WELL COMPLETION TECHNICAL MEMORANDUM FOR NESTED GROUNDWATER MONITORING WELLS SVMW-1 & SVMW-2

SONOMA VALLEY, CALIFORNIA

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CALIFORNIA DEPARTMENT OF WATER RESOURCES
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On Behalf of:

BASIN ADVISORY PANEL
Sonoma Valley Groundwater Management Program

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1.0 INTRODUCTION

This Technical Memorandum has been prepared by the Sonoma County Water Agency (Water Agency) on behalf of the Basin Advisory Panel (Panel) for the Sonoma Valley Groundwater Management Program (GMP) to describe the drilling, construction and initial monitoring of two multilevel (nested) groundwater monitoring wells performed under a Local Groundwater Assistance (LGA) Grant awarded to the Water Agency in 2008.

On behalf of the Panel, the Water Agency applied for and obtained the LGA Grant from DWR for $249,908 for installation of the two multilevel groundwater monitoring wells and a groundwater recharge mapping project. While a Grant Agreement between the Agency and DWR was initially entered in 2009, funding was frozen on the grant due to state budgetary constraints. In March 2010, the Water Agency received notification that DWR was able to fully-fund the grant award. On April 27, 2010, the Water Agency and DWR executed Amendment No. 1 to the Agreement, which extended the term of the Agreement to May 15, 2011 to accommodate Project delays related to the State funding-freeze. The term of the Agreement was subsequently further extended to May 15, 2012 by Amendment No.2 to accommodate delays in the drilling schedule related to weather conditions.

This technical memorandum documents the methodology and results of the drilling, construction and initial monitoring of the two nested groundwater monitoring wells pursuant to Task 1.4 of the Grant Agreement. A report documenting the completion of the groundwater recharge mapping component of the Grant Agreement (Task 2.5) was completed in February 2011 and submitted to DWR.

2.0 BACKGROUND

Groundwater resources have long played a significant role in the development, growth and sustainability of the Sonoma Valley, with more than half the water demand in a given year met by local groundwater resources. With increasing demand on finite local groundwater supplies, overall groundwater storage in the Sonoma Valley has been and will continue to be depleted, without appropriate actions being taken in the near future.

In 2006, the Water Agency coordinated development of a voluntary, non-regulatory Sonoma Valley Groundwater Management Plan (Plan) with the participation and collaboration of a broad range of local stakeholders who served as a Basin Advisory Panel (Panel). The Plan, adopted by the Sonoma County Board of Supervisors, Valley of the Moon Water District, and City of Sonoma in 2007, identifies Basin Management Objectives (BMOs) and a range of actions to be taken to sustain groundwater resources. The Panel and a Technical Advisory Committee (TAC), which provides technical support to the BAP, have been carrying out the actions according to the Plan's schedule (Appendix F in Water Agency, 2007) and implementing the Groundwater

Management Program (GMP). One of the primary components of the Plan is to improve the monitoring of groundwater-levels and groundwater quality in Sonoma Valley.

2.1 Setting

The area covered by the GMP consists of the entire Sonoma Creek Watershed (Sonoma Valley) and encompasses the Sonoma Valley groundwater subbasin (DWR basin 2-2.02) and portions of the Kenwood Valley groundwater basin (DWR basin 2-19) within DWR's North Central Region. The Kenwood Valley groundwater basin straddles the Sonoma Creek and the Laguna de Santa Rosa watersheds (Figure 1). The Sonoma Valley is approximately 166 square miles in size, and is bounded by the Sonoma Mountains to the West, the Mayacamas Mountains to the east and north, and San Pablo Bay to the South.

The current understanding of the groundwater resources in the basin comes primarily from: (1) a study conducted by the United States Geological Survey (USGS) which was co-funded by the Water Agency to evaluate the ground water resources of the Sonoma Valley (USGS, 2006); and (2) subsequent studies and monitoring associated with implementing the GMP. The USGS study updated the hydrogeologic characterization of the basin and provided a current assessment of hydrologic conditions, including a description of historical groundwater levels and water quality changes.

A groundwater flow model was also developed as part of the study that was used to evaluate conjunctive water management options during development of the GMP. The USGS study identified two primary areas of declining groundwater levels in Sonoma Valley, which are present in the El Verano area and southeast of the City of Sonoma. Subsequent monitoring and studies performed during implementation of the GMP have better defined these areas and indicate that the declining groundwater levels are primarily associated with deeper aquifer zones in these areas (i.e., greater than 200 feet below ground surface). The USGS study also found that electrical conductivity measurements from wells located in the southern portions of Sonoma Valley exhibited increases over time, potentially due to saline water intrusion and/or upwelling of geothermal waters. Groundwater levels in some these areas range up to 100 feet below sea level, which can potentially cause additional saline water intrusion.

2.1 Geologic and Hydrogeologic Conditions

Sonoma Valley is located within a geologically complex region. The entire watershed is underlain by basement rocks consisting of metamorphic, igneous and metasedimentary rocks of the Jurassic/Cretaceous-aged Franciscan Complex, Coast Range Ophiolite, and Great Valley Sequence. A mixture of younger (Tertiary and Quaternary-aged) volcanic and sedimentary rocks and unconsolidated sediments overlies these basement rocks. In general, groundwater flows from recharge areas in the mountains and uplands surrounding the Sonoma Valley toward the valley axis and in a generally southern direction towards San Pablo Bay. Several faults have been mapped in these mountains and one northwest-striking fault has been mapped along the eastside of the valley floor. This fault, referred to as the Eastside Fault, may act as a conduit for the

upward circulation of deeper thermal waters in the Sonoma area, and may restrict groundwater flow (USGS, 2006).

All geologic formations in the Sonoma Valley contain groundwater; however the water-bearing properties and wells yields of the formations vary significantly. Four geologic units are identified that are of greatest importance for groundwater supply within Sonoma Valley (USGS, 2006). These geologic units are described in order of increasing age.

- **Quaternary Alluvial Units** – lenses of interbedded cobbles, sand, silt, and clay interlaced with coarse-grained stream channel deposits near the Sonoma Creek and tributaries, including alluvial fan deposits. These deposits form a broad blanket in the lower valley, a narrower band and discontinuous patches through the hilly middle valley, and a wide blanket in the upper valley. Where these deposits are thick and saturated, they are the highest yielding aquifers in the valley, with well yields of more than 100 gallons per minute (gpm).

- **Glen Ellen Formation** - clay-rich stratified deposits of poorly sorted sand, silt, and gravel interbedded with minor beds of conglomerate and volcanic tuffs. This unit interfingers with the Huichica Formation and lies on top of the Sonoma Volcanics in some regions and on the Franciscan Complex in other regions. The well yields are significantly lower in this formation than in the Quaternary alluvial deposits, with well yields generally less than 20 gpm, and often only 1 to 2 gpm.

- **Huichica Formation** – thick silt and clay with interbedded lenses of sands, gravels and tuff beds; this unit overlies and is interbedded with the Sonoma Volcanics; like the Glen Ellen Formation, well yields are low, typically 2 to 20 gallons per minute, however, in some areas, the lower part of this formation can be higher yielding.

- **Sonoma Volcanics** – thick sequences of volcanic rocks interbedded with sedimentary deposits derived from volcanic rocks and lake beds. This unit overlies the Franciscan Complex or other basement rock. This formation has the highest variability in water-bearing properties in the valley. Yields generally range between 10 and 50 gallons per minute and occasionally as much as several 100 gallons per minute.

The shallow portions of the Quaternary alluvial deposits are commonly unconfined, while deeper portions of the Quaternary alluvial deposits, the Glen Ellen Formation, Huichica Formation, and Sonoma Volcanics are commonly confined to semi-confined. These geologic units overly the basement rocks of the Franciscan Complex, which for the most part acts as a barrier to flow, but can yield water near fault zones or where heavily fractured (USGS, 2006).

As described in the 2010 Annual Report for the Sonoma Valley GMP, wells have been subdivided according to their relative well screen depth or total depth into the following categories: (1) a shallow-zone of less than 200 feet deep, (2) an intermediate-zone of 200-500 feet deep and (3) a deep-zone of greater than 500 feet deep. The two groundwater pumping depressions, originally described in the 2006 USGS report, predominantly occur in the

intermediate/deep-zones: southeast of the City of Sonoma measured groundwater levels ranged up to 116 feet below sea level and southwest of El Verano groundwater levels ranged up to 45 feet below sea level in intermediate- and deep-zone wells.

3.0 GOALS AND OBJECTIVES OF SCOPE OF WORK

The scope of work described in this memorandum consists of the drilling, construction and initial monitoring of two nested groundwater monitoring wells in southern Sonoma Valley. The goal of the scope of work is to help address primary data gaps identified in Section 2.9 of the Sonoma Valley Groundwater Management Plan and to further characterize two of the more significant groundwater concerns in the basin – declining groundwater levels and saline intrusion. Specific objectives of the scope of work are to:

- Increase the horizontal and vertical distribution of groundwater level and groundwater quality monitoring in the basin
- Obtain additional borehole geophysical and geologic data in the basin
- Improve the understanding of hydrostratigraphic conditions in southern Sonoma Valley
- Provide additional data on potential outflow (groundwater discharge) from the basin to the south
- Conduct additional characterization of the source and distribution of chloride (and salinity) in the southern portion of the basin

Additional objectives of the work include:

- Further characterize surface water-groundwater interaction
- Help evaluate groundwater recharge.

The nested groundwater monitoring wells will be incorporated into the long-term and ongoing groundwater-level and water quality monitoring programs conducted as part of the Sonoma Valley GMP implementation, in addition to the California Statewide Groundwater Elevation Monitoring (CASGEM) program and Salt and Nutrient Management Planning effort currently underway.

4.0 SUMMARY OF WORK ACTIVITIES

This section summarizes work activities and field methods performed as part of the scope of work, including:

- Planning and Field Preparation
- Borehole Drilling and Formation Sampling
- Borehole Geophysical Logging
- Well Design and Construction
- Well Development

- Well Instrumentation
- Groundwater Sampling
- Wellhead Surveying
- Groundwater Management Program Updates

4.1 Planning and Field Preparation Activities

Field preparation activities included the final selection of drilling locations, securing a drilling contractor, obtaining necessary permits for the work, and screening the drilling locations for the presence of subsurface utilities.

The monitoring wells are located within an unincorporated area of Sonoma Valley, south of the City of Sonoma, California (Figure 1). The locations of the monitoring wells were selected to be at the southern margin of the groundwater pumping depression southeast of the City of Sonoma and the inland (northern) margin of a region of elevated salinity levels in groundwater. Thus, the wells are suitably located to serve as "sentry wells" to track the potential for expansion of the pumping depression further to the south and the potential for movement of saline groundwater into the groundwater basin. Additionally SVMW-2 was sited close to Sonoma Creek to assess surface water/groundwater interaction in this area of Sonoma Valley.

- Nested Monitoring Well SVMW-1 is located on property owned by the Sonoma Valley County Sanitation District at 22333 Eighth Street East; and
- Nested Monitoring Well SVMW-2 is located within the County of Sonoma right-of-way along the northern shoulder of Watmaugh Road approximately 300 feet west of Sonoma Creek.

After selection of the monitoring well locations, a Water Agency Environmental Specialist determined that the project qualified for a Categorical Exemption under CEQA and a notice of exemption was filed with the Department of Fish and Game on January 26, 2009. Additionally, well permits and an encroachment permit (for SVMW-2 located within the County of Sonoma right-of-way along Watmaugh Road) were obtained from the County of Sonoma Permit and Resource Management Department. Copies of the permits are included in Appendix A.

To procure the services of a qualified drilling contractor for constructing the nested groundwater monitoring wells, the Water Agency developed a Project Manual, including technical specifications, for the project. A Request For Bid (RFB) was released in December 2010 and bids were received from three qualified drilling contractors on January 18, 2011. The Water Agency's Board of Directors awarded the drilling contract for constructing the two nested groundwater monitoring wells to Maggiora Brothers Drilling of Watsonville, California on February 8, 2011.

Underground Service Alert (USA) was notified at least 48 hours in advance of the drilling activities at each monitoring well location to screen the drilling locations for subsurface utilities.

Construction oversight of field activities was performed by Water Agency staff with assistance provided by DWR staff geologists for borehole logging and data interpretation. During the project, daily field logs were prepared and submitted by the contractor to track the progress of the project. The sequence of the field work and methods employed are summarized below and described in the following sections.

4.2 Borehole Drilling and Formation Sampling

Maggiora performed the borehole drilling utilizing direct mud rotary drilling equipment between May 31 and June 6, 2011 at SVMW-1 and between July 8 and 14, 2011 at SVMW-2. The drilling equipment included a portable mud system comprised of fluid tanks with de-sanders and shaker screens to separate the drill cuttings and suspended solids from the drilling fluids. Drilling fluids consisted of a mixture of powdered bentonite and potable water obtained from a City of Sonoma fire hydrant. Drilling fluid properties, including mud weight, viscosity and sand content were measured at approximate 100-foot intervals and recorded on daily field logs.

At each location 8¾-inch pilot boreholes were advanced to approximately 500-feet. Formation samples of drill cuttings were collected from the drilling-fluid returns at approximate five-foot intervals. The samples were washed to remove drilling mud and logged by DWR Professional Geologists in the field. Representative portions of each sample were placed in chip sample trays for archiving purposes and remaining sample materials were placed in one-gallon re-sealable plastic bags. Lithologic samples were described according to the Unified Soil Classification System and Munsell Color Index. The lithologic information recorded in the field is included in the lithologic logs for the two monitoring wells prepared by DWR and included in Appendix B.

4.3 Borehole Geophysical Logging

Following the completion of each borehole, down-hole geophysical logging was performed. Geophysical logging included spontaneous potential, resistivity (single point, and 16-inch and 64-inch normal), natural gamma, and caliper logs. The geophysical logs were used to supplement lithologic characterization and to facilitate final selection of the screen intervals for the proposed multidepth groundwater monitoring wells. The caliper log was used to confirm interpretation of the geophysical logs and verify the final diameter of the boring prior to well installation.

Upon achieving the target depth in the proposed borehole, fresh drilling mud was circulated through the borehole until it was free of cuttings and filled above the interval to be logged. Geophysical logging was performed by a Registered Geophysicist from Norcal Geophysical of Petaluma, California on June 6, 2011 (SVMW-1) and July 14, 2011 (SVMW-2). The borehole geophysical logs are on the boring logs in Appendix B.

4.4 Well Design and Construction

Following the review of lithologic and geophysical information, the well screen intervals and final well designs were selected for each well. At SVMW-1, four target zones were selected and

a nested groundwater monitoring well was constructed comprising four individual nested 3-inch diameter polyvinyl chloride (PVC) well casings within a single borehole. At SVMW-2, five target zones were selected and a nested groundwater monitoring well was constructed comprising four individual nested 3-inch diameter PVC well casings within a single borehole and a separate shallow-zone groundwater monitoring well was constructed within a separate borehole. The position of the well screen intervals were generally selected to coincide with coarser-grained sedimentary units (e.g., sand and gravel zones) with well screen intervals ranging from 10 to 20 feet in thickness, as summarized in Table 1.

The construction of the nested monitoring wells initiated with placement of 18-inch diameter steel conductor casing (5/16 -inch wall thickness) to stabilize the upper coarser-grained portions of the boreholes before reaming the pilot holes. The conductor casings were installed and cemented within 22-inch diameter borings to depths of 50 feet below grade (SVMW-2) and 20 feet below grade (SVMW-2). After allowing the conductor casing cement to set for a minimum of 24 hours, the borehole was telescopically reamed to diameters ranging from 16-inches in diameter (for the upper two screened zones) to 9-inches in diameter (deepest screened zone).

Prior to well construction, each borehole was conditioned by thinning and displacing the more viscous circulation fluids with potable water through a tremie pipe. Circulation through the tremie pipe continued throughout the casing installation process. Each three-inch diameter monitoring well was constructed using flush-threaded Schedule 80 PVC well casing, factory slotted 0.020-inch well screen, a 10-foot long flush threaded PCV blank sump and end cap. The three-inch diameter well casings were sequentially lowered into the borehole and were fastened together with steel spacing devices placed above and below each well screen interval and at approximate 50-foot intervals, which ensured that a minimum 2-inches of space separated each individual casing string. Stainless steel centralizing guides were placed at approximate 50-foot intervals to center the casings within the borehole and maintain a minimum 2-inch annular space between the well casings and the borehole wall.

A filterpack of #2/12 water washed, kiln dried sand was placed in the annular space adjacent to the entire screened interval of each well casing to a level of approximately 5-feet above the top of the screened interval. Five feet of No. 60 sand was placed above each filter pack to serve as a transition to bentonite seal materials. Filterpack materials were installed by pumping with potable water through the tremie pipe and were tagged with a weighted surveyors tape during placement to confirm proper placement. Each well screen was swabbed using a vented surge block prior to placing the bentonite seals to facilitate settling of the filterpack. Bentonite seals were emplaced within the annular space of the borehole between each well screen interval to prevent vertical movement of groundwater through the annular space surrounding the three-inch casings.

The annular space above the uppermost bentonite seal in each nested well was grouted with neat cement, extending from near the ground surface to 70 feet below grade at SVMW-1 and 65 feet below grade at SVMW-2. The surface completion of each nested well was constructed below grade with a locking cover and traffic-rated well vault that was set flush with the surrounding ground surface.

4.5 Well Development

The drilling contractor performed several phases of well development on the groundwater monitoring wells between August and September, 2011. Initial well development consisted of airlifting and surging until the discharge water was visually clear of sand and drilling fluids between August 22 and 26. Pumping was then performed using a 2-inch diameter submersible pump. Field parameters, including pH, electrical conductivity, temperature and turbidity were periodically measured during pumping. For several of the wells, elevated pH levels (ie, ranging up to 10) of the discharge water were measured indicating that residual drilling fluid still remained in the formation and/or well casings. A subsequent phase of development was therefore performed between September 7 and 14, 2011 utilizing a double surge block air lift tool to perform isolation-zone airlifting and mechanical surging of the well screens until field parameter stabilized to more reasonable levels.

4.6 Instrumentation of Monitoring Wells

Following completion of the additional well development, the monitoring wells were instrumented with dedicated pressure transducers and temperature and electrical conductivity probes on November 7 and 8, 2011. Two of the well casings at SVMW-1 and three of the well casings at SVMW-2 were instrumented with submersible CTD-Divers (manufactured by Schlumberger Water Services), which monitor groundwater conductivity, temperature and pressure (elevation). The remaining well casings were instrumented with Schlumberger Mini-Divers (manufactured by Schlumberger Water Services), which monitor temperature and pressure. Each of the transducers/probes were connected to a direct-read cable and installed within or near the screened interval of the monitoring wells to ensure that temperature and electrical conductivity measurements are representative of conditions within the aquifer.

Additionally, a stream staff gauge was established in Sonoma Creek at Watmaugh Road and instrumented with a CDT-Diver to allow for assessment of surface water/groundwater interaction in this area.

4.7 Groundwater Sampling

Following the second phase of well development, the monitoring wells were outfitted with HydraSleeve passive groundwater samplers. The HydraSleeve samplers are comprised of 4-mil polyethylene sample sleeves, which are suspended using nylon tethers and equipped with stainless-steel weights affixed to the bottom of the sampler. The samplers were suspended within the lower portions of the screened interval of each well casing on November 7 and 8, 2011.

On November 16, 2011, Water Agency and DWR staff retrieved and collected groundwater samples from each of the HydraSleeve samplers. Based on the visual presence of drilling mud within portions of the HydraSleeve samplers and elevated pH levels measured from the sampled water, several of the well casings appeared to still contain residual drilling fluids (likely within

the sumps beneath the well screens), which impacted the several of the groundwater samples. As discussed in Section 6.0, additional development to remove the remaining drilling fluids is scheduled to occur in August 2012. A summary of the laboratory analytical results are presented in Table 2 and discussed in Section 5.3.3.

4.8 Wellhead Surveying

The top-of-casing elevations for the wells were surveyed by Water Agency licensed land surveyors in December 2011. Each PVC casing was marked to indicate the point on the well casing that was surveyed and used as a reference point for water-level measurements. Each individual well casing was surveyed to establish the horizontal and vertical coordinates. Survey results were reported to the nearest one foot relative to the horizontal datum and referenced to the North American Datum of 1983 and the vertical elevations were reported to the nearest 0.01 feet using the National Geodetic Vertical Datum of 1988. Results of the surveying are included on Table 1.

4.9 Groundwater Management Program Updates

During the course of the implementation of this scope of work, regular updates were provided to the TAC and BAP on the progress and results of the groundwater monitoring well installations and monitoring. Additionally, field visits were conducted by TAC members, during drilling, well construction and groundwater monitoring activities and a press release was issued to local media outlets regarding the drilling program on June 2, 2011.

5.0 RESULTS

This section summarizes results obtained from the scope of work, including:

- Geologic conditions from lithologic and geophysical data;
- Groundwater hydraulic conditions, including surface water and groundwater interaction; and
- Groundwater quality.

5.1 Geologic Conditions From Lithologic and Geophysical Data

The geologic materials encountered during the drilling of the two nested groundwater monitoring wells consist of alluvial deposits consisting of variable mixtures of sand, gravel, silt and clay. The materials primarily appear to correspond to sediments mapped as Quaternary Alluvium and the Pliocene-aged Huichica Formation, which includes massive silt and clay with interbedded sands, gravels, and tuff beds (USGS, 2006). Lithologic logs prepared by DWR geologists for the two boreholes are provided in Appendix B and include lithologic descriptions of formation samples collected during drilling, borehole geophysical data, and well construction details. Primary findings from examination of lithologic samples collected during drilling and borehole geophysical logging of the two nested groundwater monitoring wells indicate the following:

- The sand and gravel aquifer zones and clay aquitard zones identified in the two boreholes correlate reasonably well and may be laterally continuous between the two locations.
- Permeable deposits of sand and gravel dominate the shallow aquifer (generally less than 100 feet deep) at both locations.
- Thick sequences of clay with minor sand and gravel form an aquitard generally present between approximately 100 and 360 feet below ground surface (bgs).
- Deeper aquifers comprised of sand and gravel deposits occur between 350 and 500 feet bgs at both locations and are thicker and coarser-grained at SVMW-2.

