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Appendix 5-A
Monitoring Protocols

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Monitoring Protocols
Sonoma Valley Groundwater Subbasin

In accordance with the GSP Regulations, monitoring protocols have been established for the Sonoma Valley Groundwater Subbasin monitoring networks. The following monitoring protocols, intended to ensure the quality and consistency of data, are adapted from DWR's BMPs for Monitoring Protocols, Standards and Sites (DWR 2016).

General Well Monitoring Information

- Long-term access agreements should be maintained for each monitoring site. Access agreements should include year-round site access to allow for increased monitoring frequency. At the time of GSP submittal, some sites included in the monitoring networks for GSP implementation may lack or have outdated access agreements. A basin-wide inventory of access agreement status and efforts to standardize access agreements will be conducted in the early phases of GSP implementation.

- Each monitoring site shall have unique identifier and documentation should include a general written description of the site location, date established, access instructions and point of contact (if necessary), type of information to be collected, latitude, longitude, and elevation. Each monitoring location should also track all modifications to the site in a modification log. This information is stored in the Data Management System (DMS).

- Groundwater elevation data from Spring and Fall semi-annual measurement events will form the basis of Subbasin-wide potentiometric surface maps and should approximate conditions at a discrete period in time. Therefore, all groundwater-level measurements for the semi-annual events should be collected within as short a time as possible, preferably within a 1-to-2-week period.

- Depth to groundwater must be measured relative to an established Reference Point (RP) on the well casing. The RP is usually identified with a permanent marker, paint spot, or a notch in the lip of the well casing. By convention in open casing monitoring wells, the RP reference point is located on the north side of the well casing. If no mark is apparent, the person performing the measurement should measure the depth to groundwater from the north side of the top of the well casing.

- The elevation of the RP of each well must be surveyed to the North American Vertical Datum of 1988 (NAVD88), or a local datum that can be converted to NAVD88. The elevation of the RP must be accurate to within 0.5 foot. It is preferable for the RP elevation to be accurate to 0.1 foot or less. At the time of GSP submittal, some sites included in the monitoring networks for

GSP implementation lack sufficient RP survey data. Information related to this data gap, including plans to address it, is included in Section 5 of this GSP.

- Depth to groundwater must be measured to an accuracy of 0.1 foot below the RP. It is preferable to measure depth to groundwater to an accuracy of 0.01 foot. Air lines and acoustic sounders may not provide the required accuracy of 0.1 foot. While the GSA recognizes that acoustic sounders may not produce data as accurate as that produced by electronic sounding tape or steel tape, for certain privately owned wells in voluntary monitoring programs, an acoustic sounder may be used if requested by the well owner or deemed the only feasible measurement device. For all groundwater-level measurements, the measurement device type shall be noted.

Groundwater-Level Measurement and Field Data Recording Protocols

- The sampler should remove the appropriate cap, lid, or plug that covers the monitoring access point listening for pressure release. If a release is observed, the measurement should follow a period of time to allow the water level to equilibrate. For measuring wells that are under pressure, multiple measurements should be collected to ensure the well has reached equilibrium such that no significant changes in water level are observed. Every effort should be made to ensure that a representative stable depth to groundwater is recorded. If a well does not stabilize, the quality of the value should be appropriately qualified as a questionable measurement. In the event that a well is artesian, site-specific procedures should be developed to collect accurate information and be protective of safety conditions associated with a pressurized well.

- Measure depth to water in the well using procedures appropriate for the measuring device. A typical measuring device should be an electronic sounding tape (electronic water-level meter) capable of 0.01-foot accuracy unless conditions at a particular well require an alternate type of measuring device. Equipment must be operated and maintained in accordance with manufacturer's instructions. Groundwater levels should be measured to the nearest 0.01 foot relative to the RP.

- The sampler should calculate the groundwater elevation as:

  GWE = RPE – DTW

  Where:
  GWE = Groundwater Elevation
  RPE = Reference Point Elevation
  DTW = Depth to Water

  The sampler must ensure that all measurements are in consistent units of feet, tenths of feet, and hundredths of feet. Measurements and RPEs should not be recorded in feet and inches.

