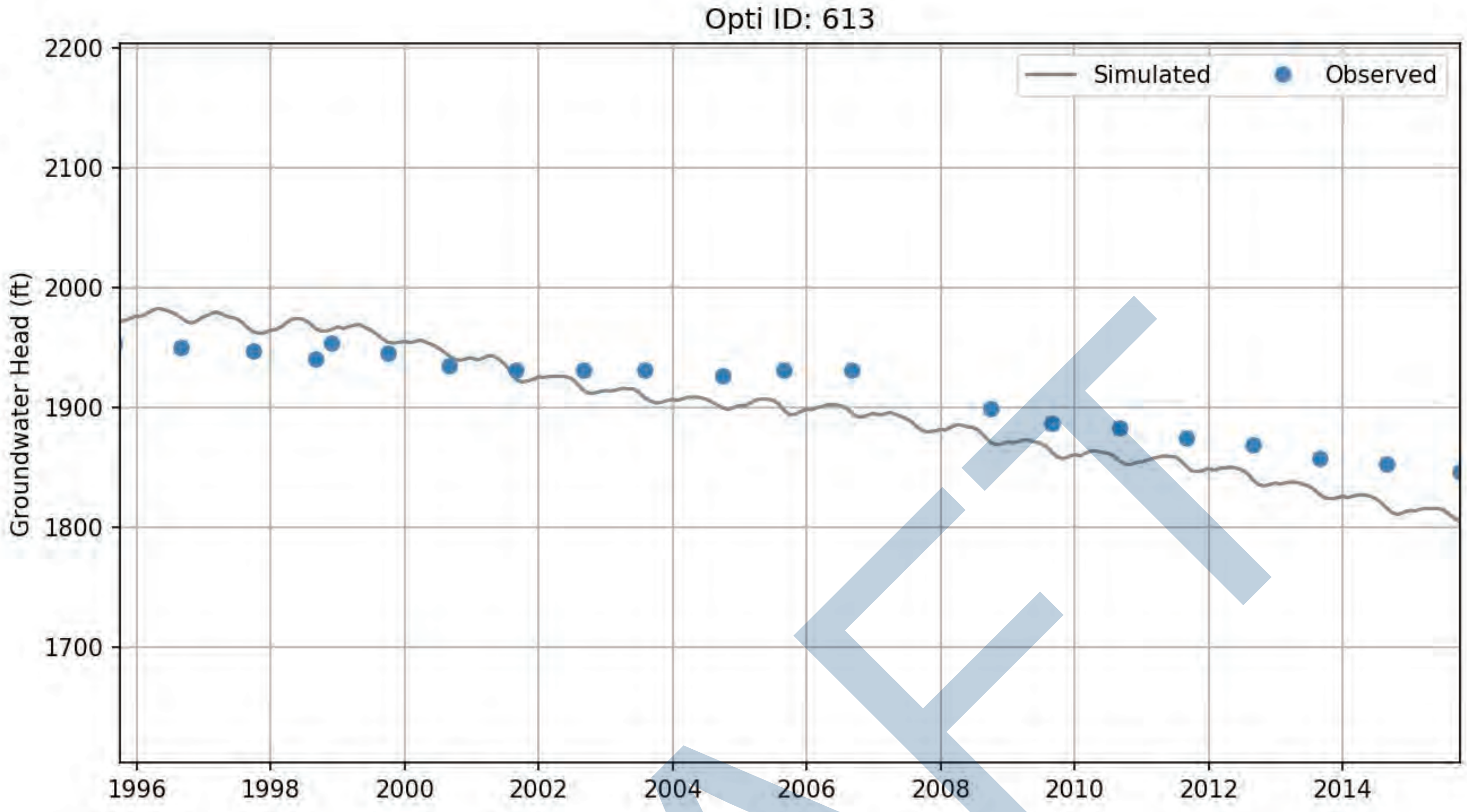

Opti ID: 608
Simulated
Observed
Groundwater Head (ft)
2100
2000
1900
1800
1700
1600
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

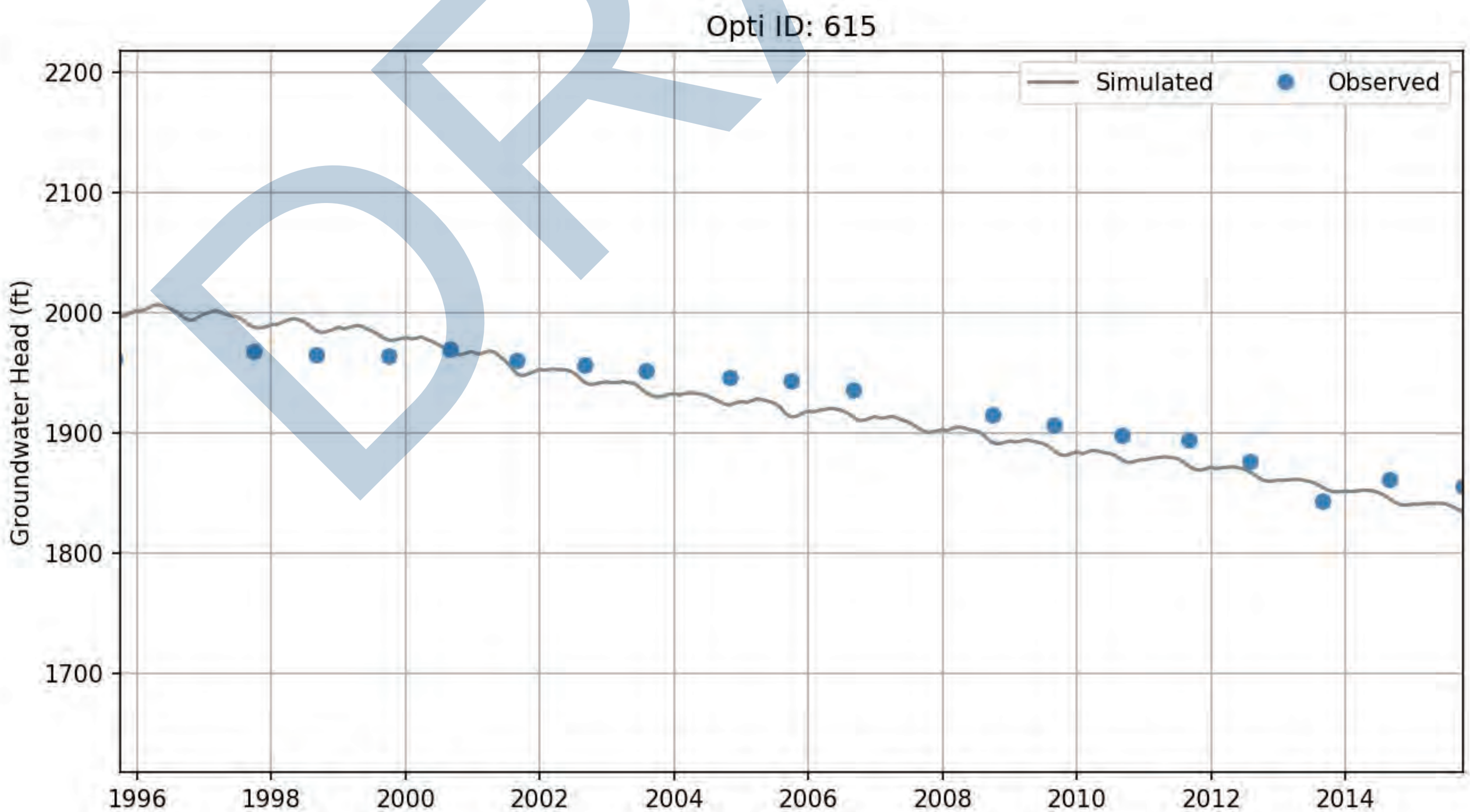

Opti ID: 609
Simulated
Observed
Groundwater Head (ft)
2100
2000
1900
1800
1700
1600
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

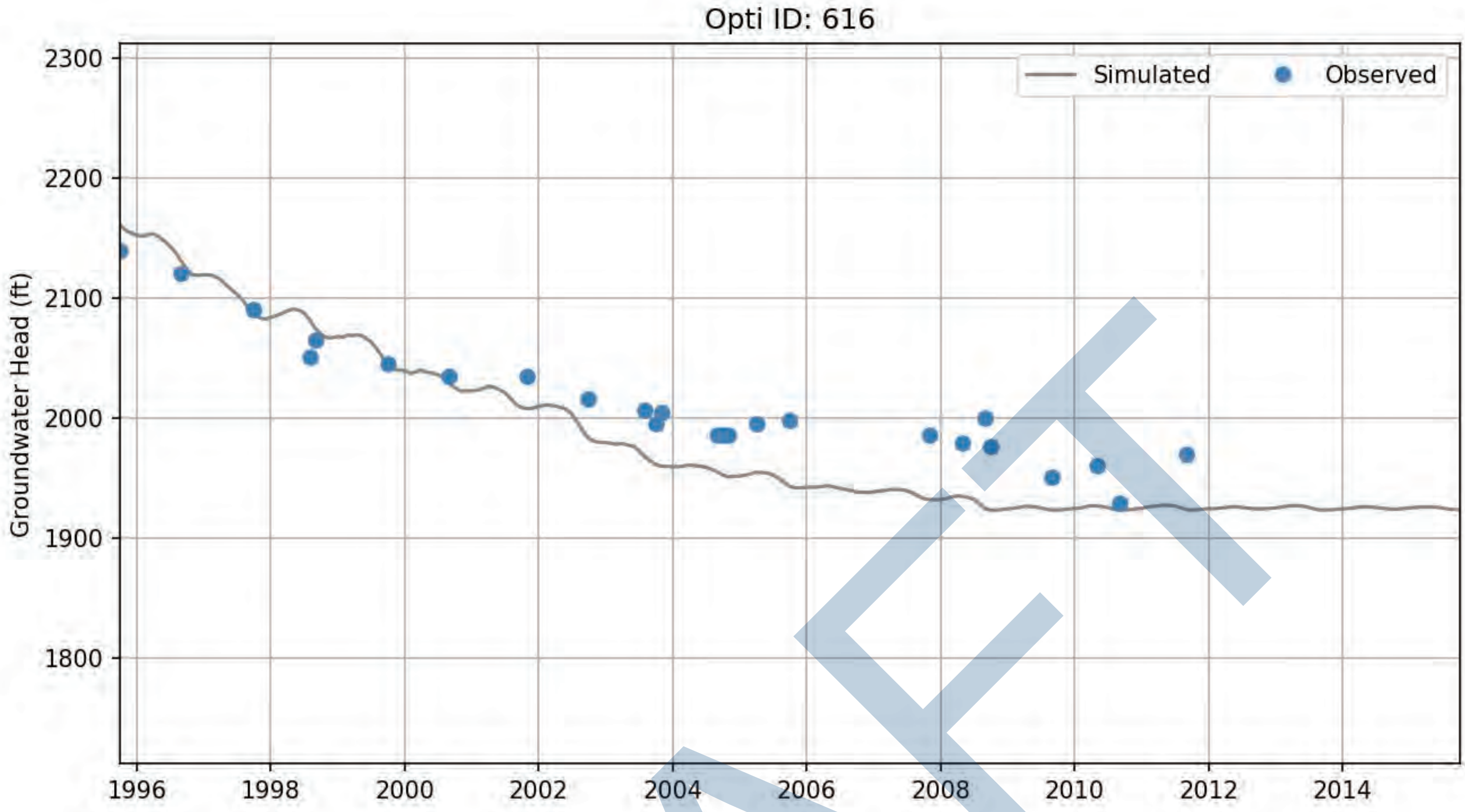

Opti ID: 610
Simulated
Observed
Groundwater Head (ft)
2200
2100
2000
1900
1800
1700
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

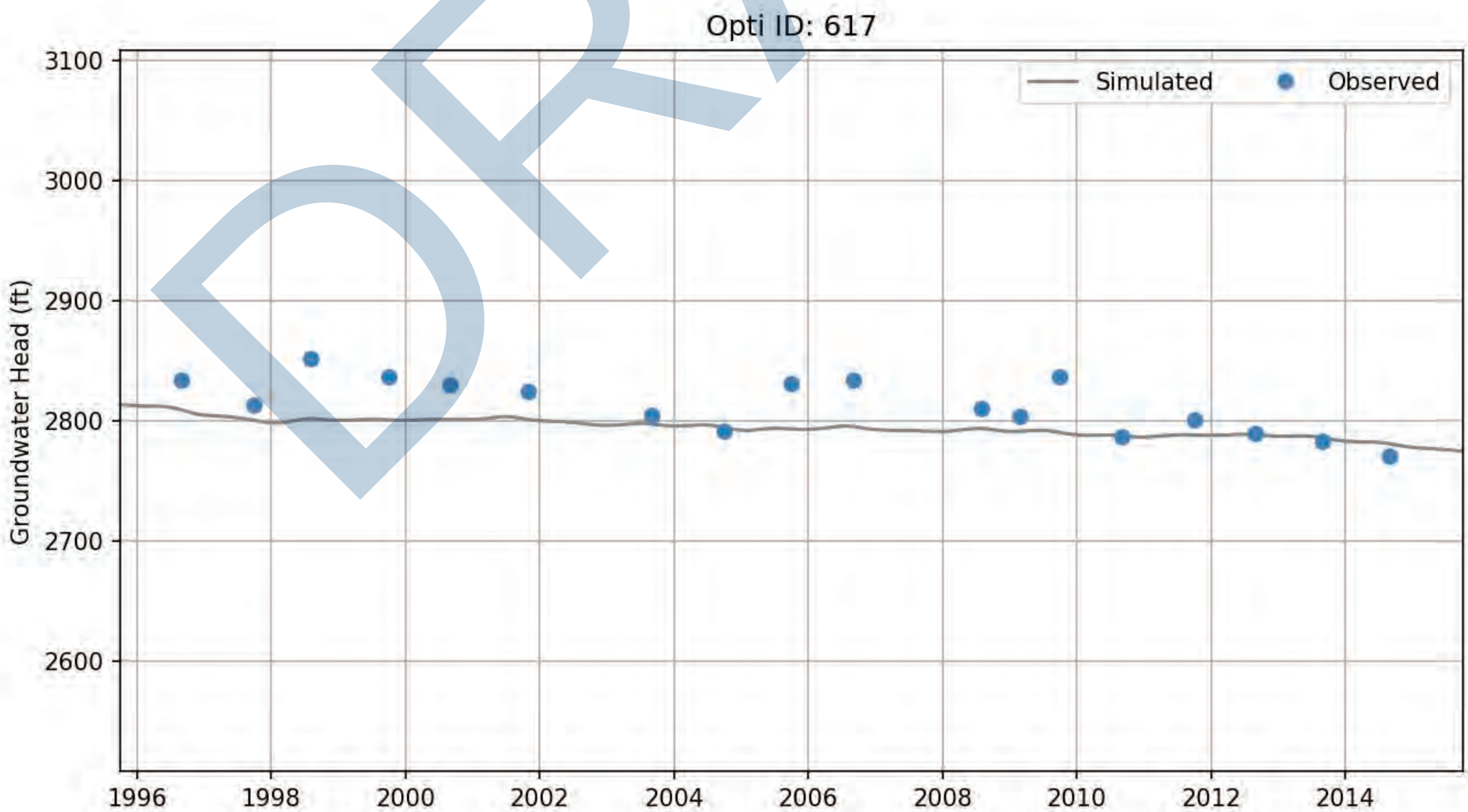

Opti ID: 611
Simulated
Observed
Groundwater Head (ft)
2200
2100
2000
1900
1800
1700
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

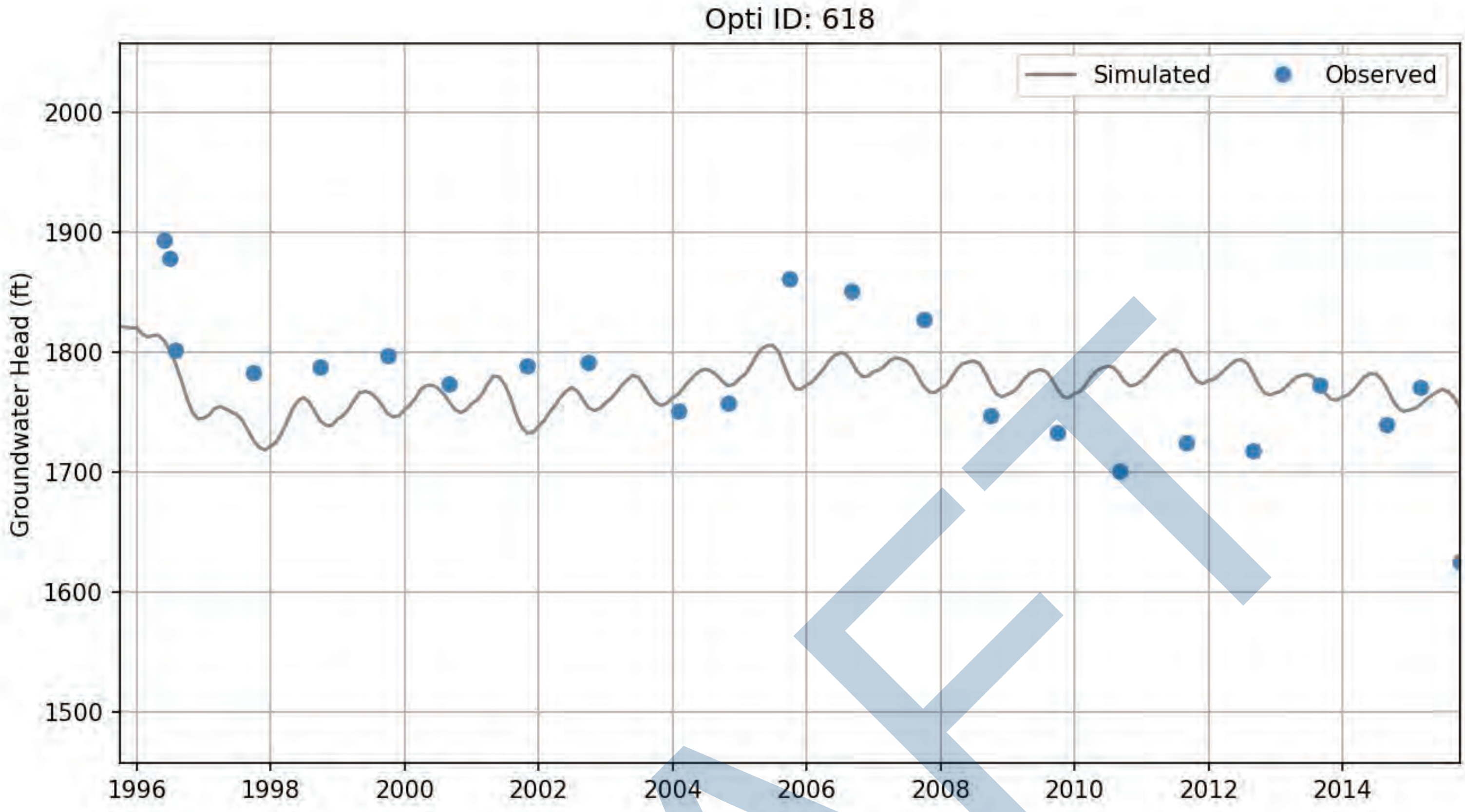

Opti ID: 612
Simulated
Observed
Groundwater Head (ft)
2100
2000
1900
1800
1700
1600
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

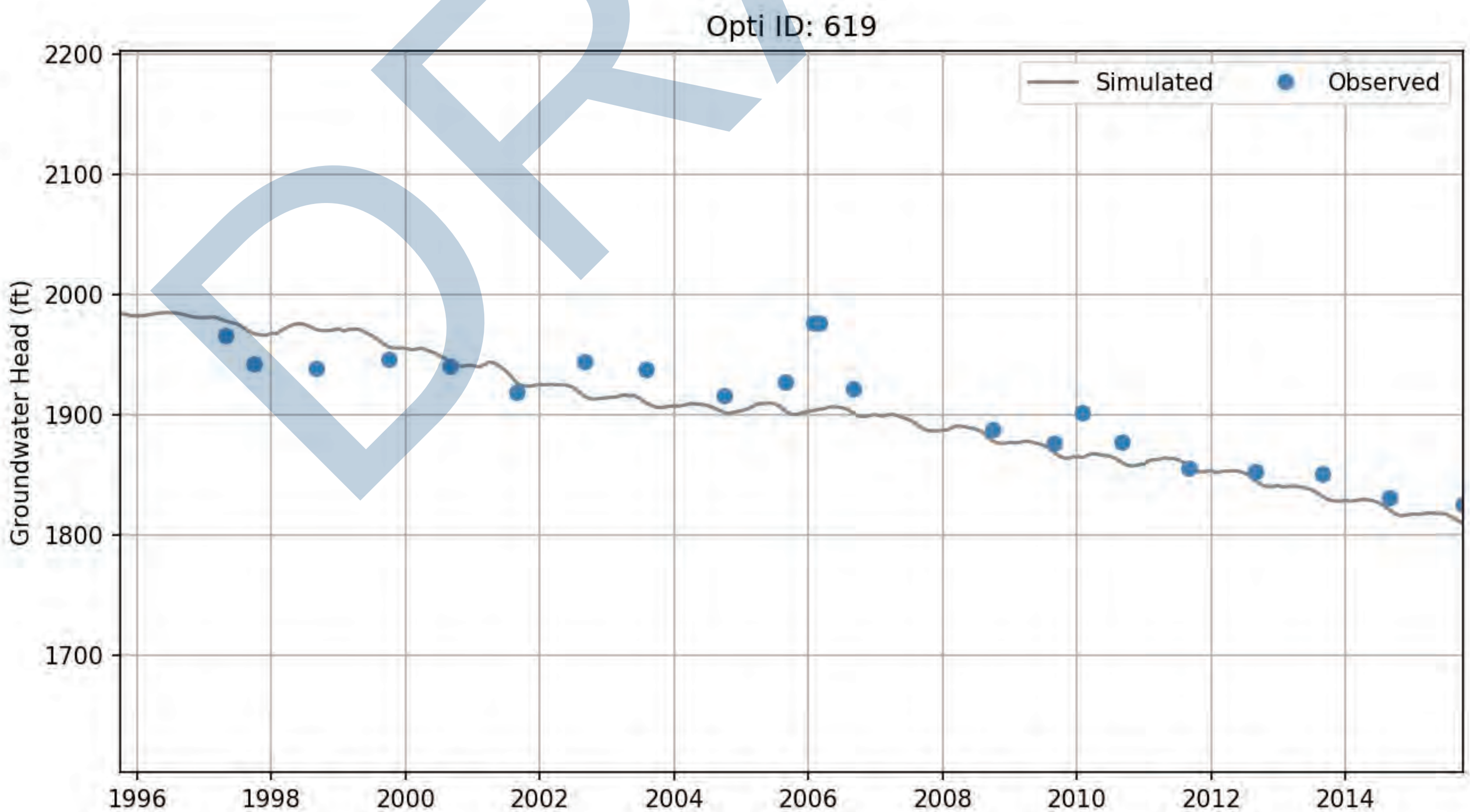

Opti ID: 613
Simulated
Observed
Groundwater Head (ft)
2200
2100
2000
1900
1800
1700
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014


Opti ID: 615
Simulated
Observed
Groundwater Head (ft)
2200
2100
2000
1900
1800
1700
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014


Opti ID: 616
Simulated
Observed
Groundwater Head (ft)
2300
2200
2100
2000
1900
1800
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014


Opti ID: 617
Simulated
Observed
Groundwater Head (ft)
3100
3000
2900
2800
2700
2600
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014


Opti ID: 618
Simulated
Observed
Groundwater Head (ft)
2000
1900
1800
1700
1600
1500
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014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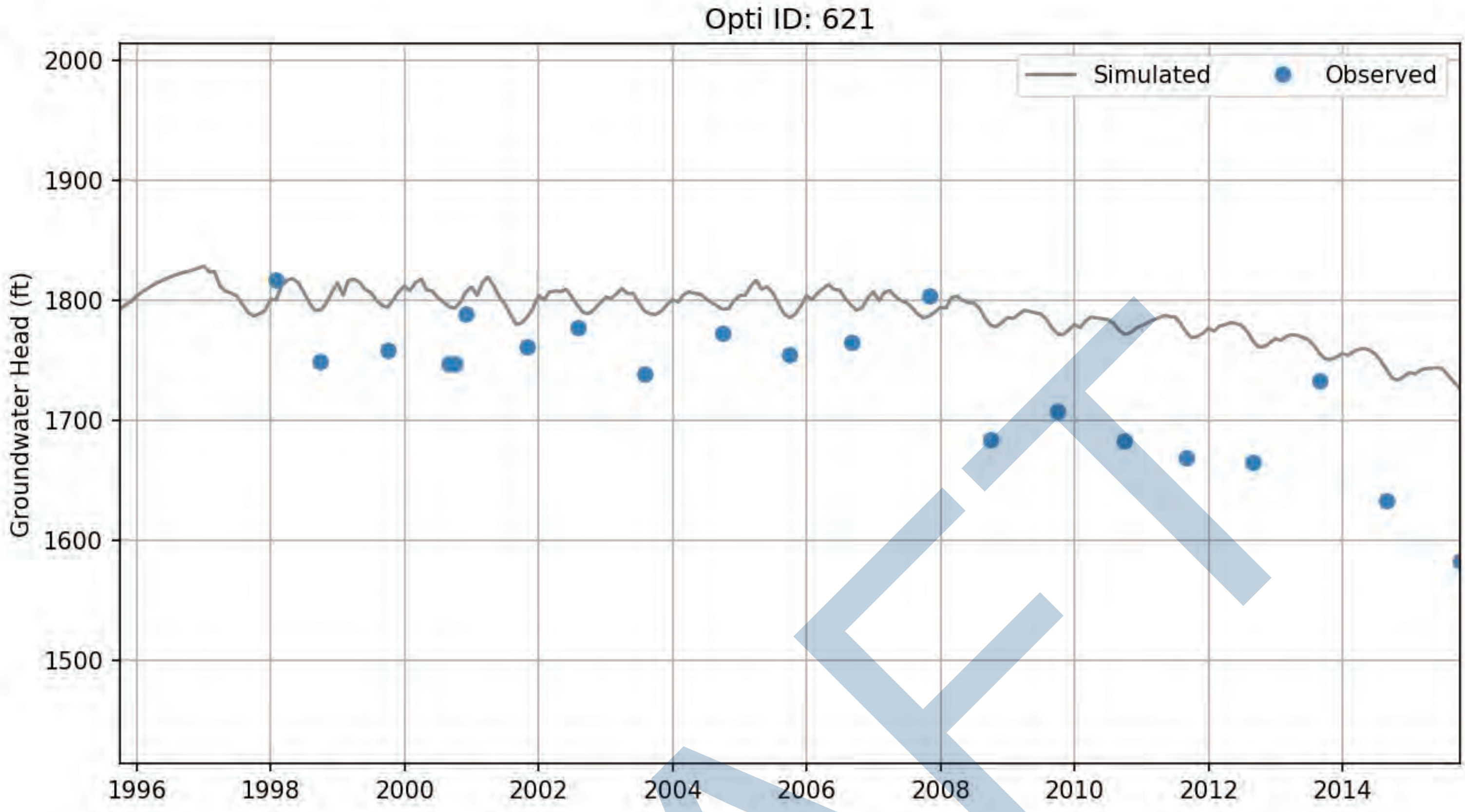
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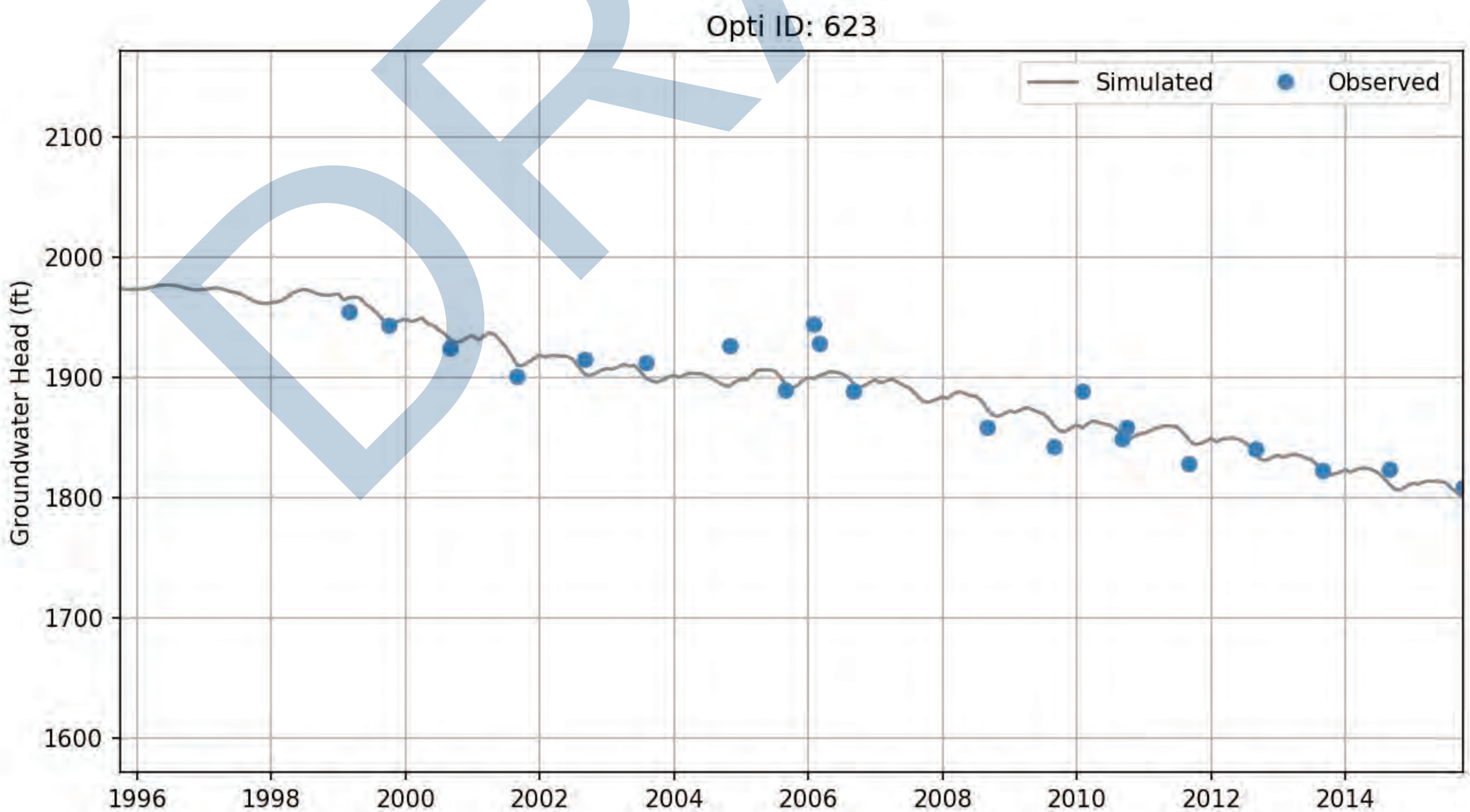
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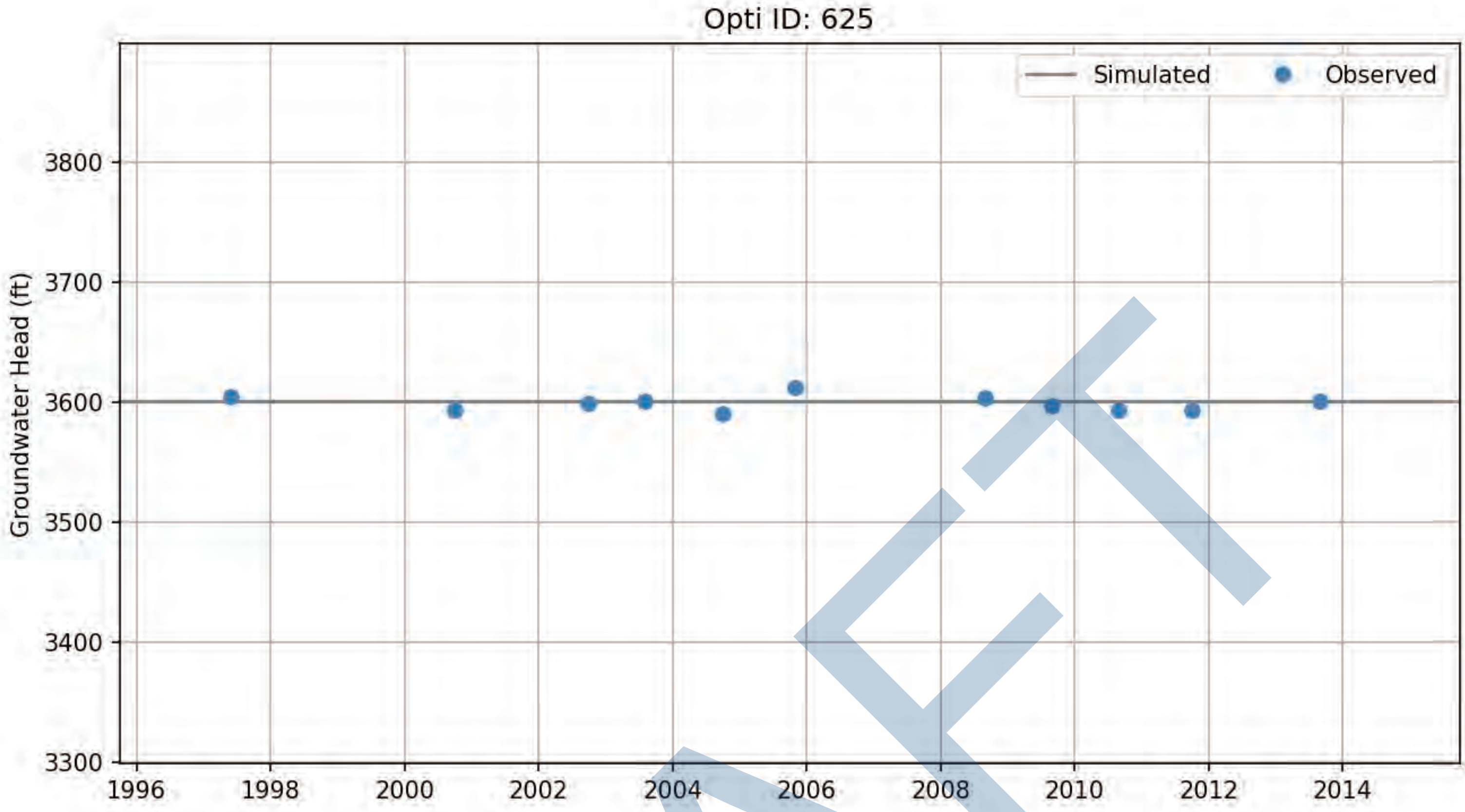
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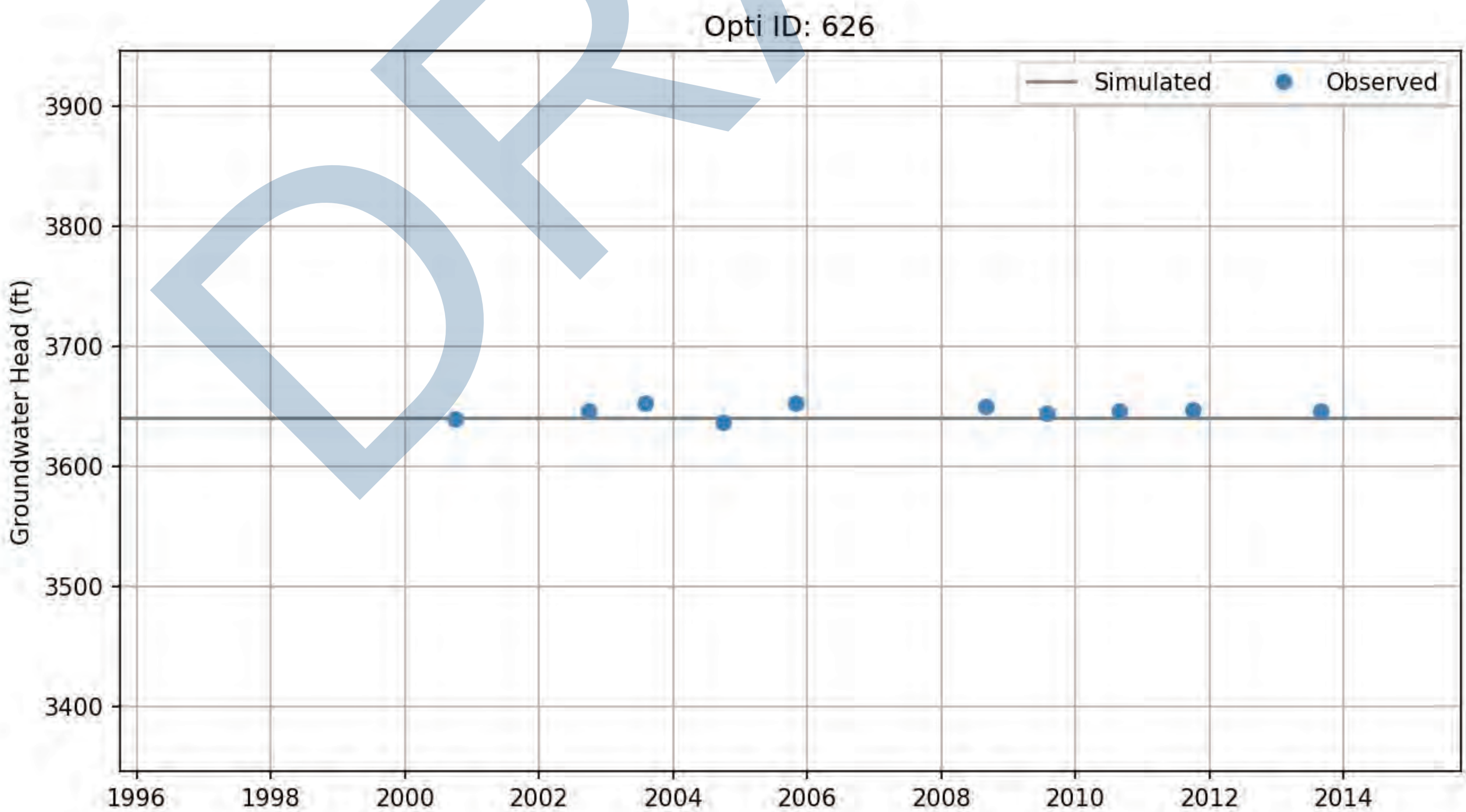
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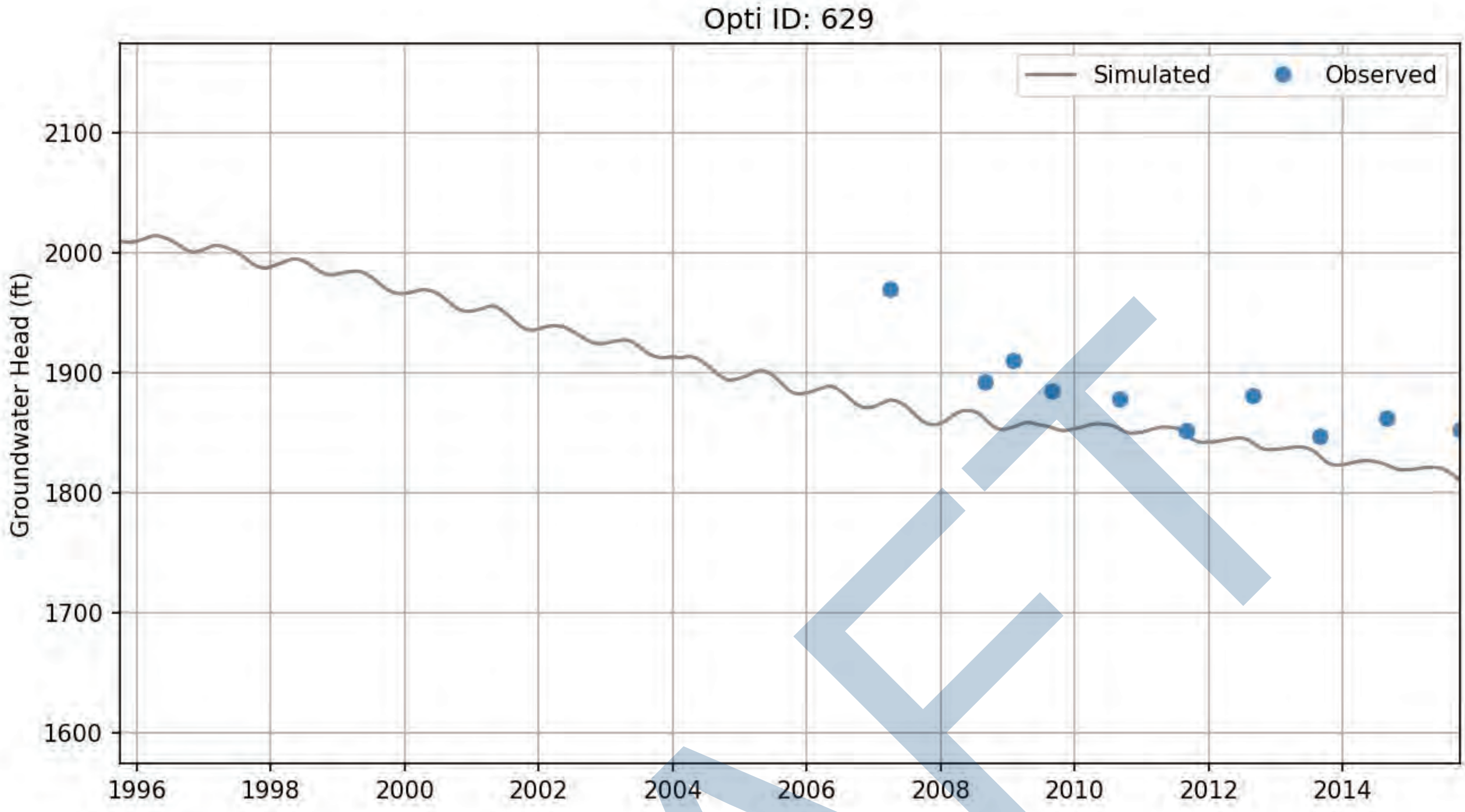
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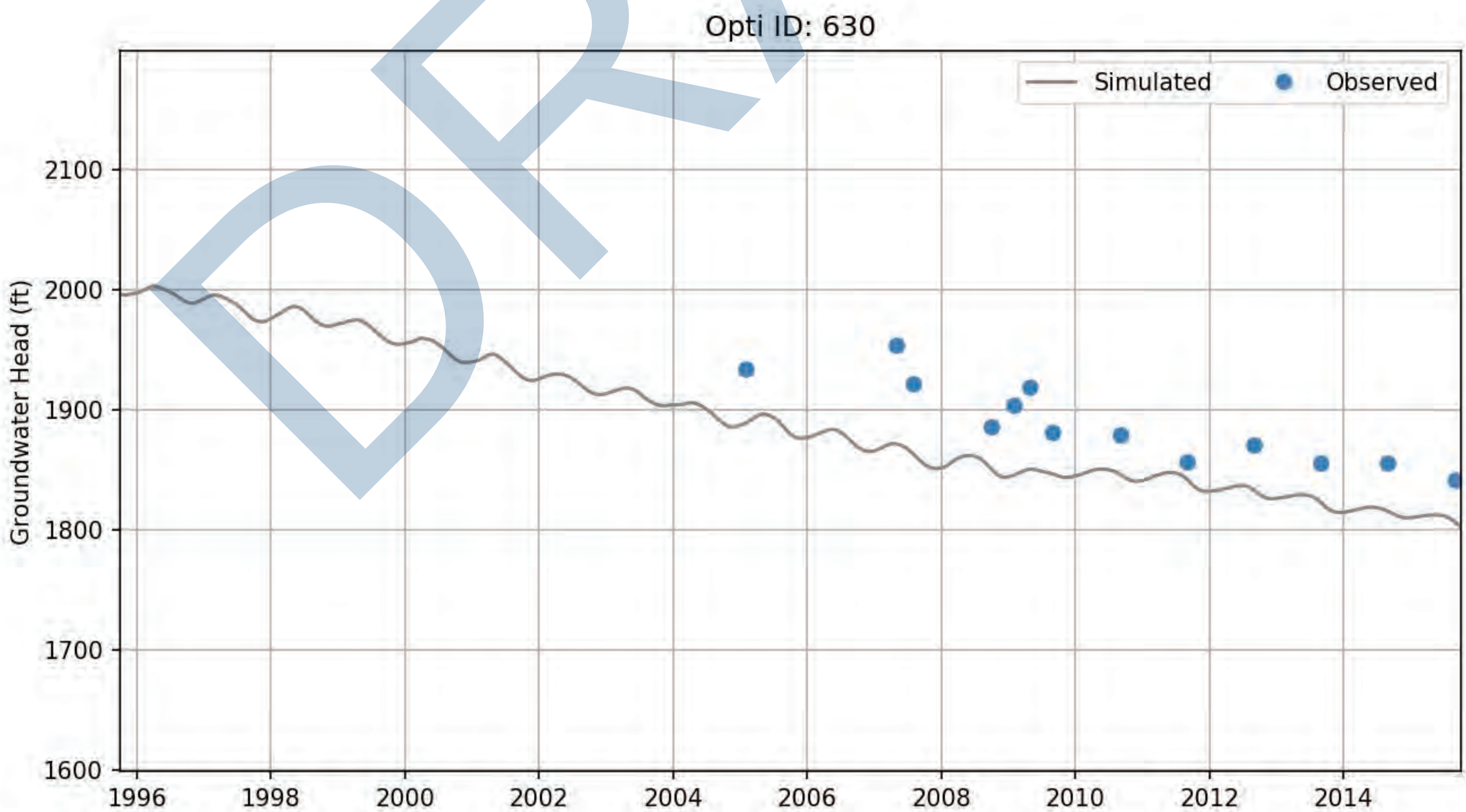
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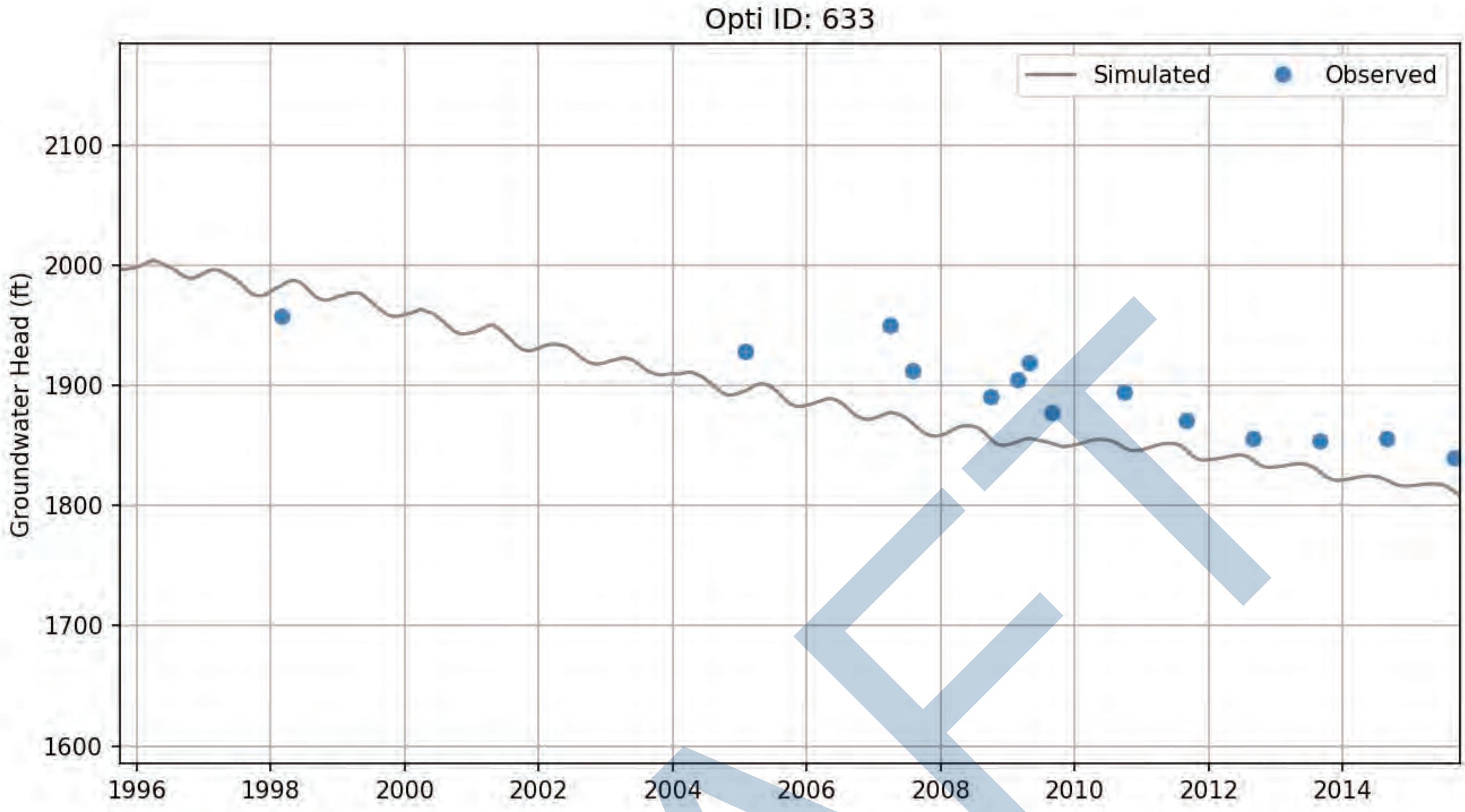
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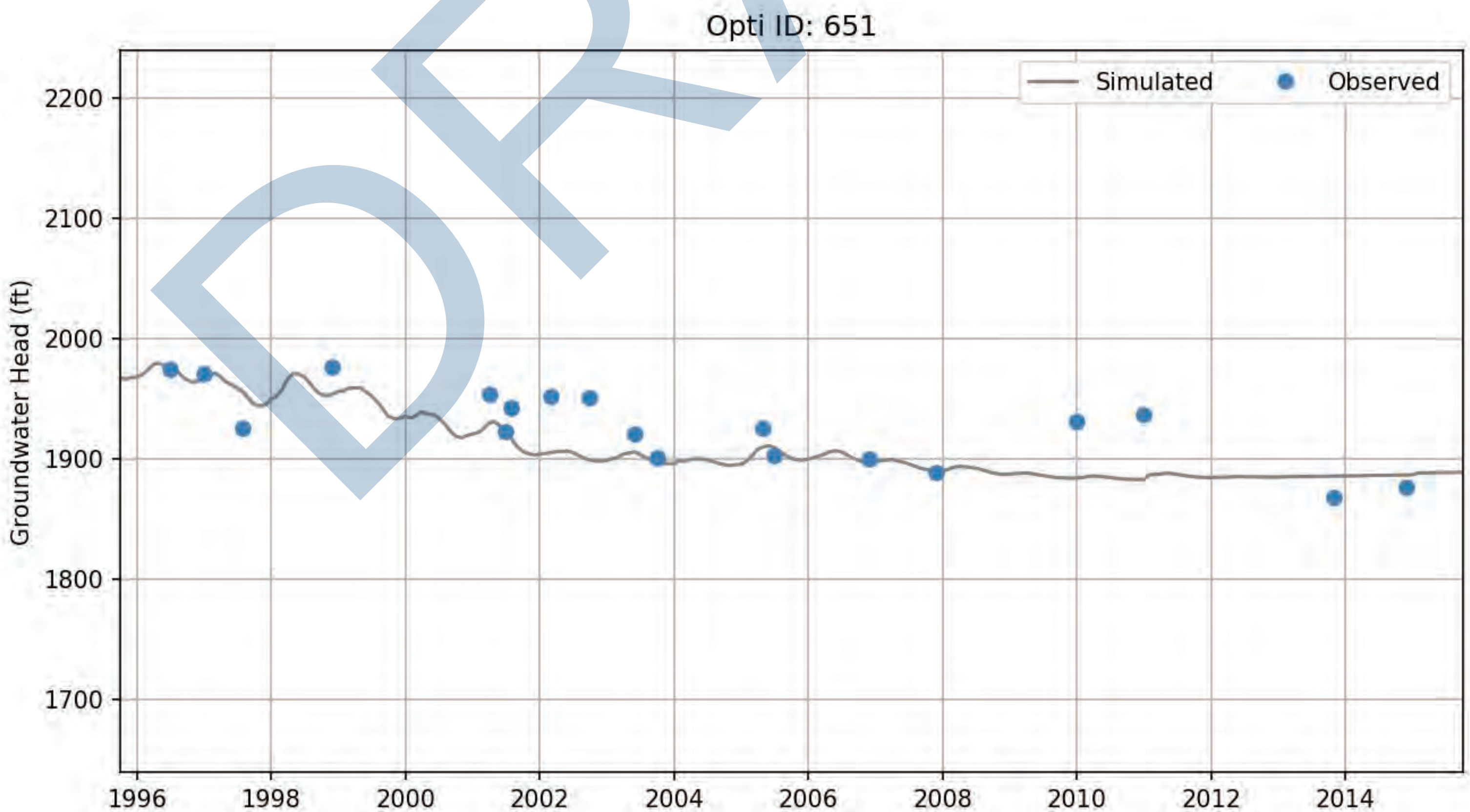
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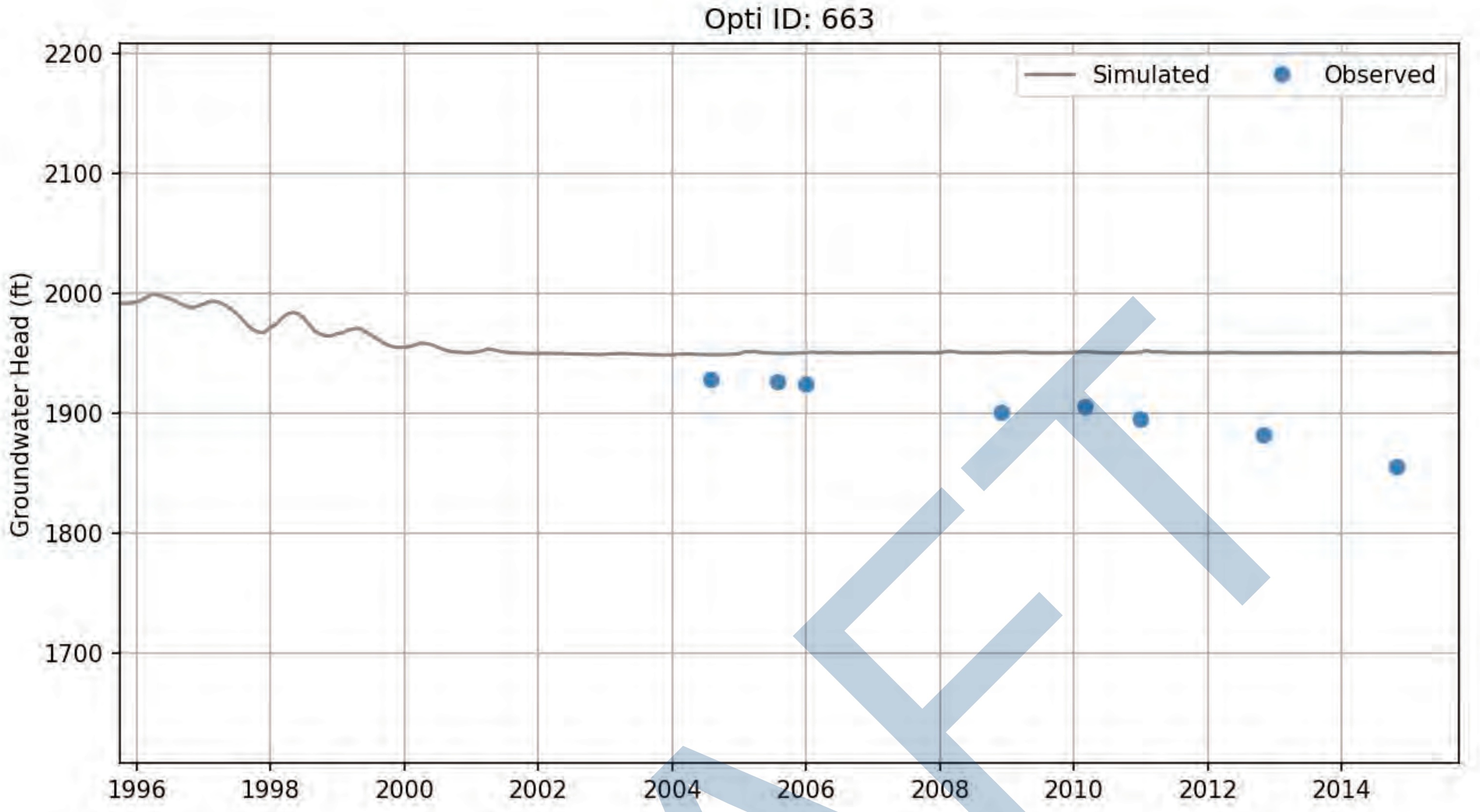
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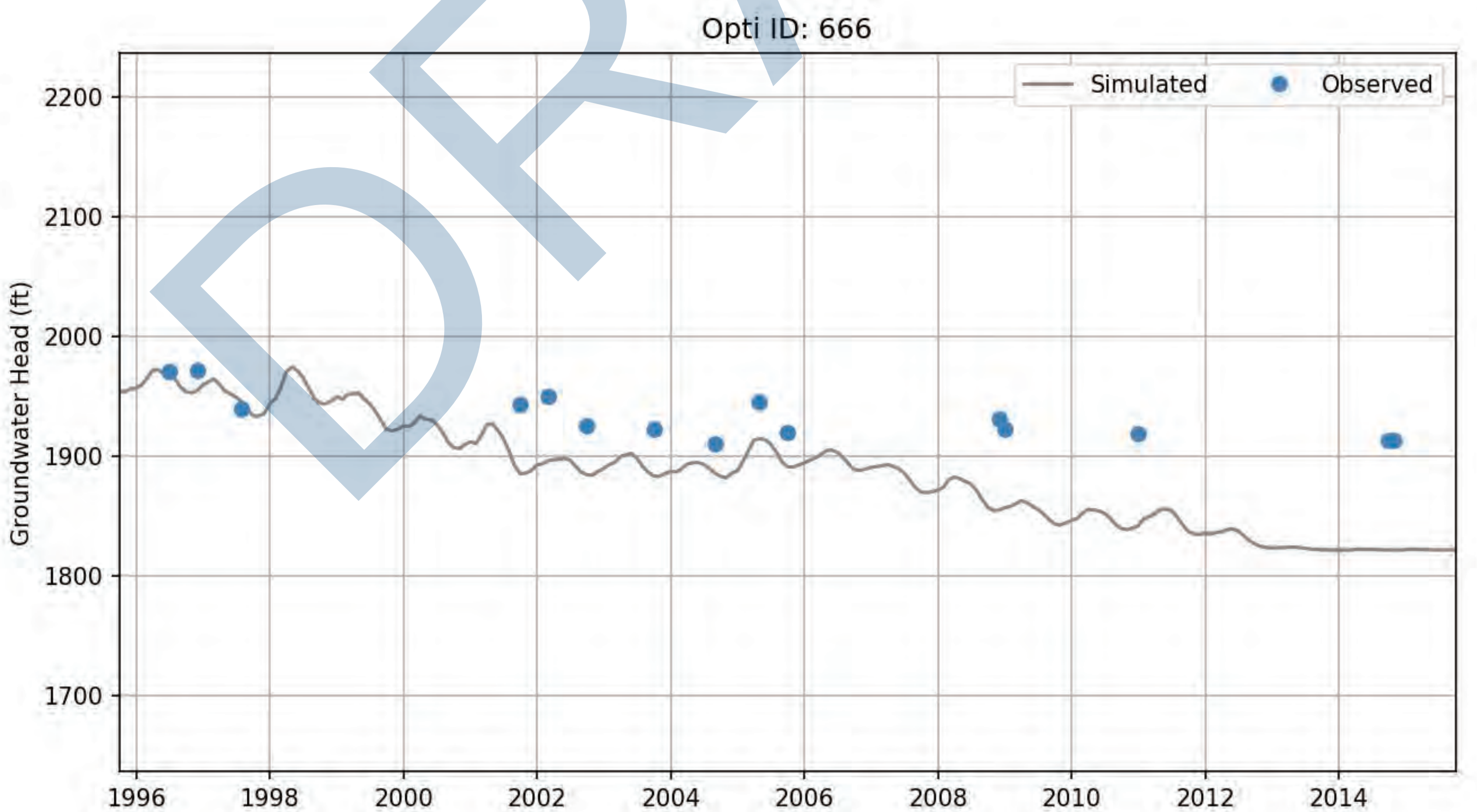
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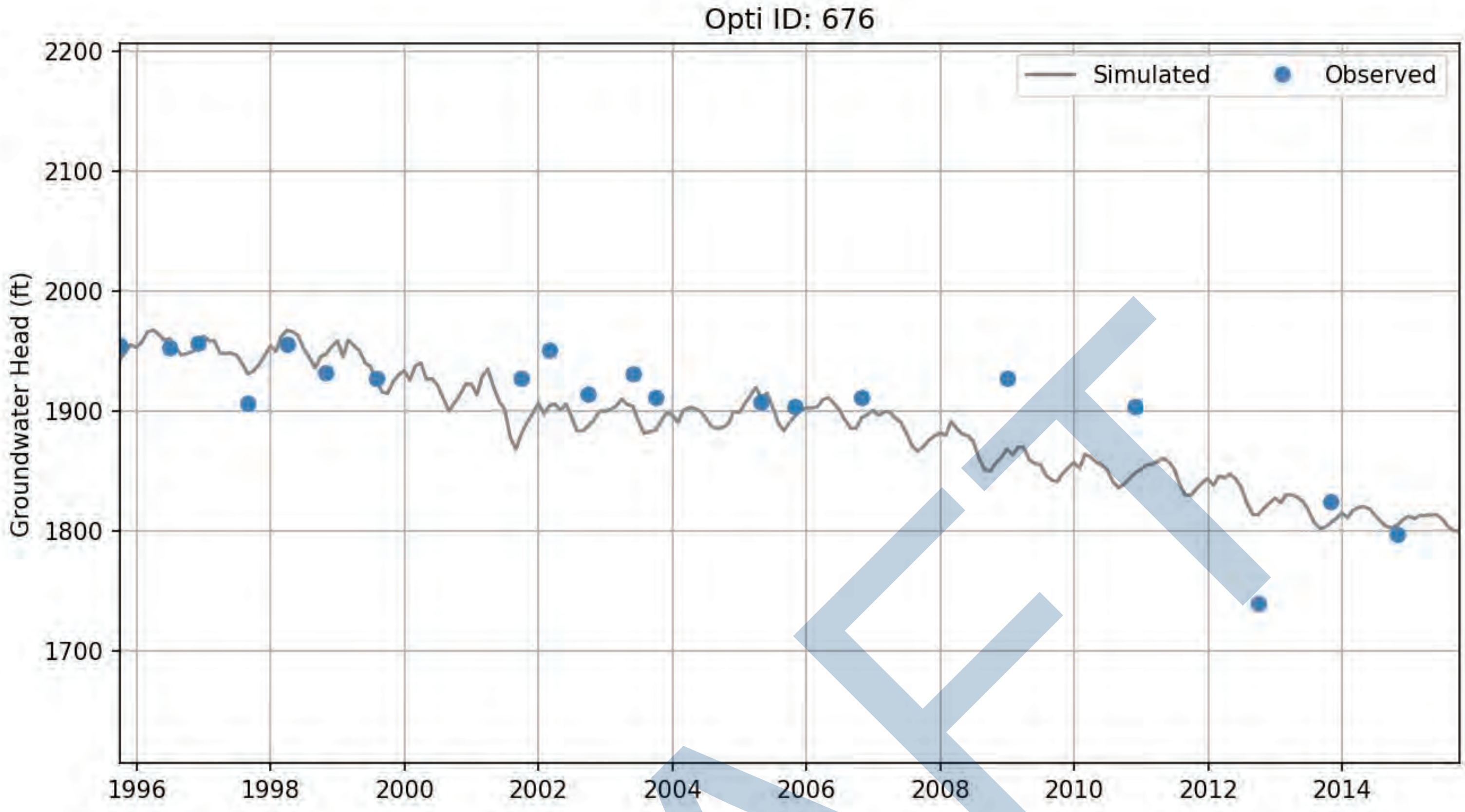
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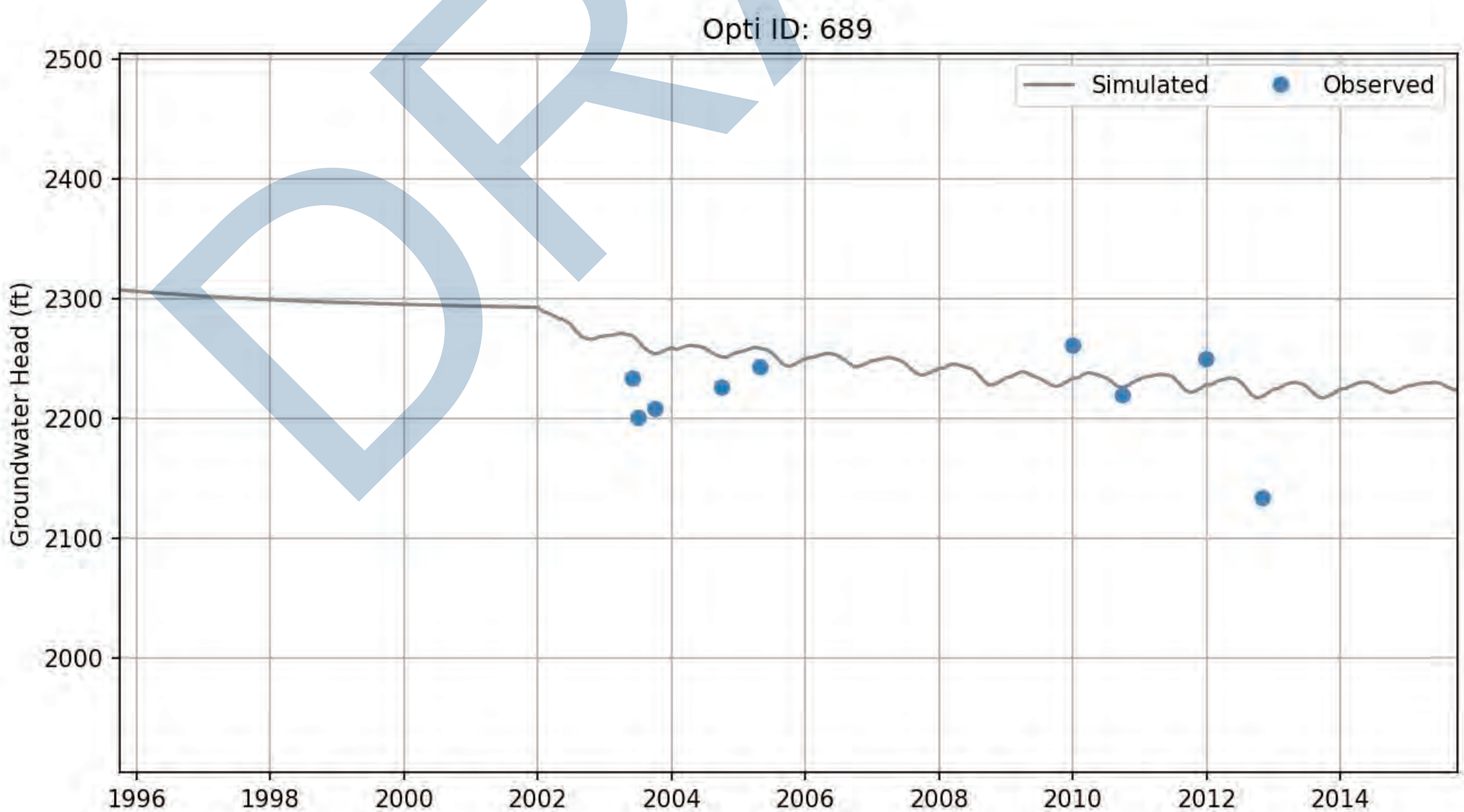
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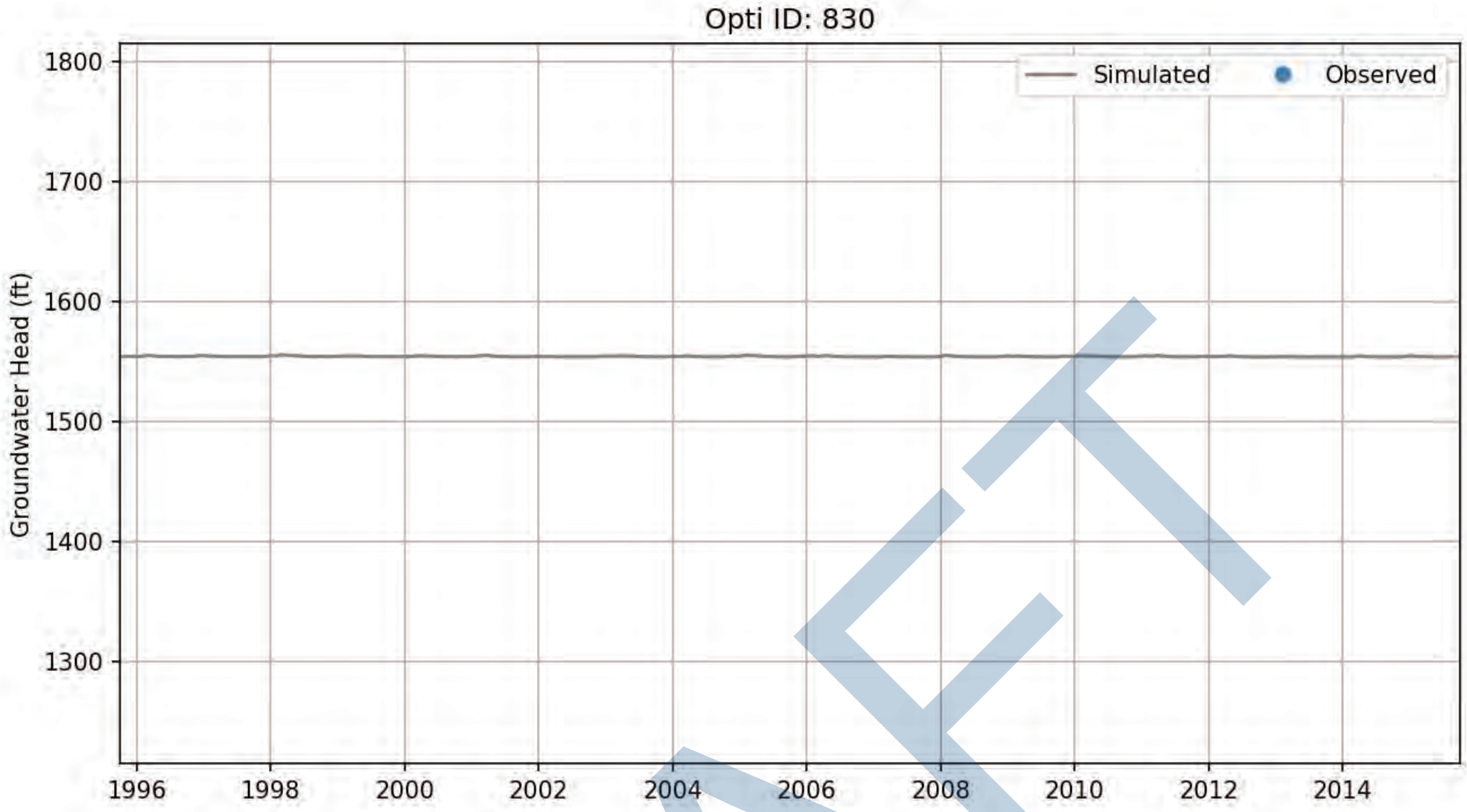
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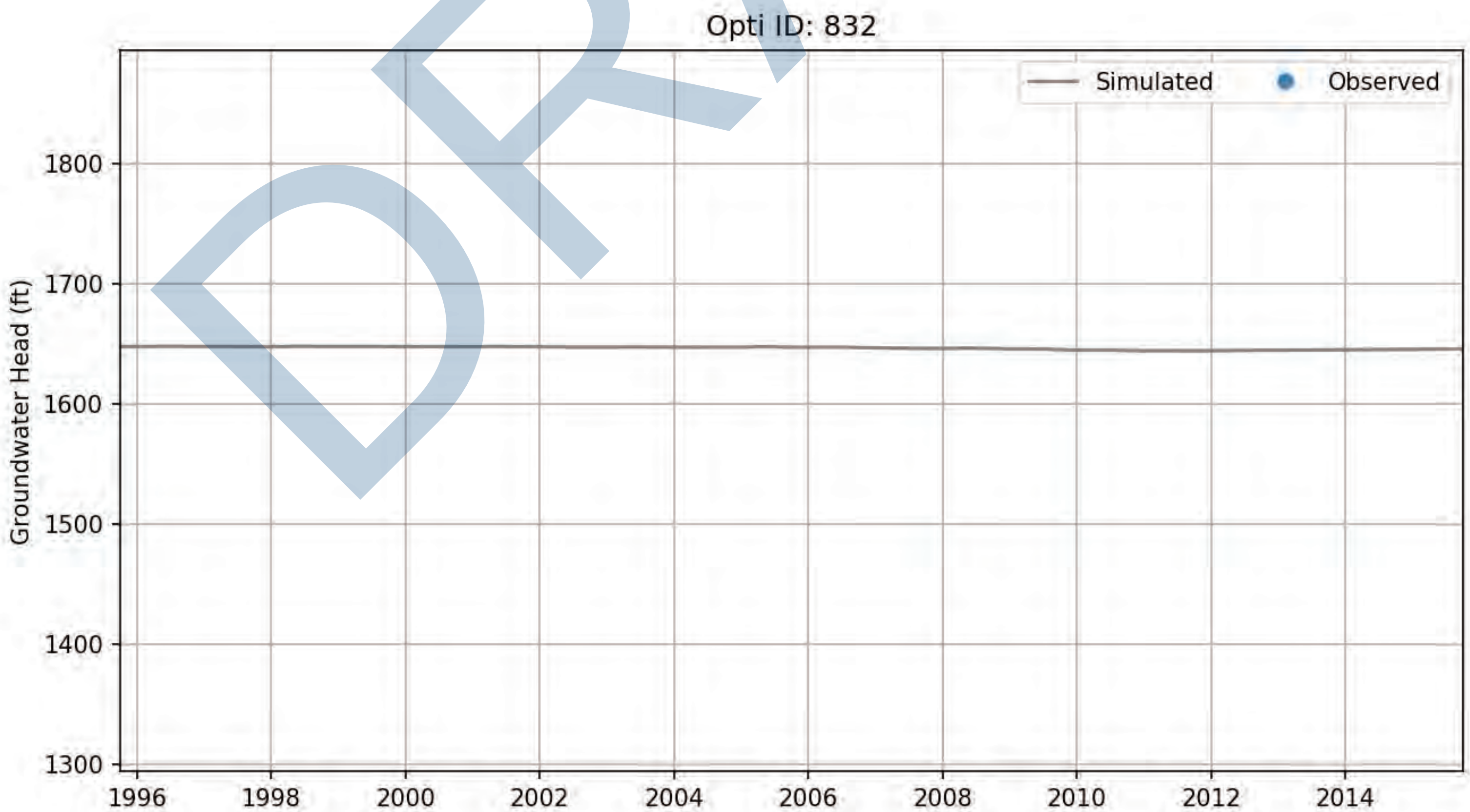
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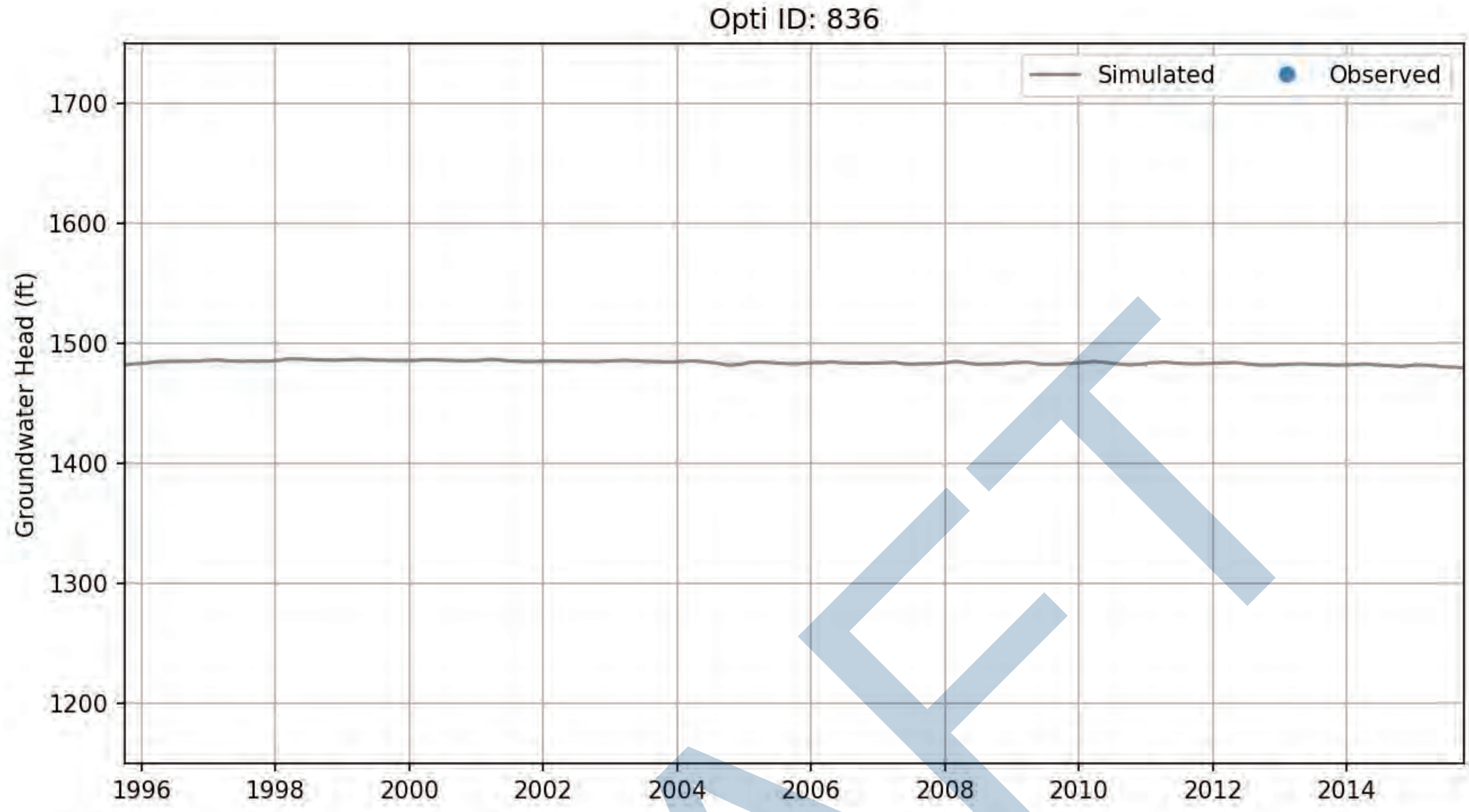
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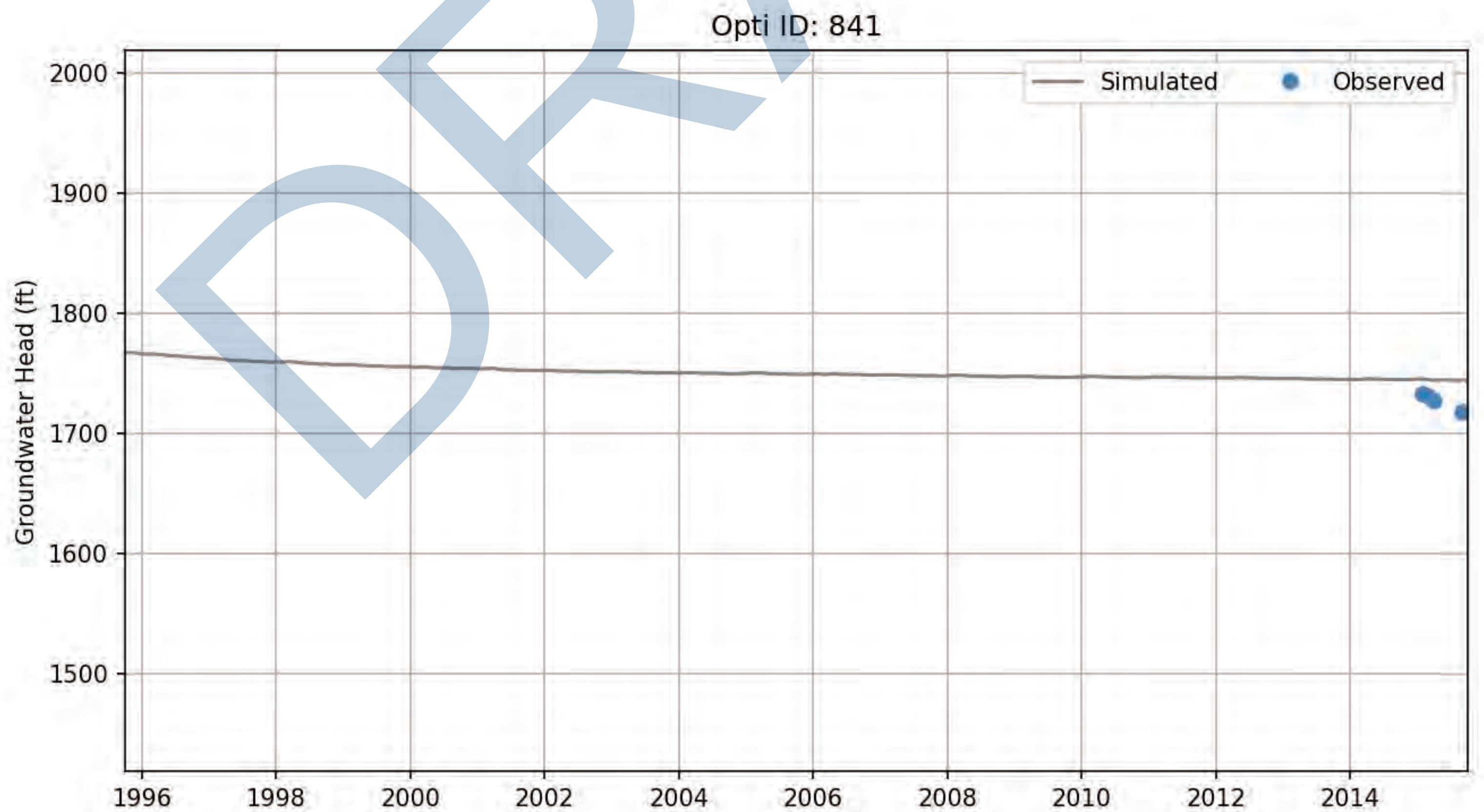
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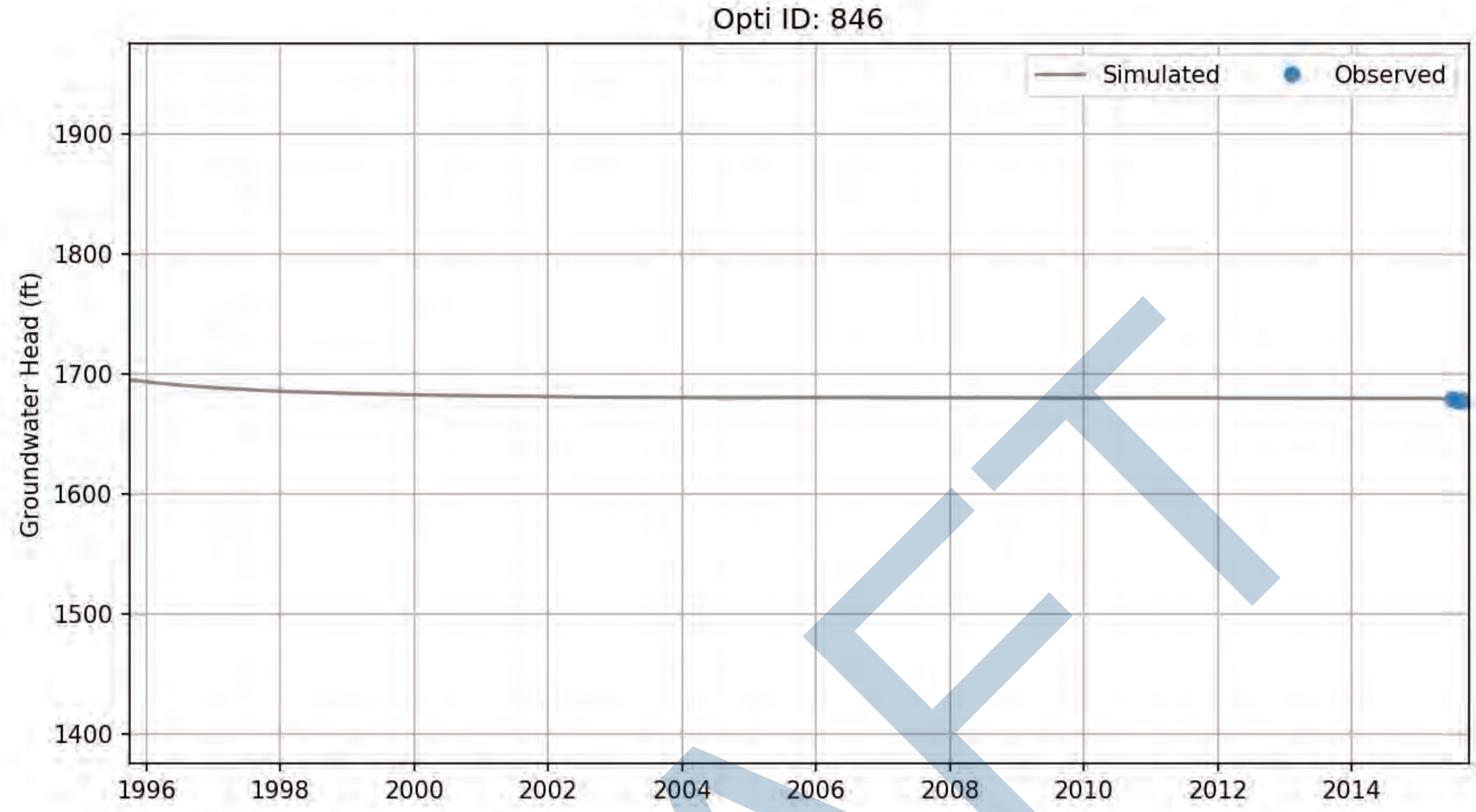
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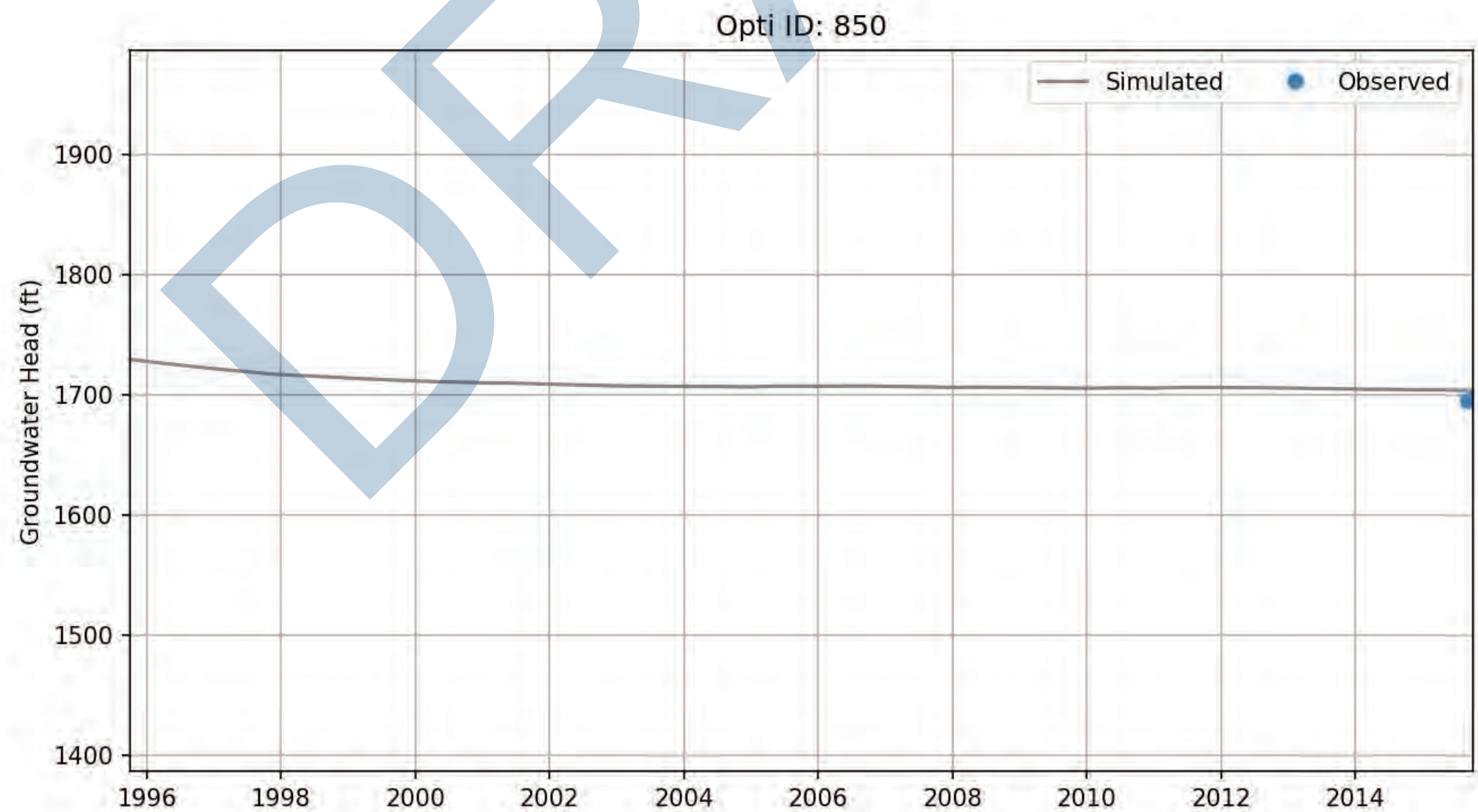
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Appendix D

Technical Memorandum: Verification of NCCAG-Identified Locations

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TECHNICAL MEMORANDUM

TO: Cuyama Groundwater Sustainability Agency

CC: Brian Van Lienden, Woodard & Curran PM

PREPARED BY: William L. Medlin, PWS, ENV SP

REVIEWED BY: John Ayres and Micah Eggleton

DATE: February 15, 2019

RE: Cuyama GSP Groundwater Dependent Ecosystems Study

As part of the California Sustainable Groundwater Management Act (SGMA), Groundwater Sustainability Agencies (GSAs) are required to develop a Groundwater Sustainability Plan (GSP) to help ensure that groundwater is available for long-term, reliable water supply uses. SGMA was put into place and is enforced by the California Department of Water Resources (DWR). Once implemented, each GSP must address certain key elements such as a baseline groundwater assessment, monitoring, establishing best management practices (BMPs), and setting new regulations with the goal of defining a pathway to achieve sustainable groundwater management within 20 years (DWR 2018).

Within the GSP, a baseline assessment of groundwater conditions must be completed, and part of that assessment includes identification of groundwater dependent ecosystems (GDEs) and an assessment of potential impacts on GDEs. SGMA defines GDEs as "ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface." The identification and determination of GDEs within a groundwater basin is the responsibility of the GSA that governs the basin. This study specifically focuses on GDEs identified within the Cuyama Valley groundwater basin.

1. CUYAMA VALLEY GROUNDWATER BASIN ECOLOGICAL SETTING

The Cuyama Valley groundwater basin encompasses multiple California ecoregions (Griffith et al. 2016). In terms of land area, the dominant ecoregion is the Central California Foothills and Coastal Mountains (6), sub-ecoregion Cuyama Valley (6am). This ecoregion is characterized by its Mediterranean climate with hot, dry summers and cool, moist winters. Typical vegetative communities consist of chaparral and oak woodlands; grasslands are present at some lower elevations and pine forests are observed at high elevations. Most of the region is comprised of open, low mountains and foothills with some irregular plains and narrow valleys in certain locations. More specifically, the Cuyama Valley is a narrow valley with significant agricultural production. The mainstem Cuyama River flows through the center of the valley from southeast to northwest.

A minor part of the Cuyama Valley ground water basin is in the Southern California Mountains (8) ecoregion, in the Northern Transverse Range (8g) sub-ecoregion. This ecoregion, like other California ecoregions, is characterized by a Mediterranean climate of hot, dry summers and cool, moist winters. Chaparral and oak woodland vegetative communities are still ever-present, however the elevations in this ecoregion are higher generally leading to cooler summers and greater rainfall which result in denser vegetation and large areas of coniferous forests. There is a slope effect that causes some significant ecological differences in the Transverse Range. South-facing slopes receive more annual precipitation (30-40 inches) than the northern-facing slopes (15-20 inches), yet evaporation rates contribute to the development of chaparral communities. While on the northern-facing side of parts of the ecoregion, lower temperatures and evaporation coupled with slow snow melt allow for a coniferous forest that transitions to desert montane habitat. Some areas of severe erosion are common where vegetation has been removed via fire, overgrazing, or other land clearing practices. Many areas in this ecoregion are National Forest public land (Griffith et al. 2016). The Cuyama River headwaters (Quatal Canyon Creek, Apache Canyon Creek, and Cuyama Creek) flow through this ecoregion. Figure 1 (Attachment A) illustrates the general location of the Cuyama Valley groundwater basin in the context of the Ecoregions of California.

2. GDE ASSESSMENT AND FIELD VALIDATION

Using Geographic Information Systems (GIS), Woodard & Curran completed a preliminary desktop analysis of the California DWR *Natural Communities Commonly Associated with Groundwater* (NCCAG) geospatial data set. Woodard & Curran attempted to identify NCCAG polygons that appeared to be "probable GDEs" based on the following observations:

- Presence of a mapped USGS spring or seep
- Inundation visible on aerial imagery
- Saturation visible on aerial imagery
- Dense riparian and/or wetland vegetation visible on aerial imagery

Areas that did not exhibit the above characteristics (or similar) were considered "probable non-GDEs" for purposes of this study. Reference Figure 2 (Attachment A) for geospatial representation of our basin-wide GDE desktop assessment.

In addition to the preliminary desktop analysis of the NCCAG data set, Woodard & Curran also completed a preliminary GDE field validation study throughout portions of the Cuyama Valley groundwater basin. The field study was conducted only on publicly accessible lands (including the Los Padres National Forest) where the NCCAG data set indicated potential presence of GDEs. Field observations were made at NCCAG-mapped seeps, springs, and at other riparian habitats to document plant communities, aquatic or semi-aquatic wildlife, indicators of surface and subsurface hydrology, presence of hydric soils, and other relevant ecological and hydrological data. Photographs were taken in the four cardinal directions (north, east, south, west) at each field validation assessment location, and additional photographs were taken of plant species and other relevant ecological data. Global Positioning System (GPS) points were also collected using a sub-meter Trimble Geo 7x GPS unit at the field validation assessment locations. Preliminary determinations were made at these field assessment locations as to whether an area would be classified as a GDE. Figure 3 (Attachment A) shows the locations of GDE field validation assessment data collection points.

3. RESULTS

Out of 486 NCCAG-mapped polygons (128 GDE_wetland and 358 GDE_vegetation), the preliminary desktop analysis yielded 123 "probable GDEs" and 275 "probable non-GDEs" based on the above-described methodology. Individual polygons were not assessed due to time constraints, but rather groupings of similarly-situated riparian areas or clusters of polygons were assessed via GIS for probability of GDE classification.

The preliminary GDE field validation study assessed six (6) locations in the field on publicly accessible lands. All field assessment sites were in the Los Padres National Forest public lands. One (1) location was along the upper mainstem of the Cuyama River, and the other five (5) locations were in the Apache Canyon Creek watershed. Table 1 below describes each of the field assessment sites in more detail.

Table 1: GDE Field Validation Data Collection Sites

GPS Data Point Name	Latitude / Longitude	NCCAG-Mapped Polygon?	NCCAG Vegetation / Wetland Type	Dominant Plant Species Observed	Other Notes
probable Non-GDE 1	34.760116 N, 119.419661 W	Yes	Vegetation - Riversidean Alluvial Scrub	*Hesperoyucca whipplei, Arctostaphylos glauca, Lepidospartum squamatum, Ericameria nauseosa, Eriogonum fasiculatum, Bromus carinatus*	Soils at data point are sandy, dry and friable; would not stay in soil auger. This location does not appear to be a GDE.
probable Non-GDE 2	34.761994 N 119.375711 W	Yes	Vegetation - Scalebroom	*Lepidospartum squamatum, Ericameria nauseosa, Eriogonum fasiculatum*	Soils at data point are dry and friable; Some pines and junipers are growing in the riparian zone adjacent to river bed; no evidence of hydrology that persists beyond flashy storm events. This location does not appear to be a GDE.
GDE 1	34.778902 N 119.341961 W	No	N/A	*Juncus xiphoides, Juncus patens, Typha domingensis, Scirpus microcarpus, Salix exigua, Salix laevigata, Castilleja sp., Isoetes howellii*	A small stream is flowing at this location and hydrophytic vegetation is present throughout the channel; brown algae observed in flowing stream; crystallized salt or other calcic material observed on stream channel sediments; soils are saturated to the surface in this area. This location appears to be a GDE.
GDE 2	34.801748 N 119.293979 W	Yes	Wetland - Palustrine, Scrub-Shrub, Seasonally Saturated	*Clematis ligusticifolia, Juncus effusus, Salix laevigata, Urtica dioica*	Data point is located at US Forest Service Nettle Springs Campground; USGS mapped spring indicated at data point; groundwater is seeping out of the hillside at this data point; soils sampled on hillslope are hydric and saturated at the surface; water flows in a small channel for approximately 300-500 feet downstream of the spring before drying up. This location appears to be a GDE.
GDE 3	34.772312 N 119.346965 W	No	N/A	*Salix lasiolepis, Baccharis salicifolia, Baccharis pilularis Distichlis spicata, Artemisia californica,*	Data point is located within a small floodplain depression willow thicket. Hydrophytes are present and soils are saturated at

				Juncus patens, Anemopsis californica, Leymus triticoides	the surface by what appears to be groundwater. Soils are hydric. This location appears to be a GDE.
GDE 4	34.773548 N 119.346732 W	Yes	Vegetation - Riparian Mixed Shrub	*Salix laevigata, Juncus patens, Leymus triticoides, Anemopsis californica, Melilotus sp., Isoetes howellii*	A small stream is flowing at this location and hydrophytic vegetation is present throughout the channel; crystallized salt or other calcic material observed on stream channel sediments; soils are saturated to the surface in this area. This location appears to be a GDE.

4. CONCLUSIONS

The Cuyama Valley groundwater basin is a significantly stressed aquifer due to several factors including climate, industrial-scale agriculture, oil and gas exploration and production, ranching, and other land uses. The combination of these factors has drawn the groundwater down to greater than 600 feet below the ground surface in some locations, and this affects GDEs by limiting the amount of groundwater available to ecological communities living at the surface. Especially affected is the Cuyama River mainstem which was observed to be dry throughout much of its reach that was visible during our preliminary GDE field validation study.

However, there do appear to be some GDEs present within the Cuyama Valley groundwater basin as indicated in Table 1. All these areas (GDE 1 – 4) were located within the headwaters of the Cuyama River along Apache Canyon Creek and its floodplain. Areas mapped by the NCCAG data set as seeps and/or springs and the immediately downstream riparian corridors were among the GDEs that were assessed in the field. These locations had hydrophytic vegetation and other near-surface hydrologic indicators that would suggest that the ecological community is dependent on groundwater being present for significant durations during the growing season each year.

Due to access limitations because of private property restrictions, further study should be done along the mainstem of the Cuyama River (and other select tributaries) to determine if GDEs are present within the channel or riparian area.

5. REFERENCES

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Griffith, G.E., Omernik, J.M., Smith, D.W., Cook, T.D., Tallyn, E., Moseley, K., and Johnson, C.B., 2016, Ecoregions of California (poster): U.S. Geological Survey Open-File Report 2016–1021, with map, scale 1:1,100,000, http://dx.doi.org/10.3133/ofr20161021.

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Ventura County (CA) Planning Division. 2006. Guide to Native and Invasive Streamside Plants: Restoring Riparian Habitats in Ventura County & along the Santa Clarita River in Los Angeles County.

ATTACHMENT A: FIGURES

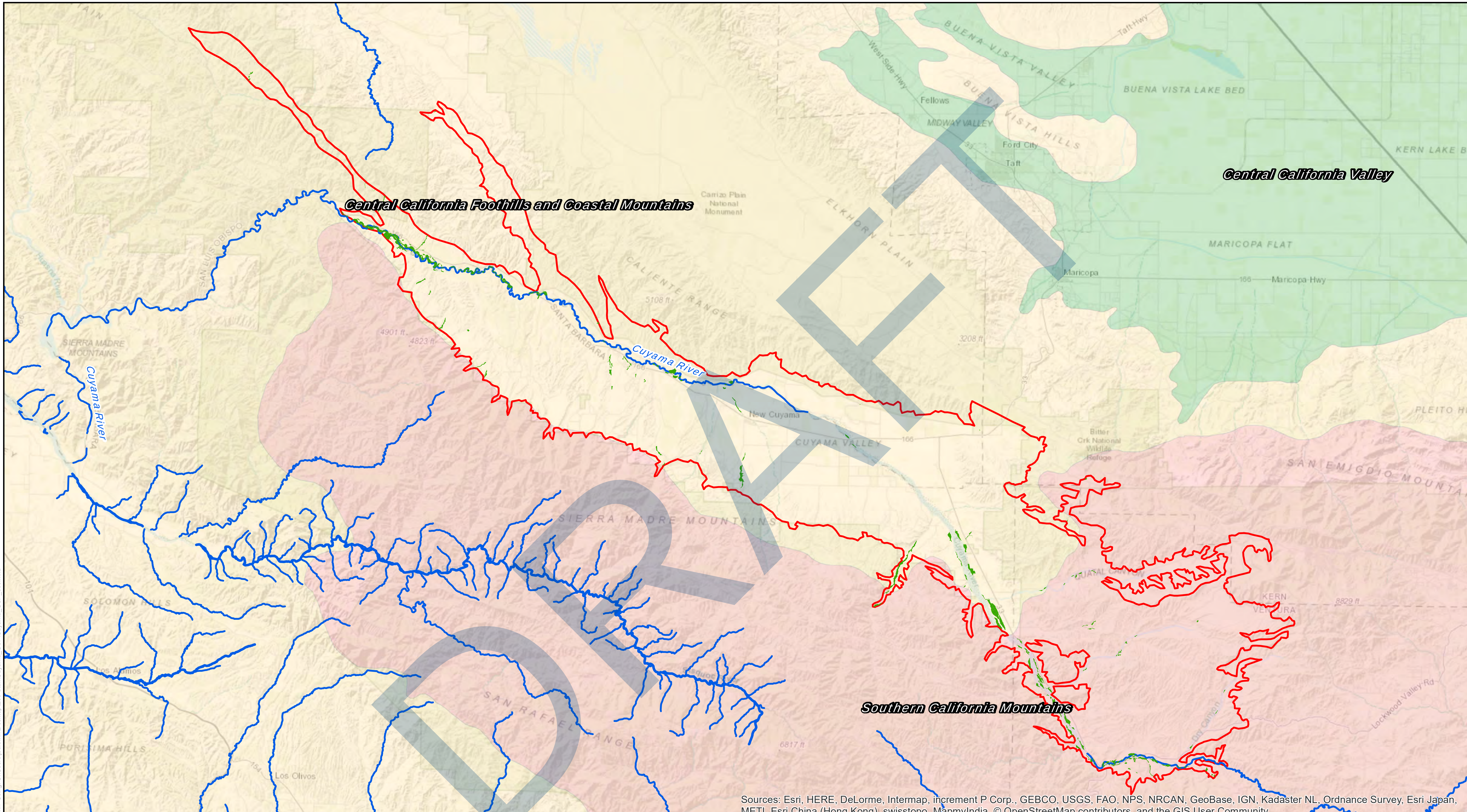

Figure 1:
California Ecoregions

Cuyama Valley Groundwater Basin

Kern, San Luis Obispo, Santa Monica, and Ventura Counties, CA

Legend

- NCCAG Groundwater Dependent Ecosystem
- USGS NHD Streams
- Cuyama Valley Groundwater Basin
- Central California Foothills and Coastal Mountains
- Central California Valley
- Southern California Mountains

0 1.25 2.5 5 Miles

N

WOODARD & CURRAN

Project #: 0011078.01
Map Created: February 2019

Third Party GIS Disclaimer: This map is for reference and graphical purposes only and should not be relied upon by third parties for any legal decisions.
Any reliance upon the map or data contained herein shall be at the users' sole risk. **Data Sources: USEPA Level III Ecoregions of California(2016), USGS NHD**

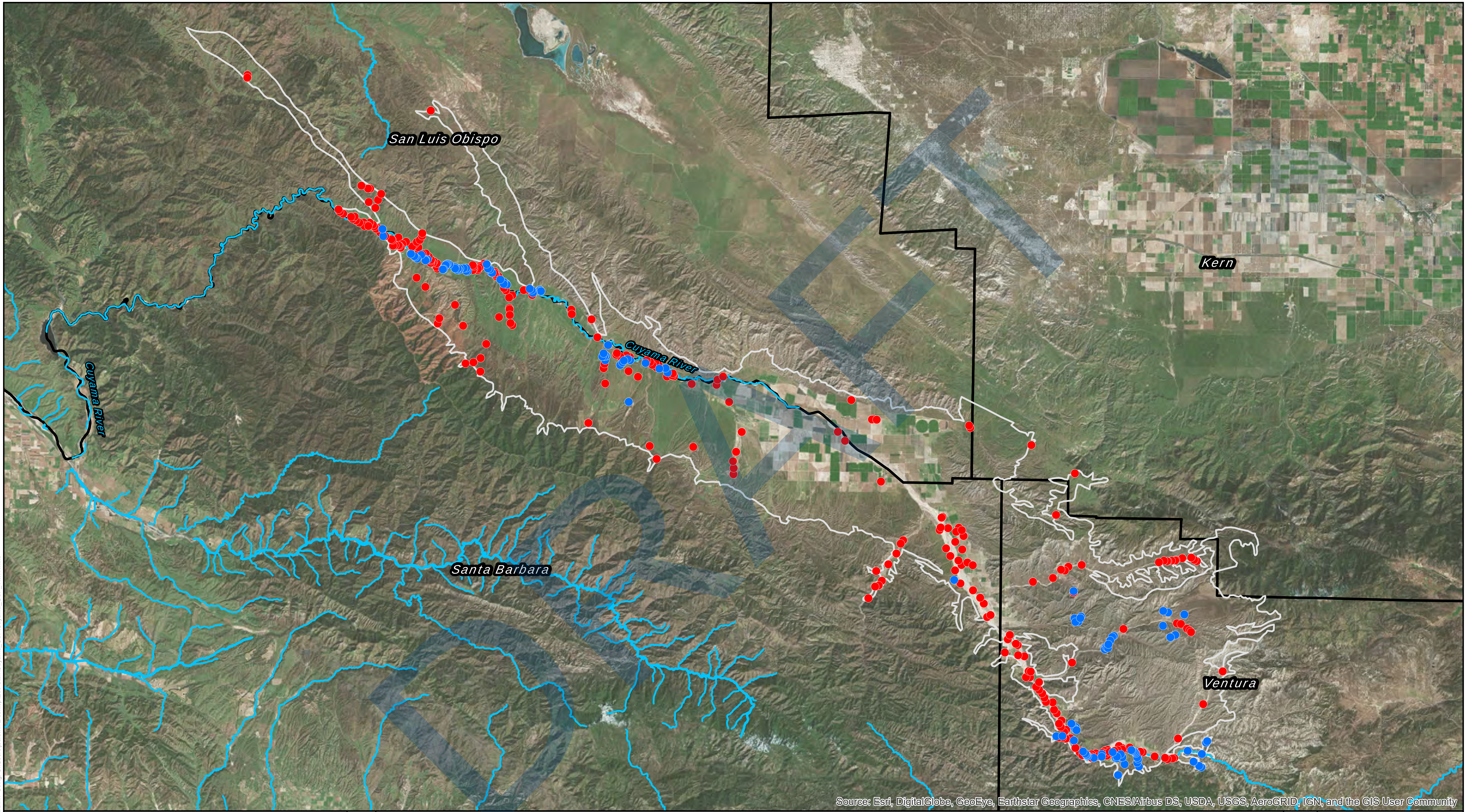

Figure 2: Basin-Wide Groundwater Dependent Ecosystem (GDE) Desktop Assessment

Cuyama Valley Groundwater Basin

Kern, San Luis Obispo, Santa Monica, and Ventura Counties, CA

Legend

- Probable GDE
- Probable Non-GDE
- Streams
- Cuyama Valley Groundwater Basin
- County Boundary

0 1.25 2.5 5 Miles

N

WOODARD & CURRAN

Project #: 0011078.01
Map Created: February 2019

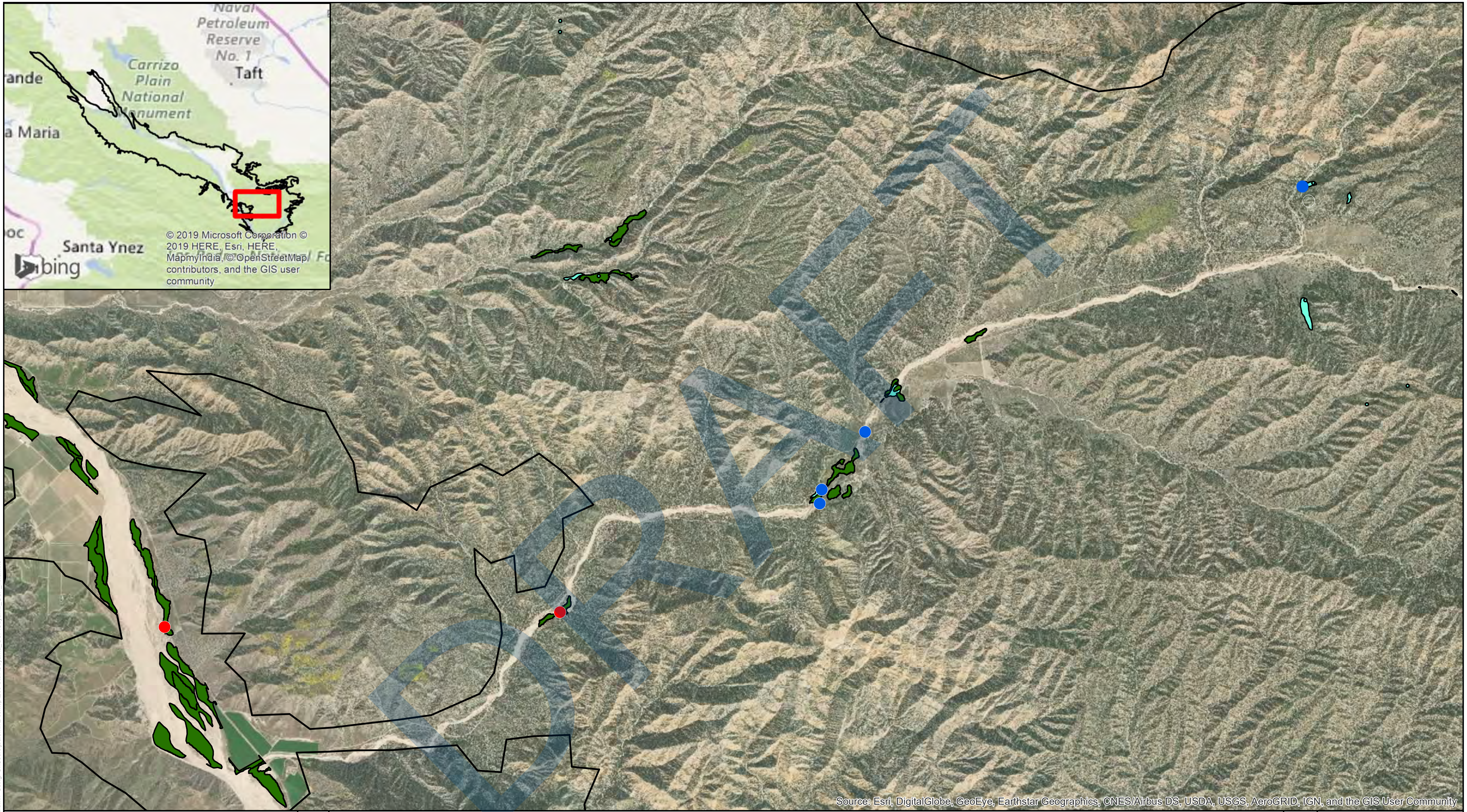

Figure 3: Groundwater Dependent Ecosystem (GDE) Field Validation Sites

Cuyama Valley Groundwater Basin

Kern, San Luis Obispo, Santa Monica, and Ventura Counties, CA

Legend

- Confirmed GDE Data Point
- Probable Non-GDE Data Point
- NCCAG GDE Wetland
- NCCAG GDE Vegetation
- Cuyama Valley Groundwater Basin

1 inch = 3,000 feet

0 1,500 3,000 6,000 Feet

N

WOODARD & CURRAN

Project #: 0011078.01

Map Created: February 2019

Third Party GIS Disclaimer: This map is for reference and planning purposes only and should not be relied upon by third parties for any legal decisions. Any reliance upon the map or data contained herein shall be at the users' sole risk. **Data Sources: CADWR - Natural Communities Commonly Associated with Groundwater(2018)**

ATTACHMENT B: PHOTOGRAPHS

Photo Number: 1 | View Direction: North | Date: October 23, 2018
Description: Representative photograph taken of potential incorrectly mapped groundwater dependent ecosystem (CA DWR NCAG dataset 2018). Photo taken a GPS point "probable non-GDE 1".

Photo Number: 2 | View Direction: South | Date: October 23, 2018
Description: Representative photograph taken of potential incorrectly mapped groundwater dependent ecosystem (CA DWR NCAG dataset 2018). Photo taken a GPS point "probable non-GDE 1".

Photo Number: 3 | **View Direction: North** | **Date: October 23, 2018**

Description: Representative photograph taken of potential incorrectly mapped groundwater dependent ecosystem (CA DWR NCAG dataset 2018). Photo taken a GPS point "probable non-GDE 2".

Photo Number: 4 | **View Direction: South** | **Date: October 23, 2018**

Description: Representative photograph taken of potential incorrectly mapped groundwater dependent ecosystem (CA DWR NCAG dataset 2018). Photo taken a GPS point "probable non-GDE 2".

Photo Number: 5 | **View Direction: North** | **Date: October 23, 2018**

Description: **Representative photograph taken of unmapped groundwater dependent ecosystem (CA DWR NCAG dataset 2018). Photo taken a GPS point "GDE 1".**

Photo Number: 6 | **View Direction: South** | **Date: July 26, 2018**

Description: **Representative photograph taken of unmapped groundwater dependent ecosystem (CA DWR NCAG dataset 2018). Photo taken a GPS point "GDE 1".**

Photo Number: 7 | **View Direction: North** | **Date: October 23, 2018**

Description: **Representative photograph taken of field-verified mapped groundwater dependent ecosystem (CA DWR NCAG dataset 2018). Photo taken a GPS point "GDE 2".**

Photo Number: 8 | **View Direction: South** | **Date: July 26, 2018**

Description: **Representative photograph taken of field-verified mapped groundwater dependent ecosystem (CA DWR NCAG dataset 2018). Photo taken a GPS point "GDE 2".**

Photo Number: 9 | **View Direction: North** | **Date: October 23, 2018**

Description: Representative photograph taken of unmapped groundwater dependent ecosystem (CA DWR NCAG dataset 2018). Photo taken a GPS point "GDE 3".

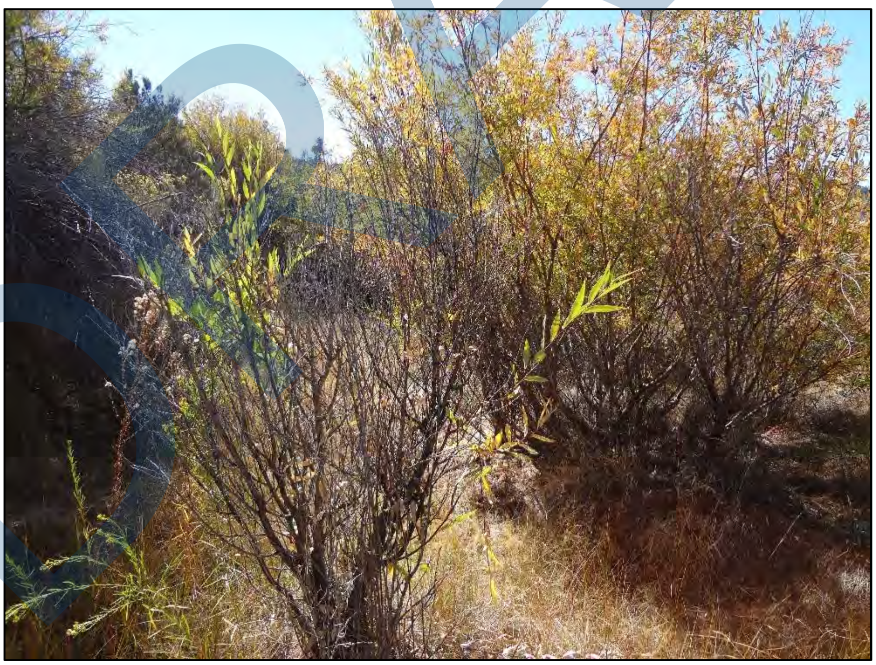

Photo Number: 10 | **View Direction: South** | **Date: October 23, 2018**

Description: Representative photograph taken of unmapped groundwater dependent ecosystem (CA DWR NCAG dataset 2018). Photo taken a GPS point "GDE 3".

Photo Number: 11 | **View Direction: East** | **Date: October 23, 2018**

Description: Representative photograph taken of field-verified mapped groundwater dependent ecosystem (CA DWR NCAG dataset 2018). Photo taken a GPS point "GDE 4".

Photo Number: 12 | **View Direction: South** | **Date: October 23, 2018**

Description: Representative photograph taken of field-verified mapped groundwater dependent ecosystem (CA DWR NCAG dataset 2018). Photo taken a GPS point "GDE 4".

Cuyama Valley Groundwater Basin

Draft Groundwater Sustainability Plan: Undesirable Results

Prepared by:

April 2019

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Appendices

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3. Undesirable Results

This chapter presents the Undesirable Results statements for the Cuyama Valley Groundwater Basin (Basin). This chapter is a key component of the Cuyama Basin Groundwater Sustainability Agency's (CBGSA's) *Groundwater Sustainability Plan* (GSP), as other GSP components must be developed to set quantitative thresholds on monitoring points that indicate where Undesirable Results might occur on the monitoring network, and to shape the monitoring network to detect Undesirable Results.

The first section of this chapter is the draft Undesirable Results section. The second section contains guidance from relevant portions of the Sustainable Groundwater Management Act (SGMA) regulations about Undesirable Results, and lists guidance about addressing Undesirable Results from the *Sustainable Management Criteria Best Management Practices* (BMPs) (DWR, 2017).

On June 6, 2018, a public workshop was held where sustainability and undesirable outcomes were discussed with the public. Input from stakeholders at the meeting was tabulated, and stakeholder input was tied to the most relevant GSP component. The sorted results were used to guide creation of the Undesirable Results statements, and are included in Appendix A.

3.1 Sustainability Goal

Sustainability Goal 1: To maintain a viable groundwater resource for the beneficial use of the people and the environment of the Cuyama Groundwater Basin now and into the future.

3.2 Undesirable Results Statements

Undesirable Results are defined for use in SGMA as one or more of the following effects caused by groundwater conditions occurring throughout the Basin:

- Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods.
- Significant and unreasonable reduction of groundwater storage.
- Significant and unreasonable seawater intrusion.
- Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies.
- Significant and unreasonable land subsidence that substantially interferes with surface land uses.
- Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

Undesirable Results related to seawater intrusion are not present in the Basin, and are not likely to occur in the Basin.

Information is provided below for each effect as it applies to the Basin. For the sustainability indicators relevant to the Basin, the discussion:

- Describes the Undesirable Result
- Identifies Undesirable Results
- Identifies potential causes of Undesirable Results
- Identifies potential effects of Undesirable Results on beneficial uses

For any indicator not present, a justification for not establishing Undesirable Results is provided. This information was developed based on the California Water Code, SGMA regulations, BMPs, and stakeholder input.

3.2.1 Chronic Lowering of Groundwater Levels

Description of Undesirable Results

The Undesirable Result for the chronic lowering of groundwater levels is a result that causes significant and unreasonable reduction in the long-term viability of domestic, agricultural, municipal, or environmental uses over the planning and implementation horizon of this GSP.

Identification of Undesirable Results

This result is considered to occur during GSP implementation when 30 percent of representative monitoring wells (i.e., 18 of 60 wells) fall below their minimum groundwater elevation thresholds for two consecutive years.

Potential Causes of Undesirable Results

Potential causes of Undesirable Results for the chronic lowering of groundwater levels are groundwater pumping that exceeds the average sustainable yield in the Basin, and changes in precipitation in the Cuyama Watershed in the future.

Potential Effects of Undesirable Results

If groundwater levels were to reach Undesirable Results levels, the Undesirable Results could cause potential de-watering of existing groundwater infrastructure, starting with the shallowest wells, could potentially adversely affect groundwater dependent ecosystems, and could potentially cause changes in irrigation practices, crops grown, and adverse effects to property values. Additionally, reaching Undesirable Results for groundwater levels could adversely affect domestic and municipal uses, including uses in disadvantaged communities, which rely on groundwater in the Basin.

3.2.2 Reduction of Groundwater Storage

Description of Undesirable Results

The Undesirable Result for the reduction in groundwater storage is a result that causes significant and unreasonable reduction in the viability of domestic, agricultural, municipal, or environmental uses over the planning and implementation horizon of this GSP.

Justification of Groundwater Elevations as a Proxy

Use of groundwater elevation as a proxy metric for Undesirable Results is appropriate for groundwater storage. The change in storage is directly correlated to changes in groundwater elevation. By setting minimum thresholds for levels, storage is also effectively managed.

Identification of Undesirable Results

This result is considered to occur during GSP implementation when 30 percent of representative monitoring wells (i.e., 18 of 60 wells) fall below their minimum groundwater elevation thresholds for two consecutive years.

Potential Causes of Undesirable Results

Potential causes of Undesirable Results for the reduction in groundwater storage are groundwater pumping that exceeds the average sustainable yield in the Basin, and decreases in precipitation in the Cuyama Watershed in the future.

Potential Effects of Undesirable Results

If reduction of groundwater in storage were to reach Undesirable Results levels, the Undesirable Results could cause potential de-watering of existing groundwater infrastructure and springs, starting with the shallowest wells, could potentially adversely affect groundwater dependent ecosystems, and potentially cause changes in irrigation practices, crops grown, and adverse effects to property values. Additionally, reaching Undesirable Results for reduction of groundwater in storage could adversely affect domestic and municipal uses, which rely on groundwater in the subbasin.

3.2.3 Seawater Intrusion

Seawater intrusion is not an applicable sustainability indicator in the Basin, because seawater intrusion is not present and is not likely to occur due to the distance between the Basin and the Pacific Ocean, bays, deltas, or inlets.

3.2.4 Degraded Water Quality

Description of Undesirable Results

The Undesirable Result for degraded water quality is a result stemming from a causal nexus between SGMA-related groundwater quantity management activities and groundwater quality that causes significant and unreasonable reduction in the long-term viability of domestic, agricultural, municipal, or environmental uses over the planning and implementation horizon of this GSP.

Identification of Undesirable Results

This result is considered to occur during GSP implementation when 30 percent of the representative monitoring points (i.e., 20 of 64 sites) exceed the minimum threshold for a constituent for two consecutive years.

Potential Causes of Undesirable Results

Potential causes of Undesirable Results for the degraded water quality are conditions where groundwater pumping degrades the groundwater quality.

Potential Effects of Undesirable Results

If groundwater quality were degraded to reach Undesirable Results levels, the Undesirable Results could potentially cause a shortage in supply to groundwater users, with domestic wells being most vulnerable as treatment costs or access to alternate supplies can be high for small users. Water quality degradation could cause potential changes in irrigation practices, crops grown, and adverse effects to property values. Additionally, reaching Undesirable Results for groundwater quality could adversely affect municipal uses, including disadvantaged communities, which could have to install treatment systems.

3.2.5 Land Subsidence

Description of Undesirable Results

The Undesirable Result for land subsidence is a result that causes significant and unreasonable reduction in the viability of the use of infrastructure over the planning and implementation horizon of this GSP.

Identification of Undesirable Results

This result is detected to occur during GSP implementation when 30 percent of representative subsidence monitoring sites (i.e., 1 of 2 sites) exceed the minimum threshold for subsidence over two years.

Potential Causes of Undesirable Results

Potential causes of future Undesirable Results for land subsidence are likely tied to groundwater pumping resulting in dewatering of compressible clays in the subsurface.

Potential Effects of Undesirable Results

If land subsidence conditions were to reach Undesirable Results, the Undesirable Results could potentially cause damage to infrastructure, including water conveyance facilities and flood control facilities roads, utilities, buildings, and pipelines.

3.2.6 Depletions of Interconnected Surface Water

Description of Undesirable Results

The Undesirable Result for depletions of interconnected surface water is a result that causes significant and unreasonable reductions in the viability of agriculture or riparian habitat within the Basin over the planning and implementation horizon of this GSP.

Identification of Undesirable Results

This result is considered to occur during GSP implementation when 30 percent of representative monitoring wells (i.e., 18 of 60 wells) fall below their minimum groundwater elevation thresholds for two consecutive years.

Justification of Groundwater Elevations as a Proxy

Use of groundwater elevation as a proxy metric for Undesirable Results is necessary given the difficulty and cost of direct monitoring of depletions of interconnected surface water. The depletion of interconnected surface water is driven by a gradient between water surface elevation in the surface water body and groundwater elevations in the connected, shallow groundwater system. By setting minimum thresholds on shallow groundwater wells near surface water, this gradient is managed, and in turn, depletions of interconnected surface water are managed.

Potential Causes of Undesirable Results

Potential causes of future Undesirable Results for depletions of interconnected surface water are likely tied to groundwater production, particularly in the shallowest zones, where surface water and groundwater are connected. Increased depletions could result in lowering of groundwater elevations in shallow aquifers near surface water courses, which changes the hydraulic gradient between the water surface elevation in the surface water course and the groundwater elevation, resulting in an increase in depletion.

Potential Effects of Undesirable Results

If depletions of interconnected surface water were to reach Undesirable Results, groundwater dependent ecosystems could be affected.

3.3 Evaluation of the Presence of Undesirable Results

DWR developed the *Sustainable Management Criteria* BMP (DWR, 2017) to help GSAs develop their sustainability criteria, and to identify the presence of Undesirable Results. The *Sustainable Management Criteria* BMP states: "Undesirable results will be defined by minimum threshold exceedances." The *Sustainable Management Criteria* BMP helps GSAs identify the presence of an Undesirable Result by identifying a quantitative number and location of monitoring points that may be below the minimum threshold prior to a GSA identifying conditions as an Undesirable Result.

