Cuyama Basin
Groundwater Sustainability Plan—
2020 Annual Report

Prepared by:

WOODARD & CURRAN

March 2020

This page intentionally blank

Table of Contents

Tables

Figures

Appendices

Abbreviations and Acronyms

AF	acre-feet
CBGSA	Cuyama Basin Groundwater Sustainability Agency
CBWD	Cuyama Basin Water District
CBWRM	Cuyama Basin Water Resources Model
CCSD	Cuyama Community Services District
DMS	Data Management System
DWR	California Department of Water Resources
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
SAC	Standing Advisory Committee
SBCWA	Santa Barbara County Water Agency
SGMA	Sustainability Groundwater Management Act
SR	State Route
TSS	Technical Support Services
USGS	United States Geological Survey

This page intentionally blank

ES-1 Executive Summary

§356.2 (a)	General information, including an executive summary and a location map depicting the basin covered by the report.

ES-2 Introduction

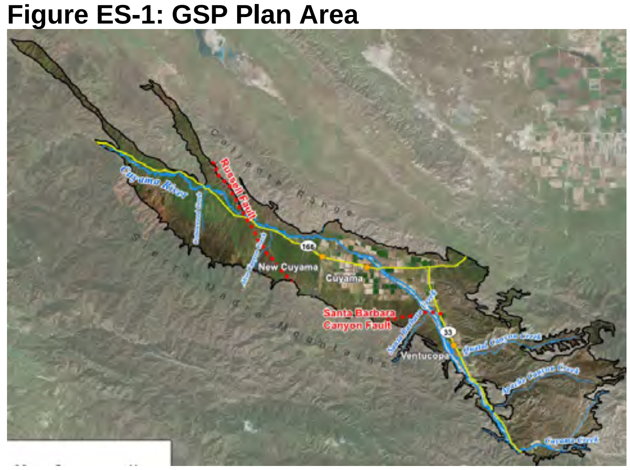
In 2014, the California legislature enacted the Sustainable Groundwater Management Act (SGMA) in response to continued overdraft of California's groundwater resources. The Cuyama Groundwater Basin (Basin) is one of 21 basins and subbasins identified by the California Department of Water Resources (DWR) as being in a state of critical overdraft. SGMA requires that a Groundwater Sustainability Plan (GSP) be prepared to address the measures necessary to attain sustainable conditions in the Cuyama Groundwater 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.

In response to SGMA, the Cuyama Basin Groundwater Sustainability Agency (CBGSA) was formed in 2017. 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 was adopted on December 4, 2019 by the CBGSA and submitted to DWR on January 28, 2020. SGMA requires that the CBGSA develop a GSP that achieves groundwater sustainability in the Basin by the year 2040.

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

Figure ES-1: GSP Plan Area



ES-3 Groundwater Conditions

The Annual Report for 2019 includes groundwater contours for Fall of 2018 and Spring and Fall of 2019, and updated hydrographs for the groundwater level monitoring network identified in the Cuyama Basin GSP. The Cuyama Basin consists of a single principal aquifer, and water levels in Basin monitoring wells are considered representative of conditions in that aquifer. 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. Groundwater levels vary across the Basin, with the highest depth to water occurring in the central portion of the Basin (Figure ES-2). The western and eastern portions of the Basin have generally shallower depth to water. Generally, depth to water and groundwater elevation in 2019 have not changed substantially from 2018 levels and elevations.

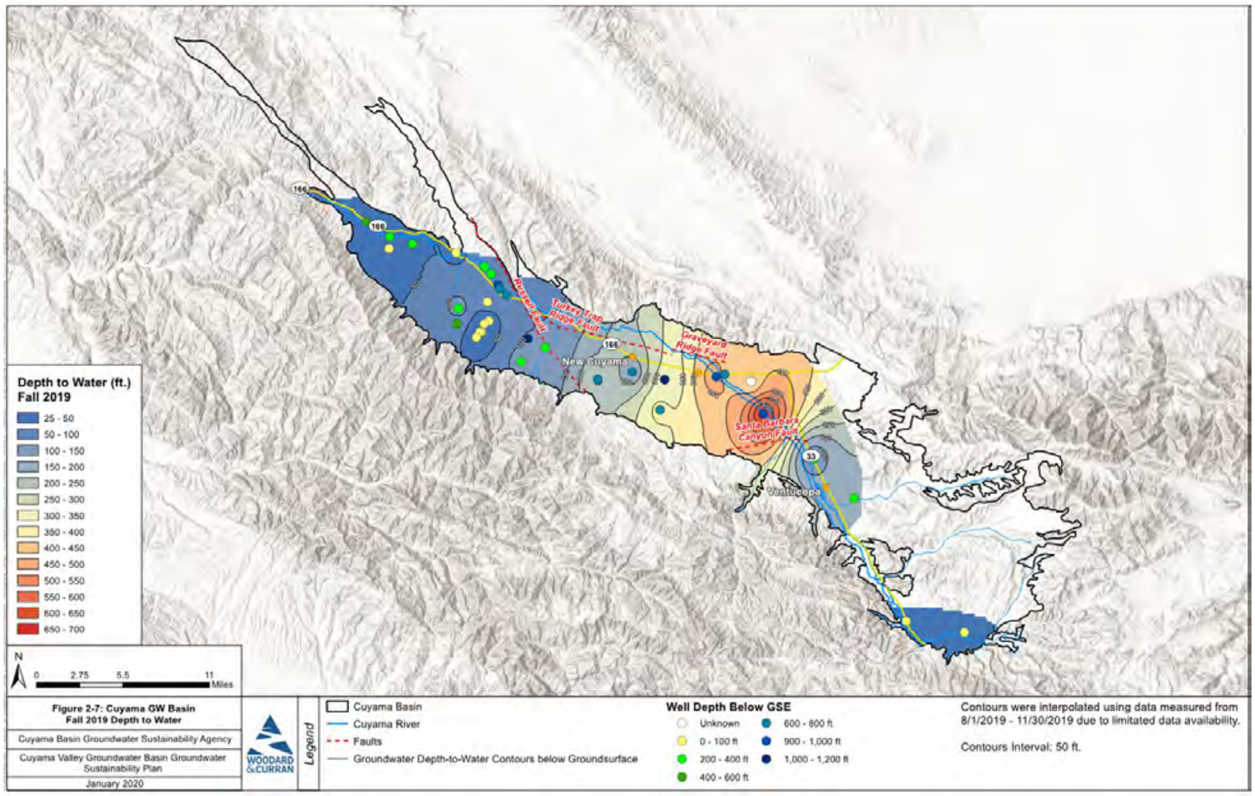


Figure ES-2: Cuyama Basin Depth to Water Contour Map (Fall 2019)

ES-4 Water Use

The Cuyama Groundwater Basin is supplied entirely by groundwater, with virtually no surface water use. Groundwater pumping in the Basin is estimated to have been about 60,000 acre-feet (AF) in 2018 and about 47,000 AF in 2019. While the 2018 value is near the average of the long-term trend in groundwater pumping, estimated pumping in 2019 is among the lowest in the 22-year period since 1998. (See Figure ES-3).

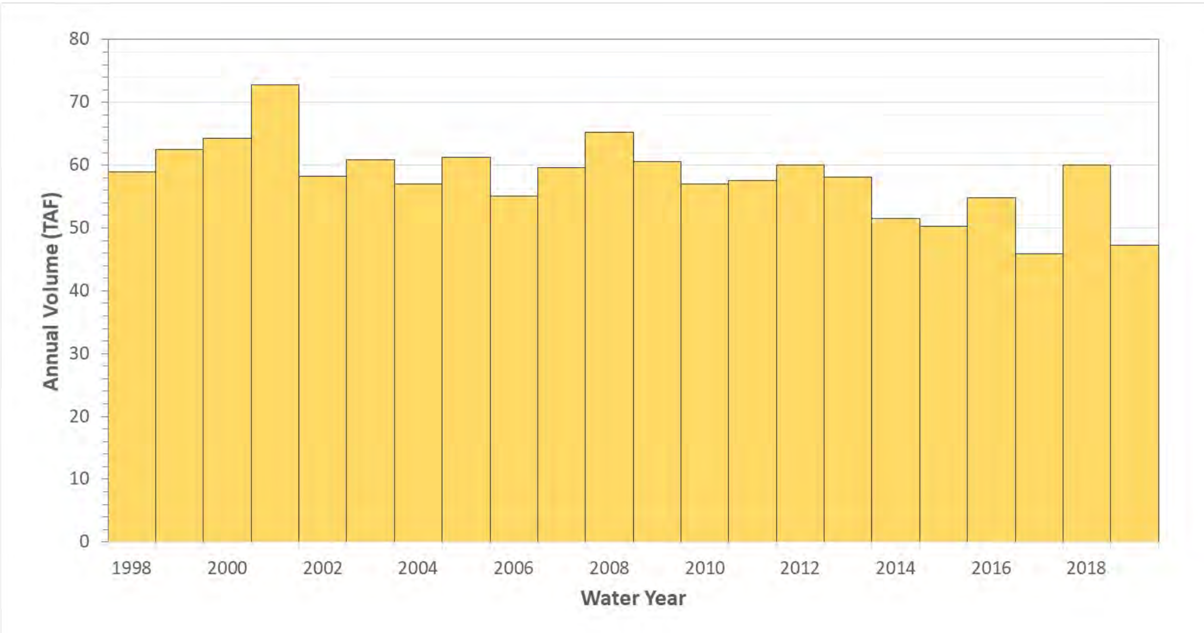


Figure ES-3: Annual Groundwater Extraction in the Cuyama Basin in Water Years 1998-2019

ES-5 Change in Groundwater Storage

It is estimated that there were reductions in Basin groundwater storage of 39,400 AF in 2018 and 11,100 AF in 2019. This continues the long-term trend in groundwater storage reduction in the Basin since 1999. Figure ES-4 shows the historical change in groundwater storage by year, water year type,[1] and cumulative water volume in each year for the period from 1998 through 2019.

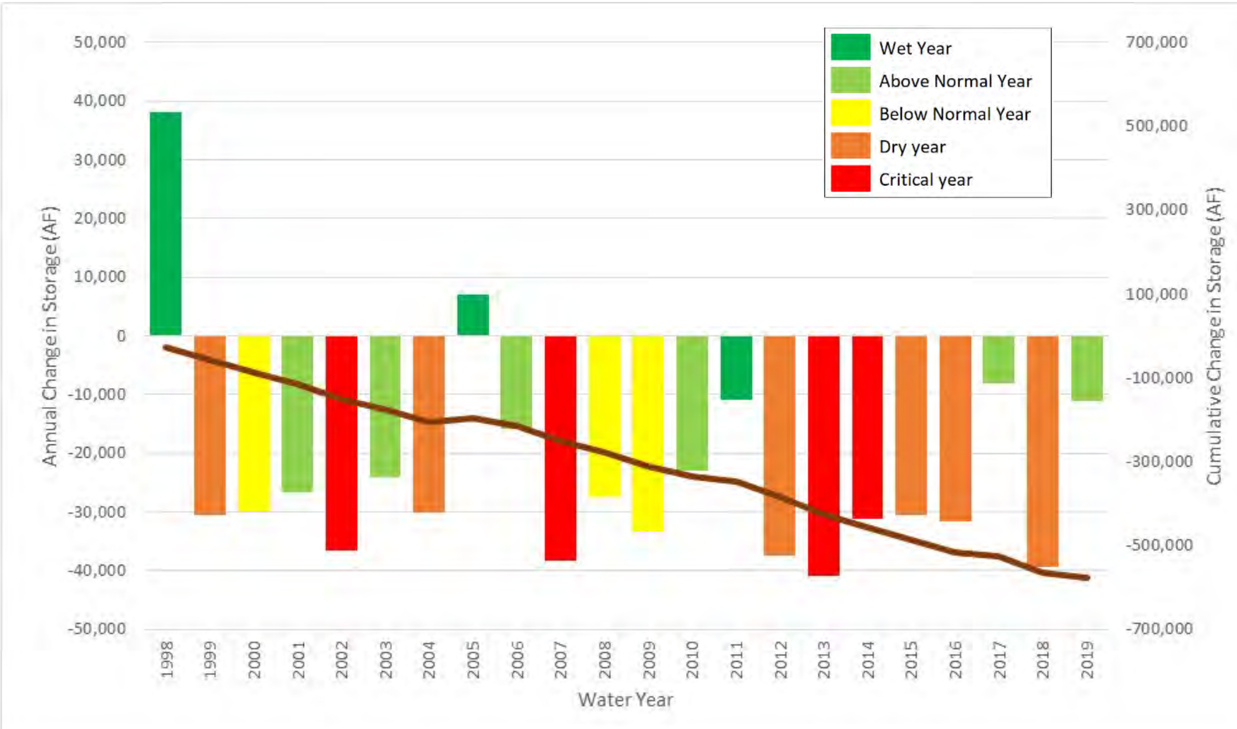


Figure ES-4: Change in Groundwater Storage by Year, Water Year Type, and Cumulative Water Volume

[1] 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.

ES-6 Plan Implementation

The following plan implementation activities were accomplished in 2019:

- Approval of a groundwater extraction fee, which is expected to generate $1,021,936 in revenue to cover the administrative costs of the CBGSA.
- A total of 21 public meetings were conducted at which GSP development and implementation was discussed.
- A Basin-wide, direct economic analysis of proposed GSP management actions was completed. The results of this analysis were presented to the GSP Board on December 4, 2019.
- The CBGSA Board approved a task to begin implementation of the groundwater levels monitoring network, which supplements ongoing efforts to install continuous monitoring equipment in wells and surface flow gages under an ongoing DWR grant. In addition, the CBGSA is pursuing DWR Technical Support Services assistance to install three new monitoring wells.

This page intentionally blank

Section 1. Introduction

§356.2 (a)	General information, including an executive summary and a location map depicting the basin covered by the report.

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 Annual Report.

This Annual Report meets regulatory requirements established by the California Department of Water Resources (DWR) as provided in Article 7 of the California Code of Regulations, Title 23, Division 2, Chapter 1.5, Subchapter 2.

The CBGSA was created by a Joint Exercise of Powers Agreement among the following agencies:

- Counties of Kern, San Luis Obispo, and Ventura
- Santa Barbara County Water Agency (SBCWA), representing the County of Santa Barbara
- Cuyama Basin Water District (CBWD)
- Cuyama Community Services District (CCSD)

The CBGSA Board of Directors includes the following individuals:

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

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 Management Structure

The CBGSA is governed by an 11-member Board of Directors that meets monthly. A 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. The Board also formed a Standing Advisory Committee comprised of 11 stakeholders to provide recommendations to the Board on key technical issues which also meets regularly.

1.1.2 Legal Authority

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

1.1.3 Groundwater Sustainability Plan

The CBGSA Board of Directors approved the first iteration of the Cuyama Groundwater Sustainability Plan (GSP) on December 4, 2019. The GSP was submitted to DWR for approval on January 28, 2020 and is available for viewing online at http://cuyamabasin.org/.

1.2 Plan Area

Figure 1-1 shows the Basin and its key geographic features. The Basin encompasses an area of about 378 square miles[2] 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 toward 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 the Cuyama Valley Groundwater Basin.

[2] The current Bulletin 118 section on the Cuyama Valley Groundwater Basin incorrectly states that the Basin area is 230 square miles. The estimate of 378 square miles shown here and in the GSP is consistent with the mapping shown on DWR's GSA Map Viewer.

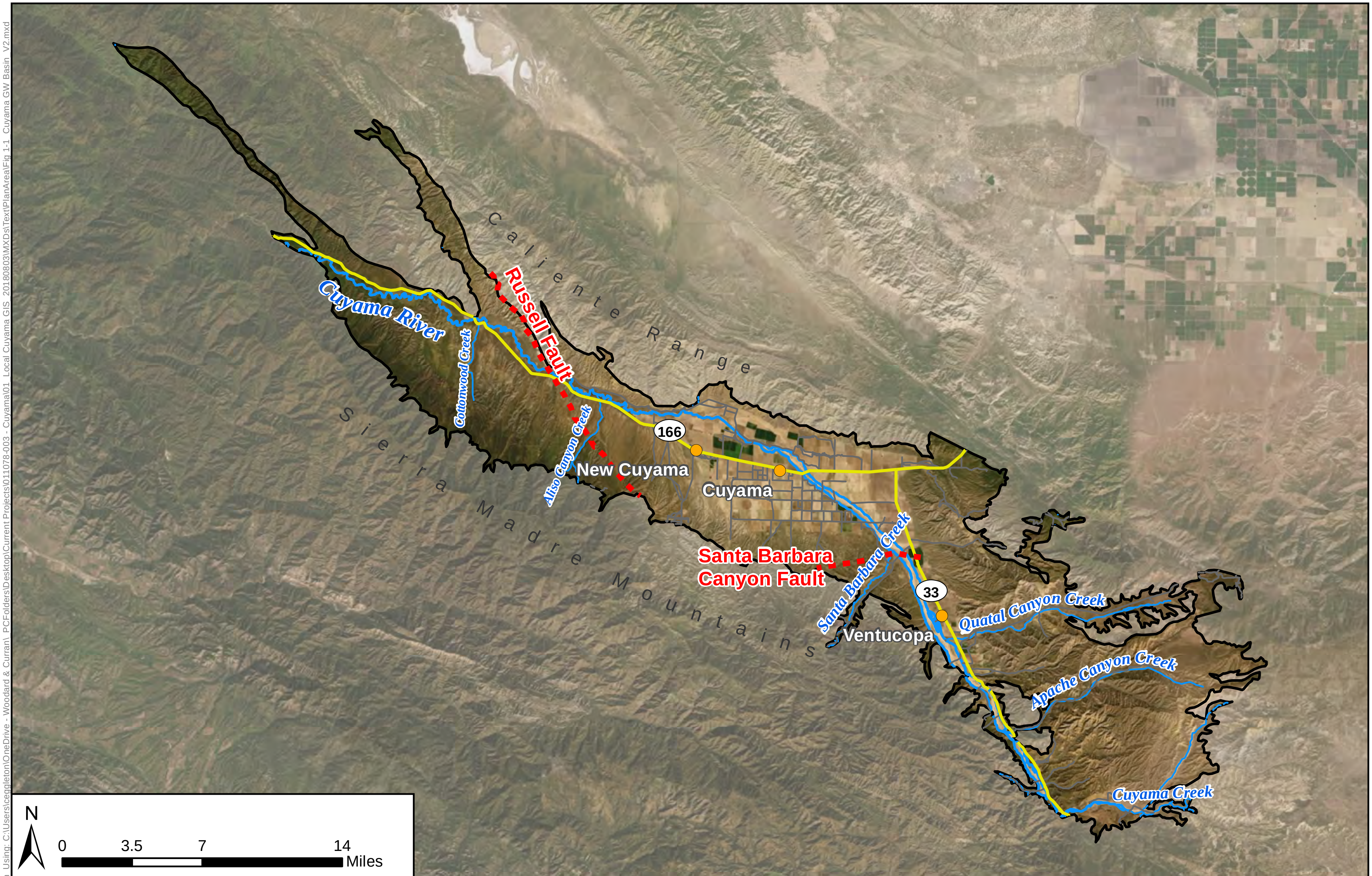


Figure 1-1 - Cuyama Valley Groundwater Sustainability Plan Area

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

February 2020

WOODARD & CURRAN

Legend

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

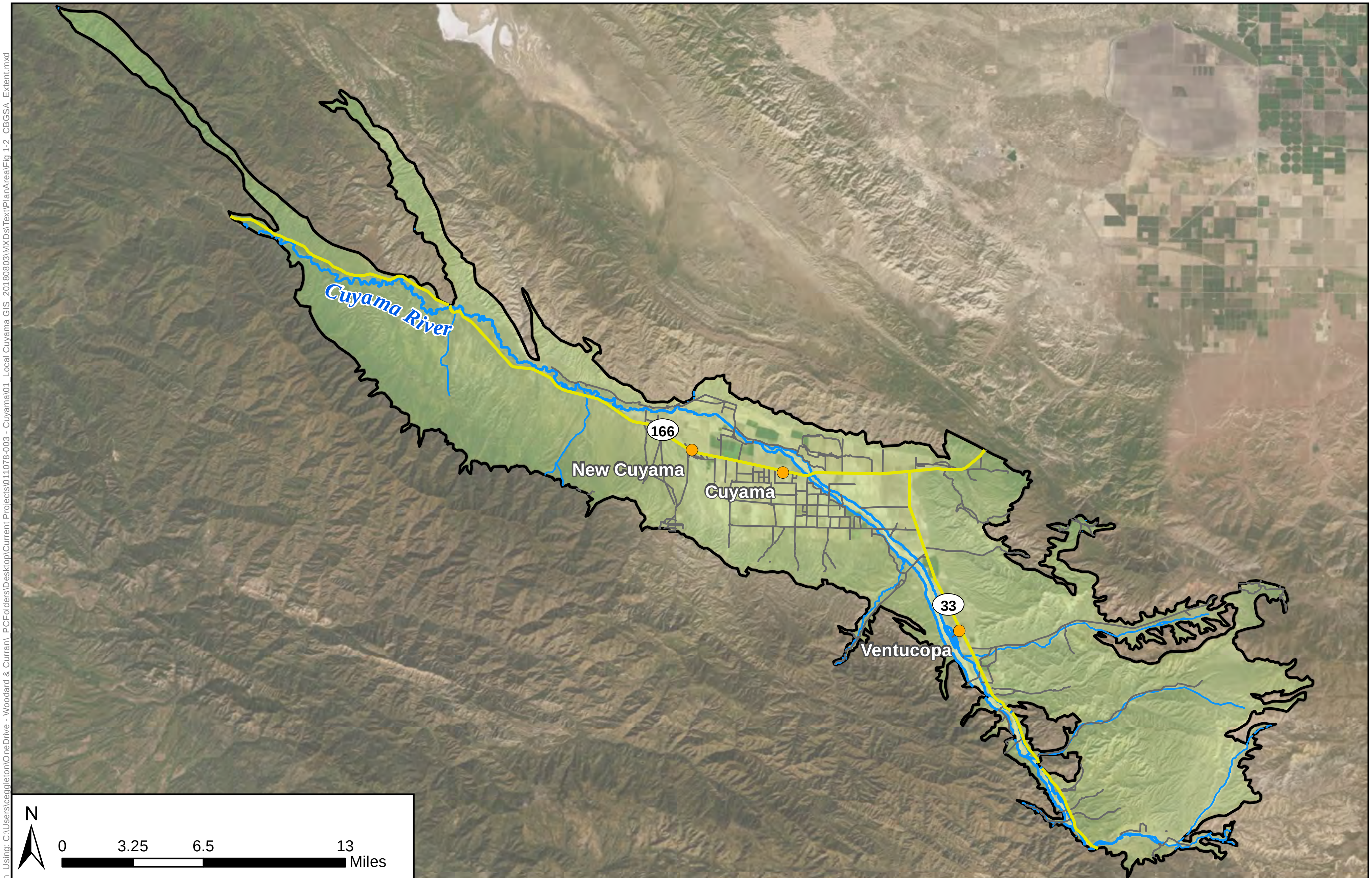


Figure 1-2: Cuyama Valley Groundwater Sustainability Agency Boundary

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

January 2020

WOODARD & CURRAN

Legend

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

Figure Exported: 2/12/2020 By: ceggleton Using: C:\Users\ceggleton\OneDrive - Woodard & Curran\ PCFolders\Desktop\Current Projects\0011078-003 - Cuyama\01 Local Cuyama GIS 20180803\MXDs\Text\PlanArea\Fig 1-2 CBGSA Extent.mxd

Section 2. Groundwater Conditions

§356.2 (b)(1)	Groundwater elevation data from monitoring wells identified in the monitoring network shall be analyzed and displayed as follows:
§356.2 (b)(1)(A)	Groundwater elevation contour maps for each principal aquifer in the basin illustrating, at a minimum, the seasonal high and seasonal low groundwater conditions.
§356.2 (b)(1)(B)	Hydrographs of groundwater elevations and water year type using historical data to the greatest extent available, including from January 1, 2015, to current reporting year.

2.1 Representative Monitoring Network

As required by DWR's SGMA regulations, a monitoring network and representative monitoring network were identified in the Cuyama Basin GSP utilizing existing wells. The groundwater levels representative monitoring network that was included in the GSP is shown on Figure 2-1. The Cuyama Basin consists of a single principal aquifer, and water levels in monitoring network wells are considered representative of conditions in that aquifer. The objective of the representative monitoring network is to detect undesirable results in the Basin related to groundwater levels using the sustainability thresholds described in the GSP. 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.
- Monitoring that has occurred on the groundwater level monitoring network since the development of the Cuyama Basin GSP is included in this Annual Report. Collected groundwater level data has been analyzed to prepare contour maps and updated hydrographs, which are presented in the following sections.

This page intentionally blank

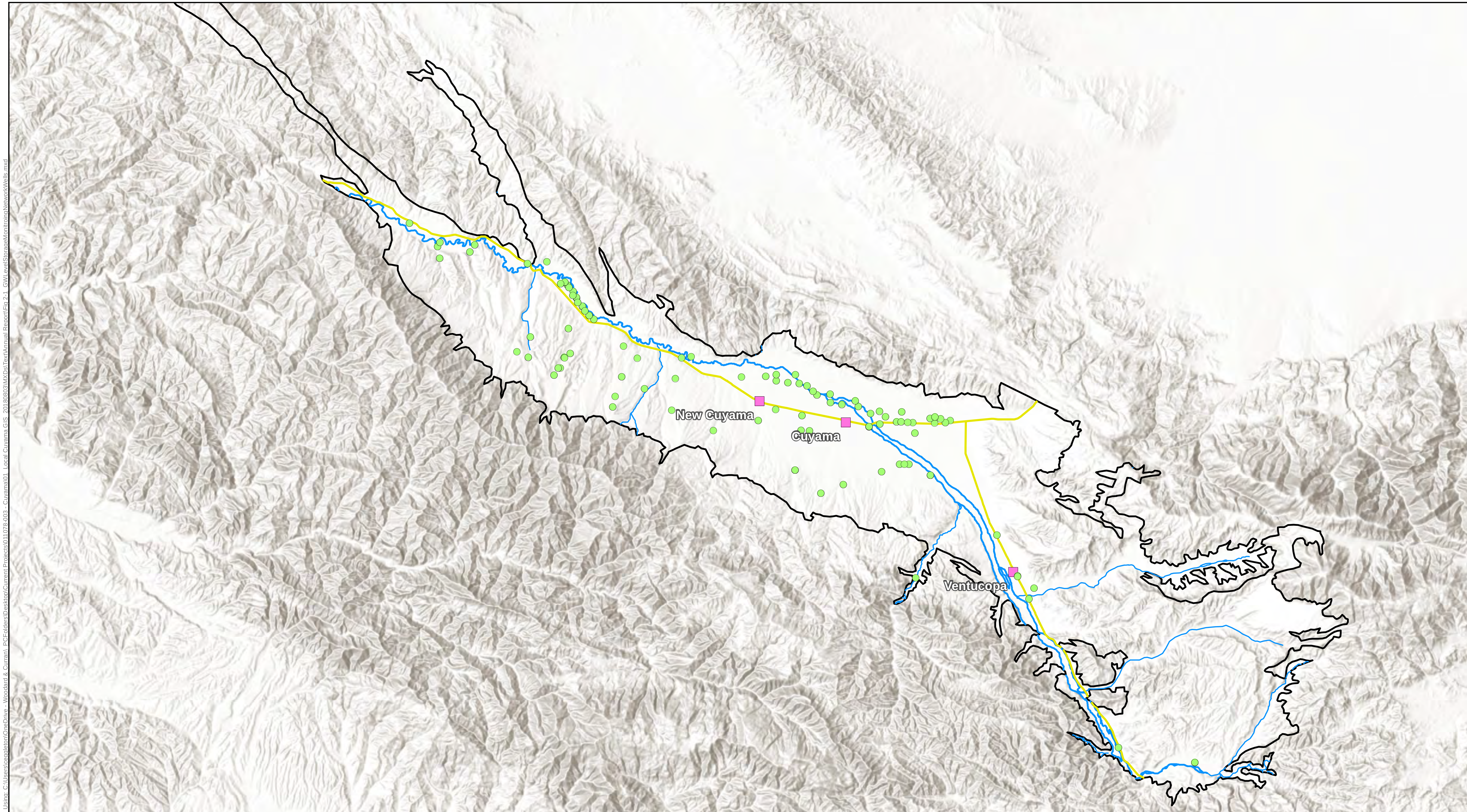


Figure 2-1: Groundwater Level Monitoring Network

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

January 2020

WOODARD & CURRAN

Legend

- Cuyama Basin
- Towns
- Highways
- Cuyama River
- Streams

Monitoring Network Wells

- Monitoring Network Wells

N

0 2.5 5 10 Miles

This page intentionally blank

2.2 Groundwater Contour Maps

The GSP included contour maps through the spring of 2018. For the Annual Report, analysis was conducted to incorporate data from June 2018 to December 2019 that was received from the United States Geological Survey (USGS), DWR, private landowners, and local counties and agencies. Data was then added to the Data Management System (DMS) and processed to analyze the current groundwater conditions by creating seasonal groundwater contour/raster maps and hydrographs.

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 under the supervision of a Certified Hydrogeologist in the State of California for both groundwater elevation and depth to water for the following periods:

- Fall 2018
- Spring 2019
- Fall 2019

Each contour map is contoured at a 50-foot contour interval, with contour elevations indicated in white numeric label. 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 significant known 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.

Figure 2-2 shows groundwater elevation contours for fall of 2018. Data was collected from Santa Barbara County, Ventura County, DWR, USGS, and local landowners, however, data collected between August and November was limited and was not available for the south eastern portion of the Basin. However, available data shows a depression in the central portion of the Basin between Ventucopa and New Cuyama. Groundwater elevations then rise between Cuyama and New Cuyama, before decreasing again in a northwestern trend to the bottom of the Basin. Groundwater flows are to the northwest in the western portion of the Basin, and toward the north east in the central portion of the basin

Figure 2-3 shows the depth to groundwater contours for fall 2018 and shows a depression in the central portion of the Basin greater than 600 ft below ground surface. Groundwater levels then increase toward the west reaching depths above 100 ft in the western portion of the Basin. These levels align with trends seen in older counter maps provided in the Cuyama Valley Basin 2020 GSP.

Figure 2-4 shows the groundwater elevation contours for spring of 2019. Data for this time period provides greater Basin coverage than in fall of 2018. Groundwater elevations show a clear depression in the central portion of the Basin and a steep gradient between the central portion of the Basin and the Ventucopa area, which is consistent with contour maps for 2015 and 2017 conditions. Groundwater elevations steadily increase toward the east through Ventucopa.

Figure 2-5 shows the depth to groundwater contours for the spring of 2019. Data collected in 2019 provided more spatial coverage than 2018 measurements did. The contours and also shows a depression in the central portion of the Basin, and a steep gradient between the central portion of the Basin and the Ventucopa area, which is consistent with contour maps for 2015 and 2017 conditions. When compared with Figure 2-4, it is clear that Basin topography is not the sole factor of groundwater level changes because both groundwater elevations and depths below ground surface rise between Cuyama and Ventucopa. Groundwater level data was available in fall of 2019 for two monitoring wells in the far east portion of the Basin, and that data indicates that groundwater levels in that area are within 50 feet of the ground surface

Figure 2-6 and Figure 2-7 show the groundwater elevation contours and depth to groundwater levels for fall of 2019. These figures show the same trends as provided in figures Figure 2-2 through Figure 2-5, however some levels in these figures are even lower in the central portion of the Basin. Groundwater level data was available in fall of 2019 for two monitoring wells in the far east portion of the Basin, and that data indicates that groundwater levels in that area are within 50 feet of the ground surface.

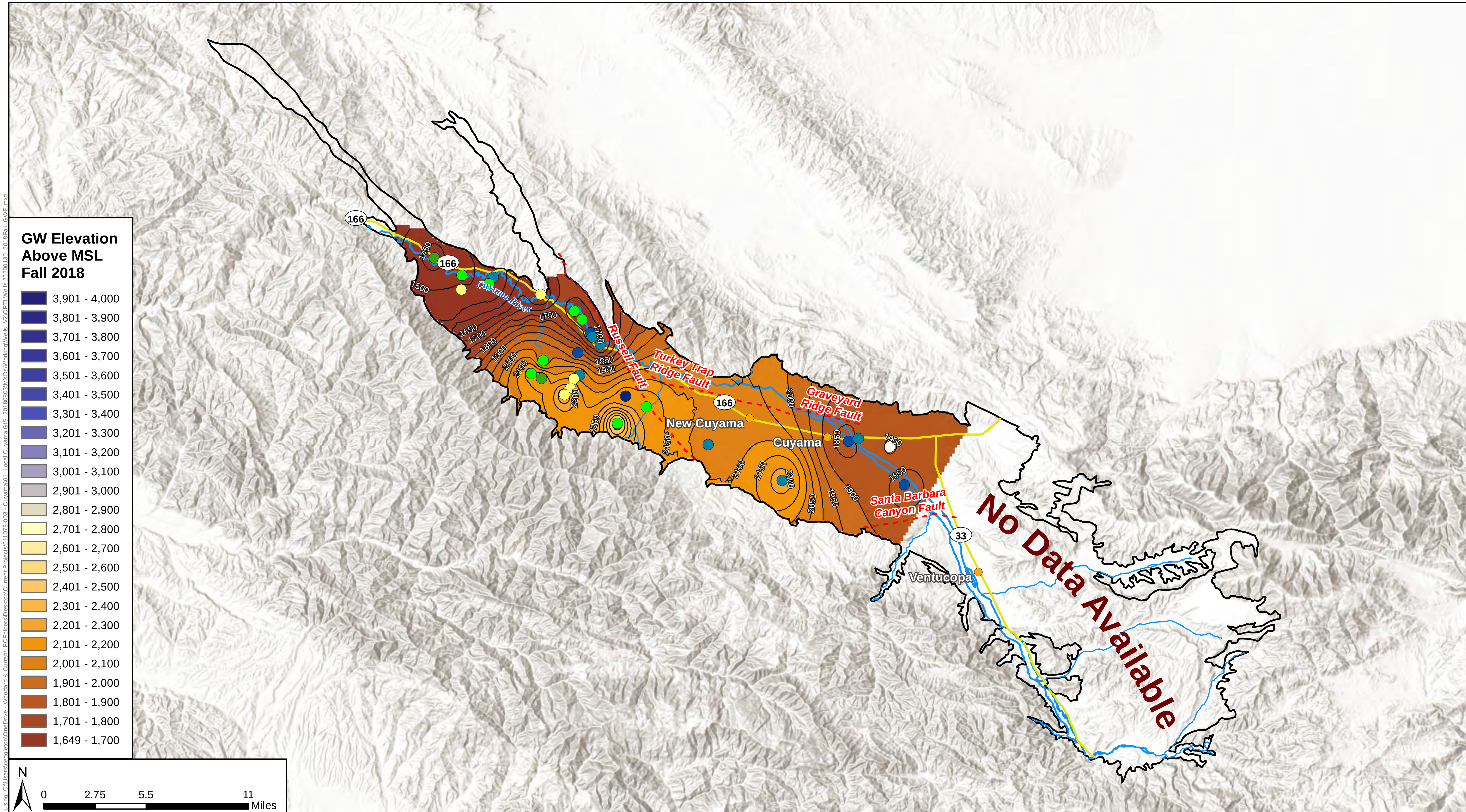


Figure 2-2: Cuyama Basin Fall 2018 Groundwater Elevation Contours

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

January 2020

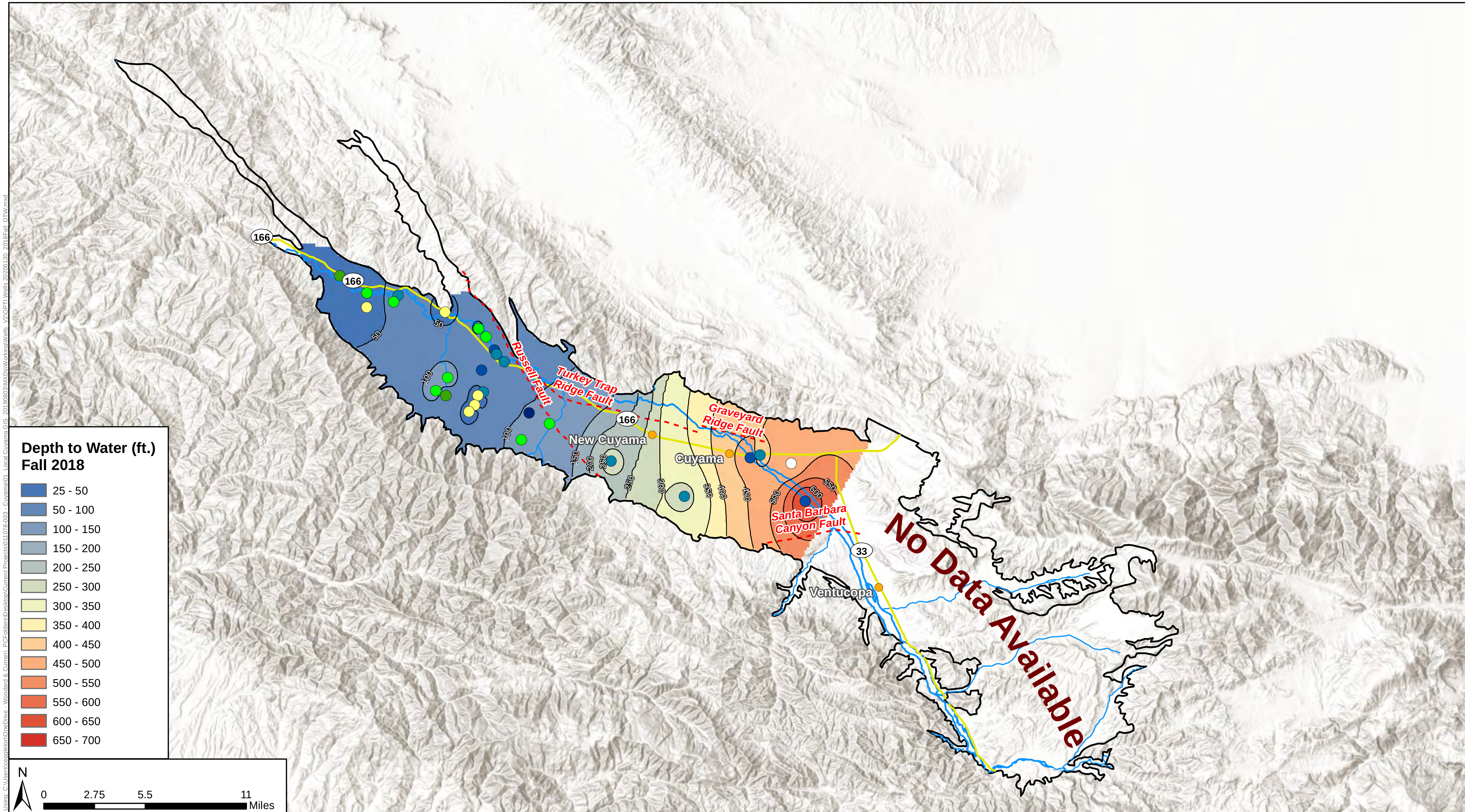


Figure 2-3: Cuyama Basin Fall 2018
Depth to Groundwater Contours

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

January 2020

WOODARD & CURRAN

Legend

- Cuyama Basin
- Cuyama River
- Faults
- 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 8/1/2018 - 11/30/2018 due to limitated data availability.

Contours Interval: 50 ft.

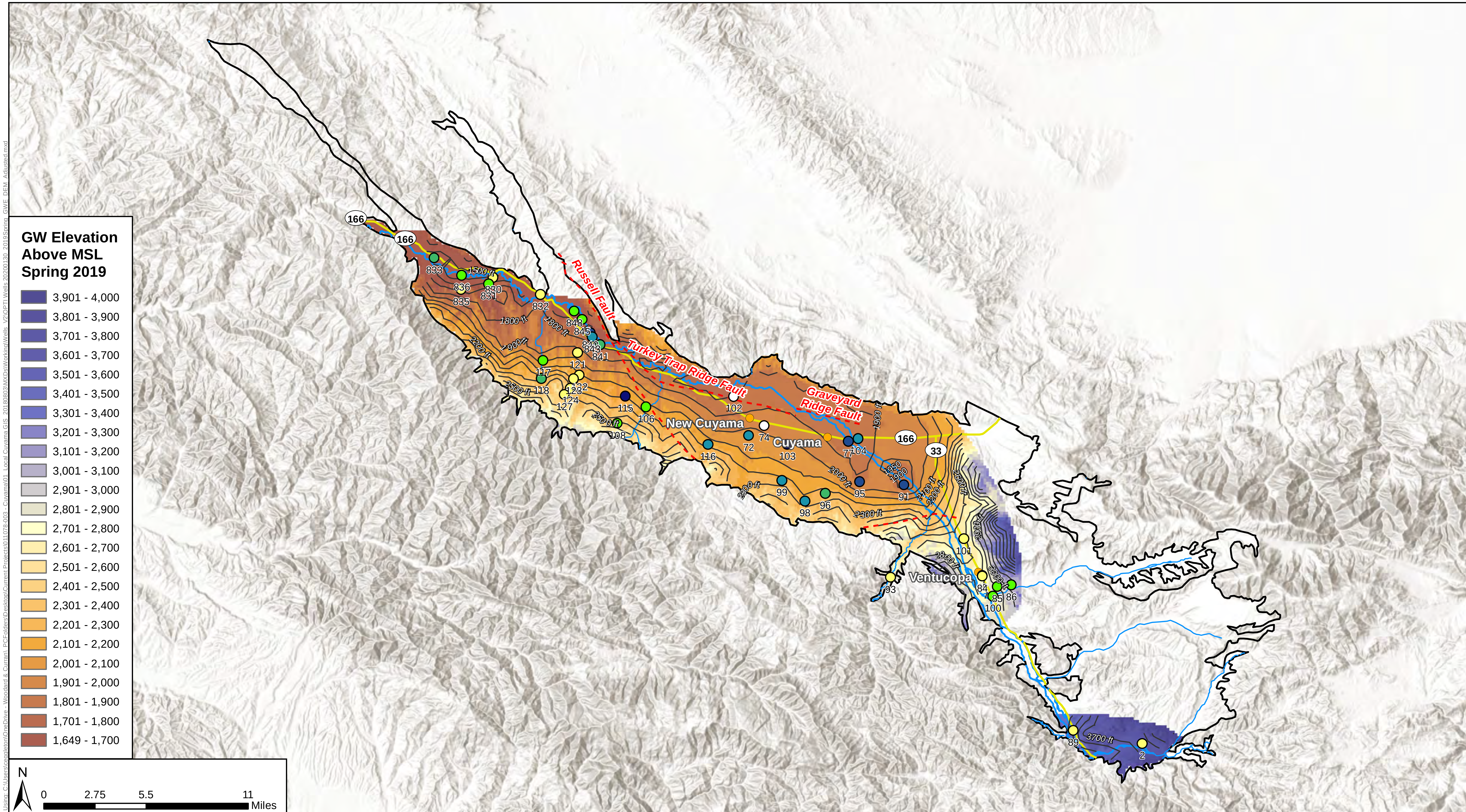


Figure 2-4: Cuyama Basin Spring 2019 Groundwater Elevation Contours

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

January 2020

WOODARD & CURRAN

Legend

- Cuyama Basin
- Cuyama River
- Faults
- 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 2/1/2019 - 4/30/2019 due to limited data availability.

Contours Interval: 100 ft.

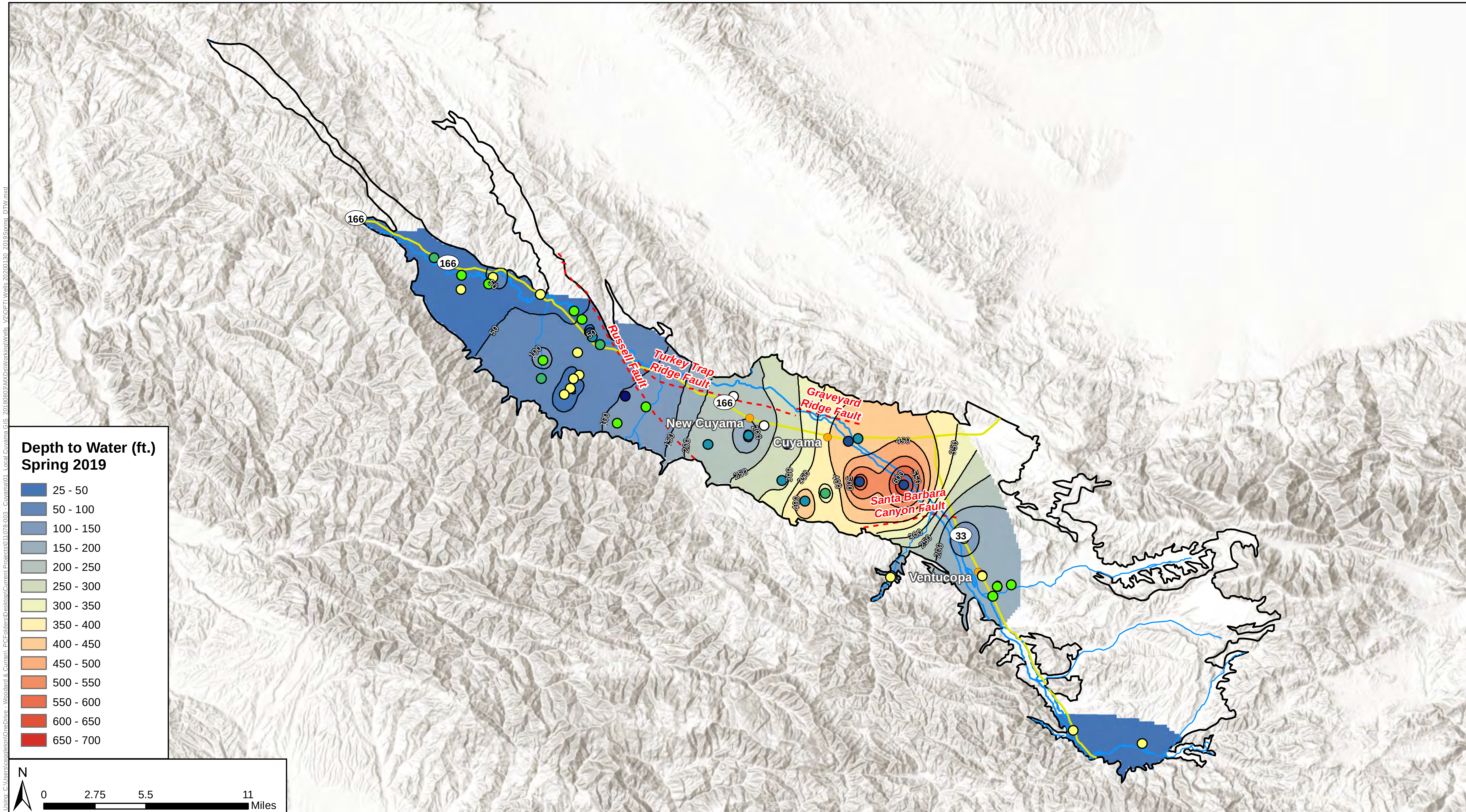


Figure 2-5: Cuyama Basin Spring 2019
Depth to Groundwater Contours

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

January 2020

WOODARD & CURRAN

Legend

- Cuyama Basin
- Cuyama River
- Faults
- 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 2/1/2019 - 4/30/2019 due to limitated data availability.

Contours Interval: 50 ft.

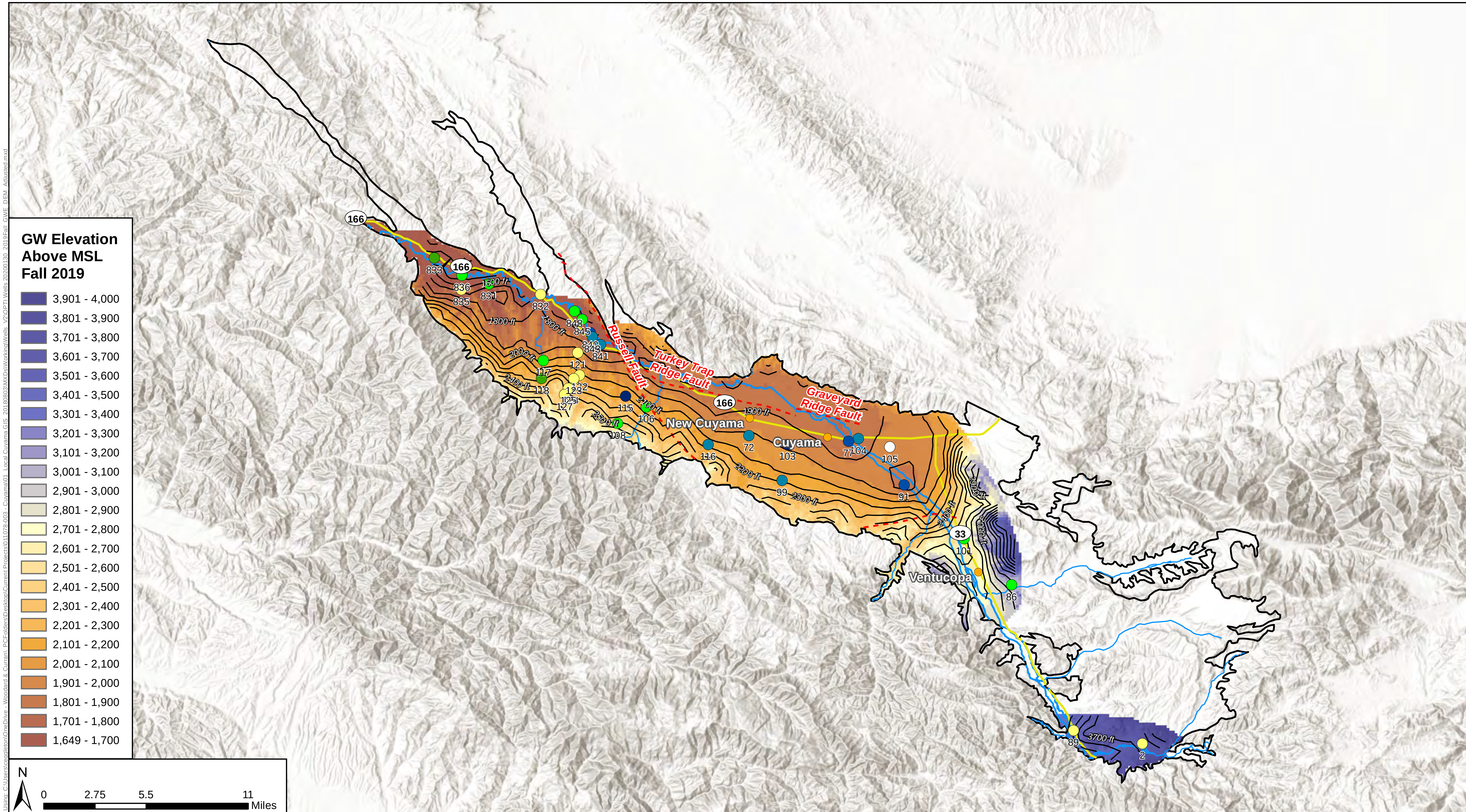


Figure 2-6: Cuyama Basin Fall 2019 Groundwater Elevation Contours

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

January 2020

WOODARD & CURRAN

Legend

- Cuyama Basin
- Cuyama River
- Faults
- Groundwater Elevation Above MSL

Well Depth Below GSE

- Unknown
- 0 - 100 ft
- 200 - 400 ft
- 400 - 600 ft
- 600 - 800 ft
- 900 - 1,000 ft
- 1,000 - 1,200 ft

Contours were interpolated using data measured from 8/1/2019 - 11/30/2019 due to limitaed data availbility.

Contours Interval: 100 ft.

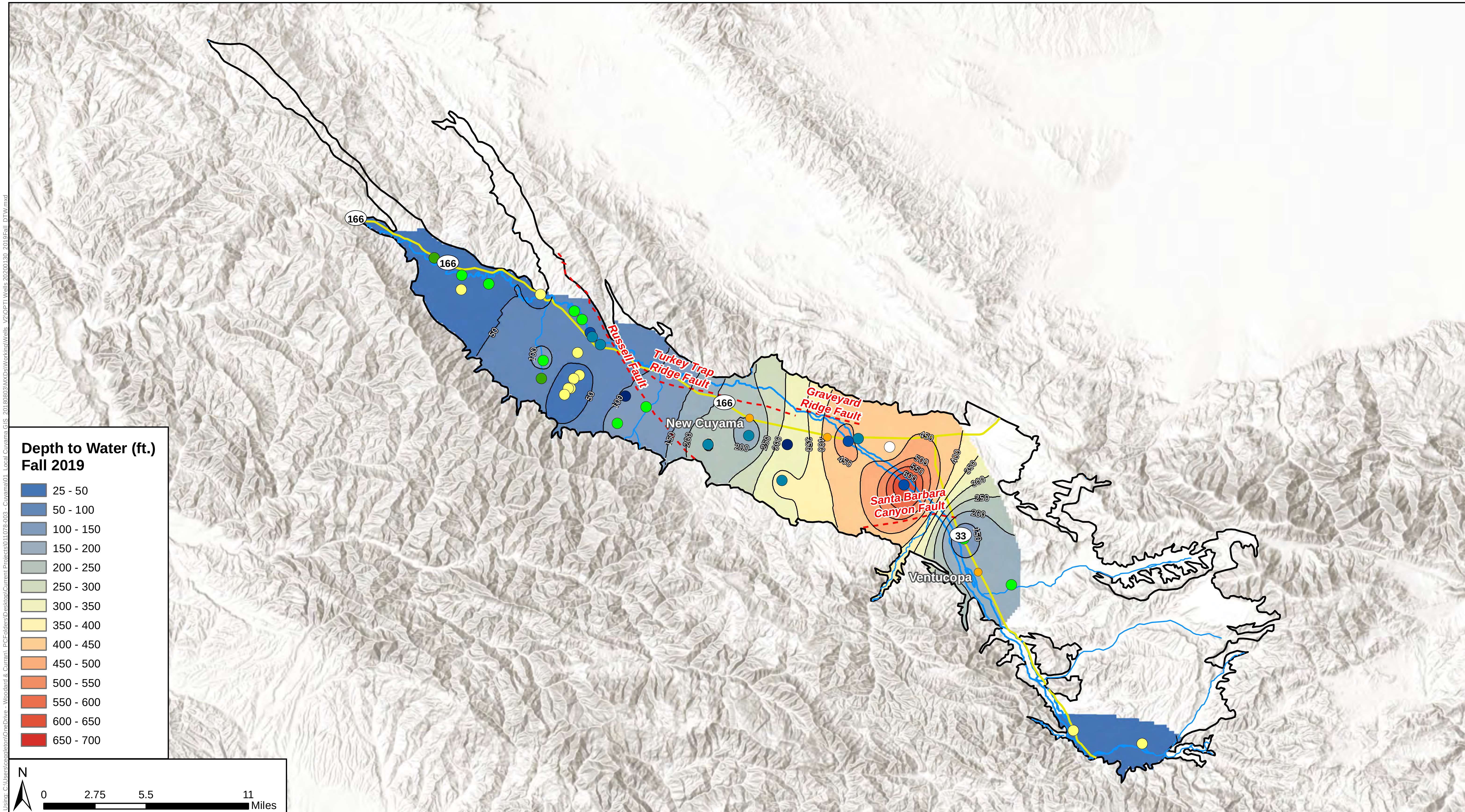


Figure 2-7: Cuyama Basin Fall 2019
Depth to Groundwater Contours

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

January 2020

WOODARD & CURRAN

Legend

- Cuyama Basin
- Cuyama River
- Faults
- Groundwater Depth-to-Water Contours below Groundsurface

Well Depth Below GSE

- Unknown
- 0 - 100 ft
- 200 - 400 ft
- 400 - 600 ft
- 600 - 800 ft
- 900 - 1,000 ft
- 1,000 - 1,200 ft

Contours were interpolated using data measured from 8/1/2019 - 11/30/2019 due to limitated data availability.

Contours Interval: 50 ft.

2.3 Hydrographs

Groundwater hydrographs were developed for each monitoring network well 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. A selection of wells from each threshold region are provided below, while hydrographs for every well 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. 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. To provide a comparative analysis general groundwater trends are provided in Table 2-1 and are accompanied by hydrographs for each threshold regions. A map of threshold regions is provided in Figure 2-8, which also shows the locations of example wells used in each threshold region.

Table 2-1: Groundwater Trends by Threshold Region

Threshold Region	Groundwater Trend	Example Well
Northwestern Region	Slight downward trend influenced by seasonal fluctuations. This is expected as recent changes in land use have begun to pump groundwater. Levels are still approximately 80 ft above the Measurable Objective.	841 (Figure 2-9)
Western Region	Levels in this region have either stayed relatively flat or slightly increased.	108 (Figure 2-10)
Central Region	Levels have historically had a steady downward trend with some seasonal fluctuations. This pattern remains with trends continuing downward and, in some cases, levels surpassing minimum thresholds.	91 (Figure 2-11)
Eastern Region	This region has seen an overall decline over several decades, however, recent groundwater trends appear to be equilibrizing.	62 (Figure 2-12)
Southeastern Region	Levels in this relatively small region decreased slightly during the last drought but have recovered over the past few years and are well above the Measurable Objective.	89 (Figure 2-13)

This page intentionally blank

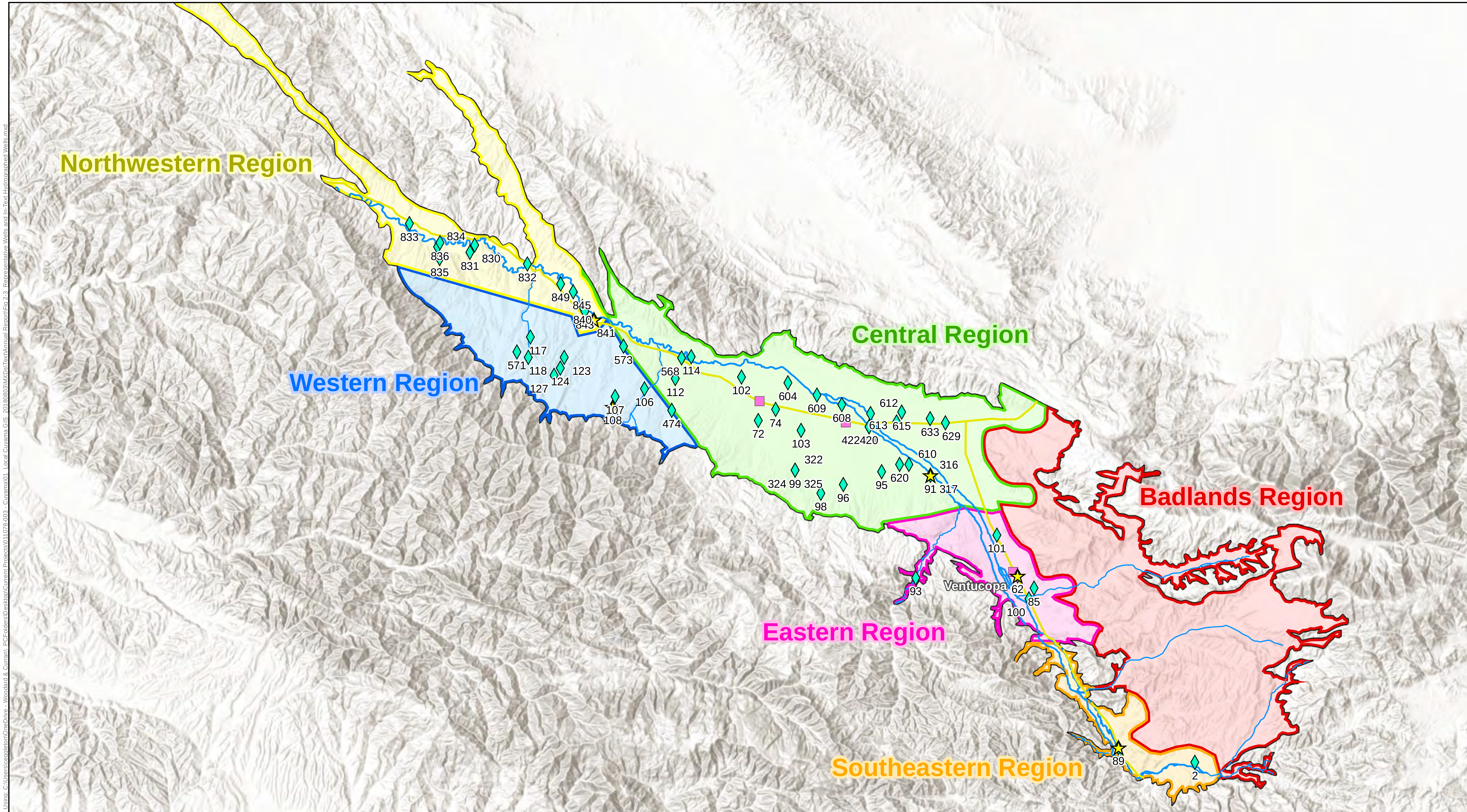


Figure 2-8: Cuyama Basin Threshold Regions	
Cuyama Basin Groundwater Sustainability Agency	
Cuyama Valley Groundwater Basin Groundwater Sustainability Plan	WOODARD & CURRAN
January 2020	

Legend

- Towns
- Highways
- Cuyama River
- Streams
- Cuyama Basin
- Representative Wells
- Wells with Example Hydrographs in Annual Report

N

0 2.5 5 10 Miles

This page intentionally blank

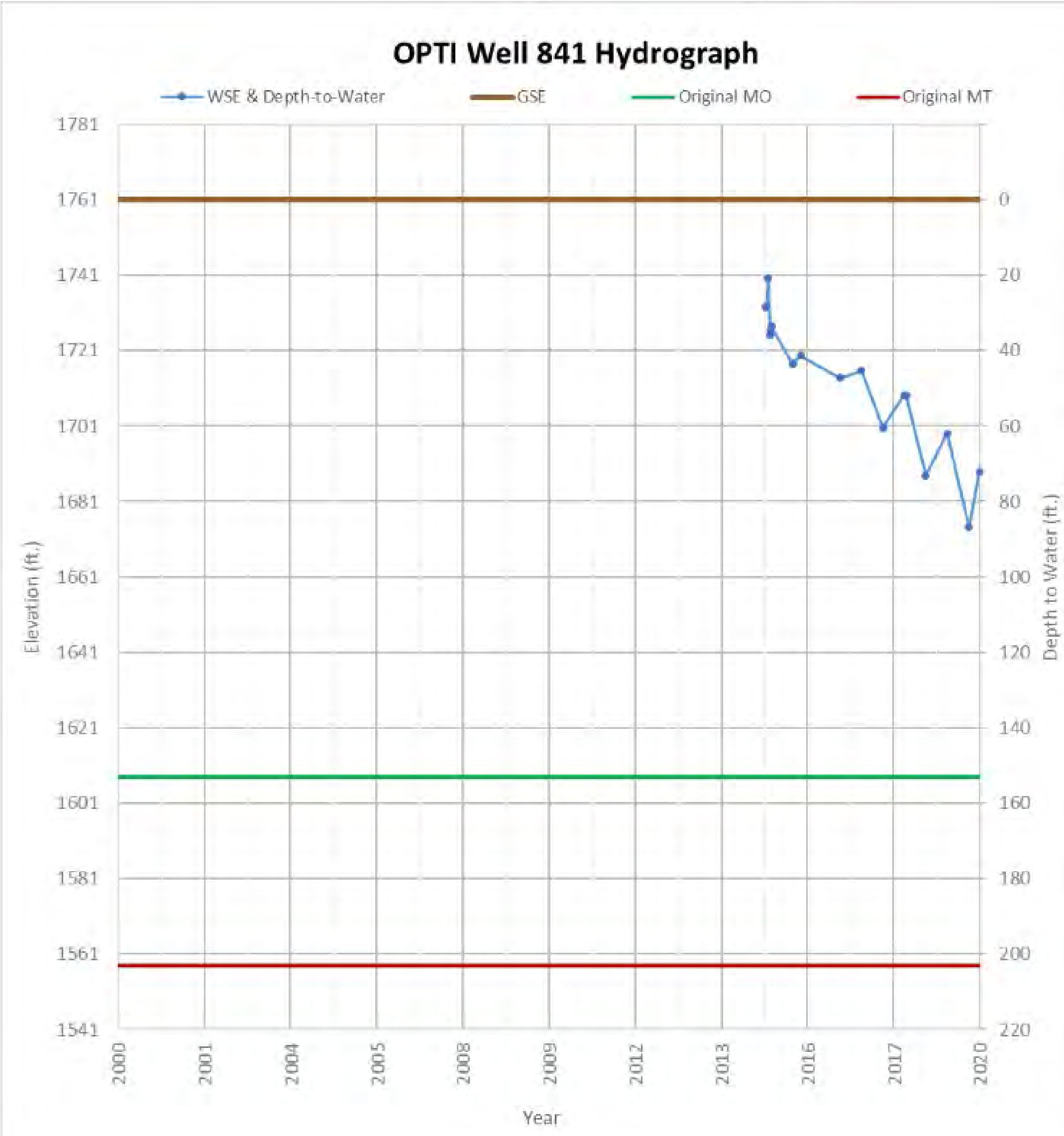


Figure 2-9: Example Well Hydrographs – Northwestern Region

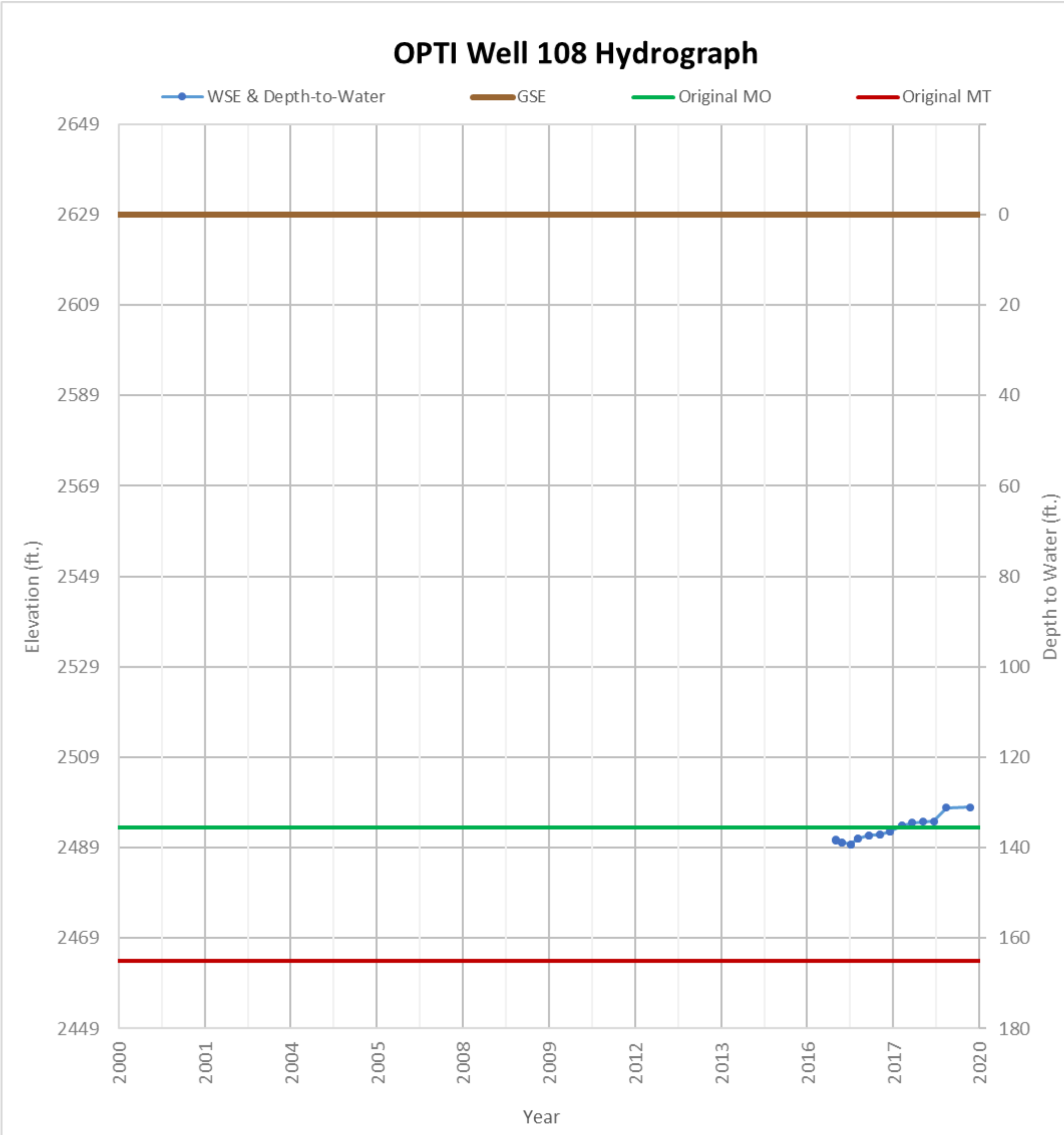


Figure 2-10: Example Well Hydrographs – Western Region

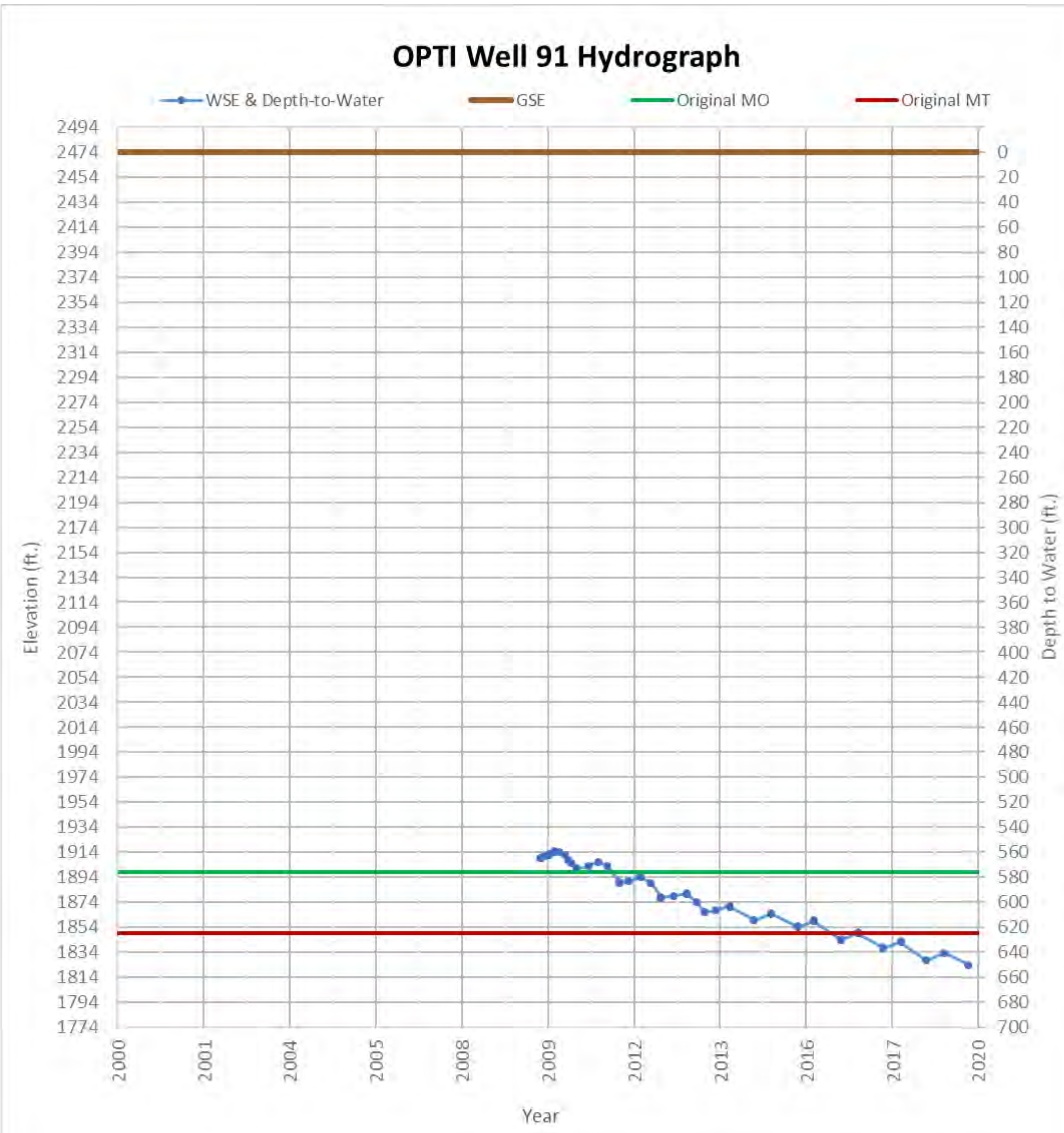


Figure 2-11: Example Well Hydrographs – Central Region

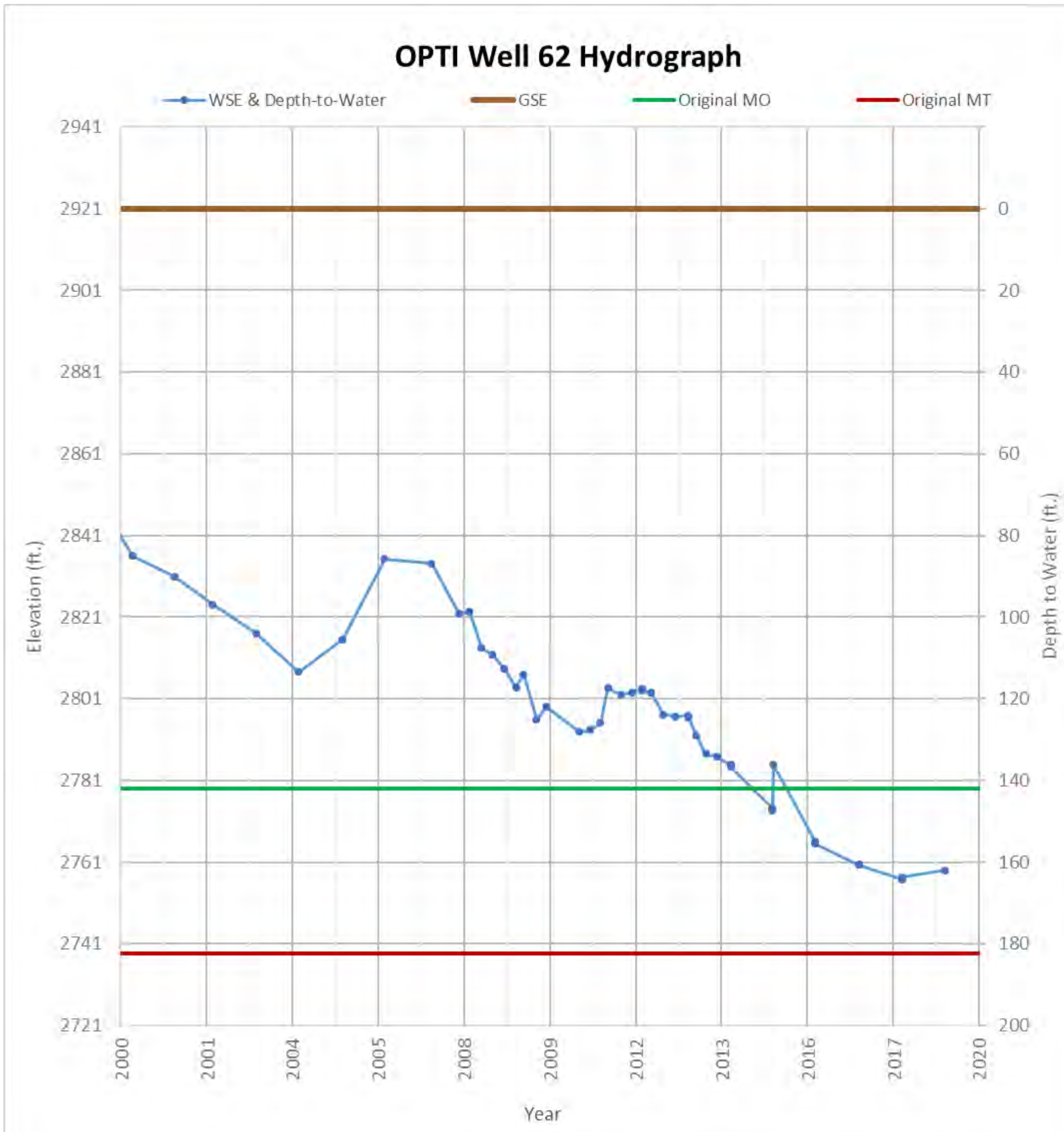


Figure 2-12: Example Well Hydrographs – Eastern Region

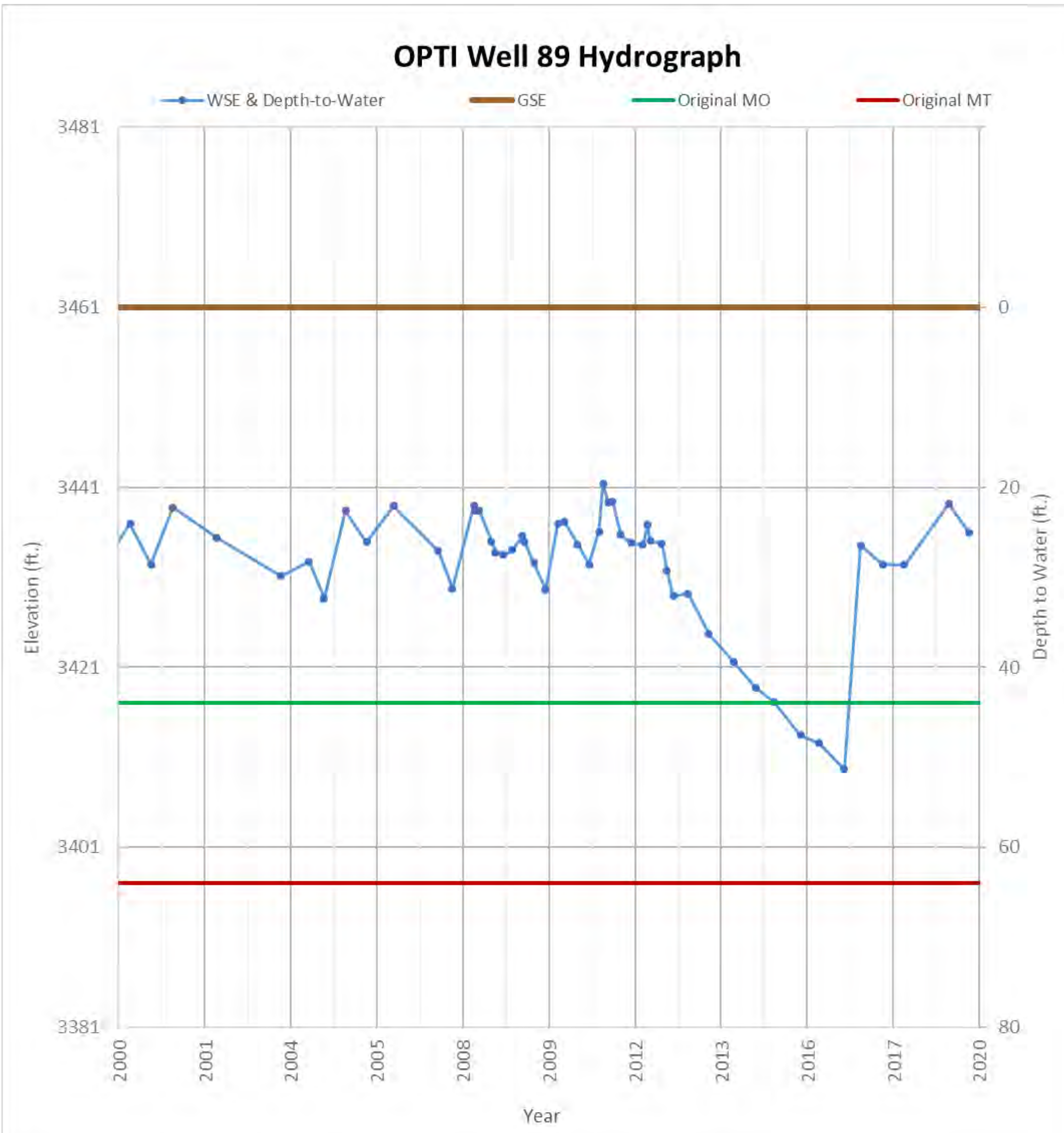


Figure 2-13: Example Well Hydrographs – Southeastern Region

This page intentionally blank

Section 3. Water Use

§356.2 (b) (2)	Groundwater extraction for the preceding water year. Data shall be collected using the best available measurement methods and shall be presented in a table that summarizes groundwater extractions by water use sector, and identifies the method of measurement (direct or estimate) and accuracy of measurements, and a map that illustrates the general location and volume of groundwater extractions.
§356.2 (b) (3)	Surface water supply used or available for use, for groundwater recharge or in-lieu use shall be reported based on quantitative data that describes the annual volume and sources for the preceding water year.
§356.2 (b) (4)	Total water use shall be collected using the best available measurement methods and shall be reported in a table that summarizes total water use by water use sector, water source type, and identifies the method of measurement (direct or estimate) and accuracy of measurements. Existing water use data from the most recent Urban Water Management Plans or Agricultural Water Management Plans within the basin may be used, as long as the data are reported by water year.