- The sampler should record the well identifier, date, time (24-hour format), RPE, height of RP above or below ground surface, DTW, GWE, and comments regarding any factors that may influence the depth to water readings such as weather, nearby irrigation, flooding, potential for tidal influence, or well condition. If there is a questionable measurement or the measurement cannot be obtained, it should be noted. Standardized field forms should be used for all data collection.

- The sampler should replace any well caps or plugs and lock any well buildings or covers.

- The water-level meter and/or any other downhole equipment should be decontaminated after measuring each well.

- All data should be entered into the DMS as soon as possible. Care should be taken to avoid data entry mistakes and the entries should be checked by a second person for quality assurance.

Pressure Transducer Protocols

Pressure transducers with dataloggers are used in many dedicated monitoring wells and inactive supply wells in the Sonoma Valley Groundwater Subbasin monitoring networks to record groundwater-level, temperature, and conductivity data. The following monitoring protocols apply to the use of pressure transducers:

- When installing pressure transducers, care must be exercised to ensure that the data recorded by the transducers is confirmed with hand measurements.

- The sampler must use an electronic water-level meter and follow the protocols listed above to measure the groundwater level and calculate the groundwater elevation in the monitoring well to properly program and reference the pressure transducer installation. It is recommended that transducers record pressure or measured groundwater level to conserve data capacity; groundwater elevations can be calculated at a later time after downloading.

- The sampler must note the well identifier, the associated transducer serial number, transducer range, transducer accuracy, and cable serial number.

- Transducers must be able to record groundwater levels with an accuracy of at least 0.1 foot. Professional judgment should be exercised to ensure that the data being collected is meeting the monitoring objectives and that the instrument is capable. Consideration of the battery life, data storage capacity, range of groundwater level fluctuations, and natural pressure drift of the transducers should be included in the evaluation.

- The sampler must note whether each pressure transducer uses a vented or non-vented cable for barometric compensation. If non-vented units are utilized, they must be properly corrected for natural barometric pressure changes. This requires the consistent logging of barometric pressure to coincide with measurement intervals.

- Follow manufacturer specifications for installation, calibration, data logging intervals, battery life, correction procedure (if non-vented cables used), and anticipated life expectancy to assure that monitoring objectives are being met for the GSP.

- Secure the cable to the well head with a well dock or another reliable method. Mark the cable at the elevation of the reference point with tape or a permanent marker to allow for estimates of future cable slippage.

- Manual groundwater-level measurements should be collected in accordance with the procedures outlined above at least semi-annually to confirm the accuracy of transducer data and monitor for electronic drift or cable movement.

- The data should be downloaded as necessary (at least semi-annually) to ensure no data is lost and entered into the Data Management System following established protocols as soon as possible. Data collected with non-vented data logger cables should be corrected for atmospheric barometric pressure changes, as appropriate. After the sampler is confident that the transducer data have been safely downloaded and stored, the data should be deleted from the data logger to ensure that adequate data logger memory remains.

Protocols for Installation of New Monitoring Wells

It is anticipated that several new dedicated monitoring wells will be installed to fill data gaps during GSP implementation. The design, installation, and documentation of new monitoring wells must consider the following:

- Construction consistent with California Well Standards as described in Bulletins 74-81 and 74-90, and local permitting agency standards of practice.

- Logging of borehole cuttings under the supervision of a California Professional Geologist and described consistent with the Unified Soil Classification System methods according to ASTM standard D2487-11.

- Written criteria for logging of borehole cuttings for comparison to known geologic formations, principal aquifers and aquitards/aquicludes, or specific marker beds to aid in consistent stratigraphic correlation within and across basins, to the extent feasible.

- Geophysical surveys of boreholes to aid in consistency of logging practices, when funding allows. Methodologies should include resistivity, spontaneous potential, spectral gamma, or other methods as appropriate for the conditions. Selection of geophysical methods should be based upon the opinion of a professional geologist or professional engineer and address the objectives for the specific borehole and characterization needs.

- Ensure that the drilling contractor submits State well completion reports according to the requirements of §13752. Well completion report documentation should include geophysical logs, detailed geologic log, and formation identification as attachments, if available.

Groundwater Quality Monitoring Protocols

In general, the GSP relies on water quality data generated through existing programs. In some cases, it may be necessary to collect additional water quality data to support monitoring programs or evaluate specific projects. The USGS National Field Manual for the Collection of Water Quality Data (USGS, 2018) should be used to guide the collection of reliable data.

