ESJ Public Comments Response

Comment #	Commenter	Commenter Organization	Section, Figure, or Table Number	Comment	Category	Response to Comment
625	Martin Harris	Terra Land Group, LLC		What effect will the Daniels Street extension have on stormwater drainage flows currently being drained in and along the French Camp Outlet Canal? [SEE MORE SPECIFICS IN COMMENT LETTER]	Flood Risk	There are several ongoing efforts in the Subbasin for stormwater and flood work, including through regional flood control agencies as well as planning and implementation activities. The San Joaquin Area Flood Control Agency (SJAFCA) covers San Joaquin County with the exception of a few select city areas and aims to address flood protection in the area it covers. Projects SJAFCA has worked on include flood walls, levees, detention basins, and other flood control improvements. SB 985 (Water Code section 10563, subdivision (c)(1)), requires a Storm Water Resource Plan as a condition of receiving funds for storm water and dry weather runoff capture projects from any bond approved by voters after January 2014. SWRPs are intended to develop multiple benefit projects for upcoming funding opportunities. SWRP projects can include benefits such as improved storm drainage, reduced impervious surfaces, flood protection, etc. Areas in the Subbasin have developed stormwater management plans and programs, including the City of Stockton and City of Manteca.
626	Martin Harris	Terra Land Group, LLC		What effect will the proposed formation of the San Joaquin County Flood Control & Water Conservation District ("SJCFCWCD") Zone 9 Flood Conveyance and Levee Maintenance Benefit Assessment District (and related projects) have on changing drainage patterns and associated outfall locations currently existing and relied upon by the South San Joaquin Irrigation District and its members? [SEE MORE SPECIFICS IN COMMENT LETTER]	Flood Risk	There are several ongoing efforts in the Subbasin for stormwater and flood work, including through regional flood control agencies as well as planning and implementation activities. The San Joaquin Area Flood Control Agency (SJAFCA) covers San Joaquin County with the exception of a few select city areas and aims to address flood protection in the area it covers. Projects SJAFCA has worked on include flood walls, levees, detention basins, and other flood control improvements. SB 985 (Water Code section 10563, subdivision (c)(1)), requires a Storm Water Resource Plan as a condition of receiving funds for storm water and dry weather runoff capture projects from any bond approved by voters after January 2014. SWRPs are intended to develop multiple benefit projects for upcoming funding opportunities. SWRP projects can include benefits such as improved storm drainage, reduced impervious surfaces, flood protection, etc. Areas in the Subbasin have developed stormwater management plans and programs, including the City of Stockton and City of Manteca.
627	Martin Harris	Terra Land Group, LLC		What effect will filing and/or extending an Exclusive Negotiating Agreement for the Recycled Water Project have on sustaining total potable and irrigation water (i.e.. groundwater and surface water) volumes available to the urban and rural areas in and around Lathrop and Manteca? [SEE MORE SPECIFICS IN COMMENT LETTER]	Projects and Management Actions	SGMA looks at the basin-scale. Project impacts will be evaluated; it is the GSA's responsibility to meet project-level environmental regulations. CEQA compliance will be done at the GSA level.
628	Martin Harris	Terra Land Group, LLC		What short term and/or long range changes to flood water, storm water, waste water, potable and irrigation water delivery, and other hydrology related drainage and conveyance patterns may be irreversibly altered due to approval of the proposed Raymus Expressway roadway alignment as detailed in the 5/22/19 Manteca General Plan Land Use Alternative Maps "A" or "B"? [SEE MORE SPECIFICS IN COMMENT LETTER]	Flood Risk	There are several ongoing efforts in the Subbasin for stormwater and flood work, including through regional flood control agencies as well as planning and implementation activities. The San Joaquin Area Flood Control Agency (SJAFCA) covers San Joaquin County with the exception of a few select city areas and aims to address flood protection in the area it covers. Projects SJAFCA has worked on include flood walls, levees, detention basins, and other flood control improvements. SB 985 (Water Code section 10563, subdivision (c)(1)), requires a Storm Water Resource Plan as a condition of receiving funds for storm water and dry weather runoff capture projects from any bond approved by voters after January 2014. SWRPs are intended to develop multiple benefit projects for upcoming funding opportunities. SWRP projects can include benefits such as improved storm drainage, reduced impervious surfaces, flood protection, etc. Areas in the Subbasin have developed stormwater management plans and programs, including the City of Stockton and City of Manteca.
629	Martin Harris	Terra Land Group, LLC		Will drainage impacts in and along the South Delta be reduced or adversely affected due to any future improvements to be considered in association with the Upper Jones Tract (RD 2039)/Lower Jones Tract (RD 2038) consolidation? [SEE MORE SPECIFICS IN COMMENT LETTER]	Flood Risk	There are several ongoing efforts in the Subbasin for stormwater and flood work, including through regional flood control agencies as well as planning and implementation activities. The San Joaquin Area Flood Control Agency (SJAFCA) covers San Joaquin County with the exception of a few select city areas and aims to address flood protection in the area it covers. Projects SJAFCA has worked on include flood walls, levees, detention basins, and other flood control improvements. SB 985 (Water Code section 10563, subdivision (c)(1)), requires a Storm Water Resource Plan as a condition of receiving funds for storm water and dry weather runoff capture projects from any bond approved by voters after January 2014. SWRPs are intended to develop multiple benefit projects for upcoming funding opportunities. SWRP projects can include benefits such as improved storm drainage, reduced impervious surfaces, flood protection, etc. Areas in the Subbasin have developed stormwater management plans and programs, including the City of Stockton and City of Manteca.
630	Martin Harris	Terra Land Group, LLC		Are local authorities aware that SSJID Drain #11, in its present form, has deviated from a course that appears to be called for in Enclosure 16? [SEE MORE SPECIFICS IN COMMENT LETTER]	Flood Risk	There are several ongoing efforts in the Subbasin for stormwater and flood work, including through regional flood control agencies as well as planning and implementation activities. The San Joaquin Area Flood Control Agency (SJAFCA) covers San Joaquin County with the exception of a few select city areas and aims to address flood protection in the area it covers. Projects SJAFCA has worked on include flood walls, levees, detention basins, and other flood control improvements. SB 985 (Water Code section 10563, subdivision (c)(1)), requires a Storm Water Resource Plan as a condition of receiving funds for storm water and dry weather runoff capture projects from any bond approved by voters after January 2014. SWRPs are intended to develop multiple benefit projects for upcoming funding opportunities. SWRP projects can include benefits such as improved storm drainage, reduced impervious surfaces, flood protection, etc. Areas in the Subbasin have developed stormwater management plans and programs, including the City of Stockton and City of Manteca.
631	Martin Harris	Terra Land Group, LLC		Will any and all flow impedances and back water effects be considered as part of any drainage analysis to be performed? (See Enclosures 14 & 15) [SEE MORE SPECIFICS IN COMMENT LETTER]	Flood Risk	There are several ongoing efforts in the Subbasin for stormwater and flood work, including through regional flood control agencies as well as planning and implementation activities. The San Joaquin Area Flood Control Agency (SJAFCA) covers San Joaquin County with the exception of a few select city areas and aims to address flood protection in the area it covers. Projects SJAFCA has worked on include flood walls, levees, detention basins, and other flood control improvements. SB 985 (Water Code section 10563, subdivision (c)(1)), requires a Storm Water Resource Plan as a condition of receiving funds for storm water and dry weather runoff capture projects from any bond approved by voters after January 2014. SWRPs are intended to develop multiple benefit projects for upcoming funding opportunities. SWRP projects can include benefits such as improved storm drainage, reduced impervious surfaces, flood protection, etc. Areas in the Subbasin have developed stormwater management plans and programs, including the City of Stockton and City of Manteca.
632	Martin Harris	Terra Land Group, LLC		For what purpose are San Joaquin County land use and/or zoning reclassifications in and along the South Delta being considered? (See Enclosure 17) [SEE MORE SPECIFICS IN COMMENT LETTER]	Projects and Management Actions	Some of the more specific processes can be addressed through land use decision making processes. There is a SGMA requirement to coordinate in land use policy development, and GSAs will comply with the requirement to coordinate with land use development partners.
633	Martin Harris	Terra Land Group, LLC		If the French Camp Outlet Canal (FCOC) is abandoned or no longer able to accept drainage flows from the developing areas of Zone 34, where will Zone 34 storm water be drained to? [SEE MORE SPECIFICS IN COMMENT LETTER]	Flood Risk	There are several ongoing efforts in the Subbasin for stormwater and flood work, including through regional flood control agencies as well as planning and implementation activities. The San Joaquin Area Flood Control Agency (SJAFCA) covers San Joaquin County with the exception of a few select city areas and aims to address flood protection in the area it covers. Projects SJAFCA has worked on include flood walls, levees, detention basins, and other flood control improvements. SB 985 (Water Code section 10563, subdivision (c)(1)), requires a Storm Water Resource Plan as a condition of receiving funds for storm water and dry weather runoff capture projects from any bond approved by voters after January 2014. SWRPs are intended to develop multiple benefit projects for upcoming funding opportunities. SWRP projects can include benefits such as improved storm drainage, reduced impervious surfaces, flood protection, etc. Areas in the Subbasin have developed stormwater management plans and programs, including the City of Stockton and City of Manteca.
634	Martin Harris	Terra Land Group, LLC		What effect will any public facility/infrastructure rehabilitation or improvement projects in and along Little Johns Creek have on the continued operation of the FCOC as well as other upstream and downstream areas to be affected? [SEE MORE SPECIFICS IN COMMENT LETTER]	Projects and Management Actions	SGMA looks at the basin-scale. Project impacts will be evaluated; it is the GSA's responsibility to meet project-level environmental regulations. CEQA compliance will be done at the GSA level.

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635	Martin Harris	Terra Land Group, LLC		Are the effects of climate change and unresolved sedimentation issues along the South Delta being fully considered while making the assumption that the water surface elevation in the San Joaquin River at the railroad bridge crossing near the Oakwood Lake Water District storm drain outfall is: (a) 20.6 feet for a 10-year event; (b) 28.0 feet for a 100-year event; (c) 29.0 feet for a 200-year event. [SEE MORE SPECIFICS IN COMMENT LETTER]	Flood Risk	SGMA looks at the basin-scale. Project impacts will be evaluated; it is the GSA's responsibility to meet project-level environmental regulations. CEQA compliance will be done at the GSA level.
636	Martin Harris	Terra Land Group, LLC		In the event of a right bank San Joaquin River or Stanislaus River levee breach, how will flood waters be drained from the urbanizing and non-urbanizing areas south of Manteca? [SEE MORE SPECIFICS IN COMMENT LETTER]	Flood Risk	There are several ongoing efforts in the Subbasin for stormwater and flood work, including through regional flood control agencies as well as planning and implementation activities. The San Joaquin Area Flood Control Agency (SJAFCA) covers San Joaquin County with the exception of a few select city areas and aims to address flood protection in the area it covers. Projects SJAFCA has worked on include flood walls, levees, detention basins, and other flood control improvements. SB 985 (Water Code section 10563, subdivision (c)(1)), requires a Storm Water Resource Plan as a condition of receiving funds for storm water and dry weather runoff capture projects from any bond approved by voters after January 2014. SWRPs are intended to develop multiple benefit projects for upcoming funding opportunities. SWRP projects can include benefits such as improved storm drainage, reduced impervious surfaces, flood protection, etc. Areas in the Subbasin have developed stormwater management plans and programs, including the City of Stockton and City of Manteca.
637	Martin Harris	Terra Land Group, LLC		When considering the magnitude of 100-year, 200-year, or other periodic levels of flood events that are expected to occur, isn't it likely that water elevations (NAV D88 datum) on the land side (east of the San Joaquin River in the areas south of Manteca) could exceed the 29'-0" elevation as forecasted in the Request for Proposal? [SEE MORE SPECIFICS IN COMMENT LETTER]	Flood Risk	There are several ongoing efforts in the Subbasin for stormwater and flood work, including through regional flood control agencies as well as planning and implementation activities. The San Joaquin Area Flood Control Agency (SJAFCA) covers San Joaquin County with the exception of a few select city areas and aims to address flood protection in the area it covers. Projects SJAFCA has worked on include flood walls, levees, detention basins, and other flood control improvements. SB 985 (Water Code section 10563, subdivision (c)(1)), requires a Storm Water Resource Plan as a condition of receiving funds for storm water and dry weather runoff capture projects from any bond approved by voters after January 2014. SWRPs are intended to develop multiple benefit projects for upcoming funding opportunities. SWRP projects can include benefits such as improved storm drainage, reduced impervious surfaces, flood protection, etc. Areas in the Subbasin have developed stormwater management plans and programs, including the City of Stockton and City of Manteca.
638	Martin Harris	Terra Land Group, LLC		What facilities and other actions are planned to safeguard and protect our local urban and rural communities against the unplanned release of right bank San Joaquin River levee breach flood waters that historically accumulate and rise in height against the South Manteca portion of the RD 17 dryland cross levee? [SEE MORE SPECIFICS IN COMMENT LETTER]	Flood Risk	There are several ongoing efforts in the Subbasin for stormwater and flood work, including through regional flood control agencies as well as planning and implementation activities. The San Joaquin Area Flood Control Agency (SJAFCA) covers San Joaquin County with the exception of a few select city areas and aims to address flood protection in the area it covers. Projects SJAFCA has worked on include flood walls, levees, detention basins, and other flood control improvements. SB 985 (Water Code section 10563, subdivision (c)(1)), requires a Storm Water Resource Plan as a condition of receiving funds for storm water and dry weather runoff capture projects from any bond approved by voters after January 2014. SWRPs are intended to develop multiple benefit projects for upcoming funding opportunities. SWRP projects can include benefits such as improved storm drainage, reduced impervious surfaces, flood protection, etc. Areas in the Subbasin have developed stormwater management plans and programs, including the City of Stockton and City of Manteca.
639	Chris Thomas cthomas@thefreshwatertrust.org /northerndeltagsa@gmail.com	Northern Delta Sustainability Agency/NDGSA Associate Member Staten Island-Conservation Farms and Ranches	Public and Agency Comment Disposition/Coordination	The Groundwater Sustainability Plan ("GSP") development process could be improved with greater integration of public comments into the GSP. Specifically, there should be a disposition process for both oral and written comments. In addition, engagement and coordination with adjacent agencies/ subbasins should be clearly documented. The subbasin planning processes in our region will benefit from greater coordination, and doing so will be essential to completing successful GSPs.	Outreach	This has been noted as a future item for consideration as the GSAs move into GSP implementation.
640	Chris Thomas cthomas@thefreshwatertrust.org /northerndeltagsa@gmail.com	Northern Delta Sustainability Agency/NDGSA Associate Member Staten Island-Conservation Farms and Ranches	2.1.10 HCM Data Gaps	The draft GSP has significant and critical gaps in understanding of conditions, which contributes to inadequate modeling. The data gaps identified in the draft GSP include the following: —Water quality of principal aquifers —Aquifer characteristics —Groundwater Level Data —Groundwater Quality Data —Subsurface Conditions This extensive list of missing data indicates that the technical fundamentals of the subbasin's hydrologic and water quality are absent, that the ongoing lack of data collection and analysis is problematic, and calls into question the basis for establishing reliable and defensible thresholds.	Model Uncertainties	The HCM data gaps identified in the GSP are areas where sufficient data was either unavailable or nonexistent at the time the GSP was put together and the model was calibrated. The model will continue to be refined with every update to the GSP and as data becomes available to fill in any data gaps.
641	Chris Thomas cthomas@thefreshwatertrust.org /northerndeltagsa@gmail.com	Northern Delta Sustainability Agency/NDGSA Associate Member Staten Island-Conservation Farms and Ranches	Proposed Monitoring Well Network	To rectify data gaps, a concerted program to resolve data gaps should be developed, funded and implemented. Further, these data gaps preclude the ability to track consistency with the GSP, and ultimately to ensure sustainability. furthermore, there are significant defects in the GSPs proposed monitoring approach.	Monitoring Network	The ESJGWA is committed to resolving the data gaps identified during the GSP development process. The Prop 68 funds are designed to help address identified data gaps and the current application focuses on groundwater flow in the northwestern portion of the Subbasin with plans for additional monitoring wells in that area. As discussed in Section 7.6.4 (Monitoring Network Description), a program may be developed for the GSP update to help fill new or remaining data gaps.
642	Chris Thomas cthomas@thefreshwatertrust.org /northerndeltagsa@gmail.com	Northern Delta Sustainability Agency/NDGSA Associate Member Staten Island-Conservation Farms and Ranches		Sampling frequency was reduced to 2 events a year for 'representative' monitoring wells. This seems far too infrequent, given the DWR documented 'critically over-drafted' basin condition, existing cones of depression, and the limited number of monitoring wells proposed . (Discussed at July 10, 2019 GWA Board Meeting.) DWR has identified that the well sampling frequency should be based on groundwater conditions and hydrogeologic understanding. https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/BMP-2-Monitoring-Networks-and-Identification-of-Data-Gaps.pdf	Monitoring Network	Frequency of groundwater level monitoring is cited in the Draft Monitoring Networks and Identification of Data Gaps Best Management Practice. While semi-annual monitoring is required for groundwater levels, DWR guidance recommends monthly sampling of groundwater levels for the Subbasin based on aquifer type, volume of long-term aquifer withdrawals, and recharge potential. The ESJGWA Board determined semi-annual sampling was appropriate as it will capture seasonal highs and lows and that additional monitoring would not necessarily provide additional information on trends. If a need for more frequent monitoring is recognized, the monitoring frequency will be reevaluated as updates to the GSP occur.
643	Chris Thomas cthomas@thefreshwatertrust.org /northerndeltagsa@gmail.com	Northern Delta Sustainability Agency/NDGSA Associate Member Staten Island-Conservation Farms and Ranches		The draft GSP approach in number, location and frequency of sampling of wells appears to be inconsistent with the DWR BMPs. Generally, there are too few wells, and they are spatially dispersed outside of the cone(s) of depression over a very large subbasin, and limited sampling frequency will make it difficult to track the sustainability criteria and associated thresholds, the effectiveness of the GSP, and to begin to detect impacts to Groundwater Dependent Ecosystems (GDEs).	Monitoring Network	The ESJGWA Board supports the inclusion of the monitoring network as presented and approved it in July 2019. If a need for more detail is recognized, the monitoring network will be reevaluated as updates to the GSP occur. Data gaps are discussed in Section 4.7 (Data Gaps) and include a plan for the drilling of up to 12 additional monitoring wells to help resolve identified gaps in well locations. Frequency of groundwater level monitoring is cited in the Draft Monitoring Networks and Identification of Data Gaps Best Management Practice. While semi-annual monitoring is required for groundwater levels, DWR guidance recommends monthly sampling of groundwater levels for the Subbasin based on aquifer type, volume of long-term aquifer withdrawals, and recharge potential. The ESJGWA Board determined semi-annual sampling was appropriate as it will capture seasonal highs and lows and that additional monitoring would not necessarily provide additional information on trends.
644	Chris Thomas cthomas@thefreshwatertrust.org /northerndeltagsa@gmail.com	Northern Delta Sustainability Agency/NDGSA Associate Member Staten Island-Conservation Farms and Ranches	Figure 2-37	Only one large cone of depression, an area of significantly reduced water table elevation, is identified in the GSP. This singular feature differs from previous analyses in the Cosumnes and South American subbasins; and, the degree of resolution of the data presented makes it difficult to tell if there are one or more distinct cones in the central part of the subbasin, but in any case the model shows depletion along Staten Island.	Basin Setting	Added text to Section 2.2.1.2 (Current Groundwater Conditions) referencing the localized depression forming across the Cosumnes-Eastern San Joaquin Subbasin boundary and clarifying that the central depression in the Subbasin is most significant to achieving sustainability in the Subbasin: A localized depression area is shown expanding from Cosumnes Subbasin across Dry Creek to Eastern San Joaquin Subbasin in Fourth Quarter 2017. However, from the perspective of the entire Eastern San Joaquin Subbasin, the central pumping depression east of the City of Stockton is most significant to achieving sustainability in the Subbasin.

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645	Chris Thomas cthomas@thefreshwatertrust.org /northerndeltagsa@gmail.com	Northern Delta Sustainability Agency/NDGSA Associate Member Staten Island-Conservation Farms and Ranches	Figure 2-37 Figure 2-38,	The model(s) appear to show groundwater elevation declines in the Delta, including Staten Island. These data need further investigation since that condition seems unlikely and not supported by DWR and other groundwater elevation analyses. ESJ consultants were asked to explain why there were so many apparent discontinuities from the adjacent subbasin documented depressions, and the apparent errors in reporting of groundwater elevations in the Delta. For example, there are inexplicably irregular patterns of groundwater elevations shown for the Delta. The response was that the model itself had some challenges in development and that stakeholders could ignore those results. There is apparently limited quality control in the modeling effort, and erroneous results were not identified in the draft GSP. To the extent the GSP continues to rely on this modeling, it should identify where and how the data is not considered accurate. Or, if there are significant caveats, how and where those apply.	Model Uncertainties	Groundwater conditions in the Delta area are not depressed and are not contributing to the overall groundwater issues in the Subbasin. During the development of the model there was not sufficient data in terms of groundwater usage and/or long-term trends in groundwater levels that would support detailed calibration of the model in the Delta area. Therefore, in consultation with the stakeholders representing the Delta area, the level of effort in calibrating the model for that area was minimized and more effort was put into the calibration of the central portion of the Subbasin. Depending on the quality of additional data that could become available, further refinements in calibration could be performed during the next round of model refinements.
646	Chris Thomas cthomas@thefreshwatertrust.org /northerndeltagsa@gmail.com	Northern Delta Sustainability Agency/NDGSA Associate Member Staten Island-Conservation Farms and Ranches	Sections 3.4-9	At the July 10, 2019 GWA Board Meeting, the consultants discussed use of The Nature Conservancy-initiated GDE assessment approach, "somewhat," but that in any case that their analysis was "consistent." The approach to GDEs should be clearly disclosed in the GSP.	GDEs	Section 2.2.7.1 (Methodology for GDE Identification) was updated to better articulate the methodology used and the describe data gaps within the NCCAG dataset.
647	Chris Thomas cthomas@thefreshwatertrust.org /northerndeltagsa@gmail.com	Northern Delta Sustainability Agency/NDGSA Associate Member Staten Island-Conservation Farms and Ranches	Figure 3-64 Figure 3-65	Similarly, Interconnected Surface Waters (ISW) analysis in the draft GSP shows portions the sloughs as being variously 'always losing' and 'always gaining' around the perimeter of Staten Island. Yet, these gaining sections (all at or below sea level) are further identified 'disconnected' from the groundwater system. When asked about this obvious error in groundwater depletion modeling below sea level for several streams and Delta sloughs, the staff response was that it appears to be a modeling calibration error. It seems unlikely that these data were reviewed before publication. If they were reviewed, it would be expected that the text of the draft GSP would explain why it was incorrect or uncertain and how that was being resolved. This discrepancy raises concerns about the quality and the reliability of the GDE and ISW analyses.	Model Uncertainties	See Master Response 2 - ISW.
648	Chris Thomas cthomas@thefreshwatertrust.org /northerndeltagsa@gmail.com	Northern Delta Sustainability Agency/NDGSA Associate Member Staten Island-Conservation Farms and Ranches		The draft GSP has set water quality standards for salinity intrusion that appear inconsistent with meeting environmental and agricultural beneficial uses, and protecting crops from yield losses associated with cumulative impacts of salinity. The GSP sets the isocontour line for reporting at 500 mg/L, ostensibly "same as Secondary Maximum Contaminant Level (SMCL) for chloride." (P. 12 July 10, 2019 GWA Board Meeting.) The Chloride SMCL set by the USEPA is 250 mg/L: https://www.epa.gov/dwregdev/drinking-water-regulations-and-contaminants https://www.epa.gov/sites/production/files/2018-03/documents/dwtable2018.pdf	Seawater Intrusion	The seawater intrusion chloride isocontour is intended to monitor for a seawater intrusion front. Harm related to agricultural crops, as well as drinking water supplies is address through the Degraded Water Quality Sustainability Indicator.
649	Chris Thomas cthomas@thefreshwatertrust.org /northerndeltagsa@gmail.com	Northern Delta Sustainability Agency/NDGSA Associate Member Staten Island-Conservation Farms and Ranches		The SMCL for Total Dissolved Solids (TDS) set by the USEPA is 500 mg/L: https://www.epa.gov/sites/production/files/2019-03/documents/cfr-2011-title40-vol23-part143.pdf However, the GSP set the measurable objective at 600 mg/L for TDS and the minimum threshold for TDS at 1,000 mg/L., double the SMCL. This measurable objective is above the SMCL, and the maximum threshold is not protective of drinking water supplies and agricultural uses. By the time water quality has reached the measurable objective it is unlikely to be used for potable water, and places agriculture at risk from yield losses.	Groundwater Quality	The ESJGWA considers minimum thresholds and measurable objectives for groundwater quality to be protective of drinking water supplies and agricultural uses, as secondary maximum contaminant levels (SMCL) are established for aesthetic reasons such as taste, odor, and color and are not based on public health concerns. The three levels of SMCLs for TDS are: Recommended (500 mg/L), Upper (1,000 mg/L), and Short Term (1,500 mg/L). Language was added in Section 3.2.3.2 (Degraded Water Quality Minimum Thresholds) to include information on salinity tolerances of Subbasin crops.
650	Chris Thomas cthomas@thefreshwatertrust.org /northerndeltagsa@gmail.com	Northern Delta Sustainability Agency/NDGSA Associate Member Staten Island-Conservation Farms and Ranches		The subbasin's GSP defined minimum threshold for chloride has been set at 2,000 mg/L, well above the limits for harm for many agricultural crops. http://lawr.ucdavis.edu/cooperative-extension/irrigation/drought-tips/water-quality-guidelines-trees-and-vines https://catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/pnw597.pdf	Seawater Intrusion	The seawater intrusion chloride isocontour is intended to monitor for a seawater intrusion front. Harm related to agricultural crops, as well as drinking water supplies is address through the Degraded Water Quality Sustainability Indicator.
651	Chris Thomas cthomas@thefreshwatertrust.org /northerndeltagsa@gmail.com	Northern Delta Sustainability Agency/NDGSA Associate Member Staten Island-Conservation Farms and Ranches		The minimum threshold is set at 1,000 mg/L for TDS, also at or above the level of impact to agricultural most agricultural crops. https://www.usbr.gov/lc/phoenix/programs/cass/pdf/Phase1/ATechapdxTDS.pdf	Groundwater Quality	The minimum thresholds are intended to define levels that are significant and unreasonable and are not the desired state of the subbasin. The ESJGWA considers minimum thresholds and measurable objectives for groundwater quality to be protective of agricultural uses. Language was added in Section 3.2.3.2 (Degraded Water Quality Minimum Thresholds) to include information on salinity tolerances of Subbasin crops.
652	Chris Thomas cthomas@thefreshwatertrust.org /northerndeltagsa@gmail.com	Northern Delta Sustainability Agency/NDGSA Associate Member Staten Island-Conservation Farms and Ranches		The monitoring triggers in the draft GSP for chloride and TDS are too high to avoid undesirable effects, and do consider leaching fractions or soil salinity accumulation rates in its assumptions that further chronic reductions in crop productivity and other negative impacts would be avoided. The analysis in the draft GSP does not appear to follow a best available science (BAS) approach. For instance, the draft GSP fails to disclose that the levels of TDS identified as acceptable are associated with levels found to have a 50% yield loss of crops.	Groundwater Quality	The minimum thresholds are intended to define levels that are significant and unreasonable, and are not the desired state of the subbasin. The ESJGWA considers minimum thresholds and measurable objectives for groundwater quality to be protective of agricultural uses. Language was added in Section 3.2.3.2 (Degraded Water Quality Minimum Thresholds) to include information on salinity tolerances of Subbasin crops.
653	Chris Thomas cthomas@thefreshwatertrust.org /northerndeltagsa@gmail.com	Northern Delta Sustainability Agency/NDGSA Associate Member Staten Island-Conservation Farms and Ranches		The trigger at 400% SMCL would clearly cause negative impacts to domestic well users drinking water quality. The threshold for chloride is impermissibly high and would cause degradation of existing water quality, and potentially institutionalize unsustainable and undesirable water quality.	Seawater Intrusion	The seawater intrusion chloride isocontour is intended to monitor for a seawater intrusion front. Harm related to agricultural crops, as well as drinking water supplies is address through the Degraded Water Quality Sustainability Indicator.
654	Chris Thomas cthomas@thefreshwatertrust.org /northerndeltagsa@gmail.com	Northern Delta Sustainability Agency/NDGSA Associate Member Staten Island-Conservation Farms and Ranches	Figure 2-31	The well network and associated chloride concentrations used in the analysis do not adequately represent Delta locations or the potential for associated sea/brackish water intrusion into shallow groundwater. Significantly more wells at various depths are required to show current conditions, and to detect future impacts within the Delta.	Monitoring Network	Data gaps are discussed in Section 4.7 (Data Gaps) and include a plan for the drilling of up to 12 additional monitoring wells to help resolve identified gaps. Two of these wells are shallow and planned for locations along San Joaquin River in the Delta and, if constructed, would provide more data on both water quality and groundwater levels in the Delta.
655	Chris Thomas cthomas@thefreshwatertrust.org /northerndeltagsa@gmail.com	Northern Delta Sustainability Agency/NDGSA Associate Member Staten Island-Conservation Farms and Ranches	Figure 2-52 Figure 2-53	Where chloride concentrations are described, there are a disproportionate amount of observations above 250 mg/L. in the Delta. If this threshold were approved it is possible that agricultural groundwater users would not be able to use this water for crops without reductions in productivity, and that continued irrigation with this water could reduce the ability to continue farming current crops. This standard is entirely inappropriate for drinking water quality.	Seawater Intrusion	The seawater intrusion chloride isocontour is intended to monitor for a seawater intrusion front. Harm related to agricultural crops, as well as drinking water supplies is address through the Degraded Water Quality Sustainability Indicator.

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656	Chris Thomas cthomas@thefreshwatertrust.org /northerndeltagsa@gmail.com	Northern Delta Sustainability Agency/NDGSA Associate Member Staten Island-Conservation Farms and Ranches	Section 3.2.3.1.2	Whatever the particular standard, protection from seawater intrusion is reliant on the ability of the subbasin to detect undesirable effects. For the entire ESJ subbasin, the draft GSP provides: "Undesirable results occur during GSP implementation when more than 25 percent of representative monitoring wells (3 of 10 sites) exceed the minimum thresholds for water quality for two consecutive years and where these concentrations are the result of groundwater management activities."	Seawater Intrusion	The ESJGWA has determined this to be protective as representative monitoring locations as SGMA is intended to manage at the basin scale.
657	Chris Thomas cthomas@thefreshwatertrust.org /northerndeltagsa@gmail.com	Northern Delta Sustainability Agency/NDGSA Associate Member Staten Island-Conservation Farms and Ranches		Given the limited number of monitoring wells over a vast area, this standard is inadequate for the detection of a groundwater impact. The standard would require the source of the exceedance to be known, and that source to be the 'result of groundwater management activities'; that there is a monitoring well in proximity, that the exceedance in detected in the twice a year sampling; that two additional wells are located in the proximity and have similar detections with similar identified causes; and, moreover that those detections happen over two years. Those conditions are obviously unlikely to ever be met; the proposed well monitoring network appears to be so dispersed to ensure that exceedances could only be met at one well at the most.	Monitoring Network	The ESJGWA Board supports the inclusion of the monitoring network as presented and approved it in July 2019. If a need for more frequent monitoring or more monitoring wells is recognized, the monitoring program and groundwater quality sustainable management criteria will be reevaluated as updates to the GSP occur. The broad monitoring network for groundwater quality will also be evaluated to test for the extent of exceedances and will help indicate if the monitoring program should be reexamined in future updates to the GSP.
658	Chris Thomas cthomas@thefreshwatertrust.org /northerndeltagsa@gmail.com	Northern Delta Sustainability Agency/NDGSA Associate Member Staten Island-Conservation Farms and Ranches		The draft GSP is lacking in available data and an adequate proposed monitoring approach. The draft GSP should be modified and updated to include reasonable, scientifically supported thresholds, better track sustainability, and meet SGMA statutory requirements. The draft GSP should also be updated to clarify where the data and the visualizations are not accurate and what process will be applied to improve them.	Monitoring Network	The ESJGWA recognizes a number of data gap areas related to GDEs, interconnected surface waters, and overall monitoring network coverage, as discussed in Section 4.7 (Data Gaps). The plan is supported by the best available data and science and meets the requirements of SGMA. The ESJGWA Board supports the inclusion of the monitoring network as presented and approved it in July 2019.
659	Chris Thomas cthomas@thefreshwatertrust.org /northerndeltagsa@gmail.com	Northern Delta Sustainability Agency/NDGSA Associate Member Staten Island-Conservation Farms and Ranches		The salinity and TDS limits are not likely to meet sustainability and could allow significant degradation of water quality if applied.	Groundwater Quality	The ESJGWA considers minimum thresholds and measurable objectives for groundwater quality to be protective of agricultural uses. Language was added in Section 3.2.3.2 (Degraded Water Quality Minimum Thresholds) to include information on salinity tolerances of Subbasin crops.
660	Sandi Matsumoto	The Nature Conservancy		The Nature Conservancy has thoroughly reviewed the Eastern San Joaquin Subbasin Draft GSP. We appreciate the work that has gone into the preparation of this plan. However, we consider it to be inadequate under SGMA because the basis for removing the majority of the potential GDEs identified in the NC Dataset from further consideration and management as GDEs is not scientifically supported, and could lead to significant and unreasonable impacts. Based on the available data, the removed polygons should be retained and managed as potential GDEs in the plan. If further analysis were to provide substantial evidence that groundwater level declines would not result in an adverse impact to the species in these ecosystems, then consideration could be given to removing them at that time; however, no such evidence has been presented in the draft GSP.	GDEs	See Master Response 1 - GDEs.
661	Sandi Matsumoto	The Nature Conservancy	N/A	Considering Nature under SGMA: A Checklist "Environmental User Checklist" [SEE MORE SPECIFICS IN ATTACHMENT A IN COMMENT LETTER]	GDEs	The methodology presented in the Environmental User Checklist goes above and beyond the requirements of SGMA and can be evaluated in future iterations of the GSP as determined by the ESJGWA. The ESJGWA considers the methodology used in the GSP to be appropriate at this time given the existing data gap limitations, and can be refined further in future GSP updates.
662	Sandi Matsumoto	The Nature Conservancy	Section 1.3.1	Caswell Memorial State Park is incorrectly referred to as being located outside the Eastern San Joaquin Subbasin. The following additional protected lands are located near surface waters within the Subbasin that may be interconnected with groundwater, and/or may rely at least partly on groundwater to support vegetation and sensitive natural communities. These protected lands represent potential beneficial users of groundwater: Durham Ferry State Recreational Area, a small portion (approximately 200 acres) of San Joaquin River National Wildlife Refuge, Army Corps Park, Vernalis Riparian Habitat (Public Conservation Lands), Seegers Preserve, Cabral Island Preserve, Machado Preserve, Hansen Preserve, Micke Grove Park and Zoo, Oak Grove Regional Park, Nakagawa Preserve, El Rio Farms Preserve, Lodi Lake Nature Area, Woodbridge Regional Park, Woodbridge Ecological Preserve, White Slough WA, Nuss Farms, Beck Preserve, Hilder Preserve, Staten Island Ranch, Burchel Preserve, and Ishizuka Preserve. The authors referred to the San Joaquin County General Plan documents, including background reports, for information regarding these important resources. These potential beneficial groundwater users should be described in the text on pp. 1-18 and shown in Figure 1-11. Please include a description recognizing all of the protected areas in the Subbasin and their beneficial groundwater uses. Section 2.2.8 includes a geospatial analysis that removes managed wetlands from consideration as GDEs. The managed wetlands in the Subbasin should be identified in this section.	Clarifying Edit	1) Caswell Memorial State Park is within the Subbasin. Section 1.2.1 (Description of Plan Area) includes text that it is the only State Park within the Eastern San Joaquin Subbasin boundary. 2) Comment noted. This information (potential beneficial groundwater users) is beyond the scope of the GSP. Consider for inclusion in future updates to the GSP.
663	Sandi Matsumoto	The Nature Conservancy	Section 1.2.1	Critical habitat is known to exist for protected aquatic species, such as California Tiger Salamander, Steelhead, Delta Smelt, Giant Gartersnake and California Red-Legged Frog in and around the Subbasin (https://fws.maps.arcgis.com/home/webmap/viewer.html?webmap=9d8de5e265ad4fe09893cf75b8dbfb77). There are likely ongoing monitoring programs associated with critical habitat areas and the protected lands. Please include a description of these habitat areas, and associated programs and requirements pertinent to ISWs, GDEs and wetlands. Identify areas where critical habitat exists and overlaps with ISWs and GDEs.	GDEs	The comment request goes above and beyond the requirements of SGMA and can be evaluated in future iterations of the GSP as determined by the ESJGWA.
664	Sandi Matsumoto	The Nature Conservancy	Section 1.2.2	Per the GSP Regulations (23 CCR §354.34 (a) and (b)), monitoring must address trends in groundwater and related surface conditions (emphasis added). In order for this section to provide the appropriate context and help assure integration of GSP implementation with other ongoing regulatory programs, this section should describe the following: - Monitoring activities and responsibilities by State, Federal and local agencies and jurisdictions related to aquatic resources and GDEs that could be affected by groundwater withdrawals should be discussed. Section 1.2.2.6 states that there are no agencies that do monitoring specific to surface-groundwater interconnection. While this may be technically correct insofar as it relates to hydrogeologic monitoring, it ignores ongoing monitoring programs related to the state of aquatic resources and GDEs that could be affected by groundwater withdrawals, and that are a direct indicator of potential undesirable results. For example, there are likely ongoing monitoring programs associated with the protected lands listed in our comments to Section 1.3.1, and other open space or preserve areas that may be monitored by public, private or nonprofit entities. A discussion of monitoring programs related to GDEs and ISWs should be included. - The lack of existing hydrologic monitoring of surface-groundwater interconnection is a significant data gap as it relates to classification and management of GDEs and should be identified as such and further discussed and addressed in the appropriate subsequent sections of the GSP. - Monitoring activities and responsibilities related to instream flow and water quality requirements under applicable Federal Energy Regulatory Commission licenses, Biological Opinions and other regulations or programs are relevant and should be identified. Please include a discussion of water flow and quality monitoring requirements pertinent to ISWs.	Monitoring Network	1) The GSP monitoring network section meets the requirements of SGMA regulations. Publicly available data through other monitoring programs was reviewed for the GSP and will be utilized in future updates. 2) Section 4.7 (Data Gaps) was updated to specifically include interconnected surface water as a data gap. Many of the 12 proposed monitoring wells discussed in Section 4.7 are specifically located near streams with the intent of enhancing the monitoring and analysis of interconnected surface water.
665	Sandi Matsumoto	The Nature Conservancy	Section 1.2.3	This section should include a discussion of General Plan goals and policies related to the protection and management of GDEs and aquatic resources that could be affected by groundwater withdrawals, rather than being limited to goals and policies directly related to groundwater resources alone. Section 1.3.1 correctly identifies environmental uses of groundwater as including "...species and habitat reliant on instream flows, as well as wetlands and GDEs," and yet Section 1.2.3 and Appendix 1-E do not identify any General Plan policies related to these resources. Section 1.2.3 should identify if there are any Habitat Conservation Plans (HCPs) or Natural Community Conservation Plans (NCCPs) within the Subbasin and if they are associated with critical, GDE and/or ISW habitats. Appendix 1-E should identify General Plan policies related to wetlands, riparian habitat, streams, aquatic habitat, and related threatened and endangered species. Section 1.2.3.2 should include a discussion of the relationship of GSP implementation to General Plan goals and policies related to GDEs and aquatic habitat; and also address how GSP implementation will coordinate with the goals of any HCPs or NCCPs.	GDEs	The GSP includes General Plan goals and policies the ESJGWA has determined to be relevant to the GSP. This plan identifies GDEs as a beneficial use and there will be additional coordination and refinement of GDE data gap areas as the plan is refined.

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666	Sandi Matsumoto	The Nature Conservancy	Section 1.2.3.4	This section should include a discussion of the following: - Future well permitting must be coordinated with the GSP to assure achievement of the Plan's sustainability goals. - The State Third Appellate District recently found that Counties have a responsibility to consider the potential impacts of groundwater withdrawals on public trust resources when permitting new wells near streams with public trust uses (ELF v. SWRCB and Siskiyou County, No. C083239). The need for well permitting programs to comply with this requirement should be stated. - Section 2.3.3.3 discusses potential exemptions from the Stanislaus County Groundwater Ordinance but does not mention the fact that applicants who are not exempt are required to provide substantial evidence that their proposed extraction will not result in undesirable results, including significant and unreasonable impacts to GDEs and surface waters.	Well Permitting	1) Well permitting requirements for San Joaquin, Calaveras, and Stanislaus counties are identified in Section 1.2.3.4 (Well Permitting) of the GSP. An additional subsection has been added to include Sacramento County well permitting requirements. GSAs do not have well permitting authority, unless as authorized by the respective county. SGMA does not provide a GSA with the authority to issue or regulate permits for the construction, modification, or abandonment of groundwater wells, but maintains the authority for well permitting activities with the county. (Water Code, § 10726.4(b).) A GSA may request the county provide the GSA with notice of any permit applications (10726.4(b)) and a GSA may impose spacing requirements on new well construction (10726.4(a)(1)). The ESJGWA will continue to coordinate with its member GSAs that are well permitting agencies. Language has been added to Section 4.7.1 (Plan to Fill Data Gaps) referencing applicable Calaveras County, Stanislaus County, and San Joaquin County monitoring well drilling standards. 2) Section 1.2.3.4.3 (Well Permitting, Stanislaus County) has been updated to include language on procedures for applicants not exempt from the Stanislaus County Groundwater Ordinance.
667	Sandi Matsumoto	The Nature Conservancy	Section 2.1.7	Please clearly state whether localized perched aquifers are present in the basin. Include example near-surface cross section details that depict the conceptual understanding of shallow groundwater and stream interactions at different locations, including perched and regional aquifers.	Basin Setting	The level of detail in the GSP is appropriate for a conceptual model of the Subbasin.
668	Sandi Matsumoto	The Nature Conservancy	Section 2.1.8.2	The Bottom of the Basin Boundary was defined by the base of freshwater, which was mapped 45 years ago and pumping since then has very likely resulted in shift in the isohaline contouring in the basin. Defining the bottom of the Subbasin based on geochemical properties is a suitable approach for defining the base of freshwater, however, as noted on page 9 of DWR's Hydrogeologic Conceptual Model BMP (https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/BMP_HCM_Final_2016-12-23.pdf) "the definable bottom of the basin should be at least as deep as the deepest groundwater extractions". Thus, groundwater extraction well depth data should also be included in the determination of the basin bottom. This will prevent the possibility of extractors with wells deeper than the basin boundary from claiming exemption of SGMA due to their well residing outside the vertical extent of the basin boundary. Also, pumping saline groundwater and desalinating it will become increasingly economical under SGMA due to pumping restrictions in the basin.	Basin Setting	The location and depth of the base of freshwater was confirmed by the values presented in the California Department of Conversation DOGGR wells. Comment noted for follow up in next round of GSP refinements and updates.
669	Sandi Matsumoto	The Nature Conservancy	Section 2.1.10	The Hydrologic Conceptual Model identified several data gaps including the following for groundwater level data: - Depth- or zone-specific water levels to assess vertical interconnection, including zones within the Principal Aquifer. Nested monitoring wells would be helpful near surface water to show how pumping is impacting surface water flows and GDEs. - Additional shallow groundwater data near surface waters and NCCAGs. - Additional groundwater level data in the east and northwest areas of the Subbasin. - Additional groundwater level data near the Mokelumne River to improve quantification and understanding of subsurface flows. Of these, the second data gap is the information that is most critical to identifying GDEs or potential GDEs and understanding their characteristics.	GDEs	Comment noted. As GDEs are a recognized data gap in the GSP, the list of identified GDEs will continue to be refined. Language was added to Section 4.7 (Data Gaps) to identify NCCAG areas removed through the GDE analysis are data gaps areas requiring further refinement. The purpose of this is to identify potential existing GDEs that may have been incorrectly eliminated through this screening process.
670	Sandi Matsumoto	The Nature Conservancy	Section 2.1.4.2	This section should discuss (or reference the sections discussing) the following: - Specific ISWs, including the extent of both gaining and losing reaches. - In-stream flow requirements in each of the interconnected rivers/streams including the amount, time of year when the flow minimum is specified, the duration, the freshwater fish species for which it applies, associated permits that set forth the requirements, and the regulating agency setting forth the compliance requirements. - Areas of critical habitat that exist within rivers and streams.	Interconnected Surface Water	See Master Response 2 - ISW.
671	Sandi Matsumoto	The Nature Conservancy	Section 2.1.5	Table 2-2 states that Holocene Stream Channel Deposits are generally not saturated except by the San Joaquin River. Based on the available data, it would be expected that the stream channel deposits associated with the other ISWs in the Subbasin would be saturated near those streams and rivers.	Clarifying Edit	Removed in response to comment.
672	Sandi Matsumoto	The Nature Conservancy	Section 2.1.9.2.2	This section focuses on groundwater flow direction and defers further discussion of groundwater conditions to Section 2.2, which does not provide information on historical groundwater-surface water interaction. This section should include a discussion of historic groundwater-surface water interaction.	Interconnected Surface Water	See Master Response 2 - ISW
673	Sandi Matsumoto	The Nature Conservancy	Section 2.2.6	- The determination as to whether or not a stream reach is interconnected or disconnected was made based on whether modeling conducted for the GSP indicated that it is interconnected more than 25 percent of the time. Even if the stream is only connected 25% of the time, it is still connected, and that short period of connectivity may be during critical times for select species or provide a cooling or biogeochemical effect during a critical period. Please describe the technical basis for selecting a 25 percent interconnection threshold, and how it will adequately protect the environmental beneficial uses of surface water in potentially interconnected surface waters from significant and unreasonable impacts related to groundwater extraction. - Shallow groundwater monitoring data near surface waters and NCCAGs are identified as a data gap in Section 2.1.10, and the use of the Eastern San Joaquin Water Resources Model (ESJWRM) to determine the percentage of time that stream reaches are groundwater connected entails inherent uncertainty. The potential presence of shallow or perched aquifers near the rivers is not assessed or discussed in the GSP. Groundwater modeling conducted by the United States Geological Survey (USGS), DWR and others (e.g., JJ&A, 2018) has considered some river reaches shown as disconnected in Figure 2-66 (pp. 2-99) to be groundwater-connected. No data or discussion is presented regarding the potential groundwater connection of other streams associated with significant wetland and riparian resources, including Pixley Slough, Mormon Slough, Littlejohns Creek, Bear Creek, Potter Creek, Duck Creek and Lone Tree Creek. As such, there is considerable uncertainty regarding the designation of interconnected and disconnected surface water resources in Figure 2-66. The uncertainty regarding the groundwater interconnection of streams in the Subbasin should be identified as a data gap.	Interconnected Surface Water	See Master Response 2 - ISW.
674	Sandi Matsumoto	The Nature Conservancy	Section 2.2.7	This section includes the incorrect statement that SGMA does not require sustainable management criteria to be established for the management of GDEs. Section 1.3.1 of the GSP states that beneficial users of groundwater and ISWs include "environmental users of groundwater, including species and habitat reliant on instream flows, as well as wetlands and GDEs." Undesirable results under SGMA include chronic lowering of groundwater levels resulting in significant and unreasonable depletion of supply for beneficial groundwater users, including GDEs. Undesirable results also include depletion of ISWs resulting in significant and unreasonable adverse impacts on beneficial users of surface water, including wetlands and GDEs. The incorrect statement that SGMA does not require the establishment of sustainable management criteria for GDEs should be removed.	Clarifying Edit	Clarified text in Section 2.2.7 (Groundwater-Dependent Ecosystems): SGMA requires the identification of GDEs. SGMA does not require that additional sustainable management criteria be established to specifically manage these areas, but rather includes GDEs as a beneficial user of water to be considered when developing other sustainable management criteria.

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675	Sandi Matsumoto	The Nature Conservancy	Section 2.2.8	The GSP relies on the NCCAG database developed by TNC for the DWR to identify potential GDEs, and then provides a framework for removing most of these areas from further consideration. It appears that the preliminary desktop analysis documented in the draft GSP resulted an excessive elimination of the NC dataset polygons mapped in the Eastern San Joaquin Subbasin. In particular, the methods used to confirm whether or not polygons in the NC Dataset are connected to groundwater in the Eastern San Joaquin Subbasin are highly flawed. We have the following comments on the proposed approach: The GSP takes the approach of removing NCCAGs with "access to alternate water supplies" from consideration as GDEs, and states that in order to be considered GDEs, "there must not be alternate water supplies". Alternate water supplies are assumed to include potential sources of surface water including managed wetlands, irrigated agricultural fields, perennial surface water sources, and other unspecified sources determined by stakeholders on a case-specific basis. This approach is inappropriate and deficient for several important reasons: - There is no hydrologic analysis or empirical data provided as a basis for the proposed buffer zones. The hydrologic connectivity between a GDE and a nearby alternative water source is highly dependent on local conditions and can vary seasonally and by year type. In the case of managed wetlands, no consideration is given to the nature of the wetland and surrounding area, the source and frequency of inundation, the soil types, and other features that would be needed to understand the hydrologic connectivity between the wetland and the surrounding area, or even whether the wetland itself it groundwater dependent for a portion of the year. Similarly, no information is given to the topography and hydrology surrounding irrigated agricultural fields, the soil types involved, irrigation practices, whether irrigation is likely to be curtailed during dry years or during certain crop rotations, and other relevant factors. The hydrologic connectivity of perennial surface water sources cannot be assessed without specific knowledge of the water source, topography and soil conditions. In summary, the adequacy of generic buffer zones to assure GDE access to surface water is unsubstantiated. - No information is provided regarding the species residing in the GDEs, their sensitivity to groundwater level declines, or the extent of their reliance on groundwater vs. the proposed "alternate water supplies." - There is no evidence of consultation with the regulatory agencies responsible for the protection and management of these resources in the establishment of the proposed framework. It does not appear that any habitat assessments have been conducted. - Ecosystems often rely both on groundwater and surface water to meet their water needs (see Best Management Practice #3 in Attachment C of this letter). The availability of "alternate water supplies" to provide some portion of a GDE's water demand does not mean all of its water needs can be met through alternate supplies (i.e., without reliance on groundwater). - Groundwater pumping depletes ISWs under both gaining or losing conditions, and GDEs may rely on the interactions of surface water to [SEE MORE SPECIFICS IN COMMENT LETTER]	GDEs	See Master Response 1 - GDEs.
676	Sandi Matsumoto	The Nature Conservancy	Section 2.3.5	The following items related to GDEs, wetlands and riparian areas should be clarified or considered: - "Riparian intake from streams" is identified as a stream system water budget component and is defined as the portion of riparian evapotranspiration (ET) met by streamflows. Please include an explanation of the approach to determining the amount of riparian ET demand met by streamflow vs. groundwater evapotranspiration. - Groundwater outflow to ET does not appear to be identified as a groundwater budget component (for example see Figure 2-74, p. 2-125). In addition, the ET demand of natural vegetation does not appear to be considered in water supply and demand calculations (for example see Table 2-16, p. 2-126). Since GDEs (including wetlands, riparian vegetation, phreatophytes and other communities) are recognized as beneficial users of groundwater in the Subbasin, it is appropriate to include them in these calculations.	Water Budget	1) Riparian evapotranspiration is included in the water budget (part of "Refuge, Native, and Riparian Evapotranspiration" in Table 2-14) and simulated in the model. Both streamflow and groundwater can contribute to meeting riparian evapotranspiration demand and the amount of demand met by each component is estimated directly by the model. "Riparian Intake from Streams" in Tables 2-13 and 2-14 includes all surface water and groundwater contributing to riparian demand through stream-aquifer interaction. The ESJWRM model does not have the level of detail to determine how much groundwater is consumed by riparian demand. 2) Groundwater outflow to evapotranspiration is not directly included as a water budget component and is simulated indirectly in ESJWRM through stream-aquifer interaction and seepage of pumped groundwater. 3) Wetlands, GDEs, riparian vegetation, and native (or natural) vegetation are recognized as beneficial users and are included in the water budget, though not separated out and are part of "Refuge, Native, and Riparian Evapotranspiration". There is not enough information at this time to determine how much groundwater is consumed by each of these demands. 4) This GSP recognized GDEs as a data gap in both the determination of GDEs in the Subbasin as well as the simulation of GDEs in the model. In the model, GDEs are broadly assumed to be represented as native vegetation as they are not specifically included in land use surveys. This representation removes the realistic variation of rooting depths across GDEs and we will consider the specific simulation of GDEs in future updates to the model. Comment noted for follow up in next round of model refinements and updates.
677	Sandi Matsumoto	The Nature Conservancy	Section 3.1	The Sustainability Goal is defined as being " … to maintain an economically-viable groundwater resource for the beneficial use of the people of the Eastern San Joaquin Subbasin … ." Since GDEs, are recognized as beneficial users of groundwater in the Subbasin, they should be mentioned in the Sustainability Goal.	Sustainable Management Criteria	The ESJGWA Board determined the sustainability goal meets the requirements of SGMA. GDEs are included in Section 1.3.1 (Beneficial Uses and Users in the Subbasin) and considered as an undesirable result in the Chronic Lowering of Groundwater Levels sustainability indicator in Section 3.2.1. As groundwater levels are a key indicator in achieving the Subbasin's sustainability goal, the sustainability criteria should help prevent adverse effects on GDEs.
678	Sandi Matsumoto	The Nature Conservancy	Section 3.2.1.1.1	This section only describes undesirable results relating to human beneficial uses of groundwater and neglects environmental beneficial uses that could be adversely affected by chronic groundwater level decline. On page 3-5 in Section 3.2.1.2, impacts to GDEs are correctly identified as an undesirable result potentially associated with chronic groundwater level decline. Please add "potential adverse impacts to GDEs" to the list of potential undesirable results presented in Section 3.2.1.1.1.	GDEs	Language was added to Section 3.2.1.1.1 to include: Adverse impacts to environmental uses and users, including interconnected surface waters and groundwater-dependent ecosystems (GDEs).
679	Sandi Matsumoto	The Nature Conservancy	Section 3.2.3.1.1	This section only describes undesirable results in terms of total dissolved solids concentrations and related impacts. The section should be modified to state that overpumping and dewatering of aquitards has been identified as a potential source of elevated arsenic concentrations above drinking water standards in San Joaquin Valley aquifers. The following is a link to a paper by Smith, Knight and Fendorf (2018) titled "Overpumping leads to California groundwater arsenic threat": (https://www.nature.com/articles/s41467-018-04475-3).	Groundwater Quality	Comment noted. Thank your providing a link to the arsenic paper. Text was added to Section 3.2.3.1.1 (Description of Undesirable Results) to discuss management of arsenic and nitrate.
680	Sandi Matsumoto	The Nature Conservancy	Section 3.2.6.1.1	This section states that undesirable results related to surface water depletion were defined and evaluated only for major streams and rivers including the Calaveras River, Dry Creek, Mokelumne River, San Joaquin River, and Stanislaus River. The section goes on to state that many of the smaller creeks and streams are solely used for the conveyance of irrigation water and these systems have not been considered in the analysis of depletions. Contrary to these statements, surface water resources in these creeks support significant recognized aquatic habitat, wetlands and riparian zones that represent potential environmental beneficial uses and users of groundwater. A number of these streams are associated with designated protected lands. The analysis for potential depletion of ISWs in Section 3.2.6 should include all beneficial users of surface water that could be affected by groundwater withdrawals, including environmental beneficial users along creeks, even if the creeks are interconnected less than 75% of the time.	Interconnected Surface Water	1) The ESJGWA recognizes that interconnected surface water is a data gap area and supports the use of groundwater levels as a proxy as the best information currently available. The ESJGWA has identified a need for future study and refinement will continue coordination efforts to better inform conditions. 2) Language has been added to Section 4.7 (Data Gaps) identifying interconnected surface water as a data gap area for future study and refinement. It also has been updated to clarify and better articulate the ESJGWA's focus on installing additional monitoring wells near streams, which can be evaluated for use as representative monitoring wells in the future.
681	Sandi Matsumoto	The Nature Conservancy	Section 3.2.6.1.2	The section states that "undesirable results would occur if groundwater extractions depleted interconnected streams and there was not sufficient surface water to supply … fish and wildlife demands." This definition of undesirable results is overly narrow and recognizes only a limited subset of the environmental beneficial users of ISWs. A more complete definition would be that undesirable results would occur if groundwater extraction resulted in a depletion of surface water that caused significant impacts to aquatic species or wildlife, or degradation of GDEs. Please expand the definition of undesirable results to include all of the environmental beneficial uses and users of ISWs, and expand the analysis in Section 3.2.6, as appropriate.	Interconnected Surface Water	Comment noted, the ESJGWA supports the definition of undesirable results provided in the GSP, which identifies GDEs and freshwater fish and wildlife species as beneficial users. The ESJGWA will continue to collect data to better inform connectivity conditions in the Subbasin.
682	Sandi Matsumoto	The Nature Conservancy	Section 3.2.6.1.3	The potential effects of undesirable results on environmental beneficial users are not described. Please expand the section to describe the potential effects of undesirable results on all beneficial uses and users of ISWs, including environmental uses and users. The GDE Pulse web application developed by The Nature Conservancy provides easy access to 35 years of satellite data to view trends of vegetation metrics, groundwater depth (where available), and precipitation data. This satellite imagery can be used to observe trends for NC dataset polygons within the Subbasin. Over the past 10 years (2009-2018), some NC dataset vegetation polygons have experienced adverse impacts to vegetation growth and moisture in the western portion of the Subbasin. An example screen shot from the GDE Pulse tool is presented below. Please review these spatial patterns and, where possible, correlate them with water level trends. Any indications of adverse trends and any data gaps should be identified. [SEE MORE SPECIFICS IN COMMENT LETTER]	GDEs	1) Language was added to Section 3.2.6.1.1 to reference Section 1.3.1 (Beneficial Uses and Users in the Basin). 2) Language was added to Section 4.7 (Data Gaps) to indicate that the ESJGWA would evaluate using the GDE Pulse Tool and other tools to monitor GDEs.

Comment #	Commenter	Commenter Organization	Section, Figure, or Table Number	Comment	Category	Response to Comment
683	Sandi Matsumoto	The Nature Conservancy	Section 3.2.6.2	The GSP proposes to use the Minimum Thresholds and Measurable Objectives associated with Chronic Decline in Groundwater Levels as a proxy for management of depletion of ISWs, and concludes that these criteria will be protective of the depletion of ISWs and prevent significant and unreasonable impacts to beneficial surface water uses and users. This conclusion is not adequately supported by data and/or consultation with the agencies that are responsible for the regulation of GDE habitats. We have the following comments: - The section states that current or historical issues associated with depletion of ISWs were not indicated to be significant and unreasonable based on discussions at GWA Board, Advisory Committee, and Workgroup meetings and through input from GSA staff, and that it was therefore assumed that historical conditions are protective of beneficial uses. It does not appear that any consultation occurred with the Federal, State and local agencies responsible for management and regulation of environmental beneficial uses of ISWs, or with the private parties, agencies and NGOs involved in managing the protected lands listed in our response to Section 1.3.1. In addition, no reference is made to the review of supporting documents for General Plan Conservation or Land Use Elements, or to the review of environmental management studies and documents such as Biological Assessments, Biological Opinions, HCPs or other studies regarding the current and historical conditions of the beneficial uses being evaluated. Please provide a more thorough explanation of the basis for the assumption that current and historical groundwater level conditions are protective of beneficial uses related to ISWs. Data gaps should be acknowledged. - The GDE Pulse web application developed by The Nature Conservancy provides easy access to 35 years of satellite data to view trends of vegetation metrics, groundwater depth (where available), and precipitation data. This satellite imagery can be used to observe trends for NC dataset polygons within the Subbasin. Over the past 10 years (2009-2018), some NC dataset vegetation polygons have experienced adverse impacts to vegetation growth and moisture in the western portion of the Subbasin. Please review these spatial patterns and, where possible, correlate them with water level trends. Any indications of adverse trends and any data gaps should be identified. - The section discusses future use scenarios, associated groundwater level declines and ISW depletions on a broad level. The potential effects of these declines on environmental beneficial uses, including GDEs, are not discussed. In addition to discussion of potential adverse effects at a general level, a conclusion that significant adverse impacts are unlikely generally requires more site- and resource-specific analysis. Please include a discussion of the potential for adverse effects of surface water depletions on environmental resources, as well as a reasoned analysis of the likelihood of their occurrence under future scenarios. The lack of site-specific data to draw conclusions about specific environmental beneficial users should be recognized as a data gap. - Please expand the analysis of potential undesirable results to include all environmental beneficial uses and users, including those associated with more local streams and creeks. - The statement that an additional depletion of the surface water due to groundwater pumping of 50,000 acre-feet per year is not significant and unreasonable needs to be further analyzed. The conclusion is based on analyzing the estimated depletion as a percentage of total surface water discharge. The significance of such a depletion relative to specific beneficial uses and users will depend on its distribution throughout the surface water system. Even a modest amount of depletion may have a significant local adverse effect. The limitations of broad conclusions regarding basin-wide surface water flow depletions should be recognized and any data gaps identified.	Interconnected Surface Water	See Master Response 2 - ISW.
684	Sandi Matsumoto	The Nature Conservancy	Section 4.1 and Section 4.6	The GSP proposes to use groundwater level monitoring for chronic groundwater level decline as a surrogate for monitoring the depletion of ISWs. We have the following comments. - The areas identified as potential GDEs in the GSP are located near the western boundary of the Subbasin. Only one of the representative monitoring wells appears to be located near those areas (Figure 4-1 on p. 4-5). Very few of the remaining monitoring wells are located near potential ISWs and GDEs. Specific monitoring should be described to further evaluate, monitor, manage and protect areas with ISWs and GDEs. - Per the GSP Regulations (23 CCR §354.34 (a) and (b)), monitoring must address trends in groundwater and related surface conditions (emphasis added). Groundwater level monitoring alone may be insufficient to establish a linkage between groundwater extraction and potentially resulting impacts to environmental resources associated with GDEs and ISWs. The cause-effect relationship between groundwater levels and the biological responses that could result in significant and unreasonable impacts to ISWs and GDEs depends on a number of complicated factors, and this relationship is not characterized or discussed. As such, it is not possible to determine whether the proposed monitoring, minimum thresholds and measurable objectives are sufficiently protective to ensure significant and unreasonable impacts to GDEs and ISWs will be prevented. The GDE Pulse interactive mapping application provides an example of a linkage between groundwater level data and GDE health that could be used to incorporate remote sensing into an efficient and incisive monitoring program. Please provide an explanation how groundwater levels will specifically be used to assess adverse impacts to GDEs and ISWs, and identify any data gaps and how they will be addressed.	Interconnected Surface Water	See Master Response 2 - ISW.
685	Sandi Matsumoto	The Nature Conservancy	Section 4.7	Twelve new monitoring wells are proposed to measure groundwater levels and quality in critical areas where data are sparse. These include increased coverage near streams, Subbasin boundaries, and in the central area of groundwater depression. We have the following comments. oLocations should be prioritized near high value or sensitive resources that are vulnerable to significant and unreasonable impacts, such as near the protected lands identified in our comments on Section 1.3.1 or the GDEs identified in the Subbasin. In addition to the major streams and rivers in the subbasin, impacts to smaller creeks and wetland areas should be considered, as these may be the most vulnerable resources. Please discuss the results of a resource assessment or consultations with resource managers that demonstrates a sufficient number of wells is proposed to address data gaps near GDEs and ISWs, and that they are being sited where they will provide the most benefit. Alternatively, please outline the process by which this will be accomplished. - As discussed in our comments above, please address how the need to link and correlate groundwater level declines to biological responses, and significant and unreasonable impacts to GDEs and ISWs will be addressed. - Well sites near ISWs should be selected at varying distances from streams and completed as vertically-nested clusters to capture the lateral and vertical gradients between the pumped depths in the aquifer system and the shallow groundwater aquifers that are in communication with ISWs or GDEs. There is a need to enhance monitoring of stream flow and vertical groundwater gradients by installing more stream gauges and clustered/nested wells near streams, rivers or wetlands. Ideally, co-locating stream gauges with clustered wells would enhance understanding about where ISWs exist in the basin and whether pumping is causing depletions of surface water or impacts on beneficial users of surface water and groundwater. - Addressing data gaps is typically iterative and it is not reasonable to expect it will be a one-time process. Please describe the process by which data gaps will be identified and addressed on an ongoing basis.	Monitoring Network	1) Comment noted for consideration as proposed monitoring well locations are finalized and future updates to the monitoring network is considered. Interconnected surface water was a major consideration in the placement of the proposed wells and almost all of the locations are very close to either major or minor streams. The two wells included in the TSS application are both deep, nested wells located near streams (Dry Creek and Calaveras River) and are anticipated to be drilled within a year. 2) The impact of groundwater level declines to beneficial users, as well as the effect of interconnected surface water and GDEs, will be considered in updates to the GSP and in the annual reports. 3) Comment noted for consideration as proposed monitoring well locations are finalized and future updates to the monitoring network (including evaluating the need for the installation of stream gauges) is considered. 4) The ESJGWA is committed to resolving the data gaps identified during the GSP development process. As discussed in Section 7.6.4 (Monitoring Network Description), a program may be developed for the GSP update to help fill any new or remaining data gaps. Data gaps will be continually reevaluated and addressed in updates to the GSP and in annual reports.
686	Sandi Matsumoto	The Nature Conservancy	Section 5.3, Table 5.3	Table 5.3 indicates that data regarding streamflow and GDEs is not currently included in the proposed Data Management System. Per the GSP Regulations (23 CCR §354.34 (a) and (b)), monitoring must address trends in groundwater and related surface conditions (emphasis added). You cannot manage what you do not measure. Please discuss which monitoring data for "related surface conditions" will be gathered and incorporated in the DMS to assess potential significant and unreasonable impacts to environmental beneficial uses and users.	DMS	Surface water data, including streamflow and water quality, is readily and publicly available online and has not be separately added to the DMS, though the system is set up to store streamflow and many other different types of data. Streamflow and surface water gage data was used both to build and calibrate the model, as well as in various analyses for the GSP. All groundwater level monitoring data will be evaluated for analysis of groundwater-surface water interaction and other surface conditions. As GDEs are a recognized data gap in the GSP, additional data may be collected that will be considered for addition to the DMS.
687	Sandi Matsumoto	The Nature Conservancy	Section 7.3.1	This section lists the key components involved in implementation of the monitoring network. Groundwater levels and monitoring will occur semi-annually, but no other information is given. Section 6.3 states that "additional management activities are discussed in Chapter 7: Plan Implementation", and would include monitoring groundwater use through use of satellite imagery. However, Chapter 7 does not discuss using imagery or any remote sensing, which is a great tool for monitoring ecosystem health of GDEs and ISWs. Please clarify the potential use of imagery as a monitoring tool, and expand it to monitoring surface indicators of ISW and GDE ecosystem health.	Monitoring Network	While there are currently no specific plans regarding the use of imagery is a monitoring tool, any publicly available tools will be evaluated for use in updates to the GSP. The text in Section 6.3 was edited to remove a mention of satellite imagery.
688	Sandi Matsumoto	The Nature Conservancy	Section 7.3.2.2	This section describes what current groundwater conditions and monitoring results will be included in the annual monitoring report. Please specifically address ecosystem health of GDEs and ISWs as a surface indictor to subsurface conditions. This can be done using GDE Pulse, remote sensing, imagery or other feasible methods.	Monitoring Network	While there are currently no specific plans regarding the use of imagery is a monitoring tool, any publicly available tools, including GDE Pulse, will be evaluated for use in updates to the GSP.

ESJ Public Comments Response

Comment #	Commenter	Commenter Organization	Section, Figure, or Table Number	Comment	Category	Response to Comment
689	Sandi Matsumoto	The Nature Conservancy	Section 6.2.1	The Subbasin includes many GDEs and ISWs which represent beneficial uses and users of groundwater, and which include potentially sensitive resources and protected lands. Environmental resource protection needs should be considered in establishing project priorities. In addition, consistent with existing grant and funding guidelines for SGMA-related work, priority should be given to multi-benefit projects that can address water quantity as well as providing environmental benefits or benefits to disadvantaged communities. Please include environmental benefits and multiple benefits as criteria for assessing project priorities.	Projects and Management Actions	See Master Response 5 - Projects. Multi-benefit projects will be pursued when feasible.
690	Sandi Matsumoto	The Nature Conservancy	Table 6.1	Table 6-1 lists potential projects and the Measurable Objective that is expected to benefit. Only water level benefits are listed, but maintenance or recovery of groundwater levels, or construction of recharge facilities, also will have environmental benefits in many cases. From the table, it is not possible to distinguish the full range of project benefits or how the projects will be prioritized. It would be advantageous to demonstrate multiple benefits from a funding and prioritization perspective.	Projects and Management Actions	Comment noted. The text in Chapter 6 (Projects and Management Actions) provides summaries of all potential SGMA projects, including expected project benefits.
691	Sandi Matsumoto	The Nature Conservancy	Section 6.2.4	- For the projects already identified, please consider stating how ISWs and GDEs will benefit or be protected, or what other environmental benefits will accrue. - If ISWs will not be adequately protected by those listed, please include and describe additional management actions and projects targeted for protecting ISWs. - Recharge ponds, reservoirs and facilities for managed stormwater recharge can be designed to include elements that act functionally as wetlands and provide a benefit for wildlife and aquatic species. In some cases, such facilities have been incorporated into local HCPs, more fully recognizing the value of the habitat that they provide and the species they support. For projects that will be constructing recharge ponds, please consider identifying if there will be habitat value incorporated into the design and how the recharge ponds will be managed to benefit environmental users. - Specific examples of how project descriptions may be refined to incorporate environmental benefits include the following: - Project 21: Winery Recycled Water will recycle winery wastewater and reuse it for irrigation and in-lieu recharge, or the water will be put into ponds. Please consider identifying what proportion of water will be put into ponds for direct recharge that could also provide a benefit for wildlife and aquatic species. - Project 23: SSJID Stormwater Reuse will capture stormwater for reuse and recharge. Project 18: Farmington Dam Repurpose Project proposes to more than double storage in Farmington Basin for water supply. Please consider assessing ways in which these projects could also provide enhanced wildlife and aquatic species benefits. - For examples of case studies on how to incorporate environmental benefits into groundwater projects, please visit our website: https://groundwaterresourcehub.org/case-studies/recharge-case-studies/E698	Projects and Management Actions	1) GSP projects have been proposed by individual GSAs and will be implemented at the GSA level. Although the ESJGWA does not have authority to direct project design or implementation, the ESJGWA's role will be to oversee essential project coordination by identifying where projects would be beneficial, synthesize how GSAs are doing projects, and make sure that GSA projects are getting the Subbasin to sustainability. Multi-benefit projects will be pursued when feasible. 2) Flood-Managed Aquifer Recharge (Flood-MAR) is an integrated and voluntary resource management strategy that uses flood water resulting from, or in anticipation of, rainfall or snow melt for managed aquifer recharge (MAR) on agricultural lands and working landscapes, including but not limited to refuges, floodplains, and flood bypasses. Flood-MAR can be implemented at multiple scales, from individual landowners diverting flood water with existing infrastructure, to using extensive detention/recharge areas and modernizing flood management infrastructure/operations (Source: https://water.ca.gov/Programs/All-Programs/Flood-MAR). 3) See also: Master Response 5 - Projects.
692	Sandi Matsumoto	The Nature Conservancy	Section 6.3	This section lists only administrative actions the GSA will undertake to implement the GSP, and does not identify the management actions to be taken if to assure SGMA compliance if monitoring data indicate that measurable objectives or interim milestones are not being achieved. An adaptive management approach, where monitoring data are used to assess results and inform refinement of the management approach is typically specified. Please identify what management actions will be taken if monitoring data indicate that Measurable Objectives or Interim Milestones are not being achieved, or undesirable results are imminent.	Projects and Management Actions	See Master Response 5 - Projects.
693	Sandi Matsumoto	The Nature Conservancy	N/A	IDENTIFYING GDEs UNDER SGMA Best Practices for using the NC Dataset [SEE MORE SPECIFICS IN ATTACHMENT C IN COMMENT LETTER]	GDEs	Comment noted, this is not a requirement of SGMA and can be evaluated in future iterations of the GSP as determined by the ESJGWA. Language was added to Section 4.7 (Data Gaps) to indicate that the ESJGWA would evaluate using the GDE Pulse Tool and other tools to monitor GDEs.
694	Sandi Matsumoto	The Nature Conservancy	N/A	GDE Pulse A new, free online tool that allows Groundwater Sustainability Agencies to assess changes in groundwater dependent ecosystem (GDE) health using satellite, rainfall, and groundwater data. [SEE SPECIFICS IN ATTACHMENT D IN COMMENT LETTER]	GDEs	Language was added to Section 4.7 (Data Gaps) to indicate that the ESJGWA would evaluate using the GDE Pulse Tool and other tools to monitor GDEs.
695	Joey Giordano	The Wine Group	Figure ES-6	On Figure ES-6, I would recommend adding the total for each column/section of the bar graph below the text for each section (i.e. "Pumping under Projected Conditions XX,XXX AF". The figure has less value when you have to rely on the units on the y-axis rather than having the totals for each section explicitly marked.	Mechanics - Graphics	Comment noted. This is beyond the scope of the GSP.
696	David Weisenberger	Banta-Carbona Irrigation District on behalf of Tracy Subbasin GSAs	Table 2-15	Table 2-15 on page 2-121 of the Draft GSP indicates that the Tracy Subbasin has historically contributed 35,000 acre-feet while it is projected to increase to 41,000 acre-feet of subsurface inflow annually to the Eastern San Joaquin Groundwater Basin. These figures have not been documented or confirmed by those GSAs participating in preparation of the Tracy Subbasin Groundwater Sustainability Plan (GSP). This line should be footnoted to indicate that these figures will be further refined upon completion of the Tracy Subbasin GSP in January of 2022, and coordination of these figures with the Tracy Subbasin GSAs.	Clarifying Edit	Added to note 6 on Table 2-15 to clarify that subsurface flows are an important component of continuing inter-basin coordination: Continuing inter-basin coordination may refine these numbers.

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APPENDIX 1-K.
NOTICE OF INTENT TO ADOPT A GSP

EASTERN SAN JOAQUIN GROUNDWATER AUTHORITY

1810 E. Hazelton Avenue
P. O. Box 1810
Stockton, CA 95201

(209) 468-3089
ESJgroundwater@sjgov.org
esjgroundwater.org

August 16, 2019

Via email and U.S. mail

To Whom it May Concern:

SUBJECT: NOTICE OF INTENT TO ADOPT A GROUNDWATER SUSTAINABILITY PLAN

On behalf of the Groundwater Sustainability Agencies (GSAs) comprising the Eastern San Joaquin Groundwater Authority (referred to herein as the ESJ GWA and as listed below), pursuant to California Water Code Section 10728.4, the ESJ GWA, on behalf of its member agencies, hereby gives notice to the legislative body of any City, County, or Public Utilities Commission-regulated company within the geographic area covered by the pending Eastern San Joaquin Groundwater Subbasin Groundwater Sustainability Plan (GSP) that its member GSAs intend to adopt the GSP for the Eastern San Joaquin Groundwater Subbasin (Basin No. 5-022.01). A map of the GSP area is included herein.

Interested parties may provide comments on the Public Draft GSP during the scheduled public comment period, July 10 through August 25, 2019. Information regarding the Draft GSP has been posted on the ESJ GWA website at www.esjgroundwater.org. The Draft Plan can be viewed on the website homepage. According to Water Code Section §10728.4: "A groundwater sustainability agency may adopt or amend a groundwater sustainability plan after a public hearing, held at least 90 days after providing notice to a city or county within the area of the proposed plan or amendment. The groundwater sustainability agency shall review and consider comments from any city or county that receives notice pursuant to this section and shall consult with a city or county that requests consultation within 30 days of receipt of the notice."

No sooner than 90 days from the date of this Notice, each of the GSAs identified below will hold a public hearing and consider adopting the GSP. For meeting information and public hearing dates, please refer to the ESJ GWA website.

Should you have any questions about this notice, please contact me by email at kbalaji@sjgov.org or by phone at (209) 468-3100.

Sincerely,

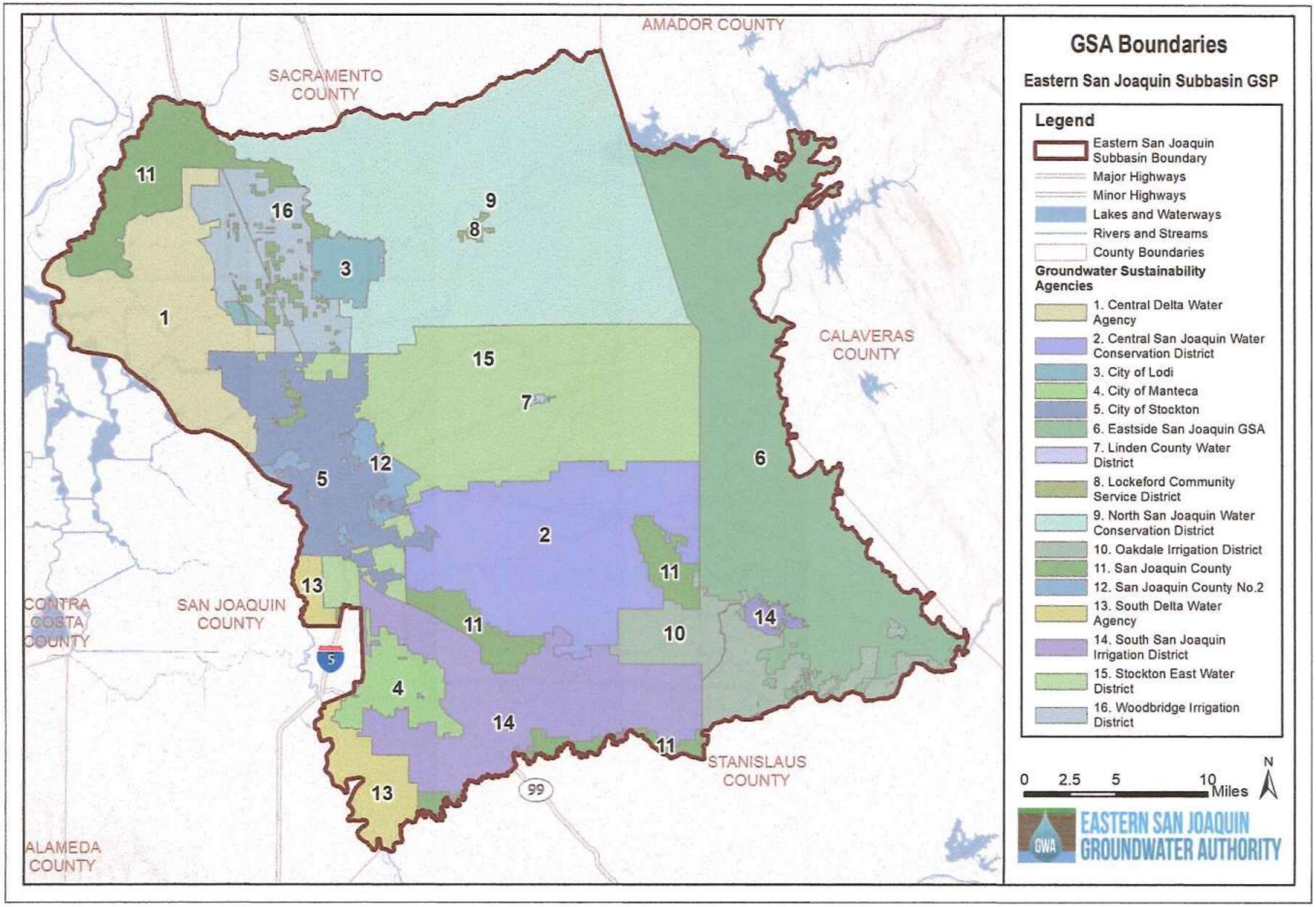
KRIS BALAJI, PMP, P.E.
Eastern San Joaquin Subbasin Plan Manager

NOTICE OF INTENT TO ADOPT A GROUNDWATER SUSTAINABILITY PLAN

Eastern San Joaquin Region Plan Manager: Kris Balaji, San Joaquin County

GSAs:

- Central Delta Water Agency
- Central San Joaquin Water Conservation District
- City of Lodi
- City of Manteca
- City of Stockton
- Eastside San Joaquin GSA
- Linden County Water District
- Lockeford Community Services District
- North San Joaquin Water Conservation District
- Oakdale Irrigation District
- County of San Joaquin GSA – Eastern San Joaquin 1
- County of San Joaquin GSA – Eastern San Joaquin 2
- South Delta Water Agency
- South San Joaquin GSA
- Stockton East Water District
- Woodbridge Irrigation District


GSA Boundaries
Eastern San Joaquin Subbasin GSP
Legend
Eastern San Joaquin Subbasin Boundary
Major Highways
Minor Highways
Lakes and Waterways
Rivers and Streams
County Boundaries
Groundwater Sustainability Agencies
1. Central Delta Water Agency
2. Central San Joaquin Water Conservation District
3. City of Lodi
4. City of Manteca
5. City of Stockton
6. Eastside San Joaquin GSA
7. Linden County Water District
8. Lockeford Community Service District
9. North San Joaquin Water Conservation District
10. Oakdale Irrigation District
11. San Joaquin County
12. San Joaquin County No.2
13. South Delta Water Agency
14. South San Joaquin Irrigation District
15. Stockton East Water District
16. Woodbridge Irrigation District
0 2.5 5 10 Miles
N
EASTERN SAN JOAQUIN GROUNDWATER AUTHORITY
GWA
AMADOR COUNTY
SACRAMENTO COUNTY
CALAVERAS COUNTY
SAN JOAQUIN COUNTY
CONTRA COSTA COUNTY
ALAMEDA COUNTY
STANISLAUS COUNTY
5
99

NOTICE OF INTENT TO ADOPT A GROUNDWATER SUSTAINABILITY PLAN

ATTEST:

CLERK

CENTRAL DELTA WATER AGENCY

AGENCY LEGAL NAME

8-15-19

By: Signature | Date

Dante John Nomellini

Printed Name

Manager and Cocounsel

Title

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NOTICE OF INTENT TO ADOPT A GROUNDWATER SUSTAINABILITY PLAN

ATTEST:

CLERK

Central San Joaquin WCD
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Grant Thompson
Printed Name

President
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NOTICE OF INTENT TO ADOPT A GROUNDWATER SUSTAINABILITY PLAN

ATTEST:

for Pamela M. Farris
CLERK

City of Lodi
AGENCY LEGAL NAME

[signature] 8/15/2019
By: Signature Date

Stephen Schwabauer
Printed Name

City Manager
Title

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(209) 333-6807
Fax

Approved as to Form:

JANICE D. MAGDICH
City Attorney

NOTICE OF INTENT TO ADOPT A GROUNDWATER SUSTAINABILITY PLAN

ATTEST:

[signature]
CLERK

City of Manteca
AGENCY LEGAL NAME

[signature] 8/15/19
By: Signature Date

TIM OGDEN
Printed Name

City Manager
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NOTICE OF INTENT TO ADOPT A GROUNDWATER SUSTAINABILITY PLAN

ATTEST:

CLERK

City of Stockton

AGENCY LEGAL NAME

By: Signature 8/15/19 Date

Laurie Montes

Printed Name

Acting City Manager

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209-937-7149

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ATTEST:

County of San Joaquin
AGENCY LEGAL NAME

CLERK ~~CLERK~~ , Deputy Director, Public Works

By: Signature 8/15/19
Date

Kris Balaji
Printed Name

Director of Public Works
Title

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NOTICE OF INTENT TO ADOPT A GROUNDWATER SUSTAINABILITY PLAN

ATTEST:

[signature]

CLERK

Eastside San Joaquin Groundwater Sustainability Agency
AGENCY LEGAL NAME

[signature] 8/16/2019
By: Signature Date

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NOTICE OF INTENT TO ADOPT A GROUNDWATER SUSTAINABILITY PLAN

ATTEST:

____
CLERK

LINDEN COUNTY WATER DISTRICT
AGENCY LEGAL NAME

[signature] 8/16/19
By: Signature Date

PAUL BRENNAN
Printed Name

PRESIDENT / ALTERNATE ADVISORY COMMITTEE MEMBER
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NOTICE OF INTENT TO ADOPT A GROUNDWATER SUSTAINABILITY PLAN

ATTEST:

CLERK

Email

Lockeford Community Services District

AGENCY LEGAL NAME

By: Signature 08/15/2019 Date

Joseph Salzman

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District Mananger

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n/a

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NOTICE OF INTENT TO ADOPT A GROUNDWATER SUSTAINABILITY PLAN

ATTEST:

____
CLERK

North San Joaquin Water Conservation District.
AGENCY LEGAL NAME

______________________ 8/15/19
By: Signature Date

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NOTICE OF INTENT TO ADOPT A GROUNDWATER SUSTAINABILITY PLAN

ATTEST:

CLERK

OAKDALE IRRIGATION DISTRICT
AGENCY LEGAL NAME

By: Signature 08/15/19
Date

Eric C. Thorburn
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NOTICE OF INTENT TO ADOPT A GROUNDWATER SUSTAINABILITY PLAN

ATTEST:

____
CLERK

SOUTH DELTA WATER AGENCY GSA
AGENCY LEGAL NAME

[signature] 8/15/19
By: Signature Date

JOHN HERRICK
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COUNSEL & MANAGER
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____
Fax

ATTEST:

South San Joaquin GSA
AGENCY LEGAL NAME

____
CLERK

By: Signature 8/15/19 Date

Brandon W. Nakagawa
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Water Resources Coordinator
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NOTICE OF INTENT TO ADOPT A GROUNDWATER SUSTAINABILITY PLAN

ATTEST:

CLERK

Stockton East Water District

AGENCY LEGAL NAME

08/15/19

By: Signature Date

Melvin Panizza

Printed Name

Board President

Title

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NOTICE OF INTENT TO ADOPT A GROUNDWATER SUSTAINABILITY PLAN

ATTEST:

Jessy Librato
CLERK

Woodbridge Irrigation District
AGENCY LEGAL NAME

Anders Christensen 8-16-2019
By: Signature Date

Anders Christensen
Printed Name

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EASTERN SAN JOAQUIN GROUNDWATER AUTHORITY
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Stockton, CA 95201
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ESJgroundwater@sjgov.org
esjgroundwater.org

April 15, 2022

Via E-mail and U.S. Mail

Calaveras County
San Joaquin County
Stanislaus County
City of Escalon
City of Lodi
City of Manteca
City of Ripon
City of Stockton

Re: ***Notice of Intent to Adopt an Amended Groundwater Sustainability Plan***

On behalf of the Groundwater Sustainability Agencies ("GSAs") comprising the Eastern San Joaquin Groundwater Authority (collectively, the "GSAs", as listed below), the Eastern San Joaquin Groundwater Authority ("Authority") hereby gives notice on behalf of its members that the GSAs intend to adopt an amended Groundwater Sustainability Plan for the Eastern San Joaquin Subbasin pursuant to California Water Code Section 10728.4. Pursuant to this section, this notice is provided to the cities and counties within the area of the proposed amended GSP.

The GSP, originally adopted by the GSA members of the Authority, was submitted to the Department of Water Resources ("DWR") on January 29, 2020, in compliance with the Sustainable Groundwater Management Act.[1] DWR completed its two-year review, and by letter dated January 28, 2022, determined the GSP to be incomplete and identified corrective actions that must be completed within 180 days of the determination.[2] Each of the GSAs intend to hold separate public hearings to consider adoption of the amended GSP after July 15, 2022, which is no earlier than ninety (90) days from the date of this notice.

Cities or counties that receive this notice may request in writing to consult on the GSP. Please submit any such requests to the undersigned using the contact information below within thirty (30) calendar days of receipt of this notice.

[1] Water Code §§ 10720, *et seq*.
[2] DWR's letter determination can be accessed on DWR's SGMA Portal website: https://sgma.water.ca.gov/portal/gsp/status

For further information regarding the amended GSP, to download copies of the public drafts of the amended GSP and for other information regarding the amendment and readoption of the GSP, please visit www.esjgroundwater.org.

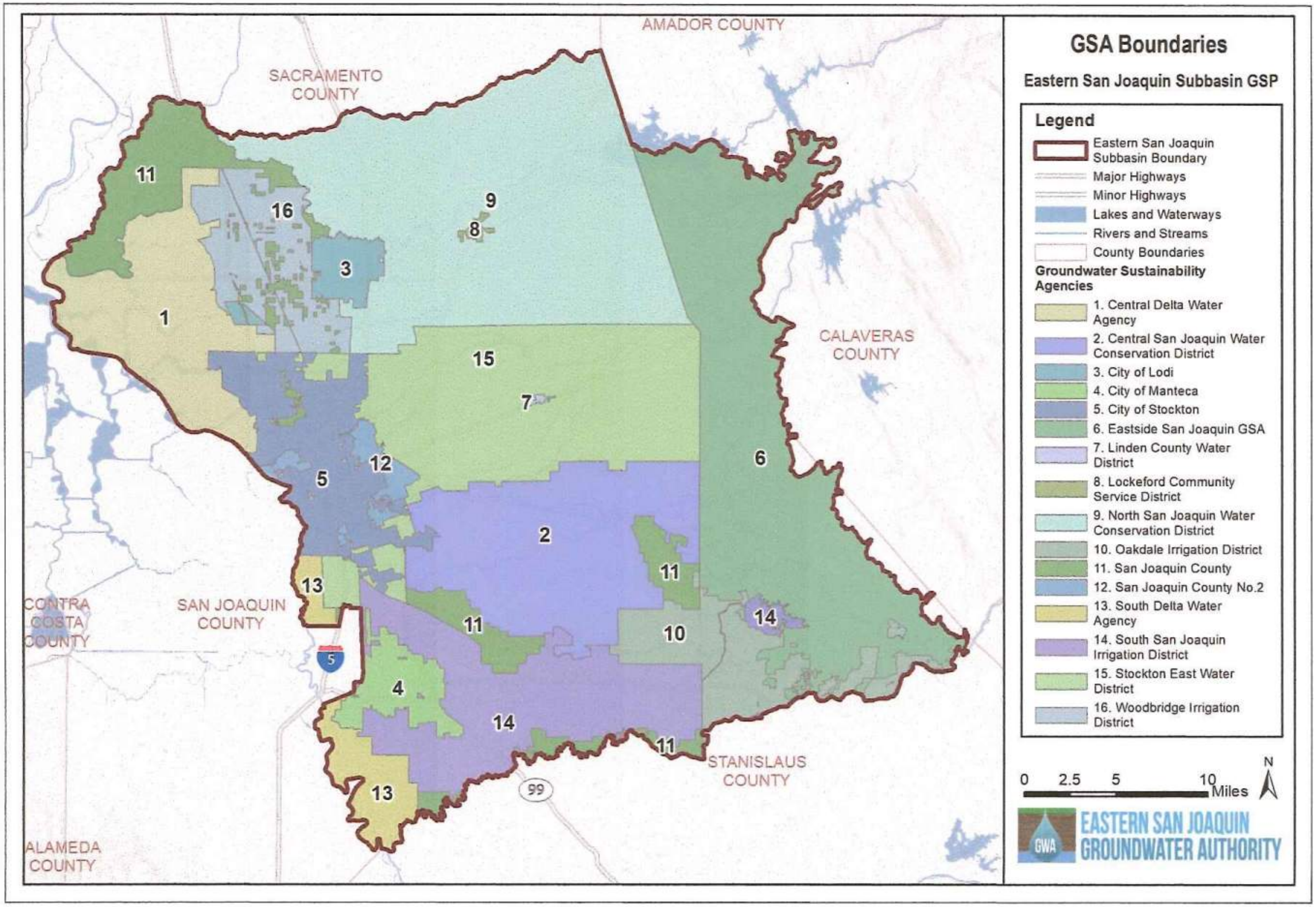
Very Truly Yours,

Kris Balaji, PMP, P.E.
Eastern San Joaquin Subbasin Plan Manager
kbalaji@sjgov.org
209-468-3100

GSAs in the Eastern San Joaquin Groundwater Subbasin:

Central Delta Water Agency
Central San Joaquin Water Conservation District
City of Lodi
City of Manteca
City of Stockton
Eastside San Joaquin GSA
Linden County Water District
Lockeford Community Services District
North San Joaquin Water Conservation District
Oakdale Irrigation District
San Joaquin County GSA No. 1
San Joaquin County GSA No. 2
South Delta Water Agency
South San Joaquin GSA
Stockton East Water District
Woodbridge Irrigation District

NOTICE OF INTENT TO ADOPT A GROUNDWATER SUSTAINABILITY PLAN



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APPENDIX 1-L.
NOTICE OF INTENT TO ADOPT A REVISED GSP

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APPENDIX 2-A.
EASTERN SAN JOAQUIN WATER RESOURCES MODEL (ESJWRM) REPORT

Eastern San Joaquin Water Resources Model (ESJWRM)

AUGUST 2018

WOODARD & CURRAN

EASTERN SAN JOAQUIN WATER RESOURCES MODEL (ESJWRM)

Final Report

August 2018

Prepared by

WOODARD & CURRAN

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SECTION **PAGE NO.**

TABLES

FIGURES

APPENDICES

LIST OF ABBREVIATIONS

AF and AFY	Acre-Feet and Acre-Feet Per Year
ASTM	American Standard Testing Method
AWMP	Agricultural Water Management Plan
C2VSim	California Central Valley Groundwater-Surface Water Simulation Model
Cal Water	California Water Service Company Stockton District
CALSIMETAW	California Simulation of Evapotranspiration of Applied Water
CASGEM	California Statewide Groundwater Elevation Monitoring
CCWD	Calaveras County Water District
CDEC	California Data Exchange Center
CFS	Cubic Feet per Second
CIMIS	California Irrigation Management Information System
County	San Joaquin County
CSJWCD	Central San Joaquin Water Conservation District
CVHM	Central Valley Hydrologic Model
DEM	Digital Elevation Model
DWR	California Department of Water Resources
ESJ Subbasin	Eastern San Joaquin Groundwater Subbasin
ESJWRM	Eastern San Joaquin Water Resources Model
ET	Evapotranspiration
ETAW	Evapotranspiration of Applied Water
GBA	Eastern San Joaquin County Groundwater Basin Authority
GMS	Aquaveo Groundwater Modeling System
GPCD	Gallons Per Capita Per Day
GSA	Groundwater Sustainability Agency
GSE	Ground Surface Elevation
GSP	Groundwater Sustainability Plan
GWA	Eastern San Joaquin Groundwater Authority
IDC	IWFM Demand Calculator
IGSM	Integrated Groundwater and Surface Water Model
IRWMP	Integrated Regional Water Management Plan
IWFM	Integrated Water Flow Model
KH	Aquifer Hydraulic Conductivity
KV	Aquifer or Aquitard Vertical Hydraulic Conductivity
LCSD	Lockeford Community Services District
LCWD	Linden County Water District
MAF and MAFY	Million Acre-Feet and Million Acre-Feet Per Year
METRIC	Mapping Evapotranspiration at High Resolution with Internalized Calibration
NASS	National Agricultural Statistics Service
NRCS	Natural Resource Conservation Service
NSJWCD	North San Joaquin Water Conservation District
OID	Oakdale Irrigation District
OSWCR	Online System for Well Completion Reports
PRISM	Precipitation-Elevation Regressions on Independent Slopes Model

PSDI	Pore Size Distribution Index
RMS	Root Mean Square
SEWD	Stockton East Water District
SGMA	Sustainable Groundwater Management Act
SS	Aquifer Specific Storage
SSJID	South San Joaquin Irrigation District
SSURGO	Soil Survey Geographic Database
STATSGO2	Digital General Soil Map of the United States
SY	Aquifer Specific Yield
TAF and TAFY	Thousand Acre-Feet and Thousand Acre-Feet Per Year
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UWMP	Urban Water Management Plan
WDL	Water Data Library
WID	Woodbridge Irrigation District

ACKNOWLEDGEMENTS

In December 2015, San Joaquin County (County) applied for Proposition 1's Counties with Stressed Basins Grant and received approval for $499,900. With a fifty percent cost share with the California Department of Water Resources, the County executed a contract with Woodard & Curran (formerly RMC Water and Environment), on September 13, 2016 to begin work on a hydrologic model for the Eastern San Joaquin Groundwater Subbasin. The purpose of the resulting model, the Eastern San Joaquin Water Resources Model (ESJWRM), is to support activities in long-term management of the Eastern San Joaquin Subbasin at the local scale, specifically focusing on meeting the goals and requirements of the Sustainable Groundwater Management Act.

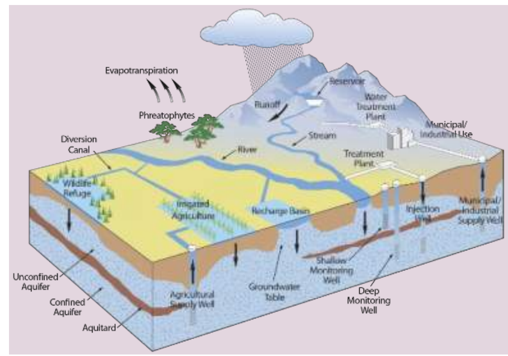
A technical committee provided quality assurance and technical support throughout the project, resulting in a groundwater model widely accepted by local shareholders and public agencies. The committee was an informal group consisting of technical representatives from local agencies, consultants with knowledge of the area, representatives for neighboring groundwater subbasins, Department of Water Resources (DWR) staff, and San Joaquin County personnel. Local agencies with consistent representation included San Joaquin County, Woodbridge Irrigation District, City of Lodi, North San Joaquin Water Conservation District, Lockeford Community Services District, Calaveras County Water District, City of Stockton, California Water Service Company Stockton District, Stockton East Water District, City of Lathrop, City of Manteca, South San Joaquin Irrigation District, City of Escalon, Oakdale Irrigation District, and Stanislaus County.

The Main Project Team included:

- Woodard & Curran (formerly RMC Water and Environment)
    - Alyson Watson, Project Principal
    - Ali Taghavi, Project Manager
    - Sevim Onsoy, Project Support
    - Jeanna Long, Data Management System Lead
    - Sara Miller, Project Engineer
- NV5

EXECUTIVE SUMMARY

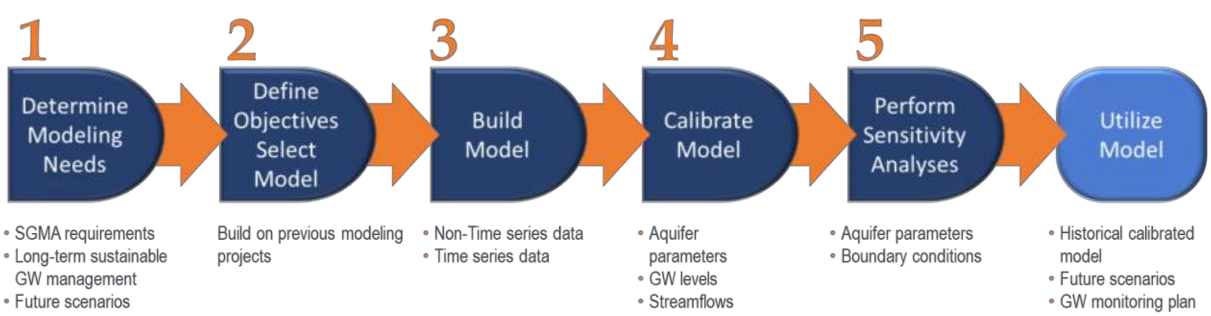
The Eastern San Joaquin Water Resources Model (ESJWRM) was developed to evaluate the surface water and groundwater resources in the Eastern San Joaquin Groundwater Subbasin (ESJ Subbasin) during recent historical hydrologic conditions. This period covers water years 1995 through 2015, and includes several above normal and wet years, as well as the most recent drought conditions. The model is designed to simulate the regional water resources conditions in the ESJ Subbasin, including the land surface processes, groundwater operations, stream and river systems, and the interaction between these resources.



Development of the ESJWRM occurred in an open and transparent process over approximately 24 months, starting in September 2016. Model development was a collaborative process between San Joaquin County staff, local water agencies, and Woodard & Curran, as consultant and developers of the model. The model was developed by partial funding from the Department of Water Resources (DWR), and as such, the DWR staff were engaged and collaborated in development of the model.

A technical committee provided quality assurance and technical support throughout the project, resulting in an integrated water resources model widely accepted by local shareholders and public agencies. The committee was an informal group consisting of technical representatives from local agencies, consultants with knowledge of the area, representatives from neighboring groundwater subbasins, DWR staff, and San Joaquin County personnel. Local agencies with consistent representation included San Joaquin County, Woodbridge Irrigation District, City of Lodi, North San Joaquin Water Conservation District, Lockeford Community Services District, Calaveras County Water District, City of Stockton, California Water Service Company Stockton District, Stockton East Water District, City of Lathrop, City of Manteca, South San Joaquin Irrigation District, City of Escalon, Oakdale Irrigation District, and Stanislaus County.

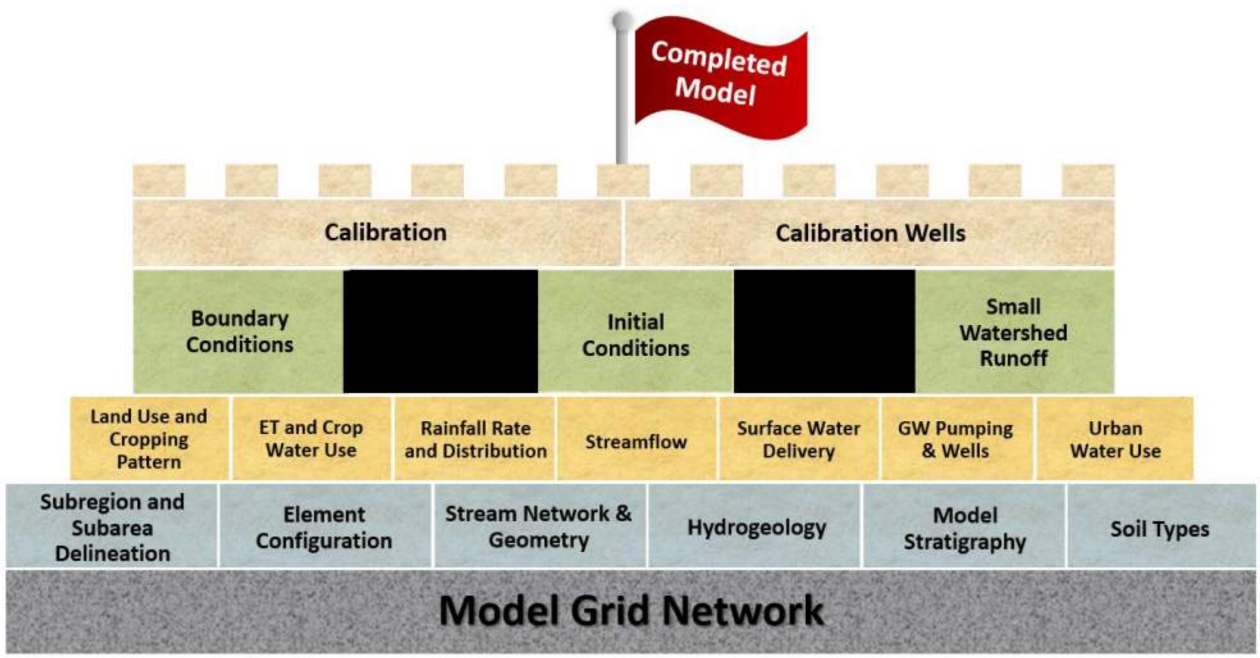
ESJWRM development followed a robust process as shown below. Modeling needs were established in early 2015, shortly after the passage of the Sustainable Groundwater Management Act (SGMA). Subsequently, modeling goals and objectives were discussed and established, and San Joaquin County was successful in securing funds through Proposition 1 to begin development of the model.



ESJWRM development required a significant amount of data and information, including hydrologic, hydrogeologic, topographic and soil conditions, land use and cropping patterns, urban and agricultural water demand, urban and agricultural water supplies, surface water conveyance and distribution systems, groundwater infrastructure and extraction, and irrigation practices. The following figure shows the type of data and information needed to develop the model. A collaborative process was followed to collect and analyze, fill data gaps, and develop proper assumptions for the use, context, and accuracy of the data, before analyzing and properly formatting the data for input in the model.

Once the model was constructed, appropriate state-of-the-art scientific and engineering protocols and guidelines were utilized to calibrate the model to ensure that:

- Water budgets generated by the model represent the regional and local understanding of the agricultural and urban entities represented in the model. The model-generated water budgets showing water demand and supply and the groundwater system are prepared and reported on both monthly and annual scales for urban and agricultural entities as well as at the subbasin scale.
- Monthly groundwater levels generated by the model at select observation wells throughout the subbasin closely follow the long-term annual trends and short-term seasonal fluctuations that are recorded and reported at the observation wells.
- Monthly streamflow generated by the model at select gauging stations closely follow the high and low flows as reported.

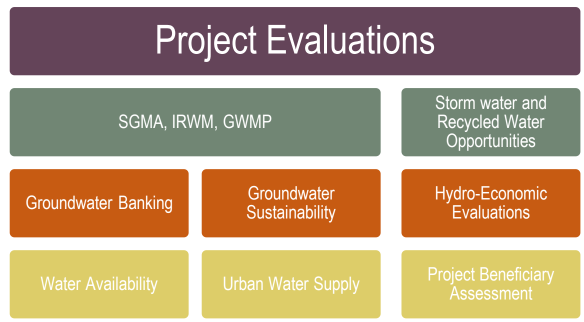


The calibrated ESJWRM provides detailed conditions of the ESJ Subbasin over the calibration period of water years 1996 through 2015. This calibrated model can be used for understanding subbasin characteristics and the effects of historical surface water and groundwater operations as well as irrigation practices or urban operations on the groundwater and surface water resources in the ESJ Subbasin. These include:

- Historical and current levels of development
- Subbasin operations under natural conditions
- Nature, extent, and rates of stream-aquifer interaction

- Effects and benefits of upstream regulation of rivers on the operations of the groundwater subbasin
- Effects of operations of regional water supply projects, including conjunctive use, on subbasin conditions
- Evaluation of water quality conditions in the subbasin

Additionally, the calibrated model can be used to develop baseline conditions representing projections of land use, population growth, water demand, and water supply conditions, as estimated based on local and regional planning activities. The baseline model, as a robust, defensible, and detailed tool, may be used for assessing the current and projected water resources conditions in the basin to support various local and regional planning projects and programs, such as the development and implementation of a Groundwater Sustainability Plan (GSP). ESJWRM may also be used to evaluate the effectiveness of different projects that may be proposed through the GSP development process. The fine scale of the model also provides the opportunity for individual Groundwater Sustainability Agencies (GSAs) to evaluate the effects of ESJ Subbasin conditions on smaller GSA areas.



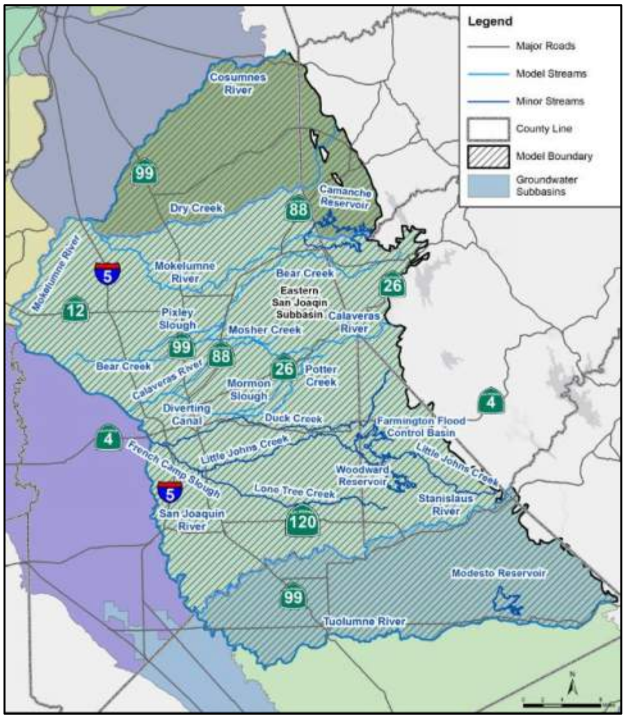
Some of the key features of the ESJWRM are as follows:

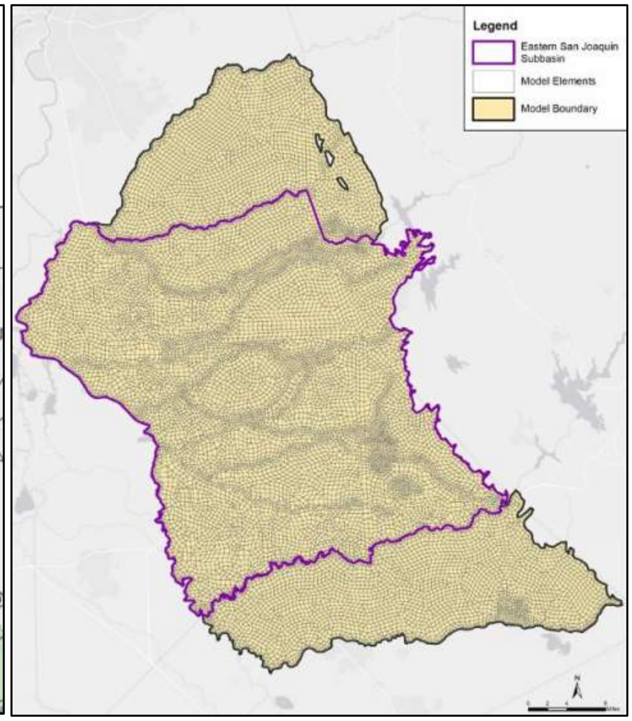
Model Platform

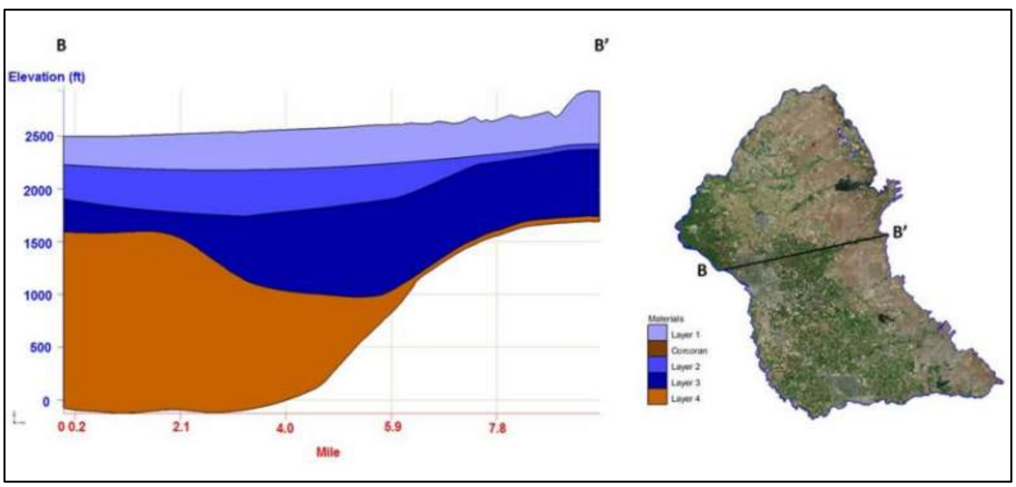
The model code platform is the DWR's Integrated Water Flow Model (IWFM-2015). This code platform was developed by DWR to simulate the integrated hydrologic conditions of a groundwater basin, with interactions between the surface water, groundwater, and stream system. The code platform has specific strengths in the calculation of agricultural water demand in a predominantly agricultural area, such as the Eastern San Joaquin Subbasin. The code platform is supported by the DWR modeling support staff for local and regional applications, including SGMA implementation.