This section evaluates current conditions and compares them with the minimum thresholds established in Chapter 5. Using the method identified above for each sustainability indicator, a GSA can identify the presence of Undesirable Results. For the Basin, Undesirable Results are identified at the Basin scale; this scale may be modified by the CBGSA Board if appropriate or necessary in the future.

3.3.1 Chronic Lowering of Groundwater Levels

The Undesirable Result for the chronic lowering of groundwater levels is considered to occur during GSP implementation when 30 percent of representative monitoring wells (i.e., 18 of 60 wells) fall below their minimum groundwater elevation thresholds for two consecutive years (Section 3.1.1).

Chapter 5 discusses how minimum thresholds were selected. Appendix A of Chapter 5 presents the hydrographs of groundwater levels through 2018 and the established depth of the minimum threshold for each monitoring site. Of the 60 monitoring sites, nine were below the minimum threshold in the latest measurement in 2018, which is 15 percent of representative monitoring wells (i.e., 9 of 60), indicating that the Basin does not have an undesirable condition for the chronic lowering of groundwater levels.

3.3.2 Reduction of Groundwater Storage

The Undesirable Result for the reduction of groundwater storage is monitored by proxy using groundwater levels and groundwater level minimum thresholds (Section 3.1.2). Because measurements show that levels are not in an undesirable condition, reduction of groundwater storage is not identified to be in an undesirable condition.

3.3.3 Seawater Intrusion

Seawater intrusion is not an applicable sustainability indicator, because seawater intrusion is not present and is not likely to occur due to the distance between the Basin and the Pacific Ocean, bays, deltas, or inlets (Section 3.1.3). Therefore, there is no possibility of an undesirable result due to seawater intrusion.

3.3.4 Degraded Water Quality

The Undesirable Result for the chronic lowering of groundwater levels is considered to occur during GSP implementation when 30 percent of representative monitoring wells (i.e., 20 of 64 wells) for levels fall below their minimum groundwater elevation thresholds for two consecutive years (Section 3.1.4).

Discussion of how minimum thresholds were selected is presented in Chapter 5. Table 5-2 in Chapter 5 shows the minimum thresholds and the most recent measurement for each monitoring site. Of the 64 monitoring sites, none were worse than the minimum threshold in the latest measurement in 2018, which is 0 percent of representative monitoring wells (i.e., 0 of 60), indicating that the Basin does not have an undesirable condition for the chronic lowering of groundwater levels.

3.3.5 Land Subsidence

The Undesirable Result for land subsidence is considered to occur during GSP implementation when 30 percent of representative subsidence monitoring sites (i.e., 1 of 2 sites) exceed the minimum threshold for subsidence over two consecutive years (Section 3.1.5).

Chapter 5 discussed how minimum thresholds were selected is.The minimum threshold for subsidence has been set at 2 inches per year.

The rate of subsidence at the Cuyama Valley High School (CVHS) station is measured daily. Subsidence at the CVHS station cycles annually, with elastic rebound occurring in the winter, indicated by an annual high. Highs during the period of rebound occur between January 1 and March 10 each year. Measurements taken from January 1, 2017 to March 10, 2017 were compared with measurements from January 1, 2018 to March 10, 2018. Each daily measurement was compared and the difference between each day was averaged. The average decline from a day in 2017 during that period and the same day in 2018 during that period was 33 millimeters (1.3 inches).

The rate of subsidence on the Ventucopa station was 0 inches over the same period. Because neither station showed a rate of subsidence over 2 inches per year, the Basin does not have an undesirable condition for land subsidence.

3.3.6 Depletions of Interconnected Surface Water

The Undesirable Result for the depletion of interconnected surface water is monitored by proxy using groundwater levels and groundwater level minimum thresholds (Section 3.1.6). Because measurements show that levels are not in an undesirable condition, depletion of interconnected surface water is not identified to be in an undesirable condition.

3.4 References

California Department of Water Resources (DWR). 2018. *Sustainable Management Criteria Best Management Practice.* Sustainable Groundwater Management Program. November. https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/BMP-6-Sustainable-Management-Criteria-DRAFT.pdf. Accessed March 30, 2018.

Appendix A

Framework for Developing Sustainable Management Criteria

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Appendix A

Cuyama Basin Groundwater Sustainability Agency Groundwater Sustainability Plan

Framework for Developing Sustainable Management Criteria

Sustainability Goal [1]**: To maintain a viable groundwater resource for the beneficial use of the people and the environment of the Cuyama Groundwater Basin now and into the future.**

Sustainability Indicator [2]	I. GROUNDWATER ELEVATION	II. GROUNDWATER STORAGE	III. WATER QUALITY	IV. LAND SUBSIDENCE	V. SURFACE WATER CONNECTIVITY
Undesirable Result Considerations [3]	Chronic lowering of groundwater levels indicating unreasonable depletion of supply, which results in: • Adverse impacts to the viability of agriculture, and the agricultural economy. • Adverse impacts to the viability of CSD and other domestic water users. • Dewatering of wells. • Groundwater Dependent Ecosystems	Unreasonable reduction of groundwater storage, which results in: • Adverse impacts to the viability of agriculture, and the agricultural economy. • Adverse impacts to the viability of CSD and domestic uses. • Dewatering of wells.	Significant and unreasonable degraded water quality that adversely impacts drinking, irrigation, industrial, and environmental uses: • Drinking • Domestic uses (Swamp coolers, laundry) • Agriculture • Local economy	Significant and unreasonable land subsidence that substantially interferes with surface land uses causing: • Damage to public and private infrastructure (e.g., roads and highways, pipelines, utilities, public buildings, residential and commercial structures). • Permanent loss of groundwater storage capacity.	Significant and unreasonable depletions of interconnected surface water that results in: • Adverse impacts to agricultural uses • Adverse impacts to riparian habitat
Minimum Threshold Considerations [4]	• Well depths • Historic recorded lows in monitoring wells • Conditions in spring of 2015 • Allowance for operational flexibility during GSP implementation	• Well depths • Historic recorded lows in monitoring wells • Conditions in spring of 2015 • Use groundwater levels as a proxy	• Salinity MCL (Maximum Contaminant Level) for drinking water and agriculture • Arsenic MCL for drinking water • Conditions in spring of 2015 • Consider other constituents	• Land subsidence rate and magnitude indicating inelastic land subsidence at established monuments. • Conditions in spring of 2015 • Delayed compaction estimates	• Estimated volume of water contributed from surface water to groundwater.
Measurable Objective Considerations [5]	• Drought buffer • Operational flexibility buffer • Conditions prior to 2015 • Consideration of climate change	• Drought buffer • Operational flexibility buffer • Conditions prior to 2015 • Use groundwater levels as a proxy	• Drought buffer • Operational flexibility buffer • Conditions prior to 2015 • Secondary MCLs	• Conditions at 2015	• Conditions at 2015
Planning Principles [6]	• All stakeholders, and other agencies/entities will cooperatively develop the GSP. • The planning process will be inclusive and transparent. • The GSP will use empirical data and quantitative objectives.		• The GSP will be considerate of the diverse needs of the basin's population. • The GSP will work towards sustaining economic activity in the region. • Consideration of mitigation measures as part of establishing Undesirable Results		

Notes:

1. **Sustainability Goal** refers to the existence and implementation of one or more groundwater sustainability plans that achieve sustainable groundwater management by identifying and causing the implementation of measures targeted to ensure that the applicable basin is operated within its sustainable yield.
2. **Sustainability Indicator** refers to any of the effects caused by groundwater conditions occurring throughout the basin that, when significant and unreasonable, cause undesirable results.
3. **Undesirable Result** means one or more of the following effects caused by groundwater conditions occurring in the basin: (1) Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. (2) Significant and unreasonable reduction of groundwater storage. (3) Significant and unreasonable seawater intrusion. (4) Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies. (5) Significant and unreasonable land subsidence that substantially interferes with surface land uses. (6) Depletion of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water.
4. **Minimum Threshold** refers to a numeric value for each sustainability indicator used to define undesirable results.
5. **Measurable Objective** refers to specific, quantifiable goals for the maintenance or improvement of specified groundwater conditions that have been included in an adopted Plan to achieve the sustainability goal for the basin within 20 years. Uses the same metric as defined by the minimum threshold for the same sustainability indicator.
6. **Planning Principles** describes "how" the planning process will be conducted and provide overall guidance.

Cuyama Valley Groundwater Basin

Draft Groundwater Sustainability Plan: Monitoring Networks

Prepared by:

CUYAMA BASIN GROUNDWATER SUSTAINABILITY AGENCY

WOODARD & CURRAN

April 2019

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B USGS *Ground-Water Data-Collection Protocols and Procedures for the National Water-Quality Assessment Program: Collection and Documentation of Water-Quality Samples and Related Data*

Acronyms

Basin	Cuyama Valley Groundwater Basin
BMP	best management practice
CASGEM	California Statewide Groundwater Elevation Monitoring
CBGSA	Cuyama Basin Groundwater Sustainability Agency
CCR	California Code of Regulations
CCSD	Cuyama Community Services District
CEDEN	California Environmental Data Exchange Network
CGPS	continuous global positioning system
DWR	California Department of Water Resources
EPA	United States Environmental Protection Agency
GAMA	Groundwater Ambient Monitoring and Assessment
GSP	Groundwater Sustainability Plan
ILRP	Irrigated Lands Regulatory Program
InSAR	interferometric synthetic aperture radar
LiDAR	light detection and ranging
NWIS	National Water Information System
NWQMC	National Water Quality Monitoring Council
SBCWA	Santa Barbara County Water Agency
SGMA	Sustainable Groundwater Management Act
SLOCFC&WCD	San Luis Obispo County Flood Control & Water Conservation District
TSS	Technical Services Support
USGS	United States Geological Survey
VCWPD	Ventura County Water Protection District

Chapter 4 Monitoring Networks

Chapter 4 Monitoring Networks

This chapter of the *Cuyama Basin Groundwater Sustainability Plan* (GSP) discusses the planned monitoring networks needed to guide the Cuyama Basin Groundwater Sustainability Agency (CBGSA) toward their sustainability goals. Monitoring networks need to be established for each sustainability indicator either directly or through monitoring through a proxy. This section satisfies Subarticle 4 of the Sustainable Groundwater Management Act (SGMA) regulations. This chapter also discusses the following:

- Monitoring network objectives
- Existing monitoring programs used as part of each network
- Monitoring network establishment for each sustainability indicator
- Monitoring network data gaps, and a plan to fill data gaps if they are present for each monitoring network

4.1 Useful Terms

This chapter describes groundwater wells, water quality measurements, subsidence stations, and other related components. Technical terms are defined below. Figure 4-1 is a diagram of a monitoring well with well-related terms identified on the diagram. Terms are defined here to guide readers through this chapter, and are not a definitive definition of each term:

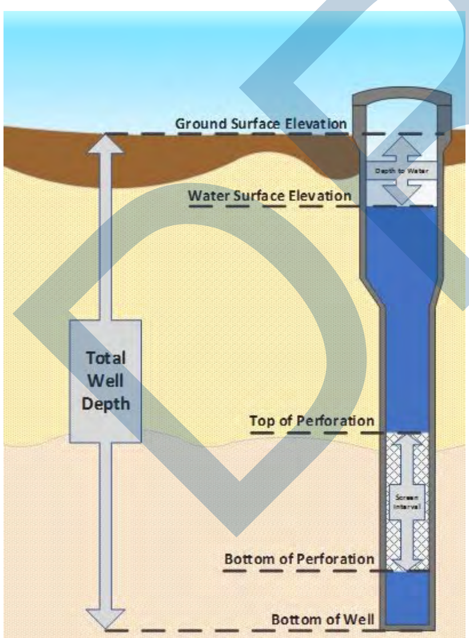

Figure 4-1: Well Completion Diagram

4.1.1 Well-Related Terms

- **Ground surface elevation –** The elevation in feet above mean sea level at the well's location.
- **Total well depth** – The depth that a well is installed to. This is often deeper than the bottom of the screened interval.
- **Screened interval** – The portion of a well casing that is screened to allow water from the surrounding soil into the well pipe. There can be several screened intervals within the same well. Screened interval is usually reported in feet below ground surface (bgs) for both the upper most limit and lower most limit of the screen.
- **Top perforation –** The distance to the top of the perforation from the ground surface elevation.
- **Bottom perforation –** The distance to the bottom of the perforation from the ground surface elevation.
- **Water surface elevation –** The elevation above mean sea level that water is encountered inside the well
- **Depth to water –** The distance from the ground surface or the well' to where water is encountered inside the well

4.1.2 Other Terms

- **Historical high groundwater elevations –** This is the highest recorded measurement of static groundwater elevation (closest to the ground surface) in a monitoring well. Measurements of groundwater elevation are used to indicate the elevation of groundwater levels in the area near the monitored well.
- **Historical low groundwater elevations –** This is the lowest measurement of static groundwater elevation (furthest from the ground surface) in a monitoring well that was recorded. Measurements of groundwater elevation are used to indicate the elevation of groundwater levels in the area near the monitored well.
- **Depth to groundwater –** This is the distance from the ground surface to groundwater typically reported at a well.
- **Hydrograph –** A hydrograph is a graph that shows the changes in groundwater elevation over time for each monitoring well. Hydrographs show how groundwater elevations change over the years and indicate whether groundwater is rising or descending over time.
- **Constituent** – Refers to a water quality parameter measured to assess groundwater quality.
- **Subsidence** – Refers to the sinking or downward settling of the earth's surface, not restricted in rate, magnitude, or area involved, and is often the result of over-extraction of subsurface water. For more information, see the Groundwater Conditions chapter.
- **Best management practice** – Refers to a practice, or combination of practices, that are designed to achieve sustainable groundwater management and have been determined to be technologically and

economically effective, practicable, and based on best available science (Title 23 of the California Code of Regulations [CCR], Article 2).

- **Data gap** – Refers to a lack of information that significantly affects the understanding of the Basin setting or evaluation of the efficacy of Plan implementation and could limit the ability to assess whether a Basin is being sustainably managed (Title 23 of the CCR, Article 2).
- **Representative monitoring** – Refers to a monitoring site within a broader network of sites that typifies one or more conditions within the Basin or an area of the Basin (Title 23 of the CCR, Article 2).

4.2 Monitoring Network Objectives

This chapter describes the Cuyama Valley Groundwater Basin (Basin) monitoring networks for the five sustainability indicators that apply to the Basin. The objective of these monitoring networks is to detect undesirable results in the Basin as described in Chapter 3 using the sustainability thresholds described in Chapter 5. Other related objectives of the monitoring network are defined via the SGMA regulations as follows:

- Demonstrate progress toward achieving measurable objectives described in the GSP
- Monitor impacts to the beneficial uses or users of groundwater
- Monitor changes in groundwater conditions relative to measurable objectives and minimum thresholds
- Quantify annual changes in water budget components

The monitoring network plan provided to the Basin is intended to monitor:

- Chronic lowering of groundwater levels
- Reduction in groundwater storage
- Degraded water quality
- Land subsidence
- Depletions of interconnected surface water

The monitoring networks described in this chapter were designed by evaluating data provided by the California Department of Water Resources (DWR), the United States Geological Survey (USGS), participating counties, and private landowners. The monitoring network consists of wells that are already being used for monitoring in the Basin. Decisions to include wells in the monitoring network were based on the criteria described below.

4.2.1 Basin Conditions Relevant to Measurement Density and Frequency

This section summarizes key Basin conditions that influence the development of monitoring networks. These key conditions include hydrogeologic considerations, land use considerations, and historical groundwater conditions.

The Basin, as described in the Section 2.1, is composed of one principal aquifer comprised of three geologic groups: Younger Alluvium, Older Alluvium, and Morales Formation. The majority of groundwater in the aquifer is stored in the Younger and Older alluvium. While there are many faults in the Basin, there are no major stratigraphic aquitards or barriers to vertical groundwater movement among the alluvium and Morales Formation. The aquifer has a wide range of thicknesses that vary spatially, with median reported hydraulic conductivity ranges from 1.22 to 72.1 feet per day (see Table 2-1 in Chapter 2 for detailed values). Figures 2-19 and 2-20 in Chapter 2 show the extent of these formations throughout the Basin.

The largest groundwater uses in the Basin are for irrigated agriculture. The figures shown in Chapter 1, Section 1.2, Plan Area show the extent of land used for irrigated agriculture in the Basin. Based on the most recent data from 2016, there are approximately 53 square miles of agricultural land in the Basin out of approximately 378 square miles, equaling approximately 14 percent of the Basin's land.

Data provided in Chapter 2, Section 2.2 shows the historical decline groundwater levels in the Basin's central portion. Groundwater elevations in this portion of the Basin have decreased by more than 400 feet from the 1940s to the present, as shown in Figure 4-2.

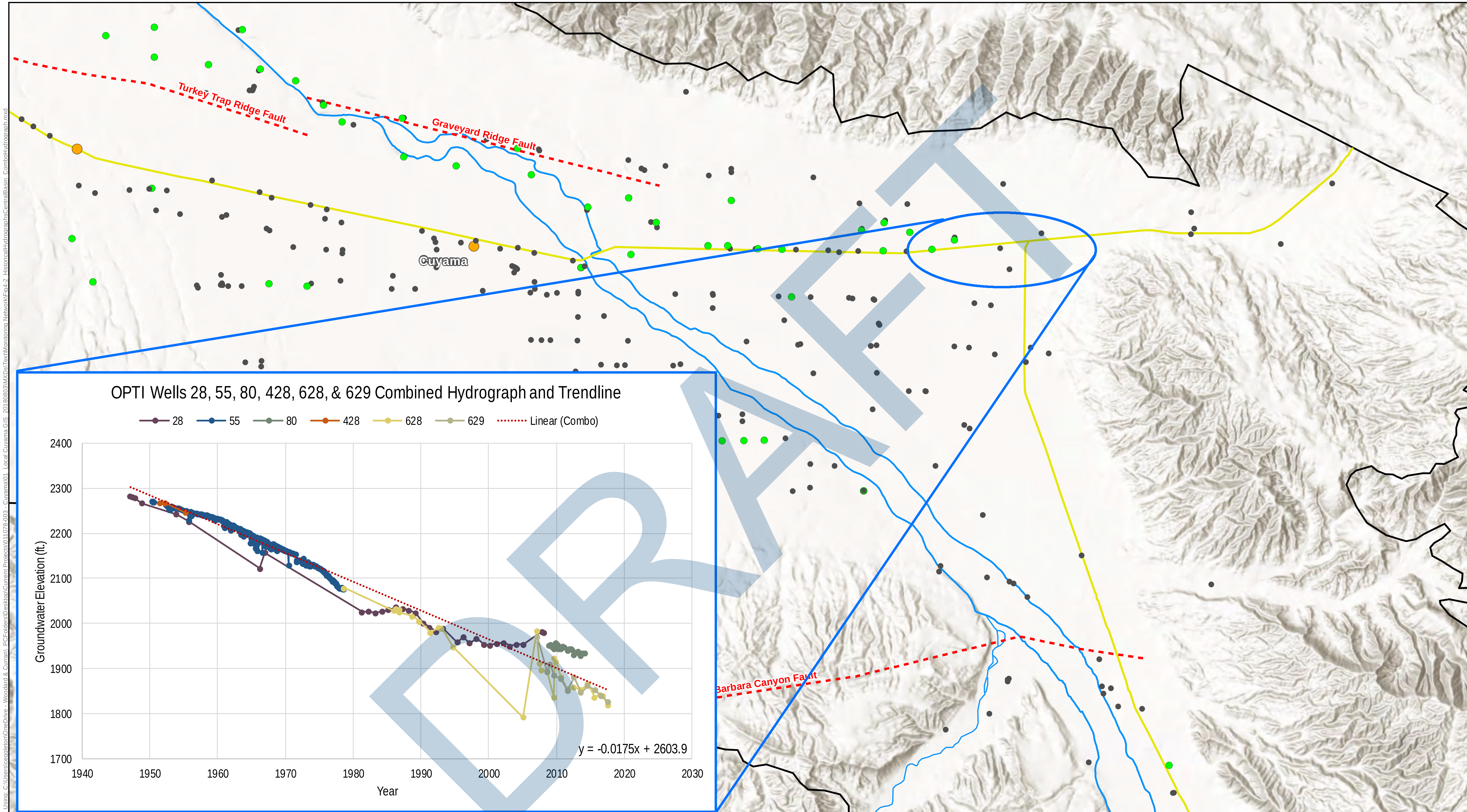

Figure 4-2: Cuyama GW Basin Central Basin with Combined Hydrograph

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- Towns
- Highways
- Cuyama River
- Streams
- Faults
- Currently Monitored Wells
- Not Currently Monitored

N

0 0.5 1 2 Miles

4.3 Existing Monitoring Used

4.3.1 Groundwater Level Monitoring

This section describes groundwater level monitoring conducted by agencies and private land owners in the Basin.

DWR, Statewide Dataset/California Statewide Groundwater Elevation Monitoring (CASGEM)

The State of California has several water-related database portals accessible online. These include the following:

- CASGEM Program
- Water Data Library
- Groundwater Information Center Interactive Map Application

The data for these portals are organized and saved in one master database, where each portal accesses and displays data depending on the search criteria and portal used.

The CBGSA contacted DWR directly to acquire all available data related to the Basin. DWR provided a customized hyperlink for CBGSA representatives to download the State's database in whole. Cuyama Basin data were then extracted from this dataset.

Although the master dataset was used to collect initial data, the CASGEM portal was used throughout the planning process to verify that data (DWR CASGEM Online System, 2018). The CASGEM Program is tasked with tracking seasonal and long-term groundwater elevation trends in groundwater basins throughout the State. In 2009, Senate Bill Senate Bill x7-6 establish collaboration between local monitoring parties and DWR, enabling DWR to collect groundwater elevation data, and ultimately establishing the CASGEM Program.

The CASGEM Program allows local agencies to be designated as CASGEM monitoring entities for groundwater basins throughout the State (CASGEM Brochure, 2018). CASGEM monitoring entities can measure groundwater elevations or compile data from other agencies to fulfill a monitoring plan, and each entity is responsible for submitting that data to DWR. Three monitoring entities operate as CASGEM monitoring entities in the Cuyama Basin as follows:

- Santa Barbara County Water Agency (SBCWA)
- Ventura County Watershed Protection District (VCWPD)
- San Luis Obispo Flood Control & Water Conservation District (SLOFC&WCD)

The CASGEM Program includes two kinds of wells in its database as follows:

- CASGEM wells, all of which include well construction information
- Voluntary wells that are included in the CASGEM database on a volunteer basis; well construction may not be identified or made public

The Basin has six CASGEM wells and 107 voluntary wells. Figure 4-3 shows the locations of these wells.

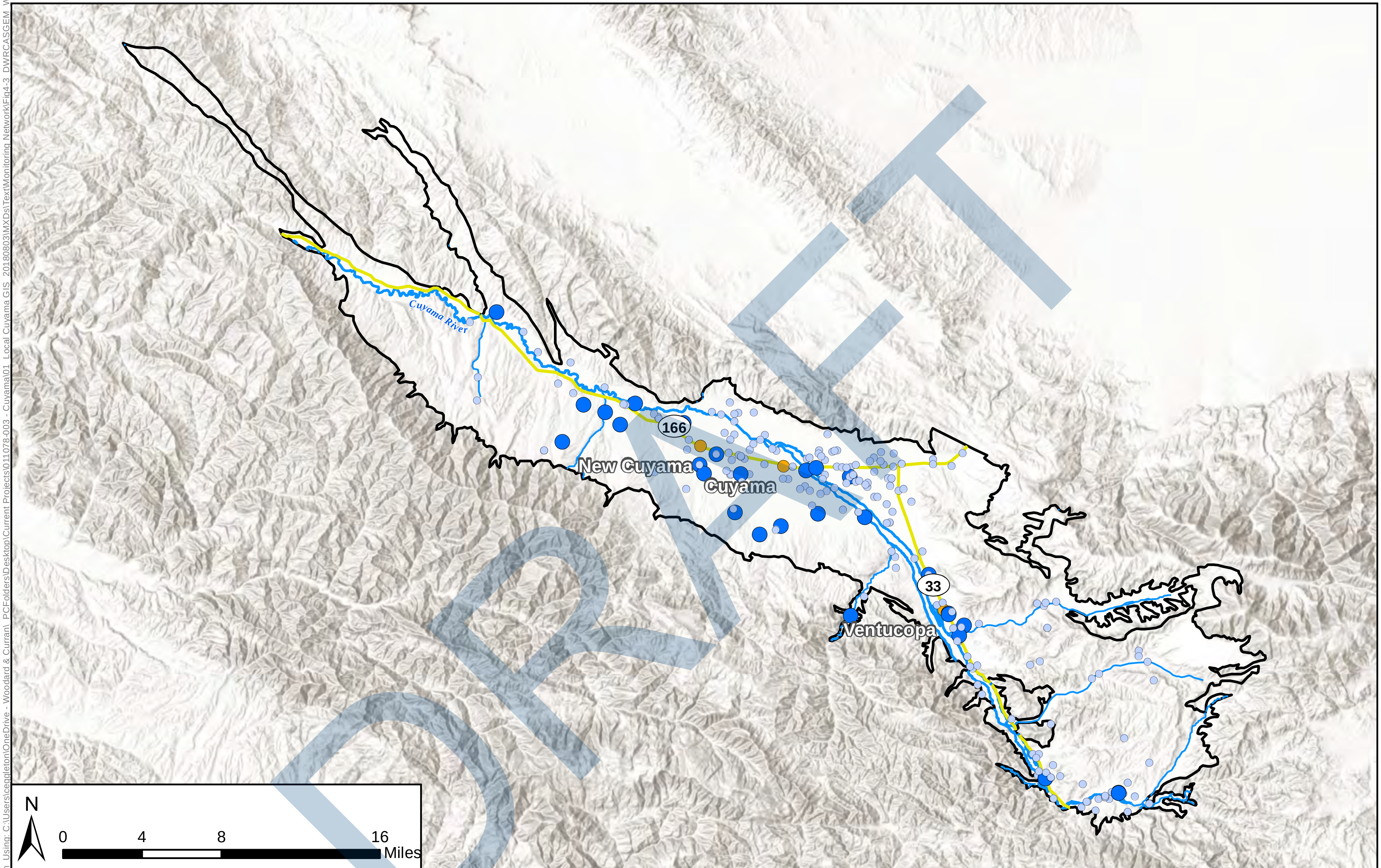

Figure 4-3: Cuyama GW Basin Wells with Monitoring Data Provided by DWR

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- Towns
- Highways
- Cuyama River
- Streams
- DWR Database Wells Last Measured in 2017-2018
- DWR Database Wells Last Measured 2016 and Earlier

Most wells are measured on either a semi-annual or annual schedule. Summary statistics about these wells are listed below.

- Number of CASGEM wells: 6
- Number of voluntary wells: 107
- Total number of DWR and CASGEM wells: 222
- Earliest measurement year: 1946
- Longest period of record: 68 years
- Median period of record: 12 years
- Median number of records for a single well: 19

The greatest well density among current wells is in the central portion of the Basin and in the area around Ventucopa. There are also several monitoring wells in the south eastern portion of the Basin upstream of Ventucopa. CASGEM data are sparser along the north facing slopes of the main Cuyama Valley and the western portion of the Basin, as can be seen in Figure 4-3.

USGS

The USGS has the most groundwater elevation monitoring locations in the Basin. Many of these wells were installed for a 1966 groundwater study and have since been retired.

There are significant overlaps between the DWR provided datasets and the USGS provided datasets. Approximately 106 wells appear in both downloaded datasets. Overlapping data is discussed below.

USGS data may be accessed through their online portals for the National Ground-Water Monitoring Network, Groundwater Watch, and the National Water Information System (NWIS).

The USGS online data portals provide approved data that has been quality-assured and deemed fit to be published by USGS. The portals also provide provisional data that is unverified and subject to revision. The CBGSA contacted USGS directly and coordinated download of USGS monitoring records in the Basin. The CBGSA used the USGS URL Generation tool was used to download all provisional and approved data about the Basin.

USGS has approximately 476 wells in the Basin. Summary statistics about these wells are listed below.

- Total number of USGS wells: 476
- Earliest measurement date: 1946
- Longest period of record: 68 years
- Median period of record: 2 years
- Median number of records for a single well: 2 years

A significant portion of the wells included in the USGS dataset are located near the Cuyama River and are in the central portion of the Basin. Wells are also found along many of the tributaries that feed the Cuyama River, recording data during large precipitation events. Figure 4-4 shows well locations included in the USGS dataset.

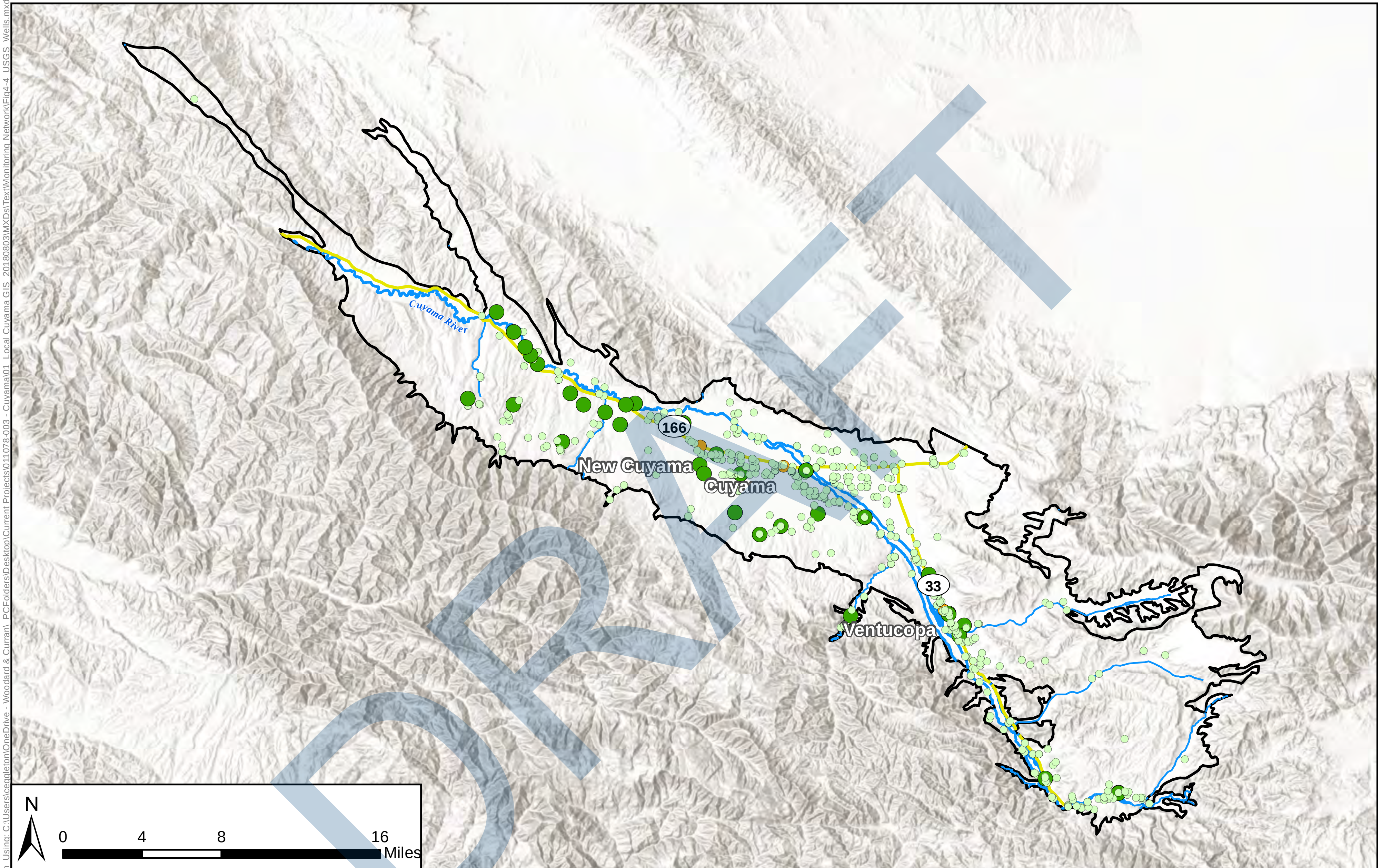

Figure 4-4: Cuyama GW Basin Wells with Monitoring Data Provided by USGS

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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WOODARD & CURRAN

Legend

- Cuyama Basin
- Towns
- Highways
- Cuyama River
- Streams
- USGS Database Wells Last Measured in 2017-2018
- USGS Database Wells Last Measured 2016 or Earlier

SBCWA

SBCWA maintains data for 36 wells in the Cuyama Basin. Some of those wells are owned by private land owners, and others are owned by local agencies such as the California Department of Transportation and the California Department of Fish and Wildlife. Summary statistics about these wells are listed below.

- Number of SBCWA-monitored wells: 36
- Earliest measurement date year: 1950
- Longest period of record: 68 years
- Median period of record: 2 years
- Median number of records for a single well: 8
- Number of SBCWA wells included in the monitoring network: 20

Wells included in the SBCWA dataset are in Santa Barbara County near the Cuyama River, and in the hills to the south of the river. Figure 4-5 shows the locations of these wells.

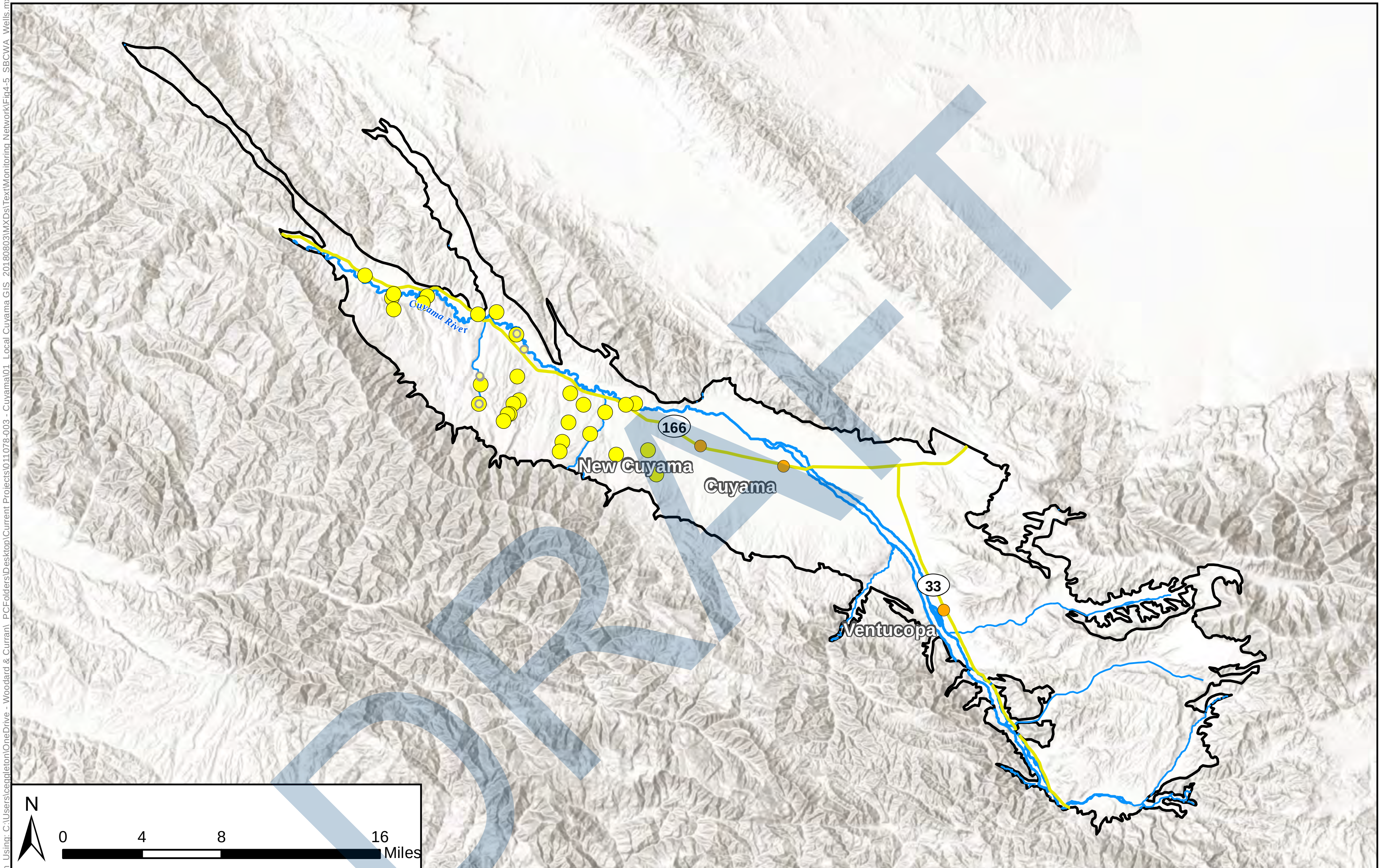

Figure 4-5: Cuyama GW Basin Wells with Monitoring Data Provided by SBCWA

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- Towns
- Highways
- Cuyama River
- Streams
- Santa Barbara County Database Wells Last Measured in 2017-2018
- Santa Barbara County Database Wells Last Measured 2016 or Earlier

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SLOCFC&WCD

SLOCFC&WCD maintains data for two wells within the Basin. SLOCFC&WCD also reports theses data to DWR; all data are for the wells is incorporated through the DWR CASGEM Program dataset.

These wells are in the central portion of the Basin, north of the Cuyama River and west of State Route (SR) 33. Both wells meet the minimum requirements for inclusion in the monitoring network, and summary statistics about these wells are listed below.

- Number of SLOCFC&WCD-monitored wells: 2
- Earliest measurement year: 1990
- Longest period of record: 28 years
- Median period of record: 18 years
- Median number of records for a single well: 35

Figure 4-6 show the well locations.

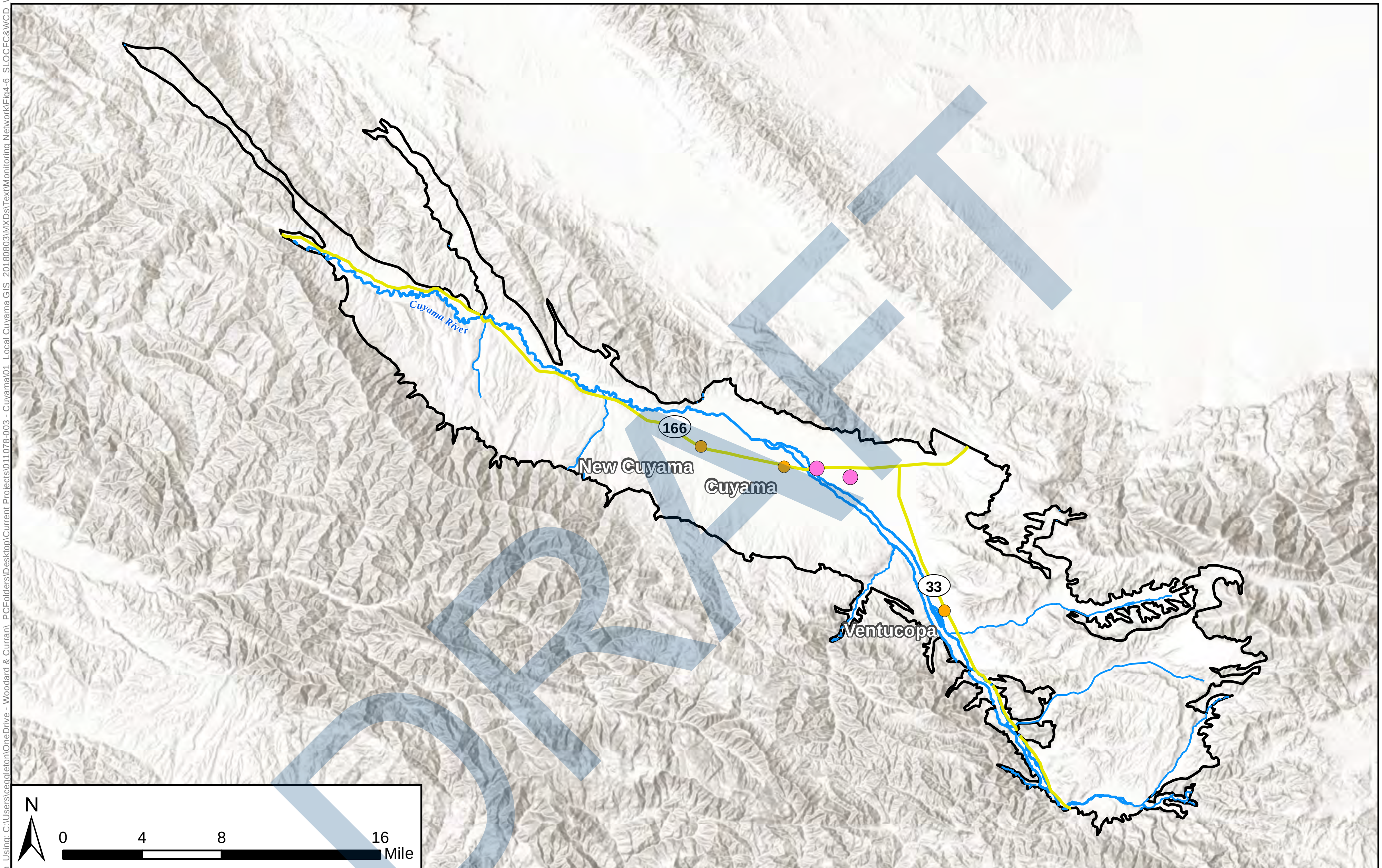

Figure 4-6: Cuyama GW Basin Wells with Monitoring Data Provided by SLOCFC&WCD

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- San Luis Obispo County Wells Last Measured in 2017-2018
- Towns
- Highways
- Cuyama River
- Streams

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VCWPD

VCWPD manages 22 groundwater elevation monitoring wells in the Basin. A total of 20 wells are incorporated in the DWR CASGEM Program dataset.

The majority of wells managed by VCWPD are discontinued, and no longer measure groundwater elevations. Of the 22 wells, five have measured elevation data during the last decade. Summary statistics about these wells are listed below.

- Number of VCWPD-monitored wells: 22
- Earliest measurement year: 1971
- Longest period of record: 46 years
- Median period of record: 5.8 years
- Median number of records for a single well: 21.5

The wells included in the VCWPD dataset are in the southeastern portion of the Basin that intersects with Ventura County. The wells are primarily found near the Cuyama River close to agricultural land. Figure 4-7 shows well locations.

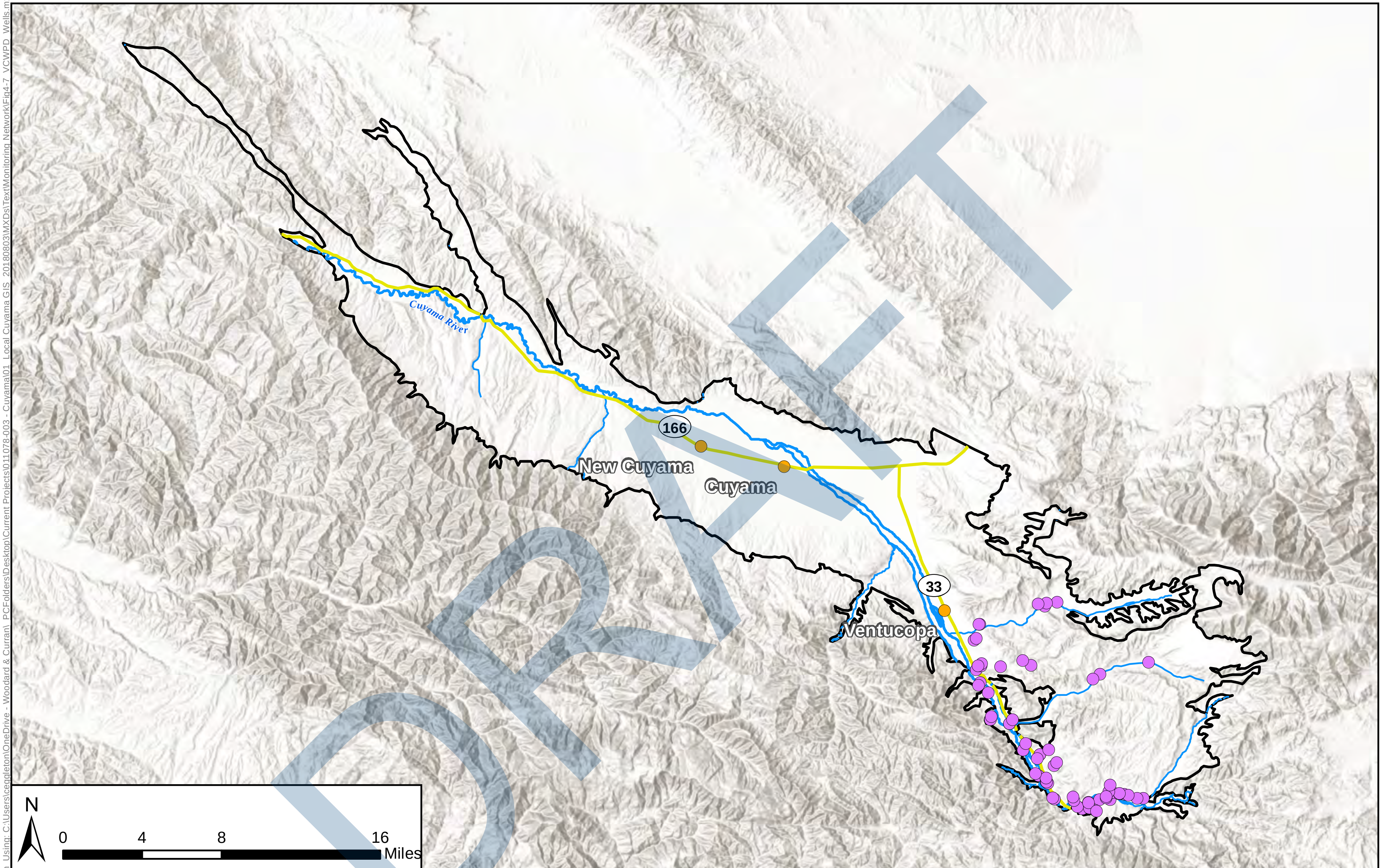

Figure 4-7: Cuyama GW Basin Wells with Monitoring Data Provided by VCWPD

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- Towns
- Highways
- Cuyama River
- Streams
- Ventura County Watershed Protection District

Cuyama Community Services District

The Cuyama Community Services District (CCSD) performs monitoring on its two production wells, one of which has been retired. The CCSD wells are just south of the CCSD. Data for these wells are included in the SBCWA dataset, and in the DWR and USGS datasets. Summary statistics about these wells are listed below. Figure 4-8 shows the location of these wells.

- Number of CCSD-monitored wells: 2
- Earliest measurement year: 1981
- Longest period of record: 37 years
- Median period of record: 26.5 years
- Median number of records for a single well: 79

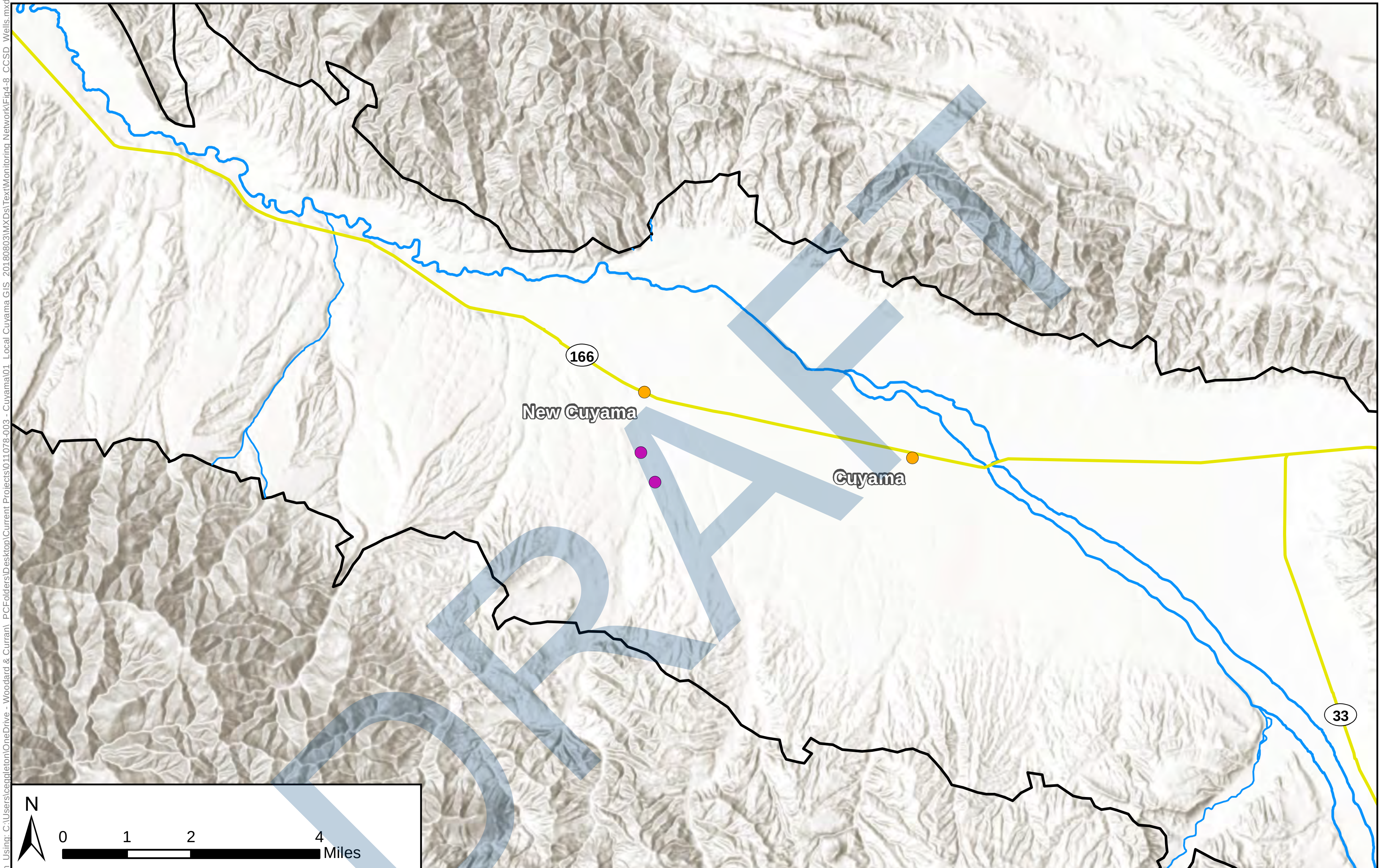

Figure 4-8: Cuyama GW Basin Wells with Data Provided by CCSD

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- CCSD Wells
- Towns
- Highways
- Cuyama River
- Streams

Private Landowners

Private landowners in the Basin own and operate large numbers of wells, primarily for irrigation and domestic use. Many wells owned by private landowners are included in the databases described above. In addition, and at the request of CBGSA, these landowners have provided additional monitoring data about 99 private wells. Summary statistics about these wells are listed below.

- Number of private landowner wells with monitoring data: 99
- Earliest measurement date year: 1975
- Longest period of record: 42 years
- Median period of record: 15 years
- Median number of records for a single well: 16

The private landowner wells are distributed throughout the Basin.. The majority of wells are located in the central portion of the Basin near the Cuyama River and SR 166. There is an additional cluster of wells toward the western portion of the Basin running along the Cuyama River. Figure 4-9 shows private landowner wells.

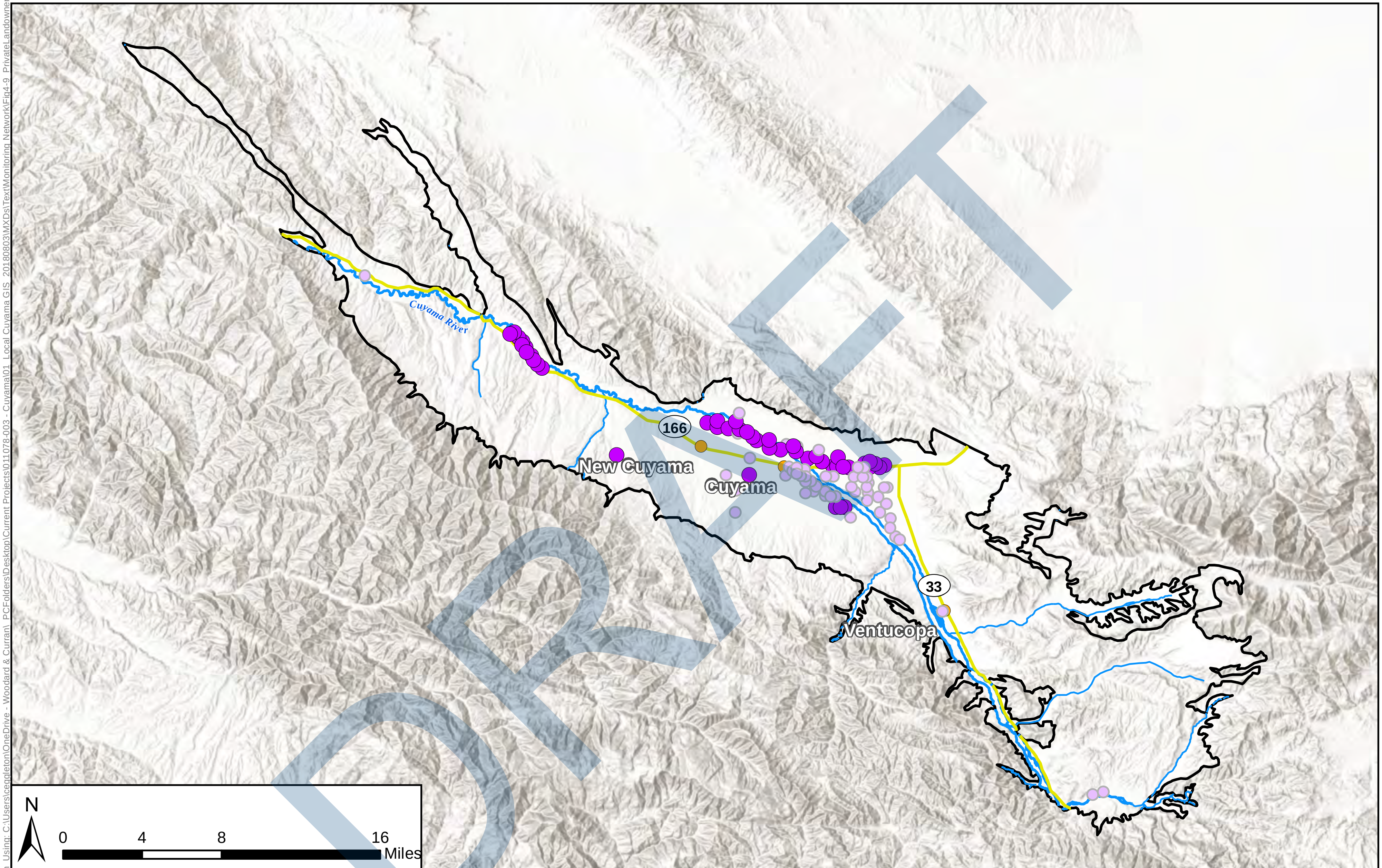

Figure 4-9: Cuyama GW Basin Wells with Monitoring Data Provided by Private Landowners

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- Towns
- Highways
- Cuyama River
- Streams
- Private Landowner Reported Wells Last Measured in 2017-2018
- Private Landowner Reported Wells Last Measured 2016 and Earlier

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4.3.2 Overlapping and Duplicate Data

Many of the data sources used to compile and create the Cuyama Basin database contain duplicate entries for wells, metadata, groundwater level measurements, and groundwater quality measurements. Much of the well information managed by counties in the Basin is also provided and incorporated into the DWR dataset. Many of the USGS wells and DWR wells overlap between datasets.

To avoid duplicate entries when compiling the Cuyama Basin database, wells were organized by their State Well Number, Master Site Code, USGS identification number, local name, and name. Analysts identified duplicates and removed or combined entries as necessary. Each unique well was then assigned an OPTI ID which was used as the primary identification number for all other processes and mapping exercises. Additional information about the management of well data is provided in Chapter 6.

OPTI IDs were used to identify Basin wells in the database because not all data sources use similar identification methods, as shown in Table 4-1 below.

Table 4-1: Well Identification Matrix

Data Maintaining Entity	State Well Number	CASGEM ID	USGS ID	Master Site Code	Local Name	Name
DWR	✓ [green]	✓ [green]		✓ [green]		
USGS	✓ [black]		✓ [green]		✓ [red]	
SLOCFC&WCD	✓ [green]					
SBCWA	✓ [black]		✓ [red]		✓ [black]	
VCWPD	✓ [green]					
Private Landowners					✓ [black]	✓ [green]

✓ [green] = All wells had this information, ✓ [black] = Some wells had the information, ✓ [red] = Few wells had the information

4.3.3 Groundwater Quality Monitoring (Combined Existing Programs)

This section discusses existing groundwater quality monitoring programs in the Cuyama Basin.

National Water Quality Monitoring Council (NWQMC)/USGS/ Irrigated Land Regulatory Program (ILRP)

The NWQMC was created in 1997 to provide a collaborative, comparable, and cost-effective approach for monitoring and assessing the United States' water quality. Several organizations contribute to the database, including the Advisory Committee on Water Information, the United States Department of Agriculture's (USDA's) Agricultural Research Service, the United States Environmental Protection Agency (EPA), and USGS (NWQMC, 2018).

A single online portal provides access to data from the contributing agencies. Data are included from the USGS NWIS, the EPA Storage and Retrieval Data Warehouse, and the USDA's Agricultural Research Service Program, Sustaining The Earth's Watersheds – Agricultural Research Database System. Data incorporate hundreds of different water quality constituents from the different contributing agencies. Initial water quality data for the Cuyama Basin was downloaded through NWQMC, and included data about USGS monitoring sites and ILRP monitoring sites. ILRP was initiated in 2003 to prevent agricultural runoff from impairing surface waters, and in 2012, groundwater regulations were added to the program. ILRP water quality measurements are sampled from surface locations (DWR ILRP, 2018). There are currently five ILRP measurement sites in the Cuyama Basin. ILRP uses the California Environmental Data Exchange Network (CEDEN) to manage associate program data. CEDEN data are then integrated with USGS data, and then included in the NWQMC database (DWR CEDEN, 2018).

The NWQMC database provides TDS data about 180 water quality monitoring sites. This database also provides data for a variety of constituents not included here.

Summary statistics for the NWQMC, USGS and ILRP monitoring sites is shown below.

- Number of measurement sites: 180
- Earliest measurement date year: 1940
- Longest period of record: 53 years
- Median period of record: less than 1 year
- Median number of records for a single site: 2

The majority of the water quality monitoring sites included in the NWQMC database are located in the central portion of the Basin and along the Cuyama River as it follows SR 33. Figure 4-10 shows these monitoring sites.

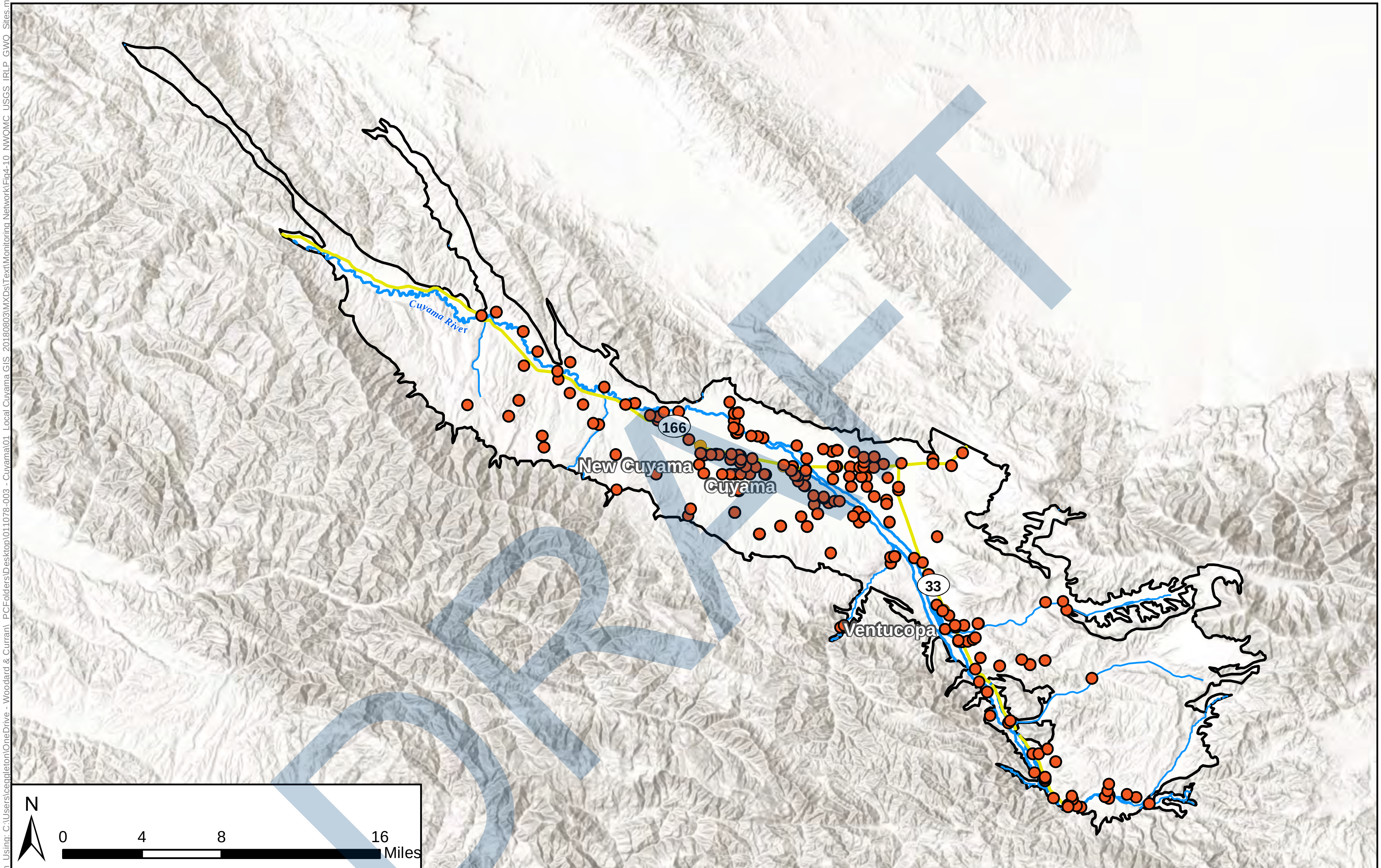

Figure 4-10: Cuyama GW Basin USGS/NWQMC/ IRLP Groundwater Quality Monitoring Sites

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- USGS/NWQMC/IRLP Groundwater Quality Sites
- Towns
- Highways
- Cuyama River
- Streams

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Groundwater Ambient Monitoring and Assessment (GAMA) Program/DWR

The GAMA Program is the State of California's groundwater quality monitoring program created by the State Water Resources Control Board in 2000. Assembly Bill 599 later expanded the Groundwater Quality Monitoring Act of 2001 (DWR GAMA, 2018). The purpose of GAMA is to improve statewide comprehensive groundwater monitoring and increase the availability of information to the general public about groundwater quality and contamination information. Additionally, the GAMA Program aims to establish groundwater quality on basin-wide scales, continue with groundwater quality sampling and studies, and centralize the information and data for the public and decision makers to enhance groundwater resource protection.

DWR also publishes statewide water quality data via the California Natural Resources Agency. Access to DWR and GAMA information and data are accessible through separate online portals.

There are 213 GAMA and DWR groundwater quality monitoring sites in the Basin. Summary statistics for these sites is shown below.

- Number of measurement sites: 213
- Earliest measurement date year: 1942
- Longest period of record: 41 years
- Median period of record: less than 1 year
- Median number of records for a single site: 2

The GAMA/DWR groundwater quality monitoring locations are spread throughout the Basin, loosely following the Cuyama River. There are 60 water quality monitoring sites per 100 square miles in the Basin. Figure 4-11 shows these locations.

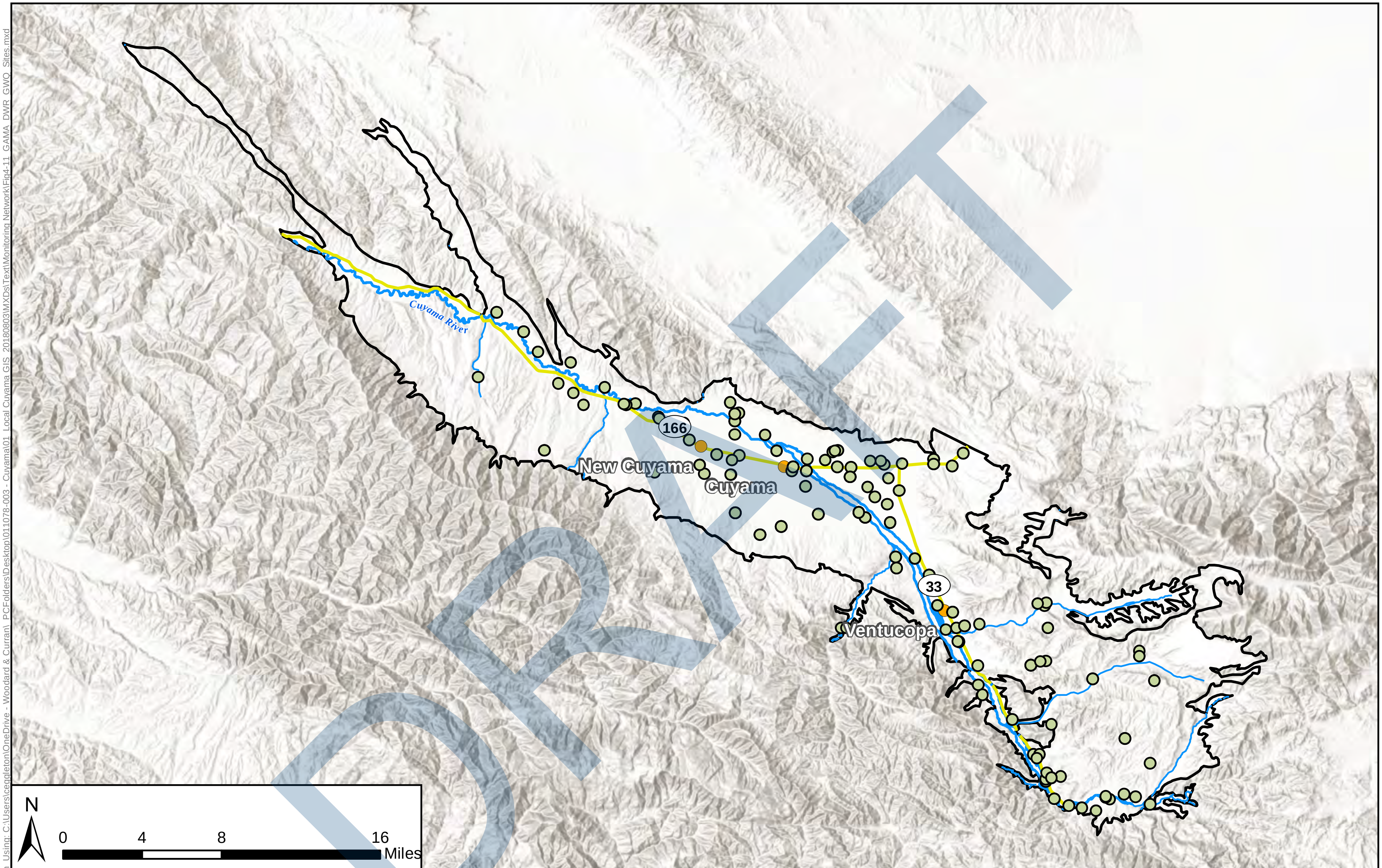

Figure 4-11: Cuyama GW Basin GAMA/DWR Groundwater Quality Monitoring Sites

Cuyama Basin Groundwater Sustainability Agency

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Legend

- Cuyama Basin
- GAMA/DWR Groundwater Quality Sites
- Towns
- Highways
- Cuyama River
- Streams

CCSD

CCSD currently operates one production well for residential distribution in the Basin. Although some data for this well are included in the NWQMC dataset, annual Consumer Confidence Reports from 2011 to 2017 were processed for additional water quality data measurements. Summary statistics for the CCSD well are listed below and the well location is shown in Figure 4-12.

- Number of measurement sites: 1
- Earliest measurement date: 2008
- Period of record: 10 years
- Number of records: 21

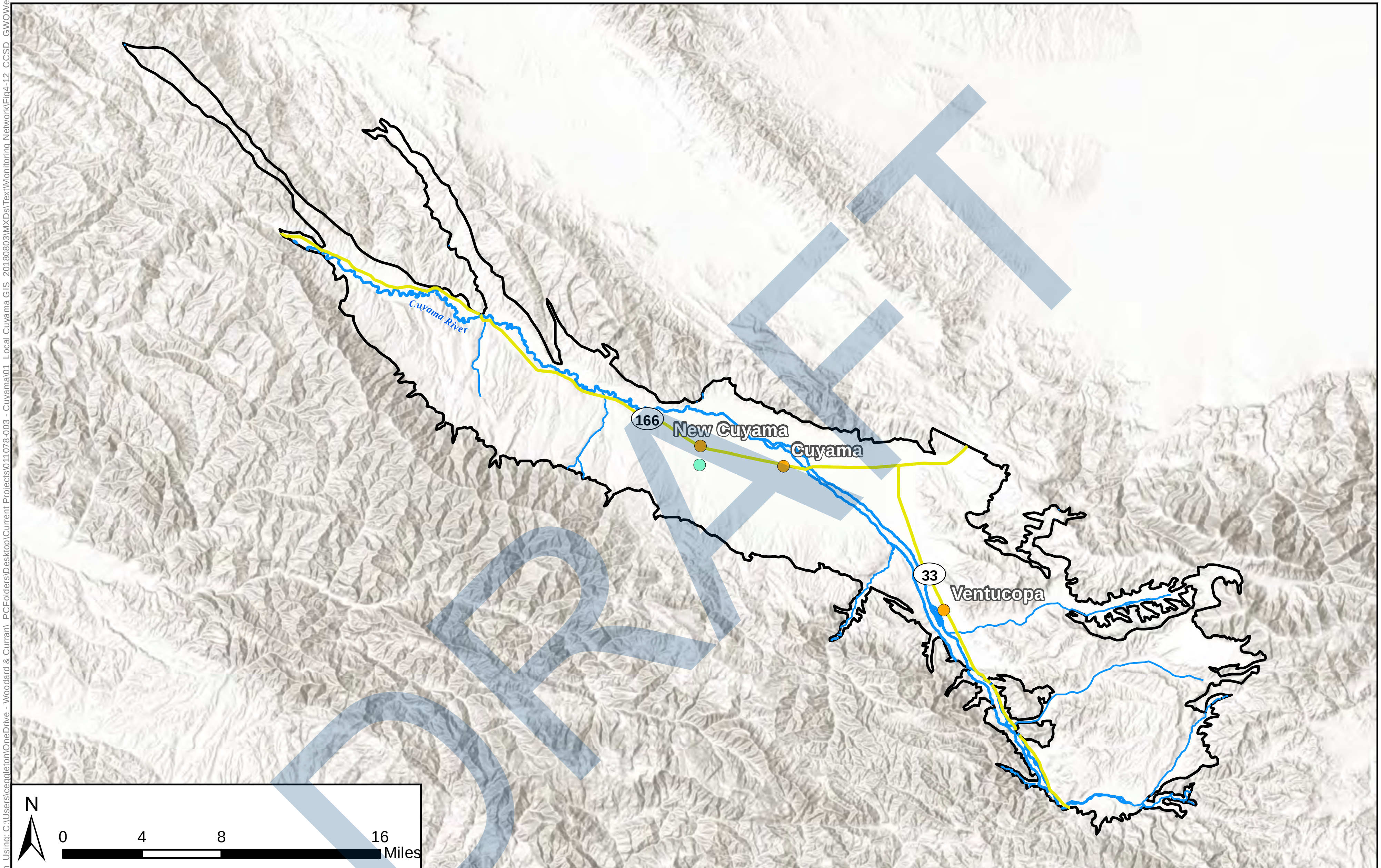

Figure 4-12: Cuyama GW Basin CCSD Groundwater Quality Well

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Legend

- Cuyama Basin
- Cumaya Community Services District Water Quality Monitoring Well
- Towns
- Highways
- Cuyama River
- Streams

VCWPD

VCWPD has 51 groundwater wells that are used for groundwater quality monitoring in the Basin. All of the wells are incorporated into the DWR, GeoTracker, or USGS datasets. Sampling data include numerous water quality constituents; however, this GSP only addresses TDS. Summary statistics for the wells are listed below, and locations of these wells are included in Figure 4-13.

Number of measurement sites: 51

Earliest measurement date: 1957

Longest period of record: 45

Median period of record: 7

Median number of records for a single site: 5

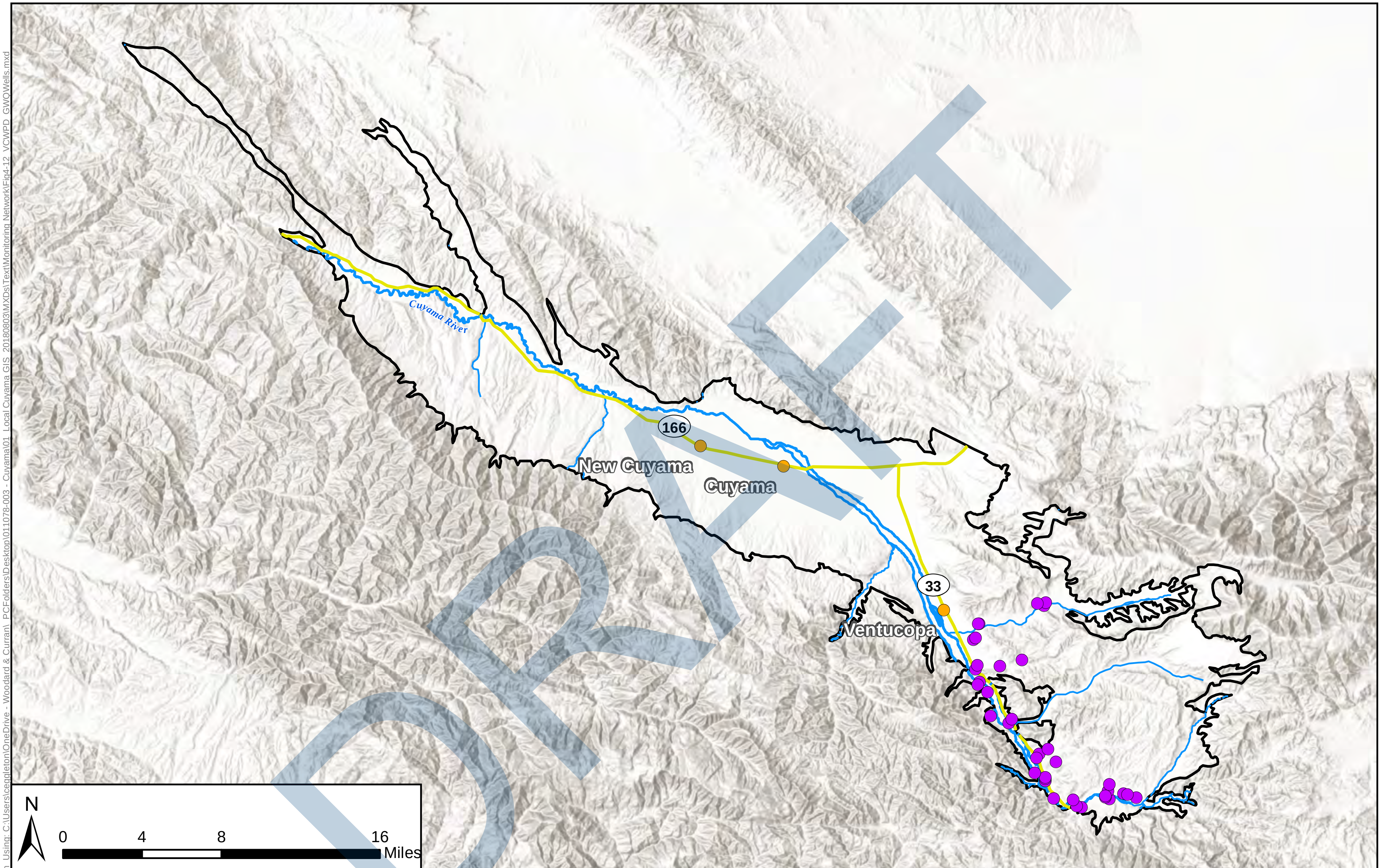

Figure 4-13: Cuyama GW Basin
VCWPD Groundwater Quality Wells

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Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- Towns
- Highways
- Cuyama River
- Streams
- Ventura County Watershed Protection District Groundwater Quality Monitoring Wells

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Private Landowners

Private landowners in the Basin conducted groundwater quality testing, which has been incorporated into this document and associated analysis. In 2015, 11 wells measured for TDS. Summary statistics about these wells are listed below, and locations are shown in Figure 4-14.

- Number of measurement sites: 11
- Earliest measurement date: January 12, 2015
- Longest period of record: Not applicable
- Median period of record: Not applicable
- Median number of records for a single site: 1

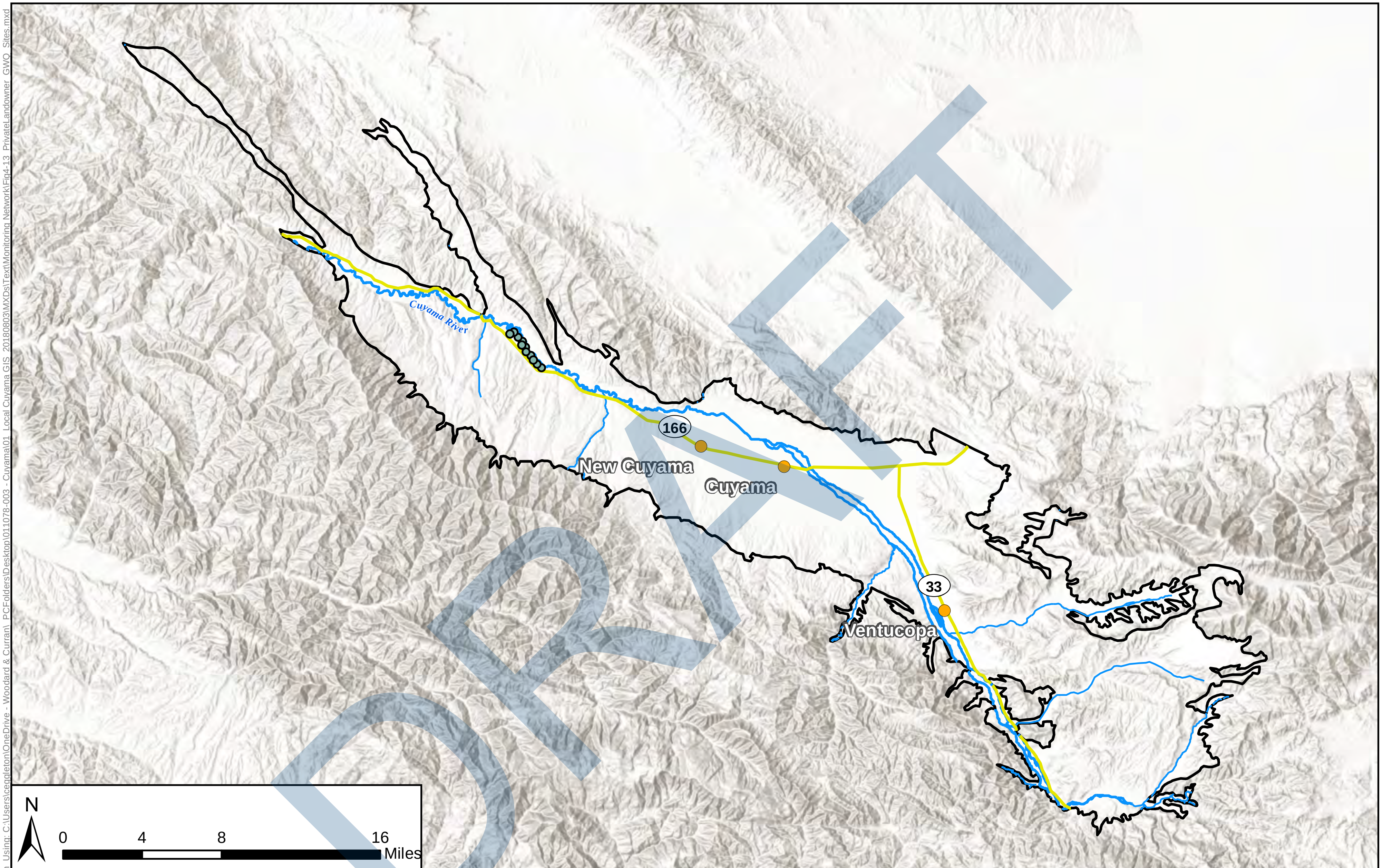

Figure 4-14: Cuyama GW Basin Private Landowner Groundwater Quality Monitoring Sites

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Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- Private Landowner Groundwater Quality Monitoring Sites
- Towns
- Highways
- Cuyama River
- Streams

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4.3.4 Subsidence Monitoring

Subsidence is the sinking or downward settling of the earth's surface, and is often the result of over-extraction of subsurface water. Subsidence can be directly measured using a few different methods, such as light detection and ranging (LiDAR), interferometric synthetic aperture radar (InSAR), continuous geographic positioning system (CGPS), extensometers, and spirit leveling. For more information, see Appendix B in Chapter 2, which contains further information about these methods and the physics behind land subsidence. The subsidence monitoring network described below assumes the use of extensometers to monitor subsidence in the Basin. However, the CBGSA should evaluate other methods, including LiDAR and InSAR during the implementation phase to identify an optimal approach.

The Basin hosts two CGPS stations, and three others are just outside the Basin's boundary, as shown in Figure 2-51. CGPS stations measure surface movement in all three axis directions (i.e., up, down, east, west, north, and south). CGPS stations are in the center of the Cuyama Valley, and measure subsidence, while other are placed on ridges around the valley to also measure tectonic movement.

4.3.5 Surface Water Monitoring

Surface water monitoring in the Basin is conducted through stream and river gages placed along the Cuyama River or one of its tributaries. USGS manages most flow gages in California, and currently operates one active stream gage along Santa Barbara Creek. There is an additional gage (1136800) along the Cuyama River downstream of the Basin before Twitchell Reservoir; however, this gage also receives water from non-Cuyama Basin watershed areas. Data for surface flow gages are obtained through the NWIS Mapping portal (USGS NWIS, 2017). Existing and discontinued gages are shown in Figure 4-15.

USGS has operated three additional gages in the Basin; however, two of those gages were discontinued in the 1970s. Gage 1136500 operated from 1945 to 1958 and was brought back into service from 2009 to 2014.

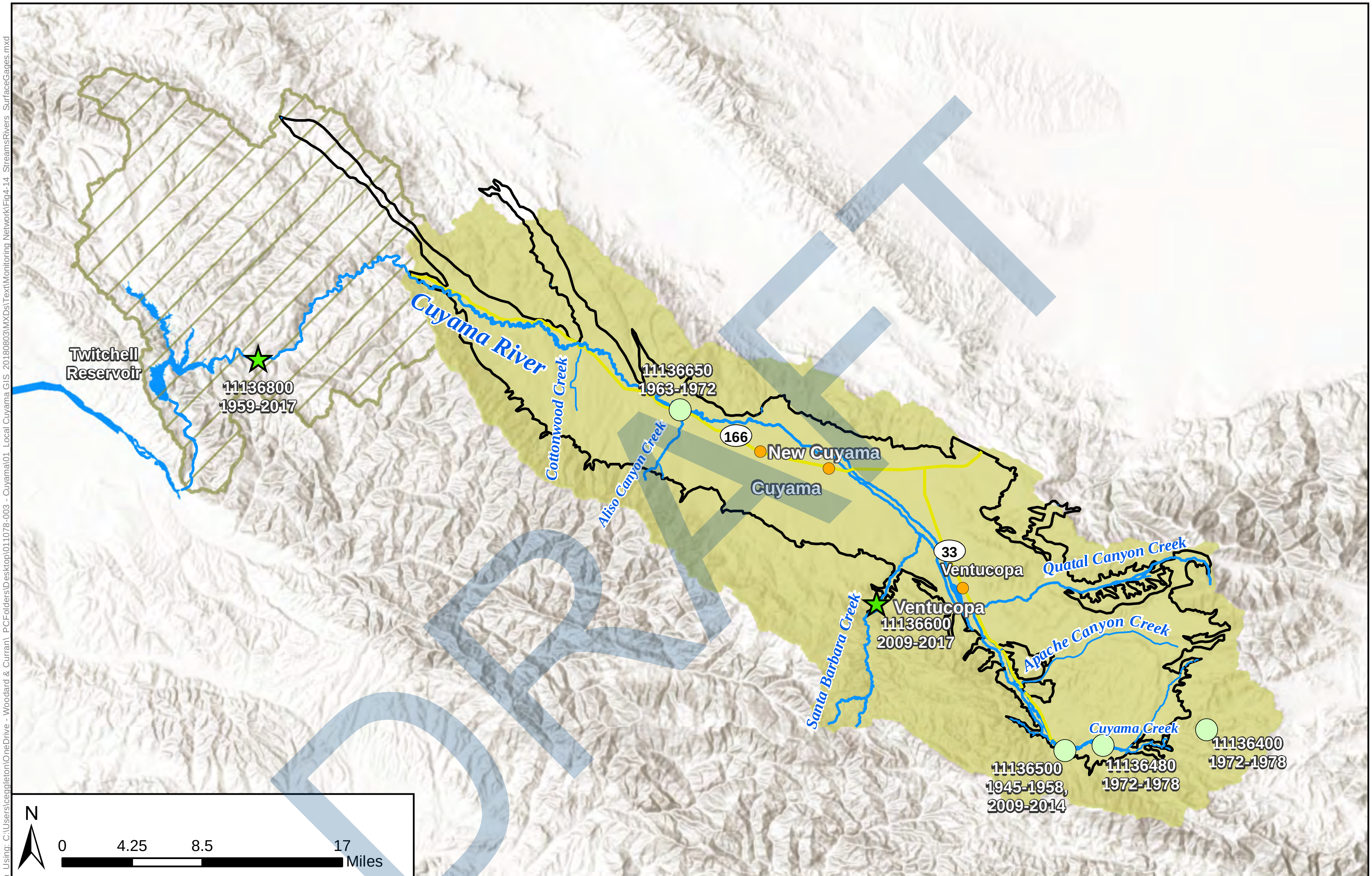

Figure 4-15: Rivers, Streams, and Surface Flow Gages

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- Towns
- Highways
- Cuyama River
- Inactive Flow Gages
- Active Flow Gages

Cuyama Watershed

- Contributes to Cuyama GW Basin
- Does Not Contribute to Cuyama GW Basin

4.4 Monitoring Rationales

This section discusses the reasoning behind monitoring network selection. Monitoring networks in the CBGSA area were developed to ensure they could detect changes in Basin conditions so CBGSA could manage the Basin and ensure sustainability goals were met. Additionally, monitoring can help assure that no undesirable results are present after 20 years of sustainable management.

The monitoring networks were selected specifically to detect short-term, seasonal, and long-term trends in groundwater levels and storage. The monitoring networks were also selected to include information about temporal frequency and spatial density so the CBGSA can evaluate information about groundwater conditions necessary to evaluate project effectiveness and the effectiveness of any management actions undertaken by the CBGSA.

Chapter 8 describes how each monitoring network will be developed and implemented as individual projects the GSA will undertake as part of GSP implementation. The schedule and costs associated with developing and implementing each monitoring network are discussed in the Chapter 9.

4.5 Groundwater Level Monitoring Network

Groundwater level monitoring is conducted through a groundwater well monitoring network. This section will provide information about how the level monitoring network was developed, the criteria for selecting representative wells, monitoring frequency, spatial density, summary protocols, and identification and strategies to fill data gaps.

4.5.1 Monitoring Wells Selected for Monitoring Network

A set of well tiering criteria were created to rank existing groundwater level measuring sites in the Basin, and were arranged into six different tiers, as shown in Figure 4-16.

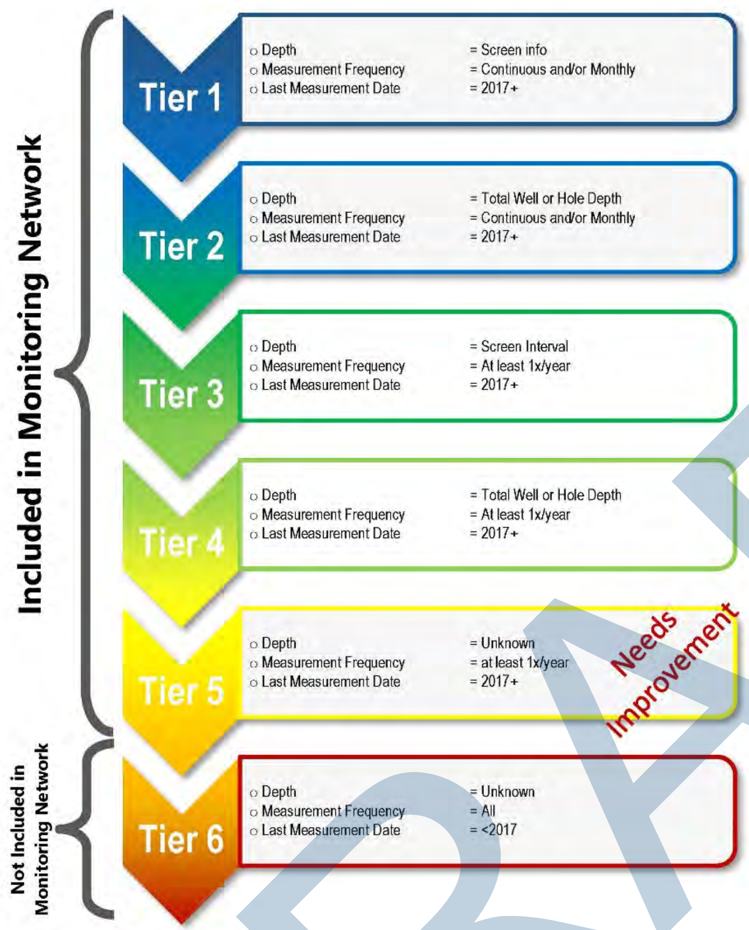

Figure 4-16: Cuyama Well Tiering Criteria

Tier 1 in the figure above shows wells with the most amount of metadata and consistent water elevation data that are still operating and functional. As tiering levels increase, requirements around well metadata and frequency of monitoring decrease; however, all wells are still active and functioning. Tier 5 captures the remaining active wells, but the metadata and/or frequency of monitoring would benefit from improvement.

Tier 6 includes all other wells that are no longer operational, which are categorized as those who do not have recorded data from January 1, 2017 to August 1, 2018 This approximate two-year cut off was determined as a reasonable amount of time for a monitoring agency or organization to obtain, log, and report well information and measurements, and as an indicator of whether a well was currently monitored or not.

Table 4-2 shows the number of monitoring wells selected from each existing monitoring data maintaining entity.

Table 4-2: Number of Wells Selected for Monitoring Network

Monitoring Data Maintaining Entity	Number of Wells Selected for Monitoring Network
CASGEM	28
USGS	43
SBCWA	30
SLOCFC&WCD	2
VCWPD	5
CCSD	1
Private Landowner	43
Total	**89**

Note: Total does not equal sum of rows due to duplicate entries in multiple databases

Figure 4-17 shows the Monitoring Network wells by their tier level.

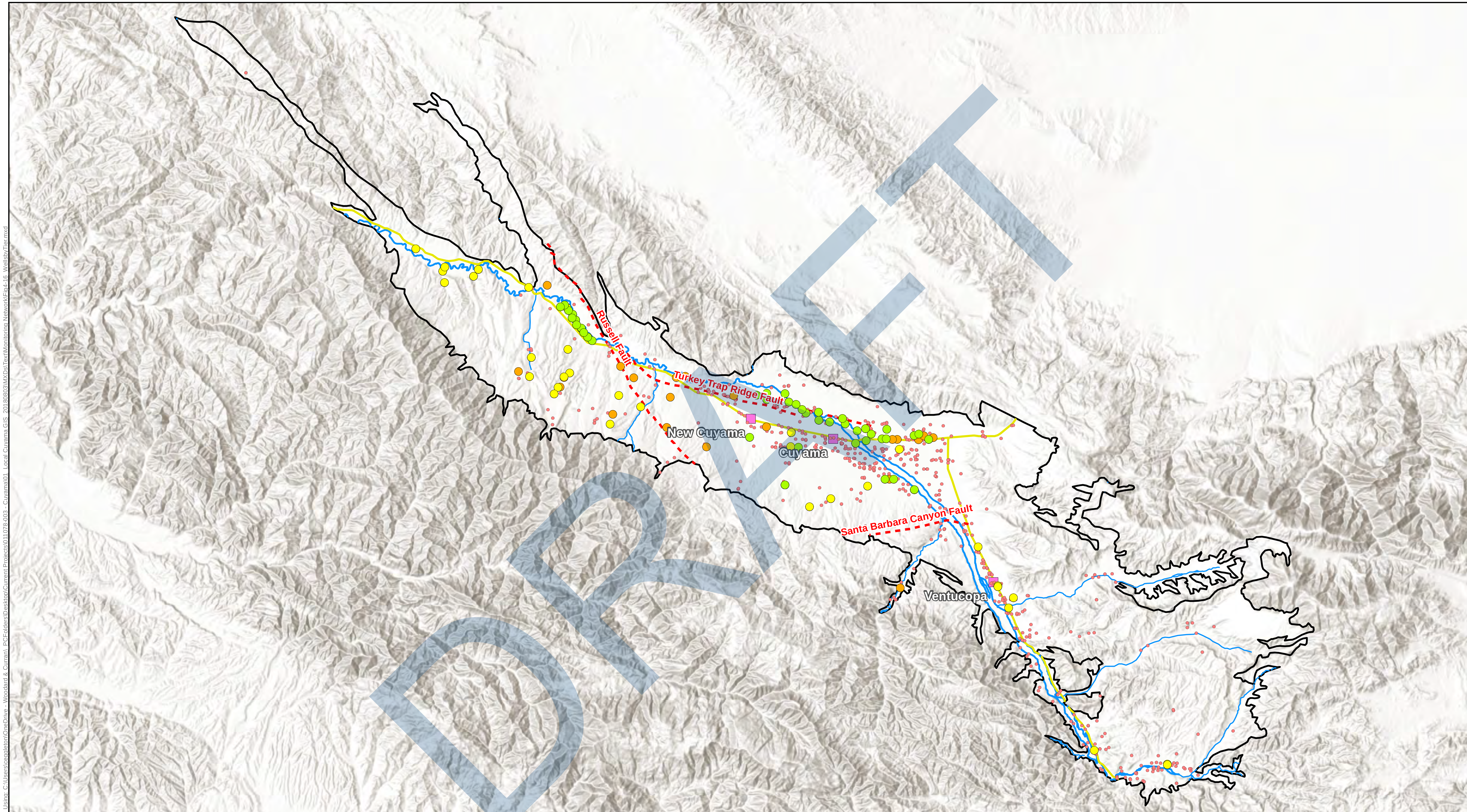

Figure 4-17: Cuyama GW Basin Groundwater Level Wells by Tier

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- Towns
- Faults
- Highways
- Cuyama River
- Streams

Monitoring Network Wells

- Tier 1
- Tier 2
- Tier 3
- Tier 4
- Tier 5
- Tier 6

N

0 2.5 5 10 Miles

4.5.2 Monitoring Frequency

A successful monitoring frequency and schedule should allow the monitoring network to adequately interpret fluctuations over time of the groundwater system based on shorter-term and longer-term trends and conditions. These changes may be the result of storm events, droughts or other climatic variations, seasons, and anthropogenic activities such as pumping.

Monitoring frequency must, at a minimum, occur within the same designated time-period for all wells to ensure that measurements represent the same condition for the aquifer.

The *Monitoring Networks and Identification of Data Gaps Best Management Practices* (BMPs) published by DWR provides guidance for monitoring frequency based on the discussion presented in the *National Framework for Ground-water Monitoring in the United States* (Advisory Committee on Water Information, 2013). This analysis and discussion provide guidance on monitoring frequency based on aquifer properties and degree of use, as shown in Table 4-3.

The BMP guidance recommends that initial characterization of monitoring locations use frequent measurements to establish the dynamic range at each monitoring site and to identify external stresses affecting groundwater levels. An understanding of these conditions based on professional judgement should be reached before normal monitoring frequencies are followed.

Table 4-3: Monitoring frequency Based on Aquifer Properties and Degree of Use

Aquifer Type	Nearby Long-Term Aquifer Withdrawals		
	Small Withdrawals	Moderate Withdrawals	Large Withdrawals
Unconfined Aquifer			
Low recharge (<5 inches/year)	Quarterly	Quarterly	Monthly
High recharge (>5 inches/year)	Quarterly	Monthly	Daily
Confined Aquifer			
Low hydraulic conductivity (<200 feet/day)	Quarterly	Quarterly	Monthly
High hydraulic conductivity (>200 feet/day)	Quarterly	Monthly	Daily

The Basin is an unconfined aquifer with large withdrawals, with a low recharge rate of less than 5 inches per year. According to the data in Table 4-3, which is provided by DWR, the Basin's groundwater monitoring frequency should be monthly. This GSP recommends monitoring the groundwater level network monthly for the first three years of GSP implementation and consideration of reducing monitoring frequency to quarterly measurements after that. Ideally, the monitoring network would be monitored simultaneously to gain a snapshot of groundwater conditions. As this is not practical currently, monitoring of the level network should be conducted within one week for each measurement period.

4.5.3 Spatial Density

Spatial density of the monitoring network was considered both for the selection of the entire monitoring network, and for the selection of representative wells (Section 4.5.5) The goal of the groundwater level monitoring network is to provide adequate coverage of the entire Basin aquifer. This includes the ability to monitor and identify groundwater changes across the Basin over time. Consideration of the spatial location of monitoring wells should include proximity to other monitoring wells and ensure adequate coverage near other prominent features, such as faults or production wells. Monitoring wells in close proximity to active pumping wells could be influenced by groundwater withdrawals, thus skewing static level monitoring.

The *Monitoring Networks and Identification of Data Gaps BMP* published by DWR provides different sources and condition dependent densities to guide monitoring network implementation (Table 4-4). This information was adapted from the *CASGEM Groundwater Elevation Monitoring Guidelines* (DWR, 2010). While these estimates provide guidance to monitoring well site spatial densities, monitoring points should primarily be influenced by local geology, groundwater use, and GSP-defined undesirable rates. Professional judgment is essential when determining final locations.

Table 4-4: Monitoring Well Density Considerations

Reference	Monitoring Well Density (wells per 100 square miles)
Heath (1976)	0.2-10
Sophocleous (1983)	6.3
Hopkins (1994)	
Basins pumping more than 10,000 acre-feet per year per 100 square miles	4.0
Basins pumping between 1,000 and 10,000 acre-feet per 100 square miles	2.0
Basins pumping between 250 and 1,000 acre-feet per year per 100 square miles	1.0
Basins pumping between 100 and 250 acre-feet per year per 100 square miles	0.7

The Basin has 378 square miles of area. According to Hopkins (1994) well density estimate guidelines, the Basin should have four monitoring wells per 100 square miles. Sophocleous (1983) recommends 6.3 monitoring wells per 100 square miles. According to Heath (1976), the Basin should have between 0.2 and 10 monitoring wells per 100 square miles. Due to geologic and topographic variability in the Basin, the severity of groundwater declines, and hydrogeologic uncertainty in various portions of the

Basin, this GSP recommends a density greater than the most conservative estimate of 10 wells per 100 square miles, which is over 38 monitoring wells.

4.5.4 Representative Monitoring

There are two categories of wells identified within the monitoring network as follows:

- **Representative Wells.** These wells will be used to monitor sustainability in the Basin. Minimum thresholds and measurable objectives will also be calculated for these wells.
- **Supplemental Wells.** Other wells are included in the monitoring network to provide redundancy for representative wells, and to maintain a robust network for evaluation as part of five-year GSP updates.

Representative monitoring wells were selected as part of monitoring network development. Representative monitoring wells are wells that represent conditions in the Basin, and are in locations that allow monitoring to indicate long-term, regional changes in its vicinity.

Representative groundwater level and groundwater storage sites within each management area were selected by several different criteria. These criteria include the following:

- **Adequate Spatial Distribution –** Representative monitoring does not require the use of all wells that are spatially grouped together in a portion of the Basin. Adequately spaced wells will provide greater Basin coverage with fewer monitoring sites.
- **Robust and Extensive Historical Data –** representative monitoring sites with longer and more robust historical data provide insight into long-term trends that can provide information about groundwater conditions through varying climatic periods such as droughts and wet periods. Historical data may also show changes in groundwater conditions through anthropogenic effects. While some sites chosen may not have extensive historical data, they may still be selected because there are no wells nearby with longer records.
- **Increased Density in Heavily Pumped Areas –** Selection of additional wells in heavily pumped areas such as in the central portion of the Basin and other agriculturally intensive areas will provide additional data where the most groundwater change occurs.
- **Increased Density near Areas of Geologic, Hydrologic, or Topologic Uncertainty** – Having a greater density of representative wells in areas of uncertainty, such as around faults or large elevation gradients may provide insightful information about groundwater dynamics to improve management practices and strategies.
- **Wells with Multiple Depths** – The use of wells with different screen intervals is important for collecting data about groundwater conditions at different elevations in the aquifer. This can be achieved by using wells with different screen depths that are close to one another, or by using multi-completion wells.

- **Consistency with BMPs –** Using published BMPs provided by DWR will ensure consistency across all basins and ensure compliance with established regulations.
- **Adequate Well Construction Information –** Well information such as perforation depths, construction date, and well depth should be considered and encouraged when considering wells to be included.
- **Professional Judgment** – Professional judgment is used to make the final decision about each well, particularly when more than one suitable well exists in an area of interest.
- **Maximum Coverage** – Any monitoring network well that was suitable for use in the representative network was used to maximize spatial and vertical density of monitoring.

4.5.5 Groundwater Level Monitoring Network

The groundwater level monitoring network is comprised of 88 of wells in the Basin. A total of 49 of those wells are representative wells. Overall well density is 23.3 wells per 100 square miles. Figure 4-18 shows the locations of the groundwater level monitoring network monitoring wells and representative wells.

Table 4-5 lists the wells in the groundwater level monitoring network. Representative wells, those with sufficient data and representative trends within the Basin, are identified with the asterisk (*) next to the OPTI ID and are sorted first. Metadata for the wells are also included.

The proposed monitoring frequency is monthly for the first three years of GSP implementation, with an option to reduce to quarterly monitoring if the CBGSA Board decides that is appropriate. This monitoring frequency captures short-term, seasonal, and long-term trends in groundwater levels. A well density of 23.3 wells per 100 square miles in the monitoring network provides a spatial density that adequately covers the primary aquifer in the Basin, and is useful for determining flow directions and hydraulic gradients, as well as changes in storage calculations for use in future water budgeting efforts in portions of the Basin with significant land use.

Table 4-5: Wells included in the Groundwater Levels and Storage Monitoring Network

OPTI ID	Data Maintaining Entity as of 2018	Well Construction Date	Well Depth (feet)	Hole Depth (feet)	Screen Interval (feet)	Well Elevation (feet above mean sea level)	Reference Point Elevation (feet above mean sea level)	First Measurement Year	Last Measurement Year	Measurement Period (years)	Measurement Count
2*	Ventura County	--	73.0	--	--	3,720	--	2011	2017	6	17
62*	SBCWA	--	212	--	--	2,921	--	1966	2018	52	65
72*	SBCWA	1/1/1980	790	820	350 – 340	2,171	--	1981	2018	37	114
74*	SBCWA	--	--	--	--	2,193	--	2008	2018	10	45
77*	SBCWA	12/4/2008	980	1,003.5	980 – 960	2,286	--	2009	2018	9	47
84	SBCWA	--	200	--	--	2,923	--	2008	2018	10	28
85*	SBCWA	--	233	--	--	3,047	--	1950	2018	68	282
89*	VWPD	1/1/1965	125	--	--	3,461	--	1965	2017	52	68
91*	SBCWA	9/29/2009	980	1,000	980 – 960	2,474	--	2009	2018	9	47
93*	SBCWA	10/18/1967	151	165	--	2,928	--	1971	2018	47	36
95*	SBCWA	4/9/2009	805.	825	--	2,449	--	2009	2018	9	32
96*	SBCWA	2/1/1980	500	--	--	2,606	--	1983	2018	35	61
98*	SBCWA	--	750	--	--	2,688	--	2008	2018	10	32
99*	SBCWA	9/10/2009	750	906	750 – 730	2,513	--	2009	2018	9	43
100*	SBCWA	11/1/1988	284	302	--	3,004	--	2010	2018	8	28
101*	SBCWA	--	200	220	--	2,741	--	2008	2018	10	42
102*	SBCWA	--	--	--	--	2,046	--	2010	2018	8	22
103*	SBCWA	7/23/2010	1,030	1,040	--	2,289	--	2012	2018	6	25
104	Unknown	--	640	--	638.64 – 478.64	2,299	2301	2008	2017	9	32
105	SLOCF&CWC	--	750	--	--	2,374	2375	1990	2017	27	38
106*	Unknown	--	227.5	--	--	2,327	2327	2016	2018	2	9
107*	Unknown	1/1/1950	200	--	--	2,482	--	1950	2018	68	12
108*	Private Landowner	--	328.75	--	--	2,629	2630	2016	2018	2	8
110	Unknown	1/1/1948	603	--	--	2,046	--	1950	2018	68	17
112*	Unknown	--	441	--	--	2,139	--	1966	2018	52	10
114*	DWR	1/1/1947	58.0	--	--	1,925	--	1967	2017	50	9
115	Private Landowner	--	1200	--	--	2,276	2278	2016	2018	2	4
116	Private Landowner	10/1/1980	700	--	700 – 240	2329	2329	1980	2018	38	6

Table 4-5: Wells included in the Groundwater Levels and Storage Monitoring Network

OPTI ID	Data Maintaining Entity as of 2018	Well Construction Date	Well Depth (feet)	Hole Depth (feet)	Screen Interval (feet)	Well Elevation (feet above mean sea level)	Reference Point Elevation (feet above mean sea level)	First Measurement Year	Last Measurement Year	Measurement Period (years)	Measurement Count
117*	Private Landowner	--	212	--	--	2,098	2095	2016	2018	2	10
118*	Private Landowner	--	500	--	--	2,270	2271	2016	2018	2	11
119	DWR	--	92.0	--	--	1,713	--	1955	2017	62	10
120	Private Landowner	--	15.4	--	--	1,705	1707	2016	2017	1	2
121	Private Landowner	--	98.25	--	--	1,984	1985	2016	2018	2	16
122	Private Landowner	--	63.2	--	--	2,129	2131	2016	2018	2	16
123*	Private Landowner	--	138	--	--	2,165	2167	2016	2018	2	14
124*	Private Landowner	--	160.55	--	--	2,287	2288	1988	2018	30	22
125	Private Landowner	--	26	--	--	2,283	2284	2016	2018	2	9
127*	Private Landowner	--	100.25	--	--	2,364	2365	2016	2018	2	14
128	Unknown	3/15/1990	140	150	--	3,721	--	2014	2017	3	8
316*	Unknown	9/29/2009	830	1,000	--	2,474	--	2009	2018	9	27
317*	Unknown	9/29/2009	700	1,000	--	2,474	--	2009	2018	9	28
322*	Unknown	4/9/2009	850	906	--	2,513	--	2009	2018	9	27
324*	Unknown	9/10/2009	560	906	--	2,513	--	2009	2018	9	26
325*	Unknown	9/10/2009	380	906	--	2,513	--	2009	2018	9	26
420*	Unknown	12/4/2008	780	1,003.5	--	2,286	--	2009	2018	9	29
421*	Unknown	12/4/2008	620	1,003.5	--	2,286	--	2009	2018	9	29
422*	Unknown	12/4/2008	460	1,003.5	--	2,286	--	2009	2018	9	28
467	Unknown	1/1/1963	1,140	1,215	--	2,224	--				
474*	Unknown	--	213	--	--	2,369	--	1955	2017	62	6
564	Unknown	1/1/1920	--	--	--	2,172	--	2017	2017	0	1
566	Unknown	--	500	520	--	2,263	--				
568*	Unknown	1/1/1948	188	188	--	1,905	--	1967	2018	51	22
571*	Private Landowner	1/1/1951	280	--	--	2,307	--	2016	2018	3	14
573*	Unknown	--	404	--	--	2,084	--	1950	2018	68	12
584	Unknown	--	450	606	--	1,753	--	2018	2018	0	1
586	Unknown	--	620	622	--	1,761	--				

Table 4-5: Wells included in the Groundwater Levels and Storage Monitoring Network

OPTI ID	Data Maintaining Entity as of 2018	Well Construction Date	Well Depth (feet)	Hole Depth (feet)	Screen Interval (feet)	Well Elevation (feet above mean sea level)	Reference Point Elevation (feet above mean sea level)	First Measurement Year	Last Measurement Year	Measurement Period (years)	Measurement Count
587	Unknown	12/29/2014	900	960	--	1,713	--	2018	2018	0	1
591	Unknown	--	720	740	--	1,715	--	2017	2018	1	2
597	Unknown	--	390	670	--	1,694	--	2017	2018	1	2
601	Private Landowner	6/14/1905	723	--	723 – 338	2,074	--	1993	2017	24	32
602	Private Landowner	6/12/1905	725	--	725 – 325	2,114	--	1992	2017	25	29
603	Private Landowner	6/15/1905	800	--	800 – 398	2,097	--	1994	2017	23	33
604*	Private Landowner	--	924	--	924 – 454	2,125	--	1995	2017	22	28
608*	Private Landowner	6/10/1905	745	--	745 – 440	2,224	--	1995	2017	22	26
609*	Private Landowner	6/15/1905	970	--	970 – 476	2,167	--	1995	2017	22	31
610*	Private Landowner	--	780	--	780 – 428	2,442	--	1995	2017	22	27
612*	Private Landowner	--	1070	--	1,070 – 657	2,266	--	1995	2017	22	24
613*	Private Landowner	--	830	--	830 – 330	2,330	--	1995	2017	22	24
614	Private Landowner	--	745	--	745 – 405	2,337	--	1995	2017	22	25
615*	Private Landowner	--	865	--	865 – 480	2,327	--	1995	2017	22	22
618	Private Landowner	6/18/1905	927	--	927 – 496	2,163	--	1996	2017	21	31
619	Private Landowner	6/19/1905	1,040	--	1,040 – 569	2,307	--	1997	2017	20	28
620*	Private Landowner	6/19/1905	1,035	--	1,035 – 50	2,432	--	1997	2017	20	25
621	Private Landowner	6/19/1905	974	--	974 – 540	2,126	--	1998	2017	19	30
623	Private Landowner	6/21/1905	1,040	--	1,040 – 530	2,288	--	1999	2017	18	29
627	Private Landowner	6/23/1905	960	--	960 – 460	2,279	--	2001	2017	16	19
628	Private Landowner	5/31/1905	941	--	941 – 593	2,388	--	1978	2017	39	32
629*	Private Landowner	--	1,000	--	1,000 – 500	2,379	--	2005	2017	12	13
630	Private Landowner	--	900	--	900 – 360	2,371	--	1991	2017	26	22
631	Private Landowner	5/31/1905	960	--	960 – 600	2,367	--	1986	2017	31	22
633*	Private Landowner	--	1,000	--	1,000 – 500	2,364	--	1998	2017	19	23
635	Private Landowner	--	1,050	--	1,050 – 549	2,356	--	2003	2017	14	10
636	Private Landowner	5/27/1905	924	--	924 – 474	2,348	--	1975	2017	42	15
637	Private Landowner	6/30/1905	980	--	980 – 540	2110	--	2009	2017	8	10

Table 4-5: Wells included in the Groundwater Levels and Storage Monitoring Network

OPTI ID	Data Maintaining Entity as of 2018	Well Construction Date	Well Depth (feet)	Hole Depth (feet)	Screen Interval (feet)	Well Elevation (feet above mean sea level)	Reference Point Elevation (feet above mean sea level)	First Measurement Year	Last Measurement Year	Measurement Period (years)	Measurement Count
638	Private Landowner	6/30/1905	1,006	--	1,006 – 526	2,437	--	2008	2017	9	9
640	Private Landowner	6/30/1905	840	--	840 – 400	2,239	--	2008	2017	9	16
641	Private Landowner	7/2/1905	800	--	800 – 360	2,204	--	2010	2017	7	7
642	Private Landowner	7/2/1905	1,000	--	1,000 – 550	2,232	--	2010	2017	7	8
644	Private Landowner	7/5/1905	950	--	950 – 490	2,143	--	2013	2017	4	10

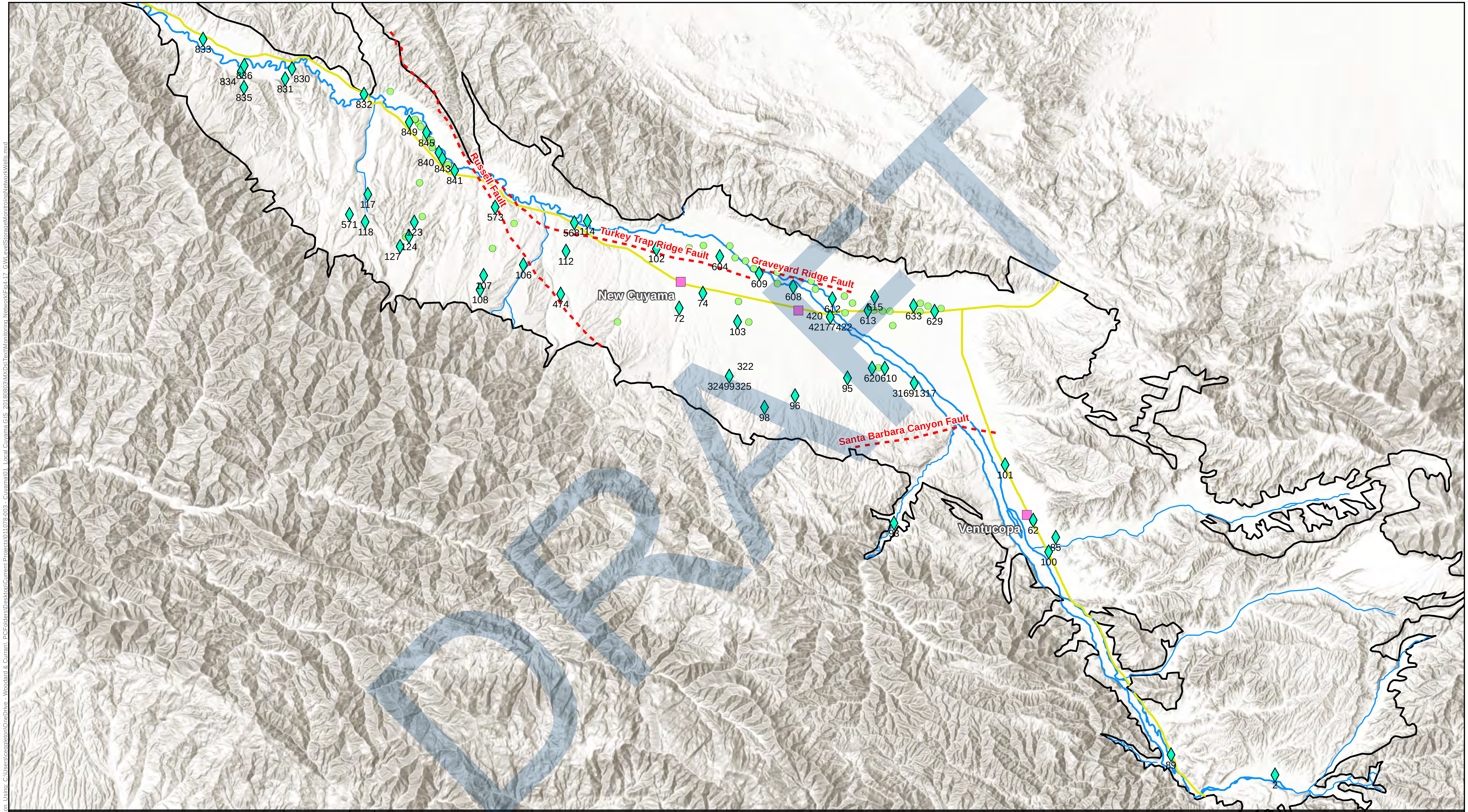

Figure 4-18: Cuyama GW Basin Groundwater Level & Storage Monitoring Network Wells

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

April 2019

WOODARD & CURRAN

Legend

Cuyama Basin
Towns
Faults
Highways
Cuyama River
Streams

Monitoring Network Wells

Representative Wells
Monitoring Network Wells

N

0 1.75 3.5 7 Miles

4.5.6 Monitoring Protocols

For additional monitoring recommended in Section 4.5.8, the monitoring protocols will use DWR's *Monitoring Networks and Identification of Data Gaps BMP*, which sites the DWR's 2010 publication *California Statewide Groundwater Elevation Monitoring (CASGEM) Program Procedures for Monitoring Entity Reporting* (Appendix A) for the groundwater level sampling protocols. This publication includes protocols for equipment selection, setup, use, field evaluation, and sample collection techniques..

4.5.7 Data Gaps

Groundwater level monitoring data gaps are the result of poor spatial distribution among available wells in the Basin, and a lack of well construction information.

The spatial distribution of groundwater level monitoring network wells provides coverage of the majority of the Basin. However, there are several areas, identified by the red ovals in Figure 4-19, that do not have adequate monitoring. If additional monitoring wells were added in these areas, they may provide more information that could be used to detect changes in Basin conditions,

Well construction information is not available for many wells in the Basin. Monitoring wells with construction information featuring total depth and screened interval are preferred for inclusion in the monitoring network, because that information is useful in understanding what monitoring measurements mean in terms of Basin conditions at different depths.

4.5.8 Plan to Fill Data Gaps

This GSP identifies a number of ways to refine the the groundwater level monitoring network and improve reporting.

The CBGSA has been awarded a Proposition 1 Category 1 Grant, which includes a task to expand the groundwater level monitoring network. This task includes identification of additional monitoring wells for hand measurements and installation of continuous monitoring equipment into 10 existing wells, which could be used to augment the existing monitoring network. This task would both increase the spatial distribution of the monitoring network and temporal coverage in the wells with additional continuous monitoring.

The CBGSA has applied for assistance from DWR's Technical Support Services (TSS), which provides support to GSAs as they develop GSPs. TSS opportunities include help installing new monitoring wells, and downhole video logging services. New wells drilled by DWR's TSS will improve the density and sampling frequency for level monitoring in the Basin. Downhole video logging will provide more well construction information to better utilize well data in the Basin. As of Draft GSP publication, the DWR TSS program has not provided any TSS services for the Cuyama Basin.

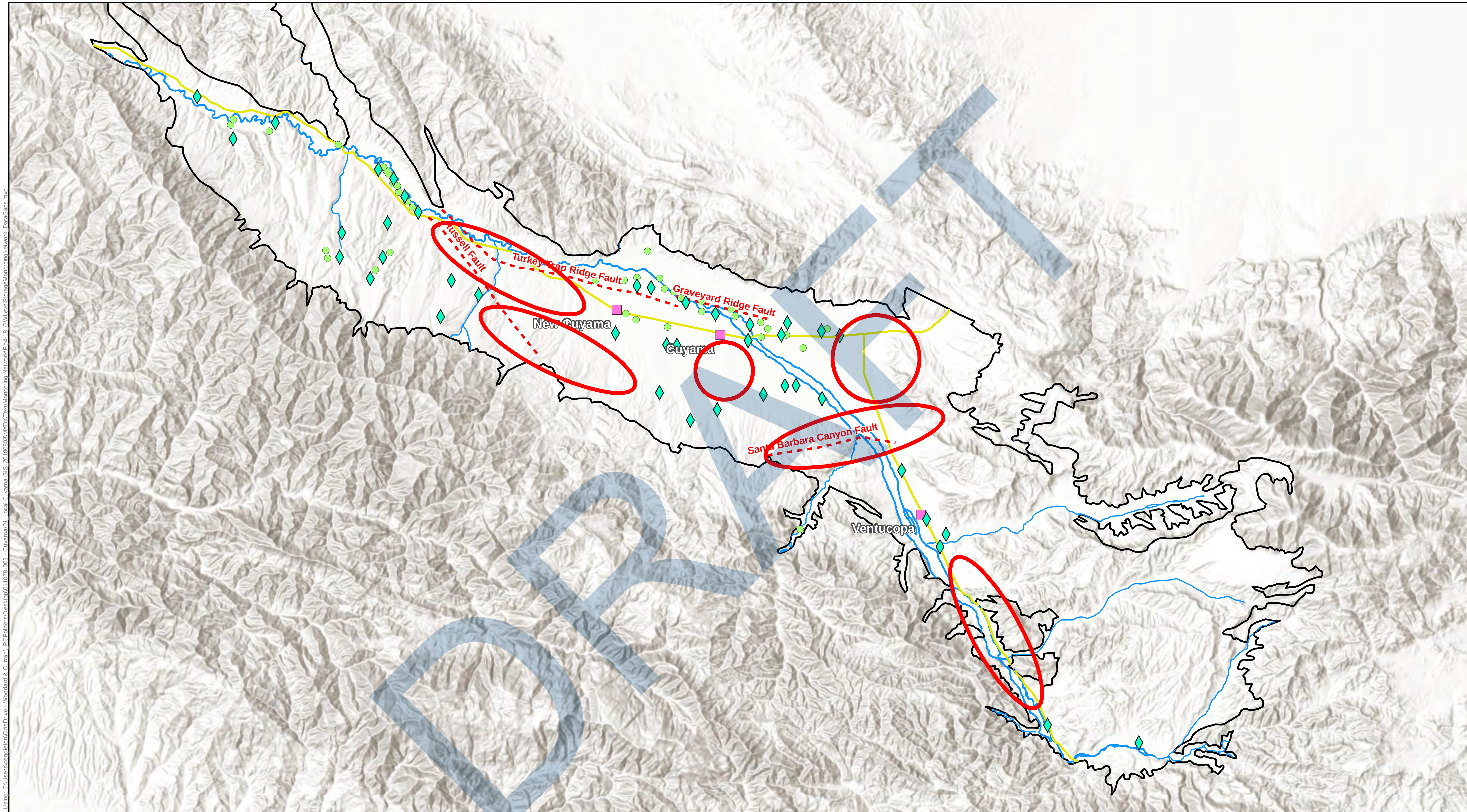

Figure 4-19: Cuyama GW Basin Groundwater Level & Storage Monitoring Network Data Gaps

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

April 2018

WOODARD & CURRAN

Legend

- Cuyama Basin
- Towns
- Faults
- Highways
- Cuyama River
- Streams

Monitoring Network Wells

- Representative Wells
- Monitoring Network Wells

N

0 2 4 8 Miles

4.6 Groundwater Storage Monitoring Network

Groundwater in storage is monitored through the measurement of groundwater levels. Therefore, the groundwater storage monitoring network will use the groundwater level monitoring network. Thresholds for groundwater storage are be discussed in Chapter 5.

4.7 Seawater Intrusion Monitoring Network

The Basin is geographically and geologically isolated from the Pacific Ocean and any other large source of saline water. As a result, the Basin is not at risk for seawater intrusion. Salinity (i.e., total dissolved solids, or TDS) is monitored as part of the groundwater quality network, but seawater intrusion is not a concern for the Basin.

4.8 Degraded Groundwater Quality Monitoring Network

Salinity (measured as TDS), arsenic, and nitrates have all been identified by local stakeholders as potentially being of concern for water quality in the Basin. However, as noted in the Groundwater Conditions chapter, there have only been two nitrate measurements and fewer than 10 arsenic measurements in recent years that exceeded maximum contaminant levels. In the case of arsenic, the high concentration measurements have been taken either at CCSD Well 2, which is no longer in operation, or at groundwater depths of greater than 700 feet, which is outside of the range of pumping for drinking water. Furthermore, unlike with salinity, there is no evidence to suggest a causal nexus between potential actions under the CBGSA's authority and arsenic or salinity. Therefore, the groundwater quality network has been established to monitor for salinity but does not consider arsenic or nitrates at this time.

4.8.1 Management Areas

Management Areas have not been selected at the time of publishing the Draft GSP. Management Areas may allow flexibility in establishing monitoring networks both spatially and temporally to match conditions and use in the Management Area. Given the scarcity of monitored sites, the CBGSA should use the same monitoring network selection criteria across all management areas in the Basin.

4.8.2 Monitoring Sites Selected for Monitoring Network

Table 4-6 lists the monitoring sites selected for the groundwater quality monitoring network by monitoring group. Monitoring sites selected for inclusion in the network were monitored from 2008 to 2018. It was assumed that wells that had previously been monitored for salinity prior to 2008 are unlikely to be monitored again by that monitoring agency. Due to the overlap of wells in both the USGS and DWR networks, the 64 selected groundwater quality networks wells is less than the sum of wells shown in Table 4-6.

Table 4-6: Groundwater Quality Monitoring Sites by Source	
Monitoring Data Maintaining Entity	**Number of Wells Selected for Monitoring Network**
NWQC, USGS, ILRP	43
GAMA, DWR	20
BCWPD	7
Private Landowner	11
Total	**64**
Note: Total does not equal sum of rows due to duplicate entries in multiple databases	

4.8.3 Monitoring Frequency

The Basin, in coordination with partnering agencies, will compile salinity samples once a year. Monitoring agencies such as USGS and DWR were contacted to inquire about when they would monitor their sites for groundwater quality, including salinity. These agencies stated they usually monitor annually, but the timing of that monitoring was not set, and changes from year to year. Additionally, depending on funding and staff availability, there may be years where no groundwater quality monitoring is conducted by an agency.

Although DWR does not provide specific recommendations on the frequency of monitoring in relationship to the described groundwater characteristics, concentrations of groundwater quality, especially salinity, do not fluctuate significantly over a year to require multiple samples per year.

4.8.4 Spatial Density

DWR's *Monitoring Networks and Identification of Data Gaps BMP* states "The spatial distribution must be adequate to map or supplement mapping of known contaminants." Using this guidance, professional judgment was used to identify representative wells in each management area. Heavily pumped areas, such as the central portion of the Basin, require additional monitoring sites, while areas of lower pumping or less agricultural or municipal groundwater use need less monitoring.

Any well measured from 2008 to June 2018 was included in the monitoring network. The overall monitoring network was selected as representative monitoring. The selected groundwater quality representative and monitoring wells provide adequate coverage of the Basin's aquifer. The groundwater quality monitoring network is composed of 64 of wells in the Basin, which providing a monitoring site density of 17 sites per 100 square miles. This exceeds the density recommended by reference materials for groundwater level density shown in Table 4-4.

4.8.5 Representative Monitoring

Representative monitoring sites were selected for groundwater quality using the criteria used to select representative groundwater level monitoring wells (Section 4.5.4). Due to the uncertainty of monitoring frequency, all monitoring network wells were selected as representative wells in the monitoring network.

