The following is an excerpt from the Groundwater Surface Water Interactions Monitoring Method [MM-07]

SGM Grant Program Requirements for Post-Performance Monitoring and Reporting

Groundwater Surface Water Interactions Monitoring Method

Project / Action Type	Monitoring streamflow depletions along interconnected surface waters.
Similar / Related Project Types	This Monitoring Method describes monitoring of a specific sustainability indicator for a variety of potential projects, rather than describing a monitoring method for a particular project. Other similar Monitoring Methods include seawater intrusion, groundwater dependent ecosystems, and subsidence.
Metric	Groundwater levels. Surface water flow rates. Surface water stage. Groundwater dependent ecosystems (situationally).
Measurement Unit	Groundwater levels measured in feet in a consistent vertical datum. Surface water flow rate in cubic feet per second (streamflow). Surface water levels in feet (stage/depth, channel elevation). Vegetation vigor and plant surveys (root zone index, wetland species) of groundwater dependent ecosystems habitats.
Beneficial User	Municipal and domestic water supply (MUN) Industrial service supply (IND) Industrial process supply (PROC) Freshwater replenishment to surface waters (FRSH)

Groundwater and Surface Water Interactions Monitoring

Management practices to consider for supporting assessment of ISW can be found in California Department of Water Resources' (*DWR's) Best Management Practice (BMP) 2 Monitoring Networks and Identification of Data Gaps* (DWR, 2016). Additional guidance can be found in The Nature Conservancy *Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act: Guidance for Preparing Groundwater Sustainability Plans* (Rohde et al., 2018) and the Environmental Defense Fund *Addressing Regional Surface Water Depletions in California: A Proposed Approach for Compliance with the Sustainable Groundwater Management Act* (Environmental Defense Fund, 2018).

The project proponent should monitor both surface water and groundwater in the vicinity of potential ISW or known ISW reaches. Monitoring both is needed to fully characterize spatial and temporal exchanges between surface water and groundwater, and to calibrate and apply the tools and methods necessary to calculate depletions of surface water. The combined use of groundwater elevation and streamflow data can allow managers to assess temporal changes in conditions due to variations in stream discharge, natural recharge, and regional groundwater extraction, as well as other factors that may be necessary to identify adverse impacts on beneficial uses of the surface water.

Additional information on tools and monitoring protocols relevant to ISW can be found at DWR's BMP 1 Monitoring Protocols Standards and Sites (DWR, 2016) and the *USGS California Water Science Center* website.

Background and Context

A variety of projects designed to improve groundwater sustainability may reduce depletion of ISW or increase groundwater contributions to baseflow. Monitoring project benefits or impacts on ISW primarily relies on monitoring both groundwater levels and streamflow. The SGMA metric quantifying depletion of ISW is a volume or rate of surface water depletion. This is a difficult metric to quantify since the sustainability indicator of depletion of ISW is specific to depletions caused by groundwater use. Surface water depletions caused by groundwater use can be too small to directly measure through changes in streamflow. SGMA GSP Regulations allow for the use of groundwater elevations as a proxy for volume or rate of surface water depletion. The general approach to demonstrating no increased ISW depletion using groundwater levels instead of a volume or rate of depletion is that if groundwater levels connected to surface water are kept at or above a specified level, then there would not be more surface water depletion than what occurred historically when groundwater levels were at the specified level. Under SGMA, to use groundwater elevations as a proxy, it must be demonstrated that there is a significant correlation between groundwater elevations and volume or rate of surface water depletion. Where changes in streamflow from groundwater extractions cannot be directly measured, changes in depletion flow rate or volume can be demonstrated with a numerical model that has an integrated surface water component calibrated to historical streamflows and/or stage, or other analytical methods.

The established GSP monitoring networks may be suitable for monitoring project impacts or benefits to ISW. However, given the project type, its location and potential influence on groundwater near ISW, additional monitoring points are likely necessary to monitor local ISW impacts. Where possible and appropriate, multi-depth monitoring well clusters should be used for evaluating relationships between shallow groundwater levels and any deeper aquifers where groundwater pumping occurs. The ISW monitoring network should be capable of providing sufficient data for evaluating short-term, seasonal, and long-term trends in groundwater levels.

A Step-by-Step Guide to Applying the Groundwater and Surface Water Interactions Monitoring Method

1. **Safety plan:** All projects with fieldwork related activities should produce a Safety Plan. Planning for fieldwork and availability of access to the site, such as monitoring wells, is necessary to maintain project safety. Projects with an impact on groundwater and surface water interactions may require a Safety Plan to address these and other potential safety concerns.
2. **Groundwater influence area:** Determine the project's area of groundwater influence and determine if the basin's GSP indicates whether groundwater and surface water are connected. If disconnected or unknown, go to Step 3, otherwise go to Step 4.

