Draft SMC for Surface Water Depletion in Scott Valleys

Abbreviations

- CWA: Clean Water Act, 1972
- ESA: Endangered Species Act
- GSA: Groundwater Sustainability Agency
- GSP: Groundwater Sustainability Plan
- PTD: Public Trust Doctrine
- SMC: Sustainable Management Criteria
- TMDL: Total Maximum Daily Load program in the Clean Water Act

Background

- SGMA requires a GSP to avoid significant and unreasonable undesirable results (URs) that occurred after 2014. Economic considerations may play a role in allowing for some URs to arise during the transition period, but ultimately all URs must be avoided at all cost (water level decline, storage decline, continued land subsidence, continued seawater intrusion, water quality degradation, additional surface water depletion, additional impacts to GDs). This may require large scale pumping retirement, where projects cannot provide additional recharge.
- SGMA allows, but does not require a GSP to also address URs that already existed in 2014 (or during the baseline period of 20 to 30 years prior to 2014).
- SGMA requires a GSP's SMC design to be consistent with existing water rights (adjudication) and regulations. For the surface water depletion SMC, these additional rights and regulations may include adjudication, CWA (TMDL), ESA, and PTD requirements in a groundwater basin.
    - TMDL, ESA, and PTD may require only partial reversal of anthropogenic impacts, especially with respect to stream flow and stream temperature.
    - Under TMDL, ESA, and PTD, targets for the partial reversal of anthropogenic impacts are driven by a consideration of environmental outcomes, but also best available technology and the economic cost of projects and management actions.
- All existing GSPs already submitted to DWR that include a surface water depletion SMC only consider future URs. All of these existing GSPs currently rely on water level monitoring near streams. A minimum threshold is set by setting a minimum water level for these wells. We are

not aware of any existing GSP that uses measured streamflow or modeled surface water depletion as a metric for setting the minimum threshold.

- The regulatory requirements for minimum threshold explicitly allow for use of a numerical groundwater and surface water model to quantify the amount of surface water depletion caused by groundwater pumpers and to set the minimum threshold using such a model:
  - Minimum Threshold, Section 254.28(c) of DWR regulations:
    - "(c) Minimum thresholds for each sustainability indicator shall be defined as follows: […] (6) Depletions of Interconnected Surface Water. The minimum threshold for depletions of interconnected surface water shall be the rate or volume of surface water depletions **caused by groundwater use** that has adverse impacts on beneficial uses of the surface water and may lead to undesirable results. The minimum threshold established for depletions of interconnected surface water shall be supported by the following:

      (A) The location, quantity, and timing of depletions of interconnected surface water.

      (B) A description of the groundwater and surface water model used to quantify surface water depletion. If a numerical groundwater and surface water model is not used to quantify surface water depletion, the Plan shall identify and describe an equally effective method, tool, or analytical model to accomplish the requirements of this Paragraph." (**emphasis added**)
  - Measurable Objective, Section 254.309(b) of DWR regulations:
    - "(b) Measurable objectives shall be established for each sustainability indicator, based on quantitative values using the same metrics and monitoring sites as are used to define the minimum thresholds."

Scott Valley Situation

- Until the late 1950s, Scott Valley agriculture (about 30,000 acres of pasture and alfalfa hay) was exclusively flood irrigated from surface water diversions. Alfalfa was typically cut twice in June and in late July.
- Inefficiency of flood irrigation caused significant groundwater recharge during the irrigation season. Some irrigation water may have directly runoff into streams.
- Large scale groundwater pumping for irrigation began when irrigation efficiencies were improved by converting from flood irrigation to pressurized sprinkler irrigation in the 1960s and 1970s. This also allowed alfalfa growers (about half of the irrigated acreage of 30,000 acres) to regularly obtain a third cutting in early September due to the reliability of groundwater supplies.
- A 1980 adjudication secured the right of landowners within the adjudicated zone, in the immediate vicinity of the Scott River, to pump groundwater needed for irrigation of crop on overlying lands. The right to pump groundwater in the adjudicated zone is not limited by the

amount of streamflow in the Scott River. The GSP is not allowed to alter adjudicated water rights.

- No overdraft exists in Scott Valley.
- Water level and groundwater storage SMCs will be set with minimum thresholds that likely represent lowest measured levels during the baseline period (1991-2014) and consider the risk of well outages. Their MO will likely be to maintain baseline conditions.
- Total average annual Scott River flows are about 400 TAF[1] (with a range of 54 to 1082 TAF per year). Average annual applied water needs in Scott Valley are about 67 TAF (with a range of 84-53 TAF).
- However, since the 1970s, summer baseflow at the Fort Jones gauge has been measurably lower compared to gage measurements from the 1940s to the 1960s. Dry year flows are typically less than 10 cfs with much of Scott River and lower tributaries (within the GSA boundaries) falling dry until the first major fall precipitation events.
- Low stream flows affect fall migration of anadromous Chinook and coho salmon and the health of the summer habitat for juvenile coho.
- In response to these negative ecosystem impacts, the North Coast Regional Water Board set a Scott River TMDL under the Clean Water Act to achieve reduction of stream water temperatures in the summer that protect salmon habitat, through voluntary management actions including expanded riparian shading and through groundwater management actions that increase baseflow.
- A recent court decision affirmed the role of the county (and, hence, the GSA) in actively managing the implementation of the Public Trust doctrine through groundwater management that supports protection of salmon habitat in the Scott River system.
- The average decrease in summer streamflow before and after the 1970s (69.9 and 35.0 cfs, respectively) is approximately 30 cfs in baseflow.
- That difference in baseflow is equivalent to a difference of about 3/10ths of 1 percent in hydraulic gradient of the groundwater level near the stream. At 100 feet from the Scott River, that is a 3 inches difference in water level if water level next to the Scott River remains the same. The difference is much smaller than typical transient variations induced by pumping wells and seasonal climate variability ("white noise") in water levels measured in monitoring wells near the stream. Furthermore, water levels near the stream are impacted by factors other than groundwater pumping outside the adjudicated zone (see next bullet). Water level monitoring is therefore not a suitable tool to measure whether groundwater users' projects and management actions have effectively decreased streamflow depletion. However, the water level SMC includes an extension to the existing monitoring network that also monitors water level