4.8.6 Groundwater Quality Monitoring Network

Figure 4-20 shows the monitoring network, and representative and monitoring sites. The monitoring network is comprised of 64 wells, all of which are representative wells.

Table 4-7 shows the wells in the groundwater quality monitoring network. Metadata for the wells is also included.

Table 4-7: Wells Included in the Groundwater Quality Monitoring Network

OPTI ID	Managing Agency as of 2018	Well Construction Date	Well Depth (feet)	Hole Depth (feet)	Screen Interval	Well Elevation)feet_	First Measurement Date	Last Measurement Date	Measurement Period (years)	Measurement Count
61*	DWR	--	357		Unknown	3,681	2008-09-25	2008-09-25	0	3
72*	SBCWA	1/1/1980	790	820	340 – 350	2,171	2008-09-15	2017-07-14	9	13
73*	SBCWA	8/26/1982	880	1021.	Unknown	2,252	2010-08-03	2011-07-12	1	2
74*	SBCWA	--			Unknown	2,193	2008-09-17	2017-07-13	9	11
76*	USGS	9/1/1960	720		Unknown	2,277	1960-09-22	2008-09-17	48	10
77*	SBCWA	12/4/2008	980	1003.5	960 – 980	2,286	2009-04-08	2009-04-08	0	1
79*	USGS	--	600	750	Unknown	2,374	2008-07-08	2011-08-11	3	7
81*	USGS	--	155		Unknown	2,698	2011-08-16	2011-08-16	0	1
83*	SBCWA	1/1/1972	198		Unknown	2,858	2011-08-16	2011-08-16	0	1
85*	SBCWA	--	233		Unknown	3,047	1964-02-07	2011-07-12	47	46
86*	USGS	1/1/1995	230		Unknown	3,141	--	--	--	0
87*	USGS	--	232		Unknown	3,546	--	--	--	0
88*	USGS	9/4/2007	400	400.	Unknown	3,549	2011-08-18	2011-08-18	0	1
90*	SBCWA	8/8/2006	800	800	Unknown	2,552	2008-09-17	2012-09-20	4	6
91*	SBCWA	9/29/2009	980	1000	960 – 980	2,474	2009-11-05	2009-11-05	0	1
94*	USGS	--	550	720	Unknown	2,456	2008-07-29	2010-07-29	2	6
95*	SBCWA	4/9/2009	805	825.	Unknown	2,449	2011-08-19	2011-08-19	0	1
96*	SBCWA	2/1/1980	500		Unknown	2,606	2011-08-19	2011-08-19	0	1
98*	SBCWA	--	750		Unknown	2,688	2011-08-16	2011-08-16	0	1
99*	SBCWA	9/10/2009	750	906	73 – 750	2,513	2009-11-04	2009-11-04	0	1
101*	SBCWA	--	200	220	Unknown	2,741	2008-09-25	2008-09-25	0	3
102*	SBCWA	--			Unknown	2,046	2011-08-15	2017-07-13	6	7
130*	USGS	--			Unknown	3,536	2011-08-19	2011-08-19	0	1
131*	USGS	--			Unknown	2,990	2011-08-17	2011-08-17	0	1
157*	USGS	--	71		Unknown	3,755	--	--	--	0
196*	USGS	--	741	755	Unknown	3,117	--	--	--	--
204*	USGS	1/1/1935			Unknown	3,693	2011-08-18	2011-08-18	0	1
226*	USGS	1/1/1971		220.	Unknown	2,945	2011-08-18	2011-08-18	0	1

Table 4-7: Wells Included in the Groundwater Quality Monitoring Network

OPTI ID	Managing Agency as of 2018	Well Construction Date	Well Depth (feet)	Hole Depth (feet)	Screen Interval	Well Elevation)feet_	First Measurement Date	Last Measurement Date	Measurement Period (years)	Measurement Count
227*	USGS	--			Unknown	3,002	1966-07-01	2011-08-17	45	2
242*	USGS	--	155	187	Unknown	2,933	2012-07-18	2012-07-18	0	1
269*	USGS	1/1/1951			Unknown	2,756	2008-09-16	2008-09-16	0	3
309*	USGS	2/2/1980	1,100	1100	Unknown	2,513	2011-08-11	2011-08-11	0	1
316*	USGS	9/29/2009	830	1000	Unknown	2,474	2009-11-05	2009-11-05	0	1
317*	USGS	9/29/2009	700	1000	Unknown	2,474	2009-11-05	2009-11-05	0	1
318*	USGS	9/29/2009	610	1000	Unknown	2,474	2009-11-04	2009-11-04	0	1
322*	USGS	4/9/2009	850	906	Unknown	2,513	2009-11-03	2009-11-03	0	1
324*	USGS	9/10/2009	560	906	Unknown	2,513	2009-11-04	2009-11-04	0	1
325*	USGS	9/10/2009	380	906	Unknown	2,513	2009-11-04	2009-11-04	0	1
400*	USGS	--	2,120	2200.	Unknown	2,298	1958-05-26	2011-08-15	53	8
420*	USGS	12/4/2008	780	1003.5	Unknown	2,286	2009-04-07	2009-04-07	0	1
421*	USGS	12/4/2008	620	1003.5	Unknown	2,286	2009-04-07	2009-04-07	0	1
422*	USGS	12/4/2008	460	1003.5	Unknown	2,286	2009-04-08	2009-04-08	0	1
424*	USGS	--	1,000	1020.	Unknown	2,291	2011-08-15	2011-08-15	0	1
467*	USGS	1/1/1963	1,140	1215.	Unknown	2,224	2012-07-18	2017-07-13	5	6
568*	USGS	1/1/1948	188	188	Unknown	1,905	2008-09-15	2008-09-15	0	3
702*	USGS	--	--		Unknown	3,539	--	--	--	--
703*	USGS	--	--		Unknown	1,613	--	--	--	--
710*	DWR	--	--		Unknown	2,942	--	--	--	--
711*	DWR	--	--		Unknown	1,905	--	--	--	--
712*	DWR	--	--		Unknown	2,171	--	--	--	--
713*	DWR	--	--		Unknown	2,456	--	--	--	--
721*	DWR	--	--		Unknown	2,374	--	--	--	--
758*	DWR	--	--		Unknown	3,537	--	--	--	--
840*	Private Landowner	11/21/2014	900		200 – 880	1,713	--	--	--	--
841*	Private Landowner	12/12/2014	600		170 – 580	1,761	--	--	--	--
842*	Private Landowner	12/19/2014	450		60 – 430	1,759	--	--	--	--

Table 4-7: Wells Included in the Groundwater Quality Monitoring Network

OPTI ID	Managing Agency as of 2018	Well Construction Date	Well Depth (feet)	Hole Depth (feet)	Screen Interval	Well Elevation)feet_	First Measurement Date	Last Measurement Date	Measurement Period (years)	Measurement Count
843*	Private Landowner	1/5/2015	620		60 – 600	1,761	--	--	--	--
844*	Private Landowner	7/17/2015	730		100 – 720	1,713	--	--	--	--
845*	Private Landowner	7/12/2015	380		100 – 360	1,712	--	--	--	--
846*	Private Landowner	6/15/2015	610		130 – 590	1,715	--	--	--	--
847*	Private Landowner	7/26/2015	600		180 – 580	1,733	--	--	--	--
848*	Private Landowner	6/30/2015	390		110 – 370	1,694	--	--	--	--
849*	Private Landowner	6/23/2015	570		150 – 550	1,713	--	--	--	--
850*	Private Landowner	8/13/2015	790		180 – 780	1,759	--	--	--	--

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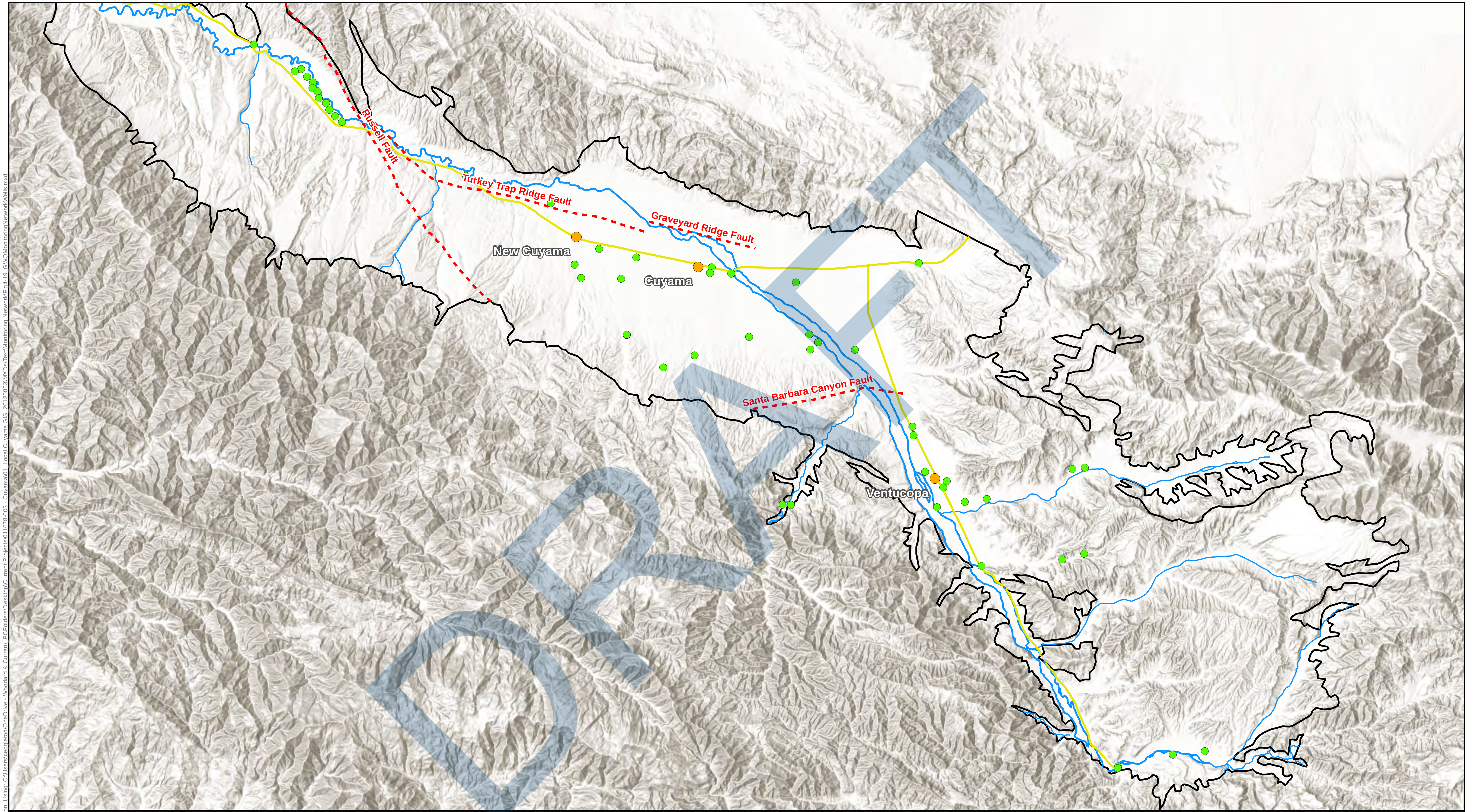

All wells included in the Groundwater Quality Monitoring Network have been measured since 1/1/2008. Wells measured prior to 2008 are not included.

Figure 4-20: Cuyama GW Basin Groundwater Quality Monitoring Network Wells

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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4.8.7 Monitoring Protocols

For additional monitoring recommended in Section 4.8.9, the monitoring protocols will use DWR's *Monitoring Networks and Identification of Data Gaps BMP*, which sites the USGS's 1995 publication *Ground-Water Data-Collection Protocols and Procedures for the National Water-Quality Assessment Program: Collection and Documentation of Water-Quality Samples and Related Data* (Appendix B) for the groundwater quality sampling protocols. This publication includes protocols for equipment selection, setup, use, field evaluation, sample collection techniques, sample handling, and sample testing.

4.8.8 Data Gaps

Groundwater quality monitoring data gaps have three components as follows:

- Spatial distribution of the wells
- Well/measurement depths for three-dimensional constituent mapping
- Temporal sampling

The spatial distribution of the groundwater quality monitoring network provides coverage of several portions of the Basin. There are several areas, identified by the red ovals in Figure 4-21, that do not have adequate monitoring. Additional samples taken in these identified areas will provide more information about salinity in the indicated locations.

Well construction for existing salinity sampling efforts is mostly unknown, and the depth of water used for sampling is not known at most monitoring sites. The monitoring network will collect additional information about how salinity may change at different depths in the aquifer, which will require taking samples from wells that have more detailed construction information.

Water quality sampling is inconsistently performed throughout the Basin; as a result, the Basin itself is identified as a groundwater quality monitoring temporal data gap. In September 2018, a CBGSA representative contacted management entities in the Basin responsible for groundwater quality sampling, to help understand the timing of current monitoring schedules, and to determine whether those management entities intended to continue quality monitoring in the future. This GSP assumes all management entities anticipate continuing groundwater quality sampling in the Basin; however, this will need to be confirmed, and the anticipated schedule of sampling by each entity will also need to be confirmed.

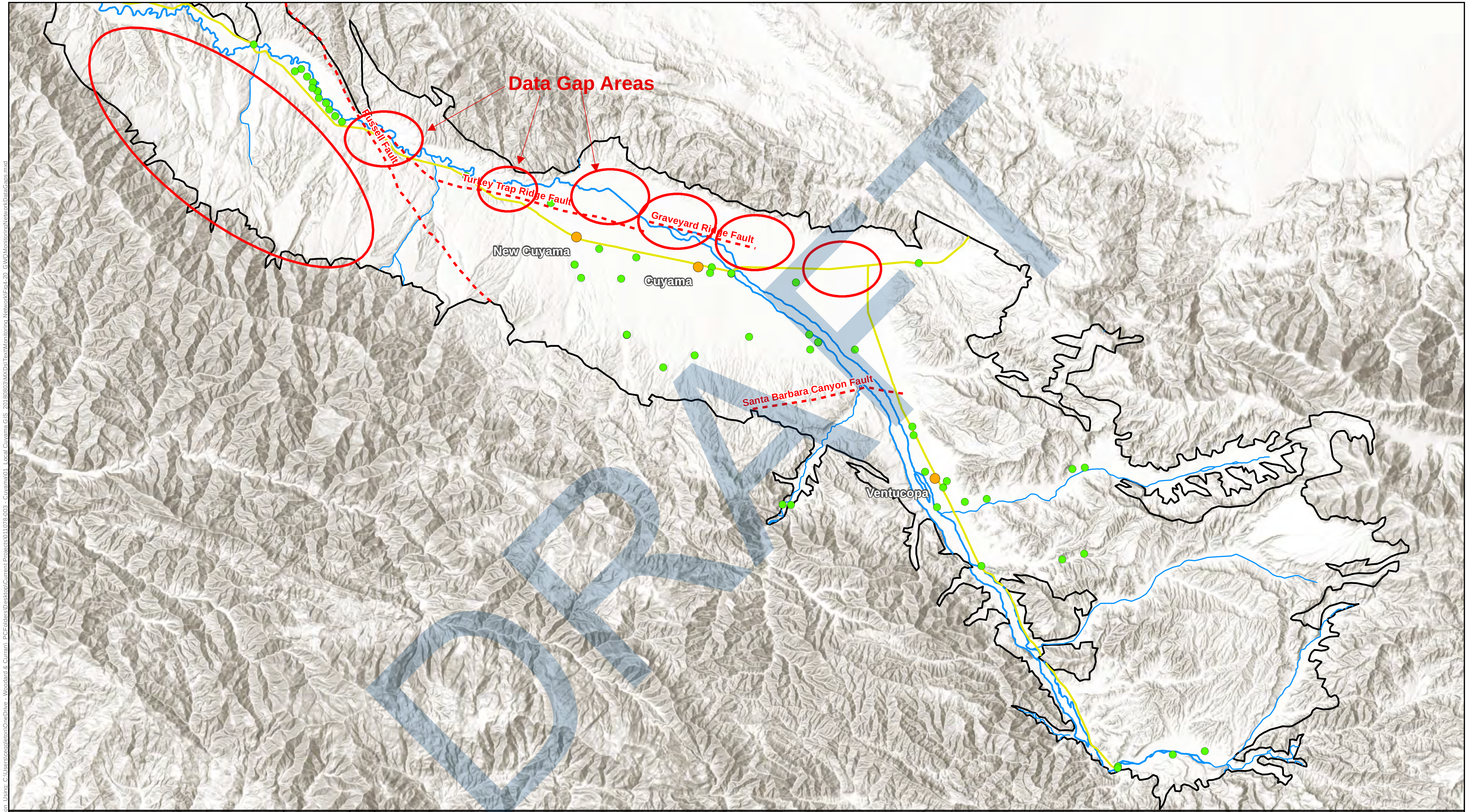

Figure 4-21: Cuyama GW Basin Groundwater Quality Monitoring Network Data Gaps

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Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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Legend

- Cuyama Basin
- Towns
- Highways
- Cuyama River
- Streams
- Faults
- Representative Wells and Groundwater Quality Monitoring Network Wells

N

0 1.75 3.5 7 Miles

4.8.9 Plan to Fill Data Gaps

The CBGSA will fill the temporal and spatial data gaps by implementing its own salinity sampling program, and will fill the well construction knowledge gap at least partially by using DWR's TSS program to perform downhole logging of a subset of wells.

The CBGSA will develop and perform a project to perform annual monitoring of salinity in the Basin. This new monitoring program will focus on using wells that have both construction information and pumps installed. Details of the new monitoring program, such as the targeted number and distribution of sampling sites will be detailed as a project in the projects and management actions section of this GSP (Chapter 6).

DWR's TSS supports GSAs as they develop GSPs. Downhole video logging performed by TSS in existing salinity monitoring wells could provide more well construction information, which may help to better use well data in the Basin.

4.9 Land Subsidence Monitoring Network

4.9.1 Management Areas

Subsidence is managed basin-wide; as a result, no management areas are used.

4.9.2 Monitoring Sites Selected for Monitoring Network

There are two subsidence monitoring stations in the Basin, and three outside of the Basin. Figure 4-22 shows the locations of existing subsidence monitoring stations, which make up the current subsidence monitoring network. The two stations in the Basin, sites CUHS and VCST, are both included in the monitoring network because they are active and provide Basin-specific data. The three stations located outside of the Basin, sites P521, BCWR, and OZST, are also included in the monitoring network. These stations are important for understanding general dynamic movement trends in the Basin because they detect tectonic movement in the Basin.

4.9.3 Monitoring Frequency

Subsidence monitoring frequencies should capture long-term and seasonal fluctuations in ground level changes. DWR's *Monitoring Networks and Identification of Data Gaps BMP* does not provide specific monitoring frequency or interval guidance. However, CGPS stations allow for data sampling several times a minute, which is sufficient for seasonal fluctuations to be captured in the data. Long-term trends are compiled from continuous data. Therefore, the CBGSA will use the same monitoring frequency currently used by the CGPS stations.

4.9.4 Spatial Density

Because there are only two monitoring stations, the current spatial density of subsidence monitoring in the Basin is 0.5 stations per 100 square miles. These stations are included in Figure 4-22. DWR's *Monitoring Networks and Identification of Data Gaps BMP* does not provide specific spatial density guidelines for subsidence monitoring networks, and thus relies on professional judgment for site identification. Current stations, both in and outside of the Basin, do not adequately cover the Basin for capturing subsidence variations. Potential areas for new stations are discussed below.

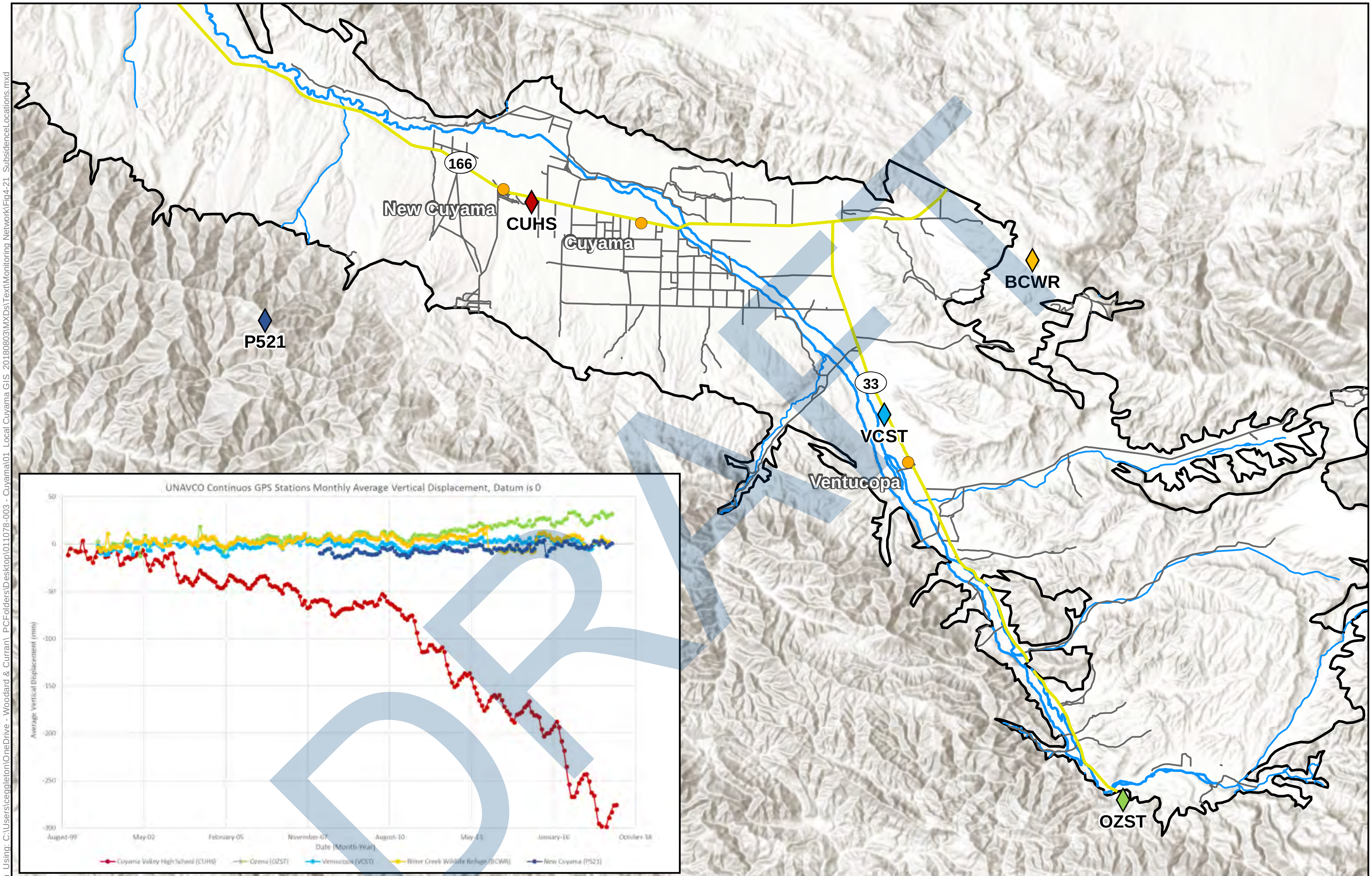

Figure 4-22: Currently Active Subsidence Monitoring Locations

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Figure Exported: 9/18/2018 By: ceggleton Using: C:\Users\ceggleton\OneDrive - Woodard & Curran_PCFolders\Desktop\011078-003 - Cuyama\01_Local Cuyama GIS_20180803\MXDs\Text\Monitoring Network\Fig4-21_SubsidenceLocations.mxd

4.9.5 Monitoring Protocols

DWR's provided *Monitoring Networks and Identification of Data Gaps BMP* does not provide specific monitoring protocols for subsidence monitoring networks. CGPS station measurements are logged digitally, and depending on the station and network setup, either require downloading at the physical station site or are uploaded automatically to a server. Data management will also depend on the monitoring agency. Current operating stations will continue to be managed by their current entity, and the CBGSA will be responsible for downloading data on a fixed schedule. The addition of new stations will require developing procedures for downloading and storing data, and for a quality assurance review of the data.

Data should be saved in the Cuyama Basin data management system on a regular annual schedule. All data should be reviewed for quality and logged appropriately.

4.9.6 Data Gaps

New subsidence monitoring sites should be chosen to provide data on areas most at risk for land subsidence. Six potential new locations were identified in the Basin, as shown in Figure 4-23. These locations were identified by focusing on areas with significant or new groundwater pumping that did not have subsidence monitoring nearby. Criteria for selection are as follows:

- Identified as an area with relatively new and increased agricultural activity and pumping with no nearby stations.
- Identified because there are currently no nearby stations and the Russell Fault bisects this area
- Identified because of the CCSD and proximity to the heavily pumped central portion of the Basin
- Identified because this is the most heavily pumped portion of the Basin and there are currently no nearby stations
- Identified because of its proximity to the heavily pumped portion of the Basin, on the north facing slop of the valley; additionally, there are currently no stations nearby
- Identified because this is the transition into the heavily pumped central portion of the Basin near current agricultural pumping; this is also an area with faults

4.9.7 Plan to Fill Data Gaps

New monitoring sites should be located near areas with the greatest groundwater pumping, or where pumping is new. This is because pumping is the driving force for subsidence in the Basin. Although there are multiple ways to measure subsidence, CGPS stations are likely the best option for the Basin. CGPS stations are relatively low cost when compared to gathering data via labor-intensive land surveys, construction of borehole extensometers, and frequent satellite data processing. CGPS stations require comparatively little maintenance and provide continuous information allowing detailed land subsidence analysis.

Increasing data collection about subsidence for the Basin requires addition of several new CGPS stations. These stations could be managed solely by the CBGSA, or could be incorporated into the Continuously Operating Reference Station (CORS) via coordination with USGS. Site selection, equipment, and management will require coordination with USGS.

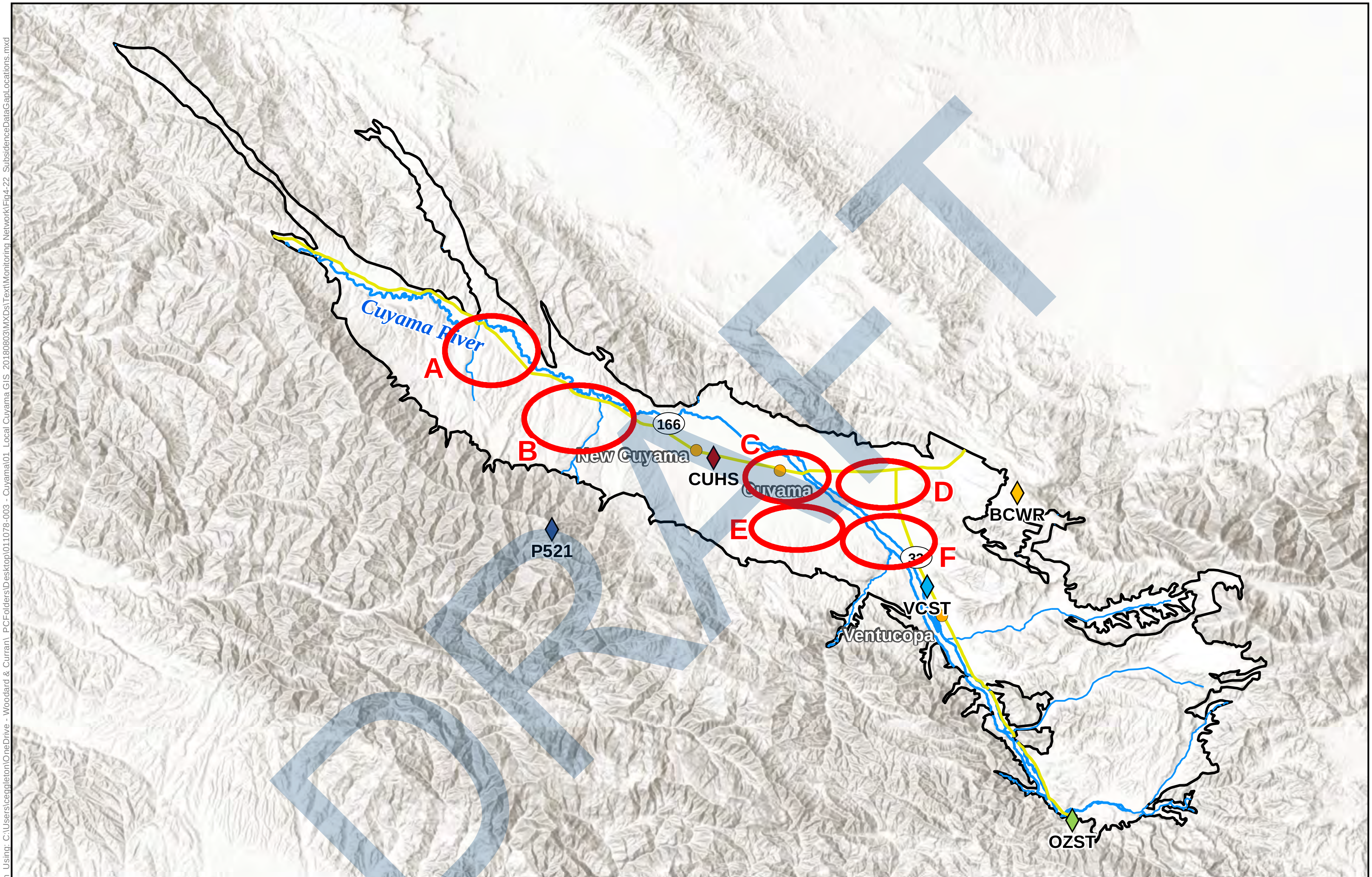

Figure 4-23: Subsidence Monitoring Location Data Gap Areas

Cuyama Basin Groundwater Sustainability Agency

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4.10 Depletions of Interconnected Surface Water Monitoring Network

DWR's emergency regulations Section 354.28 (c) (6) states that "The minimum threshold for depletions of interconnected surface water shall be the rate or volume of surface water depletions caused by groundwater use that has adverse impacts on beneficial uses of the surface water and may lead to undesirable results. The minimum threshold established for depletions of interconnected surface water shall be supported by the following: (A) The location, quantity, and timing of depletions of interconnected surface water, and (B) A description of the groundwater and surface water model used to quantify surface water depletion."

Since the emergency regulations require a numerical model to estimate the depletions of interconnected surface water, there is no functional monitoring network that can be used to measure depletions of interconnected surface water. Therefore, the monitoring networks for depletions of interconnected surface water will include two components as follows:

- Groundwater level monitoring to serve as monitoring by proxy of depletions of interconnected surface water
- Pursuit of additional surface water gage stations to improve numerical model accuracy

Because there are currently no operating stream gage stations on the Cuyama River in the Basin, the CBGSA is pursuing installation of three stream gages to assist in filling the data gap.

4.11 References

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Appendix A

DWR California Statewide Groundwater Elevation Monitoring (CASGEM) Program Procedures for Monitoring Entity Reporting

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California Statewide Groundwater Elevation Monitoring (CASGEM) Program

Procedures for Monitoring Entity Reporting

December 2010

Department of Water Resources (DWR) will use the internet as the primary communication tool to notify interested parties and groundwater Monitoring Entities of the status of the CASGEM program on an ongoing basis. Information will be posted at the following website: http://www.water.ca.gov/groundwater/casgem

In addition to the above-referenced website, DWR will distribute information via email. In order to be placed on the CASGEM contact list, please register your contact information at the following website: http://www.water.ca.gov/groundwater/casgem/register/

For questions about the Reporting Procedures, or other technical issues, please contact:

DWR Headquarters
Mary Scruggs
901 P Street
Sacramento, CA 95814
(916) 654-1324
mscruggs@water.ca.gov

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West Sacramento, CA 95691
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INTRODUCTION TO CASGEM PROGRAM

In November 2009 Part 2.11 (Groundwater Monitoring) was added to Division 6 of the Water Code by Senate Bill 6 (7th Extraordinary Session) (SB 6), a copy of which is included in the Appendix. (All statutory references in this document are to the Water Code.) The new law directs that groundwater elevations in all basins and subbasins in California be regularly and systematically monitored, preferably by local entities, with the goal of demonstrating seasonal and long-term trends in groundwater elevations. The Department of Water Resources (DWR) is directed to make the resulting information readily and widely available.

DWR developed the California Statewide Groundwater Elevation Monitoring (CASGEM) program in accordance with SB 6 to establish a permanent, locally-managed system to monitor groundwater elevation in California's alluvial groundwater basins and subbasins identified in DWR Bulletin 118. The CASGEM program will rely and build on the many, established local long-term groundwater monitoring and management programs. DWR's role is to coordinate information collected locally through the CASGEM program and to maintain the collected groundwater elevation data in a readily and widely available public database. DWR will also continue measuring its current network of groundwater monitoring wells as funding allows.

The goals of the CASGEM program are to:

- Establish procedures for notification and data reporting by prospective Monitoring Entities (this document)
- Verify local Monitoring Entities in accordance with the Water Code
- Develop an interface for local entities to enter data into a database compatible with DWR's Water Data Library
- Maintain the database and make it easily accessible to the public and local entities for use in water supply planning and management

If no local entities volunteer to monitor groundwater elevations in a basin or part of a basin, DWR may be required to develop a monitoring program for that part. If DWR takes over monitoring of a basin, certain entities in the basin may not be eligible for water grants or loans administered by the state.

During August and September 2010, DWR held 10 workshops throughout the state in cooperation with Association of California Water Agencies (ACWA) to introduce the CASGEM program and explain the purpose and process of the program to local agencies and stakeholders. A copy of the DWR presentation is available on the CASGEM website (http://www.water.ca.gov/groundwater/casgem). A summary of

Frequently Asked Questions (FAQs), primarily from the workshops, is provided in on the CASGEM website.

DWR's main role is to administer the CASGEM program through providing public outreach; creating and maintaining the CASGEM website and online data submittal system; and, supporting local entities through the process of becoming a Monitoring Entity and preparing Monitoring Plans. DWR will use the CASGEM website to provide up-to-date information on the program. The website will also be the access point for the online notification and data submittal systems.

Staff from the DWR regional offices will be available to assist potential Monitoring Entities with the online notification submittal process. After receiving notification from prospective Monitoring Entities, DWR will review them for completeness, verify the authority of the applying entity under Section 10927, and check for overlapping monitoring areas. DWR will advise each party on the status of their notification within three months of submittal and will work with entities to address any deficiencies in their submittals.

DWR encourages local agencies and groups to collaborate to determine who will serve as the Monitoring Entity for the area. However, if more than one party seeks to become the Monitoring Entity for the same area and overlapping monitoring area issues cannot be resolved locally, DWR will make a final determination of the Monitoring Entity for the area. DWR's determinations will consider the order in which entities are identified in Section 10927 and other factors as described in the Water Code.

DWR will post the selection of each Monitoring Entity and its monitoring area on the CASGEM website and will notify each Monitoring Entity in writing. A map-based interface will be available for users to identify the Monitoring Entity for each basin in the state.

DWR will prepare the first status report on the CASGEM program for the Governor and Legislature by January 1, 2012. In this initial report, DWR will report on the extent of groundwater elevation monitoring within each basin. This report will include a statewide prioritization of basins based on water supply, water demand, and other factors identified in Section 10933. DWR will explore options for basins without identified monitoring, with a focus on identifying options for local monitoring. Future status reports on the CASGEM program will be prepared by DWR in years ending in 5 or 0.

Purpose of Monitoring Entity Reporting Procedures

The purpose of these procedures is to introduce the CASGEM program and its components as the framework for implementing SB 6, with particular emphasis on the initial step of establishing Monitoring Entities for each Bulletin 118 basin in the state.

A summary of the requirements of local entities to comply with the CASGEM program is presented in Table 1.

Table 1. Quick Guide for Local Entities

- Determine whether you qualify as a potential Monitoring Entity (see "Requirements to become Monitoring Entity" on pages 9-13)
- Identify the basins within your area (see Bulletin 118)
- Collaborate with other local entities to identify and choose the prospective Monitoring Entity (or Entities) for your area
- Submit Monitoring Entity notification to DWR through CASGEM website (http://www.water.ca.gov/groundwater/casgem) on or before January 1, 2011
- DWR will review the notification and advise the prospective Monitoring Entity of the status of the notification within 3 months of submittal
- Work with staff of the DWR regional office to address any deficiencies in the submittal
- If more than one party seeks to become the Monitoring Entity for the same area, work with staff of the DWR regional office to resolve
- Check the CASGEM website for a listing of the selected Monitoring Entities
- Develop and submit a Monitoring Plan to DWR through the CASGEM website
- Staff from the DWR regional office are available to assist with the Monitoring Plan and to recommend changes
- Submit monitoring data to DWR through the CASGEM website on or before January 1, 2012

CASGEM SCHEDULE

<table>
<tr><th colspan="2">CASGEM Schedule</th><th colspan="2">DWR Activities</th><th>Local Entity Activities</th></tr>
<tr><td rowspan="3">2010</td><td>July-September</td><td colspan="2">ACWA/DWR Workshops</td><td rowspan="2">Collaborate to identify prospective Monitoring Entities</td></tr>
<tr><td rowspan="2">October-December</td><td colspan="2">•Draft Procedures and Guidelines
•Solicit Comments
•Finalize Procedures and Guidelines</td></tr>
<tr><td colspan="2">Notification System ready online</td><td>Prospective Monitoring Entities submit notifications to DWR</td></tr>
<tr><td rowspan="5">2011</td><td>January 1, 2011</td><td rowspan="4">Review and designation of Monitoring Entities</td><td rowspan="4">Review Monitoring Plans and provide recommendations</td><td>Monitoring Entity notifications due to DWR on or before 1/1/2011</td></tr>
<tr><td>January-March</td><td rowspan="2">Monitoring Entities develop and submit Monitoring Plans to DWR</td></tr>
<tr><td>April-June</td></tr>
<tr><td>July-September</td><td rowspan="2">Groundwater elevation monitoring begins and continues</td></tr>
<tr><td>October-December</td><td colspan="2">Preparation of first CASGEM status report</td></tr>
<tr><td>2012</td><td>January 1, 2012</td><td colspan="2">DWR submits first CASGEM status report to Governor and Legislature</td><td>First CASGEM data submittals due to DWR on or before 1/1/2012</td></tr>
</table>

A timetable for implementing the CASGEM schedule is shown above.

MONITORING ENTITIES

The CASGEM program establishes the framework for collaboration between local monitoring parties and DWR to collect groundwater elevation data throughout the state's 515 basins as defined in Bulletin 118. A Monitoring Entity is a local agency or group that voluntarily takes responsibility for conducting or coordinating groundwater elevation monitoring and reporting for all or part of a groundwater basin.

To determine if you are within a Bulletin 118 basin, please refer to maps and descriptions in Bulletin 118, available online at: http://www.water.ca.gov/groundwater/bulletin118/gwbasin_maps_descriptions.cfm. Geographic Information System (GIS) shapefiles of the basins are also available at this website. DWR can assist in identifying other potential local monitoring parties in each basin.

ROLES AND RESPONSIBILITIES OF MONITORING ENTITIES

Through the CASGEM program, local entities with appropriate authority may notify DWR of their intent to be a Monitoring Entity. Monitoring Entities will have specific responsibilities, including:

- Coordinate with DWR to establish a Monitoring Plan
- Conduct or coordinate the regular and systematic monitoring of groundwater elevations as specified in the Monitoring Plan
- Submit monitoring data to DWR in a timely manner

A Monitoring Entity can perform monitoring for any number of basins or portions thereof, but no area can have more than one Monitoring Entity. While the Monitoring Entity is responsible for compiling the data and submitting it to DWR for a particular area, the actual measurements can be taken by any number of agencies that would work under the direction of the Monitoring Entity. (Cooperating agencies would submit data to the Monitoring Entity, not to DWR.) Thus, assuming there are no overlapping areas or gaps in basin coverage for a given area, there are three possible basic scenarios, illustrated in Figure 1:

- A single Monitoring Entity that collects and reports groundwater elevation data for the entire basin (Scenario A);
- Multiple Monitoring Entities that collect and report groundwater elevation data for their portion of the basin (Scenario B); or

- An umbrella Monitoring Entity that coordinates and reports groundwater elevation data collected by multiple agencies within the basin (Scenario C).

Scenario A. One Monitoring Entity collects and reports data for entire basin

Scenario B. One basin, several Monitoring Entities collecting and submitting data

Scenario C. One basin, one Monitoring Entity coordinating and submitting data collected by several agencies

Figure 1. Illustration of possible Monitoring Entity scenarios for a monitored basin.

DWR currently monitors water elevations in about 4,000 wells statewide and cooperates with local and federal agencies to monitor roughly an additional 6,000 wells. DWR plans to continue monitoring groundwater elevations, contingent upon available funding. In some basins DWR currently does most, if not all, of the water-elevation monitoring. In these basins, a local entity still needs to notify DWR of their intent to become the Monitoring Entity. The Monitoring Entity must determine which DWR wells will be included in their CASGEM monitoring network. As long as DWR continues its monitoring program, the department will transmit its groundwater elevation data to the CASGEM system. However, if DWR is unable to continue monitoring for any reason, the Monitoring Entity will be required to re-evaluate its monitoring network to determine which wells to retain in its monitoring network.

REQUIREMENTS TO BECOME MONITORING ENTITY

Section 10927 of the Water Code defines the types of entities that may assume responsibility for monitoring and reporting groundwater elevations as part of the CASGEM program.

A summary list of eligible entities, in order of priority, and notification requirements for each entity is provided below:

1. A **watermaster or water management engineer** appointed by a court or pursuant to statute to administer a final judgment determining rights to groundwater [Section 10927(a)].
   Notification Requirements:
   - Name of Agency
   - Agency Contact Name
   - Address
   - Telephone Number
   - Email Address
   - Any other relevant contact information
   - Authority (as listed in Section 10927)
   - Name and number of basin to be monitored (from Bulletin 118)
   - Map and shapefile showing area to be monitored (Shapefiles do not need to be submitted by the initial January 1, 2011 notification date; Regional Offices can provide assistance to potential Monitoring Entities with shapefiles.)
   - Statement that the entity will comply with the requirements of Water Code Part 2.11
   - Additional information deemed necessary by DWR to identify monitoring area or qualifications of the Monitoring Entity

2. A **groundwater management agency** with statutory authority to manage groundwater pursuant to its principal act that is monitoring groundwater elevations in all or a part of a groundwater basin on or before January 1, 2010 [Section 10927(b)(1)].
   Notification Requirements:
   - Name of Agency
   - Agency Contact Name
   - Address
   - Telephone Number
   - Email Address
   - Any other relevant contact information
   - Authority (as listed in Section 10927)

- Name and number of basin to be monitored (from Bulletin 118)
- Map and shapefile showing area to be monitored (Shapefiles do not need to be submitted by the initial January 1, 2011 notification date; Regional Offices can provide assistance to potential Monitoring Entities with shapefiles.)
- Statement that the entity will comply with the requirements of Water Code Part 2.11
- Additional information deemed necessary by DWR to identify monitoring area or qualifications of the Monitoring Entity

3. A **water replenishment district** established pursuant to Water Code Division 18 (commencing with Section 60000). This part does not expand or otherwise affect the authority of a water replenishment district relating to monitoring elevations [Section 10927(b)(2)].

   Notification Requirements:

   - Name of Agency
   - Agency Contact Name
   - Address
   - Telephone Number
   - Email Address
   - Any other relevant contact information
   - Authority (as listed in Section 10927)
   - Name and number of basin to be monitored (from Bulletin 118)
   - Map and shapefile showing area to be monitored (Shapefiles do not need to be submitted by the initial January 1, 2011 notification date; Regional Offices can provide assistance to potential Monitoring Entities with shapefiles.)
   - Statement that the entity will comply with the requirements of Water Code Part 2.11
   - Additional information deemed necessary by DWR to identify monitoring area or qualifications of the Monitoring Entity

4. A **local agency that is managing all or part of a groundwater basin pursuant to Water Code Part 2.75** (commencing with Section 10750) and that was monitoring groundwater elevations in all or part of a groundwater basin on or before January 1, 2010, or a local agency or county that is managing all or part of a groundwater basin pursuant to any other legally enforceable groundwater management plan with provisions that are substantively similar to those described in that part and that was monitoring groundwater elevations in all or a part of a groundwater basin on or before January 1, 2010 [Section 10927(c)].

Notification Requirements:

- Name of Agency
- Agency Contact Name
- Address
- Telephone Number
- Email Address
- Any other relevant contact information
- Authority (as listed in Section 10927)
- Name and number of basin to be monitored (from Bulletin 118)
- Map and shapefile showing area to be monitored (Shapefiles do not need to be submitted by the initial January 1, 2011 notification date; Regional Offices can provide assistance to potential Monitoring Entities with shapefiles.)
- Statement that the entity will comply with the requirements of Water Code Part 2.11
- Copy of current groundwater management plan
- Statement describing the ability or qualifications of the entity to conduct the groundwater monitoring functions required
- Additional information deemed necessary by DWR to identify monitoring area or qualifications of the Monitoring Entity

5. A **local agency that is managing all or part of a groundwater basin pursuant to an integrated regional water management plan** prepared pursuant to Water Code Part 2.2 (commencing with Section 10530) that includes a groundwater management component that complies with the requirements of Section 10753.7 [Section 10927(d)].

Notification Requirements:

- Name of Agency
- Agency Contact Name
- Address
- Telephone Number
- Email Address
- Any other relevant contact information
- Authority (as listed in Section 10927)
- Name and number of basin to be monitored (from Bulletin 118)
- Map and shapefile showing area to be monitored (Shapefiles do not need to be submitted by the initial January 1, 2011 notification date; Regional Offices can provide assistance to potential Monitoring Entities with shapefiles.)
- Statement that the entity will comply with the requirements of Water Code Part 2.11
- Copy of current groundwater component of integrated regional water management plan
- Statement describing the ability or qualifications of the entity to conduct the groundwater monitoring functions required

- Additional information deemed necessary by DWR to identify monitoring area or qualifications of the Monitoring Entity

6. A **county** that is not managing all or a part of a groundwater basin pursuant to a legally enforceable groundwater management plan with provisions that are substantively similar to those described in Water Code Part 2.75 (commencing with Section 10750) [Section 10927(e)].
   Notification Requirements:
   - Name of County
   - County Contact Name
   - Address
   - Telephone Number
   - Email Address
   - Any other relevant contact information
   - Authority (as listed in Section 10927)
   - Name and number of basin to be monitored (from Bulletin 118)
   - Map and shapefile showing area to be monitored (Shapefiles do not need to be submitted by the initial January 1, 2011 notification date; Regional Offices can provide assistance to potential Monitoring Entities with shapefiles.)
   - Statement that the entity will comply with the requirements of Water Code Part 2.11
   - Statement describing the ability or qualifications of the entity to conduct the groundwater monitoring functions required
   - Additional information deemed necessary by DWR to identify monitoring area or qualifications of the Monitoring Entity

7. A **voluntary cooperative groundwater monitoring association** formed pursuant to Section 10935 [Section 10927(f)]. As described in the Water Code Section 10935, the voluntary associations may be established by contract, a joint powers agreement, a memorandum of agreement, or other form of agreement deemed acceptable by DWR, so long as it contains: the names of the participants; the boundaries of the area covered by the agreement; the name or names of the parties responsible for meeting the requirements; the method of recovering the costs associated with meeting the requirements; and other provisions that may be required by DWR. Entities seeking to form a voluntary association should notify DWR, which will work cooperatively with the interested parties to facilitate the formation of the association.

Notification Requirements:

- Name of Association
- Association Contact Name
- Address
- Telephone Number
- Email Address
- Any other relevant contact information
- Authority (as listed in Section 10927)
- Name and number of basin to be monitored (from Bulletin 118)
- Map and shapefile showing area to be monitored (Shapefiles do not need to be submitted by the initial January 1, 2011 notification date; Regional Offices can provide assistance to potential Monitoring Entities with shapefiles.)
- Statement that the entity will comply with the requirements of Water Code Part 2.11
- Statement describing the ability or qualifications of the entity to conduct the groundwater monitoring functions required
- Statement of intent to meet the association formation requirements described in Section 10935
- Additional information deemed necessary by DWR to identify monitoring area or qualifications of the Monitoring Entity

Local agencies are encouraged to coordinate among themselves to determine the proposed Monitoring Entity or Entities that best suits their area. The resulting interested entity (or entities) should notify DWR of its intent to become a groundwater Monitoring Entity for one or more basins, or portions thereof by the January 1, 2011 deadline. Certain basic information is required for notification, including contact information and additional details depending on the authority of the entity desiring to monitor groundwater (Section 10928), as listed above. This notification information will be submitted to DWR using an online system that will be available by mid-December 2010.

MONITORING PLANS

Monitoring Entities will each develop a Monitoring Plan that includes the following sections: Monitoring Sites and Timing, Field Methods, and Data Reporting. Monitoring Plans should be completed and submitted to DWR by summer 2011. Staff from the DWR regional offices will be available to assist Monitoring Entities with the development of Monitoring Plans, if needed. In determining what information should be reported to DWR, the department will defer to existing monitoring programs if those programs result in information that demonstrates seasonal (annual high and low groundwater elevations) and long-term trends in groundwater elevations. Staff from the DWR regional offices will assist Monitoring Entities to address any gaps in basin coverage (see below) and other monitoring issues and may make recommendations for the location of additional wells. However, the department has no authority to require a Monitoring Entity to install additional wells unless funds are provided for that purpose. Once a Monitoring Plan is established with DWR, Monitoring Entities should notify DWR of any changes to the plan.

Key Components of Monitoring Plans

Submit to DWR by summer 2011

- Monitoring Sites and Timing
  - Well Network Design
  - Selected wells (current)
  - Planned (future) wells
  - Frequency to capture seasonal highs and lows
  - Map and shapefile of monitoring area and well locations

Field Methods for groundwater monitoring

- Methods for measuring
  - Reference Point
  - Static water level
  - Depth to water
  - Standardized form for data collection

Data Reporting

- Online data submittal, minimum July & January each year

DATA GAPS

A data gap refers to a basin or portion of a basin that is not included in any of the Monitoring Plans submitted to DWR. This is essentially an area that lacks the density of monitoring wells that would allow seasonal and long-term trends in groundwater elevations to be determined for the basin, subbasin, or a portion thereof. Among the 515 basins defined by Bulletin 118, data gaps may exist for a variety of reasons, including a lack of suitable monitoring wells, lack of groundwater use, access issues, and jurisdictional issues, among others.

If no local entity is able and/or willing to fill a data gap, the department may be required to perform groundwater monitoring functions. If DWR performs this monitoring, local agencies and the county that have the authority under Section 10927 to monitor the area of the data gap would be potentially ineligible for a water grant or loan awarded or administered by the state. The Monitoring Entity or entities with the authority to monitor the area of the data gap should provide detailed information regarding the nature of and reason for the data gap so that DWR may include such information in the prioritization of groundwater basins and subbasins as appropriate.

Agencies and counties that are eligible to be designated Monitoring Entities but choose not participate in the CASGEM program will not lose their state water grant and loan eligibility if their entire service area qualifies as a disadvantaged community (Water Code Section 10933.7(b)). It will be the responsibility of the local agency or county applying for a state water grant or loan to demonstrate their disadvantaged community status at the time they are applying for the grant or loan.

MONITORING SITES AND TIMING

The Monitoring Plan will identify the wells to be monitored and the frequency with which they will be monitored. The Monitoring Plan should explain how proposed monitoring will be sufficient to demonstrate the seasonal and long-term groundwater elevation trends in the monitored area. The density of monitoring locations will depend on the complexity of the basin.

Because of security concerns, the California Department of Public Health (DPH) routinely limits the disclosure of detailed public water supply well location information. Pursuant to Water Code Section 10931, the DWR is required to collaborate with DPH to ensure that the information reported to the CASGEM program will not result in the inappropriate disclosure of information of concern to DPH. At this time, DWR has reached no agreement with DPH regarding the appropriate treatment of public water supply well data. As a result, CASGEM does not currently plan to use such well information in its database.

The Monitoring Plan should contain a table identifying the wells to be monitored and the timing of that monitoring. Because the law specifies that information should demonstrate seasonal and long-term trends in groundwater elevations, at a minimum monitoring should be conducted at each location for the yearly high and low for the basin. The yearly high and low groundwater elevations typically occur in spring and fall, but this may vary from basin to basin. It is very important that the timing of all the measurements in the basin is coordinated. Rationale for selection of the timing (seasonal highs and lows) should be included in the Monitoring Plan.

The information on the monitoring sites and timing to be submitted in the online system should include:

- Well identification number
- State well number
- Location (decimal latitude and longitude, North American Datum (NAD) 83)
- Reference point elevation (feet, North American Vertical Datum (NAVD) 88)
- Land surface datum (feet, NAVD88)
- Map and shapefile with monitoring locations, Bulletin 118 groundwater basin boundary, and boundary of monitoring area
- Frequency and timing of measurements

FIELD METHODS

The consistent and documented collection of groundwater elevation data is important for ensuring that the data can be used across the state, regardless of the Monitoring Entity. The field methods should meet a common set of basic requirements; however, the methods do not have to be exactly the same. Many entities already have in place monitoring efforts that are successful in meeting local needs and that can meet the needs for this program, either as-is or with the incorporation of individual components. The CASGEM program wishes to maintain, to the greatest extent possible, the procedures of high-quality local groundwater elevation monitoring programs, so long as they meet the overall program goals and policies. Of particular concern are the following basic requirements:

- Method(s) to establish the Reference Point, including step-by-step instructions
- Method(s) to ensure static groundwater elevation
- Method(s) to measure depth to water, including step-by-step instructions
- Method(s) and form(s) for recording measurements

It is the responsibility of each Monitoring Entity to develop and implement monitoring protocols that are appropriate to local groundwater basin conditions, protect the water quality of its monitoring wells, and maintain the quality of the data that it submits to the CASGEM Program. DWR has developed field guidelines (Department of Water Resources Groundwater Elevation Monitoring Guidelines) based on a review of existing field methods from DWR and other organizations, which is available on the CASGEM website. Monitoring Entities are welcome to refer to these guidelines when developing field methods for their own Monitoring Plans. However, the DWR guidelines are for internal use in the event that the Department is required to perform groundwater monitoring functions pursuant to Section 10933.5 and are not binding on any other agency. The core of the CASGEM program will rely and build on the many, established local long-term groundwater monitoring and management programs. The department will defer to existing monitoring programs that result in information that demonstrates seasonal and long-term trends in groundwater elevations.

DATA REPORTING

DWR will develop an online data submittal system for Monitoring Entities to submit their groundwater elevation data. Several methods of submitting data will be available, such as direct online data entry, or upload of data files for batch entry. Initial groundwater elevation data should be submitted to DWR by January 1, 2012. Thereafter, data should be submitted as soon as possible after collection, but no later than January 1st and July 1st of each year, at the minimum. Historical data can also be submitted via the DWR data system to aid in data interpretation. All submitted data will be available to the public, except for confidential data.

Each groundwater elevation data measurement submitted to the online system should include:

- Well identification number
- Measurement date
- Reference point and land surface elevation
- Depth to water
- Method of measuring water depth
- Measurement quality codes

The Monitoring Entity information, well information, and groundwater elevation information is to be provided by the Monitoring Entity. Items labeled as required must be submitted to DWR to report groundwater elevations. Items labeled as recommended should be submitted to DWR if they are available, as they assist in fully evaluating the quality of measurements. DWR will provide standard form(s) for Monitoring Entities to submit groundwater elevation data online. However, if Monitoring Entities cannot use the standard form(s) or provide the data elements listed below, DWR will work cooperatively with Monitoring Entities to develop alternate methods of submitting data.

Entity Information

All entities assuming groundwater monitoring functions as delineated in Section 10927 (a)-(f) are required to submit the following information:

- Monitoring Entity's name, address, telephone number, contact person name and email address, and any other relevant contact information (Section 10928 (a) (1), 10928 (b) (1))
- Name, address, telephone number, email address and any other relevant contact information for entities collecting data that is submitted by a designated submitting entity (Monitoring Entity)
- Groundwater basins being monitored
    - Identify entire basins monitored
    - Identify partial basins monitored

Well Information

The following information about each well is required for the CASGEM online system:

- Unique well identification number. Agencies may use an existing State Well Number, an existing local well designation, or develop their own identification name, using the following protocol:
    - Agency name, abbreviation, or acronym followed by a sequential number (e.g., SGA 01)
    - Groundwater basin – followed by a sequential number (e.g., Llagas 03)
    - Geographic name – followed by a sequential number (e.g., Yolo 12)
    - Well names should be 15 characters long or less
    - Avoid using owner/business names or specific locational information for privacy and security
- Decimal latitude/longitude coordinates of well, using horizontal datum NAD83, and the method of determining coordinates (Actual coordinates are preferred; however, Monitoring Entities may submit approximate locations, as needed, to protect the privacy of well owners. For example, to protect the privacy of a well owner, a Monitoring Entity may submit well coordinate locations that are only within 1000-feet of the actual well location.)
- Groundwater basin or sub-basin
- Reference point elevation of the well (feet) using NAVD88 vertical datum
- Elevation of land surface datum at the well (feet) using NAVD88 vertical datum
- Use of well (e.g., dedicated monitoring, irrigation, domestic, etc)
- Well completion type (e.g. single well, nested, or multi-completion wells)
- Depth of screened interval(s) and total well depth of well, if available (feet)
- Well Completion Report number (DWR Form 188), if available

The following information about each well is recommended for the CASGEM online system:

- State Well Number – assigned by DWR in most cases
- Method by which land surface elevation was determined (for example, topographic map, GPS, etc.)
- Written description of location of well, including distance from nearby landmarks and location of reference point in relation to well appurtenances (DWR Form 429)
- Well information comments

Groundwater Elevation Information

The following information for each groundwater elevation measurement is required for the CASGEM online system:

- Well identification number (see Well Information, above)
- Measurement date
- Reference point elevation of the well (feet) using NAVD88 vertical datum
- Elevation of land surface datum at the well (feet) using NAVD88 vertical datum
- Depth to water below reference point (feet) (unless no measurement was taken)
- Method of measuring water depth
- Measurement Quality Codes

- If no measurement is taken, a specified "no measurement" code, must be recorded. Standard codes will be provided by the online system. If a measurement is taken, a "no measurement" code is not recorded.)
- If the quality of a measurement is uncertain, a "questionable measurement" code can be recorded. Standard codes will be provided by the online system. If no measurement is taken, a "questionable measurement" code is not recorded.)

* Measuring agency identification

The following information for each groundwater elevation measurement is recommended for the CASGEM online system:

* Measurement time (PST/PDT with military time/24 hour format)
* Comments about measurement, if applicable

Groundwater elevation data shall be submitted electronically to DWR's online system. DWR will develop electronic data transmittal (EDT) alternatives and data standards to permit bulk data transfer and assist Monitoring Entities in EDT reporting to DWR. As stated above, if Monitoring Entities cannot use the standard form(s) or provide the necessary groundwater elevation data elements, DWR will work cooperatively with Monitoring Entities to develop alternate methods of submitting data.

The CASGEM online data submittal system will be compatible with the Water Data Library (WDL) (http://www.water.ca.gov/waterdatalibrary/), DWR's existing groundwater elevation database. The CASGEM system will include data reporting options similar to those in WDL, such as hydrographs, seasonal contour data, and data downloads. The combined accessibility of the WDL and the CASGEM system will be a significant resource for local agencies in making sound groundwater management decisions.

REFERENCES

California Departement of Water Resources. (2003). *California's Groundwater, Bulletin 118-03.*

California Department of Water Resources. (2009). *California Water Plan Update 2009, Bulletin 160-09.*

APPENDIX – SENATE BILL 6 (7TH EXTRAORDINARY SESSION) - GROUNDWATER MONITORING

Senate Bill No. 6

CHAPTER 1

An act to add Part 2.11 (commencing with Section 10920) to Division 6 of, and to repeal and add Section 12924 of, the Water Code, relating to groundwater.

[Approved by Governor November 6, 2009. Filed with Secretary of State November 6, 2009.]

Legislative Counsel's Digest

SB 6, Steinberg. Groundwater.

(1) Existing law authorizes a local agency whose service area includes a groundwater basin that is not subject to groundwater management to adopt and implement a groundwater management plan pursuant to certain provisions of law. Existing law requires a groundwater management plan to include certain components to qualify as a plan for the purposes of those provisions, including a provision that establishes funding requirements for the construction of certain groundwater projects.

This bill would establish a groundwater monitoring program pursuant to which specified entities, in accordance with prescribed procedures, may propose to be designated by the Department of Water Resources as groundwater monitoring entities, as defined, for the purposes of monitoring and reporting with regard to groundwater elevations in all or part of a basin or subbasin, as defined. The bill would require the department to work cooperatively with each monitoring entity to determine the manner in which groundwater elevation information should be reported to the department. The bill would authorize the department to make recommendations for improving an existing monitoring program, and to require additional monitoring wells under certain circumstances. Under certain circumstances, the department would be required to perform groundwater monitoring functions. In that event, prescribed entities with authority to assume groundwater monitoring functions with regard to a basin or subbasin for which the department has assumed those functions would not be eligible for a water grant or loan awarded or administered by the state.

(2) Existing law requires the department to conduct an investigation of the state's groundwater basins and to report its findings to the Governor and the Legislature not later than January 1, 1980.

This bill would repeal that provision. The department would be required to conduct an investigation of the state's groundwater basins and to report its findings to the Governor and the Legislature not later than January 1, 2012, and thereafter in years ending in 5 or 0.

(3) The bill would take effect only if SB 1 and SB 7 of the 2009–10 7th Extraordinary Session of the Legislature are enacted and become effective.

The people of the State of California do enact as follows:

SECTION 1. Part 2.11 (commencing with Section 10920) is added to Division 6 of the Water Code, to read:

PART 2.11. GROUNDWATER MONITORING

Chapter 1. General Provisions

10920. (a) It is the intent of the Legislature that on or before January 1, 2012, groundwater elevations in all groundwater basins and subbasins be regularly and systematically monitored locally and that the resulting groundwater information be made readily and widely available.

(b) It is further the intent of the Legislature that the department continue to maintain its current network of monitoring wells, including groundwater elevation and groundwater quality monitoring wells, and that the department continue to coordinate monitoring with local entities.

10921. This part does not require the monitoring of groundwater elevations in an area that is not within a basin or subbasin.

10922. This part does not expand or otherwise affect the powers or duties of the department relating to groundwater beyond those expressly granted by this part.

Chapter 2. Definitions

10925. Unless the context otherwise requires, the definitions set forth in this section govern the construction of this part.

(a) “Basin” or “subbasin” means a groundwater basin or subbasin identified and defined in the department’s Bulletin No. 118.

(b) “Bulletin No. 118” means the department’s report entitled “California’s Groundwater: Bulletin 118” updated in 2003, or as it may be subsequently updated or revised in accordance with Section 12924.

(c) “Monitoring entity” means a party conducting or coordinating the monitoring of groundwater elevations pursuant to this part.

(d) “Monitoring functions” and “groundwater monitoring functions” means the monitoring of groundwater elevations, the reporting of those elevations to the department, and other related actions required by this part.

(e) “Monitoring groundwater elevations” means monitoring groundwater elevations, coordinating the monitoring of groundwater elevations, or both.

(f) “Voluntary cooperative groundwater monitoring association” means an association formed for the purposes of monitoring groundwater elevations pursuant to Section 10935.

Chapter 3. Groundwater Monitoring Program

10927. Any of the following entities may assume responsibility for monitoring and reporting groundwater elevations in all or a part of a basin or subbasin in accordance with this part:

(a) A watermaster or water management engineer appointed by a court or pursuant to statute to administer a final judgment determining rights to groundwater.

(b) (1) A groundwater management agency with statutory authority to manage groundwater pursuant to its principal act that is monitoring groundwater elevations in all or a part of a groundwater basin or subbasin on or before January 1, 2010.

(2) A water replenishment district established pursuant to Division 18 (commencing with Section 60000). This part does not expand or otherwise affect the authority of a water replenishment district relating to monitoring groundwater elevations.

(c) A local agency that is managing all or part of a groundwater basin or subbasin pursuant to Part 2.75 (commencing with Section 10750) and that was monitoring groundwater elevations in all or a part of a groundwater basin or subbasin on or before January 1, 2010, or a local agency or county that is managing all or part of a groundwater basin or subbasin pursuant to any other legally enforceable groundwater management plan with provisions that are substantively similar to those described in that part and that was monitoring groundwater elevations in all or a part of a groundwater basin or subbasin on or before January 1, 2010.

(d) A local agency that is managing all or part of a groundwater basin or subbasin pursuant to an integrated regional water management plan prepared pursuant to Part 2.2 (commencing with Section 10530) that includes a groundwater management component that complies with the requirements of Section 10753.7.

(e) A county that is not managing all or a part of a groundwater basin or subbasin pursuant to a legally enforceable groundwater management plan with provisions that are substantively similar to those described in Part 2.75 (commencing with Section 10750).

(f) A voluntary cooperative groundwater monitoring association formed pursuant to Section 10935.

10928. (a) Any entity described in subdivision (a) or (b) of Section 10927 that seeks to assume groundwater monitoring functions in accordance with this part shall notify the department, in writing, on or before January 1, 2011. The notification shall include all of the following information:

(1) The entity's name, address, telephone number, and any other relevant contact information.

(2) The specific authority described in Section 10927 pursuant to which the entity qualifies to assume the groundwater monitoring functions.

(3) A map showing the area for which the entity is requesting to perform the groundwater monitoring functions.

(4) A statement that the entity will comply with all of the requirements of this part.

(b) Any entity described in subdivision (c), (d), (e), or (f) of Section 10927 that seeks to assume groundwater monitoring functions in accordance with this part shall notify the department, in writing, by January 1, 2011. The information provided in the notification shall include all of the following:

(1) The entity's name, address, telephone number, and any other relevant contact information.

(2) The specific authority described in Section 10927 pursuant to which the entity qualifies to assume the groundwater monitoring functions.

(3) For entities that seek to qualify pursuant to subdivision (c) or (d) of Section 10927, the notification shall also include a copy of the current groundwater management plan or the groundwater component of the integrated regional water management plan, as appropriate.

(4) For entities that seek to qualify pursuant to subdivision (f) of Section 10927, the notification shall include a statement of intention to meet the requirements of Section 10935.

(5) A map showing the area for which the entity is proposing to perform the groundwater monitoring functions.

(6) A statement that the entity will comply with all of the requirements of this part.

(7) A statement describing the ability and qualifications of the entity to conduct the groundwater monitoring functions required by this part.
(c) The department may request additional information that it deems necessary for the purposes of determining the area that is proposed to be monitored or the qualifications of the entity to perform the groundwater monitoring functions.

10929. (a) (1) The department shall review all notifications received pursuant to Section 10928.

(2) Upon the receipt of a notification pursuant to subdivision (a) of Section 10928, the department shall verify that the notifying entity has the appropriate authority under subdivision (a) or (b) of Section 10927.

(3) Upon the receipt of a notification pursuant to subdivision (b) of Section 10928, the department shall do both of the following:

(A) Verify that each notification is complete.

(B) Assess the qualifications of the notifying party.

(b) If the department has questions about the completeness or accuracy of a notification, or the qualifications of a party, the department shall contact the party to resolve any deficiencies. If the department is unable to resolve the deficiencies, the department shall notify the party in writing that the notification will not be considered further until the deficiencies are corrected.

(c) If the department determines that more than one party seeks to become the monitoring entity for the same portion of a basin or subbasin, the department shall consult with the interested parties to determine which party will perform the monitoring functions. In determining which party will perform the monitoring functions under this part, the department shall follow the order in which entities are identified in Section 10927.

(d) The department shall advise each party on the status of its notification within three months of receiving the notification.

10930. Upon completion of each review pursuant to Section 10929, the department shall do both of the following if it determines that a party will perform monitoring functions under this part:

(a) Notify the party in writing that it is a monitoring entity and the specific portion of the basin or subbasin for which it shall assume groundwater monitoring functions.

(b) Post on the department's Internet Web site information that identifies the monitoring entity and the portion of the basin or subbasin for which the monitoring entity will be responsible.

10931. (a) The department shall work cooperatively with each monitoring entity to determine the manner in which groundwater elevation information should be reported to the department pursuant to this part. In determining what information should be reported to the department, the department shall defer to existing monitoring programs if those programs result in information that demonstrates seasonal and long-term trends in groundwater elevations. The department shall collaborate with the State Department of Public Health to ensure that the information reported to the department will not result in the inappropriate disclosure of the physical address or geographical location of drinking water sources, storage facilities, pumping operational data, or treatment facilities.

(b) (1) For the purposes of this part, the department may recommend improvements to an existing monitoring program, including recommendations for additional monitoring wells.

(2) The department may not require additional monitoring wells unless funds are provided for that purpose.

10932. Monitoring entities shall commence monitoring and reporting groundwater elevations pursuant to this part on or before January 1, 2012.

10933. (a) On or before January 1, 2012, the department shall commence to identify the extent of monitoring of groundwater elevations that is being undertaken within each basin and subbasin.

(b) The department shall prioritize groundwater basins and subbasins for the purpose of implementing this section. In prioritizing the basins and subbasins, the department shall, to the extent data are available, consider all of the following:

(1) The population overlying the basin or subbasin.

(2) The rate of current and projected growth of the population overlying the basin or subbasin.

(3) The number of public supply wells that draw from the basin or subbasin.

(4) The total number of wells that draw from the basin or subbasin.

(5) The irrigated acreage overlying the basin or subbasin.

(6) The degree to which persons overlying the basin or subbasin rely on groundwater as their primary source of water.

(7) Any documented impacts on the groundwater within the basin or subbasin, including overdraft, subsidence, saline intrusion, and other water quality degradation.

(8) Any other information determined to be relevant by the department.

(c) If the department determines that all or part of a basin or subbasin is not being monitored pursuant to this part, the department shall do all of the following:

(1) Attempt to contact all well owners within the area not being monitored.

(2) Determine if there is an interest in establishing any of the following:

(A) A groundwater management plan pursuant to Part 2.75 (commencing with Section 10750).

(B) An integrated regional water management plan pursuant to Part 2.2 (commencing with Section 10530) that includes a groundwater management component that complies with the requirements of Section 10753.7.

(C) A voluntary groundwater monitoring association pursuant to Section 10935.

(d) If the department determines that there is sufficient interest in establishing a plan or association described in paragraph (2) of subdivision (c), or if the county agrees to perform the groundwater monitoring functions in accordance with this part, the department shall work cooperatively with the interested parties to comply with the requirements of this part within two years.

(e) If the department determines, with regard to a basin or subbasin, that there is insufficient interest in establishing a plan or association described in paragraph (2) of subdivision (c), and if the county decides not to perform the groundwater monitoring and reporting functions of this part, the department shall do all of the following:

(1) Identify any existing monitoring wells that overlie the basin or subbasin that are owned or operated by the department or any other state or federal agency.

(2) Determine whether the monitoring wells identified pursuant to paragraph (1) provide sufficient information to demonstrate seasonal and long-term trends in groundwater elevations.

(3) If the department determines that the monitoring wells identified pursuant to paragraph (1) provide sufficient information to demonstrate seasonal and long-term trends in groundwater elevations, the department shall not perform groundwater monitoring functions pursuant to Section 10934.

(4) If the department determines that the monitoring wells identified pursuant to paragraph (1) provide insufficient information to demonstrate seasonal and long-term trends in groundwater elevations, and the State Mining and Geology Board concurs with

that determination, the department shall perform groundwater monitoring functions pursuant to Section 10934.[1]

10933.5. (a) Consistent with Section 10933, the department shall perform the groundwater monitoring functions for those portions of a basin or subbasin for which no monitoring entity has agreed to perform the groundwater monitoring functions.

(b) Upon determining that it is required to perform groundwater monitoring functions, the department shall notify both of the following entities that it is forming the groundwater monitoring district:

(1) Each well owner within the affected area.

(2) Each county that contains all or a part of the affected area.

(c) The department shall not assess a fee or charge to recover the costs for carrying out its power and duties under this part.

(d) The department may establish regulations to implement this section.

10933.7. (a) If the department is required to perform groundwater monitoring functions pursuant to Section 10933.5, the county and the entities described in subdivisions (a) to (d), inclusive, of Section 10927 shall not be eligible for a water grant or loan awarded or administered by the state.

(b) Notwithstanding subdivision (a), the department shall determine that an entity described in subdivision (a) is eligible for a water grant or loan under the circumstances described in subdivision (a) if the entity has submitted to the department for approval documentation demonstrating that its entire service area qualifies as a disadvantaged community.

10934. (a) For purposes of this part, neither any entity described in Section 10927, nor the department, shall have the authority to do either of the following:

(1) To enter private property without the consent of the property owner.

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[1] The reference in Section 10933(e)(4) to Section 10934 has been amended by Stats. 2010, Ch. 328, sec. 237 (S.B. 1330). The new reference will be to Section 10933.5.

(2) To require a private property owner to submit groundwater monitoring information to the entity.

(b) This section does not apply to a county or an entity described in subdivisions (a) to (d), inclusive, of Section 10927 that assumed responsibility for monitoring and reporting groundwater elevations prior to the effective date of this part.

10935. (a) A voluntary cooperative groundwater monitoring association may be formed for the purposes of monitoring groundwater elevations in accordance with this part. The association may be established by contract, a joint powers agreement, a memorandum of agreement, or other form of agreement deemed acceptable by the department.

(b) Upon notification to the department by one or more entities that seek to form a voluntary cooperative groundwater monitoring association, the department shall work cooperatively with the interested parties to facilitate the formation of the association.

(c) The contract or agreement shall include all of the following:

(1) The names of the participants.

(2) The boundaries of the area covered by the agreement.

(3) The name or names of the parties responsible for meeting the requirements of this part.

(4) The method of recovering the costs associated with meeting the requirements of this part.

(5) Other provisions that may be required by the department.

10936. Costs incurred by the department pursuant to this chapter may be funded from unallocated bond revenues pursuant to paragraph (12) of subdivision (a) of Section 75027 of the Public Resources Code, to the extent those funds are available for those purposes.

SEC. 2. Section 12924 of the Water Code is repealed.

SEC. 3. Section 12924 is added to the Water Code, to read:

12924. (a) The department, in conjunction with other public agencies, shall conduct an investigation of the state's groundwater basins. The department shall identify the state's groundwater basins on the basis of geological and hydrological conditions and consideration of political boundary lines whenever practical. The department shall also investigate existing general patterns of groundwater pumping and groundwater recharge within those basins to the extent necessary to identify basins that are subject to critical conditions of overdraft.

(b) The department shall report its findings to the Governor and the Legislature not later than January 1, 2012, and thereafter in years ending in 5 or 0.

SEC. 4. This act shall take effect only if Senate Bill 1 and Senate Bill 7 of the 2009–10 Seventh Extraordinary Session of the Legislature are enacted and become effective.

Appendix B

USGS Ground-Water Data-Collection Protocols and Procedures for the National Water-Quality Assessment Program: Collection and Documentation of Water-Quality Samples and Related Data

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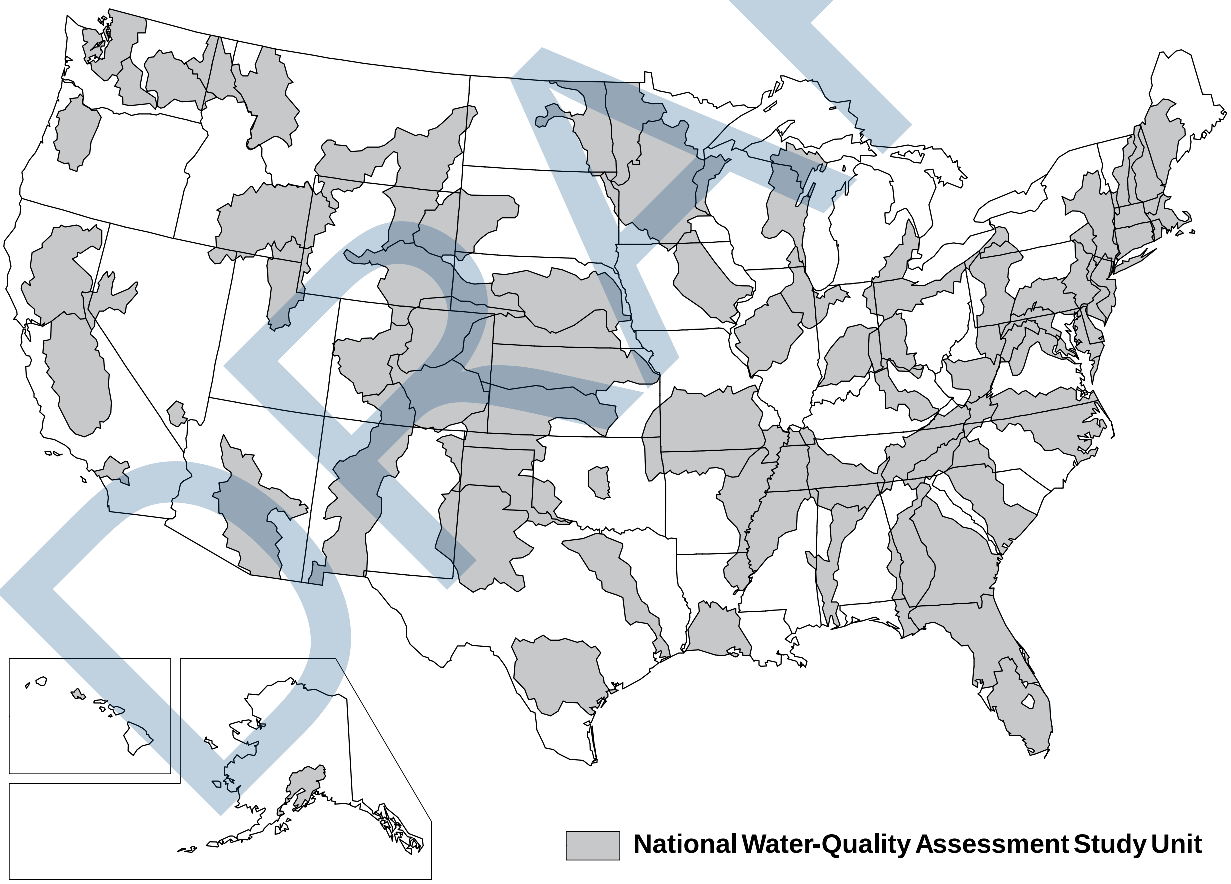
GROUND-WATER DATA-COLLECTION PROTOCOLS AND PROCEDURES FOR THE NATIONAL WATER-QUALITY ASSESSMENT PROGRAM: COLLECTION AND DOCUMENTATION OF WATER-QUALITY SAMPLES AND RELATED DATA

U.S. GEOLOGICAL SURVEY

Open-File Report 95-399



NATIONAL WATER-QUALITY ASSESSMENT PROGRAM

GROUND-WATER DATA-COLLECTION PROTOCOLS AND PROCEDURES FOR THE NATIONAL WATER-QUALITY ASSESSMENT PROGRAM: COLLECTION AND DOCUMENTATION OF WATER-QUALITY SAMPLES AND RELATED DATA

By Michael T. Koterba, Franceska D. Wilde, and Wayne W. Lapham

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U.S. Geological Survey

Open-File Report 95-399

Reston, Virginia
1995

U.S. DEPARTMENT OF THE INTERIOR

BRUCE BABBITT, Secretary

Seal

U.S. GEOLOGICAL SURVEY

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FOREWORD

The mission of the U.S. Geological Survey (USGS) is to assess the quantity and quality of the earth resources of the Nation and to provide information that will assist resource managers and policymakers at Federal, State, and local levels in making sound decisions. Assessment of water-quality conditions and trends is an important part of this overall mission.

One of the greatest challenges faced by water-resources scientists is acquiring reliable information that will guide the use and protection of the Nation's water resources. That challenge is being addressed by Federal, State, interstate, and local water-resource agencies and by many academic institutions. These organizations are collecting water-quality data for a host of purposes that include: compliance with permits and water-supply standards; development of remediation plans for specific contamination problems; operational decisions on industrial, wastewater, or water-supply facilities; and research on factors that affect water quality. An additional need for water-quality information is to provide a basis on which regional- and national-level policy decisions can be based. Wise decisions must be based on sound information. As a society we need to know whether certain types of water-quality problems are isolated or ubiquitous, whether there are significant differences in conditions among regions, whether the conditions are changing over time, and why these conditions change from place to place and over time. The information can be used to help determine the efficacy of existing water-quality policies and to help analysts determine the need for and likely consequences of new policies.

To address these needs, the U.S. Congress appropriated funds in 1986 for the USGS to begin a pilot program in seven project areas to develop and refine the National Water-Quality Assessment (NAWQA) Program. In 1991, the USGS began full implementation of the program. The NAWQA Program builds upon an existing base of water-quality studies of the USGS, as well as those of other Federal, State, and local agencies. The objectives of the NAWQA Program are to:

- Describe current water-quality conditions for a large part of the NationÕs freshwater streams, rivers, and aquifers.
- Describe how water quality is changing over time.
- Improve understanding of the primary natural and human factors that affect water-quality conditions.

This information will help support the development and evaluation of management, regulatory, and monitoring decisions by other Federal, State, and local agencies to protect, use, and enhance water resources.

The goals of the NAWQA Program are being achieved through ongoing and proposed investigations of 60 of the Nation's most important river basins and aquifer systems, which are referred to as study units. These study units are distributed throughout the Nation and cover a diversity of hydrogeologic settings. More than two-thirds of the Nation's freshwater use occurs within the 60 study units and more than two-thirds of the people served by public water-supply systems live within their boundaries.

National synthesis of data analysis, based on aggregation of comparable information obtained from the study units, is a major component of the program. This effort focuses on selected water-quality topics using nationally consistent information. Comparative studies will explain differences and similarities in observed water-quality conditions among study areas and will identify changes and trends and their causes. The first topics addressed by the national synthesis are pesticides, nutrients, volatile organic compounds, and aquatic biology. Discussions on these and other water-quality topics will be published in periodic summaries of the quality of the Nation's ground and surface water as the information becomes available.

This report is an element of the comprehensive body of information developed as part of the NAWQA Program. The program depends heavily on the advice, cooperation, and information from many Federal, State, interstate, Tribal, and local agencies and the public. The assistance and suggestions of all are greatly appreciated.

(signed)

Robert M. Hirsch
Chief Hydrologist

CONTENTS

ILLUSTRATIONS

TABLES

TABLES--Continued

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CONVERSION FACTORS AND ABBREVIATIONS

Multiply	By	To obtain
	Length	
inch (in)	25.4	millimeter
	2.54	centimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
	Area	
square mile (mi^2)	2.590	square kilometer
	Volume	
gallon (gal)	3.785	liter
	3785	milliliter
	Flow	
gallon per minute (gal/min)	0.06308	liter per second

Physical and Chemical Water-Quality Units

Temperature: Water and air temperature are given in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by use of the following equation:

$$°F = 1.8(°C) + 32$$

Specific electrical conductance of water is expressed in microsiemens per centimeter at 25 degrees Celsius (µS/cm). This unit is equivalent to micromhos per centimeter at 25 degrees Celsius.

method detection limit (MDL): The minimum concentration of a substance that can be identified, measured, and reported with 99-percent confidence that the analyte concentration is greater than zero; determined from analysis of a sample in a given matrix containing analtye.

minimum reporting level (MRL): The smallest measured concentration of a constituent that may be reliably reported using a given analytical method. In many cases, the MRL is used when documentation for the method detection limit is not available.

micrometer (µm), or "micron": The millionth part of the meter--the pore diameter of filter membranes is given in micrometer units.

milligrams per liter (mg/L) or micrograms per liter (µg/L): Milligrams per liter is a unit expressing the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) or water. One thousand micrograms per liter is equivalent to one milligram per liter. For concentrations less than 7,000 mg/L, the numerical value is the same as for concentrations in parts per million.

millivolt (mV): A unit of electromotive force equal to one thousandth of a volt.

nephelometric turbidity unit (NTU): A measure of turbidity in a water sample, roughly equivalent to Formazin turbidity unit (FTU) and Jackson turbidity unit (JTU).

normality, *N* (equivalents/L): The number of equivalents of acid, base, or redox-active species per liter of solution. Examples: a solution that is 0.01 formal in HCl is 0.01 *N* in H^+. A solution that is 0.01 formal in H_2SO_4 is 0.02 *N* in H^+.

GROUND-WATER DATA-COLLECTION PROTOCOLS AND PROCEDURES FOR THE NATIONAL WATER-QUALITY ASSESSMENT PROGRAM: COLLECTION AND DOCUMENTATION OF WATER-QUALITY SAMPLES AND RELATED DATA

By Michael T. Koterba, Franceska D. Wilde, and Wayne W. Lapham

ABSTRACT

Protocols for ground-water sampling are described in a report written in 1989 as part of the pilot program for the National Water-Quality Assessment (NAWQA) Program of the U.S. Geological Survey (USGS). These protocols have been reviewed and revised to address the needs of the full-scale implementation of the NAWQA Program that began in 1991. This report, which is a collaborative effort between the NAWQA Program and the USGS Office of Water Quality, is the result of that review and revision.

This report describes protocols and recommended procedures for the collection of water-quality samples and related data from wells for the NAWQA Program. Protocols and recommended procedures discussed include (1) equipment setup and other preparations for data collection; (2) well purging and field measurements; (3) collecting and processing ground-water-quality samples; (4) equipment decontamination; (5) quality-control sampling; and (6) sample handling and shipping.

INTRODUCTION

The full-scale implementation of the National Water-Quality Assessment (NAWQA) Program in 1991 required updating the ground-water protocols prepared for the NAWQA pilot program (Hardy and others, 1989) and more detailed information for collecting ground-water-quality data in the NAWQA Program. That effort has resulted in this report and a companion report by Lapham and others (in press). Broader based reports that establish and document ground-water data-collection protocols and procedures for all U.S. Geological Survey (USGS) programs include Radtke and Wilde (in press) and two planned companion reports.[1]

This report describes protocols and recommended procedures for collecting ground-water-quality samples and related data (hereafter referred to as ground-water-quality data) specifically for the Occurrence and Distribution Assessment component of the full-scale NAWQA Program. In addition to updating and expanding the report by Hardy and others (1989), this report complements other reports prepared for the NAWQA Program, including those that describe NAWQA well installation, selection, and documentation (Lapham and others, in press), design of the NAWQA Program (Gilliom and others, 1995; Alley and Cohen, 1991), the conceptual

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[1]For further information about the status of these planned reports contact the Office of Water Quality, U.S. Geological Survey, 412 National Center, Reston, VA 22092.

framework of the NAWQA Program (Leahy and Wilber, 1991; Hirsch and others, 1988; Cohen and others, 1988), an implementation plan for the NAWQA Program (Leahy and others, 1990), and a description of a quality-assurance (administrative) plan for the NAWQA pilot program (Mattraw and others, 1989).

For the purposes of this report, a protocol identifies a course of action that is mandatory under most circumstances as a consequence of USGS and NAWQA policies. For example, the routine collection of quality-control samples throughout the period during which ground-water-quality data are being collected is a protocol, and the requirement that equipment be decontaminated between uses according to prescribed methods to avoid cross-contamination of water-quality samples and the wells being sampled is a protocol. A recommended procedure is one that generally is preferred over other procedures that are available or commonly used. A procedure generally is recommended for the purpose of conforming to rules for good field practices and is expected to result in reproducible data of a desired and defined quality. Recommended procedures are not protocols because they are either too restrictive or possibly inappropriate in some situations. For example, one recommended procedure is to measure the water level in the well before ground-water-quality data are collected; this is not possible for some water-supply wells. Another recommended procedure is that equipment decontamination, which is required, be conducted in the field immediately after use; this, however, is not possible for some field-site conditions.

Although modifications are likely as new technologies evolve, the protocols and recommended procedures for data collection and documentation described in this report are considered capable of producing representative data of known quality that are suitable for assessment, while also being feasible to employ, given limitations of time and funds. Their use promotes consistency and comparability of ground-water data among Study Units in the NAWQA Program.

Background

The USGS began full-scale implementation of the NAWQA Program in 1991. The goals of the NAWQA Program are to (1) provide a nationally consistent description of current water-quality conditions for a large part of the Nation's water resources; (2) define long-term trends in water quality; and (3) identify, describe, and explain major factors that could affect observed water-quality conditions and trends (Hirsch and others, 1988).

The design concepts of the NAWQA Program are based in part on a pilot program that began in 1986. The NAWQA pilot program consisted of seven Study Units conducting water-quality assessment in separate study areas. These study areas were distributed geographically throughout the continental United States and represented diverse hydrologic environments and water-quality conditions. Four of the pilot assessments focused on surface water and three focused on ground water. The ground-water pilot study areas were the Carson River Basin in Nevada and California (Welch and Plume, 1987); the Central Oklahoma Aquifer in Oklahoma (Christenson and Parkhurst, 1987); and the Delmarva Peninsula in Delaware, Maryland, and Virginia (Bachman and others, 1987).

The NAWQA Program design that has evolved from the pilot program consists of two major components: (1) Study-Unit Investigations of both surface and ground water, and (2) National Assessment activities, which combine results of individual Study Units for selected topics. This design provides information on water quality for policymakers and managers at local, State, regional, and national scales.

Components and attributes of the current ground-water-sampling design for a Study Unit are described in Lapham and others (in press) and Gilliom and others (1995). In brief, for the full-scale NAWQA Program, investigations of 60 Study Units, ranging in area from 1,200 to more than 60,000 square miles, are ongoing or planned. The 60 Study Units include parts of most of the major river basins and aquifer systems in the Nation, and incorporate about 60 to 70 percent of the Nation's water use and population served by public water supply. Investigations in each Study Unit are being conducted on a rotational rather than a continuous basis. One-third of the Study Units are being studied intensively at any given time. For each Study Unit, a 3- to 4-year intensive period of data collection and analysis will be alternated with a 6- to 7-year period of low-intensity assessment activities. The first intensive period of study for 20 of the 60 Study Units, which is referred to as the Occurrence and Distribution Assessment, began in 1993.

Data from each Occurrence and Distribution Assessment will be aggregated and compared for selected topics from all Study Units, as well as from other programs, to obtain regional and national perspectives on water quality. Consistent methods of data collection by the Study Units are needed for comparability of data. The protocols and recommended procedures described in this report are intended to ensure that consistency.

Purpose and Scope

This report describes protocols and recommended procedures to be used by the NAWQA Program for the collection of ground-water-quality data from wells. Protocols and recommended procedures discussed relate to the plans and preparations for ground-water sampling, and the collecting, processing, and handling of ground-water samples, including well purging, field measurements taken during purging, equipment decontamination, quality-control sampling, and sample documentation, handling, and shipping. Quality-assurance protocols and procedures are incorporated for each data-collection activity.

Quality Assurance and Quality Control

In this report, quality assurance refers to activities that control or guide data-collection methods, such as protocols, recommended procedures, and work plans and schedules. Quality control refers to the data or measurements generated to quantify measurement bias and variability associated with the data-collection process. The quality assurance (QA) activities and quality control (QC) data associated with NAWQA protocols and recommended procedures described in this report are best carried out as an integral part of the plans, preparations, implementation, and documentation used to obtain ground-water-quality data (Shampine and others, 1992). To emphasize the importance of an integrated approach, and the need for all NAWQA ground-water staff to participate, the protocols and recommended procedures that relate to QA and QC appear throughout this report in relation to a variety of responsibilities and activities, rather than being segregated in a separate section.

An integrated approach to QA and QC helps to clarify what needs to be done, when, and by whom through QA activities that are logically and efficiently coordinated with other activities and through the collection of data to assess that the ground-water data collected are of a quality suitable for Study-Unit and National Assessments. In order of discussion, the data-quality requirements for NAWQA ground-water sampling and the role of QC sampling are described in “Data-Quality Requirements.” Equipment and supplies specific to QC sampling are described, along with those generally required to obtain water-quality data, in “Selection and Purchase of Equipment and Supplies.” The QA requirements for field instruments and water-quality vehicles are incorporated under the respective topics (see “Field Instruments” and “Water-Quality Vehicles”). The design for selecting QC sample types and scheduling their collection are described immediately following the discussion of the design of water-quality sampling schedules.

Protocols and recommended procedures to be followed in collecting QC samples are incorporated as part of a number of activities that occur in chronological order and that define the overall data-collection process at a well. For example, the collection of replicate ground-water samples is described after well purging, and as part of the discussion on the collection of water-quality samples (see “Sample Collection and Processing”), whereas the collection of field blanks is described after equipment decontamination (see “Preparation of Blank Samples”). Preparing special types of samples, including QC samples such as field spikes, is described after the section on field blanks because that is when field-spiked samples for pesticides and volatile organic compounds will be prepared (see “Preparation of Other Routine Quality-Control Samples and Field Extracts of Pesticide Samples”). Finally, documentation activities relating directly to QA and QC are described throughout this report.

Although this report includes many QA-QC protocols and recommended procedures, it does not replace the need for individual Study Units to assess, review, and possibly expand on those described. Study Units are encouraged to publish their QA-QC plans and results independent of any work performed at the national level of the NAWQA Program, and as appropriate for their particular needs.

Acknowledgments

The authors gratefully acknowledge the contributions and assistance of many colleagues within the USGS in producing this document. In particular, thorough and thoughtful reviews and discussions were provided by Mark A. Hardy, William H. Werkheiser, and Neil M. Dubrovsky of the USGS on preliminary drafts, and by David W. Clark, Dorinda J. Gellenbeck, and W. Brian Hughes of the USGS National Water-Quality Assessment Program on subsequent drafts of this report. Editorial assistance was provided by Iris M. Collies.

COLLECTION AND DOCUMENTATION OF WATER-QUALITY SAMPLES AND RELATED DATA

Ground-water-quality data for the Occurrence and Distribution Assessment of the NAWQA Program are to be collected and documented in accordance with the specific protocols and recommended procedures described in this report and in Lapham and others (in press). Protocols and recommended procedures are provided that cover plans and preparations, collection methods, and the documentation of activities before, during, and after water-quality data are collected. The principles underlying these protocols and recommended procedures have been shown to produce data suitable for the Occurrence and Distribution Assessments of NAWQA in selected pilot areas (Christenson and Rea, 1993; Hamilton and others, 1993; Koterba and others, 1993; and Rea, in press).

The NAWQA ground-water protocols and recommended procedures are applicable for data commonly collected for all three ground-water components (Study-Unit Surveys, Land-Use Studies, and Flowpath Studies) of the NAWQA Program (table 1). Although they are consistent with general guidelines for USGS ground-water data collection (F.D. Wilde, U.S. Geological Survey, written commun., 1995--see footnote 1), these protocols and recommended procedures reflect NAWQA Program objectives, and could differ in some aspects from those of other USGS programs. In particular, because of the perennial nature of the NAWQA Program, methods used by individual Study Units are constrained by the need for national consistency in the quality of data collected and by the degree and type of documentation required.

Data-Quality Requirements

The importance of national consistency in data collection cannot be overstated. Inconsistent methods can lead to variable and biased data measurements.[2] Modifications to collection and analytical methods potentially result in data whose measurements vary or are biased in relation to previously collected data. If not quantified and documented, such modifications complicate trend analysis (Smith and Alexander, 1989).

The protocols and recommended procedures for NAWQA are designed to reduce inconsistencies and enhance the quality of data used in spatial and trend analysis. The purpose of data-quality requirements is to ensure that data-collection methods are consistent, and that the data obtained meet study needs. The NAWQA Program has three requirements related to sample collection: (1) document the methods used to collect ground-water-quality data and all quality-assurance and quality-control measures, (2) ensure that the quality of data collected is known, and (3) demonstrate that the quality of data obtained is suitable for assessment objectives. In meeting these requirements, it is necessary that data-collection and analytical methods be designed, planned, and executed as consistently as possible. This will help reduce bias and variability among the data collected within a single Study Unit and among Study Units.

[2]The term "bias" is defined in this report as a systematic error that is manifested as a consistent positive or negative deviation from the known or true value. "Variability" is defined as measurement reproducibility or the degree of similarity among independent measurements of the same quantity, often measured as a variance or relative standard deviation and without reference to the known probable or true value.

Table 1. Summary of current (1995) required, recommended, and optional water-quality constituents to be measured in the three ground-water components of the Occurrence and Distribution Assessment, National Water-Quality Assessment Program (from Lapham and others, in press)

[Required water-quality constituents to be measured for the Occurrence and Distribution Assessment are determined partly by the water-quality topics of national interest selected for National Assessment. Topics selected for National Assessment (1994) are nutrients, pesticides, and volatile organic compounds. The topics selected can change over time. Quality-control samples also are required - types of quality-control samples depend on study component. Req, Required; Rec, Recommended; Opt, Optional; NWQL, National Water Quality Laboratory; SC, Schedule; LC, Laboratory Code]

Water-quality constituent or constituent class	**Study-Unit Survey**	**Land-Use Studies**	**Flowpath Studies**[1]	**Method**[2]
Field measurements				
- Temperature	Req	Req	Req	Field
- Specific electrical conductance	Req	Req	Req	Field
- pH	Req	Req	Req	Field
- Dissolved oxygen	Req	Req	Req	Field
- Acid neutralizing capacity (ANC) (unfiltered sample)[3]	Rec	Rec	Rec	Field incremental
- Alkalinity (filtered sample)[3]	Req	Req	Req	Field incremental
- Turbidity[4]	Rec	Rec	Rec	Field
Major inorganics	Req	Req	Req	NWQL SC2750
Nutrients	Req	Req	Req	NWQL SC2752
Filtered organic carbon	Req	Req	Opt	NWQL SC2085
Pesticides	Req	Req	Opt	NWQL SC2001/2010 NWQL SC2050/2051
Volatile organic compounds (VOCs)	Req	Req or Opt[5]	Req or Opt[6]	NWQL SC 2090
Radon	Req	Req or Rec[7]	Req or Rec[6]	NWQL LC 1369
Trace elements[4]	Opt	Opt	Opt	NWQL SC 2703
Radium	Opt	Opt	Opt	NWQL-Opt
Uranium	Opt	Opt	Opt	NWQL-Opt
Tritium, tritium-helium, chlorofluorocarbons (CFCs)[8]	Rec	Rec	Rec	NWQL LC1565 (tritium)
Environmental isotopes[9]	Rec	Rec	Rec	NWQL-Opt

Table 1. Summary of current (1995) required, recommended, and optional water-quality constituents to be measured in the three ground-water components of the Occurrence and Distribution Assessment, National Water-Quality Assessment Program (from Lapham and others, in press)--Continued

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[1]Selection of constituents for measurement in Flowpath Studies is determined by Flowpath-Study objectives. During at least the first round of sampling, however, the broad range of constituents measured in Study-Unit Surveys and Land-Use Studies will be measured.

[2]Schedules and laboratory codes listed are required for Study Units that began their intensive phase in 1991 or 1994, and apply until changed by National Program directive. Schedules for radium and uranium can be selected by the Study Unit, but require NAWQA Quality-Assurance Specialist approval. A detailed discussion is found in the “Sample Collection and Processing” section of this report.

[3]ANC (formerly referred to as unfiltered alkalinity) is measured on an unfiltered sample. Alkalinity is measured on a filtered sample. A Study Unit could have collected ANC, alkalinity, or both to date.

[4]Turbidity measurements are required whenever trace-element samples are collected to evaluate potential colloidal contributions to measured concentrations of iron, manganese, and other elements.

[5]VOCs are required at all urban Land-Use Study wells, but are optional in agricultural Land-Use Studies. If VOCs are chosen as part of an agricultural Land-Use Study, then they should be measured in at least 20 of the Land-Use Study wells.

[6]VOCs are required at all urban flowpath wells for at least the first round of sampling. If VOCs are measured in an agricultural Land-Use Study, then they should be measured at all Flowpath-Study wells within that Land-Use Study for at least the first round of sampling.

[7]Radon is required at any Land-Use or Flowpath Study well if that well also is part of a Study-Unit Survey; otherwise radon collection is recommended for Land-Use or Flowpath-Study wells located in likely source areas.

[8]Collection of tritium, tritium-helium, chlorofluorocarbons (CFCs), and (or) other samples for dating ground water is recommended, depending on the hydrogeologic setting. For tritium methods, see NWQL catalog; for CFCs, see Office of Water Quality Technical Memorandum No. 95.02 (unpublished document located in the USGS Office of Water Quality, MS 412, Reston, VA 22092).

[9]For a general discussion of the use of environmental isotopes in ground-water studies, see Alley (1993).

This report comprises a substantial part of the documentation requirement. Because of diverse site conditions, well types, equipment requirements, and staff experience, situations could arise where NAWQA protocols and recommended procedures described in this report need to be modified. Modifications at the program level will be made in a systematic manner and initially documented through internal, regional, or national memorandums. For modifications internal to Study Units, the chief of the Study Unit is responsible for ensuring that the proposed modification is discussed with the NAWQA Program Quality-Assurance (QA) Specialist before implementation, and that any modifications used are clearly documented in Study-Unit publications. It also is necessary for the NAWQA Program or individual Study Units to provide evidence of the effect, or lack thereof, of modifications on data quality.

To ensure data quality and suitability (the second and third data-quality requirements) each Study Unit will routinely follow protocols and recommended procedures that are described in detail in the following sections. The QA-QC measures include (1) the collection of selected QC samples in the field to test equipment and methods before data collection begins, and (2) the routine collection of selected QC samples (such as blanks, replicates, and spiked replicate samples) during ground-water-quality sampling. Additional QC samples and QA measures will be taken if modifications in methods of sample and data collection occur that require quantification.

Individual NAWQA Study Units or National Synthesis teams may find it necessary to expand QC data collection to identify specific sources of measurement bias or variability. In addition, it has been necessary in some cases to enhance collection of QC data in order to interpret the corresponding ground-water-quality data (Koterba and others, 1991; Ferree and others, 1992; and Koterba and others, 1994). Study-Unit and National-Synthesis-Team budgets, plans, and preparations need to remain flexible to allow for the possibility that additional QC data could be needed.

Plans and Preparations

Plans and preparations for ground-water sampling are completed well in advance of data-collection activities, yet must remain flexible enough to be modified if circumstances dictate. Preparations include becoming familiar with the protocols and recommended procedures described in this document. Sampling equipment and supplies need to be obtained in time for sampling and for the staff to be trained in their use. The ground-water staff also needs to become familiar with and develop the documentation and management of samples and data, including that for QC samples. Finally, the ground-water staff should make detailed plans and preparations for the first field season, which for most Study Units commonly will begin early in the first year of the Occurrence and Distribution Assessment.

As the Study-Unit Investigation progresses, subsequent plans and preparations for each field season are required annually, and are developed as part of the general workplan. Study Units commonly will complete preparations for sampling several weeks in advance of each field season. Documenting site conditions, water-quality data collection, and reviewing collected data are processes that begin before each field season, continue during data collection, and often extend months beyond each field season.

Five key elements to consider in the initial and (in some cases) annual plans and preparations include (1) site visits to assess conditions that could affect sample and data collection; (2) selecting and obtaining sampling equipment and supplies early, to ensure that those eventually used best meet field conditions and fall within NAWQA Program requirements or recommendations; (3) training, to prepare field teams; (4) conducting a field evaluation, to determine that the equipment and procedures will provide high-quality data and that planned documentation and management activities are adequate; and (5) developing detailed schedules that clearly describe staff responsibilities before, during, and after each field season. Each of these planning and preparation elements is described below in detail.

Site Visits

Wells selected or installed for each ground-water component are visited at least once before sampling. During this or any other visit, site data are reviewed to determine if information is needed to (1) complete documentation requirements (Lapham and others, in press), and (2) plan water-quality sampling activities (table 2). In addition, plans currently (1995) are being developed for screening wells for high concentrations (10 µg/L or greater) of volatile-organic-compound (VOC) contamination (John Zogorski, VOC National Synthesis Team, U.S. Geological Survey, written commun., 1995). This could add to the information that needs to be collected during these site visits for selected wells sampled after 1995.

Selection and Purchase of Equipment and Supplies

Because of the need to obtain nationally consistent data over many years on a wide variety of chemical constituents (table 1), most equipment and supplies not provided by the Study Unit generally should be obtained from one of three USGS suppliers: the Hydrologic Instrumentation Facility, Quality Water Service Unit, and National Water Quality Laboratory (table 3). Each of these suppliers offers the advantage of stocking equipment that otherwise would have to be obtained from multiple sources. These suppliers also conduct QC checks and provide QC data for selected supplies and equipment distributed to USGS personnel. For these reasons, these suppliers are designated as the required or sole-source supplier for such items (table 3, USGS supplier with “S” designation). The USGS suppliers also are recommended as sources for other equipment (table 3, USGS supplier with “R” designation) in order to reduce the time, effort, paperwork, and cost to the Study Unit to locate and obtain equipment. Should the need arise, each supplier also can provide equipment not previously available.

Table 2. Information to obtain when planning water-quality data-collection activities

1. **Type of Well Hookup for Sampling:** Determine if a hookup to a garden-hose-threaded flow valve (common for water-supply wells) or to a portable, submersible pump (common for monitoring wells) is needed for sample collection.

2. **Depth Measurements**: Measure the depth of the well and depth to the water level in the well to check well-construction integrity and to determine pump lift, height of water column, volume of standing water held in the well, and purge volume.[1]

3. **Site Conditions and Restrictions:** Note road or access conditions to the well, areas of low clearance, limits on arrival and departure times, or presence of roaming animals (for example, livestock or pets) that could create problems for a field team.

4. **Contact Person**: Obtain land- or well-owner name and telephone numbers (business and home) and contact owner before or upon arrival, and perhaps upon departure.

5. **Local Maps and Photographs**: Locate well on maps, site sketches, or photographs, and indicate the measuring point for well-depth measurements, as well as areas for equipment setup and waste discharge.

6. **Travel Maps and Travel Times**: Identify route and travel times from District office or previous site, and possible tunnel or bridge restrictions on the transport of gasoline, bottled gas, or methanol (or other organic cleaning agent).

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[1]Measurements are made in accordance with National Water-Quality Assessment Program and U.S. Geological Survey protocols (Lapham and others, in press). Purge volume is defined as three times the volume of standing water in the well casing or, in absence of a casing, the borehole.

Table 3. Equipment, supplies, and suppliers for ground-water-quality sampling for the National Water-Quality Assessment Program

[OM, open market; HIF, U.S. Geological Survey Hydrologic Instrument Facility, Stennis Space Center, Miss.; R, recommended supplier; QWSU, Quality Water Service Unit, Ocala, Fla,; SU, Study Unit; µm, micrometer; mm, millimeter; S, sole (required) source of supplies indicated; NWQL, National Water Quality Laboratory, Arvada, Colo.; mL, milliliter; L, liter; ASTM, American Society for Testing and Materials; SC, NWQL analytical schedule; FA, filtered and acidified sample; FU, filtered (unacidified) sample; RU, raw (unfiltered) sample; FCC, filtered, chilled (no preservative added) sample; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; DIW, deionized water; BTD&QS, Branch of Technical Development and Quality Systems, Arvada, Colo.]

Equipment and supplies	Suppliers
1. Well-head setup or connection	
• Monitoring well: submersible pump and reel system	OM[1]
• Water-supply well: hook-up segment with garden-hose thread	HIF[2], R
2. Sample-flow transfer system from pump reel to collection point	
• Antibacksiphon device, Teflon, connected in line	HIF, R[3]
• Extension lines for sample flow, Teflon, with connectors	HIF, R
• Manifold, with connectors and Teflon valves, for routing sample flow	HIF, R
• Sample-collection equipment that has connectors to manifold:	
Radon collector with septa, and connectors to manifold	HIF, R
Glass syringe with leur-locked stainless-steel needles	QWSU, R
Teflon, line with connector to manifold, either open ended for turbidity sample collection, or with connector to flowthrough turbidimeter	HIF, R
• Sample-collection and processing chamber frame, PVC or inert material with sample-flow-transfer port	HIF, R
• Preservation-chamber frame, PVC or inert material	HIF, R
• Transparent disposable covers and plastic clips to hold covers inside frames for sample and preservation chamber frames	SU, HIF, R[4]
• Flowthrough chamber with field-instrument ports, manifold connections, and waste line	OM[5]
3. Sample-filtration equipment	
Organic carbon, filtered fractions	
• Stainless-steel cylinder unit with nitrogen-gas deso-quick connect, gas scrubber, and gas line with connector to secondary regulator	HIF, R
• Nitrogen gas tank, with primary and secondary regulators	OM
• Filter membranes, 0.45-µm, 47-mm diameter, silver	QWSU, S
• Safety belts, to secure gas tank	OM
• Container, to collect spent silver nitrate membranes	SU
Pesticides	
• Aluminum or stainless-steel unit	OM, NWQL[6]
• Filter membranes, 0.7-µm, 142-mm diameter, baked, GF/F grade glass microfiber	QWSU, S
• Connector from filter unit to sample-chamber outflow tube	SU[6]

Table 3. Equipment, supplies, and suppliers for ground-water-quality sampling for the National Water-Quality Assessment Program--Continued

Equipment and supplies	**Suppliers**
Inorganic (major ions, nutrients, and trace elements)	
• Filter units, capsule with self-contained 0.45-µm[7], pleated, Supor capsule	QWSU, S
• Convoluted (spiral configuration) Teflon sample-flow lines from filter unit to sample-chamber outflow tube[8]	OM
4. Sample Bottles (sample containers, caps, and protective foam sleeves)	
Organic samples	
• Volatile organic sample (SC2090), 40-mL amber vial, baked (Teflon-lined cap)--three vials per sample (Also includes trip blanks.)	NWQL, S
• Pesticides (SC2001 or 2010) sample: 1-L amber bottle, baked (Teflon-lined cap)	QWSU, S
• Pesticides (SC2050 or 2051) sample: 1-L amber bottle, baked (Teflon-lined cap)	QWSU, S
• Organic carbon (SC2085) samples (filtered): 125-mL, amber bottle, baked (Teflon-lined cap)	QWSU, S
• Sleeves, foam, for 40-mL, 1-L, and 125-mL containers	QWSU, S
Inorganic samples	
• Radon (LC1369) sample: scintillation vial (one per transport tube)	NWQL, S
• Major cations (SC2750): filtered, acid-rinsed, 250-mL clear polyethylene bottle (with clear cap), FA--two per sample (one archived by SU)	QWSU, S
• Trace elements (SC2703, SC172, LC112 for arsenic and LC87 for selenium for field blanks): acid-rinsed, 250-mL clear polyethylene bottle (with clear cap), FA--one per sample	QWSU, S
• Major anions (SC2750): 500-mL, clear polyethylene bottle labeled FU, clear 28-mm neck (with black cap)--one per sample	QWSU, S[9]
• Nutrients (SC2752): 125-mL amber polyethylene bottle (with black cap), FCC--one per sample	QWSU, S
• Unfiltered sample (SC2750) RU for laboratory measurements: 250-mL clear polyethylene bottle (with black cap)--one per sample	QWSU, S
(Order black caps for 28-mm bottle neck separately)	QWSU, S
5. Sample and Shipping Forms and Shipping Supplies	
• Field form (standard National Water Quality Field Form or District analog)[10]	SU
• Analytical Services Request (ASR) forms for NWQL	NWQL, S
• Sample Reply Form (Study Unit to NWQL) and return envelope, self-addressed, stamped (see appendix, fig. A20, for example)	SU
• Overnight shipping labels	Contract Carrier
• Surface-mail shipping labels (supplied and prepared at District Office)	SU

Table 3. Equipment, supplies, and suppliers for ground-water-quality sampling for the National Water-Quality Assessment Program--Continued

Equipment and supplies	**Suppliers**
• Coolers, with latch lid and drain port, maximum loaded weight of 50-60 lbs. (for overnight sample delivery)	OM
• Heavy cardboard boxes, maximum loaded weight, 20 lbs. (surface delivery)	OM
• Plastic bags, heavy, 4-mil (for holding ice and overnight samples in cooler)	OM
• Plastic bags, resealable (for holding ASR and other forms mailed with samples)	OM
• Filament tape (to secure lid and drain cap of cooler, and surface-delivery boxes)	OM
6. Field-titration equipment[11]	
• Digital or other titrator meeting USGS specifications	QWSU, R
• Acid cartridges (for digital titrator)--0.16 and 1.6 Normal sulfuric acid	QWSU, S
• Extra acid-delivery tubes for digital titrator, clear plastic	QWSU, R
• Glass beakers (250 mL)	OM
• Volumetric pipets, glass, Class A (for preparing filtered samples)	OM
• Magnetic stirrer and small Teflon-coated stir bars	OM
7. Field instruments[11]	
• pH (electrometric) meter	OM
• pH electrodes and refill solutions (specify type of electrode)	QWSU, R
• Specific electrical conductance meter	OM
• Dissolved-oxygen (amperometric) meter and associated equipment (sensor cable, membrane and solution kit)	OM or QWSU
• Pocket barometer (used for pressure correction to dissolved-oxygen meter)	HIF, R
• Calibration wand and cup (for dissolved oxygen)	HIF, R[12]
• Turbidity (nephelometric) meter (turbidity measurement generally is recommended, but required for trace-element sampling)	OM
• Temperature measurement: thermistor thermometer (recommended), possibly part of other field meters. Also need a liquid-in-glass thermometer, ASTM certified, 0.1°C-graduated range of -5 to 45°C (for calibrating thermistor thermometer)	QWSU, R OM, R
8. Miscellaneous equipment and supplies	
• Parafilm	HIF, R
• Forceps (tweezers), Teflon-tipped stainless steel (to handle filter membranes for organic and inorganic samples); or steel forceps (for flat glass-fiber and silver membranes) and plastic forceps (for cellulose nitrate or other inorganic-sample membranes)	OM
• Plastic beakers and small cups, used to hold solutions for calibrating or checking field-instrument sensors	OM, R

Table 3. Equipment, supplies, and suppliers for ground-water-quality sampling for the National Water-Quality Assessment Program---Continued

Equipment and supplies	Suppliers
9. Decontamination equipment and supplies	
• District deionized water (DIW) (conductivity ≤1 µS/cm), quality controlled	SU
• Inorganic-free blank water (IBW) (quality controlled for major ions and trace elements)	QWSU, S[13]
• Pesticide-free blank water (PBW) or volatile and pesticide-free blank water (VPBW) (for pesticides or volatile organics)	NWQL, S[13]
• Methanol, pesticide-grade high purity (organic-sampling equipment)	OM
• Laboratory detergent, phosphate free, concentrated: diluted to a 0.1 percent decontamination solution, by volume, with DIW	QWSU, R
• Wash bottles, polyethylene, 250 mL or 500 mL (for DIW and IBW)	QWSU, R
• Wash bottles, Teflon, 500 mL (for PBW and VPBW)	QWSU, R
• Wash bottle, for methanol or other organic solvent, 250 mL	OM
• Laboratory gloves, powderless (latex or vinyl) (for decontamination and sample collection)	QWSU, R
• Plastic trays (3)	HIF, R
• Pump standpipes (glass graduated cylinders or pipette jars are preferred)	HIF, R[14]
• Forced-hot-air dryer, portable, vehicle-powered (for evaporating methanol residues)	OM
• Teflon bags, small (for small organic-sampling equipment and pump intake)	HIF, R
• Heavy aluminum foil (for wrapping organic-carbon and pesticide-filter-unit inlets and outlets	OM
• Plastic bags, resealable (for small inorganic sampling equipment)	OM
• Plastic bags, large, for enclosing cleaned pump reel, extension lines, and other large equipment	HIF, R
• Paper tissues, lint free, soft, disposable, large and small sizes (for example, Kimwipes)	OM
10. Safety equipment	OM[15]
• Fire extinguishers (A-B-C type) with mounts	
• Safety goggles or glasses	
• Eye-wash bottle	
• Emergency spill kits for any chemicals being used	
• Approved containers for transporting pure and used methanol	
• Safety cones, large	
• Material Safety Data Sheets	
11. Chemical reagents (kits include equipment for dispensing reagent)	
Preservatives	
• VOC samples (SC2090) -- 1:1 hydrochloric acid (kit)	NWQL, S
• Acrolein and acrylonitrile samples (SC1401) -- 1:1 hydrochloric acid	NWQL, S[16]
• VOC samples in chlorinated water matrix--ascorbic acid (with scoop)	NWQL, S[17]
• Inorganic (FA) samples for major cations (SC2750) and trace elements (SC2703)--nitric acid, 1-mL glass ampoule, one per sample	QWSU, S[18]

Table 3. Equipment, supplies, and suppliers for ground-water-quality sampling for the National Water-Quality Assessment Program--Continued

Equipment and supplies	**Suppliers**
Standards	
• pH standard buffers (pH 4, 7, and 10)	QWSU, S
• Specific electrical conductance standards (50 to 50,000 µS/cm; for low-conductivity waters of ≤20 µS/cm, use pH 4.31 buffer)	QWSU, S[19]
• Turbidity standards--Formazin	OM
• Dissolved-oxygen "zero" standard dilutions, freshly prepared with reagent grade sodium sulfite and cobalt chloride	OM[20]
Spike and other solutions	
• VOCs (SC2090, SC2091, SC2092): standard NAWQA spike solution and spike-solution kit	NWQL, S
• Pesticides (SC2050 or 2051 and SC2001 or 2010): standard NAWQA spike solution and spike-solution kits	NWQL, S
• Mixtures, required for trace elements (SC2703)	BTD&QS, S
• IBW, PBW, VPBW (see no. 9, "Decontamination equipment and supplies")	NWQL and QWSU, S
12. Optional Equipment[21]	
• Equipment for isotope, radiochemical, and other special samples--for example, deuterium-oxygen, tritium, uranium, radium, mercury, chlorofluorocarbons	OM
• Field solid-phase-extraction equipment for pesticide samples	NWQL, S

[1] That meets NAWQA Program requirements; see text.

[2] To remove oils and other manufacturing or shipping residues, and before assembling HIF or other equipment that includes Teflon tubing (without metal fittings), soak tubing for 30 minutes in a 5 percent hydrochloric acid solution rinsed with tap water until rinsate has pH similar to tap water, then final rinse three times with DIW. For a 5-percent acid solution, add 5 milliliters of 12 normal (concentrated) acid (specific gravity 1.19 and trace-element free) to each 100 milliliters of DIW (specific conductance not to exceed 1.0 microsiemens at 25 degrees Celsius).

[3] Required for each portable pump system (monitoring wells) or hook-up setup (water-supply wells). Purchase separately from pump system; a single unit can be interchanged between portable-pump and hook-up systems.

[4] Recommended design that allows cover to be attached inside frame with small, plastic clips.

[5] Flowthrough chamber from HIF meets design criteria for use with individual field instruments--pH, dissolved oxygen, specific electrical conductance, and temperature--required for ground-water-quality sample collection.

[6] For aluminum filter unit purchased through NWQL that is set up for solid-phase extraction, SU supplies a short Teflon tube (1/2-inch outer diameter, 3/8-inch inner diameter) that slips over standard nipple connection on filter unit and is connected by a 5/8-inch outer diameter by 1/2-inch inner diameter Teflon sleeve to the tube extending from the sample chamber frame to the filter unit.

[7] For ground water that contains colloidal material, filter membranes with a pore size less than 0.45 µm are required if the filtrate data must represent ion concentrations in solution. The filter pore size in general should not exceed 0.2 µm.

[8] Commonly sold in 5-foot lengths and can be cut into small lengths. Convoluted is preferred over corrugated type because latter is prone to trapping sediment, and must be replaced frequently (Johnson and Swanson, 1994).

[9] RU sample is not needed with trace-element schedule SC2703 if field conductivity is recorded on trace-element ASR form, along with a notation (in comment line to laboratory) that there is "no RU sample."

Table 3. Equipment, supplies, and suppliers for ground-water-quality sampling for the National Water-Quality Assessment Program--Continued

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[10]To be filed with ASR Forms (SU copy) every time samples are collected at well (see appendix, fig. A8, for example).

[11]Refer to table 5 and Radtke and Wilde (in press) for descriptions of equipment and equipment specifications.

[12]Use air-calibration-chamber-in-water method (Radtke and Wilde, in press, Sec. 6.2).

[13]IBW, PBW and VPBW are laboratory-produced waters quality-controlled for specified analyses. The primary use of these waters is for blank samples, but they also can be used in small quantities for ultraclean decontamination procedures. PBW and VPBW contain about 0.1 mg/L of organic carbon (NWQL Technical Memorandum 92.01--unpublished document available from NWQL, 5293 Ward Road, Arvada, CO 80002), but analyses could differ among lots.

[14]Glass is the preferred standpipe material for decontaminating pump equipment because it does not readily absorb contaminants (Reynolds and others, 1990), especially if used repeatedly after equipment exposure to volatile organic compounds.

[15]Contact District Safety Officer for suppliers and specifications.

[16]Acrolein requires careful acidification to pH between 4 and 5 (acrylonitrile can withstand acidification to pH less than 2).

[17]Only required if sample water for VOC analyses is chlorinated; ascorbic acid will be supplied with the VOC preservative kit (NWQL) upon request. Otherwise, obtain ascorbic acid from the OM. DO NOT SUBSTITUTE SODIUM THIOSULFATE for ascorbic acid.

[18]Ultrapure nitric acid also available in 1-mL glass or Teflon ampoules.

[19]Purchase standards that bracket water-quality sample values.

[20]Prepare dissolved-oxygen standard solution fresh on day of use instead of repeatedly purchasing and discarding commercially available solutions.

[21]For assistance with (1) isotope, radiochemical, and other specialized equipment, contact the NAWQA Quality Assurance Specialist; (2) solid-phase extraction equipment, contact the NWQL, Methods Research and Development Program; and (3) chlorofluorocarbons (CFCs), contact Niel Plummer or Ed Busenberg, USGS National Research Program, MS 432, Reston, VA 22092.

Equipment not commonly provided by the Study Unit or USGS suppliers usually can be obtained on the open market (table 3, OM under supplier) and includes portable pumps for collecting samples at monitoring wells, and field instruments, vehicles, and storage facilities associated with ground-water-quality data collection. Each of these items is discussed separately below.

Pump systems

Several low-discharge, submersible pumps are available for collecting water-quality samples from wells. These pumps contain sample-wetted parts that consist mainly of Teflon and corrosion-resistant 316-stainless steel. On the basis of pump characteristics and results from decontamination tests (F.D. Wilde, U.S. Geological Survey, written commun., 1995--see footnote 1) these pumps are suitable for collecting a wide array of samples, including those required for NAWQA (table 1).

Use of low-discharge, submersible, portable pumps (such as the Fultz Model No. SP-300, Keck Model No. SP-84, Grundfos Model No. Redi-Flo2, and Bennett Model No. 180 or 1800) is required for NAWQA when sample collection from monitoring wells involves microgram-per-liter concentrations of VOCs, pesticides, or possibly trace elements. These pumps also are suitable for the collection of major ion, nutrient, and selected radionuclide samples.

From among suitable pump types, the choice for each Study Unit comes down to weighing the differences in pump performance characteristics (for example, pump diameter, lift capability, flow rate, portability, repairability, and power requirements) against characteristics of wells in the network (for example, well internal diameter, accessibility, purge volumes and times, and lift requirements) to determine the pump(s) that best meet Study-Unit needs. This decision process is illustrated for three pumps and shallow wells (table 4). (A similar process can be used to evaluate other pumps and deeper wells than those illustrated in table 4.) To select which of these pumps best meets sampling needs, the Study Unit can compare selected pump characteristics--primarily lift potential and pumping rate--with anticipated well or site characteristics--primarily depth to water level (lift), purge volume, and purge time (which, for practical reasons, is best kept to less than about 2 hours). If more than one pump type is adequate, other factors, such as repairability, power requirements, or cost can be used to refine the selection process. If most wells can be sampled with one pump type, and only a few wells require a second pump type (for example, deep wells), the Study Unit should consider collaborating with other Study Units or projects within the District to obtain the second pump to collect samples. (Well development is not at issue in this discussion. Pumps to be used for the collection of water-quality samples are not designed, and should not be used, to develop wells.)

Table 4. Example of a method to determine pump-system suitability as a function of selected well and pump characteristics

[in, inches; ft, feet; gal, gallons; ---, not applicable]

Well characteristics					Pump characteristics and suitability	
Well	Diameter (in)	Water-column height (ft)	Required purge volume[1] (gal)	Required lift or total dynamic head[2] (ft)	Maximum pumped volume at given lift in 2 hours for indicated pump system[3,4]	Pump-system suitability[5,6]
1	2	20	10	25	120 (Fultz SP-300)	Suitable
1	2	20	10	25	144 (Keck SP-84)	Suitable
1	2	20	10	25	840 (Grunfos Redi-Flo2)	Suitable
2	4	60	118	75	96 (Fultz SP-300)	Unsuitable
2	4	60	118	75	132 (Keck SP-84)	Suitable
2	4	60	118	75	768 (Grunfos Redi-Flo2)	Suitable
3	2	40	20	160	---[7] (Fultz SP-300)	Unsuitable[7]
3	2	40	20	160	---[7] (Keck SP-84)	Unsuitable[7]
3	2	40	20	160	538 (Grunfos Redi-Flo2)	Suitable

[1]**Required purge volumes** (in gallons) as a function of well diameter and water-column height.

Well diameter (in inches)	Water-column height (in feet): 20	40	60	80	100	120	140	160	180	200	240	260
	Required purge volume (in gallons)											
2	10	20	29	39	49	59	69	78	88	98	108	118
4	39	78	118	157	196	235	274	313	353	392	431	470
6	88	176	264	353	441	529	617	705	793	881	969	1,058

Where **purge volume** equals three times the borehole or casing volume. The borehole or casing volume, V (in gallons), is calculated as $V = 0.0408 \times H \times D^2$, where H is the **water-column height** (in feet), and D is the well **diameter** (in inches).

[2]In these examples, the **required lift** is equivalent to total dynamic head and is estimated as the depth to water in the well. This assumes that the purge takes place with the pump intake at the top of the water column, and that the water level in the well does not decline appreciably with pumping. Note that for submersible pumps (for example, helical rotor gear, progressing cavity, bladder, and piston pumps) Lift = pump depth + frictional tubing loss; for centrifugal-pump designs, this is more accurately described as total dynamic head (TDH), where TDH = depth to water + frictional tubing loss.

Table 4. Example of a method to determine pump-system suitability as a function of selected well and pump characteristics--Continued

[3]**Maximum pumped volume** is calculated using the pumping rate for a given pump system from manufacturer's specifications at the required lift (or TDH) multiplied by an assumed purging time of 2 hours.

Example pumping rates in gallons per minute (gpm) as a function of lift (TDH) for selected pump systems from manufacturer's specifications. With antibacksiphon device, extension lines, and directional-control flow valves that follow pump-reel system, effective pumping rate is assumed to be 80 percent of that given by the manufacturer. Actual rates, particularly as lifts approach the limit of each system, could be less than those specified.

	Lift (in feet)											
Pump system	0	25	50	75	100	125	150	175	200	225	250	275
	Pumping rate (gpm)											
Fultz Model No. SP-300	1.1	1.0	0.9	0.8	0.7	0.5	0.4	---	---	---	---	---
Keck Model No. SP-84	1.3	1.2	1.2	1.1	1.0	0.9	0.8	---	---	---	---	---
Grunfos Model No. Redi-Flo2	7.2	7.0	6.7	6.4	6.0	5.7	5.0	4.4	3.8	3.0	2.1	---

Example **maximum pumped volume** (gal) as a function of lift for the three pump systems given above, assuming pumping time is 2 hours.

