Twenty-first Annual Groundwater Report (January 2018 - December 2018) & Fourth Five-Year Summary Report (January 2014 – December 2017)

Prepared for

CADIZ

Cadiz Valley Agricultural Development

Prepared By:
GEOSCIENCE Support Services, Inc.

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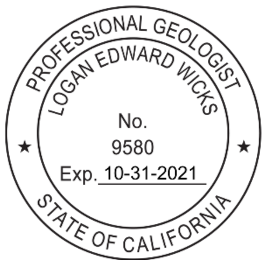

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CADIZ, INC.

TWENTY-FIRST ANNUAL GROUNDWATER REPORT (JANUARY 2018 – DECEMBER 2018)

AND

FOURTH FIVE-YEAR SUMMARY REPORT (JANUARY 2013 – DECEMBER 2017)

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CADIZ, INC.

TWENTY-FIRST ANNUAL GROUNDWATER REPORT (JANUARY 2018 – DECEMBER 2018)

AND

FOURTH FIVE-YEAR SUMMARY REPORT (JANUARY 2013 – DECEMBER 2017)

1.0 EXECUTIVE SUMMARY

This Twenty-First Annual and Fourth Five-Year Monitoring Report was completed in accordance with recommendations presented in the 1993 Final Environmental Impact Report (FEIR) developed by URS Consultants, Inc. (URS) for the Cadiz Valley Agricultural Development, Cadiz, Inc. (Cadiz) and required by San Bernardino County (County). In compliance with the County approved 1993 FEIR which requires monitoring of groundwater levels, electrical conductivity of groundwater, groundwater extraction, and changes in land surface elevation, a Groundwater Monitoring Plan (GWMP), was prepared and submitted to the County by GEOSCIENCE Support Services, Inc. (GEOSCIENCE) on July 24, 1997 which was also approved by the County Planning Department in 1997. In accordance with the GWMP and County requirements, the first two Five-Year Summary Reports have been submitted to San Bernardino County for the five years prior to 2003, and 2008. A comprehensive groundwater assessment was also completed as part of the Cadiz Valley Water, Conservation, Recovery and Storage Project (Water Project) Environmental Impact Report in 2012[1], which included required monitoring data from 2008 through 2012 and was accepted as the Third Five-Year Report. This will report serve as the Fourth Five-Year Summary Report and the Twenty-First Annual Groundwater Report, which provides a summary, comparison, and analysis of all monitoring data collected during the period from January 2013 through December 2018.

Cadiz owns approximately 34,000 acres in the Cadiz and Fenner Valleys located in eastern San Bernardino County, California, and actively farms 700 acres of irrigated crops. Agricultural efforts are mainly citrus orchards with a few seasonal vegetables. Irrigation water for agricultural purposes is supplied by seven production wells.

Key findings for the combined Five-Year and Annual Reports covering the period from January 2013 through December 2018 are as follows:

[1] Complete 2012 Water Project FEIR available at: https://www.cadizwaterproject.com/public-environmental-review/

- Groundwater levels and trends over the entire six-year monitoring period were generally stable, with slight increases and decreases in groundwater elevations in localized areas.
- Groundwater quality (as measured by total dissolved solids and electrical conductivity) continues to remain consistent with data from previous years.
- Total average groundwater production decreased during the monitoring period from approximately 2,196 acre-ft/yr for the period from 2009 through 2012 to approximately 1,690 acre-ft/yr for the period from 2013 through 2018.
- The most recent land surface elevation survey indicates that no ground subsidence has occurred over the reporting period.

2.0 INTRODUCTION

Cadiz, Inc. (Cadiz) is working with water agencies in Southern California to develop the Cadiz Valley Water, Conservation, Recovery and Storage Project (Water Project). The Water Project will provide an initial addition of 50,000 acre-feet per year (AFY) from a wellfield south-southwest of the Fenner Gap area (Figure 1) to the Metropolitan Water District of Southern California (MWD). As part of the Water Project development process, GEOSCIENCE Support Services, Inc. (GEOSCIENCE) presents the Twenty-First Annual Monitoring Report (January 2018 – December 2018) and Fourth Five-Year Summary Report (January 2013 – December 2017). This report has been prepared in compliance with the Groundwater Monitoring Plan (GWMP) submitted by Cadiz on May 1, 1997 and accepted by the San Bernardino County Planning Department. The GWMP addresses groundwater monitoring requirements specified in the FEIR, entitled "Findings, Facts in Support of Findings, and Statement of Overriding Considerations Regarding Final Environmental Impact Report (FEIR) for Cadiz Valley Agricultural Development, County of San Bernardino" (URS, 1993b).

After County approvals of the GWMP in 1997, and since 2009, Cadiz has been working with water agencies in Southern California to develop the Water Project. Santa Margarita Water District became the lead agency for California Environmental Quality Act (CEQA) compliance, and certified the Water Project FEIR on July 31, 2012. San Bernardino County approved the FEIR and the Groundwater Management, Monitoring, and Mitigation Plan (GMMMP)[2] on October 1, 2012. The GMMMP outlines specific management, monitoring, and mitigation guidelines for the Water Project, including pre-operational monitoring activities. The GMMMP also provides specific significance criteria for the Water Project, which will be applied to the Cadiz Valley Agricultural Development in a transition period from the GWMP to the GMMMP. The GMMMP is intended to replace the GWMP as Cadiz transitions the use of groundwater from irrigated agriculture to the Water Project. This Twenty-First Annual Monitoring Report and Fourth Five-Year Monitoring Report is being submitted in compliance with the GWMP; however, additional monitoring data are provided as a part of the transition toward the GMMMP. Figure 2 shows existing and planned monitoring components to be developed under the GMMMP.

As described in previous reports, after the Water Project passed the CEQA-required FEIR, continued geologic and hydrogeologic investigations in the Fenner Valley have been undertaken to support the FEIR conclusions. Dr. Miles Kenney (2011) presented findings regarding detailed geologic mapping of the Fenner Gap area. CH2M Hill (2010) presented an updated assessment of recharge to Fenner and Orange Blossom Wash Watershed areas, as well as an assessment of evaporative discharges from Bristol and Cadiz Dry Lakes. The CH2M Hill study included measurements of evaporation at the dry lakes taken by the Desert Research Institute (DRI). GEOSCIENCE (2011) conducted detailed groundwater flow and solute

[2] Updated GMMMP is available at: http://www.cadizwaterproject.com/wp-content/uploads/2015/07/V7_Appx-B1-UPDATED-GMMMP.pdf

transport, and subsidence modeling. GEOSCIENCE (2011) model runs assess potential impacts to groundwater levels, groundwater quality, and land subsidence caused by groundwater extraction and storage during the active phase of the Water Project. Dr. David Groeneveld (2012) completed two assessments – one of potential impacts to vegetation, and a second potential for dust generation due to lowered groundwater levels in the vicinity of the project. These assessments are included in the FEIR in Appendix E2, Fugitive Dust and Effects from Changing Water Table at Bristol and Cadiz Playas; Appendix F4, Vegetation, Groundwater Levels and Potential Impacts from Groundwater Pumping near Bristol and Cadiz Playas; and Appendix H, Hydrology Reports. These assessments represent the most up-to-date evaluation of groundwater conditions in the area. These additional assessments fulfill (and exceed) the GWMP's requirement to prepare a comprehensive five-year hydrogeologic report that re-analyzes the basin, used to create a comprehensive and revised monitoring plan, and establishes significance criteria. The County approved GMMMP is based on findings from these assessments.

As per County requirements and mitigation and monitoring suggestions outlined in the FEIR, this report summarizes annual and five-year changes in groundwater production, groundwater elevation, groundwater quality, groundwater storage and recharge, and land surface elevation.

2.1 Purpose and Scope

In accordance with the GWMP, the purpose and scope of this report is to summarize and compare monitoring data during the period from January 2013 through December 2018, including:

- Analyze static groundwater level data over the report period and compare to baseline[3] conditions;
- Analyze groundwater quality data over the report period and compare to baseline conditions;
- Compile and discuss groundwater extraction data for the report period;
- Discuss changes in land surface elevation for the report period;
- Discuss potential impacts regarding water levels, water quality, and subsidence; and
- Present updated estimates of natural groundwater recharge to the Cadiz Valley Agricultural Development.

In preparation for the transition from GWMP to GMMMP reporting, this report includes groundwater level data from additional monitoring wells which will be used to establish additional baselines for the Water Project.

[3] Baseline conditions are primarily considered to be the average conditions of water level and quality from December 1995 through December 1996.

2.2 Location of Study Area

Cadiz Valley Agricultural Development (the study area) is in the Cadiz and Fenner Valleys, approximately 200 miles east of Los Angeles and 60 miles northeast of Twentynine Palms, within San Bernardino County, California (Figure 1). Cadiz owns approximately 34,000 acres of land located between the Marble and Ship Mountains and currently irrigates approximately 700 acres of farmland.

2.3 Groundwater Monitoring Well Network

In compliance with the GWMP, one monitoring well – Well 5/14-13[4] – has been designated in the Fenner Gap area to provide groundwater monitoring upgradient from Cadiz's seven-well agricultural wellfield. As part of the transition to the GMMMP, Well SCE-5 has been designated as an additional monitoring well. SCE-5 is in the Orange Blossom Wash, between the agricultural wellfield and Bristol Dry Lake, and will provide early indication of potential migration of groundwater with elevated levels of total dissolved solids (TDS) towards the agricultural wellfield. This group of nine wells comprises "Group 1" of Figure 1 and are referred to as "Group 1 Wells" in the remainder of the document. Monitoring of water levels and TDS in these and other wells began in 2012, expanding the extent of groundwater monitoring conducted in previous investigations. Since the release of the original GWMP which consisted of seven irrigation wells and one monitoring well, the monitoring well network has expanded to include a total of forty-seven (47) monitoring locations throughout the Cadiz and Fenner Valleys. The seven irrigation wells are Included in the 47 monitoring well locations. However, two of the irrigation wells – Cadiz Well No. 33 and Cadiz Well No. 27N – have been taken off-line and are strictly used for monitoring purposes only (i.e., no groundwater extraction). All monitoring network wells are identified in Table 1 and shown on Figures 1 and 2.

2.4 Land Subsidence Survey

Joseph E. Bonadiman & Associates, Inc. (JBA) performed a baseline survey of the Cadiz irrigation wells and the designated monitoring well 5/14-13 in December 1997. These baseline elevation data[5] are presented in previous Annual Reports (Foreman, 2016). JBA conducted subsequent surveys in 1999, 2000, 2001, 2002, 2007, 2010, 2013, 2014, and 2015 to continue to monitor the study area for land subsidence. As per the GMMMP, the land subsidence monitoring program will be expanded, including the establishment of a baseline condition as part of the pre-operational monitoring activities before groundwater pumping begins for the Water Project. As a part of this transition, a new base reference station has been established

[4] Some of the monitoring wells and all of the irrigation wells are in part, named from their corresponding township and range see link for more information on Township and Range survey system (ex., 5/14-13 = Township 05N Range 14E Section 13 San Bernardino Baseline Meridian, or 21N = northern area of Section 21).

[5] Baseline elevation data was initially established at all irrigation wells and monitoring well 5/14-13 in December 1997. Five new points have been added since 2015 for additional control points.

in the Marble Mountains for use in future subsidence surveys, as described in the Seventeenth Annual Report (Foreman, 2016). In addition, Cadiz established five new land subsidence control points in 2015 as an ongoing transition from the GWMP to the GMMMP. Towill, Inc. (Towill) surveyed all original eight wells and the five new survey monuments in December 2016, 2017, and 2018. These data are presented and described in the most recent Five-Year Summary Report, the FEIR Appendix H, and the Cadiz Valley Agricultural Development Annual Monitoring Reports.

2.5 Sources of Data

Production data, water quality data, and static groundwater elevation data from the irrigation and monitoring wells were used in preparation of this report. These data were collected by Cadiz and staff of West Yost Associates, Inc. (West Yost) and GEOSCIENCE, which include State of California Professional Geologists, Certified Hydrogeologists, and Certified Engineering Geologists. Land surface elevation data were collected by staff at Towill.

3.0 GEOLOGY AND HYDROGEOLOGY

A detailed description of the geology and hydrogeology of the Fenner, Orange Blossom Wash, Bristol, and Cadiz Watersheds are provided in Appendix H of the Water Project FEIR. Following is a brief summary of the geology and hydrogeology of the area in the vicinity of the Cadiz Valley Agricultural Development.

3.1 Geologic Setting

The Cadiz Valley Agricultural Development is in part of the Basin and Range province of North America, in the eastern Mojave Desert of California, within portions of the Bristol, Cadiz, and Fenner Watersheds. Geologic formations in the area are composed of a variety of bedrock, alluvial, dune, and lacustrine deposits. Bedrock is composed of igneous, metamorphic, and consolidated sedimentary rocks which include carbonates, and generally form the perimeter of the main watersheds, however large bedrock masses also occur within the watersheds, such as the Clipper Mountains.

The Bristol and Cadiz Watersheds form a broad depression that is referred to as the Bristol Trough (Thompson, 1929; Bassett et al., 1964; Jachens and Howard, 1992). This depression formed as a result of regional fault movement and is thought to be 6 to 10 million years old (Rosen, 1989). Unconsolidated alluvial, dune, stream, aeolian, and playa lake deposits fill the Bristol Trough.

3.1.1 Stratigraphy

The geology of the Bristol, Cadiz, and Fenner Watersheds is composed of three broad categories: crystalline bedrock exposed in the mountain ranges and hills, alluvial fan and valley fill sediments weathered from uplifted bedrock, and fine-grained (silt and clay) sediments and evaporite (sodium-chloride (NaCl), Calcium-chloride (CaCl), and gypsum) deposits of the Bristol and Cadiz Dry Lakes. The crystalline basement rocks exposed in the mountain ranges of the study area consist primarily of Precambrian granitic and metamorphic rocks locally overlain by Paleozoic sedimentary rocks. Paleozoic rocks are sandstones, shales, slates, limestones, and dolomites. These sediments and the underlying basement rocks have been faulted and folded by periods of regional tectonism. The crystalline basement rocks are generally much less permeable than alluvial deposits – yielding limited quantities of groundwater (Freiwald, 1984). However, previously conducted field investigations of the Paleozoic limestone and dolomite sections that are fractured or contain solution cavities yield large quantities of groundwater (CH2M Hill, 2010). Outcrops of these carbonate units can be found on the eastern slope of the New York Mountains, in Lanfair Valley, north of the Clipper Mountains, in the Marble Mountains, in the Ship Mountains, in the southeast end of the Bristol Mountains, in the southern Kilbeck Hills, and in the eastern Old Woman Mountains (see Kenney, 2011, and Howard, 1992; for locations of these carbonate units). The carbonate units are significant aquifers where dissolution features are present in the subsurface, such as in the Fenner Gap area (CH2M Hill, 2010). Throughout the subject area, mostly fractured crystalline basement rocks form the boundaries of the groundwater aquifer system (CH2M Hill, 2010).

In the Fenner Valley, the Paleozoic section is unconformably overlain by clastic sediments and interbedded volcanic rocks of mid-to late-Tertiary age. The Tertiary volcanic rocks consist of lava flows of basaltic to andesitic composition, and pyroclastic tuffs of rhyolitic to dacitic composition. The United States Geological Survey (USGS) reports that a shallow trap-door caldera, roughly 10 kilometers in diameter, is centered in the eastern Woods Mountains (based on gravity and aeromagnetic anomalies). It was formed during a major eruption 15.8 million years ago, with resurgent eruptions filling the caldera with rhyolitic flows and tuffs. Dikes of similar composition are exposed in the Marble and Ship Mountains (CH2M Hill, 2010). The Tertiary sediments consist of conglomerate, fanglomerate, sandstone, siltstone, water-laid tuff, and lake sediments, which form a composite section more than 7,000 feet thick (Dibblee, 1980). The Tertiary sediments and interlayered volcanic rocks are gently dipping due to late-Tertiary extensional normal faulting.

The Quaternary and late-Tertiary alluvial fill in the Bristol Trough is largely derived from Precambrian basement rocks, Paleozoic sediments, and Tertiary volcanic rocks. USGS mapped alluvial deposits exceeding 300 meters in thickness in the northern Fenner Valley. Geophysical evidence indicates this alluvial fill locally exceeds 3,500 feet in thickness beneath a portion of the southern Fenner Valley (Maas, 1994) and even greater under Bristol Valley (CH2M Hill, 2010). These alluvial sediments form one of the principal aquifers in the subject area.

The playa sediments underlying the Bristol and Cadiz Dry Lakes consist of highly saline (brine-saturated) clay, silt, fine-grained sand, and evaporite deposits. The clastic sediments were deposited when stream flow and sheet flow from the surrounding alluvial fans spread onto the playas during major storm events (Gale, 1951). The evaporite deposits formed from evaporation of both surface water and groundwater that seeps into the playa sediments from the adjacent alluvial fans (Rosen, 1989).

Bristol and Cadiz Dry Lakes have static groundwater levels at or near the playa surfaces (Moyle, 1967; Rosen, 1989). Geophysical surveys of Bristol Dry Lake and Cadiz Dry Lake indicate sediments underlying the playas may extend to depths greater than 6,000 feet below ground surface (Simpson et al., 1984; Maas, 1994). These sediments have been penetrated by drill holes to depths of over 1,000 feet (Bassett et al., 1959; Rosen, 1989). Sodium chloride and/or calcium chloride are currently being recovered from trenches and brine wells on both playas. The principal recharge to the playas occurs as diffuse seepage of groundwater onto the playas from adjacent alluvial fans (Thompson, 1929; Gale, 1951; Bassett et al., 1959; Handford, 1982; Rosen, 1989).

Cadiz and Bristol Dry Lakes are locally bordered by dune deposits of fine- to medium-grained windblown sand. These Holocene deposits overlie older playa deposits of differentiated Quaternary age (Moyle, 1967). Amboy Crater, located near the western margin of Bristol Dry Lake, is a basaltic cinder cone and lava field believed to be as young as 6,000 years (Hazlett, 1992).

3.1.2 Structure

The project area is located at the eastern margin of the Eastern California Shear Zone, a broad seismically active region dominated by northwest-trending, right-lateral strike-slip faulting (Dokka and Travis, 1990). Roughly a dozen fault zones showing evidence of Quaternary movement (during the last 1.6 million years) have been identified in and adjacent to Bristol, Cadiz, and Fenner Valleys (Howard and Miller, 1992).

Cadiz Valley is underlain by two inferred, major northwest-trending faults based on gravity and magnetic data (Simpson et al., 1984). These fault zones have strike lengths of at least 25 miles and may merge to the north and northwest with extensions of the Bristol-Granite Mountains and South Bristol Mountains fault zones (Howard and Miller, 1992; see MWD, 2001 for locations).

Right-lateral slip of as much as 16 miles along the Cadiz Valley fault zone has been postulated because of correlation of a distinctive Precambrian gneiss unit across the zone (Howard and Miller, 1992). Slickenside surfaces produced by fault movement and steeply dipping sediments recovered from cored drill holes beneath Cadiz Dry Lake suggest the fault zone displaces sediments of Pleistocene age (Bassett et al., 1959). Bristol Dry Lake is bordered by probable extensions of the Cadiz Valley and South Bristol Mountains fault zones to the east, and by probable extensions of the Broadwell Lake and Dry Lake fault zones to the west (Howard and Miller, 1992). Geophysical data indicate this structural depression may exceed 6,000 feet in depth (Simpson et al., 1984; Maas, 1994). Drill cores recovered from depths of more than 1,000 feet beneath Bristol Dry Lake indicate that subsidence of this basin began by Pliocene time and continues to the present (Rosen, 1989), suggesting that the area may be tectonically active.

3.2 Aquifer Systems

Based on available geologic, hydrologic, and geophysical data, the principal formations in the study area that can readily store and transmit groundwater (aquifers) are divided into three general units—an upper (younger) alluvial aquifer, a lower (older) alluvial aquifer, and a carbonate rock unit aquifer. However, the carbonate aquifers contain interbedded non-water bearing quartzite and shale (CH2M Hill, 2010; GEOSCIENCE, 2012).

The younger alluvial aquifer consists of Quaternary and late-Tertiary alluvial sediments, including stream-deposited sand and gravel with lesser amounts of silt (Moyle, 1967; GEOSCIENCE, 1999). The upper alluvial unit is as thick as approximately 1,000 feet in some locations (GEOSCIENCE, 1999 and 2012; CH2M Hill, 2010).

The lower alluvial aquifer consists of older sediments, including interbedded sand, gravel, silt, and clay of mid- to late-Tertiary age. Where these materials extend below the water table, they yield water freely to wells but generally may be less permeable than the upper aquifer sediments (Moyle, 1967; GEOSCIENCE, 1999; CH2M Hill, 2010). Production Well PW-1, located in Fenner Gap, draws water primarily from the upper and lower aquifers and yields 3,000 gallons per minute (gpm) with less than 20 feet of drawdown (GEOSCIENCE, 1999). The Cadiz agricultural wells draw water from the alluvial aquifers and typically yield 1,000 gpm to more than 2,000 gpm.

Based on findings from recent drilling in Fenner Gap, carbonate bedrock of Paleozoic age located beneath the alluvial aquifers contain groundwater and is considered a significant aquifer (GEOSCIENCE, 1999; CH2M Hill, 2010). Groundwater movement and storage in this carbonate bedrock aquifer primarily occurs in secondary porosity features (i.e., joints, faults, and dissolution cavities that have developed over time). Granite and metamorphic basement rock form the subsurface margins of the aquifer system. This basement rock is generally less permeable and typically yields smaller quantities of water to wells (Freiwald, 1984).

3.2.1 Groundwater Recharge and Flow Patterns

The primary sources of replenishment to the groundwater system in the project area include direct infiltration of precipitation (both rainfall and snowfall) in fractured bedrock exposed in mountainous terrain and infiltration of ephemeral streamflow in sand-bottomed washes – particularly in the higher elevations of the watershed. The source of much of the groundwater recharge within the regional watershed occurs at higher elevation (MWD, 2001; Davisson and Rose, 2000, USGS, 2014).

