Initial Groundwater Sustainability Plan

for the Ukiah Valley Groundwater Basin

Ukiah Valley Groundwater Basin
Draft Groundwater Monitoring Protocol Manual

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Prepared for

Mendocino County Water Agency

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1 Introduction

This Groundwater Monitoring Protocol Manual describes monitoring objectives, data and reporting standards, and monitoring protocols for the Ukiah Valley Groundwater Basin (UVGB) CASGEM network (Appendix C). The UVGB boundary as defined by the Department of Water Resources is demonstrated in Appendix B. The UVGB Groundwater Sustainability Agency (GSA) is a developing local agency permitted to regulate groundwater use in the Ukiah Valley. The Sustainable Groundwater Management Act (SGMA) mandates the creation of GSAs and Groundwater Sustainability Plans (GSP) for medium and high priority groundwater basins. The UVGB has been designated as a medium priority groundwater basin and is required to develop a GSA and a GSP. One component of a GSP involves the development of a Monitoring Protocol Manual for groundwater wells. There are currently 39 groundwater monitoring wells in the UVGB in the California Statewide Groundwater Elevation Monitoring (CASGEM) program. This document describes the background of the UVGB monitoring network, monitoring frequency protocols, field methods, data gaps, and reporting guidelines to aid in the characterization of long-term, short-term, and seasonal trends in both groundwater heads and surface water-groundwater interactions. Bi-annual monitoring is deemed adequate to demonstrate short-term, seasonal, and long-term trends.

The UVGB GSA will work with the Mendocino County Water Agency (MCWA) and the Mendocino County Resource Conservation District (MCRCD) to integrate the updating processes of California Statewide Groundwater Elevation Monitoring (CASGEM) program, which is administered by the California Department of Water Resources (DWR), and the GSP Historical Groundwater Elevation Database. Pursuant to requirements of the CASGEM program and regulations set forward by SGMA, the developing GSA is submitting this Groundwater Monitoring Protocol for Ukiah Valley Groundwater Basin, which describes the monitoring well network and the frequency and methods with which the Agency plans to conduct its monitoring efforts. Under this Plan, the MCRCD will act as the central clearinghouse for groundwater data collected by cooperators in the County.

1.1 Groundwater Monitoring Background

The Mendocino County Water Agency (MCWA) began involvement in ground water resources in 1993 by contracting with the USGS to conduct ground water monitoring in Redwood Valley as part of a ground water resources reconnaissance project and to ascertain the possible location of a surface reservoir for the valley. MCWA contacted other water agencies in the area after SBX 7 6 was passed, seeking collaboration and the Mendocino City Community Services District (MCCSD) and Redwood Valley Community Water District (RVCWD) responded favorably.

There has been relatively little focus on ground water resources within Mendocino County and the County does not have a Ground Water Management Plan prior to the development of this initial Groundwater Sustainability Plan. The primary groundwater studies or actions are the following:

- "Dry Year Groundwater Monitoring Program Groundwater Level and Quality Evaluation, Mendocino County, California", Department of Water Resources, Division of Integrated Regional Water Management, Memorandum Report, by Chris Bonds, 2011.

- "Groundwater Monitoring Well Installation Dry Year Groundwater Monitoring Program, Mendocino County, California", Department of Water Resources, Division of Planning and Local Assistance, Central District, Technical Memorandum Report, 2003.

- "Ground-Water Resources in Mendocino County, California", by C. D. Farrar, U.S. Geological Survey, Water Resources Report 85-4258, 1986.

- "Water Supply Assessment for the Ukiah Valley Area Plan." Mendocino County Water Agency. October 20, 2010.

- California Groundwater Bulletin 118

In October 2014, the MCRCD started integrating wells in the Ukiah Valley into the CASGEM system under contract with MCWA. Initially, advertisements were placed in local newspapers that requested homeowners and farmers to contribute their wells to the CASGEM study. In addition, a cold-call list was developed by MCWA and MCRCD of potential well owners that would be willing to contribute and they were contacted. Recently, advertisements have been placed in the Farm Bureau and MCRCD newsletters. Other wells owners have added to their wells to the CASGEM network after being contacted through word of mouth.

1.2 Monitoring Network Data Gaps

Many of the wells proposed for use in the Ukiah Valley Basin have incomplete well completion data. The mechanism to identify potential wells was the following. Based on Sonoma County's experience, an advertisement was placed in the Ukiah Valley Daily Journal newspaper seeking volunteer wells. The RCD and or the Mendocino County Water Agency then contacted the responders and asked for additional information. In most cases, the current owners obtained the property many years or decades after the well was drilled and simply do not have any other information about the well. The Department of Water Resources was provided the location information and asked to check their records for more information. Data gaps are present in the northern, north central, and southern portions of the Ukiah Valley Basin. Data gaps are present in the Plumb, Wells, McKee, and McLeod wells in which total depth is known but not the screened interval. The UVGB GSA will continue to try and identify additional suitable wells for CASGEM that can be added to fill data gaps. Several thousand well completion reports were provided by the DWR and have been spatially referenced to provide information on well owners who can be contacted for integration into the CASGEM system. CASGEM Well data gaps were analyzed based on proximity to tributaries that contribute flow into the Russian River (Appendix C).

1.3 Ukiah Valley Groundwater Basin Hydrology and Hydrogeology

The UVGB GSA will monitor wells within the Ukiah Valley Groundwater Basin which includes the City of Ukiah and extending to Redwood Valley. The UVGB is the largest of the Mendocino County interior valleys and is located in the south-eastern portion of Mendocino

County. This is the highest priority Basin in Mendocino County as it contains the highest population density, includes the County seat, the largest city in the County, and contains significant agricultural operations.

The UVGB is approximately 30 miles long and ranges in width from 4 to 6 miles along the Russian River. Other population centers in the Basin include the communities of Talmage and Calpella. All communities are served by municipal and community water systems that obtain water from wells; surplus water from Lake Mendocino augments the water supply for Redwood Valley (USGS Water-Resources Investigations Report 35-4258, 1986). Rural residents obtain their water from private domestic wells or springs and irrigation water is obtained from wells and direct pumping from the Russian River and its tributaries. The Russian River and its tributaries are listed as full-appropriated in the summer.

Lake Mendocino stores a maximum of 122,500 acre-feet and is located about 4 miles northeast of Ukiah. The reservoir was created when Coyote Dam was constructed by the Army Corps of Engineers in 1958 and captures inflows from the East Fork of the Russian River. Eight thousand acre-feet of this water is currently appropriated for supply to the Russian River Flood Control and Water Conservation Improvement District (USGS, 1986). The bulk of Lake Mendocino water is controlled by the Sonoma County Water Agency for use in that County and for contract with Marin County.

1.3.1 Geology and Groundwater

The following geologic and groundwater information is obtained from the USGS Water-Resources Investigations Report 35-4258 from 1986. The valley fill occupies about 70 square miles in Ukiah Valley. The fill has been subdivided into continental basin deposits, continental terrace deposits and Holocene alluvium.

1.3.2 Continental Basin Deposits

Continental Basin Deposits crop out over about 20 square miles of the valley floor. Surface exposures are widespread over the northern part of the valley and along the east side of the valley from Lake Mendocino to about 5 miles north of Hopland. These deposits underlie younger valley-fill units and, where not exposed at the surface, may be present at depth throughout most of the remaining area of valley fill. The thickness of continental basin deposits ranges from 0 feet near the valley margins to an estimated maximum of 2,000 feet near the valley axis. This estimate is based on stratigraphic analysis of outcrops, as the deepest wells in this unit are about 500 feet deep.

These deposits consist of poorly sorted, heterogeneous mixtures of gravel, sand, silt and clay, with drillers logs indicating clay to be the most abundant constituent of the unit. The clay occurs as beds and as interstitial material between coarser grains of sand and gravel. The high clay content and poor sorting result in low permeability within this unit. However, the small grain size and lack of cementing provide high porosity. Because permeable materials are interbedded with impermeable clays, ground water occurs under confined conditions.

1.3.3 Continental Terrace Deposits

The USGS Water-Resources Investigations Report 35-4258 from 1986 states that the Continental Terrace Deposits occupy about 20 square miles of the Ukiah Valley. These rocks are subdivided into older and younger units based on topographic expression and degree of dissection. The older deposits are exposed mostly in the northern part of the valley around Redwood Valley. These deposit ranges in thickness from zero at the valley margins to roughly 25 feet near the axis of the valley. This thin unit is generally unsaturated in the summer and is therefore not considered an important source of water. The younger terrace deposits out crop discontinuously along both sides of the valley from Redwood Valley to near Morrison Creek. Less affected by erosion, the younger terraces are thicker than the older terraces and their original topographic form is better preserved. The younger terraces consist of gravel and sand, with silt and clay filling the intergranular spaces. This unit is of low to moderate permeability. Maximum thickness is difficult to estimate because the unit is generally difficult to distinguish from the underlying continental basin deposits on drillers' logs. Maximum thickness may reach 100 feet or more and generally these units are partially saturated during all or part of the year.

The younger terrace deposits are not considered a major ground-water source because they are relatively thin and have low permeability. Wells completed in terrace deposits generally yield 1 to 10 gal/min; yields as high as 100 gal/min have been reported. These values are based on short-term pump tests that may overestimate the long-term yield. Specific capacities calculated for 25 wells tapping the terraces range from 0.02 to 7.1 gal/min/ft. Of these wells, 17 had specific capacities of less than 1.0 gal/min/ft and only 4 had specific capacities greater than 2.0 gal/min/ft.

1.3.4 Holocene Alluvium

Holocene-age alluvium deposits cover about 30 square miles of the valley floor according to the 1986 USGS Water-Resources Investigations Report 35-4258. The alluvium is distributed as narrow bands along tributaries and along the Russian River north of The Forks. The alluvium occupies broad areas of the floodplain, as much as 2 miles wide, in the Ukiah-Talmage and Hopland areas. The alluvium of uncemented gravel, sand, silt and clay varies in thickness, with a maximum of about 200 feet; however, the thickness is generally less than 100 feet. The thickest section is along the Russian River.

Porosity and permeability are high because the alluvium is generally uncemented coarse-grained material. The alluvium is the most productive aquifer in the Ukiah Valley and can provide sufficient water for sustained pumping from municipal and irrigation wells. Well yields of 1,000 gal/min or greater have been documented. Groundwater in the alluvium occurs under unconfined conditions. Because the Russian River and tributary streams generally occupy channels cut into the alluvial deposits, groundwater and surface water are connected.

The permeable alluvium allows infiltration of considerable precipitation, which recharges the alluvial aquifer and underlying units. During most river stages, water moves from the alluvium into the Russian River; during high river stage, water moves from the river into the alluvial aquifer and is held as bank storage. Bank storage is depleted as river stage drops.

1.3.5 Groundwater Availability

There are four categories of available groundwater in the Ukiah Valley. The Type I area is the most favorable for groundwater development and is underlain by alluvial deposits that typically provide year round water for domestic use. The Type I area is generally narrow, except in the central part of the Ukiah Valley, where it broadens to about 2 miles wide, and near Hopland, where it is about 1.5 miles wide. The Type I areas have been described as producing 100 to 1,000 gal/min (USGS, 1986).

The Type II areas, distributed along the valley margins, are generally underlain by terrace deposits or thin alluvium. Wells completed in this unit may yield less than 10 gal/min. Type III areas, underlain by thin terrace deposits and continental basin deposits, cover much of the northern part of the valley and smaller areas along the eastern side of the valley. Wells completed in this unit generally provide only a few gallons of water per minute. Type IV areas include all the mountainous terrain around the valley floor and are underlain by mostly Franciscan rocks. In general, the prospect for obtaining water in these units is very poor.

1.3.6 Estimated Storage Capacity

1986 USGS Water-Resources Investigations Report 35-4258 estimates the Type I (alluvial fill) total maximum storage capacity as ranging from 60,000 to 120,000 acre-ft. The Type II total maximum storage capacity is estimated as 45,000 acre-ft. Type III and Type IV areas were not assessed for storage capacities as these areas have marginal capacities to yield water to wells. The groundwater reservoir is estimated to be fully recharged each year, except when precipitation falls below about 60% of normal. After 2 years of drought, the groundwater system can be fully recharged by 1 year of normal or above-normal precipitation.

2 Monitoring Well Network Objectives

The objective of obtaining historical groundwater data is to characterize long-term groundwater trends, provide data for surface water-groundwater interaction analysis, provide observation points for future groundwater model calibration, and provide information for evaluating hydrologic conditions that may contribute to salmonid kills or be adverse to salmonid health. Measureable objectives are required per SGMA to ensure that the groundwater basin reaches sustainable management within 20 years of acceptance of the GSP by the DWR. In the case of the UVGB, the sustainability indicator is defined by the following (DWR, 2016):

Depletions of Interconnected Surface Water. Monitor surface water and groundwater, where interconnected surface water conditions exist, to characterize the spatial and temporal exchange between surface water and groundwater, and to calibrate and apply the tools and methods necessary to calculate depletions of surface water caused by groundwater extractions. The monitoring network shall be able to characterize the following:

(A) Flow conditions including surface water discharge, surface water head, and baseflow contribution.
(B) Identifying the approximate date and location where ephemeral or intermittent flowing streams and rivers cease to flow, if applicable.
(C) Temporal change in conditions due to variations in stream discharge and regional groundwater extraction.
(D) Other factors that may be necessary to identify adverse impacts on beneficial uses of the surface water.

The affected region in the UVGB is near Talmage due to the large concentration of surface water and underflow well diversions are permitted to extract water near the Russian River. Frost protection regulations did not include Russian River or tributary diversions north of Coyote Dam, so it is assumed that those regions will not be the focus of this GSP. Diversions in Redwood Valley are predominantly based from ponds near tributaries to the Russian River. Other sustainability indicators are not included as part of the UVGB GSP due to the complete recharge of the aquifer systems each year water quality is described as “generally good and suitable for most uses” (USGS, 1986), the aquifer is not adjacent to the ocean, and existing CASGEM well hydrographs do not demonstrate hydraulic declines over time.

In April of 2008, salmonids were mortally stranded south of the UVGB boundary near Hopland. Extensive frost protection extractions were occurring in the vineyard areas near the Russian River in the Ukiah Valley during this time period (SWRCB, 2011a). According to the State Water Resources Control Board (SWRCB) Environmental Impact Report, naturally dry conditions and frost protection diversions were the primary contributors to the low water levels during the 2008 fish kill. The fish kill triggered a new frost protection regulation (Section 862 as an amendment to Division 3 of Title 23 of the California Code of Regulations) mandated by the SWRCB after being recommended by the National Marine Fisheries Service (NMFS) (SWRCB, 2011b). The regulations mandate that any “significant” diversions, either surface water or from hydrologically connected groundwater in aquifers, “shall be considered unreasonable” between March 15th and May 15th. Since the 2015 frost protection season, the SWRCB mandates that any frost protection diverters must participate in a Water Demand Management Program. It is expected that farmers who are extracting groundwater in compliance with their approved Water Demand Management Program will not contribute to salmon kills and that additional regulation as a part of this GSP is not necessary.

Salmonid stranding and death is the primary concern and groundwater regulations should be implemented to ensure that groundwater extraction does not negatively affect fish health and passage. Other issues from surface water depletions, such as limiting supply of Russian River water for Sonoma and Marin Counties, are not noted in the DWR Groundwater Basin Prioritization description for the Ukiah Valley (DWR, 2014). In addition, Sonoma County Water Agency (SCWA) controls the releases from Lake Mendocino through operation of Coyote Dam to satisfy their downstream demands (SCWA, 2016). If salmonid kills occur, or if diversions cause a decrease in streamflow that causes a potential risk for stranding mortality, corrective actions must be taken and a corrective action plan must be added to the Water Demand Management Program submitted to the SWRCB. If salmonid kills are not occurring, then it can be assumed that the regulations are adequate if not over-intensive. Additional measurable objectives can be created based on an Instream Flow Incremental Methodology (IFIM) study. IFIM studies demonstrate habitat requirements for juvenile, fry, and adult salmonids for a specific stream segment. This criteria can provide minimum flow and minimum stage requirements for the West Fork of the Russian River and downstream of Coyote Dam that can be used to identify measurable objectives for the GSP based on Russian River and tributary flow rates and stream stages. An IFIM study can determine minimum thresholds for flows and the effectiveness of groundwater regulation can be demonstrated by comparing the flows to the minimum thresholds.

3 Description of Monitoring Well Network and Monitoring Frequency

The UVGB GSA will monitor 39 wells in the Ukiah Valley Groundwater Basin on a bi-annual basis. Additional wells are proposed as part of the GSP and contact with well owners will be made in an attempt to increase the well density of the UVGB monitoring network. The City of Ukiah will supply data from two wells on a semi-annual basis.

Long term trends will be evaluated semiannually to evaluate the consistency of surface water-groundwater fluxes and the magnitude of hydraulic gradients between the groundwater and surface water environments. It is important to gather monitoring data at all groundwater monitoring wells within a few days in order to generate accurate and representative hydraulic gradient contour maps for the entire basin. The frequency of monitoring data acquisition for the UVGB is semiannual and data should be collected in March for the spring and in October for the fall. Semiannual frequency is expected to be adequate and has been confirmed by Aaron Cuthbertson: the DWR manager for the Ukiah Valley Groundwater Sustainability Plan.

According to the draft Best Management Practices for groundwater monitoring protocols, each well must have a unique well identifier written on the well to avoid confusion (DWR, 2016). A reference point must be established for each well and a mark must be made to obtain consistent data over time. These reference points must be surveyed to the North American Vertical Datum of 1988 by a licensed surveyor.

4 Field Methods

The well locations were surveyed by DWR Central District staff using Global Positioning System equipment. The coordinate system is Universal Transverse Mercator (UTM) Zone 10, North American Datum (NAD) 1927, in meters. The ground surface elevations at each well site were estimated based on interpolation between known contours on a U.S. Geological Survey (USGS) 7.5-minute quadrangle topographic map of each area. All of the wells monitored by MCWA are observation wells with no pumps installed, so all readings record static conditions. The procedure is described by the following:

- Open the locked steel casing.

- Remove the 2” PVC cap to access the well.

- Allow adequate time (approximately 10 minutes [DWR, 2016]) for hydraulic equilibrium to occur prior to taking measurements in wells that have different pressure than the atmosphere. Variation in hydraulic head in wells can generate suction or positive pressure.

- Wipe the Solinst Water Level meter with alcohol solution.

- Groundwater level is determined manually in each well by inserting a Solinst Water Level Meter which emits an audible tone when water is encountered. Each observation well has a permanent mark where each measurement is taken.

- When three consecutive measurements are identical, record the distance to water and replace the well cap and close and lock the well casing.

- The Solinst probe is wiped with an alcohol solution prior to obtaining a reading in a different well.

- All data are collected in the field by the same staff person and entered into an Excel spreadsheet in the office by the same person and then provided to the DWR. Groundwater elevation is computed by subtracting the depth to water in the well from the well reference point.

- Data records should include the well identification number, date, time, depth to water, reference point, groundwater elevation, and a notes section with pertinent information regarding data accuracy.

Manuals for use and calibration of field monitoring equipment are presented (Appendix K). Currently, wells SV-1, SV-2A and SV-2B have In-Situ dataloggers set for 15-minute intervals. The location of the continuous recording dataloggers has changed over time and may change in the future. The groundwater depth recorded by the continuous dataloggers is compared to the manual reading obtained with the Solinst Water Level Meter, and if the results are more than 0.2' different, the pressure transducer is re-calibrated to match the manual readings. The pressure transducer manual is located at the RCD office in Ukiah.

It is important to gather monitoring data at all groundwater monitoring wells within a few days in order to generate accurate and representative hydraulic gradient contour maps for the entire basin. The frequency of monitoring data acquisition for the UVGB is semiannual and data should be collected in March for the spring and in October for the fall.

5 Groundwater Monitoring Data Reporting

Groundwater monitoring data is obtained in the field and is input into both the CASGEM monitoring system and the Historical Groundwater Elevation Database for submission to the DWR. Russian River stage at nearby gauge locations at the time of groundwater well data acquisition should be obtained and input into the Historical Groundwater Elevation Database for future data analysis. The Historical Groundwater Elevation Database will be located with MCWA. Table 1 demonstrates the nearest gauge and the distance to the gauge from the CASGEM well. The Historical Groundwater Elevation Database will be submitted as a component of the annual GSA report to the DWR.

Table 1 – CASGEM Well and Streamflow Gauge Correlation

CASGEM Well ID	Distance to Gauge (ft)	Gauge Name
392606N1232098W001	1,748	NMFS WEST BRANCH RUSSIAN RIVER
392455N1231977W001-W003	4,927	NMFS WEST BRANCH RUSSIAN RIVER
392358N1232020W001	8,317	NMFS WEST BRANCH RUSSIAN RIVER
391917N1232000W001	850	USGS 11461000 RUSSIAN R NR UKIAH CA
391860N1232039W001	3,894	USGS 11461000 RUSSIAN R NR UKIAH CA
391482N1231810W001	4,289	RR-SFG-1 (Russian River)
391334N1231885W001	1,084	RR-SFG-2 (Russian River)
391322N1231929W001	2,305	RR-SFG-2 (Russian River)
391304N1231929W001	2,751	RR-SFG-2 (Russian River)
391174N1231836W001	3,041	USGS 11462080 RUSSIAN R NR TALMAGE CA
391086N1231710W001	1,509	AG-SFG-1 (Howell Creek)

The proposed streamflow gauges in the Russian River provide four additional data points for surface water-groundwater interaction analysis. These gauges will also enhance the understanding of surface water-groundwater fluxes over a given segment of river.

6 Surface Water – Groundwater Interaction Data Reporting

Surface water-groundwater interaction can be characterized by comparing the hydraulic head in monitoring wells to the stage of the Russian River. Six CASGEM wells are located near the Russian River and existing streamflow gauges. Five other CASGEM wells are located near the Russian River and proposed streamflow gauge locations. Most of the wells are near the town of Talmage in the vineyard and pear orchard areas. The current most useful well for quantifying surface water-groundwater interaction is 391917N1232000W001, due to its close proximity to both the river and the streamflow gauge. CASGEM well 391086N1231710W001 is located near Howell Creek and can be correlated with the proposed streamflow gauge AG-SFG-1 on Howell Creek. Table 2 describes the distance between the CASGEM well and the river, as well as the height above the river of the top of the well casing and the expected surface water-groundwater correlation at that point.

The surface water-groundwater correlation factor demonstrates the expected response in change in river stage due to groundwater extraction from underflow wells near the river. Using an equation relating the radius of influence of a well to the transmissivity, storativity, and time of pumping, it was found that the radius of influence for a 400 gpm well in the Ukiah Valley is 2,000 feet using a typical transmissivity for the Ukiah Valley (Bear, 1979). This value represents the distance that it is expected where the drawdown from the well will go to zero. Drawdown has concave form, and the magnitude decreases quickly as the distance from the center of the well increases. It is therefore expected that frost protection wells within 500 feet of the River will generate noticeable variation in the hydraulic contribution or deficit in the river. Frost protection wells between 500 feet and 1,000 feet from the Russian River or its tributaries are provided with a medium correlation factor, and frost protection wells greater than 1,000 feet from the Russian River or its tributaries are provided with a low correlation factor.

Table 2 – CASGEM Well Proximity to Russian River

CASGEM Well ID	Distance to River (ft)	Expected SW-GW Correlation	Height Above River (ft)
392606N1232098W001	1,294	Low	182
392455N1231977W001-W003	1,005	Low	37

CASGEM Well ID	Distance to River (ft)	Expected SW-GW Correlation	Height Above River (ft)
392358N1232020W001	586	Medium	26
391917N1232000W001	271	High	22
391860N1232039W001	945	Low	15
391482N1231810W001	87	High	1
391334N1231885W001	156	High	1
391322N1231929W001	1,228	Low	1
391304N1231929W001	772	Medium	1
391174N1231836W001	832	Low	1
391086N1231710W001	1,509	Low	12

It should be noted that the monitoring wells are not necessarily extraction wells, and that the locality to underflow pumping centers must be evaluated. CASGEM well 391334N1231885W001 can be used to correlate surface water and groundwater hydrologic connectivity given that the RR-SFG-2 streamflow gauge is installed. Groundwater discharge to the river is expected during times when the hydraulic head elevation is greater than the river stage, and vice versa when the river stage elevation is greater than the well hydraulic head. The time and date must be recorded during acquisition of CASGEM well monitoring data in order to correlate the streamflow stage. Both the CASGEM well hydraulic head and the river stage should be recorded in the Historical Groundwater Elevation Database that manages the monitoring data.

7 Appendix A - References

Bear, Jacob (1979) “Hydraulics of Groundwater.” McGraw-Hill International Book Co., 1979.