	Lift (in feet)											
Pump system	0	25	50	75	100	125	150	175	200	225	250	275
	Maximum pumped volume in 2 hours (in gallons)											
Fultz Model No. SP-300	132	120	108	96	84	60	48	---	---	---	---	---
Keck Model No. SP-84	156	144	144	132	120	108	96	---	---	---	---	---
Grunfos Model No. Redi-Flo2	864	840	804	768	720	684	600	538	456	360	252	---

[4]For practical reasons, and except when quality-control samples are taken, field teams aim to complete all activities at each well within 4 to 6 hours. Thus, purge times generally need to be kept under 2 1/2 hours, with the pumping rate during the last half hour equal to the sampling rate (no more than about one tenth of a gallon per minute).

[5]Pump-system suitability is determined as follows:

Suitable if the **maximum pumped volume** at a given lift (or TDH) in 2 hours for the indicated pump type is equal to or greater than the **required purge volume**.

Unsuitable if the **maximum pumped volume** at a given lift in 2 hours for the indicated pump system is less than the **required purge volume** or if the **required lift** (or TDH) exceeds the maximum for the pump.

[6]When two or more pump types meet requirements outlined above, other factors considered in pump selection include ability of pump system to be decontaminated adequately, portability, susceptibility of pump to seizure, ease of repair and use in the field, and cost. It is assumed comparison is among pumps that are constructed and can be operated in a manner suitable for NAWQA sampling.

[7]**Required lift** exceeds maximum lift of the pump; therefore, pump is unsuitable under conditions given in this example.

Regardless of the pump type chosen, the pump system (pump intake, tubing, and reel) must meet certain requirements. The pump can be purchased without an antibacksiphon because a suitable antibacksiphon is to be added by the Study Unit (table 3). The pump line should be solid, high-density Teflon tubing. Teflon-lined polypropylene or other tubing is not recommended because the exterior tubing often is not as inert as Teflon. In addition, the outer tubing can separate from the Teflon lining, causing the thin-walled Teflon tubing to pinch or collapse. Suitable pump tubing can be ordered in 50-ft segments connected with 316-stainless steel (SS-316) quick connections, which makes it possible to use the shortest length of tubing needed for each well. In addition, it is recommended that the reel that holds the tubing be designed to turn (while raising or lowering the pump intake and tubing), while the pump is in operation, and while the pump-reel outlet is connected to an extension line that runs to the remainder of the sample-collection setup.

Other types of equipment (bailers, bladder pumps, peristaltic pumps) can be considered for some site conditions, or special data-collection needs. The use of such equipment generally is not recommended. Most alternative sample-collection devices are either limited in their lift potential, constructed of materials that are unsuitable or difficult to decontaminate, or deliver the sample in a manner (for example, under suction) that they cannot be used for most sites, or do not provide data of suitable quality for all NAWQA constituents (F.D. Wilde, U.S. Geological Survey, written commun., 1995--see footnote 1).

Study Unit staff that need to collect ground-water-quality samples using equipment other than that specified (table 3) must discuss their plans with the NAWQA QA Specialist. At a minimum, it is expected that sufficient QC data are available, or will be collected, to verify that the ground-water data obtained with the alternative equipment is similar in quality to data being obtained by the NAWQA Program in general.

Field instruments

Each Study Unit is to obtain suitable field instruments to collect data for pH, specific electrical conductance (SC), dissolved oxygen (DO), and temperature (T). If samples for trace elements (such as iron, manganese, aluminum, or uranium) are collected, sample turbidity (TU) also is measured. These data (pH, SC, DO, T, and possibly TU) are part of the required water-quality record for each ground-water sampling site (table 1), and also serve as QC measures that are used to assess the chemical variability of water before and at the time samples for other chemical constituents are collected. In collecting these data, however, the field instruments used must meet certain requirements (table 5).

Table 5. Requirements for meters and sensors used for field measurements taken at ground-water-quality sites of the National Water-Quality Assessment Program (modified from Radtke and Wilde, in press)

[°C, degrees Celsius; mV, millivolt; Δmv/ΔpH, change in millivolts divided by change in pH at measurement temperature (in °C); ≥, greater than or equal to; µS/cm, microsiemens per centimeter at 25°C; ≤, less than or equal to; >, greater than; mg/L, milligrams per liter; NTU, nephelometric turbidity units; NWIS-I, National Water Information System-I]

Field measurement	Performance requirements
Temperature (°C) (recommend thermistor-type thermometer)	Reading to 0.1°C for temperatures from -5 to 45°C; bias within 0.2°C. (Requirement applies to any thermistors used in association with other field measurements, including those contained in other field-measurement systems. Sampling thermal systems can require readings and calibration to 52°C.)
pH (standard units; require electrometric method) and field titrations	Reading to 0.1 standard unit (or 0.05 unit for instruments that display more than two digits to the right of the decimal). Temperature compensating; mV readout; rapid electrode response--maximum 15- to 20-second elapsed time for reading to "lock-on" the low pH calibration buffer after meter is calibrated with high pH 7 buffer; pH electrode must pass slope-test [(Δmv/ΔpH) ≥ 0.94 x (Theoretical Nernst slope)], corrected for temperature.[1]
Specific electrical conductance (µS/cm at 25°C)	Reading within 5 percent of full scale at ≤100 µS/cm or within 3 percent of full scale at >100 µS/cm; temperature compensation range from -2 to 45°C or greater, if needed. Instrument must compensate for temperature to provide readings at 25°C, or temperature readings are required to apply correction factor and report measurement at 25°C.
Dissolved oxygen[2] (require amperometric method)	Reading to 0.3 mg/L or less for concentrations ≥1 mg/L. Temperature compensation and temperature measurement required. Field barometer needed to determine barometric pressure correction factor.
Turbidity (recommend nephelometric method)	Select instrument designed to provide precise and unbiased measurements at 0 to 40 NTU. Reading within 5 percent full scale for 1 to 500 NTU, and within 0.02 NTU for turbidity less than 1 NTU. Turbidity entered into the NWIS-I data base must be made using nephelometric measurements.

[1]Slope test and temperature correction are described in Radtke and Wilde (in press).

[2]Use spectrophotometric or iodometric method for accurate measurements of dissolved-oxygen concentrations less than 1 mg/L (Radtke and Wilde, in press).

Water levels are to be determined whenever possible before other water-quality data are collected from wells (Lapham and others, in press). The static water level within a few hundred feet below land surface is measured using a chalked steel tape, and the measurement is repeated until two consecutive measurements differ by no more than 0.02 ft, or until the reason for less precise measurements is determined and documented. In addition, the depth from land surface to the bottom of the well is measured during each site visit whenever possible to verify the integrity of the well construction.

Each field instrument must be calibrated, operated, maintained, and stored, and the necessary calibration and test results documented according to USGS protocols. The protocols for ground-water-quality field measurements are described in Radtke and Wilde (in press).

Water-quality vehicles

Different vehicle designs will be used among Study Units because of differences in terrain, accessibility of sites, travel distances, trip duration, and other factors. In selecting and modifying a vehicle for water-quality data collection, however, it is recommended that safety and quality control be given high priorities. Study Unit staff also are encouraged to research designs already in use and to dedicate vehicle(s) solely to the collection of water-quality data.

Safety is a vital concern. The most important thing a water-quality vehicle will carry is the field team. To protect the team, all equipment is secured and properly stored behind passenger barriers when in transit, and without affecting the driver's visibility. In addition, vehicle supplies should include safety cones; safety glasses; fire extinguishers; first-aid, eye-wash, and chemical-spill kits; and Material Safety Data Sheets--all placed where they are readily accessible. If sample collection or processing occurs inside the vehicle, ventilation must be adequate and there must be sufficient room to operate. Flex hose is used to vent combustion exhaust away from a vehicle that is stationary with the engine running, and is stored and transported outside of the sampling vehicle. Flammable solvents (such as methanol) and pressurized gases (such as nitrogen) are transported according to local and State regulations. Regular service and maintenance and before-departure safety inspections of the vehicle are scheduled by the field team. If questions arise in regard to safety or inspection procedures, methods, or equipment, contact the District safety officer.

Quality assurance of the sampling vehicle is critical to a successful investigation. This vehicle should enable the field team to collect high-quality samples and data. Despite diverse external conditions, the vehicle should provide a clean environment for sampling and equipment, and a suitable environment for protecting equipment from damage during transport. The vehicle design also should provide temporary protection of field instruments, chemical reagents, buffers, preservatives, standards, and most water-quality samples from extreme heat and cold. It also must provide for the temporary (and contaminant-free) storage of some samples (VOCs, pesticides, nutrients), and some reagents (for example, spike solutions for pesticides and VOCs and VOC acid preservative) at near-freezing temperatures. If the vehicle interior is used for the collection or processing of water-quality samples, then adequate lighting, plumbing, and counter space are needed. Sample collection and preservation chambers are used whether working inside or outside the vehicle. These reduce contamination of and from the vehicle interior.

Obtain and design vehicles that can be dedicated solely to water-quality sampling. A vehicle used for water-quality data collection is not used for the storage (even temporary) of a generator using gasoline or other types of fume-producing fuels, or of heavily soiled equipment, clothing, or tools. Nor should a vehicle previously used for such storage be converted to a water-quality vehicle. One might even question the adoption of a used water-quality vehicle if samples were collected and, in particular, preserved within the vehicle without regard to possible vehicle contamination. In each case above, there is a risk that the vehicle will be, or has been, permanently contaminated.

Storage facilities

Field vehicles are not suitable for storage of most supplies and some equipment used for water-quality data collection. When not in operation, the vehicles cannot provide adequate protection from extreme heat or cold, which can destroy or degrade chemical standards, buffers, and other reagents, as well as damage some field instruments. Especially during extremes in temperature, remove sensitive supplies and equipment from an idle vehicle to a safe indoor location on a daily basis. Clean and secure facilities, which are separate from those used for other types of NAWQA equipment (such as generators, fuel, drilling supplies and materials, and permanently soiled gear), are needed for longer periods of storage.

Timing of purchases

Durable equipment and supplies (such as vehicles, pump systems, plastic bottles) are ordered well in advance of the first field season, and thereafter on an as-needed basis. Begin vehicle purchase and modification(s) 12 to 14 months before the vehicle is needed for water-quality data collection. Nonperishable, and limited quantities of perishable supplies (see below) are purchased and on hand at least 3 to 6 months before water-quality data collection begins. Pump systems and other sample-collection equipment also can take up to several months to obtain, assemble, and modify to complement vehicle design.

Some supplies, such as most chemical solutions, have a limited shelf life. As part of their planning, Study Units should (1) follow manufacturer's recommendations on storage, and (2) query their suppliers about shelf life for any preservatives, buffers, standards, and reference samples, as well as for blank, spike, surrogate, and instrument-sensor solutions, or any other chemical reagents. This will prevent overstocking and reduce waste. Upon receiving these supplies, the date of receipt and the expiration date should be marked clearly on time-sensitive supplies. Study Units also are required to record supply lot numbers. Without these records, the QA and QC information that exists for these supplies, and provided by lot number, cannot be utilized by the Study-Unit or NAWQA National Program. This is one of the quality-assurance measures that could be needed to correctly interpret water-quality QC data.

Study-Unit staff are likely to select the most appropriate vehicle design, pump system, and related equipment after information from site visits is obtained, and after sampling teams have had some training (see "Training" below). Following training, the field teams need their equipment and supplies for practice, and to verify that they are suitable for water-quality data collection (see “Field Evaluation” below). Therefore, most nonperishable equipment and supplies need to be on hand at least 3 to 6 months in advance of the first field season of data collection.

Training

Modifications in USGS protocols and recommended procedures (F.D. Wilde, U.S. Geological Survey, written commun., 1995--see footnote 1), and the need for consistency dictate that training in the collection and management of water-quality data is required for most Study-Unit staff. This training is to be obtained through USGS Level I courses and field experience, ideally before water-quality data collection begins (table 6).

Field Evaluation

Each Study Unit is required to test and evaluate the sample-collection equipment and procedures that commonly will be used (table 6, no. 4). This is separate from, and occurs after, the field training with Study-Unit equipment. To avoid unnecessary delay in planned data collection while awaiting laboratory results, this test should be conducted at least 2 months before sample and data collection begin. Ideally, the evaluation can occur toward the end or after the field exercise devoted to equipment shakedown and cross-training (table 6, no. 3).

To conduct the test, the Study Unit selects a well with measurable concentrations of as many of the following contaminants as possible: VOCs, pesticides, nutrients, and (if targeted for investigation by the Study Unit) trace elements. The field team collects samples for all constituents (in the order and manner in which samples commonly are going to be collected--see “Sample Collection and Processing”). After sample collection, equipment is decontaminated. Field blanks for all constituents are collected with the decontaminated equipment. Two field-spiked, blank samples are prepared for the VOC schedule and for each pesticide schedule. One blank sample for the VOC schedule is spiked by one field-team member, and its replicate is spiked by the other field-team member. One field-team member also spikes the blank sample for one pesticide schedule; the other field-team member spikes the other blank sample for the second pesticide schedule. (Definition of QC samples is provided in “Design of Quality-Control Sampling and Schedules.”) All ground-water-quality samples and QC samples are sent to the NWQL for analysis.

Data from the ground-water-quality and QC samples are evaluated by the Study Unit, and the evaluation and data are forwarded as soon as possible to the National Program (NAWQA QA Specialist). These data are to confirm that (1) the ground water contained measurable levels of some contaminants, (2) decontamination procedures removed contaminants from equipment, and (3) the procedures used to prepare spiked blanks led to acceptable recoveries of selected VOCs and pesticides.

The evaluation assures the field team, Study Unit, and National Program that the protocols and procedures are satisfactory. Potential problems identified by the Study Unit(s) are corrected before sample and data collection begins.

Table 6. Recommended sequence of training-related activities to prepare for National Water-Quality Assessment (NAWQA) Program ground-water-quality data collection

[USGS, U.S. Geological Survey; QC, quality control; NWQL, National Water Quality Laboratory]

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1. Determine data-collection and management training needs.

- Review protocols and recommended procedures (this report).
- Review National Field Manual (Radtke and Wilde, in press).
- Incorporate possible modifications to above (commonly described in NAWQA or USGS internal memorandums).

2. Train field team(s) and data-management personnel accordingly and formally.

- Through USGS Level I and higher level training courses.[1] Field Water-Quality Methods for Ground Water and Surface Water (G0282) currently is required for at least one member of each team placed in field for data collection. It is recommended that at least one member of the Study-Unit staff attend the course Quality-Control and Sample Design and Interpretation (GO342). (A field team is assumed to consist of two people.)
- Take data-collection and QC training courses early, ideally in the fiscal year before intensive data collection begins.

3. Enhance and reinforce formal training.[2]

- New field team(s) can accompany or temporarily employ experienced (mentor) teams from another Study Unit that is completing data collection in the fiscal year before the new team will begin data collection. Select mentors on the basis of similarities in types of wells, terrain, equipment, and other factors that the two Study Units have in common.
- New field team(s) should practice data collection with equipment that will be used, and alternate activities to ensure each team member is cross-trained in all aspects of data collection.

4. Evaluate data-collection protocols, recommended procedures, and equipment.[3]

- Conduct data collection at a contaminated well at least 2 months before any water-quality data collection begins. Include field blanks and field-spiked source-solution blanks. Submit ground-water-quality and all QC samples to NWQL for analysis.
- Evaluate and share results with the National Program. (See text for further discussion).

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[1]The Level I course provides individual training in ground-water-quality and surface-water-quality data-collection protocols and procedures that include those for the National Water-Quality Assessment Program. Other courses can be taken that cover data management and analysis, such as that recommended for QC.

[2]Because modifications to protocols and recommended procedures are likely to occur, training without taking the formal course currently is not considered an acceptable substitute for all members of a field team.

[3]See discussion in section entitled "Field Evaluation."

Design of Ground-Water-Quality Sampling Schedules

As part of planning for field sampling, schedules are prepared annually or more frequently, if needed, for the collection of ground-water-quality and QC data for each ground-water component (Study-Unit Survey, Land-Use Study or Flowpath Study) targeted for investigation each year. These schedules list the daily activities for the field team, data managers, and support staff.

For ground-water-quality samples, the schedule describes the timing and order in which wells for each ground-water component are targeted for data collection (table 7). General scheduling considerations include component factors, travel times, personnel requirements, and site conditions (table 8). Each schedule is designed over a period of several months, and before any ground-water-quality samples are collected.

Study Units will pay particular attention to factors that enhance the consistency and quality of samples and data obtained and provide the Study Unit and National Program with the necessary data to determine the quality and suitability of data collected for NAWQA assessments (table 9). The design and scheduling of QC data collection, which are critical and integral parts of water-quality data and data collection (Shampine and others, 1992), are discussed in detail in the next section. For most of the other factors (tables 8 and 9), it is assumed that the information needed is obtained through staff planning meetings and site visits conducted before data collection begins.

As a general rule, except for Flowpath Studies, most Study Units will find that a single, two-person field team often needs a day to conduct data-collection activities at one well. With experience, and under the optimum field conditions, some teams will be able to collect data from more than one well per day. In the case of Flowpath Studies, the close proximity and shallow depths of wells also could permit sampling at more than one well per day. In addition, wells targeted for QC data collection could require an additional team member to complete activities in a single day.

Table 7. Example of a sampling schedule for a 28-well Land-Use Study

[Assumes (a) one (two-person) field team generally collects samples on a weekly run (Monday-Thursday); (b) incorporation of general scheduling considers component factors, travel times, personnel, and site conditions (table 8), as well as requirements to enhance data quality (table 9); and (c) routine quality-control sampling occurs at selected wells distributed throughout the collection period (third person possibly joins team). SRS, standard reference samples for trace elements; VOC, volatile organic compound]

Period of activity		Activity to be conducted by team
Week 1	Day 1 (M)	Depart for Well 1: collect ground-water (GW) samples.
	2 (T)	Well 2: Collect GW and quality-control (QC) samples.
	3 (W)	Well 3: Collect GW samples.
	4 (Th)	Well 4: Collect GW samples, return to office, unload vehicle.
	5 (F)	Evaluation and preparation: Study Unit reviews progress, plans, sampling schedule, and completes final preparations for following week's activities.
Week 2	Days 8-12	Wells 5-8: Similar schedule as week 1, but without QC data collection.
Week 3	Day 15 (M)	Well 2: Review QC data and continue sampling if no problems appear; decision to sample two wells per day when possible is made.
	16 (T)	Team and staff complete preparations, team departs office.
	17 (W)	Well 9: Collect GW and QC samples (including one SRS).
	18 (Th)	Wells 10 and 11: Collect GW samples.
	19 (F)	Team returns to office and, aided by staff, unloads and cleans vehicle.
Week 4	Days 22-26	Wells 12-15: Similar to schedule for week 2.
Week 5	Day 29 (M)	Well 9: Review QC data and continue sampling if no problems appear. Team, aided by staff, completes preparations, and departs office.
	30 (T)	Wells 16 and 17: Collect GW samples.
	31 (W)	Well 18: Collect GW samples.
	32 (Th)	Well 19: Collect GW and QC samples (with VOC trip blank, as planned); team returns to office late in day.
	33 (F)	Team and staff unload, clean, and restock vehicle.
Week 6	Days 36-40	Wells 20-23: Similar to schedule for week 2.
Week 7	Day 43 (M)	Well 24: Team departs office, collects GW samples.
	44 (T)	Well 25: Collect GW samples.
	45 (W)	Wells 26 and 27: Collect GW samples.
	46 (Th)	Well 28: Collect GW and QC samples, team returns to office and with staff unloads and cleans vehicle.
	47 (F)	Vehicle goes in for regular service and maintenance.
Week 8	Day 50 (M)	Team and staff receive QC data (wells 19 and 28). If QC data are satisfactory, sample collection continues unabated. Team and staff prepare for next component to be sampled. Remaining two SRS samples needed for the year will be included in data collection for the next component.

Table 8. Basic considerations in designing annual ground-water-quality sampling schedules for Study-Unit components (Land-Use Studies, Study-Unit or Subunit Surveys, and Flowpath Studies) of the National Water-Quality Assessment Program

1. **Component factors**
   - Number of each type of component.
   - Number of wells per component.

2. **Travel times**
   - Between office and wells.
   - Between wells.
   - Between well and overnight shipping sites.

3. **Personnel**
   - Number of field teams.
   - Number of individuals per team (generally consider two members; possibly third person at wells that include QC sample collection).
   - Experience of personnel in team.
   - Office staff support.

4. **Site and seasonal conditions**
   - Equipment setup time (water-supply or monitoring well).
   - Purge time.
   - Data-collection requirements (ground-water quality only or ground-water quality and quality control).
   - Duration of field season.

Table 9. Requirements for the design of National Water-Quality Assessment Program ground-water-quality sampling schedules to enhance data quality

[QA, quality assurance; QC, quality control; VOC, volatile organic compound; NWQL, National Water Quality Laboratory; µg/L, micrograms per liter]

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1. **Schedule to avoid seasonal or other problems in data used for spatial analysis**
   - Except for Flowpath Studies, collect all samples for all components in shallow-depth wells between late spring and early fall if those samples include seasonally-applied chemicals.[1]
   - Except as noted below, complete sampling for a given component in the shortest time possible, and before the same field team begins data-collection at another component.

2. **Integrate quality-assurance and quality-control (QA and QC) data collection** into each component schedule
   - Conduct QA procedures and collect QC data at selected sites in each component throughout the period of water-quality data collection.

3. **Set reasonable performance levels;** initially, collect samples at one well per day for Land-Use Studies (or Study-Unit Survey) so that:
   - With time and experience, the long-term average could approach two wells per day.
   - Wells selected for QC data collection typically will require a full day and possibly an additional person.
   - Sampling at more than two wells per day could be possible, particularly for Flowpath Studies (shallow-depth wells in close proximity).

4. **Avoid over-specialization**; schedule frequent rotation of duties among the field-team members
   - Prepare for unexpected absences to prevent a halt in sampling, or the collection of potentially poor-quality data.

5. **Schedule data collection at wells known or suspected of having high (greater than 10 µg/L) VOC or pesticide concentrations** near the end of the data-collection period to avoid cross-contamination of other wells or samples
   - Take additional field blanks to check that equipment is decontaminated before the same equipment is used at another well.
   - Notify NWQL (on Analytical Service Request form--comment to laboratory line) if it is known or suspected that VOC or pesticide concentrations are expected to exceed 10 µg/L.

6. **Plan for resampling**, regardless of whether or not it can be anticipated
   - Despite the best planning, teams sometimes find they are inadequately equipped for data collection..
   - Data-quality reviews could indicate resampling is necessary.
   - Resampling is recommended near the end of the fiscal year (first week in September).

7. **Provide time for data review, schedule revision, and equipment maintenance**, if the component consists of 20 or more wells, which generally will require 2 or more months to sample
   - With intermittent periods (day or two in length) of no data collection.
   - To review progress, make scheduled revisions, and discuss QC data.
   - To restock, maintain, repair, or replace equipment and supplies.

8. **Schedule data collection to avoid exceeding sample-holding time**, which begins when the sample is collected, and ends with sample analysis
   - Holding times for water samples of radon, nutrients, pesticides, and VOCs are the shortest--3, 5, 7, and 14 days, respectively.
   - From late spring to early fall (the peak analysis period) at least half the holding time can expire **after** samples are logged in at the NWQL.
   - Because radon has a short half-life (3.6 days), samples for this element should not be collected on a Friday, unless they can reach the NWQL by noon on that Friday.

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[1]Pesticide concentrations measured in ground water nationwide appear higher and more uniform throughout this period than the concentrations measured from late fall to early spring (J.E. Barbash and E.A. Resek, in prep., Pesticides in Ground Water; Distribution, Trends, and Governing Factors: Ann Arbor Press, Chelsea, Mich.).

Design of Quality-Control Sampling and Schedules

Each Study Unit is required to collect similar types of QC samples (table 10). Those that are collected regularly throughout each field season are referred to as "routine QC samples." Additional QC samples, referred to as "topical QC samples," occasionally could be collected by some or all Study Units to isolate and resolve problems or evaluate modifications to NAWQA field methods.

The data obtained from routine or topical QC sampling are used to estimate the potential bias (either from contamination or in recovery) and measurement variability for selected analytes. Routine QC samples provide the data required by the NAWQA Program to make general inferences about bias and variability for all water-quality data collected. Bias and variability measurements from routine QC samples reflect combined field and laboratory errors that occur during data collection. Measurements obtained from topical QC sampling will reflect errors associated with a specific field or laboratory procedure employed by NAWQA and targeted for study.

Study Units can use QC data in several ways. Those that can derive bias and variability estimates from routine QC sampling in a timely manner can use the results not only to assess the quality of data being collected, but also, in some cases, to identify wells that need to be resampled (Koterba and others, 1991). In the case of topical QC data, sources of sample contamination or bias that occur as a result of sample collection and processing, initially identified through routine QC sampling, can be isolated and eliminated (Rea, in press; Koterba and others, 1991).

Bias and variability estimates also can be used during data analysis and interpretation of ground-water-quality data. For each ground-water component, the magnitude of these error estimates provide an indication of the quality of ground-water data collected (Koterba and others, 1991 and 1993). In addition, as water-quality data from different Land-Use Studies or Subunit Surveys are compared, contrasted, or combined, the corresponding routine estimates of bias and variability from QC data also can be compared, contrasted, and combined to make inferences about the quality and suitability of the aggregated water-quality data that are being used for Study-Unit or National Assessments.

In some cases, data analysis and interpretation can depend on the timely analysis of routine and topical QC data obtained in the field combined with timely discussion of these data with the National Program and the NWQL. Examples of the above, which led to modifications in Study-Unit field methods and in the QC sampling design, and ultimately improved data quality, analysis, and interpretation include studies by Ferree and others (1992) and Koterba and others (1994). Their experience indicates how critical it is for Study-Unit plans to remain flexible. These plans must allow for the possible modification of the initial designs for routine QC sampling (as described below), or the methods used to collect these and ground-water-quality samples (described later in this report). Such modification could prove critical to correctly identifying the occurrence and distribution of contaminants in ground water and their relation to Study-Unit landscape and subsurface features.

Table 10. Quality-control samples for ground-water components of the National Water-Quality Assessment (NAWQA) Program

[Definitions are consistent with those of the U.S. Geological Survey Branch of Technical Development and Quality Systems (BTD&QS) and the Office of Water Quality. NWQL, National Water Quality Laboratory; VOCs, volatile organic compounds]

Sample type	Description	Purpose
1. Blanks[1]	Types include field, source-solution, and trip.	Assess bias from contamination of blank water.
•Field	Blank water passed through equipment in the field, and collected in a manner similar to that used to collect water-quality data, but after equipment is used and decontaminated.	Verify that decontamination procedures are adequate, and that field and laboratory protocols and recommended procedures do not contaminate samples.
•Source solution[2]	Blank water placed directly in the sample container, but in a clean environment.	Verify that blank water is contaminant-free just before it is used for a field blank.
•Trip	Blank water placed in sample container by NWQL, shipped to study with empty containers, and returned unopened by Study Unit from field for analysis.	Verify that shipping, handling, and intermittent storage of containers does not result in contamination or cross-contamination of samples.
2. Replicates[3]	Two or more ground-water-quality samples collected sequentially for the same analytes.	Assess combined effects of field and laboratory procedures on measurement variability.
3. Field spikes[4]	Types include samples prepared from blank water or from ground water.	Assess recovery bias of analytes in spike solution.
•Source-solution water[5]	Two source-solution blanks to which identical volumes of spike solution are added, but by different members of field team. For VOCs, preserve with NWQL acid before spiking.	Verify equipment and procedures for field spiking, handling, shipping, and analysis lead to similar results among Study Units.
•Ground water	Two or more replicate ground-water-quality samples to which identical volumes of spike solution are added in a manner that does not substantially alter sample matrix. For VOCs, preserve with NWQL acid before spiking.	Assess recovery bias and variability in relation to different ground-water matrices.

Table 10. Quality-control samples for ground-water components of the National Water-Quality Assessment (NAWQA) Program--Continued

Sample type	Description	Purpose
4. Standard reference (mixtures)	Prepared by BTD&QS as mixtures, sent to Study Units collecting trace-element samples, shipped unopened from field to NWQL for analysis.	Assess recovery bias and variability of selected trace elements.

[1]Blank water is certified by supplier as free of analytes of interest at concentrations that exceed NAWQA detection or reporting level. A trip blank is only required for VOCs.

[2]Because blank solutions are not regularly analyzed for dissolved organic carbon (DOC), source-solution blanks are required along with field blanks for this analyte. A source-solution blank for DOC is required each time a field blank for DOC is taken.

[3]Chemical composition of water entering the well and being collected is assumed constant during time needed to collect sequential samples (including replicates).

[4]Spike solutions for NAWQA contain either selected VOC or pesticide analytes; solutions are obtained and used in accordance with instructions from the NWQL. At least one unspiked (background) ground-water sample from the same well used to obtain the samples for field spikes is analyzed in conjunction with field-spiked samples (see text).

[5]Preserved and spiked source-solution blanks for pesticides and VOCs are prepared only as part of the initial evaluation of equipment and procedures before data collection begins.

Routine quality-control samples: type, number, site selection, and timing

The current NAWQA QC sampling design for ground water is based on the integrated approach described by Shampine and others (1992). Under this design, it is recommended that each Study Unit follow similar procedures (tables 11 and 12) to identify (1) the types of routine QC samples collected, (2) the wells at which these samples will be obtained, and (3) the timing of QC sample collection for each of the ground-water components scheduled for data collection in each field season. These procedures ensure that the data obtained for each routine QC sample type (1) represent major differences in the major ion chemistry (sample matrix) of ground water targeted for study, (2) are suitable for estimating measurement bias and variability for the analytes of interest, and (3) reflect possible temporal variations in field and laboratory methods during the time period that ground-water-quality data are collected (table 13).

It would be ideal in terms of planning, efficiency in the field, and costs **if similar routine QC designs** could be used for **all** ground-water components. Because Land-Use Studies, Study-Unit (or Subunit) Surveys, and Flowpath Studies differ in their design and scope, the types and numbers of routine QC samples, the wells selected for collecting these samples, and the timing of visits to the wells selected will differ somewhat among these components.

It would be ideal in terms of planning, efficiency, and costs if **all** routine QC samples could be collected at the **same** well sites for each ground-water component. Representative and suitable QC data, however, often can only be obtained by scheduling the collection of different types of routine QC samples at different wells within a given component (see below), or, in the case of the VOC trip blank and (possibly) trace-element standard reference samples, at wells selected from among several components sampled in the same field season (table 13, footnote 1).

Land-Use Studies. A typical Land-Use Study is focused primarily on one major land-use classification, and for ground water, involves the collection of samples for a variety of analytes (table 1) from each of a relatively small number of wells (about 30, including reference wells) completed at shallow depths and often in a single aquifer. Therefore, a typical design for routine QC data collection requires the collection of many different QC sample types to cover the variety of analytes being investigated (table 12). It also requires a minimal number of samples for each QC-sample type because differences in the quality of ground water among wells are assumed to reflect chiefly the intensity of a single land use on the shallow part a single aquifer.

Some wells in the Land-Use Study will need to be chosen (if possible, and according to methods described later in this section) specifically to collect the required number of routine, replicate ground-water samples and routine field blanks (table 13). These wells are chosen, in part, because they are likely to provide samples with measurable (greater-than-method-reporting-level) concentrations. (Estimating the variability of measurements for a given analyte using replicate samples requires that these samples contain measurable, greater-than- or equal-to-method reporting-level concentrations for that analyte.) They also are selected, if possible, to provide a range in measurable concentrations that reflect the effects of that land use on shallow ground-water quality.

Table 11. Procedures to identify the type and schedule the annual collection of routine quality-control data for ground-water components of the National Water-Quality Assessment Program

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1. Identify analyte groups for which water-quality data will be collected that field season

- On the basis of national requirements (table 1).
- To which are added local Study-Unit interests, such as trace elements.

2. Identify routine quality-control (QC) data to be collected

- On the basis of the Study-Unit component (for example, see table 12).
- Determine QC sample types by analyte group to be collected.
- Determine number (or frequency) of each type to be collected.

3. Identify wells and develop schedules for routine QC data collection for each component[1]

- Select wells to provide suitable and representative QC data (see text and table 13).
- Schedule visits to these wells to provide QC data collection for each analyte group throughout the months that water-quality data for that analyte group and component are being collected (see text and table 13).

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[1]If volatile-organic-compound (VOC) and trace-element samples are collected during a given field season, then at least one VOC trip blank, in addition to field blanks and spiked replicate samples, and at least three trace-element standard-reference samples are sent from the field to the National Water Quality Laboratory for analysis.

Table 12. Required type and minimum number (or frequency) of routine quality-control samples for a Land-Use Study of the National Water-Quality Assessment Program

[Field blanks and field-spiked, source-solution blanks taken during the evaluation of methods are not included below. Assume study consists of 25 to 30 wells. Trace-element field blanks use National Water Quality Laboratory (NWQL) Schedule SC172 with selenium (LC0087) and arsenic (LC0112). All other routine quality-control samples use the same NWQL schedule or laboratory code used for the corresponding water-quality samples. DOC, dissolved (filtered) organic carbon; ALK, alkalinity (field-titration, filtered ground-water sample); and ANC, acid-neutralizing capacity (field titration, unfiltered ground-water sample; VOCs, volatile organic compounds]

Analyte group[a]	Routine quality-control sample type	Required number (frequency)
1. Commonly present in measurable concentrations: major ions, nutrients, and DOC. (ALK and ANC--replicates only)	**Field blanks**	Minimally at 2, but preferably at 3, well sites.
	Source-solution blanks	(Every time a DOC field blank is taken, only for DOC.)
	Replicate (2) ground-water samples per well	Minimally from 2, but preferably from 3 wells at different sites.
2. Commonly present in measurable concentrations in some, but usually not all, areas:		
• Pesticides or VOCs	**Field blanks**	Minimally at 2, but preferably at 3, well sites.
	Trip blank	(One per field season, only for VOCs.)
	Field-spiked, replicate (2) samples per well	Minimally at 2 well sites.
• Trace elements (such as NWQL SC2703)[b]	**Field blanks**	Minimally at 3 to 5 well sites.[c]
	Standard-reference-sample mixtures	(Three per field season.)
	Replicate (2) ground-samples per well	Minimally from 3 to 5 wells at different sites.
• Radionuclides (such as radon)	**Replicate (2) ground-samples per well**	Minimally from 3 wells at different sites.

[a]For tritium, deuterium-oxygen isotopes, or chlorofluorocarbons, contact a National Water-Quality Assessment Program Quality-Assurance Specialist.

[b]Through 1995, some Study Units collected and temporarily archived water-quality and quality-control samples.

[c]If trace-element concentrations of interest are low (less than 10 µg/L), collect the maximum number of field blanks, and the minimum number of replicate sample sets specified. For high concentrations, collect the minimum number of field blanks, and maximum number of replicate sample sets.

Table 13. Well- and site-selection criteria for routine quality-control samples collected for ground-water components of the National Water-Quality Assessment Program

[Field blanks and field-spiked, source-solution blanks taken during the evaluation of data-collection methods are not considered below. DOC, dissolved (filtered) organic carbon; VOC, volatile organic compounds; NWQL, National Water Quality Laboratory]

Routine QC sample type	Well (site) selection criteria for Study-Unit (or Subunit) Survey, or Land-Use or Flowpath Study ground-water components
Field blanks (all analytes, except radon)	Select wells where it is known or suspected that ground water (1) at each well contains measurable (greater-than-method-reporting-level) concentrations of most to all analytes and (2) collectively, for the wells chosen, reflects some of the diversity in ground-water-quality conditions (range in concentrations for these analytes) for which the ground-water component is designed.[a]
Source-solution blanks (DOC)	Use the same well sites selected for DOC field blanks (above) for each component.
Trip blank (VOC)	Sent from one randomly selected well site from among all well sites for all components at which VOC samples are collected during the same field season.
Replicate ground-water samples (inorganic analytes, radionuclides (radon), and DOC)	Use the same wells selected for field blanks (above) for each component.[a]
Field-spiked, replicate, ground-water samples (VOC and pesticides)	Select wells where it is known or suspected that ground water at each well (1) contains measurable concentrations of inorganic analytes and DOC (similar to those found at routine QC sites selected for field blanks and replicate ground-water samples), but (2) do not contain measurable concentrations of those VOCs or pesticides found in NAWQA-NWQL spike solutions and of interest to the Study Unit for each component.[a]
Standard-reference samples (trace elements)	Sent from 3 well sites selected from among all well sites for all components at which trace-element samples are collected during the same field season.[a]

[a]Schedule data collection for selected wells so that water-quality and routine QC samples are obtained from at least one of these wells early, at least another of these wells mid-way through, and at least at still another of these wells near the end of the entire time period during which water-quality data that relate to the type of QC sample type specified are being collected for the component or, in the case of trace-element standard reference samples, for the field season.

Field blanks are collected at the same wells used to obtain replicate ground-water samples; namely, at wells likely to have measurable concentrations of analytes in ground water. This makes it possible to verify that (1) the sampling equipment was exposed to measurable concentrations of contaminants, and (2) equipment decontamination procedures were effective. (The latter cannot be verified if the wells selected for field blanks contain no measurable contaminants.)

Additional Land-Use Study wells that differ from those selected for replicate ground-water samples and field blanks need to be selected for VOC and pesticide field-spiked samples. Criteria for selection of wells for spiked samples (table 13) ensure that the QC data are representative--reflect the type(s) of ground water in the Land-Use Study area where VOC or pesticide contaminants are found but that unspiked samples do not contain the VOCs or pesticides of interest. This means that recovery estimates from spiked samples (in which the analytes of interest have been added in the spike solution) are likely to reflect recoveries from ground-water samples that contain these same analytes in similar concentrations.

The criteria also ensure that the field-spiked QC data are suitable--reflect recoveries that are unbiased. Samples that contain measurable concentrations of pesticides or VOCs--in excess of a few tenths of a microgram per liter--and that are spiked with similar VOCs or pesticides in accordance with current NWQL protocols generally will provide recovery estimates that have a positive bias. The bias results because the recovery generally is calculated on the basis of the measured concentration divided by the theoretical concentration of the spiked sample, where the latter is estimated from the amount of analyte added in the spike solution. Recovery estimates cannot be determined precisely by correcting for the background (unspiked) sample concentration, unless at least triplicate unspiked, and triplicate spiked, samples are collected.

The scheduling (timing) of routine QC data collection for the Land-Use Study is determined after the wells for routine QC data collection have been selected. This involves scheduling site visits at these wells such that routine QC data are obtained early, about mid-way through, and near the end of the 1- to 3-month period it commonly takes to complete data collection for a Land-Use Study. This implies that the ground-water sampling schedule for a Land-Use Study, or any other ground-water component, cannot be finalized until the routine QC sampling design is developed (table 7).

Study-Unit (or Subunit) Surveys. A typical Study-Unit Survey is designed to obtain occurrence and distribution data on a variety of analytes (table 1). In this respect, a Study-Unit Survey is somewhat similar to a Land-Use Study. A Study-Unit Survey differs from a Land-Use Study in some respects, which affects the routine QC design.

A Study-Unit Survey can involve data collection from as many as 100 to 120 wells associated with multiple, rather than one, land use. These wells also often will be distributed among several Subunit Surveys, each consisting of about 30 wells. The 30 wells in each Subunit Survey often will be completed in shallow and deep parts of one or more aquifers. Thus, wells in a subunit generally will reflect a greater diversity in land-use and water-quality conditions than that associated with a single Land-Use Study. Overall, data collection from these Subunit Surveys collectively will take more time to complete than it will take to complete a single Land-Use Study.

Because Study-Unit or Subunit Surveys and Land-Use Studies often will involve the collection of similar types of ground-water-quality data, the types of routine QC samples required for a survey for each analyte are similar to those required for a Land-Use Study (table 12). The minimum number of each type of QC sample required for each Subunit Survey is at least the same number as that required for a Land-Use Study. Because of the potential for a greater diversity in landscape and subsurface conditions in Subunit Surveys compared to Land-Use Studies, however, it is recommended that at least one or two additional sites be selected for replicate ground-water samples for the inorganic analytes (major ions, nutrients, alkalinity, acid neutralizing capacity, dissolved organic carbon, and possibly trace elements) and the field blanks in each Subunit Survey.

If the Study-Unit Survey is designed as a single entity (not conducted using Subunit Surveys), then the minimum number of QC samples required for each sample type for the survey is increased in direct proportion to the number required for a Land-Use Study (table 12) on the basis of the total number of wells being sampled for the survey divided by the total number of wells being sampled for a Land-Use Study (which for the purposes of this calculation is taken as 25). Thus, a survey that involves 50 wells requires twice the minimum number of each type of QC sample than generally is required for a Land-Use Study.

Survey wells are selected for routine QC samples and scheduled for data collection using the same approach outlined above for a Land-Use Study. Different wells are selected for the different types of QC samples to provide QC data that are representative of differences in water quality, suitable for providing estimates of measurement bias, variability, and recovery, and cover the time period during which the Survey ground-water-quality data are collected (table 13).

Flowpath Studies. A typical Flowpath Study will assess spatial differences and possibly temporal variability in each of a selected number of analytes among wells located in different parts of a local ground-water flow system. The number of wells used for water-quality data collection commonly will be less than 20, with most wells completed in a single aquifer that underlies a single land use.

The routine QC design for a Flowpath Study involves the selection of routine QC sample types (as described in table 12) that relate to only those analytes that are targeted for investigation by the Study Unit. These routine QC sample types are to be collected at selected sites the first time the flowpath wells are sampled and, thereafter, at sites and times that reflect Flowpath Study objectives--such as evaluating spatial or temporal differences in analyte concentrations. As a general rule, the sites selected and frequency of routine QC sample collection are to be sufficient to establish that possible spatial differences or temporal trends in analyte concentrations at, or among, flowpath wells are not primarily a function of measurement bias or variability that result from field and laboratory methods.

Nested Studies. Ideally, the ground-water design for a Study Unit calls for Flowpath Studies to be located in selected Land-Use Study areas, and that each Land-Use Study be located in a (Subunit) Survey area. Theoretically, this implies that routine QC data collected for one component could serve as routine QC data for another component. Ideally, this also is efficient in terms of planning, field work, and costs. Use of this approach, however, requires the routine QC design requirements be met for each individual component.

To ensure that routine QC data from one component are valid routine QC data for another component, one component must be geographically nested within the other. That is, at least one well must be part of both components--the well that will be used to obtain the QC data common to both components. Data collection for both components must overlap in time, and occur at the well targeted to provide the required ground-water and routine QC data needed for both components during that period of data-collection overlap.

Example of routine quality-control design: a case study

Regardless of the ground-water component, the design, and in particular, selection of sites for routine QC data collection commonly will be determined using limited information. In particular, to obtain representative QC data, the wells selected are to reflect the diversity of water-quality conditions likely to be found among the wells used to collect ground-water data in each component. In a number of cases, however, the quality of ground water in terms of analyte concentrations at each well will not be known until after NAWQA data are collected.

When water-quality data are lacking, other types of data are used to make inferences about the likely quality of water at each well. Useful ancillary data include (1) water-quality data from nearby wells (retrospective data), (2) data on surface features (such as land use, crop types, and associated chemical use) from site visits and published data, and (3) data on subsurface features (such as lithology and well depth) which are obtained during well selection (or installation) and from published data on aquifer characteristics.

An inferential approach to identify and evaluate routine QC-sample data-collection sites and data was employed in the Delmarva Peninsula pilot NAWQA study. In this study, Hamilton and others (1992) used retrospective water-quality data (primarily major cations and anions) to describe spatial and depth-related differences in ground water throughout the Study Unit, and to identify agriculturally-affected ground water as well as unaffected (or natural) types of ground water in the study area (fig. 1-A, encircled regions). To design QC sampling for this Study-Unit Survey, Koterba and others (1991) used the above information along with data on surface features (general land use, and different agricultural activities such as crop type and related liming, and fertilizer and pesticide use) and subsurface features (well depth and aquifer lithology) at each well to select those for replicate routine QC samples (except those for field spikes) and some field blanks. The combined ancillary data described above indicated that different types of ground water were likely to be encountered (fig. 1-A), and that most analytes (major ions, nutrients, organic carbon, trace elements, and perhaps pesticides) were likely to be found at detectable (above detection level, but less than reporting level) or higher concentrations at the selected wells.

Additional wells for QC data collection were selected that reflected a diversity in ground-water types, but where it was initially inferred that pesticides found in NAWQA spike solutions and of interest to the Delmarva Peninsula Study-Unit staff (primarily triazines and acetanilides) were not likely to be found in samples from this second set of wells. These wells were used to obtain samples for pesticide field spikes.

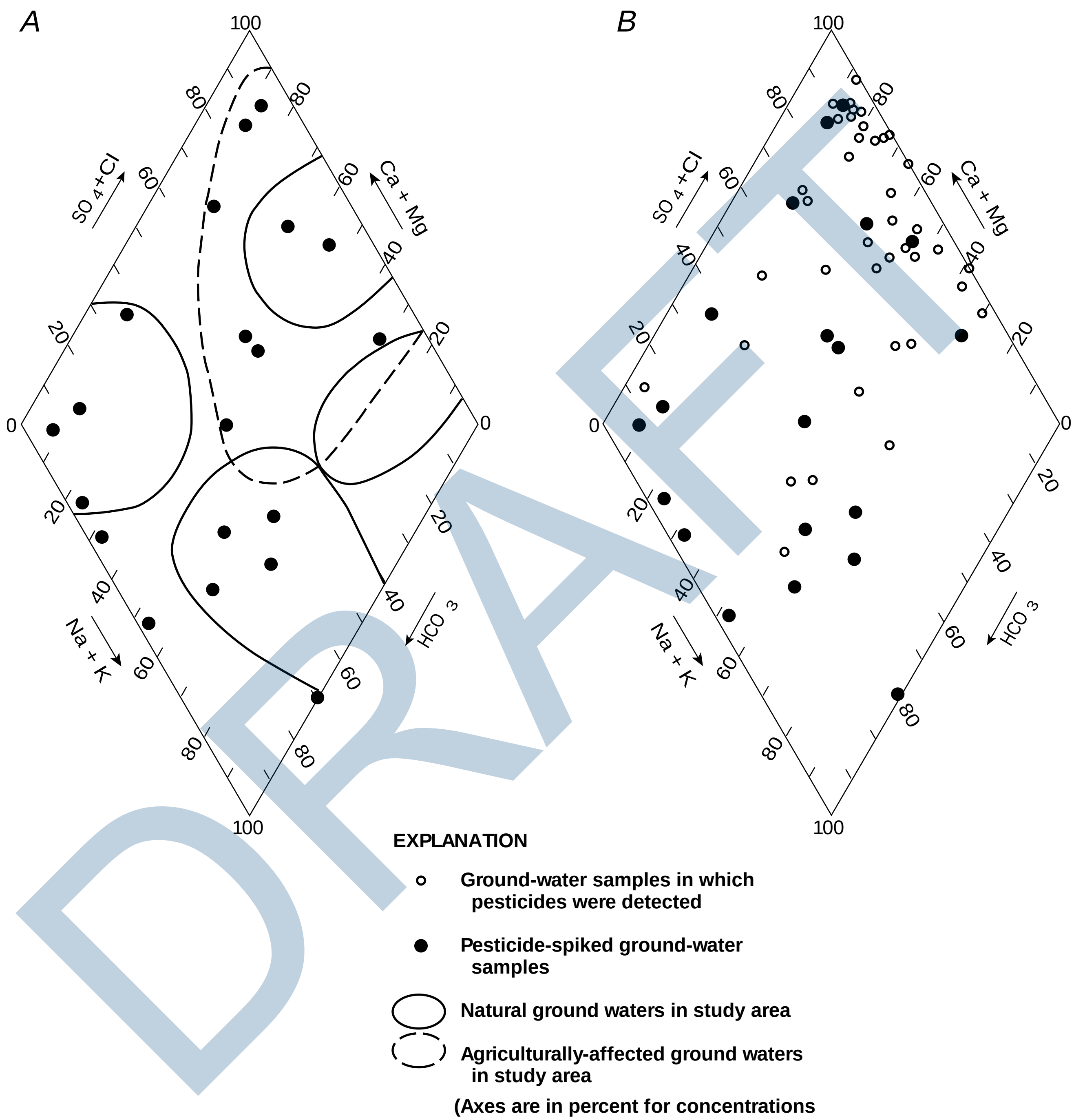

Figure 1. Distribution of wells selected for pesticide spikes in relation to the major-ion composition of (A) natural and agriculturally-affected ground waters, and (B) ground-water samples in which pesticides were detected in the Delmarva Peninsula (Koterba and others, 1993).

As water-quality samples and data were obtained by the Delmarva Study Unit, the major-ion data were plotted, including data from those wells selected for routine QC sampling. In general, plots illustrated that the different types of ground water described by Hamilton and others (1992) were being collected, and in particular, that the sites chosen for QC data collection also reflected most of the different types of ground water found in the Study-Unit Survey area (fig. A1, plotted points). Thus, the QC data were considered representative of the types of ground-water quality found in the study area.

Another key element addressed by the staff of the Delmarva Peninsula Study was to assess the suitability of replicate ground-water sample or field-spiked ground-water sample QC data to provide estimates of the method (field and laboratory) variability in concentration measurements or method bias in recovery, respectively, for selected analytes. This was done in part by using field-blank and unspiked (background) concentration data. In the Delmarva Peninsula Study, field blanks (12) were collected at different sites and times, and in each case, after equipment was contaminated (as later verified by the ground-water samples collected), and then field decontamination procedures were conducted. Blank data provided no evidence that samples (ground-water or other QC, including replicate or field-spiked samples) were subject to contamination in the field (by ambient conditions or equipment cross-contamination) or thereafter (during handling, shipping, and laboratory analysis). Further evidence that the QC data from field-spiked samples was suitable also came from the corresponding unspiked ground-water samples. Of 21 wells selected for field-spiked samples, only one yielded an unspiked sample that had a measurable concentration for any of the pesticides of interest. Thus, on the basis of field-blank and background-sample concentration data, it was demonstrated that there was: (1) no evidence samples of any type were contaminated during or after their collection, (2) that field decontamination procedures were adequate, and (3) that replicate and field-spiked data were not compromised by ambient or cross-contamination, and were suitable for estimating, in an unbiased manner, the method variability in concentration measurements and the method bias in recovery for selected analytes.

Additional data plots (for example, fig. 1-B) were constructed to illustrate that the wells chosen for pesticide field spikes generally reflected the types of ground water in which these same pesticides appeared as a result of what was considered normal pesticide use in the Study-Unit Survey area. Thus, it was argued that field-spiked sample data were representative of the types of ground water in which pesticides sometimes were found.

In terms of estimating pesticide recovery and measurement variability, only one of the 21 wells chosen by the Delmarva Peninsula Study-Unit staff for field spikes yielded a background sample with measurable concentrations of some of the pesticides found in NAWQA spike solutions and of interest to the Study Unit. This implied that, except for the data from that one well, the field-spiked sample data were suitable for obtaining unbiased recovery and variability estimates for those pesticides of primary interest to the Study Unit. Thus, for most of the pesticide analytes in question, recovery and measurement variability estimates were obtained using spiked samples from all 21 wells (Koterba and others, 1993). In the case of the one analyte found in the background sample from one well, the data from only 20 wells was used to estimate recovery and measurement variability.

The preceding discussion offers one approach that made it possible to select wells and design ground-water and routine QC sampling schedules each year to provide representative and suitable QC data for a 100-well Study-Unit Survey, which took 2 years to complete sample collection. Although the example above is for a Study-Unit Survey, the approach also is applicable to Land-Use and Flowpath Studies.

The above approach also illustrates how a Study Unit can graphically demonstrate that the wells selected for routine QC data collection represent different types of ground-water quality found in a component study area. If this visual analysis of QC data is made in a timely manner (before ground-water sampling for a component is complete), it is possible to incorporate wells not yet sampled, or initially selected, into the routine QC design to improve the representative nature of the QC data.

Topical quality-control samples

Field and laboratory equipment and methods for the collection of ground-water-quality data, including those for QC, could be modified as a result of routine QC data analysis, shifts in National Program priorities, or results from other studies. Modifications will be designed and implemented in a systematic manner, preceded by a NAWQA memorandum that explains the nature of the modification, the reason for the modification, and the manner in which the modification will be documented and evaluated. As part of this modification process, which is considered topical in nature, Study-Unit participation could be requested by the National Program. On some occasions, this could require additional QC samples be collected by some or all Study Units.

Individual Study Units could find additional QC samples are necessary to address a topic of local concern. For example, additional field and trip blanks could be required to verify that VOC contaminants are in the ground water, and are not being introduced during and after sample collection (Rea, in press). In other cases, additional blanks and spiked samples could be required to correctly assess method-related problems (Koterba and others, 1994).

Sample Coding and Data Management

The current electronic systems for sample and data management (LIMS-NWQL, NWIS-I-QWDATA, and NWIS-I-QADATA) do not provide a simple means of relating or differentiating among ground-water-quality and QC samples obtained from a single well. Although there are several ways to overcome this problem, the need to aggregate ground-water-quality and QC data on a regular basis at the Study Unit and National Program level requires consistent coding and management of samples and data among Study Units. For this reason, protocols for coding and electronically storing routine QC samples and data were developed (tables 14 and 15). In the case of topical QC data, coding is provided as part of each national topical QC-data request.

Table 14. Sample container coding requirements for ground-water-quality and routine quality-control samples of the National Water-Quality Assessment (NAWQA) Program

[NWQL, National Water Quality Laboratory, Denver, Colo.; SC, laboratory schedule; LC, laboratory code (in lieu of schedule); FA, filtered and acidified (nitric acid); RU, raw (unfiltered) and untreated; FU, filtered and untreated]

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1. Routine ground-water sample-bottle labels:

- NAWQA and Study-Unit four-letter code: for example, "NAWQA-POTO" (for Potomac NAWQA Study Unit)
- Local well identifier code
- Bottle type--NWQL sample designation schedule or laboratory code: for example, FA-SC2750
- Date of sample collection (MM-DD-YY, month-day-year), for example, 06-31-94
- Time of sample collection (HH:**00**, hours-minutes, military time)[a] for example, 12:00

2. Routine quality-control sample-bottle labels:

- NAWQA and Study-Unit four-letter code, same as above
- Local well identifier code, same as above
- Bottle type--NWQL schedule or laboratory code, where schedule or laboratory code used is given below
- Date of sample collection (MM-DD-YY, month-day-year), same as above
- Time of sample collection (HH:MM, hours-minutes, military time) where minutes are assigned values other than 00, according to the following format:

Time	Routine QC-sample type time-of-collection codes.[b]
HH:**01**	**Replicate--organic-carbon, nutrient, pesticide, volatile-organic, radon or major ion samples,** use SC2085, SC2752, SC2001 and SC2050, SC2090, SC2091, or SC2092, LC1369, and SC2750 (FA, RU, and FU), respectively. (For replicate cartridges, use SC2010 and SC2050, in lieu SC2001 and SC2051, respectively. Replicates for pesticide and volatile-organic compounds are optional.)
HH:**02**	**Field spike-1st--for pesticide or volatile-organic samples,** use same schedules cited under replicates above.
HH:**03**	**Field spike-2nd--for pesticide or volatile-organic samples,** use same schedules cited under replicates above.
HH:**04**	**Field spike-3rd (optional)--for pesticides or volatile-organic samples,** use schedules cited under replicates above.
HH:**05**	**Field blank--pesticide, volatile-organic, organic-carbon samples--(which require NWQL pesticide and VOC-free blank water, or if no field blank for VOCs taken, require NWQL pesticide-free blank water),** use same schedules cited for replicates above. **Field blank--nutrient samples (which require QWSU inorganic-free blank water),** for SC2752**.**
HH:**06**	**Field blank--major-ion (which require QWSU inorganic-free blank water)** for SC2750.
HH:**07**	**Solution blank--organic carbon only, (required because NWQL blank water is not analyzed for organic carbon),** use SC2085.

Table 14. Sample container coding requirements for ground-water-quality and routine quality-control samples of the National Water-Quality Assessment (NAWQA) Program--Continued

Time	Routine QC-sample type time-of-collection codes.[b]
HH:**08**[b]	**Trip blank--volatile organic samples only (which requires NWQL trip blanks found in box that sample vials are obtained in),** use SC2090.
HH:**09**[b]	**Primary trace-element ground-water-quality sample**, such as for SC2703.
HH:**10**[b]	**Replicate trace-element ground-water-quality sample,** such as for SC2703.
HH:**11**[b]	**Field blank--trace-element samples only (which require QWSU inorganic-free water),** and in lieu of SC2703 use SC172 and add LC0112 (arsenic) and LC0087 (selenium).
HH:12[b]	**Standard Reference Sample--for trace-element samples only,** such as for SC2703.

[a]This is a generic time value--the nearest hour to the true time--that is the basis for linking samples taken from a well during a particular visit. Some situations, or samples, require the true time of collection also be recorded--for example, to identify the time at which radon is taken. True time can be recorded, along with the reason it is being recorded, on the field form, as in the case of radon, in the message to the laboratory section on the NWQL-ASR form.

[b]Except for trace elements (for example, SC2703), additional sample bottles under other schedules can be added under the above time codes if and only if (1) they do not contain analytes in common with the samples and schedules already listed, and (2) if they are composed of blank water, it is the same type of blank water being used for the samples already listed above. If these conditions cannot be met, use other time codes (and NWQL analytical service request forms) for the additional samples. Note that for trace elements, unique time codes are required.

Table 15. Storage and coding requirements for ground-water-quality and quality-control samples and data of the National Water-Quality Assessment Program

[NWIS-I, National Water Inventory System; QWDATA, Quality of Water Data Base; QADATA, Quality-Assurance Data Base; NWQL, National Water Quality Laboratory; BTD&QS, Branch of Technical Development and Quality Systems; QWSU, Quality Water Service Unit; mL, milliliters]

1. Data Storage (check District policy):

- Routine ground-water-quality data in NWIS-I (QWDATA) database.
- Routine quality-control data in NWIS-I (QADATA) database.
- Topical quality-control data in NWIS-I (QADATA) database.

2. Sample and Data Coding on Analytical Service Request (ASR) Forms:

- Use same local well identifier as on sample container, add corresponding station identification code (15-digit latitude-longitude-sequence number) and use same date for all ground-water and quality-control samples collected at a well during a site visit.
- Use different time-of-sample collection codes for quality-control samples.[1]
- Use additional codes below for quality-control samples (in accordance with BTD&QS):[2]

For BLANKS: Coding required

Blank type	Sample medium	Sample type	Blank solution type (99100)	Blank solution source (99101)	Blank sample type (99102)
Trip	Q	2	10, 40, or 50	10, 60, or 80	30
Equipment	Q	2	10, 40, or 50	10, 60, or 80	80
Field	Q	2	10, 40, or 50	10 or 80 only	100
Solution	Q	2	10, 40, or 50	10 or 80 only	1

where Q denotes an artificial sample; 2 implies a blank sample; blank solution type 10, 40, or 50 implies inorganic-free, pesticide-free, or volatile-organic-free blank water, respectively; blank solution source 10, 60, or 80, implies blank water from the NWQL, District, or QWSU (Ocala), respectively; blank sample type 30, 80, 100, and 1 correspond to the blank types specified in the first column, respectively. Only NWQL or QWSU water should be used for field blanks. Record lot number of blank solution on ASR form.[3]

For REPLICATES: Coding required

	Sample medium	Sample type	Replicate type (99105)
Regular sample	6	7	20
Second sample	S	7	20

where 6 implies a ground-water sample; S implies a replicate ground-water sample; 7 implies replicate samples; and 20 implies samples were collected sequentially.

Table 15. Storage and coding requirements for ground-water-quality and quality-control samples and data of the National Water-Quality Assessment Program--Continued

2. Sample and Data Coding on Analytical Service Request (ASR) Forms--continued

- Use additional codes below for quality-control samples (in accordance with BTD&QS)[2]--continued

For SPIKED SAMPLES (pesticides and volatile organic compounds):

	Coding required					
	Sample medium	Sample type	Replicate type (99105)	Type of spike (99106)	Source of spike (99107)	Volume of spike (mL) (99108)
For each spiked sample	S	1	20	10 or 20	10	0.1

where S denotes a replicate ground-water sample; 1 implies a spiked sample; 20 implies a sequentially-collected sample; 10 or 20 implies spike was done in field, or at NWQL, respectively, 10 implies source of spike solution was the NWQL (required); 0.1 implies a 100-microliter volume of spike solution was used. Record lot number of spike vial on ASR form.[3]

For REFERENCE SAMPLES (of trace elements, obtained from BTD&QS):

	Coding required		
	Sample medium	Sample type	Reference type (99103)
For each reference sample	Q	3	35

where Q denotes an artificial sample; 3 implies a reference sample; and 35 implies a reference sample that is a blend of standards. Record reference sample bottle code as received from BTD&QS on ASR form.[3]

[1]Use different time codes to distinguish QC samples and prevent data overwrites (see table 14).

[2]Storage of ground-water-quality and quality-assurance data in NWIS, Branch of Quality Assurance Memorandums 90.03 and 92.01 (unpublished memorandums located in the USGS BTD&QS, P.O. Box 25046, Mail Stop 414, Denver Federal Center, Lakewood, CO 80225).

[3]Write message to lab on comment line on ASR form.

To easily group ground-water-quality and QC data from selected sites, the containers for these samples are coded in a systematic manner that employs some common codes (table 14--NAWQA Study-Unit code, local well-identifier code, schedule or laboratory code, and date of collection). For example, ground-water-quality and routine QC samples from the same well and time of site visit are given the same local well-identifier code (on sample containers), and the same local well and 15-digit (latitude-longitude-sequence number) identification codes in NWIS-I, and the same date of collection (on containers and in NWIS-I). These common codes facilitate linking selected types of samples (field blanks with the ground-water sample collected before the blank was taken, one replicate sample with another, or a spiked sample with an un-spiked sample). If common codes are not used, recoding, or the creation of additional codes by the Study Unit, will be needed to link data requested by the National Program. In either case, the Study Unit will be adding unnecessarily to its workload.

To manage sample data efficiently, and reduce confusion, it is best if routine QC sample data are stored and managed through NWIS-I QADATA, and ground-water-quality sample data are stored and managed through NWIS-I QWDATA (table 15). Efficient data management, reduced data loss, and improved ease of interpretation also are best achieved if different routine QC-sample types, taken in relation to the same well and time of site visit, are uniquely coded in at least some respects, and ancillary information that relates to each routine QC-sample type is documented on the ASR form (tables 14 and 15). Thus, different time, medium, and QC-sample codes are used for different types of routine QC samples. Ancillary information, such as the lot number of the blank water or the spike solution, also is coded and essential to interpreting QC data correctly. Illustrations of how data and codes are to be stored are provided for each type of QC sample routinely collected (see appendix).

Consistent coding benefits each Study Unit in several ways. First, except for a few codes, such as time of sample collection, most sample containers and forms generally can be filled out before the field team departs for sampling. Most of this same information also can be logged into NWIS-I in advance. This report (tables 14 and 15 along with the appendix) provides a comprehensive summary of appropriate codes that are needed to complete these presampling coding and management activities.

The prescribed codes will reduce the loss of data through overwrites. Data overwrites can occur in several ways. For example, one of the most common overwrite problems occurs when two different sample containers and their corresponding ASR forms have the same identification, date, and time codes, and one inadvertently requests analyses that involve at least one common analyte (parameter code) for both samples. Another common problem arises when one makes corrections to NWIS-I (QADATA or QWDATA), but does not have these processed through NWQL-LIMS. In either case, corrections are overwritten and data can be lost electronically when the NWQL submits or resubmits analytical results to NWIS-I through LIMS original record or provides updates to this record. To avoid problems, the Study Unit must code samples correctly. In addition, if corrections are made in the District, the Study Unit also must request the corrections be processed through the NWQL-LIMS system.

The prescribed codes will ensure that the sample container for a particular analysis is used for that analysis. For example, if sample containers are sent for major ions (SC2750--FA) and trace elements (SC2703--FA), they must be sent under separate ASR forms with different times to ensure that the trace-element analysis is done using the SC2703 sample and not the SC2750 sample. Because of potential differences in filter loading that affect filtrate concentrations between these two samples, it is critical that trace-element data come from an analysis of the SC2703 sample.

Finally, use of the prescribed codes (tables 14 and 15) is necessary for requests from the National Program for ground-water and QC data. If alternative coding is used, the data will need to be recoded by the Study Unit before the data are forwarded to the National Program.

Final Presampling Plans and Preparations

During the last month or two before the first field season for data collection begins, the Study Unit will complete presampling plans and preparations. This will involve a number of activities (table 16) that, in addition to scheduling water-quality and QC sampling, will include the following:

1. Creating a field file that contains copies of all the information needed for the current sampling run;

2. Preparing sample containers and filter units;

3. Checking that all the equipment and supplies needed for sample collection at each well listed in the file have been obtained and safely stored in the vehicle; and

4. Checking that the vehicle is in good and safe working condition, and that safety equipment is present and functioning properly.

In addition to the well schedule (table 7), the field file contains information critical to completing activities at each well (table 16), which could differ among wells. As sampling continues, the file is updated regularly in terms of those wells scheduled for data collection throughout the remainder of the field season.

Table 16. Activities related to final plans and preparations before sampling begins

1. **Create a field file,** in part, from previously collected information, that contains:
   - A well schedule (chronological list of wells to be sampled during the scheduled run).
   - A checklist of the sample and data-collection activities to be carried out at each well--
     (a) a list of analytes to be sampled--by bottle type (for example, FA), in order of collection and processing, including quality-control samples,
     (b) a list of information required, and the necessary forms, to complete any documentation not completed during previous site visits, and
     (c) a form for noting changes in, or providing additional information on, land use.
   - Copies of site, well, measurement point, and sampling setup location maps and photographs for each well.
   - Notes on any special site conditions that could affect sample and data collection at a well, including roaming animals and locked gates, or a well, that on the basis of screening tests, might require special QC sampling and decontamination procedures.
   - The contact person’s (well or land-owner’s) name and telephone number for each well.
   - Field cover, well-purge, Analytical Service Request, and field-instrument calibration forms--completed to extent possible for each well. Also include some extra, blank copies of each form. (Calibration notebooks can be used instead of individual forms.)
   - Overnight-mail shipping forms and labels, completed to extent possible, and the shipper’s telephone number.
   - Study-Unit (SU) sample-transfer and temperature-check form for NWQL (Sample login) with SU-addressed, stamped envelope for each well. (Also have the telephone number for NWQL (Sample login)).
   - Calibration notebook(s) for field meters.
   - Copies of the NAWQA protocols for sample and data collection, and the U.S. Geological Survey National Field Manual for Collection of Water-Quality Data (Radtke and Wilde, in press).

2. **Prepare sample containers and filter units** that are:
   - Cleaned if necessary,
   - Labeled to the extent possible, and
   - Bagged, for each well,
   - With each container tightly capped. (Recommend plastic container be half filled with DIW.)

3. **Provide routine checks** that cover the equipment and supplies stored in field vehicles (see table 3 for detailed list), for:
   - Calibration and use of field meters for temperature, pH, acid-neutralization capacity, alkalinity, specific electrical conductance, dissolved oxygen, and possibly turbidity.
   - Collection, processing, preservation, and, possibly field extraction of ground-water and quality-control samples.
   - Field-equipment decontamination.
   - Sample shipment or temporary storage.
   - Disposal or temporary storage of waste materials.

4. **Provide predeparture checks** each time the field team leaves the District office or a well that:
   - Cover vehicle safety and condition.
   - Ensure all field equipment is properly and safely stored.

As part of the final presampling preparations, some sample containers require rinsing (table 16). For example, it is required that all sample containers and caps for filtered and acidified samples (FA designation), which includes those for major ions and trace elements, be rinsed at least three times with either QWSU IBW or DIW -- ASTM Type 1 water (conductivity less than 1.0 µS/cm at 25°C). It is recommended, however, that FU, RU, and FCC containers also be rinsed as described above before use. After the final rinse, it also is recommended, as a QC measure on the container seal, that each container be half-filled with the same water used for rinsing and capped before storing the container for transport to the field. If the container is less than half full when pulled from storage in the field, the container is discarded, and another similarly rinsed container is used in its place. This implies that several additional containers for each sample type are prepared as above and in advance of at least the first field-team trip. After rinsing, sample containers can be labeled with the appropriate codes, except for date and time of collection, before they are transported to the field. This will reduce the time necessary to complete setup activities in the field before samples are collected.

Although at least three different filter units commonly will be used (table 3), only the one for filtered inorganic samples, the 0.45-µm fibrous filter (capsule), can be prepared before the field team departs for the field. It is required that 1.0 L of QWSU water or DIW (ASTM-Type-1) be passed through this filter before it is used. Preconditioning is to occur within 5 days before use. A peristaltic pump head with Tygon tubing, or a Teflon diaphragm pump head with convoluted Teflon tubing can be used to force the preconditioning water through the capsule filter. The pump also is used to force as much water as possible from the capsule after it is preconditioned. To avoid mildew, the preconditioned capsules are placed in nested, resealable plastic bags and stored in a cool environment (refrigerator or cooler with ice) before use.

Different filter units might need to be prepared to address topics of interest germane to a specific Study Unit component. A Flowpath Study that involves geochemical modeling and other techniques to interpret dissolved inorganic chemical data from ground water requires additional samples be obtained with these samples filtered through a membrane with a pore size of 0.2 or 0.1 µm or less. Currently, only flat (plate) filter membranes are available with a pore size of 0.1 µm or less. Preparation of these membranes and the equipment needed is described in an internal document (F.D. Wilde, U.S. Geological Survey, written commun., 1995--see footnote 1). To determine the appropriate filter type and pore size, it is recommended that a comparison sample analysis be made between data obtained from NAWQA samples passed through 0.45–µm capsule filters and Study-Unit samples passed through 0.1–µm membranes to determine if there is an appreciable difference in trace-element concentrations.

Final plans before sample collection include the office support effort required to maintain the field effort. The field effort typically involves repeating activities (such as those in table 16) on a regular basis during a single field season. To plan for the office support needed, consider that each time the field team returns: (1) the sampling vehicle(s) generally is (are) unloaded, cleaned, and restocked; (2) forms and other information are transferred from field to office files; (3) the field file is restocked with information on the next set of wells to be sampled; (4) samples brought from the field are archived or shipped from the office; and (5) field and sample-related data and forms are transferred to data managers, with copies being archived into NAWQA site files.

If the planning document or workplan assigns all of the above activities solely to the field team, their field schedule must allow ample time to complete these activities. The workplan also should reflect that team members could have a backlog of work pending as a result of their absence. A field team that keeps good records in the field--of supplies that are running low, or of equipment that is in need of repair or replacement--can expedite preparations for the next field effort. While in the field, mobile phones also provide an efficient means of communicating needs in advance or when emergencies arise.

During final preparations, Study-Unit data managers integrate their plans to review the data-collection process. Workplans, developed during the last month or two before sampling begins, include verification of field forms returned by field teams, the login of sample and data information from these forms, and the updating of any new information (such as changes in land use). Workplans also include regular retrievals and quality-control checks on NWQL data returns. Of particular importance is the timely retrieval and evaluation of routine QC data, which can be used to assure field teams that data collection can continue unabated. Finally, data management workplans are to include the development of NAWQA water-quality files for wells at which ground-water samples are collected. These files generally are distinct from other files, such as the GWSI file, in that they chiefly contain records and information pertaining to ground-water-quality sampling. Thus, each of these files contains copies of sample-collection field forms, NWQL and other laboratory request forms, and water-quality-data summaries (in particular, NWIS-I site and time-specific lists (WATLISTS) of water-quality data).

Field Protocols and Recommended Procedures

A field team could spend 2 to 5 hours traveling to and from each well that is scheduled for the collection of ground-water-quality samples. At each well, the team will perform some, or all, of the following activities:

(1) Equipment setup.

(2) A well purge, to remove standing water, and field measurements.

(3) Sample collection and processing.

(4) Decontamination of field equipment, including possible breakdown and storage of sampling equipment.

(5) Preparation of blank samples.

(6) Preparation of other routine quality-control samples and field extracts for pesticide samples.

(7) Handling and shipping of samples, including completion and verification of field, laboratory, and other forms.

Each activity is described below in its approximate chronological order of occurrence.

Equipment Setup

Upon arrival, the field team contacts the land or well owner (if necessary), and locates the well and areas for conducting on-site activities (table 17). The field team carries out the remaining setup and other on-site activities after selecting one field-team member, hereafter referred to as **Team Member A**, who is responsible for the collection of all water-quality samples throughout the day. From this point on, **Team Member A** generally performs only those on-site activities that are least likely to lead to the contamination of samples during or after collection. The other field person, **Team Member B**, also performs activities required in order to collect samples and data, but in some cases the activities performed potentially heighten the risk of sample contamination if that person also were to collect water-quality samples.

Field team roles, which are maintained throughout the day regardless of the number of wells visited, are alternated between team members on a regular, preferably day-to-day, basis. This ensures that each team member can perform all on-site activities associated with ground-water-quality data collection.

It is recommended that team members wear clothing appropriate to their assigned activities. **Team Member A** wears clothing that is tightly knit and not likely to shed lint. Powderless latex (when using methanol) or powderless vinyl gloves are required. **Team Member B** initially wears work gloves and coveralls over attire, similar to that of Team Member A. Work gloves and overalls are removed after the completion of setup activities that involve handling equipment that could be heavily soiled or contaminated (table 17). **Team Member B** also is required to wear powderless latex or vinyl gloves during sample handling and preservation. Safety goggles or glasses are worn whenever either team member is handling chemical reagents that are potentially toxic or hazardous.

Well Purging, Grab Samples, and Field Measurements

Before water-quality samples are collected, the well is purged of standing water. Grab samples taken near the end of the purge are used to determine (1) the amount of NWQL hydrochloric acid needed to acidify the VOC samples, and (2) the normality of QWSU sulfuric acid to use for field titrations. Field data are obtained during the latter stage of the purge, immediately before sample collection. The purge, as well as grab-sample analyses and field measurements, are carried out in an efficient, and to the extent possible, consistent manner throughout the NAWQA Program (table 18).

The well purge ensures that the field-measurement and sample data that are subsequently collected reflect the chemistry of water in the aquifer, and not that of the water that has been standing in the well. The purge also conditions sampling equipment and reduces turbidity (sediment and colloids) caused by either the lowering and start-up of a portable pump, or the start-up of a water-supply pump.

Table 17. Initial field-team setup activities related to on-site protocols and procedures at wells used for ground-water-quality and routine quality-control data collection for the National Water-Quality Assessment Program

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1. Field team arrives, consults field file (table 16), and carries out initial setup activities as follows:

   - Contacts land or well owner (if necessary)
   - Verifies following points and areas of interest (modify site-file maps and update photographs and forms as necessary):

     Land use and land cover in vicinity of well[1]
     Well location and water-level measurement point
     Parking areas for vehicle(s)
     Areas for field-equipment setup and well-water discharge

2. To provide quality assurance, the field team divides remaining setup duties, which are carried out as follows:

   - **Team Member A**

     Calibrates and sets up field instruments for titrations, turbidity, and flowthrough chamber[2]
     Assembles sample-wetted equipment for purge and collection[3]
     Completes labeling of sample containers and forms (primarily by adding date and time of collection)[4]

   - **Team Member B**

     Sets up safety cones (as needed)
     Measures water levels (if possible, static depth to water and depth of well)[3]
     Checks for oil residues in well (on measurement tape)
     Calculates purge volume (from well diameter and depth measurements, otherwise assumes it equals three casing (or wellbore) volumes)[5]
     Attaches waste lines to purge setup (see fig. 2, routes to prevent flooding in work area and near power supplies)
     Sets up pump system (as needed, fig.2, for monitoring well, in well drained area)
     Sets up power supply (for portable pump, avoids wastewater areas; using vehicle power, checks fuel is sufficient, attaches exhaust hose(s) to vehicle(s), and voids exhaust downwind of work areas; using portable generator, checks and, if necessary, fills fuel tank)

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[1]See appendix, figure A1, and update as necessary.
[2]According to “Field Instruments” section and appendix, figures A2 to A6.
[3]See text and figure 2.
[4]According to “Sample Coding and Data Management” section and appendix, figures A8 to A20.
[5]See appendix, figure A7.

Table 18. Field-team activities for purging a well for ground-water-quality and quality-control data collection

[NWQL, National Water Quality Laboratory; HCl, hydrochloric acid; VOC, volatile organic compound; QWSU, Quality Water Service Unit; mL, milliliter; H_2SO_4, hydrosulfuric acid; ANC, acid-neutralizing capacity; ALK, alkalinity]

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1. Field team identifies approach to be used to purge well on basis of:
   - Standard purge protocol (see table 19)
   - Recent pumpage from well
   - Possible use of packers
   - Well capacity
   - Possible use of other customized purge criteria
   - Well type (monitoring or water-supply well)[1]

2. Field team divides site duties on the basis of assigned roles for the day, and carries them out as follows:

Team Member A

- Records flow rate and volume of flow from the well and through the equipment setup.[2]
- Collects grab samples near end of purge to determine and record:[3]
  (1) the number of drops of NWQL HCl required to reduce the pH of VOC 40-mL sample to 1.7 to 2.0 (to a maximum of 5 drops for VOC sample preservation), and
  (2) the normality (1.6 or 0.16) of QWSU H_2SO_4 titrant, and volume in milliliters (50 or 100) of the ground-water sample (for field titrations of ANC and ALK).
- Records field measurements, including final median values required under protocol.[2]

Team Member B

- Conducts purge (and routes flow as needed to obtain field measurement data (see fig.2)).
- Adjusts and measures initial and final flow rates through purging setup and pump rates in well (as required and needed)[1].
- Monitors (if necessary) pump work rate (amperage) and power supplies (fuel levels).

Both Team Members

- Assess stability of chemical and physical measures to determine when samples are collected.[4]
- Document decision on whether or not to sample, and why.

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[1]See text, including section on "Purging Different Types of Wells."
[2]See appendix, figure A7.
[3]See "Grab Samples for Titrations and Volatile-Sample Preservation" and appendix, figures A8 and A9.
[4]See "Final Assessment of Chemical Stability."

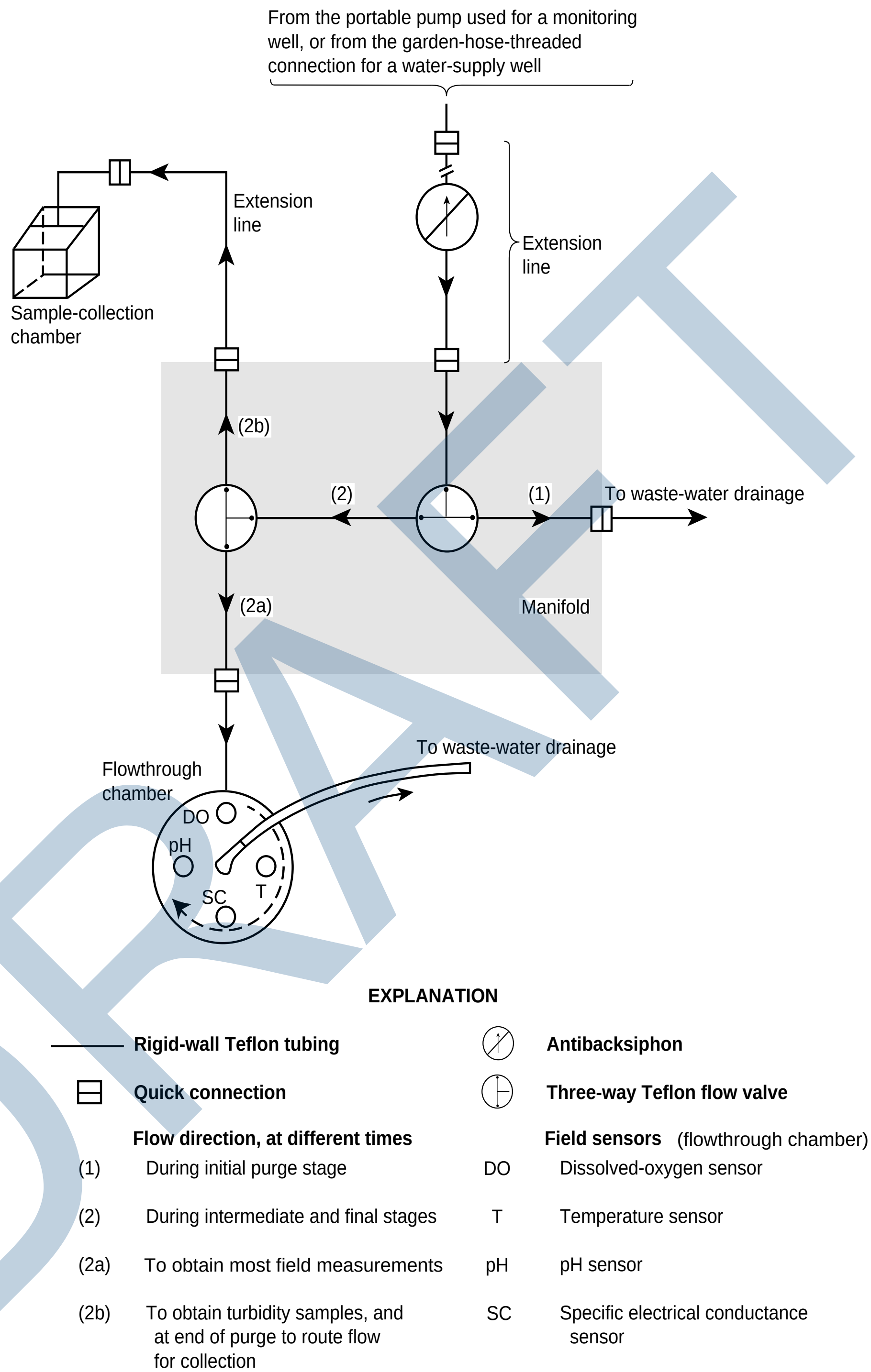

Figure 2. Schematic of equipment setup for well purge and sample collection.

Despite differences in scientific opinion as to when and how much purging are necessary, and the criteria used to assess when purging is complete, NAWQA field teams will use the standard USGS procedures and criteria for purging and collecting field measurements (table 19). In applying the purge protocols, the equipment and procedures used can differ in some respects on the basis of recent pumping, well capacity, study component, and well type (see below). With some exceptions, the same equipment (fig. 2), criteria (table 19), and similar procedures are used to purge and collect ground-water-quality samples. Deviations from the standard purge protocols that are not described below are discussed in advance, if possible, with the NAWQA QA Specialist.

Acceptable deviations from standard purge protocols

Four possible exceptions to the standard purge procedures are recognized and accepted. The first relates to recent pumping. If it can be documented that a volume of water equivalent to the purge volume already has been pumped from a water-supply or monitoring well within the 24-hour period before the field team arrives, sample collection can begin after equipment has been flushed or "conditioned" with ground water and field measurements have been shown to be stable. This effectively reduces the purge time to that needed to achieve stable field measurements (table 19, minimally about 15 to 25 minutes).

The second exception to the standard purge protocols relates to well capacity. When the permeability of the aquifer is low, and a slow recovery limits well capacity, it often is possible to quickly evacuate the standing water from the well. For a monitoring well, the field team lowers the pump intake slowly, and evacuates the well at a pump rate that does not suspend sediments. Field measurements and samples are obtained after the water level has recovered to at least 90 percent of the level measured before evacuation, and provided recovery occurs within 24 hours of evacuation.

The third exception to the standard purge protocols also relates to well capacity. When packers have been placed in a well to restrict the zone of water withdrawal, the purge volume is equivalent to three times the volume between the packers. Given that this purge volume could be quite small, the field team again could find that only a 15- to 25-minute purge at the low flow rate is needed to remove the necessary water and obtain stable field measurements. As a quality-control measure, pressure transducers, installed above and below the packers, are recommended to determine that leakage is not occurring across packers or from above or below the zone isolated for sampling.

The fourth exception to the standard purge protocols is related to the ground-water component sampled. When purge criteria can be customized for the well and in relation to specific sampling objectives, these purge criteria can be used in place of the standard criteria. This exception is most appropriate for investigations that focus on a specific, but limited group of analytes, such as in a NAWQA Flowpath Study (table 1). In fact, it is recommended that Study Units develop and use purging procedures and criteria that best correlate with the concentrations of analytes being investigated. For example, a customized purge criteria for sampling VOCs is described by Gibs and Imbrigiotta (1990).

Table 19. Standard protocols and recommended procedures for conducting and assessing well purging for the National Water-Quality Assessment Program (modified from F.D. Wilde, U.S. Geological Survey, written commun., 1995--see footnote 1)

[Assumes that well capacity is not a limiting factor; see text for further discussion of exceptions. °C, degrees Celsius; %, percent; ≤, less than or equal to; >, greater than; <, less than; µS/cm, microsiemens per centimeter at 25°C; mg/L, milligrams per liter; NTU, nephelometric turbidity units]

1. Purge a minimum volume of water equal to three times the casing (or wellbore) volume.[1]
2. Reduce rate of flow from well, if possible, but at least through setup, to no more than about 0.1 gallon (~500 milliliters) per minute for 15 to 25 minutes near end of purge (sample-collection rate).[2]
3. Monitor pH, temperature, specific electrical conductance, and dissolved oxygen throughout the purging process, but particularly during last 15 to 25 minutes. (If trace-element samples are being collected, include turbidity measurements as part of monitoring.)
4. The well is considered purged after at least three casing volumes have been removed and values of monitored parameters between 5 successive measurements separated by about 3- to 5-minute time intervals are within the allowable difference specified below:

Parameter	Allowable difference or value
pH	± 0.1 units (± 0.05 units if instrument displays 2 or more digits to the right of the decimal)
Temperature	± 0.2°C (thermistor)
Specific electrical conductance (SC)	± 5%, for SC ≤ 100 µS/cm ± 3%, for SC > 100 µS/cm
Dissolved oxygen (DO)	± 0.3 mg/L
Turbidity (TU)	± 10%, for TU < 100 NTU: ambient TU is <5NTU for most ground-water systems (visible TU > 5 NTU)

- If measurements appear stable, the median value of the last five measurements for each parameter (except for pH) is recorded on the appropriate forms (see appendix, figs. A7 and A8), and the field team proceeds with sample collection. For pH, only the last measurement is recorded.
- If criteria for stability is not achieved, purging is continued until either the field measurements stabilize, or the equivalent of five or more wellbore or casing volumes have been removed, depending on the judgment of the field team. The field team records the final field measurements in the manner noted above, and notes any parameters which remain unstable.
- If measurements remain unstable, the field team must decide whether or not to continue with sample collection.
- A lack of stability, indicated by a consistent trend in values upward or downward for pH, SC, DO, and TU, indicates possible problems in well design, or purging setup or technique. It is recommended that samples not be collected from a well if the setup or technique cannot be altered to obtain stable measurements.

[1]Standing volume is calculated from depth to water and depth of well measurements (see appendix, fig. A7).

[2]If a high initial rate is used, reduce rate of flow from well and through purge-collection setup to this rate.

Each of the above exceptions actually fulfills the intent of the standard protocols. In each case, the procedures and criteria used ensure the removal of stagnant water, and the chemical and physical stability in flow before samples are collected. In addition, and regardless of what purge criteria are used, the standard field measurements (DO, SC, T, pH, and, if trace-element samples are collected, TU) also are determined and documented. They are part of the NAWQA data collected at each well (table 1). Thus, except for pH, the median value of the last five stable values for each standard measurement, and any customized purge criterion, are recorded as part of the data of record. For pH, only the last measurement is recorded.

Purging with different flow rates

With the exception of some Study-Unit Survey Flowpath-Study components (table 1), wells used by NAWQA generally are completed at relatively shallow depths in water-table aquifers. As a general rule, the purge procedures described above are completed within about 2 to 2 1/2 hours, which includes the 15- to 25-minute period at the low flow rate required for sample collection (about 0.1 gal/min or 500 mL).

A low flow rate is required at the end of the purge (and during sample collection) for consistency and technical reasons. In combination with a portable, submersible pump, a low flow rate:

(1) is obtainable and maintainable for most, if not all, wells;
(2) reflects a discharge that can be sustained at low pump amperage and without surging;
(3) reduces the likelihood that sources of ground water entering the well will change (Reilly and others, 1989);
(4) is likely to lead to uniform, or at least less turbulent, flow;
(5) reduces the potential for degassing of some constituents, such as VOCs and radon;
(6) reduces the likelihood of entraining colloids and other artifacts dislodged and suspended by turbulence; and
(7) provides a rate of flow that is manageable during sample collection.

To achieve some of the above in sampling water-supply wells when the rate of flow through the well is high and uncontrollable, part of the flow is diverted (through the equipment setup) at the required low rate.

Although use of a higher rate of flow throughout the purge and sample-collection period than that required near the end of the purge reduces purge and sample-collection times, it also reduces the likelihood that the benefits described above will be achieved. As a compromise that aids in reducing field times, while maintaining some consistency and quality control, higher flow rates (during the initial part of the purge) than the required low flow rate (near the end of the purge) can be used provided these conditions are met: (1) that the high flow is sustainable, (2) that the high flow is not highly turbulent, (3) that field measurements, including turbidity, which could change precipitously at first under the high flow, stabilize relatively quickly, and remain about the same (no abrupt changes), and (4) that turbidity, in particular, does not remain elevated, but approaches a generally acceptable value (table 19).

Purging different types of wells

Perhaps the most substantial differences among wells that the field team could encounter in applying the standard purging protocol (table 19), or one of the acceptable deviations to that protocol, occurs in relation to well type (monitoring or water-supply well). Because water-supply wells for NAWQA are chosen on the basis of suitable construction for ground-water-quality data collection (Lapham and others, in press), they are equipped with pumps that can be used to obtain water samples. The location of the well pump intake and the pump rate, however, generally cannot be controlled by the field team. This implies that the field team only has limited control of some aspects of the purge and sample-collection process at these wells. This is not the case for most monitoring wells. Because data collection at most monitoring wells selected by NAWQA will require the use of a portable pump whose intake location and flow rate can be modified, the field team has considerable control over the purge and sample collection process for this type of well. Despite the differences in level of control between water-supply and monitoring wells, and to promote consistency in purging and data collection from these two types of wells, it is required that field teams follow the standard procedures (table 19), when possible, or follow acceptable alternative procedures for purging each type of well. Further guidance on purging either type of well is provided below.

Water-Supply Wells. Water-supply wells used by NAWQA are selected, in part, because they have pumps deemed suitable for producing samples of suitable quality. The field team, however, generally cannot alter the rate at which these pumps operate, nor the location of the pump intake. Generally, the field team only can control the flow rate through their own equipment when purging or collecting samples.

To determine the manner in which the purge of a water-supply well is conducted, the field team first estimates the volume of water that will be removed from the well using the ground-water supply-pump rate and the final 15 to 25 minutes of purging (when stability measurements must be made). If the estimated volume is about equal to or exceeds the required purge volume, then evacuation of the required purge volume will take only about 15 to 25 minutes. In this case, the field team sets up the equipment and then conducts the purge. This situation commonly arises for small water-supply wells, such as those used for single dwellings. Setting the equipment up first, and then purging this type of well will prevent overpurging, which could adversely affect the quality of data obtained by NAWQA for some VOCs (Gibs and Imbrigotta, 1990).

For a water-supply well that requires a purge time considerably longer than 15 to 25 minutes (for example, more than 2 hours), the field team has the option to request that the well pump be turned on before they arrive. This approach commonly is needed for high-capacity wells used for irrigation or drinking-water supplies. The field team arrives, however, in time to set up equipment, complete the final 15- to 25-minute phase of purging using the low flow rate through their equipment, and obtain stable field measurements before the required purge volume is evacuated. If this option is used, the field team also requests that static water-level data be collected by the pump operator before pumping begins.

As a final consideration in purging a water-supply well, the field team keeps the water-supply pump operating throughout the purge and sample collection. This ensures the removal of standing water from the well, and clears standing water from any plumbing lines leading to the sampling equipment.

To ensure the water-supply well continues to operate, the field team can open more flow valves than just the one connected to their equipment. This also will reduce the likelihood of back-flow of water stored in plumbing lines that could be connected to the line that transports water to the sample-collection setup. Backflow often occurs if the plumbing system is not equipped with antibacksiphons. Antibacksiphons generally are absent in secondary distribution lines on low-capacity supply wells, such as those used by rural homeowners for local supplies.

Since water-supply pumps operate continuously during the purge and sample collection, there is a chance that the supply pump could burn out. Although most commercial pumps are designed to operate for hours without problems, old, worn pumps are a potential problem. If a pump burns out, the field team generally should expect to replace it upon the owner's request. To limit the chance of pump burnout, the field team needs to work quickly and efficiently to keep the total pumping time required to purge and sample as short as possible. If this is achieved by using a high flow rate, through setup equipment, this flow rate is reduced to about 0.1 gal (500 mL) per minute during the final stage of the purge and during sample collection.

Monitoring Wells. Because the field team supplies the pump, they control the rate at which water is pumped from the well and through their equipment, as well as the location of the pump intake in the well. During the purge of a monitoring well, it is important to recognize that pump intake rate, emplacement, and location can influence the quality of the water obtained. Thus, it is important that these pumps be used in a consistent manner for the purge and sample collection at different monitoring wells.

As in the case of a water-supply well, the first step in applying the purge protocol to a monitoring well is to determine if the required purge volume can be evacuated in the 15 to 25 minutes needed for field measurements at the required low-flow rate for sample collection. For this 15- to 25-minute period, and a rate of about 0.1 gal (500 mL) per minute, about 1.5-2.5 gal (7-11 L) will be evacuated from the well. If the required purge volume is less than or equal to this volume, the field team sets up all equipment and then purges the well at this low rate. If the required purge volume exceeds about 1.5-2.5 gal, the field team can purge the well at an initially high, but acceptable, flow rate (as described earlier) to reduce the purge time, and then reduce the flow rate to the sample-collection rate for the final 15 to 25 minutes of the purge, and take and document final field measurements.

Pump intake emplacement is a consideration in the purge of a monitoring well. To reduce the suspension of sediments in the well, the pump intake always is lowered slowly into the well. Initially, the intake is placed just below the surface of the water standing in the well.

With the setup equipment properly configured to route flow directly to waste (fig. 2), the pump is turned on at an initially low rate to avoid sediment suspension in the well. If the required purge volume is small, and the entire purge can be conducted within 2 hours at the low rate required for final field measurements and sample collection, the pump rate is slowly adjusted to a rate of about 0.1 gal (500 mL) per minute. This rate is verified by measuring the outflow from the waste line, and recorded (appendix, fig. A7).

If the required purge volume is high, and an initially high pump rate is desired, the pump rate is slowly increased until either the maximum acceptable flow (as described earlier) or pumping capacity is reached (because of pump limitations or well capacity). In general, unless the well capacity is extremely low and purging cannot be completed within 2 to 2 1/2 hours, rapid evacuation of the standing water in the well is avoided. As noted earlier, the initial flow rate is measured at the waste-line outflow and recorded (appendix, fig. A7).

After the initial flow rate has been measured, the flow is rerouted through the instrumented flowthrough chamber (fig. 2) and the purge continues. Field measurements are made and recorded from this point on (appendix, fig. A7).

As the purge continues, and to enhance the evacuation of all standing water, the pump intake in unpacked wells is lowered slowly until it resides a distance above the open (perforated, or screened) interval that is equal to 7 to 10 times the diameter of the well casing (borehole). Assuming the monitoring well was designed correctly with a short open interval of 2 to 10 ft (Lapham and others, in press), this final location of the intake aids in promoting the flow of water from the entire screened interval to the pump intake.

Any substantial changes in pump intake location (lift) could affect the flow rate. Thus, all changes in pump intake location are completed before the final 15- to 25-minute stage of the purge. At this time, any high pump intake rate is reduced to about 0.1 gal (500 mL) per minute, and the last five sets of successive field measurements are taken, while the last of the required purge volume is evacuated from the monitoring well.

<u>Grab samples for titrations and volatile-sample preservation</u>

During the final 15 to 25 minutes of the purge, or whenever measurements appear stable in relation to the purge criteria (table 19), two grab samples are taken**.** The first is a 100-mL sample which, if the pH exceeds 4.5, is quickly titrated to roughly determine the acid neutralizing capacity (ANC) of the sample (Radtke and Wilde, in press). From the ANC value, the field team determines the optimum sample volumes and titrant normality (1.6 *N* or 0.16 *N* sulfuric acid) to be used for subsequent, quantitative field titrations (table 20). If the sample pH is 4.5 or less, no field titrations for ANC or alkalinity are required.

If VOC samples are scheduled for collection at the well, a second 40-mL grab sample is obtained in a clean glass beaker to determine the amount of NWQL hydrochloric acid needed to preserve VOC samples (from March 31, 1993 to January 31, 1994, samples were preserved with NWQL-concentrated hydrochloric acid). The acid is added drop by drop to this beaker, the sample is stirred or mixed, and the pH is measured after each acid addition until it is between 1.7 and 2.0. The number of drops of NWQL acid used must be recorded on field forms (appendix, figs. A8, A10-A, A11-A, A12-A, and A13-A). To avoid damage to NWQL instruments, however, no more than 5 drops of NWQL hydrochloric acid are to be added to a VOC sample (Bruce Darnel, VOC National Synthesis Team, U.S. Geological Survey, written commun., 1995).

Table 20. Field-titration procedures for ground-water samples of the National Water-Quality Assessment Program

[mg/L, milligrams per liter; mL, milliliters]

- Except when replicate titrations are scheduled at selected wells, one filtered, and (optionally) one unfiltered, sample will be titrated at each site.[1]

- The unfiltered sample is titrated for acid-neutralizing capacity (ANC, mg/L[2]). The filtered sample is titrated for alkalinity (ALK, as mg/L $CaCO_3$; carbonate, as mg/L CO_3^{-2}, bicarbonate, as mg/L HCO_3^{-}; and hydroxide, as mg/L OH^{-}).

- Conducted in the field on fresh samples by the incremental addition of titrant, generally with digital equipment, and the recommended volume of sample and normality of titrant, as follows:

Parameter(s)	Expected Value	Sample Volume	Titrant Normality
ANC or ALK	0.0-50 mg/L as $CaCO_3$	100 mL	0.16
ANC or ALK	50-200 mg/L as $CaCO_3$	50 mL	0.16
ANC or ALK	200-1,000 mg/L as $CaCO_3$	100 mL	1.6
ANC or ALK	Exceeds 1,000 mg/L as $CaCO_3$	50 mL	1.6

- Estimates of ANC, ALK, and contributing species are determined by the Inflection-Point Method (Radtke and Wilde, in press). Inflection points to determine ANC or ALK and contributing species are near pH values of about 8.2 and 4.5 for most waters buffered by the carbonate system.

- If difficulties arise in determining titration endpoints--which could be encountered for saline, low-conductivity, low-alkalinity, anoxic, or organic-rich ground waters--the Gran-Function Plot Method is recommended (Radtke and Wilde, in press).

- Field titration data are recorded (appendix, fig. A9) and later stored electronically under the appropriate parameter codes in NWIS-I QWDATA (for primary ground-water samples) or NWIS-I QADATA (for replicate ground-water samples).

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[1]Before 1996, titration of an unfiltered sample was required and titration of a filtered sample was optional.

[2]Reporting values above assigns carbonate chemical species as the primary sources of neutralizing capacity. At this writing, appropriate parameter codes are not available to enter data above in NWIS-I in milliequivalent units.

Final assessment of chemical stability

The field team decides whether or not to collect ground-water-quality samples on the basis of the relative stability of field measurements taken near the end of the purge, as the last of the required purge volume is evacuated from the well (table 19). It is recommended that samples not be collected if unstable field measurements persist. Unstable measurements generally indicate one or more of the following is true: (1) that the source of water entering the well is changing with time, (2) that a decreasing proportion of water leaving the well is water that initially was standing in the well, or (3) that water is entering the well in a disproportionate manner as time elapses from a new source or from several sources. Thus, the resulting water-quality data obtained from sampling a well with unstable field measurements may or may not relate to the land use, aquifer, or other conditions being investigated.

Sample Collection and Processing

Sample collection begins when purge criteria have been met. The type and number of individual ground-water-quality and QC samples obtained, however, depend on the ground-water component (Study Unit Survey, Land-Use Study, or Flowpath Study) for which samples are being collected (table 1). Study-Unit (or Subunit) Surveys and Land-Use Studies commonly include the collection of samples for organic, inorganic, and possibly trace-element, radiochemical, and isotopic analyses. Flowpath Studies generally are limited in scope and require fewer samples than either Surveys or Land-Use Studies. For each component, routine, and possibly topical, quality-control samples also are scheduled for collection at selected wells.

Regardless of the particular component under investigation, protocols and procedures are followed in a consistent, timely, efficient, and quality-controlled manner. The protocols and procedures that follow describe the sample-collection methods to be used for NAWQA ground-water-quality studies (table 21), and include the collection and processing (filtration, preservation, handling, and shipment) of water-quality and QC samples for a given analysis. In addition, the protocols also specify an order or sequence in which groups of samples for different analytes are collected under these protocols, which generally is to be similar at each well in a given component, and among components with similar data-collection requirements.

Overall, the NAWQA sample-collection protocols and recommended procedures (table 21) follow USGS protocols and procedures (F.D. Wilde, U.S. Geological Survey, written commun., 1995--see footnote 1). Thus, samples for organic analytes (unfiltered, then filtered) are collected first, followed by samples for inorganic analytes (filtered, then unfiltered), which in turn are followed by the collection of samples for other (ancillary) analytes--isotopes, radiochemicals, and chlorofluorocarbons (table 21). Routine replicate ground-water-quality samples, including those for field spikes, are collected in conjunction with the primary ground-water-quality samples (table 21). (Routine QC samples that use blank water are collected in the field after ground-water-quality samples and after the decontamination of sample-collection equipment.)

Table 21. Collection order, processing, preservation, and field storage required for ground-water-quality and replicate samples for the National Water-Quality Assessment Program

[Except as noted, equipment used is described earlier (table 3). Except as noted, samples are (possibly filtered and) obtained in a collection chamber, and (if necessary) chemically preserved in another chamber. Except for filtered inorganic samples (see below), all routine replicate samples, including those for field spikes, are obtained sequentially for each National Water Quality Laboratory (NWQL) schedule or laboratory code. Replicate samples for filtered inorganics (FA, FCC, FU, and alkalinity) are collected after the first set of these samples are obtained, and with a second Quality Water Service Unit (QWSU) capsule.

GCV	glass chilled volatile	GCC	glass chilled chromatograph	SC	(NWQL) schedule	LC	(NWQL) lab code
HCl	(NWQL) hydrochloric acid	**CG**	change gloves	mL	milliliter	mm	millimeters
µm	micrometers	L	liters	N_2(g)	nitrogen gas	lb/in^2	pounds/square inch
PBW	(NWQL) pesticide blank water	FA	filtered acidified	FCC	filtered chilled	HNO_3	(NWQL) nitric acid
DIW	deionized water	FU	filtered untreated	RU	raw untreated	U	Uranium
Ra	Radium	ASR	analytical service request	°C	degrees Celsius	≤	less than or equal to]

	Team Member A			Team Member B	
Sample type (SC, LC) and order of collection	Filtration	Collect, by filling	Quality-assurance checks or measures	Chemical preservation	Temporary storage
1. Organic filtered and unfiltered					
• Volatile organics (SC2090, SC2091, or SC2092 with SC1306)	None	3, GCV, 40-mL amber, glass vials, sequentially; using Teflon tube to fill each vial from its base until overflow occurs	Avoid sample aeration when filling. Replace vial if gas bubble appears after capping. (Team Member B, re-check, immediately after preserving)	Add 1 to 5 drops HCl to each vial, and record amount [on field and ASR forms]	Sleeve and chill[1]
• Organic carbon (SC2085)	**CG**, use tweezers, and place a QWSU, 0.45 µm, 47-mm-diameter silver filter in cylinder. Fill with sample, cap, and (outside of chamber) pressure-filter [N_2(g), ≤15 lb/in^2][2]	1, GCC, 125-mL, amber bottle to neck base after first discarding the initial 25 mL of filtrate to waste (do not rinse bottle)	Do not include plastic filter separator, or flip filter over during removal from package. Do not overpressurize filter cylinder	None	Sleeve and chill[1]
• Pesticides (SC2001 or SC2010, SC2050 or SC2051)[3]	**CG**, use tweezers, and place a NWQL, 0.7 µm, 142-mm-diameter, baked, glass-fiber filter in plate unit, prewet the filter, close unit, and void air[4]	1, GCC, 1.0-L, amber glass bottle for each SC after first discarding the initial 125 mL of filtrate to waste (do not rinse bottle)	Prewet membrane with 10 - 20 mL of NWQL PBW. Do not fill bottle beyond neck to reduce breakage if sample volume expands on chilling	None	Sleeve and chill[1]

Table 21. Collection order, processing, preservation, and field storage required for ground-water-quality and replicate samples for the National Water-Quality Assessment Program--Continued

	Team Member A			Team Member B	
Sample type (SC, LC) and order of collection	Filtration	Collect, by filling	Quality-assurance checks or measures	Chemical preservation	Temporary storage
2. Inorganic, filtered					
• Trace elements (SC2703-FA)	**CG**, and attach QWSU 0.45-µm, preconditioned Supor capsule filter with flexible Teflon tubing, and void air[3] from capsule.	1, FA, 250-ml, clear, prerinsed, poly bottle to neck base after a 25-mL filtrate rinse (include cap)	Invert capsule (arrow up), and tap to evacuate air while filling. Verify DIW is still in sample bottle from office prerinse before use; otherwise replace bottle	Add 1-mL ampoule of HNO_3	In dry cooler, avoid extreme heat or cold
• Major ions (SC2750-FA and archive)	If possible, use same capsule as above, otherwise replace with another preconditioned capsule in manner above.	2, FA, 250-mL, clear, prerinsed, poly bottles to necks after 3, 25-mL filtrate rinses on each (include cap)	Verify DIW is still in each bottle from office prerinse before use; otherwise replace bottle	Add 1-ml ampoule HNO_3 to each bottle, **CG**	In dry cooler, avoid extreme heat or cold
• Nutrients (SC2752-FCC)	**CG**, and, if possible, use the same capsule as above, otherwise replace in manner above.	1, FCC, 125-mL amber, prerinsed, poly bottle to neck base after 3, 25-mL filtrate rinses (include cap)	Verify DIW is still in bottle from office prerinse before use; otherwise replace bottle	None	Sleeve and chill[1]
• Major ions (SC2750-FU)	If possible, use same capsule as above, otherwise replace in manner above.	1, FU, 250-mL, clear, prerinsed, poly bottle to neck base after 3, 25-mL filtrate rinses (include cap)	Verify DIW is still in bottle from office prerinse before use; otherwise replace bottle	None	In dry cooler, avoid extreme heat or cold
• Alkalinity (ALK)	If possible, use same capsule as above, otherwise replace in manner above.	1, FA, 250-mL, clear, prerinsed, poly bottle to top after 3, 25-mL filtrate rinses (include cap), and cap bottle	Verify DIW is still in bottle from office prerinse before use; otherwise replace bottle	On basis of grab sample, pipette the required volume of filtrate into 250-mL beaker, titrate, and record data[5]	None

Table 21. Collection order, processing, preservation, and field storage required for ground-water-quality and replicate samples for the National Water-Quality Assessment Program--Continued

	Team Member A			Team Member B	
Sample type (SC, LC) and order of collection	Filtration	Collect, by filling	Quality-assurance checks or measures	Chemical preservation	Temporary storage
2. Inorganic unfiltered					
• Major ions (SC2750-RU)	None	1, RU, 500-ml, clear, prerinsed poly bottle to neck base after 3 25-mL rinses with raw sample (include cap)	Verify DIW is still in bottle from office prerinse before use; otherwise replace bottle	None	In dry cooler, avoid extreme heat or cold.
• Acid-neutralization capacity (ANC), recommended	None	1, FA, 250-mL, clear, prerinsed poly bottle to top after 3, 25-mL rinses with raw sample (include cap)	Verify DIW is still in bottle from office prerinse before use; otherwise replace bottle	On basis of grab sample, pipette the required volume into a clean, 250-mL beaker, titrate, and record data[5]	None
3. Other Samples					
• Trace elements (1.0-L samples, for example, U, and Ra)	**CG**, and attach preconditioned capsule in manner similar to that used for SC2703 above[3]	1, FA, 1-L, clear, prerinsed, poly bottle to neck base for each element after a 25-mL rinse of bottle and cap	Verify DIW is still in bottle from office prerinse before use, otherwise replace bottle	**CG**, and add 2 HNO_3 ampoules to each bottle	In dry cooler, avoid extreme heat or cold.
• Tritium isotopes	None	1, 1.0-L, clear, prerinsed poly bottle, filled to top after 3, 25-mL rinses (include cap with conical insert)	Verify DIW is still in bottle from office prerinse before use, otherwise replace bottle. Leave no headspace in bottle	None	In dry cooler, avoid extreme cold or heat.
• Deuterium-Oxygen isotopes	None	1, 125-ml, glass, amber bottle to top after 3, 25-ml rinses (include cap with conical insert)	Leave no headspace in bottle	None	In dry cooler, avoid extreme heat or cold.

Table 21. Collection order, processing, preservation, and field storage required for ground-water-quality and replicate samples for the National Water-Quality Assessment Program--Continued

Sample type (SC, LC) and order of collection	Team Member A: Filtration	Team Member A: Collect, by filling	Team Member A: Quality-assurance checks or measures	Team Member B: Chemical preservation	Team Member B: Temporary storage
3. Other, continued					
• Radon (LC1369)	Disconnect extension line to sample chamber, attach radon-collection unit to manifold, partly close valve on unit. Check all sample-wetted lines up to unit for gas bubbles, and dislodge any by tapping lines with hard object. (Record on ASR form if bubbles reform before samples are obtained)	1, radon scintillation vial, after rinsing syringe barrel twice with sample before injecting 10.0 mL of sample into vial at base of mineral oil. Cap and shake 10 seconds. Note and record actual time on ASR form (comments-to-NWQL line)	Compare oil level in vial before use to that in vial from another tube. Return vial unused to NWQL if oil level is low. Create sufficient back-pressure in device to create easy with-drawal of sample without degassing. Void all air from syringe after second rinse before inserting syringe needle into septum of device. Initially withdraw 15 mL of sample, invert syringe [needle up], void sample to leave 10.0 mL in syringe barrel, re-insert needle (down) into vial to collect	None	Repack vial in shipping tube, wrap ASR form (with collection time) around tube, fix with rubber band, and place tube in resealable plastic bag.
• Chlorofluorocarbons (CFCs)	Modify setup to attach CFC--collection unit (Busenberg and Plummer, 1992) to manifold or pump tubing outlet	Three to five CFC vials filled according to procedures used by Busenberg and Plummer (1992)	Critical to avoid air entrainment or sample degassing during collection (See radon above)	None; can be stored indefinitely if not biologically active	In partitioned box to reduce breakage

[1]Glass containers are placed in foam sleeves, and chilled samples generally stored in ice. Desired temperature of chilled samples is 0 to 4 °C

[2]Cylinder and nitrogen-gas filtration system are available from Hydrologic Instruments Facility (table 3, in this report).

[3]Possible flow adjustment could be required to increase flow from filtration unit to about 0.1 gallon (500 mL) per minute.

[4]Samples under schedules SC2010 and SC2051 require Study Unit to extract water samples and send extracts to NWQL (see section on Pesticide Solid-Phase Extraction).

[5]Volume of filtrate and normality of titrant determined from grab sample taken near end of purge (table 20, in this report). National Field Manual (Radtke and Wilde, in press) discusses incremental and Gran titration methods and calculations. For NWIS-I, recommend using parameter codes as indicated in appendix (fig. A8).

Field-team functions

The setup (fig. 2) used to purge the well is modified slightly for sample collection. The short turbidity-collection line is replaced by an extension line that runs to the sample-collection chamber. The flow, which has been passing through an instrumented flowthrough chamber, is rerouted (for example, using the second three-way flow valve as shown in fig. 2) through this extension line that is connected to the sample-collection chamber. The rate of flow through the sample-collection setup is about 0.1 gal (500 mL) per minute.

In general, samples are obtained and, with one or two exceptions, processed (for example, filtered) by **Team Member A** (table 21). Except for radon and chlorofluorocarbons, which require special collection equipment, and dissolved organic carbon, which requires a pressurized filtration, samples are obtained (sample containers are opened, if necessary, final rinsed, filled, and closed) only within the collection chamber. As each sample container is removed from the chamber, it is set aside on a clean surface, and not handed directly to **Team Member B**. This reduces the likelihood of contamination of **Team Member A**, the chamber, and subsequent samples, as collection continues.

In general, **Team Member B**, who has removed coveralls and work gloves, preserves (if necessary) and temporarily stores samples (table 21). **Team Member B** also performs field titrations.

Chemical preservation of NAWQA samples currently (1995) requires a single preservation chamber (for NWQL hydrochloric and nitric acids). This chamber is separate from that used to collect samples (table 3). During preservation, samples are opened, preserved, and closed in this chamber by **Team Member B**.

Throughout the collection process, the field-team members frequently replace their gloves at logical intervals to further reduce sample contamination (table 21, CG). If either one leaves the collection or preservation areas to perform other tasks, gloves must be replaced before activities in these areas are resumed.

Near the end of the sample-collection process, field titrations (particularly when replicate filtered (ALK) or unfiltered (ANC) samples are taken) generally will require most of **Team Member B's** time. Therefore, **Team Member A** often will complete the collection of all samples after that for ANC with little or no assistance (table 21).

Special considerations for selected sample types

With adequate training and preparation, collection procedures for most sample types require no more than a conscientious effort to rinse and fill a bottle in a clean setting to obtain high-quality data. Situations arise, however, which necessitate processing samples simultaneously with their collection, or which require modifications to the general field-equipment setup and protocols described (table 21).

Filtered Samples. To obtain high-quality samples, care must be taken in the use of filter units and to avoid overpressurizing these units. The NWQL aluminum plate filter (for pesticide samples) is prepared in the collection chamber (table 21) and has a simple nipple fitting, which is connected to the sample outflow orifice inside the sample chamber by a short piece of Teflon tube. Air is evacuated from the plate unit using the trip valve on top of the unit as it is filled by raw sample flow. After evacuating the air, the trip valve is closed. Initially, some filtrate is discarded before any samples are collected (table 21).

The sample for dissolved (filtered) organic carbon (DOC) is collected directly in the DOC filter cylinder in the collecting chamber. The DOC cylinder subsequently is capped, removed from the chamber, and the sample filtered under N_2 gas at a low (15 lbs/in^2 or less) internal pressure. (Pressures in excess of 15 lbs/in^2 can be hazardous and can rupture the filter membrane and invalidate the sample.)

Routine NAWQA 0.45-µm-filtered inorganic samples are obtained using the QWSU capsule filter (for inorganic samples). The capsule is preconditioned before use (see “Final Presampling Plans and Preparations”). The capsule nipples are attached to flexible Teflon lines, which allow the capsule to be inverted (arrow on capsule denotes direction of flow) during its final rinse and use. Inverting the capsule so that the flow is vertically upward while the capsule initially fills with water, combined with tapping the side of the capsule several times while it fills, forces most air out of the capsule. Purging most of the air from the capsule filter helps prevent oxidation and possible precipitation of redox-sensitive analytes (for example, iron, manganese, aluminum, and uranium) that would (negatively) bias filtrate concentrations. Procedures for filtering inorganic samples that require filters with 0.2-µm or smaller pores are described in an internal document (F.D. Wilde, U.S. Geological Survey, written commun., 1995--see footnote 1).

In some instances, filter clogging by fine sediment, or even finer colloids, could markedly reduce the rate of sample flow through the filter units described. Field teams are not to increase flow by forcing water through a filter unit under increasing pressure. Instead, either clean the clogged unit (see “Decontamination of Field Equipment” below) and reinstall the cleaned filter, or simply replace the clogged unit with a second filter unit of similar type. It is most efficient to have a second unit available. A second capsule filter unit also is required for the collection of replicate, filtered inorganic ground-water samples.

Radon and Chlorofluorocarbon (CFC) Samples. Collection of these samples occurs outside the sample-collection chamber and requires modifying the sample collection setup--replace the extension line from the flow manifold to the sample-collection chamber with the appropriate collection device (fig. 2). In either case, sample extension and pump-reel lines are inspected to determine if gas bubbles are forming inside the line, or if any air is being drawn into the sample flow at any connection. If these lines are adequately insulated to prevent warming of the sample flow and connections are air tight, bubbles generally are not present. The presence of bubbles indicates possible degassing of radon and CFCs from sample flow or entrainment of CFCs from air that enters loose connections. Initially, bubbles often can be dislodged and evacuated with sample flow by striking the extension or pump-reel line sharply with a hard, blunt object. Connections can be tightened to prevent air entrainment. This, combined with backpressure created by partially closing the valve on the radon-collection unit or backpressure created in the operation of the CFC collection unit, often will reduce degassing during sample collection.

For radon samples, the collection unit valve is partially closed, the glass syringe needle is inserted through the septum port of the unit, and the unit valve is further closed until there is sufficient backpressure to create an almost effortless withdrawal of water into the syringe. The syringe is partially filled, withdrawn from the septum, inverted (needle up), and the water ejected to waste. This syringe rinse is repeated at least one time. After the final rinse, and with the syringe plunger completely depressed (no air or water in syringe barrel) the needle is reinserted through the septum, and about 15 mL of sample are withdrawn slowly into the syringe barrel to avoid suction and degassing. The needle is withdrawn from the septum, the syringe inverted (needle up), and the sample slowly ejected to waste until only 10.0 mL remains in syringe barrel. The syringe needle is tipped downwards, and the needle tip inserted into the mineral oil, and to the bottom of the radon sample vial. The 10.0 mL sample is injected slowly, the syringe removed, the vial firmly capped, and the actual time (in military format) of sample collection is recorded (see appendix, fig. A10). If no replicate sample is taken, the vial is shaken for 15 seconds, repacked in tube, the tube capped, and the NWQL-ASR form (lab copy) for radon (LC1369) is wrapped around the tube, secured with a rubber band, and the tube temporally stored (table 21). If a replicate sample also is collected, the height of the oil levels in the two vials is compared before either sample is collected and should be similar. If levels are noticeably different, return the vial with the low oil level to NWQL with a note explaining the problem.

Because it can take a considerable amount of time to set up and collect samples for chlorofluorocarbons (CFCs), they generally are the last samples collected at a well. As in the case of radon, their collection requires that the sample-collection setup be modified. The CFC unit used to collect samples (Busenberg and Plummer, 1992) replaces the extension line and sample-collection chamber, or the CFC unit can be connected directly to the portable pump outlet (fig. 2). Before connecting the CFC unit, it is recommended that flow be routed through the flowthrough chamber, and field measurements be taken to characterize conditions at the onset of CFC sampling. The procedures for collecting CFC samples are described in Busenberg and Plummer (1992).

Decontamination of Field Equipment

Decontamination is the cleaning process used to remove contaminants from equipment. Sample-wetted equipment used by NAWQA is decontaminated after sample collection at each well, preferably before the equipment dries. Decontamination is conducted in clean and protected environments (in field area, vehicle, or chamber) as is appropriate to the equipment being cleaned. If this is not possible, the equipment is at least flushed and rinsed, preferably with a low-phosphate detergent, followed by a clean water (DIW) rinse, before it is temporarily stored for thorough cleaning at a later date and before it is reused to collect samples.

On the basis of NAWQA pilot studies, studies conducted by the Office of Water Quality, and data reported from other sources, the decontamination protocols and procedures for NAWQA (tables 22 and 23) generally are capable of removing a broad suite of contaminants from equipment affected by (a) milligram-per-liter contaminant levels for metals and metal complexes, and (b) microgram per liter contaminant levels for pesticides and volatile organic compounds. The decontamination protocols and recommended procedures for NAWQA assume equipment was (or will be) used to collect filtered and unfiltered samples for most analytes (table 1). The actual efficiency of these protocols and recommended procedures to remove contaminants to below NAWQA method-detection or reporting levels can differ depending on the type of equipment used, the solubility and concentration of the contaminant, and the length of time equipment is exposed to the contaminant.

Table 22. Decontamination of small equipment used for sample collection

[Volumes of solutions used (detergent, deionized water-DIW, methanol, and final rinse water) depend on Study-Unit equipment setup. DIW used for rinses must have a conductivity that does not exceed 1.0 microsiemens per centimeter at 25 degrees Celsius. A 0.1- to 0.2-percent detergent solution is prepared by adding about 5 to 10 drops of detergent concentrate to each gallon of DIW. **CG** indicates field-team members are to change to clean, powderless, latex or vinyl gloves before proceeding. Latex gloves are used when handling methanol. DOC, dissolved (filtered) organic carbon; VOCs, volatile organic compounds]

	SMALL FIELD-EQUIPMENT CATEGORIES[1]		
DECONTAMINATION STEPS BY CATEGORY	Equipment with nonmetallic parts (for inorganics only). Includes convoluted Teflon tubing used on capsule filter, turbidity sample vials, and field-titration Teflon stir bars, glass beakers, volumetric pipettes, graduated cylinders, and polyethylene bottle for ALK (ANC) sample collection.	Equipment with metal parts and for inorganics, but not exposed to methanol. Includes the DOC filter unit, the short Teflon line with metal quick-connect used to obtain turbidity samples, and the radon-collection equipment--syringe with metal leur-lock fitting, syringe needles, and the sample-collection unit.	Equipment with nonmetallic parts, and rinsed with methanol for organics. Includes pesticide filter unit, the short Teflon tubes for VOC sample-collection and for attaching pesticide filter unit to a sample-chamber outflow port, tweezers, and the short Teflon-metal hook-up line (without plastic garden-hose-threaded fitting to well).
1. PREPARATION	For each equipment category, disassemble parts, and place them in a small, clean, colorless, polypropylene basin dedicated to that category.		
2. DETERGENT WASH	Cover and fill parts in each basin with detergent, and let stand at least 10 minutes; then scrub each part gently with a soft-bristled brush that contains no metal parts and is dedicated to that basin.		
3. DIW RINSE	Rinse each part thoroughly with DIW at least three times to remove detergent solution and any particulate matter. Complete rinsing of equipment, and also rinse basin and brush, in one category, and **CG** before proceeding to equipment in the next category. Place rinsed equipment on a non-contaminating surface dedicated to the equipment in that category, and loosely cover equipment to prevent recontamination. Plastic sheets can be used for equipment in the first category; aluminum foil can be used for equipment in the other categories. **Complete decontamination step (5) below for first two categories before proceeding with the methanol rinse (4) of equipment in the last category).**		
4. METHANOL RINSE	**(Third equipment category only) CG (latex),** wear safety glasses; in a well-ventilated area free of open flames or sparks, rinse each piece of equipment at least three times with small amounts of methanol from a Teflon squeeze bottle. Place each rinsed part on a clean, noncontaminating surface (such as aluminum foil) and loosely cover rinsed parts (with foil sheet) to avoid recontamination. Rinse each part over the basin previously used for detergent and DIW rinse. Transfer used methanol from this basin to a waste container after all parts are rinsed, and before drying parts.		
5. DRY, INSPECT, and STORE	**CG** and use a portable dryer, or air dry, each part, in clean area. After each part is dried, inspect it. Replace chipped or cracked glassware, or scratched turbidity vials. Replace tubing if mold, mildew, or imbedded sediment are present. Replace filter seals if cracked or severely crimped. Store equipment in the first category in two nested, resealable plastic bags, and that from other categories in Teflon bags or wrap in aluminum foil and then place in a resealable plastic bag.		

[1]Field sensors are each thoroughly rinsed with DIW, blotted dry, inspected along with field meters, and (if necessary) reconditioned and stored according to manufacturers' recommendations.

Table 23. Decontamination of setup equipment used for sample collection

[Volumes of solutions used (detergent, deionized water (DIW), methanol, and final-rinse water) depend on the Study-Unit equipment setup used. DIW used for final rinse must have a specific conductance that does not exceed 1.0 microsiemens per centimeter at 25 degrees Celsius. For methanol-rinsed equipment, it also should be volatile-organic-compound-free and pesticide-free. A 0.1- to 0.2-percent detergent solution is prepared by adding about 5 to 10 drops of detergent concentrate to each gallon of DIW. **CG** indicates the field-team members are to change to clean, powderless latex or vinyl gloves before proceeding. Use latex gloves when handling methanol.]

DECONTAMINATION STEP	Exterior of portable pump intake and pump tubing drawn from pump reel	Interior of pump intake and sample-wetted tubing[1]; including that from reel, flow manifold, flowthrough chamber, and all extension lines
1. PREPARATION	**CG**, raise intake from well, coil tubing onto plastic sheet set to drain, or into plastic basin, and disconnect tubing at pump-reel that runs to remainder of setup.	Place pump intake[2] in clean standpipe.[3] Route flow from pump intake through setup to sample chamber. Temporarily attach one end of a Teflon return-flow line to the outflow tube in the sample chamber, and run the other end of this line back to the standpipe.
2. DETERGENT WASH	Pour detergent solution over pump intake and tubing. Scrub both gently with a soft-bristled brush that has no metal parts.	Fill standpipe with detergent solution to level above pump intake. Begin pumping, and note the time when return-flow line has filled. Direct flow from this line back into standpipe, and cycle detergent at 500 milliliters per minute for at least 5 cycles, or 10 minutes. At end of cycling, add more detergent to the standpipe, route flow to partially fill field-instrument flowthrough chamber and waste lines. Stop pump.
3. DIW RINSE	**CG**, raise intake and tubing above sheet or basin, and rinse at least 3 times with DIW to remove detergent and any particulates. Proceed to inspection and storage (Steps No. 6 and 7).	**CG**, rinse standpipe and intake, individually, at least 3 times to remove detergent. Reroute flow back to sample chamber, add DIW to standpipe, and pump, without cycling, until grab samples from the open end of return-flow line (now directed to waste) indicate DIW rinse is detergent free (no sudsing). Halt pump. Shake flowthrough chamber to suspend any sediment, then drain detergent from this chamber and waste lines. Add more DIW to standpipe, start pump, route flow to the flowthrough chamber, and rinse chamber several times to remove detergent. Repeat for waste lines. (Flowthrough chamber and waste lines are inspected and stored at this time, see below. If methanol is not required, go to Step No. 5, FINAL RINSE, second paragraph).
4. METHANOL RINSE[4]	None. (Detergent scrub considered effective for cleaning exterior of pump intake and pump tubing.)	Reroute flow to sample chamber, and put free end of return-flow line near the methanol waste container. **CG,** rinse intake and standpipe, individually 3 times, place intake in standpipe, and, if possible, force air into first several feet of pump tubing (to mark end of DIW and beginning of methanol rinse.) Fill the stand pipe with methanol to level above pump intake. Add and pump at least 2 liters of methanol into setup. If the setup storage is less than 2 liters, collect methanol as it leaves from end of return-flow line in waste container. Halt pump. Put methanol left in standpipe into waste container. Pump air if possible into tubing (to mark end of methanol). Proceed to final rinse.

