Twentieth Annual Groundwater Monitoring Report January - December 2017

Prepared for

CADIZ

Cadiz Valley
Agricultural Development

Prepared by

Terry L. Foreman, PG 4020, CHg 155
TLF Consulting, LLC

December 2018

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Acronyms and Abbreviations

AFY	acre-feet per year
Annual Report	Nineteenth Annual Groundwater Monitoring Report
Cadiz	Cadiz, Inc.
Water Project	Cadiz Valley Water Conservation, Recovery and Storage Project
CEQA	California Environmental Quality Act
County	San Bernardino County
EC	electrical conductivity
FEIR	Final Environmental Impact Report
GMMMP	Groundwater Management, Monitoring, and Mitigation Plan
gpm	gallons per minute
GPS	Global Positioning System
GWMP	Groundwater Monitoring Plan
mg/L	milligrams per liter
NAD83	North American Datum 83
NAVD88	North American Vertical Datum of 1988
TDS	total dissolved solids
USGS	U.S. Geological Survey
µmho/cm	micro-mhos per centimeter

Executive Summary

This Annual Groundwater Monitoring Report (Annual Report) is the twentieth in a series of monitoring reports that summarize data collected for the Cadiz Valley Agricultural Development. Cadiz, Inc. (Cadiz) owns approximately 34,000 acres of land in the Cadiz and Fenner valleys located in eastern San Bernardino County, California, and currently grows approximately 660 acres of irrigated crops (citrus orchards, grape vineyards, and seasonal vegetables) on this property. A total of 1,900 acres are developed for agriculture, which includes a network of seven irrigation wells that are used to irrigate crops in production. San Bernardino County (County) analyzed the agricultural development under the California Environmental Quality Act (CEQA). The Final Environmental Impact Report (FEIR) for the Cadiz Valley Agricultural Development, approved by the County in 1993, requires monitoring of groundwater levels, electrical conductivity of groundwater, groundwater extraction, and potential land subsidence. A Groundwater Monitoring Plan (GWMP), prepared in compliance with the FEIR, was approved by the San Bernardino County Planning Department in 1997. In accordance with the GWMP, a Five-Year Summary Report was submitted to the County in January of 2003, and January of 2008, and a comprehensive groundwater assessment was completed as a part of the Cadiz Valley Water, Conservation, Recovery and Storage Project (Water Project) Environmental Impact Report in 2012.

The purpose of this Annual Report is to summarize data collected during the period January – December 2017:

- Total groundwater production decreased to 1,222.82 AF from 1,857.99 AF in 2016.
- Groundwater levels and trends during the monitoring period are stable and occur within normal variations expected during pumping and recovery cycles.
- Groundwater levels and trends are within expected FEIR guidelines.
- Groundwater quality (based on total dissolved solids [TDS]) has not changed significantly over time and is within expected variations.
- An updated land subsidence survey conducted in 2017 found no apparent significant changes in land surface elevations.

Over the next few years, this monitoring report will continue to transition from the GWMP for Cadiz's agricultural operations to the Water Project's Groundwater Management, Monitoring, and Mitigation Plan (GMMMP) as approved by the County on October 1, 2012. This transition includes application of significance thresholds and additional monitoring features as described in the GMMMP. This Twentieth Annual Report continues presentation of additional groundwater level and TDS data as initiated in the Fifteenth Annual Report. Cadiz and the Fenner Valley Water Authority will work with the County to discuss inclusion of additional GMMMP requirements as implementation of the Water Project proceeds.

SECTION 1
Introduction

This Twentieth Annual Monitoring Report (January - December 2017) (Annual Report) has been prepared in compliance with the Groundwater Monitoring Plan (GWMP) submitted by Cadiz, Inc. (Cadiz) on May 1, 1997, and accepted by the County Planning Department. Since 2009, Cadiz has been working with water agencies in Southern California to develop the Water Project, which would provide for an initial extraction[1] of 50,000 acre-feet per year (AFY) from a wellfield south southwest of the Fenner Gap area (Figure 1). Santa Margarita Water District, as the Lead Agency for CEQA compliance, certified the FEIR for the Water Project on July 31, 2012. In addition, the County, as a CEQA Responsible Agency, approved the FEIR and the GMMMP on October 1, 2012. The GMMMP defines specific management, monitoring and mitigation for the Water Project, including pre-operational 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 Twentieth Annual Monitoring Report is being submitted in compliance with the GWMP; however, supplemental information is being provided as a transition toward the requirements of the approved GMMMP. Figure 1 shows existing and planned monitoring components to be developed under the GMMMP, which will ultimately be reported on when the GMMMP is fully implemented.

Substantial geologic and hydrogeologic information was developed and impact analyses were conducted to support the Water Project FEIR. Dr. Miles Kinney presented findings regarding detailed geologic mapping of the Fenner Gap area. CH2M HILL presented an updated assessment of the recharge to the Fenner and Orange Blossom Wash Watershed areas, as well as an assessment of evaporative discharges from the Bristol and Cadiz Dry Lakes, which included actual measurements of evaporation from the dry lakes by the Desert Research Institute. Geosciences Support Services, Inc., conducted detailed groundwater flow and solute transport modeling, including subsidence, to assess potential impacts to groundwater levels, groundwater quality, and land subsidence. Dr. David Groeneveld completed an assessment of potential impacts to vegetation and 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 5-year hydrogeologic report that re-analyzes the basin, results in a revised monitoring plan, and establishes significance criteria. The approved GMMMP is based on the findings of these assessments and support by the County.

1.1 Purpose and Scope

This Twentieth Annual Monitoring Report (January - December 2017) has been prepared in compliance with the 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 document *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* (November 1993).

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[1] Actual total pumping would vary depending on the Water Project participant supply needs. The maximum extraction rate in any given year would be limited to 75,000 AFY with the long-term average of up to 50,000 AFY as measured over a 10-year period.

The scope and purpose of this Twentieth Annual Monitoring Report is to summarize data collected from January - December 2017 in compliance with the GWMP, as well as begin to gather data to establish new baselines for the Water Project:

- Compile and discuss groundwater extraction data.
- Compile and analyze static groundwater level data and compare these data to baseline conditions.
- Compile and analyze groundwater quality data and compare these data to baseline conditions.
- Discuss potential impacts with regard to water levels, water quality, and subsidence.

Additional wells and groundwater monitoring data for 2016 are included with this Nineteenth Annual Monitoring Report as an ongoing transition from the GWMP to the GMMMP.

1.2 Location of Study Area

Cadiz owns approximately 34,000 acres of land in the Cadiz and Fenner valleys in eastern San Bernardino County, California. This landholding is located approximately 200 miles east of Los Angeles, 60 miles southwest of Needles, and 50 miles northeast of Twentynine Palms (Figure 1). The Cadiz property extends from the northern portion of the Cadiz Valley through Fenner Gap (located between the Marble and Ship mountains), into the southwestern portion of Fenner Valley (Figure 2).

The Cadiz Valley Agricultural Development, which is located upon 9,600 acres of Cadiz property in the Cadiz and Fenner valleys, currently includes approximately 660 acres of irrigated crops (citrus orchards, grape vineyards and seasonal vegetables).

1.3 Groundwater Monitoring Well Network

Cadiz owns and operates seven irrigation wells in the Cadiz Valley. In compliance with the GWMP, one monitoring well (5/14-13) has been designated in the Fenner Gap area (Figure 2) to provide groundwater monitoring upgradient from the irrigation wellfield. A number of monitoring and test wells related to investigations for the Water Project were completed and are identified. In addition, additional existing wells are identified in the region for incorporation into the GMMMP. Figures 1 and 2 show the locations of these existing wells, and Table 1 summarizes well completion details for the 37 wells. Cadiz has completed a resurvey of all of these wells to accurately establish their locations and elevations. The resurvey includes conversion of the horizontal coordinates to the current North American Datum 83 (NAD83). The vertical datum is the current North American Vertical Datum of 1988 (NAVD88). The GWMP groundwater monitoring well network consists of seven irrigation wells and a designated monitoring well located in Fenner Gap (eight wells total). Those wells listed in Table 1, will ultimately become a part of the GMMMP for the Water Project. Cadiz has initiated groundwater level monitoring of the wells in Table 1 and completed limited water quality sampling in some wells.

The GWMP calls for construction of an outpost well in the SW1/4 of Section 6, Township 4N, Range 14E. This well was never constructed. The approved GMMMP requires monitoring of a number of existing, and to be constructed wells, to monitor brackish water migration between the proposed Water Project wellfield and the Bristol Dry Lake. Well SCE-5 is one of the existing wells that are part of the approved GMMMP monitoring program for that purpose. Well SCE-5 is intended to serve as the interim "outpost" monitoring well between the agricultural wellfield and Bristol Dry Lake in order to provide early warning of potential migration of poor quality groundwater known to exist beneath Bristol Dry Lake. Monitoring of water levels and TDS in this and other wells began in 2012, which adds to the historical monitoring that was conducted in previous investigations.

1.4 Land Subsidence Survey

Joseph E. Bonadiman & Associates, Inc. performed a baseline survey for each of the Cadiz production wells and the designated monitoring well 5/14-13 in December 1997. These baseline elevation data were presented previous Annual Reports. In order to determine if any land subsidence has occurred at any of the wells, Joseph E. Bonadiman & Associates, Inc. conducted subsequent surveys in 1999, 2000, 2001, 2002, 2007, 2010, 2013,2014 and 2015. In each case, the surveyed ground surface elevations suggested that no significance subsidence has occurred at the eight well sites based on the accuracy of the survey approach. These data are presented and described in the most recent Five-Year Summary Report (2008) and in the FEIR Appendix H, as well as the Cadiz Valley Agricultural Development annual monitoring reports.

The land subsidence monitoring program will 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 part of the initial efforts, a new base reference station was established in the Marble Mountains in order to provide a stable benchmark for use in future subsidence surveys as described in the Seventeenth Annual Report. In addition, Cadiz has established five new land subsidence control points in 2015 as an ongoing transition from the GWMP to the GMMMP. Towill Inc., surveyed all eight wells and the five new survey monuments in December 2016 and resurveyed them in December 2017 as described below.

1.5 Sources of Data

Production data, water quality data, and static groundwater level data from the seven irrigation wells and monitoring wells were used in preparation of this report.

These data were collected by Cadiz and staff of West Yost Associates, Inc. and Geosciences Support Services, Inc, including State of California Professional Geologists. Data collection procedures used in connection with this report have been reviewed and approved by Terry Foreman, a State of California Professional Geologist and Certified Hydrogeologist.

SECTION 2

Geology and Hydrogeology

The geology and hydrogeology of the Fenner, Orange Blossom Wash, Bristol, and Cadiz Watersheds are described most recently in Appendix H of the Water Project FEIR. The reader is referred to Appendix H for this more detailed description. Following is a brief summary of the geology and hydrogeology of the area in the vicinity of the Cadiz Valley Agricultural Development.

2.1 Geologic Setting

The Cadiz Valley Agricultural Development is located within portions of the Bristol, Cadiz, and Fenner watersheds in the eastern Mojave Desert of California, part of the Basin and Range province of North America. The area features bedrock and alluvial/dune/lacustrine deposits. Bedrock includes igneous, metamorphic, and consolidated sedimentary rocks (including carbonates). Alluvial/dune/lacustrine deposits are unconsolidated sediments deposited by streams, wind, or in playa lakes. In general, bedrock forms the perimeter of the major watersheds. Large bedrock masses occur within watersheds, such as the Clipper Mountains, which are located in the Fenner Watershed.

The Bristol and Cadiz watersheds form a broad depression that is referred to as the Bristol Trough (Thompson, 1929; Bassett et al., 1964; Jachens et al., 1992). This depression is thought to be 6 to 10 million years old (Rosen, 1989), having formed as a result of regional movement along faults.

2.1.1 Stratigraphy

Geologic formations found in the Bristol, Cadiz, and Fenner watersheds can be grouped into three broad categories: crystalline bedrock exposed in the mountain ranges and hills, alluvial sediments that weathered from the crystalline bedrock, and fine-grained (silt and clay) sediments and evaporite (NaCl, CaCI, and gypsum) deposits that underlie Bristol and Cadiz Dry Lakes.

The crystalline basement rocks exposed in the mountain ranges of the subject area consist primarily of Precambrian granitic and metamorphic rocks that are locally overlain by a sequence of Paleozoic sedimentary rocks. The Paleozoic rocks consist of sandstones, shales, slates, limestones, and dolomites. These Paleozoic sediments and the underlying basement rocks have been faulted and folded by numerous periods of regional tectonism. The crystalline basement rocks are generally much less permeable than alluvium and typically yield only small quantities of water to wells (Freiwald, 1984). Some of the Paleozoic sedimentary sections, particularly those limestone and dolomites sections that are fractured or contain solution cavities, yield large quantities of water to wells (CH2M HILL, 2010). The widespread distribution of these carbonate units can be seen by the distribution of other outcrops that can be found on the eastern slope of the New York Mountains, in Lanfair Valley, just north of the Clipper Mountains, in the Marble Mountains, in the Ship Mountains, in the southeast end of the Bristol Mountains, the Kilbeck Hills on the south, and the Old Woman Mountains on the east (see USGS, 2006; Howard, 2002; and Bedford et al., 2006, Hazzard, 1956 for locations of these carbonate units). These carbonate units are significant aquifers where dissolution features are present in the subsurface, such as in the Fenner Gap area (CH2M HILL, 2010).

The basement complex and the overlying Paleozoic section were locally metamorphosed and intruded by granitic plutons during Mesozoic time. In the Old Woman Mountains, the Precambrian and Paleozoic section was also intensely deformed by ductile thrusting that accompanied the Mesozoic plutonism (Karlstrom et al., 1993). 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 U.S. Geological Survey

(USGS, 2006) 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) and was formed from 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 extensional normal faulting of late-Tertiary age.

The Quaternary and late-Tertiary alluvial fill in the basins is largely derived from the Precambrian basement rocks, Paleozoic sediments, and Tertiary volcanic rocks. The USGS (2006) 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 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 form 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 the 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 2,000 feet (Bassett et al., 1959; Rosen, 1989). Sodium chloride and/or calcium chloride are currently being recovered from trenches and brine wells on both of these playas. Thompson (1929), Gale (1951), Bassett et al. (1959), Handford (1982), and Rosen (1989) concur that the principal recharge to the playas occurs as diffuse seepage of groundwater onto the playas from the adjacent alluvial fans.

Cadiz and Bristol dry lakes are locally bordered by active dunes formed by 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 (Parker, 1963; Hazlett, 1992).

2.1.2 Structure

The subject 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 major northwest-trending faults, inferred on the basis of 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 the Final EIR/EIS, 2001 for locations).

Right-lateral slip of as much as 16 miles along the Cadiz Valley fault zone has been postulated on the basis 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 suggest that subsidence of this basin began by Pliocene time and continues to the present (Rosen, 1989), and therefore may be tectonically active.

Fenner Gap appears to be a structural half-graben, formed by a system of northeast trending, northwest-dipping normal faults, some of which are exposed in outcrops of the bedrock that flank the gap (Kenney, 2011). The presence of these northeast-trending faults beneath the alluvial deposits that underlie the gap can be inferred from surface geology mapping by Kenney (2011) and others, gravity surveys, a seismic reflection survey conducted across the gap by NORCAL Geophysical Consultants, Inc. (1997), and recent test wells drilled as a part of a CH2M HILL study (2010).

The system of normal faults that formed the half-graben of Fenner Gap displaces and tilts volcanic rocks of mid- to late-Tertiary age (Kenney, 2011). However, because these faults do not displace Quaternary sediments, they are considered neither active nor potentially active.

2.2 Geohydrology

2.2.1 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. Principally carbonate units are aquifers, but the unit contains interbedded quartzite and shale (CH2M HILL, 2010; GSSI, 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; GSSI, 1999). The thickness of the upper alluvial sediments ranges to approximately 1,000 feet (GSSI, 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; GSSI, 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 (GSSI, 1999). The Cadiz Inc. 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 contains groundwater and is considered a significant aquifer (GSSI, 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).

2.2.2 Groundwater Recharge & 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 stream flow 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 in the higher elevations (Metropolitan, 2001; USGS, 2000; Davisson and Rose, 2000).

Precipitation infiltrates and moves downward to the water table. In some cases, the infiltrating water may be diverted to the land surface or groundwater may intersect land 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 (Mendenhall, 1909). 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). The USGS documented at least 10 wells and springs in the mountains and hills around the Fenner Watershed and a number of wells 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. Additional wells and springs were identified in the area of study and described by Thompson (1929). 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). Bristol and Cadiz have static groundwater levels at or near the playa surfaces (Moyle, 1967; Rosen, 1989). Sodium chloride and/or calcium chloride are currently being recovered from trenches and brine wells on all three of these playas. Thompson (1929), Gale (1951), Bassett et al. (1959), Handford (1982), and Rosen (1989) concur 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 the 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 flows generally southward from the Granite Mountains into Bristol Dry Lake. (GSSI, 1999; CH2M HILL, 2010). CH2M HILL (2012) estimated the discharge from Bristol and Cadiz dry lakes to be approximately 33,890 AFY, 7,550 AFY, and 26,340 AFY, respectively, based on measurements made by the Desert Research Institute (2012), extrapolated over the surface areas of these dry lakes for a full year. This evaporative discharge compares well with the estimated recharge rate of 32,500 AFY.

SECTION 3

Groundwater Extraction

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 to 2002 was approximately 5,600 AFY; and from 2003 to 2007 approximately 4,390 AFY. Annual average production from 2008 through 2013 has been about 2,160 AFY. Total production during 2017 decreased slightly to 1,222.82 AF, compared to 1,857.99 AF in 2016. This decrease in extraction is likely associated with increases in irrigation efficiency practices implemented recently. Figure 3 shows annual (calendar year) groundwater production by Cadiz since 1986, which totals 123,500 AF. This production does not include extractions at the office, trailer park, and labor camp wells, which are just a few acre-feet per year in addition to their pumping for irrigated agriculture.