Precipitation infiltrates and moves downward to the water table. In some areas, the infiltrating water may be diverted to land surface or groundwater may intersect buried flow barriers (i.e., bedrock or faults) which can bring the groundwater to the surface, creating a spring. Otherwise, this infiltrating water moves vertically downward where it ultimately reaches the regional groundwater system and continues to flow downgradient through principal aquifer systems. (CH2M Hill, 2010).

Groundwater occurrence in fractured bedrock of the watershed-perimeter's mountains has been known since before the turn of the twentieth century. The USGS documented the occurrence of wells and springs (referred to as "some desert watering places") throughout southeastern California and southwestern Nevada for the benefit of travelers and prospectors (Mendenhall, 1909). At least 10 wells and springs were documented in the mountains and hills around the Fenner Watershed and a number of wells were drilled into the alluvium by the Santa Fe Railroad. Another USGS study by Thompson (1929) provided additional information on more wells and springs in the study area to survey, mark, and provide protection of watering places. A more recent USGS survey of wells and springs in the area of study was conducted by Freiwald (1984). These studies provide evidence of the fractured nature of the surrounding bedrock and the continuous infiltration of precipitation and movement of water through these perimeter rocks. Although some groundwater is tapped by vegetation near the range fronts, the remainder moves slowly downgradient through Fenner Valley and Orange Blossom Wash into the Bristol and Cadiz depressions, where it eventually discharges to Bristol and Cadiz Dry Lakes. Evaporation of groundwater and surface water from the dry lakes over the past several million years has resulted in thick deposits of salt (primarily calcium chloride and sodium chloride) and brine-saturated sediments (Rosen, 1989). Thompson (1929), Gale (1951), Bassett et al. (1959), Handford (1982), and Rosen (1989) agree that the principal source of groundwater recharge to the playas occurs as diffuse seepage of groundwater into the playa sediments from the adjacent alluvial fans.

In general, groundwater within the watersheds flows downgradient in the same direction as the slope of the land surface. In Fenner Valley, groundwater generally flows southward and discharges through Fenner Gap toward Bristol and Cadiz Dry Lakes. In Orange Blossom Wash, located between the Marble and Bristol Mountains, groundwater generally flows southward from the Granite Mountains into Bristol Dry Lake. (GEOSCIENCE, 1999; CH2M Hill, 2010). CH2M Hill (2012) estimated the discharge to Cadiz area to be approximately 33,890 AFY, based on measurements made by DRI (2012), extrapolated over the surface areas of dry lakes for a full year. This evaporative discharge compares well with the estimated recharge rate of 32,000 AFY (GEOSCIENCE 1995 and CH2M 2010).

4.0 GROUNDWATER LEVEL CONDITIONS

4.1 Baseline Groundwater Elevations

In the First Annual Report (GEOSCIENCE, 1997a), groundwater elevations in feet above mean sea level (ft amsl) were calculated by subtracting the depth to groundwater from an estimated reference point elevation for each well. Approximate reference point elevations were determined by estimating the surface elevation of each well from the USGS 7.5-minute quadrangles (Cadiz Summit, Cadiz Lake NW, Calumet Mine, and Cadiz).

In December 1997, JBA (a California licensed land surveyor) performed a survey to establish the baseline elevation of the seven agricultural wells and monitoring well 5/14-13. JBA has since resurveyed all wells and surveyed newly installed monitoring wells through 2015, as described in the Eighteenth Annual Groundwater Monitoring Report (Foreman, 2016). Since 2015, five additional control points have been added and all thirteen points have been resurveyed by Towill since 2016. In addition, the resurvey includes conversion of the horizontal coordinates and vertical datum to the current NAD83 and NAVD88, respectively. Table 1 presents the location coordinates and vertical elevation with respect to these data.

In order to determine baseline groundwater level conditions for the Cadiz wellfield, historical groundwater level elevation data from November 1993 through December 1996 were evaluated. Baseline groundwater level conditions for the Cadiz wellfield have been based primarily on an average of December 1995 through December 1996 static groundwater levels. Table 2 presents a summary of these baseline groundwater levels, converted to the new datums.

Depth to groundwater is measured on a monthly basis by Cadiz and GEOSCIENCE staff, as feasible, for Group 1 Wells. In 2018, seven of the wells in the monitoring network were equipped with transducers to measure water levels several times a day as part of the ongoing transition from the GWMP to the GMMMP. All other monitoring wells are measured by GEOSCIENCE staff on a quarterly basis. The measured depths to groundwater are converted to groundwater elevations by subtracting the depth to groundwater from the surveyed reference point elevation for each well.

4.2 Groundwater Level Trends

Hydrographs for irrigation wells and monitoring wells have been prepared and show groundwater elevation measurements. These wells have been grouped for purposes of displaying these hydrographs over the large geographical area covered by the monitoring network. Generally, wells were grouped for presentation purposes as opposed to any common features or characteristics; however, they are generally in the same geographic area. Figure 1 shows the well groups and Figures 3 through 8 present hydrographs for each well group. In general, groundwater levels in and near the Cadiz wellfield fluctuate in response to pumping and recovery cycles.

Groundwater levels near wellfield declined consistently in response to Cadiz pumping, which reached maximum levels in the 1990s. Water levels then stabilized in the late 1990s and early 2000s, and have since recovered as extraction was reduced from the early 2000s through present (see Section 6 for more details). Table 2 provides a comparison of baseline groundwater levels with both December 2013 and 2018 static groundwater levels. In general, static groundwater levels have recovered above baseline groundwater levels (the baseline was established during a period when Cadiz was actively farming a larger portion of their property, effectively lowering groundwater levels due to increased pumping). Monitoring well hydrographs outside the wellfield area, especially in and just north of the Fenner Gap area, suggest that groundwater levels have not fluctuated significantly over the long-term.

5.0 GROUNDWATER QUALITY CONDITIONS

TDS concentrations in groundwater in the vicinity of the Cadiz Valley Agricultural Development irrigation wells are relatively low, with values generally around 300 milligrams per liter (mg/L). At Bristol and Cadiz Dry Lakes, evaporation of surface water and shallow groundwater concentrates dissolved salts, resulting in TDS concentrations as high as 298,000 mg/L (Shafer, 1964). In general, as groundwater moves toward the dry lakes from Fenner Gap and the surrounding mountains, it becomes more saline as "fresh" groundwater mixes with saline groundwater underlying the dry lakes. The fresh/saline groundwater interface, designated by a TDS concentration of 1,000 mg/L, is located near the margins of the two dry lakes (Figure 9). This interface is estimated using the TDS values of the wells in Group 6.

5.1 Baseline Groundwater Quality Conditions

Electrical conductivity (EC), which is directly proportional to TDS, and is an employed measure of groundwater quality for the Water Project. Baseline EC measurements for Group 1 wells were collected starting in 1996 and were converted to TDS for comparison with 2013 and 2018 TDS values which are shown in Table 5-1 below. Average baseline TDS levels for the Group 1 Wells range from 221 mg/L in Well 21S to 282 mg/L in Well 27N. Increases in TDS over time within the irrigation field are expected, see section 5.2 for a detailed discussion.

Table 5-1. Comparison of Baseline (1996) Calculated TDS with 2013 and 2018 TDS (mg/L)

Date	Well 21N	Well 21S	Well 22	Well 27N	Well 27S	Well 28	Well 33	Well 5/14-13	SCE-5
1st Qtr 1996[1]	256	214	256	311	262	-	-	220	-
2nd Qtr 1996[1]	220	360	410	520	410	360	370	460	-
3rd Qtr 1996[1]	238	232	268	278	259	259	220	281	-
Baseline TDS (Average)	238	221	258	282	257	240	223	261	-
2013 TDS[2]	254	288	416	660	282	258	512	298	292
2018 TDS[2]	270	330	290	570	290	210	440	312	305
Change in TDS 2013 to 2018	6%	15%	-30%	-14%	3%	-19%	-14%	5%	4%
Change in TDS 1996 to 2013	7%	30%	61%	134%	10%	8%	130%	14%	-
Change in TDS 1996 to 2018	13%	49%	12%	102%	13%	-12%	98%	20%	-

Notes:
All 2013 and 2018 TDS values are Laboratory reported except those mentioned below. A negative value denotes a decrease in TDS. Results for Well 27N, 28, 33, SCE-5, 5/14-13, used bailer to sample. Values may be unusually high. Results from for Well 27N, 28, 33, SCE-5, 5/14-13, used bailer to sample, values may be unusually high. Well 28 - December 2017 TDS value used, well was not accessible in 2018. Well 5/14-13 - 2018 TDS value reported from dedicated transducer in well. Well 33 - used May 2017 TDS value as well was not accessible in 2018. Well SCE-5 - 2018 TDS value reported from dedicated transducer in well.
[1]1st - 3rd Quarter 1996 laboratory E.C. values were converted to TDS for comparison
[2]Values used for TDS comparison for 2013 and 2018 were sampled in November and December respectively

5.2 Groundwater Quality Trends

Field measurements of EC and TDS were made with a portable MyronL Ultrameter II hand meter that is calibrated to standard conductivity solutions. As EC is a relative indicator of TDS concentration, actual TDS measurements are reported along with EC data as an initial transition step toward the requirements of the approved GMMMP.

Group 1 Wells were sampled for water quality, including TDS, during December of 2017, and have been sampled quarterly from December 2018 through present. As an additional step towards GMMMP compliance, Cadiz is equipping some irrigation and monitoring wells with transducers that can continuously record EC, water level, and temperature data. It is expected that groundwater data collected since 2012 will be used to begin to define pre-operational groundwater quality conditions for the Water Project.

Table 3 shows recent average TDS values for the Group 1 Wells. TDS has remained consistently below the 500 mg/L secondary Maximum Contaminant Level (MCL) for drinking water in all Group 1 Wells except Well No. 27N and Well No. 33, which are discussed below. Figure 10 shows Group 1 Well chemograph plots of TDS from 2013 through 2018.

TDS in Group 1 Wells appears relatively stable, except for Wells 27N and 33. Groundwater samples collected from Well No. 33 in 2012 and 2014 were collected with a bailer, whereas in 2013 and 2017 a temporary pump was installed to purge the well before sample collection. These latter samples are likely a more representative sample of groundwater conditions at Well No. 33. Like Well 33, Well 27N has been taken permanently offline since 2013 and has since been only sampled with a bailer. Difference in sampling technique likely accounts for the some of the variation in TDS values. increased Irrigation, damage to the well during the last attempted rehabilitation, and leaks in the system may account for the rest (discussed below). The samples collected at Well No. 33 in 2014 and 2015 show a drop in TDS levels from 512 mg/L in 2013 back to 308 and 338 mg/L, respectively, which is consistent with the longer-term trend. Well 33 has recently been equipped with a pump and samples collected from Well 33 while pumping had a TDS value of 330 mg/L, which is consistent with historical pumping TDS values.

Well 27N was taken offline and redeveloped in 2011. Problems were encountered during the redevelopment process and the integrity of the well casing/screen was damaged, including loss of the bottom seal. A concrete plug was installed to reseal the bottom. However, it was apparent that the casing/screen required further repairs as the well produced significant quantities of sand when in service. Well 27N was permanently taken offline in the middle of 2013. It is unclear if damage to the well casing/screen may have affected the distribution of flow of groundwater vertically along the casing, resulting in some changes in groundwater quality produced by the well. The groundwater samples collected in 2014 and 2015 at Well 27N showed a TDS value of 246 and 364 mg/L, respectively, consistent with historical levels. Well 27N showed a relatively high values of 472 mg/L, 530 mg/L, and 570 mg/L in the 2016 through 2018 samples, which may be due to residual effects from concentrated increased irrigation and leaky irrigation pipes, earlier redevelopment efforts, and sampling techniques as indicated by the fluctuations seen in Figure 10.

As described in the Sixteenth Annual Report, the TDS spike observed in 2013 in Wells 33 and 27N may have been caused by leaks in irrigation system distribution piping near Well 27N and the resultant flushing of salts from the thick vadose zone to underlying groundwater near these wells (Foreman, 2014). Nearby irrigation wells (Wells 27S and 28) do not show increases in TDS concentrations (Figure 10), so it is probable that the TDS spikes in Well 27N are due to some localized condition instead of a long-term trend. The leaks have since been addressed and the cause of these spikes are anomalous and need to be investigated further. The Twentieth Annual Report summarizes abnormal TDS and nitrate values collected from Wells 27N, 21S, and 33 in 2017 – 2018 (Foreman, 2018). Well 33 has been equipped with a pump and motor and has since been sampled multiple times and have recorded normal TDS values[6]. Well 27N will soon be equipped with a dedicated transducer with EC recording to help understand fluctuations in TDS.

Ongoing monitoring will be used to assess the origin of TDS spikes at any wells. Monitoring Well SCE-5 is one of several existing and new monitoring wells identified in the GMMMP for the Water Project to monitor the freshwater/saline groundwater interface between Bristol Dry Lake and the Cadiz wellfield (Figure 2). Well SCE-5 was sampled in 2012, 2013, and 2015 through 2018 to monitor any potential encroachment of the freshwater/saline groundwater interface toward the agricultural well field. As shown in Figure 10 and Table 3, TDS of groundwater at Well SCE-5 has remained stable over time.

[6] Well 33 pump and motor were installed in late 2019 and samples collected in December 2019 and March 2020 have TDS values of 330 mg/L.

6.0 GROUNDWATER EXTRACTION

Monthly groundwater extraction totals for each of the Cadiz irrigation wells are compiled in Appendix A. As described in the previous Five-Year Monitoring Reports, average annual groundwater production for the Cadiz Valley Agricultural Development from 1998 through 2002 was approximately 5,600 AFY; and 4,390 AFY from 2003 through 2007. Average annual production from 2008 through 2012 and 2013 through 2017 has been approximately 2,090 AFY and 1,660 AFY, respectively. In 2018 the annual production from January to December 2018 was approximately 1,827 AFY. The general decrease in total production is likely associated with implementation of more efficient irrigation practices. Figure 11 shows annual (calendar year) groundwater production by Cadiz since 1986, which totals approximately 125,327 acre-feet (AF). This production does not include extractions at the office, trailer park, and labor camp wells, which are just an additional few acre-feet per year.

An additional production well (PW-1) was constructed in 1999 in the Fenner Gap as a test well for the proposed Cadiz Groundwater Storage and Dry-Year Supply Program, developed in partnership with MWD from 1997 through 2002. This well was used to supply water to two spreading basins during an 8-month investigation of the response of the aquifer system to artificial recharge. The total amount of groundwater pumped during this test (conducted between March and October 1999) was approximately 975 AF. Because water pumped from PW-1 was allowed to percolate back into the subsurface via the spreading basins, there was essentially no net withdrawal of groundwater from the aquifer system. The engine and pump assembly for PW-1 were removed in late 2002. A new engine and pump assembly were installed in 2008 to allow for further testing. A minor amount of groundwater (generally 10 AF or less) has been pumped annually since 2009 for the purpose of well maintenance and demonstrating the function of the spreading basins and the infiltration properties of the soils in the Project area.

Three additional test wells were constructed in 2009 and the beginning of 2010 in Fenner Gap as part of an updated hydrological and geological assessment of the groundwater resources in the Cadiz and Fenner Valleys conducted by CH2M Hill. The three test wells (TW-1, TW-2, and TW-3) were utilized to assess the hydrogeologic properties of the carbonate rock units and alluvium in Fenner Gap as part of feasibility studies for the Water Project. Since 2009, a minor amount of groundwater per year has been pumped from these wells for testing of water quality and aquifer capacity.

Figure 11 shows total annual groundwater production for all wells, and Figures 12 through 18 show monthly pumping and groundwater elevation by well. Well 27N has not been utilized since June 2013 (permanently offline) and Wells 28 and 33 have been offline since 2009 (Well 28 is permanently offline). Wells 21S, 22, and 33 were redeveloped and aquifer tests were conducted to assess improvement in specific capacity of each well. A total of 24.14, 6.1, and 8.1 AF were pumped from these three wells, respectively, during the aquifer tests. Inset Table 6-1 below summarizes annual groundwater production from each irrigation well from 1993 through 2018, individual well data from 1986 through 1992 is not available and only total annual production is displayed for those years.

Table 6-1. Annual Irrigation Well Groundwater Production

Year	Well 21S	Well 21N	Well 28*	Well 33 (Acre-Ft)	Well 27N*	Well 22	Well 27S	Total
1986	-	-	-	-	-	-	-	3,000
1987	-	-	-	-	-	-	-	3,400
1988	-	-	-	-	-	-	-	4,100
1989	-	-	-	-	-	-	-	6,000
1990	-	-	-	-	-	-	-	3,588
1991	-	-	-	-	-	-	-	3,768
1992	-	-	-	-	-	-	-	4,274
1993	0	0	0	5	99	0	67	4,796
1994	836	0	554	1,125	1,021	63	1,136	4,736
1995	713	948	630	1,024	1,086	285	1,282	5,969
1996	834	520	702	1,156	1,045	343	1,120	5,720
1997	882	750	511	1,062	931	289	1,038	5,463
1998	699	1,033	507	1,047	493	583	725	5,087
1999	867	1,331	366	1,097	827	731	857	6,076
2000	783	1,263	512	1,145	738	893	759	6,092
2001	825	894	400	960	590	770	797	5,237
2002	881	1,008	495	1,012	759	799	540	5,495
2003	775	1,013	404	760	711	529	904	5,095
2004	712	524	376	686	819	543	569	4,229
2005	694	551	420	765	771	612	805	4,618
2006	806	731	166	840	840	861	193	4,438
2007	581	706	65	572	899	276	489	3,588
2008	329	463	2	6	435	0	735	1,970
2009	366	584	0	502	154	62	215	1,882
2010	356	590	0	0	0	62	858	1,867
2011	482	538	0	0	0	478	842	2,341
2012	511	559	0	0	536	7	751	2,364
2013	705	674	0	0	357	0	791	2,526
2014	421	405	0	0	0	0	498	1,324
2015	522	596	0	0	0	0	260	1,377
2016	884	613	0	0	0	0	361	1,858
2017	252	504	0	8	0	102	356	1,223
2018	458	666	0	0	0	163	540	1,827

*Well Nos. 28 and 27N have been taken permanently offline since 2009 and 2013 respectively.

Groundwater levels measured in each well are shown in Figures 12 through 18; static (non-pumping), near-static (groundwater levels which may not have fully recovered from pumping conditions), and pumping groundwater levels are shown. Sharp drawdowns in groundwater elevation during pumping is expected and is not indicative of regional groundwater elevation trends. These figures show trends in groundwater levels within the wellfield area. In general, groundwater levels declined slightly in the wellfield area as pumping increased in the late 1990s, largely stabilized in the early 2000s as groundwater levels equilibrated to maximum pumping levels, and then rebounded in the late 2000s as groundwater pumping was reduced. For this report period (2013 through 2018), and as early as 2005, groundwater elevations in most of the Group 1 Wells show obvious increases (see Figure 3). Based on the monitoring data, at the height of well extractions in 1999/2000, pumping did not affect groundwater levels on average beyond a distance of slightly over one mile from the center of the wellfield.

7.0 LAND SURFACE ELEVATION SURVEY

JBA conducted a Global Positioning System (GPS) survey in December 1997 to establish a baseline elevation for each of the seven irrigation wells and monitoring well 5/14-13 to facilitate detection of changes in land surface elevation over time. Subsequent surveys were conducted in 1999, 2000, 2002, 2007, 2010, 2013 to 2015, 2017, and 2018 to assess changes in land surface elevation at the benchmarks. These data are summarized in previous monitoring reports and data from 2015 to 2018 are in Table 7-1 below. The complete 2018 survey report can also be found in Appendix B of this report.

As described in the first Five-Year Summary Report (GEOSCIENCE, 2003), no apparent land subsidence was observed during the four surveys conducted between 1997 and 2002. Because both the area of irrigated land and the amount of groundwater extraction decreased during the period 2003 through 2007, annual land surface elevation surveys were not conducted for that period. JBA conducted a repeat survey of land surface elevation benchmarks in December 2007. The results of this survey document that all 2007 elevations are similar to those originally measured in 1997. Land surface elevation surveys were not conducted in 2008 and 2009 because there were no significant changes to acreage under cultivation or water use in those years. A land surface elevation survey was completed in 2010 as part of technical reporting for the Water Project, and another survey was completed in 2013. The results of these surveys are similar to the 1997 baseline measurements. Any variations observed are considered to be within expected limitations of the approach.

The land subsidence monitoring program has been and will continue to be expanded as part of the GMMMP, including establishment of a baseline condition as part of the pre-operational monitoring activities, before groundwater pumping is ramped up. As a first step in transitioning to the GMMMP, CH2M Hill (in coordination with JBA) established a new stable benchmark in the Marble Mountains and identified several existing stable benchmarks to serve as reference benchmarks for future subsidence surveys, as reported in the Seventeenth Annual Report (Foreman, 2015). In addition, five new survey control points for subsidence monitoring were added in 2015. These monitoring points are shown in Figure 2. Appendix B provides the Dec 2018 GPS survey report from Towill Inc.

New survey procedures were implemented in the December 2014 survey, as described in the Seventeenth Annual Report (Foreman, 2015). The new survey procedures establish benchmarks on Marble Mountain as reference points for the Cadiz subsidence surveys. The goal of the new procedures is to obtain a vertical accuracy of +/- 0.10 feet tolerance threshold. As shown below in Table 7-1, all survey points are within or very near the +/- 0.10 feet limit of instrument accuracy. As groundwater elevations have not declined significantly, and have largely recovered over time, it is likely that the differences in year-to-year values are within the vertical accuracy of the survey capability, which may be slightly larger than the goal of +/-

0.10 feet. Future surveys will determine if these variations are anomalies or a trend. The results of all GPS surveys of ground surface elevations suggest that no significant subsidence has occurred to date.