DWR (2014) "Groundwater Basin Prioritiziation - Final CASGEM Basin Prioritiziation Results - June 2014." California Department of Water Resources. North Central Region – Run Version 05262014C http://www.water.ca.gov/groundwater/casgem/pdfs/lists/NCRO_Priority_05262014.pdf

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SCWA (2016) "Water Supply." Sonoma County Water Agency - Russian River System. http://www.scwa.ca.gov/water-supply/

SWRCB (2011a) "State Water Resources Control Board Resolution No. 2011-0047. To Adopt a Proposed Russian River Frost Protection Regulation and Associated Environmental Impact Report." Frost Protection Regulation - Russian River Watershed. http://www.waterboards.ca.gov/waterrights/water_issues/ programs/hearings/russian_river_frost/docs/rs2011_0047.pdf

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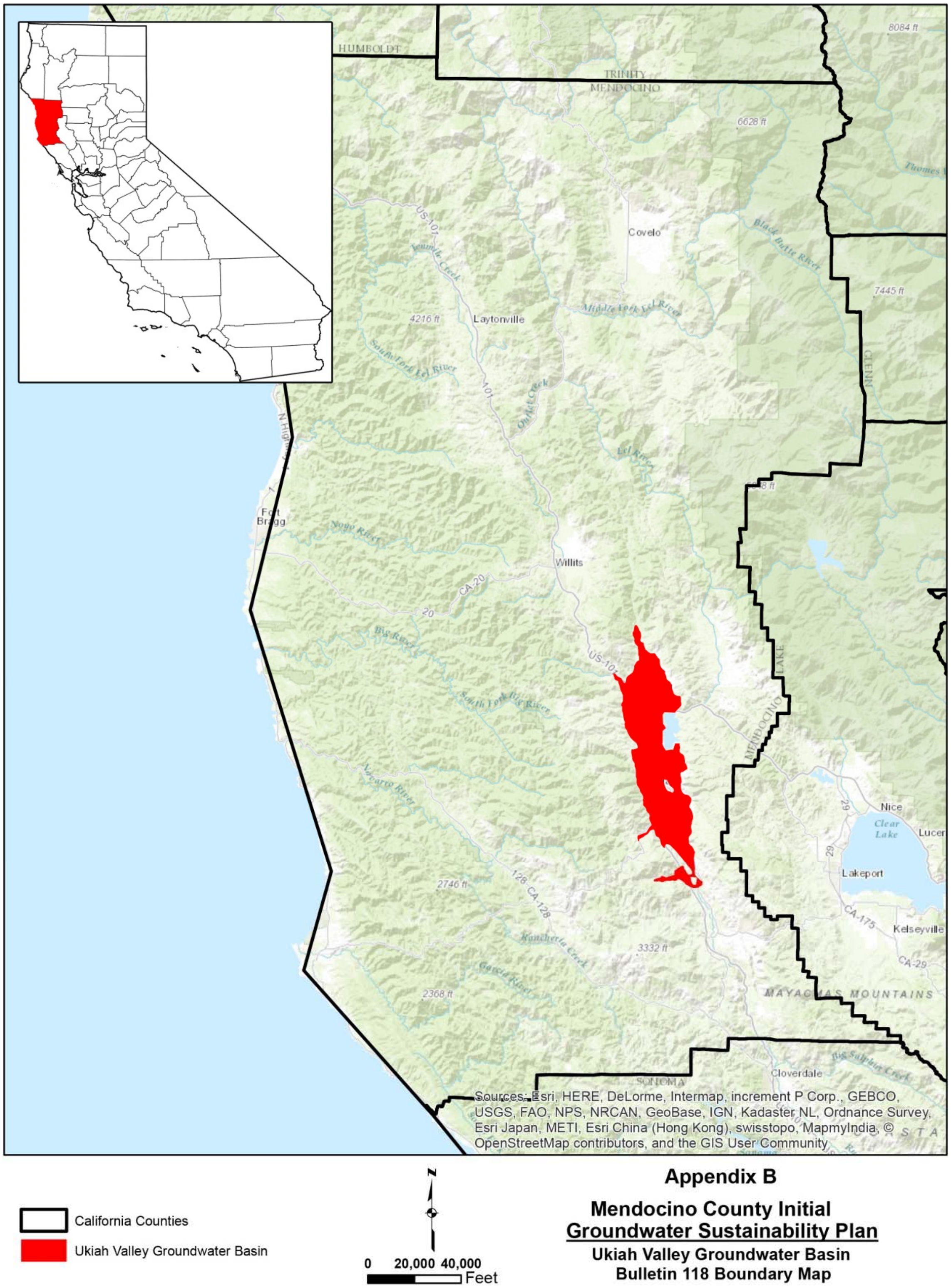
SWRCB (2016) “Frost Protection Regulation – The State Water Resources Control Board.” Russian River Watershed. http://www.waterboards.ca.gov/waterrights/water_issues/programs/hearings/russian_river_frost/

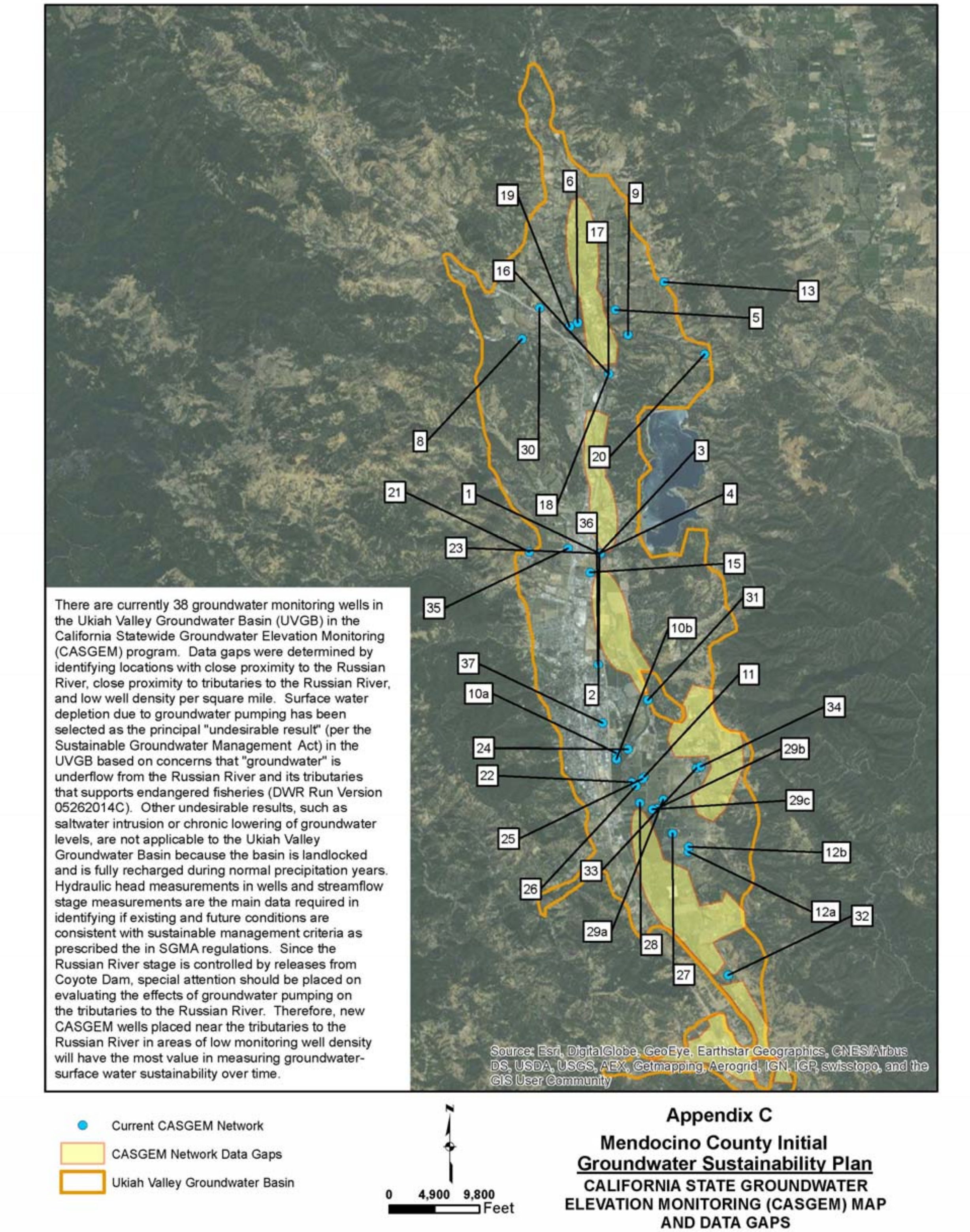
8 Appendix B – Overview Map of Ukiah Valley Groundwater Basin

Figure 1 – Ukiah Valley Groundwater Basin Boundary Map



9 Appendix C – Map of CASGEM Well Locations and Data Gaps

Figure 2 – Ukiah Valley Groundwater Basin CASGEM Well Network Map



10 Appendix D – CASGEM Well Hydrographs

Figure 3 – CASGEM Well Cluster 391918N1232003W001-004 Hydrograph

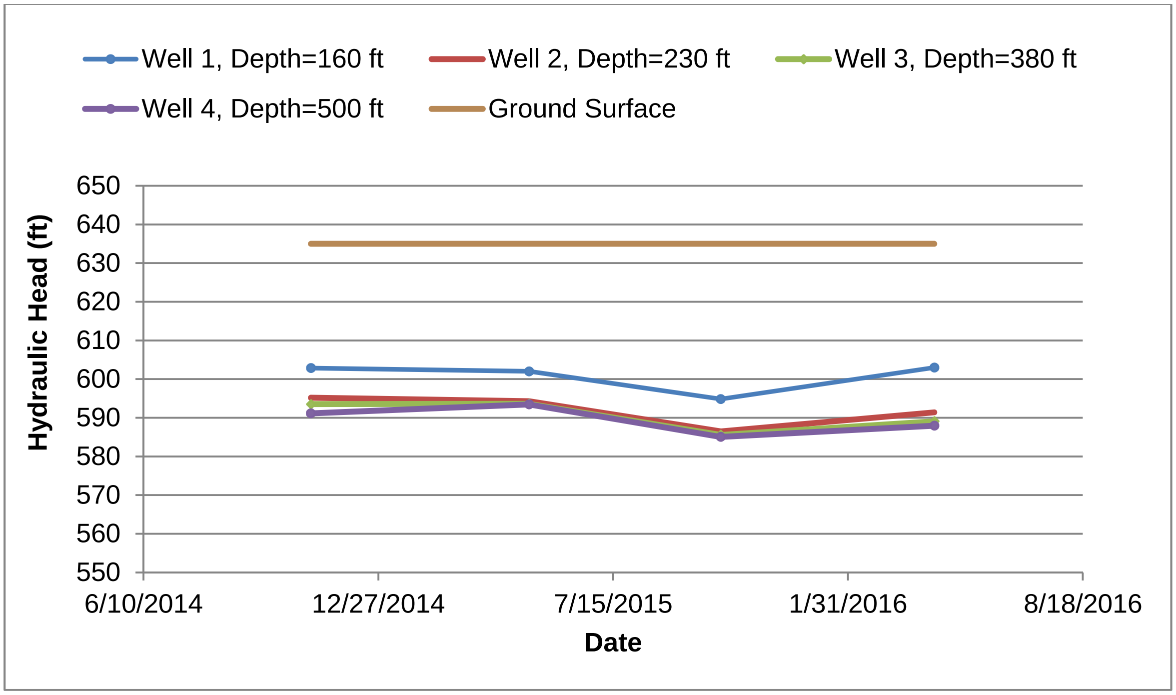


Figure 4 – CASGEM Well Cluster 392455N1231977W001-003 Hydrograph

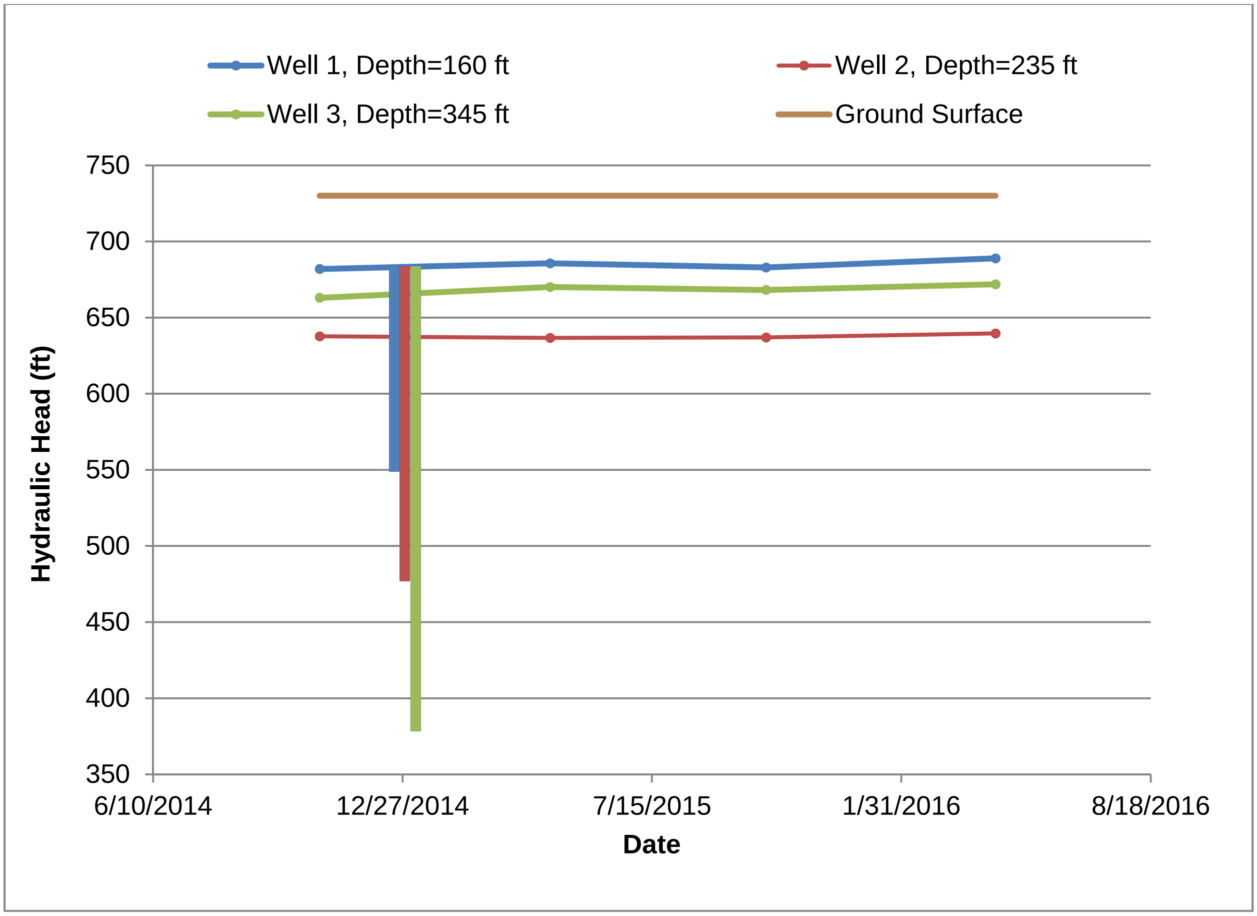


Figure 5 – CASGEM Well 391096N1231677W001 Hydrograph

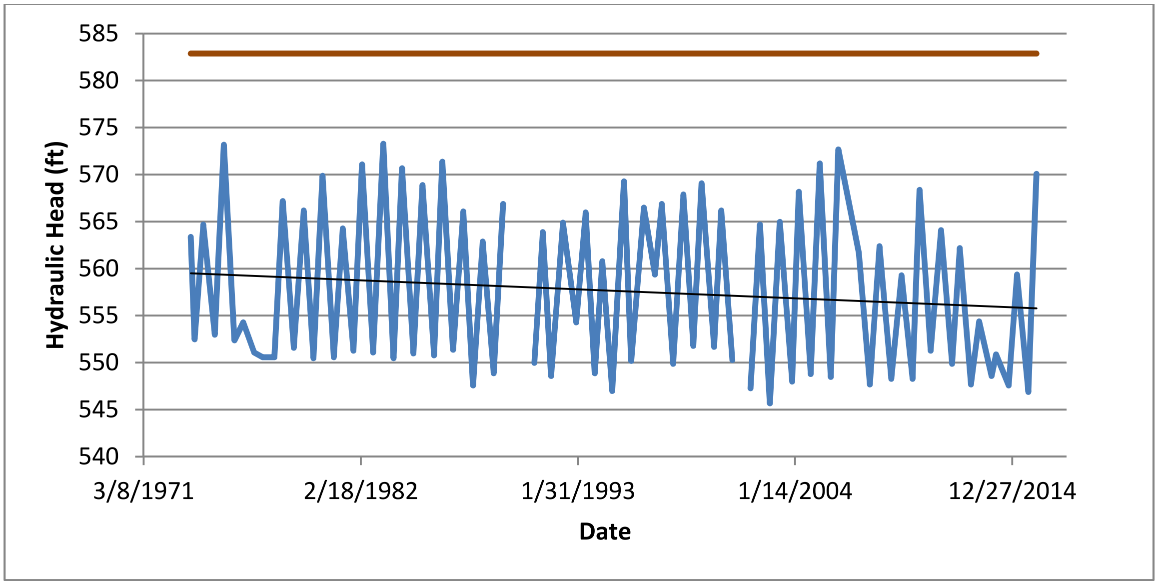


Figure 6 – CASGEM Well 392962N1232047W001 Hydrograph

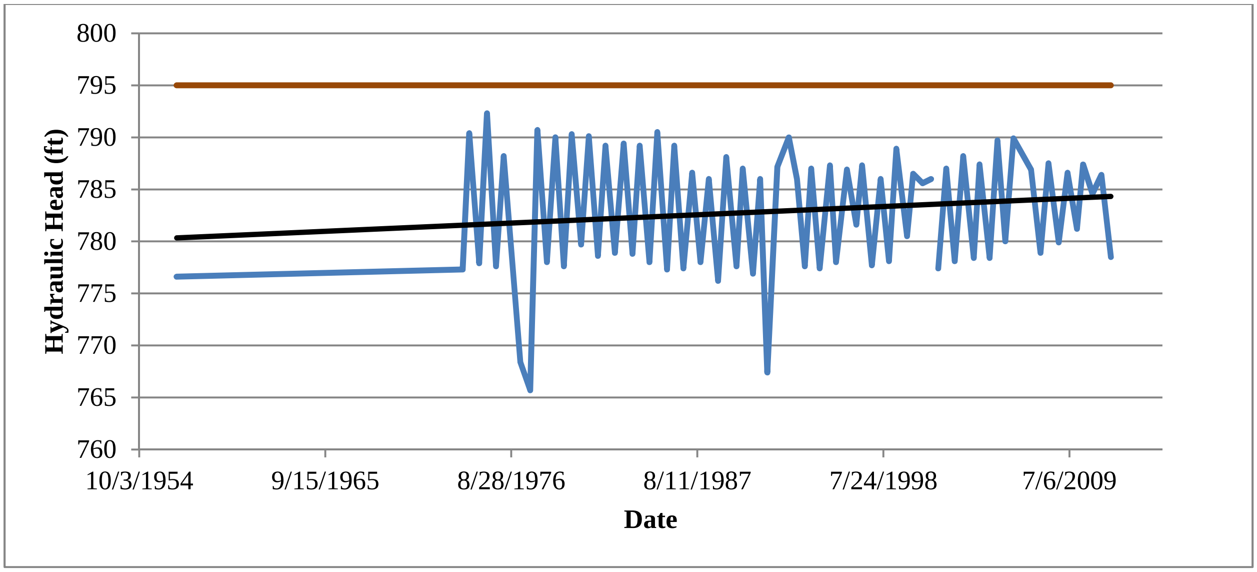


Figure 7 – CASGEM Well 392358N1232020W001 Hydrograph

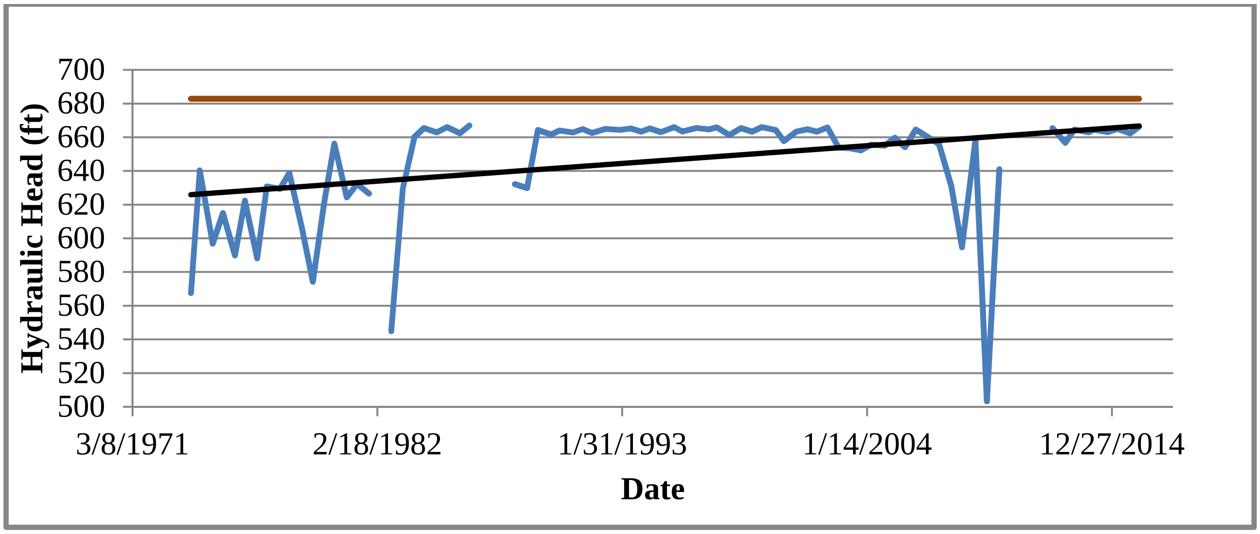
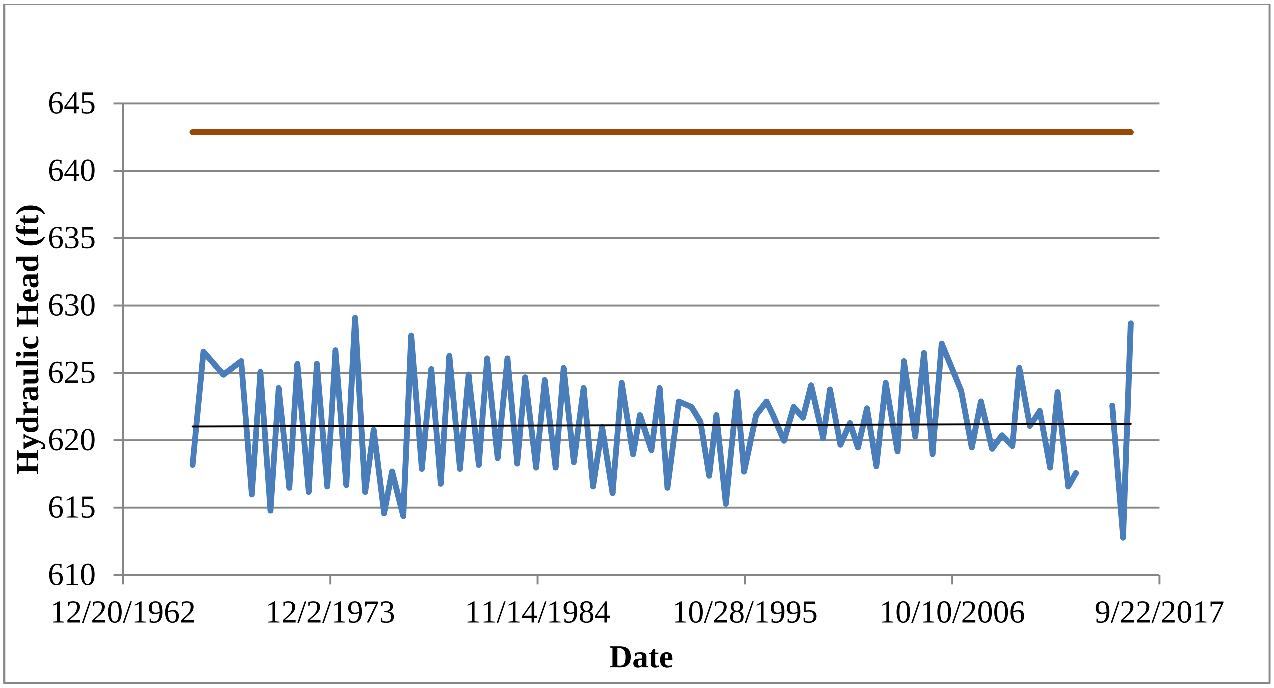


Figure 8 – CASGEM Well 39717030N1232108W001



11 Appendix E – CASGEM Well Parameters

Table 3 – CASGEM Well Locations, Uses, and Well Completion Report Numbers

CASGEM Well Number	Local Well Designation:	Latitude (NAD83):	Longitude (NAD83):	Well Use:	Well Completion Report Number:
391918N1232003W001	Ukiah Valley-1	39.191770	-123.200310	Observation	e0207604 A-D - N/A
391918N1232003W002	Ukiah Valley-2	39.191770	-123.200310	Observation	e0207604 A-D - N/A
391918N1232003W003	Ukiah Valley-3	39.191770	-123.200310	Observation	e0207604 A-D - N/A
391918N1232003W004	Ukiah Valley-4	39.191770	-123.200310	Observation	e0207604 A-D - N/A
392645N1231955W001	Ukiah Valley-5	39.264460	-123.195460	Unknown	N/A
392606N1232098W001	Ukiah Valley-6	39.260570	-123.209810	Unknown	N/A
392556N1232312W001	Ukiah Valley-8	39.255550	-123.231160	Unknown	N/A
392572N1231906W001	Ukiah Valley-9	39.257178	-123.190578	Unknown	N/A
391322N1231929W001	Ukiah Valley-10a	39.132200	-123.192884	Irrigation	N/A
391304N1231929W001	Ukiah Valley-10b	39.130389	-123.192880	Irrigation	N/A
391252N1231822W001	Ukiah Valley-11	39.125238	-123.182166	Unknown	N/A
391031N1231649W001	Ukiah Valley-12a	39.103106	-123.164941	Unknown	N/A
391046N1231647W001	Ukiah Valley-12b	39.104619	-123.164739	Irrigation	N/A
392730N1231770W001	Ukiah Valley-13	39.273000	-123.177000	Unknown	e066664
391860N1232039W001	Ukiah Valley-15	39.185992	-123.203880	Unknown	34445
392455N1231977W001	Ukiah Valley-16	39.245510	-123.197680	Observation	N/A
392455N1231977W002	Ukiah Valley-17	39.245510	-123.197680	Observation	N/A
392455N1231977W003	Ukiah Valley-18	39.245510	-123.197680	Observation	N/A
392594N1232129W001	Ukiah Valley-19	39.259390	-123.212880	Residential	N/A
392516N1231610W001	Ukiah Valley-20	39.251614	-123.160997	Residential	N/A
391920N1232273W001	Ukiah Valley-21	39.191990	-123.227260	Unknown	N/A
391236N1231869W001	Ukiah Valley-22	39.123610	-123.186870	Irrigation	N/A
391917N1232000W001	Ukiah Valley-23	39.191747	-123.200031	Other	e0232792 - N/A
391334N1231885W001	Ukiah Valley-24	39.133440	-123.188470	Irrigation	N/A
391246N1231827W001	Ukiah Valley-25	39.124642	-123.182678	Irrigation	N/A
391225N1231852W001	Ukiah Valley-26	39.122450	-123.185200	Irrigation	N/A
391086N1231710W001	Ukiah Valley-27	39.108600	-123.171010	Irrigation	N/A
391174N1231836W001	Ukiah Valley-28	39.117440	-123.183620	Irrigation	N/A
391185N1231747W001	Ukiah Valley-29a	39.118470	-123.174690	Residential	N/A
391159N1231770W001	Ukiah Valley -29b	39.115860	-123.176950	Irrigation	N/A
391156N1231788W001	Ukiah Valley-29c	39.115600	-123.178820	Irrigation	N/A
392647N1232245W001	Ukiah Valley-30	39.264700	-123.224520	Residential	N/A
391482N1231810W001	Ukiah Valley-31	39.148150	-123.181010	Residential	e071160
390664N1231491W001	Ukiah Valley-32	39.066390	-123.149070	Residential	17867
391281N1231621W001	Ukiah Valley-33	39.128060	-123.162140	Irrigation	N/A
391285N1231607W001	Ukiah Valley-34	39.128530	-123.160680	Irrigation	811129
391932N1232124W001	Ukiah Valley-35	39.193150	-123.212360	Unknown	N/A
N/A	Ukiah Valley-36	39.158611	-123.200278	N/A	e0316347
N/A	Ukiah Valley-37	39.141111	-123.198333	N/A	e0317247