[1] Min: 54.2 TAF, 1st Quartile: 284.7, Median: 356.4, Mean: 442.9, 3rd Quartile: 599.0, Max: 1,082.9, driest years: 54 TAF in 1977, 95 TAF in 2001, wettest years: 1,082 TAF in 1974, 944 TAF in 1958

conditions near the Scott River. Future assessment will be needed to re-evaluate whether, where, and when expanded future measurements of water levels are suitable as proxy measurements for surface water depletion from groundwater use in the non-adjudicated zone.

- The Fort Jones gage streamflow during the summer baseflow season is a direct measure of the total groundwater contribution of the stream. That groundwater contribution to streamflow is a function of groundwater use inside and outside the adjudicated zone, winter and spring recharge from precipitation and irrigation on the valley floor, winter and spring recharge from tributaries on the upper alluvial fans, mountain front recharge, and surface water diversion. The Fort Jones gage is therefore not suitable to directly measure streamflow depletion caused specifically by groundwater users outside the adjudicated zone.
- For all SMCs other than surface water depletion, model-independent measurements are used to set minimum thresholds (measurements of water levels, land subsidence, water quality). Groundwater storage is computed from water level measurements through simple equations (a kind of model). Hence, an evaluation of the status of these SMCs is obtained directly from instrument measurements.