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 the Metropolitan Water District of Southern California from 1997 - 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 the 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 (generally 10 AF or less) of groundwater has been pumped annually since 2009 for the purpose of 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 the 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.

Figures 4 through 10 show monthly pumping by well. Wells 27N and 28 were not utilized in 2017. 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 these aquifer tests. Groundwater levels measured in each well are shown in these figures; however, only static (nonpumping) or near-static (groundwater levels may not have fully recovered from pumping conditions in all cases) groundwater levels are shown. This shows the trends in groundwater levels in the aquifer 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.

SECTION 4

Groundwater Level Conditions

4.1 Baseline Groundwater Elevations

In the first annual report, groundwater elevations in feet above mean sea level 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, Joseph E. Bonadiman & Associates, Inc. (California licensed land surveyor) performed a survey in order to establish the baseline elevation of the seven agricultural wells and monitoring well 5/14-13. Joseph E. Bonadiman & Associates, Inc. has since resurveyed all wells and surveyed newly installed monitoring wells through 2015, as described in the Eighteenth Annual Groundwater Monitoring Report. In addition, the resurvey includes conversion of the horizontal coordinates to the current NAD83. The vertical datum is the current NAVD88. 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 3 presents a summary of these baseline groundwater levels, converted to the new NAD83 and NAVD88 data. As shown in Table 3, groundwater levels have recovered above the baseline levels in the wellfield area.

Depth to groundwater is measured on a monthly basis, as feasible, for each of the seven irrigation wells and designated monitoring well 5/14-13. All other monitoring wells are measured on more irregular schedules due to the large aerial distribution and time required to travel to all wells, but they each have been measured many times over the last few years and approximately twice annually in the last several years. 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 based on available groundwater level measurements. These wells have been grouped for purposes of displaying these hydrographs over the large geographical area covered by all the monitoring wells. 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 11 shows the well groups and Figures 12 through 17 present hydrographs for each individual well group.

In general, groundwater levels in and near the Cadiz wellfield fluctuate in response to pumping and recovery cycles. Maximum groundwater level declines are far less than the maximum predicted drawdown values presented in the Draft Environmental Impact Report for the Cadiz Valley Agricultural Development (URS Consultants, 1993).

As mentioned above in Section 4, Groundwater Extraction, groundwater levels declined consistent with expectations in response to pumping by Cadiz through the 1990s as pumping reached maximum levels, then stabilized in the late 1990s/early 2000s, and have since recovered as extraction levels were reduced in the late 2000s. Table 3 provides a comparison of baseline groundwater levels with current static groundwater levels. In general, most wells have recovered well above those baseline groundwater levels. (The baseline was established during a period when Cadiz had been and was actively farming, so groundwater levels were lowered due to that pumping). Monitoring well hydrographs outside the wellfield area, especially in and north of the Fenner Gap area, suggest that groundwater levels do not fluctuate significantly over the long term.

SECTION 5

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 in the vicinity of the dry lakes as the "fresh" groundwater mixes with the saline groundwater underlying the dry lakes. The fresh/saline groundwater interface, as defined by TDS concentrations of 1,000 mg/L, is located near the margins of the two dry lakes.

5.1 Groundwater Quality Conditions

Electrical conductivity (EC), which is directly proportional to TDS concentration, has been employed as a measure of groundwater quality. Field measurements of EC are made with a portable meter that is calibrated to standard solutions. Comparisons of available EC measurements to baseline conditions are presented in previous Annual Reports. As EC is a relative indicator of TDS concentration, actual TDS measurements will be reported as opposed to EC data as an initial transition step toward the requirements of the approved GMMMP.

Irrigation wells and monitoring wells 5/14-13 and SCE-5 were sampled for water quality, including TDS, during December of 2017. As stated in the Introduction, supplemental information is being provided as an ongoing transition toward the requirements of the approved GMMMP. Figure 18 shows those wells that were sampled for groundwater quality in 2017. It is expected that those groundwater data collected since 2012 will be used to begin to define pre-operational groundwater quality conditions.

Figure 18 shows the TDS values in groundwater based on those well groundwater samples collected in 2017. Overall, TDS is considered to be relatively low, averaging around 330 mg/l, compared to the Secondary Maximum Contaminant Level for drinking water of 500 mg/l.

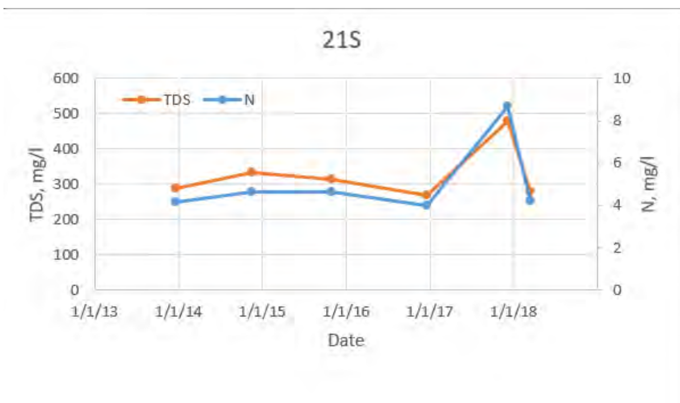
Figure 19 shows plots of TDS over time from available historical data. These data show that TDS varies spatially and temporally throughout the study, so that TDS may be expected to fluctuate over time at individual wells. The brief high TDS spikes at MW-1 in 1999 are from flushing of the vadose zone during infiltration testing at the Cadiz test recharge basins. The initial high TDS value reported in MW-3 is suspected to be due to residual drilling mud as reported by GSSI (1999). In addition, all the monitoring wells have been sampled using bailers prior to the 2014 sampling event, except sampling conducted in 2013 and 2017, so part of the variation may be due to the variation in sampling methods. In the future, many of these monitoring wells will be equipped with permanent pumps to obtain water samples.

In general, TDS in the Cadiz irrigation wells appears relatively stable, with the exception of wells 27N and 33. Elevated TDS levels were observed at these wells in 2013 and 2017, which are inconsistent with the other TDS data. Well 33 has not been pumped since 2009, so it has been inactive for many years. The groundwater sample collected from this well in 2012 was collected with a bailer, whereas in 2013 and 2017 a temporary pump was installed to purge the well before sample collection and was again sampled with a bailer in 2014. So, the difference in sample techniques may account for some of the variation in the TDS values but it is not expected to explain the large spike observed in 2013. The samples collected at Well 33 in 2014 and 2015 shows a drop in TDS levels back to 308 and 338 mg/l, respectively, which is consistent with the longer-term trend.

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. It appears that the casing/screen requires repairs as the well has been pumping sand when in service, which has been somewhat limited as a result of the sand production. It is unclear if the damage to the well casing/screen may have potentially affected the distribution of flow of groundwater vertically along the casing and thus 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 and 530 mg/l in the 2016 and 2017 samples, which may be due to residual effects from earlier redevelopment efforts (or leaks in irrigation system piping as described below) as indicated from the fluctuations seen in Figure 19.

As the Sixteenth Annual Report further explains, the spike in TDS observed in 2013 in wells 33 and 27N may have been caused by leaks in irrigation system distribution piping near well 27N, and resultant flushing of salts from the thick vadose zone to the underlying groundwater near these wells.

The December 2017 sample from well 21S showed an anomalous spike in its TDS level as shown in Figure 19. In addition, nitrate levels spiked from an average of approximately 4.3 mg/l (as N) to 8.7 mg/l. These spikes and apparent anomalous fluctuations in TDS levels in wells 27N and 33 prompted further investigation of possible sources of high TDS concentrations. It was suspected that a source might be leaking check valves, which would allow irrigation water containing fertilizers to flow back into irrigation wells. It was found that well 21S had a leaky check valve upon inspection of the valve. Upon discovery of this finding, well 21S was pumped continuously to see if the nitrate and TDS could be removed from the well and vicinity, assuming that the suspected leak is the source of the anomalous levels. As shown in the graphics below, both TDS and N levels were reduced to typical levels observed historically. In addition, TDS and nitrate levels for well 27N show similar trends as well 21S, which suggests that there may have been check valves issues with this well, in addition to other possible explanation of the sources of high TDS and N. Well 33 may have experienced similar issues as well.



Ongoing monitoring will be used to confirm that the spikes in TDS levels at wells 21S, 33 and 27N are localized temporary conditions.

A number of existing and new monitoring wells were identified in the GMMMP for the Water Project to monitor the freshwater/saline groundwater interface between Bristol Dry Lake and the Cadiz wellfield. Well SCE-5 is one of those monitoring wells. Well SCE-5 was sampled in 2012, 2013, 2015, 2016 and 2017 for TDS for comparison to earlier samples. As shown in Figure 19, TDS of groundwater at well SCE-5 appears to have remained relatively stable since 1997.

SECTION 6

Land Surface Elevation Survey

A baseline survey of land surface elevation benchmarks in the project area was conducted by Joseph E. Bonadiman & Associates, Inc. in December 1997. This survey was performed using Global Positioning System (GPS) equipment. The purpose of the survey was 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, 2014 and 2015 to assess changes in land surface elevation at the benchmarks. These data are presented in previous monitoring reports.

As described in the first Five-Year Summary Report (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. Joseph E. Bonadiman &Associates, Inc. conducted a repeat survey of land surface elevation benchmarks in December 2007. The results of this survey document that all 2007 elevations were 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 new 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 those 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 Joseph E. Bonadiman & Associates, 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. In addition, five new survey control points for subsidence monitoring were added in 2015. These monitoring points are shown in Figure 20 along with the seven irrigation and monitoring well 5/14-13 included in the original land subsidence monitoring program. Towill, Inc., surveyed the eight irrigation wells, monitoring well 5/14-13 and five new survey monuments in December 2017. Appendix B provides the survey report from Towill Inc.

Table 2 summarizes survey results since December 2014. Earlier subsidence survey results can be found in previous submitted monitoring reports. The new survey procedures were implemented in the December 2014 survey as described in the Seventeenth Annual Report. The new survey procedures establish benchmarks on Marble Mountain as reference points for the Cadiz subsidence surveys. The goal of the new procedure is to obtain a vertical accuracy of ± 0.10 feet tolerance threshold. As shown in Table 2, all survey points are within this 0.1 feet. As groundwater level values have not declined significantly, and in fact have largely recovered over time, it is likely that the differences in year over year values are within the actual vertical accuracy of the survey capability, which may be slightly larger than the goal of ±0.1 feet. Future surveys will determine if these variations are anomalies or a trend.

SECTION 7

Analysis of Potential Impacts

Monitoring of groundwater levels and water quality is an important component of the Cadiz Valley Agricultural Development. During the past 17 years, monitoring of groundwater levels, EC, and/or TDS provides for an assessment of groundwater conditions within the development area. No significant changes in groundwater levels or trends have been observed during sixteen years of monitoring. The observed variations in groundwater levels and water quality indicate that water levels and water quality have remained relatively stable overall.

Land subsidence is a potential concern that can be triggered by groundwater pumping. Elevations measured by the GPS survey performed in 1997 established benchmarks from which changes in land surface elevation can be detected. Subsidence is most likely to occur in environments where groundwater withdrawals result in significant lowering of static groundwater levels within sediments dominated by silt and clay. Significant declines in static groundwater levels have not occurred in the area of the Cadiz agricultural wellfield. Towill Inc., conducted a survey of land surface elevation benchmarks in 2017. The results of this survey document that all 2017 NAVD88 elevations are similar to those originally measured in 2016 and there is no long-term trend of land subsidence since 1997. The land subsidence monitoring program 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.

SECTION 8

Summary and Conclusions

The following summarizes groundwater conditions in the Cadiz Valley Agricultural Development project area in 2016:

- 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 reduced pumping in recent years.
- Irrigation wells and monitoring wells were sampled for water quality, including TDS, during December 2017. As stated in the 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 historically reported. Generally, groundwater quality appears to be stable. There are several irrigation wells that have experienced increases in TDS and nitrate, which seem to be localized conditions, likely due to temporary leaks from the irrigation system into the irrigation wells. Ongoing monitoring will be used to confirm that these TDS spikes at irrigation wells 21S, 33 and 27N are localized temporary conditions.
- Average annual groundwater production for the Cadiz Valley Agricultural Development from 1998 to 2002 was approximately 5,600 AFY, and from 2003 to 2007 approximately 4,390 AFY. Annual average production from 2008 through 2012 was 2,080 AFY. Total production during 2017 decreased slightly to 1,222.82 AF compared to 1,857.99 AF in 2016, likely due to more efficient irrigation practices recently implemented. Groundwater production by Cadiz since 1986 totals 123,500 AF.
- A new survey of land surface elevation benchmarks was conducted in 2017, including five new survey monuments installed in 2015. The results of this survey document that all NAVD88 elevations are similar to those measured in 2016. There is no apparent evidence of subsidence since 1997 (baseline year). Those variations observed between surveys generally are considered to be within an acceptable range of values. In addition, five new subsidence monitoring control points have been added in 2015 as part of the transition to the GMMMP.
- 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, groundwater quality or land surface stability.

SECTION 9
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Tables

TABLE 1

Drilling and As-Built Well Construction Details

Fifteenth Annual Monitoring Report

Well Designation	Date Completed	Coordinates (1)		Elevation (1) (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 (2)	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	6/16/1905	34° 31' 14"	115° 28' 11"	894.86	NA	NA	NA	592	590 (5-inch)	280 - 590	NA	NA
6\15-1	1/1/1994	34° 38' 23"	115° 21' 22"	1,374.68	NA	NA	NA	799	500 (5-inch)	300 - 793	NA	NA
6\15-29	1/1/1994	34° 34' 33"	115° 26' 04"	1,136.99	NA	NA	NA	809	809 (5-inch)	305 - 809	NA	NA
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)	NA	320	310 (2")	250 - 310	200 - 320	0 - 20

TABLE 1

Drilling and As-Built Well Construction Details

Fifteenth Annual Monitoring Report

Well Designation	Date Completed	Coordinates [(1)] Latitude	Longitude	Elevation [(1)] (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)
CI-2	12/1/1998	34° 31' 14"	115° 27' 44"	904.77	Track mounted rotery drilling rig	12.25 (to 20 ft) 6.5 (to 690 ft)	NA	690	420 (2")	300 - 420	250 - 420	0 - 20
CI-3	12/1/1998	34° 30' 46"	115° 28' 14"	876.43	Track mounted rotery drilling rig	12.25 (to 20 ft) 6.5 (to 800)	NA	800	500 (2")	300 - 500	250 - 500	0 - 20
MW-1	1/1/1999	34° 31' 01"	115° 27' 44"	897.02	Track mounted rotery drilling rig	12.25 (to 20 ft) 6.5 (to 500)	NA	500	400 (2")	300 - 400	250 - 400	0 - 20
MW-2	1/1/1999	34° 30' 39"	115° 27' 57"	877.30	Track mounted rotery drilling rig	12.25 (to 20 ft) 6.5 (to 400)	NA	400	400 (2")	300 - 400	250 - 400	0 - 20
MW-3	1/1/1999	34° 30' 50"	115° 27' 25"	897.57	Track mounted rotery drilling rig	12.25 (to 20 ft) 6.5 (to 550)	NA	550	400 (2")	300 - 400	250 - 400	0 - 20
MW-5	1/1/1999	34° 31' 08"	115° 27' 22"	913.30	Track mounted rotery drilling rig	12.25 (to 20 ft) 6.5 (to 400)	NA	400	400 (2")	300 - 400	250 - 400	0 - 20
MW-6	1/1/1999	34° 31' 20"	115° 27' 01"	928.77	Track mounted rotery drilling rig	12.25 (to 20 ft) 6.5 (to 800)	NA	400	400 (2")	300 - 400	250 - 400	0 - 20
MW-7	1/1/1999	34° 31' 38"	115° 26' 54"	940.57	Track mounted rotery drilling rig	12.25 (to 20 ft) 6.5 (to 600)	NA	600	600 (2")	500 - 600	265 - 600	0 - 30
MW-7a	1/1/1999	"	"	"	Track mounted rotery drilling rig	12.25 (to 20 ft) 6.5 (to 600)	NA	600	400 (1")	300 - 400	265 - 600	0 - 30
SCE 5[2]	NA	34° 28' 18"	115° 32' 37"	686.84'	NA	NA	NA	NA	137 (1.5-inch)	49 - 135	NA	NA
SCE 10[2]	NA	34° 28' 22"	115° 29' 59"	748.84'	NA	NA	NA	NA	178 (1.5-inch)	47 - 176	NA	NA
SCE 11[2]	NA	34° 25' 51"	115° 27' 25"	672.40'	NA	NA	NA	NA	120 (1.5-inch)	84 - 117	NA	NA

TABLE 1

Drilling and As-Built Well Construction Details

Fifteenth Annual Monitoring Report

Well Designation	Date Completed	Coordinates (1)		Elevation (1) (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									
SCE 17[2]	NA	34° 29' 55"	115° 31' 58"	731.99'	NA	NA	NA	NA	158 (1.5-inch)	148 - 156	NA	NA
SCE 18[2]	NA	34° 26' 37"	115° 34' 59"	631.13	NA	NA	NA	NA	79 (1.5-inch)	69 - 79	NA	NA
21N	1995	34° 30' 36"	115° 30' 35"	793.47	NA	42 (to 50 ft) 26 (to 928 ft)	50' (30-inch)	920	920 (16-inch)	250 - 490 570 - 900	250 - 900	0 - 50
21S	1984	34° 30' 09"	115° 31' 13"	763.03	NA	28	40' (30-inch)	790	790 (16-inch)	348 - 778	NA	NA
22	1994	34° 30' 25"	115° 29' 57"	813.18	NA	26	60'	894	890 (16-inch)	320 - 400 580 - 630 670 - 710 740 - 880	NA	NA
27N	1989	34° 29' 46"	115° 30' 02"	790.94	NA	28	40' (30-inch)	800	800 (16-inch)	360 - 760	NA	NA
27S	1989	34° 29' 19"	115° 30' 04"	778.40	NA	28	40' (30-inch)	990	990' (16-inch)	400 - 900	NA	NA
28	1987	34° 29' 07"	115° 31' 06"	741.21	NA	28	40' (30-inch)	800	800 (16-inch)	400 - 800	NA	NA
33	1984	34° 28' 32"	115° 31' 09"	729.13	NA	28	40' (30-inch)	790	790' (16-inch)	355 - 776	NA	NA
Labor Camp	NA	34° 31' 24"	115° 30' 50"	785.74	NA	NA	NA	NA	NA	NA	NA	NA
Office	NA	34° 34' 03"	115° 33' 15"	736.64	NA	NA	NA	NA	NA	NA	NA	NA
Dorm	NA	34° 33' 18"	115° 32' 23"	711.49	NA	NA	NA	NA	NA	NA	NA	NA
Park	NA	34° 33' 47"	115° 33' 00"	721.09	NA	NA	NA	NA	NA	NA	NA	NA
Piute (Ibis)	NA	34° 56' 31"	114° 47' 33"	1,457.89	NA	26	50	924	860	290 - 840	0 - 860	0 - 50

Notes:

(1) Latitude/Longitude NAD83; elevation data NAVD88.