Table 4 – CASGEM Well Elevation Parameters, Depths, and Perforated Intervals

CASGEM Well Number	Local Well Designation	Reference Point Elevation (ft)	Ground Surface Elevation (ft)	Depth (ft)	Perforated Interval Depths (ft):
391918N1232003W001	Ukiah Valley-1	639	635	160	130-150
391918N1232003W002	Ukiah Valley-2	638	635	230	200-220
391918N1232003W003	Ukiah Valley-3	638	635	380	350-370
391918N1232003W004	Ukiah Valley-4	638	635	500	470-490
392645N1231955W001	Ukiah Valley-5	813	812	100	N/A
392606N1232098W001	Ukiah Valley-6	848	847	347	N/A
392556N1232312W001	Ukiah Valley-8	739	738	200	N/A
392572N1231906W001	Ukiah Valley-9	738	737	133	N/A
391252N1231822W001	Ukiah Valley-11	583	582	105	30-105
392730N1231770W001	Ukiah Valley-13	927	924	400	186-400
N/A	Ukiah Valley-37	601	600	222	35-55, 75-95, 115-135,
391860N1232039W001	Ukiah Valley-15	621	620	45	20-45
392455N1231977W001	Ukiah Valley-16	733	730	95	80-90
392455N1231977W002	Ukiah Valley-17	733	730	235	190-200, 220-230
392455N1231977W003	Ukiah Valley-18	732	730	345	280-291, 330-340
392594N1232129W001	Ukiah Valley-19	884	883	N/A	N/A
392516N1231610W001	Ukiah Valley-20	1121	1120	200	80-140, 180-200
391920N1232273W001	Ukiah Valley-21	669	667	140	20-40, 60-80, 120-140
391236N1231869W001	Ukiah Valley-22	541	538	100	30-100
391917N1232000W001	Ukiah Valley-23	626	624	420	120-220
391334N1231885W001	Ukiah Valley-24	588	584	120	40-120
391246N1231827W001	Ukiah Valley-25	583	580	80	30-80
391174N1231836W001	Ukiah Valley-28	578	574	75	26-70
392647N1232245W001	Ukiah Valley-30	812	811	80	20-80
391482N1231810W001	Ukiah Valley-31	638	633	283	60-283
390664N1231491W001	Ukiah Valley-32	554	553	60	36-56
391281N1231621W001	Ukiah Valley-33	650	648	41	13-41
391285N1231607W001	Ukiah Valley-34	657	655	160	80-160
391932N1232124W001	Ukiah Valley-35	654	654	N/A	Confidential
N/A	Ukiah Valley-36	N/A	N/A	N/A	N/A
391225N1231852W001	Ukiah Valley-26	603	599	60	30-60
391086N1231710W001	Ukiah Valley-27	582	581	107	30-107
391322N1231929W001	Ukiah Valley-10a	584	583	60	20-60
391304N1231929W001	Ukiah Valley-10b	586	582	200	30-200
391031N1231649W001	Ukiah Valley-12a	589	588	105	30-105
391046N1231647W001	Ukiah Valley-12b	591	589	100	30-100
391185N1231747W001	Ukiah Valley-29a	582	580	170	80-170
391159N1231770W001	Ukiah Valley -29b	576	574	91	25-85
391156N1231788W001	Ukiah Valley-29c	576	574	100	25-95

12 Appendix F – CASGEM Well Completion Reports

Figure 9 – Well Completion Report for CASGEM Well 390664N1231491W001

ORIGINAL
File with DWR

APR 2 5 1969

LOCATION NOT FIELD CHECKED

Do Not Fill In

WATER WELL DRILLERS REPORT
(Sections 7079, 7080, 7081, 7082, Water Code)

THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

№ 17867

State Well No.
Other Well No. 14/12-3

(1) OWNER:
Name H. A. OSWALD
Address P.O. BOX 157
TALMADGE, CALIF 95481

(2) LOCATION OF WELL:
County MENDOCINO Owner's number, if any
Township, Range, and Section T14N, R12W, SEC 3
Distance from cities, roads, railroads, etc. 60 FT. EAST OF LABOR CAMP IN OSWALD'S PEAR ORCHARD

(3) TYPE OF WORK *(check)*:
New Well ☒ Deepening ☐ Reconditioning ☐ Destroying ☐
If destruction, describe material and procedure in Item 11.

(4) PROPOSED USE *(check)*:
Domestic ☒ Industrial ☐ Municipal ☐
Irrigation ☐ Test Well ☐ Other ☐

(5) EQUIPMENT:
Rotary ☐
Cable ☒
Other ☐

(6) CASING INSTALLED:
STEEL: SINGLE ☒ DOUBLE ☐ OTHER:

From ft.	To ft.	Diam.	Gage or Wall	Diameter of Bore	From ft.	To ft.
0	60	8	.188"			

(If gravel packed: Diameter of Bore, From, To)

Size of shoe or well ring: 3/8 X 6 Size of gravel:
Describe joint BUTT WELD

(7) PERFORATIONS OR SCREEN:
Type of perforation or name of screen

From ft.	To ft.	Perf. per row	Rows per ft.	Size in. x in.
36	56	5	4	5/32 X 3

(8) CONSTRUCTION:
Was a surface sanitary seal provided? Yes ☒ No ☐ To what depth 22 ft.
Were any strata sealed against pollution? Yes ☐ No ☒ If yes, note depth of strata
From ft. to ft.
From ft. to ft.
Method of sealing

(9) WATER LEVELS:
Depth at which water was first found, if known ft. 19
Standing level before perforating, if known ft. —
Standing level after perforating and developing ft. 16

(10) WELL TESTS:
Was pump test made? Yes ☐ No ☒ If yes, by whom? BAIL TEST
Yield: 180 gal./min. with 1 ft. drawdown after 2 hrs.
Temperature of water Was a chemical analysis made? Yes ☐ No ☒
Was electric log made of well? Yes ☐ No ☒ If yes, attach copy

(11) WELL LOG:
Total depth 56 ft. Depth of completed well 56 ft.
Formation: *Describe by color, character, size of material, and structure*
ft. to ft.
0–6 SOIL
6–19 BROWN CLAY
19–40 BROWN SANDY CLAY
40–56 BROWN CEMENTED GRAVEL (DIRTY)

CONFIDENTIAL LOG
Water Code Sec. 7080

~~FOR OFFICIAL USE ONLY~~

Work started 11/27 1968. Completed 11/30 1968

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME J. W. HUTTON
(Person, firm, or corporation) *(Typed or printed)*
Address LAKEPORT, CA
[SIGNED] J W Hutton
(Well Driller)
License No. 153912 Dated 12/4/68, 19

SKETCH LOCATION OF WELL ON REVERSE SIDE

DWR 188 (REV. 9-65)

56391-950 10-65 50M TRIP Ⓞ △ OSP

Figure 10 – Well Completion Report for CASGEM Well 391096N1231677W001

15N/12W-34Q1

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
WATER WELL DRILLERS REPORT

ORIGINAL
File with DWR

Do Not Fill In
No 74481
State Well No. 15N/12W.34Q
Other Well No.

(1) OWNER:
Name Roderick Shippey
Address 1990 South Dora
Ukiah, California 95482

(2) LOCATION OF WELL:
County Mendocino Owner's number, if any
Township, Range, and Section
Distance from cities, roads, railroads, etc. Off Ruddick Cunningham Rd. Ukiah

(3) TYPE OF WORK (check):
New Well ☒ Deepening ☐ Reconditioning ☐ Destroying ☐
If destruction, describe material and procedure in Item 11.

(4) PROPOSED USE (check):
Domestic ☒ Industrial ☐ Municipal ☐
Irrigation ☐ Test Well ☐ Other ☐

(5) EQUIPMENT:
Rotary ☒
Cable ☐
Other ☐

(6) CASING INSTALLED:
STEEL: OTHER:
SINGLE ☐ DOUBLE ☐

If gravel packed

From ft.	To ft.	Diam.	Gage or Wall	Diameter of Bore	From ft.	To ft.
0	111	8"	10 gauge	18"	0	111

Size of shoe or well ring: none
Size of gravel: 3/4
Describe joint weld

(7) PERFORATIONS OR SCREEN:
Type of perforation or name of screen slots

From ft.	To ft.	Perf. per row	Rows per ft.	Size in. x in.
0	51	4	1	1/4 x 10
51	71	4	1	1/4 x 10
71	91	4	1	1/4 x 10
91	111	4	1	1/4 x 10

(8) CONSTRUCTION:
Was a surface sanitary seal provided? Yes X No ☐ To what depth ft.
Were any strata sealed against pollution? Yes ☐ No X If yes, note depth of strata
From ft. to ft.
From ft. to ft.
Method of sealing Cement on gravel pack

(9) WATER LEVELS:
Depth at which water was first found, if known ft.
Standing level before perforating, if known ft.
Standing level after perforating and developing 10 ft.

(10) WELL TESTS:
Was a pump test made? Yes ☐ No X If yes, by whom?
Yield: 50 gal./min. with 30 ft. drawdown after hrs.
Temperature of water cold Was a chemical analysis made? Yes ☐ No X
Was electric log made of well? Yes ☐ No X If yes, attach copy

(11) WELL LOG:
Total depth 112 ft. Depth of completed well 112 ft.
Formation: Describe by color, character, size of material, and structure
ft. to ft.

0	3	Top soil
3	15	Embedded gravel
15	24	Bolders
24	41	Brown Sandy clay
41	45	Gravels
45	48	Gravels
48	56	Bolders
56	59	Gravel
59	61	Bolders
61	65	Gravel
65	72	Embedded gravel
72	88	Gravel
88	94	Bolders
94	108	Gravel
108	112	Sandy clay

~~15N/12W-34N80~~

Work started 5-29-73 19 Completed 5-31-73 19

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Welks Drilling and Pump Company
(Person, firm, or corporation) (Typed or printed)
Address Sebastopol Road
Sebastopol, Calif.
[SIGNED] Gerald Thompson
By Mary E. Thompson (Well Driller)
Mary E. Thompson
License No. 177681 Dated June 1, 19 73

CONFIDENTIAL
Water Code Sec. 13752

SKETCH LOCATION OF WELL ON REVERSE SIDE

DWR 188 (REV. 9-68)

25179-950 9-68 50M TRIP OSP

Figure 11 – Well Completion Report for CASGEM Well 391285N1231607W001

ORIGINAL
File with DWR
Page 1 of 1
Owner's Well No.
Date Work Began 12/12/12, Ended 1/9/13
Local Permit Agency ENVironmenTAl HealTh
Permit No. 22112 Permit Date 12/12/12

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet
No. 811129

DWR USE ONLY - DO NOT FILL IN
15N12W27
STATE WELL NO./STATION NO.
390741 1230938
LATITUDE LONGITUDE
APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)
DRILLING METHOD CAble FLUID WATer

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	21	Brown soil
21	38	Brown clay
38	40	Brown clay & Gravel (water)
40	66	Brown clay w. Th Embedded Grvel
66	71	Brown & Blue clay Mixed
71	79	Blue clay
79	145	Brown clay Embedded Gravel with Lenses of Small Gravel & Sand
145	165	Blue clay

TOTAL DEPTH OF BORING 165 (Feet)
TOTAL DEPTH OF COMPLETED WELL 160 (Feet)

WELL OWNER
Name Ausch vineyards
Mailing Address PO Box 189
Talmage CA 95481
CITY STATE ZIP

WELL LOCATION
Address 3401 old River Rd
City Ukiah
County Mendocino
APN Book ___ Page ___ Parcel 182-180-20
Township ___ Range ___ Section ___
Latitude ___ NORTH Longitude ___ WEST
DEG. MIN. SEC.

LOCATION SKETCH
NORTH
WEST EAST
SOUTH
Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)
X NEW WELL
MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)
___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USES (✓)
WATER SUPPLY
___ Domestic ___ Public
X Irrigation ___ Industrial
MONITORING ___
TEST WELL ___
CATHODIC PROTECTION ___
HEAT EXCHANGE ___
DIRECT PUSH ___
INJECTION ___
VAPOR EXTRACTION ___
SPARGING ___
REMEDIATION ___
OTHER (SPECIFY) ___

WATER LEVEL & YIELD OF COMPLETED WELL
DEPTH TO FIRST WATER 38 (Ft.) BELOW SURFACE
DEPTH OF STATIC WATER LEVEL 9 (Ft.) & DATE MEASURED 1/9/13
ESTIMATED YIELD * 75 (GPM) & TEST TYPE PUMP
TEST LENGTH 7 (Hrs.) TOTAL DRAWDOWN 29 (Ft.)
* *May not be representative of a well's long-term yield.*

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE: BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
1?	80	12"	X				Steel	8"	188	
80	16	12"		X			Steel	8"	188	1/8 x 2

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	50	X			
					Pea Gravel

ATTACHMENTS (✓)
___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other ___
ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT
I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.
NAME DAVE GIESE
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)
200 Cobalet Ln Ukiah CA 95482
ADDRESS CITY STATE ZIP
Signed [signature] 1/10/13 304165
WELL DRILLER/AUTHORIZED REPRESENTATIVE DATE SIGNED C-57 LICENSE NUMBER

DWR 188 REV. 11-97
IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

Figure 12 – Well Completion Report for CASGEM Well 391285N1231607W001

STATE OF CALIFORNIA
WELL COMPLETION REPORT
No. e071160

DWR USE ONLY – DO NOT FILL IN
15N12W21
STATE WELL NO. STATION NO.
LATITUDE LONGITUDE
APN / TRS / OTHER

OWNER'S WELL No. 6377
Date Work Began 4/2/08 Ended 4/9/08
Local Permit Agency MENDOCINO
Permit No. WW20974 Permit Date 6-1-2007

GEOLOGIC LOG

ORIENTATION Vertical Degree of Angle ____
DEPTH TO FIRST WATER ____ (ft.) BELOW SURFACE

DEPTH FROM SURFACE Ft.	Ft.	DESCRIPTION
0	10	brown clay with cemented gravels
10	110	cemented gravels
110	115	cemented gravels with some brown clay
115	180	cemented gravels
180	185	brown clay
185	240	cemented gravels
240	270	harder cemented gravels
270	300	cemented gravels with brown clay
		* 200 - 400 - gpm

TOTAL DEPTH OF BORING 300 (Feet)
TOTAL DEPTH OF COMPLETED WELL 280 (Feet)

WELL OWNER
ROGINA WATER COMPANY
P.O. BOX 310
TALMAGE CA 95481

WELL LOCATION
Address 600 RECREATION ROAD
City UKIAH County MENDOCINO
Apn Book 181 Page 010 Parcel 01
or Township ____ Range ____ Section ____ 1/4 ____ 1/4
or Latitude ____ ____ ____ NORTH Longitude ____ ____ ____ WEST
Deg. Min. Sec. Deg. Min. Sec.

LOCATION SKETCH

ACTIVITY NEW WELL PLANNED USE(S) PUBLIC WATER
DRILLING METHOD ROTARY AIR FLUID
DEPTH OF STATIC WATER LEVEL 30 (Ft.) & DATE MEASURED Apr 8, 2008
ESTIMATED YIELD * ★ (G.P.M.) & TEST TYPE Airlift
TEST LENGTH. 2 (Hrs.) TOTAL DRAWDOWN ____ (FT.)
*May not be representative of a well's long-term yield.

DEPTH FROM SURFACE Ft.	To Ft.	BORE-HOLE DIA.	CASING TYPE	Material / Grade	Dia.	Gauge	Slot size
0	60	20	BLANK	STEEL	14	250	
60	283	20	PERF	STEEL	14	250	Factory

DEPTH FROM SURFACE Ft.	To Ft.	ANNULAR MATERIAL Seal Material	Filter Pack (Type / Size)
0	50	CEMENT	
50	283		12 YDS 1/4 X 1/8 GRAVEL

Attachments
no Geologic Log
no Well Construction Diagram
Geophysical Logs
Soil Water Chemical Analyses
no Other

CERTIFICATION STATEMENT
I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.
NAME FISCH BROS DRILLING INC
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)
5001 Gravenstein Hwy No. Sebastopol CA 95472
Signed Scot Untersehar 040908 399226
WELL DRILLER / AUTHORIZED REPRESENTATIVE DATE SIGNED C-57 LICENSE NUMBER

Figure 13 – Well Completion Report for CASGEM Well 391860N1232039W001

DEPARTMENT OF WATER RESOURCES
WATER WELL DRILLERS REPORT

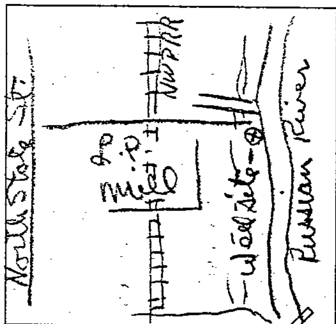
No. 34445

Notice of Intent No.______
Local Permit No. or Date______

State Well No. 15N/12W05@J04M
Other Well No. #6

(1) OWNER: Name Millview Co. Water Dist.
Address 3081 - North State St
City Ukiah Calif. Zip 95482

(2) LOCATION OF WELL (See instructions):
County Mendocino Owner's Well Number 6
Well address if different from above______
Township 15N Range 12W Section 4
Distance from cities, roads, railroads, fences, etc. 1/4 East of NWPRR Between Rwy & Russian River



WELL LOCATION SKETCH

(3) TYPE OF WORK:
New Well ☒ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☐
Destruction ☐ (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE:
Domestic ☐
Irrigation ☐
Industrial ☐
Test Well ☐
Stock ☐
Municipal ☒
Other ☐

(5) EQUIPMENT:
Rotary ☐ Reverse ☐
Cable ☐ Air ☐
Other ☐ Bucket ☐

(6) GRAVEL PACK:
Yes ☐ No ☒ Size______
Diameter of bore______
Packed from______ to______ ft.

(7) CASING INSTALLED:
Steel ☐ Plastic ☐ Concrete ☐

(8) PERFORATIONS:
Type of perforation or size of screen Johnson

From ft.	To ft.	Dia. in.	Gage or Wall	From ft.	To ft.	Slot size
0	20	10 3/4	.250	20	40	.175
~~40~~	~~45~~			40		3/16 x 3

(9) WELL SEAL:
Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth 20 ft.
Were strata sealed against pollution? Yes ☐ No ☐ Interval 0 - 20 ft.
Method of sealing Neat Cement

(10) WATER LEVELS:
Depth of first water, if known 13 ft.
Standing level after well completion 9 ft.

(11) WELL TESTS:
Was well test made? Yes ☒ No ☐ If yes, by whom? Rainbow
Type of test Pump ☒ Bailer ☐ Air lift ☐
Depth to water at start of test 9 ft At end of test 19 ft
Discharge 175 gal/min after 12 hours Water temperature Cool
Chemical analysis made? Yes ☐ No ☒ If yes, by whom?______
Was electric log made? Yes ☐ No ☒ If yes, attach copy to this report

(12) WELL LOG: Total depth 45 ft. Depth of completed well 45 ft.
from ft. to ft. Formation (Describe by color, character, size or material)

0-8 - Sandy large to fine gravel
8-13 - multi colored lt. Brn & blue clay embedded w/ brts. fine gravel
13-33 - lt. Brn. sandy cemented gravel
33-35 - lt. gray cemented gravel
35-45 lt. gray clay embedded w/ 3/4 minus gravel

ground level
0-20 10 3/4" Std line pipe .250 wall
20-40 19" .175 slot 10 3/4 KS Johnson screen Xtra heavy Const.
40-45 5' 10 3/4" Std. Perf. .250 wall
45' 3/8" plate welded

Work started 15 Apr 1980 Completed 1 May 1980

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

SIGNED Thomas J. Oster (Well Driller)
NAME Ost-Air Drilling (Person, firm, or corporation) (Typed or printed)
Address 13500 Tomki Rd.
City Redwood Valley Calif. Zip 95470
License No. 302814 Date of this report 1 July 80

DWR 188 (REV. 7-76) IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

OST-AIR DRILLING
13500 Tomki Road
Redwood Valley, CA 95470
(707) 485-8646
Tom Oster - Lic. #302814

Figure 14 – Well Completion Report for CASGEM Well 392358N1232020W001

√ 16N/12W.16N2

ORIGINAL
File with DWR

CONFIDENTIAL LOG
Water Code Sec. 13752

WATER WELL DRILLERS REPORT
(Sections 7079, 7080, 7081, 7082, Water Code)

THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

Do Not Fill In
№ 15976
State Well No.
Other Well No. 16N/12W-16N2

(1) OWNER:
Name Crawford Lumber Products, Inc.
Address P.O. Box C
Calpella, Calif.

(2) LOCATION OF WELL:
County Sonoma Owner's number, if any
Township, Range, and Section
Distance from cities, roads, railroads, etc. In parking lot of Calpella plant

(3) TYPE OF WORK (check):
New Well ☒ Deepening ☐ Reconditioning ☐ Destroying ☐
If destruction, describe material and procedure in Item 11.

(4) PROPOSED USE (check):
Domestic ☒ Industrial ☒ Municipal ☐
Irrigation ☐ Test Well ☐ Other ☐

(5) EQUIPMENT:
Rotary ☒
Cable ☐
Other ☐

(6) CASING INSTALLED:
STEEL: X OTHER:
SINGLE ☒ DOUBLE ☐

From ft.	To ft.	Diam.	Gage or Wall	Diameter of Bore	From ft. (If gravel packed)	To ft. (If gravel packed)
0	274	8"	10ga	15"	0	274

Size of shoe or well ring: Size of gravel: Pea
Describe joint Welded

(7) PERFORATIONS OR SCREEN:
Type of perforation or name of screen Torch

From ft.	To ft.	Perf. per row	Rows per ft.	Size in. x in.
214	274	1	5	3/16 x 6
94	194	1	5	"

(8) CONSTRUCTION:
Was a surface sanitary seal provided? Yes ☒ No ☐ To what depth 35 ft.
Were any strata sealed against pollution? Yes ☐ No ☒ If yes, note depth of strata
From ft. to ft.
From ft. to ft.
Method of sealing Concrete on Peak

(9) WATER LEVELS:
Depth at which water was first found, if known ft.
Standing level before perforating, if known ft.
Standing level after perforating and developing 20 ft.

(10) WELL TESTS:
Was pump test made? Yes ☐ No ☒ If yes, by whom? Bail
Yield: 30 gal./min. with 100 ft. drawdown after hrs.
Temperature of water cool Was a chemical analysis made? Yes ☐ No ☐
Was electric log made of well? Yes ☐ No ☒ If yes, attach copy

(11) WELL LOG:
Total depth 274 ft. Depth of completed well 274 ft.
Formation: *Describe by color, character, size of material, and structure*

ft.	to	ft.	Formation
0	-	1	Gravel fill
1	-	10	~~Brown clay with cemented gravel~~
10	-	25	~~Conglomerant rock & boulders~~
25	-	50	~~Brown sandy clay~~
50	-	67	~~Blue sandy clay~~
67	-	96	~~Blue sandy clay~~
96	-	110	~~Brown sandy clay w/ cemented gravel~~
110	-	115	~~Brown sandy clay w/ small streaks of gravel & sand~~
115	-	125	~~Brown sandy clay~~
125	-	130	~~Blue clay~~
130	-	136	~~Brown sandy clay w/ small streaks of gravel~~
136	-	142	~~Brown sandy clay~~
142	-	214	~~Brown sandy clay w/ cemented gravel~~
214	-	230	~~Brown clay w/ cemented gravel~~
230	-	240	~~Blue sandy clay~~
240	-	243	~~Brown gravel & sand~~
243	-	274	~~Brown clay w/ streaks of blue clay~~

CONFIDENTIAL LOG
Water Code Sec. 13752

Work started 10/8, 19 70, Completed 10/15 19 70

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Weeks Drilling & Pump Company
(Person, firm, or corporation) (*Typed or printed*)
Address 6100 Sebastopol Ave.
Sebastopol, Calif.
[SIGNED] Gerald G. Thompson (Well Driller)
By Mary E. Thompson License No. 177681 Dated Oct. 23, 19 70

SKETCH LOCATION OF WELL ON REVERSE SIDE

DWR 188 (REV. 9-65)

56391-950 10-65 50M TRIP OSP

Figure 15 – Well Completion Report for CASGEM Well 392730N1231770W001

ORIGINAL
File with DWR

Page 1 of 1

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

No. **E066664**

DWR USE ONLY — DO NOT FILL IN
17N12W34
STATE WELL NO./STATION NO.
LATITUDE | LONGITUDE
APN/TRS/OTHER

Owner's Well No. WELL #1

Date Work Began 11/29/2007, Ended 5/5/2008

Local Permit Agency Mendocino County Environmental

Permit No. WW21078 Permit Date 9/11/2007

GEOLOGIC LOG

ORIENTATION (✓) ✓ VERTICAL — HORIZONTAL — ANGLE — (SPECIFY)

DRILLING METHOD AIR FLUID N/A

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION Describe material, grain, size, color, etc.
0	3	Damp brown clay
3	14	Brown clay, some embedded rock
14	35	Brown clay and embedded rock
35	110	Blue clay and rock
110	224	Brown clay and rock
224	235	Blue clay and rock
235	400	Shalee sandstone and shale
		TO BE COMPLETED WHEN
		WEATHER PERMITS
		COMPLETED ON 05/05/08

TOTAL DEPTH OF BORING 400 (Feet)

TOTAL DEPTH OF COMPLETED WELL 306 (Feet)

WELL OWNER

Name Redwood Valley County Water Dist

Mailing Address POB 399

Redwood Valley CA

CITY STATE ZIP

WELL LOCATION

Address 2370 Webb Ranch Road

City Redwood Valley CA

County Mendocino

APN Book 161 Page 300 Parcel 06-00

Township — Range — Section —

Latitude — DEG. MIN. SEC. Longitude — DEG. MIN. SEC.

LOCATION SKETCH

NORTH

WEST EAST

SOUTH

Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

✓ NEW WELL

MODIFICATION/REPAIR
— Deepen
— Other (Specify)

— DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USES (✓)

WATER SUPPLY
— Domestic — Public
— Irrigation — Industrial

MONITORING —
TEST WELL —
CATHODIC PROTECTION —
HEAT EXCHANGE —
DIRECT PUSH —
INJECTION —
VAPOR EXTRACTION —
SPARGING —
REMEDIATION —
OTHER (SPECIFY) —

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER N/A (Ft.) BELOW SURFACE

DEPTH OF STATIC WATER LEVEL 10 (Ft.) & DATE MEASURED 5/5/2008

ESTIMATED YIELD * 15 (GPM) & TEST TYPE Air Lift

TEST LENGTH 2 (Hrs.) TOTAL DRAWDOWN 294 (Ft.)