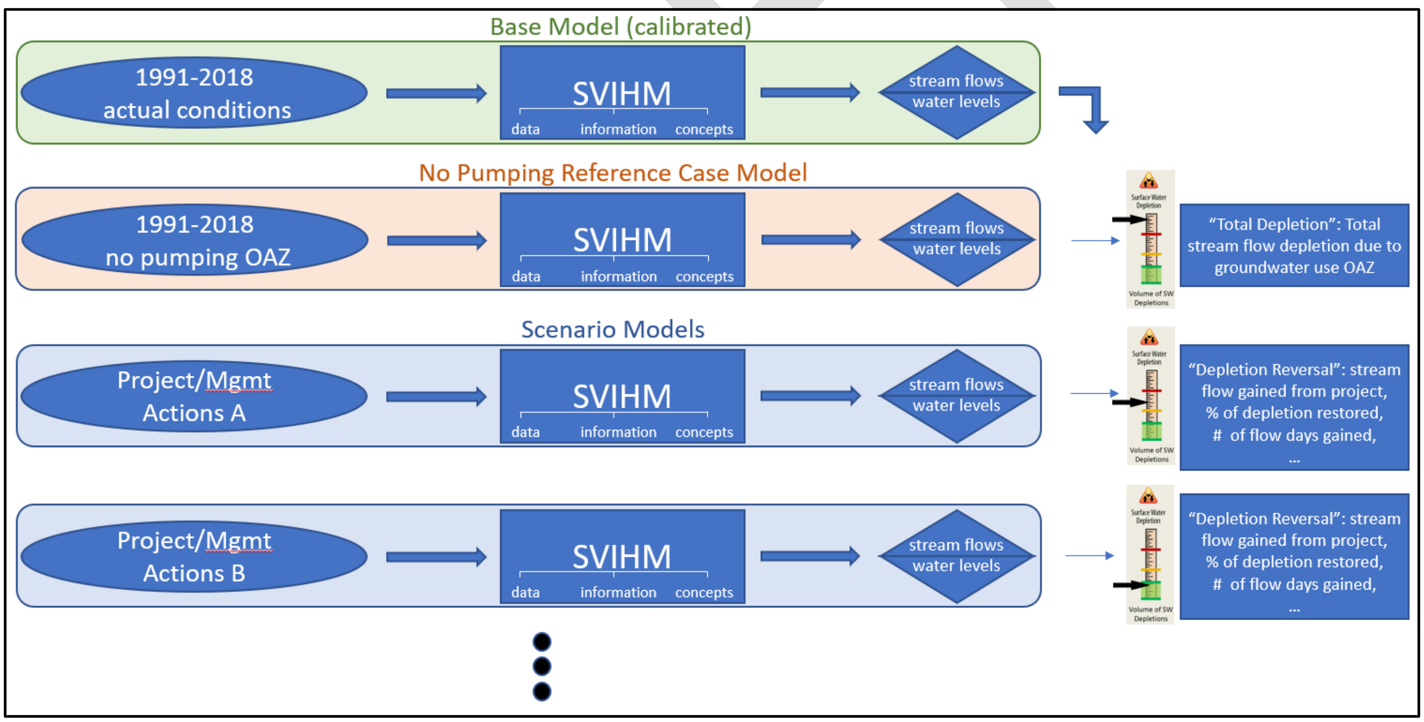

Figure 1 Conceptual outline of "measuring" surface water depletion due to groundwater use outside of the adjudicated zone in Scott Valley ("Total Depletion") and to "measure" the contribution of projects and management actions performed toward restoring flows lost due to that depletion ("Depletion Reversal"). The light-colored shaded box represents the modeling process, including inputs and outputs. Relevant outcomes computed from model results are shown to the right

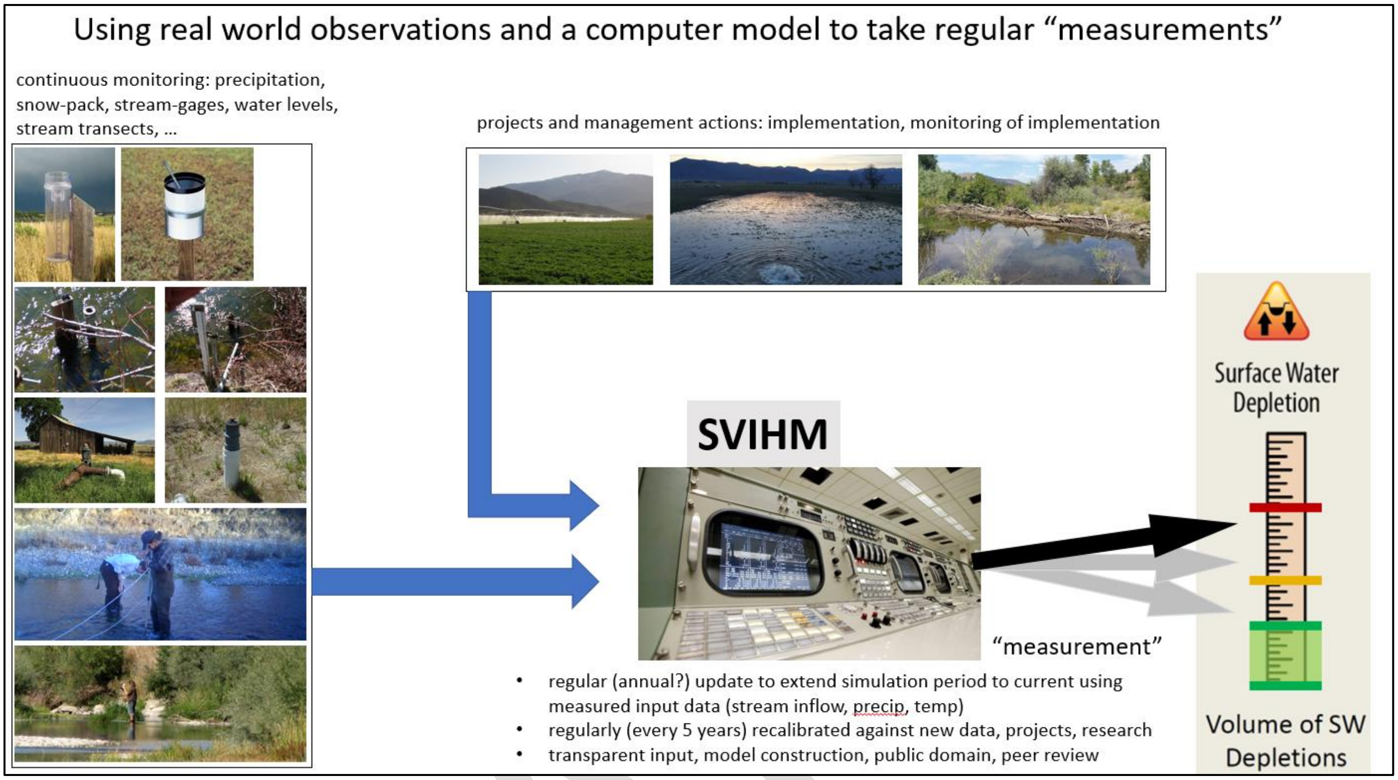

Figure 2 The "measurement" of Total Depletion and of the Depletion Reversal requires that numerous data (precipitation gages, snowpack, stream gages, water level monitoring, special monitoring programs such as stream transects, etc) as well as projects and management actions are run through a computer model (SVIHM: Scott Valley Integrated Hydrologic Model) to provide a quantitative "measurement".