At SVMW-1, the shallow aquifer is comprised of permeable sand and gravel deposits present from near the ground surface to approximately 60 feet bgs and a five foot thick gravel deposit (extending from approximately 88 to 93 feet bgs) which are separated by brown low plasticity clay from 60 to approximately 88 feet bgs. Immediately beneath the gravel deposits at 93 feet bgs, a sharp transition to high plasticity dark greenish gray clay occurs. Clay with minor interbedded sand and gravel are present from approximately 93 feet bgs to 355 feet and forms a thick aquitard. Due to the large quantities of clay encountered in the borehole, the precise depth, composition and thickness of the interbedded sand and gravel deposits were difficult to discern from the lithologic samples collected during the drilling. Therefore, the results of the geophysical logging were used to identify the depth and thickness of relatively permeable zones. A thin deposit of sand and gravel (between approximately 220 and 230 feet bgs) was identified within the thick clay aquitard. While clay also dominates the interval between approximately 355 and 500 feet bgs (the maximum depth explored), two sequences of sand and gravel deposits were identified between approximately 355 and 365 feet bgs, and 440 and 453 feet bgs based on the geophysical logs.

At SVMW-2, clay is present from the ground surface to approximately 30 feet below ground surface. The shallow aquifer is comprised of permeable sand and gravel deposits present from approximately 30 to 110 feet bgs with a thin zone of clay between approximately 68 and 71 feet bgs. Beneath the sand and gravel deposits at 110 feet bgs, a transition to clay with interspersed gravel occurs, which grades into a high plasticity clay at 120 feet bgs. Clay with minor interspersed sand and gravel is present from approximately 120 feet bgs to 360 feet bgs. Small gastropod fossils and fossil hash were identified within the clay at approximately 125, 130, 140 and 190 feet bgs, indicating that the depositional environment transitions from a fluvial/alluvial setting to a shallow marine or lacustrine environment beneath approximately 120 feet. A potential horizon of volcanic ash, although not directly observed in the lithologic samples, is inferred based on a spike in the Natural Gamma log at approximately 165 feet bgs. Beneath the thick clay sequence (extending between 120 to 360 feet bgs), two relatively thick permeable zones were identified in the borehole drilled for SVMW-2. A gravel and sand deposit with a 10-foot thick interbedded clay is present between approximately 360 and 410 feet bgs and a sand deposit is located between approximately 460 and 485 feet bgs. Clay aquitards between approximately 410 and 460 feet bgs and from 485 to the maximum depth explored of 500 feet bgs are present between and beneath these two permeable sand and gravel zones.

5.2 Groundwater Hydraulic Conditions

Groundwater-level data collected from the nested monitoring wells utilizing electronic pressure transducers between November 2011 and April 2012 (subject monitoring period) is provided on hydrograph plots in Figures 2 and 3, respectively. Prior to developing the groundwater-level hydrographs, data obtained from the electronic pressure transducers was corrected for barometric pressure changes using a nearby pressure transducer which records barometric pressure. The plots display groundwater elevations, daily rainfall totals, and (for SVMW-2) the surface water elevation (stage) of Sonoma Creek. Primary findings from the groundwater-level data collected from the two nested groundwater monitoring wells indicate the following:

- At both locations, groundwater levels are appreciably higher within the shallow aquifer than in the deeper aquifer zones. The degree of separation (between groundwater levels in the shallow and deeper aquifer zones) is greater at nested groundwater monitoring well SVMW-2, which is closer to the central portions of the groundwater pumping depression (where groundwater levels in the deeper aquifer are lowest).
- Groundwater levels in the shallow aquifer respond rapidly to precipitation events and changes in streamflow.
- Sonoma Creek is predominantly a gaining stream near Watmaugh Road where groundwater from the shallow aquifer locally discharges to Sonoma Creek.
- Groundwater levels within the deeper sand and gravel aquifer zones generally present between approximately 360 and 485 feet bgs exhibit fluctuations that appear to be related to localized groundwater pumping, with the possible exception of the aquifer zone between 460 and 480 feet bgs at SVMW-2.
- Groundwater levels within the thin relatively permeable zones of the thick clay aquitard (generally present between approximately 110 and 360 feet bgs) do not exhibit short-term fluctuations and exhibit a slower and moderate response to seasonal recharge. This indicates that the thin permeable zones within this thick sequence of clay are not laterally continuous and are not directly connected to shallow and deeper aquifer zones.

As indicated on Figure 2, at SVMW-1, groundwater-level data obtained from the transducers during the monitoring period, indicates that groundwater levels were consistently approximately 10 to 20 feet higher in the shallow aquifer than the deeper aquifers indicating a downward vertical gradient occurs between the shallow and deeper aquifers. Vertical gradients amongst the deeper aquifers varied during the monitoring program. Vertical gradients between the two deepest aquifer zones monitored at SVMW-1 (-365 and -455) were upward during the monitoring period, while the vertical gradients between these two zones and the thin permeable zone within the thick clay aquitard (SVMW1-233) ranged from downward (in the fall and early winter) to upward (following precipitation events in the winter and spring). Observations specific to each screened interval for nested groundwater monitoring well SVMW-1 are summarized below.

- <u>SVMW1-95 (screened within permeable deposits of the shallow alluvial aquifer)</u>: Groundwater levels ranged from approximately 9 feet above mean sea level (msl) to 16

feet msl and exhibit minor short term (daily) fluctuations of less than one foot that may be attributed to local groundwater pumping of the shallow aquifer. Groundwater levels also responded to precipitation events by exhibiting increases of 2 to 3 feet following rainfall events in mid-January and mid- to late-March, respectively.

- SVMW1-233 (screened within thin permeable zone of thick sequence of clay aquitard): Groundwater levels ranged from approximately 0 feet msl to 2 feet msl and do not exhibit short-term fluctuations or respond directly to precipitation events.
- SVMW1-365 (screened within permeable deposits of deeper aquifer): The pressure head exceeded the instrument's pressure threshold during portions of the initial monitoring period, and data was not recorded for this well between November 21 and December 25, 2011 and between January 10 and March 10, 2012. This has since been corrected by adjusting the pressure transducer placement in the well. Data recorded during the monitoring period show that groundwater levels ranged from approximately -20 feet msl to 6 feet msl. Based on the available data, short term fluctuations are evident and appear to range up to 5 feet and may be attributed to local groundwater pumping of the deeper aquifer zones. Responses to precipitation events could not be discerned based on the available data, but will be assessed during subsequent precipitation events.
- SVMW1-455 (screened within permeable deposits of deeper aquifer): Groundwater levels ranged from approximately -17 feet msl to 8 feet msl and exhibit minor short term fluctuations of up to several feet that may be attributed to local groundwater pumping of the deeper aquifer zones. Groundwater levels also exhibit increases of 2 to 5 feet following rainfall events in mid-January and mid- to late-March, respectively, indicating a correlation with precipitation events and/or decreases in local groundwater pumping.

As indicated on Figure 3, at SVMW2, groundwater-level data obtained from the transducers indicates that during the monitoring period, groundwater levels were generally consistently 20 to 30 feet higher in the shallow aquifer than the deeper aquifers indicating a downward vertical gradient occurs between the shallow and deeper aquifers. Vertical gradients amongst the deeper aquifers were also generally downward, with the exception of SVMW2-220 (screened within the clay aquitard), which exhibits a potentiometric head 5 to 10 feet lower than deeper monitoring well SVMW2-409. Observations specific to each screened interval for SVMW-2 are summarized below.

- SVMW2-52 and -100 (both screened within permeable deposits of the shallow alluvial aquifer): Groundwater levels ranged from approximately 25 feet msl to 30 feet msl. Groundwater levels ranged from 2 to 3 feet higher in the shallower monitoring well (SVMW2-52) in comparison with the deeper monitoring well (SVMW2-100) indicating a downward vertical gradient exists between the upper and lower portions of the shallow aquifer. Short term fluctuations, which may be attributed to groundwater pumping, are more pronounced in SVMW2-100. Groundwater levels also responded similarly to precipitation events in both shallow wells by exhibiting increases of 2 to 3 feet following rainfall events in mid-January and mid- to late-March, respectively.

- SVMW2-220 (screened within thick sequence of clay aquitard): Groundwater levels exhibited a gradual recovery from approximately -5 feet msl to 5 feet msl and do not exhibit short-term fluctuations or a direct response to precipitation events.
- SVMW2-409 (screened within permeable deposits of deeper aquifer): The pressure head exceeded the instrument's pressure threshold during portions of the initial monitoring period, and data was not recorded for this well between November 7 and January 8, 2011 and between January 10 and after March 10, 2012. This has since been corrected by adjusting the pressure transducer placement in the well. Data recorded during the monitoring period show that groundwater levels ranged from approximately 5 feet msl to 10 feet msl. Based on the available data, short term fluctuations are evident and appear to range up to 5 feet and may be attributed to local groundwater pumping of the deeper aquifer zones. Responses to precipitation events could not be discerned based on the available data, but will be assessed during subsequent precipitation events
- SVMW2-480 (screened within permeable deposits of deeper aquifer): Groundwater levels exhibited a gradual increase in elevation from approximately -5 feet msl to 5 feet msl over the monitoring period and do not exhibit appreciable short-term fluctuations or a direct response to precipitation events.

5.2.1 Surface Water and Groundwater Interaction

Data obtained from the stream staff gauge installed within Sonoma Creek at Watmaugh Road is included on Figure 3 and indicates that in the vicinity of SVMW-2, groundwater from the shallow aquifer is predominantly locally discharging to Sonoma Creek, with the exception of short periods of time immediately following storm events when surface water recharges the shallow aquifer (likely predominantly through the banks of the creek).

Groundwater levels in shallow monitoring wells SVMW2-52 and SVMW2-100 range from 3 to 5 feet and 2 to 4 feet above the stage (water surface) in Sonoma Creek, respectively, except during short periods of time immediately following storm events in January and March. During these storm events the stage of the creek increases by approximately 8 to 10 feet and remains higher than groundwater levels in the shallow aquifer for an approximate 2-day period before receding again to levels below groundwater levels of the shallow aquifer. When the stage of the stream increases, groundwater levels also rise within the shallow aquifer indicating that surface water from Sonoma Creek is likely recharging the shallow aquifer during these short term events (i.e., during these storm events Sonoma Creek temporarily converts from a gaining stream to a losing stream).

5.3 Groundwater Quality

Groundwater quality data collected from the nested groundwater monitoring wells includes both continuous temperature and electrical conductivity data collected from water quality probes placed within the wells and laboratory analytical data for groundwater samples collected from the nested monitoring wells. Groundwater samples were analyzed for general minerals and the stable isotopes of oxygen (delta oxygen 18 [$\delta^{18}O$]) and hydrogen (delta deuterium [δD]).

5.3.1 Temperature

As indicated on Figures 4 and 5, the results of temperature monitoring performed in the monitoring wells indicate that groundwater temperature remains stable over time in each of the wells during the monitoring period (generally do not vary more than 0.2 ˚F) and increases with depth at each location.

Temperature measurements collected from the probes placed in SVMW-1 range from approximately 65 ˚F in the shallow aquifer to 75 ˚F in the deepest zone and indicate an approximate geothermal gradient of 2.5 ˚F per 100 feet (approximately 1.4 ˚C per 100 feet), which is slightly higher than the average geothermal gradient calculated by the USGS in Sonoma Valley of 1.2 ˚C (USGS, 2006).

Temperature measurements collected from the probes placed in SVMW-2 range from approximately 62 ˚F in the shallow aquifer to 72 ˚F in the deepest zone and indicate an approximate geothermal gradient of 2.1 ˚F per 100 feet (approximately 1.2 ˚C per 100 feet), which is corresponds to the average geothermal gradient calculated by the USGS in Sonoma Valley of 1.2 ˚C (USGS, 2006). Temperature measurements collected from Sonoma Creek near Watmaugh Road exhibit diurnal temperature fluctuations typical of surface waters exposed to atmospheric temperature fluctuations. Over the monitoring period the surface water temperature ranges from approximately 47 ˚F in January to approximately 67 ˚F in April. The surface water remains cooler than groundwater temperature until April 19, 2012 when a warming trend results in the surface water exceeding the temperatures of the three shallowest monitoring wells (SVMW2-52, -100, and -220).

The slightly higher geothermal gradient and slightly higher temperatures observed at SVMW-1 in comparison with comparable depths at SVMW-2 could reflect the relative proximity of SVMW-1 to the Eastside Fault (or other unmapped fault), which may provide a localized conduit for the upwelling of deeper (and warmer) groundwater.

5.3.2 Electrical Conductivity

As indicated on Figures 6 and 7, the results of electrical conductivity monitoring performed in the monitoring wells indicate that groundwater electrical conductivity remains stable over time in each of the wells during the monitoring period (i.e., generally does not vary more than 20 microsiemens per centimeter [µS/cm]). Marked changes observed in monitoring well SVMW2-480 are the result of the raising and lowering of the probe within the wellbore during probe maintenance and inspection activities. This indicates that electrical conductivity is stratified within groundwater of the monitoring well with higher electrical conductivity occurring deeper within the well casing.

At nested groundwater monitoring well SVMW-1, electrical conductivity is slightly higher (averaging approximately 500 µS/cm) in the deeper monitored zone compared with the shallow aquifer zone (averaging approximately 410 µS/cm).

At nested groundwater monitoring well SVMW-2, electrical conductivity is highest in the upper portions of the shallow aquifer (averaging approximately 690 µS/cm in SVMW2-52) and lowest in the lower portions of the shallow aquifer (averaging approximately 420 µS/cm in SVMW2-100). The electrical conductivity within the deeper aquifer at SVMW2-480 ranges from approximately 460 to 600 µS/cm depending upon the depth at which the probe is placed. During the monitoring period, the electrical conductivity of surface water in Sonoma Creek varied with flow and exhibits decreases during storm events. The electrical conductivity ranged from approximately 100 µS/cm to 390 µS/cm and remained below the electrical conductivity measured in groundwater at each of the aquifer zones at nearby nested well SVGMW-2 throughout the entire monitoring period. Short term rapid decreases in electrical conductivity events followed by gradual increases correlate with times when the creek converts from gaining to losing back to gaining in response to storm events.

5.3.3 Water Quality Sampling

Laboratory analytical results for groundwater samples collected from the monitoring wells on November 16, 2011 are summarized in Table 2. As indicated in Section 4.5, several of the well casings appear to contain residual drilling fluids (SVMW1-233 and -365 and SVMW2-220 and -409), therefore data from these wells are not included in Table 2.

Groundwater quality data which appears representative (i.e., not affected by drilling fluids) is plotted on a trilinear ("Piper") diagram on Figure 8 to display the relative proportions of common anions and cations and group samples that have similar relative ionic concentrations. Figure 8 contains the following groupings of previous groundwater surface water and groundwater samples collected from Sonoma Valley by DWR in 2010:

- Group I samples are characterized generally as mixed bicarbonate type water and include both surface water and groundwater samples
- Group II samples are generally a sodium-bicarbonate type water and include only groundwater samples
- Group III samples are generally sodium-chloride and sodium-sulfate type water, and include surface water and groundwater samples

As shown on Figure 8, the groundwater samples from each of the aquifer zones monitored by SVMW-1 and SVMW-2 plot within Group I type samples (characterized by mixed bicarbonate waters). However, the surface water and shallow aquifer zone samples are more calcium/magnesium rich and group more closely with other surface water samples collected from Sonoma Valley, while samples from the deeper aquifer zones are slightly higher in sodium and potassium.

Laboratory analytical results from groundwater samples analyzed for isotopes of oxygen (delta oxygen 18 [$\delta^{18}O$]) and hydrogen (delta deuterium [δD]) are plotted on Figure 9. As indicated on Figure 9, shallow aquifer zone samples and surface water are less negative and plot along or slightly above the global meteoric water line (GMWL), except SVMW1-95 which plots below the GMWL. Deeper aquifer groundwater samples are generally more negative and plot along or

slightly below the GMWL indicating the groundwater within the deeper aquifer zones have been modified by evaporation prior to infiltration.

6.0 SUMMARY, CONCLUSIONS AND FUTURE EFFORTS

This section provides a summary of the work conducted, conclusions, and recommendations for additional efforts to further the understanding and continue progress on the Sonoma Valley Groundwater Management Program.

6.1 Summary

Two nested groundwater monitoring wells were drilled, geophysically logged, constructed, developed, and monitored under this scope of work completed under an LGA grant awarded by DWR in support of the Sonoma Valley GMP. The groundwater monitoring wells were completed as nested wells:

- SVMW-1 with discrete well screens located at the following nominal depths: 85 to 95, 223 to 233, 355 to 365, and 440 to 455 ft bgs

- SVMW-2 with discrete well screens located at the following nominal depths: 32 to 52 (separate borehole), 80 to 100, 200 to 220, 374 to 409, and 460 to 480 feet bgs

All screened intervals were instrumented with pressure transducers with temperature sensors, and several of the intervals are instrumented with electrical conductivity sensors. Groundwater samples were collected from several screened intervals of the two wells and analyzed for general minerals and stable isotopes of oxygen (delta oxygen 18 [$\delta^{18}O$]) and hydrogen (delta deuterium [δD]). The scope of work was conducted with the funding from an LGA Grant, awarded by DWR to SCWA in 2009, but with state funding delays the actual award and agreement was not activated until 2010. The drilling and well construction work were completed in 2011 and the initial monitoring was conducted in 2012.

A summary of primary findings from the scope of work include:

- Permeable deposits of sand and gravel dominate the shallow aquifer (generally less than 100 feet deep) at both locations.

- Thick sequences of clay with minor sand and gravel form an aquitard generally present between approximately 100 and 360 feet below ground surface (bgs).

- Deeper aquifers comprised of sand and gravel deposits occur between 350 and 500 feet bgs at both locations and are thicker and coarser-grained at SVMW-2.

- The shallow and deep aquifer zones and clay aquitard zones identified in the two boreholes correlate reasonably well and may be laterally continuous across the one and a half mile between the two locations.

- Groundwater levels in the shallow aquifer respond rapidly to precipitation events and changes in streamflow.

- Sonoma Creek is predominantly a gaining stream near Watmaugh Road where groundwater from the shallow aquifer locally discharges to Sonoma Creek, except during precipitation events when the stream level rises above groundwater and recharges groundwater short-term.

- At both locations, groundwater levels are appreciably higher within the shallow aquifer than in the deeper aquifer zones. The degree of separation (between groundwater levels in the shallow and deeper aquifer zones) is greater at nested groundwater monitoring well SVMW-2, which is closer to the central portions of the groundwater pumping depression where groundwater levels in the deeper aquifer are lowest.

- Groundwater levels within the deeper sand and gravel aquifer zones generally present between approximately 360 and 485 feet bgs exhibit fluctuations that appear to be related to localized groundwater pumping, with the possible exception of the aquifer zone between 460 and 480 feet bgs at SVMW-2.

- Groundwater levels within the thin relatively permeable zones of the thick clay aquitard (generally present between approximately 110 and 360 feet bgs) do not exhibit short-term fluctuations and exhibit a slower and moderate response to seasonal recharge. This indicates that the thin permeable zones within this thick sequence of clay are likely not laterally continuous and are not directly connected to shallow and deeper aquifer zones.

- Surface water and shallow aquifer zone samples are more calcium/magnesium rich and group more closely with other surface water samples collected from Sonoma Valley, while samples from the deeper aquifer zones are slightly higher in sodium and potassium.

6.2 Conclusions

The drilling, construction and monitoring of nested groundwater monitoring wells SVMW-1 and SVMW-2 has successfully helped to further address a number of significant data gaps associated with the groundwater system in Sonoma Valley, including:

- Increasing the horizontal and vertical distribution of groundwater level and groundwater quality monitoring in the basin;

- Improving the understanding of hydrostratigraphic conditions in southern Sonoma Valley by providing additional borehole geophysical and geologic data in the basin; and

- Improving the understanding surface water-groundwater interaction, and groundwater recharge and discharge.

The following conclusions can be drawn from the groundwater monitoring well installation, data collection and interpretation:

- Surface water-groundwater interaction is an important component of the groundwater system in Sonoma Valley, with data from the subject scope of work demonstrating the importance of groundwater discharge from the shallow aquifer in providing baseflow to Sonoma Creek.

- Downward vertical hydraulic gradients from the shallow to deeper aquifers are present in the area of the new monitoring wells and are likely due to annual recharge which maintains high water levels in the shallow aquifer in conjunction with groundwater pumping from the deeper aquifers.

- Thick sequences of clay generally present between approximately 100 and 360 feet bgs form an effective aquitard which generally limits hydraulic communication between the shallow and deeper aquifer zones.

- Groundwater-level and groundwater quality data collected through this program indicate that the two nested wells are appropriately located to serve as "sentry wells" to track the potential for expansion of the current pumping depression further to the south and the potential movement of saline groundwater into the groundwater basin.

- Additional multi-depth groundwater monitoring wells are needed to further understand the hydrostratigraphy and interconnection of shallow and deep aquifer zones, and source and distribution of salinity in the southern Sonoma Valley.

6.3 Future Efforts

The following future efforts are planned to build on the information obtained from the subject scope of work and results described above:

- Groundwater level and groundwater quality data will continue to be collected from the transducers and probes currently instrumented within the two nested groundwater monitoring wells SVMW-1 and SVMW-2. The data collected from the wells have been incorporated into the long-term and ongoing groundwater-level and water quality monitoring programs conducted as part of the Sonoma Valley GMP implementation, including the CASGEM program and Salt and Nutrient Management Planning effort currently underway.

- The hydrogeologic conceptual model will be updated to include the additional hydrostratigraphic and hydraulic information collected from this work. The updated hydrogeologic conceptual model will be incorporated into a revised groundwater flow model being developed by the USGS. The updated flow model will be used to further understand and simulate groundwater conditions in the Sonoma Valley, as well as for planning future groundwater management activities.

- Additional multi-depth groundwater monitoring wells are needed to further assess the hydrostratigraphy and interconnection of shallow and deep aquifer zones, and salinity sources and distribution in the Sonoma Valley. Additional funding will be needed and pursued to install additional groundwater monitoring wells.

- Continued monitoring activities and implementation of the GMP will be conducted in coordination with and under the guidance of the Sonoma Valley GMP Panel and TAC through regularly scheduled meetings and other planned public outreach activities.

7.0 REFERENCES

Metzger, L.F., Farrar, C.D., Koczot, K.M., and Reichard, E.G., 2006 *Geohydrology and Water Chemistry of the Alexander Valley, Sonoma County, California*: U.S. Geological Survey Scientific Investigations Report 2006-5115

Sonoma County Water Agency, 2007, *Sonoma Valley Groundwater Management Plan*.

Sonoma County Water Agency, 2010, *Sonoma Valley Groundwater Management Program 2010 Annual Report*.