* *May not be representative of a well's long-term yield.*

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	50	11"								
50	400	8"								
+2.5	306		✓				PVC	5	SDR21	
186	306			✓						.032

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	3	✓			CONCRETE
3	50.5	✓			
50.5	55		✓		
55	306			✓	3/8 GRAVEL

ATTACHMENTS (✓)

— Geologic Log
— Well Construction Diagram
— Geophysical Log(s)
— Soil/Water Chemical Analysis
— Other

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Weeks Drilling & Pump
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

ADDRESS P.O. Box 176 CITY Sebastopol STATE CA ZIP 95473

Signed Melissa G. Lopez
WELL DRILLER/AUTHORIZED REPRESENTATIVE

DATE SIGNED 05/07/08 C-57 LICENSE NUMBER 177681

DWR 188 REV. 11-97

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

*The free Adobe Reader may be used to view and complete this form. However, software must be purchased to complete, save, and reuse a saved form.

File Original with DWR

State of California

Well Completion Report

Refer to Instruction Pamphlet

No. e0316347

Page 1 of 2

Owner's Well Number mw-9

Date Work Began 05/16/2016 Date Work Ended 5/27/2016

Local Permit Agency Mendocino county

Permit Number HZ236625 Permit Date 4/21/16

DWR Use Only – Do Not Fill In

State Well Number/Site Number

N | W

Latitude | Longitude

APN/TRS/Other

Geologic Log

Orientation ⦿ Vertical ○ Horizontal ○ Angle Specify

Drilling Method reverse circulation Drilling Fluid Bentonite mud

Depth from Surface Feet	to Feet	Description (Describe material, grain size, color, etc)
0	4	silty sand
4	9	sandy silt
9	18	lean clay
18	28	clay silt
28	35	silty sand
35	53	clay gravel
53	75	silt/sand w/ gravel
75	89	fat clay
89	92	clay/sand w/gravel
92	102	well graded gravel w/ sand
102	109	silty sand
109	113	sand w/gravel
113	137	well graded gravel w/sand
137	140	silty clay
140	184	well graded gravels
184	187	lean clay
187	213	well graded gravel
213	223	lean clay w/sand
223	225	well graded gravel
225	230	fat clay
230	235	lean clay w/sand
235	264	well graded gravel
264	270	fat clay

Total Depth of Boring 270 Feet

Total Depth of Completed Well 260 Feet

Well Owner

Name City of Ukiah

Mailing Address 300 Seminary

City Ukiah State ca Zip 95482

Well Location

Address 509 Brush st.

City Ukiah County Mendocino

Latitude 39 Deg. 9 Min. 31 Sec. N Longitude 123 Deg. 12 Min. 1 Sec. W

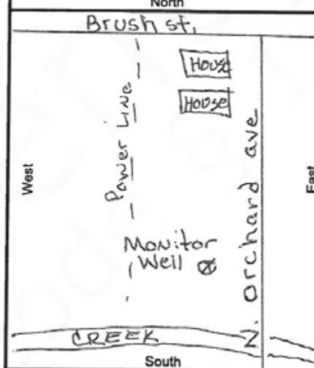
Datum ___ Dec. Lat. ___ Dec. Long. ___

APN Book 002 Page 101 Parcel 27

Township ___ Range ___ Section ___

Location Sketch

(Sketch must be drawn by hand after form is printed.)



Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. Please be accurate and complete.

Activity

⦿ New Well
○ Modification/Repair
○ Deepen
○ Other
○ Destroy
Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

○ Water Supply
☐ Domestic ☐ Public
☐ Irrigation ☐ Industrial
○ Cathodic Protection
○ Dewatering
○ Heat Exchange
○ Injection
⦿ Monitoring
○ Remediation
○ Sparging
○ Test Well
○ Vapor Extraction
○ Other

Water Level and Yield of Completed Well

Depth to first water 17 (Feet below surface)

Depth to Static Water Level 30 (Feet) Date Measured 05/20/2016

Estimated Yield * 100 (GPM) Test Type Constant Rate

Test Length 48.0 (Hours) Total Drawdown 60 (Feet)

*May not be representative of a well's long term yield.

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	77	24	Conductor	Low Carbon Steel	.375	14		
0	80	12.25	Blank	PVC Sch. 40	.280	6.625		
80	120	12.25	Screen	PVC Sch. 40	.280	6.625	Milled Slots	0.040
120	150	12.25	Blank	PVC Sch. 40	.280	6.625		
150	180	12.25	Screen	PVC Sch. 40	.280	6.625	Milled Slots	0.040
180	230	12.25	Blank	PVC Sch. 40	.280	6.625		

Annular Material

Depth from Surface Feet	to Feet	Fill	Description

Attachments

☐ Geologic Log
☐ Well Construction Diagram
☐ Geophysical Log(s)
☐ Soil/Water Chemical Analyses
☐ Other

Attach additional information, if it exists.

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name NorCal Pump and Well Drilling
Person, Firm or Corporation

1325 Barry rd. Yuba City CA 95993
Address City State Zip

Signed ___ 7/21/2016 908591
C-57 Licensed Water Well Contractor Date Signed C-57 License Number

DWR 188 REV. 1/2006

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

*The free Adobe Reader may be used to view and complete this form. However, software must be purchased to complete, save, and reuse a saved form.

File Original with DWR

State of California

Well Completion Report

Refer to Instruction Pamphlet

No. xxxxxxx

DWR Use Only – Do Not Fill In

State Well Number/Site Number

N Latitude | W Longitude

APN/TRS/Other

Page 2 of 2

Owner's Well Number mw-9

Date Work Began ______ Date Work Ended ______

Local Permit Agency Mendocino

Permit Number ______ Permit Date ______

Geologic Log

Orientation O Vertical O Horizontal O Angle Specify ______

Drilling Method ______ Drilling Fluid ______

Depth from Surface Feet	to Feet	Description (Describe material, grain size, color, etc)

Total Depth of Boring ______ Feet

Total Depth of Completed Well ______ Feet

Well Owner

Name City of Ukiah

Mailing Address 300 seminary ave

City Ukiah State ca Zip 95482

Well Location

Address 509 Brush st.

City Ukiah County Mendocino

Latitude 309 Deg. 9 Min. 31 Sec. N Longitude 123 Deg. 12 Min. 1 Sec. W

Datum ______ Dec. Lat. ______ Dec. Long. ______

APN Book 002 Page 101 Parcel 27

Township ______ Range ______ Section ______

Location Sketch

(Sketch must be drawn by hand after form is printed.)

North

West

East

South

Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. Please be accurate and complete.

Activity

O New Well

O Modification/Repair

O Deepen

O Other ______

O Destroy

Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

O Water Supply

☐ Domestic ☐ Public

☐ Irrigation ☐ Industrial

O Cathodic Protection

O Dewatering

O Heat Exchange

O Injection

O Monitoring

O Remediation

O Sparging

O Test Well

O Vapor Extraction

O Other ______

Water Level and Yield of Completed Well

Depth to first water ______ (Feet below surface)

Depth to Static Water Level ______ (Feet) Date Measured ______

Estimated Yield * ______ (GPM) Test Type ______

Test Length ______ (Hours) Total Drawdown ______ (Feet)

*May not be representative of a well's long term yield.

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
230	260	12.25	Screen	PVC Sch. 40	.280	6.625	Milled Slots	0.040

Annular Material

Depth from Surface Feet	to Feet	Fill	Description

Attachments

☐ Geologic Log

☐ Well Construction Diagram

☐ Geophysical Log(s)

☐ Soil/Water Chemical Analyses

☐ Other ______

Attach additional information, if it exists.

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name NorCal pump and well drilling

Person, Firm or Corporation

1325 Barry rd (Address) Yuba City (City) CA (State) 95993 (Zip)

Signed ______ (C-57 Licensed Water Well Contractor) 7/21/2016 (Date Signed) 908591 (C-57 License Number)

*The free Adobe Reader may be used to view and complete this form. However, software must be purchased to complete, save, and reuse a saved form.

File Original with DWR

State of California

Well Completion Report

Refer to Instruction Pamphlet

No. e0317247

Page 1 of 2

Owner's Well Number MW-4

Date Work Began 06/02/2016 Date Work Ended 6/14/2016

Local Permit Agency Mendocino

Permit Number HZ236085 Permit Date 4/21/16

DWR Use Only – Do Not Fill In

State Well Number/Site Number

N Latitude W Longitude

APN/TRS/Other

Geologic Log

Orientation ⦿ Vertical ○ Horizontal ○ Angle Specify

Drilling Method Reverse Circulation Rotary Drilling Fluid Bentonite mud

Depth from Surface Feet	to Feet	Description (Describe material, grain size, color, etc)
0	8	clay/sand and gravel
8	15	sandy clay
15	22	clay gravel w/sand
22	25	lean clay w/sand
25	32	clay,gravel w/sand
32	34	clay/sand
34	42	clay gravel
42	46	clay sand gravel
46	50	clay gravel
50	53	fat clay
53	57	well graded gravel
57	65	clay w/sand
65	68	well graded gravel
68	73	lean clay w/sand
73	75	clay gravel
75	97	fat clay
97	100	clay gravel
100	104	poorly graded gravel
104	153	well graded gravel
153	157	clay/gravel
157	163	well graded gravel
163	169	clay/gravel
169	178	well graded gravel w/sand
178	183	clay/gravel
183	213	well graded gravel
213	221	fat clay

Total Depth of Boring 221 Feet

Total Depth of Completed Well 215 Feet

Well Owner

Name City of Ukiah

Mailing Address 300 Seminary ave

City Ukiah State ca Zip 95482

Well Location

Address 56 Lorraine st.

City Ukiah County Mendocino

Latitude 39 Deg. 8 Min. 28 Sec. N Longitude 123 Deg. 11 Min. 54 Sec. W

Datum ____ Dec. Lat. ____ Dec. Long. ____

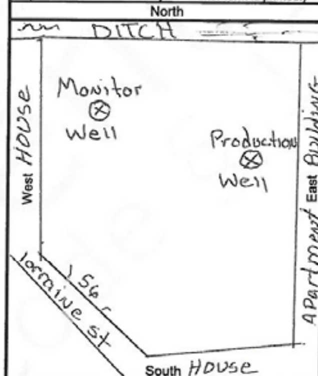
APN Book 003 Page 572 Parcel 15

Township ____ Range ____ Section ____

Location Sketch

(Sketch must be drawn by hand after form is printed.)

North



South HOUSE

Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. Please be accurate and complete.

Activity

⦿ New Well
○ Modification/Repair
○ Deepen
○ Other ____
○ Destroy
Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

○ Water Supply
☐ Domestic ☐ Public
☐ Irrigation ☐ Industrial
○ Cathodic Protection
○ Dewatering
○ Heat Exchange
○ Injection
⦿ Monitoring
○ Remediation
○ Sparging
○ Test Well
○ Vapor Extraction
○ Other ____

Water Level and Yield of Completed Well

Depth to first water 14 (Feet below surface)

Depth to Static Water Level 50 (Feet) Date Measured 06/14/2016

Estimated Yield * 100 (GPM) Test Type Air Lift

Test Length 48.0 (Hours) Total Drawdown ____ (Feet)

*May not be representative of a well's long term yield.

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	61	24	Conductor	Low Carbon Steel	.375	14		
0	60	12	Blank	PVC Sch. 40	.280	6		
60	70	12	Screen	PVC Sch. 40	.280	6	Milled Slots	0.040
70	100	12	Blank	PVC Sch. 40	.280	6		
100	140	12	Screen	PVC Sch. 40	.280	6	Milled Slots	0.040
140	170	12	Blank	PVC Sch. 40	.280	6		

Annular Material

Depth from Surface Feet	to Feet	Fill	Description
0	59	Cement	11 sack
3	45	Cement	11 sack
45	55	Bentonite	chips
55	75	Filter Pack	# 6 sand
75	95	Bentonite	chips
95	145	Filter Pack	# 6 sand

Attachments

☐ Geologic Log
☐ Well Construction Diagram
☐ Geophysical Log(s)
☐ Soil/Water Chemical Analyses
☐ Other ____

Attach additional information, if it exists.

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name NorCal Pump and Well Drilling
Person, Firm or Corporation

1325 Barry rd. Yuba City CA 95993
Address City State Zip

Signed [signature] 7/21/2016 908591
C-57 Licensed Water Well Contractor Date Signed C-57 License Number

DWR 188 REV. 1/2006

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

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File Original with DWR

State of California

Well Completion Report

Refer to Instruction Pamphlet

No. xxxxxxx

DWR Use Only – Do Not Fill In

State Well Number/Site Number

N Latitude W Longitude

APN/TRS/Other

Owner's Well Number MW-4

Date Work Began 06/02/2016 Date Work Ended 6/14/2016

Local Permit Agency Mendocino County

Permit Number HZ236085 Permit Date 6/21/16

Geologic Log

Orientation ○ Vertical ○ Horizontal ○ Angle Specify

Drilling Method Drilling Fluid

Depth from Surface Feet to Feet		Description: Describe material, grain size, color, etc

Total Depth of Boring 221 Feet

Total Depth of Completed Well 215 Feet

Well Owner

Name City of Ukiah

Mailing Address 300 seminary ave

City Ukiah State ca Zip 95482

Well Location

Address 56 Lorraine st.

City Ukiah County Mendocino

Latitude 39 Deg. 8 Min. 28 Sec. N Longitude 123 Deg. 11 Min. 54 Sec. W

Datum Dec. Lat. Dec. Long.

APN Book 003 Page 572 Parcel 15

Township Range Section

Location Sketch

(Sketch must be drawn by hand after form is printed.)

North

West

East

South

Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. Please be accurate and complete.

Activity

○ New Well
○ Modification/Repair
○ Deepen
○ Other
○ Destroy
Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

○ Water Supply
☐ Domestic ☐ Public
☐ Irrigation ☐ Industrial
○ Cathodic Protection
○ Dewatering
○ Heat Exchange
○ Injection
○ Monitoring
○ Remediation
○ Sparging
○ Test Well
○ Vapor Extraction
○ Other

Water Level and Yield of Completed Well

Depth to first water (Feet below surface)

Depth to Static Water Level (Feet) Date Measured

Estimated Yield * (GPM) Test Type

Test Length (Hours) Total Drawdown (Feet)

*May not be representative of a well's long term yield.

Casings

Depth from Surface Feet to	Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
170	210	12	Screen	PVC Sch. 40	.280	6	Milled Slots	0.040
210	215	12	Blank	PVC Sch. 40	.280	6		

Annular Material

Depth from Surface Feet to	Feet	Fill	Description
145	165	Bentonite	chips
165	215	Filter Pack	#6
215	221		native

Attachments

☐ Geologic Log
☐ Well Construction Diagram
☐ Geophysical Log(s)
☐ Soil/Water Chemical Analyses
☐ Other

Attach additional information, if it exists.

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name Norcal Pump and Well Drilling
Person, Firm or Corporation

1325 Barry rd. Yuba City CA 95993
Address City State Zip

Signed
C-57 Licensed Water Well Contractor

7/21/15 Date Signed

908591 C-57 License Number

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

13 Appendix G – Well Monitoring Data Entry Sheet

PROJECT:______________________________ SITE ID #____________________

WELL NUMBER____________________DATE DRILLED_______SUBAREA______________

BASIN________________________SECTION____________MAP____________________

LAND
OWNER_________________ADDRESS_______________TOPOGRAPHY________________

____

LSD ELEVATION_____TOP OF CASING ELEV.________FT. ABOVE LSD DEPTH-PILOT HOLE____

CASING DIAMETER____IN. CASING LENGTH___FT. FIRST WATER_____FT BELOW MP

PERFORATIONS____

LOCATION____

____

REMARKS____

____

LOCATION SKETCH

WELL SKETCH

14 Appendix H – CASGEM Well Monitoring Protocol

CASGEM Well Monitoring Protocol

Checklist Before Leaving:

- Do you have the keys?
- Do you have the map, GIS locations, and contact names and numbers for the wells?
- Do you have the log book?
- Do you need the stainless steel tape and chalk, and if so do you have them?

For County Monitoring Wells:

1. Write basic data in log book: date, time, weather, name of monitor, other people present, identification number and location of well
2. Unlock well cover
3. Remove well cap
4. Unlock the sounding tape (lock on the side of the tape canister)
5. Turn on the sounding tape; test with test button or look for red light
6. Use rag and alcohol to sterilize the entire metal portion of the probe
7. Identify the marked spot and insert the tape at that spot
8. Take three (3) readings
9. Record readings in the official log book
10. Turn off tape and re-scroll
11. Replace cap loosely
12. Lock up

For Other Wells:

1. Write basic data in log book: date, time, weather, name of monitor, other people present, identification number and location of well
2. Unlock well cover
3. Remove well cap
4. Unlock the sounding tape (lock on the side of the tape canister)
5. Turn on the sounding tape; test with test button or look for red light
6. Use rag and alcohol to sterilize the entire metal portion of the probe
7. Identify the marked spot, if one, and insert the tape at that spot
8. If no marked spot, use a Sharpie to establish one
9. Take three (3) readings
10. Record readings in the official log book
11. Turn off tape and rescroll
12. Replace cap loosely
13. Lock up

If the Sounding Tape is Too Large to Fit:

1. Use stainless steel tape with a thin fishing line weight at the end.
2. Mark the tape with blue carpenter's chalk at the 10-15 foot interval and slowly insert into the well.
3. Raise the tape and see if/where the tape is wet.
4. If it is dry, repeat by marking at 5 foot intervals until the depth of the well is established.

15 Appendix I – Installation of Monitoring Well Access Boxes

Installation of Monitoring Well Access Boxes

1. Top of the well casing shall be 3 to 6 inches below the bottom of the access box lid.

2. The high strength grout apron shall extend 2 feet below final grade and a minimum 6 inches around the access box. This is not the well seal. Wells located in a concrete surface may be set with a smaller apron.

3. Contact with the well seal shall be free of debris and the shoulder between the borehole and access box hole shall be flat.

4. For flush mounted boxes, the top of the access box shall be even with the existing grade.

5. High strength grout shall be mixed with approximately 4 parts coarse silica sand, 2 parts cement and 1 part water by volume. The mix should have the consistency of thick paste.

6. The finished surface shall be smooth and neat.

16 Appendix J – DWR Evaluation of Extent of Monitoring under CASGEM Program

STATE OF CALIFORNIA – CALIFORNIA NATURAL RESOURCES AGENCY EDMUND G. BROWN JR., *Governor*

DEPARTMENT OF WATER RESOURCES
1416 NINTH STREET, P.O. BOX 942836
SACRAMENTO, CA 94236-0001
(916) 653-5791

August 7, 2014

Evaluation of the Extent of Monitoring Under the California Statewide
Groundwater Elevation Monitoring (CASGEM) Program

Dear CASGEM Monitoring Entity:

To date, 208 groundwater basins and subbasins are either fully or partially monitored under the CASGEM Program. The Department of Water Resources (DWR) continues to work with agencies across the State in an effort to establish CASGEM monitoring and reporting in groundwater basins where they do not currently exist.

The California Water Code directs DWR to:

- Evaluate the extent of monitoring within the State's 515 groundwater basins and subbasins - Water Code Section 10933(a)
- Report the extent of monitoring and status of the CASGEM Program, to the Governor and Legislature every 5 years - Water Code Section 12924(b)

The next CASGEM status report to the Governor and Legislature is due in January 2015. In addition, the Governor's Drought Proclamation requires DWR to report the effects of the current drought on groundwater resources. The last such report was in April 2014, and the next report is due in November 2014. A discussion of the extent of CASGEM groundwater monitoring will be included in the November 2014 drought report.

DWR staff are evaluating the information submitted to the CASGEM Online System by the designated Monitoring Entities. Staff are using the data and monitoring plans to evaluate the extent and adequacy of CASGEM groundwater elevation monitoring efforts, and documenting data gaps. Specific data gaps identified in the review include:

- Horizontal (areal, or x and y axes) data gaps in the defined monitoring area;
- Vertical data gaps in groundwater basins having more than one distinct aquifer zone;
- Insufficient density of monitoring locations with respect to the areal size of basin (recommendations range from 2-10 wells per 100 square miles, but high and medium priority groundwater basins could warrant well densities toward the upper end);
- Well construction data gaps (CASGEM wells with missing total depth and/or screened intervals, well completion report said to be available yet well construction information was not submitted to CASGEM Online System);

- Temporal data gaps
  - CASGEM wells not monitored on a frequency of at least twice a year since the Monitoring Entity was designated for the basin/subbasin; or
  - Monitoring is occurring twice a year, but not all of the CASGEM wells identified in the monitoring plan are reported;
- Insufficient data gap documentation in the monitoring plans – lack of discussion of data gaps in the monitoring network.

The results of this assessment of the extent of monitoring will be included in the upcoming reports, which will be available to the public. DWR recognizes that most designated monitoring entities made substantial efforts to avoid data gaps in their monitoring networks. In cases where data gaps could not be avoided, a description of them, and the plan to fill them, was expected to be included in the monitoring plan for the respective designated basin/subbasin/portion.

DWR has completed an initial screening of the data in the CASGEM Online System and compiled the results for each designated basin, subbasin, and basin portion. The compilation includes what appears to be data gaps in some designated basins. Before releasing this information to the public in the reports, DWR wants to be sure the information is accurate, and therefore is providing the designated monitoring entities the opportunity to review the information and submit corrections, if needed.

By August 15, 2014, DWR staff will be contacting each designated monitoring entity to discuss the results of the data compilation and any data gaps identified for their basin(s). DWR is requesting all of the designated monitoring entities review the information, report any errors to their respective DWR contact, and upload correct data/information in the CASGEM online system by September 15, 2014. If there are any errors in the Online System that the monitoring entity is unable to fix themselves, DWR Region Office staff are available to work with your staff to make the corrections by September 15, 2014.

The DWR Region Office contacts for evaluation of the CASGEM monitoring are the following:

Northern Region
Bill Ehorn
Senior Engineering Geologist
2440 Main Street
Red Bluff, CA 96080
(530) 528-7403
Bill.Ehorn@water.ca.gov

North Central Region
Erin Smith
Engineering Geologist
3500 Industrial Blvd
West Sacramento, CA 95691
(916) 376-9623
Erin.Smith@water.ca.gov

South Central Region
Mike McKenzie
Engineering Geologist
3374 East Shields Avenue
Fresno, CA 93726
(559) 230-3308
Charles.McKenzie@water.ca.gov

Southern Region
Eric Gorman
Engineering Geologist
770 Fairmont Ave, Ste 102
Glendale, CA 91203
(818) 500-1645 Ext. 336
Eric.Gorman@water.ca.gov

DWR appreciates your cooperation in this effort and your assistance helping ensure that the accuracy and quality of data in the CASGEM Online System is reported to the public and is maintained at a high level.

Thank you for your participation in the CASGEM program.

Sincerely,

Mary Scruggs

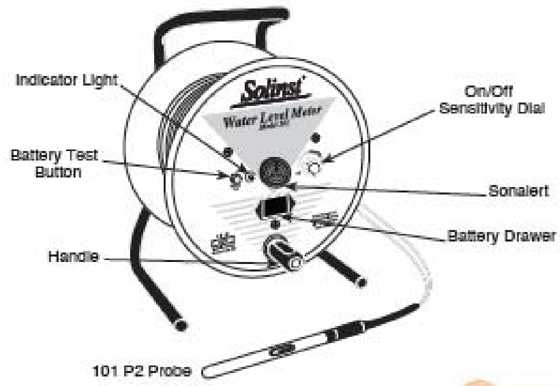
Mary Scruggs
CASGEM Program Manager
Division of Integrated Regional Water Management

cc: Paula Landis, Chief
Division of Integrated Regional Water Management

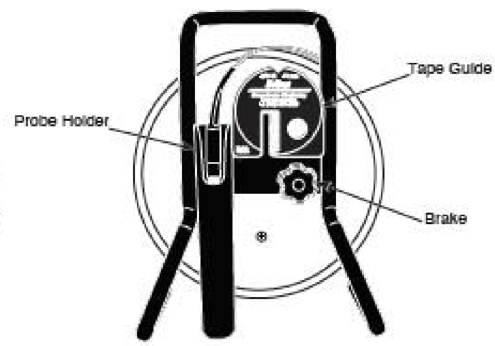
Brett Wyckoff, HQ-Bonderson
Bill Ehorn, Northern Region Office
Chris Bonds, North Central Region Office
Dane Mathis, South Central Region Office
Tim Ross, Southern Region Office

17 Appendix K – Monitoring Equipment Manuals

Model 101 P2



Front View



Back View

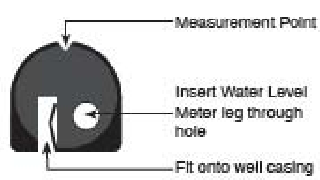
Equipment Check

1. Turn sensitivity dial fully clockwise.

> Notes: 1. Clockwise rotation of sensitivity dial turns meter on and increases sensitivity.
> 2. Always set switch to highest sensitivity position, then decrease if necessary.

2. Depress the Battery Test button to test the battery and main circuitry (does not test the tape or probe).
3. Submerse the probe in tap water. This completes the circuit and activates the buzzer and light.

The Tape Guide



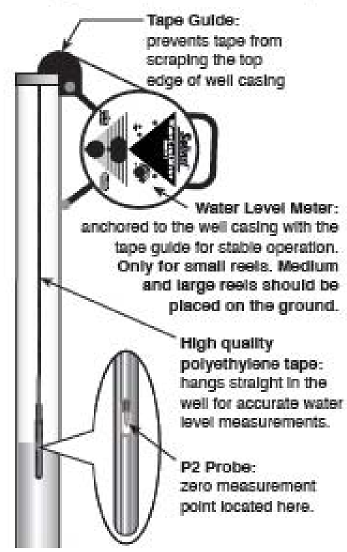
The Tape Guide has been designed to:

- Improve accuracy when reading water levels,
- Easily obtain repeatable measurements,
- Prevent tape being cut by well casing,
- Allow the tape and probe to hang straight from the side of the well.

1. Fit the small end of the Tape Guide onto the edge of well casing 2" (50 mm) diameter or larger.
2. For small reels only, insert the leg of the Water Level Meter into the hole on the Tape Guide and rest the Water Level Meter on the side of the well casing. (See diagram at right).
3. To store the Tape Guide, simply clip it onto the support bracket located on the back of the Water Level Meter.

Water Level Measurements

1. The P2 Probe zero measurement point is the tip of the needle in the center of the probe.
2. For ease of operation the Tape Guide can be used to support the Water Level Meter. (See diagram below).
3. Feed the tape into and out of the well using the groove in the top of the Tape Guide. The light and buzzer activate when the needle tip enters water. To ensure accuracy, lower and raise the probe a few times and then record the depth measurement from the tape at the top of the well.
4. When using the Tape Guide, the measuring point is offset from the top of casing. To adjust your measurements to the top of the casing, simply subtract the amount indicated on the front of the Tape Guide (i.e. 6 cm or 2/10 ft).



Routine Care

1. After the depth to water has been recorded, the tape should be carefully rewound onto the reel, the probe wiped dry and placed into the probe holder.
2. The probe, tape and reel can be cleaned with phosphate free (non-abrasive) detergent and warm water. Do not submerge the reel.
3. Use of a Water Level Meter Carrying Bag adds to the service life of the meter.
4. Use of the Tape Guide adds to the life of the tape.