Model Area

The model covers the entire area of the Eastern San Joaquin Groundwater Subbasin, as defined by DWR Bulletin 118, as well as the areas of the Modesto and Cosumnes Groundwater Subbasins (the basins immediately north and south of the ESJ Subbasin). The model area is subdivided into small units (elements). A comprehensive integrated hydrologic process and analysis is conducted at each model element, and surface water and groundwater flows are calculated and simulated across elements, and throughout the entire model area on a monthly time step, in such a way that mass balance is preserved every month. Additionally, each element represents the geologic and hydrogeologic conditions of the subsurface environment as represented by four model layers in a conceptual context.

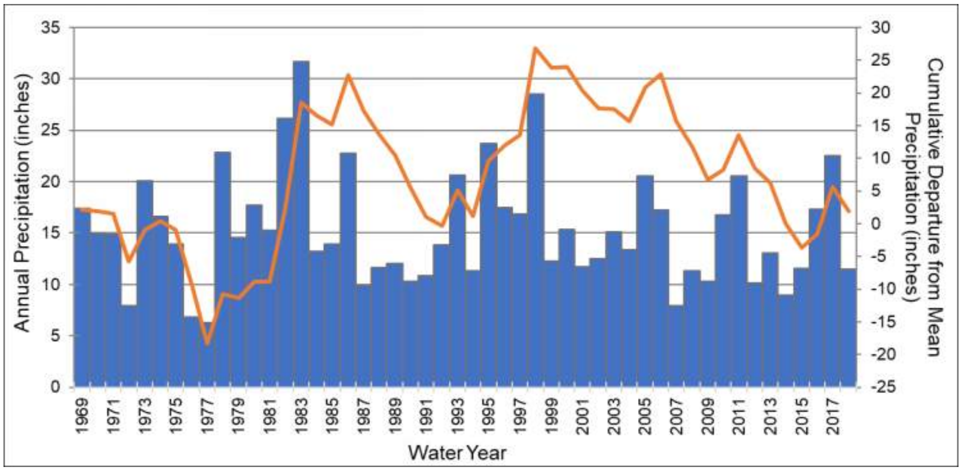


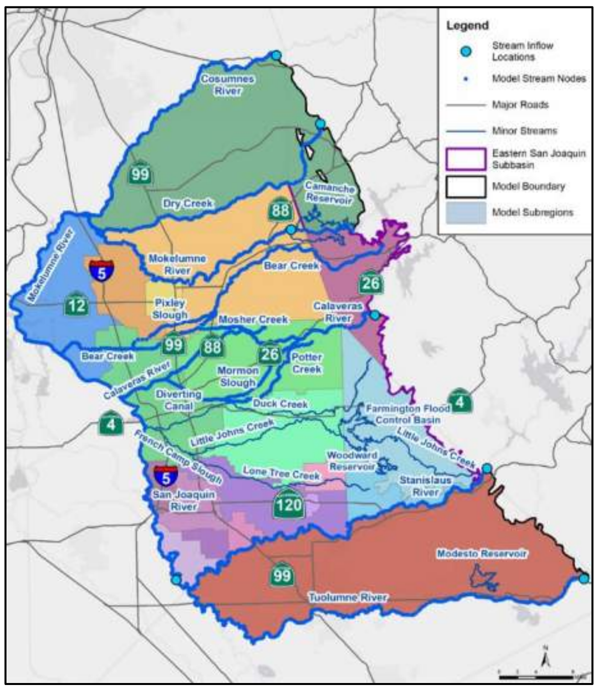




Hydrology

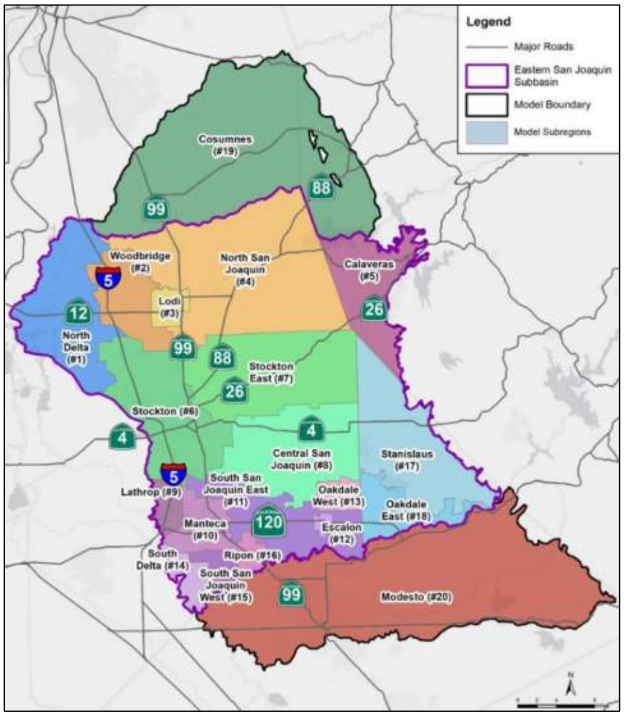
The model contains 50 years of hydrologic period (water years 1969 through 2018), which provides opportunities to assess the basin conditions during above normal, below normal, and drought periods. The model is calibrated during the period of 1996-2015, during which there are more robust and defensible data available for model calibration. In addition, the model includes major and minor rivers and creeks in the area and calculates stream-aquifer interaction along the major rivers and creeks. The minor creeks and canals represented in the model are used for conveyance of irrigation water and drainage.

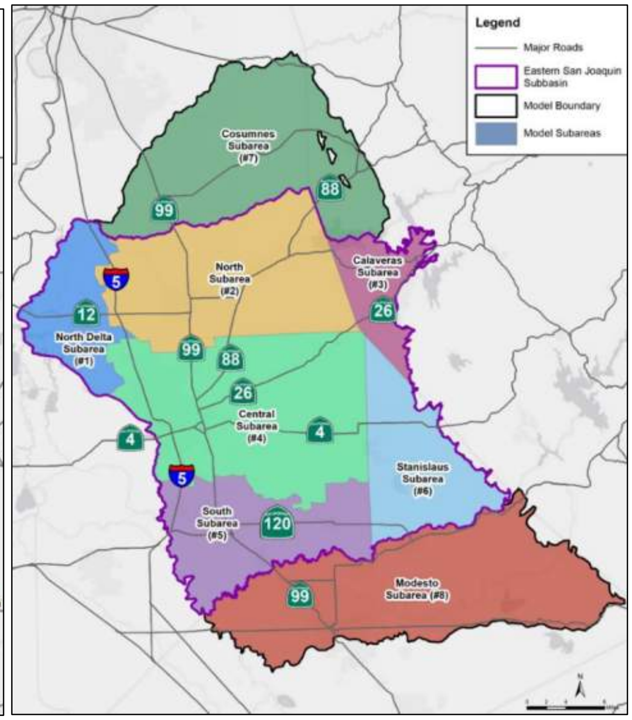




Model Subareas

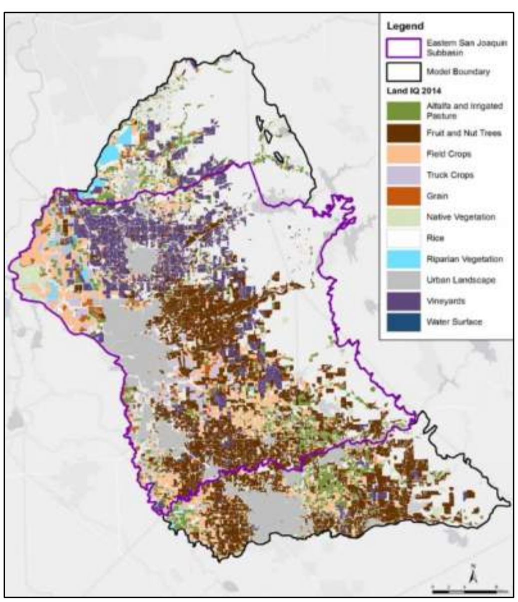
The model elements are aggregated into larger geographic areas, which represent individual agricultural and urban entities (Subregions) and larger planning areas (Subareas). These larger areas can be used to prepare model input data and to analyze model generated water budgets for planning purposes.

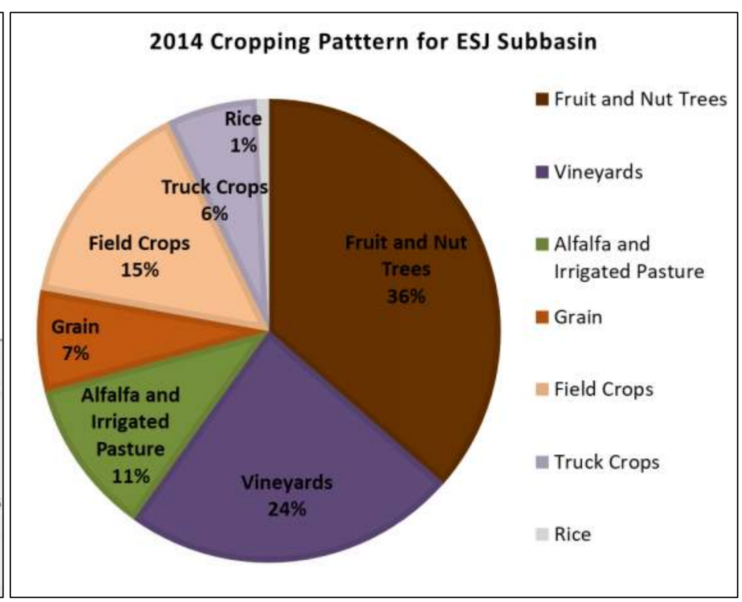




Land Use and Agricultural Cropping Pattern

A key data set used in the model is the distribution of land between agricultural, urban, native, and riparian land use categories, as well as acreages of major crops in the agricultural lands. This information is prepared and processed based on land use surveys prepared and reported by the DWR (DWR, 1993-2000), remote sensing data from the United States Department of Agriculture called CropScape (USDA NASS, 2007-2015), and the DWR Land IQ dataset (DWR, 2014). This information was compiled, analyzed, and evaluated for each model element; compared and cross-checked with data and information from the agricultural entities; and finalized for use in the model.

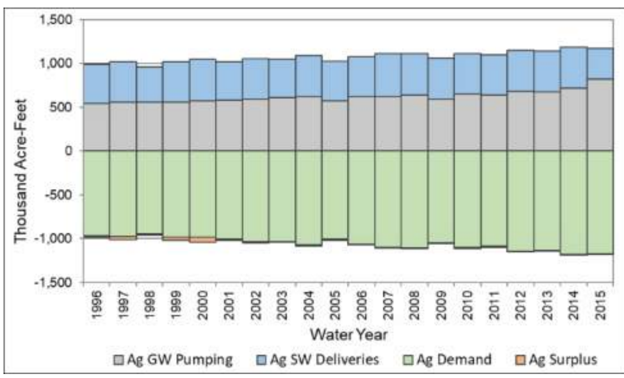


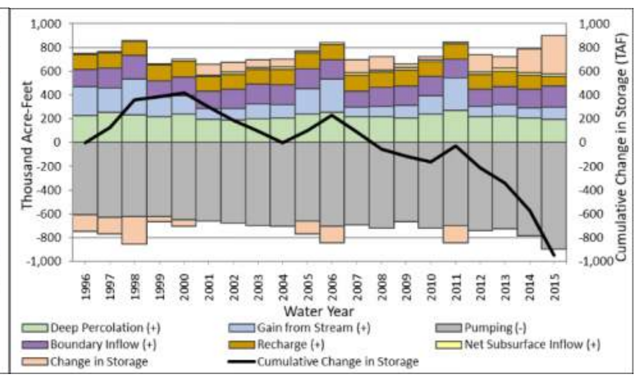


Water Budgets

The model produces water budgets for land surface processes, including an estimate of urban and agricultural water demands, and water supplies. In addition, the model produces water budgets for the groundwater system, including groundwater pumping to meet irrigation demand and urban water needs, deep percolation from rainfall and irrigation applied water, subsurface flows from neighboring groundwater subbasins and the Sierra Nevada foothills, seepage from unlined conveyance canals, and flows between the stream and the aquifer system. The model can present this information on both a monthly and annual basis. Local operations data and information was collected from various water users and model parameters were adjusted to calibrate the model outcome to the reported values. Model calibration was conducted in an open and transparent process to ensure that the water budgets and model calibration results are properly representing the conditions of the groundwater basin to the extent that information is available.

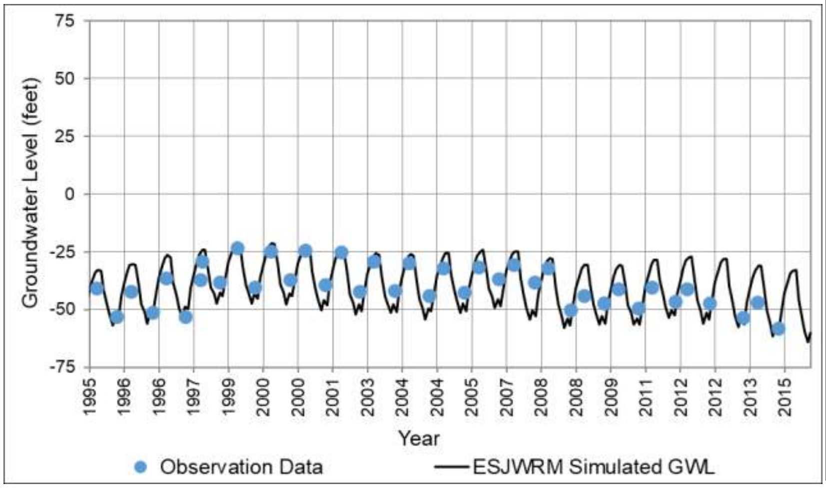
An annual representation of the groundwater budget can reveal overall changes in groundwater storage, as depicted in the chart below. Uncertainties are inherent in every data set and calculation. Through a systematic sensitivity analysis, the range of impacts of uncertainties on model calculations was quantified. Knowledge of this range of uncertainties can assist in providing flexibility in decisions that rely on model results. The average annual depletions in groundwater storage for the historical period of 1996-2015 is estimated to be about 24,000 to 70,000 acre-feet per year (AFY), with an average depletion of 47,000 AFY.

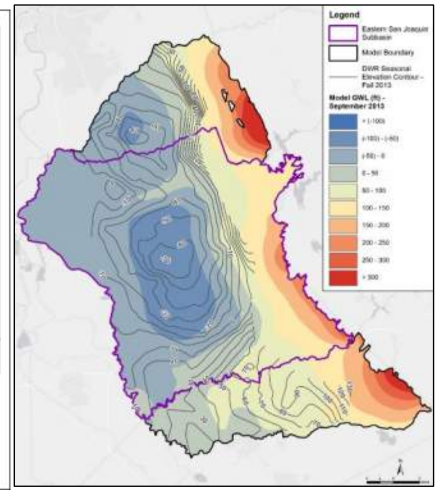


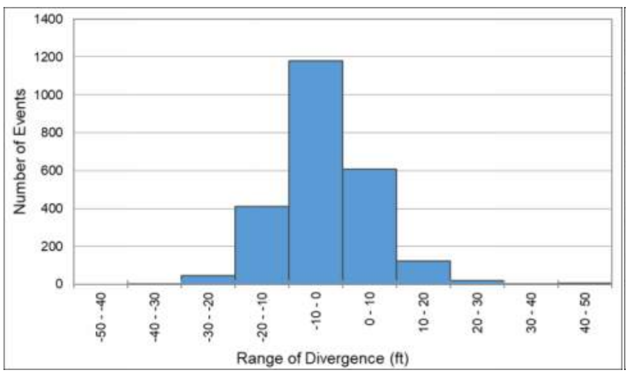


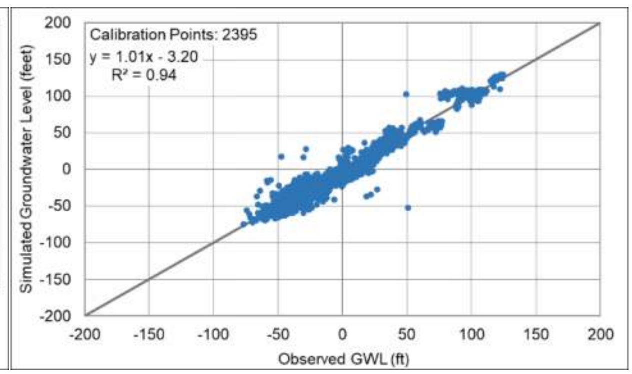
Groundwater Levels

The model-calculated groundwater levels are calibrated to observed groundwater levels at key wells over time. The typical goal of this calibration process is to adjust hydraulic parameters that influence the movement of groundwater such that the groundwater levels calculated by the model at the specific observation wells throughout the model area track short-term seasonal fluctuations and long-term trends as closely as possible. A typical model produced result is shown in the chart below. Once calibrated, the model produces regional groundwater levels for select points in time, as shown in the figure below. Model calibration statistics are represented in the following figures, which indicate that 75% of model calculated groundwater levels are within 10 feet of reported observations, and 97% are within 20 feet of reported observations. Given the uncertainties in the measurement of reported values, as well as uncertainties in model calculations, and expected calibration results for similar models as reported in the scientific communities, this statistic represents a very good model performance.



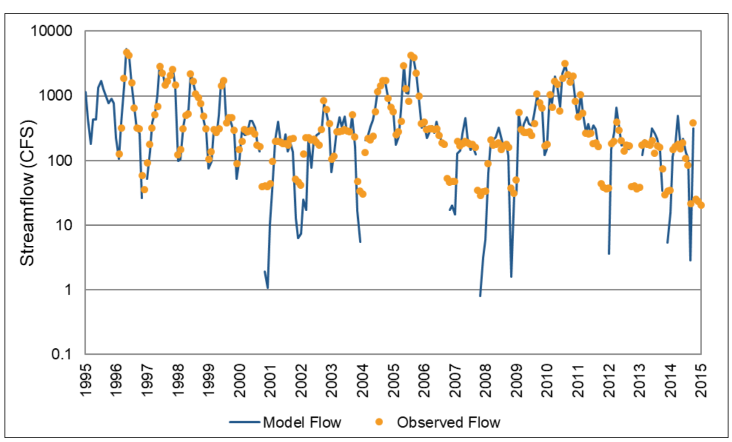






Streamflows

The model calculates flow of water in the stream system throughout the basin. Streamflows are subject to the diversion of water for beneficial agricultural uses or urban consumption, return flows from irrigation practices, runoff of rainfall, as well as gains and losses due to interaction with the groundwater system. The model stream system is calibrated to reported flows at the downstream gauging stations. The chart below shows the comparison between model calculated streamflow and gauge records on Mokelumne River at Woodbridge. The results indicate that the model is capable of simulating both the low and the high flows reasonably well.



Conclusions and Recommendations

The ESJWRM, in its current state, is a robust, comprehensive, defensible and well-established model for assessing the water resources in the ESJ Subbasin under historical and projected conditions. The following recommendations are to be considered for further refinements and enhancements of the model:

- **Continue engagement with local groundwater users and managers**. Continue working with local agencies and groundwater users in ESJ Subbasin to further understand the local operations of the groundwater system and improve representation of groundwater users in the ESJWRM.
- **Refinement of boundary flows**. The current boundary flows at the northern, western, and southern boundaries of the model area are based on an older version of the C2VSim with adjustments made based on initial groundwater levels assumed for the beginning of the model (October 1994). DWR is currently in the process of updating the C2VSIm model. Once the latest fine grid version (C2VSim-2015) is publicly available, boundary flows for the ESJ model area should be verified and updated, as necessary.
- **Enhance variability of potential evapotranspiration**. The current version of the IDC used for estimation of the consumptive use of crops in the ESJWRM uses monthly potential ET values that are the same for all years during the model period. Given that there may be annual variability in the potential ET data with possible effects on the annual estimation of crop water demand, it is recommended to use more detailed data with temporal variability to develop a full time series of ET values for use in the model.
- **Refine surface water deliveries in Cosumnes and Modesto Subbasins.** The surface water deliveries in the Cosumnes and Modesto Subbasins are currently at the subregion level and do not have the detailed spatial resolution of other areas within the ESJ Subbasin. This data may need to be verified and updated as modeling efforts in those subbasins progress to meet the requirements of SGMA.
- **Update C2VSim based on ESJWRM**. The fine grid version of C2VSim was developed by the DWR to evaluate the integrated surface water and groundwater conditions at a regional scale; whereas, the ESJWRM is capable of evaluation at the local scale. To increase the accuracy of regional groundwater conditions in the fine grid C2VSim, the County is encouraged to work with DWR to provide data and information for further refinement and update of C2VSim in the ESJWRM area.
- **Develop model update schedule**. In order to keep the ESJWRM up-to-date and current for analysis of water resources and especially for supporting SGMA implementation, it is recommended that the model be updated every 3 to 5 years. A possible update schedule can be kept consistent with the GSP updates, with a lead time of 2 to 3 years relative to the GSP update schedule.

1. INTRODUCTION

1.1 Goals of Model Development

The Eastern San Joaquin Water Resources Model (ESJWRM) was developed primarily to evaluate the current and recent historical groundwater conditions of the Eastern San Joaquin Groundwater Subbasin (ESJ Subbasin) and simulate various future condition scenarios as part of the Groundwater Sustainability Plan (GSP) preparation process under the Sustainable Groundwater Management Act (SGMA). ESJWRM will also be used to evaluate the effectiveness of different projects that may be proposed through the GSP development process. The fine scale of the model also provides the opportunity for individual Groundwater Sustainability Agencies (GSAs) to evaluate the effect of changing ESJ Subbasin conditions on smaller GSA areas.

1.2 Eastern San Joaquin Groundwater Subbasin

The ESJ Subbasin underlies portions of San Joaquin, Calaveras, and Stanislaus counties, with the majority of the area in San Joaquin County (Figure 1). San Joaquin County is located in the northeastern San Joaquin Valley and contains portions of the Sacramento-San Joaquin River Delta.

In 2014, the ESJ Subbasin was categorized as a high priority groundwater subbasin under the California Statewide Groundwater Elevation Monitoring (CASGEM) program. The ESJ Subbasin has been identified by the California Department of Water Resources (DWR) as critically overdrafted and is included in the List of Critically Overdrafted Basins finalized in January 2016. As a critically overdrafted subbasin, GSAs in the ESJ Subbasin must develop a GSP by January 31, 2020 that details how the ESJ Subbasin will be managed in a sustainable manner by 2040. The other groundwater subbasins immediately surrounding the ESJ Subbasin are not critically overdrafted except for the Delta-Mendota Subbasin (Figure 2).

The major municipalities in the ESJ Subbasin are the cities of Lodi, Stockton (including California Water Service Company Stockton District or Cal Water), Lathrop, Manteca, Ripon, and Escalon. The major agricultural water providers in the ESJ Subbasin include Woodbridge Irrigation District (WID), North San Joaquin Water Conservation District (NSJWCD), Stockton East Water District (SEWD), Central San Joaquin Water Conservation District (CSJWCD), South San Joaquin Irrigation District (SSJID), and Oakdale Irrigation District (OID). The major municipalities and agricultural water providers are all GSAs. Other agencies which supply water or have land use authority within the ESJ Subbasin and have been designated as GSA's are San Joaquin County, Stanislaus County (in combination with CCWD and Rock Creek Water District), Calaveras County Water District (CCWD), North and South Delta Water Agencies, Lockeford Community Services District (LCSD), and Linden County Water District (LCWD). The 17 GSAs covering ESJ Subbasin and their corresponding member agencies are listed in Table 1. The water purveyors are shown in Figure 3a and the GSAs are shown in Figure 3b.

Table 1: ESJ Subbasin GSAs and Member Agencies

GSA	Member Agency
Central Delta Water Agency	Central Delta Water Agency
Central San Joaquin Water Conservation District	Central San Joaquin Water Conservation District
City of Lathrop	City of Lathrop
City of Lodi	City of Lodi

GSA	Member Agency
City of Manteca	City of Manteca
City of Stockton	City of Stockton
Eastside San Joaquin GSA	Calaveras County Water District Stanislaus County Rock Creek Water District
Linden County Water District	Linden County Water District
Lockeford Community Services District	Lockeford Community Services District
North San Joaquin Water Conservation District	North San Joaquin Water Conservation District
Oakdale Irrigation District ESJ Subbasin GSA	Oakdale Irrigation District
San Joaquin County	San Joaquin County
San Joaquin County No. 2	San Joaquin County Cal Water
South Delta Water Agency	South Delta Water Agency
South San Joaquin GSA	South San Joaquin Irrigation District City of Ripon City of Escalon
Stockton East Water District	Stockton East Water District
Woodbridge Irrigation District	Woodbridge Irrigation District

1.3 Local Coordination

The development of the ESJWRM took place in an open and transparent process. The 17 GSAs of the ESJ Subbasin coordinate SGMA activities through the formation of the Eastern San Joaquin Groundwater Authority (GWA). The Eastern San Joaquin County Groundwater Basin Authority (GBA) was the organizational structure for agency coordination of water resources activities before SGMA regulations and the formation of the GWA. Many of the GBA/GWA agency members participated in a Technical Review Committee, which acted as the forum to review model input data and assumptions, as well as calibration results. The Technical Review Committee helped to facilitate major modeling decisions, provided input data, and reviewed results. The monthly Technical Review Committee meetings were open to all interested parties and generally consisted of technical representatives from local agencies, consultants with knowledge of the area, representatives for neighboring groundwater subbasins, DWR staff, and San Joaquin County personnel. Presentations given to this group are included in Appendix A and highlight major model configuration decisions, data analysis, and draft model results.

Local agencies with consistent representation at the Technical Review Committee meetings included San Joaquin County, WID, City of Lodi, NSJWCD, LCSD, CCWD, City of Stockton, Cal Water, SEWD, City of Lathrop, City of Manteca, SSJID, City of Escalon, OID, and Stanislaus County.

1.4 Model Platform

The ESJ Subbasin has been modeled since the mid-1980s. In 1993, as part of the Bureau of Reclamation's American River Watershed Investigation, an integrated model was developed based on the Integrated

Groundwater and Surface Water Model (IGSM) code. This model was developed in coordination with the San Joaquin County (County) and DWR and was used to analyze several conjunctive use programs and projects. In 2001, the San Joaquin County IGSM model was converted to a DYNFLOW platform (a proprietary finite element groundwater flow model) and was used for the County's Water Management Plan (CDM, 2008). The model originally simulated a period of October 1969 through September 1993 and was updated in 2007 for the Eastern San Joaquin Integrated Regional Water Management Plan (IRWMP) to simulate hydrologic conditions through September 2006. The proprietary nature of DYNFLOW makes the model not suitable to support subbasin analysis as part of GSP development per SGMA requirements.

With the award of Proposition 1's Counties with Stressed Basins Grant, the determination was made to combine data from the older models into a new, local-scale model using DWR's code that updated and replaced IGSM, called Integrated Water Flow Model (IWFM). IWFM is an open-source, finite element simulation code that supports triangular and quadrilateral elements (Dogrul et al., 2017a). It was specifically designated in GSP regulations as being supported by DWR for water budget development and SGMA compliance. It is also the code used for DWR's California Central Valley Groundwater-Surface Water Simulation Model (C2VSim), the fine grid version of which is being refined and enhanced by DWR to support SGMA activities throughout the Central Valley at the regional scale (Brush et al., 2013). C2VSim was developed using the same methodology and source data as were ESJWRM's datasets. To maintain consistency, ESJWRM relies on C2VSim for many of its datasets.

The IWFM Demand Calculator (IDC) is the stand-alone root zone component of IWFM that simulates land surface and root zone flow processes (Dogrul et al., 2017b). It calculates agricultural and urban water demands using inputs including climate conditions, soil parameters, and land use types and distribution. It can be run separately or combined with IWFM. IDC data development and results in this documentation are included as part of all other IWFM datasets and results. The IDC major data pieces and draft results were initially presented in a February 1, 2018 Technical Memorandum (Appendix B).

At the October 26, 2016 Technical Review Committee meeting, the decision was made to keep the model domain the same as for the DYNFLOW model. The County's DYNFLOW model included the ESJ Subbasin, as well as the Cosumnes Subbasin to the north and the Modesto Subbasin to the south. The ESJ Subbasin is the primary model area and the secondary model area includes the Cosumnes and Modesto Subbasins. The physical model boundaries are included in Table 2 and shown in Figure 4.

Table 2: Physical Model Boundaries

Boundary	Entire Model	Primary Model Area (ESJ Subbasin)
North	Cosumnes River	Dry Creek and County Boundary (including Mokelumne River)
East	Sierra Nevada Foothills	Sierra Nevada Foothills
South	Tuolumne River	Stanislaus River
West	San Joaquin River	San Joaquin River

2. MODEL DEVELOPMENT

This section presents the source and analysis of input data used in the development of ESJWRM. This includes spatial and temporal information for hydrologic and hydrogeologic data sets included in the model, as well as physical parameters and assumptions.

2.1 Model Input Data

The historical ESJWRM simulates water years 1995 through 2015 (October 1, 1994 through September 30, 2015). All data and computations are performed on a monthly time step. IWFM model files and corresponding major data sources and report sections are referenced below in Table 3.

Table 3: ESJWRM Major Model Data

Major Data Category	Minor Data Category	Data Source	Report Section
Hydrogeological Data	Geologic Stratification	C2VSim	2.9
	Aquifer Parameters	USGS Texture Model	4.7
Stream Data	Stream Configuration	C2VSim & San Joaquin County	2.3
	Stream Inflow	USGS & USACE Stream Gauges	2.3
	Calibration Gauges	USGS & CDEC Stream Gauges	4.3
Hydrological Data	Precipitation	PRISM & CalSIMETAW	2.4
Agricultural Water Demand	Land Use	DWR CropScape Land IQ Ag Commissioner's Report Local Information	2.6
	Evapotranspiration	C2VSim METRIC Local Information	2.7
	Soil Properties	SSURGO & STATSGO2	2.5
Urban Water Demand	Population	U.S. Census Bureau & Local Information	3.2
	Per Capita Water Use	Local Information (UWMPs)	3.2
Water Supply	Groundwater Pumping	Local Information	3.3.2
	Surface Water Deliveries	Local Information	3.3.1
Other	Boundary Conditions	C2VSim & Local Information	2.11
	Initial Conditions	C2VSim	2.12
	Small Watersheds	C2VSim	2.10
	Calibration Wells	DWR & Local Information	4.5

The hydrologic period used to build the model data files was water years 1969 through 2018 (October 1, 1968 through September 30, 2018). This allows for future work to use a longer model run time using actual historical rainfall and stream inflow records.

2.2 Model Grid and Reporting Units

The finite element grid was developed using Aquaveo's Groundwater Modeling System (GMS) software. The grid includes quadrilateral and triangular elements based on selected input lines and control points. Features included in the development of the model grid are shown in Figure 5 and included:

- Groundwater subbasin boundaries
- Hydrologic and hydrogeologic features (i.e., major and minor streams, reservoirs/lakes, and outcroppings)
- City spheres of influence boundaries
- ESJ Subbasin GSA boundaries
- County boundaries
- Subsurface flow patterns
- Other boundaries

The model grid contains 16,054 elements and 15,302 nodes with an average element area of 76.5 acres (Figure 6). The average node spacing is 0.37 miles overall, ranging from about 0.28 miles near hydrologic features to 0.42 miles in other areas. There was a 0.75-mile buffer included around the streams to transition from the finer to coarser node spacing. Primary objectives during grid development were to maintain a manageable number of elements and nodes, to optimize resolution for data analysis, to contain a finer resolution along rivers to allow for better simulation of stream-aquifer interaction, to optimize the model run time, and to streamline model output.

The model elements are grouped into 20 model subregions that are used to organize input data for the model and report standard model output water budgets (Figure 7). Subregion borders were delineated using boundaries including city spheres of influence, water agencies, subbasin, and county lines. These subregions are aggregated into 8 larger units (model subareas), which are the primary units to present results and are used for basin-scale planning (Figure 8). ESJ Subbasin, the primary model area, is made up of 6 subareas and 18 subregions or a total of 772,377 acres (about 1,207 square miles). The entire ESJWRM area covers 1,228,194 acres (about 1,919 square miles). A description of model subregions, including the subarea they are part of and the number of model elements they contain, is in Table 4.

Table 4: Model Subregions and Subareas

Subregion Number	Subregion Name	Subarea Name and Number	Number of Elements
1	North Delta	North Delta Subarea (#1)	872
2	Woodbridge	North Subarea (#2)	485
3	Lodi		104
4	North San Joaquin		1,969

Subregion Number	Subregion Name	Subarea Name and Number	Number of Elements
5	Calaveras	Calaveras Subarea (#3)	664
6	Stockton	Central Subarea (#4)	1,074
7	Stockton East		1,314
8	Central San Joaquin		929
9	Lathrop	South Subarea (#5)	119
10	Manteca		224
11	South San Joaquin East		632
12	Escalon		33
13	Oakdale West		128
14	South Delta		254
15	South San Joaquin West		74
16	Ripon		86
17	Stanislaus	Stanislaus Subarea (#6)	1,312
18	Oakdale East		332
19	Cosumnes	Cosumnes Subarea (#7)	2,378
20	Modesto	Modesto Subarea (#8)	3,071

2.3 Stream Configuration and Stream Inflow

The model hydrology is represented by 25 model stream reaches, which are largely defined to start and/or end at confluences. Major streams include Cosumnes River, Dry Creek, Mokelumne River, Bear Creek, Calaveras River, Stanislaus River, Tuolumne River, and San Joaquin River (Figure 9). Many of these streams route water along connecting sloughs and canals, including Pixley Slough, Mosher Creek, Potter Creek, Mormon Slough, and Diverting Canal. As described in Section 2.2, the model grid was designed to include other hydrologic features such as major reservoirs or other important streams that may be simulated in ESJWRM in the future. Hydrologic features used during grid development (i.e., reservoirs and minor streams) include Camanche Reservoir, Duck Creek, Farmington Flood Control Basin, French Camp Slough, Little Johns Creek, Lone Tree Creek, Modesto Reservoir, Tracy Lakes, and Woodward Reservoir (Figure 5 and Figure 9). These hydrologic features represent important drainage and conveyance water courses in the model, while the model streams interactively simulate flows and stream-aquifer interaction at every model stream node.

The streams and creeks are represented in the model by 1674 stream nodes on a quarter-mile interval. The number of stream nodes and their refined resolution provide increased accuracy when depicting stream-groundwater interaction. Physical characteristics, including the stream invert elevation, channel width, and a stream flow rating table, were obtained from the closest C2VSim stream nodes and United States Geological Survey (USGS) Digital Elevations Models (DEM).

Time series of stream inflow data is available from 7 USGS and the United States Army Corps of Engineers (USACE) gauging stations. This data is consistent with C2VSim streamflow data (Brush, 2013). A table of stream input data and a map of available stream gauge locations may be found in Table 5 and Figure 9.

There was not sufficient data available for Bear Creek to generate a full time series record and it is only receiving runoff and/or drainage from nearby model elements.

Table 5: Summary of ESJWRM Stream Inflow Data

Stream	Stream Node	Source	Gauge Name	Period of Record	Average Annual Streamflow (acre-feet)
Cosumnes River	1	USGS	USGS 11335000: Cosumnes River at Michigan Bar, CA	October 1907 to present/ongoing	365,000
Dry Creek	140	USGS	Estimated in C2VSim by correlation with USGS 11329500: Dry Creek near Galt, CA	Not continuous October 1926 to December 1997	25,000
		USGS	Estimated in C2VSim by correlation with USGS 11335000: Cosumnes River at Michigan Bar, CA	Used October 1987 to September 1995 and January 1998 to present/ongoing	
Mokelumne River	290	USGS	USGS 11323500: Mokelumne River below Camanche Dam, CA	October 1904 to present/ongoing	525,000
Calaveras River	758	USGS	USGS 11308900: Calaveras River below New Hogan Dam near Valley Springs, CA	February 1961 to September 1990	151,000
		USACE	New Hogan Dam releases	October 1990 to present/ongoing	
Stanislaus River	1033	USGS	USGS 11302000: Stanislaus River below Goodwin Dam near Knights Ferry, CA	February 1957 to present/ongoing	575,000
Tuolumne River	1248	USGS	USGS 11289650: Tuolumne River below Lagrange Dam near Lagrange, CA	October 1970 to present/ongoing	835,000
San Joaquin River	1497	USGS	USGS 11303500: San Joaquin River near Vernalis, CA	October 1923 to present/ongoing	3,089,000

ESJWRM also specifies how water routes at forks in the rivers. Ten percent of Bear Creek flows through Pixley Slough before returning to Bear Creek, while 90% continues in Bear Creek. Eighty percent of Calaveras River flows through Mormon Slough and the Diverting Canal before returning to Calaveras River, while 20% continues in Calaveras River.

2.4 Precipitation

Rainfall data for the model area is derived from the PRISM (Precipitation-Elevation Regressions on Independent Slopes Model) database used in the DWR's CALSIMETAW (California Simulation of Evapotranspiration of Applied Water) model. The database contains daily precipitation data from October 1, 1921 on a 4-kilometer grid throughout the model area. ESJWRM has monthly rainfall data defined for every model element in order to preserve the spatial distribution of the monthly rainfall. Each of the model elements was mapped to the nearest of 364 available PRISM reference nodes, uniformly distributed across the model domain. The resulting average annual precipitation is shown in Figure 10.

Figure 11 shows the annual rainfall in the model area and the cumulative departure from mean, which is an indication of long-term rainfall trends in the area. The minimum precipitation during the simulation period was in water year 2007 with 8.0 inches, while the maximum occurred in water year 1998 with 28.5 inches. The average precipitation was 15.1 inches, with 9 above average and 12 below average simulation years.

2.5 Root Zone Soil Parameters

The soil properties specified in the model are field capacity, wilting point, total porosity, saturated hydraulic conductivity, and pore size distribution index (PSDI). A recent update to IWFM added the capability to specify a separate saturated hydraulic conductivity for areas covered by rice or wetlands, which prevents the overestimation of deep percolation during periods of ponded water. All the soil properties are used to determine the soil types and characteristics of each model element.

DWR's IWFM Soil Data Builder (DWR, 2017) was used in conjunction with the United States Department of Agriculture (USDA) Soil Survey Geographic Database (SSURGO) (USDA, 2017a) soil data to determine the five soil properties for each model element. The IWFM Soil Data Builder extracts the SSURGO data relevant to the model area (in this case, 6 counties) and associates it with each grid element. For ESJWRM elements where SSURGO data was incomplete, USDA's Digital General Soil Map of the United States (STATSGO2) data were used instead (USDA, 2017b). In total, a little over 3,500 elements (about 22% of all elements) used STATSGO2 data for at least one of the parameters. Editing of soil parameters is a standard part of IDC calibration and the final soil parameter values and their spatial distributions are discussed and shown in figures in Section 4.2.

Model elements are associated with the four hydrological soil groups according to their runoff potential and infiltration characteristics. ESJWRM elements with their corresponding hydrologic soil group are shown in Figure 12. The Natural Resource Conservation Service (NRCS) (USDA NRCS, 2009) defines these hydrological soil groups as follows:

- Group A – Soils in this group have low runoff potential when thoroughly wet. Water is transmitted freely through the soil. Group A soils typically have less than 10 percent clay and more than 90 percent sand or gravel and have gravel or sand textures. Some soils having loamy sand, sandy loam, loam or silt loam textures may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.
- Group B – Soils in this group have moderately low runoff potential when thoroughly wet. Water transmission through the soil is unimpeded. Group B soils typically have between 10 percent and 20 percent clay and 50 percent to 90 percent sand and have loamy sand or sandy loam textures.

Some soils having loam, silt loam, silt, or sandy clay loam textures may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.

- Group C – Soils in this group have moderately high runoff potential when thoroughly wet. Water transmission through the soil is somewhat restricted. Group C soils typically have between 20 percent and 40 percent clay and less than 50 percent sand and have loam, silt loam, sandy clay loam, clay loam, and silty clay loam textures. Some soils having clay, silty clay, or sandy clay textures may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.
- Group D – Soils in this group have high runoff potential when thoroughly wet. Water movement through the soil is restricted or very restricted. Group D soils typically have greater than 40 percent clay, less than 50 percent sand, and have clayey textures. In some areas, they also have high shrink-swell potential.

2.6 Land Use and Cropping Patterns

For the model to calculate water supply requirements, every model element needs to have land use defined for every year of the simulation. ESJWRM includes 23 irrigated crop categories and 4 general land use categories. All of the irrigated crop categories except for rice are simulated as non-ponded crops, meaning they are grown without standing water. Rice is simulated as both no decomposition (assumed 20% of total rice area) and flooded decomposition (assumed 80% of total rice area) to represent the current understanding of local growing practices. The general land use categories include urban landscape (e.g., residential areas, golf courses, and school fields), water surface (e.g., streams, lakes, and reservoirs), riparian vegetation (e.g., native vegetation located near surface water), and native vegetation. The irrigated crop categories were combined into 6 high-level groupings of crops with similar water use or irrigation practices. Table 6 lists the land use categories.

The crop categories are identical to those in C2VSim, except that ESJWRM breaks out almonds, cherries, pistachios, and walnuts as individual categories. This was done at the request of the Technical Review Committee based on the importance and amount of these crops in the ESJ Subbasin.

Spatial land use data was used to specify land use types and crop acreages for each model element for each year. The three major reference sources include DWR land use surveys, CropScape, and Land IQ. As crop categories were not consistent across all the land use data sources, individual mappings matched up each crop type to model land use category.

DWR conducts periodic land use surveys for each county that include over 70 different crop categories, as well as urban and native vegetation, for each parcel or field (DWR, 1993-2000). DWR land use surveys have high accuracy due to extensive ground truthing. For ESJWRM, the land use surveys by county were merged and assumed to represent water year 1995 in the model. The surveys used include:

1. San Joaquin County (1996)
2. Sacramento County (1993)
3. Amador County (1997)
4. Calaveras County (2000)
5. Stanislaus County (1996)

Data for water years 2007 through 2015 are from the USDA's remote sensing CropScape data (USDA NASS, 2007-2015). CropScape includes 256 land use categories that come from annual satellite imagery collected during the growing season on 30-meter by 30-meter pixels. Based on reports on the CropScape website, the level of accuracy for this data is about 85-97% for crop-specific land cover categories. Although this level of accuracy is relatively high, the accuracy varies depending on many factors, including the time of the satellite image, growing season timing, cloud cover, type of crop, and maturity state of the crop.

DWR retained Land IQ to develop a statewide assessment of agricultural land use in summer 2014. Land IQ used remote sensing methods to collect and process the data at the parcel scale, which was then ground truthed for a reported overall accuracy of 96.6% (DWR, 2014). In ESJWRM, this data was used as verification of CropScape 2014 data and, in some cases, as replacement or enhancement of the CropScape data. Land IQ did not include a native vegetation category, so any blank land was assumed to be native vegetation.

Table 6: Land Use Categories

Land Use Type	Model Category	Grouped Categories
Irrigated Crops	Almonds Cherries Citrus & Subtropical Other Orchard Pistachios Walnuts	Fruit and Nut Trees
	Vineyards	Vineyards
	Alfalfa Pasture	Alfalfa and Irrigated Pasture
	Grain	Grain
	Corn Cotton Dry Beans Field Crops Safflower Sugar Beets	Field Crops
	Cucurbits Onion & Garlic Potatoes Tomato Fresh Tomato Processing Truck Crops	Truck Crops
	Rice	Rice
Other Land Use	Urban Landscape Water Surface Riparian Vegetation Native Vegetation	

Local data and knowledge was also utilized to refine and correct, when necessary, the cropping acreages developed based on the DWR land use surveys and CropScape years. To fill the gap between 1995 and 2007, all land use and crop categories were interpolated at the spatial resolution level of the model element. Thus, the geographic distribution of interpolated land use and cropping patterns are honored.

Consistent mappings were developed to link crop categories from the various data sources to model categories based on previous work done for C2VSim. Adjustments were made, as needed, at the element level to ensure that the land use and cropping pattern trends over time are reflective of local data. These adjustments were mostly based on local knowledge and information received from various entities, including irrigation districts, water districts, and municipalities.

Figure 13 and Figure 14 show the spatial distribution of the major land use categories in the ESJ Subbasin for 1995 and 2015. Figure 15 shows the annual trends of land use categories in the ESJ Subbasin.

Figure 16, Figure 17, and Figure 18 show the spatial distribution of the irrigated crops for 1995, 2014, and 2015. Figure 19a-19g show the annual cropping patterns, by high level categories, for the entire ESJ Subbasin and major model subareas.

Overall, land use trends from 1995 through 2015 show significant increases in total and irrigated agricultural acreage, with about 384,000 irrigated acres in ESJ Subbasin at the beginning of simulation and about 398,000 acres with agricultural production by 2015. This change from native to agricultural area brings additional stresses on the hydrological system, particularly as the majority of this increase comes from conversion to higher water permanent crops, particularly vineyards, almonds, and walnuts. This translates to a higher water requirement, largely provided either by groundwater or surface water, though changes in irrigation methods may mitigate some of the increased water need due to land use changes.

Not all the subareas show an increase in agricultural land; many remain relatively consistent through the entire simulation period. When there was a decrease in agricultural land, there was a compensating increase in urban land, indicating the expansion of urban areas.

2.7 Evapotranspiration

The crop evapotranspiration (ET) requirement is an important factor in agricultural demand estimation. Every ESJWRM land use category (except for water surface) plus small-stream watersheds must have average monthly values used for the entire simulation. To allow for spatial variability within the model, ET rates are also defined by model subregion.

The ET values are based on a variety of sources, including locally-developed data for the SSJID and the OID Agricultural Water Management Plans (AWMPs) (SJJID, 2015; OID, 2016) and averages for DWR's CIMIS (California Irrigation Management Information System) Zone 12 developed using the Mapping Evapotranspiration at High Resolution with Internalized Calibration (METRIC) methodology, which is a remote-sensing based technology to estimate crop actual ET. Based on discussions with locals (pers. comm. Jennifer Spaletta representing NSJWCD and Bryan Thoreson representing SSJID), deficit irrigation of vineyards was simulated in ESJWRM with reference to the growing season ET values in the Lodi area (Prichard).

In IWFM, ET represents the net vertical water flux from the land surface and root zone through the upper model boundary. Figure 20 shows the range in annual evapotranspiration rates from the various sources for the 27 categories. Final model ET depends on the model subregion, with SSJID and OID using their locally-developed ET rates and the remainder of the model using the METRIC data.

2.8 Drainage

Surface water drainage (e.g., runoff from rainfall and excess applied water) for each model element is assigned to a stream node representing where the drainage ultimately flows to. These drainage patterns were delineated using the USGS Watershed Boundary Dataset for 12-digit hydrologic units, also called subwatersheds. Each 12-digit hydrologic unit located within the model boundaries was associated with the model stream node it ultimately drained into through both visual analysis as well as information provided on the subwatersheds. Elements falling within the hydrologic units were assigned to the model stream node indicating the ultimate surface water drainage direction. A total of 94 unique stream nodes receive surface water drainage in ESJWRM from 79 subwatersheds. Figure 21 shows these stream nodes and the subwatersheds mapped to the model elements.

2.9 Model Layering

The subsurface zone is characterized by four model layers (three freshwater aquifers and one saline aquifer) representing the different geology from the ground surface to the bedrock. A small portion of the southwestern part of the subbasin has a confining unit of Corcoran Clay. The layering extents and thicknesses are all consistent with C2VSim. Descriptions of each of the model layers are listed below, from top to bottom.

- Layer 1: Layer 1 represents the top unconfined portion of the aquifer. The ground surface elevation (GSE), or the top of Layer 1, comes from the USGS DEM at a resolution of 10 meters. The bottom of Layer 1 is defined as the top of Corcoran Clay where the confining unit exists or else as the bottom of Layer 1 in C2VSim. The layer thickness is limited by the stream invert elevation and ranges from 34 to 966 feet. The GSE is shown in Figure 22 and thickness of Layer 1 is shown in Figure 23.
- Aquitard 1: Corcoran Clay (i.e., E Clay) separates Layers 1 and 2 in a small portion of the southwest corner of the model. The extent, thickness, and depth of the Corcoran Clay originated from the Central Valley Hydrologic Model (CVHM) Spatial Database. The depth to the Corcoran Clay, ranging from 20 to 280 feet below the GSE, is shown in Figure 24 and the thickness of the Corcoran Clay, ranging from 10 to 160 feet, is in Figure 25.
- Layer 2: Layer 2 represents the primary pumping layer and is beneath the confining layer where Corcoran Clay exists. Layer 2 is principally bounded on the top by the bottom of Layer 1 or the bottom of Corcoran Clay (where it exists) and on the bottom by Layer 2 in C2VSim. The thickness of Layer 2, ranging from 50 to 540 feet, is in Figure 26.
- Layer 3: Layer 3 extends to the base of fresh water. Information used in developing the bottom of Layer 3 includes data from Steven Springhorn of DWR's North Central Regional Office, Christopher Olvera of DWR's South Central Regional Office, and Williamson et al. 1989. The thickness of Layer 3, ranging from 50 to 1,335 feet, is in Figure 27.
- Layer 4: Layer 4 consists of the saline water ranging from the base of fresh water to the base of continental deposits and is a current non-production zone. Information used in developing the bottom of Layer 4 includes Page's 1974 Base and Thickness of the Post Eocene Continental Deposits in the Sacramento Valley and the thickness of the aquifer developed by Williamson et al. 1989. The thickness of Layer 4, ranging from 50 to 2,250 feet, is in Figure 28.

Cross sections of the model layering in various locations across the model extent can be seen in Figure 29a-29f.

2.10 Small-Stream Watersheds

The inflow from the eastern boundary of the model (i.e., Sierra Nevada foothills) originates from both gauged and ungauged watersheds. The simulation of gauged watersheds (i.e., stream inflows into the model) was discussed in Section 2.3 and shown in Figure 9. The simulation of the ungauged watersheds is explained in this section.

Flow from ungauged small watersheds is estimated based on precipitation rates and characteristics assigned to each identified ungauged watershed. A portion of flow from the small watershed enters the model area as surface runoff and flows to simulated streams. The remaining small watershed inflow infiltrates to groundwater.

ESJWRM simulates the ungauged eastern inflow using 39 distinct small watersheds (Figure 30), consistent with those on the eastern boundary of C2VSim. These were delineated originally from the USGS Watershed Boundary Dataset.

All subsurface inflows from these small watersheds are routed to model Layer 1 along specified groundwater nodes (Figure 30), with a user-defined maximum percolation rate at each node. Excess flows that do not infiltrate to groundwater enter the simulated streams at user-specified locations (Figure 30) delineated using a similar methodology to the drainage pattern discussed above in Section 2.8. The hydrologic conditions of these small watersheds used to estimate the subsurface and surface flows are represented using site-specific parameters (e.g., precipitation, surface layer soil parameters, runoff coefficient) based on C2VSim.

2.11 Boundary Conditions

As discussed in the previous section, inflows along the eastern boundary are represented using small watersheds. Boundary conditions define the subsurface inflows from all other boundaries of the model (i.e., northern, western, and southern), as well as areas with known groundwater levels.

Time series general head boundary conditions representing groundwater levels outside of the model area were defined for 596 boundary nodes on the northern, western and southern limits (i.e., along Cosumnes, Mokelumne, San Joaquin, and Tuolumne Rivers). Groundwater flow at the model boundaries was quantified based on the groundwater gradient across the model boundary. The head inside the model area is simulated by ESJWRM and the head outside the model area is based on historical groundwater elevation data from DWR's Water Data Library (WDL).

Additional groundwater boundary conditions were defined to simulate known groundwater elevations for the Sacramento-San Joaquin Delta and lakes or reservoirs (reservoir locations shown in Figure 5). ESJWRM specifies high groundwater levels at or near zero feet for 60 groundwater nodes representing the edges of the Sacramento-San Joaquin Delta. Using data available in C2VSim, seepage from Camanche Reservoir was represented by specifying the full time series of groundwater levels for the 270 groundwater nodes representing the reservoir. The other reservoirs in the model were not included in C2VSim, so did not have boundary conditions available to estimate reservoir seepage. Instead, Woodward Reservoir seepage is included as a stream diversion from Stanislaus River (see Section 3.3.1). Farmington Flood Control Basin is used primarily for flood control purposes. Any recharge is incidental to the operation of the dam and is currently not included in ESJWRM. Modesto Reservoir, as it is located outside of the focus area of ESJ Subbasin, was not simulated.

2.12 Initial Conditions

Groundwater heads for each model node and each layer at the beginning of the simulation (i.e., October 1, 1994) were developed using the DWR's WDL database and San Joaquin County's database of historical groundwater monitoring. Over 1,100 wells with data for Fall 1993, Fall 1994, or Fall 1995 were compiled and interpolated to create a raster representing initial groundwater levels for each model groundwater node. Due to the lack of information on well perforation and even depth for many of the WDL and San Joaquin County monitoring locations, the groundwater heads for each model layer are assumed to all begin at the same value. This assumption means the model needs about a year for groundwater levels to stabilize, so model results focus on water years 1996 through 2015 (a 20-year period). The initial conditions for ESJWRM representing October 1, 1994 are shown in Figure 31.

3. WATER SUPPLY AND DEMAND DATA

The following sections describe the data and methodology for the ESJWRM water demand and supply calculations. Agricultural and urban demand are calculated in the IDC portion of IWFM. Agricultural and urban supply are specified in IWFM's groundwater pumping and surface water diversion data.

3.1 Agricultural Water Demand

Agricultural water demand is the amount of irrigation water that is required to satisfy the crops evapotranspiration requirement. The IWFM Demand Calculator or IDC is designed to estimate the agricultural water demand for each model element through consumptive use methodology. The IDC calculations rely on model input data for historical crop acreage, irrigation practices (e.g., return and reuse fractions, irrigation period), soil moisture requirements, effective rainfall (the portion of rainfall available for crop consumptive use), crop evapotranspiration, and localized soil parameters. This data was compiled, analyzed, synthesized, and processed for input in ESJWRM.

Precipitation, land use, evapotranspiration, and soil properties are discussed in the relevant sections in Chapter 2. Irrigation period, using data from C2VSim, defines irrigation as either on or off for each crop and each month of the model simulation period. These were vetted and revised as necessary by the Technical Review Committee to better represent local practices in the ESJWRM area. Most trees are assumed irrigated from April through October (with almonds and pistachios from February through October), vineyards from May through October, most field crops from May through September, and most truck crops from April through September. Crops with irrigation assumed year-round include citrus and subtropical trees, irrigated pasture, alfalfa, and onions and garlic. Fractions to represent return flow (i.e., irrigation flow following the model drainage pattern discussed in Section 2.8) and reuse (i.e., the fraction of applied irrigation water to be reused for irrigation) are from C2VSim and are defined by subregion. For all ESJWRM, agricultural lands are given a 1% return flow and 1% reuse factor and urban landscape areas are assumed to have 15% return flow and 0% reuse.

3.2 Urban Water Use

IDC calculates urban demand based on per capita water use, population, and the breakdown of indoor versus outdoor water use by month. Figure 32 shows the annual population trends for each urban center. Figure 33 shows the annual per capita water use values of these urban centers used in the calculation of urban water demand.

Population and per capita water use for the major urban areas were largely provided directly by the urban areas or were obtained from the respective Urban Water Management Plans (UWMP). Additional annual population, including an estimate for rural urban areas, came from the United States Census Bureau and the California Department of Finance. Monthly per capita water use, commonly reported in gallons per capita per day (GPCD), was generally estimated for each urban entity using the annual population and monthly urban water use (provided by cities based on water delivery records). To estimate the urban water demand of rural domestic water areas, the average major urban area GPCD was combined with estimated rural population.

It was assumed that an annual average of 60% of urban water was used indoors and 40% was used outdoors. The monthly fractions entered into the model had the majority of urban water demand due to indoor activities from November through March and up to a maximum of 60% of urban water used outdoors for the remainder of the year.

The indoor/outdoor breakdown received concurrence from the urban water providers who attended the Technical Review Committee meetings. Population and per capita water use data were reviewed by the major urban areas and confirmed at the meetings (pers. comm. Kathryn Garcia from Lodi, Andrew Richle from Lodi, Michael Bolzowski from Cal Water, Greg Gibson from Lathrop, and Elba Mijango from Manteca).

3.3 Water Supply Summary

Both the agricultural and urban demands estimated by IDC are primarily met through the IWFM representation of surface water diversions and groundwater pumping. Other sources of water simulated in IWFM to meet demand include precipitation and existing moisture in the soil.

3.3.1 Surface Water

Historical surface water diversions for the simulation period were compiled from a combination of sources discussed in more detail in Section 3.4, including gauge data, water rights reports, UWMPs, AWMPs, and other sources. Some diversions were estimated based on historical demands. A summary of diversions simulated in the model is provided in Table 7, along with fractions for recoverable loss (i.e., percolation or canal seepage), non-recoverable loss (i.e., evaporation), and delivery (i.e., amount delivered is equal to the total amount minus the recoverable and non-recoverable losses).

The monthly data for all these diversions came from local agencies or C2VSim (Modesto Subbasin diversions and riparian diversions) as discussed in more detail in Section 3.4. Many diversions provide water across model subregions, so deliveries are assigned to a group of elements representing the delivery area. Diversions either are taken out of streams at specified model streams nodes or are imported into the model area (i.e., diversion location occurs upstream of stream inflow gauge). Figure 34 shows the stream nodes where diversions occurred.

Table 7: Summary of ESJWRM Surface Water Deliveries

ID	Description	Diversion Location	Delivery Area	Use	Fraction			Average Annual Diversion*** (acre-feet)	Data Source
					RL*	NL**	Delivery		
1	Mokelumne River to Woodbridge ID for Ag	Mokelumne River at Lodi Lake	Element group representing Woodbridge Irrigation District	Ag	30%	2%	68%	56,700	WID
2	Mokelumne River to City of Lodi (by agreement with Woodbridge ID)	Mokelumne River at Lodi Lake	Lodi Sphere of Influence	Urban	3%	1%	96%	5,000	WID

ID	Description	Diversion Location	Delivery Area	Use	Fraction			Average Annual Diversion*** (acre-feet)	Data Source
					RL*	NL**	Delivery		
3	Mokelumne River to City of Stockton for Delta Water Supply Project (by agreement with Woodbridge ID)	Mokelumne River at Lodi Lake	Element group representing Stockton area minus Cal Water	Urban	3%	1%	96%	5,400	WID
4	Mokelumne River to Contra Costa WD (by agreement with Woodbridge ID)	Mokelumne River at Lodi Lake	Export out of model	Urban	0%	0%	100%	2,000 (one year only)	WID
5	Mokelumne River to North San Joaquin WCD For Ag	Mokelumne River between Camanche Reservoir and Lodi Lake	Element group representing North San Joaquin WCD	Ag	10%	2%	88%	2,200	NSJWCD
6	Calaveras River to Bellota Pipeline to Stockton East WD WTP for M&I	Calaveras River at split with Mormon Slough	Stockton Sphere of Influence	Urban	3%	1%	96%	15,800	SEWD
7	Calaveras River to Calaveras County WD for Ag	Import (outside of ESJWRM)	Calaveras Subregion (Subregion 5)	Ag	9%	1%	90%	1,100	CCWD
8	Calaveras River to Stockton East WD for Ag	Calaveras River at split with Mormon Slough	Element group representing Stockton East Water District agricultural customers	Ag	40%	5%	55%	42,600	SEWD
9	Calaveras River to Farmington Groundwater Recharge Program	Calaveras River at split with Mormon Slough	Element group representing recharge locations	Ag	100%	0%	0%	1,300	SEWD
10	San Joaquin River at Empire Tract to City of Stockton for Delta Water Supply Project	San Joaquin River at Empire Tract just after junction with Bear Creek	Element group representing Stockton area minus Cal Water	Urban	3%	1%	96%	7,800	City of Stockton

ID	Description	Diversion Location	Delivery Area	Use	Fraction			Average Annual Diversion*** (acre-feet)	Data Source
					RL*	NL**	Delivery		
11	San Joaquin River to North Delta	San Joaquin River near North Delta Subregion	Element group representing North Delta	Ag	5%	1%	94%	107,000	Estimated by model
12	San Joaquin River to South Delta	San Joaquin River near South Delta Subregion	Element group representing South Delta	Ag	5%	1%	94%	14,200	Estimated by model
13	Farmington Reservoir via Lower Farmington Canal to Peters Pipeline to Stockton East WD WTP	Import (outside of ESJWRM)	Stockton Sphere of Influence	Urban	3%	1%	96%	33,300	SEWD
14	Farmington Reservoir via Lower Farmington Canal to Stockton East WD for Ag	Import (outside of ESJWRM)	Element group representing Stockton East Water District agricultural customers	Ag	15%	2%	83%	5,300	SEWD
15	Farmington Reservoir via Little Johns Creek and Lower Farmington Canal to Central San Joaquin WCD for Ag	Import (outside of ESJWRM)	Element group representing Central San Joaquin WCD	Ag	28%	2%	70%	38,800	SEWD
16	Stanislaus River to Farmington Groundwater Recharge Program	Import (outside of ESJWRM)	Element group representing recharge locations	Ag	100%	0%	0%	3,000	SEWD
17	Woodward Reservoir to South San Joaquin ID for Ag	Import (outside of ESJWRM)	Element group representing South San Joaquin ID minus Division 6	Ag	21%	6%	74%	195,300	SSJID
18	Stanislaus River at Goodwin Dam to Oakdale ID for Ag	Import (outside of ESJWRM)	Element group representing Oakdale ID	Ag	16%	1%	83%	111,100	OID

ID	Description	Diversion Location	Delivery Area	Use	Fraction			Average Annual Diversion*** (acre-feet)	Data Source
					RL*	NL**	Delivery		
19	Woodward Reservoir Seepage	Import (outside of ESJWRM)	Element group representing Woodward Reservoir	Ag	100%	0%	0%	17,500	SSJID
20	Woodward Reservoir to Nick C. DeGroot WTP to City of Manteca for M&I	Import (outside of ESJWRM)	Manteca Sphere of Influence	Urban	3%	1%	96%	6,300	AWMP/ UWMP
21	Woodward Reservoir to Nick C. DeGroot WTP to City of Escalon for M&I	Import (outside of ESJWRM)	Escalon Sphere of Influence	Urban	3%	1%	96%	0	AWMP/ UWMP
22	Woodward Reservoir to Nick C. DeGroot WTP to City of Lathrop for M&I	Import (outside of ESJWRM)	Lathrop Sphere of Influence	Urban	3%	1%	96%	1,100	AWMP/ UWMP
23	Woodward Reservoir to Nick C. DeGroot WTP to City of Ripon for M&I	Import (outside of ESJWRM)	Ripon Sphere of Influence	Urban	3%	1%	96%	0	AWMP/ UWMP
24	Tuolumne River to Modesto ID	Import (outside of ESJWRM)	Element group representing Modesto ID	Ag	15%	3%	82%	307,600	C2VSim
25	Tuolumne River to City of Modesto (via Modesto ID)	Import (outside of ESJWRM)	Element group representing City of Modesto	Urban	5%	1%	94%	30,600	C2VSim
26	Cosumnes River to Riparian for Ag	Along Cosumnes River near confluence with Mokelumne River	Element group representing riparian diverters	Ag	10%	2%	88%	4,300	C2VSim
27	Dry Creek to Riparian for Ag	Approximately midway along Dry Creek	Element group representing riparian diverters	Ag	10%	2%	88%	6,000	C2VSim

ID	Description	Diversion Location	Delivery Area	Use	Fraction			Average Annual Diversion*** (acre-feet)	Data Source
					RL*	NL**	Delivery		
28	Mokelumne River to Riparian for Ag	Approximately midway along Mokelumne River	Element group representing riparian diverters	Ag	10%	2%	88%	9,700	C2VSim
29	Calaveras River to Riparian for Ag	Calaveras River at split with Mormon Slough	Element group representing riparian diverters	Ag	10%	2%	88%	20,400	C2VSim
30	Stanislaus River to Riparian for Ag	Approximately midway along Stanislaus River	Element group representing riparian diverters	Ag	15%	3%	82%	20,700	C2VSim
31	Tuolumne River to Riparian for Ag	Approximately midway along Tuolumne River	Element group representing riparian diverters	Ag	15%	3%	82%	2,500	C2VSim
32	San Joaquin River to Riparian for Ag	San Joaquin River near confluence with Tuolumne River	Element group representing riparian diverters	Ag	15%	3%	82%	6,200	C2VSim
33	Woodward Reservoir to South San Joaquin ID Division 6 for Ag	Import (outside of ESJWRM)	Element group representing South San Joaquin ID Division 6	Ag	15%	2%	83%	5,200	SSJID

*RL = Recoverable Loss (canal seepage or recharge)
**NL = Non-Recoverable Loss (evaporation)
*** Averages calculated only for years with diversions occurring (i.e., non-zero average)

3.3.2 Groundwater Pumping

Groundwater pumping within ESJWRM is separated into well- or element-based pumping. The former largely includes district-operated wells that feed into the surface water supply network, while the latter includes estimated private groundwater pumping.

District pumping (or well pumping) is specified monthly throughout the simulation period. Data was provided by local agencies and included well locations, depths and perforations, use (agricultural or urban) and historical monthly pumping records. Table 8 lists the number of wells by type and agency included in ESJWRM. Figure 35 shows all the district pumping wells (separated by agricultural and municipal wells) in ESJWRM.

Table 8: Summary of ESJWRM Well Pumping

Agency	Number of Urban Pumping Wells	Number of Agricultural Pumping Wells	Average Annual Urban Pumping (acre-feet)	Average Annual Agricultural Pumping (acre-feet)
Cal Water	56	---	9,600	0
Escalon	4	---	1,400	0
Lathrop	6	---	2,200	0
Linden County WD	4	---	450	0
Lockeford CSD	4	---	530	0
Lodi	29	---	15,200	0
Manteca	15	31	9,500	1,300
Oakdale ID	---	24	0	5,800
Ripon	9	9	3,900	1,100
SEWD	5	---	3,100	0
SSJID	---	28	0	5,200
Stockton	37	---	9,300	0
Total Average Annual Pumping (acre-feet)			55,180	13,400

Private groundwater pumping quantities on an individual well basis are largely unknown, though aggregate estimates for private pumping are often included in planning documents (e.g., AWMPs, UWMPs, groundwater management plans). Therefore, private agricultural pumping in ESJWRM is estimated by IWFM on an element basis by assigning two virtual wells at the centroid of each model element. One well represents private agricultural pumping and one well represents rural residential pumping. These wells are used to calculate any additional pumping necessary to meet the agricultural and urban demand estimated by IDC for an element after district pumping and surface water has been distributed.

The perforation interval, which dictates the layers a simulated well extracts water from, were assigned separately to the agricultural and domestic (i.e., rural residential) wells. All agricultural wells were assumed to pump 40% from Layer 1 and 60% from Layer 2. Rural residential wells used a statistical analysis of perforation interval developed for C2VSim. Perforation interval data was compiled by DWR using data from the CASGEM and Online System for Well Completion Reports (OSWCR) databases. Simulated perforation intervals were assigned as the 5th and 95th percentiles of the well perforation interval data for each township/range block.

3.4 Water Supply Sources

This section provides a detailed description of the sources of water supply (both surface water and pumping) occurring in ESJWRM.

3.4.1 Delta Areas

The North Delta and South Delta Subregions (Subregion 1 and 14) are mostly assumed to cover the portion of the Sacramento-San Joaquin River Delta overlying the ESJ Subbasin. As discussed at the Technical Review Committee meetings, the majority of the agricultural water demand in these areas is known to be entirely served by surface water taken off the San Joaquin River. Therefore, almost all of the agricultural demand is assumed to be supplied by the San Joaquin River (Diversion #11 and #12 for North Delta and

South Delta, respectively). A small portion of the agricultural land is assumed to rely on groundwater via element pumping. All of the urban demand is supplied by small, private residential wells and is estimated in ESJWRM using element pumping.

Though Subregions 1 and 14 are assumed to represent the Delta, elements in Subregions 1 and 14 receive surface water from other diversions unrelated to the assumed riparian Delta diversions. A portion of WID's delivery area extends into Subregion 1 and is supplied by WID's diversion off the Mokelumne River (Diversion #1) as discussed in Section 3.4.2. Portions of other riparian diversions discussed in Section 3.4.19 extend into Subregions 1 and 14, specifically Dry Creek (Diversion #27) in Subregion 1 and San Joaquin River (Diversion #32) in Subregion 14.

3.4.2 Woodbridge Irrigation District

WID receives water from the Mokelumne River, which is provided to its agricultural customers through a distribution canal network or is sold to nearby municipalities. Through agreements, Lodi and Stockton use some of WID's surface water right beginning in water years 2013 and 2012, respectively (Diversion #2 and #3). In water year 2013, WID supplied Contra Costa Water District with a one-time transfer of 2,000 AF (acre-feet), represented by Diversion #4. Diversion #1 delivers water to the element group representing WID's service area, which spans portions of Subregion 1, most of Subregion 2, part of Subregion 3, and a small area of Subregion 6. The scale of the ESJWRM element grid is not refined enough to simulate deliveries on the parcel scale, so model elements may include parcels which do not in actuality receive surface water from WID.

Some of the agricultural demand (largely native landscape) adjacent to streams is met by the riparian diversion from Mokelumne River (Diversion #28) as discussed in Section 3.4.19. All remaining agricultural demand is estimated in ESJWRM as element pumping. All urban demand is likewise element pumping.

3.4.3 City of Lodi

The City of Lodi purchases surface water from WID, which it takes from the Mokelumne River adjacent to the city. Diversion #2 supplies part of the urban demand beginning in water year 2013, with all of the previous demand being met exclusively by groundwater. 29 municipal wells are simulated in the model, with at least 3 becoming inactive during the simulation period. Since Lodi began receiving surface water, its supply mix has steadily decreased its reliance on groundwater, from 100% of the urban demand in water year 2012 to 55% of the demand in water year 2015, with its increase in surface water use.

The agricultural land surrounding the current city boundaries is supplied by either WID on the west or NSJWCD to the east. Though the agricultural demand in these areas is small, WID's Diversion #1 or NSJWCD's Diversion #5, along with the riparian diversion from Mokelumne River (Diversion #28) (see Section 3.4.19), are able to supply some of the agricultural demand adjacent to Lodi. The city's wastewater treatment plant, located to the west of the city in Subregion #1, is surrounded by fields irrigated using recycled water from the treatment plant. Any additional agricultural or urban demand is estimated in ESJWRM as element pumping.

3.4.4 North San Joaquin Water Conservation District

NSJWCD receives water from the Mokelumne River, which is provided to its agricultural customers as Diversion #5. Historically, NSJWCD has not used its entire water right allotment and did not divert any water towards the end of the simulation (starting water year 2013).

Some of the agricultural demand adjacent to water is met by the riparian diversions from Dry Creek (Diversion #27) and Mokelumne River (Diversion #28) (see Section 3.4.19). Any additional agricultural demand is estimated in ESJWRM as element pumping, while small domestic urban demand is met by element pumping.

3.4.5 Lockeford Community Services District

LCSD is located within ESJWRM Subregion 4 and is surrounded by agricultural land under NSJWCD. LCSD has 4 municipal pumping wells used to meet all the urban demand generated by its customers. Some of the agricultural demand is met by the riparian diversion from Mokelumne River (Diversion #28) (see Section 3.4.19), while the remaining is met by element pumping.

3.4.6 Calaveras County

Only a small portion of Calaveras County extends into the ESJ Subbasin and the land is mostly unirrigated or native vegetation with small residential pockets and some irrigated agricultural parcels. CCWD uses a small amount of Calaveras River water for agricultural demand in the ESJ Subbasin (Diversion #7). Additional agricultural demand is met by the riparian diversion from Calaveras River (Diversion #29) (see Section 3.4.19) or element pumping. All the residential demand is met by element pumping.

3.4.7 Stockton Area

The Stockton area includes service areas of both the City of Stockton as well as Cal Water. San Joaquin County also manages water for several unincorporated areas in and around the city.

Both the City of Stockton and Cal Water purchase surface water for urban use from SEWD. The water originates from either the Calaveras or Stanislaus Rivers and is delivered to customers after treatment at the SEWD water treatment plant (Diversion #6 and Diversion #13). Additionally, Stockton began the Delta Water Supply Project in water year 2012 and built a water treatment plant, providing another source of surface water for the area from San Joaquin River at Empire Tract (Diversion #10) and Mokelumne River via agreement with WID (Diversion #3).

Stockton, Cal Water, and San Joaquin County maintain pumping wells for urban water use. Due to the scale of the element grid, many of the San Joaquin County areas were too small to be simulated separately from Stockton or Cal Water. Thus, San Joaquin County groundwater pumping is instead estimated by element pumping in ESJWRM. Stockton itself has 37 municipal wells in the area, though only about 14 are still active at the end of the simulation. Cal Water maintains a separate delivery area and operates 56 wells to meet urban demand, though only about 20 wells are active at the end of ESJWRM's historical simulation. Due to the complexity of the water supply in the area, the supply mix for urban water use in ESJWRM is difficult to separate by agency, though for the entire area is, on average, 70% surface water and 30% groundwater pumping with the reliance on groundwater decreasing toward the end of simulation due to the construction of the Delta Water Supply Project.

One riparian diversion from Calaveras River (Diversion #29) provides water to areas adjacent to the river (see Section 3.4.19). Additional agricultural demand may be met by surface water from WID (Diversion #1) where it extends into the northern part of the Stockton area or SEWD (Diversion #8 and Diversion #14). Any additional agricultural demand occurring in the area is supplied by the estimated element pumping.

3.4.8 Stockton East Water District

SEWD receives water from both Calaveras River (i.e., New Hogan Lake) and Stanislaus River (i.e., New Melones Lake) and sells water to its customers for both agricultural and municipal purposes. Agricultural water is delivered directly to customers scattered across the district area (model Subregions 6 and 7). Municipal water, as discussed in Section 3.4.7, is routed to SEWD's water treatment plant and is sold to the City of Stockton and Cal Water. Beginning in water year 2003, SEWD has operated groundwater recharge projects near its water treatment plant, utilizing water taken from both the Calaveras and Stanislaus Rivers.

In Table 7, SEWD's two urban diversions are Diversion #6 and Diversion #13, the two agricultural diversions are Diversion #8 and Diversion #14, and the two diversions used for recharge are Diversion #9 and Diversion #16. One riparian diversion from Calaveras River (Diversion #29) provides water to areas adjacent to the river (see Section 3.4.19). SEWD operates 5 urban pumping wells in the vicinity of the water treatment plant that are mixed with the surface water for use in the Stockton area and are utilized rarely (only during water year 2015 during the simulation period of ESJWRM). Any additional agricultural or urban demand is met by element pumping.

3.4.9 Linden County Water District

LCWD is located within ESJWRM Subregion 7 and is surrounded by agricultural land under SEWD. Though it receives no surface water, LCWD has 4 municipal pumping wells to meet all the urban demand generated by its customers. By the end of the simulation, only 2 of the wells are still active.

3.4.10 Central San Joaquin Water Conservation District

CSJWCD receives water from Stanislaus River (i.e., New Melones Lake) (Diversion #15) that is used for agricultural demand in model Subregion 8. Any additional agricultural demand is estimated as element pumping by ESJWRM. All the private residential urban demand is likewise calculated as element pumping.

3.4.11 South San Joaquin Irrigation District

SSJID's service area covers the agricultural lands around the cities of Manteca, Ripon, and Escalon. SSJID provides water to agricultural customers within the district using water from the Stanislaus River (taken out at Goodwin Dam) and then stored in Woodward Reservoir just east of the district's area in Stanislaus County. Diversion #17 represents the agricultural diversion from Woodward Reservoir that is delivered to SSJID's customers through its series of canals covering the district. Based on communication with SSJID, one portion of SSJID, Division 6 (formerly Division 9), began receiving more surface water beginning in water year 2011. An increase in surface water to Division 6 (near Ripon in Subregions 15 and 16) is simulated using Diversion #33. Diversion #19 represents the seepage from Woodward Reservoir as SSJID had monthly data estimating the groundwater recharge due to the reservoir. Diversion #30 simulates the riparian diverters along Stanislaus River (see Section 3.4.19).

SSJID maintains 28 agricultural wells located in and around the City of Manteca to augment their surface water supply. Any remaining agricultural demand in the district is met by element pumping estimated by ESJWRM.

The Nick C. DeGroot Water Treatment Plant located at Woodward Reservoir was constructed as part of the South County Water Supply Project through the collaboration of SSJID and the cities of Escalon, Lathrop, Manteca, and Tracy. Beginning in water year 2005, surface water deliveries from the treatment plant began to Lathrop, Manteca, and Tracy with Escalon deliveries to begin in the future (currently

Escalon's allotment is sold to Tracy). Ripon potentially may be added to the project at a later point. These deliveries are simulated in ESJWRM as Diversion #20 (Manteca), #21 (Escalon), #22 (Lathrop), and #23 (Ripon). Urban demand in these areas in discussed further in the relevant sections below. Any private residential demand estimated by ESJWRM in SSJID is met by element pumping.

3.4.12 City of Lathrop

Lathrop has 6 municipal pumping wells, one of which was inactive for the entire simulation period but may come back online for future use. The city began receiving surface water from the South County Water Supply Project in water year 2005 (Diversion #22) and will receive a higher allotment in future phases of the project.

Since Lathrop began receiving surface water and normalized for the drought, its supply mix has steadily decreased its reliance on groundwater, from 100% of the urban demand in water year 2004 to an average of 74% of the demand after the South County Water Supply Project began (ranging from 53% to 92% at the peak of the drought).

The small amount of agricultural demand in the vicinity of Lathrop is supplied by element pumping in ESJWRM. Recycled water is utilized for some fodder crop irrigation and will be incorporated in baseline runs of the model.

3.4.13 City of Manteca

Manteca has 15 active municipal wells that provide water for urban use and 31 active agricultural wells used to irrigate city landscaping. Agricultural land near the city is irrigated by SSJID's diversion from Stanislaus River (Diversion #17). Starting in water year 2005, Manteca began receiving water from the South County Water Supply Project (Diversion #20). Additional agricultural and urban demand not met by the mix of groundwater pumping and surface water supply is estimated in the model as element pumping.

Since Manteca began receiving surface water, its supply mix has steadily decreased its reliance on groundwater, from 100% of the urban demand before water year 2005 to an average of 62% of the demand after.

3.4.14 City of Ripon

Ripon has 9 municipal pumping wells, at least 5 of which remain active at the end of the historical simulation. In addition, Ripon has 3 agricultural wells used for the city's non-potable system and 6 non-potable wells owned by Nestle. The groundwater pumping is augmented by SSJID's diversion from Stanislaus River (Diversion #17) used for agricultural land surrounding the city. The city is currently not receiving surface water for municipal use from the South County Water Supply project, but may pursue that possibility in the future (Diversion #23). Currently, all the urban demand is met by groundwater pumping.

Adjacent to the Stanislaus River, some elements are receiving water for agricultural purposes from the Stanislaus River riparian diversion (Diversion #30) as discussed in Section 3.4.19.

3.4.15 City of Escalon

Escalon has 4 municipal pumping wells, at least 3 of which remain active at the end of the simulation. Starting in water year 2005, the city was eligible to receive water from the South County Water Supply Project (Diversion #21), but has yet to build the pipeline necessary to take advantage of the allotted surface water. Currently, Escalon sells its allotment to the City of Tracy (located in San Joaquin County but outside of the ESJ Subbasin).

Agricultural land near the city is irrigated by SSJID's diversion from Stanislaus River (Diversion #17) as discussed in Section 3.4.19. Any remaining agricultural demand is supplied using ESJWRM's element pumping estimates.

3.4.16 Oakdale Irrigation District

OID takes surface water from Stanislaus River at Goodwin Dam that splits from SSJID's water to go into OID's distribution system to supply to agricultural users (Diversion #18). The district's delivery area is spread between elements in ESJWRM Subregions 13, 18, and 20. Additional agricultural water comes from OID's 24 wells spread around the district's area.

3.4.17 Cosumnes Subbasin

As it is outside of the model focus area of ESJ Subbasin, the only diversions simulated in the Cosumnes Subbasin in ESJWRM are the riparian diversions from Cosumnes River (Diversion #26) and Dry Creek (Diversion #27) (see Section 3.4.19). Any additional agricultural or urban demands are met in the model by element pumping.

3.4.18 Modesto Subbasin

Three riparian diversions extend to elements in the Modesto Subbasin—Stanislaus River (Diversion #30), Tuolumne River (Diversion #31), and San Joaquin River (Diversion #32) (see Section 3.4.19). Additional agricultural surface water comes from the Tuolumne River to Modesto Irrigation District using data in C2VSim (Diversion #24). OID's delivery area extends into the Modesto Subbasin and receives a portion of OID's diversion off Stanislaus River (Diversion #18). Any remaining agricultural demand is supplied by ESJWRM-calculated element pumping.

Urban demand in the Modesto Subbasin is largely met using element pumping, except in the area of the City of Modesto, which receives surface water from Tuolumne River (via Modesto Irrigation District) in Diversion #25, with data from C2VSim.

3.4.19 Riparian Diverters

C2VSim includes surface water diversions to non-district riparian water users along simulated streams. This information (diversion volumes, locations, and delivery areas) was pulled from C2VSim and used to simulate riparian diversions in ESJWRM. These diversions are from Cosumnes River (Diversion #26), Dry Creek (Diversion #27), Mokelumne River (Diversion #28), Calaveras River (Diversion #29), Stanislaus River (Diversion #30), Tuolumne River (Diversion #31), and San Joaquin River (Diversion #32). The riparian lands receiving these diversions are shown in Figure 36.

4. MODEL CALIBRATION

The goals of model calibration are (1) to achieve a reasonable water budget for each component of the hydrologic cycle modeled (i.e., land and water use, soil moisture, stream flow, and groundwater) and (2) to maximize the agreement between simulated and observed groundwater levels at selected well locations and simulated and observed streamflow hydrographs at selected gauging stations. These objectives are achieved through verification of the model input data and adjustment of model parameters.

4.1 Model Calibration

Model calibration begins after data analysis and input data file development is completed. The calibration effort can be broken down into subsets that align with packages within the IWFM platform. As an integrated groundwater model, the results of each part of the simulation are dependent on one another. The model calibration can be considered a systematic process that includes the following activities:

- Calibrate hydrologic demand
- Calibrate surface water features
- Calibrate overall water budgets for the model area
- Calibrate simulated groundwater levels to observed groundwater levels
- Compare calibration performance with the calibration targets
- Conduct additional refinements to model as necessary

ESJWRM was calibrated to local data and knowledge, surface water flows, groundwater hydrographs, and groundwater contours. The sources used to check model results include local knowledge (mainly gathered during Technical Review Committee meetings), AWMPs, UWMPs, other local planning efforts, measured groundwater levels and contours, and observed streamflow data.

Due to uncertainty in the initial conditions, a one year "ramp up" period is included to allow groundwater levels to stabilize. Thus, the model calibration period for the ESJWRM is October 1995 through September 2015 or water years 1996 through 2015 (20 years).

4.2 Calibration of the IDC and Root-Zone Parameters

The goal of the IDC calibration process is to determine reasonable urban and agricultural demand and develop the components of a balanced root zone budget. IDC calibration serves as the foundation of the IWFM calibration as demand estimated translates directly to groundwater pumping, which is the primary stress on the groundwater system. This part of the calibration effort focused primarily on refining individual budget items while maintaining reasonable root zone parameters.

The calibrated IDC was used to estimate monthly agricultural water demand at each model element during the model hydrologic period. To adjust agricultural demand, elemental root zone parameters, particularly the soil hydraulic conductivity and the pore size distribution index, were adjusted in accordance with the hydrologic soil group and subregion. Spatial representation of these calibrated parameters is shown in Figure 37 though Figure 41. The IDC model was calibrated to agricultural water use values reported by irrigation districts in their AWMPs and then checked against local data with input from irrigation district representatives and consultants (pers. comm. Doug Heberle from WID, Jennifer Spaletta representing

NSJWCD, Tom Flinn from NSJWCD, Peter Martin from CCWD, Cathy Lee from SEWD, Manuel Verduzco from SEWD, Sam Bologna from SSJID, Peter Rietkerk from SSJID, Bryan Thoreson representing SSJID, Emily Sheldon from OID, Eric Thorburn from OID, and Byron Clark representing OID). Figure 42a-42n show the agricultural water demand, unit agricultural water use, and unit evapotranspiration of applied water (ETAW) estimates by the total ESJ Subbasin area and major subareas. Differences in the charts between the subregion and subareas is due the differences in cropping patterns and evapotranspiration rates, which drive the estimation of agricultural demand. The difference between the two unit water use columns provide an indication of the efficiency of agricultural practices in the subregion or subarea. Overall, the estimated agricultural demand reflects the same variability seen in irrigation practices and major crops from area to area within the ESJ Subbasin.

Figure 43a-43g show the model estimated annual urban demand for the total ESJ Subbasin area and subareas. Urban demand reflects the population and per capita water use defined for each urban area and estimated for the remaining rural residential areas.

4.3 Calibration of Surface Water Features

The ESJWRM simulates streamflow in 39 small watersheds and several major rivers and creeks across the model domain.

As discussed in Section 2.10, small watersheds are used to simulate inflows into the model from ungauged watersheds. The small watershed contributions are split between surface water runoff that enters the stream system, percolation that occurs during transport to the streams, and baseflow entering the groundwater system at the model boundary. Groundwater level hydrographs along the model boundary selected for groundwater level calibration (Section 4.5) were referenced to confirm and edit, as necessary, the various parameters of the small watersheds.

Streamflow calibration is primarily performed by comparing the simulated streamflow with local data from 11 stream gauges (Table 9 and Figure 44). Data for these gauges came from USGS or the California Data Exchange Center (CDEC). Two of these stream gauges (Mokelumne River below Camanche Dam and San Joaquin River near Vernalis) are duplicates of gauges used to estimate stream inflow into the model area and were not referenced for streamflow calibration and only verification of model setup.

Table 9: Summary of ESJWRM Stream Calibration Gauges

Stream	Stream Node	Agency	Gauge Name	Period of Record
Cosumnes River	98	USGS	USGS 11336000: Cosumnes River at McConnell, CA	October 1941 to October 1982
Dry Creek	222	USGS	USGS 11329500: Dry Creek near Galt, CA	October 1926 to December 1997
Mokelumne River*	290	USGS	USGS 11323500: Mokelumne River below Camanche Dam, CA	October 1904 to present/ongoing
Mokelumne River	382	USGS	USGS 11325500: Mokelumne River at Woodbridge, CA	June 1924 to present/ongoing
Mokelumne River	501	USGS	USGS 11336930: Mokelumne River at Andrus Island near Terminous, CA	July 2006 to present/ongoing

Stream	Stream Node	Agency	Gauge Name	Period of Record
Mormon Slough	876	USACE	CDEC MRS: Mormon Slough at Bellota	December 1997 to present/ongoing
Stanislaus River	1067	DWR	CDEC OBB: Stanislaus River at Orange Blossom Bridge	January 1993 to present/ongoing
Stanislaus River	1186	USGS	USGS 11303000: Stanislaus River at Ripon, CA	October 1940 to present/ongoing
Tuolumne River	1382	USGS	USGS 11290000: Tuolumne River at Modesto, CA	April 1940 to present/ongoing
San Joaquin River*	1497	USGS	USGS 11303500: San Joaquin River near Vernalis, CA	October 1923 to present/ongoing
San Joaquin River	1597	USGS	USGS 11304810: San Joaquin River below Garwood Bridge at Stockton, CA	December 1995 to present/ongoing

*Same as stream inflow gauge, so not used for calibration and included as verification of model setup

Stream flow calibration included refinement of the stream bed hydraulic conductivity originally from C2VSim (Figure 45). Simulated stream flows were compared with observed records and exceedance charts were also used to check the model performance when simulating high and low flows at each gauge location. Calibration results for select stream gauges are included in Figure 46a-46j.

4.4 Calibration of Water Budgets

The aim of the calibration process is to ensure the accurate representation of the hydrologic characteristics of the groundwater basin, confirmed through the analysis of the resulting water budgets. A water budget balances all supplies, demands, and any subsequent change in storage occurring within that specific portion of the hydrologic cycle. IWFM automatically outputs budgets at the subregion scale for processes involving groundwater, the surface layer, streams, the root zone, small watersheds, and the unsaturated zone. IWFM can output select budgets down to a single element or any specific grouping of elements.

During this step of the calibration process, model results are reviewed and summarized into monthly and annual (by water year) budgets. The most important budgets reviewed for calibration are the groundwater budget and the land and water use budget. After extensive budget analysis, key model datasets and parameters are adjusted, particularly groundwater aquifer parameters, to better match local budgets from AWMPs or other planning efforts. The ESJWRM water budget results are summarized in the following sections.

4.4.1 Land and Water Use Budget

The land and water use budget includes two different versions, agricultural and urban, and represents the balance of the IDC-calculated water demands with the water supplied. Both the agricultural and urban versions include the same components that make up the water balance:

- Inflows:
    - Demand (either agricultural or urban)
    - Surplus (if applicable)

- Outflows:
    - Groundwater pumping
    - Surface water deliveries
    - Shortage (if applicable)

The average annual water demand for the subbasin within the calibration period was 1.2 million acre-feet (MAF), consisting of approximately 1.1 MAF agricultural demand and 0.1 MAF urban demand. This demand was met by approximately an average annual of 0.50 MAF of surface water deliveries (0.45 MAF of agricultural and 0.05 MAF of urban deliveries) and was supplemented by approximately 0.69 MAF of groundwater production (0.62 MAF of agricultural and 0.07 MAF of urban pumping). The annual estimated land and water use budgets for the calibration period are presented in Figure 47a-47g and Figure 48a-48g, showing the agricultural and urban, respectively, demands and water supplies in the ESJ Subbasin and its component subareas. Due to uncertainties in the reported and estimated values of agricultural and urban water supplies, as well as respective estimates of the demands, there are some imbalances between the demand and supply values. These imbalances are shown as surplus or shortage and are typically less than 10% of the reported supplies, and within the margin of errors of the analysis.

4.4.2 Groundwater Budget

The primary components of the groundwater budget, corresponding to the major hydrologic processes affecting groundwater flow in the model area, are:

- Inflows:
    - Deep percolation (from rainfall and excess irrigation applied water)
    - Gain from stream (or recharge due to stream seepage)
    - Recharge (from other sources such as irrigation canal seepage and recharge ponds)
    - Boundary inflow (from outside the model area)
    - Subsurface inflow (from adjacent subregions)
- Outflows:
    - Groundwater pumping
    - Loss to stream (or outflow to streams and rivers)
    - Boundary outflow (to outside the model area)
    - Subsurface outflow (to adjacent subregions)
- Change in groundwater storage (either an inflow or outflow)

The groundwater budget consists of inflows to and outflows from the groundwater system. Figure 49a-49g show the annual components of the groundwater budget, including cumulative change in groundwater storage for ESJ Subbasin. Primary components of the groundwater budget are as follows: average annual groundwater pumping is estimated to be 0.70 MAF, which is offset by approximately 0.22 MAF of deep percolation from rainfall and applied water, net gain from stream of 0.15 MAF, recharge from conveyance and unlined canals of approximately 0.12 MAF, and a total net subsurface inflow of approximately 0.16 MAF from neighboring subbasins and foothills. The cumulative change in groundwater storage is calculated from the change in groundwater storage. Due to inherent uncertainties in data and assumptions used in the model, approximations used in representing physical features in the aquifer system, and uncertainties in the model calibration, all budget components have some degree of uncertainty. A sensitivity analysis was performed to estimate the sensitivity of the model results to the changes in each of the key model parameters. Given the overall range of uncertainties, the long-term average annual depletion in groundwater storage in ESJ Subbasin during the model historical period is estimated to range between 24 to 70 TAF, with an average of approximately 47 TAF per year.

4.5 Groundwater Level Calibration

Like streamflow calibration, the goal of groundwater level calibration is to achieve reasonable agreement between the simulated and observed values (in this case, groundwater levels at calibration wells). Within the ESJWRM, over 3,000 wells were evaluated for developing groundwater observation locations to track ESJWRM's calibration at both a regional and local scale. The records for these wells were obtained from San Joaquin County's monitoring database, DWR's CASGEM program, and local monitoring wells from the City of Lodi and Oakdale Irrigation District. The calibration wells were selected based on their period of record, spatial distribution across the model, representativeness of good indicators of model responses to the various stresses, availability of observation data, and trends of nearby wells. Though a working set of 160 wells was tentatively selected initially, this was narrowed to an ultimate set of 70 wells that are representative of the long-term conditions of groundwater levels both at a local and regional scale in ESJWRM. These 70 calibration wells are shown in Figure 50 with information tabulated in Appendix C.

Simulated groundwater levels are calibrated to observed levels through adjustments to hydrogeologic parameters or aquifer parameters including hydraulic conductivity, specific storage, and specific yield (discussed in Section 4.7). The goal of groundwater level calibration is to achieve the maximum agreement between simulated and observed groundwater elevations at calibration wells while maintaining reasonable values for aquifer parameters. The groundwater level calibration is performed in two stages:

- The initial calibration effort is focused on the regional scale to verify hydrogeological assumptions made during data development and confirm the accuracy of general groundwater flow vectors. During this iteration, simulated groundwater elevation trends, flow directions, and groundwater gradients are compared to measured data. DWR's groundwater level contours for spring and fall many years starting in the 2010s were used to evaluate ESJWRM's groundwater contours from matching time periods. Figure 51a-51d show the resulting ESJWRM groundwater level elevations (average of the top 2 layers of the model where most of the pumping in the subbasin occurs) compared to DWR contours for 4 different seasons and years: Spring 2011, Fall 2013, Spring 2015, and Fall 2015. Fall 2015 also represents the end of simulation groundwater levels.
- The second stage of calibration of groundwater levels is to compare the simulated and observed groundwater level at each calibration well. This comparison provides information on the overall model performance during the simulation period. The simulated groundwater elevations at the 70 calibration wells were compared with corresponding observed values for concurrence in long-term trends as well as seasonal fluctuations.

Discussed further in the next section (Section 4.6), the results of the groundwater level calibration indicate that the ESJWRM reasonably simulates the long-term hydrologic responses under various hydrologic conditions. Figure 52a-52r show a selection of calibration wells (1 representing each ESJ Subbasin model subregion or 18 wells) with their resulting groundwater level hydrographs. All 70 calibration well hydrographs are included in Appendix C.

4.6 Measurement of Calibration Status

The ESJWRM calibration status was measured using two metrics: the groundwater level trend and the relationship between simulated and observed groundwater levels. The statistics were evaluated to meet the American Standard Testing Method (ASTM) standard. In addition to quantifiable metrics, the ESJWRM calibration was evaluated by generating reasonable regional groundwater flow directions and producing realistic water budgets.

The "Standard Guide for Calibrating a Groundwater Flow Model Application" (ASTM D5981) states that "the acceptable residual should be a small fraction of the head difference between the highest and lowest heads across the site." The residual is defined as the simulated head minus the observed head. An analysis of all calibration water levels within the model indicated the presence of 200+ feet of water level changes. Using 10 percent as the "small fraction", the acceptable residual level would be 20 feet. Calibration goals for the groundwater level residuals were set such that no more than 10 percent of the observed groundwater levels would exceed the acceptable residual level of 20 feet.

- 75% of observed groundwater levels are within +/- 10 feet of its respective simulated values
- 97% of observed groundwater levels are within +/- 20 feet of its respective simulated values
- 99% of observed groundwater levels are within +/- 30 feet of its respective simulated values

The residual histogram for the ESJ Subbasin is shown in Figure 53. Additionally, a scatter plot of simulated versus observed values is shown in Figure 54.

4.7 Final Calibration Parameters

The initial aquifer parameters for the ESJWRM came from DWR's texture model values extracted to C2VSim coarse grid nodes. These coarse grid nodes formed a parametric grid covering the model area and reflected the scale at which parameters were adjusted throughout the calibration process. The grid was slightly modified to cover the entire ESJWRM model along the boundaries and additional nodes were added or moved within areas of the model to provide better control (Figure 55). The parameters resulting from the calibration process are listed in Table 10.

Table 10: Range of Aquifer Parameter Values

Stream	Layer 1	Layer 2	Layer 3	Layer 4
Horizontal Hydraulic Conductivity (ft/day)	11.5 – 72.7	6.4 – 44.8	1.1 – 4.6	1.8 – 5.2
Vertical Hydraulic Conductivity (ft/day)	0.005 – 0.14	0.004 – 0.07	0.004 – 0.05	0.004 – 0.15
Corcoran Clay Vertical Hydraulic Conductivity (ft/day)	3.6×10^{-4} – 1.5×10^{-3}	3.6×10^{-4} – 1.5×10^{-3}	3.6×10^{-4} – 1.5×10^{-3}	3.6×10^{-4} – 1.5×10^{-3}
Specific Storage (unitless)	8.55×10^{-5} – 1.57×10^{-4}	4.18×10^{-6} – 1.97×10^{-4}	4.21×10^{-6} – 2.05×10^{-4}	2.53×10^{-5} – 1.75×10^{-4}
Specific Yield (unitless)	0.04 - 0.10	0.04 – 0.09	0.04 – 0.09	0.05 – 0.09

Horizontal Hydraulic Conductivity – The hydraulic conductivity (KH) in the ESJWRM varies across the horizontal direction and across model layers. The fully calibrated values remain descriptive of the initial hydrogeologic analysis, range from 1.1 ft/day to 72.7 ft/day, and the spatial distribution is represented in Figure 56 through Figure 58.

Vertical Hydraulic Conductivity – Primarily a constraining factor across the Corcoran Clay in the small portion of the model underlain by it, the Vertical Hydraulic Conductivity (KV) facilitates the separation between the unconfined and confined aquifers within the ESJWRM. The KV values of the Corcoran aquitard is found to be less than one one-thousandth of the horizontal conductivity of the surrounding aquifer systems. For those parts of ESJWRM without Corcoran Clay, the KV controls the flow of groundwater between the materials making up the different modeled aquifer layers.

Specific Storage – Specific Storage (SS) is used to represent the available storage at nodes in a confined aquifer, where the hydraulic head is above the top of the aquifer. Specific Storage is the unit volume of water released or taken into storage per unit change in head. Calibrated specific storage values range from 4.18×10^{-6} to 2.05×10^{-4}, as shown in Figure 59 through Figure 61.

Specific Yield – Specific Yield (SY) is representative of the available storage in an unconfined aquifer and defined as the unit volume of volume released from the aquifer per unit change in head due to gravity. Calibrated specific storage values range from 0.04 to 0.10 and are shown in Figure 62 through Figure 64.

4.8 Sensitivity Analysis

Sensitivity analysis is an important step in the model development process. It is defined as "the study of distribution of dependent variables (e.g., groundwater elevations in a groundwater model) in response to changes in the distribution of independent variables, initial conditions, boundary conditions, and physical parameters" (AWWA, 2001). In general, a sensitivity analysis of an integrated groundwater and surface water model is performed for the following purposes:

- To test the robustness and stability of the model by establishing tolerance within which the model parameters can vary without significantly changing the model results;
- To understand the impact of inaccuracies in input data on model results (e.g., how model results can change because of a 10% error in the estimation of agricultural pumping); and
- To develop an understanding of the relative sensitivity of the components of the hydrologic cycle and data, so that an effective data collection and monitoring plan can be developed.

A sensitivity analysis was performed using the ESJWRM to assess the sensitivity of model results to specific model parameters and input data. Two different metrics were selected to measure the sensitivity of the ESJWRM. A sensitivity metric is a single number derived from the ESJWRM results and has a unique value for each model run corresponding to a given set of data or parameter value. The sensitivity metrics used here:

- Average groundwater elevation in the study areas, and
- Average root mean square (RMS) error aggregated from selected calibration wells.

Average groundwater elevation in the study areas is defined as a three-way average of simulated groundwater elevations at model nodes. The average is taken over the model layers, model nodes, and time.

This can be mathematically expressed by:

$$\overline{H} = \frac{1}{M}\sum_{K=1}^{M} H_k$$

Such that,

$$H_k = \frac{1}{N}\sum_{i=1}^{N}\left[\frac{1}{L}\sum_{j=1}^{L} h_j\right]_i^k$$

Where,

M total number of simulation time steps,

H_k average head in the model area at k-th time step,

N number of model nodes,

L number of model layers in aquifer,

H_j groundwater elevation at layer j, and

i, j, k are indices for node, layer, and time, respectively.

The average RMS error at selected calibration wells is defined as the average of individual RMS error at each calibration well. The RMS error at a calibration well is defined as follows:

$$RMS_w = \sqrt{\left\{\frac{1}{N}\sum_{k=1}^{N_0}\left[h_{k,w}^0 - h_{k,w}^s\right]^2\right\}}$$

where,

N_0 is the number of observations at well k,

$h_{k,w}^0$ is the observed groundwater elevation at time step k, at well w,

$h_{k,w}^s$ is the simulated groundwater elevation at time step k, at well w.

4.8.1 Sensitivity Analysis Results

Adjustments of aquifer parameters, and the analysis the resulting groundwater head, was performed at all groundwater nodes within the model domain. Similarly, streambed conductance was analyzed at all model stream nodes. Sensitivity analyses were performed for the ESJWRM for the following parameters with results discussed below.

Horizontal Hydraulic Conductivity – The sensitivity of the ESJWRM to changes in hydraulic conductivity are presented in Figure 65 and Figure 66. Reduction of hydraulic conductivity to one-fourth of the calibrated value results in 10.13 feet higher groundwater levels in the model, whereas increases to hydraulic conductivity decrease the average groundwater levels by 2.05 feet. Changes to horizontal hydraulic conductivity have small impacts to RMS values.

Vertical Hydraulic Conductivity – The sensitivity of the ESJWRM to changes in vertical hydraulic conductivity are presented in Figure 67 and Figure 68. Reduction of this parameter to one-fourth of the calibrated value results in 10.34 feet higher groundwater levels in the model, whereas increases to the vertical hydraulic conductivity decrease the average groundwater levels by 4.80 feet. Changes to vertical hydraulic conductivity have very little impact on RMS values.

Specific Storage – The sensitivity of the ESJWRM to changes in specific storage are presented in Figure 69 and Figure 70. Reduction of specific storage to one-fourth of the calibrated value results in approximately 12.64 feet higher groundwater levels in the model, whereas increases to specific storage decrease the average groundwater levels by 1.49 feet. Changes to specific storage have very little impact on RMS values.

Specific Yield – The sensitivity of the ESJWRM to changes in specific yield are presented in Figure 71 and Figure 72. Reduction of specific yield to one-fourth of the calibrated value results in 11.67 feet higher groundwater levels in the model and increases to specific yield increase the average groundwater levels by 1.82 feet. Changes to specific yield have slight impacts to RMS values.

Streambed Conductance – The sensitivity of the ESJWRM to changes in streambed conductance are presented in Figure 73 and Figure 74. Reduction of conductance to one-fourth of the calibrated value results in 8.09 feet higher groundwater levels in the model, whereas increases to conductance decrease the average groundwater levels by 5.09 feet. Changes to streambed conductance have slight impacts to RMS values.

The results of the sensitivity analysis for the ESJWRM indicate that the model is a stable model and the system responds in the expected manner because of changes in aquifer parameters and other input data.

5. CONCLUSIONS AND RECOMMENDATIONS

The ESJWRM, in its current state, is a robust, comprehensive, defensible and well-established model for assessing the water resources in the ESJ Subbasin under historical and projected conditions. The following recommendations are to be considered for further refinements and enhancements of the model:

- **Continue engagement with local groundwater users and managers**. Continue working with local agencies and groundwater users in ESJ Subbasin to further understand the local operations of the groundwater system and improve representation of groundwater users in the ESJWRM.
- **Refinement of boundary flows**. The current boundary flows at the northern, western, and southern boundaries of the model area are based on an older version of the C2VSim with adjustments made based on initial groundwater levels assumed for the beginning of the model (October 1994). DWR is currently in the process of updating the C2VSIm model. Once the latest fine grid version (C2VSim-2015) is publicly available, boundary flows for the ESJ model area should be verified and updated, as necessary.
- **Enhance variability of potential evapotranspiration**. The current version of the IDC used for estimation of the consumptive use of crops in the ESJWRM uses monthly potential ET values that are the same for all years during the model period. Given that there may be annual variability in the potential ET data with possible effects on the annual estimation of crop water demand, it is recommended to use more detailed data with temporal variability to develop a full time series of ET values for use in the model.
- **Refine surface water deliveries in Cosumnes and Modesto Subbasins.** The surface water deliveries in the Cosumnes and Modesto Subbasins are currently at the subregion level and do not have the detailed spatial resolution of other areas within the ESJ Subbasin. This data may need to be verified and updated as modeling efforts in those subbasins progress to meet the requirements of SGMA.
- **Update C2VSim based on ESJWRM**. The fine grid version of C2VSim was developed by the DWR to evaluate the integrated surface water and groundwater conditions at a regional scale; whereas, the ESJWRM is capable of evaluation at the local scale. To increase the accuracy of regional groundwater conditions in the fine grid C2VSim, the County is encouraged to work with DWR to provide data and information for further refinement and update of C2VSim in the ESJWRM area.
- **Develop model update schedule**. In order to keep the ESJWRM up-to-date and current for analysis of water resources and especially for supporting SGMA implementation, it is recommended that the model be updated every 3 to 5 years. A possible update schedule can be kept consistent with the GSP updates, with a lead time of 2 to 3 years relative to the GSP update schedule.