TABLES

Table 1
Summary of Monitoring Well Construction Details
Nested Groundwater Monitoring Wells SVMW-1 and SVMW-2
Sonoma Valley Groundwater Management Program

	SV-MW1								**SV-MW-2**									
Well Name	SV-MW1-95		SV-MW1-233		SV-MW1-365		SV-MW1-455		SV-MW2-52		SV-MW2-100		SV-MW2-220		SV-MW2-409		SV-MW2-480	
Casing Diameter (in)	3		3		3		3		3		3		3		3		3	
Easting	1855125.749		1855125.340		1855125.604		1855125.550		1858847.879		1858850.984		1858851.429		1858851.375		1858851.040	
Northing	6434681.583		6434681.626		6434681.929		6434681.351		6427141.840		6427149.617		6427150.032		6427149.700		6427149.953	
Top of Casing Elevation (ft msl)	22.87		22.83		22.85		22.83		45.20		45.43		45.42		45.42		45.42	
Well Screen Interval (feet bgs)	85	95	223	233	355	365	440	455	32	52	80	100	200	220	374	384	460	480
Well Screen Interval (feet bgs)															399	409		
Well Screen Interval (feet msl)	-61.63	-71.63	-199.67	-209.67	-331.65	-341.65	-416.67	-431.67	13.70	-6.30	-34.07	-54.07	-154.08	-174.08	-328.08	-338.08	-414.08	-434.08
Well Screen Interval (feet msl)															-353.08	-363.08		

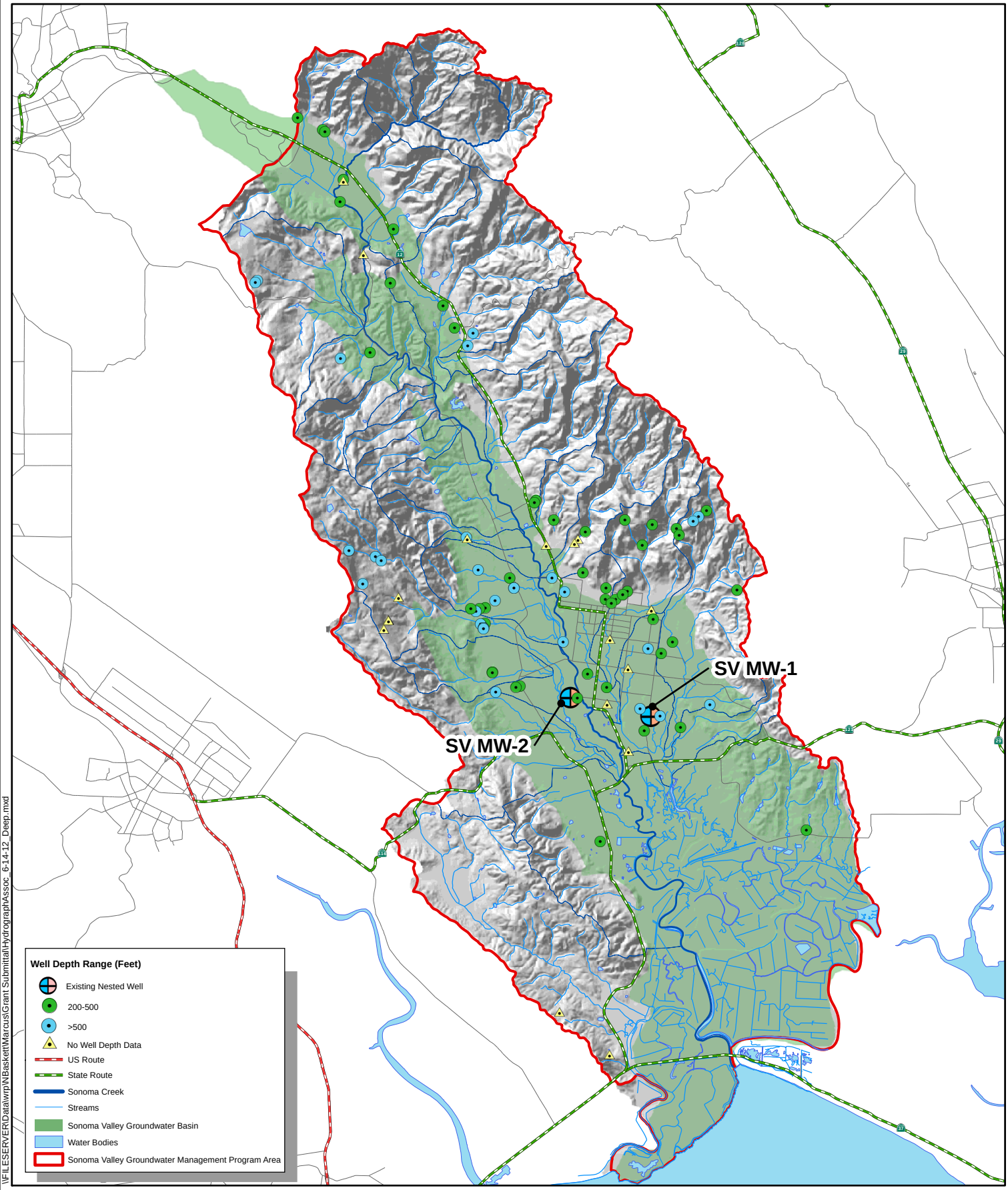
*Coordinates in NAD83 Zone II (feet)

Table 2
Summary of Laboratory Analytical Results
Nested Groundwater Monitoring Wells SVMW-1 and SVMW-2
Sonoma Valley Groundwater Management Program

Parameters	Units	Locations and Depth					
		SV-MW1-95	SV-MW1-455	SV-MW2-52	SV-MW2-100	SV-MW2-480	Sonoma Creek
		95	455	52	100	480	0
Temp (Field)	C	18.32	20.66	17.48	17.92	20.89	12.4
pH (Field)		7.85	6.99	6.53	8.06	6.95	7.14
pH (Lab)		7.3	8.3	7.3	7.7	7.8	8.1
Cond (Field)	uS/cm	429	550	581	450	447	351
Cond (Lab)	uS/cm	494	587	674	509	489	442
Al	mg/L	0.022	< .01	<.01	< .01	< .01	< .01
Sb	mg/L	< .001	< .001	< .001	< .001	< .001	< .001
As	mg/L	0.004	0.004	0.003	0.003	0.004	0.002
Ba	mg/L	0.078	0.085	0.075	0.068	0.085	0.064
Be	mg/L	< .001	< .001	< .001	< .001	< .001	< .001
HCO3-	mg/L as CaCO3	122	173	251	195	199	173
B	mg/L	0.22	0.25	0.086	0.057	0.44	0.38
Bromide	mg/L	< 2.	< 2.	< 2.	< 2.	< 2.	< 2.
Cd	mg/L	< .001	< .001	< .001	< .001	< .001	< .001
Ca	mg/L	18	20	46	31	24	26
CO3--	mg/L as CaCO3	< 1.	4	1	1	1	2
Chloride	mg/L	38	34	27	21	15	21
Cr	mg/L	0.004	0.003	0.001	0.001	0.001	< .001
Co	mg/L	< .005	< .005	< .005	< .005	< .005	< .005
Cu	mg/L	0.001	< .001	< .001	< .001	0.001	0.002
Hardness	mg/L as CaCO3	148	161	317	217	142	176
OH-	mg/L as CaCO3	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
Fe	mg/L	0.033	< .005	0.007	< .005	< .005	0.022
Pb	mg/L	< .001	< .001	< .001	< .001	< .001	< .001
Mg	mg/L	25	27	49	34	20	27
Mn	mg/L	0.021	0.027	0.054	0.074	0.091	0.016
Hg	mg/L	< .0002	< .0002	< .0002	< .0002	< .0002	< .0002
Molybdenum	mg/L	< .005	< .005	< .005	< .005	0.009	< .005
Ni	mg/L	0.002	< .001	0.011	0.002	0.001	0.003
NO3-	mg/L	42	39	9.4	< 2.	< 2.	< 2.
K	mg/L	3.3	16	1.8	8.6	3.6	2.9
Se	mg/L	0.001	0.001	0.001	0.001	0.001	0.001
Ag	mg/L	< .001	< .001	< .001	< .001	< .001	< .001
Na	mg/L	43	52	25	24	49	27
Sr	mg/L	0.145	0.179	0.192	0.173	0.178	0.148
SO4-	mg/L	23	21	58	33	29	22
Tl	mg/L	< .001	< .001	< .001	< .001	< .001	< .001
V	mg/L	0.005	< .005	0.005	< .005	< .005	<.005
Zn	mg/L	< .005	< .005	0.223	< .005	< .005	0.009
Total Alk	mg/L as CaCO3	122	176	251	196	200	175
TDS	mg/L	349	379	432	314	313	267
Iodide	mg/L	ND	ND	ND	ND	71	ND
$\delta^{18}O$		-6.16	-6.31	-6.25	-6.13	-6.51	-6.06
δD		-40.2	-40.6	-39.8	-39	-42.3	-38.2

(1) Initial groundwater samples collected from SVMW1-233, SVMW1-365, SVMW2-220 and SVMW2-409 are not shown, as they were potentially impacted with residual drilling fluid and not representative of native groundwater.

FIGURES



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Sonoma Valley
Groundwater Management Program
Location Map
Groundwater Level Monitoring Network
(Deep & Nested Wells)

June 14, 2012

Figure 1

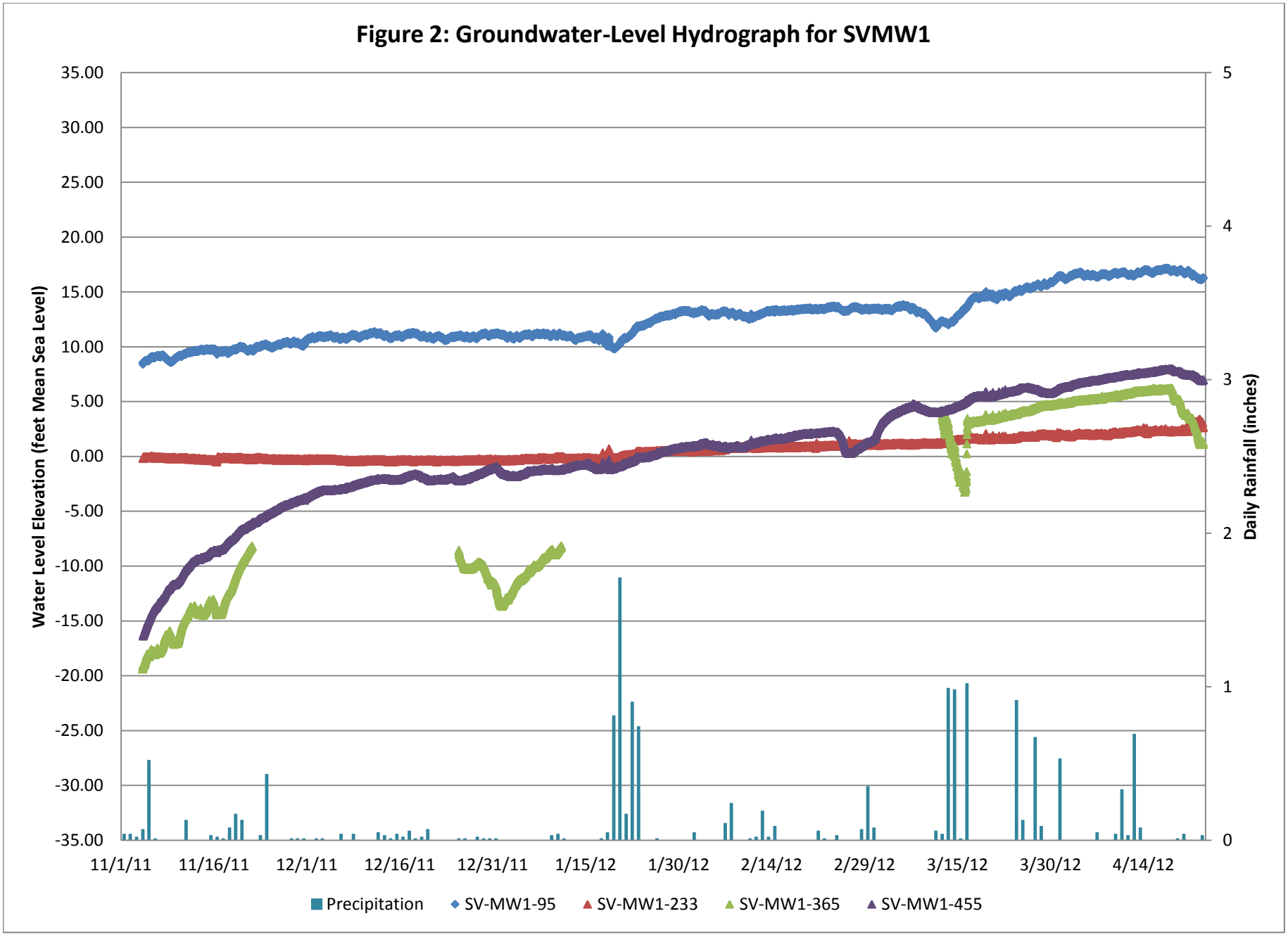
Figure 2: Groundwater-Level Hydrograph for SVMW1
Water Level Elevation (feet Mean Sea Level)
Daily Rainfall (inches)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
-30.00
-35.00
5
4
3
2
1
0
11/1/11
11/16/11
12/1/11
12/16/11
12/31/11
1/15/12
1/30/12
2/14/12
2/29/12
3/15/12
3/30/12
4/14/12
Precipitation
SV-MW1-95
SV-MW1-233
SV-MW1-365
SV-MW1-455

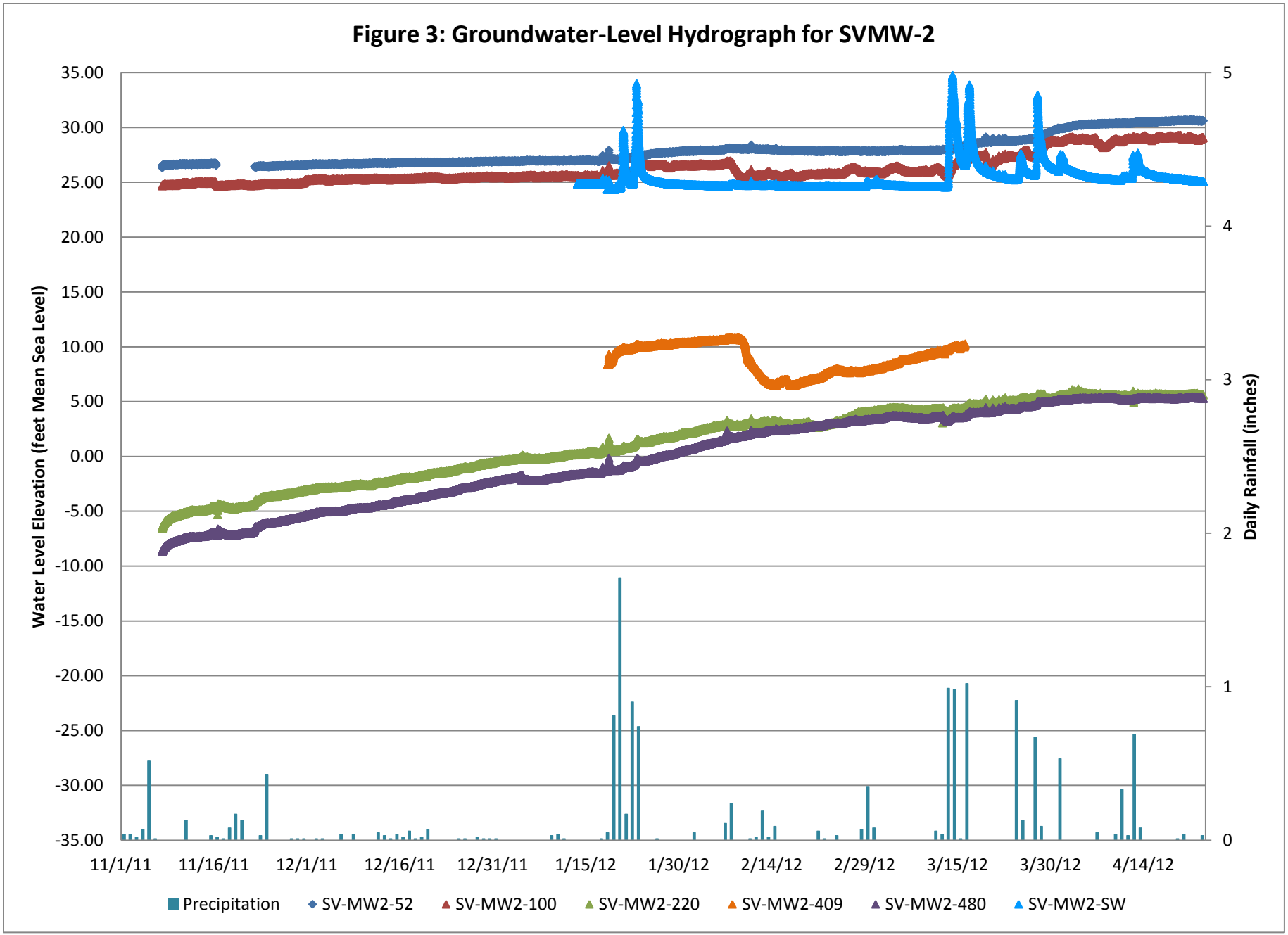
Figure 3: Groundwater-Level Hydrograph for SVMW-2
Water Level Elevation (feet Mean Sea Level)
Daily Rainfall (inches)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
-30.00
-35.00
5
4
3
2
1
0
11/1/11
11/16/11
12/1/11
12/16/11
12/31/11
1/15/12
1/30/12
2/14/12
2/29/12
3/15/12
3/30/12
4/14/12
Precipitation
SV-MW2-52
SV-MW2-100
SV-MW2-220
SV-MW2-409
SV-MW2-480
SV-MW2-SW

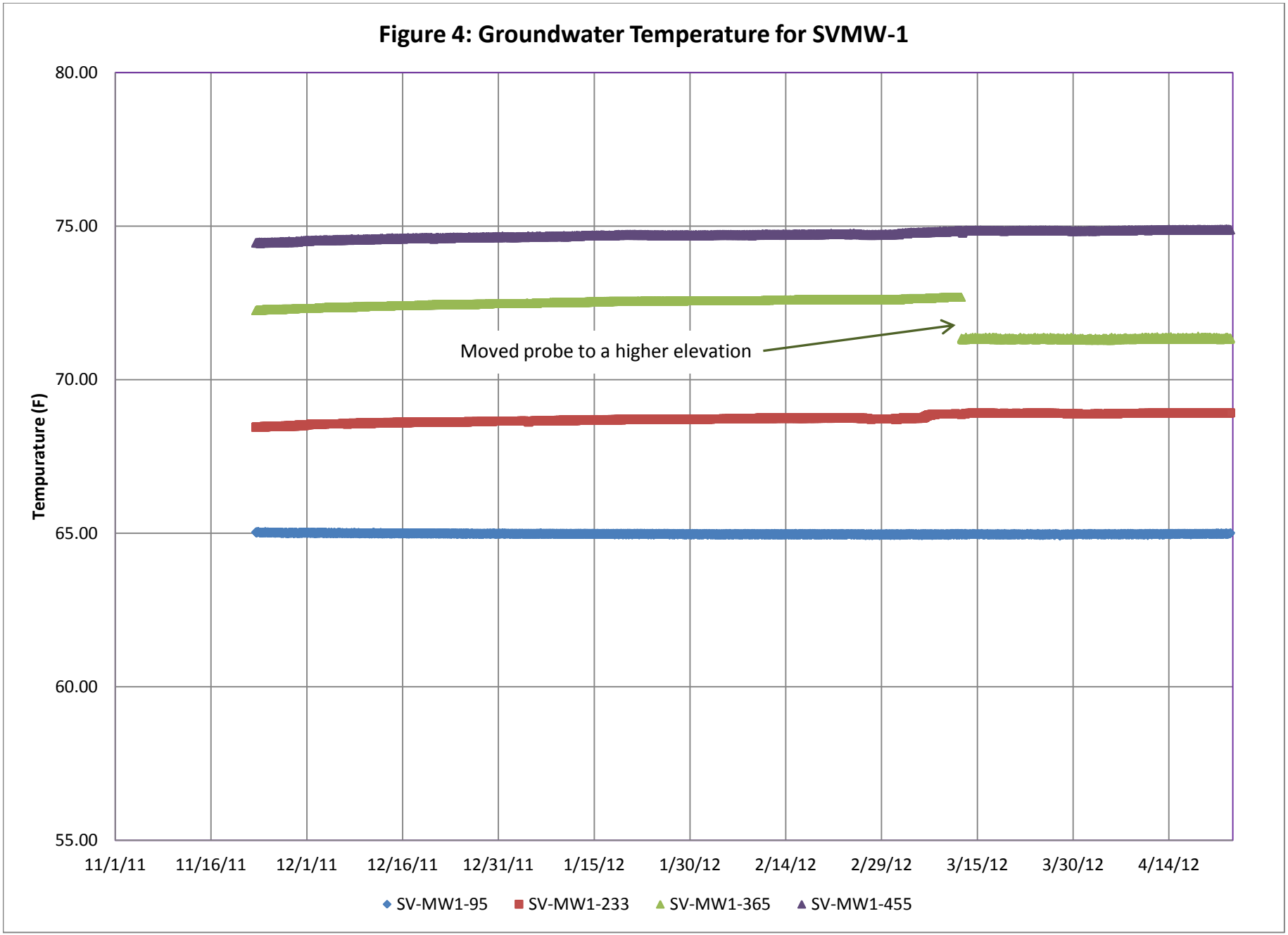
Figure 4: Groundwater Temperature for SVMW-1
80.00
75.00
70.00
65.00
60.00
55.00
Tempurature (F)
Moved probe to a higher elevation
11/1/11
11/16/11
12/1/11
12/16/11
12/31/11
1/15/12
1/30/12
2/14/12
2/29/12
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SV-MW1-95
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SV-MW1-365
SV-MW1-455