Table 7-1. 2015 and 2018 Land Surface Elevation GPS Survey Data

Well	Monument Identification	GPS Coordinates (NAD83)		Averages of Measurements 1 and 2 (Elevations in Feet NAVD88)		Difference
		Northing	Easting	2015 (Baseline)	2018 (December)	
5/14-13	2" Brass Disk	2021446.843	7323740.959	894.83	894.852	-0.025
21N	2" Brass Disk	2017242.060	7311758.242	793.43	793.343	0.085
21S	2" Brass Disk	2014440.506	7308662.988	762.91	762.889	0.019
22	2" Brass Disk	2016211.523	7314994.086	813.17	813.102	0.063
27N	2" Brass Disk	2012283.246	7314707.336	790.94	790.887	0.053
27S	2" Brass Disk	2009515.074	7314616.661	778.36	778.331	0.024
28	2" Brass Disk	2008178.187	7309388.482	741.07	741.053	0.014
33	2" Brass Disk	2004655.788	7309287.950	729.08	728.963	0.113
MP1	2" Brass Disk	2007954.448	7272935.594	612.032	611.919	0.113
MP2	2" Brass Disk	2006251.211	7280193.280	613.796	613.662	0.134
MP3	2" Brass Disk	2016868.780	7326083.132	878.959	878.939	0.020
MP4	2" Brass Disk	2001630.764	7301909.678	683.635	683.507	0.128
MP5	2" Brass Disk	2027229.717	7333049.646	970.578	970.531	0.047

8.0 GROUNDWATER BASIN RECHARGE AND STORAGE

8.1 Groundwater Storage in the Cadiz Agricultural Area

The volume of groundwater in storage within the aquifers in the vicinity of the Cadiz Agricultural Development is estimated to range from approximately 4 to 7 million acre-ft (MWD, 1999). The estimated range in storage does not include groundwater with TDS concentrations greater than 1,000 mg/L and does not include water stored in the bedrock aquifer. Monitoring well hydrographs of Group 2, 3, and 4 wells, located outside the wellfield area (especially in and north of the Fenner Gap area), suggest that groundwater levels have not fluctuated significantly over the long-term (Figures 1, 4, 5, and 6). Therefore, overall groundwater in storage has not changed during the reporting period.

8.2 Average Annual Recharge to Cadiz Agricultural Area

Natural replenishment of groundwater resources beneath Bristol, Cadiz and Fenner Watersheds occurs from both surface runoff and percolation of precipitation. The majority of rainfall in lower elevations (valleys) is evaporated or consumed by plants before it enters the groundwater system. Therefore, the groundwater system is primarily replenished through infiltration of precipitation at higher elevations and surface water infiltration in the sandy-bottomed washes (e.g., Orange Blossom Wash) during major storm events. Average annual precipitation in the area ranges from approximately 3.4 inches at the Amboy Station (located adjacent to Bristol Dry Lake) to 10.44 inches at the Mitchell Caverns Station (located at an elevation of 4,350 ft in the Providence Mountains). Davisson & Rose (2000) have estimated that average annual precipitation in the highest portions of the Fenner Watershed (the New York Mountains, which exceed 7,500 ft in elevation) may exceed 18 inches.

Although some of the groundwater is tapped by vegetation near the range fronts, much of the groundwater slowly moves downgradient – eventually discharging to Bristol and Cadiz Dry Lakes. Thompson (1929), Gale (1951), Bassett et al. (1959), Handford (1982)y, and Rosen (1989) concur that the principal discharge to the dry lakes occurs from seepage of groundwater into the lakebed sediments from adjacent alluvial deposits. This groundwater discharge to the dry lakes is ultimately lost to evaporation.

The occurrence of active groundwater replenishment within the Bristol, Cadiz, and Fenner Watershed area is supported by: (1) the existence of a regionally consistent hydraulic gradient that is based on water level measurements from more than 50 wells in the region; (2) isotopic evidence for a geologically "recent" (Holocene) age for the groundwater; and (3) relatively stable groundwater elevations recorded in wells located between Fenner Gap and Bristol Dry Lake, despite continuous groundwater pumping by the Cadiz agricultural operation for more than 33 years.

Recent estimates of average annual recharge in the Fenner Watershed include those from the USGS Basin Characterization Model (BCM) water balance model (6,873 acre-ft/yr; USGS BCM Model, 2014). However, the BCM model is a regional model developed to assess the effects of climate change regionally and has not been validated against local data and observations. Local Investigations in the Cadiz area using a combination of integrated groundwater/surface water model results and observed evaporation measurements indicate recharge at 33,885 acre-ft/yr; (CH2M Hill, 2012). Using Darcy's Law to estimate underflow, the estimated recharge rate in the Cadiz area ranged from 18,000 to 32,000 acre-ft/yr (GEOSCIENCE, 1995).

9.0 SUMMARY AND CONCLUSIONS

The following summarizes groundwater conditions in the Cadiz Valley Agricultural Development project area over the five-year period between January 2013 and December 2018:

- Variations in groundwater elevations measured in the irrigation wells are within normal ranges expected during seasonal pumping and recovery cycles. Generally, groundwater levels are above baseline levels in Cadiz irrigation wells as a result of pumping decreases and recharge in recent years.

- Groundwater levels in the monitoring wells in the vicinity of the irrigation wellfield are stable with slight increases. Groundwater levels in monitoring wells located as far as 12 miles upgradient from the wellfield and other pumping wells also show increasing trends. Because these monitoring wells are located far beyond the area of influence of any pumping wells, these fluctuations in water levels most probably reflect natural variations in recharge (i.e., wet and dry cycles).

- Irrigation and monitoring wells were sampled for water quality, including TDS, from 2013 through present. As stated in Section 1.0: Introduction, supplemental information is being provided as an ongoing transition toward the requirements of the approved GMMMP. No significant changes in groundwater quality have been reported. Generally, groundwater quality appears to be stable. There are a few irrigation wells that have experienced increases in TDS and nitrate, which seem to be localized conditions – wells sitting idle or permanently offline, sampling methods used, redevelopment issues, and possibly increased irrigation and leaks from the irrigation system. Ongoing monitoring has indicated that TDS spikes at irrigation wells 21N and 33 were temporary and the TDS values have since dropped back down to normal immediately after well had been turned back on (see footnote on page 16). Recent samples collected at Well 27N show a drop of TDS of over 100 mg/L, however, these spikes in TDS are anomalous and additional investigations will need to be conducted to help understand this localized TDS increases.

- Average annual groundwater production for the Cadiz Valley Agricultural Development from 1998 through 2002 was approximately 5,600 AFY; and 4,390 AFY from 2003 through 2007. Average annual production from 2008 through 2012 and 2013 through 2017 has been approximately 2,090 AFY and 1,660 AFY, respectively. Total production during 2018 increased slightly to 1,827 AF, compared to 1,223 AF in 2017 – likely due to more mature irrigated crops. Groundwater production by Cadiz since 1986 totals 125,327 AF.

- A new survey of land surface elevation benchmarks was conducted in 2018, including the five new survey monuments installed in 2015 as part of the transition to the GMMMP. Results of this survey indicate that all NAVD88 elevations are similar to those measured in 2015. There is no apparent evidence of subsidence since 1997 (baseline year). Variations observed between surveys are considered to be within expected limitations of the approach.

- Based on the groundwater conditions observed during this monitoring period, irrigation pumping by the Cadiz Valley Agricultural Development has not resulted in any significant changes or adverse impacts to groundwater levels, change in storage, groundwater quality, or land surface stability.

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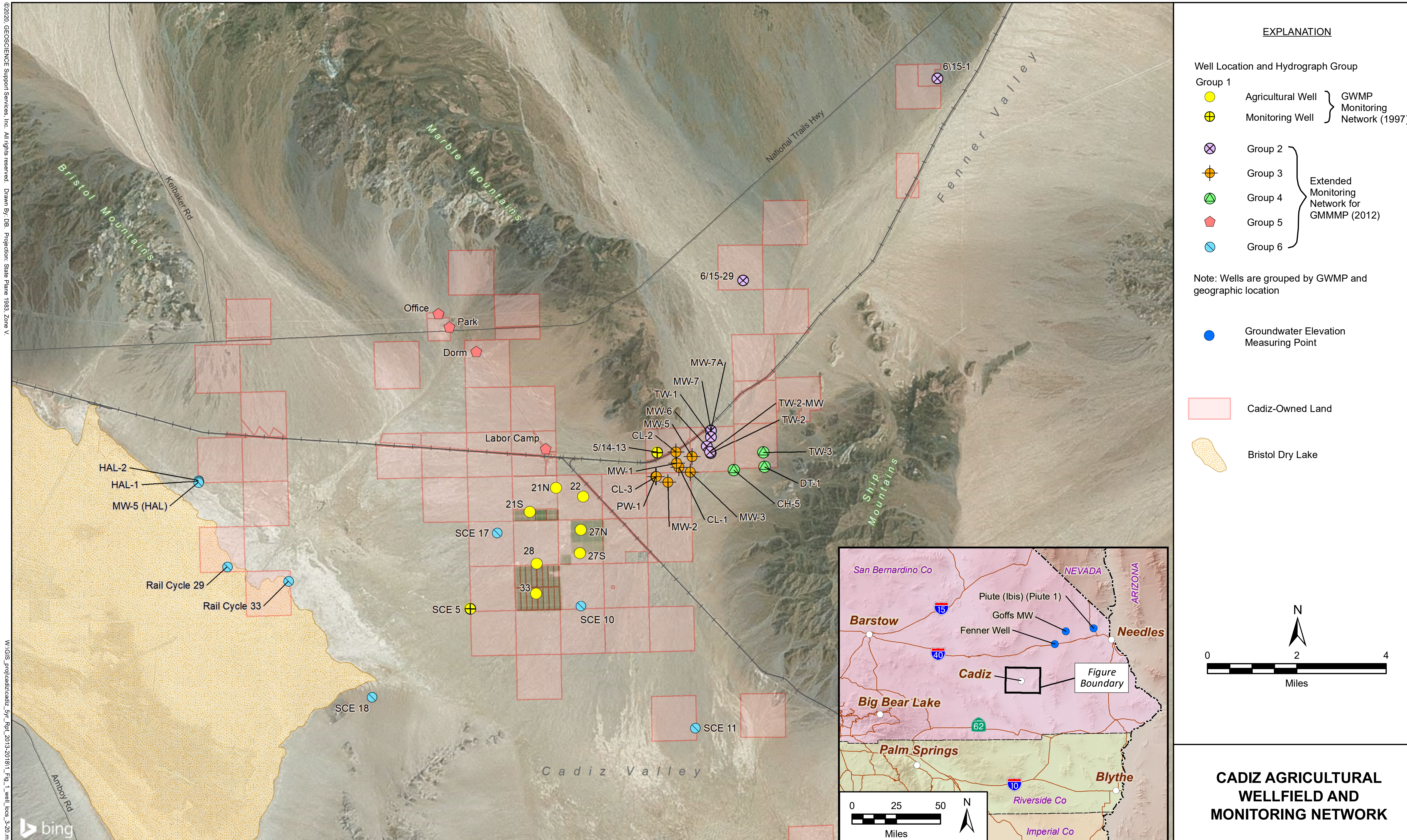
FIGURES

GEOSCIENCE



10-Jun-20

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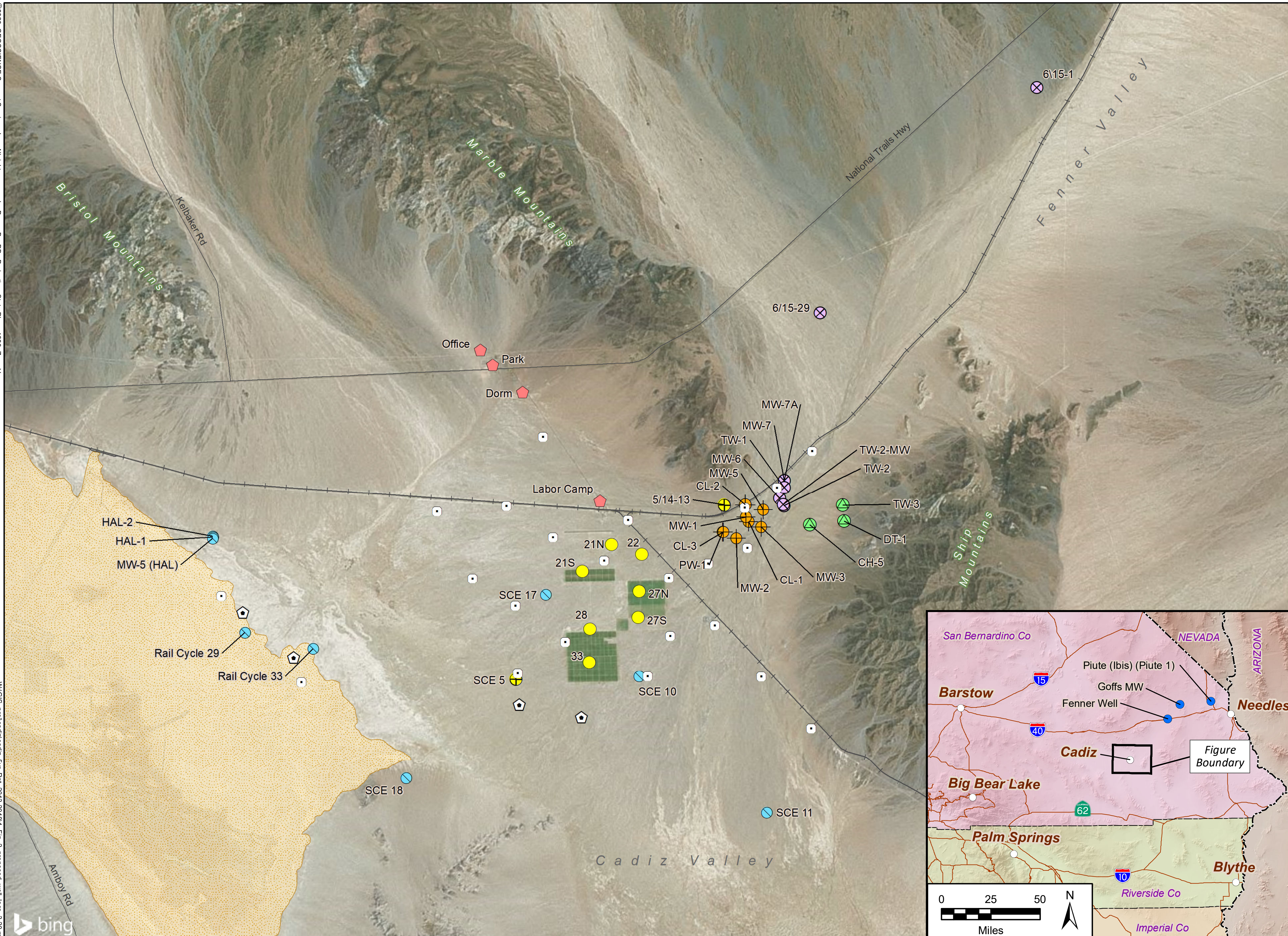
FIGURE 1

CADIZ VALLEY AGRICULTURAL DEVELOPMENT - TWENTY-FIRST ANNUAL GROUNDWATER REPORT (JANUARY 2018 - DECEMBER 2018) & Fourth Five-Year Summary REPORT (JANUARY 2013 - DECEMBER 2018)

GEOSCIENCE



EXPLANATION

- Proposed Induced Flow and Brine Migration Cluster Well
- Proposed Land Survey Benchmark

Well Location and Hydrograph Group

Group 1

- Agricultural Well
- Monitoring Well

} GWMP Monitoring Network (1997)

- Group 2
- Group 3
- Group 4
- Group 5
- Group 6

} Extended Monitoring Network for GMMMP (2012)

Note: Wells are grouped by GWMP and geographic location

- Cadiz-Owned Land
- Bristol Dry Lake

N

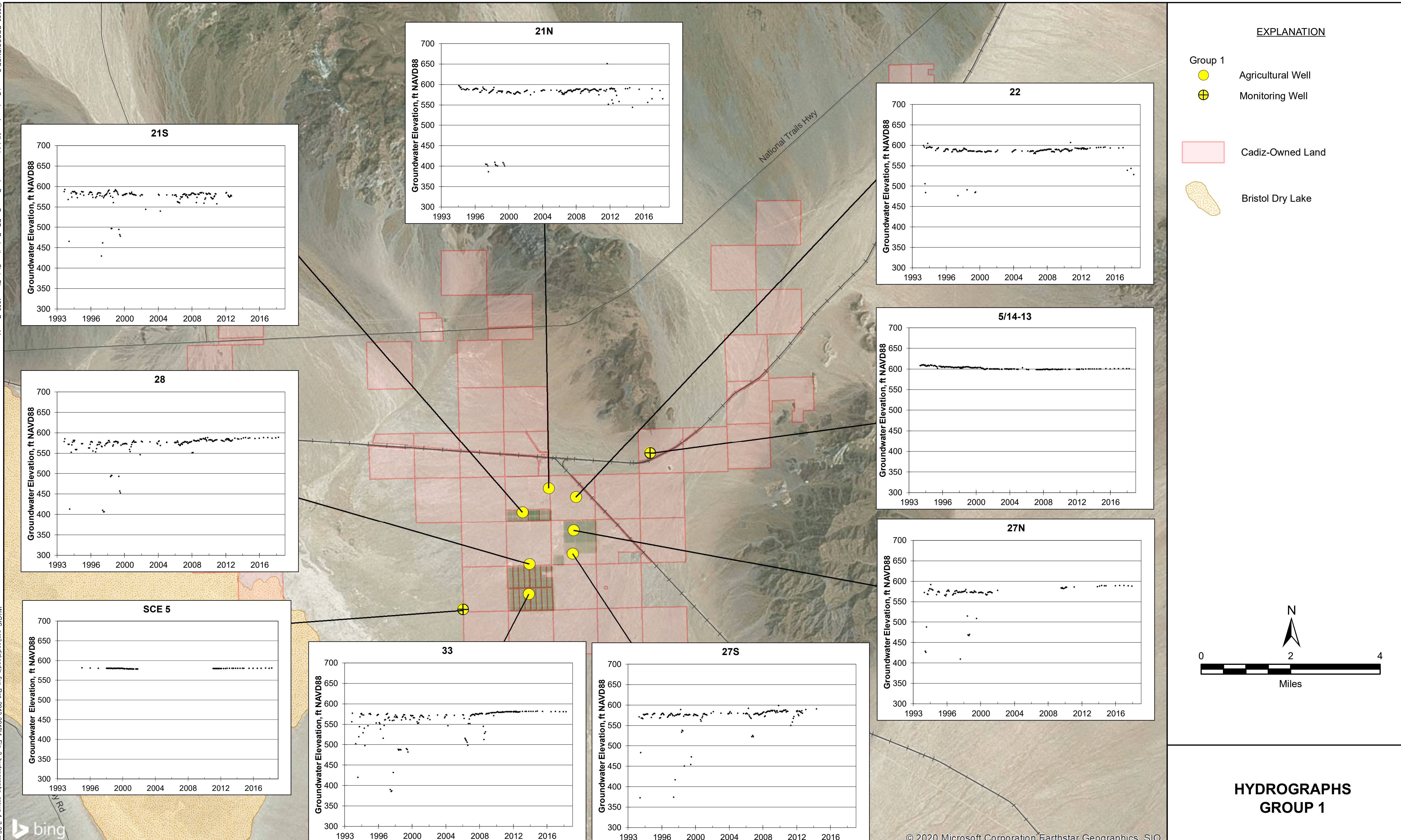
0 2 4

Miles

PROPOSED GMMMP MONITORING POINTS (SUBSIDENCE AND WELLS)

W:\GIS_proj\cadiz\cadiz_5yr_Rpt_2013-2018\1_Fig_2_proposed_well_locs_3-20.mxd

10-Jun-20



W:\GIS_proj\cadiz\cadiz_5yr_Rpt_2013-2018\1_Fig_3_hydrographs_group-1_3-20.mxd

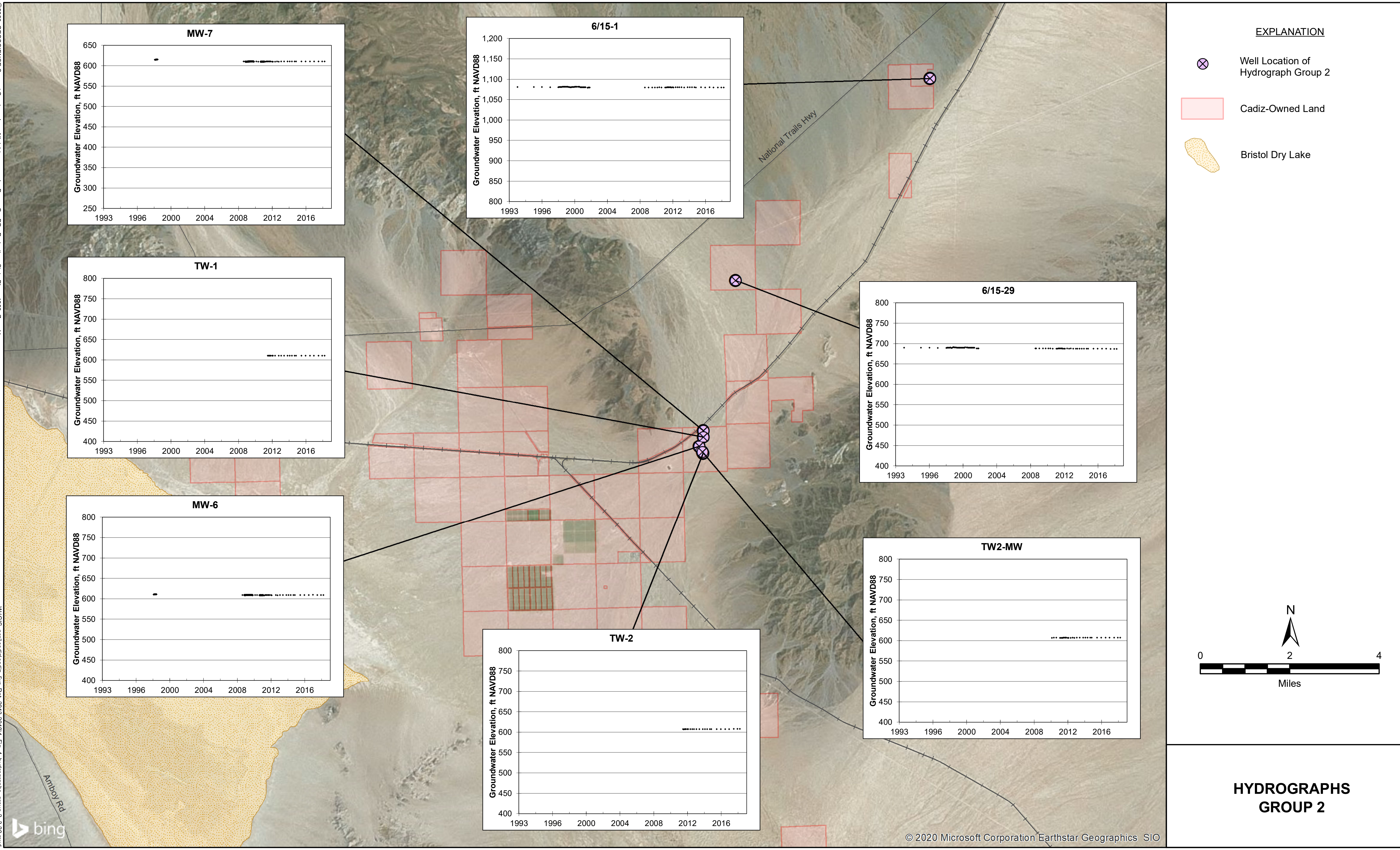
10-Jun-20

CADIZ, INC.