Table 23. Decontamination of setup equipment used for sample collection--Continued

DECONTAMINATION STEP	Exterior of portable pump intake and pump tubing drawn from pump reel	Interior of pump intake, and sample-wetted tubing, including that from reel, flow manifold, flowthrough chamber, and all extension lines
5. FINAL RINSE) (DIW)	None	**CG**, and DIW rinse standpipe and intake individually at least 3 times. Add and pump DIW through setup to sample-collection chamber and out return-flow line. On basis of air marking, line storage, and pump rate, collect methanol from return-flow line as it is forced out by final rinse. Pump at least an additional 0.1 gallons of DIW through setup for every 10 feet of methanol-wetted tubing, including return-flow line, to waste after used methanol is collected. Disconnect sample chamber from manifold, discard used chamber bag, DIW-rinse chamber frame, and dry. Repeat above for the preservation chamber. DIW rinse and dry exterior of extension lines and flow manifold. Inspect and store each piece of equipment as it is dried according to procedures below.
6. INSPECTION	Simultaneously dry, inspect, and recoil tubing on pump reel. Dry with large, disposable, lint-free towels. Check for stains, cuts, or abrasions, and repair or replace as necessary. Check and repair pump intake and antibacksiphon for loose or missing screws.	Inspect to ensure flowthrough chamber and waste lines are free of sediment. Extensions lines also are inspected for stains, cuts, or serious abrasions. and sediment. The flow manifold also is checked for stains or sediment, and to ensure valves and quick-connect fittings are in good working order. Repair or replace as necessary to eliminate any problems.
7. STORAGE	Except for pump intake and sufficient pump tubing to place intake in standpipe, cover the pump reel and recoiled tubing with a clean, plastic sheet or bag or other noncontaminating material. Clean pump intake as described on right.	Store flowthrough chamber, waste lines, looped and recoupled extension lines, and flow manifold in clean plastic bags. Place pump intake inside Teflon or other noncontaminating bag, and then under material used to cover pump-reel assembly. Fit sample and preservation chambers with clean bags. Unless field blanks are taken, store equipment in vehicle for transport.

[1] Before their initial use, all sample lines are acid washed to remove oils and other manufacturing residues. (See table 3.)

[2] Pump intake and reel tubing are that used on-site to collect samples. For a hook-up connection that attached setup to a garden-threaded-hose valve on a water-supply pump, a small, portable pump, such as a Teflon diaphragm pump head mounted on a 12-volt electric drive pump, or a valveless metering pump with a ceramic piston (for example, Fluid Metering Instrument Model QB1-CSC or CSV) with 12-volt power can be used. Either pump is fitted with Teflon convoluted or rigid-wall tubing (acid-washed when first obtained). The outflow tube from the pump is fitted with the appropriate quick-connect to attach it to the extension line that ran from the hook-up connection to the flow manifold (fig. 2).

[3] Standpipe is of sufficient height to supply necessary head for pump intake to operate. For some pumps, such as the Grundfos Redi-Flo2, this head requirement is critical. Standpipe also must not absorb methanol (table 3).

[4] Performed when it is known or suspected that equipment was exposed to pesticides or volatile organic compounds.

In general, decontamination by NAWQA field teams includes a low-phosphate, dilute-detergent wash and scrub of equipment, followed by multiple rinses with DIW (tables 22 and 23). A methanol wash also is used on selected equipment that is likely to have been contaminated by volatile organic compounds or pesticides.

Except for CFCs, the equipment required for decontamination, including that for safe handling of methanol, has been described (table 3). Decontamination of CFC sample-collection equipment is to be done by the supplier of that equipment (Eurybiades Busenberg, U.S. Geological Survey, written commun., 1995).

During field decontamination of NAWQA equipment, it is essential that the cleaning solutions used be completely removed as part of the decontamination process before equipment is reused. The residual presence in sample-collection equipment of detergent and methanol can bias some measurements. Reports of organic carbon samples being affected by residues of detergent and methanol have been verified. Removal of methanol and detergent from pump-reel lines or the purge and collection setup (fig.2) requires that adequate volumes of rinse water are passed through these lines. Study Units can calculate the storage volume of these lines (table 24). The sample-collecting setup storage volume is not only useful in estimating the amount of dilute detergent and DIW needed for decontamination, but also is needed to determine the volume of high-purity water needed for field blanks.

Ideally, the final rinse water after the methanol rinse (table 23) should not contain detectable quantities of the analytes of interest. Study Units need to ensure that rinse-water composition does not lead to equipment contamination that can ultimately compromise the interpretation of the water-quality data.

To obtain the suitable quality of DIW final rinse water for methanol-rinsed equipment, ASTM Type 1 DIW is passed through a charcoal filtration system, stored in noncontaminating containers under noncontaminating conditions, and periodically analyzed to ascertain that it is free of the compounds of interest at the method detection limit. Alternatively, NWQL volatile- and pesticide-free blank water (VPBW) can be used for the final DIW rinse.

Decontamination of equipment exposed to high concentrations of contaminants (for example, VOCs in excess of 10 μg/L) could require procedures that are more rigorous than the protocols and recommended procedures described here and involve cleaning agents that differ from those commonly used (such as hexane). Whatever procedures are used, they must be documented by the Study Unit. This enables the National Program to identify potential problems and modify procedures accordingly. Questions regarding equipment decontamination and the use of other decontamination procedures can be directed to the NAWQA QA Specialist.

Table 24. Estimation of decontamination solution volumes for standpipe and sample-wetted tubing

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The storage volume, Vs, of a set of pump-reel and extension lines can be estimated as follows:

$$Vs = [(Lp \times Cp) + (Le \times Ce)] + [Csp \times Vsp]$$

where Vs is storage volume, in gallons
Lp is length of pump-line segment being cleaned, in feet
Le is length of extension lines, in feet
Cp (or Ce) = 0.023 gallons per foot for a 3/8-inch internal-diameter (ID) line
or = 0.041 gallons per foot for a 1/2-inch ID line
Csp = 0.264 gallons per liter,
Vsp is volume of solution needed to fill standpipe to minimum level required to operate pump, in liters.[1]

Examples:

Given: (1) Lp; the sample-wetted line segment is 100 feet for a pump-reel system that has a 1/2-inch ID line;
(2) Le; two 10-foot, 3/8-inch ID extension lines, one running from the pump-reel outlet to the sample collection chamber, and another running from the chamber back to the pump-reel (return-flow line to standpipe), and
(3) Lsp; that the minimum volume of solution required in the standpipe to operate the pump is 0.8 liter.

(A) Estimate the volume of detergent solution needed for the detergent wash cycle.
Answer:

$$Vs = [(100 \times 0.041) + (20 \times 0.023)] + [0.264 \times 0.8] = 4.87 \text{ gallons}$$

(B) Estimate volume of District deionized water needed to displace detergent solution.
Answer: Vs, ideally.[2]

(C) Estimate volume of high-purity water needed to displace 2 liters of methanol just pumped into the system.
Answer: Vs, ideally.[3]

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[1]The minimal volume is that which corresponds to a level of solution in the standpipe which, if maintained, allows the pump to operate without entraining air into flow. Once this level is reached, remove pump and measure this volume.

[2]Estimate assumes no mixing of the two solutions and ignores potential for detergent to adhere to tubing walls. As a general rule, it is recommended that outflow from end of return-flow line be checked for sudsing to determine when detergent has been removed.

[3]Estimate assumes no mixing at the interface of the two solutions and ignores potential for methanol to adhere to tubing walls. As a general rule, it is recommended that an additional 0.1 gallons (~ 0.4 liters) of high-purity water for each 10 feet of pump and extension line used be displaced from sample-wetted lines (pump-reel line-to-sample chamber) to remove methanol residues. Thus in the example above, another 0.2 (= [(100 + 10) x (0.1/20)]) gallons (4 L) of DIW would be pumped from the system. This implies a total of about 6.1 (= 4.9 + 1.2) gallons (24 L) of water would be used to remove methanol from the setup equipment.

Preparation of Blank Samples

To verify that decontamination is adequate, field and possibly other blanks are prepared at selected well sites in each ground-water component (see "Routine Quality-Control Samples: Type, Number, Site Selection, and Timing"; and appendix, figs. A13 (A,B), A14, A18, and A19). These field blanks are collected immediately after the equipment that was used to collect samples at the well has been decontaminated. Methods used to obtain, process, preserve, temporarily store, and analyze field blanks (table 25) generally are similar to those used for corresponding ground-water samples (table 21). With the exception of trace-element field blanks, field blanks are analyzed using the same NWQL schedules used to analyze ground-water-quality samples.

Study Units are required to use specific types of water for field blanks (table 3). Generally, NWQL VPBW is required for VOC field blanks, and either NWQL VPBW or NWQL PBW is required for pesticide field blanks. Field blanks for dissolved organic carbon are obtained using either NWQL water types, but a DOC source-solution blank also must be taken (table 25, footnote 3; and appendix, fig. A14). The QWSU IBW is required for trace-element, major-ion, and nutrient field blanks. These blank solutions are analyzed regularly (by lot number) by the NWQL to certify that they are free of measurable concentrations of NAWQA analytes. Lot numbers are recorded by the field team as part of the required data record for NAWQA field, solution, and trip blanks (see appendix, figs. A13, A14, and A19).

Except for trace elements, all field blanks are analyzed using the analytical NWQL schedule or laboratory code used for the corresponding ground-water-quality samples. For trace-element field blanks, NWQL schedule SC172 and laboratory codes LC0112 (As) and LC0087 (Se) are used in lieu of SC2703 to obtain concentration data at method detection limits (equal to or in excess of 0.1 μg/L).

Preparation of Other Routine Quality-Control Samples and Field Extracts of Pesticide Samples

As part of their data-collection activities, field teams will sometimes need to obtain, prepare, or process selected types of samples at some sites on the basis of required routine QC sampling for each ground-water component (for example, table 12). For example, the field team occasionally will collect replicate ground-water-quality samples at selected wells and field spike these samples with known amounts of selected VOCs or pesticides. If VOC samples are being collected for a Study-Unit (or Subunit) Survey or Land-Use Study, spiked VOC ground-water samples are required at selected sites. The field team also will submit at least one trip blank per field season for VOCs from the field. If pesticide ground-water samples are being collected, pesticide field spikes are required. The field team also has the option of either extracting pesticides (under NWQL schedules SC2010 and SC2051) from spiked or unspiked ground-water samples, or sending these water-quality samples to the NWQL for extraction (under NWQL schedules SC2001 and SC2050). Finally, if trace-element samples (SC2703) are collected, the field team will send three standard reference samples per field season from the field to the NWQL for analysis. Each of these activities requires that special equipment be used, or that specific procedures be followed (described below). It is strongly recommended that field spikes, solid-phase extraction, and the preparation of trip-blank and reference samples be done after all ground-water samples have been collected, equipment has been decontaminated, and (if applicable) field blanks have been collected.

Table 25. Field-blank sample-collection protocols and procedures for ground-water components of the National Water-Quality Assessment Program

[DIW, District deionized water with specific conductance less than 1.0 microsiemens per liter; NWQL-VPBW, National Water Quality Laboratory volatile organic and pesticide-free blank water; NWQL-PBW, pesticide-free blank water; QWSU-IBW, Quality Water Service Unit inorganic-free blank water; DOC, dissolved (filtered) organic carbon; gal, gallons; L, liters; ~, approximately]

1. **Assumptions:** Equipment just used to collect ground-water samples has been decontaminated and, except for the pump intake being in a standpipe, is set up on site in the same manner as it was for the collection of ground-water samples.

2. **Determine Blank-Solution Types and Volumes Required[1]:**

Field blank(s) collected	Required blank-solution type	Minimum volume in gal (L)	Required procedure
VOCs and DOC[2] or pesticides and DOC	NWQL-VPBW NWQL-PBW	1.5 (~ 6)	Waste 0.5 gal, then collect field blanks; can use DIW to force last of VPBW or PBW water through the system.
VOCs, DOC, and pesticides	NWQL-VPBW	2.0 (~ 8)	Waste 0.5 gal, then collect field blanks; can use DIW to force last of VPBW or PBW water through the system.
Major ions, and nutrients, or trace elements	QWSU-IBW	1.0 (~ 4)	Waste 0.5 gal, then collect field blanks; can use DIW to force last of IBW water through the system.
Major ions and nutrients, and trace elements	QWSU-IBW	1.5 (~ 6)	Waste 0.5 gal, then collect field blanks; if necessary, use DIW to force last of IBW water through the system.
Combinations of organics and in-organics above	NWQL-VPBW or NWQL-PBW and QWSU-IBW	1.5 to 2.0 1.0 to 1.5	Waste 0.5 gal of the VPBW or PBW water, then collect organic field blanks; can use the IBW water to force the VPBW or PBW water through the system; waste 0.5 gal of IBW water, then can collect inorganic field blanks using DIW to force IBW water through the system.

Table 25. Field-blank sample-collection protocols and procedures for ground-water components of the National Water-Quality Assessment Program--Continued

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3. General Field-Blank Collection Procedure--The procedure for collection of blanks assumes organic (VOC--SC2090, SC2091, or SC2092, Pesticide--SC2001 or SC2010 and SC2050 or SC2051, and DOC--SC2085) and inorganic (Trace-element--SC2703, Major ion--SC2750, and Nutrient--SC2752) field blanks are collected. This is the most complex type of field-blank collection.[3]

- Divide Field-Team Duties--Recommend that a three-person team be used. The standard two-person field team collects samples in a manner similar to that used to collect ground.-water samples; the third person adds blank water(s) to standpipe, and controls flow through system as needed to facilitate field-blank collection.

- Check Flow Setup--from standpipe to sample collection chamber (fig.2), ensure that adequate volumes of DIW and the required blank water(s) are arranged in order and within easy reach of person stationed at standpipe.

- Set Low Flow Rate--Once pumping is initiated, set flow (on basis of measurement at chamber outflow) to about 0.1 gal. (500 mL) per minute or less to avoid wasting excessive amounts of blank water.

- Route blank solutions in presorted manner--As solutions are changed, pump operator should change to clean gloves, empty residual solution from standpipe, and rinse pump intake and standpipe, individually, at least three times each, with the next solution, and attempt to pump air segment into pump line before adding next solution to standpipe to mark change in solution type.

  If air segment cannot be used to mark end of one solution and beginning of next, then the change in solutions is determined solely on the basis of the storage volume in lines (table 24) divided by the pumping rate (estimated above) to determine the time it takes for the solution to travel from the standpipe to the outflow chamber. Once pump is started, and this time has elapsed, it is assumed the correct solution is flowing from chamber outflow.

  Regardless of whether air segments or timed flow or both are used to assess when the desired solution arrives at the chamber, 0.5 gal (~ 2 L) of the solution are passed to waste before the field blanks that require that water type are collected.

  To limit the amount of blank water used, and left standing in pump-reel or extension lines after all samples that require that blank-water type have been collected, one type of water can be used to force the last of another type from the lines and to the chamber for collection.

- Collect field blanks in prescribed manner --The order, manner, and quality-control measures and checks associated with obtaining, processing, preserving, and temporarily storing field blanks are identical to the order, manner, and quality-control measures and checks that would be used to collect a corresponding set of ground-water-quality samples (see table 21).

Table 25. Field-blank sample-collection protocols and procedures for ground-water components of the National Water-Quality Assessment Program--Continued

4. Break Down Equipment Setup--After field blanks have been collected, equipment is broken down and stored, accordingly (see tables 22 and 23). Exceptions include filter units using filter membranes that are removed and discarded, and the sample preservation chamber. If filters for organics (pesticides and DOC) were used, the units are opened and filters discarded. Units are final rinsed, reassembled and stored (see table 22, step 5, and table 23, step 7). The sample-preservation chamber also is decontaminated before it is stored.

[1]If portable pump was used, the same pump and length of pump line used to collect ground-water samples is decontaminated and used to obtain field blanks.

[2]Note that VPBW and PBW are not certified free of organic carbon. A solution blank of that lot of water used for the DOC field blank is sent to the NWQL for DOC analysis (see footnote no. 3 below).

[3]NWQL-PBW cannot be used for VOC field blanks. Either NWQL water type can be used for DOC field blank, but both water types contain about 0.1 mg/L of organic carbon. A solution blank sample of water from the same lot of NWQL water used for DOC field blank, poured directly into DOC 125-mL amber sample bottle) is required for every DOC field blank. The lot number of the water used for the solution blank is recorded on the ASR form (see appendix, fig. A14).

[4]With one exception, samples are analyzed using NAWQA schedules. The exception is trace-element field blanks, for which the low-level NWQL blank schedule (SC172 with laboratory codes added for arsenic and selenium) is recommended (see appendix, fig. A18).

Pesticide and volatile-organic-compound (VOC) spiked samples

Required equipment and procedures to spike ground-water samples in the field are obtained from the NWQL in kits prepared for the NAWQA Program (table 3). Training in field spiking is required, and can be obtained through the basic course required for NAWQA ground-water field teams (table 6). Because of the need for recovery and variability data on field spikes for the National Program, Study Units that wish to modify spike equipment or procedures as described below, or in NWQL kits for the NAWQA Program, by using different spike solutions or volumes for routine QC spiked samples, are to discuss their plans with the National Program (NAWQA QA Specialist).

At each site where pesticide field spikes are scheduled, at least three 1.0-L ground-water sample bottles are required for each NWQL pesticide schedule (SC2001 or SC2010 and SC2050 or SC2051). These samples are collected sequentially during the collection of ground-water-quality samples and chilled (table 21). One bottle for each schedule serves as the ground-water-quality sample for the well. It also serves as a background sample (to determine what pesticides, if any, were present in the other two sample bottles before they were spiked). The other two sample bottles are used for replicate field spikes. Each of these is spiked with 100 µL of NWQL-pesticide-spike solution.

Currently, for VOC field spikes (SC2090, SC2091, or SC2092), at least seven sample vials of ground water are collected sequentially and chilled (table 21). Three vials are needed for the ground-water-quality sample, which also is the background sample for the field-spiked samples. Replicate, field-spiked VOC samples (consisting of two vials each) are prepared by spiking each vial with 100 µL of NWQL-VOC-spike solution.

In general, all samples (pesticide or VOC) are spiked with 100 µL of spike solution, which results in a concentration of about 1 to 3 mg/L, depending on the analyte. If the background sample concentration of the analyte (in the unspiked sample) exceeds about one-tenth the concentration in spiked samples, the recovery data from spiked samples generally is considered positively biased (dependent in part on the amount of analyte present before spiking). Use of a volume of spike solution in excess of 100 µL, or a spike solution with higher concentrations than that commonly prepared by the NWQL, could reduce the bias. Recovery data from the use of such a spike solution, however, will relate only to the high, and not the low, concentrations of the analyte.

Once prepared, field-spiked samples are chilled to 0 to 4°C, and generally treated in a manner identical to that of the corresponding background sample. Important information that relates to the spiked sample (lot number, volume, and source of spike solution) are recorded on field and NWQL ASR forms (appendix, fig. A12).

Pesticide solid-phase extractions

The option is available for Study Units to extract pesticides from ground-water-quality samples (unspiked and spiked) or field blanks in the field, rather than having extractions done at the NWQL. Extracts are collected on solid-phase cartridges and sent to the NWQL for analysis under SC2010 and SC2051. Extraction equipment and procedures, prepared by the NWQL for

NAWQA, can be obtained from HIF or NWQL (table 3). Training in the extraction procedure is required, and is obtained through the basic course required for NAWQA ground-water sampling field teams (table 6).

The decision to submit solid-phase extracts instead of water samples to the NWQL requires careful consideration. Field extractions are practical and should be considered in situations where transporting glass bottles, shipping weights, or shipping times pose a serious problem. Extraction is recommended if pesticide water samples (for SC2001 and SC2050) cannot be shipped and reach the laboratory within 72 hours after collection, or when information is available that indicates the analytes of interest could degrade rapidly during transit. Field extractions also are recommended if the transportation of large, glass, sample bottles, or the sheer weight of water samples, poses a hazard for the samples or the field team (for example, if wells are located in remote areas that are accessible only by foot or light plane).

For Study Units that require a quick turnaround time on analytical results, sending field extractions rather than water samples, particularly at peak production times at the NWQL, could expedite data returns. The Study Unit should contact the NWQL in advance of adopting this strategy, however, as there may be no backlog in analysis. In addition, special handling to expedite analysis can be arranged with the NWQL at an additional cost.

Sending field extractions instead of water samples has another potential benefit. Field extractions allow the field team to extract less than a liter of sample, which is useful if water samples are known or suspected to contain concentrations that exceed the linear operating range of NWQL methods (currently about 100 µg/L). In such cases, a measured (by weight difference) sub-volume of the original 1-L water sample can be extracted. As an alternative, however, the field team can request that the NWQL extract only part of a water sample (use comment line on NWQL ASR form), and thereby achieve the same results.

Field extractions can reduce the costs of NWQL analysis and overnight shipping, particularly if the Study Unit is some distance from the NWQL. Whether or not sending field extractions instead of water samples is cost effective depends on whether or not the reduced costs in analysis and shipping are less than the cost of obtaining, using, and maintaining extraction equipment and related supplies. The cost and time of labor associated with extracting samples also should be factored into the decision. A 1-L sample typically requires one field-team member about 45 minutes to extract, not including the time and labor cost needed for equipment assembly and decontamination. Overall, Johnson and Swanson (1994) found laboratory processing required 32 percent fewer hours than on-site processing of extracts by a field team for each of two prototype sites in the Central Nebraska Study Unit.

The time involved to set up equipment, conduct the extraction, and decontaminate, disassemble, and store this equipment can make it difficult for a two-person field team to perform extractions on-site at every well, given all the other on-site activities that the field team typically is required to perform. Therefore, extractions usually are performed after most other on-site activities are completed. Alternatively, extractions can be performed by a third person, perhaps off-site at a designated facility. This is probably the only practical method to field extract numerous pesticide samples in the field. For example, each routine QC site for pesticides requires a minimum of six field extractions (one 1-L ground-water sample, plus two 1-L spiked ground-water samples for each of the two pesticide schedules).

VOC trip-blank and trace-element standard reference samples

Two types of routine QC samples require no sample collection, but are routinely sent from selected sites in the field--the VOC trip blank and the standard trace-element reference sample (table 10). Neither is ever opened by Study Unit personnel.

The VOC trip blank can be found in the box in which NWQL VOC vials are shipped. When shipped by the NAWQA team from the field, the lot number (if not on the vial) can be found on the box, and is recorded on the NWQL ASR form sent with the vial (appendix, fig. A15).

Each Study Unit that conducts trace-element sampling in a given field season must request three standard trace-element reference samples from the BTD&QS (table 10). These reference samples are sent from different ground-water sites by the field team during that field season. At each site, the field team records on the NWQL ASR form the original sample identification code found on each bottle and relabels the bottle with the site identification code (appendix, fig. A19) before the sample is shipped.

Handling and Shipping of Samples

Handling and shipping protocols divide ground-water-quality and routine QC samples collected at a well into three groups (table 26). One group requires samples be shipped overnight at less than 4°C. Another group can be shipped by surface (first class) mail at an ambient temperature. The third group is stored by the Study Unit, and possibly shipped for analysis at a later date by surface mail.

To ensure that the samples collected will provide the data desired, the field team verifies that all sample containers required from the well are present, and that all the information required on container labels and field, NWQL-ASR, and other forms, is complete. It is important that the containers are properly labeled, and that all forms contain the information needed by the NWQL and the Study-Unit data manager (see appendix).

Samples that require overnight shipping (table 26, Group One) can undergo physical, biological, or radiochemical transformation or degradation within a short period of time. This is reflected in their maximum holding times (elapsed time between sample collection and analysis). The maximum holding time for Group One samples is 3 to 5 days, except for VOCs, which have a 14-day holding time. Holding times for most of these samples are dependent on maintaining low sample temperature (less than 4°C). During the period when most samples are being sent to the NWQL (about April through October), at least half the holding time can expire after these samples reach NWQL login and before they are analyzed. Thus, all of these samples must be shipped without delay. In addition, and except for radon, these samples also must be packed in a sufficient amount of ice to maintain low temperatures until received at NWQL and refrigerated.

Table 26. Sample handling for shipment of ground-water-quality and quality-control samples

[°C, degrees Celsius; lbs, pounds; mil, manufacturer bag thickness; SASE, self addressed and stamped envelope; NWQL, National Water Quality Laboratory; ASR, Analytical Service Request; SC or LC, NWQL schedule or laboratory code; FCC, FA, FU, and RU are bottle-type designations; CFC, chlorofluorocarbon]

Sample	Shipping	Procedures
Group One:		
Volatiles--SC2090, SC2091, and SC2092 Pesticides--SC2001 and SC2050 or SC2010 and SC2051 Nutrients--SC2752-FCC Organic Carbon--SC2085 (Add small (250-mL) polyethylene bottle filled with water and labeled “For Temperature Check, at Login.”)	Overnight at 0 to 4°C, and for safe handling, at weight less than 50 lbs.	Place samples in mesh bag and place “Temperature Check” bottle in middle of sample containers. Place a large, 4-mil plastic bag in cooler, add layer of ice, and place mesh bag on ice inside plastic bag. Surround and cover mesh bag with ice, then twist and seal outer plastic bag with waterproof tape.
Radon--LC1369	Overnight (with above or separate from above).	Place resealable plastic bag containing radon tube(s) atop large plastic bag above. Combine ASR forms with Study-Unit Login reply form and SASE in nested, resealable, plastic bags, and tape to inside of cooler lid. Put return address on inside of lid. Close lid, secure it, and cooler drain cap with strong tape. Attach air bill.
Group Two:		
Major ions--SC2750--FA FU, and RU Trace elements--samples SC2703 (blanks--SC172)	Surface, first-class mail, at ambient temperature and, for safe handling, weight less than 50 lbs.	Place trace-element samples in two nested, resealable plastic bags and place sealed bags in a heavy cardboard container; pack in bubble pack, enclose forms (ASR and login-reply forms, and SASE) in nested, resealable plastic bags. Seal container with strong tape and attach mailing label with return address.
Group Three:		
Isotopes of tritium, deuterium, and oxygen; major-ion (archive) sample (SC2750--FA); and possibly CFC samples	Initially archive in a dry, cool, and clean storage area; possibly ship (via regular surface mail).	Archive individual samples in a partitioned, heavy cardboard container. List sample types and date on side of container. Also archive ASR and any other forms.

To verify that low temperatures are maintained, each overnight shipment includes a small (250-mL) polyethylene bottle filled with uncontaminated water (for example, deionized), marked “For Temperature Check at Login.” This bottle is placed in the middle of the other samples being shipped. The NWQL login personnel will check the temperature of the water in this bottle, record it on the Study-Unit’s “Login-Reply Return Form” (appendix, fig. A20), and return this form via the self-addressed and stamped envelope provided by the Study Unit. This form and envelope initially are included with the NWQL ASR forms, which are double bagged in resealable plastic bags, and taped to the inside of the shipping cooler (table 26). Study-Unit data managers are to file the return forms, and keep a record of sample temperatures, particularly those that exceeded 4°C.

As a rule, water-quality samples with 3- to 5-day holding times should not be collected on a Friday, particularly Fridays associated with 3-day weekends, because 3 to 5 days could elapse before samples are analyzed. Radon, with a short half-life of approximately 3.6 days, is definitely not collected if it cannot be shipped within 24 hours of collection and arrive at NWQL login before 12:00 p.m. on any Friday.

Samples sent by regular surface mail (first class) have longer holding times than overnight samples and do not need to be chilled (table 26, Group Two). It is recommended, however, that these samples be shipped within a week or two of collection.

Samples archived by the Study Unit (table 26, Group Three) can include replicates (distinct from those required for routine QC samples) of major ions (SC2750, FA bottle only), trace elements (for example, SC2703), isotope samples (for tritium, deuterium, and oxygen), and chlorofluorocarbon (CFC) samples. Archived major-ion and trace-element samples should be discarded as soon as it is known that analytical reruns are not required. Isotope samples can be held for several years provided bottles remain sealed. Samples for CFCs can be held for at least several years, provided they are not biologically active (Eurybiades Busenberg, U.S. Geological Survey, written commun., 1995).

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APPENDIX. EXAMPLES OF FIELD FORMS FOR THE COLLECTION OF GROUND-WATER DATA AND SAMPLES FOR THE NATIONAL WATER-QUALITY ASSESSMENT PROGRAM

Examples of field and analytical service request forms for the National Water Quality Laboratory are provided in this appendix. Included are forms for the following:

A1. Land-use and land-cover field sheet for the 1991 Study Units, National Water-Quality Assessment Program.[1]
A2. Example of quality-control and calibration form for the dissolved-oxygen sensor and meter.
A3. Example of quality-control and calibration form for the specific electrical conductance sensor and meter.
A4. Example of quality-control form for a thermistor thermometer.
A5. Example of quality-control form for a pH sensor and meter.
A6. Theoretical slope values of Nerst equation for pH electrode (modified from Plummer and Busenberg, 1981).
A7. Example of a purge form for a well.
A8. Example of a ground-water-quality sample-collection field form.
A9. Example of field-titration form.
A10-A. Example of an analytical service request form for primary ground-water-quality samples that require overnight shipping.
A10-B. Example of an analytical service request form for primary ground-water-quality samples that can be shipped surface (first class) mail.
A11-A. Example of an analytical service request form for replicate ground-water-quality samples that require overnight shipping.
A11-B. Example of an analytical service request form for replicate ground-water-quality samples that can be shipped surface (first class) mail.
A12-A. Example of an analytical service request form for replicate field-spiked, ground-water samples for pesticides and volatile organic compounds: first set, TIME: HH:02.
A12-B. Example of analytical service request form for replicate field-spiked, ground-water samples for pesticides and volatile organic compounds: second set, TIME: HH:03. (If optional third set is taken, use a third form similar to the one above but with TIME: HH:04.)
A13-A. Example of analytical service request form for field blanks that require National Water Quality Laboratory blank water and overnight shipping.
A13-B. Example of an analytical service request form for field blanks that require Quality of Water Service Unit inorganic-free blank water (QWSU-IBW) and surface mail shipping.
A14. Example of an analytical service request form for dissolved (filtered) organic carbon (DOC) solution blank composed of either NWQL volatile pesticide-free blank water (VPBW) or pesticide-free blank water (PBW).
A15. Example of an analytical service request form for a volatile-organic-compound (VOC) trip blank.
A16. Example of an analytical service request form for a primary trace-element ground-water sample (SC2703).
A17. Example of an analytical service request form for a replicate trace-element ground-water sample (SC2703).
A18. Example of an analytical service request form for a ground-water trace-element (SC2703) field blank.
A19. Example of an analytical service request form for a standard-reference trace-element (SC2703) sample for ground water.
A20. Example of Study Unit login reply form sent with samples shipped by overnight mail.

[1]Land-use and land-cover field sheet for the 1991 Study Units is being evaluated for use by the 1994 Study Units.

LAND-USE/LAND-COVER FIELD SHEET - GROUND-WATER COMPONENT OF NAWQA STUDIES - Page 1 (04/93)

1. NAWQA Study-Unit name using 4-letter abbreviation: ____________
   Field-check date ___/___/___ Person conducting field inspection:_______________________________
   Well station-id:___________________ Latitude:_________________ Longitude:_____________________

2. LAND USE AND LAND COVER CLASSIFICATION - (modified from Anderson and others, 1976, p.8). Check all land uses that occur within each approximate distance range from the sampled well. Identify the predominant land use within each distance range and estimate its percentage of the total area within a 1/4-mile radius of the well.

Land use and land cover	Within 100 ft	100 ft-1/4 mi	Comments
I. URBAN LAND			
--Residential			
--Commercial			
--Industrial			
--Other (Specify)________			
II. AGRICULTURAL LAND			
--Nonirrigated cropland			
--Irrigated cropland			
--Pasture			
--Orchard, grove, vineyard, or nursery			
--Confined feeding			
--Other (Specify)________			
III. RANGELAND			
IV. FOREST LAND			
V. WATER			
VI. WETLAND			
VII. BARREN LAND			
Predominant land use			
Approximate percentage of area covered by predominant land use			

3. AGRICULTURAL PRACTICES within 1/4 mile of the sampled well.

   a. Extent of irrigation - Indicate those that apply.
      Nonirrigated ____ Supplemental irrigation in dry years only ____, Irrigated ____

   b. Method of irrigation - Indicate those that apply.
      Spray ___ Flood ___ Furrow ___ Drip ___ Chemigation ___ Other ___ (Specify) ____________

   c. Source of irrigation water - Indicate those that apply.
      Ground water ____ Surface water ____ Spring ____
      Sewage effluent ____ (treatment): Primary ____ Secondary ____ Tertiary ____

   d. Pesticide and fertilizer application - Provide information about present and past pesticides and fertilizers used, application rates, and application methods.____
      ____

   e. Crop and animal types - Provide information about present and past crop and animal types, and crop rotation practices.____
      ____

Entered by___________________ Date ___/___/___ Checked by _________________ Date ___/___/___

Figure A1. Land-use and land-cover field sheet for the 1991 Study Units, National Water-Quality Assessment Program.

LAND-USE/LAND-COVER FIELD SHEET - GROUND-WATER COMPONENT OF NAWQA STUDIES-Page 2 (04/93)

Well station-id: ______________________________ Field-check date: ____/____/____

4. LOCAL FEATURES - Indicate all local features that may affect ground-water quality which occur within each approximate distance range from the sampled well.

Feature	within 100 ft	100 ft - 1/4 mi	Comments
Gas station			
Dry cleaner			
Chemical plant or storage facility			
Airport			
Military base			
Road			
Pipeline or fuel storage facility			
Septic field			
Waste disposal pond			
Landfill			
Golf course			
Stream, river, or creek Perennial __ Ephemeral __			
Irrigation canal Lined __ Unlined __			
Drainage ditch Lined __ Unlined __			
Lake Natural __ Manmade __			
Reservoir Lined __ Unlined __			
Bay or estuary			
Spring Geothermal (> 25 C)__ Nongeothermal__			
Salt flat or playa Dry __ Wet __			
Mine, quarry, or pit Active __Abandoned__			
Oil well			
Major withdrawal well			
Waste injection well			
Recharge injection well			
Other _______________			

Figure A1. Land-use and land-cover field sheet for the 1991 Study Units, National Water-Quality Assessment Program--Continued.

LAND-USE/LAND-COVER FIELD SHEET - GROUND-WATER COMPONENT OF NAWQA STUDIES -Page 3 (04/93)

Well station-id: ______________________________ Field-check date: ____/____/____

5. LAND-USE CHANGES - Have there been major changes in the last 10 years in land use within 1/4 mile of the sampled well? Yes __, Probably __, Probably not __, No __ If yes, describe major changes.

6. ADDITIONAL COMMENTS - Emphasize factors that might influence local ground-water quality.

Remarks

Figure A1. Land-use and land-cover field sheet for the 1991 Study Units, National Water-Quality Assessment Program--Continued

Model ______________________; Serial Number (W) ________________

Date	Time	Electrode Condition					Calibration									
		Membrane	Membrane changed last	Gold cathode and silver anode	Electro-lyte	Battery	Red-line	Zero	Meter[1] temper-ature (°C)	Saturated DO at temperature (mg/L)	Atmo-spheric. pressure (mm Hg)	Correction factor	Calibra-tion DO (mg/L)	Adjusted (Y or N)	Initials of testor

°C = degrees Celsius; mg/L = milligram per liter; mm Hg = millimeters of mercury
[1]See temperature quality-control form for thermistor used with this instrument (fig. A4).

Figure A2. Example of quality-control and calibration form for the dissolved-oxygen (DO) sensor and meter.

Model ____________________; Serial number (W) _____________________

	Condition of:			Conductance calibration:						
Date	Electrode	Meter	Therm-istor[1]	Standard # 1 less than 100 µS/cm	Reading µS/cm at 25^{o}C	Within 5% of standard	Standard # 2 greater than 100 µS/cm	Reading µS/cm at 25^{o}C	Within 3% of standard	Initials and action taken

[1]See thermistor form for quality-control tests on thermistor, all readings at 25^{o} Celsius (25^{o}C) in microsiemens per centimeter (µS/cm).

Figure A3. Example of quality-control and calibration form for the specific electrical conductance sensor and meter.

Model ____________________ Serial number (W) __________________

Date	Low temperature (0 to 5°C)			High temperature (15 to 35°C)			Action taken	Initials
	ASTM thermometer[1] reading (°C)	Meter reading (°C)	Within 0.2°C?	ASTM thermometer reading (°C)	Meter reading (°C)	Within 0.2°C?		

[1]American Society for Testing and Materials (ASTM) thermometer, serial number ________________________.
Specify thermistor use by checking one below:
pH ____ Specific electrical conductance ____ Dissolved oxygen ____ Turbidity ____ Temperature _____

Figure A4. Example of quality-control form for a thermistor thermometer measuring degrees Celsius (°C).

Date	Low pH buffer	High pH buffer	Reading		Reading		Buffer temperature (^oC)	Actual slope[1] $\Delta mV/\Delta pH$	Theoretical slope at temperature[2]	Slope ratio[3] (%)	Pass (Y or N)	Response time[4] (seconds)	Initials/ action taken[5]
			mV low	mV high	pH low	pH high							

[1]Actual slope = $\Delta mV/\Delta pH$, where ΔmV is difference in millivolt readings between low and high pH buffers, and ΔpH is difference in measured pH (that meter locks on) between low and high pH buffers.

[2]Theoretical slope of Nernst equation (see fig. A6) as function of buffer temperature in degrees Celsius (^oC).

[3]Slope ratio in percent = (actual slope/theoretical slope) x 100. An acceptable ratio is one greater than or equal to 95.0 percent.

[4]Response time for meter to lock onto low pH buffer after calibration on high pH buffer. An acceptable value is less than or equal to 15 seconds.

[5]Initials of person performing quality control, and action taken by that person. See temperature quality-control form for thermistor used with this instrument (fig. A4).

Figure A5. Example of quality-control form for a pH sensor and meter.

Temperature[1]	Theoretical slope[2]	Temperature	Theoretical slope
0	54.197	21	58.364
1	54.396	22	58.562
2	54.594	23	58.761
3	54.792	24	58.959
4	54.991	25	59.157
5	55.189	26	59.356
6	55.388	27	59.554
7	55.586	28	59.753
8	55.784	29	59.951
9	55.983	30	60.149
10	56.181	31	60.348
11	56.380	32	60.546
12	56.578	33	60.745
13	56.777	34	60.943
14	56.975	35	61.141
15	57.173	36	61.340
16	57.372	37	61.538
17	57.570	38	61.737
18	57.769	39	61.935
19	57.967	40	62.133
20	58.165		

[1]Degrees Celsius, record to nearest tenth of degree.
[2]Interpolate theoretical slope for buffer temperatures between whole degree values.

Figure A6. Theoretical slope values of Nerst equation for pH electrode at temperature specified (modified from Plummer and Busenberg, 1981).

WATER-LEVEL MEASUREMENTS, PURGE VOLUME, AND FIELD MEASUREMENTS BEFORE SAMPLING

USGS I.D.: ______________________________ Date ___________________________ Time ____________________

Local Well I.D.: __________________________ Field Team I.D.: ________________________

Well diameter (D, inches): ____________ Depth to water[1] (feet): _____________ Depth of well[1] (feet):______________

Height of water column (H, feet): __________________ Casing (borehole) wetted volume (= $0.0408HD^2$, gallons)

____

Purge volume (= 3 x casing volume, gallons): ____________________ Pump type: _________________________________

Time (min.)	Pump depth (feet)	Pump rate (gpm)	Volume pumped (gal)	Water appearance (clear, cloudy, etc.)	Temper-ature (^{o}C)	Dissolved oxygen (mg/L)	pH	Specific conductance (µS/cm at 25^{o}C)	Turbidity (NTU)
Except for pH, median values of final 5 measurements; to be used on ASR forms and field sample-collection forms (fig. A9).[2]									

min. = minutes; gpm = gallons per minute; gal = gallons; ^{o}C = degrees Celsius; mg/L = milligrams per liter; µS/cm at 25^{o}C = microsiemens per centimeter at 25^{o}C; NTU = nephelometric turbidity unit

[1]Reference datum was measurement point __________________ Land surface datum (surveyed) ____________________

Equipment used ____ Accuracy ______________________

[2]For pH, after other final measurements are taken, temporarily divert flow and use final pH value obtained on standing water in flowthrough chamber.

Figure A7. Example of purge form for a well.

LOCAL ID ________________ **RECORD #** ________________

Station identification number (lat. / long. / seq.)	Type	Date (Y M D)	Time
1 ‖ 2 – 16	17	18 – 23	24 – 27

Local Well Number	Site	Geologic Unit	Hydrologic Unit

State	District	County

Sampled by ________________

Location ________________

*	Code	Value	Remarks
Yield when sampling (GPM)	00059		
Minutes pumped before sampling	72004		
Sampling method	82398		

4010 = thief sample
4020 = bailer
4030 = suction pump
4040 = submersible pump
4050 = squeeze pump
4060 = gas reciprocating
4070 = air lift
4080 = peristaltic pump
4090 = jet pump
4100 = flowing well

	Code	Value	Remarks
Sampling condition	72006		

0.10 = site was being pumped
0.11 = site had been pumped recently
4. = flowing
8. = pumping
30. = seeping

	Code	Value	Remarks
Static water level (feet)	72019		
Altitude lsd (feet)	72000		
Depth to top sample interval	72015		
Depth to bottom sample interval	72016		
Finished well depth (feet)	72008		
Hole depth (feet)	72001		

	Code	Value	Remarks
Water temperature	00010		
Air temperature	00020		
Specific conductance	00095		
Dissolved oxygen	00300		
Turbidity	72008		
pH field	00400		
Alkalinity total field*	39086		
Bicarbonate total field	00453		
Carbonate total field	00452		
Acid neutralization capacity*	00419		

*For Gran-method titrations, values of Alk and ANC in mg/L have parameter codes 29802 and 29813, respectively.

Bottles Filled	Volume	Treatment

Comments:

Quality-control samples taken? ☐ Yes ☐ No

Any land-use changes? ☐ Yes ☐ No

Was form updated? ☐ Yes ☐ No

VOCs--acid used: Drops to pH 2 ☐ Drops used ☐

Figure A8. Example of a ground-water-quality sample-collection field form.

Units of acid	pH	Δ pH	Δ units acid	Δ ph/ Δ units

Units of acid	pH	Δ pH	Δ units acid	Δ ph/ Δ units

Station identifier | Date | Time

Normality of acid | Volume of acid to pH ~ 8.3

Type of titration: Incremental, inflection point | Volume of acid to pH ~ 4.5

ANC, mg/L $CaCo_3$[a]

Comments:

Alk, mg/L $CaCo_3$[b]

Bicarbonate, mg/L HCO_3^-

Carbonate, mg/L $CO_3^=$

[a]ANC - acid neutralizing capacity; on unfiltered sample from inflection point at about pH = 4.5.

[b]ALK - alkalinity, carbonate, and bicarbonate, on filtered sample from inflection points at about pH = 8.3 and 4.5.

Figure A9. Example of field-titration form.

US. GEOLOGICAL SURVEY - NATIONAL WATER QUALITY LABORATORY
ANALYTICAL SERVICES REQUEST FORM

SMS CONTROL NO | NWIS RECORD NO | LABORATORY ID | SAMPLE SET

WICh52 — STATION NAME
382454075200301 — STATION ID OR UNIQUE NO

TOWSON, MD — FIELD OFFICE
(410) 512-4800 — *PHONE NO.
SHEDLOCK — *PROJECT CHIEF
WICh52 — FIELD SAMPLE ID
GW — SITE TYPE

24 — *STATE
024 — *DISTRICT/USER
045 — CNTY
442400000 — *PROJECT ACCT NO

	YEAR	MONTH	DAY	TIME
BEGIN DATE:	1995	01	20	0800
END DATE:				

SCHEDULES, FIELD AND LABORATORY CODES

SCHEDULE 1: SC2090
SCHEDULE 2: SC2001
SCHEDULE 3: SC2050
SCHEDULE 4: SC2085
SCHEDULE 5: SC2752

**SAMPLE MEDIUM: 6
GEOLOGIC UNIT: 112BVDM
**ANALYSIS STATUS: H
**ANALYSIS SOURCE: 9
**HYDRO CONDITION: 9

**SAMPLE TYPE: 9 or 7 [a]
**HYDRO EVENT: 9

A/D (A circled)
CODE: 1369 | 82303
CODE: |
CODE: |
CODE: |

FIELD VALUES [b]

LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK
21/ 00095	245		51/ 00400	6.1		2 / 00419	11.5	
/00010	11.1		/00300	2.2		/00452	1.2	
/00076	2		/99105	20		/00453	9.3	
						39086	11.2	

+COMMENTS: (LIMIT TO 138 CHARACTERS): [c] Time of radon sample: 08:40; VOC, HCl added: 4 drops

LOGIN COMMENTS:

SHIPPED BY: M. KOTERBA PHONE: (410) 512-48400 DATE: 01 /20 /95[d]

BOTTLE TYPES (PLEASE FILL IN NO. OF TYPES SENT)

___FA ___RU ___FU ___FAM ___RAM ___RC ___FC ___FAB ___CU
___RA ___RAH ___S= ___CN- ___RCB 1___DOC ___TOC ___SOC ___COD
___VOA ___CHY ___O&G ___PHENOL 2___GCC 3 GCV, 1 FN, 1 FCC ___OTHER

CUSTOM/SPECIAL SAMPLE APPROVED BY: ________ APPROVAL NO. ________
PROGRAM/PROJECT: XX NAWQA ___DRINKING H20 FILL IN OTHER ________
POSSIBLE HAZARDS ________

REVISED 04/92 +COMMENTS TO BE STORED BY THE LABORATORY *MANDATORY FOR ACCEPTANCE FOR LABORATORY ANALYSIS
**MANDATORY FOR STORAGE IN WATSTORE/NWIS

[a]Use 7 if any replicate ground-water samples are taken for the above schedules or those on figure A10-B.

[b]If 9 used for sample type, add all P-codes, including those under field values, except for 99105, which is left blank. If 7 used for sample type, inlcude P code 99105. Also add P codes to QWDATA record for sample.

[c]This is a priority message, must appear.

[d]Overnight shipping is recommended for all samples. Do not put radon tube in ice.

Figure A10-A. Example of an analytical service request form for primary ground-water-quality samples (including radon) that require overnight shipping.

U.S. GEOLOGICAL SURVEY - NATIONAL WATER QUALITY LABORATORY
ANALYTICAL SERVICES REQUEST FORM

SMS CONTROL NO	NWIS RECORD NO	LABORATORY ID	SAMPLE SET

STATION NAME: WICh52
STATION ID OR UNIQUE NO: 382459075200301

FIELD OFFICE: TOWSON, MD
*PHONE NO.: (410) 512-4800
*PROJECT CHIEF: SHEDLOCK
FIELD SAMPLE ID: WICh52
SITE TYPE: GW

*STATE: 24
*DISTRICT/USER: 024
CNTY: 045
*PROJECT ACCT NO: 442400000

	YEAR	MONTH	DAY	TIME
BEGIN DATE:	1995	01	20	0800
END DATE:				

SCHEDULES, FIELD AND LABORATORY CODES

SCHEDULE 1: SC2750
SCHEDULE 2: ______
SCHEDULE 3: ______
SCHEDULE 4: ______
SCHEDULE 5: ______

**SAMPLE MEDIUM: 6
GEOLOGIC UNIT: 112BVDM
**ANALYSIS STATUS: H
**ANALYSIS SOURCE: 9
**HYDRO CONDITION: 9

**SAMPLE TYPE: 9 or 7[a]
**HYDRO EVENT: 9

CODE:	A/D	CODE:	A/D	CODE:	A/D	CODE:	A/D

FIELD VALUES[b]

LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK
21 / 00095	245		51 / 00400	6.1		2 / 00419	11.5	
/ 00010	11.1		/ 00300	2.2		/ 00452	1.2	
/ 00076	2		/ 99105	20		/ 00453	9.3	
						39086	11.2	

+COMMENTS: (LIMIT TO 138 CHARACTERS: _[c]

LOGIN COMMENTS:

SHIPPED BY: M. KOTERBA PHONE: (410) 512-48400 DATE: 01 /27 /95[d]

BOTTLE TYPES (PLEASE FILL IN NO. OF TYPES SENT)

1 FA, RA, VOA, 1 RU, RAH, CHY, 1 FU, S=, O&G, FAM, CN-, PHENOL, RAM, RCB, GCC, RC, DOC, FC, TOC, FAB, SOC, CU, COD, OTHER

CUSTOM/SPECIAL SAMPLE APPROVED BY: ______ APPROVAL NO. ______
PROGRAM/PROJECT: XX NAWQA __ DRINKING H20 FILL IN OTHER ____
POSSIBLE HAZARDS ______

REVISED 04/92 +COMMENTS TO BE STORED BY THE LABORATORY *MANDATORY FOR ACCEPTANCE FOR LABORATORY ANALYSIS **MANDATORY FOR STORAGE IN WATSTORE/NWIS

[a]Use 7 if any replicate ground-water samples are taken for the above schedules or those on figure A10-A.

[b]If 9 used for sample type, add all P codes, including those under field values, except for 99105, which is left blank. If 7 used for sample type, include P code 99105. Also add P-codes to QWDATA record for sample.

[c]No comments; otherwise, priority comments on figure A10-A could be overwritten.

[d]Recommend samples be sent surface mail within 2 weeks of collection date.

Figure A10-B. Example of an analytical service request form for primary ground-water-quality samples that can be shipped surface (first class) mail.

U.S. GEOLOGICAL SURVEY - NATIONAL WATER QUALITY LABORATORY
ANALYTICAL SERVICES REQUEST FORM **QA**

SMS CONTROL NO	NWIS RECORD NO	LABORATORY ID	SAMPLE SET

STATION NAME: WICh52 STATION ID OR UNIQUE NO: 382459075003 01

FIELD OFFICE: TOWSON, MD *PHONE NO.: (410) 512-4800 *PROJECT CHIEF: SHEDLOCK FIELD SAMPLE ID: WICh52 SITE TYPE: GW

*STATE: 24 *DISTRICT/USER: 024 CNTY: 045 *PROJECT ACCT NO: 442400000

	YEAR	MONTH	DAY	TIME
BEGIN DATE:	1995	01	20	0801
END DATE:				

SCHEDULES, FIELD AND LABORATORY CODES

SCHEDULE 1: SC2085 **SAMPLE MEDIUM: S **SAMPLE TYPE: 7
SCHEDULE 2: SC2752 GEOLOGIC UNIT:
SCHEDULE 3: SC2090 **ANALYSIS STATUS: H **HYDRO EVENT: 9
SCHEDULE 4: SC2001 **ANALYSIS SOURCE: 9
SCHEDULE 5: SC2050 **HYDRO CONDITION: 9

CODE:	A/D	CODE:	A/D	CODE:	A/D	CODE:	A/D
1369	82303						

FIELD VALUES[a]

LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK
21/ 00095			51/ 00400			2 / 00419		
/99105	20		/			/		
/			/			/		

+COMMENTS: (LIMIT TO 138 CHARACTERS): [b]Time of radon sample: 08:45; VOC, HCl added: 4 drops

LOGIN COMMENTS:

SHIPPED BY: M. KOTERBA PHONE: (410) 512-4840 DATE: 01 |20 |95[c]

BOTTLE TYPES (PLEASE FILL IN NO. OF TYPES SENT)

___FA ___RU ___FU ___FAM ___RAM ___RC ___FC ___FAB ___CU
___RA ___RAH ___S= ___CN- ___RCB ___DOC ___TOC ___SOC ___COD
___VOA ___CHY ___O&G ___PHENOL 2 GCC 3 GCV, 1 RN, 1 FCC OTHER

CUSTOM/SPECIAL SAMPLE APPROVED BY: ______ APPROVAL NO. ______
PROGRAM/PROJECT: XX NAWQA ___ DRINKING H20 FILL IN OTHER ______
POSSIBLE HAZARDS ______

REVISED 04/92 +COMMENTS TO BE STORED BY THE LABORATORY *MANDATORY FOR ACCEPTANCE FOR LABORATORY ANALYSIS **MANDATORY FOR STORAGE IN WATSTORE/NWIS

[a]Add P codes noted above to form and to QADATA record for this sample.
[b]This is a priority message, must appear.
[c]Overnight shipping with primary samples (fig. A10-A) is recommended.

Figure A11-A. Example of an analytical service request form for replicate ground-water-quality samples (including radon) that require overnight shipping.

U.S. GEOLOGICAL SURVEY - NATIONAL WATER QUALITY LABORATORY
ANALYTICAL SERVICES REQUEST FORM **QA**

SMS CONTROL NO	NWIS RECORD NO	LABORATORY ID	SAMPLE SET

STATION NAME: WICh52 STATION ID OR UNIQUE NO: 38245907500301

FIELD OFFICE: TOWSON, MD *PHONE NO.: (410) 512-4800 *PROJECT CHIEF: SHEDLOCK FIELD SAMPLE ID: WICh52 SITE TYPE: GW

*STATE: 24 *DISTRICT/USER: 024 CNTY: 045 *PROJECT ACCT NO: 442400000

	YEAR	MONTH	DAY	TIME
BEGIN DATE:	1995	01	20	0801
END DATE:				

SCHEDULES, FIELD AND LABORATORY CODES

SCHEDULE 1: SC2750 **SAMPLE MEDIUM: ___ **SAMPLE TYPE: 7
SCHEDULE 2: ___ GEOLOGIC UNIT: ___
SCHEDULE 3: ___ **ANALYSIS STATUS: H **HYDRO EVENT: 9
SCHEDULE 4: ___ **ANALYSIS SOURCE: 9
SCHEDULE 5: ___ **HYDRO CONDITION: 9

CODE:	A/D	CODE:	A/D	CODE:	A/D	CODE:	A/D

FIELD VALUES[a]

LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK
21/ 00095	245		51/ 00400	6.1		2 / 00419	11.5	
/00010	11.1		/ 00300	2.2		/00452	1.2	
/00076	2		/99105	20		/00453	9.3	
						39086	11.2	

+COMMENTS: (LIMIT TO 138 CHARACTERS): [b]

LOGIN COMMENTS:

SHIPPED BY: M. KOTERBA PHONE: (410) 512-48400 DATE: 01 /27 /95[c]

BOTTLE TYPES (PLEASE FILL IN NO. OF TYPES SENT)

1 FA, RA, VOA; 1 RU, RAH, CHY; 1 FU, S=, O&G; FAM, CN-, PHENOL; RAM, RCB, GCC; RC, DOC; FC, TOC; FAB, SOC; CU, COD; OTHER

CUSTOM/SPECIAL SAMPLE APPROVED BY: ___ APPROVAL NO. ___
PROGRAM/PROJECT: XX NAWQA __ DRINKING H20 FILL IN OTHER ___
POSSIBLE HAZARDS

REVISED 04/92 +COMMENTS TO BE STORED BY THE LABORATORY *MANDATORY FOR ACCEPTANCE FOR LABORATORY ANALYSIS
**MANDATORY FOR STORAGE IN WATSTORE/NWIS

[a]Add P codes noted above to form and to QADATA record for this sample.
[b]No comments; otherwise, priority comments on figure A11-A could be overwritten.
[c]Surface (first-class) shipping with primary samples (fig. A10-B) is recommended.

Figure A11-B. Example of an analytical service request form for replicate ground-water-quality samples that can be shipped surface (first class) mail.

U.S. GEOLOGICAL SURVEY - NATIONAL WATER QUALITY LABORATORY
ANALYTICAL SERVICES REQUEST FORM — **QA**

SMS CONTROL NO	NWIS RECORD NO	LABORATORY ID	SAMPLE SET

STATION NAME: WICh52 — STATION ID OR UNIQUE NO: 382459075200301

FIELD OFFICE	*PHONE NO.	*PROJECT CHIEF	FIELD SAMPLE ID	SITE TYPE
TOWSON, MD	(410) 512-4800	SHEDLOCK	WICh52	GW

*STATE	*DISTRICT/USER	CNTY	*PROJECT ACCT NO
24	024	045	442400000

	YEAR	MONTH	DAY	TIME
BEGIN DATE:	1995	01	20	0802
END DATE:				

SCHEDULES, FIELD AND LABORATORY CODES [a]

SCHEDULE 1: SC2090
SCHEDULE 2: SC2001
SCHEDULE 3: SC2050
SCHEDULE 4: ___
SCHEDULE 5: ___

**SAMPLE MEDIUM: S
GEOLOGIC UNIT: ___
**ANALYSIS STATUS: H
**ANALYSIS SOURCE: 9
**HYDRO CONDITION: 9

**SAMPLE TYPE: 1
**HYDRO EVENT: 9

CODE	A/D	CODE	A/D	CODE	A/D	CODE	A/D
99105	20	99107	10				
99106	10	99108	0.1				

FIELD VALUES

LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK
21/ 00095			51/ 00400			2 / 00419		
/			/			/		
/			/			/		

put lot numbers for all spikes on this form

+COMMENTS: (LIMIT TO 138 CHARACTERS): [b]SC2090: spike lot no.; SC2001: spike lot no.; SC2050: spike lot no.

LOGIN COMMENTS: ___

SHIPPED BY: M. KOTERBA — PHONE: (410) 512-4840 — DATE: 01 / 20 / 95[c]

BOTTLE TYPES (PLEASE FILL IN NO. OF TYPES SENT)

___FA ___RU ___FU ___FAM ___RAM ___RC ___FC ___FAB ___CU
___RA ___RAH ___S= ___CN- ___RCB ___DOC ___TOC ___SOC ___COD
___VOA ___CHY ___O&G ___PHENOL 2 GCC 2 GCV ___OTHER

CUSTOM/SPECIAL SAMPLE APPROVED BY: ___ APPROVAL NO. ___
PROGRAM/PROJECT: XX NAWQA ___DRINKING H20 FILL IN OTHER ___
POSSIBLE HAZARDS ___

REVISED 04/92 — +COMMENTS TO BE STORED BY THE LABORATORY — *MANDATORY FOR ACCEPTANCE FOR LABORATORY ANALYSIS **MANDATORY FOR STORAGE IN WATSTORE/NWIS

[a]Use indicated spiked-sample P codes; include in QADATA record for sample.
[b]Include lot number of each spike vial used with each schedule.
[c]Ship overnight with primary unspiked (background) ground-water samples (fig. A10-A).

Figure A12-A. Example of an analytical service request form for replicate field-spiked, ground-water samples for pesticides and volatile organic compounds; first set, TIME: HH:02.

U.S. GEOLOGICAL SURVEY - NATIONAL WATER QUALITY LABORATORY
ANALYTICAL SERVICES REQUEST FORM

QA

SMS CONTROL NO	NWIS RECORD NO	LABORATORY ID	SAMPLE SET

STATION NAME: WICh52 — STATION ID OR UNIQUE NO: 382459075200301

FIELD OFFICE: TOWSON, MD — *PHONE NO.: (410) 512-4800 — *PROJECT CHIEF: SHEDLOCK — FIELD SAMPLE ID: WICh52 — SITE TYPE: GW

*STATE: 24 — *DISTRICT/USER: 024 — CNTY: 045 — *PROJECT ACCT NO: 442400000

	YEAR	MONTH	DAY	TIME
BEGIN DATE:	1995	01	20	0803
END DATE:				

SCHEDULES, FIELD AND LABORATORY CODES [a]

SCHEDULE 1: SC2090 — **SAMPLE MEDIUM: S — **SAMPLE TYPE: 1
SCHEDULE 2: SC2001 — GEOLOGIC UNIT: ____
SCHEDULE 3: SC2050 — **ANALYSIS STATUS: H — **HYDRO EVENT: 9
SCHEDULE 4: ____ — **ANALYSIS SOURCE: 9
SCHEDULE 5: ____ — **HYDRO CONDITION: 9

CODE	A/D	CODE	A/D	CODE	A/D	CODE	A/D
99105	20	99107	10				
99106	10	99108	0.1				

(A circled in the A/D columns for the first two code columns.)

FIELD VALUES [b]

LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK
21 / 00095			51 / 00400			2 / 00419		
/			/			/		
/			/			/		

put lot numbers for all spikes on this form

+COMMENTS: (LIMIT TO 138 CHARACTERS): [b]SC2090: spike lot no.; SC2001: spike lot no.; SC2050: spike lot no.

LOGIN COMMENTS: ____

SHIPPED BY: M. KOTERBA — PHONE: (410) 512-4840 — DATE: 01 / 20 / 95[c]

BOTTLE TYPES (PLEASE FILL IN NO. OF TYPES SENT)

___FA ___RU ___FU ___FAM ___RAM ___RC ___FC ___FAB ___CU
___RA ___RAH ___S= ___CN- ___RCB ___DOC ___TOC ___SOC ___COD
___VOA ___CHY ___O&G ___PHENOL 2 GCC 2 GCV ___OTHER

CUSTOM/SPECIAL SAMPLE APPROVED BY: ____ APPROVAL NO. ____
PROGRAM/PROJECT: XX NAWQA ___ DRINKING H20 FILL IN OTHER ____
POSSIBLE HAZARDS ____

REVISED 04/92 — +COMMENTS TO BE STORED BY THE LABORATORY — *MANDATORY FOR ACCEPTANCE FOR LABORATORY ANALYSIS — **MANDATORY FOR STORAGE IN WATSTORE/NWIS

[a]Use indicated spiked-sample P codes; include in QADATA record for sample.
[b]Include lot number of each spike vial used with each schedule.
[c]Ship overnight with primary unspiked (background) ground-water samples (fig. A10-A).

Figure A12-B. Example of an analytical service request form for replicate field-spiked, ground-water samples for pesticides and volatile organic compounds; second set, TIME: HH:03. (If optional third set is taken, use a third form similar to the one above but with TIME: HH:04.)

U.S. GEOLOGICAL SURVEY - NATIONAL WATER QUALITY LABORATORY
ANALYTICAL SERVICES REQUEST FORM

QA

SMS CONTROL NO | NWIS RECORD NO | LABORATORY ID | SAMPLE SET

STATION NAME: WICh52
STATION ID OR UNIQUE NO: 382459075003O1

FIELD OFFICE: TOWSON, MD
*PHONE NO.: (410) 512-4800
*PROJECT CHIEF: SHEDLOCK
FIELD SAMPLE ID: WICh52
SITE TYPE: GW

*STATE: 24
*DISTRICT/USER: 024
CNTY: 045
*PROJECT ACCT NO: 442400000

BEGIN DATE: YEAR 1995 MONTH 01 DAY 20 TIME 0805
END DATE:

SCHEDULES, FIELD AND LABORATORY CODES [a]

SCHEDULE 1: SC2090
SCHEDULE 2: SC2001
SCHEDULE 3: SC2050
SCHEDULE 4: SC2085
SCHEDULE 5:

**SAMPLE MEDIUM: Q
GEOLOGIC UNIT:
**ANALYSIS STATUS: 4
**ANALYSIS SOURCE: 9
**HYDRO CONDITION: 9

**SAMPLE TYPE: 2
**HYDRO EVENT: 9

CODE	A/D	CODE	A/D	CODE	A/D	CODE	A/D
99100	50						
99101	10						
99102	100						

FIELD VALUES [b]

LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK
21 / 00095			51 / 00400			2 / 00419		
/			/			/		
/			/			/		

+COMMENTS: (LIMIT TO 138 CHARACTERS): NWQL VPBW: Lot no.

LOGIN COMMENTS:

SHIPPED BY: M. KOTERBA PHONE: (410) 512-4840 DATE: 01 /20 /95[c]

BOTTLE TYPES (PLEASE FILL IN NO. OF TYPES SENT)

___FA ___RA ___VOA ___RU ___RAH ___CHY ___FU ___S= ___O&G ___FAM ___CN- ___PHENOL ___RAM ___RCB 2 GCC ___RC 1 DOC 3 GCV ___FC ___TOC ___FAB ___SOC ___CU ___COD ___OTHER

CUSTOM/SPECIAL SAMPLE APPROVED BY: APPROVAL NO.
PROGRAM/PROJECT: XX NAWQA ___DRINKING H20 FILL IN OTHER
POSSIBLE HAZARDS

REVISED 04/92 +COMMENTS TO BE STORED BY THE LABORATORY *MANDATORY FOR ACCEPTANCE FOR LABORATORY ANALYSIS **MANDATORY FOR STORAGE IN WATSTORE/NWIS

[a]Add all P-codes to form and to QADATA record for sample.

[b]Priority comment, blank water lot number. If SC2090 not taken, NWQL pesticide-free blank water can be used, and if it is used, change the P code 99100 to "40" and the comment to "NWQL PBW: lot no."

[c]Ship blank samples with corresponding ground-water-quality samples.

Figure A13-A. Example of an analytical service request form for field blanks that require National Water Quality Laboratory blank water and overnight shipping.

U.S. GEOLOGICAL SURVEY - NATIONAL WATER QUALITY LABORATORY
ANALYTICAL SERVICES REQUEST FORM **QA**

SMS CONTROL NO: ___ NWIS RECORD NO: ___ LABORATORY ID: ___ SAMPLE SET: ___

STATION NAME: WICh52 STATION ID OR UNIQUE NO: 382459075200301

FIELD OFFICE: TOWSON, MD *PHONE NO.: (410) 512-4800 *PROJECT CHIEF: SHEDLOCK FIELD SAMPLE ID: WICh52 SITE TYPE: GW

*STATE: 24 *DISTRICT/USER: 024 CNTY: 045 *PROJECT ACCT NO: 442400000

	YEAR	MONTH	DAY	TIME
BEGIN DATE:	1995	01	20	0806
END DATE:				

SCHEDULES, FIELD AND LABORATORY CODES [a]

SCHEDULE 1: SC2750
SCHEDULE 2: ___
SCHEDULE 3: ___
SCHEDULE 4: ___
SCHEDULE 5: ___

**SAMPLE MEDIUM: Q
GEOLOGIC UNIT: ___
**ANALYSIS STATUS: H
**ANALYSIS SOURCE: 9
**HYDRO CONDITION: 9

**SAMPLE TYPE: 2
**HYDRO EVENT: 9

CODE	A/D	CODE	A/D	CODE	A/D	CODE	A/D
	50						
	10						
	100						

FIELD VALUES

LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK
21/ 00095			51/ 00400			2 / 00419		
/99100	10		/ 99102	100		/		
/99101	80		/			/		

+COMMENTS: (LIMIT TO 138 CHARACTERS)[b]: QWSU IBW: Lot no.

LOGIN COMMENTS: ___

SHIPPED BY: M. KOTERBA PHONE: (410) 512-4840 DATE: 01 /27 /95[c]

BOTTLE TYPES (PLEASE FILL IN NO. OF TYPES SENT)

1 FA, RA, VOA; 1 RU, RAH, CHY; 1 FU, S=, O&G; FAM, CN-, PHENOL; RAM, RCB, GCC; RC, DOC; FC, TOC; FAB, SOC; CU, COD; OTHER

CUSTOM/SPECIAL SAMPLE APPROVED BY: ___ APPROVAL NO. ___
PROGRAM/PROJECT: XX NAWQA ___ DRINKING H20 FILL IN OTHER ___
POSSIBLE HAZARDS ___

REVISED 04/92 +COMMENTS TO BE STORED BY THE LABORATORY *MANDATORY FOR ACCEPTANCE FOR LABORATORY ANALYSIS **MANDATORY FOR STORAGE IN WATSTORE/NWIS

[a]Add all P codes to form and to QADATA record for this sample.
[b]Priority comment, must appear.
[c]Recommend field-blank samples be shipped surface mail with corresponding ground-water samples (see figs. A10-A,B).

Figure A13-B. Example of an analytical service request form for field blanks that require Quality of Water Service Unit inorganic-free blank water (QWSU-IBW) and surface mail shipping.

U.S. GEOLOGICAL SURVEY - NATIONAL WATER QUALITY LABORATORY
ANALYTICAL SERVICES REQUEST FORM

QA

SMS CONTROL NO | NWIS RECORD NO | LABORATORY ID | SAMPLE SET

STATION NAME: WICh52
STATION ID OR UNIQUE NO: 382459075200301

FIELD OFFICE: TOWSON, MD
*PHONE NO.: (410) 512-4800
*PROJECT CHIEF: SHEDLOCK
FIELD SAMPLE ID: WICh52
SITE TYPE: GW

*STATE: 24
*DISTRICT/USER: 024
CNTY: 045
*PROJECT ACCT NO: 442400000

	YEAR	MONTH	DAY	TIME
BEGIN DATE:	1995	01	20	0807
END DATE:				

SCHEDULES, FIELD AND LABORATORY CODES [a]

SCHEDULE 1: SC2085
SCHEDULE 2: ______
SCHEDULE 3: ______
SCHEDULE 4: ______
SCHEDULE 5: ______

ORY CODES [a] SAMPLE MEDIUM: Q
GEOLOGIC UNIT: ______
**ANALYSIS STATUS: H
**ANALYSIS SOURCE: 9
**HYDRO CONDITION: 9

**SAMPLE TYPE: 2
**HYDRO EVENT: 9

CODE:	A/D	CODE:	A/D	CODE:	A/D	CODE:	A/D

FIELD VALUES [b]

LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK
21 / 00095			51 / 00400			2 / 00419		
/ 99100	50		/ 99102	1		/		
/ 99101	10		/			/		

+COMMENTS: (LIMIT TO 138 CHARACTERS) [c]: NWQL VPBW: Lot no.

LOGIN COMMENTS: ______

SHIPPED BY: M. KOTERBA
PHONE: (410) 512-4840
DATE: 01 | 20 | 95 [d]

BOTTLE TYPES (PLEASE FILL IN NO. OF TYPES SENT)

___FA ___RU ___FU ___FAM ___RAM ___RC ___FC ___FAB ___CU
___RA ___RAH ___S= ___CN- ___RCB 1 DOC ___TOC ___SOC ___COD
___VOA ___CHY ___O&G ___PHENOL ___GCC ______OTHER

CUSTOM/SPECIAL SAMPLE APPROVED BY: ______ APPROVAL NO. ______
PROGRAM/PROJECT: XX NAWQA ___DRINKING H20 FILL IN OTHER ______
POSSIBLE HAZARDS ______

REVISED 04/92 +COMMENTS TO BE STORED BY THE LABORATORY *MANDATORY FOR ACCEPTANCE FOR LABORATORY ANALYSIS **MANDATORY FOR STORAGE IN WATSTORE/NWIS

[a] Add all P codes noted to form and to QADATA record for this sample.

[b] If DOC field blank (fig. A13-A) taken with NWQL PBW, instead of NWQL VPBW, change the P code 99100 to "40" and the comment to "NWQL PBW: lot no."

[c] Priority comment, must appear in relation to blank water used (NWQL PBW or NWQL VPBW).

[d] This DOC solution blank is shipped overnight with the corresponding DOC field blank (fig. A13-A).

Figure A14. Example of an analytical service request form for dissolved (filtered) organic carbon (DOC) solution blank composed of either NWQL volatile pesticide-free blank water (VPBW) or pesticide-free blank water (PBW).

U.S. GEOLOGICAL SURVEY - NATIONAL WATER QUALITY LABORATORY
ANALYTICAL SERVICES REQUEST FORM **QA**

SMS CONTROL NO ____ NWIS RECORD NO ____ LABORATORY ID ____ SAMPLE SET ____

STATION NAME: WICh52 STATION ID OR UNIQUE NO: 382459075200301

FIELD OFFICE: TOWSON, MD *PHONE NO.: (410) 512-4800 *PROJECT CHIEF: SHEDLOCK FIELD SAMPLE ID: WICh52 SITE TYPE: GW

*STATE: 24 *DISTRICT/USER: 024 CNTY: 045 *PROJECT ACCT NO: 442400000

	YEAR	MONTH	DAY	TIME
BEGIN DATE:	1995	01	20	0808
END DATE:				

SCHEDULES, FIELD AND LABORATORY CODES [a]

SCHEDULE 1: SC2090
SCHEDULE 2: ____
SCHEDULE 3: ____
SCHEDULE 4: ____
SCHEDULE 5: ____

**SAMPLE MEDIUM: Q
GEOLOGIC UNIT: ____
**ANALYSIS STATUS: H
**ANALYSIS SOURCE: 9
**HYDRO CONDITION: 9

**SAMPLE TYPE: 2
**HYDRO EVENT: 9

A/D CODE: ____ | ____ (four columns of four blank CODE lines)

FIELD VALUES [b]

LAB/P CODE	VALUE	RMK
21 / 00095		
/ 99100	50	
/ 99101	10	
51 / 00400		
/ 99102	30	
2 / 00419		

+COMMENTS: (LIMIT TO 138 CHARACTERS): VOC trip-blank vial: Lot no.

LOGIN COMMENTS: ____

SHIPPED BY: M. KOTERBA PHONE: (410) 512-4840 DATE: 01 | 20 | 95[c]

BOTTLE TYPES (PLEASE FILL IN NO. OF TYPES SENT)

___FA ___RU ___FU ___FAM ___RAM ___RC ___FC ___FAB ___CU
___RA ___RAH ___S= ___CN- ___RCB ___DOC ___TOC ___SOC ___COD
___VOA ___CHY ___O&G ___PHENOL ___GCC 2 GCV ___OTHER

CUSTOM/SPECIAL SAMPLE APPROVED BY: ____ APPROVAL NO. ____
PROGRAM/PROJECT: XX NAWQA ___ DRINKING H20 FILL IN OTHER ____
POSSIBLE HAZARDS ____

REVISED 04/92 +COMMENTS TO BE STORED BY THE LABORATORY *MANDATORY FOR ACCEPTANCE FOR LABORATORY ANALYSIS **MANDATORY FOR STORAGE IN WATSTORE/NWIS

DRAFT

[a]Add all P codes noted to form and to QADATA record for this sample.
[b]NWQL VPBW is assumed for trip blanks; priority comment, lot no. of VOC trip blank vials.
[c]Ship overnight with corresponding volatile ground-water samples collected in vials from same lot (fig. A10-A).

Figure A15. Example of an analytical service request form for a volatile-organic-compound (VOC) trip blank.

U.S. GEOLOGICAL SURVEY - NATIONAL WATER QUALITY LABORATORY
ANALYTICAL SERVICES REQUEST FORM

QA

SMS CONTROL NO ____ NWIS RECORD NO ____ LABORATORY ID ____ SAMPLE SET ____

STATION NAME: WICh52 STATION ID OR UNIQUE NO: 382459075200301

FIELD OFFICE: TOWSON, MD *PHONE NO.: (410) 512-4800 *PROJECT CHIEF: SHEDLOCK FIELD SAMPLE ID: WICh52 SITE TYPE: GW

*STATE: 24 *DISTRICT/USER: 024 CNTY: 045 *PROJECT ACCT NO: 442400000

	YEAR	MONTH	DAY	TIME
BEGIN DATE:	1995	01	20	0809
END DATE:				

SCHEDULES, FIELD AND LABORATORY CODES [a]

SCHEDULE 1: SC2703
SCHEDULE 2: ____
SCHEDULE 3: ____
SCHEDULE 4: ____
SCHEDULE 5: ____

**SAMPLE MEDIUM: 6
GEOLOGIC UNIT: 112BVDM
**ANALYSIS STATUS: H
**ANALYSIS SOURCE: 9
**HYDRO CONDITION: 9

**SAMPLE TYPE: 9 or 7[b]
**HYDRO EVENT: 9

CODE	A/D [c]	CODE	A/D	CODE	A/D	CODE	A/D
LC0112							
LC0087							

FIELD VALUES [d]

LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK
21/ 00095	245		51/ 00400	6.1		2 / 00419	11.5	
/00010	11.1		/ 00300	2.2		/00452	1.2	
/00076	2		/99105	20		/00453	9.3	
						39086	11.2	

+COMMENTS: (LIMIT TO 138 CHARACTERS: (INDICATE HERE IF SC EXCEEDS 2,000)

LOGIN COMMENTS: ____

SHIPPED BY: M. KOTERBA PHONE: (410) 512-4840 DATE: 01 /27 /95[e]

BOTTLE TYPES (PLEASE FILL IN NO. OF TYPES SENT)

1 FA [f] ___RU ___FU ___FAM ___RAM ___RC ___FC ___FAB ___CU
___RA ___RAH ___S= ___CN- ___RCB ___DOC ___TOC ___SOC ___COD
___VOA ___CHY ___O&G ___PHENOL ___GCC ________OTHER

CUSTOM/SPECIAL SAMPLE APPROVED BY: ____ APPROVAL NO. ____
PROGRAM/PROJECT: XX NAWQA ___DRINKING H20 FILL IN OTHER ____
POSSIBLE HAZARDS ____

REVISED 04/92 +COMMENTS TO BE STORED BY THE LABORATORY *MANDATORY FOR ACCEPTANCE FOR LABORATORY ANALYSIS **MANDATORY FOR STORAGE IN WATSTORE/NWIS

[a]Add all P codes noted to form and to QADATA record for this sample.

[b]If a replicate trace-element sample is collected (fig. A17), code sample type as 7; otherwise, code as 9.

[c]Add labcodes for arsenic (LC0112) and selenium (LC0087).

[d]Include field measurements (median values), particularly for specific electrical conductance (SC) at 25 degrees Celsius (P code 00095), and note on comment line if SC exceeds 2,000.

[e]Recommend sample be shipped surface mail with other primary inorganic samples (see fig. A10-B).

[f]Only the FA sample bottle is required if Study Unit acidifies sample, provides field SC value, and indicates in comment field if SC exceeds 2,000 microsiemens per centimeter at 25 degrees Celsius.

Figure A16. Example of an analytical service request form for a primary trace-element ground-water sample (SC2703).

U.S. GEOLOGICAL SURVEY - NATIONAL WATER QUALITY LABORATORY
ANALYTICAL SERVICES REQUEST FORM **QA**

SMS CONTROL NO	NWIS RECORD NO	LABORATORY ID	SAMPLE SET

STATION NAME: WICh52
STATION ID OR UNIQUE NO: 382459075200301

FIELD OFFICE: TOWSON, MD
*PHONE NO.: (410) 512-4800
*PROJECT CHIEF: SHEDLOCK
FIELD SAMPLE ID: WICh52
SITE TYPE: GW

*STATE: 24
*DISTRICT/USER: 024
CNTY: 045
*PROJECT ACCT NO: 442400000

	YEAR	MONTH	DAY	TIME
BEGIN DATE:	1995	01	20	0810
END DATE:				

SCHEDULES, FIELD AND LABORATORY CODES [a]

SCHEDULE 1: SC2703
SCHEDULE 2: ______
SCHEDULE 3: ______
SCHEDULE 4: ______
SCHEDULE 5: ______

**SAMPLE MEDIUM: S
GEOLOGIC UNIT: ______
**ANALYSIS STATUS: H
**ANALYSIS SOURCE: 9
**HYDRO CONDITION: 9

**SAMPLE TYPE: 7
**HYDRO EVENT: 9

CODE	A/D [b]	CODE	A/D	CODE	A/D	CODE	A/D
LC0112							
LC0087							

FIELD VALUES

LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK
21/ 00095	245	[c]	51/ 00400			2 / 00419		
/99105	20		/			/		
/			/			/		

+COMMENTS: (LIMIT TO 138 CHARACTERS): ______

LOGIN COMMENTS: ______

SHIPPED BY: M. KOTEREA PHONE: (410) 512-4840 DATE: 01 27 95[d]

BOTTLE TYPES (PLEASE FILL IN NO. OF TYPES SENT)

1 FA [e], __ RA, __ VOA, __ RU, __ RAH, __ CHY, __ FU, __ S=, __ O&G, __ FAM, __ CN-, __ PHENOL, __ RAM, __ RCB, __ GCC, __ RC, __ DOC, __ FC, __ TOC, __ FAB, __ SOC, __ CU, __ COD, __ OTHER

CUSTOM/SPECIAL SAMPLE APPROVED BY: ______ APPROVAL NO. ______
PROGRAM/PROJECT: XX NAWQA __ DRINKING H20 FILL IN OTHER ______
POSSIBLE HAZARDS ______

REVISED 04/92 +COMMENTS TO BE STORED BY THE LABORATORY
*MANDATORY FOR ACCEPTANCE FOR LABORATORY ANALYSIS
**MANDATORY FOR STORAGE IN WATSTORE/NWIS

[a]Add all P codes noted to form and to QADATA record for this sample.

[b]Add labcodes for arsenic (LC0112) and selenium (LC0087).

[c]Include field measurements (median values), particularly for specific electrical conductance (SC) at 25 degrees Celsius (P code 00095), and note on comment line if SC exceeds 2,000.

[d]Recommend sample be shipped surface mail with other primary inorganic samples (see fig. A10-B).

[e]Only the FA sample bottle is required if Study Unit acidifies sample, provides field SC value, and indicates in comment field if SC exceeds 2,000 microsiemens per centimeter at 25 degrees Celsius.

Figure A17. Example of an analytical service request form for a replicate trace-element ground-water sample (SC2703).

U.S. GEOLOGICAL SURVEY - NATIONAL WATER QUALITY LABORATORY
ANALYTICAL SERVICES REQUEST FORM

QA

SMS CONTROL NO	NWIS RECORD NO	LABORATORY ID	SAMPLE SET

WICh52 — STATION NAME
382459075200301 — STATION ID OR UNIQUE NO

TOWSON, MD — FIELD OFFICE
(410) 512-4800 — *PHONE NO.
SHEDLOCK — *PROJECT CHIEF
WICh52 — FIELD SAMPLE ID
GW — SITE TYPE

24 — *STATE
024 — *DISTRICT/USER
045 — CNTY
442400000 — *PROJECT ACCT NO

	YEAR	MONTH	DAY	TIME
BEGIN DATE:	1995	01	20	0811
END DATE:				

SCHEDULES, FIELD AND LABORATORY CODES [a]

SCHEDULE 1: SC172[b]
SCHEDULE 2: ____
SCHEDULE 3: ____
SCHEDULE 4: ____
SCHEDULE 5: ____

**SAMPLE MEDIUM: Q
GEOLOGIC UNIT: ____
**ANALYSIS STATUS: H
**ANALYSIS SOURCE: 9
**HYDRO CONDITION: 9

**SAMPLE TYPE: 2
**HYDRO EVENT: 9

(A)/D [c]
CODE: LC0112 | ____
CODE: LC0087 | ____
CODE: ____ | ____
CODE: ____ | ____

A/D
CODE: ____ | ____
CODE: ____ | ____
CODE: ____ | ____
CODE: ____ | ____

A/D
CODE: ____ | ____
CODE: ____ | ____
CODE: ____ | ____
CODE: ____ | ____

A/D
CODE: ____ | ____
CODE: ____ | ____
CODE: ____ | ____
CODE: ____ | ____

FIELD VALUES[d]

LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK
21/ 00095			51/ 00400			2 / 00419		
/99100	10		/ 99102	100		/		
/99101	80		/			/		

+COMMENTS: (LIMIT TO 138 CHARACTERS) QWSU IBW: Lot no.; SC is less than 2,000

LOGIN COMMENTS: ____

SHIPPED BY: M. KOTERBA   PHONE: (410) 512-4840   DATE: 01 /27 /95[e]

BOTTLE TYPES (PLEASE FILL IN NO. OF TYPES SENT)

1 FA [f] ___RU ___FU ___FAM ___RAM ___RC ___FC ___FAB ___CU
___RA ___RAH ___S= ___CN- ___RCB ___DOC ___TOC ___SOC ___COD
___VOA ___CHY ___O&G ___PHENOL ___GCC ___OTHER

CUSTOM/SPECIAL SAMPLE APPROVED BY: ____ APPROVAL NO. ____
PROGRAM/PROJECT: XX NAWQA ___DRINKING H20 FILL IN OTHER ____
POSSIBLE HAZARDS ____

REVISED 04/92   +COMMENTS TO BE STORED BY THE LABORATORY   *MANDATORY FOR ACCEPTANCE FOR LABORATORY ANALYSIS
**MANDATORY FOR STORAGE IN WATSTORE/NWIS

[a]Add all P codes noted to form and to QADATA record for this sample.
[b]SC172 required for field blanks instead of SC2703--provides detection-level or higher concentration data.
[c]Add labcodes for arsenic (LC0112) and selenium (LC0087).
[d]Include priority comments; note that SC value is not given under the P code (this is blank water).
[e]Recommend sample be shipped surface mail with other primary inorganic samples (fig. A10-B).
[f]Only the FA sample bottle is required if the Study Unit acidifies sample and provides SC comment.

Figure A18. Example of an analytical service request form for a ground-water trace-element (SC2703) field blank.

U.S. GEOLOGICAL SURVEY - NATIONAL WATER QUALITY LABORATORY
ANALYTICAL SERVICES REQUEST FORM

QA

SMS CONTROL NO ____ NWIS RECORD NO ____ LABORATORY ID ____ SAMPLE SET ____

STATION NAME: WICh52

STATION ID OR UNIQUE NO: 382459075200301

FIELD OFFICE: TOWSON, MD
*PHONE NO.: (410) 512-4800
*PROJECT CHIEF: SHEDLOCK
FIELD SAMPLE ID: WICh52
SITE TYPE: GW

*STATE: 24
*DISTRICT/USER: 024
CNTY: 045
*PROJECT ACCT NO: 442400000

	YEAR	MONTH	DAY	TIME
BEGIN DATE:	1995	01	20	0812
END DATE:				

SCHEDULES, FIELD AND LABORATORY CODES [a]

SCHEDULE 1: SC2703
SCHEDULE 2: ____
SCHEDULE 3: ____
SCHEDULE 4: ____
SCHEDULE 5: ____

**SAMPLE MEDIUM: Q
GEOLOGIC UNIT: ____
**ANALYSIS STATUS: H
**ANALYSIS SOURCE: 9
**HYDRO CONDITION: 9

**SAMPLE TYPE: 3
**HYDRO EVENT: 9

CODE	A/D [b]	CODE	A/D	CODE	A/D	CODE	A/D
LC0112							
LC0087							

FIELD VALUES [c]

LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK	LAB/P CODE	VALUE	RMK
21/ 00095			51/ 00400			2 / 00419		
/ 99103	35		/			/		
/			/			/		

+COMMENTS: (LIMIT TO 138 CHARACTERS) Bottle Code: ; SC less than 2,000

LOGIN COMMENTS: ____

SHIPPED BY: M. KOTERBA PHONE: (410) 512-4840 DATE: 01 / 27 /

BOTTLE TYPES (PLEASE FILL IN NO. OF TYPES SENT)

1 FA [e] ___ RU ___ FU ___ FAM ___ RAM ___ RC ___ FC ___ FAB ___ CU
___ RA ___ RAH ___ S= ___ CN- ___ RCB ___ DOC ___ TOC ___ SOC ___ COD
___ VOA ___ CHY ___ O&G ___ PHENOL ___ GCC ______ OTHER

CUSTOM/SPECIAL SAMPLE APPROVED BY: ____ APPROVAL NO. ____
PROGRAM/PROJECT: XX NAWQA ___ DRINKING H20 FILL IN OTHER ____
POSSIBLE HAZARDS ____

REVISED 04/92 +COMMENTS TO BE STORED BY THE LABORATORY *MANDATORY FOR ACCEPTANCE FOR LABORATORY ANALYSIS **MANDATORY FOR STORAGE IN WATSTORE/NWIS

[a]Add all P codes noted to form and to QADATA record for this sample.

[b]Add labcodes for arsenic (LC0112) and selenium (LC0087).

[c]Include priority comments; note that SC value is not given under the P code (this is blank water). Specify bottle code originally found on bottle as received from BTD&QS.

[d]Recommend sample be shipped surface mail with other primary inorganic samples (fig. A10-B).

[e]Only the FA sample bottle is required if the Study Unit acidifies sample and provides the SC comment.

Figure A19. Example of an analytical service request form for a standard-reference trace-element (SC2703) sample for ground water.

LOGIN REPLY SHEET

Date Mailed: ____________________ Person sending shipment: ________________________

Place from which shipment was mailed: ______________________________________

Shipped via: ____

Type of Sample (circle one): ORG NUT PEST VOC RADON INORG

Station Numbers of Samples in This Shipment

____ ______________________________________

____ ______________________________________

____ ______________________________________

____ ______________________________________

____ ______________________________________

LOGIN STAFF:

Please enter the following information on this form and mail the form back to us with the attached self-addressed, franked envelope. Note that there is an 8-ounce bottle of tap water in this shipment marked "TEMPERATURE" for use in measuring water temperature.

Person logging in shipment: ____

Date Shipment Arrived:

Water Temperature:

Comments (if applicable):

If you have any questions about this shipment, please contact:

Name: ______________________________________

Telephone: ( ) __________ - _______________

E-mail or Internet: _____________________________

Thank You For Your Participation in This Quality Assurance Program.

Figure A20. Example of Study Unit login reply form sent with samples shipped by overnight mail.

Errata for Open-File Report 95-399

Corrections are by Michael Koterba; January 24, 1996

Page 16, Table 3, Footnote 21, Item (1)--**change from**:

"For assistance with (1) isotope, radiochemical, and other specialized equipment, contact the NAWQA Quality Assurance Specialist;"

to:

"For assistance with (1) deuterium-oxygen isotopes, and quality-assured sample bottles and caps for these isotopes, contact Tyler Coplen, Isotope Fractionation, USGS National Research Program, MS 431, Reston, Va. (via isotopes@usgs.gov); for assistance with tritium isotopes, and quality-assured sample bottles and caps for these isotopes, contact Robert Michel, Isotope Tracers, MS 434, USGS National Research Program, Menlo Park, Calif. (via tritium@mailrcamnl.wr.usgs.gov);"

Page 66, Table 21, 3. Other Samples--Columns for Tritium isotopes and Deuterium-Oxygen isotopes **change from**:

Team Member A

Sample type (SC, LC) and order of collection	Collect, by filling	Quality-assurance checks or measures
• Tritium isotopes	1, 1.0-L, clear, prerinsed poly bottle, filled to top after 3, 25-mL rinses (include cap with conical insert)	Verify DIW is still in bottle from office prerinse before use, otherwise replace bottle. Leave no headspace in bottle
• Deuterium-Oxygen isotopes	1, 125-ml, glass, amber bottle to top after 3, 25-ml rinses (include cap with conical insert)	Leave no headspace in bottle

to:

Team Member A

Sample type (SC, LC) and order of collection	Collect, by filling	Quality-assurance checks or measures
• Tritium isotopes	1, 1.0-L, dry, high-density-poly (preferred) or glass bottle, without prerinsing, until it overflows, and seal with a cap with conical insert	To reduce breakage of glass bottles caused by samples freezing during shipment, pour out sample until the water level is at the bottle shoulder seam.
• Deuterium-Oxygen isotopes	1, 60-mL, dry, clear, glass (preferred) or poly bottle, without prerinsing, until it overflows, and seal with a cap with conical insert	To reduce breakage of glass bottles caused by samples freezing during shipment, pour out sample until the water level is at the bottle shoulder seam. Samples collected in poly bottles are sent immediately for analysis, and are unsuitable for archiving.

Cuyama Valley Groundwater Basin

Draft Groundwater Sustainability Plan: Minimum Thresholds, Measurable Objectives, and Interim Milestones

Prepared by:

April 2019

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Table of Contents

Tables

Figures

Appendices

Acronyms

Basin	Cuyama Groundwater Basin
CBGSA	Cuyama Basin Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
IM	Interim Milestone
MCL	Maximum Contaminant Levels
mg/L	milligrams per liter
MO	Measurable Objective
MT	Minimum Threshold
SGMA	Sustainable Groundwater Management Act
TDS	Total Dissolved Solids

Chapter 5 Minimum Thresholds, Measurable Objectives, and Interim Milestones

This chapter of the Cuyama Groundwater Basin (Basin) *Groundwater Sustainability Plan* (GSP) defines the sustainability criteria used to avoid undesirable results during GSP implementation. The Sustainable Groundwater Management Act (SGMA) requires the application of minimum thresholds (MTs), measurable objectives (MOs), and interim milestones (IMs) to all representative monitoring sites identified in the GSP. These values, or thresholds, will help the Cuyama Basin Groundwater Sustainability Agency (CBGSA) and other groundwater users in the Basin identify sustainable values for the established SGMA sustainability indicators, and will help identify progress indicators over the 20-year GSP implementation period.

5.1 Useful Terms

There are several terms used in this chapter that describe Basin conditions and the values calculated for the representative sites. These terms are intended as a guide for readers, and are not a definitive definition of any term.

- **Sustainability Goals** – Sustainability goals are the culmination of conditions in the absence of undesirable results within 20 years of the applicable statutory deadline.
- **Undesirable Results** – Undesirable results are the significant and unreasonable occurrence of conditions that adversely affect groundwater use in the Basin, as defined in Chapter 3.
- **Measurable Objectives** – MOs are specific, quantifiable goals for maintaining or improving specified groundwater conditions that are included in the adopted GSP to achieve the Basin's sustainability goal.
- **Minimum Thresholds** – MTs are a numeric value for each sustainability indicator, which are used to define when undesirable results occur if minimum thresholds are exceeded in a percentage of sites in the monitoring network.
- **Interim Milestones** – IMs are a target value representing measurable conditions, set in increments of five years. They are set by the CBGSA as part of the GSP; IMs will help the Basin reach sustainability by 2040.

- **Sustainability Indicators** – These indicators refer to any of the effects caused by groundwater conditions occurring throughout the Basin that, when significant and unreasonable, cause undesirable results, as described in Water Code Section 10721(x). These include the following:
  - — Lowering groundwater levels
  - — Reduction of groundwater storage
  - — Seawater intrusion
  - — Degraded water quality
  - — Land subsidence
  - — Depletion of interconnected surface water

Both MOs and MTs are applied to all sustainability indicator representative sites. Sites in the Basin's monitoring networks that are not classified as representative sites are not required to have MOs or MTs. All of the Basin's representative sites will also have IMs calculated for 2025, 2030, and 2035 to help guide the CBGSA toward its 2040 sustainability goals. All wells meeting the representative well criteria outlined in this GSP are included in the Basin's monitoring network, although participation in the SGMA monitoring program is dependent upon agreements between the CBGSA and the well owners.

The following subsections describe the process of establishing MOs, MTs, and IMs for each of the sustainability indicators described above. They also discuss the results of this process.

5.2 Chronic Lowering of Groundwater Levels

The undesirable result for the chronic lowering of groundwater levels is a result that causes significant and unreasonable reduction in the long-term viability of domestic, agricultural, municipal, or environmental uses over the planning and implementation horizon of this GSP.

Groundwater conditions, as discussed in Chapter 2, Section 2.2, vary across the Basin. Groundwater conditions are influenced by geographic attributes, geologic attributes, and overlying land uses in the Basin. Because of the variety of conditions, six threshold regions were established in the Basin so appropriate sustainability criteria could be set more precisely for each region.

5.2.1 Threshold Regions

The six threshold regions were defined to allow areas with similar conditions to be grouped together for calculation of MOs, MTs, and IMs. These threshold regions are shown in Figure 5-1. The following subsections discuss threshold region characteristics and boundaries.

Southeastern Threshold Region

The Southeastern Threshold Region lies on the southeastern edge of the Basin, and is characterized as having moderate agricultural land use with steep geographic features surrounding the valley. Groundwater is generally high in this area, with recent historical data showing levels around 50 feet or less below ground surface, which indicates that this region is likely currently in a full condition. Groundwater levels in this region are subject to declines during drought periods, but have typically recovered back to previous levels during historically wet periods. The northern boundary of this region is the narrows at the Cuyama River, and the eastern boundary is the extent of alluvium. The southern and western extent of this region is defined by the groundwater basin boundary.

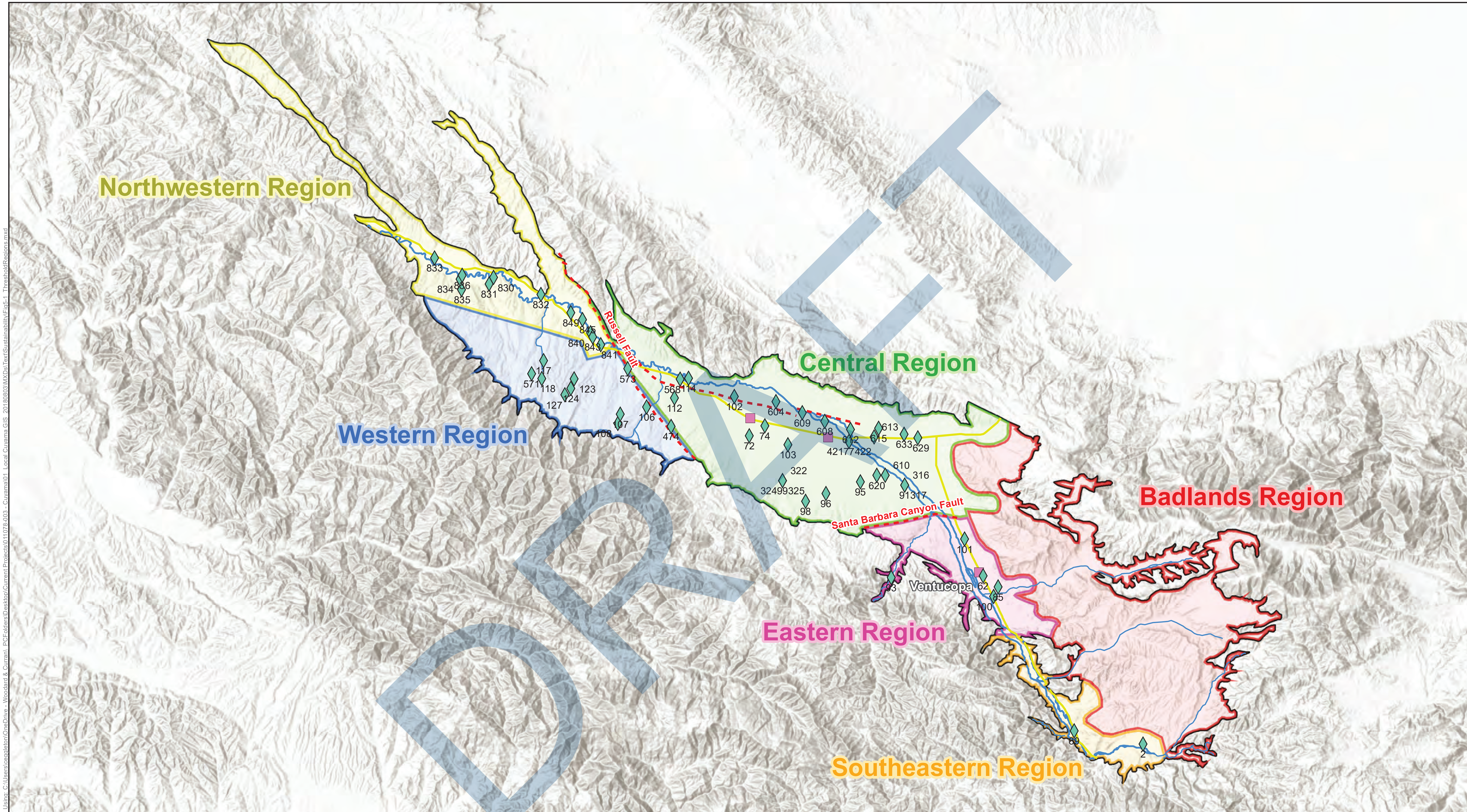

Figure 5-1: Cuyama GW Basin Groundwater Level Representative Wells & Threshold Regions

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

April 2019

WOODARD & CURRAN

Legend

- Cuyama Basin
- Towns
- Representative Wells
- Faults
- Highways
- Cuyama River
- Streams

Threshold Regions

- Badlands Region
- Central Region
- Eastern Region
- Northwestern Region
- Southeastern Region
- Western Region

N

0 2.75 5.5 11 Miles

Eastern Threshold Region

The Eastern Threshold Region lies southeast of the central part of the Basin and encompasses Ventucopa and much of the surrounding agricultural property. This part of the Basin has agricultural pumping. Hydrographs in this region indicate that groundwater levels have historically ranged widely and repeatedly over the last 50 years, and in general, are declining over the past 20 years. However, these levels are generally higher than those in the Central Threshold Region. The northern boundary of this region is the Santa Barbara Canyon Fault, and the southern boundary is where the Cuyama Valley significantly narrows due to geographic changes. The eastern boundary is the extent of the boundary, and the western boundary is defined by the groundwater basin boundary.

Central Threshold Region

The Central Threshold Region incorporates the majority of agricultural land use in the Basin, as well as the towns of Cuyama and New Cuyama. The greatest depths to groundwater are also found in the Central Threshold Region, and groundwater levels have generally been declining in this region since the 1950s. The southeastern boundary is defined by the Santa Barbara Canyon fault, and the western boundary by the Russell Fault. The northern and southern boundary of this region is defined by the Basin boundary.

Western Threshold Region

The Western Threshold Region is characterized by shallow depth to water, and recent historical data and hydrographs in this region indicate that it is likely this portion of the Basin is currently in a full condition. Land uses in this area generally include livestock and small agricultural operations. It lies primarily on the north facing slope of the lower Cuyama Valley. The eastern boundary is defined by the Russell Fault, and the northern boundary was drawn to differentiate distinct land uses. The southwestern boundary is defined by the groundwater basin boundary.

Northwestern Threshold Region

The Northwestern Threshold Region is the bottom of the Cuyama Basin and has undergone changes in land use from small production agricultural and grazing to irrigated crops over the last four years. Recent historical data and hydrographs in this portion of the Basin indicate that this portion is likely currently in a full condition. The southern border was drawn to differentiate between the land uses of the Western and Northwestern Threshold regions, resulting in different kinds of agricultural practices. The rest of the region is defined by the Basin boundary.

Badlands Threshold Region

The Badlands Threshold Region includes the areas east of the Central, East, and Southeast Threshold regions on the west facing slope of the Cuyama Valley. There are no active wells and there is little groundwater use in this area. There is no monitoring in this region, and no sustainability criteria were developed for this region.

5.2.2 Minimum Thresholds, Measurable Objectives, and Interim Milestones

This section describes how MTs, MOs, and IMs were established by threshold region, and explains the rationale behind each selected methodology.

Southeastern Threshold Region

Monitoring in this threshold region indicates groundwater levels are static except during drought conditions from 2013 to 2018. Static groundwater levels indicate this area of the Basin is generally at capacity; therefore, the MT is protective of domestic, private, public, and environmental uses.

The MO for the Southeastern Threshold Region's wells was calculated by finding the measurement taken closest to (but not before) January 1, 2015 and not after April 30, 2015. If no measurement was taken during this four-month period, then a linear trendline was applied to the data and the value for January 1, 2015 was extrapolated.

To provide an operational flexibility range, the MT was calculated by subtracting five years of groundwater storage from the MO. Five years of storage was calculated by finding the decline in groundwater levels from 2013 to 2018, which was considered a period of drought. If measurements were insufficient for this time period, a linear trendline was used to extrapolate the value decline value.

IMs were set to equal the MT in all incremental years between 2020 and 2040. This reflects a policy goal of minimizing the exceedance of MTs between now and 2040. As a result, IMs will a way to measure progress toward sustainability over the GSP's planning horizon.

Groundwater levels will be measured using the protocols documented in Chapter 4's Appendix A.

Eastern Threshold Region

Monitoring in this threshold region indicates a downward trend in groundwater levels. The MT for wells in this region intends to protect domestic, private, public and environmental uses of the groundwater by allowing for managed extraction in areas that have beneficial uses and protecting those with at risk infrastructure.

Stakeholders reported concern about the dewatering of domestic wells in this region, and groundwater levels have been declining in monitoring wells. Both the MT and MO consider the sustainability of water levels in regard to both domestic and agricultural users.

The MT was calculated by taking the total historical range of recorded groundwater levels and used 35 percent of the range. This 35 percent was then added below the value closest to January 1, 2015 (as described above).

MOs were calculated by subtracting five years of groundwater storage from the MT. Five years of storage was found by calculating the decline in groundwater levels from 2013 to 2018 (a drought period). If measurements were insufficient for this time period, a linear trendline was used to extrapolate the value.

IMs were set to equal the MT in all incremental years between 2020 and 2040. This reflects a policy goal of minimizing the exceedance of MTs between now and 2040. As a result, IMs will a way to measure progress toward sustainability over the GSP's planning horizon.

Groundwater levels will be measured using the protocols documented in Chapter 4's Appendix A.

Central Threshold Region

Monitoring in this threshold region indicates a decline in groundwater levels, indicating an extraction rate that exceeds recharge rates. The MT for this region is set to allow current beneficial uses of groundwater while reducing extraction rates over the planning horizon to meet sustainable yield. The MO is intended to allow sufficient operational flexibility for future drought conditions.

The MT for representative wells in the Central Threshold Region was calculated by finding the maximum and minimum groundwater levels for each representative well, and calculating 20 percent of the historical range. This 20 percent was then added to the depth to water measurement closest to, but not before, January 1, 2015, and no later than April 30, 2015. If no measurement was taken during this four-month period, then a linear trendline was applied to the wells data, and the value for January 1, 2015 was extrapolated.

The MO was calculated by subtracting five years of groundwater storage from the MT. Five years of storage was found by calculating the decline in groundwater levels from 2013 to 2018 (a drought period). If measurements were insufficient for this time period, a linear trendline was used to extrapolate the value.

For Opti Wells 74, 103, 114, 568, 609, and 615, a modified MO calculation was used where the MO used the linear trendline of the full range of measurements to extrapolate a January 1, 2015 value.

IMs were set to equal the MT in all incremental years between 2020 and 2040. This reflects a policy goal of minimizing the exceedance of MTs between now and 2040. As a result, IMs will a way to measure progress toward sustainability over the GSP's planning horizon.

Groundwater levels will be measured using the protocols documented in Chapter 4's Appendix A.

Western Threshold Region

Monitoring in this threshold region indicates groundwater levels are stable, and levels varied significantly depending on where representative wells were in the region. The most common use of groundwater in this region is for domestic use. Due to these hydrologic conditions, the MT was set to protect the water levels from declining significantly, while allowing beneficial land surface uses of the groundwater and protection of current well infrastructure. The MT was calculated by taking the difference between the total well depth and the value closest to mid-February, 2018, and calculating 15 percent of that depth. Values from 2018 are used because data collected during this time represent a full basin condition. That value was then subtracted from the mid-February, 2018 measurement to calculate the MT. This allows users in this region to use their groundwater supply without increasing the risk of running a well beyond acceptable limits, and this methodology is responsive to the variety of conditions and well depths in this region.

The MO was then calculated by finding the measurement closest to mid-February, 2018, which monitoring indicates is likely a full condition.

Opti Well 474 uses a modified MO calculation where the historical high elevation measurement was used as the MO. This was done to allow for a sufficient operational flexibility based on historical data for the well.

IMs were set to equal the MT in all incremental years between 2020 and 2040. This reflects a policy goal of minimizing the exceedance of MTs between now and 2040. As a result, IMs will a way to measure progress toward sustainability over the GSP's planning horizon.

Groundwater levels will be measured using the protocols documented in Chapter 4's Appendix A.

Northwestern Threshold Region

Monitoring in this threshold region indicates levels are stable, with some declines in the area where new agriculture is established. Due to these hydrologic conditions, the MT was set to protect the water levels from declining significantly, while allowing beneficial land surface uses and using the storage capacity of this region. The MT for the this region was found by determining the region's total average saturated thickness for the primary storage area, and calculating 15 percent of that depth. This value was then set as the MT.

The MO for this region was calculated using 5 years of storage. Because historical data reflecting new operations in this region are limited, 50 feet was used as 5 years of storage based on local landowner input.

There are several representative wells in this region that were reclassified as far-west northwestern wells, and include Opti Wells 830, 831, 832, 833, 834, 835, and 836. These wells have total depths that is shallower, and they use the same strategies as the Western Threshold Region for their MOs and MTs.

IMs were set to equal the MT in all incremental years between 2020 and 2040. This reflects a policy goal of minimizing the exceedance of MTs between now and 2040. As a result, IMs will a way to measure progress toward sustainability over the GSP's planning horizon.

Groundwater levels will be measured using the protocols documented in Chapter 4's Appendix A.

Badlands Threshold Region

This threshold region has no groundwater use or active wells. As a result, no MO, MT, or IM was calculated.

5.2.3 Selected MT, MO, and IM Graphs, Figures, and Tables

Figure 5-2 shows an example hydrograph with indicators for the MT, MO, and IM over the hydrograph. The left axis shows elevation above mean sea level, the right axis shows depth to water below ground surface. The brown line shows the ground surface elevation, and time in years is shown on the bottom axis. Each measurement taken at the monitoring well is shown as a blue dot, with blue lines connecting between the blue dots indicating the interpolated groundwater level between measurements. The MT and IM are shown as a red line, and the MO is shown as a green line. Appendix A includes hydrographs with MT, MO and IM for each representative monitoring well.

Table 5-1 shows the representative monitoring network and the numerical values for the MT, MO, and IM.

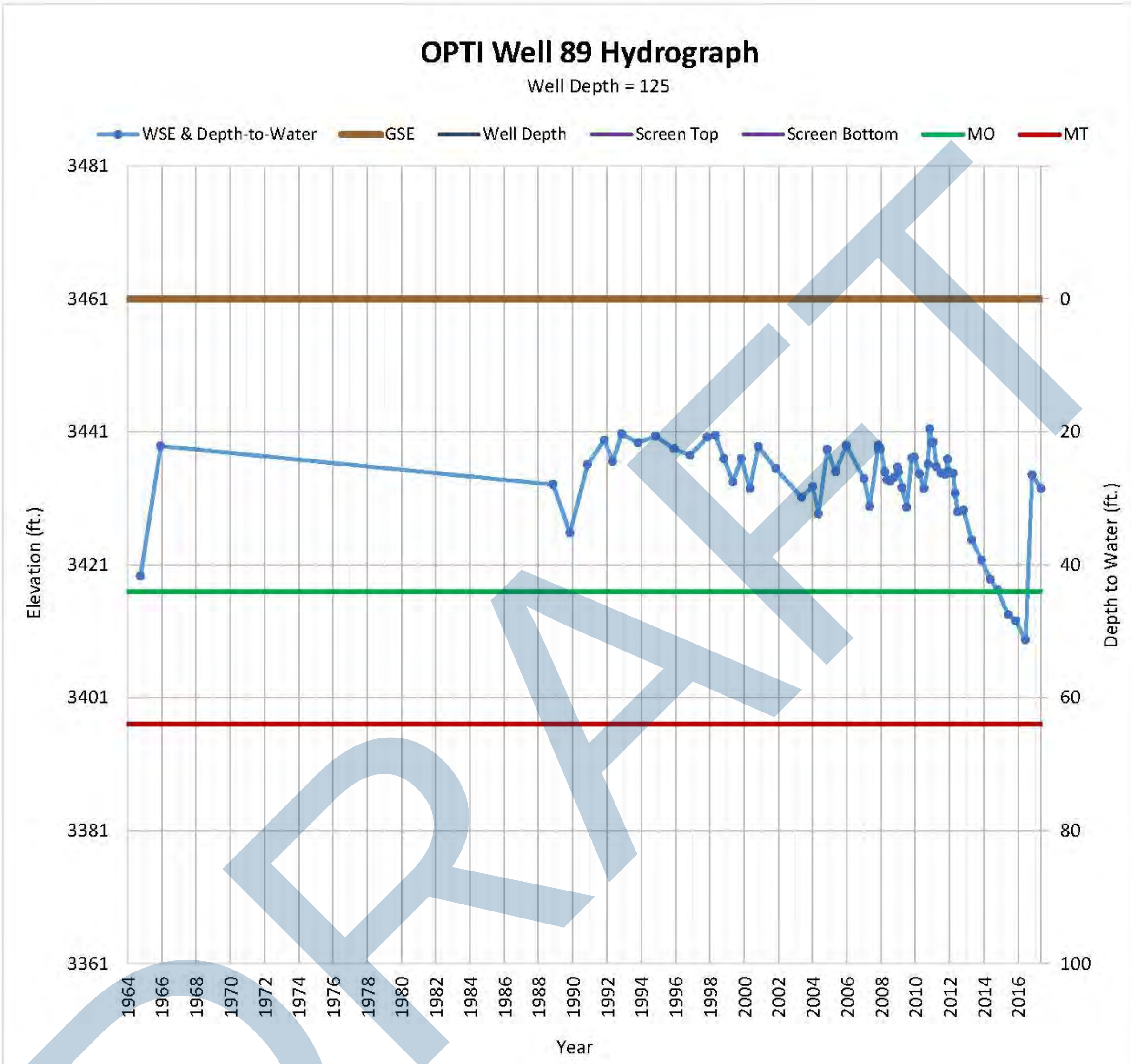

Figure 5-2: Example Hydrograph

Table 5-1: Representative Monitoring Network and Sustainability Criteria

OPTI Well	Region	Final MT	Final MO	2025 IM	2030 IM	2035 IM	Well Depth (feet)	Screen Top (feet)	Screen Bottom (feet)	GSE (feet)
72	Central	169	124	169	169	169	790	340	770	2,171
74	Central	256	243	256	256	256	--	--	--	2,193
77	Central	450	400	450	450	450	980	960	980	2,286
91	Central	625	576	625	625	625	980	960	980	2,474
95	Central	573	538	573	573	573	805	--	--	2,449
96	Central	333	325	333	333	333	500	--	--	2,606
98	Central	450	439	450	450	450	750	--	--	2,688
99	Central	311	300	311	311	311	750	730	750	2,513
102	Central	235	197	235	235	235	--	--	--	2,046
103	Central	290	235	290	290	290	1,030	--	--	2,289
112	Central	87	85	87	87	87	441	--	--	2,139
114	Central	47	45	47	47	47	58	--	--	1,925
316	Central	623	574	623	623	623	830	--	--	2,474
317	Central	623	573	623	623	623	700	--	--	2,474
322	Central	307	298	307	307	307	850	--	--	2,513
324	Central	311	299	311	311	311	560	--	--	2,513
325	Central	300	292	300	300	300	380	--	--	2,513
420	Central	450	400	450	450	450	780	--	--	2,286

Table 5-1: Representative Monitoring Network and Sustainability Criteria

OPTI Well	Region	Final MT	Final MO	2025 IM	2030 IM	2035 IM	Well Depth (feet)	Screen Top (feet)	Screen Bottom (feet)	GSE (feet)
421	Central	446	398	446	446	446	620	--	--	2,286
422	Central	444	397	444	444	444	460	--	--	2,286
474	Central	188	169	188	188	188	213	--	--	2,369
568	Central	37	36	37	37	37	188	--	--	1,905
604	Central	526	487	526	526	526	924	454	924	2,125
608	Central	436	407	436	436	436	745	440	745	2,224
609	Central	458	421	458	458	458	970	476	970	2,167
610	Central	621	591	621	621	621	780	428	780	2,442
612	Central	463	440	463	463	463	1,070	657	1070	2,266
613	Central	503	475	503	503	503	830	330	830	2,330
615	Central	500	468	500	500	500	865	480	865	2,327
620	Central	606	566	606	606	606	1,035	550	1035	2,432
629	Central	559	527	559	559	559	1,000	500	1000	2,379
633	Central	547	493	547	547	547	1,000	500	1000	2,364
62	Eastern	182	157	182	182	182	212	--	--	2,921
85	Eastern	233	209	233	233	233	233	--	--	3,047
100	Eastern	181	152	181	181	181	284	--	--	3,004
101	Eastern	111	88	111	111	111	200	--	--	2,741

Table 5-1: Representative Monitoring Network and Sustainability Criteria

OPTI Well	Region	Final MT	Final MO	2025 IM	2030 IM	2035 IM	Well Depth (feet)	Screen Top (feet)	Screen Bottom (feet)	GSE (feet)
840	Northwestern	203	153	203	203	203	900	200	880	1,713
841	Northwestern	203	153	203	203	203	600	170	580	1,761
843	Northwestern	203	153	203	203	203	620	60	600	1,761
845	Northwestern	203	153	203	203	203	380	100	360	1,712
849	Northwestern	203	153	203	203	203	570	150	550	1,713
2	Southeastern	72	55	72	72	72	73	--	--	3,720
89	Southeastern	64	44	64	64	64	125	--	--	3,461
106	Western	154	141.4	154	154	154	227.5	--	--	2,327
107	Western	91	72.23	91	91	91	200	--	--	2,482
108	Western	165	135.62	165	165	165	328.75	--	--	2,629
117	Western	160	150.82	160	160	160	212	--	--	2,098
118	Western	124	57.22	124	124	124	500	--	--	2,270
123	Western	31	12.59	31	31	31	138	--	--	2,165
124	Western	73	57.12	73	73	73	160.55	--	--	2,287
127	Western	42	31.74	42	42	42	100.25	--	--	2,364
571	Western	144	120.5	144	144	144	280	--	--	2,307
573	Western	118	67.5	118	118	118	404	--	--	2,084
830	Far-West Northwestern	59	56	59	59	59	77.2	--	--	1,571

Table 5-1: Representative Monitoring Network and Sustainability Criteria

OPTI Well	Region	Final MT	Final MO	2025 IM	2030 IM	2035 IM	Well Depth (feet)	Screen Top (feet)	Screen Bottom (feet)	GSE (feet)
831	Far-West Northwestern	77	52	77	77	77	213.75	--	--	1,557
832	Far-West Northwestern	45	30	45	45	45	131.8	--	--	1,630
833	Far-West Northwestern	96	24	96	96	96	503.55	--	--	1,457
834	Far-West Northwestern	84	42	84	84	84	320	--	--	1,508
835	Far-West Northwestern	55	36	55	55	55	162.2	--	--	1,555
836	Far-West Northwestern	79	36	79	79	79	325	--	--	1,486

5.3 Reduction of Groundwater Storage

The undesirable result for the reduction in groundwater storage is a result that causes significant and unreasonable reduction in the viability of domestic, agricultural, municipal, or environmental uses over the planning and implementation horizon of this GSP.

Direct measurement of the reduction of groundwater storage in the Basin is not needed because monitoring in several areas of the Basin (i.e., the western, eastern, and portions of the north facing slope of the Cuyama Valley near the center of the Basin) indicate that those regions are likely near, or at full conditions. Additionally, the Basin's primary aquifer is not confined and storage closely matches groundwater levels.

SGMA regulations define the MT for reduction of groundwater storage as "…the total volume of groundwater that can be withdrawn from the basin without causing conditions that may lead to undesirable results."

Undesirable results for groundwater storage volumes in this GSP will use groundwater levels as a proxy, as the groundwater level sustainability criteria are protective of groundwater in storage.

5.3.1 Threshold Regions

Groundwater storage is measured by proxy using groundwater level thresholds, and thus uses the same methodology and threshold regions as groundwater levels.

5.3.2 Proxy Monitoring

Reduction of groundwater storage in the Basin uses groundwater levels as a proxy for determining sustainability, as permitted by Title 23 of the California Code of Regulations in Section 354.26 (d), Chapter 1.5.2.5. Additionally, there are currently no state, federal, or local standards that regulate groundwater storage. As described above, any benefits to groundwater storage are expected to coincide with groundwater level management.

5.4 Seawater Intrusion

Due to the geographic location of the Basin, seawater intrusion is not a concern, and thus is not required to establish criteria for undesirable results for seawater intrusion, as supported by Title 23 of the California Code of Regulations in Section 354.26 (d), Chapter 1.5.2.5

5.5 Degraded Water Quality

The undesirable result for degraded water quality is a result stemming from a causal nexus between SGMA-related groundwater quantity management activities and groundwater quality that causes significant and unreasonable reduction in the long-term viability of domestic, agricultural, municipal, or environmental uses over the planning and implementation horizon of this GSP.

The SGMA regulations specify that, “minimum thresholds for degraded water quality shall be the degradation of water quality, including the migration of contaminant plumes that impair water supplies or other indicator of water quality as determined by the Agency that may lead to undesirable results.”

Salinity (measured as total dissolved solids [TDS]), arsenic, and nitrates have all been identified as potentially being of concern for water quality in the Basin. However, as noted in the Groundwater Conditions section, there have only been two nitrate measurements and three arsenic measurements in recent years that exceeded MCLs. In the case of arsenic, all of the high concentration measurements have been taken at groundwater depths of greater than 700 feet, outside of the range of pumping. Furthermore, unlike with salinity, there is no evidence to suggest a causal nexus between potential GSP actions and arsenic or salinity. Therefore, the groundwater quality network has been established to monitor for salinity (measured as TDS) but does not include arsenic or nitrates at this time.

TDS is being monitored by the GSA for several reasons. Local stakeholders identified TDS as one of the constituents of concerns in the GSP development processes, and TDS has had several exceedance measurements near domestic and public supply wells. Although high TDS concentrations are naturally occurring within the Basin, it is believed that management of groundwater levels may help improve TDS concentration levels towards levels reflective of the natural condition.

5.5.1 Threshold Regions

Groundwater quality monitoring does not use threshold regions. because the same approach is used for all wells in the Basin. Figure 5-3 shows groundwater quality representative well locations in the Basin.

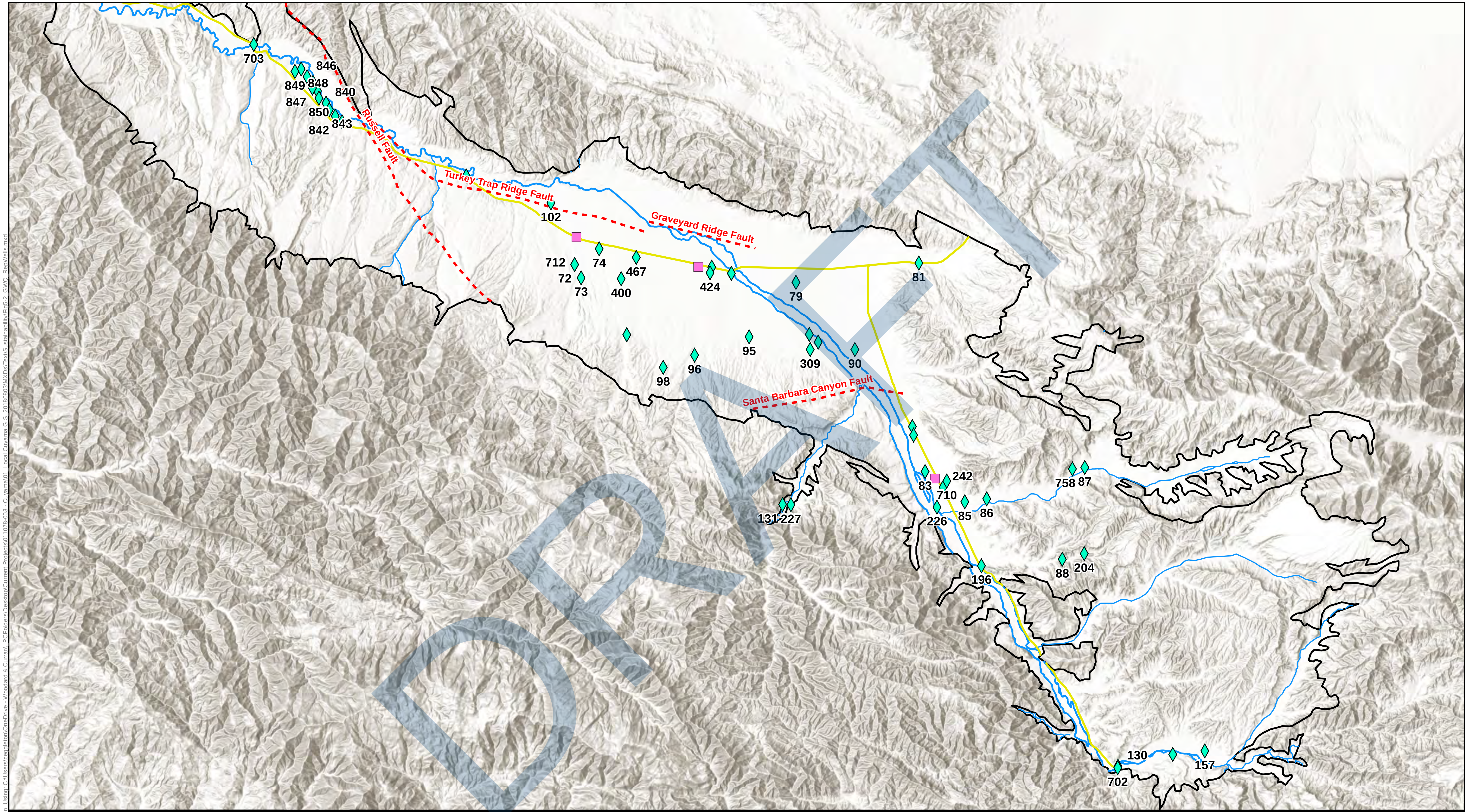

Figure 5-3: Cuyama GW Basin Groundwater Quality Representative Wells

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Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

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5.5.2 Proxy Monitoring

Proxy monitoring is not used for groundwater quality monitoring in the Basin.

5.5.3 Minimum Thresholds, Measurable Objectives, and Interim Milestones

The CBGSA has decided to address TDS within the Basin by setting MTs, MOs, and IMs as shown in Table 5-2. TDS does not have a primary maximum contaminant level (MCL), but does have both a California Division of Drinking Water and U.S. Environmental Protection Agency. Secondary standard of 500 milligrams per liter (mg/L), and a short-term standard of 1,500 mg/L. Current levels in the Basin range from 84 to 4,400 mg/L. This is due to saline conditions in the portions of the watershed where rainfall percolates through marine sediments that contain large amounts of salt.

Due to this natural condition, additional data will be collected during GSP implementation to increase the CBGSA's understanding of TDS sources in the Basin. It should be noted however, that TDS levels in groundwater do not detrimentally impact the agricultural economy of the Basin. Much of the crops grown in the Basin, including carrots, are not significantly affected by the kinds of salts in the Basin.

Due to these factors, the MT for representative well sites was set to be the 20 percent of the total range of each representative monitoring site above the 90^{th} percentile of measurements for each site. For example, Opti Well 72 has a minimum recorded TDS value of 955 mg/L and a maximum of 1,020 mg/L. This is a range of 65 mg/L, and 20 percent of that range is 13 mg/L. The 90^{th} percentile for Opti Well 72 is 1,010 mg/L. The MT is then calculated by taking the 90^{th} percentile of 1,010 mg/L and adding 13mg/L to reach a final MT of 1,023 mg/L.

To provide for an acceptable margin of operational flexibility, the MO for TDS levels in the Basin have been set to the temporary MCL of 1,500 mg/L for each representative well where the latest measurements as of 2018 are greater than 1,500 mg/L. For wells with recent measurements of less than 1,500 mg/L, the MO was set to the most recent measurement as of 2018.

GSP regulations require GSAs to avoid undesirable results by 2040, which means they must meet or exceed the MTs. The CBGSA also recognizes that reaching an MO is a priority, but meeting or exceeding the MT is required by SGMA. For this reason, the IMs for 2025, 2030, and 2035 have been set as the same value as the MT.