TABLE 1

Drilling and As-Built Well Construction Details

Fifteenth Annual Monitoring Report

Well Designation	Date Completed	Coordinates (1)		Elevation (1) (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									

(2) Screened Interval Determined from Video Log of Wells - May 2013

ft = foot/feet

ft bgs = feet below ground surface

ft msl = feet (relative to) mean sea level

Table 2.

Land Survey Results For Cadiz Wells and Survey Monuments

Well/Monument Designation	State Well Number	Elevation (Ft AMSL) Dec 17/18, 2014 (NGVD 88)	Elevation (Ft AMSL) Jun 1/2, 2015 (NGVD 88)	Elevation (Ft AMSL) December/ February, 2016/17 (NGVD 88)	Elevation (Ft AMSL) December/ December 2017 (NGVD 88)
21N	5N/14E-21H01	793.33	793.43	793.32	793.34
21S	5N/14E-21P01	762.98	762.91	762.92	762.89
22	5N/14E-22K01	813.11	813.17	813.07	813.10
27N	5N/14E-27B01	790.91	790.94	790.88	790.89
27S	5N/14E-27Q01	778.34	778.36	778.34	778.33
28	5N/14E-28Q01	741.10	741.07	741.07	741.05
33	5N/14E-33K01	729.07	729.08	728.99	728.96
5/14-13 (Fenner Gap)	5N/14E-13F01	894.83	894.83	894.78	894.85
MP1	NA	NA	612.03	611.94	611.92
MP2	NA	NA	613.80	613.67	613.66
MP3	NA	NA	878.96	878.88	878.94
MP4	NA	NA	683.64	683.54	683.51
MP5	NA	NA	970.58	970.48	970.53

Table 3. Baseline Groundwater Levels and Comparison to 2016 Maximum Groundwater Levels

Well	Date for computing adjustment from NAVD27 to NAVD88	Value	Correction (NAVD27 to NAVD88)	Baseline Value based on NAVD27	Adjusted Baseline Value to NAVD88	Maximum Non-pumping GW Level for 2017	Difference (2017 Max Level - Baseline)
21N	Dec-95	583.15	3.72	584.32	588.04	589.59	1.55
21S[1]	Dec-95	583.45	4.09	580.38	584.47	585.26	0.79
22	Dec-95	587.99	3.01	586.62	589.63	594.19	4.56
27N	Dec-95	571.38	2.45	567.56	570.01	589.73	19.72
27S[2]	Dec-95	573.73	2.66	572.57	575.23	590.18	14.95
28	Dec-95	570.39	3.10	565.61	568.71	588.21	19.50
33	Dec-95	572.62	2.79	571.33	574.12	581.78	7.66
5/14-13	Dec-95	603.99	3.46	602.85	606.31	600.8	-5.51

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

[1] Denotes 2013 value as measurements not available in 2016

[2] Denotes 2015 value as measurement not available in 2016

Figures

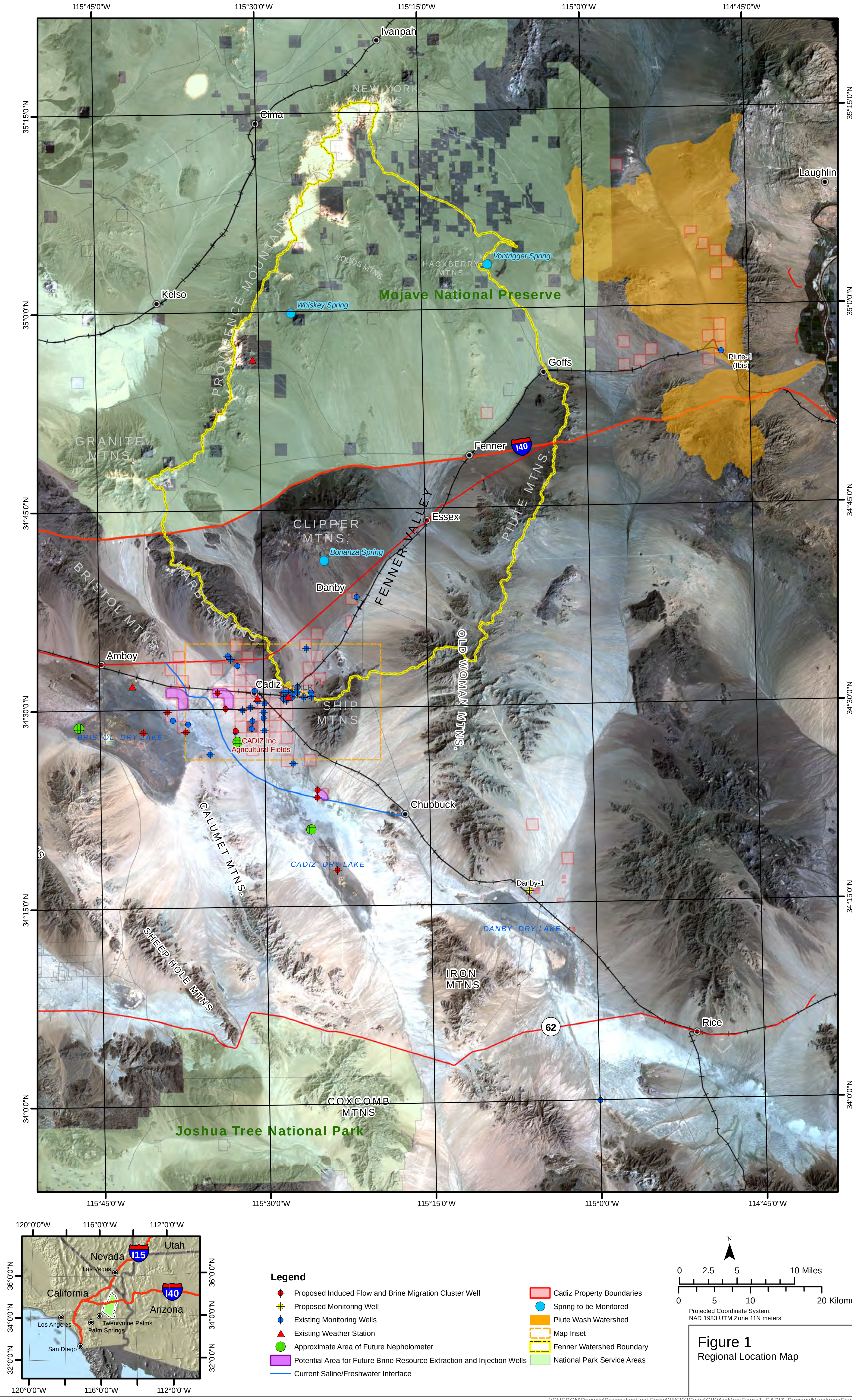

Figure 1
Regional Location Map

\\CHERON\Projects\BrownsteinHyattFarbe\386303Cadiz\GIS\ArcMap\Figure1_CADIZ_RegionalMonitoringFeatures.mxd

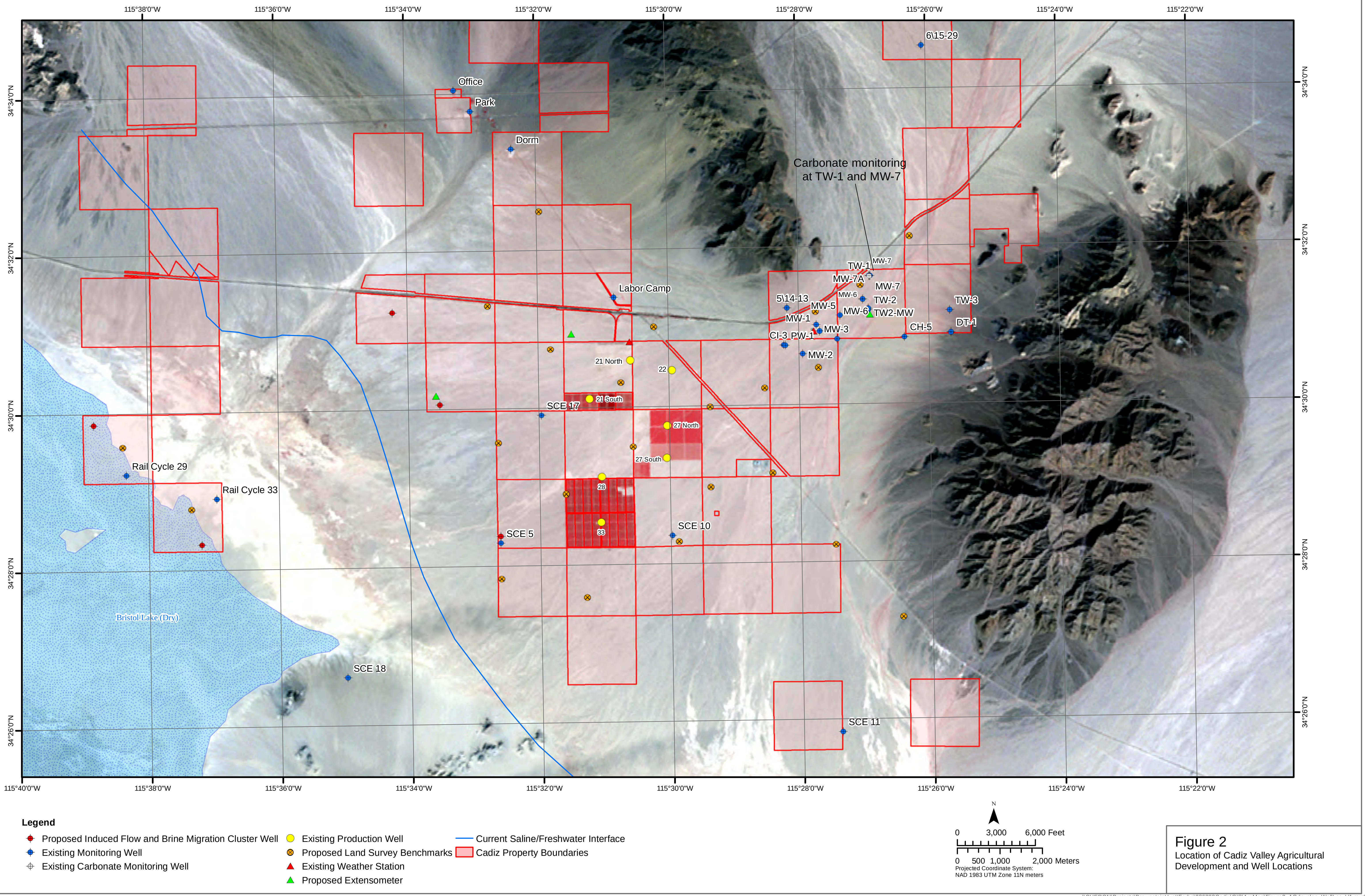

Figure 2
Location of Cadiz Valley Agricultural Development and Well Locations

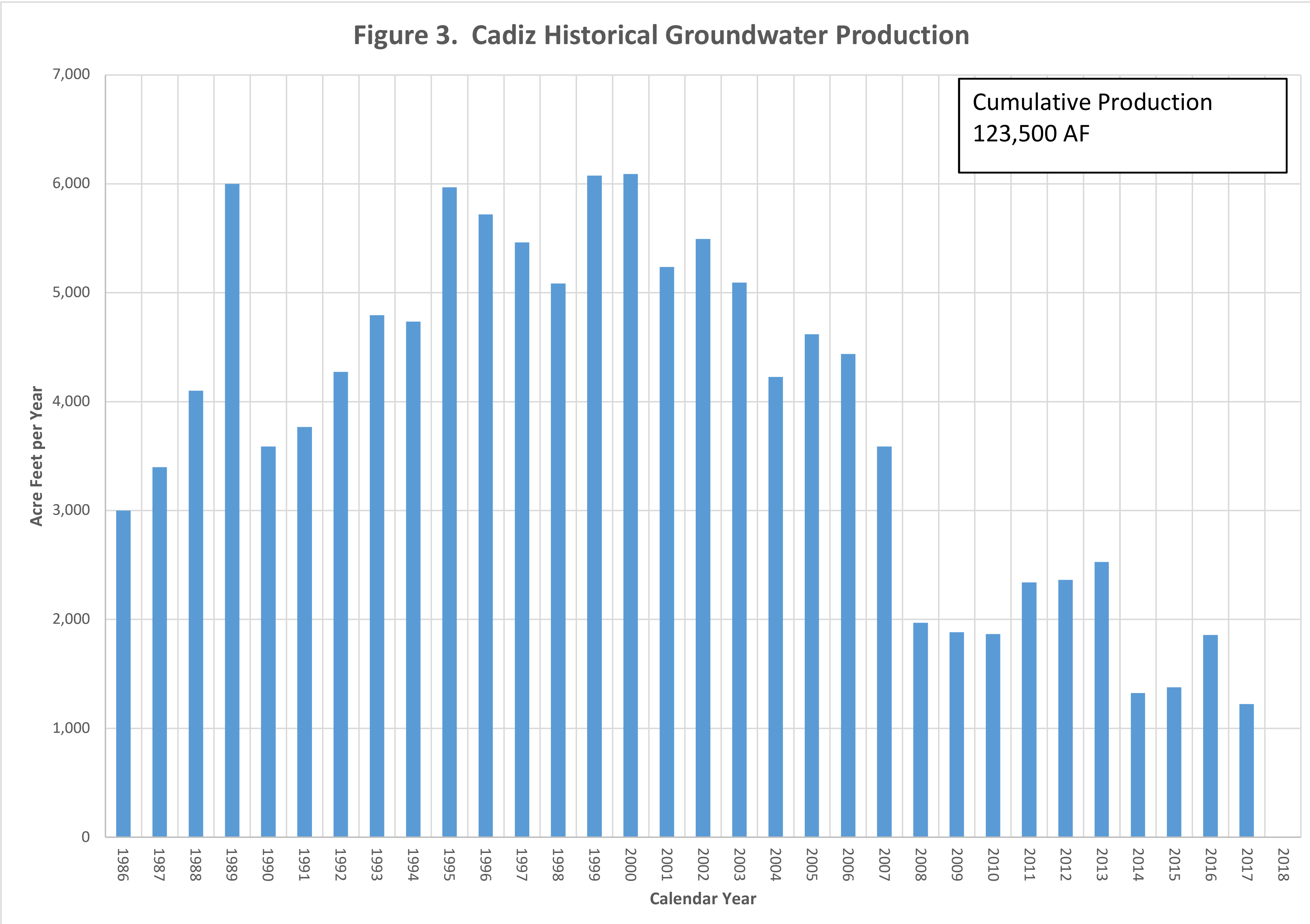

Figure 3. Cadiz Historical Groundwater Production
Cumulative Production
123,500 AF
Acre Feet per Year
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
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2004
2005
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2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Calendar Year