FIGURE 3

CADIZ VALLEY AGRICULTURAL DEVELOPMENT - TWENTY-FIRST ANNUAL GROUNDWATER REPORT (JANUARY 2018 - DECEMBER 2018) & Fourth Five-Year Summary REPORT (JANUARY 2013 - DECEMBER 2018)

GEOSCIENCE



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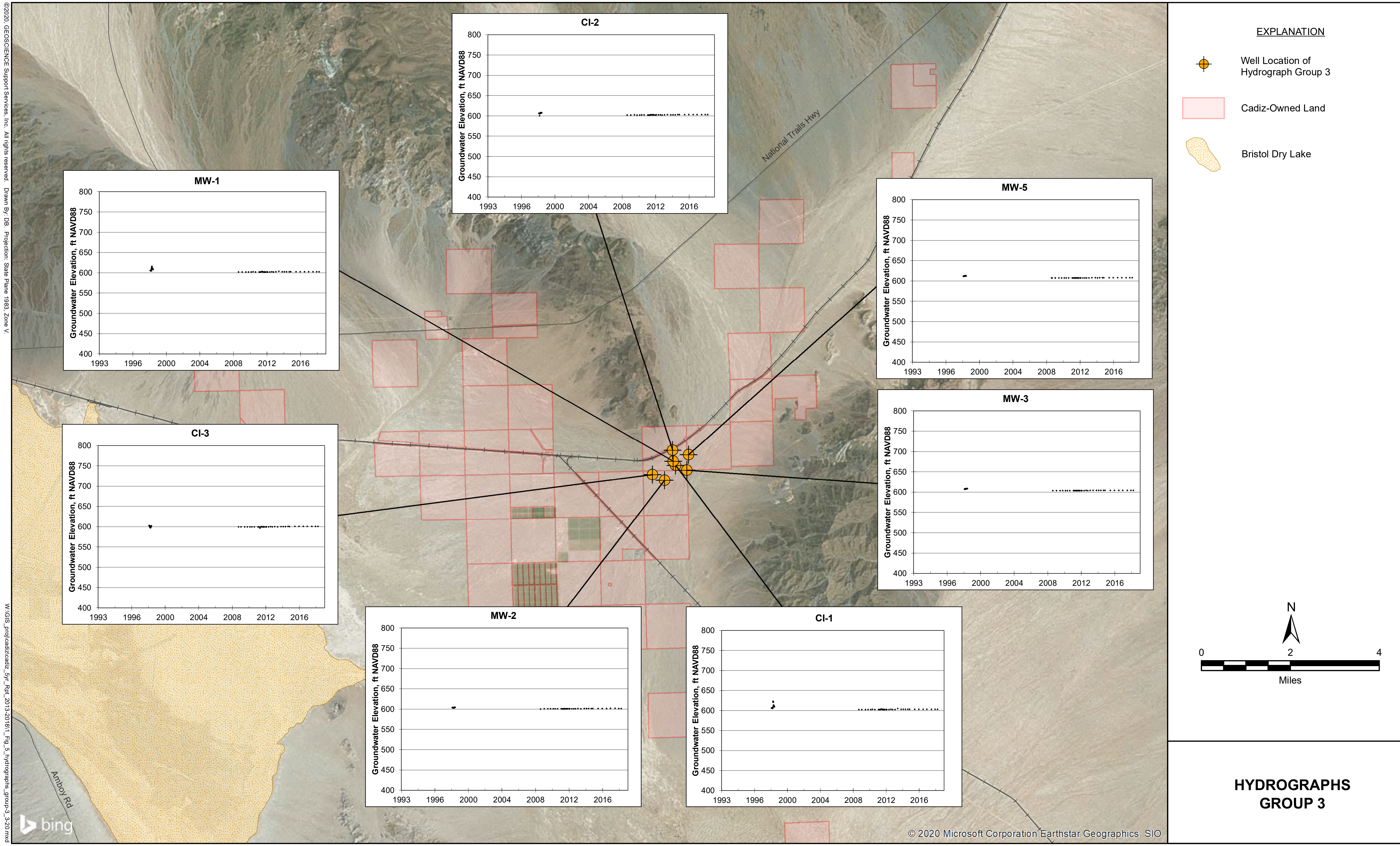
10-Jun-20

CADIZ, INC.

FIGURE 4

CADIZ VALLEY AGRICULTURAL DEVELOPMENT - TWENTY-FIRST ANNUAL GROUNDWATER REPORT (JANUARY 2018 - DECEMBER 2018) & Fourth Five-Year Summary REPORT (JANUARY 2013 - DECEMBER 2018)

GEOSCIENCE



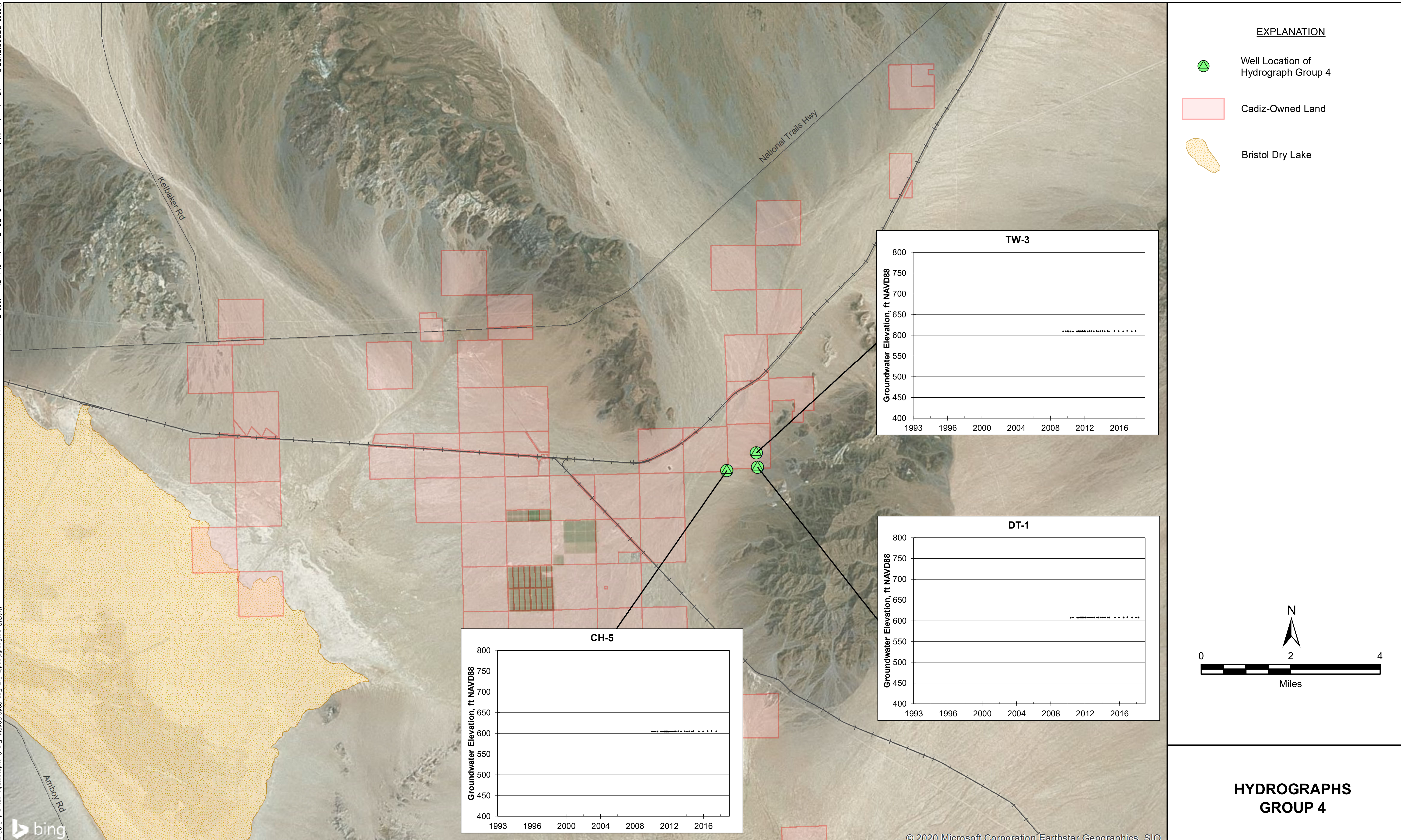
10-Jun-20

CADIZ, INC.

FIGURE 5

CADIZ VALLEY AGRICULTURAL DEVELOPMENT - TWENTY-FIRST ANNUAL GROUNDWATER REPORT (JANUARY 2018 - DECEMBER 2018) & Fourth Five-Year Summary REPORT (JANUARY 2013 - DECEMBER 2018)

GEOSCIENCE



W:\GIS_proj\cadiz\cadiz_5yr_Rpt_2013-2018\1_Fig_6_hydrographs_group-4_3-20.mxd

10-Jun-20

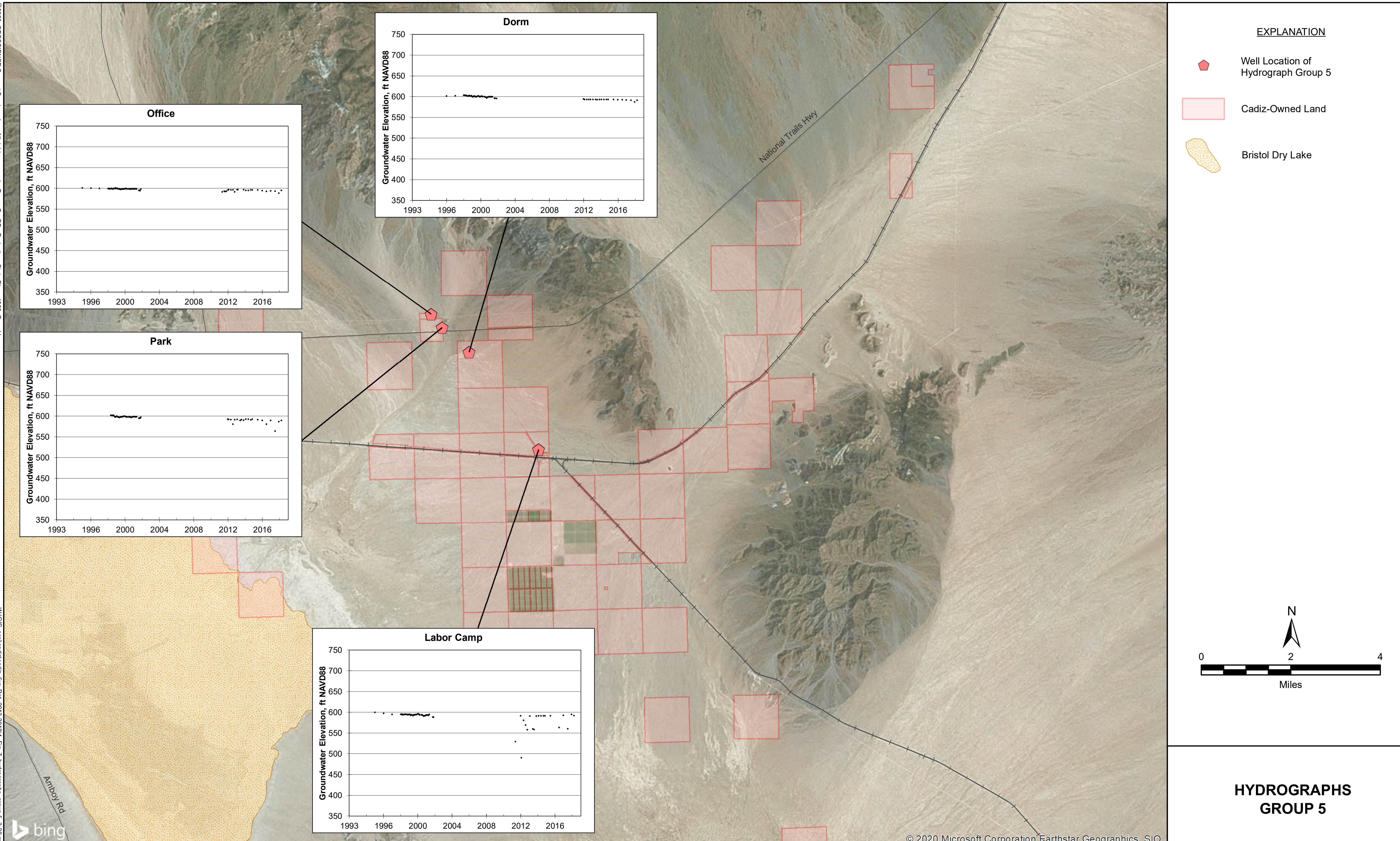
HYDROGRAPHS GROUP 4

CADIZ, INC.

FIGURE 6

CADIZ VALLEY AGRICULTURAL DEVELOPMENT - TWENTY-FIRST ANNUAL GROUNDWATER REPORT (JANUARY 2018 - DECEMBER 2018) & Fourth Five-Year Summary REPORT (JANUARY 2013 - DECEMBER 2018)

GEOSCIENCE



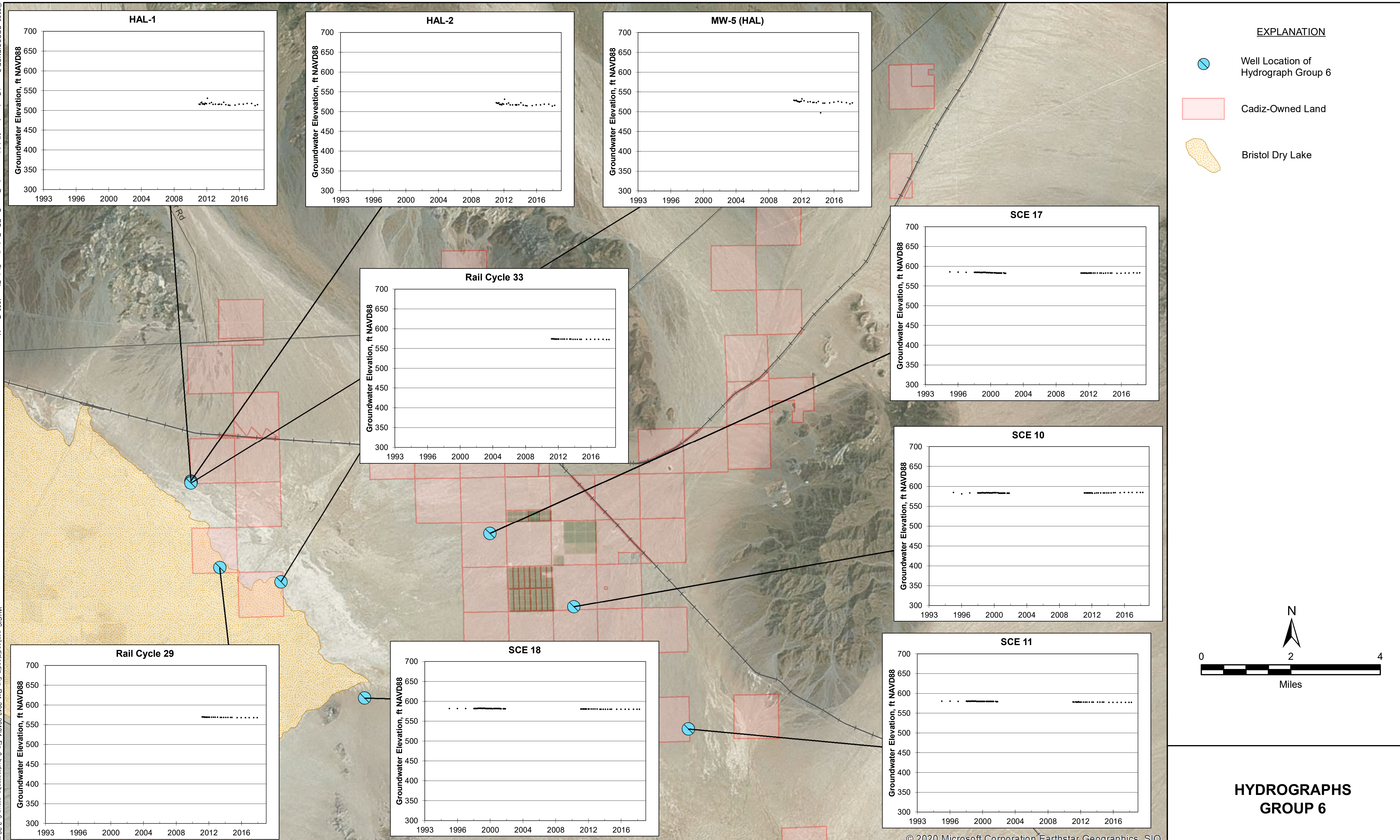
10-Jun-20

FIGURE 7

CADIZ, INC.

CADIZ VALLEY AGRICULTURAL DEVELOPMENT - TWENTY-FIRST ANNUAL GROUNDWATER REPORT (JANUARY 2018 - DECEMBER 2018) & Fourth Five-Year Summary REPORT (JANUARY 2013 - DECEMBER 2018)

GEOSCIENCE



W:\GIS_proj\cadiz\cadiz_5yr_Rpt_2013-2018\1_Fig_8_hydrographs_group-6_3-20.mxd

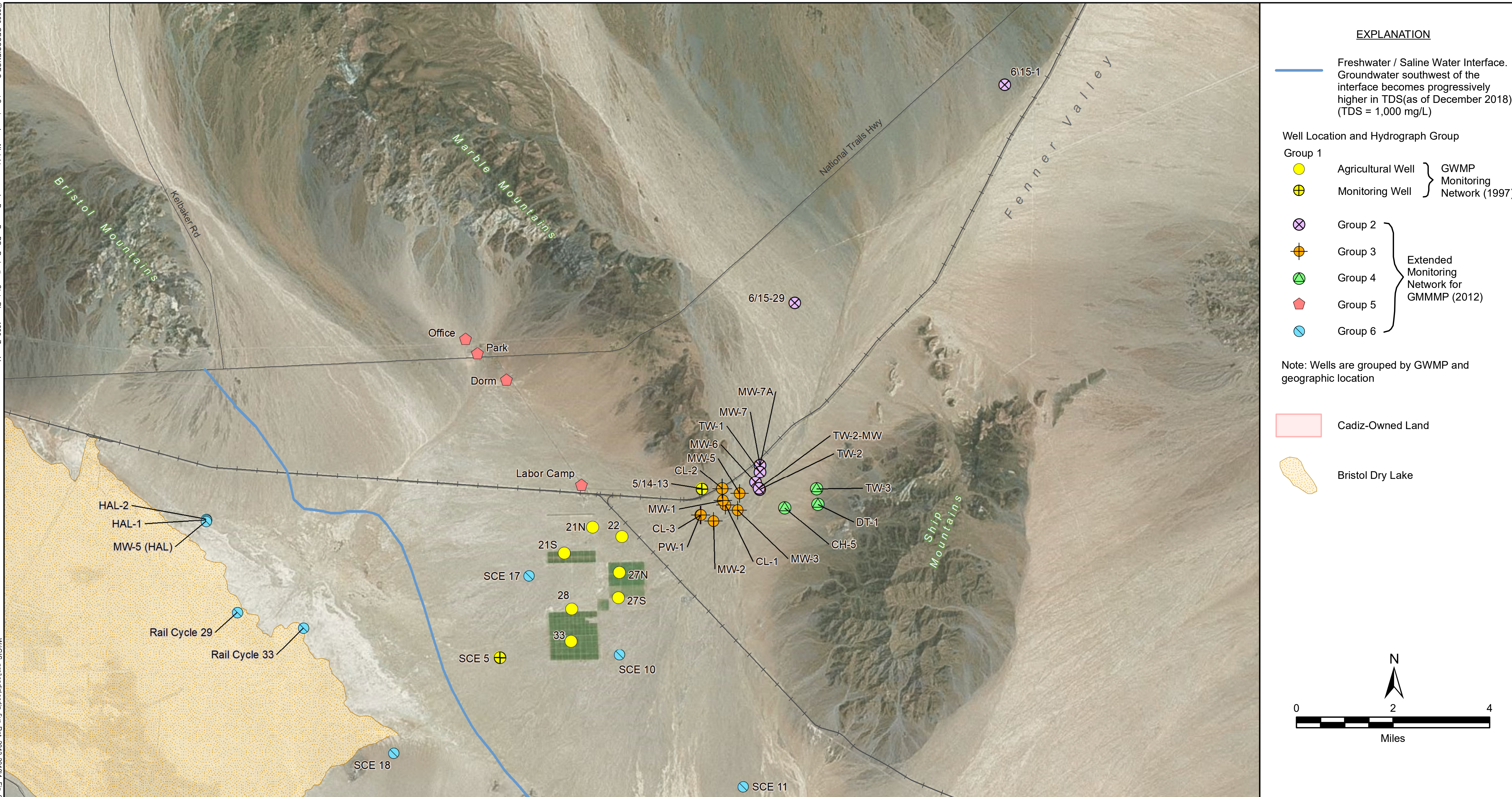
10-Jun-20

CADIZ, INC.

