Attachment 8
Quality Assurance

8.1 Quality Assurance-Quality Control

Appropriate quality assurance and quality control measures will be utilized for each task to address the following data quality objectives of the proposed project:

- Obtain adequate geologic and hydrologic data during drilling and logging of the boreholes to ensure wells are designed properly to assess water quality and hydraulic conditions
- Obtain high quality and accurate water quality data
- Obtain accurate estimates of aquifer properties during the proposed aquifer testing program
- Accurately assess potential geochemical interactions during future aquifer storage and recovery pilot-scale testing
- Develop high quality reporting documents

Specific QA/QC procedures established for individual components of the scope of work are provided in the following sections.

8.2 Monitoring Well Drilling, Construction and Monitoring

Drilling methods employed during performance of the scope of work will include both direct mud rotary and hollow-stem auger drilling techniques and will be consistent with standard practices for construction of environmental monitoring systems. All drilling and sampling activities will be performed in accordance with California Department of Water Resources Water Well Standards (Bulletins 74-81 and 74-90) and County of Sonoma Ordinance 25B. Drilling and well construction activities will be performed by a contractor possessing a C-57 Water Well Drilling license issued by the State of California and overseen by a California Professional Geologist. Lithologic logs will be prepared in the field by an experienced engineer or geologist in accordance with the Unified Soil Classification System and Munsell Color Index under the supervision of a California Professional Geologist.

8.2.1 Mud Rotary Drilling Methods

Direct mud rotary drilling methods will be used to construct the two nested groundwater monitoring wells. Control of drilling fluid properties shall be maintained throughout all drilling operations. Mud based systems shall consist of pre-approved additives for ease of drilling, filtrate control, flow control, and protection of the drilling operation. Adequate facilities for the

collection of representative drill cutting samples shall be maintained at all times for drilling operations.

To obtain accurate depth determination, representative cuttings samples, and a straight and plumb borehole, the following guidelines will be followed:

- A reasonable constant weight on the bit and rotary speed will be maintained.
- Drill collars of appropriate diameter, weight, and length will be used and will be of the maximum size allowable without interference with circulation.

Supporting equipment will include a portable mud tank, equipped with a separation system comprised of sand cones and a shaker screen, tipping hoppers and closed-top roll-off bins.

All down-hole drilling tools and equipment shall be thoroughly cleaned using a steam cleaner or pressure washer prior to commencement of work.

The quality of drilling fluids will be maintained and monitored throughout the drilling process to assure protection of water bearing formations exposed in the borehole and the ability to obtain reliable representative samples of the formation materials. The following drilling fluid properties will be monitored: (1) drilling fluid weight; (2) drilling fluid viscosity; and (3) drilling fluid sand content; and (4) wall cake thickness and water loss (via filter press). Drilling fluid properties will be tested once for every 100 feet of borehole drilled or 4 hours of circulating time, whichever is more frequent.

- Drilling fluids will maintain the following average properties:
- Weight 8.33–9.0 lb./gal.
- Marsh Funnel Viscosity 30–40 sec./qt.
- Sand Content less than 1% by volume
- Filter Cake Thickness 1/16-inch

The powder bentonite for the drilling mud shall be mechanically dispersed and mixed prior to introduction to the borehole. The drilling fluid will be run through a solids separator after exiting the borehole and prior to being recirculated to the borehole. Once the full depth of the exploratory borehole has been reached, the drilling mud will be prepared with sufficient viscosity and borehole wall thickness for the borehole to stand open for geophysical logging.

Throughout the drilling program, the reference of each depth given shall be properly denoted and the distance from ground level to the reference point shall be measured and recorded. A pipe tally shall be maintained for each type of pipe introduced into the borehole, including the drill string (consisting of all cross-over subs, drill collars, and drill pipes), tremie pipe, and well casings. For each tally log, the type of pipe, diameter, material type, and in-place length will be recorded to the nearest 0.1 feet.

8.2.2 Hollow-Stem Auger Drilling Methods

Hollow-stem auger drilling will be utilized for the four shallow monitoring wells and consists of a hollow, steel stem or shaft with a continuous, spiraled steel flight, welded onto the exterior stem. A hollow auger bit, generally with carbide teeth, disturbs soil material when rotated, allowing the spiral flights to transport the cuttings to the surface. In addition to continuous examination and logging of cuttings returned from the hollow-stem augers, split-spoon sampling will be conducted at five-foot intervals in accordance with ASTM Specification D-1586-84 for standard penetration test and split barrel sampling.