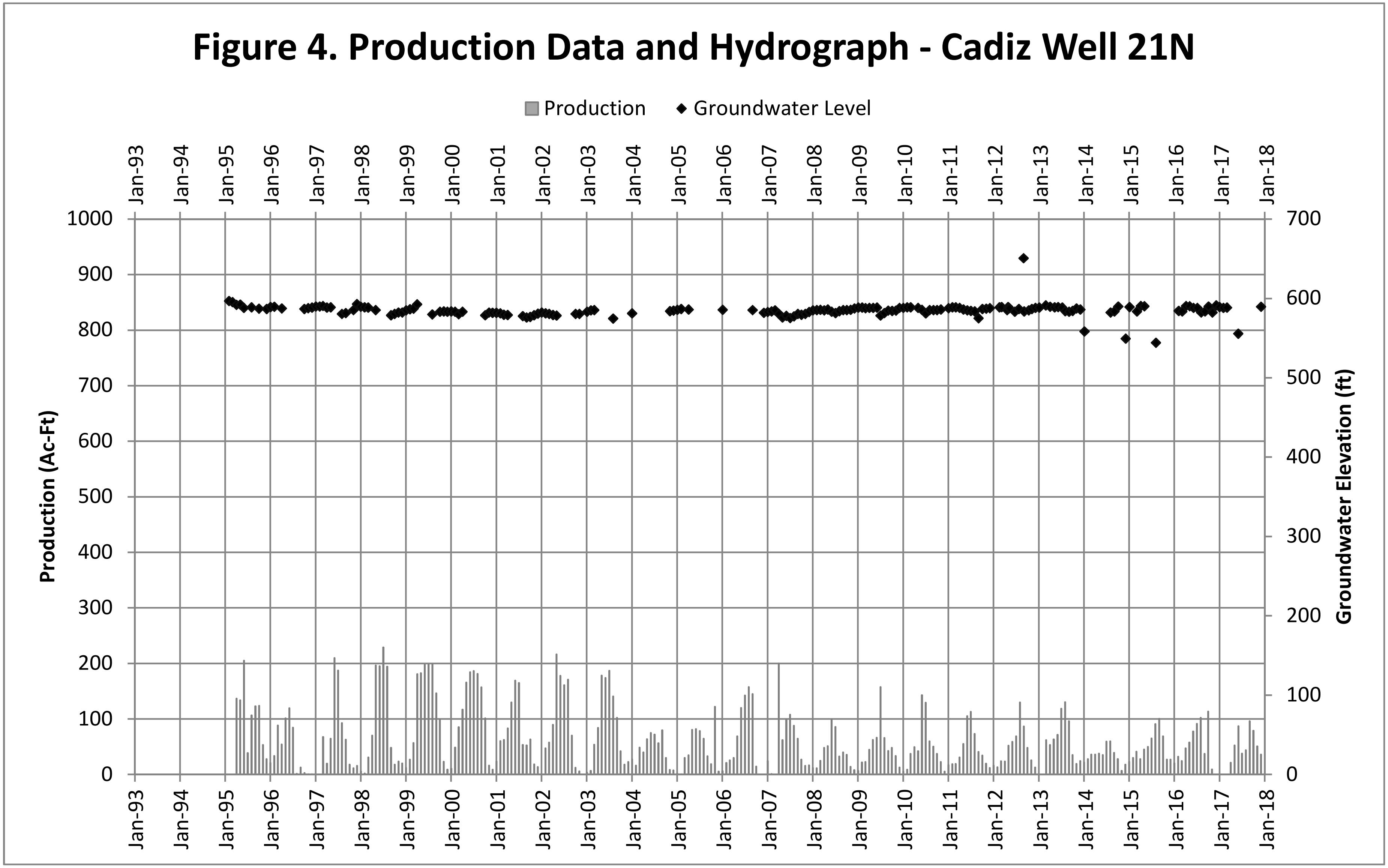


Figure 4. Production Data and Hydrograph - Cadiz Well 21N
Production
Groundwater Level
Production (Ac-Ft)
Groundwater Elevation (ft)
0
100
200
300
400
500
600
700
800
900
1000
0
100
200
300
400
500
600
700
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18

Figure 5. Production Data and Hydrograph - Cadiz Well 21S

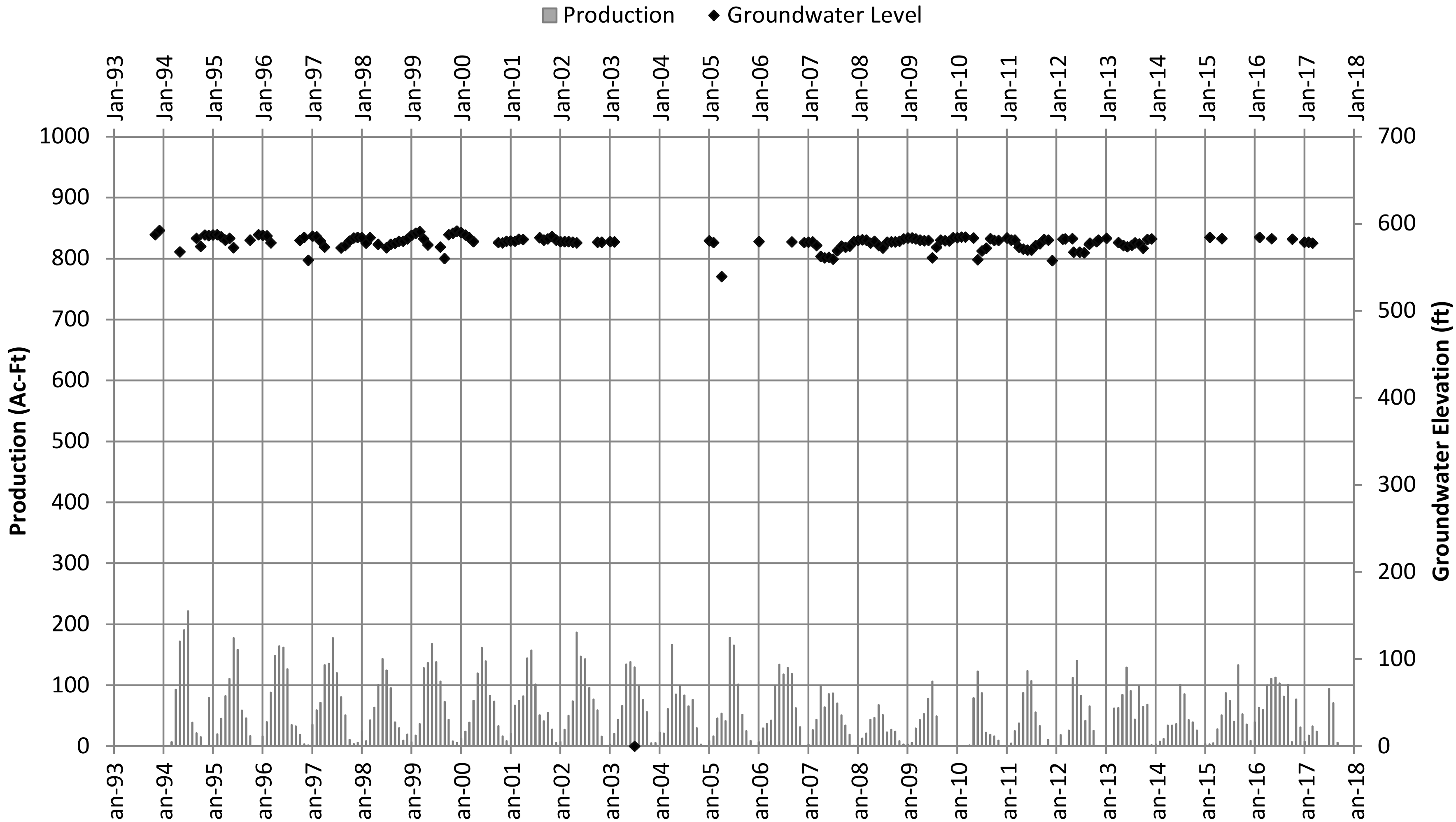
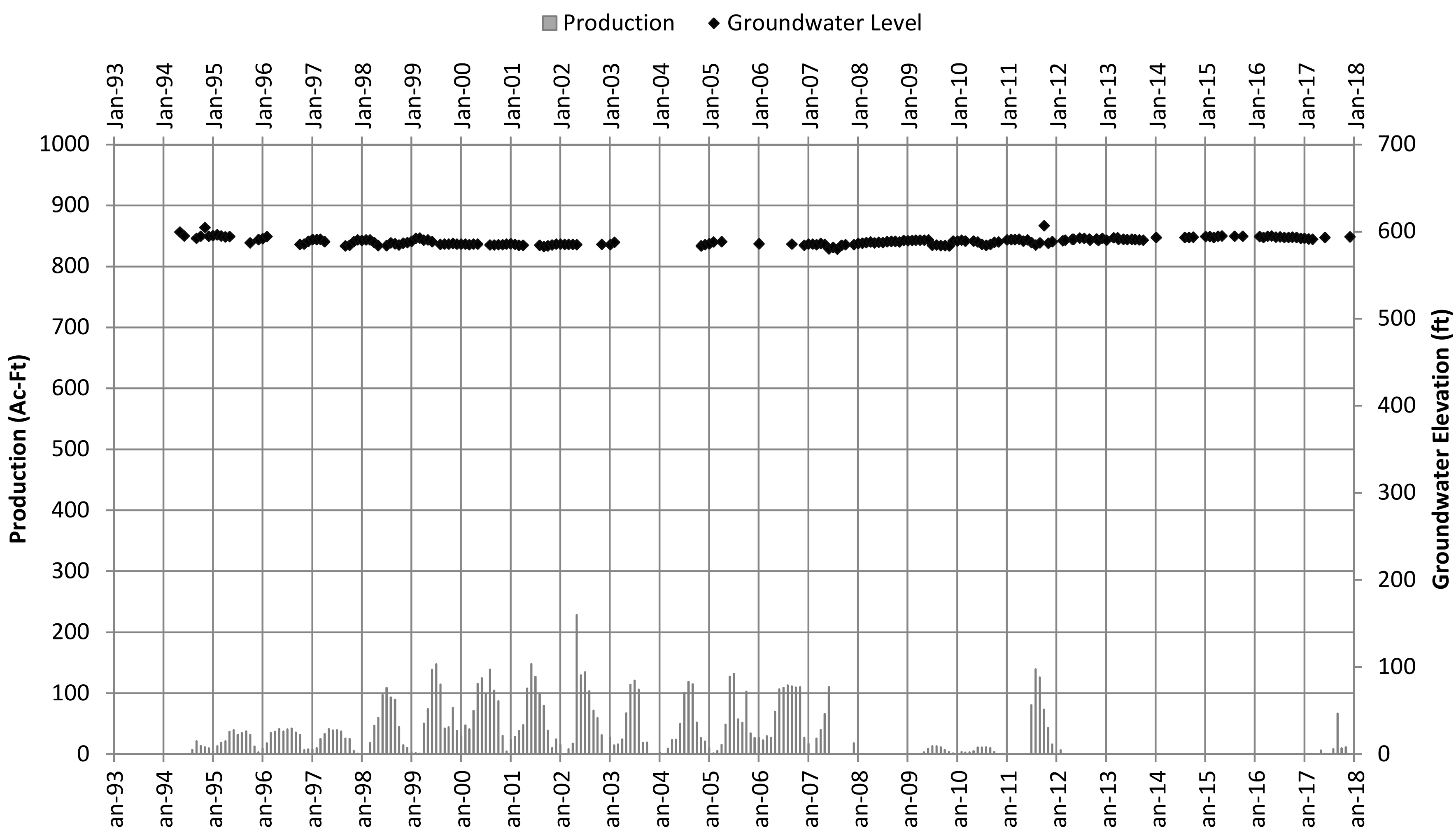


Figure 6. Production Data and Hydrograph - Cadiz Well 22



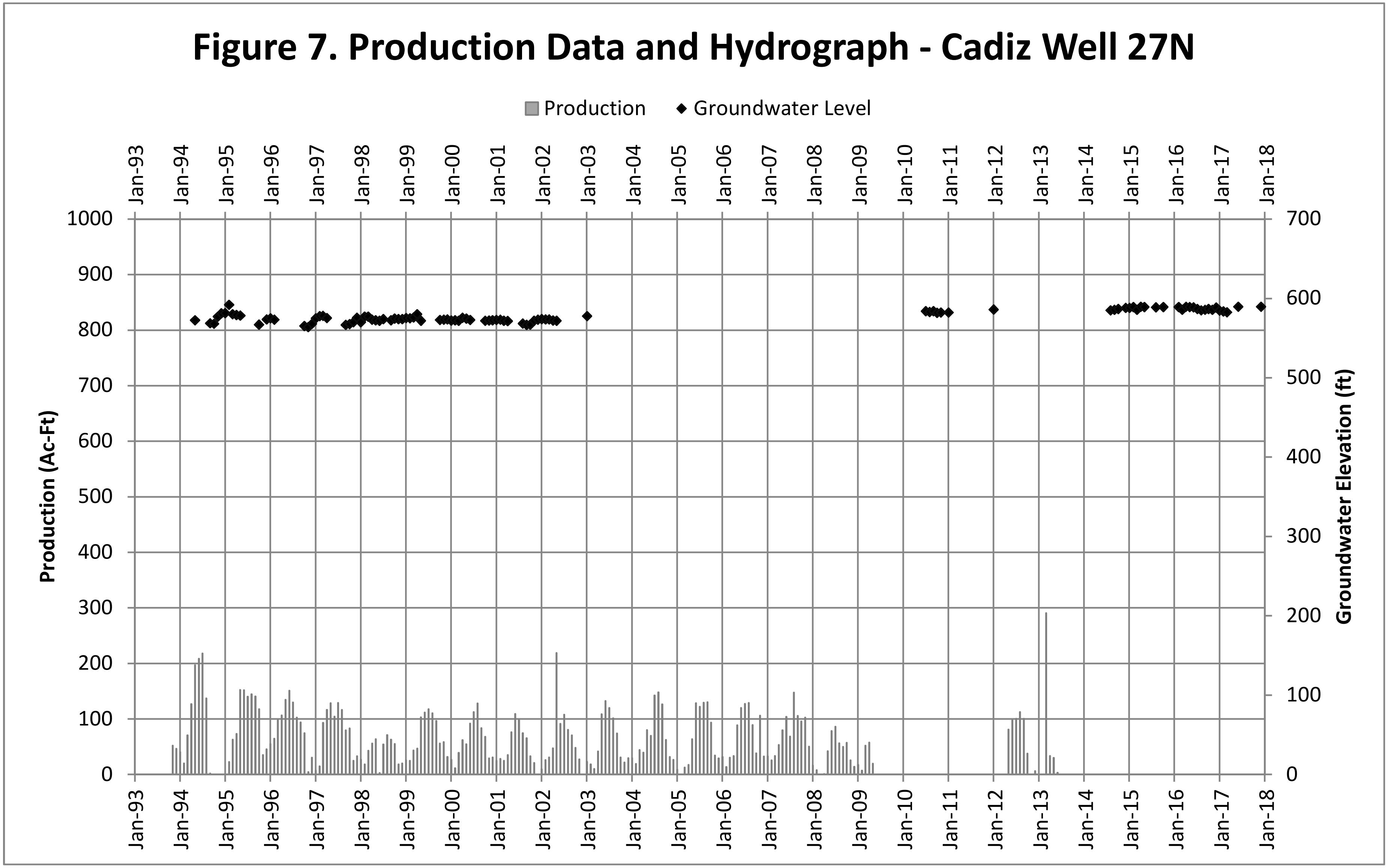


Figure 7. Production Data and Hydrograph - Cadiz Well 27N
Production
Groundwater Level
Production (Ac-Ft)
Groundwater Elevation (ft)
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
0
100
200
300
400
500
600
700
800
900
1000

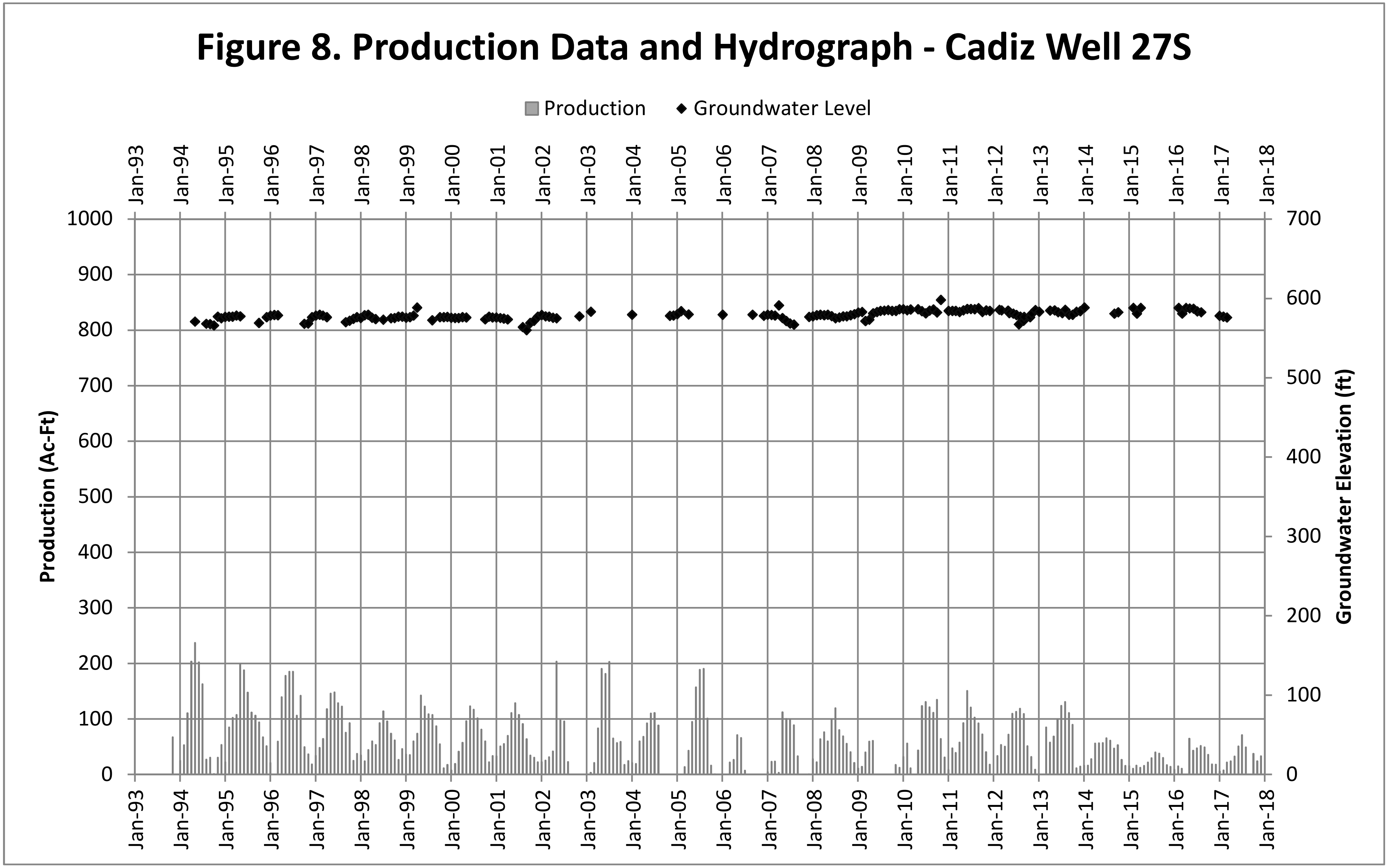


Figure 8. Production Data and Hydrograph - Cadiz Well 27S
Production
Groundwater Level
Production (Ac-Ft)
Groundwater Elevation (ft)
0
100
200
300
400
500
600
700
800
900
1000
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18