FIGURE 8

CADIZ VALLEY AGRICULTURAL DEVELOPMENT - TWENTY-FIRST ANNUAL GROUNDWATER REPORT (JANUARY 2018 - DECEMBER 2018) & Fourth Five-Year Summary REPORT (JANUARY 2013 - DECEMBER 2018)

GEOSCIENCE

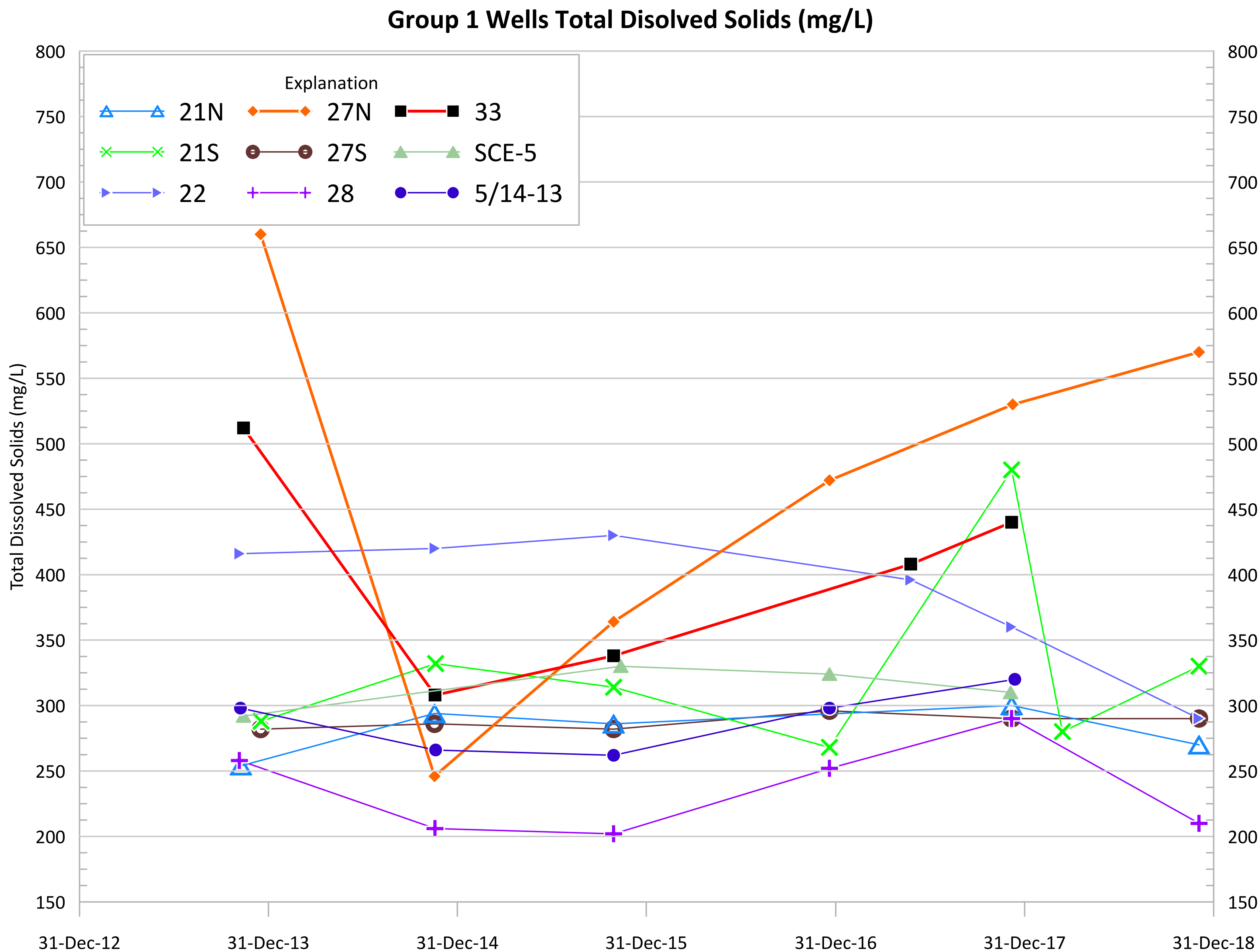


FRESHWATER / SALINEWATER INTERFACE (TDS = 1,000 mg/L)

10-Jun-20

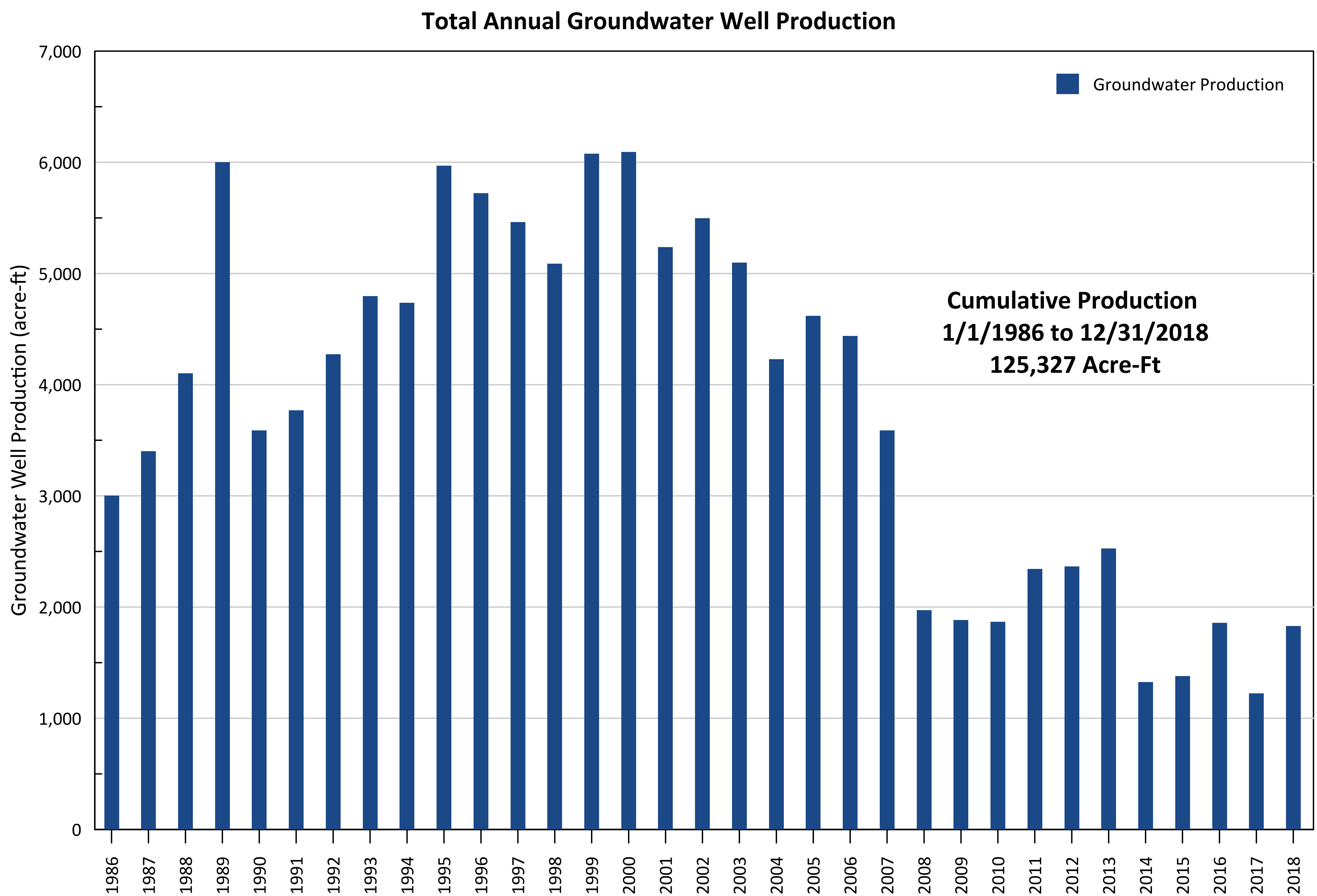
CADIZ, INC.

FIGURE 9


Group 1 Wells Total Disolved Solids (mg/L)
Explanation
21N
27N
33
21S
27S
SCE-5
22
28
5/14-13
Total Dissolved Solids (mg/L)
800
750
700
650
600
550
500
450
400
350
300
250
200
150
31-Dec-12
31-Dec-13
31-Dec-14
31-Dec-15
31-Dec-16
31-Dec-17
31-Dec-18

GEOSCIENCE

FIGURE 11



10-Jun-20

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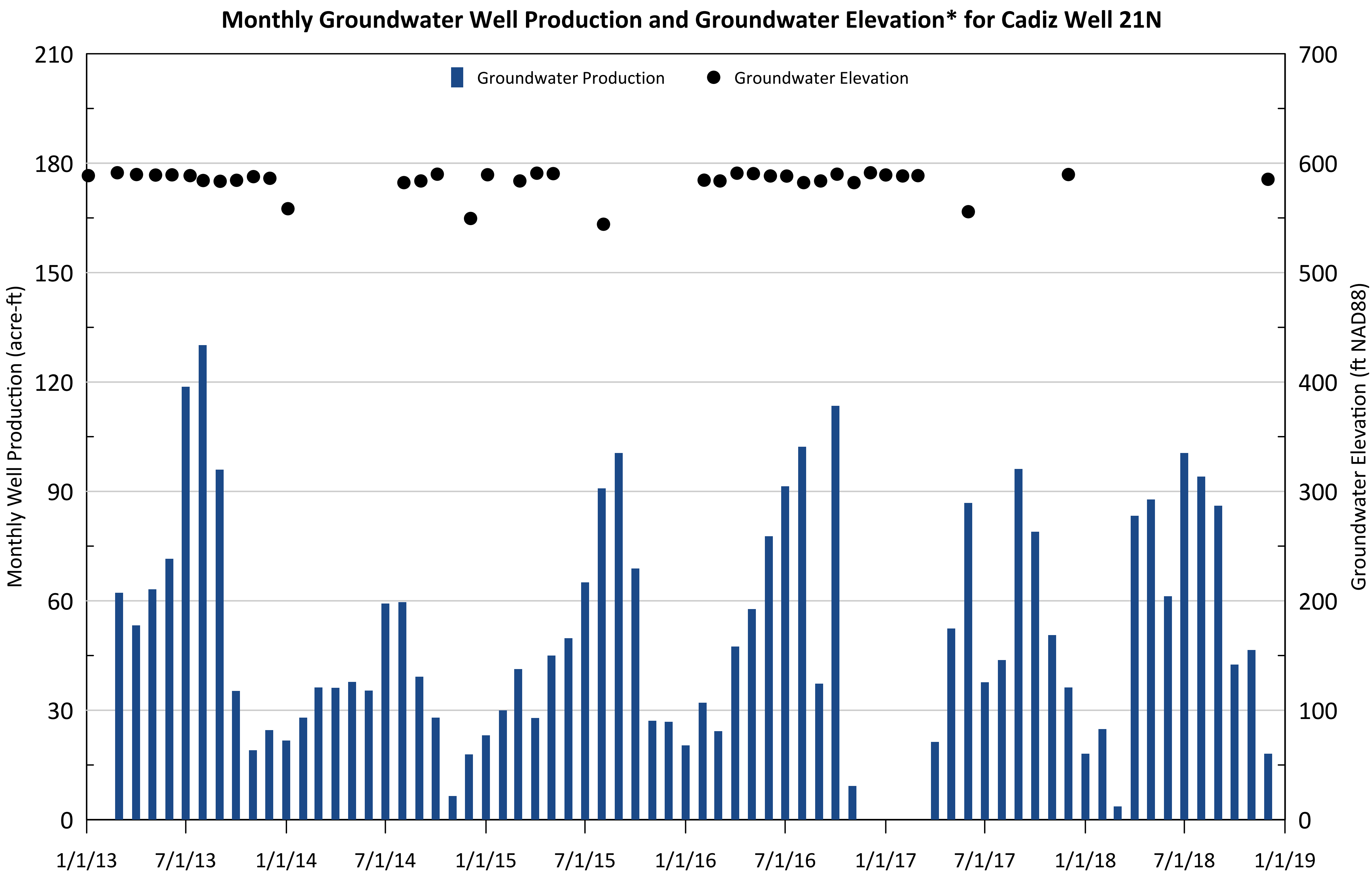
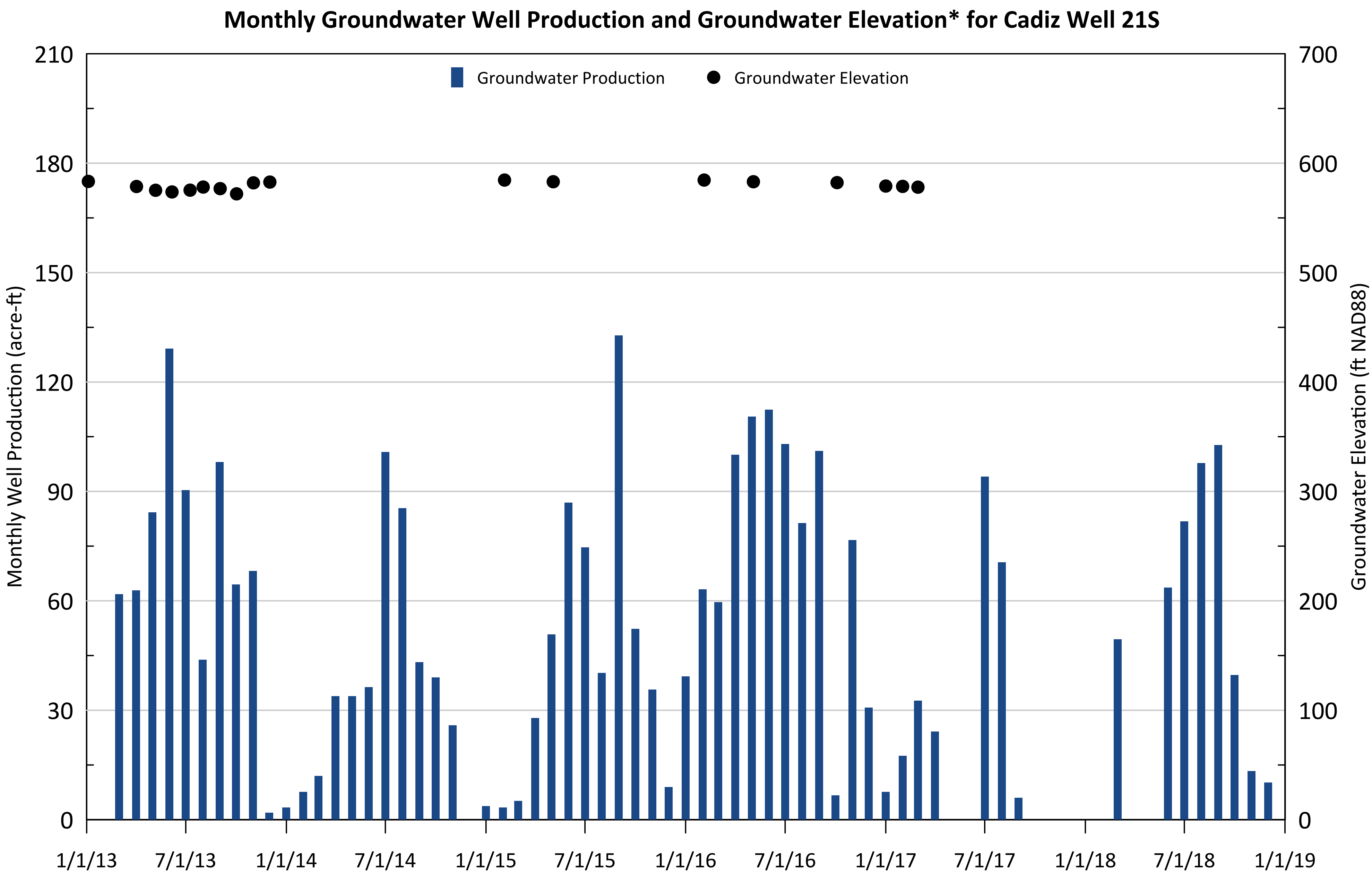
FIGURE 12



*Groundwater elevations were recorded monthly as static water levels; However, in some cases, the recording was taken too soon after pump shut off which resulted in a lower than normal elevations.

10-Jun-20

GEOSCIENCE

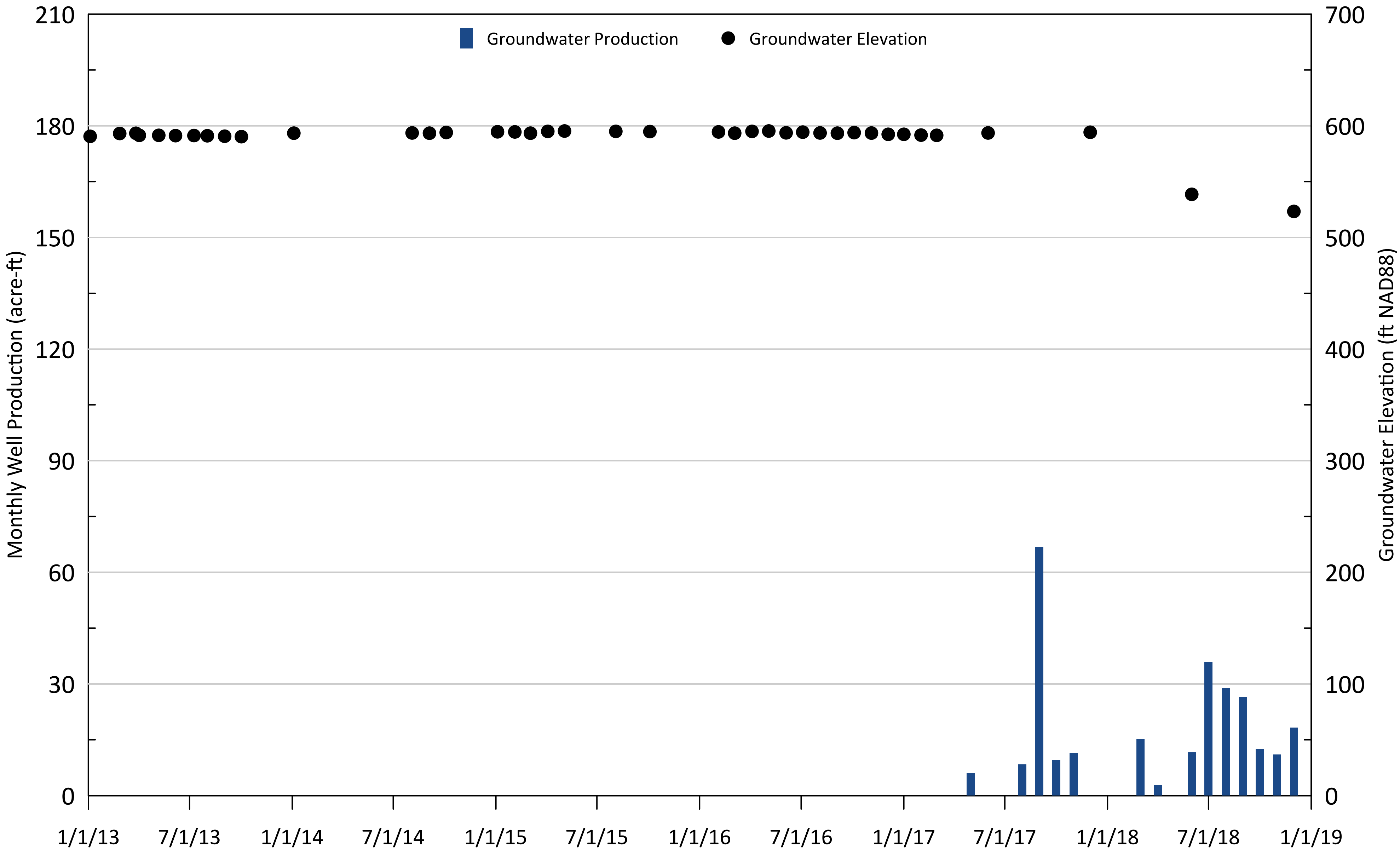


*Groundwater elevations were recorded monthly as static water levels; However, in some cases, the recording was taken too soon after pump shut off which resulted in a lower than normal elevations.