3.1 Groundwater Extraction

Water budgets in the Cuyama Basin GSP were developed using the Cuyama Basin Water Resources Model (CBWRM) model, which is a fully integrated surface and groundwater flow model covering the Basin. The CBWRM was used to develop a historical water budget that evaluated the availability and reliability of past surface water supply deliveries, aquifer response to water supply, and demand trends relative to water year type. For the GSP, the CBWRM was used to develop water budget estimates for the hydrologic period of 1998 through 2017. As discussed in the GSP, the model was developed based on the best available data and information as of June 2018. An assessment of model uncertainty included in the GSP estimated an error range in overall model results of about +/- 10%. It is expected that the model will be refined in the future as improved and updated monitoring information becomes available for the Basin. For the Annual Report, the CBWRM model was extended to include the 2018 and 2019 water years, utilizing updated land use, temperature and precipitation data from those years.

- Figure 3-1 shows the annual time series of groundwater pumping for the water years 1998 through 2019. The CBWRM estimates the following total groundwater extraction amounts in the Cuyama Basin in the 2018 and 2019 water years:
- 2018 Water Year: 60,000 acre-feet (AF)
- 2019 Water Year: 47,200 AF
- Almost all groundwater extraction in the Basin is for agriculture use. There is approximately 300 AF of domestic use in each year, with the remainder in each year being for agricultural use.

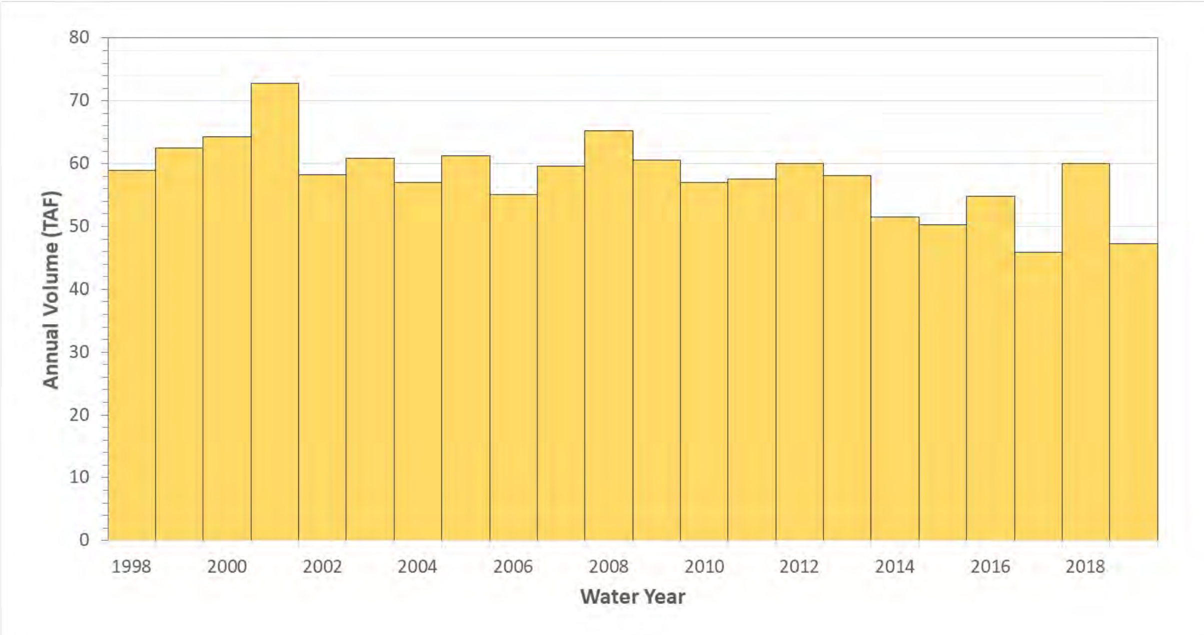


Figure 3-1: Annual Groundwater Extraction in the Cuyama Basin in Water Years 1998-2019

Figure 3-2 shows the locations where groundwater is applied in the Basin. The locations of groundwater use have not changed since completion of the GSP.

3.2 Surface Water Use

No surface water was used in the Cuyama Basin during the reporting period.

3.3 Total Water Use

Since there is no surface water use in the Cuyama Basin, the total water use equals the groundwater extraction in each year, as shown in Section 3.1.

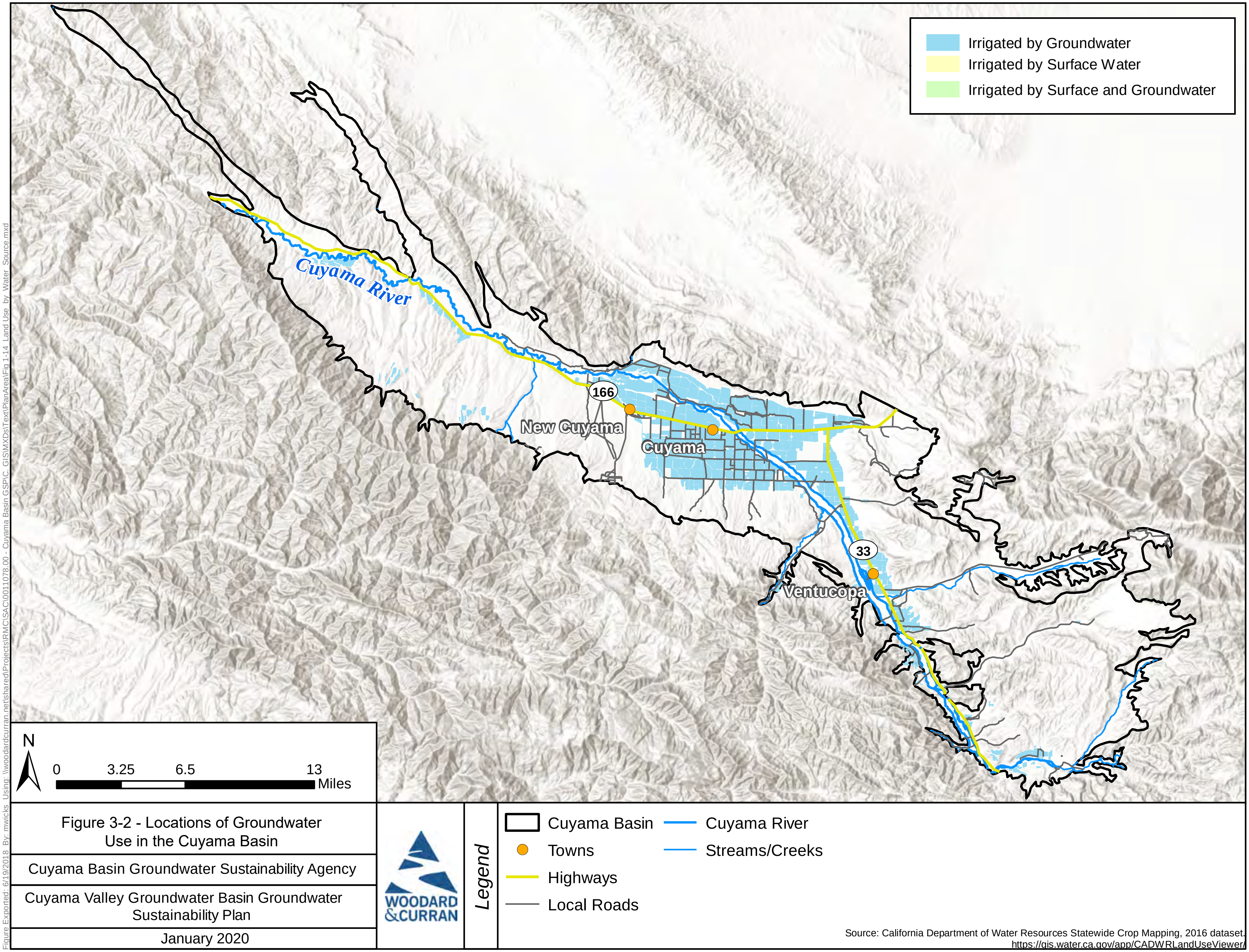


Figure 3-2 - Locations of Groundwater Use in the Cuyama Basin

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

January 2020

WOODARD & CURRAN

This page intentionally blank

Section 4. Change in Groundwater Storage

§356.2 (b) (5)	Change in groundwater in storage shall include the following:
§356.2 (b) (5) (A)	Change in groundwater in storage maps for each principal aquifer in the basin.
§356.2 (b) (5) (B)	A graph depicting water year type, groundwater use, the annual change in groundwater in storage, and the cumulative change in groundwater in storage for the basin based on historical data to the greatest extent available, including from January 1, 2015, to the current reporting year.

Figure 4-1 shows contours of the estimated change in groundwater levels in the Cuyama Basin between 2018 and 2019. The changes shown are based on historical measurements of groundwater elevations in Cuyama Basin representative wells that have recorded measurements in each year. Since the Cuyama Basin monitoring network has not yet been fully implemented, the change in groundwater levels are based on only a limited number of wells, especially in the Central Basin. It is expected that the estimated annual change in groundwater levels can be improved in the future as more comprehensive monitoring data becomes available in the Basin.

A quantitative estimate of the annual change in groundwater storage was estimated using the CBWRM model, which was extended to include the 2018 and 2019 water years as described in the groundwater extraction section above. The CBWRM was used to estimate the full groundwater budget for each year in the Cuyama Basin, which consists of a single principal aquifer. The estimated values for each water budget component in each year are shown in Table 4-1. The CBWRM estimates reductions in groundwater storage of 39,400 AF in 2018 and 11,100 AF in 2019.

Table 4-1: Groundwater Budget Estimates for Water Years 2018 and 2019

Component	Water Year 2018 (AFY)	Water Year 2019 (AFY)
Inflows		
Deep percolation	17,200	26,300
Stream seepage	2,000	8,000
Subsurface inflow	1,400	1,800
Total Inflow	20,600	36,100
Outflows		
Groundwater pumping	60,000	47,200
Total Outflow	60,000	47,200
Change in Storage	**(39,400)**	**(11,100)**

This page intentionally blank

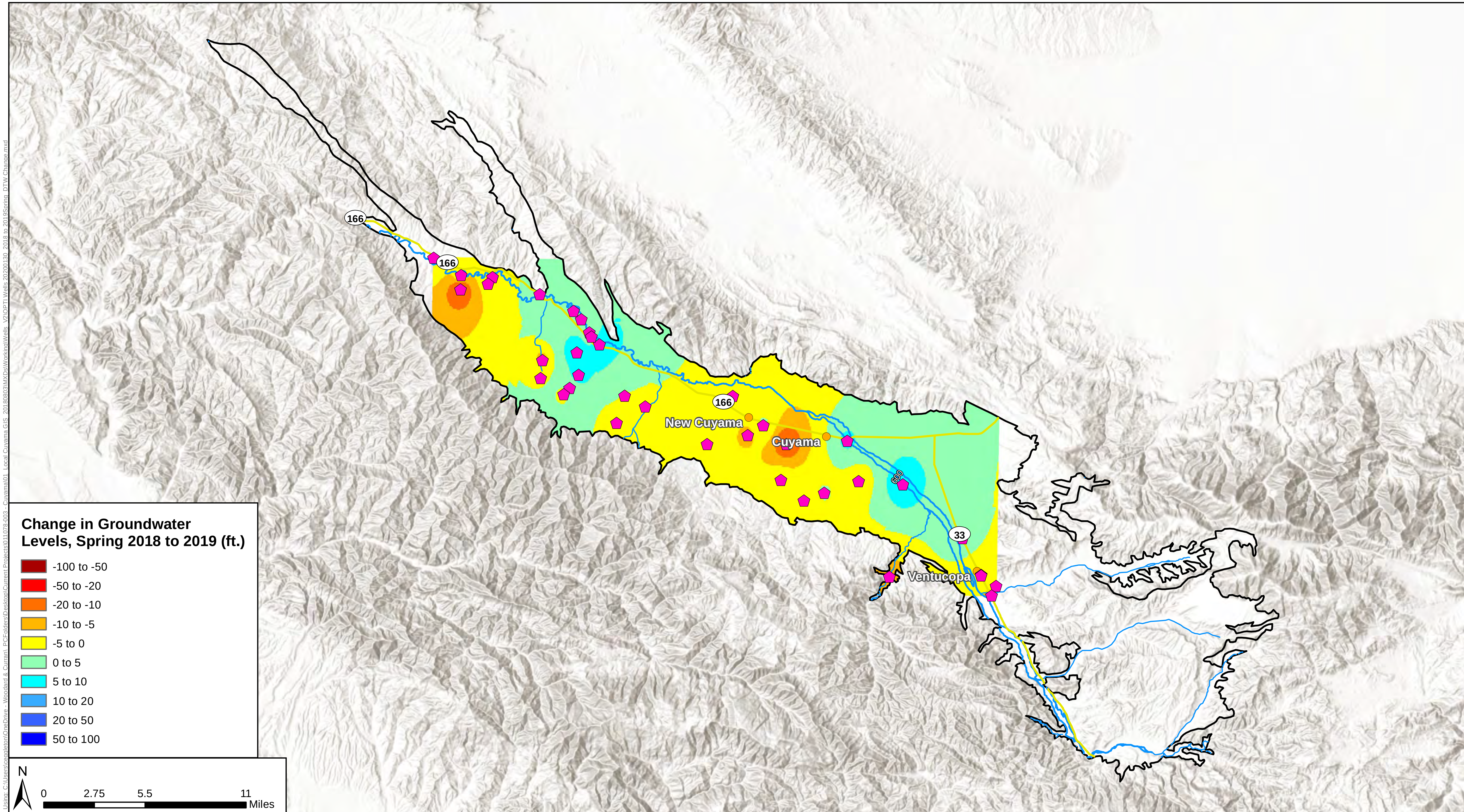


Figure 4-1: Estimated Groundwater Level Storage Change between 2018 and 2019

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

January 2020

WOODARD & CURRAN

Legend

- Cuyama Basin
- Cuyama River
- Spring 2018-2019 Overlapping Wells

Rasters have been developed as an estimation tool. Areas of overlapping interpolation data for Spring 2019 and Spring 2018 ere interpolated using data measured from February 1st and April 30th of each year due to limiated data avilability. It should be noted this information should be used with individual well hydrographs to make a more informative analysis of groundwater conditions.

This page intentionally blank

Figure 4-2 shows the historical shows change in groundwater storage by year, water year type,[3] and cumulative water volume in each year for the period from 1998 through 2019. The change in groundwater storage in each year was estimated by the CBWRM model. The color of bar for each year of change in storage correlates a water year type defined by Basin precipitation.

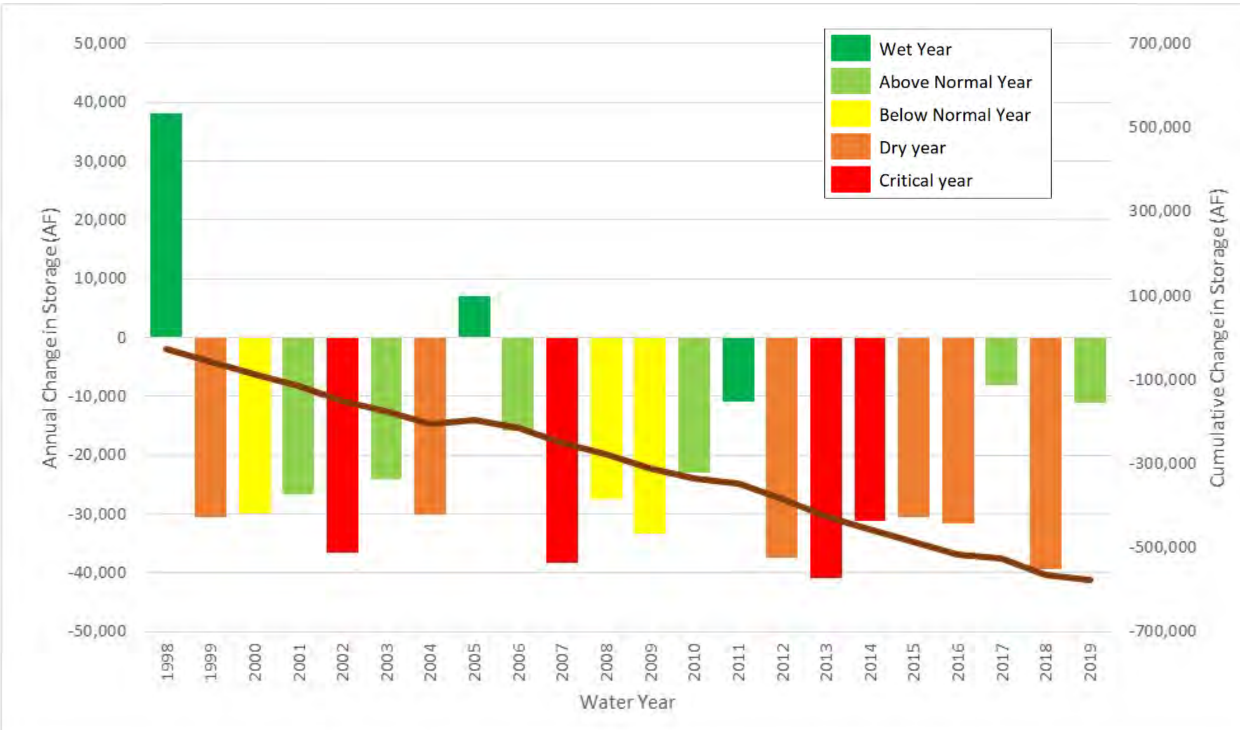


Figure 4-2: Change in Groundwater Storage by Year, Water Year Type, and Cumulative Water Volume

[3] 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.

This page intentionally blank

Section 5. Plan Implementation

§356.2 (c)	A description of progress toward implementing the Plan, including achieving interim milestones, and implementation of projects or management actions since the previous annual report.

This section describes management activities taken by the CBGSA to implement the Cuyama Basin GSP from adoption of the GSP through preparation of this Annual Report.

5.1 Progress Toward Achieving Interim Milestones

Since the plan was adopted by the CBGSA Board only recently, progress toward achieving interim milestones has not been evaluated. Progress will be reported in the next Annual Report.

5.2 Funding to Support GSP Implementation

On November 6, 2019, the CBGSA Board approved the implementation of a groundwater extraction fee of $19 per acre-foot of pumping in 2019 to provide revenue to fund CBGSA administration and GSP implementation activities. It is estimated that the extraction fee will provide approximately $1,021,936 in revenue.

5.3 Stakeholder Outreach Activities in Support of GSP Implementation

The following is a list of public meetings where GSP development and implementation was discussed during 2019.

- CBGSA Board meetings: January 9, February 6, April 3, June 5, July 10, August 7, and December 4
- Standing Advisory Committee (SAC) meetings: January 8, January 31, February 28, March 28, April 25, May 30, and June 27
- Joint meetings of the CBGSA Board and SAC: March 6, May 1, and November 6
- Community workshops (in both English and Spanish): March 6 and May 1

5.4 Progress on Implementation of GSP Projects

Table 5-1 shows the projects and management actions that were included in the GSP. The following subsections describe the progress of implementation of each GSP project.

Table 5-1: Summary of Projects and Management Actions Included in the GSP

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)

Table 5-1: Summary of Projects and Management Actions Included in the GSP

Activity	Current Status	Anticipated Timing	Estimated Cost[a]
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	Completed	• December 2020	• $60,000
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

5.4.1 Project 1: Flood and Stormwater Capture

No progress was made toward implementation of this project since completion of the GSP in January 2020.

5.4.2 Project 2: Precipitation Enhancement

No progress was made toward implementation of this project since completion of the GSP in January 2020.

5.4.3 Project 3: Water Supply Transfers or Exchanges

No progress was made toward implementation of this project since completion of the GSP in January 2020.

5.4.4 Project 4: Improve Reliability of Water Supplies for Local Communities

No progress was made toward implementation of this project in 2019.

5.5 Management Actions

Table 5-1 shows the projects and management actions that were included in the GSP. The following subsections describe the progress of implementation of each GSP management action.

5.5.1 Management Action 1: Basin-Wide Economic Analysis

A Basin-wide direct economic analysis of proposed GSP actions was completed. The results of this analysis were presented to the GSP Board on December 4, 2019, and the final report was completed in December 2019. The final Basin-wide economic analysis report is provided in Appendix B. This management action is 100% complete.

5.5.2 Management Action 2: Pumping Allocations in Central Basin Management Area

An agreement was executed between the CBGSA and CBWD for the CBWD to administer management actions in the Central Basin management area. Beyond that agreement, no significant progress was made toward implementation of this management action since completion of the GSP in January 2020.

5.6 Adaptive Management

No adaptive management activities have been conducted since completion of the GSP in January 2020.

5.7 Progress Toward Implementation of Monitoring Networks

This section provides updates about implementation of the monitoring networks identified during GSP development.

5.7.1 Groundwater Levels Monitoring Network

On December 4, 2019, the CBGSA Board approved a task to begin implementation of the groundwater levels monitoring network. As part of this task, well information sheets will be prepared for 40 wells in the monitoring network to allow for implementation of regular monitoring at each well. Work on this task will be completed by the end of 2020, allowing for the initiation of monthly groundwater levels monitoring.

In addition, under a Category 1 grant from DWR, continuous monitoring equipment will be installed in 10 additional wells during 2020. Figure 5-1 shows the preliminary locations selected for installation.

Finally, the CBGSA has approved applications to be submitted to DWR's Technical Support Services (TSS) for installation of three new monitoring wells within the Basin.

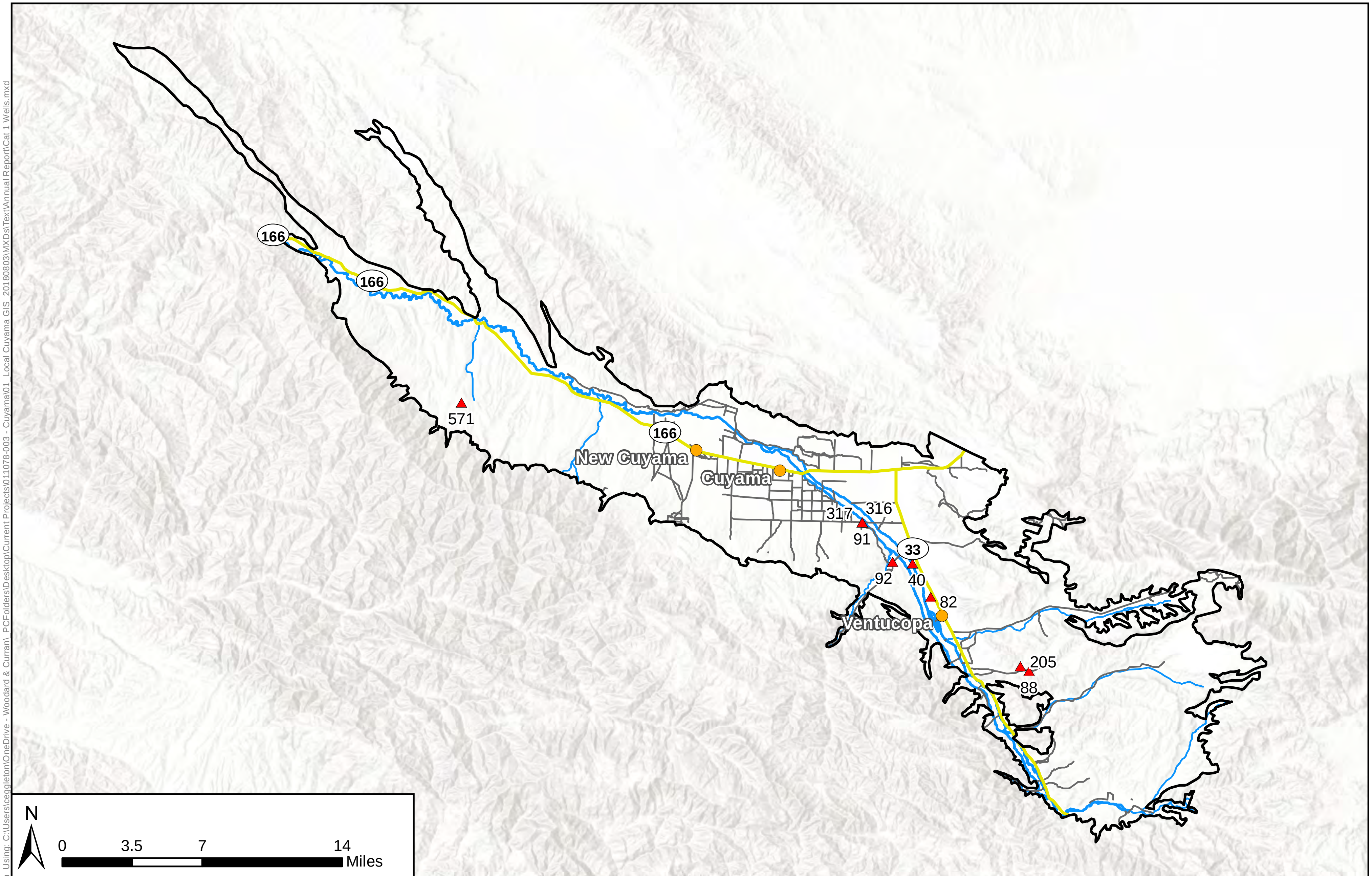


Figure 5-1: Preliminary Locations for Continuous Monitoring Equipment

Cuyama Basin Groundwater Sustainability Agency

Cuyama Valley Groundwater Basin Groundwater Sustainability Plan

January 2020

WOODARD & CURRAN

5.7.2 Surface Water Monitoring Network

Under a Category 1 grant from DWR, it is expected that two new surface flow gages will be installed on the Cuyama River during 2020.

This page intentionally blank

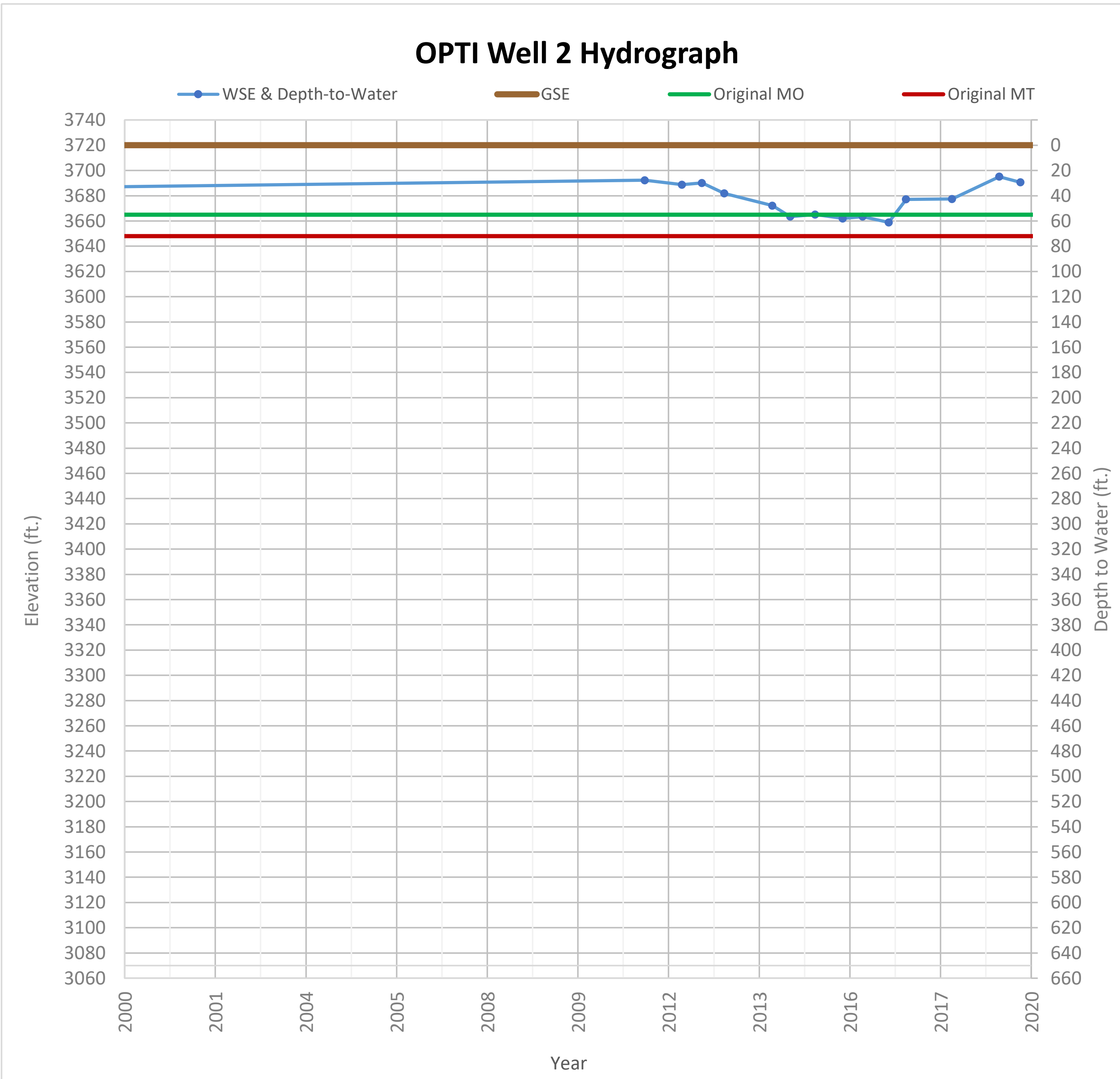
Section 6. References

California Department of Water Resources (DWR). 2003. *California's Groundwater Bulletin 118—Update 2003*. https://water.ca.gov/LegacyFiles/groundwater/bulletin118/basindescriptions/3-13.pdf

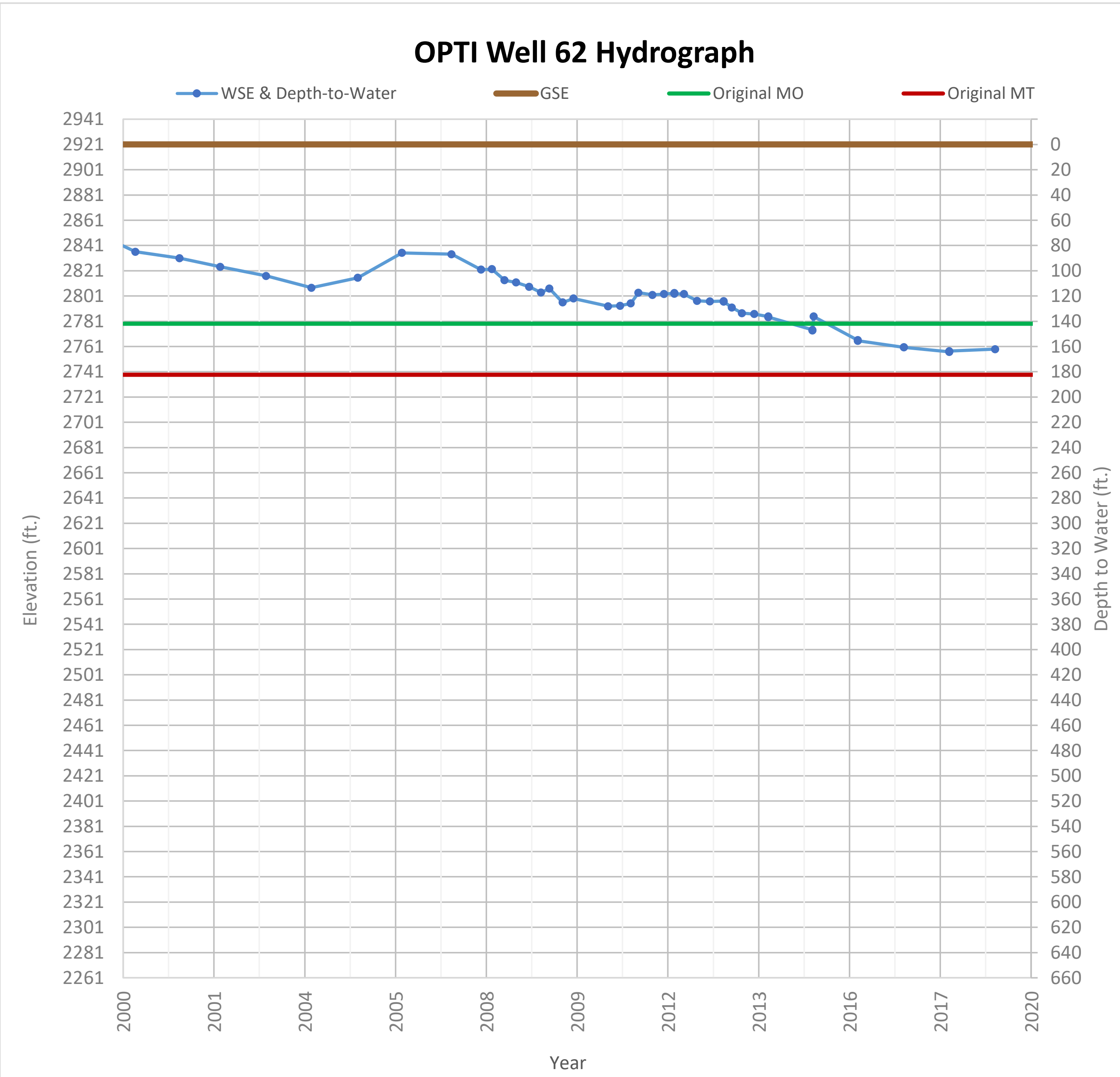
This page intentionally blank

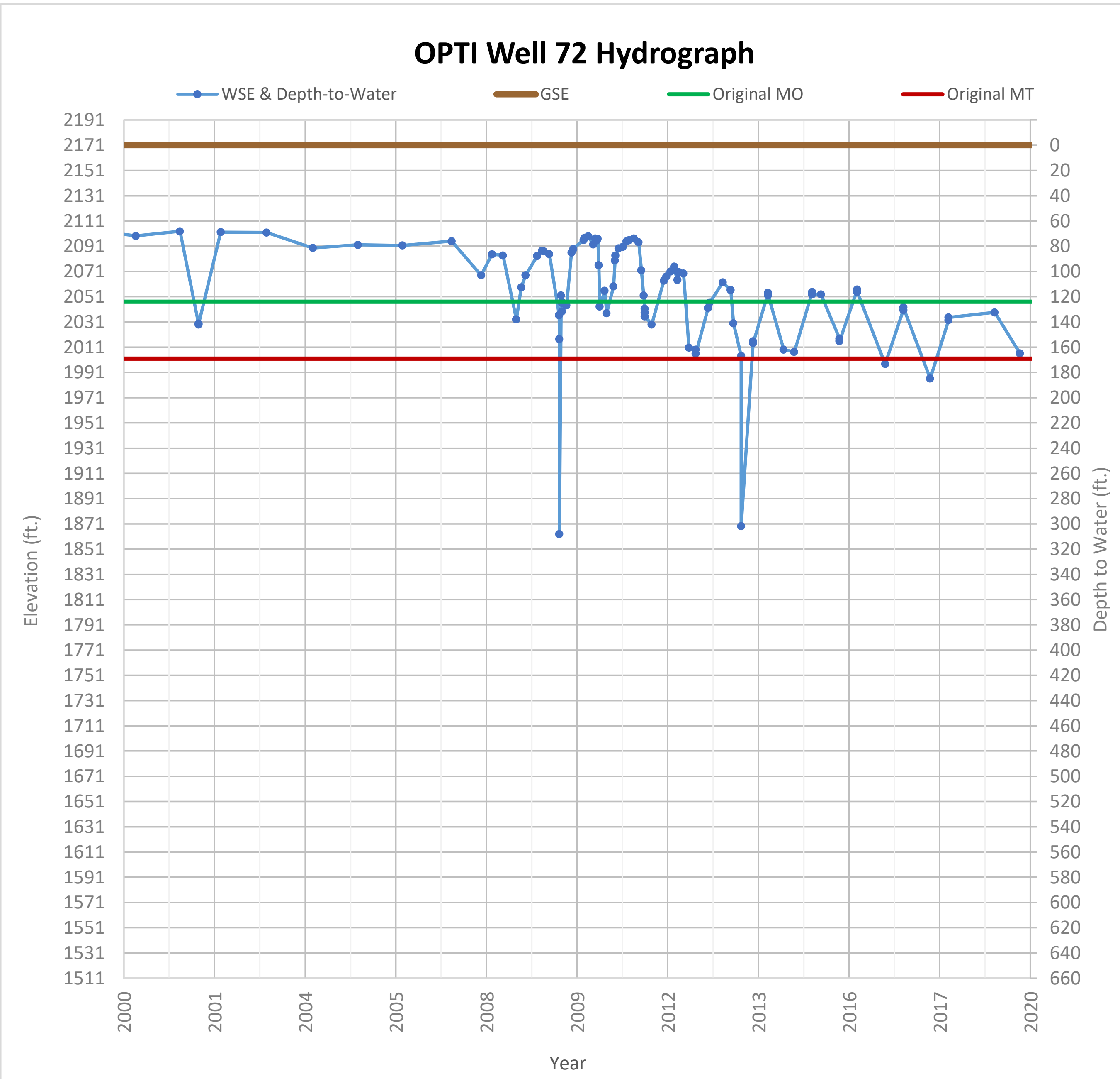
Appendix A
Updated Hydrographs for Representative Wells

This page intentionally blank

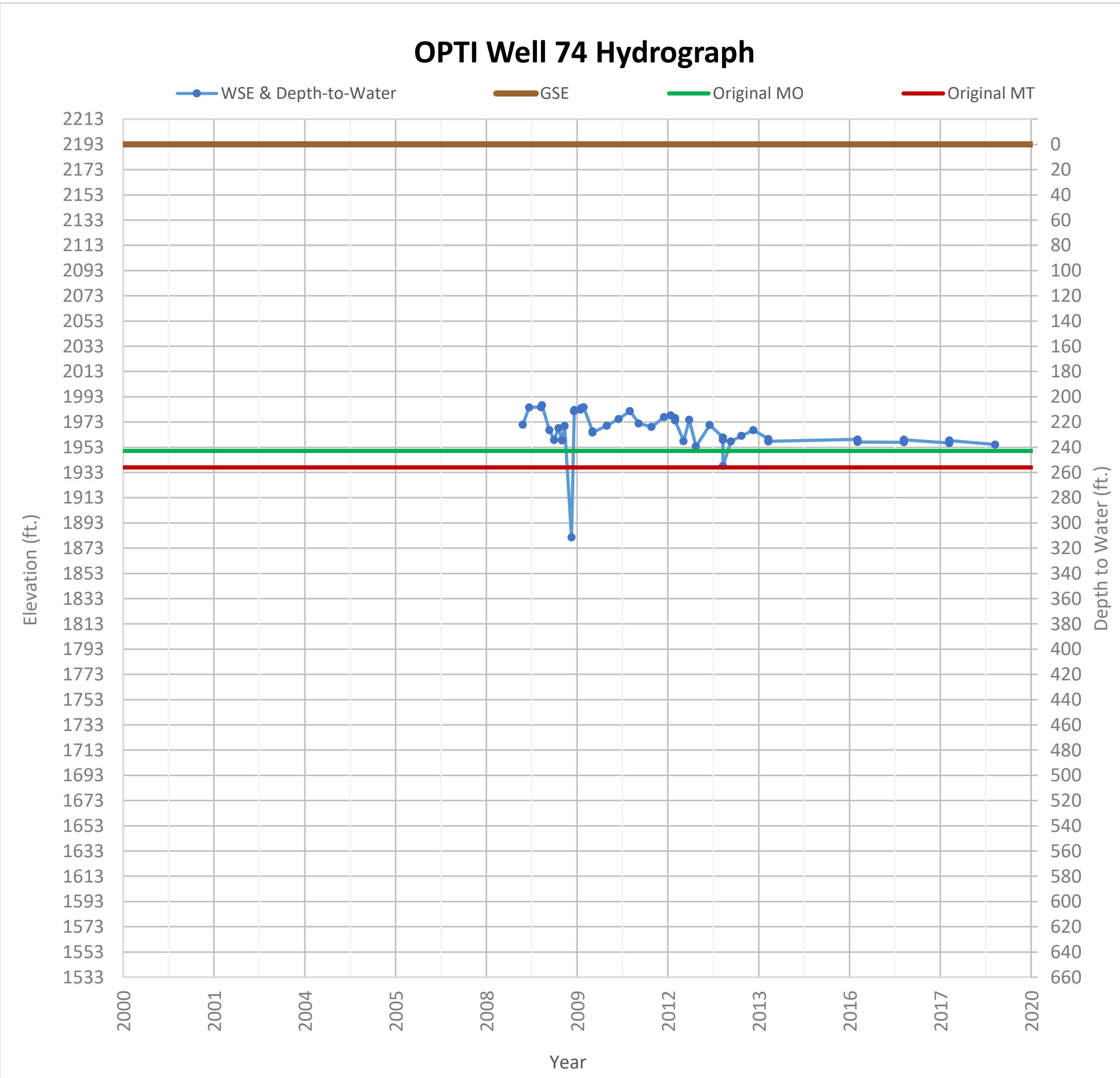


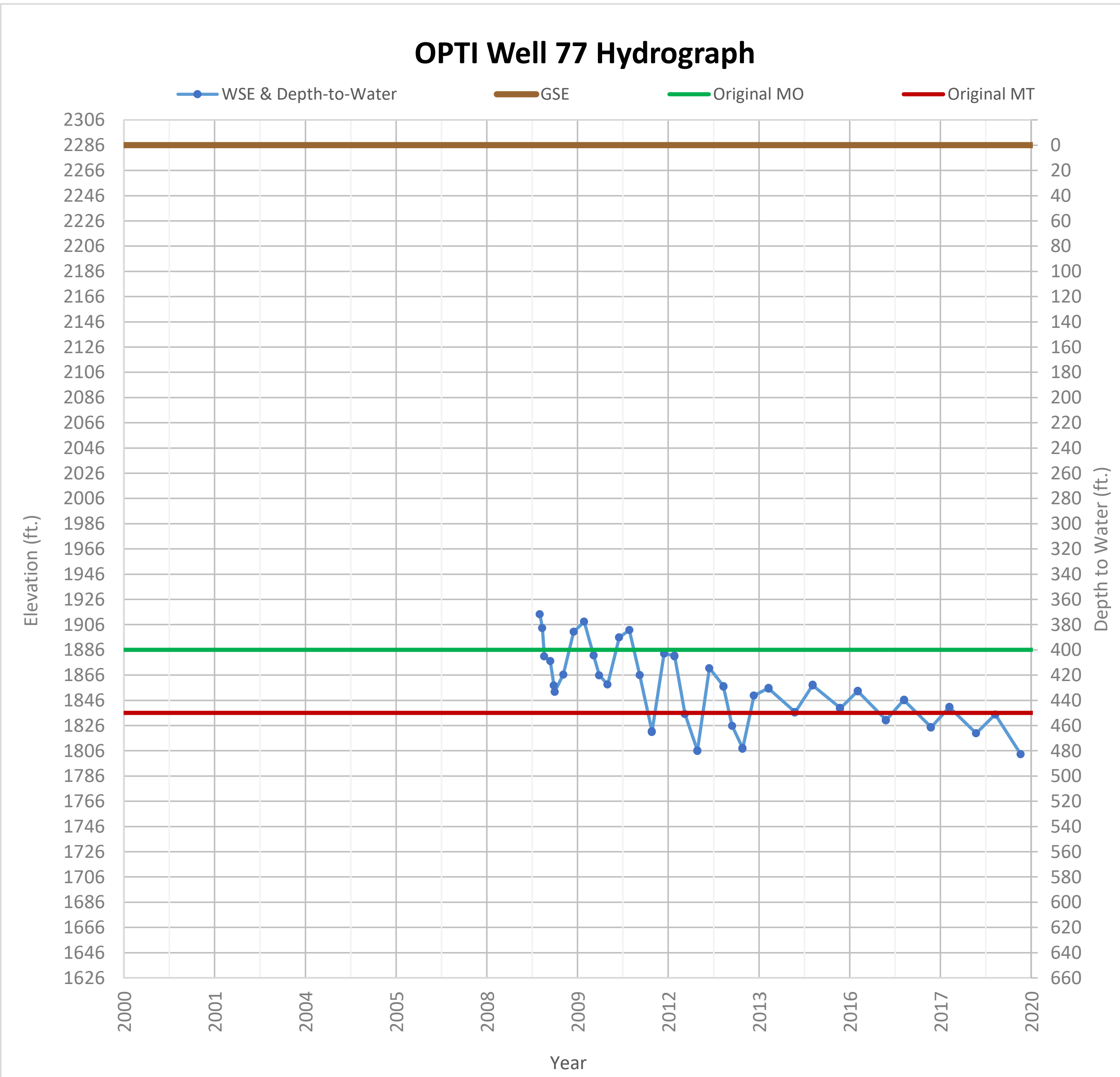
OPTI Well 2 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
3740
3720
3700
3680
3660
3640
3620
3600
3580
3560
3540
3520
3500
3480
3460
3440
3420
3400
3380
3360
3340
3320
3300
3280
3260
3240
3220
3200
3180
3160
3140
3120
3100
3080
3060
0
20
40
60
80
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
2000
2001
2004
2005
2008
2009
2012
2012
2013
2016
2017
2020


OPTI Well 62 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2941
2921
2901
2881
2861
2841
2821
2801
2781
2761
2741
2721
2701
2681
2661
2641
2621
2601
2581
2561
2541
2521
2501
2481
2461
2441
2421
2401
2381
2361
2341
2321
2301
2281
2261
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

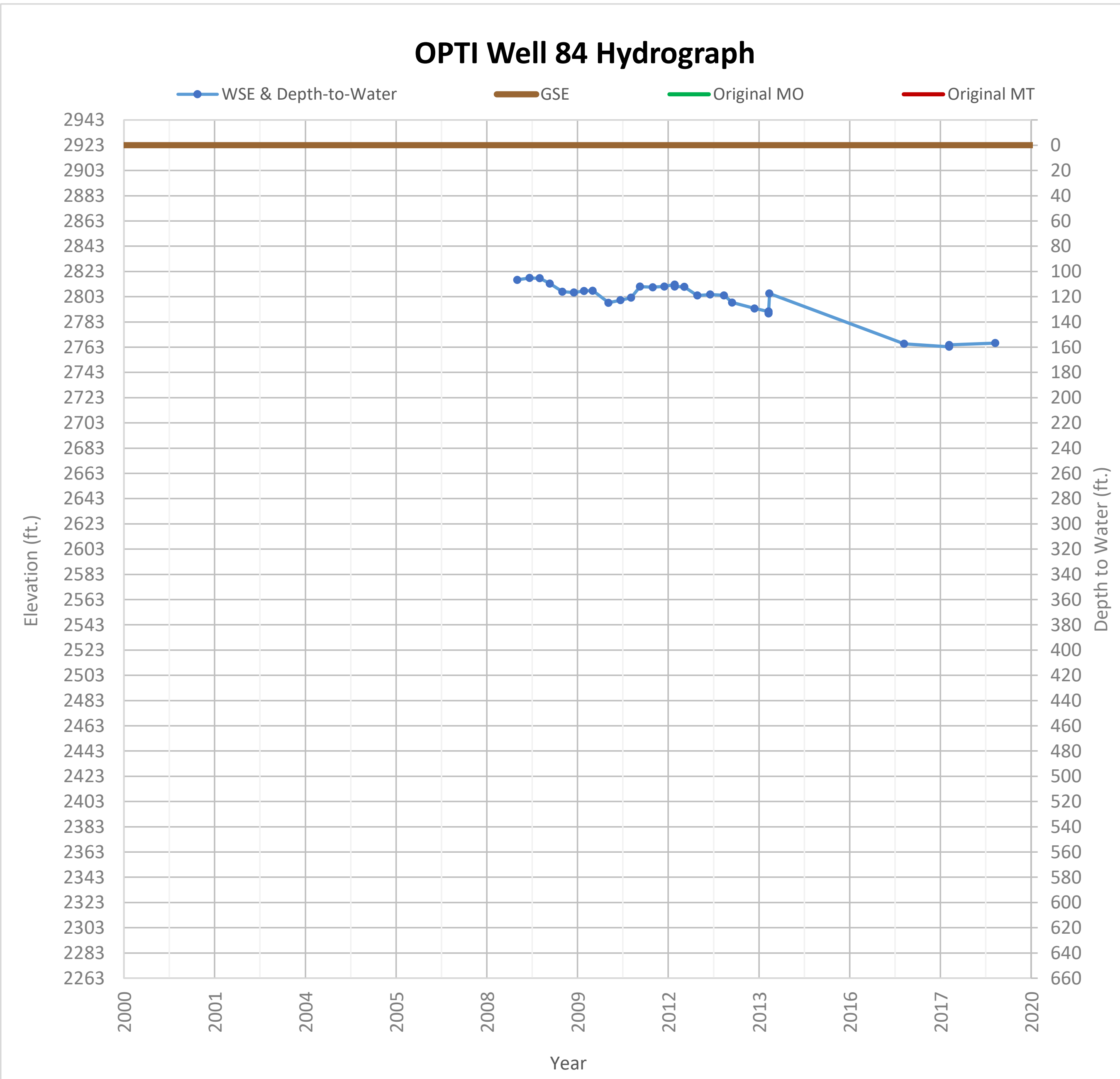


OPTI Well 72 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2191
2171
2151
2131
2111
2091
2071
2051
2031
2011
1991
1971
1951
1931
1911
1891
1871
1851
1831
1811
1791
1771
1751
1731
1711
1691
1671
1651
1631
1611
1591
1571
1551
1531
1511
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

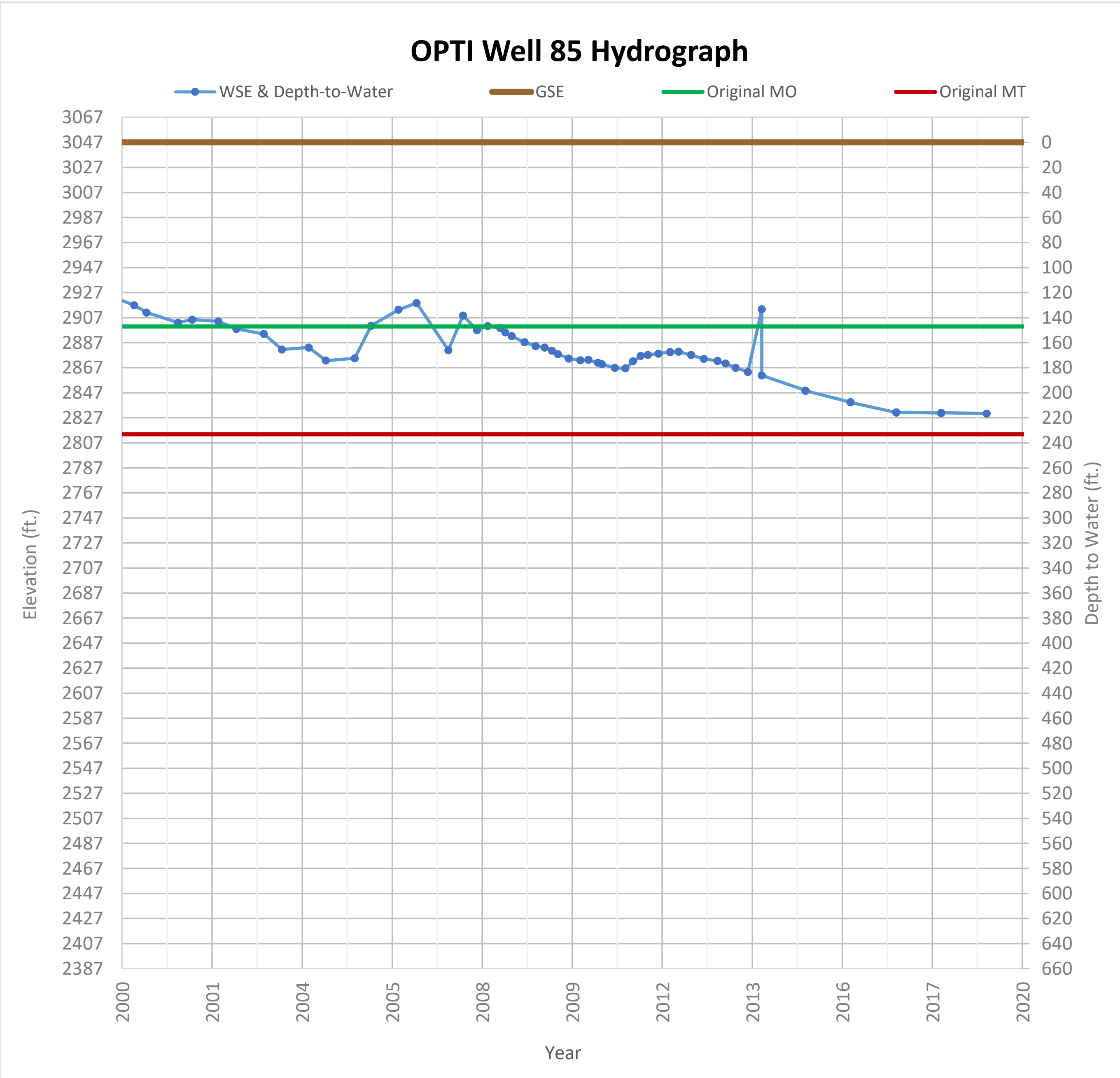

OPTI Well 74 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2213
2193
2173
2153
2133
2113
2093
2073
2053
2033
2013
1993
1973
1953
1933
1913
1893
1873
1853
1833
1813
1793
1773
1753
1733
1713
1693
1673
1653
1633
1613
1593
1573
1553
1533
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

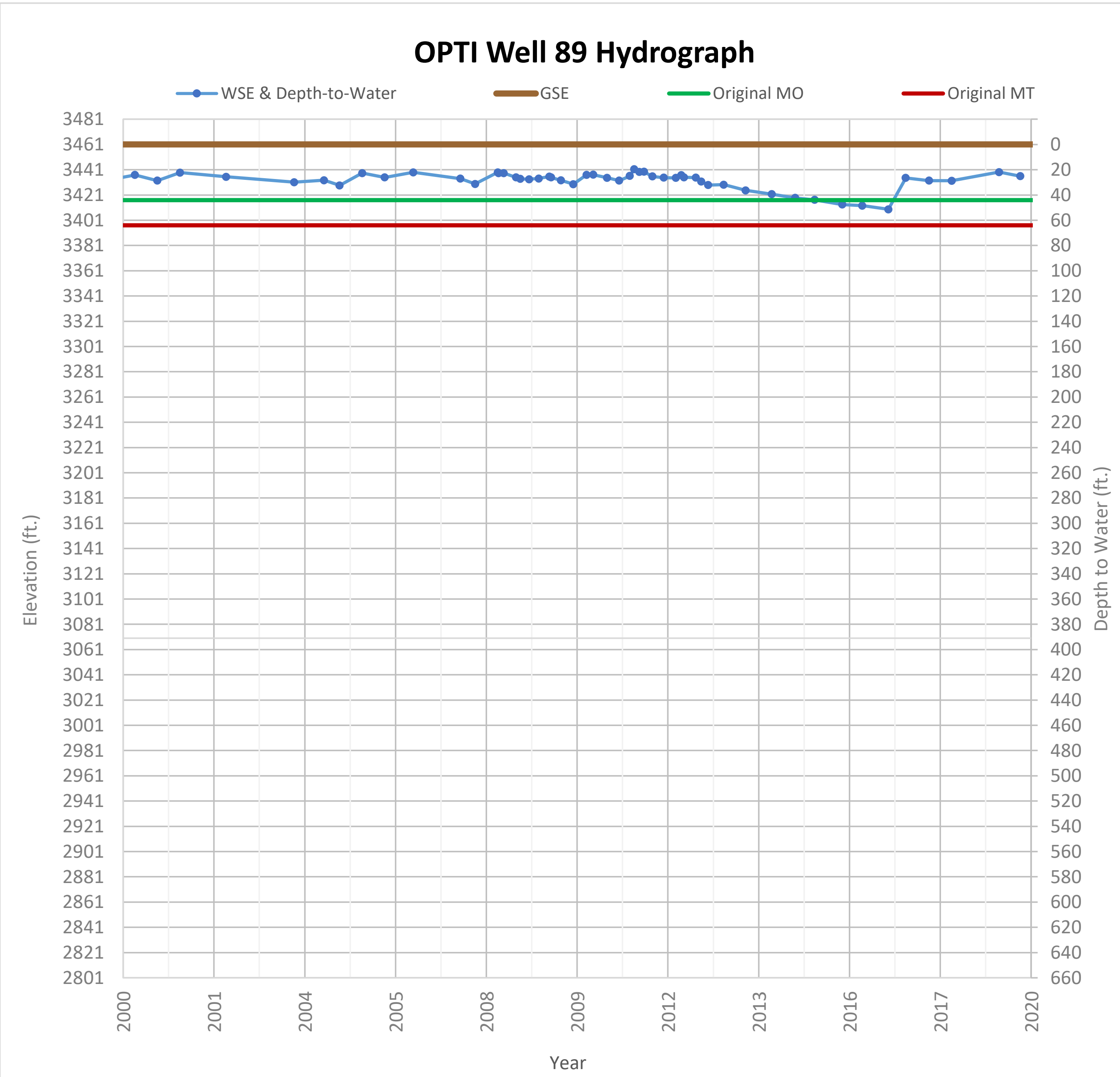


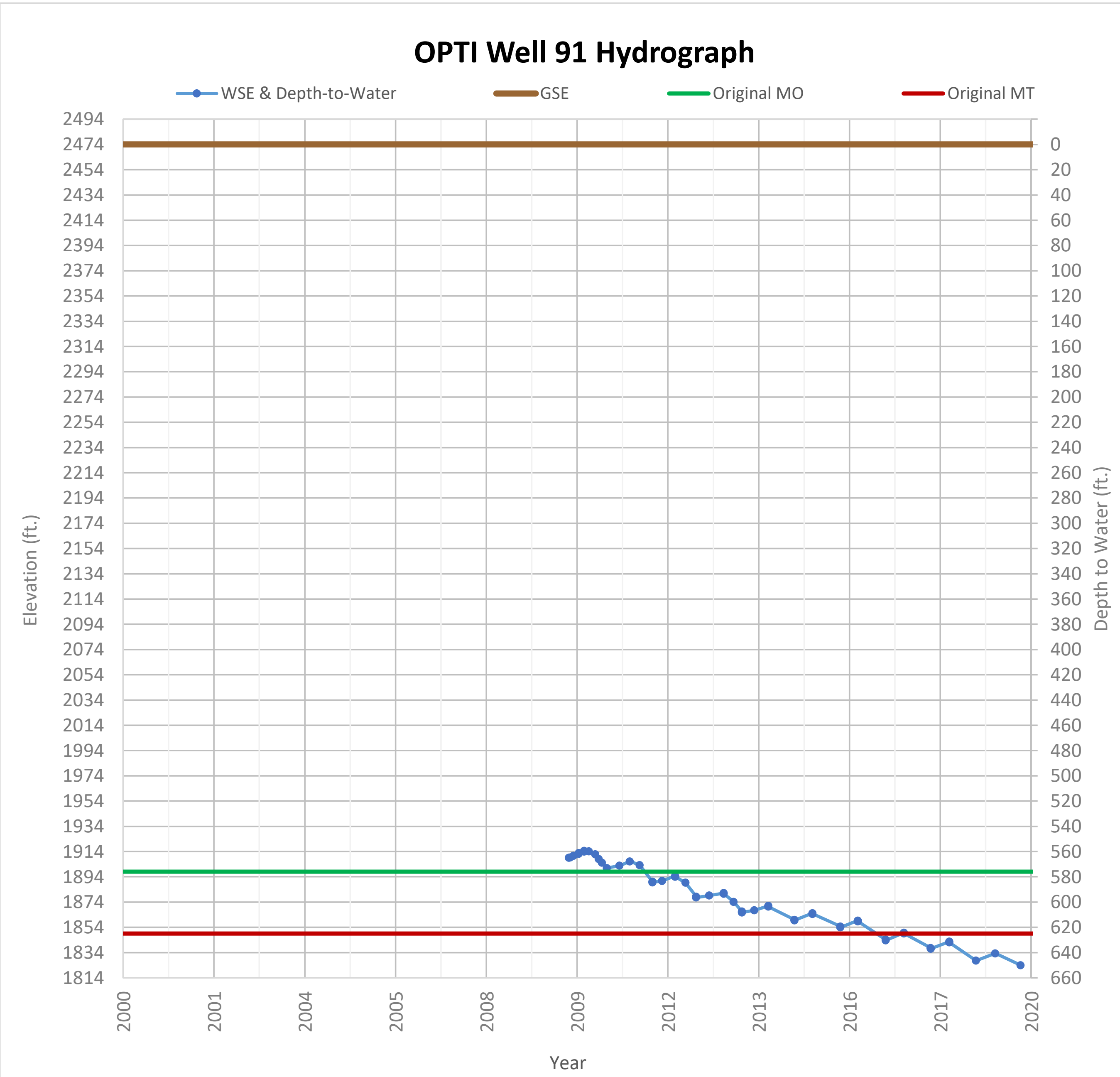
OPTI Well 77 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2306
2286
2266
2246
2226
2206
2186
2166
2146
2126
2106
2086
2066
2046
2026
2006
1986
1966
1946
1926
1906
1886
1866
1846
1826
1806
1786
1766
1746
1726
1706
1686
1666
1646
1626
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020



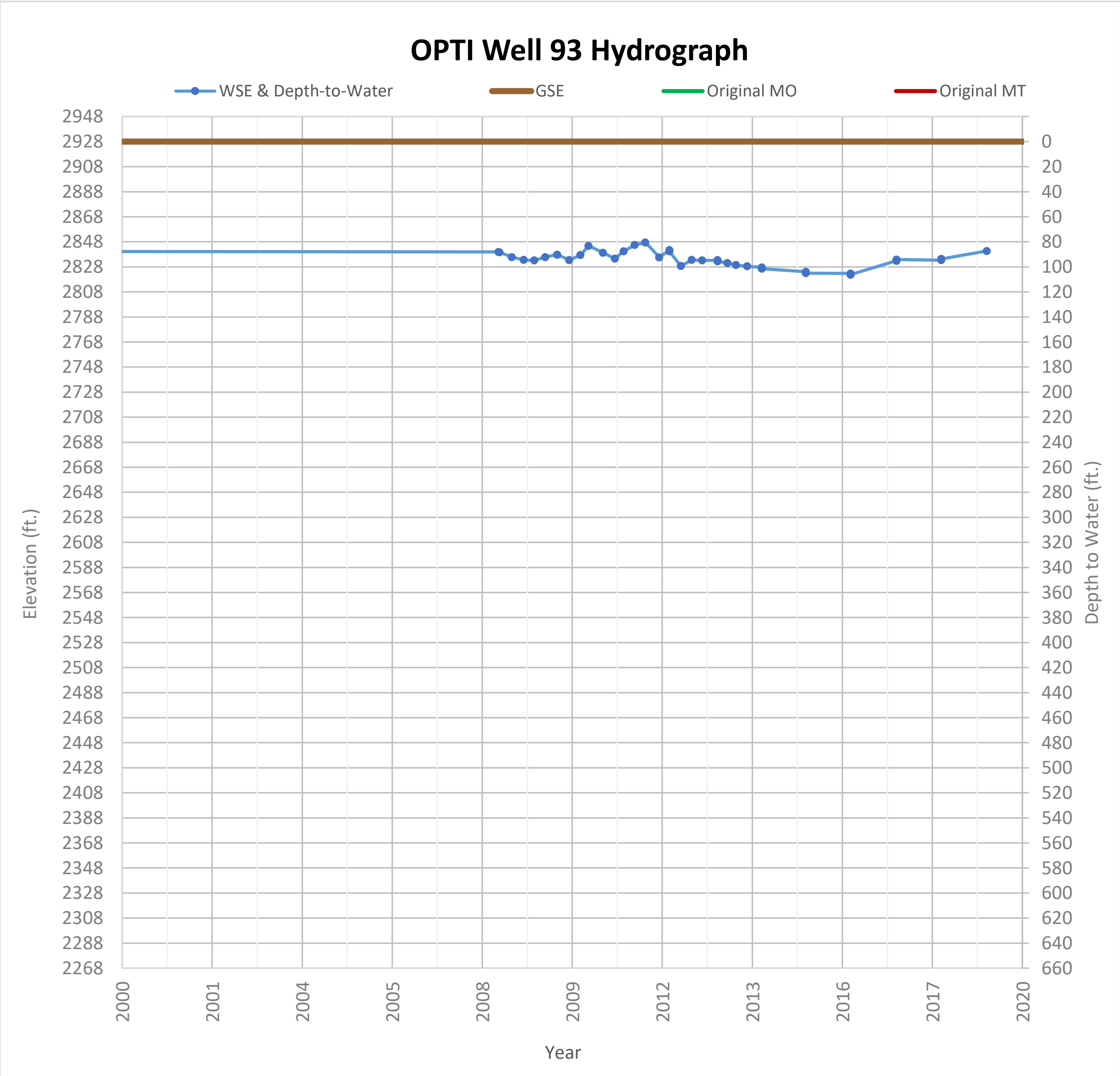
OPTI Well 84 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2943
2923
2903
2883
2863
2843
2823
2803
2783
2763
2743
2723
2703
2683
2663
2643
2623
2603
2583
2563
2543
2523
2503
2483
2463
2443
2423
2403
2383
2363
2343
2323
2303
2283
2263
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020