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FIGURES

Figure 1: ESJ Subbasin with County Lines

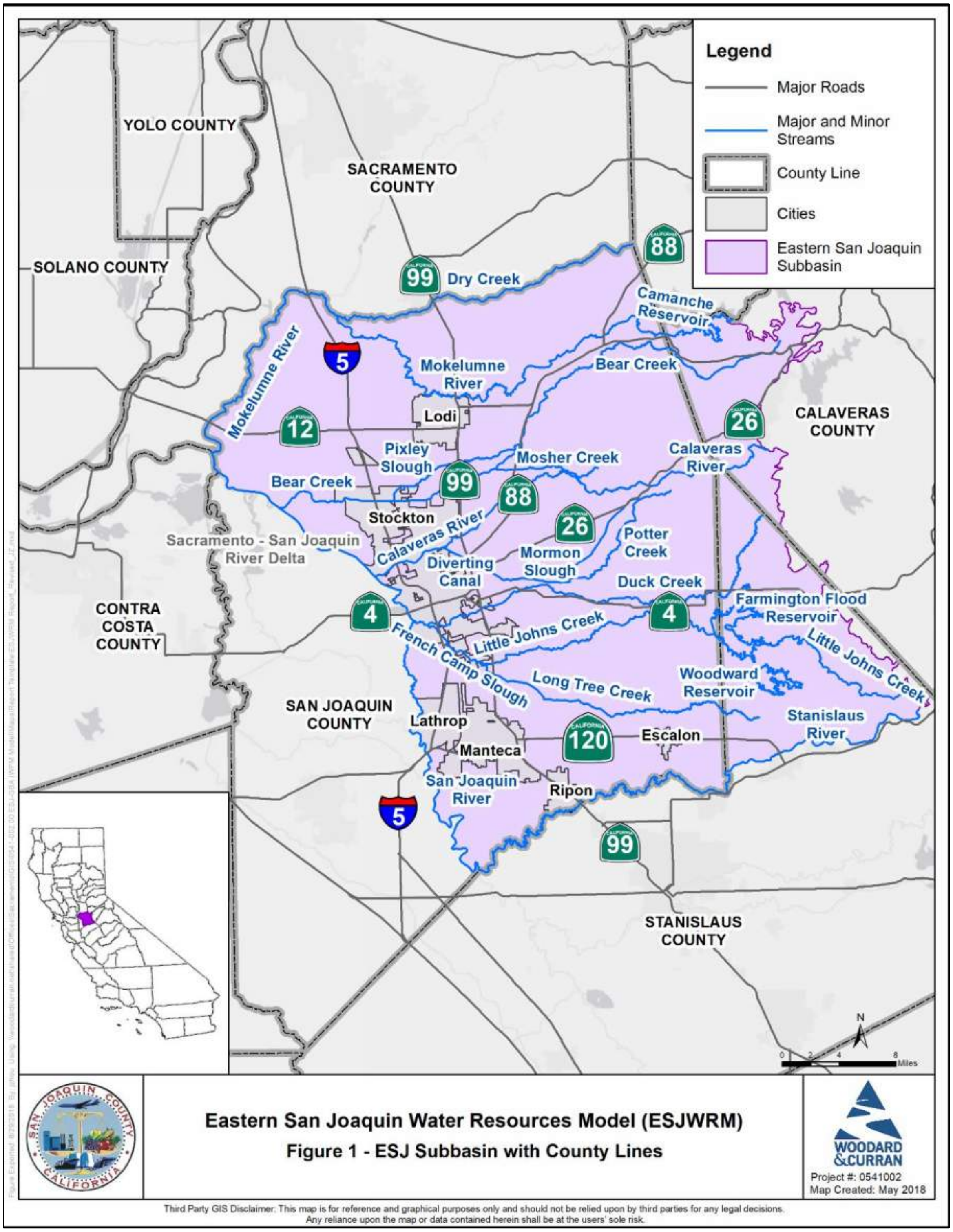


Figure 2: Groundwater Subbasins

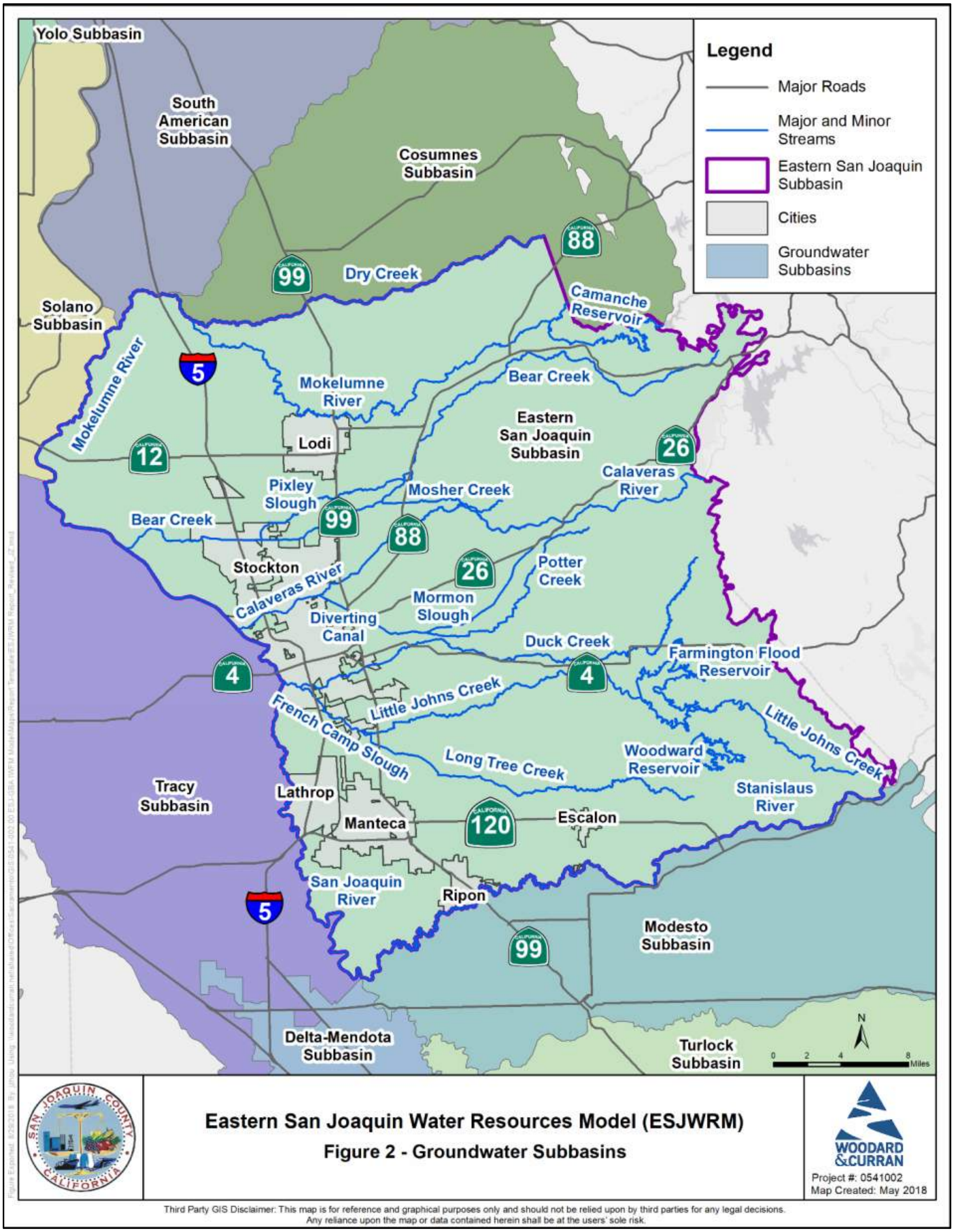


Figure 3a: ESJ Subbasin Major Water Purveyors

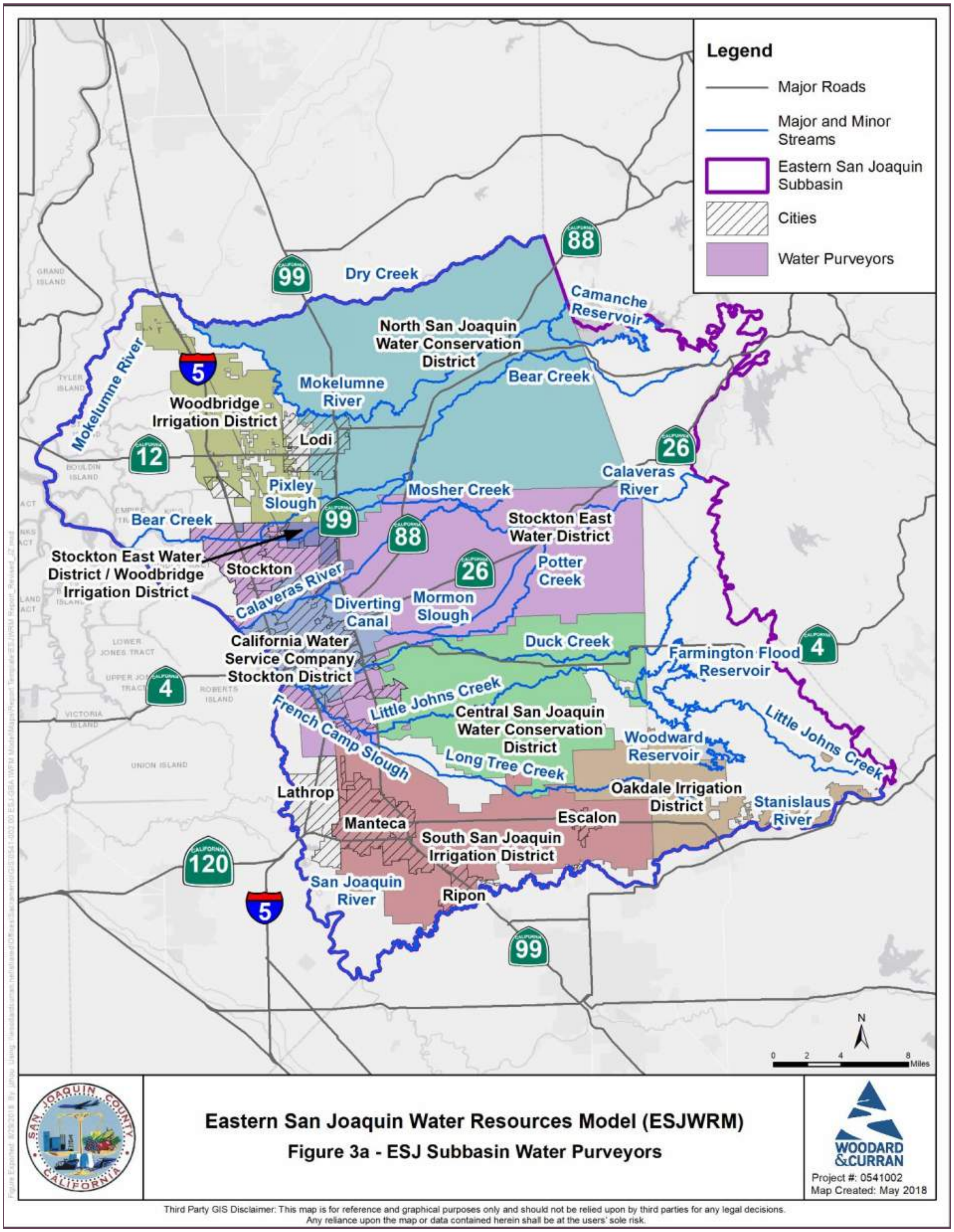


Figure 3b: ESJ Subbasin Groundwater Sustainability Agencies

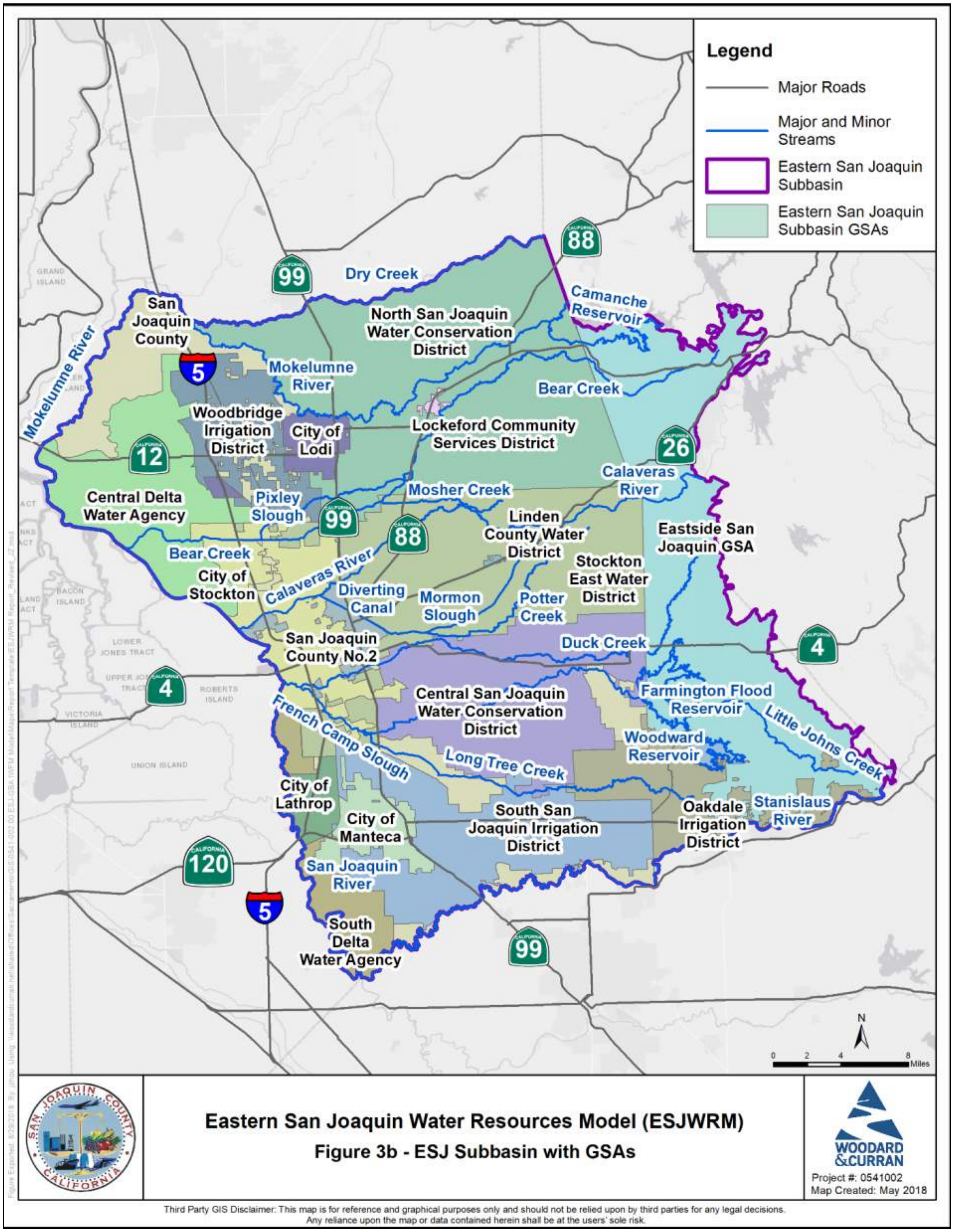


Figure 4: ESJWRM Boundaries

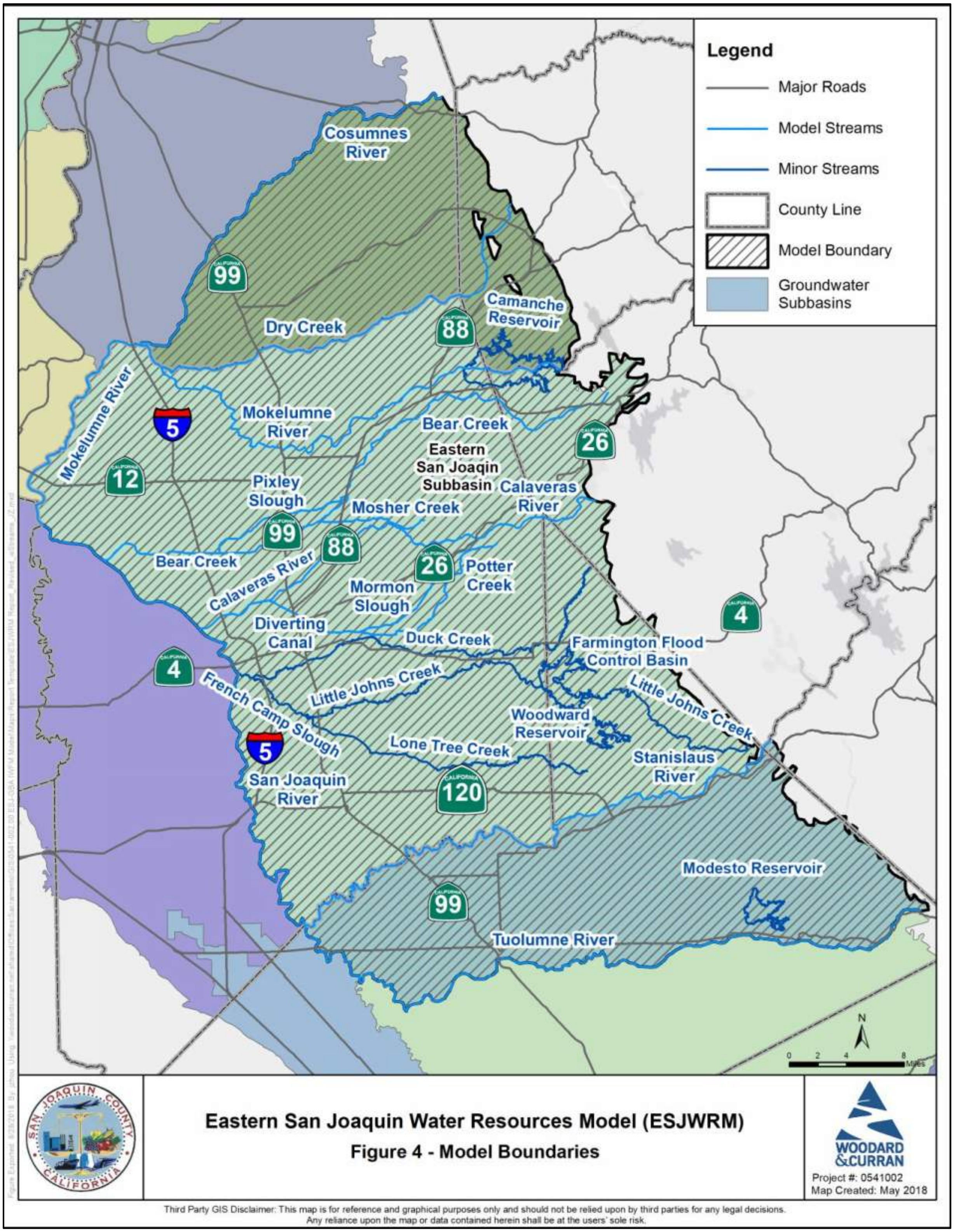


Figure 5: ESJWRM Grid Development Features

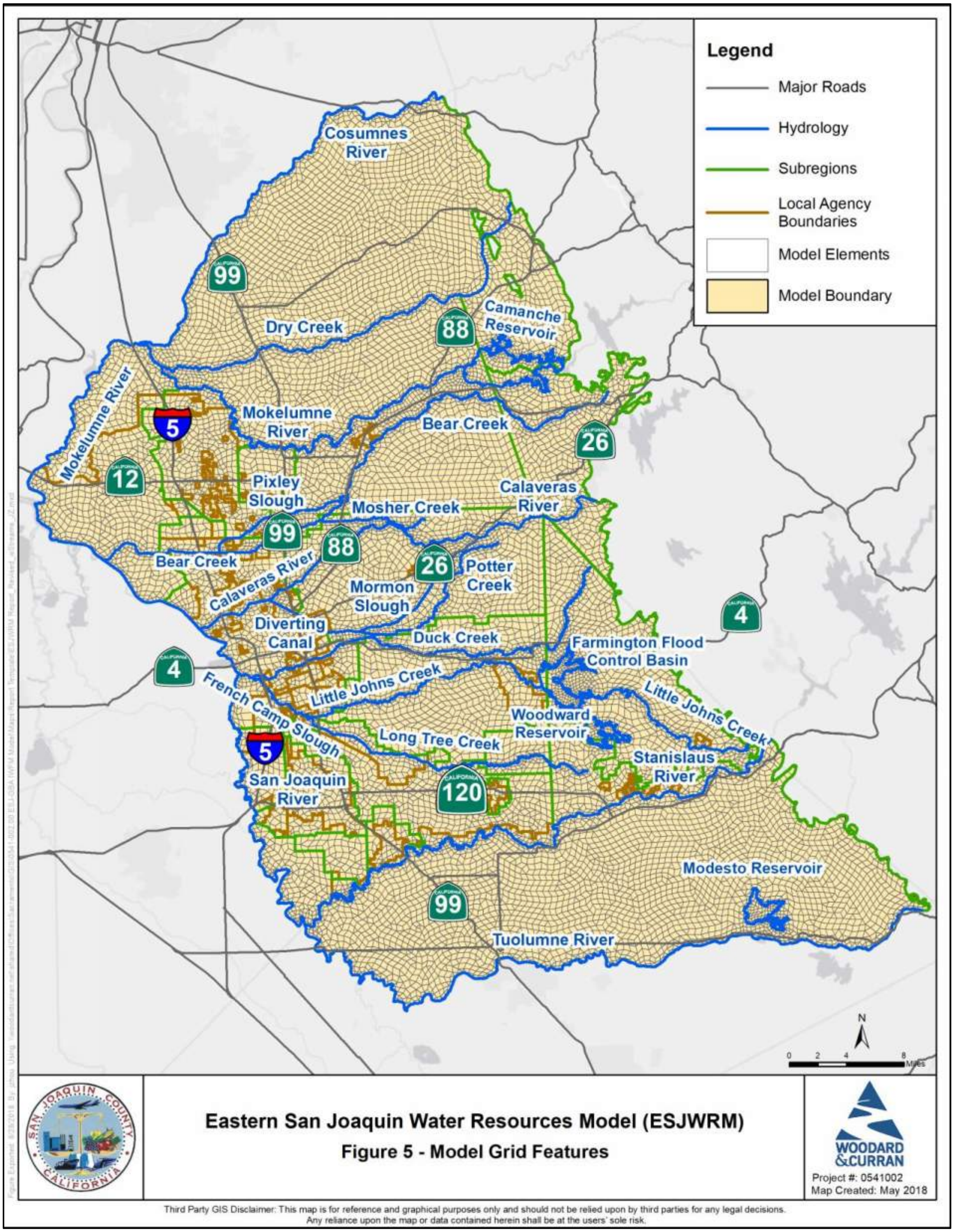


Figure 6: ESJWRM Elements

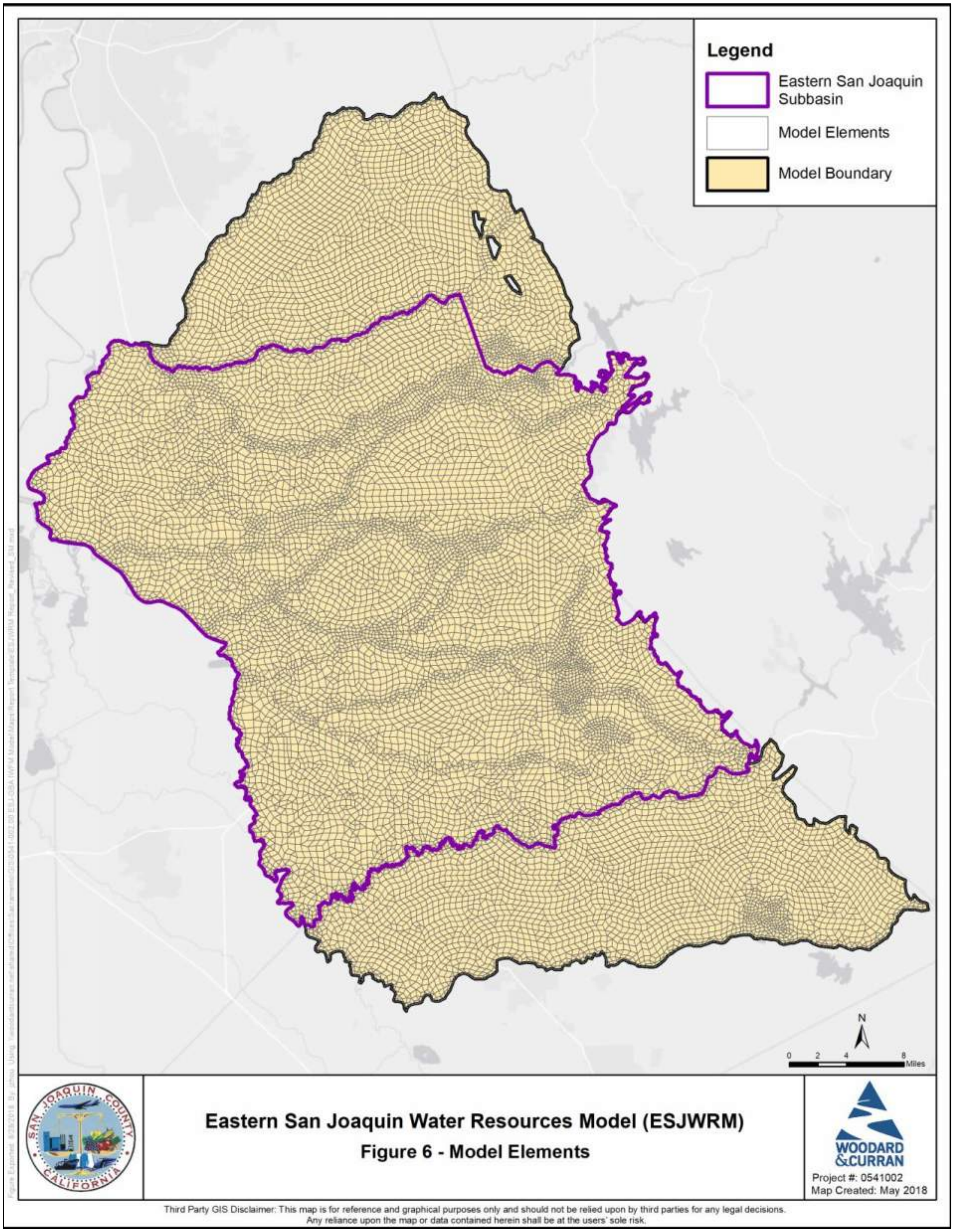


Figure 7: ESJWRM Subregions

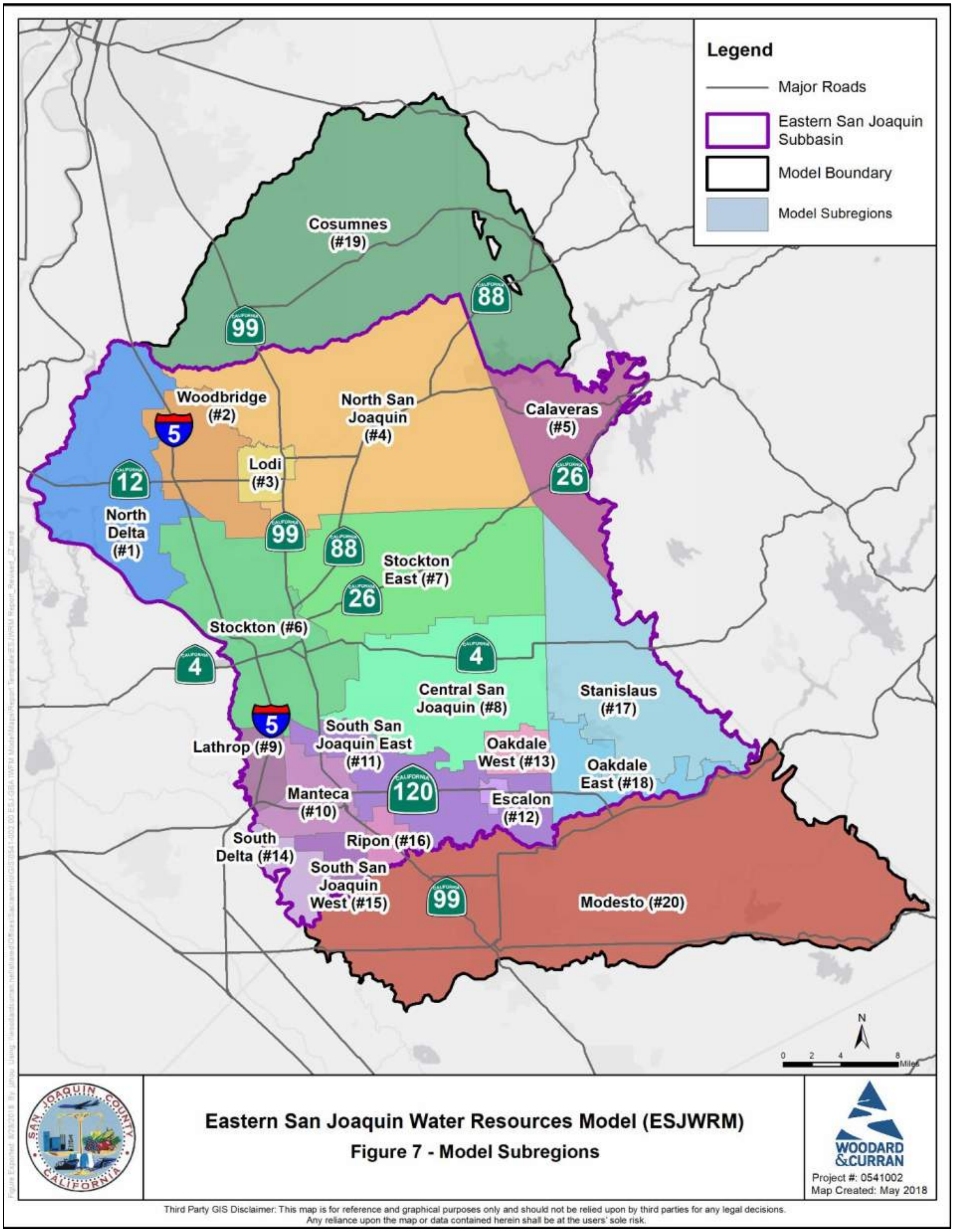


Figure 8: ESJWRM Subareas

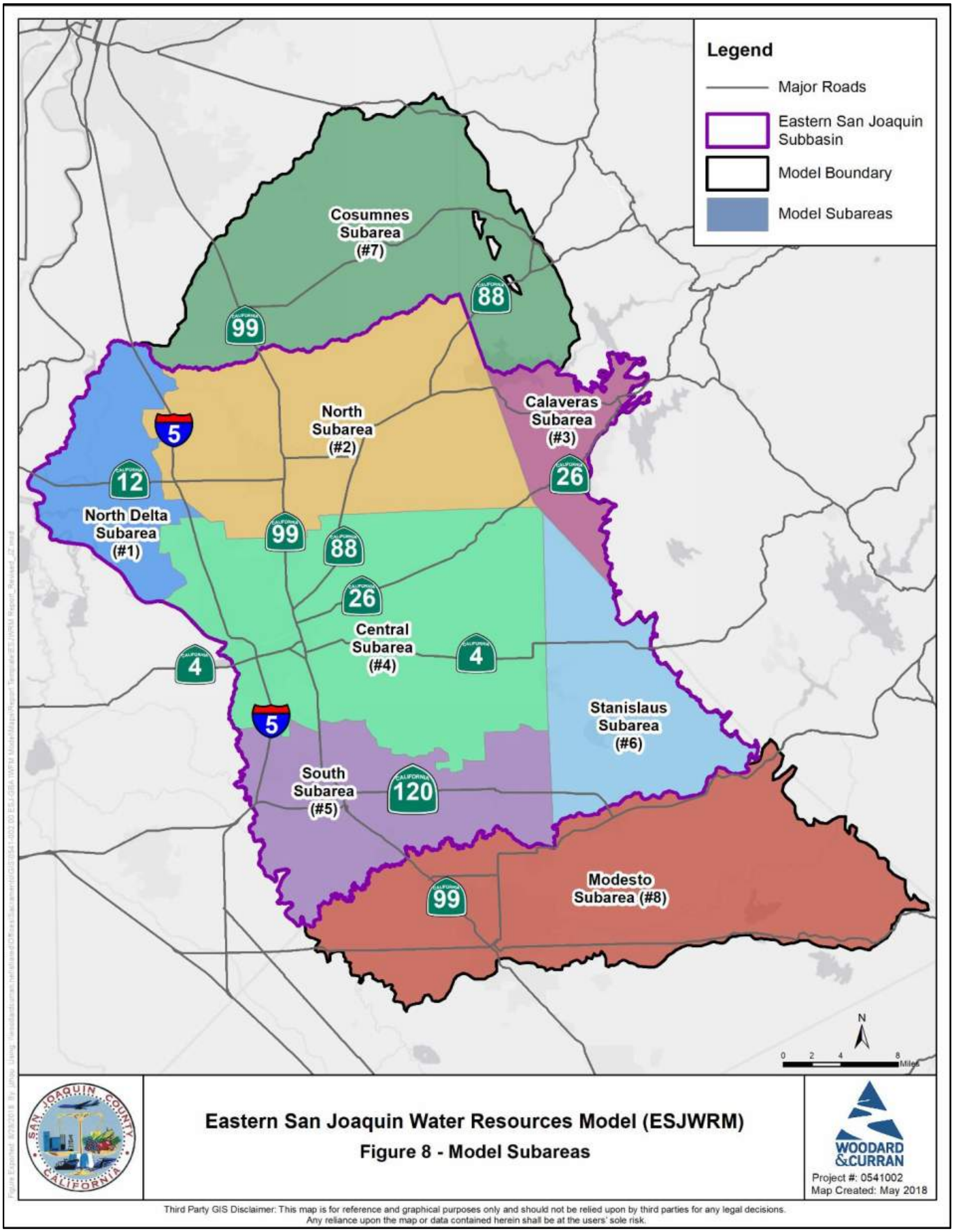


Figure 9: ESJWRM Streams and Stream Inflow Locations

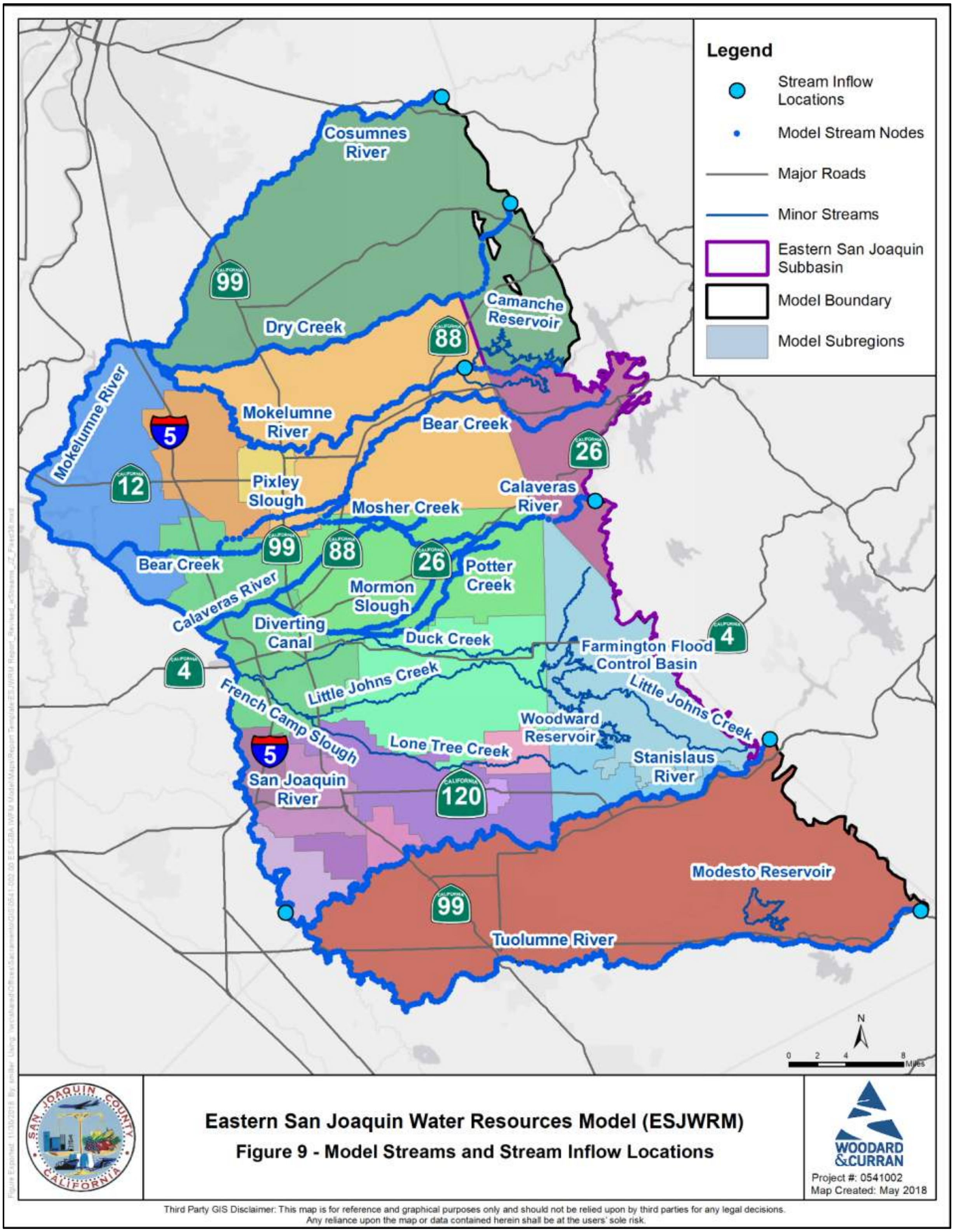


Figure 10: ESJWRM Average Annual Precipitation

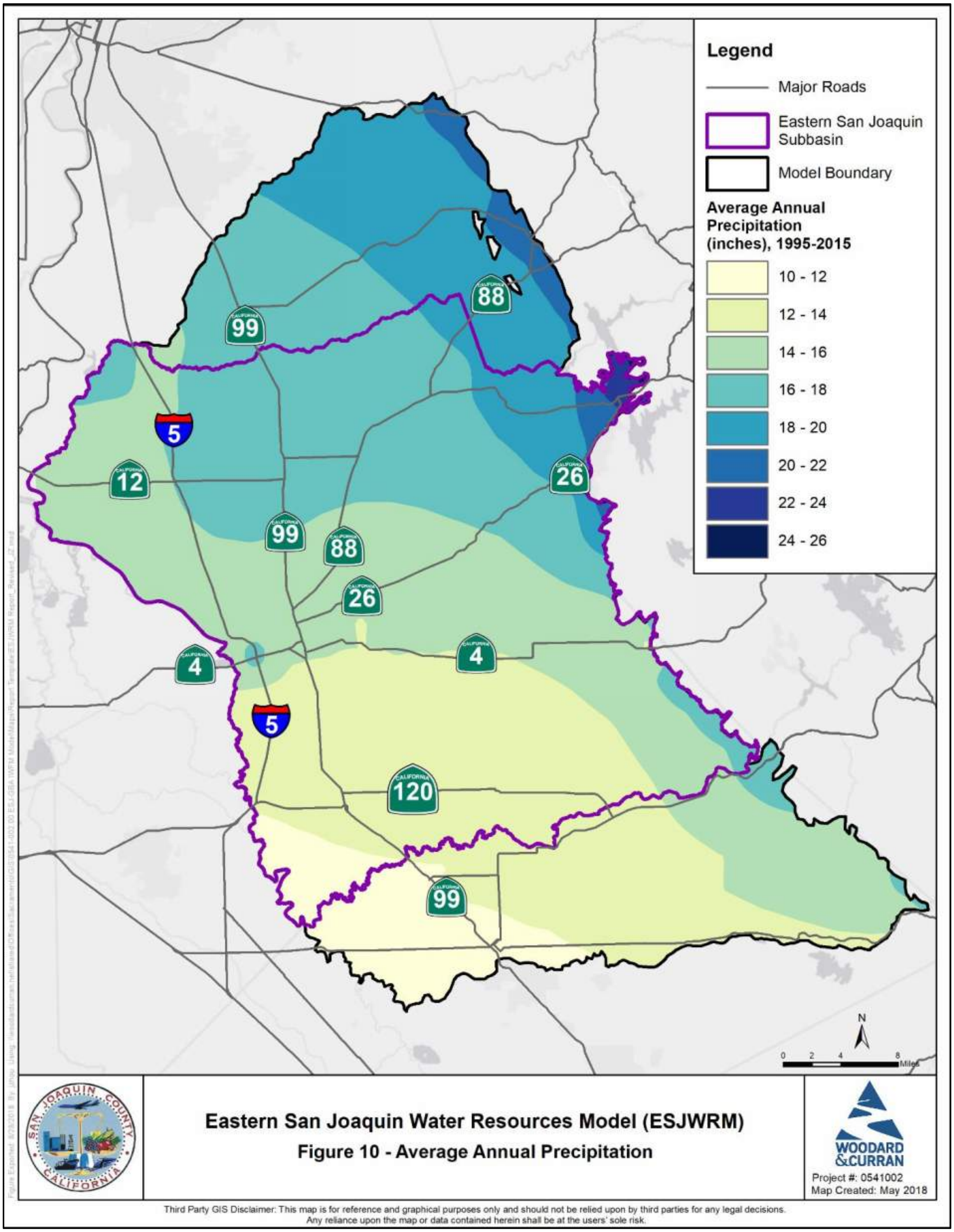


Figure 11: ESJWRM Annual Rainfall

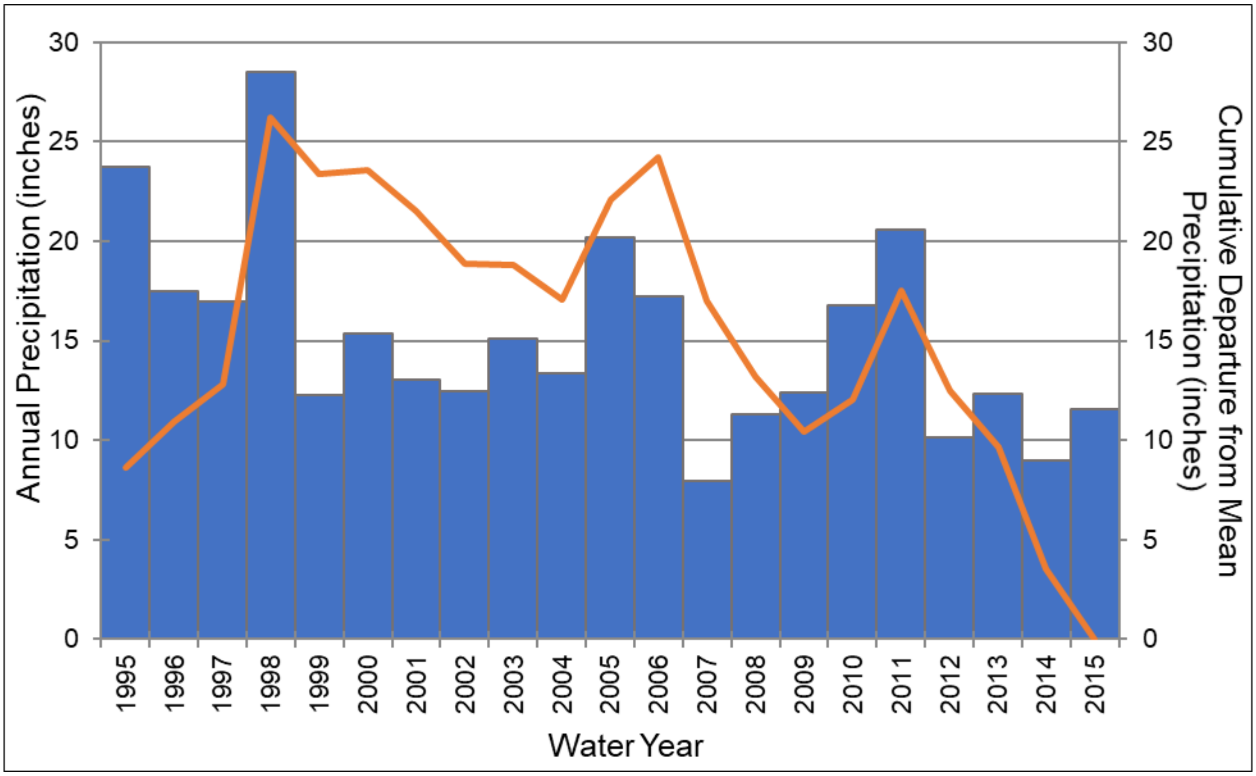


Figure 12: ESJWRM Hydrologic Soil Group

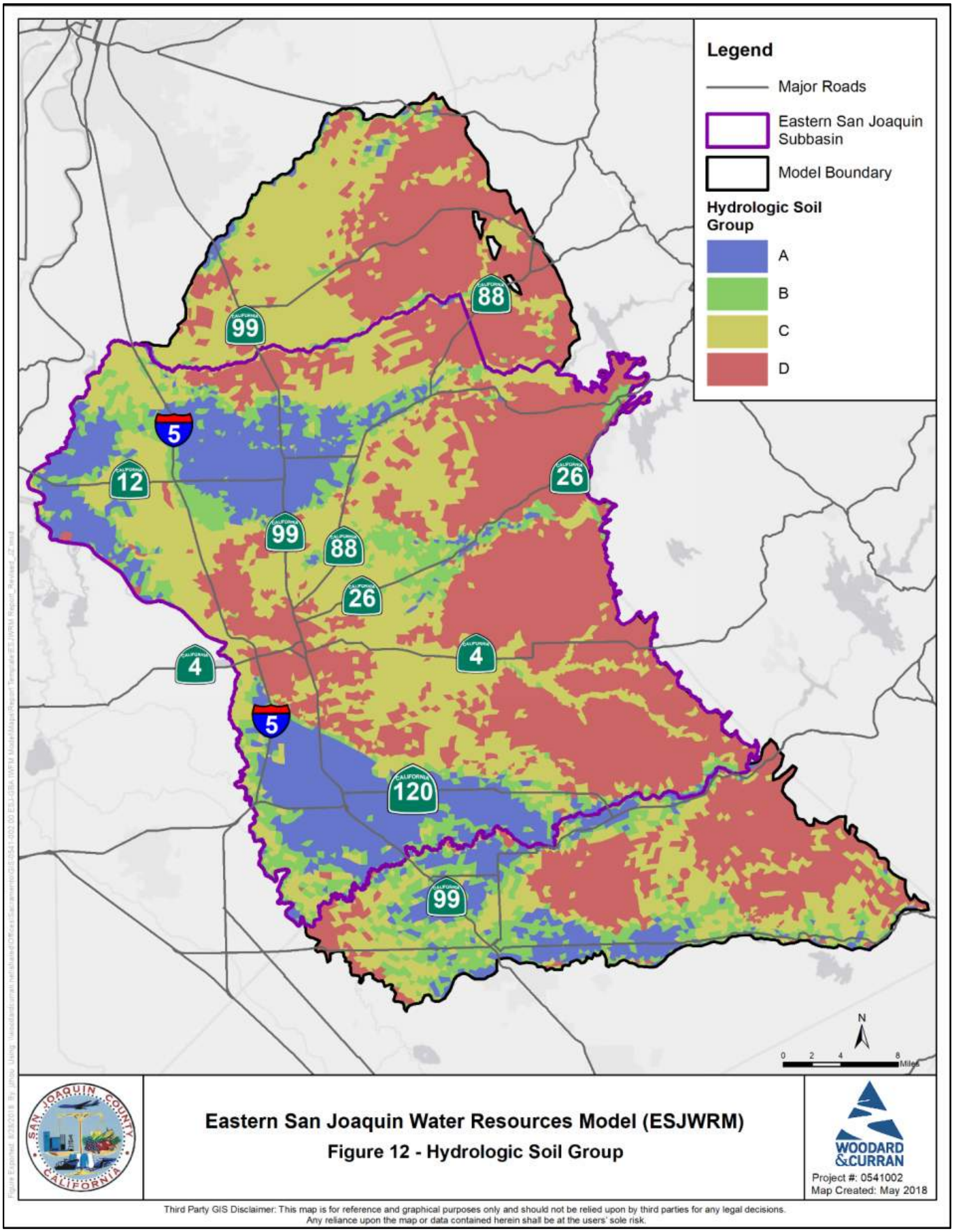


Figure 13: ESJWRM General Land Use in 1995 DWR Land Use Survey

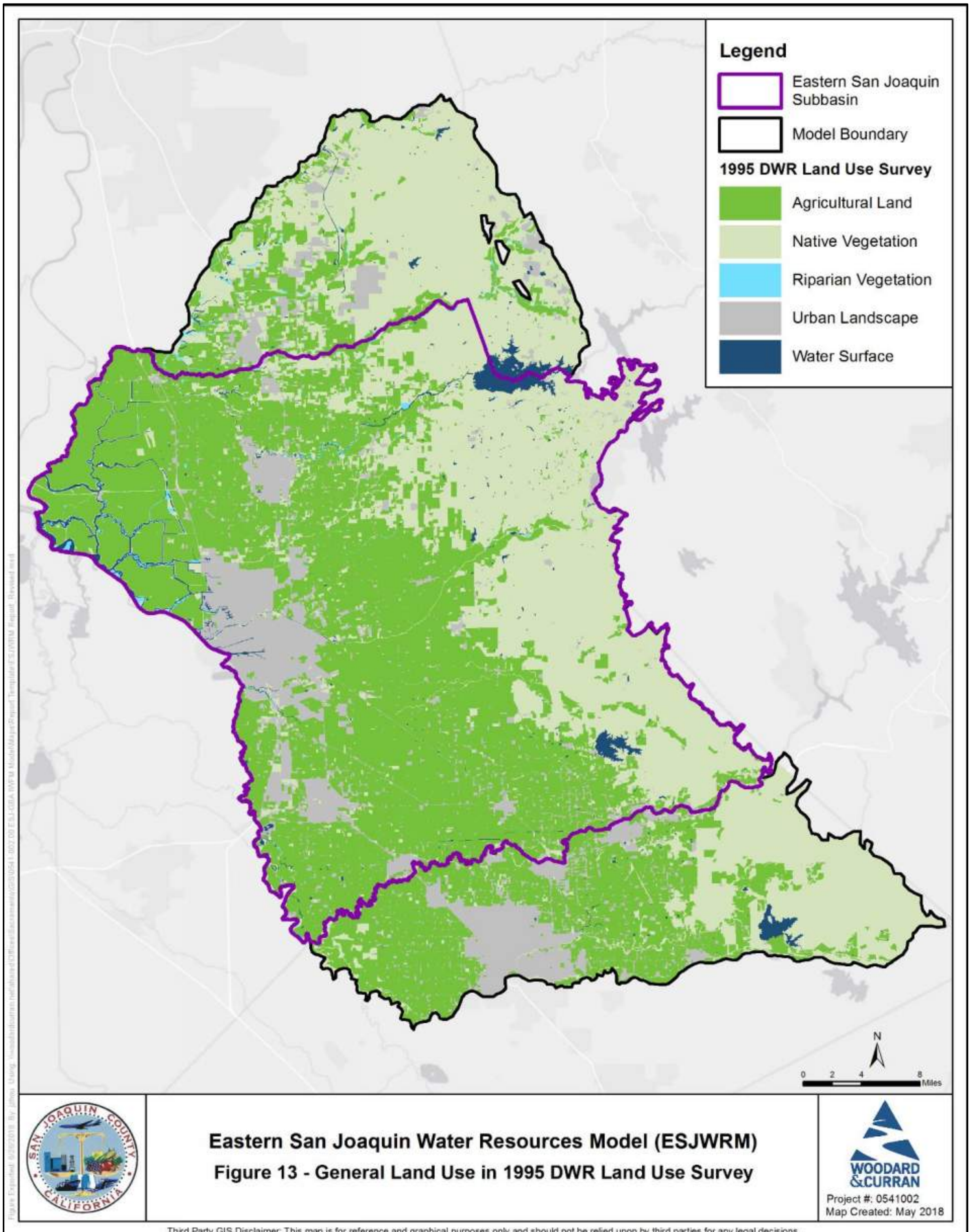


Figure 14: ESJWRM General Land Use in 2015 CropScape

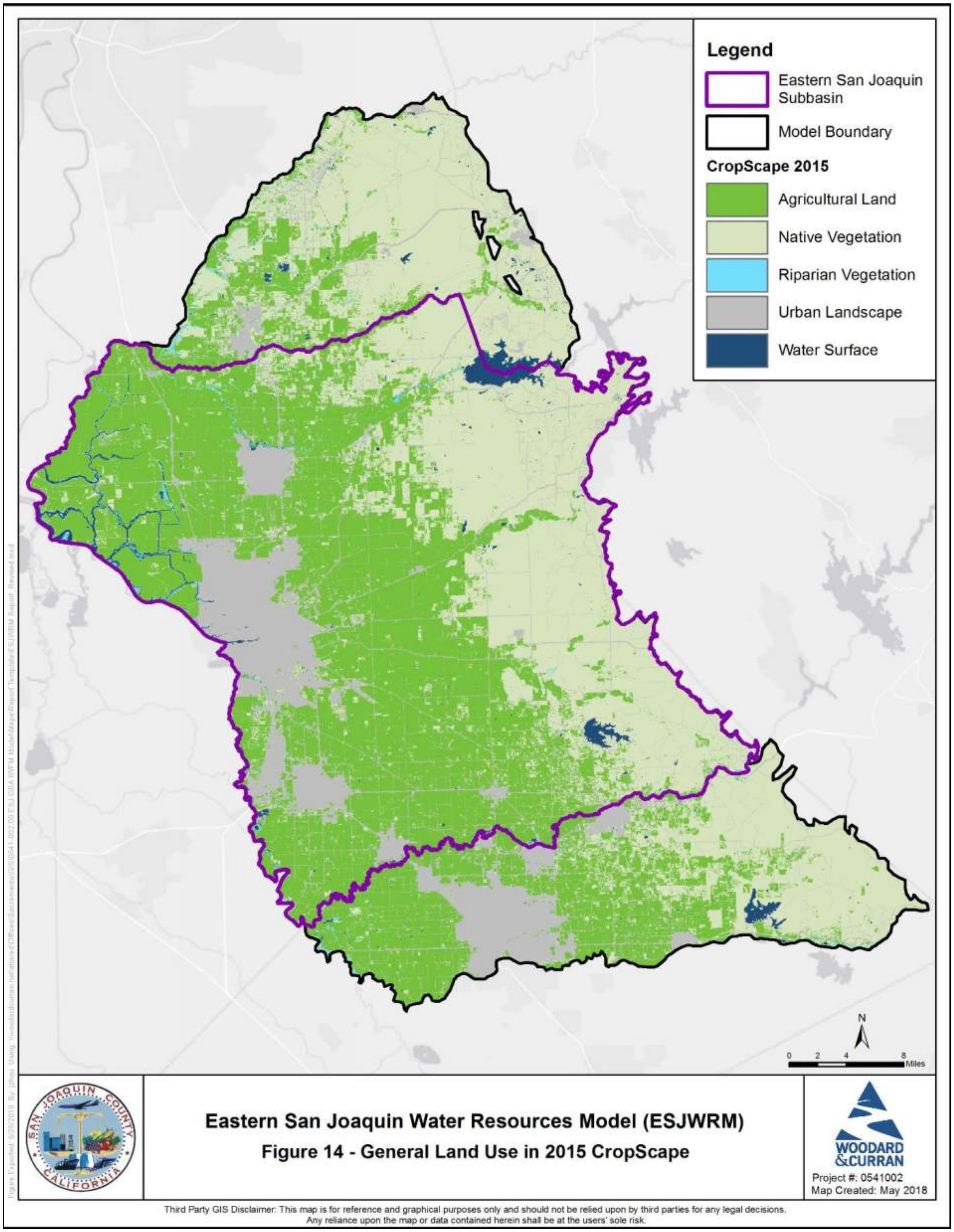


Figure 15: ESJWRM ESJ Subbasin Annual General Land Use

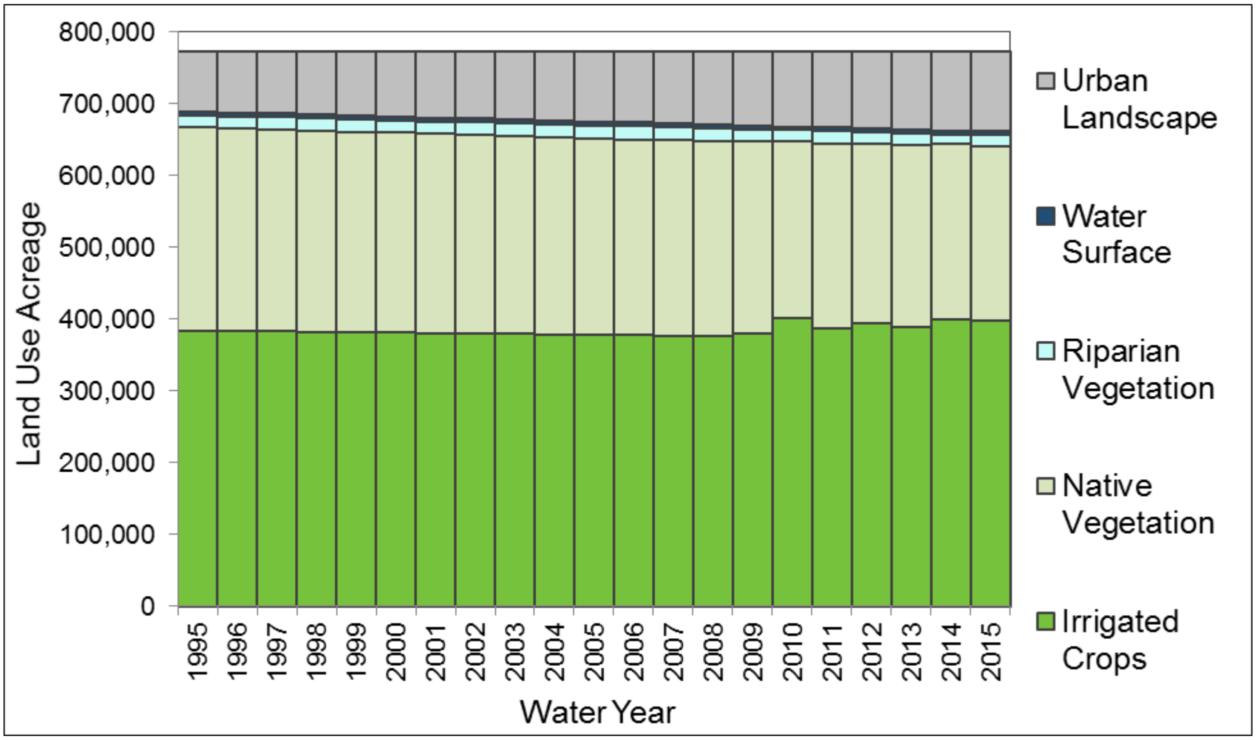


Figure 16: ESJWRM Cropping Pattern in 1995 DWR Land Use Survey

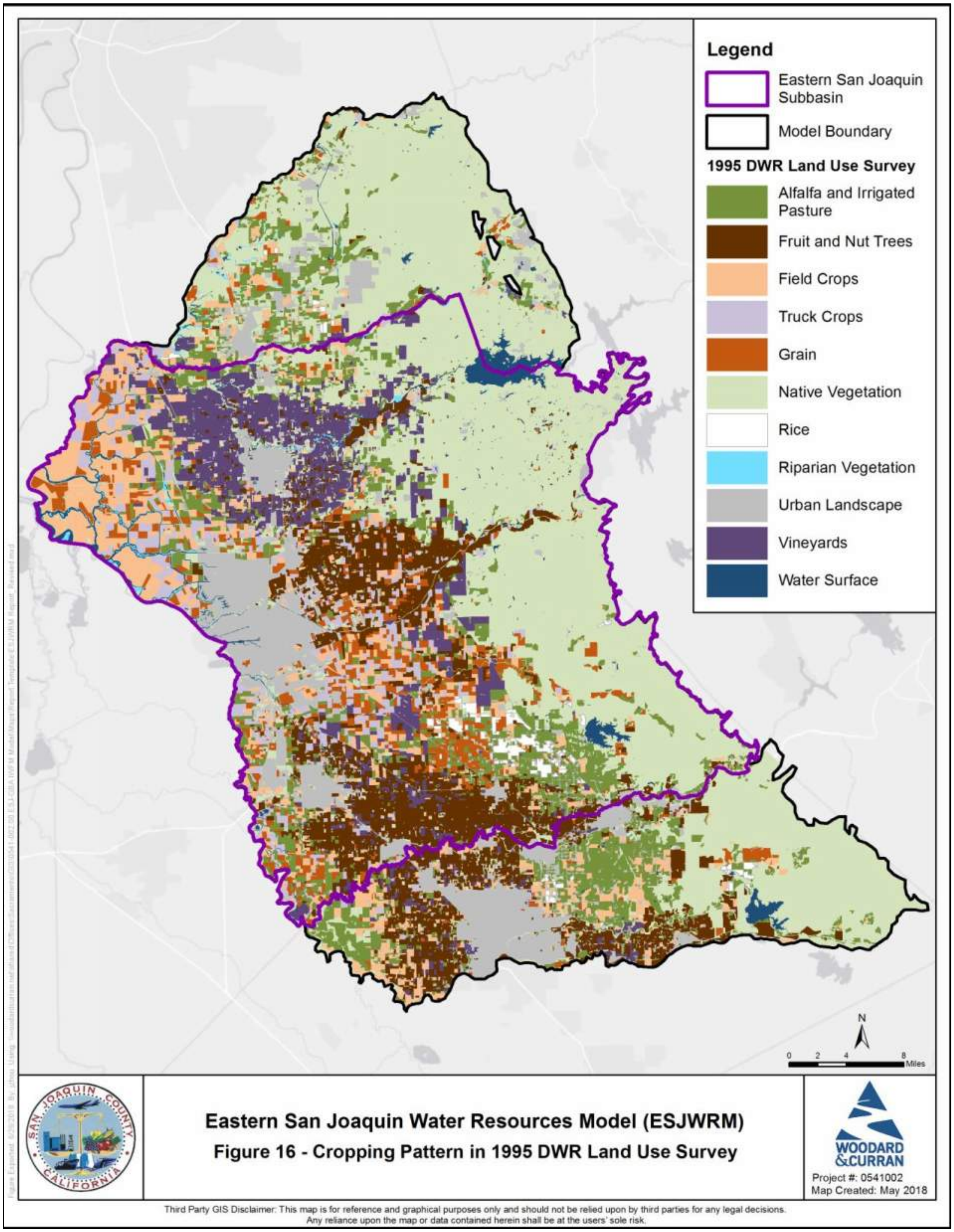


Figure 17: ESJWRM Cropping Pattern in 2014 Land IQ

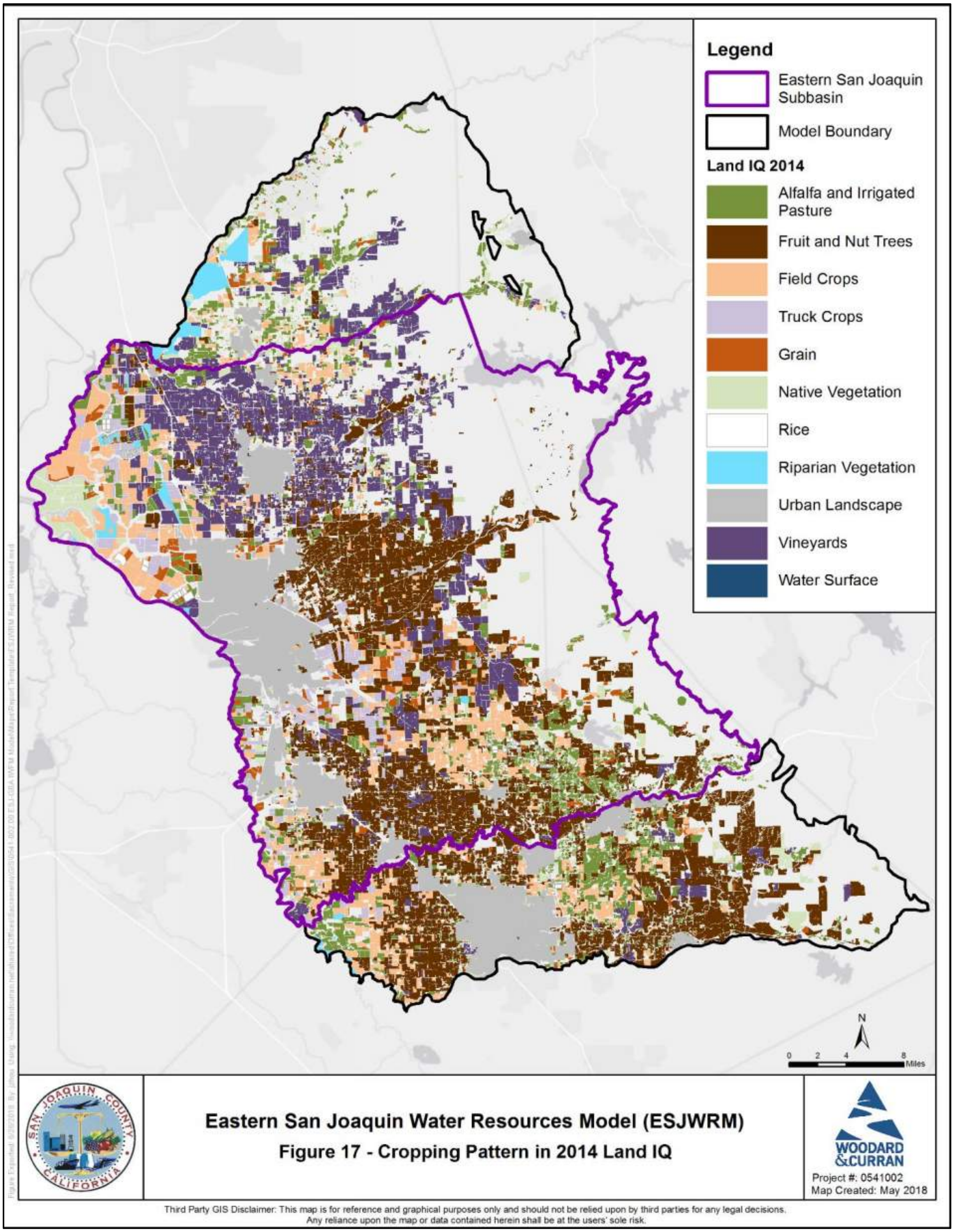


Figure 18: ESJWRM Cropping Pattern in 2015 CropScape

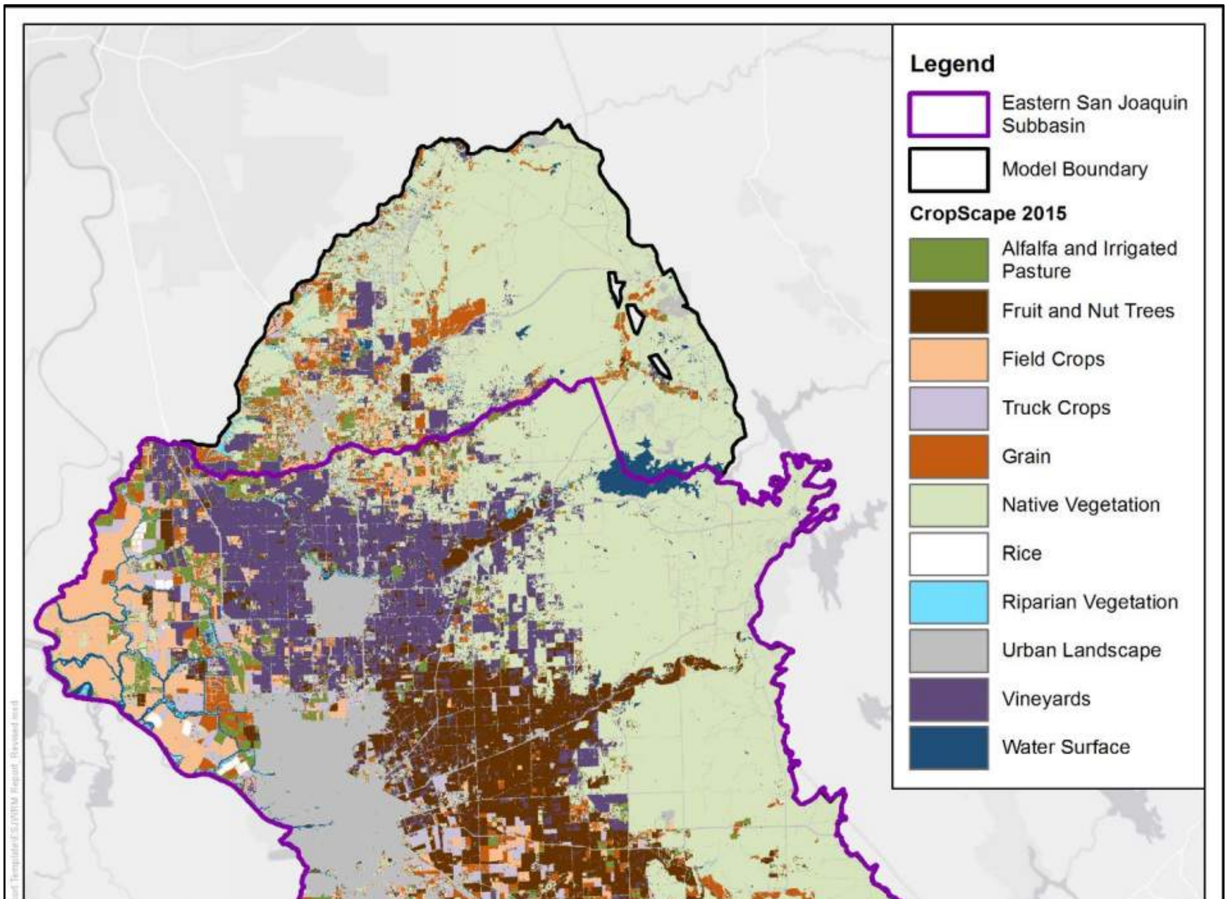


Figure 19a: ESJWRM Annual Cropping Pattern – Eastern San Joaquin Subbasin

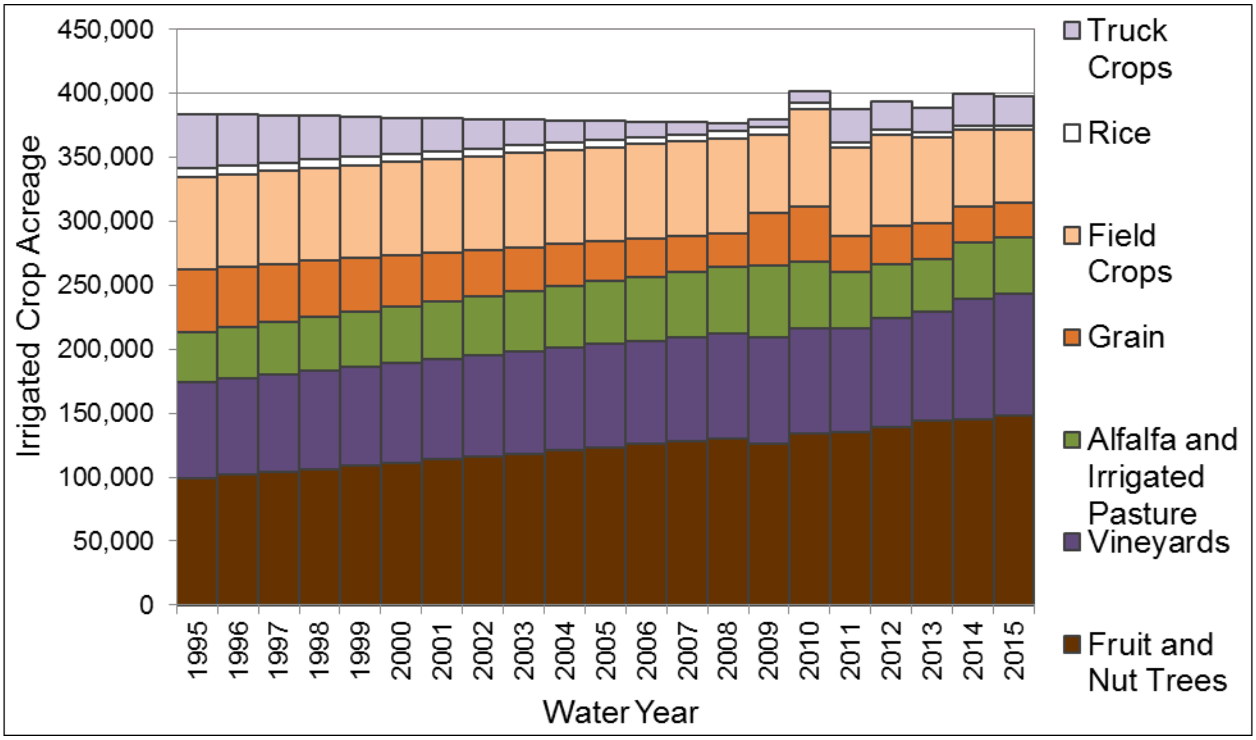


Figure 19b: ESJWRM Annual Cropping Pattern – Subarea 1 (North Delta Subarea)

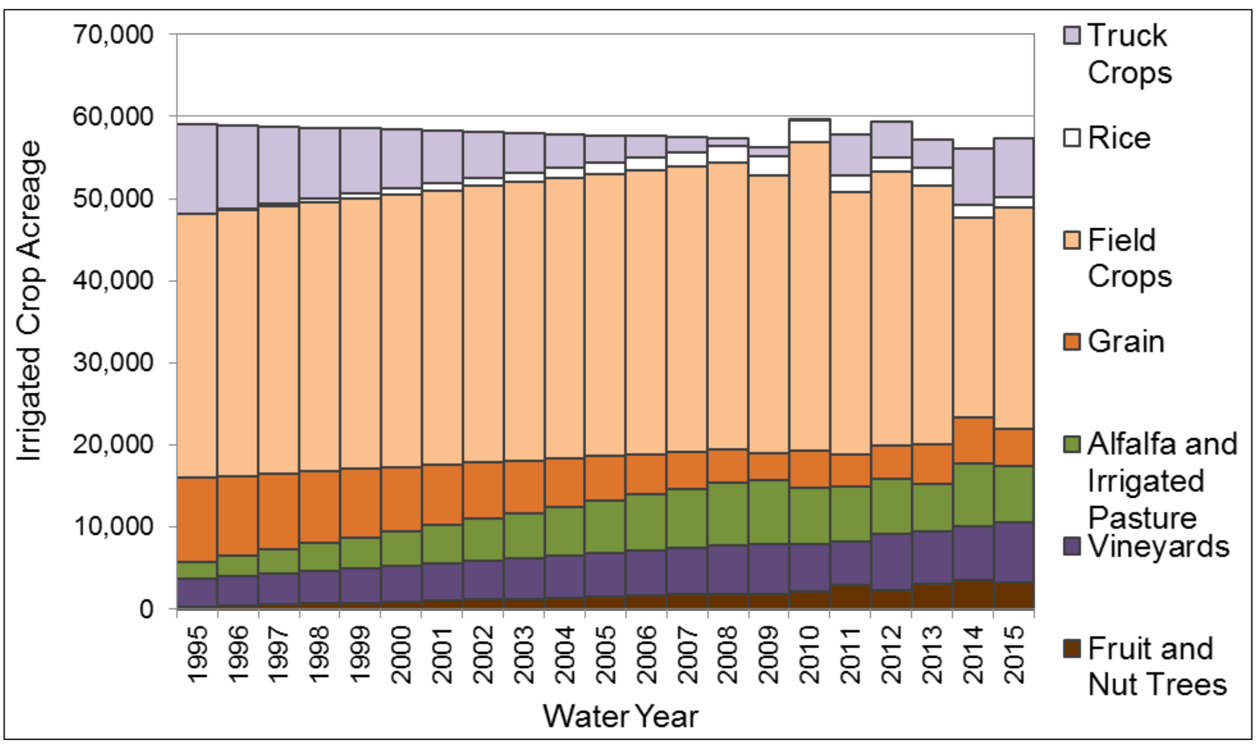


Figure 19c: ESJWRM Annual Cropping Pattern – Subarea 2 (North Subarea)

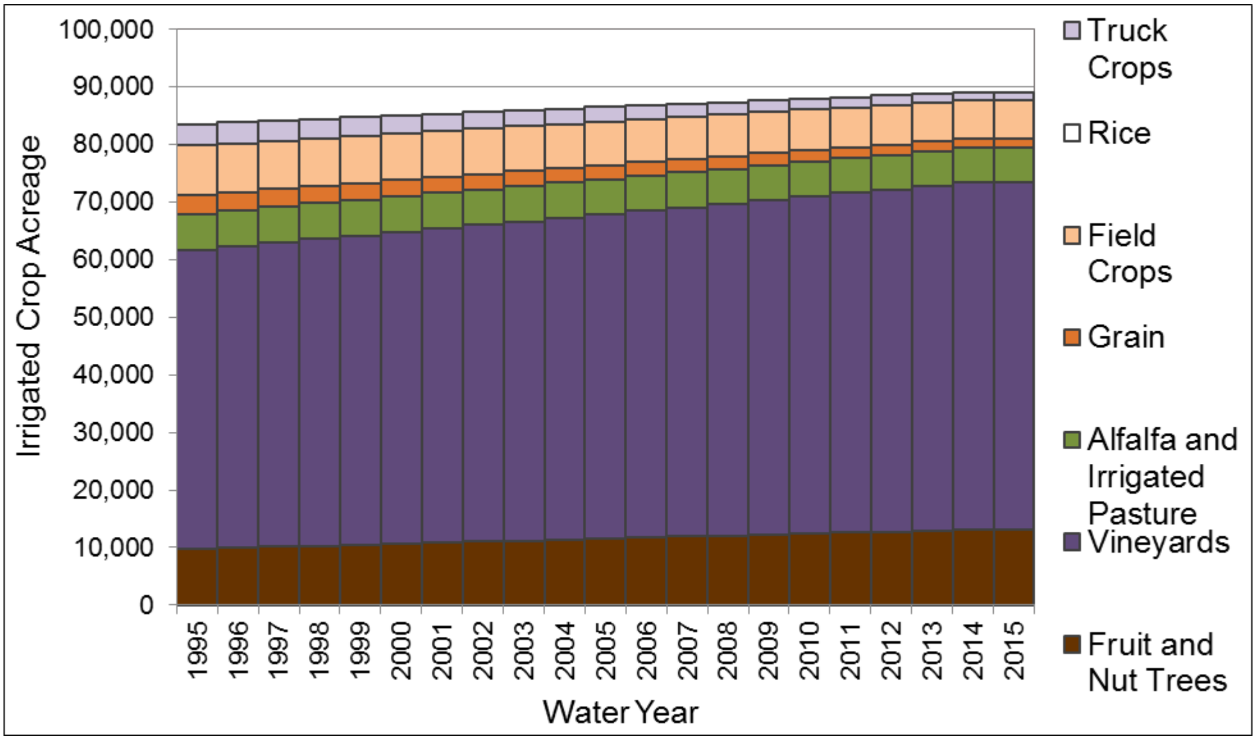


Figure 19d: ESJWRM Annual Cropping Pattern – Subarea 3 (Calaveras Subarea)

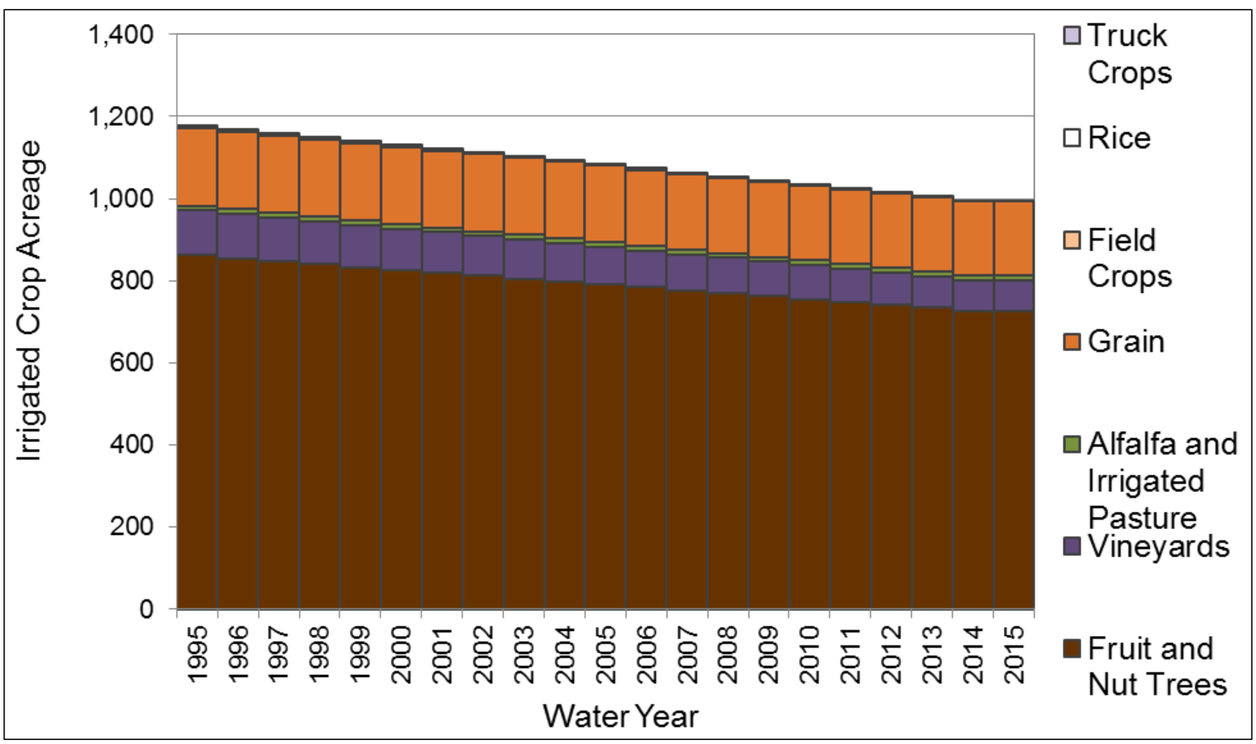


Figure 19e: ESJWRM Annual Cropping Pattern – Subarea 4 (Central Subarea)

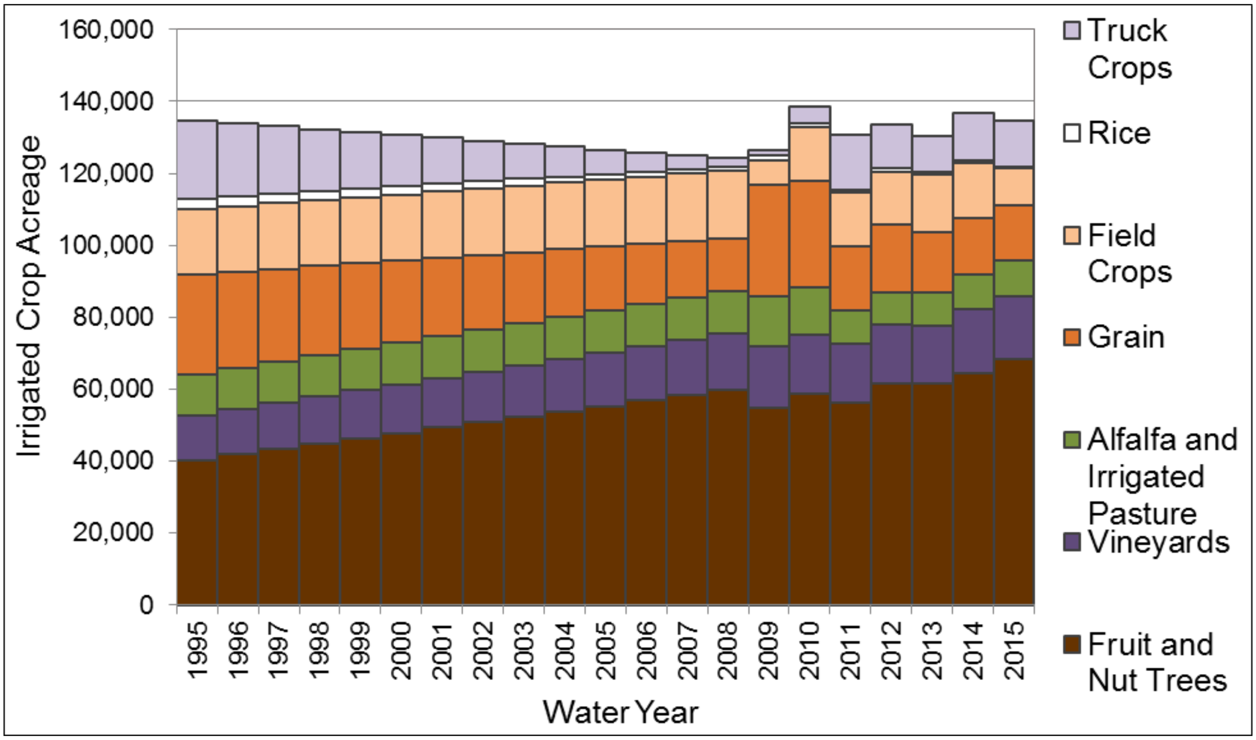


Figure 19f: ESJWRM Annual Cropping Pattern – Subarea 5 (South Subarea)

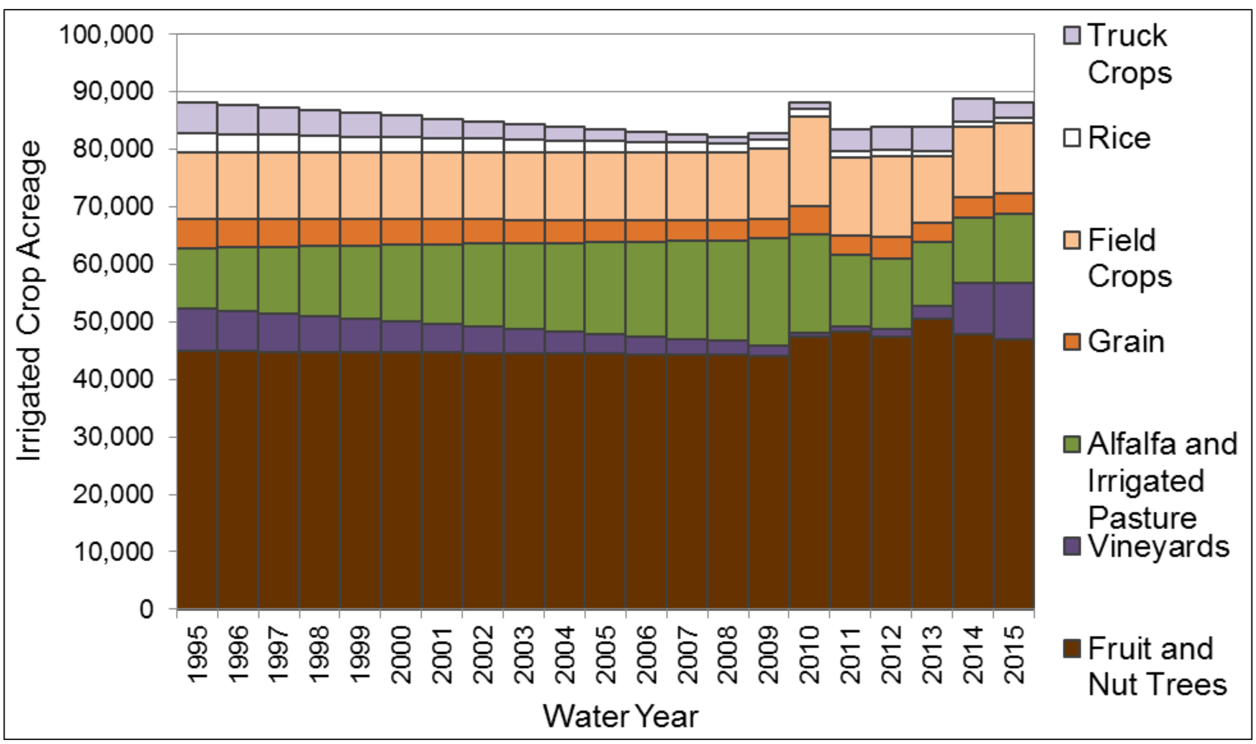


Figure 19g: ESJWRM Annual Cropping Pattern – Subarea 6 (Stanislaus Subarea)

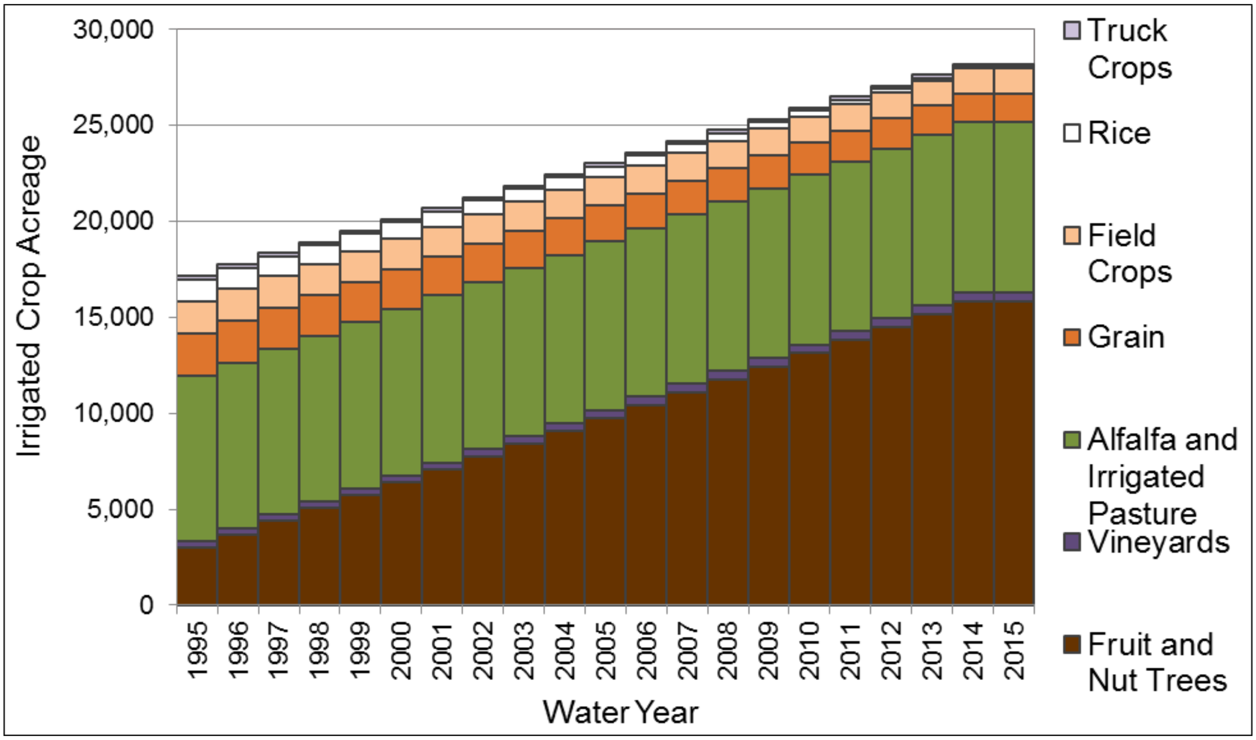


Figure 20: ESJWRM Annual Evapotranspiration

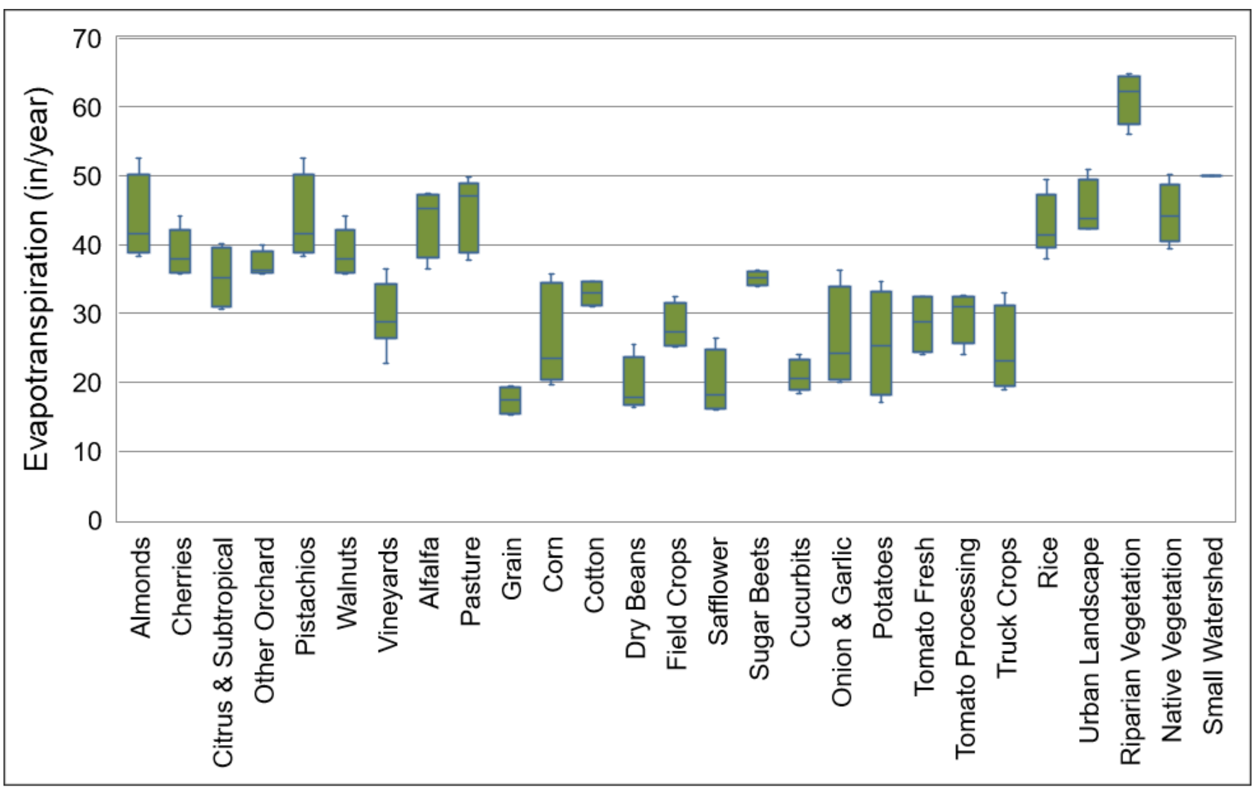


Figure 21: ESJWRM Surface Water Drainage Watersheds

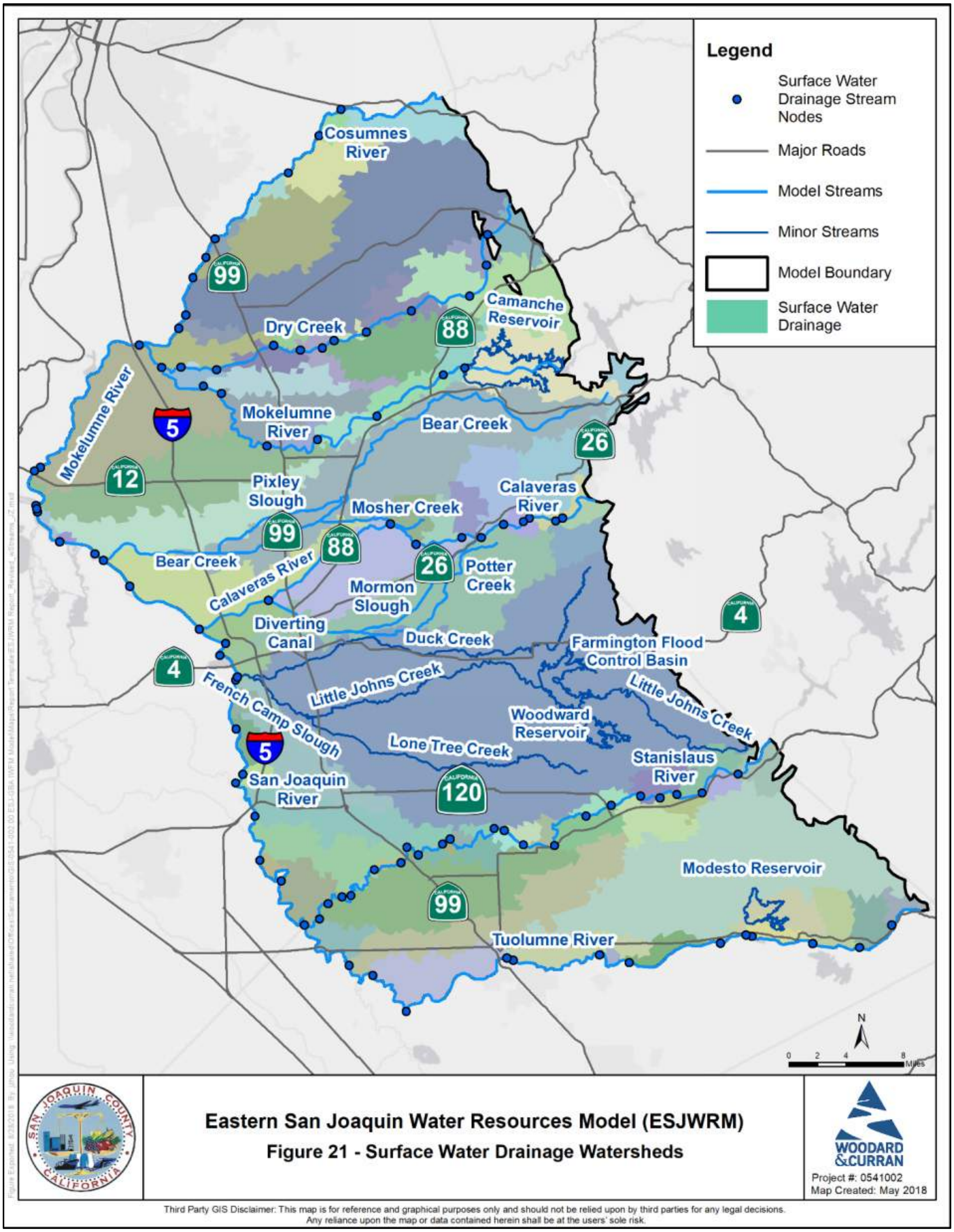


Figure 22: ESJWRM Ground Surface Elevation

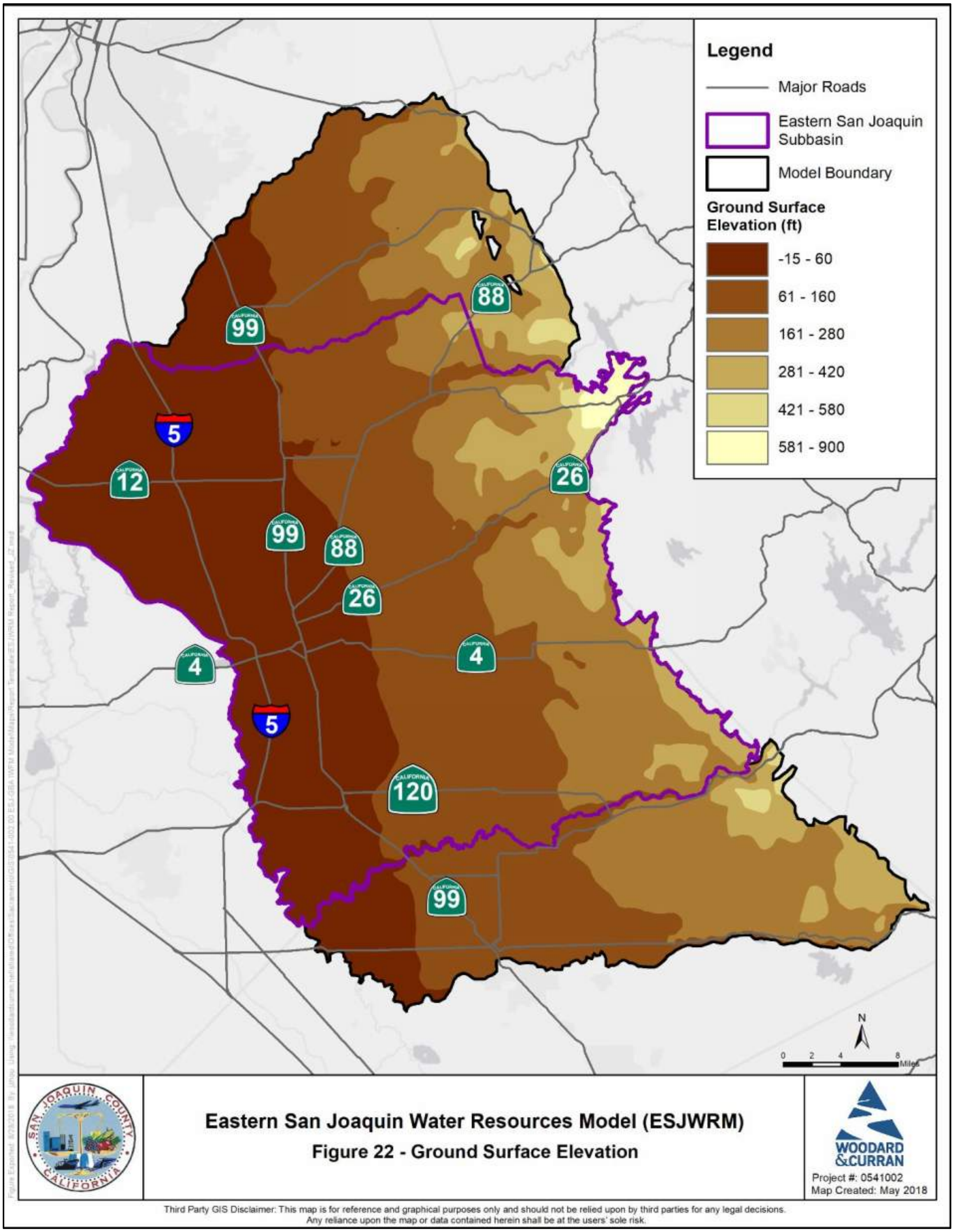


Figure 23: ESJWRM Layer 1 Thickness

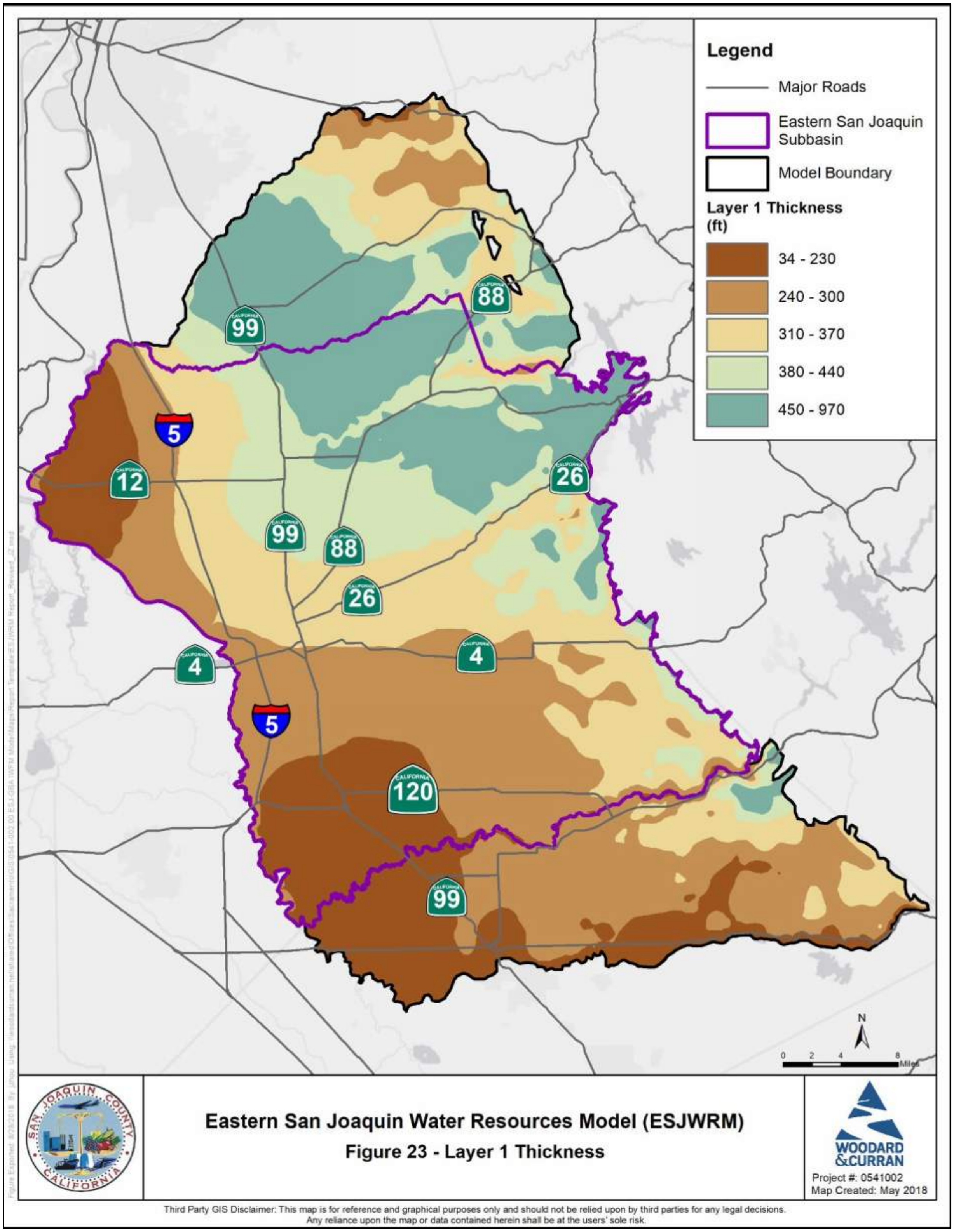


Figure 24: ESJWRM Corcoran Clay Depth to Top

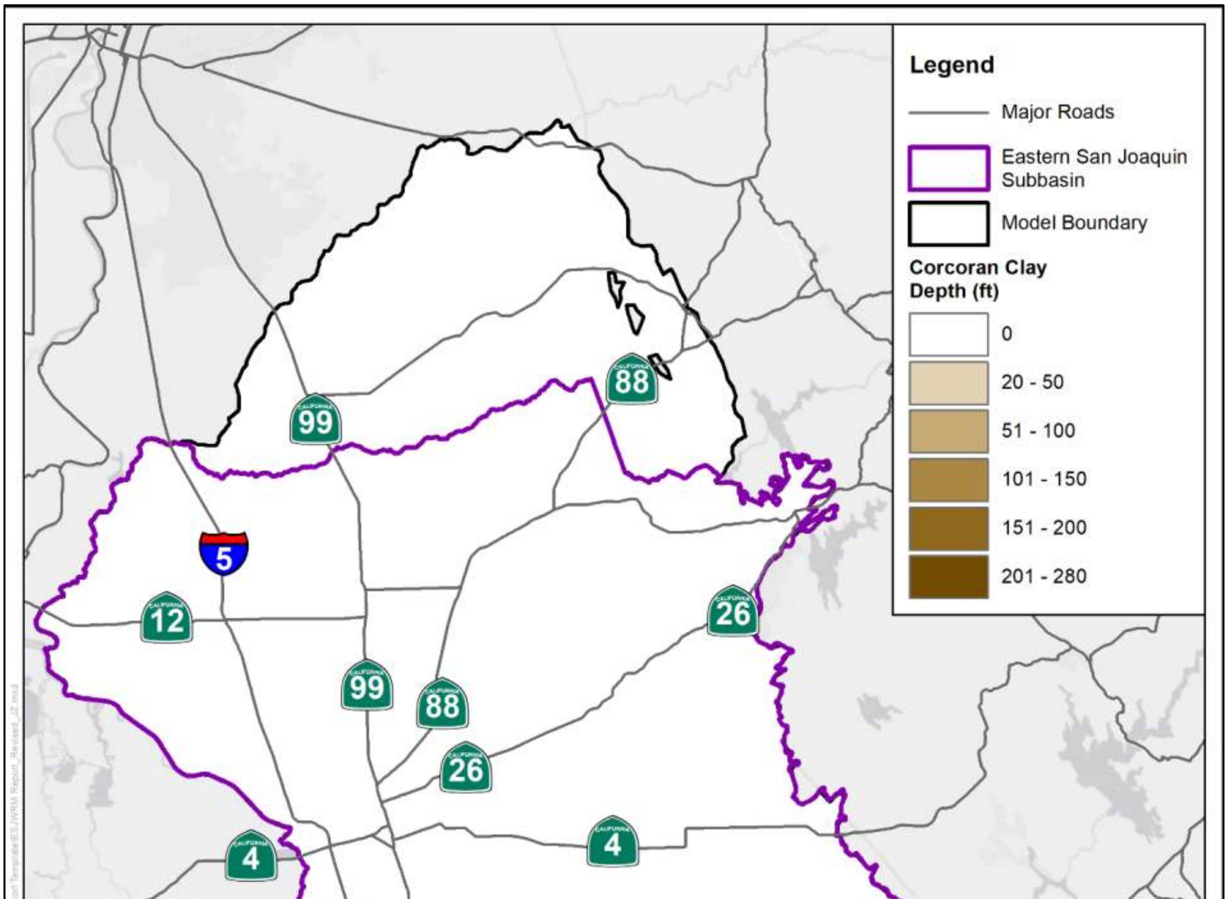


Figure 25: ESJWRM Corcoran Clay Thickness

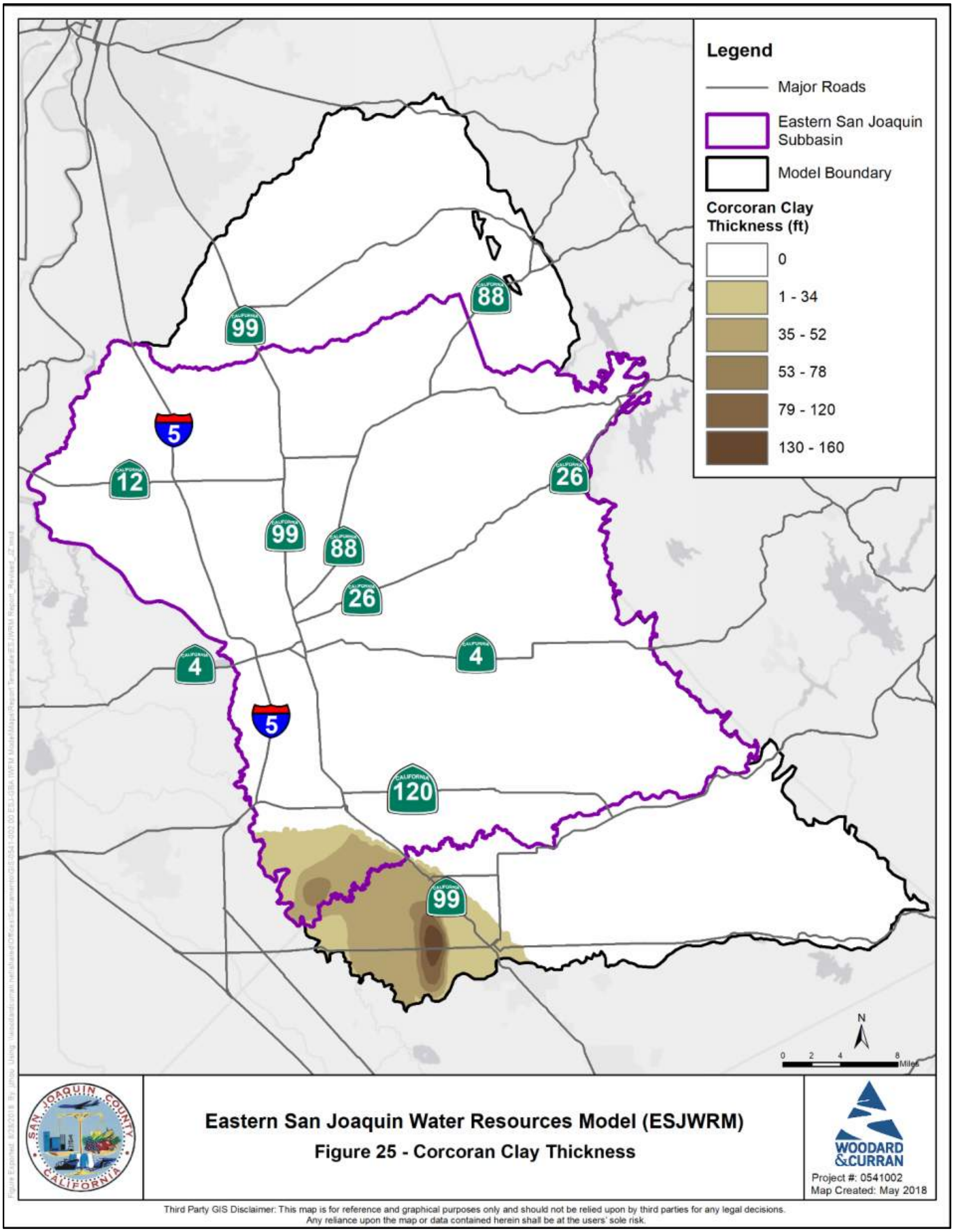


Figure 26: ESJWRM Layer 2 Thickness

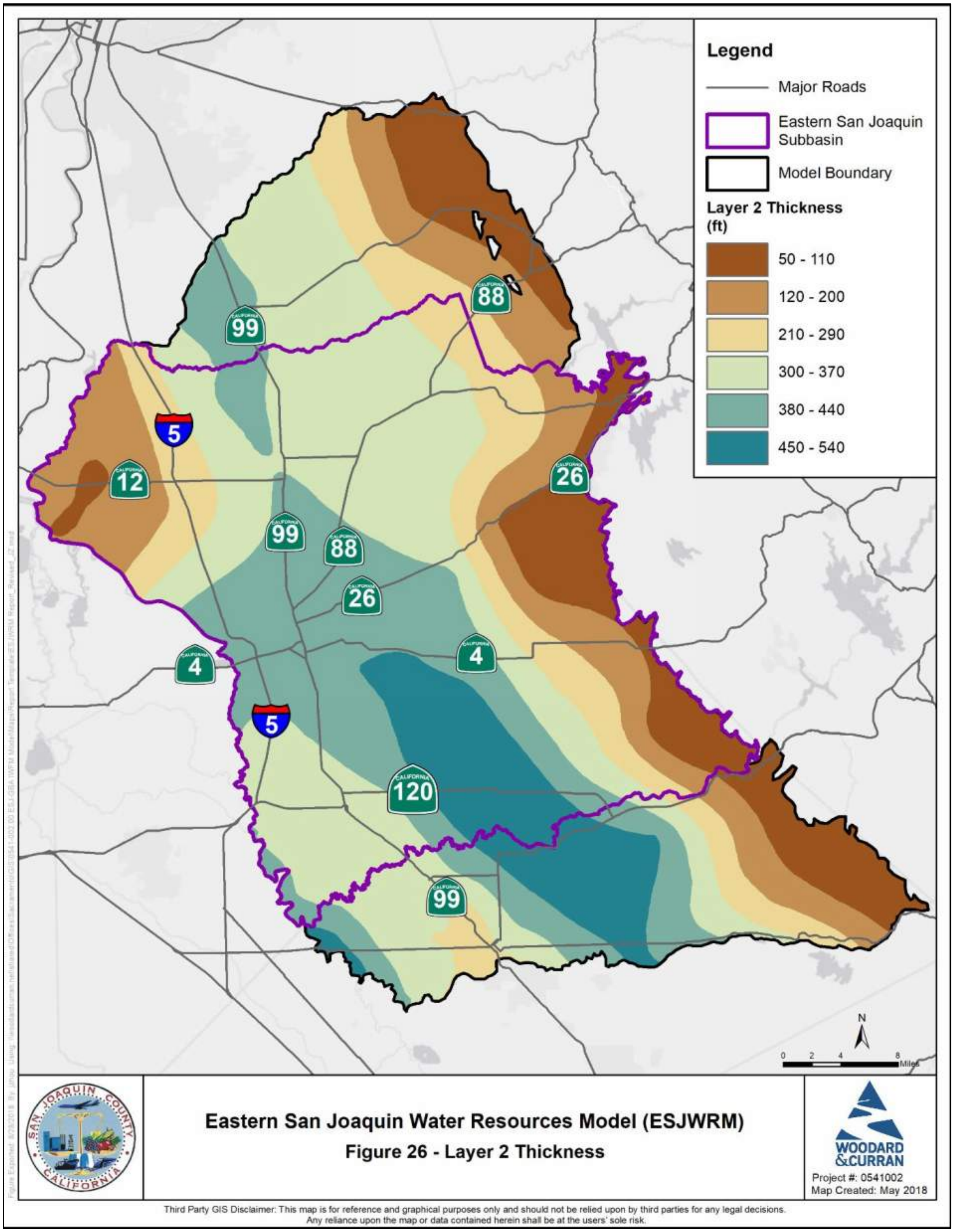


Figure 27: ESJWRM Layer 3 Thickness

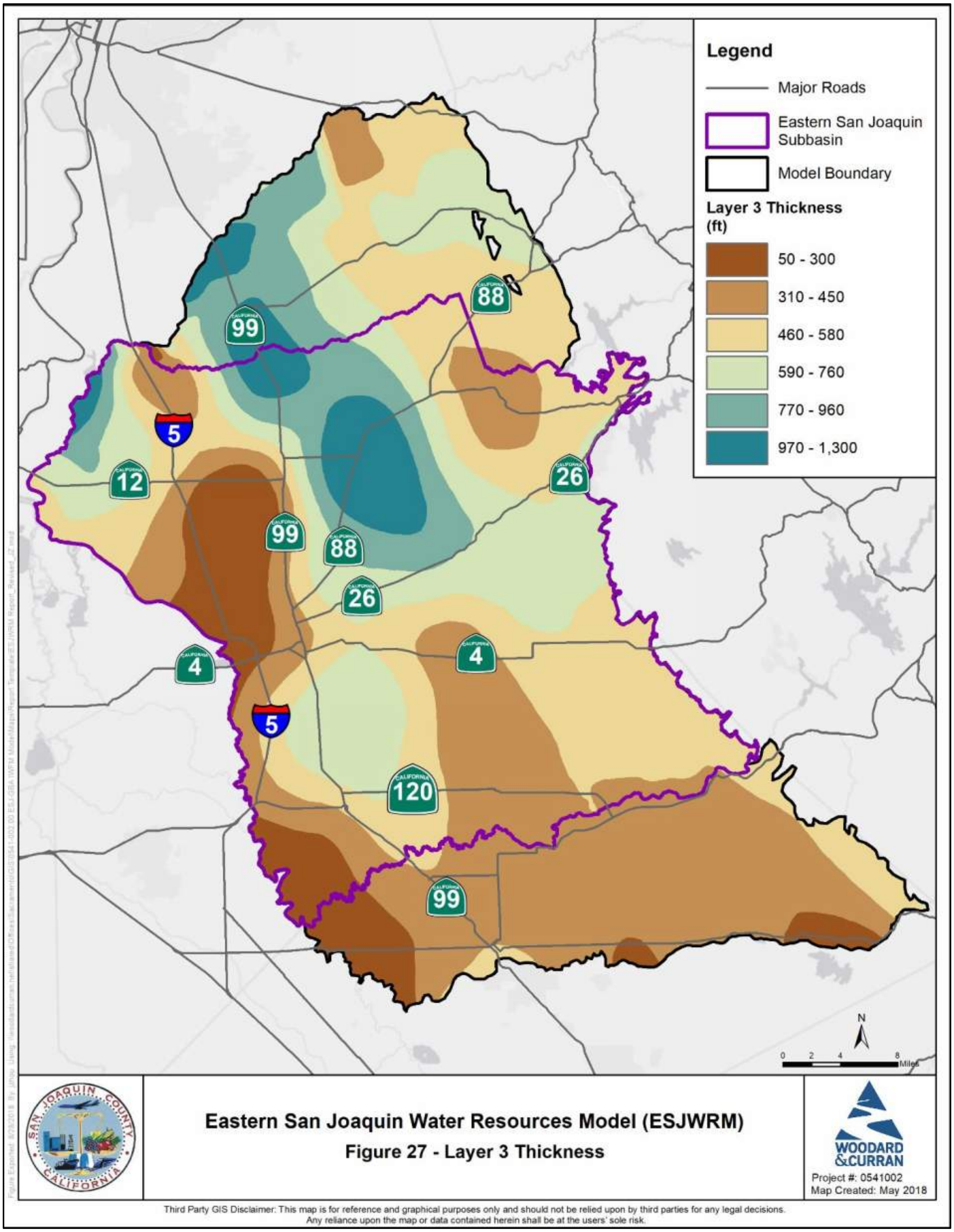


Figure 28: ESJWRM Layer 4 Thickness

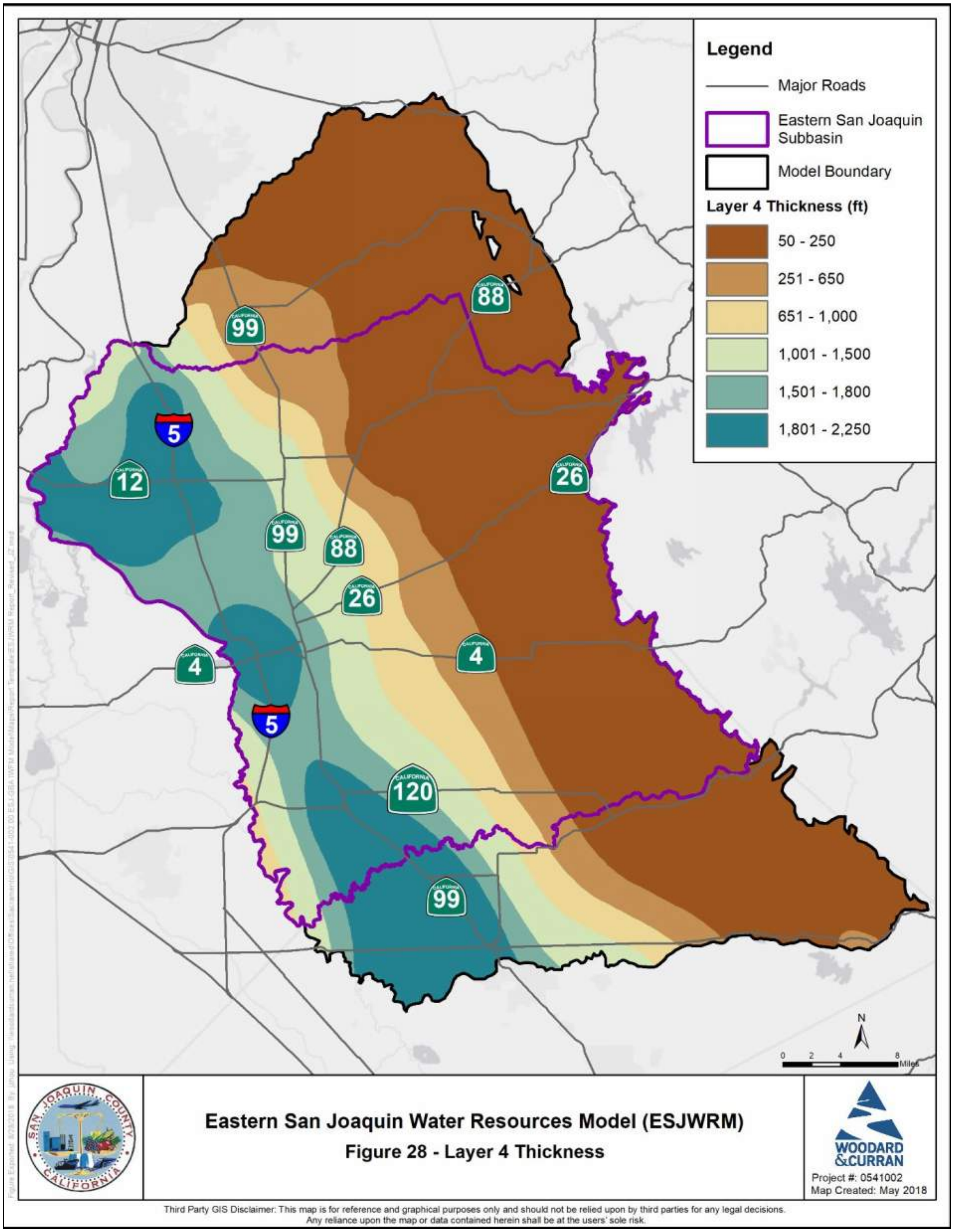


Figure 29a: ESJWRM Cross Section A - A'