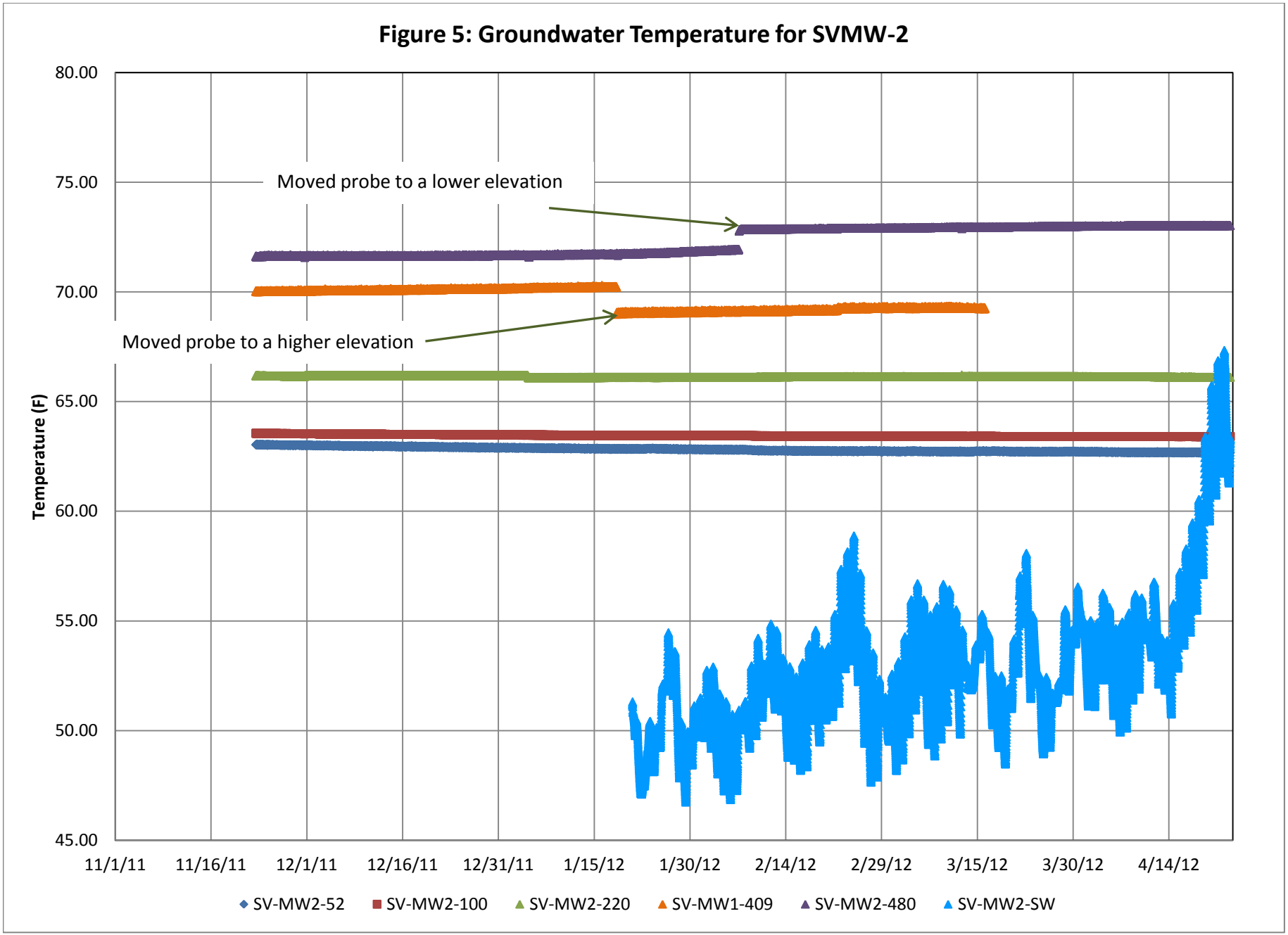
Figure 5: Groundwater Temperature for SVMW-2
80.00
75.00
70.00
65.00
60.00
55.00
50.00
45.00
Temperature (F)
Moved probe to a lower elevation
Moved probe to a higher elevation
11/1/11
11/16/11
12/1/11
12/16/11
12/31/11
1/15/12
1/30/12
2/14/12
2/29/12
3/15/12
3/30/12
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SV-MW2-480
SV-MW2-SW

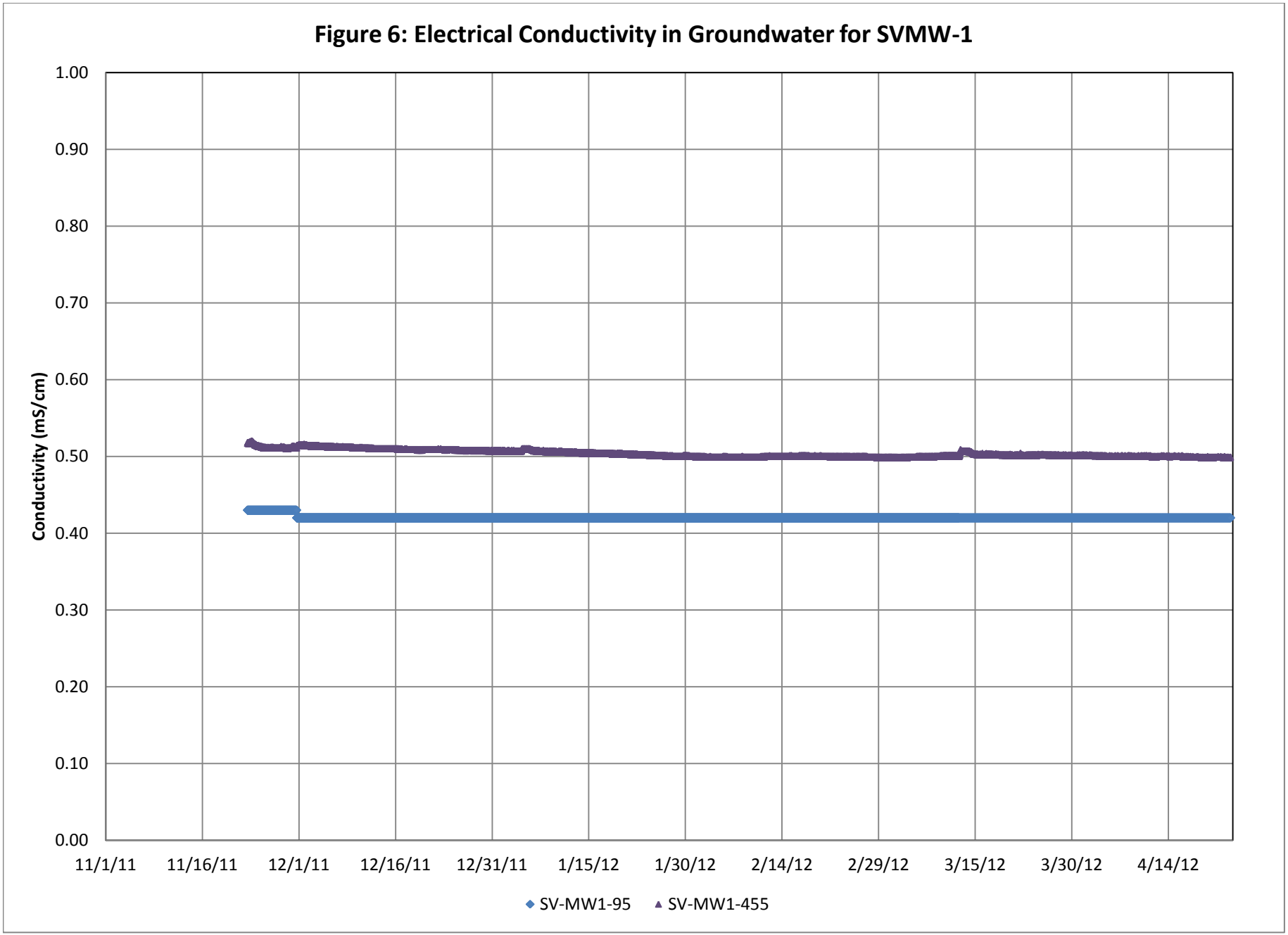
Figure 6: Electrical Conductivity in Groundwater for SVMW-1
Conductivity (mS/cm)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
11/1/11
11/16/11
12/1/11
12/16/11
12/31/11
1/15/12
1/30/12
2/14/12
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4/14/12
SV-MW1-95
SV-MW1-455

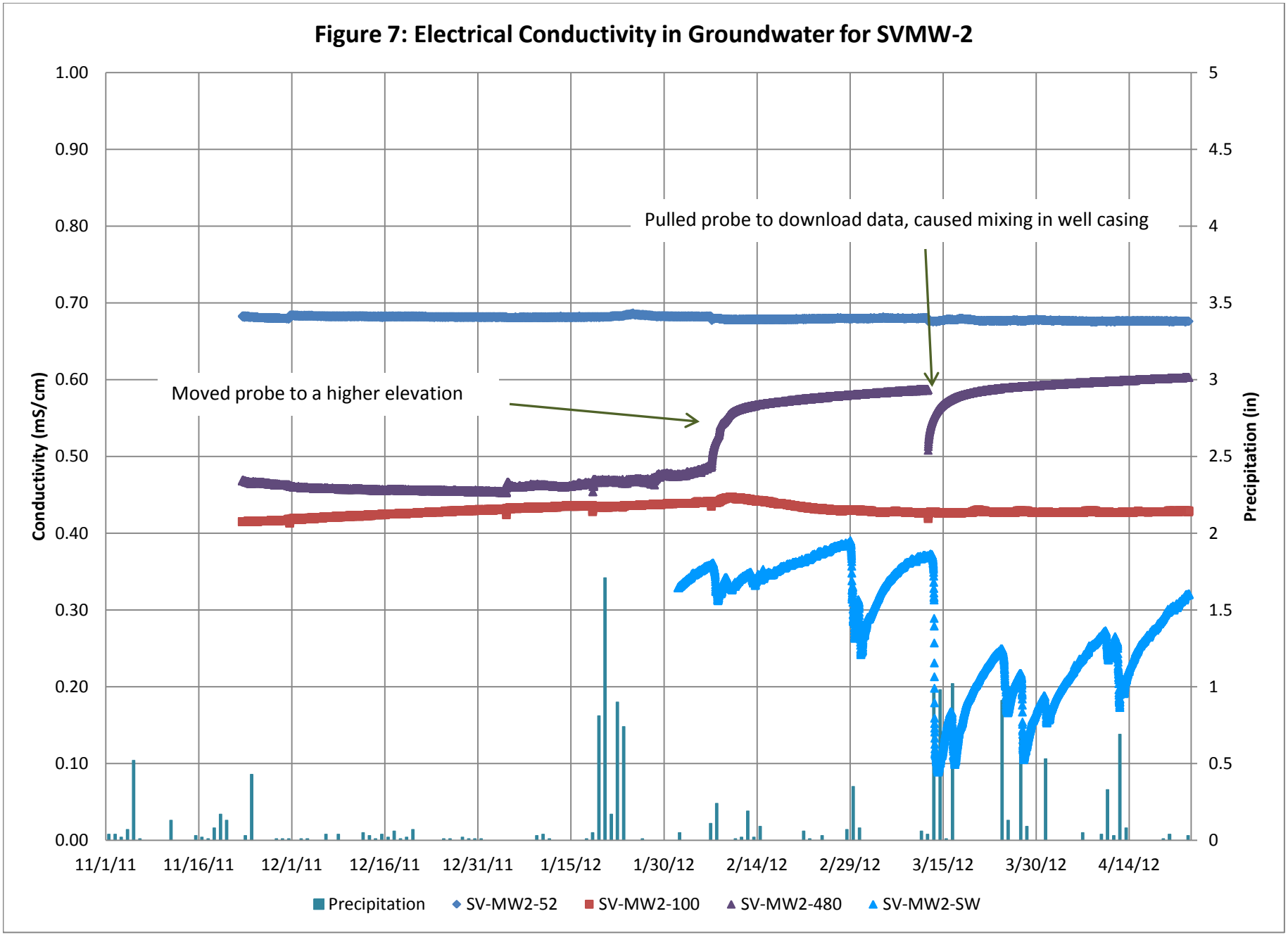


Figure 7: Electrical Conductivity in Groundwater for SVMW-2
Conductivity (mS/cm)
Precipitation (in)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
11/1/11
11/16/11
12/1/11
12/16/11
12/31/11
1/15/12
1/30/12
2/14/12
2/29/12
3/15/12
3/30/12
4/14/12
Pulled probe to download data, caused mixing in well casing
Moved probe to a higher elevation
Precipitation
SV-MW2-52
SV-MW2-100
SV-MW2-480
SV-MW2-SW

Figure 8: Trilinear Piper Plot

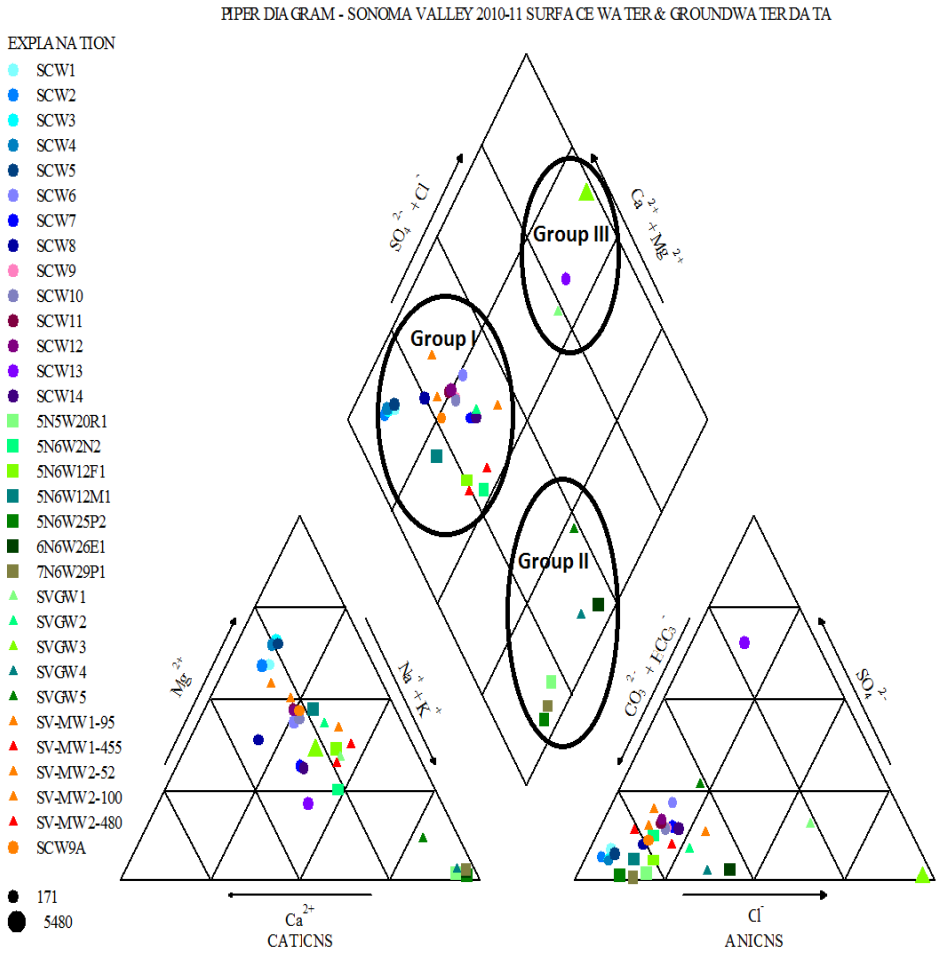
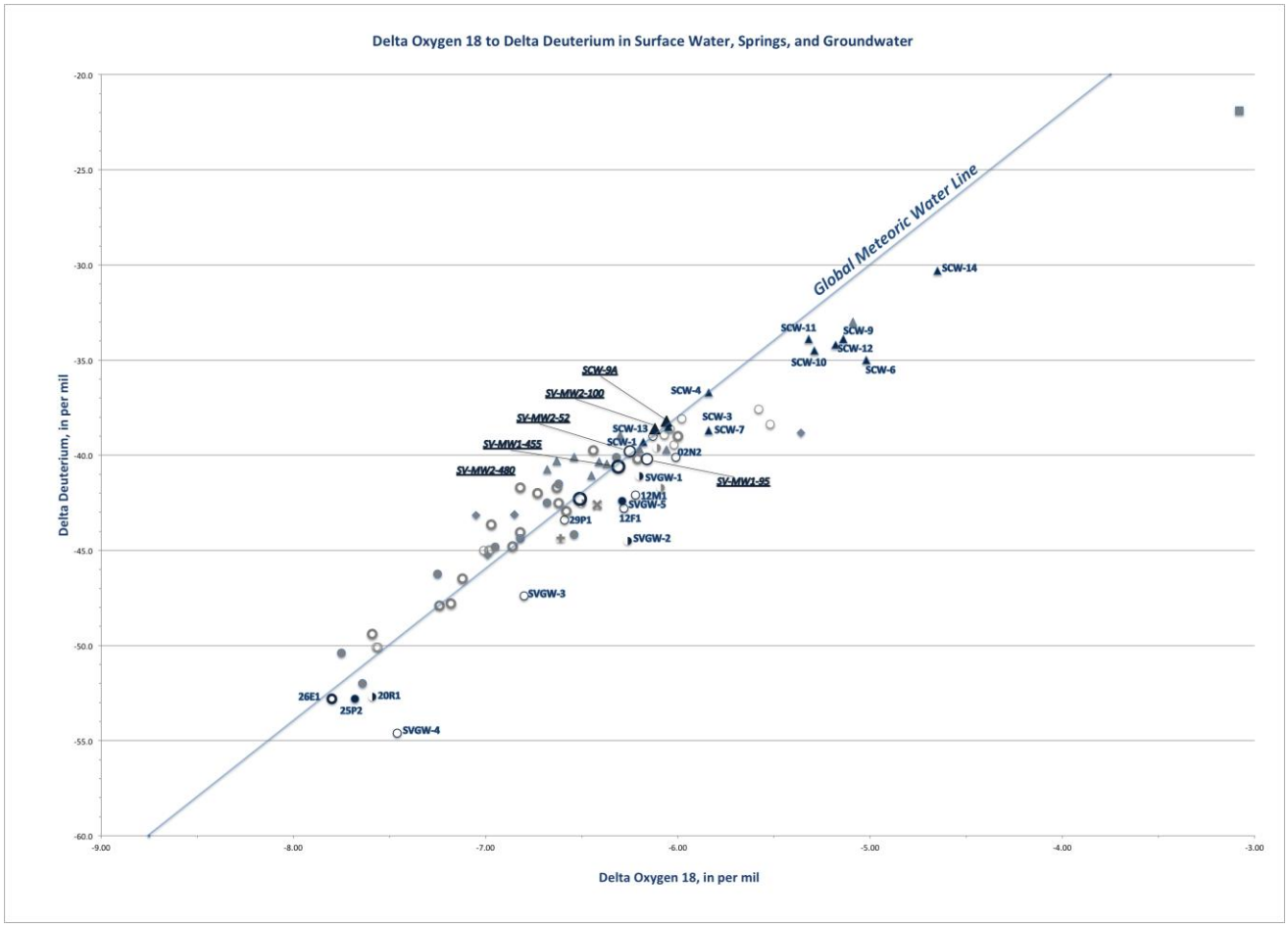


Figure 9: Stable Isotope Results – 2011 Surface Water and Groundwater Samples



Explanation

2006 USGS Study Samples
- ▲ Surface Water Sample
- ○ Well Depth Less Than 200 ft
- ○ Well Depth 200 -500 ft
- ● Well Depth Greater Than 500 ft
- ◗ Well Depth Unknown
- ◆ Spring Samples
- ✚ Imported Aqueduct Water
- ■ Napa-Sonoma Marshes
- ✖ Wastewater Treatment Plant Water

2010 Water Samples
- ▲ SCW-1 Surface Water Sample
- ○ 12F1 Well Depth Less Than 200 ft
- ○ 26E1 Well Depth 200-500 ft
- ● 25P2 Well Depth Greater Than 500 ft
- ◗ SVGW-2 Well Depth Unknown

2011 sample identifiers underlined and symbols are larger. 2010 samples include a sample identifier. 2006 USGS study sample identifiers are available in the 2006 Report.

APPENDIX B

BOREHOLE LITHOLOGIC & GEOPHYSICAL LOGS AND WELL CONSTRUCTION DIAGRAMS

COUNTY OF SONOMA

PERMIT AND RESOURCE MANAGEMENT DEPARTMENT

2550 VENTURA AVENUE, SANTA ROSA, CA 95403-2829
(707) 565-1900 FAX (707) 565-1103

Application Fees / Invoice for: WEL11-0056

Project Address: 1 TEST ST COU

Cross Street:

APN: 000-000-001

Description: MONITORING WELL IN THE RIGHT OF WAY OF WATMAUGH

Printed: March 14, 2011
Initialized by: CSTENLUN
Activity Type: B-WEL 1001
PCAS #:

Owner: PUBLIC JOHN Q
111 MAIN ST
ANYWHERE CA

Applicant: MAGGIORA BROS DRILLING INC
595 AIRPORT BLVD
WATSONVILLE CA
95076
831 724 1338

Fees:

Item#	Description	Account Code	Tot Fee	Prev. Pmts	Cur. Pmts
403	MONITORING WELLS	025015-1343	609.00	.00	.00
5403	MONITORING WELLS	025015-1343-	-609.00	.00	.00
			$0.00	$0.00	

Total Fees: $0.00
Total Paid: $0.00
Balance Due: $0.00

Refunds will not be authorized unless circumstances comply with established PRMD refund policy provisions.

When validated below, this is your receipt.

PAYMENT REC'D
$ 525 check 3/17-09
MAR 14 2011
PERMIT AND RESOURCE MANAGEMENT DEPARTMENT COUNTY OF SONOMA

Well Permit Application

WLS-031

WATMAUGH Rd. PM 11.80
Site Address

SONOMA CA 95476
City/Town State Zip

SONOMA COUNTY WATER AGENCY
Owner Name

404 AVIATION BLVD
Mailing Address

SANTA ROSA CA 95403
City/Town State Zip

707 547-1978
Phone

MARCUS TROTTA
Contact Person

Permit Number

Assessor's Parcel Number

Maggiora Bros. Drilling, Inc.
Well Driller Name

595 Airport Blvd.
Mailing Address

Watsonville, CA 95076
City/Town State Zip

249957
License Number

(831) 724-1338 (831) 724-3229
Phone Fax

The validity of this permit depends upon the accuracy of the information provided by the applicant. A site plan must accompany this application. In addition to the information required on the Minimum Standard Site Plan (Form CSS-019), the site plan shall also include the proposed well location, existing well(s) location(s), GPS coordinates of proposed well, sewer mains and laterals, and other potential sources of contamination. If an inadequate site plan is provided and a second field visit is required, a charge at the current hourly rate will be assessed. The precise site location of the proposed well must be staked with the driller's name.

INDICATE TYPE AND NUMBER OF PROPOSED WELLS/BORINGS:

Indicate use: ☐ Residential ☐ Community ☐ Irrigation ☐ Industrial

Reason for new well: GROUNDWATER MONITORING

☐ Destruct ☒ Class I Well ☐ Class II Well Reason for Class II: _____

[ ] Geotechnical Borings [ ] Geoexchange [X] Monitoring [ ] Cathodic [ ] Dewatering

[ ] Performance Well [ ] Piezometer [ ] Inclinometer [ ] Other: _____

Total number of wells on property: _____ Number in use: _____ Number inactive: 0 Number abandoned: 0

Well located within an existing public water system boundary: Yes ☐ No ☒ Name of System: _____

CONSTRUCTION PROPOSED:

Casing: Diameter: 3-inch Gauge: Sched 80 Material: PVC Gravel Pack ☐ Sand Pack ☒ Conductor: Yes ☒ No ☐

Multiple Nested Completion

Annular Space: Size: 2-inch Depth of Seal: 40 feet Seal Material: Neat Cement

Method of Disinfection: N/A Method of Sealing Access Opening: Locking Expandable plug Type of Joint: Threaded

DESTRUCTION PROPOSED: Well Diameter: _____ Well Depth: _____ Well Casing: _____

Method of Destruction: _____

WORKER'S COMPENSATION DECLARATION

I hereby affirm under penalty of perjury one of the following declarations:

☐ I have and will maintain a certificate of consent to self-insure for worker's compensation, as provided for by Section 3700 of the Labor Code, for the performance of the work for which this permit is issued.