OPTI Well 85 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
3067
3047
3027
3007
2987
2967
2947
2927
2907
2887
2867
2847
2827
2807
2787
2767
2747
2727
2707
2687
2667
2647
2627
2607
2587
2567
2547
2527
2507
2487
2467
2447
2427
2407
2387
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

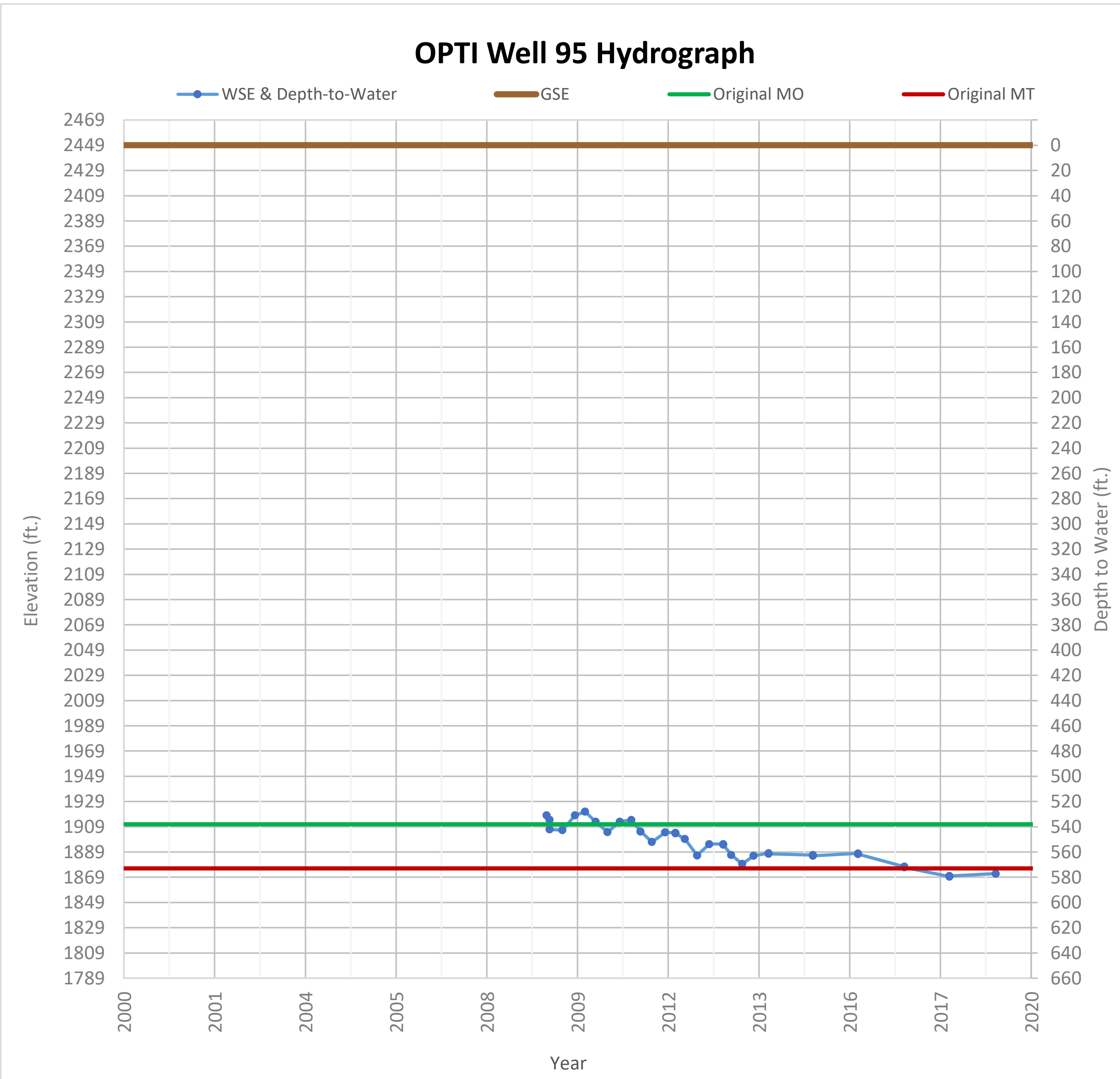

OPTI Well 89 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
3481
3461
3441
3421
3401
3381
3361
3341
3321
3301
3281
3261
3241
3221
3201
3181
3161
3141
3121
3101
3081
3061
3041
3021
3001
2981
2961
2941
2921
2901
2881
2861
2841
2821
2801
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

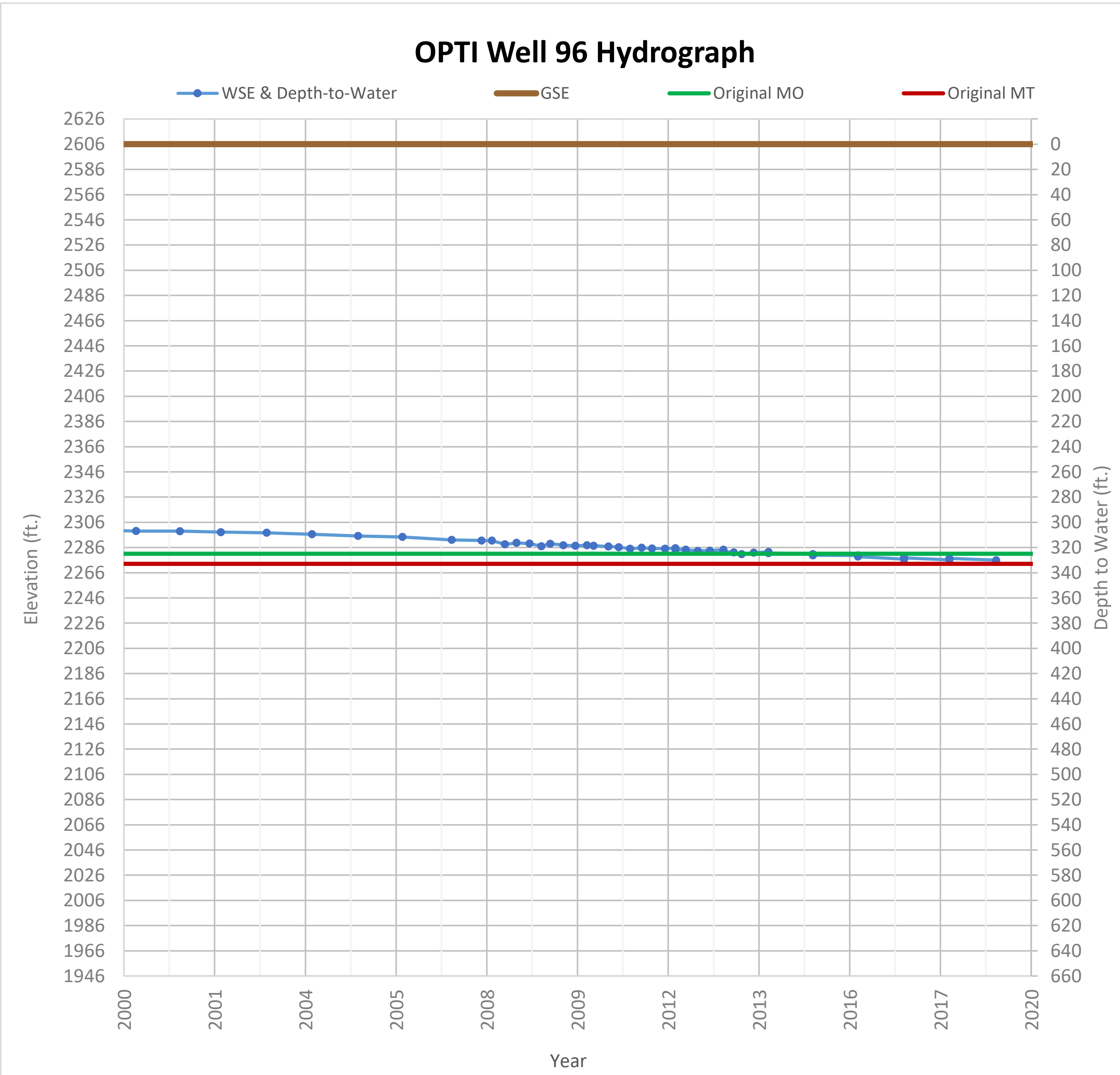


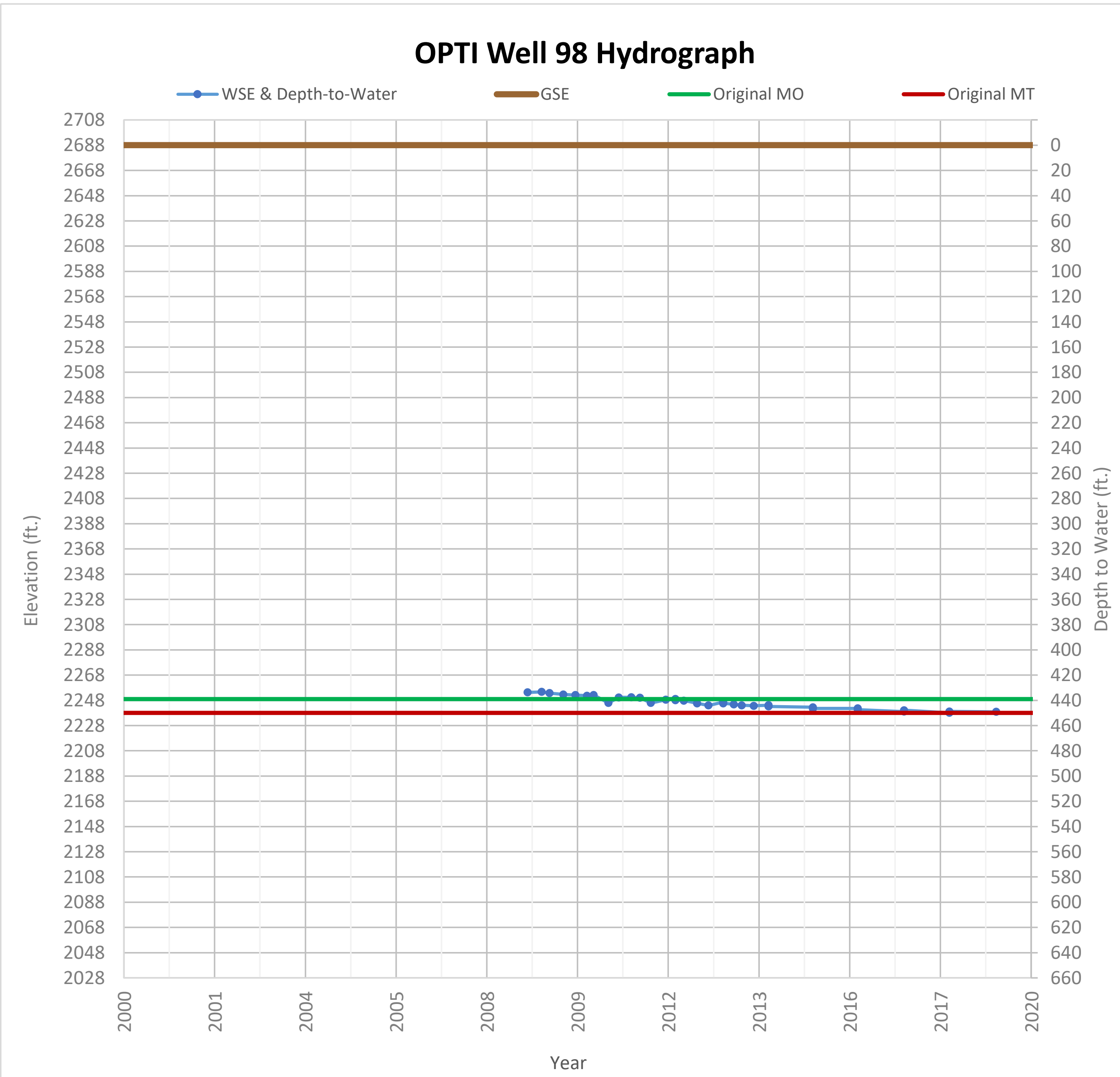
OPTI Well 91 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
2494
2474
2454
2434
2414
2394
2374
2354
2334
2314
2294
2274
2254
2234
2214
2194
2174
2154
2134
2114
2094
2074
2054
2034
2014
1994
1974
1954
1934
1914
1894
1874
1854
1834
1814
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020
Year



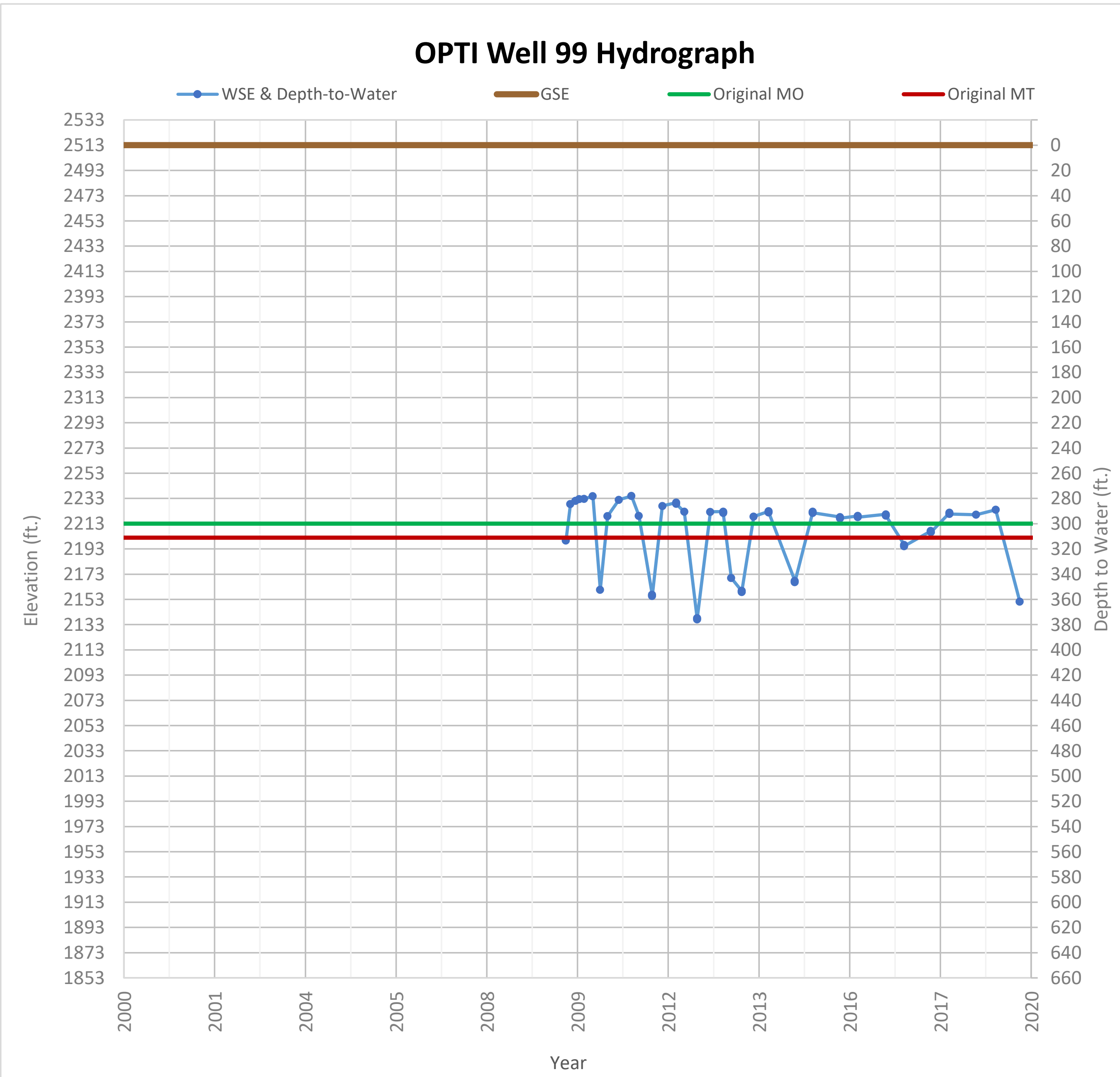
OPTI Well 93 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
2948
2928
2908
2888
2868
2848
2828
2808
2788
2768
2748
2728
2708
2688
2668
2648
2628
2608
2588
2568
2548
2528
2508
2488
2468
2448
2428
2408
2388
2368
2348
2328
2308
2288
2268
0
20
40
60
80
100
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020
Year


OPTI Well 95 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
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
2069
2049
2029
2009
1989
1969
1949
1929
1909
1889
1869
1849
1829
1809
1789
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

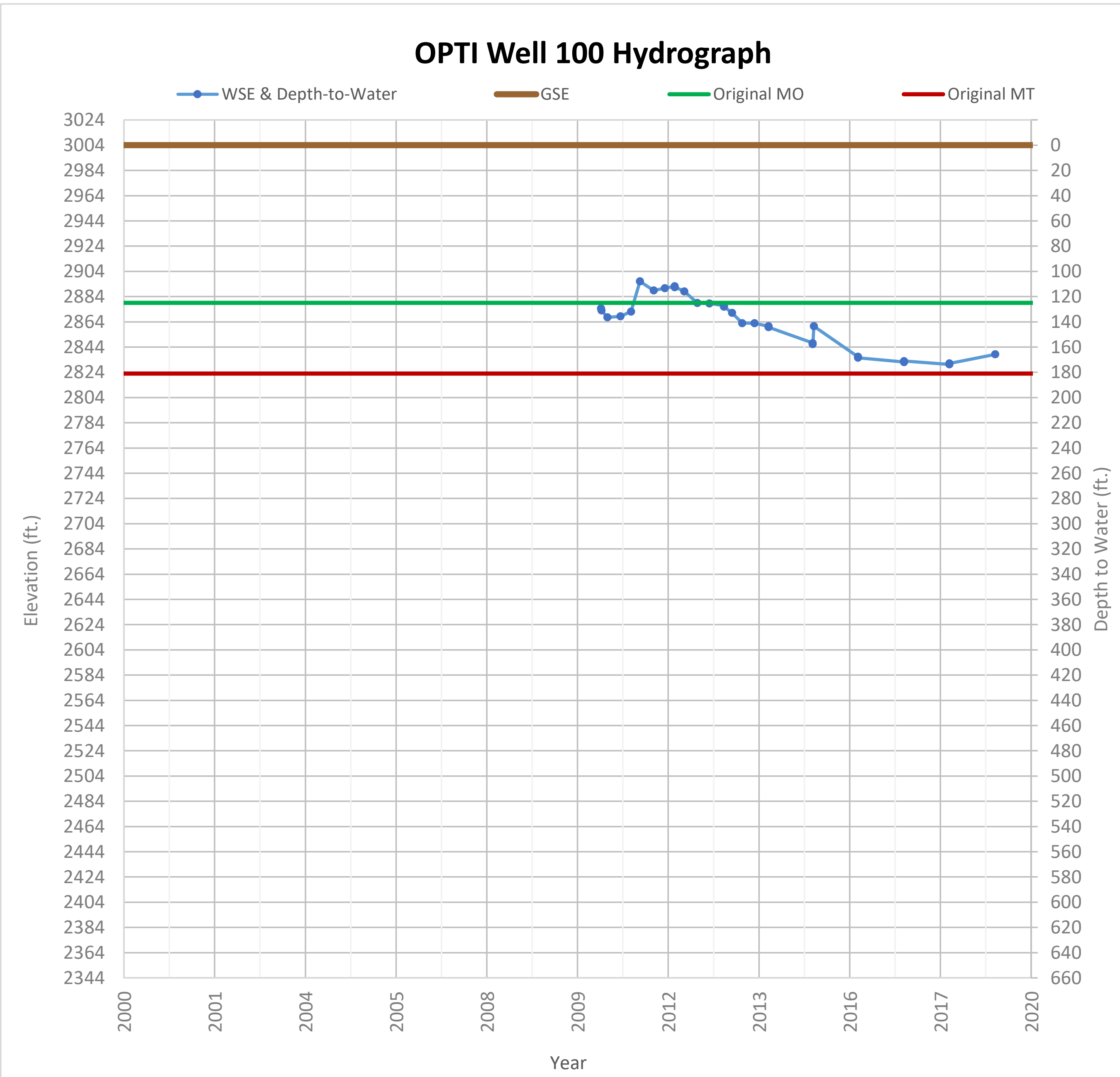

OPTI Well 96 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2626
2606
2586
2566
2546
2526
2506
2486
2466
2446
2426
2406
2386
2366
2346
2326
2306
2286
2266
2246
2226
2206
2186
2166
2146
2126
2106
2086
2066
2046
2026
2006
1986
1966
1946
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020



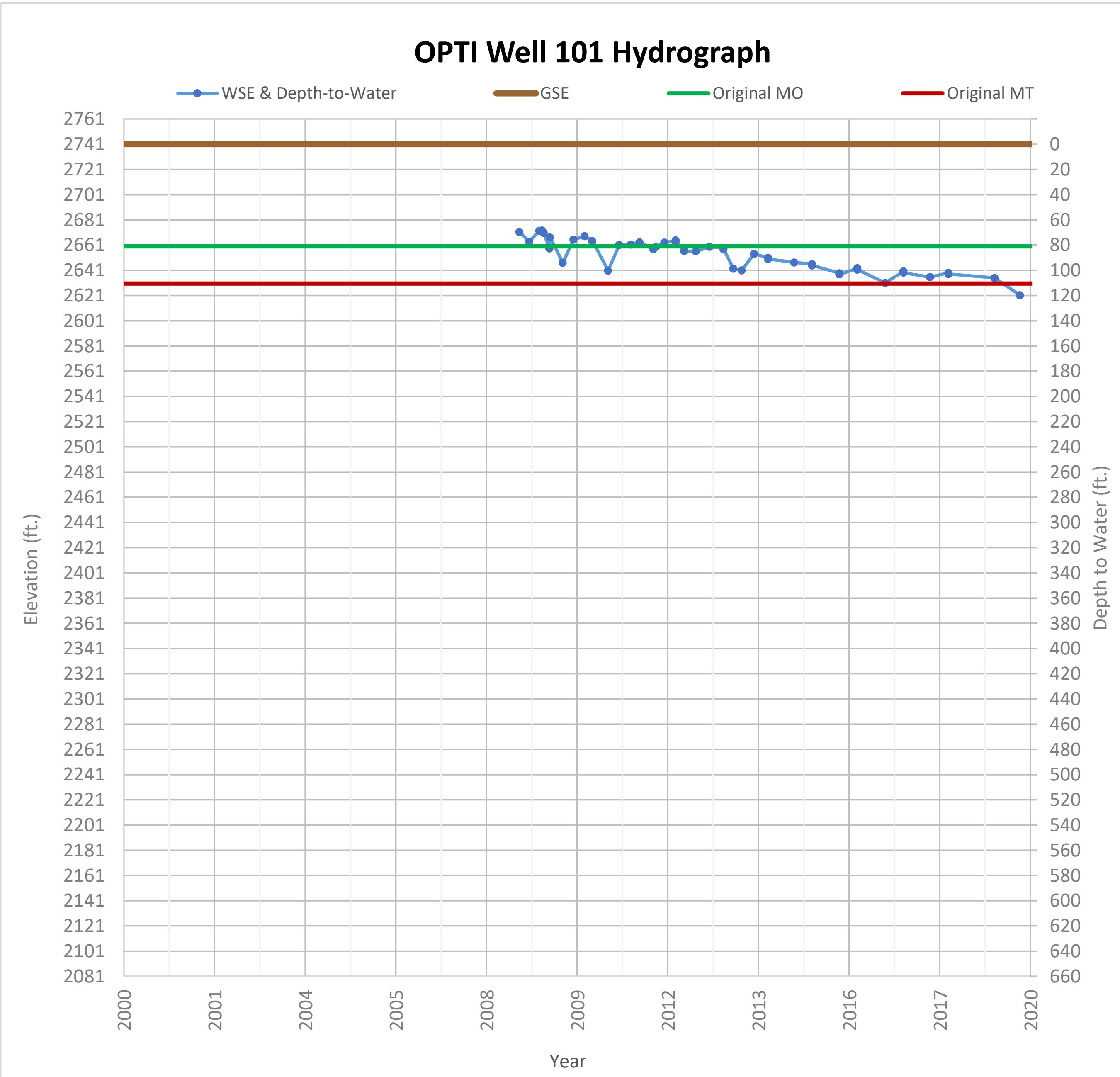
OPTI Well 98 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
2708
2688
2668
2648
2628
2608
2588
2568
2548
2528
2508
2488
2468
2448
2428
2408
2388
2368
2348
2328
2308
2288
2268
2248
2228
2208
2188
2168
2148
2128
2108
2088
2068
2048
2028
Depth to Water (ft.)
0
20
40
60
80
100
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020
Year

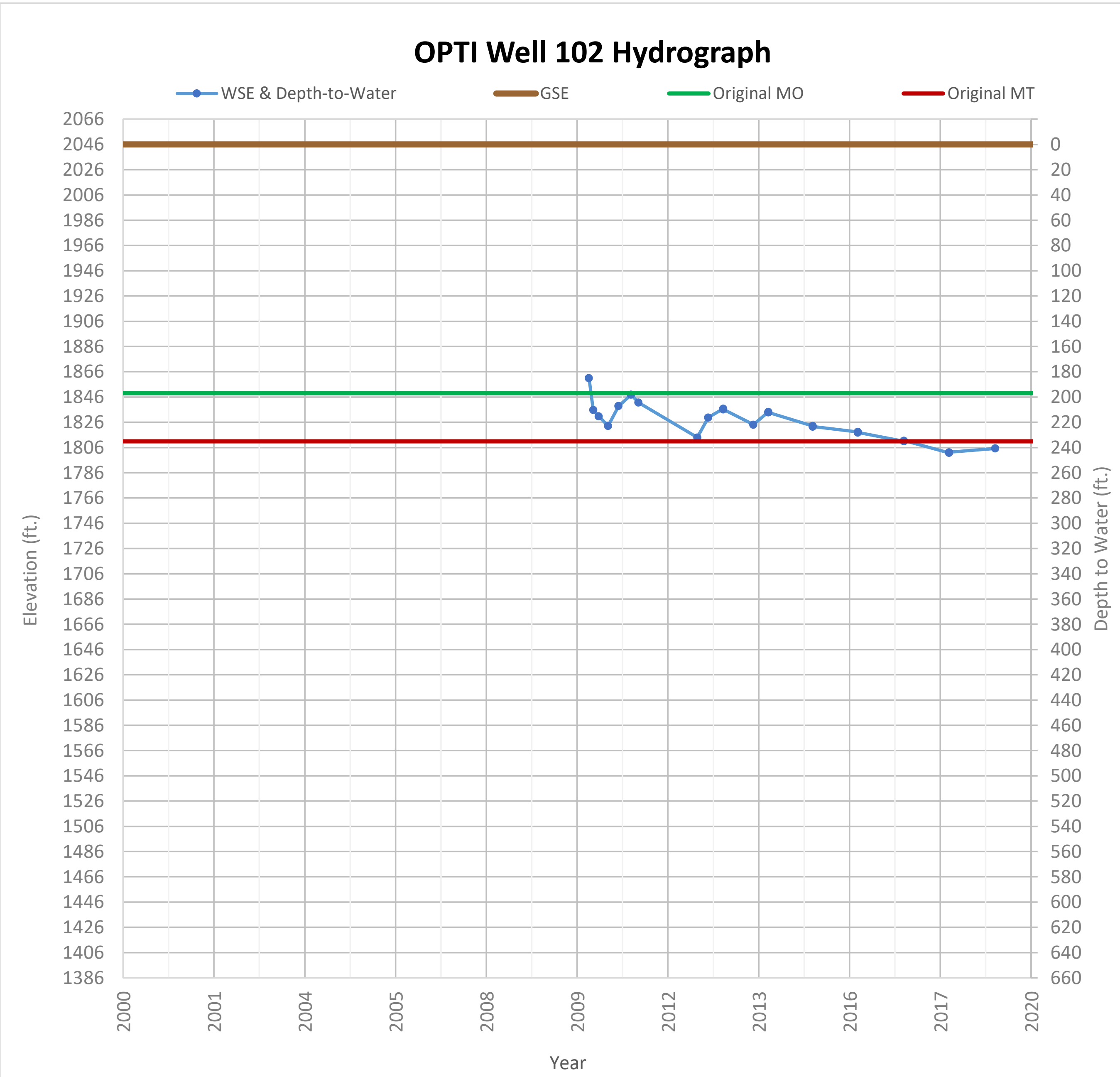


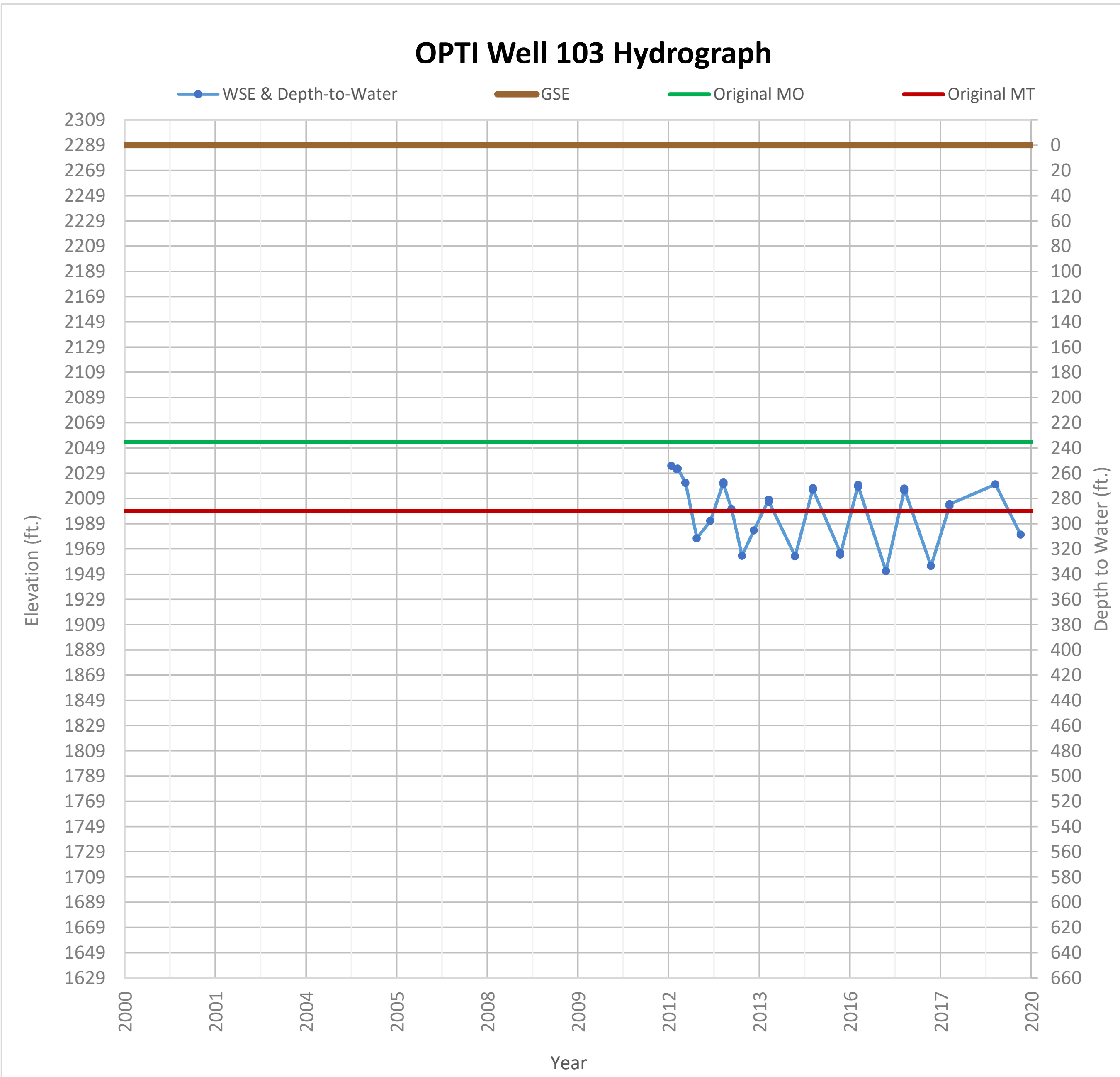
OPTI Well 99 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2533
2513
2493
2473
2453
2433
2413
2393
2373
2353
2333
2313
2293
2273
2253
2233
2213
2193
2173
2153
2133
2113
2093
2073
2053
2033
2013
1993
1973
1953
1933
1913
1893
1873
1853
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

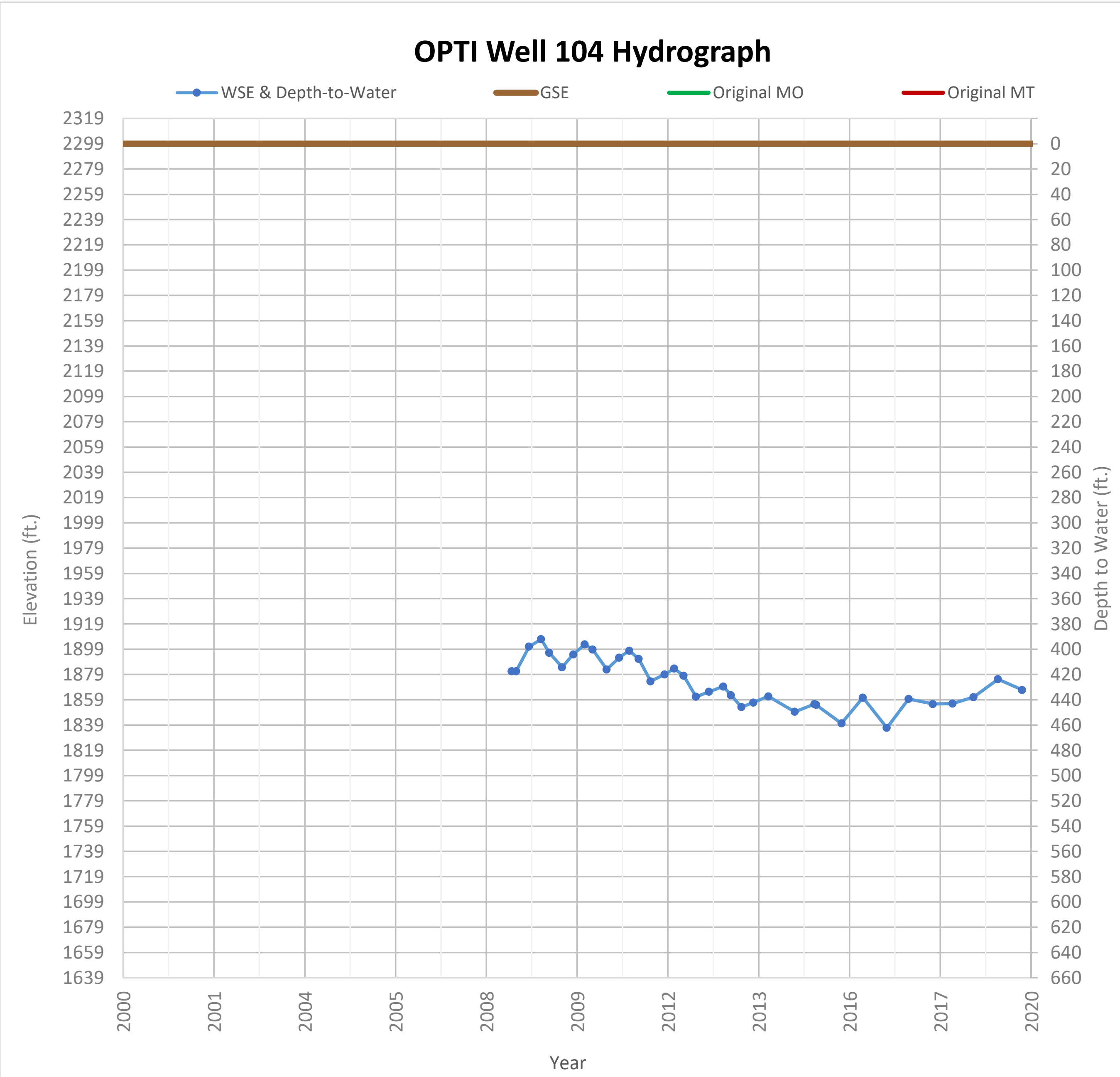


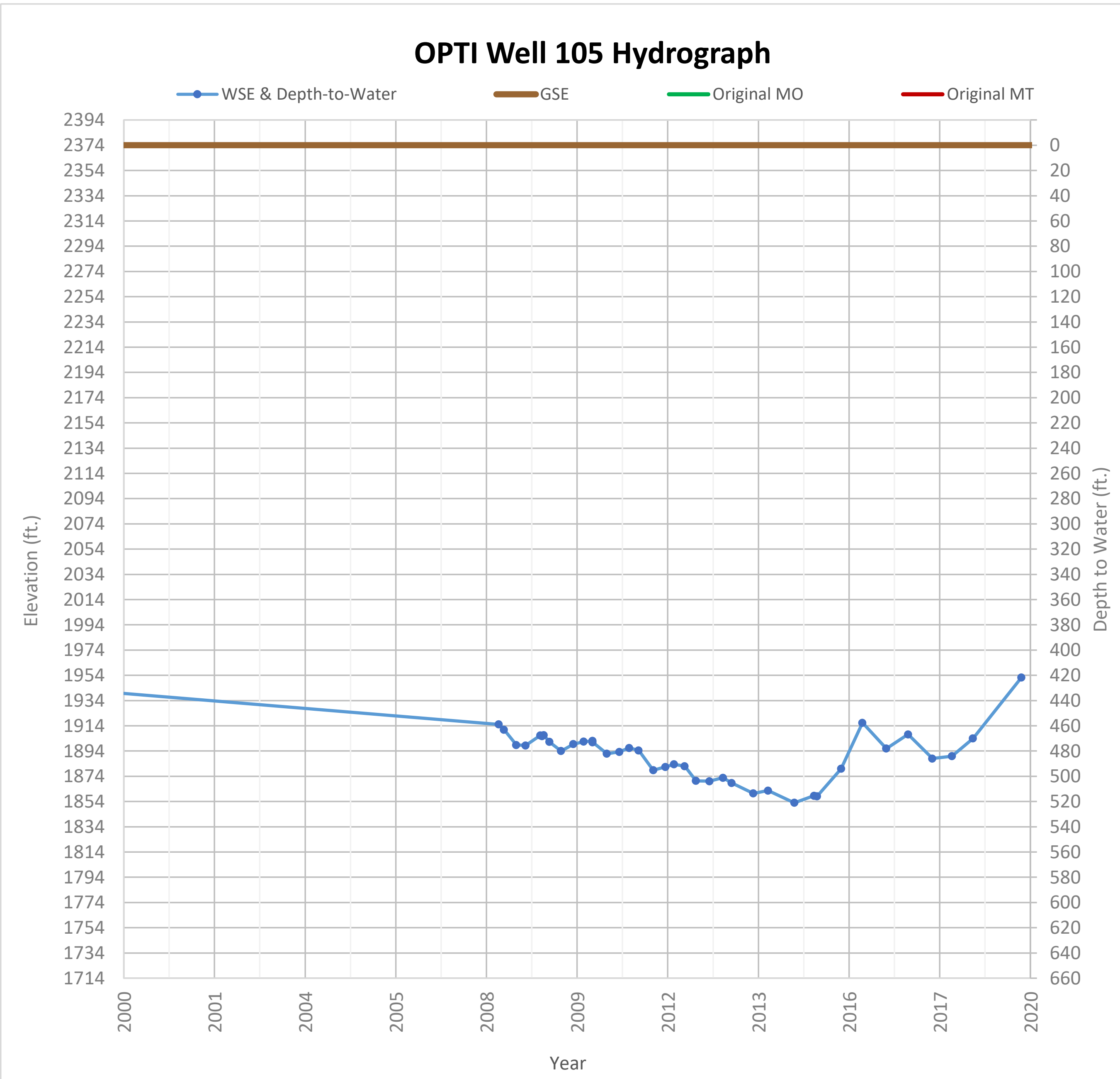
OPTI Well 100 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
3024
3004
2984
2964
2944
2924
2904
2884
2864
2844
2824
2804
2784
2764
2744
2724
2704
2684
2664
2644
2624
2604
2584
2564
2544
2524
2504
2484
2464
2444
2424
2404
2384
2364
2344
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020


OPTI Well 101 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2761
2741
2721
2701
2681
2661
2641
2621
2601
2581
2561
2541
2521
2501
2481
2461
2441
2421
2401
2381
2361
2341
2321
2301
2281
2261
2241
2221
2201
2181
2161
2141
2121
2101
2081
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

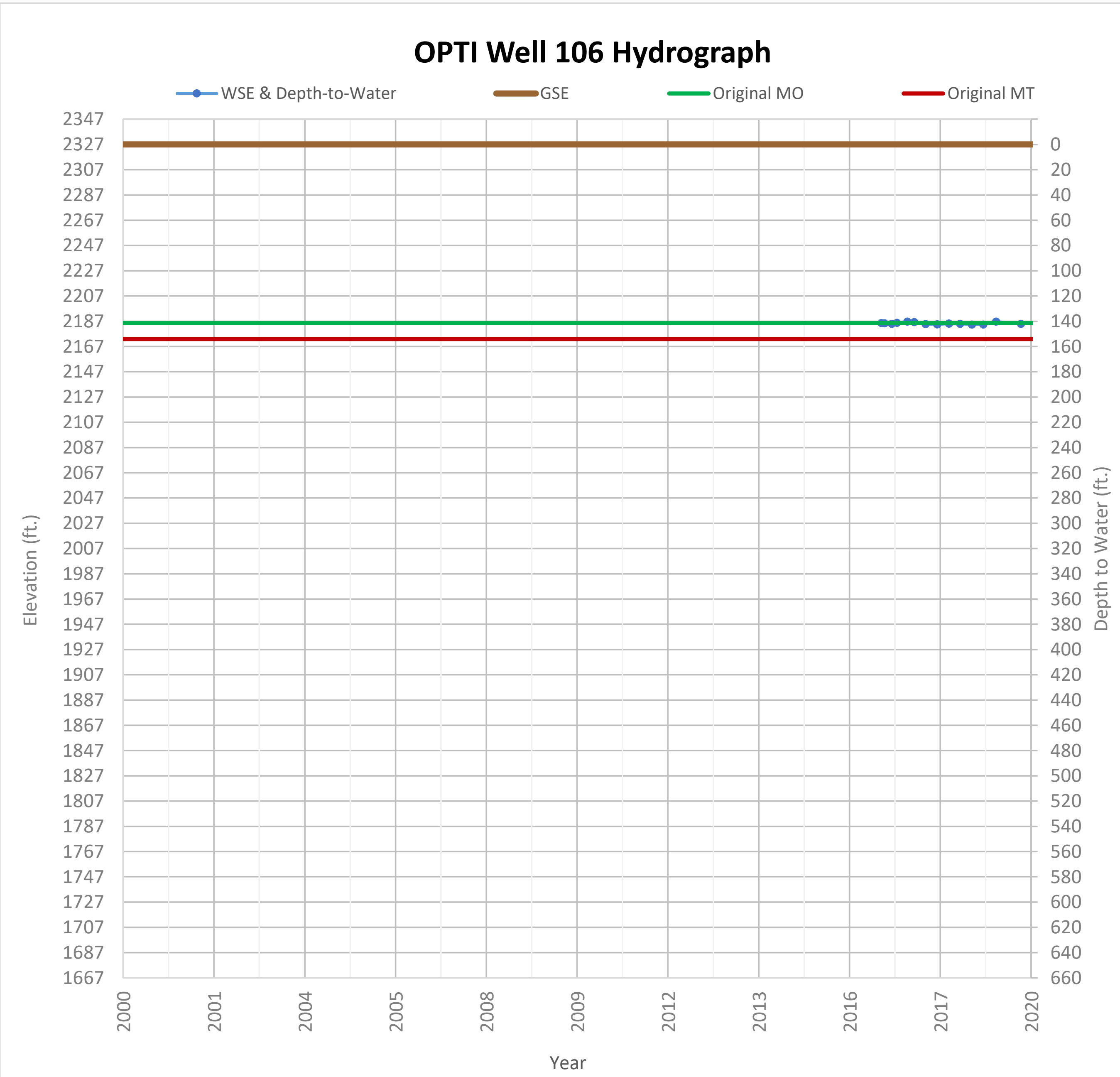

OPTI Well 102 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2066
2046
2026
2006
1986
1966
1946
1926
1906
1886
1866
1846
1826
1806
1786
1766
1746
1726
1706
1686
1666
1646
1626
1606
1586
1566
1546
1526
1506
1486
1466
1446
1426
1406
1386
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

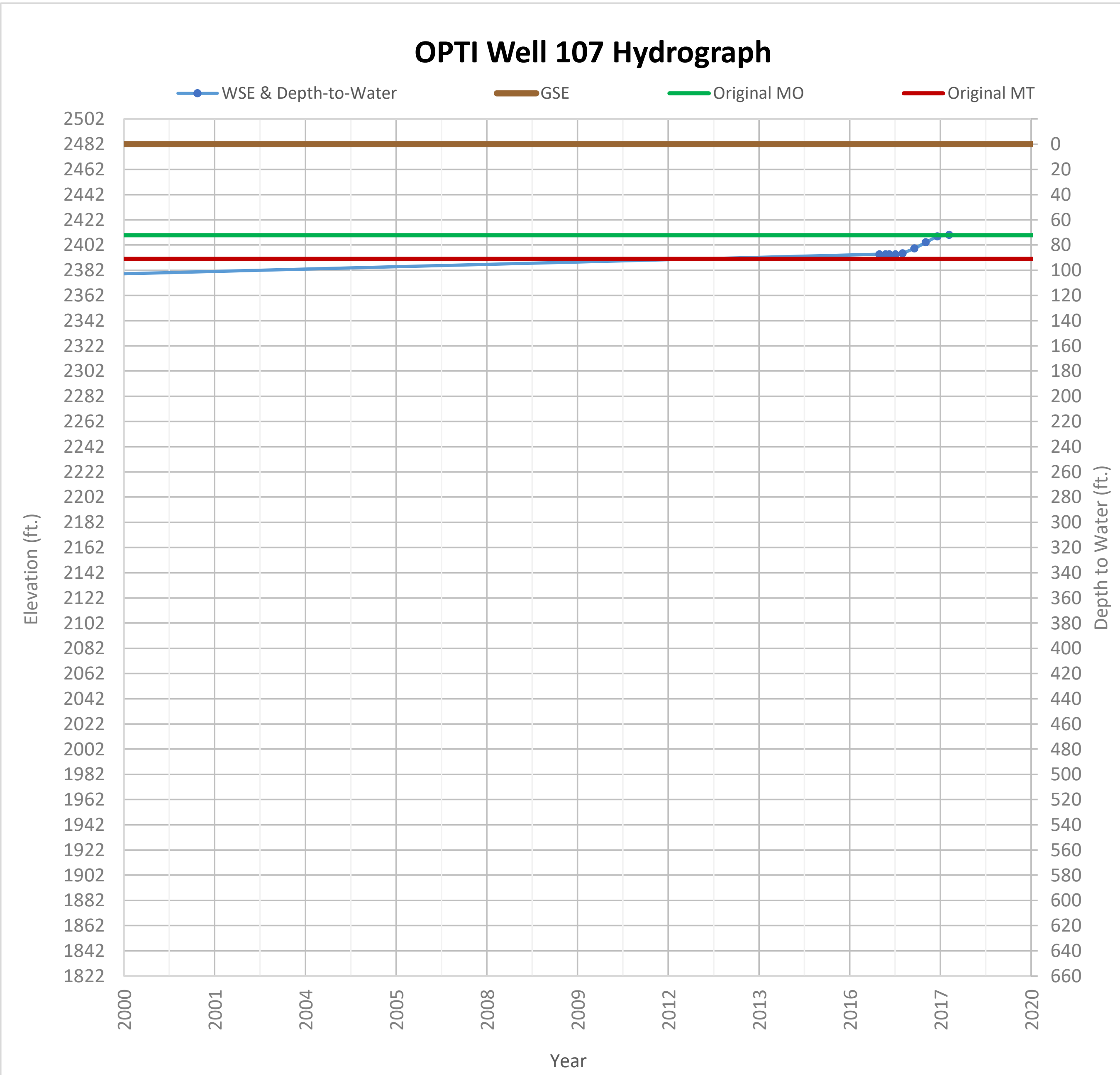

OPTI Well 103 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2309
2289
2269
2249
2229
2209
2189
2169
2149
2129
2109
2089
2069
2049
2029
2009
1989
1969
1949
1929
1909
1889
1869
1849
1829
1809
1789
1769
1749
1729
1709
1689
1669
1649
1629
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020


OPTI Well 104 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
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
1639
Elevation (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
Depth to Water (ft.)
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020
Year

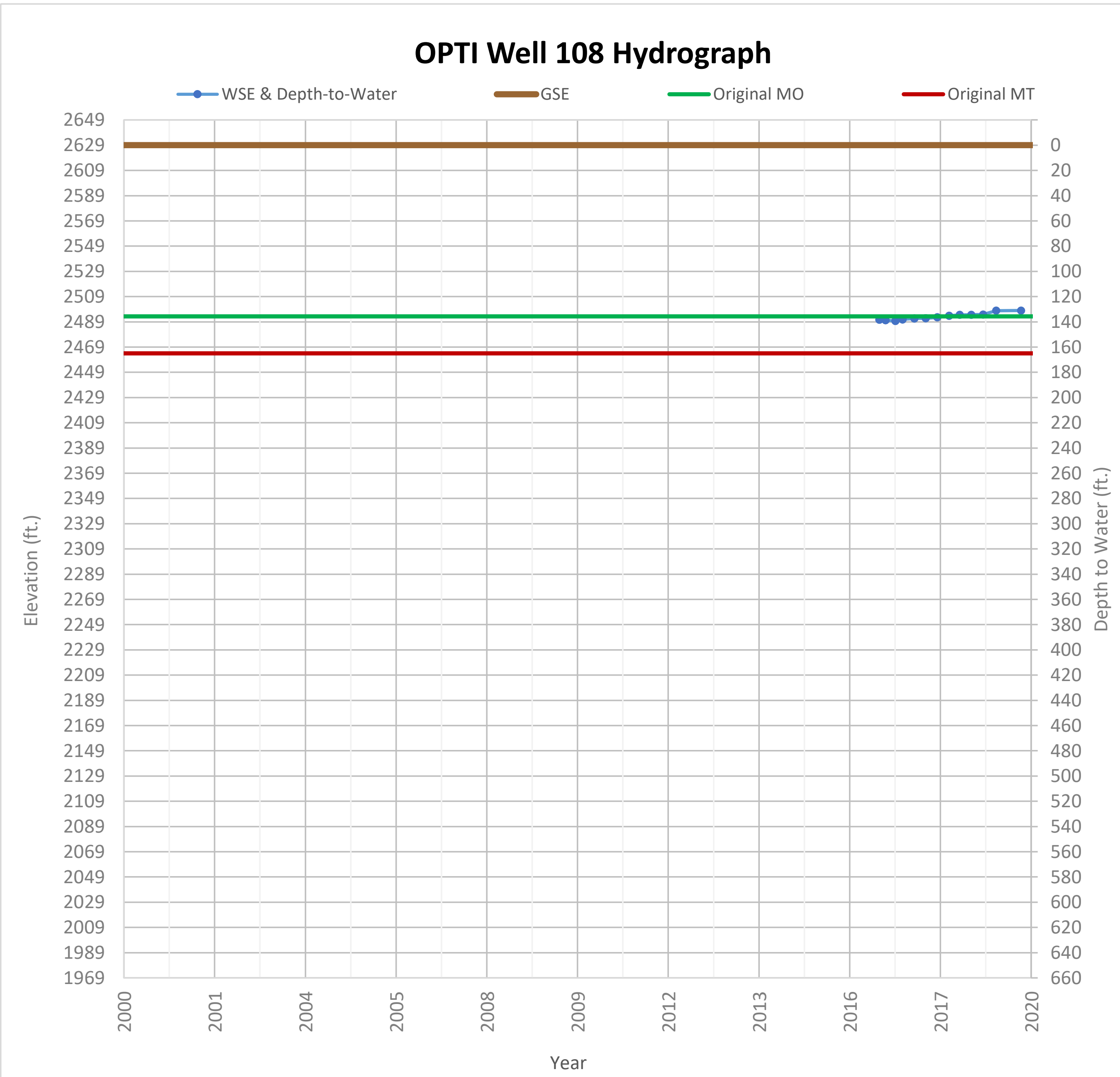


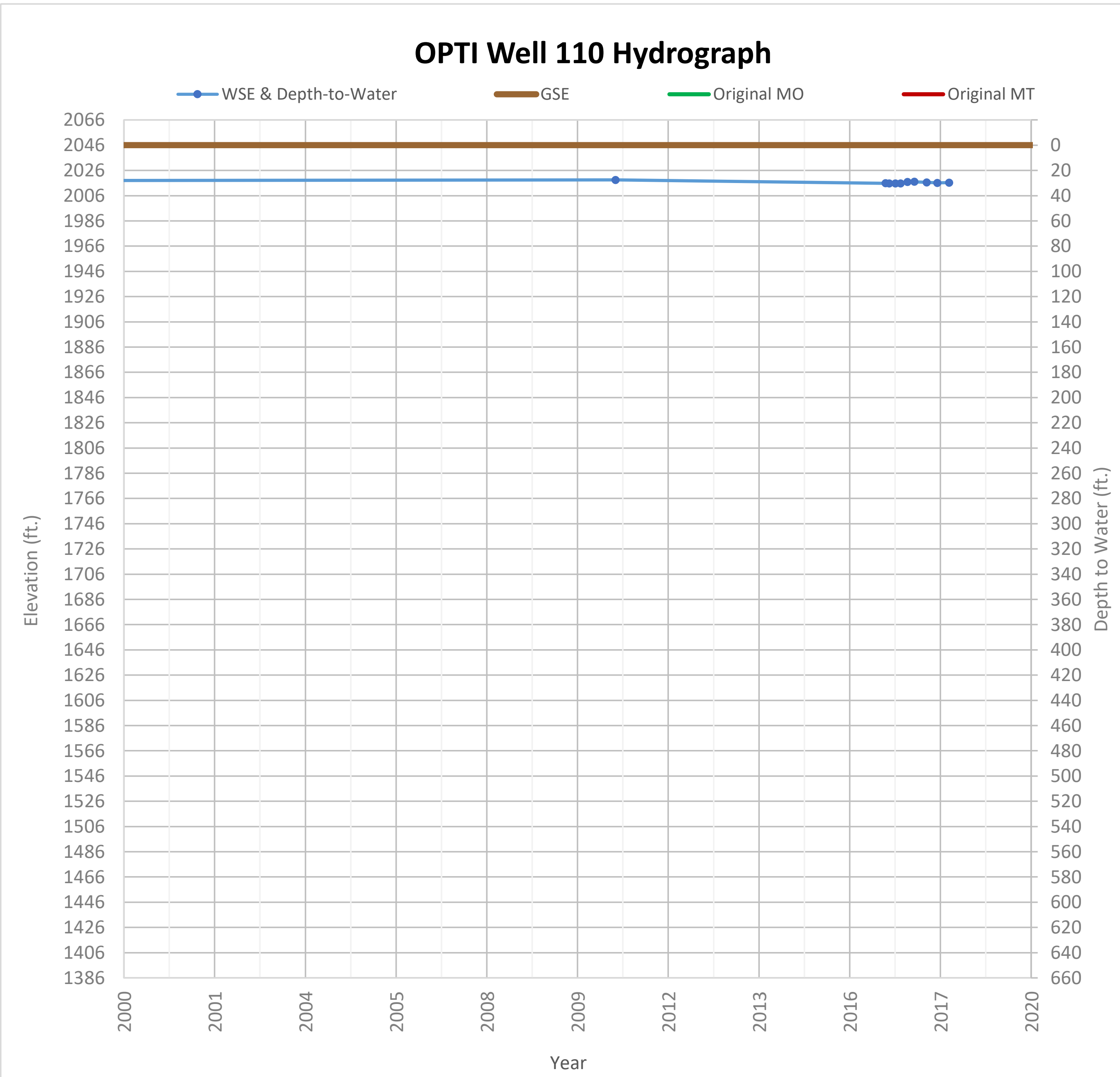
OPTI Well 105 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
2394
2374
2354
2334
2314
2294
2274
2254
2234
2214
2194
2174
2154
2134
2114
2094
2074
2054
2034
2014
1994
1974
1954
1934
1914
1894
1874
1854
1834
1814
1794
1774
1754
1734
1714
Depth to Water (ft.)
0
20
40
60
80
100
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020
Year


OPTI Well 106 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
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
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
520
540
560
580
600
620
640
660
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

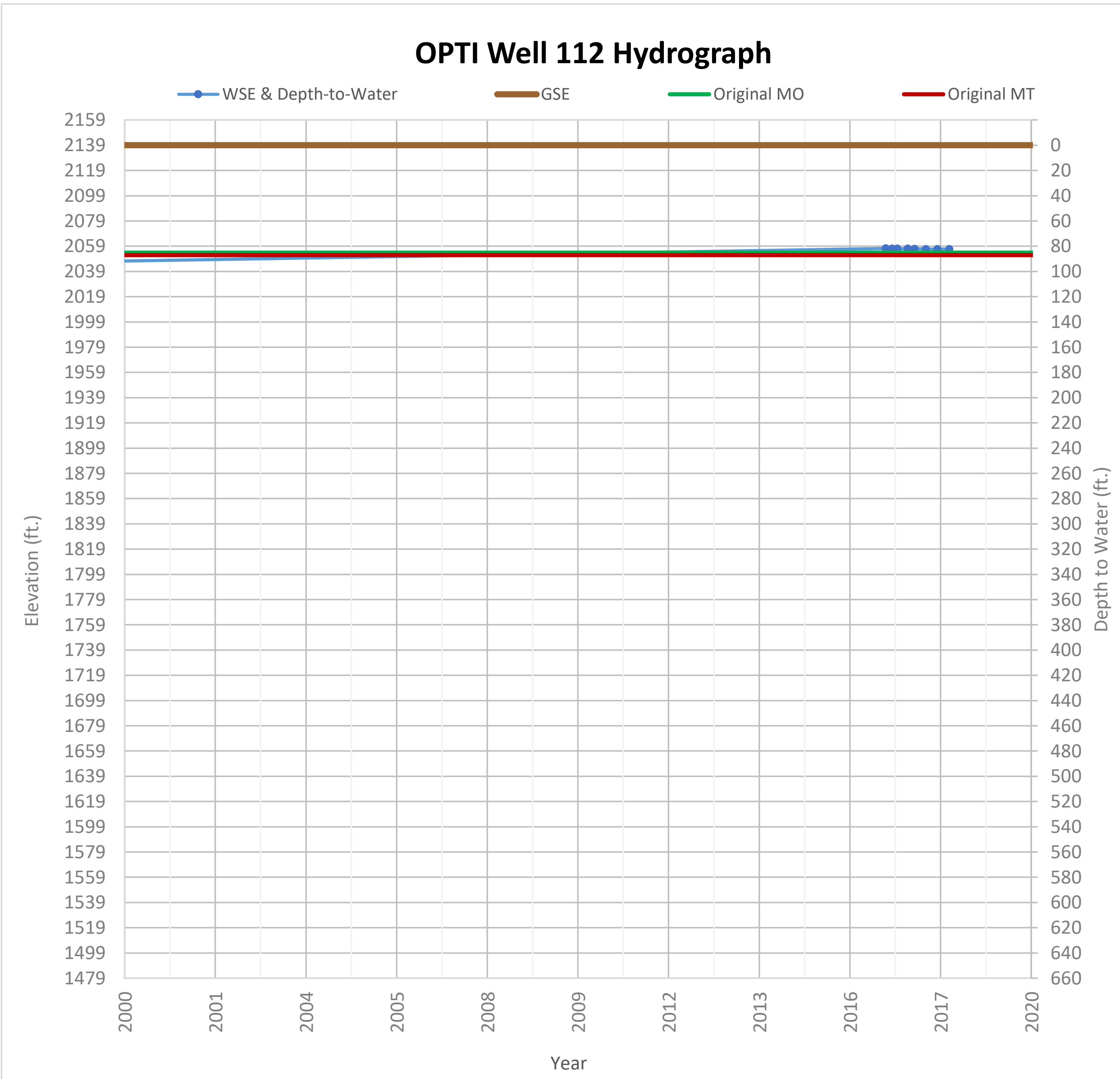


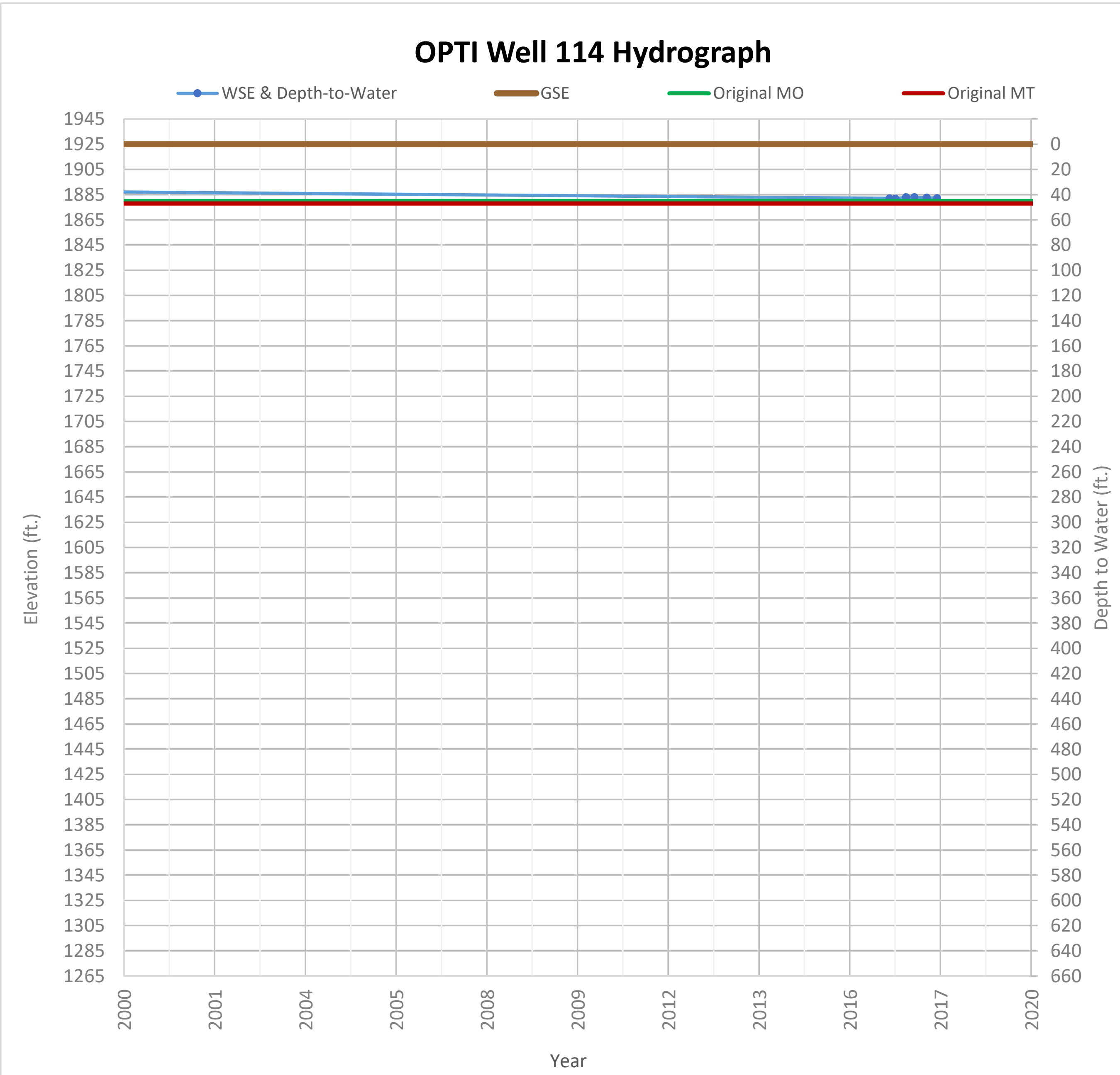
OPTI Well 107 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2502
2482
2462
2442
2422
2402
2382
2362
2342
2322
2302
2282
2262
2242
2222
2202
2182
2162
2142
2122
2102
2082
2062
2042
2022
2002
1982
1962
1942
1922
1902
1882
1862
1842
1822
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020


OPTI Well 108 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
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
2089
2069
2049
2029
2009
1989
1969
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

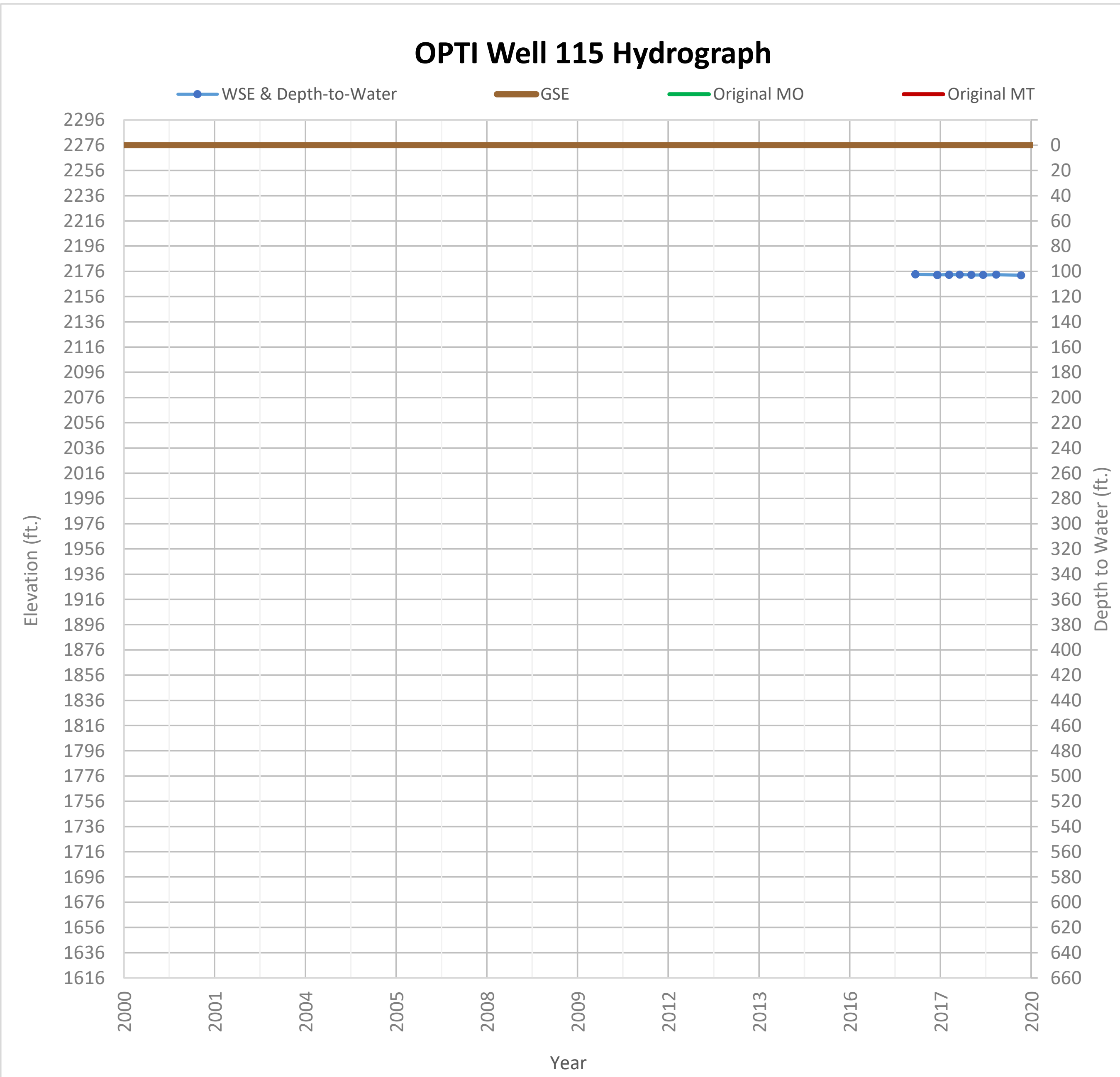


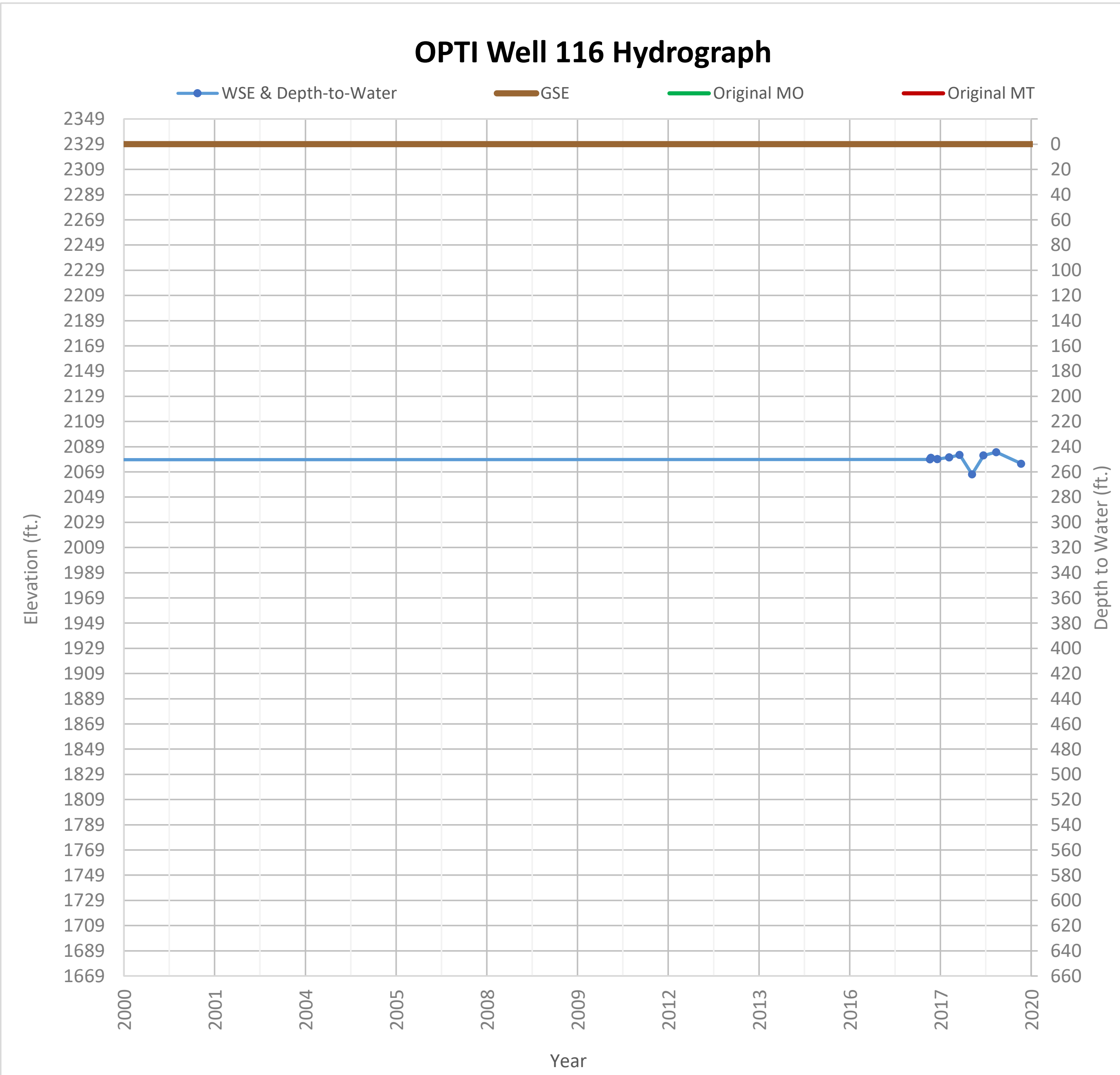
OPTI Well 110 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
2066
2046
2026
2006
1986
1966
1946
1926
1906
1886
1866
1846
1826
1806
1786
1766
1746
1726
1706
1686
1666
1646
1626
1606
1586
1566
1546
1526
1506
1486
1466
1446
1426
1406
1386
0
20
40
60
80
100
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020
Year