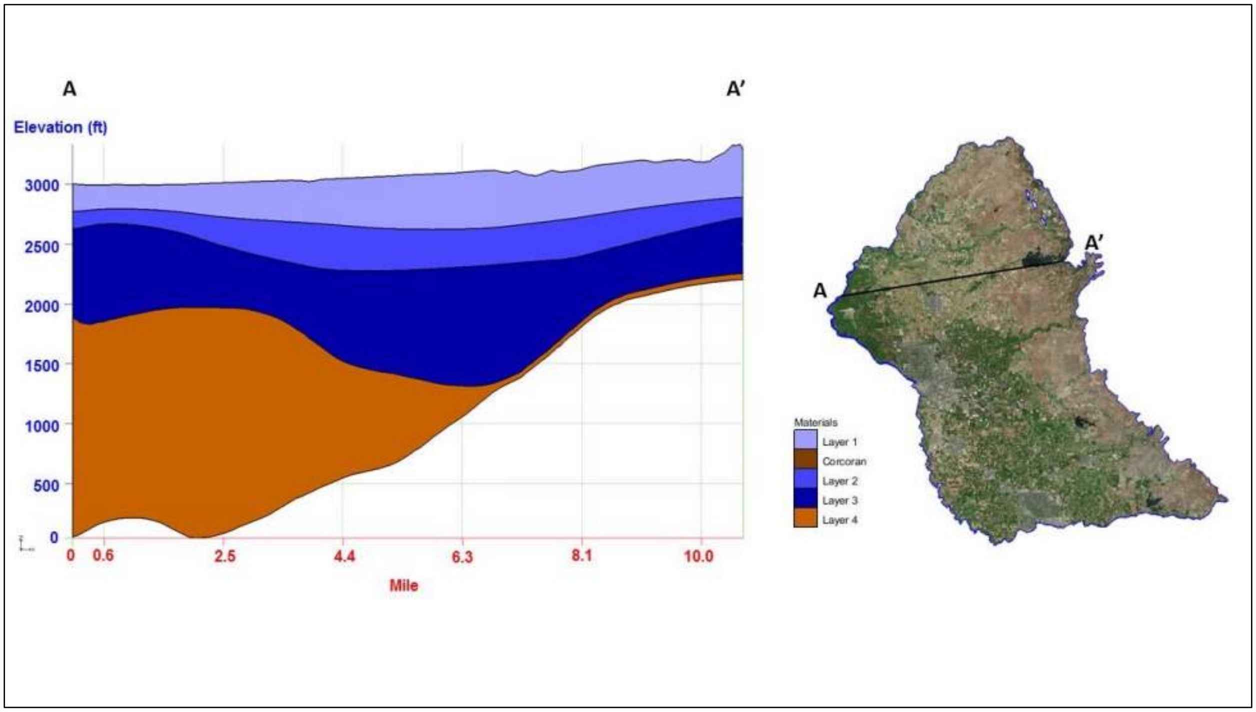


Figure 29b: ESJWRM Cross Section B - B'

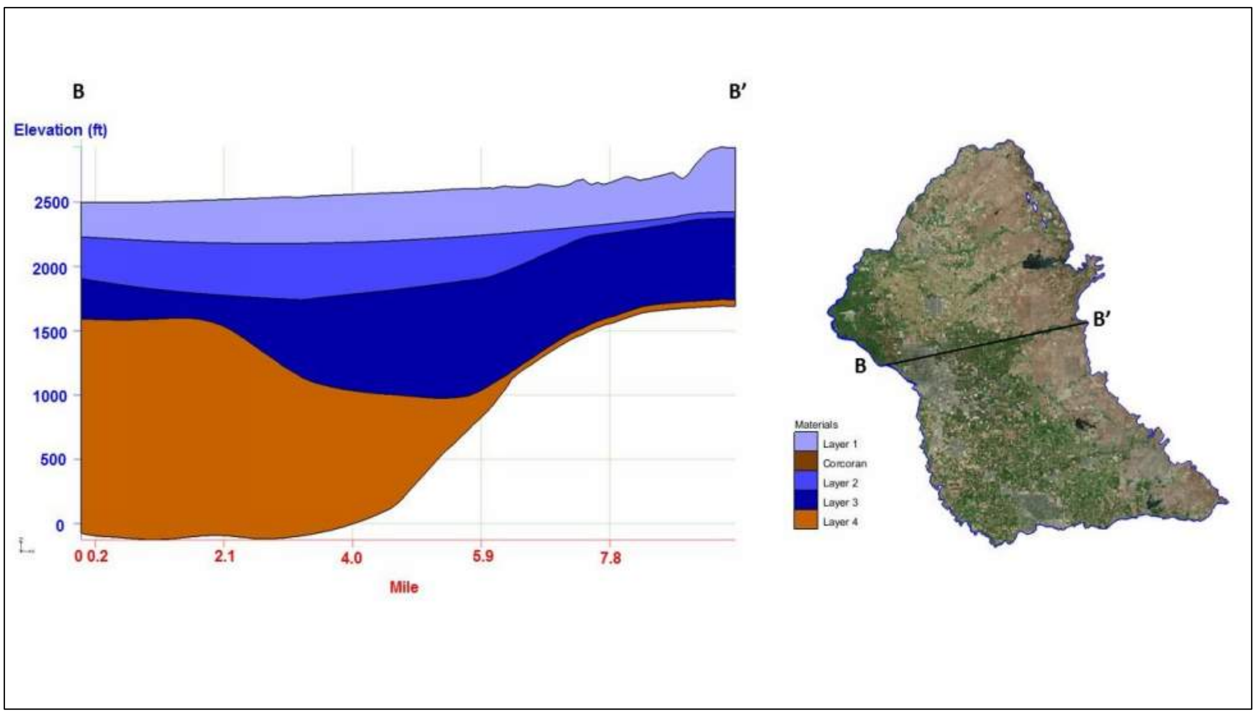


Figure 29c: ESJWRM Cross Section C - C’

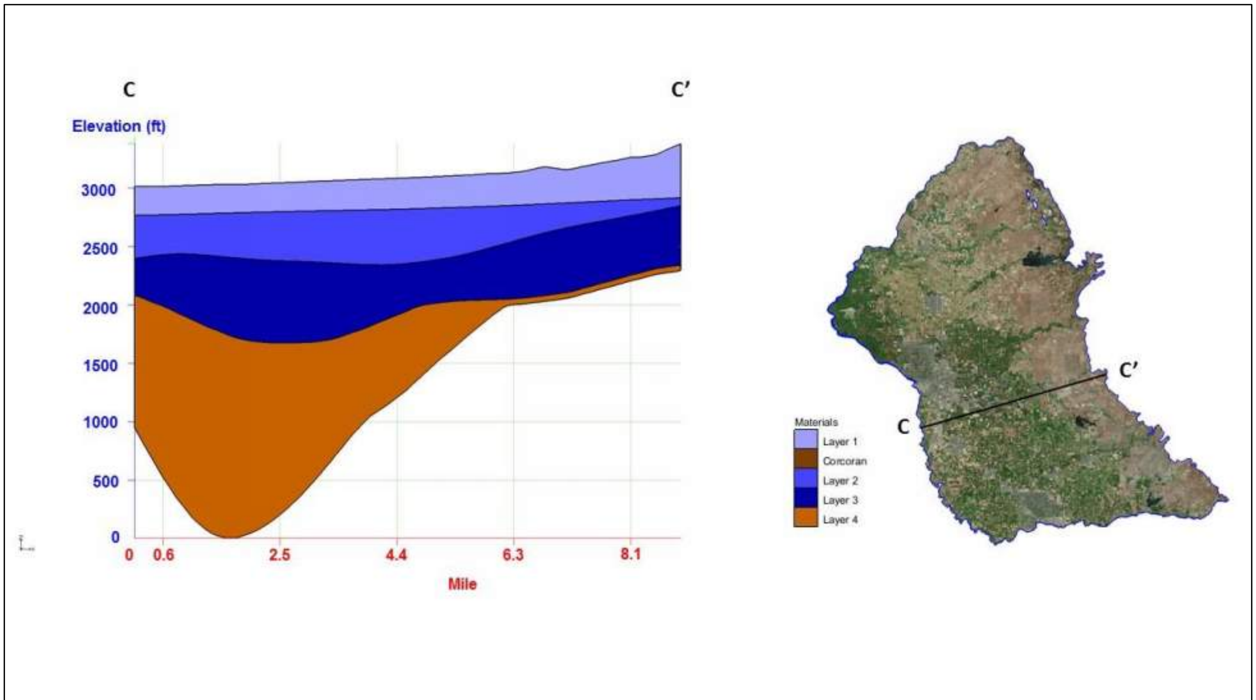


Figure 29d: ESJWRM Cross Section D - D’

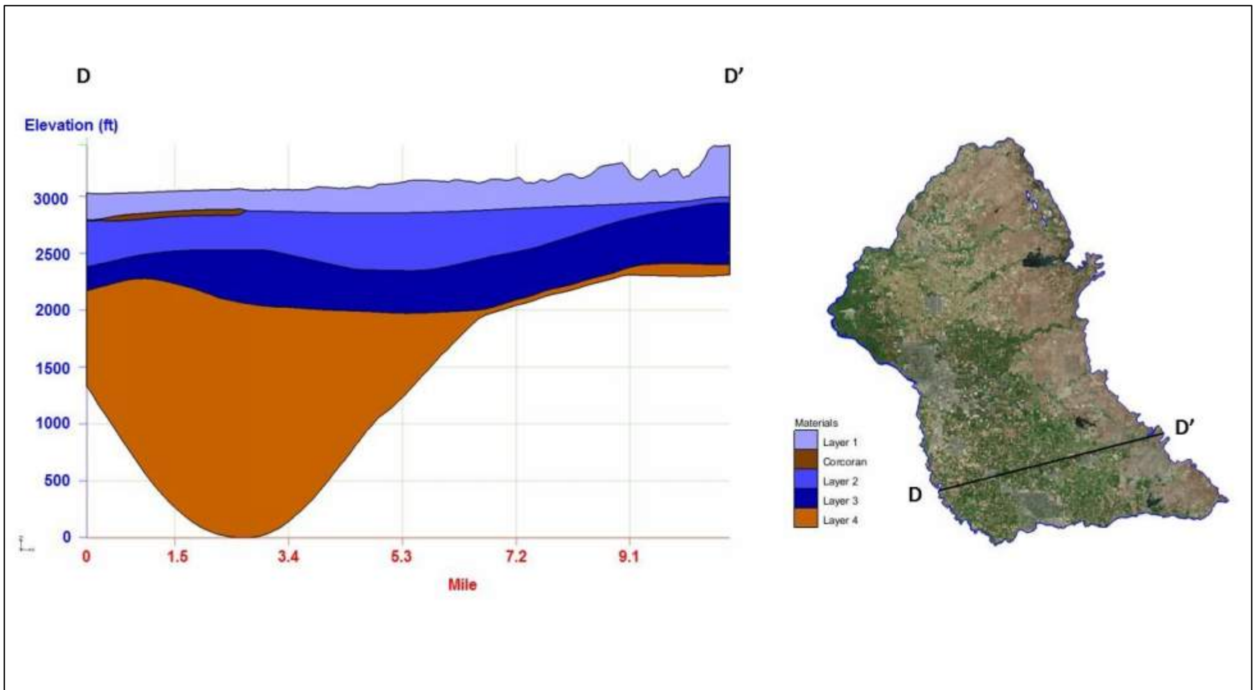


Figure 29e: ESJWRM Cross Section E - E'

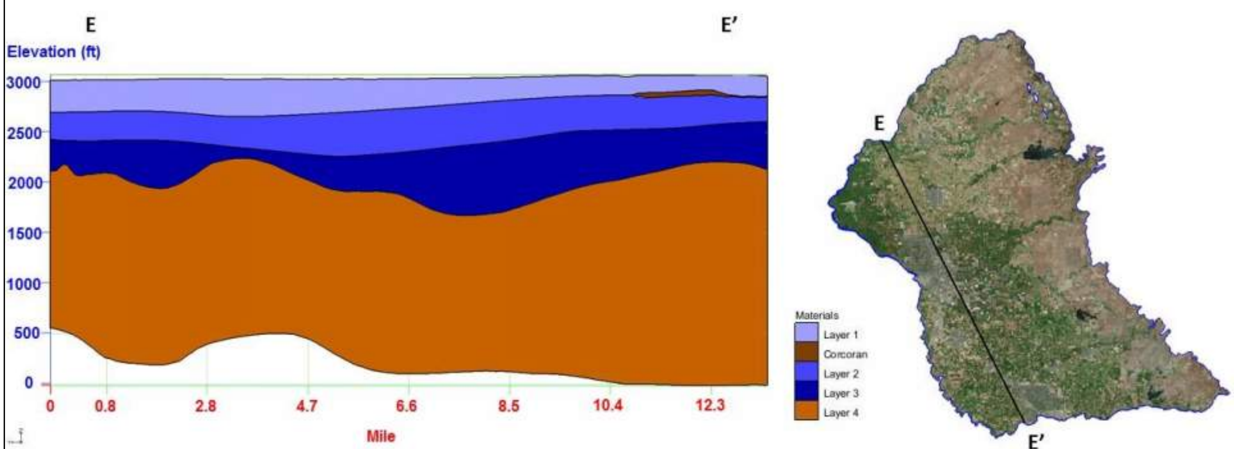


Figure 29f: ESJWRM Cross Section F - F'

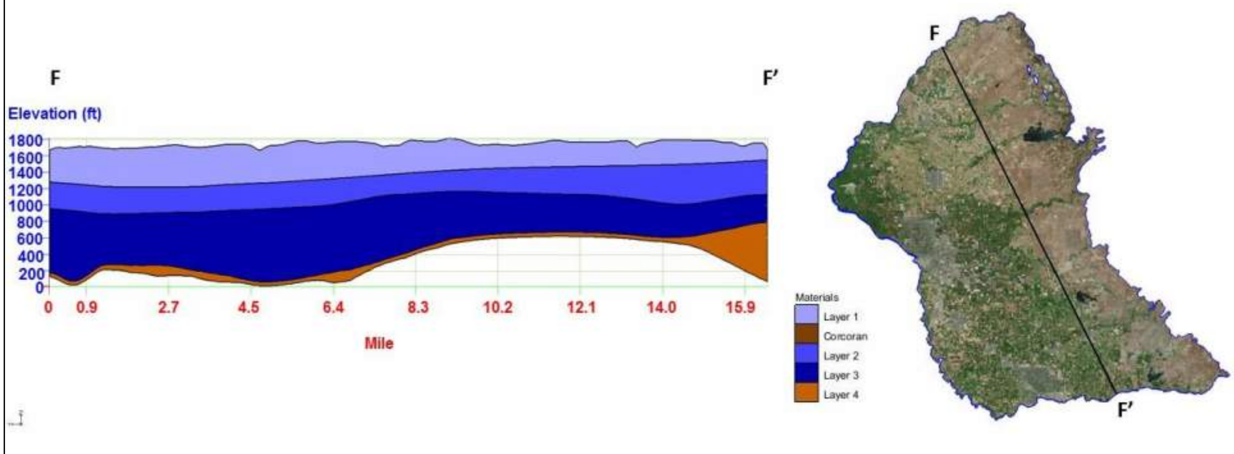


Figure 30: ESJWRM Small Watersheds

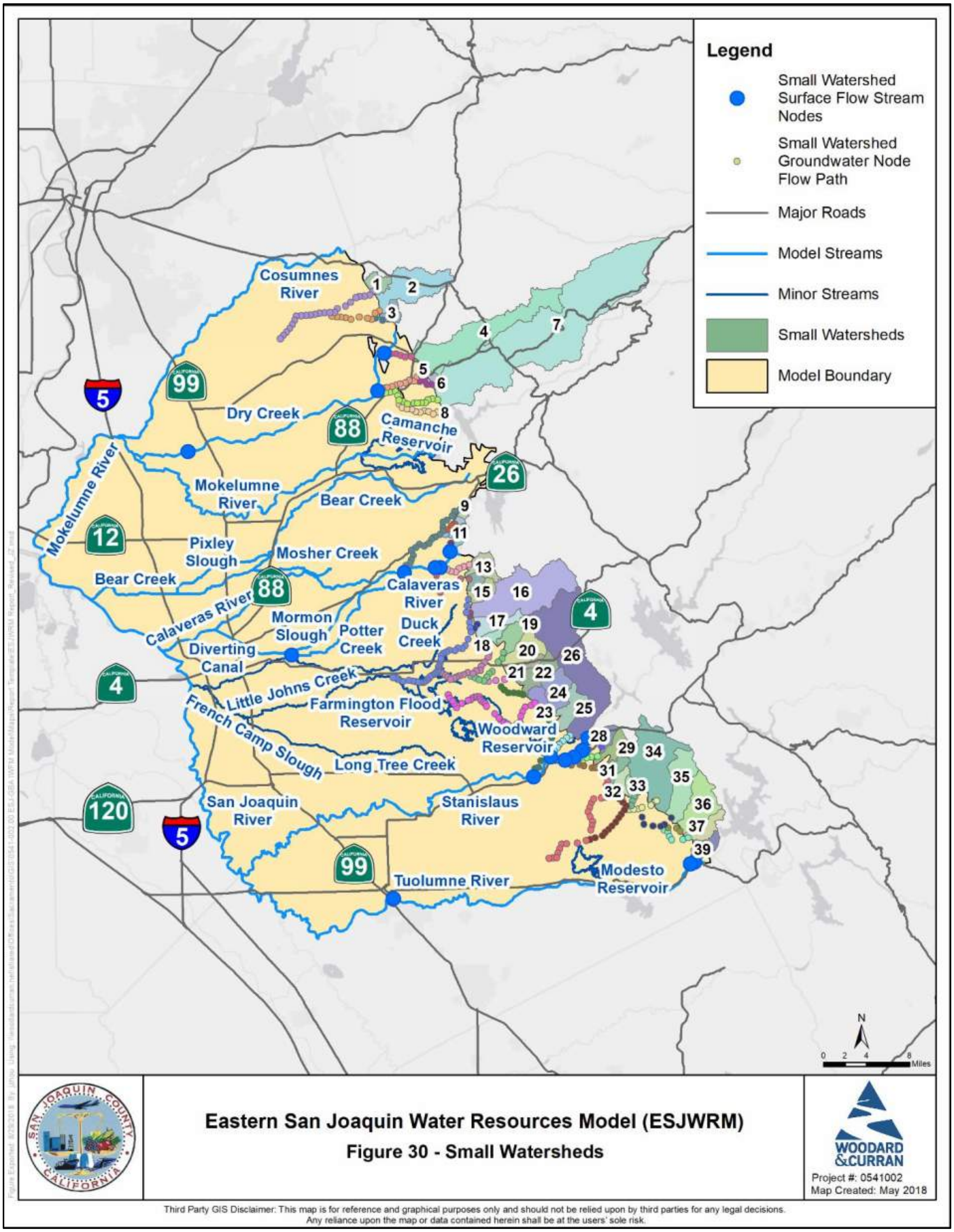


Figure 31: ESJWRM Initial GW Levels (Fall 1994)

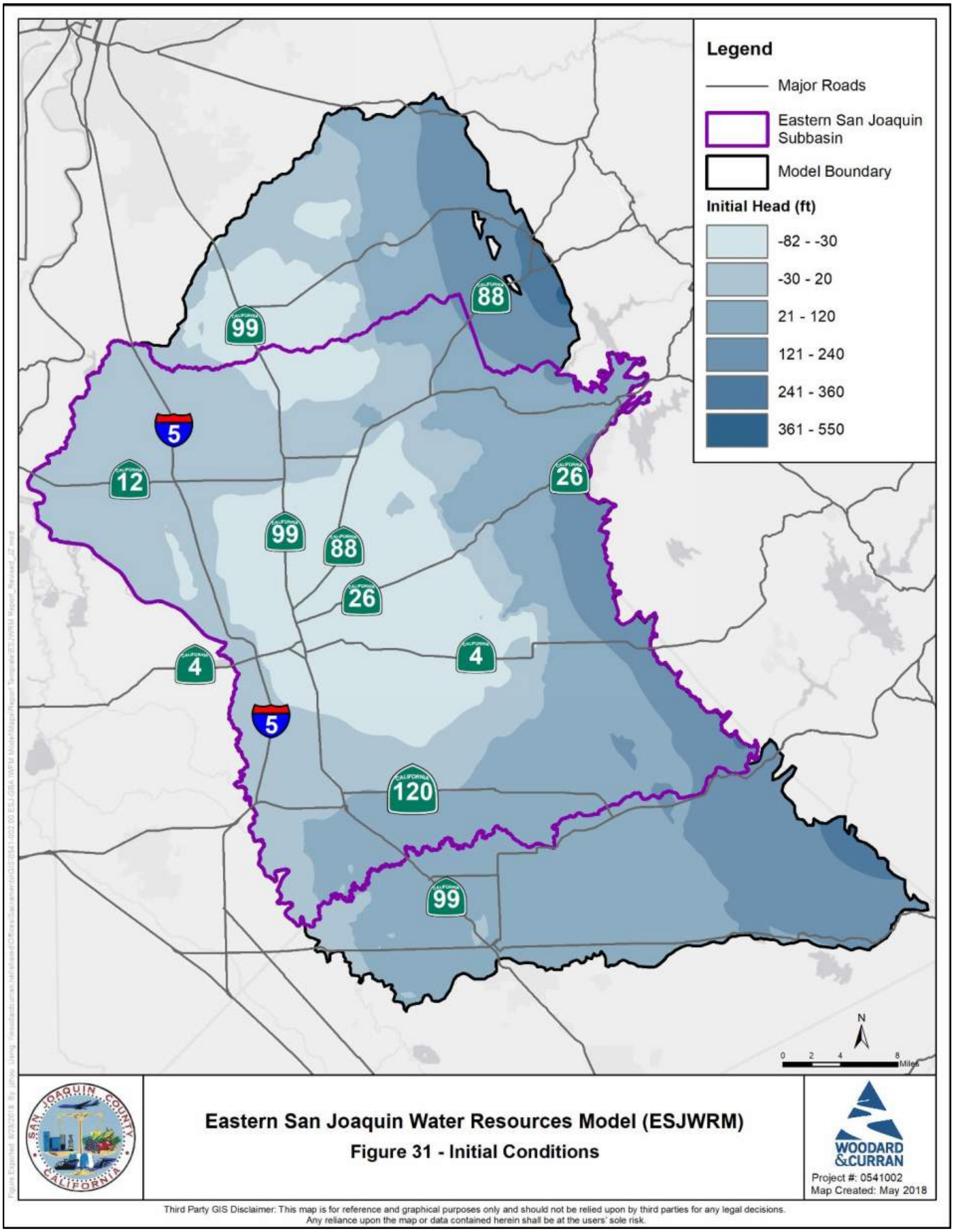


Figure 32: ESJWRM Annual Population by Urban Center

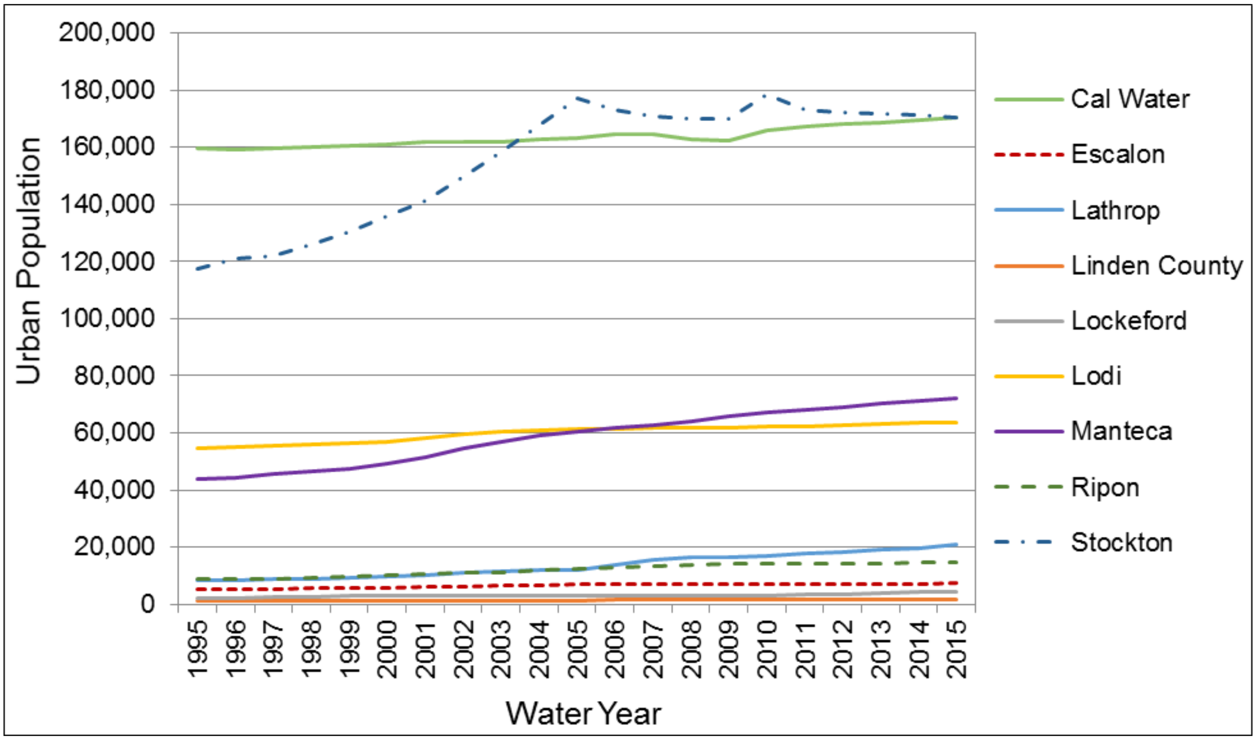


Figure 33: ESJWRM Annual Per Capita Water Use by Urban Center

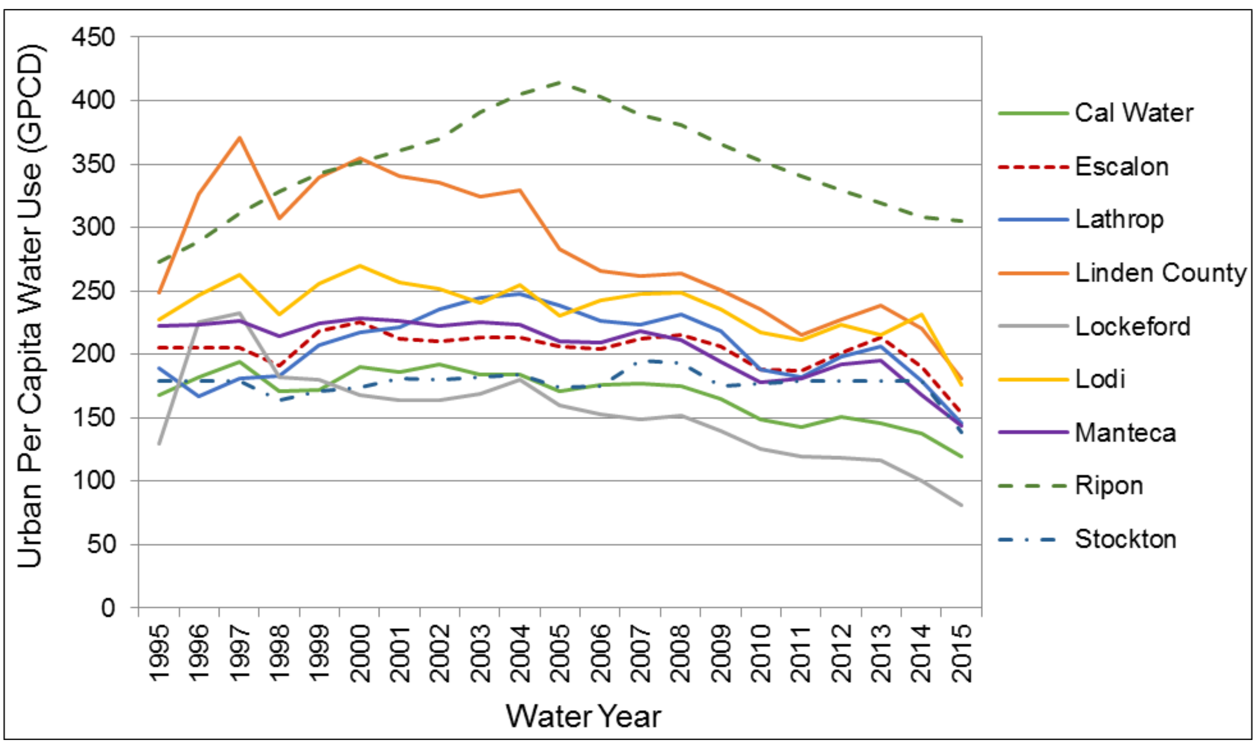


Figure 34: ESJWRM Surface Water Diversion Locations

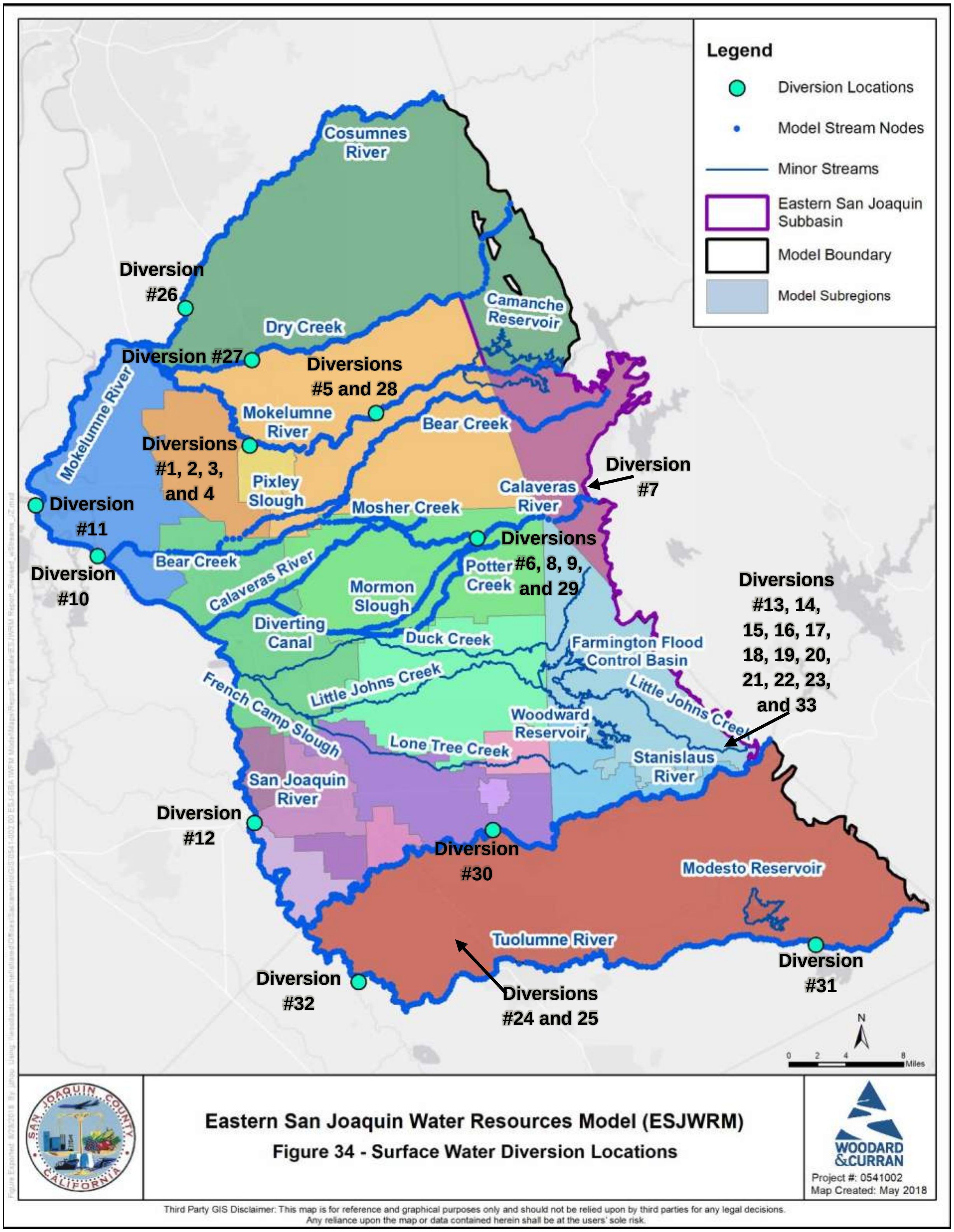


Figure 35: ESJWRM Groundwater Production Wells

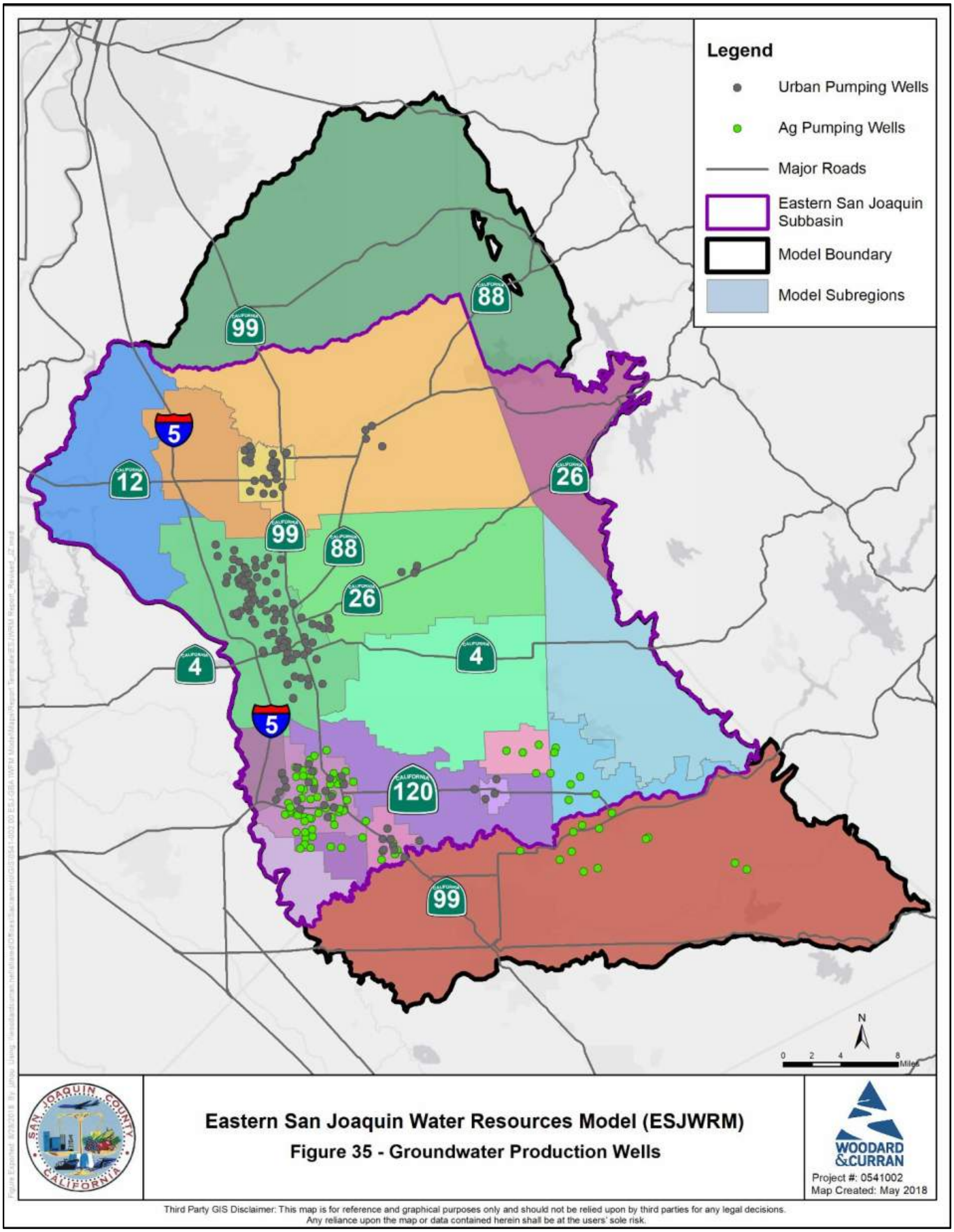


Figure 36: ESJWRM Riparian Surface Water Diversion Areas

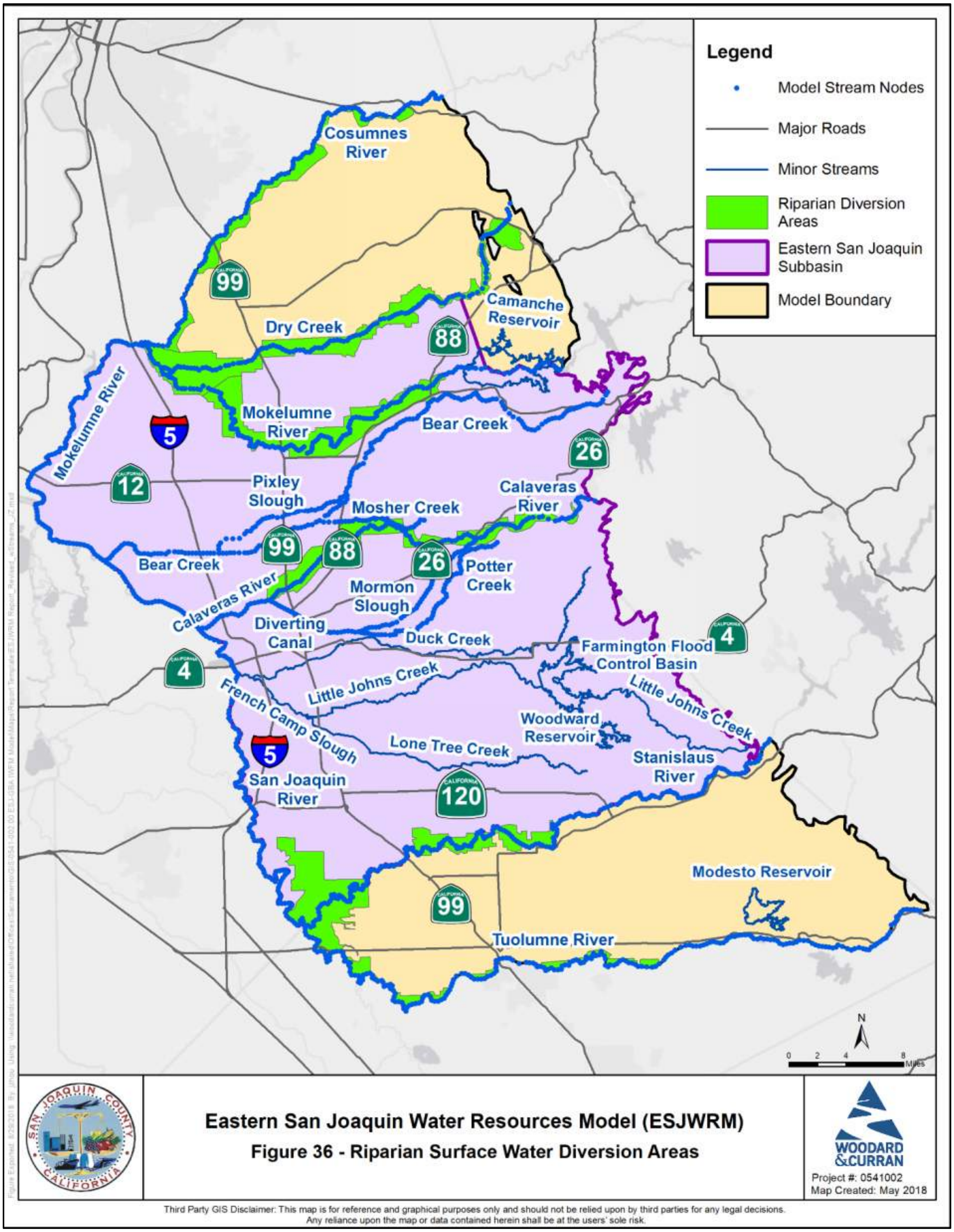


Figure 37: ESJWRM Field Capacity

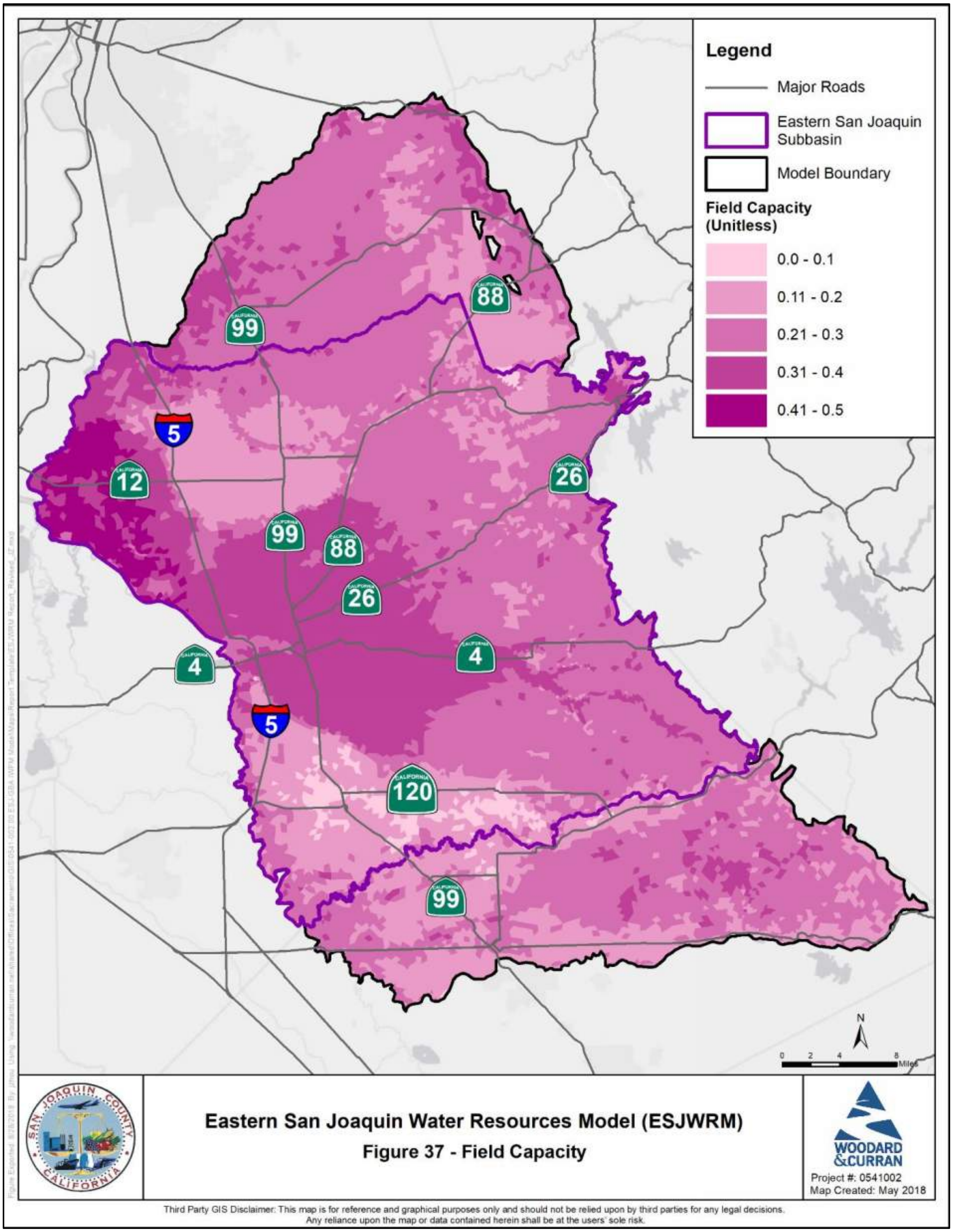


Figure 38: ESJWRM Wilting Point

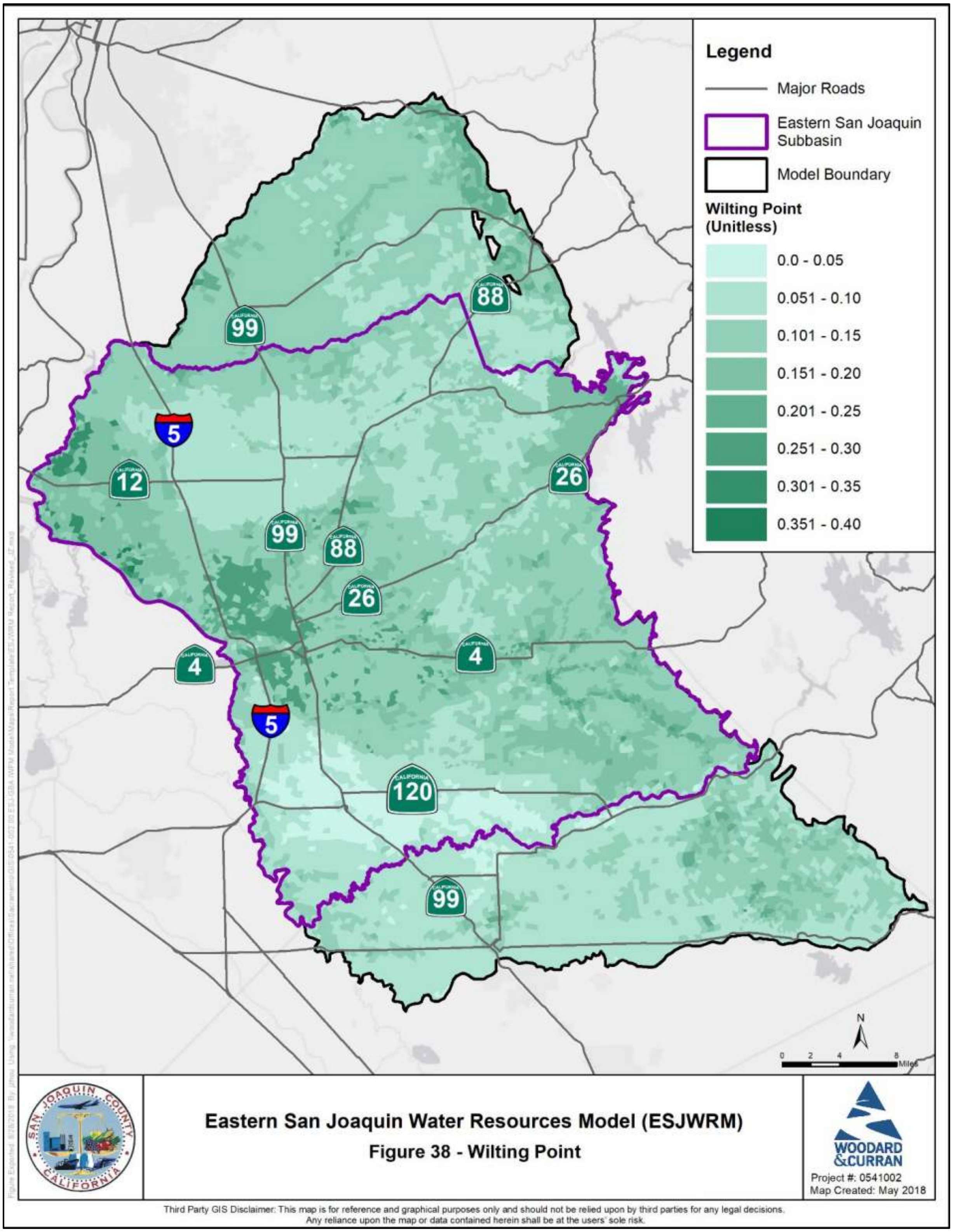


Figure 39: ESJWRM Total Porosity

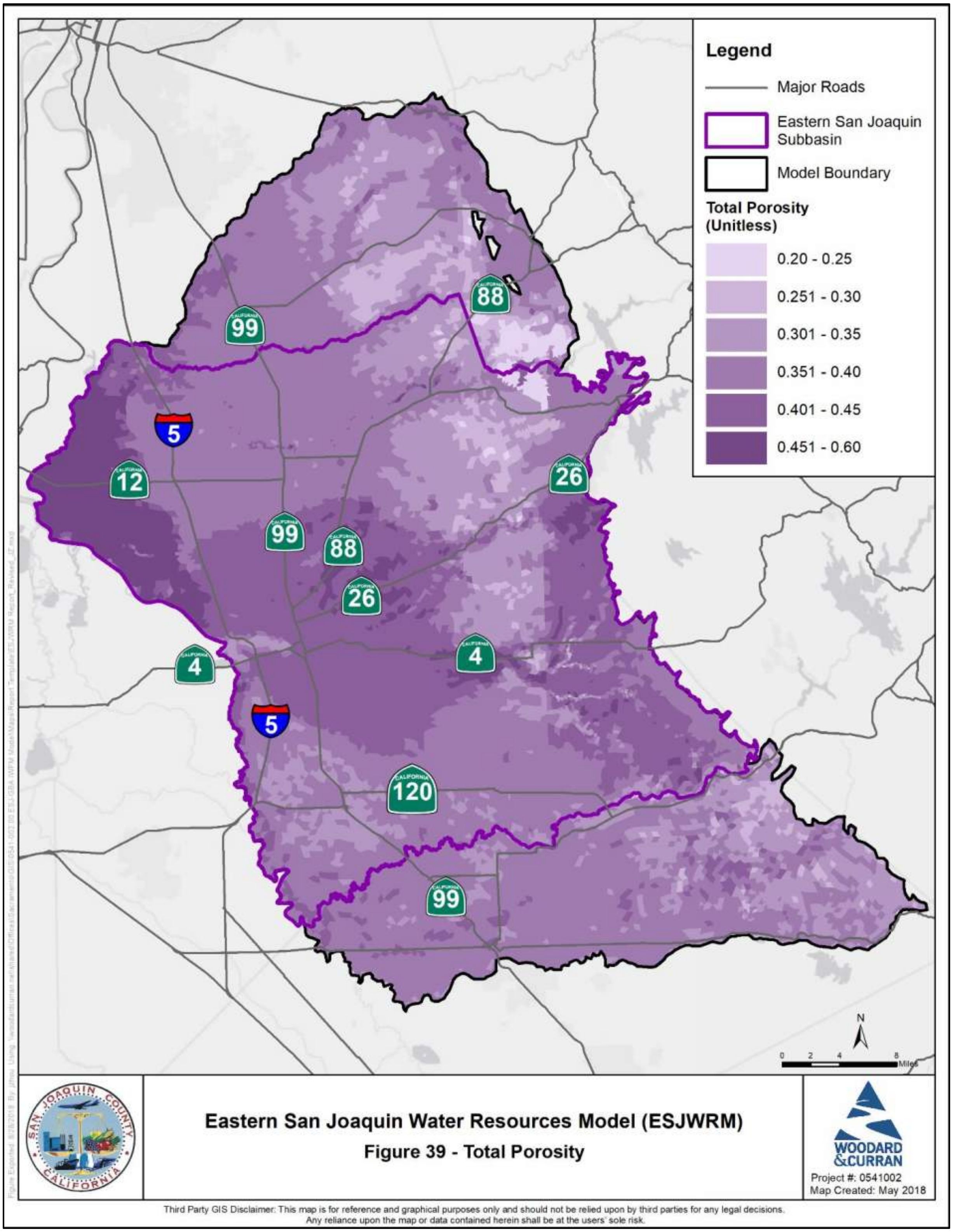


Figure 40: ESJWRM Saturated Hydraulic Conductivity

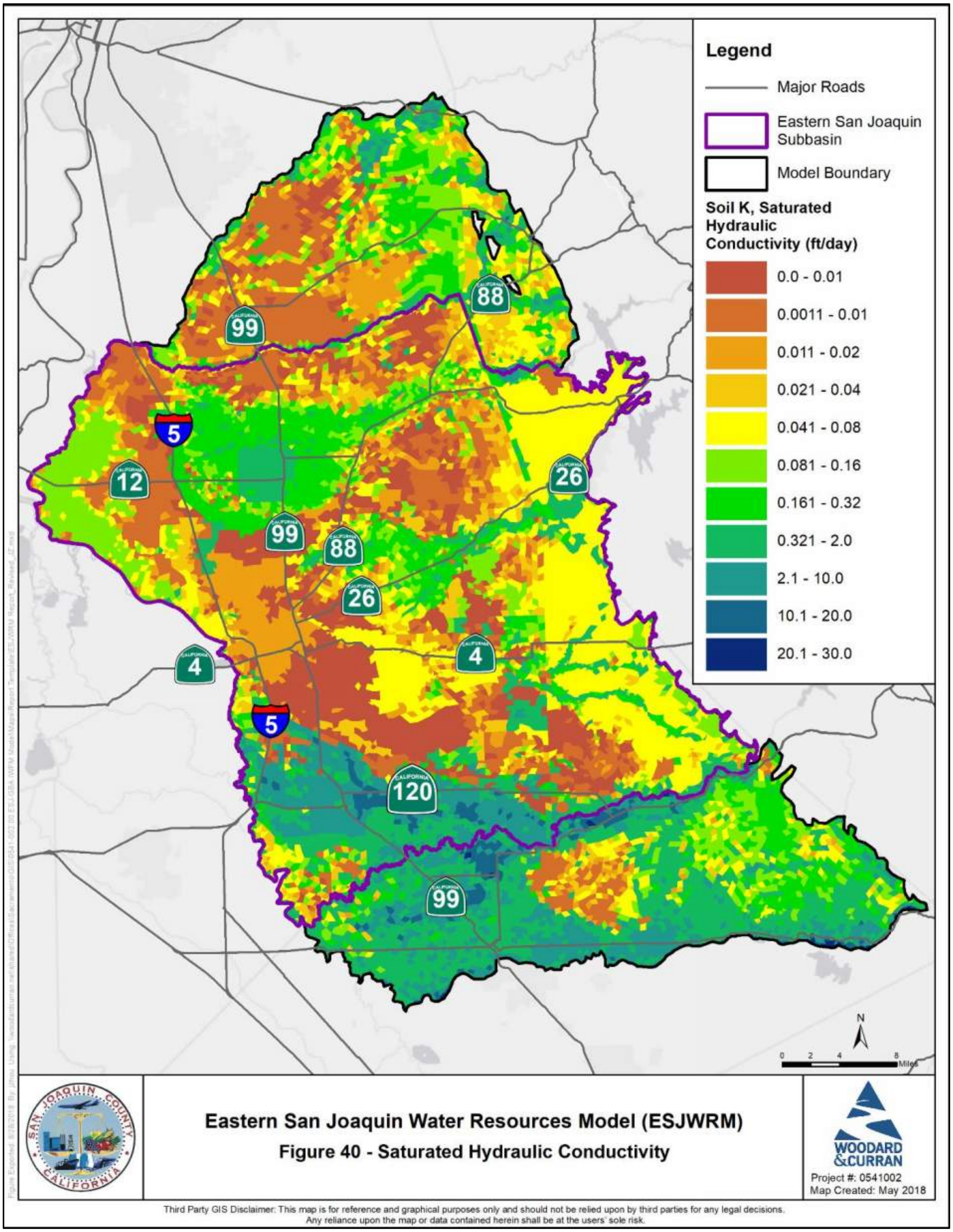


Figure 41: ESJWRM Pore Size Distribution Index

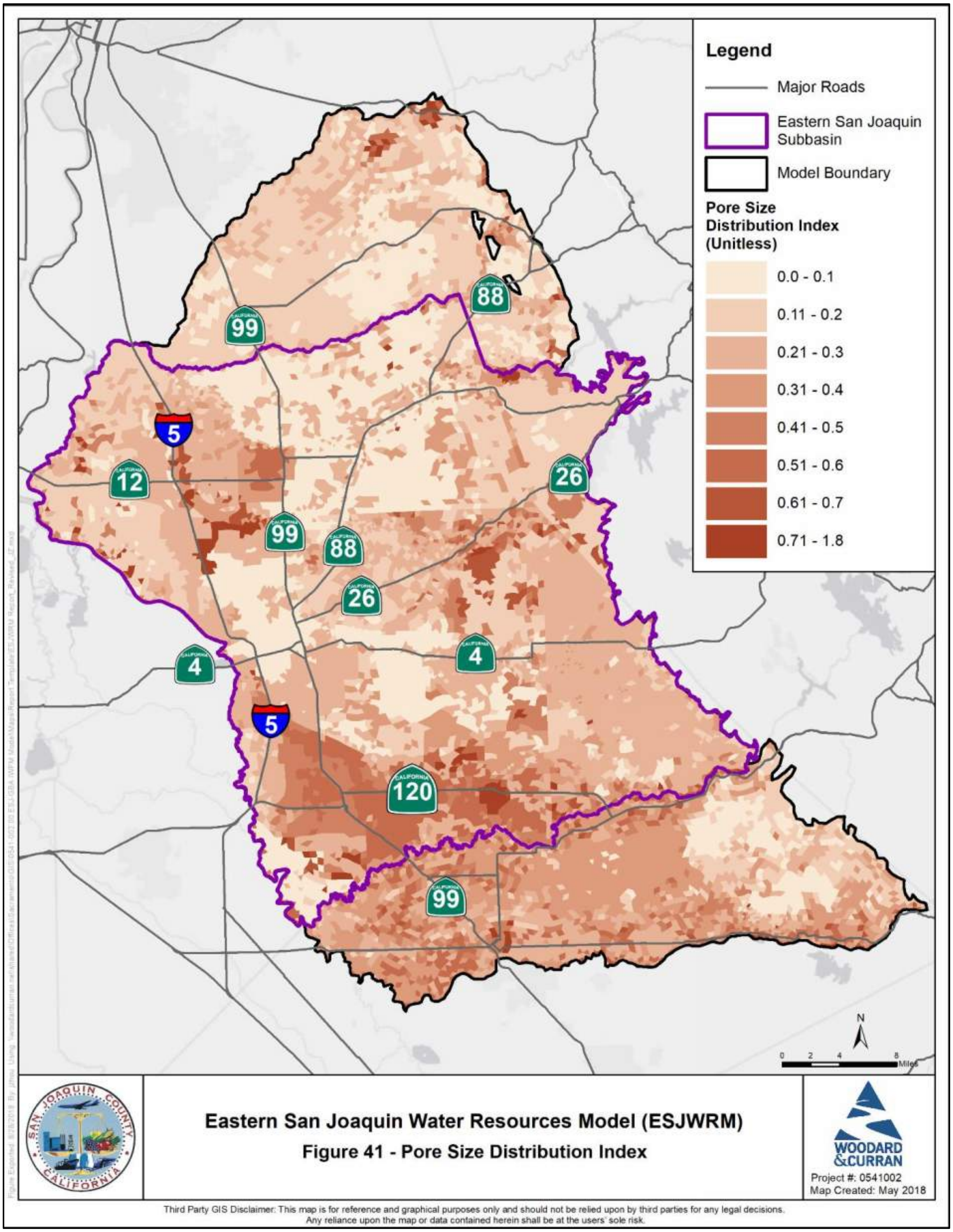


Figure 42a: ESJWRM Agricultural Water Demand – Eastern San Joaquin Subbasin

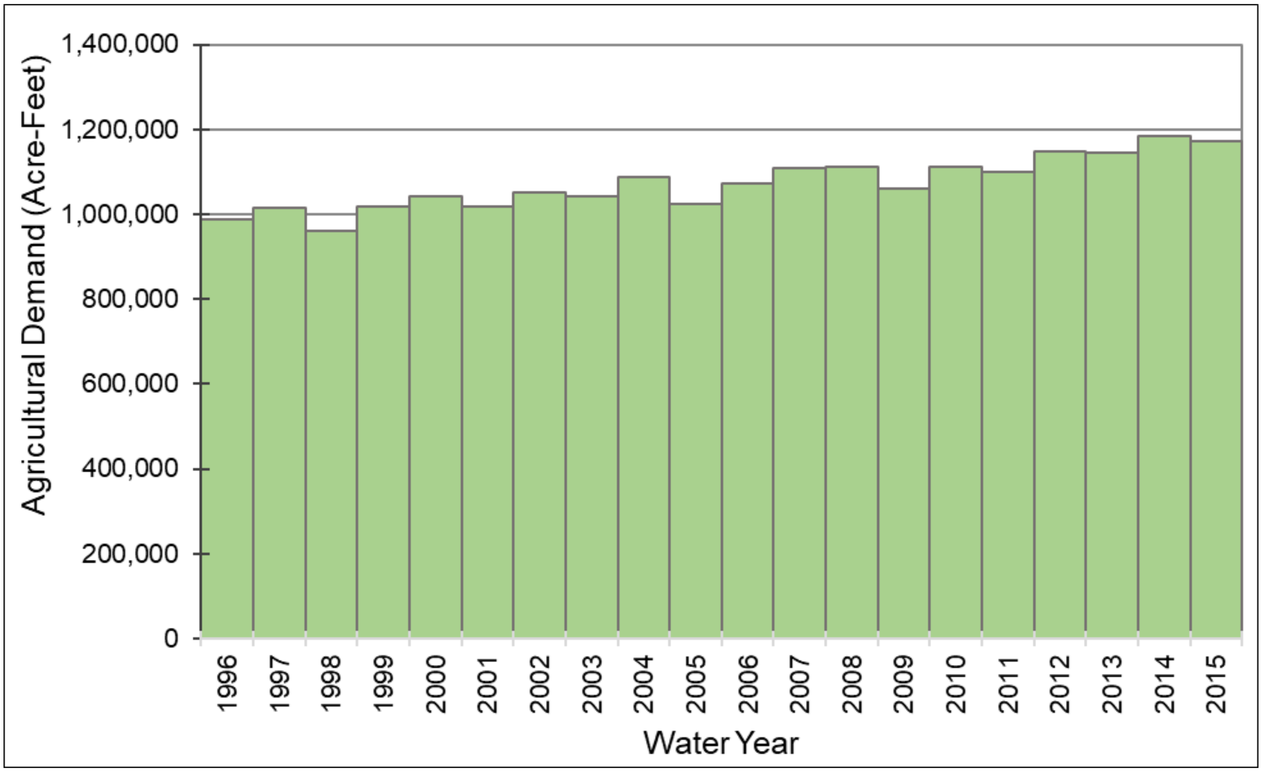


Figure 42b: ESJWRM Unit Agricultural Water Use and ETAW – Eastern San Joaquin Subbasin

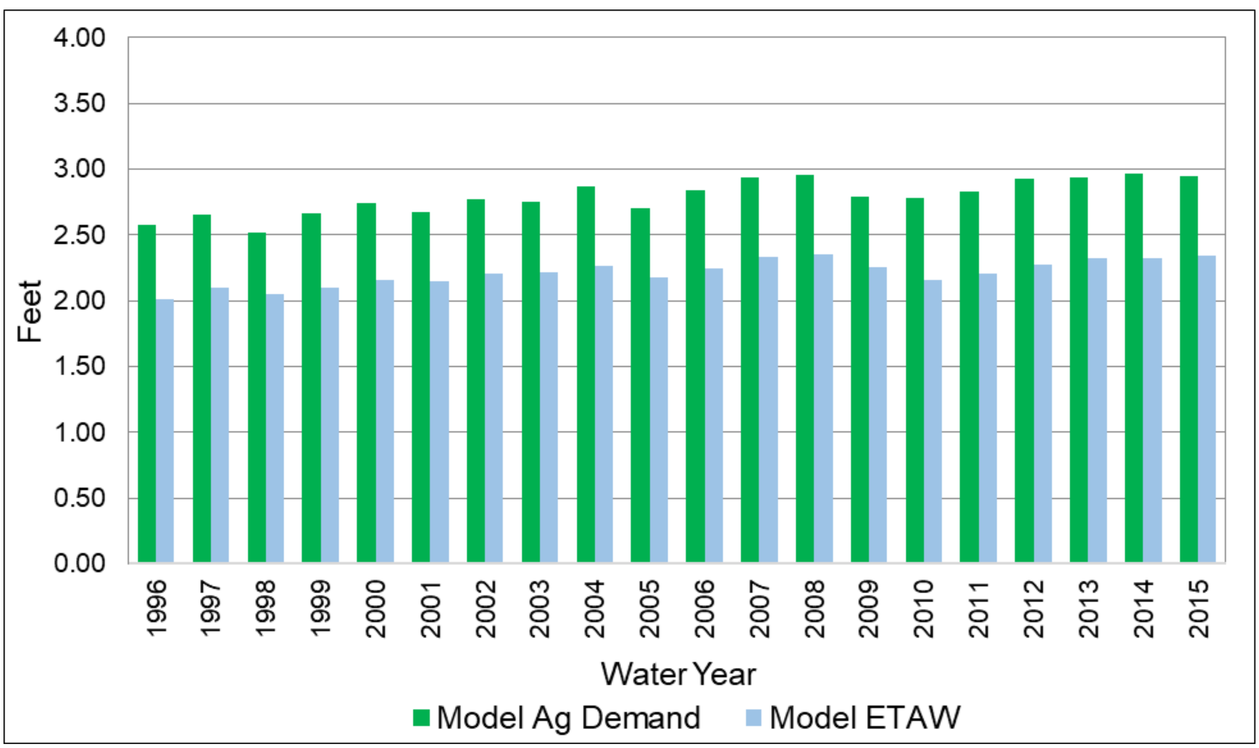


Figure 42c: ESJWRM Agricultural Water Demand – Subarea 1 (North Delta Subarea)

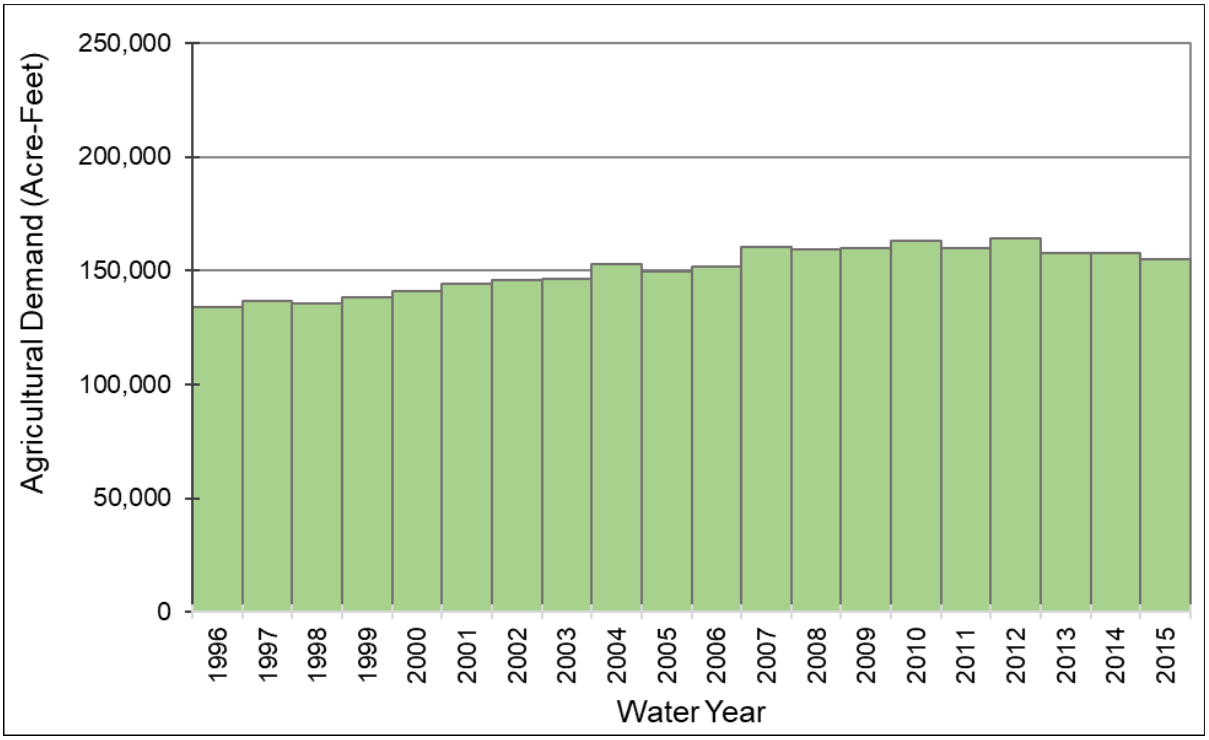


Figure 42d: ESJWRM Unit Agricultural Water Use and ETAW – Subarea 1 (North Delta Subarea)

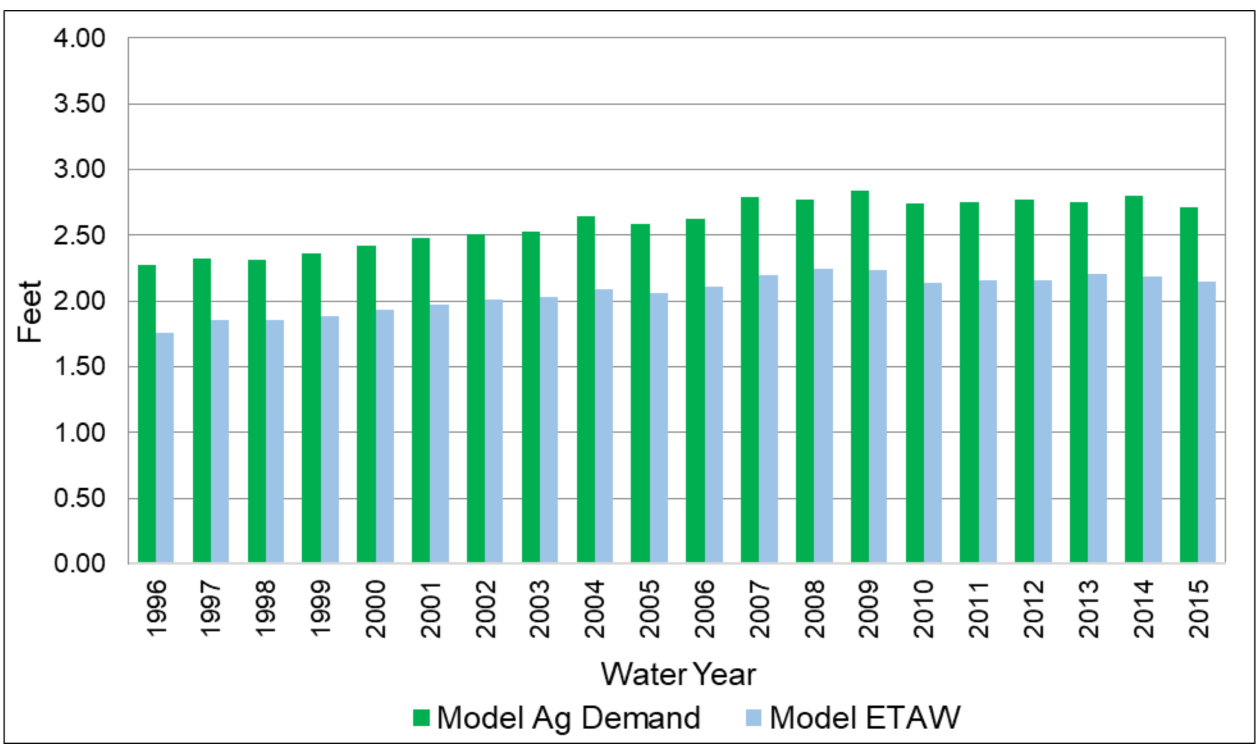


Figure 42e: ESJWRM Agricultural Water Demand – Subarea 2 (North Subarea)

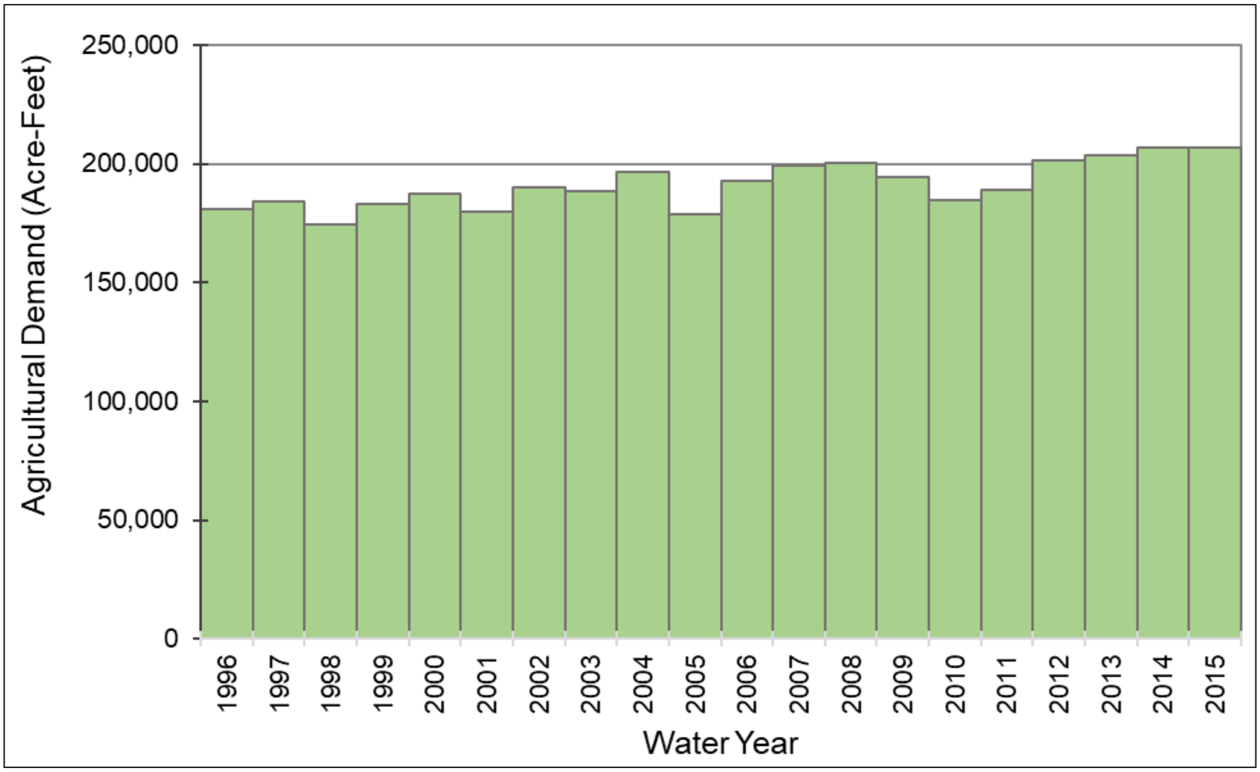


Figure 42f: ESJWRM Unit Agricultural Water Use and ETAW – Subarea 2 (North Subarea)

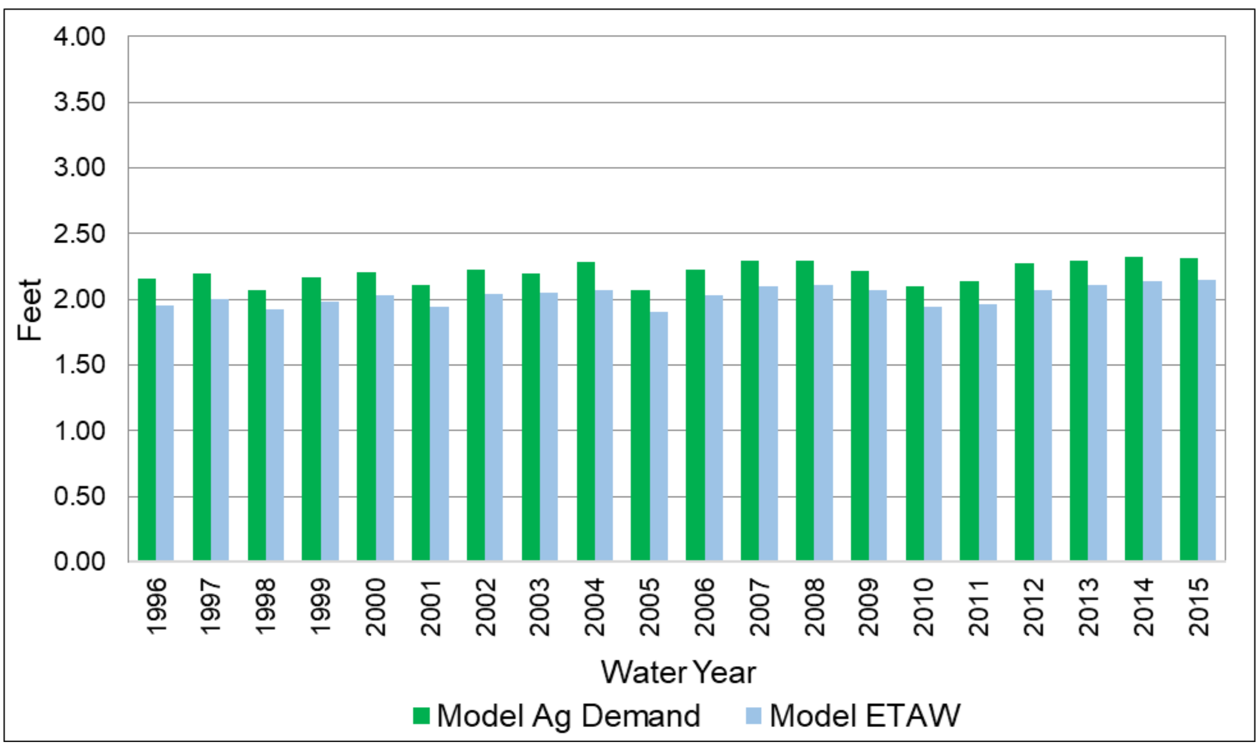


Figure 42g: ESJWRM Agricultural Water Demand – Subarea 3 (Calaveras Subarea)

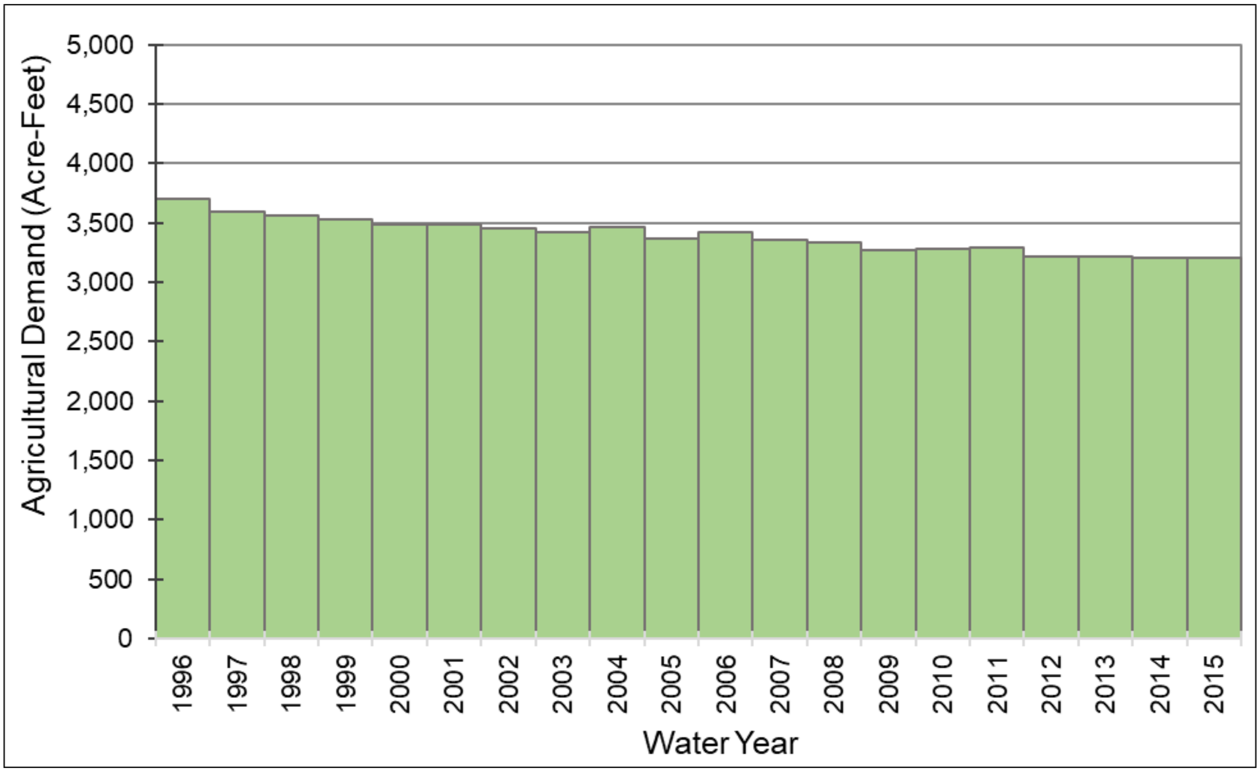


Figure 42h: ESJWRM Unit Agricultural Water Use and ETAW – Subarea 3 (Calaveras Subarea)

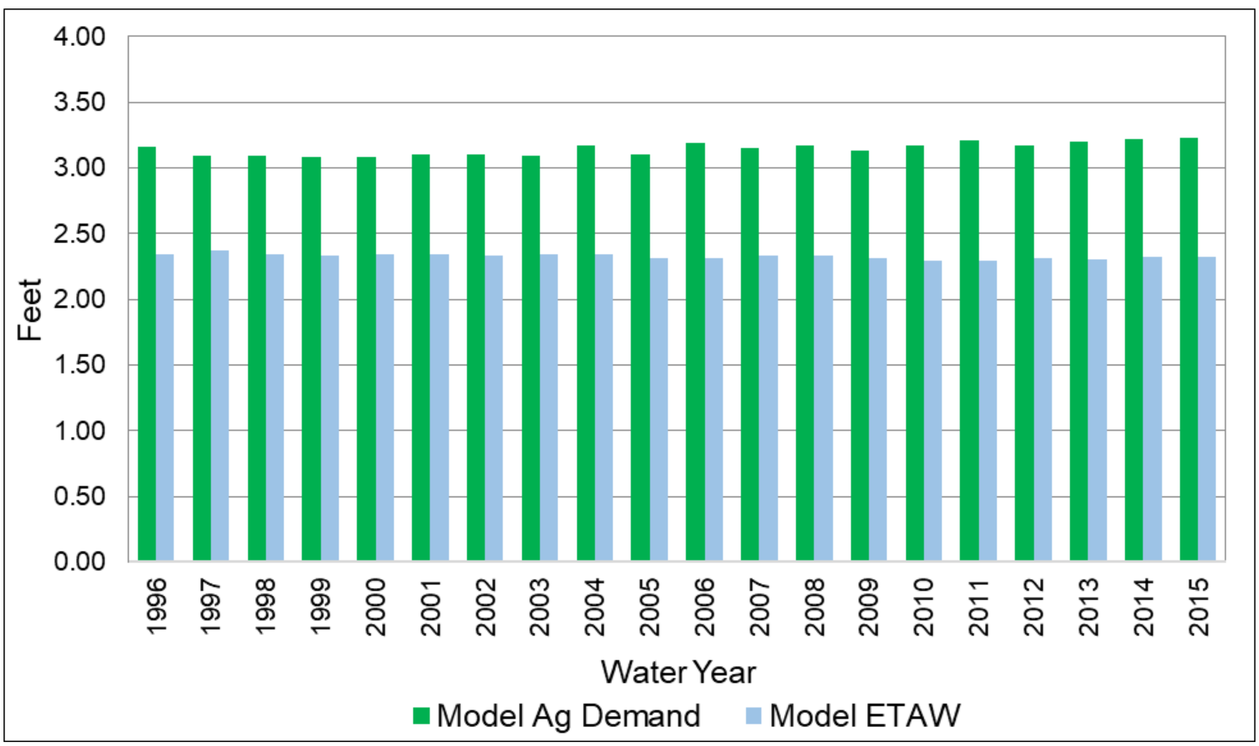


Figure 42i: ESJWRM Agricultural Water Demand – Subarea 4 (Central Subarea)

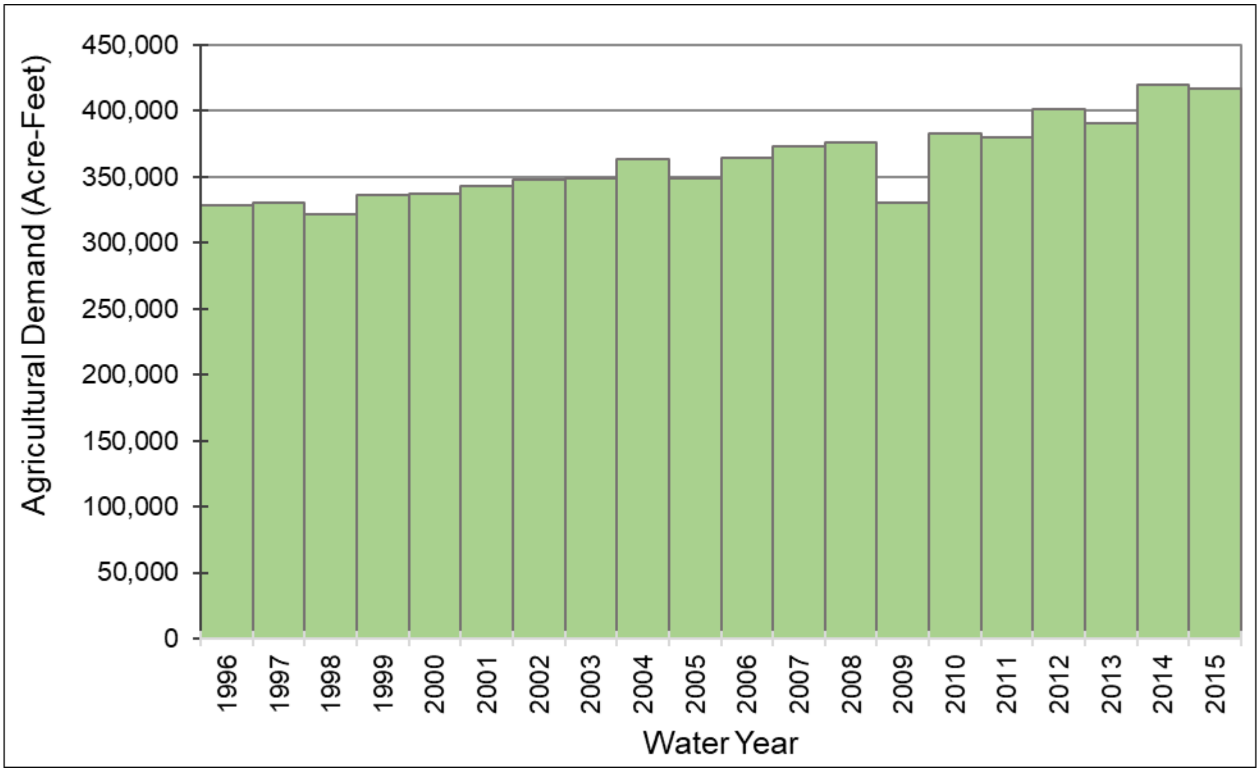


Figure 42j: ESJWRM Unit Agricultural Water Use and ETAW – Subarea 4 (Central Subarea)

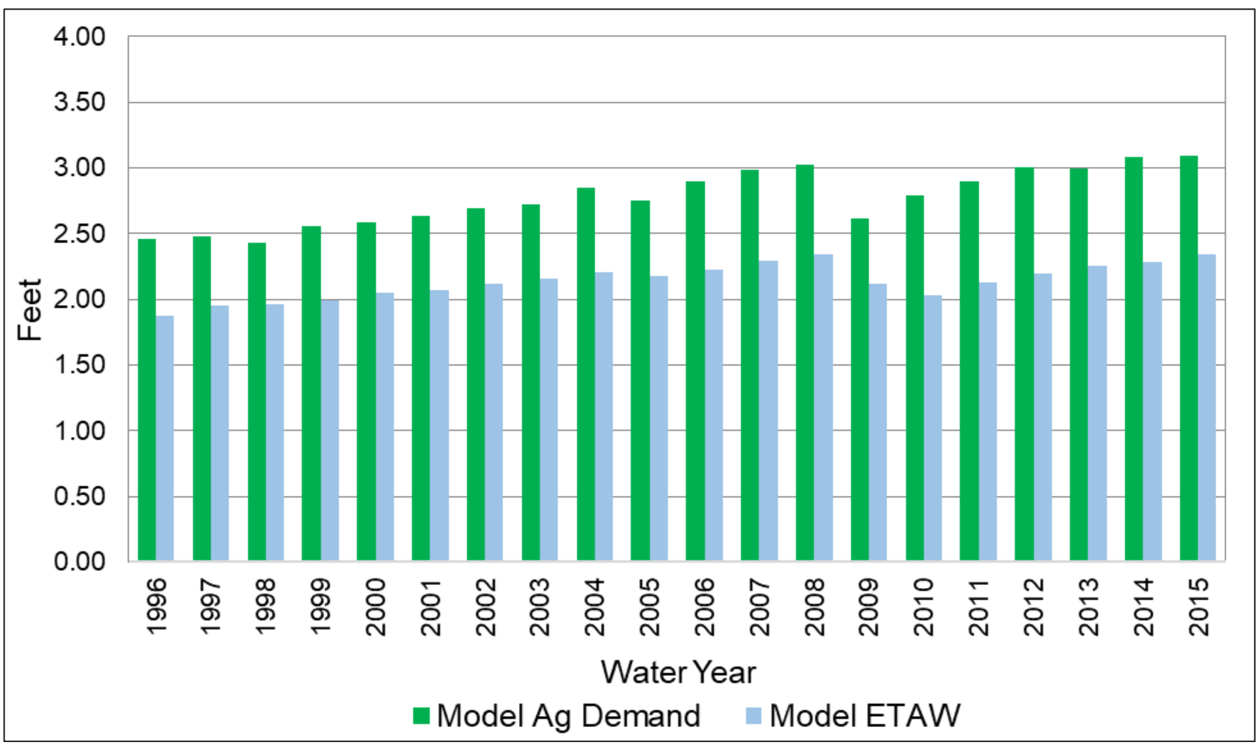


Figure 42k: ESJWRM Agricultural Water Demand – Subarea 5 (South Subarea)

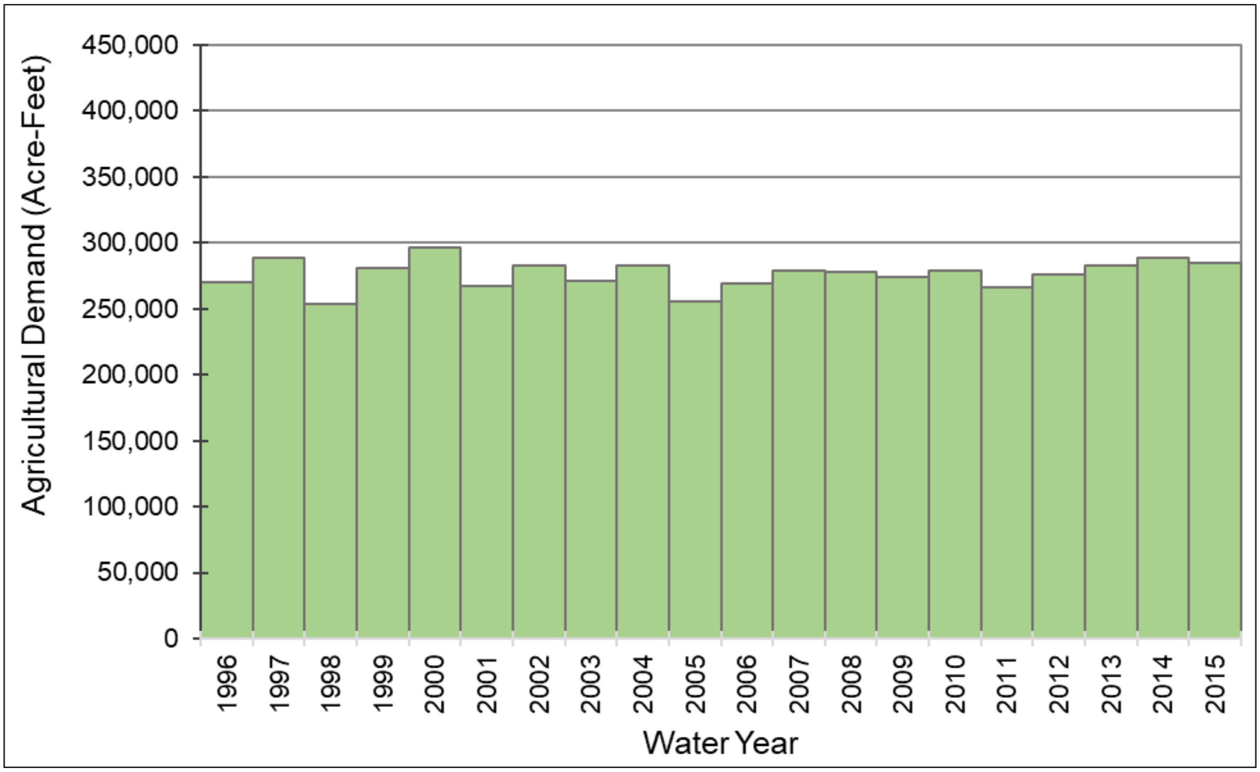


Figure 42l: ESJWRM Unit Agricultural Water Use and ETAW – Subarea 5 (South Subarea)

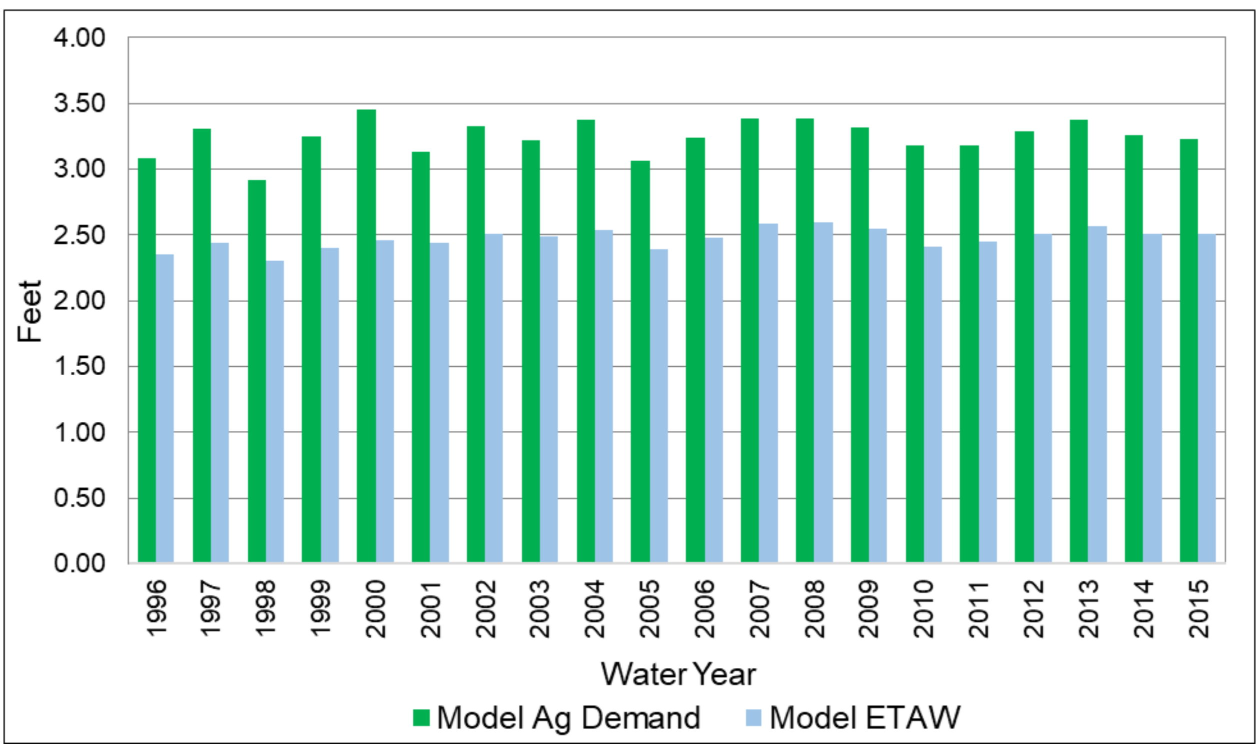


Figure 42m: ESJWRM Agricultural Water Demand – Subarea 6 (Stanislaus Subarea)

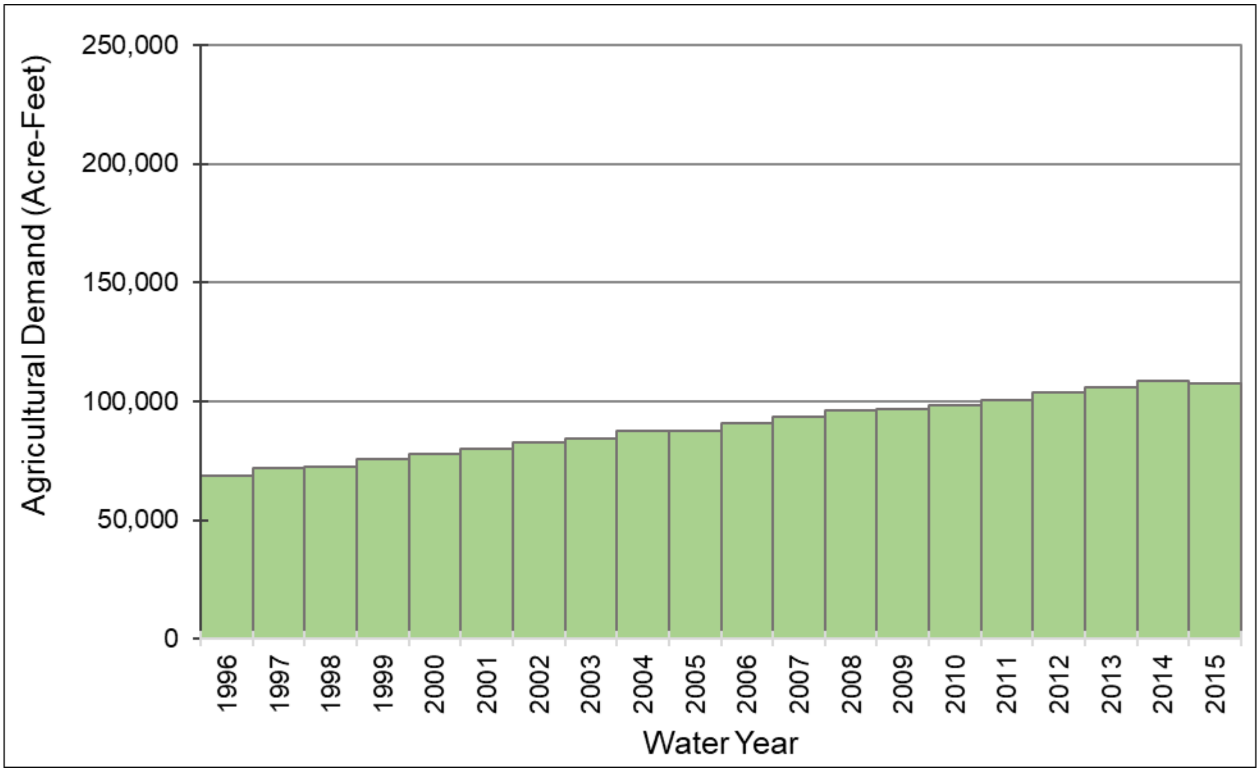


Figure 42n: ESJWRM Unit Agricultural Water Use and ETAW – Subarea 6 (Stanislaus Subarea)

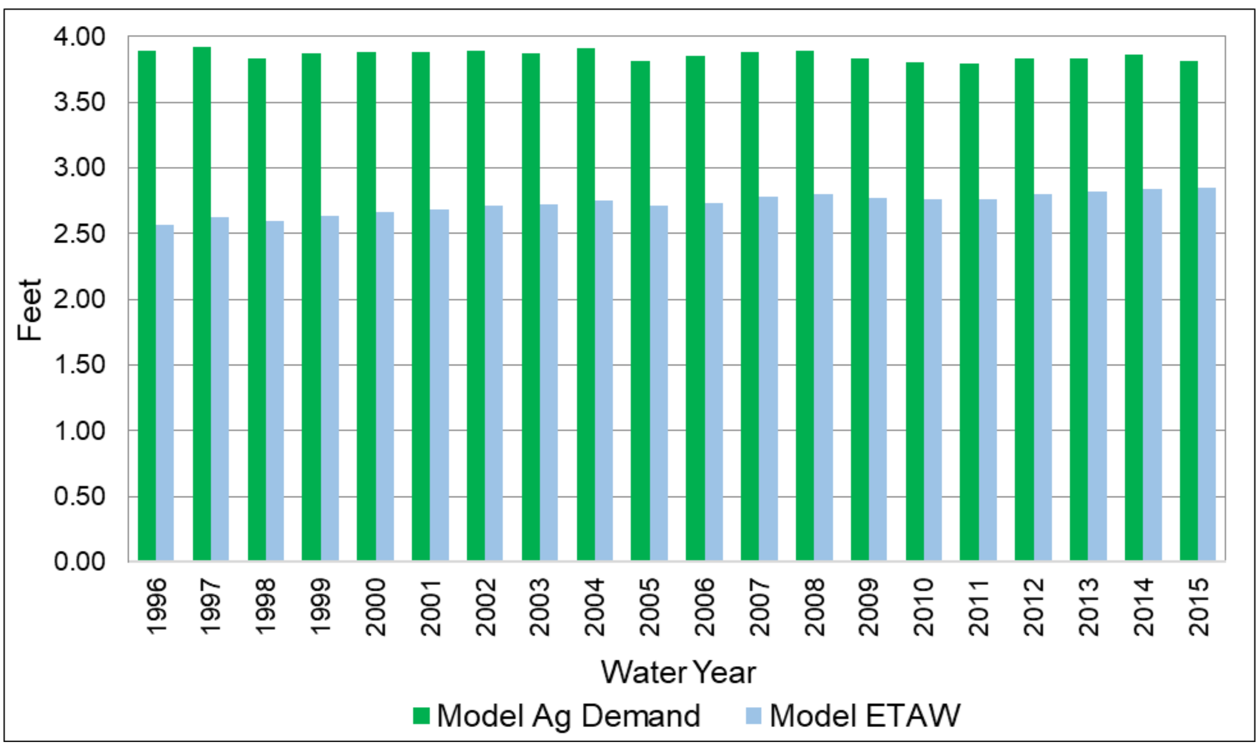


Figure 43a: ESJWRM Urban Water Demand – Eastern San Joaquin Subbasin

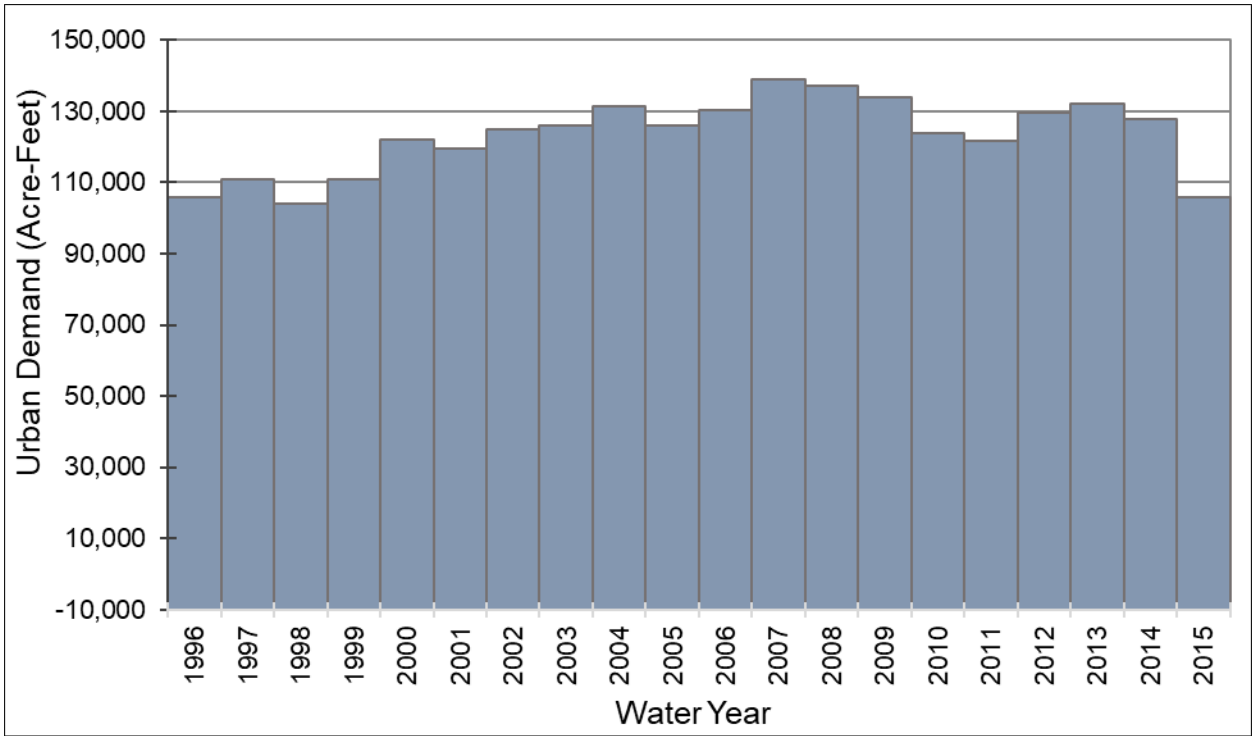


Figure 43b: ESJWRM Urban Water Demand – Subarea 1 (North Delta Subarea)