Probe Care and Cleaning

1. The P2 Probe should be wiped clean after each use.
2. Remove any dirt or water from around the central sensor pin.
3. If the central sensor pin is corroded or coated, use emery cloth to polish it.
4. Check the P2 Probe seal/strain relief and replace the black heat shrink if there is any cracking or other damage.
5. After cleaning, place probe back in its holder.

Battery Replacement

- Battery type - alkaline, 9 volt.

1. The battery is housed in a convenient battery drawer located in the faceplate of the Water Level Meter.
2. To replace the battery, simply press the drawer in, lift then pull.
3. The battery drawer should slide out of the faceplate enough to pull it out.
4. Note the polarity (positive (+) terminal should be towards the small notch in the end of the drawer) and place new battery in the drawer and slide it back into the faceplate.

Replacement Parts

The following parts can be provided should they become lost or damaged.

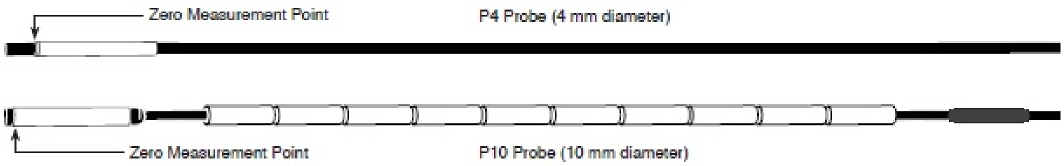
1. Probes and seal kits
2. Splice kits
3. Lights, switches, etc.
4. Reels
5. Replacement tape with probe (Complete)
6. Assembled probes on shorter lengths of tape

Troubleshooting

SYMPTOM	CAUSE	REMEDY
No sound when probe immersed in water.	Dead battery.	Replace with 9V Alkaline.
	Water Conductivity is very low.	Increase sensitivity switch setting (turn clockwise) or call Solinst for assistance.
	Disconnected wires on circuit board.	Check all connections inside hub of reel for loose/disconnected wires - solder or reconnect.
	Broken wire in tape.	Locate break in tape - splice and seal, or replace. (Contact Solinst)
	Disconnected wire inside probe.	Contact Solinst to obtain parts/repair instructions.
Instrument continuously sounds after being immersed in water.	Water in probe. Probe may be dirty which could interfere with the circuit connection.	Contact Solinst for probe seal kit. Disassemble, clean and reassemble probe using the new seal kit.

For further information contact: Solinst Canada Ltd.
Fax: +1 (905) 873-1992; (800) 516-9081 Tel: +1 (905) 873-2255; (800) 661-2023
35 Todd Road, Georgetown, Ontario Canada L7G 4R8
Web Site: www.solinst.com E-mail: instruments@solinst.com

Solinst®



Routine Care

1. After the depth to water has been recorded, the cable should be carefully rewound onto the reel, the probe wiped dry and placed into the probe holder.
2. The probe, weights, cable and reel can be wiped clean with phosphate free (non-abrasive) detergent and warm water. Do not submerge the reel.
3. Use of a Water Level Meter Carrying Bag adds to the service life of the meter.
4. Use of the Tape Guide adds to the life of the cable.

Replacement Parts

The following parts can be provided should components become lost or damaged.

1. Splice kits
2. Lights, dials, etc.
3. Reels and/or faceplates
4 Replacement cable with probe (complete)
5. Assembled probes on 10 ft or 3 m lengths of cable
6. Weights

Battery Replacement

- Battery type - alkaline, 9 volt.

1. The battery is housed in a convenient battery drawer located in the faceplate of the Water Level Meter.
2. To replace the battery, simply press the drawer in, lift, then pull.
3. The battery drawer should slide out of the faceplate enough to pull it out.
4. Note the polarity. The positive (+) terminal should be towards the small notch in the end of the drawer. Place new battery in the drawer and slide it back into the faceplate.

Troubleshooting

SYMPTOM	CAUSE	REMEDY
No sound when probe immersed in water.	Dead battery.	Replace with 9V Alkaline.
	Water Conductivity is very low.	Increase sensitivity dial setting (turn clockwise) or call Solinst for assistance.
	Disconnected wires on circuit board.	Check all connections inside hub of reel for loose/disconnected wires - solder or reconnect.
	Broken wire in cable.	Locate break in cable - splice and seal, or replace. (Contact Solinst)
	Disconnected wire inside probe.	Contact Solinst to obtain parts/repair instructions.
Instrument continuously sounds after being immersed in water.	Water in probe. Probe may be dirty which could interfere with the circuit connection.	Contact Solinst for instructions to clean or replace the probe.

For further information contact: Solinst Canada Ltd.
Fax: +1 (905) 873-1992; (800) 516-9081 Tel: +1 (905) 873-2255; (800) 661-2023
35 Todd Road, Georgetown, Ontario Canada L7G 4R8
Web Site: www.solinst.com E-mail: instruments@solinst.com

Solinst®

RAVENSGATE
SONIC WATER LEVEL METERS

SONIC WATER LEVEL METERS

USER GUIDE
MODEL 300

Table of Temperature Control Settings
Ts, degrees F

Well Water Temperature, Tw, degrees F	Average Daily Surface Temperature, Tg, degrees F																			
	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95
36	31	31	32	33	34	34	35	36	37	37	38	39	40	40	41	42	43	43	44	45
38	32	33	34	35	35	36	37	38	38	39	40	41	41	42	43	44	44	45	46	47
40	34	35	36	36	37	38	39	39	40	41	42	42	43	44	45	45	46	47	48	48
42	36	36	37	38	39	39	40	41	42	42	43	44	45	45	46	47	48	48	49	50
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88	75	76	76	77	78	79	79	80	81	82	82	83	84	85	85	86	87	88	88	89
90	77	77	78	79	80	80	81	82	83	83	84	85	86	86	87	88	89	89	90	91

Ravensgate Corporation, Ridgecrest, CA, 93555

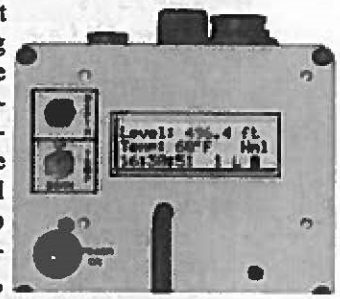
CONTENTS

Revised May 19, 2014

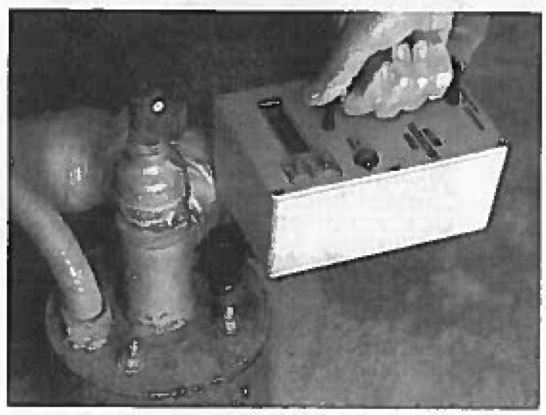
INTRODUCTION

Thank you for purchasing a RAVENSGATE SONIC WATER LEVEL METER, Model 300. You will find that it provides fast, accurate measurements of static water level and draw-down. Furthermore, its small size and light weight make it very convenient to carry to work sites and other locations where measurements are necessary.

Unlike most other water level measurement devices, our Sonic method operates by injecting sound waves into the well casing. The wave reflected from the water surface is then analyzed to determine the level and the result displayed on the front panel. Thus, down-hole probes or instrumentation are not necessary. All that is required is an access port in the well cap 5/8 inches (16 mm) or greater in diameter. Simply insert the measuring duct through the cap, push the power-on button and the measurement is displayed in a few seconds. If the well is uncapped, we supply the meter with an easily fitted cap for diameters up to 6 inches (150 mm). Larger diameter caps can be fabricated as needed from plastic or sheet metal.



A typical meter reading on the Model 300



Model 300 shown with the duct properly inserted into the well head.

OPERATING INSTRUCTIONS

MODES OF OPERATION

In all modes, the user should choose either the **NORMAL** or **DEEP** setting according the type of well, Also, for best accuracy the temperature **(TEMP)** setting should be adjusted for the climate where the well is. These settings will be described in more detail in later sections.

The simplest mode, **QUICK START MODE,** provides "no frills" operation for basic water level measurements.

For well installations that are more involved measurements are sometimes more easily obtained by changing some of the Model 300 default parameters. Making such changes is described in the section titled ***BASIC CONFIGURATION MENU SETUP.***

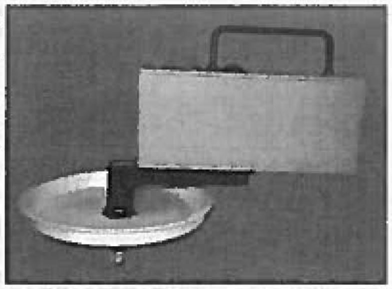
The **DATA LOGGING** mode, an optional addition to the Unit, allows the user to collect data on a well over a period of time with or without the user having to remain on site. The Model 300 can retain data on a large number of wells. This mode is described in detail in the ***DATA LOGGING*** supplement included with the option.

BASIC SETTINGS

Operating the meter requires choosing the **NORMAL** or **DEEP** setting. This can be done with the **DEPTH** switch on the front of the Unit (See the **QUICK START** section) or through the **CONFIGURATION MENU.** The **NORMAL** setting should be used when the static water level is between 10 and 500 feet (3 and 150 meters) . If the static water level is outside this range, inaccurate readings may occur. Likewise, in the **DEEP** setting, the static water level must be deeper than 200 feet (60 meters) to avoid inaccurate readings. However, when applicable, using this setting can reduce the possibility of false readings from obstructions in the upper end of the well casing or from the lower end of the casing in rock wells. The above limits assume the Unit is set to the factory default settings. The **IGNORE DISTANCE,** the initial distance the Unit skips over can be changed. See the ***CONFIGURATON MENU SETUP*** section for more information on this setting.

SETTING THE TEMPERATURE

Accurate measurements are best assured when the temperature setting equals the average air temperature in the well casing. The effect of an incorrect setting is approximately one-tenth percent (0.1%) of the depth reading per degree F of



Model 300 with 6 in. cap installed

error. As an example, if the error is 10°F (5.5°C), the measurement will be in error by 1%.

The map and tables furnished with the meter facilitate setting the temperature. For each meter, a map is provided for the state (USA only) where it is to be used. The map is divided into geographical regions. To find the setting temperature, simply locate your region in the left hand column of the **map table**. Then, follow across this row to the month column to find the temperature setting.

It should be recognized that the **map table** may not be useful in regions of geothermal activity or anomalous subsurface conditions. Also, map tables are not available for regions outside the USA. In this case, for best accuracy, it is necessary to know the well water temperature and the monthly average surface temperature. With this information, the **look-up table** provided gives the appropriate temperature setting. To use it, first locate the well water temperature in the left hand column. Then, follow across this row to the surface temperature column to find the setting temperature. As an example, if the water temperature is 58°F (14°C) and the average surface temperature is 85°F (28°C) degrees F, the setting will be 62°F (16°C).

QUICK START MODE

Momentarily pushing the red **POWER ON** button activates the meter. In the **NORMAL** depth setting it will remain active for three seconds at one "ping" per second. In the **DEEP** setting it will stay active for 9 seconds at one "ping" every 2.75 seconds. The Unit will remain on for about 20 seconds after a measurement cycle.

At activation, the display comes alive and the temperature setting will appear. If necessary, raise or lower the setting by toggling the temperature switch either forward or backward to the desired value. The temperature setting will be retained when the power is off. For more information see the section, ***SETTING THE TEMPERATURE***.

Making a measurement is now very simple. Just insert the measuring duct through the access port in the well cap. Make sure that the measuring duct extends all the way through the well cap and seal. Then push the red **POWER ON** button. The well water level will usually be displayed after the first "ping".

It may turn out that the initial **DEPTH** setting was inappropriate. If so, it may be changed at any time when the meter is activated.. There may be a delay of a few "pings" before the unit changes modes.

If the well is uncapped and the depth to water is over 100 feet (30 meters), the cap cover furnished with the meter should be used. Just slide the cover onto the duct and place the meter over the casing. It is not necessary to have a tight seal. However, large gaps due to off-center or tilted placement can reduce the maximum measurable level.

The cover furnished with the unit is for casing diameters up to six inches (150 mm). For larger diameters, a cover may be easily made from any convenient material such as plastic or sheet metal.

BASIC CONFIGURATION MENU SETUP

CONFIGURATION OPTIONS

The following parameters can be changed in the *Configuration Setup Mode*:

1. Units of Measurement - Metric or English/Imperial
2. Temperature and Type (Depth) - also settable during operation.
3. Gain/Sensitivity - Variable or Fixed; factory setting is Variable
4. Ignore Distance: the initial distance to ignore when a measurement is taken
   a. for *Normal Mode* the range is 10 to 65 ft (3 to 20 m) in 1 ft (0.5m) steps. (factory setting is 10 ft (3 m)
   b. for *Deep Mode* the range is 200 to 600 ft (60 to 200 m) in approx 1 ft (0.5 m) steps. (factory setting is 200 ft (60 m)
5. Time - Set the time of the 24 hour clock

CONFIGURATION SETUP

The Configuration Setup Mode is accessed as follows:

While the unit is off and before pressing the **POWER** button, hold the **Temp** switch in either the up or down position.

While holding the **Temp** Switch in either position press the power button.

The unit will come on in Setup Mode. The **POWER** button and **Temp** switch may be released at this time and the unit will stay on until setup is complete.

Changing the settings:

1. The first parameter that can be set will be displayed. This will be the choice of "Units" of measurement.

   Use the **Temp** switch to change between "Metric" or "English", whichever is preferred.

2. To change to the next parameter, press the **POWER** switch.

   The display will change to "Temp & Type". The temperature setting can be changed up or down with the **Temp** switch and the type, Normal or Deep, with the **Depth** switch. Both parameters can also be changed when the unit is in normal operation.

3. Press the **POWER** switch again to go to the next option.

   The display will change to "Gain Mode". The choices are "Variable" or "Fixed". Use the **Temp** switch to make your choice. The information in the section "Which Gain Setting to Use?" will help you decide which to choose under different circumstances.

4. Press the **POWER** switch again. The display will read "Norm: Ignore 1st" followed by the distance to ignore in Normal Mode. Use the **Temp** switch to change this distance if desired. The range is 10 to 65 ft (3 to 20 m) in 1 ft (0.5 m) steps. (factory setting is 10 ft (3 m)).

5. Press the **POWER** switch again. The display will read "Deep: Ignore 1st" followed by the distance to ignore in Deep Mode. Use the **Temp** switch to change this distance if desired. The range is 200 to 600 ft (60 to 200 m) in approx 1 ft (0.5 m) steps. (factory setting is 200 ft (60 m)).

6. The next press of the **POWER** switch starts the clock setting. Each time the **POWER** button is pressed the submenu moves to the next step in the following sequence. The **TEMP** switch is used to make the selection for each item.

   1. Hour: Set the hour in 24 hour mode.
   2. Minute: Set the minutes.
   3. Year: Set the last two digits of the current year.
   4. Month: Set the month
   5. Day: Set the day.

6. Press the **POWER** switch once more will terminate the Setup Mode and the unit will start operation.

The parameters that you have chosen will be retained until they are changed again by the user.

If you only want to change one of the parameters just enter the Setup Mode and keep pressing the **POWER** switch until you get to the item you want to change . Make your change and then press the **POWER** switch until you are out of setup mode.

You can also review the settings by entering Setup Mode and simply cycling through all of the parameters.

ITEMS THAT INFLUENCE CONFIGURATION CHOICES

Gain/Sensitivity - "Which Setting to Use?"

Two choices are available - Fixed or Variable

The Variable gain mode provides, in effect, a rising gain or sensitivity with time. This method gives greater weight to return signals that occur later in the measurement cycle and is beneficial on deeper wells where the return signal is more attenuated. This also makes the units less susceptible to unwanted returns from various surfaces in the well casing that might interfere with a proper measurement.

The variable gain mode is somewhat more susceptible to interference from pump noise or other sources of high ambient noise. Also, in some specific configurations it is possible for the unit to favor a secondary return over the primary one and give a reading that is twice the actual water level.

The Fixed mode is less susceptible to interference from ambient noise and the secondary return problem. This mode can be used to advantage in such cases. Some sensitivity is sacrificed so the unit might not read the deepest water levels in this mode.

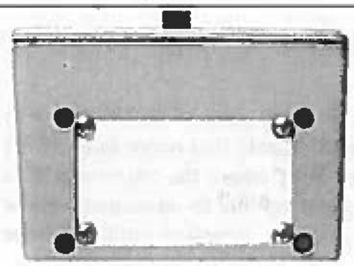
Ignore distance

The factory defaults values are set at 10 ft (5 meters) in **Normal** mode and 200 ft (100 meters) in **Deep** mode. If problems occur due to reflections from liners that don't come all the way to the top of the casing or unwanted signal returns from such things as pitless adaptors and such that interfere with getting a proper reading the default values can be increased so that returns within that distance are ignored. Also, if you are making draw-down measurements that require the use of deep mode but you wish to be able to measure to less than 200 ft (60 meters) you can reduce the minimum distance accordingly so that you don't have to switch modes during the test.

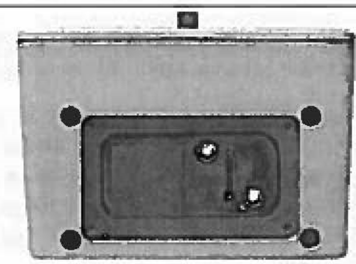
BATTERY REPLACEMENT

The Battery Level Icon in the lower right corner of the display indicates the battery voltage.

The meter comes provided with eight, AA alkaline batteries. Battery replacement is indicated when the battery icon appears empty rather than solid. The batteries are located behind the cover plate on the end of the Unit. To access the holder remove the four screws holding the battery cover plate and then the cover plate itself.

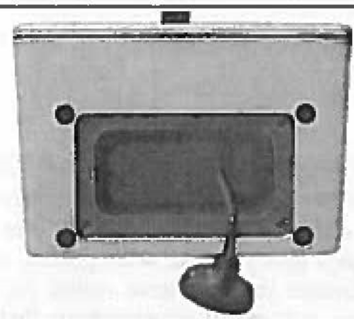


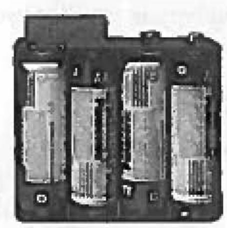
The Battery Cover is held by the four binder head screws,



Battery Cover Removed

Pull the battery pack out from the housing and unsnap the battery pack connector The new batteries are then inserted into the battery pack according to the polarity indications on the holder and batteries. Alkaline batteries should be used.





Battery Pack Removed

Next, snap the connector back on the holder, slide the battery pack into the housing, and replace the cover plate and the four cover plate screws. Tighten the screws firmly so that pressure is put on the gasket that keeps water out of the battery compartment but do not over tighten or the threads might strip out.

MEASUREMENT PROBLEMS

In older wells, the casing may be highly corroded or rough, causing high signal attenuation and unreliable water level readings. In this situation, the higher sensitivity **DEEP** setting will minimize the problem. However, to use this setting, the water level must be greater than 200 feet (60 meters).

A measurement error might occur if the casing has a discontinuity causing an erroneous reflection of the sonic pulse. This situation may occur in rock wells if there are voids or fissures in the rock wall. It may also occur in continuously cased wells if the casing diameter abruptly changes somewhere down the well.

Perforations or "slots" in the casing that are above the water surface can reflect the sonic pulse resulting in a measurement that is shorter than the actual water level.

Obstructions in the well casing such as torque arresters, wire shields or anything exceeding ½ the area of the casing may also cause erroneous level readings.

Sleeves in the well casing can sometimes cause a problem depending on how far down in the casing the top of the sleeve is because the sonic pulse can reflect from the top edge of the sleeve. **Loose fitting sleeves can cause an additional problem** because the sonic pulse can divide between the inside and outside of the sleeve which will reduce the signal level.

In some cases the signal coupling to the well casing may be poor. To avoid this, be sure that the measuring duct goes all the way through the well cap or seal. Cover plates should normally be used. Be sure that there is no large gap between the plate and the well casing.

Gases in the well casing or bore other than air can cause a measurement error. The amount of error will depend on the air to gas ratio. The water level measurement depends on knowing the velocity of sound in the well casing. This parameter is different in different gasses. The unit is calibrated for air filled casings with a nominal humidity. (For a methane filled casing the difference can be as much as 30 %).

SPECIFICATIONS

Dimensions:

Length not including duct: 7 inches (180 mm)
Height not including duct: 4 inches (100 mm)
Width: 5 inches (125 mm)

Measuring duct:

Diameter. 5/8 inches (16 mm)
Length. 2 inches (50 mm)

Weight: 4 lbs (1.8 kg)

Power: 8, AA alkaline batteries. Model 300DL has provision for external power: 12 - 14 Volts DC

Measurement range with factory default settings:

Normal setting: 10 to 500 feet (3 to 150 meters)
Deep setting: 200 to 1200 feet (60 to 350 meters)
(Under certain conditions this may be less. See ***Measurement Problems***.)

Display Resolution: 0.1 foot (0.01 meters)

Measurement accuracy *:

(Applies for casing diameters from 2 to 10 inches (50 to 250 mm). Outside this range accuracy may vary.)

+/- 0.2 ft (+/- 0.06 m) for water level less than 100 ft (30 m);
+/- 0.2% of depth reading for water levels 100 ft (30 m) or greater.

Operating temperature range: 30°F to 140°F (0°C to 60°C)

The outside or ambient air temperature does not affect the meter operation provided the meter and its components remain within the operating temperature range.

*Under certain conditions, measurement accuracy may exceed this limit. See the previous section, *MEASUREMENT PROBLEMS.*

OPTIONS - Call for information on these Options

Carrying Case
Data Logger - Model 300DL
External AC Power Adaptor

WARRANTY

We, The Ravensgate Corporation warrant this product against defects or malfunctions in materials or workmanship for one year from the date of purchase by you, the original purchaser. WE MAKE NO OTHER EXPRESS WARRANTY OR REPRESENTATION OF ANY KIND WHATSOEVER CONCERNING THIS PRODUCT. If any such defect or malfunction occurs within one year of the date of your original purchase, the unit will be repaired or replaced by us without charge.

This warranty does not apply when: (1) the unit has been opened, repaired or modified by anyone other than Ravensgate Corporation. (2) any defect or problem has resulted from accident, misuse, negligence or carelessness.

Return authorization under the warranty or for repair or replacement must be obtained. Contact the Ravensgate Corporation for shipping and packaging instructions.

Ravensgate Corporation is not responsible for loss or damage due to misuse or inappropriate application.

DISCLAIMER:

Ravensgate Corporation will not be responsible or liable for consequential damages caused by instrument failure for any reason whatsoever. Also, Ravensgate Corporation can not be responsible for specifications given by dealers, resellers or others that differ from those given herein.

CONTACT INFORMATION:

THE RAVENSGATE CORPORATION:

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Ridgecrest, CA 93555

internet: www.ravenscorp.com

e-mail: info@ravenscorp.com

Frequently Asked Questions about the Performance of the Ravensgate Model 300 Series Sonic Water Level Meters

Q. Can the meters be used when measuring crooked wells?

A. Yes, you can even measure the length of coiled pipe.

Q. Can the meters be used with wells that have submersible pumps installed?

A. Yes, you can use our meters on wells that have submersible pumps.

Q. Can the meters be used with capped wells?

A. Yes, our meters can be used on either capped or uncapped wells.

Q. Do pipes, wires, screens, or anything that covers the cross sectional area of the well cause a problem when using the meters?

A. Not usually, as long as the pipes and wires occupy NO MORE THAN one half of the bore area.

Q. Can the meters be used with partially cased rock wells?

A. Yes, our meters can be used with partially cased wells.

Q. Can the meters be used with irrigation wells?

A. We usually do not recommend using our meters for this purpose because overhead pumps are installed at the top of the casing which causes accessibility problems; our meter works the best when reading at the top of the well.

Q. What is the purpose of the temperature setting on the Ravensgate Sonic Water Level Meters?

A. Accurate measurements are best assured when the temperature setting equals the average air temperature in the well casing. The temperature setting corrects for the variation of the velocity of sound with the air temperature in the well bore. The error is 0.1% per degree of temperature error.

Q. How can the temperature setting be determined?

A. Ravensgate Corporation provides maps (U.S.A. only) and tables . See "Setting The Temperature" on page 3.

Q. Does cascading water affect the accuracy of the meter?

A. No, cascading water usually does not affect the accuracy of the readings.

Q. Do gases present in the well casing other than air affect the accuracy?

A. Yes! The water level measurement depends on knowing the velocity of sound in the well casing. This parameter is different in different gasses. The unit is calibrated for air filled casings with a nominal humidity. (For a methane filled casing the difference can be as much as 30 %.)

Q. Can perforations in the casing cause measurement problems?

A. Perforations in the casing that are above the water surface can reflect the sonic pulse and result in a measurement that is less than the true water level.

Q. Can a reading be made through a small diameter pipe between the meter and the top of the well casing when access is limited?
A. No, this approach will usually not result in a reliable reading.

Frequently Asked Questions about the Specifications of the Ravensgate Model 300 Series Sonic Water Level Meters

Q. What is the measurement accuracy of the meter?
A. Accuracy is +/- 0.2% of the reading, exclusive of temperature setting errors.

Q. What is the measurement range of the meter?
A. Measurement range is 10 to 500 ft (3 to 150 m) in the "NORMAL" setting and 200 to 1200 ft (60 to 350 m) in the "DEEP" setting.

Q. What well bore diameter range is necessary for best accuracy?
A. The meter is specified for a bore diameter range of 1 to 10 in (25 to 250 mm).

Q. What access in the well cap is necessary to use the meter?
A. A hole that is at least big enough to allow the 5/8 in (16 mm) diameter round aluminum duct to pass through.

Frequently Asked Questions about Ravensgate Model 300 Series Sonic Water Level Meters

Q. What power source does the Ravensgate Sonic Water Level Meter use?
A. Our meter uses 8 internal AA Alkaline batteries. Yearly battery replacement is recommended. The Data Logger Option includes provision for external power in addition to the internal battery power.

Q. What is the availability of the meter?
A. Your meter can be shipped within two weeks, once a payment or purchase order is received.