Figure 9. Production Data and Hydrograph - Cadiz Well 28

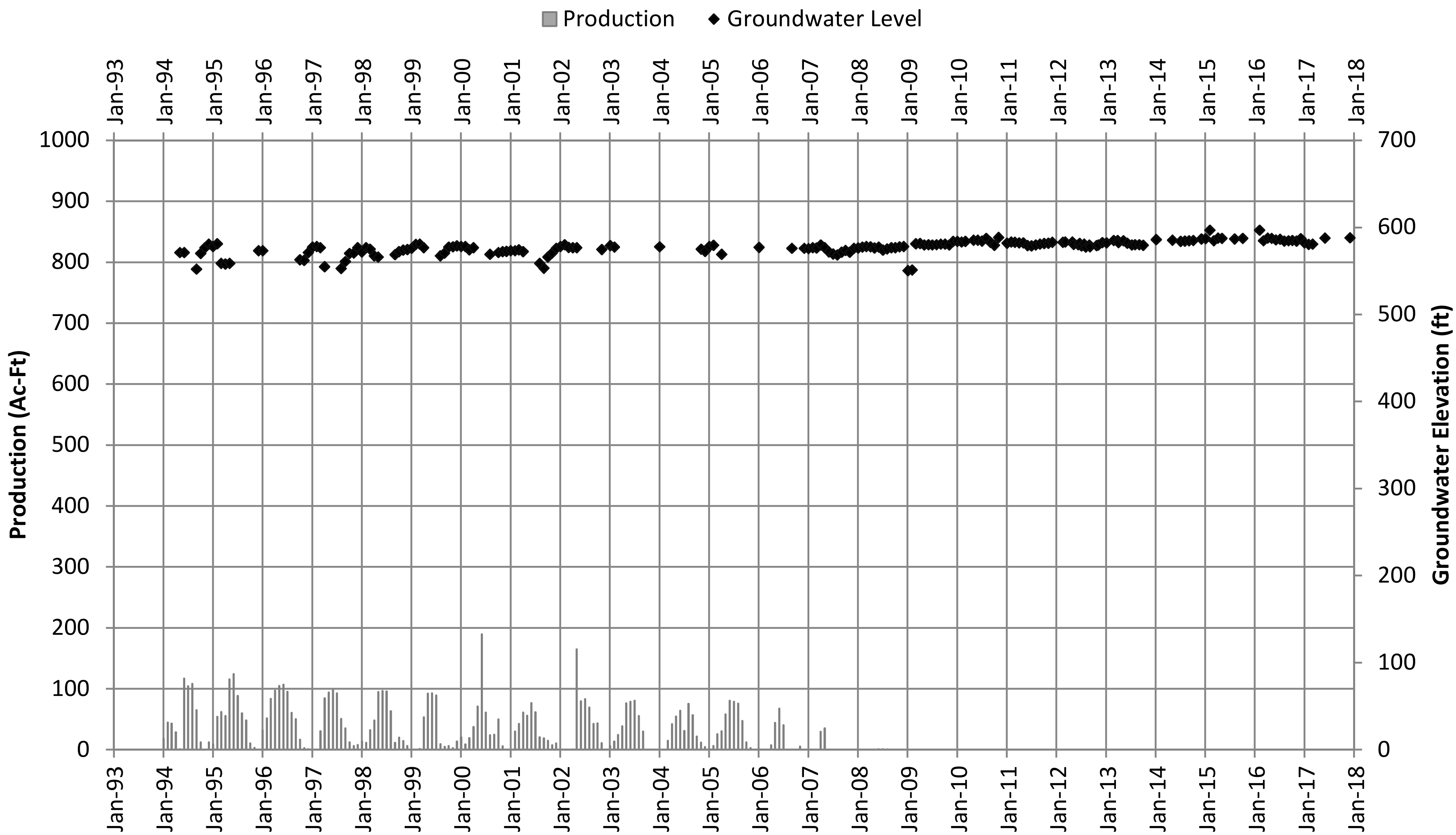
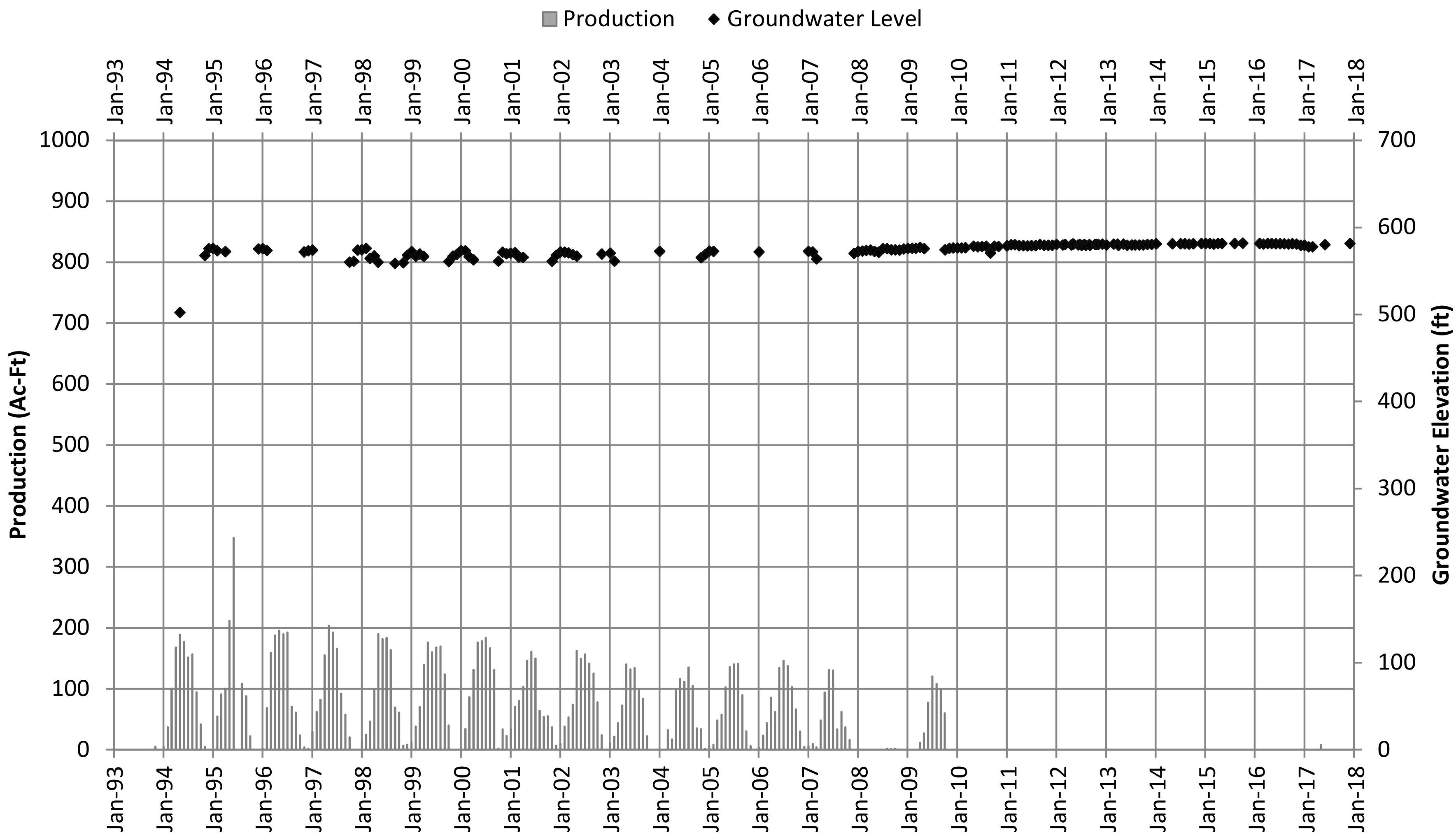


Figure 10. Production Data and Hydrograph - Cadiz Well 33



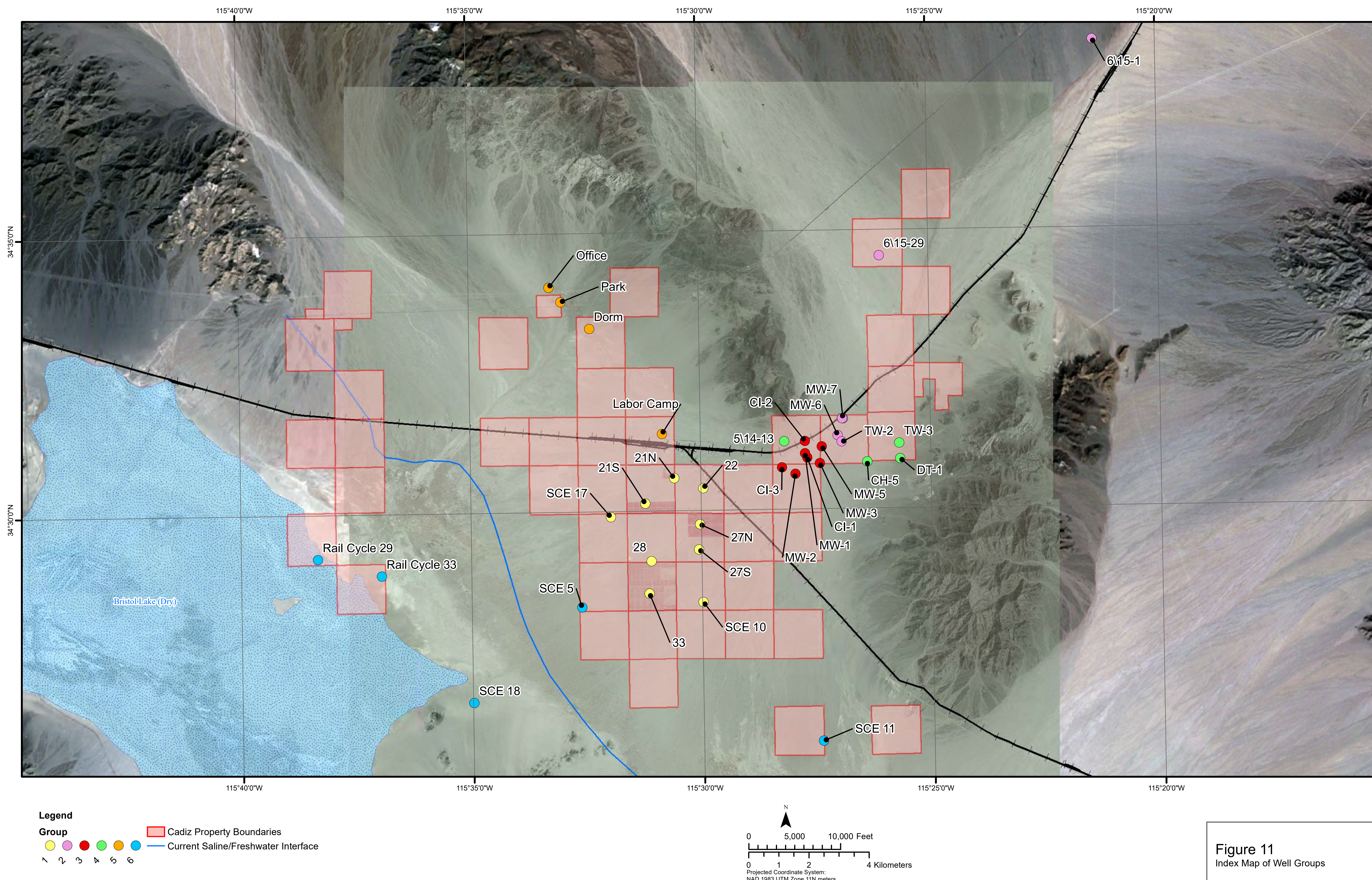
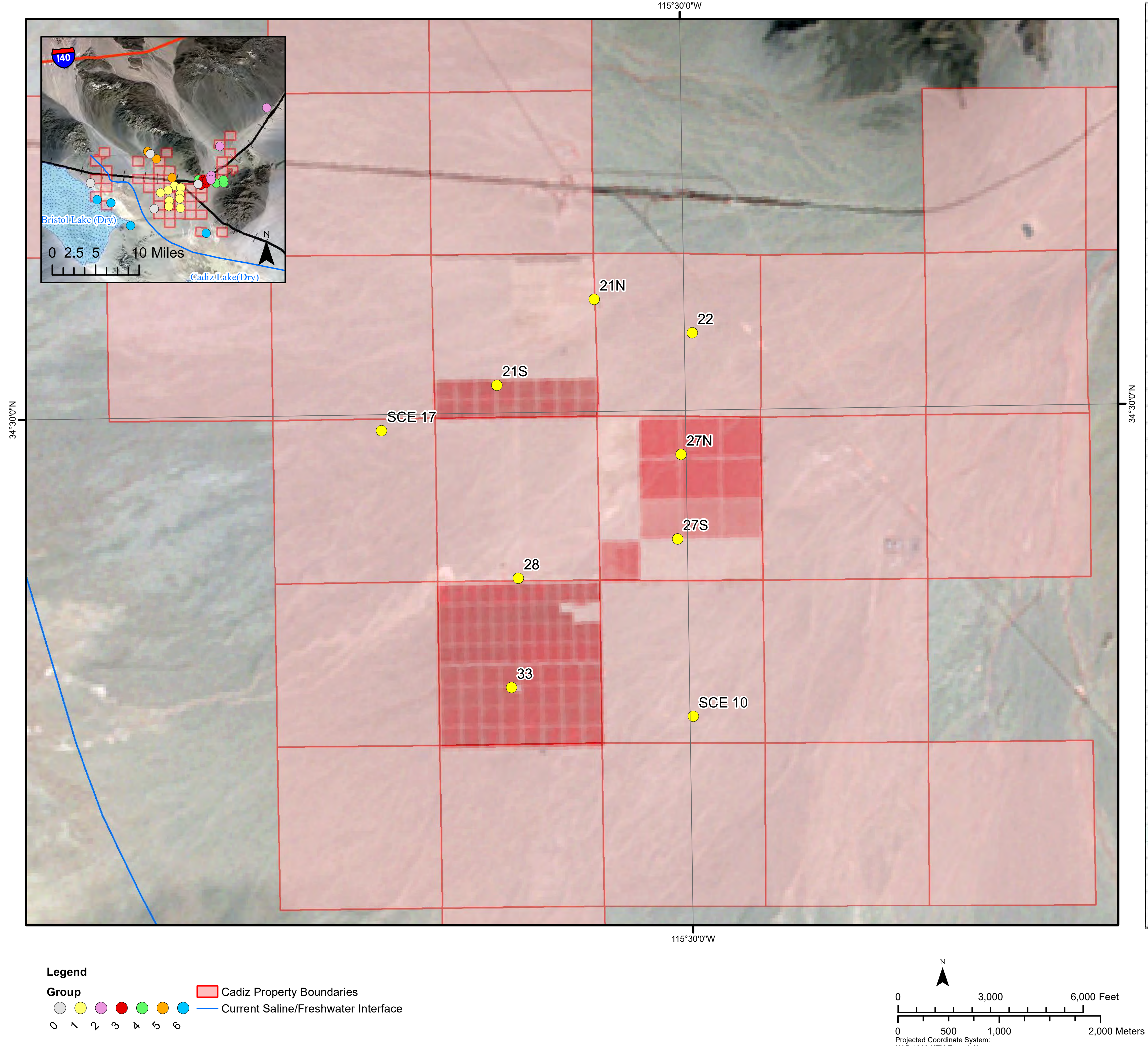


Figure 11
Index Map of Well Groups

C:\Users\Terry\Documents\Workarea\386303Cadiz\GIS\ArcMap\SBC\AnnualGWMonitoringReport\CADIZ_MonitoringFeatures_mrV3



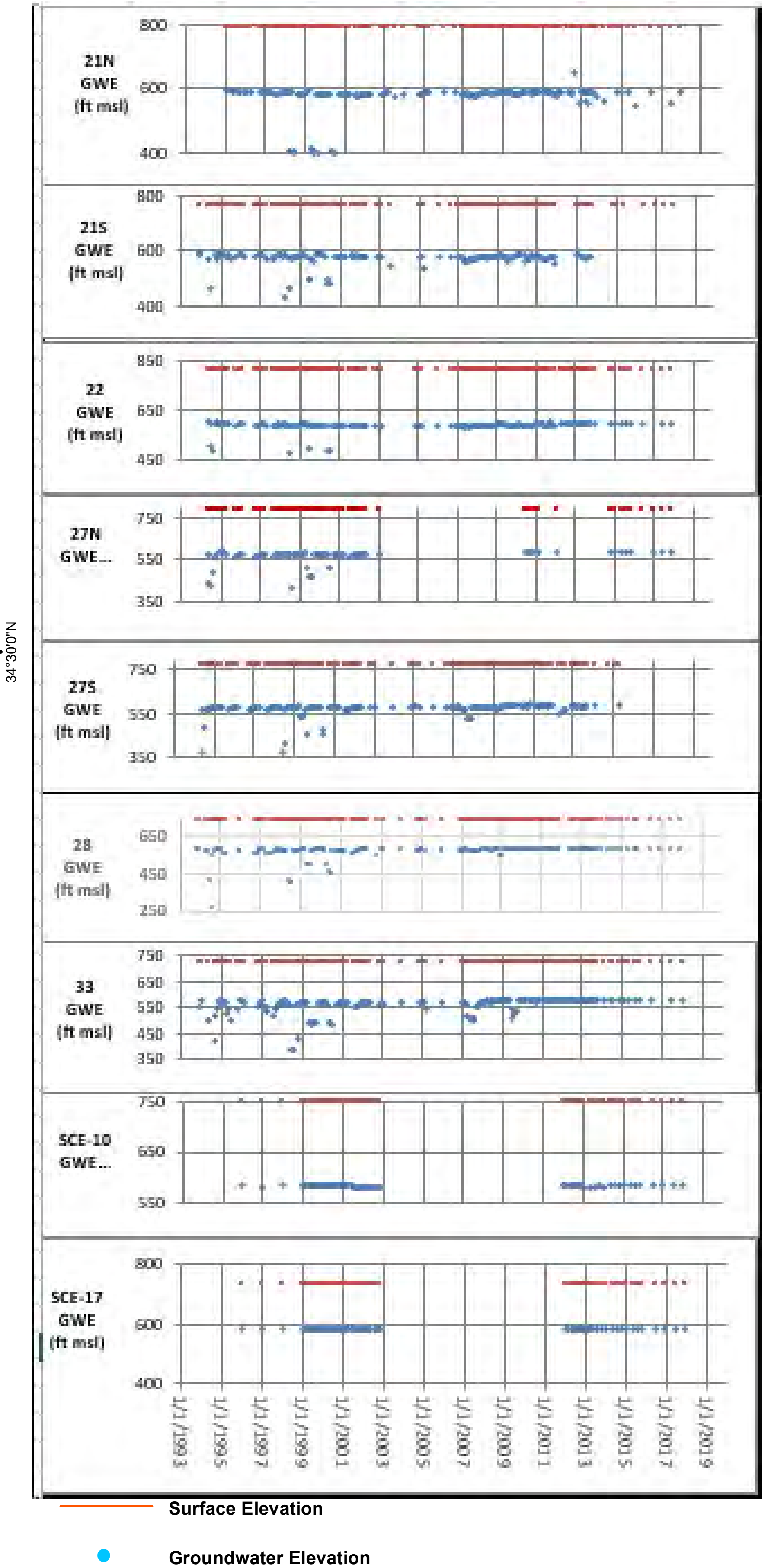


Figure 12
Hydrographs of Wells in Group 1

C:\Users\Terry\Documents\Workarea\Cadiz\SBC-Reports\2018Rpt\ARCMAP\CADIZ_MonitoringFeatures_mrV5_cluster1.mx