Table 5-2: MOs, MTs, and Interim Milestones for Groundwater Quality Representative Sites - TDS

Opti Well	Well Depth (feet below GSE)	Screen Interval (feet below GSE)	Well Elevation (feet above MSL)	Most Recent Measurement (feet)	Minimum Value (mg/L)	Maximum Measurement Value (mg/L)	20% of Range (mg/L)	90th Percentile (mg/L)	MO (mg/L)	MT (mg/L)	2025 IM (mg/L)	2030 IM (mg/L)	2035 IM (mg/L)
61	357	Unknown	3,681	585	468	602	26.8	588.4	585	615.2	615.2	615.2	615.2
72	790	340 – 350	2,171	996	955	1020	13	1010	996	1,023	1023	1023	1023
73	880	Unknown	2,252	805	777	844	13.4	842.5	805	855.9	855.9	855.9	855.9
74	--	Unknown	2,193	1,550	1,530	1,820	58	1775	1,500	1,833	1833	1833	1833
76	720	Unknown	2,277	1,700	1,280	2,190	182	2,124.9	1,500	2,306.9	2,306.9	2306.9	2306.9
77	980	960 – 980	2,286	1,520	1,520	1,580	12	1580	1,500	1,592	1592	1592	1592
79	600	Unknown	2,374	2,140	1,810	2,280	94	2226	1,500	2,320	2320	2320	2320
81	155	Unknown	2,698	2,620	2,620	2,760	28	2760	1,500	2,788	2788	2788	2788
83	198	Unknown	2,858	1,660	1,660	1,720	12	1714	1,500	1,726	1726	1726	1726
85	233	Unknown	3,047	618	491	1,500	201.8	1,189.4	618	1,391.2	1,391.2	1391.2	1391.2
86	230	Unknown	3,141	969	912	969	11.4	963.3	969	974.7	974.7	974.7	974.7
87	232	Unknown	3,546	1,090	891	1,160	53.8	1,111	1,090	1,164.8	1,164.8	1164.8	1164.8
88	400	Unknown	3,549	302	302	302	0	302	302	302	302	302	302
90	800	Unknown	2,552	1,530	1,440	1,580	28	1,565	1,500	1,593	1,593	1593	1593
91	980	960 – 980	2,474	1,410	1,410	1,480	14	1,473	1,410	1,487	1,487	1487	1487
94	550	Unknown	2,456	1,050	1,050	1,230	36	1,209	1,050	1,245	1,245	1245	1245
95	805	Unknown	2,449	1,710	1,710	1,840	26	1,840	1,500	1,866	1,866	1866	1866
96	500	Unknown	2,606	1,500	1,500	1,620	24	1,608	1,500	1,632	1,632	1632	1632
98	750	Unknown	2,688	2,220	2,220	2,370	30	2,370	1,500	2,400	2,400	2400	2400
99	750	730 – 750	2,513	1,490	1,490	1,550	12	1,550	1,490	1,562	1,562	1562	1562
101	200	Unknown	2,741	1,550	1,550	1,680	26	1,667	1,500	1,693	1,693	1693	1693
102	--	Unknown	2,046	1,970	1,920	2,290	74	2,277	1,500	2,351	2,351	2351	2351
130	--	Unknown	3,536	1,800	1,800	1,850	10	1,845	1,500	1,855	1,855	1855	1855
131	--	Unknown	2,990	1,850	1,850	1,970	24	1,958	1,500	1,982	1,982	1982	1982
157	71	Unknown	3,755	1,930	1,910	2,320	82	2,278	1,500	2,360	2,360	2360	2360
196	741	Unknown	3,117	851	682	868	37.2	866.5	851	903.7	903.7	903.7	903.7
204	--	Unknown	3,693	253	253	266	2.6	266	253	268.6	268.6	268.6	268.6
226	--	Unknown	2,945	1,760	1,760	1,830	14	1,830	1,500	1,844	1,844	1,844	1,844

Table 5-2: MOs, MTs, and Interim Milestones for Groundwater Quality Representative Sites - TDS

Opti Well	Well Depth (feet below GSE)	Screen Interval (feet below GSE)	Well Elevation (feet above MSL)	Most Recent Measurement (feet)	Minimum Value (mg/L)	Maximum Measurement Value (mg/L)	20% of Range (mg/L)	90th Percentile (mg/L)	MO (mg/L)	MT (mg/L)	2025 IM (mg/L)	2030 IM (mg/L)	2035 IM (mg/L)
227	--	Unknown	3,002	1,780	1,780	2,200	84	2,146	1,500	2,230	2,230	2,230	2,230
242	155	Unknown	2,933	1,470	1,470	1,510	8	1,510	1,470	1,518	1,518	1,518	1,518
269	--	Unknown	2,756	1,570	1,570	1,690	24	1,678	1,500	1,702	1,702	1,702	1,702
309	1,100	Unknown	2,513	1,410	1,410	1,500	18	1,491	1,410	1,509	1,509	1,509	1,509
316	830	Unknown	2,474	1,380	1,380	1,460	16	1,452	1,380	1,468	1,468	1,468	1,468
317	700	Unknown	2,474	1,260	1,260	1,330	14	1,323	1,260	1,337	1,337	1,337	1,337
318	610	Unknown	2,474	1,080	1,080	1,140	12	1,140	1,080	1,152	1,152	1,152	1,152
322	850	Unknown	2,513	1,350	1,350	1,380	6	1,380	1,350	1,386	1,386	1,386	1,386
324	560	Unknown	2,513	746	746	772	5.2	772	746	777.2	777.2	777.2	777.2
325	380	Unknown	2,513	1,470	1,470	1,560	18	1,551	1,470	1,569	1,569	1,569	1,569
400	2,120	Unknown	2,298	918	680	948	53.6	922	918	975.6	975.6	975.6	975.6
420	780	Unknown	2,286	1,430	1,430	1,480	10	1,480	1,430	1,490	1,490	1,490	1,490
421	620	Unknown	2,286	1,520	1,520	1,600	16	1,600	1,500	1,616	1,616	1,616	1,616
422	460	Unknown	2,286	1,810	1,810	1,930	24	1,918	1,500	1,942	1,942	1,942	1,942
424	1,000	Unknown	2,291	1,540	1,540	1,580	8	1,580	1,500	1,588	1,588	1,588	1,588
467	1,140	Unknown	2,224	1,630	1,530	1,730	40	1,724	1,500	1,764	1,764	1,764	1,764
568	188	Unknown	1,905	871	871	1,180	61.8	1,129.6	871	1,191.4	1,191.4	1,191.4	1,191.4
702	--	Unknown	3,539	110	48	1,900	370.4	1,704	110	2,074.4	2,074.4	2,074.4	2,074.4
703	--	Unknown	1,613	400	16	4,500	896.8	3,200	400	4,096.8	4,096.8	4,096.8	4,096.8
710	--	Unknown	2,942	1,040	1,040	1,040	0	1,040	1,040	1,040	1,040	1,040	1,040
711	--	Unknown	1,905	928	928	928	0	928	928	928	928	928	928
712	--	Unknown	2,171	977	972	977	1	9,76.5	977	977.5	977.5	977.5	977.5
713	--	Unknown	2,456	1,200	1,200	1,200	0	1,200	1,200	1,200	1,200	1,200	1,200
721	--	Unknown	2,374	2,170	2,170	2,170	0	2,170	1,500	2,170	2,170	2,170	2,170
758	--	Unknown	3,537	900	760	923	32.6	9,21.7	900	954.3	954.3	954.3	954.3
840	900	200 – 880	1,713	559	559	559	0	559	559	559	559	559	559
841	600	170 – 580	1,761	561	561	561	0	561	561	561	561	561	561
842	450	60 – 430	1,759	547	547	547	0	547	547	547	547	547	547

Table 5-2: MOs, MTs, and Interim Milestones for Groundwater Quality Representative Sites - TDS

Opti Well	Well Depth (feet below GSE)	Screen Interval (feet below GSE)	Well Elevation (feet above MSL)	Most Recent Measurement (feet)	Minimum Value (mg/L)	Maximum Measurement Value (mg/L)	20% of Range (mg/L)	90th Percentile (mg/L)	MO (mg/L)	MT (mg/L)	2025 IM (mg/L)	2030 IM (mg/L)	2035 IM (mg/L)
843	620	60 – 600	1,761	569	569	569	0	569	569	569	569	569	569
844	730	100 – 720	1,713	481	481	481	0	481	481	481	481	481	481
845	380	100 – 360	1,712	1,250	1,250	1,250	0	1,250	1,250	1,250	1,250	1,250	1,250
846	610	130 – 590	1,715	918	918	918	0	918	918	918	918	918	918
847	600	180 – 580	1,733	480	480	480	0	480	480	480	480	480	480
848	390	110 – 370	1,694	674	674	674	0	674	674	674	674	674	674
849	570	150 – 550	1,713	1,780	1,780	1,780	0	1,780	1,500	1,780	1,780	1,780	1,780
850	790	180 – 780	1,759	472	472	472	0	472	472	472	472	472	472

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5.6 Subsidence

The undesirable result for land subsidence is a result that causes significant and unreasonable reduction in the viability of the use of infrastructure over the planning and implementation horizon of this GSP.

5.6.1 Threshold Regions

Subsidence monitoring does not use threshold regions. because the same approach is used for all wells in the Basin. Figure 5-4 shows representative locations of subsidence in the Basin.

5.6.2 Representative Monitoring

As discussed in Chapter 4, Section 4.9, all monitoring network subsidence monitoring stations in the Basin, and three additional sites outside of the Basin are designated as representative monitoring sites (Figure 5-4). Detrimental impacts of subsidence include groundwater storage reductions and potential damage to infrastructure, such as large pipelines, roads, bridges and canals. However, the Basin does not currently have infrastructure of this type, and storage losses are small enough they may be considered superficial.

Subsidence in the central portion of the Basin is approximately 0.5 inches per year, as shown in Chapter 2, Section 2.2. Currently, there are no state, federal, or local standards that regulate subsidence rates.

5.6.3 Minimum Thresholds, Measurable Objectives, and Interim Milestones

Although several factors may affect subsidence rates, including natural geologic processes, oil pumping, and groundwater pumping, the primary influence within the Basin is due to groundwater pumping. Because current subsidence rates (approximately 0.8 inches per year) are not significant and unreasonable, the MT rate for subsidence was set at 2 inches per year to allow for flexibility as the Basin works toward sustainability in 2040. This rate is applied primarily to the two stations in the Basin (CUHS and VCST), as the other stations in the monitoring network represent ambient changes in vertical displacement, primarily due to geological influences. This level of subsidence is considered unlikely to cause a significant and unreasonable reduction in the viability of the use of infrastructure over the planning and implementation horizon of this GSP.

Subsidence is expected to be influenced through the management of groundwater pumping through the groundwater level MOs, MTs, and IMs. Thus, the MO for subsidence is set for zero lowering of ground surface elevations.

IMs are not needed for the subsidence sustainability indicator because the current rate of subsidence is above the MT.

Subsidence rates will be measured in the frequency of measurement and monitoring protocols documented in Section 4's Appendix A..

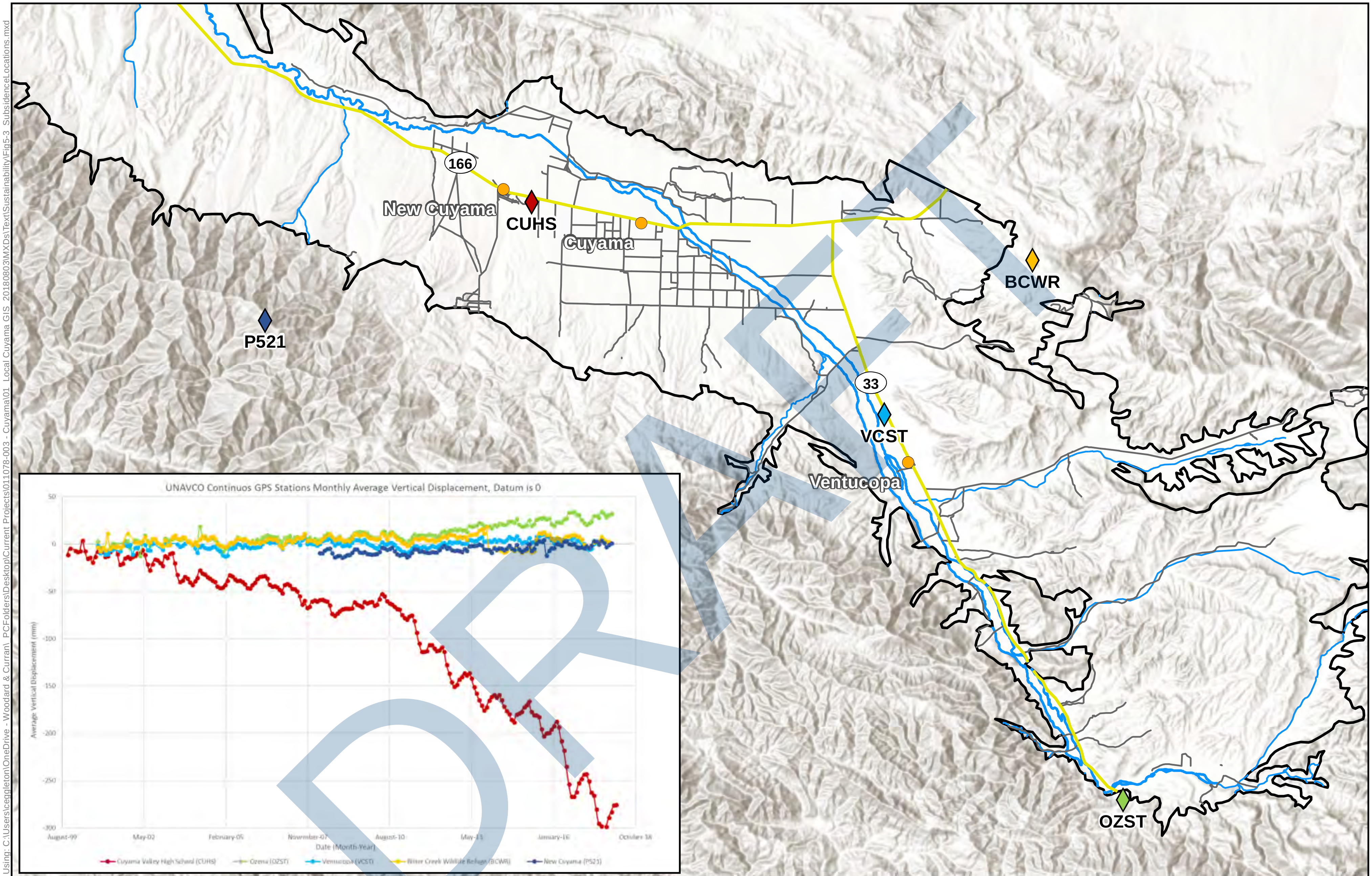

Figure 5-4: Cuyama GW Basin Subsidence Monitoring Locations

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Legend

- Cuyama Basin
- Towns
- Highways
- Local Roads
- Cuyama River
- Streams

0 2 4 8 Miles

N

Figure Exported: 2/1/2019 By: ceggleton Using: C:\Users\ceggleton\OneDrive - Woodard & Curran_PCFolders\Desktop\Current Projects\011078-003 - Cuyama\01_Local Cuyama GIS_20180803\MXDs\Text\Sustainability\Fig5-3_SubsidenceLocations.mxd

5.7 Depletions of Interconnected Surface Water

The undesirable result for depletions of interconnected surface water is a result that causes significant and unreasonable reductions in the viability of agriculture or riparian habitat in the Basin over the planning and implementation horizon of this GSP.

SGMA regulations define the MT for interconnected surface water as "…the rate or volume of surface water depletions caused by groundwater use that has adverse impacts on the beneficial uses of the surface water and may lead to undesirable results." Under normal surface water conditions in the Basin as of January 1, 2015, surface flows infiltrate into the groundwater system and are used by phreatophytes, except in the most extreme flash flood events, when surface water flows out of the Basin. Historically, these flash flood events flow for less than one week of the year. Conditions have not changed since January 1, 2015, and surface flows continue to infiltrate into the groundwater system for use by local phreatophytes.

Because current Basin conditions have not varied from January 1, 2015 conditions, the groundwater level thresholds established in Section 5.2 will act to maintain depletions of interconnected surface water at similar levels to those that existed in January 1, 2015. Therefore, groundwater level thresholds are used by proxy to protect the Basin from undesirable results related to depletion of interconnected surface water.

5.8 References

California Water Boards Irrigated Land Regulatory Program (ILRP) website. https://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/. Accessed January 11, 2019.

Appendix A

Hydrographs Showing Minimum Thresholds, Measurable Objectives and Interim Milestones

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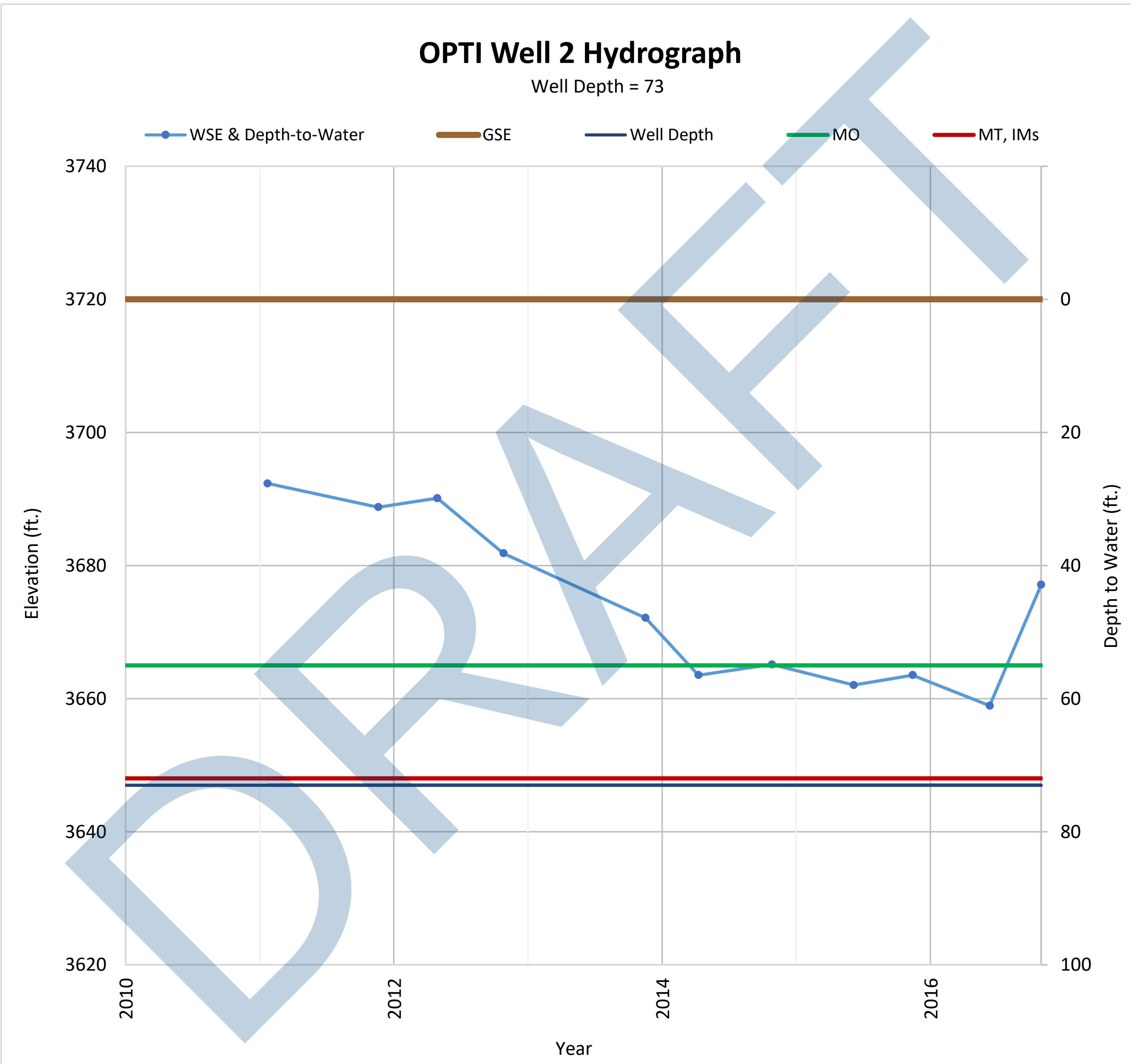
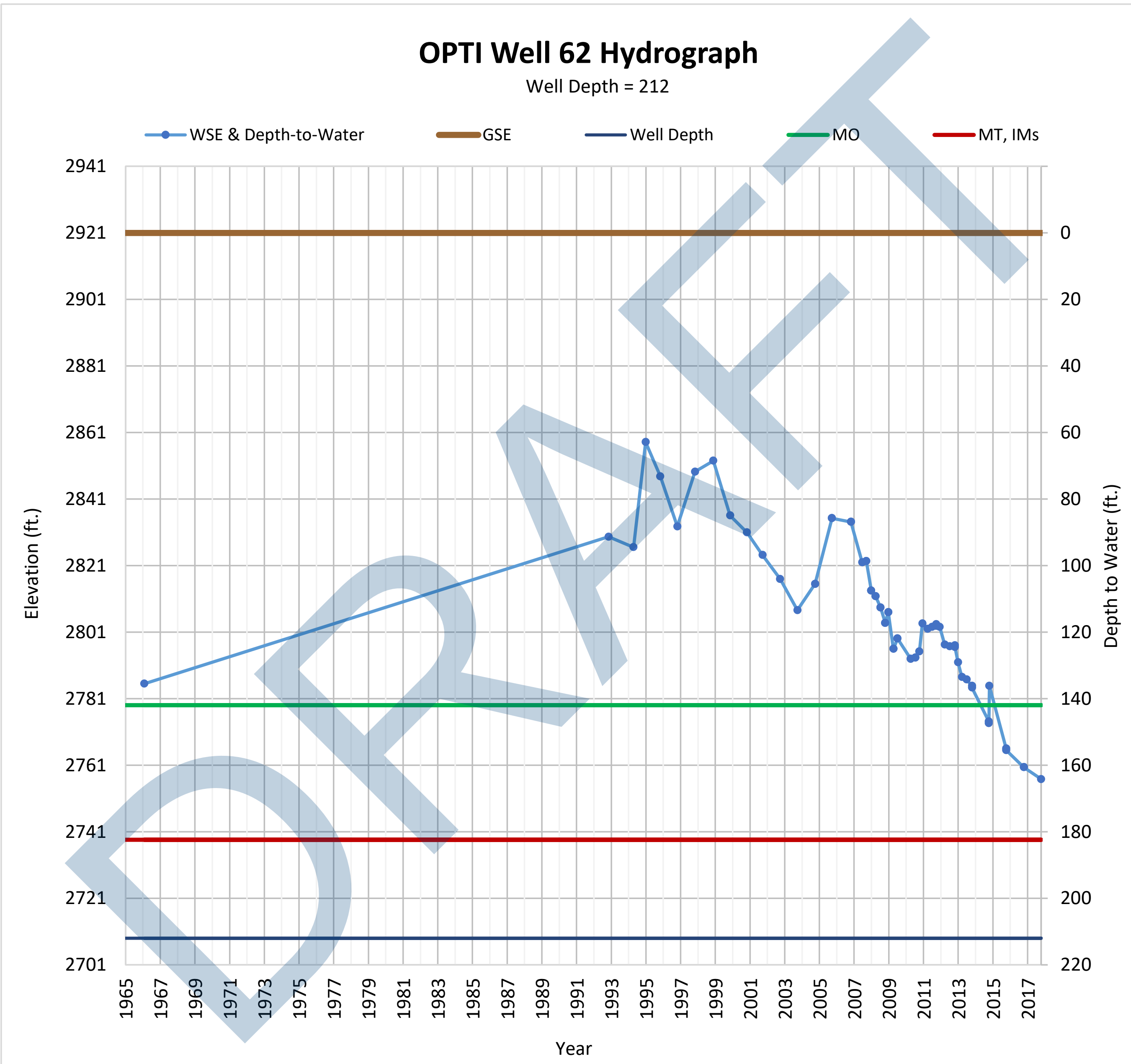
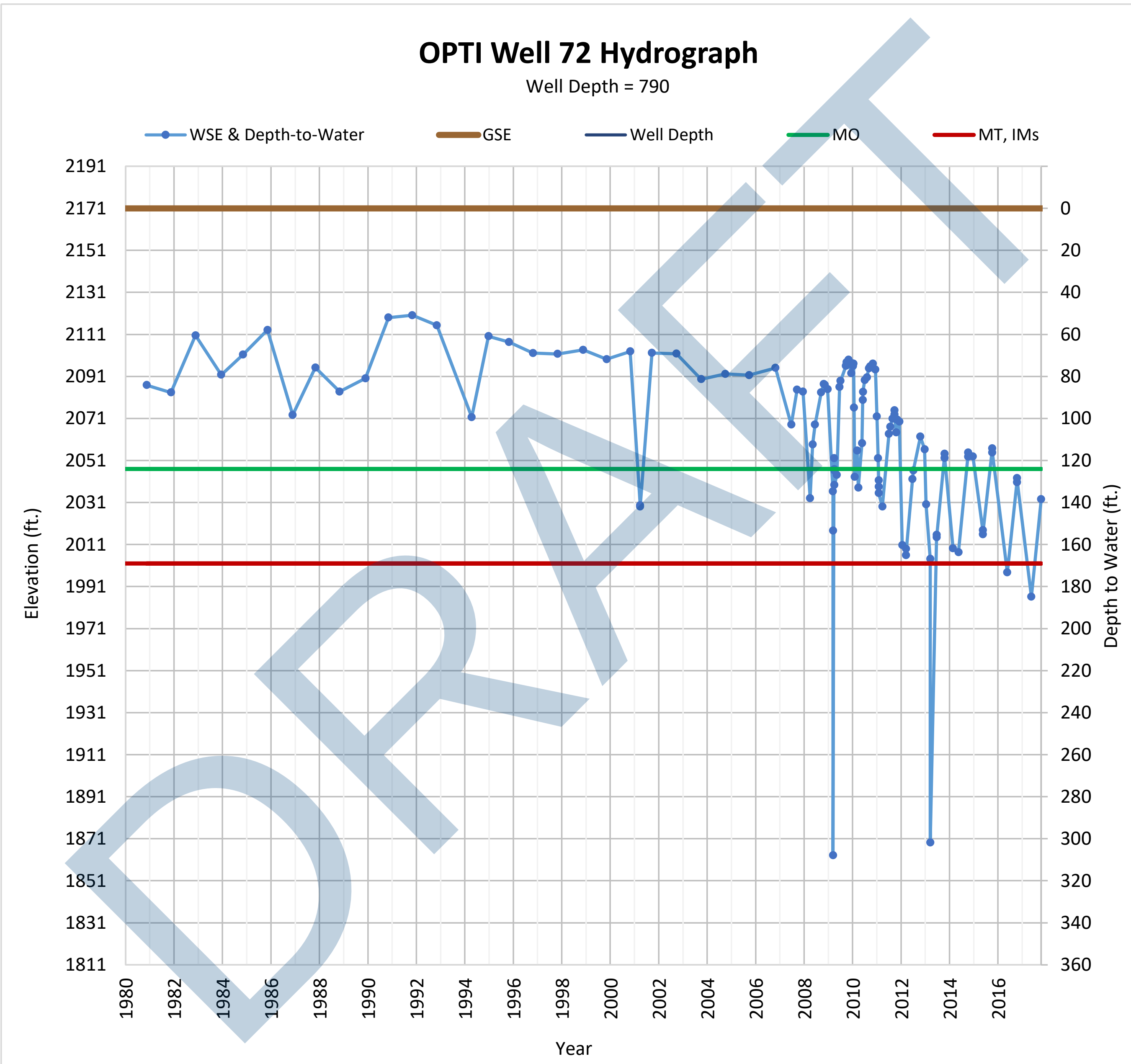
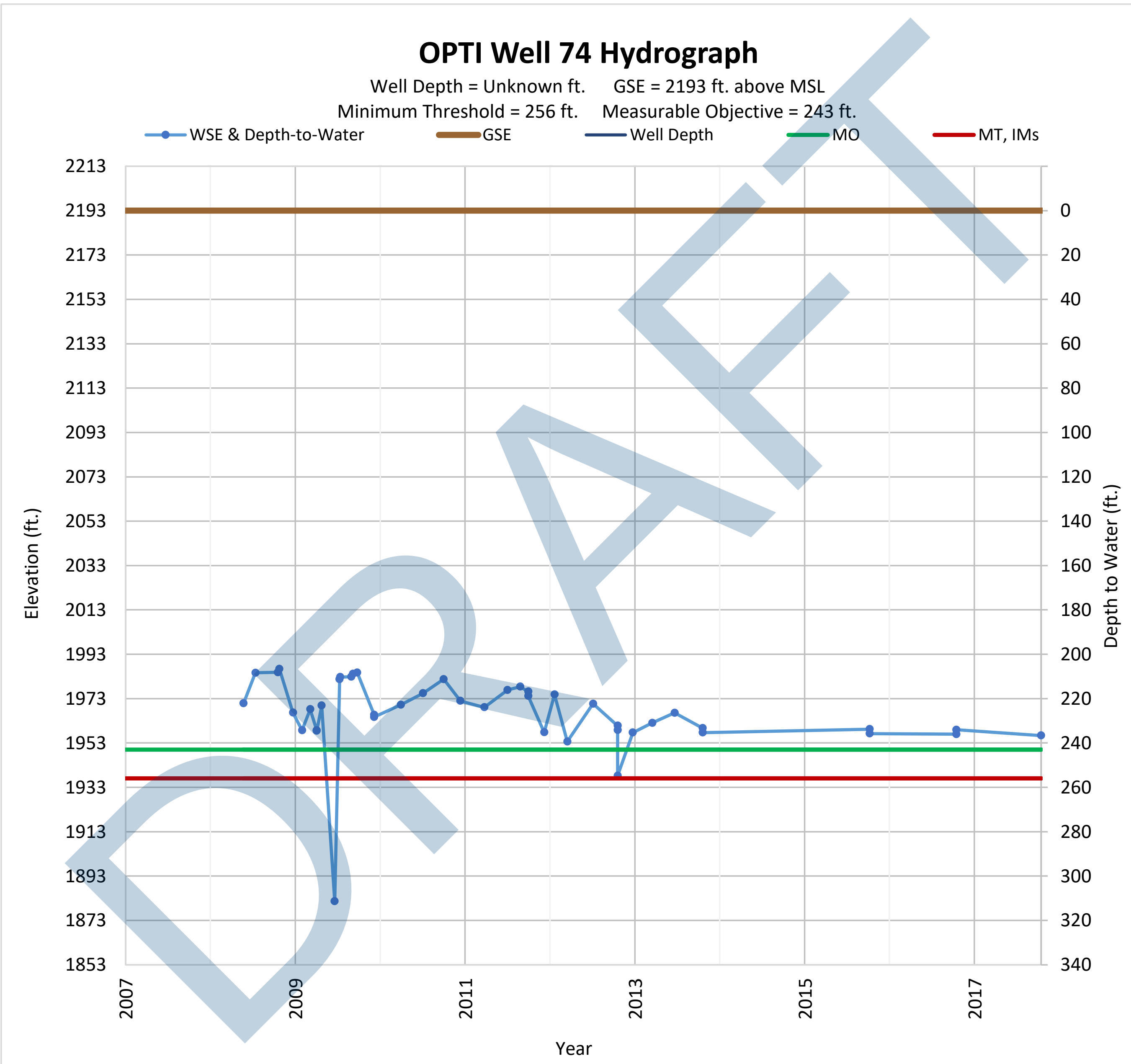

OPTI Well 2 Hydrograph
Well Depth = 73
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
3740
3720
3700
3680
3660
3640
3620
Elevation (ft.)
0
20
40
60
80
100
Depth to Water (ft.)
2010
2012
2014
2016
Year

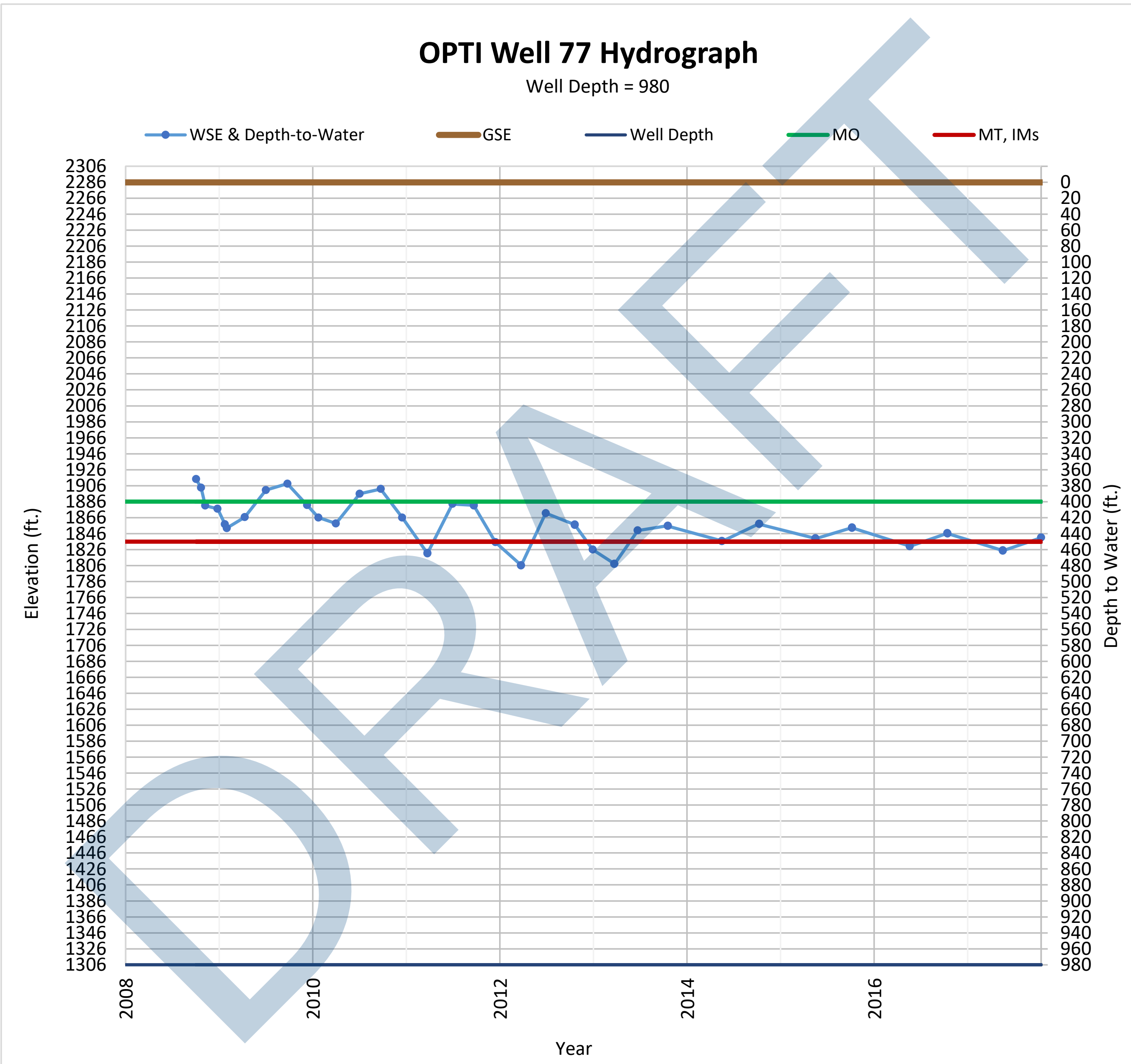


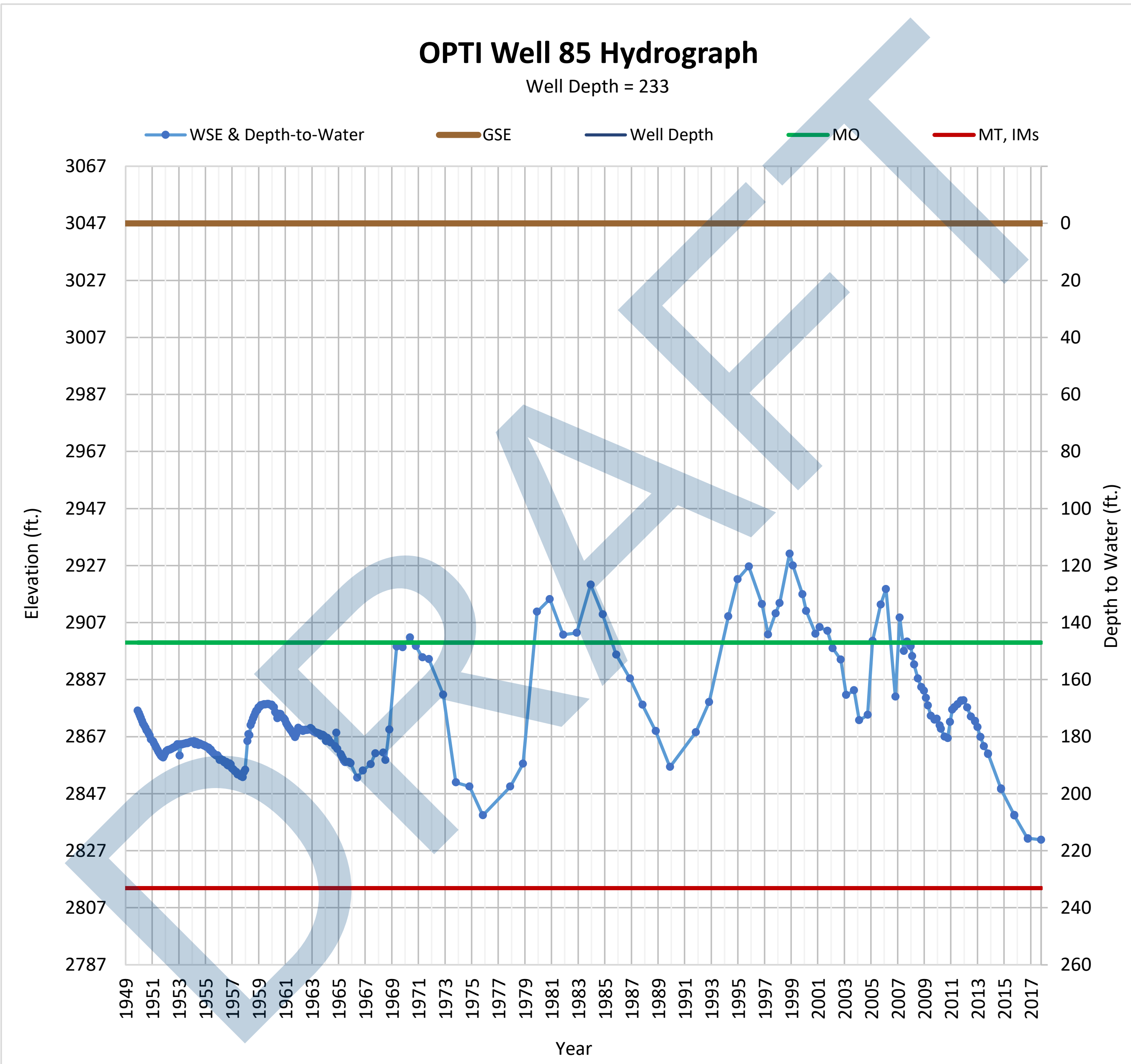
OPTI Well 62 Hydrograph
Well Depth = 212
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT



OPTI Well 72 Hydrograph
Well Depth = 790
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
Year
2191
2171
2151
2131
2111
2091
2071
2051
2031
2011
1991
1971
1951
1931
1911
1891
1871
1851
1831
1811
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
DRAFT


OPTI Well 74 Hydrograph
Well Depth = Unknown ft.
GSE = 2193 ft. above MSL
Minimum Threshold = 256 ft.
Measurable Objective = 243 ft.
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT


OPTI Well 77 Hydrograph
Well Depth = 980
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
Year
2008
2010
2012
2014
2016
DRAFT


OPTI Well 85 Hydrograph
Well Depth = 233
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
3067
3047
3027
3007
2987
2967
2947
2927
2907
2887
2867
2847
2827
2807
2787
Depth to Water (ft.)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
Year
1949
1951
1953
1955
1957
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
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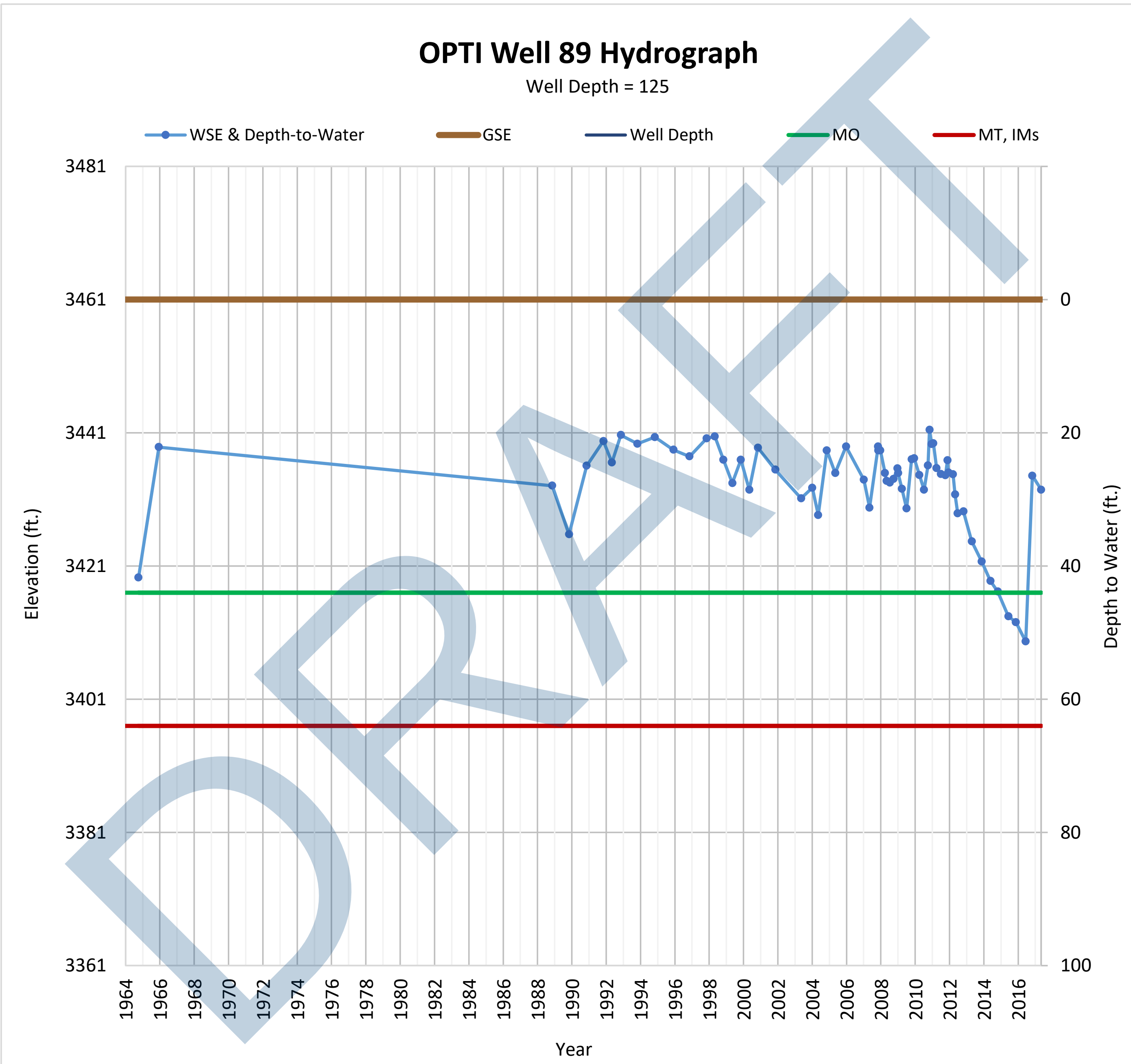
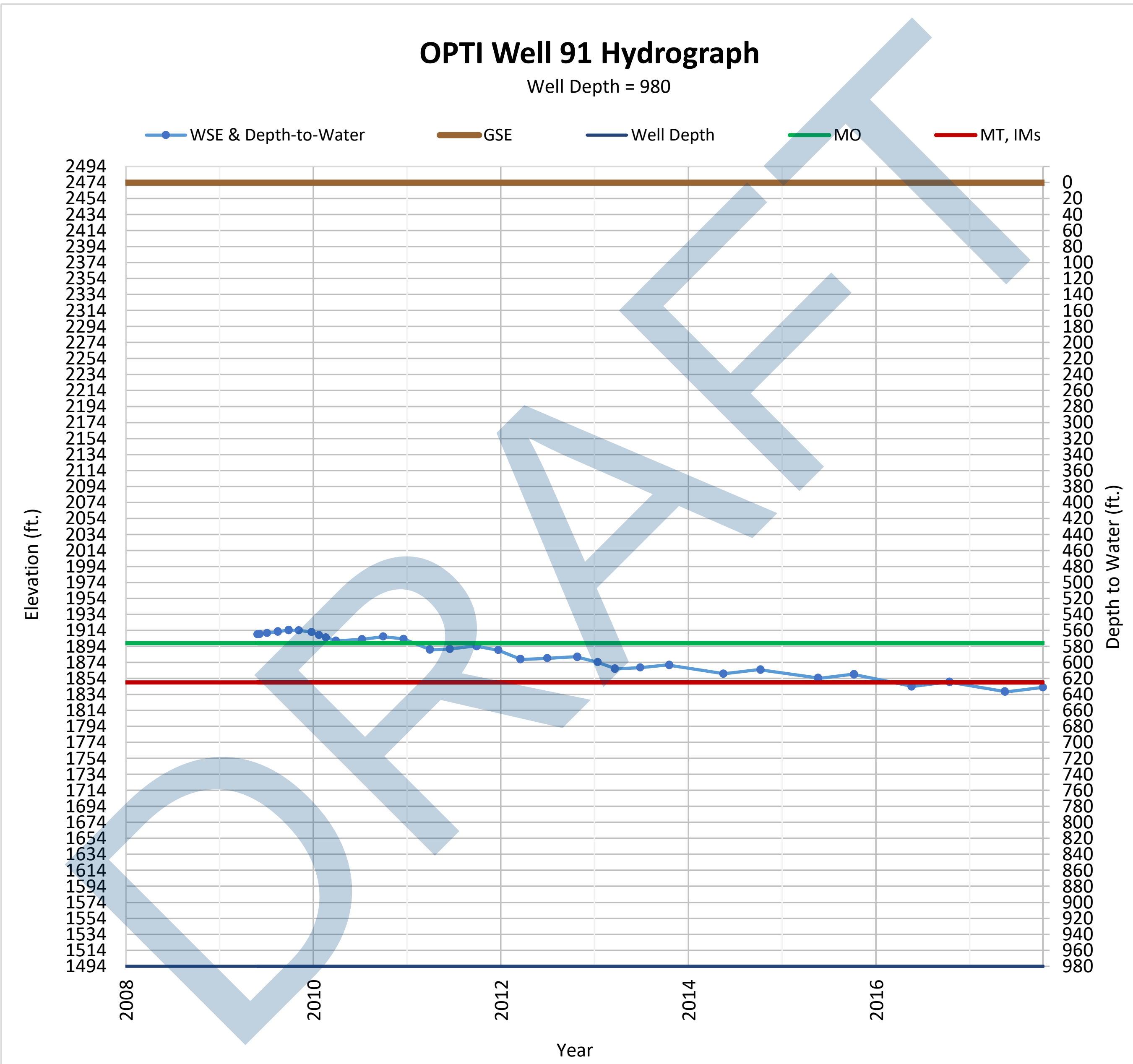
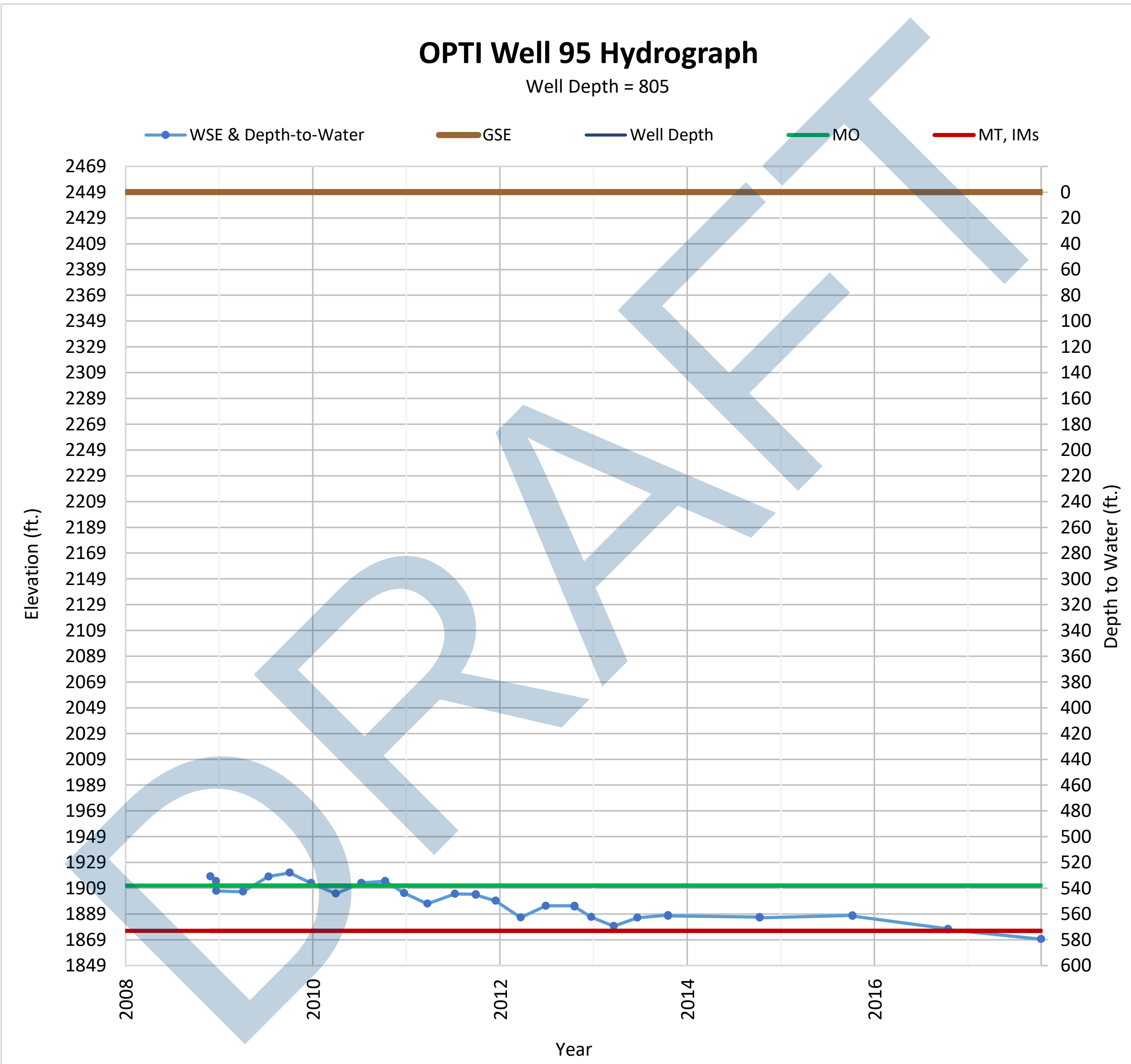
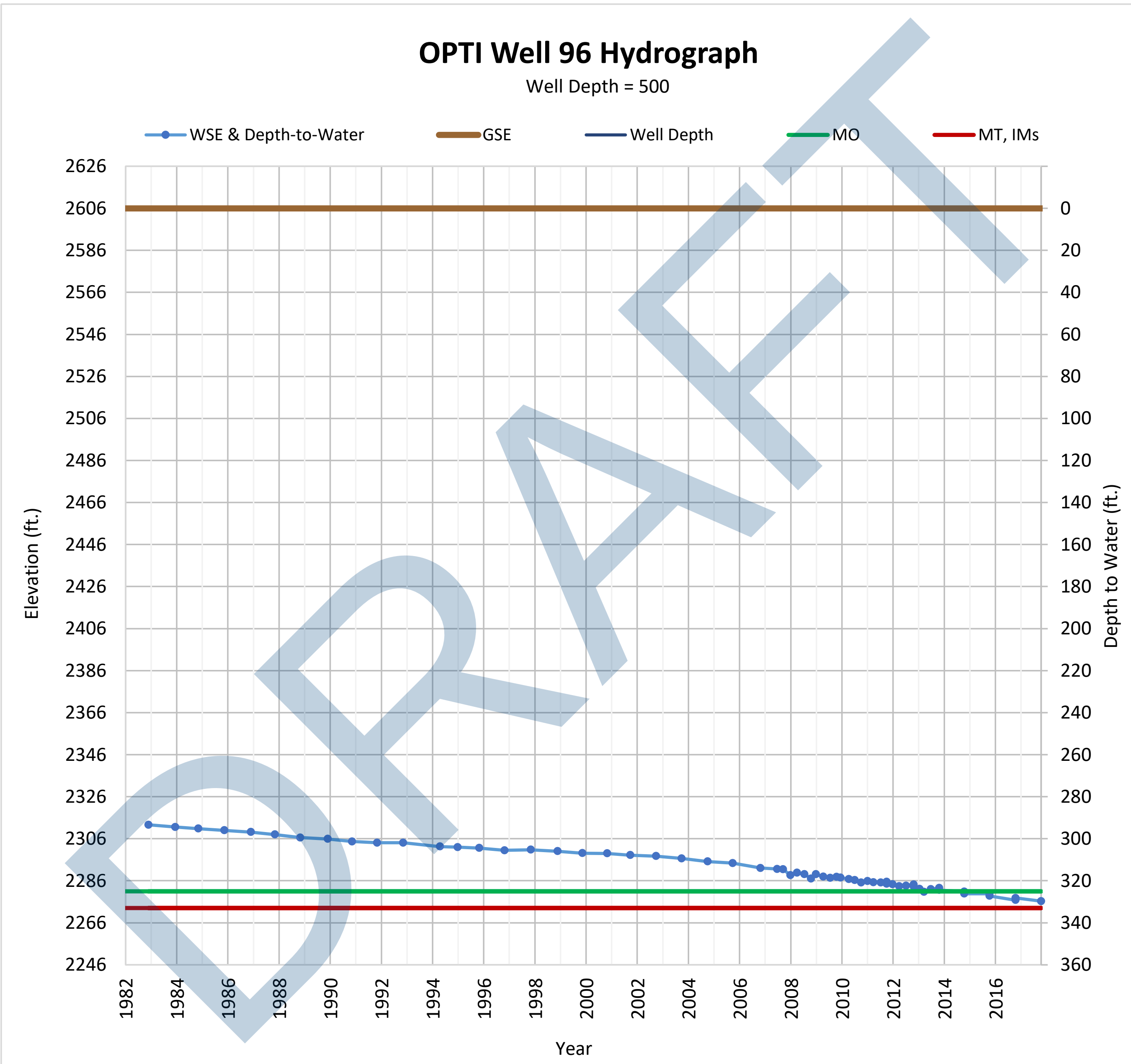

OPTI Well 89 Hydrograph
Well Depth = 125
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
3481
3461
3441
3421
3401
3381
3361
0
20
40
60
80
100
Elevation (ft.)
Depth to Water (ft.)
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Year
DRAFT

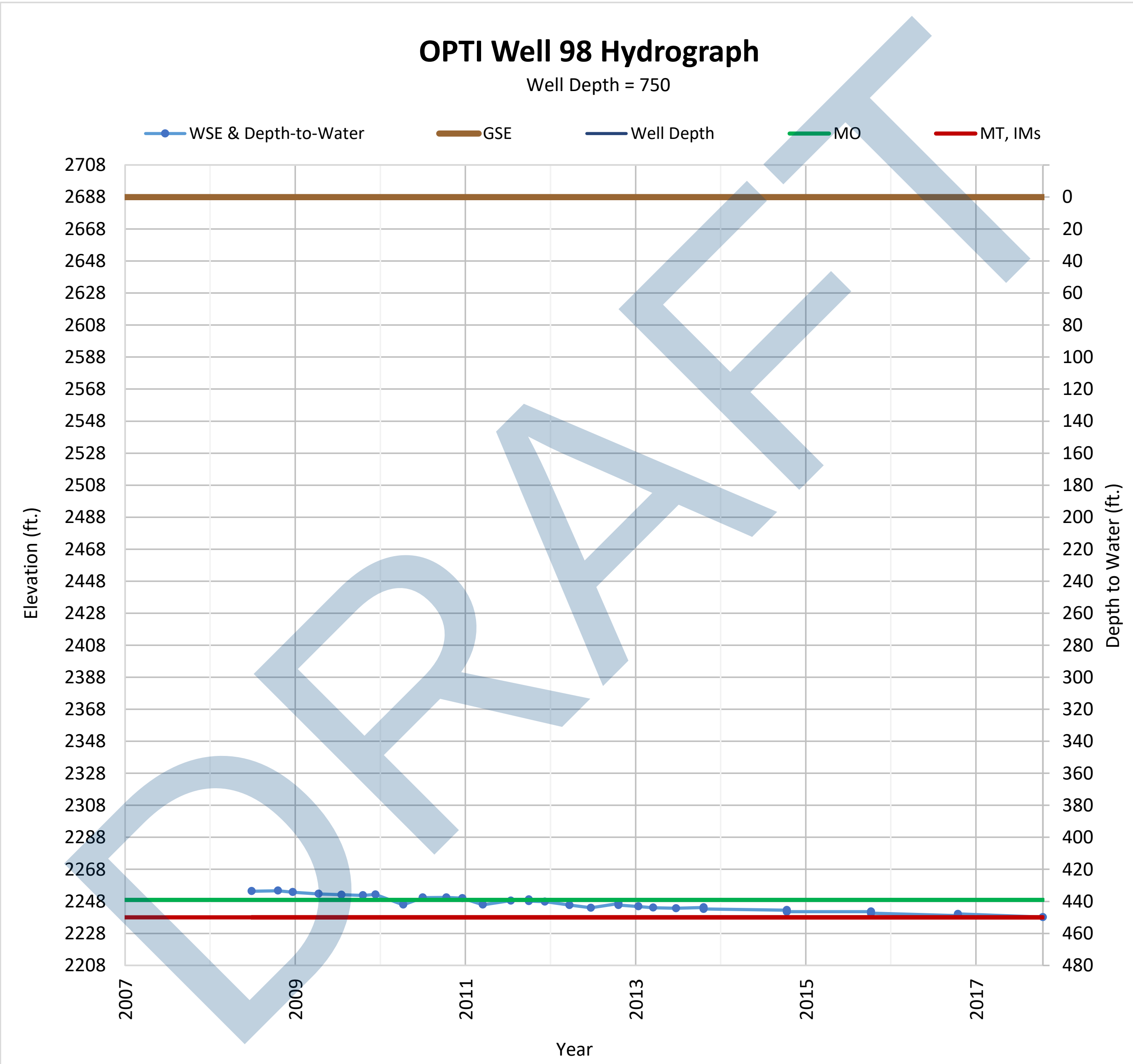

OPTI Well 91 Hydrograph
Well Depth = 980
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
Year
2008
2010
2012
2014
2016
DRAFT



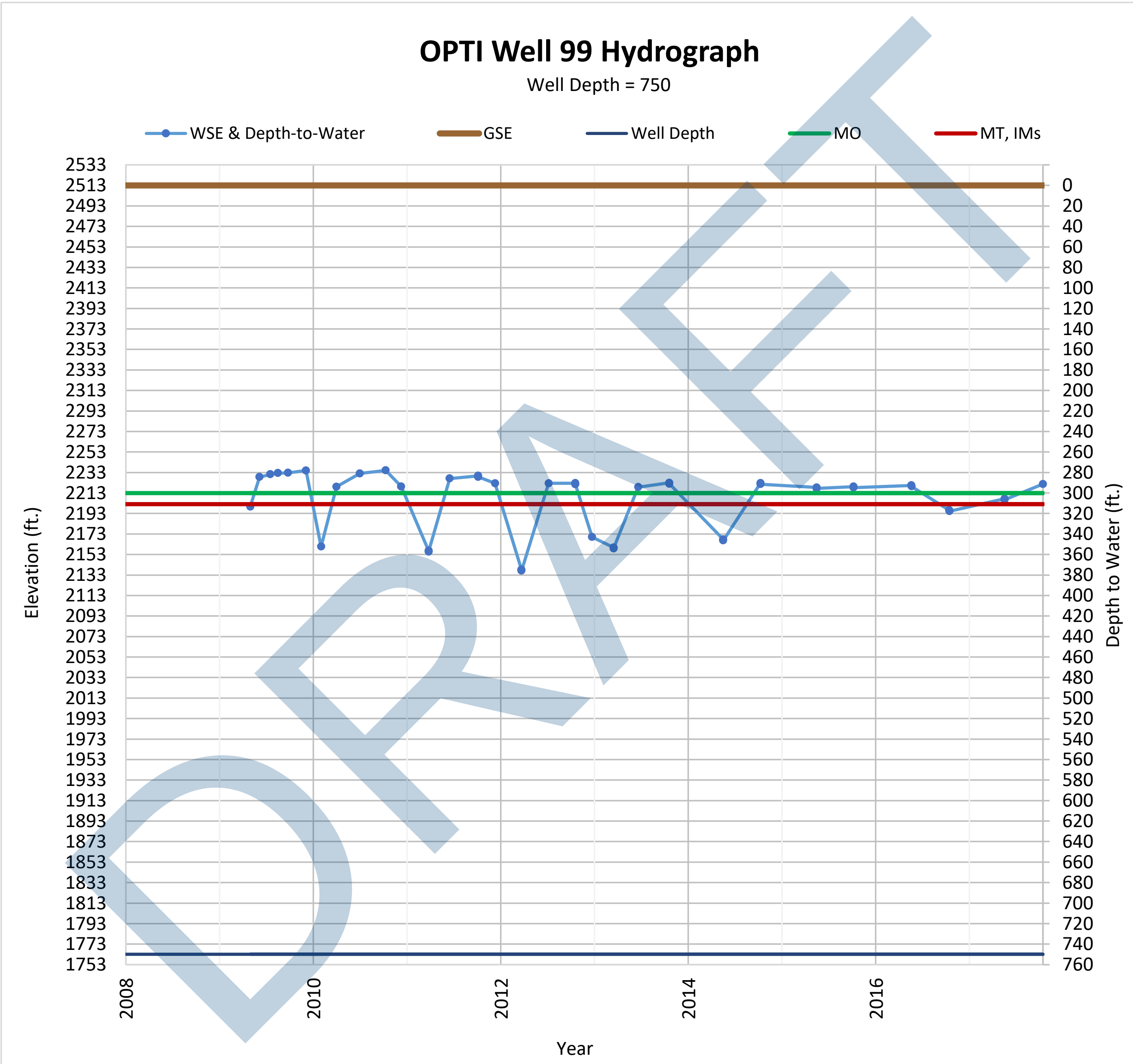
OPTI Well 95 Hydrograph
Well Depth = 805
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
2469
2449
2429
2409
2389
2369
2349
2329
2309
2289
2269
2249
2229
2209
2189
2169
2149
2129
2109
2089
2069
2049
2029
2009
1989
1969
1949
1929
1909
1889
1869
1849
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
2008
2010
2012
2014
2016
Year
DRAFT



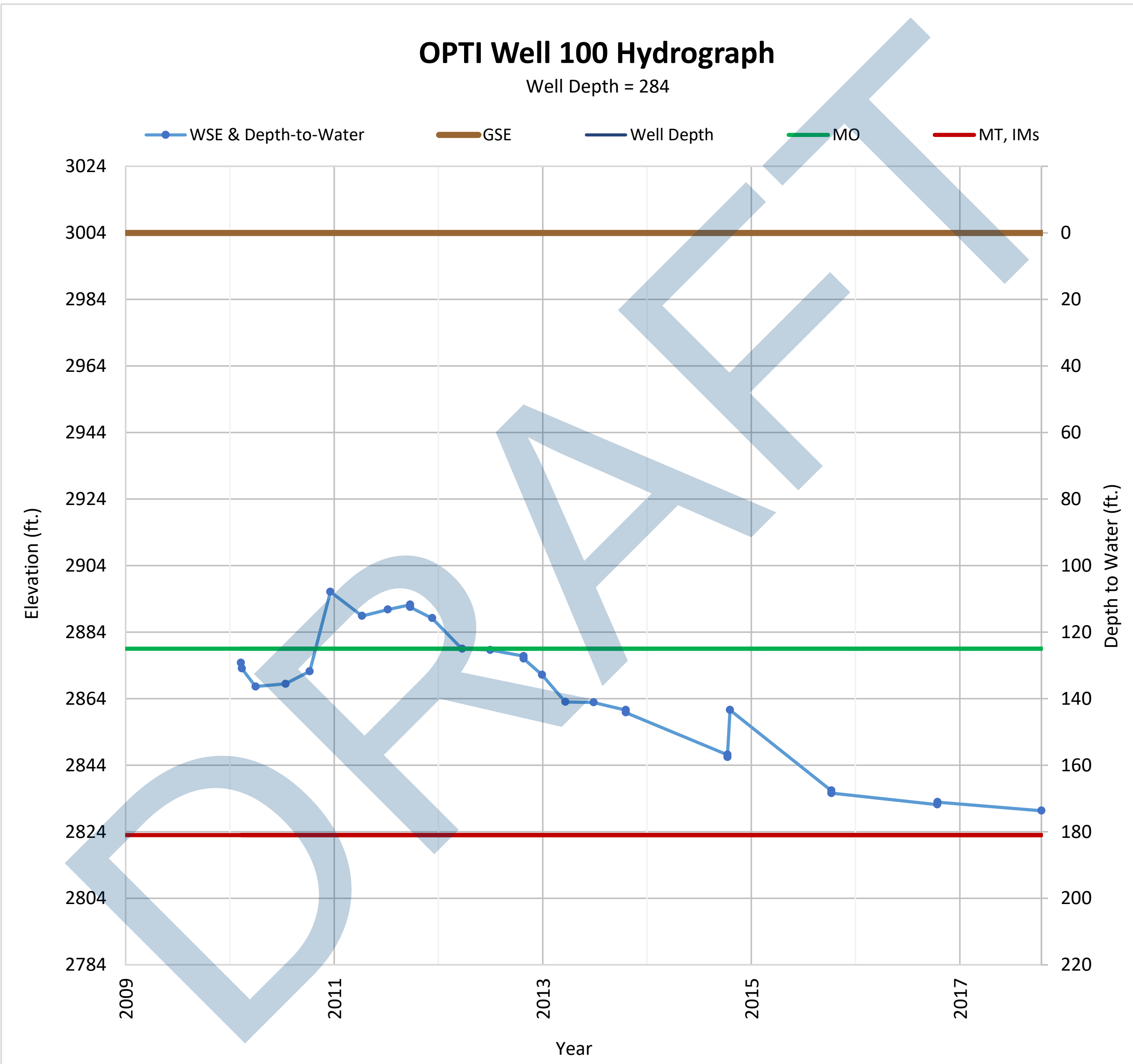
OPTI Well 96 Hydrograph
Well Depth = 500
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
Year
2626
2606
2586
2566
2546
2526
2506
2486
2466
2446
2426
2406
2386
2366
2346
2326
2306
2286
2266
2246
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
DRAFT



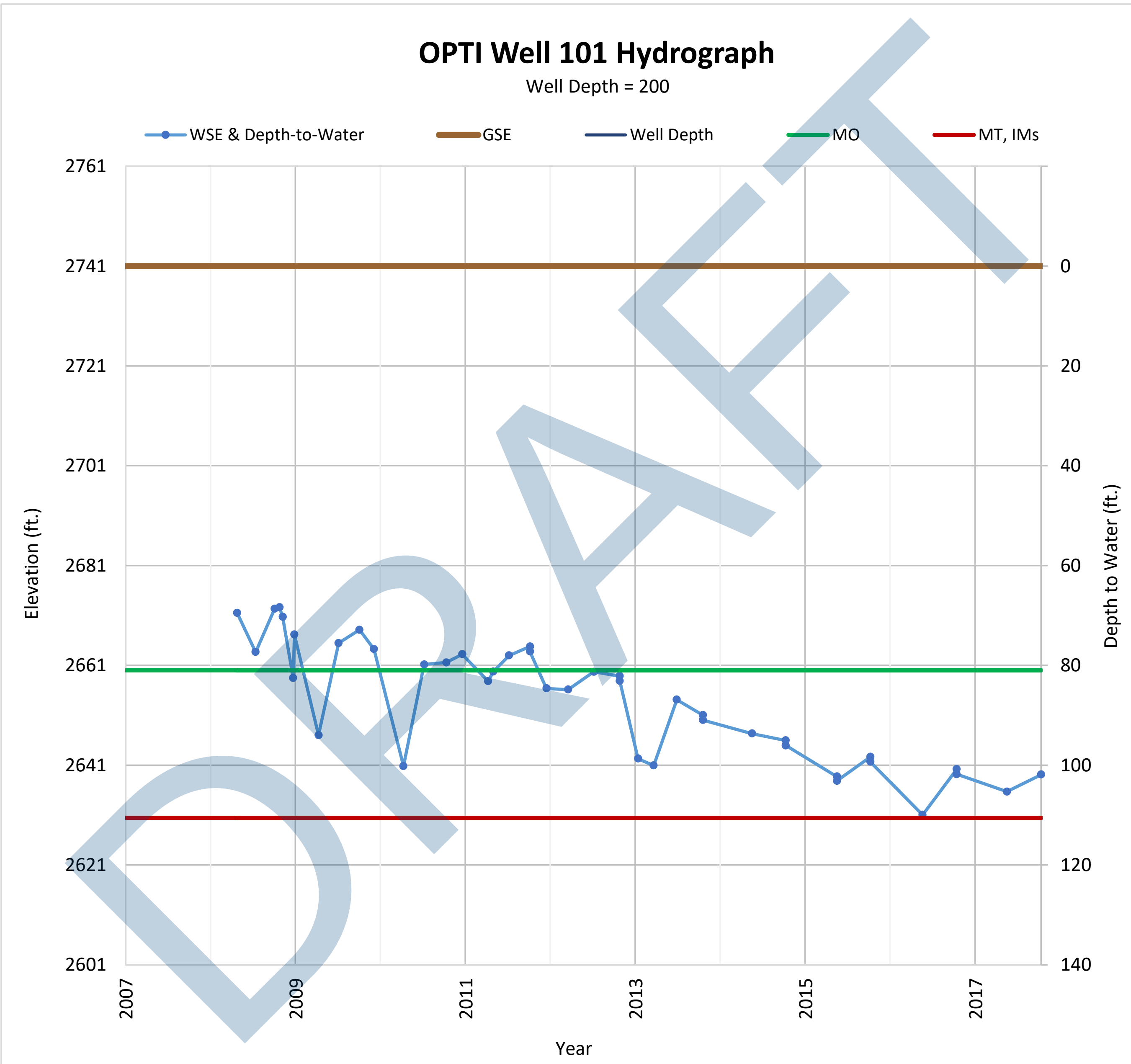
OPTI Well 98 Hydrograph
Well Depth = 750
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
Year
2708
2688
2668
2648
2628
2608
2588
2568
2548
2528
2508
2488
2468
2448
2428
2408
2388
2368
2348
2328
2308
2288
2268
2248
2228
2208
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
2007
2009
2011
2013
2015
2017
DRAFT



OPTI Well 99 Hydrograph
Well Depth = 750
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
Year
2008
2010
2012
2014
2016
DRAFT



OPTI Well 100 Hydrograph
Well Depth = 284
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
3024
3004
2984
2964
2944
2924
2904
2884
2864
2844
2824
2804
2784
Depth to Water (ft.)
0
20
40
60
80
100
120
140
160
180
200
220
2009
2011
2013
2015
2017
Year
DRAFT



OPTI Well 101 Hydrograph
Well Depth = 200
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
2761
2741
2721
2701
2681
2661
2641
2621
2601
0
20
40
60
80
100
120
140
2007
2009
2011
2013
2015
2017
Year
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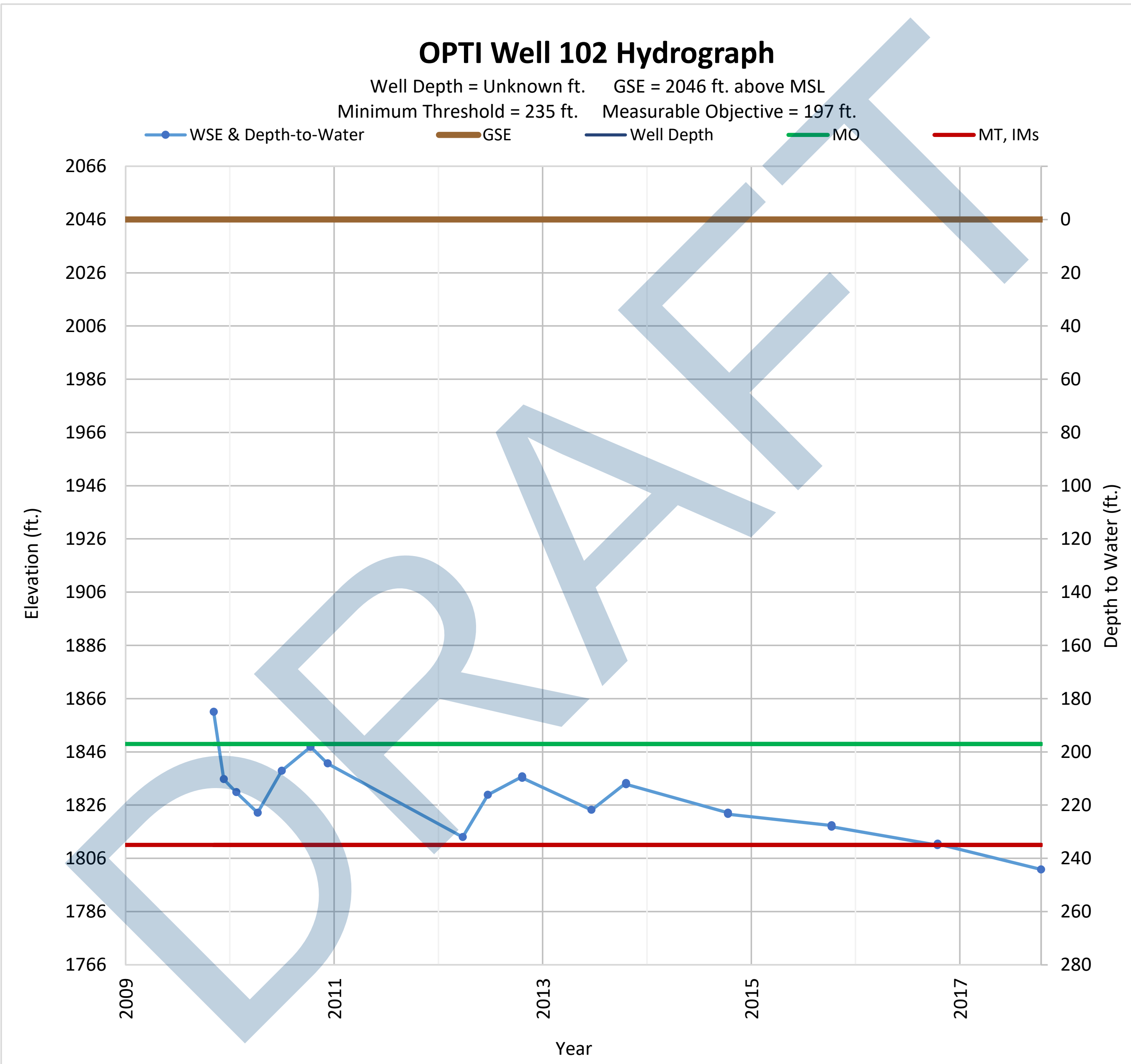
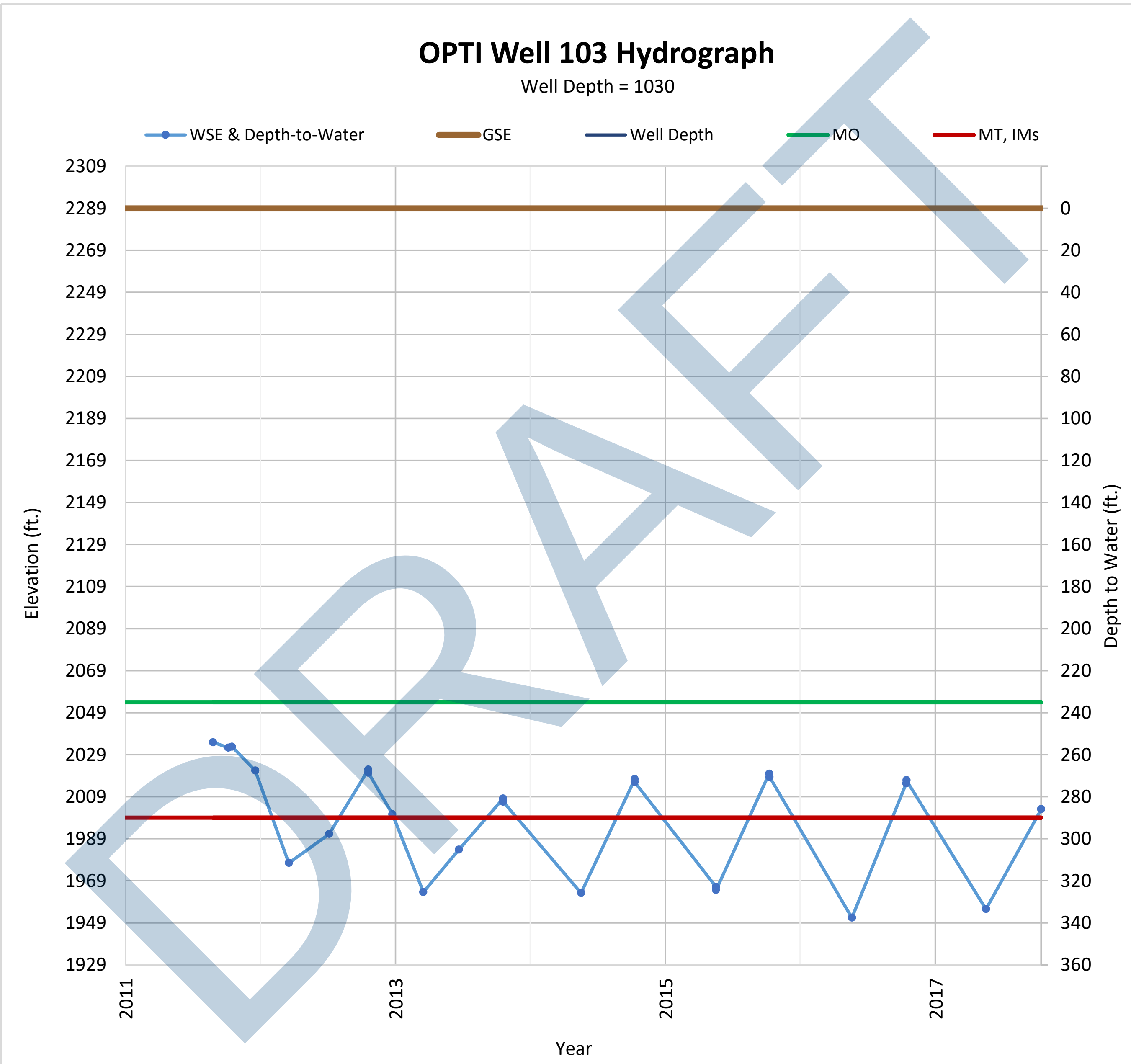
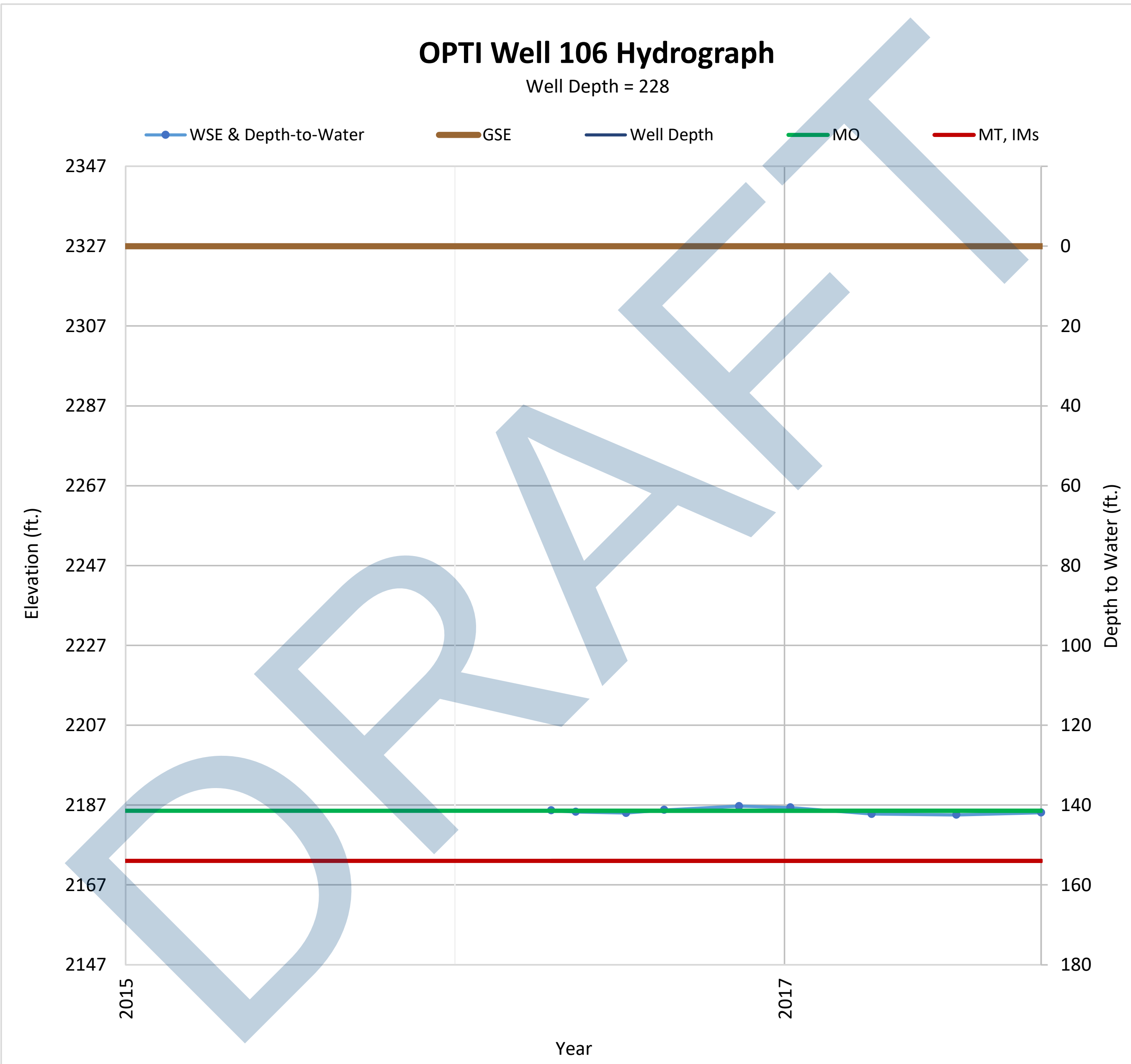


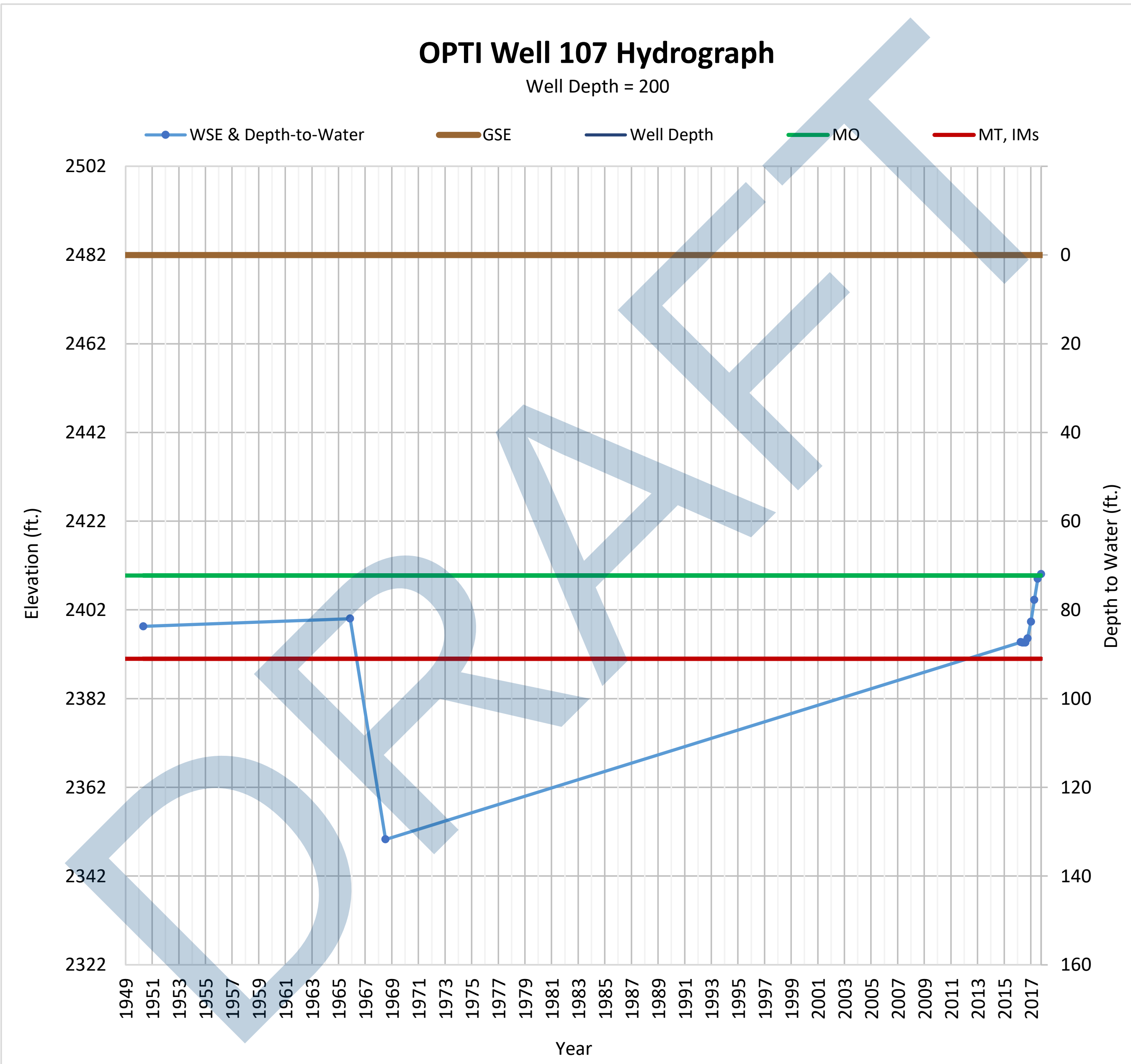
OPTI Well 102 Hydrograph
Well Depth = Unknown ft.
GSE = 2046 ft. above MSL
Minimum Threshold = 235 ft.
Measurable Objective = 197 ft.
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
Year
2066
2046
2026
2006
1986
1966
1946
1926
1906
1886
1866
1846
1826
1806
1786
1766
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
2009
2011
2013
2015
2017
DRAFT



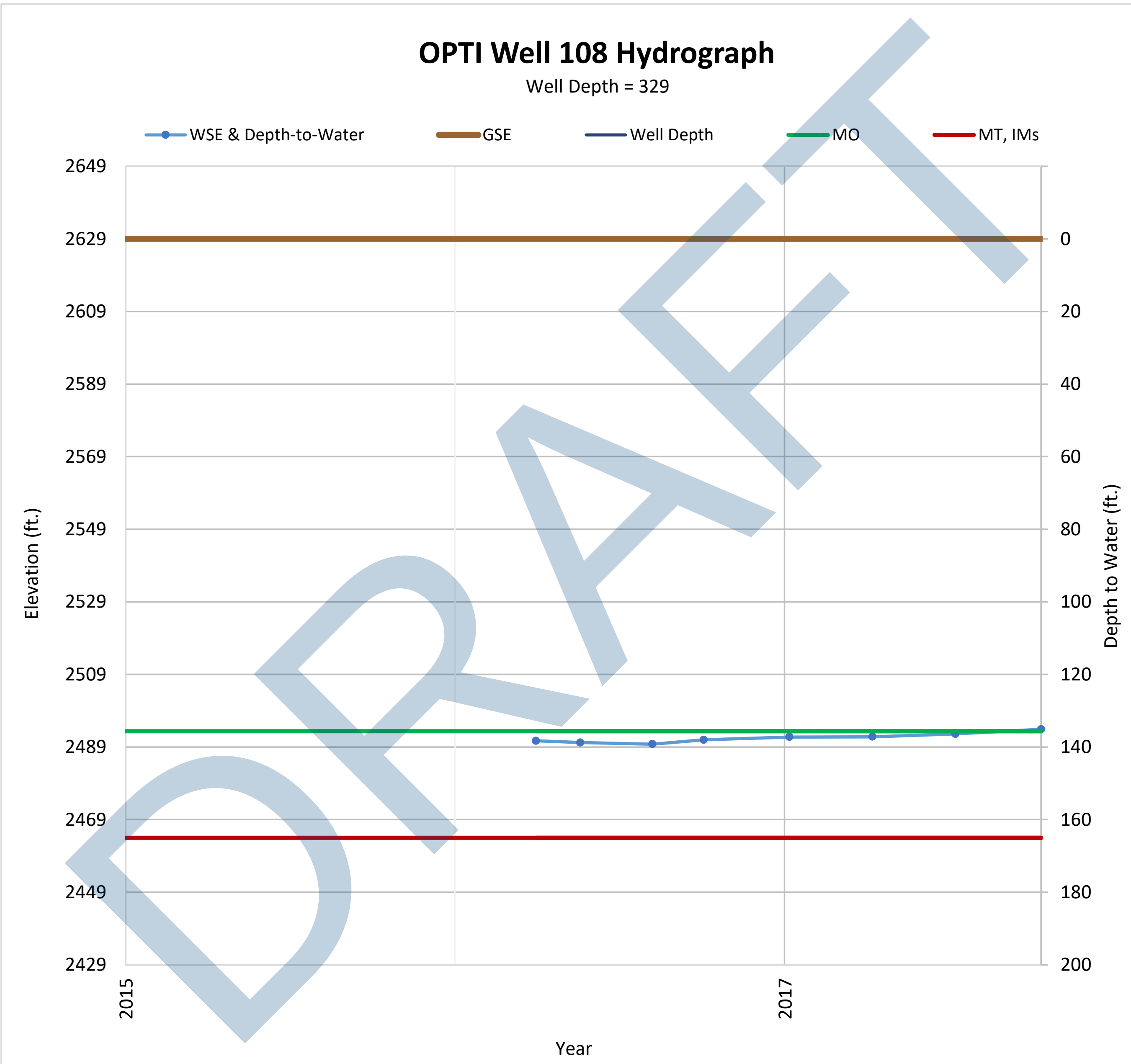
OPTI Well 103 Hydrograph
Well Depth = 1030
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
2309
2289
2269
2249
2229
2209
2189
2169
2149
2129
2109
2089
2069
2049
2029
2009
1989
1969
1949
1929
Depth to Water (ft.)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
2011
2013
2015
2017
Year
DRAFT



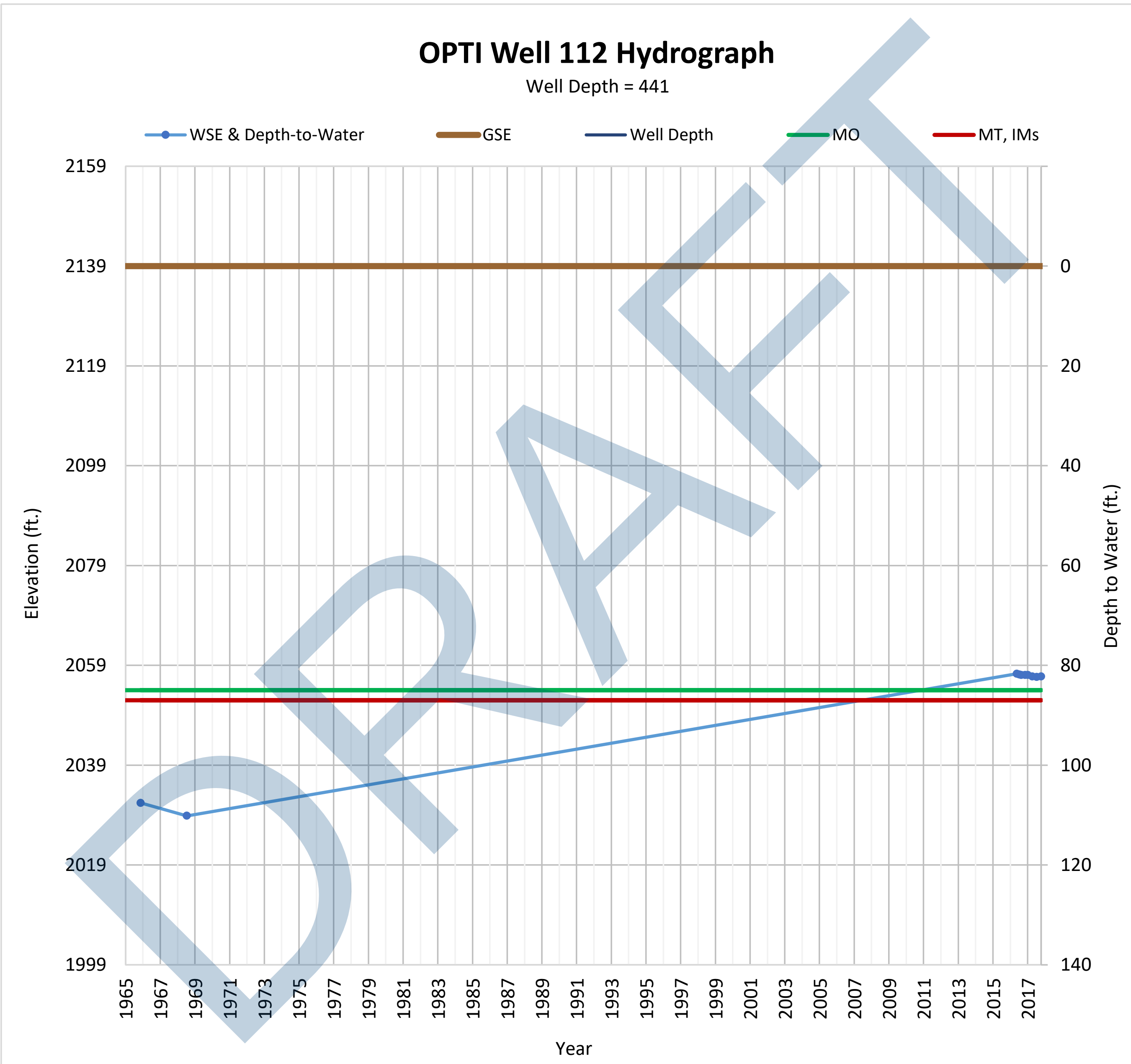
OPTI Well 106 Hydrograph
Well Depth = 228
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
2347
2327
2307
2287
2267
2247
2227
2207
2187
2167
2147
Elevation (ft.)
0
20
40
60
80
100
120
140
160
180
Depth to Water (ft.)
2015
2017
Year
DRAFT



OPTI Well 107 Hydrograph
Well Depth = 200
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
2502
2482
2462
2442
2422
2402
2382
2362
2342
2322
Depth to Water (ft.)
0
20
40
60
80
100
120
140
160
1949
1951
1953
1955
1957
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
Year
DRAFT



OPTI Well 108 Hydrograph
Well Depth = 329
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
2649
2629
2609
2589
2569
2549
2529
2509
2489
2469
2449
2429
Depth to Water (ft.)
0
20
40
60
80
100
120
140
160
180
200
2015
2017
Year
DRAFT



OPTI Well 112 Hydrograph
Well Depth = 441
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
Year
2159
2139
2119
2099
2079
2059
2039
2019
1999
0
20
40
60
80
100
120
140
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
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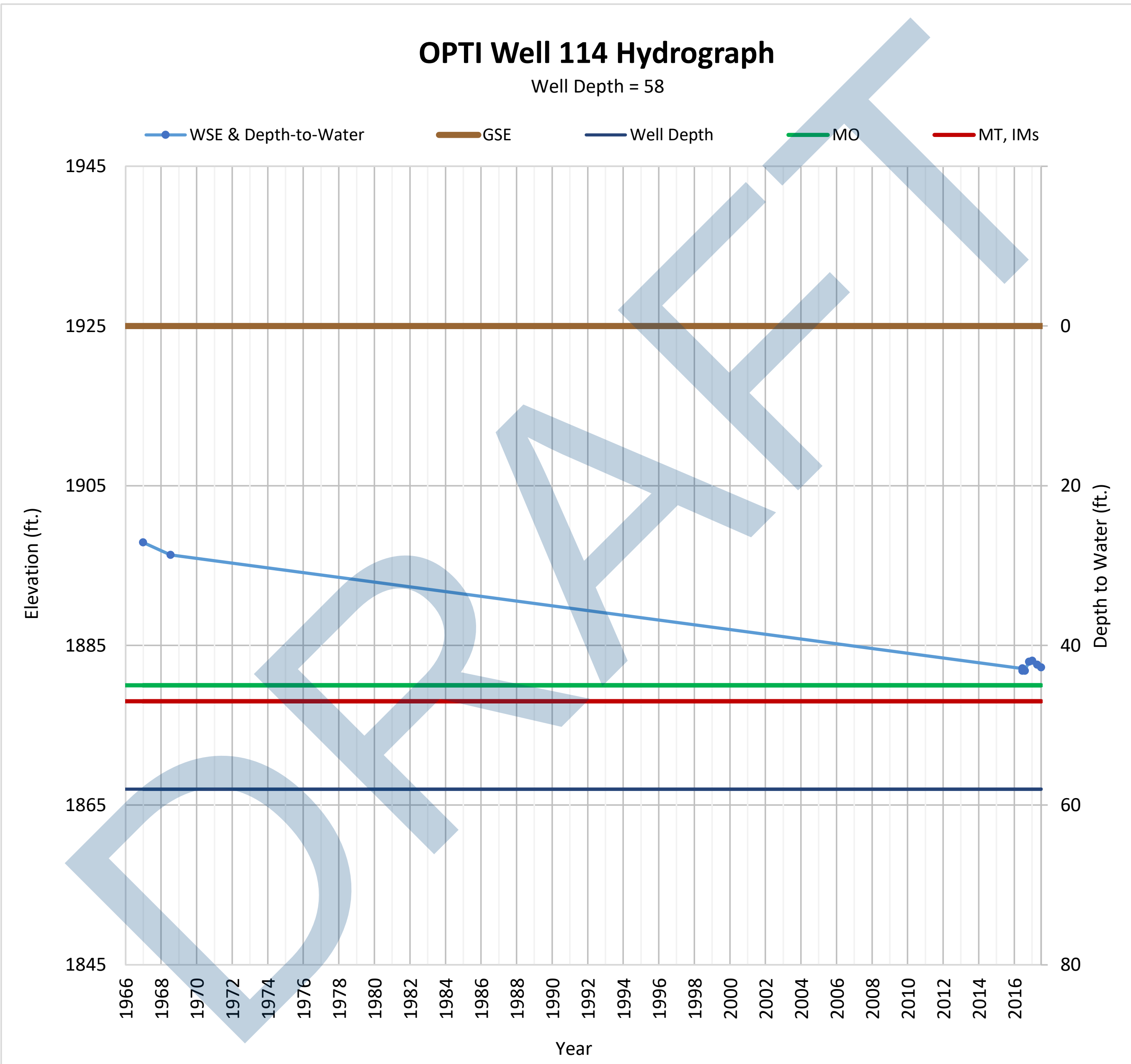
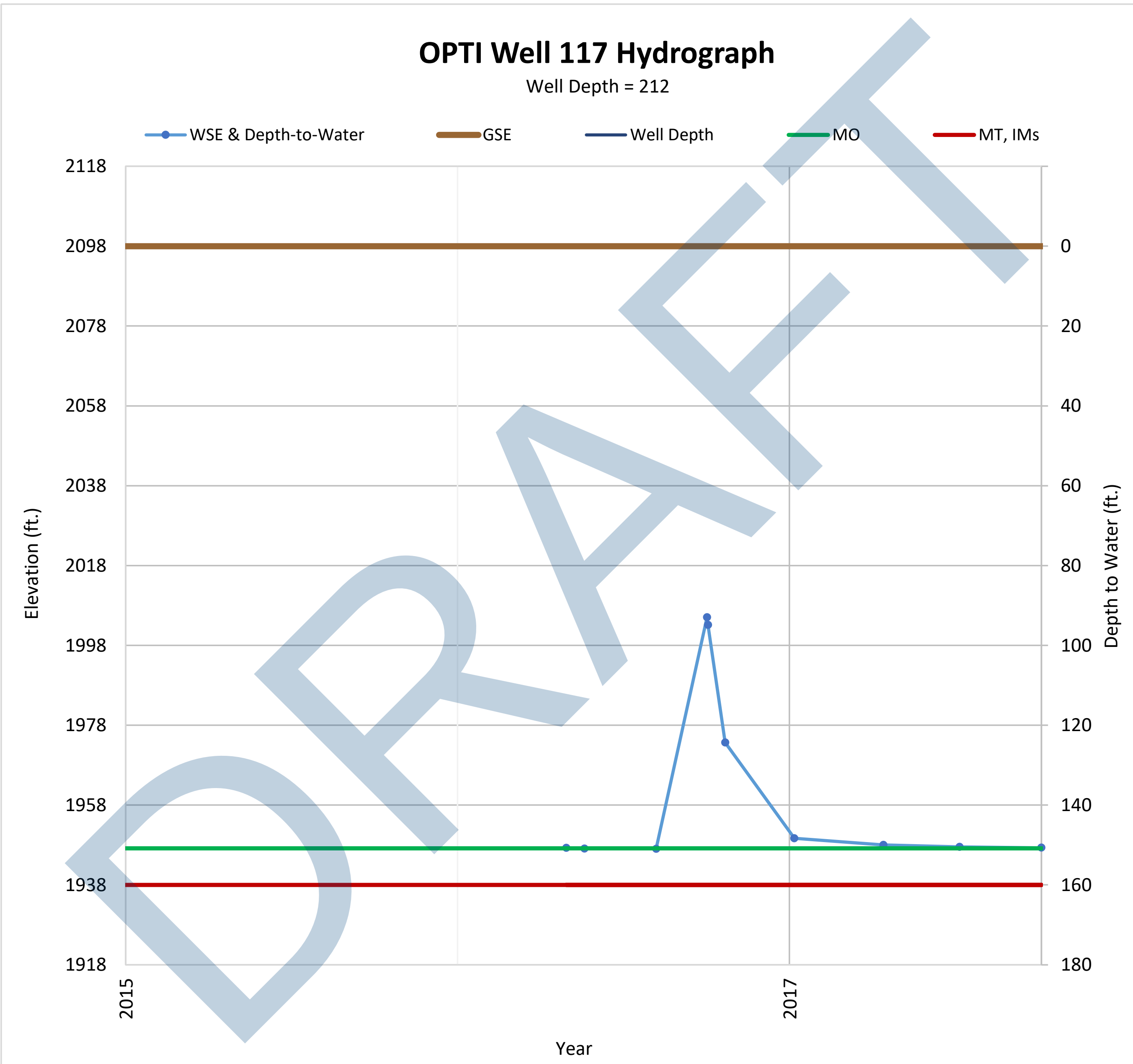
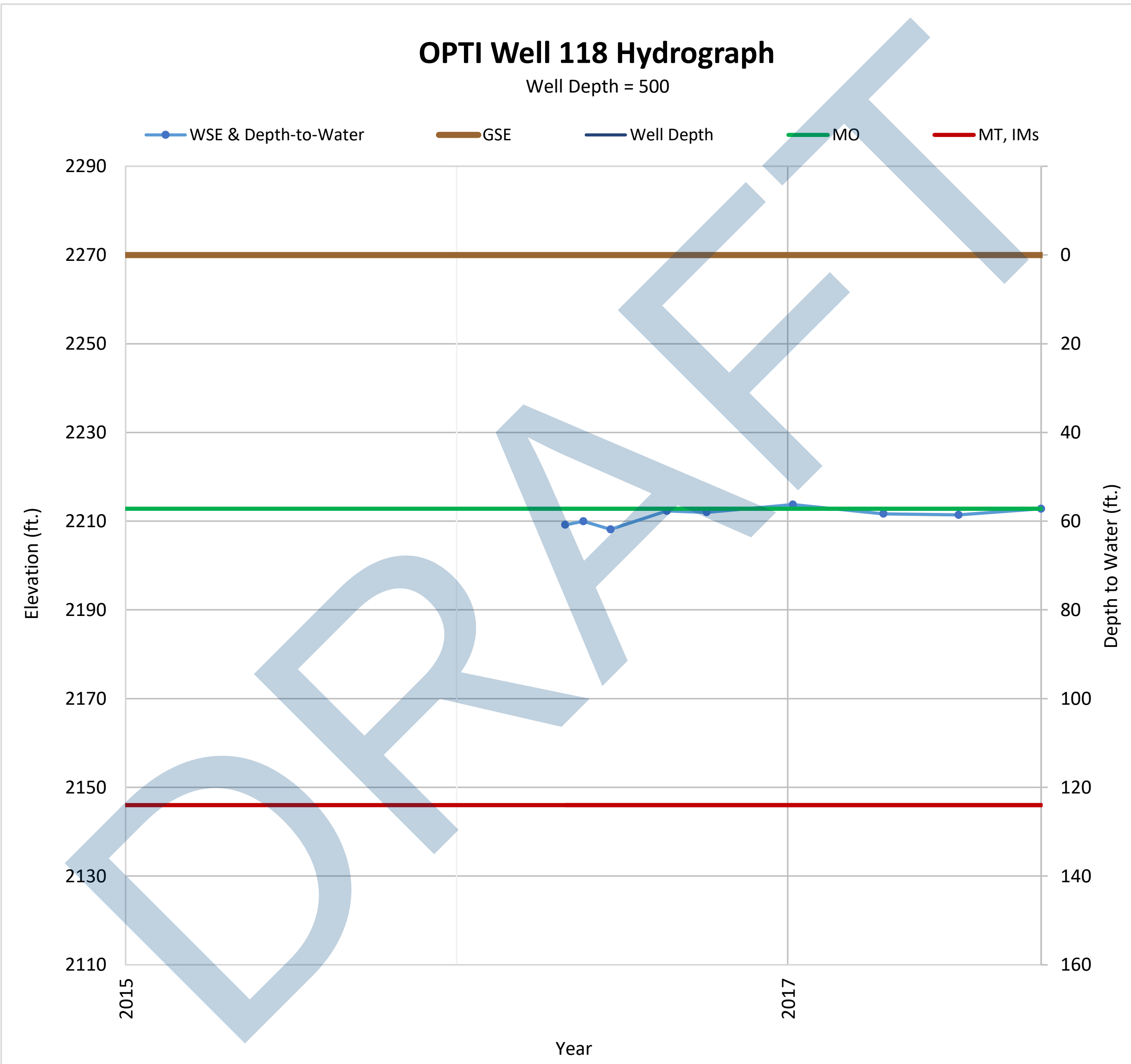
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
DRAFT



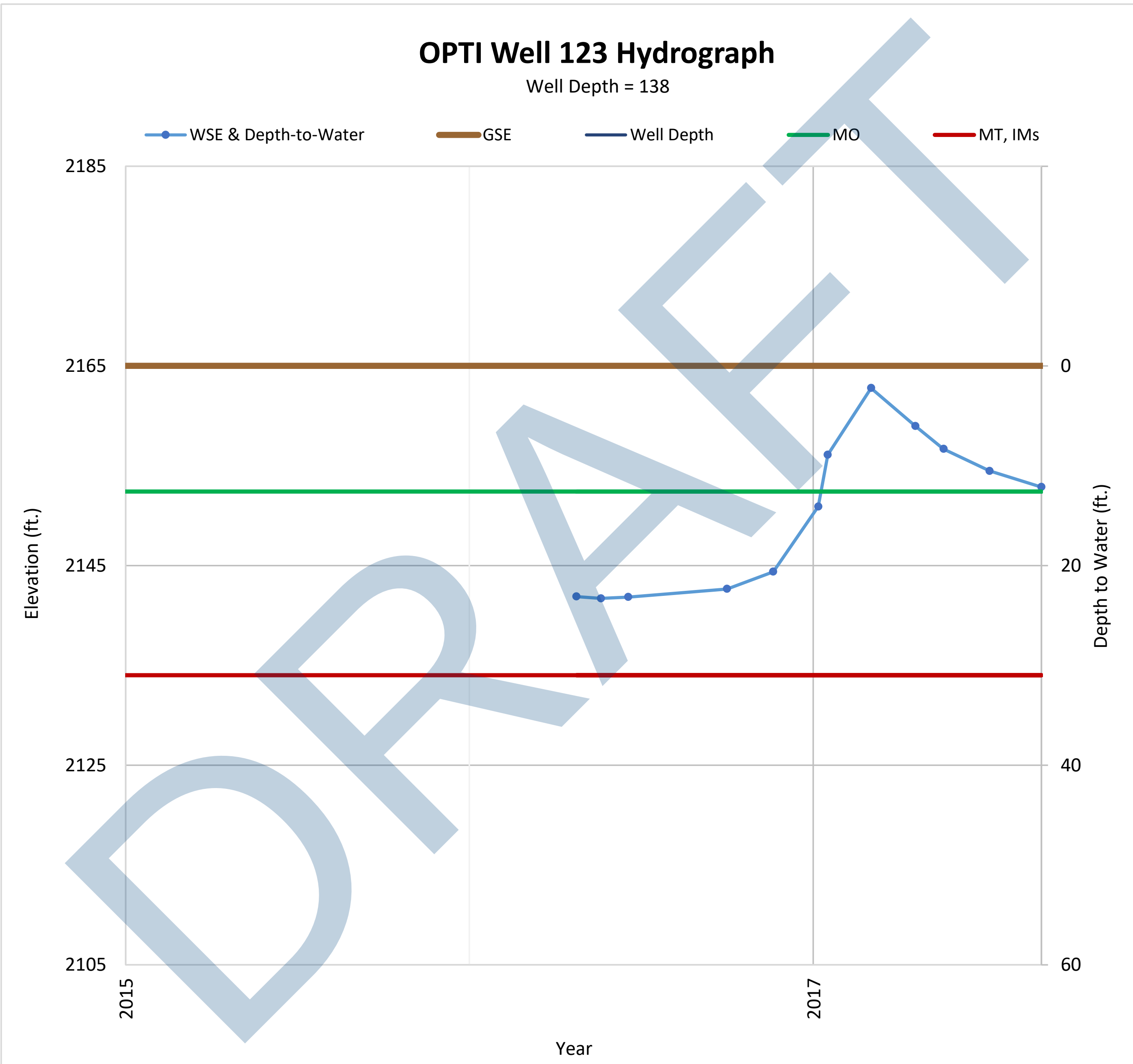
OPTI Well 114 Hydrograph
Well Depth = 58
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
1945
1925
1905
1885
1865
1845
0
20
40
60
80
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Year
DRAFT



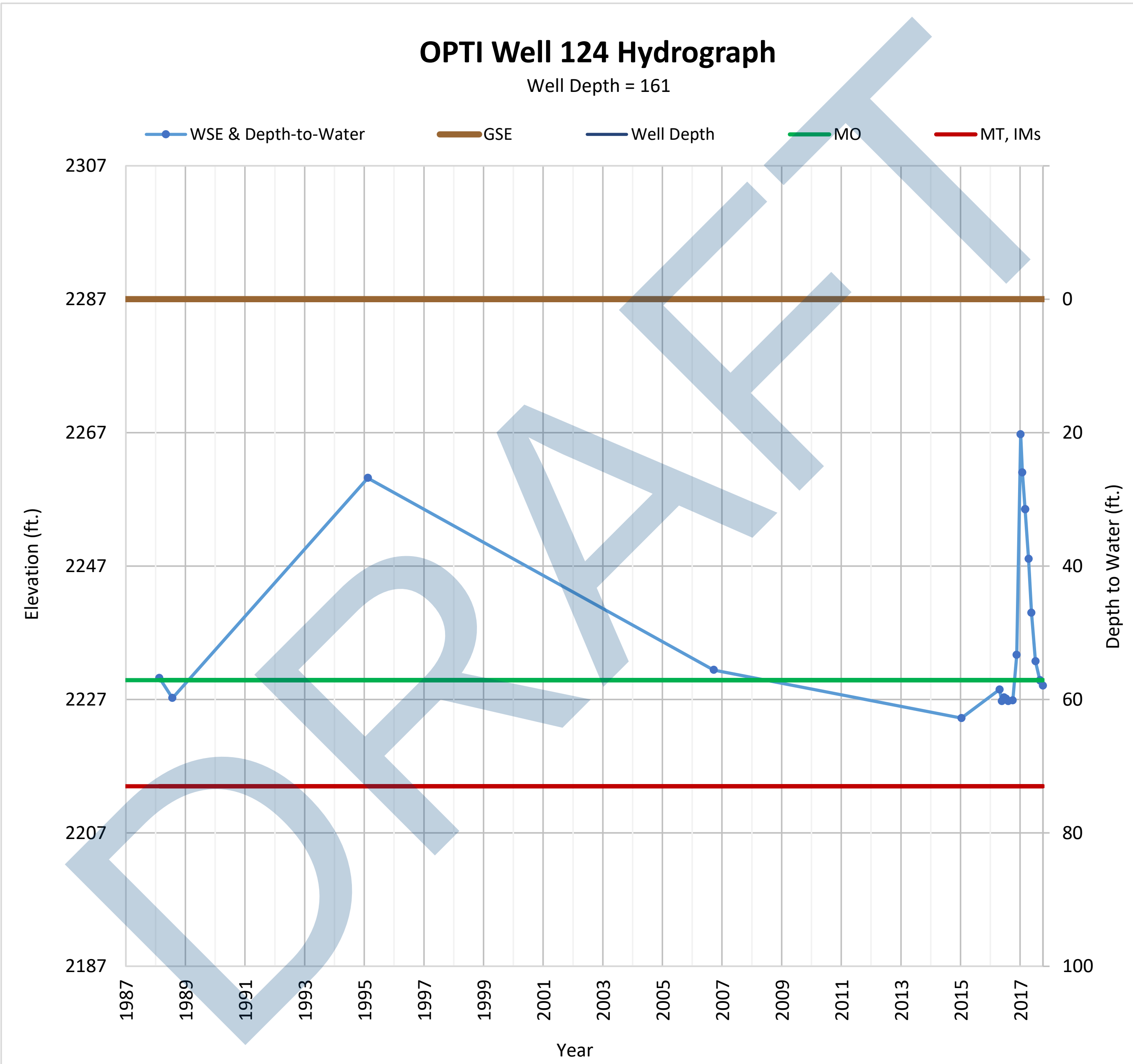
OPTI Well 117 Hydrograph
Well Depth = 212
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
2118
2098
2078
2058
2038
2018
1998
1978
1958
1938
1918
Elevation (ft.)
0
20
40
60
80
100
120
140
160
180
Depth to Water (ft.)
2015
2017
Year
DRAFT



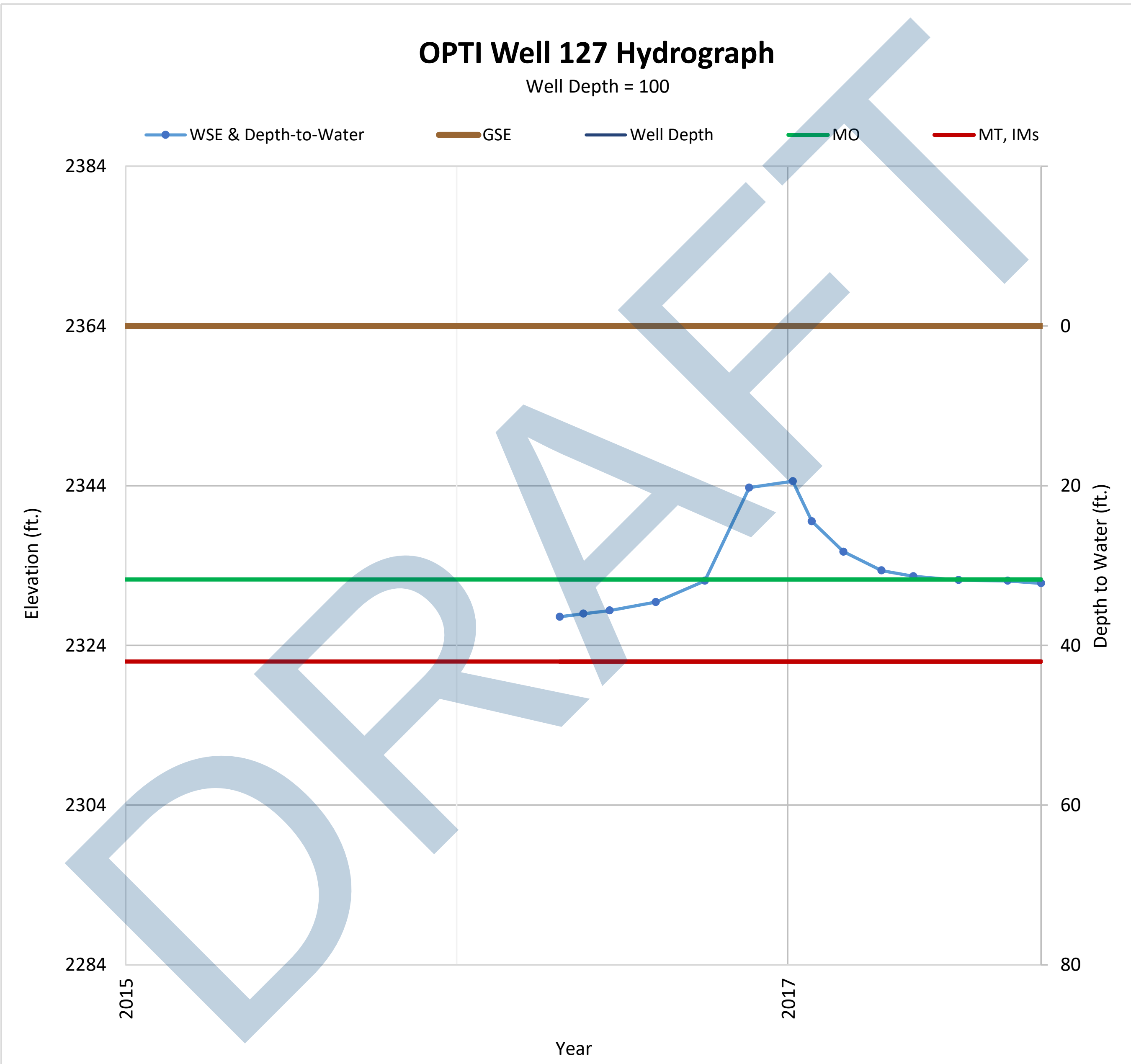
OPTI Well 118 Hydrograph
Well Depth = 500
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
2290
2270
2250
2230
2210
2190
2170
2150
2130
2110
0
20
40
60
80
100
120
140
160
Elevation (ft.)
Depth to Water (ft.)
2015
2017
Year
DRAFT

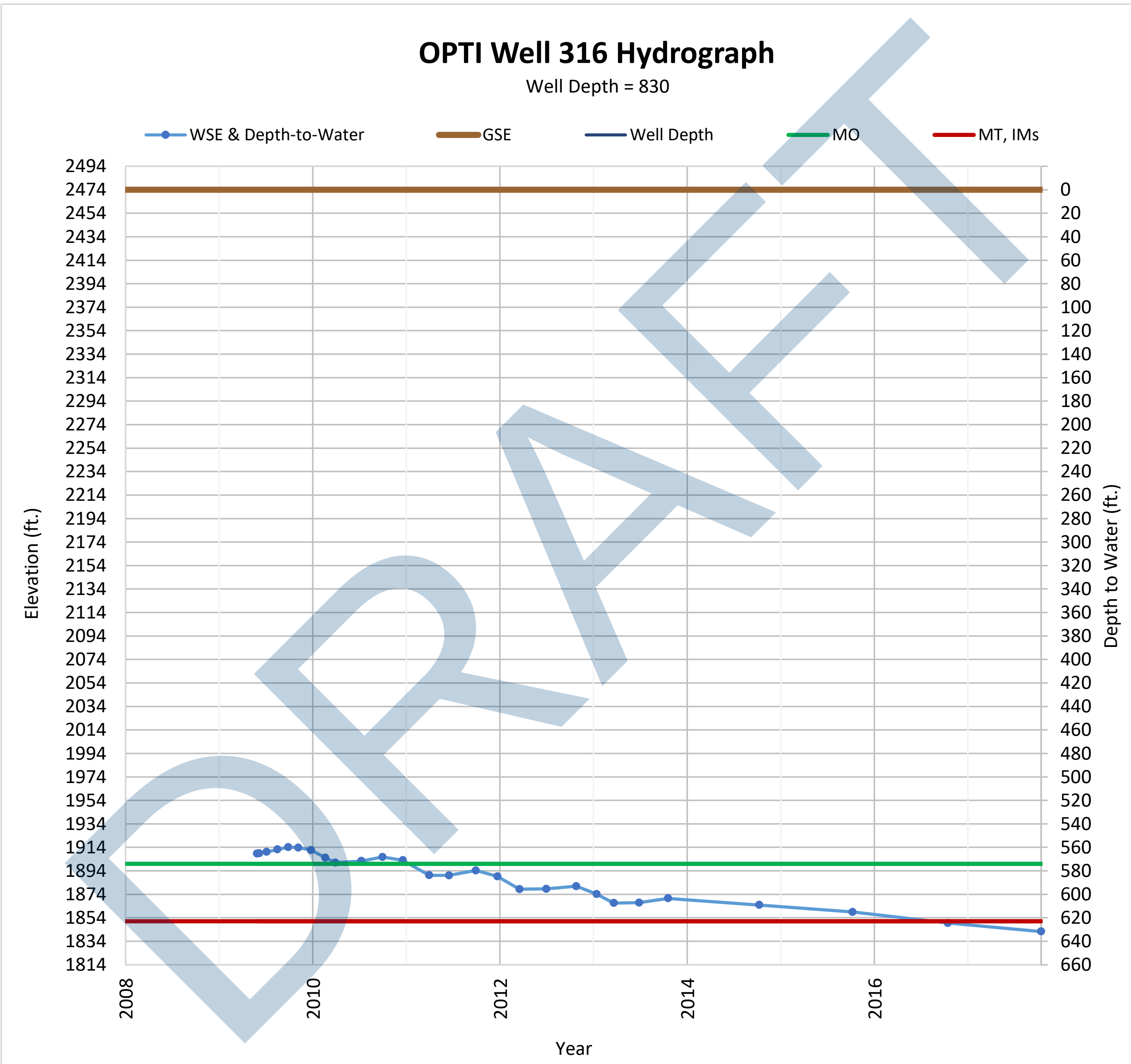


OPTI Well 123 Hydrograph
Well Depth = 138
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
2185
2165
2145
2125
2105
Elevation (ft.)
0
20
40
60
Depth to Water (ft.)
2015
2017
Year
DRAFT



OPTI Well 124 Hydrograph
Well Depth = 161
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
2307
2287
2267
2247
2227
2207
2187
0
20
40
60
80
100
Elevation (ft.)
Depth to Water (ft.)
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
Year
DRAFT


OPTI Well 127 Hydrograph
Well Depth = 100
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
2384
2364
2344
2324
2304
2284
0
20
40
60
80
Elevation (ft.)
Depth to Water (ft.)
2015
2017
Year



OPTI Well 316 Hydrograph
Well Depth = 830
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
2494
2474
2454
2434
2414
2394
2374
2354
2334
2314
2294
2274
2254
2234
2214
2194
2174
2154
2134
2114
2094
2074
2054
2034
2014
1994
1974
1954
1934
1914
1894
1874
1854
1834
1814
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
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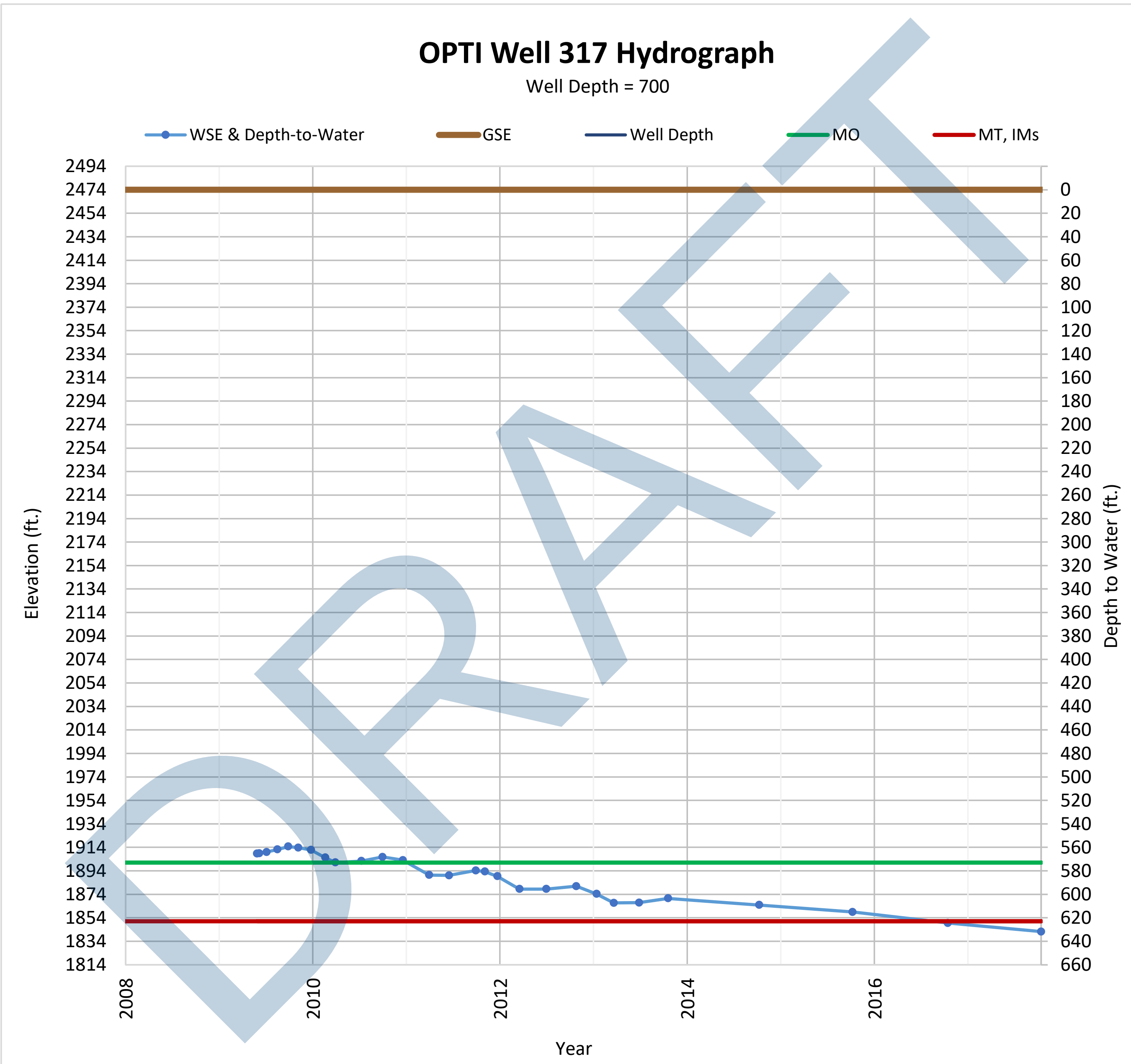
620
640
660
2008
2010
2012
2014
2016
Year
DRAFT