GEOSCIENCE

FIGURE 14

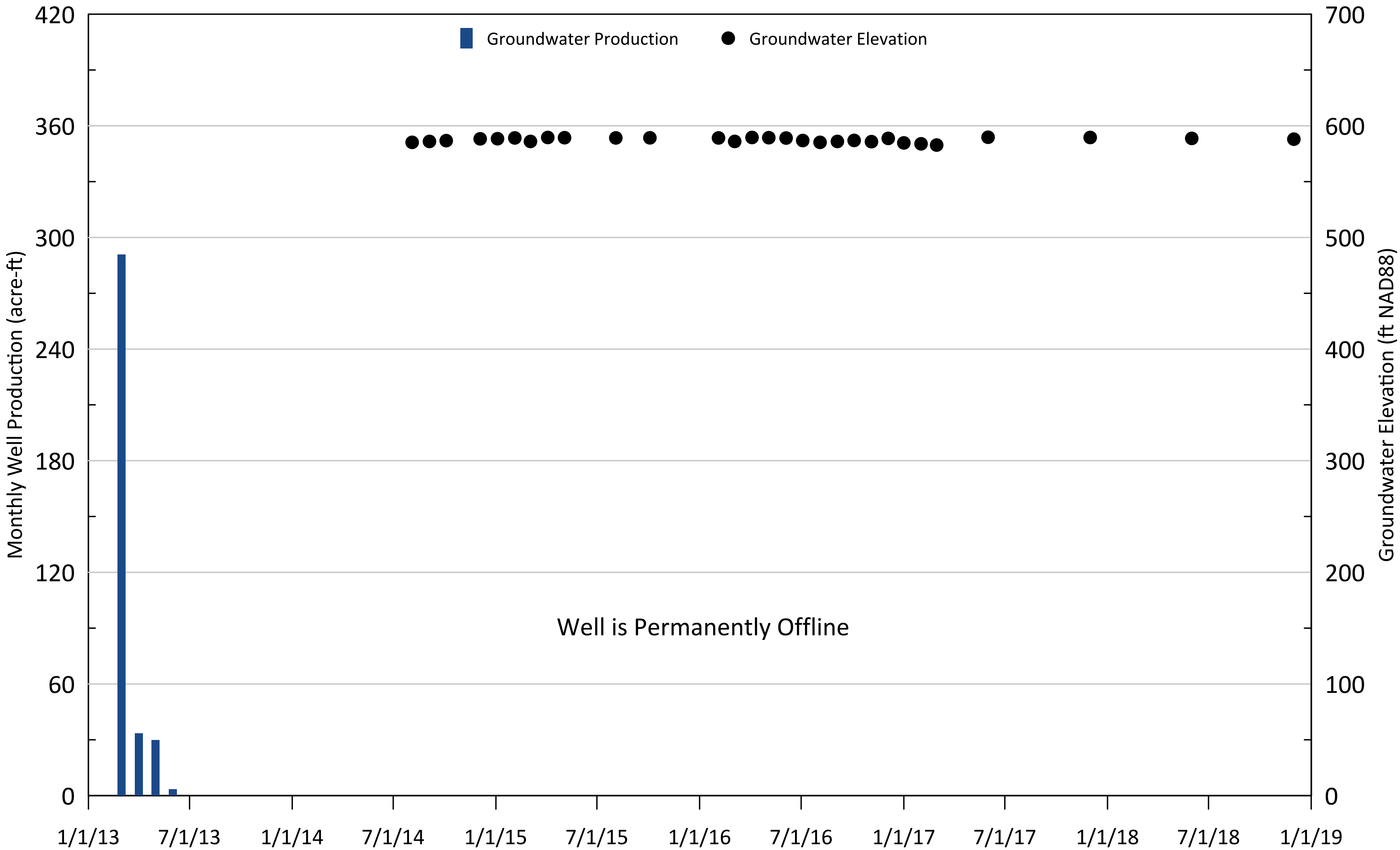
Monthly Groundwater Well Production and Groundwater Elevation* for Cadiz Well 22



*Groundwater elevations were recorded monthly as static water levels; However, in some cases, the recording was taken too soon after pump shut off which resulted in a lower than normal elevations.

GEOSCIENCE

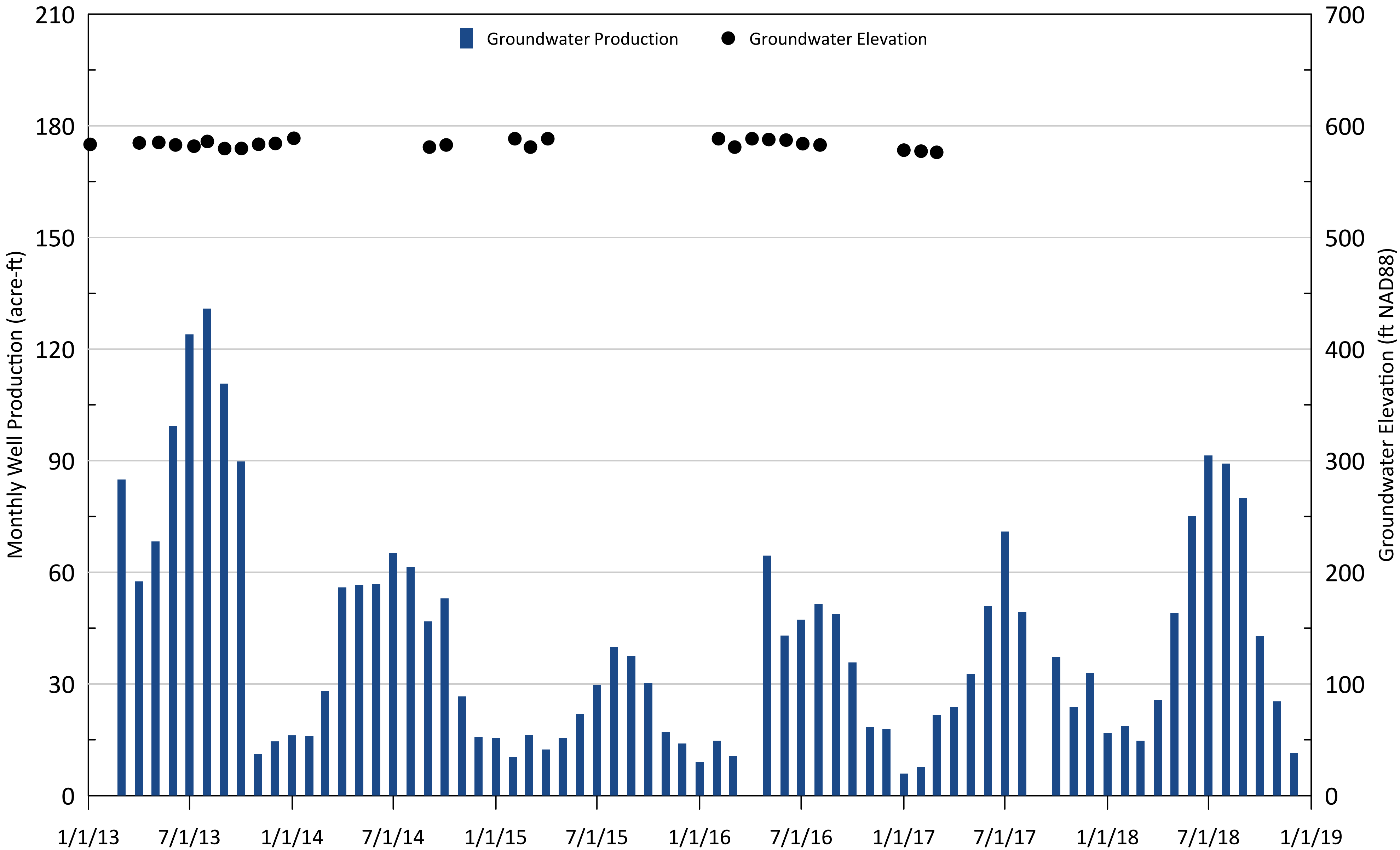
Monthly Groundwater Well Production and Groundwater Elevation* for Cadiz Well 27N



*Groundwater elevations were recorded monthly as static water levels; However, in some cases, the recording was taken too soon after pump shut off which resulted in a lower than normal elevations.

FIGURE 16

Monthly Groundwater Well Production and Groundwater Elevation* for Cadiz Well 27S

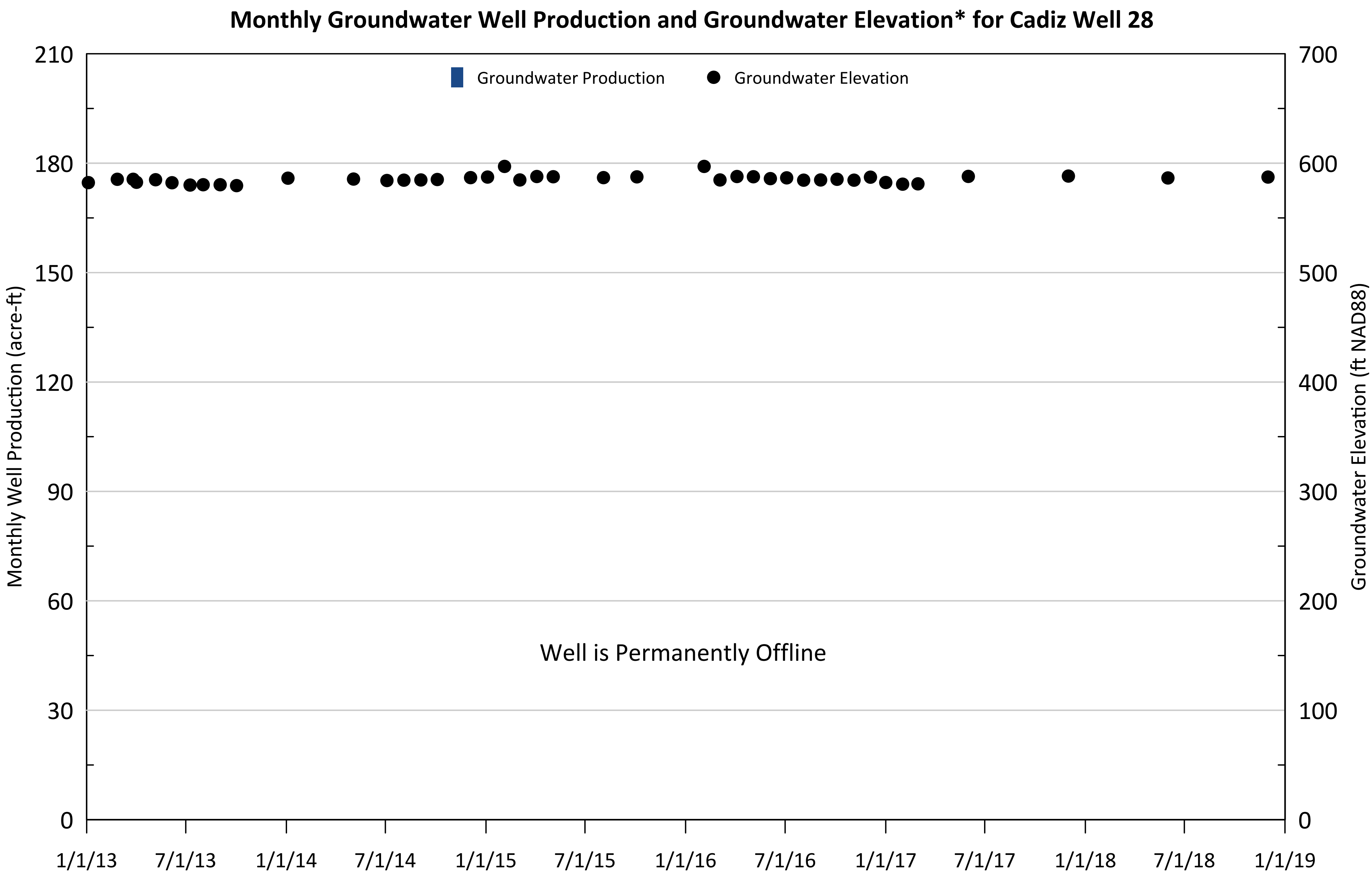


*Groundwater elevations were recorded monthly as static water levels; However, in some cases, the recording was taken too soon after pump shut off which resulted in a lower than normal elevations.

10-Jun-20

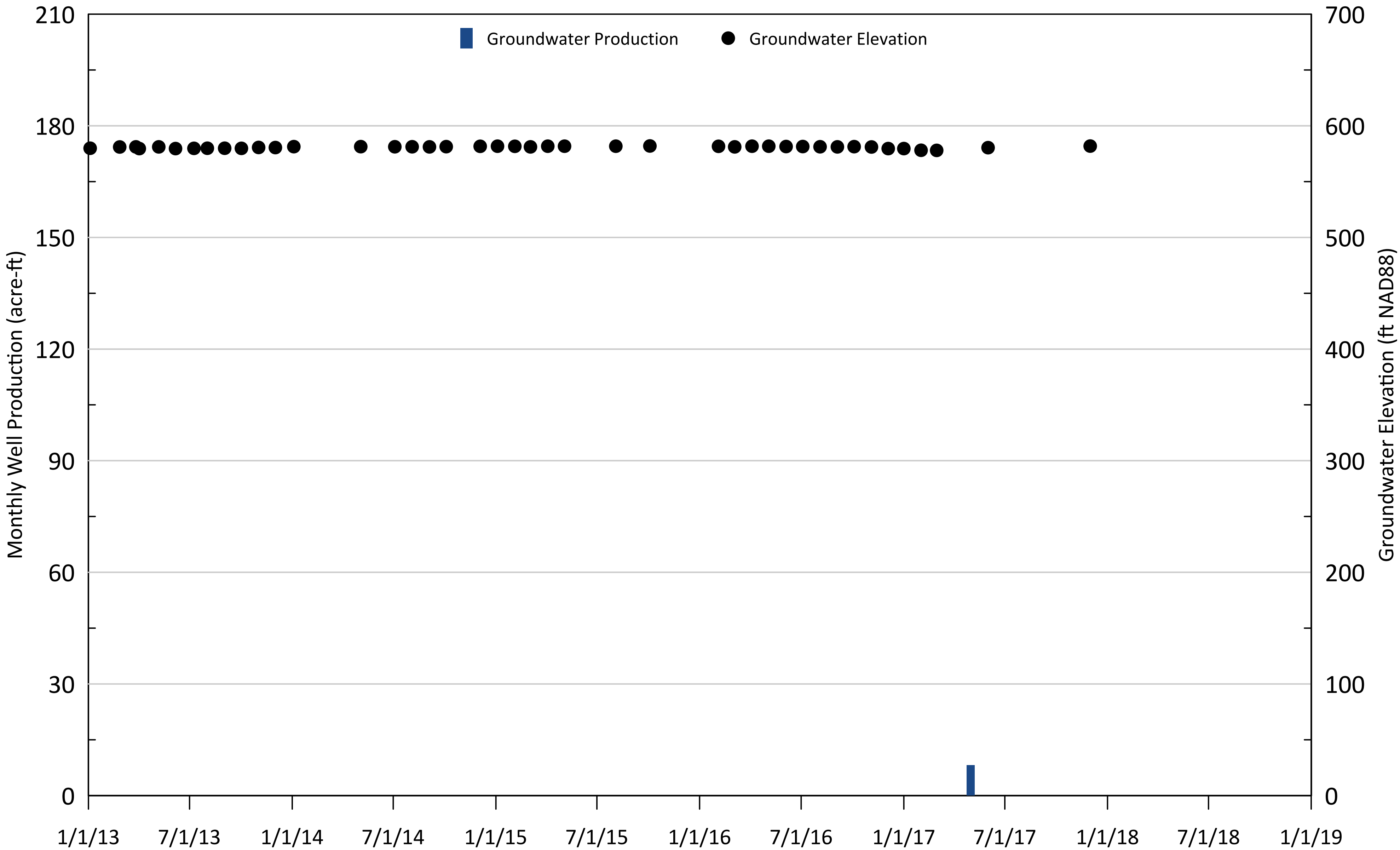
GEOSCIENCE

FIGURE 17



*Groundwater elevations were recorded monthly as static water levels; However, in some cases, the recording was taken too soon after pump shut off which resulted in a lower than normal elevations.

Monthly Groundwater Well Production and Groundwater Elevation* for Cadiz Well 33



*Groundwater elevations were recorded monthly as static water levels; However, in some cases, the recording was taken too soon after pump shut off which resulted in a lower than normal elevations.

GEOSCIENCE

TABLES

Table 1: Production and Monitoring Well Construction Details

Well Designation	Date Completed	Coordinates (NAD83)		Elevation (ft msl)	Drilling Method	Borehole Diameter (inches)	Conductor Depth (ft bgs) (Diameter)	Total Borehole Depth (ft bgs)	Cased Depth (ft bgs) (Diameter)	Screened Interval (ft bgs)	Filter Pack Interval (ft bgs)	Seal Interval (ft bgs)
		Latitude	Longitude									
TW-1 (Alluvium Section)	10/28/2009	34° 31' 38"	115° 26' 55"	940.04	Mud Rotary (to 455 ft) Dual Tube (to 1,002 ft)	24 (to 50 ft) 17.5 (to 461 ft) 9.5 (to 1,022 ft)	50' (18-inch)	1,022	455 (10")	355 - 440	335 - 445	0 - 335
TW-1 (Carbonate Section Open Borehole)	"	"	"	"	"	"	"	"	"	455 - 1,002	"	"
TW-2	12/8/2009	34° 31' 12"	115° 26' 56"	921.29	Flooded Reverse (to 798 ft) Dual Tube (to 1,380 ft)	42 (to 35 ft) 32 (to 340 ft) 17.5 (to 798 ft) 9.5 (to 1,160 ft) 5.25 (to 1,380 ft)	35' (32-inch) 340' (24-inch)	1,380	799 (10")	340 - 779	0 - 785 [1]	0 - 340
TW-2 (post May 2011)	5/14/2011	"	"	"	Dual Rotary (redrilled 870 - 1160 ft)	"	"	1,160	10" to 799 8" to 1,004	340 - 779 869 - 992	"	"
TW2-MW	10/21/2010	34° 31' 13"	115° 26' 56"	921.87	Dual Tube (to 740 ft)	5.25 (to 740 ft)	-	740	720	600 - 700	575 - 740	0 - 575
TW-3	2/22/2010	34° 31' 11"	115° 25' 41"	1,055.73	Dual Tube (to 960 ft) Rock Core (to 1,942 ft)	6 (to 85 ft) 5.25 (to 960 ft) 3.5 (to 1,230 ft) 2.75 (to 1,942 ft)	-	1,942	522	502 - 522	472 - 1,774	0 - 472
CH-5	11/5/2010	34° 30' 51"	115° 26' 23"	975.34	Dual Tube (to 349 ft) Rock Core (to 1,191 ft)	6 (to 55 ft) 5.25 (to 349 ft) 3.5 (to 1,191 ft)	-	1,191	438 (1.5")	338 - 438	55 - 1,191	0-55
DT-1	2/28/2011	34° 30' 54"	115° 25' 40"	1079.74'	Dual Tube (to 1,500 ft)	30 (to 42 ft) 20 (to 935 ft) 12 (to 1,285 ft) 6.5 (to 1,500 ft)	38' (24-inch) 935' (12-inch)	1,500	980	935 - 975	895 - 900	0-895
PW-1	8/20/2009	34° 30' 46"	115° 28' 13"	875.72	Mud Rotary	36 (to 30 ft) 26 (to 830)	30' (30-inch)	830	820	300 - 800	50 - 830	0-50
5\14-13[1]	6/16/1905	34° 31' 14"	115° 28' 11"	894.86	Unknown	Unknown	Unknown	592	590 (5-inch)	280 - 590	Unknown	Unknown
6\15-1[1]	1/1/1994	34° 38' 23"	115° 21' 22"	1,374.68	Unknown	Unknown	Unknown	799	500 (5-inch)	300 - 793	Unknown	Unknown
6\15-29[1]	1/1/1994	34° 34' 33"	115° 26' 04"	1,136.99	Unknown	Unknown	Unknown	809	809 (5-inch)	305 - 809	Unknown	Unknown
CI-1	1/1/1999	34° 30' 56"	115° 27' 41"	896.96	Track mounted rotary drilling rig	12.25 (to 20 ft) 6.5 (to 320 ft)	Unknown	320	310 (2")	250 - 310	200 - 320	0 - 20
CI-2	12/1/1998	34° 31' 14"	115° 27' 44"	904.77	Track mounted rotary drilling rig	12.25 (to 20 ft) 6.5 (to 690 ft)	Unknown	690	420 (2")	300 - 420	250 - 420	0 - 20
CI-3	12/1/1998	34° 30' 46"	115° 28' 14"	876.43	Track mounted rotary drilling rig	12.25 (to 20 ft) 6.5 (to 800)	Unknown	800	500 (2")	300 - 500	250 - 500	0 - 20
MW-1	1/1/1999	34° 31' 01"	115° 27' 44"	897.02	Track mounted rotary drilling rig	12.25 (to 20 ft) 6.5 (to 500)	Unknown	500	400 (2")	300 - 400	250 - 400	0 - 20