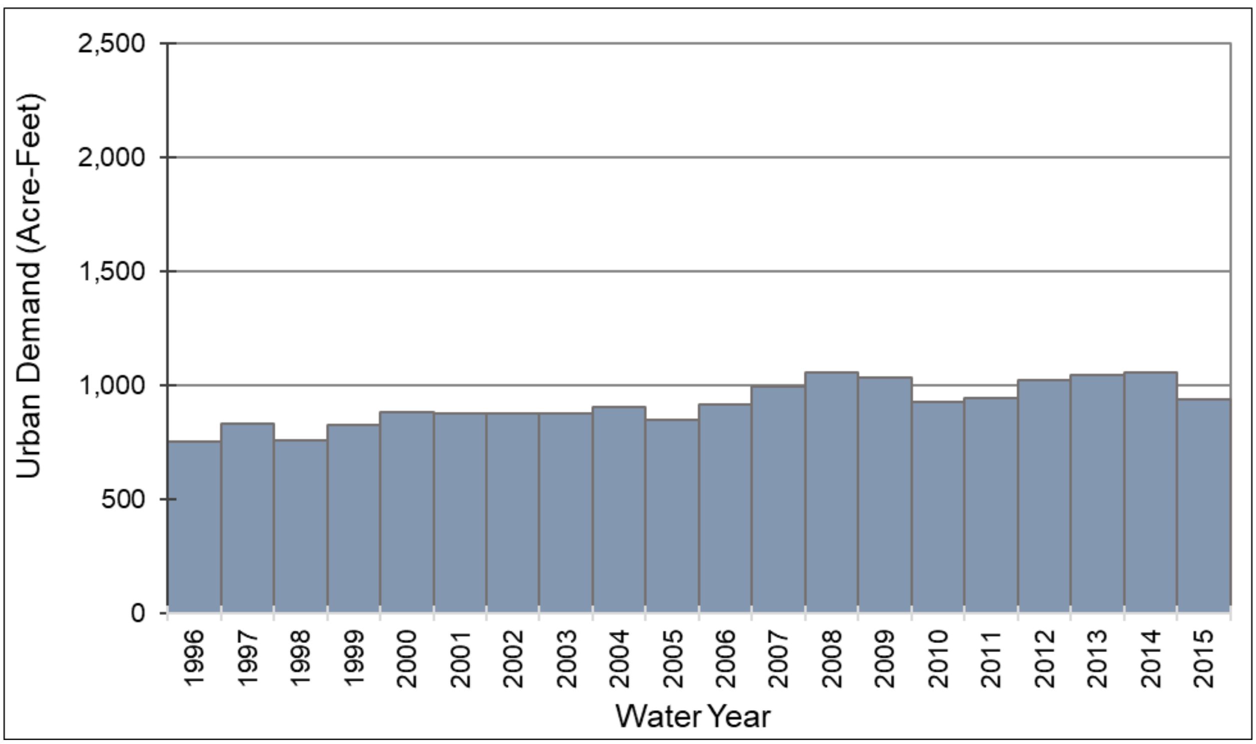


Figure 43c: ESJWRM Urban Water Demand – Subarea 2 (North Subarea)

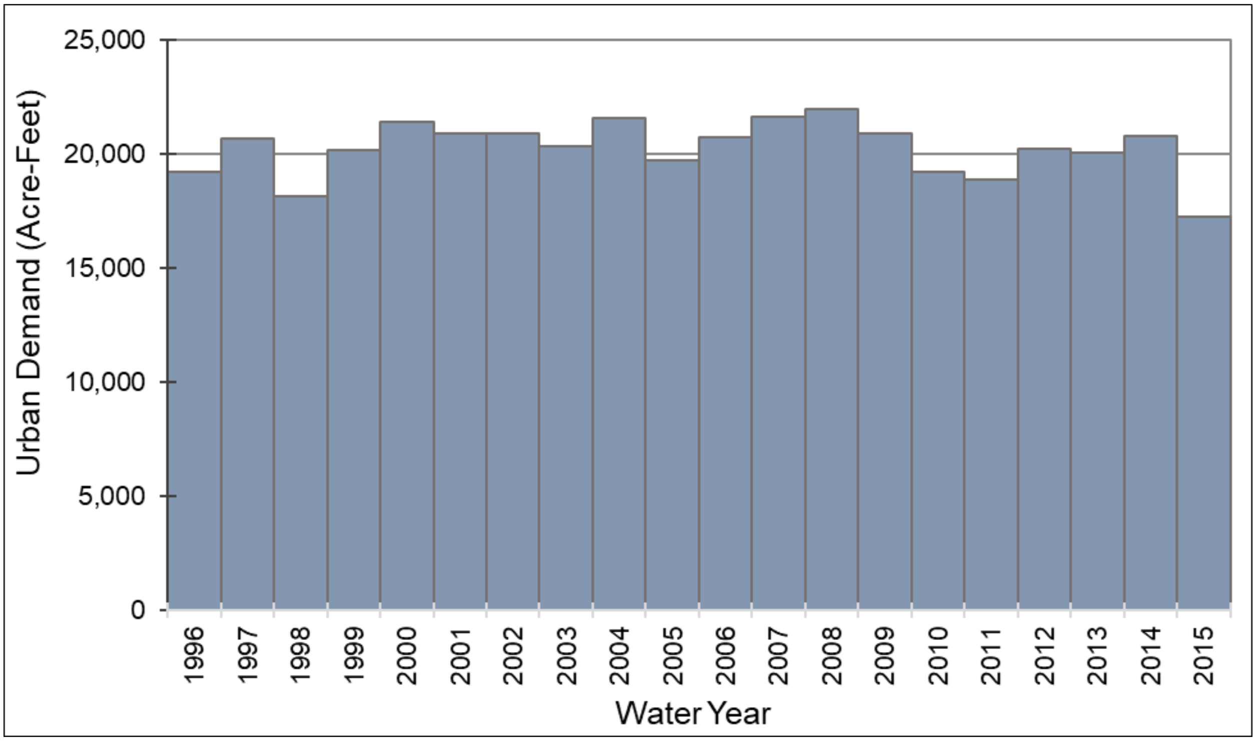


Figure 43d: ESJWRM Urban Water Demand – Subarea 3 (Calaveras Subarea)

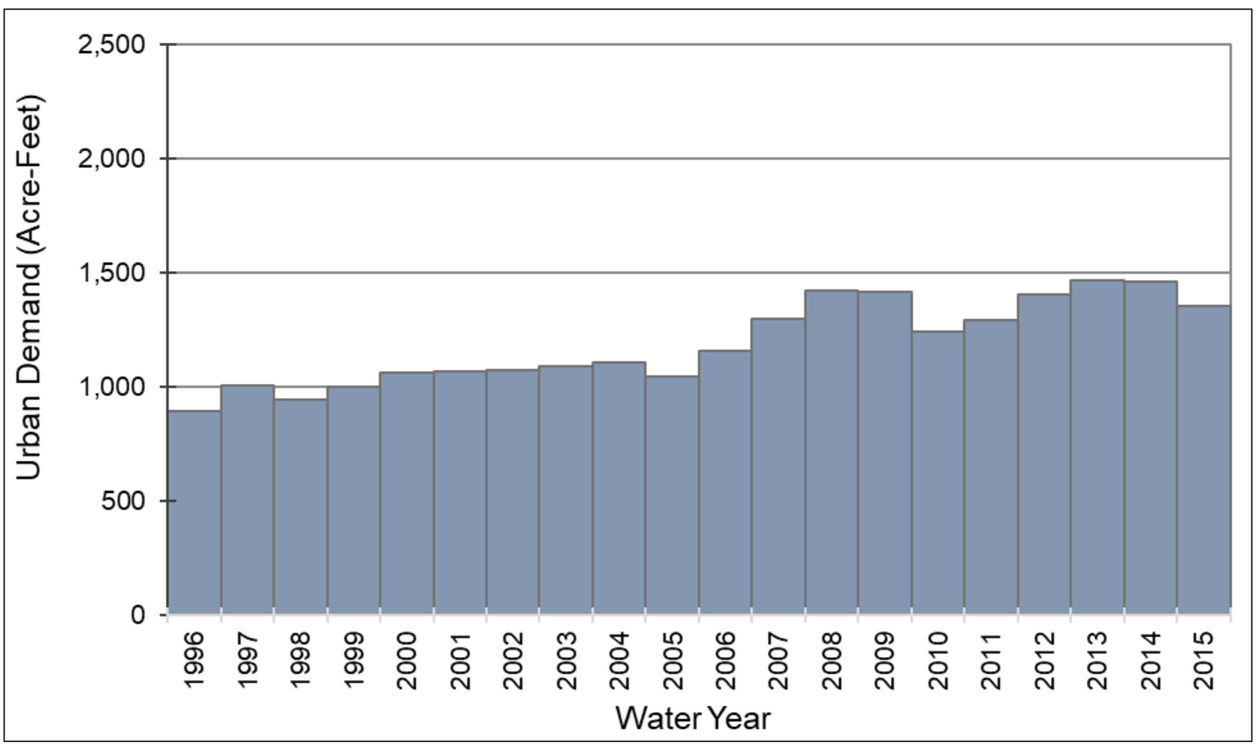


Figure 43e: ESJWRM Urban Water Demand – Subarea 4 (Central Subarea)

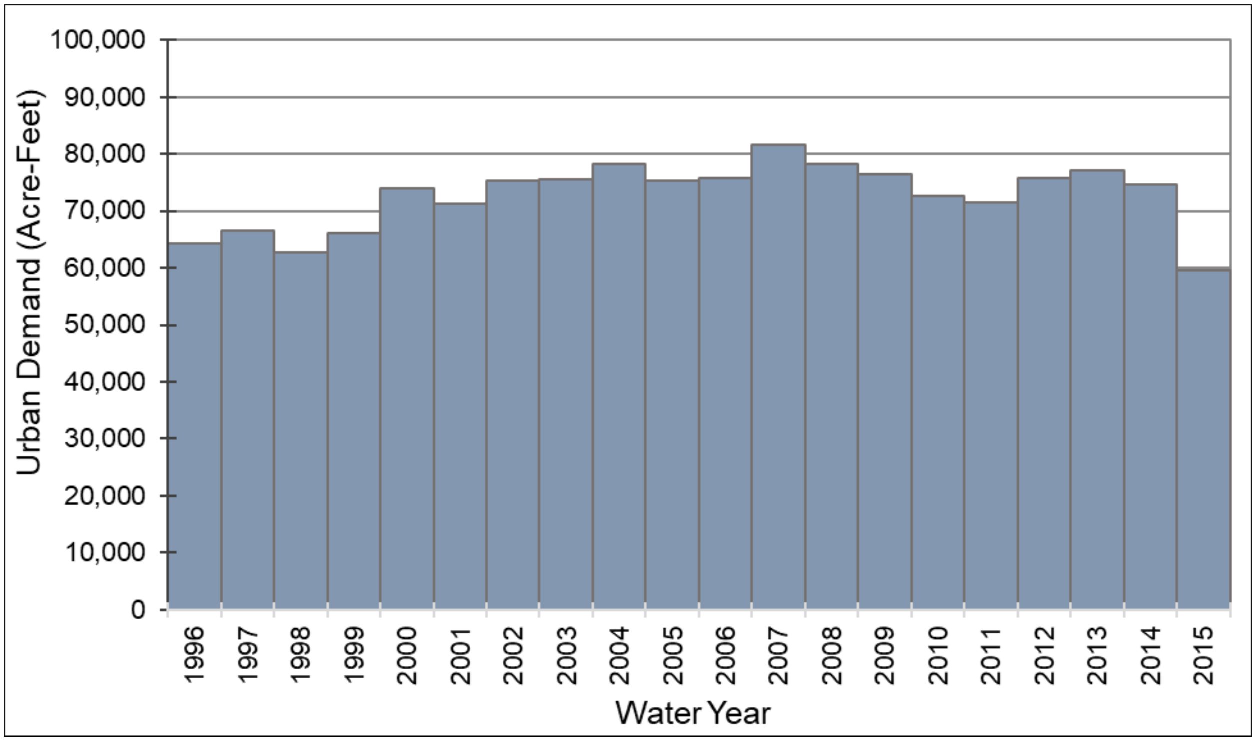


Figure 43f: ESJWRM Urban Water Demand – Subarea 5 (South Subarea)

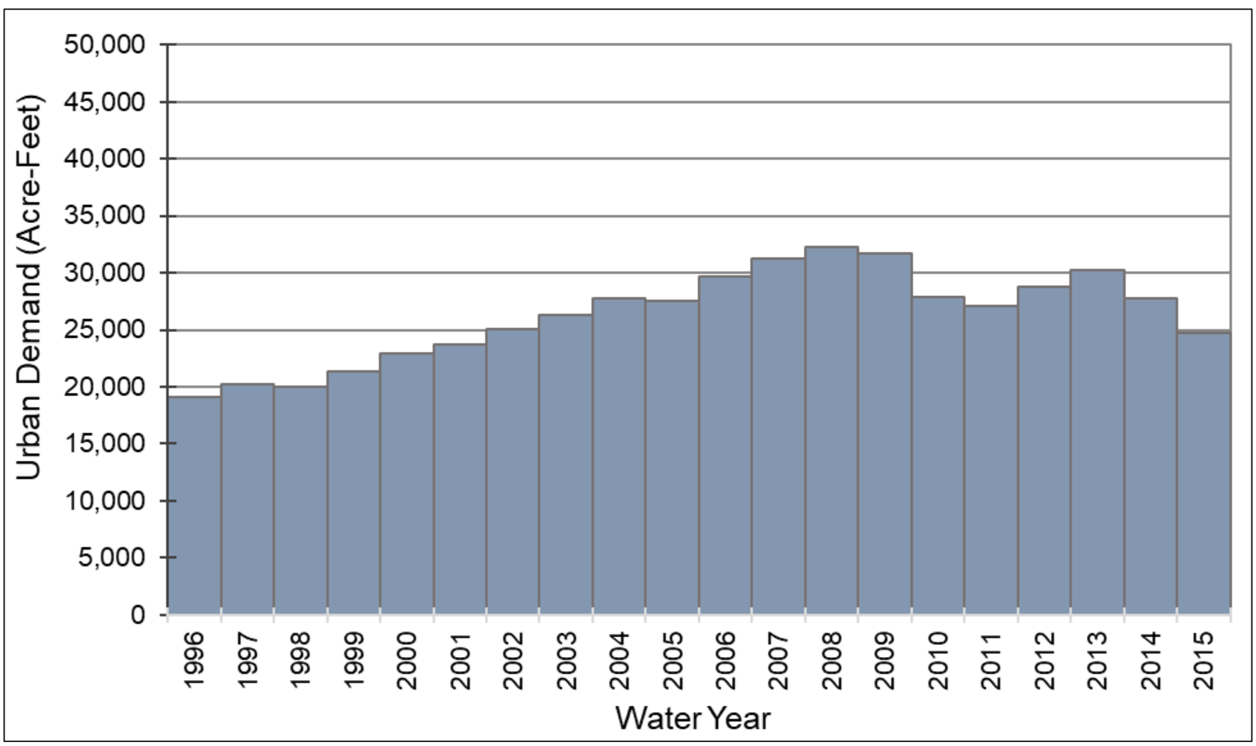


Figure 43g: ESJWRM Urban Water Demand – Subarea 6 (Stanislaus Subarea)

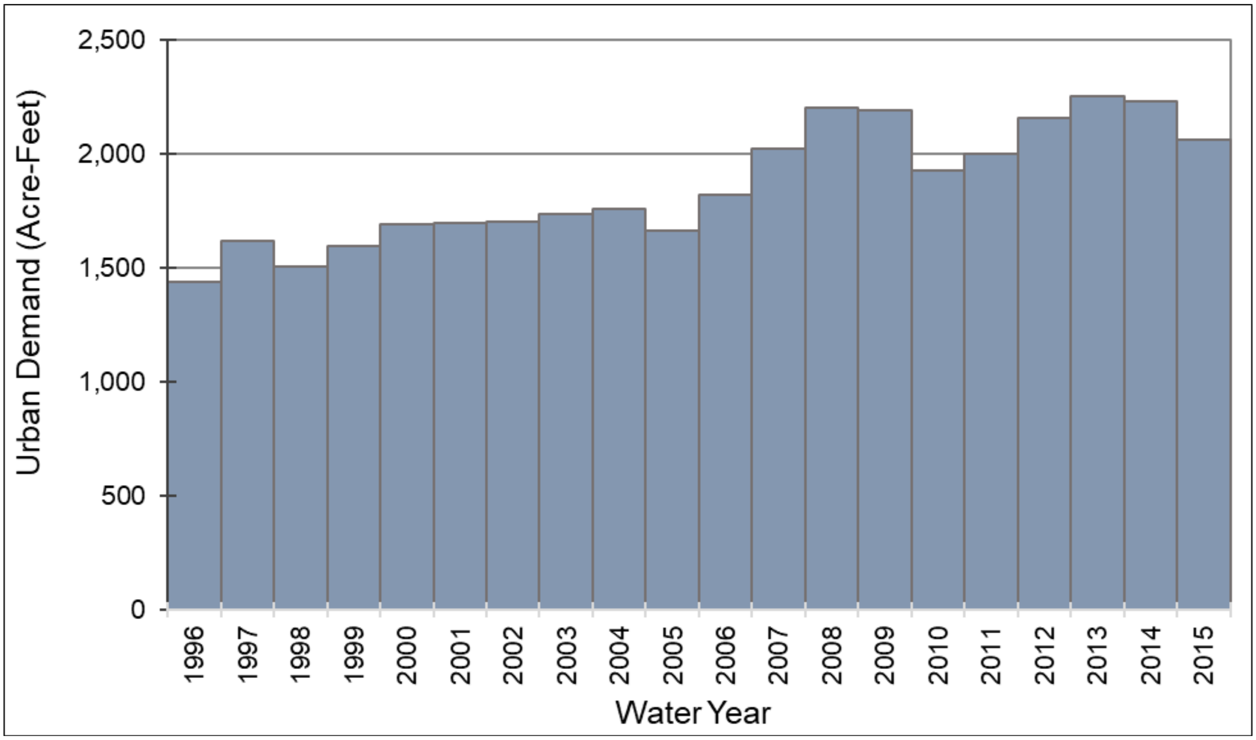


Figure 44: ESJWRM Stream Calibration Gauges

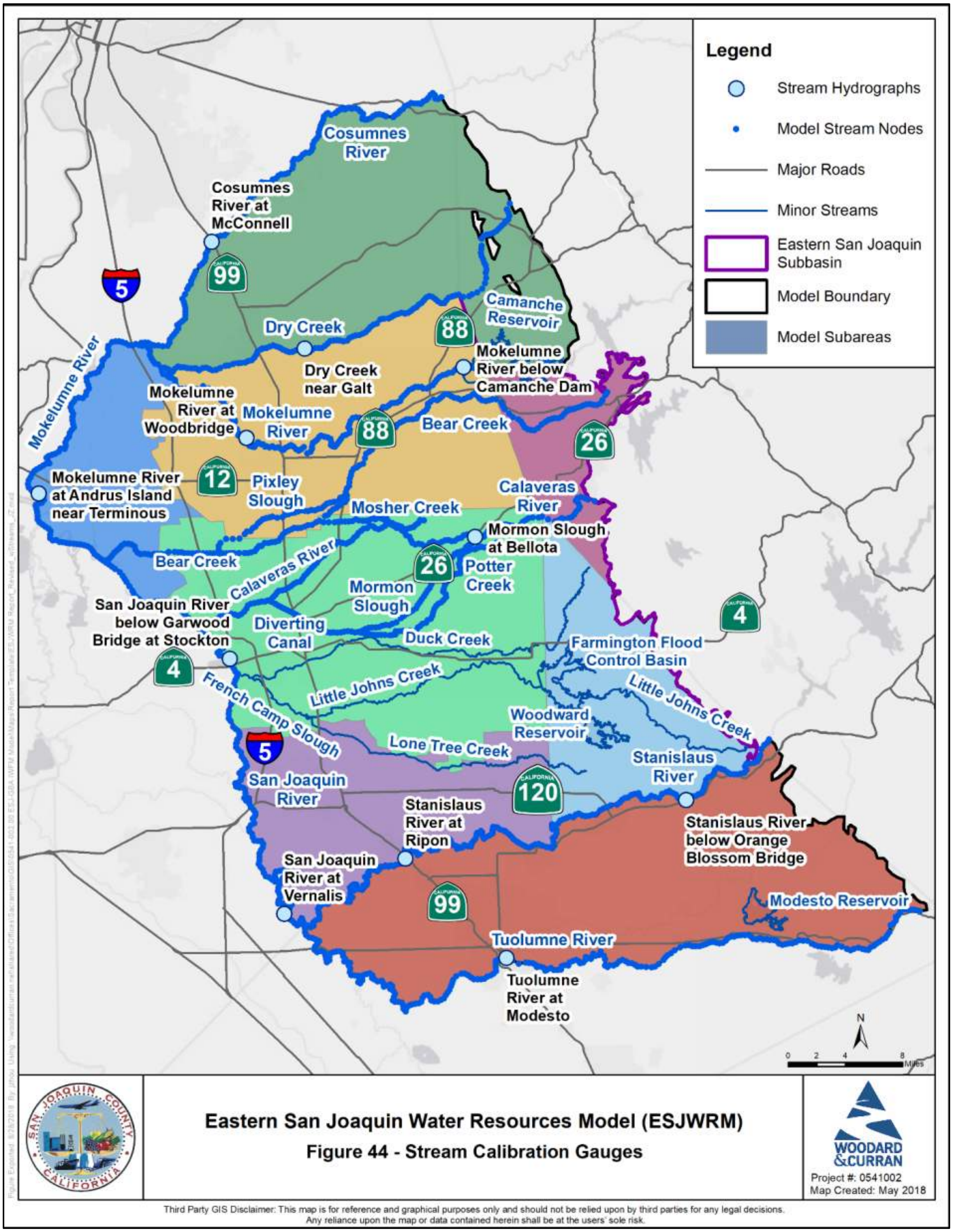


Figure 45: ESJWRM Stream Bed Hydraulic Conductivity

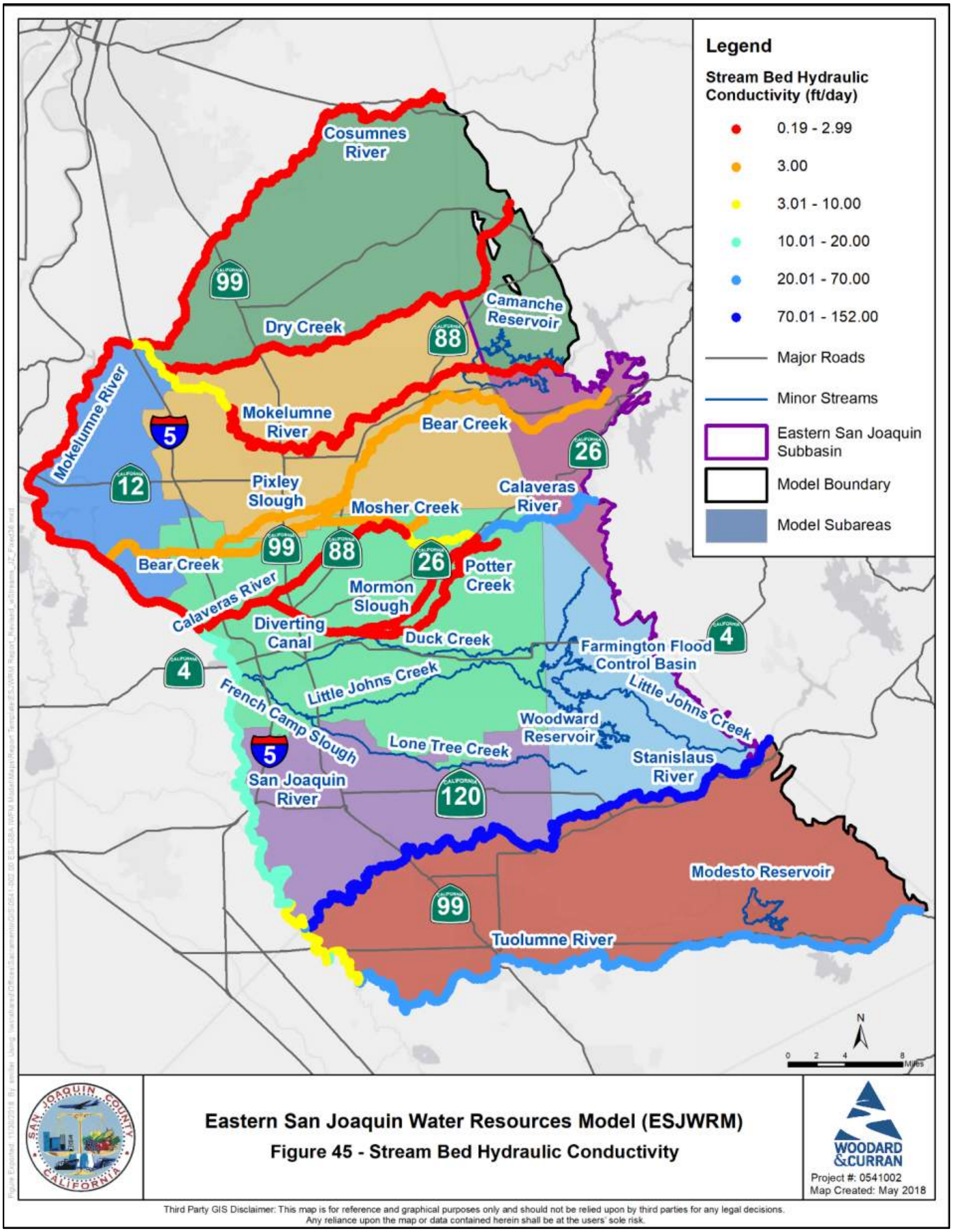


Figure 46a: ESJWRM Stream Calibration Gauges Streamflow – Dry Creek near Galt

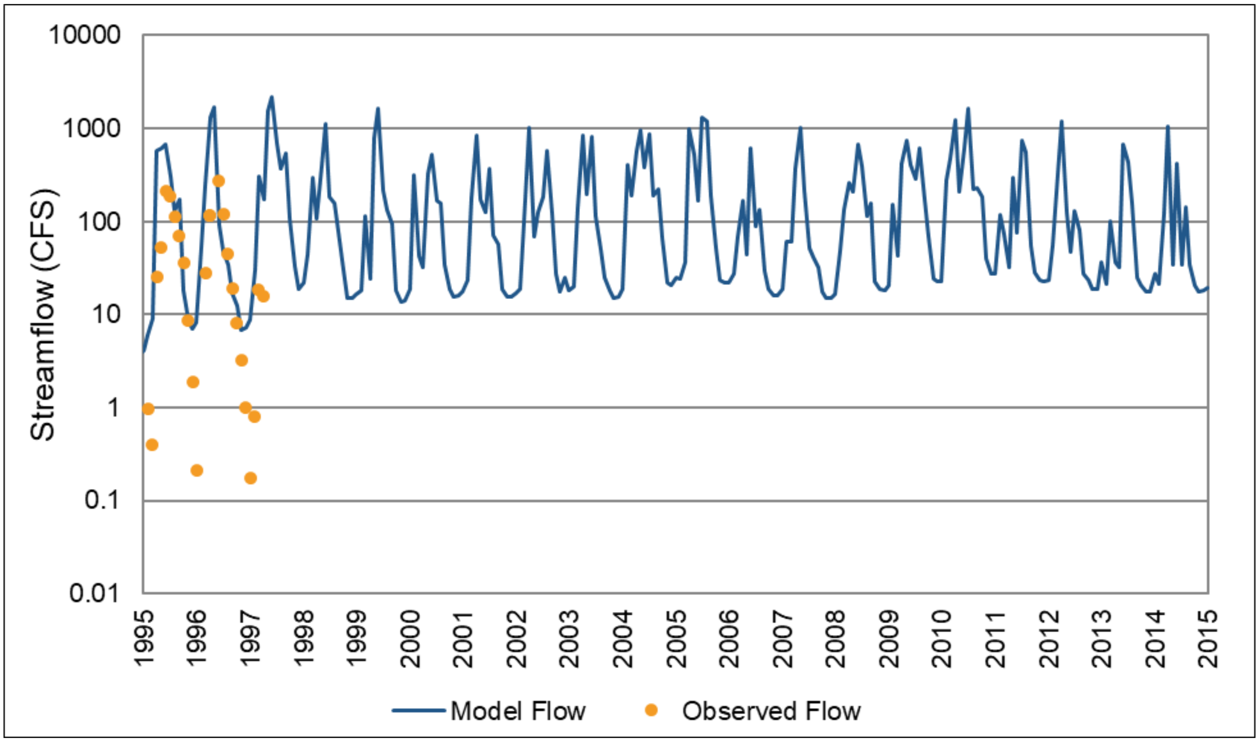


Figure 46b: ESJWRM Stream Calibration Gauges Exceedance – Dry Creek near Galt

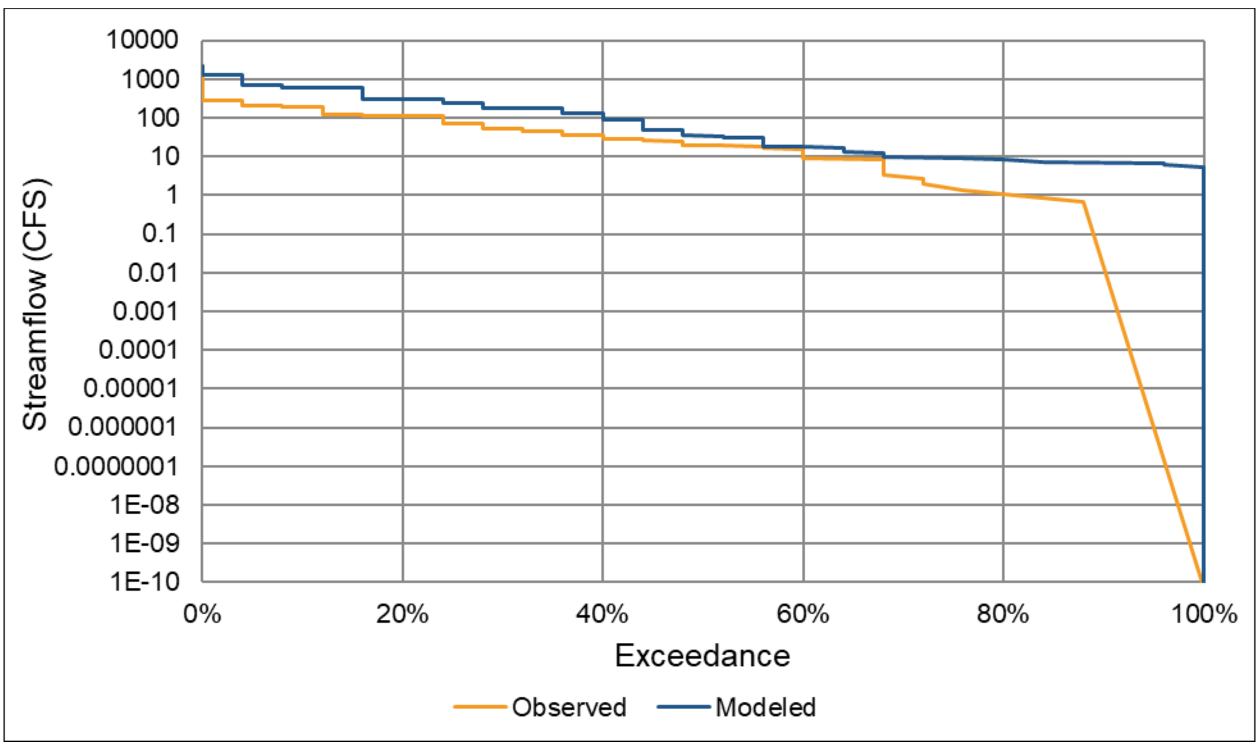


Figure 46c: ESJWRM Stream Calibration Gauges Streamflow – Mokelumne River at Woodbridge

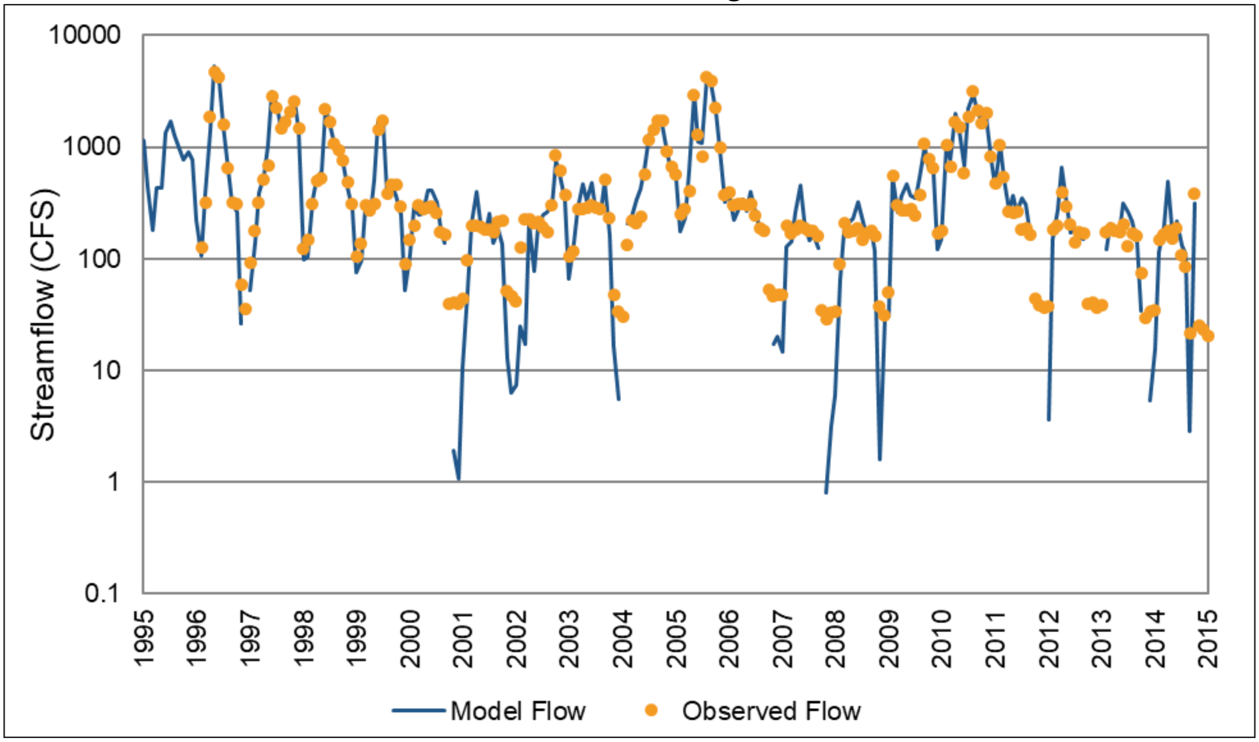


Figure 46d: ESJWRM Stream Calibration Gauges Exceedance – Mokelumne River at Woodbridge

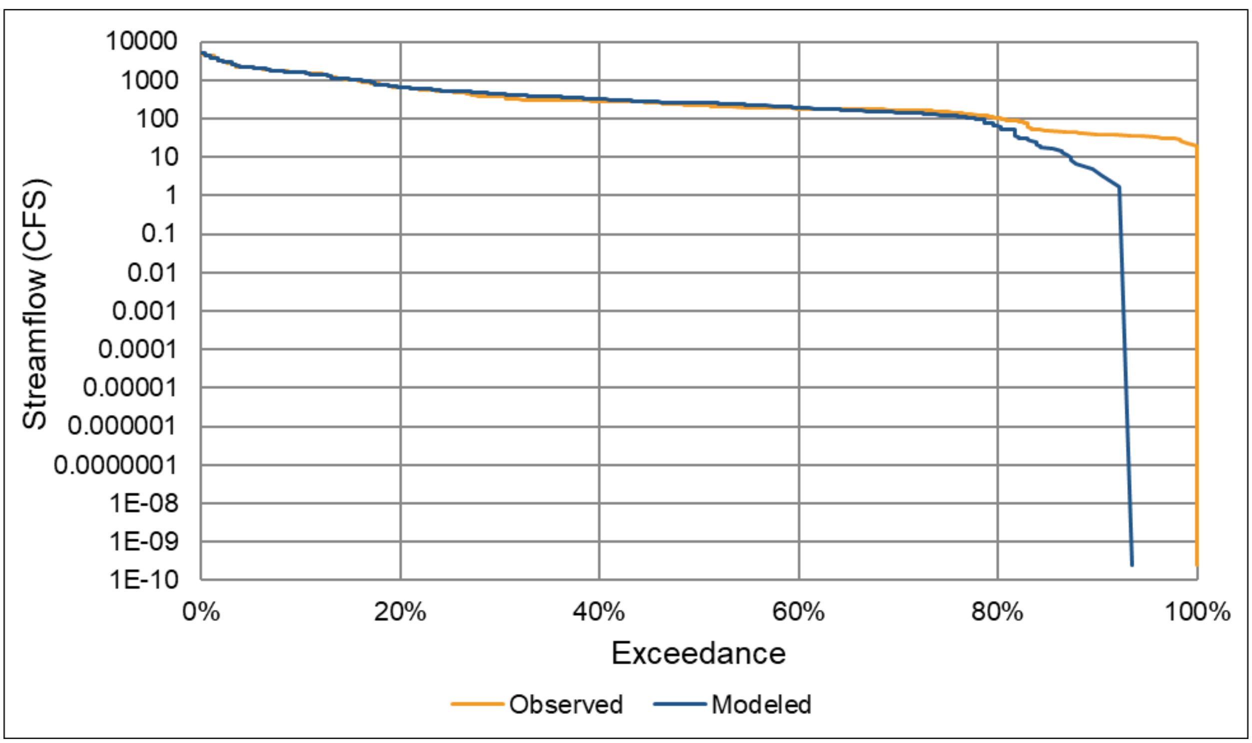


Figure 46e: ESJWRM Stream Calibration Gauges Streamflow – Mormon Slough at Bellota

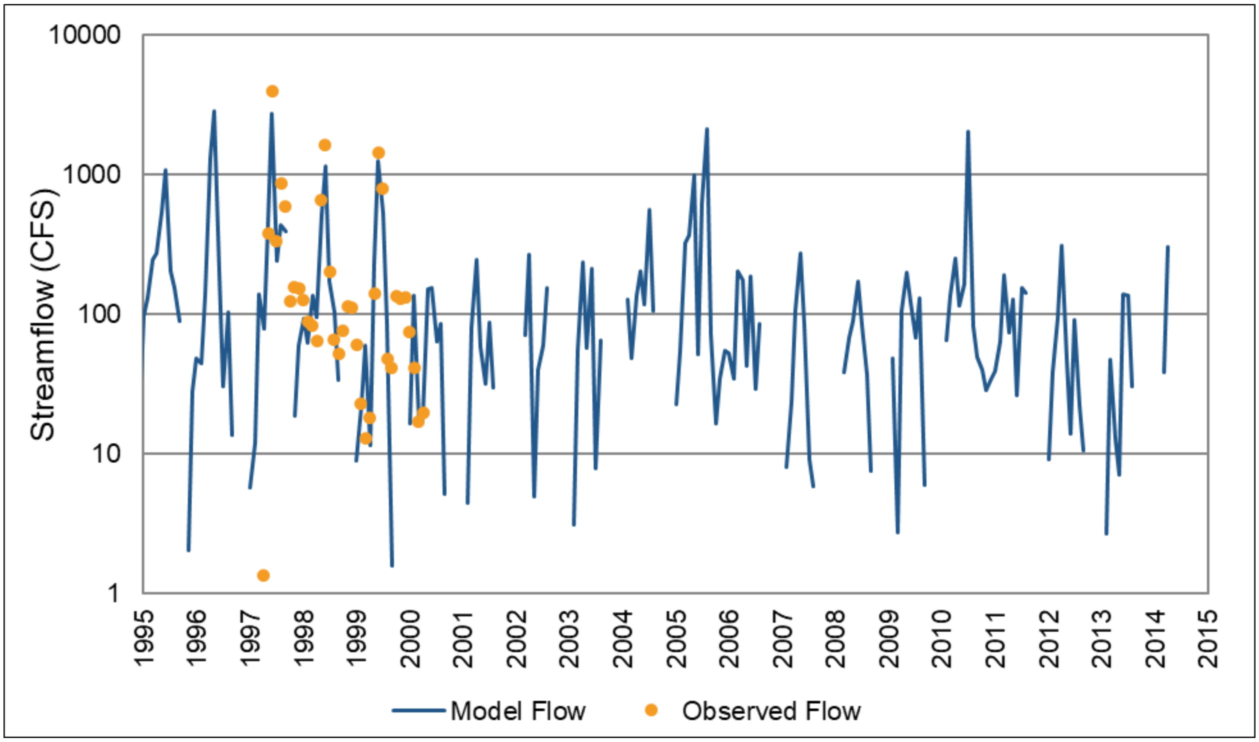


Figure 46f: ESJWRM Stream Calibration Gauges Exceedance – Mormon Slough at Bellota

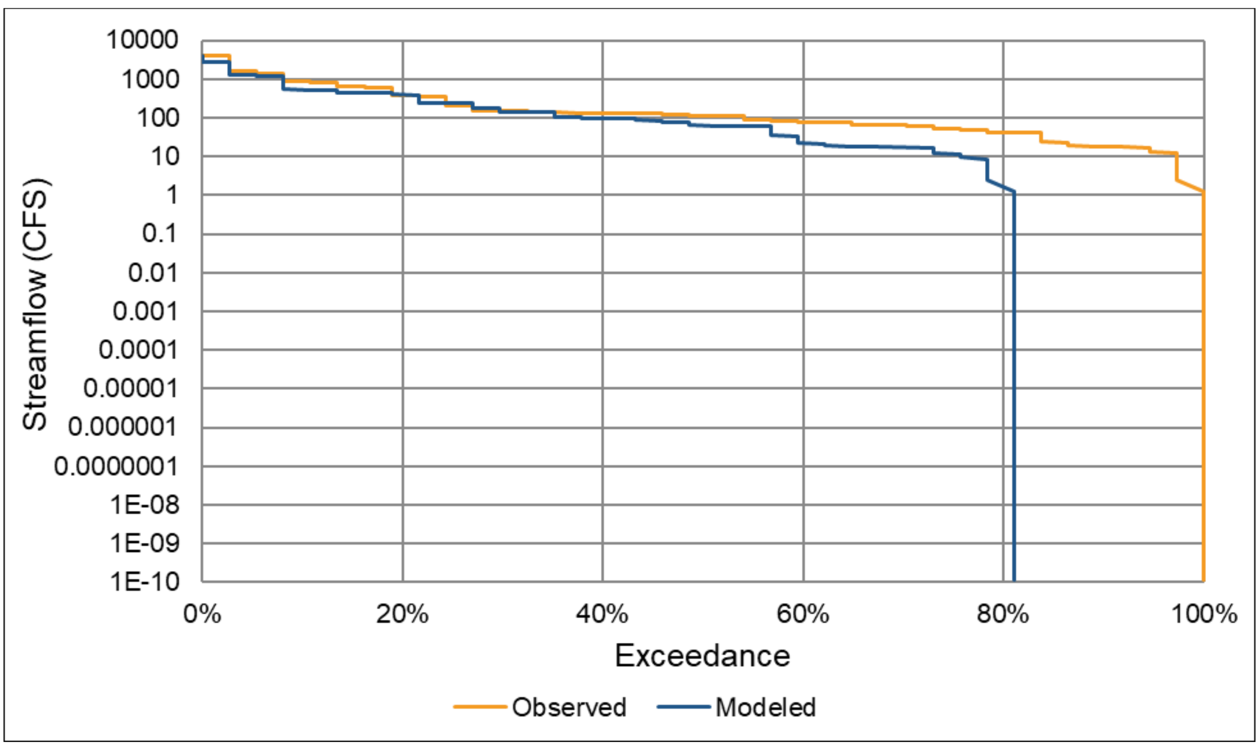


Figure 46g: ESJWRM Stream Calibration Gauges Streamflow – Stanislaus River below Orange Blossom Bridge

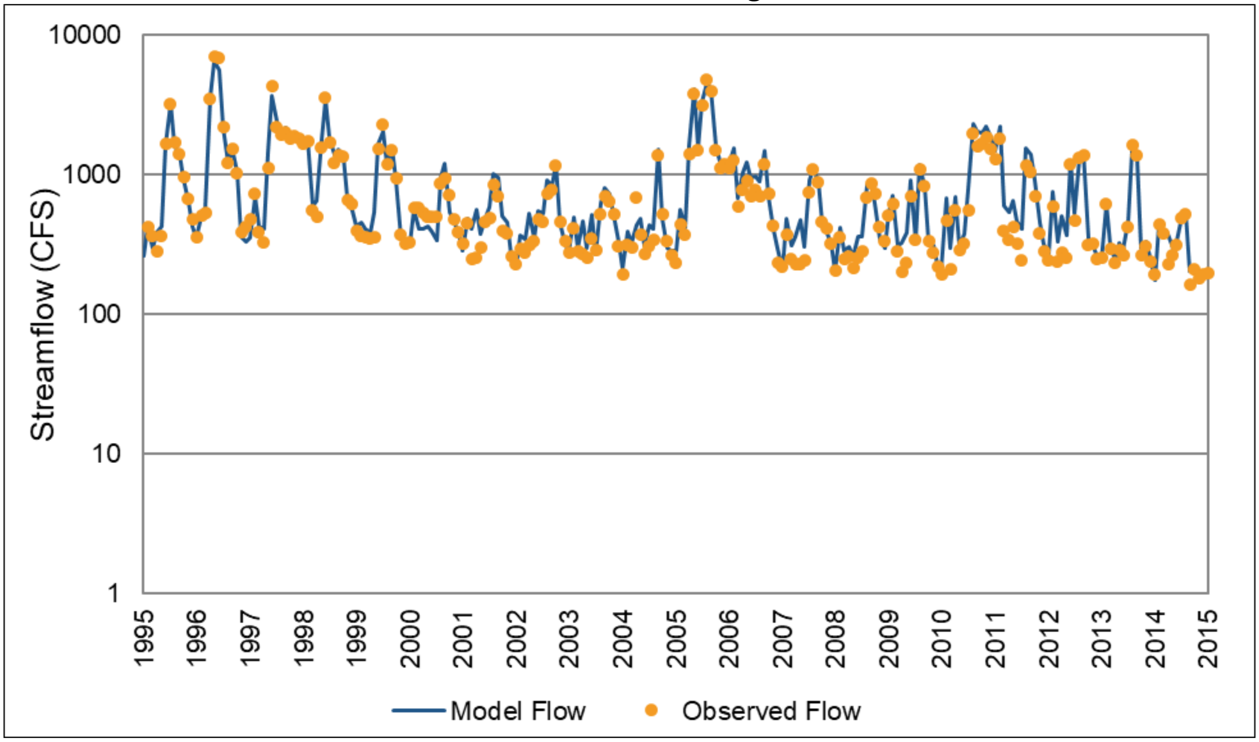


Figure 46h: ESJWRM Stream Calibration Gauges Exceedance – Stanislaus River below Orange Blossom Bridge

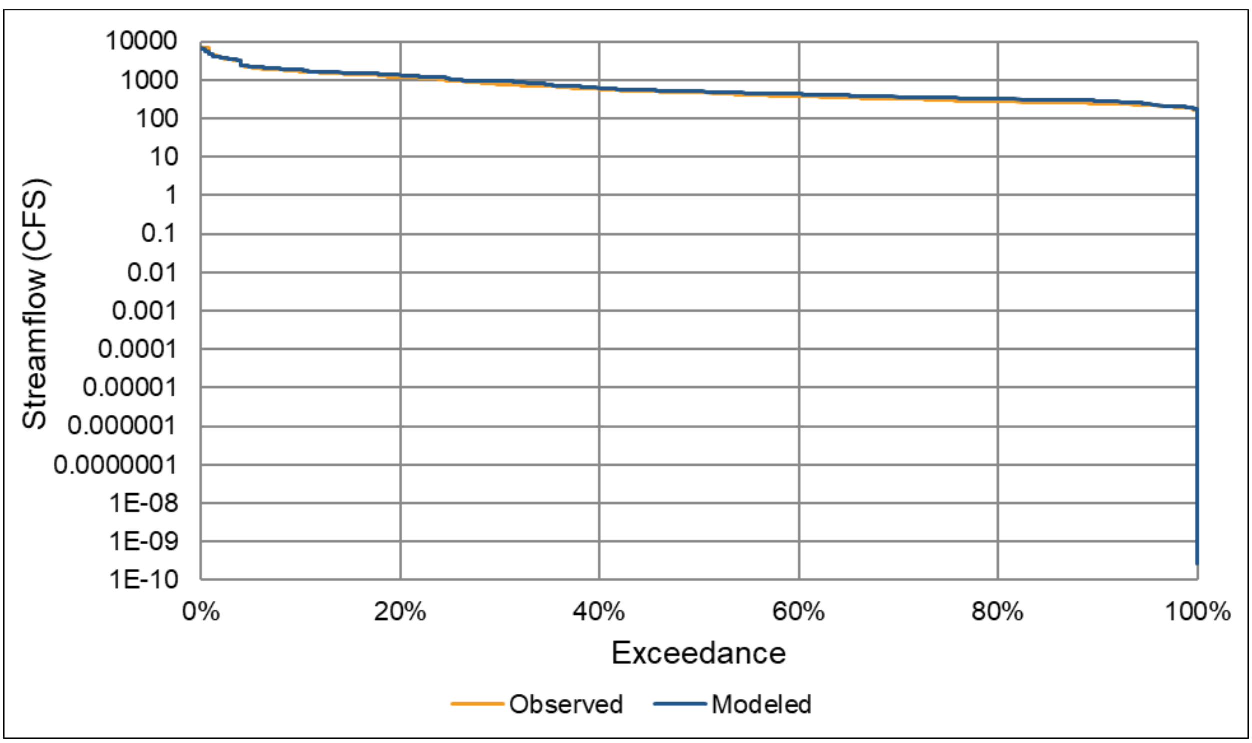


Figure 46i: ESJWRM Stream Calibration Gauges Streamflow – San Joaquin River below Garwood Bridge at Stockton

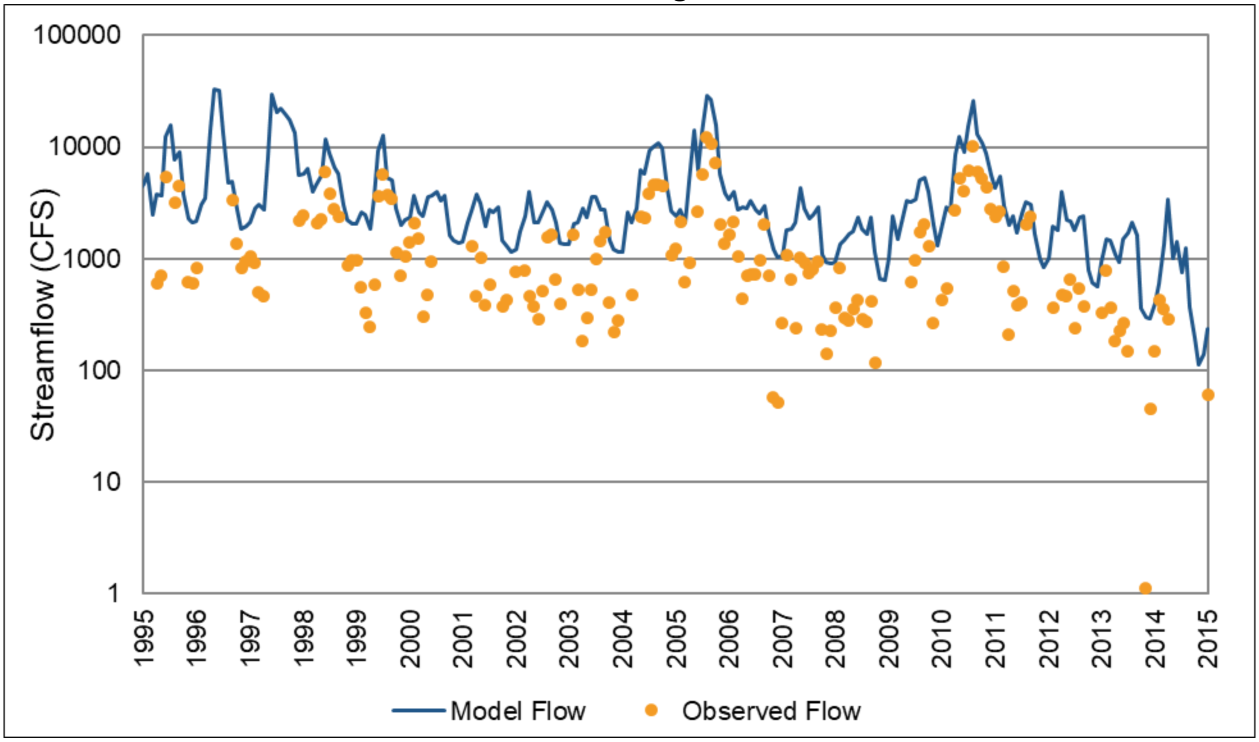


Figure 46j: ESJWRM Stream Calibration Gauges Exceedance – San Joaquin River below Garwood Bridge at Stockton

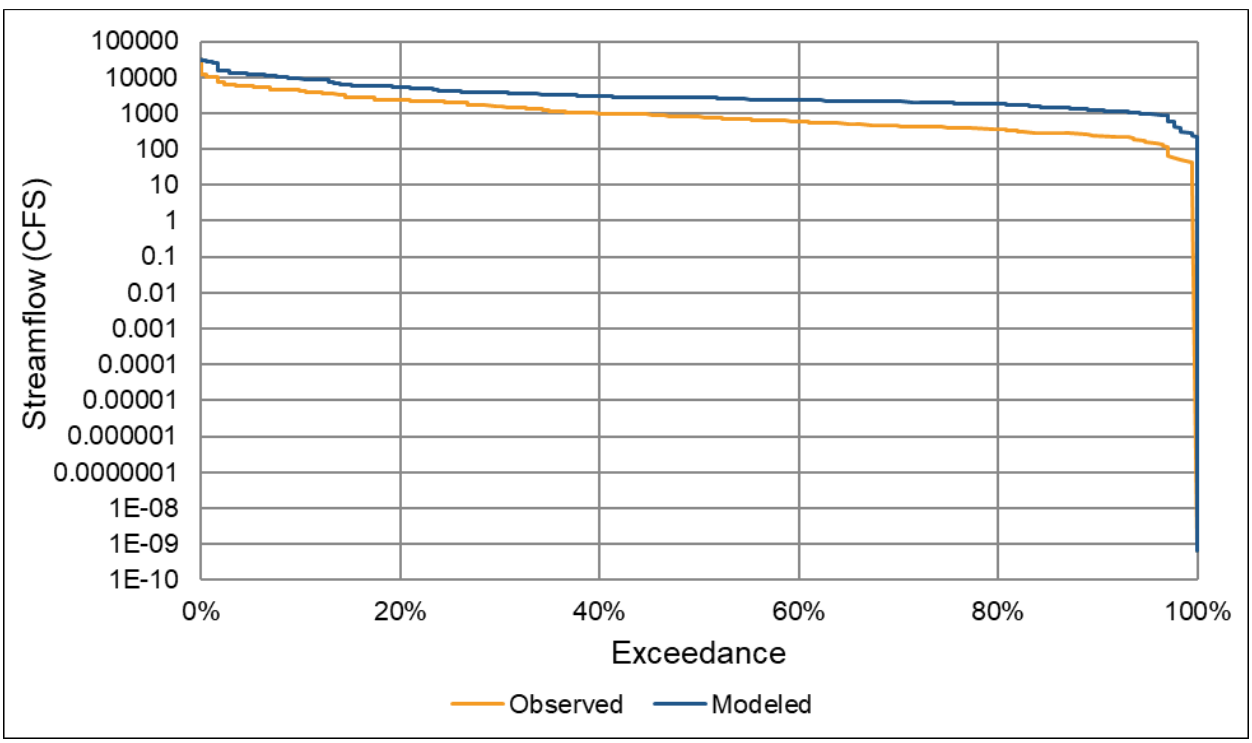


Figure 47a: ESJWRM Agricultural Land and Water Use Budget – Eastern San Joaquin Subbasin

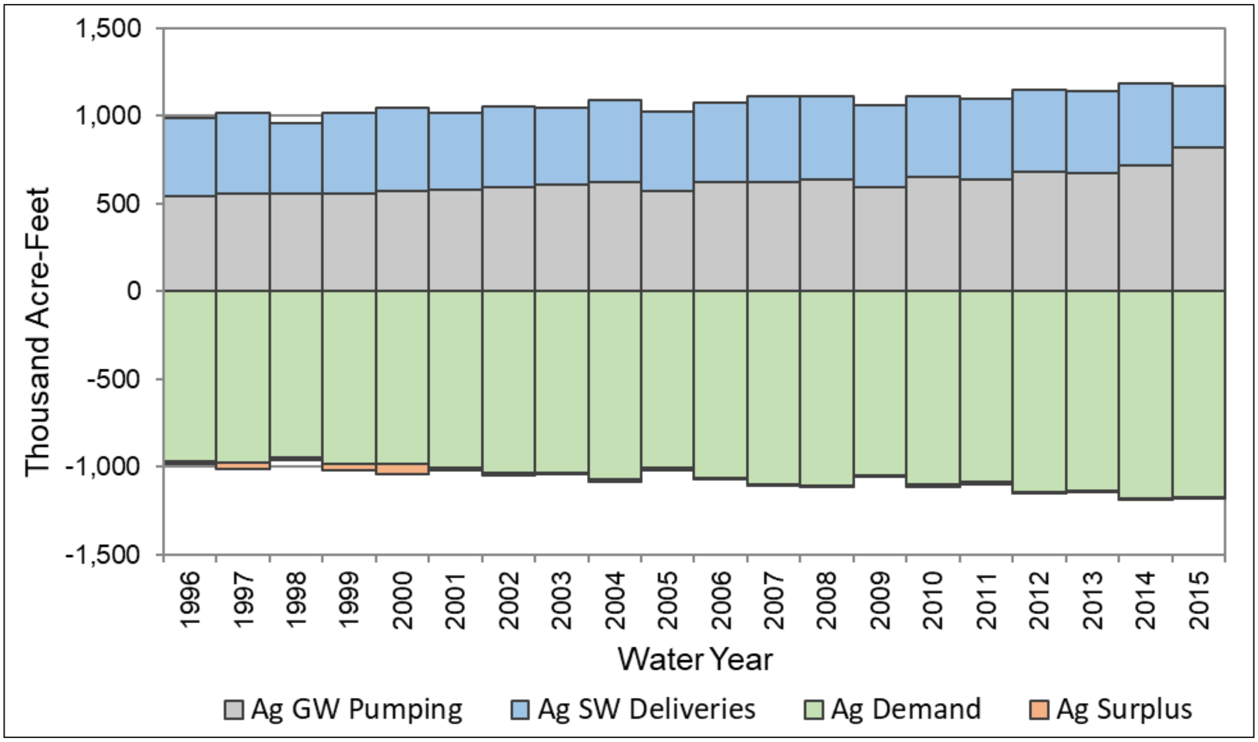


Figure 47b: ESJWRM Agricultural Land and Water Use Budget – Subarea 1 (North Delta Subarea)

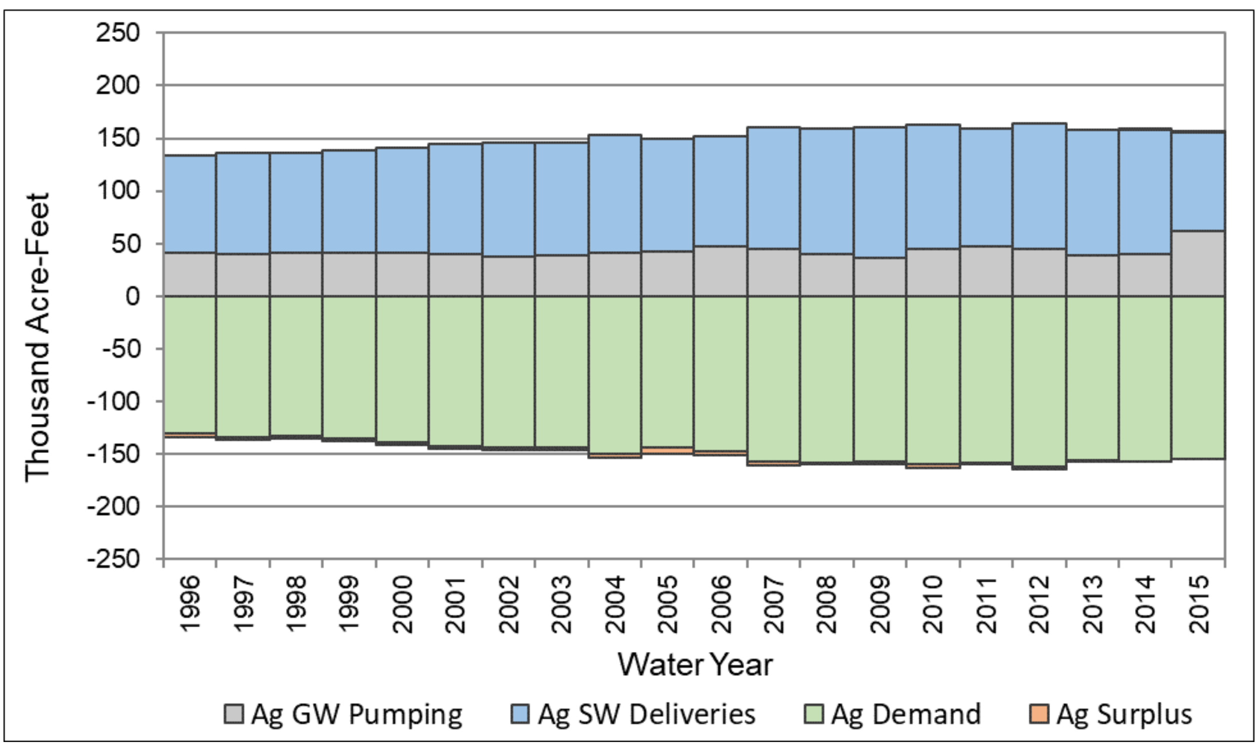


Figure 47c: ESJWRM Agricultural Land and Water Use Budget – Subarea 2 (North Subarea)

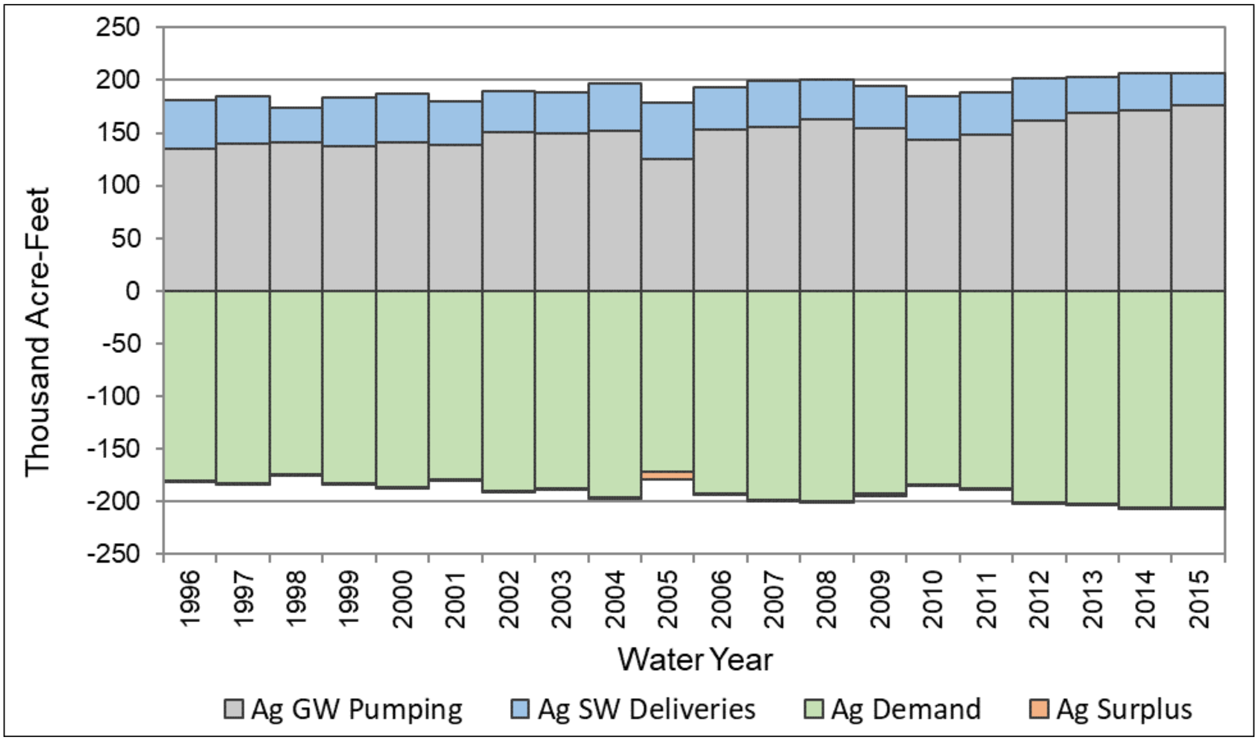


Figure 47d: ESJWRM Agricultural Land and Water Use Budget – Subarea 3 (Calaveras Subarea)

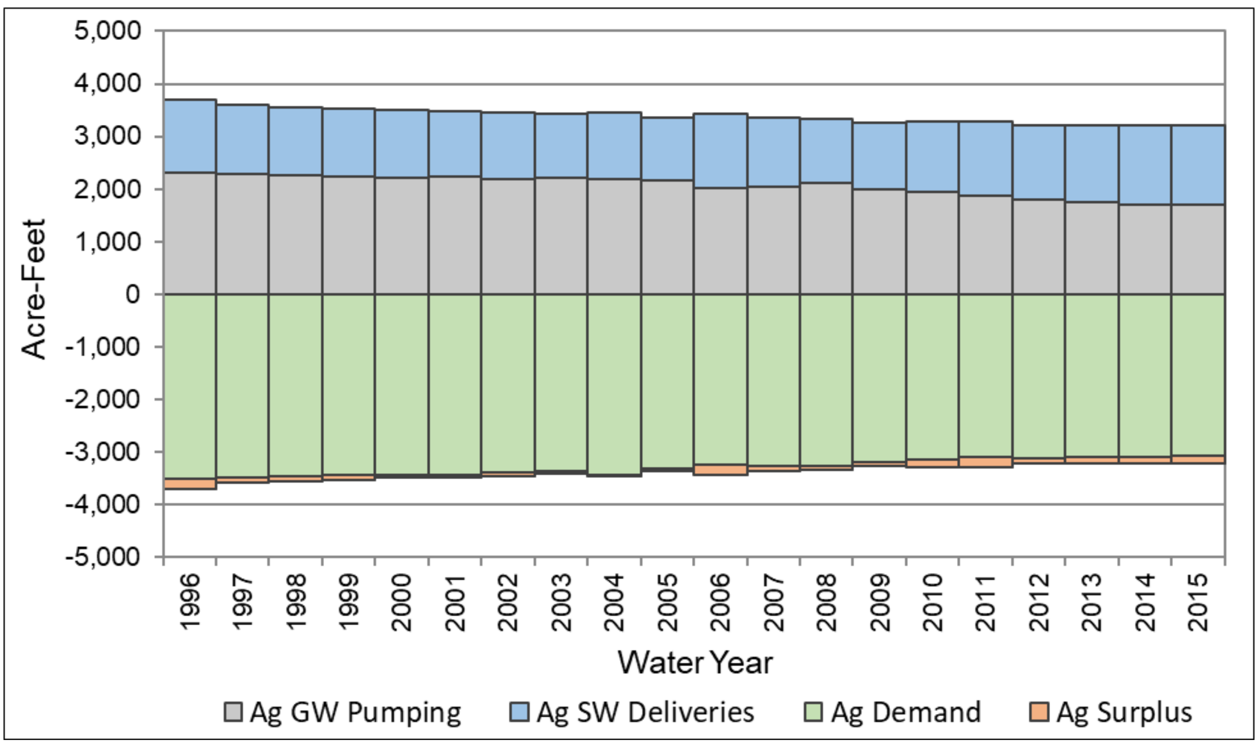


Figure 47e: ESJWRM Agricultural Land and Water Use Budget – Subarea 4 (Central Subarea)

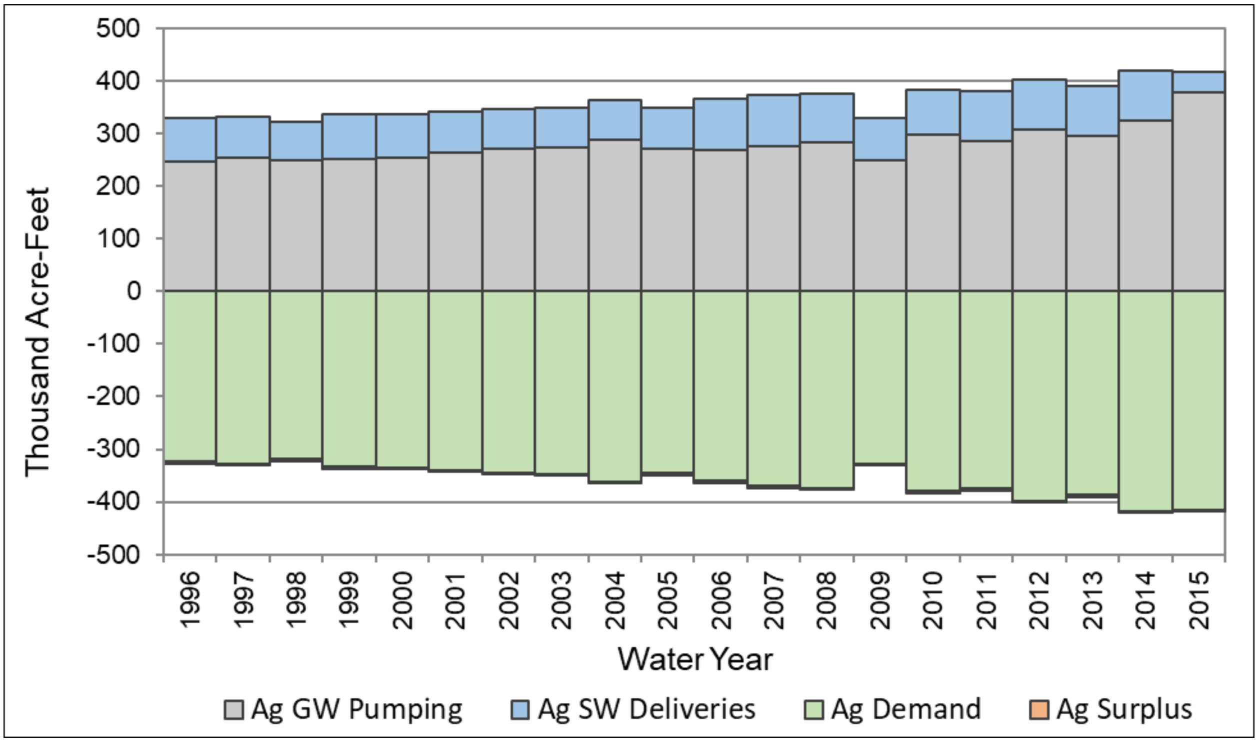


Figure 47f: ESJWRM Agricultural Land and Water Use Budget – Subarea 5 (South Subarea)

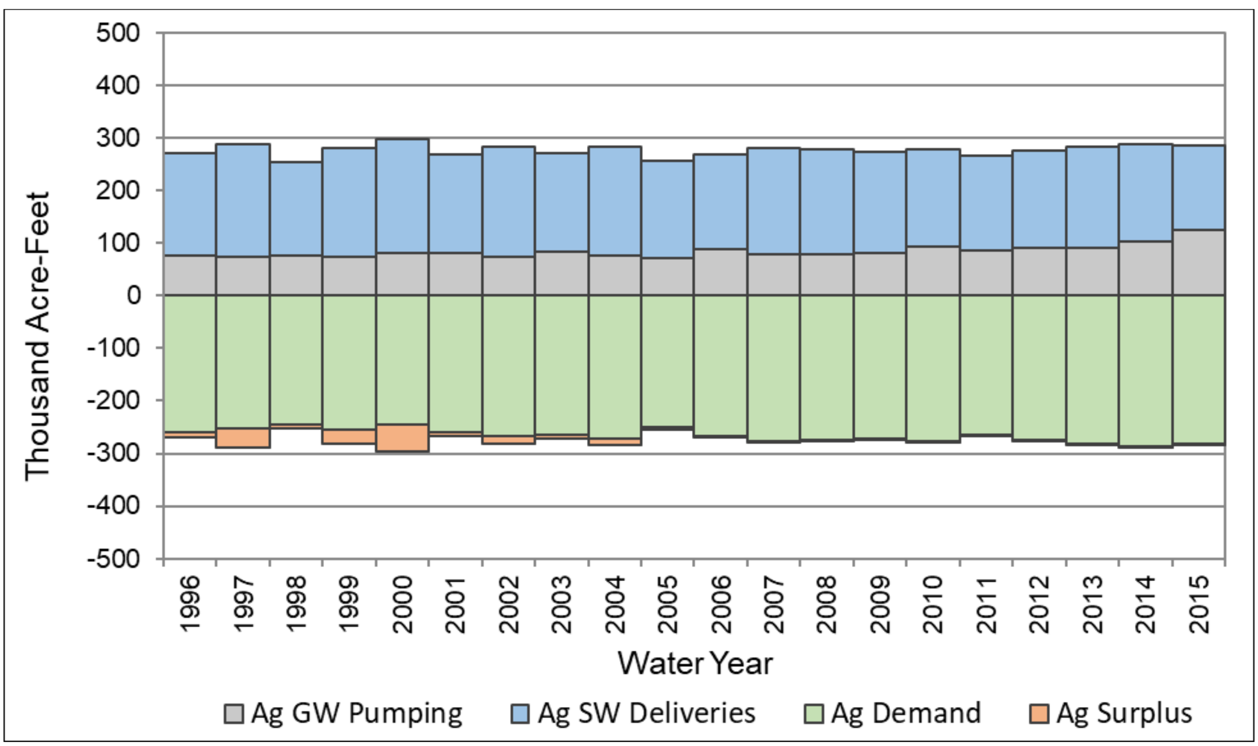


Figure 47g: ESJWRM Agricultural Land and Water Use Budget – Subarea 6 (Stanislaus Subarea)

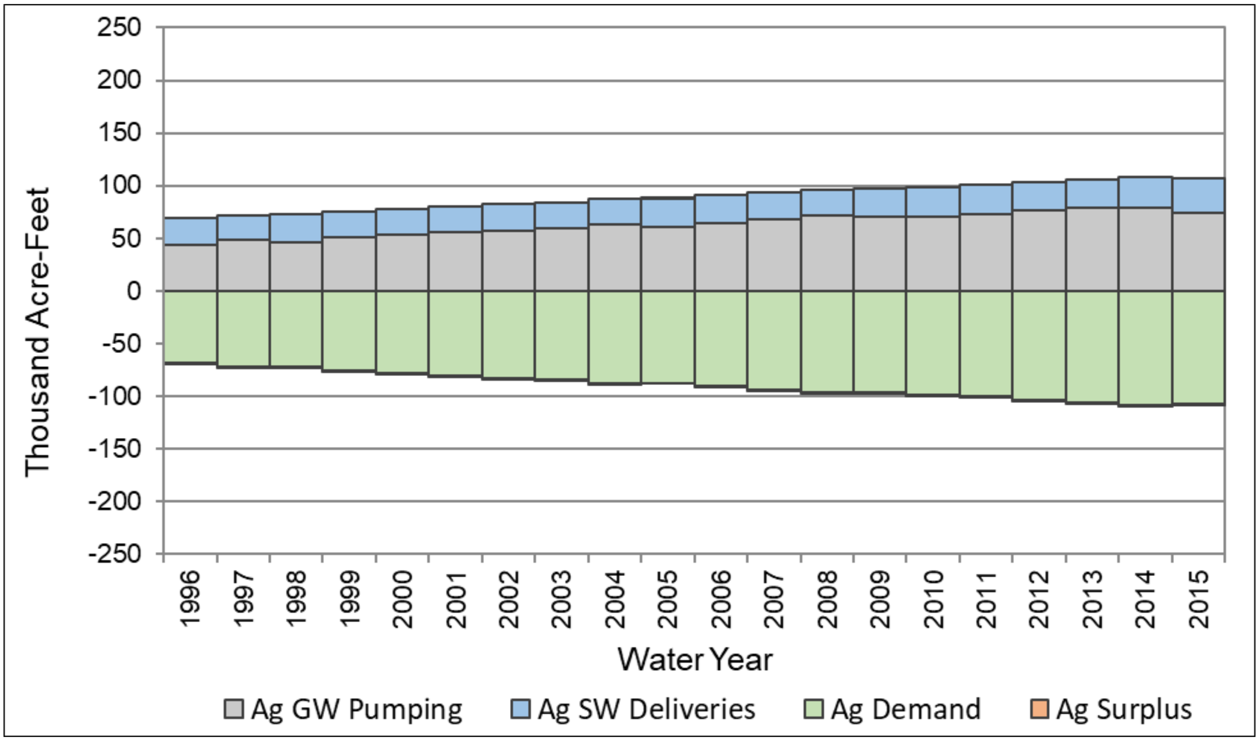


Figure 48a: ESJWRM Urban Land and Water Use Budget – Eastern San Joaquin Subbasin

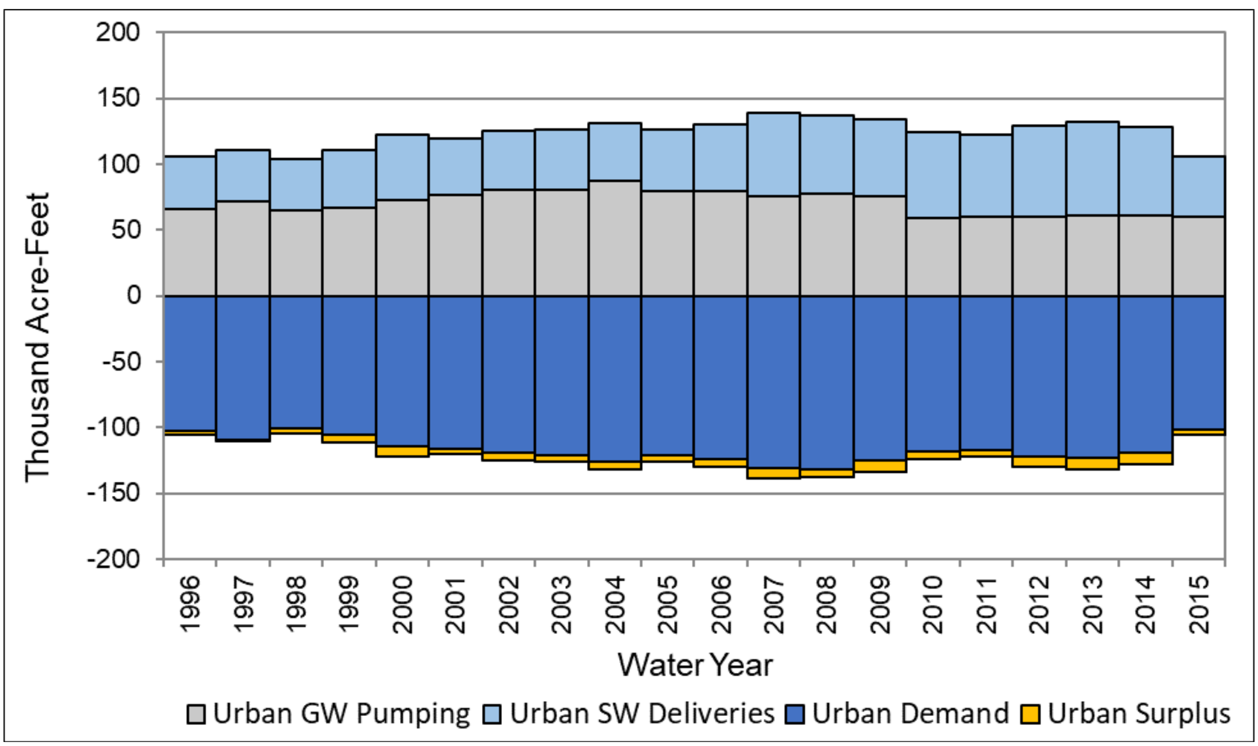


Figure 48b: ESJWRM Urban Land and Water Use Budget – Subarea 1 (North Delta Subarea)

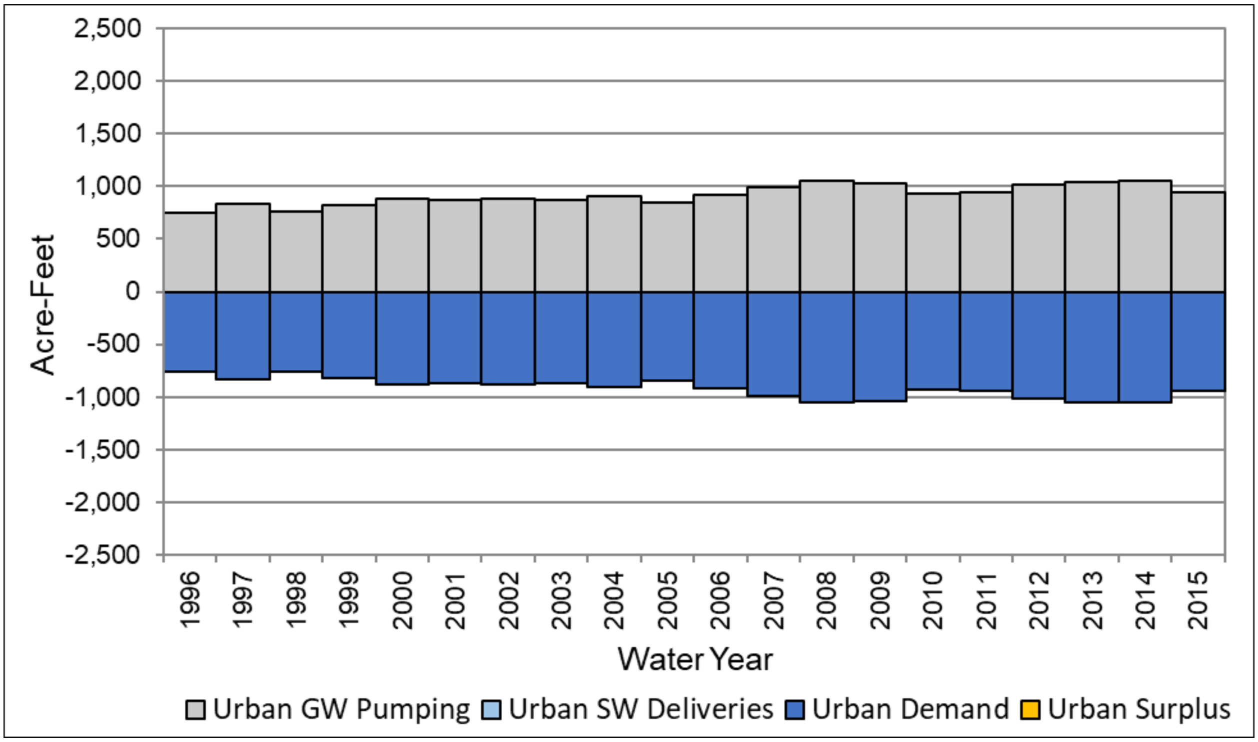


Figure 48c: ESJWRM Urban Land and Water Use Budget – Subarea 2 (North Subarea)

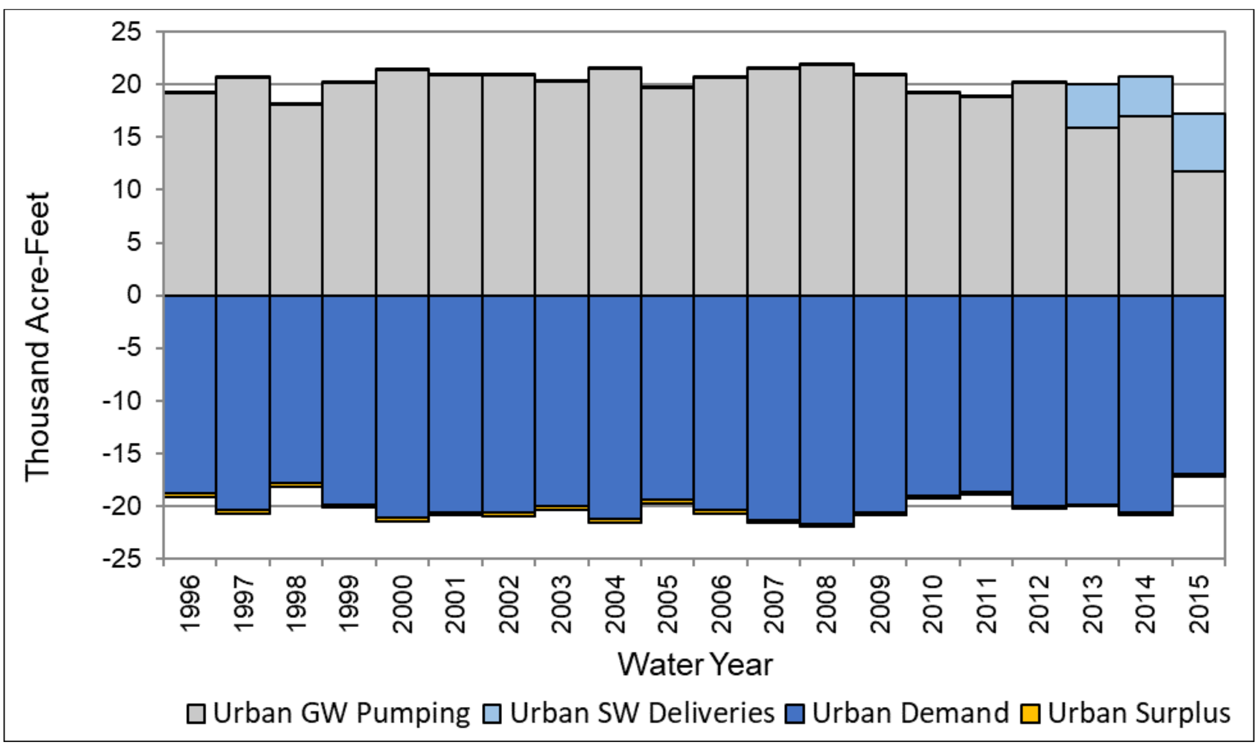


Figure 48d: ESJWRM Urban Land and Water Use Budget – Subarea 3 (Calaveras Subarea)

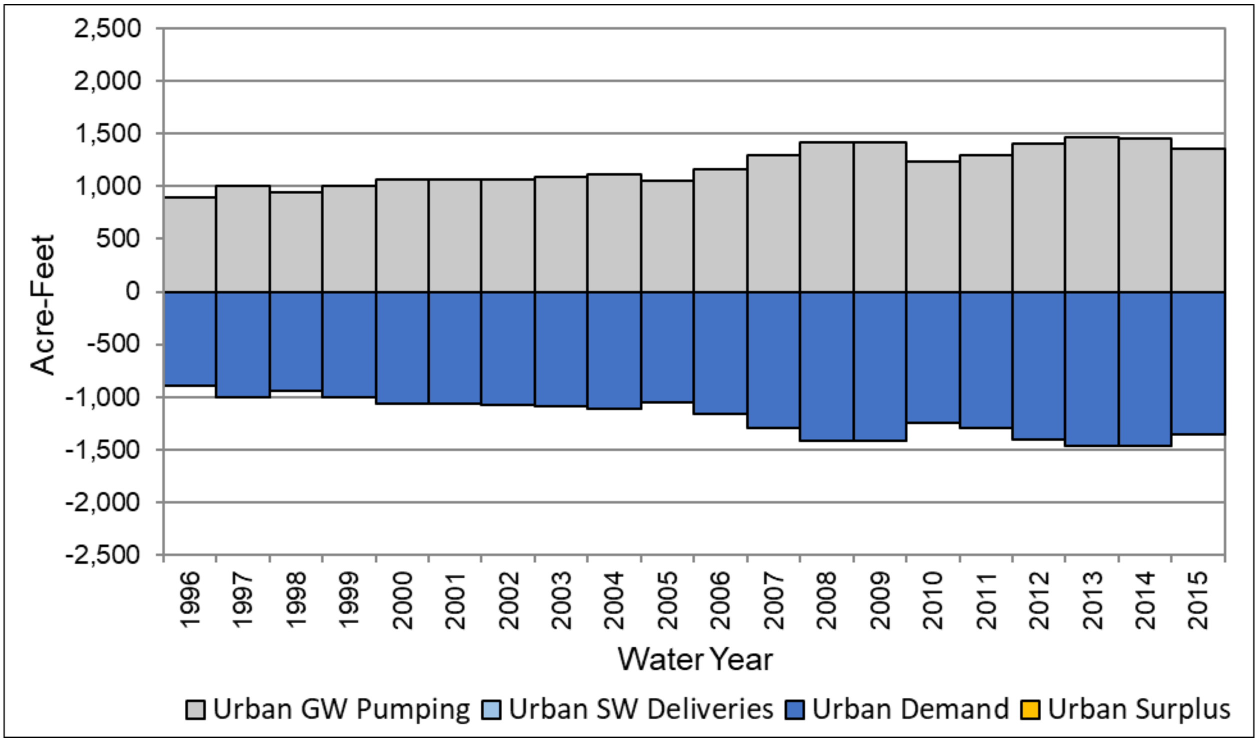


Figure 48e: ESJWRM Urban Land and Water Use Budget – Subarea 4 (Central Subarea)

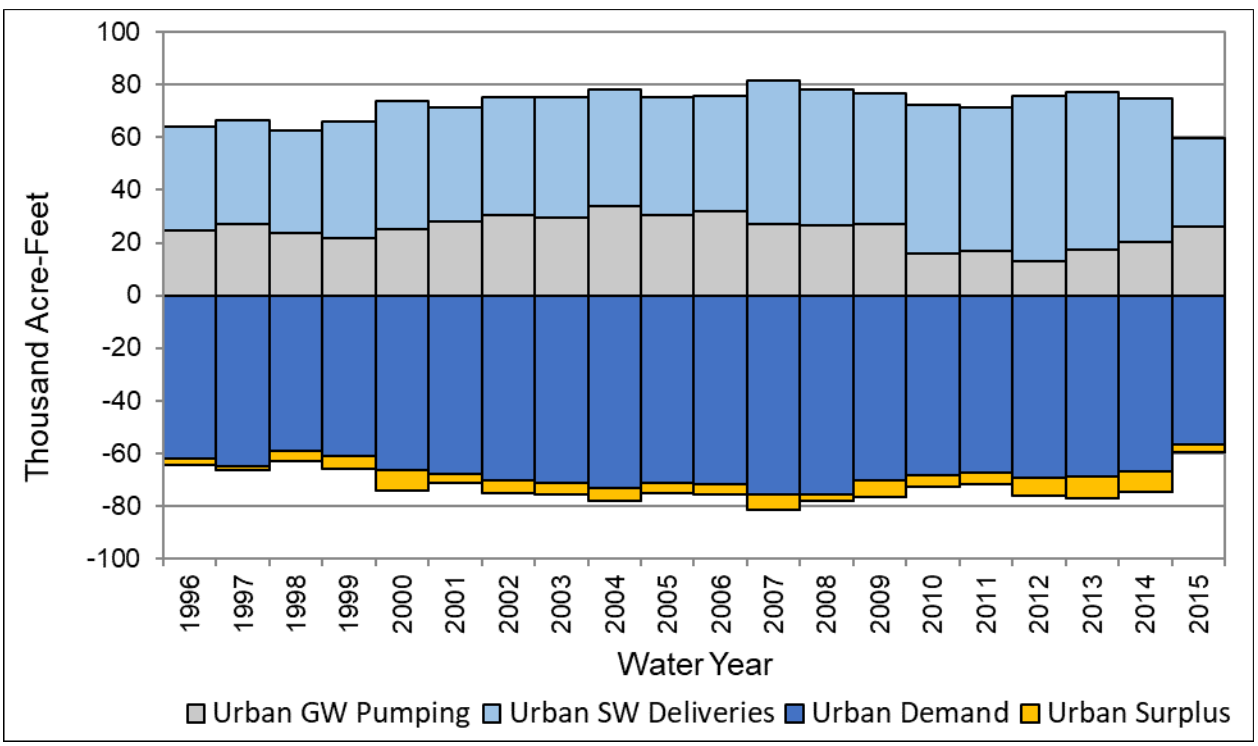


Figure 48f: ESJWRM Urban Land and Water Use Budget – Subarea 5 (South Subarea)

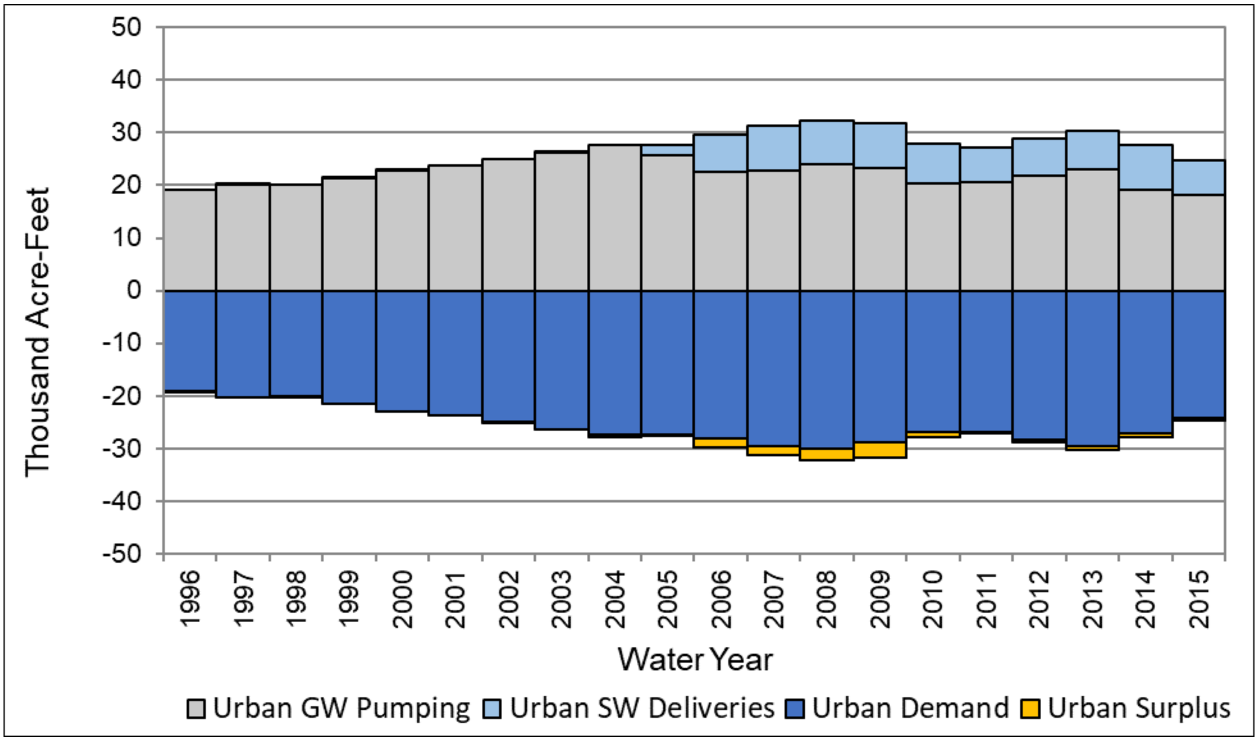


Figure 48g: ESJWRM Urban Land and Water Use Budget – Subarea 6 (Stanislaus Subarea)

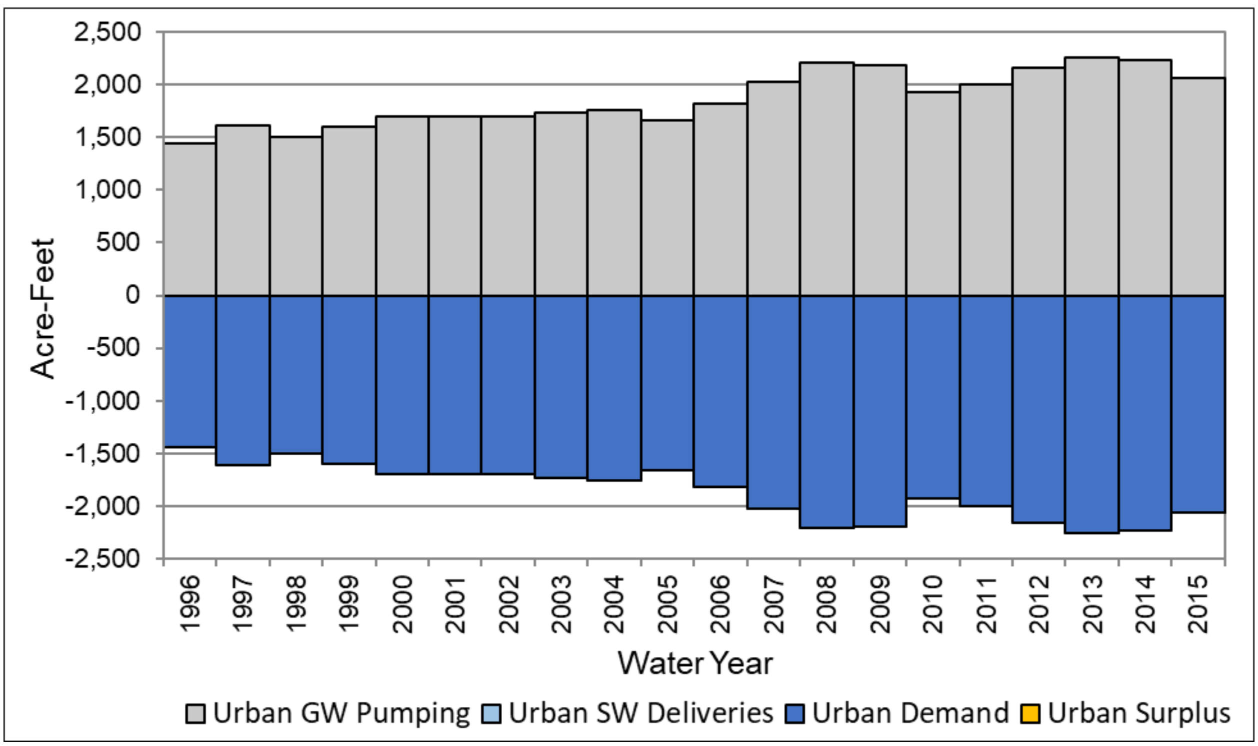


Figure 49a: ESJWRM Groundwater Budget – Eastern San Joaquin Subbasin

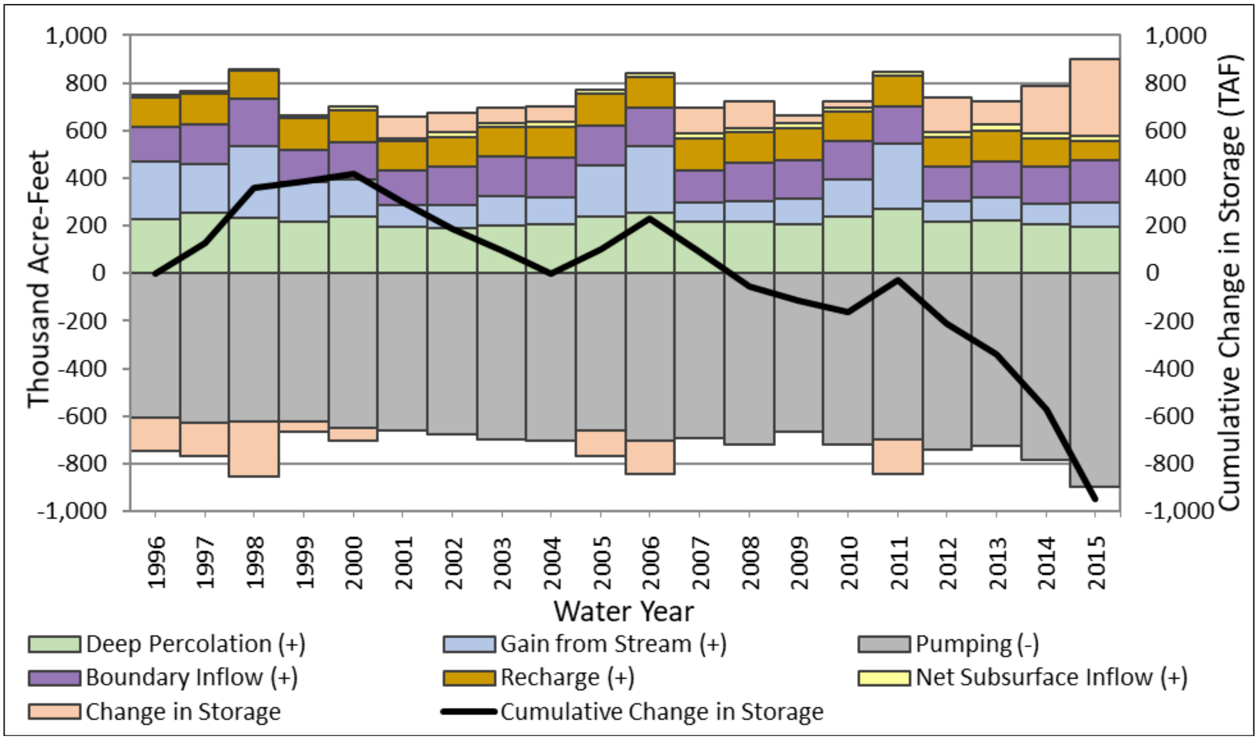


Figure 49b: ESJWRM Groundwater Budget – Subarea 1 (North Delta Subarea)

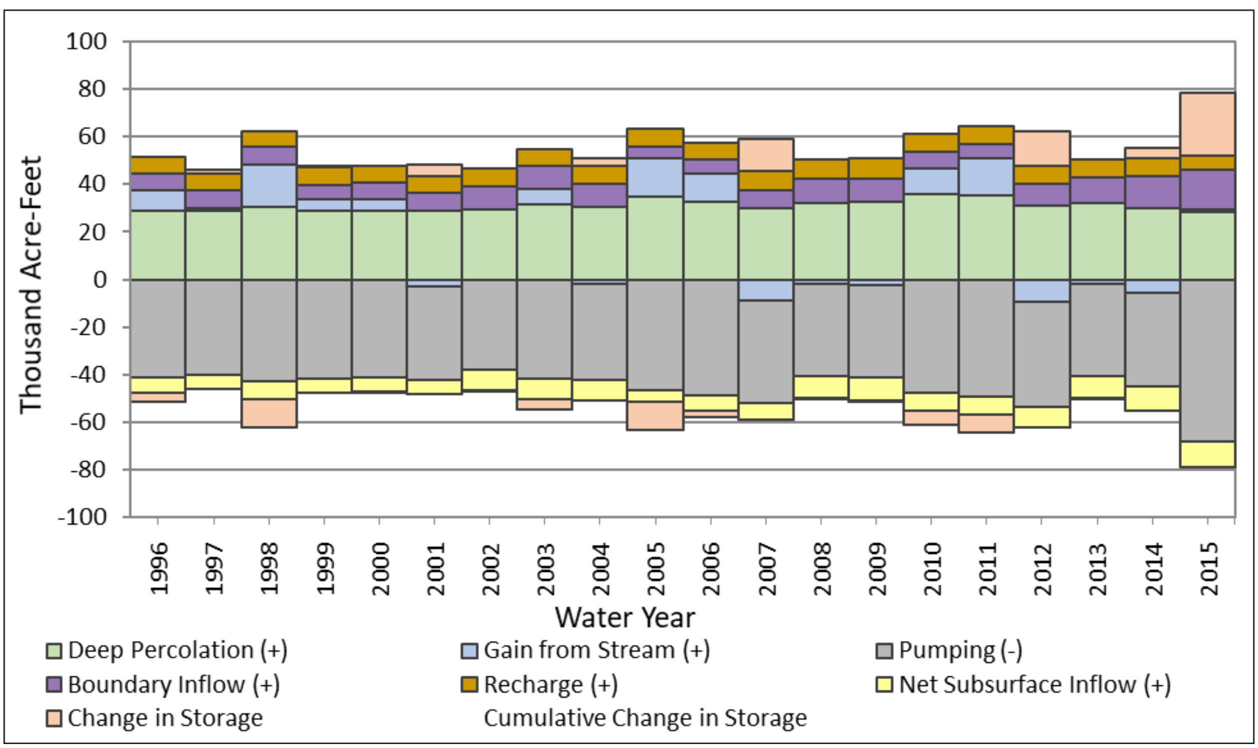


Figure 49c: ESJWRM Groundwater Budget – Subarea 2 (North Subarea)

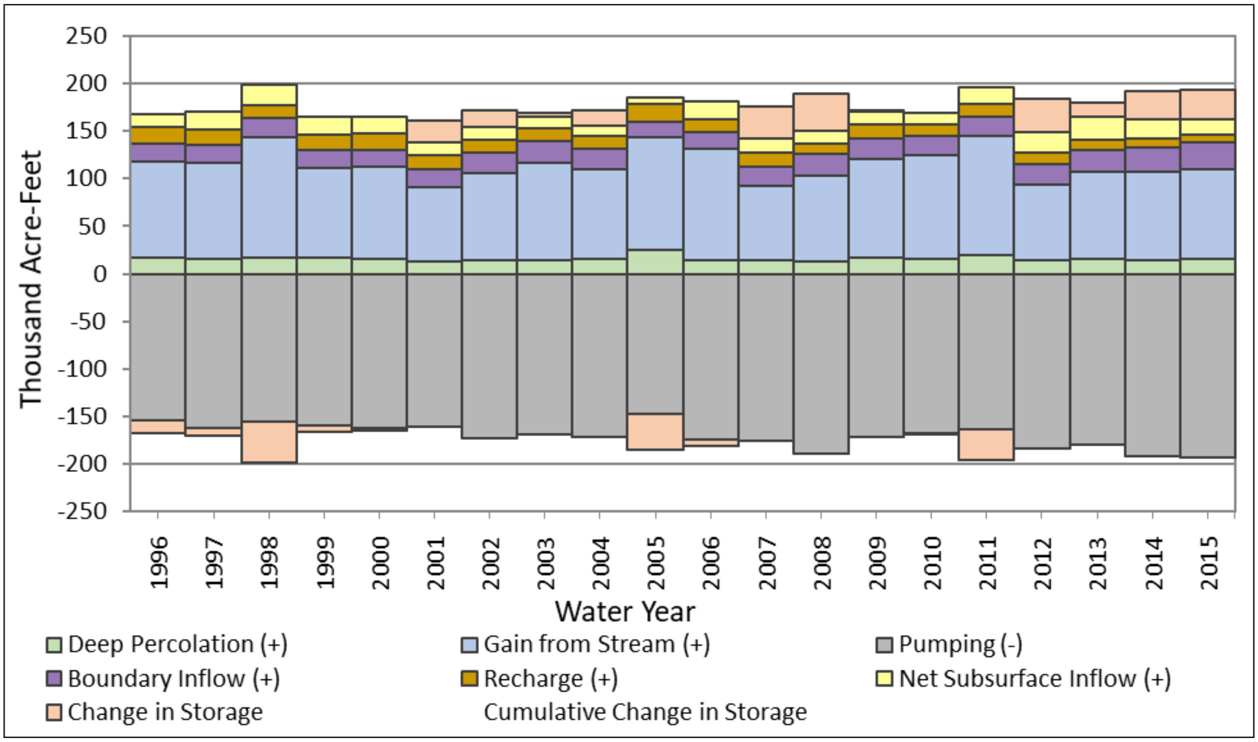


Figure 49d: ESJWRM Groundwater Budget – Subarea 3 (Calaveras Subarea)

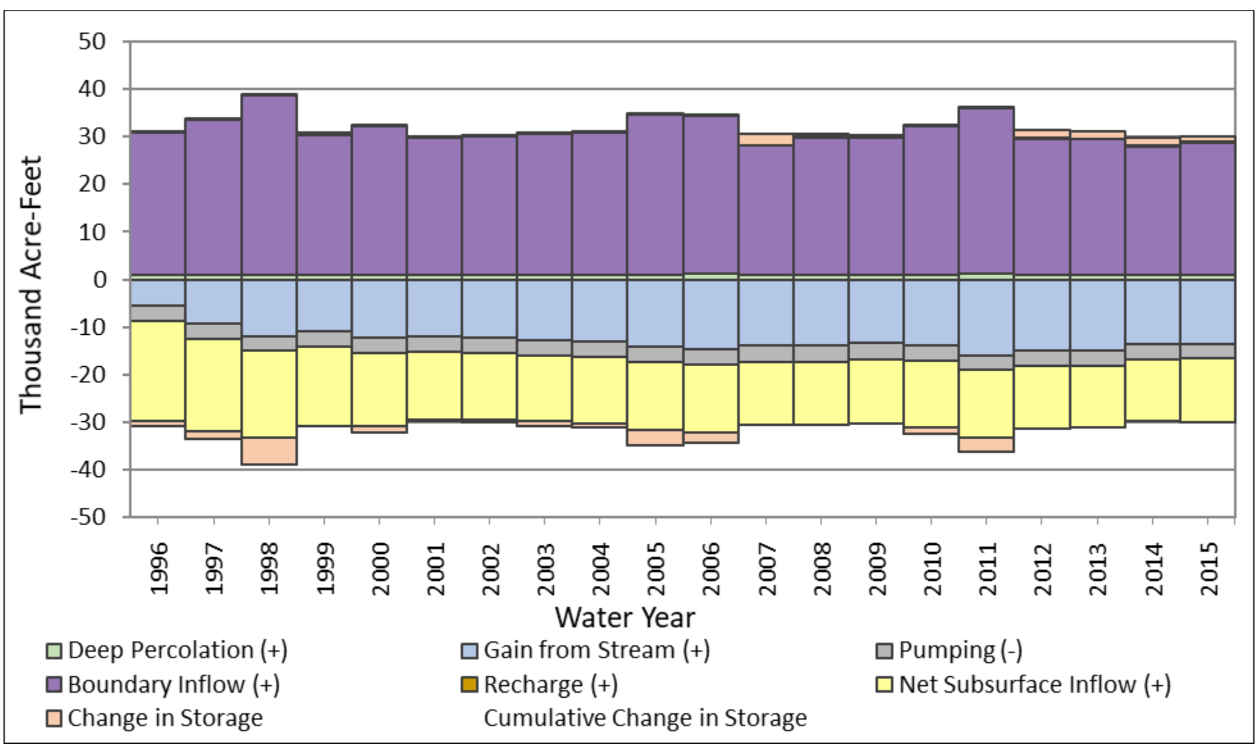


Figure 49e: ESJWRM Groundwater Budget – Subarea 4 (Central Subarea)

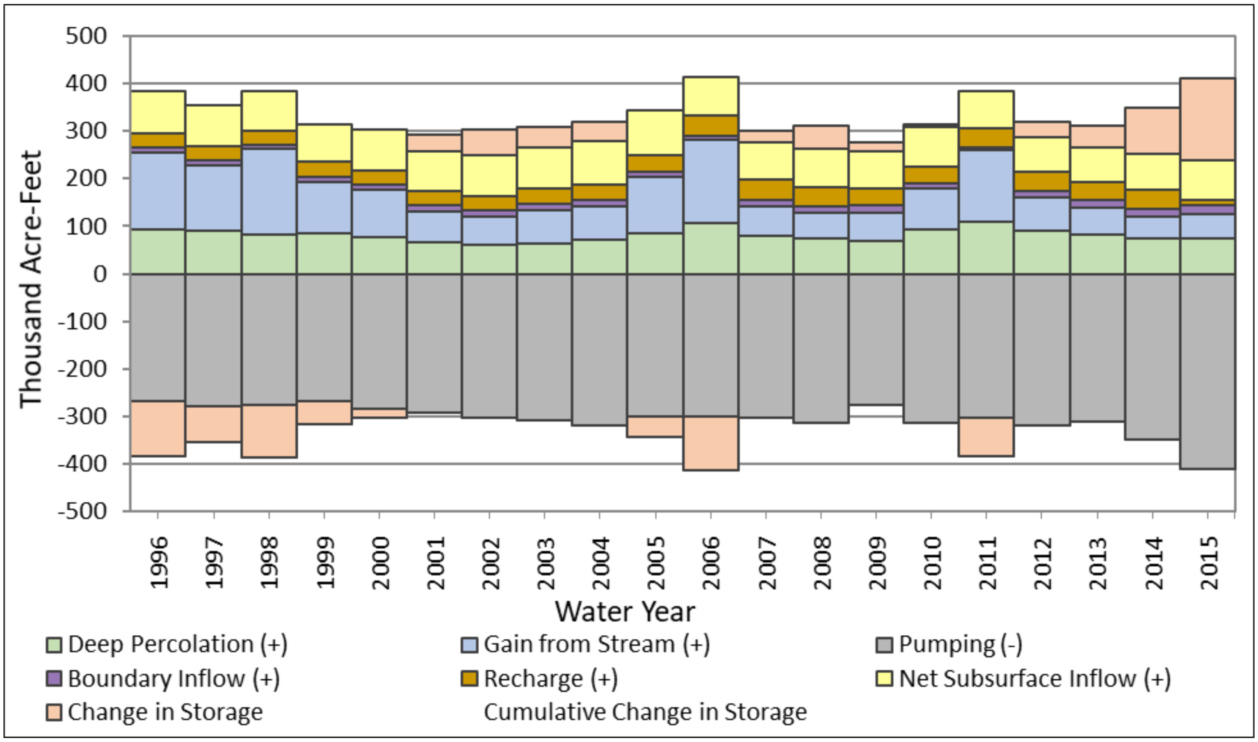


Figure 49f: ESJWRM Groundwater Budget – Subarea 5 (South Subarea)