Measuring Surface Water Depletion

- The SVIHM model, simulating Scott Valley conditions for 1991 – 2018 climate conditions is publicly available, documented, and suitable to be used to support the SMC. The model is based on best available information, including numerous monitoring data about Scott Valley conditions and calibrated against hundreds of streamflow and water level measurements. A SGMA compliant software (MODFLOW 2005) is used for SVIHM.
- SVIHM is the only suitable tool to evaluate surface water depletion SMC conditions in Scott Valley and to quantify the amount of depletion attributable to groundwater use outside of the adjudicated zone.
- In Scott Valley, surface water depletion is therefore "measured" with SVIHM as "measurement instrument". The measurement process occurs as follows:
    - SVIHM, a calibrated model using available information, data, and appropriate scientific information, is used to compute daily streamflow at the Fort Jones gage (and other locations) for actual pumping conditions during the period of 1991 – 2018. The

calibration process provides a necessary check on the reliability of the model. This is the "Base Model"

- SVIHM is used to compute daily streamflow at the same times and locations as the Base Model, but for conditions of no pumping outside the adjudicated zone. This constitutes the "No Pumping Reference Model"
- The total surface water depletion due to groundwater use outside of the adjudicated zone **("Total Depletion")** is "measured" by computing the difference in **simulated streamflow** at the Fort Jones gage between the Base Model and the No Pumping Reference Model. Total Depletion is a time-series with daily values for 1991-2018 (or future simulation periods). It is measured in the same units as average daily streamflow (cubic-feet per second, cfs).

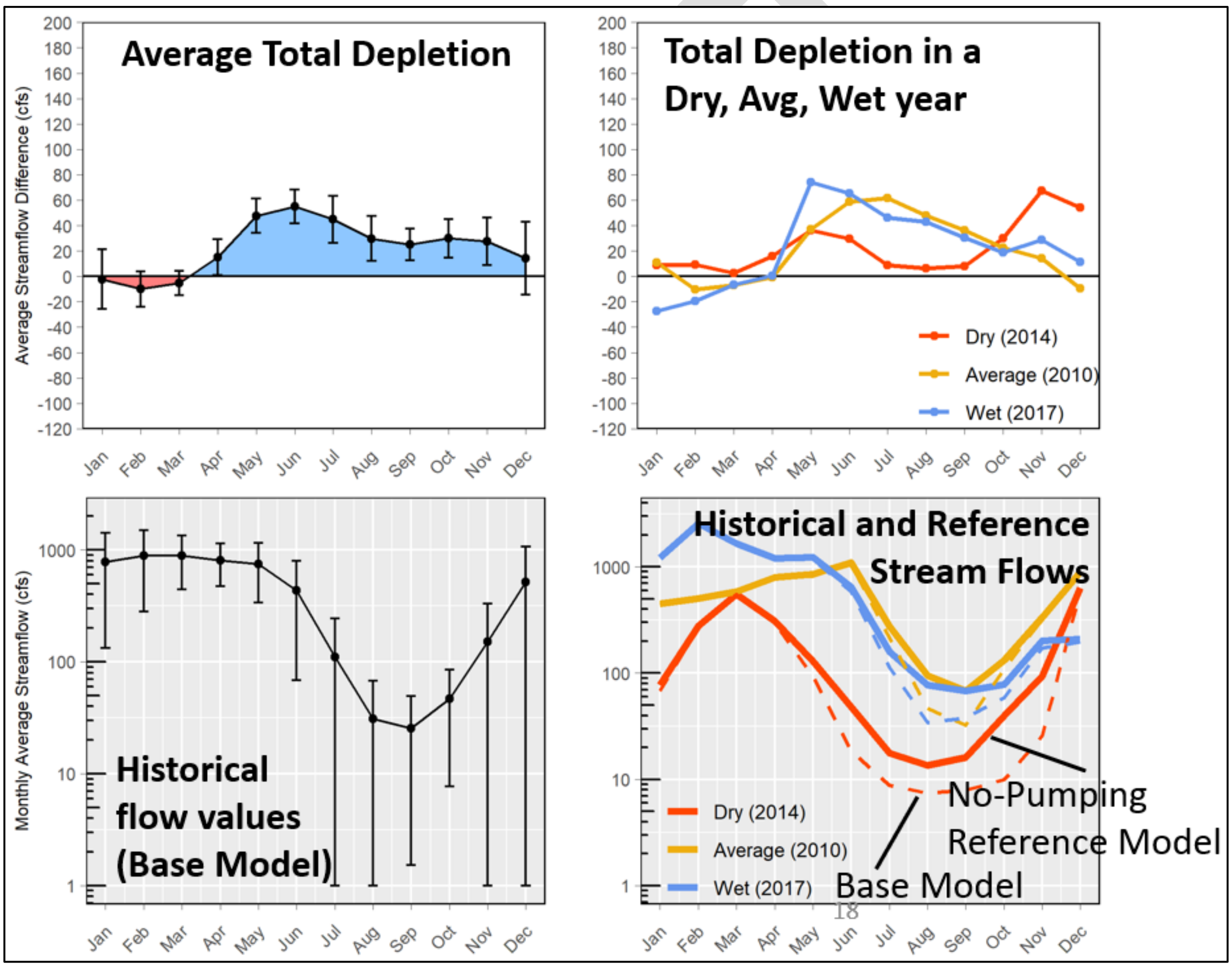

Figure 3 For 1991-2018, this graph shows measured average Total Depletion with vertical bars indicating the standard deviation of year-over-year variability in Total Depletion (top left); measured Total Depletion for a wet year (2017), average year (2010), and dry year (2014) (top right). For the top graphs, the vertical axis is showing Total Depletion on a linear scale in units of cfs. The bottom graphs show simulated stream flow at the Fort Jones gage, using a logarithmic (order of magnitude) scale for the y-axis (vertical axis): average simulated stream flow (vertical bars showing standard deviation of

year-over-year variability in stream flow) (lower left); No Pumping Reference Model stream flows in three example years (solid lines, lower right) compared to the same year Base Model stream flows (dashed lines, lower right).