Table 1: Production and Monitoring Well Construction Details

Well Designation	Date Completed	Coordinates (NAD83)		Elevation (ft msl)	Drilling Method	Borehole Diameter (inches)	Conductor Depth (ft bgs) (Diameter)	Total Borehole Depth (ft bgs)	Cased Depth (ft bgs) (Diameter)	Screened Interval (ft bgs)	Filter Pack Interval (ft bgs)	Seal Interval (ft bgs)
		Latitude	Longitude									
MW-2	1/1/1999	34° 30' 39"	115° 27' 57"	877.30	Track mounted rotary drilling rig	12.25 (to 20 ft) 6.5 (to 400)	Unknown	400	400 (2")	300 - 400	250 - 400	0 - 20
MW-3	1/1/1999	34° 30' 50"	115° 27' 25"	897.57	Track mounted rotary drilling rig	12.25 (to 20 ft) 6.5 (to 550)	Unknown	550	400 (2")	300 - 400	250 - 400	0 - 20
MW-5	1/1/1999	34° 31' 08"	115° 27' 22"	913.30	Track mounted rotary drilling rig	12.25 (to 20 ft) 6.5 (to 400)	Unknown	400	400 (2")	300 - 400	250 - 400	0 - 20
MW-6	1/1/1999	34° 31' 20"	115° 27' 01"	928.77	Track mounted rotary drilling rig	12.25 (to 20 ft) 6.5 (to 800)	Unknown	400	400 (2")	300 - 400	250 - 400	0 - 20
MW-7	1/1/1999	34° 31' 38"	115° 26' 54"	940.57	Track mounted rotary drilling rig	12.25 (to 20 ft) 6.5 (to 600)	Unknown	600	600 (2")	500 - 600	265 - 600	0 - 30
MW-7a	1/1/1999	"	"	"	Track mounted rotary drilling rig	12.25 (to 20 ft) 6.5 (to 600)	Unknown	600	400 (1")	300 - 400	265 - 600	0 - 30
SCE 5[2]	Unknown	34° 28' 18"	115° 32' 37"	686.84'	Unknown	Unknown	Unknown	Unknown	137 (1.5-inch)	49 - 135	Unknown	Unknown
SCE 10[2]	Unknown	34° 28' 22"	115° 29' 59"	748.84'	Unknown	Unknown	Unknown	Unknown	178 (1.5-inch)	47 - 176	Unknown	Unknown
SCE 11[2]	Unknown	34° 25' 51"	115° 27' 25"	672.40'	Unknown	Unknown	Unknown	Unknown	120 (1.5-inch)	84 - 117	Unknown	Unknown
SCE 17[2]	Unknown	34° 29' 55"	115° 31' 58"	731.99'	Unknown	Unknown	Unknown	Unknown	158 (1.5-inch)	148 - 156	Unknown	Unknown
SCE 18[2]	Unknown	34° 26' 37"	115° 34' 59"	631.13	Unknown	Unknown	Unknown	Unknown	79 (1.5-inch)	69 - 79	Unknown	Unknown
21N[1]	1995	34° 30' 36"	115° 30' 35"	793.47	Unknown	42 (to 50 ft) 26 (to 928 ft)	50' (30-inch)	920	920 (16-inch)	250 - 490 570 - 900	250 - 900	0 - 50
21S[1]	1984	34° 30' 09"	115° 31' 13"	763.03	Unknown	28	40' (30-inch)	790	790 (16-inch)	348 - 778	Unknown	Unknown
22[1]	1994	34° 30' 25"	115° 29' 57"	813.18	Unknown	26	60'	894	890 (16-inch)	320 - 400 580 - 630 670 - 710 740 - 880	Unknown	Unknown
27N[1]	1989	34° 29' 46"	115° 30' 02"	790.94	Unknown	28	40' (30-inch)	800	800 (16-inch)	360 - 760	Unknown	Unknown
27S[1]	1989	34° 29' 19"	115° 30' 04"	778.40	Unknown	28	40' (30-inch)	990	990' (16-inch)	400 - 900	Unknown	Unknown
28[1]	1987	34° 29' 07"	115° 31' 06"	741.21	Unknown	28	40' (30-inch)	800	800 (16-inch)	400 - 800	Unknown	Unknown
33[1]	1984	34° 28' 32"	115° 31' 09"	729.13	Unknown	28	40' (30-inch)	790	790' (16-inch)	355 - 776	Unknown	Unknown
Labor Camp	Unknown	34° 31' 24"	115° 30' 50"	785.74	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Office	Unknown	34° 34' 03"	115° 33' 15"	736.64	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Dorm	Unknown	34° 33' 18"	115° 32' 23"	711.49	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown

Table 1: Production and Monitoring Well Construction Details

Well Designation	Date Completed	Coordinates (NAD83)		Elevation (ft msl)	Drilling Method	Borehole Diameter (inches)	Conductor Depth (ft bgs) (Diameter)	Total Borehole Depth (ft bgs)	Cased Depth (ft bgs) (Diameter)	Screened Interval (ft bgs)	Filter Pack Interval (ft bgs)	Seal Interval (ft bgs)
		Latitude	Longitude									
Park	Unknown	34° 33' 47"	115° 33' 00"	721.09	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Piute (Ibis)	Unknown	34° 56' 31"	114° 47' 33"	1,457.89	Unknown	26	50	924	860	290 - 840	0 - 860	0 - 50

Notes:
[1] Township/ Range and Section used for well name (ex., 5/14-13 = Township 05N Range 14E Section 13 San Bernardino Baseline Meridian, or 21N = northern area of Section 21)
[2] Screened Interval Determined from Video Log of Wells - May 2013 ft = foot/feet

Table 2: Recent Groundwater Elevations Compared to Baseline

Well	Date for computing adjustment from NAVD27 to NAVD88	Value	Correction (NAVD27 to NAVD88)	Baseline Value NAVD27	Adjusted Baseline Value NAVD88	Maximum Non-pumping GW Level for 2013	Difference (2013 Max Level from Baseline)	Maximum Non-pumping GW Level for 2018	Difference (2018 Max Level from Baseline)
21N[1]	Dec-95	583.15	3.72	584.32	588.04	583.42	-4.62	589.59	1.55
21S[2]	Dec-95	583.45	4.09	580.38	584.47	583.33	-1.14	576.73	-7.74
22[1]	Dec-95	587.99	3.01	586.62	589.63	590.61	0.98	594.64	5.01
27N	Dec-95	571.38	2.45	567.56	570.01	586.04	16.03	587.96	17.95
27S[3]	Dec-95	573.73	2.66	572.57	575.23	579.63	4.40	590.18	14.95
28	Dec-95	570.39	3.10	565.61	568.71	579.96	11.25	586.5	17.79
33	Dec-95	572.62	2.79	571.33	574.12	581.38	7.26	580.33	6.21
5/14-13	Dec-95	603.99	3.46	602.85	606.31	599.64	-6.67	601.19	-5.12

Note: Positive values indicate groundwater level rise relative to Baseline levels

[1] Denotes static water levels taken during December 2017 for 2018 value as measurments in 2018 was not available.

[2] Denotes January and September 2013 values for Max Non-Pumping Levels for 2013 and 2018 respectively as measurements not available in 2018.

[3] Denotes static water levels taken during December 2015 for 2018 value.

APPENDICES

GEOSCIENCE

APPENDIX A

MONTHLY GROUNDWATER EXTRACTION TOTALS

GEOSCIENCE

Monthly Irrigation Well Groundwater Production								
Year	Date first of the month	Well 21N	Well 21S	Well 22	Well 27N*	Well 27S	Well 28	Well 33
1993	11/1/1993	0.00	0.00	0.00	52.20	67.18	0.00	5.49
1993	12/1/1993	0.00	0.00	0.00	46.30	0.00	0.00	0.00
1994	1/1/1994	0.00	0.23	0.00	40.35	24.96	18.13	4.81
1994	2/1/1994	0.00	0.00	0.00	20.25	53.03	44.59	36.89
1994	3/1/1994	0.00	6.59	0.00	70.65	110.54	42.82	100.26
1994	4/1/1994	0.00	92.47	0.00	126.90	203.41	28.85	167.78
1994	5/1/1994	0.00	171.72	0.00	196.95	237.11	0.91	189.02
1994	6/1/1994	0.00	190.18	0.00	208.50	202.09	116.94	177.15
1994	7/1/1994	0.00	221.41	0.00	217.95	162.82	104.22	151.62
1994	8/1/1994	0.00	38.61	7.05	137.40	26.99	108.03	156.47
1994	9/1/1994	0.00	21.17	21.46	1.94	30.60	65.13	94.35
1994	10/1/1994	0.00	14.72	13.73	0.00	1.18	12.38	41.49
1994	11/1/1994	0.00	0.00	11.49	0.00	30.42	0.00	4.77
1994	12/1/1994	0.00	79.21	9.71	0.00	53.24	12.20	0.00
1995	1/1/1995	0.00	0.00	4.06	0.00	22.04	8.81	0.00
1995	2/1/1995	0.00	19.81	13.16	22.57	84.72	54.18	54.51
1995	3/1/1995	0.00	45.04	18.86	62.70	102.23	61.89	90.92
1995	4/1/1995	136.55	82.34	21.20	73.20	107.39	55.65	100.61
1995	5/1/1995	133.62	110.44	36.95	152.45	199.42	115.45	211.69
1995	6/1/1995	204.91	177.47	39.29	151.78	187.78	124.10	347.74
1995	7/1/1995	38.79	157.95	31.82	140.11	147.75	88.26	0.00
1995	8/1/1995	106.49	58.44	34.63	144.52	111.56	59.84	108.43
1995	9/1/1995	123.01	45.37	37.52	140.44	106.21	48.33	88.09
1995	10/1/1995	123.79	16.55	31.77	117.52	94.06	10.71	22.11
1995	11/1/1995	53.30	0.00	12.80	34.99	67.13	3.26	0.00
1995	12/1/1995	27.72	0.00	3.17	45.34	51.26	0.00	0.00
1996	1/1/1996	20.71	16.28	9.42	54.92	20.99	32.11	1.70
1996	2/1/1996	33.26	39.63	17.84	64.65	0.00	51.41	68.42
1996	3/1/1996	88.45	87.95	35.16	98.39	59.26	83.70	159.20
1996	4/1/1996	54.34	148.20	36.88	106.50	139.28	97.15	187.71
1996	5/1/1996	101.20	163.83	41.16	134.51	177.93	104.59	195.33
1996	6/1/1996	119.54	161.71	37.30	151.18	185.21	106.73	189.67
1996	7/1/1996	84.65	126.36	40.96	130.02	185.22	95.12	192.62
1996	8/1/1996	1.63	34.52	42.18	102.41	106.06	60.51	70.73
1996	9/1/1996	12.73	32.51	35.59	93.76	141.74	50.41	60.99
1996	10/1/1996	2.53	18.73	31.55	74.36	49.54	16.68	23.36
1996	11/1/1996	0.02	3.10	6.77	4.32	36.42	2.57	4.08
1996	12/1/1996	0.64	1.60	7.95	30.33	18.34	1.15	1.85
1997	1/1/1997	0.49	35.09	7.40	7.23	33.71	0.00	29.72
1997	2/1/1997	0.00	59.09	9.91	14.98	47.99	0.00	62.53
1997	3/1/1997	67.42	70.99	24.58	93.20	64.13	30.20	82.05
1997	4/1/1997	19.65	132.65	33.02	116.35	117.63	84.59	154.95
1997	5/1/1997	64.46	135.58	41.22	128.73	145.81	93.77	203.96

Monthly Irrigation Well Groundwater Production								
Year	Date first of the month	Well 21N	Well 21S	Well 22	Well 27N*	Well 27S	Well 28	Well 33
1997	6/1/1997	209.91	177.31	39.13	104.53	147.91	97.83	192.44
1997	7/1/1997	187.32	119.98	39.37	129.02	128.38	92.84	165.59
1997	8/1/1997	92.87	80.70	37.19	116.51	122.62	50.68	92.25
1997	9/1/1997	62.71	50.90	25.47	79.68	75.25	35.03	57.84
1997	10/1/1997	17.66	10.41	25.07	83.17	92.78	12.08	20.68
1997	11/1/1997	11.43	3.59	5.39	24.70	24.70	6.19	0.00
1997	12/1/1997	15.68	5.67	1.12	32.83	37.27	7.94	0.00
1998	1/1/1998	5.60	24.63	-	27.13	34.87	13.85	13.77
1998	2/1/1998	1.68	8.52	-	18.22	23.85	11.24	24.93
1998	3/1/1998	31.05	42.71	18.24	42.87	44.30	31.95	46.35
1998	4/1/1998	70.25	63.08	46.92	55.99	59.60	48.02	98.24
1998	5/1/1998	196.46	100.50	59.78	63.59	53.27	94.79	189.75
1998	6/1/1998	195.12	143.44	97.20	2.82	92.59	96.67	181.67
1998	7/1/1998	229.04	124.27	108.56	54.35	113.66	95.53	183.41
1998	8/1/1998	194.23	95.39	93.15	71.10	95.59	63.15	163.74
1998	9/1/1998	48.20	38.89	88.99	62.89	73.44	11.21	69.25
1998	10/1/1998	17.90	29.74	44.48	55.02	61.55	20.14	60.98
1998	11/1/1998	23.35	9.30	15.02	18.43	26.68	14.57	6.44
1998	12/1/1998	19.94	18.97	10.35	20.09	45.91	6.34	8.21
1999	1/1/1999	11.79	6.67	2.98	25.75	36.12	0.00	11.90
1999	2/1/1999	27.07	17.46	1.87	24.83	35.37	0.00	38.34
1999	3/1/1999	56.57	36.52	0.91	43.30	59.96	1.61	70.15
1999	4/1/1999	180.78	127.97	50.36	46.82	73.55	53.42	139.27
1999	5/1/1999	182.42	136.65	74.15	103.00	142.16	92.19	176.28
1999	6/1/1999	198.16	167.99	138.63	111.81	122.66	92.83	159.98
1999	7/1/1999	197.98	138.23	147.64	117.74	108.69	89.29	167.67
1999	8/1/1999	199.31	106.12	114.27	110.50	107.22	9.13	169.82
1999	9/1/1999	146.11	72.95	42.22	96.43	87.03	4.70	123.98
1999	10/1/1999	99.48	43.35	44.24	56.11	54.75	6.32	40.05
1999	11/1/1999	22.91	8.04	75.63	58.52	11.52	2.58	0.00
1999	12/1/1999	8.90	5.23	38.30	31.84	17.61	13.72	0.00
2000	1/1/2000	10.45	12.16	29.37	26.62	7.57	20.29	0.00
2000	2/1/2000	48.61	23.90	47.06	11.22	19.00	8.81	33.88
2000	3/1/2000	85.45	38.61	40.88	38.94	41.34	19.10	86.36
2000	4/1/2000	116.71	74.38	70.94	62.07	57.17	37.46	131.28
2000	5/1/2000	165.85	119.46	115.47	54.79	96.30	71.23	176.19
2000	6/1/2000	184.27	161.30	124.79	91.70	123.10	189.29	178.46
2000	7/1/2000	186.65	139.46	99.34	112.59	116.70	61.12	183.68
2000	8/1/2000	181.25	82.82	138.78	127.92	101.28	24.02	166.70
2000	9/1/2000	157.14	73.38	104.44	83.45	80.90	24.73	130.59
2000	10/1/2000	101.52	32.95	87.21	68.20	59.71	50.08	1.70
2000	11/1/2000	16.13	16.16	29.83	29.07	22.12	5.80	33.33
2000	12/1/2000	8.82	8.53	4.54	30.99	33.34	0.00	22.77

Monthly Irrigation Well Groundwater Production

Year	Date first of the month	Well 21N	Well 21S	Well 22	Well 27N*	Well 27S	Well 28	Well 33
2001	1/1/2001	23.50	20.59	23.42	24.91	33.02	0.00	33.74
2001	2/1/2001	60.17	66.71	28.66	28.22	50.94	29.92	70.54
2001	3/1/2001	62.39	74.65	38.38	24.68	55.26	42.40	79.97
2001	4/1/2001	82.98	81.72	47.80	35.11	69.60	61.26	103.13
2001	5/1/2001	130.03	144.10	107.64	76.31	110.98	55.80	146.05
2001	6/1/2001	169.23	157.16	147.96	109.00	128.71	76.51	160.87
2001	7/1/2001	164.90	101.47	126.60	98.24	107.20	61.46	149.52
2001	8/1/2001	53.48	50.85	97.79	74.49	91.09	20.50	63.58
2001	9/1/2001	52.57	40.62	79.14	65.42	63.80	18.76	53.92
2001	10/1/2001	63.24	54.42	38.50	32.96	34.40	14.99	55.19
2001	11/1/2001	18.18	27.47	10.04	20.77	30.33	7.56	36.88
2001	12/1/2001	13.64	5.33	24.47	0.00	22.05	10.37	6.64
2002	1/1/2002	NA	7.07	15.13	9.47	22.72	0.87	10.02
2002	2/1/2002	47.13	27.16	0.00	26.12	25.31	0.00	38.02
2002	3/1/2002	57.57	49.96	8.27	30.71	31.47	0.00	53.30
2002	4/1/2002	89.44	73.69	17.36	47.19	41.60	0.03	74.16
2002	5/1/2002	216.11	186.40	228.51	219.07	203.18	164.65	162.14
2002	6/1/2002	177.80	146.93	129.62	91.35	97.71	79.63	149.22
2002	7/1/2002	160.89	143.01	134.76	107.71	95.80	83.33	156.70
2002	8/1/2002	170.83	95.68	103.49	80.59	22.64	69.38	141.70
2002	9/1/2002	70.04	76.51	71.36	70.79	0.00	42.49	125.10
2002	10/1/2002	12.20	59.13	59.34	48.19	0.00	43.52	78.08
2002	11/1/2002	5.81	15.87	31.39	27.38	0.00	11.16	24.05
2002	12/1/2002	NA	NA	NA	NA	NA	NA	NA
2003	1/1/2003	3.62	2.82	26.78	23.11	0.00	6.12	10.06
2003	2/1/2003	6.69	19.89	14.57	18.26	3.11	13.60	21.38
2003	3/1/2003	53.86	43.47	16.35	10.13	20.96	24.15	43.69
2003	4/1/2003	84.19	66.36	24.20	41.51	83.03	38.51	72.95
2003	5/1/2003	178.31	134.26	67.26	108.64	190.42	76.42	140.26
2003	6/1/2003	173.96	138.26	113.85	132.42	181.12	78.70	132.08
2003	7/1/2003	186.94	129.53	120.74	120.00	202.84	80.50	134.18
2003	8/1/2003	140.70	98.02	105.94	101.40	64.87	55.59	99.61
2003	9/1/2003	102.23	75.98	18.93	73.88	56.86	30.13	83.62
2003	10/1/2003	42.20	55.73	19.12	30.82	58.86	0.00	22.12
2003	11/1/2003	17.73	4.78	0.79	21.93	17.64	0.00	0.00
2003	12/1/2003	22.42	5.42	0.00	29.38	24.43	0.00	0.00
2004	1/1/2004	27.26	22.69	2.50	29.33	20.87	0.00	0.00
2004	2/1/2004	16.11	20.77	0.00	19.03	19.37	0.00	0.00
2004	3/1/2004	48.59	61.11	9.37	44.13	59.85	14.77	32.02
2004	4/1/2004	40.10	166.76	23.32	39.29	67.82	41.91	17.15
2004	5/1/2004	63.50	84.98	23.83	80.18	92.20	54.72	98.30
2004	6/1/2004	74.80	99.23	49.94	69.60	110.01	64.03	116.57
2004	7/1/2004	71.71	83.26	100.94	142.27	110.74	30.90	111.84

Monthly Irrigation Well Groundwater Production								
Year	Date first of the month	Well 21N	Well 21S	Well 22	Well 27N*	Well 27S	Well 28	Well 33
2004	8/1/2004	56.15	65.27	118.64	147.80	88.44	75.18	135.14
2004	9/1/2004	79.83	75.76	114.58	126.51	0.00	56.65	104.98
2004	10/1/2004	30.05	29.52	51.91	62.46	0.00	21.55	35.18
2004	11/1/2004	8.44	2.60	26.73	31.80	0.00	11.76	33.66
2004	12/1/2004	7.30	0.00	20.94	26.53	0.00	4.62	1.43
2005	1/1/2005	1.82	8.72	10.09	8.94	0.00	1.96	5.34
2005	2/1/2005	0.54	16.30	1.50	0.00	0.00	6.35	8.44
2005	3/1/2005	29.86	45.71	5.49	12.78	13.55	25.77	48.09
2005	4/1/2005	34.55	53.28	15.18	17.54	42.85	30.50	57.68
2005	5/1/2005	80.43	41.18	48.75	63.76	94.92	57.95	102.61
2005	6/1/2005	82.04	178.02	127.06	128.65	156.93	80.48	135.70
2005	7/1/2005	78.33	165.09	131.88	122.15	188.54	78.78	140.03
2005	8/1/2005	64.62	101.12	57.07	129.46	190.25	75.80	141.23
2005	9/1/2005	33.14	51.61	51.52	130.18	101.04	47.09	89.51
2005	10/1/2005	18.57	24.75	102.51	93.71	16.29	12.43	30.54
2005	11/1/2005	122.23	8.67	34.14	34.43	0.43	2.77	5.76
2005	12/1/2005	5.25	0.00	26.59	29.24	0.00	0.00	0.00
2006	1/1/2006	6.13	6.51	26.34	31.66	0.00	0.93	3.71
2006	2/1/2006	20.71	29.14	22.65	13.46	0.00	0.00	23.21
2006	3/1/2006	25.80	36.60	29.60	30.51	21.98	0.00	43.81
2006	4/1/2006	29.92	41.91	26.92	33.51	26.68	7.64	85.76
2006	5/1/2006	68.94	99.73	69.94	88.81	70.91	44.14	61.95
2006	6/1/2006	120.04	133.80	106.38	119.88	65.96	67.60	134.44
2006	7/1/2006	142.57	117.91	109.09	127.03	6.97	40.37	146.28
2006	8/1/2006	157.45	128.63	112.85	129.03	0.00	0.00	137.55
2006	9/1/2006	145.14	118.58	111.31	89.41	0.00	0.00	102.89
2006	10/1/2006	14.49	62.37	109.39	38.11	0.00	0.00	66.26
2006	11/1/2006	0.00	31.21	109.79	105.89	0.00	5.21	29.88
2006	12/1/2006	0.00	0.00	26.77	32.77	0.00	0.00	4.70
2007	1/1/2007	24.40	2.94	16.96	33.13	4.60	0.00	5.73
2007	2/1/2007	1.05	26.50	0.00	25.62	23.20	0.00	9.75
2007	3/1/2007	0.00	43.59	25.71	33.25	23.66	0.00	4.22
2007	4/1/2007	199.89	98.27	39.79	53.23	2.96	29.54	48.34
2007	5/1/2007	61.86	63.48	65.69	79.82	112.22	35.14	93.99
2007	6/1/2007	99.20	85.15	109.95	103.76	100.18	0.00	130.51
2007	7/1/2007	108.00	86.82	0.00	68.61	99.64	0.00	130.24
2007	8/1/2007	87.77	69.99	0.00	147.46	88.98	0.00	33.58
2007	9/1/2007	64.67	50.75	0.00	105.62	33.20	0.00	62.45
2007	10/1/2007	26.80	33.89	0.00	95.51	0.00	0.00	36.91
2007	11/1/2007	15.63	18.66	0.00	102.64	0.00	0.00	16.28
2007	12/1/2007	16.52	1.23	17.79	50.47	0.14	0.00	0.00
2008	1/1/2008	12.00	2.00	0.00	15.98	28.00	0.00	0.00
2008	2/1/2008	11.39	12.87	0.00	7.96	22.27	0.00	0.00