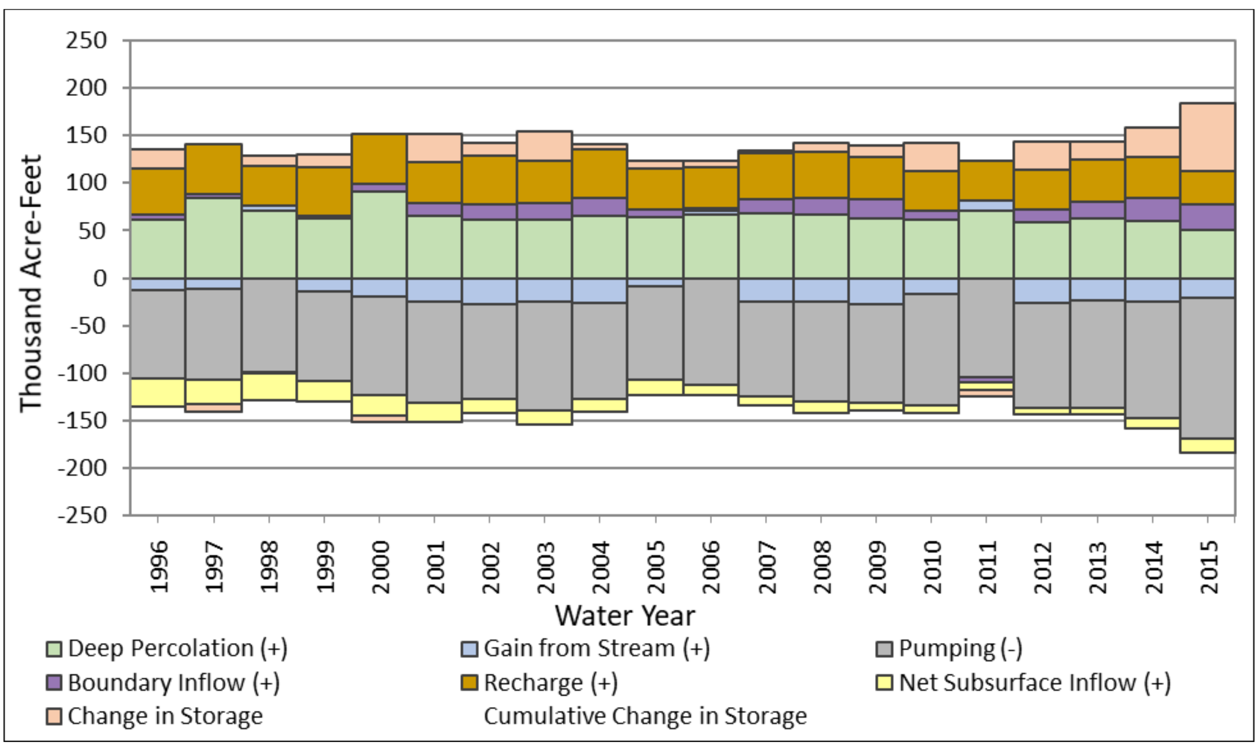


Figure 49g: ESJWRM Groundwater Budget – Subarea 6 (Stanislaus Subarea)

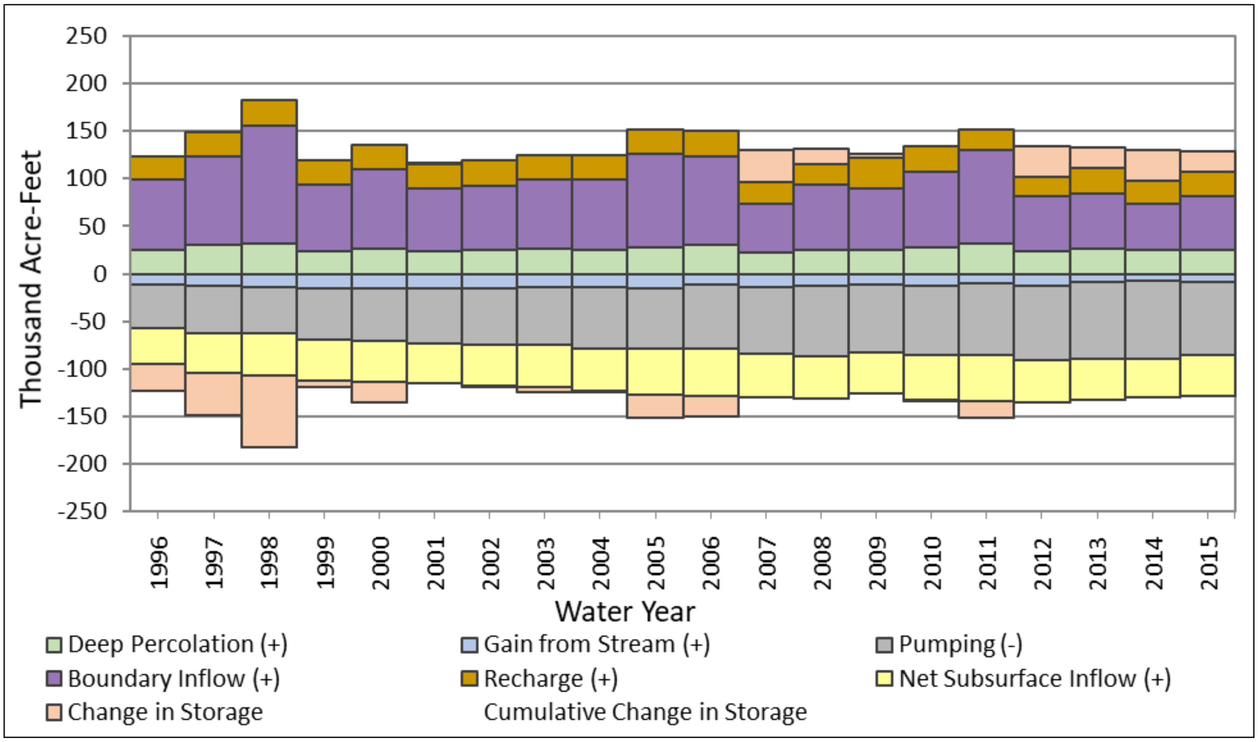


Figure 50: ESJWRM Groundwater Level Calibration Wells

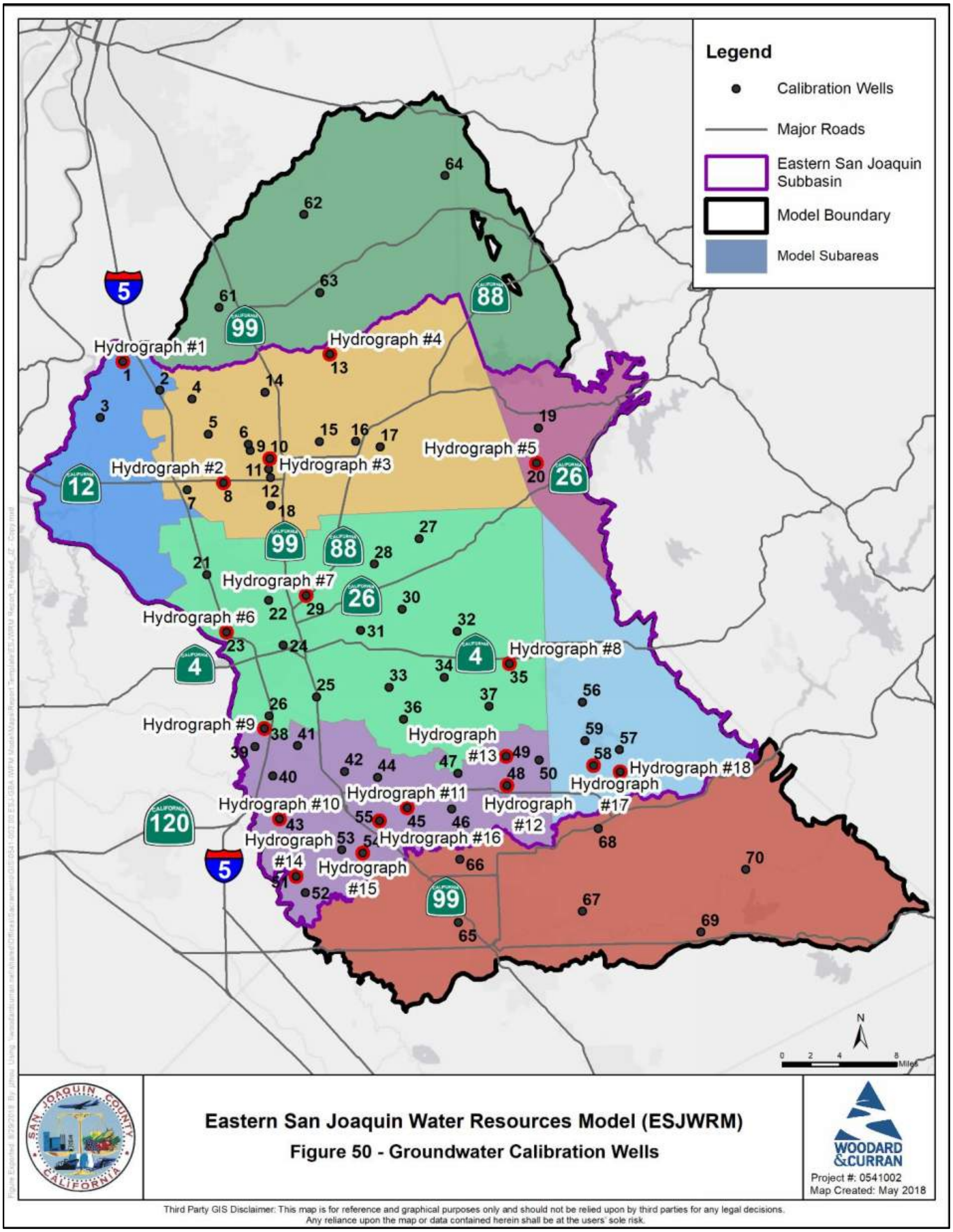


Figure 51a: ESJWRM Groundwater Level Contours (Fall 2015)

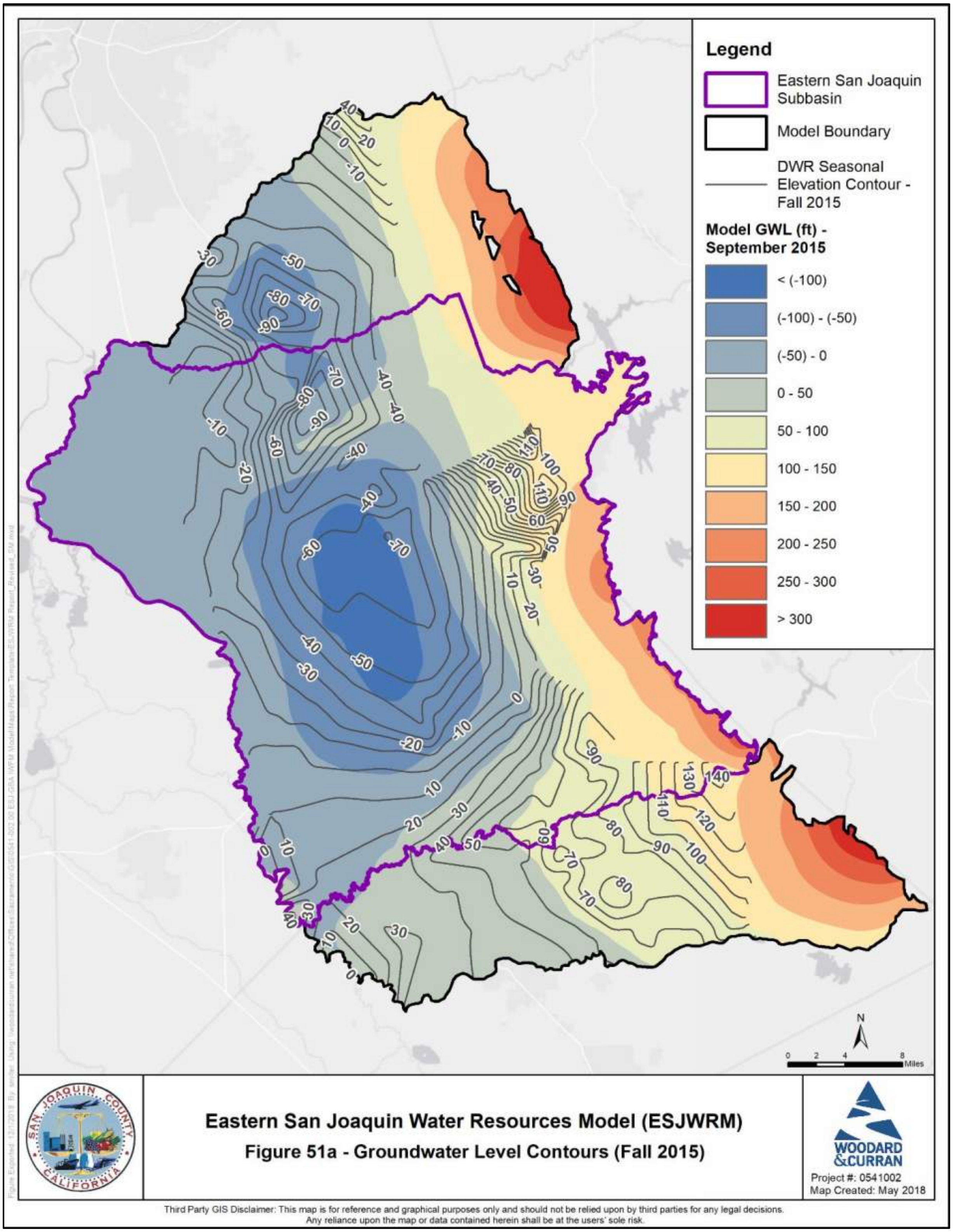


Figure 51b: ESJWRM Groundwater Level Contours (Spring 2015)

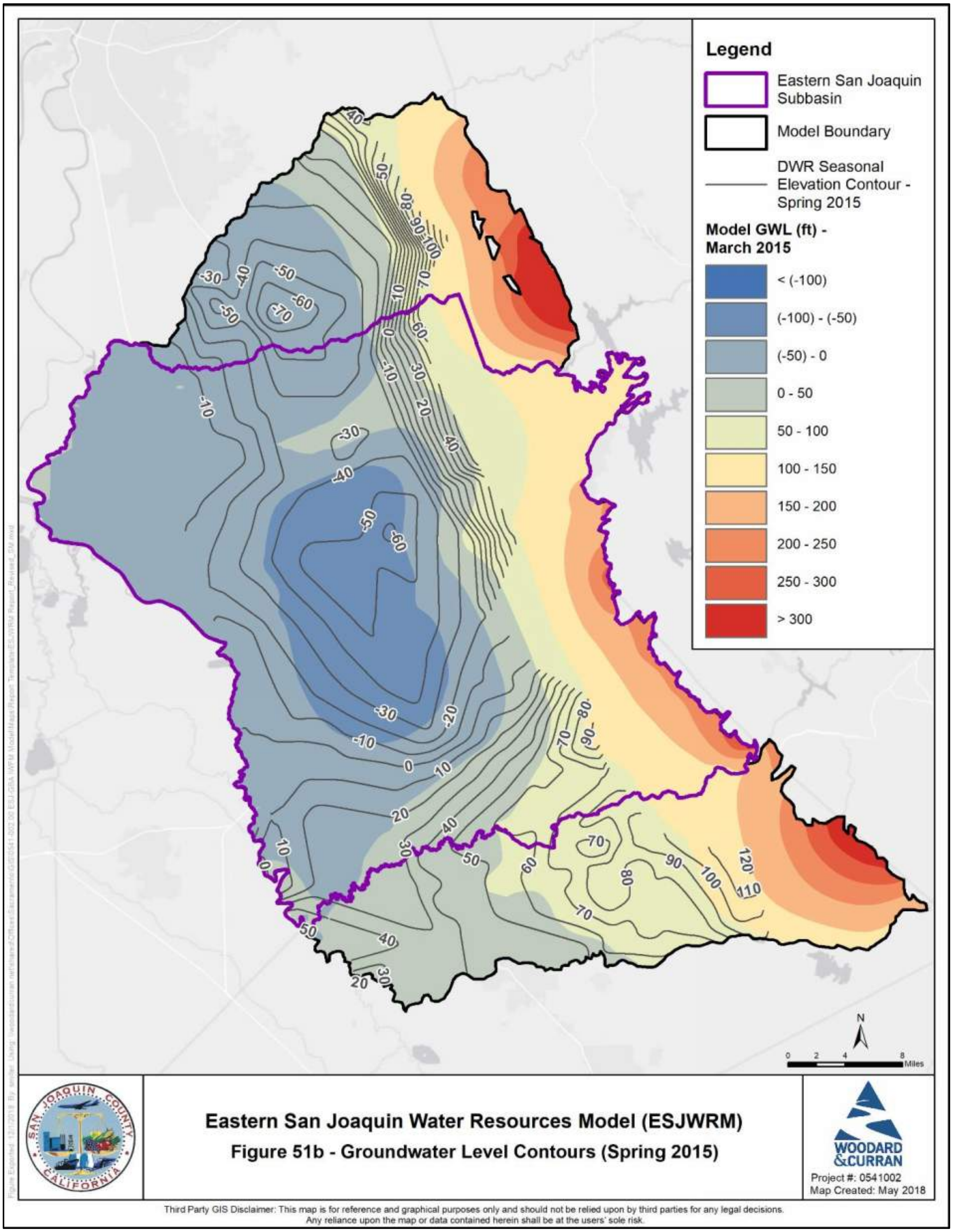


Figure 51c: ESJWRM Groundwater Level Contours (Fall 2013)

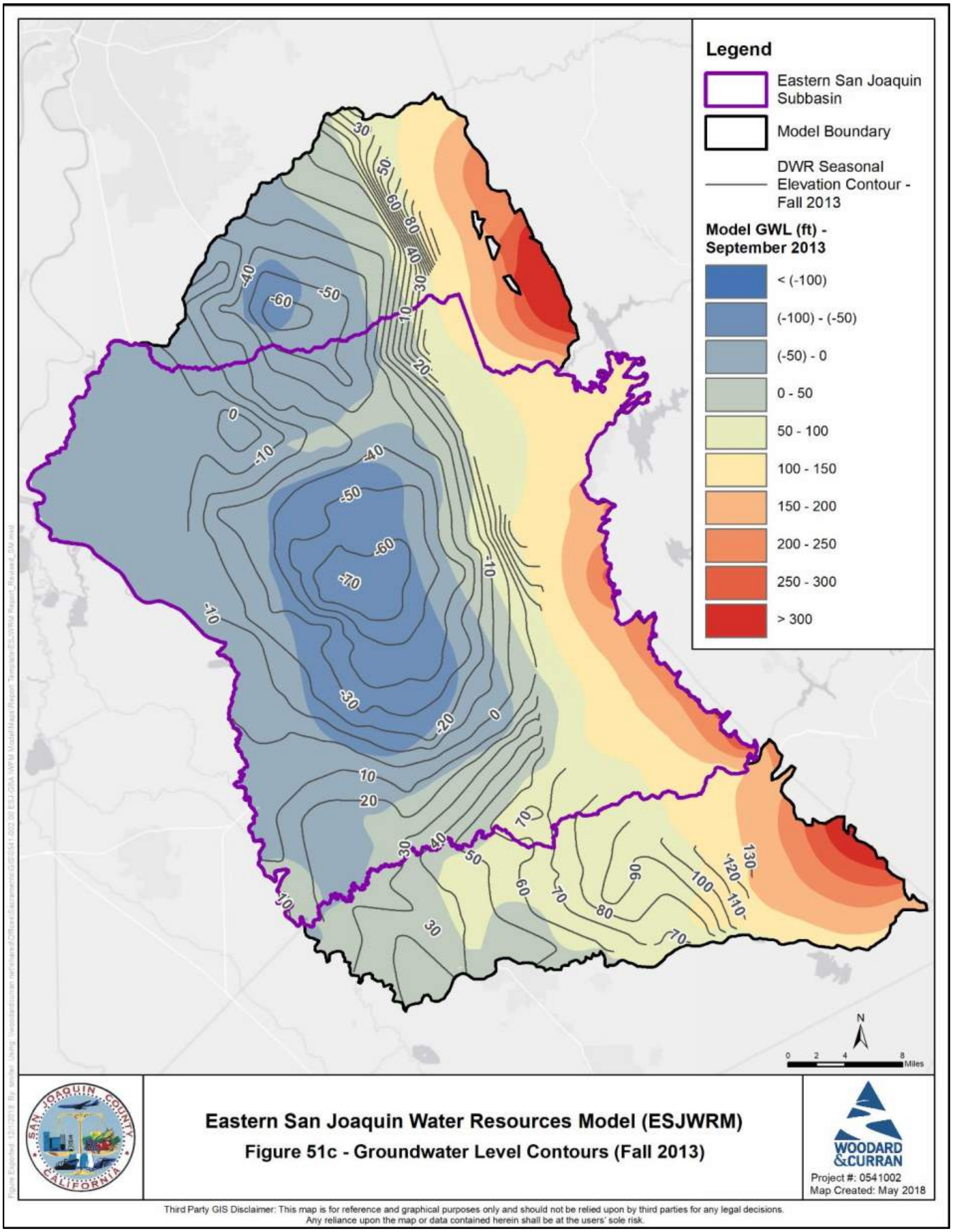


Figure 51d: ESJWRM Groundwater Level Contours (Spring 2011)

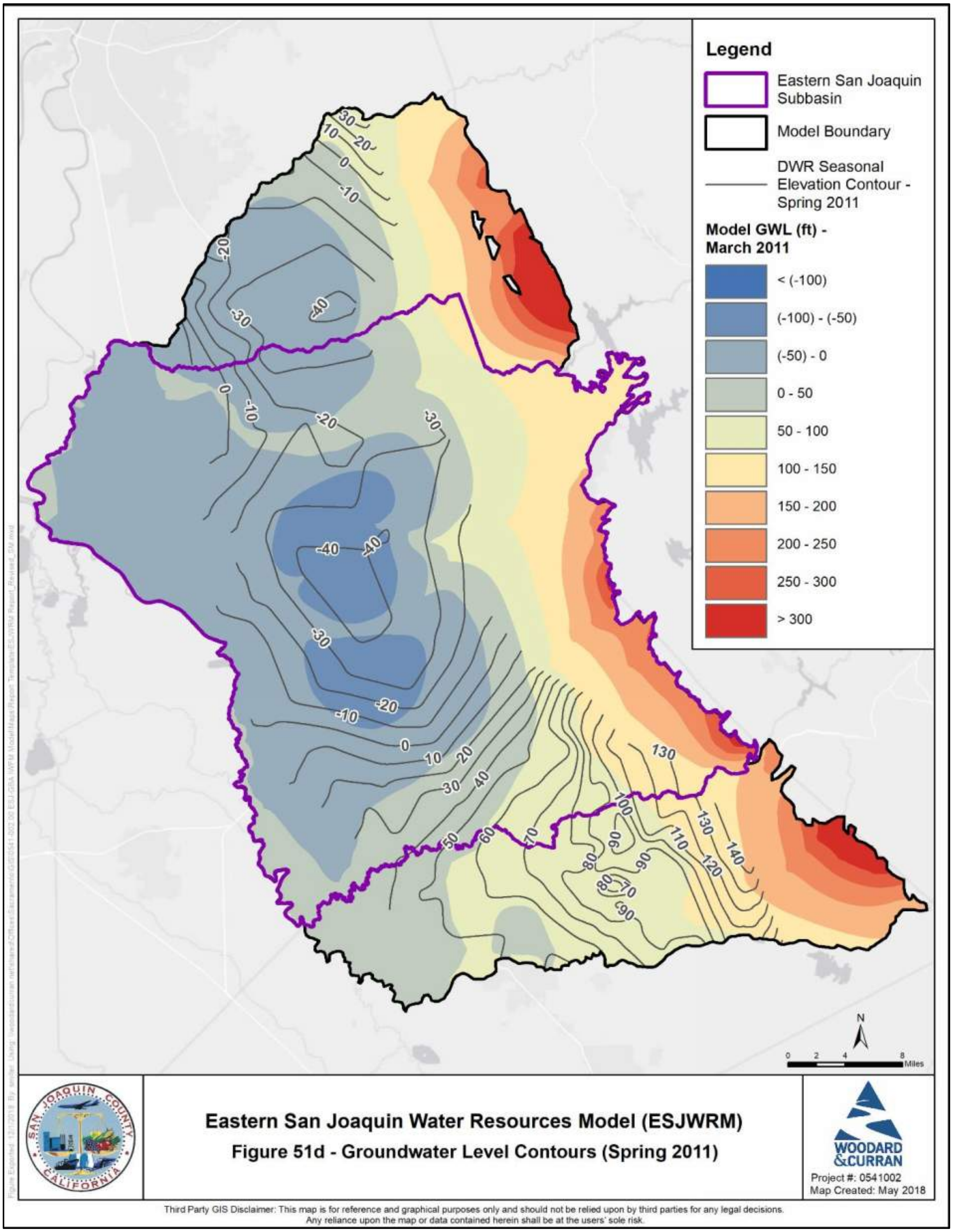


Figure 52a: ESJWRM Groundwater Level Hydrograph – Hydrograph #1

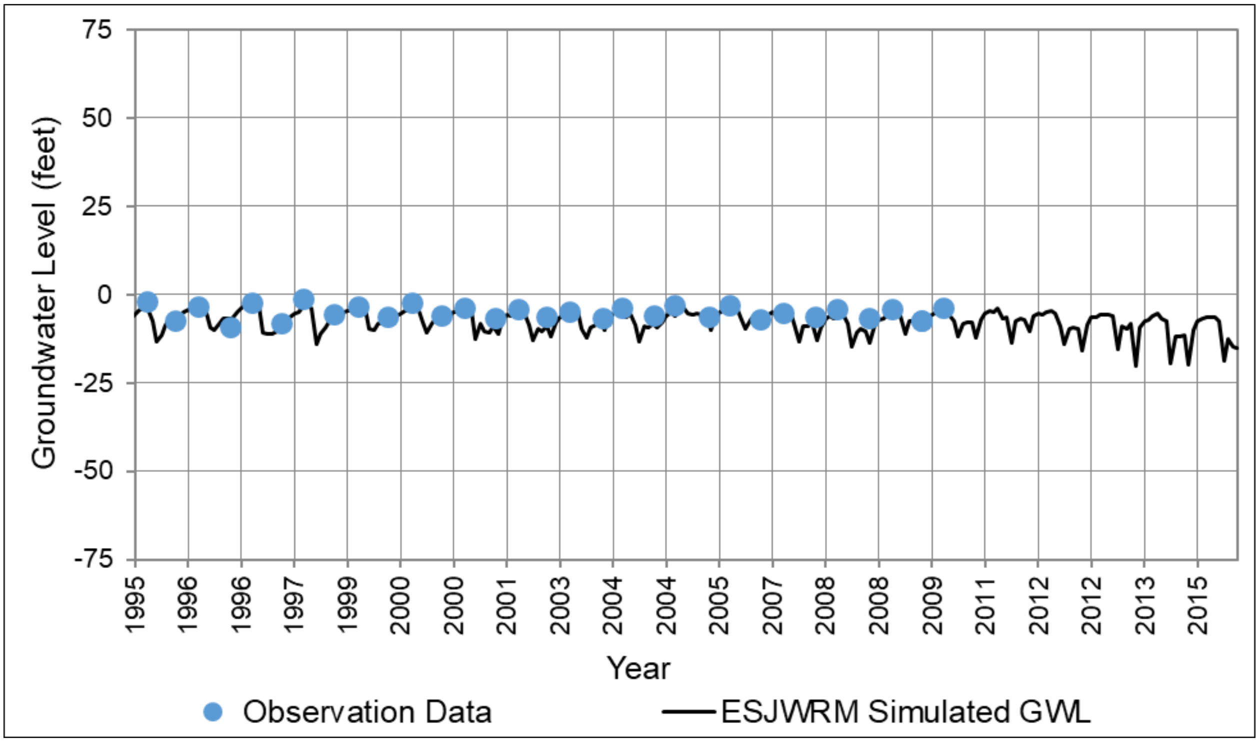


Figure 52b: ESJWRM Groundwater Level Hydrograph – Hydrograph #2

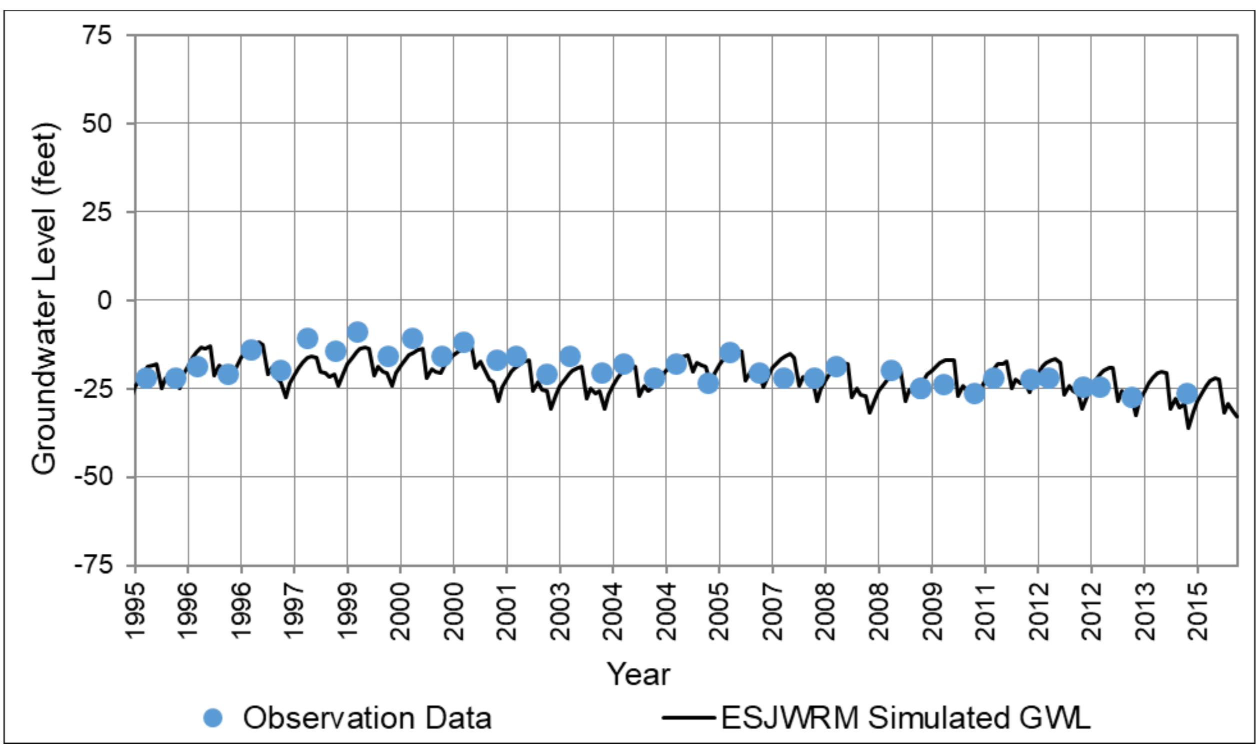


Figure 52c: ESJWRM Groundwater Level Hydrograph – Hydrograph #3

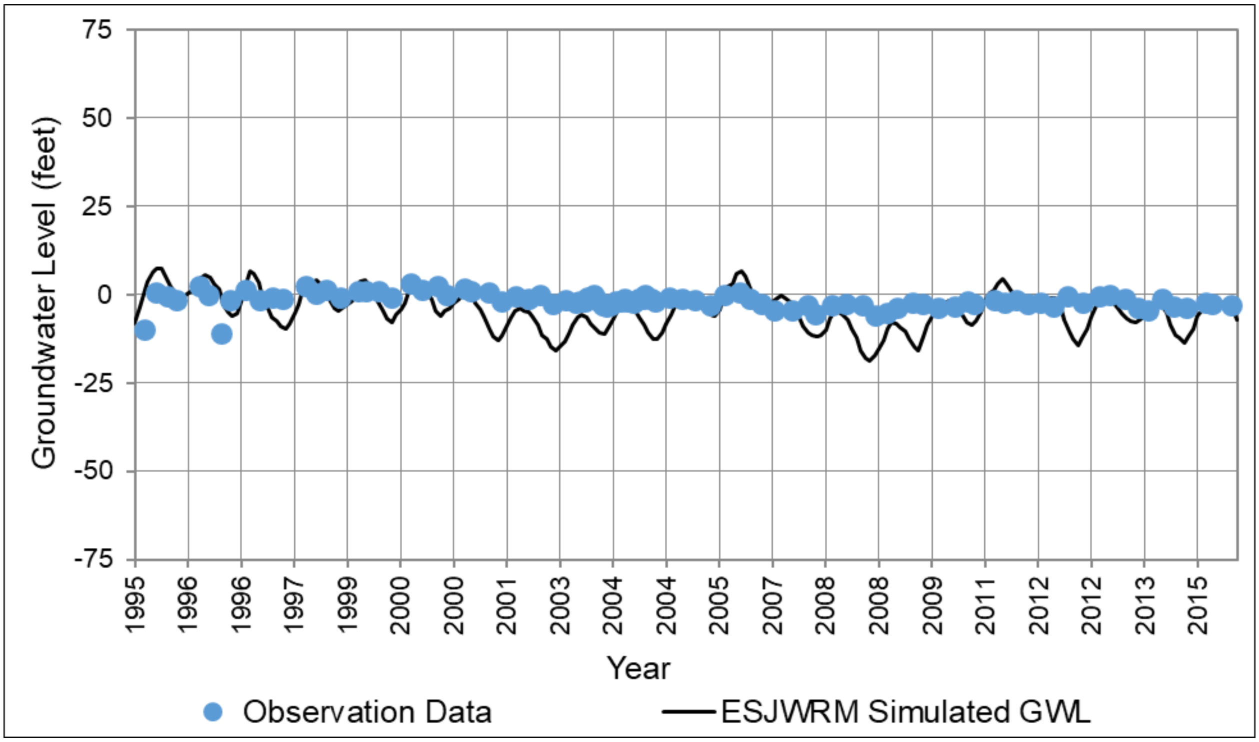


Figure 52d: ESJWRM Groundwater Level Hydrograph – Hydrograph #4

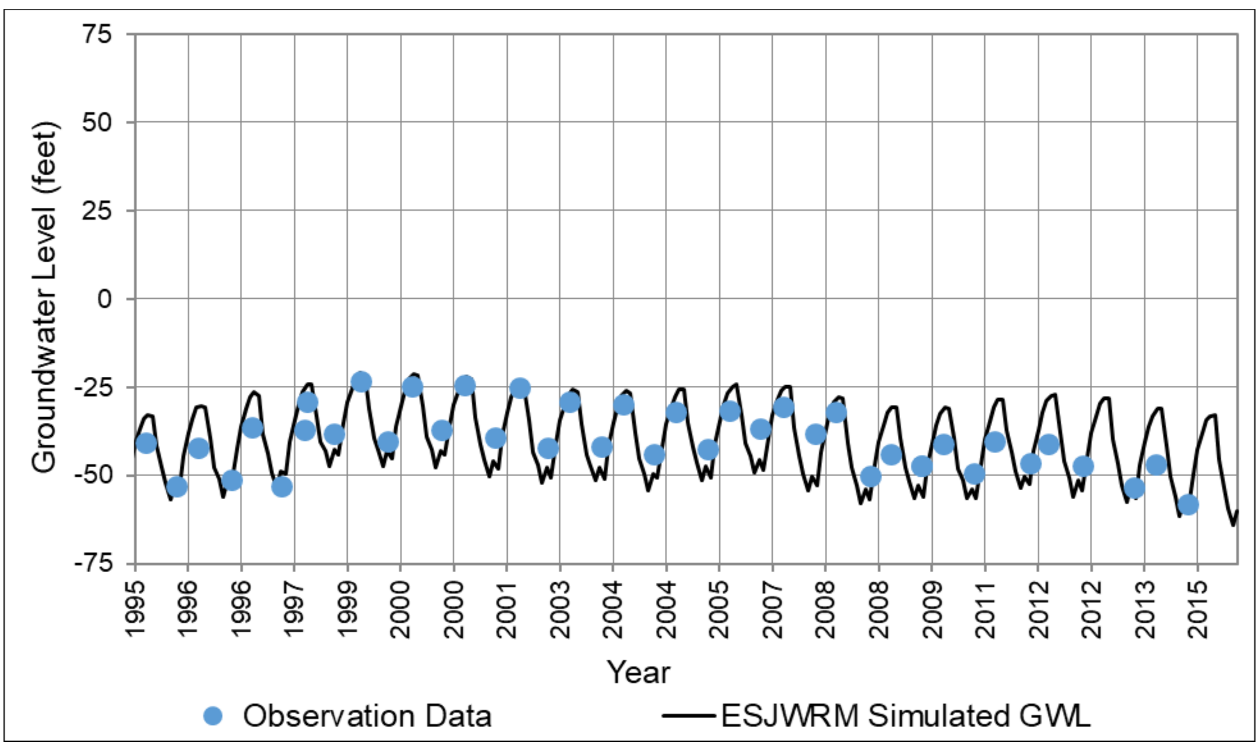


Figure 52e: ESJWRM Groundwater Level Hydrograph – Hydrograph #5

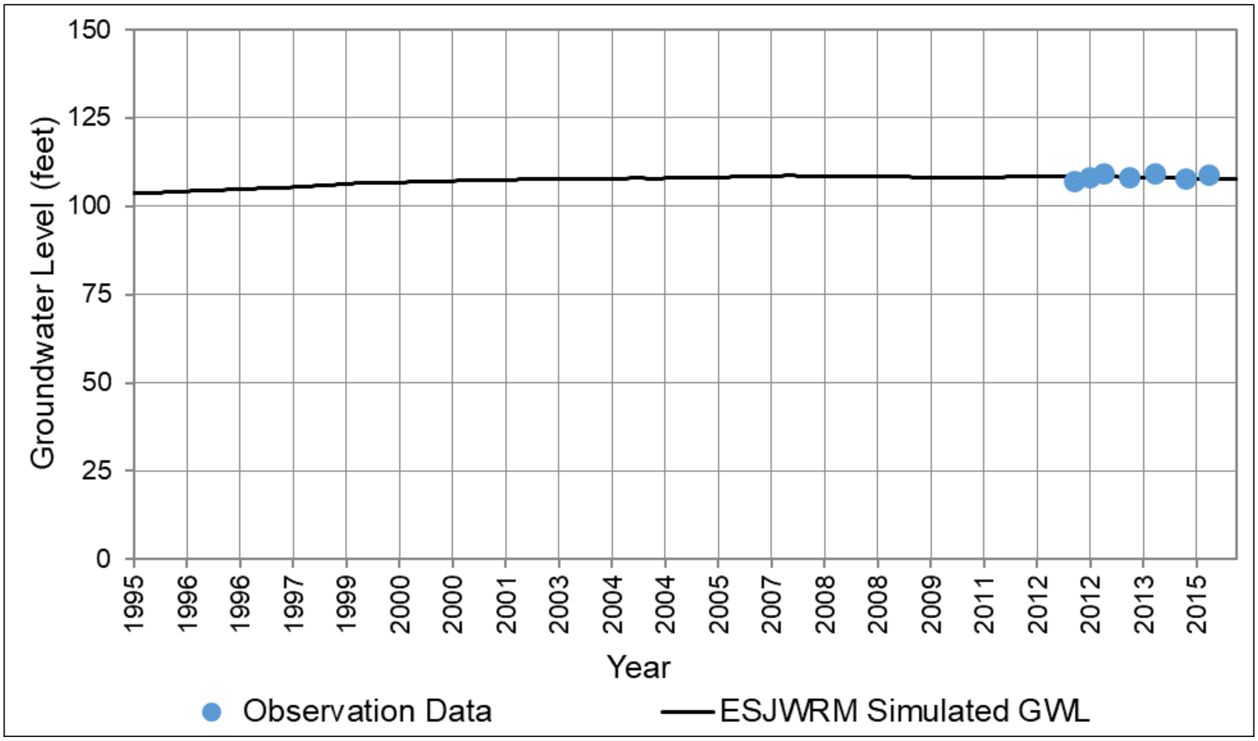


Figure 52f: ESJWRM Groundwater Level Hydrograph – Hydrograph #6

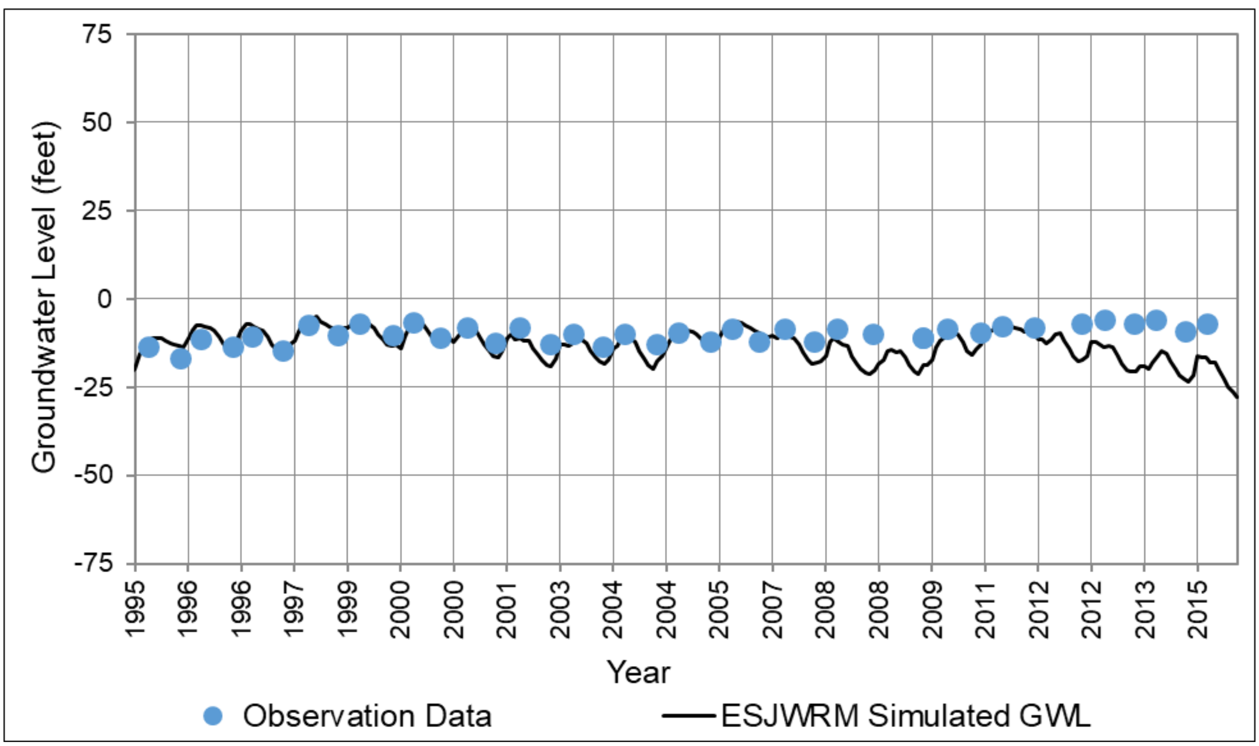


Figure 52g: ESJWRM Groundwater Level Hydrograph – Hydrograph #7

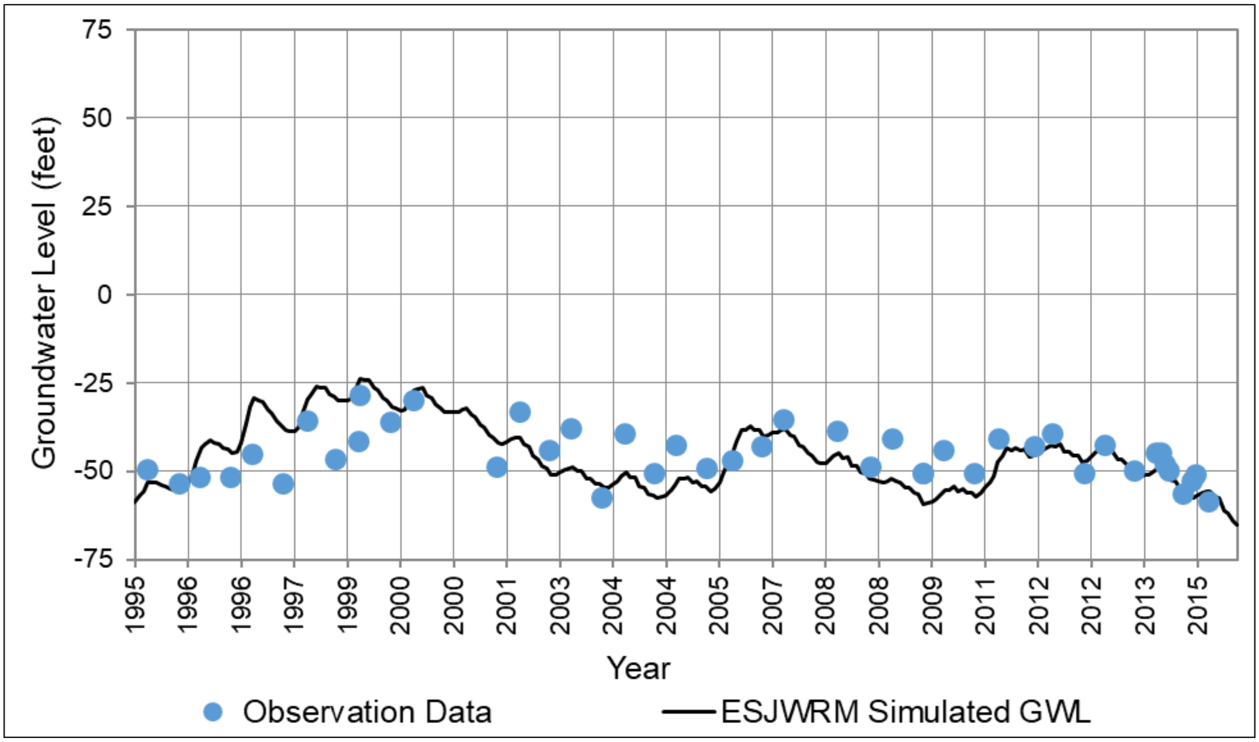


Figure 52h: ESJWRM Groundwater Level Hydrograph – Hydrograph #8

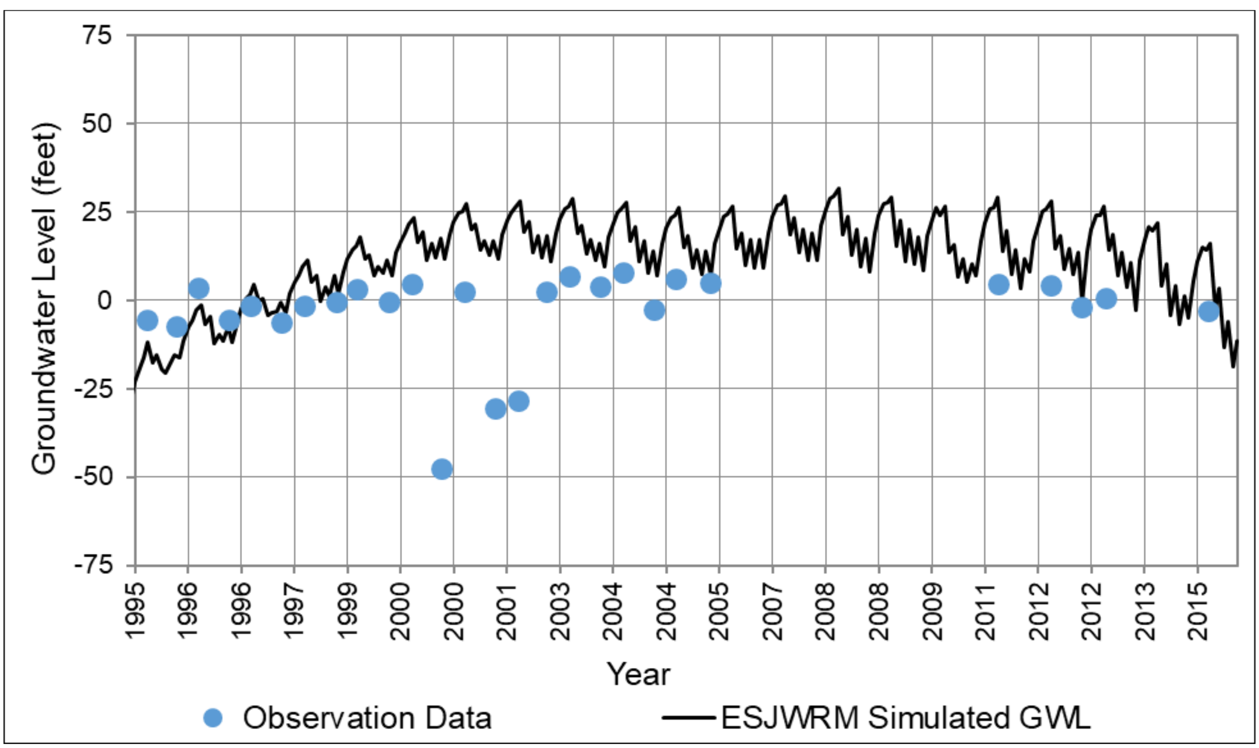


Figure 52i: ESJWRM Groundwater Level Hydrograph – Hydrograph #9

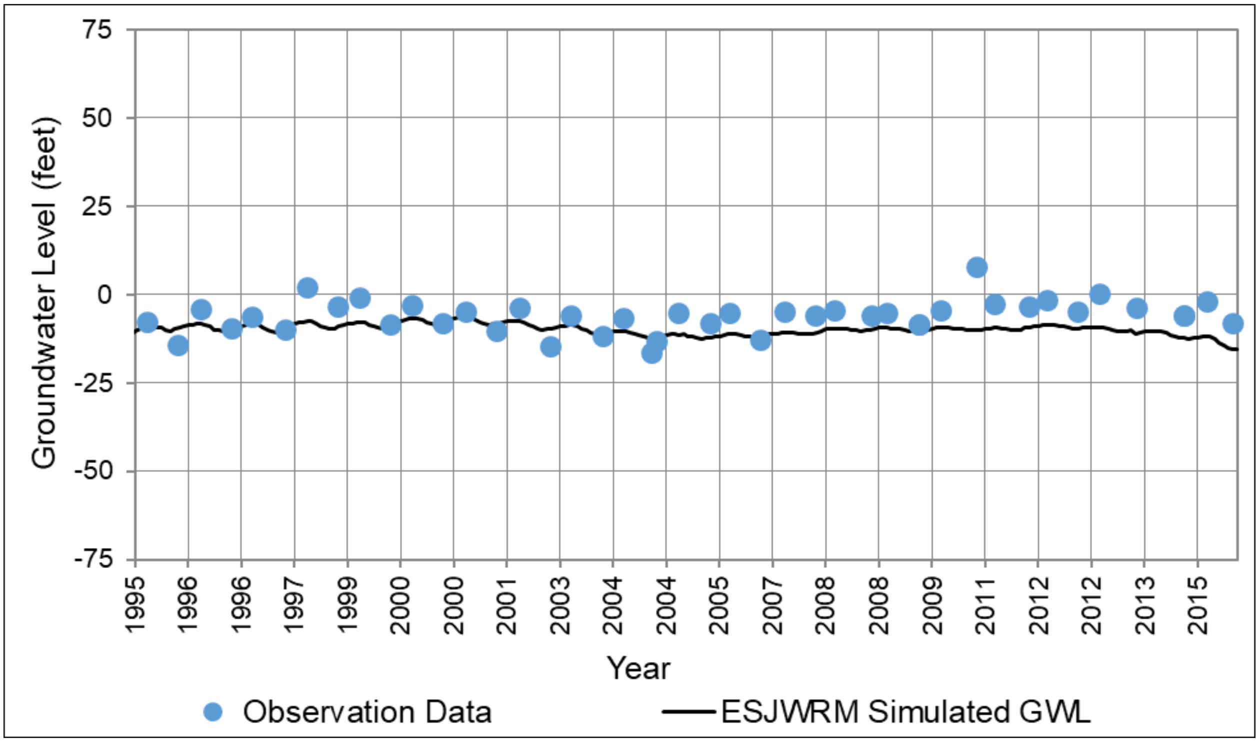


Figure 52j: ESJWRM Groundwater Level Hydrograph – Hydrograph #10

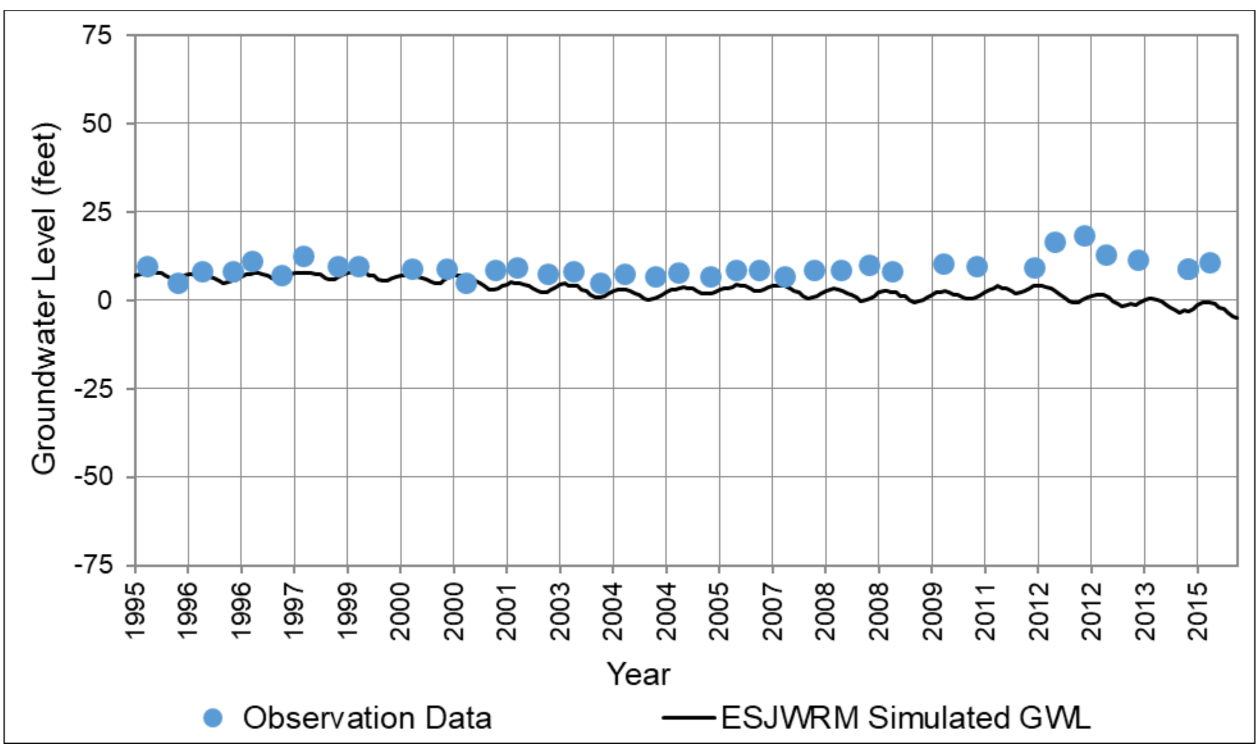


Figure 52k: ESJWRM Groundwater Level Hydrograph – Hydrograph #11

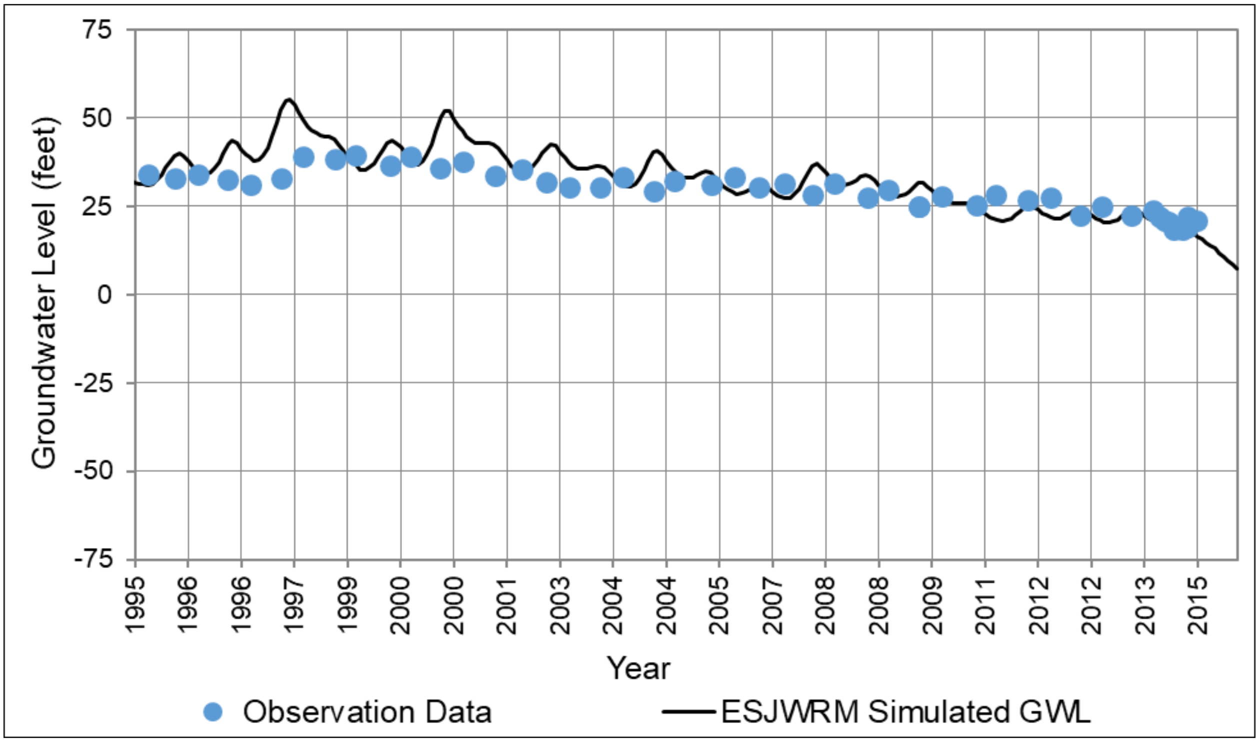


Figure 52l: ESJWRM Groundwater Level Hydrograph – Hydrograph #12

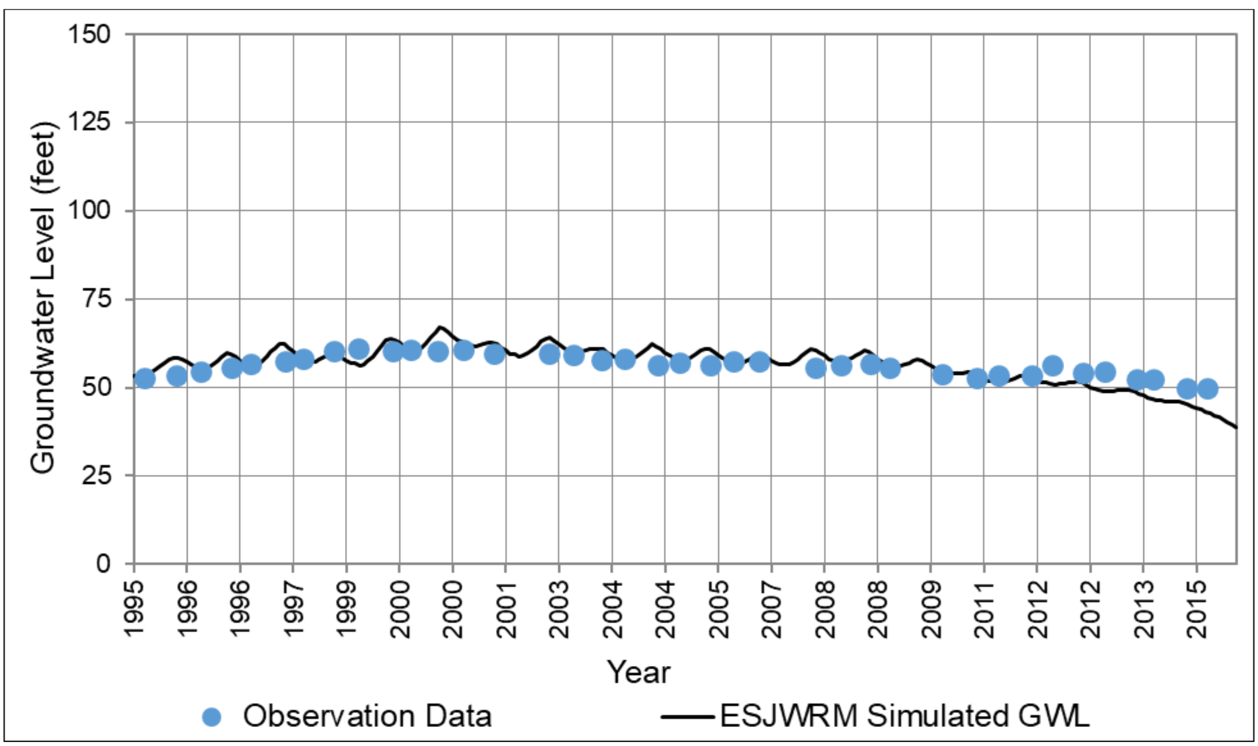


Figure 52m: ESJWRM Groundwater Level Hydrograph – Hydrograph #13

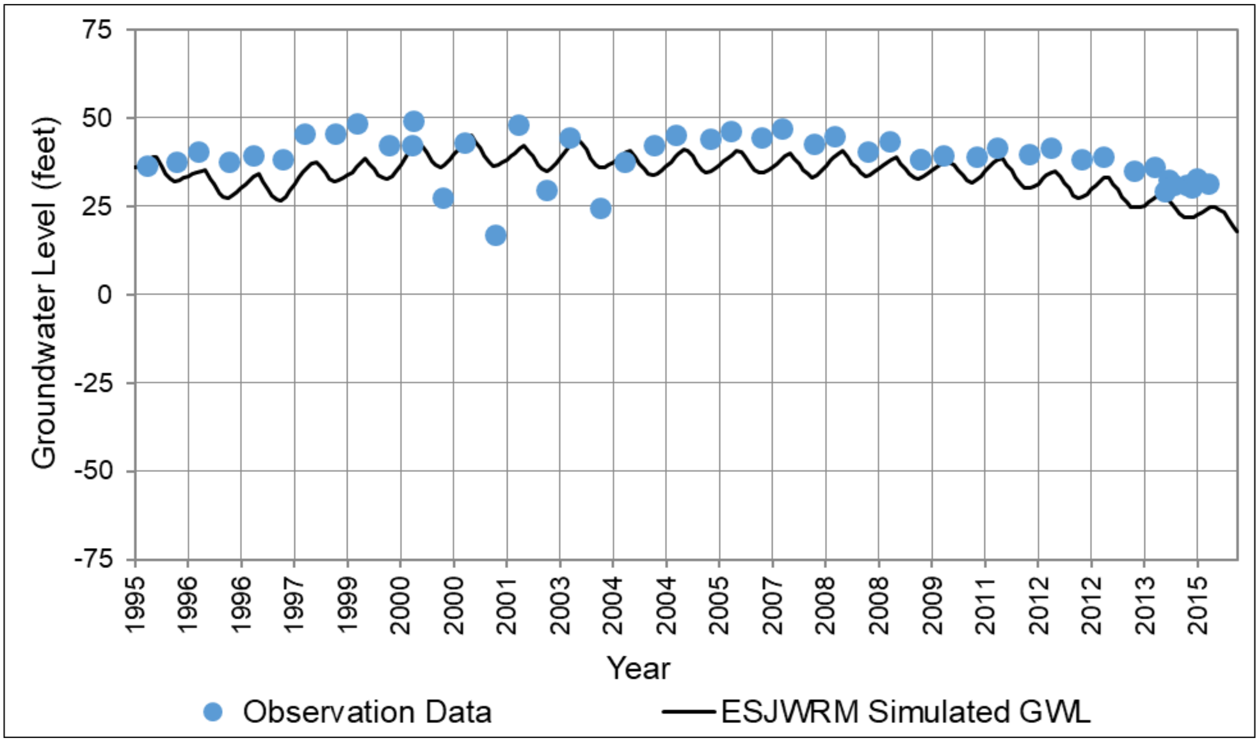


Figure 52n: ESJWRM Groundwater Level Hydrograph – Hydrograph #14

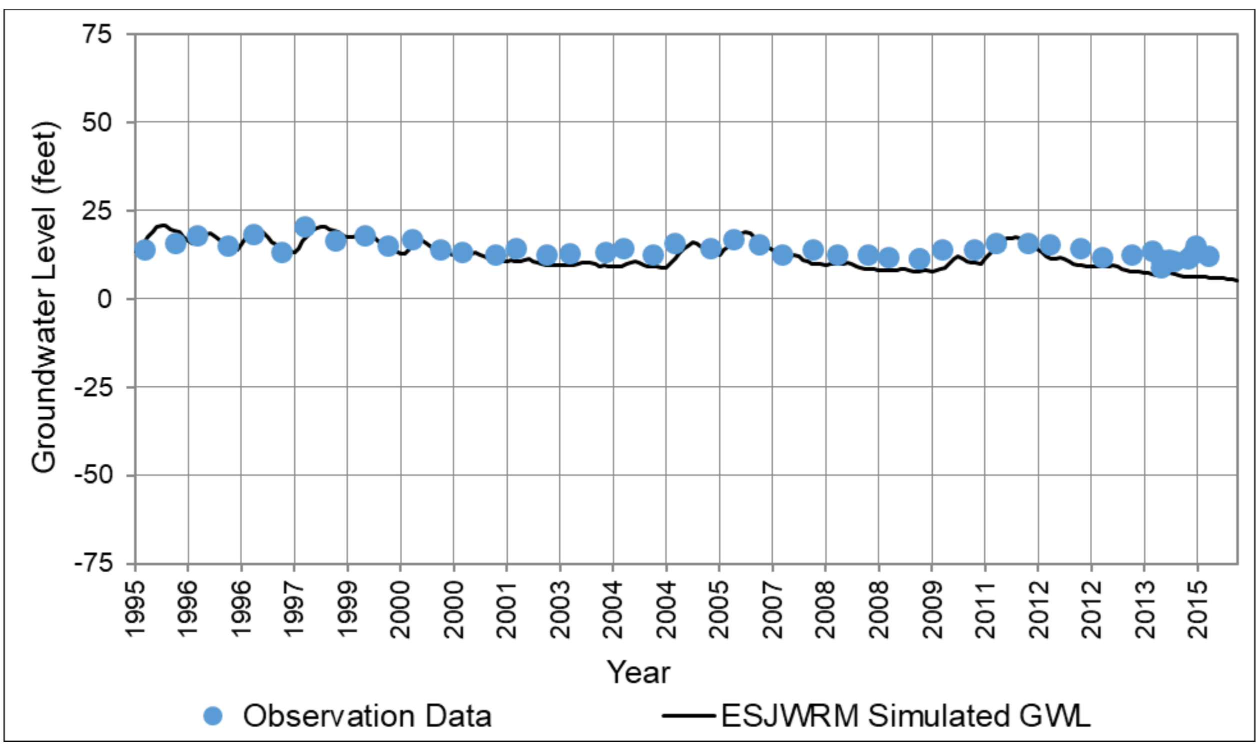


Figure 52o: ESJWRM Groundwater Level Hydrograph – Hydrograph #15

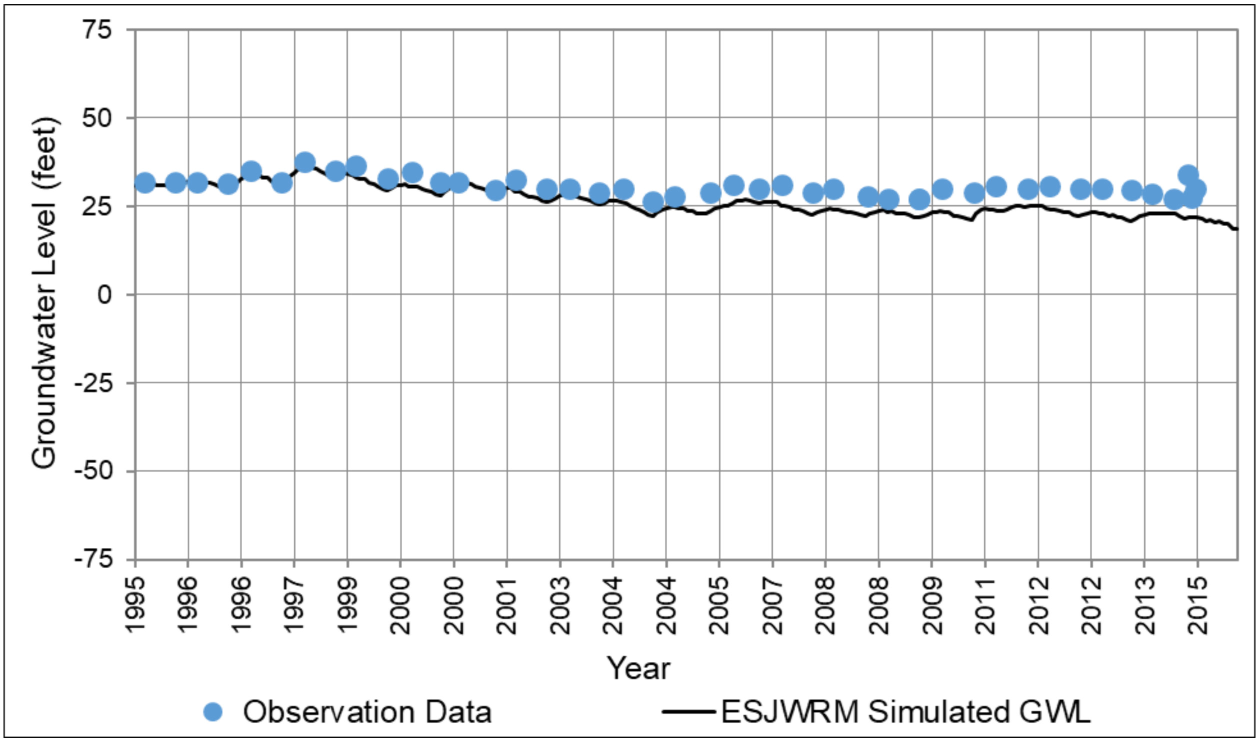


Figure 52p: ESJWRM Groundwater Level Hydrograph – Hydrograph #16

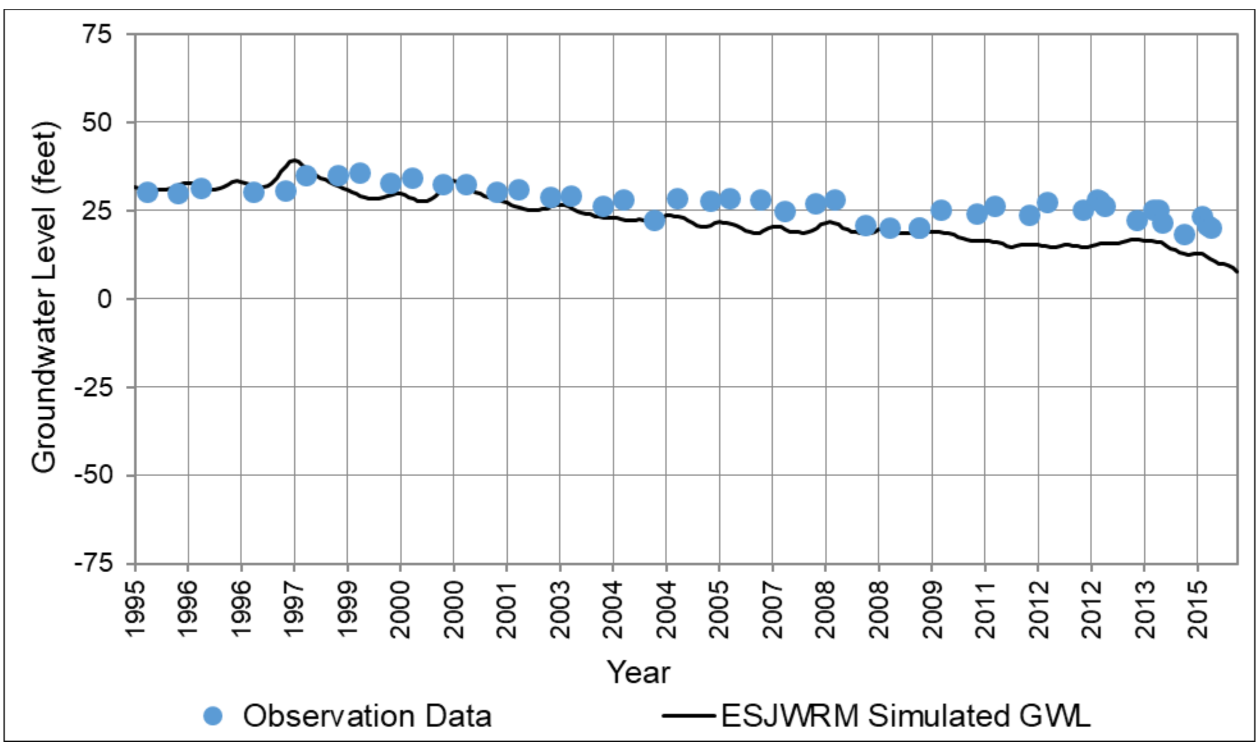


Figure 52q: ESJWRM Groundwater Level Hydrograph – Hydrograph #17

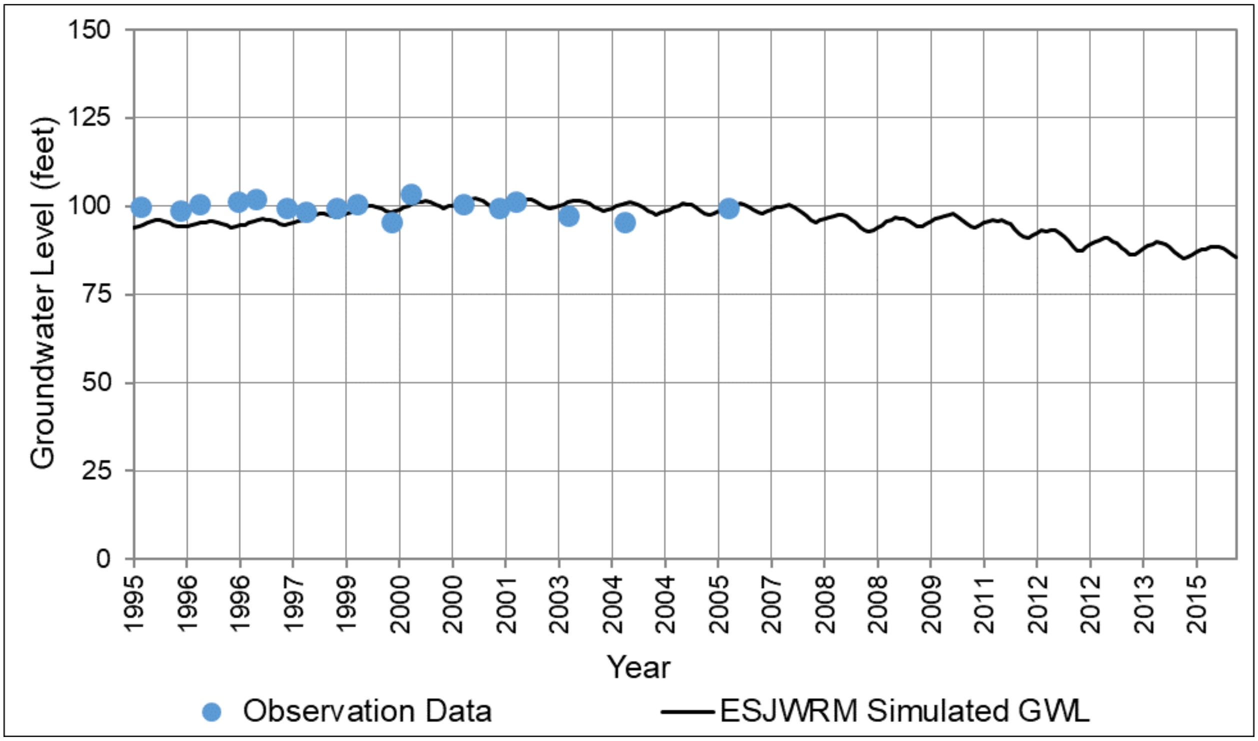


Figure 52r: ESJWRM Groundwater Level Hydrograph – Hydrograph #18

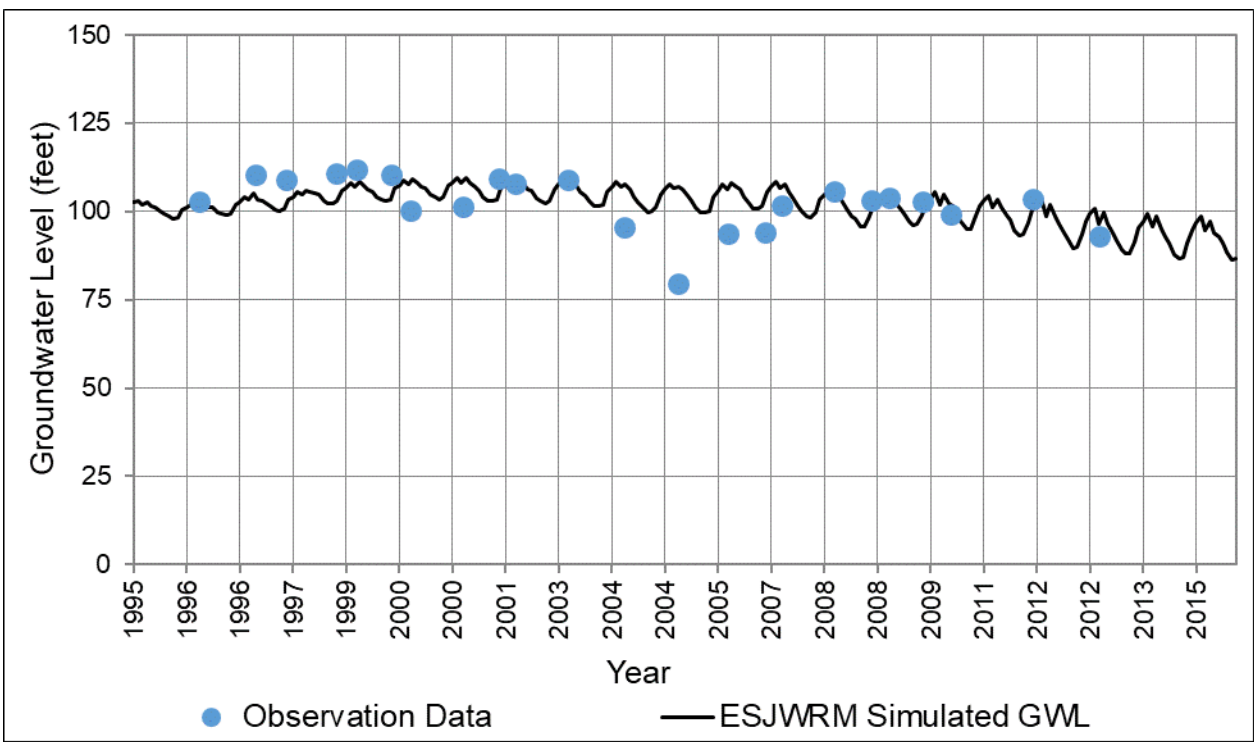


Figure 53: ESJWRM ESJ Subbasin Groundwater Level Histogram

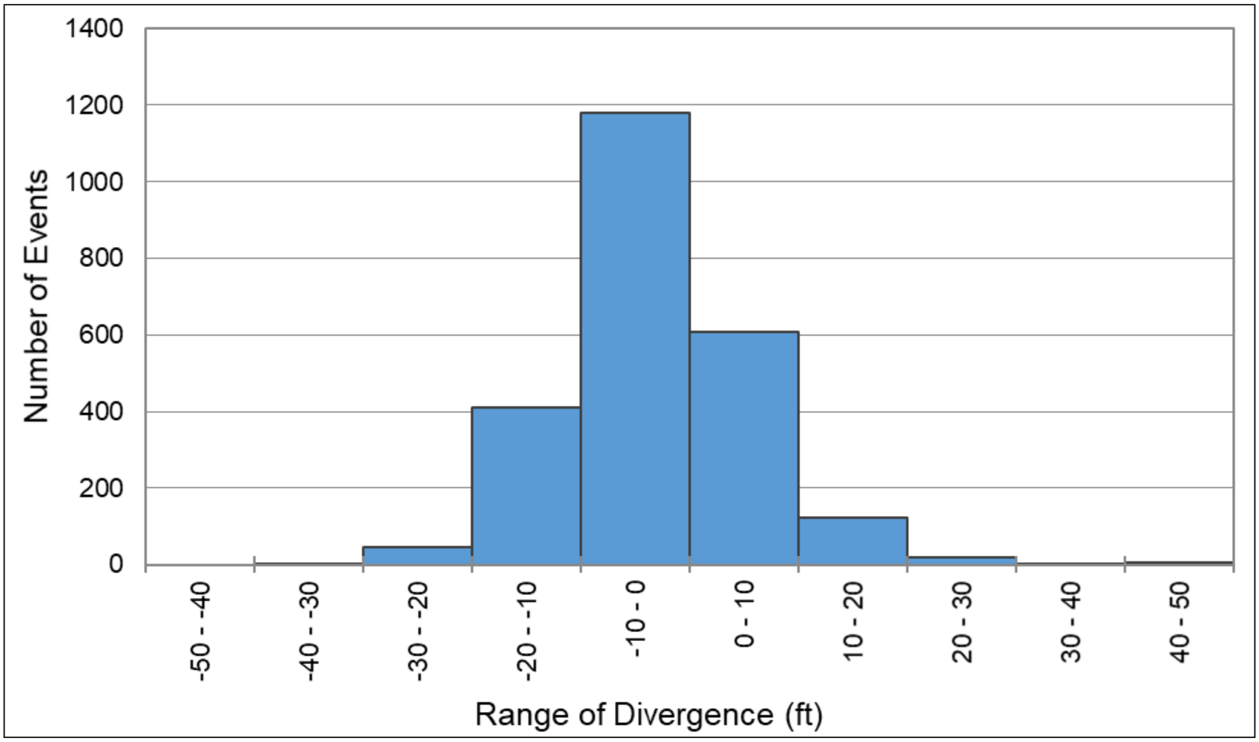


Figure 54: ESJWRM ESJ Subbasin Groundwater Level Scatter Plot

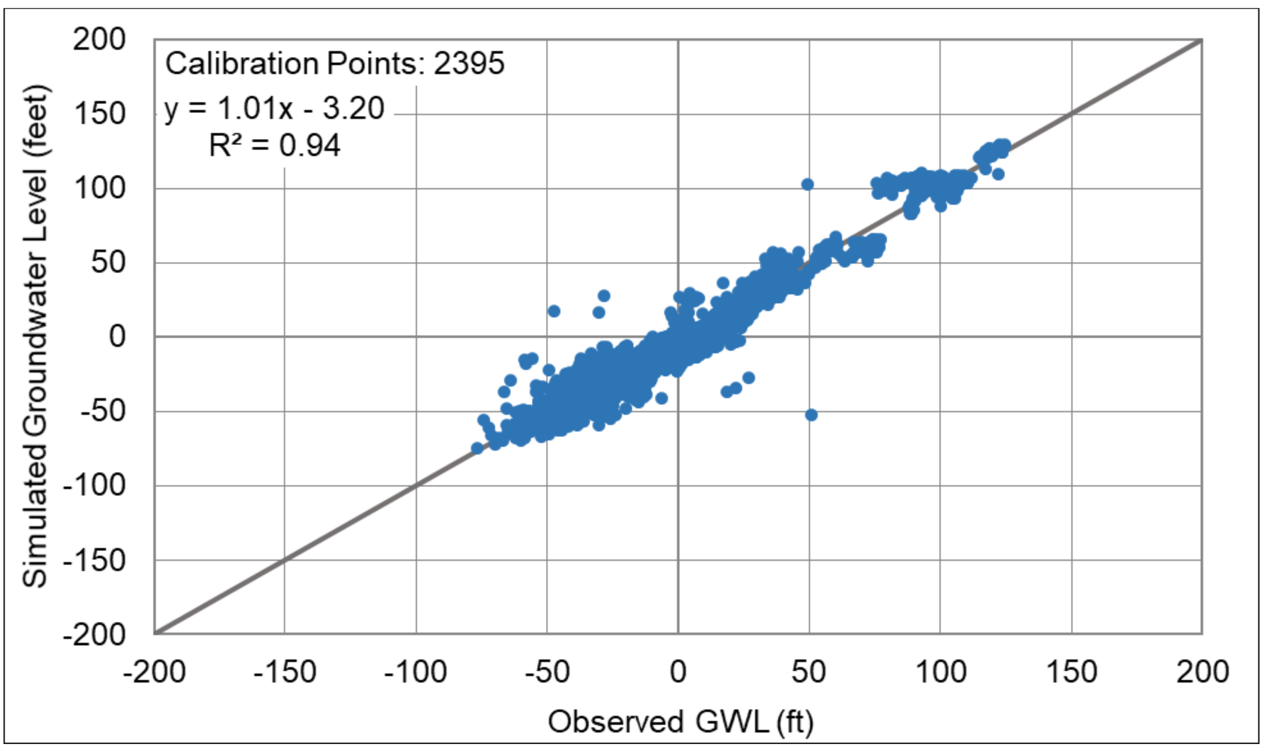


Figure 55: ESJWRM Parametric Grid

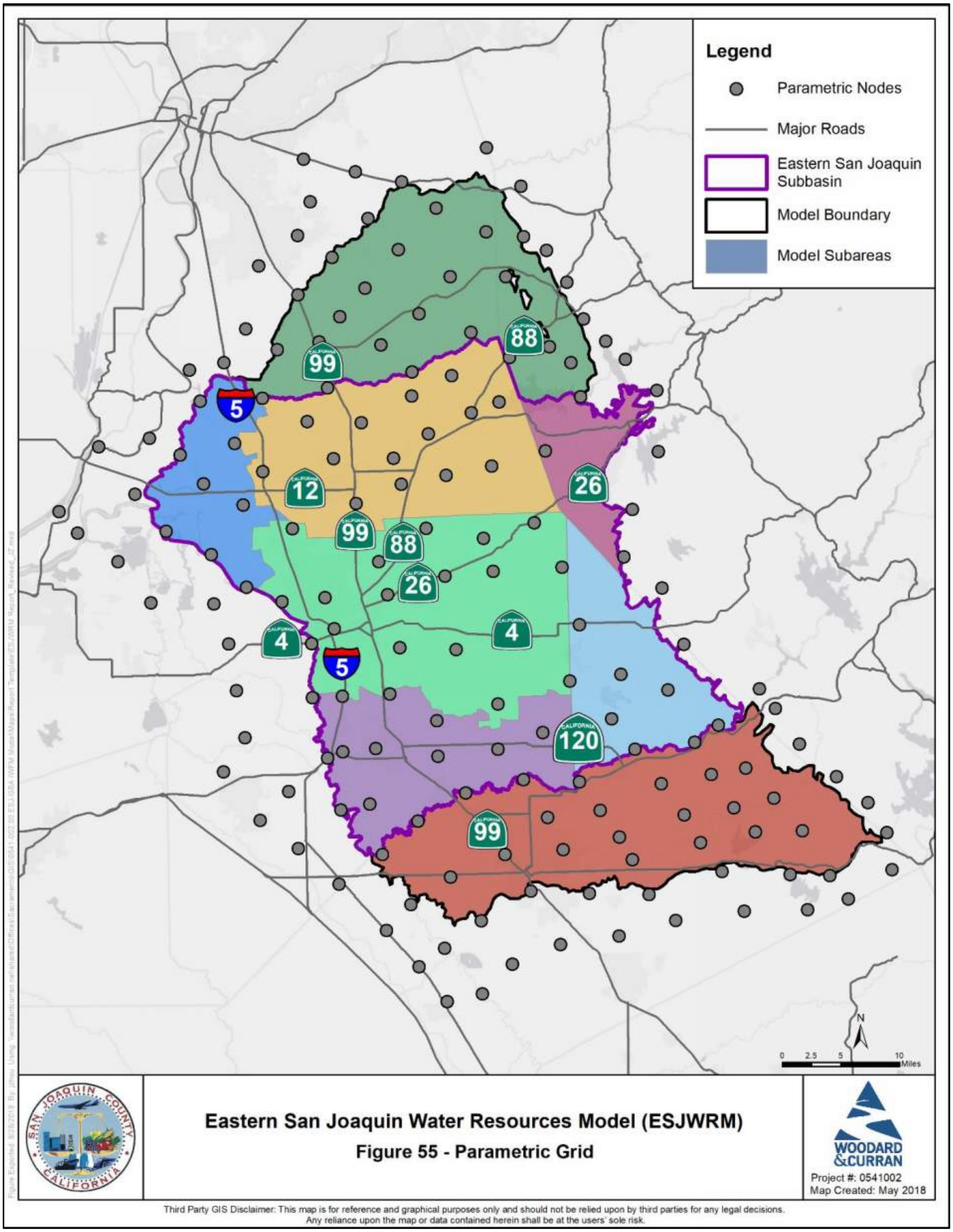


Figure 56: ESJWRM Layer 1 Horizontal Hydraulic Conductivity

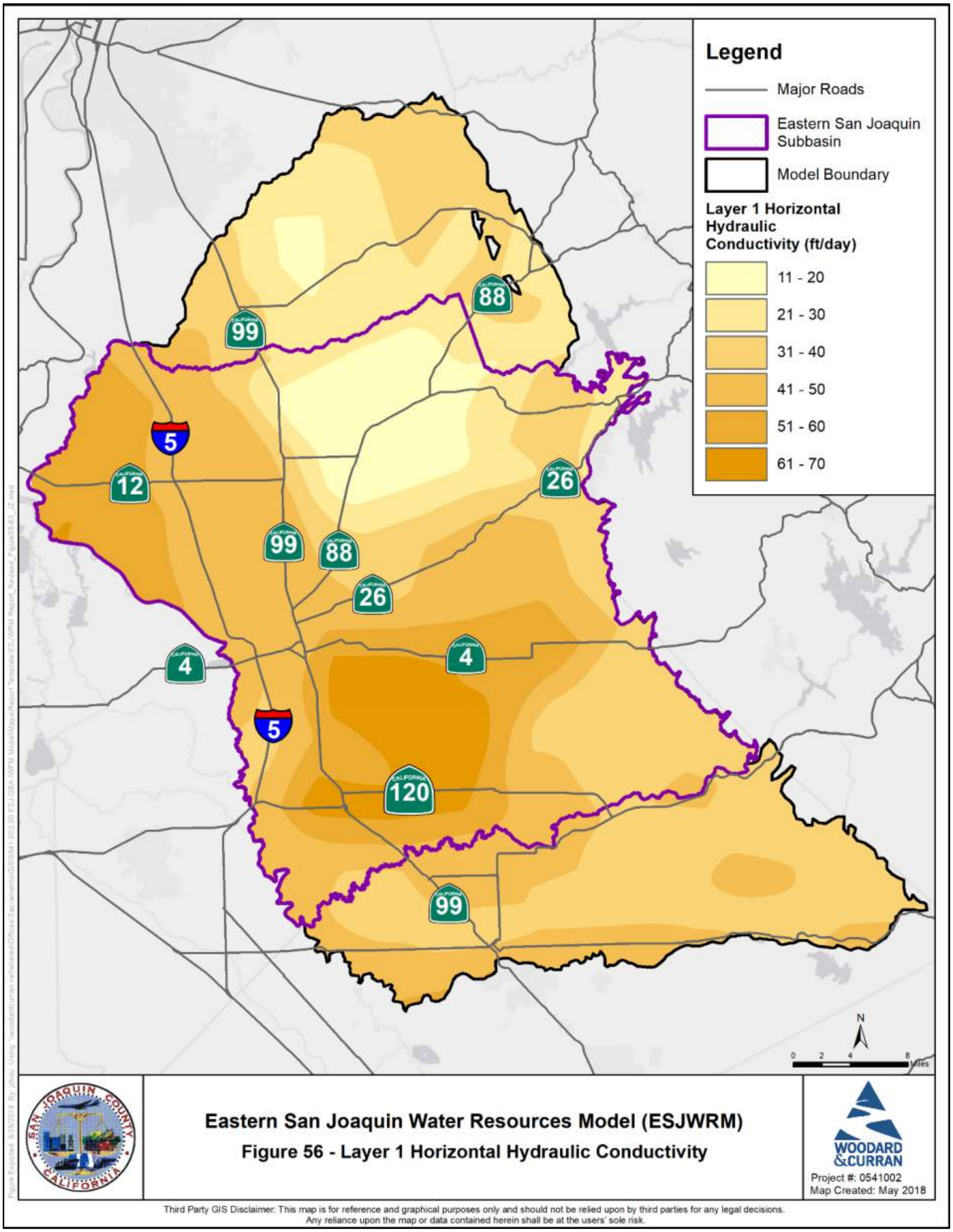


Figure 57: ESJWRM Layer 2 Horizontal Hydraulic Conductivity

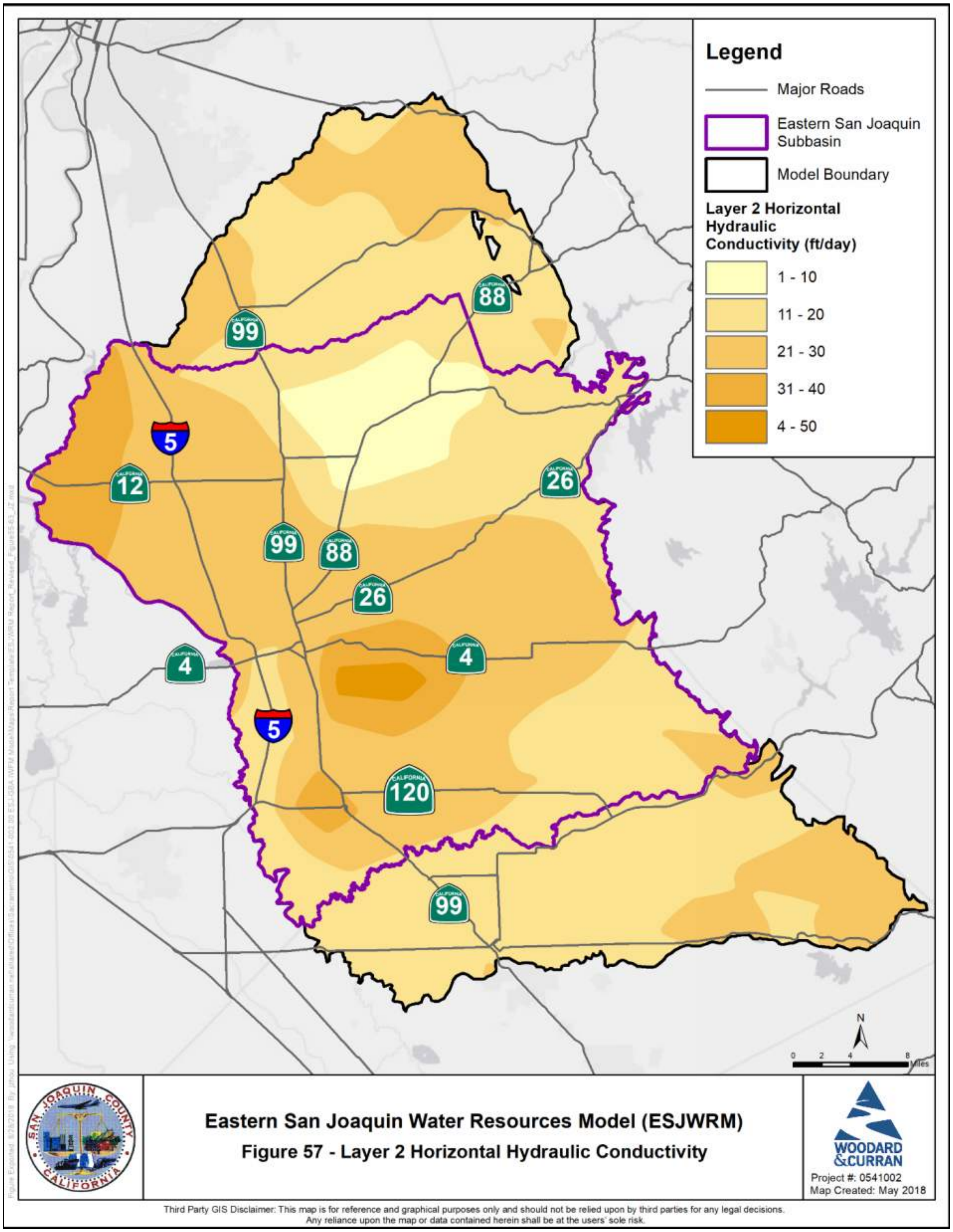


Figure 58: ESJWRM Layer 3 Horizontal Hydraulic Conductivity

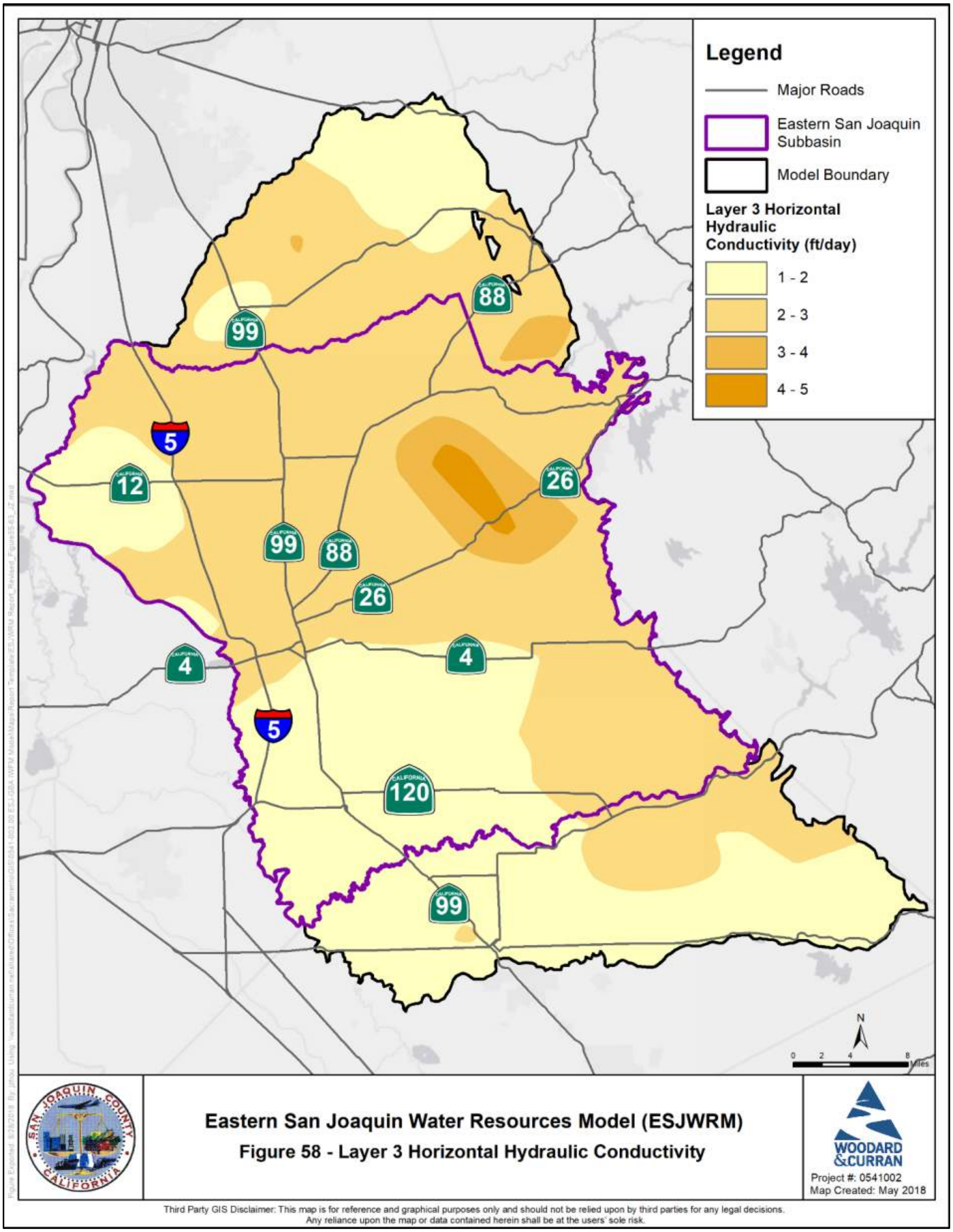


Figure 59: ESJWRM Layer 1 Specific Storage

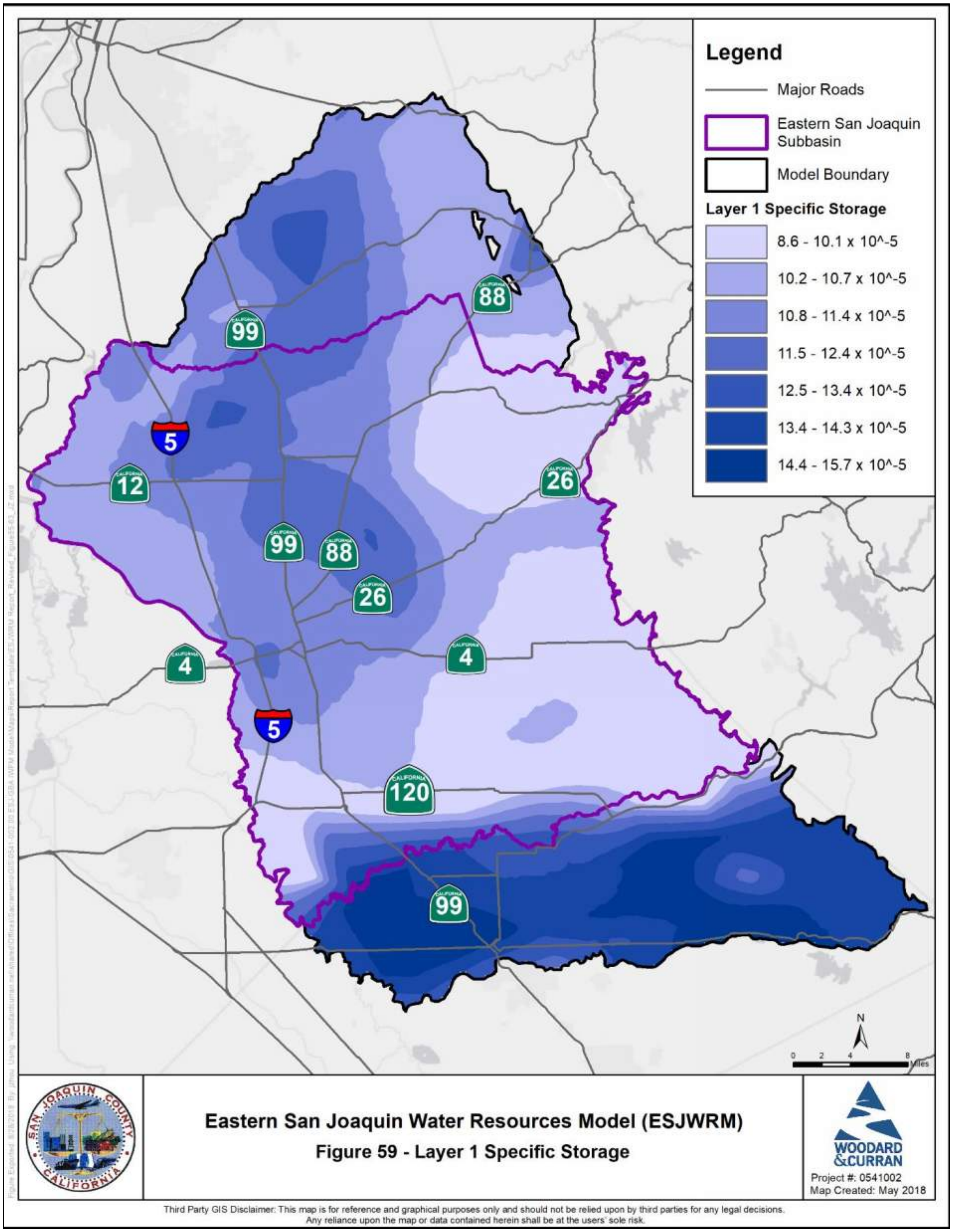


Figure 60: ESJWRM Layer 2 Specific Storage

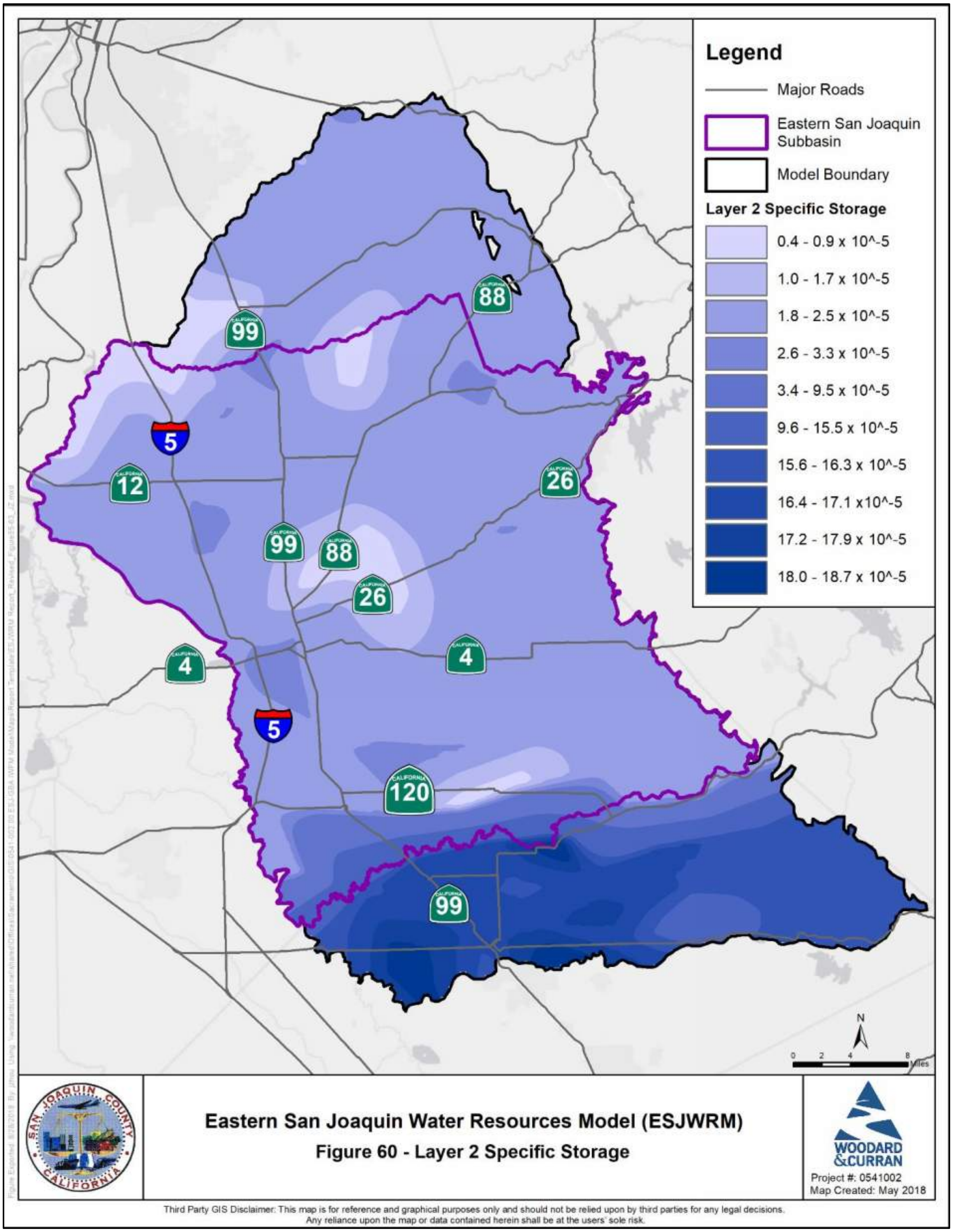


Figure 61: ESJWRM Layer 3 Specific Storage

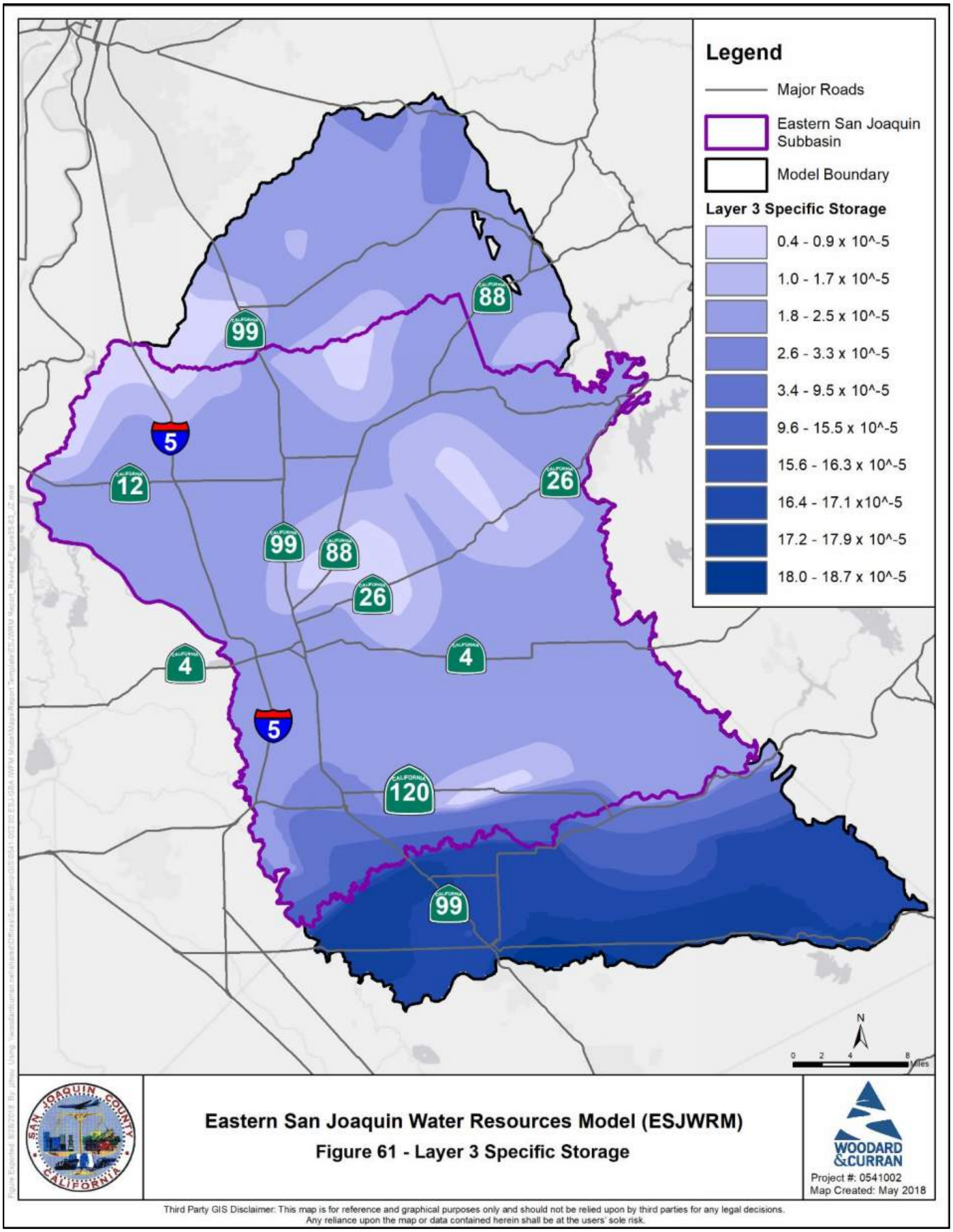


Figure 62: ESJWRM Layer 1 Specific Yield

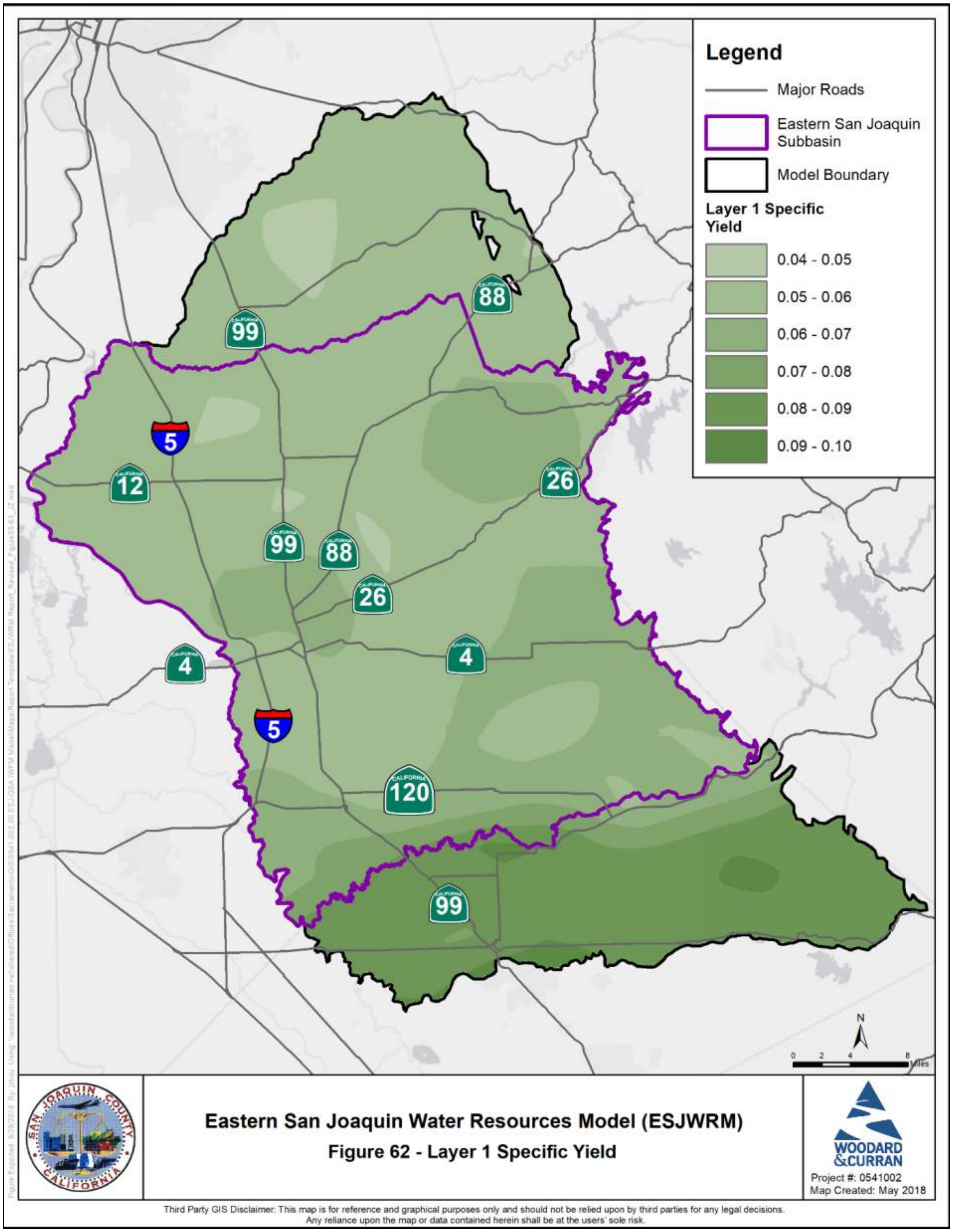


Figure 63: ESJWRM Layer 2 Specific Yield

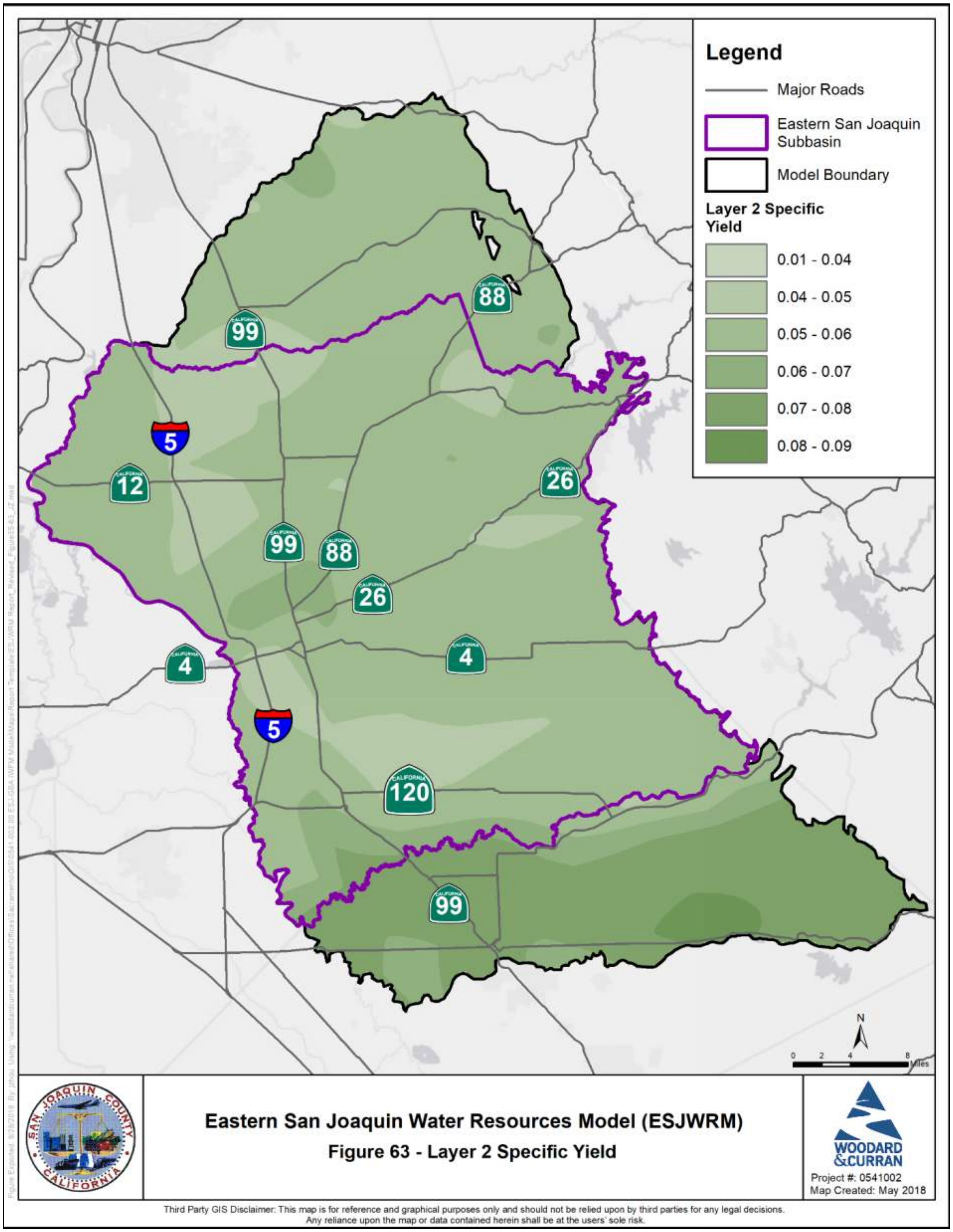


Figure 64: ESJWRM Layer 3 Specific Yield

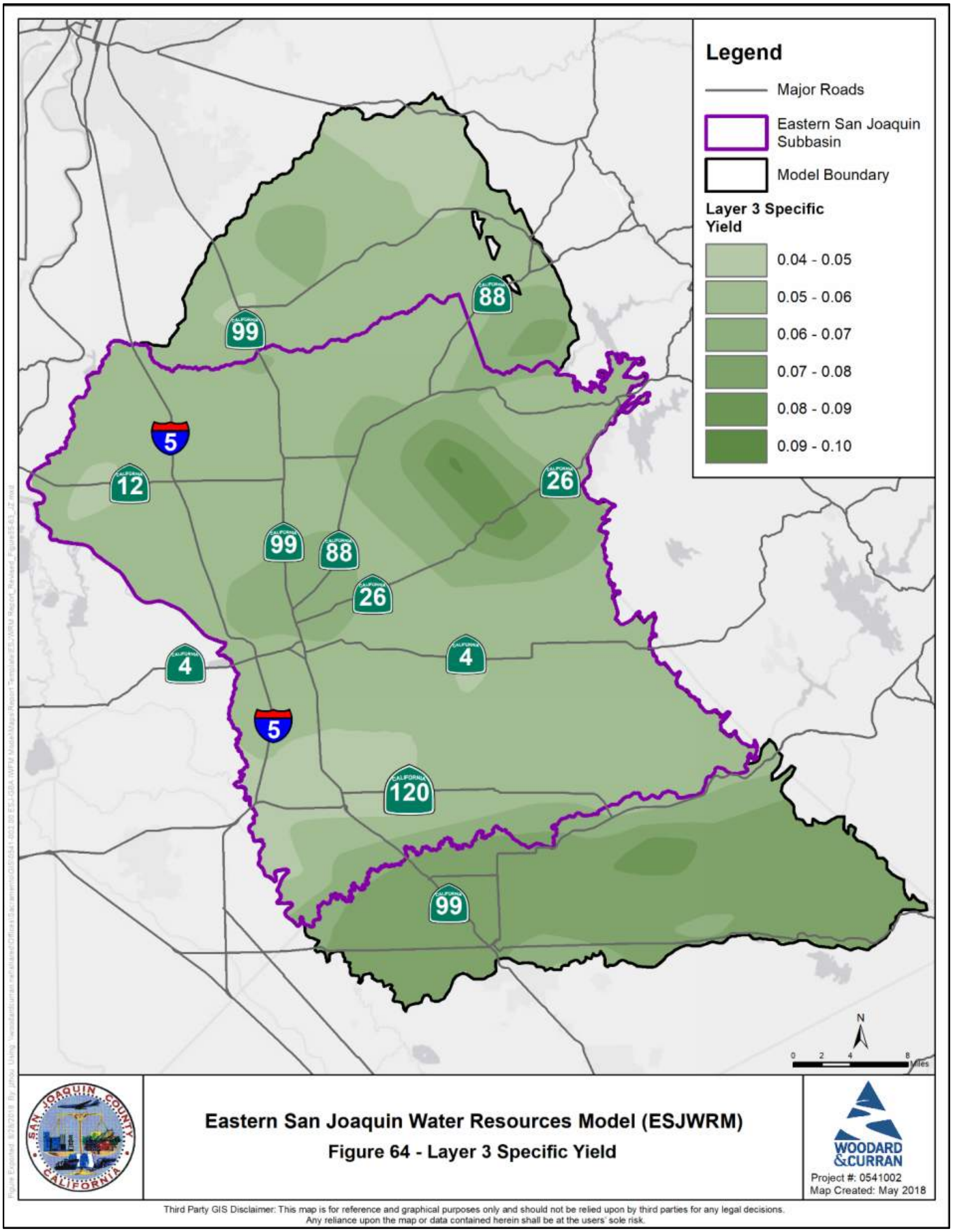


Figure 65: ESJWRM Sensitivity Analysis of Horizontal Hydraulic Conductivity – Difference in Average Groundwater Elevation (feet)