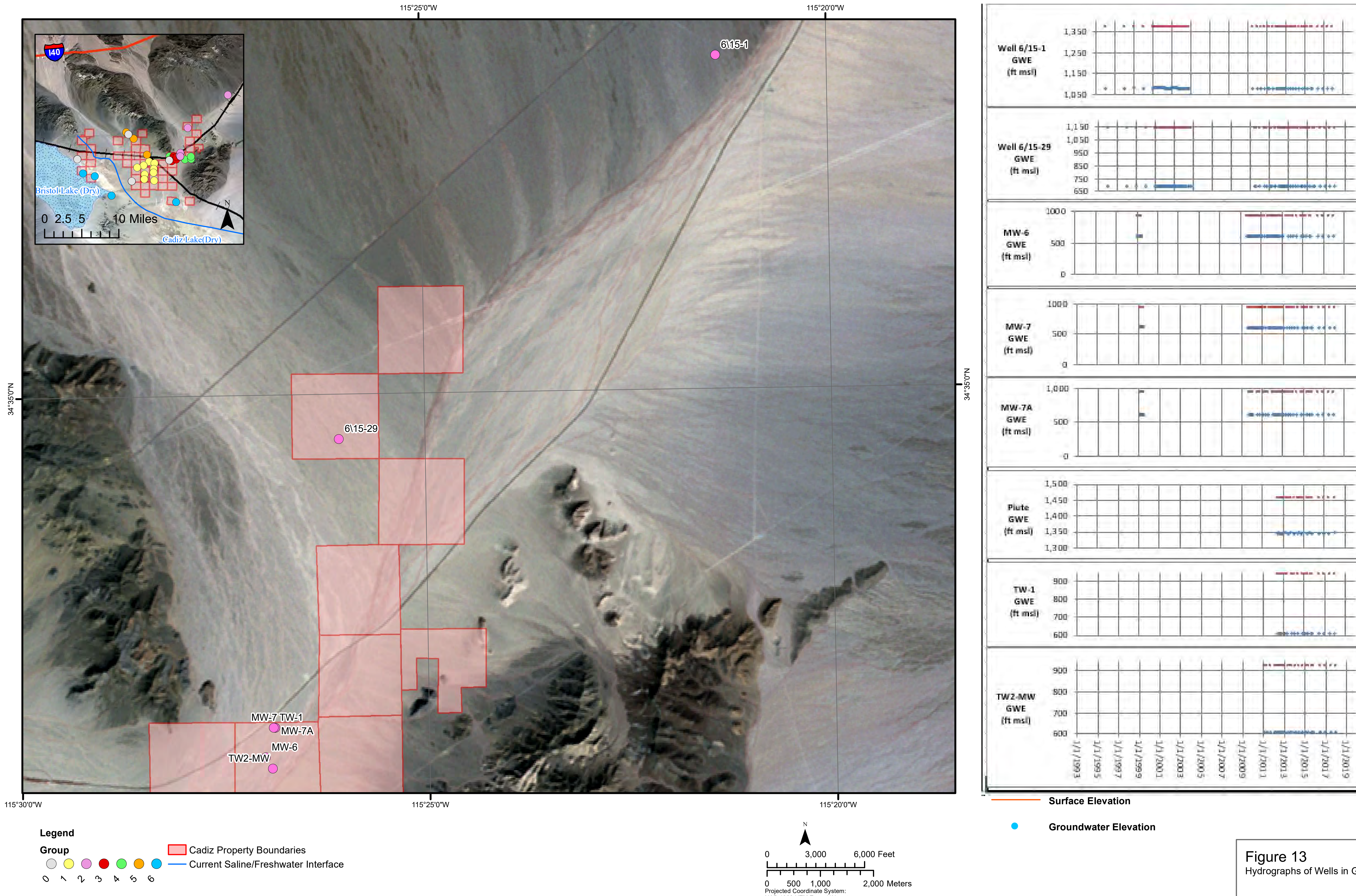
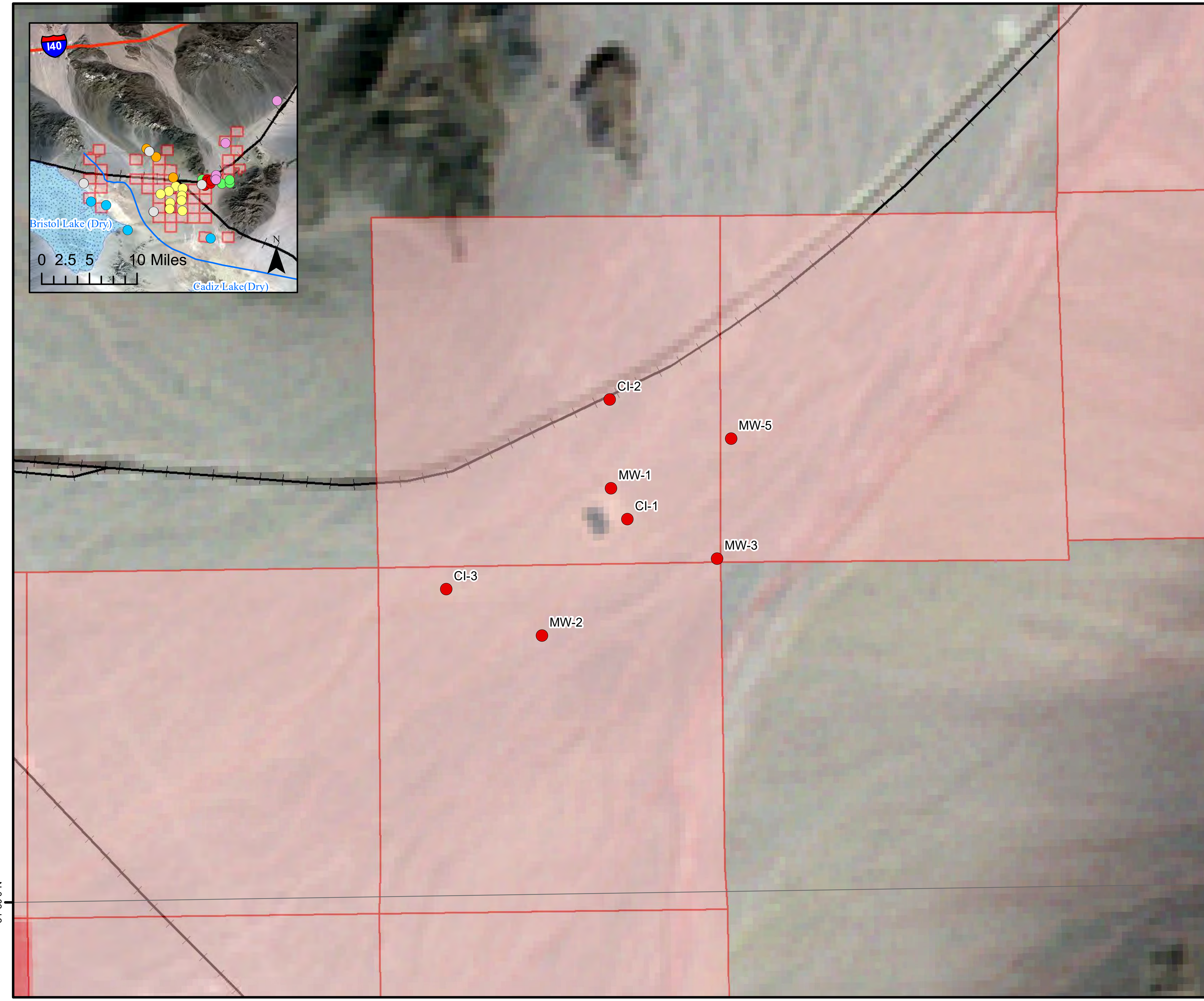
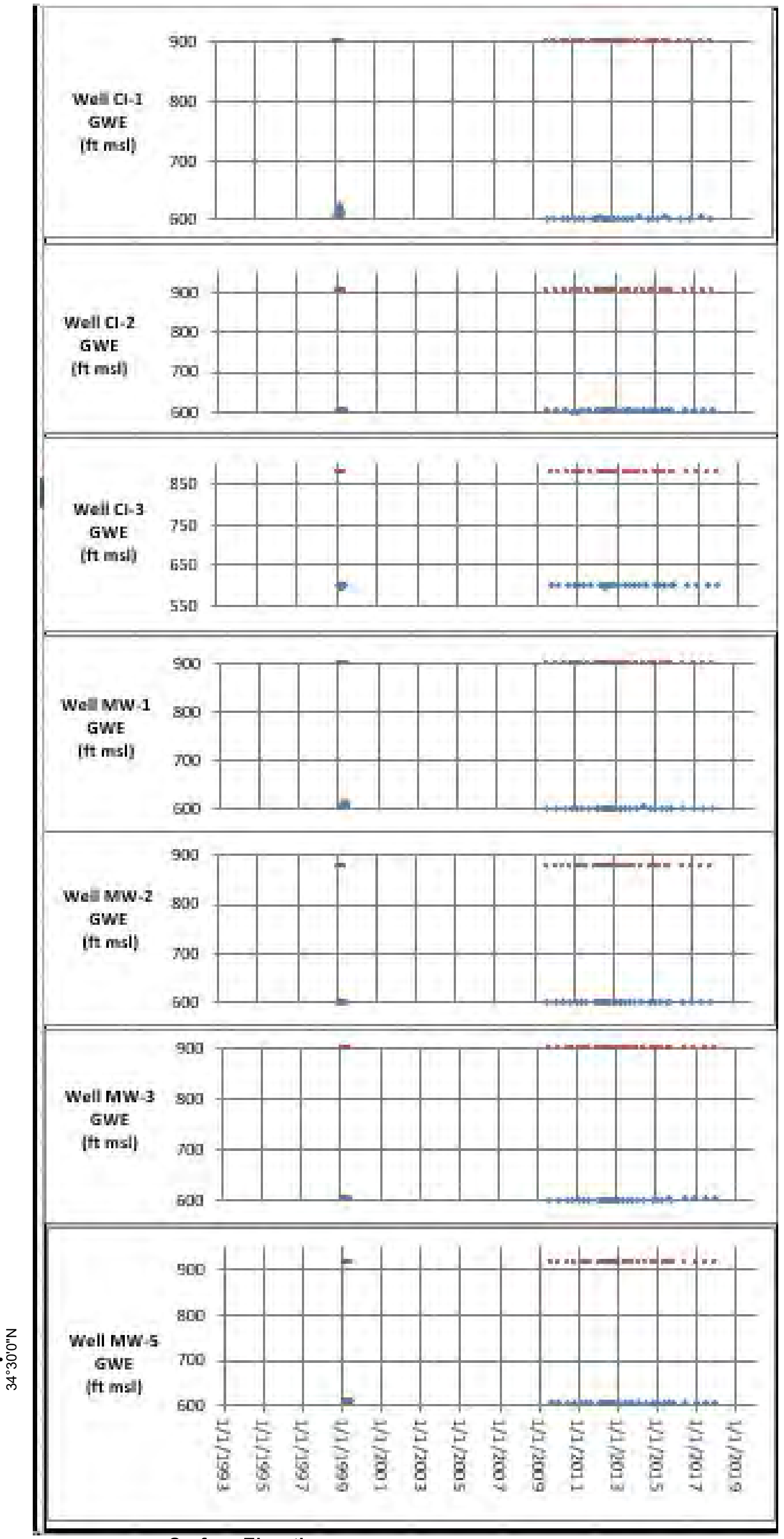


Figure 13
Hydrographs of Wells in Group 2

C:\Users\Terry\Documents\Workarea\Cadiz\SBC-Reports\2018Rpt\ARCMAP\CADIZ_MonitoringFeatures_mrV5_cluster2.mxd





Surface Elevation

Groundwater Elevation

Legend

Group

0 1 2 3 4 5 6

Cadiz Property Boundaries

Current Saline/Freshwater Interface

N

0 3,000 6,000 Feet

0 500 1,000 2,000 Meters

Projected Coordinate System:
NAD 1983 UTM Zone 11N meters

Figure 14
Hydrographs of Wells in Group 3

C:\Users\Terry\Documents\Workarea\Cadiz\SBC-Reports\2018Rpt\ARCMAP\CADIZ_MonitoringFeatures_mrV5_cluster3.mx

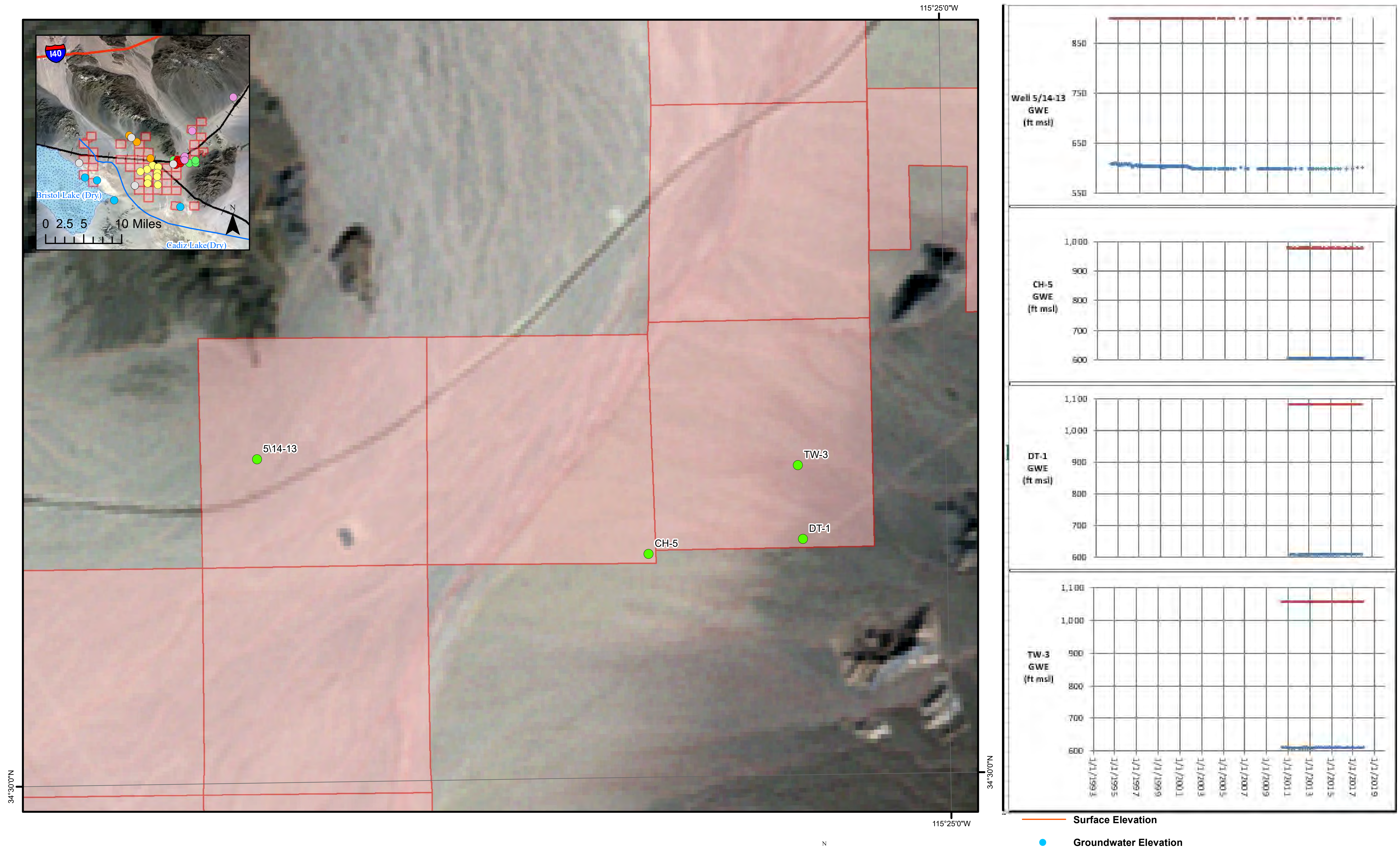


Figure 15
Hydrographs of Wells in Group 4

C:\Users\Terry\Documents\Workarea\Cadiz\SBC-Reports\2018Rpt\ARCMAP\CADIZ_MonitoringFeatures_mrV5_cluster4.mxd