While specific groundwater sampling protocols vary depending on the constituent being sampled for, the protocols listed below provide guidance which is applied to all groundwater quality sampling.

- Prior to sampling, the sampler must contact the laboratory to schedule laboratory time, obtain appropriate sample containers, and clarify any sample holding times or sample preservation requirements.

- Each well used for groundwater quality monitoring must have a unique identifier. This identifier should appear on the well housing or the well casing to avoid confusion.

- In the case of wells with dedicated pumps, samples should be collected at or near the wellhead. Samples should not be collected from storage tanks, at the end of long pipe runs, or after any water treatment.

- The sampler should clean the sampling port and/or sampling equipment and the sampling port and/or sampling equipment must be free of any contaminants. The sampler must decontaminate sampling equipment between sampling locations or wells to avoid cross-contamination between samples.

- The groundwater elevation in the well should be measured following the protocols described above.

- For any well not equipped with low-flow or passive sampling equipment, an adequate volume of water should be purged from the well to ensure that the groundwater sample is representative of ambient groundwater and not stagnant water in the well casing. Purging three well casing volumes is generally considered adequate. Professional judgment should be used to determine the proper configuration of the sampling equipment with respect to well construction such that a representative ambient groundwater sample is collected. If pumping causes a well to be evacuated (go dry), document the condition and allow well to recover to within 90% of original level prior to sampling.

- Field parameters of pH, electrical conductivity, and temperature should be collected for each sample. Field parameters should be evaluated during the purging of the well and should stabilize prior to sampling. Other parameters, such as oxidation-reduction potential (ORP), dissolved oxygen (DO - in situ measurements preferable), or turbidity, may also be useful for meeting monitoring objectives and assessing purge conditions. All field instruments should be calibrated daily and evaluated for drift throughout the day.

- Sample containers should be labeled prior to sample collection. The sample label must include: sample ID (often well ID), sample date and time, sample personnel, sample location, preservative used, and analytes and analytical method.

- Samples should be collected under laminar flow conditions. This may require reducing pumping rates prior to sample collection.

- All samples requiring preservation must be preserved as soon as practically possible, ideally at the time of sample collection. Ensure that samples are appropriately filtered as recommended for the specific analyte. Entrained solids can be dissolved by preservative leading to inconsistent results of dissolve analytes. Specifically, samples to be analyzed for metals should be field-filtered prior to preservation; do not collect an unfiltered sample in a preserved container.

- Samples should be chilled and maintained at 4 °C to prevent degradation of the sample. The laboratory's Quality Assurance Management Plan should detail appropriate chilling and shipping requirements.

- Samples must be transported under chain of custody documentation to the appropriate laboratory promptly to avoid violating holding time restrictions.

- Instruct the laboratory to use reporting limits that are equal to or less than applicable Sustainable Management Criteria values or regional water quality objectives/screening levels.

Seawater Intrusion Monitoring Protocols

Monitoring seawater intrusion requires analysis of chloride concentrations within groundwater of each principal aquifer subject to seawater intrusion. While no significant standardized approach exists, the methodologies described above for groundwater quality monitoring also apply to seawater intrusion monitoring. In addition to the protocols described above, the following protocols should be followed for seawater intrusion monitoring:

- Water quality samples should be collected and analyzed at least semi-annually. Samples will be analyzed for dissolved chloride at a minimum. It may be beneficial to include analyses of iodide and bromide to aid in determination of salinity source. The development of surrogate measures of chloride concentration may facilitate cost-effective means to monitor more frequently to observe the range of conditions and variability of the flow dynamics controlling seawater intrusion.

- Groundwater levels will be collected at a frequency adequate to characterize changes in head in the vicinity of the leading edge of degraded water quality in each principal aquifer. Frequency may need to be increased in areas of known preferential pathways, groundwater pumping, or efficacy evaluation of mitigation projects.

- The use of geophysical surveys, electrical resistivity, or other methods may provide for identification of preferential pathways and optimize monitoring well placement and evaluation of the seawater intrusion front. Professional judgment should be exercised to determine the appropriate methodology and whether monitoring objectives would be met.