☒ I have and will maintain worker's compensation insurance, as required by Section 3700 of the Labor Code, for the performance of the work for which this permit is issued. My worker's compensation insurance carrier and policy number are:

Carrier Seabright Ins.

Policy No. BB1183317

(This section need not be completed if the permit is for one hundred dollars ($100) or less).

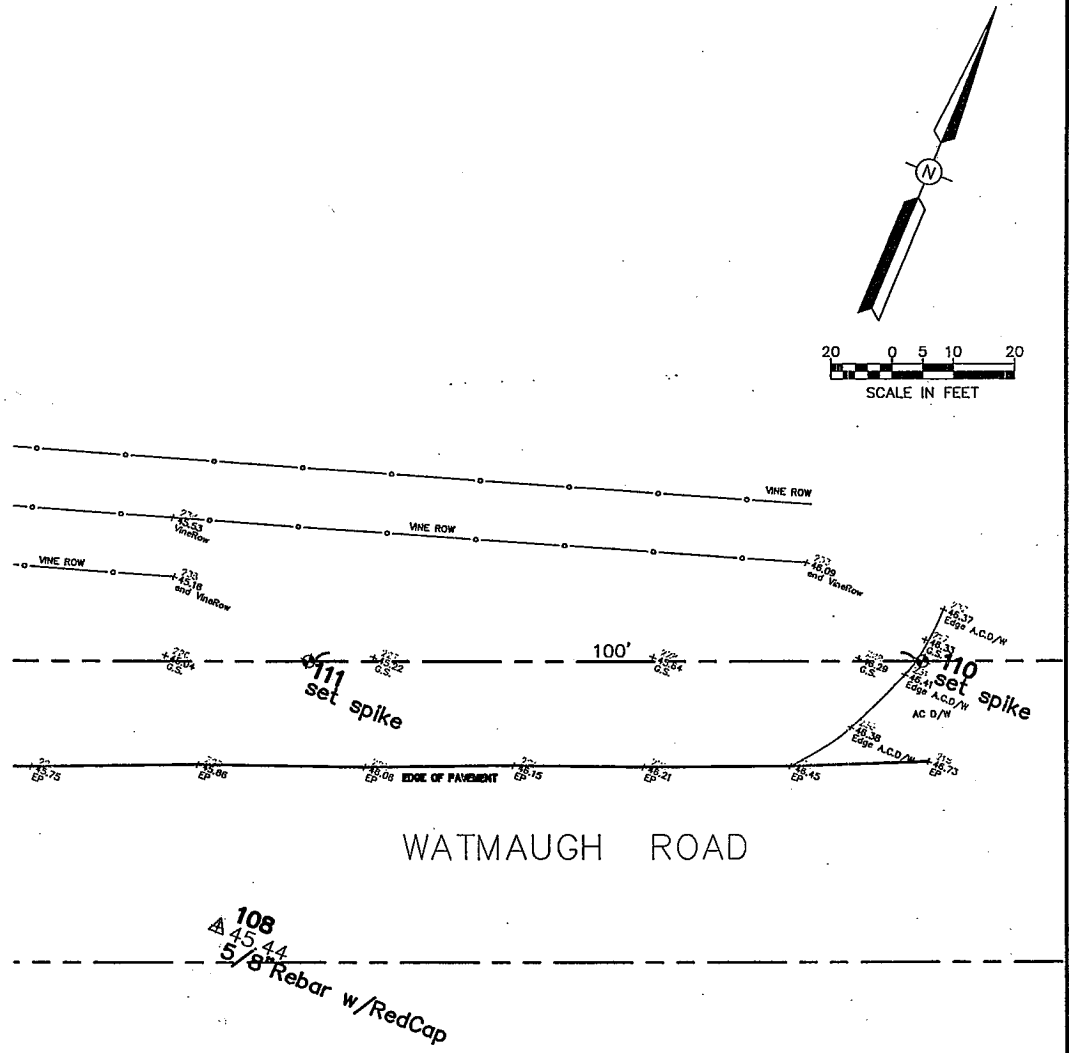
I hereby agree to comply with all laws and regulations of the County of Sonoma and State of California pertaining to water well construction. I will telephone (707) 565-6120 to notify the Environmental Health Specialist 24 hours prior to commencing this work. **I will furnish the Permit and Resource Management Department and the owner a copy of the State Well Completion Report within thirty (30) days in order to obtain final approval on this well as required by SONOMA COUNTY CODE, CHAPTER 25B.** I acknowledge that the application will become a permit only after site approval and payment of fee. I understand that this permit is not transferrable and expires one year from the date of issuance.

Signature of Well Driller [signature] Date 2/25/11

WARNING: FAILURE TO SECURE WORKER'S COMPENSATION COVERAGE IS UNLAWFUL, AND SHALL SUBJECT AN EMPLOYER TO CRIMINAL PENALTIES AND CIVIL FINES UP TO ONE HUNDRED THOUSAND DOLLARS ($100,000), IN ADDITION TO THE COST OF COMPENSATION, DAMAGES AS PROVIDED FOR IN SECTION 3706 OF THE LABOR CODE, INTEREST, AND ATTORNEY'S FEES.

DO NOT WRITE BELOW THIS LINE - To Be Completed by PRMD Staff

Site approved by:	Date:	Seal Inspection Date:	EHS
Finaled by:		Date:	GW Zone: 1 2 3 4
Comments			



P.M. 11.80

SONOMA VALLEY

SITE B (WEST)

PROPOSED MONITORING WELL LOCATION

PROJECT/TASK:	7287-01
DATE :	11/19/08
DRAWN BY:	EKM/JRM
CHECKED BY:	JRM
SHEET NO.	1 OF 1

REVISIONS

REV.	DATE	BY

SONOMA COUNTY WATER AGENCY

\\SD-Data\Survey\Land Projects\Sonoma Valley Well Monitoring\dwg\TestWellSites_PN7287.dwg

COUNTY OF SONOMA
PERMIT AND RESOURCE MANAGEMENT DEPARTMENT

2550 VENTURA AVENUE, SANTA ROSA, CA 95403-2829
(707) 565-1900 FAX (707) 565-1103

Encroachment Permit # ENC10-0286

To request an inspection, call (707) 565-3551 (5 days advance notice required)

County Road Name	Road Number	Postmile
WATMAUGH RD	5504	11.80

Plancheck Fee:	$0.00
Permit Fee:	$272.00
Inspection Fee:	$339.00
SUSMP Fee:	$28.00
NPDES Fee:	$39.00
Penalty Fee:	$0.00
Previously Paid:	.00
Additional Fee(s):	$0.00
Balance Due:	$0.00

Work Site Address: 1 TEST ST COU
Type of Activity: Miscellaneous
Parcel Number: 000-000-001
128-301-015 Issue Date: 12/21/2010
Project: MONITORING WELLS

To Expire: 12/20/2013

APPLICANT:
SONOMA COUNTY WATER AGENCY
404 AVIATION BLVD
SANTA ROSA CA 95403

707 526 5370

CONTRACTOR:
CONTRACTOR TO BE DETERMINED
THRU BID PROCESS
CONTRACTOR MUST COMPLY WITH
ALL CONDTIONS OF THIS PERMIT

License #

Contact: BERRY, FRED
547-1917

Bonding Co:	NEEDED PRIOR TO WORKING IN ROW	Bond #:	Exp. Date:
2nd Bond Co:		Bond #:	Exp. Date:
Insurance Co:	NEEDED PRIOR TO WORKING IN ROW	Policy #:	Exp. Date:

Permittee agrees to accept all responsibility for loss or damage to any person or entity and to indemnify, hold harmless, and defend and release County of Sonoma, its agents, and employees from and against any and all liability actions, claims, damages, costs, or expenses which may be asserted by any person or entity, including Permittee, arising out of or in connection with the willful act or negligence of Permittee performing the work associated with this Encroachment Permit, whether or not there is concurrent negligence on the part of the County, but excluding liability due to the sole active negligence or sole willful misconduct of County.

THE PERMITTEE AGREES THAT THE EVENT ACTIVITY WILL BE CONDUCTED IN ACCORDANCE WITH AND SUBJECT TO THIS PERMIT'S TERMS AND CONDITIONS, THE STATE VEHICLE CODE, THE STATE STREETS AND HIGHWAYS CODE AND IS SUBJECT TO INSPECTION AND APPROVAL.

This permit is to be strictly construed and no work other than that specifically mentioned below is authorized hereby. Whenever Engineer concludes persons performing encroachment work are not complying with the provisions of this permit, Engineer may revoke permit. Subject to all the terms, conditions and restrictions written hereon or attached hereto, permission is hereby granted Permittee to:

INSTALL NESTED GROUND MONITORING WELL AS PER ATTACHED WATER AGENCY PLANS, OFF THE PAVEMENT ON THE NORTH SIDE OF WATMAUGH ROAD, .08 MI WEST OF SONOMA CREEK, LOCATED IN SONOMA

ATTACHMENTS:
(X) Special Provisions
( ) Signing
( ) Standard Drawings
(X) Permit Plans
(X) Standard Conditions
(X) Backfill from Approved Source

COMPLETION CERTIFICATION

Permit
Inspected By:_____
Date

APPROVED: David R. Caldwell 12-20-2010
DeWayne Starnes
Deputy County Engineer
Date

Road Yard: SONOMA Area No. 22

Refunds will not be authorized unless circumstances comply with established PRMD refund policy provisions.

Special Provisions
Encroachment Permit # ENC10-0286

December 21, 2010

Permit # ENC10-0286 is issued subject to the following conditions:

1: WELL PERMITS FROM PRMD WELL AND SEPTIC REQUIRED PRIOR TO STARTING CONSTRUCTION

2: BONDING AND INSURANCE REQUIREMENTS TO BE MET PRIOR TO START OF ANY WORK IN RIGHT OF WAY

Standards for Construction Activity Within the County Road Right-of-Way

Note: Approval from PRMD Engineering Construction Inspection Staff must be granted prior to commencing any work in the County Right-of-Way. Approval shall be requested by scheduling a "Start Work Notice (Item 240)" using the automated inspection system at (707) 565-3551. Failure to obtain approval to start work will result in penalty fees and/or permit revocation.

I. General

a. *Acceptance of the terms of the encroachment permit*: It is understood and agreed by the Permittee that performance of any work authorized by the encroachment permit shall constitute acceptance of all of the terms, provisions, and conditions of the permit and its attachments. Failure to comply with any of terms, provisions, or conditions of the permit and its attachments may result in penalty fees, permit revocation, and/or direction to immediately cease work and vacate the County Road Right-of-Way.

b. *Standards*: Work shall comply with the latest edition of the State Specifications of the State of California Department of Transportation, County of Sonoma Transportation and Public Works Standards, or other standards and specifications as approved by the permit or its attachments.

c. *Control of Work*: All work and all materials used to complete the work authorized by the encroachment permit shall be subject to the inspection and approval of the Inspector. Such inspection and approval of the work and materials shall not relieve the Permittee of any of their obligations to complete the work in conformance with all applicable specifications. Work and materials not meeting these requirements shall be rejected. If determined to be unsuitable, work and materials may be rejected even if previously inspected and approved by the Inspector.

d. *Access to Work*: The Inspector shall have access to the work at all times to determine that the methods, materials and workmanship are in accordance with the terms of the encroachment permits and all applicable specifications. The Inspector may reject defective work and shall require its repair, replacement, or removal by the Permittee.

e. *Permit On-Site*: The encroachment permit and all of its attachments shall be kept at the job site and must be made immediately available to the Inspector or any law enforcement officer upon demand.

f. *Trench Permit*: The Permittee shall obtain a trench permit from the California Division of Industrial Safety prior to the excavation of any trench over five feet in depth.

g. *Other Authorization*: When required, it is the Permittee's responsibility to ensure that all approval(s) have been obtained by other required jurisdictions.

h. *Restoration of Right-of-Way*: Upon completion of the construction activity, the right-of-way shall be restored to as good as or better than its pre-construction condition. The permit shall not be finaled until the Inspector is satisfied that the right-of-way has been adequately restored It is the responsibility of the Permittee to photograph and/or video the right-of-way affected by the work prior to beginning construction, and to make available said photograph(s) and/or video(s) to the Inspector before commencing work. If no such photograph(s) and/or videos are available, the right-of-way shall be assumed to have been in good condition and shall be restored as directed by the Inspector.

i. *Storage of Material and Equipment*: Unless allowed by the Inspector, no material or equipment shall be stored within ten (10) feet from the edge of the traveled way.

j. *Approval of Work*: The inspector shall approve all work at the completion of each of the following stages of work and such approval must be obtained before subsequent stages of work may be commenced. The Permittee shall call the automated inspection system at (707) 565-3551 and use the codes provided on the green Engineering Division Permit Inspection Record (job card) to request inspection and/or approval to proceed.

1. Earthwork:
   Construction of embankments, excavations.
   Excavation for storm drains and culverts.
   Preparation of subgrade
   Back-filling of structures and pipes and public utilities.
2. Concrete work:
   Construction of forms, for all concrete structures, including curbs, gutters, and sidewalks.
   Placing of concrete in structures, including curbs, gutters, and sidewalks.
3. Drainage facilities:
   Placing of storm drains and culvert pipes.
   Construction of roadside ditches and other drainage ways
4. Roadway construction:
   Placing and compacting of base material. If more than one course or type of base or sub-base is to be used, approval shall be necessary for each course and/or type.
   Placing of pavement or surfacing.
5. Final clean-up.

k. *Additional Work or Facilities*: The Inspector may require additional work or facilities in the course of the construction of the project in order for the improvements to reasonably provide for the intended function or for public safety.

l. *Maintenance and Repair*: The Permittee agrees by the acceptance of the encroachment permit to exercise reasonable care in properly maintaining any encroachment placed by the Permittee. The Permittee shall exercise reasonable care in inspecting and immediately repairing any damage to any portion of the road right-of-way which occurs as a result of the work done under the encroachment permit. If the Permittee does not repair existing road facilities, County crews may perform the repair work at their cost plus 100% for administration and overhead. The Permittee is responsible for paying the County for these costs within 30 days of receipt of invoice from the County.

m. *Permit Revocation*: All encroachment permits are subject to revocation for failure to comply with the any of the conditions contained herein, or as deemed necessary by the Inspector for the protection of public safety or the protection of the County road right-of-way.

n. *Future Removal or Relocation*: In the event of the future improvement of the County road right-of-way necessitating the relocation or removal of the encroachment(s) permitted herein, the permittee shall relocate or remove the same at their sole expense. In such event, written notice shall be served on the permittee specifying the work required and specifying a time within which the work of relocation or removal shall be commenced and completed.

o. *Conflicting Construction*: When this permit authorizes work that occurs in the vicinity of a County

project, the work conducted under this permit shall be coordinated with the Sonoma County Department of Transportation and Public Works so as not to cause any conflict with said County project, or the encroachment permit shall be revoked.

p. *Ownership of Land in County Road Right-of-Way*: In many instances, the County does not own the underlying fee of the land in the County road right-of-way; its interest is limited to an easement only. In all such cases, it is the responsibility of the Permittee to obtain the consent of the owner or owners of the underlying fee before undertaking any below surface operations. (Note: Public Utility companies are afforded certain underground rights in the public road right-of-way by State law.)

q. *Underground Service Alert (U.S.A.) Notification*: The Permittee shall be responsible for notifying U.S.A. Call toll-free (800) 642-2444 at least two working days prior to excavation. The Permittee shall uncover existing buried utilities with utility owner to verify locations and elevations of utilities. Buried utilities include but are not limited to: water, sewer, electrical, gas, cable, and telephone.

r. *Cultural Resources*: In the event cultural resources (i.e., historical, archaeological, and paleontological resources and human remains) are discovered during grading or other construction activities, work shall be halted within a 100 foot radius of the find. The Northwest Information Center shall be notified at (707) 664-0880. A qualified archeologist shall be consulted for an on-site evaluation. Additional mitigation may be required by the County per the archeologist's recommendations. If human burials or human remains are encountered, the contractor shall also notify the County Coroner at (707) 565-5070.

s. *Hazardous Materials*: Should hazardous materials, or apparent hazardous materials, be discovered during the course of work, work in the affected area shall be stopped immediately. Emergency Services, or the appropriate agency, and the Inspector shall be immediately notified.

t. *Existing Striping and Pavement Markings*: All existing striping and pavement markings disturbed by construction activity shall be replaced in kind and shall be approved by the Encroachment Inspector or by the Sonoma County Traffic Engineering Department Inspector.

u. *Existing Public Signs*: Relocation or removal of existing public signs shall not occur until approval has been obtained by the Inspector.

v. *Precedent*: This permit is granted with the understanding that this action is not to be considered as establishing any precedent on the expediency of permitting or establishing any precedence on the permitting of a certain kind of encroachment within the County road right-of-way.

w. *Conflict with Approved Plans*: If this permit contains a set of approved Encroachment plans and a conflict exists between the approved plans and these notes, the more restrictive shall prevail, or the Inspector may determine which is appropriate.

II. Liability

a. *Liability for Damages*: Permittee agrees to accept all responsibility for loss or damage to any person or entity and to indemnify, hold harmless, and defend and release the County of Sonoma, its agents and employees of and against any and all liability, actions, claims, damages, costs or expenses which may be asserted by any person or entity, including Permittee, arising out of or in connection with the willful act or negligence of Permittee performing the work associated with this Encroachment Permit, whether or not there is concurrent negligence on the part of the County.

III. Traffic Control

a. *Traffic Control Plan*: Permittee shall provide and install all traffic control devices per the CA Supplement to the Manual of Uniform Traffic Control Devices (CA MUTCD) Typical Applications, or as otherwise required on the approved traffic control plan issued as an attachment to the encroachment permit.

b. *Traffic Control Approval*: No construction activity shall commence until traffic control at the job site has been approved by the Inspector.

c. *Other Authorization*: Where applicable, the Permittee shall obtain approval from any other jurisdictions necessary to place traffic control devices in their rights-of-way, or shall obtain permission from any applicable entity for the placement of traffic control devices outside of the County of Sonoma's right-of-way.

d. *Lane of Travel*: One ten foot (10') wide lane shall be kept open at all times, unless otherwise approved by the Inspector or permitted by the approved traffic control plan.

e. *Flaggers*: Flaggers shall be required per the CA MUTCD, the approved traffic control plan, or at the Inspector's discretion as necessary to protect public safety.

f. *Pedestrians and Cyclists*: Permittee shall provide for and protect pedestrian and cyclist traffic per the CA MUTCD Typical Applications, the approved traffic control plan, or per the Inspector's direction. Where pedestrian or cyclist traffic is permitted to pass through the work zone, the Permittee shall provide them an appropriate escort.

IV. Backfill and Paving

a. *Trench Backfill and Paving*: All trenching in the right-of-way shall conform to Sonoma County Transportation and Public Works Standard Drawing 219, unless otherwise specified on the encroachment permit, the attached approved plans, or as otherwise approved by the Inspector.

b. *Trench Stability*: If the trench is not stable, remedial work may be required and the Permittee shall be responsible for submitting a proposal to address any unstable trench conditions.

c. *Compaction Testing*: The Permittee shall hire individuals certified to perform testing in accordance with Caltrans' test method No. 216 Part II or ASTM 1557, and shall provide those test results to the Inspector. As an alternative to testing, the use of the County approved cement backfill (also known as CDF or CLSM) shall be used.

d. *Compaction Requirements*: The subgrade, Class II Aggregate Base, and AC shall be compacted to 95% relative compaction.

e. *Minimum Depths*: Underground utilities shall be located per the utility company or agency's standards, but in no case shall they be located any shallower than is allowed by Sonoma County Transportation and Public Works Standard Drawing 219.

f. *Driveway Trench Crossings*: Trench backfill within driveway crossings shall conform to Sonoma County Transportation and Public Works Standard Drawing 804.

g. *Temporary Patching*: Any trench within the paved roadway left without final paving shall have cold patch material added at the end of each day. The Permittee, at their expense, shall continually maintain the cold patch, as directed by the Inspector, until the final pavement is placed. Temporary paving shall be completely removed prior to the final paving.

h. *Paving Provisions*: Permittee shall restore the roadway to as good as or better than its pre-construction condition, as noted in the following:

1. The Permittee shall restore the roadway to its pre-construction condition. Any pavement cracked, broken or damaged by the Permittee during construction shall be replaced or repaired to the satisfaction of the Inspector. This requirement does not preclude the overlaying (in kind) of the entire roadway if deemed necessary by the Inspector.

2. The Permittee shall remove a minimum of 18 inches of existing asphalt between the edge of the trench and the existing edge of pavement or between the edge of the trench and existing lip of the gutter before placing the new asphalt.

i. *Liquid Anti-Stripping Agent (LAS)*: LAS shall be added to the asphalt binder at a rate of 0.5% by weight of asphalt binder. The LAS shall be AD-here LOF 65-00 or equivalent, and shall be stored, measured, and blended with the asphalt binder in accordance with the anti-stripping agent manufacturer's recommended practice. The LAS can be added at the asphalt plant or at the refinery. When added at the asphalt plant, the equipment shall indicate and record the amount of LAS added. If added at the refinery, the shipping ticket from the refinery shall certify the type and amount of LAS added.

j. *Final Paving*: Unless otherwise approved by the Inspector, final paving shall be applied no later than ten (10) working days after traffic is allowed to pass over the work area.

V. Work Hours

a. *Work Hours*: Work shall generally be permitted from 7:00AM - 7:00PM, but shall not begin earlier than one half hour after sunrise or end later than one half hour before sunset, unless otherwise noted in the special conditions of the encroachment permit or as approved by the Inspector.

b. *Weekends, Nights, and Holidays*: No work shall be performed during weekends, nights, or holidays unless authorized by the Inspector or the special conditions of the encroachment permit.