Q. What is the warranty on the meter?
A. Our warranty for parts and workmanship is one year.

Q. Is there a trial period?
A. Yes. Our meters come with a 30 day trial period. Contact us for details.

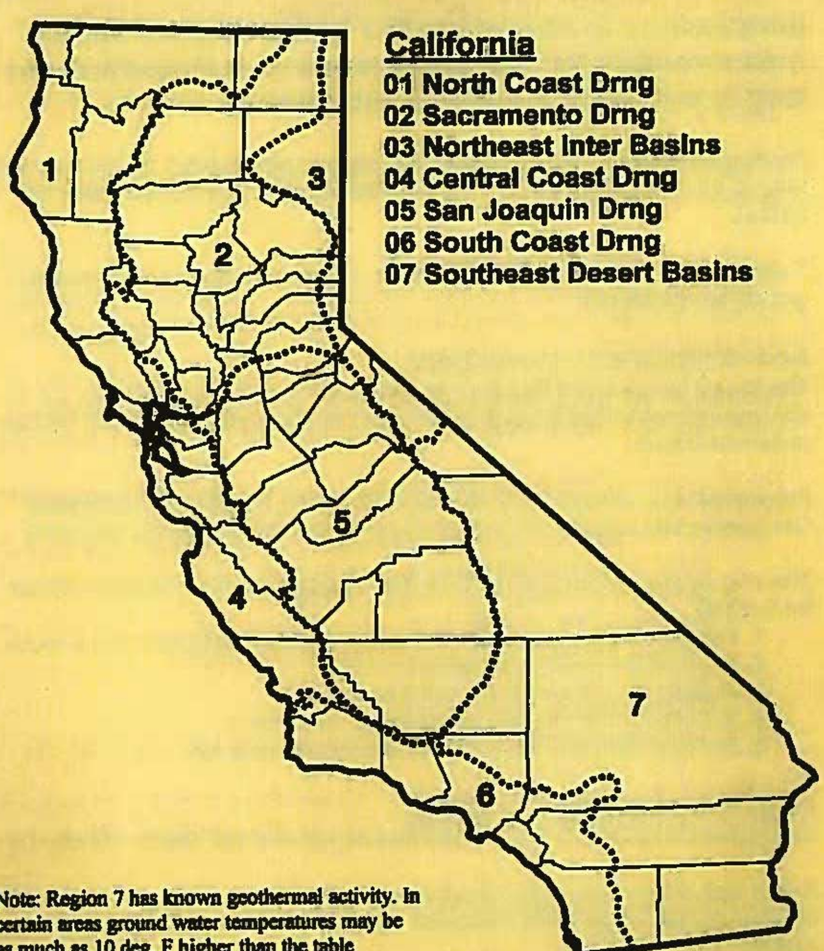
CARE OF THE UNIT

The Model 300/300DL is water resistant but not guaranteed to be completely waterproof. Do not submerge the unit in liquid or leave it exposed to precipitation. If it gets wet, wipe it off as soon as possible. If the carrying case gets wet it should be left open and allowed to dry *completely* before storing the meter in it.

Avoid setting the meter down in a way that the measuring duct is in the mud or dirt. If the measuring duct becomes clogged the unit will not work properly. Cleaning mud out of the duct can be difficult and care must be taken to avoid damaging the microphone that is just behind the screen.

NOTES

Regional Map and Table of Monthly Temperature Settings for CALIFORNIA



California

01 North Coast Drng
02 Sacramento Drng
03 Northeast Inter Basins
04 Central Coast Drng
05 San Joaquin Drng
06 South Coast Drng
07 Southeast Desert Basins

Note: Region 7 has known geothermal activity. In certain areas ground water temperatures may be as much as 10 deg. F higher than the table

Region	Temperature Control Setting For Month of:											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	53	53	54	55	55	56	57	57	56	55	54	53
2	54	54	55	55	57	58	58	58	58	56	55	54
3	42	43	43	45	47	47	49	48	47	45	44	43
4	57	57	57	58	58	59	59	59	59	58	57	57
5	58	58	59	59	61	62	63	62	62	60	59	58
6	60	60	60	61	61	62	63	63	62	62	60	60
7	62	63	64	65	66	67	68	68	67	65	64	62

Appendix A

Instructions to correcting the temperature distance measurement setting when required temperature setting is outside the meter's temperature range.

For temperature conditions outside the range or not covered by the Regional Map or the Temperature Table the SET temperature can be calculated as follows:

T set = 0.15 X T ground + 0.85 X T water (T ground is the average surface ground temperature.)

Low-temperature correction:

The lowest temperature that the unit can be set to is 32 deg F (0 deg. C). If the required set temperature is lower than this the depth reading can be corrected as follows:

Fahrenheit: WL actual = WL indicated-((32-Tset) x 0.0009 x WL indicated)
Centigrade: WL actual = WL indicated-((0-Tset) x 0.00162 x WL indicated)

The step by step procedure for °F is: (for °C substitute 0 for 32 and 0.00162 for 0.0009)

1. Set the temperature to 32 and read the water level (WL) on the meter.
2. Subtract the needed set temp from 32.
3. Multiply the number from step 2 by 0.0009.
4. Multiply the WL reading by the result from step 3.
5. Subtract the value from step 4 from the WL reading.

High-temperature correction:

The highest temperature that the unit can be set to is 100 deg F. (38 deg C)

Fahrenheit: WL actual = WL indicated + ((Tset-100) x 0.0009 x WL indicated)
Centigrade: WL actual = WL indicated + ((Tset -38) x 0.00162 x WL indicated)

The step by step procedure for °F is: (for °C substitute 38 for 100 and 0.00162 for 0.0009)

1. Set the temperature to 100 and read the water level (WL) on the meter.
2. Subtract 100 from the needed set temp.
3. Multiply the number from step 2 by 0.0009.
4. Multiply the WL reading by the result from step 3.
5. Add the value from step 4 from the WL reading.

Average Daily Surface Temperature, Tg, degree[s]

Well Water Temperature, Tw, degrees F

	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	[illegible]
36	31	31	32	33	34	34	35	36	37	37	38	39	40	40	41	42	43	[illegible]
38	32	33	34	35	35	36	37	38	38	39	40	41	41	42	43	44	44	[illegible]
40	34	35	36	36	37	38	39	39	40	41	42	42	43	44	45	45	46	47
42	36	36	37	38	39	39	40	41	42	42	43	44	45	45	46	47	48	[illegible]
44	37	38	39	40	40	41	42	43	43	44	45	46	46	47	48	49	49	50
46	39	40	41	41	42	43	44	44	45	46	47	47	48	49	50	50	51	52
48	41	42	42	43	44	45	45	46	47	48	48	49	50	51	51	52	53	54
50	43	43	44	45	46	46	47	48	49	49	50	51	52	52	53	54	55	55
52	44	45	46	46	47	48	49	49	50	51	52	52	53	54	55	55	56	57
54	46	47	47	48	49	50	50	51	52	53	53	54	55	56	56	57	58	59
56	48	48	49	50	51	51	52	53	54	54	55	56	57	57	58	59	60	60
58	49	50	51	52	52	53	54	55	56	56	57	58	58	59	60	61	61	62
60	51	52	53	53	54	55	56	56	57	58	59	59	60	61	62	62	63	64
62	53	53	54	55	56	56	57	58	59	59	60	61	62	62	63	64	65	65
64	54	55	56	57	57	58	59	60	60	61	62	63	63	64	65	66	66	67
66	56	57	58	58	59	60	61	61	62	63	64	64	65	66	67	67	68	69
68	58	59	59	60	61	62	62	63	64	65	65	66	67	68	68	69	70	71
70	60	60	61	62	63	63	64	65	66	66	67	68	69	69	70	71	72	72
72	61	62	63	63	64	65	66	66	67	68	69	69	70	71	72	72	73	74
74	63	64	64	65	66	67	67	68	69	70	70	71	72	73	73	74	75	76
76	65	65	66	67	68	68	69	70	71	71	72	73	74	74	75	76	77	77
78	66	67	68	69	69	70	71	72	72	73	74	75	75	76	77	78	78	79
80	68	69	70	70	71	72	73	73	74	75	76	76	77	78	79	79	80	81
82	70	70	71	72	73	73	74	75	76	76	77	78	79	79	80	81	82	82
84	71	72	73	74	74	75	76	77	77	78	79	80	80	81	82	83	83	84
86	73	74	75	75	76	77	78	78	79	80	81	81	82	83	84	84	85	86
88	75	76	76	77	78	79	79	80	81	82	82	83	84	85	85	86	87	88
90	77	77	78	79	80	80	81	82	83	83	84	85	86	86	87	88	89	89

Table of Temperature Control Settings

Ts, degrees C

Average Daily Surface Temperature, Tg, degrees C

Well Water Temperature, Tw, degrees C

1.5	2.0	2.5	3.0	3.0	3.5	4.0	4.5	4.5	5.0	5.5	6.0	6.0	6.5	7.0
2.5	3.0	3.5	3.5	4.0	4.5	5.0	5.0	5.5	6.0	6.5	6.5	7.0	7.5	8.0
3.5	4.0	4.0	4.5	5.0	5.5	5.5	6.0	6.5	7.0	7.0	7.5	8.0	8.5	8.5
4.5	4.5	5.0	5.5	6.0	6.0	6.5	7.0	7.5	7.5	8.0	8.5	9.0	9.0	9.5
5.0	5.5	6.0	6.0	6.5	7.0	7.5	7.5	8.0	8.5	9.0	9.0	9.5	10.0	10.5
6.0	6.5	6.5	7.0	7.5	8.0	8.0	8.5	9.0	9.5	9.5	10.0	10.5	11.0	11.0
7.0	7.0	7.5	8.0	8.5	8.5	9.0	9.5	10.0	10.0	10.5	11.0	11.5	11.5	12.0
7.5	8.0	8.5	9.0	9.0	9.5	10.0	10.5	10.5	11.0	11.5	12.0	12.0	12.5	13.0
8.5	9.0	9.5	9.5	10.0	10.5	11.0	11.0	11.5	12.0	12.5	12.5	13.0	13.5	14.0
9.5	9.5	10.0	10.5	11.0	11.0	11.5	12.0	12.5	12.5	13.0	13.5	14.0	14.0	14.5
10.0	10.5	11.0	11.5	11.5	12.0	12.5	13.0	13.0	13.5	14.0	14.5	14.5	15.0	15.5
11.0	11.5	12.0	12.0	12.5	13.0	13.5	13.5	14.0	14.5	15.0	15.0	15.5	16.0	16.5
12.0	12.5	12.5	13.0	13.5	14.0	14.0	14.5	15.0	15.5	15.5	16.0	16.5	17.0	17.0
13.0	13.0	13.5	14.0	14.5	14.5	15.0	15.5	16.0	16.0	16.5	17.0	17.5	17.5	18.0
13.5	14.0	14.5	14.5	15.0	15.5	16.0	16.0	16.5	17.0	17.5	17.5	18.0	18.5	19.0
14.5	15.0	15.0	15.5	16.0	16.5	16.5	17.0	17.5	18.0	18.0	18.5	19.0	19.5	19.5
15.5	15.5	16.0	16.5	17.0	17.0	17.5	18.0	18.5	18.5	19.0	19.5	20.0	20.0	20.5
16.0	16.5	17.0	17.5	17.5	18.0	18.5	18.0	19.0	19.5	20.0	20.5	20.5	21.0	21.5
17.0	17.5	18.0	18.0	18.5	19.0	19.5	19.5	20.0	20.5	21.0	21.0	21.5	22.0	22.5
18.0	18.0	18.5	19.0	19.5	19.5	20.0	20.5	21.0	21.0	21.5	22.0	22.5	22.5	23.0
18.5	19.0	19.5	20.0	20.0	20.5	21.0	21.5	21.5	22.0	22.5	23.0	23.0	23.5	24.0
19.5	20.0	20.5	20.5	21.0	21.5	22.0	22.0	22.5	23.0	23.5	23.5	24.0	24.5	25.0
20.5	21.0	21.0	21.5	22.0	22.5	22.5	23.0	23.5	24.0	24.0	24.5	25.0	25.5	25.5
21.5	21.5	22.0	22.5	23.0	23.0	23.5	24.0	24.5	24.5	25.0	25.5	26.0	26.0	26.5
22.0	22.5	23.0	23.0	23.5	24.0	24.5	24.5	25.0	25.5	26.0	26.0	26.5	27.0	27.5
23.0	23.5	23.5	24.0	24.5	25.0	25.0	25.5	26.0	26.5	26.5	27.0	27.5	28.0	28.0
24.0	24.0	24.5	25.0	25.5	25.5	26.0	26.5	27.0	27.0	27.5	28.0	28.5	28.5	29.0
24.5	25.0	25.5	26.0	26.0	26.5	27.0	27.5	27.5	28.0	28.5	29.0	29.0	29.5	30.0
25.5	26.0	26.5	26.5	27.0	27.5	28.0	28.0	28.5	29.0	29.5	29.5	30.0	30.5	31.0
26.5	26.5	27.0	27.5	28.0	28.0	28.5	29.0	29.5	29.5	30.0	30.5	31.0	31.0	31.5
27.0	27.5	28.0	28.5	28.5	29.0	29.5	30.0	30.0	30.5	31.0	31.5	31.5	32.0	32.5
28.0	28.5	29.0	29.0	29.5	30.0	30.5	30.5	31.0	31.5	32.0	32.0	32.5	33.0	33.5

Table of Temperature Control Settings
Ts, degrees C

Average Daily Surface Temperature, Tg, degrees C

Well Water Temperature, Tw, degrees C	0.0	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0	27.5	30.0	32.5	35.0
2.0	1.5	2.0	2.5	3.0	3.0	3.5	4.0	4.5	4.5	5.0	5.5	6.0	6.0	6.5	7.0
3.0	2.5	3.0	3.5	3.5	4.0	4.5	5.0	5.0	5.5	6.0	6.5	6.5	7.0	7.5	8.0
4.0	3.5	4.0	4.0	4.5	5.0	5.5	5.5	6.0	6.5	7.0	7.0	7.5	8.0	8.5	8.5
5.0	4.5	4.5	5.0	5.5	6.0	6.0	6.5	7.0	7.5	7.5	8.0	8.5	9.0	9.0	9.5
6.0	5.0	5.5	6.0	6.0	6.5	7.0	7.5	7.5	8.0	8.5	9.0	9.0	9.5	10.0	10.5
7.0	6.0	6.5	6.5	7.0	7.5	8.0	8.0	8.5	9.0	9.5	9.5	10.0	10.5	11.0	11.0
8.0	7.0	7.0	7.5	8.0	8.5	8.5	9.0	9.5	10.0	10.0	10.5	11.0	11.5	11.5	12.0
9.0	7.5	8.0	8.5	9.0	9.0	9.5	10.0	10.5	10.5	11.0	11.5	12.0	12.0	12.5	13.0
10.0	8.5	9.0	9.5	9.5	10.0	10.5	11.0	11.0	11.5	12.0	12.5	12.5	13.0	13.5	14.0
11.0	9.5	9.5	10.0	10.5	11.0	11.0	11.5	12.0	12.5	12.5	13.0	13.5	14.0	14.0	14.5
12.0	10.0	10.5	11.0	11.5	11.5	12.0	12.5	13.0	13.0	13.5	14.0	14.5	14.5	15.0	15.5
13.0	11.0	11.5	12.0	12.0	12.5	13.0	13.5	13.5	14.0	14.5	15.0	15.0	15.5	16.0	16.5
14.0	12.0	12.5	12.5	13.0	13.5	14.0	14.0	14.5	15.0	15.5	15.5	16.0	16.5	17.0	17.0
15.0	13.0	13.0	13.5	14.0	14.5	14.5	15.0	15.5	16.0	16.0	16.5	17.0	17.5	17.5	18.0
16.0	13.5	14.0	14.5	14.5	15.0	15.5	16.0	16.0	16.5	17.0	17.5	17.5	18.0	18.5	19.0
17.0	14.5	15.0	15.0	15.5	16.0	16.5	16.5	17.0	17.5	18.0	18.0	18.5	19.0	19.5	19.5
18.0	15.5	15.5	16.0	16.5	17.0	17.0	17.5	18.0	18.5	18.5	19.0	19.5	20.0	20.0	20.5
19.0	16.0	16.5	17.0	17.5	17.5	18.0	18.5	19.0	19.0	19.5	20.0	20.5	20.5	21.0	21.5
20.0	17.0	17.5	18.0	18.0	18.5	19.0	19.5	19.5	20.0	20.5	21.0	21.0	21.5	22.0	22.5
21.0	18.0	18.0	18.5	19.0	19.5	19.5	20.0	20.5	21.0	21.0	21.5	22.0	22.5	22.5	23.0
22.0	18.5	19.0	19.5	20.0	20.0	20.5	21.0	21.5	21.5	22.0	22.5	23.0	23.0	23.5	24.0
23.0	19.5	20.0	20.5	20.5	21.0	21.5	22.0	22.0	22.5	23.0	23.5	23.5	24.0	24.5	25.0
24.0	20.5	21.0	21.0	21.5	22.0	22.5	22.5	23.0	23.5	24.0	24.0	24.5	25.0	25.5	25.5
25.0	21.5	21.5	22.0	22.5	23.0	23.0	23.5	24.0	24.5	24.5	25.0	25.5	26.0	26.0	26.5
26.0	22.0	22.5	23.0	23.0	23.5	24.0	24.5	24.5	25.0	25.5	26.0	26.0	26.5	27.0	27.5
27.0	23.0	23.5	23.5	24.0	24.5	25.0	25.0	25.5	26.0	26.5	26.5	27.0	27.5	28.0	28.0
28.0	24.0	24.0	24.5	25.0	25.5	25.5	26.0	26.5	27.0	27.0	27.5	28.0	28.5	28.5	29.0
29.0	24.5	25.0	25.5	26.0	26.0	26.5	27.0	27.5	27.5	28.0	28.5	29.0	29.0	29.5	30.0
30.0	25.5	26.0	26.5	26.5	27.0	27.5	28.0	28.0	28.5	29.0	29.5	29.5	30.0	30.5	31.0
31.0	26.5	26.5	27.0	27.5	28.0	28.0	28.5	29.0	29.5	29.5	30.0	30.5	31.0	31.0	31.5
32.0	27.0	27.5	28.0	28.5	28.5	29.0	29.5	30.0	30.0	30.5	31.0	31.5	31.5	32.0	32.5
33.0	28.0	28.5	29.0	29.0	29.5	30.0	30.5	30.5	31.0	31.5	32.0	32.0	32.5	33.0	33.5

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18 Appendix L – DWR Groundwater Elevation Monitoring Guidelines

Department of Water Resources

Groundwater Elevation Monitoring

Guidelines

December 2010

Table of Contents

Introduction to the CASGEM Program

On November 4, 2009 the state legislature amended the Water Code with SB 6, which mandates a statewide, locally-managed groundwater elevation monitoring program to track seasonal and long-term trends in groundwater elevations in California's groundwater basins. To achieve that goal the amendment requires collaboration between local Monitoring Entities and the Department of Water Resources (DWR) to collect groundwater elevation data. In accordance with the amendment, DWR developed the California Statewide Groundwater Elevation Monitoring (CASGEM) program.

If no local entities volunteer to monitor groundwater elevations in a basin or part of a basin, DWR may be required to develop a monitoring program for that part. If DWR takes over monitoring of a basin, certain entities in the basin may not be eligible for water grants or loans administered by the state.

DWR will report findings of the CASGEM program to the Governor and the Legislature by January 1, 2012 and thereafter in years ending in 5 or 0.

Purpose of Guidelines for DWR Monitoring

The following Guidelines were developed to assist DWR by establishing criteria for the selection and measurement of monitoring wells in the event that DWR is required to perform the groundwater monitoring functions in lieu of a local monitoring agency pursuant to Water Code Section 10933.5(a).

The primary objective of the CASGEM monitoring program is to define the seasonal and long-term trends in groundwater elevations in California's groundwater basins. The scale for this evaluation should be the static, regional groundwater table or potentiometric surface. A secondary objective is to provide sufficient data to draw representative contour maps of the elevations. These maps could be used to estimate changes in groundwater storage and to evaluate potential areas of overdraft and subsidence.

Although it is not an objective of the CASGEM program, it would be valuable to include monitoring wells near localized features that impact more dynamic groundwater elevations. These features would include wells near aquifer storage and recovery projects, near high volume pumping wells, and near rivers.

NETWORK DESIGN CONCEPTS

SELECTION OF MONITORING WELLS FOR MONITORING PLANS

The number of groundwater wells that need to be monitored in a basin to adequately represent static water levels (and corresponding elevations) depends on several factors, some of which include: the known hydrogeology of the basin, the slope of the groundwater table or potentiometric surface, the existence of high volume production wells and the frequency of their use, and the availability of easily-accessible monitoring wells. Dedicated groundwater monitoring wells with known construction information are preferred over production wells to determine static water levels, and monitoring wells near rivers or aquifer storage and recovery projects should be avoided due to the potential for rapidly fluctuating water levels and engineered groundwater systems. The selection of wells should be aquifer-specific and wells which are screened across more than one aquifer should not be candidates for selection.

Heath (1976) suggested a density of groundwater monitoring wells ranging from 2 wells per 1,000 square miles (mi^2) for a large area in which only major features are to be mapped, to 100 wells per 1,000 mi^2 for a complex area to be mapped in considerable detail. The objective of the Heath (1976) design was to evaluate the status of groundwater storage and the areal extent of aquifers.

Sophocleous (1983) proposed a redesign of a water-level monitoring program for the state of Kansas based on efficiency, economics, statistical analysis, comparison of water-level hydrographs, and consistency across the state. The Sophocleous study recommended a "square well network" with a density of 1 observation well per 16 mi^2.

The Texas Water Development Board proposed varying well network densities for counties according to the amount of groundwater pumpage. These densities range from 0.7 wells per 100 mi^2 for counties with 1,000-2,500 acre-feet per year (AF/yr) of pumpage to 4 wells per 100 mi^2 for counties with over 100,000 AF/yr of pumpage (Hopkins, 1994). These densities were converted to pumpage per 100 mi^2 area by dividing by the size of an average county in Texas of about 1,000 mi^2 (Table 2)

Most designs of water-level monitoring programs rely on a probabilistic approach. Alley (1993) discussed four probabilistic designs: (1) simple random sampling throughout an aquifer; (2) stratified random sampling within different strata of an aquifer; (3) systematic grid sampling (e.g., at the midpoint of each section within an aquifer); and (4) random sampling within blocks (e.g., randomly selected wells within each section of an aquifer). The Sophocleous (1983) program used the third approach, systematic grid sampling. The guidelines on well density from the programs mentioned above are summarized in Table 2.

Based on the few referenced studies with specific recommendations, the consensus appears to fall between 2 and 10 groundwater monitoring wells per 100 mi^2. The exceptions to this density range include the lower end of the Heath (1976) range and the low-use counties in Texas.

There will always be a tradeoff between the improved spatial (and temporal) representation of water levels in an aquifer and the expense of monitoring. A higher-resolution contour map would be warranted in an area with a greater reliance upon groundwater in order to anticipate potential problems, such as supply and groundwater contamination concerns, while a lower-resolution contour map might be sufficient in an area with few people or a low reliance upon groundwater. Ideally, areas with relatively steep groundwater gradients or areas of high recharge or discharge would have a greater density of monitoring wells.

The illustrations in Figure 1 show a local groundwater elevation contour map developed with different numbers of wells. The examples cover the same area and use the same dataset, with wells randomly deleted by grid area from the full dataset to create a less dense network of wells. The resulting range of plotting density is 2 to 20 groundwater monitoring wells per 100 mi^2. The contours in Figure 1 show how the accuracy and resolution of the contour map increases with the density of wells used for plotting. To avoid presenting misleading contour maps, only wells with the best possible elevation accuracies should be used. These accuracies are a combination of the accuracies in the water-level measurement and the reference point (RP) measurement. Unless the RP elevation has been surveyed, it will be the limiting factor on elevation accuracy.

Program and(or) Reference	Density of monitoring wells (wells per 100 mi^2)
Heath (1976)	0.2 – 10
Sophocleous (1983)	6.3
Hopkins (1994) (a) Basins with >10,000 AF/yr groundwater pumping per 100 mi^2 area	4.0
(b) Basins with 1,000-10,000 AF/yr groundwater pumping per 100 mi^2 area	2.0
(c) Basins with 250-1,000 AF/yr groundwater pumping per 100 mi^2 area	1.0
(d) Basins with 100--250 AF/yr groundwater pumping per 100 mi^2 area	0.7

Table 1. Recommended density of monitoring wells for groundwater-level monitoring programs.

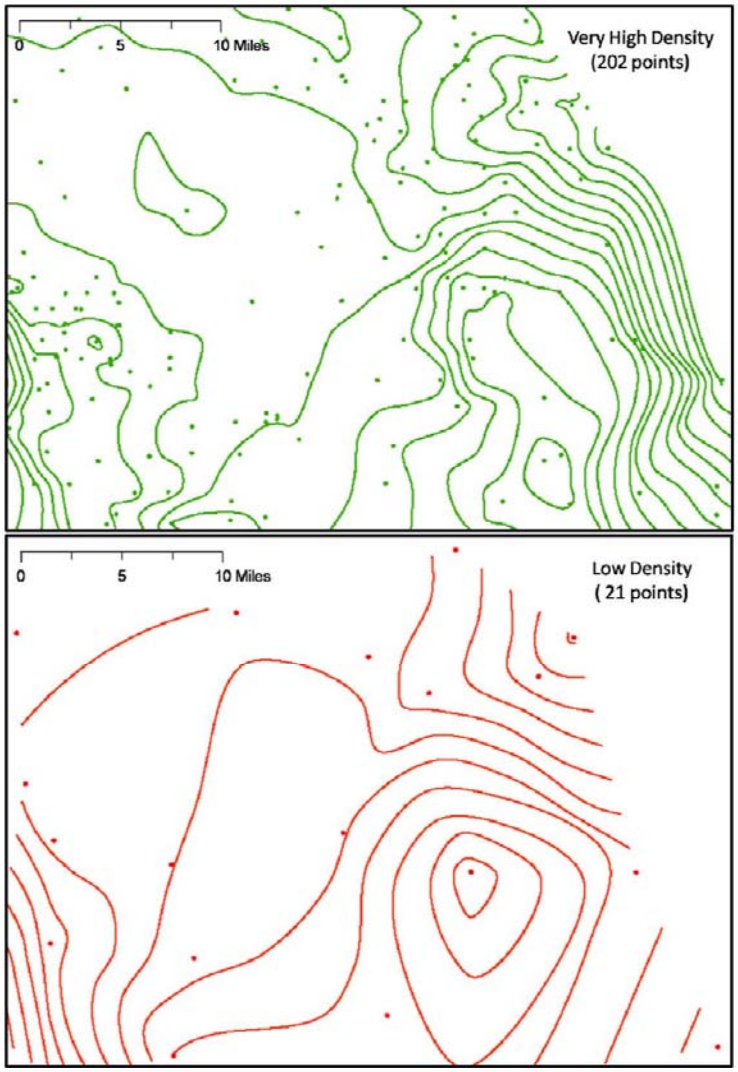

Figure 1. Contour maps – Contours of a very high-density well network (about 20 wells per 100 mi^2) compared to a low-density well network (about 2 wells per 100 mi^2).