- In Scott Valley, the amount of additional streamflow generated by projects and management actions, relative to the Base Model, is “measured” as follows:
    - A project or management action, or a combination of projects and management actions are built as new boundary conditions into the input to SVIHM. SVIHM is then used to compute daily streamflow at the same times and locations as the Base Model. This constitutes a “Scenario X Model”, where X stands for some index (A,B,C or 1,2,3) that distinguishes different project and management action scenarios.
    - The total additional streamflow generated by the set X of project or management actions is “measured” by computing the difference in **simulated streamflow** at the Fort Jones gage between the Scenario X Model and the Base Model.
    - The total additional streamflow rate generated by projects and management actions at the Fort Jones gage is henceforth referred to as the **“Depletion Reversal”**. Depletion reversal is a time-series with daily values for 1991-2018 (or future simulation periods). It is measured in the same units as average daily streamflow (cubic-feet per second, cfs).

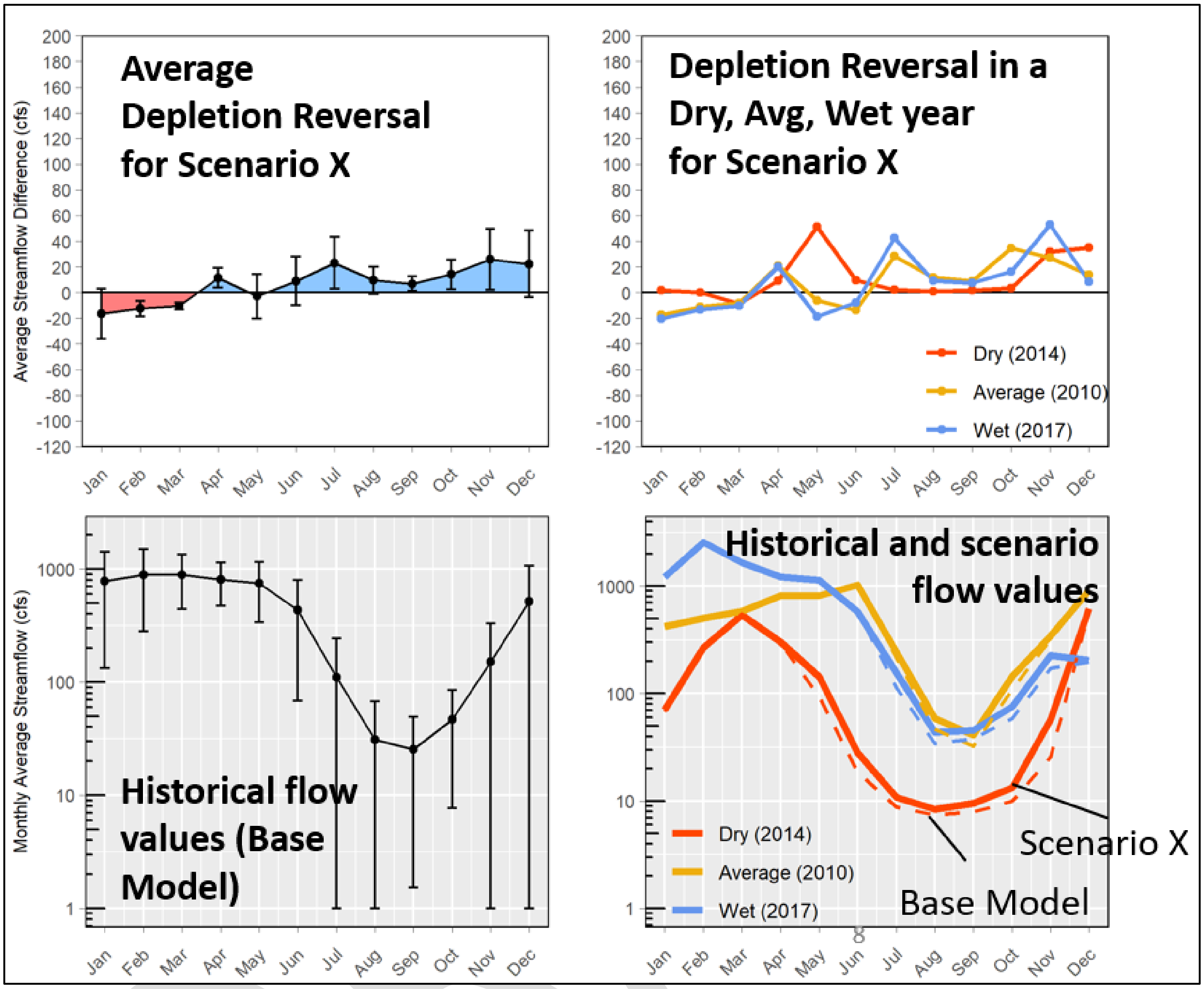

Figure 4 For 1991-2018, this graph shows measured average Depletion Reversal under a MAR and In-Lieu Recharge (ILR) project scenario, with vertical bars indicating the standard deviation of year-over-year variability in Depletion Reversal (top left); measured Depletion Reversal from this project for a wet year (2017), average year (2010), and dry year (2014) (top right). For the top graphs, the vertical axis is showing Depletion Reversal on a linear scale in units of cfs. The bottom graphs show simulated stream flow at the Fort Jones gage, using a logarithmic (order of magnitude) scale for the y-axis (vertical axis): average simulated stream flow (vertical bars showing standard deviation of year-over-year variability in stream flow) (lower left); "MAR+ILR" Scenario Model stream flows in three example years (solid lines, lower right) compared to the same year Base Model stream flows (dashed lines, lower right).

- Each set of projects and management actions is "measured" separately through the simulation process.
- "Monitoring" is the measurement of surface water depletion over time. Here, SVIHM is the observation tool. New future "measurements" with SVIHM ("monitoring") require an update and re-calibration of SVIHM with newly available field data within an adaptive management

process. Initially, SVIHM will be updated every 5 years, along with GSP updates. The "monitoring process" includes the following steps:

  - Future updates of SVIHM are informed by and recalibrated against continued and extended monitoring and measurements of climate, hydrologic conditions (pumping, stream diversions, land use), stream flow and water levels. Monitoring data come from the GSA and other monitoring networks, updated climate data series, research studies, and additional data
  - Reassess the Total Depletion over the period from 1991 – current
  - Reassess the Depletion Reversal of implemented, planned, or potential projects and management actions
  - The five-yearly re-assessment shall constitute the "measurement" of the surface water depletion due to groundwater pumping outside of the adjudicated zone over the previous five-year period

- Using SVIHM in this way is the best available tool to
  - Predict current Total Depletion
  - Evaluate past Total Depletion
  - Assess the future Depletion Reversal generated by various sets of projects and management actions being proposed, assessed, or implemented
  - Predict future Total Depletion and future Depletion Reversal generated by projects and management actions under any climate conditions, not only 1991-2018 climate conditions
- The approach of using a model to measure an impact is analogous to that in the Superfund process, where hydrogeologic models are frequently used to determine:
  - Principle responsible parties (PRPs)
  - Attribution of liability to PRPs
  - Aid the design of remediation measures to assess the environmental outcomes of remediation projects and management actions
  - Adaptive management steps and recalibrated models with new data