Monthly Irrigation Well Groundwater Production								
Year	Date first of the month	Well 21N	Well 21S	Well 22	Well 27N*	Well 27S	Well 28	Well 33
2008	3/1/2008	24.75	20.78	0.00	0.00	63.91	0.00	0.00
2008	4/1/2008	48.11	43.59	0.00	1.04	76.24	0.00	0.00
2008	5/1/2008	51.01	46.48	0.00	42.19	59.92	0.00	0.00
2008	6/1/2008	99.67	67.43	0.00	78.41	99.78	0.85	0.00
2008	7/1/2008	85.80	51.04	0.00	86.37	119.49	1.03	0.00
2008	8/1/2008	32.60	22.82	0.00	56.54	79.99	0.35	1.88
2008	9/1/2008	39.92	26.93	0.00	49.70	68.95	0.00	1.47
2008	10/1/2008	35.67	23.80	0.00	57.17	55.43	0.00	1.78
2008	11/1/2008	13.77	8.43	0.00	25.83	40.21	0.00	0.50
2008	12/1/2008	7.93	2.58	0.00	13.99	20.94	0.00	0.00
2009	1/1/2009	6.72	2.61	0.00	17.53	11.17	0.00	0.00
2009	2/1/2009	21.60	5.54	0.00	6.95	14.01	0.00	0.00
2009	3/1/2009	22.62	29.02	0.00	52.17	39.73	0.00	0.00
2009	4/1/2009	44.76	42.93	0.00	57.43	59.58	0.00	11.26
2009	5/1/2009	62.22	53.02	3.25	19.80	60.63	0.00	26.94
2009	6/1/2009	66.22	77.82	8.61	0.00	0.00	0.00	77.65
2009	7/1/2009	157.58	106.07	13.11	0.00	0.00	0.00	120.32
2009	8/1/2009	65.77	48.95	12.99	0.00	0.00	0.00	108.03
2009	9/1/2009	42.57	0.00	11.51	0.00	0.00	0.00	98.21
2009	10/1/2009	47.94	0.00	6.99	0.00	0.00	0.00	59.67
2009	11/1/2009	33.32	0.00	3.80	0.00	17.51	0.00	0.00
2009	12/1/2009	12.66	0.00	1.29	0.00	12.19	0.00	0.00
2010	1/1/2010	5.17	0.00	0.74	0.00	31.51	0.00	0.00
2010	2/1/2010	8.76	0.00	3.67	0.00	55.91	0.00	0.00
2010	3/1/2010	37.33	0.00	2.56	0.00	11.38	0.00	0.00
2010	4/1/2010	49.36	1.31	3.00	0.00	0.00	0.00	0.00
2010	5/1/2010	42.14	78.87	4.69	0.00	43.43	0.00	0.00
2010	6/1/2010	142.82	122.48	10.92	0.00	123.51	0.00	0.00
2010	7/1/2010	129.54	87.18	11.13	0.00	130.77	0.00	0.00
2010	8/1/2010	59.90	22.37	11.57	0.00	121.11	0.00	0.00
2010	9/1/2010	50.08	18.62	10.06	0.00	111.15	0.00	0.00
2010	10/1/2010	37.30	16.25	3.81	0.00	134.52	0.00	0.00
2010	11/1/2010	22.72	9.12	0.00	0.00	63.93	0.00	0.00
2010	12/1/2010	5.30	0.00	0.13	0.00	30.94	0.00	0.00
2011	1/1/2011	17.00	0.00	0.00	0.00	8.54	0.00	0.00
2011	2/1/2011	18.54	4.42	0.00	0.00	47.07	0.00	0.00
2011	3/1/2011	19.07	24.60	0.00	0.00	38.91	0.00	0.00
2011	4/1/2011	30.90	37.20	0.00	0.00	57.73	0.00	0.00
2011	5/1/2011	54.84	87.42	0.00	0.00	92.85	0.00	0.00
2011	6/1/2011	105.07	123.30	0.00	0.00	150.71	0.00	0.00
2011	7/1/2011	113.00	106.73	80.45	0.00	120.58	0.00	0.00
2011	8/1/2011	73.35	55.41	139.28	0.00	102.67	0.00	0.00
2011	9/1/2011	40.82	33.03	126.11	0.00	92.31	0.00	0.00

Monthly Irrigation Well Groundwater Production								
Year	Date first of the month	Well 21N	Well 21S	Well 22	Well 27N*	Well 27S	Well 28	Well 33
2011	10/1/2011	34.22	0.00	73.06	0.00	72.37	0.00	0.00
2011	11/1/2011	19.47	10.35	42.91	0.00	40.34	0.00	0.00
2011	12/1/2011	11.99	0.00	16.32	0.00	17.97	0.00	0.00
2012	1/1/2012	16.15	0.00	0.00	0.00	0.00	0.00	0.00
2012	2/1/2012	13.30	18.43	6.79	0.00	33.65	0.00	0.00
2012	3/1/2012	23.88	0.00	0.00	0.00	53.24	0.00	0.00
2012	4/1/2012	23.38	25.73	0.00	0.00	50.50	0.00	0.00
2012	5/1/2012	52.07	111.95	0.00	81.10	71.76	0.00	0.00
2012	6/1/2012	58.97	140.00	0.00	97.90	109.59	0.00	0.00
2012	7/1/2012	68.92	82.82	0.00	100.43	112.84	0.00	0.00
2012	8/1/2012	129.71	41.58	0.00	112.65	118.47	0.00	0.00
2012	9/1/2012	86.46	65.38	0.00	100.34	109.10	0.00	0.00
2012	10/1/2012	48.21	25.40	0.00	37.68	51.13	0.00	0.00
2012	11/1/2012	25.53	0.00	0.00	0.00	31.56	0.00	0.00
2012	12/1/2012	12.69	0.00	0.00	6.21	8.85	0.00	0.00
2013	1/1/2013	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2013	2/1/2013	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2013	3/1/2013	62.15	61.83	0.00	290.77	84.89	0.00	0.00
2013	4/1/2013	53.20	62.80	0.00	33.51	57.53	0.00	0.00
2013	5/1/2013	63.14	84.23	0.00	29.88	68.26	0.00	0.00
2013	6/1/2013	71.53	129.09	0.00	3.30	99.26	0.00	0.00
2013	7/1/2013	118.70	90.35	0.00	0.00	123.91	0.00	0.00
2013	8/1/2013	130.08	43.84	0.00	0.00	130.87	0.00	0.00
2013	9/1/2013	95.95	98.03	0.00	0.00	110.66	0.00	0.00
2013	10/1/2013	35.27	64.42	0.00	0.00	89.73	0.00	0.00
2013	11/1/2013	19.02	68.12	0.00	0.00	11.22	0.00	0.00
2013	12/1/2013	24.50	1.90	0.00	0.00	14.54	0.00	0.00
2014	1/1/2014	21.68	3.27	0.00	0.00	16.10	0.00	0.00
2014	2/1/2014	27.96	7.63	0.00	0.00	15.95	0.00	0.00
2014	3/1/2014	36.18	11.99	0.00	0.00	28.00	0.00	0.00
2014	4/1/2014	36.09	33.87	0.00	0.00	55.90	0.00	0.00
2014	5/1/2014	37.70	33.87	0.00	0.00	56.50	0.00	0.00
2014	6/1/2014	35.32	36.25	0.00	0.00	56.75	0.00	0.00
2014	7/1/2014	59.17	100.76	0.00	0.00	65.23	0.00	0.00
2014	8/1/2014	59.61	85.37	0.00	0.00	61.30	0.00	0.00
2014	9/1/2014	39.14	43.13	0.00	0.00	46.73	0.00	0.00
2014	10/1/2014	27.92	39.00	0.00	0.00	52.98	0.00	0.00
2014	11/1/2014	6.47	25.79	0.00	0.00	26.59	0.00	0.00
2014	12/1/2014	17.82	0.00	0.00	0.00	15.79	0.00	0.00
2015	1/1/2015	23.05	3.71	0.00	0.00	15.34	0.00	0.00
2015	2/1/2015	29.97	3.29	0.00	0.00	10.34	0.00	0.00
2015	3/1/2015	41.22	5.06	0.00	0.00	16.23	0.00	0.00
2015	4/1/2015	27.86	27.84	0.00	0.00	12.32	0.00	0.00

Monthly Irrigation Well Groundwater Production								
Year	Date first of the month	Well 21N	Well 21S	Well 22	Well 27N*	Well 27S	Well 28	Well 33
2015	5/1/2015	44.95	50.77	0.00	0.00	15.50	0.00	0.00
2015	6/1/2015	49.73	86.90	0.00	0.00	21.80	0.00	0.00
2015	7/1/2015	64.99	74.67	0.00	0.00	29.71	0.00	0.00
2015	8/1/2015	90.78	40.22	0.00	0.00	39.81	0.00	0.00
2015	9/1/2015	100.53	132.76	0.00	0.00	37.58	0.00	0.00
2015	10/1/2015	68.83	52.26	0.00	0.00	30.10	0.00	0.00
2015	11/1/2015	27.08	35.62	0.00	0.00	17.04	0.00	0.00
2015	12/1/2015	26.78	8.91	0.00	0.00	13.94	0.00	0.00
2016	1/1/2016	20.30	39.29	0.00	0.00	8.92	0.00	0.00
2016	2/1/2016	31.99	63.06	0.00	0.00	14.72	0.00	0.00
2016	3/1/2016	24.24	59.57	0.00	0.00	10.55	0.00	0.00
2016	4/1/2016	47.46	100.01	0.00	0.00	0.00	0.00	0.00
2016	5/1/2016	57.71	110.51	0.00	0.00	64.46	0.00	0.00
2016	6/1/2016	77.66	112.34	0.00	0.00	42.99	0.00	0.00
2016	7/1/2016	91.36	102.97	0.00	0.00	47.25	0.00	0.00
2016	8/1/2016	102.20	81.23	0.00	0.00	51.42	0.00	0.00
2016	9/1/2016	37.23	101.08	0.00	0.00	48.81	0.00	0.00
2016	10/1/2016	113.49	6.66	0.00	0.00	35.78	0.00	0.00
2016	11/1/2016	9.25	76.62	0.00	0.00	18.30	0.00	0.00
2016	12/1/2016	0.00	30.72	0.00	0.00	17.84	0.00	0.00
2017	1/1/2017	0.00	7.54	0.00	0.00	5.87	0.00	0.00
2017	2/1/2017	0.00	17.42	0.00	0.00	7.66	0.00	0.00
2017	3/1/2017	0.00	32.58	0.00	0.00	21.57	0.00	0.00
2017	4/1/2017	21.29	24.14	0.00	0.00	23.85	0.00	0.00
2017	5/1/2017	52.40	0.00	6.10	0.00	32.61	0.00	8.10
2017	6/1/2017	86.83	0.00	0.00	0.00	50.82	0.00	0.00
2017	7/1/2017	37.61	94.07	0.00	0.00	70.92	0.00	0.00
2017	8/1/2017	43.73	70.55	8.38	0.00	49.21	0.00	0.00
2017	9/1/2017	96.12	5.98	66.85	0.00	0.00	0.00	0.00
2017	10/1/2017	78.87	0.00	9.50	0.00	37.18	0.00	0.00
2017	11/1/2017	50.58	0.00	11.48	0.00	23.81	0.00	0.00
2017	12/1/2017	36.24	0.00	0.00	0.00	32.96	0.00	0.00
2018	1/1/2018	18.08	0.00	0.00	0.00	16.76	0.00	0.00
2018	2/1/2018	24.80	0.00	0.00	0.00	18.72	0.00	0.00
2018	3/1/2018	3.59	49.38	15.14	0.00	14.67	0.00	0.00
2018	4/1/2018	83.32	0.00	2.85	0.00	25.66	0.00	0.00
2018	5/1/2018	87.74	0.00	0.00	0.00	48.95	0.00	0.00
2018	6/1/2018	61.25	63.60	11.58	0.00	75.12	0.00	0.00
2018	7/1/2018	100.51	81.73	35.82	0.00	91.36	0.00	0.00
2018	8/1/2018	94.06	97.74	28.87	0.00	89.19	0.00	0.00
2018	9/1/2018	86.05	102.71	26.44	0.00	79.99	0.00	0.00
2018	10/1/2018	42.50	39.67	12.54	0.00	42.90	0.00	0.00
2018	11/1/2018	46.46	13.32	11.03	0.00	25.29	0.00	0.00

APPENDIX B

LAND SURFACE ELEVATION SURVEY

GEOSCIENCE

TOWILL
SURVEYING | MAPPING | GIS

Subsidence Monitor Survey Report

prepared by: Towill, Inc.

for: Cadiz, Inc.

December 10, 2018

1.0 Introduction

The purpose of this project is to establish horizontal and vertical control values on 13 subsidence monitoring locations associated with the Cadiz Pipeline in San Bernardino County, California.

2.0 Field Survey Operations

2.1 Field Equipment

Trimble GNSS Receivers with internal antennae were used for all GPS Observations.

Trimble Geodetic Receivers, R10
Serial Numbers: 5433475779, 5430473783

2.2 Survey Team and Dates

Date of Survey: December 3-5, 2018

Field Survey Members: Oliver Rocha, Certified Party Chief – Local 12
Alex Schlangen, Apprentice – Local 12

2.3 GPS Processing and Adjustment Software

Trimble's Trimble Business Center Software v4.00 was utilized for all data processing and least squares network adjustments.

3.0 Horizontal and Vertical Control Surveys

3.1 Primary Control

The primary control values utilized for the monitoring well survey were taken from the CH2MHill "Report on Establishing and Monitoring Survey Monuments in the Cadiz Valley, California" dated May 2015. These values include:

Station Name	Northing	Easting	Elevation
MARBLE BM	2023673.689	7323716.382	963.397
PBB 12 USGS	2038964.266	7318487.888	1280.408
Z 1308	2036442.464	7315249.324	1099.525

3.1.1 Horizontal Coordinate Datum

The horizontal datum for the resultant coordinate values is the North American Datum of 1983 (NAD83, 2011.0 Epoch).

3.1.2 **Vertical Datum**

Elevations established in this survey are North American Vertical Datum of 1988 (NAVD88, Geoid12A) based upon the value published for MARBLE BM.

3.1.3 **Units of Measure**

Units of measure for this survey are US Survey Feet.

4.0 Primary Control Procedures and Adjustments

4.1 Primary Controls

GPS Real Time Kinematic surveys were performed to verify the position and elevation of MARBLE BM in comparison to the other project bench marks, Z 1308 and PBB 12 USGS.

4.1.1 **Primary Control Constraints**

Control surveys completed confirmed horizontally and vertically to the primary controls provided by the client.

BM NUMBER	DIFF. NORTH	DIFF. EAST	DIFF. ELEV.
PBB 12	0.022	0.022	0.002
Z 1308	0.015	0.067	-0.035

4.1.2 **Field Methods**

Real Time Kinematic GPS methods were utilized to position and elevate the primary control. A minimum of 4-minutes of GPS data was collected at least two separate times on different days at each monitoring well location.

4.1.3 **Data Processing and Comparison**

The GPS data sets collected were downloaded daily and processed through Trimble baseline processing software. The Real Time Kinematic baselines for each measurement were reviewed. In addition, the data was reviewed and the resulting values compared to the May 2015 values. This comparison is based on utilizing MARBLE BM as the horizontal and vertical constraint. The following tables illustrate the measured values and the differences in data sets:

Results for Measurement #1

WELL NUMBER	MEASURE 1						
	NORTH	EAST	ELEV	DATE	TIME	SATS.	PDOP
5/14-13	2021446.843	7323740.959	894.856	12/3/2018	3:31:23 PM	14	1.463
21N	2017242.060	7311758.242	793.368	12/3/2018	3:09:02 PM	16	1.351
21S	2014440.506	7308662.988	762.971	12/4/2018	10:58:44 AM	17	1.349
22	2016211.523	7314994.086	813.107	12/4/2018	12:22:58 PM	16	1.388
27N	2012283.246	7314707.336	790.910	12/4/2018	12:13:31 PM	16	1.583
27S	2009515.074	7314616.661	778.355	12/4/2018	12:01:58 PM	15	1.926
28	2008178.187	7309388.482	741.115	12/4/2018	11:11:40 AM	17	1.356
33	2004655.788	7309287.950	729.054	12/4/2018	11:25:19 AM	17	1.385
MP1	2007954.448	7272935.594	611.884	12/3/2018	2:16:03 PM	13	1.715
MP2	2006251.211	7280193.280	613.715	12/3/2018	2:28:22 PM	15	1.485
MP3	2016868.780	7326083.132	878.937	12/4/2018	1:02:17 PM	18	1.428
MP4	2001630.764	7301909.678	683.548	12/4/2018	11:42:44 AM	16	1.566
MP5	2027229.717	7333049.646	970.558	12/4/2018	1:20:42 PM	17	1.423

Results for Measurement #2

WELL NUMBER	MEASURE 2						
	NORTH	EAST	ELEV	DATE	TIME	SATS.	PDOP
5/14-13	2021446.854	7323740.947	894.860	12/4/2018	1:37:54 PM	17	1.322
21N	2017242.054	7311758.247	793.369	12/4/2018	12:33:18 PM	16	1.376
21S	2014440.539	7308662.989	763.007	12/5/2018	9:20:11 AM	14	1.639
22	2016211.489	7314994.110	813.132	12/5/2018	10:34:14 AM	17	1.216
27N	2012283.218	7314707.336	790.924	12/5/2018	10:24:08 AM	16	1.200
27S	2009515.089	7314616.695	778.341	12/5/2018	10:15:43 AM	15	1.644
28	2008178.162	7309388.477	741.170	12/5/2018	9:30:47 AM	14	1.809
33	2004655.779	7309287.942	729.053	12/5/2018	9:40:15 AM	14	1.732
MP1	2007954.383	7272935.626	611.876	12/4/2018	9:45:12 AM	14	1.808
MP2	2006251.179	7280193.263	613.647	12/4/2018	10:00:15 AM	14	1.556
MP3	2016868.760	7326083.123	878.960	12/5/2018	10:53:49 AM	18	1.295
MP4	2001630.703	7301909.683	683.580	12/5/2018	9:56:35 AM	14	1.581
MP5	2027229.721	7333049.630	970.535	12/5/2018	11:11:44 AM	18	1.323

Difference between Measurement #1 and Measurement #2

WELL NUMBER	DIFF.NORTH M1 V M2	DIFF.EAST M1 V M2	DIFF.ELEV. M1 V M2
5/14-13	-0.011	0.012	-0.004
21N	0.006	-0.005	-0.001
21S	-0.033	-0.001	-0.036
22	0.034	-0.024	-0.025
27N	0.028	0.000	-0.014
27S	-0.015	-0.034	0.014
28	0.025	0.005	-0.055
33	0.009	0.008	0.001
MP1	0.065	-0.032	0.008
MP2	0.032	0.017	0.068
MP3	0.020	0.009	-0.023
MP4	0.061	-0.005	-0.032
MP5	-0.004	0.016	0.023

Difference between the average of Measurement #1 and #2 and the May 2015 Survey

WELL NUMBER	DIFF. NORTH	DIFF. EAST	DIFF. ELEV.
5/14-13	-0.003	-0.009	0.029
21N	0.018	0.033	0.036
21S	-0.007	0.000	0.010
22	-0.017	-0.011	0.010
27N	-0.004	-0.023	0.008
27S	0.040	0.002	0.005
28	0.026	-0.007	0.045
33	-0.003	-0.004	-0.016
MP1	-0.028	-0.038	-0.152
MP2	0.005	-0.036	-0.115
MP3	0.006	-0.007	-0.011
MP4	0.040	-0.005	-0.071
MP5	0.014	0.012	-0.032

A complete Listing of State Plane coordinate values are attached under the Appendices 5.1.

5.0 Appendix

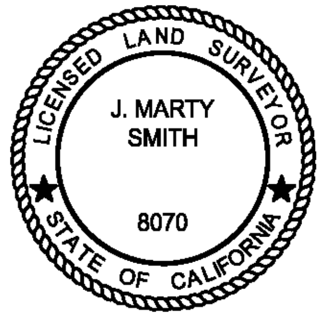
5.1 **Final Control Values**

5.2 **Field Notes**

6.0 Surveyor's Statement

This report represents a survey made by me or under my direct supervision in December 2018.

J. Marty Smith, PLS
Dated: December 10, 2018



APPENDIX 5.1
Final Coordinate Values

CADIZ PIPELINE

MONITOR SURVEY COORDINATE VALUES

SURVEYED DECEMBER 2018

Horizontal Datum: NAD83 (2011.0 Epoch)
Projection: CCS83, Zone 5
Vertical Datum: NAVD88 (Geoid 12A) base on MARBLE Bench Mark

WELL	DESCRIPTION	MEASUREMENT 1 & 2 AVERAGE		
		NORTHING	EASTING	ELEVATION
		US SURVEY FEET		
5/14/2013	2" Brass Disk in Conc.Pad	2021446.865	7323740.954	894.852
21N	2" Brass Disk in Conc.Pad	2017242.075	7311758.255	793.343
21S	2" Brass Disk in Conc.Pad	2014440.499	7308663.01	762.889
22	2" Brass Disk in Conc.Pad	2016211.537	7314994.098	813.102
27N	2" Brass Disk in Conc.Pad	2012283.247	7314707.354	790.887
27S	2" Brass Disk in Conc.Pad	2009515.092	7314616.679	778.331
28	2" Brass Disk in Conc.Pad	2008178.14	7309388.483	741.053
33	2" Brass Disk in Conc.Pad	2004655.786	7309287.96	728.963
MP1	2" Brass Disk in Square Well	2007954.423	7272935.631	611.919
MP2	2" Brass Disk in Square Well	2006251.195	7280193.263	613.662
MP3	2" Brass Disk in Conc.Pad	2016868.776	7326083.132	878.939
MP4	2" Brass Disk in Square Well	2001630.728	7301909.696	683.507
MP5	2" Brass Disk in Conc.Pad	2027229.722	7333049.645	970.531
PBB 12M	BM-3 1/2"Brass Disk	2038964.276	7318487.908	1280.431
Z 1308M	BM-3 1/2"Brass Disk	2036442.479	7315249.356	1099.522
MARBLE BM	BM-2"Brass Disk	2023673.689	7323716.382	963.397

APPENDIX 5.2
Field Notes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