3. **Identify monitoring network:** Identify locations and extents of ISW in the project area, based on historical measurements of groundwater elevations and streambed elevations, or field-based methods such as:
    a. *Seepage (or Accretion) Measurements*: Field discharge measurements at selected intervals in a creek or river to determine gaining and losing reaches. Often environmental tracers such as temperature and electrical conductivity are used in conjunction with discharge to determine groundwater and surface water exchange.
    b. *Environmental Tracers:* Physical or chemical properties of water, or any substance dissolved in water that can be used to identify the origin or the age of groundwater. Environmental tracers can be used to:
        i. identify if and where groundwater discharge occurs in a surface water body
        ii. estimate the proportion of different sources of water in a water body
        iii. estimate the age and velocity of groundwater
        iv. quantify the groundwater flux to a surface water body.
        v. Examples of environmental tracers are total dissolved solids / electrical conductivity / salinity, temperature, dissolved oxygen, pH, major ions, stable isotopes, radionuclides, and naturally occurring and anthropogenic tracers for groundwater dating such as naturally occurring (14C, 36Cl, 4He) and anthropogenic chlorofluorocarbons (CFCs) and sulfur hexafluoride (SF6) tracers.
    c. *Artificial Tracers*: Analysis of deliberately introduced hydrochemical tracers to identify water sources and groundwater-surface water mixing relationships. Introduced dyes and conservative tracers, typically to surface water, have a wide range of applications in groundwater dependent ecosystem studies, including the identification of groundwater discharge zones and the quantification of groundwater – surface water exchange rates.
    d. *Geophysical Surveys*: Geophysical methods, such as electrical resistivity tomography and electrical magnetism, can provide relatively inexpensive and high-resolution spatial data to identify and map regions of differing soils and water.
4. **Install monitoring network:**
    a. Identify and/or install stream gauging stations (see Figure 1) along identified connected stream reach or water body. Stream gauging stations should be established based on DWR’s BMP 1 Monitoring Protocols Standards and Sites (DWR, 2016) and DWR’s BMP 2 Monitoring Networks and Identification of Data Gaps (DWR, 2016).
    b. Identify and/or install shallow groundwater elevation monitoring wells. The well network should be established based on DWR’s BMP 2 Monitoring Networks and Identification of Data Gaps (DWR, 2016). Where possible, the wells should be located adjacent to the connected stream or waterbody, and between the stream and project. The established GSP monitoring network may be suitable for monitoring impacts from regional projects; however, additional monitoring sites may be necessary to monitor the benefits of local-scale projects in vicinity of a connected stream. Pairing a groundwater elevation monitoring well with a nearby stream gauge is useful for identifying consistent trends in the datasets that indicate hydraulic connection between the monitoring sites. The location of the monitoring network should be easily accessible such that gaining access to the site does not inhibit gathering and downloading data (refer to Step 1).
5. **Data collection:** Measure hourly streamflow and hourly or daily groundwater levels to establish baseline characterization of the dynamic connection between groundwater and surface water. Data collected in the summer and fall months when there is no rainfall are easier to evaluate groundwater’s contribution to streamflow. It may also be possible to use these data to identify that there are non-groundwater related streamflow influences.

Figure 1. Simple stilling well and Staff Gauge Setup (DRW, 2016).

   a. Collect background data. Collecting seasonal data for up to 1 year prior to project implementation is useful for establishing a baseline.

   b. Use baseline monitoring data to determine if there is a correlation between groundwater extraction and shallow groundwater levels adjacent to the ISW and/or streamflow. When possible, estimate depletion of surface water due to pumping using numerical or analytical methods. A groundwater model, calibrated at industry standards to historical groundwater level and streamflow measurements, could be used to simulate conditions with and without groundwater pumping. The difference in streamflow between the two scenarios is depletion due to groundwater pumping. Continue monitoring during project implementation to assess impacts and benefits to ISW, while considering non-project groundwater extraction taking place.

   c. Quantify the volume and timing of groundwater extractions near the ISW. These data are used for estimating depletion of surface water due to groundwater extractions.

   d. Review data at least annually for comparison to any regional based sustainable management criteria generated the project’s region GSPs, to evaluate whether undesirable results are being avoided and progress toward measurable objectives is being achieved. If applicable, the GSAs will include this evaluation in its annual report.