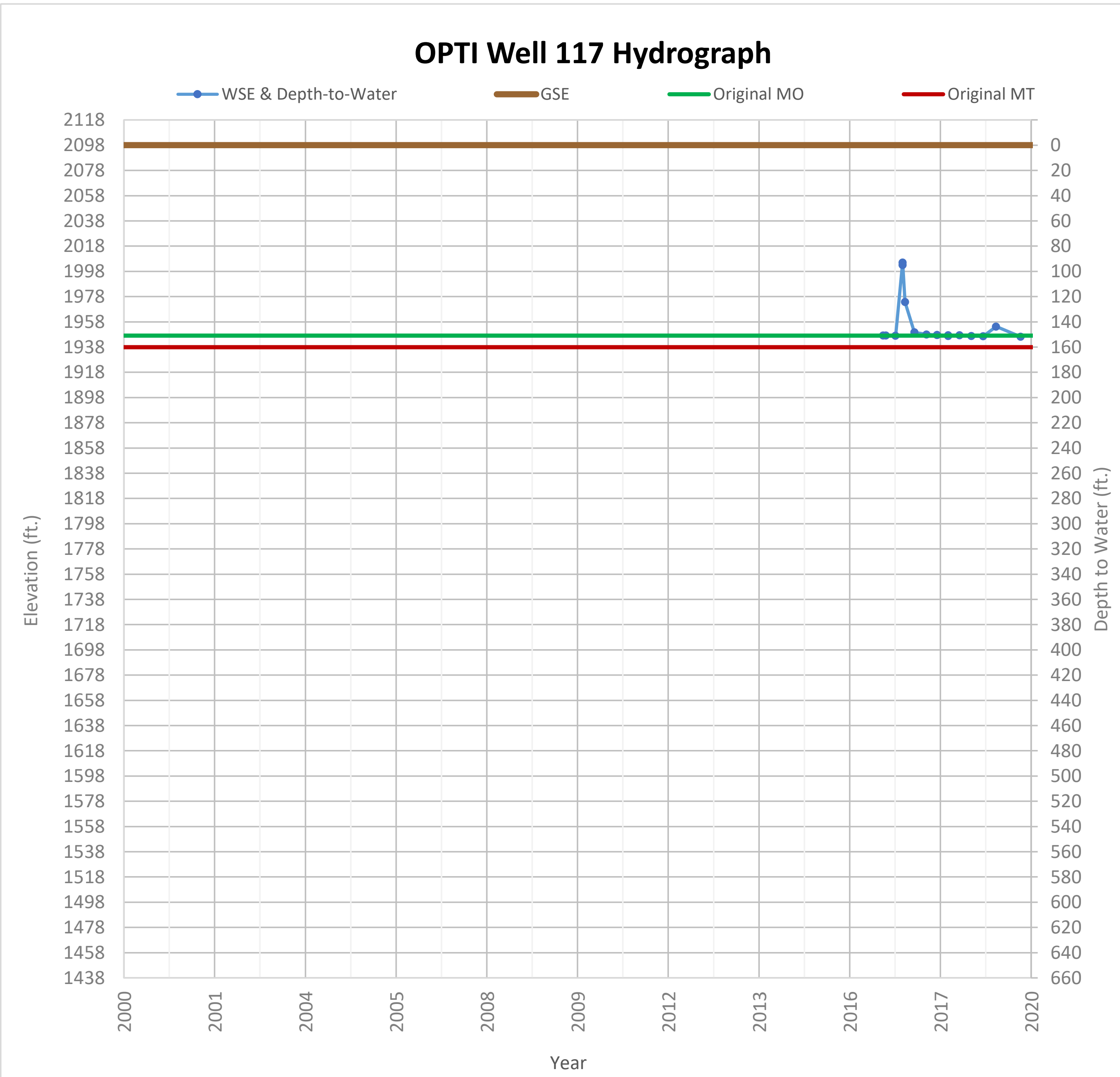

OPTI Well 112 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2159
2139
2119
2099
2079
2059
2039
2019
1999
1979
1959
1939
1919
1899
1879
1859
1839
1819
1799
1779
1759
1739
1719
1699
1679
1659
1639
1619
1599
1579
1559
1539
1519
1499
1479
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

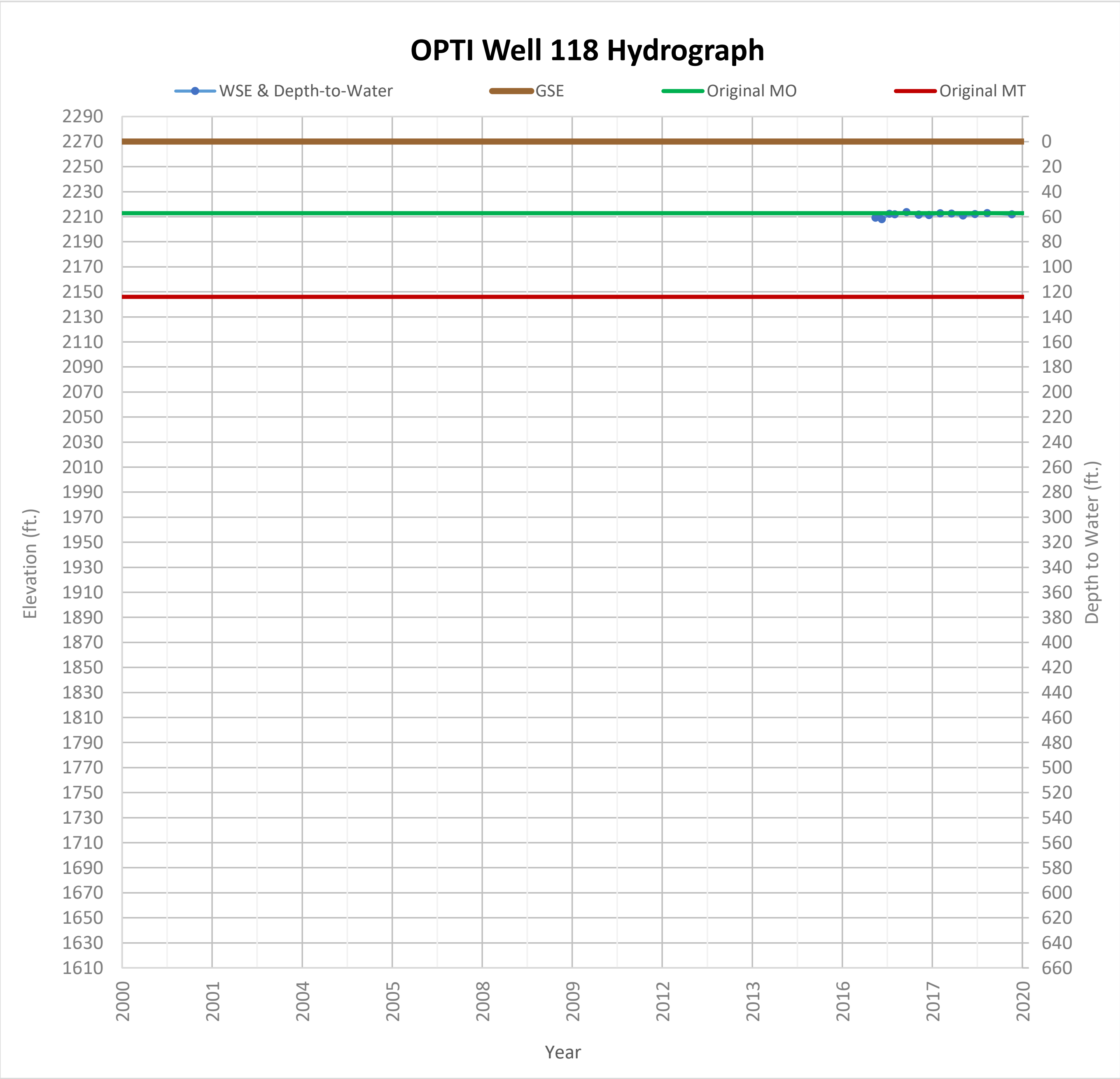


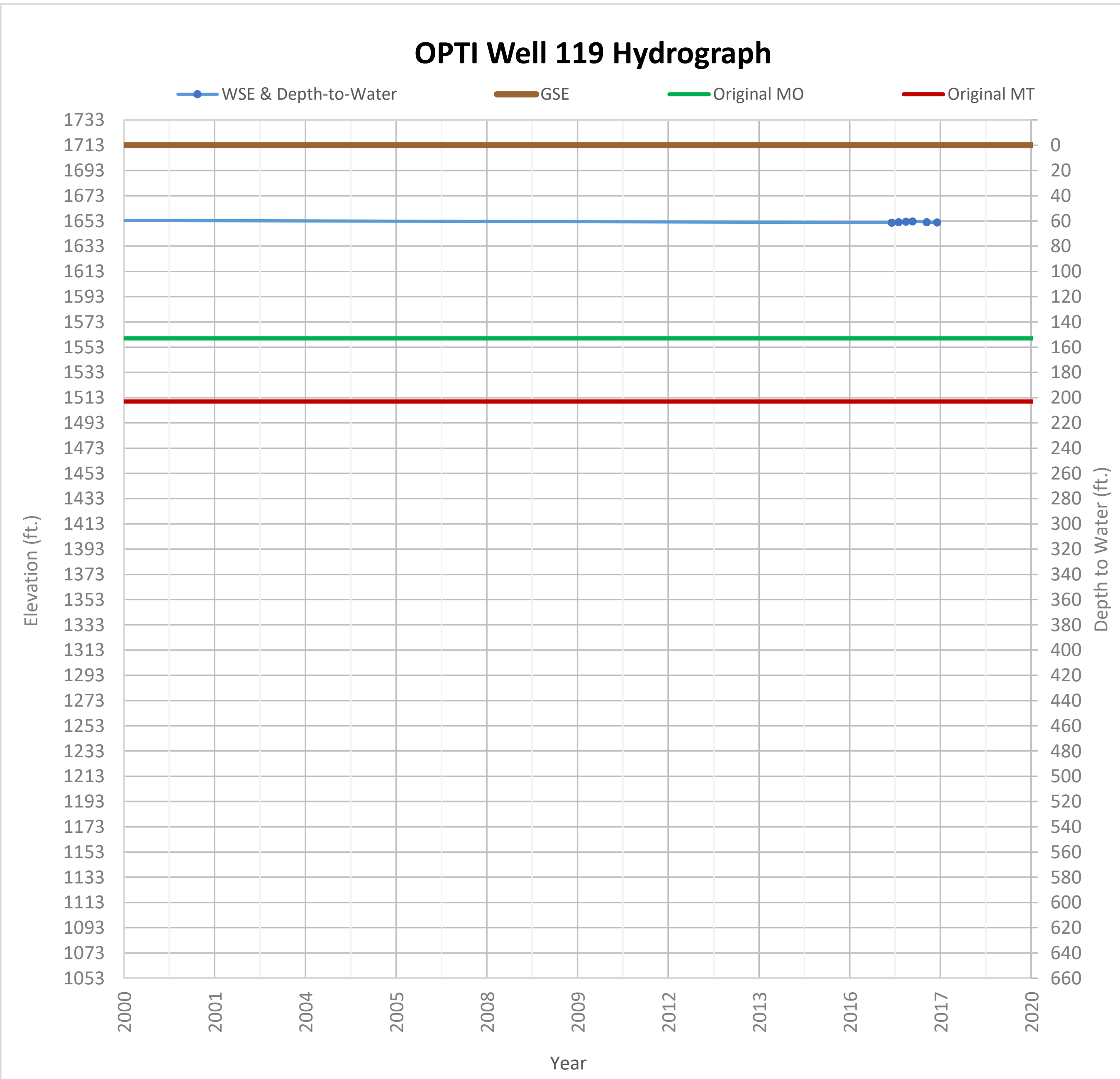
OPTI Well 114 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
1945
1925
1905
1885
1865
1845
1825
1805
1785
1765
1745
1725
1705
1685
1665
1645
1625
1605
1585
1565
1545
1525
1505
1485
1465
1445
1425
1405
1385
1365
1345
1325
1305
1285
1265
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020


OPTI Well 115 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2296
2276
2256
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
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

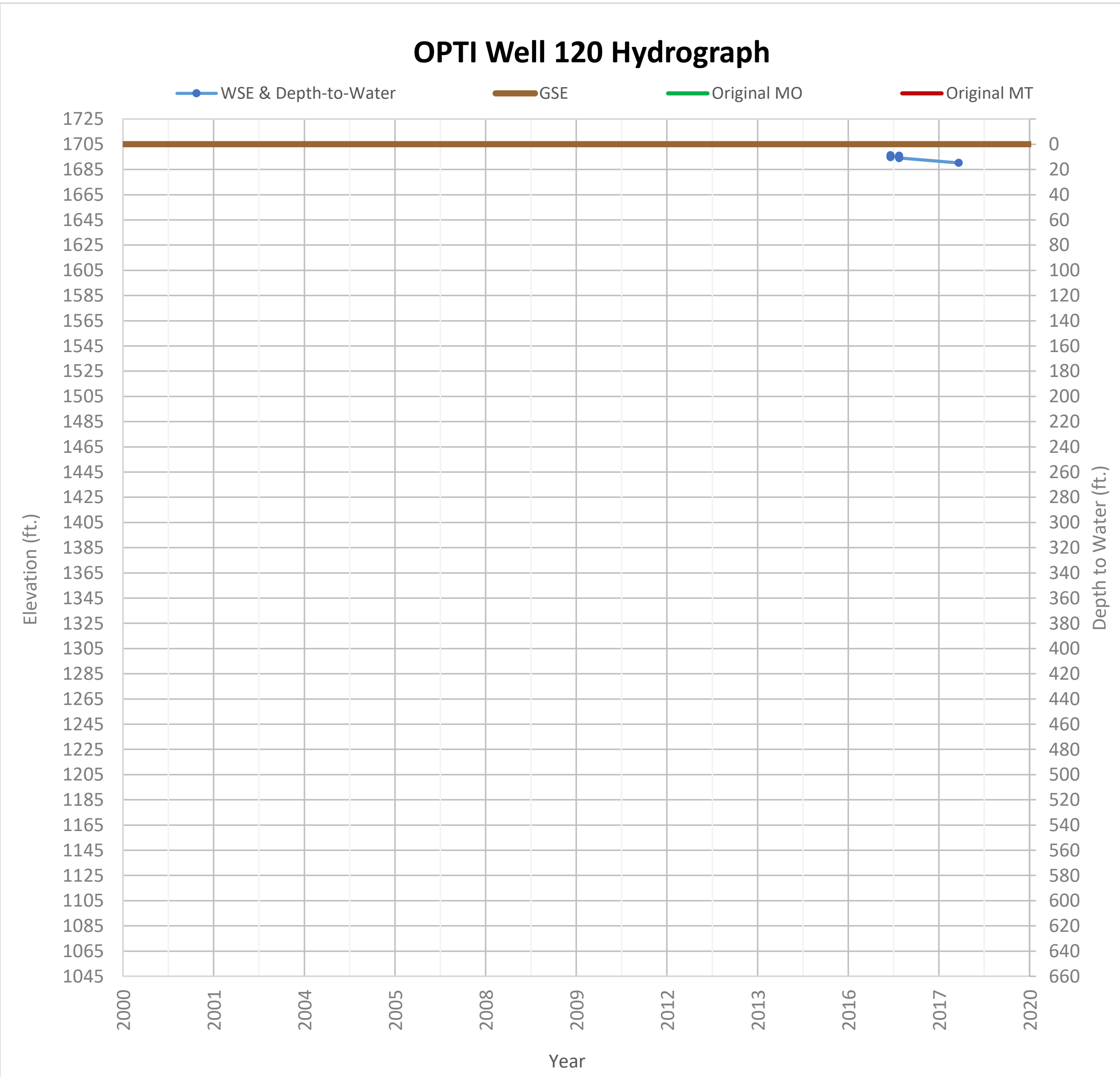

OPTI Well 116 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2349
2329
2309
2289
2269
2249
2229
2209
2189
2169
2149
2129
2109
2089
2069
2049
2029
2009
1989
1969
1949
1929
1909
1889
1869
1849
1829
1809
1789
1769
1749
1729
1709
1689
1669
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

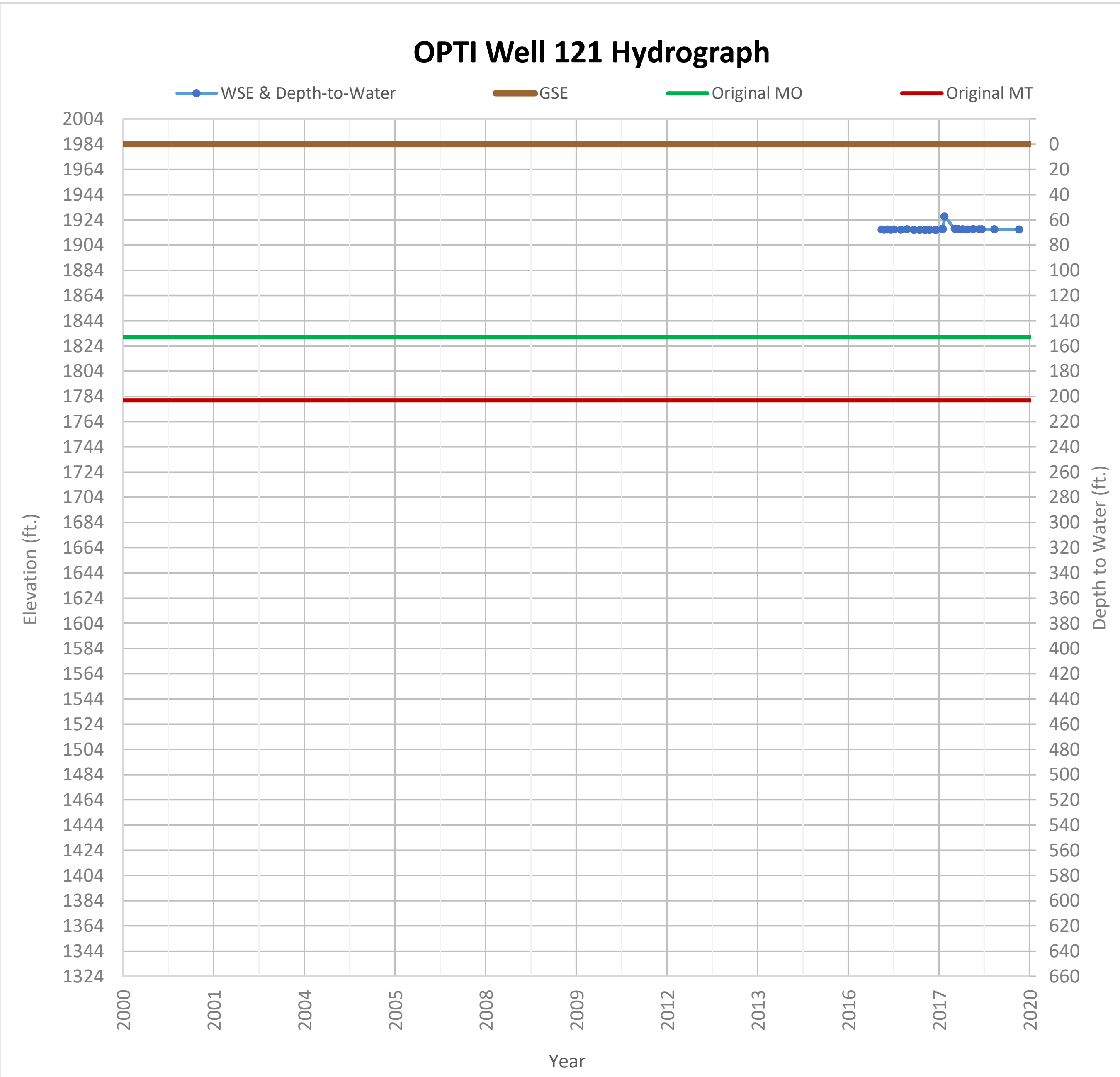

OPTI Well 117 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2118
2098
2078
2058
2038
2018
1998
1978
1958
1938
1918
1898
1878
1858
1838
1818
1798
1778
1758
1738
1718
1698
1678
1658
1638
1618
1598
1578
1558
1538
1518
1498
1478
1458
1438
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

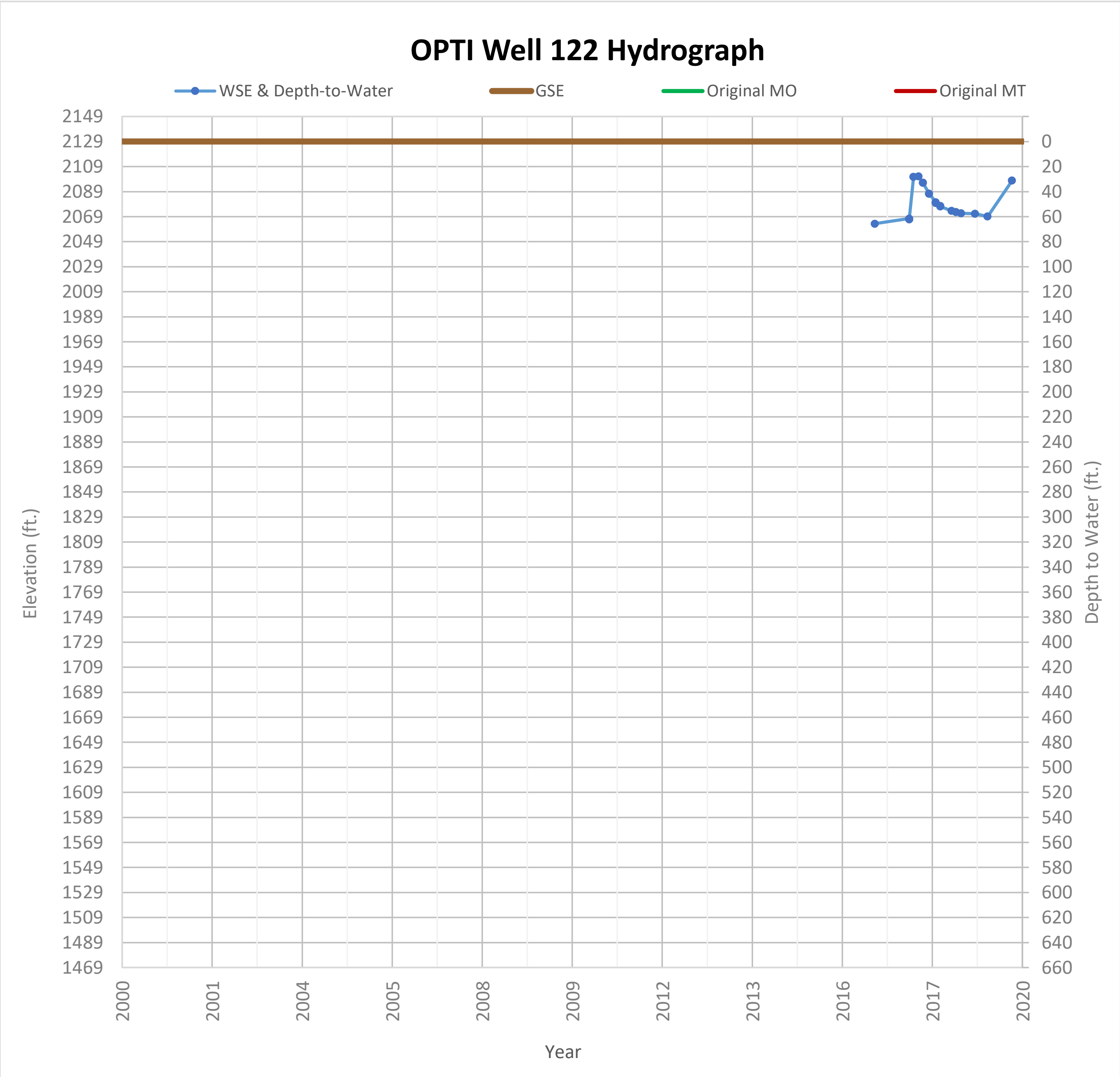

OPTI Well 118 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2290
2270
2250
2230
2210
2190
2170
2150
2130
2110
2090
2070
2050
2030
2010
1990
1970
1950
1930
1910
1890
1870
1850
1830
1810
1790
1770
1750
1730
1710
1690
1670
1650
1630
1610
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020



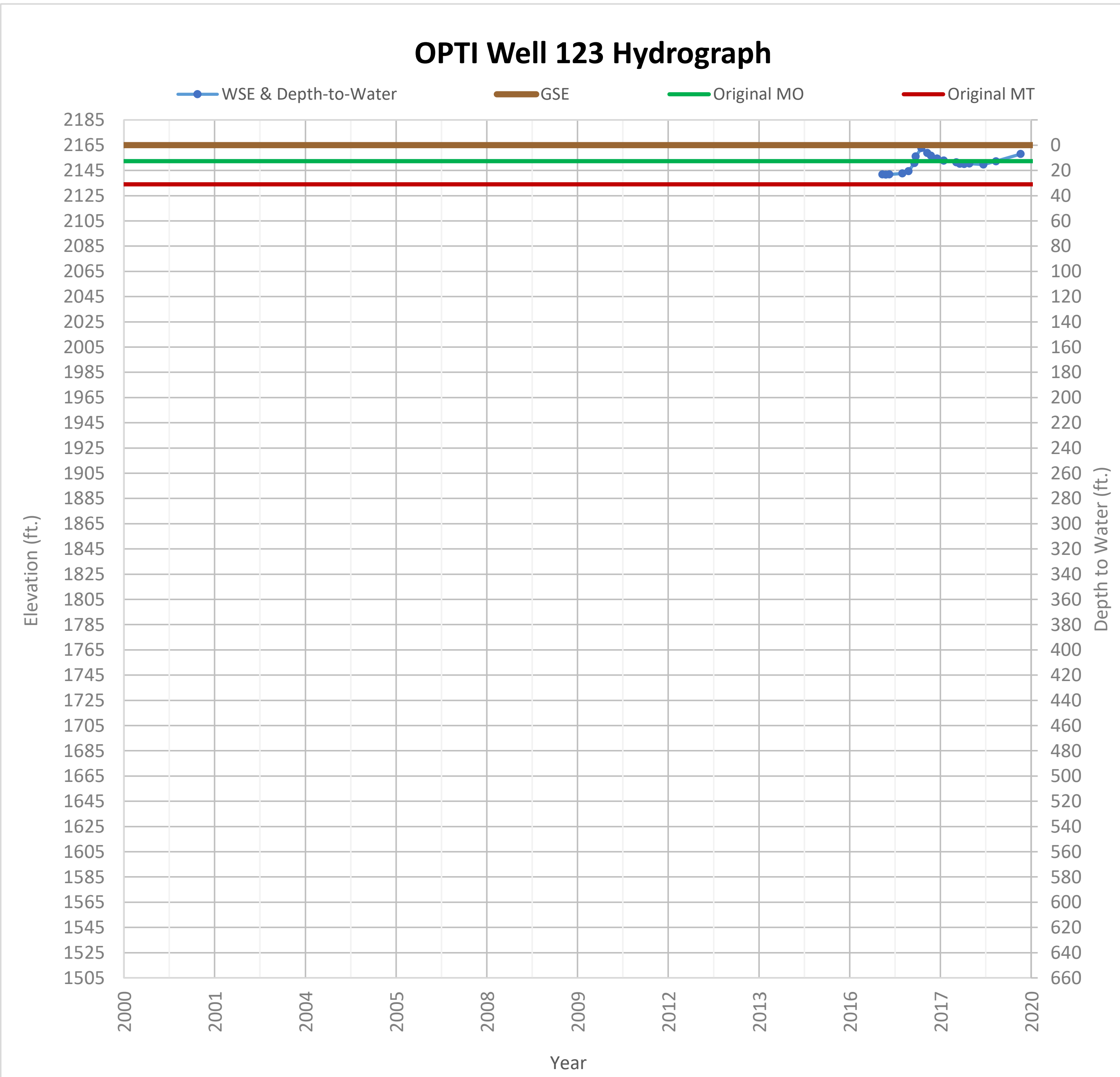
OPTI Well 119 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
1733
1713
1693
1673
1653
1633
1613
1593
1573
1553
1533
1513
1493
1473
1453
1433
1413
1393
1373
1353
1333
1313
1293
1273
1253
1233
1213
1193
1173
1153
1133
1113
1093
1073
1053
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

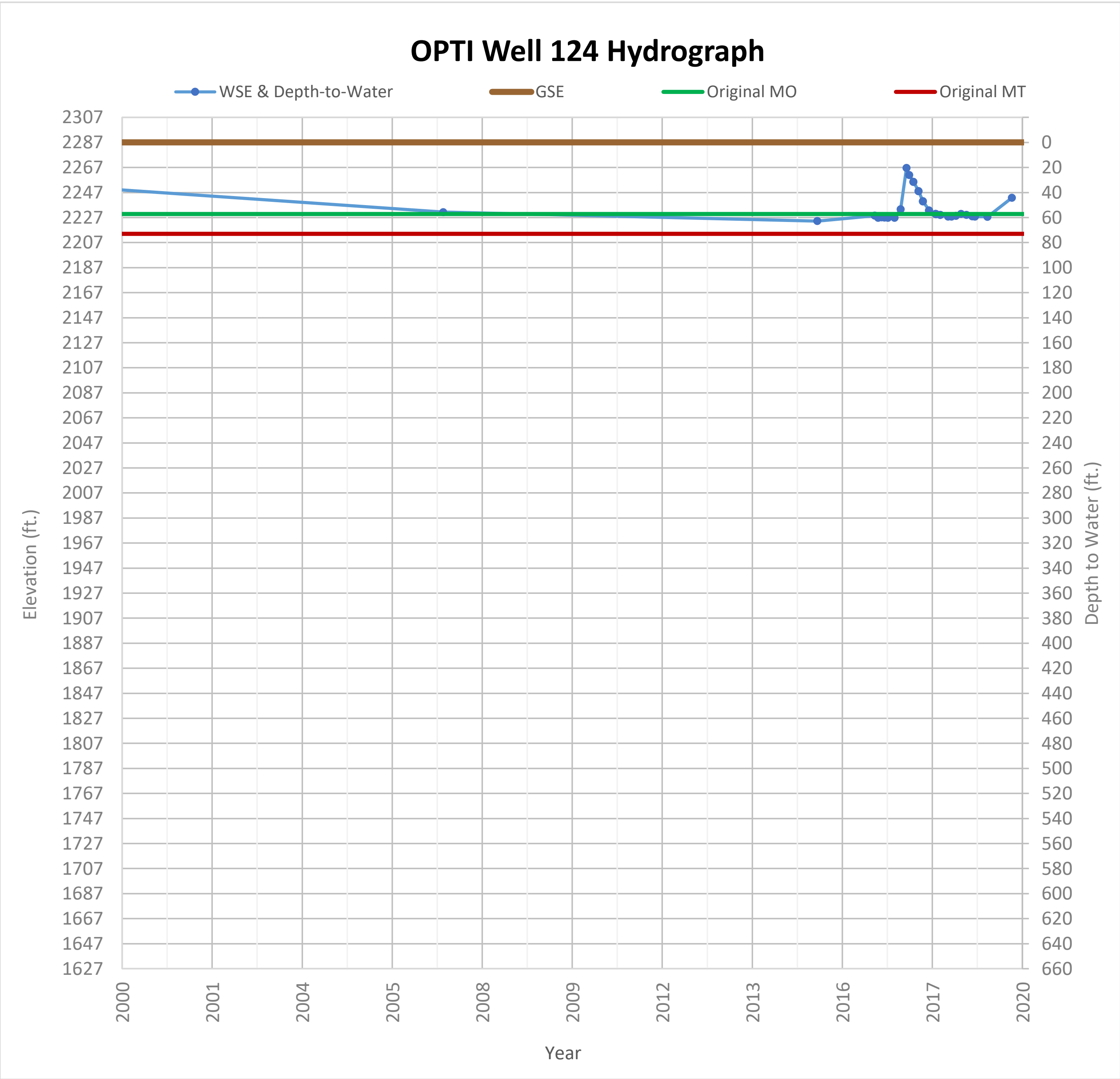

OPTI Well 120 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
1725
1705
1685
1665
1645
1625
1605
1585
1565
1545
1525
1505
1485
1465
1445
1425
1405
1385
1365
1345
1325
1305
1285
1265
1245
1225
1205
1185
1165
1145
1125
1105
1085
1065
1045
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

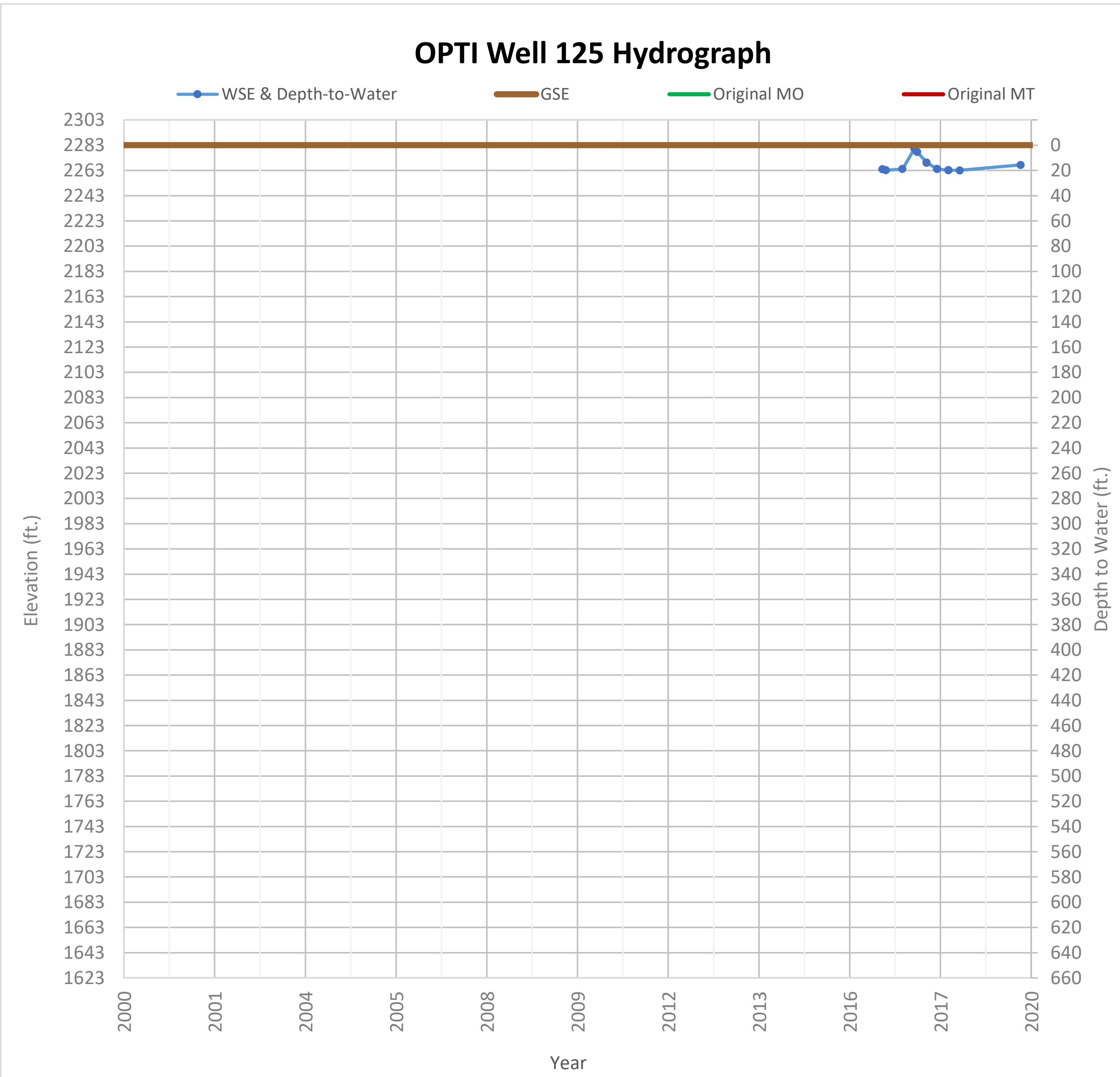

OPTI Well 121 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2004
1984
1964
1944
1924
1904
1884
1864
1844
1824
1804
1784
1764
1744
1724
1704
1684
1664
1644
1624
1604
1584
1564
1544
1524
1504
1484
1464
1444
1424
1404
1384
1364
1344
1324
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

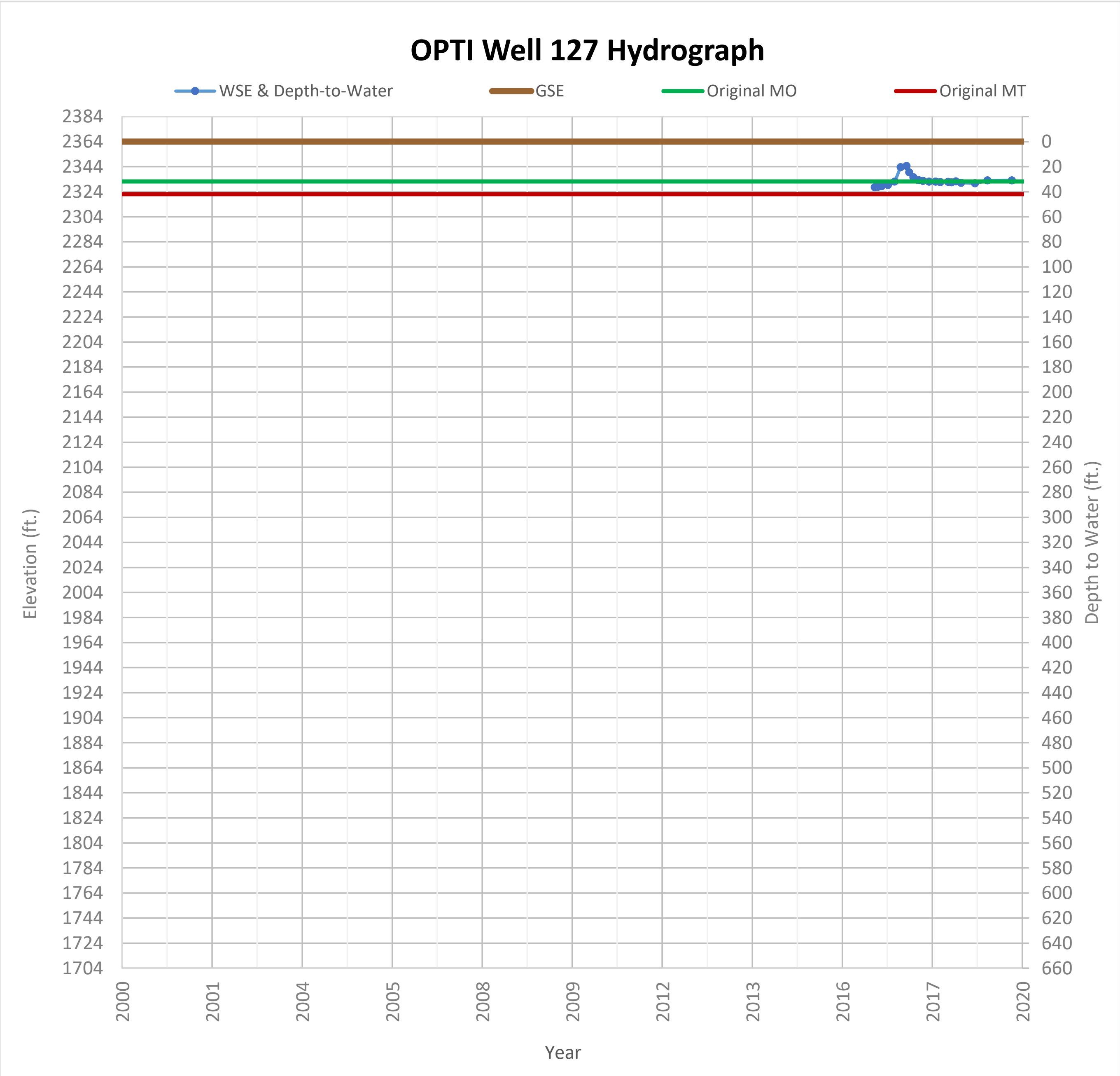


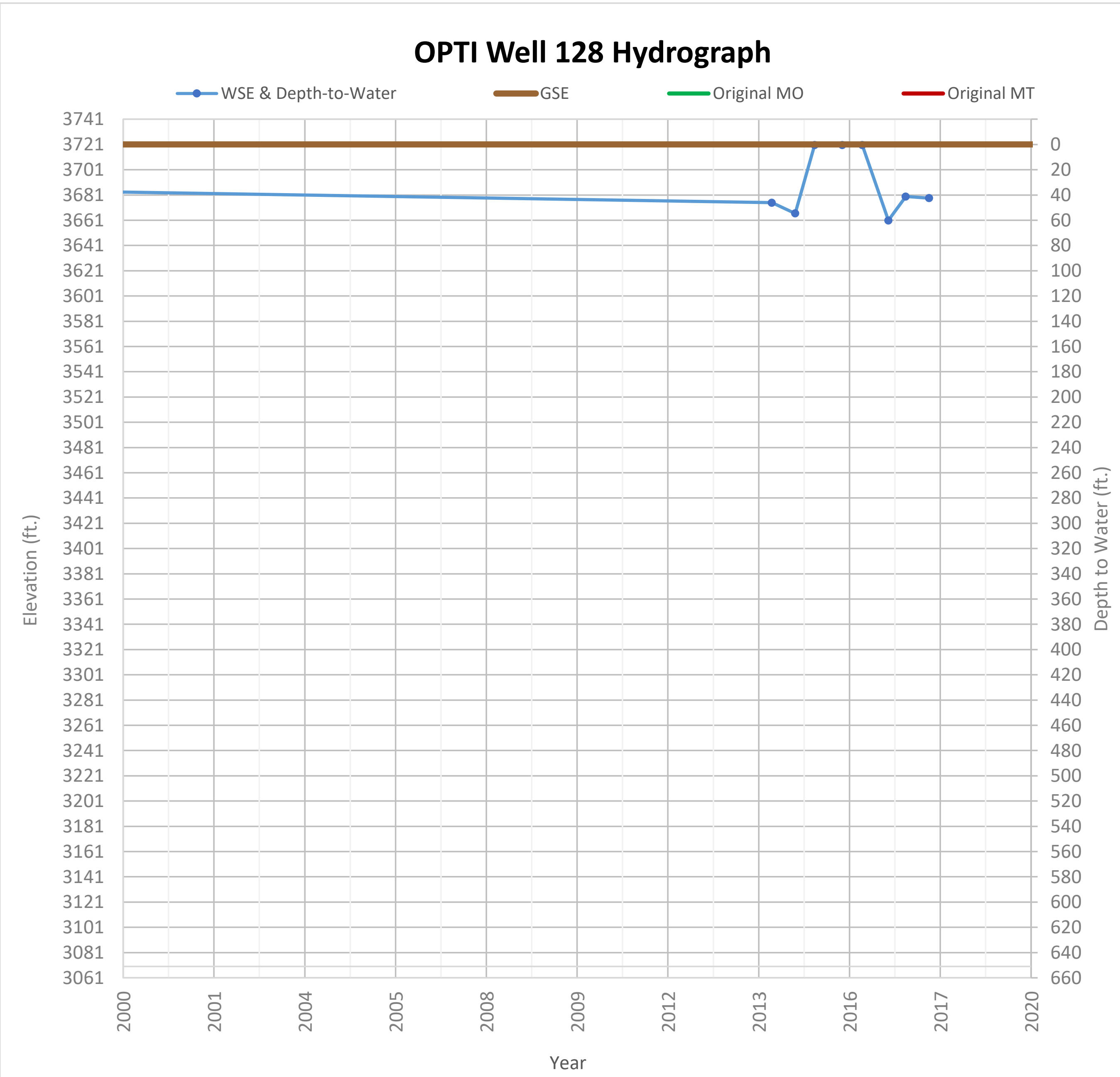
OPTI Well 122 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2149
2129
2109
2089
2069
2049
2029
2009
1989
1969
1949
1929
1909
1889
1869
1849
1829
1809
1789
1769
1749
1729
1709
1689
1669
1649
1629
1609
1589
1569
1549
1529
1509
1489
1469
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

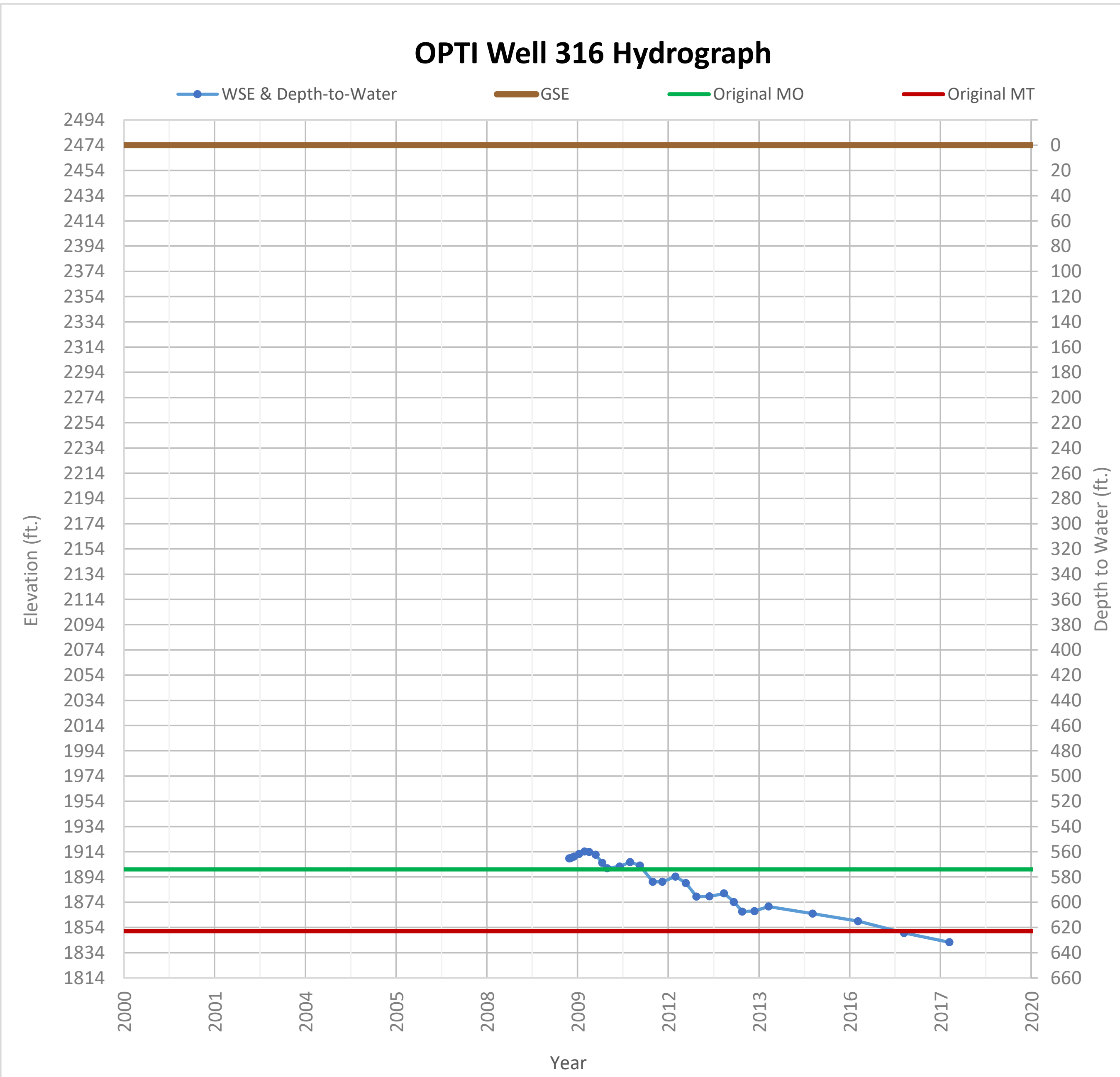

OPTI Well 123 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2185
2165
2145
2125
2105
2085
2065
2045
2025
2005
1985
1965
1945
1925
1905
1885
1865
1845
1825
1805
1785
1765
1745
1725
1705
1685
1665
1645
1625
1605
1585
1565
1545
1525
1505
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

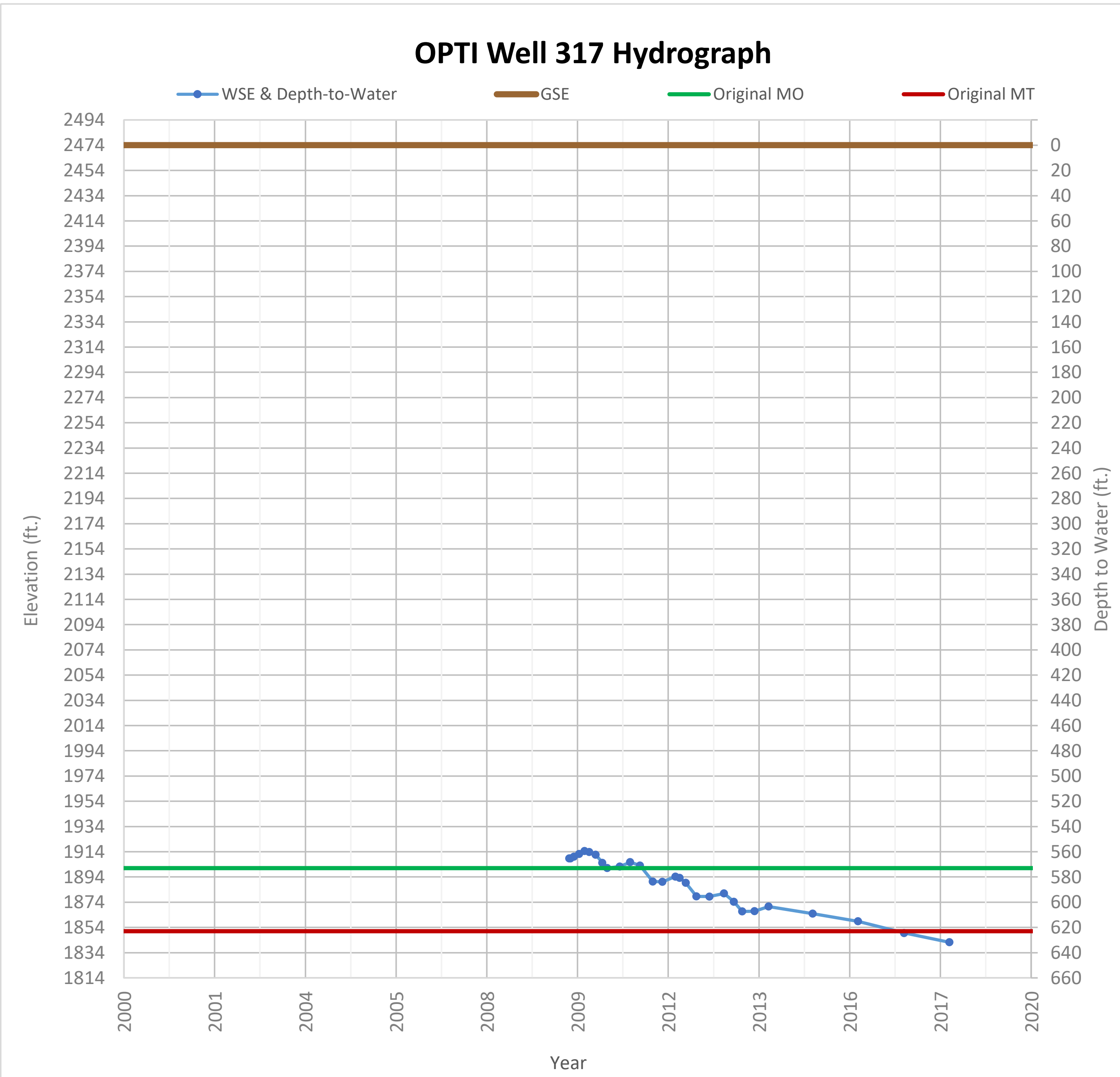

OPTI Well 124 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2307
2287
2267
2247
2227
2207
2187
2167
2147
2127
2107
2087
2067
2047
2027
2007
1987
1967
1947
1927
1907
1887
1867
1847
1827
1807
1787
1767
1747
1727
1707
1687
1667
1647
1627
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

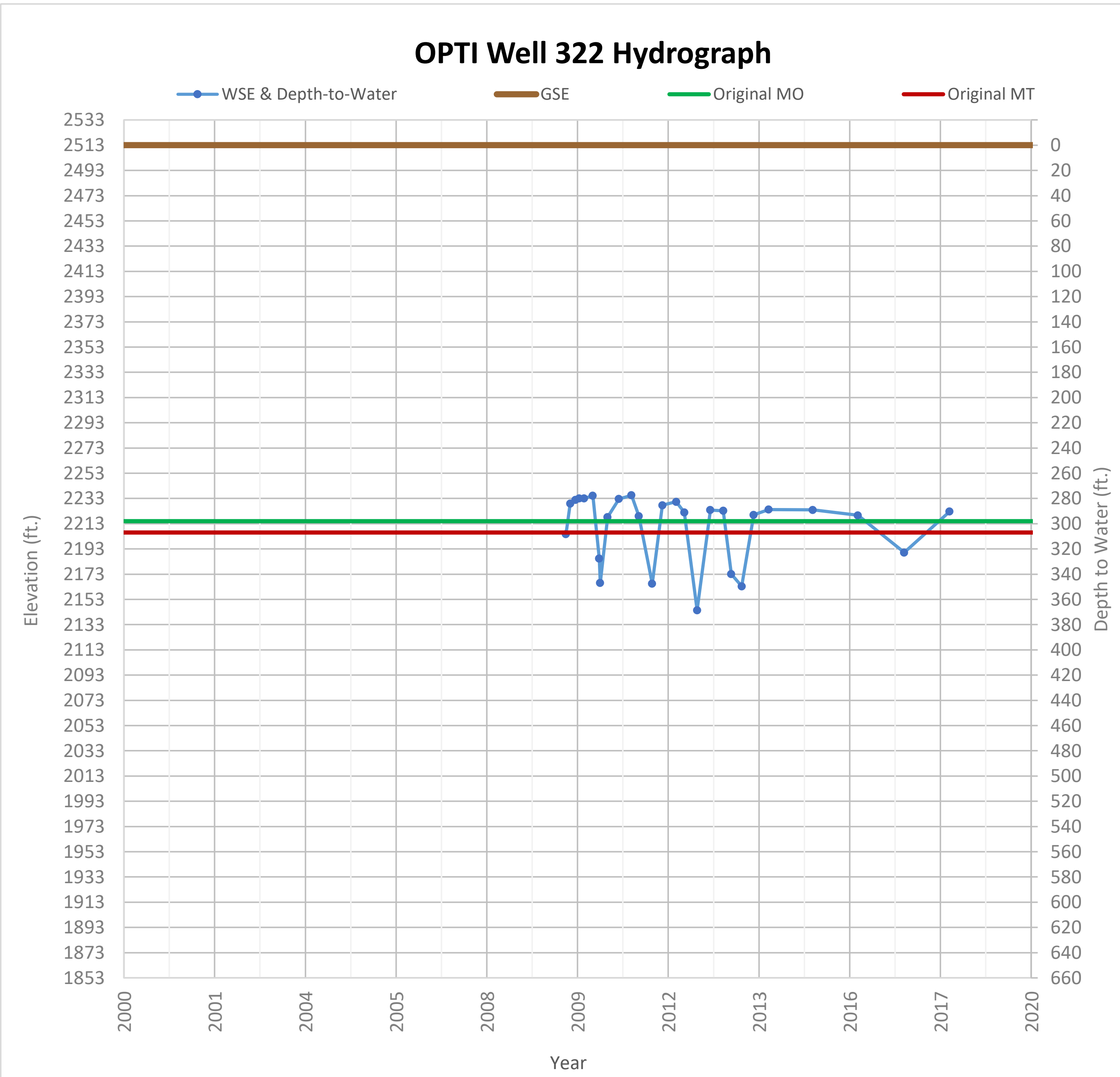

OPTI Well 125 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2303
2283
2263
2243
2223
2203
2183
2163
2143
2123
2103
2083
2063
2043
2023
2003
1983
1963
1943
1923
1903
1883
1863
1843
1823
1803
1783
1763
1743
1723
1703
1683
1663
1643
1623
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020


OPTI Well 127 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
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
1764
1744
1724
1704
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

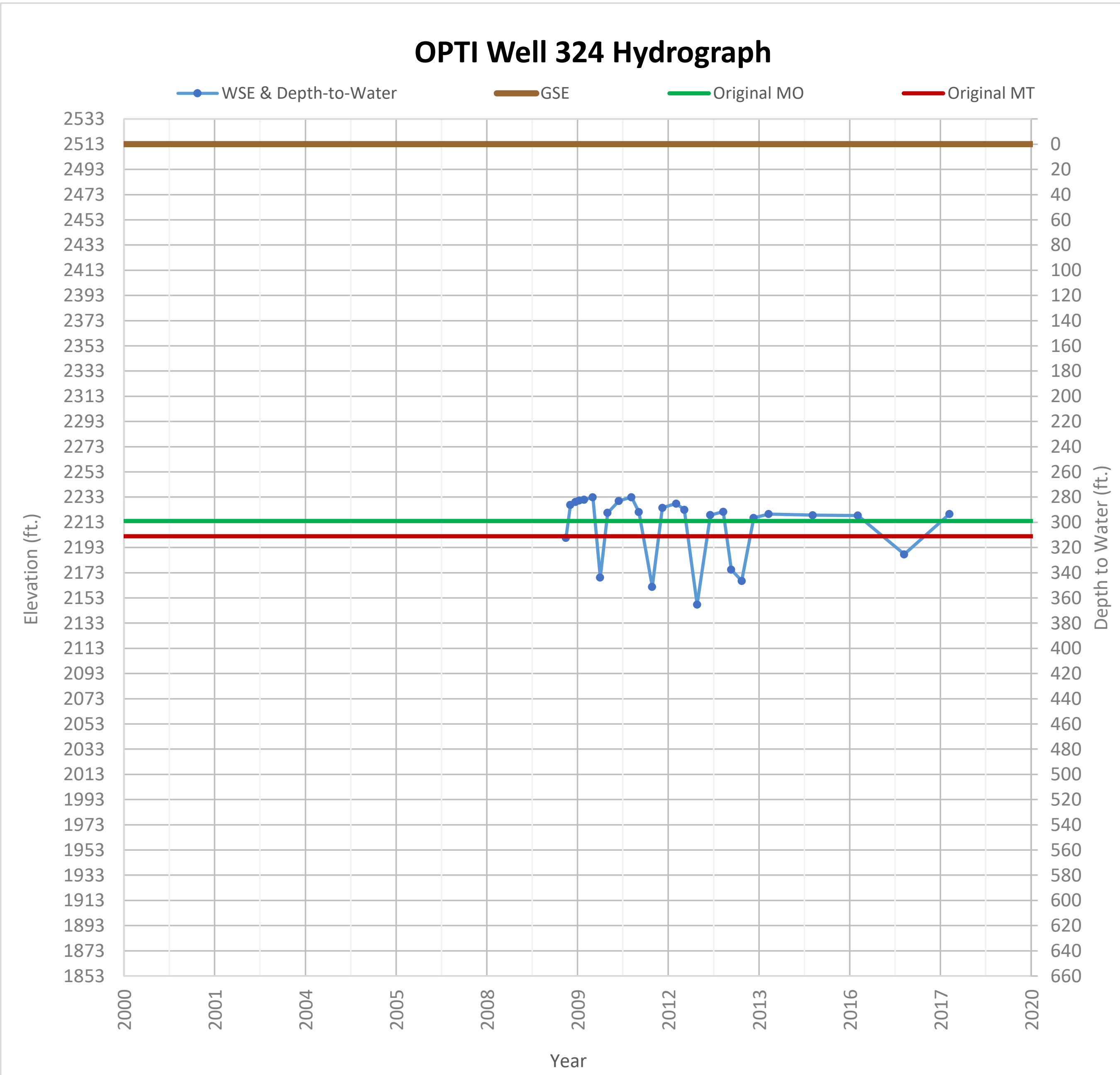

OPTI Well 128 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
3741
3721
3701
3681
3661
3641
3621
3601
3581
3561
3541
3521
3501
3481
3461
3441
3421
3401
3381
3361
3341
3321
3301
3281
3261
3241
3221
3201
3181
3161
3141
3121
3101
3081
3061
Elevation (ft.)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
Depth to Water (ft.)
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020
Year


OPTI Well 316 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
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
440
460
480
500
520
540
560
580
600
620
640
660
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

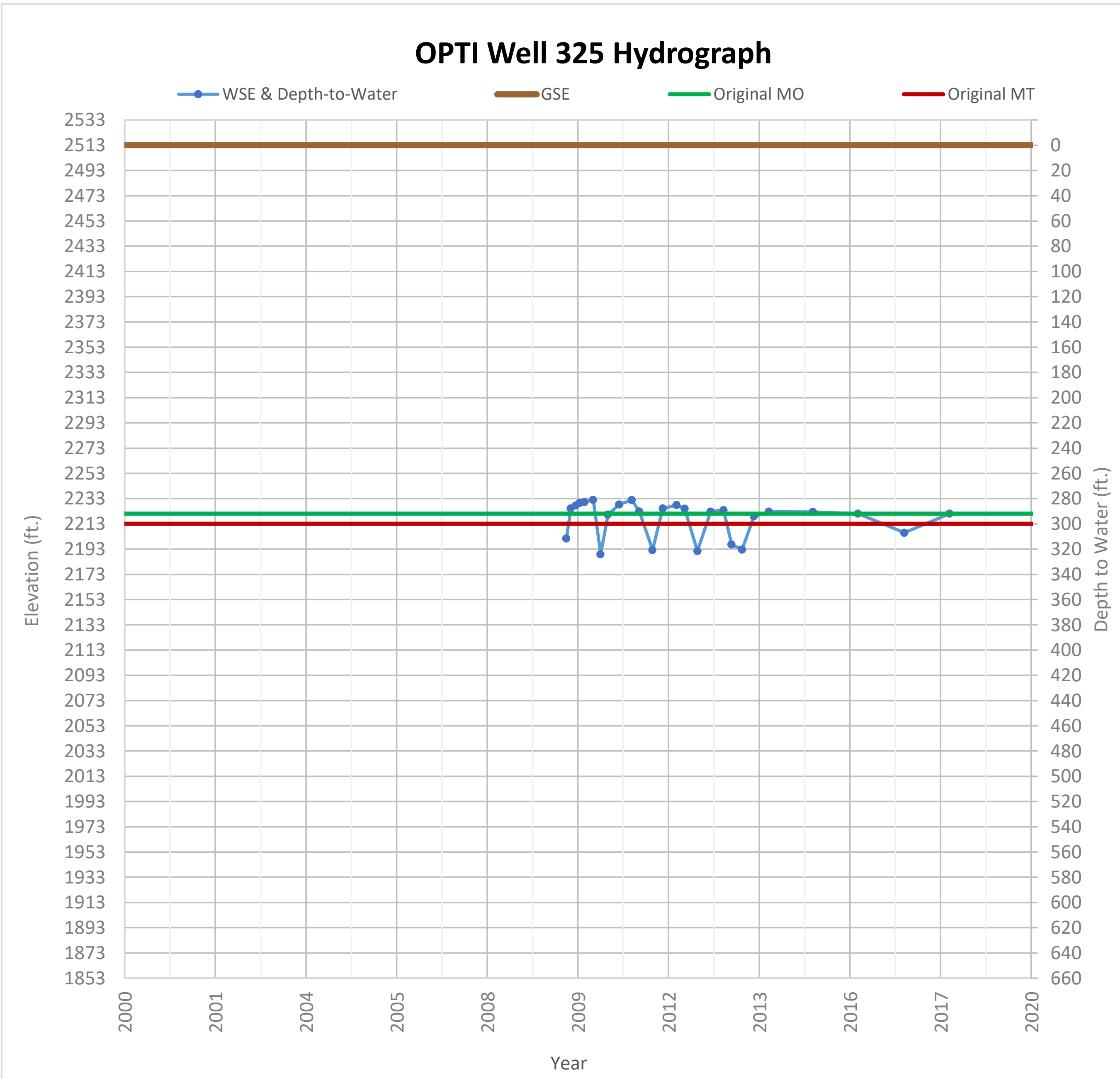

OPTI Well 317 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2494
2474
2454
2434
2414
2394
2374
2354
2334
2314
2294
2274
2254
2234
2214
2194
2174
2154
2134
2114
2094
2074
2054
2034
2014
1994
1974
1954
1934
1914
1894
1874
1854
1834
1814
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

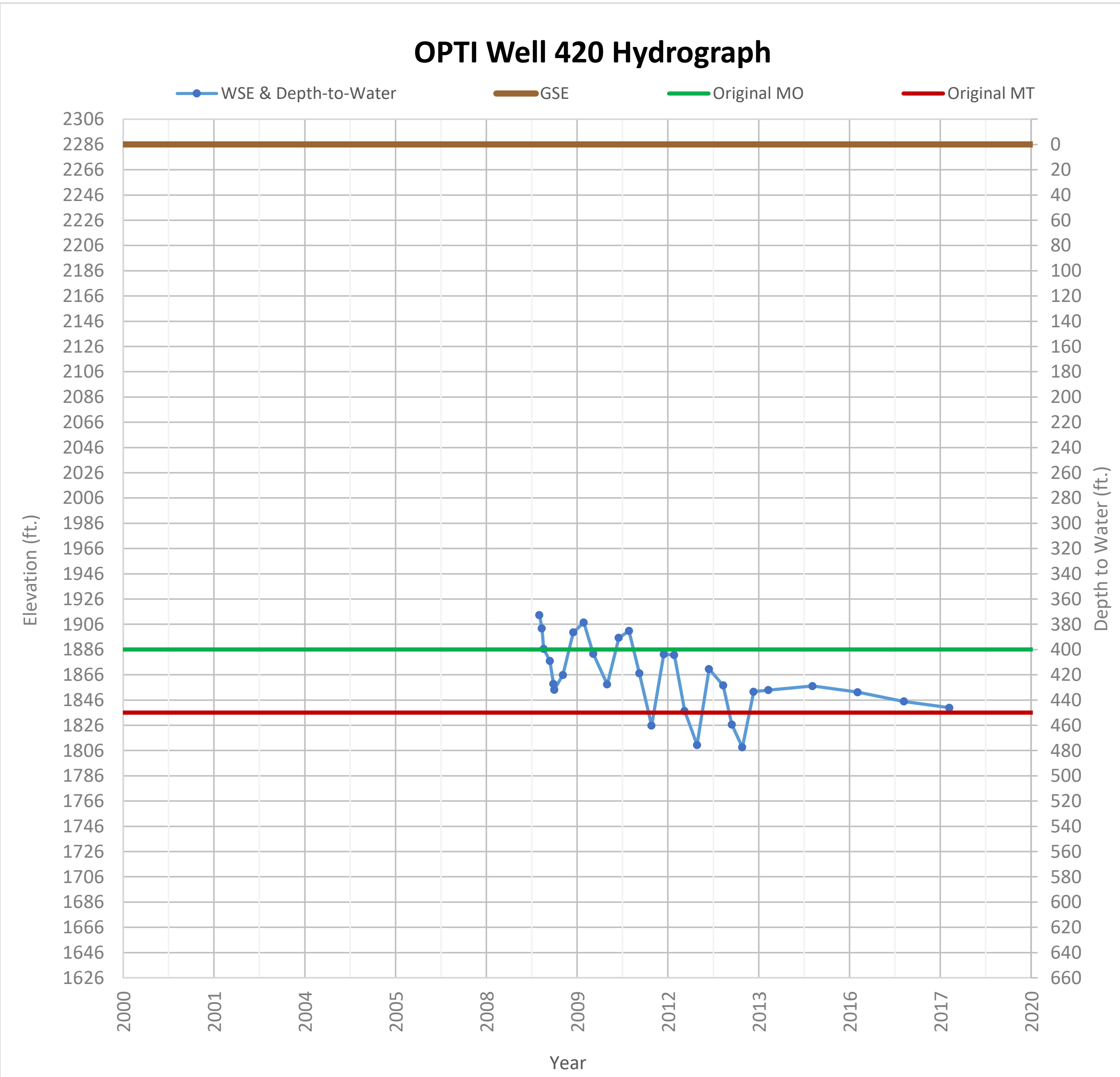


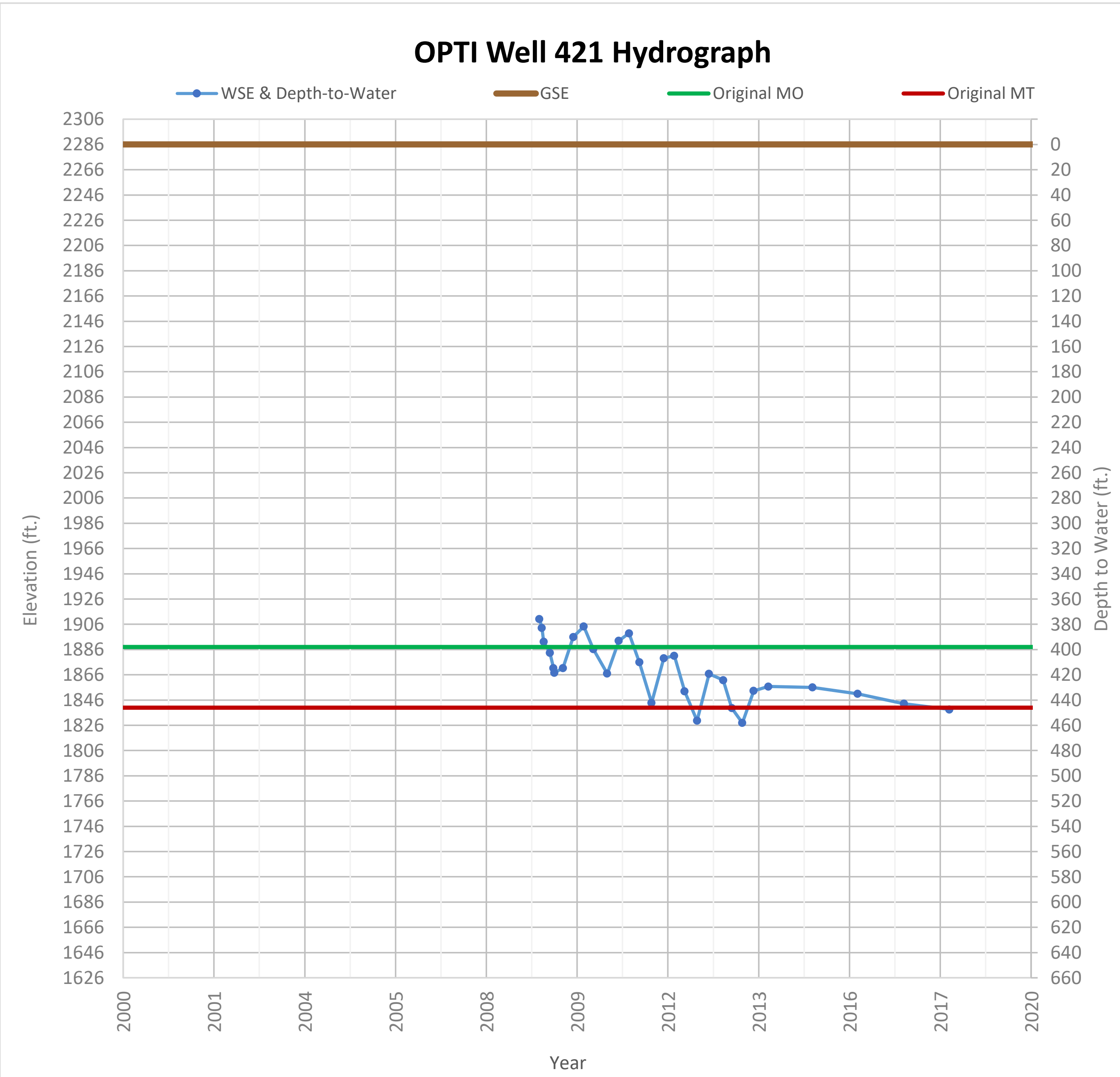
OPTI Well 322 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
2533
2513
2493
2473
2453
2433
2413
2393
2373
2353
2333
2313
2293
2273
2253
2233
2213
2193
2173
2153
2133
2113
2093
2073
2053
2033
2013
1993
1973
1953
1933
1913
1893
1873
1853
Depth to Water (ft.)
0
20
40
60
80
100
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020
Year