OPTI Well 317 Hydrograph
Well Depth = 700
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
Year
2008
2010
2012
2014
2016
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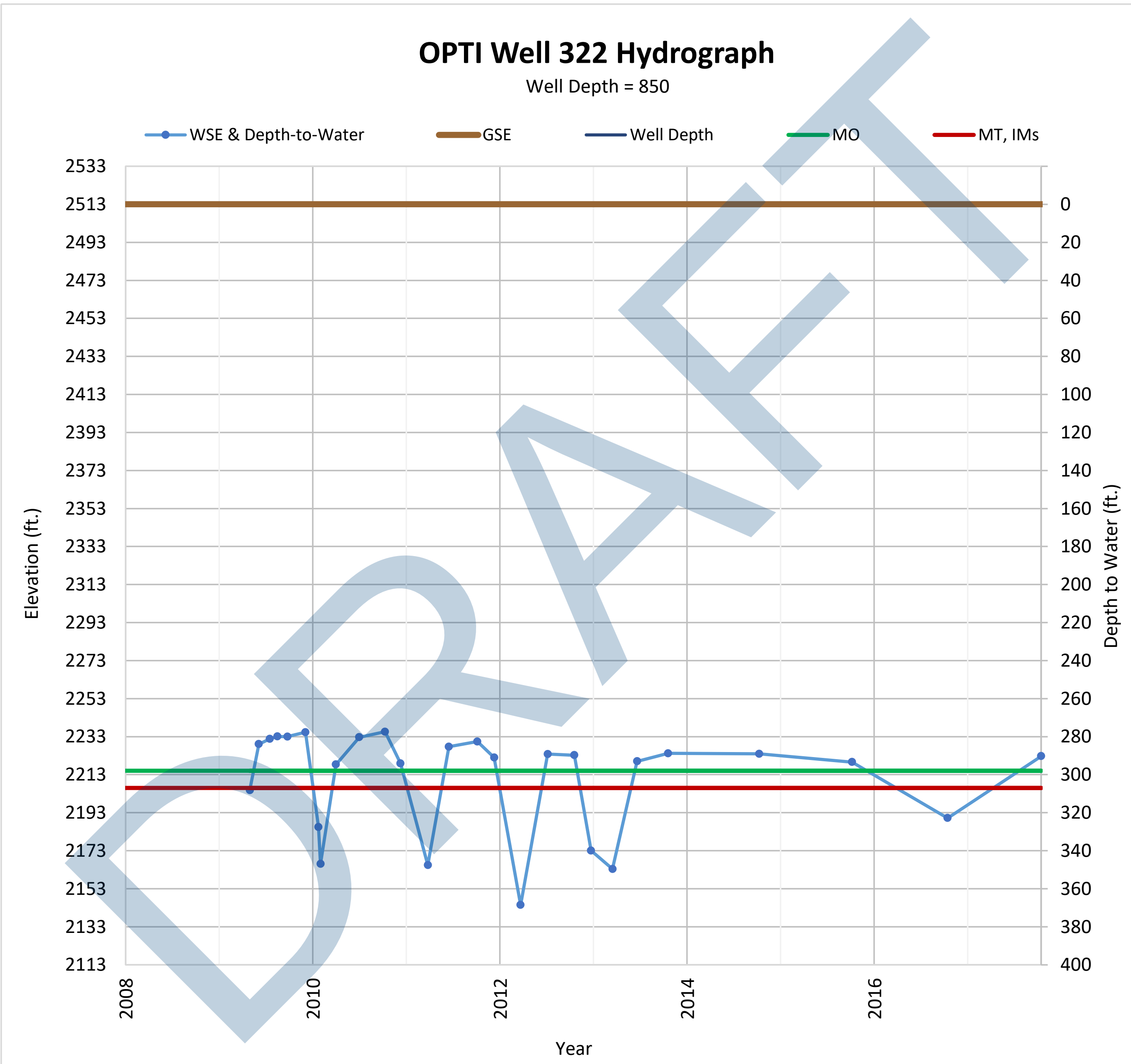
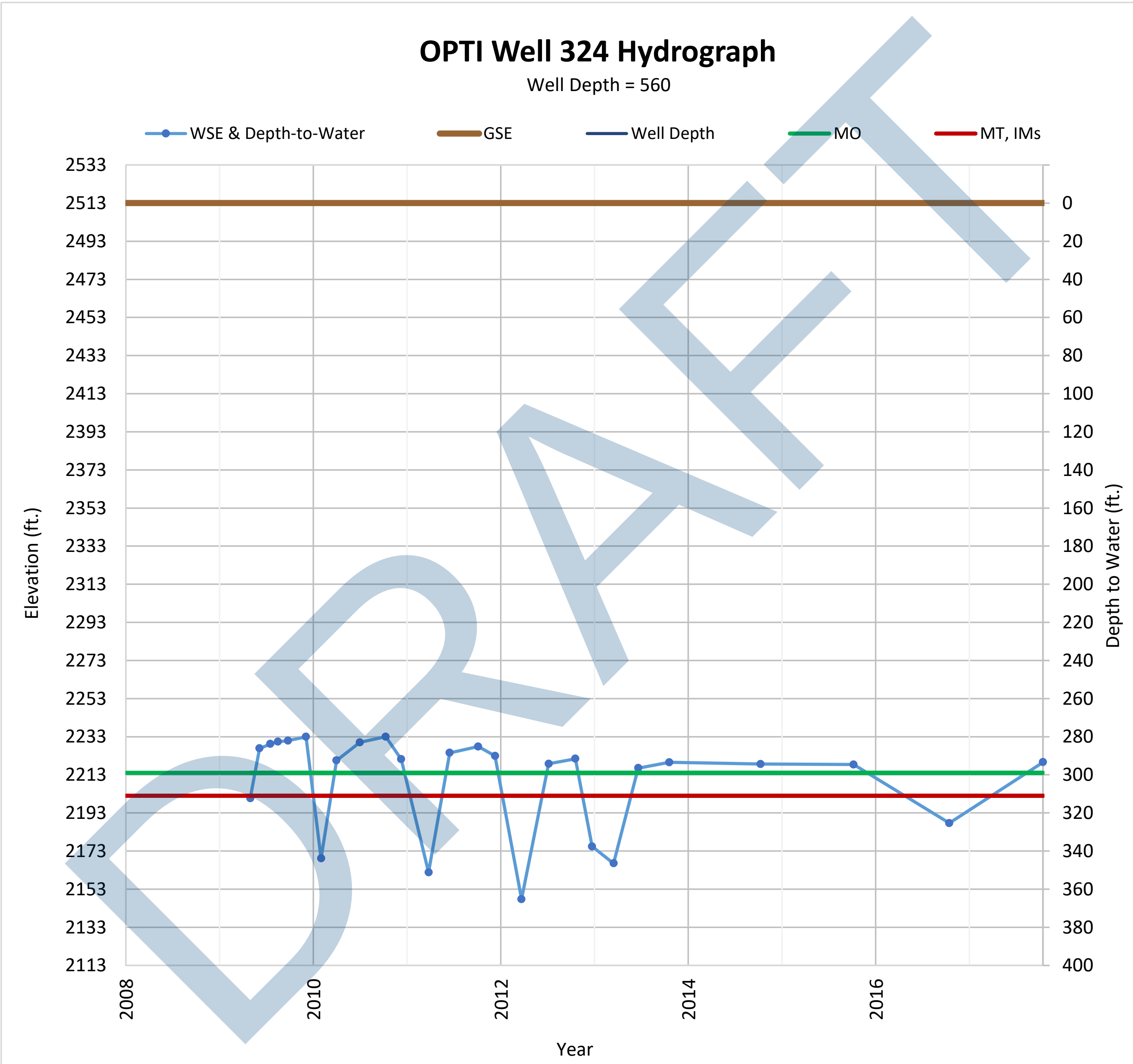
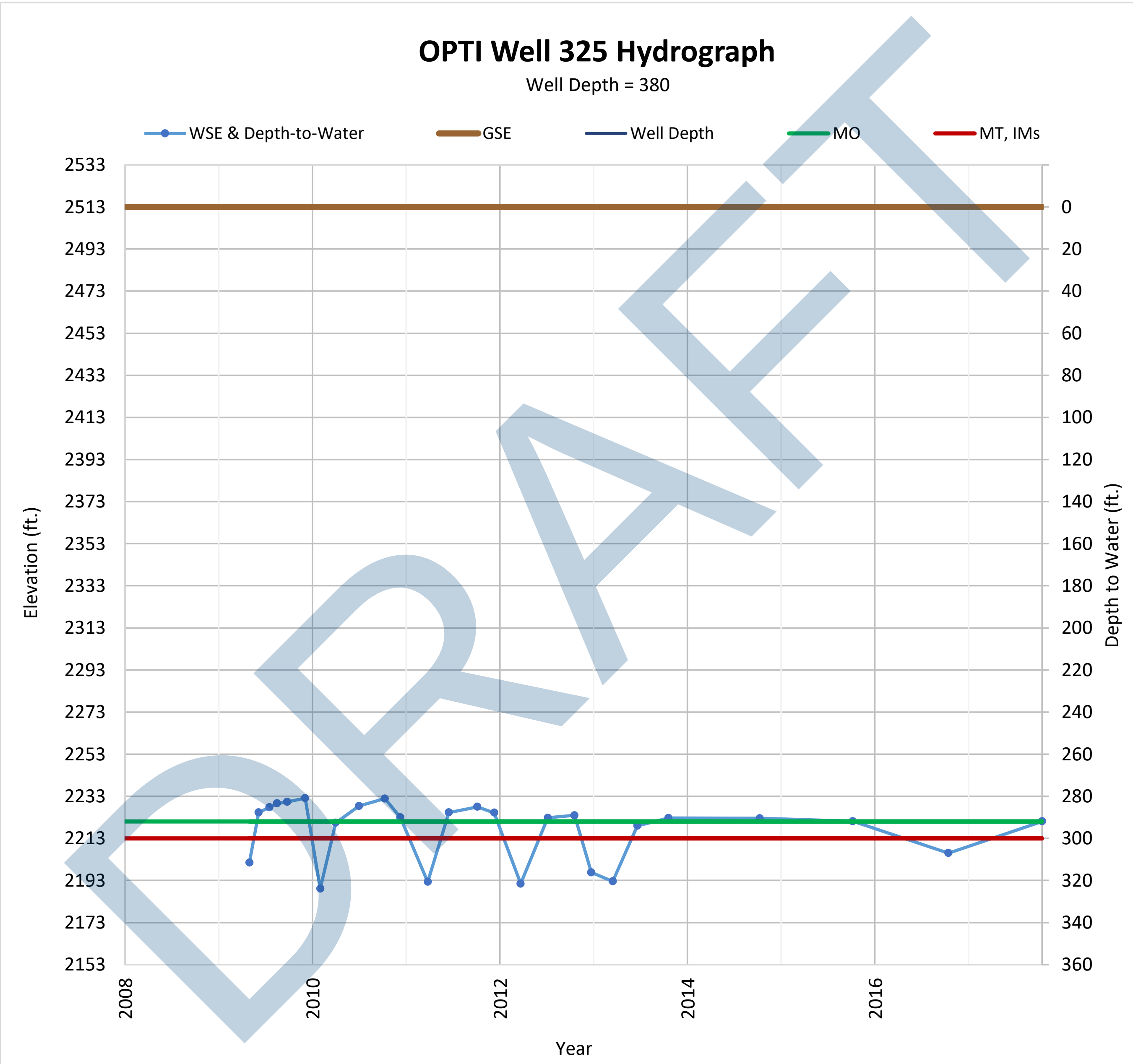
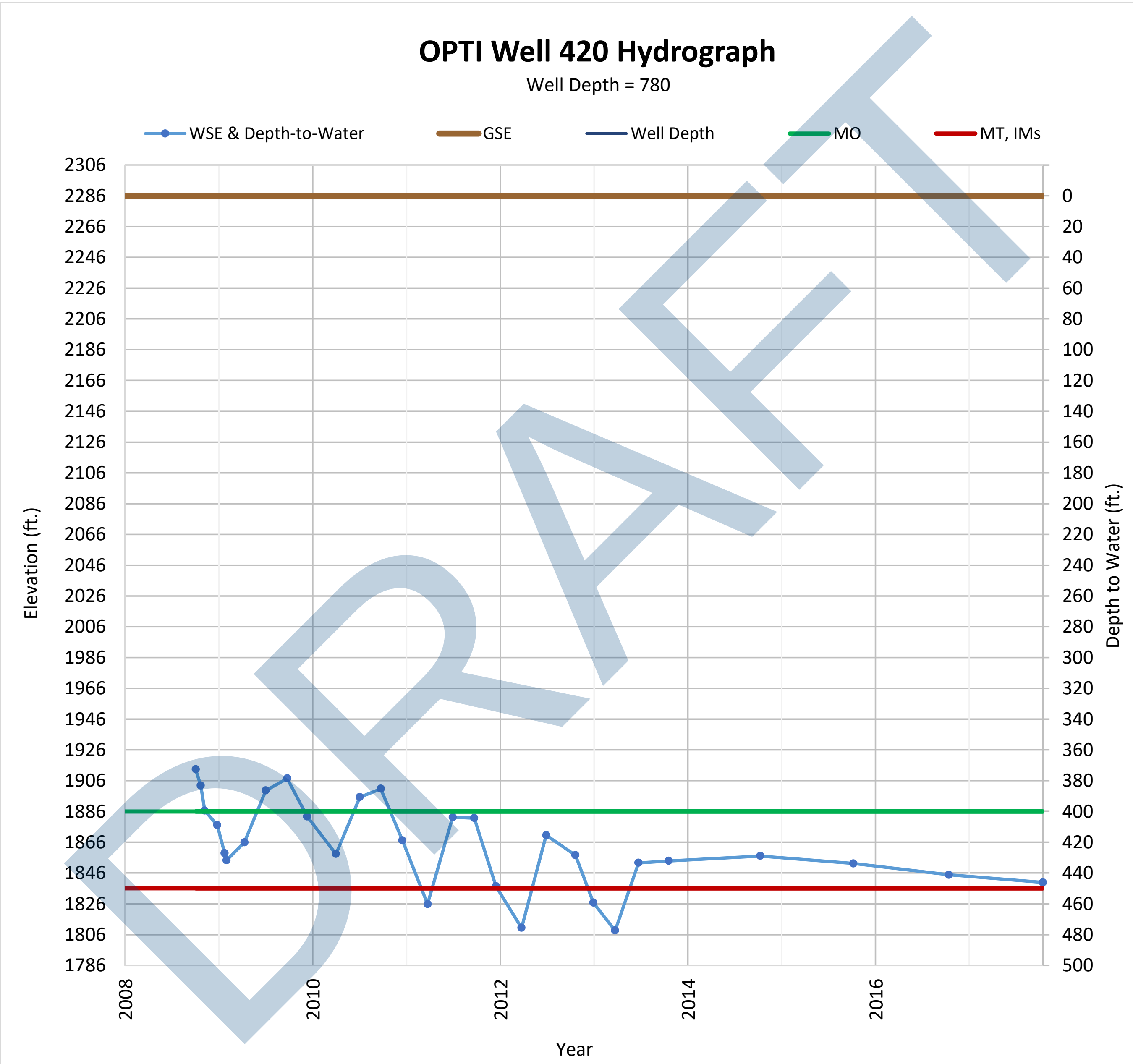

OPTI Well 322 Hydrograph
Well Depth = 850
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
2533
2513
2493
2473
2453
2433
2413
2393
2373
2353
2333
2313
2293
2273
2253
2233
2213
2193
2173
2153
2133
2113
Depth to Water (ft.)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
2008
2010
2012
2014
2016
Year
DRAFT

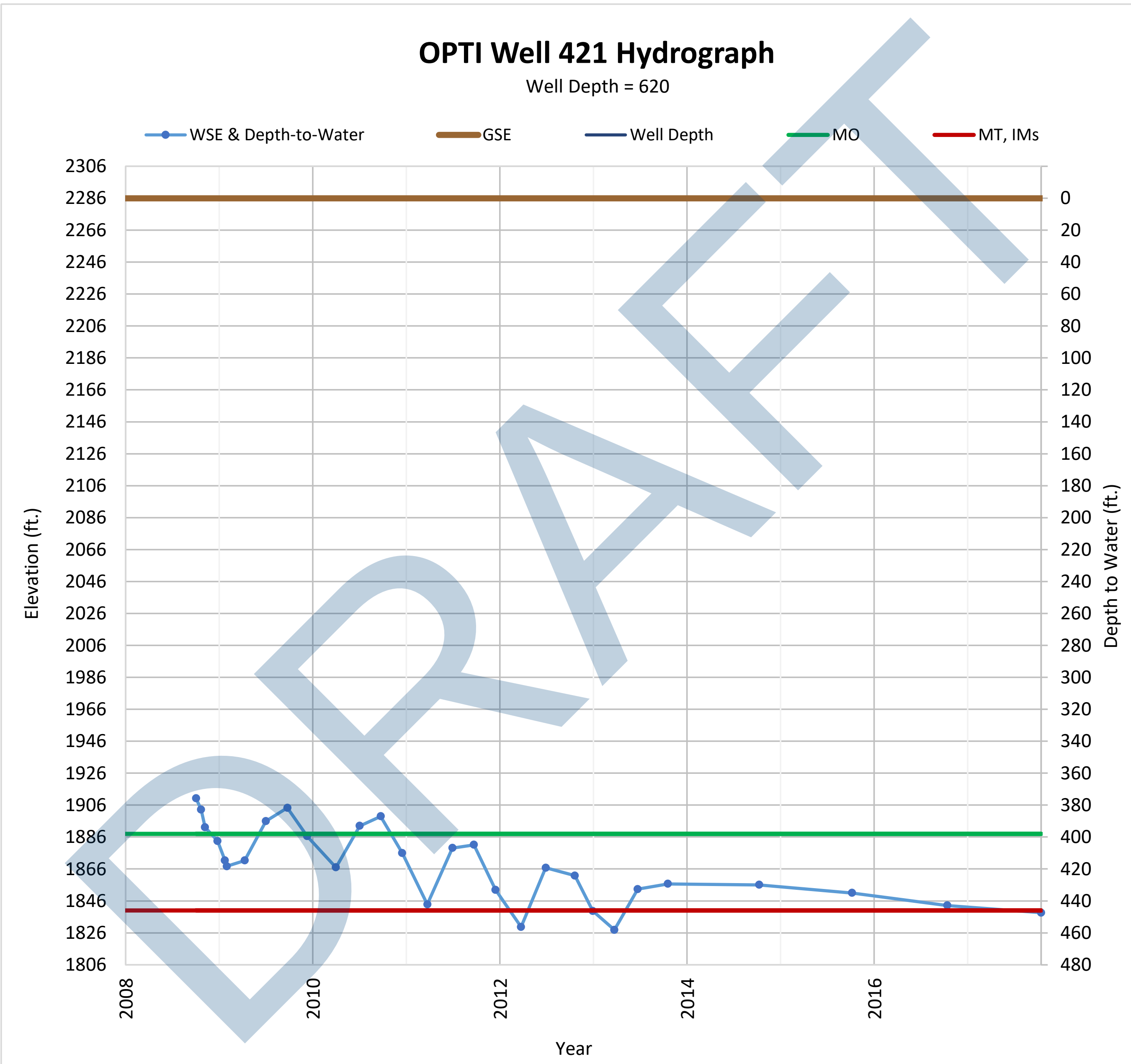


OPTI Well 324 Hydrograph
Well Depth = 560
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
Year
2533
2513
2493
2473
2453
2433
2413
2393
2373
2353
2333
2313
2293
2273
2253
2233
2213
2193
2173
2153
2133
2113
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
2008
2010
2012
2014
2016
DRAFT

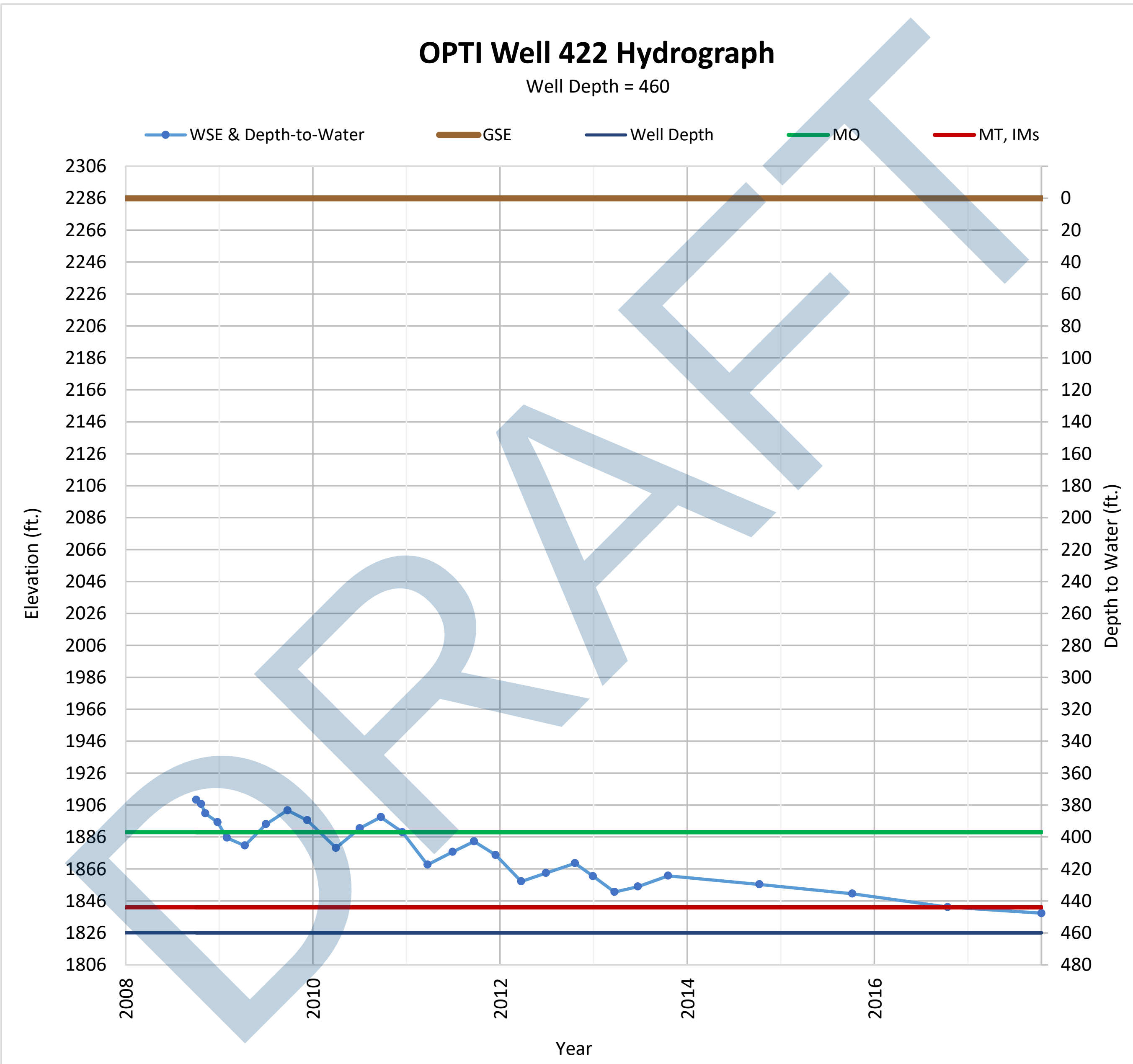

OPTI Well 325 Hydrograph
Well Depth = 380
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
2533
2513
2493
2473
2453
2433
2413
2393
2373
2353
2333
2313
2293
2273
2253
2233
2213
2193
2173
2153
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
2008
2010
2012
2014
2016
Year
DRAFT



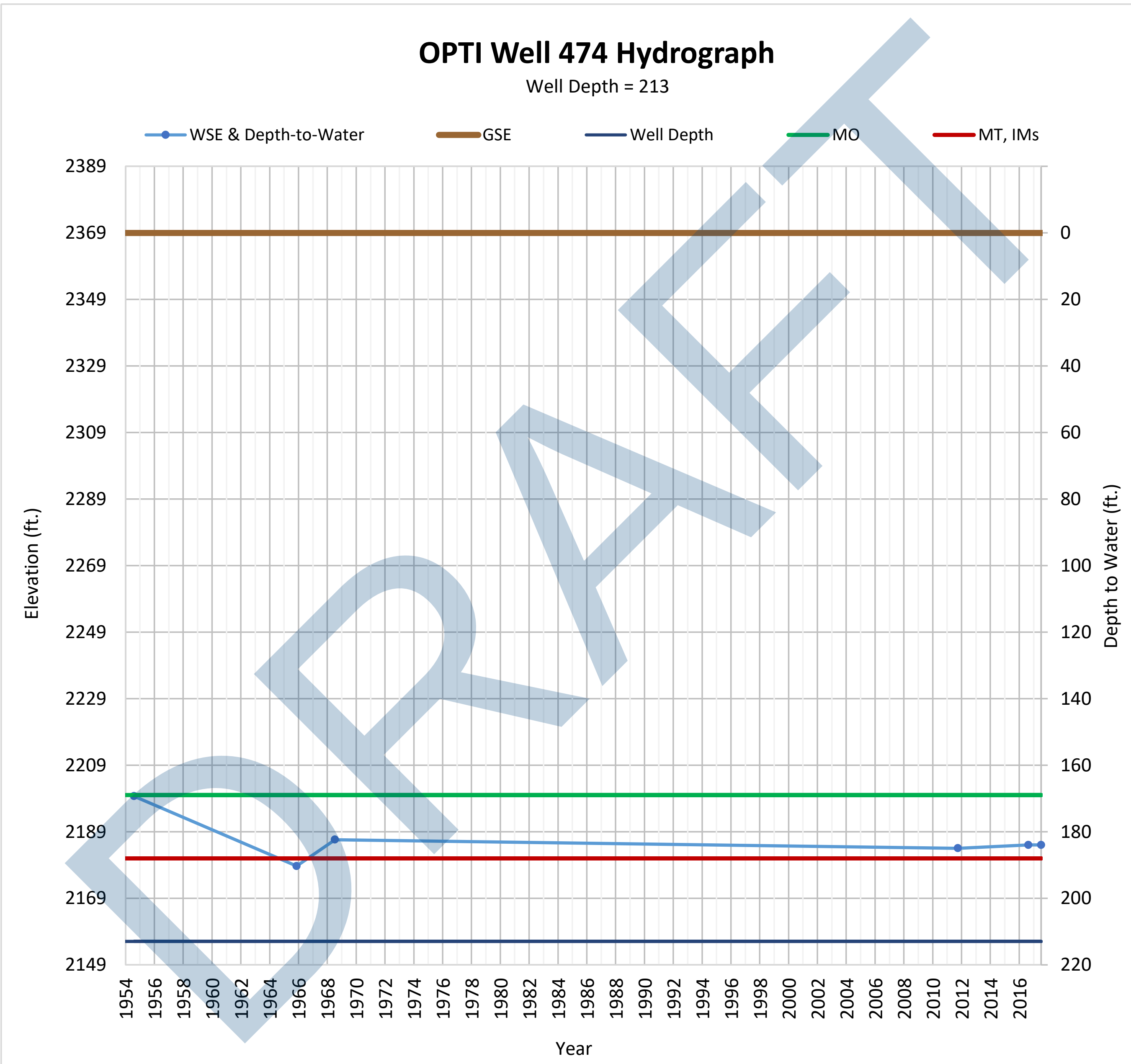
OPTI Well 420 Hydrograph
Well Depth = 780
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
Year
2306
2286
2266
2246
2226
2206
2186
2166
2146
2126
2106
2086
2066
2046
2026
2006
1986
1966
1946
1926
1906
1886
1866
1846
1826
1806
1786
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
2008
2010
2012
2014
2016
DRAFT



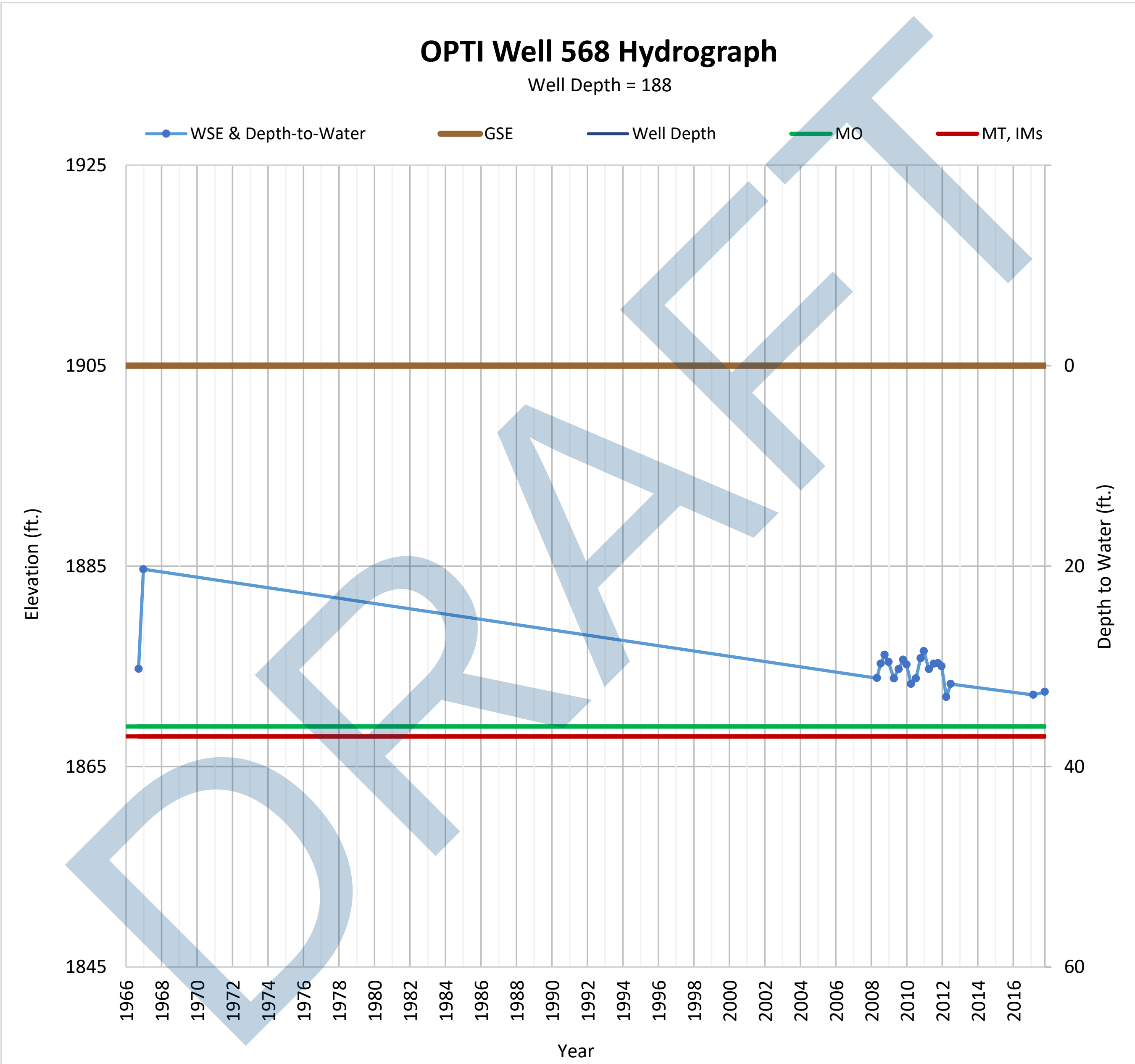
OPTI Well 421 Hydrograph
Well Depth = 620
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
Year
2306
2286
2266
2246
2226
2206
2186
2166
2146
2126
2106
2086
2066
2046
2026
2006
1986
1966
1946
1926
1906
1886
1866
1846
1826
1806
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
2008
2010
2012
2014
2016
DRAFT



OPTI Well 422 Hydrograph
Well Depth = 460
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
2306
2286
2266
2246
2226
2206
2186
2166
2146
2126
2106
2086
2066
2046
2026
2006
1986
1966
1946
1926
1906
1886
1866
1846
1826
1806
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
2008
2010
2012
2014
2016
Year
DRAFT



OPTI Well 474 Hydrograph
Well Depth = 213
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
Year
2389
2369
2349
2329
2309
2289
2269
2249
2229
2209
2189
2169
2149
0
20
40
60
80
100
120
140
160
180
200
220
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
DRAFT



OPTI Well 568 Hydrograph
Well Depth = 188
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
Year
1925
1905
1885
1865
1845
0
20
40
60
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
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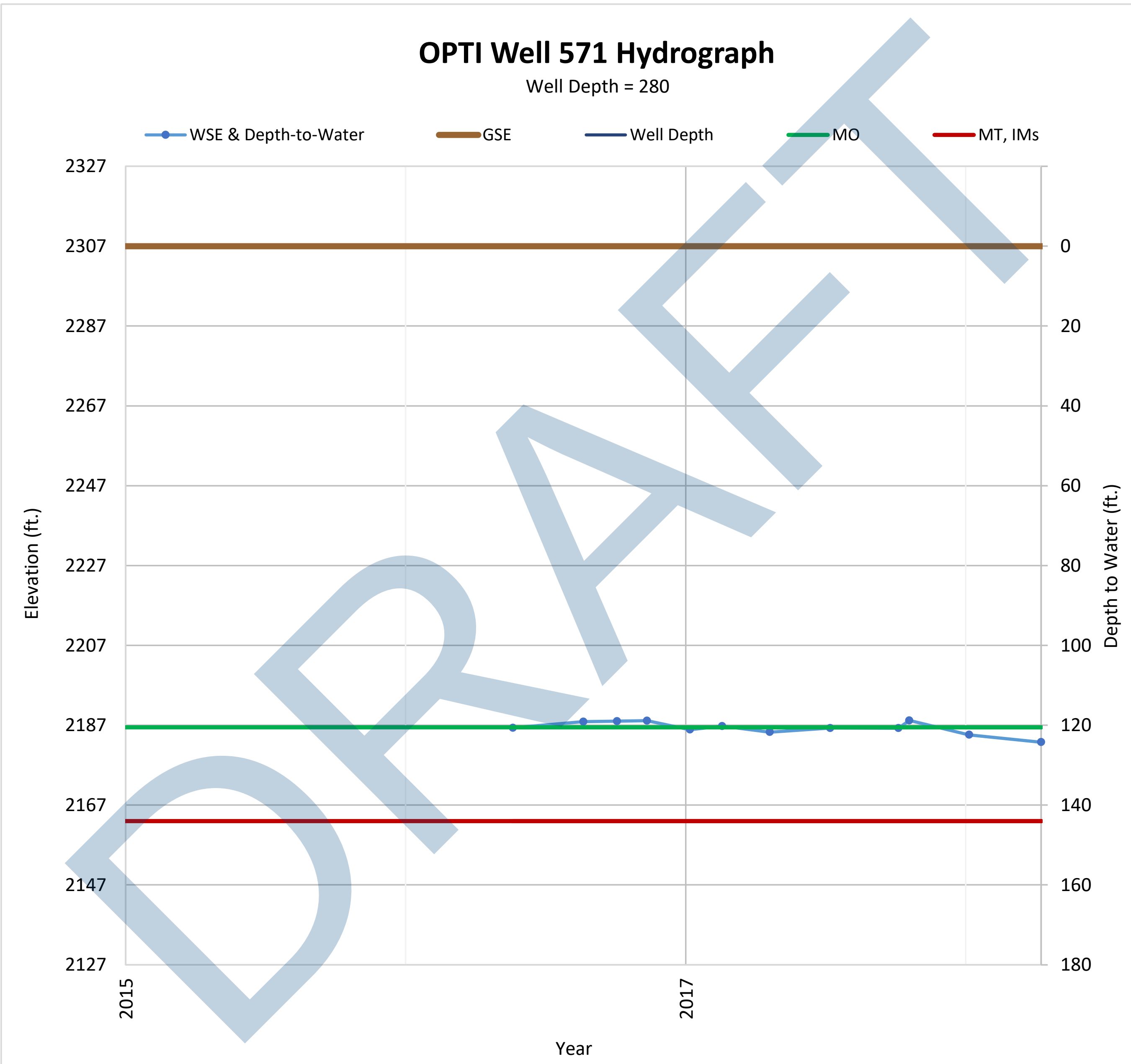
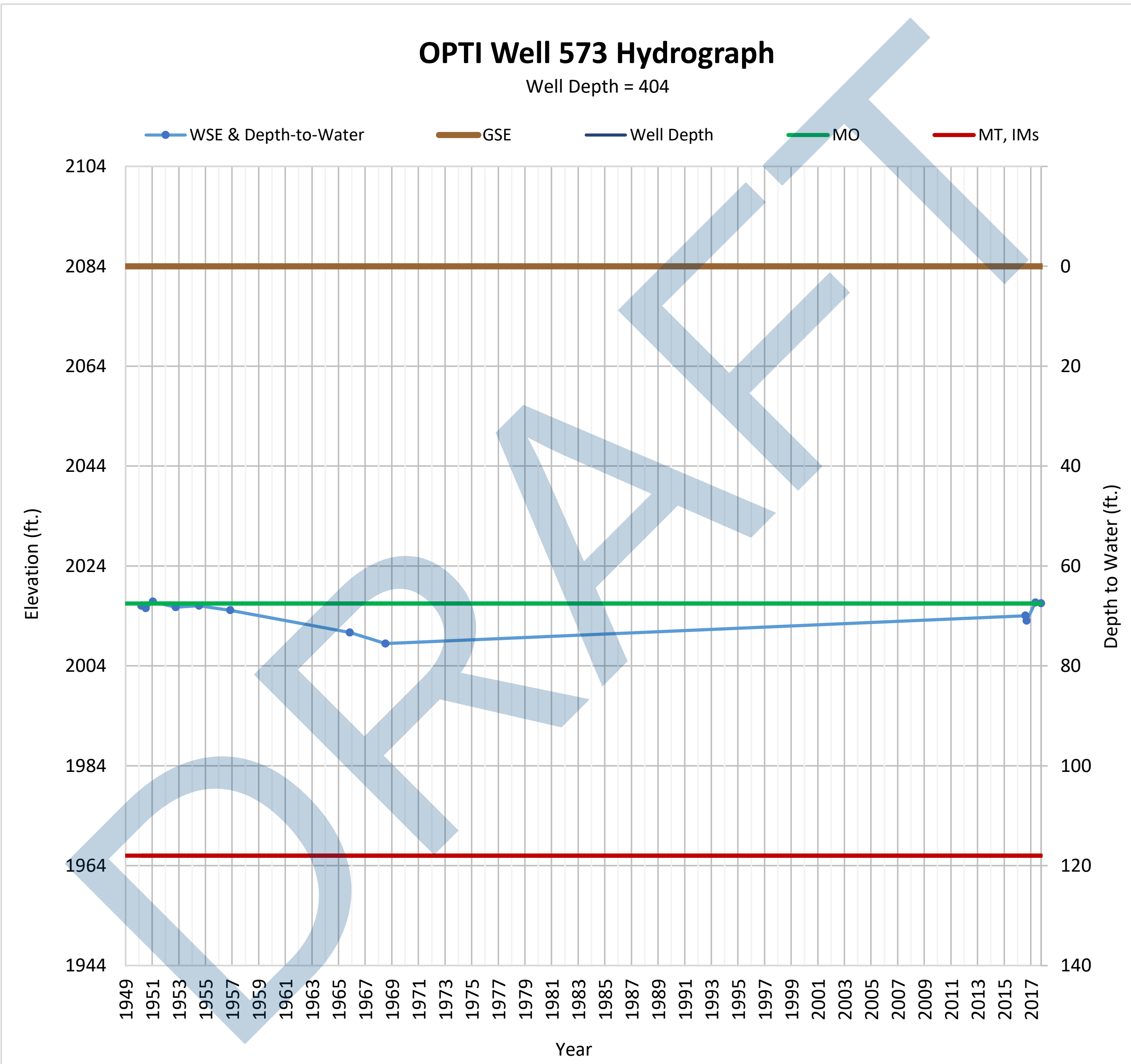
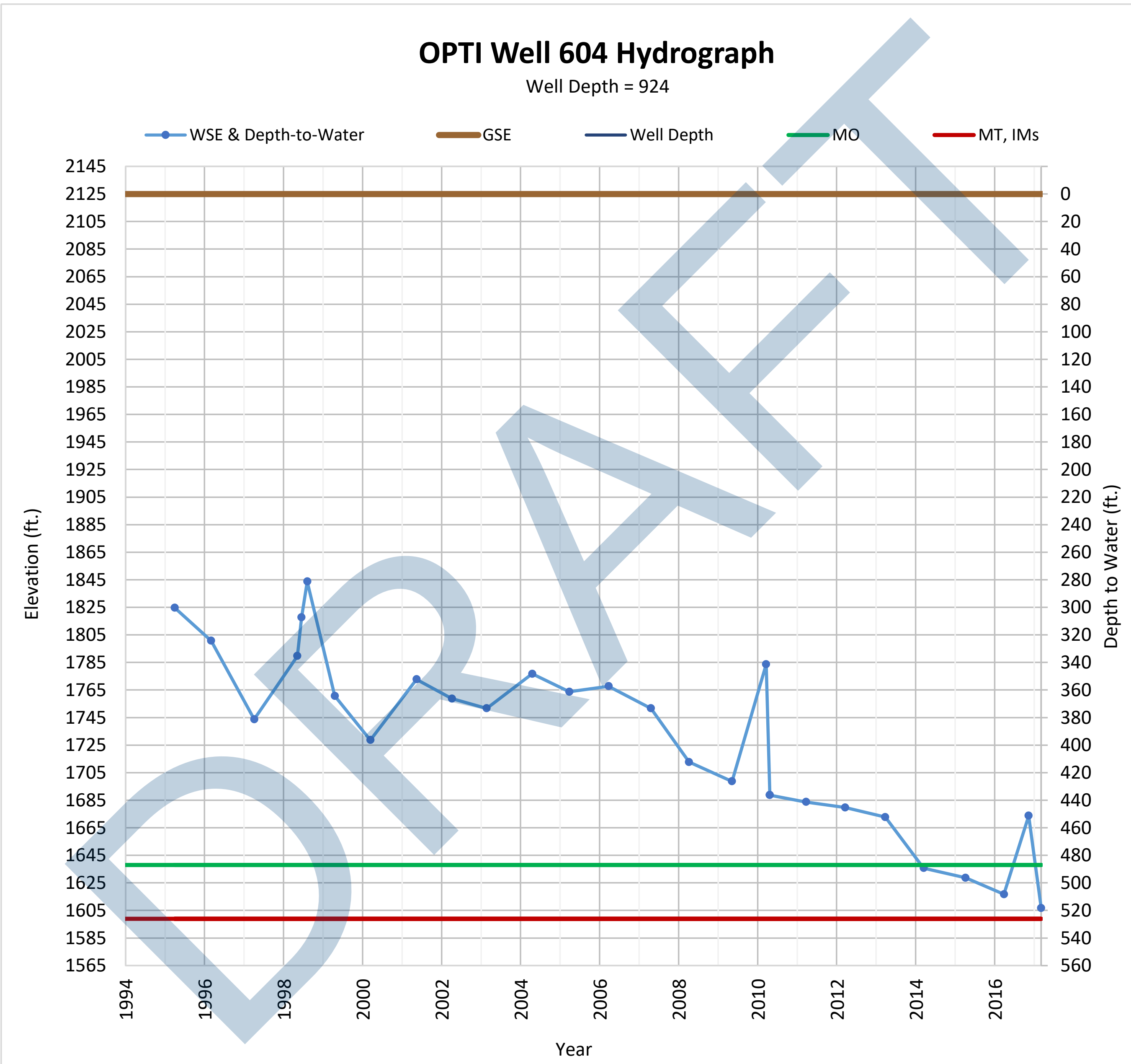
2006
2008
2010
2012
2014
2016
DRAFT



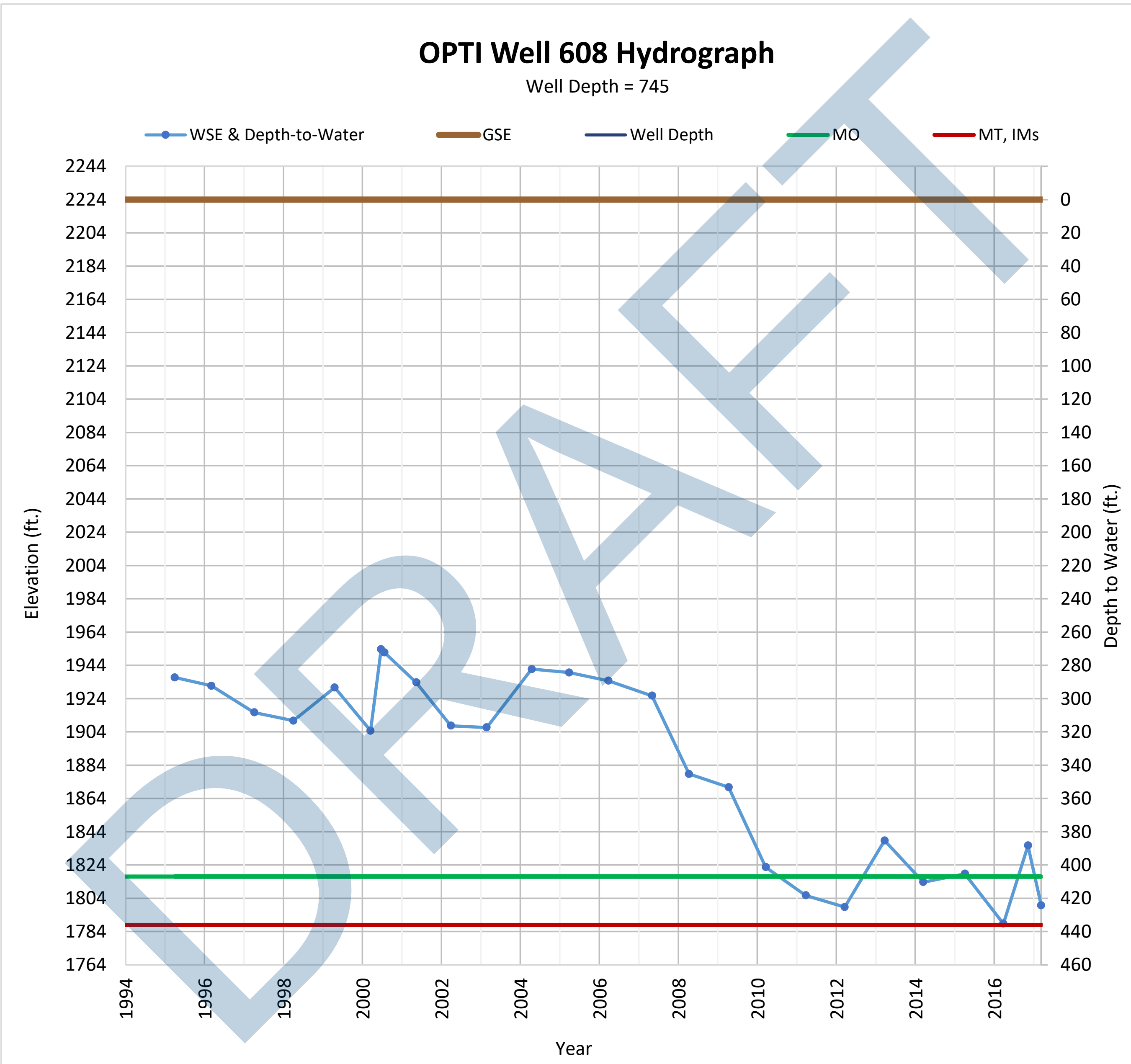
OPTI Well 571 Hydrograph
Well Depth = 280
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
2327
2307
2287
2267
2247
2227
2207
2187
2167
2147
2127
0
20
40
60
80
100
120
140
160
180
2015
2017
Year
DRAFT

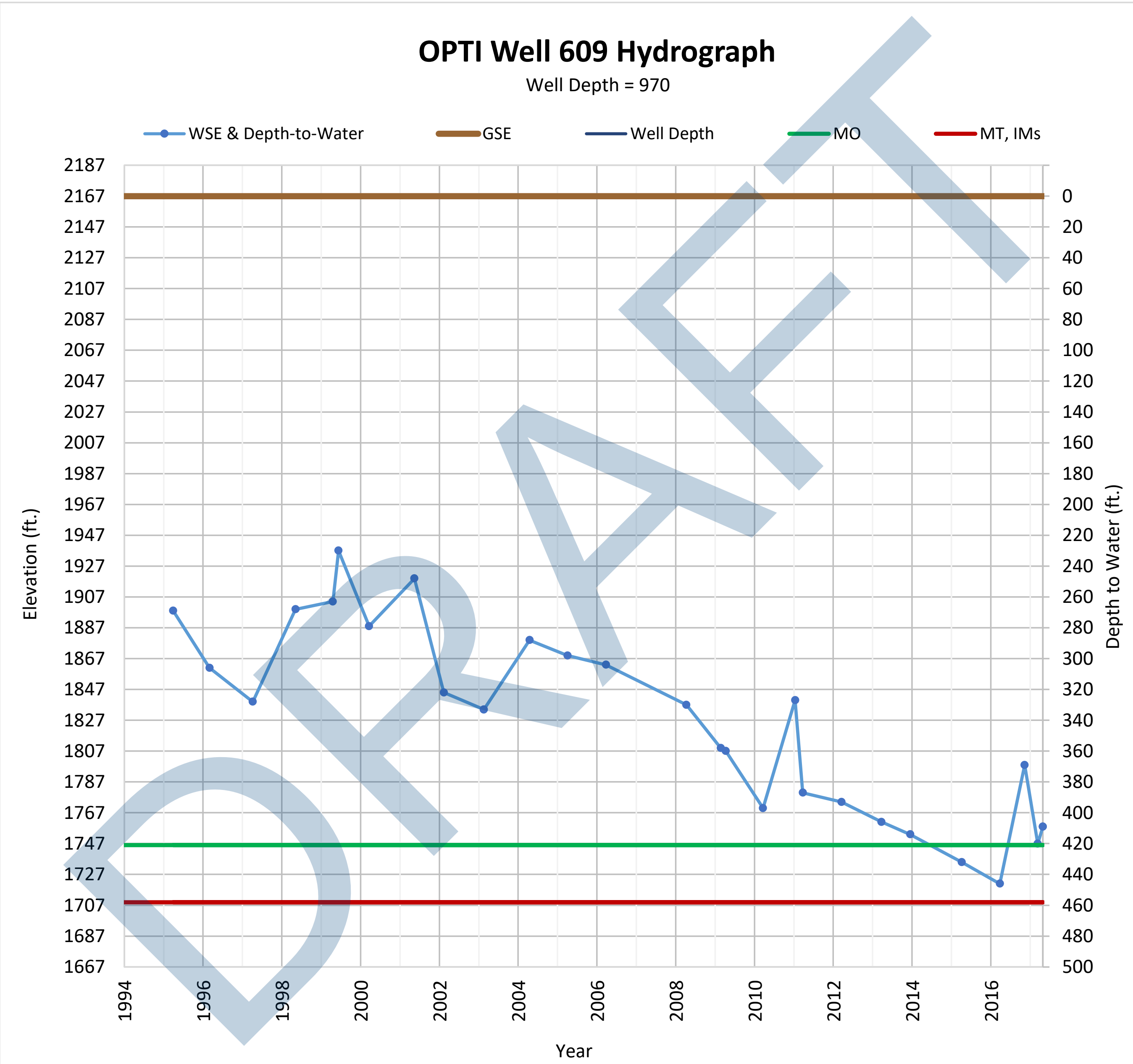


OPTI Well 573 Hydrograph
Well Depth = 404
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
Year
2104
2084
2064
2044
2024
2004
1984
1964
1944
0
20
40
60
80
100
120
140
1949
1951
1953
1955
1957
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
DRAFT

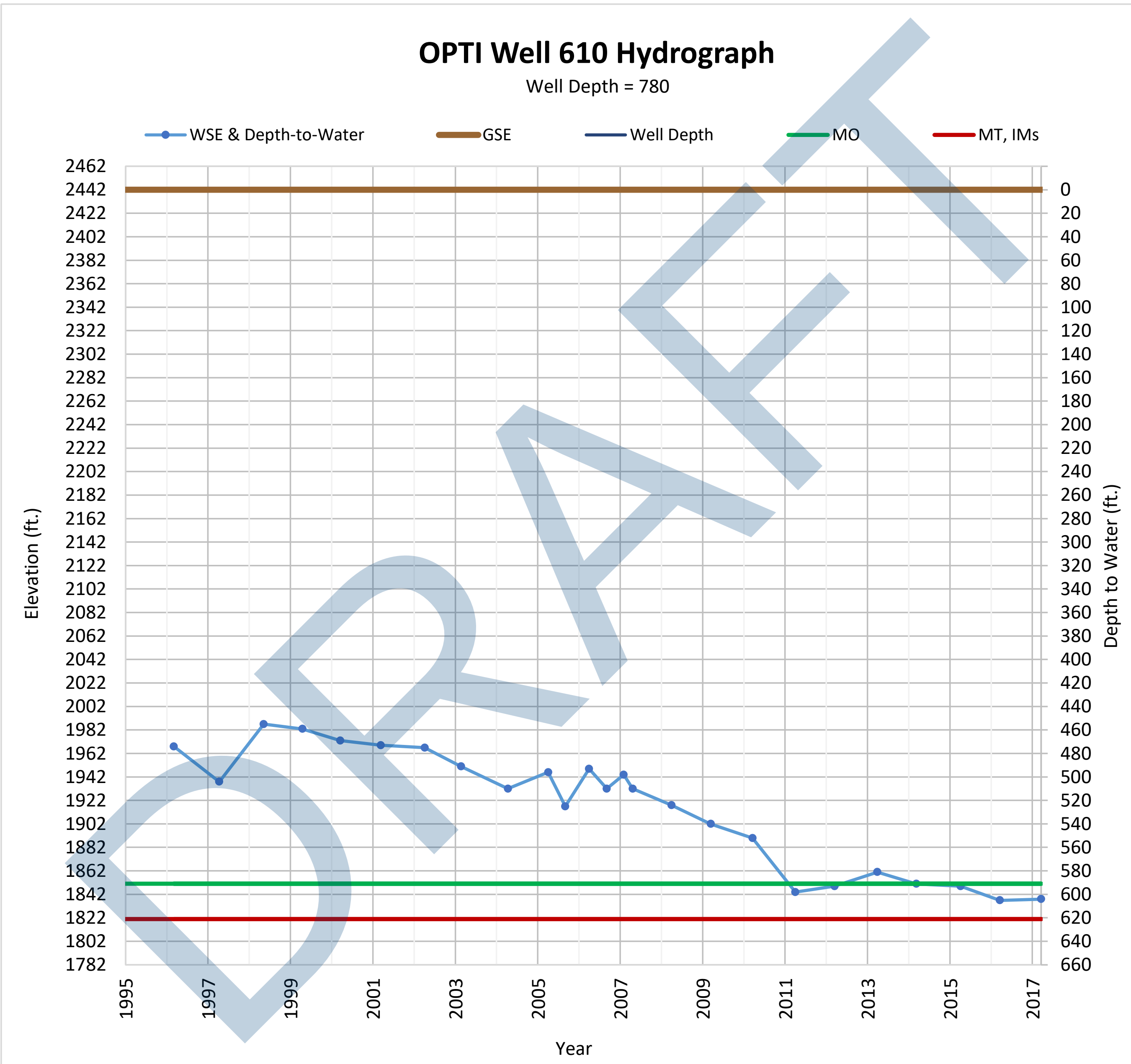


OPTI Well 604 Hydrograph
Well Depth = 924
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
Year
2145
2125
2105
2085
2065
2045
2025
2005
1985
1965
1945
1925
1905
1885
1865
1845
1825
1805
1785
1765
1745
1725
1705
1685
1665
1645
1625
1605
1585
1565
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016

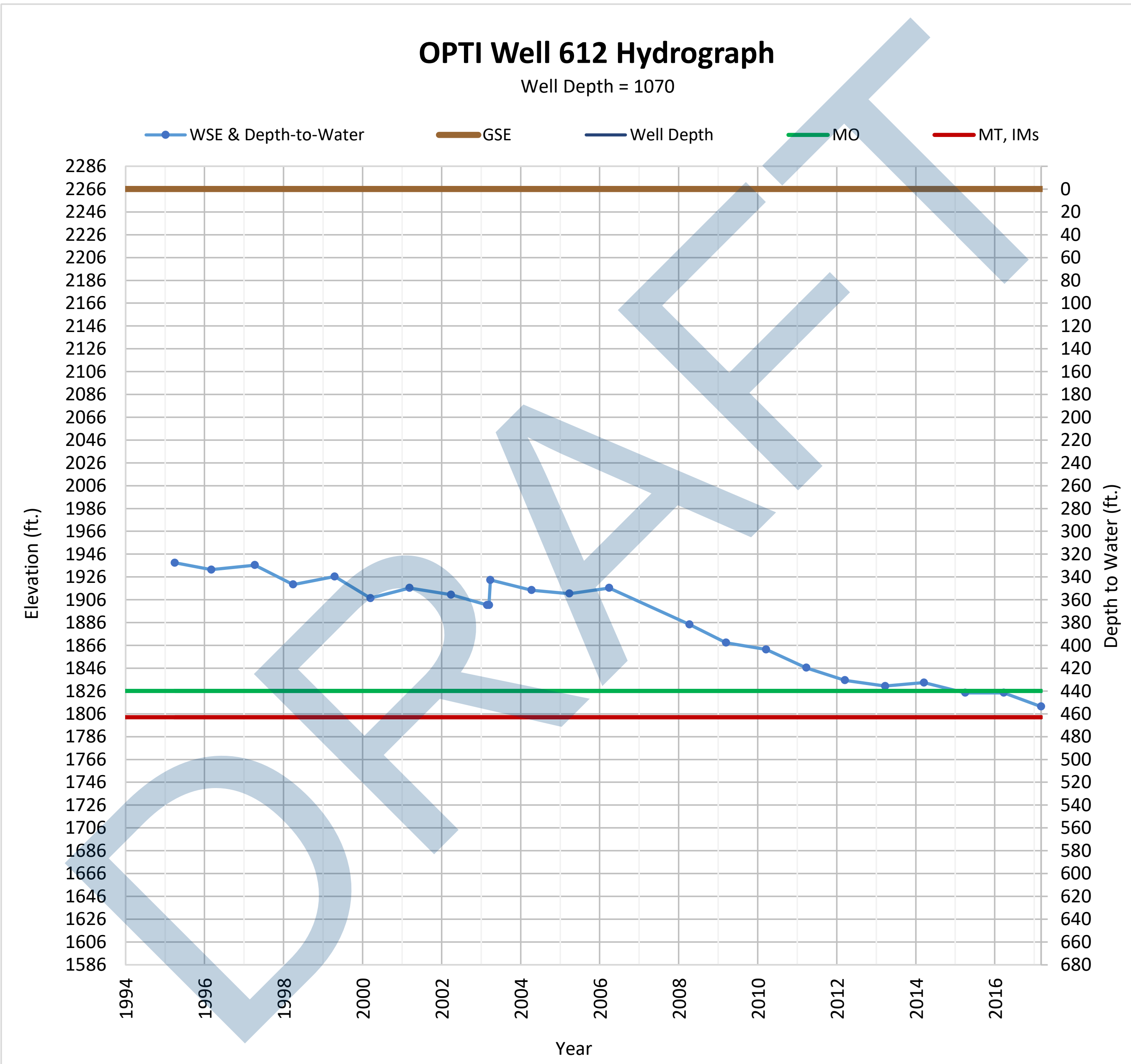

OPTI Well 608 Hydrograph
Well Depth = 745
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
Year
2244
2224
2204
2184
2164
2144
2124
2104
2084
2064
2044
2024
2004
1984
1964
1944
1924
1904
1884
1864
1844
1824
1804
1784
1764
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
DRAFT



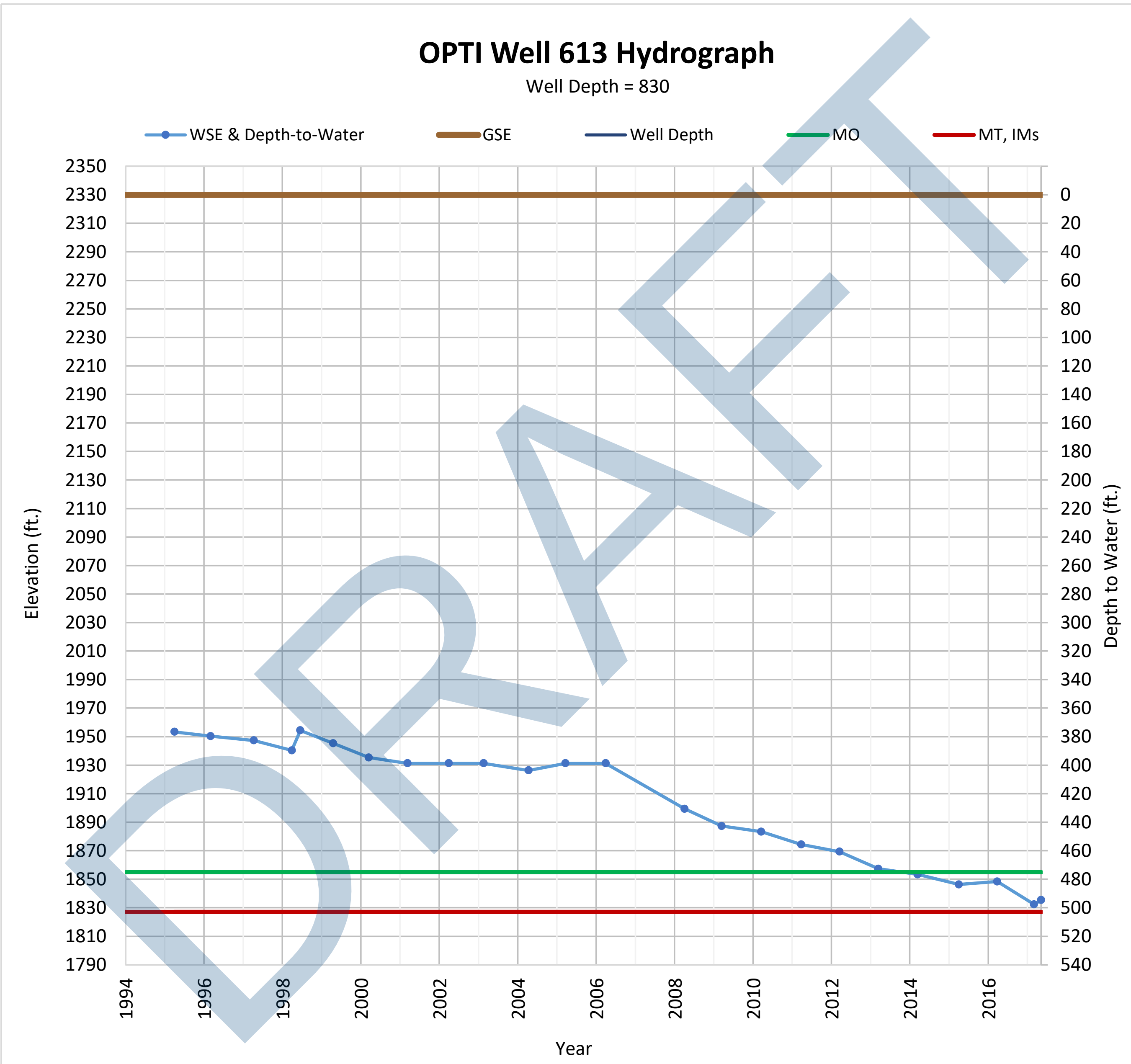
OPTI Well 609 Hydrograph
Well Depth = 970
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
Year
2187
2167
2147
2127
2107
2087
2067
2047
2027
2007
1987
1967
1947
1927
1907
1887
1867
1847
1827
1807
1787
1767
1747
1727
1707
1687
1667
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
DRAFT



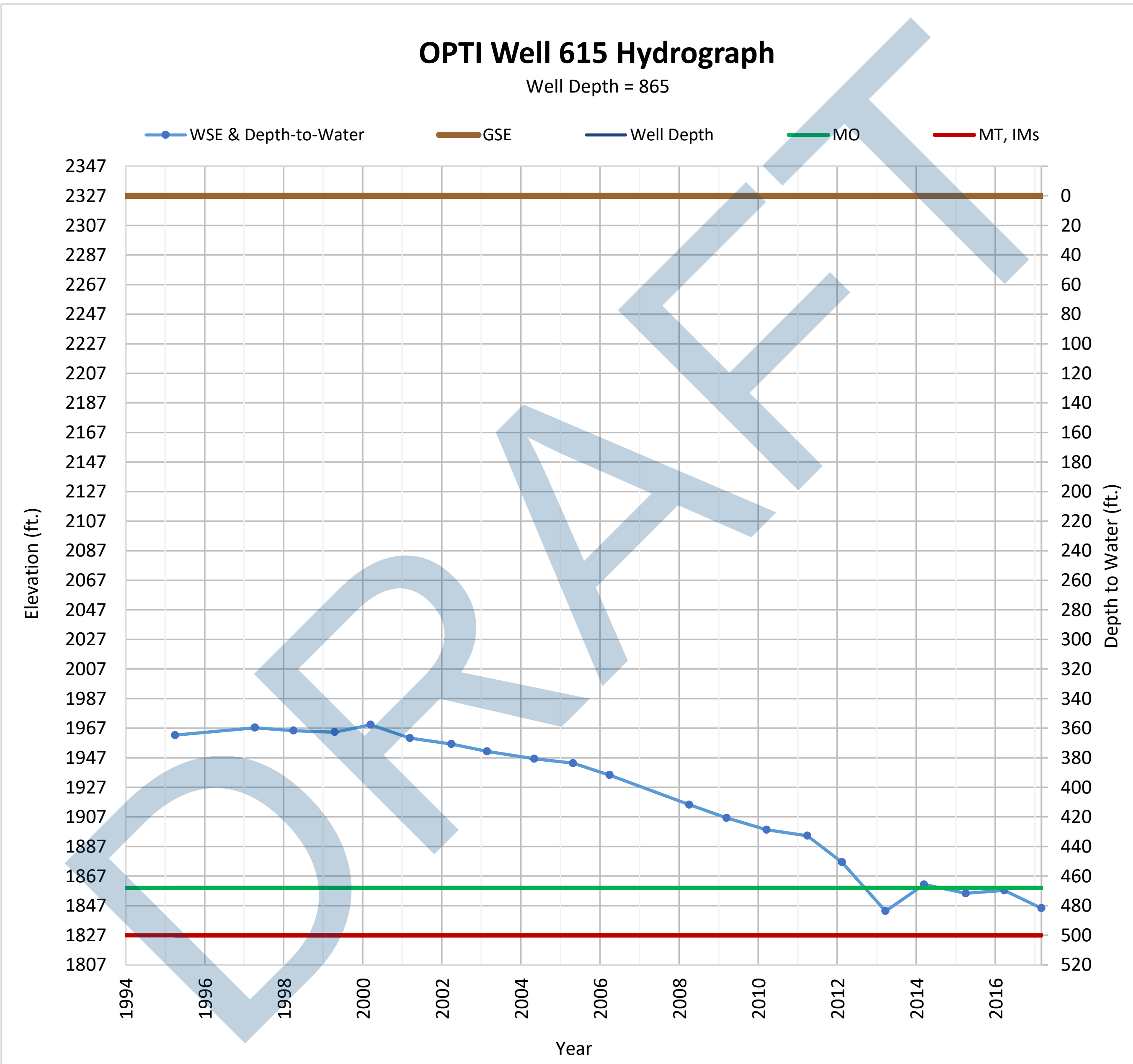
OPTI Well 610 Hydrograph
Well Depth = 780
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
Year
2462
2442
2422
2402
2382
2362
2342
2322
2302
2282
2262
2242
2222
2202
2182
2162
2142
2122
2102
2082
2062
2042
2022
2002
1982
1962
1942
1922
1902
1882
1862
1842
1822
1802
1782
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
DRAFT



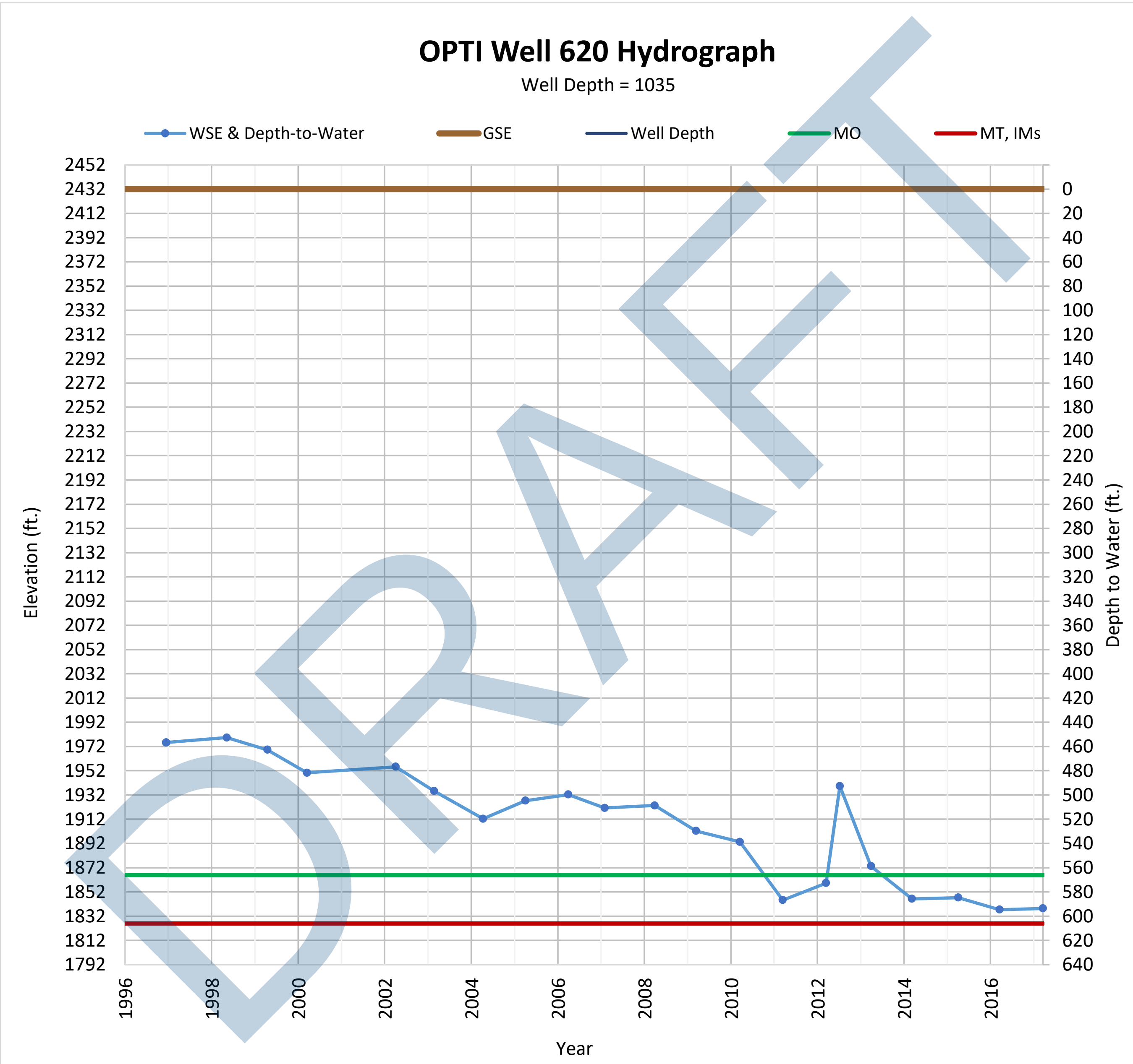
OPTI Well 612 Hydrograph
Well Depth = 1070
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
Year
DRAFT

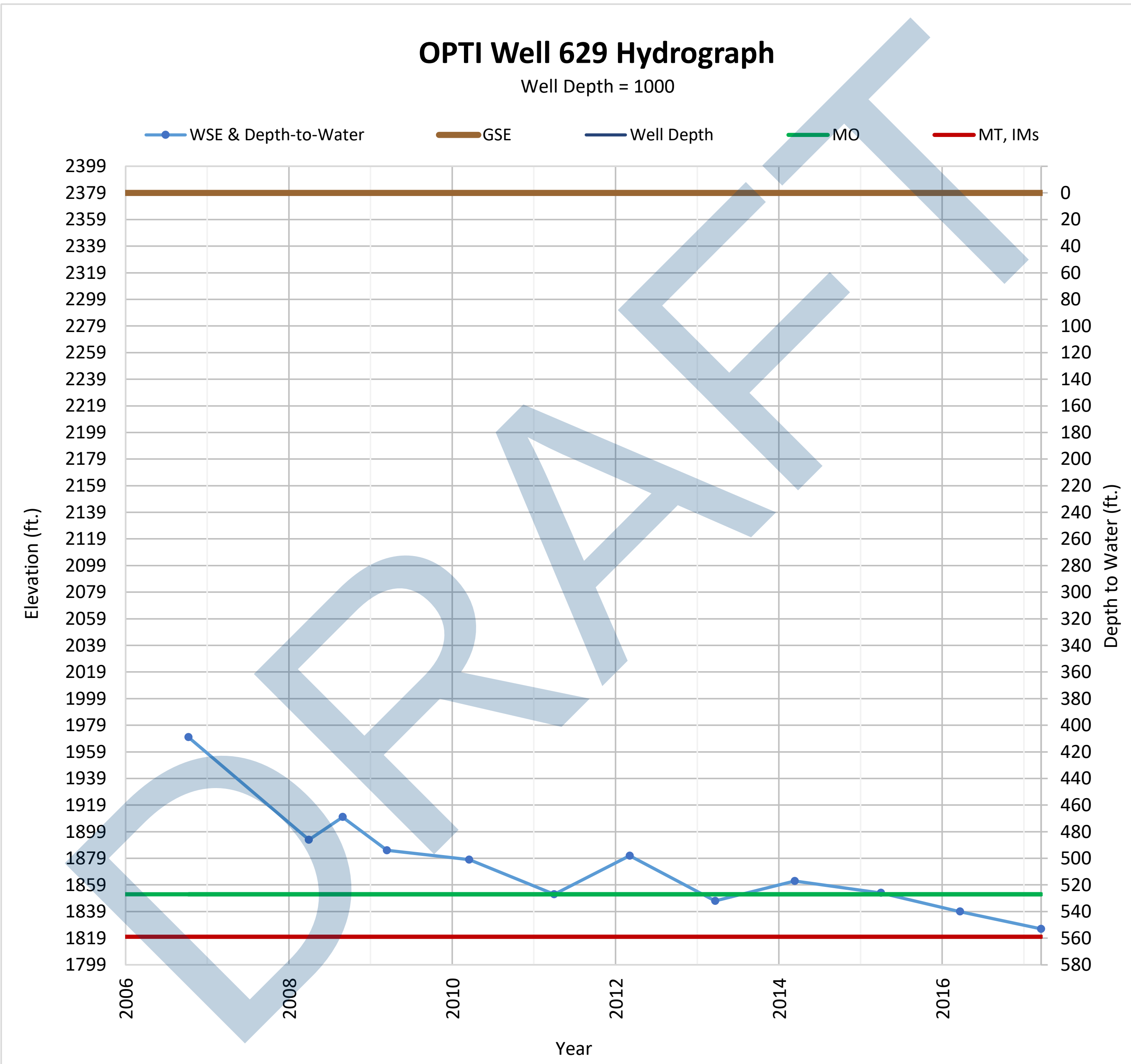


OPTI Well 613 Hydrograph
Well Depth = 830
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
Year
2350
2330
2310
2290
2270
2250
2230
2210
2190
2170
2150
2130
2110
2090
2070
2050
2030
2010
1990
1970
1950
1930
1910
1890
1870
1850
1830
1810
1790
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
DRAFT

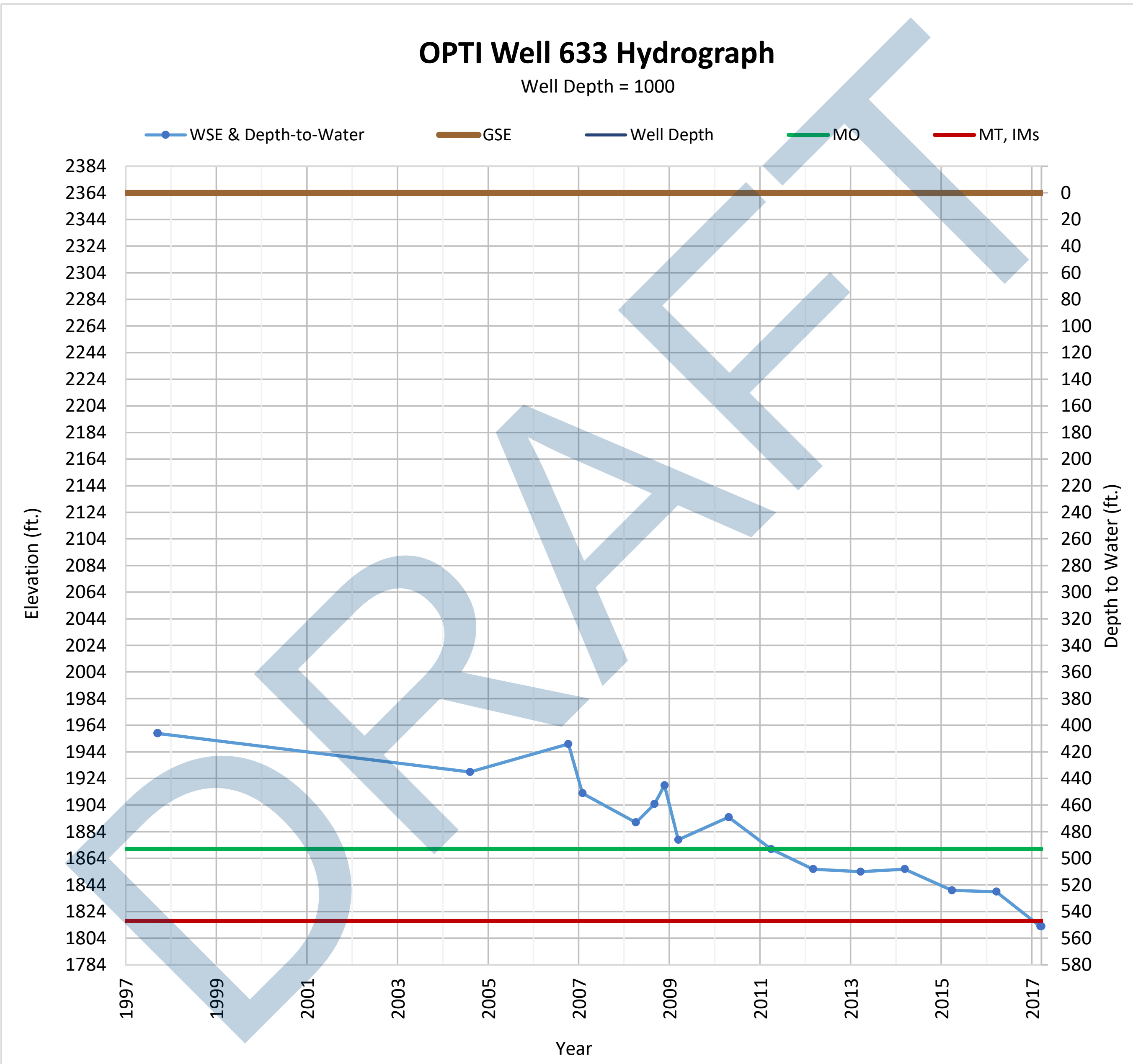


OPTI Well 615 Hydrograph
Well Depth = 865
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
Year
2347
2327
2307
2287
2267
2247
2227
2207
2187
2167
2147
2127
2107
2087
2067
2047
2027
2007
1987
1967
1947
1927
1907
1887
1867
1847
1827
1807
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
DRAFT

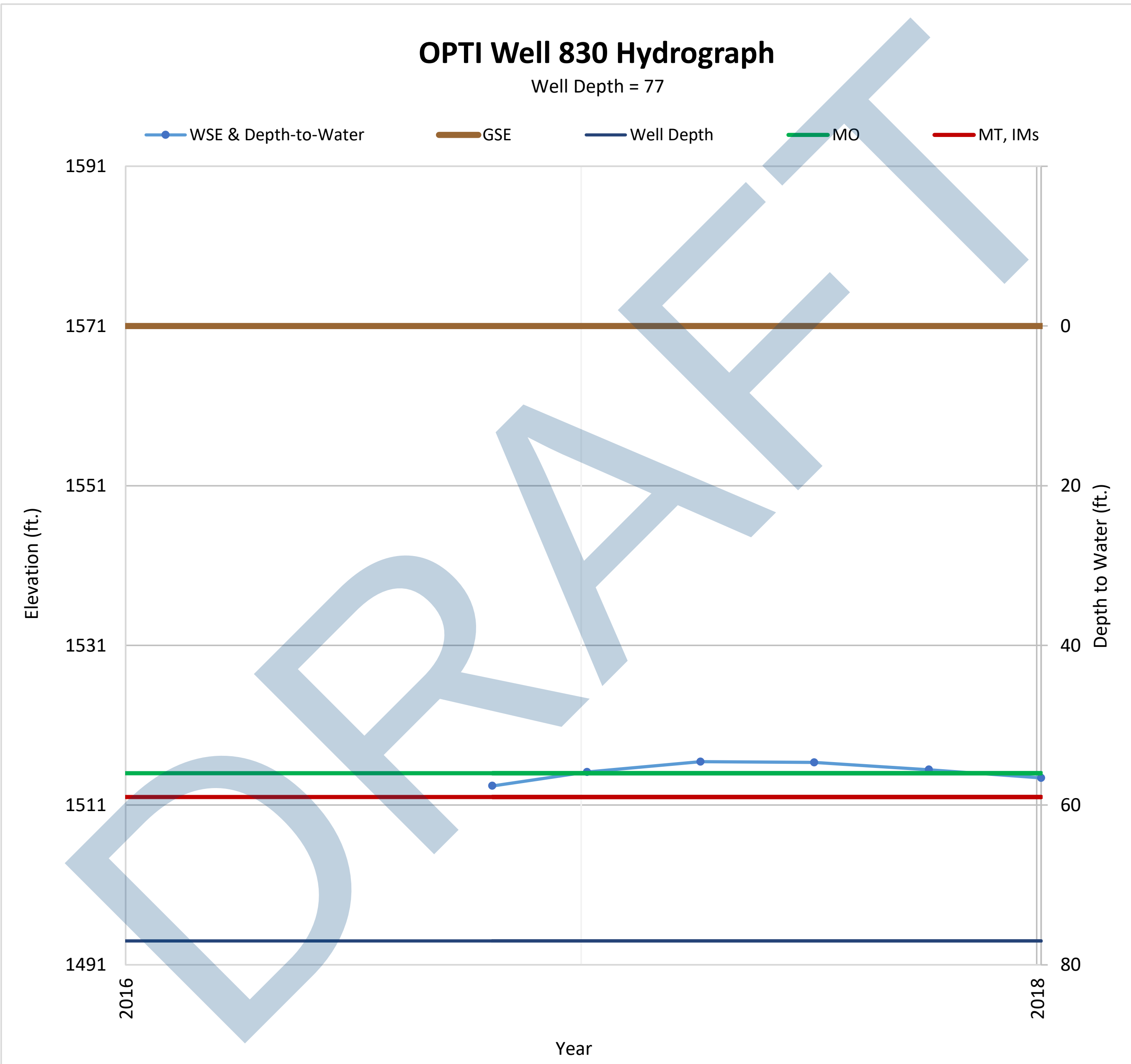

OPTI Well 620 Hydrograph
Well Depth = 1035
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
Year
2452
2432
2412
2392
2372
2352
2332
2312
2292
2272
2252
2232
2212
2192
2172
2152
2132
2112
2092
2072
2052
2032
2012
1992
1972
1952
1932
1912
1892
1872
1852
1832
1812
1792
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
DRAFT

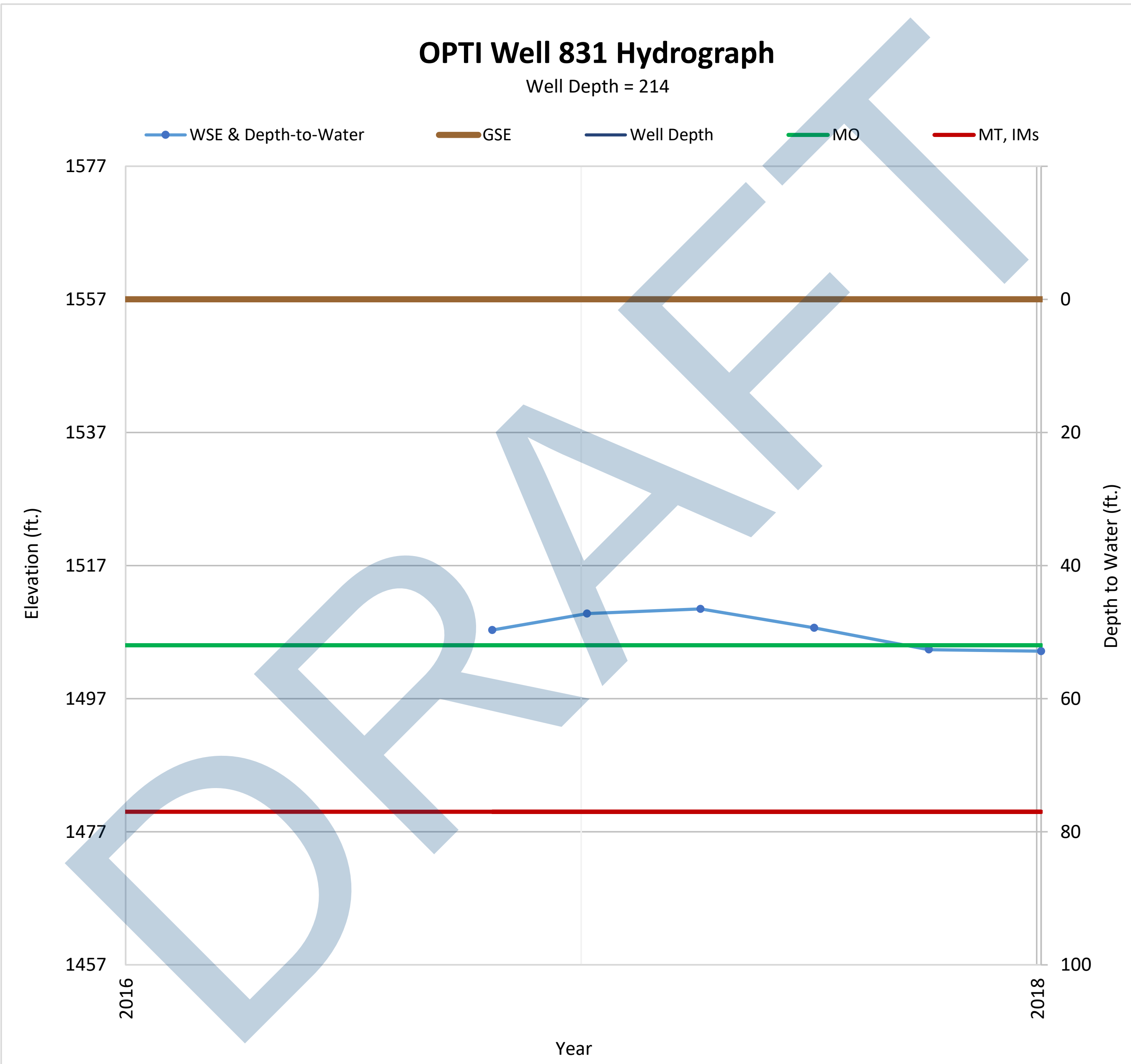


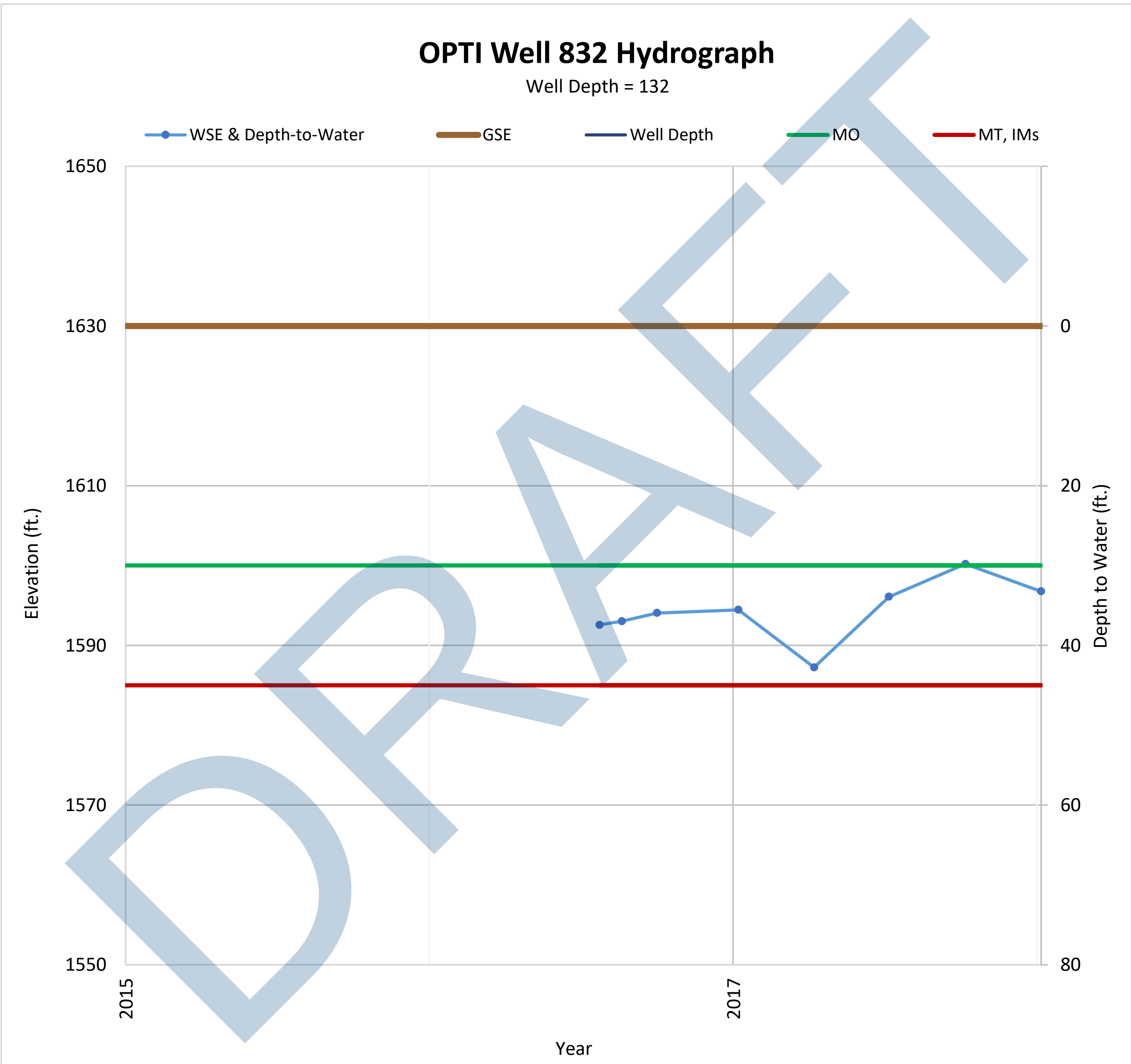
OPTI Well 629 Hydrograph
Well Depth = 1000
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
Year
2399
2379
2359
2339
2319
2299
2279
2259
2239
2219
2199
2179
2159
2139
2119
2099
2079
2059
2039
2019
1999
1979
1959
1939
1919
1899
1879
1859
1839
1819
1799
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
2006
2008
2010
2012
2014
2016
DRAFT



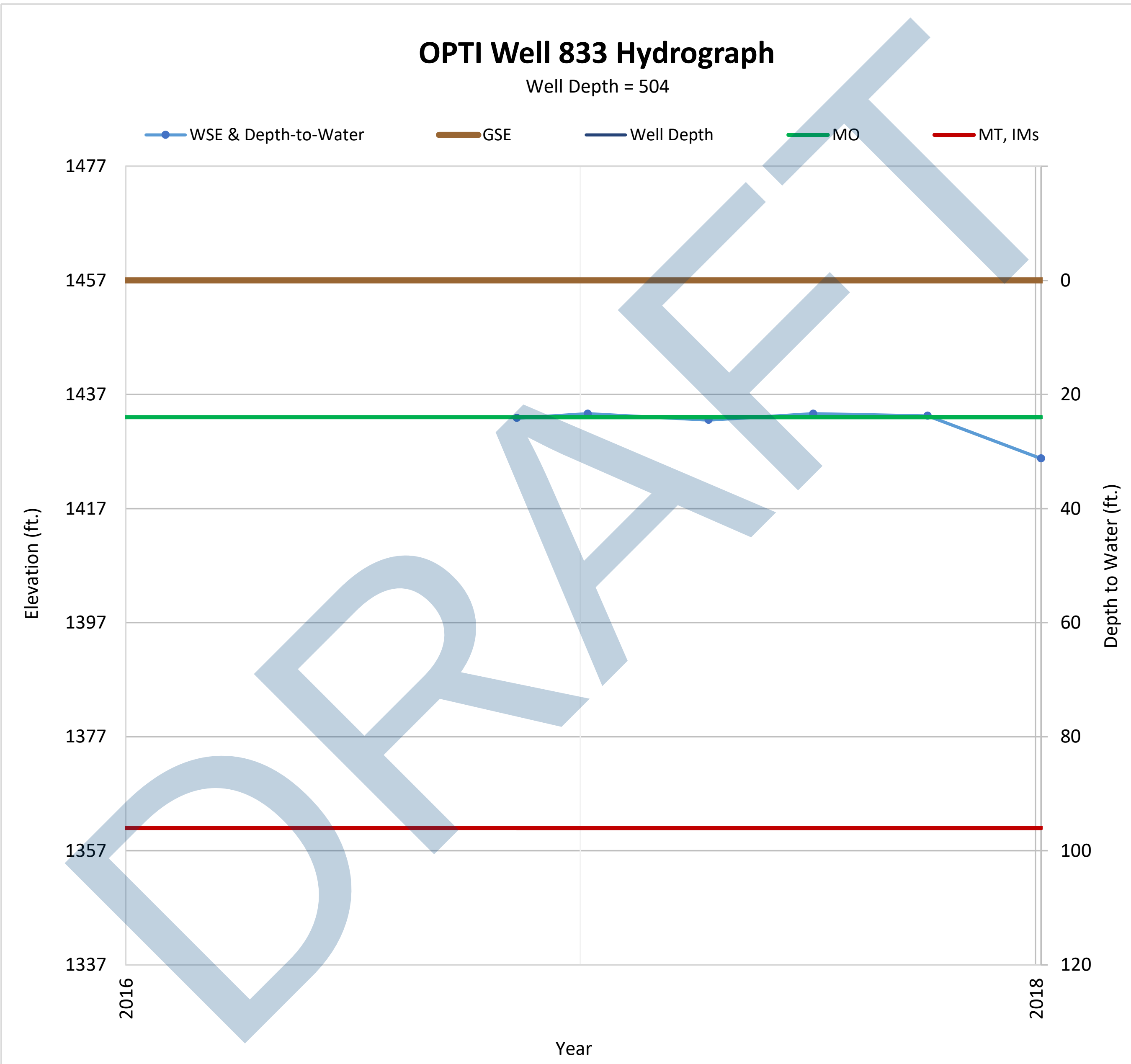
OPTI Well 633 Hydrograph
Well Depth = 1000
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
Year
2384
2364
2344
2324
2304
2284
2264
2244
2224
2204
2184
2164
2144
2124
2104
2084
2064
2044
2024
2004
1984
1964
1944
1924
1904
1884
1864
1844
1824
1804
1784
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
DRAFT


OPTI Well 830 Hydrograph
Well Depth = 77
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
1591
1571
1551
1531
1511
1491
Elevation (ft.)
0
20
40
60
80
Depth to Water (ft.)
2016
2018
Year
DRAFT

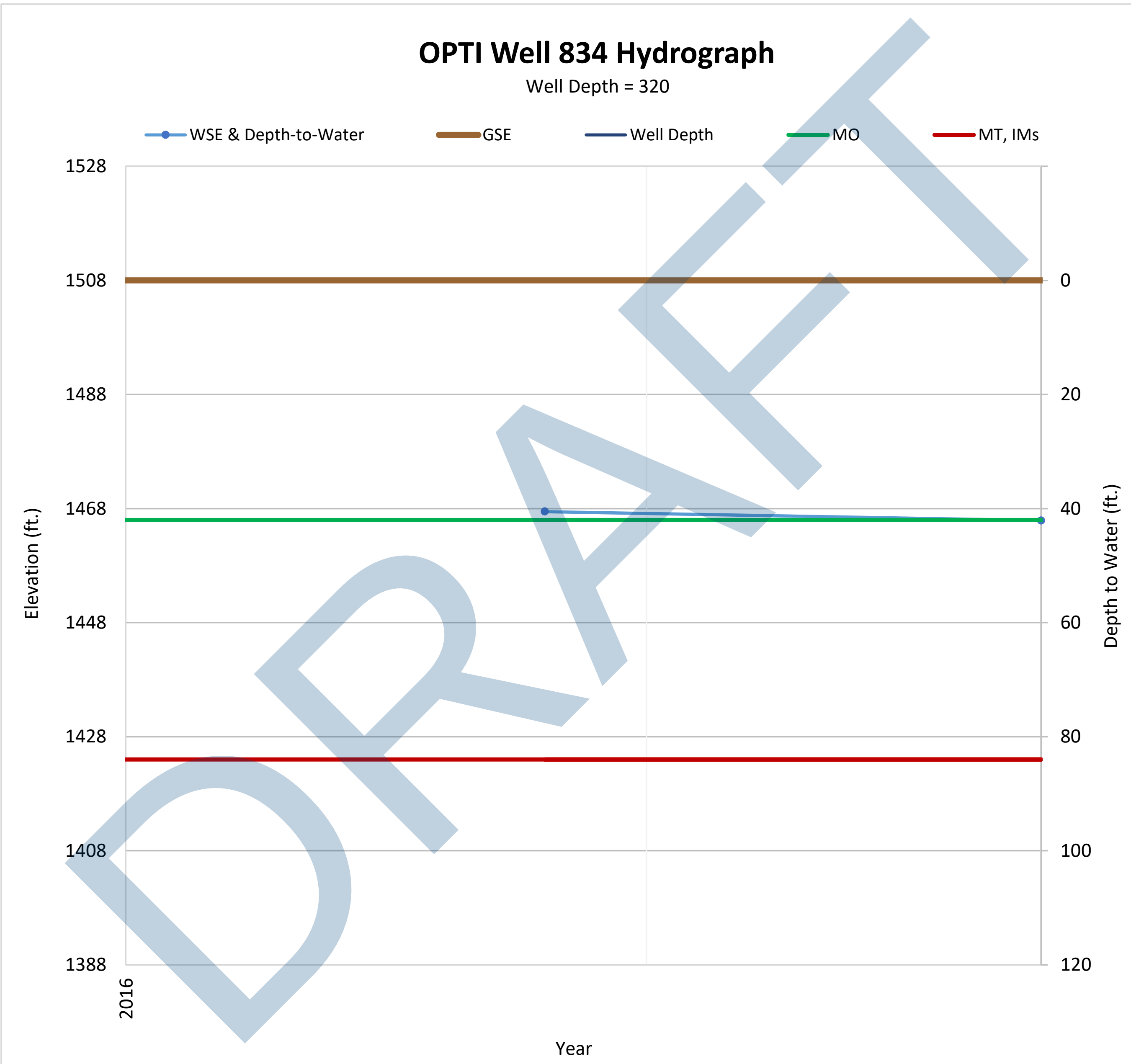

OPTI Well 831 Hydrograph
Well Depth = 214
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
1577
1557
1537
1517
1497
1477
1457
0
20
40
60
80
100
Elevation (ft.)
Depth to Water (ft.)
2016
2018
Year
DRAFT



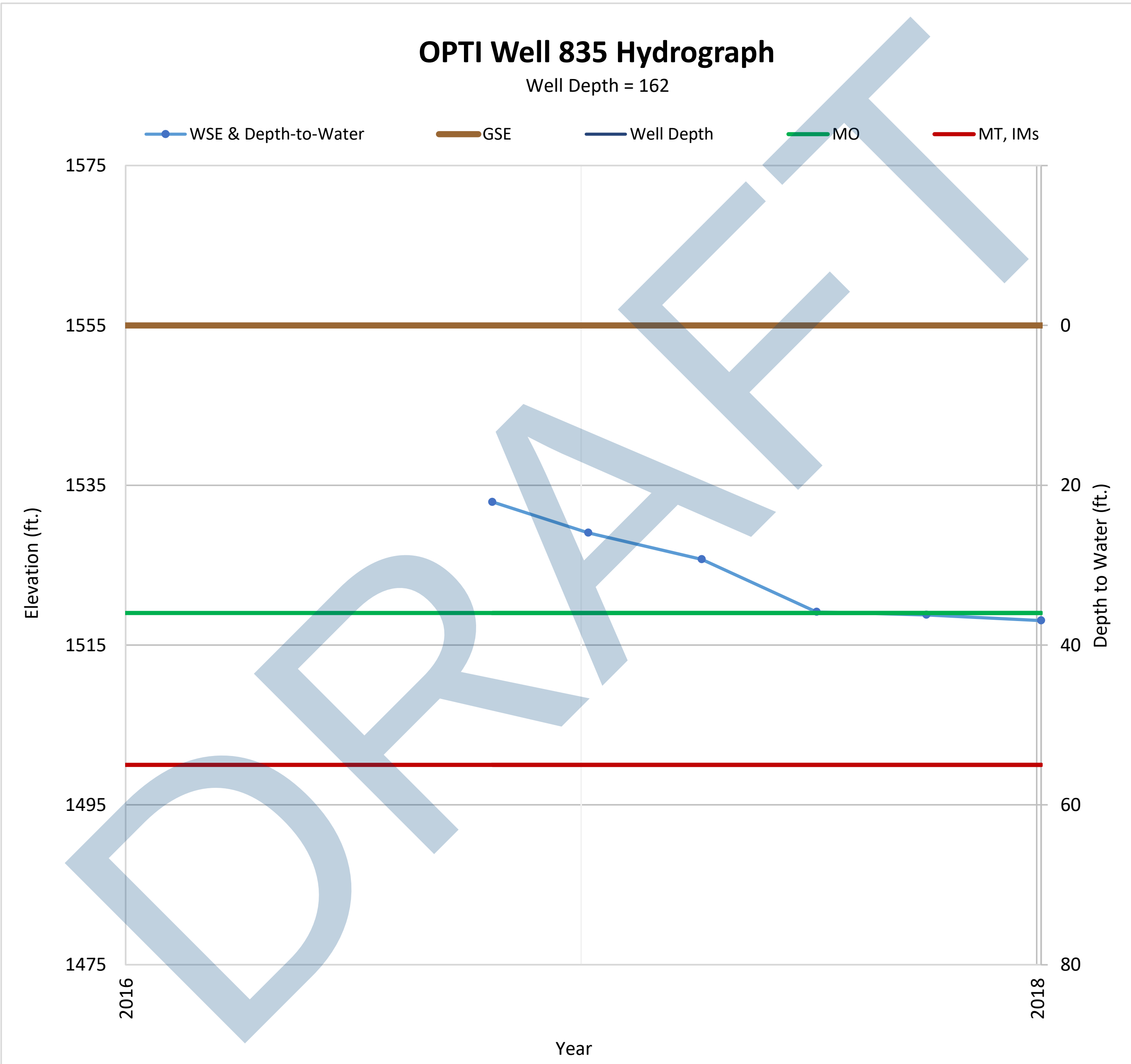
OPTI Well 832 Hydrograph
Well Depth = 132
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
1650
1630
1610
1590
1570
1550
Elevation (ft.)
0
20
40
60
80
Depth to Water (ft.)
2015
2017
Year
DRAFT

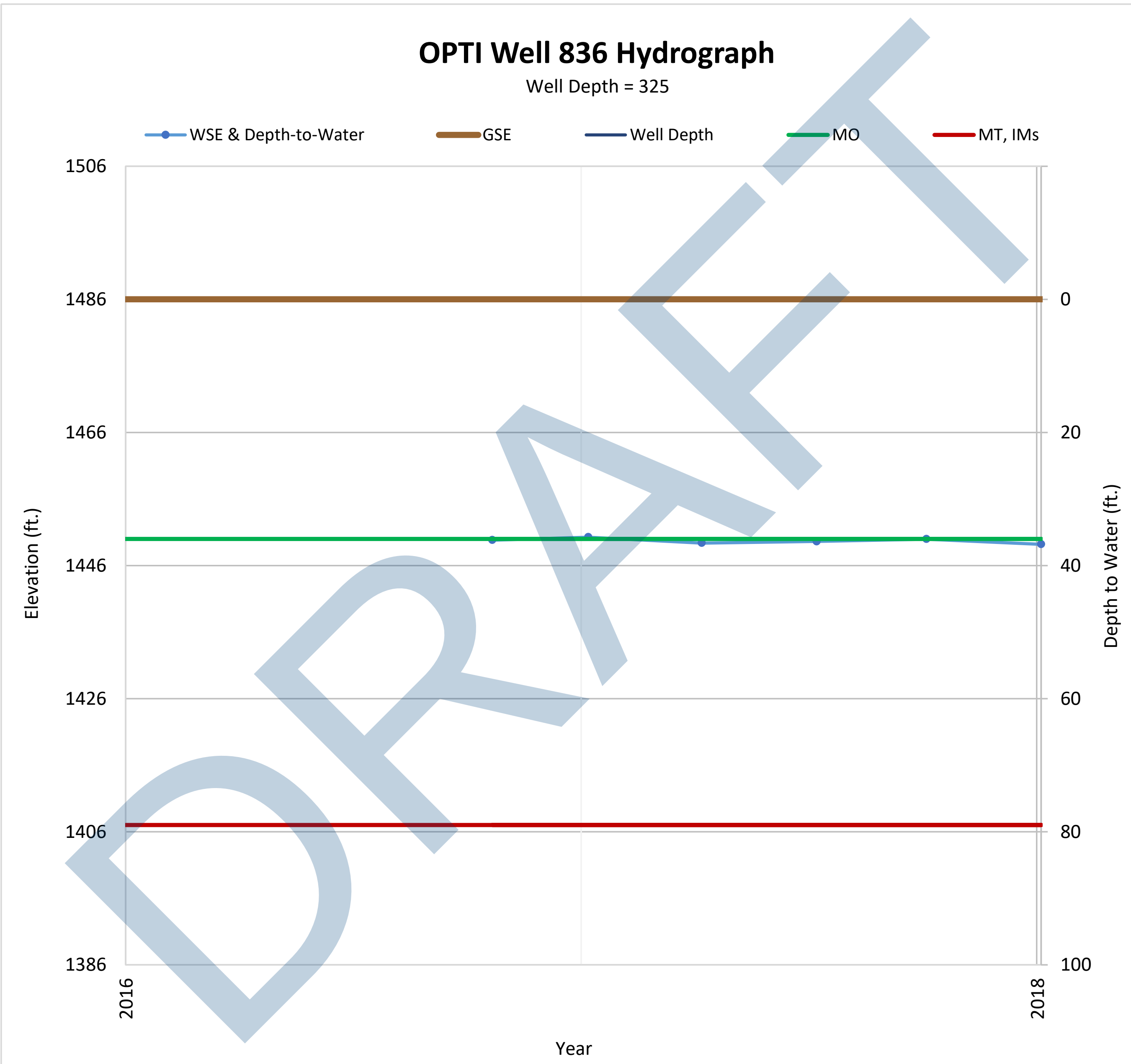


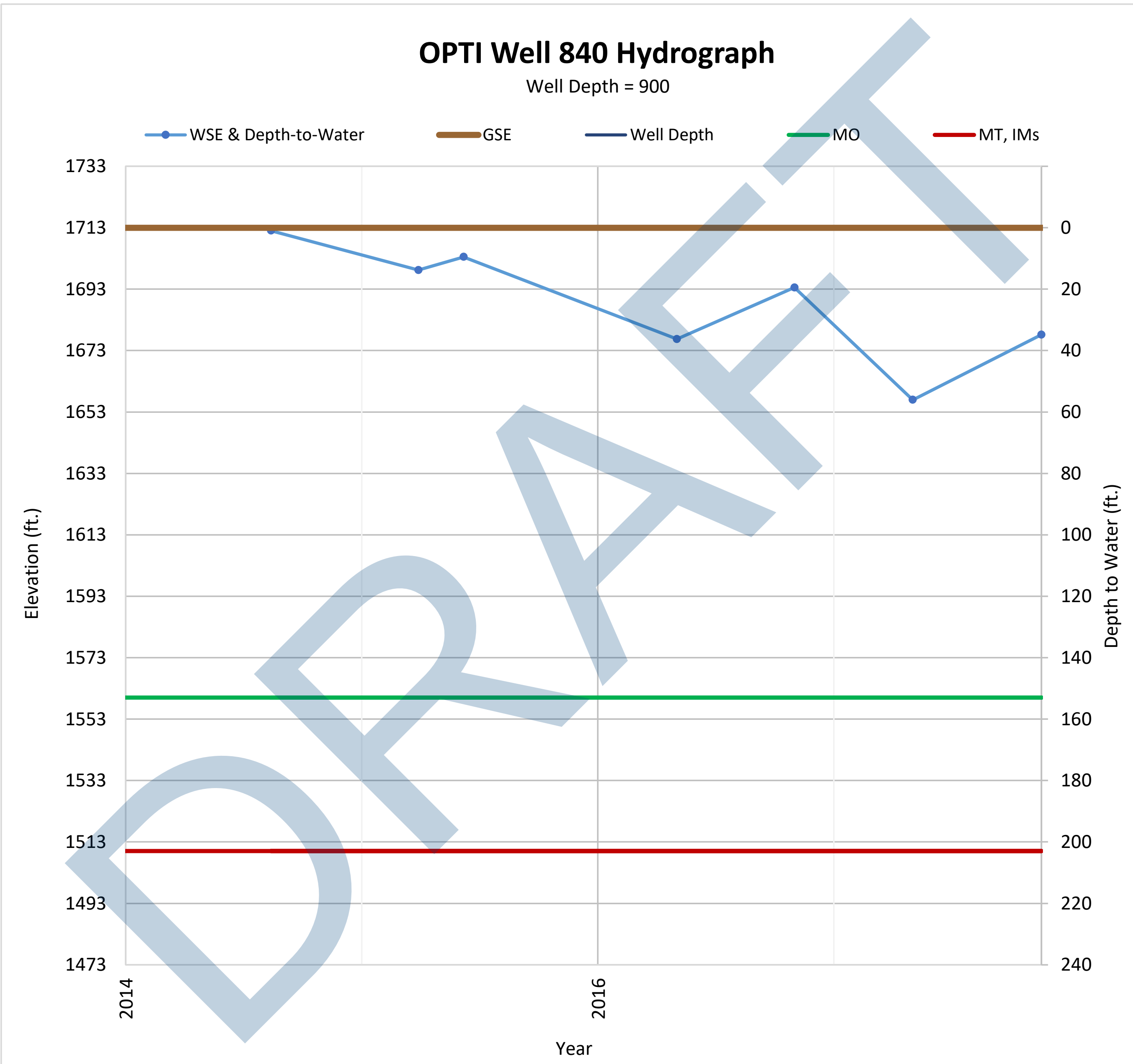
OPTI Well 833 Hydrograph
Well Depth = 504
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
1477
1457
1437
1417
1397
1377
1357
1337
0
20
40
60
80
100
120
Elevation (ft.)
Depth to Water (ft.)
2016
2018
Year
DRAFT

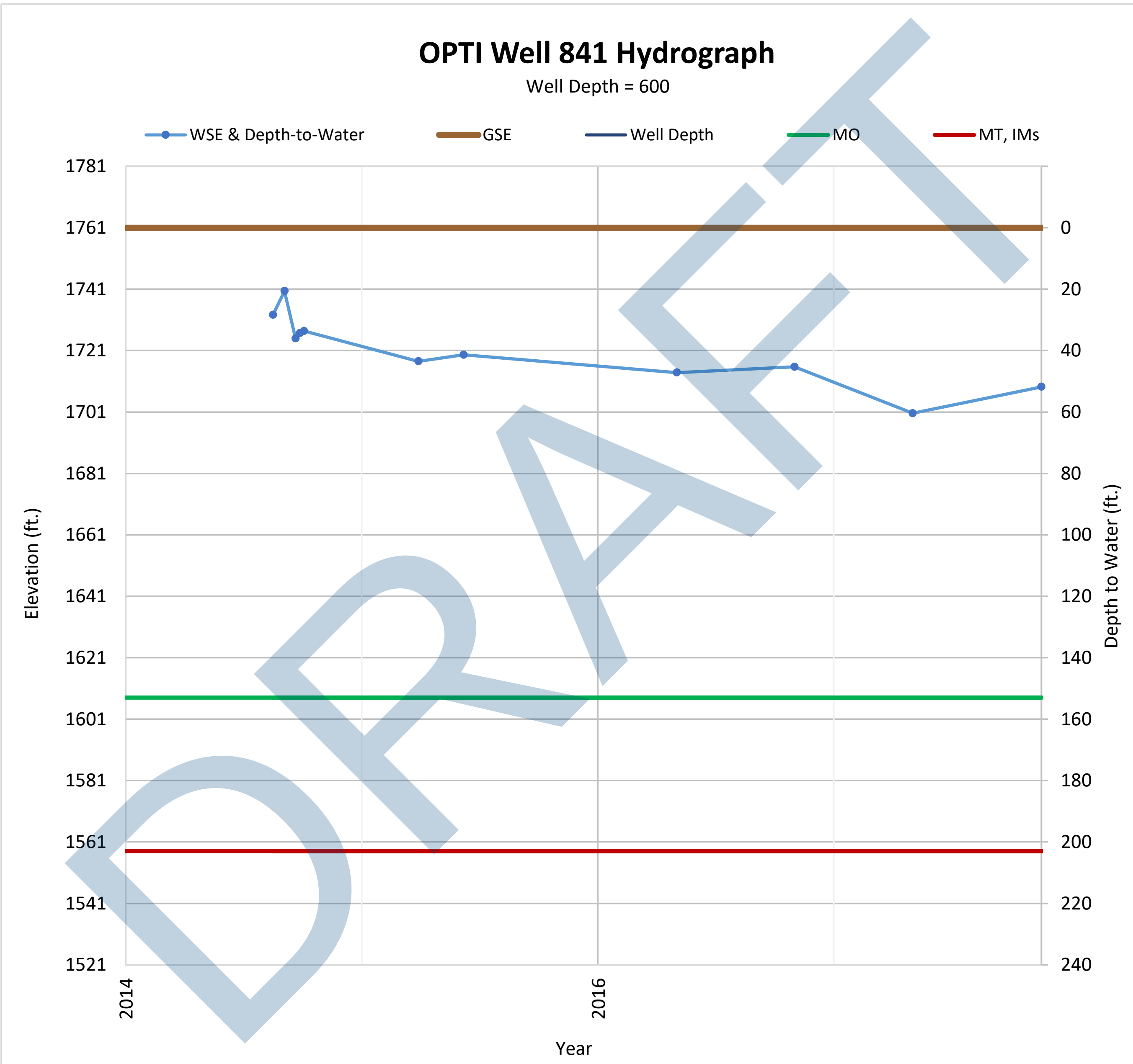


OPTI Well 834 Hydrograph
Well Depth = 320
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
1528
1508
1488
1468
1448
1428
1408
1388
0
20
40
60
80
100
120
Elevation (ft.)
Depth to Water (ft.)
2016
Year
DRAFT

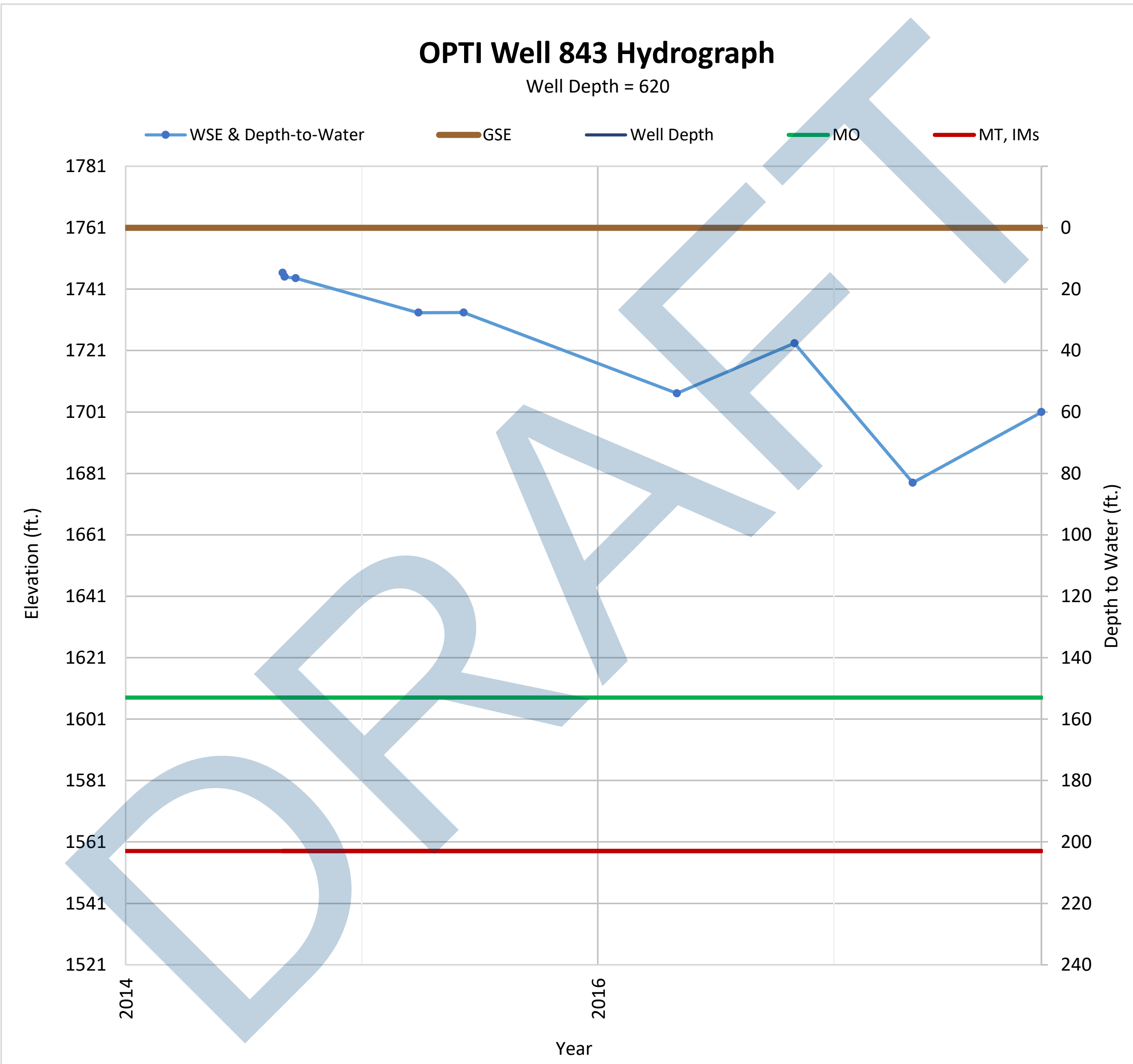

OPTI Well 835 Hydrograph
Well Depth = 162
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
1575
1555
1535
1515
1495
1475
0
20
40
60
80
Elevation (ft.)
Depth to Water (ft.)
2016
2018
Year
DRAFT


OPTI Well 836 Hydrograph
Well Depth = 325
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
1506
1486
1466
1446
1426
1406
1386
0
20
40
60
80
100
Elevation (ft.)
Depth to Water (ft.)
2016
2018
Year
DRAFT

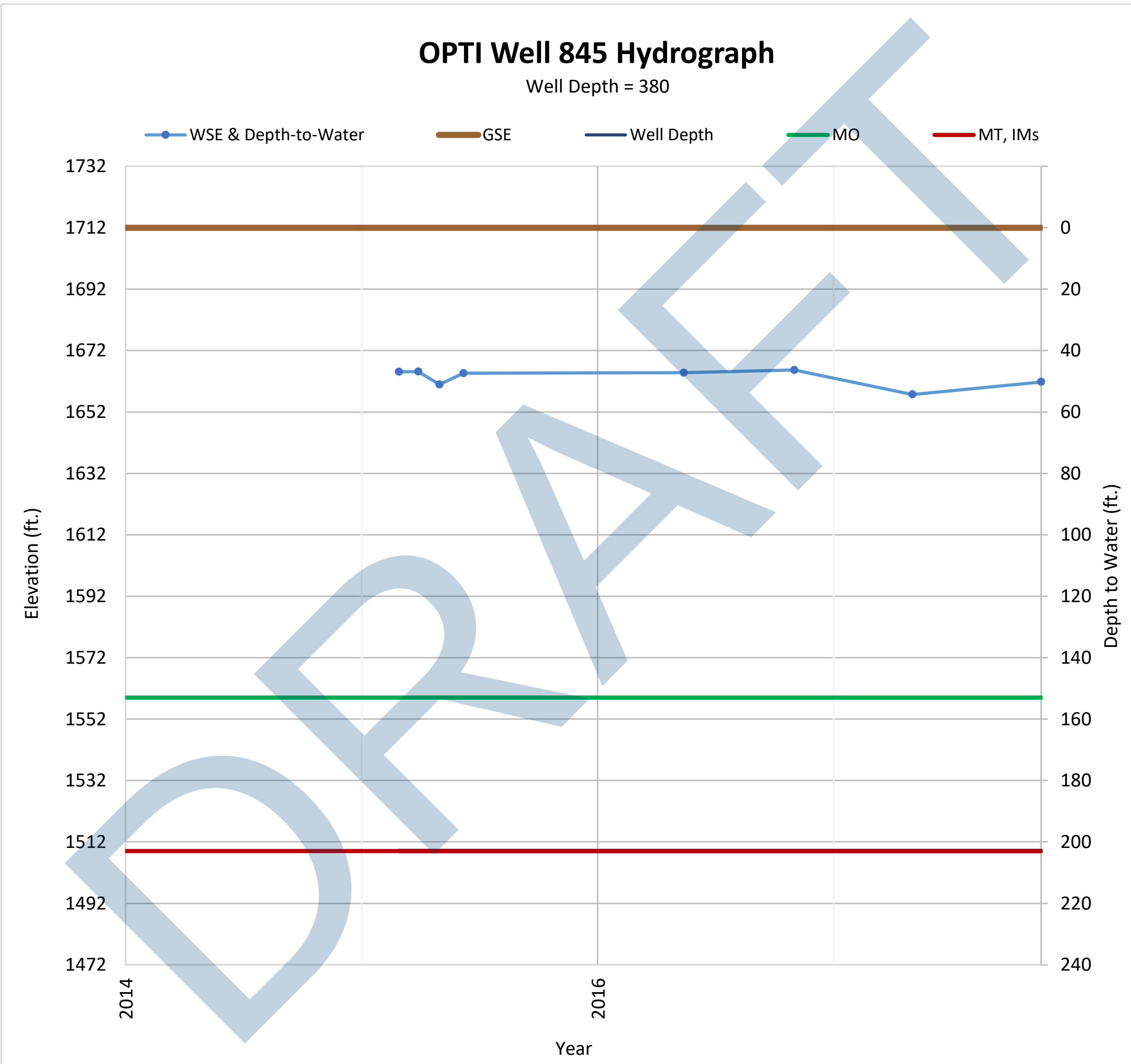

OPTI Well 840 Hydrograph
Well Depth = 900
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
1733
1713
1693
1673
1653
1633
1613
1593
1573
1553
1533
1513
1493
1473
0
20
40
60
80
100
120
140
160
180
200
220
240
Elevation (ft.)
Depth to Water (ft.)
2014
2016
Year
DRAFT



OPTI Well 841 Hydrograph
Well Depth = 600
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
1781
1761
1741
1721
1701
1681
1661
1641
1621
1601
1581
1561
1541
1521
0
20
40
60
80
100
120
140
160
180
200
220
240
Elevation (ft.)
Depth to Water (ft.)
2014
2016
Year
DRAFT



OPTI Well 843 Hydrograph
Well Depth = 620
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
1781
1761
1741
1721
1701
1681
1661
1641
1621
1601
1581
1561
1541
1521
0
20
40
60
80
100
120
140
160
180
200
220
240
Elevation (ft.)
Depth to Water (ft.)
2014
2016
Year
DRAFT



OPTI Well 845 Hydrograph
Well Depth = 380
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
Depth to Water (ft.)
1732
1712
1692
1672
1652
1632
1612
1592
1572
1552
1532
1512
1492
1472
0
20
40
60
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180
200
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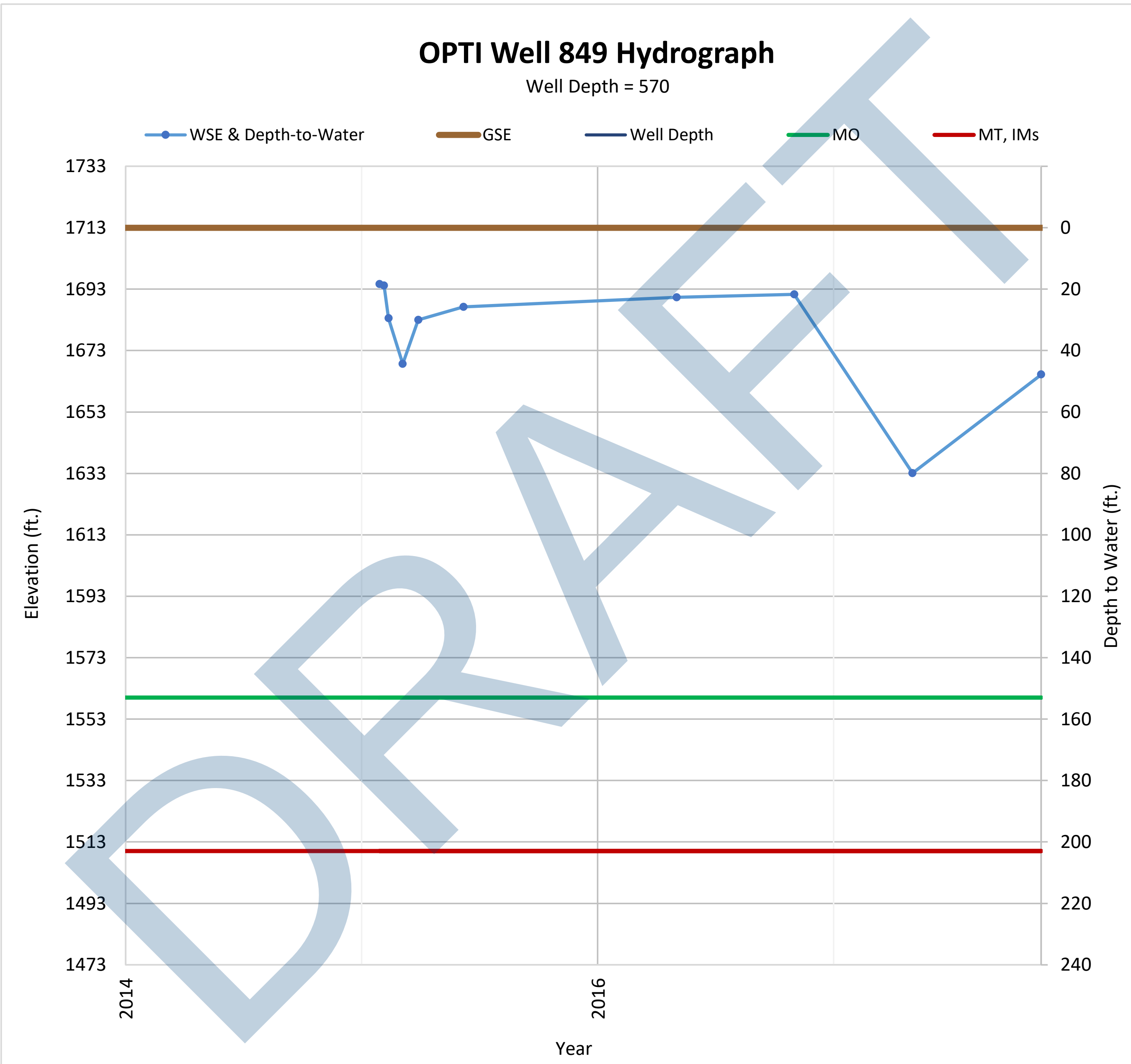
240
2014
2016
Year
DRAFT



OPTI Well 849 Hydrograph
Well Depth = 570
WSE & Depth-to-Water
GSE
Well Depth
MO
MT, IMs
Elevation (ft.)
1733
1713
1693
1673
1653
1633
1613
1593
1573
1553
1533
1513
1493
1473
Depth to Water (ft.)
0
20
40
60
80
100
120
140
160
180
200
220
240
2014
2016
Year
DRAFT

Cuyama Valley Groundwater Basin

Draft Groundwater Sustainability Plan: Data Management System

Prepared by:

CUYAMA BASIN GROUNDWATER SUSTAINABILITY AGENCY

WOODARD & CURRAN

April 2019

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Acronyms

CASGEM	California Statewide Groundwater Elevation Monitoring Program
CBGSA	Cuyama Basin Groundwater Sustainability Agency
CEDEN	California Environmental Data Exchange Network
DEM	digital elevation model
DMS	Data Management System
DWR	California Department of Water Resources
GAMA	Groundwater Ambient Monitoring and Assessment Program
GICIMA	Groundwater Information Center Interactive Map
GSE	ground surface elevation
GSP	Groundwater Sustainability Plan
ID	identification number
MSC	Master State Well Code
SGMA	Sustainable Groundwater Management Act
TDS	total dissolved solids
USGS	United States Geological Survey
USGS	United States Geological Survey
WDL	Water Data Library

Chapter 6 Data Management System

This chapter includes an overview of the Cuyama Basin Data Management System (DMS), describes how the DMS works, and details the data used in the DMS. This chapter satisfies Section 352.6 of the Sustainable Groundwater Management Act (SGMA) regulations.