- Another analogous regulatory program is the Central Valley Irrigated Lands Regulatory Program, where agricultural coalitions are charged with developing modeled estimates of agricultural nitrogen loading to groundwater and targets of loading (similar to minimum thresholds) for meeting environmental outcomes (here: groundwater quality). Using those models and modeled outcomes, management actions and projects are identified for growers that meet targeted loading outcomes. Implementation of those practices constitutes compliance (i.e., equivalent to meeting minimum thresholds requirements), since the actual groundwater loading with nitrate cannot be measured directly. Measurement and monitoring programs (e.g., Management Practices Evaluation Program, Regional Trend Monitoring) are in place to inform, improve, and recalibrate the models used to "measure" agricultural nitrate loading of

groundwater. There, an adaptive management process is envisioned that adjusts recommended compliance practices as new knowledge is gained.

Proposed Design of the SMC for Streamflow Depletion

- "Metric", "Ruler", or "Thermometer": Surface water depletion
    - As mentioned above, there is no direct measurement of Total Depletion. Neither can there be a direct measurement of Depletion Reversal, that is, the contribution of projects and management actions toward reversing part or all of the Total Depletion. The best available approach to "measure" Total Depletion and the contribution of projects and management actions toward reversing the Total Depletion is the SVIHM modeling process described above and illustrated in Figure 1 and in Figure 2.
- MT Consideration 1: Under SGMA, the Total Depletion cannot be increased above the amount of Total Depletion during the baseline period (1991 – 2014).
    - Note: For setting of the minimum threshold, it may be useful to explicitly limit the expansion of groundwater use in Scott Valley beyond 2014 conditions unless the effect of such additional groundwater use on Total Depletion can be fully reversed through projects and management actions. In other words, the additional Total Depletion should be matched by the Depletion Reversal of projects and management actions implemented by the permit holder. The latter may be part of a permit for additional groundwater use.
- MT Consideration 2: The Scott Valley GSP must consider TMDL and PTD requirements to address improvements in instream flow conditions in the Scott River. Instream flow conditions are a function of stream diversions, winter and spring groundwater recharge, groundwater pumping in the adjudicated zone, groundwater pumping outside the adjudicated zone, and other factors. Relevant factors have been built into SVIHM. The degree to which part or all of the Total Depletion must be reversed under TMDL and PTD considerations constitutes an undesirable result that groundwater users outside the adjudicated zone have a regulatory duty to address through Depletion Reversal. Therefore, in effect the minimum threshold has already been exceeded prior to 2014, during the baseline period, 1991-2014.
- Projects and Management Actions: To improve poor summer and fall baseflow conditions in dry and some average years, the GSP will consider a variety of projects and management actions, individually and in combination:
    - Winter and spring managed aquifer recharge
    - Beaver dam analogs
    - Uplands management
    - Surface water storage
    - Water trading (water trust?)
    - Seasonal pumping restrictions in the non-adjudicated zone

- Voluntary pumping restrictions in the adjudicated zone

- In addition to Depletion Reversal for each specific set X of projects and management actions, the output of SVIHM is also used to compute relevant other project outcome metrics such as:
    - stream flow on any given day and location, a metric relevant to measure environmental outcomes.
    - the ratio of Depletion Reversal and Total Depletion is the "**Relative Depletion Reversal**", measured in percent.
    - the number of days gained in stream connectivity in dry and some average years, both in the summer after the end of the spring flow recession and in the fall when streamflow increases.
    - other relevant metrics including the time series of relative streamflow increase and simulated streamflow.