FREQUENCY OF WATER-LEVEL MEASUREMENTS

To determine and define seasonal and long-term trends in groundwater levels a consistent measurement frequency must be established. At minimum, semi-annual monitoring of the designated wells in each basin or subbasin should be conducted to coincide with the high and low water-level times of year for each basin. However, quarterly- or monthly-monitoring of wells provides a better understanding of groundwater fluctuations. The DWR office responsible for monitoring a particular basin should use independent judgment to determine when the high and low water-level times occur in a groundwater basin, and to provide a justification for measurement rationale. The semi-annual frequency is a compromise between more frequent measurements (continuous, daily, monthly, or quarterly) and less frequent measurements (annual). A good discussion of water level measurement frequency and other issues related to the design of water-level monitoring programs can be found in the USGS Circular 1217 (Taylor and Alley, 2001).

An example of the effect of different measurement frequencies on the water-level hydrographs in a Northern California well is shown in Figure 2. The data shows that higher-frequency monitoring (e.g., daily or monthly) best captures the seasonal fluctuations in the groundwater levels, quarterly monitoring identifies some of the elevation change, but semi-annual measurements often miss the true seasonal highs and lows.

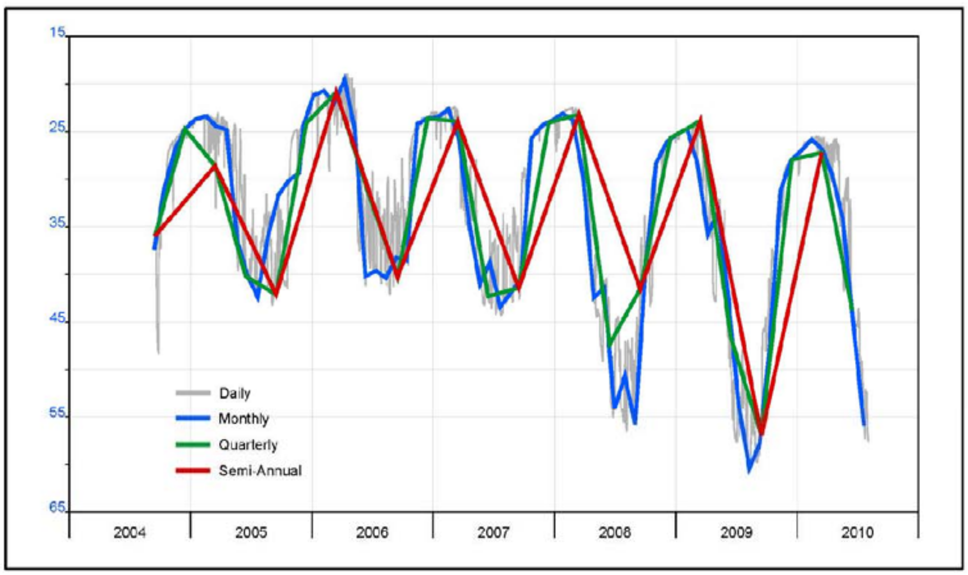

Figure 2. Groundwater Hydrographs – Groundwater elevation changes in a monitoring well over time comparing various measurement frequencies.

The Subcommittee on Ground Water of the Advisory Committee on Water Information generally recommends more frequent measurements than are being required by the CASGEM program; quarterly to annually for aquifers with very few groundwater withdrawals, monthly to quarterly for aquifers with moderate groundwater withdrawals, and daily to monthly for aquifers with many groundwater withdrawals (Table 2). The general effect of environmental factors on the recommended measurement frequency is illustrated in Figure 3.

Measurement Type	**Aquifer Type**	**Nearby Long-Term Aquifer Withdrawals**		
		Very Few Withdrawals	***Moderate Withdrawals***	***Many Withdrawals***
Baseline Measurements	**All aquifer types**	Once per month	Once per day	Once per hour
Surveillance Measurements	**All aquifer types:** "low" hydraulic conductivity (<200 ft/d), "low" recharge (<5 in/yr)	Once per year	Once per quarter	Once per month
	All aquifer types: "high" hydraulic conductivity (>200 ft/d), "high" recharge (>5 in/yr)	Once per quarter	Once per month	Once per day
Data made available to NGWMN	All aquifer types, throughout range of hydraulic conductivity	As stored in local database, but at least annually	As stored in local database, but at least annually	As stored in local database, but at least annually

Table 2. Information on recommended minimum water-level measurement frequency from the Subcommittee on Ground Water of the Advisory Committee on Water Information (2009) (abbreviations: ft/d, feet per day; in/yr, inches per year; NGWMN, National Ground Water Monitoring Network). NOTE: These are not recommendations of the CASGEM program.

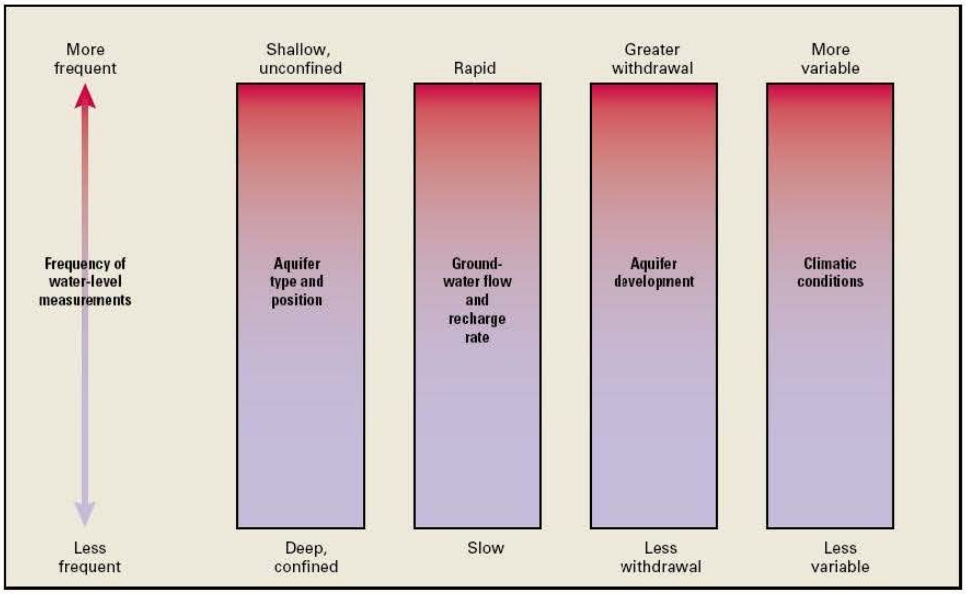

Figure 3. Common environmental factors that influence the choice of frequency of water-level measurements (from Taylor and Alley, 2001).

FIELD GUIDELINES FOR CASGEM WATER-LEVEL MEASUREMENTS

INTRODUCTION

This document presents guidelines for measuring groundwater levels in wells for the CASGEM program to ensure consistency between DWR offices. Following these guidelines will help ensure that groundwater level measurements are accurate and consistent in both unconfined and confined aquifers. Although a well network comprised entirely of dedicated monitoring wells (hereafter referred to as monitoring wells) is preferred, by necessity active production wells used for irrigation or domestic purposes and abandoned production wells that were used for domestic, irrigation, and public supply purposes will also need to be included. **The portions of these guidelines that apply to only production wells will be shown in bold throughout.** DWR does not currently plan to include public supply wells in the CASGEM well networks due to security concerns of the California Department of Public Health.

The main reference used for these guidelines is the United States Geological Survey (USGS) National Field Manual (NFM) (U.S. Geological Survey, 2006). The final report of the Subcommittee on Groundwater (SOGW) of the Advisory Committee on Water Information was also used as a main reference, although in general it relied on the USGS guidelines (Subcommittee on Ground Water of the Advisory Committee on Water Information, 2009). The water-level measurement portion of the USGS guidelines were written for monitoring wells and not for production wells (Taylor and Alley, 2001; U.S. Geological Survey, 2006). Thus, although the USGS guidelines have been adopted with only minor modifications for the monitoring well guidelines of the CASGEM program, additional modifications have been incorporated in the guidelines for production wells. **The most significant changes made to the USGS guidelines for production wells are: (1) reducing the required precision for consecutive depth to water measurements, (2) checking for obstructions in the well, and (3) not attaching weights to the steel tape so as not to hang up on obstructions.**

The guidelines presented in this document are for the use of steel tape, electric sounding tape, sonic water-level meters, or pressure transducers. Although the semi-annual measurements required by the CASGEM program can be satisfied with the use of a steel or electric sounding tape or sonic meter, a pressure transducer with a data logger provides a much better picture of what is happening with water levels over time. The use of the air-line or flowing-well methods should not be needed in most basins. However, if they are, guidelines for these methods are available in sections A4-B-4 (pages B17-B20) and A4-B-5 (pages B21-B24), respectively of the NFM (U.S. Geological Survey, 2006).

ESTABLISHING THE REFERENCE POINT

Water-level measurements from a given well must be referenced to the same datum (the reference point, or RP) to ensure data comparability (see Figure 4). For monitoring wells, the RP should be marked on the top of the well casing. For production wells, the RP will most likely be the top of the access tube or hole to the well casing. The RP must be as permanent as possible and be clearly visible and easily located. It can be marked with a permanent marker, paint, imprinting a mark with a chisel or punch, or by cutting a slot in the top of the casing. In any case, the location of the RP should be clearly described on DWR Form 429 (see Table 3). A photograph of the RP, with clear labeling, should be included in the well folder. In some cases, it may be valuable to establish multiple RPs for a well, depending on the consistent accessibility of the primary RP. In this case, each RP should be clearly described on DWR Form 429 and labeled in the field. The RP should be established with the following coordinate system: horizontal location (decimal latitude and longitude referenced to the North American Datum of 1983; NAD83) and vertical elevation (referenced to the North American Vertical Datum of 1988; NAVD88, in feet).

The land-surface datum (LSD) is established by the person making the initial water-level measurement at the well. The LSD is chosen to represent the average elevation of the ground around the well. Because LSD around a well may change over time, the distance between the RP and LSD should be checked every 3 to 5 years. If appropriate, a concrete well pad or well vault may be chosen as the LSD, since they will be more permanent than the surrounding ground surface.

The elevation of the RP can be determined in several ways: (1) surveying to a benchmark, (2) using a USGS 7.5' quadrangle map, (3) using a digital elevation model (DEM), or (4) using a global positioning system (GPS). While surveying is the most accurate (± 0.1 ft), it is also the most expensive. Depending on the distance to the nearest benchmark, the cost can be prohibitive. The latitude and longitude of the well can be established accurately using a handheld GPS. From this information, the LSD can be located on a USGS quadrangle and the elevation estimated. However, the accuracy is only about ± one half of the contour interval. Thus, for a contour interval of 5 feet, the accuracy of the elevation estimate would be about ± 2.5 feet. The contour interval of high quality DEMs is currently about 30 feet. Therefore, the accuracy of using

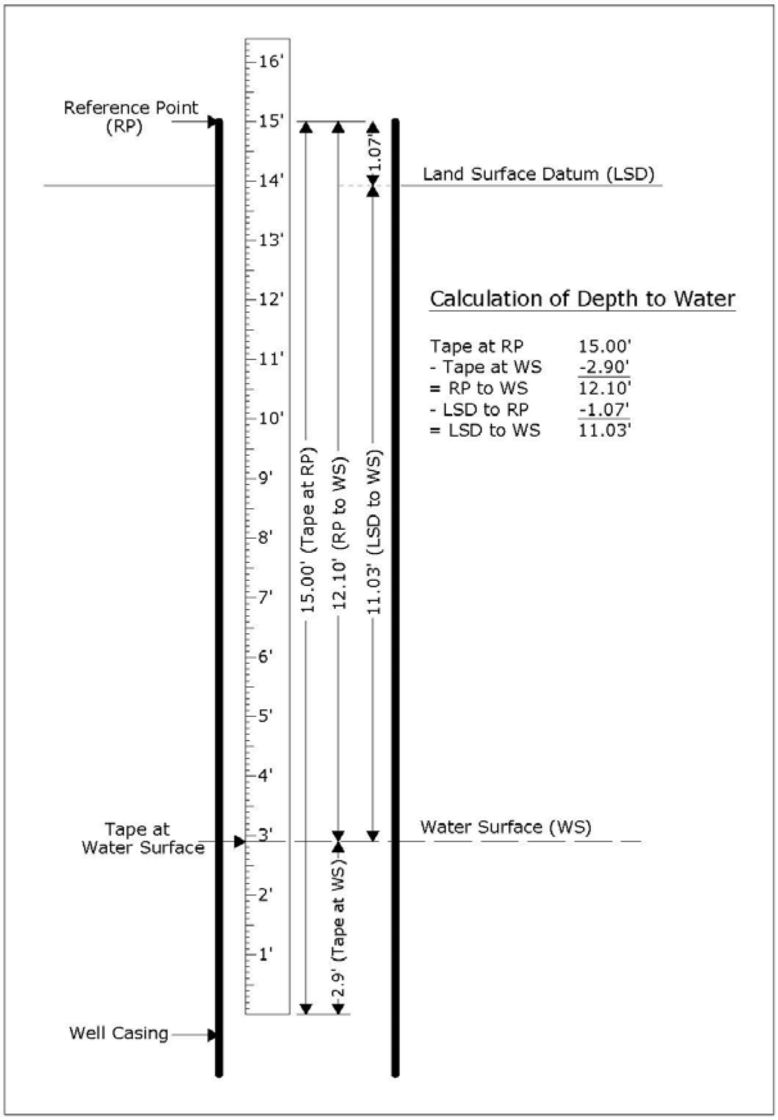

Figure 4. Groundwater-level measurements using a graduated steel tape (modified from U.S. Geological Survey, 2006).

State of California | DEPARTMENT OF WATER RESOURCES | California Natural Resources Agency

WELL DATA

State No. ____________________

District ____________________

OWNER	STATE NO.
ADDRESS	OTHER NO.
TENANT	
ADDRESS	

TYPE OF WELL	☐ SPECIAL STUDIES	☐ MONTHLY	☐ SEMI ANNUAL	☐ WATER QUALITY
LOCATION: COUNTY	BASIN		NO.	
U.S.G.S. QUAD.			QUAD NO.	
1/4	1/4 SECTION	TWP.	RGE.	MD ☐ SB ☐ H ☐ BASE & MERIDIAN
COORDINATES X:	Y:		SOURCE:	

DESCRIPTION

REFERENCE POINT DESCRIPTION

WHICH IS	FT.	ABOVE ☐ BELOW ☐	LAND SURFACE.	GROUND ELEVATION FT.
REFERENCE POINT ELEVATION	FT.	DETERMINED FROM		
WELL: USE	CONDITION		DEPTH	FT.
CASING, SIZE	IN.,	PERFORATIONS		

MEASUREMENTS BY: ☐ DWR ☐ USGS ☐ USBR ☐ COUNTY ☐ IRR. DIST. ☐ WATER DIST. ☐ CONS. DIST.

CHIEF AQUIFER: NAME	DEPTH TO TOP AQ.	DEPTH TO BOT. AQ.
TYPE OF MATERIAL	PERM. RATING	THICKNESS
GRAVEL PACKED? ☐ YES ☐ NO	DEPTH TO TOP GR.	DEPTH TO BOT GR.
SUPP. AQUIFER	DEPTH TO TOP AQ.	DEPTH TO BOT. AQ.
DRILLER	DATE DRILLED:	LOG NUMBER:

EQUIPMENT: PUMP, TYPE		MAKE		
SERIAL NO.	SIZE OF DISCHARGE PIPE IN.	WATER ANALYSIS: MIN. (1)	SAN. (2)	H.M. (3)
POWER, KIND	MAKE	WATER LEVELS AVAILABLE: YES (1)	NO	
H.P.	MOTOR SERIAL NO	PERIOD OF RECORD: BEGIN	END	
ELEC. METER NO.	TRANSFORMER NO.	COLLECTING AGENCY:		
YIELD	G.P.M. PUMPING LEVEL FT.	PROD. REC. (1)	PUMP TEST (2)	YIELD (3)

SKETCH	REMARKS
N	
	RECORDED BY:
	DATE:

DWR 429 (Rev. 1/09)

Table 3. General well data form (DWR Form 429).

DEMs to determine the elevation of the LSD is about ± 15 feet. While a handheld GPS unit is not very accurate for determining elevation, more expensive units with the Wide Area Augmentation System can be more accurate. However, GPS readings are subject to environmental conditions, such as weather conditions, overhead vegetative cover, topography, interfering structures, and location. Thus, the most common method of determining the elevation will probably be the use of USGS quadrangles. The method used needs to be identified on DWR Form 429 (Table 3). The important matter is that all measurements at a well use the same RP, as the elevation of that point can be more accurately established at a later date. The equipment and supplies needed for establishing the RP are shown in Table 4.

If possible, establish a clearly displayed reference mark (RM) in a location near the well; for example, a lag bolt set into a nearby telephone pole or set in concrete in the ground. The RM is an arbitrary datum established by permanent marks and is used to check the RP or to re-establish an RP should the original RP be destroyed or need to be changed. Clearly locate the RP and RM on a site sketch that goes into the well folder (see Table 3). Include the distance and bearing between the RP and the RM and the height of the lag bolt above the ground surface. Photograph the site, including the RP and RM locations; draw an arrow to the RP and RM on the photograph(s) using an indelible marker, and place the photos in the well file.

Table 4. Equipment and Supply List

Equipment and supplies needed for (a) all measurements, (b) establishing permanent RP, (c) steel tape method, (d) electric sounding tape method, (e) sonic water-level meter, and (f) automated measurements with pressure transducer.
(a) All measurements
GPS instrument, digital camera, watch, calculator, and maps
General well data form (DWR Form 429; see Table 3)
Pens, ballpoint with non-erasable blue or black ink, for writing on field forms and equipment log books
Well file with previous measurements
Measuring tape, graduated in feet, tenths, and hundredths of feet
Two wrenches with adjustable jaws and other tools for removing well cap
Key(s) for opening locks and clean rags
(b) Establishing a permanent reference point
Steel tape, graduated in feet, tenths, and hundredths of feet
Calibration and maintenance log book for steel tape
Paint (bright color), permanent marker, chisel, punch, and(or) casing-notching tool

Table 4. Equipment and Supply List (continued)

(c) Steel tape method
DWR field form 1213 (see Table 5)
Steel tape, graduated in feet, tenths, and hundredths of feet
Calibration and maintenance log book for steel tape
Weight (stainless steel, iron, or other noncontaminating material – do not use lead)
Strong ring and wire, for attaching weight to end of tape. Wire should be strong enough to hold weight securely, but not as strong as the tape, so that if the weight becomes lodged in the well the tape can still be pulled free.
Carpenters' chalk (blue) or sidewalk chalk
Disinfectant wipes, and deionized or tap water for cleaning tape.
(d) Electric sounding tape method
DWR field form 1213 (see Table 5)
Steel tape, graduated in feet, tenths, and hundredths of feet
An electric tape, double-wired and graduated in feet, tenths, and hundredths of feet, accurate to 0.01 ft. Electric sounding tapes commonly are mounted on a hand-cranked and powered supply reel that contains space for the batteries and some device ("indicator") for signaling when the circuit is closed.
Electric-tape calibration and maintenance log book; manufacturer's instructions.
Disinfectant wipes, and deionized or tap water for cleaning tape.
Replacement batteries, charged.
(e) Sonic water-level meter method
DWR field form 1213 (see Table 5)
Temperature probe with readout and cable
Sonic water-level meter with factory cover plate
Custom sized cover plates for larger well diameters
Replacement batteries
(f) Automated measurements with pressure transducer
Transducer field form (see Figures 1 and 2 in Drost, 2005: http://pubs.usgs.gov/of/2005/1126/pdf/ofr20051126.pdf)
Transducer, data logger, cables, suspension system, and power supply.
Data readout device (i.e., laptop computer loaded with correct software) and data storage modules.
Spare desiccant, and replacement batteries.
Well cover or recorder shelter with key.
Steel tape (with blue carpenters' chalk or sidewalk chalk) or electric sounding tape, both graduated in hundredths of feet.
Tools, including high-impedance (digital) multimeter, connectors, crimping tool, and contact-burnishing tool or artist's eraser.

Guidelines for Measuring Water Levels

Monitoring wells typically have a cap on the wellhead. After the cap is removed, the open top of the well is easily accessible for sampling water levels and water quality. If the well is to be sampled for water quality in addition to water level, the water-level measurement should be made before the well is purged. Before discussing the detailed measurement steps for different methods, some guidance is provided on the common issues of well caps, recovery time after pumping, and cascading water in a well.

Well caps are commonly used in monitoring wells to prevent the introduction of foreign materials to the well casing. There are two general types of well caps, vented and unvented. Vented well caps allow air movement between the atmosphere and the well casing. Unvented well caps provide an airtight seal between the atmosphere and the well casing.

In most cases it is preferred to use vented well caps because the movement of air between the atmosphere and the well casing is necessary for normal water level fluctuation in the well. If the cap is not vented the fluctuation of groundwater levels in the well will cause increased or decreased air pressure in the column of air trapped above the water in the casing. The trapped air can prevent free movement of the water in the casing and potentially impact the water level that is measured. Vented caps will allow both air and liquids into the casing so they should not be used for wells where flooding with surface water is anticipated or contamination is likely from surface sources near the well.

Unvented well caps seal the top of the well casing and prevent both air and liquid from getting into the well. They are necessary in areas where it is anticipated that the well will be flooded from surface water sources or where contamination is likely if the casing is not sealed. Because the air above the water in the casing is trapped in the casing and cannot equalize with the atmospheric pressure, normal water level fluctuation may be impeded. When measuring a well with an unvented cap it is necessary to remove the cap and wait for the water level to stabilize. The wait time will vary with many different factors, but if several sequential water-level measurements yield the same value it can be assumed the water level has stabilized.

Unlike monitoring wells, production wells have obstructions in the well unless it is an abandoned production well and the pump has been removed. In addition, the wellhead is not always easily accessible for monitoring water levels. Since pumping from the production wells will create a non-static water level, the water-level measurement should ideally not be made until the water level has returned to static level. However, this recovery time will vary from site to site. Some wells will recover from pumping level to static level within a few hours, while many wells will take much longer to recover. Some wells will recover from pumping level to static level within a few hours, while many wells will take much longer to recover. Thus, as a general recommendation, measurements should not be collected until 24 hours after pumping has ceased, however, site specific

conditions may require deviating from this. The time since pumping should be noted on the field form.

Water may enter a well above the water level, drip or cascade down the inside of the well, and lead to false water level measurements. Sometimes cascading water can be heard dripping or flowing down the well and other times it is discovered when water levels are abnormally shallow and/or difficult to determine. Both steel tapes and electric sounding tapes can give false readings. A steel tape may be wet from the point where water is entering the well making it hard to see the water mark where the tape intersects the water level in the well. An electric sounding tape signal may start and then stop as it is lowered down the well. If this happens, you can lightly shake the tape. The signal often becomes intermittent when water is running down the tape, but remains constant in standing water. On most electric sounding tapes, the sensitivity can be turned down to minimize false readings. It should be noted when a water level measurement is taken from a well with cascading water.

(1) Steel Tape Method

The graduated steel-tape (wetted-tape) procedure is considered to be the most accurate method for measuring water levels in nonflowing wells. A graduated steel tape is commonly marked to 0.01 foot. When measuring deep water levels (>500 ft), thermal expansion and stretch of the steel tape starts to become significant (Garber and Koopman, 1968). The method is most accurate for water levels less than 200 feet below land surface. The equipment and supplies needed for this method are shown in Table 4.

The following issues should be considered with this method:

- It may be difficult or impossible to get reliable results if water is dripping into the well or condensing on the well casing.
- If the well casing is angled, instead of vertical, the depth to water should be corrected, if possible. This correction should be recorded in the field folder.
- **Check that the tape is not hung up on obstructions.**

Before making a measurement:

1. Maintain the tape in good working condition by periodically checking the tape for rust, breaks, kinks, and possible stretch. Record all calibration and maintenance data associated with the steel tape in a calibration and maintenance log book.

2. If the steel tape is new, be sure that the black sheen on the tape has been dulled so that the tape will retain the chalk.

3. Prepare the field forms (DWR Form 1213; see Table 5). Place any previous measured water-level data for the well into the field folder.

4. Check that the RP is clearly marked on the well and accurately described in the well file or field folder. If a new RP needs to be established, follow the procedures above.

5. In the field, wipe off the lower 5 to 10 feet of the tape with a disinfectant wipe, rinse with de-ionized or tap water, and dry the tape.

6. If possible, attach a weight to the tape that is constructed of stainless steel or other noncontaminating material to protect groundwater quality in the event that the weight is lost in the well. **Do not attach a weight for production wells.**

Making a measurement:

1. If the water level was measured previously at the well, use the previous measurement(s) to estimate the length of tape that should be lowered into the well. Preferably, use measurements that were obtained during the same season of the year.

2. Chalk the lower few feet of the tape by pulling the tape across a piece of blue carpenter's chalk or sidewalk chalk (the wetted chalk mark identifies that part of the tape that was submerged).

3. Slowly lower the weight (for monitoring wells only) and tape into the well to avoid splashing when the bottom end of the tape reaches the water. Develop a feel for the weight of the tape as it is being lowered into the well. A change in this weight will indicate that either the tape is sticking to the side of the casing or has reached the water surface. Continue to lower the end of the tape into the well until the next graduation (a whole foot mark) is at the RP and record this number on DWR Form 1213 (Table 5) next to "Tape at RP" as illustrated on Figure 4.

4. Rapidly bring the tape to the surface before the wetted chalk mark dries and becomes difficult to read. Record the number to the nearest 0.01 foot in the column labeled as "Tape at WS."

5. If an oil layer is present, read the tape at the top of the oil mark to the nearest 0.01 foot and use this value for the "Tape at WS" instead of the wetted chalk mark. Mark an "8" in the QM column of DWR Form 1213 (see Table 5) to indicate a questionable measurement due to oil in the well casing. There are methods to correct for oil, such as the use of a relatively inexpensive water-finding paste. The paste is applied to the lower end of the steel tape and the top of the oil shows as a wet line and the top of the water shows as a distinct color change. Since oil density is about three-quarters that of water, the water level can be estimated by adding three-quarters of the thickness of the oil layer to the oil-water interface elevation (U.S. Geological Survey, 2006).

6. Subtract the “Tape at WS” number from the “Tape at RP” number and record the difference (to the nearest 0.01 ft) as “RP to WS”. This reading is the depth to water below the RP.

7. Wipe and dry off the tape and re-chalk based on the first measurement.

8. Make a second measurement by repeating steps 3 through 5, recording the time of the second measurement on the line below the first measurement (Table 5). The second measurement should be made using a different “Tape at RP” than that used for the first measurement. If the second measurement does not agree with the original within 0.02 of a foot **(0.2 of a foot for production wells)**, make a third measurement, recording this measurement and time on the row below the second measurement with a new time. If more than two readings are taken, record the average of all reasonable readings.