6.1 DMS Overview

The Cuyama Basin DMS uses the Opti platform, which is a flexible and open software platform that uses familiar Google maps and charting tools for analysis and visualization. The DMS serves as a data-sharing portal that enables use of the same data and tools for visualization and analysis. These tools support sustainable groundwater management and create transparent reporting on collected data and analysis results. Figure 6-1 is a screenshot of the Opti platform.

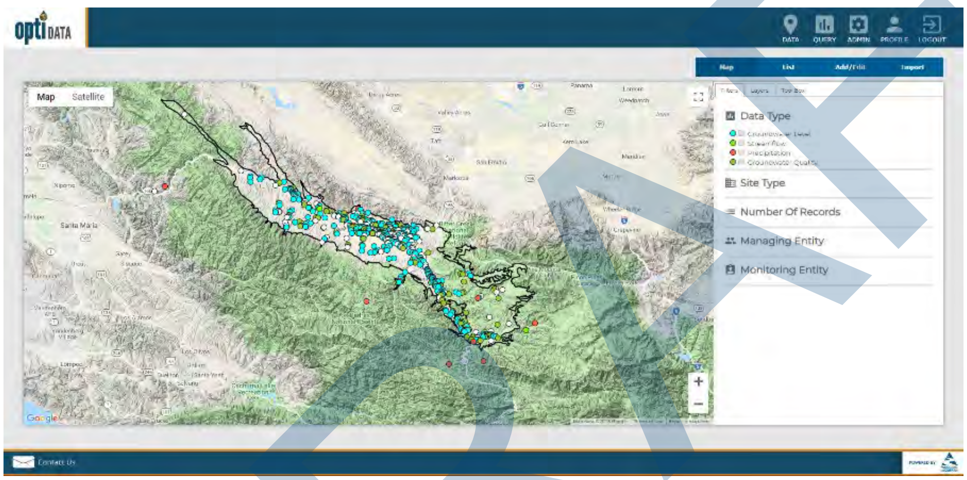

Figure 6-1. Screenshot of Opti Platform.

The Cuyama Basin DMS is a web-based publicly accessible portal that may be viewed using common web browsers such as Google Chrome, Firefox, and Microsoft Edge. The DMS utilizes Google maps and other charting tools for analysis and visualization. The site may be accessed at http://opti.woodardcurran.com/cuyama.

6.2 DMS Functionality

The DMS is a modular system that includes numerous tools to support GSP development and ongoing implementation, including the following:

- User and data access permissions
- Data entry and validation
- Visualization and analysis
- Query and reporting

As the needs of the Cuyama Basin Groundwater Sustainability Agency (CBGSA) change over time, the DMS can be configured for additional tools and functionality. The following sections describe the DMS's currently configured tools. For more detailed instructions about how to use the DMS, refer to the Cuyama Basin Data Management System Opti Data Public User Guide (Appendix A).

6.2.1 User and Data Access Permissions

DMS user access permissions are controlled through several user types. These user types have different roles in the DMS as summarized in Table 6-1 below. These user types are broken into three high-level categories as follows:

- **System Administrator** – System administrators manage information at a system-wide level, with access to all user accounts and entity information. System administrators can set and modify user access permissions when an entity is unable to do so.
- **Managing Entity (Administrator, Power User, User)** – Managing entity users are responsible for managing their entity's site/monitoring data, and can independently control access to these data. Entity users can view and edit their entity's data and view (but not edit) shared or published data supplied by other entities. An entity's site information (i.e., wells, gages, etc.) and associated data may only be edited by system administrators and power users associated with the entity. The CBGSA is currently configured as the managing entity for all datasets in the DMS.
- **Public** – Public users may view data that are published, but may not edit any information. Public users may access the DMS using the guest login feature on the DMS login screen (Figure 6-2).

Table 6-1. Data Management System User Types/Access

Modules/ Submodules	System Administrators	Managing Entity			Public
		Admin	Power User	User	
Data: Map	Access to all functionality	Access to all functionality	Access to all functionality	Access to all functionality	Access to partial functionality
Data: List	Access to all functionality	Access to all functionality	Access to all functionality	Access to all functionality	Access to partial functionality
Data: Add/Edit	Access to all functionality	Access to all functionality	Access to all functionality	--	--
Data: Import	Access to all functionality	Access to all functionality	Access to all functionality	--	--
Query	Access to all functionality	Access to all functionality	Access to all functionality	Access to all functionality	Access to partial functionality
Admin	Access to all functionality	--	--	--	--

Table 6-1. Data Management System User Types/Access

Modules/ Submodules	System Administrators	Managing Entity			Public
		Admin	Power User	User	
Profile	Access to all functionality	Access to all functionality	Access to partial functionality	Access to partial functionality	Access to partial functionality

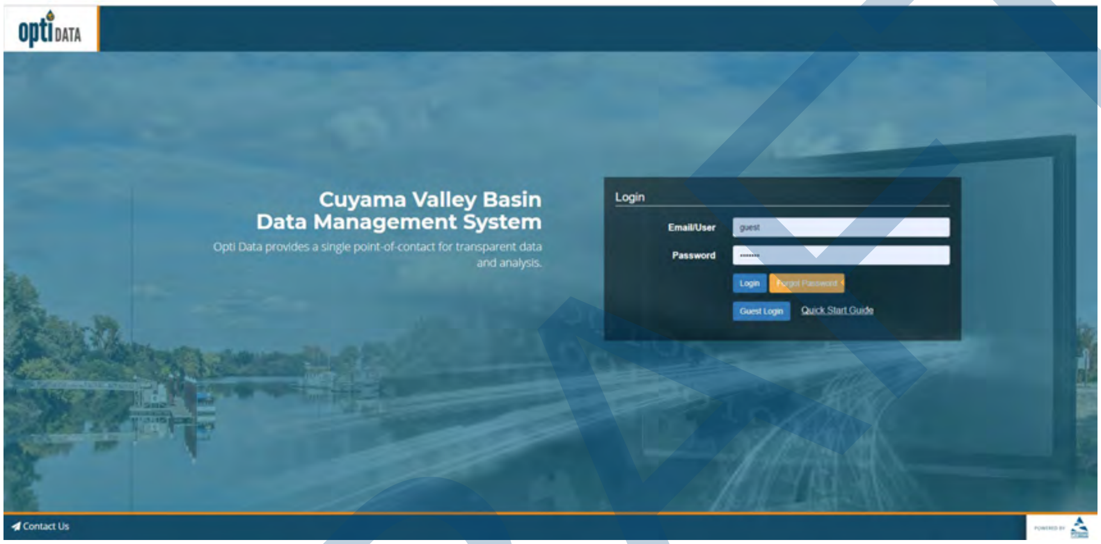

Figure 6-2: Screenshot of Opti Login Screen

Monitoring sites and their associated datasets are added to the DMS by managing entity administrators or power users. In addition to user permissions, access to the monitoring datasets is controlled through assigning one of three options to the data type as follows:

- **Private data** – Private data are monitoring datasets only available for viewing, depending on user type, by the entity's associated users in the DMS.
- **Shared data** – Shared data are monitoring datasets available for viewing by all users in the DMS, except for public users.
- **Public data** – Public data are monitoring datasets that are available publicly that can be viewed by all user types in the DMS; public datasets may also be published to other websites or DMSs as needed.

Managing entity administrators can set and maintain data access options for each data type associated with their entity.

6.2.2 Data Entry and Validation

To encourage agency and user participation in the DMS, data entry and import tools are designed to be easy to use, are accessible over the web, and help maintain data consistency and standardization. The

DMS allows entity administrators and power users to enter data either manually via easy-to-use interfaces, or through an import tool using Microsoft Excel templates, so that data may be entered into the DMS as soon as possible after collection. The data records are validated by a managing entity's administrators or power users using a number of quality control checks prior to inclusion in the DMS.

Data Collection Sites

Users can input site information about groundwater wells, stream gages, and precipitation meters manually either through the data entry tool or when prompted in the import tool. Using the data entry tool, new sites may be added by clicking on "New Site." Existing sites may be updated using the "Edit Site" tool. During data import, the sites associated with imported data are checked by the DMS against an existing site list. If the site is not in the existing site list, the user is prompted to enter the information via the new site tool before the data import can proceed.

Table 6-2 lists the information that is collected for sites. Required information is indicated with an asterisk; all other information is considered optional.

Table 6-2. Data Collection Site Information

Basic Information	Well Information	Construction Information
Site Type* Opti Site Name* Local Site Name* Additional Name Latitude/Longitude* Description County Managing Entity* Monitoring Entity* Type of Monitoring Type of Measurement Monitoring Frequency	State Well ID MSC (Master State Well Code) USGS Code CASGEM ID Ground Surface Elevation (feet) Reference Point Elevation (feet) Reference Point Location Reference Point Description Well Use Well Status Well Type Aquifers Monitored Groundwater Basin Name/Code Groundwater Elevation Begin/End Date Groundwater Elevation Measurement Count Water Level Measurement Method Groundwater Quality Begin/End Date Groundwater Quality Measurement Count Comments	Total Well Depth Borehole Depth Casing Perforations Top/Bottom Elevation Casing Diameter Casing Modifications Well Capacity Well Completion Report Number Comments

Notes:
ID = identification number
MSC = Master State Well Code
USGS = United States Geological Survey
CASGEM = California Statewide Groundwater Elevation Monitoring Program

Monitoring Data Entry

Monitoring data, including groundwater elevation, groundwater quality, streamflow, and precipitation may be input either manually through the data entry tool or by using templates in the import tool. Figure 6-3 is a screenshot of the data entry interface.

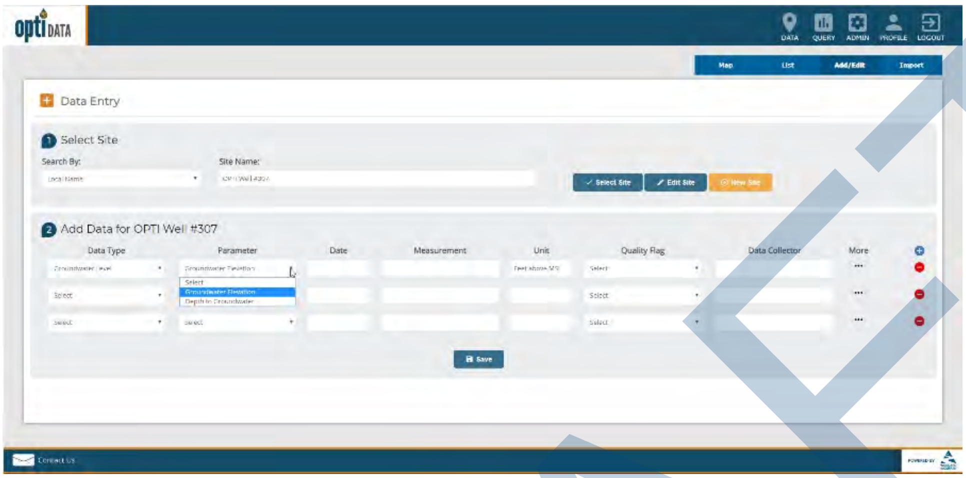

Figure 6-3. Screenshot of Data Entry Tool Interface.

The data entry tool allows users to select a site and add data for the site using a web-based form. The following information is collected:

- Data type (e.g. groundwater elevation, groundwater quality, streamflow, or precipitation)
- Parameter for selected data type, units populate based on selection
- Date of measurement
- Measurement value
- Quality flag (i.e., quality assurance description for the measurement such as “Pumping,” “Can’t get tape in casing,” etc. as documented by the data collector)
- Data collector
- Supplemental information based on data type (i.e., reference point elevation, ground surface elevation, etc.)

Data import templates include the same data entry fields and are available for download from the DMS. The Microsoft Excel-based templates contain drop-down options and field validation similar to the data entry interface.

Data Validation

Quality control helps ensure the integrity of the data added to the DMS. The entities that maintain the monitoring data loaded into the DMS may have performed previous validation of that data; no effort was made to check or correct that previous validation, and it was assumed that all data records provided were valid. While it is nearly impossible to determine complete accuracy of the data added to the DMS since the DMS cannot detect incorrect measurements due to human error or mechanical failure, it is possible to verify that the data input into the DMS meets some data quality standards. This helps promote user confidence in the data both stored and published for visualization and analysis.

Upon saving the data via the data entry interface or by importing the data using the Microsoft Excel templates, the following data validation checks are performed by the DMS:

- **Duplicate measurements** – The DMS checks for duplicate entries based on the unique combination of site, data type, date, and measurement value.
- **Inaccurate measurements** – The DMS compares data measurements against historical data for the site and flags entries that are outside the historical minimum and maximum values.
- **Incorrect data entry** – Data field entries are checked for correct data type (e.g., number fields do not include text, date fields contain dates, etc.).

Users are alerted to any validation issues and may either update the data entries or accept the values and continue with the entry/import. Users may access partially completed import validation through the import logs that are saved for each data import. The partially imported datasets are identified in the import log with an incomplete icon under the status field. This allows a second person to also access the imported data and review prior to inclusion in the DMS.

6.2.3 Visualization and Analysis

Transparent visualization and analysis tools enable use of the same data and methodologies, allowing stakeholders and neighboring GSAs to use the same data and methods for tracking and analysis. In the DMS, data visualization and analysis are performed in both map and list views, as described below.

Map View

The map view displays all sites (i.e., groundwater wells, stream gages, precipitation meters, etc.) in a map-based interface (Figure 6-4). The sites are color-coded based on associated data type and may be filtered by different criteria, such as number of records or monitoring entity. Users may click on a site to view the site detail information and associated data. The monitoring data records are displayed in both chart and table formats. In these views, the user may view different parameters for the data type. The chart and table may be updated to display selected date ranges, and the data may be exported to Microsoft Excel.

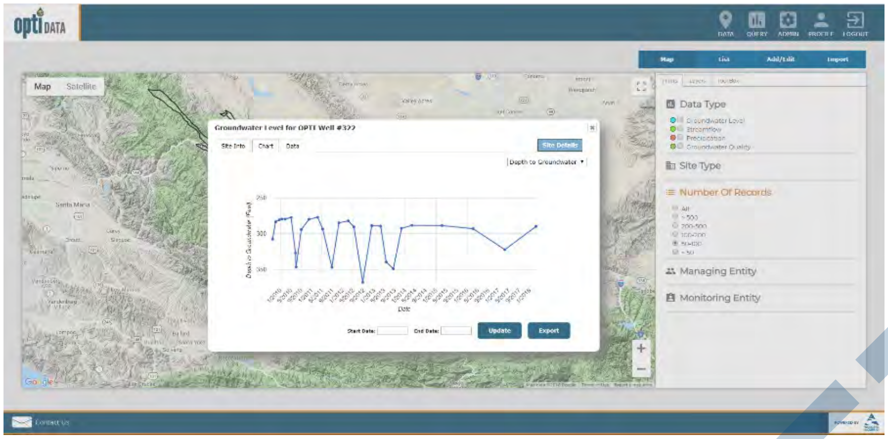

Figure 6-4. DMS Map View.

List View

The list view displays all sites (i.e., groundwater wells, stream gages, precipitation meters, etc.) in a tabular interface. The sites are listed according to names and associated entities. The list can be sorted and filtered by different criteria such as number of records or monitoring entity. Similar to the map view, users may click on a site to view the site detail information and associated data. The monitoring data records are displayed in both chart and table formats. In these views, the user may view different parameters for the data type. The chart and table may be updated to display selected date ranges, and the data may be exported to Microsoft Excel.

Analysis Tools

The toolbox is available in the map view and offers administrative and entity users access to the well tiering tool to support monitoring plan development. The DMS' flexible platform allows for the development and addition of future analysis tools, including contouring, total water budget visualization, and management area tracking.

6.2.4 Query and Reporting

The DMS has the ability to format and export data and analysis at different levels of aggregation, and in different formats, to support local decision making and for submission to various statewide and local programs (i.e., SGMA, CASGEM Program, Groundwater Ambient Monitoring and Assessment (GAMA) Program, etc.).

Ad Hoc Query

Data in the DMS can be queried and reported using the query tool. The query tool includes the ability to build ad hoc queries using simple options. The data can be queried by the following criteria:

- Monitoring or managing entity
- Site name
- Data type

Once the type of option is selected, the specific criteria may be selected (e.g., groundwater elevation greater than 100 feet). Additionally, users may include time periods as part of the query. The query options can build upon each other to create reports that meet specific needs. Queries may be saved and will display in the saved query drop-down menu for future use.

Query results are displayed in a map format and a list format. In both the map and list views, the user may click on a well to view the associated data. Resulting query data may be exported to Microsoft Excel.

Standard Reports

The DMS can be configured to support wide-ranging reporting needs through the reports tool. Standard report formats may be generated based on a predetermined format and may be created at the click of a button. These report formats may be configured to match state agency requirements for submittals, including annual reporting of monitoring data that must be submitted electronically on forms provided by the California Department of Water Resources (DWR).

6.3 Data Included in the DMS

Because many monitoring programs operate in the Basin at both the local and state/federal levels, a cross-sectional analysis was conducted during GSP development in the Cuyama Basin to document and assess the availability of water-related data in the Basin. Statewide and federal databases that provide data relevant to Basin were also assessed.

The DMS can be configured to include a wide variety of data types and associated parameters. Based on the analysis of existing datasets from the Basin and GSP needs, Table 6-3 lists the data that are identified and currently configured in the DMS.

Table 6-3. Data Types and Their Associated Parameters Configured in the DMS

Data Type	Parameter	Units	Currently Has Data in DMS
Groundwater Elevation	Depth to Groundwater	feet	Yes
	Groundwater Elevation	feet	Yes
Groundwater Quality	Total Dissolved Solids (TDS)	milligrams per liter (mg/L)	Yes
	Nitrate (NO_3)	mg/L	Yes
	Arsenic	micrograms per liter (µg/L)	Yes
	Benzene	µg/L	--
	Chloride	mg/L	--
	Hexavalaent Chromium (Cr(VI))	µg/L	--
	1,2-Dibromo-3-Chloropropane (DBCP)	µg/L	--
	Methyl Tertiary-Butyl Ether (MTBE)	µg/L	--
	Perchlorate	µg/L	--
	Tetrachloroethylene (PCE)	µg/L	--
	Specific Electrical Conductivity (SC)	micromhos per centimeter (µmhos/cm)	--
	1,1,1-Trichloroethane (111-TCA)	µg/L	--
	Trichloroethylene (TCE)	µg/L	--
	1,2,3-Trichloropropane (123-TCP)	µg/L	--
	Chloride (CL)	parts per million (ppm)	--
	Electrical Conductivity (EC)	millimhos (mmhos)	--
	Total Dissolved Solids (TDS)	ppm	--
Streamflow	Streamflow	cubic feet per second (cfs)	Yes
Precipitation	Precipitation	inches	Yes
	Reference Evapotranspiration (ETo)	--	--
	Average Air Temperature	--	--
Subsidence	Subsidence	vertical (in millimeters)	Yes

Additional data types and parameters can be added and modified as the DMS grows over time.

The datasets were collected from a variety of sources, as shown in Table 6-4. Each dataset was reviewed for overall quality and consistency prior to consolidation and inclusion in the database. In many cases, there were discrepancies between the ground surface elevation (GSE) of a well from different sources. In these cases of discrepancy, the GSE of the well was updated using the USGS digital elevation model (DEM).

The groundwater wells shown in the DMS are those that included datasets provided by the monitoring data sources for groundwater elevation and quality. These do not include all wells currently used for production, and may include wells historically used for monitoring that do not currently exist. Care was taken to minimize duplicate well information in the DMS. As datasets were consolidated, sites were evaluated based on different criteria (e.g., naming conventions, location, etc.) to determine if the well was included in a different dataset. Data records for the wells were then associated with the same well, where necessary.

After the datasets were consolidated and reviewed for consistency, they were loaded into the DMS. Using the DMS data viewing capabilities, the datasets were then reviewed for completeness and consistency to ensure imports were successful.

Table 6-4. Sources of Data Included in the Data Management System

Data Source	Datasets Collected	Date Collected	Activities Performed
US Geological Survey (USGS)	• Groundwater Elevation • Streamflow • Precipitation	5/4/2018	• Removed duplicate records • Recalculated GSE based on DEM on select wells
DWR CASGEM/Water Data Library (WDL)	• Groundwater Elevation	4/18/2018	• Removed duplicate records • Recalculated GSE based on DEM on select wells
San Luis Obispo County	• Groundwater Elevation • Groundwater Quality	4/2/2018	• Removed duplicate records • Recalculated GSE based on DEM on select wells
Santa Barbara County Water Agency	• Groundwater Elevation • Precipitation	3/27/2018	• Removed duplicate records • Recalculated GSE based on DEM on select wells
Ventura County	• Groundwater Elevation • Groundwater Quality • Precipitation	3/8/2018	• Removed duplicate records • Recalculated GSE based on DEM on select wells
DWR Natural Resources Agency	• Groundwater Quality	6/14/2018	• Removed duplicate records
GeoTracker	• Groundwater Quality	6/5/2018	• Removed duplicate records
California Environmental Data Exchange Network (CEDEN)	• Groundwater Quality	8/29/2018	• Removed duplicate records
National Water Quality Monitoring Council	• Groundwater Quality	6/1/2018	• Removed duplicate records
UNAVCO	• Ground Surface Elevation	3/12/2018	• None
Local Data	• Groundwater Elevation • Groundwater Quality • Other	Various	• Removed duplicate records • Recalculated GSE based on DEM on select wells

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Appendix A

Cuyama Basin Data Management System
Opti Data Public User Guide

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Cuyama Basin Data Management System

optiDATA

Public User Guide

CUYAMA BASIN GROUNDWATER SUSTAINABILITY AGENCY

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Opti Public User Guide

Opti is a one-stop-shop for transparent data management and analysis that enables integrated performance tracking to support sustainable water management. This Public User Guide has been developed to assist you with navigation and usage of the Cuyama Basin Data Management System (DMS). Please see the Appendix for specific data types and quality codes configured in this implementation.

The DMS may be accessed at: http://opti.woodardcurran.com/cuyama

Please click on Guest Login to access the DMS as a guest user. If you would like to gain additional access to the DMS for data updates and management, please contact: Taylor Blakslee (tblakslee@hgcpm.com).

Public usage of the DMS is explained in the following modules:

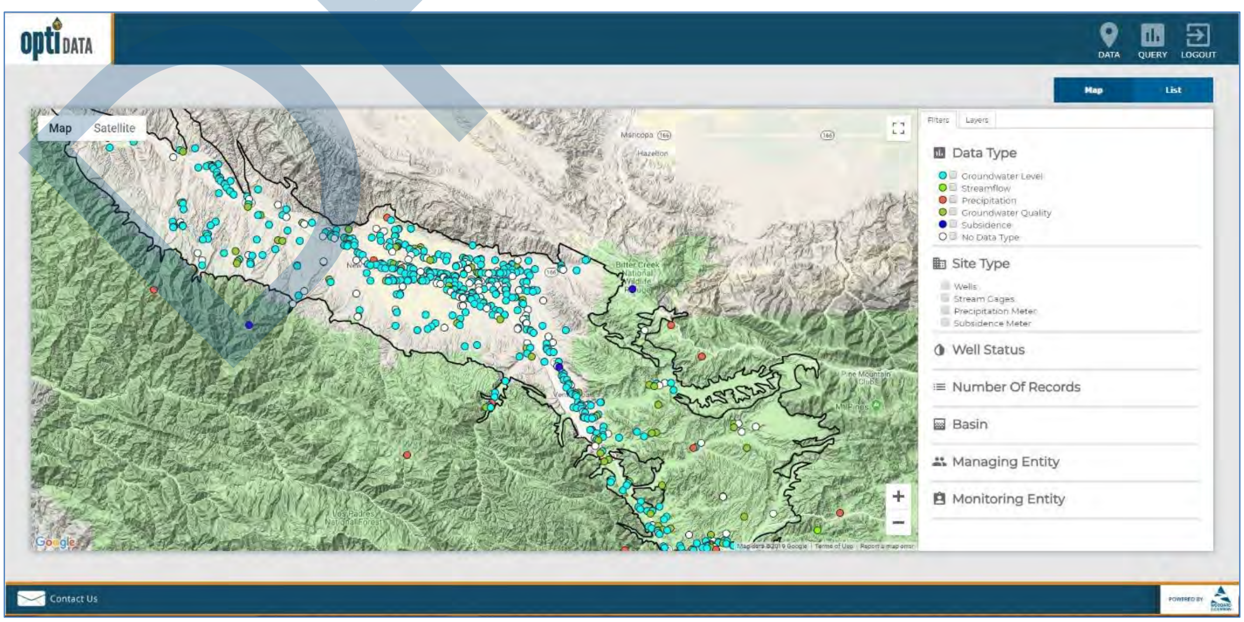
- Data
- Query

Module: Data (Top)

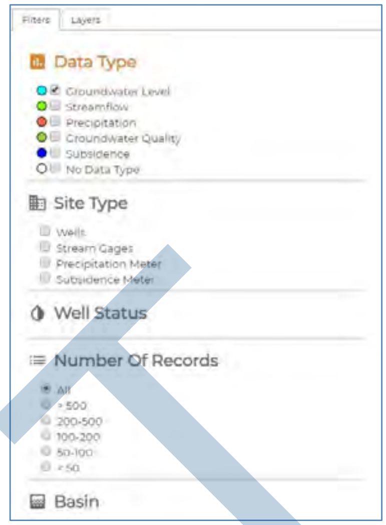
The Data module contains two available submodules that allow you to view water resources data and their associated site information: Map and List. Upon entering the DMS, a welcome message will be displayed. Click Close to continue to the Map.

Submodule: Map

The Map submodule displays the sites (wells, stream gages, facilities, etc.) as point locations on the map.



Feature: Change the Google Map display



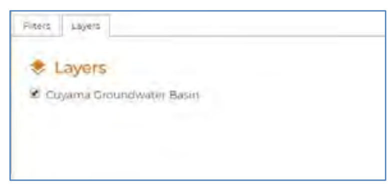
- To move the location or extent of the map display, use the "+" and "-" icons in the lower right-hand corner of the map. You may use the pan tool to move the focal location of the display.
- To change the base layer of the map display, select an option from the upper l eft-hand side of the map display (Map or Satellite).

Feature: Filter the results displayed on the map

- On the Filters tab on the right-hand panel, select the checkboxes for the options for which you would like to filter the results.
- Select sites based on:
  - o data type associated with the site,
  - o site type,
  - o number of data records,
  - o entity, or
  - o a combination of any filter.

Please note that sites may have more than one data type associated with them, e.g., groundwater level and groundwater quality.

Feature: Change the layers displayed on the map



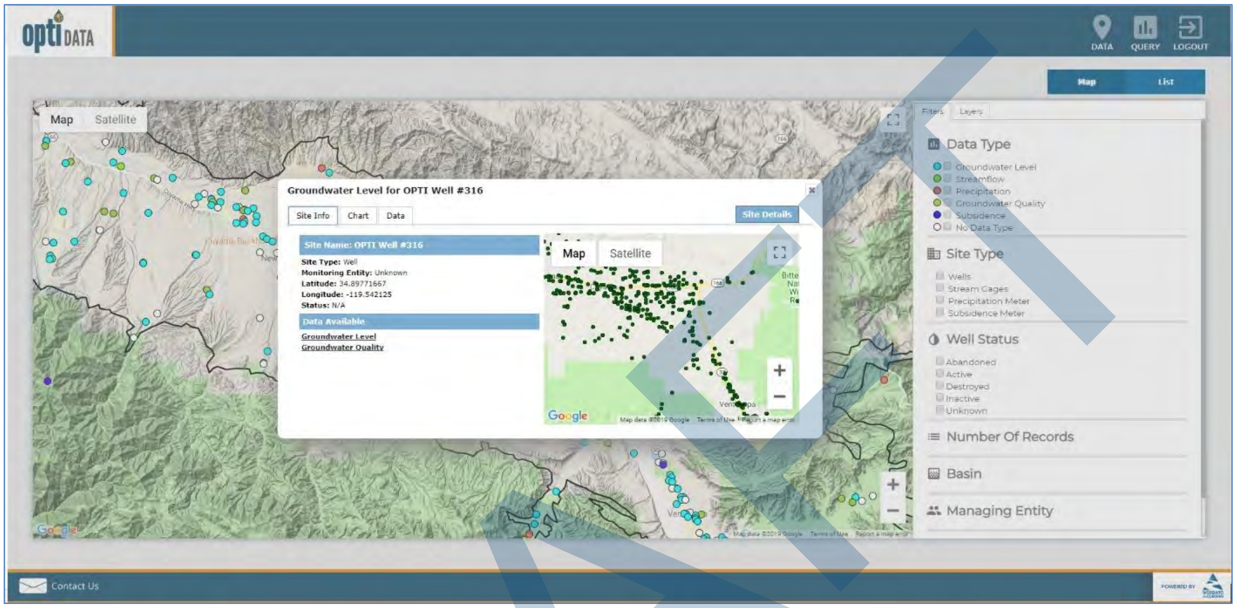
- Click on the Layers tab on the right-hand panel.
- Select the layers that you wish to have displayed. Upon selection, the map will be updated to show the selected layers.
- You may click on features on the layer to view information on that feature.

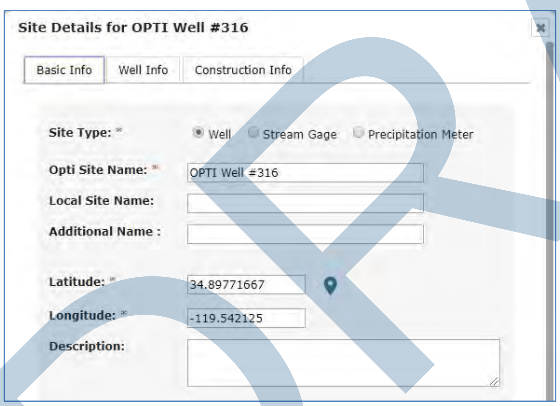
Feature: View site information on the map

- Click on a site on the map. The site information will be displayed with tabs for Site Info, Chart, and Data.
- To view site detailed information, click on the Details link. The Site Details page will open.
- To view a chart of the data, click on the Chart tab. You may change the parameter by selecting a parameter from the drop-down list in the upper right-hand corner. You may update the chart timeline by selecting the Start Date and End Date and clicking Update. You may export the data to Excel by clicking Export.
- To view a table of the data, click on the Data tab. You may change the parameter by selecting a parameter from the drop-down list in the upper right-hand corner. You may narrow the tabular

list by selecting the Start Date and End Date and clicking Update. You may export the data by clicking Export.

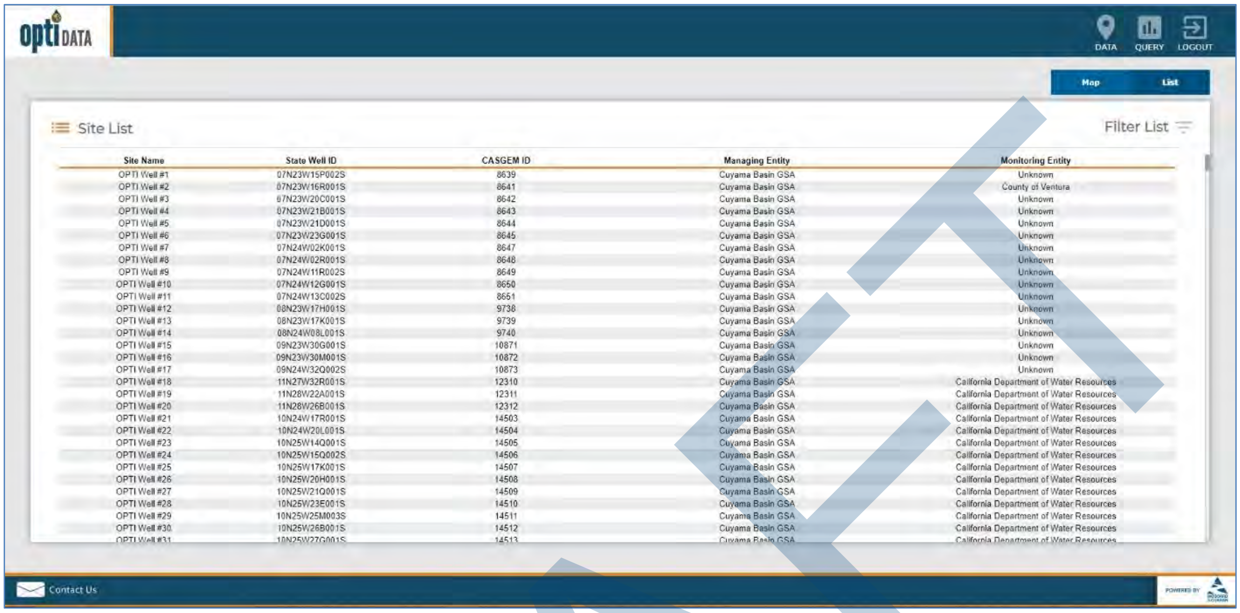
- To select a different data type for the site, click on the data type available under "Data Available" on the Site Info tab.





Submodule: List

The List submodule contains a list of sites in a sortable, tabular format.



Feature: Filter and/or sort sites

- Select data type, site type, number of records, or entity from the drop-down menu at the top of the table to filter sites.
- Click on the table headers to alphabetically or numerically sort the selected column.

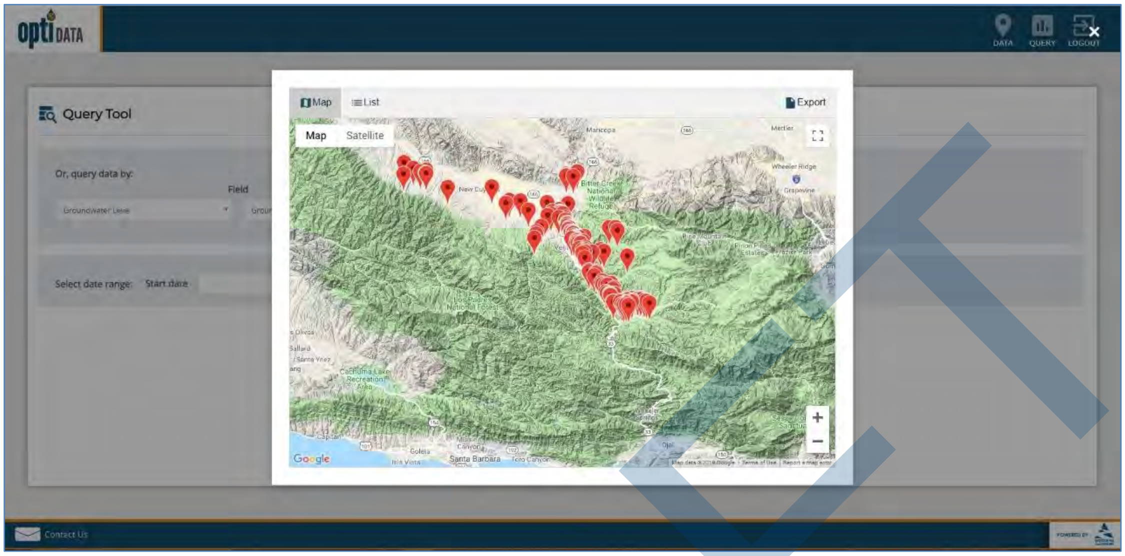
Feature: View site information from list

- Click on the selected site name in the list. The site information will be displayed with tabs for Site Info, Chart, and Data. The Site Details page is available through this dialogue box. The following information may be available:

Basic Info	Well Info	Construction Info
Site Type Opti Site Name Local Site Name Additional Name Latitude/Longitude Description County Managing Entity Monitoring Entity Type of Monitoring Type of Measurement Monitoring Frequency	State Well ID MSC (Master State Well Code) USGS Code CASGEM ID Ground Surface Elevation (ft) Reference Point Elevation (ft) Reference Point Location Reference Point Description Well Use Well Status Well Type Aquifers Monitored Groundwater Basin Name/Code Groundwater Elevation Begin/End Date Groundwater Elevation Measurement Count Water Level Measurement Method Groundwater Quality Begin/End Date Groundwater Quality Measurement Count Comments	Total Well Depth Borehole Depth Casing Perforations Top/Bottom Elevation Casing Diameter Casing Modifications Well Capacity Well Completion Report Number Comments

Module: Query (Top)

The Query module allows users to search for sites and data using different parameters and values.



Feature: Create new query

- Click on the Query icon in the menu.
- To create a new query:
    - Select the following options from the drop-down menu under “Or, query data by:”:
        - Entity
        - Site Name
        - Groundwater Level
        - Streamflow
        - Precipitation
        - Groundwater Quality
        - Surface Water Quality
    - If the selected option has associated parameters, select a parameter in the second drop-down menu.
    - Select an Operator. Please note that for text searches, you may use the “Like” option with wildcards (%).
    - To add additional rows to the query, click on the blue “+” button and complete.
    - To remove rows from the query, click on the red “-“ button.
- To select data within a particular date range, complete the Start date and End date fields.
- Click Run. A window will open with a map view of the results.
    - Click on the site in the map to view the data for the site.
    - Click on the List tab to view the data in a list format. You may click on a site to view the data.
    - Click on Export to export the data to Excel.
- To clear the query, click the Clear button at the bottom of the page.

Appendix – Cuyama Basin Specific Implementation Information

Data Types

The following data types are currently configured in the DMS. Please note that this list may change as more data becomes available.

Data Type	Parameter	Units	Currently Has Data in DMS
Groundwater Elevation	Depth to Groundwater	feet	Yes
	Groundwater Elevation	feet	Yes
Groundwater Quality	Total Dissolved Solids (TDS)	MG/L	Yes
	Nitrate (NO3)	MG/L	Yes
	Arsenic	UG/L	Yes
	Benzene	UG/L	
	Chloride	MG/L	
	Hexavalaent Chromium (CR6)	UG/L	
	Dibromochloropropane (DBCP)	UG/L	
	Methyl Tertiary Butyl Ether (MTBE)	UG/L	
	Perchlorate	UG/L	
	Tetrachloroethylene (PCE)	UG/L	
	Specific Electrical Conductivity (SC)	UMHOS/CM	
	1,1,1-Trichloroethane (111-TCA)	UG/L	
	Trichloroethylene (TCE)	UG/L	
	1,2,3-Trichloropropane (123-TCP)	UG/L	
	CL	PPM	
	EC	Mmhos	
	TDS	PPM	
Streamflow	Streamflow	CFS	Yes
Precipitation	Precipitation	inches	Yes
	Reference Evapotranspiration (ETo)		
	Average Air Temperature		
Subsidence	Subsidence	Vertical (mm)	Yes

Quality Flags for Measurement Data

The following quality flags are currently configured in the DMS. Please note that this list may change as more data becomes available.

ID	Quality Flag	Associated Data Type
1	Caved or deepened	Groundwater Level
2	Pumping	Groundwater Level
3	Nearby pump operating	Groundwater Level
4	Casing leaking or wet	Groundwater Level
5	Pumped recently	Groundwater Level
6	Air or pressure gauge measurement	Groundwater Level
7	Other	Groundwater Level
8	Recharge or surface water effects near well	Groundwater Level
9	Oil or foreign substance in casing	Groundwater Level
10	Acoustical sounder	Groundwater Level
11	Recently flowing	Groundwater Level
12	Flowing	Groundwater Level
13	Nearby flowing	Groundwater Level
14	Nearby recently flowing	Groundwater Level
15	Measurement Discontinued	Groundwater Level
16	Pumping	Groundwater Level
17	Pump house locked	Groundwater Level
18	Tape hung up	Groundwater Level
19	Can't get tape in casing	Groundwater Level
20	Unable to locate well	Groundwater Level
21	Well has been destroyed	Groundwater Level
22	Special/Other	Groundwater Level
23	Casing leaking or wet	Groundwater Level
24	Temporarily inaccessible	Groundwater Level
25	Dry well	Groundwater Level
26	Flowing artesian well	Groundwater Level

Cuyama Valley
Groundwater Basin

Draft Groundwater Sustainability Plan: Projects and Management Actions

Prepared by:

April 2019

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Acronyms

Basin	Cuyama Valley Groundwater Basin
CBGSA	Cuyama Basin Groundwater Sustainability Agency
CCSD	Cuyama Community Services District
GSP	Groundwater Sustainability Plan
SBCWA	Santa Barbara County Water Agency
SGMA	Sustainable Groundwater Management Act
VWSC	Ventucopa Water Supply Company
CMWC	Cuyama Mutual Water Company
CEQA	California Environmental Quality Act
NEPA	National Environmental Policy Act
AF	acre-feet
AFY	acre-feet per year
AHOG	ground-based cloud seeding site

Chapter 7 Projects and Management Actions

7.1 Introduction

This chapter of the Cuyama Basin Groundwater Sustainability Agency's (CBGSA's) Draft *Groundwater Sustainability Plan* (GSP) includes the Projects, Management Actions and Adaptive Management information that satisfies Sections 354.42 and 354.44 of the Sustainable Groundwater Management Act (SGMA) regulations.[1] These projects and their benefits will help achieve sustainable management goals in the Cuyama Groundwater Basin (Basin).

7.2 Management Areas

The CBGSA has designated two areas in the Basin as management areas: the Central Basin Management Area and the Ventucopa Management Area, which are both defined as regions with modeled overdraft conditions greater than 2 feet per year (see Figure 7-1). The Central Basin Management Area is located in the middle of the CBGSA area, and includes the community of Cuyama as well as the surrounding agricultural land uses that are located in areas with greater than 2 feet overdraft. While the Cuyama Community Service District (CCSD) service area also has modeled overdraft exceeding 2 feet, it is not included in the management area. The Ventucopa Management Area is located south of the Central Basin Management Area and includes the community of Ventucopa. The two management areas are generally separated from one another by the Santa Barbara Canyon Fault. Both are located nearly entirely within the boundaries of the Cuyama Basin Water District. The remaining areas in the Basin are not included in a management area, and generally operate with balanced groundwater pumping and recharge, based on modeling of Basin water budgets.

[1] SGMA's requirements for GSPs can be read here: https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/GSP_Emergency_Regulations.pdf

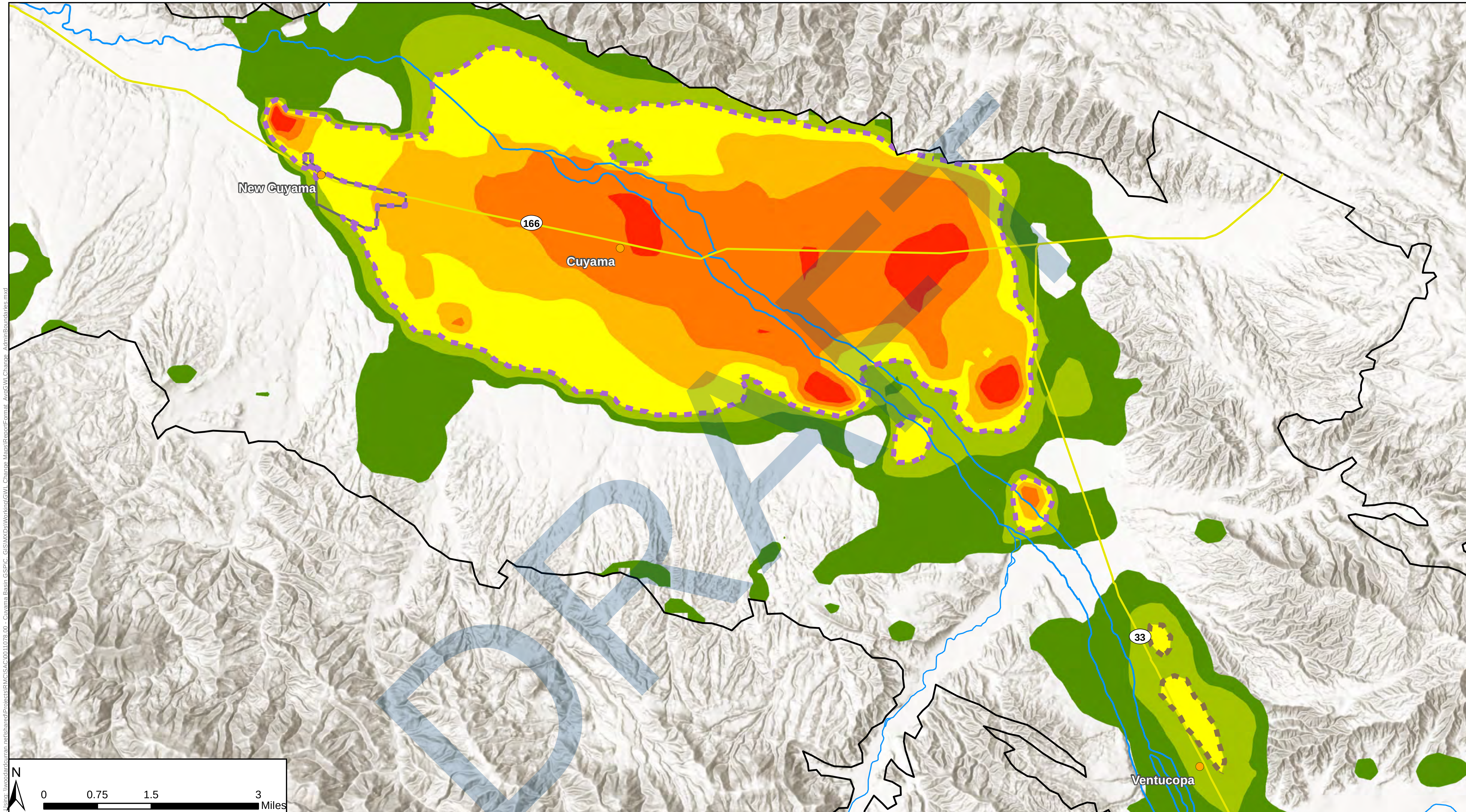

Figure 7-1 - Cuyama GW Basin CBGSA Management Areas

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

April 2019

WOODARD & CURRAN

Legend

- Cuyama Basin
- Cuyama Community Service District
- Towns
- Central Management Area
- Ventucopa Management Area
- Cuyama River
- Streams
- Highways

Average Annual Modeled Groundwater Level Change (ft./year)

- -7.7 to -5
- -5 to -4
- -4 to -3
- -3 to -2
- -2 to -1
- -1 to -0.2
- >-0.2

Figure Exported: 4/17/2019 By: ceggleton Using: \\woodardcurran.net\shared\Projects\RMC\SAC\0011078.00 - Cuyama Basin GSP\C. GIS\MXDs\Working\GWL Change Maps\ReportFormat_AvgGWLChange_AdminBoundaries.mxd

7.3 Overview of Projects and Management Actions

The CBGSA has developed a number of potential project and management actions to help address overdraft and move the Basin toward sustainability. Table 7-1 lists these proposed activities, along with their current status, potential timing, and anticipated costs. Benefits are summarized in Section 7.2 and discussed in detail in Sections 7.3 and 7.4.

Table 7-1. Proposed Projects, Management Actions, and Adaptive Management Strategies

Activity	Current Status	Anticipated Timing	Estimated Cost[a]
Project 1: Flood and Stormwater Capture	Conceptual project evaluated in 2015	• Feasibility study: 0 to 5 years • Design/Construction: 5 to 15 years	• Study: $1,000,000 • Flood and Stormwater Capture Project: $600-$800 per AF ($2,600,000 – 3,400,000 per year)
Project 2: Precipitation Enhancement	Initial Feasibility Study completed in 2016	• Refined project study: 0 to 2 years • Implementation of Precipitation Enhancement: 0 to 5 years	• Study: $200,000 • Precipitation Enhancement Project: $25 per AF ($150,000 per year)
Project 3: Water Supply Transfers/Exchanges	Not yet begun	• Feasibility study/planning: 0 to 5 years • Implementation in 5 to 15 years	• Study: $200,000 • Transfers/Exchanges: $600-$2,800 per AF (total cost TBD)
Project 4: Improve Reliability of Water Supplies for Local Communities	Preliminary studies/planning complete	• Feasibility studies: 0 to 2 years • Design/Construction: 1 to 5 years	• Study: $100,000 • Design/Construction: • $1,800,000
Management Action 1: Basin-Wide Economic Analysis	Not yet begun	2020-2021	$100,000
Management Action 2: Pumping Allocations in Central Basin Management Area	Preliminary coordination begun	• Pumping Allocation Study completed: 2022 • Allocations implemented: 2023 through 2040	• Plan: $300,000 • Implementation: $150,000 per year
Adaptive Management	Not yet begun	Only implemented if triggered; timing would vary	TBD

[a] Estimated cost based on planning documents and professional judgment
AF = acre-feet

7.3.1 Addressing Sustainability Indicators

The proposed projects would contribute toward eliminating the projected groundwater overdraft described in the Chapter 2's Water Budget section and in maintaining groundwater levels above those identified in Chapter 5 by reducing groundwater pumping or enhancing net recharge into the groundwater aquifer. The sustainability indicators are measured directly or by proxy, with groundwater elevation used as either the direct or proxy indicator. Table 7-2 summarizes of how the projects and management actions in this GSP will address the applicable sustainability indicators for the Basin. Seawater intrusion is not applicable to the Basin, due to distance from the Pacific Coast.

Physical benefits of the projects and management actions in the GSP are described under each project and action in Section 7.3 and Section 7.4, below.

Table 7-2. Summary of how Projects and Management Actions Address Sustainability Indicators

Activity	Sustainability Indicator				
	Chronic Lowering of Groundwater Levels	Reduction of Groundwater Storage	Degraded Water Quality	Subsidence	Depletions of Interconnected Surface Water
Project 1: Flood and Stormwater Capture	Would increase recharge in the Basin, directly contributing to groundwater levels.	Would increase recharge in the Basin, directly contributing to groundwater storage.	Would contribute to groundwater levels through increased recharge, reducing groundwater quality degradation associated with declining groundwater levels.	Would support maintaining groundwater levels in the Basin, reducing potential for subsidence.	Increasing groundwater recharge with flood and stormwater capture would reduce the potential for groundwater levels to decline and negatively impact surface water flows.
Project 2: Precipitation Enhancement	Increases precipitation and associated groundwater recharge; reduces groundwater pumping because increased precipitation would reduce irrigation needs.	Increases volume of stored groundwater; reduces groundwater pumping	Would increase groundwater recharge, reducing groundwater quality degradation associated with declining groundwater levels.	Reduced groundwater pumping and increased groundwater recharge reduces the cause of subsidence	Would increase surface water flows in the Basin and increase groundwater recharge, which together would reduce the potential for negative surface water flow impacts associated with decreasing groundwater levels.
Project 3: Water Supply Transfers/Exports	Would allow for increased stormwater capture without interfering with downstream water rights, directly contributing to groundwater levels.	Would allow additional groundwater recharge of stormwater, directly contributing to groundwater storage.	Would allow for increased groundwater recharge, reducing groundwater quality degradation associated with lowering of groundwater levels.	Would increase potential groundwater recharge, reducing the potential for subsidence.	Would increase groundwater recharge, which would reduce the potential for negative surface water flow impacts associated with decreasing groundwater levels.
Project 4: Improve Reliability of Water Supplies for Local Communities	Would provide an alternate pumping supply for CCSD, CMWC and VWSC customers to reduce water supply reliability issues caused by historical groundwater level reductions in the Basin.	N/A	Provides for improved water quality in the potable water system, and through construction of compliant wells, reduces potential for groundwater quality impacts of improperly designed/constructed wells and failing wells within CCSD and VWSC systems.	N/A	N/A
Management Action 1: Basin-Wide Economic Analysis	Would evaluate the long-term economic impacts of project implementation, which will allow the region to plan for economic changes if implementation is pursued and help avoid economically catastrophic decision-making that could result in dramatic changes to groundwater use and levels.				
Management Action 2: Pumping Allocations in Central Basin Management Area	Would limit groundwater pumping, with allocations decreasing over time until groundwater pumping reaches sustainability	Reducing groundwater pumping will help decrease the reduction of groundwater storage associated with high levels of pumping.	Reducing groundwater pumping will help alleviate groundwater degradation associated with lowering of groundwater levels.	Reduced groundwater pumping would reduce the risk of subsidence associated with lowering of groundwater levels.	Reduced groundwater pumping would help protect groundwater levels, thereby reducing the potential for negative impacts to surface water flows associated with lowering groundwater levels.
Adaptive Management	Adaptive management actions would be triggered if groundwater levels decrease sufficiently or do not demonstrate adequate recovery as projects are implemented. Adaptive management projects that are implemented would be selected because they would help address these sustainability indicators.				

Notes:
CCSD = Cuyama Community Services District
CMWC = Cuyama Mutual Water Company
VWSC = Ventucopa Water Supply Company

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7.3.2 Overdraft Mitigation

The proposed projects and management actions would support maintenance of groundwater levels above minimum thresholds through increased recharge or through reductions in pumping. Overdraft is caused when pumping exceeds recharge and inflows in the Basin over a long period of time. Improving the water balance in the Basin will help to mitigate overdraft.

7.3.3 Water Balance Management for Drought Preparedness

Communities in the Basin rely on groundwater to meet water needs. During drought, groundwater becomes more important due to limited precipitation. Projects that support groundwater levels through increased recharge help to protect groundwater resources for use during future drought, as well as help protect the Basin from the impacts of drought on groundwater storage. Projects that reduce pumping will help manage the Basin for drought preparedness by reducing demands on the Basin both before and during drought, supporting groundwater levels in non-drought years, and decreasing the impacts of drought on users, reducing the need to increase pumping when precipitation levels are low.

7.4 Projects

Projects included in this GSP are generally capital projects that could be implemented by the CBGSA or its member agencies that provide physical benefits to enhance supplies.

7.4.1 Flood and Stormwater Capture

Flood and stormwater capture would include infiltration of stormwater and flood waters to the groundwater basin using spreading facilities (recharge ponds or recharge basins) or injection wells. Spreading basins are generally more affordable than injection wells because water does not need to be treated prior to recharge into the Basin. While specific recharge areas have not yet been selected, areas of high potential for recharge were identified north and east of the Cuyama River near the Ventucopa Management Area, as well as in select areas of the Central Management Area. It is likely that locating spreading facilities near the Cuyama River represents the easiest method of capturing and recharging flood and stormwaters. Agricultural lands may be used in lieu of or in addition to specialized spreading facilities, or installation of “mini dams” on the Cuyama river to slow flows and increase in-stream recharge. The likeliest of these flood and stormwater capture and recharge options to be implemented is the use of spreading basins, because it will maximize volumes of water captured. Agricultural spreading is usually achieved through intentional overirrigation; in the Basin, agricultural irrigation uses groundwater, and new facilities would still be required to implement agricultural spreading that would not negatively impact groundwater levels. Mini dams could have negative environmental impacts and would not capture as much flow as dedicated spreading basins.

This project would include development of a feasibility study to identify flood capture and recharge locations and to refine the potential yield and cost, as well as determine the downstream impacts of implementation and how to address potential downstream supply challenges implementation may create.

Public Notice and Outreach

Project notice and outreach would likely be conducted during implementation of a flood and stormwater capture project. Some of this outreach would likely occur as part of the California Environmental Quality Act (CEQA) process (see below), though additional outreach may be conducting depending on public perception of the proposed project. Public notice and outreach is not anticipated during development of the feasibility study, beyond potential outreach to landowners whose property is identified as potential sites for spreading facilities.

Permitting and Regulatory Processes

Completion of a feasibility study would not require any permits or regulatory approvals beyond approval of the governing board for the agency funding the study or contracting with any potential consultant who may be retained to complete the analysis.

Implementation of a flood and stormwater capture and recharge project would require construction permits, streambed alteration agreements for diversions from the Cuyama River, CEQA approvals, and potential 401 permits from U.S. Army Corps of Engineers. Additional permits may be required to complete construction and initiate operation of spreading facilities. The CBGSA would need to secure easements to or purchase the land for the spreading facilities. Additionally, the CBGSA may need to negotiate surface water rights agreements with downstream users to avoid violating existing water rights.

Project Benefits

Implementation of flood and stormwater capture projects would provide additional infiltration into the Basin, which would increase the volume of groundwater in the Basin, reducing overdraft and increasing available supply. The 2015 *Long Term Supplemental Water Supply Alternatives Report* (Santa Barbara County Water Agency [SBCWA], 2015), completed an analysis of potential stormwater recharge options along multiple rivers in Santa Barbara County, including Cuyama River. The analysis assumed the Cuyama River would experience sufficient flows for stormwater recharge three of every 10 years, and a maximum available stormwater volume during those events as 14,700 acre-feet (AF). Capturing this volume of water would require 300 acres of land for spreading facilities, and could provide a up to 4,400 acre-feet per year (AFY) of stormwater (averaged over 10 years), assuming the maximum event year supply is captured. Benefits of an implemented floodwater/stormwater capture project would be measured by the volume of flow entering the spreading facility, less an assumed percentage of evaporative loss.

Actual benefits could be lower once evaporative loss is accounted for, and if the final design for spreading facilities is not sized for the maximum storm event, or if the maximum event year is not realized as frequently as anticipated. If coupled with precipitation enhancement (see Section 7.3.2), additional benefits may be realized, though some overlap in benefits may occur.

Project Implementation

The circumstance of implementation for a flood or stormwater capture project would be if the refined feasibility study recommends a project and finds it is both cost effective and would result in meaningful volume of supply. The circumstance of implementation for the feasibility study is now, to determine the potential for flood and stormwater capture as a future means of contributing to Basin sustainability.

Implementation of the feasibility study would be undertaken by the CBGSA, which would hire a consultant to perform the analysis. In addition, the CBGSA would initiate coordination activities with downstream users to evaluate the potential for a stormwater capture project in the Basin to affect downstream users' supply reliability and develop potential projects or actions to offset supplies that may be diverted by stormwater capture and recharge in the Basin.

Implementation of spreading facilities for stormwater capture would require land acquisition, construction of spreading facilities, diversion from Cuyama River, and associated pipelines and pumps. If pursued, the CBGSA anticipates implementing the project either directly or through one of its member agencies.

Supply Reliability

The success of a flood and stormwater capture project depends on the frequency of precipitation events that result in sufficient flows for capture and recharge, the recharge capacity of the spreading facilities, and the location of flows in relation to the diversion point to the spreading facilities. Rainfall is generally limited to November through March in the region, and total rainfall is low, averaging 13 inches over the last 50 years (see Water Budget section of Chapter 2). The project would allow for the limited surface water flows to be captured and used, and if implemented, a flood and stormwater capture project would improve supply reliability in the Basin by increasing groundwater recharge, allowing more water to be available to Basin users.

Legal Authority

The CBGSA has the legal authority to conduct a feasibility study for flood and stormwater capture and recharge project. Once a preferred alternative is identified by the feasibility study, the CBGSA or one of its member agencies would implement the project. Implementation of the project would also depend on the outcomes of a water rights evaluation to clarify the CBGSA's ability capture flood and stormwater without impeding downstream water rights. If this project would affect downstream water rights, the CBGSA would need to negotiate an exchange with downstream users to avoid adverse downstream effects.

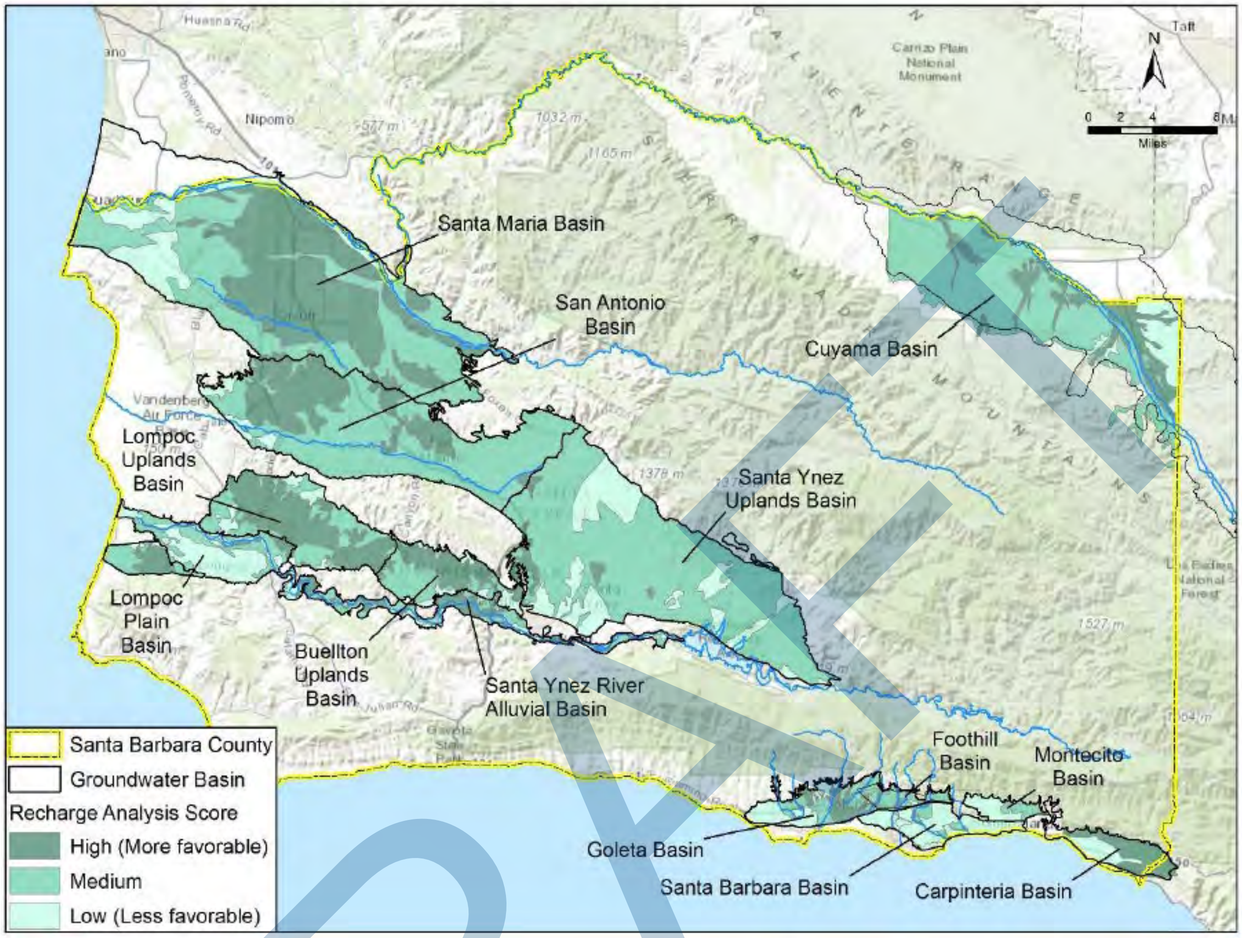
Implementation would require acquisition of targeted land for spreading facilities, which may require purchase or an easement to allow for project implementation. As public water supply agencies, any of the CBGSA members have authority to implement the project once land is acquired and applicable permits secured.

Project Costs

Implementation costs would vary depending on the ultimate size and location of the spreading facilities, and any compensatory measures required for downstream users. Per acre-foot costs would also vary depending on the amount of stormwater captured and successfully recharged. The primary cost for implementation of spreading facilities is the land purchase cost. Because the project would capture flood and stormwater (as opposed to imported or purchased water), there would be no supply costs to operate the project. The 2015 report estimated flood and stormwater capture and recharge from Cuyama River using spreading basins would cost $600 to $800 per AF (SBCWA, 2015).

Technical Justification

The use of spreading facilities for groundwater recharge is common in many areas across the state where groundwater basins are used for storage. The 2015 *Long Term Supplemental Water Supply Alternatives Report* (SBCWA, 2015) provides the basis for the estimated maximum volume of water that could be recharged by a flood or stormwater capture and recharge project. The storage potential of the Basin is based on the highest historical storage less the current storage, with the difference being unused storage potential. The Cuyama Basin has a high storage potential, greater than 100,000 AF, meaning it would be able to accommodate recharge of more than 100,000 AF. The size of the spreading facility(ies) is based on the volume of water available for capture, and the recharge factor of a proposed site. The volume of water that could be recharged is based on the volume of water that could be diverted off of the river during peak storm flow events. Recharge potential was determined by analyzing the existing groundwater depth and hydrological soil type, and infiltration rates based on relative infiltration rate for hydrologic soil groups. High recharge potential were areas with hydrologic soils in group A/B, and had infiltration rates of 0.6 feet per day. As shown in Figure 7-2, the majority of the Basin located in Santa Barbara County has medium or high potential for groundwater recharge, with the highest potential east of the Cuyama River in the Ventucopa Management Area. The 2015 report was limited to Santa Barbara County and does not cover the portions of the Basin located in Ventura, San Luis Obispo, and Kern counties.



Source: SBCWA, 2015

Figure 7-2: Groundwater Recharge Potential in Santa Barbara County

The 2015 report recommended additional studies to refine the high-level analysis in the report. Under this project, the CBGSA would develop a study to refine the areas of potential recharge, including areas of the Basin with potential to provide land for spreading facilities that were excluded from the 2015 report due to being located outside of Santa Barbara County. The feasibility study would, calculate the potential evaporative loss, evaluate alternatives to determine the preferred size and location of spreading facilities, refine costs for the alternatives, and calculate the potential supply from implementation of the preferred alternative.

Basin Uncertainty

This project would take advantage of the uncertain rainfall in the region and capture it for future use when precipitation levels are high. This would help bolster groundwater supplies and improve supply reliability in the Basin.

CEQA/NEPA Considerations

The feasibility study would not trigger CEQA or National Environmental Policy Act (NEPA) actions because it does not qualify as a project under either program. If a flood and stormwater capture project is implemented, CEQA would be required and completed prior to construction. NEPA would only be required if federal permitting, such as a 401 permit from U.S. Army Corps of Engineers, or if federal funding is pursued.

7.4.2 Precipitation Enhancement

A precipitation enhancement project would involve implementation of a cloud seeding program to increase precipitation in the Basin. This project would target cloud seeding in the upper Basin, southeast of Ventucopa, and would include injection of silver iodide into clouds to increase nucleation (the process by which water in clouds freeze to then precipitate out). Based on the findings of the *Feasibility/Design Study for a Winter Cloud Seeing Program in the Upper Cuyama River Drainage, California* (SBCWA, 2016), such a program would use both ground-based seeding and aerial seeding to improve the outcomes of the program. Ground-based seeding would be conducted using remote-controlled flare systems, set up along key mountain ridges and could be automated. Aerial seeding would use small aircraft carrying flare racks along its wings to release silver iodide into clouds while flying through and above them.

Precipitation enhancement modeling assumed cloud seeding would increase precipitation by 10 percecnt from November through March, the rainiest part of the year for the Basin, for an average annual increase in precipitation of about 16,000 AF. With this assumption regarding precipitation increase, the numerical modeling estimated that an increase of 1,500 AF of additional annual average supply within the Basin over 50 years could be achieved.

This project would complete a detailed study to refine the potential yield and cost of implementation in the Basin.

Public Notice and Outreach

Completion of a detailed study would include at least one public meeting (potentially at an existing governing board meeting) to present the details of a precipitation enhancement project, costs and benefits, as well as provide an opportunity to receive comments from the public about potential concerns. If a precipitation enhancement project is pursued for implementation, it would not require public notice or outreach, except for approval by a governing body for the CBGSA that would occur in a public meeting.

Permitting and Regulatory Processes

Completion of a study to refine the feasibility of a precipitation enhancement project would not require any permits or undergo a regulatory process. If a precipitation enhancement project is pursued for implementation, it is expected to be implemented under the existing SBCWA program, and would be covered under existing permits for that program.

Project Benefits

The *Feasibility/Design Study for a Winter Cloud Seeing Program in the Upper Cuyama River Drainage, California* (SBCWA, 2016) found that cloud seeding activities both in the region and in other locations around the world resulted in increased precipitation. This increase was found to be an increase in duration, rather than intensity. The existing cloud seeding program in Santa Barbara County was estimated to increase precipitation between 9 and 21 percent between December and March. The feasibility study estimated average seasonal increases of 5 to 15 percent if this program is implemented.

Based on a 10 percent increase in precipitation between November and March, modeling demonstrates that total benefit of 4,200 AF could be achieved over a 50 year period. This includes an annual average of 400 AF of deep percolation, 400 AF available in stream seepage, and 700 AF in boundary flow. There would also be an average annual increase in Cuyama River outflow of 2,700 AF. Figure 7-3 shows the potential long-term benefits of a precipitation enhancement program. Actual benefits would be measured by evaluating rainfall data after seeding compared to long-term average rainfall in non-seeded years.

The project would complete a refined feasibility study to determine the expected precipitation yield and costs of a precipitation enhancement project. Expected benefits would be refined in that study, prior to the CBGSA making a decision to implement a precipitation enhancement program.

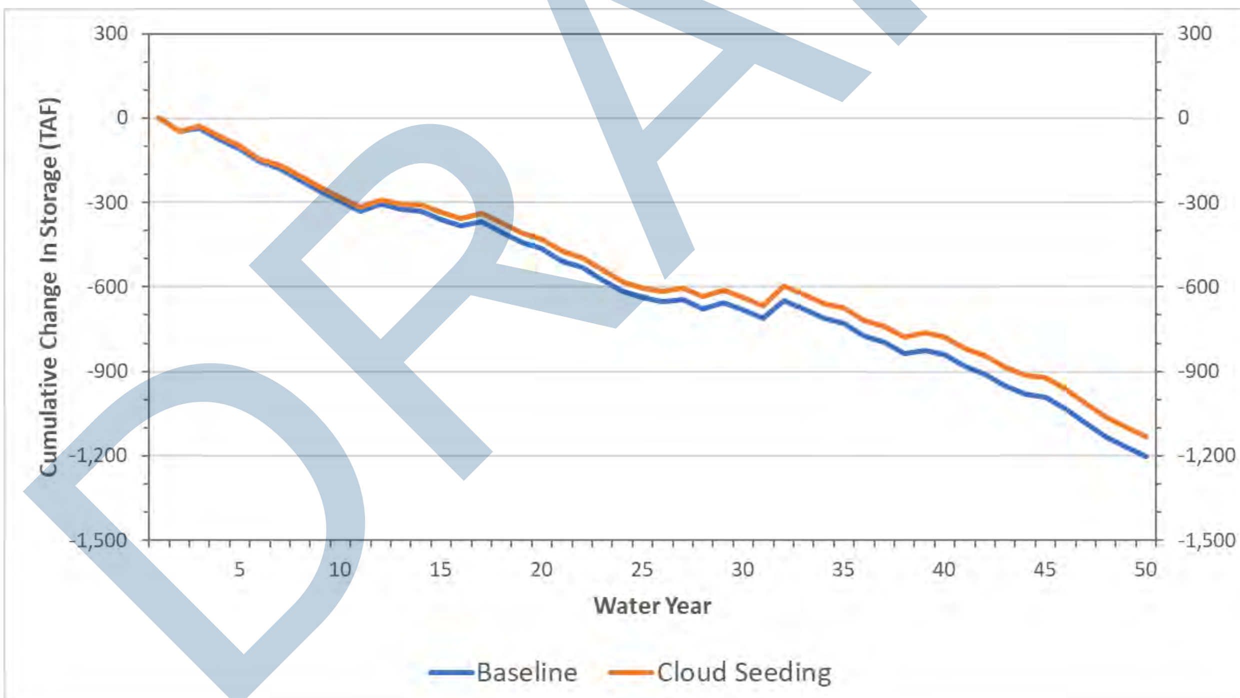


Figure 7-3: Potential Change in Groundwater Storage from Precipitation Enhancement

Project Implementation

The circumstance of implementation for a precipitation enhancement project would be if the refined project study determines it is a cost-effective measure likely to result in meaningful increases in precipitation in the Basin. The circumstance of implementation for the refined study is current conditions, where the CBGSA is ready to consider implementation of precipitation enhancement to support reduced overdraft in the Basin.

Implementation of this project would require installation of two or three additional ground-based seeding sites, referred to as AHOGS. Each AHOGS site would include:

- Two flare masts, which each hold 32 flares and includes spark arrestors to minimize fire risk
- A control box with communications system, firing sequence relays and controls, data logger, and battery
- A solar panel/charge regulation system to power the site
- Cell phone antenna
- Lightning protection

Aerial seeding would require outfitting the appropriate plane with flare racks.

Implementation of this project would likely be achieved by incorporating it into the existing precipitation enhancement activities being implemented by the SBCWA. Because implementation would be achieved through an existing program, the CBGSA does not anticipate needing to purchase and install new models or control systems beyond those necessary for the additional seeding sites and equipment.

Supply Reliability

Precipitation enhancement has been shown to provide measurable benefit to regions when implemented thoughtfully. Although the amount of precipitation increase that the project could provide is uncertain, evidence suggests potential for an average annual increase of 0.5 to 2.5 inches if this project is implemented (SBCWA, 2016), which would help to improve overall supply reliability in the Basin by increasing precipitation, reducing the need for groundwater pumping and increasing groundwater recharge. This project is not dependent on existing supplies or imported supplies for successful implementation and benefits to the Basin.

Legal Authority

The project would be implemented by the SBCWA, one of the member agencies of the CBGSA. The SBCWA already implements precipitation enhancement in the region, and has the legal authority to expand the program within its service area, which includes the Basin.

Project Costs

The 2016 *Feasibility Study* (SBCWA, 2016) recommended installing two or three AHOGS units for ground-based seeding. Each AHOGS unit would cost $30,000 to build and test, and between $4,000 and

$6,000 each to install. Annual maintenance was estimated at $10,000 each. There would be minimal costs associated with initiating aerial seeding for the Basin because it would be implemented as part of the existing precipitation enhancement efforts in the region. Operational costs for aerial seeding would include flight costs ($550 per hour in 2016), and the cost of the seeding flares. Seeding flares in 2016 cost $90 apiece, and up to 50 flares used aerially and approximately 25 flares per AHOGS site in the four-month project period. Annual set-up, take-down, and reporting costs for this project are estimated at $15,000 for a combined ground-based and aerial seeding effort for the Basin, as well as personnel costs of $5,000 per month.

The 2015 *Feasibility Study* estimated that ground-based seeding would cost $45,500 to $67,500 for four months, and aerial seeding would cost $37,750 for four months, assuming that aircraft costs are funded by the existing program.

Total costs are expected to be between $20 and $30 per AF of water under this project, though exact costs would depend on the success of the program in a given year, and market conditions for project materials and aircraft time.

Technical Justification

Cloud seeding as a concept has existed for decades, and target nucleation of supercooled water droplets that exist in clouds. Supercooled water is water that has been cooled below freezing temperatures (0 degrees Celsius or 32 degrees Fahrenheit), but remains in liquid form, rather than frozen. Supercooled water above -39 degrees Celsius must encounter an impurity to freeze, referred to as freezing nuclei. In the 1940s, particles of silver iodide were discovered to be able to cause freezing of supercooled water droplets in clouds. Silver iodide is the most common freezing nuclei used for cloud seeding in which silver iodide is injected into clouds to promote precipitation. A research program in Santa Barbara County on cloud seeding was conducted in the 1960-70s in which silver iodide was released into "convective bands" as random "seeded" or "non-seeded" (no iodide) convective bands, and resulting precipitation measured by a large network of precipitation gauges. This studied evaluated both ground-based seeding and seeding by aircraft. Both methods found seeding resulted in a large area of increased precipitation. Additional studies in other regions in the 1990s found that additional precipitation from cloud seeding was a result of the increased duration of the precipitation event, rather than an increase in intensity. Cloud seeding has been conducted most winters since 1981 in portions of Santa Barbara and San Luis Obispo counties, which have had an estimated benefit of 9 to 21 percent increase in precipitation. The 2016 *Feasibly Study* for precipitation enhancement in the Upper Cuyama River Basin estimated a potential 5 to 15 percent increase in rainfall if a seeding project was implemented (SBCWA, 2016).

Basin Uncertainty

This project would improve precipitation yields in the Basin, helping to reduce the impacts of variable precipitation and providing for increased opportunities for groundwater recharge and stormwater capture. Further, increased precipitation duration and yields would reduce demands for groundwater for irrigation, reducing the risk of crop failure associated with water supply reliability challenges.

CEQA/NEPA Considerations

If this project is implemented, it is anticipated to be incorporated into the existing cloud seeding program implemented by SBCWA. The existing seeding program achieved CEQA coverage under the Santa Barbara Mitigated Negative Declaration (MND), finalized in 2013. This project would achieve CEQA coverage either under this existing MND, or Santa Barbara Water Agency would be required to prepare an addendum to the MND to incorporate the Cuyama Basin target area for the seeding program. Unless the project pursues federal funding, NEPA is not anticipated to be required.

7.4.3 Water Supply Transfers/Exchanges

This project would evaluate the feasibility of purchasing transferred water and exchanging it with downstream users (downstream of Lake Twitchell) to allow for additional stormwater and floodwater capture in the Basin without violating water rights of downstream users. The study would be coordinated with the floodwater and stormwater capture in Section 7.3.1, as the feasibility of such an exchange would affect the maximum volumes of stormwater that would be captured under that project. If the feasibility study finds there is limited interest from downstream users, implementation would not be pursued.

Public Notice and Outreach

Public noticing would not be required for the feasibility study though outreach would be conducted as part of the study to determine willingness of downstream users to participate in an exchange.

Permitting and Regulatory Processes

No permits or regulatory processes would be necessary for development of the feasibility study. Agreements would need to be executed to secure additional water supply for use in a transfer/exchange, as well as to exchange water with downstream users. No other permits are anticipated to be required to implemented water transfers/exchanges.

Project Benefits

Implementation of a water transfer/exchange program would allow the CBGSA to increase stormwater capture if the Flood and Stormwater Capture project (see Section 7.3.1) is implemented because it would reduce the potential water rights conflicts that could arise from increased stormwater capture. The Basin does not have a physical connection to supplies outside the Basin, and is therefore limited in the types of projects that could be implemented to increase supplies. This project would allow the CBGSA to maximize the new water supply that could be available to the Basin if flood and stormwater capture is implemented. This project would be limited to the feasibility study, and would not have direct benefits. If a water transfer/exchange program is implemented as a result of the outcomes of the feasibility study, benefits would be measured by the successful execution of transfer/exchange agreements and the increased capacity of the stormwater capture and spreading facilities made possible by these agreements. Water supply benefits would be measured by the volume of water captured above the volume that would have been allowed had the transfer/exchange agreements not been implemented.

Project Implementation

The circumstance for implementation of the feasibility study would be exploration of the feasibility of flood and stormwater capture and recharge (see Section 7.3.1). Implementation of this project would occur if downstream users expressed interest in participation in water transfers/exchanges and the feasibility study determined the potential increase in supply that transfer/exchanges would provide is cost effective for achieving supply reliability and groundwater sustainability goals.

The CBGSA would develop the feasibility study in coordination with the Flood and Stormwater Capture Project's feasibility study. Based on the outcomes of the two feasibility studies and the level of interest of downstream users, the CBGSA would determine whether implementation of a transfer/exchange project is a preferred action for the CBGSA. Implementation of the transfer/exchange program would entail coordination amongst participants: the CBGSA, agencies who own the water to be used in the transfer, and downstream users who participate in the exchange.

Supply Reliability

Transfers and exchanges would require access to a reliable water supply from outside the Basin currently owned by an agency that has sufficient water rights to be willing to sell a portion of their water to the CBGSA for this project. Because this project would be used to increase the capacity of the stormwater capture project, benefits would be experienced only following a heavy precipitation event. It is likely that in years with large precipitation events, other parts of the state will also experience wet winters, increasing available supplies from sources like the State Water project, or other surface water supplies. The feasibility study would require an evaluation of supply reliability, and explore the potential mechanisms for a successful transfer/exchange program that would account for the uncertainty of precipitation events on a year-to-year basis and available supply and potential benefit to the Basin.

Legal Authority

The CBGSA, through its member water supply agencies, has the legal authority to enter into transfer and exchange agreements with other water suppliers and users. The CBGSA does not have the authority to increase its stormwater capture at a level that would impede downstream senior water rights holders from accessing their water rights, making this project a critical component of an expanded capacity stormwater project (beyond what could be achieved without this project).

Project Costs

A feasibility study would likely cost between $100,000 and $200,000 to complete, including outreach to downstream water users and potential sources of supply for the transfer/exchange program. Costs to implement a transfer and exchange program would be evaluated in the feasibility study and are estimated to range from $600 to $2,800 per AF. Costs would vary depending on the details of the transfer/exchange, source of new water, and parties involved.

Technical Justification

A transfer/exchange program would be at minimum a one-to-one exchange, meaning for each AF of water provided to downstream users through the program, the CBGSA could capture an additional AF of stormwater. The feasibility study would identify which supplies could be purchased to exchange with downstream users, based on supply availability, connectivity to downstream users, willingness of supply owners to participate, and cost. One purpose of the feasibility study would be to determine a preferred alternative for the transfer/exchange program, and provide a technical justification of the preferred program. If technical justification cannot be made, the program would be considered infeasible and would not be pursued.

Basin Uncertainty

The transfer/exchange project would help address uncertainty in the basin by allowing the CBGSA to increase groundwater recharge, using years with surplus surface water flows to supplement groundwater during dry years by increasing the volume of stormwater that can be captured without interfering with downstream users' water rights.

CEQA/NEPA Considerations

Development of a feasibility study would not trigger CEQA or NEPA. If water exchanges or transfers do not require construction of new facilities, they are unlikely to be considered projects under CEQA or NEPA because the original CEQA or NEPA documentation for the diversion and conveyance facilities used for the transfer/exchange would have addressed the full capacity of those facilities. Because this project would not construct additional facilities for the transfer/exchange of water, it would not require CEQA or NEPA. Changes to stormwater capture and recharge facilities that may result from this feasibility study would receive CEQA and NEPA coverage under those facilities' environmental documentation.

7.4.4 Improve Reliability of Water Supplies for Local Communities

The Basin is experiencing overdraft in the Central and Ventucopa management areas, which are the population centers of the Basin. Domestic water users in these areas are experiencing water supply reliability challenges, and in the 2012-2016 drought experienced well failures. While the following actions would not affect the water budget in the Basin, they are intended to address ongoing water supply reliability issues affecting these communities. CCSD only has a single well to serve its customers, and no redundancy in its system. This management action would include consideration of opportunities to improve water supply reliability for Ventucopa and within the CCSD service area. Potential projects that would be considered under this management action include a replacement well for CCSD Well 2, which is currently abandoned, and improvements to Ventucopa Water Supply Company's (VWSC's) existing well. While specific information is not available for improvements (and are therefore not discussed below) for the town of Cuyama, which is served by the CMWC, the CBGSA also supports potential future actions to benefit the town of Cuyama as well.

CCSD Replacement Well

The CCSD Replacement Well would drill a new well in CCSD's service area to replace Well 2, which has been abandoned due to an electrical failure that damaged the well and pumping equipment and subsequent damage the well incurred when an attempt was made to remove the pump. A replacement well for Well 2 was attempted, but found to produce water that was unsuitable for potable use due to the design and construction of the well. Construction of the new well would include:

- Drilling, installing, and testing a new well
- Installing a well head, submersible well pump, and electrical panel
- Construction of an 8-inch pipeline to connect the new well to CCSD's system

Ventucopa Well Improvements

The Ventucopa Well Improvements would construct a new water supply pump, pipelines, and meters for the existing Ventucopa Well 2 and seek approval for the well's use for drinking water from the County of Santa Barbara's Department of Health Services (DHS). These improvements would:

- Install a pump, electrical service, and controls at Well 2
- Construct an 8-inch pipeline from Well 2 to Ventucopa's existing hydropneumatic tank
- Install meters at Well #1 and Well 2
- Install a SCADA system for Well 2
- Install piping, valves, and inline mixer to blend water from Well 1 and Well 2

Public Notice and Outreach

Public notice and outreach would not be required beyond that necessary for approval at a public Board of Directors meeting or applicable CEQA.

Permitting and Regulatory Processes

CCSD's new well construction would require acquisition of a well drilling permit and approval of well design and well completion report. It would also require well testing that demonstrates the new well is capable of producing water that is suitable for drinking water. In addition to a well drilling permit from the County, CCSD's existing water system permits would need to be revised to include the new well and associated features.

Improvements to VWSC's well would require compliance with Santa Barbara County's regulations for water systems in the unincorporated county. VWSC would need to acquire the appropriate well drilling permits from the County as well as receive DHS certification of the suitability of the upgraded well for potable use before water from Well 2 can be delivered to customers.

Project Benefits

These projects would improve supply reliability for Ventucopa and CCSD residents and customers by creating system redundancies and upgrades to address challenges with meeting existing demands associated with aging and failing infrastructure. As planned, up to 460 gallons per minute could be made available to CCSD and up to 55 gallons per minute available to VWSC as a result of this project. Benefits of this project would be measured by the volume of water produced by the two improved wells and reduction in the number of days system failures threaten access to water supplies.

Project Implementation

The circumstance of implementation for this project is identified need for system improvements to meet public health and safety concerns. Both CCSD and VWSC have documented challenges with their water supply systems, including lack of redundancy, wells that do not adequately meet domestic water supply requirements, and limited capacity (CCSD, 2018; VWSC, 2007).

The two components of this project would be implemented by their respective system owners, CCSD and VWSC. CCSD would be responsible for planning, design, construction, testing, and permitting of the new Well 4, while VWSC would be responsible for planning, design, construction, testing, and permitting of the Well 2 improvements.

Supply Reliability

This project would improve supply reliability to customers through system improvements designed to address known issues with accessing and conveying groundwater suitable for potable use.

Legal Authority

CCSD owns the property for the proposed well site, and has the legal authority to design and construct a new well. As the owner-operator of the CCSD system, CCSD also has the legal authority to connect the new well to its existing distribution system and deliver water from the new well to customers once all appropriate permits have been acquired.

VWSC already owns Well 2 and the other existing components of the proposed project. It has the legal authority to implement projects that serve the water supply needs of its customers, and once all appropriate permits have been acquired, is legally able to connect Well 2 to its existing system.

Project Costs

In total, these improvements are expected to cost approximately $1,175,000.

CCSD's 2018 Engineering Report for Well 4 estimated project costs of $489,800 for drilling and $485,280 for equipping, for a total cost of $975,080 (CCSD, 2018).

VWSC's 2007 *Ventucopa Water System Evaluation Report* estimated the well improvements included in this GSP would cost $191,200 (VWSC, 2007). Costs are assumed to have increased since 2007, and well improvements are currently expected to cost approximately $200,000 to implement.

Technical Justification

Both components of this project have completed initial planning efforts. Preliminary engineering and design has been completed for the CCSD Well 4 improvements, including the 2018 Engineering Report and preliminary design drawings. VWSC's well improvements were described and evaluated in the 2007 Evaluation Report. Implementation of this project would include final design for all components, as well as testing to ensure that well improvements meet the needs they are designed to address.

Basin Uncertainty

These improvements would reduce uncertainty associated with supply reliability in CCSD and VSWC's service areas.

CEQA/NEPA Considerations

Well drilling permits are a discretionary action in Santa Barbara County, which would trigger CEQA. CCSD and VSWC would need to complete the appropriate CEQA document to comply with these requirements prior to construction of this project. The project would not trigger NEPA unless federal funding or permits are required for completion of the project. The size and location of the project indicates it is unlikely to require federal permits, and NEPA is likely to only be required if federal funding is pursued.

7.5 Water Management Actions

Water management actions are generally administrative locally implemented actions that the CBGSA or its member agencies could take that affect groundwater sustainability. Typically, management actions do not require outside approvals, nor do they generally involve capital projects.

7.5.1 Basin-Wide Economic Analysis

Changes to pumping in the Basin and access to water supplies may have economic consequences given that the Basin is dominated by agricultural land uses that are dependent on groundwater availability. Implementation of stormwater capture may require purchase of agricultural land for the spreading facilities, which could affect agricultural output in the region. The small population of the Basin limits the available revenue to fund projects. This Project would entail developing a study of the economic impacts of the projects and management actions included in the GSP. This would include an evaluation of how implementation of the project could affect the economic health of the region and on local agricultural industry. It would also consider the projected changes to the region's land uses and population and whether implementation of these projects would support projected and planned growth. The economic analysis would be considered by the CBGSA when deciding whether to implement a proposed project and potential when to implement the projects.

Public Notice and Outreach

This project is a study and would not require public notice or outreach. The results of the economic analysis will be presented at Stakeholder Advisory Committee (SAC) and CBGSA Board meetings.

Permitting and Regulatory Processes

No permits or regulatory approvals would be required to complete the economic analysis.

Project Benefits

The economic analysis would provide information to the CBGSA regarding the potential economic benefits and drawbacks to implementation of different projects under the GSP. This project would not provide direct benefits as related to water supply or groundwater sustainability, but would allow the CBGSA to move forward with implementation of projects that would continue to sustain local economies and would not inadvertently cause substantial economic harm, which could affect the ability of a proposed project to continue to provide benefits.

Project Implementation

The circumstance of implementation for this project would be consideration of the implementation of any project included in this GSP or otherwise considered by the CBGSA. The CBGSA would implement this project with the assistance of an economic consultant that would complete the analysis based on data for the region and information provided by the CBGSA.

Supply Reliability

This project is a study and does not depend on any water supply for implementation or successful completion.

Legal Authority

The CBGSA is a joint-powers authority with authority to authorize an economic study for the projects in this GSP.

Project Costs

A basin-wide economic analysis is expected to range from $80,000 to $120,000 in costs, depending on the available data and level of analysis desired. Exact costs would be determined during selection of the economic analyst.

Technical Justification

This project is a study that would use economic methods and analysis tools consistent with the standards and practices of the industry.

Basin Uncertainty

This project would help understand the economic uncertainty around implementation of the projects in this GSP. Improved understanding of the economic implications of a project would help the CBGSA decide which projects should move forward to support basin sustainability without unintended consequences that could increase overall uncertainty in the basin, including uncertainty regarding groundwater demands in the basin associated with the local and regional economy.

CEQA/NEPA Considerations

As a study, the basin-wide economic analysis would not trigger CEQA or NEPA.

7.5.2 Pumping Allocations in Central Basin Management Area

As described in Section 2.3 of this GSP, the Basin is in overdraft conditions and to achieve balanced pumping and recharge groundwater users must decrease pumping by approximately 67 percent, in the absence of projects that increase recharge in the Basin or otherwise offset demands. While the projects identified in Section 7.3 would increase the water available to users in the Basin through increased recharge and precipitation, they are not expected to reduce the groundwater deficit sufficiently to achieve the Basin's sustainability goals. As such, the CBGSA is intending to implement pumping allocations.

Outlined here is a framework for how CBGSA would develop and implement pumping allocations in the Basin. This project would involve development of pumping allocations in the Central Basin Management Area. No pumping allocations would apply to the Ventucopa Management Area or to users outside of a Management Area. CCSD would be provided allocations based on historical use, and would not be required to reduce pumping over time, but would be limited in how much pumping could increase in the future.

There are four key steps to developing pumping allocations:

1. Determine the native Sustainable Yield of the Basin
2. Allocate sustainable yield of native groundwater to users based on:
    a. Historical use
    b. Land uses and irrigated areas
3. Determine how new/additional supplies would be allocated
4. Develop a timeline for reducing pumping to achieve allocations over time

Native Sustainable Yield of the Basin

The native sustainable yield of the Basin, the volume of water that can be extracted from the Basin annually without affecting overall groundwater storage, in the absence of additional supply enhancement projects or activities, is estimated at about 20,000 AFY, as described in the Water Budget section of Chapter 2. The native sustainable yield of the Basin represents the volume of groundwater that can be allocated. Because pumping allocations would only be imposed on users in the Central Basin Management Area, the CBGSA would need to determine the native sustainable yield for only the Central Basin Management Area, which would be less than the overall sustainable yield of the Basin.

Develop Allocations

The CBGSA would develop allocations based on estimated historical use, existing land uses and total irrigated acreage. To the extent feasible, the CBGSA would determine historical use based on average water uses from the 20-year historical period from 1998 to 2017 that aligns with the historical period included in the water budget analysis completed in Chapter 2. Water use would be estimated either using remote sensing and land use data to estimate agricultural consumption or from data provided by pumpers in the Basin, including private pumpers and water agencies. CCSD's allocation would be based entirely on historical use, with an allowance for de minimis growth. CCSD would not be required to reduce use in the future under this action. As such, once CCSD's allocation has been determined, it would be removed from the total volume of groundwater available for allocation to non-CCSD users in the Central Basin Management Area.

A specific approach for allocation of pumping volumes among agricultural users in the Central Basin management area has not been determined. Potential options include allocation on the basis of historical use, on irrigated acreage, or on total acreage. The CBGSA would work with landowners and agencies to determine the appropriate approach for pumping allocations for agricultural users.

Determine Allocation of New or Additional Supplies

As the CBGSA implements projects in this GSP, additional groundwater supplies are expected to become available. These supplies would be used to reduce groundwater overdraft. The CBGSA anticipates that any new supplies made available through project implementation would be added to the total volume of water that would be allocated to agricultural users, because domestic needs would have already been met before water is allocated to agricultural users. The mechanism for accounting for additional water made available by project implementation would be determined when the allocation method is refined.

Timeline for Implementation

The required decreases in pumping volumes to achieve balanced groundwater use in the Basin may result in substantial reductions in water availability over current use. The CBGSA plans to complete the pumping allocation plan in 2022, with pumping reductions beginning in 2023 at 5 percent of the total required reduction to achieve sustainability, and an additional 5 percent reduction in 2024. From 2025 to 2038, pumping would be reduced by 6.5 percent annually, so as to achieve sustainability in the Basin in 2038. Figure 7-4 shows the planned pumping reduction in the Basin. Individual users would be expected to reduce pumping at different rates to achieve the overall pumping reductions and meet their individual pumping allocations. The pumping allocation plan would identify how much each user or user-type would be required to reduce pumping annually to achieve the allocation and the overall Basin sustainability goals.

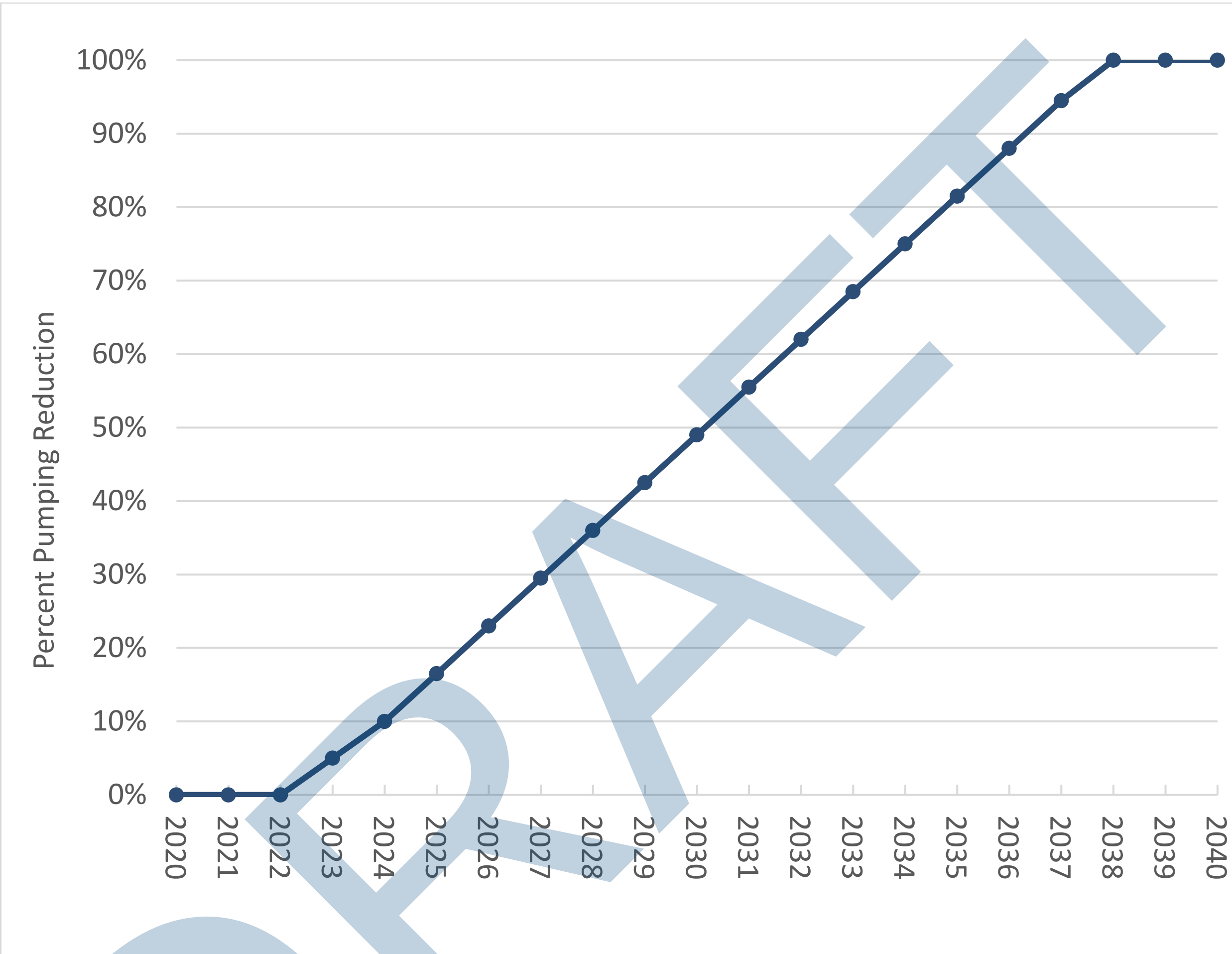


Figure 7-4: Glide Path for Central Basin Management Area Groundwater Pumping Reductions

Public Notice and Outreach

Development of a pumping allocation plan would require substantial public input to understand the potential impacts of pumping allocations and baseline needs that should be accounted for. The CBGSA anticipates that public outreach would include multiple public workshops and meetings, potential website presence or email announcements, along with other public notices for the workshops. The pumping allocation plan would be circulated for public comment before finalized, though final approval of the plan would be made by CBGSA in partnership with its member agencies.

Permitting and Regulatory Processes

Development of a pumping allocation plan would not require any permitting, but would require consideration of existing water rights and applicable permits and regulations associated with groundwater pumping in the Basin.

Management Action Benefits

A pumping allocation plan would identify how the region will achieve sustainable pumping in the Basin. Implementation and enforcement of a pumping allocation plan would directly reduce groundwater pumping. Benefits would be measured by the change in total volume of groundwater pumped from the Basin and how many users are in compliance with their pumping allocations.

Management Action Implementation

The circumstance of implementation for developing a pumping allocation plan is identification of unsustainable groundwater pumping practices in the Basin. The CBGSA recognizes recharge and pumping in the Basin are not balanced, and action must be taken to achieve sustainability. CBGSA would lead development of a pumping allocation plan, in partnership with its member agencies and local groundwater users. The planning process is expected to be completed in 2022, with allocations implemented beginning in 2023. Successful implementation would require compliance from groundwater users with the pumping allocation plan, and enforcement by the CBGSA and its member agencies. Successful roll-out of the pumping allocation plan would require substantial public outreach to inform users of their annual allocation and expected annual reduction in groundwater pumping. Mechanisms for enforcement would be outlined in the pumping allocation plan, and are expected to be enforced by CBGSA's member agencies.

Supply Reliability

This project does not rely on the supplies from outside the Basin because it is a planning effort that will result in conservation. It will support overall supply reliability by reducing overdraft in the Basin and moving the Basin towards sustainability.

Legal Authority

CBGSA has the authority to develop a pumping allocation plan, and will perform implementation and enforcement of allocations through metering, water accounting, and implementing pumping fees.

Management Action Costs

Development and initiation of a pumping allocation management and tracking program is expected to cost about $300,000 to conduct the analysis, set up the measurement and tracking system and conduct outreach. Costs to implement the plan would depend on the level of enforcement required to achieve allocation targets and the level of outreach required annually to remind users of their allocation for a given year. The pumping allocation plan would include a cost estimate for enforcement and implementation. Annual management of the program is estimated to cost about $150,000 per year.

Technical Justification

Pumping allocations would provide direct reductions of groundwater pumping. The pumping allocation plan would develop allocations based on historical use data and land use data, and would clearly describe the methodology and justification for the methodology used when setting pumping allocations.

Basin Uncertainty

The Basin is currently experiencing overdraft, and if current pumping practices continue conditions in the Basin are expected to worsen, increasing uncertainty regarding the availability of reliable groundwater supplies. Development of a pumping allocation plan would provide an opportunity to reduce overdraft-related uncertainty in the Basin by shifting pumping towards sustainable levels over time.

CEQA/NEPA Considerations

Development of a pumping allocation plan is not a project as defined by CEQA and NEPA and would therefore not trigger either. Reducing pumping over time is also not expected to trigger CEQA or NEPA because it does not meet the definition of a CEQA or NEPA project.

7.6 Adaptive Management

Adaptive management allows the CBGSA to react to the success or lack of success of actions and projects implemented in the Basin and make management decisions to redirect efforts in the Basin to more effectively achieve sustainability goals. The GSP process under SGMA requires annual reporting and updates to the GSP at minimum every 5 years. These requirements provide opportunities for the CBGSA to evaluate progress towards meeting its sustainability goals and avoiding undesirable results.

Adaptive management triggers are thresholds that, if reached, initiate the process for considering implementation of adaptive management actions or projects. For CBGSA, the trigger for adaptive management and CBGSA's next steps would be as follows:

- **Pumping reductions are more than 5 percent off the glide path identified in the pumping allocation plan:** CBGSA would evaluate why pumping allocations are not being met and implement additional outreach or enforcement, as appropriate. If the evaluation determines that the allocation is not feasible for users, the glide path and pumping allocation plan would be re-evaluated to confirm baseline water allocations are established correctly.
- **If the Basin is within the Margin of Operational Flexibility, but trending towards Undesirable Results, and within 10 percent of the Minimum Threshold:** CBGSA will implement one or more GSP projects that have not yet been implemented, or will reconsider implementation of projects included in the GSP that were found to be less feasible.
- **If the Basin is experiencing Undesirable Results *and* is not demonstrating progress towards achieving Minimum Thresholds:** CBGSA will implement one or more GSP projects that have not yet been implemented, and will reconsider implementation of projects included in the GSP that were found to be less favorable. If this does not result in demonstrable progress towards achieving

Minimum Thresholds, and the Basin is still experiencing Undesirable Results, CBGSA may reconsider implementation of projects considered, but not included, in the GSP, such as imported water via pipeline, municipal area rainwater capture, forest/rangeland management, or pumping allocation for Ventucopa Management Area.

7.7 References

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Cuyama Valley Groundwater Basin

Draft Groundwater Sustainability Plan: Implementation Plan

Prepared by:

April 2019

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Acronyms

Basin	Cuyama Valley Groundwater Basin
SGMA	Sustainable Groundwater Management Act
DWR	California Department of Water Resources
GSP	*Groundwater Sustainability Plan*
CBGSA	Cuyama Basin Groundwater Sustainability Agency
AF	acre-feet (foot)
FY	fiscal year
CCSD	Cuyama Community Services District
VWSC	Ventucopa Water Supply Company
CASGEM	California Statewide Groundwater Elevation Monitoring Program

Chapter 8 Implementation Plan

8.1 Plan Implementation

Implementation of this *Groundwater Sustainability Plan* (GSP) includes implementation of the projects and management actions included in Chapter 7, as well as the following:

- Cuyama Basin Groundwater Sustainability Agency (CBGSA) administration and management
- Implementing the monitoring program
- Developing annual reports
- Developing required five-year GSP updates

This chapter also describes the contents of both the annual and five-year reports that must be provided to the California Department of Water Resources (DWR) as required by Sustainable Groundwater Management Act (SGMA) regulations.

8.1.1 Implementation Schedule

Figure 8-1 illustrates the GSP's implementation schedule. Included in the chart are activities necessary for ongoing GSP monitoring and updates, as well as tentative schedules for projects and management actions. Additional details about the activities included in the schedule are provided in these activities' respective sections of this GSP. Adaptive management would only be implemented if triggering events are reached, as described in Chapter 7, and are shown as ongoing in the schedule.

Figure 8-1. GSP Implementation Schedule

ID	Task Name
1	**Cuyama GSP Implementation**
2	**Plan Implementation**
3	Plan submittal to the State
4	Monitoring
5	**Annual Reports**
27	Five Year Report/Interim Target Evaluation 1
28	Five Year Report/Interim Target Evaluation 2
29	Five Year Report/Interim Target Evaluation 3
30	Plan Updates (as needed)
31	**GSP Administration**
32	CBGSA Administration
33	Stakeholder and Board Engagement
34	Outreach
35	**Project Implementation**
36	**1. Flood and Stormwater Capture**
37	Planning
38	Construction
39	Benefits
40	**2. Precipitation Enhancement**
41	Planning
42	Construction
43	Benefits
44	**3. Water Supply Imports/Exports**
45	Planning
46	Agreement Negotiation
47	Implementation of Transfers
48	**4. Improve Reliability of Water Supplies for Local Communities**
49	CCSD Well #4 - Planning & Design
50	CCSD Well #4 - Construction & Permitting
51	CCSD Well #4 - Testing
52	VWSC Well #2 - Planning & Design
53	VWSC Well #2 - Construction & Permitting
54	VWSD Well #2 - Testing
55	**Management Action Implementation**
56	**1. Basin-Wide Economic Analysis**
57	Plan Development

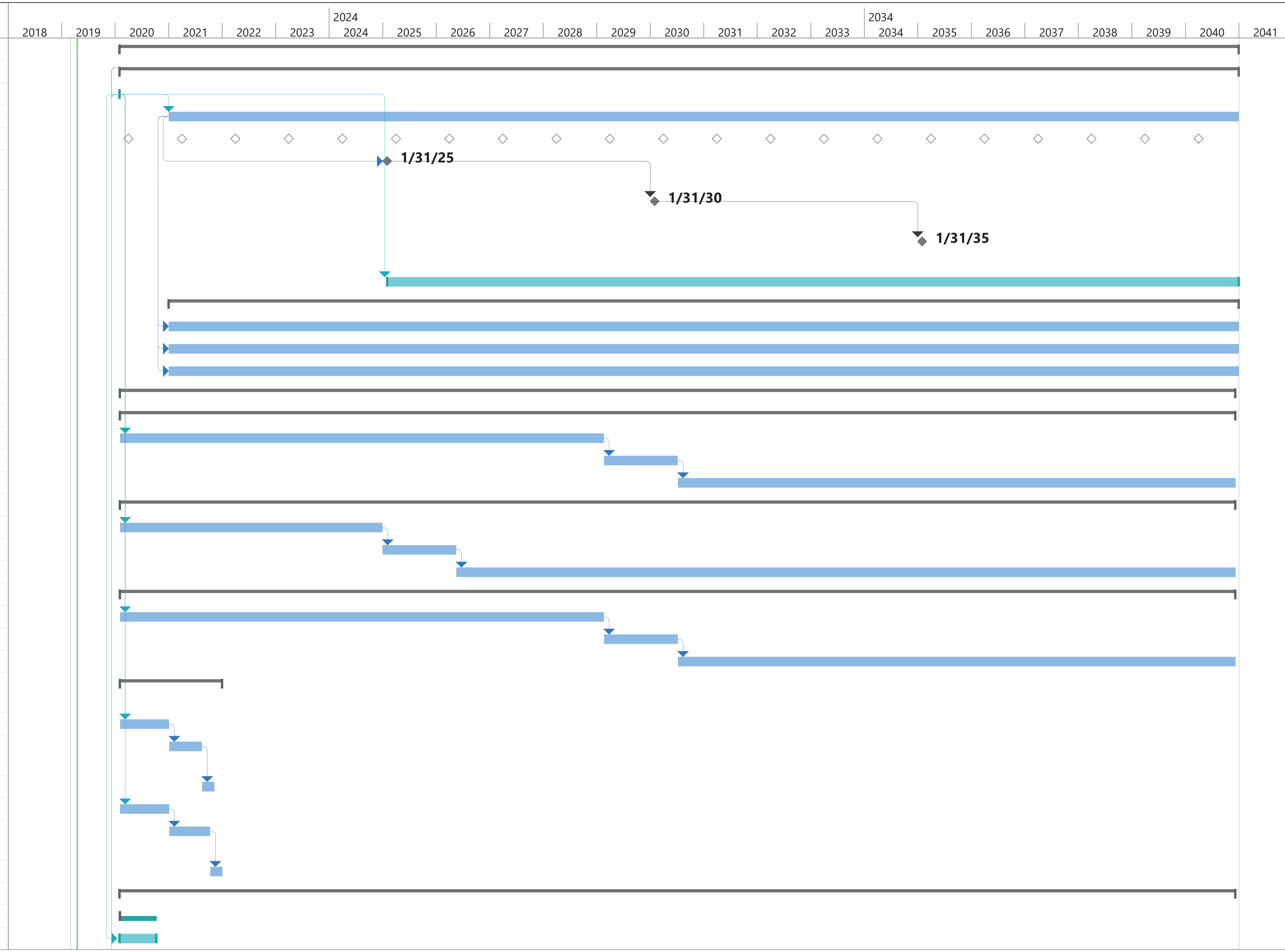
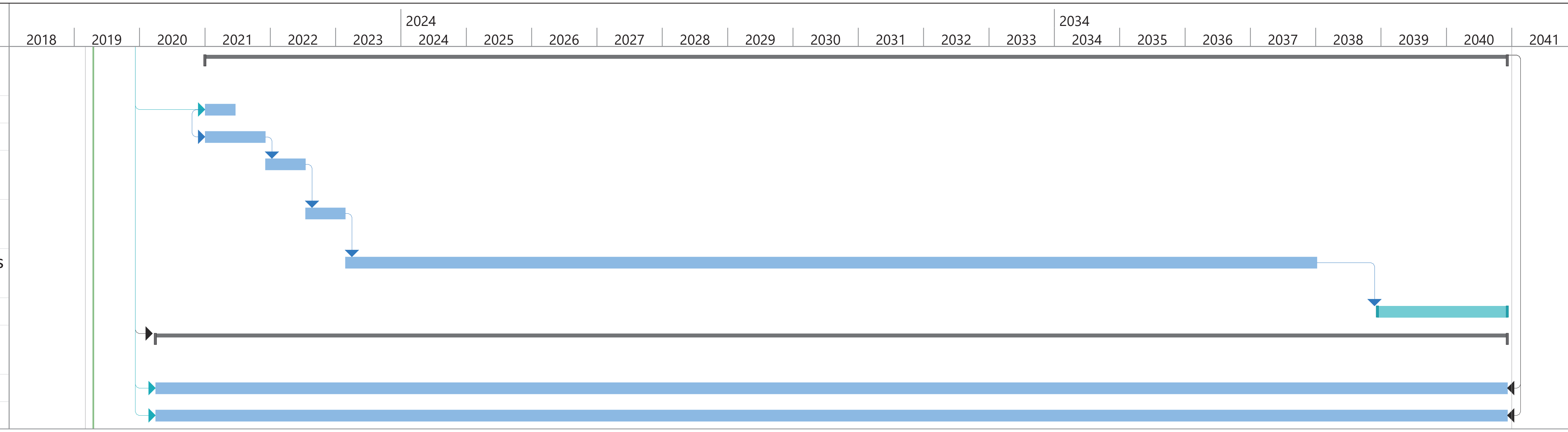


Figure 8-1. GSP Implementation Schedule

ID	Task Name
58	**2. Pumping Allocations in Central Basin Management Area**
59	Determine Sustainable Yield
60	Develop Allocation Method
61	Determine Allocation of New Water Supplies
62	Develop Timeline for Pumping Reduction
63	Implement Annual Pumping Reductions
64	Maintain Pumping Allocations
65	**Adaptive Management Action Implementation**
66	Evaluate Unimplemented Projects
67	Revisit Projects not included in GSP



8.2 Implementation Costs and Funding Sources

CBGSA operations and GSP implementation will incur costs, which will require funding by the CBGSA. The five primary activities that will incur costs are listed here. Table 8-1 summarizes these activities and their estimated costs.

- Implementing the GSP
- Implementing GSP-related projects and management actions
- CBGSA operations
- Developing annual reports
- Developing five-year evaluation reports

Table 8-1. CBGSA and GSP Implementation Costs

Activity	Estimated Cost[a]
GSP Implementation and GSA Management	
CBGSA Administration	$390,000 annually
Stakeholder and Board Engagement	$195,000 annually
Outreach	$25,000 annually
GSP Implementation Program Management	$75,000 annually for fiscal years (FYs) with no five-year reports; $125,000 annually for FYs with five-year reports.
Monitoring Program, including Data Management	$155,000 annually for FYs with no five-year reports; $170,000 annually. Additional costs to establish monitoring program in FY 2020 ($295,000) and FY 2021 ($100,000)
Annual Reporting	$40,000 annually (FY 2023 through FY 2040) Additional costs during initial years ($50,000 to $75,000 for FYs 2020 through 2022)
Five-Year GSP Updates	$800,000 every five years (across two fiscal years)
Projects and Management Actions	
Project 1: Flood and Stormwater Capture	Construction: $46 million Operations and Maintenance: $500,000
Project 2: Precipitation Enhancement	$150,000 annually
Project 3: Water Supply Transfers/Exchanges	$600 $2,800 per acre-foot (AF) (total cost to be determined)
Project 4: Basin-Wide Economic Analysis	$100,000
Management Action 1: Improve Reliability of Water Supplies for Local Communities	$1.8 million

Table 8-1. CBGSA and GSP Implementation Costs	
Activity	**Estimated Cost[a]**
Management Action 2: Pumping Allocations in Central Basin Management Area	Allocation development: $300,000 Implementation/maintenance: $150,000 annually
Adaptive Management	To be determined

[a] Estimates are rounded and based on full implementation years (FY 2021 through FY 2040). Different costs may be incurred in FY 2020 as GSP implementation begins.

8.2.1 GSP Implementation and Funding

Costs associated with GSP implementation and CBGSA operations include the following:

- **CBGSA administration:** Overall program management and coordination activities
- **Stakeholder/Board engagement:** Quarterly Stakeholder Advisory Committee (SAC) meetings, bi-monthly CBGSA Board meetings, bi-monthly calls with the CBGSA Board ad-hoc committees, and semi-annual public workshops
- **Outreach:** Email communications, newsletters, and website management
- **GSP implementation program management:** Program management and oversight of project and management action implementation, including coordination among GSA Board, staff and stakeholders, coordination of GSA implementation technical activities, oversight and management of CBGSA consultants and subconsultants, budget tracking, schedule management, and quality assurance/quality control of project implementation activities
- **Monitoring:** manage satellite imagery to track water usage, conduct groundwater level and quality monitoring, and manage data

Implementation of this GSP is projected to run between $800,000 and $1.3 million per year, and projects and management actions an additional $650,000 to $3.7 million per year. Development of this GSP was funded through a Proposition 1 Sustainable Groundwater Planning Grant. CBGSA operations are partially funded through this grant, as well as contributions from CBGSA member agencies. Although ongoing operation of CBGSA is anticipated to require contributions from its member agencies, which are ultimately funded through customer fees or other public funds, additional funding would be required to implement the GSP. Of the implementation activities in the GSP, only project implementation is likely to be eligible for grant or loan funding; funding through grants or loans have varying levels of certainty. As such, the CBGSA will develop a financing plan that will include one or more of the following financing approaches:

- **Pumping Fees**: Pumping fees would implement a charge for pumping that would be used to fund GSP implementation activities. In the absence of other sources of funding (i.e., grants, loans, or combined with assessments) fees would range between $13 and $60 per AF per year. To meet the funding needs of the GSP, fees would be lower when pumping is higher, such as current pumping levels, and higher when pumping is lower, such as when sustainable pumping levels are achieved. Although this funding approach would meet the financial needs of the GSP and CBGSA, it may discourage pumping reductions due to cost. The financing plan developed by the CBGSA would evaluate how to balance the need for funding with encouraging pumpers to commit to compliance with desired groundwater pumping reduction goals.
- **Assessments:** Assessments would charge a fee based on land areas. There are two methods for implementing an assessment based on acreage. The first option would assess a fee for all acres in the Basin, which would cost approximately $5 to $8 per acre per year. This option would not distinguish between land use types. The second option would be to assess a fee only on irrigated acres. Based on current irrigated acreage, the assessment would be $20 to $35 per acre per year. Similar to the pumping fee approach, assessment based on irrigated acreage could affect agricultural operations and contribute to land use conversions, which could affect the assessment amount or ability to fully fund GSP implementation.
- **Combination of fees and assessments:** This approach would combine pumping fees and assessments to moderate the effects of either approach on the economy in the Basin. This approach would likely include an assessment that would apply to all acres in the Basin, rather than just to irrigated acreage. It would be coupled with a pumping fee to account for those properties that use more water than others.

During development of a financing plan, the CBGSA would also determine whether to apply fees across the Basin as a whole or just within the Management Areas. The CBGSA may choose to apply an assessment across the Basin and a pumping fee within the Management Areas, or choose to set different levels of assessments or fees based on location within a Management Area or not, or they may choose another combination of the above approaches based on location. Prior to implementing any fee or assessment program, the CBGSA would complete a rate assessment study and other analysis consistent with the requirements of Proposition 218.

If grants or loans are secured for project implementation, potential pumping fees and assessments may be adjusted to align with operating costs of the CBGSA and ongoing GSP implementation activities.

8.2.2 Projects and Management Actions

Costs for the Projects and Management Actions are described in Chapter 7 of this GSP. Financing of the projects and management actions would vary depending on the activity. Potential financing for projects and management actions are provided in Table 8-2, though other financing may be pursued as opportunities arise or as appropriate.

Table 8-2. Financing Options for Proposed Projects, Management Actions, and Adaptive Management Strategies

Project/Activity		Responsible Entity	Potential Financing Options
Project 1: Flood and Stormwater Capture	Feasibility Study	CBGSA	• CBGSA Operating Funds • CBGSA Member Agencies
	Project Implementation	CBGSA or Member Agencies	• Grants • Loans • CBGSA Operating Funds • CBGSA Member Agencies
Project 2: Precipitation Enhancement	Feasibility Study	CBGSA	• CBGSA Operating Costs • CBGSA Member Agencies
	Project Implementation	CBGSA or Member Agencies	• CBGSA Operating Costs • CBGSA Member Agencies
Project 3: Water Supply Transfers/Exchanges	Feasibility Study	CBGSA	• CBGSA Operating Costs
	Project Implementation	CBGSA	• CBGSA Operating Costs
Project 4: Improve Reliability of Water Supplies for Local Communities	CCSD Well 4	Cuyama Community Services District (CCSD)	• Grants • Loans • CCSD Operating Costs
	VWSC Well 2	Ventucopa Water Supply Company (VWSC)	• Grants • Loans • VWSC Operating Costs
Management Action 1: Basin-Wide Economic Analysis	Economic Study	CBGSA	• CBGSA Operating Costs
Management Action 2: Pumping Allocations in Central Basin Management Area	Allocation Plan	CBGSA	• CBGSA Operating Costs
	Enforcement	CBGSA or Member Agencies	• CBGSA Operating Costs • Member Agency Operating Costs
Adaptive Management	-	CBGSA	• Grants • Loans • CBGSA Operating Costs

8.3 Annual Reports

Annual reports must be submitted by April 1 of each year following GSP adoption per California Code of Regulations. Annual reports must include three key sections as follows

- General Information
- Basin Conditions
- Plan Implementation Progress

An outline of what information will be provided in each of these sections in the annual report is included below. Annual reporting would be completed in a manner and format consistent with Section 356.2 of the SGMA regulations. As annual reporting continues, it is possible that this outline will change to reflect Basin conditions, CBGSA priorities, and applicable requirements.

8.3.1 General Information

General information will include an executive summary that highlights the key content of the annual report. As part of the executive summary, this section will include a description of the sustainability goals, provide a description of GSP projects and their progress as well as an annually-updated implementation schedule and map of the Basin. Key components as required by SGMA regulations include:

- Executive Summary
- Map of the Basin

8.3.2 Basin Conditions

Basin conditions will describe the current groundwater conditions and monitoring results. This section will include an evaluation of how conditions have changed in the Basin over the previous year and compare groundwater data for the year to historical groundwater data. Pumping data, effects of project implementation (e.g., recharge data, conservation, if applicable), surface water flows, total water use, and groundwater storage will be included. Key components as required by SGMA regulations include:

- Groundwater elevation data from the monitoring network
- Hydrographs of elevation data
- Groundwater extraction data
- Surface water supply data
- Total water use data
- Change in groundwater storage, including maps

8.3.3 Plan Implementation Progress

Progress toward successful plan implementation would be included in the annual report. This section of the annual report would describe the progress made toward achieving interim milestones as well as implementation of projects and management actions. Key components as required by SGMA regulations include:

- Plan implementation progress
- Sustainability progress

8.4 Five-Year Evaluation Report

SGMA requires evaluation GSPs regarding their progress toward meeting approved sustainability goals at least every five years. SGMA also requires developing a written assessment and submitting this assessment to DWR. An evaluation must also be made whenever the GSP is amended. A description of the information that will be included in the five-year report is provided below, and would be prepared in a manner consistent with Section 356.4 of the SGMA regulations.

8.4.1 Sustainability Evaluation

This section will contain a description of current groundwater conditions for each applicable sustainability indicator and will include a discussion of overall Basin sustainability. Progress toward achieving interim milestones and measurable objectives will be included, along with an evaluation of groundwater elevations (i.e., those being used as direct or proxy measures for the sustainability indicators) in relation to minimum thresholds. If any of the adaptative management triggers are found to be met during this evaluation, a plan for implementing adaptive management described in the GSP would be included.

8.4.2 Plan Implementation Progress

This section will describe the current status of project and management action implementation, and report on whether any adaptive management action triggers had been activated since the previous five-year report. An updated project implementation schedules will be included, along with any new projects that were developed to support the goals of the GSP and a description of any projects that are no longer included in the GSP. The benefits of projects that have been implemented will be included, and updates on projects and management actions that are underway at the time of the five-year report will be reported.

8.4.3 Reconsideration of GSP Elements

Part of the five-year report will include a reconsideration of GSP elements. As additional monitoring data are collected during GSP implementation, land uses and community characteristics change over time, and GSP projects and management actions are implemented, it may become necessary to revise the GSP. This section of the five-year report will reconsider the Basin setting, management areas, undesirable results, minimum thresholds, and measurable objectives. If appropriate, the five-year report will recommend revisions to the GSP. Revisions would be informed by the outcomes of the monitoring network, and changes in the Basin, including changes to groundwater uses or supplies and outcomes of project implementation.

8.4.4 Monitoring Network Description

A description of the monitoring network will be provided in the five-year report. Data gaps, or areas of the Basin that are not monitored in a manner commensurate with the requirements of Sections 352.4 and 354.34(c) of the SGMA regulations will be identified. An assessment of the monitoring network's function will also be provided, along with an analysis of data collected to date. If data gaps are identified, the GSP will be revised to include a program for addressing these data gaps, along with an implemented schedule for addressing gaps and how the CBGSA will incorporate updated data into the GSP.

8.4.5 New Information

New information that becomes available after the last five-year evaluation or GSP amendment would be described and evaluated. If the new information would warrant a change to the GSP, this would also be included, as described in Section 8.4.3.

8.4.6 Regulations or Ordinances

The five-year report will include a summary of the regulations or ordinances related to the GSP that have been implemented by DWR since the previous report, and address how these may require updates to the GSP.

8.4.7 Legal or Enforcement Actions

Enforcement or legal actions taken by the CBGSA or its member agencies in relation to the GSP will be summarized in this section along with how such actions support sustainability in the Basin.

8.4.8 Plan Amendments

A description of amendments to the GSP will be provided in the five-year report, including adopted amendments, recommended amendments for future updates, and amendments that are underway during development of the five-year report.

8.4.9 Coordination

The CBGSA is the only GSA in the Cuyama Basin. It is adjacent to the Carrizo Basin, the Mil Potrero Area Basin, and Lockwood Valley Basin, which are very low priority basins per the California Statewide Groundwater Elevation Monitoring (CASGEM) Program, and not yet required to comply with SGMA. Downstream from the Basin is the Santa Maria River Valley Basin, which is currently undergoing prioritization evaluation under the CASGEM Program. A GSA has formed for the Santa Maria Basin

Fringe Areas, which are located downstream from Twitchell Reservoir, and could be affected by stormwater capture activities by the CBGSA. The CBGSA may need to coordinate with this GSA, and will need to coordinate with various land use agencies and other entities to implement projects. This section of the five-year report will describe coordination activities between these entities, such as meetings, joint projects, or data collection efforts. If additional neighboring GSAs have been formed since the previous report, or changes in neighboring basins occurred, that result in a need for new or additional coordination within or outside the Basin, such coordination activities would be included as well.

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