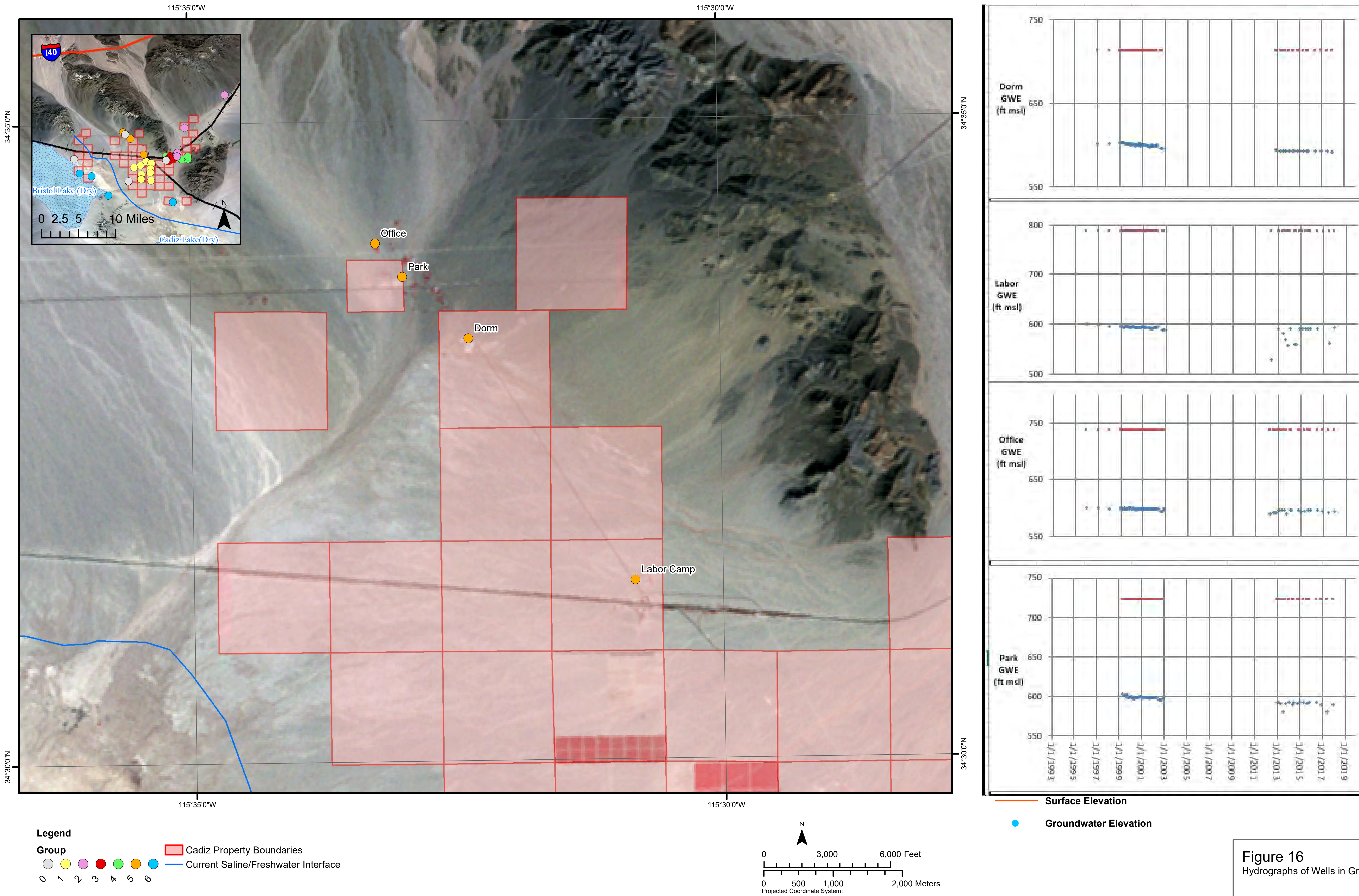


Figure 16
Hydrographs of Wells in Group 5

C:\Users\Terry\Documents\Workarea\Cadiz\SBC-Reports\2018Rpt\ARCMAP\CADIZ_MonitoringFeatures_mrV5_cluster5.mx

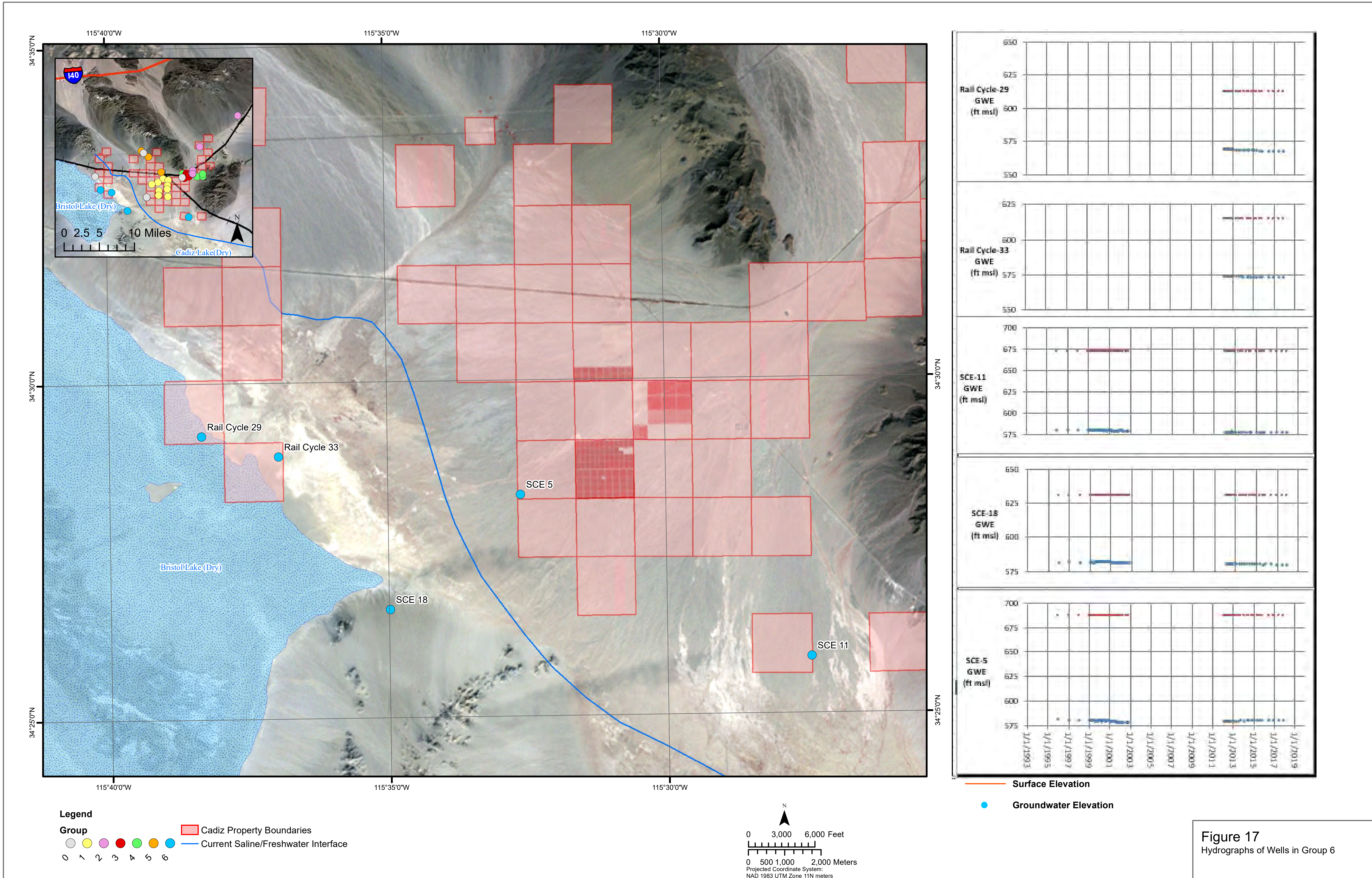


Figure 17
Hydrographs of Wells in Group 6

C:\Users\Terry\Documents\Workarea\Cadiz\SBC-Reports\2018Rpt\ARCMAP\CADIZ_MonitoringFeatures_mrV5_cluster6.mxd

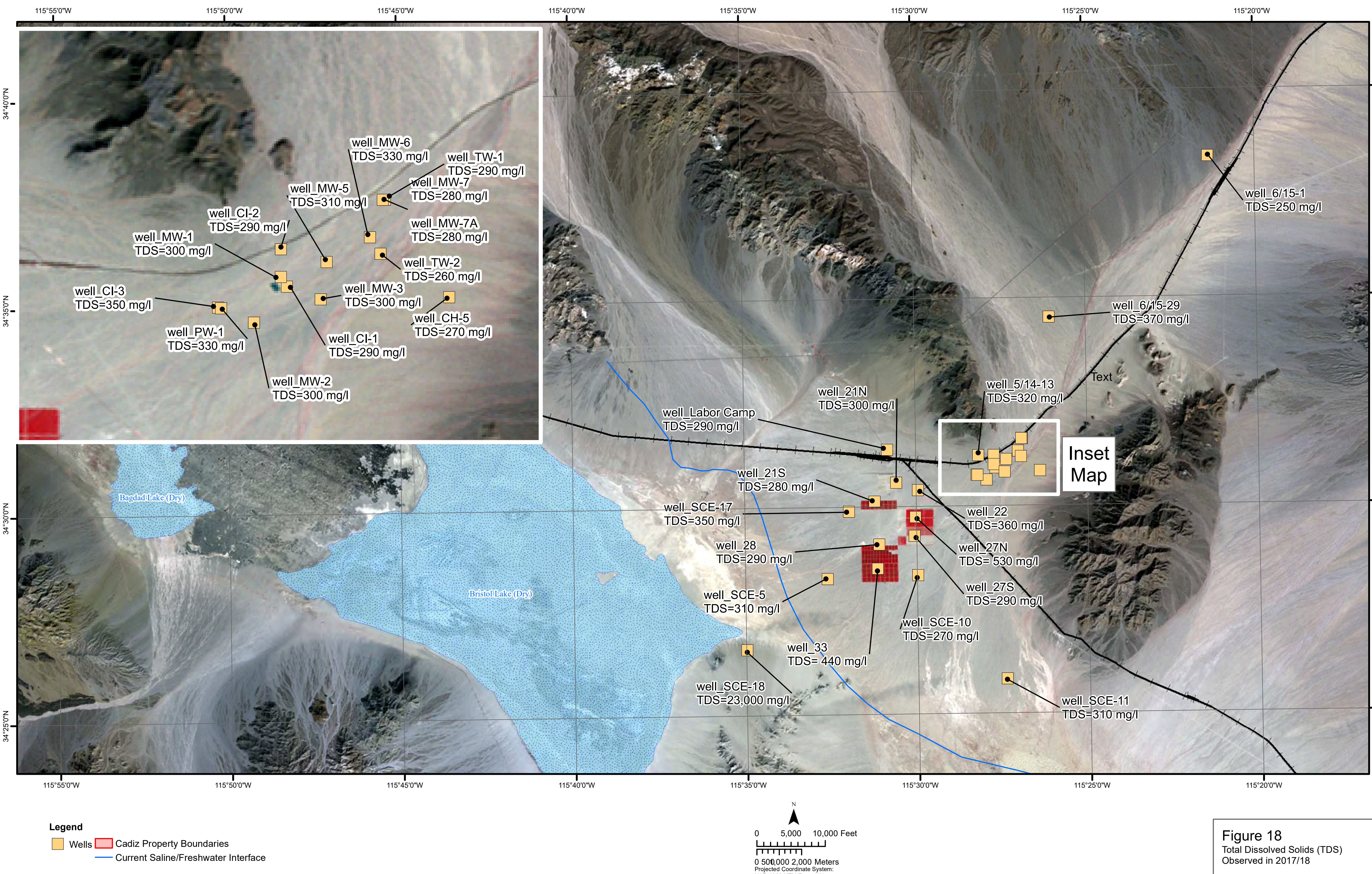


Figure 18
Total Dissolved Solids (TDS)
Observed in 2017/18

C:\Users\Terry\Documents\Workarea\Cadiz\SBC-Reports\2018Rpt\ARCMAP\CADIZ_MonitoringFeatures_mrV3_TDS2017.mxd

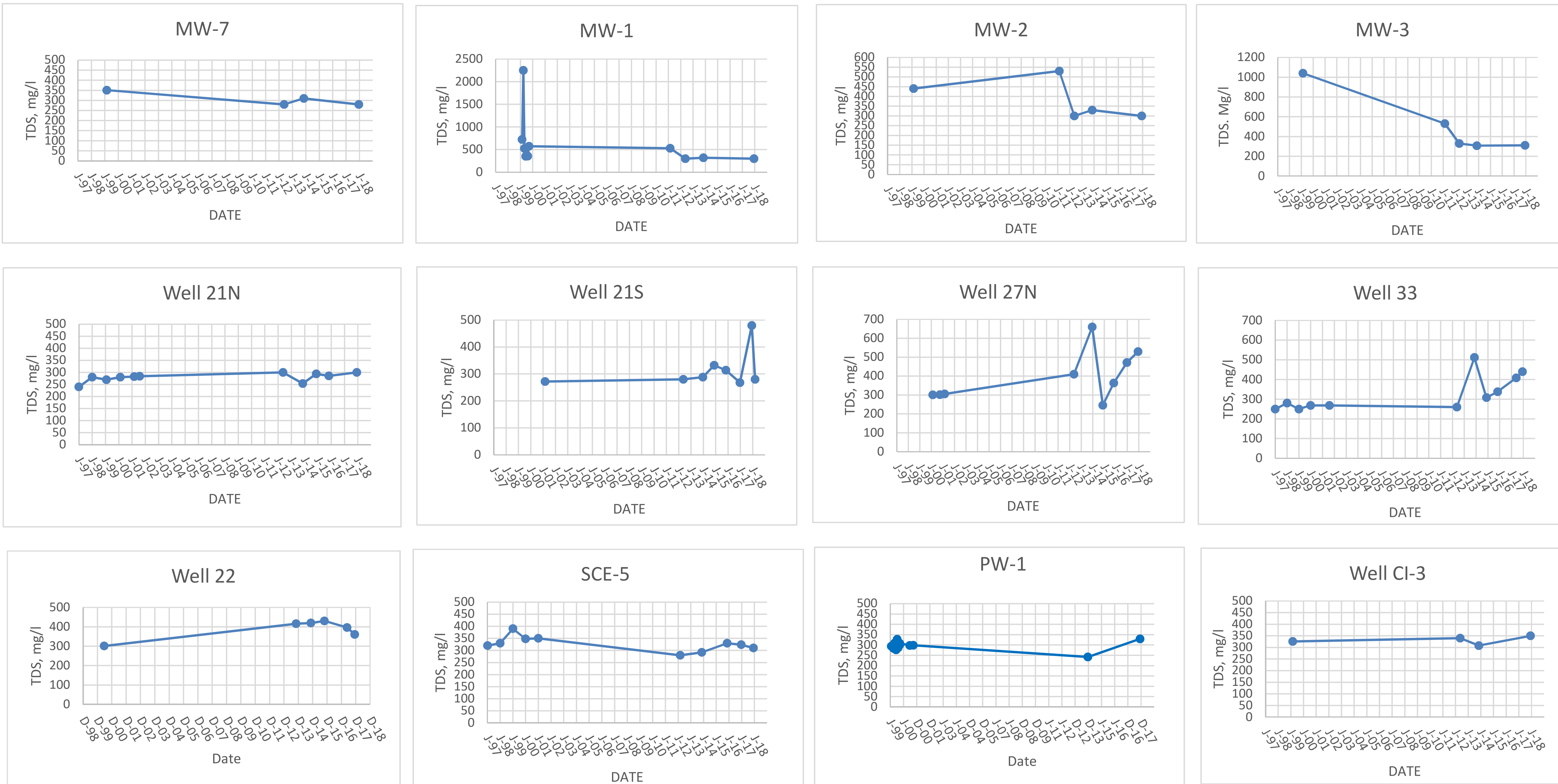


Figure 19. Trends In TDS In Selected Wells

Note: spikes in TDS levels in wells, 21S, 27N and 33 may be due to leaks in irrigation system and leaking check valves. See text for discussion.