Split spoon samples will be collected ahead of the lead auger flight. Upon collection of each split spoon sample, the lead auger will be advanced over the sampled interval prior to collection of the next split spoon sample. In addition, while the augers are being advanced a temporary auger plug will be placed at the bottom of the lead auger to minimize or eliminate the potential for formation materials to run up into the augers. The use of an auger plug will help assure that split spoon samples are representative of in-situ formation materials.

8.2.3 Monitoring Well Construction

Quality assurance-quality control procedures for the construction of the groundwater monitoring wells will included the following protocols:

- Blank and screen casing for the monitoring wells will be new and free of defect and shall comply with ASTM F480;
- All annular materials will be placed using a temporary construction tremie in a manner that prevents caving of formation materials;
- Each lift of sand filter pack and sealing material will be tagged with a weighted surveyors tape to verify the thickness and depth of placed annular fill;
- Each well screen interval will be swabbed with a vented surge block following placement of the filter pack and prior to placement of the overlying annular seal;
- The well casings will be suspended above the bottom of the borehole a sufficient distance to ensure that the casing is not placed in compression by resting on the bottom of the borehole;
- Well casings will be fitted with spacers and centering guides to allow for a minimum 2-inches of space separating each individual casing string and the borehole wall; and
- The finished well casings will be checked for plumbness and alignment using a minimum five-foot long, nominal 2-inch diameter bailer or similar tool.

8.2.4 Groundwater Monitoring

Groundwater-level measurements and groundwater quality samples collected from the monitoring wells and the placement and operation of dedicated pressure transducers will be

performed following detailed procedures described in the *Sampling and Analysis Plan and Groundwater Monitoring Protocols* for the Sonoma Valley GWMP (April 2011).

8.3 Aquifer Testing

Quality assurance-quality control for analysis and the tolerance in measurement acceptable for the step-drawdown and long-term continuous aquifer test are as follows:

1. The rate of pumping shall be maintained within 10 gpm or 10 percent of the designated rate, whichever is less
2. Depth to water measurements in the pumped well will be accurate to 0.01 feet
3. Pressure transducers will be of appropriate pressure rating and checked for accuracy prior to the aquifer testing
4. Manual elevations will also be conducted at less numerous measurement intervals using an electric sounder accurate to 0.01 inch, appropriately checked for calibration
5. Time recorded will be accurate to within 1 minute
6. Water discharged from the well during the step-drawdown and constant rate test will be carried away from the well to a distance sufficient to preclude circulation of the discharge water downward to the groundwater table

Recording of data will be on form shown in Figure 8-1.

Measurements in the observation well will occur often enough and soon enough after testing begins to avoid missing the initial drawdown values. Actual timing will depend on the aquifer and well conditions that vary from test area to test area. Estimates for timing will be made during the planning stages of aquifer testing using estimated aquifer parameters based on the conceptual model of the site, as modified from installation of the new nearby multi-depth monitoring well.

Table 1 - Pumping Well Pressure Transducer Measurements
0 to 1 minute ..... every 5 seconds
1 to 5 minutes..... every 30 seconds
5 to 15 minutes ..... every 1 minute
15 to 60 minutes ..... every 5 minutes
60 to 120 minutes ..... every 10 minutes
2 hours to 10 hours ..... every 30 minutes
10 hours to shutoff ..... every 1 hour

Table 2 - Observation Well Pressure Transducer Measurements
0 to 1 minute ..... every 5 seconds
1 to 5 minutes..... every 30 seconds
5 to 15 minutes ..... every 1 minute
15 to 60 minutes ..... every 5 minutes
60 to 120 minutes ..... every 10 minutes
2 hours to 10 hours ..... every 30 minutes
10 hours to shutoff ..... every 1 hour

Recovery measurements will be made in the same manner as the drawdown measurements. After pumping is terminated, recovery measurements will be taken at the same frequency as the drawdown measurements listed above in Table 1.

Manual water level measurements using electric sounders will be conducted as back up to the pressure transducer data to be collected during the aquifer test. A dedicated sounder capable of measuring water level elevation to 0.01 inch will be assigned to the pumping well and each observation well throughout the duration of the test. Each sounder will be checked and calibrated prior to the commencement of testing to assure accurate readings during the test. Manual measurements will be collected at frequencies indicated in the tables below, and may be modified based on additional information during the Well No.7 initial testing and new monitoring well installation information, and may also be adjusted in the field based on the aquifer response.