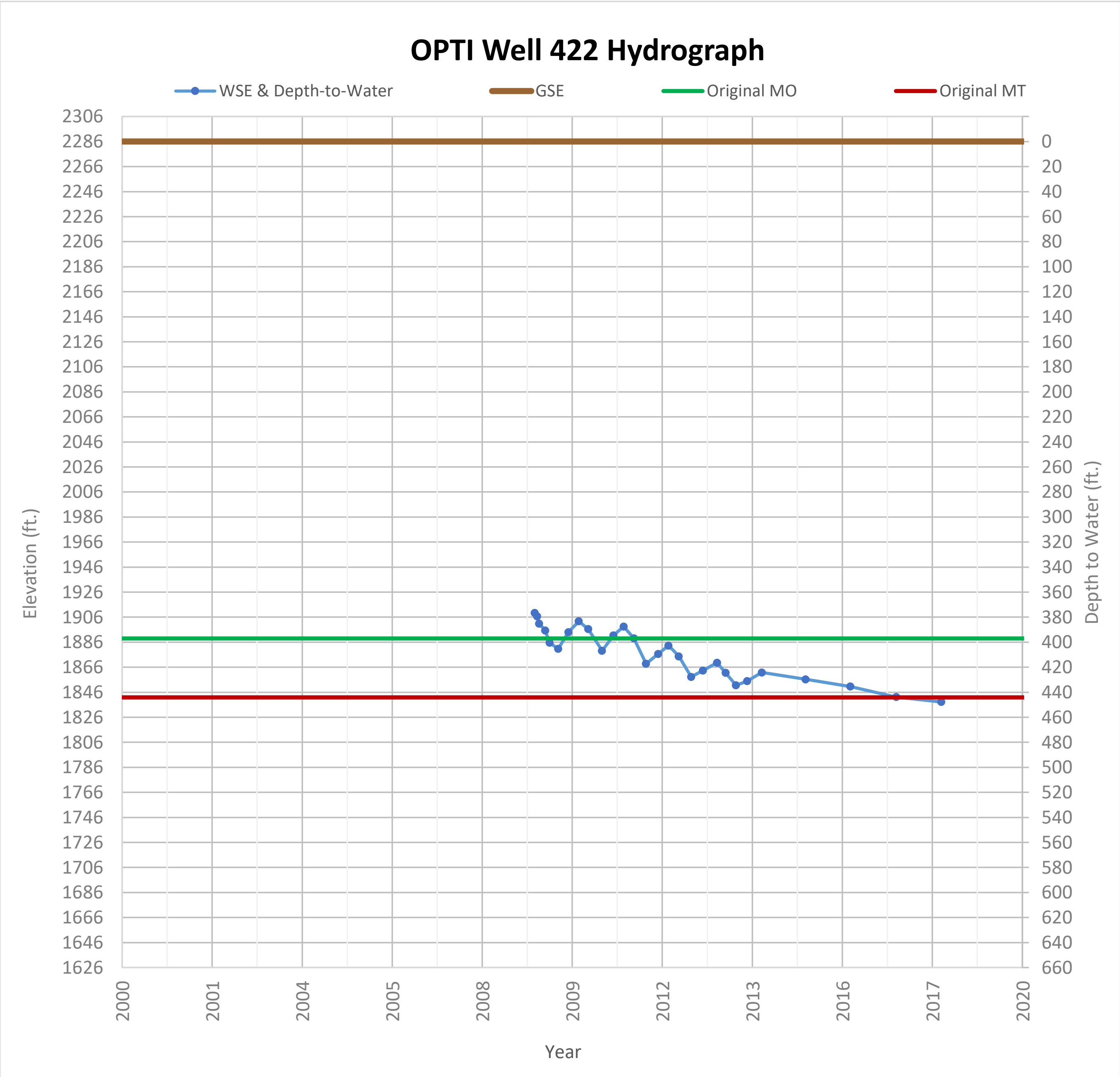


OPTI Well 324 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2533
2513
2493
2473
2453
2433
2413
2393
2373
2353
2333
2313
2293
2273
2253
2233
2213
2193
2173
2153
2133
2113
2093
2073
2053
2033
2013
1993
1973
1953
1933
1913
1893
1873
1853
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

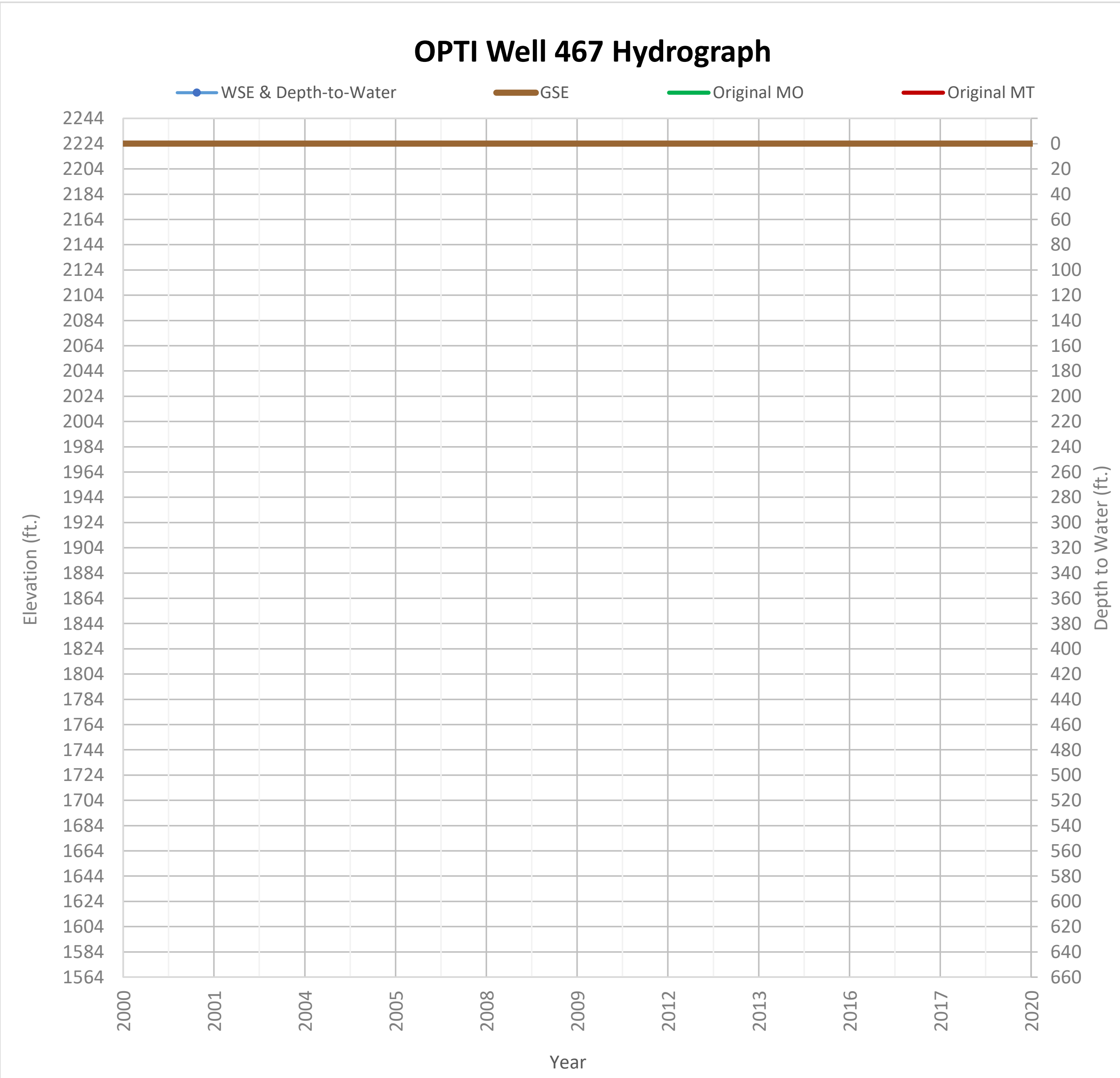

OPTI Well 325 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2533
2513
2493
2473
2453
2433
2413
2393
2373
2353
2333
2313
2293
2273
2253
2233
2213
2193
2173
2153
2133
2113
2093
2073
2053
2033
2013
1993
1973
1953
1933
1913
1893
1873
1853
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

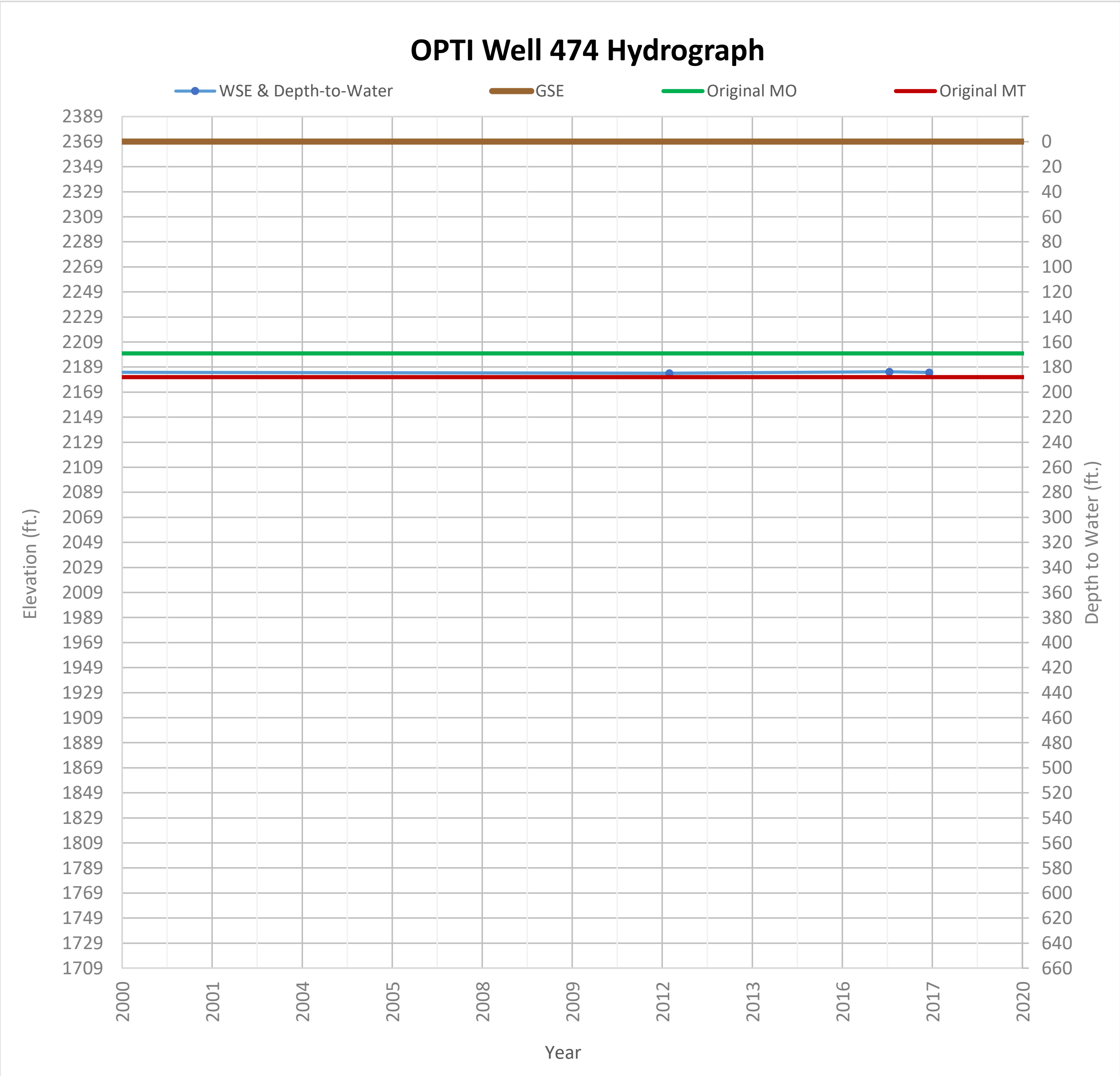

OPTI Well 420 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
2306
2286
2266
2246
2226
2206
2186
2166
2146
2126
2106
2086
2066
2046
2026
2006
1986
1966
1946
1926
1906
1886
1866
1846
1826
1806
1786
1766
1746
1726
1706
1686
1666
1646
1626
Depth to Water (ft.)
0
20
40
60
80
100
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020
Year


OPTI Well 421 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (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
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020
Year

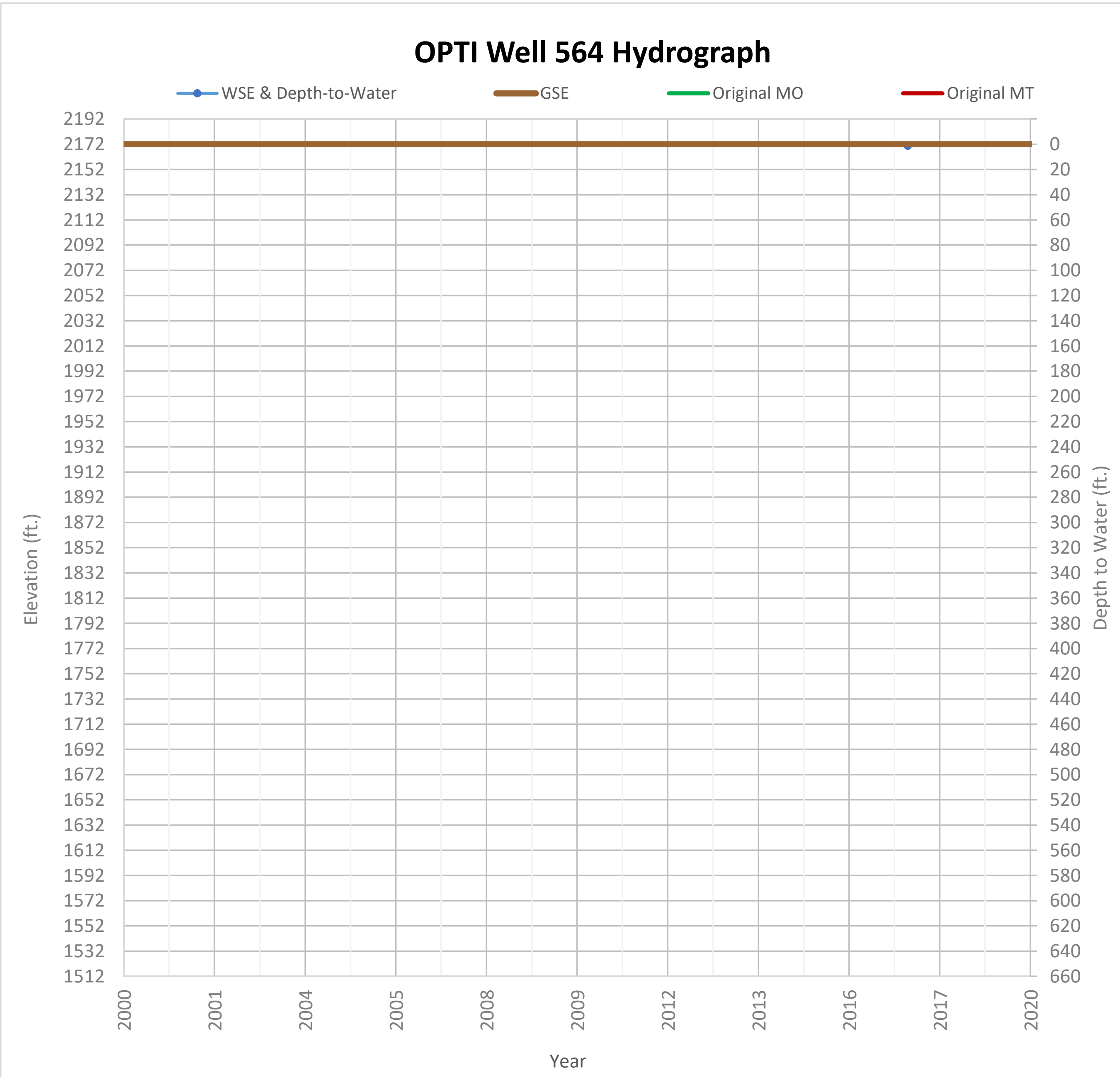


OPTI Well 422 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2306
2286
2266
2246
2226
2206
2186
2166
2146
2126
2106
2086
2066
2046
2026
2006
1986
1966
1946
1926
1906
1886
1866
1846
1826
1806
1786
1766
1746
1726
1706
1686
1666
1646
1626
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

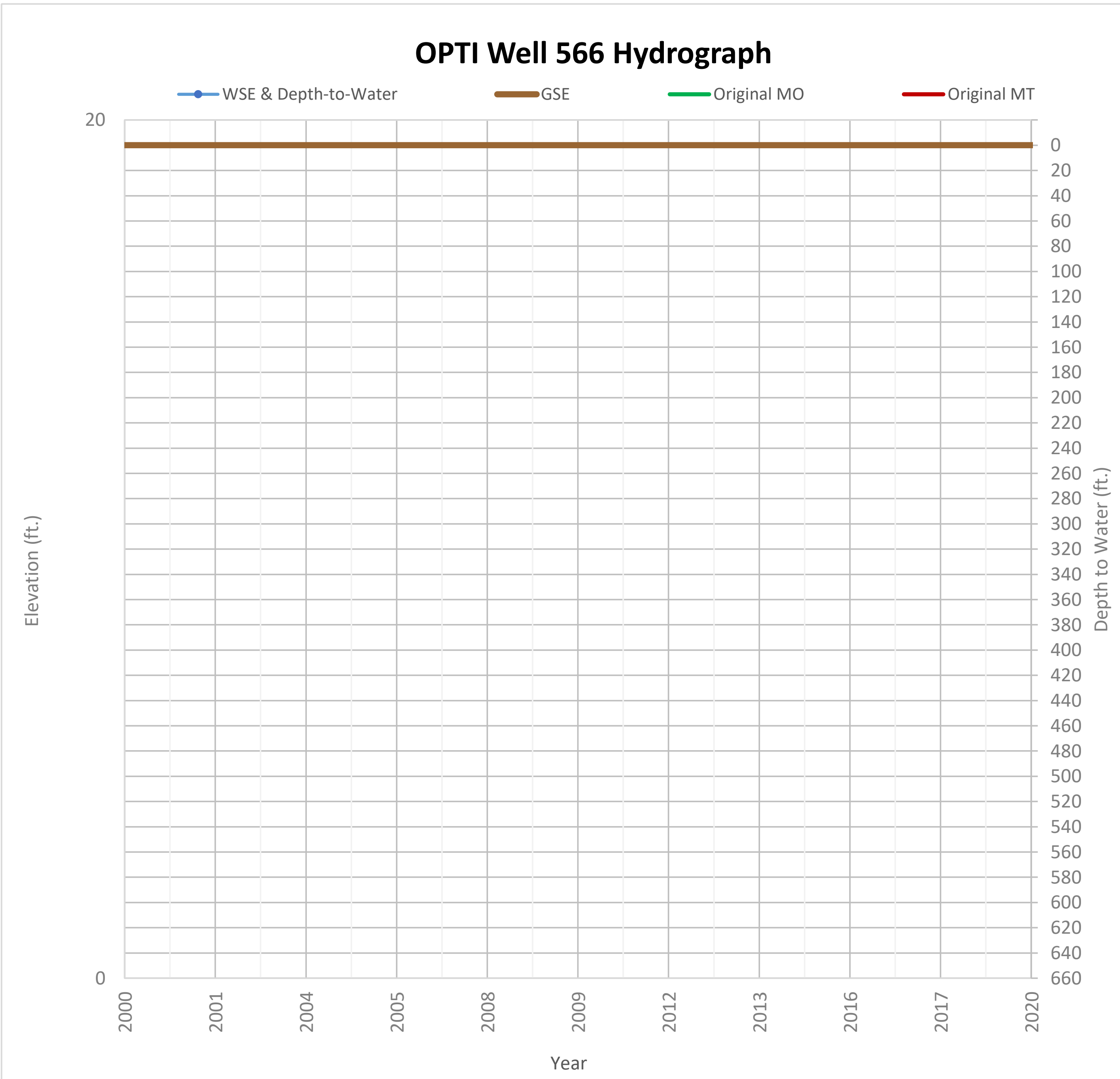

OPTI Well 467 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2244
2224
2204
2184
2164
2144
2124
2104
2084
2064
2044
2024
2004
1984
1964
1944
1924
1904
1884
1864
1844
1824
1804
1784
1764
1744
1724
1704
1684
1664
1644
1624
1604
1584
1564
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

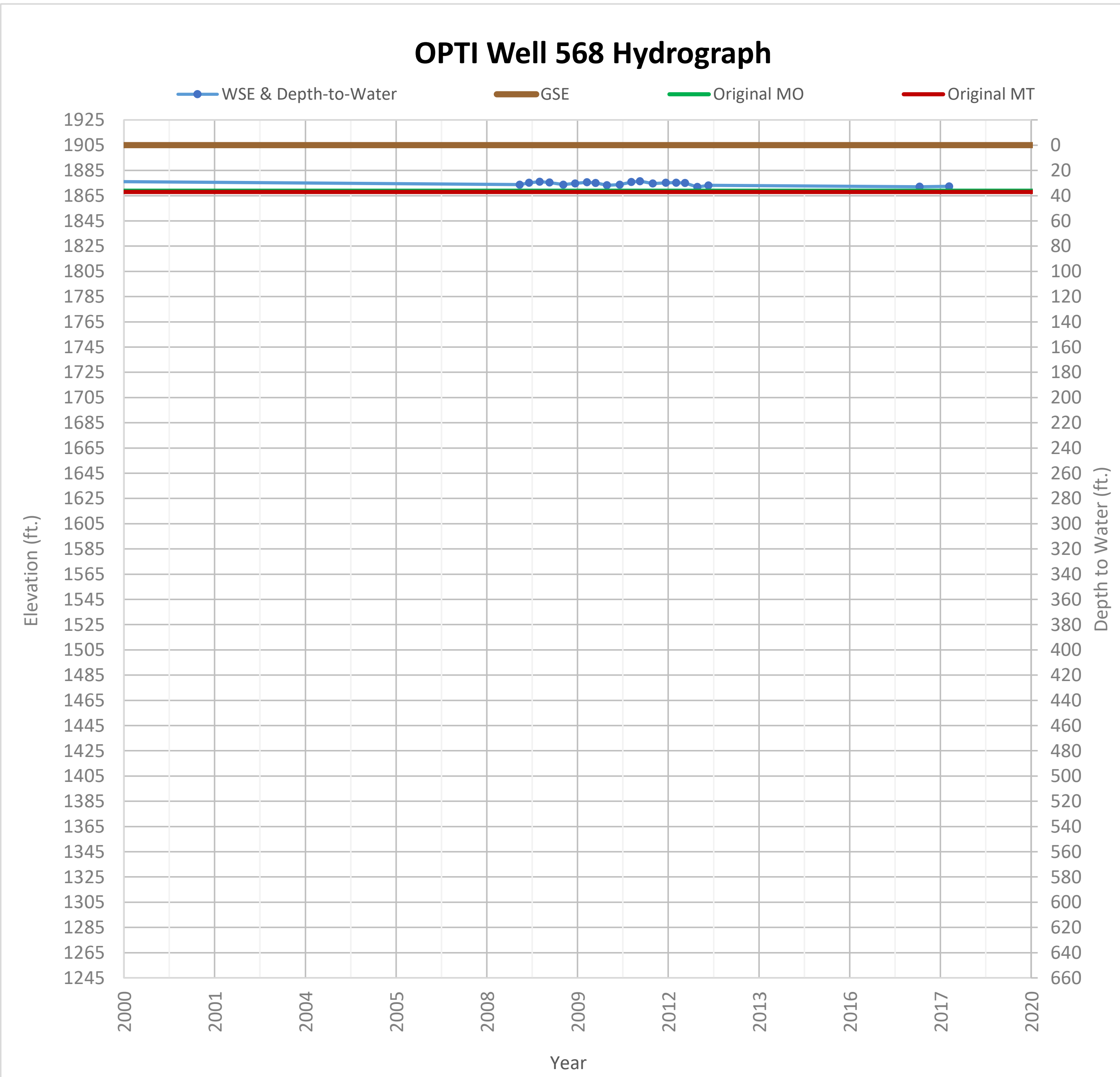


OPTI Well 474 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2389
2369
2349
2329
2309
2289
2269
2249
2229
2209
2189
2169
2149
2129
2109
2089
2069
2049
2029
2009
1989
1969
1949
1929
1909
1889
1869
1849
1829
1809
1789
1769
1749
1729
1709
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

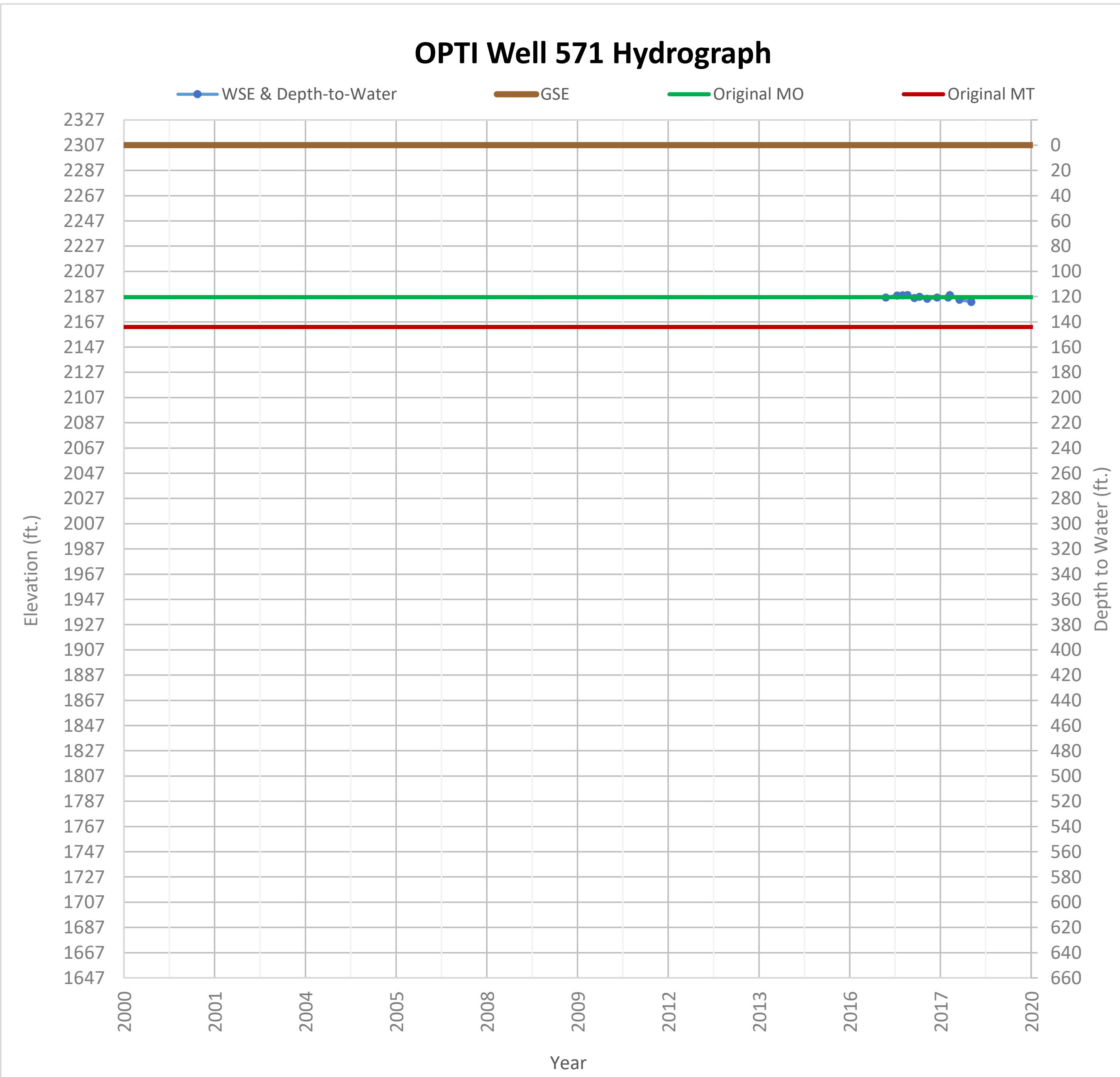


OPTI Well 564 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
2192
2172
2152
2132
2112
2092
2072
2052
2032
2012
1992
1972
1952
1932
1912
1892
1872
1852
1832
1812
1792
1772
1752
1732
1712
1692
1672
1652
1632
1612
1592
1572
1552
1532
1512
Depth to Water (ft.)
0
20
40
60
80
100
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020
Year

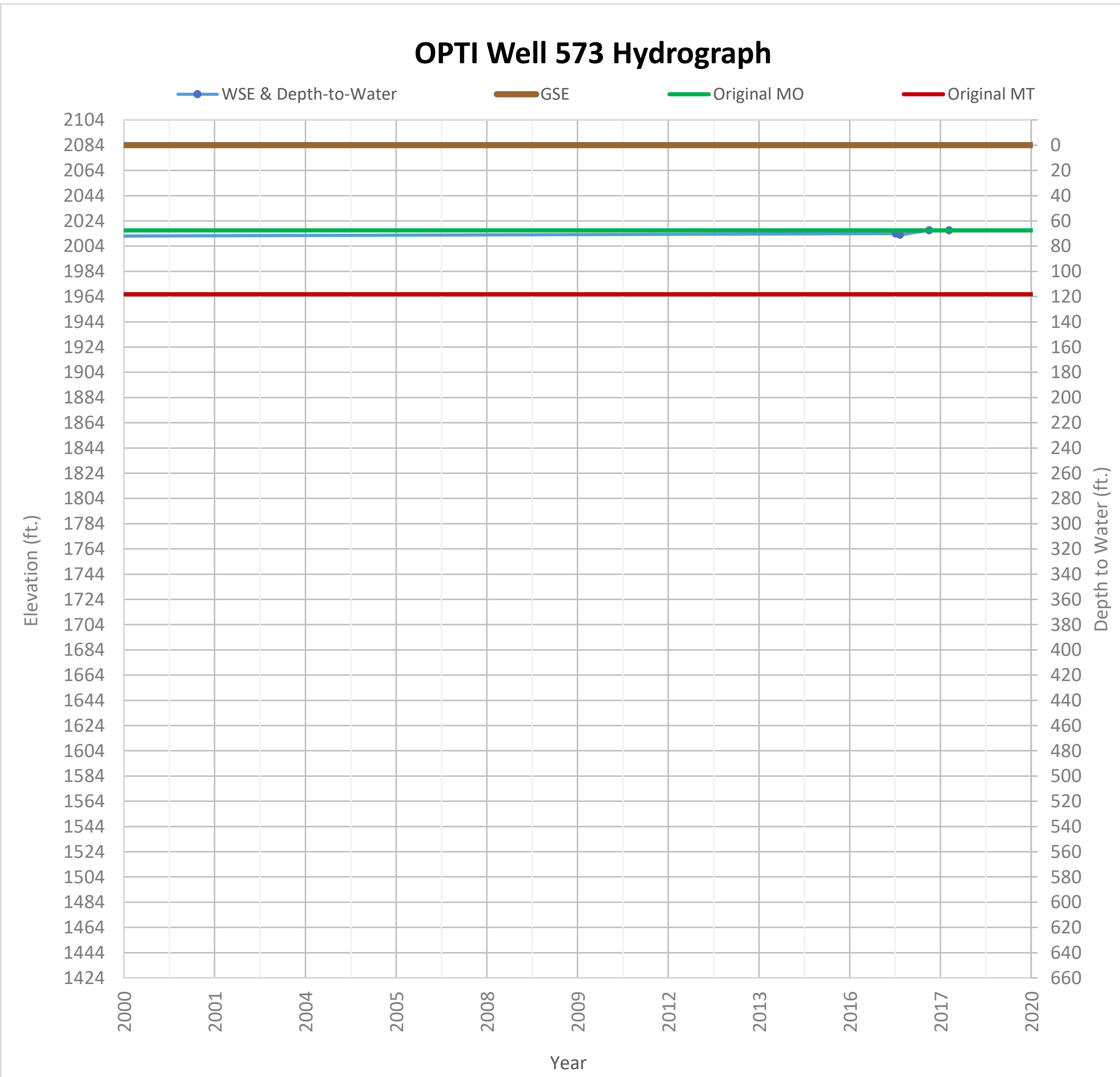

OPTI Well 566 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
20
0
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

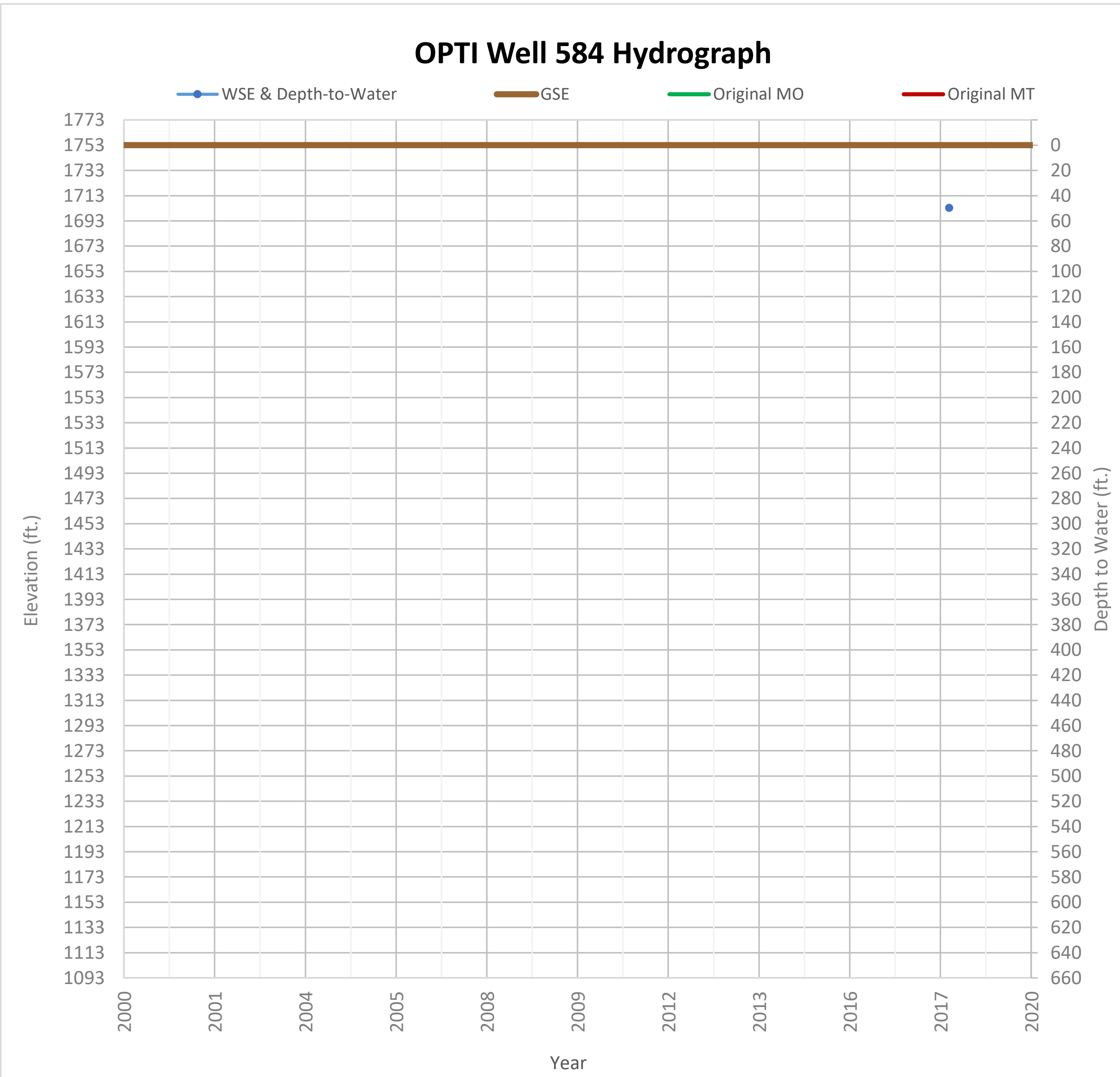


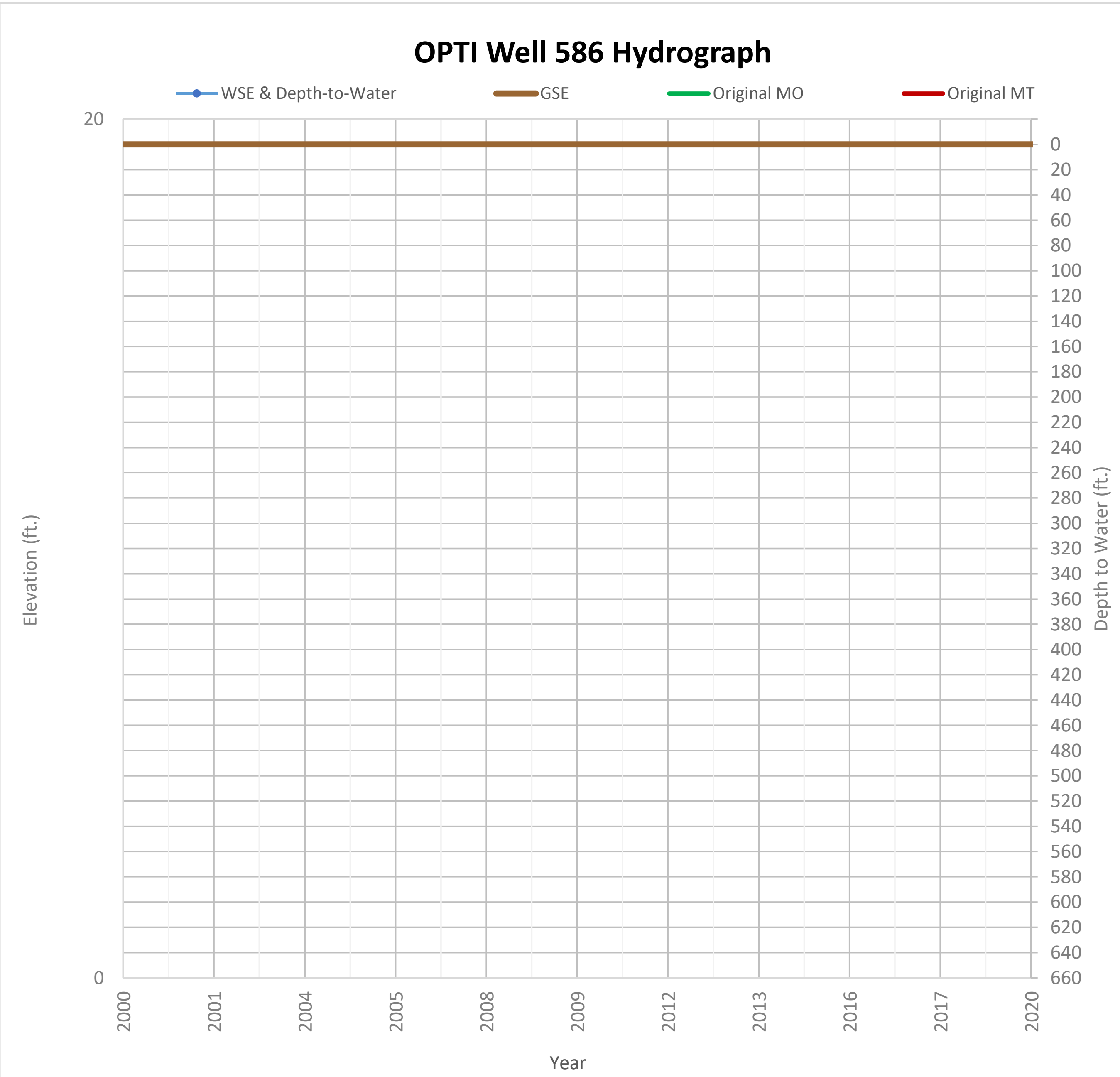
OPTI Well 568 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
1925
1905
1885
1865
1845
1825
1805
1785
1765
1745
1725
1705
1685
1665
1645
1625
1605
1585
1565
1545
1525
1505
1485
1465
1445
1425
1405
1385
1365
1345
1325
1305
1285
1265
1245
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

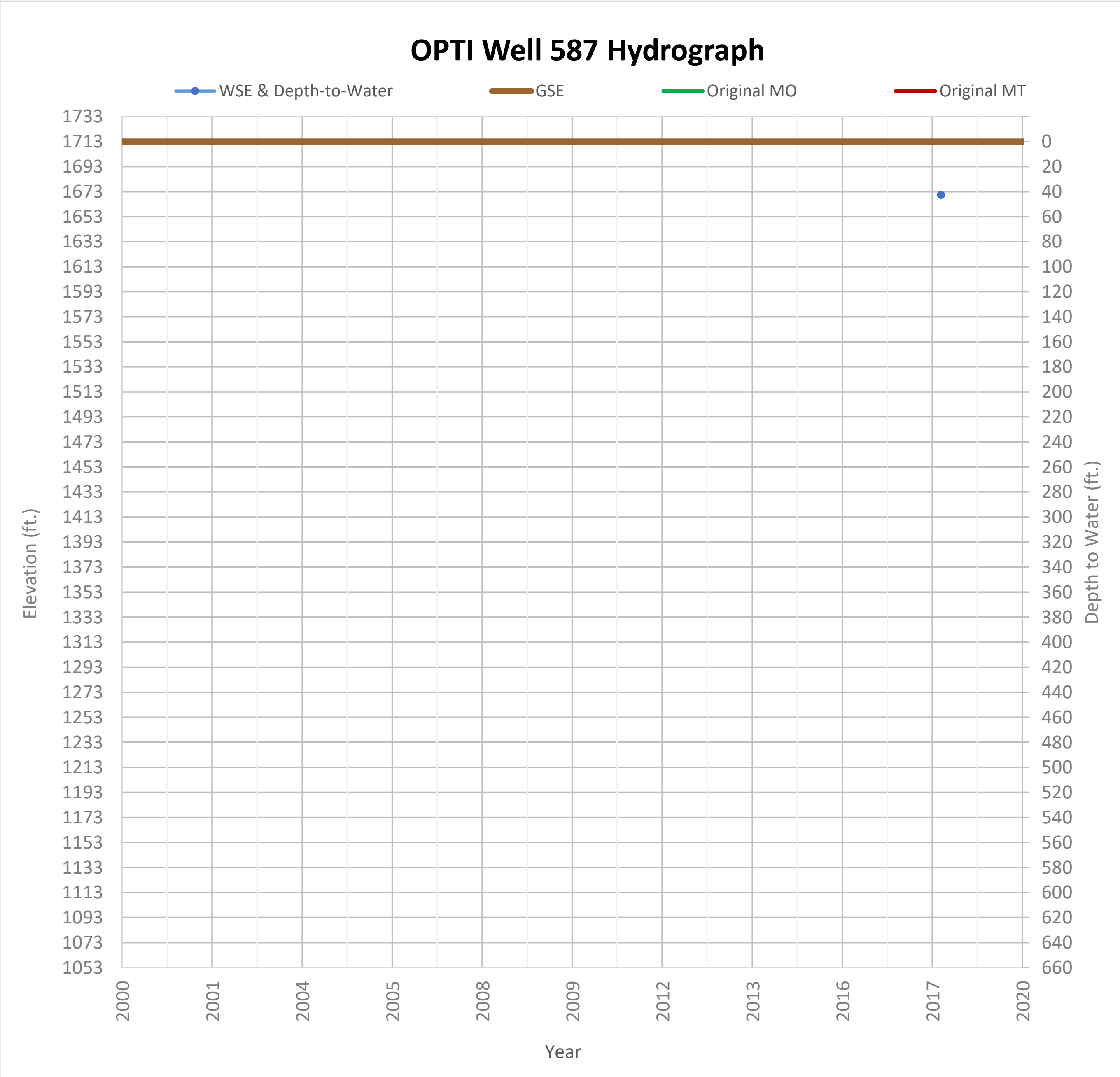


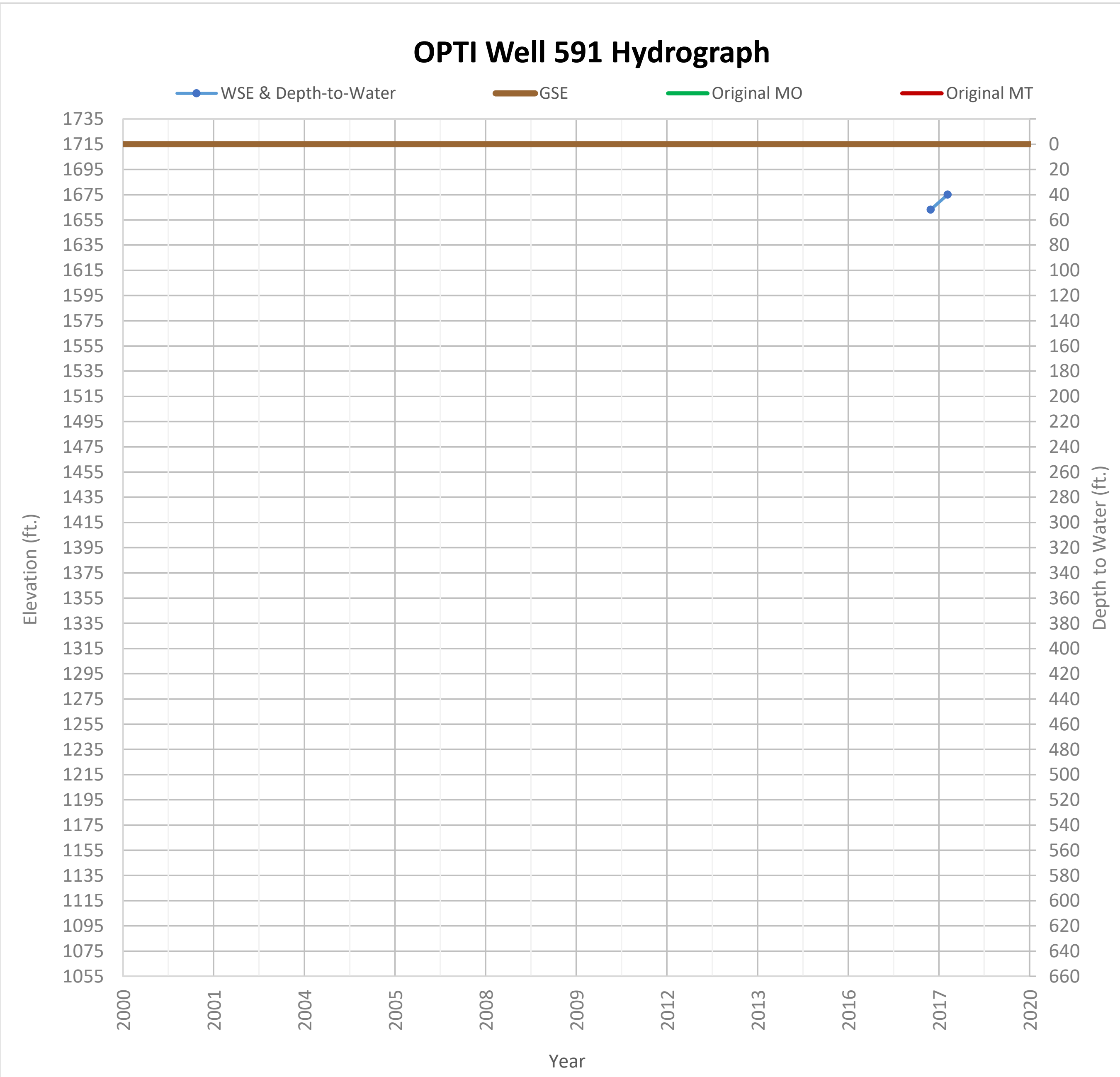
OPTI Well 571 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2327
2307
2287
2267
2247
2227
2207
2187
2167
2147
2127
2107
2087
2067
2047
2027
2007
1987
1967
1947
1927
1907
1887
1867
1847
1827
1807
1787
1767
1747
1727
1707
1687
1667
1647
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

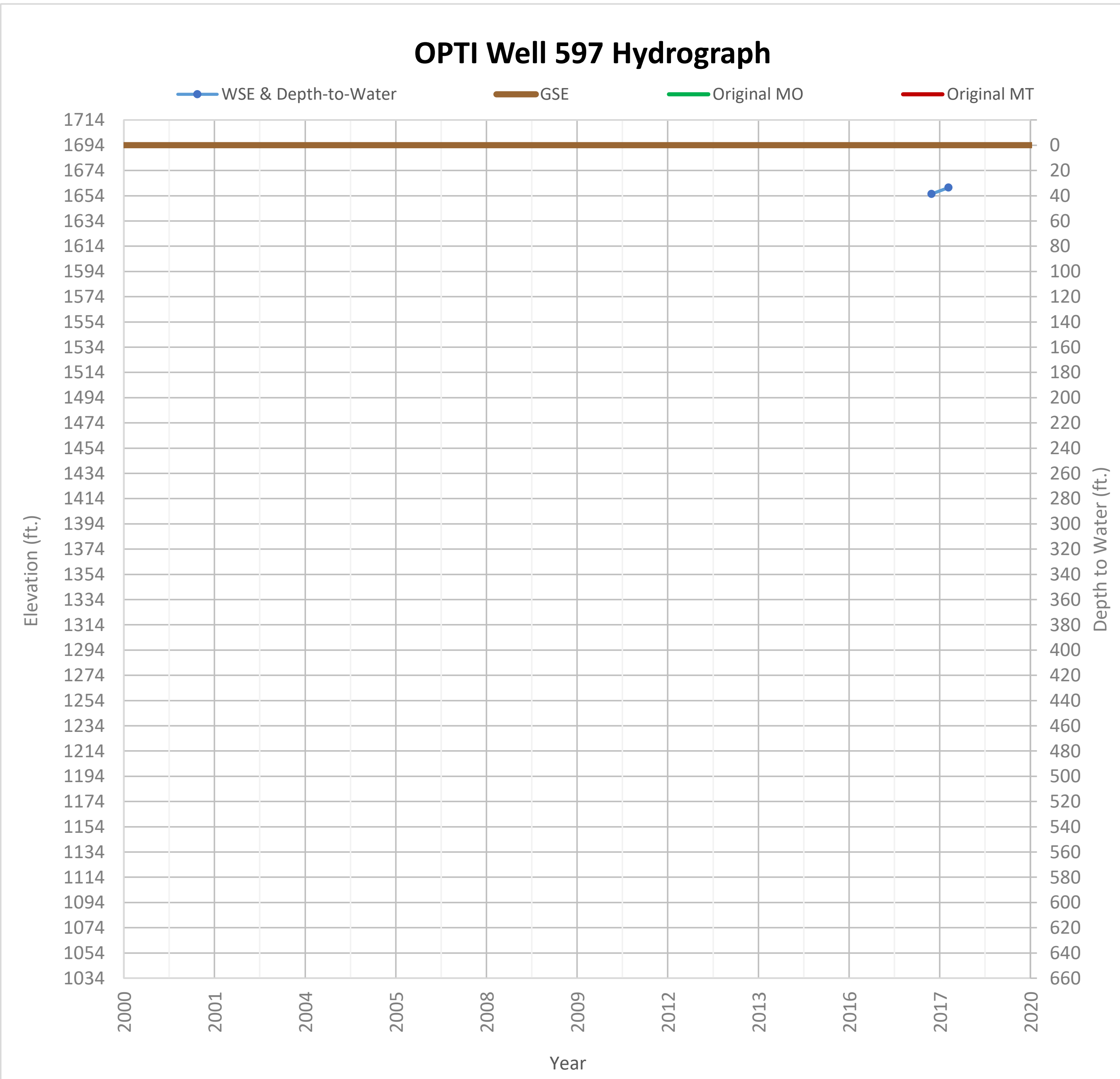

OPTI Well 573 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2104
2084
2064
2044
2024
2004
1984
1964
1944
1924
1904
1884
1864
1844
1824
1804
1784
1764
1744
1724
1704
1684
1664
1644
1624
1604
1584
1564
1544
1524
1504
1484
1464
1444
1424
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

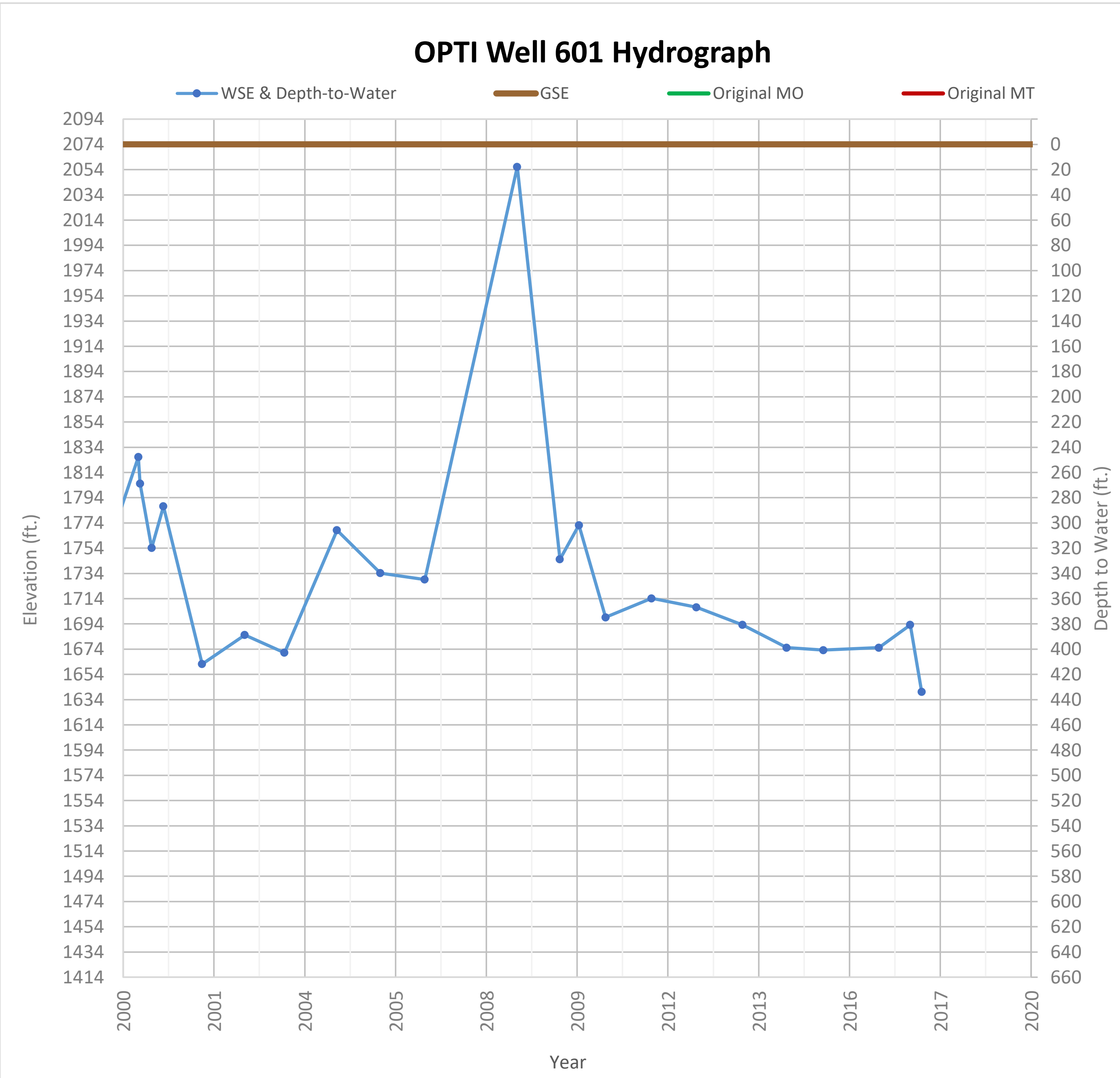

OPTI Well 584 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
1773
1753
1733
1713
1693
1673
1653
1633
1613
1593
1573
1553
1533
1513
1493
1473
1453
1433
1413
1393
1373
1353
1333
1313
1293
1273
1253
1233
1213
1193
1173
1153
1133
1113
1093
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

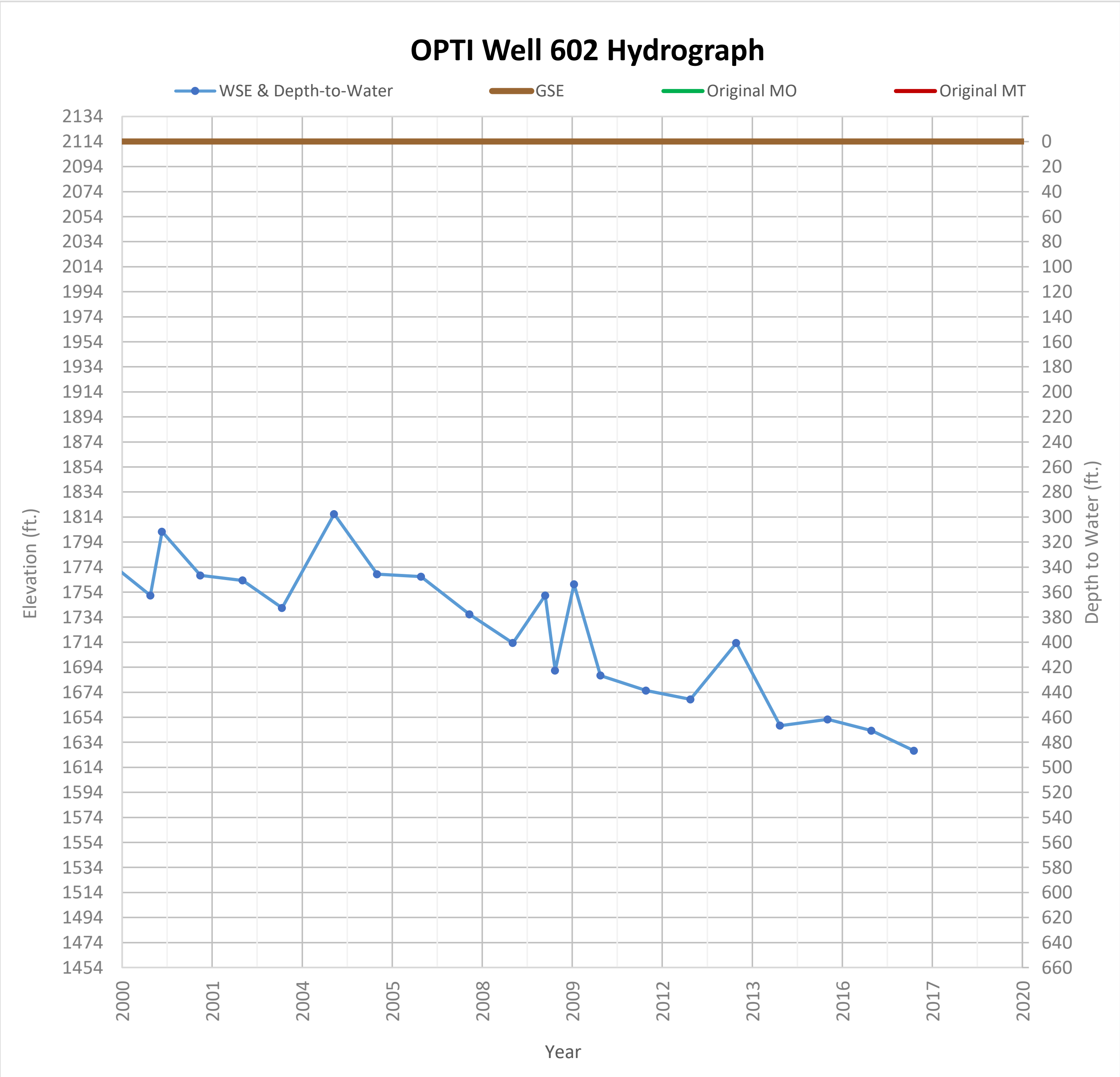

OPTI Well 586 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
20
0
Elevation (ft.)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
Depth to Water (ft.)
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020
Year


OPTI Well 587 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
1733
1713
1693
1673
1653
1633
1613
1593
1573
1553
1533
1513
1493
1473
1453
1433
1413
1393
1373
1353
1333
1313
1293
1273
1253
1233
1213
1193
1173
1153
1133
1113
1093
1073
1053
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

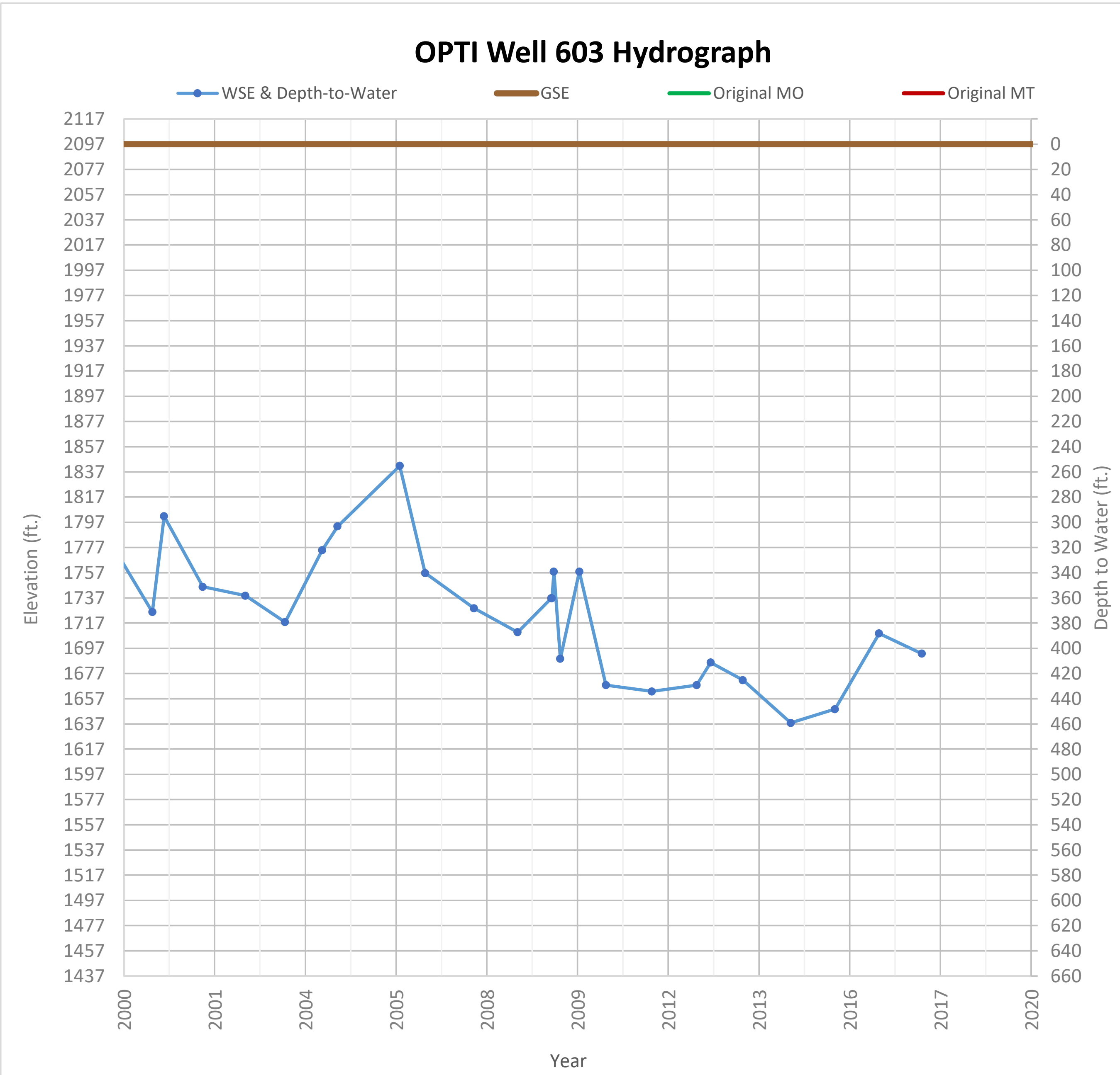

OPTI Well 591 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
1735
1715
1695
1675
1655
1635
1615
1595
1575
1555
1535
1515
1495
1475
1455
1435
1415
1395
1375
1355
1335
1315
1295
1275
1255
1235
1215
1195
1175
1155
1135
1115
1095
1075
1055
Depth to Water (ft.)
0
20
40
60
80
100
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020
Year


OPTI Well 597 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
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
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

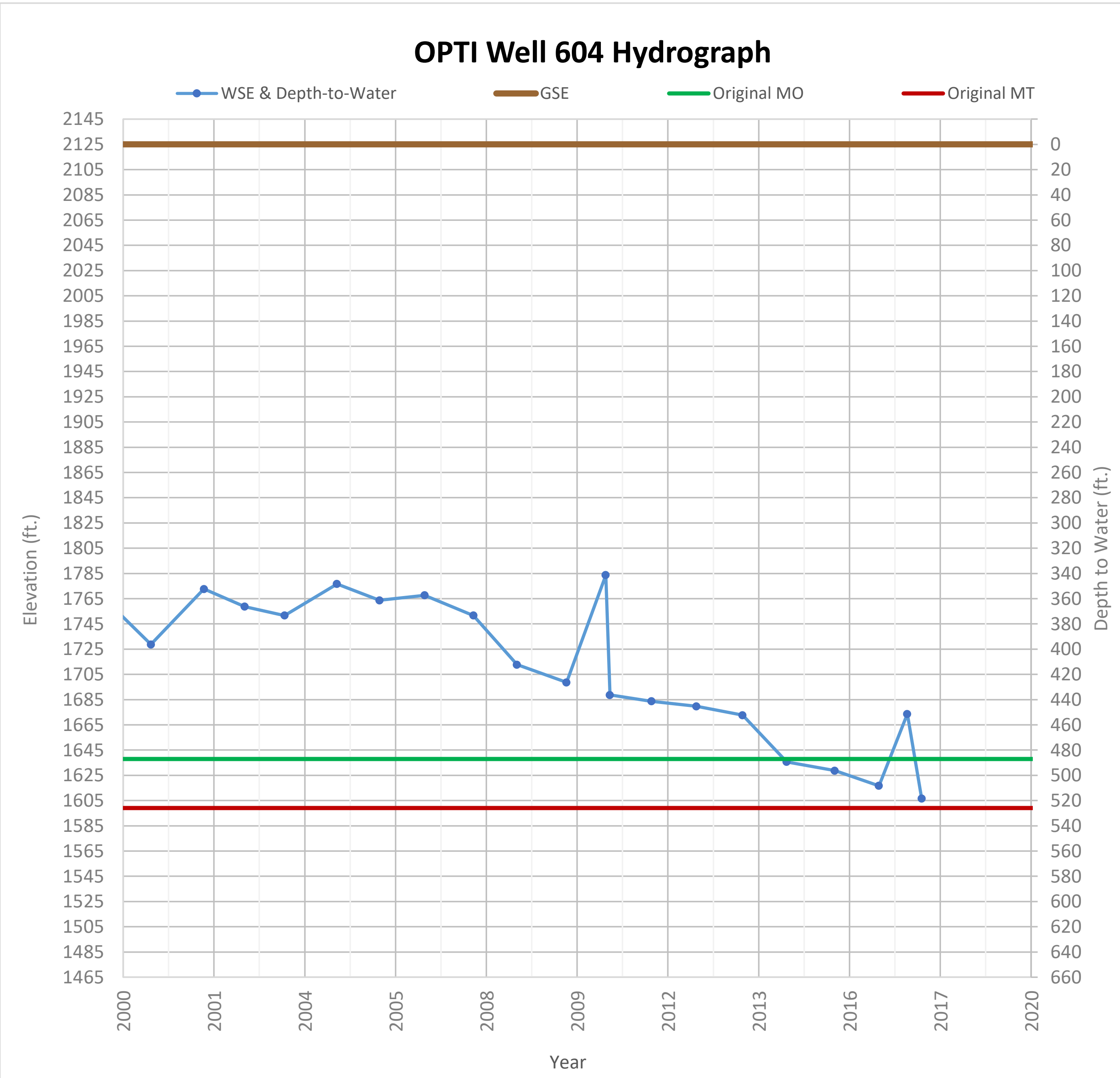

OPTI Well 601 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2094
2074
2054
2034
2014
1994
1974
1954
1934
1914
1894
1874
1854
1834
1814
1794
1774
1754
1734
1714
1694
1674
1654
1634
1614
1594
1574
1554
1534
1514
1494
1474
1454
1434
1414
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020



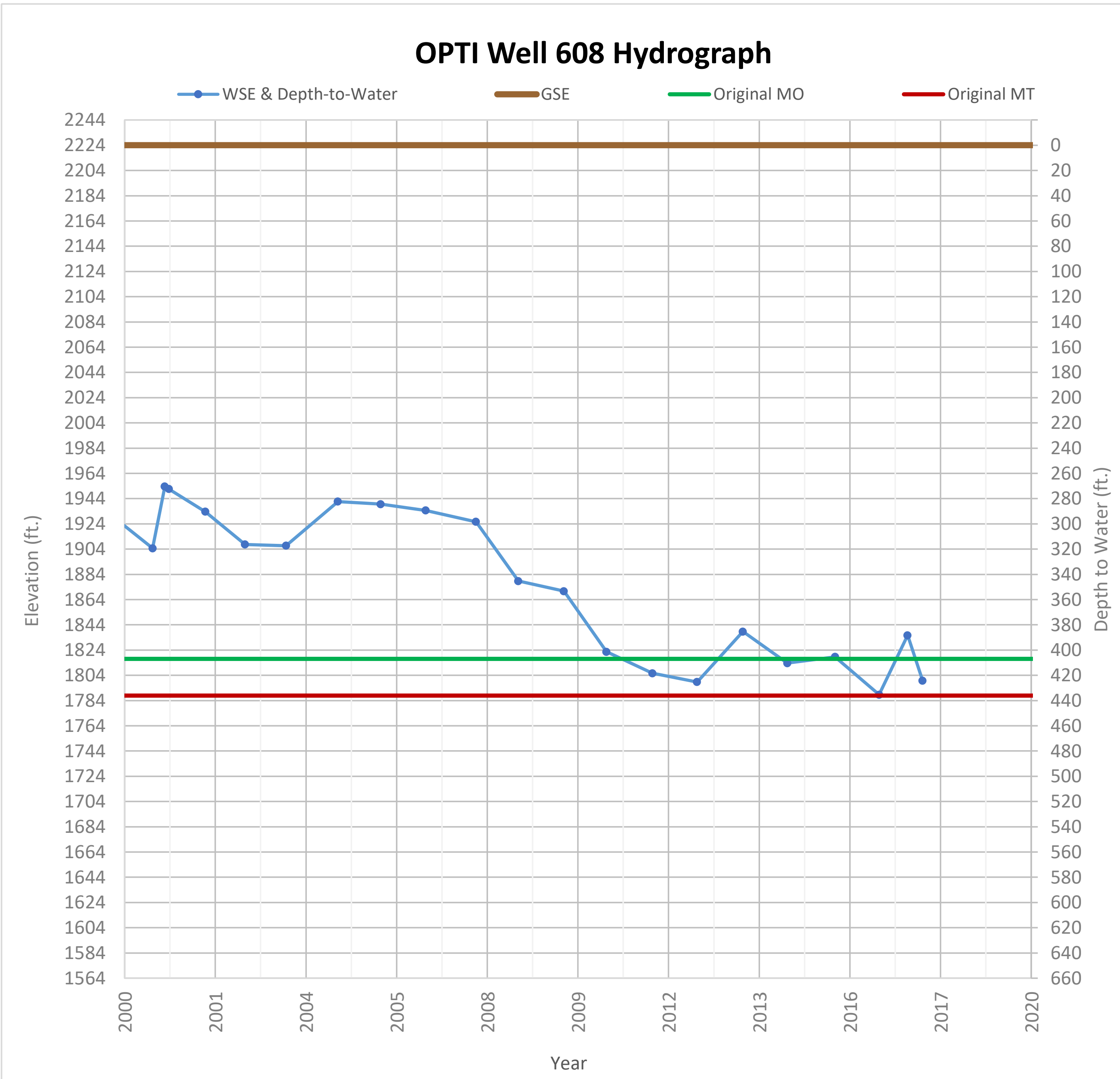
OPTI Well 602 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2134
2114
2094
2074
2054
2034
2014
1994
1974
1954
1934
1914
1894
1874
1854
1834
1814
1794
1774
1754
1734
1714
1694
1674
1654
1634
1614
1594
1574
1554
1534
1514
1494
1474
1454
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020