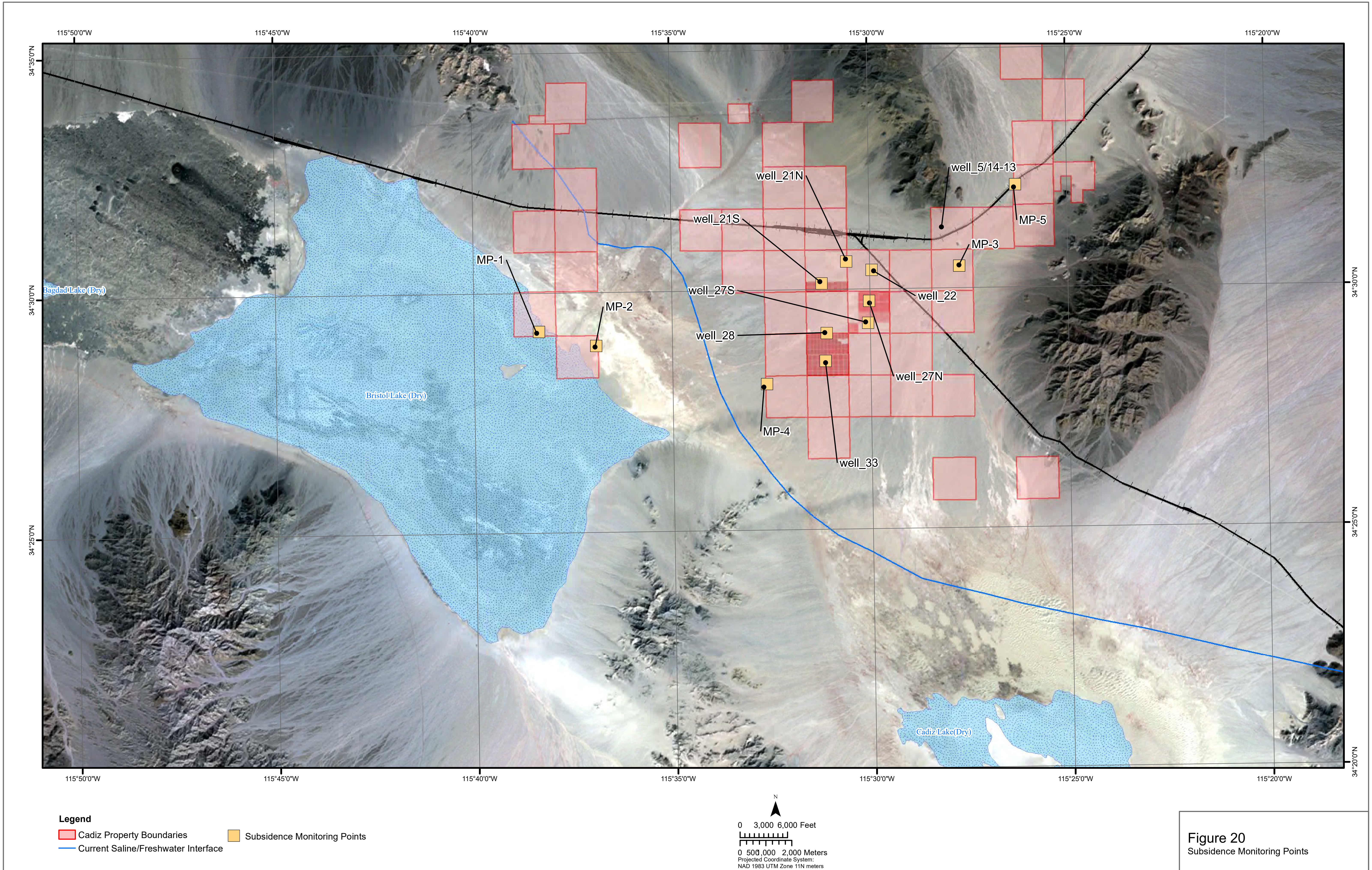


Figure 20
Subsidence Monitoring Points

C:\Users\Terry\Documents\Workarea\Cadiz\SBC-Reports\2017Rpt\Arcmap\CADIZ_MonitoringFeatures_mrV3_SubsidencePoints.mx

Appendix A
Groundwater Extraction Totals

Production Data
2017
[in Acre Feet]

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Total By Well
Well Designation													
21N				21.29	52.4	86.83	37.61	43.73	96.12	78.87	50.58	36.24	**503.67**
21S	7.54	17.42	32.58	24.14			94.07	70.55	5.98				**252.28**
22					6.10			8.38	66.85	9.50	11.48		**102.31**
27N													**0.00**
27S	5.87	7.66	21.57	23.85	32.61	50.82	70.92	49.21		37.18	23.81	32.96	**356.46**
28													**0.00**
33					8.10								**8.10**
Monthly Totals	**13.41**	**25.08**	**54.15**	**69.28**	**99.21**	**137.65**	**202.60**	**171.87**	**168.95**	**125.55**	**85.87**	**69.20**	**Annual Total 1,222.82**

Appendix B
2017 Survey Report

Subsidence Monitor Survey Report

1.0 Introduction

The purpose of this project is to establish horizontal and vertical control values on 13 monitor 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 4-6, 2017

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 v3.90 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).

3.1.2 Vertical Datum

Elevations established in this survey are North American Vertical Datum of 1988 (NAVD88) 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 USGS	0.010	0.020	0.023
Z 1308	0.015	0.032	-0.003

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	MEASUREMENT 1						
	NORTH	EAST	ELEV	DATE	TIME	SATS.	PDOP
5/14-13	2021446.881	7323740.952	894.848	12/5/2017	11:50:46 AM	18	1.293
21N	2017242.093	7311758.265	793.353	12/5/2017	12:09:00 PM	18	1.273
21S	2014440.486	7308663.008	762.884	12/5/2017	12:44:04 PM	16	1.451
22	2016211.554	7314994.083	813.073	12/5/2017	12:31:09 PM	16	1.466
27N	2012283.249	7314707.356	790.896	12/5/2017	12:20:51 PM	18	1.335
27S	2009515.094	7314616.688	778.334	12/4/2017	3:09:41 PM	14	1.715
28	2008178.150	7309388.480	741.071	12/4/2017	2:51:26 PM	15	1.337
33	2004655.788	7309287.983	728.971	12/4/2017	2:38:49 PM	17	1.198
MP1	2007954.448	7272935.640	611.954	12/4/2017	11:17:44 AM	17	1.400
MP2	2006251.213	7280193.284	613.704	12/4/2017	11:57:56 AM	18	1.297
MP3	2016868.757	7326083.142	878.926	12/4/2017	1:20:13 PM	16	1.415
MP4	2001630.740	7301909.716	683.513	12/4/2017	2:12:20 PM	18	1.214
MP5	2027229.729	7333049.644	970.528	12/4/2017	1:40:58 PM	17	1.354

Results for Measurement #2

WELL NUMBER	MEASUREMENT 2						
	NORTH	EAST	ELEV	DATE	TIME	SATS.	PDOP
5/14-13	2021446.848	7323740.957	894.856	12/6/2017	9:18:04 AM	15	1.550
21N	2017242.057	7311758.246	793.332	12/6/2017	9:32:39 AM	16	1.184
21S	2014440.513	7308663.011	762.894	12/6/2017	9:43:13 AM	15	1.326
22	2016211.519	7314994.114	813.130	12/6/2017	10:07:41 AM	14	1.598
27N	2012283.245	7314707.353	790.879	12/6/2017	9:55:50 AM	14	1.517
27S	2009515.090	7314616.670	778.328	12/5/2017	1:47:46 PM	19	1.171
28	2008178.130	7309388.486	741.035	12/5/2017	1:34:53 PM	17	1.512
33	2004655.783	7309287.937	728.955	12/5/2017	1:24:43 PM	15	1.638
MP1	2007954.398	7272935.621	611.884	12/5/2017	10:00:03 AM	14	1.537
MP2	2006251.177	7280193.243	613.619	12/5/2017	10:16:36 AM	14	1.602
MP3	2016868.795	7326083.121	878.952	12/5/2017	11:29:09 AM	18	1.126
MP4	2001630.715	7301909.675	683.501	12/5/2017	1:02:15 PM	15	1.528
MP5	2027229.716	7333049.647	970.534	12/5/2017	11:04:17 AM	14	1.633

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	0.033	-0.005	-0.008
21N	0.036	0.019	0.021
21S	-0.027	-0.003	-0.010
22	0.035	-0.031	-0.057
27N	0.004	0.003	0.017
27S	0.004	0.018	0.006
28	0.020	-0.006	0.036
33	0.005	0.046	0.016
MP1	0.050	0.019	0.070
MP2	0.036	0.041	0.085
MP3	-0.038	0.021	-0.026
MP4	0.025	0.041	0.012
MP5	0.013	-0.003	-0.006

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	0.013	-0.008	0.023
21N	0.036	0.044	0.011
21S	-0.031	0.021	-0.090
22	0.014	-0.011	-0.007
27N	0.011	-0.005	-0.022
27S	0.050	0.003	-0.012
28	-0.008	-0.003	-0.045
33	0.000	0.010	-0.107
MP1	-0.020	-0.017	-0.113
MP2	0.005	-0.044	-0.134
MP3	0.012	-0.003	-0.020
MP4	0.035	0.011	-0.128
MP5	0.017	0.019	-0.047

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 2017.

J. Marty Smith, PLS
Dated: December 15, 2017

LICENSED LAND SURVEYOR
J. MARTY SMITH
8070
STATE OF CALIFORNIA

APPENDIX 5.1
Final Coordinate Values

CADIZ PIPELINE

MONITOR SURVEY COORDINATE VALUES

SURVEYED DECEMBER 2017

Horizontal Datum: NAD83 (2011)
Projection: CCS83, Zone 5
Vertical Datum: NAVD88 base on MARBLE Bench Mark

WELL	DESCRIPTION	MEASUREMENT 1 & 2 AVERAGE		
		NORTHING	EASTING	ELEVATION
		US SURVEY FEET		
5/14-13	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	7308663.010	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	2008178.140	7309388.483	741.053
33	2" Brass Disk in Conc.Pad	2004655.786	7309287.960	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

TOWILL Surveying, Mapping and GIS Services

FB 1131 PG 21

TOWILL JOB NO.: 15373

DATE: 12-4-17

1 of 2

RTK - RTN - KINEMATIC TOPOGRAPHY SHEET

OBSERVER NAME: OOS / ASS

PROJECT NAME: CADIZ

ROVER RECEIVER TYPE: R10

JOB FILE NAME: 20171204 OOS ROV

JULIAN DAY: 338

PROJECT LOCATION: CADIZ, CA

RECEIVER S/N: 5097 TSC3

ANTENNA S/N: 5777 R10

BASE STATION #1:	MARBLE	ANTENNA HEIGHT:	4.705' / 1.435m	BASE STATION #2:	—	ANTENNA HEIGHT:	—

POINT	ANTENNA HEIGHT SFT	ANTENNA HEIGHT M	CODE	POINT DESCRIPTION
PBB 12m	6.562'	2.0	BM	ALUMINUM DISK "PBB 12 1976"
Z 1308m	"	"	BM	BRASS DISK "Z 1308 1978"
MP1 m	"	"	BM	BRASS DISK "MP1 2015" "CADIZ INC MONITOR POINT" 2"
MP2 m	"	"	BM	BRASS DISK "CADIZ INC. MP-2 2015 2" MONITOR POINT"
MP3 m	"	"	BM	BRASS DISK "CADIZ INC. MP-3 2015 2" MONITOR POINT"
MP5 m	"	"	BM	BRASS DISK "CADIZ INC MP-5 2015 2" MONITOR POINT"
MP4 m	"	"	BM	BRASS DISK "CADIZ INC MP4 2015 2" MONITOR POINT"
33 m	"	"	BM	BRASS DISK, 2"
28 m	"	"	BM	BRASS DISK 2"
275 m	"	"	BM	BRASS DISK. 2"

FB 1131 PG 22

TOWILL

TOWILL JOB NO.: 15373

DATE: 12-5-17

RTK - RTN - KINEMATIC TOPOGRAPHY SHEET

2 OF 5

OBSERVER NAME: DDR / ACS

PROJECT NAME: CADIZ

ROVER RECEIVER TYPE: R10

JOB FILE NAME: 20171204 DDR ROV

JULIAN DAY: 3.8.4

PROJECT LOCATION: CADIZ, CA

RECEIVER S/N: 5049 TSC3

ANTENNA S/N: 5779 R10

BASE STATION #1:	MARBLE	ANTENNA HEIGHT:	4.69' / 1.430m	BASE STATION #2:	—	ANTENNA HEIGHT:	—

POINT	ANTENNA HEIGHT SFT	ANTENNA HEIGHT M	CODE	POINT DESCRIPTION
MP1 m	6.562'	2º	BM	BRASS DISK. " CADIZ INC MP-1 2015
				2" MONITOR POINT"
MP2 m	"	"	Bm	2" BRASS DISK " CADIZ INC. MP-2 2015
				MONITOR POINT"
MP5 m	"	"	Bm	2" BRASS DISK " CADIZ INC. MP-5 2015
				MONITOR POINT"
MP3 m	"	"	Bm	2" BRASS DISK " CADIZ INC. MP-3 2015
				MONITOR POINT"
5/14-13 m	"	"	Bm	2" BRASS DISK.
21N m	"	"	Bm	2" BRASS DISK.
27N m	"	"	Bm	2" BRASS DISK.
22 m	"	"	Bm	2" BRASS DISK
21S m	"	"	Bm	2" BRASS DISK.
MP4 m	"	"	Bm	2" BRASS DISK. " CADIZ INC. MP-4 2015
				MONITOR POINT"
33 m	"	"	Bm	2" BRASS DISK
28 m	"	"	Bm	2" BRASS DISK

TOWILL

FB 1131 PG 23

TOWILL JOB NO.: 15373

DATE: 12-5-17

RTK - RTN - KINEMATIC TOPOGRAPHY SHEET

OBSERVER NAME: ODR / ACS

JULIAN DAY: 339

PROJECT NAME: CADIZ

PROJECT LOCATION: CADIZ, CA

ROVER RECEIVER TYPE: R10

RECEIVER S/N: 5049 TSC3

JOB FILE NAME: 20171204 ODR ROV

ANTENNA S/N: 5779 R10

BASE STATION #1:	MARBLE	ANTENNA HEIGHT:	4.69' / 1.430m	BASE STATION #2:	—	ANTENNA HEIGHT:	—

POINT	ANTENNA HEIGHT SFT	ANTENNA HEIGHT M	CODE	POINT DESCRIPTION
275 m	6.562	2.0	BM	2" BRASS DISK.

TOWILL

FB 1131 PG 24

TOWILL JOB NO.: 15373

DATE: 12-6-17

4 of 5

RTK - RTN - KINEMATIC TOPOGRAPHY SHEET

OBSERVER NAME: DDR / ACS

JULIAN DAY: 340

PROJECT NAME: CADIZ

PROJECT LOCATION: CADIZ, CA

ROVER RECEIVER TYPE: R10

RECEIVER S/N: 5049 T3C3

JOB FILE NAME: 20171204 DDR ROV

ANTENNA S/N: 5779 R10

BASE STATION #1:	MARBLE	ANTENNA HEIGHT:	5.06' / 1.543m	BASE STATION #2:	—	ANTENNA HEIGHT:	—

POINT	ANTENNA HEIGHT SFT	ANTENNA HEIGHT M	CODE	POINT DESCRIPTION
5/14-13 M	6.562'	2 m	BM	2" BRASS DISK.
21N M	"	"	BM	2" BRASS DISK.
21S M	"	"	BM	2" BRASS DISK.
27N M	"	"	BM	2" BRASS DISK.
22 M	"	"	BM	2" BRASS DISK.

TOWILL | Surveying, Mapping and GIS Services

FB 1131 PG 25

Towill Job No.: 15373

PG 5 OF 5

GPS VERIFICATION OBSERVATION LOG SHEET

OBSERVER NAME: DCF/ACS JULIAN DAY: 338 DATE: 12-4-17

PROJECT NAME: CADIZ PROJECT LOCATION: CADIZ, CA

OBS#1 RECEIVER S/N: 3783 R10 FILE NAME: 20171204 RTK BASE

CONTROLLER S/N: 5049 TSC3

OBSERVATION INFORMATION:

STATION NAME: MARBLE SESSION NUMBER: Ø FILE 37833381 TO2

START TIME: 8:51 END TIME: 3:33 FIXED HEIGHT TIPOD/ROD?:

NUMBER OF SVS: 14 PDOP: 1.2 NUMBER OF SVS: 15 PDOP: 1.3 __ Yes X No

ANTENNA HEIGHT: 4.705' sft / 1.435 m MEASURED TO: __ Bottom of Mount X R10 Bottom of Quick Release __ Bottom of Notch JULIAN DAY 338 DATE 12-4-17

OBSERVATION INFORMATION:

STATION NAME: MARBLE SESSION NUMBER: Ø FILE: 37833390 TO2

START TIME: 8:54 END TIME: 2:12 FIXED HEIGHT TIPOD/ROD?:

NUMBER OF SVS: 16 PDOP: 1.3 NUMBER OF SVS: 18 PDOP: 1.2 __ Yes X No

ANTENNA HEIGHT: 4.69' sft / 1.430 m MEASURED TO: __ Bottom of Mount X R10 Bottom of Quick Release __ Bottom of Notch JULIAN DAY 339 DATE 12-5-17

OBSERVATION INFORMATION:

STATION NAME: MARBLE SESSION NUMBER: Ø FILE 3783400 TO2

START TIME: 9:07 END TIME: 10:31 FIXED HEIGHT TIPOD/ROD?:

NUMBER OF SVS: 17 PDOP: 1.3 NUMBER OF SVS: 16 PDOP: 1.5 __ Yes X No

ANTENNA HEIGHT: 5.06' sft / 1.543 m MEASURED TO: __ Bottom of Mount X R10 Bottom of Quick Release __ Bottom of Notch JULIAN DAY 340 DATE 12-6-17

OBSERVATION INFORMATION:

STATION NAME: ____ SESSION NUMBER: ____

START TIME: ____ END TIME: ____ FIXED HEIGHT TIPOD/ROD?:

NUMBER OF SVS: ____ PDOP: ____ NUMBER OF SVS: ____ PDOP: ____ __ Yes __ No

ANTENNA HEIGHT: ____ sft / ____ m MEASURED TO: __ Bottom of Mount __ R10 Bottom of Quick Release __ Bottom of Notch JULIAN DAY ____ DATE ____

OBSERVATION INFORMATION:

STATION NAME: ____ SESSION NUMBER: ____

START TIME: ____ END TIME: ____ FIXED HEIGHT TIPOD/ROD?:

NUMBER OF SVS: ____ PDOP: ____ NUMBER OF SVS: ____ PDOP: ____ __ Yes __ No

ANTENNA HEIGHT: ____ sft / ____ m MEASURED TO: __ Bottom of Mount __ R10 Bottom of Quick Release __ Bottom of Notch JULIAN DAY ____ DATE ____

OBSERVATION INFORMATION:

STATION NAME: ____ SESSION NUMBER: ____

START TIME: ____ END TIME: ____ FIXED HEIGHT TIPOD/ROD?:

NUMBER OF SVS: ____ PDOP: ____ NUMBER OF SVS: ____ PDOP: ____ __ Yes __ No

ANTENNA HEIGHT: ____ sft / ____ m MEASURED TO: __ Bottom of Mount __ Bottom of Quick Release __ Bottom of Notch JULIAN DAY ____ DATE ____