Protocols for Measuring Streamflow

Monitoring of streamflow is necessary for incorporation into water budget analysis and for use in evaluation of stream depletions associated with groundwater extractions. The use of existing streamflow monitoring locations is incorporated into the Subbasin's monitoring networks to the greatest extent possible.

Establishment of new streamflow discharge sites should consider the existing network and the objectives of the new location. Professional judgment should be used to determine the appropriate permitting that may be necessary for the installation of any monitoring locations along surface water bodies. Regular frequent access will be necessary to these sites for the development of ratings curves and maintenance of equipment.

To establish a new streamflow monitoring station special consideration must be made in the field to select an appropriate location for measuring discharge. Once a site is selected, development of a relationship of stream stage to discharge will be necessary to provide continuous estimates of streamflow. Several measurements of discharge at a variety of stream stages will be necessary to develop the ratings curve correlating stage to discharge. The use of Acoustic Doppler Current Profilers (ADCPs) can provide accurate estimates of discharge in the correct settings. Professional judgment must be exercised to determine the appropriate methodology. Following development of the ratings curve a simple stilling well and pressure transducer with data logger can be used to evaluate stage on a frequent basis.

Streamflow measurements should be collected, analyzed, and reported in accordance with the procedures outlined in USGS Water Supply Paper 2175, Volume 1. – Measurement of Stage Discharge and Volume 2. – Computation of Discharge (Rantz and others, 1982). This methodology is currently used by both the USGS and DWR for existing streamflow monitoring throughout the State.

Protocols for Monitoring Land Subsidence

Evaluating and monitoring inelastic land subsidence can utilize multiple data sources to evaluate the specific conditions and associated causes. At the time of GSP submittal, the GSA generally relies on existing Interferometric Synthetic Aperture Radar (InSAR) data and data from continuous GPS (CGPS) stations. Subsidence can also be estimated from numerous other techniques including: level surveying tied to known stable benchmarks or benchmarks located outside the area being studied for possible subsidence; installing and tracking changes in borehole extensometers; or obtaining data from static GPS surveys or Real-Time-Kinematic (RTK) surveys. No standard procedures exist for collecting data from the potential subsidence monitoring approaches. However, an approach may include:

Identification of Land Subsidence Conditions

- Evaluation of existing regional long-term leveling surveys of regional infrastructure, i.e. roadways, railroads, canals, and levees.

- Inspection of existing County and State well records where collapse has been noted for well repairs or replacement.

- Determining if significant fine-grained layers are present such that the potential for collapse of the units could occur should there be significant depressurization of the aquifer system.

- Inspection of geologic logs and the hydrogeologic conceptual model to aid in identification of specific units of concern.

- Analysis of regional remote-sensing information such as InSAR.

- Review of seismic related data and records that might explain land subsidence observations.

- Review of groundwater elevation measurements and trends in Representative Monitoring Points (established as part of groundwater-level Sustainable Management Criteria) and other nearby wells being monitored, including an assessment as to whether groundwater levels are below historical lows or exceeding Minimum Thresholds.

- Evaluation of known or estimated groundwater pumping patterns within the vicinity of any observed potential land subsidence.

Monitor regions of suspected subsidence where potential exists

- Establish CGPS network to evaluate changes in land surface elevation.

- Establish leveling surveys transects to observe changes in land surface elevation.

- Establish extensometer network to observe land subsidence. Extensometer design should be based on local conditions, professional judgement, and monitoring objectives.

Standards and guidance documents for collecting data for land subsidence monitoring include:

- GPS and Leveling surveys must follow surveying standards set out in the California Department of Transportation's Caltrans Surveys Manual (California Department of Transportation, various dates).

- Instruments installed in borehole extensometers must follow the manufacturer's instructions for installation, care, and calibration.

References

California Department of Transportation, various dates. *Caltrans Surveys Manual*.

California Department of Water Resources (DWR). 2016. *Best Management Practices for the Sustainable Management of Groundwater, Monitoring Protocols, Standards, and Sites*. December

Rantz, S.E., and others, 1982. *Measurement and computation of streamflow*; U.S. Geological Survey, Water Supply Paper 2175.

U.S. Geological Survey, 2018, *Preparations for water sampling*: U.S. Geological Survey Techniques and Methods, book 9, chap. A1.