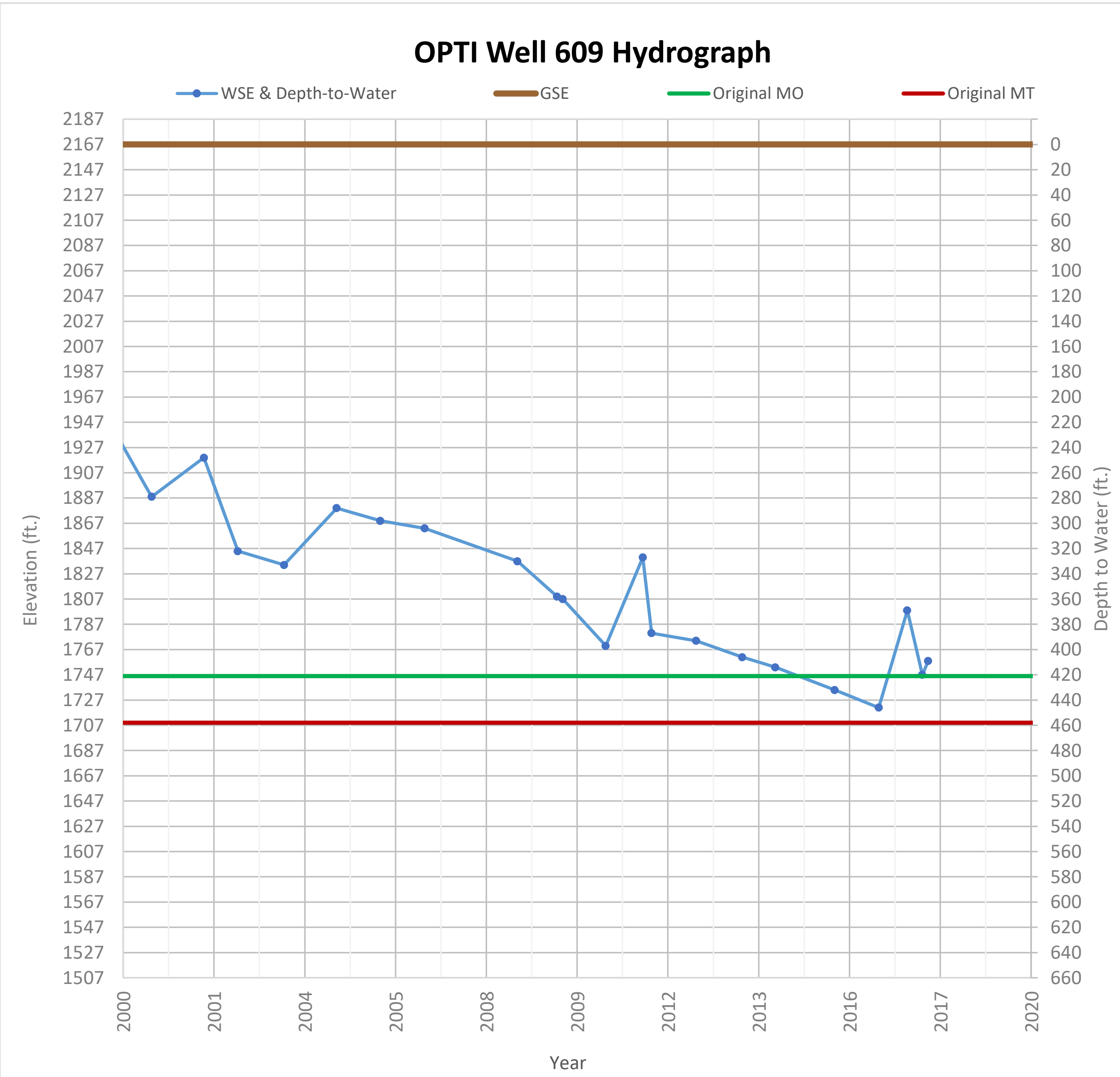
OPTI Well 603 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2117
2097
2077
2057
2037
2017
1997
1977
1957
1937
1917
1897
1877
1857
1837
1817
1797
1777
1757
1737
1717
1697
1677
1657
1637
1617
1597
1577
1557
1537
1517
1497
1477
1457
1437
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020



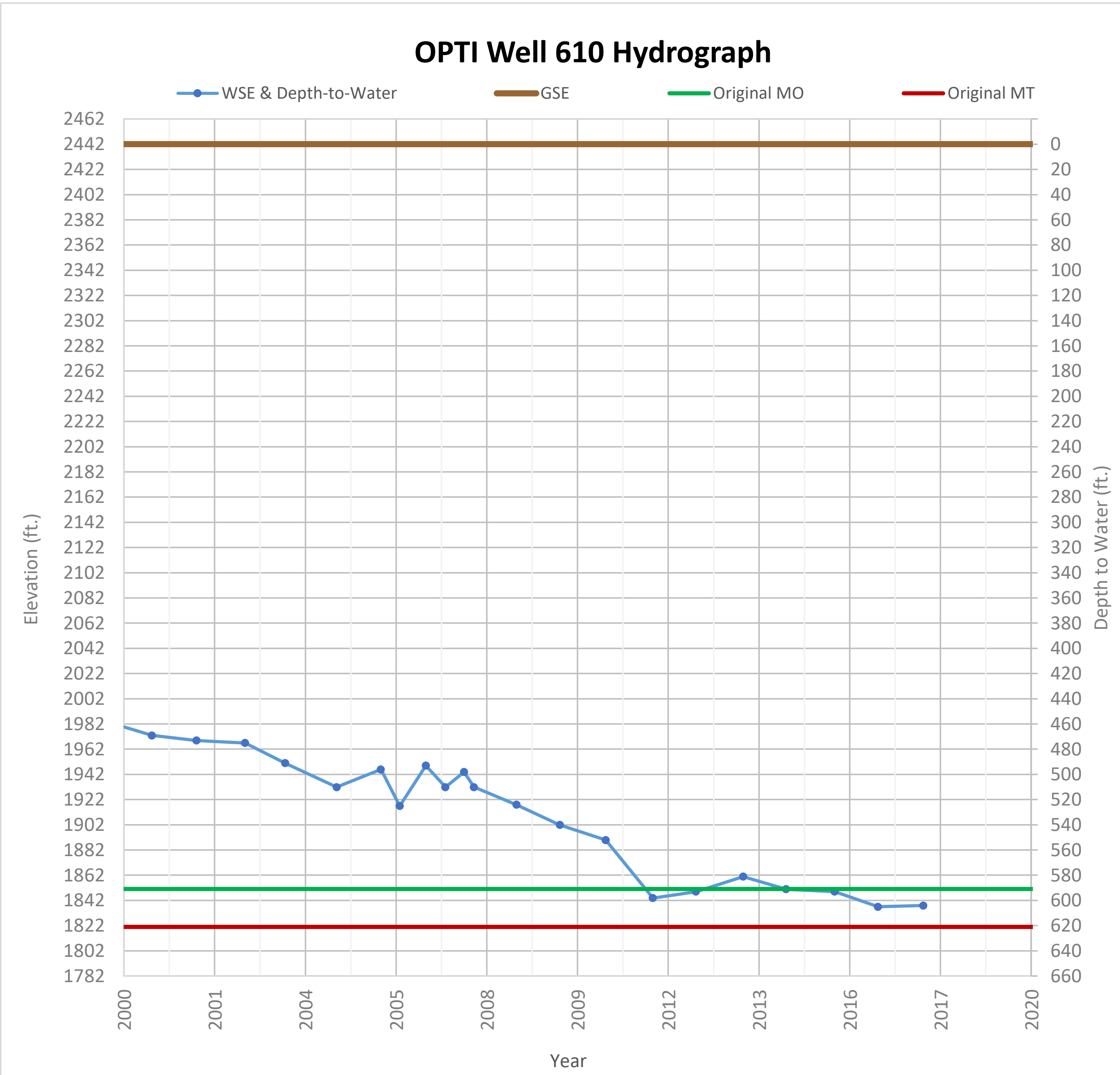
OPTI Well 604 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2145
2125
2105
2085
2065
2045
2025
2005
1985
1965
1945
1925
1905
1885
1865
1845
1825
1805
1785
1765
1745
1725
1705
1685
1665
1645
1625
1605
1585
1565
1545
1525
1505
1485
1465
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020



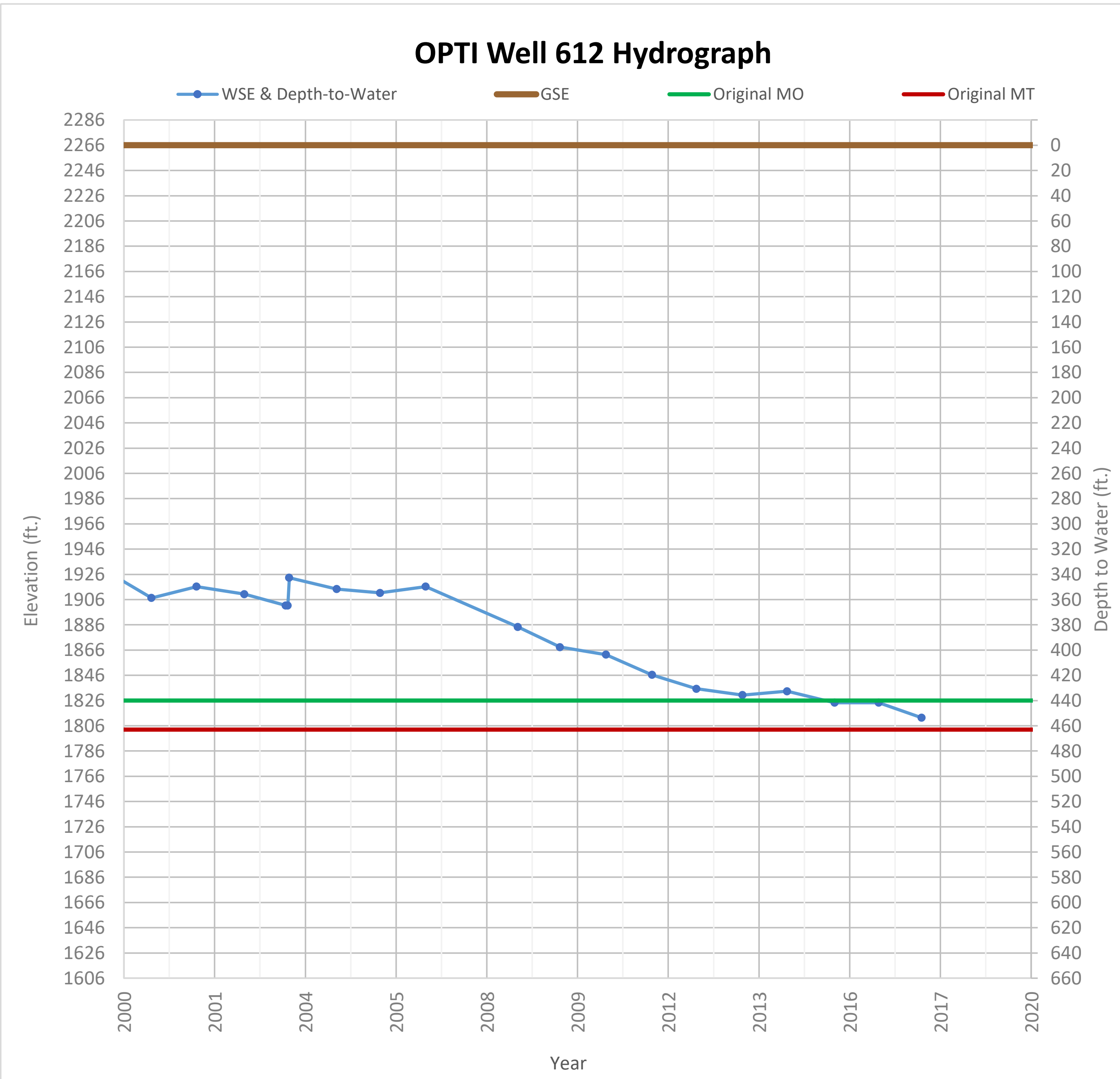
OPTI Well 608 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2244
2224
2204
2184
2164
2144
2124
2104
2084
2064
2044
2024
2004
1984
1964
1944
1924
1904
1884
1864
1844
1824
1804
1784
1764
1744
1724
1704
1684
1664
1644
1624
1604
1584
1564
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020



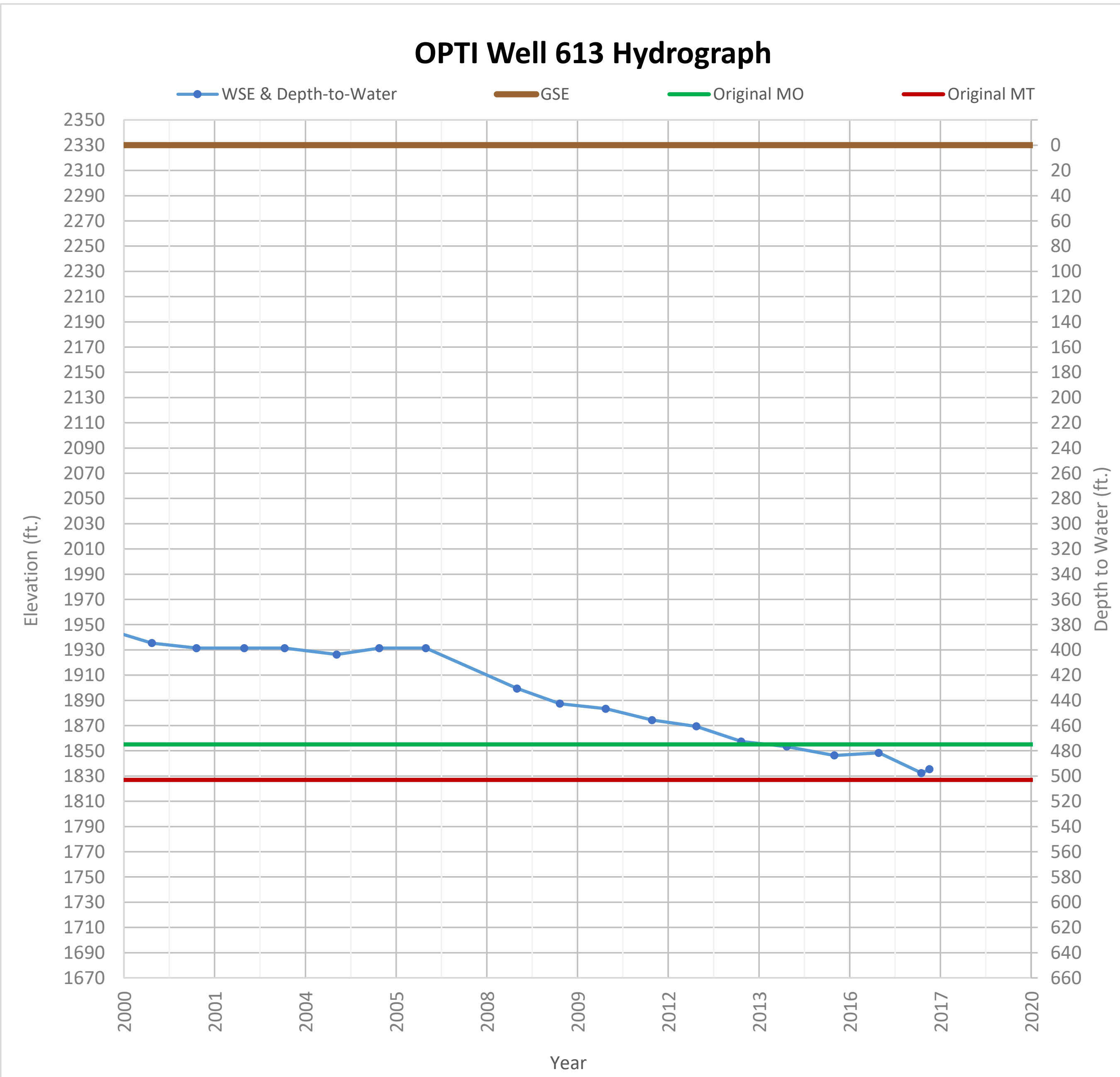
OPTI Well 609 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2187
2167
2147
2127
2107
2087
2067
2047
2027
2007
1987
1967
1947
1927
1907
1887
1867
1847
1827
1807
1787
1767
1747
1727
1707
1687
1667
1647
1627
1607
1587
1567
1547
1527
1507
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

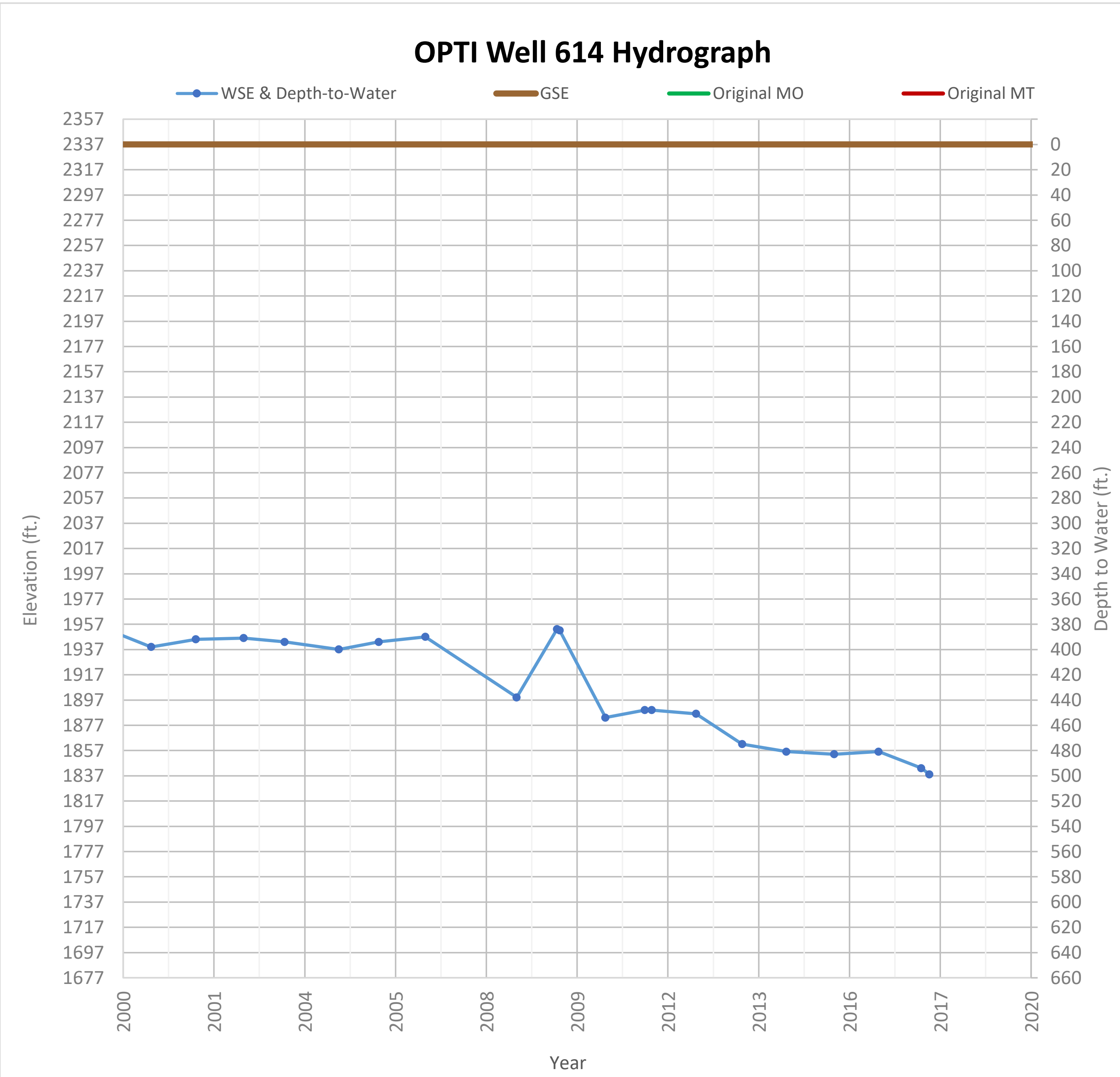


OPTI Well 610 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2462
2442
2422
2402
2382
2362
2342
2322
2302
2282
2262
2242
2222
2202
2182
2162
2142
2122
2102
2082
2062
2042
2022
2002
1982
1962
1942
1922
1902
1882
1862
1842
1822
1802
1782
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

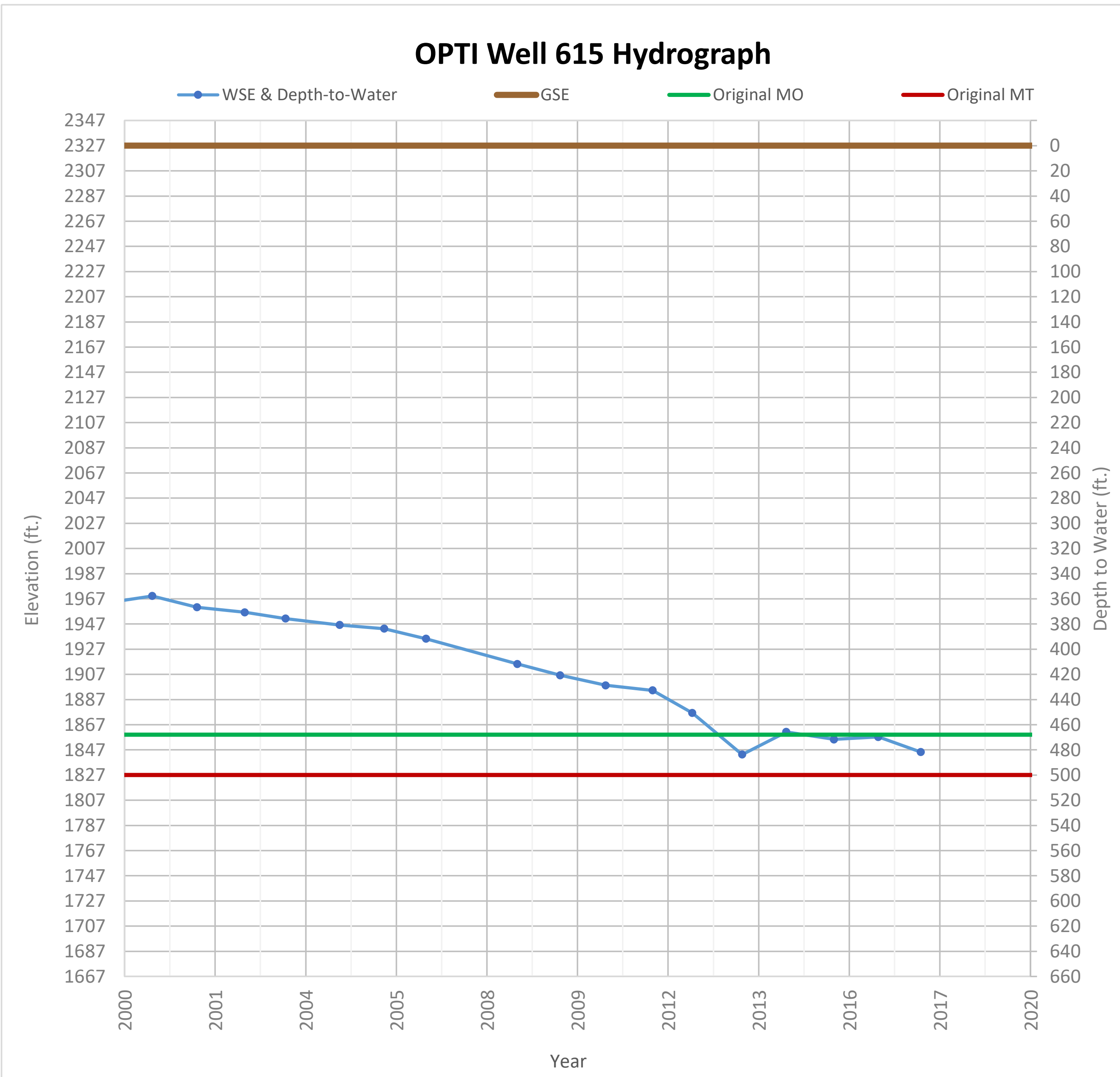


OPTI Well 612 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2286
2266
2246
2226
2206
2186
2166
2146
2126
2106
2086
2066
2046
2026
2006
1986
1966
1946
1926
1906
1886
1866
1846
1826
1806
1786
1766
1746
1726
1706
1686
1666
1646
1626
1606
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

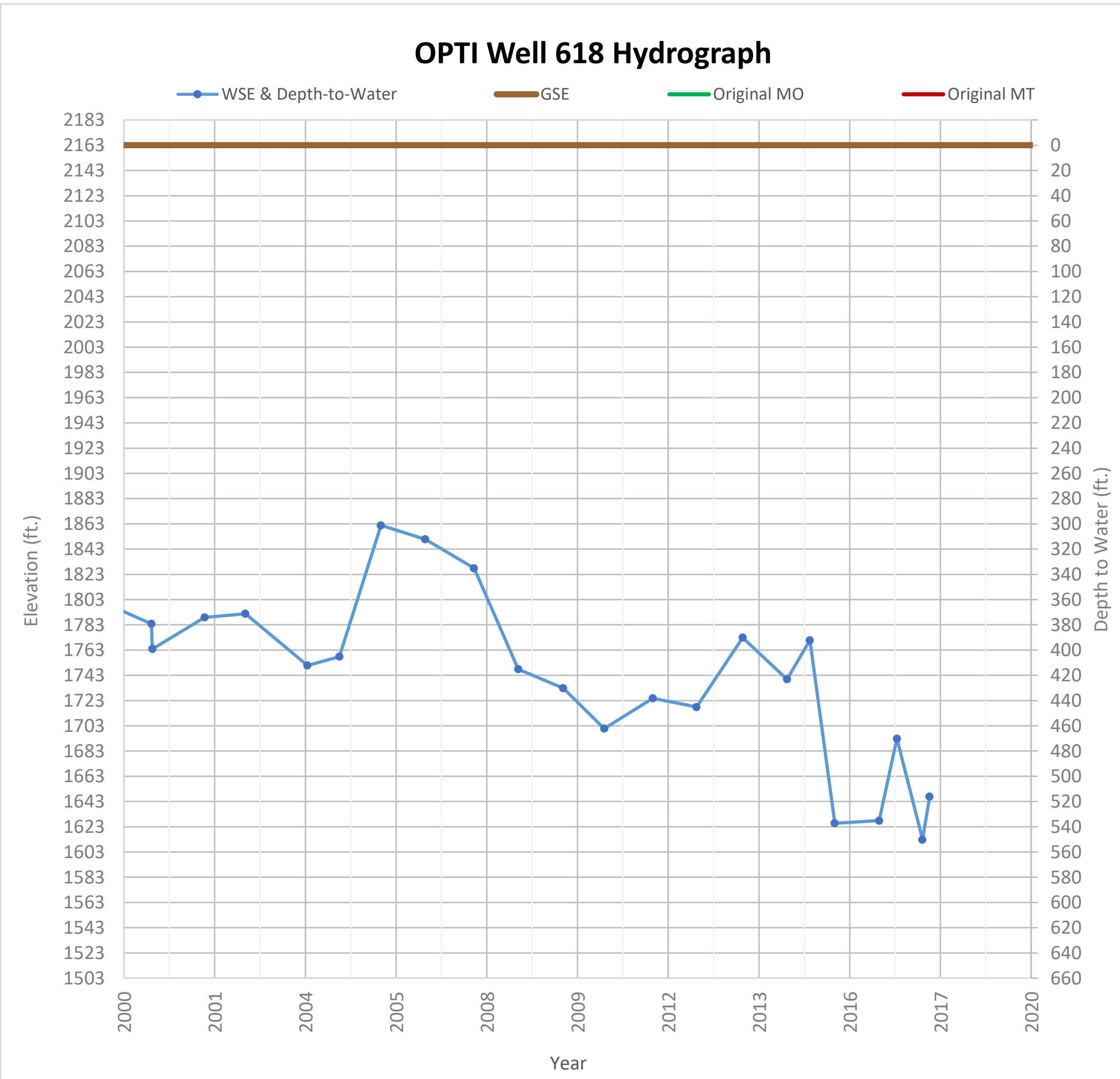

OPTI Well 613 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2350
2330
2310
2290
2270
2250
2230
2210
2190
2170
2150
2130
2110
2090
2070
2050
2030
2010
1990
1970
1950
1930
1910
1890
1870
1850
1830
1810
1790
1770
1750
1730
1710
1690
1670
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

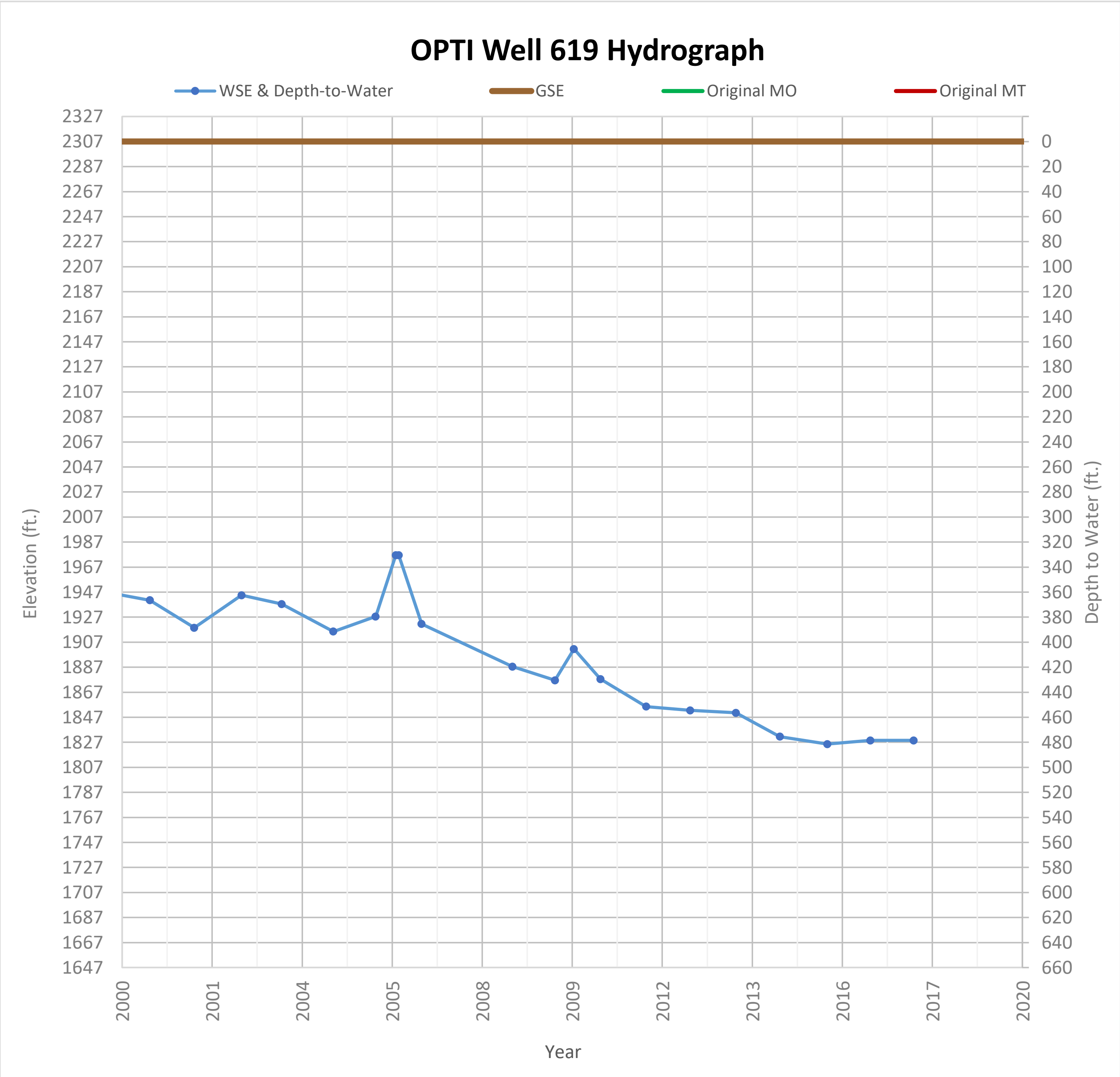


OPTI Well 614 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2357
2337
2317
2297
2277
2257
2237
2217
2197
2177
2157
2137
2117
2097
2077
2057
2037
2017
1997
1977
1957
1937
1917
1897
1877
1857
1837
1817
1797
1777
1757
1737
1717
1697
1677
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

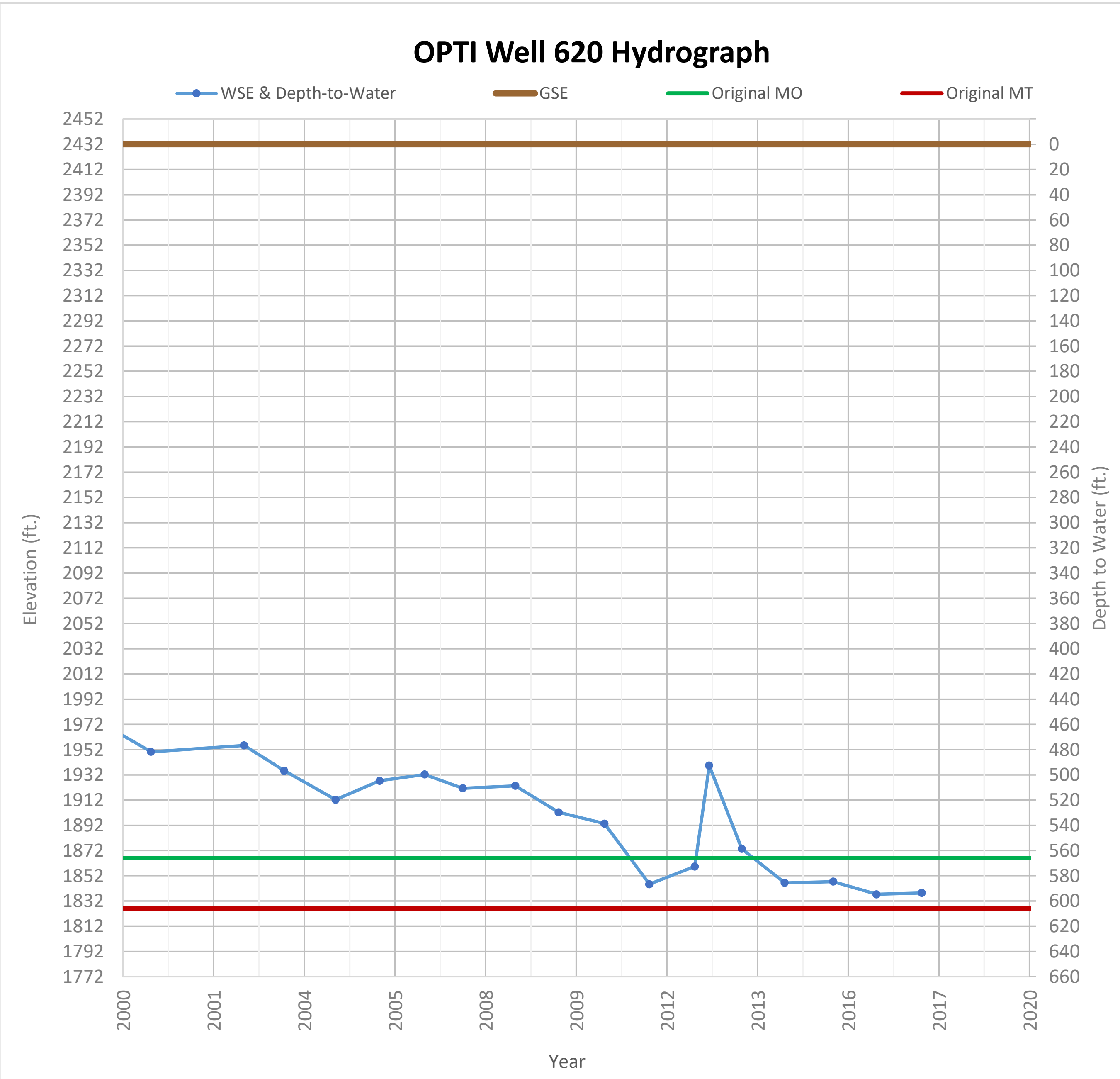


OPTI Well 615 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2347
2327
2307
2287
2267
2247
2227
2207
2187
2167
2147
2127
2107
2087
2067
2047
2027
2007
1987
1967
1947
1927
1907
1887
1867
1847
1827
1807
1787
1767
1747
1727
1707
1687
1667
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
620
640
660
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

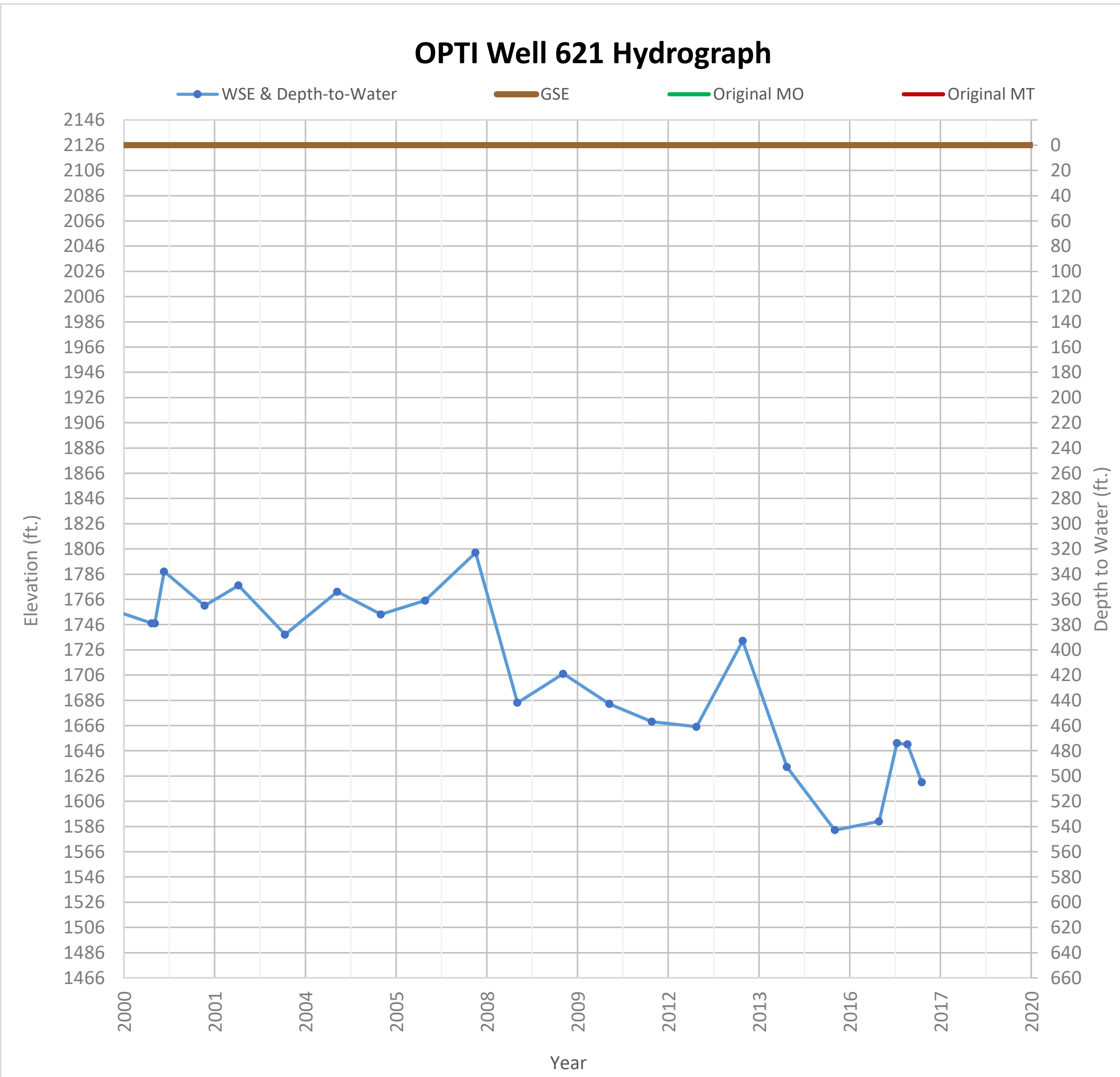

OPTI Well 618 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2183
2163
2143
2123
2103
2083
2063
2043
2023
2003
1983
1963
1943
1923
1903
1883
1863
1843
1823
1803
1783
1763
1743
1723
1703
1683
1663
1643
1623
1603
1583
1563
1543
1523
1503
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

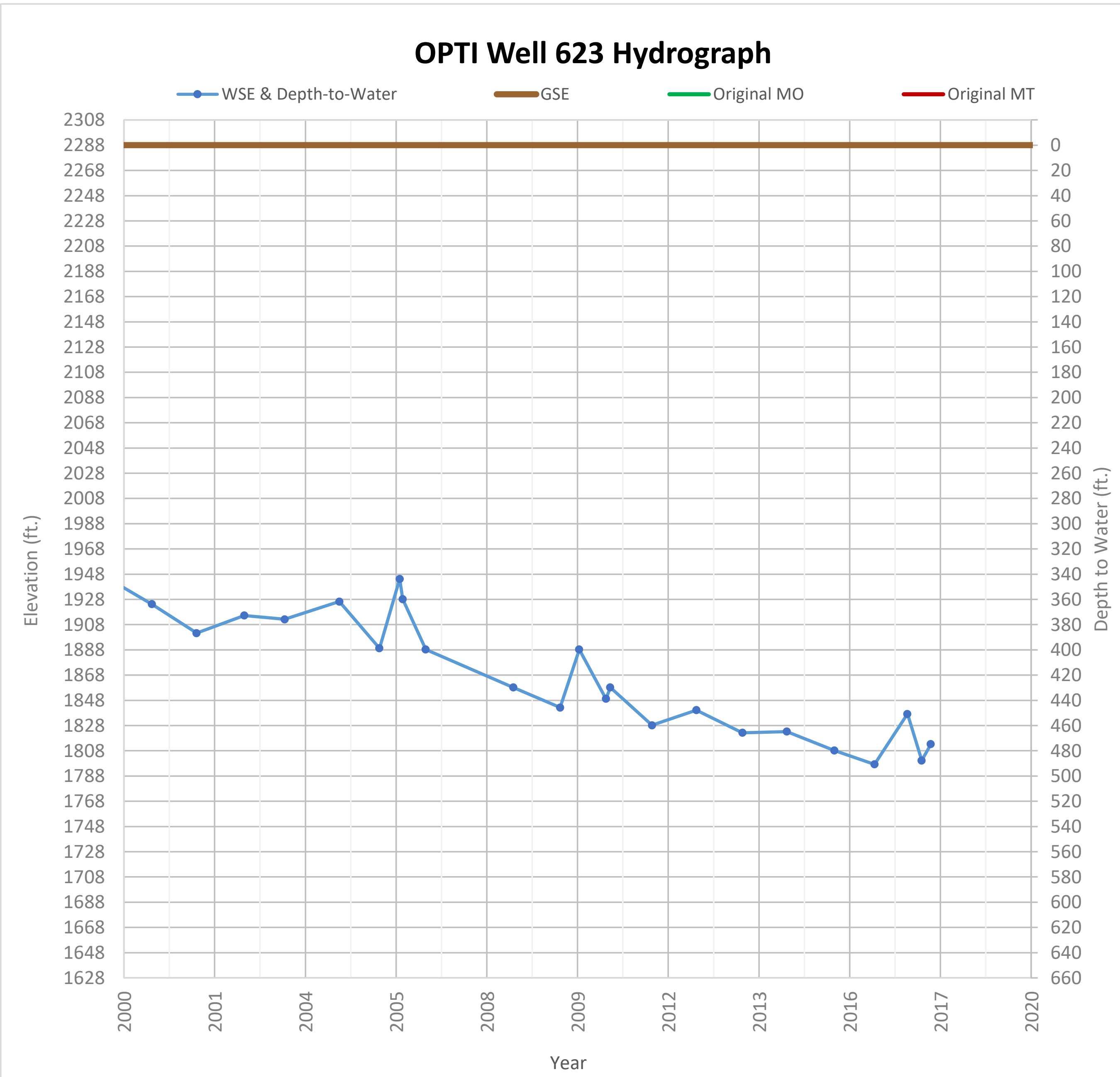


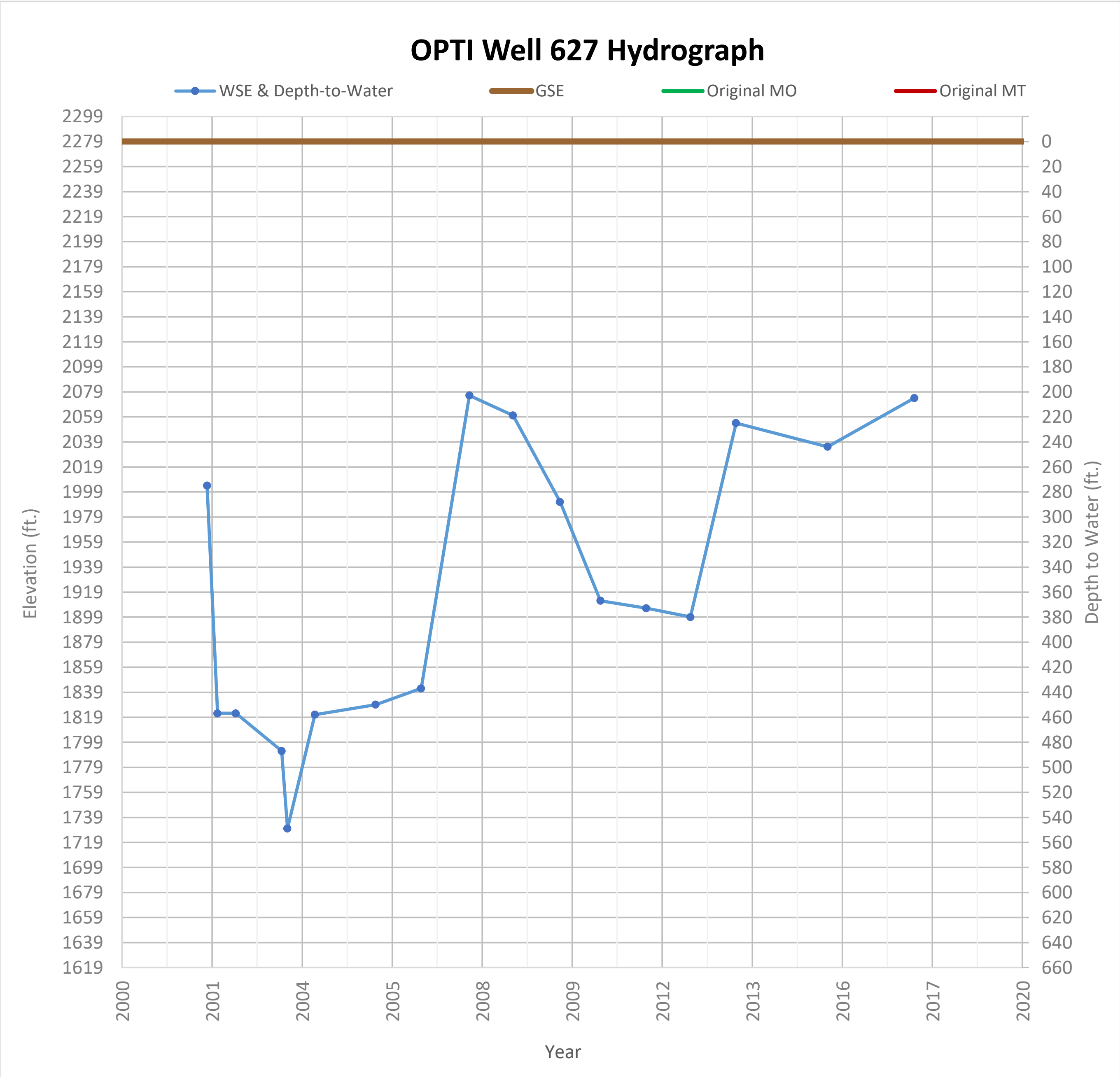
OPTI Well 619 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2327
2307
2287
2267
2247
2227
2207
2187
2167
2147
2127
2107
2087
2067
2047
2027
2007
1987
1967
1947
1927
1907
1887
1867
1847
1827
1807
1787
1767
1747
1727
1707
1687
1667
1647
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

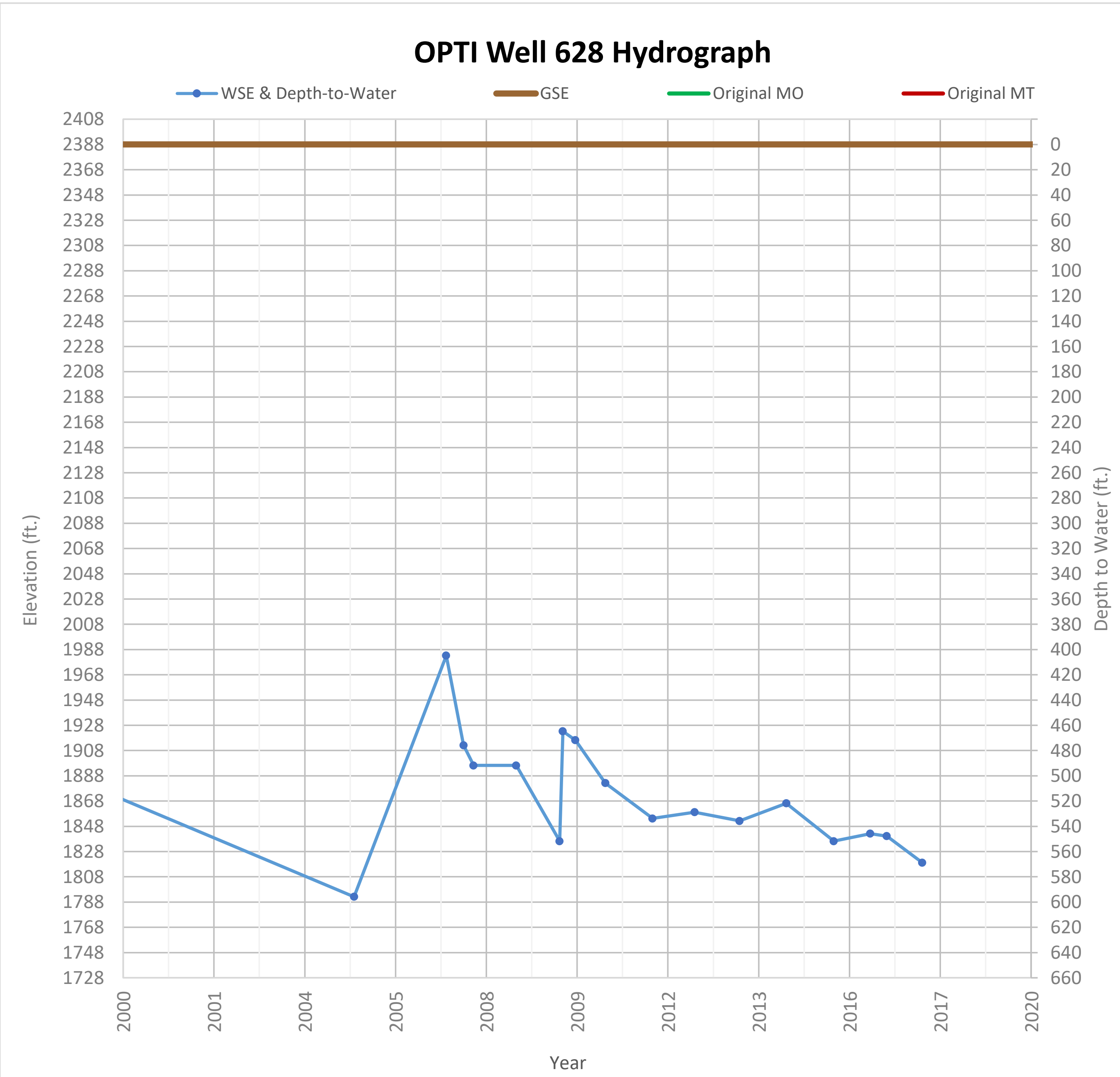


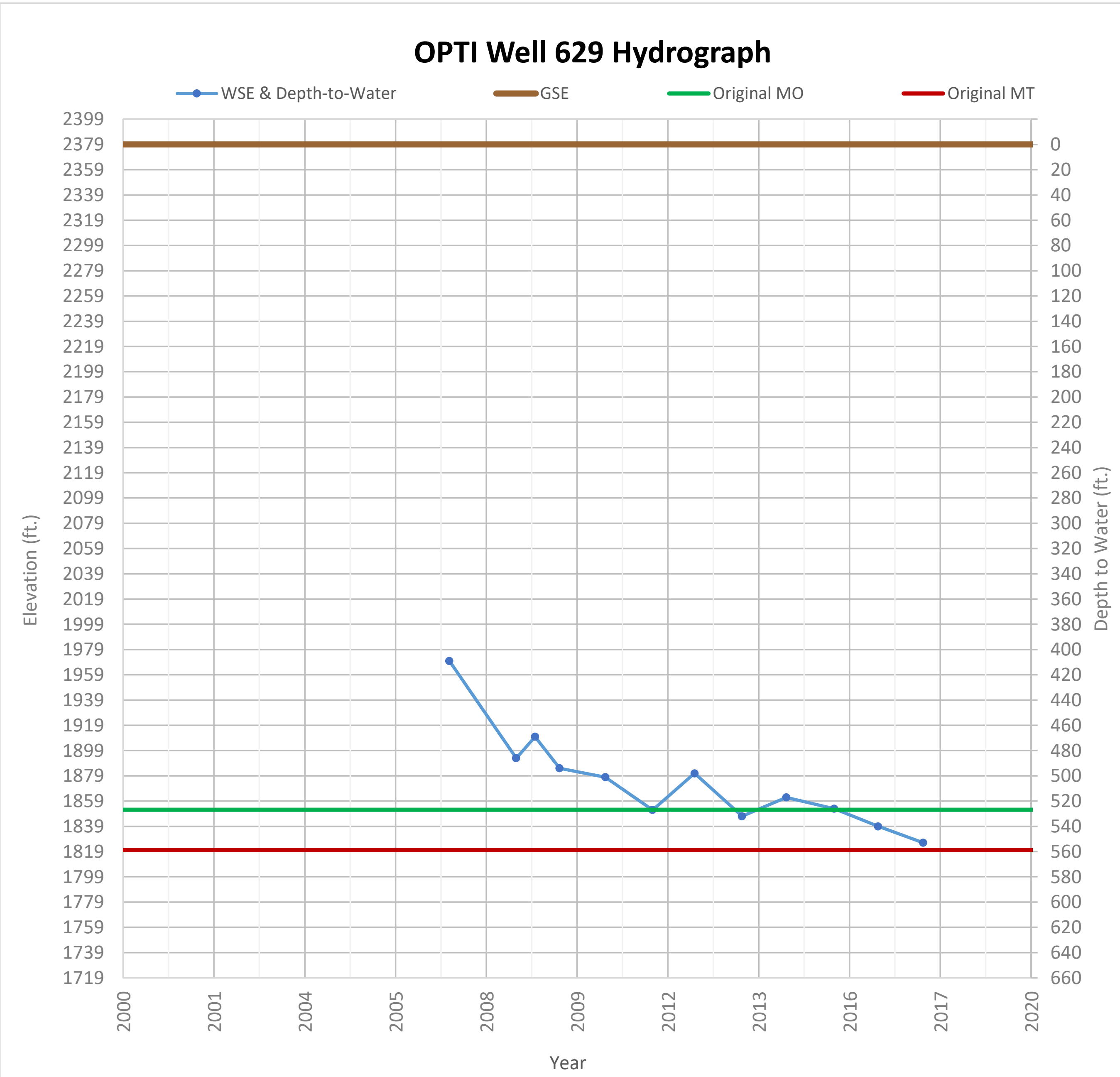
OPTI Well 620 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2452
2432
2412
2392
2372
2352
2332
2312
2292
2272
2252
2232
2212
2192
2172
2152
2132
2112
2092
2072
2052
2032
2012
1992
1972
1952
1932
1912
1892
1872
1852
1832
1812
1792
1772
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

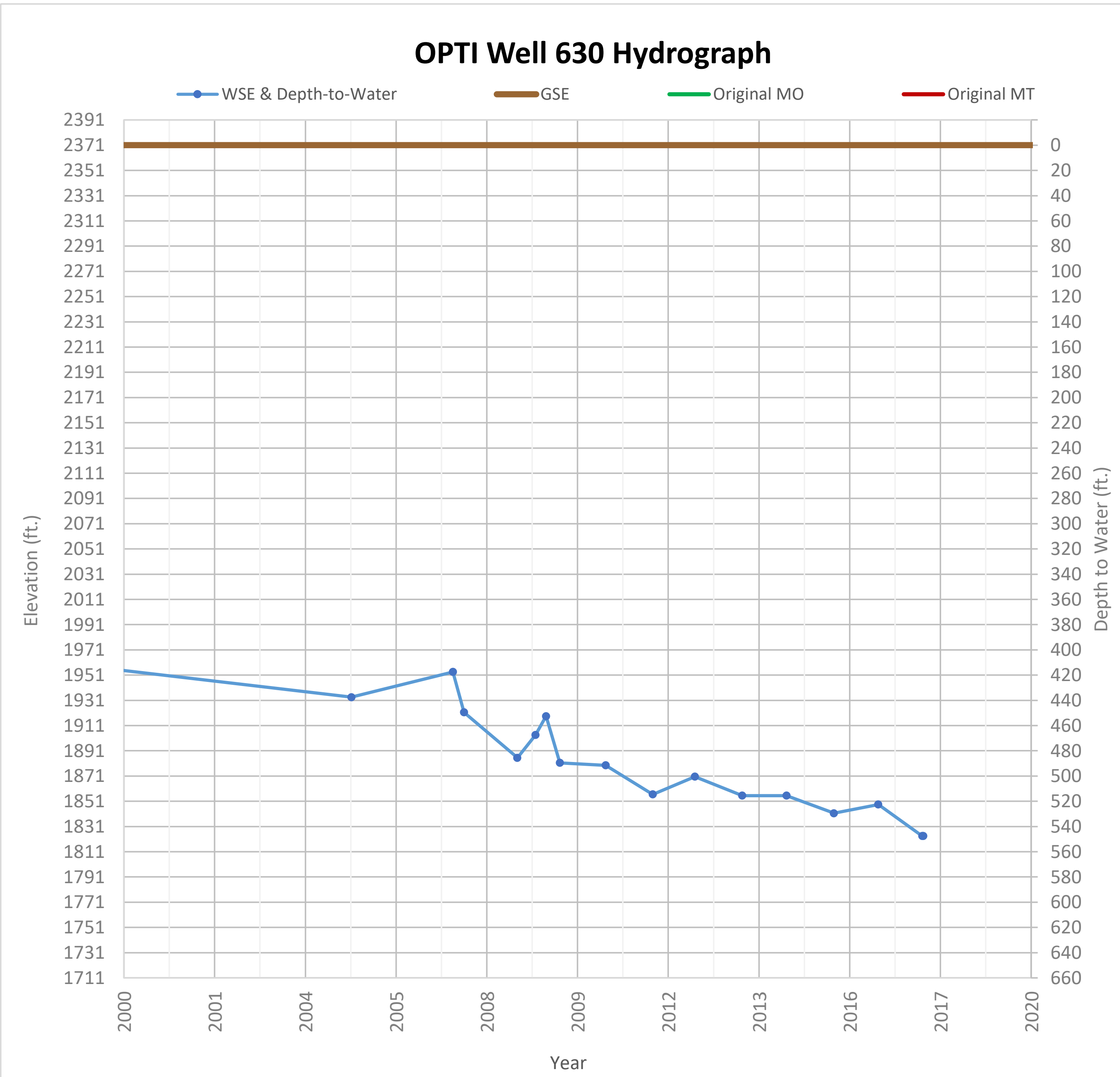

OPTI Well 621 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2146
2126
2106
2086
2066
2046
2026
2006
1986
1966
1946
1926
1906
1886
1866
1846
1826
1806
1786
1766
1746
1726
1706
1686
1666
1646
1626
1606
1586
1566
1546
1526
1506
1486
1466
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020


OPTI Well 623 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
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
1908
1888
1868
1848
1828
1808
1788
1768
1748
1728
1708
1688
1668
1648
1628
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

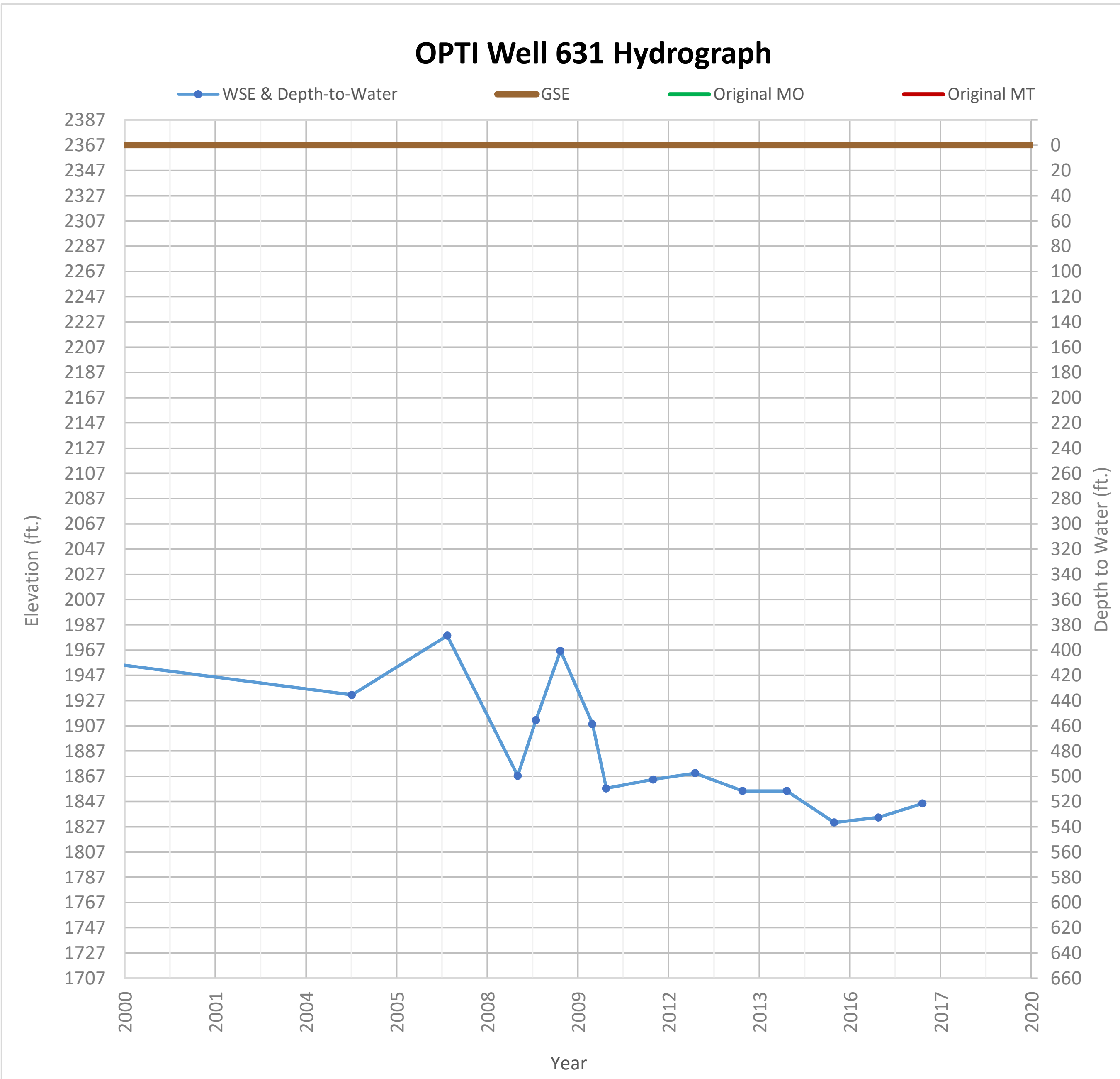

OPTI Well 627 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2299
2279
2259
2239
2219
2199
2179
2159
2139
2119
2099
2079
2059
2039
2019
1999
1979
1959
1939
1919
1899
1879
1859
1839
1819
1799
1779
1759
1739
1719
1699
1679
1659
1639
1619
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

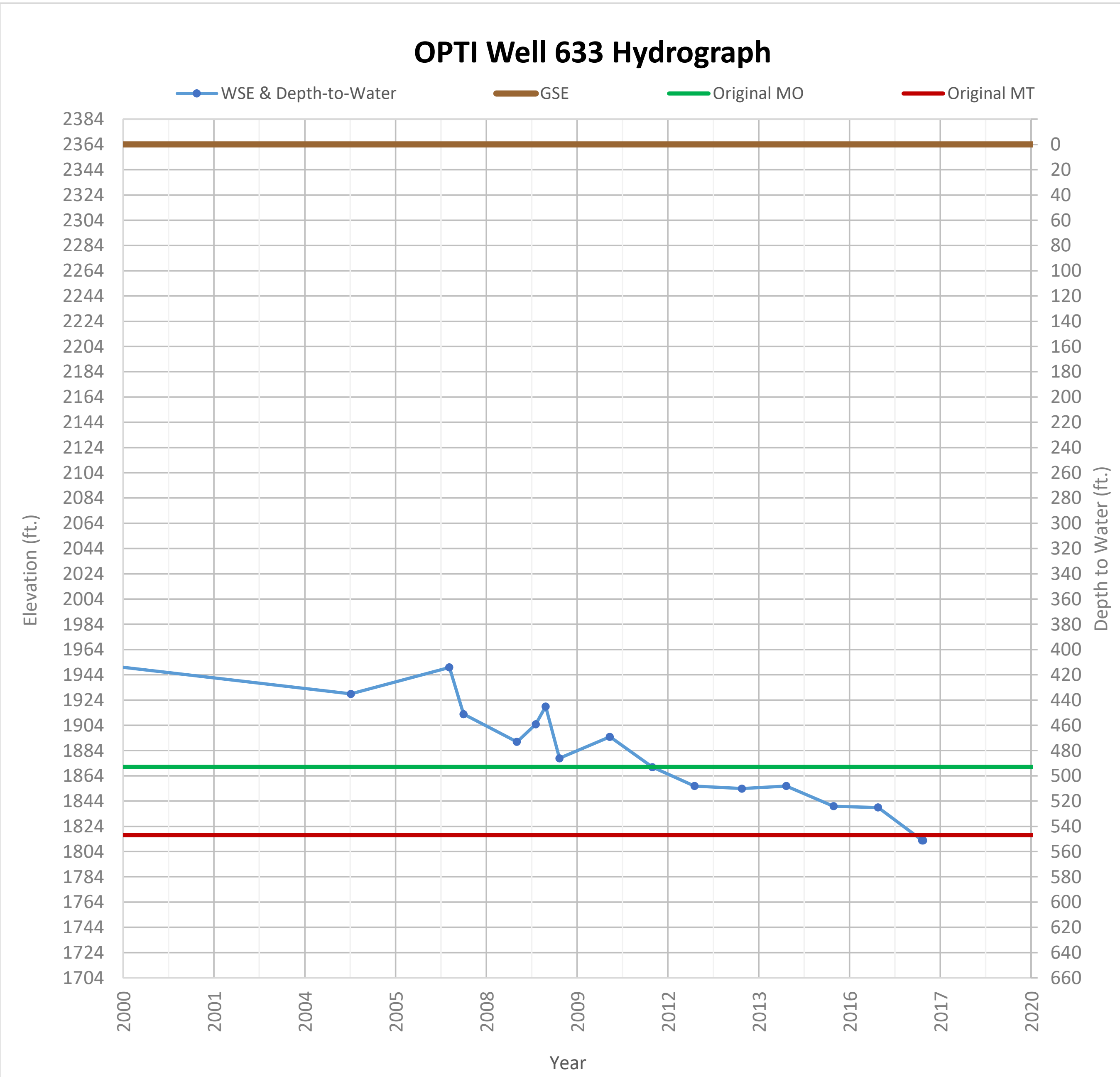

OPTI Well 628 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2408
2388
2368
2348
2328
2308
2288
2268
2248
2228
2208
2188
2168
2148
2128
2108
2088
2068
2048
2028
2008
1988
1968
1948
1928
1908
1888
1868
1848
1828
1808
1788
1768
1748
1728
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

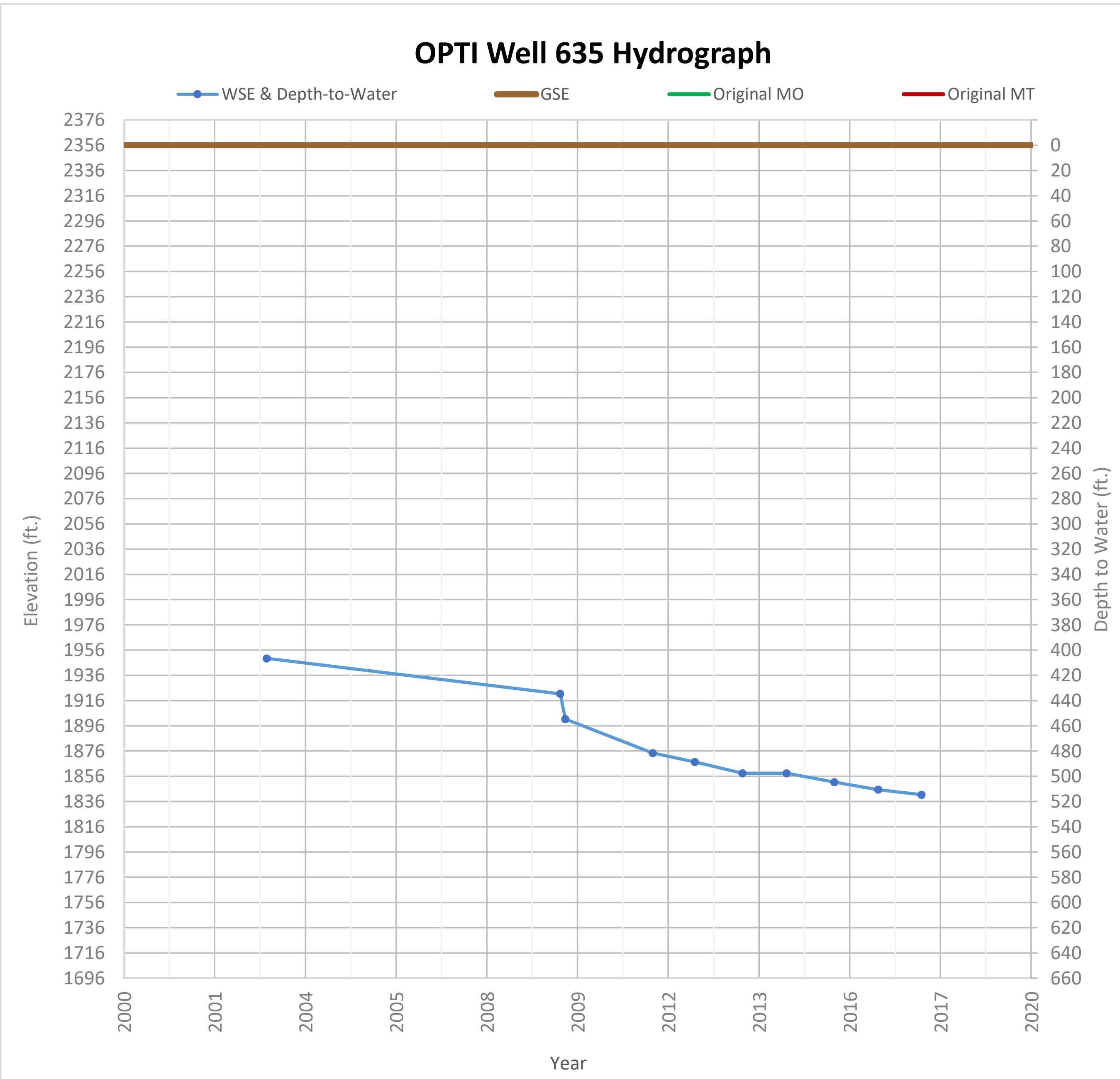

OPTI Well 629 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
2399
2379
2359
2339
2319
2299
2279
2259
2239
2219
2199
2179
2159
2139
2119
2099
2079
2059
2039
2019
1999
1979
1959
1939
1919
1899
1879
1859
1839
1819
1799
1779
1759
1739
1719
Depth to Water (ft.)
0
20
40
60
80
100
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020
Year