6. **Reporting:** Report monitoring data to the basin’s GSAs at least twice per year based on SGMA requirements if applicable.

   a. Upload project-specific monitoring data to the DWR SGMA data portal on an annual basis. This step will need to be coordinated with and completed by the GSAs.

   b. Recommend monitoring points to add to the GSP monitoring network if applicable.

   c. Recommend representative monitoring points and associated applicable sustainable management criteria that avoid conditions deemed significant and unreasonable by the GSA.

7. **Adaptive management:** Expand or refine monitoring network adaptively, as needed.

Data and Protocols - Fundamentals

Monitoring ISW involves monitoring both groundwater and streamflow. The primary monitoring requirements and tools include the following:

- Shallow monitoring wells or piezometers co-located with streamflow gauges.
- Multiple shallow monitoring wells or piezometers located perpendicular to the stream.
- Multi-depth monitoring well clusters for understanding the level of connectivity between the shallow aquifer and the deeper aquifer, which may be important in areas with perched groundwater.
- Measurements of streamflow and shallow groundwater levels adjacent to the stream should be measured at least daily to characterize the relationship between surface water and the groundwater system. Groundwater levels farther away from the stream should be measured at least monthly.
- Primary “tools” for measuring groundwater levels include electrical sounders and pressure transducers lowered into and/or installed in monitoring wells (DWR’s BMP 1 Monitoring Protocols Standards and Sites [DWR, 2016]). The use of dataloggers in association with pressure transducers allows automated collection and storage of groundwater level measurements at frequent intervals.
- Primary “tools” for measuring streamflow are gauges consisting of a mounted staff plate and pressure transducers installed in a stilling well to measure depth of water (stage); a rating curve for the gauge is required to measure discharge (flow); the use of dataloggers in association with pressure transducers allows automated collection and storage of groundwater level measurements at frequent intervals.

Groundwater levels, streamflow, and stage are primary monitoring requirements that should be supported, where appropriate, with other monitoring methods described above in the Step-by-Step Guide, such as environmental tracers (Step 3b) and geophysical surveys (Step 3d).

Table 1 provides an example of summary parameters to use to monitor groundwater and surface water interactions.

Table 1. **Example Data Monitoring Report (Generally Annually)**

Annual Monitoring Report	
Groundwater basin	XXX Basin or Subbasin
Surface water body	name of stream, lake, wetland etc.
Percentage of time over the reporting period shallow groundwater elevations adjacent to surface water are higher than the streambed or bed of the surface water body	XX.X percent
Change in reporting period dry season flow compared to pre-construction flows for past similar water year types	XXX cubic feet per second
Estimated increased surface water discharge rate compared to past similar water year types	XX acre-feet
Estimated increased surface water volume compared to past similar water year types	XXX cubic feet per second

Data Standards

Groundwater and surface water monitoring data should conform to the technical and reporting standards of the California Water Code (CWC) §352 *et seq*. Additionally, post-construction monitoring reports must be submitted per grant conditions that quantify benefits or impacts to ISW. Each surface water body benefited/impacted by the project should be reported separately.

Key Protocols

The following protocols should be followed for required ISW monitoring:

- Standard groundwater level measurement protocols as described in DWR's BMP 1 Monitoring Protocols Standards and Sites (DWR, 2016).
- Standard surface water measurements as described in DWR's BMP 1 Monitoring Protocols Standards and Sites (DWR, 2016).
- Technical and reporting standards included in CWC §352 *et seq*.

Additional guidance or references include:

- DWR's BMP 2 Monitoring Networks and Identification of Data Gaps (DWR, 2016) – Describes guidelines for establishing monitoring networks capable of providing sustainable indicator data of sufficient accuracy and quantity to demonstrate sustainable management in the basin and provides information on how to identify and resolve data gaps to reduce uncertainty (DWR, 2016).
- United States Geological Survey Water-Supply Paper on Measurement and Computation of Streamflow: Volume 1. Measurement of Stage and Discharge – Describes standardized stream-gauging procedures (Rantz and others, 1982).
- United States Geological Survey Water-Resources Investigations Report on Standards for the Analysis and Processing of Surface-Water Data and Information Using Electronic Methods – describes standards for surface water computation methods and procedures (Sauer, 2002).

The use of a data management system is required for storing and reporting information relevant to the monitoring of the basin in support of a GSP. Considerations for storing and reporting data are summarized in the Data Management and Monitoring Method (MM-12).