VI. Public Safety

a. *Excavations*: In addition to any other measures taken by the Permittee pursuant to the provisions of the Standard Specifications, Section 7-1.09, "Public Safety", the Contractor shall install temporary K-railing between any lane carrying public traffic and any excavation when the near edge of the excavation is 12 feet (12') or less from the edge of the lane, except for:

1. Excavations covered with non-skid steel plates of adequate thickness to prevent accidental entry by traffic or the public.
2. Excavations less than one foot (1') deep.
3. Trenches less than one foot (1') wide for irrigation pipe or electrical conduit or excavations less than one foot (1') in diameter.
4. Excavations in side slopes where the slope is less than 4:1.
5. Excavations protected by an existing barrier or K-railing.

b. *Elevation of Pavement*: At the end of each working day if a difference in excess of 0.15 feet exists between the elevation of the existing pavement and the elevation of any excavation within 8 feet of the traveled way, material shall be placed and compacted against the vertical cuts adjacent to the existing pavement at a maximum 4:1 slope.

c. *Trench Plates*: Trench plates placed in areas whereupon vehicles will travel shall be non-skid steel plates and shall be secured with temporary asphaltic concrete and/or pins as necessary to the Inspector's satisfaction.

VIII. Drainage

a. *Care of Drainage*: Drainage shall not be impaired. If the work permitted herein interferes with drainage, the Permittee shall make ample accommodations as necessary to satisfy the Inspector.

b. *Maintenance of Drainage*: The Permittee shall maintain drainage throughout the work area. Such maintenance shall include, but is not limited to, keeping all culverts and inlets clean and open.

IX. Removal or Trimming of Roadside Trees

a. *Removal of Trees*: When a permit is issued for removal of a tree, as part of the project, the entire stump shall be taken out to a depth of at least two feet (2') below the ground surface, unless otherwise specified in the permit. The hole left by the stump shall be backfilled, and compacted. The site shall be approved by the Inspector.

b. *Trimming of Trees*: Tree trimming shall be limited to branches up to two inches (2") in diameter unless other specified by the permit. Scars resulting from trimming shall be appropriately treated.

X. Erosion Prevention and Sediment Control

a. Perform erosion prevention and sediment control in accordance with Chapter 11 Grading, Drainage, and Vineyard and Orchard Site Development.

b. Work shall conform to the erosion prevention and sediment control best management practices contained in the latest editions of the following publications or an equivalent best management practice:

Erosion and Sediment Control Field Manual, San Francisco Bay Regional Water Quality Control Board
Manual of Standards for Erosion & Sediment Control Measures, Association of Bay Area Governments
Construction Site Best Management Practices Manual, Caltrans
Stormwater Best Management Practice Handbook, CA Stormwater Quality Association.

c. If discrepancies occur between these notes, material referenced herein or manufacturer's recommendations, then the most protective shall apply.

d. The Permittee is responsible for obtaining and complying with the National Pollutant Discharge Elimination System (NPDES) General Permit No. Cas000002 Waste Discharge Requirements for discharges of storm water runoff associated with construction activity disturbing land equal to or greater than one acre. Construction activities include but are not limited to clearing, grading, excavation, stockpiling, and reconstruction of existing facilities involving removal and replacement.

e. Preservation of existing vegetation shall occur to the maximum extent practicable.

f. The Permittee is responsible for preventing storm water pollution generated from the construction site year round. The owner must implement an effective combination of erosion prevention and sediment control on all disturbed areas during the rainy season (October 15 - April 15).

g. Erosion prevention and sediment control measures shall be inspected by the Permittee before forecasted storm events and after actual storm events to ensure measures are functioning properly. Storm events produce at least 1 inch of precipitation in a 24 hour period. Erosion prevention and sediment control measures that have failed or are no longer effective shall be promptly replaced. Erosion prevention and sediment control measures shall be maintained until disturbed areas are stabilized.

h. Changes to the erosion prevention and sediment control plan may be made to respond to field conditions. Changes shall be noted on the plan when made.

i. Discharges of potential pollutants from construction sites shall be prevented using source controls to the maximum extent practicable. Potential pollutants include but are not limited to: sediment, trash, nutrients, pathogens, petroleum hydrocarbons, metals, concrete, cement, asphalt, lime, paint, stains, glues, wood products, pesticides, herbicides, chemicals, hazardous waste, sanitary waste, vehicle or equipment wash water and chlorinated water.

j. Entrance(s) to the construction site shall be maintained in a condition that will prevent tracking or flowing of potential pollutants offsite. Potential pollutants deposited on paved areas within the County road right-of-way, such as roadways and sidewalks, shall be properly disposed of at the end of each working day or more frequently as necessary.

k. Exposed slopes shall be protected by using erosion prevention measures to the maximum extent practicable, such as establishing 70% vegetation coverage, hydroseeding, straw mulch, geotextiles, plastic covers, blankets or mats.

l. Hydroseeding shall be conducted in a three step process. First, evenly apply seed mix and fertilizer to the exposed slope. Second, evenly apply mulch over the seed and fertilizer. Third, stabilize the mulch in place.

Applications shall be broadcasted mechanically or manually at the rates specified below. Seed mix and fertilizer shall be worked into the soil by rolling or tamping. If straw is used as mulch, straw shall be derived from wheat, rice or barley and be approximately 6 to 8 inches in length. Stabilization of mulch shall be done hydraulically by applying an emulsion or mechanically by crimping or punching the mulch into the soil. Equivalent methods and materials may be used only if they adequately promote vegetation growth and protect exposed slopes.

Materials	Application Rate (Pounds per Acre)
Seed Mix	
Bromus mollis (Blando Brome)	40
Trifolium hirtum (Hykon Rose Clover)	20
Fertilizer	
16-20-0 & 15% Sulphur	500
Mulch	
Straw	4000
Hydraulic Stabilizing (Non-asphaltic, derived from plants)	
M-binder or Sentinel	75-100
Equivalent Material	Per Manufacturer

m. Whenever it is not possible to utilize erosion prevention measures, exposed slopes shall employ sediment control devices, such as fiber rolls and silt fences. Fiber rolls and silt fences shall be trenched and keyed into the soil and installed on contour. Silt fences shall be installed approximately 2 to 5 feet from toe of slope.

n. The Permittee shall protect storm drain inlets from potential pollutants until drainage conveyance systems are functional and construction has been completed.

o. Energy dissipaters shall be installed at storm drain outlets which may convey storm water flow leading to soil erosion.

p. Soil and material stockpiles shall be properly protected to minimize sediment and pollutant transport from the construction site.

q. Solid waste, such as trash, discarded building materials and debris, shall be placed in designated collection areas or containers. The construction site shall be cleared of solid waste daily, or as necessary, and regular removal and proper disposal shall be arranged.

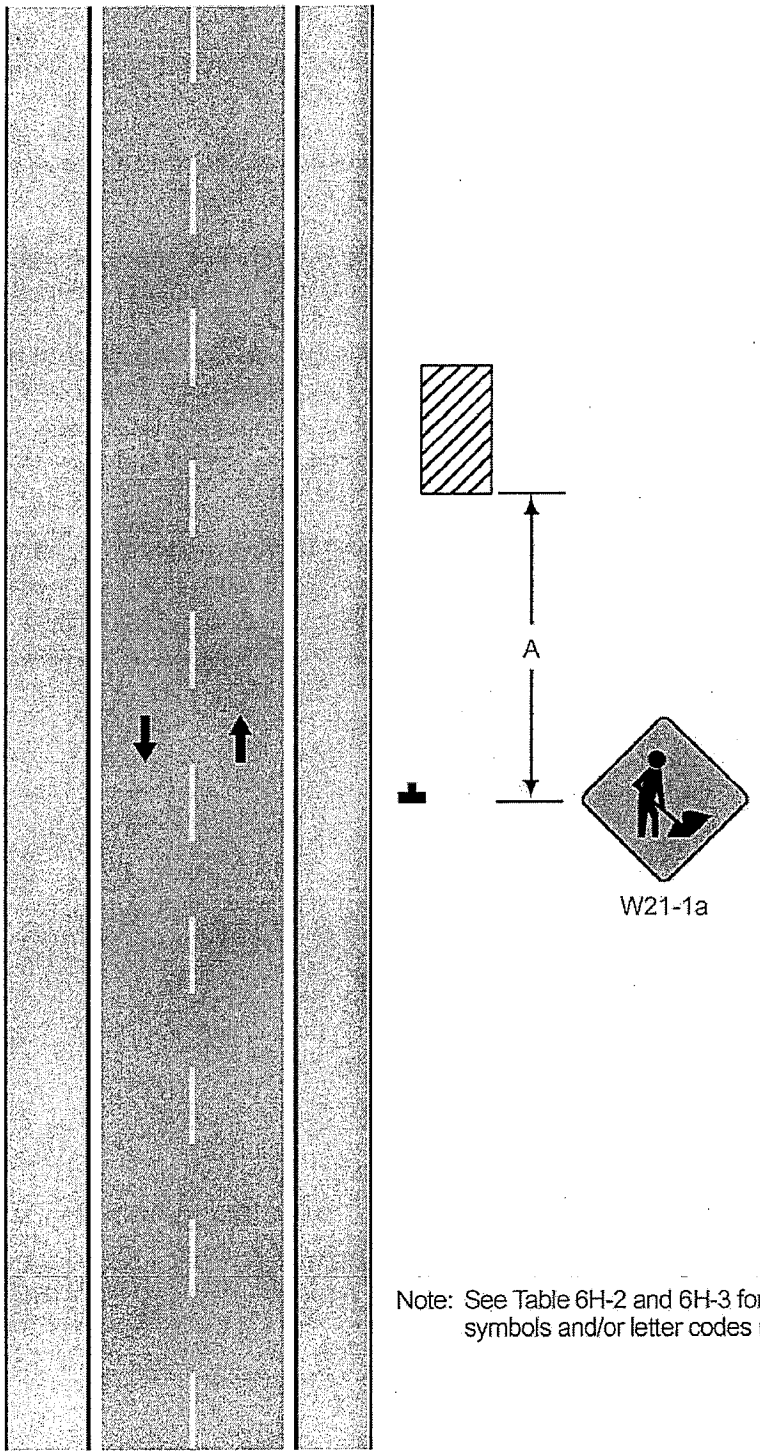
r. A concrete washout area, such as a temporary pit, shall be designated to clean concrete trucks and tools. At no time shall concrete products and waste be allowed to enter county waterways such as creeks or storm drains.

s. Proper application, cleaning and storage of potentially hazardous materials, such as paints and chemicals, shall be conducted to prevent the discharge of pollutants.

t. When utilized, temporary restrooms and sanitary facilities shall be located and maintained to prevent the discharge of pollutants.

u. Appropriate vehicle storage, fueling, maintenance and cleaning areas shall be designated and maintained to prevent discharge of pollutants.

Figure 6H-1 (CA). Work Beyond the Shoulder (TA-1)



Note: See Table 6H-2 and 6H-3 for the meaning of the symbols and/or letter codes used in this figure.

Typical Application 1

APPENDIX A

WELL CONSTRUCTION AND ENCROACHMENT PERMITS

Project: Sonoma Valley Monitoring Well #1

Location: 22333 Eighth Street East, Sonoma, CA

Drilling Contractor: Maggiora Bros. Drilling **Well Installation Date:** 6/28/2011 to 7/5/2011

Drilling Method: Mud Rotary **Coordinates:** UTM NAD83, Zone 10N, meters

Hole Size: 8.75" **Lat:** 38.2555 **Long:**-122.4422 **Surface Elevation:** 24 Ft

Drill Date: 6/1/2011 to 6/6/2011 **Geophysical Logging Contractor:** Norcal Geophysical

State of California
Department of Water Resources
North Central Region Office
Geology and Groundwater
Investigations Section

As-Built Well Details

Well ID	Screen Interval
05N05W29D001M	85-95 FT
05N05W29D002M	223-233 FT
05N05W29D003M	355-365 FT
05N05W29D004M	440-455 FT

Depth (ft.)

Lithologic Descriptions

Logged By: Mark Nordberg, Steven Springhorn

USCS Field Classification

Natural Gamma Ray 0 (API) 150

Resistivity 16" 0 (ohm-m) 50

Resistivity 16" 0 (ohm-m) 50

Spontaneous Potential -150 (10mV/div) -100

Resistivity 64" 0 (ohm-m) 50

Conductor casing present (interval not logged).

Well graded gravel with sand; very dark gray (10YR 3/1); gravel up to 8 mm with coarse sand; subangular to rounded; grains consist of volcanic and metamorphic rock fragments, trace amount of chert and white quartz, trace amount of sandstone clasts.

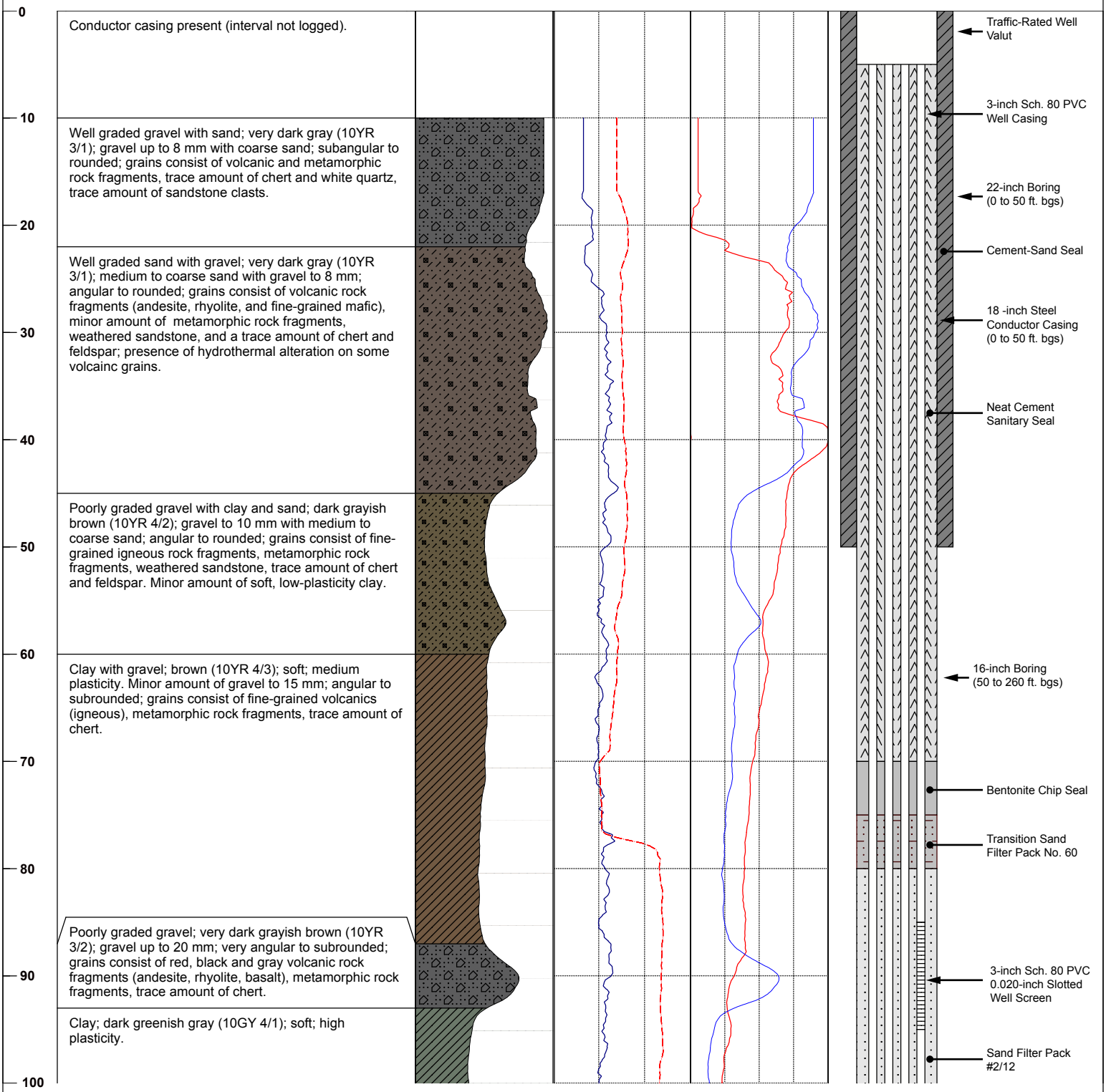
Well graded sand with gravel; very dark gray (10YR 3/1); medium to coarse sand with gravel to 8 mm; angular to rounded; grains consist of volcanic rock fragments (andesite, rhyolite, and fine-grained mafic), minor amount of metamorphic rock fragments, weathered sandstone, and a trace amount of chert and feldspar; presence of hydrothermal alteration on some volcanc grains.

Poorly graded gravel with clay and sand; dark grayish brown (10YR 4/2); gravel to 10 mm with medium to coarse sand; angular to rounded; grains consist of fine-grained igneous rock fragments, metamorphic rock fragments, weathered sandstone, trace amount of chert and feldspar. Minor amount of soft, low-plasticity clay.

Clay with gravel; brown (10YR 4/3); soft; medium plasticity. Minor amount of gravel to 15 mm; angular to subrounded; grains consist of fine-grained volcanics (igneous), metamorphic rock fragments, trace amount of chert.

Poorly graded gravel; very dark grayish brown (10YR 3/2); gravel up to 20 mm; very angular to subrounded; grains consist of red, black and gray volcanic rock fragments (andesite, rhyolite, basalt), metamorphic rock fragments, trace amount of chert.

Clay; dark greenish gray (10GY 4/1); soft; high plasticity.



Project: Sonoma Valley Monitoring Well #1

Location: 22333 Eighth Street East, Sonoma, CA

Drilling Contractor: Maggiora Bros. Drilling **Well Installation Date:** 6/28/2011 to 7/5/2011

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State of California
Department of Water Resources
North Central Region Office
Geology and Groundwater
Investigations Section

As-Built Well Details

Well ID	Screen Interval
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05N05W29D003M	355-365 FT
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Depth (ft.)

Lithologic Descriptions

Logged By: Mark Nordberg, Steven Springhorn

USCS Field Classification

Resistivity 16" 0 (ohm-m) 50

Natural Gamma Ray 0 (API) 150

Spontaneous Potential -150 (10mV/div) -100

Resistivity 16" 0 (ohm-m) 50

Resistivity 64" 0 (ohm-m) 50

100
110
120
130
140
150
160
170
180
190
200

Clay; dark greenish gray (10GY 4/1); very soft; high plasticity.

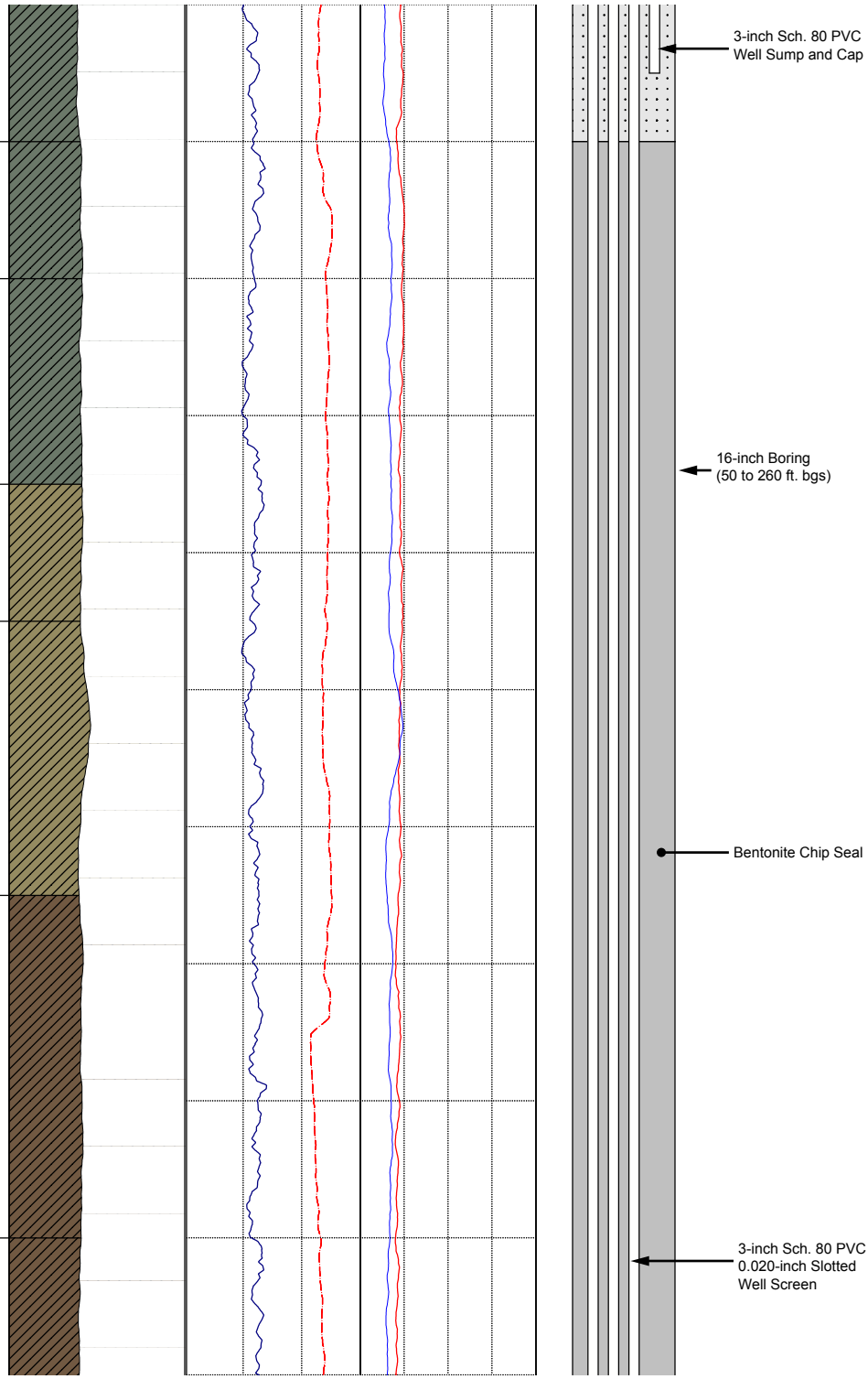
Clay; greenish gray (10Y 5/1) with yellowish brown (10YR 5/4); soft to very soft; high plasticity.

Clay; light olive brown (2.5Y 5/3) and greenish gray (5BG 5/1); very soft to soft; high plasticity.

Clay with sand; light olive brown (2.5Y 5/3) with greenish gray (5BG 5/1); very soft to soft; high plasticity. Trace amount of fine to medium sand; grains consist of metamorphic rock fragments, clear quartz, and trace amount of red and gray volcanic rock fragments.

Clay; brown (10YR 5/3) with bluish gray (5B 5/1); very soft; high plasticity

Clay with gravel; brown (10YR 5/3) with bluish gray (5B 5/2); very soft to soft; high plasticity. Minor amount of gravel to 10 mm; angular to subrounded; grains consist of fine-grained volcanics (igneous),metamorphic rock fragments, trace amount of weathered feldspar.



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05N05W29D002M	223-233 FT
05N05W29D003M	355-365 FT
05N05W29D004M	440-455 FT

Depth (ft.)