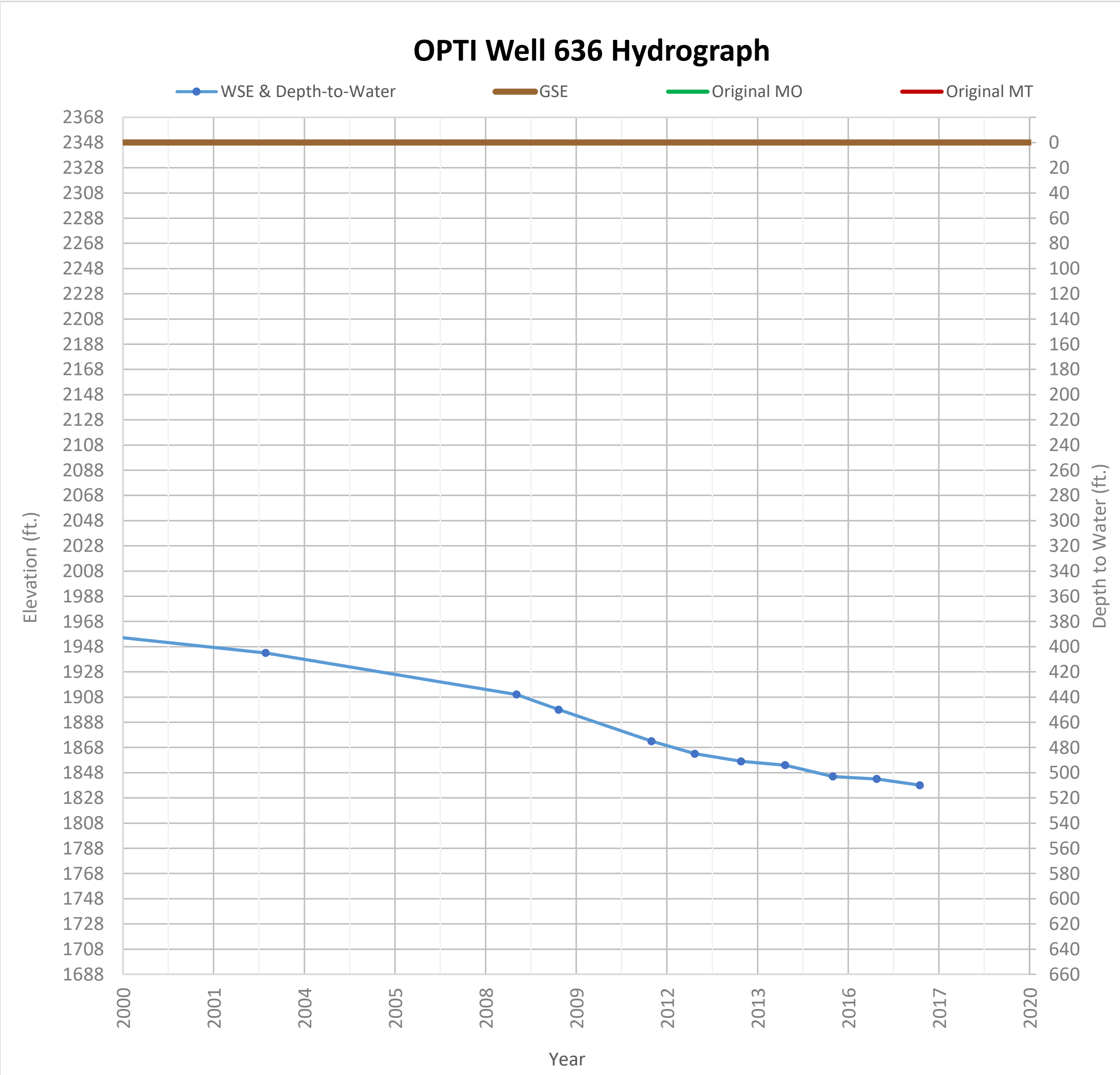
OPTI Well 630 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2391
2371
2351
2331
2311
2291
2271
2251
2231
2211
2191
2171
2151
2131
2111
2091
2071
2051
2031
2011
1991
1971
1951
1931
1911
1891
1871
1851
1831
1811
1791
1771
1751
1731
1711
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

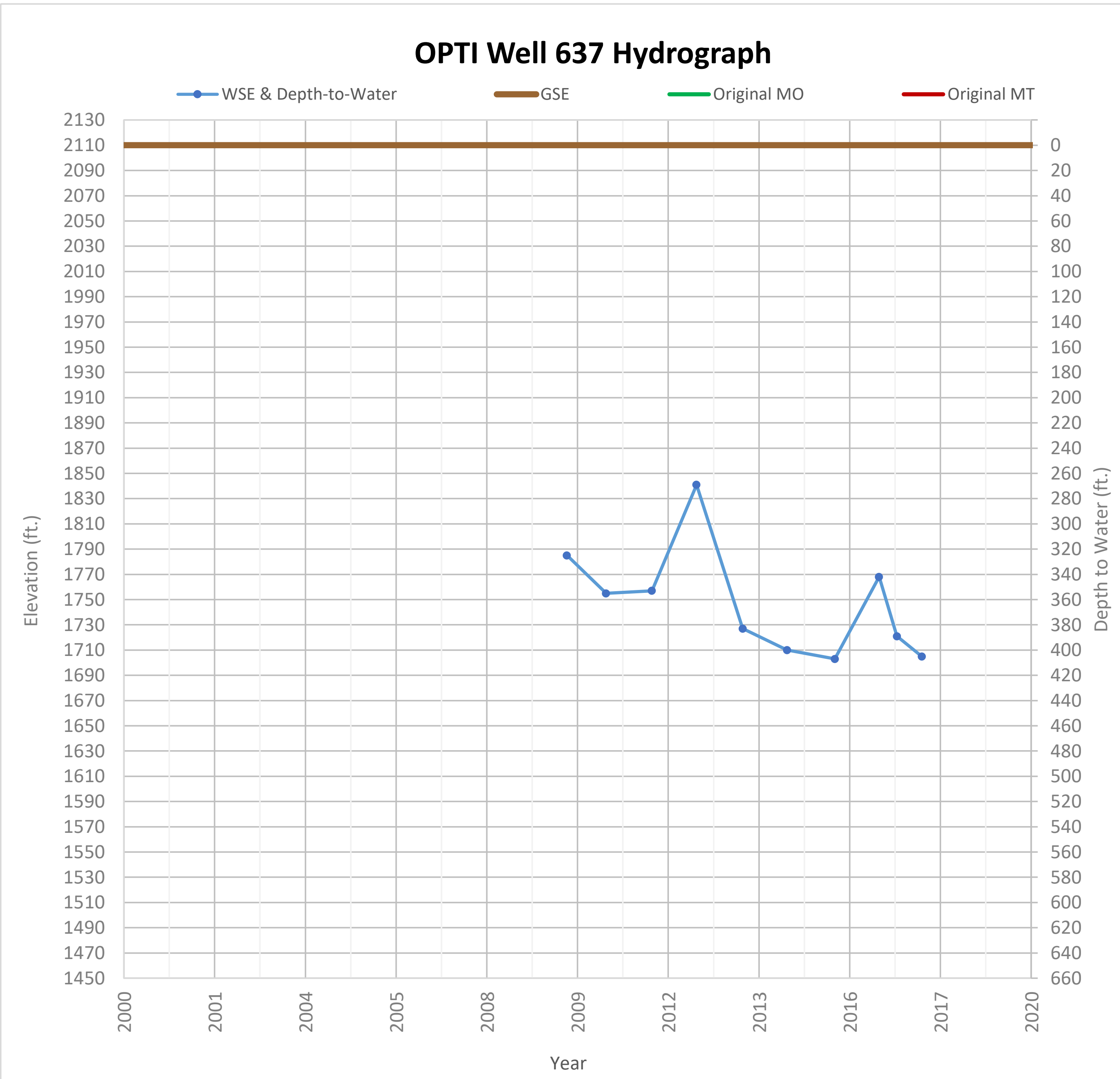

OPTI Well 631 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2387
2367
2347
2327
2307
2287
2267
2247
2227
2207
2187
2167
2147
2127
2107
2087
2067
2047
2027
2007
1987
1967
1947
1927
1907
1887
1867
1847
1827
1807
1787
1767
1747
1727
1707
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020


OPTI Well 633 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
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
1764
1744
1724
1704
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

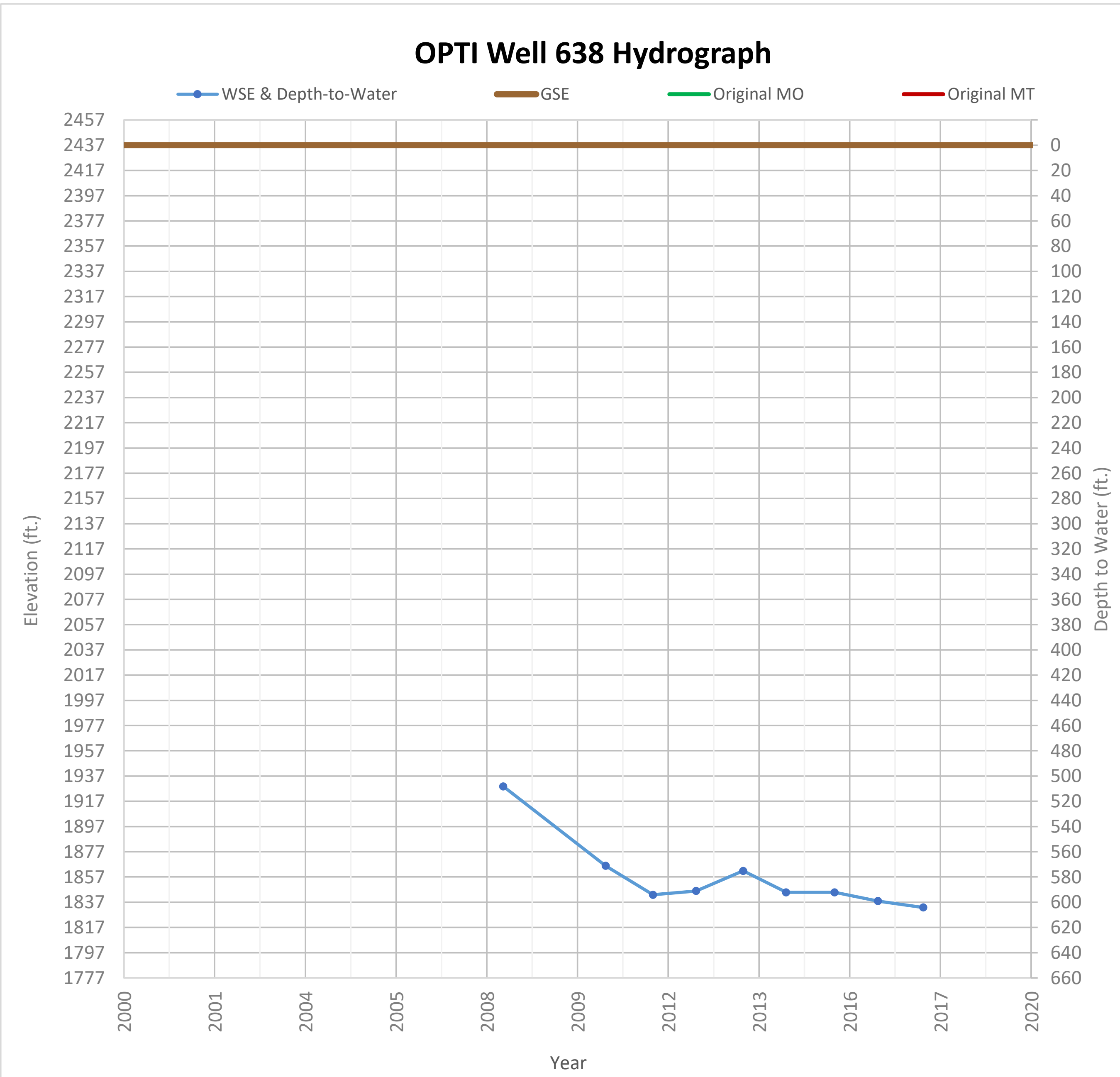


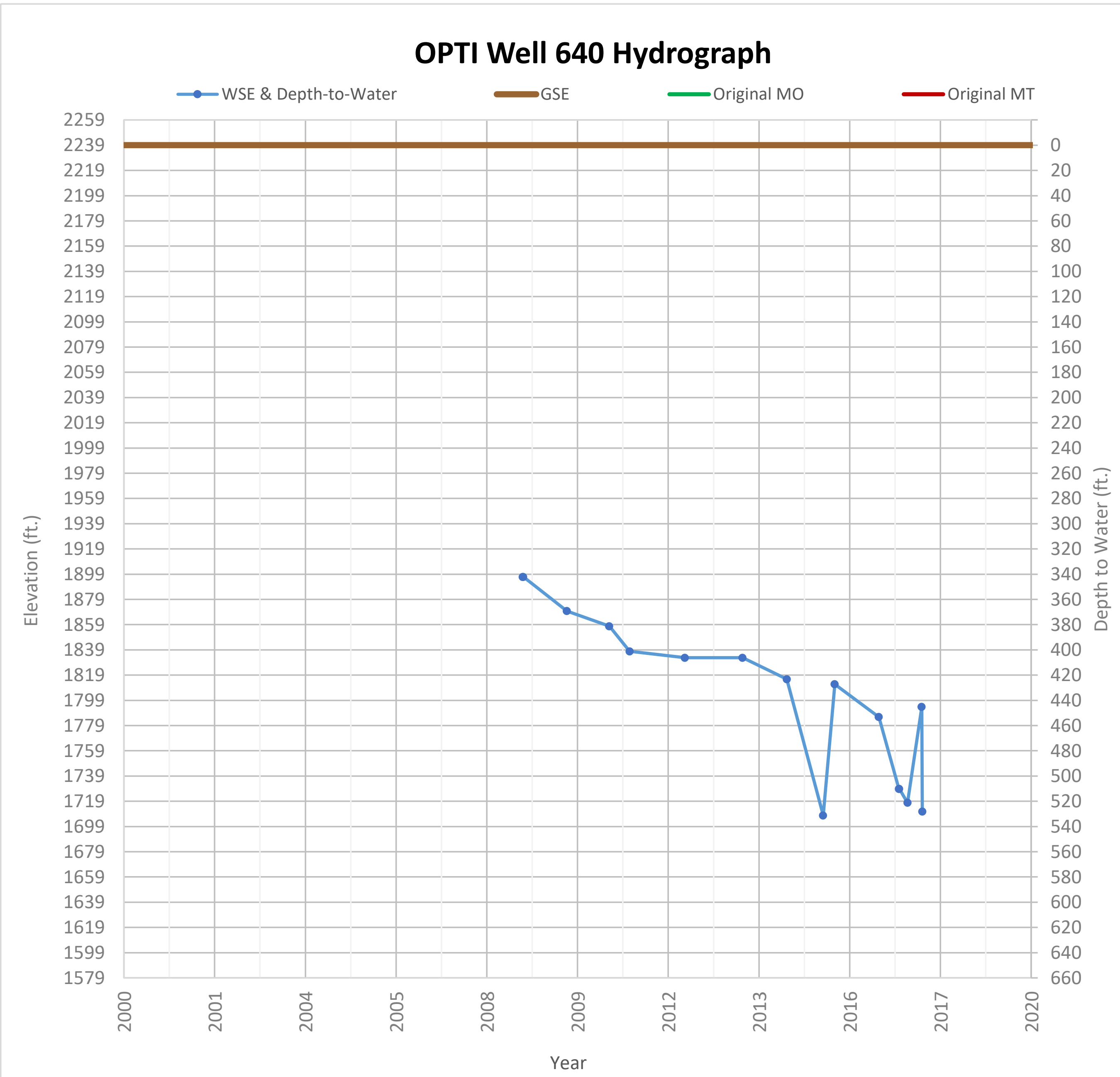
OPTI Well 635 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2376
2356
2336
2316
2296
2276
2256
2236
2216
2196
2176
2156
2136
2116
2096
2076
2056
2036
2016
1996
1976
1956
1936
1916
1896
1876
1856
1836
1816
1796
1776
1756
1736
1716
1696
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

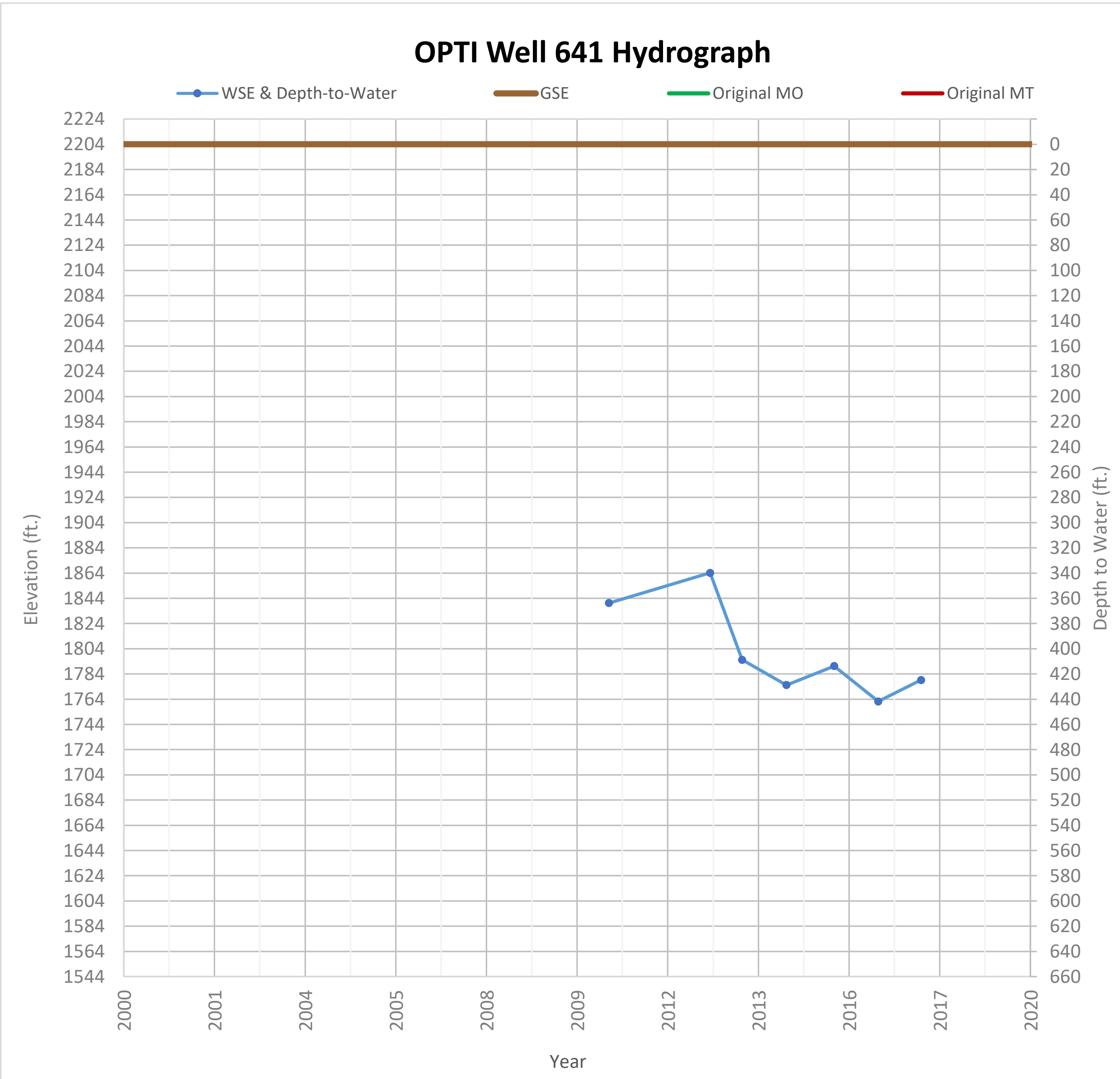

OPTI Well 636 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2368
2348
2328
2308
2288
2268
2248
2228
2208
2188
2168
2148
2128
2108
2088
2068
2048
2028
2008
1988
1968
1948
1928
1908
1888
1868
1848
1828
1808
1788
1768
1748
1728
1708
1688
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

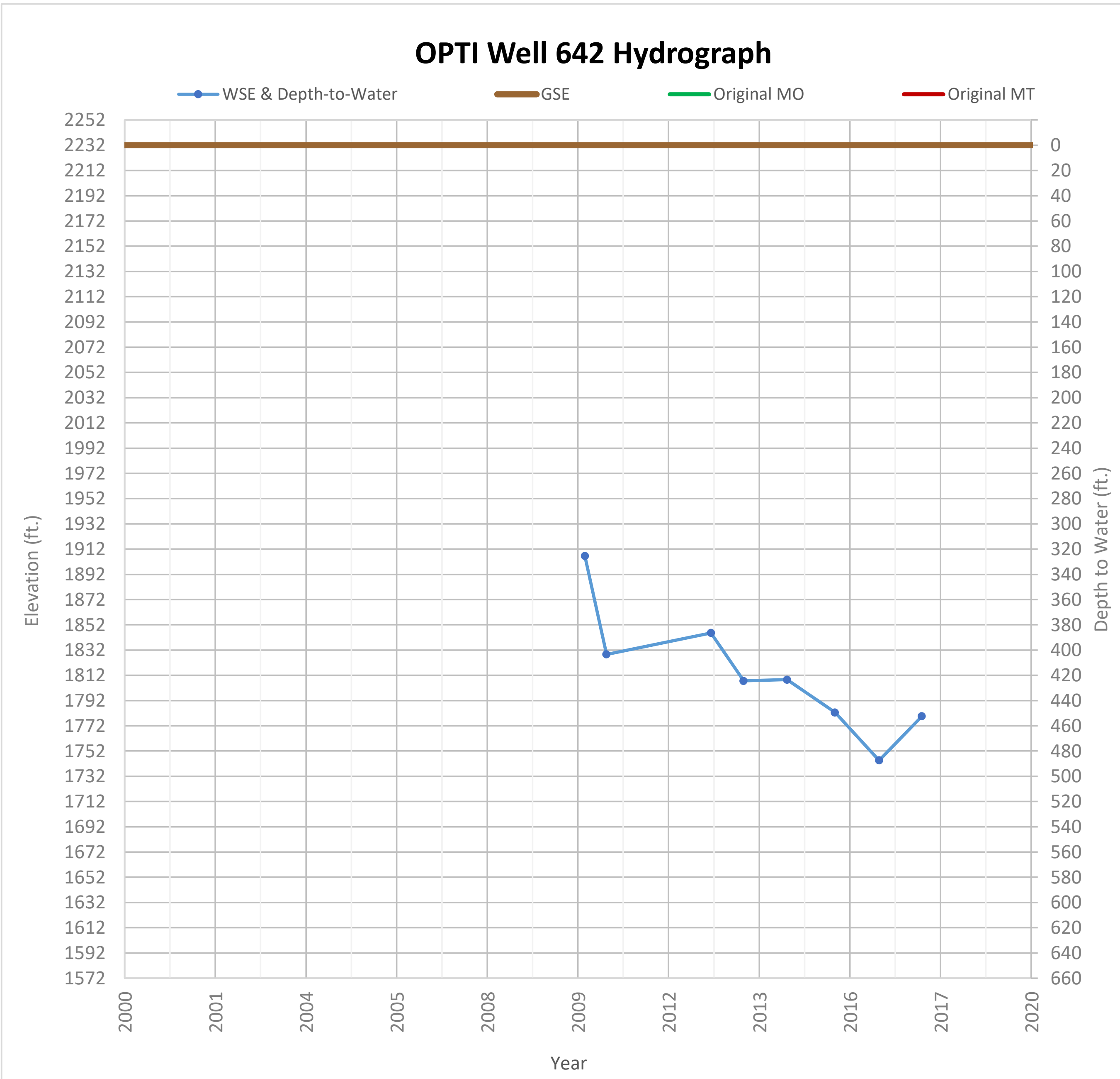


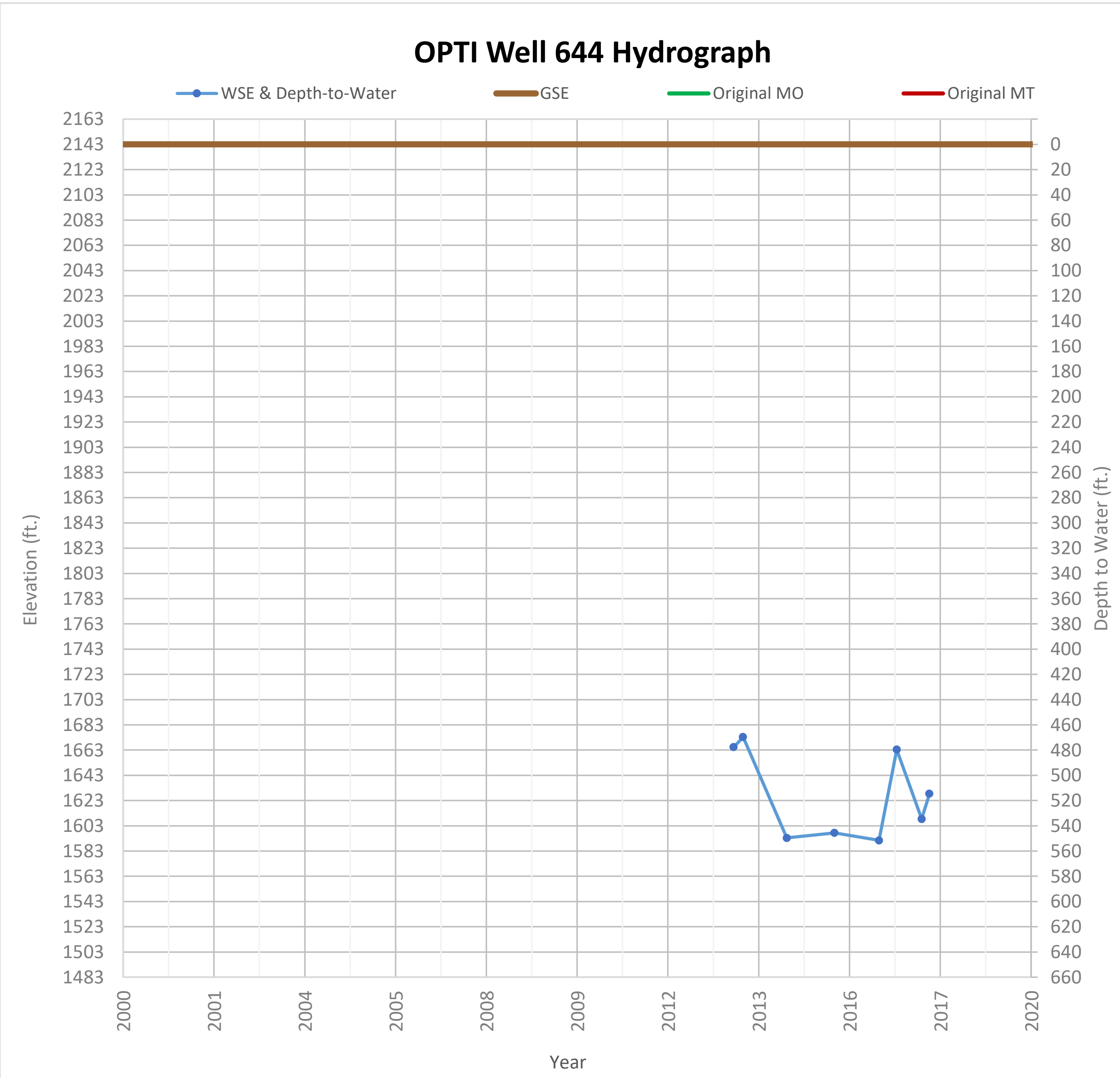
OPTI Well 637 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2130
2110
2090
2070
2050
2030
2010
1990
1970
1950
1930
1910
1890
1870
1850
1830
1810
1790
1770
1750
1730
1710
1690
1670
1650
1630
1610
1590
1570
1550
1530
1510
1490
1470
1450
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

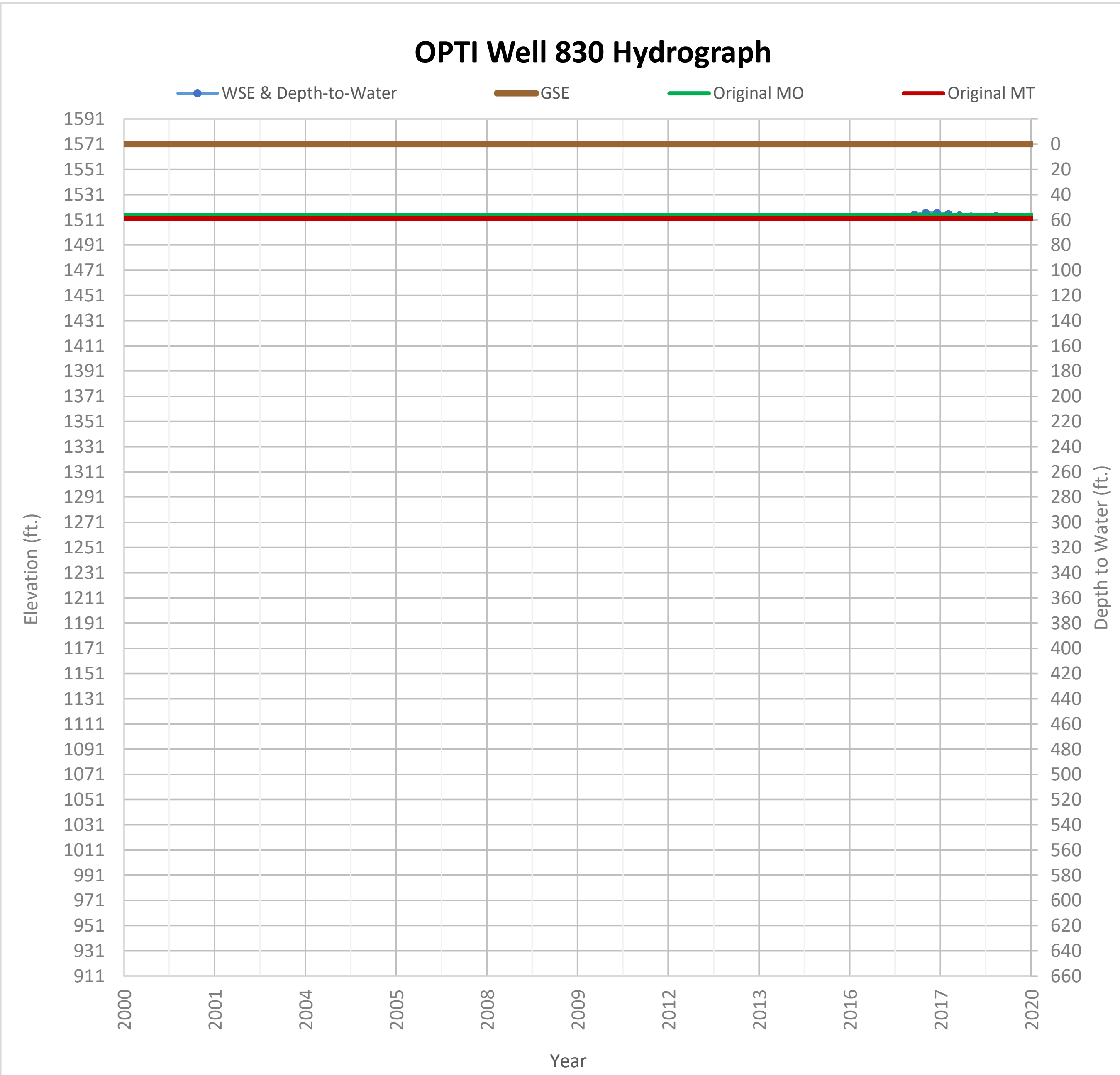

OPTI Well 638 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
2457
2437
2417
2397
2377
2357
2337
2317
2297
2277
2257
2237
2217
2197
2177
2157
2137
2117
2097
2077
2057
2037
2017
1997
1977
1957
1937
1917
1897
1877
1857
1837
1817
1797
1777
Depth to Water (ft.)
0
20
40
60
80
100
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020
Year


OPTI Well 640 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
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
1639
1619
1599
1579
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

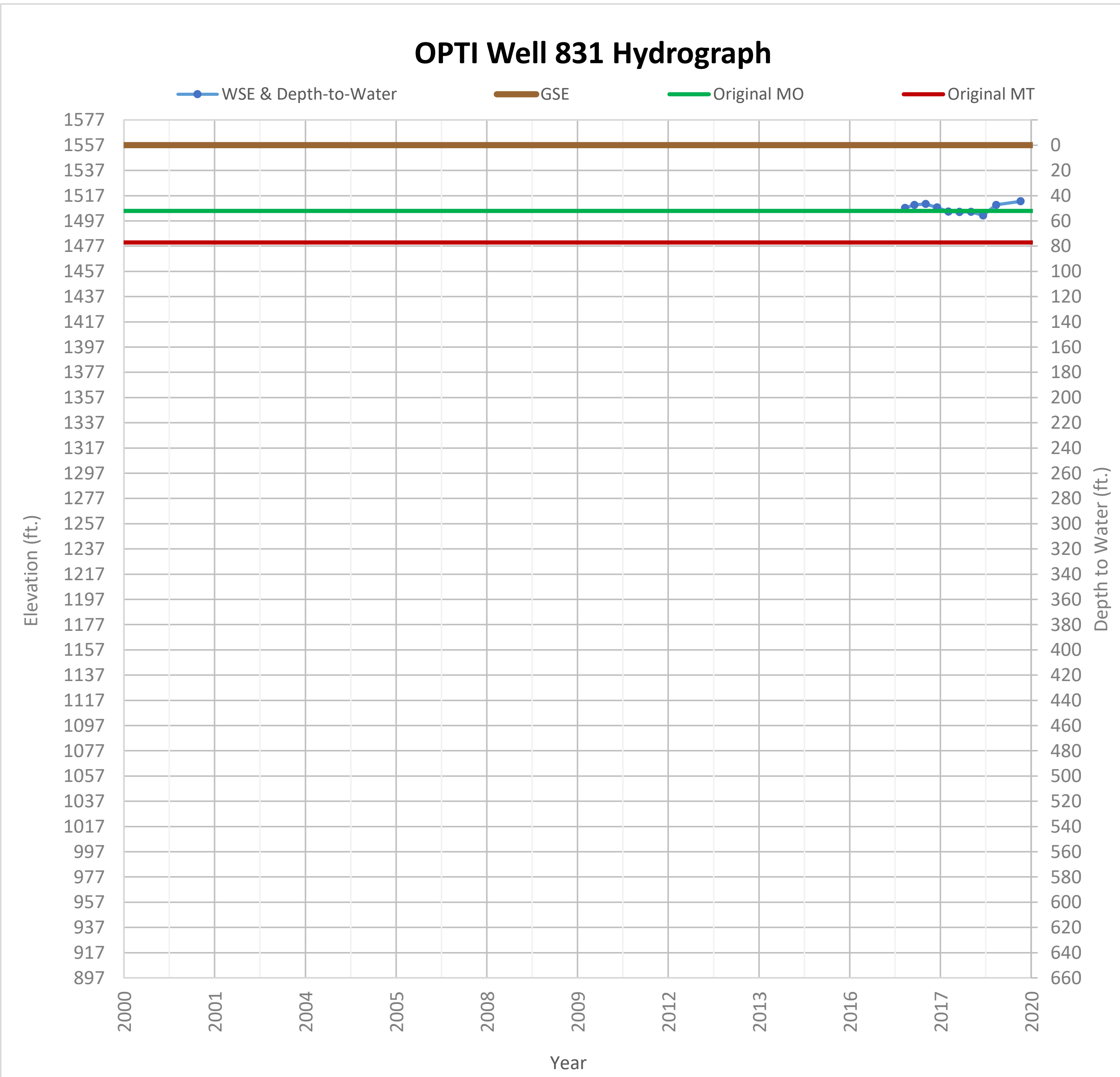

OPTI Well 641 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2224
2204
2184
2164
2144
2124
2104
2084
2064
2044
2024
2004
1984
1964
1944
1924
1904
1884
1864
1844
1824
1804
1784
1764
1744
1724
1704
1684
1664
1644
1624
1604
1584
1564
1544
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

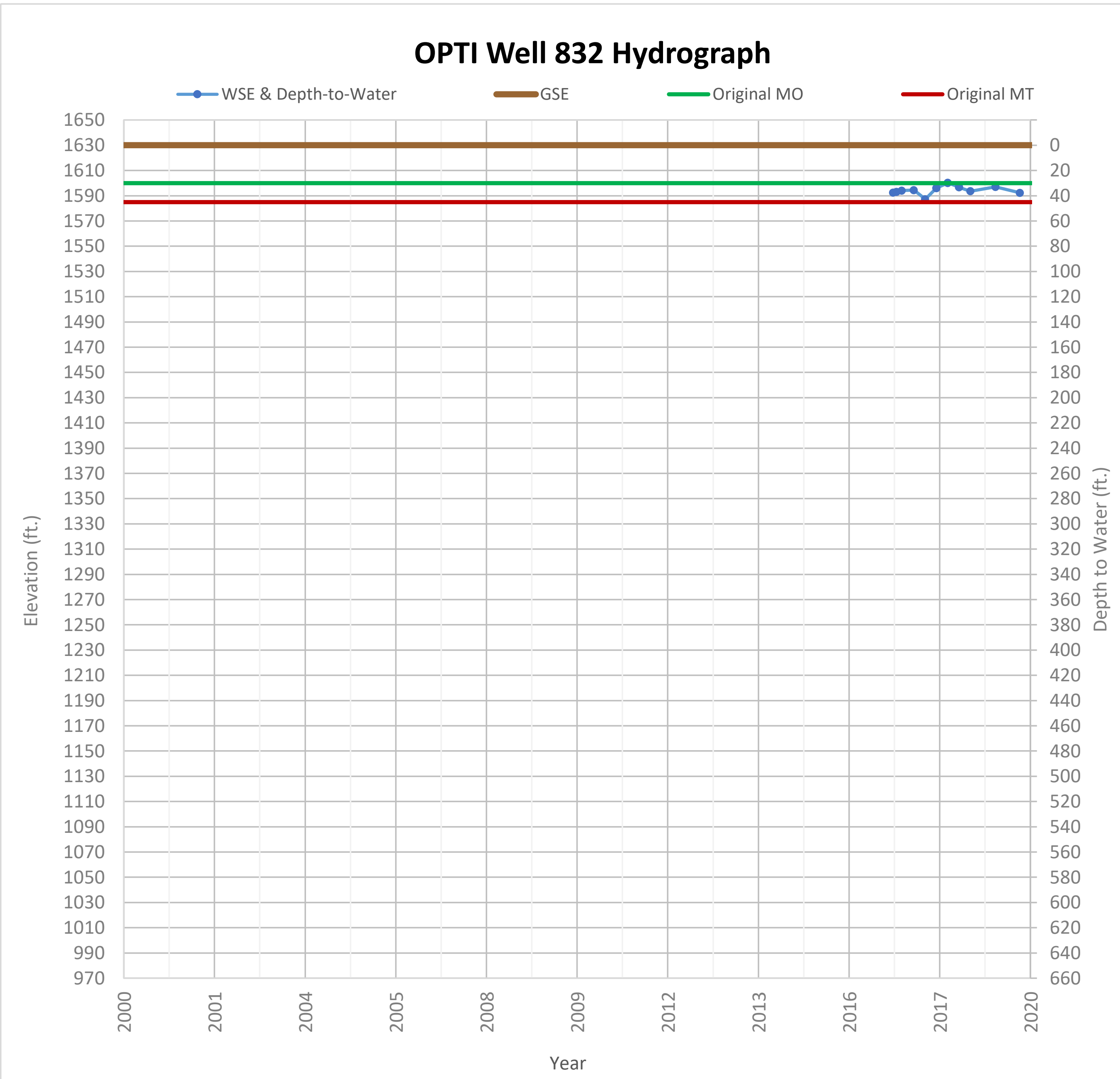

OPTI Well 642 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2252
2232
2212
2192
2172
2152
2132
2112
2092
2072
2052
2032
2012
1992
1972
1952
1932
1912
1892
1872
1852
1832
1812
1792
1772
1752
1732
1712
1692
1672
1652
1632
1612
1592
1572
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

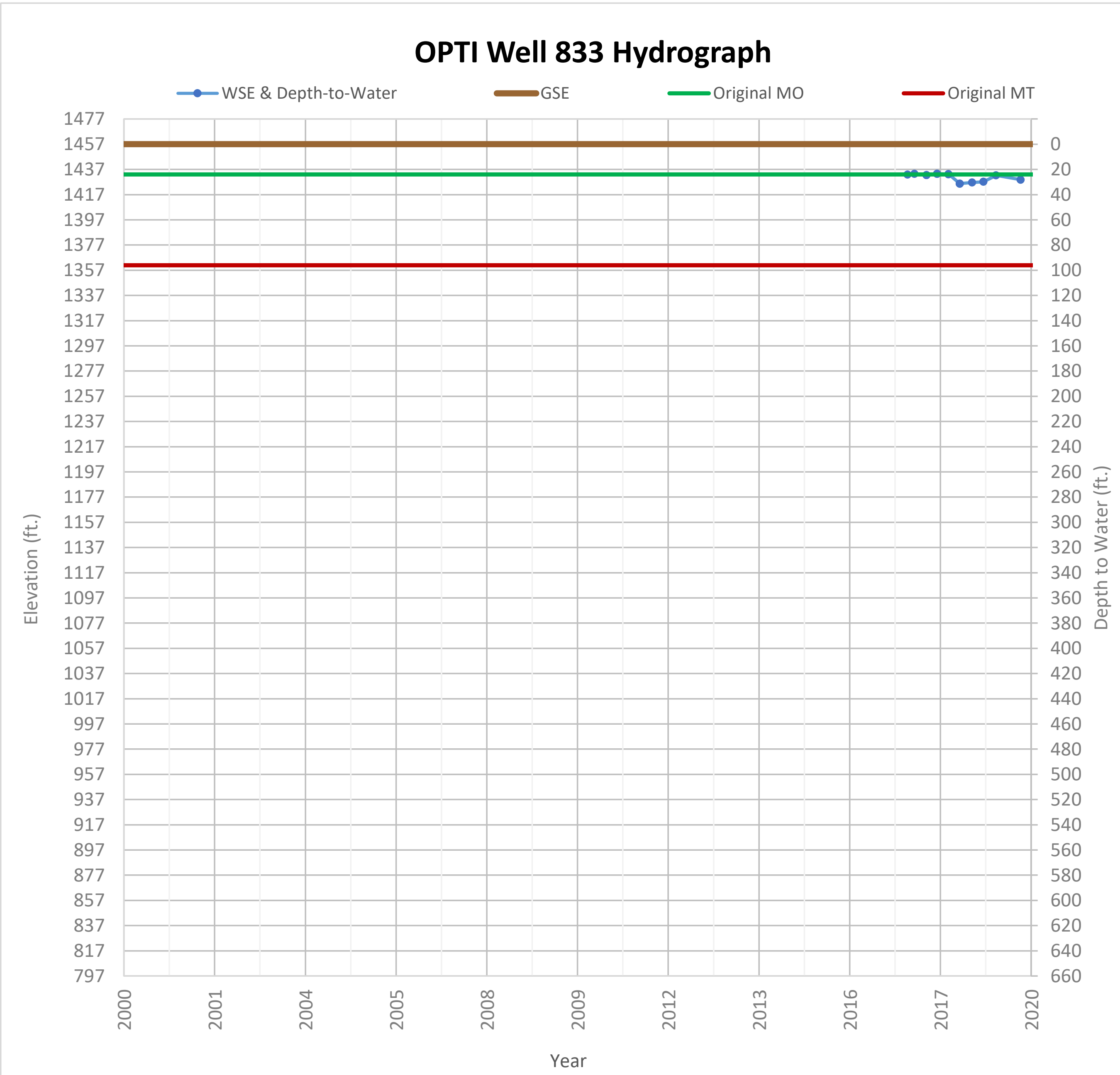

OPTI Well 644 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
2163
2143
2123
2103
2083
2063
2043
2023
2003
1983
1963
1943
1923
1903
1883
1863
1843
1823
1803
1783
1763
1743
1723
1703
1683
1663
1643
1623
1603
1583
1563
1543
1523
1503
1483
0
20
40
60
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020



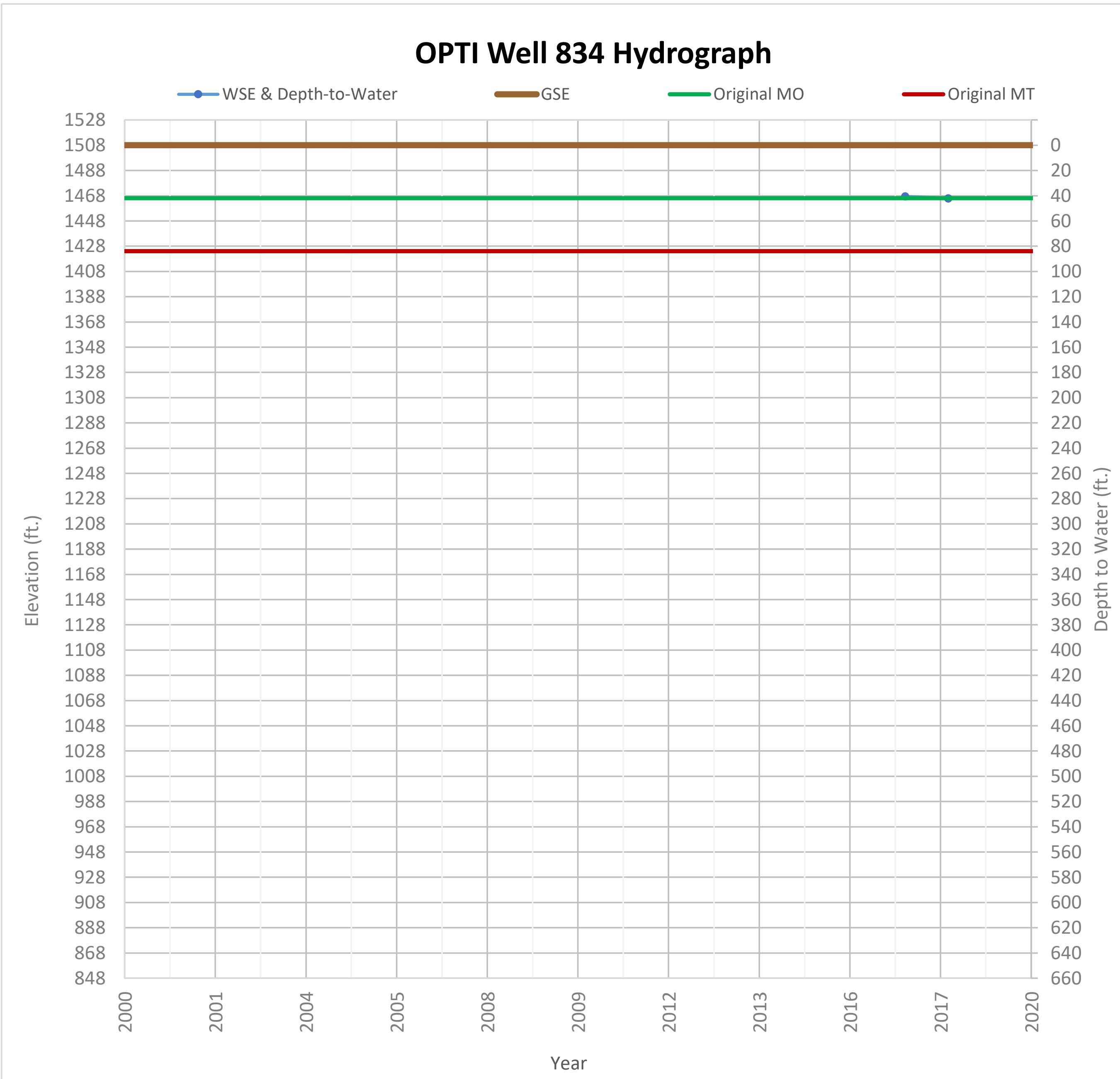
OPTI Well 830 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
1591
1571
1551
1531
1511
1491
1471
1451
1431
1411
1391
1371
1351
1331
1311
1291
1271
1251
1231
1211
1191
1171
1151
1131
1111
1091
1071
1051
1031
1011
991
971
951
931
911
0
20
40
60
80
100
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

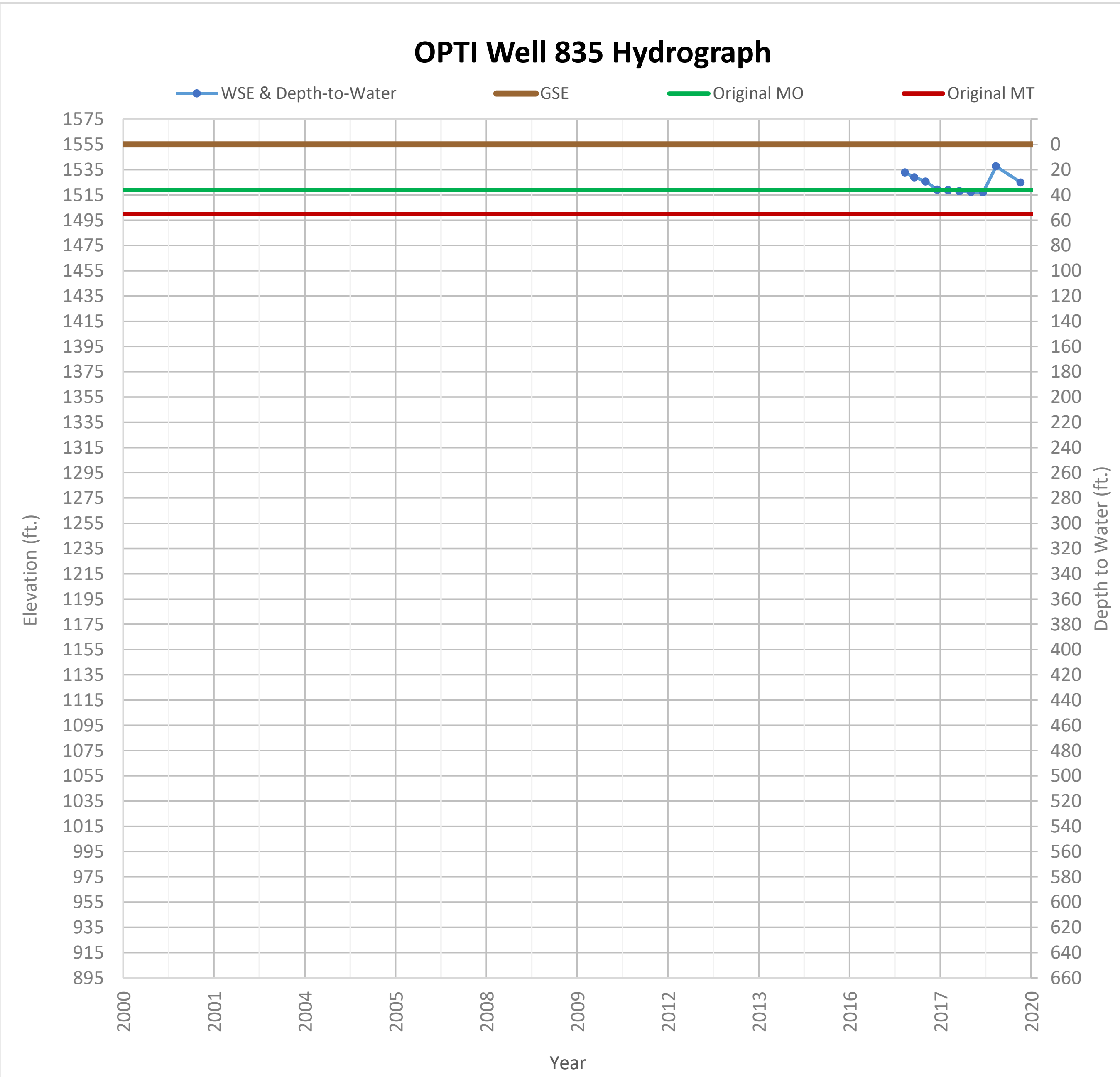

OPTI Well 831 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
1577
1557
1537
1517
1497
1477
1457
1437
1417
1397
1377
1357
1337
1317
1297
1277
1257
1237
1217
1197
1177
1157
1137
1117
1097
1077
1057
1037
1017
997
977
957
937
917
897
Depth to Water (ft.)
0
20
40
60
80
100
120
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020
Year

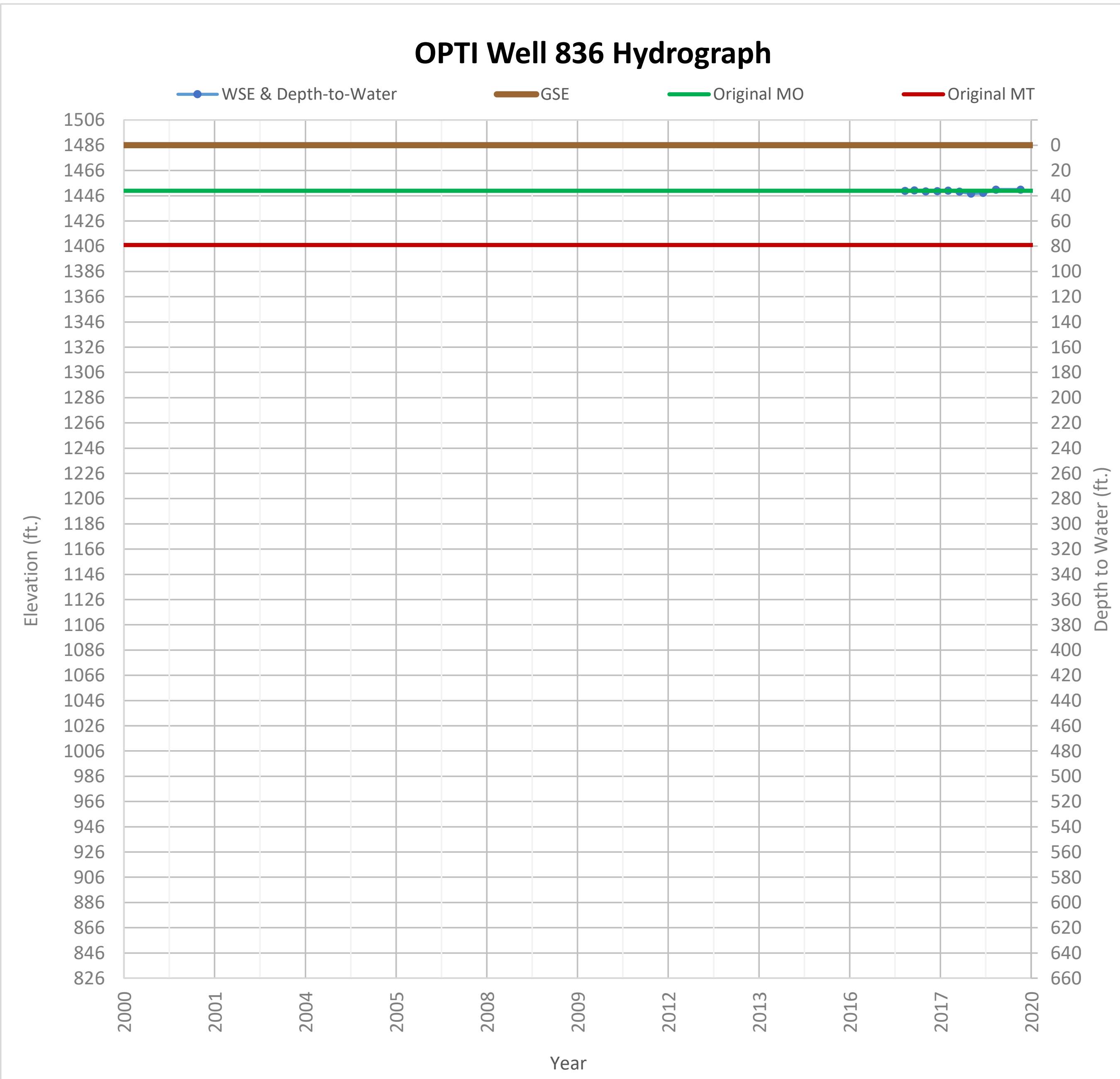

OPTI Well 832 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
1650
1630
1610
1590
1570
1550
1530
1510
1490
1470
1450
1430
1410
1390
1370
1350
1330
1310
1290
1270
1250
1230
1210
1190
1170
1150
1130
1110
1090
1070
1050
1030
1010
990
970
Depth to Water (ft.)
0
20
40
60
80
100
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020
Year



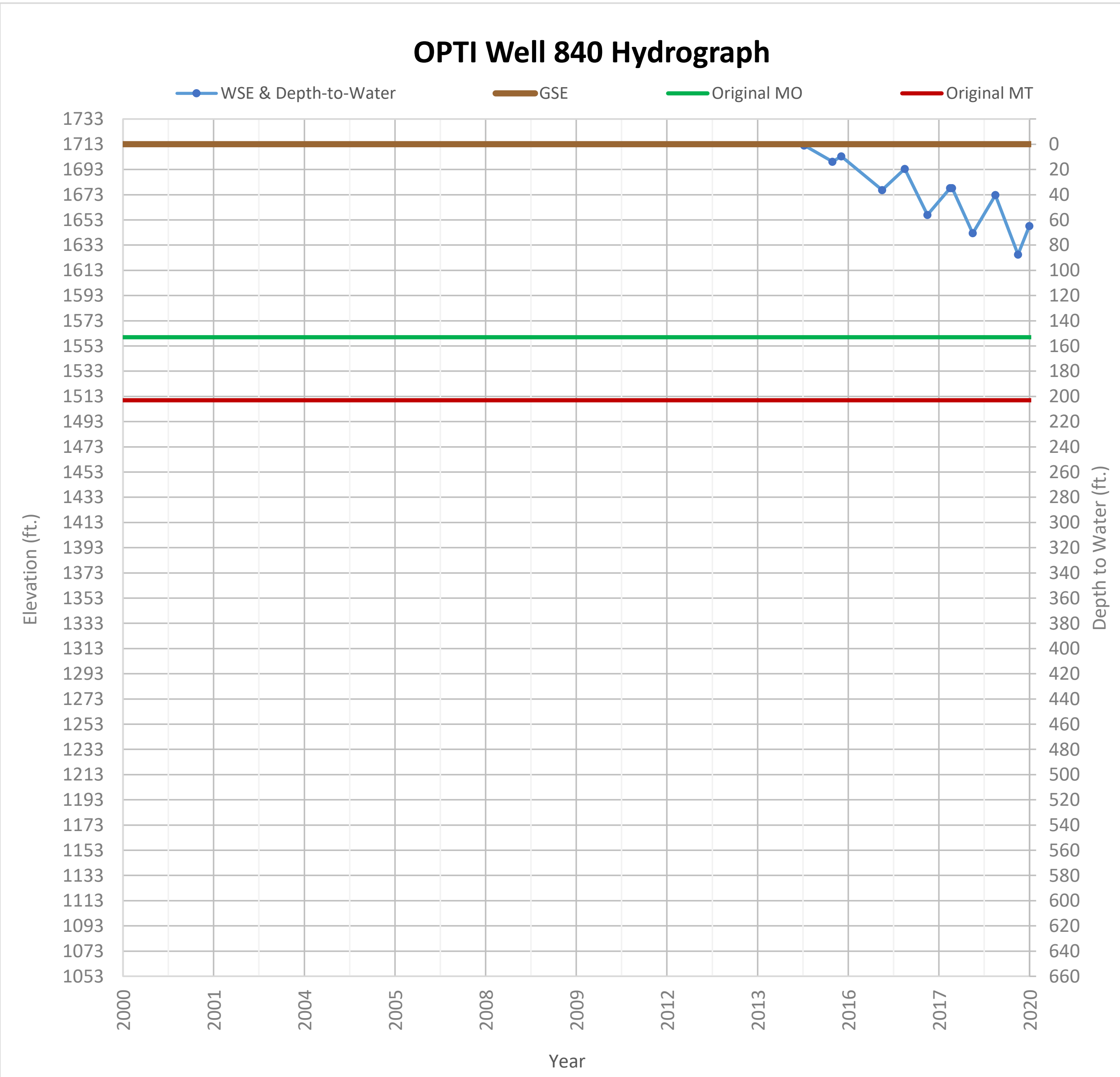
OPTI Well 833 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
1477
1457
1437
1417
1397
1377
1357
1337
1317
1297
1277
1257
1237
1217
1197
1177
1157
1137
1117
1097
1077
1057
1037
1017
997
977
957
937
917
897
877
857
837
817
797
0
20
40
60
80
100
120
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

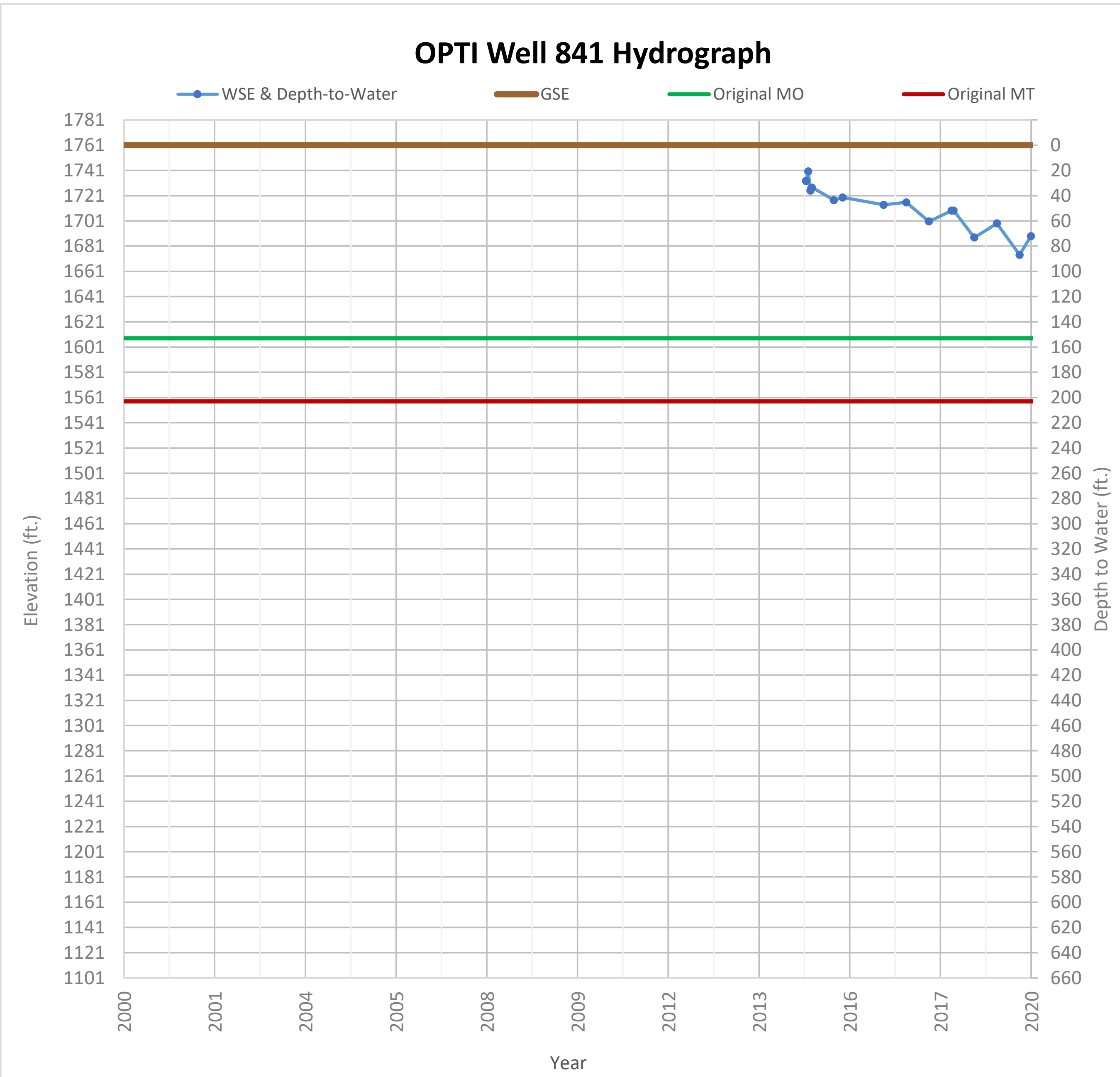

OPTI Well 834 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
1528
1508
1488
1468
1448
1428
1408
1388
1368
1348
1328
1308
1288
1268
1248
1228
1208
1188
1168
1148
1128
1108
1088
1068
1048
1028
1008
988
968
948
928
908
888
868
848
Depth to Water (ft.)
0
20
40
60
80
100
120
140
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020
Year

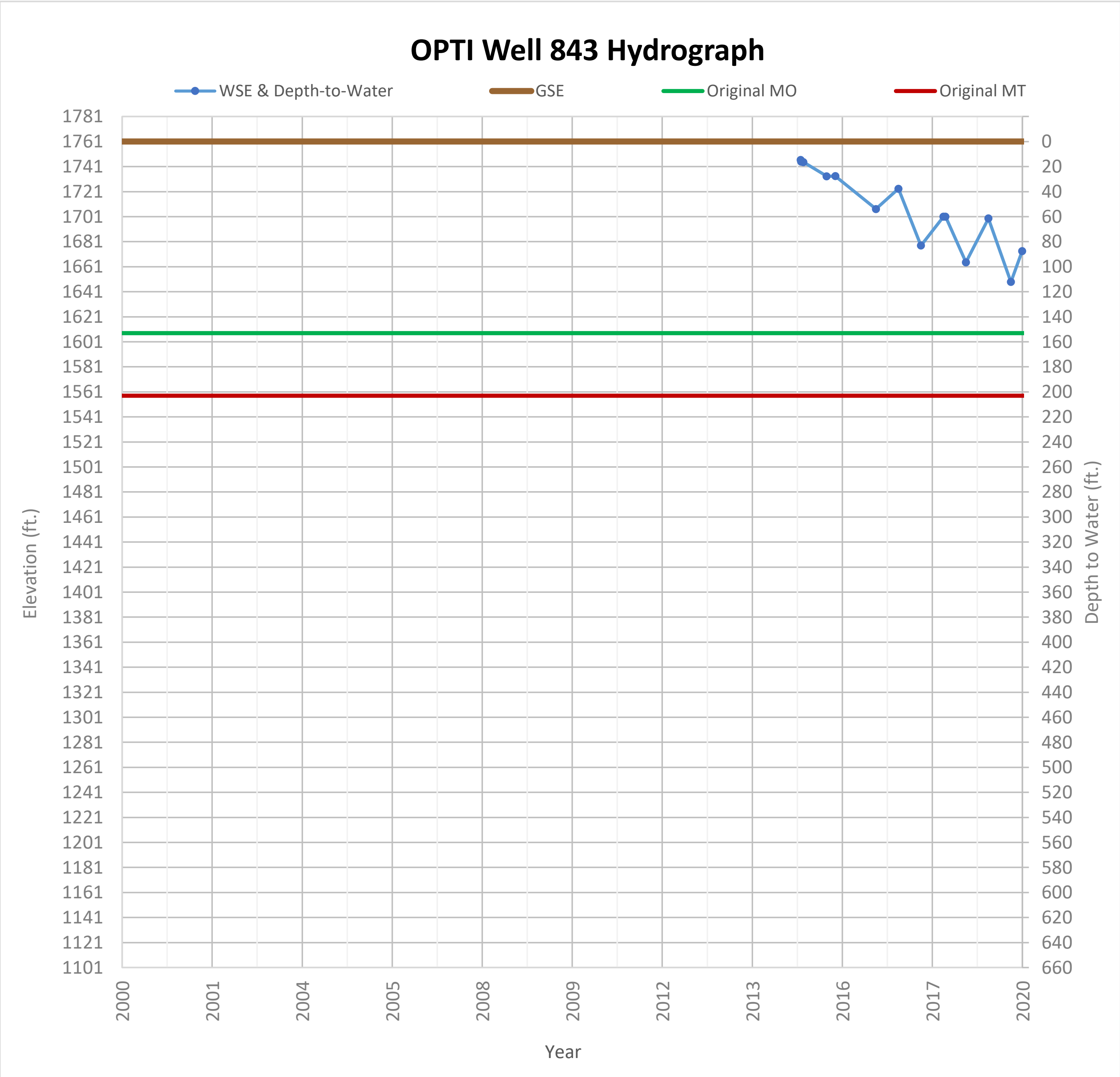

OPTI Well 835 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
1575
1555
1535
1515
1495
1475
1455
1435
1415
1395
1375
1355
1335
1315
1295
1275
1255
1235
1215
1195
1175
1155
1135
1115
1095
1075
1055
1035
1015
995
975
955
935
915
895
0
20
40
60
80
100
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

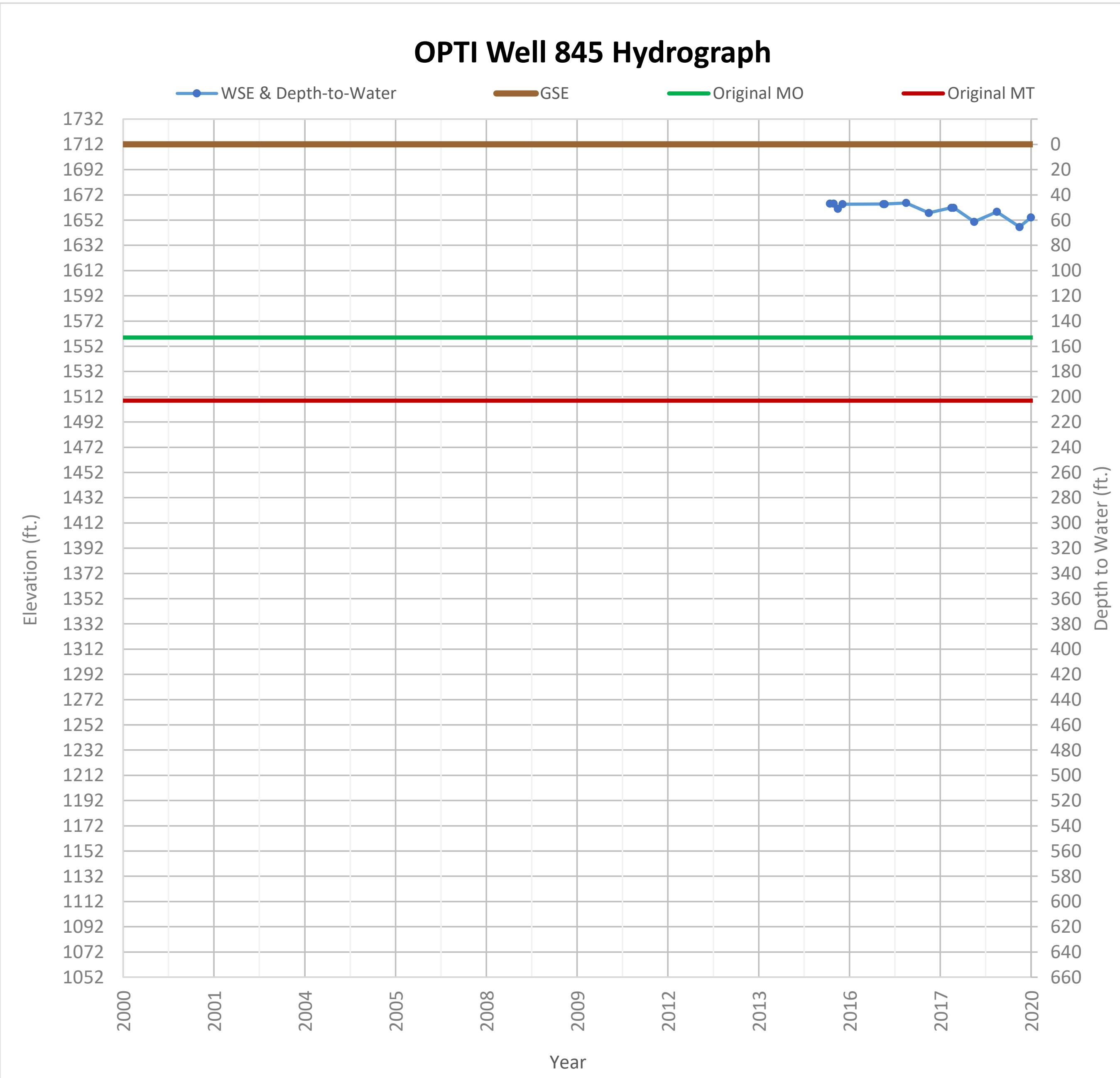


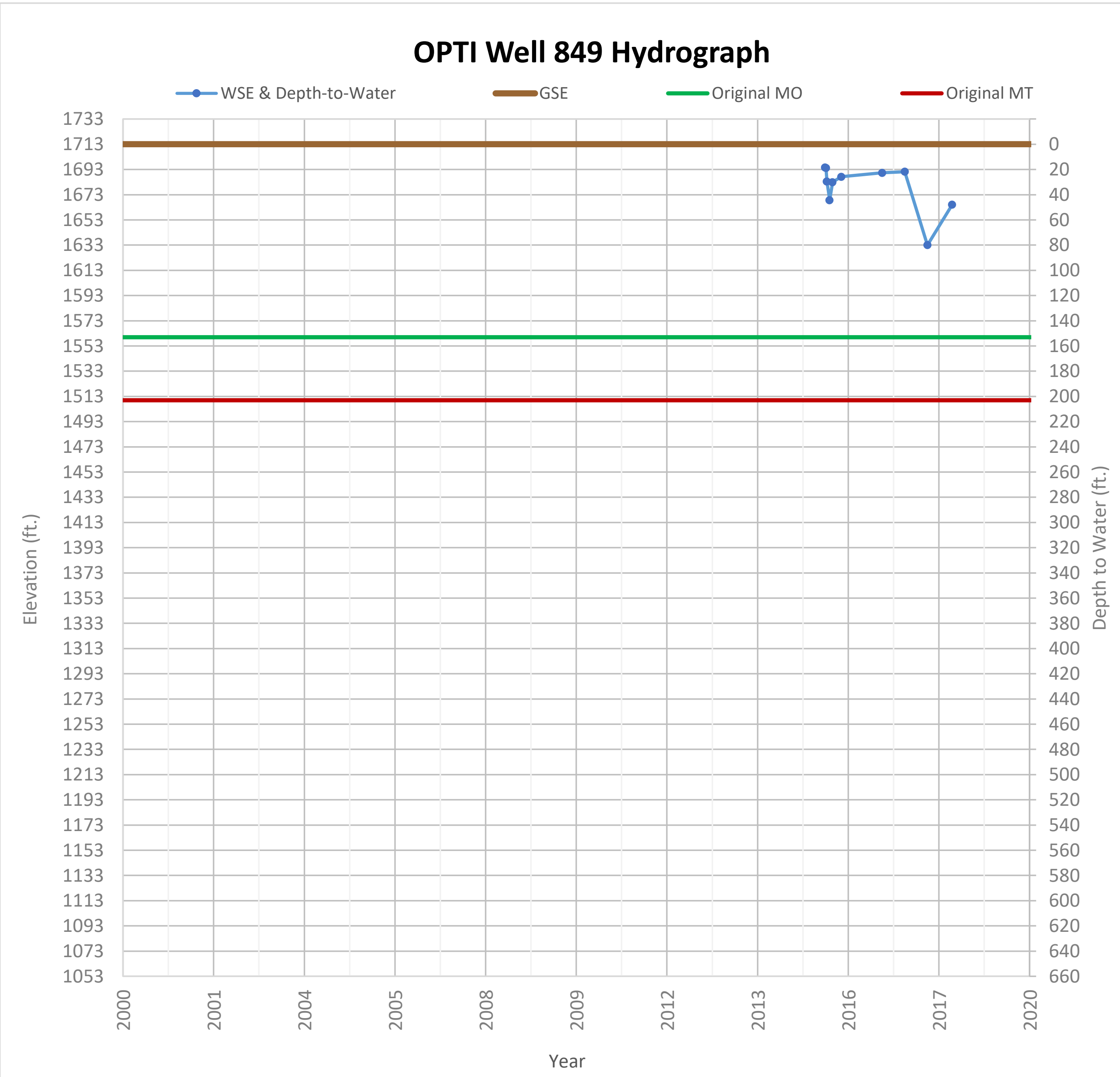
OPTI Well 836 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
1506
1486
1466
1446
1426
1406
1386
1366
1346
1326
1306
1286
1266
1246
1226
1206
1186
1166
1146
1126
1106
1086
1066
1046
1026
1006
986
966
946
926
906
886
866
846
826
Depth to Water (ft.)
0
20
40
60
80
100
120
140
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020
Year


OPTI Well 840 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
1733
1713
1693
1673
1653
1633
1613
1593
1573
1553
1533
1513
1493
1473
1453
1433
1413
1393
1373
1353
1333
1313
1293
1273
1253
1233
1213
1193
1173
1153
1133
1113
1093
1073
1053
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020


OPTI Well 841 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
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
1161
1141
1121
1101
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020


OPTI Well 843 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
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
1161
1141
1121
1101
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020
Year


OPTI Well 845 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
1732
1712
1692
1672
1652
1632
1612
1592
1572
1552
1532
1512
1492
1472
1452
1432
1412
1392
1372
1352
1332
1312
1292
1272
1252
1232
1212
1192
1172
1152
1132
1112
1092
1072
1052
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020


OPTI Well 849 Hydrograph
WSE & Depth-to-Water
GSE
Original MO
Original MT
Elevation (ft.)
Depth to Water (ft.)
Year
1733
1713
1693
1673
1653
1633
1613
1593
1573
1553
1533
1513
1493
1473
1453
1433
1413
1393
1373
1353
1333
1313
1293
1273
1253
1233
1213
1193
1173
1153
1133
1113
1093
1073
1053
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
2000
2001
2004
2005
2008
2009
2012
2013
2016
2017
2020

This page intentionally blank

Appendix B
Basin-Wide Economic Analysis Report

This page intentionally blank

F I N A L   R E P O R T

Direct Economic Impact Analysis of the Cuyama Groundwater Basin Groundwater Sustainability Plan Demand Management Program

Prepared for

Cuyama Basin Groundwater Sustainability Agency

December 19, 2019

Prepared by

ERA Economics LLC

ERA Economics
Environment • Resources • Agriculture

This page intentionally blank

Table of Contents

List of Figures

List of Tables

This page intentionally blank

1. Executive Summary

The Cuyama Basin Groundwater Sustainability Agency (CBGSA) has developed a Groundwater Sustainability Plan (GSP) designed to achieve groundwater sustainability in the Cuyama Basin by 2040. The GSP considers several elements of groundwater sustainability including groundwater overdraft. To address groundwater overdraft, the plan proposes a series of supply enhancement projects and demand management actions. Implementation of projects and demand management imposes direct costs on water users in the basin. This analysis establishes the direct economic impact of the demand management actions specified in the GSP. Water supply projects specified in the GSP are described, but the additional water supply and project costs are not included in this economic impact assessment.