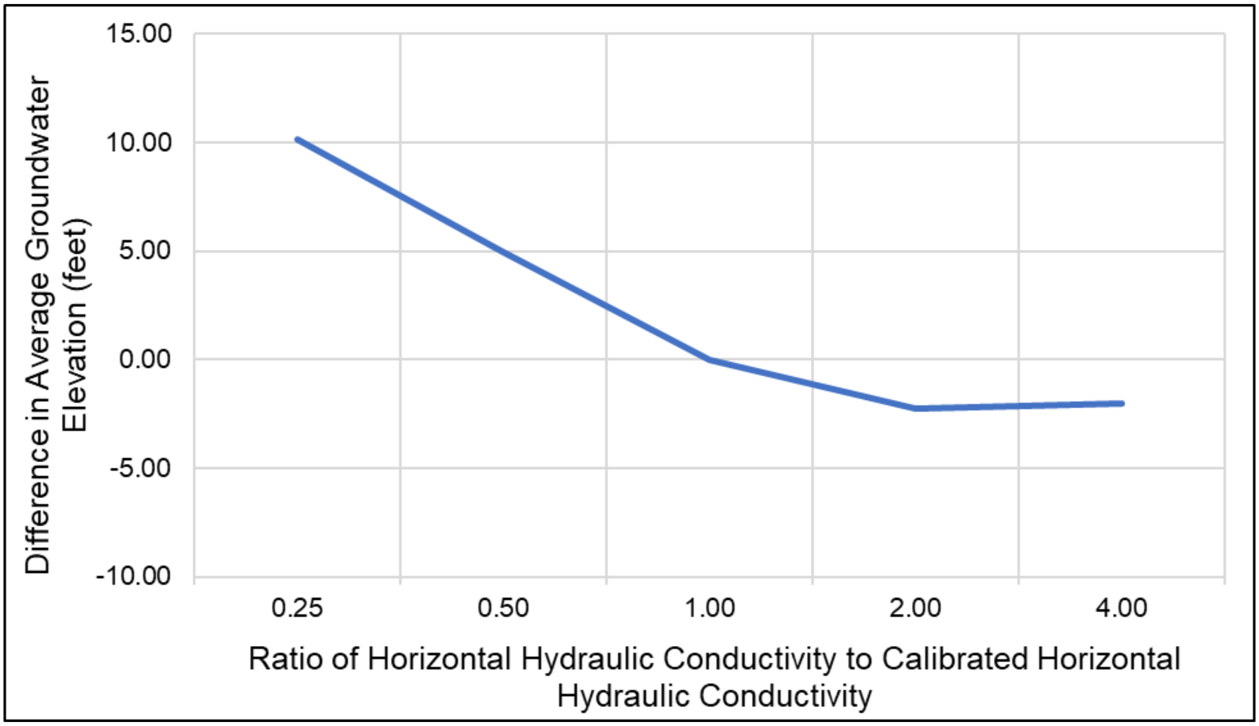


Figure 66: ESJWRM Sensitivity Analysis of Horizontal Hydraulic Conductivity – Relative Root Mean Square Error

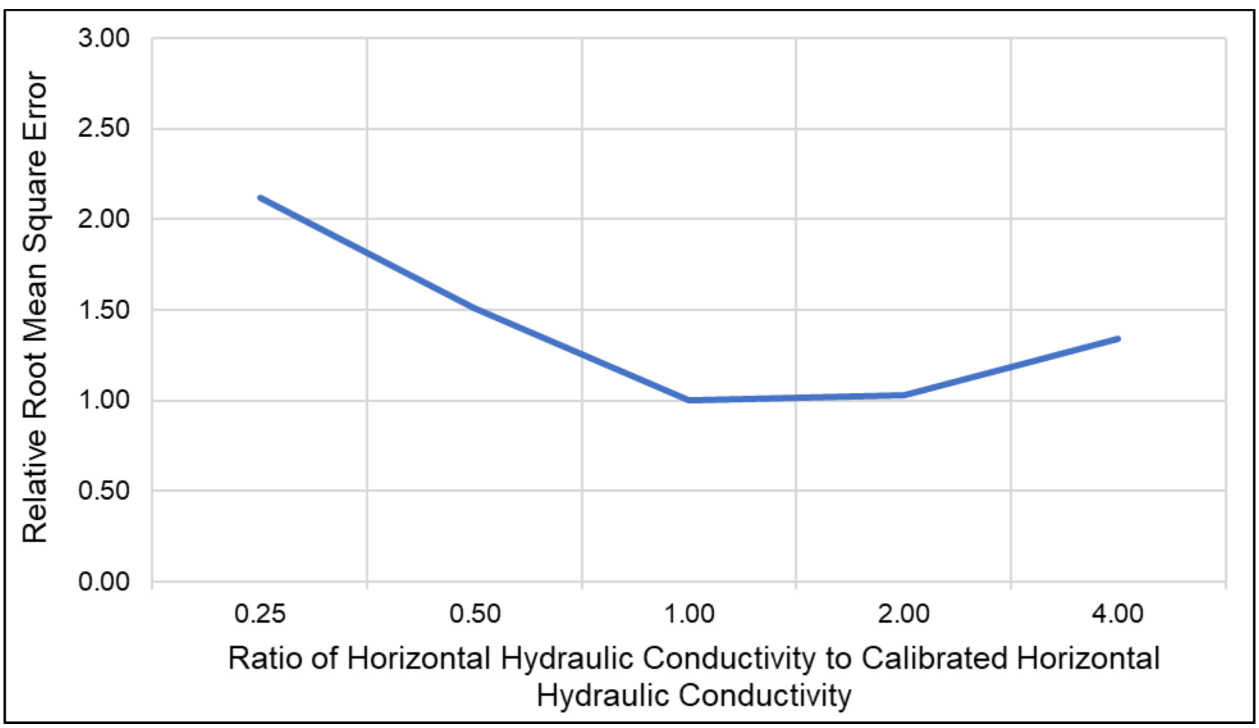


Figure 67: ESJWRM Sensitivity Analysis of Vertical Hydraulic Conductivity – Difference in Average Groundwater Elevation (feet)

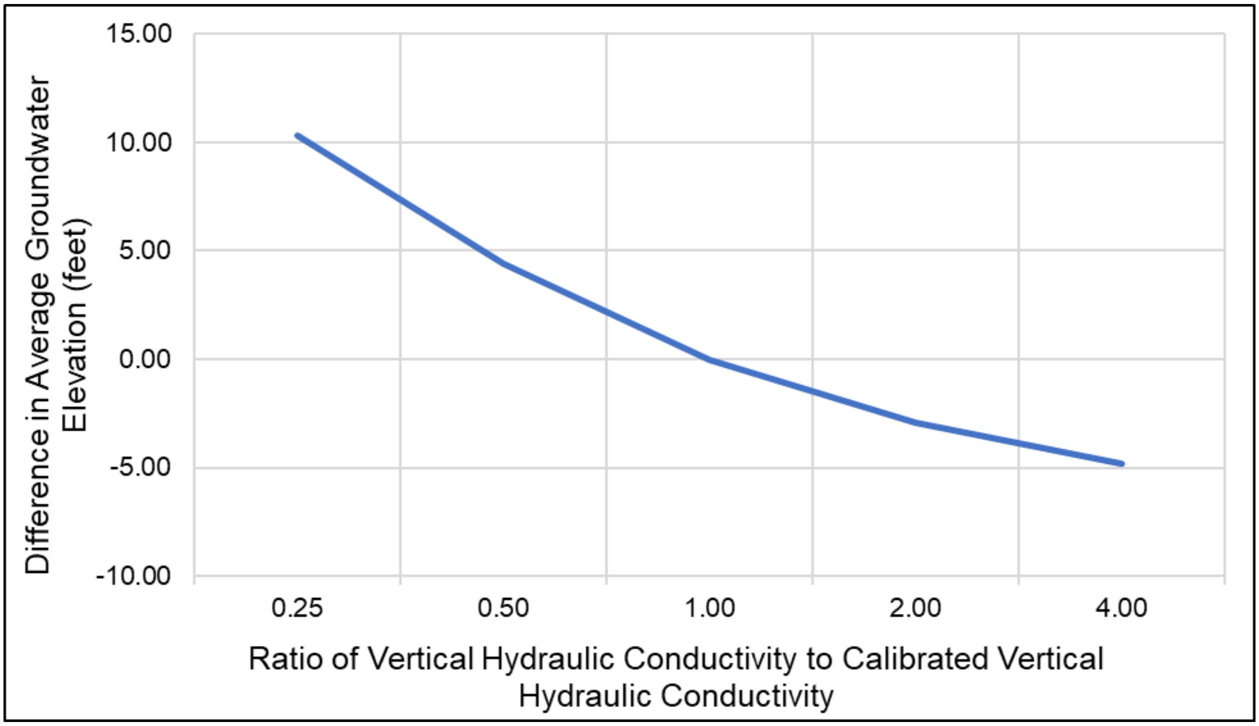


Figure 68: ESJWRM Sensitivity Analysis of Vertical Hydraulic Conductivity – Relative Root Mean Square Error

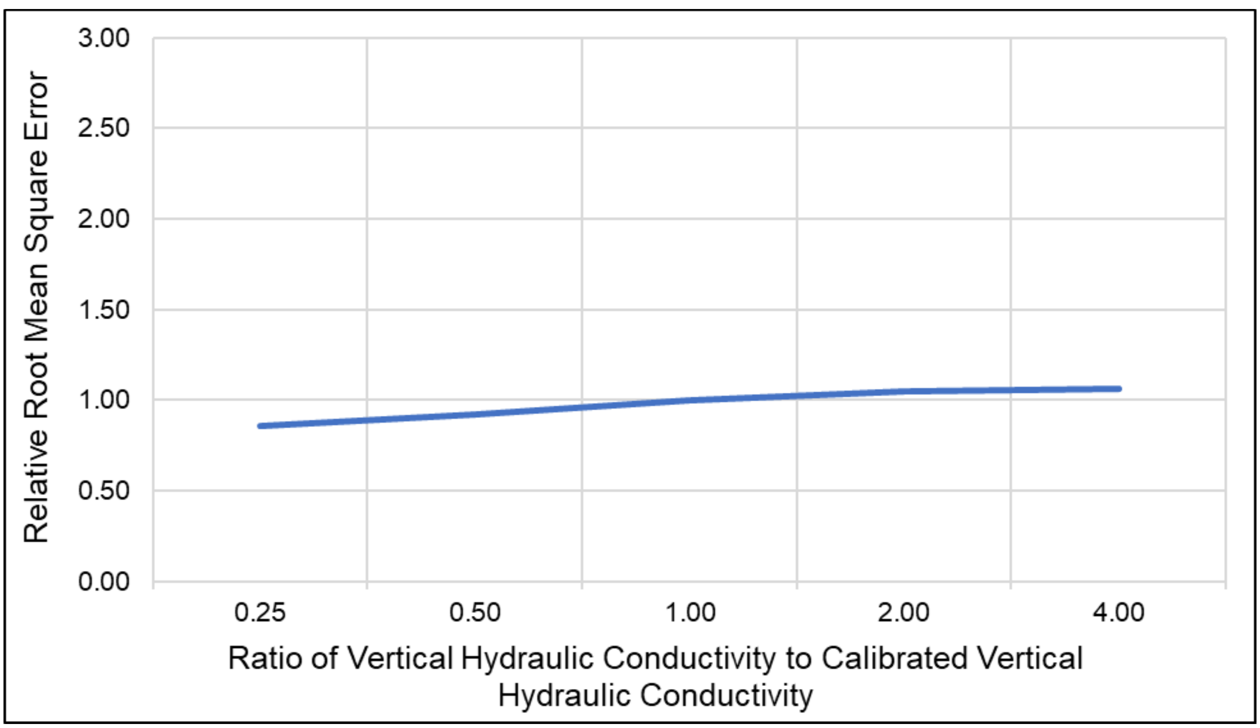


Figure 69: ESJWRM Sensitivity Analysis of Specific Storage – Difference in Average Groundwater Elevation (feet)

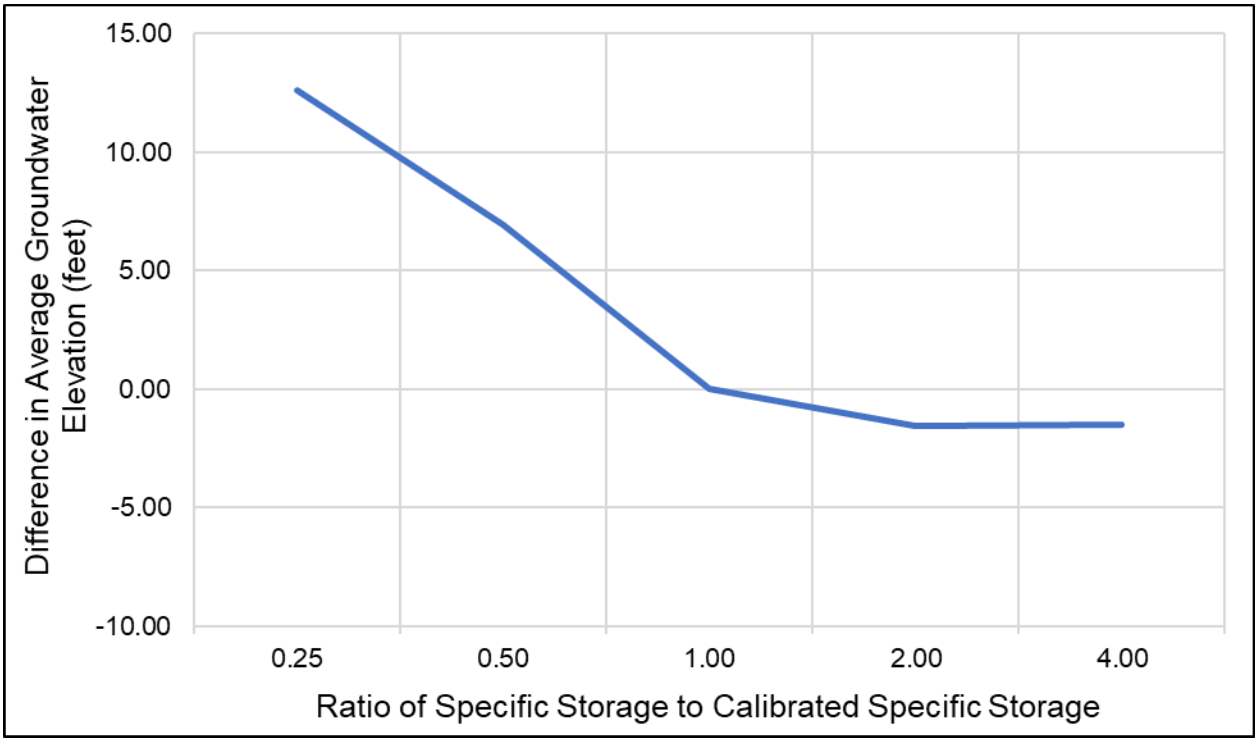


Figure 70: ESJWRM Sensitivity Analysis of Specific Storage – Relative Root Mean Square Error

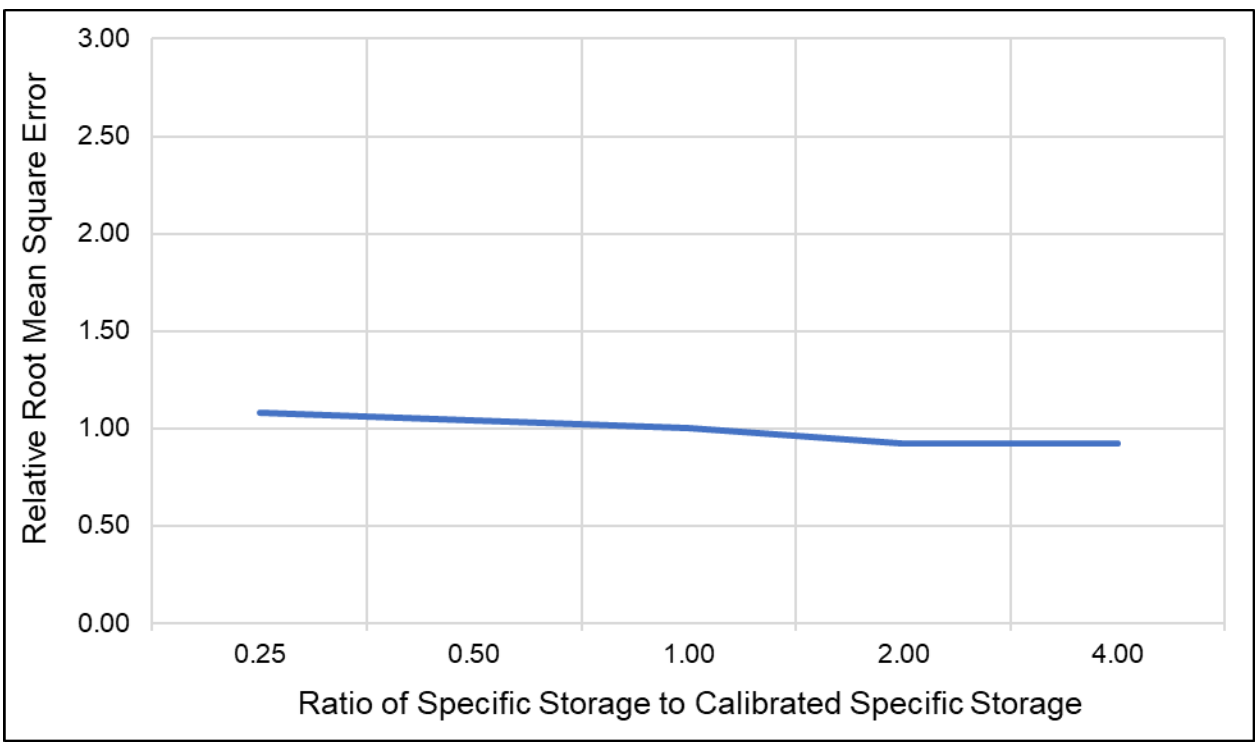


Figure 71: ESJWRM Sensitivity Analysis of Specific Yield – Difference in Average Groundwater Elevation (feet)

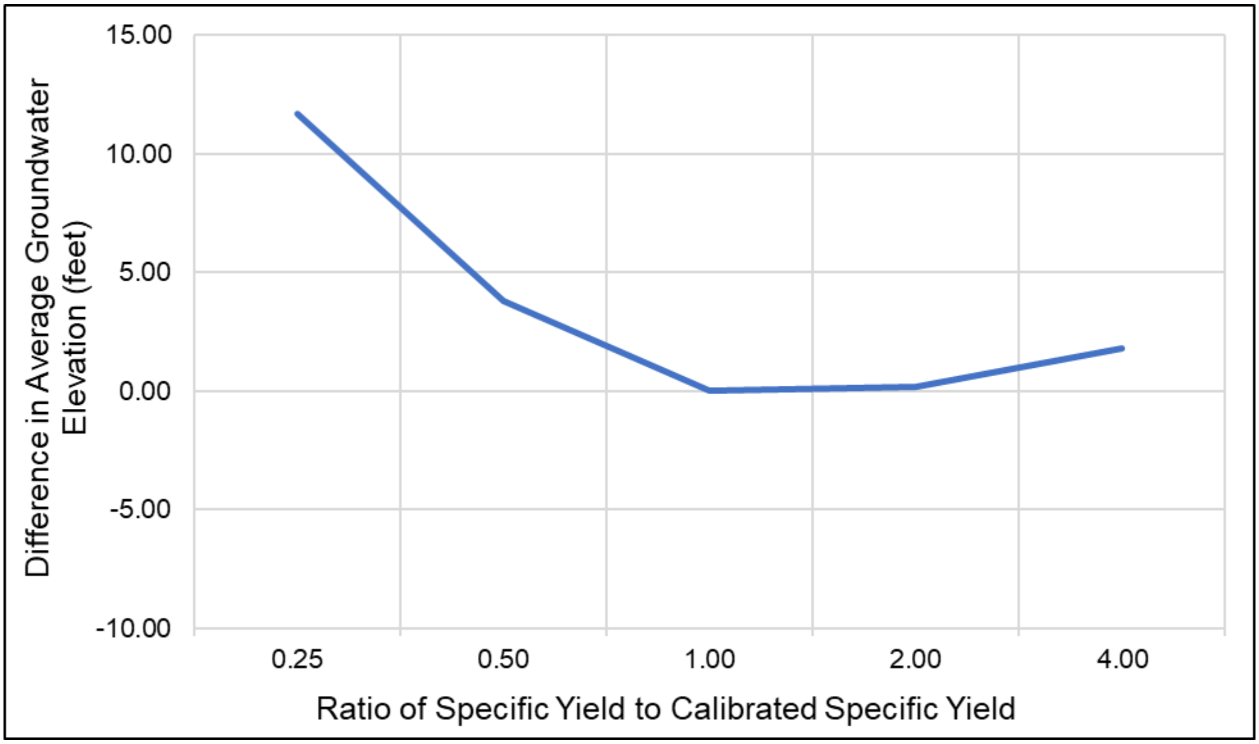


Figure 72: ESJWRM Sensitivity Analysis of Specific Yield – Relative Root Mean Square Error

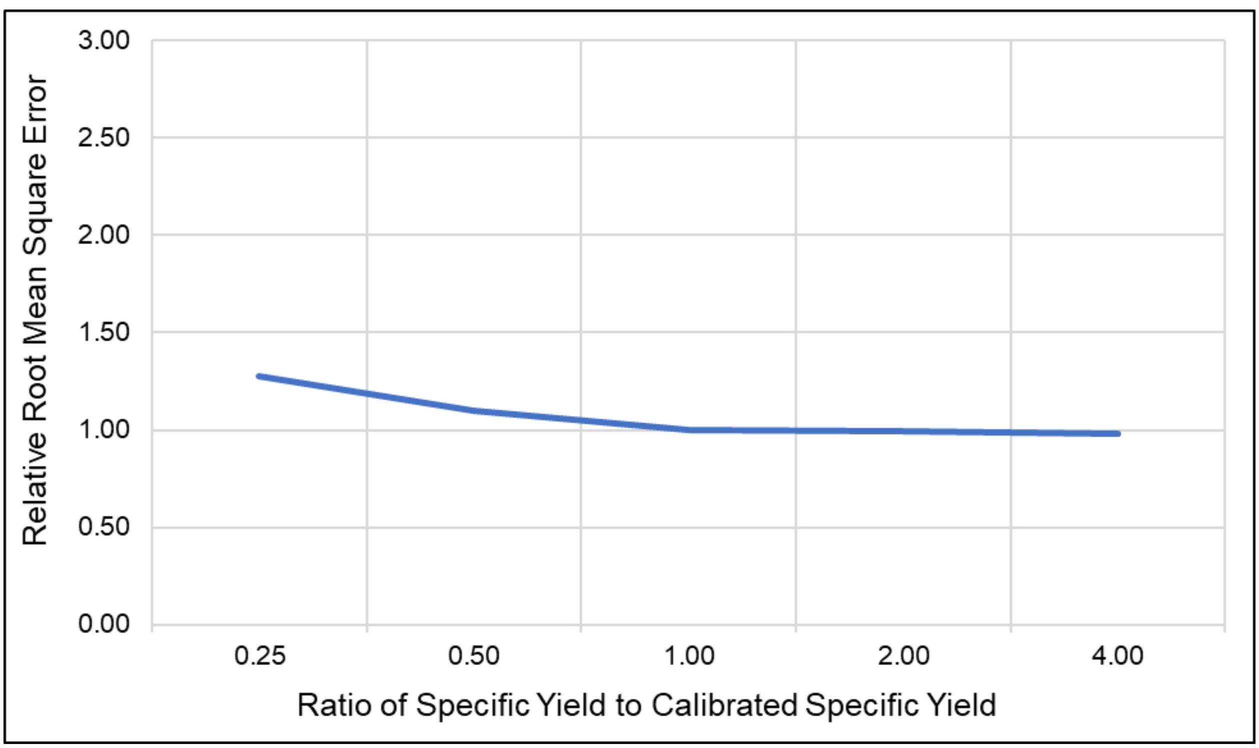


Figure 73: ESJWRM Sensitivity Analysis of Streambed Conductance – Difference in Average Groundwater Elevation (feet)

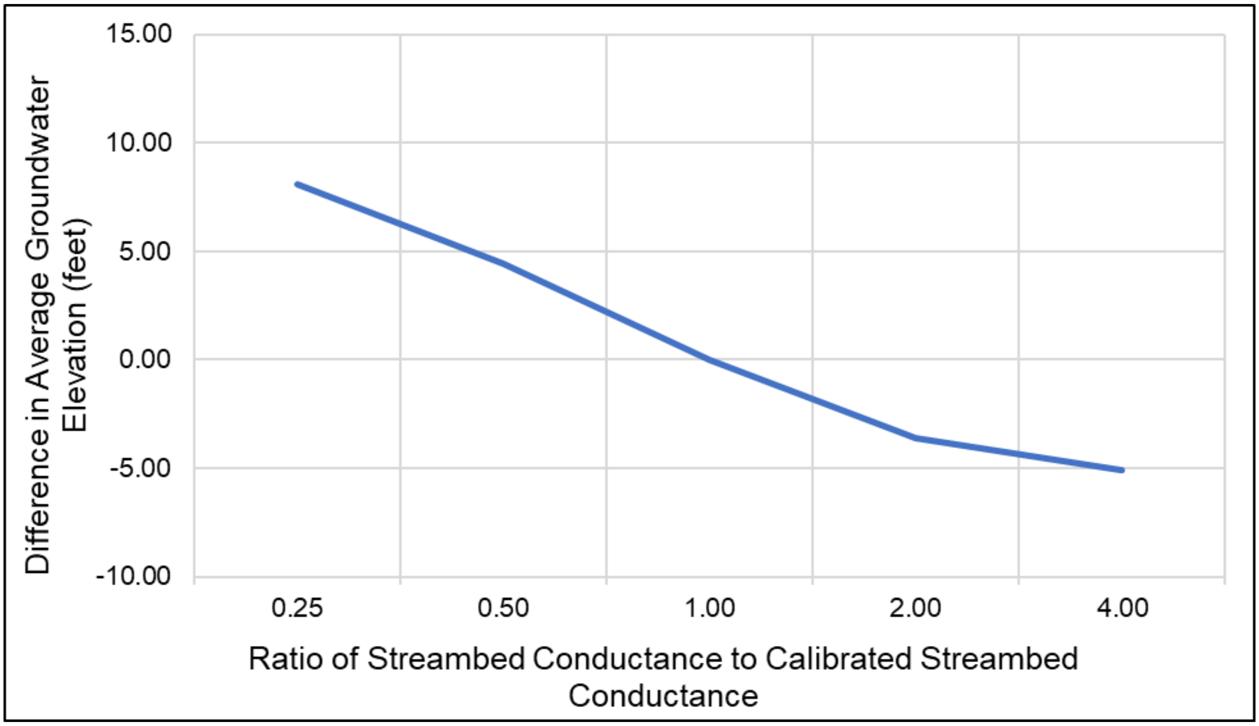
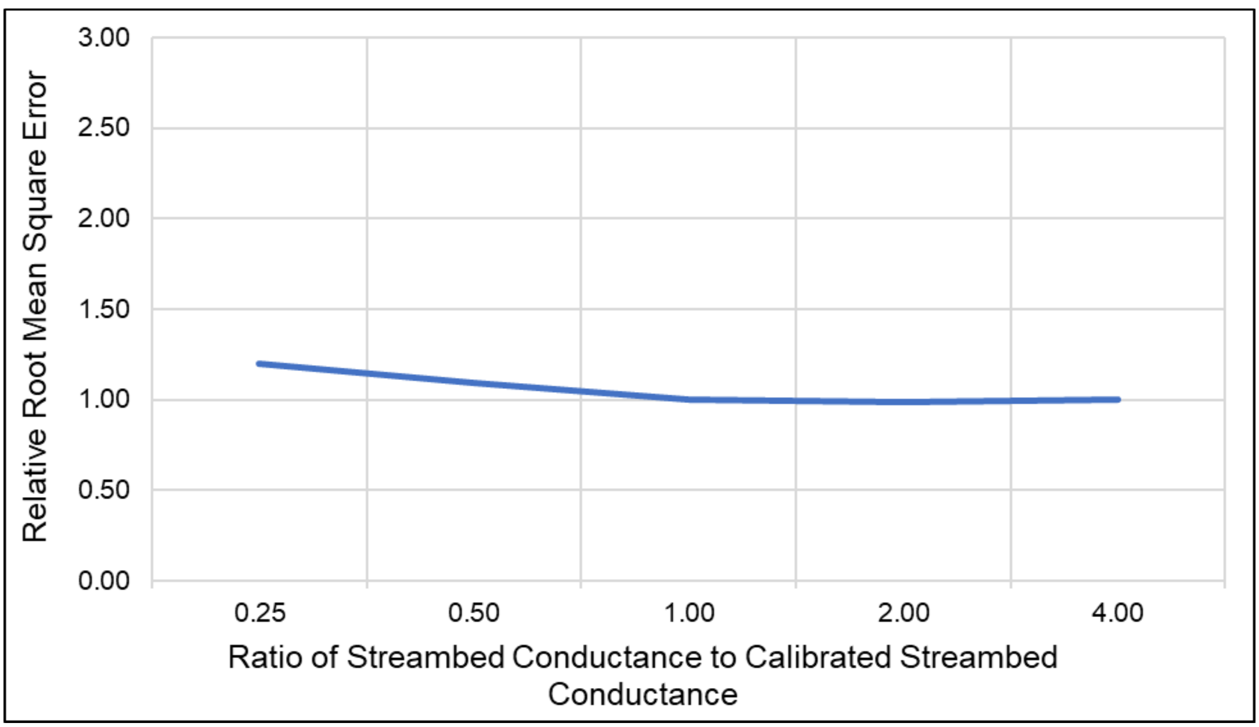


Figure 74: ESJWRM Sensitivity Analysis of Streambed Conductance – Relative Root Mean Square Error



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COMMITMENT & INTEGRITY DRIVE RESULTS

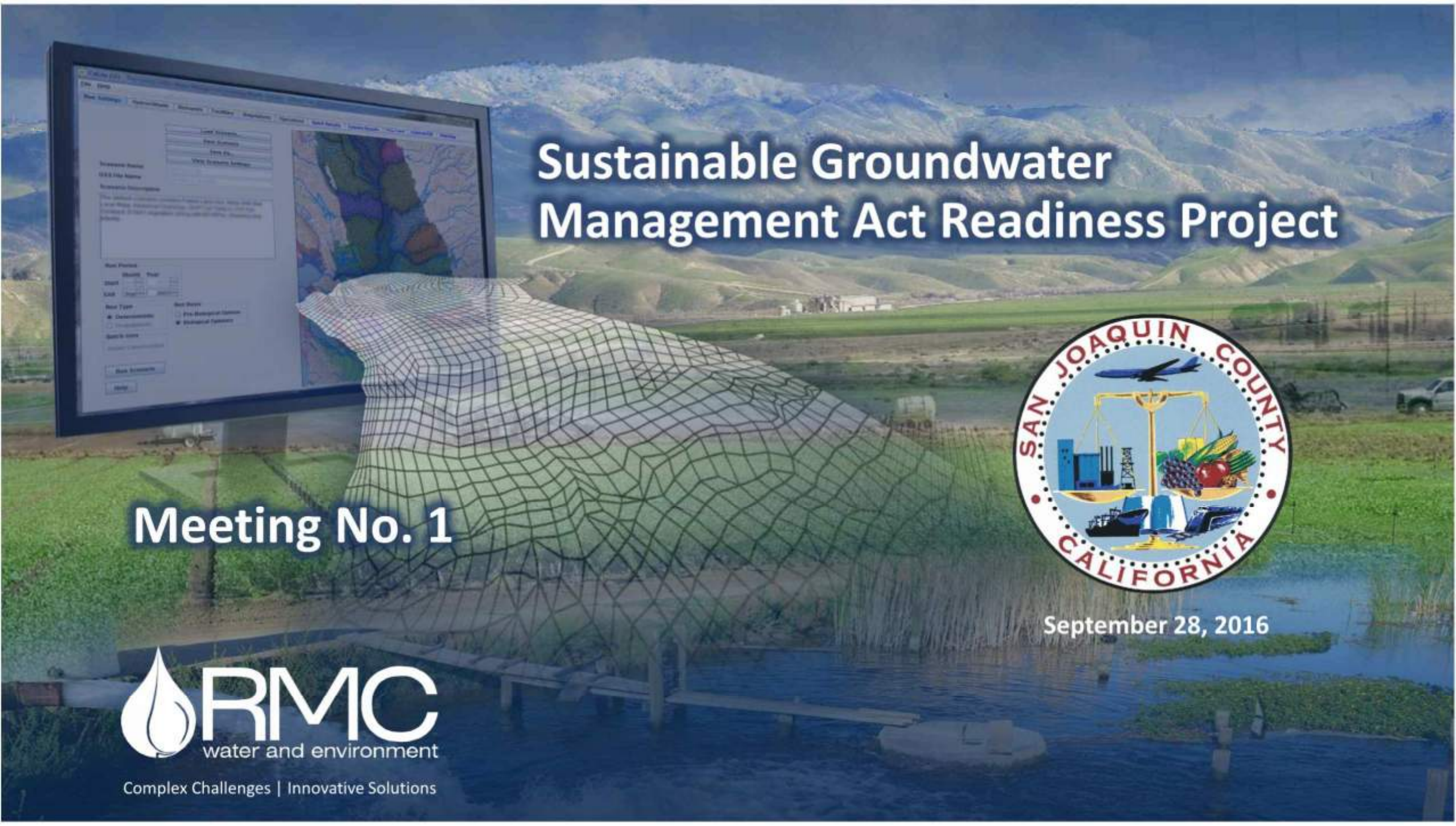
WOODARD & CURRAN

EASTERN SAN JOAQUIN WATER RESOURCES MODEL (ESJWRM)

Final Report Appendices

August 2018

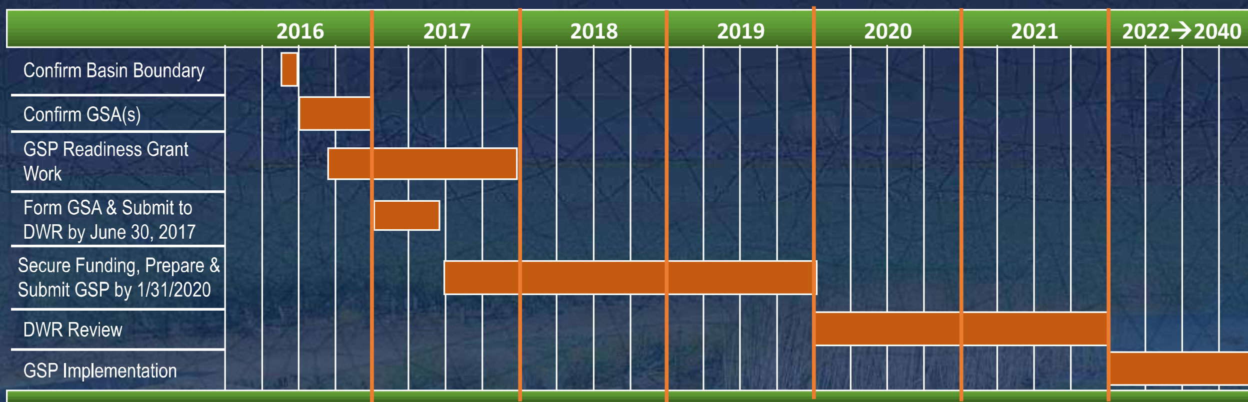
APPENDIX A: PRESENTATIONS TO TECHNICAL REVIEW COMMITTEE



Project Kick-Off Meeting
September 28, 2016
Agenda

- **Introductions**
- **Project Logistics**
- **Schedule**
- **Work Plan Review**
- **Issues/Concerns**
- **Coordination with Other On-Going Activities**
- **Other**

SGMA Timeline



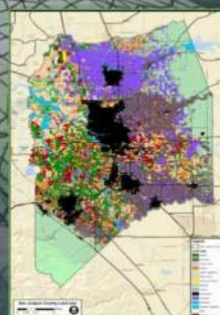
Project General Schedule

Our Approach Focuses on Delivering a Useful and Accepted Model that Meets Your Future Needs

CHALLENGE 1
Confirming Proposed Approach

CHALLENGE 2
Maintaining Compliance with DWR Funding Requirements

CHALLENGE 3
Augmenting Available Data Sources



CHALLENGE 4
Coordinating with Neighboring Regions and DWR

CHALLENGE 5
Flexibility to Adapt to Local Conditions and Operations

CHALLENGE 1
Confirming Proposed Approach

1 Determine Modeling Needs
- SGMA Requirements
- Long-term sustainable GW management
- Future scenarios

2 Define Objectives Select Model

DYNFLOW → IWFM VS. Refine C2VSim

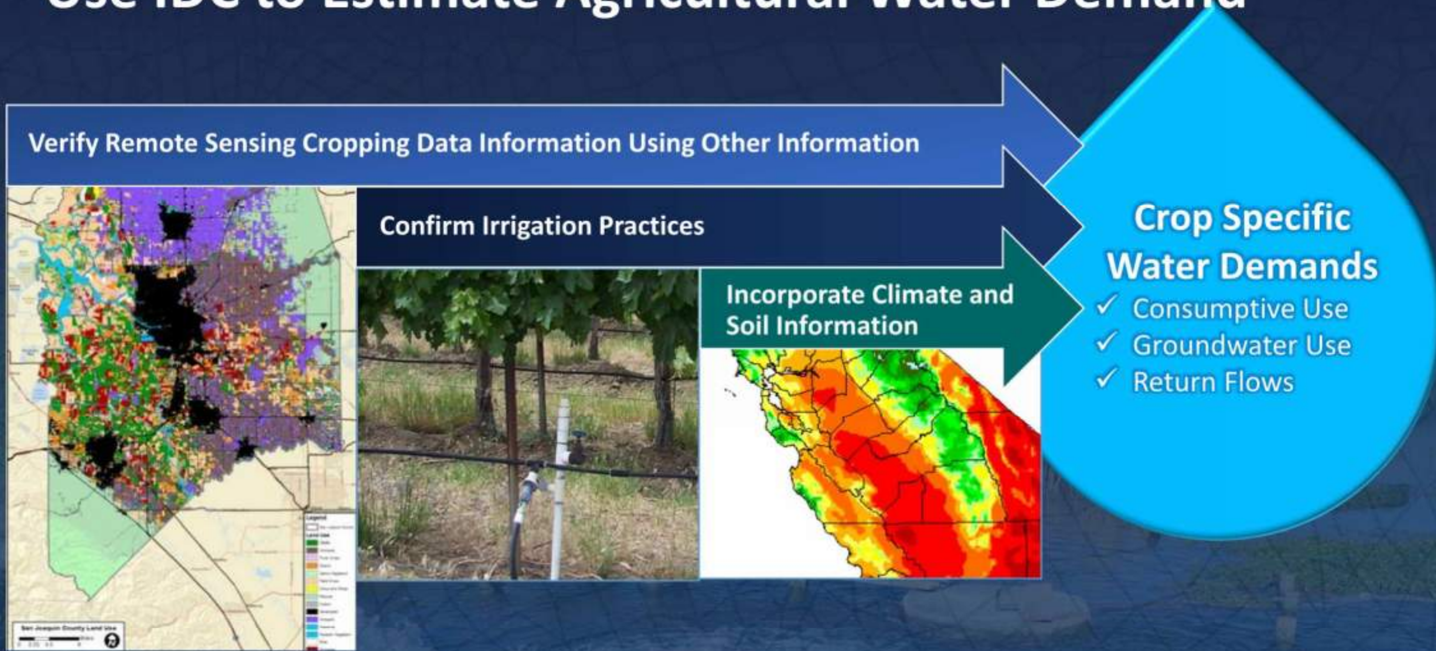
3 Build Model
- Non-Time Series Data
- Time Series Data

4 Calibrate Model
- Aquifer parameters
- GW Levels
- Stream flows

5 Perform Sensitivity Analyses
- Aquifer parameters
- Boundary conditions

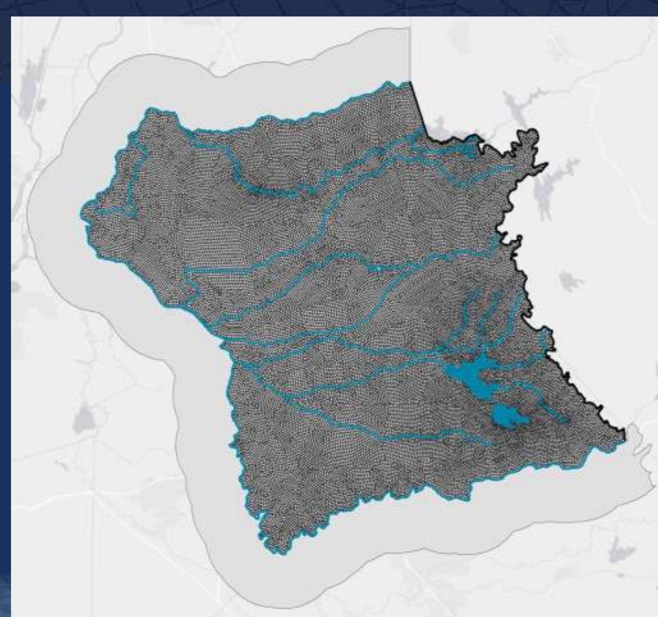
Utilize Model
- Historical calibrated model
- Future scenarios
- GW Monitoring Plan

Use IDC to Estimate Agricultural Water Demand



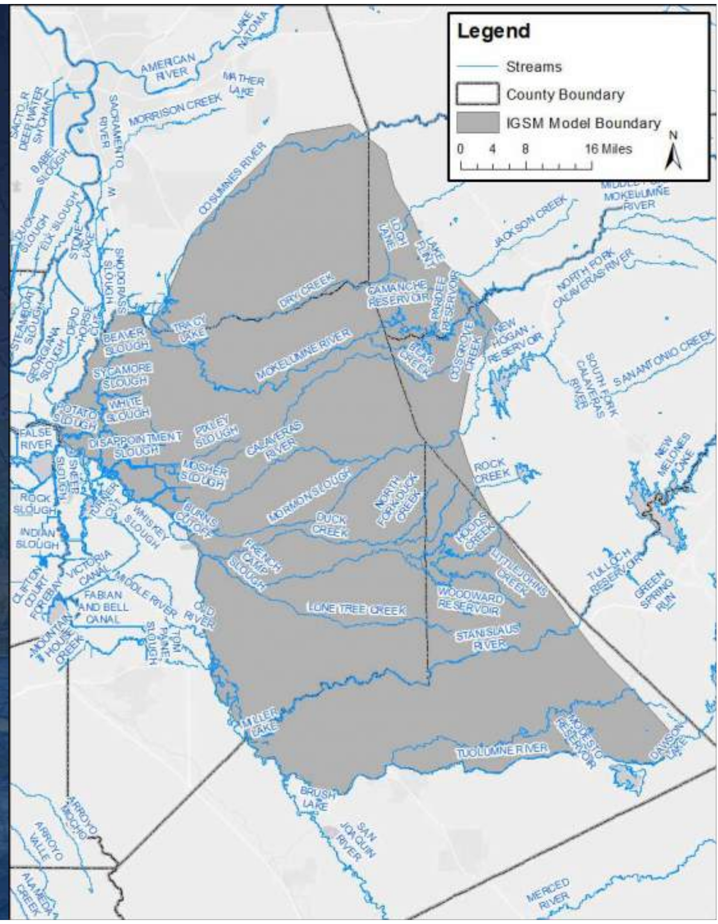
Need to confirm foundational modeling assumptions

- Model Platform
- Model Boundaries
- Hydrogeologic Conditions
- Hydrologic Period
- Calibration Period
- Hydrologic Features
- Management Regions
- Land Use and Cropping Patterns

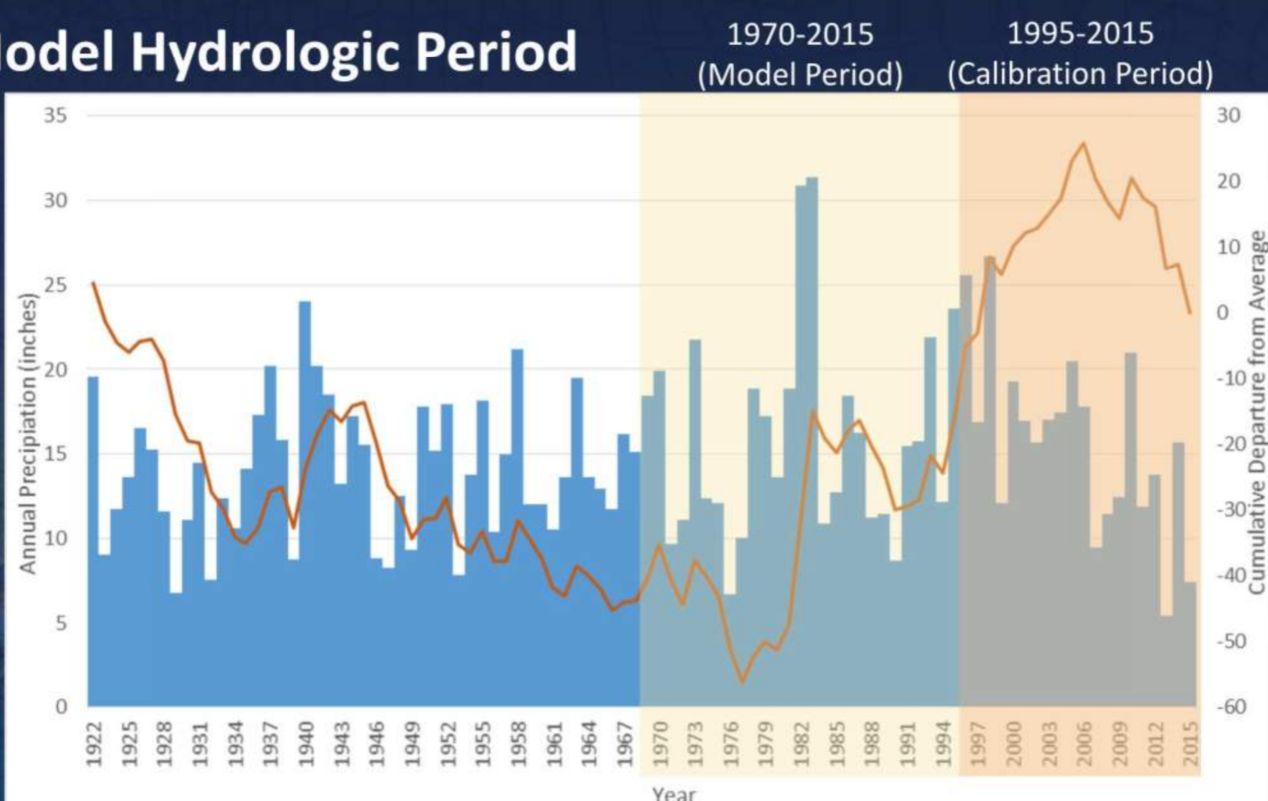


Model Features

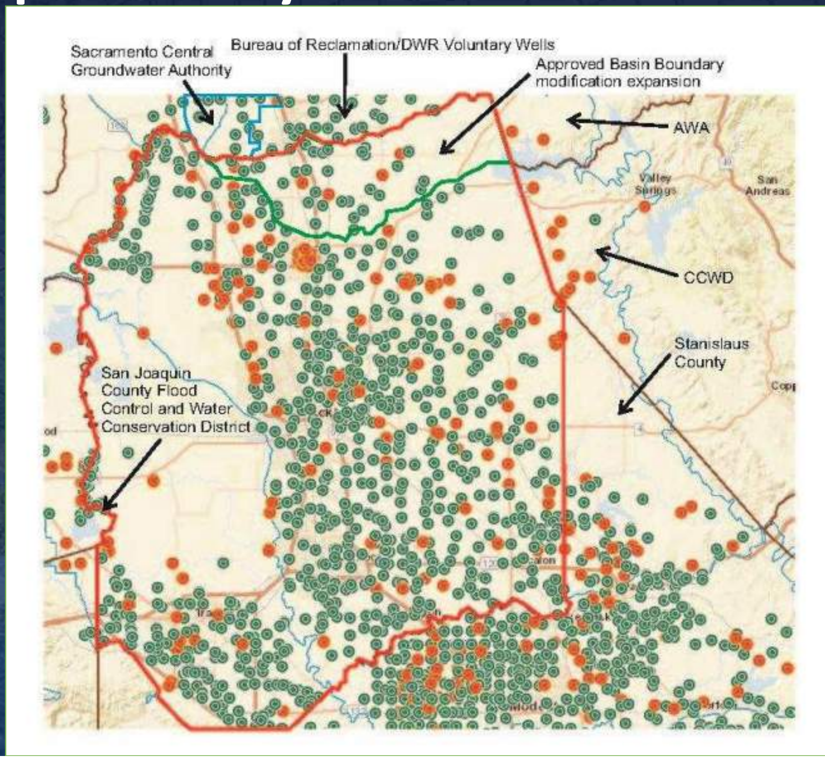
- Model Area
- ID/WD Boundaries
- GSA Boundaries
- Hydrologic Features



Model Hydrologic Period



San Joaquin County CASGEM Network

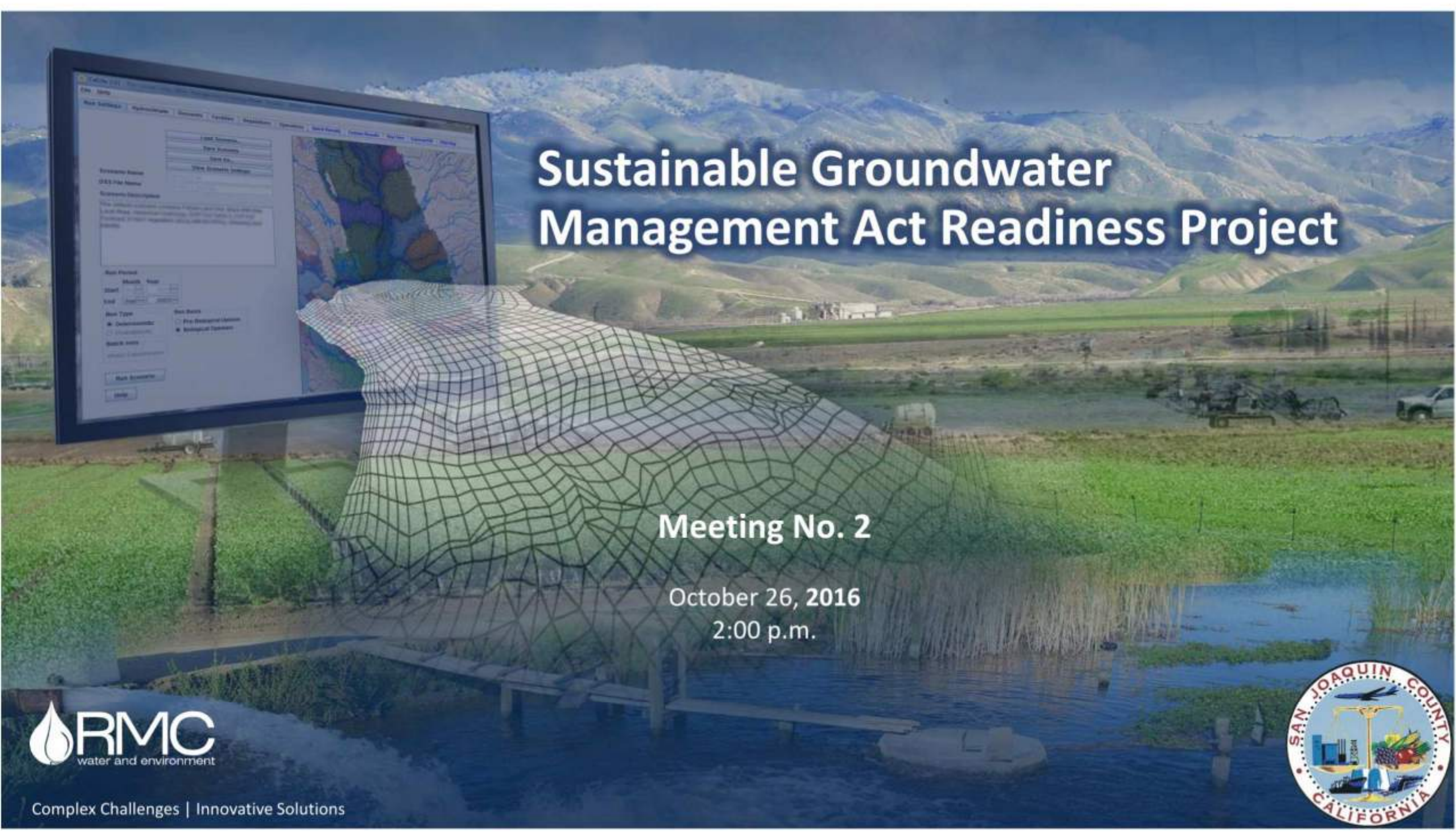


Water Quality Monitoring Program for DAC areas

- Utilize existing wells – coverage over data gaps
- Sampling of wells and water quality database management

What Data can Come from Existing Models?

Major Data Items/Types	C2VSim	DYNFLOW	Other Sources	RMC Scope
Topography	✓	✓	DEM	Only Data in DynFlow and C2VSim
Geology	✓	✓	USGS texture model, drillers logs	Only Data in DynFlow and C2VSim
Aquifer Parameters	✓	✓	USGS report	✓
Stream Geometry	✓		DWR floodplain program	Only for Rivers in Dynflow and C2VSim
Stream Flows	✓		USGS stream gages	Only for Rivers in Dynflow and C2VSim
Soil Parameters	✓	✓	SSURGO, STATSGO2	✓
Rainfall	✓		PRISM, weather stations	✓
Evapotranspiration	✓		CIMIS, Merced & SSID METRIC	Scope does not include DWR ET Maps; will report back, when data is available
Surface Water Diversion	✓	✓	Water providers, SWRCB	Only Data in DynFlow and C2VSim
Groundwater Pumping	✓	✓	Local knowledge, well permits	Municipal Pumping Rates in DynFlow and C2VSim; Ag Pumping estimated by IDC (Will need assessment of Vertical and Spatial distribution of pumping)
Land Use	✓	✓	DWR (LandIQ) LU survey, CropScape, AWMPs, Ag Commissioner Reports/Map, Local District Data	Will Evaluate the level of effort for processing LandIQ data, once its available, and report back on the level of effort



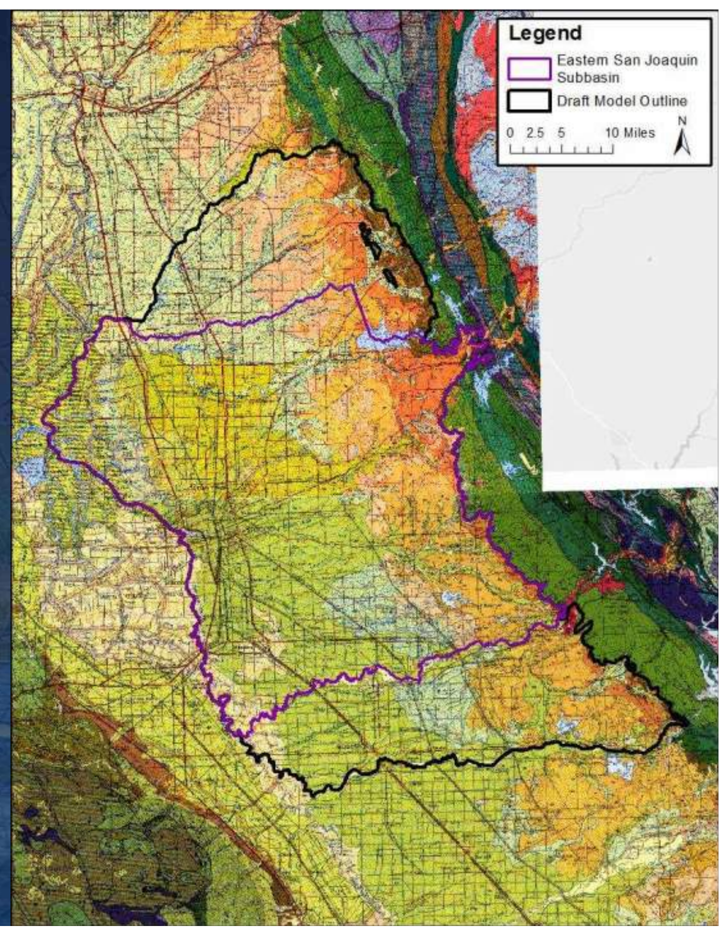
October 26, 2016
Discussion Topics

- **Model Area Boundaries**
- **Model Subregions**
- **Model Surface Water Courses**

Model Area Boundaries

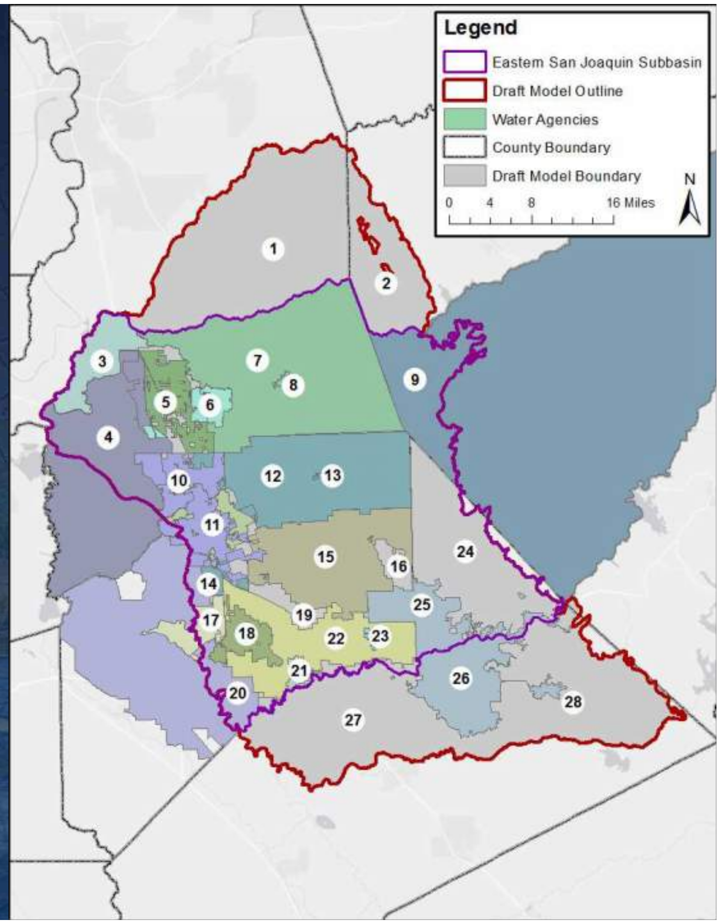
- Primary Area- DWR B-118 ESJ Subbasin
  - Major Formations:
    - Alluvium and Modesto/Riverbank
    - Flood Basin Deposits
    - Laguna
    - Mehrten
- Secondary Area- Cosumnes and Modesto GW Subbasins

California Geological Survey's regional geologic maps for the Sacramento (1981) and San Francisco (1991) quadrangles



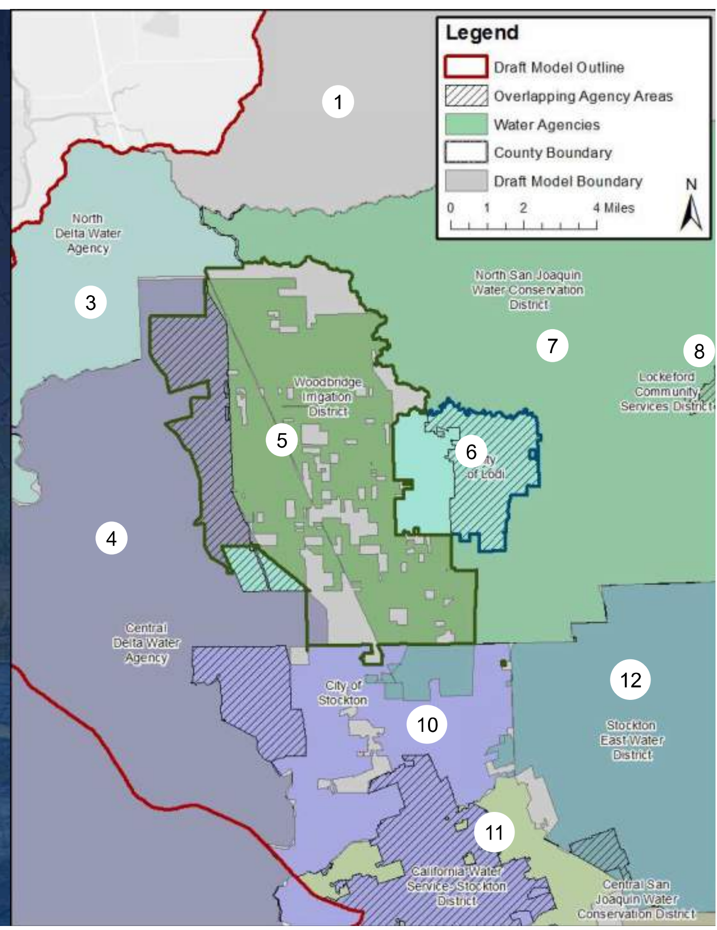
Model Subregions

- Plan to broadly delineate subregions by agency
- Issues:
  - Overlapping agencies
  - Discontinuous agency service areas, including “Swiss Cheese” areas
  - Areas of unincorporated county land



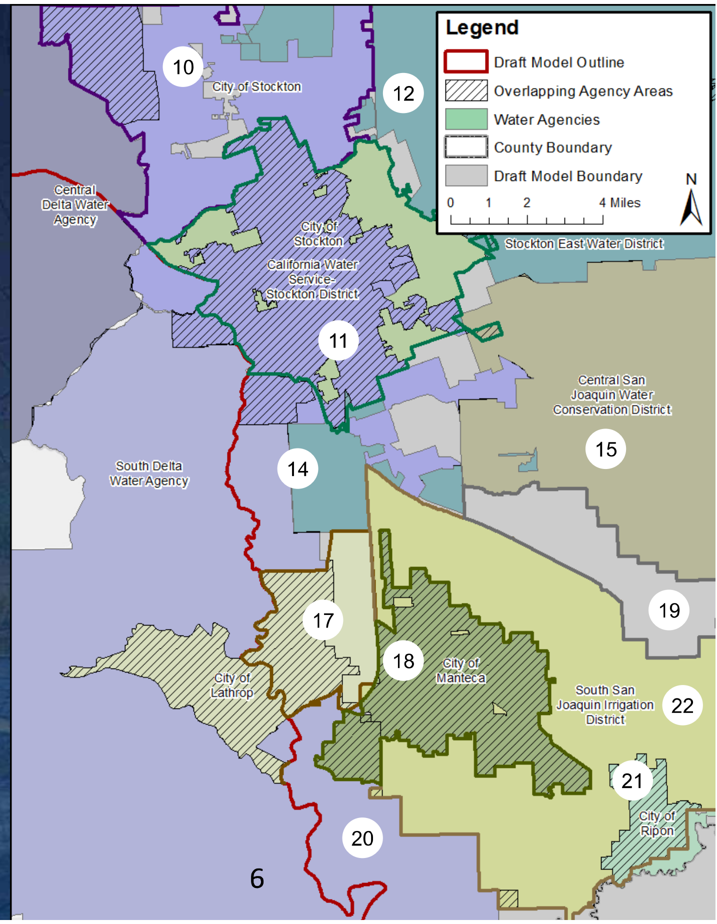
Example: Woodbridge ID Area

- Major overlaps between…
  - Central Delta Water Agency and Woodbridge Irrigation District
  - Central Delta Water Agency and City of Lodi
  - Central Delta Water Agency and City of Stockton
  - North San Joaquin Water Conservation District and City of Lodi
  - City of Stockton and California Water Service- Stockton District
- Woodbridge ID has “Swiss Cheese” exclusions in its service area
- Patches of unincorporated county land



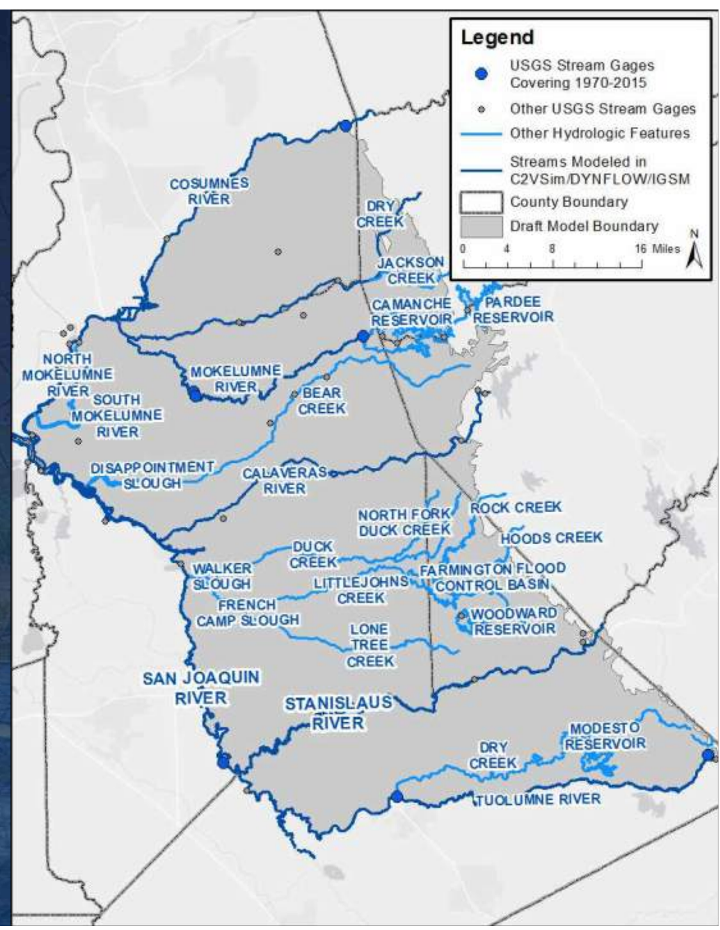
Example: South Stockton Area

- Major overlaps between…
  - California Water Service- Stockton District and City of Stockton
  - California Water Service- Stockton District and Stockton East Water District
  - California Water Service- Stockton District and Central San Joaquin Water Conservation District
  - South Delta Water Agency and City of Lathrop
  - South San Joaquin Irrigation District and City of Manteca
- Patches of unincorporated county land, including large area that could be own subregion (#19)



Streams Modeled in C2VSim, DYNFLOW, and IGSM Models

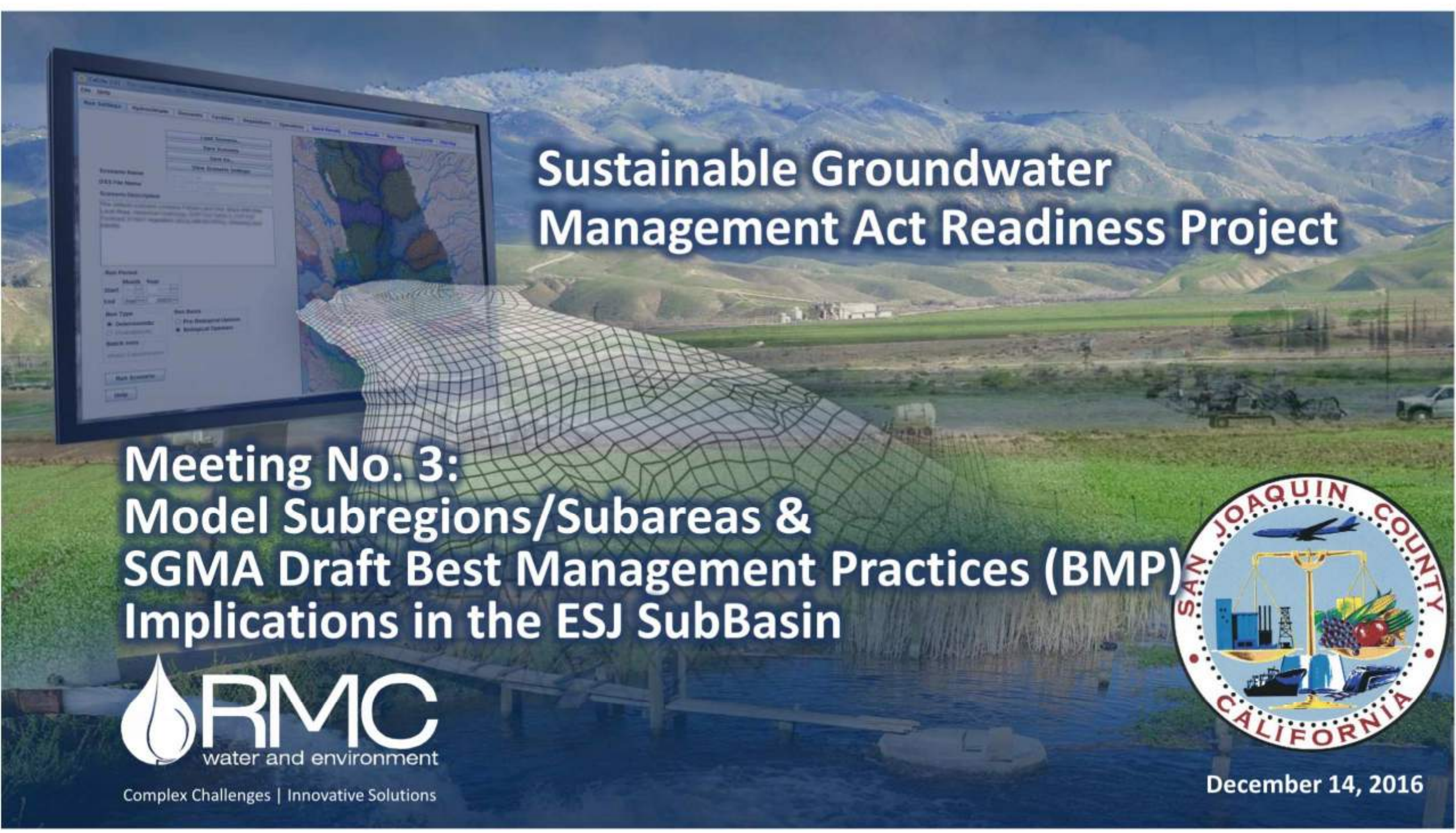
Stream Name	USGS Gage Covering 1970-2015?	Stream Geometry Available?
San Joaquin River	Yes	Yes
Cosumnes River	Yes	Yes
Dry Creek (near Mokelumne River)	No	Yes
Mokelumne River	Yes	Yes
Calaveras River	New Hogan Lake releases	Yes
Stanislaus River	Yes	Yes
Tuolumne River	Yes	Yes



Other Hydrologic Features

- Brown and Caldwell (January 1990) manual discussed seepage estimates in IGSM model for following features:
  - Calaveras River and Mormon Slough
  - Mokelumne River
  - Camanche Reservoir
  - Little Johns, Bear, Duck, and Lone Tree Creeks
  - Woodbridge Canals
  - Oakdale ID Channels
  - Woodward Reservoir
  - Farmington Flood Control Basin
- Annual seepage from studies of seepage per wetted acre, from information obtained from agencies (e.g., EBMUD, OID, and SSJID), or estimated from known seepage of nearby rivers

Stream Name	USGS Gage Covering 1970-2015?	Stream Geometry Available?
Jackson Creek	No	No
South Mokelumne River	No	No
Disappointment Slough	No	No
Bear Creek	No	No
Walker Slough	No	No
Duck Creek	No	No
North Fork Duck Creek	No	No
French Camp Slough	No	No
Little Johns Creek	No	No
Farmington Flood Control Basin	No	No
Rock Creek	No	No
Hoods Creek	No	No
Lone Tree Creek	No	No
Dry Creek (near Tuolumne River)	No	No
Camanche Reservoir	Potentially from East Bay MUD	
Pardee Reservoir	Potentially from East Bay MUD	
Woodward Reservoir	Potentially from South San Joaquin ID	
Modesto Reservoir	Potentially from Modesto ID	

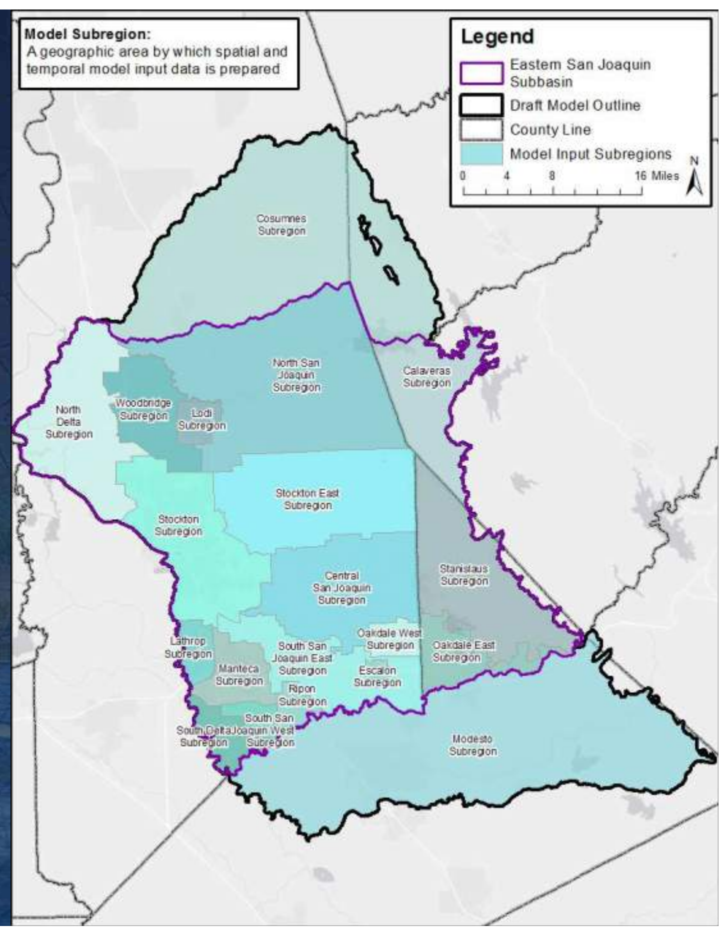


Description of ESJ GW Basin Hydrologic Model Subregions & Subareas

- Model Input Subregions - Proposed boundaries in the model domain for model input data collection and preparation
- Model Output Subareas - Proposed boundaries in the model domain for reporting model results

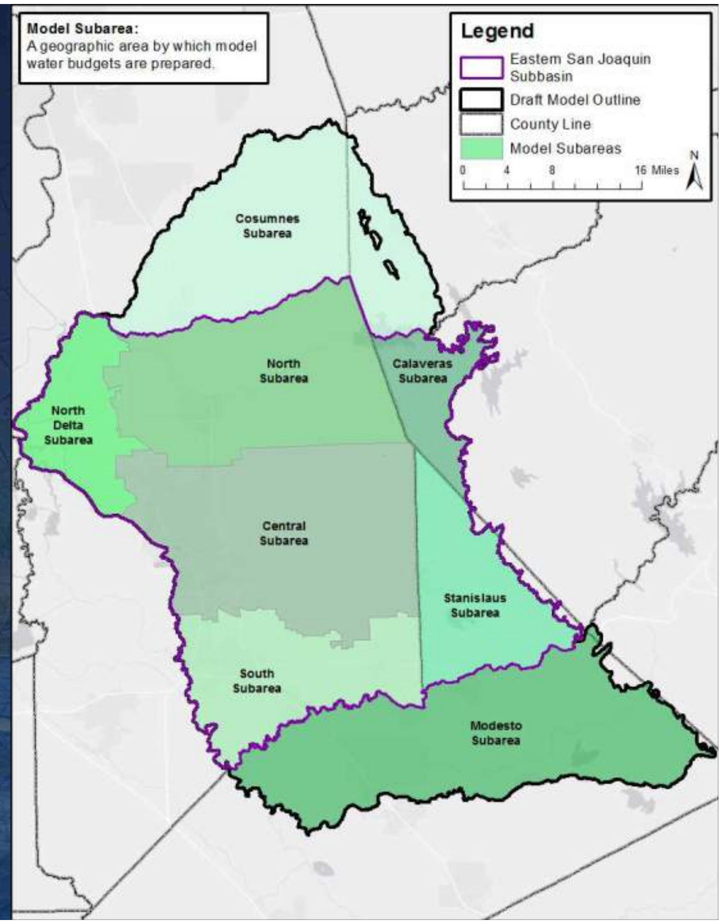
Model Input Subregions

- 20 subregions
- For data collection and preparation of model input files
- Used SOI boundaries as reference for cities



Model Output Subareas

- 8 subareas
- For model output and reporting of results



SGMA Draft Best Management Practices (BMP) Implications in the ESJ SubBasin

Purpose

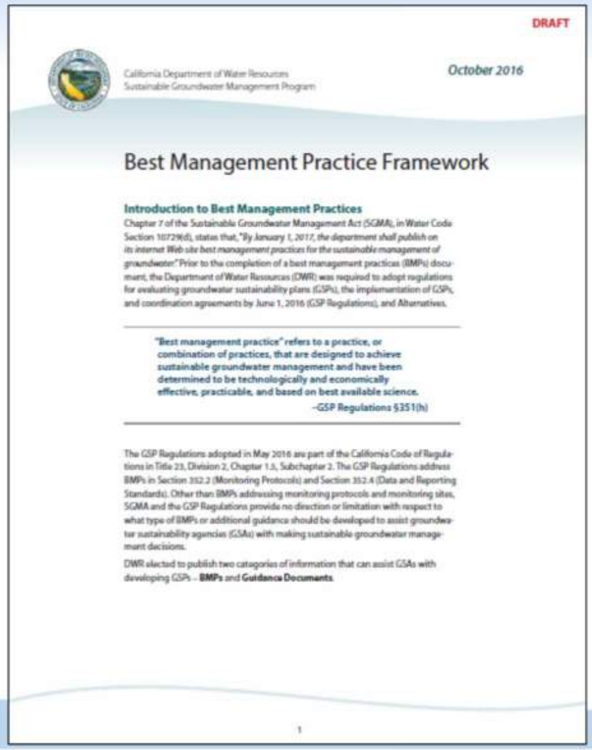
The purpose is to present the Draft SGMA Best Management Practices (BMP) as published by the DWR and discuss how the BMPs would apply to the implementation of SGMA in ESJ GW SubBasin.

Slides in Light Blue are from DWR

Slides in Dark Blue are our interpretations for application to ESJ Basin

SGMA BMP Overview
Draft BMP Framework and Intent

- Definitions
  - BMPs – DWR technical assistance
  - Guidance Documents - informational
- How to Utilize
  - Optional – do not create new requirements
  - Documents are not a substitute for GSP Regulations
- Organization/Workflow
- Identify Future Documents and Revisions
- Relationship with other BMPs



DRAFT

California Department of Water Resources
Sustainable Groundwater Management Program

October 2016

Best Management Practice Framework

Introduction to Best Management Practices

Chapter 7 of the Sustainable Groundwater Management Act (SGMA), in Water Code Section 10729(d), states that, "*By January 1, 2017, the department shall publish on its internet Web site best management practices for the sustainable management of groundwater.*" Prior to the completion of a best management practices (BMPs) document, the Department of Water Resources (DWR) was required to adopt regulations for evaluating groundwater sustainability plans (GSPs), the implementation of GSPs, and coordination agreements by June 1, 2016 (GSP Regulations), and Alternatives.

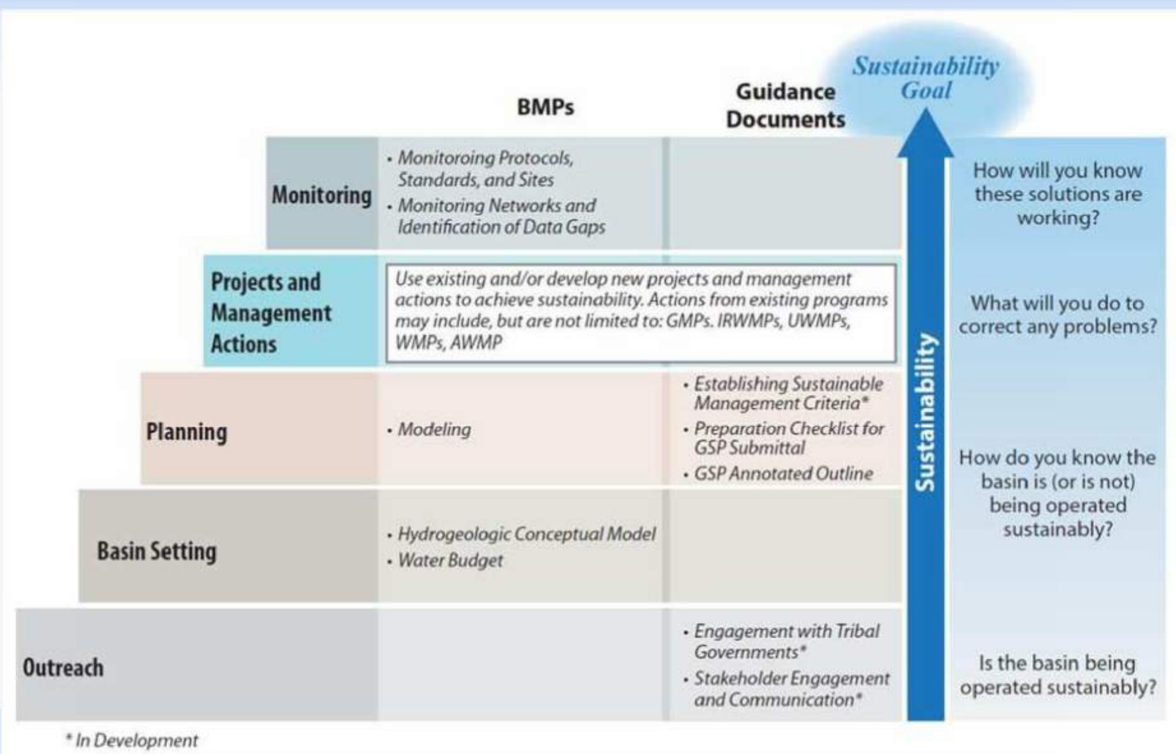
> **"Best management practice" refers to a practice, or combination of practices, that are designed to achieve sustainable groundwater management and have been determined to be technologically and economically effective, practicable, and based on best available science.**
> **–GSP Regulations §351(h)**

The GSP Regulations adopted in May 2016 are part of the California Code of Regulations in Title 23, Division 2, Chapter 1.5, Subchapter 2. The GSP Regulations address BMPs in Section 352.2 (Monitoring Protocols) and Section 352.4 (Data and Reporting Standards). Other than BMPs addressing monitoring protocols and monitoring sites, SGMA and the GSP Regulations provide no direction or limitation with respect to what type of BMPs or additional guidance should be developed to assist groundwater sustainability agencies (GSAs) with making sustainable groundwater management decisions.

DWR elected to publish two categories of information that can assist GSAs with developing GSPs – **BMPs** and **Guidance Documents**.

1

SGMA BMP Overview – BMP Building Blocks



BMP # 1 – Monitoring Protocols, Standards, and Sites

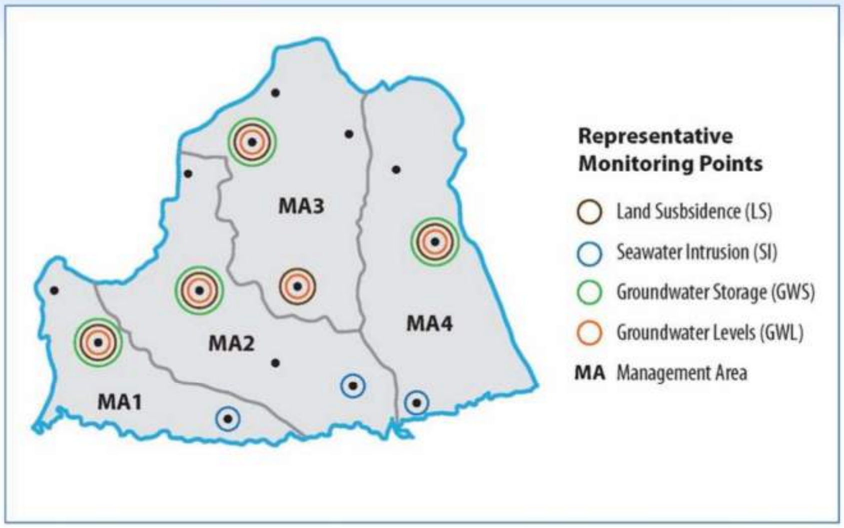
- Protocols for:
  - Establishing Monitoring Sites
  - Measuring GW Levels
  - Sampling GW Quality
  - Monitoring Seawater Intrusion
  - Measuring Streamflow
  - Measuring Subsidence

SGMA BMP 1: How It Applies to San Joaquin County SGMA Readiness Project

- Historical County program meets the intent of the BMP
- Review monitoring site unique identifiers for GIS
  - All monitoring locations update horizontal control; long term lease or access agreement review
- Compare existing monitoring protocols to determine necessary adjustments
  - Stream and sea-water intrusion locations, water quality and subsidence assessment protocols need to be updated
- Incorporate protocols and standards into GSP development for specific elements
  - Measurable indicators of sustainability

BMP # 2 – Monitoring Networks and Identification of Data Gaps

- General Monitoring Networks
  - Improvement of Monitoring Network

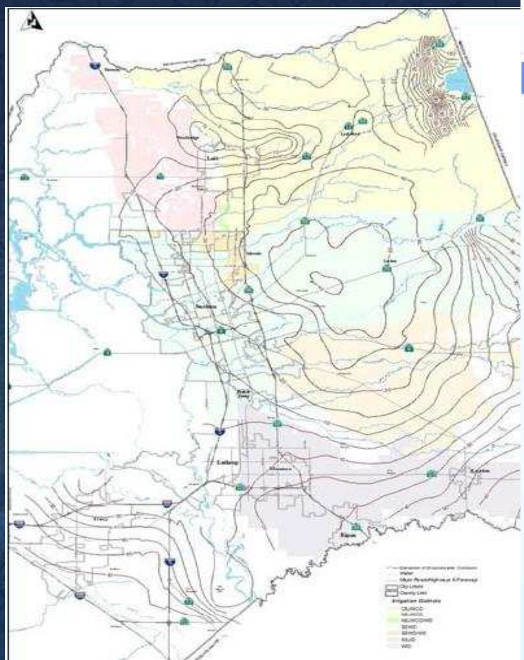


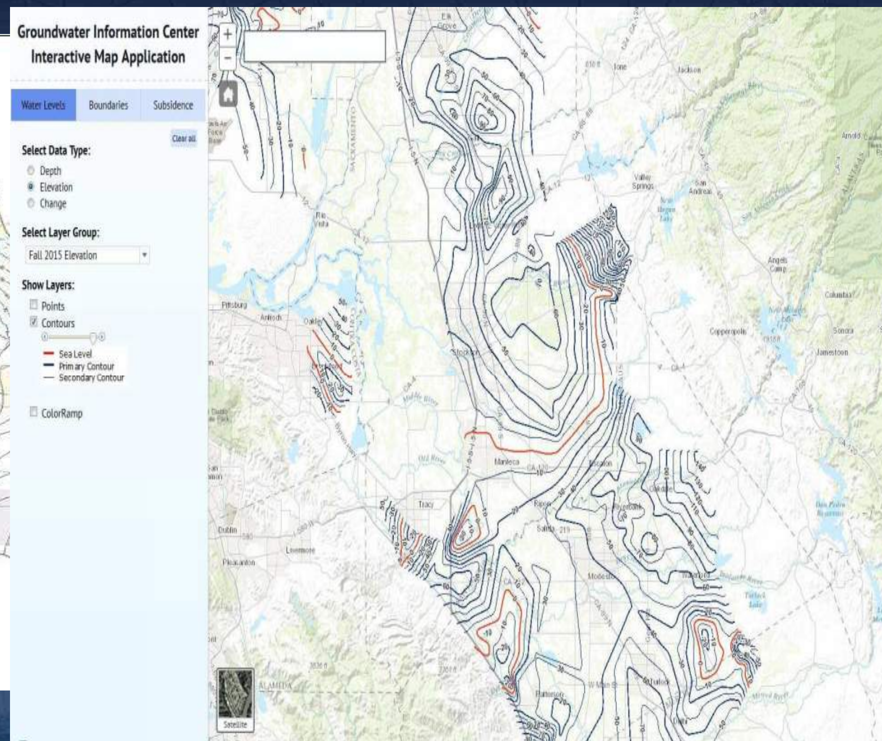
- Specific Monitoring Networks

SGMA BMP 2: How It Applies to San Joaquin County SGMA Readiness Project

- Historical Network meets the intent of the BMP
  - Spacing and seasonal and long-term trends established
- Assessment of adjustments to existing monitoring networks (CASGEM and Future Hydro Model)
  - Data gaps, shallow and deep aquifers, known well construction information, installation of new monitoring wells (State funding?)
  - Expansion on approved network (County and E-Pur Data)
  - Monitoring wells are needed east and at the base of the fresh water
- Coordination with County and State agencies to acquire well log information; coordination with land owners for long-term access
- Determination of high and low gw use areas with measurable indicators (modeling coordination)

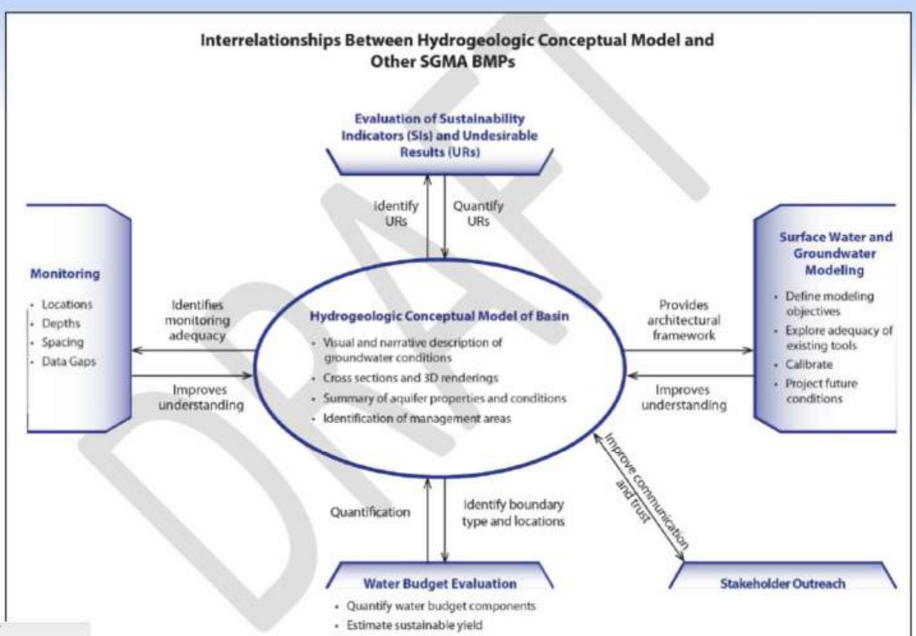
Known Data Gaps - Observed Critical Areas for Recharge and Overdraft

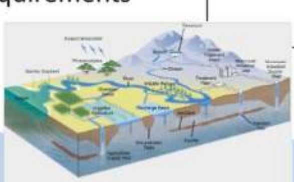


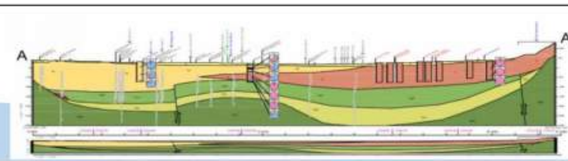


BMP # 3 – Hydrogeologic Conceptual Model

- Characterizing Physical Components
  - Geologic and structural boundaries
  - Lateral boundaries
  - Bottom of the basin
  - Principal Aquifers and Aquitards
  - Graphical Representation
- Mapping Requirements





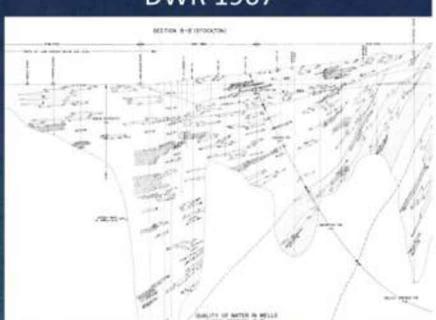


SGMA BMP 3: How It Applies to San Joaquin County SGMA Readiness Project

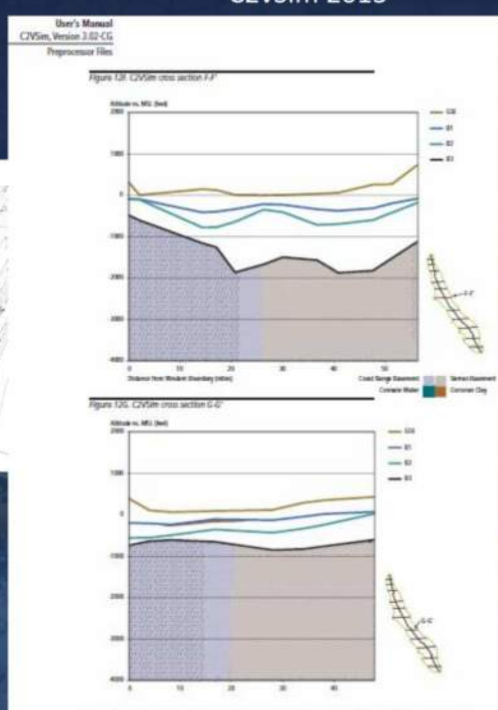
- Extensive base of existing knowledge for HCM
  - J.Montgomery, 1990, CH2MHill & Papadopoulous 2006, Taghavi 2000, 1967 Bulletin 146 – Great start for data from surface to ~400 feet; other known sources with well log information
- Data gaps in deep well logs and limited number of wells
  - More well logs >400 feet
  - Aquifer data, base of fresh aquifer, saline aquifer, bedrock Eastern Margin Area
- Coordination with DWR for technical assistance for guidance and direction on data acquisition (well logs)

Schematic Hydrogeo Cross-Sections Compared and Refined

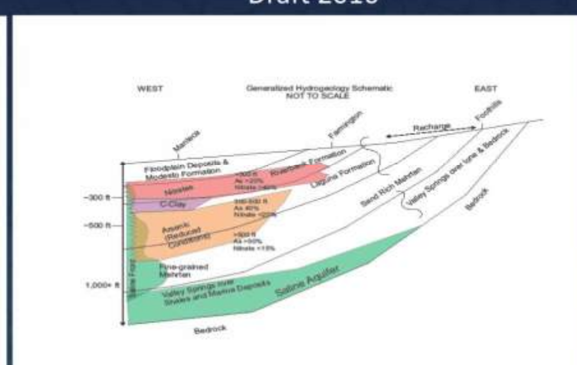
DWR 1967

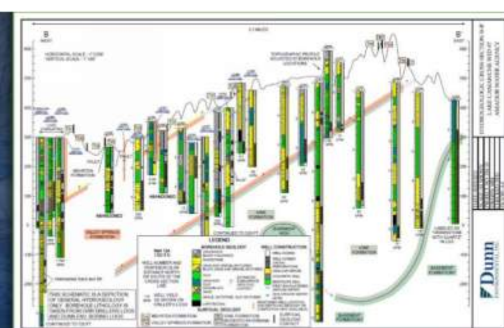


C2vSim 2013



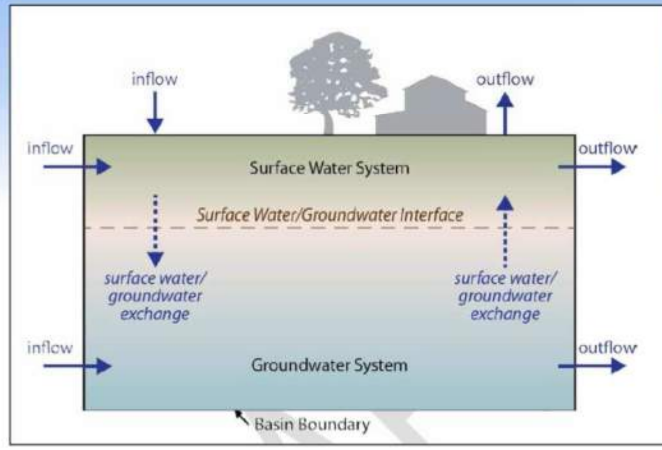
Draft 2016





BMP # 4 – Water Budget (WB)

- General WB Requirements
  - Certification
  - WB Data, Information, and Modeling Requirements
  - Defining Basin Area and Water Budget Systems
  - Accounting and Quantification of WB Components
- Tabular and Graphical Representation of WB Components
- Defining WB Time Frames
  - Current, Historical, Projected



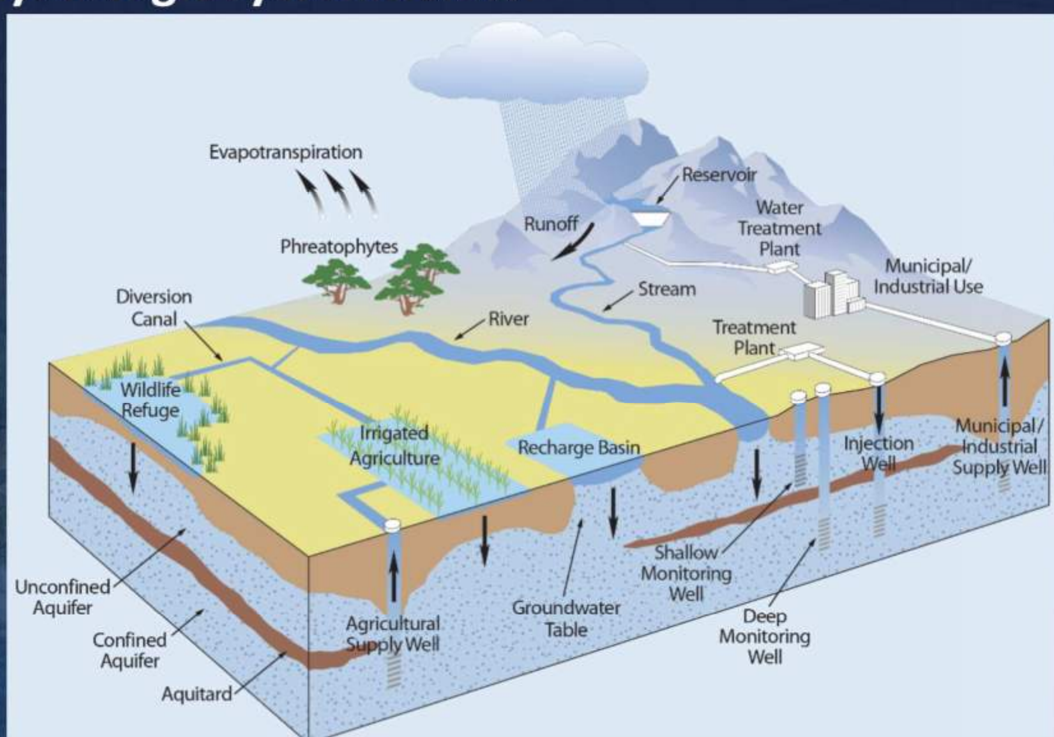
Water Year:
Water Year Type:

INFLOWS		OUTFLOWS	
Inflow Source	Volume (af/yr)	Outflow Sink	Volume (af/yr)
Surface Water Inflow\1		Surface Water Outflow\1	
Precipitation		Evapotranspiration\4	
Subsurface Groundwater Inflow		Subsurface Groundwater Outflow	
Total Basin Inflow		Total Basin Outflow	
Subsurface Groundwater Inflow		Subsurface Groundwater Outflow	
Infiltration of Precipitation		Groundwater Extraction\1	
Infiltration from Surface Water Systems\2		Discharge to surface water systems\2	
Infiltration of Applied Water\3			
Total Groundwater Inflow		Total Groundwater Outflow	