Lithologic Descriptions

Logged By: Mark Nordberg, Steven Springhorn

USCS Field Classification

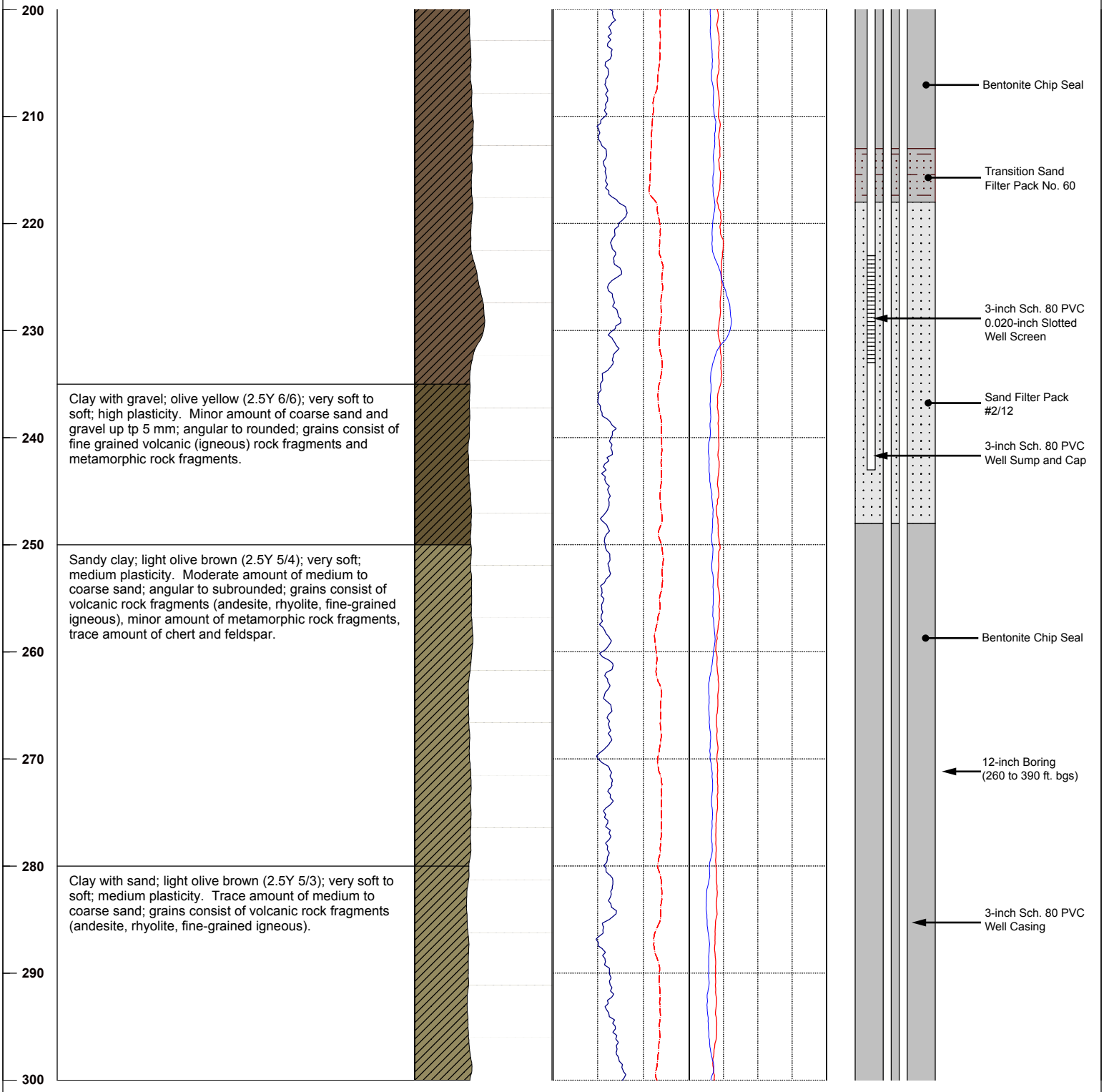
Natural Gamma Ray 0 (API) 150

Resistivity 16" 0 (ohm-m) 50

Resistivity 16" 0 (ohm-m) 50

Spontaneous Potential -150 (10mV/div) -100

Resistivity 64" 0 (ohm-m) 50



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05N05W29D002M	223-233 FT
05N05W29D003M	355-365 FT
05N05W29D004M	440-455 FT

Depth (ft.)

Lithologic Descriptions

Logged By: Mark Nordberg, Steven Springhorn

USCS Field Classification

Natural Gamma Ray 0 (API) 150

Resistivity 16" 0 (ohm-m) 50

Resistivity 16" 0 (ohm-m) 50

Spontaneous Potential -150 (10mV/div) -100

Resistivity 64" 0 (ohm-m) 50

300

Clayey sand; olive brown (2.5Y 4/4); medium to coarse with occasional gravel; subangular to subrounded; grains consist of weather volcanic rock fragments (andesite, rhyolite, fine-grained igneous). Moderate amount of soft, medium plasticity clay.

310

Clay; olive (5Y 5/4) and greenish gray (10GY 5/1); very soft to soft; high plasticity.

320

330

Clay with sand; olive (5Y 5/3); soft; high plasticity. Minor amount of fine to coarse sand; subangular to rounded; grains consist of weathered volcanic rock fragments (red andesite, white to reddish-white rhyolite, and black and gray aphanitic igneous).

340

350

Silty clay with sand; very dark greenish gray (10GY 3/1); soft; high plasticity. Moderate amount of silt. Minor amount of medium to coarsse sand; subangluar to rounded; grains consist of volcanic (rhyolite, andesite, and mafic) rock fragments; presence of stiff silt chips.

360

Silty clay with sand; very dark greenish gray (10GY 3/1); soft; high plasticity. Moderate amount of silt. Minor amount of medium to coarse sand with gravel; subangluar to rounded; grains consist of volcanic (rhyolite, andesite, and mafic) rock fragments; presence of stiff silt chips.

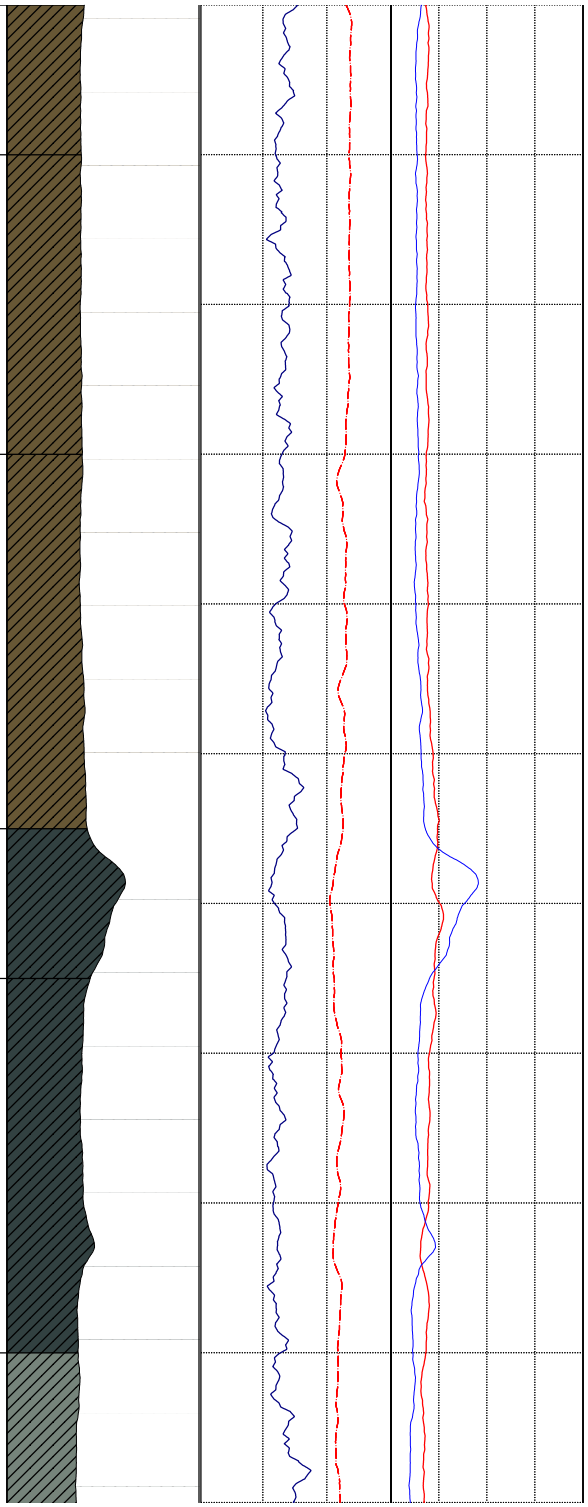
370

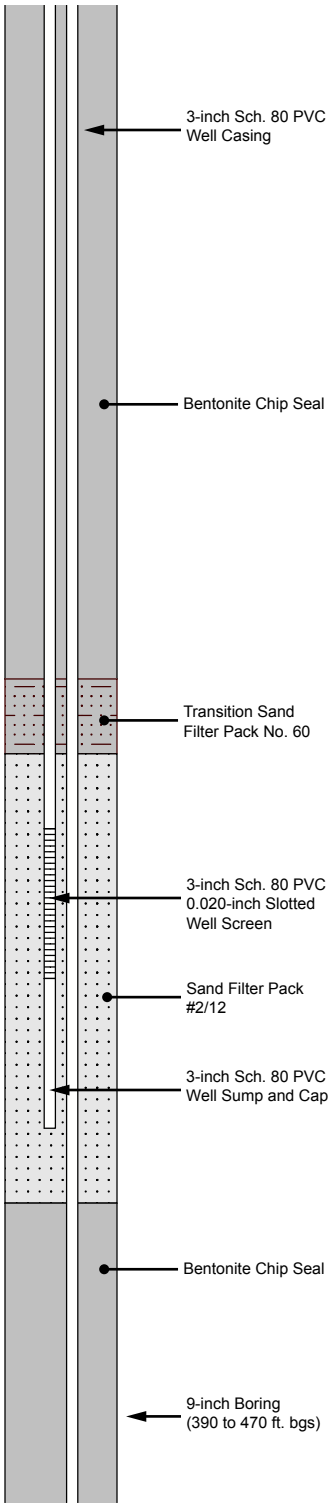
380

390

Sandy clay with silt; olive gray (5Y 4/2); soft; high plasticity. Moderate amount of coarse sand and gravel; angular to rounded; grains consist of grains consist of volcanic (rhyolite, andesite, and mafic) rock fragments; presence of stiff silt chips.

400





Project: Sonoma Valley Monitoring Well #1

Location: 22333 Eighth Street East, Sonoma, CA

Drilling Contractor: Maggiora Bros. Drilling **Well Installation Date:** 6/28/2011 to 7/5/2011

Drilling Method: Mud Rotary **Coordinates:** UTM NAD83, Zone 10N, meters

Hole Size: 8.75" **Lat:** 38.2555 **Long:**-122.4422 **Surface Elevation:** 24 Ft

Drill Date: 6/1/2011 to 6/6/2011 **Geophysical Logging Contractor:** Norcal Geophysical

State of California
Department of Water Resources
North Central Region Office
Geology and Groundwater
Investigations Section

As-Built Well Details

Well ID	Screen Interval
05N05W29D001M	85-95 FT
05N05W29D002M	223-233 FT
05N05W29D003M	355-365 FT
05N05W29D004M	440-455 FT

Depth (ft.)

Lithologic Descriptions

Logged By: Mark Nordberg, Steven Springhorn

USCS Field Classification

Natural Gamma Ray 0 (API) 150

Resistivity 16" 0 (ohm-m) 50

Resistivity 16" 0 (ohm-m) 50

Spontaneous Potential -150 (10mV/div) -100

Resistivity 64" 0 (ohm-m) 50

400

410

Sandy clay with silt; light olive gray (5Y 6/2); soft; high plasticity. Moderate amount of fine to coarse sand; angular to rounded; grains consist of volcanic (rhyolite, andesite, and mafic) rock fragments; presence of stiff silt chips.

420

Sandy clay with silt; olive gray (5Y 4/2); soft; high plasticity. Moderate amount of medium to coarse sand with gravel; angular to rounded; grains consist of volcanic (rhyolite, andesite, and mafic) rock fragments; presence of stiff silt chips.

430

Clay with sand; olive gray (5Y 4/2); very soft to soft; high plasticity. Trace amount of fine sand.

440

Clay with sand; dark greenish gray (10Y 4/1); very soft to soft; high plasticity. Trace amount of coarse sand with occasional gravel; subangular to subrounded; grains consist of volcanic (red andesite, white to reddish-white rhyolite, and black and gray aphanitic igneous) rock fragments.

450

Clay with sand; dark greenish gray (10Y 4/1); very soft to soft; high plasticity. Trace amount of fine sand.

460

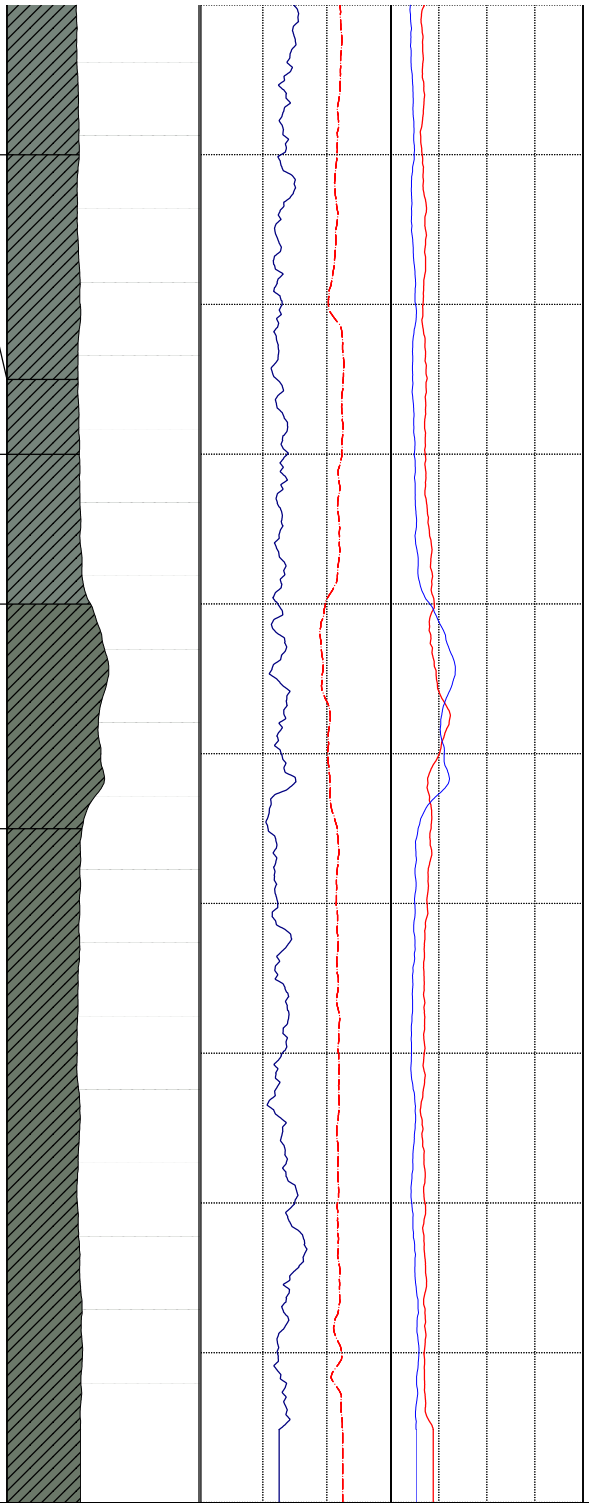
470

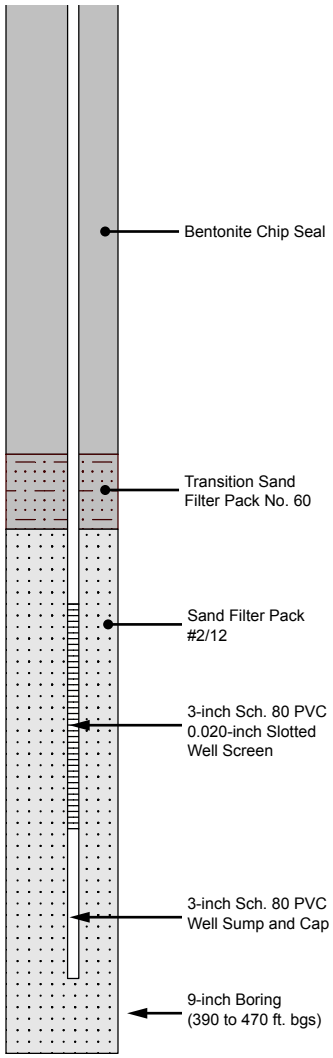
480

490

500

Total Depth of 500 ft. bgs. Target Depth Reached.





Project: Sonoma Valley Monitoring Well #2

Location: 330 West Watmaugh Rd., Sonoma, CA

Drilling Contractor: Maggiora Bros. Drilling **Well Installation Date:** 8/9/2011 to 8/16/2011

Drilling Method: Mud Rotary **Coordinates:** UTM NAD83, Zone 10N, meters

Hole Size: 8.75" **Lat:** 38.2654 **Long:**-122.4684 **Surface Elevation:** 45 Ft

Drill Date: 7/8/2011 to 7/14/2011 **Geophysical Logging Contractor:** Norcal Geophysical

State of California
Department of Water Resources
North Central Region Office
Geology and Groundwater
Investigations Section

As-Built Well Details

Well ID	Screen Interval
05N06W24G002M	80-100 FT
05N06W24G003M	200-220 FT
05N06W24G004M	374-384; 399-409 FT
05N06W24G005M	460-480 FT

Depth (ft.)

Lithologic Descriptions

Logged By: Mark Nordberg, Steven Springhorn

USCS Field Classification

Natural Gamma Ray 0 (API) 150

Resistivity 16" 0 (ohm-m) 50

Resistivity 16" 0 (ohm-m) 50

Spontaneous Potential -105 (10mV/div) -80

Resistivity 64" 0 (ohm-m) 50

Clay with Sand (CL); brown (10YR 4/3); soft; medium plasticity. Moderate amount of fine to coarse sand; angular to rounded; grains consist of red, gray, and black volcanic rock fragments.

Clay with Gravel (CL); black (5Y 2.5/1); soft; medium plasticity. Minor amount of gravel up to 2 cm; subangular to rounded; grains consist of red, gray, and tan volcanic rock fragments.

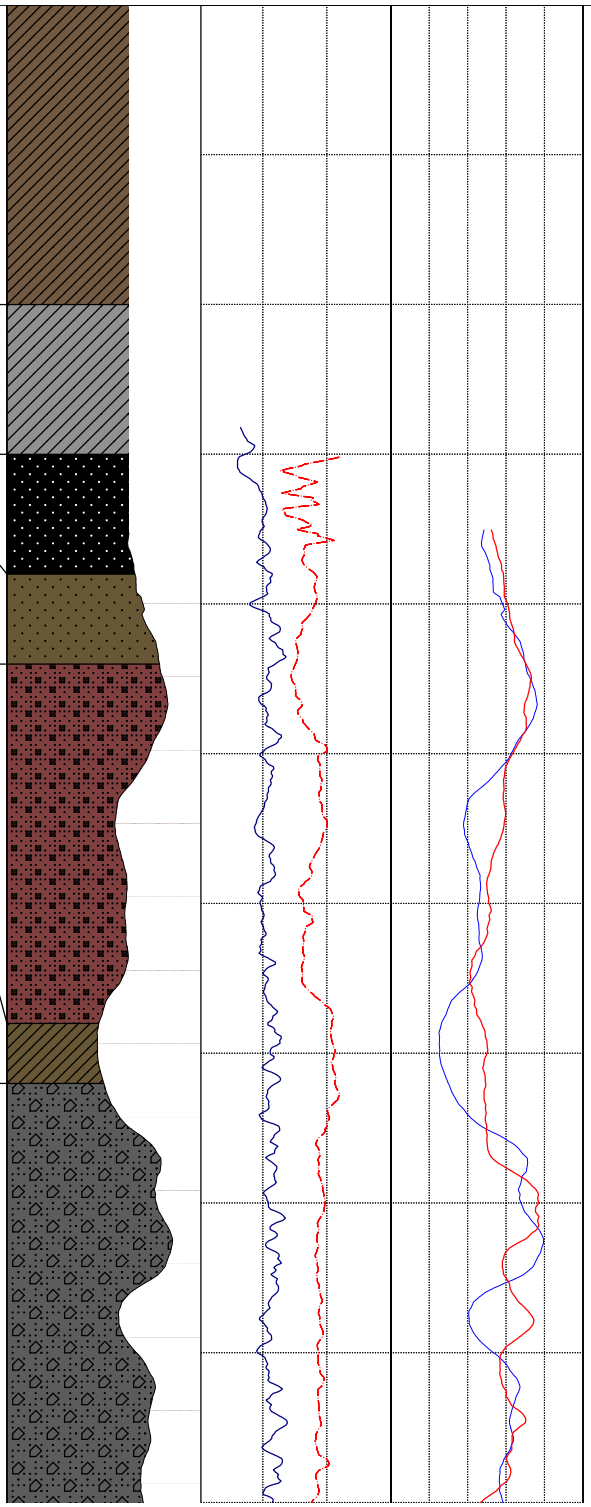
Well Graded Sand with Clay (SW); black (5Y 2.5/1); fine to coarse sand; angular to subrounded; grains consist of gray, black, tan, and red volcanic rock fragments. Minor amount of soft to medium-plasticity clay.

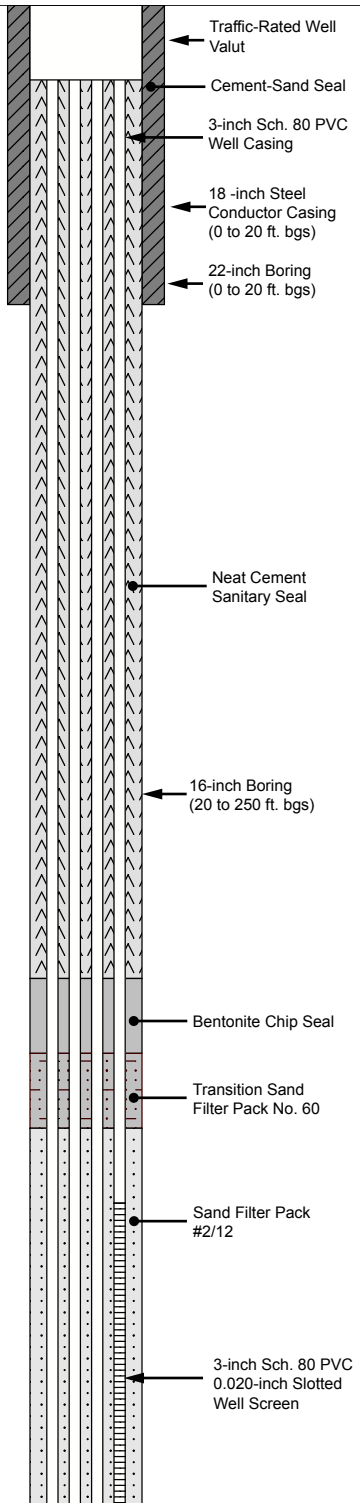
Well Graded Sand with Clay (SW); reddish brown (5YR 2.5/2); fine to coarse sand; angular to subrounded; grains consist of red, brown, black, and white red volcanic rock fragments.