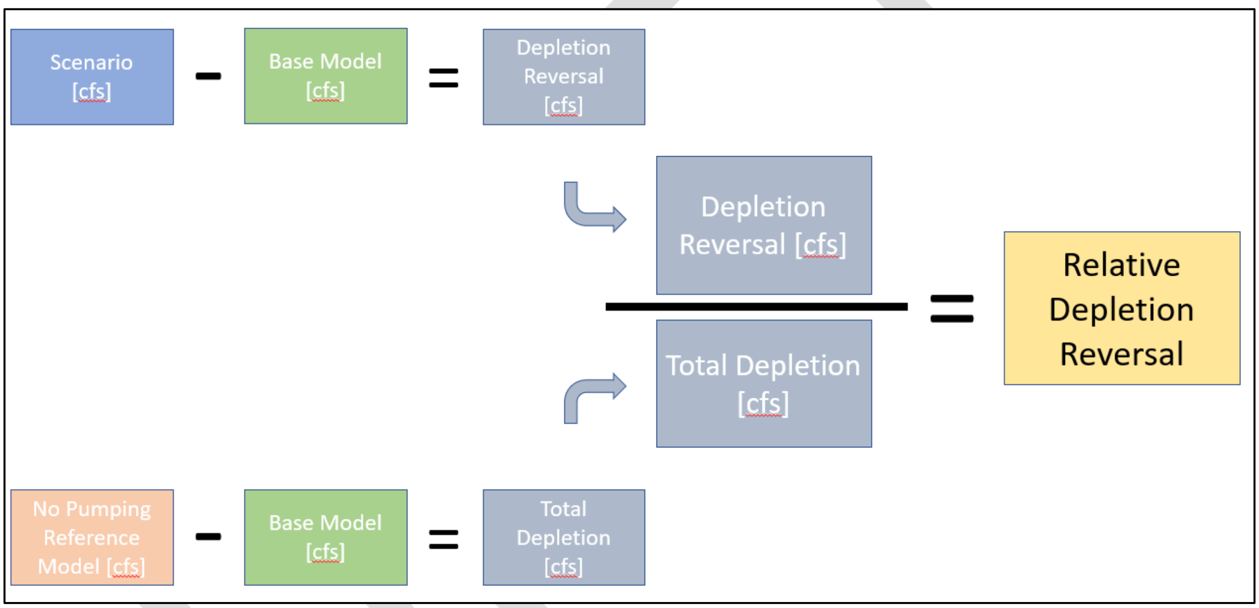

Figure 5 Computation of the Relative Depletion Reversal as the ratio of Depletion Reversal and Total Depletion. The graph also shows the computation of the Total Depletion and the Depletion Reversal as defined above. The Relative Depletion Reversal is a unit-less fraction. Multiplied by 100, it has units of percent [%]. Project and management actions may lead to less than 100% Relative Depletion Reversal, or even more than 100% Relative Depletion Reversal. Just like Total Depletion and project or management action-specific Depletion Reversal, the Relative Depletion Reversal varies from day to day.

- Evaluation under Future Climate Conditions: The Total Depletion under future climate conditions as well as the Depletion Reversal under future climate conditions can be modeled in the same way as for the 1991-2018 models, using future climate data and DWR's protocol for simulating climate change conditions.

- Uncertainty Analysis: SVIHM also allows for uncertainty analysis in predicting Total Depletion as well as Depletion Reversal for specific projects and management actions under current or future climate conditions.
- For each group of projects and management actions that are implemented, the Depletion Reversal is a measure of the amount of surface water depletion that is reversed. Projects and management actions are therefore – through SVIHM – inextricably, deterministically, and directly linked to specific "measured" outcomes: stream flow, stream flow gains, Depletion Reversal, Relative Depletion Reversal, number of days gained in stream connectivity, etc. (light-colored shaded box in Figure 1).
- The minimum threshold (and possibly the measurable objective; see final page for two possible definitions) can therefore be expressed in terms of one, several, or all of the following:
    - Required (minimum threshold) and desirable (measurable objective) projects and management actions. AND/OR
    - Required (minimum threshold) and desirable (measurable objective) simulated streamflows (note: not measured streamflows!) resulting from the projects and management actions. AND/OR
    - Required (minimum threshold) and desirable (measurable objective) Relative Depletion Reversal. AND/OR
    - Required (minimum threshold) and desirable (measurable objective) number of days in stream flow connectivity (or other ecological outcomes) gained by the projects and management actions
    - Required (minimum threshold) and desirable (measurable objective) of any other desirable outcome metrics that can be obtained from model results
- We propose to use Relative Depletion Reversal to quantify the MT (Figure 5).
- "Continuous Measurement": If considered necessary, the model can be set up to be re-run (including Base Model, No-Flow Reference Model, any relevant scenario models) with input data for weather, and stream-inflow as measured daily through the most recent week/month/quarter/water year/calendar year. It would therefore be able to generate an updated measurement of Total Depletion and project Depletion Reversal on a continuous basis, as needed for decision-making and project management.
- "Assessment": At the 5-year updates, the GSA will assess the following:
    - Modeled Surface water depletion Assessment (was the MT met?)
        - Did the implemented projects achieve the Relative Depletion Reversal stated in the previous version of the plan? This would be evaluated by applying an updated, re-calibrated version of SVIHM to the project set and identify whether the ratio of Depletion Reversal to Total Depletion remains at least as large as in the previous assessment used to set the MT.
        - If so, the GSA has met the MT and the past 5 years are considered "in compliance" with SGMA.