Farming in the Cuyama Basin is characterized by high-value, organic specialty crops produced for a wide range of domestic and export markets. The basin includes vertically integrated carrot farming operations, organic specialty apple farms, new vineyards, and a mix of other row crops, grains, and hays. Agricultural value has been increasing in the basin over the last several decades in response to strong market conditions for the crops produced in the basin. This economic activity supports the local economy, providing jobs, income, and tax revenue to the greater four-county region (Kern, Santa Barbara, San Luis Obispo, and Ventura) overlying potions of the basin.

Direct economic impacts of the GSP are quantified using an economic model of the Cuyama Basin representing crops, water use, and market conditions in the area. The economic model is developed using information gathered for the GSP, interviews with local producers, UC Cooperative Extension studies, and various production and price datasets compiled by CDFA and USDA. The economic model is calibrated to the markets, conditions, and water supply availability in the Cuyama Basin. To analyze the effects of demand management, a simulation of Cuyama Basin agriculture between 2020 -2040 is developed in which water availability is restricted, and water supply costs change, according to the demand management actions outlined in the GSP. The differences between the results of the simulation and current conditions represent the impacts associated with demand management implementation.

Current agricultural groundwater pumping in the basin is approximately 60,000 AF per year. The demand management program specified in the GSP includes a phased implementation period to achieve a total reduction in agricultural groundwater pumping of 40,000 AF per year by 2040 (average annual pumping of 20,000 AF). The program applies to regions of the Cuyama Basin where overdraft is deemed to be critical, which is primarily in the Central threshold region. The program is designed to make tiered reductions over a sixteen-year period, beginning with a 5% (2,000 AF) reduction of total overdraft in each of the first two years, followed by a 6.5% reduction of total overdraft annually over the remaining fourteen years.

As a result of the demand management program the size of the agricultural industry in the basin contracts by approximately two-thirds. The demand management results in average annual gross revenue losses of $30 million. The present, discounted value of this stream of forgone revenue during the GSP implementation period equals $261 million in current dollars. When the demand management program is fully implemented in 2040, irrigated acres will have fallen 62%, annual gross revenue will have fallen 63%, and annual water use will have fallen 67%. Land idling as a result of the demand management program (not including any rotational fallowing) equals approximately 12,300 acres per year by 2040. Table ES-1 summarizes the economic impact results in terms of irrigated acreage (land idling), gross revenue, net revenue, and applied water (groundwater pumping).

Table ES-1. Cuyama Basin Demand Management Program Direct Economic Impact Summary

Impact Measure	Current	2020 - 2040 Average	Full Implementation (2040)
Irrigated Acres	18,300	12,800	7,000
Gross Revenue (millions)	$121	$91	$45
Net Revenue (millions)	$31	$23	$12
Applied Water (AF)	60,000	40,000	20,000

In addition to a reduction in the quantity of groundwater that can be pumped, the GSP imposes additional administrative costs that increase water costs in the basin. Reduced water availability and higher costs reduce net revenue and affect the relative shares of crops grown in the basin. Typically, lower value crops, including grains and hays in the basin, are significantly impacted because these crops have limited ability and willingness to pay for water. Higher-value vegetables and perennial crops are able to absorb small changes in water cost. However, the magnitude of the demand management program in the basin (reducing pumping by 67%) results in significant losses in these crops as well. As a result, net revenues per acre fall as water costs increase and the basin crop mix shifts towards crops that generate greater returns to water.

The Cuyama Basin economy is heavily dependent on farming and related activities. This (direct) impact analysis only considered the impact of the demand management program on primary farming activities. The average annual losses of $30 million estimated in this analysis would have significant secondary (also called “multiplier” or “indirect and induced”) effects in the local economy. This includes retailers who sell inputs to producers and processors who handle the raw agricultural products produced in the basin. Local businesses will also see an impact as the individuals who work for farms and ancillary industries are forced to find work elsewhere. Exact quantification of these impacts to regional jobs, labor income (wages), and local tax revenues that support other public services in the area is a natural extension of this direct impact analysis.

Potential options for reducing economic costs are identified in the analysis. Examples include delayed pumping reduction schedules, inter-region water trading, flexibility in pumping reduction schedules, and value-based groundwater allocations. For example, delaying the pumping reduction schedule may allow producers to recover capital investments, avoid rapid changes in the agricultural footprint, and provide jobs, income, and tax revenue for the local economy. Detailed analysis of these options is a second natural extension of this study.

2. Introduction

The Cuyama Basin Groundwater Sustainability Agency (CBGSA) has prepared a draft Groundwater Sustainability Plan (GSP). The GSP provides a list of projects and management actions that may be implemented to ensure the basin achieves groundwater sustainability by 2040. Initial estimates indicate that groundwater pumping reductions on the order of 50 to 67 percent may be required to achieve sustainability in parts of the basin. This magnitude of reduction will undoubtably change the economic conditions within the basin. In order to understand what future conditions in the basin will look like, assess the magnitude of potential economic impacts, and identify ways to minimize adjustment costs, the CBGSA commissioned this economic analysis of the effects the proposed GSP on the basin.

The goal of the CBGSA GSP is to provide a framework for achieving groundwater sustainability while minimizing the economic and social consequences of any necessary reductions in agricultural production. Implementation of the GSP will include possible projects and demand management actions that over time will balance the water budget within the basin. Projects are implemented to increase water supply in the basin. Demand management actions are programs designed to reduce pumping that, together with basin projects, ensure that basin groundwater pumping is sustainable. This report focuses on the impacts of the demand management program; however, preliminary analysis of proposed projects showed relatively small changes in the outcomes presented in this report resulting from project implementation.

This analysis concludes that GSP implementation will have substantial direct impacts on the economic footprint of agriculture in the basin. Results are presented in terms of five key measures of direct impact that are either directly relevant for current policy/planning purposes (e.g. rate studies, feasibility studies, grant applications) or feed naturally into additional analysis of secondary impacts in the basin and local economy:

- Land idling as a result of the demand management program over the 2020 – 2040 implementation period
- Change in crop mix in response to changes in water supply availability and cost, and the resulting effect of the shift in crop mix on basin agricultural value
- The total cost of water and any changes in regional applied water demands; changes in water cost include GSP administration costs, demand management administration cost, and the effect of changes in pumping lift on irrigation variable costs
- Change in gross agricultural returns as a result of land idling, market conditions, and shifts in the crop mix
- Change in net agricultural returns as a result of land idling, water costs, other administrative costs, market conditions, and shifts in the crop mix

The report is structured as follows. The following section describes the current economic footprint of agriculture in the basin and the drivers behind its value. This is followed by an overview of management actions outlined in the GSP. The next sections present the methods and results of the economic impact analysis of the GSP. A concluding section summarizes limitations and extensions of this initial work. Additional details on the technical approach to the analysis are included in a technical appendix.

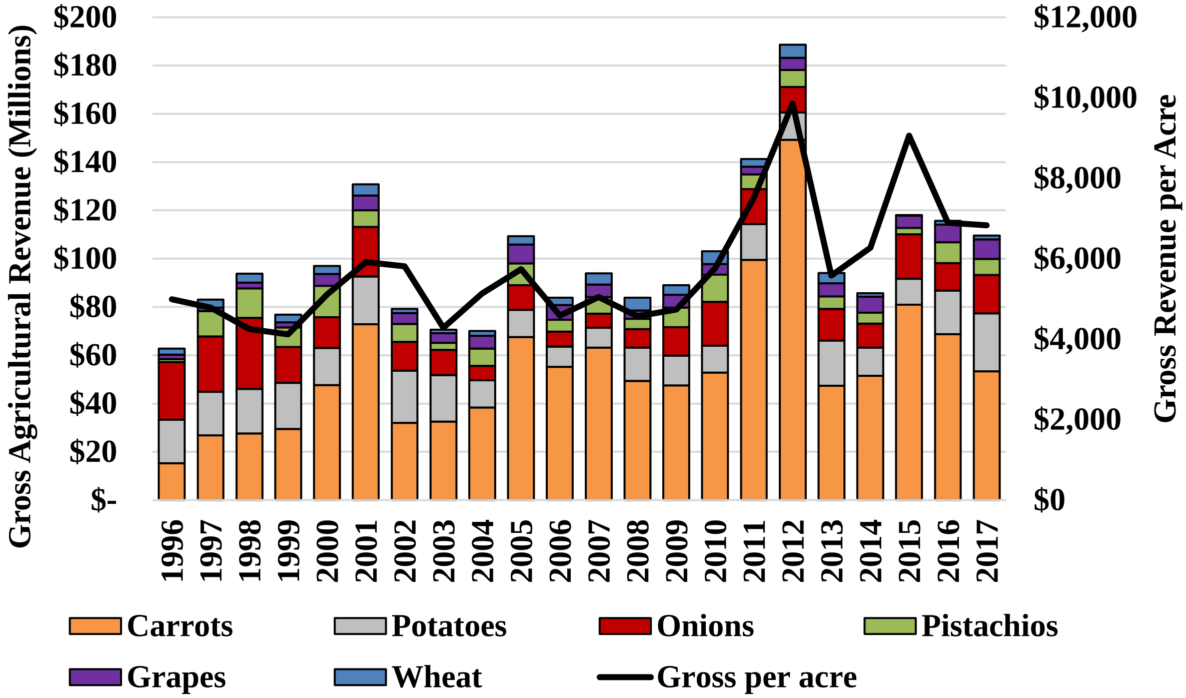
3. Economic Contribution of Agriculture

Agriculture is the most important industry in the Cuyama Basin. Historically the basin has benefited from a large oil and gas field; however, since 2008 few wells have remained in production, making agriculture the dominant industry in the region. Three unincorporated communities in the basin are recognized by the state as Economically Disadvantaged Communities (DACs).

In 2016 the Cuyama Basin had a total of 32,294 acres of irrigable land. Of this total, only 50% (16,045 acres) was actively being used for crop production. High value vegetable crops account for roughly three quarters of the basin's acreage. Carrots, which the basin is known for, are commonly rotated with onions and potatoes. Other crops like wine grapes, pistachios, apples, and wheat make up the remaining agriculture in the region. Apples historically held a larger share of acreage in the basin, but changes in market conditions have caused production to shift to the Pacific Northwest. Other perennial crops such as pistachios and olives have increased in recent years. Wine grape acreage has also increased significantly in recent years, including the establishment of an 800-acre vineyard in 2018.

The gross value (gross farm revenue) of crops produced in the Cuyama Basin was estimated at approximately $110 million in 2017. Between 1996 and 2017 value increased 75%, from $63 million to $110 million. Figure 1 illustrates trends in the gross value of agriculture in the basin between 1996 and 2017, grouped into six crop categories. Carrots make up the bulk of the revenue in the region. In 2017, carrots made up 49% of production value, potatoes made 22% of production value, and onions made up 14% of production value. The remainder of agricultural value came from three smaller crop groups: wine grapes (7%), pistachios and other orchards (6%), and wheat (2%). Figure 1 also illustrates a modest increase in production value per acre, consistent with trends across the state. Production value per acre is similar to nearby production regions in the Central Valley such as Kern County and is well above the statewide average of $4,000 per acre in 2017 (NASS).

Figure 1. Production Value and Value per Acre, 1996-2017 (in millions of 2018$)



Source: Calculations using USDA National Agricultural Statistics Service and GSP Acreage Data

Positive trends in markets and price, increased yields, and widespread changes in production practices have also benefitted the basin. Carrot yields were 50% higher in 2017 than they were in 1996 with prices being only 10% lower. At the same time, producers have shifted a large share of acreage to organic production. Apple growers raise special fresh market varieties branded with the name of the basin. Grape production has expanded, with over 15 varieties of wine grapes produced for regional wine markets. These investments have created a reputation for Cuyama as a region with high quality agricultural products.

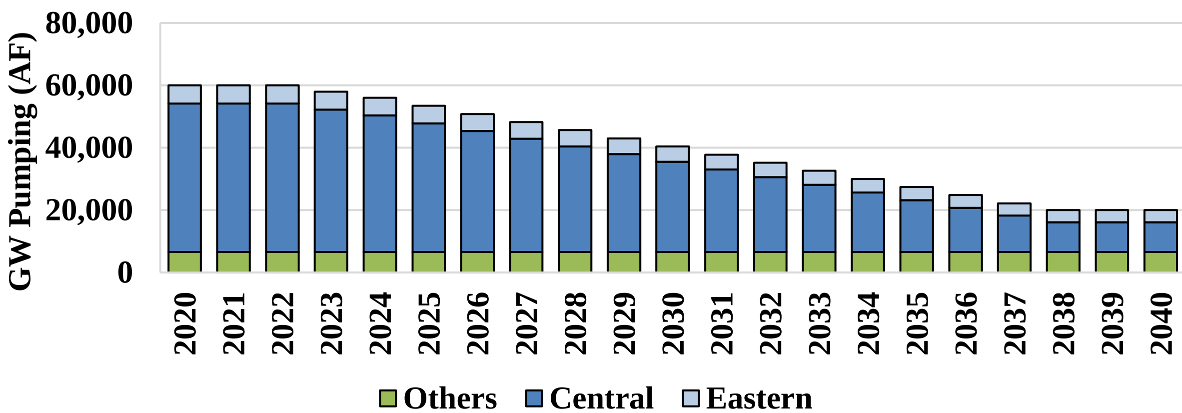
In addition to direct contribution from agricultural revenue, agriculture also provides secondary contributions to the basin local economy and surrounding areas. These indirect and induced benefits include the other income and jobs created by farm spending, additional income and jobs supported by the employed individuals, and the tax revenue created by all of this economic activity. Using default, uncalibrated economic data suggests that basin farming supports more than 1,150 full time equivalent jobs (2,300 – 3,500 seasonal jobs). A detailed assessment of the contribution of basin farming to regional jobs is beyond the scope of this direct impact analysis. A more detailed assessment of the secondary effects of basin agriculture, contribution to the regional economy, and evaluation of secondary impacts is recommended under subsequent analysis (see Section 7).

4. Cuyama Basin GSP Overview

The Sustainable Groundwater Management Act (SGMA) requires that sustainable management of groundwater be achieved by 2040, which is defined as avoiding six impacts of groundwater overdraft. The GSP identifies five sustainability indicators, most of which are expressed in terms of changes in groundwater levels or storage. The basin is divided into six threshold regions[1] for the purposes of identifying and quantifying sustainability criteria. In order to achieve and maintain sustainability, the GSP includes a mix of demand management (pumping restrictions) and supply enhancement projects to bring pumping in balance with the sustainable yield. The sustainable yield is the estimated annual groundwater pumping the basin can sustain without causing one or more of the six impacts. The GSP estimates sustainable yield in the basin to be 20,000 AF per year. Currently, agricultural users in the basin pump 60,000 AF per year creating an overdraft of 40,000 AF[2] per year.

The CBGSA plans to reduce groundwater pumping by 40,000 AF per year by implementing a demand management program. This program will only be implemented in the Central and Eastern regions of the basin, because these are the only regions with projected overdraft. The program is implemented over a sixteen-year period, beginning with a 5% (2,000 AF) reduction of total overdraft in each of the first two years, followed by a 6.5% reduction of total overdraft annually over the remaining fourteen years. Reductions in the Central region will account for 95% (38,000 AF) of overdraft and reductions may be enforced in the Eastern region to make up the other 5% (2,000 AF). This equates to annual reductions in the Central region of 1,900 AF in each of the first two years and 2,470 AF in each of the following fourteen. In the Eastern region, annual reductions of 100 AF are required in each of the first two years and 130 AF in each of the following fourteen. A regional visualization of these reductions is shown in Figure 2 below.

Figure 2. Proposed Groundwater Pumping Reductions

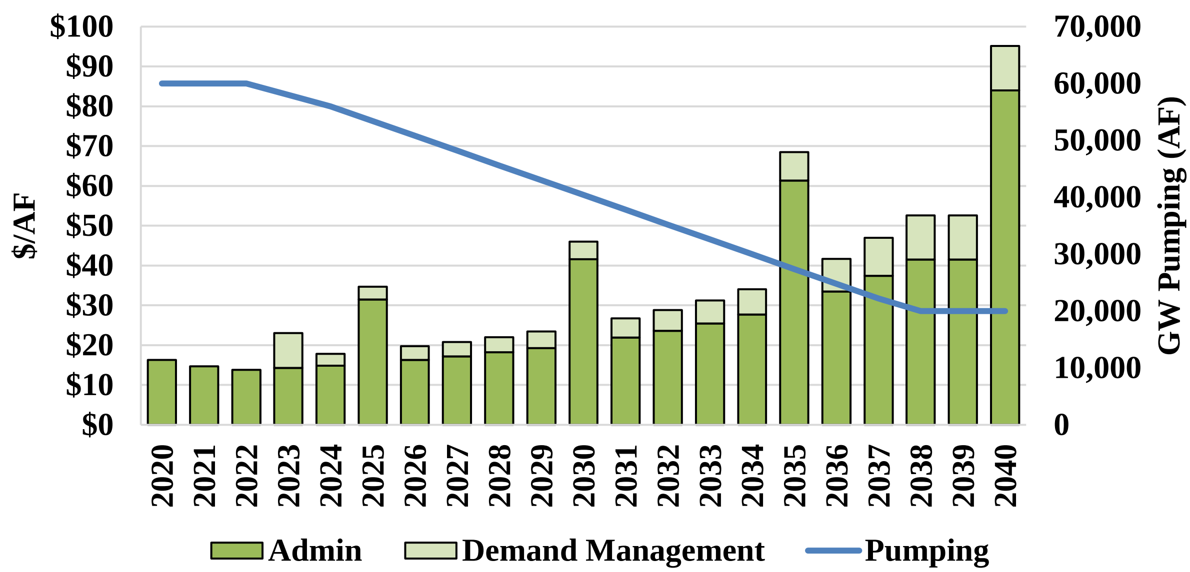


[1] Regions are defined in Section 5.2.1 of the GSP and include the Central, Eastern, Northwestern, Western, Southeastern, and Badlands threshold regions. Most irrigated agriculture is in the Central region. The Badlands regions includes no irrigated agriculture and is excluded from the analysis.

[2] All water quantities shown in this analysis are gross applied water values.

Demand management and GSP administration will impose direct costs on water users in the basin. These costs are calculated over the GSP implementation timeline (2020-2040) and broken down by individual activity. Administrative costs for the GSP plus any demand management program administration costs are approximately $1 million annually, to be raised by an assessment on each acre foot of groundwater that agricultural users withdraw. These costs include the administration[3] of the GSP and the demand management program, and do not include any additional fees or direct costs associated with the demand management program (e.g. cost of land idling). GSP administration costs are the same for all groundwater pumpers in the basin. Demand management program administration costs would be covered by the Central and Eastern regions. Figure 3 illustrates the timeline of administration costs over the GSP implementation period. Administrative costs range from $16 to $90 per AF pumped[4]. This increase is driven by the decrease in total AF pumped in the basin. However, the GSP has not specified a final schedule of fees needed to cover these costs.

Figure 3. GSP Implementation Costs per Acre Foot Pumped (2018$)



5. GSP Direct Economic Impact Analysis Methodology

The direct economic impacts of changes in water use and costs caused by the GSP demand management program are estimated using an economic model of basin agriculture and water use. This section provides a brief overview of the economic model and Appendix A provides additional technical details. The economic model calibrates to current market conditions and water use in the basin. It is used to simulate the response of the agricultural sector to changes in groundwater availability and cost imposed by the GSP. The basic assumptions of the model

---

[3] GSP administration includes annual and 5-year updates, and all required technical analysis, to the GSP to comply with the GSP regulations.
[4] These values do not reflect the total cost to producers to pump groundwater, which also includes the cost of extraction (well capital, operating, and maintenance costs for pumping).

follow standard economic practice. Producers maximize profit by producing the crops that provide the greatest return subject to costs, resources, and other technical constraints. Producers sell to a competitive market and are therefore unable to have much or any effect on the price of the product.

The diverse mix of crops grown in the basin were grouped into six crop categories (groups) for the purposes of the direct impact analysis. Costs and returns for each crop group were defined by the characteristics of a proxy crop chosen to represent all production in the crop group. Proxy crops identified for the analysis include carrots, onions, potatoes, wheat (grains and other misc. hays), pistachios, and grapes. The six crops chosen as proxy crops represent 80% of basin acreage and 84% of basin value. Table 1A in Appendix A summarizes each crop group and proxy crop.

Irrigated acreage in the basin varies from year-to-year due to market conditions, rotations, and variability in weather. The economic model was calibrated to average annual cropping patterns using the period 2010 – 2018. Trends in permanent crop plantings since 1994 were reviewed to assess establishment patterns, and capital outlays for establishment costs. Perennial crops, including pistachios, apples, and olives, have long productive economic life cycles, roughly 40 years, and establishment costs are spread across this life cycle. For a crop like pistachios, recouping establishment costs can be more than 10% of annual production costs. Fallowing an orchard early creates a significant loss in investment, therefore this acreage is less responsive to changes in the cost of water.

Land use and production information was also used to infer (calculate) other technical characteristics of crop production in the basin that are not easily represented in observed farming costs and revenues. For example, factors such as risk aversion, unique soil or microclimate, labor availability, and producer skill/preferences affect regional farming, profitability, and response to changes in water availability and cost. Appendix A provides an overview of how these factors are represented in an economic model, as well as the data used to characterize market supply and demand in the basin.

6. Cuyama Basin GSP Direct Economic Impacts

The economic model is used to estimate the direct effect of the GSP demand management program on agriculture in the subbasin. Direct impacts are a result of reduced water availability (under the demand management program) and higher water costs (as a result of GSP and demand management program administrative fees). As water scarcity increases, the mix of crops grown in the basin adjusts, land idling increases, and farm gross and net revenues fall. All dollar impacts are expressed in constant 2018 dollars, indexed using the GDP Implicit Price Deflator. Economic impacts are expressed in the following terms and summarized in Table 1:

- Gross crop revenue
- Net crop revenue

- Irrigated acreage and changes in the crop mix
- Land idling
- Groundwater pumping costs and the opportunity cost of land idling

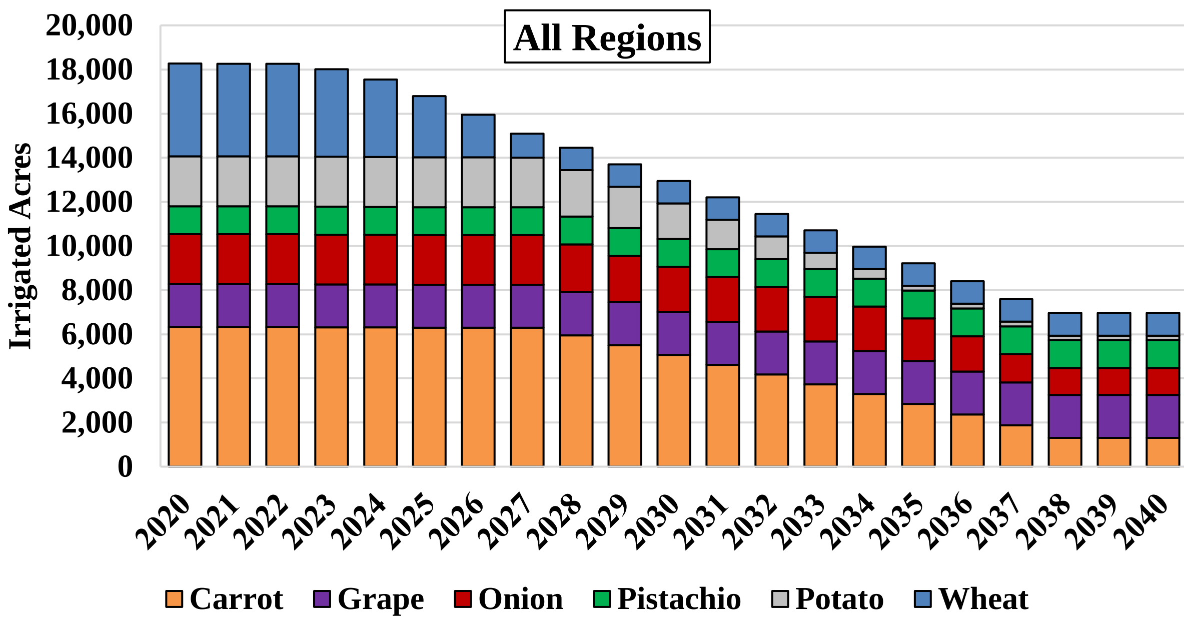
Table 1. Cuyama Basin Economic Impact Summary

Impact Measure	Units	Current	2020 - 2040 Average	Full Implementation (2040)	Percent Change (2040)
Gross Revenue	$M	$121	$91	$45	**(63%)**
Net Revenue	$M	$31	$23	$12	**(63%)**
Irrigated Acres	Acres	18,300	12,800	7,000	**(62%)**
Land Idling	Acres	0	5,500	11,300	
Applied Water	AF	60,000	40,000	20,000	**(66%)**
Pumping Cost	$/AF	$98	$110	$137	**40%**
Land Idling Cost	$/AF	$0	$263	$484	**-**

The costs of the demand management program to the basin are estimated to average $30 million per year, increase nonlinearly over time, and will reach $76 million per year in 2040 at full implementation. This is a 63% decrease in farm revenue over current conditions. These changes are non-linear, reflecting the phase-in period of the demand management program with small annual changes at the beginning of implementation and large annual value differences near the end of implementation. The present, discounted value of this stream of forgone gross revenue during the implementation period equals $261 million in current dollars. This revenue loss is a result of the land idling that occurs as groundwater pumping is gradually reduced.

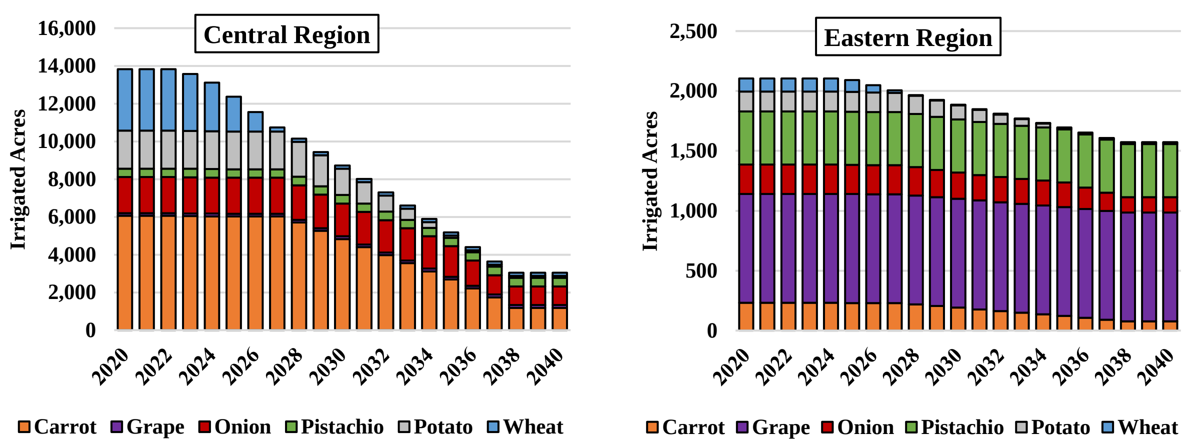
Total irrigated acreage in the basin declines from 18,264 acres to 6,960 acres, with significant changes occurring in the Central and Eastern regions. Under the demand management program specified in the GSP, by 2040 the Central region is only expected to have 3,048 acres in production, 22% of its current acreage. In the Eastern region, where demand management is more modest, there is an estimated 1,572 irrigated acres by 2040, or about 75% of its current acreage. Changes in permanent crops are more modest due to the significant capital investment in these lands. Most of the acreage decline comes from the carrots, other vegetables, rotational crops, and wheat/hay crop groups. Figure 4 illustrates changes in acreage by year for the entire basin. Wheat acreage is most affected early, followed by carrots and potatoes which begin to decline in about 2028.

Figure 4. Estimated Acreage by Crop Group, 2020-2040



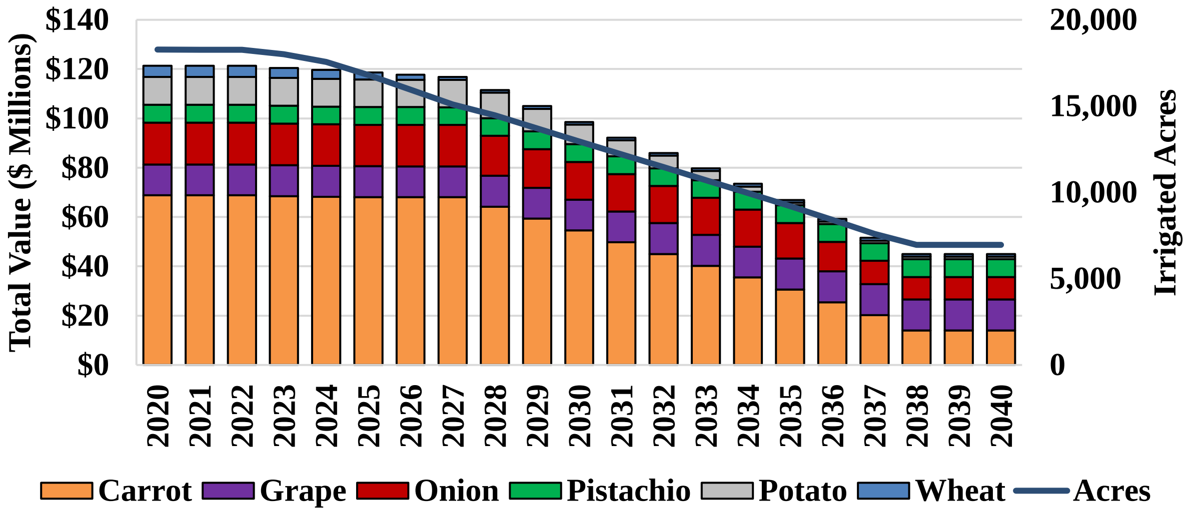
All basin crops are affected as water use is reduced, but the impact is not distributed evenly across crops, or across threshold regions in the basin. Carrots decline the most by 2040, dropping from 35% of basin acreage today to less than 18% by 2040. This is because carrots (and other rotational crops) account for a significant share of current groundwater pumping in the Central region. The reduction in grain/hay (wheat crop group) acreage is more modest, falling by around 33%, because much of its irrigated area is not in the Central and Eastern regions subject to the demand management program. Wheat acreage within the Central region falls by 95%. The share of permanent crop acreage in the basin increases from 18% to 46% by 2040, not because more acreage is planted, but rather because acreage remains more stable as other crop acreage declines. Figure 5 illustrates the change in crop mix in the Central and Eastern regions.

Figure 5. Estimated Acreage by Region and Crop Group, 2020-2040



While annual declines in acreage remain somewhat constant during the GSP implementation period, the decline in value of production is modest in early years but becomes more significant later. In response to higher water costs and increasing scarcity, lower return (low value per unit water) crops are typically idled first. Figure 5 illustrates the decline in value (gross revenue), which is initially small, but increases rapidly as progressively more valuable crops must be taken out of production. By 2040, carrots are still the highest-value crop in the region, however the share of total value is spread much more evenly across crop groups. A reduction of this magnitude in irrigated acreage in the basin would have additional impacts on farming operations. In particular, the ability to maintain a minimum viable industry scale is not guaranteed. Vertically integrated farming operations may consider moving production to other regions in the state, and this would have additional impacts in addition to the direct impacts shown in Figure 6. These secondary impacts can be evaluated under subsequent analyses.

Figure 6. Estimated Value by Crop Group, 2020-2040 (in millions of 2018$)



Net farm revenues in the basin are also affected as a result of reduced acreage, changes in water costs, yields, and cultural practices. For example, pumping limits could cause some growers to invest in technology to optimize water[5] and other input use efficiency. Table 2 below summarizes changes in average net revenue per acre by crop group under current conditions (2020) and at full implementation of the demand management program (2040). Net revenues are based on basin average returns and correspond to the return over operating costs (not including any amortized capital costs). On a percentage basis, the decline in net revenue per acre is largest for wheat, grapes, and potatoes. In contrast, carrots, onions, and pistachios decline by less than 2 percent. Total net revenue declines by 63% percent from $31 million to $12 million.

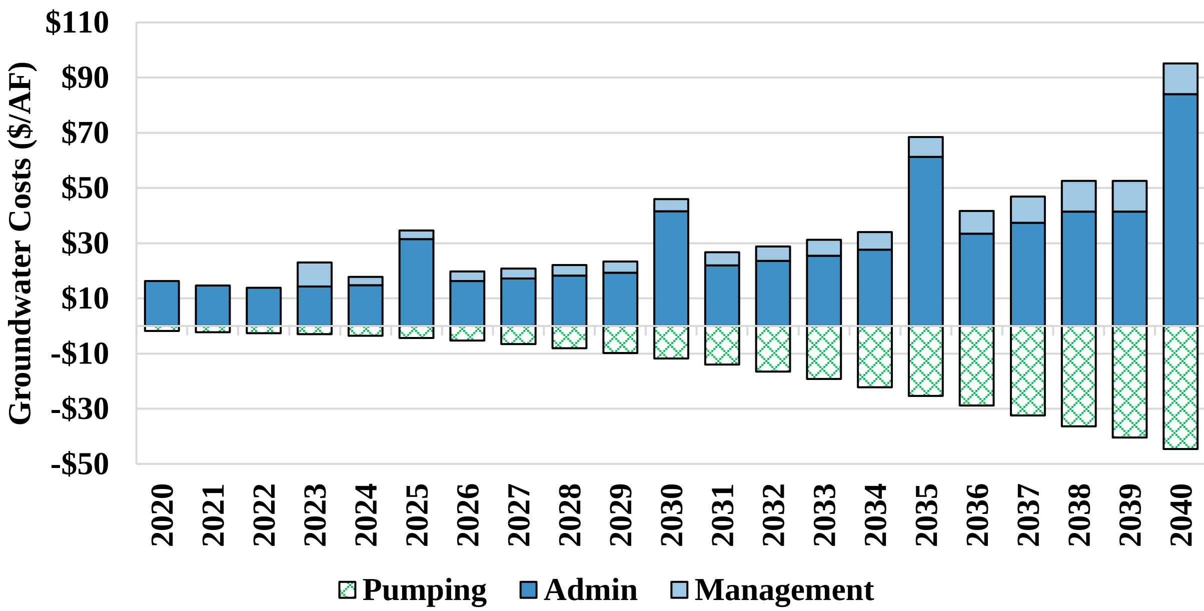
[5] Pumping reductions specified in the demand management program are expressed in terms of applied water, and therefore account for any return flows. An improvement in water use efficiency only adds groundwater to the basin if it reduces crop consumptive water use.

Table 2. Change in Net Revenue by Crop Group, 2020-2040 (2018$)

	Carrot	Grape	Onion	Pistachio	Potato	Wheat
Per Acre Change						
2020	$2,680	$755	$2,455	$2,615	$1,260	$375
2040	$2,635	$720	$2,410	$2,570	$1,210	$355
Change	**(1.6%)**	**(5.1%)**	**(1.9%)**	**(1.7%)**	**(3.7%)**	**(5.4%)**
Total Change (millions)						
2020	$16.8	$1.5	$5.5	$3.3	$2.8	$1.5
2040	$3.3	$1.4	$2.9	$3.2	$0.3	$0.4
Change	**(80.4%)**	**(6.7%)**	**(47.3%)**	**(3.0%)**	**(89.3%)**	**(73.3%)**

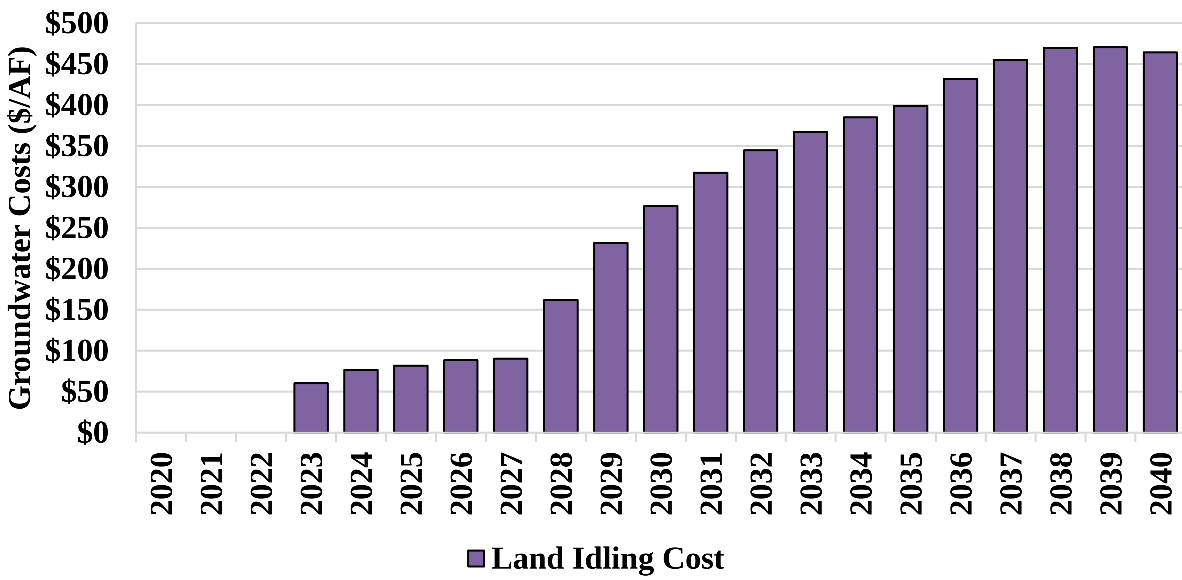
As the GSP demand management program is implemented, the cost of water per AF changes for two reasons. First, the cost of GSP implementation (administration for the GSP and the demand management program) is spread over smaller volumes of pumped water, so the cost per AF rises. Second, reduced pumping improves groundwater storage and reduces depth to water. Changes in pumping depths are estimated using the relationship between historical overdraft and depth to groundwater as reported in the GSP. These two effects somewhat offset and are presented for the Central region in Figure 7 below. The GSP administration (admin) and demand management program administrative (management) costs are shown as positive values, and the cross-hatched areas represent the reduced pumping lift and cost (shown as a negative cost savings). The net effect of the GSP demand management program is an increase in the cost of groundwater to irrigators in the basin.

Figure 7. Estimated Groundwater Pumping Costs, Central Region



In addition to the changes in water costs, groundwater pumpers in the basin also incur a cost per acre foot of forgone net revenue, otherwise known as the opportunity cost. This opportunity cost is equal to the loss in net revenue as a result of land idling and changes in crop mix divided by the quantity of groundwater pumped. Therefore, this cost increases over the implementation period for two reasons. First, the quantity of water pumped is reduced as the demand management program is implemented. Second, the cost of land idling increases with the magnitude of the demand reduction as increasingly more valuable land/crops are removed from production (see Figures 4 and 6, above). The net effect of the demand management program is an increase in land idling, which is reflected in increasing groundwater cost (see Figure 7).

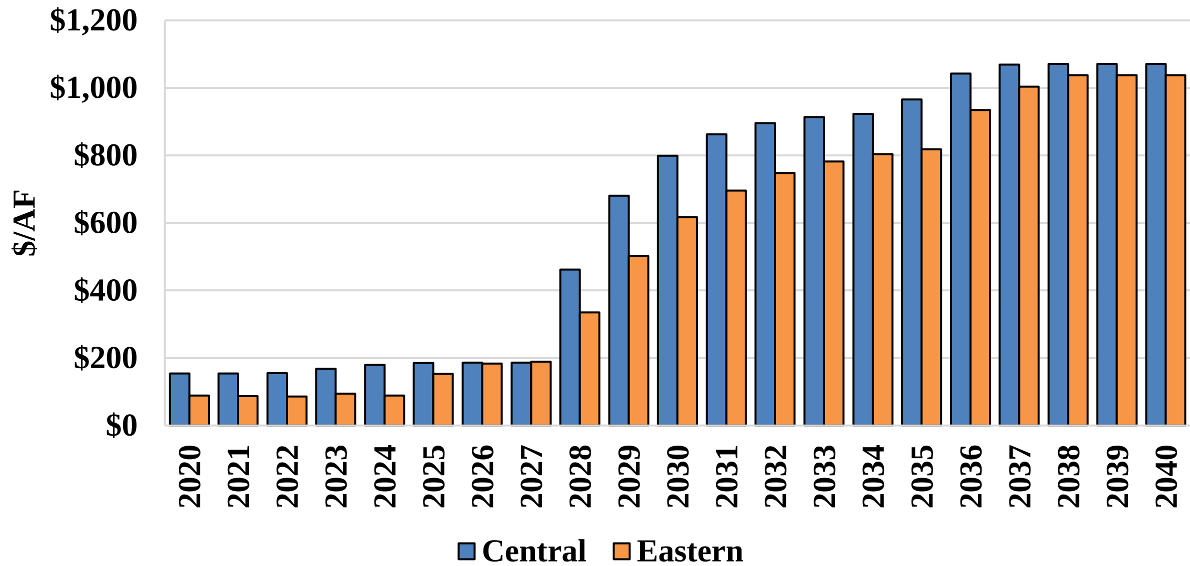
Figure 8. Estimated Opportunity Cost of Implementation, Central Region



The value of water in different regions of the basin increases significantly as the demand management program is implemented (scarcity increases). The increasing value of water is important for broader planning purposes, in particular comparing the benefit of avoiding additional demand management against the cost of implementing capital water supply projects in the basin. The incremental value of water is the value in production of one additional AF of water. The value of an additional AF is not to be confused with the price or cost of water, rather it is the incremental benefit that the basin would receive if another unit of water was available. This value can also be thought of as the amount a producer would be willing to pay for one additional unit of water.

The incremental value of water is calculated using the economic model over the implementation period. The value varies by region in responses to difference in the economic return to water across the basin and is greatest in the Central and Eastern regions. Figure 9 illustrates values in these regions over the implementation period. A notable change in water value occurs between 2027 and 2028. This is the point during the GSP implementation period when the required groundwater pumping reduction starts to affect higher-valued annual crops (e.g. carrots, other vegetable crops). That is, many of the crops/land that generates lower return to water has already been idled. By 2040 the incremental value of water exceeds $1,000 per AF in both the Central and Eastern regions. This value likely exceeds the current average return to water for many crops and growers – instead it represents the most valuable use of new water after the cuts imposed by full implementation of GSP demand management. The incremental value of water is below $200 per AF in the other regions that are not affected by the demand management program. These values are generally comparable, slightly above, values observed in other agricultural areas in the state.

Figure 9. Incremental Value of Additional Water, Central and Eastern Regions (2018$)



The net effect of the GSP demand management program and associated GSP administrative costs is a reduction in the economic footprint of basin agriculture by more than two-thirds. This would have profound effects on the basin local economy, and the broader regional economy. Impacts increase non-linearly over the implementation period, equaling $73 million per year by 2040, or over $261 million in present value over the implementation period. The incremental value of water under the demand management program exceeds $1,000 per AF at full implementation, suggesting that some water supply projects may be an economically feasible way to reduce overall implementation costs. Additional suggestions for reducing demand management program implementation costs are summarized under Section 7, below.

7. Other Considerations, Limitations, and Extensions

Quantification of direct impacts supports GSP implementation planning, however consideration of elements outside of the scope of this analysis may be equally important in protecting broader welfare considerations for basin growers, workers, and disadvantaged communities. This section provides a brief discussion of other considerations that were raised by stakeholders during interviews and meetings. These include limitations and scalability of the economic model, multiplier effects (the indirect and induced impacts resulting from the direct impacts), and resource and environmental externalities (third-party costs) created or mitigated by agriculture in the basin.

The economic model used here is based on and calibrated to recent information on agricultural production in the basin. To the extent that projected conditions fall far outside what has been recently observed, the model may not capture all the impacts. A reduction in gross economic value as great as the one projected in this analysis may cause changes that the model is not able to forecast. For example, viable farming operations require a minimum scale to continue operating, which may be approached or exceeded under the demand management program. Additionally, acreage is concentrated among a few producers in a relatively small area in the basin. As a result, this may cause sudden changes rather than the gradual shifts projected in the model.

The economic analysis used estimates of projected pumping reductions described in the GSP that are based on the best available data and information as of June 2018. As noted in the GSP, it is expected that the groundwater model will be refined in the future as improved and updated monitoring information becomes in the Basin. These refinements may result in changes in the sustainable yield estimates included in the GSP and consequently would affect the results of this economic impact analysis.

A natural extension to the analysis provided here would be a multiplier analysis of indirect and induced (secondary) economic impacts. However, off-the-shelf impact multiplier models often prove to be inadequate for estimating indirect and induced impacts in small regions undergoing large changes. They do not incorporate site-specific information on labor and production practices or on relationships among sectors. In addition, such models assume proportionality between direct and indirect impacts and cannot assess the effect of major structural economic changes. A careful and policy-relevant analysis of the total impact this type of shift would require more detailed information on the labor practices within the basin, dependence of forward-linked industries (e.g., processors) on products from the basin, and the dependence of related industries on economic activity generated by agriculture in the basin. The CBGSA is currently evaluating options to commission this additional analysis.

Finally, this analysis does not assess changes to environmental, natural, and cultural resources within and outside the basin. These changes create both economic and non-economic costs and benefits. Changes include but are not limited to improved water quality, preservation or loss of open space, and cultural and social changes that could result from population leaving the basin. These externalities associated with groundwater pumping in the basin are an additional consideration in overall basin sustainability.

The current demand management program is a conservative approach to achieving sustainability in the basin. Future analysis could explore policy alternatives to the demand management program that reduce the direct economic impact of implementation in the basin. Examples of possible value enhancing policies identified through this analysis include the following:

1. Cuyama Basin sustainability is specified in the GSP terms of physical objectives – avoiding six undesirable results of groundwater overdraft. Meeting these objectives is only possible if pumping is reduced, resulting in economic impacts for the basin. A seventh sustainability indicator, economic viability of the basin, could be considered. Delaying the pumping reduction schedule may allow producers to recover capital investments, avoid rapid changes in the agricultural footprint, and provide jobs, income, and tax revenue for the local economy. This would come at the cost of additional depletion of groundwater storage, but the benefits may outweigh any costs.
2. The economic analysis shows that there is intra- and inter-regional variability in the value of water. This suggests there are potential gains from trading (allowing water to move to its highest and best use). An inter-region water trading program that allows groundwater to be transferred between regions would allow for water to move from lower to higher value uses, providing benefits to both buyers and sellers.
3. The pumping reduction specified in the demand management program is linear. That is, the same percentage reduction is applied every year regardless of conditions in the basin, A dynamic pumping reduction schedule that allows producers to react to market and weather trends could be considered to lower costs. For example, allowing flexibility for growers to increased pumping above the sustainable yield in years with high prices or decreased rainfall, so long as it is replenished in future years, could mitigate some of the losses associated with demand management.
4. The concept of groundwater allocations is implicit to this analysis. That is, the demand management program requires a pumping quota which would include assignment of allocations (how much individuals can pump). How allocations are developed and assigned affects the distribution of costs between groundwater pumpers as well as the overall implementation costs to the local economy. A careful economic analysis of alternative allocation approaches using the framework applied in this analysis could identify ways to reduce GSP implementation costs.

Analysis of value enhancing policies could benefit from further analysis of indirect and induced effects of demand management implementation. Growers purchase inputs from regional suppliers, employ workers, and rely on local trucking, storage, processing, and related businesses for post-harvest activities. Transportation, storage, processing, and other businesses purchase trucks, warehouses, machines, and hire workers required for their operations. The economic cluster of agriculture-dependent industries generates jobs in farming and other industries, and employees in all these related industries purchase housing, consumer items, and other goods and services in the basin and regional economy. Quantifying these relationships would provide data and information to mitigate losses associated with GSP implementation and ensure that GSP implementation is not only efficient, but also equitable.

This page intentionally blank

8. Appendix A: Economic Model Technical Overview

This appendix summarizes the agricultural economic model of the Cuyama Basin that was applied to analyze the direct agricultural impacts of reducing groundwater pumping and, or, other supply augmentation projects, as discussed in the Cuyama Basin Groundwater Sustainability Plan (GSP). The following sections summarize model calibration and application to this analysis.

8.1 Cuyama Basin Economic Model Overview

The Cuyama Basin model is a regional agricultural production and economic optimization model that simulates the markets for Cuyama Basin crops. It applies the same calibration methodology and economic approach as the Statewide Agricultural Production model (SWAP), which has been subject to peer review and applied to a range of water and agricultural impact analyses in California over the last several decades (Howitt et al. 2012).

The fundamental economic logic underlying the Cuyama Basin model is as follows. Crops are produced in competitive input and output markers. That is, no individual grower/operation can affect or control the price of any commodity. The model simulates inputs, costs, returns, water supplies, and other farm inputs, subject to water availability (e.g. the demand management program) and water costs (e.g. GSP administrative costs).

Agricultural production in the Cuyama Basin is solely dependent on groundwater. As conditions change within a Cuyama Basin region (e.g., a reduction in the amount of groundwater that can be pumped), the model optimizes production by adjusting the crop mix, water quantities used, and other inputs. It also fallows land when that appears to be the most cost-effective response to resource conditions. The model can be extended to compare the long-run response of agriculture to other conditions affecting surface or groundwater conditions, markets, or other economic values or restrictions in the Cuyama Basin.

8.2 Model Calibration

The model calibrates using a procedure based on Positive Mathematical Programming (PMP) (Howitt 1995) and the assumption that crops are produced in competitive markets. This allows incorporating information on the local market conditions (factors that affect supply and demand), allowing the model to exactly replicate a base year of observed input use and output. Conditions include a mix of management skill, inter-temporal effects of crop rotation, proximity to processing facilities, management skills, farm-level effects such as risk and input smoothing, and differences in soil and other physical capital/inputs. Model calibration translates these factors, in addition to observed average conditions, into an economic representation of production (supply) and market demand conditions (Howitt et al. 2012).

On the crop demand side, the model is specified with downward-sloping California statewide demand functions. That is, the model is specific to the Cuyama Basin but recognizes that Cuyama Basin farmers compete in the statewide (and global export) market for crops. The demand curve is estimated from historical data on crop prices and quantities that reflects the consumer's willingness-to-pay for a given level of crop production.

8.2.1 Cuyama Regions and Crop Definitions

The Cuyama Basin model is modeled with five of the six regions defined in the GSP: Central, Eastern, Northwest, Southeast, and Western. Of the five regions modeled, the Central region accounts for nearly 80% of all agricultural acreage and is the only region subject to major changes in the GSP (e.g. the demand management program).

The economic model calibrates to average land use between 2010 and 2018. Crops are aggregated into 6 crop groups. Each crop group may represent several individual crops, but many are dominated by a single crop. Irrigated acres represent acreage of all crops within the group, production costs and returns are represented by a single proxy crop for each group. The current 6 crop groups were defined using the information provided Attachment C-1 of the Cuyama Basin GSP, which reports land use and consumptive water use in the Basin and information taken from interviews of local growers. Crop group and the corresponding proxy crop are shown in Table 1A.

Table 1A. Cuyama Basin Model Crop Groups

Crop Group	Proxy Crop	Other Crops
Carrots	Carrots	N/A
Potatoes	Potatoes	N/A
Grapes	Wine Grapes	N/A
Onions	Onions	Bush berries, Cole crops, Lettuce/leafy greens, Melons, Squash, Cucumbers
Pistachios	Pistachios	Apples, Citrus, Miscellaneous Deciduous, Miscellaneous Subtropical Fruit, Olives, Peaches/nectarines
Field	Wheat	Alfalfa & Alfalfa Mixtures, Beans (dry), Corn, Sorghum & Sudan, Miscellaneous Field Crops, Miscellaneous Grain and Hay, Miscellaneous Grasses, Mixed Pasture

8.2.2 Crop Acres

Most crop acreage in the basin has historically been divided between four of the six major crop groups: wheat, carrots, onions, and potatoes. In 2016, carrots accounted for 40% of non-idle cropland, however in 2017 carrots only accounted for 31% of non-idle cropland. This is not a result of sudden market changes, but rather a reflection of typical crop rotations in the area. Therefore, the model calibrates to 2010-2018 data to capture the most recent data while maintaining the effects of rotation.

While carrots may form the backbone of high-value agricultural production in the basin, other crop groups such as wine grapes are increasing. Wine grapes have steadily increased their share of acreage from 1% in 1996 to 7% of non-idle crop acreage in 2017. In addition, the planting of an 850-acre vineyard in 2018 increases this share closer to 13% of non-idle crop acreage. Figure 1A illustrates annual acreage distributions of non-idle cropland and Figure A2 illustrates the distribution of crop land use in the basin in 2014.

Figure A1. Annual Changes in Non-Idle Crop Acreage

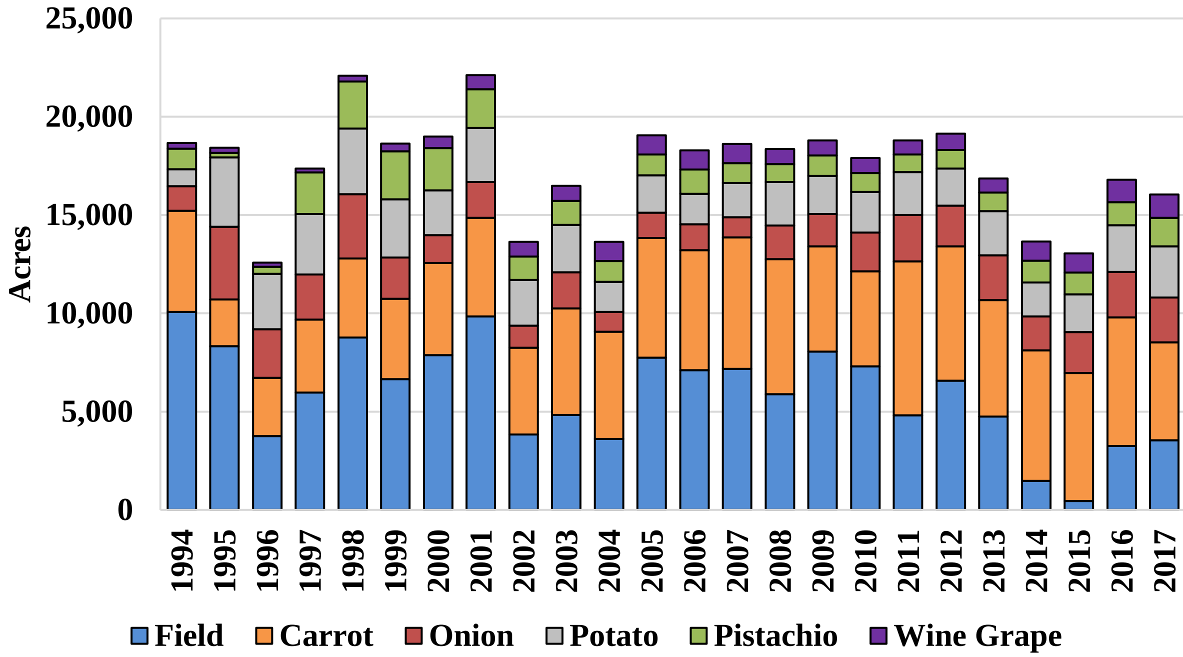
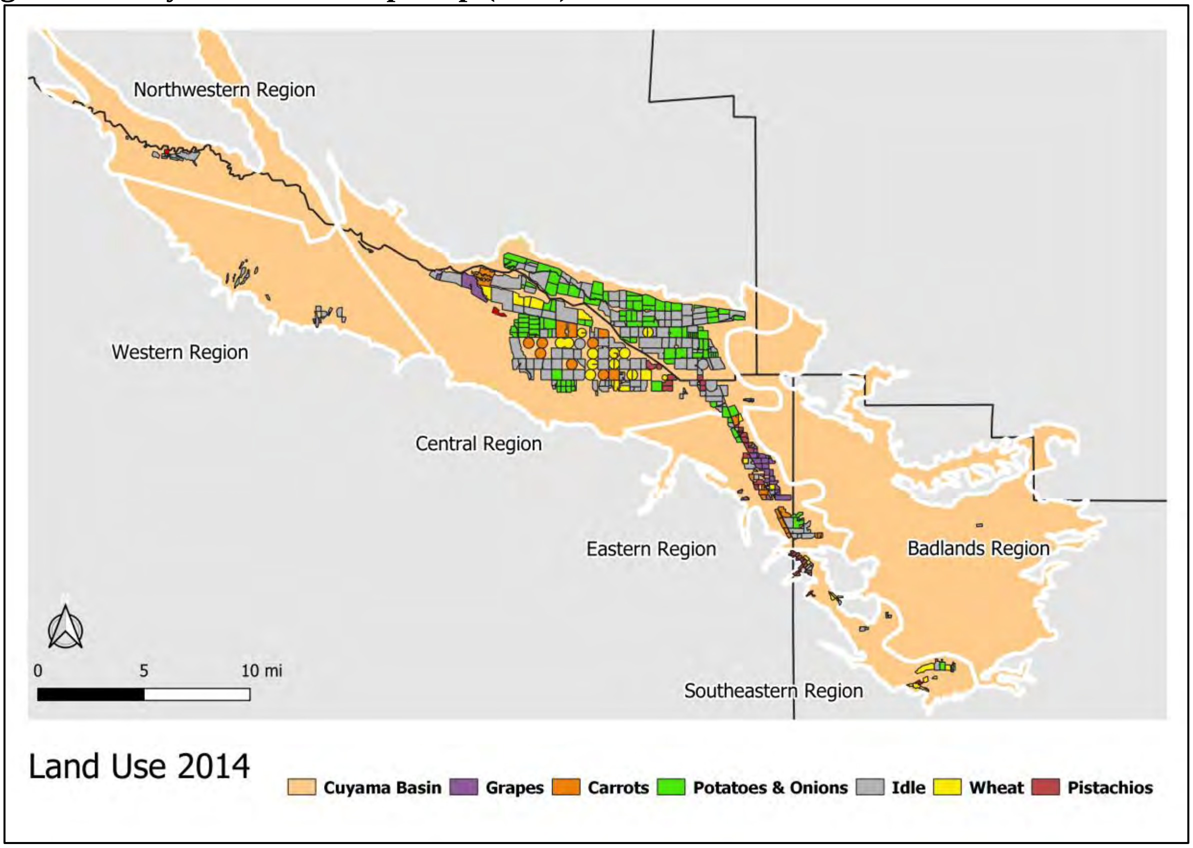


Figure A2. Cuyama Basin Crop Map (2014)



8.2.3 Crop Returns

The economic model is designed to calibrate to the current conditions (market, prices, etc.). The model uses crop price data from a combination of county reports from Santa Barbra, San Luis Obispo, Kern, and Ventura counties, statewide and national price data, local UC estimates, and feedback from individuals familiar with farming in the basin.

Crop yields for each crop group in the model correspond to the proxy crops listed in Table A1 and are based on county averages, refined based on industry feedback. The corresponding costs of production, discussed in a subsequent section, are based on cost studies that reflect best management practices. Thus, crop yields in the economic model may be slightly higher than those estimated by calculating county averages but are more consistent with the production costs. An average of yields in the surrounding counties or statewide values are used when UCCE budget yields are not representative of production in the Cuyama Basin.

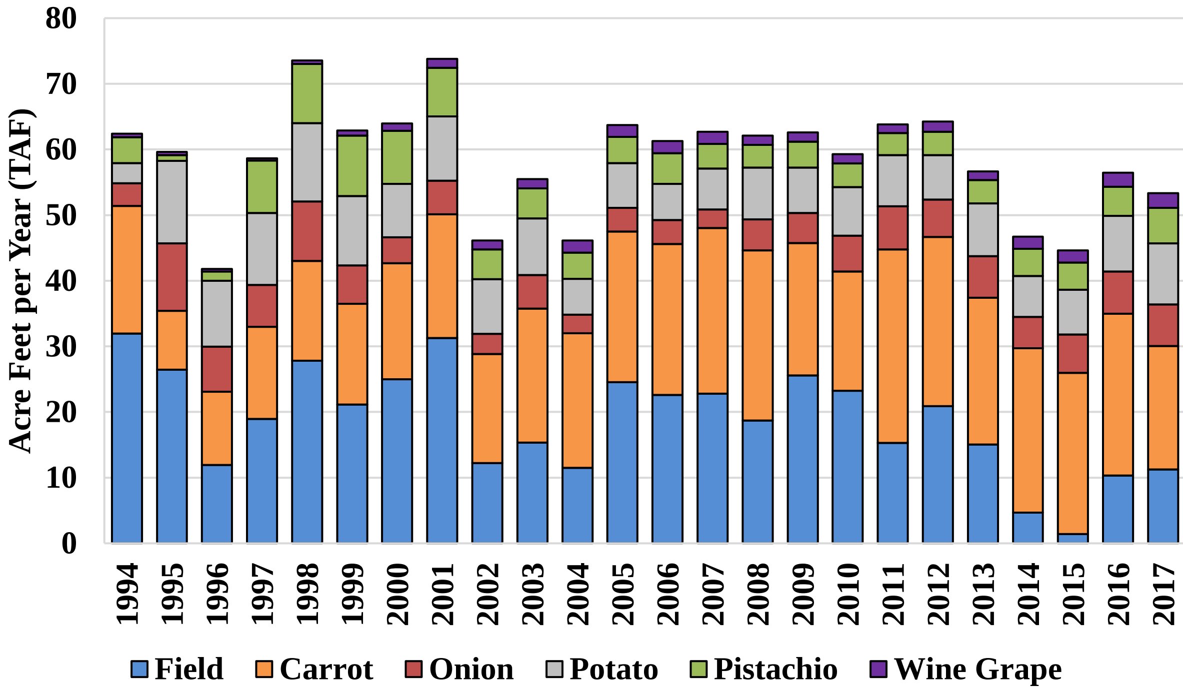
8.2.4 Crop Cost of Production Budgets

Land, labor, and other supply costs of production are estimated using internal data, UC budgets, and expert feedback to adjust for local conditions. All capital recovery and interest rates are adjusted for consistency to current conditions. Land costs are derived from county data and include land-related cash overhead plus rent and land capital recovery costs. Where appropriate, interest rates are adjusted as described above. Other operating costs are developed based on UC budgets and interviews with experts in the region.

8.2.5 Water Supplies

Agricultural production in the Cuyama Basin is solely dependent on groundwater. Groundwater pumping capacity estimates are derived from the Cuyama Basin GSP. The GSP's water budget (Table 2-5 GSP) estimates that agriculture pumps approximately 60,000 acre-feet per year (AFY). The GSP defines the "sustainable yield" for the GSA as the maximum average that the region can pump in a year given the aquifer characteristics and existing well capacities. Sustainable yield in the region is estimated at 20,000 acre-feet. Figure A3 illustrates annual groundwater pumping to meet crop demand between 1994 and 2017.

Figure A3. Cuyama Basin Groundwater Applied Water Demand by Crop and Year



Groundwater pumping costs are broken out into fixed, energy, and operations and maintenance (O&M) components in the economic model. Energy and O&M components are variable. Energy costs depend on the price of electricity. Base electricity costs are derived local data. Overall well efficiency is assumed to be 70 percent. As groundwater elevations change within the basin, variable pumping costs adjust accordingly.

8.2.1 Crop Water Requirements

Applied water is the amount of water applied by the irrigation system to an acre of a given crop for production in a typical year. Variation in rainfall and other climate effects will alter this requirement. Additionally, farmers may deficit irrigate crops or substitute other inputs in order to reduce applied water. Applied water per acre (base) requirements for crops in the model are derived from Davids Engineering estimates of Evapotranspiration Applied Water presented in Attachment C-4 of the Cuyama GSP Appendix, land use estimates presented in Attachment C-1 of the Cuyama GSP Appendix, and total water use estimates presented in Table 2-5 of the Cuyama GSP. Applied water (AW) values and evapotranspiration applied water (ETAW) are presented in Table A2.

Table A2. Applied Water (AW) and Evapotranspiration Applied Water (ETAW) by Crop

Crop Group	Proxy Crop	AW	ETAW
		acre-feet	
Carrots	Carrots	3.77	3.17
Grapes	Wine Grapes	1.88	1.58
Onions	Onions	2.78	2.33
Pistachios	Pistachios	3.77	3.17
Potatoes	Potatoes	3.57	2.67
Field	Wheat	3.17	2.67

8.2.2 Other Economic Data

The Cuyama Basin model requires a number of economic response parameters, called elasticities, to estimate rates of change in variables. An elasticity is the percent change in a variable, per unit of percent change in another variable or parameter. For example, acreage response elasticity is one component of supply response. It is the percentage change in acreage of a crop from a one percent change in that crop's price. The model contains both long run and short run estimates. Long run acreage response elasticities are used for this analysis. Other elasticities including income, demand price, and population (among others) are representative of statewide market conditions in California, or in the export market as appropriate.

8.3 References

Agricultural Commissioner of Kern County, Ventura County, Santa Barbara County, and San Luis Obispo. Various years. Agricultural Crop Report. County Department of Agriculture and Measurement Standards.

California Department of Food and Agriculture. California Agricultural Statistics Review, 2017-2018. Agricultural Statistical Overview.

Howitt, R.E. 1995. Positive Mathematical-Programming, American Journal of Agricultural Economics, 77(2), 329-342.

Howitt, R.E., J. Medellin-Azuara, D. MacEwan, and J.R. Lund. 2012. "Calibrating Disaggregate Models of Irrigated Production and Water Use: The California Statewide Agricultural Production Model." Journal of Environmental Modeling and Software.

United States Department of Agriculture National Agricultural Statistics Service (NASS). Various Years. County Agricultural Commissioners' Data.

University of California Cooperative Extension (UCCE). Various years. Cost of Production Studies.

This page intentionally blank