After making a measurement:

1. Clean the exposed portion of the tape using a disinfectant wipe, rinse with de-ionized or tap water, and dry the tape. Do not store a steel tape while dirty or wet.

GROUNDWATER LEVEL DATA FORM
MANUAL MEASUREMENTS

WELL ID NUMBER	WELL NAME	STATE WELL NUMBER	COUNTY	B-118 BASIN OR SUBBASIN	MEASURING AGENCY	LAND SURFACE DATUM (LSD) ELEV.	RP TO LAND SURFACE DATUM (LSD), IN FT	REFERENCE POINT (RP) ELEV.

NO MEASUREMENT (NM)
0. Measurement discontinued
1. Pumping
2. Pump house locked
3. Tape hung up
4. Can't get tape in casing
5. Unable to locate well
6. Well has been destroyed
7. Special
8. Casing leaky or wet
9. Temporarily inaccessible

QUESTIONABLE MEASUREMENT (QM)
0. Caved or deepened
1. Pumping
2. Nearby pump operating
3. Casing leaky or wet
4. Pumped recently
5. Air or pressure gauge measurement
6. Other
7. Recharge operation at or nearby well
8. Oil in casing

MEASUREMENT METHOD (MM)
0. Steel tape
1. Electric sounding tape
2. Other

DATE	TIME	N M	Q M	MM	TAPE at RP	TAPE at WS	RP to WS	LSD to WS	OBS	COMMENTS

[For explanation of terms, see figure 1.]

DWR Form 1213 (modified 6/28/2010) (data for Water Data Library)

Table 5. Groundwater level data form for manual measurements (DWR Form 1213).

(2) Electric Sounding Tape Method

The electric sounding tape procedure for measuring depth to the water surface is especially useful in wells with dripping water or condensation, although there are still precautions needed as noted in the beginning of this section. Other benefits of this method include:

- Easier and quicker than steel tapes, especially with consecutive measurements in deeper wells.
- Better than steel tapes for making measurements in the rain.
- Less chance for cross-contamination of well water than with steel tapes, as there is less tape submerged.

The accuracy of electric sounding tape measurements depends on the type of tape used and whether or not the tape has been stretched out of calibration after use. Tapes that are marked the entire length with feet, tenths, and hundredths of a foot should be read to 0.01 ft. Electric sounding tapes are harder to keep calibrated than are steel tapes. As with steel tapes, electric sounding tapes are most accurate for water levels less than 200 ft below land surface, and thermal expansion and stretch start to become significant factors when measuring deep water levels (>500 ft) (see Garber and Koopman, 1968). Equipment and supplies needed for this method are shown in Table 4.

The following issues should be considered with this method:

- If the well casing is angled, instead of vertical, the depth to water will have to be corrected, if possible. This correction should be recorded in the field folder.
- **Check that the electric sounding tape is not hung up on an obstruction in the well.**
- The electric sounding tape should be calibrated annually against a steel tape in the field (using monitoring wells only) as follows: Compare water-level measurements made with the electric sounding tape to those made with a steel tape in several wells that span the range of depths to water encountered in the field. The measurements should agree to within ± 0.02 ft. If this accuracy is not met, a correction factor should be applied. All calibration and maintenance data should be recorded in a calibration and maintenance log book for the electric sounding tape.
- **Oil on the surface of the water may interfere with obtaining consistent readings and could damage the electrode probe. If oil is present, switch to a steel tape for the water-level measurement.**
- If using a repaired/spliced tape: see section A4-B-3(b) (page B16) of the NFM (U.S. Geological Survey, 2006).

Before making a measurement:

1. Inspect the electric sounding tape and electrode probe before using it in the field. Check the tape for wear, kinks, frayed electrical connections and possible stretch; the

cable jacket tends to be subject to wear and tear. Test that the battery and replacement batteries are fully charged.

2. Check the distance from the electrode probe's sensor to the nearest foot marker on the tape, to ensure that this distance puts the sensor at the zero foot point for the tape. If it does not, a correction must be applied to all depth-to-water measurements. Record this in an equipment log book and on the field form.

3. Prepare the field forms (DWR Form 1213; see Table 5) and place any previous measured water-level data for the well into the field folder.

4. After reaching the field site, check that the RP is clearly marked on the well and is accurately described in the well file or field folder. If a new RP needs to be established, follow the procedures above.

5. Check the circuitry of the electric sounding tape before lowering the electrode probe into the well. To determine proper functioning of the tape mechanism, dip the electrode probe into tap water and observe whether the indicator needle, light, and/or beeper (collectively termed the "indicator" in this document) indicate a closed circuit. For an electric sounding tape with multiple indicators (sound and light, for instance), confirm that the indicators operate simultaneously. If they do not operate simultaneously, determine which is the most accurate and use that one.

6. Wipe off the electrode probe and the lower 5 to 10 feet of the tape with a disinfectant wipe, rinse with de-ionized or tap water, and dry.

Making a measurement:

1. If the water level was measured previously at the well, use the previous measurement(s) to estimate the length of tape that should be lowered into the well. Preferably, use measurements that were obtained during the same season of the year.

2. Lower the electrode probe slowly into the well until the indicator shows that the circuit is closed and contact with the water surface is made. Avoid letting the tape rub across the top of the well casing. Place the tip or nail of the index finger on the insulated wire at the RP and read the depth to water to the nearest 0.01 foot. Record this value in the column labeled "Tape at RP", with the appropriate measurement method code and the date and time of the measurement (see Table 5).

3. Lift the electrode probe slowly up a few feet and make a second measurement by repeating step 2 and record the second measurement with the time in the row below the first measurement in Table 5. Make all readings using the same deflection point on the indicator scale, light intensity, or sound so that water levels will be consistent between measurements. If the second measurement does not agree with the first measurement within 0.02 of a foot **(0.2 of a foot for production wells)**, make a third measurement,

recording this measurement with the time in the row below the second measurement. If more than two readings are taken, record the average of all reasonable readings.

After making a measurement:

1. Wipe down the electrode probe and the section of the tape that was submerged in the well water, using a disinfectant wipe and rinse thoroughly with de-ionized or tap water. Dry the tape and probe and rewind the tape onto the tape reel. Do not rewind or otherwise store a dirty or wet tape.

(3) Sonic Water-Level Meter Method

This meter uses sound waves to measure water levels. It requires an access port that is 5/8 – inch or greater in diameter and measurement of the average air temperature in the well casing. The meter can be used to quickly measure water levels in both monitoring wells and production wells. Also, since this method does not involve contact of a probe with the water, there is no concern over cross contamination between wells. However, the method is not as accurate as the other methods, with a typical accuracy of 0.2 ft for water levels less than 100 ft or 0.2% for water levels greater than 100 ft. Equipment and supplies needed for this method are shown in Table 4.

The following issues should be considered with this method:

- The accuracy of the meter decreases with well diameter and should not be used with well diameters greater than 10 inches.
- An accurate air temperature inside the well casing is necessary so that the variation of sound velocity with air temperature can be accounted for.
- **Obstructions in the well casing can cause erroneous readings, especially if the obstruction is close to half the well diameter or more.**

Before making a measurement:

1. Check the condition of the meter, especially the batteries. Take extra batteries to the field.

2. Take a temperature probe with a readout and 50-ft cable.

3. If open wellheads with diameter greater than the factory cover plate and less than 10 inches will be monitored, fabricate appropriately-sized cover plates using plastic or sheet metal.

4. Prepare the field forms (DWR Form 1213; see Table 5). Place any previous measured water-level data for the well into the field folder.

5. Check that the RP is clearly marked on the well and accurately described in the well file or field folder. If a new RP needs to be established, follow the procedures above.

Making a measurement:

1. If the water level was measured previously at the well, lower the temperature probe to about half that distance in the well casing. Preferably, use measurements that were obtained during the same season of the year.

2. Record this temperature in the comments column of DWR form 1213 (see Table 5). Use this temperature reading to adjust the temperature toggle switch on the sonic meter.

3. Select the appropriate depth range on the sonic meter.

4. For a covered wellhead, insert the meter duct into the access port and push the power-on switch. Record the depth from the readout.

5. For an open wellhead, slip the provided cover plate onto the wellhead to provide a seal. If the cover plate is not large enough, use a fabricated cover plate for diameters up to 10 inches. Record the depth from the readout.

After making a measurement:

1. Make sure the temperature probe and the sonic meter are turned off and put away in their cases.

(4) Pressure Transducer Method

Automated water-level measurements can be made with a pressure transducer attached to a data logger. Care should be taken to choose a pressure transducer that accurately measures the expected range of groundwater levels in a well. Pressure-transducer accuracy decreases linearly with increases in the depth range (also known as pressure rating). A pressure transducer with a depth range of 0 to 10 ft (0 to 4.3 psi) has an accuracy of 0.01 ft while a pressure transducer with a depth range of 0 to 100 ft (0 to 43 psi) has an accuracy of 0.1 ft. But if the measurement range exceeds the depth range of a pressure transducer, it can be damaged. So it is important to have a good idea of the expected range of groundwater levels in a well, and then refer to the manufacturer's specification when selecting a pressure transducer for that well.

Some of the advantages of automated monitoring include:

- No correction is required for angled wells, as pressure transducers only measure vertical water levels.
- A data logger can be left unattended for prolonged periods until data can be downloaded in the field.
- Downloaded data can be imported directly into a spreadsheet or database.

Some of the disadvantages of automated monitoring include:

- It may be necessary to correct the data for instrument drift, hysteresis, temperature effects, and offsets. Most pressure transducers have temperature compensation built-in.
- Pressure transducers operate only in a limited depth range. The unit must be installed in a well in which the water level will not fluctuate outside the operable depth range for the specific pressure transducer selected. Wells with widely fluctuating water levels may be monitored with reduced resolution or may require frequent resetting of the depth of the pressure transducer.
- With some data loggers, previous water-level measurements may be lost if the power fails.

There are two types of pressure transducers available for measuring groundwater levels; non-vented (absolute) and vented (gauged). A non-vented pressure transducer measures absolute pressure, is relative to zero pressure, and responds to atmospheric pressure plus pressure head in a well (see Figure 5). A vented pressure transducer measures gauge pressure, is relative to atmospheric pressure, and only responds to pressure head in a well.

Non-vented pressure transducer data require post processing. Barometric pressure data must be collected at the same time as the absolute pressure data at the well, and subtracted from each absolute pressure data record before the data can be used to calculate groundwater levels. Thus, if a non-vented pressure transducer is used, a barometric pressure transducer will also be needed near the well. This subject is usually covered in more detail by the manufacturer of the pressure transducer. In an area with little topographic relief, a barometer at one site should be sufficient for use by other sites within a certain radius (9 miles reported by Schlumberger http://www.swstechnology.com/ groundwater-monitoring/groundwater-dataloggers/baro-diver and 100 miles reported by Global Water http://www.globalw.com/support/barocomp.html). In an area of significant topographic relief, it would be advisable to have a barometer at each site.

Vented pressure transducers can be programmed so no post processing of the data is necessary. The vent is usually a small tube in the communication cable that runs from the back of the pressure transducer to the top of the well. This vent enables the pressure transducer to cancel the effect of atmospheric pressure and record groundwater level as the distance from the RP to the WS (see Figure 5). However, if the vent is exposed to excessive moisture or submerged in water it can cause failure and damage to the pressure transducer.

The existing well conditions should be considered when deciding which type of pressure transducer to use. Non-vented pressure transducers should be used when the top of a well or its enclosure may at any time be submerged in water. This can happen when artesian conditions have been observed or are likely, the well is completed at or below the LSD, or the well or its enclosure are susceptible to periods of high water. Otherwise, it is advisable to use a vented pressure transducer.

The following guidelines are USGS guidelines from Drost (2005) and Freeman and others (2004) for the use of pressure transducers. These USGS guidelines have not been incorporated as yet in the NFM. The equipment and supplies needed for automated measurements of water level using a pressure transducer are shown in Table 4.

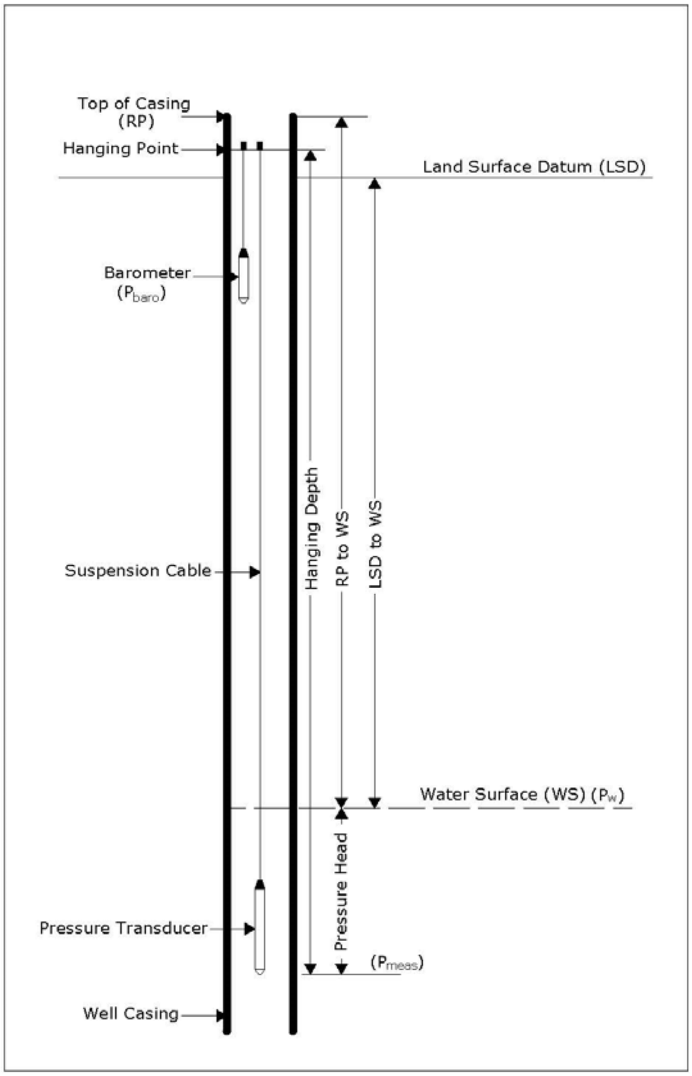

Figure 5. Groundwater-level measurements using a pressure transducer (vented or non-vented) (modified from Drost, 2005).

Before making a measurement:

1. Keep the pressure transducer packaged in its original shipping container until it is installed.

2. Fill out the DWR field form (Table 6), including the type, serial number, and range of measurement device; and what units are being measured (ft, psi).

3. Take a reading from the pressure transducer before placing into the well. For a vented pressure transducer the reading should be zero. For a non-vented pressure transducer the reading should be a positive number equivalent to atmospheric pressure. Configure the units (ft, psi) on a barometric pressure transducer the same as the non-vented pressure transducer. A reading from the barometric pressure transducer should be the same as the non-vented pressure transducer reading.

4. Lower the pressure transducer into the well slowly. Conduct a field calibration of the pressure transducer by raising and lowering it over the anticipated range of water-level fluctuations. Take two readings at each of five intervals, once during the raising and once during the lowering of the pressure transducer. Record the data on the DWR field form (see Table 6). If using a non-vented pressure transducer, take a reading from the barometric pressure transducer at the same time as the other readings.

5. Lower the pressure transducer to the desired depth below the water level (caution: do not exceed the depth range of the pressure transducer).

6. Fasten the cable or suspension system to the well head using tie wraps or a weatherproof strain-relief system. If the vent tube is incorporated in the cable, make sure not to pinch the cable too tightly or the vent tube may be obstructed.

7. Make a permanent mark on the cable at the hanging point, so future slippage, if any, can be determined.

8. Measure the static water level in the well with a steel tape or electric sounding tape. Repeat if measurements are not consistent within 0.02 ft **(0.2 ft for production wells)**.

9. Record the well and RP configuration, with a sketch. Include the RP height above the LSD, the hanging point, and the hanging depth (see Figure 5).

GROUNDWATER LEVEL DATA FORM
VENTED OR NON-VENTED PRESSURE TRANSDUCER WITH DATALOGGER

Station Information						Transducer Information						
Well ID Number	Well Name	State Well Number	County	Bulletin 118 GW Basin or Subbasin	Measuring Agency	Type of Pressure Transducer -- (A) Gauged (vented) or (B) Absolute (non-vented)?	Manufac-turer	Model	Serial Number	PSI Rating	Cable Length	Barometer Serial Number

Datum Measurements (in feet) [Date of Measurements:]

Reference Point (RP) Elevation (MSL) [from DWR Form 429]	RP to Land Surface Datum (LSD)	(1) RP to Hanging Point	(2) Hanging Depth	(3) RP to Pressure Transducer

					Manual Readings			Datalogger Readings					Datalogger Servicing			
Date	Time	Obser-ver	NM	QM	MM	(4) Tape at RP	(5) Tape at WS	(6) RP to WS	(7) Transducer pressure (psi)	(8) Barometric pressure (psi)	(9) WS pressure (psi)	(10) WS above transducer (ft)	(11) RP to WS (ft)	Test Name	Download-ed data? (Y/N)	Batt. life left / new batteries? (%; Y/N)	Comments

These cells only need to be filled out for non-vented transducers (which will have a barometer at the well in addition to the transducer)

Notes about calculated entries in form (referenced by number in cell): (3) = (1) + (2); (6) = (4) - (5) for steel tape; (6) = (4) for electric sounding tape; (9) = (7) - (8) for non-vented transducer; (9) = (7) for vented transducer; (10) = 2.3067 * (9); (11) = (3) - (10) [for explanation of terms, see figure 2]

NM (No Measurement) Codes: 0--Measurement discontinued 1--Pumping 2--Pump house locked 3--Tape hung up 4--Can't get tape in casing 5--Unable to locate well 6--Well has been destroyed 7--Special 8--Casing leaky or wet 9--Temporarily inaccessible

QM (Questionable Measurement) Codes: 0--Caved or deepened 1--Pumping 2--Nearby pump operating 3--Casing leaky or wet 4--Pumped recently 5--Air or pressure gauge measurement 6--Other 7--Recharge operation at or nearby well 8--Oil in casing

MM (Measurement Method) Codes: 0--Steel tape 1--Electric sounding tape 2--Other

DWR Form xxxx (data for Hydstra)

Table 6. Groundwater level data form for vented or non-vented pressure transducer with data logger.

10. Connect the data logger, power supply, and ancillary equipment. Configure the data logger to ensure the channel, scan intervals, units, etc., selected are correct. Activate the data logger. Most data loggers will require a negative slope in order to invert water levels for ground-water applications (i.e., distance from the RP to the WS). If using a non-vented pressure transducer the data logger will not require a negative slope, but atmospheric pressure data will need to be collected by a barometric pressure transducer.

Making a measurement:

1. Retrieve water-level data (to 0.01 ft) using instrument or data logger software. If using a non-vented pressure transducer, retrieve barometric pressure data.

2. Measure the water level with a steel tape or electric sounding tape (to 0.01 ft) and compare the reading with the value recorded by the pressure transducer and data logger. Record the reading and time in the file folder. If using a non-vented pressure transducer, subtract the barometric pressure value from the transducer pressure value to obtain the water level pressure value. The water level pressure can then be multiplied by 2.3067 to convert from psi of pressure to feet of water (Freeman and others, 2004). Report the calculated water level to the nearest 0.01 ft.

3. If the tape and pressure transducer readings differ by more than **(the greater of 0.2 ft or)** two times the accuracy of the specific pressure transducer, raise the pressure transducer out of the water and take a reading to determine if the cable has slipped, or whether the difference is due to drift. The accuracy of a pressure transducer is typically defined as 0.001 times the full scale of the pressure transducer (e.g., a 0 to 100 ft pressure transducer has a full scale of 100 ft). The accuracy of a specific pressure transducer should be specified by the manufacturer's specifications.

4. If drift is significant, recalibrate the pressure transducer as described using a steel tape. If using a non-vented pressure transducer, keep the pressure transducer out of the water and calibrate to the barometric pressure transducer value. If field calibration is not successful, retrieve the transducer and send back to the manufacturer for re-calibration.

5. Use the multimeter (see Table 4) to check the charge on the battery, and the charging current supply to the battery. Check connections to the data logger, and tighten as necessary. Burnish contacts if corrosion is occurring.

6. Replace the desiccant, battery (if necessary), and data module. Verify the data logger channel and scan intervals, document any changes to the data logger program and activate the data logger.

7. If possible, wait until data logger has logged a value, and then check for reasonableness of data.

Glossary of Terms

The following terms are used in this document. Although many are commonly used in the groundwater- and data-management fields, they are defined here to avoid confusion.

Aquifer – A geologic formation from which useable quantities of groundwater can be extracted. A confined aquifer is bounded above and below by a confining bed of distinctly less permeable material. The water level in a well installed in a confined aquifer stands above the top of the confined aquifer and can be higher or lower than the water table that may be present in the material above it. In some cases, the water level can rise above the ground surface, yielding a flowing well. An unconfined aquifer is one with no confining beds between the saturated zone and the ground surface. The water level in a well installed in an unconfined aquifer stands at the same level as the groundwater outside of the well and represents the water table. An alternative and equivalent definition for an unconfined aquifer is an aquifer in which the groundwater surface is at atmospheric pressure.

Atmospheric or barometric pressure – The force per unit area exerted against a surface by the weight of the air above that surface at any given point in the Earth's atmosphere. At sea level, the atmospheric pressure is 14.7 psi. As elevation increases, atmospheric pressure decreases as there are fewer air molecules above the ground surface. The atmospheric pressure is measured by a barometer. This pressure reading is called the barometric pressure. Weather conditions can increase or decrease barometric pressure.

Blue carpenter's chalk – A primarily calcium carbonate chalk with some silica. It is primarily used to make chalk-lines for long lasting bright marks. Some other formulations of chalk (e.g., sidewalk chalk) substitute different ingredients such as rice starch for silica.

Data logger – A microprocessor-based data acquisition system designed specifically to acquire, process, and store data. Data usually are downloaded from onsite data loggers for entry into office data systems. The storage device within a data logger is called the data module. A desiccant, such as, silica gel, calcium sulfate, or calcium chloride, is used to absorb and keep moisture away from the data module.

Dedicated monitoring well – A well designed for the sole purpose of long-term monitoring.

Domestic well – A water well used to supply water for the domestic needs of an individual residence or systems of four or fewer service connections.

DWR Bulletin 118 – DWR publication on the status of California's groundwater. Prior to this 2003 update, the latest Bulletin 118 was published in 1980. This publication defines the 515 basins to be monitored in the SB 6 monitoring program. The report reference is: California Department of Water Resources, 2003, California's groundwater: Bulletin 118, 246 p., available online at: http://www.water.ca.gov/pubs/groundwater/bulletin_118/california's_groundwater__bulletin_118_-_update_2003_/bulletin118_entire.pdf

Electric sounding tape – This term is used in this document to mean both the electric tape and the electrode probe attached to the end of the tape. This water-level measuring device is also known by many other names, including a sounder, an electric tape, an E tape, an electric sounder, an electric well sounder, a depth sounder, etc.

Electrode probe – This is the electronic sensor in the electronic sounder attached to the end of the electric tape. It senses water based on the electrical conductivity and triggers an alert.

GPS – This stands for global positioning system. These devices come in many sizes and costs. The handheld devices are capable of very accurate locations in the xy plane (latitude longitude). However, only very expensive and large GPS units are currently capable of accurate readings for the altitude (z direction).

Groundwater – Water occurring beneath the ground surface in the zone of saturation.

Groundwater basin – An alluvial aquifer or a stacked series of alluvial aquifers with reasonably well-defined boundaries in a lateral direction and having a definable bottom.

Groundwater elevation – The elevation (generally referenced to mean sea level as the datum) to which water in a tightly cased well screened at a given location will rise. Other terms that may be used include groundwater level, hydraulic head, piezometric head, and potentiometric head.

Groundwater surface – The highest elevation at which groundwater physically occurs in a given location in an aquifer (i.e., top of aquifer formation in a confined aquifer and the groundwater level or water table in an unconfined aquifer). Also referred to as a water surface in this document.

Groundwater subbasin – A subdivision of a groundwater basin created by dividing the basin using geologic and hydrologic conditions or institutional boundaries.

Hysteresis – The maximum difference in output, at any measured value within the specified range, when the value is approached first with an increasing and then a decreasing measured property. Hysteresis is expressed in percent of the full-scale output.

Instrument Drift – A change in instrument output over a period of time that is not a function of the measured property. Drift is normally specified as a change in zero (zero drift) over time and a change in sensitivity (sensitivity drift) over time.

Irrigation well – A well used to irrigate farmland. The water from the well is not intended for domestic purposes.

Metadata – "data about data"; it is the data describing context, content and structure of records and their management through time.

NFM – This stands for National Field Manual. This is a living, online, document of the USGS. It is the protocol document for USGS methods of surface water, groundwater, and water quality field activities. The portion of the NFM that related to the field methods of collecting groundwater levels is in the following reference: U.S. Geological Survey, 2006, Collection of water samples (ver. 2.0): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A4, September, accessed 12/30/09 at: http://pubs.water.usgs.gov/twri9A4/

Nonflowing well – A well in which the water level is below the land surface.

Pressure head – The height of a column of groundwater above a point that is supported by pressure at that point.

Pressure transducer – A type of measurement device that converts pressure-induced mechanical changes into an electrical signal.

Production well – A well with a pump installed that is used to bring groundwater to the land surface. This is a general term that can be applied to a domestic well, irrigation well, or public-supply well.

Public-supply well – A well that pumps groundwater from a relatively extensive saturated area and is used as part of a public water system, supplying water for human consumption to at least 3,300 people.

SOGW – This stands for Subcommittee on Groundwater. This is a subcommittee of the Advisory Committee on Water Information, which is developing a national framework for groundwater in the United States. The reference for the SOGW work is: Subcommittee on Ground Water of the Advisory Committee on Water Information, 2009, A national framework for ground-water monitoring in the United States: final version approved by the Advisory Committee on Water Information, June 2009, 78 p., accessed 1/11/10 at: http://acwi.gov/sogw/pubs/tr/index.html

Static water level – Groundwater level in a well during non-pumping conditions.

Vent tube – A tube in the cable which connects to the pressure transducer, allowing atmospheric pressure to be in contact with one side of the strain gauge in the pressure sensor. It cancels out the barometric effects in the readings.

Well casing – The metal or plastic pipe separating the well from the surrounding geologic material.

Wellhead – The top of the well containing the casing hanger and the point at which the motor is attached for a vertical line shaft turbine pump or where the seal is secured for a submersible pump.

Well purging – Pumping out standing groundwater from a monitoring well. This is done prior to water quality sampling of wells, but **not** before taking a water-level measurement.

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