Poorly Graded Gravel with Sand (GP); dark reddish brown (5Y 3/2); gravel; angular to subrounded; grains consist of dark red, brown, gray, and white volcanic rock fragments.

Clay with Gravel (CL); olive brown (2.5Y 4/3); soft; medium plasticity. Minor amount of coarse sand and gravel; angular to subrounded; grains consist of gray, black, and dark red volcanic rock fragments.

Gravel with Sand (GW); very dark gray (5YR 3/1); gravel with medium to coarse sand; angular to subrounded; grains consist of gray, black, and red volcanic rock fragments.





Project: Sonoma Valley Monitoring Well #2

Location: 330 West Watmaugh Rd., Sonoma, CA

Drilling Contractor: Maggiora Bros. Drilling **Well Installation Date:** 8/9/2011 to 8/16/2011

Drilling Method: Mud Rotary **Coordinates:** UTM NAD83, Zone 10N, meters

Hole Size: 8.75" **Lat:** 38.2654 **Long:**-122.4684 **Surface Elevation:** 45 Ft

Drill Date: 7/8/2011 to 7/14/2011 **Geophysical Logging Contractor:** Norcal Geophysical

State of California
Department of Water Resources
North Central Region Office
Geology and Groundwater
Investigations Section

As-Built Well Details

Well ID	Screen Interval
05N06W24G002M	80-100 FT
05N06W24G003M	200-220 FT
05N06W24G004M	374-384; 399-409 FT
05N06W24G005M	460-480 FT

Depth (ft.)

Lithologic Descriptions

Logged By: Mark Nordberg, Steven Springhorn

USCS Field Classification

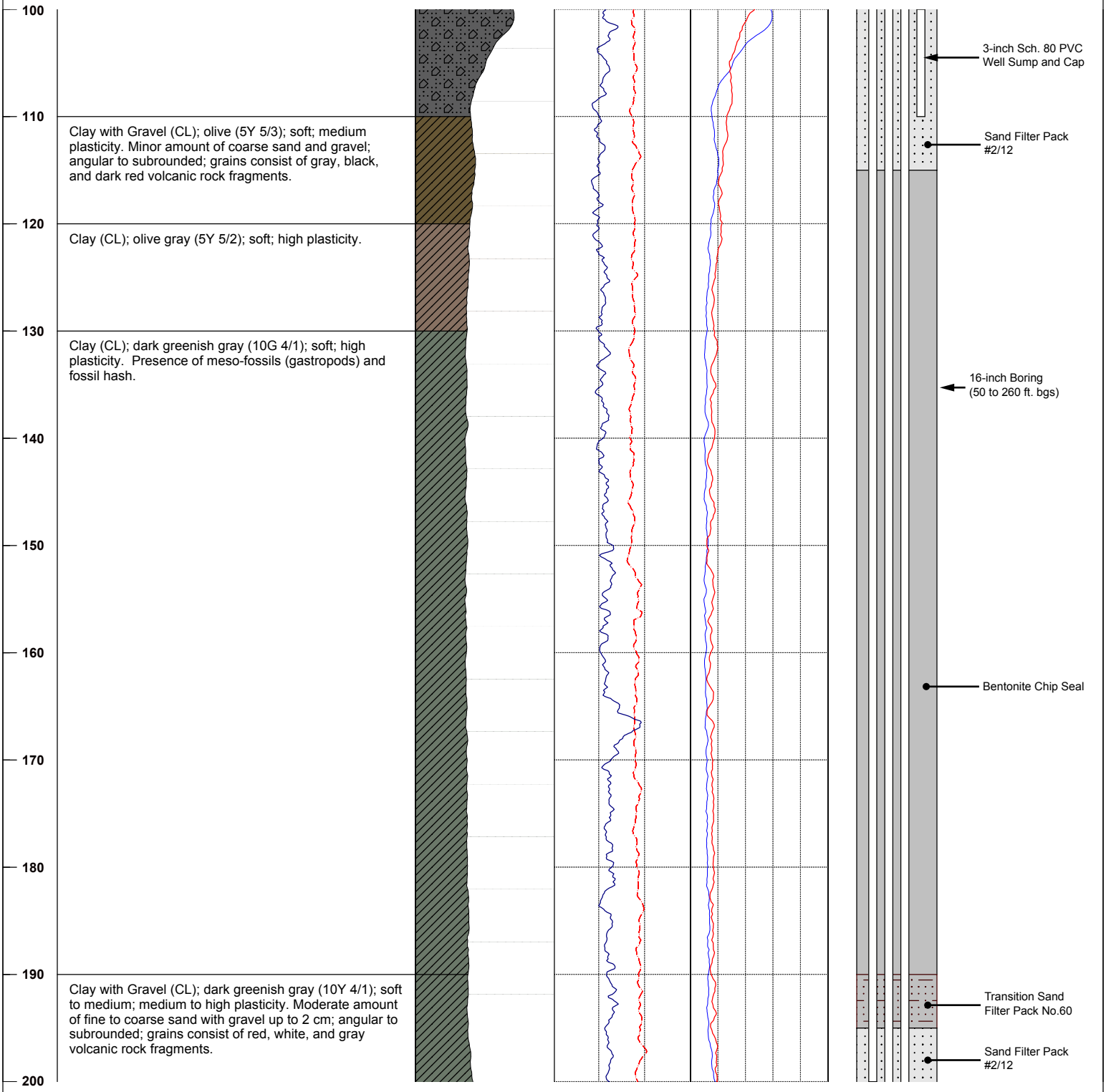
Resistivity 16" 0 (ohm-m) 50

Natural Gamma Ray 0 (API) 150

Spontaneous Potential -105 (10mV/div) -80

Resistivity 16" 0 (ohm-m) 50

Resistivity 64" 0 (ohm-m) 50



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05N06W24G004M	374-384; 399-409 FT
05N06W24G005M	460-480 FT

Depth (ft.)

Lithologic Descriptions

Logged By: Mark Nordberg, Steven Springhorn

USCS Field Classification

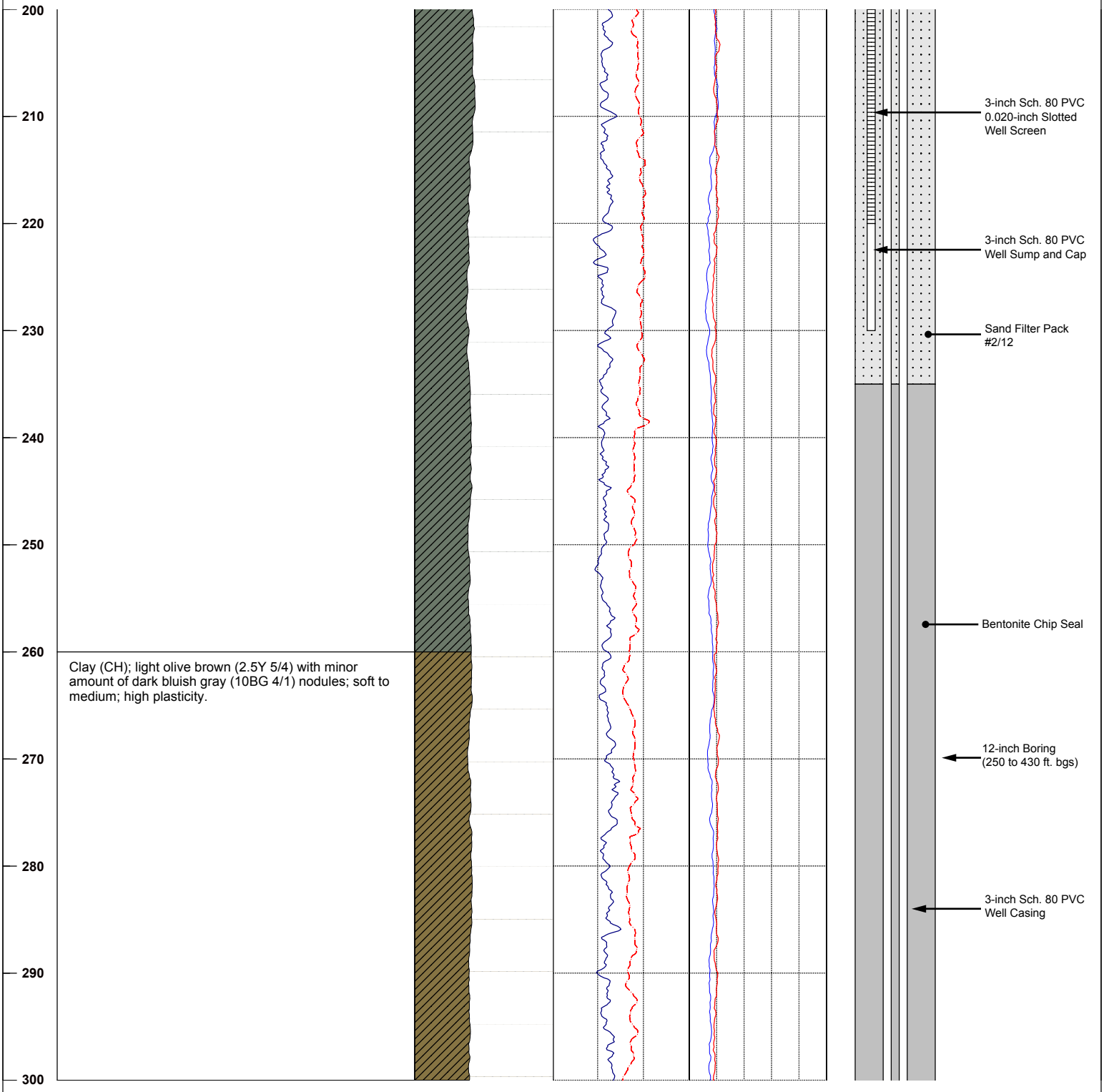
Resistivity 16" 0 (ohm-m) 50

Natural Gamma Ray 0 (API) 150

Spontaneous Potential -105 (10mV/div) -80

Resistivity 16" 0 (ohm-m) 50

Resistivity 64" 0 (ohm-m) 50



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05N06W24G005M	460-480 FT

Depth (ft.)

Lithologic Descriptions

Logged By: Mark Nordberg, Steven Springhorn

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Natural Gamma Ray 0 (API) 150

Resistivity 16" 0 (ohm-m) 50

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Spontaneous Potential -105 (10mV/div) -80

Resistivity 64" 0 (ohm-m) 50

300
310
320
330
340
350
360
370
380
390
400

Clay (CH); olive brown (2.5Y 4/3) with minor amount of dark bluish gray (10BG 4/1) nodules; soft to medium; high plasticity.

Clay with Sand (CH); olive gray (5Y 4/2) and dark greenish gray (10GY 4/1); soft; medium to high plasticity. Minor amount of fine to fine to medium sand; angular to rounded; grains consist of red, gray, and black volcanic rock fragments. Presence of one fossil fragment.

Silty Clay (CH); dark greenish gray (10BG 4/1); soft; high plasticity.

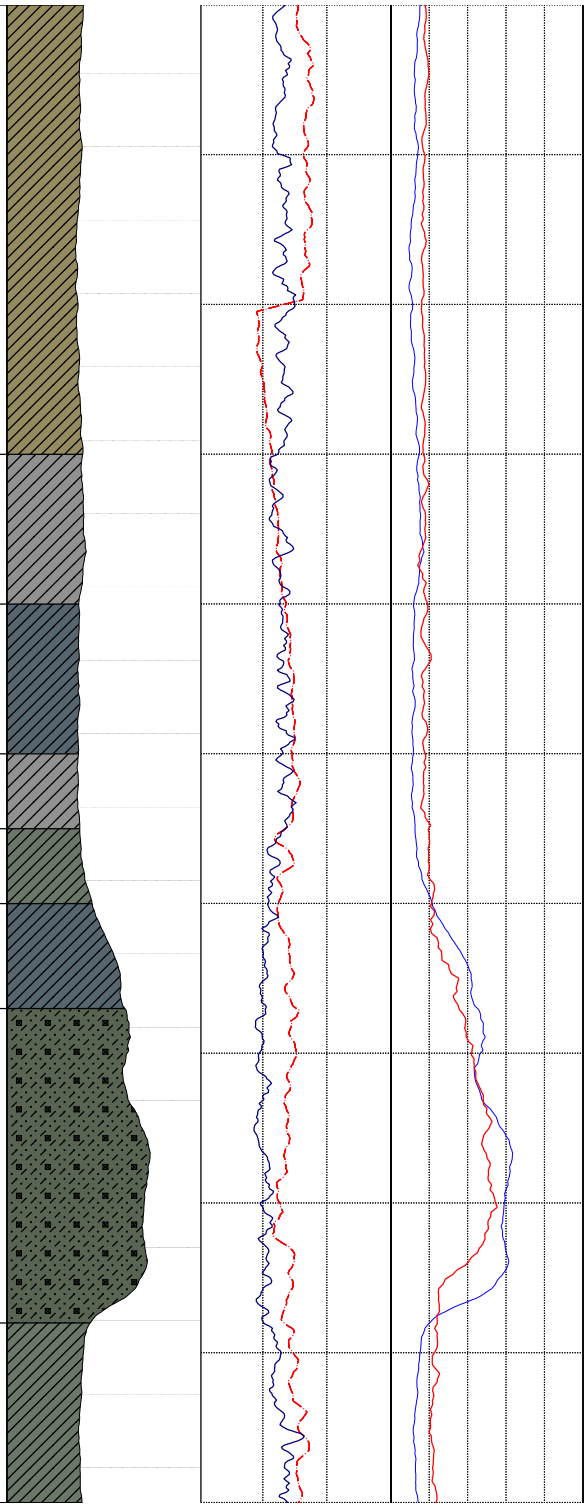
Clay (CH); olive gray (5Y 4/2) and dark greenish gray (10GY 4/1); soft; high plasticity.

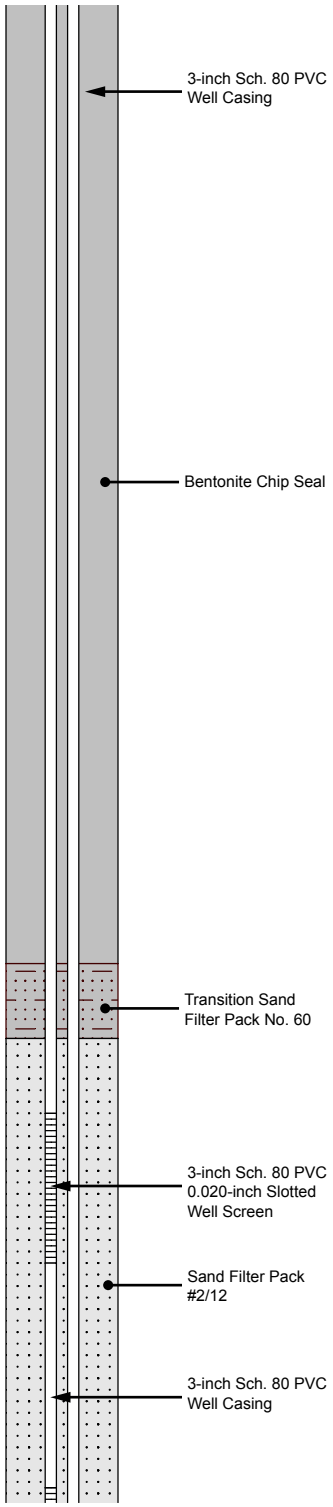
Silty Clay (CH); dark greenish gray (10GY 4/1); soft; high plasticity.

Silty Clay with Sand (CH); dark greenish gray (10BG 4/1); soft; medium to high plasticity. Minor amount of fine sand.

Clayey Gravel with Sand (GC); dark greenish gray (5GY 4/1); gravel with medium to coarse sand; angular to rounded; grains consist of volcanic rock fragments. Minor amount soft, medium- to high-plasticity clay.

Clay with Sand (CL); dark greenish gray (10Y 4/1); soft; medium to high plasticity. Minor amount of fine sand.





Project: Sonoma Valley Monitoring Well #2

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05N06W24G004M	374-384; 399-409 FT
05N06W24G005M	460-480 FT

Depth (ft.)

Lithologic Descriptions

Logged By: Mark Nordberg, Steven Springhorn

USCS Field Classification

Natural Gamma Ray 0 (API) 150

Resistivity 16" 0 (ohm-m) 50

Resistivity 16" 0 (ohm-m) 50

Spontaneous Potential -105 (10mV/div) -80

Resistivity 64" 0 (ohm-m) 50

400

Clayey Gravel with Sand (GC); dark greenish gray (5GY 4/1); gravel with medium to coarse sand; angular to rounded; grains consist of volcanic rock fragments. Minor amount soft, medium- to high-plasticity clay.

410

Clay with Sand (CL); dark greenish gray (10Y 4/1); soft; medium to high plasticity. Minor amount of fine sand.

420

430

Gravelly Clay with Sand (CL); dark greenish gray (10Y 4/1); soft; medium plasticity. Minor amount of fine to coarse sand with gravel; angular to subrounded; grains consist of black and gray volcanic rock fragments, trace red volcanic rock fragments, trace white feldspar.

440

450

Clay with Sand (CL); dark greenish gray (10Y 4/1); soft; medium plasticity. Minor amount of fine to medium sand.

460

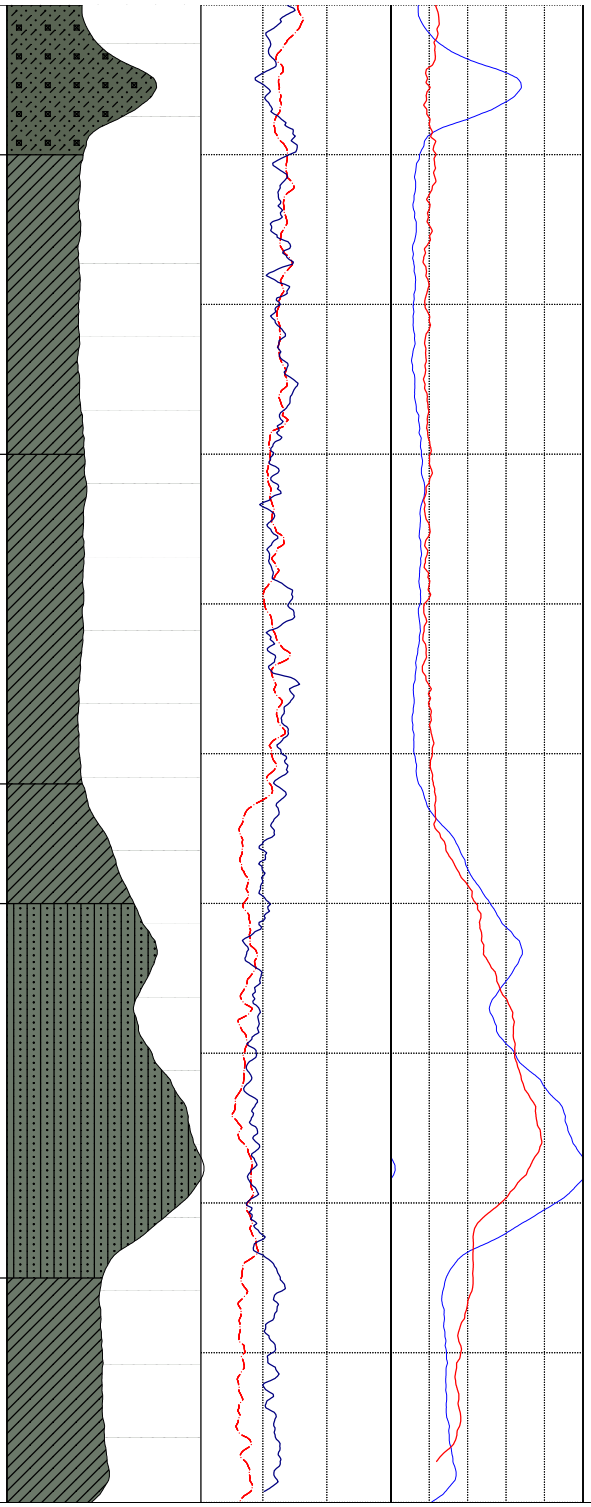
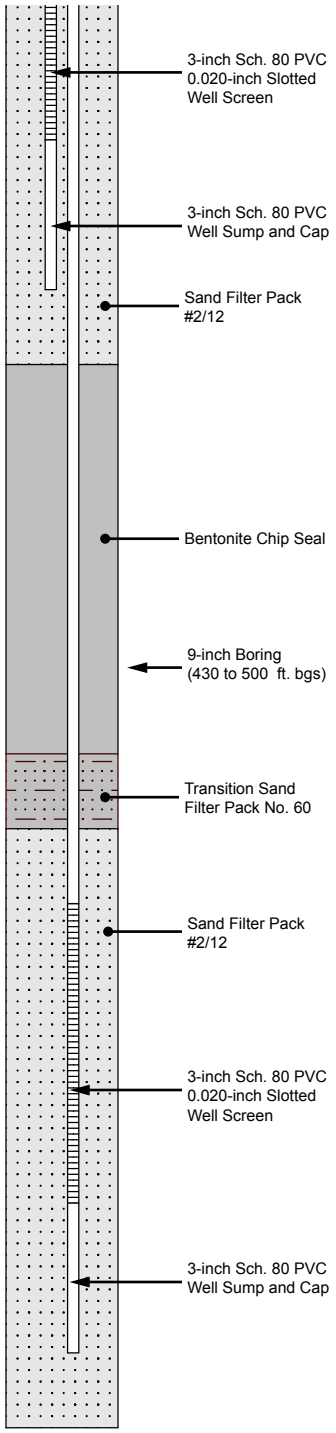
Sand with Clay (SP-SC); very dark gray (N 3/); medium sand; angular to rounded; grains consist of gray, black and white volcanic rock fragments, trace amount of red volcanic rock fragments, trace amount of clear and cloudy quartz. Minor amount of clay; very dark greenish gray (10Y 3/1); soft; medium plasticity.

470

480

Clay (CL); very dark greenish gray (10GY 3/1); soft; medium plasticity. Trace amount of medium to coarse sand with occasional gravel.

490

Total depth 500 FT. Target depth reached.

500