Table 3 - Pumping Well Manual Measurements
0 to 1 minute ..... every 10 seconds as possible
1 to 5 minutes..... every 30 seconds
5 to 15 minutes ..... every 1 minute
15 to 60 minutes ..... every 5 minutes
60 to 120 minutes ..... every 15 minutes
2 hours to 10 hours ..... every 30 minutes
10 hours to shutoff ..... every 1 hour

Table 4 - Observation Well Manual Measurements
0 to 60 minutes..... every 5 minutes
60 to 180 minutes ..... every 10 minute
3 hours to 10 hours ..... every 30 minutes
10 hours to shutoff ..... every 1 hour

During the initial hour of the aquifer test, well discharge in the pumping well will be monitored and recorded as frequently as practical. The discharge line will be setup with a totalizer and gate valve to measure and control the flow rate. Additionally, a container of known volume and a stop watch will be utilized to manually measure and verify the discharge rate periodically, which will be recorded.

The pre-test discharge will equal zero. When starting the aquifer test, the discharge will be brought up to the chosen rate as quickly as possible. The frequency of discharge rate measurements and adjustments will depend on the pump, well, aquifer, and power characteristics. At a minimum, the discharge will be checked every 15 minutes for the first hour, hourly for the next four hours, and assuming the rate remains fairly constant in the earlier measured phases, subsequently four times per day: 1) early morning (~8 AM); 2) early afternoon (~2 PM); 3) early-evening (~6 PM); and 4) late evening (~10 PM). The discharge will not be allowed to vary more than plus or minus 5 percent. The lower the discharge rate, the

more important it is to hold the variation to less than 5 percent. The variation of discharge rate has a large effect on permeability estimates calculated using data collected during a test.

8.3.1 Aquifer Test Data Form

Stand alone data forms will be used that contain all information which may have a bearing on the analysis of the data. The form provides for following data to be recorded on the data sheet for each well:

(a) date

(b) temperature

(c) discharge rate

(d) weather

(e) well location

(f) well number

(g) owner of the well

(h) type of test (drawdown or recovery)

(i) description of measuring point

(j) elevation of measuring point

(k) type of measuring equipment

(l) radial distance from center of pumped well to the center of the observation well

(m) static depth to water

(n) person recording the data

The aquifer test data recording form will have columns for recording of the following data:

(a) elapsed time since pumping started, shown as the value (t)

(b) elapsed time since pumping stopped, shown as (t')

(c) depth in feet to the water level

(d) drawdown or recovery of the water level in feet

(e) time since pumping started divided by the time since pumping stopped, shown as (t/t')

(f) discharge rate in gallons per minute

(g) comments to note any problems encountered, weather changes (i.e., barometric changes, precipitation), or other pertinent data.

Figure 8-1. Aquifer Test Field Data Form

AQUIFER TEST FIELD DATA SHEET
Pumping Well:_____
Well Owner:_____
Date:_____
Weather:_____
Monitoring Staff:_____
Prepared by:_____
Moinitoring Point Elevation (ft msl):_____
Static Water Elevation (ft msl):_____
Discharge Rate of Pumping Well:_____
Total Numer of Observation Wells:_____
Water Measrement Technique:_____
Recorded By:_____

Clock Time	Elapsed Time Since Pumping	Depth to Water (ft)	Drawdown/ Recovery (ft)	Discharge Rate (gpm)	t/t'	Commments

Figure 8-1. Aquifer Test Field Data Form (continued)

AQUIFER TEST FIELD DATA SHEET
Pumping Well: _____
Observation Well 1:_____
Observation Well Owner:_____
Date:_____
Weather:_____
Monitoring Staff:_____
Prepared by:_____
Moinitoring Point Elevation (ft msl):_____
Static Water Elevation (ft msl):_____
Distance to Pumping Well (ft) and direction (degrees):_____
Discharge Rate of Pumping Well:_____
Total Numer of Observation Wells:_____
Water Measurement Technique:_____
Recorded By:_____

Clock Time	Elapsed Time Since Pumping	Depth to Water (ft)	Drawdown/ Recovery (ft)	Discharge Rate (gpm)	t/t'	Commments