        - If not, the MT would be considered unmet for the previous 5 years. To return to SGMA compliance, the next 5 years of implemented projects would need to be augmented or adjusted to achieve a larger Relative Depletion Reversal.
        - Alternatively, the stated MT, in terms of the Relative Depletion Reversal, would need to be revised downward to reflect management or feasibility constraints relevant to TMDL and PTD considerations.
    - Measured Flows Assessment (was the MO met?)
        - Applicable **only** if the MO is defined in terms of the "watershed objective" or measured flows (see final page for details).
        - Did the measured flows at the FJ gauge meet the "watershed objective" of flows necessary to meet the minimum ecological needs of salmonids, as defined in the initial GSP using local monitoring data?
        - If not, how can the GSA engage in additional projects other than those used to meet the MT to support the watershed in meeting the "watershed objective" ?
- In summary, implementation of required projects and management actions that will achieve the MT implicitly constitutes compliance with SGMA. No other "measurement" is taken, instead SVIHM is updated at 5 year or 10 year intervals (see above). When SVIHM is updated, the Base Model, the No Pumping Reference Case Model, and relevant project scenario model runs are also updated to recompute the Total Depletion and the Depletion Reversal (to be) achieved by projects and management actions. This may trigger re-consideration of where to set MT and MO.

Consideration for Setting the MT and MO through the GSA Advisory Committee

- Setting the MT
    - The GSA will set the MT by deciding on a Relative Depletion Reversal that the GSA would implement through projects and management actions. Optionally, Relative Depletion Reversal could be different for dry, average and wet water year types.
    - In stakeholder discussions the Relative Depletion Reversal (and other relevant scenario outcomes) will be presented as the outcomes of distinct sets of projects and management actions, to allow stakeholders to weigh costs and benefits of compliance with different thresholds.
    - The technical team recommends that an MT be set that includes a moratorium on the expansion of groundwater use without replacement of the instream flow depleted by that additional groundwater use. This will prevent additional Total Depletion beyond that which already occurs over the baseline period.
    - The technical team prepares various scenarios that link projects and management actions to modeled stream flows and to specific values of Depletion Reversal and

Relative Depletion Reversal. We may be able to also obtain some limited economic analysis. The technical team will perhaps suggest three leading strawman alternatives.

- However, the degree to which the TMDL and PTD framework require groundwater users outside the adjudicated zone to provide Depletion Reversal is subject to both environmental and economic consideration. The TMDL and PTD, in principle, may not require that the Relative Depletion Reversal is 100% (i.e., Depletion Reversal = Total Depletion) if the economic cost outweighs the environmental benefit.
- The balancing of economic cost and environmental benefit is outside the technical team's competence. Hence, the technical team cannot decide on the appropriate MT.
- Instead, the technical team's responsibility will be to advise on projects and management actions, and to use SVIHM to assess these, as well as provide appropriate outcome measures of the simulated output.
- Stakeholders will need to negotiate the appropriate balance of environmentally desirable outcomes and economic costs among each other. This may include obtaining guidance from the state and looking to other instances of TMDL and PTD regulatory programs in the state.

- Setting the MO:
    - SGMA regulation requires that the MO is set by the same metric as the MT. Strict compliance therefore means that the approach for the MO is consistent with the approach chosen for the MT. Optionally, the MO could be 100% reversal of Total Depletion through additional streamflow generated by projects and management actions.
    - Alternatively, the AC may consider setting the MO equal to the "watershed objective" if that can be confirmed with DWR to be appropriate. The watershed objective is considered to be the minimum instream flow requirements for the Scott River that are protective of salmonid fish habitat. Minimum instream flows have been defined in previous reports but remain controversial, and in the 2022 GSP the surface water depletion MO could be defined either as existing instream flow recommendations (e.g. CDFW 2017) or alternative seasonal flowrates informed by local monitoring data. The GSA recognizes that a GSP can contribute to the watershed objective through projects and management actions to partially or fully reverse the impact of TSDGU, but also through collaboration with other jurisdictions and stakeholder group that have responsibilities toward meeting the watershed objective, such as surface water users, landowners in the adjudicated zone, US Forest Service, etc.