Change in Surface Storage Volume	
Change in Groundwater Volume	

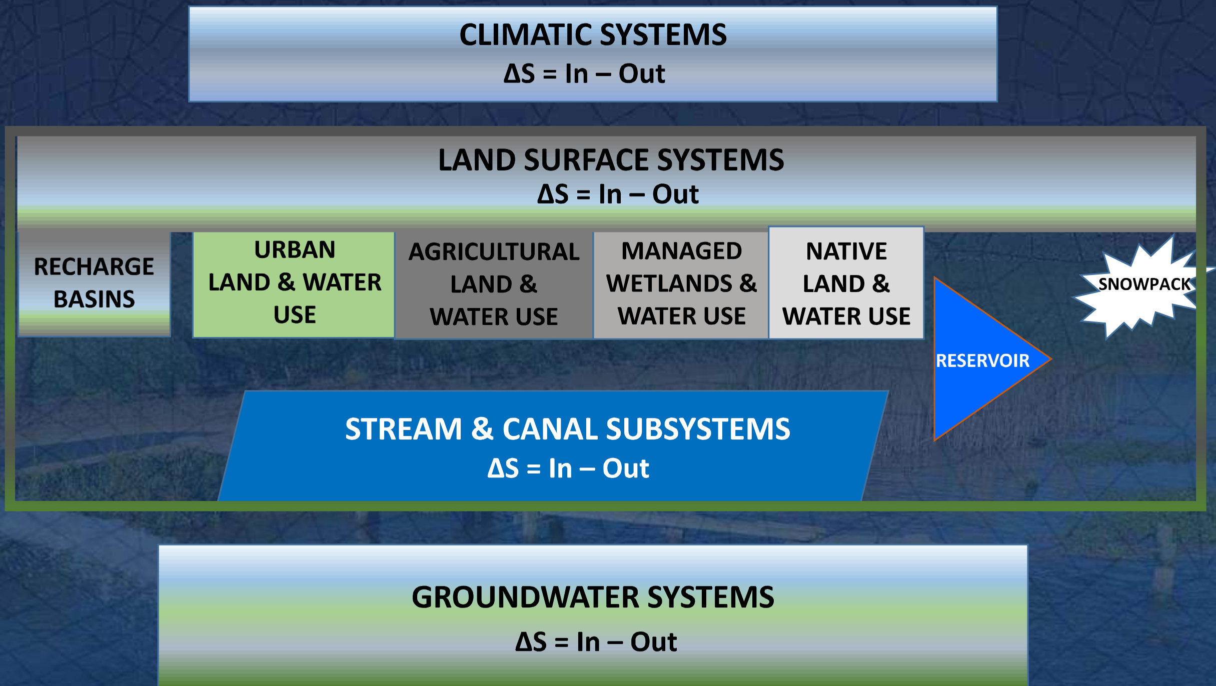
\1 by water source type
\2 lakes, streams, canals, springs, conveyance systems
\3 includes applied surface water, groundwater, recycled water, and reused water
\4 by water use sector

Water budget
A hydrologic systems view

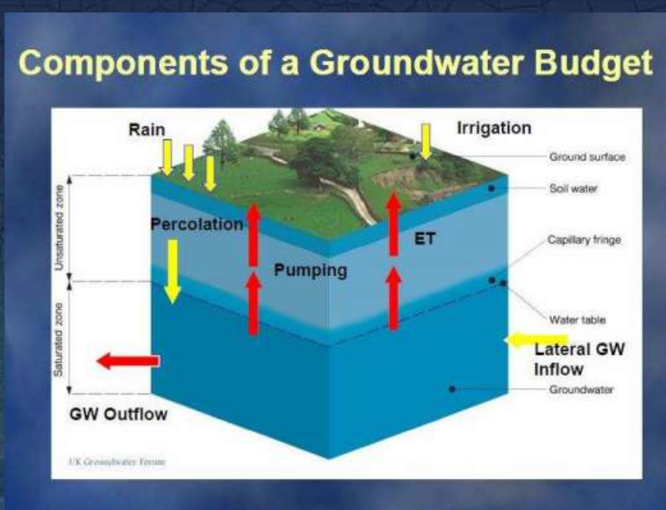


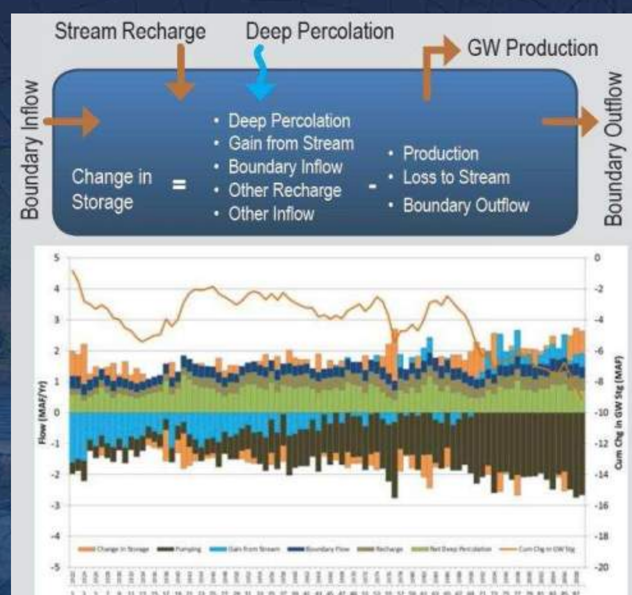
Systems Accounting

Change in storage =
water entering minus water leaving



Water Budget Components





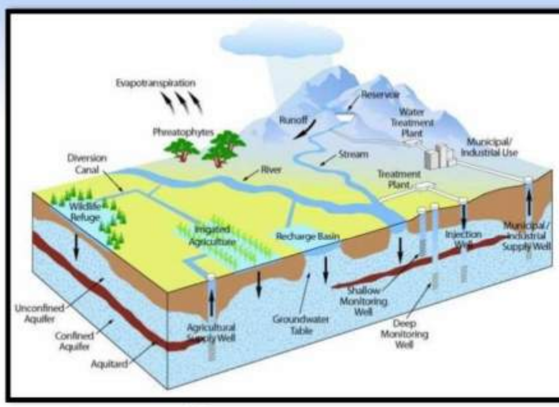
SGMA BMP 4: How It Applies to San Joaquin County SGMA Readiness Project

- Coordination with all GSPs in the basin
- Reporting WB for the basin and by subareas
- Evaluation of GW storage conditions - current and historical WB evaluations; projects/management actions for mitigation
- Sustainable yield assessment - current, historical, and projected WB conditions
- Forecasting future projected WB assessment & management actions - over 50-year planning/ implementation horizon with climate change

BMP # 5 – Modeling

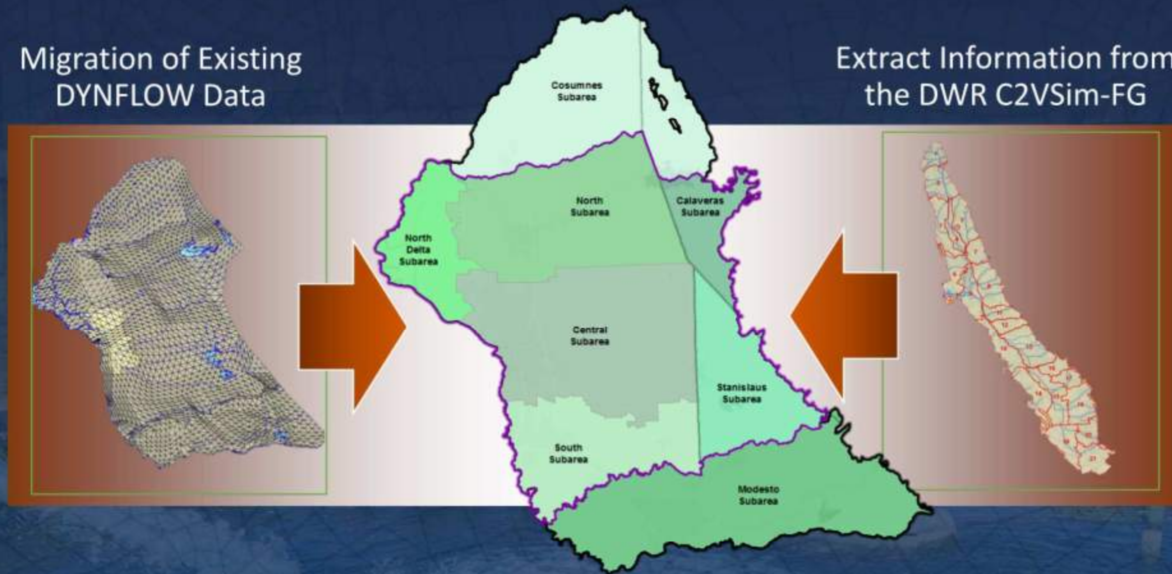
Fundamentals
- Types of Models, Software, Uses
- Models Used for SGMA

Technical Assistance
- Guiding Principles For Models
- General Modeling Requirements



- Modeling Considerations
  - Addressing Sustainability Indicators
    Lowering GW Levels | Reduction of Storage | Seawater Intrusion | Degraded Quality | Land Subsidence | Surface Water Depletion
  - Developing Water Budgets
  - Forecasting Future Conditions, Projects, Actions
  - Assessing Impacts on Adjacent Basins
- Groundwater Modeling Process
- Related References and Guidance Material

ESJ Integrated Hydrologic Model will benefit from Basin-scale models and previously developed local models and data



ESJ GW Basin Hydrologic Model Development Approach

1 Determine Modeling Needs
- Incorporate SGMA requirements
- Consider long-term sustainable GW management options
- Consider management scenarios

2 Define Objectives Select Model

Build Model based on IWFM framework

3 Build Model
- Define Model Subregions and SubAreas
- Develop IDC & Ag demand
- Develop Model data

4 Calibrate Model
- Calibrate IDC
- Calibrate to GW levels
- Calibrate to streamflows
- Develop Historical Water Budgets

5 Perform Sensitivity Analyses
- Aquifer parameters
- System Stresses
- Boundary conditions

Utilize Model
- Develop Baselines
- Perform Management scenarios
- Conduct Sustainability Analysis
- Develop Water Budgets
- Develop GW Monitoring Plan

Ad-Hoc Technical Committee Participation
Regular Reports to SGMA Workgroup
DWR Coordination

Sustainable Groundwater Management Act Readiness Project

Meeting No. 4: Model Grid Development, Model Hydrologic Data, and Model Data Request

RMC water and environment

Complex Challenges | Innovative Solutions

January 25, 2017

ESJ GBA AdHoc Technical Committee Meeting No. 4 January 25, 2017

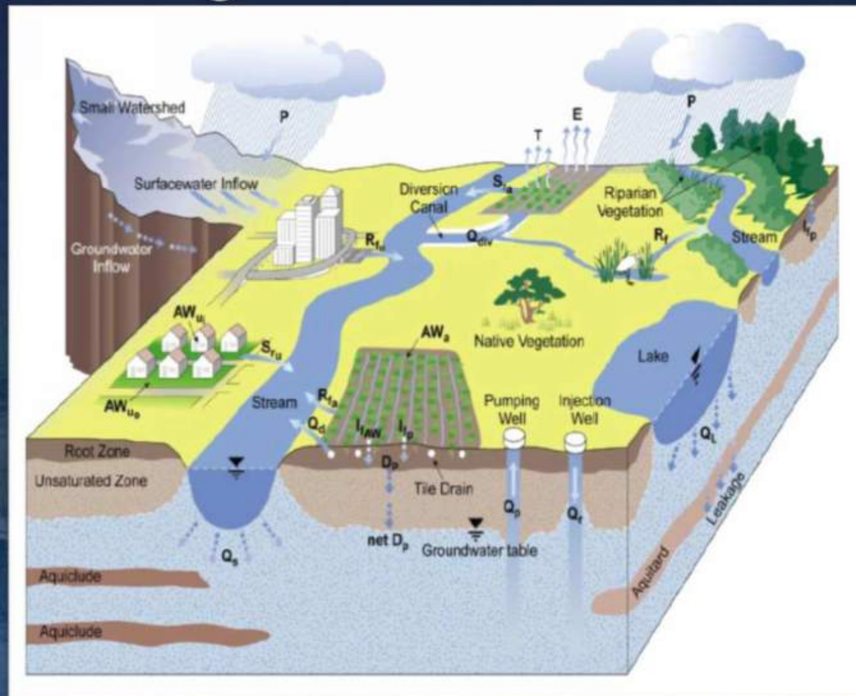
Agenda

- Model grid development
- Model hydrologic period and data
- Status of data request

RMC water and environment

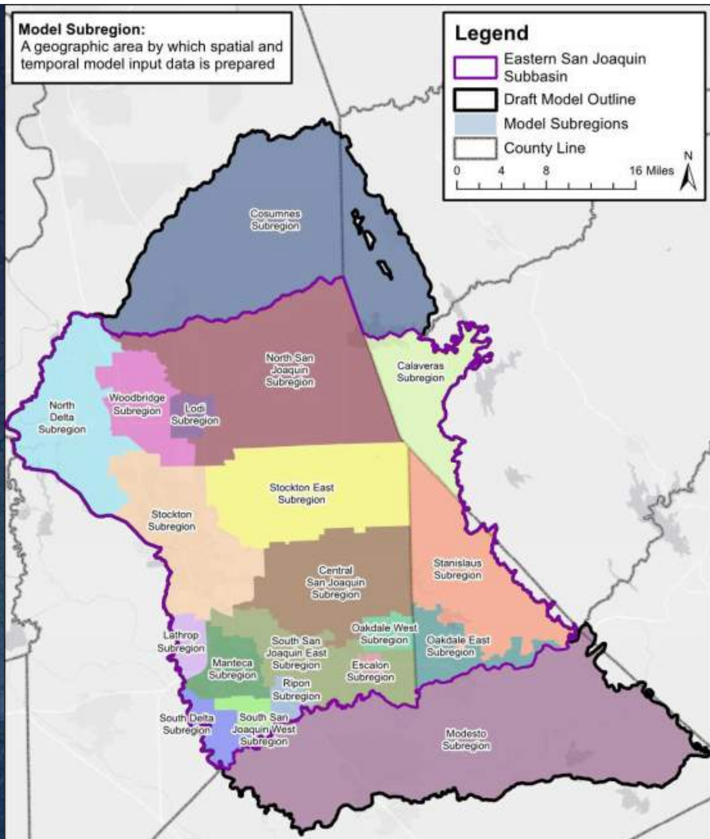
Integrated Hydrologic Modeling

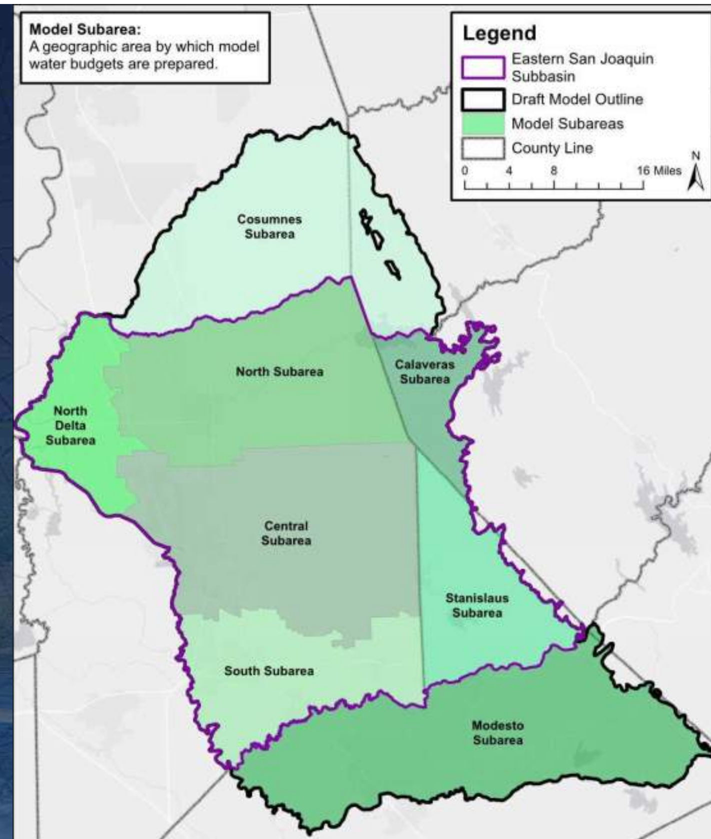
- Land Surface Processes
- Groundwater Flow
- Streamflow
- Physical Systems Integration
- Water Balance Preservation Over time and space



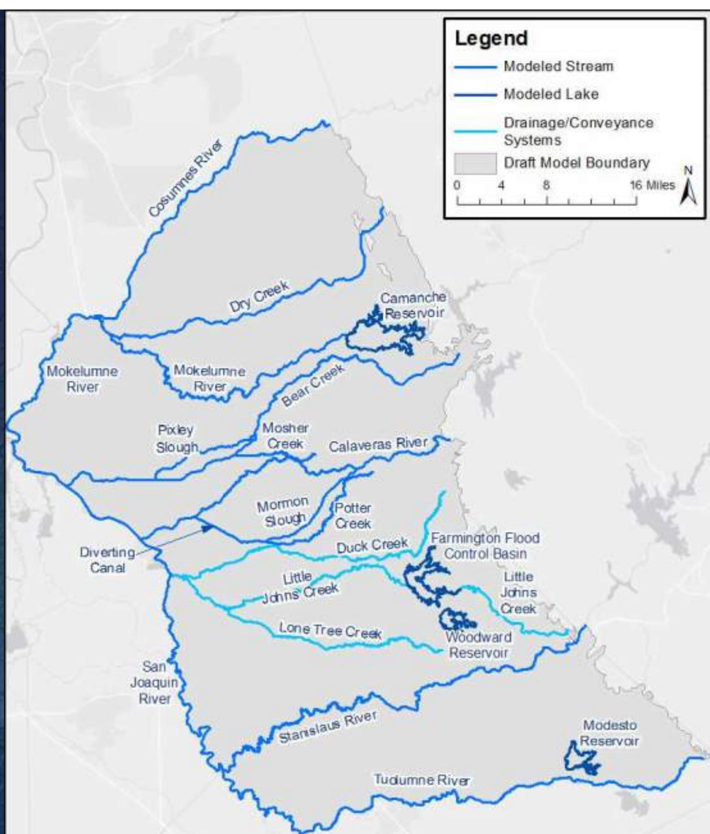
Model Grid Development Goals and Process

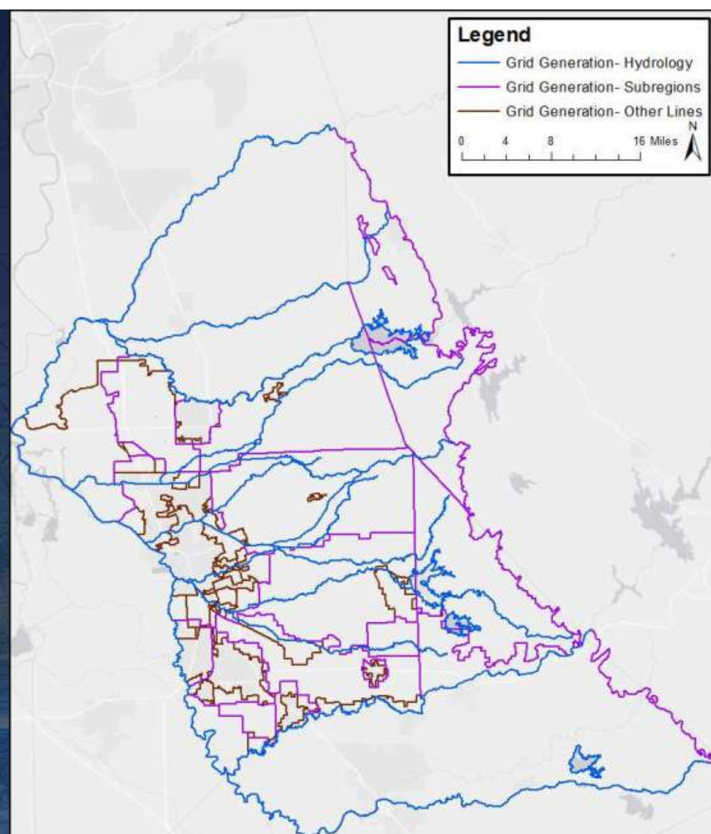
- Include Features:
  - Groundwater Subbasin Boundaries
  - Model Input Subregions/Model Output Subareas
  - Model Hydrologic and Hydrogeologic Features
  - Surface Drainage Patterns
  - Subsurface Flow Patterns
  - Other Boundaries (e.g., current city limits)
- Other Considerations:
  - Maintain manageable number of elements/nodes
  - Optimize resolution for streamlined data analysis
  - Finer resolution along rivers to allow for better stream-aquifer interaction
  - Optimize model run time
  - Streamline model output





Model Input Subregions and Reporting Subareas



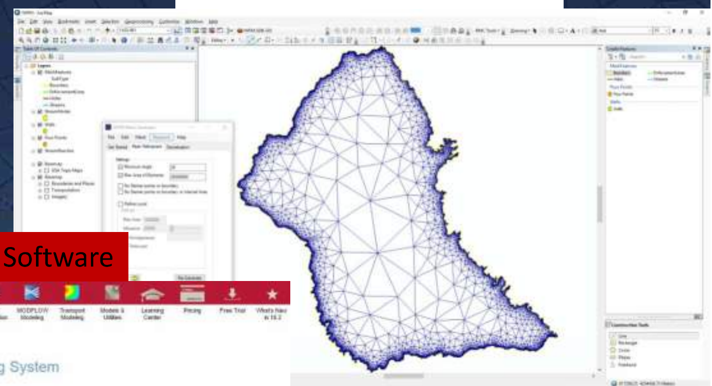


Model Hydrology and Grid Generation Lines

Tools to Develop a Model Grid

Good Old Fashion Grid Development

IWFM Grid Generator

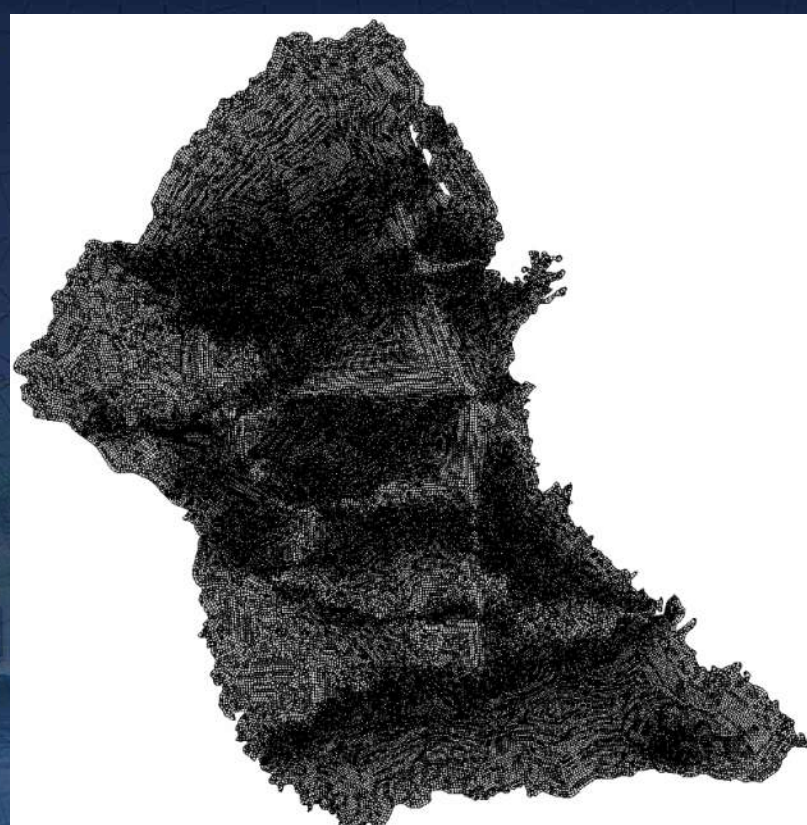


GMS Software

Grid Iteration #1

- Criteria: Hydrology and subregion lines
- Spacing:
  - Subregion lines: 0.25 miles
  - Model boundary lines (even streams): 0.25 miles
  - Other hydrology lines: 0.125 miles

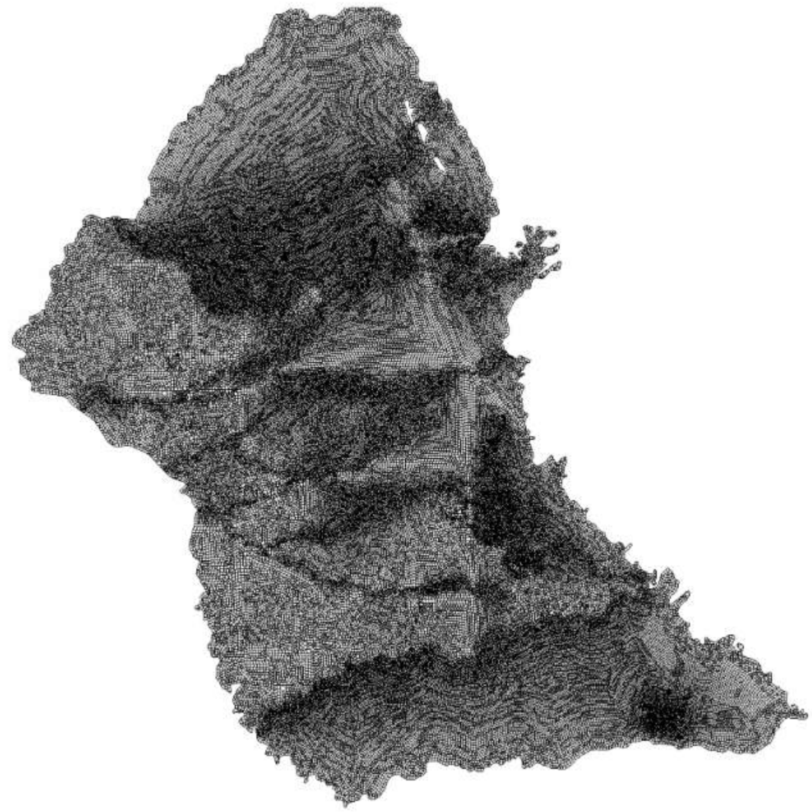
Type of Element	Number of Elements
Triangular	69,333
Quadrilateral	47,920
Total	**117,253**



Grid Iteration #2

- Criteria: Hydrology, subregion, and other features
- Spacing:
  - Subregion and other lines: 0.25 miles
  - Model boundary lines (even streams): 0.25 miles
  - Other hydrology lines: 0.125 miles

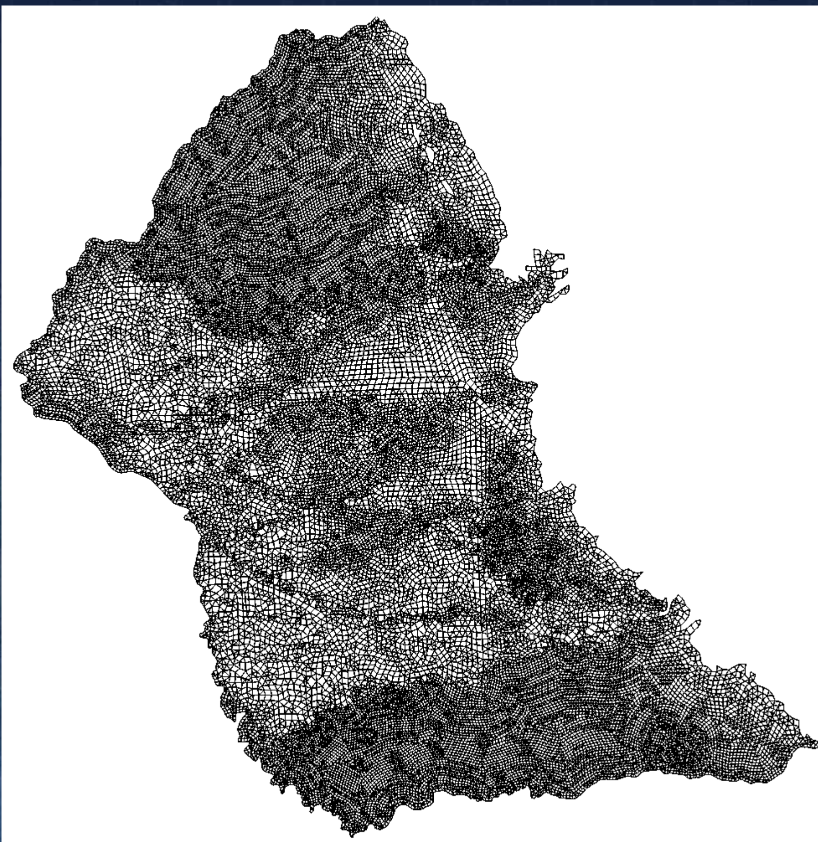
Type of Element	Number of Elements
Triangular	70,088
Quadrilateral	47,643
Total	**117,731**



Grid Iteration #3

- Criteria: Hydrology, subregion, and other features
- Spacing:
  - All subregion and other lines: 0.5 miles
  - All hydrology lines: 0.25 miles

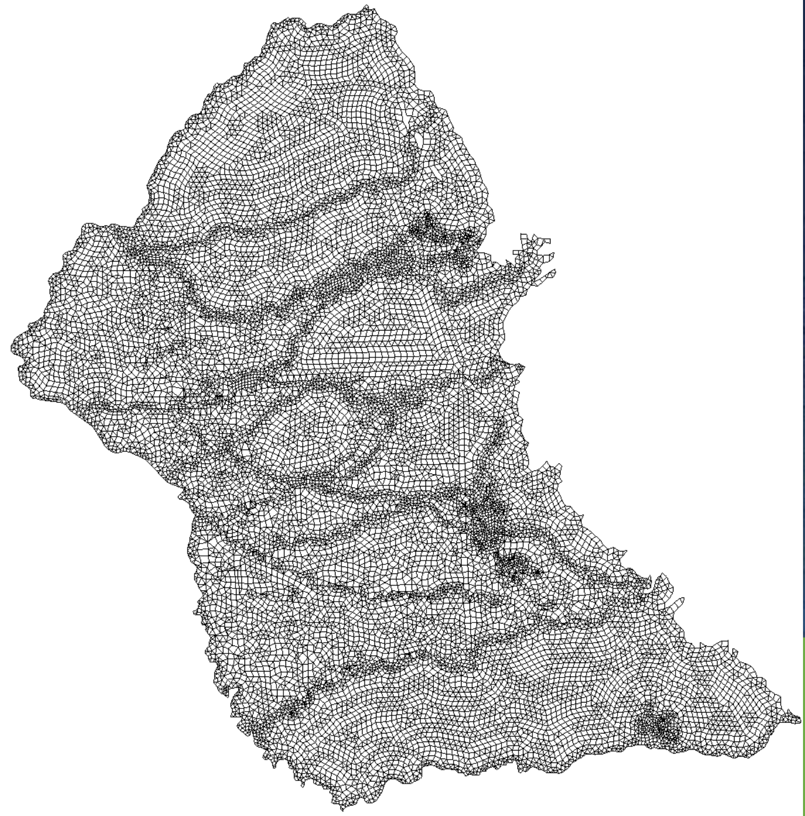
Type of Element	Number of Elements
Triangular	23,541
Quadrilateral	15,009
Total	**38,550**



Grid Iteration #4

- Criteria: Hydrology, subregion, and other features
- Buffer lines approximately 0.75 miles away from some streams
- Spacing:
  - All subregion and other lines (including stream buffers): 0.5 miles
  - All hydrology lines: 0.25 miles

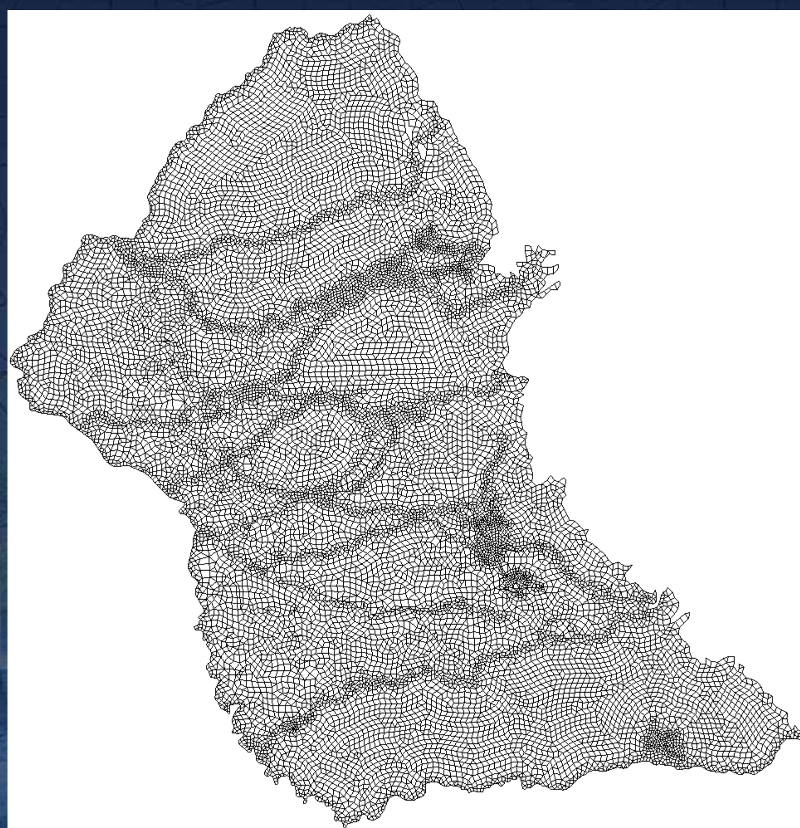
Type of Element	Number of Elements
Triangular	14,983
Quadrilateral	7,769
Total	**22,752**



Grid Iteration #5

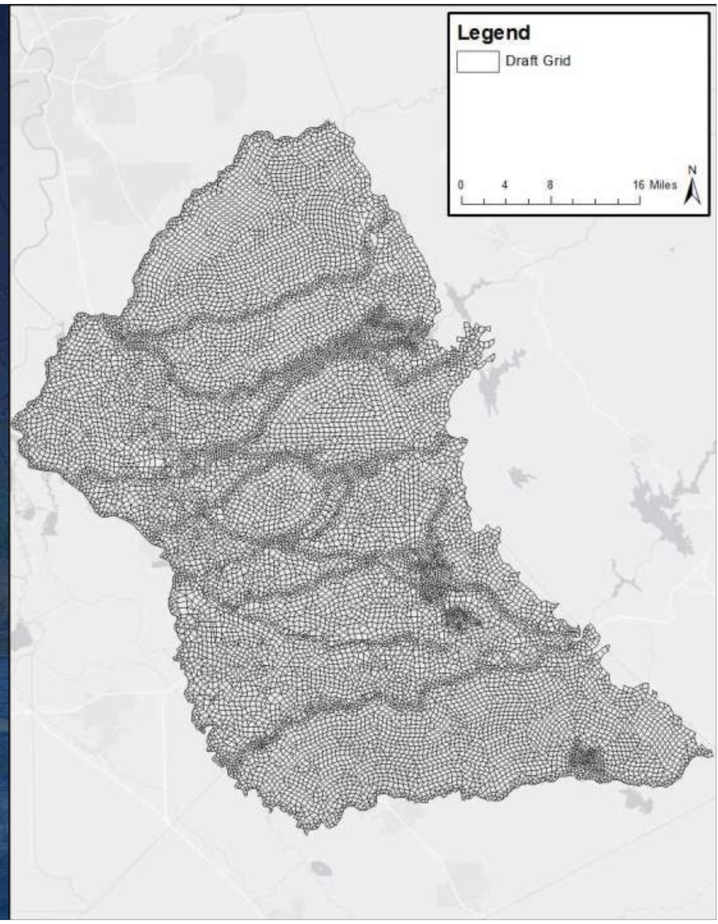
- Criteria: Hydrology, subregion, and other features
- Buffer lines approximately 0.75 miles away from some streams
- Spacing:
  - All subregion and other lines (including stream buffers): 0.5 miles
  - All hydrology lines: 0.25 miles
- Minimum interior angle for merging triangles (gradually decreased from 65° to 15°)

Type of Element	Number of Elements
Triangular	3,514
Quadrilateral	13,453
Total	**16,967**



Draft Grid with Model Features

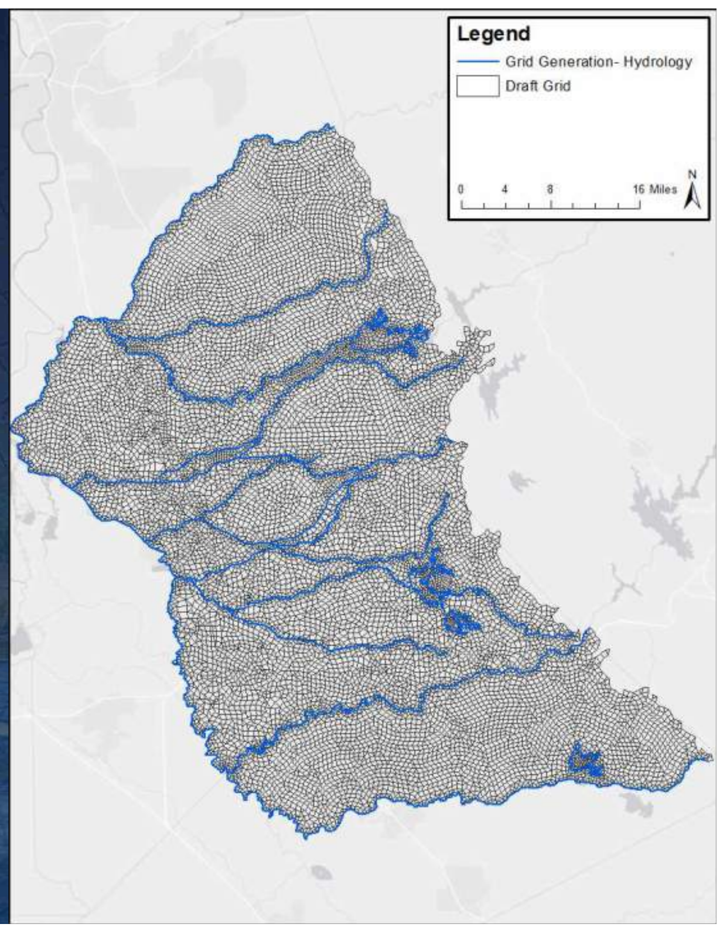
Draft Grid



Draft Grid with Model Features

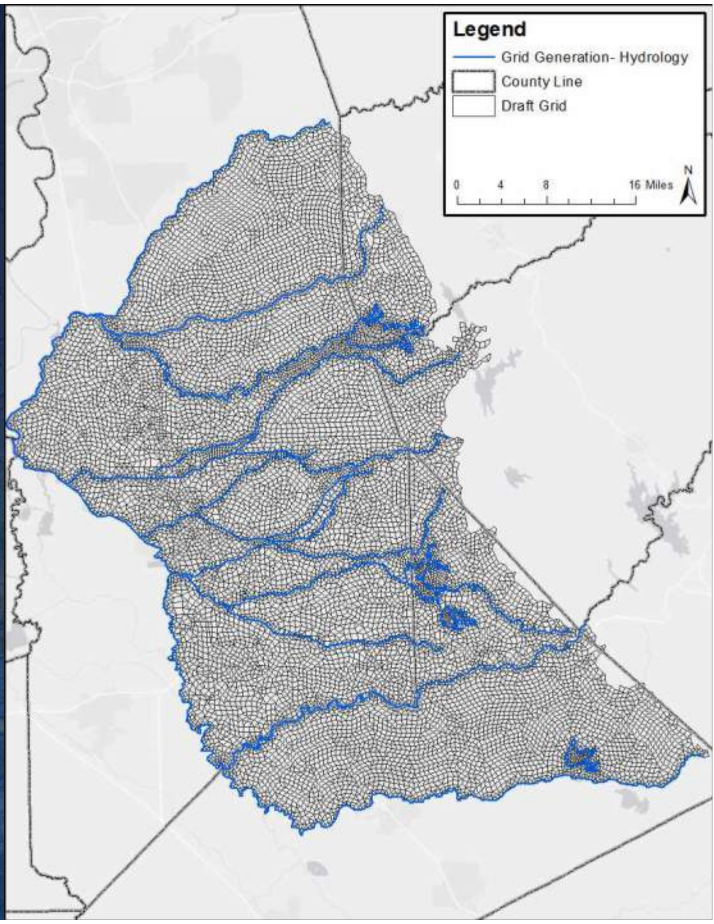
Draft Grid

+ Hydrology



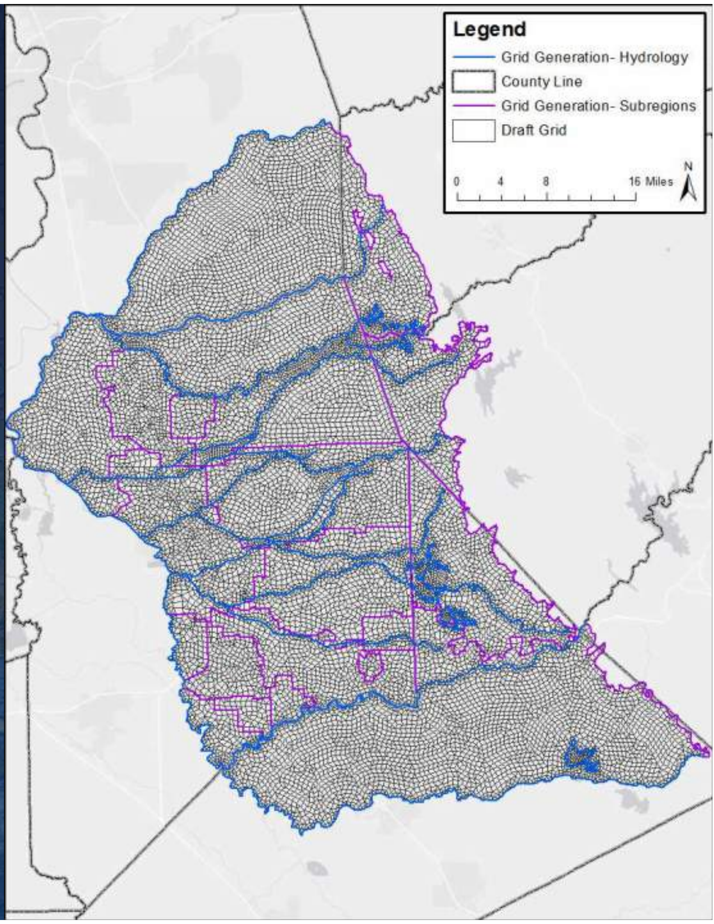
Draft Grid with Model Features

Draft Grid
+ Hydrology
+ County lines



Draft Grid with Model Features

Draft Grid
+ Hydrology
+ County lines
+ Remaining subregion lines



Draft Grid with Model Features

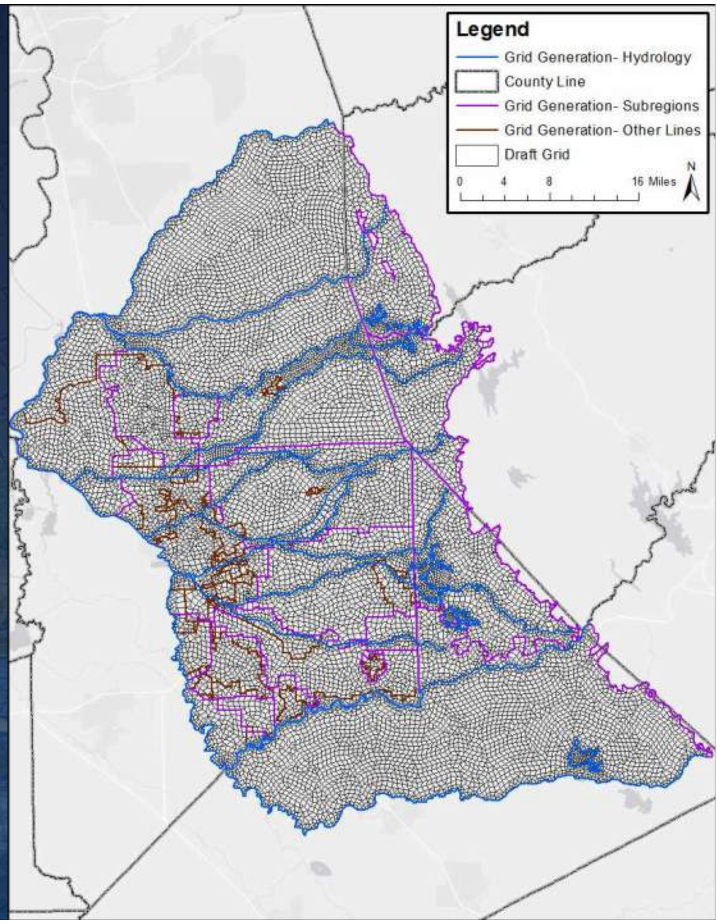
Draft Grid

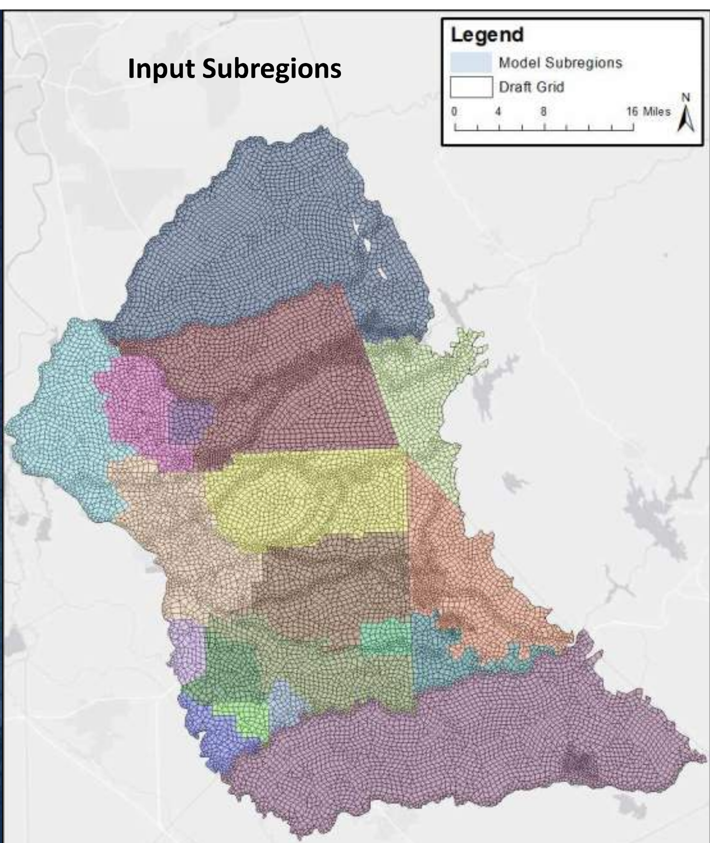
+ Hydrology

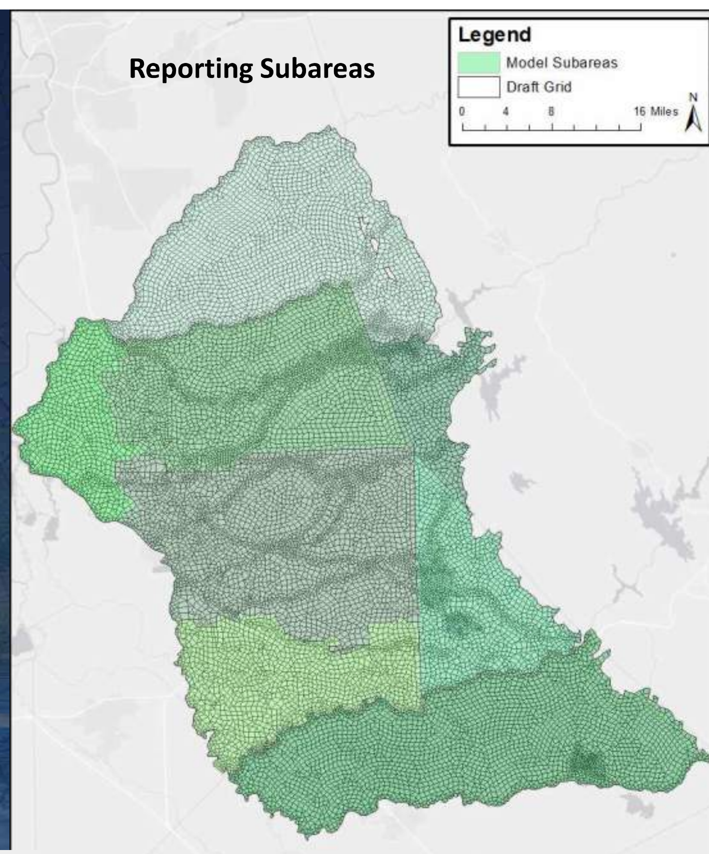
+ County lines

+ Remaining subregion lines

+ Other district lines



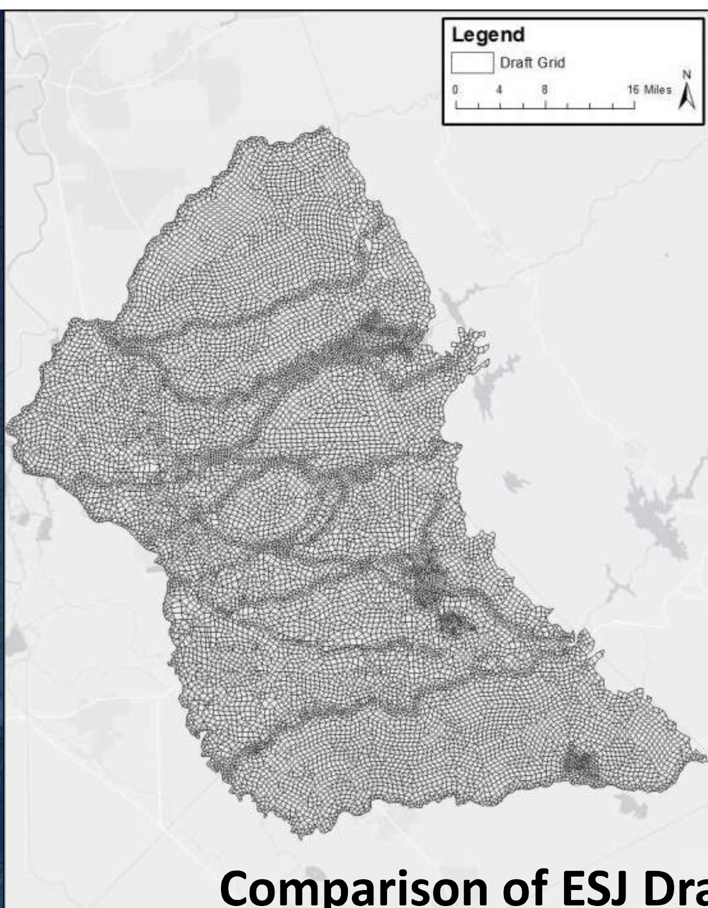


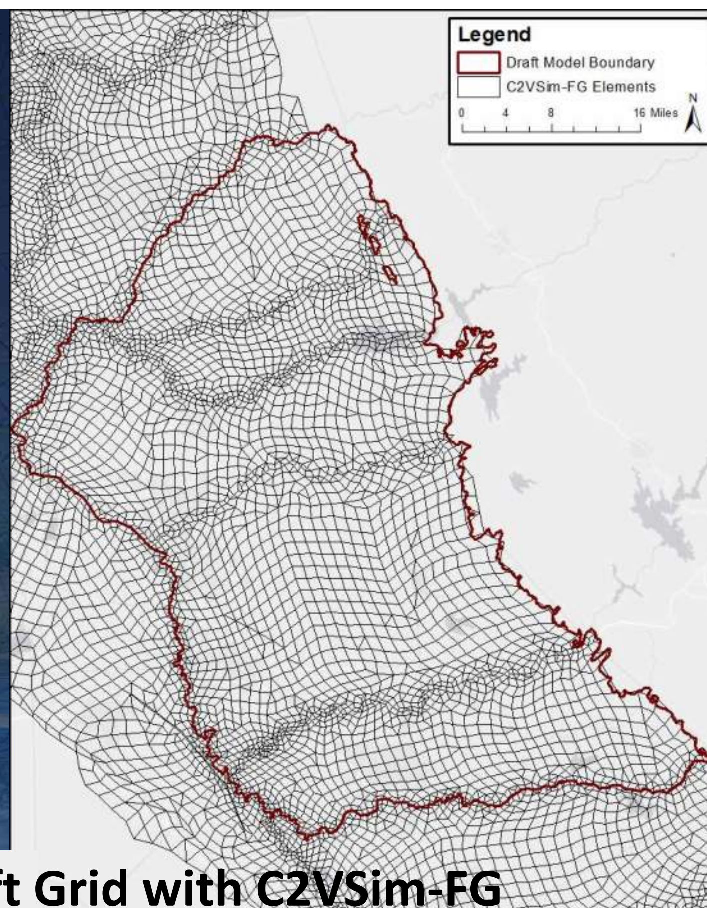


Model Input Subregions and Reporting Subareas

Comparison with Other Models

Model Name	Model Area (acres)	Number of Elements	Average Element Area (acres)	Average Stream Node Spacing	Average Other Node Spacing
Merced Water Resources Model (Merced WRM)- Merced Groundwater Region	491,000	15,441	39	0.25 miles	0.5 miles
Yuba Groundwater Model (YGM)	224,377	10,593	21	~1,000 feet (ranges 500-2,000 feet)	1,000 feet
C2VSim-FG- ESJ Subbasin (w/o Cosumnes and Modesto Subbasins)	772,376	2,093	372	0.59 miles	1.01 miles
Eastern San Joaquin Water Resources Model	**1,227,899**	**16,967**	**72**	**0.25 miles**	**0.5 miles**





Comparison of ESJ Draft Grid with C2VSim-FG

Next Steps for Finalizing Grid

- Address comments from stakeholders
- Considerations on coarser spacing in Modesto and Cosumnes subbasins
- Manual refinement to finalize grid

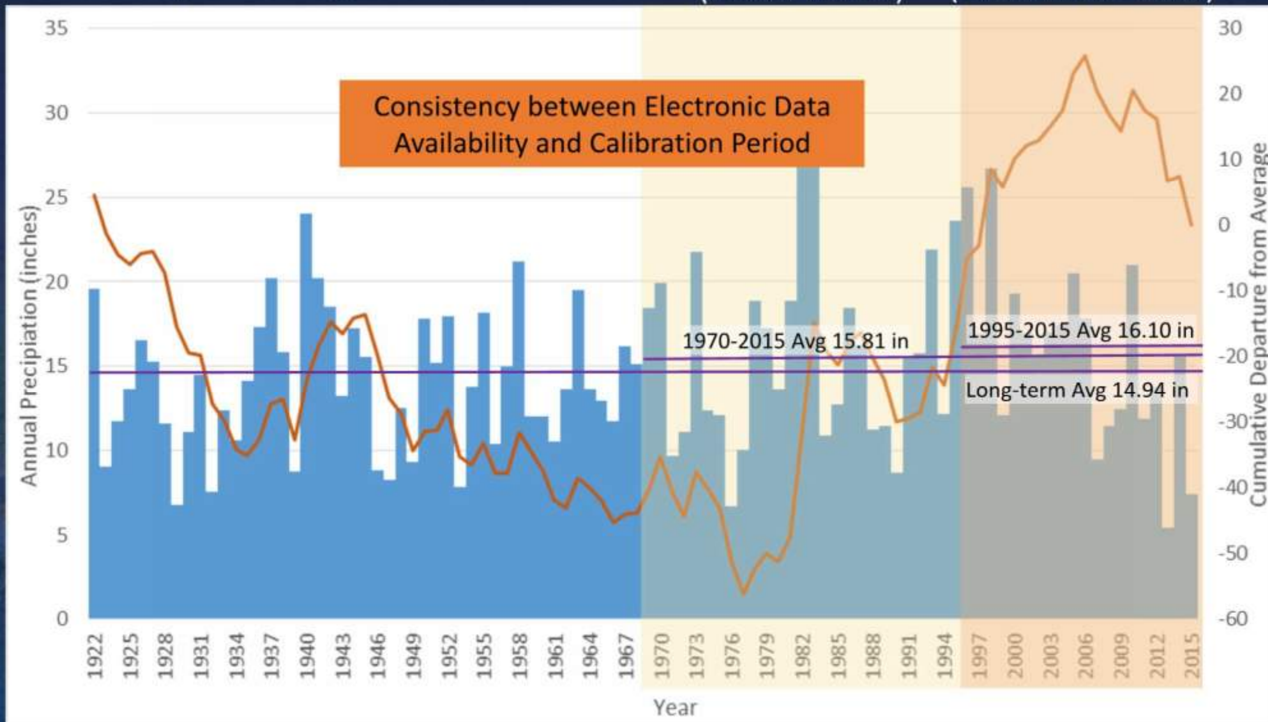
Model Data Categories

- Hydrology / Rainfall
- Geology and Hydrogeology
- Land Use and Cropping Pattern
- Ag Water Supply (SW Delivery and GW Pumping)
- Estimated Ag Demand (Applied SW or GW Pumping for Ag)
- Urban Water Use (SW, GW, and wastewater)
- GW Operations (Recharge, ASR, quality, monitoring, etc.)
- Well Information (Well IDs, locations, depths, construction, etc.)

Model Hydrologic Period

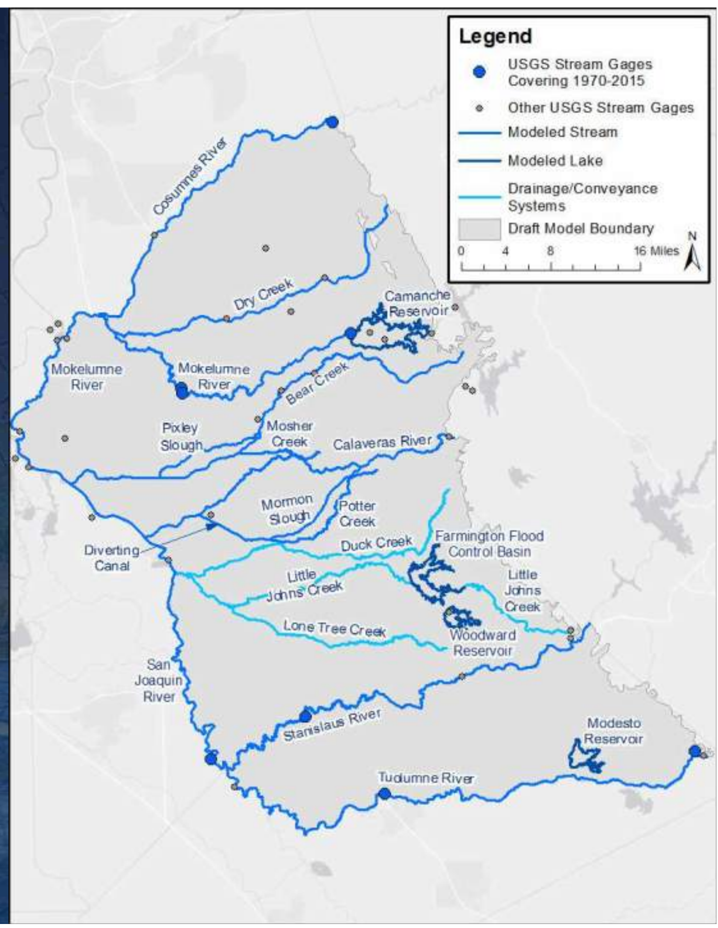
1970-2015
(Model Period)

1995-2015 (?)
(Calibration Period)



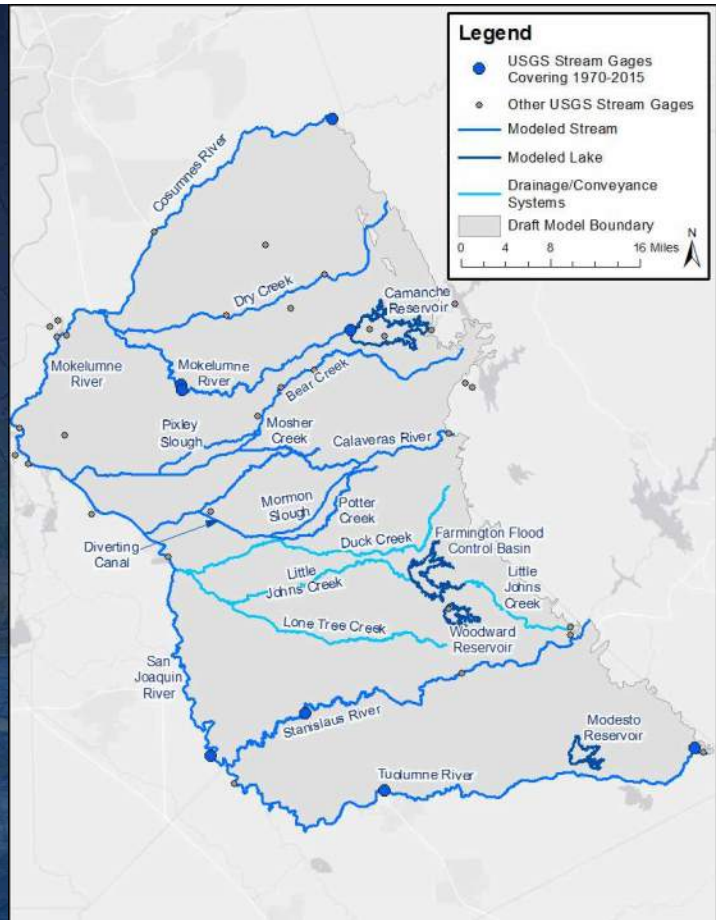
Modeled Streams

Number	Stream Name	Data Period (1970 – 2015)	Stream Geometry Available	USGS Gage
1	San Joaquin River	Yes	Yes	11303500
2	Cosumnes River	Yes	Yes	11335000
3	Dry Creek	N/A	Yes	C2VSim
4	Mokelumne River	Yes	Yes	11323500 11325500 11325000
5	Calaveras River	Yes	Yes	USACE New Hogan Lake releases
6	Stanislaus River	Yes	Yes	11303000
7	Tuolumne River	Yes	Yes	11290000 11289000



Additional Modeled Features

Additional Modeled Features		Geometry	Flow
Model Streams			
8	Bear Creek	TBD	Rainfall/Runoff + Conveyance
9	Pixley Slough	TBD	Rainfall/Runoff + Conveyance
10	Mosher Creek	TBD	Rainfall/Runoff
11	Mormon Slough	TBD	Rainfall/Runoff + Conveyance
12	Potter Creek	TBD	Rainfall/Runoff + Conveyance
13	Diverting Canal (connects Mormon Slough back to Calaveras River)	TBD	Rainfall/Runoff + Conveyance
Model Reservoirs			
14	Camanche Reservoir	N/A	CDEC
15	Farmington Flood Control Basin	N/A	USACE
16	Woodward Reservoir	N/A	SSJID
17	Modesto Reservoir	N/A	CDEC



Status of Data Request

- Land Use and Cropping Pattern
- Ag Water Supply (SW Delivery and GW Pumping)
- Estimated Ag Demand (Applied SW or GW Pumping for Ag)
- Urban Water Use (SW, GW, and wastewater)
- GW Operations (Recharge, ASR, quality, monitoring, etc.)
- Well Information (Well IDs, locations, depths, construction, etc.)

Sustainable Groundwater Management Act Readiness Project

Meeting No. 5: Integrated Water Resources Model Development Update

RMC water and environment

Complex Challenges | Innovative Solutions

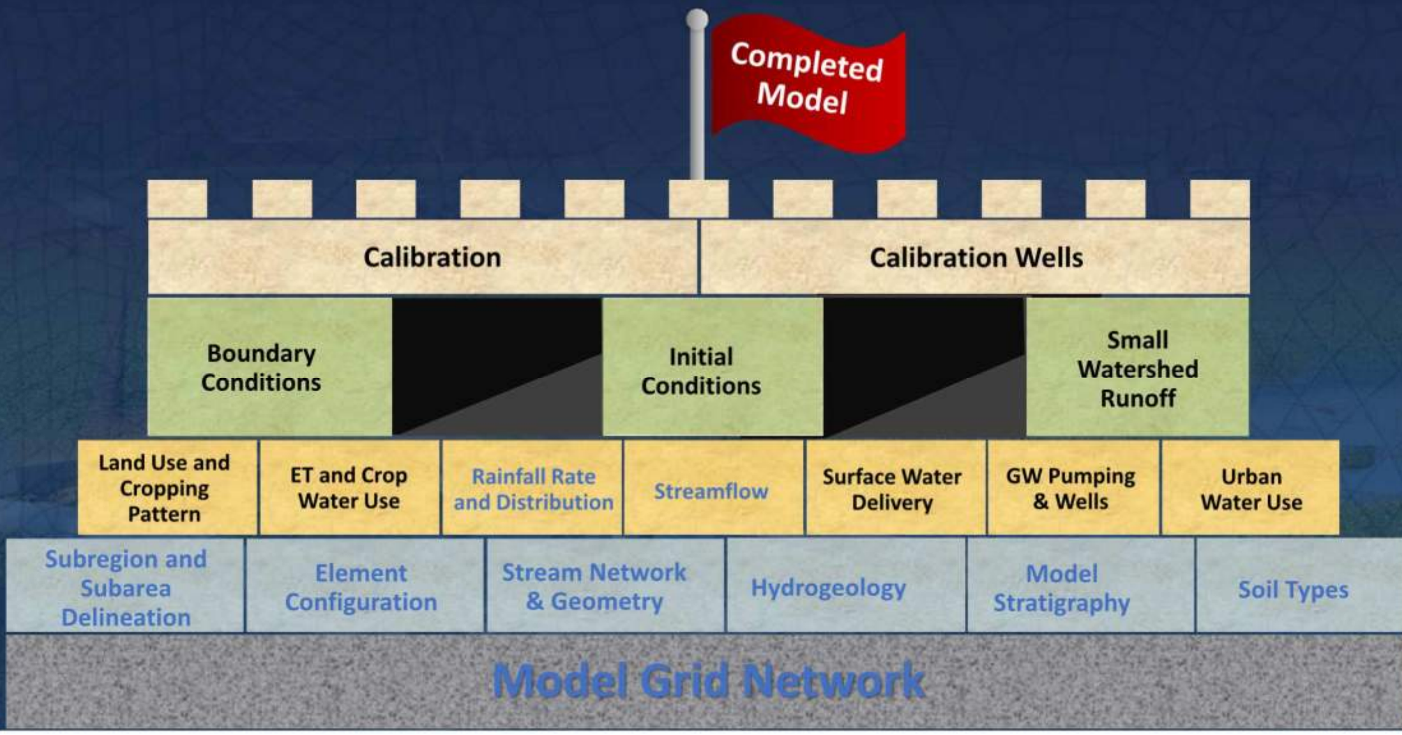
SAN JOAQUIN COUNTY CALIFORNIA

April 26, 2017

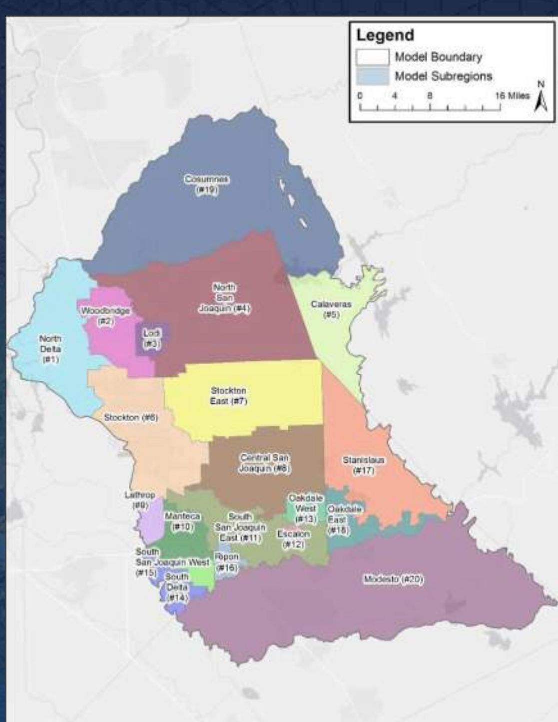
Agenda

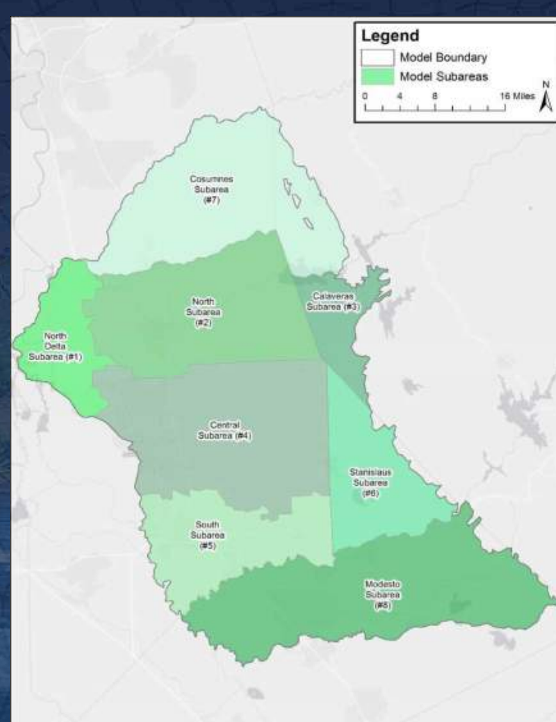
- Model Stratigraphy
- Land Use Processing Update
- Data Development for IDC Model
  - Soil
  - Precipitation
- Agency Data Compilation
  - Groundwater Pumping
  - Urban Demand
- Next Steps

Integrated Model Construction



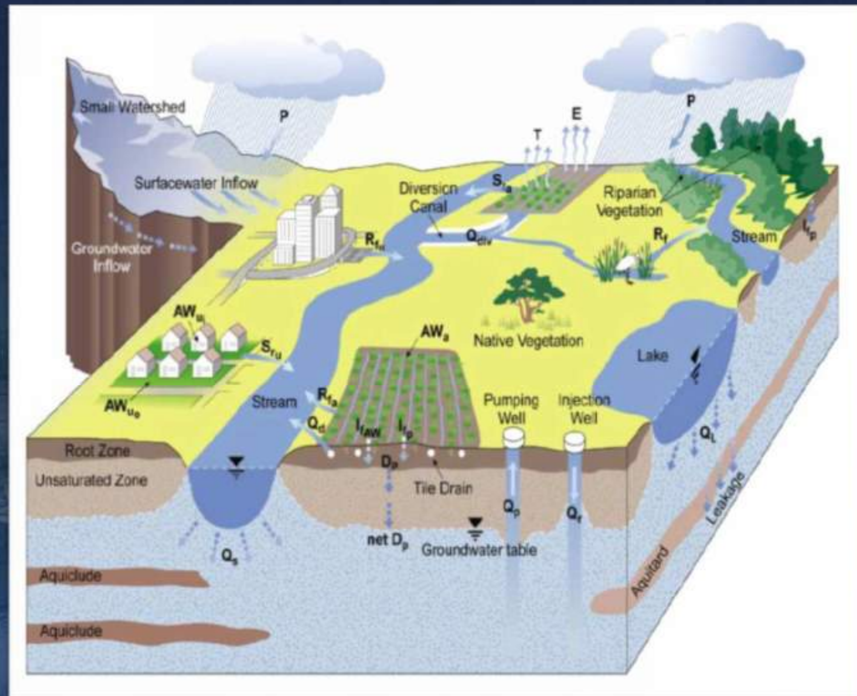
Completed Model Component: Model Boundary and Subregions





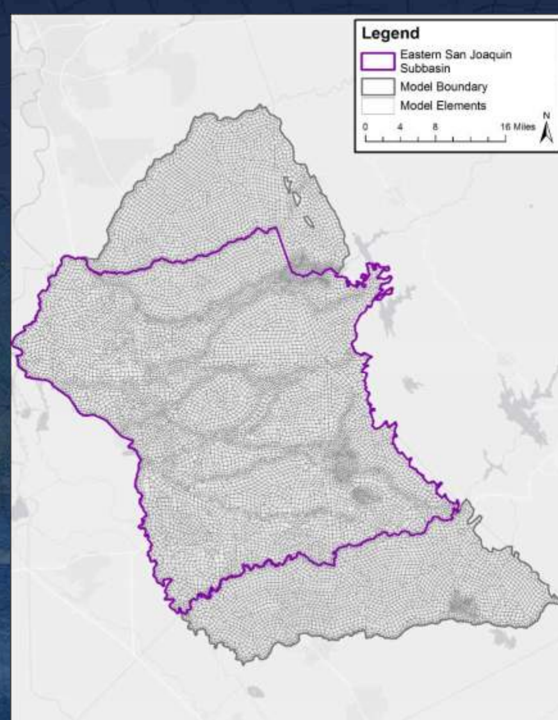
Integrated Water Resources Modeling

- Land Surface Processes
- Groundwater Flow
- Streamflow
- Physical Systems Integration
- Water Balance Preservation Over time and space

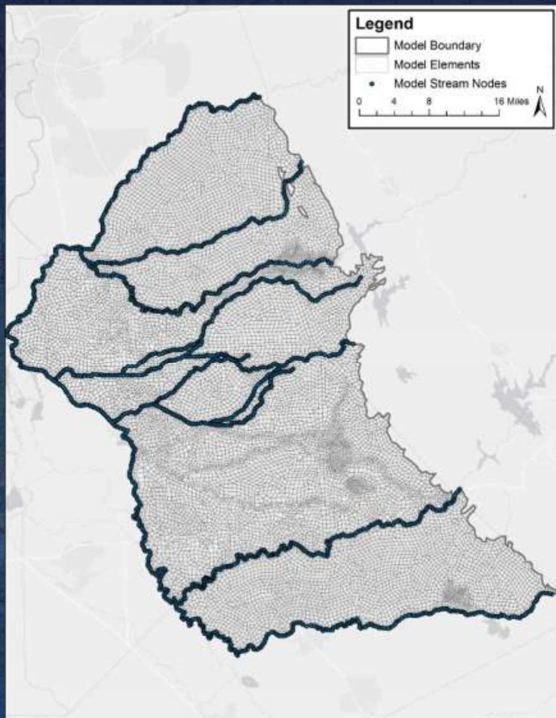


Completed Model Component: Elements and Node Configuration

- Model Grid
  - 16,054 elements
  - 15,302 nodes
- Covering Cosumnes , Eastern San Joaquin, and Modesto Groundwater Subbasins



Completed Model Component: Stream Hydrology

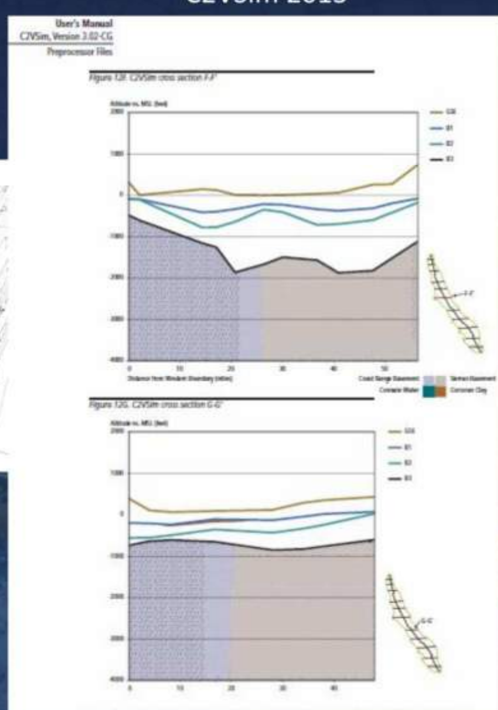


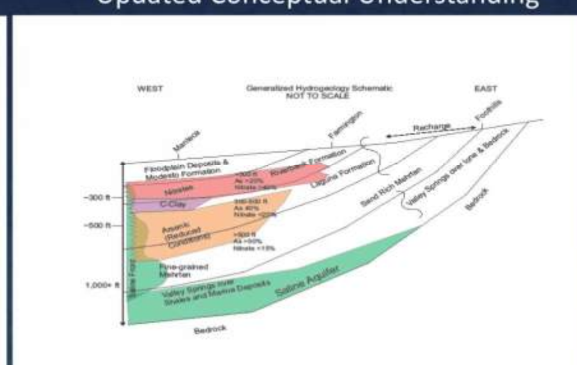
Schematic Hydrogeological Cross-Sections Compared and Refined

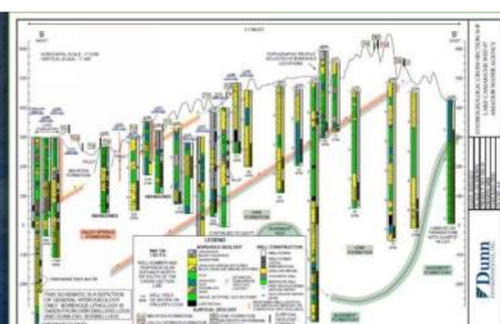
C2VSim 2013

Updated Conceptual Understanding

DWR (San Joaquin County Ground Water Investigation, 1967)





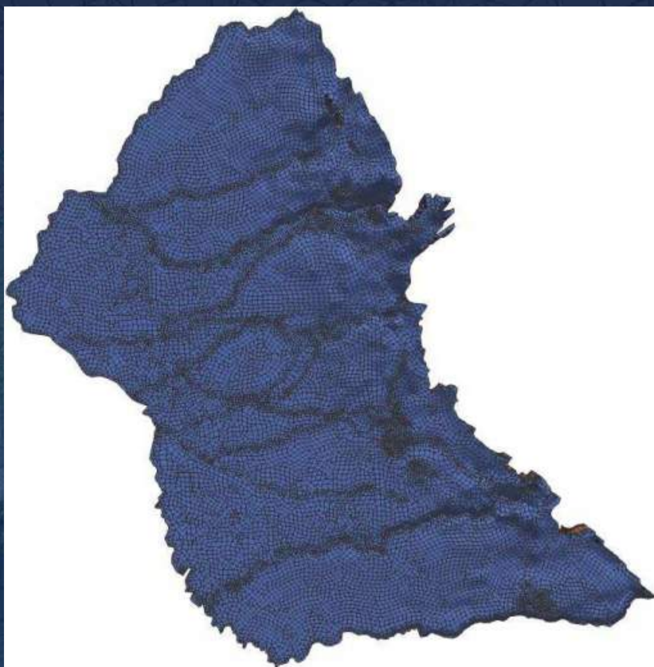


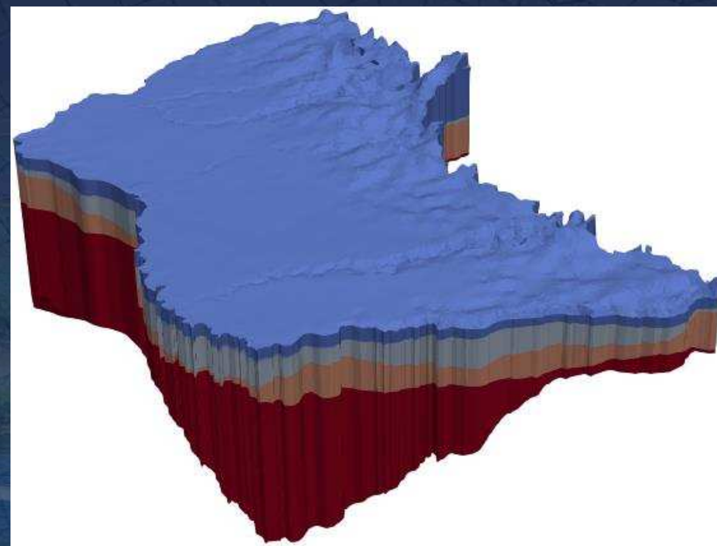
Basis for Model Stratigraphy

- Based on C2VSim-FG updated 4-layer stratigraphy:
  - Ground Surface Elevation: National Elevation Dataset (USGS, 10 meter DEM)
  - Bottom of Layers 1 and 2
    - From latest available version of C2VSim (DWR, Development and Calibration of the California Central Valley Groundwater-Surface Water Simulation Model, 2013)
    - Bottom of Layer 1 represents top of Corcoran Clay in areas with Corcoran Clay (USGS, CVHM Texture Model)
  - Bottom of Layer 3- Base of Freshwater
    - DWR North Central Regional Office (Sacramento Valley) (Pers. Comm. Steven Springhorn)
    - DWR South Central Regional Office (San Joaquin Valley) (Pers. Comm. Christopher Olvera)
    - Williamson 1989 D43 (USGS, Williamson et al., Ground-Water Flow in the Central Valley California, 1989)
    - Latest available version of C2VSim
  - Bottom of Layer 4- Bottom of Continental Deposits
    - Base and Thickness of the Post Eocene Continental Deposits in Sacramento Valley (USGS, Page, 1974)
    - Williamson 1989 D11 Thickness of Aquifer (USGS, Williamson et al., Ground-Water Flow in the Central Valley California, 1989)
    - Latest available version of C2VSim

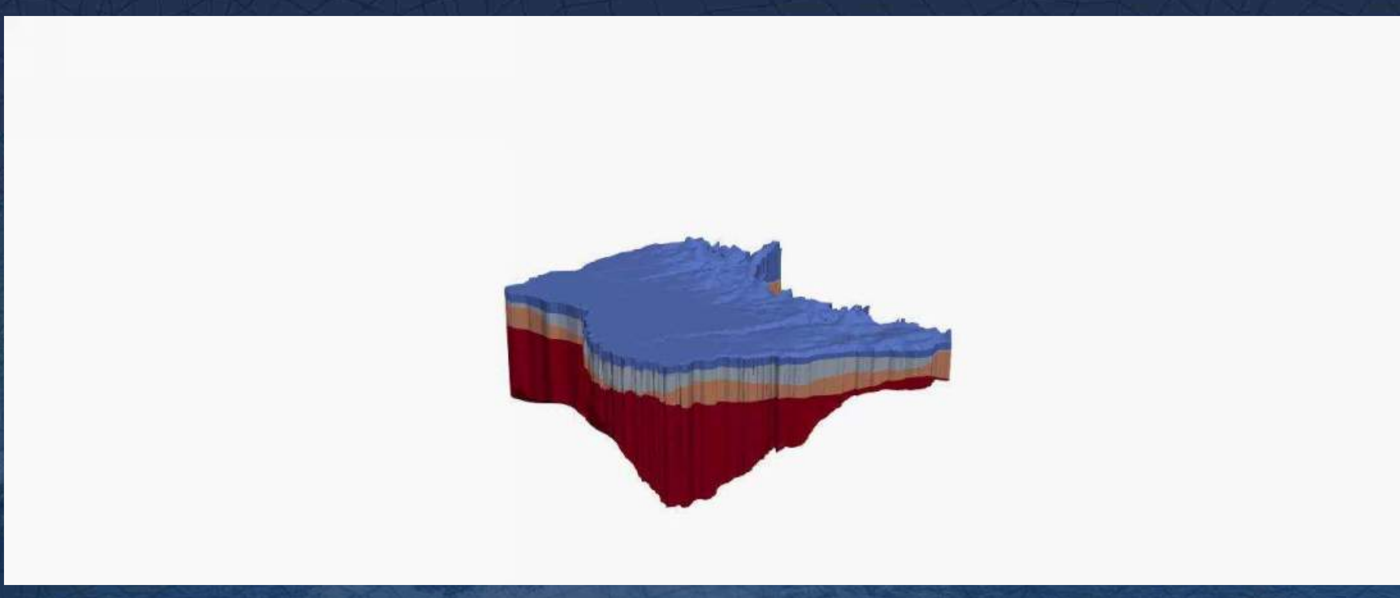
C2VSim: Sample Cross-Section Through ESJ Model Area

Model Stratigraphy

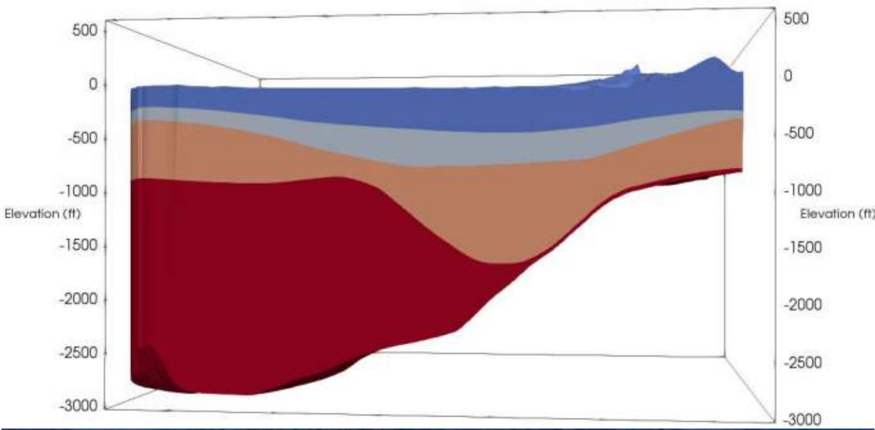


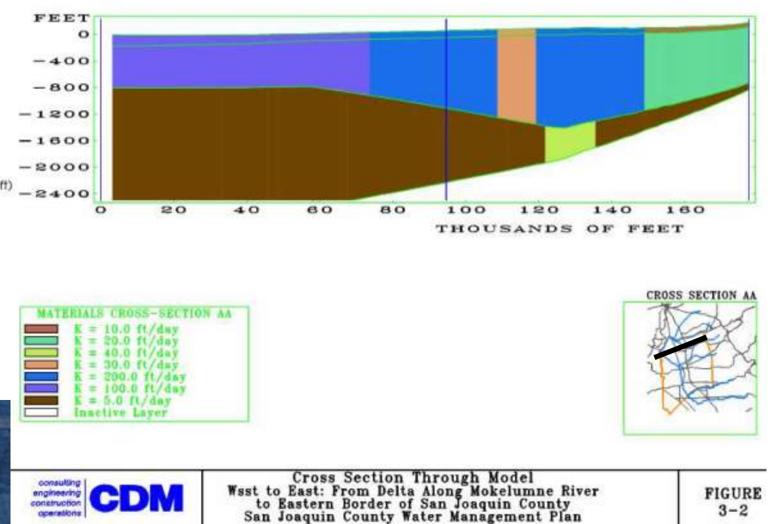


Model Stratigraphy: Rotation Around Model Edges

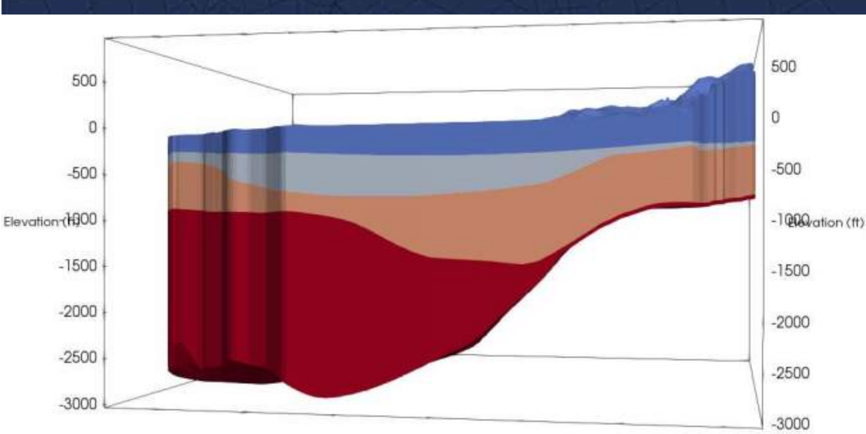


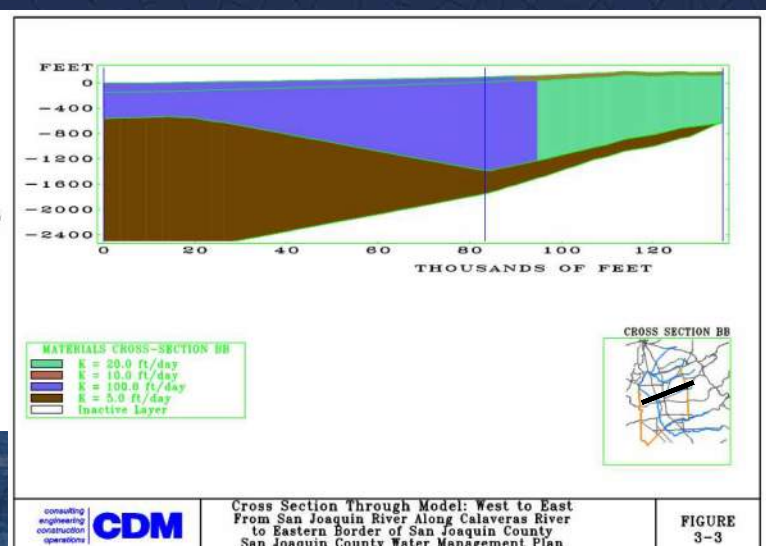
Comparison: ESJ Stratigraphy and DYNFLOW





Comparison: ESJ Stratigraphy and DYNFLOW





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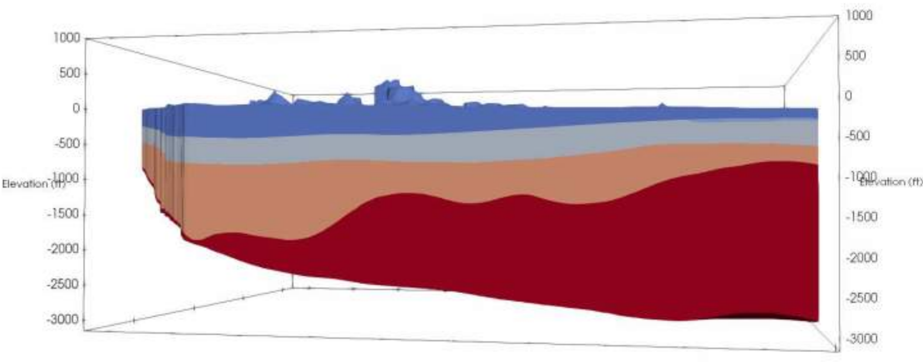
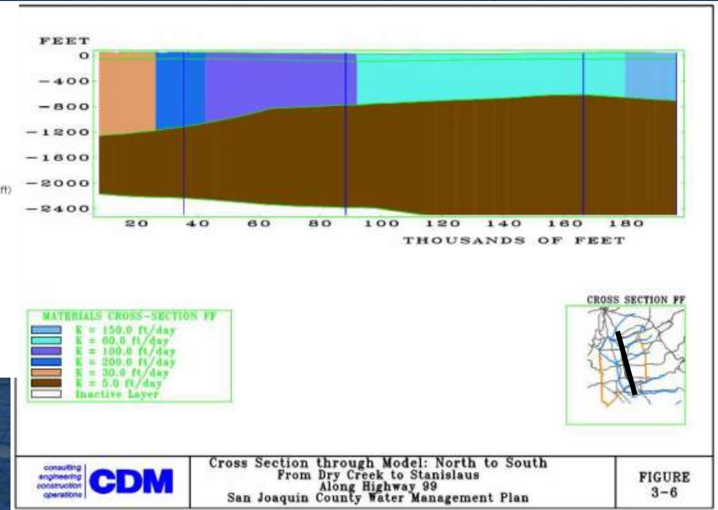
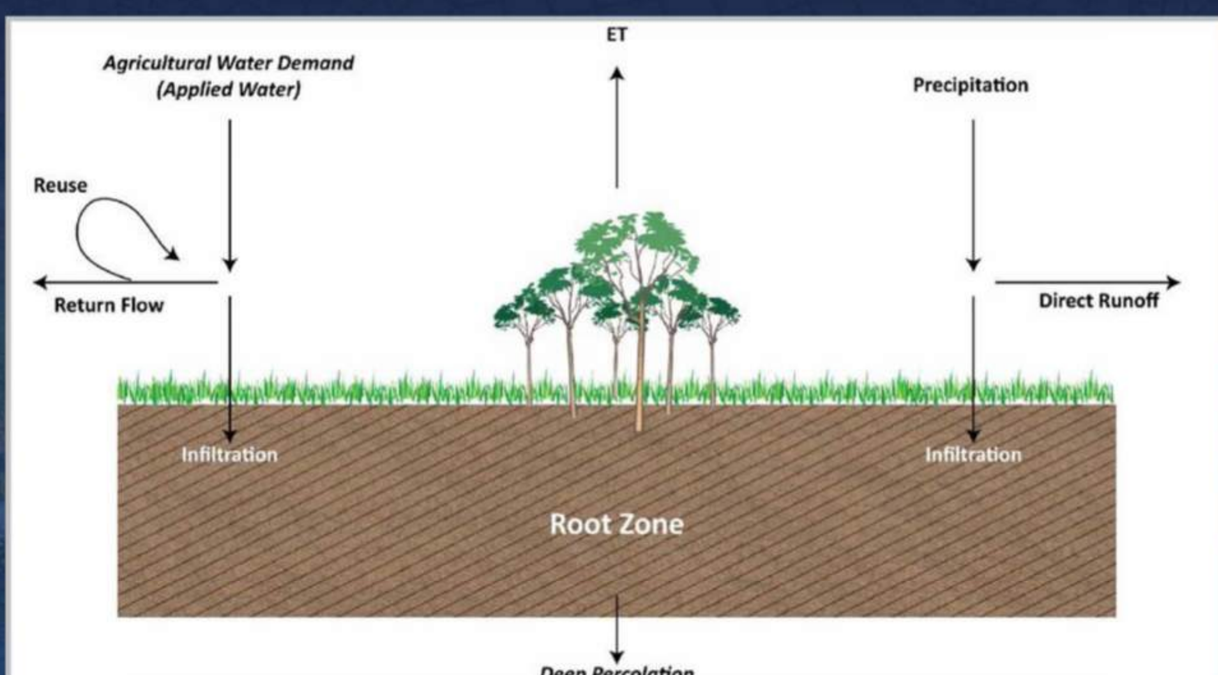


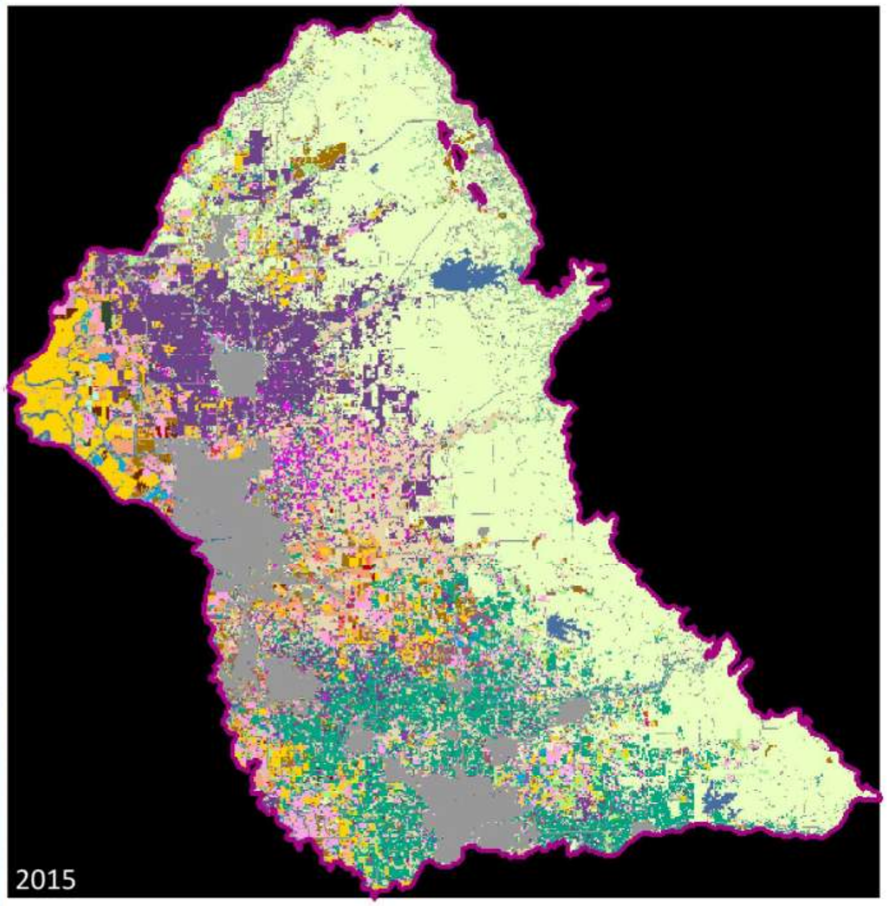


IWFM Demand Calculator: IDC

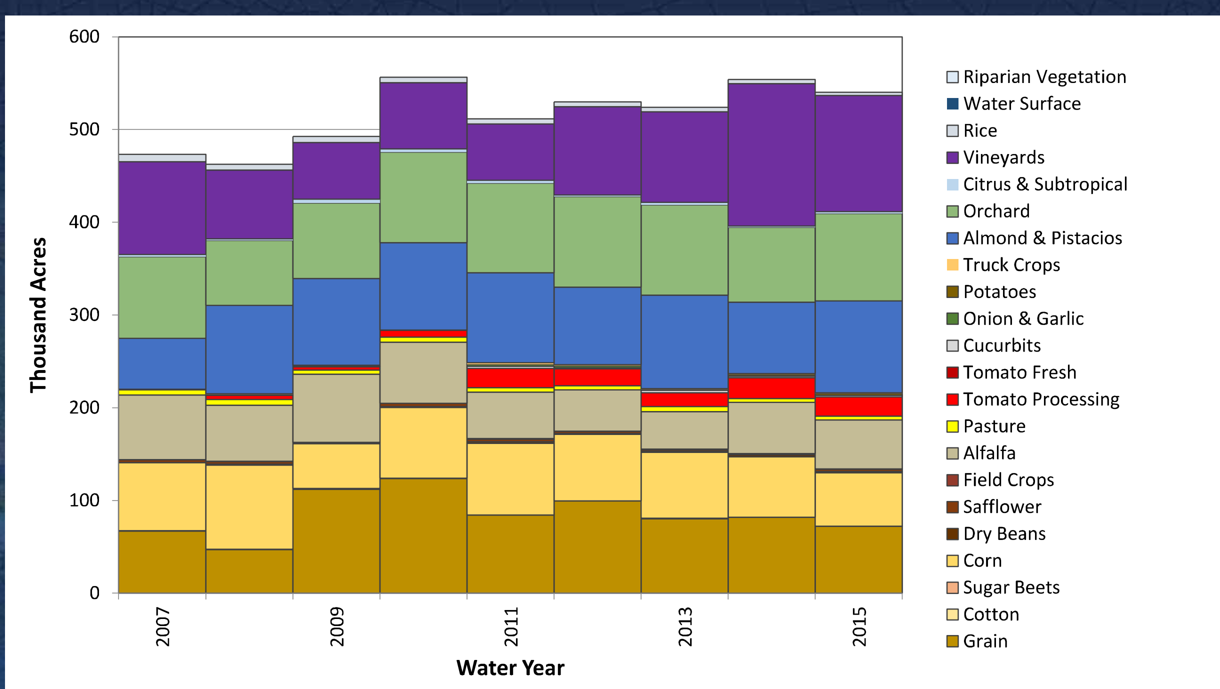


Land Use and Crop Coverage

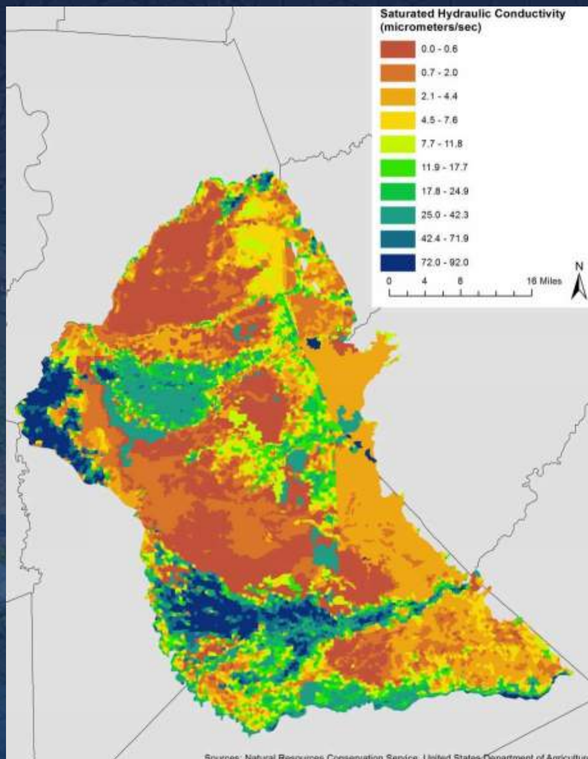
- DWR Land Use Surveys
- USDA's CropScape – Remote Sensing
- DWR's LandIQ Survey; 2014- Remote Sensing
- Local Data Sources

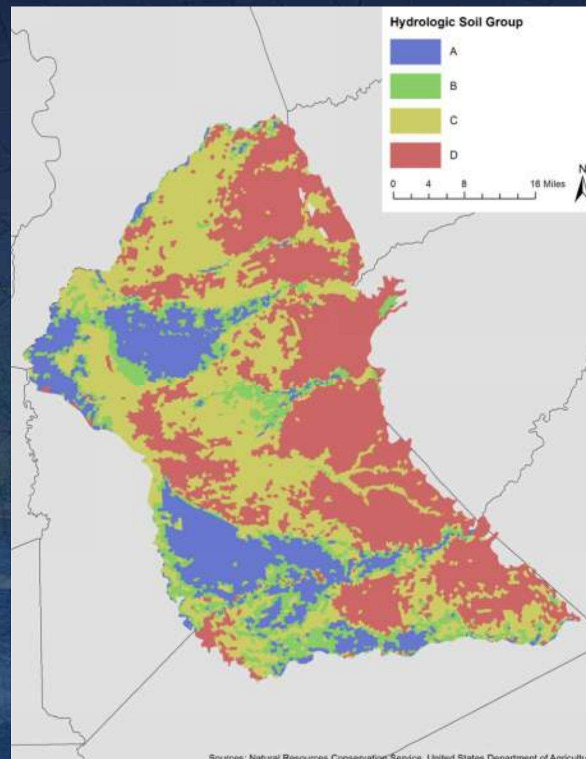


Draft Land Use Acreages



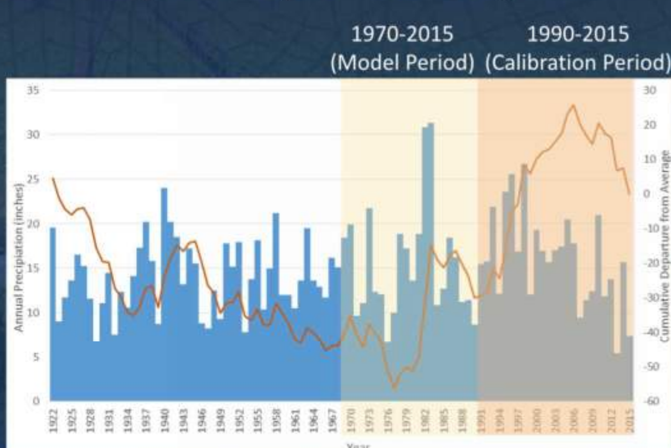
Root Zone Parameters

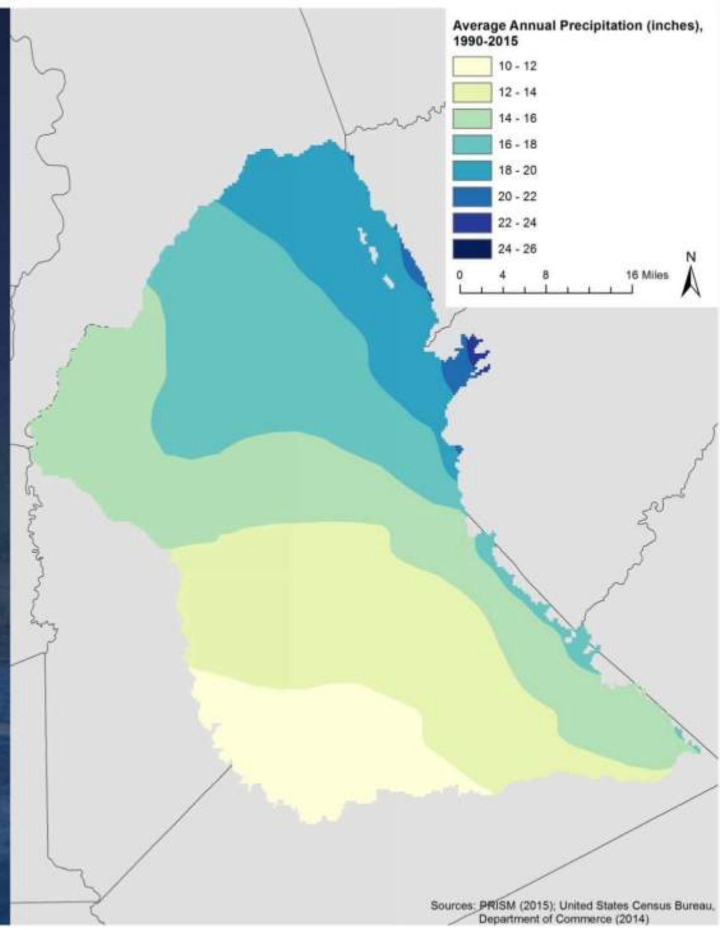




Precipitation

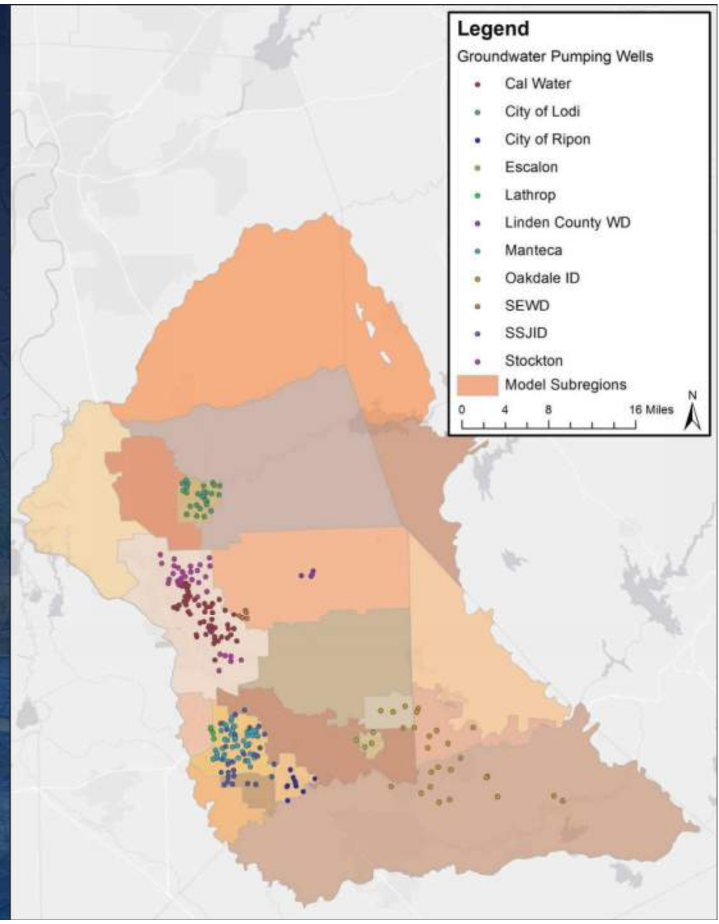
- Completed model input file for precipitation
- Source of Data: PRISM for entire model period (1990-2015)



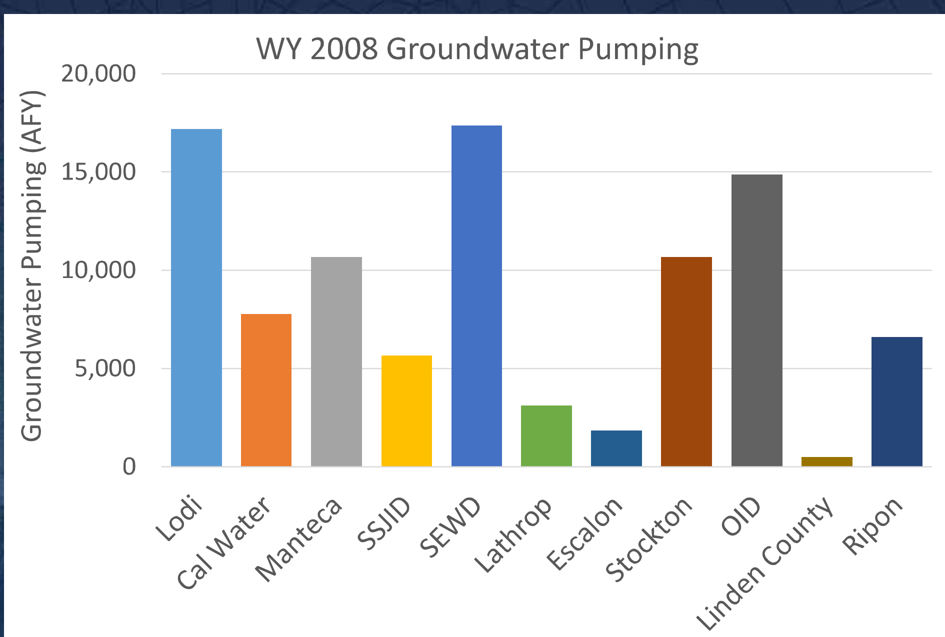


Groundwater Pumping

Agency	Number of Wells Contributing to Water Demand
Cal Water	56
City of Escalon	4
City of Lathrop	5
City of Lodi	35
City of Manteca	46
City of Ripon	10
City of Stockton	38
Linden County WD	4
Oakdale ID	26
Stockton East WD	5
South San Joaquin ID	28
TOTAL (as of 4/25/17)	**257**



Groundwater Pumping



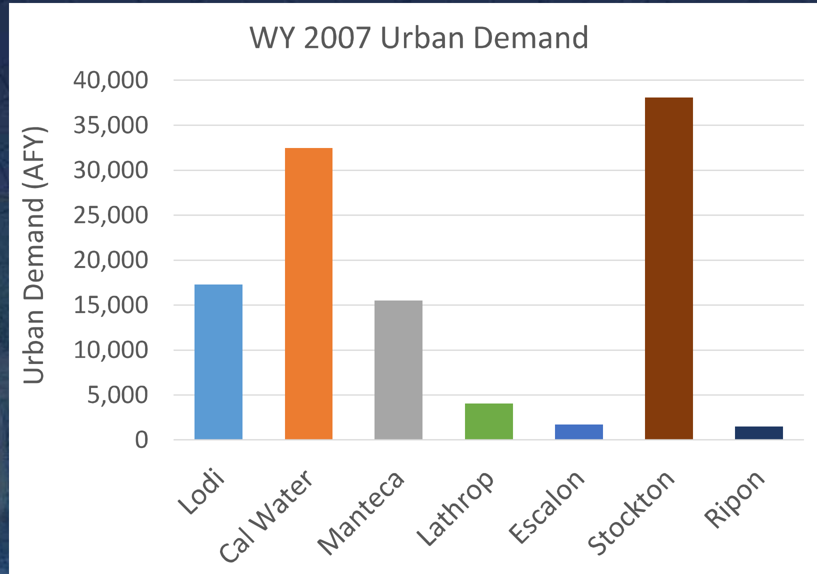
- Data issues:
  - Incomplete monthly time series for many agencies
  - Interpolation between years not always feasible

Agency	Data Period of Record
Lodi	1990-2015
Cal Water	1990-2015
Manteca	2002-2015 with gaps depending on well type
SSJID	1990-2015
SEWD	2005-2015
Lathrop	2006-2010 (need breakdown by well)
Escalon	1998-2015
Stockton	2002-2015
OID	2001-2010
Linden County	1995-2015
Ripon	Need breakdown by well

Urban Water Demand

- Based on GPCD and population if water demand information unavailable
- Data issues:
  - Incomplete agency data
  - Estimates about demand are tricky to balance with supply

Agency	Data Period of Record
Lodi	1990-2015
Cal Water	1995-2015
Manteca	1996-2007
Lathrop	1990-2011
Escalon	1998-2015
Stockton	1998-2009
Ripon	1995, 2002, 2005, 2007, 2014-2015



* Values for Cal Water and Stockton may represent total demand, not just urban

Project General Schedule

Next Steps

- Complete Stream Geometry Data
- Compile and Process pumping well construction information
- Compile and Process GW pumping for urban and agricultural use
- Compile and Process Surface water diversions for urban and agricultural use
- Communicate LU/Cropping patterns with local agencies
- Complete IDC input data files:
  - Annual land use acreages
  - ET maps from DWR
  - Ag water budget from agencies

Sustainable Groundwater Management Act Readiness Project

Meeting No. 6:

Integrated Water Resources Model Development Update

RMC water and environment

Complex Challenges | Innovative Solutions

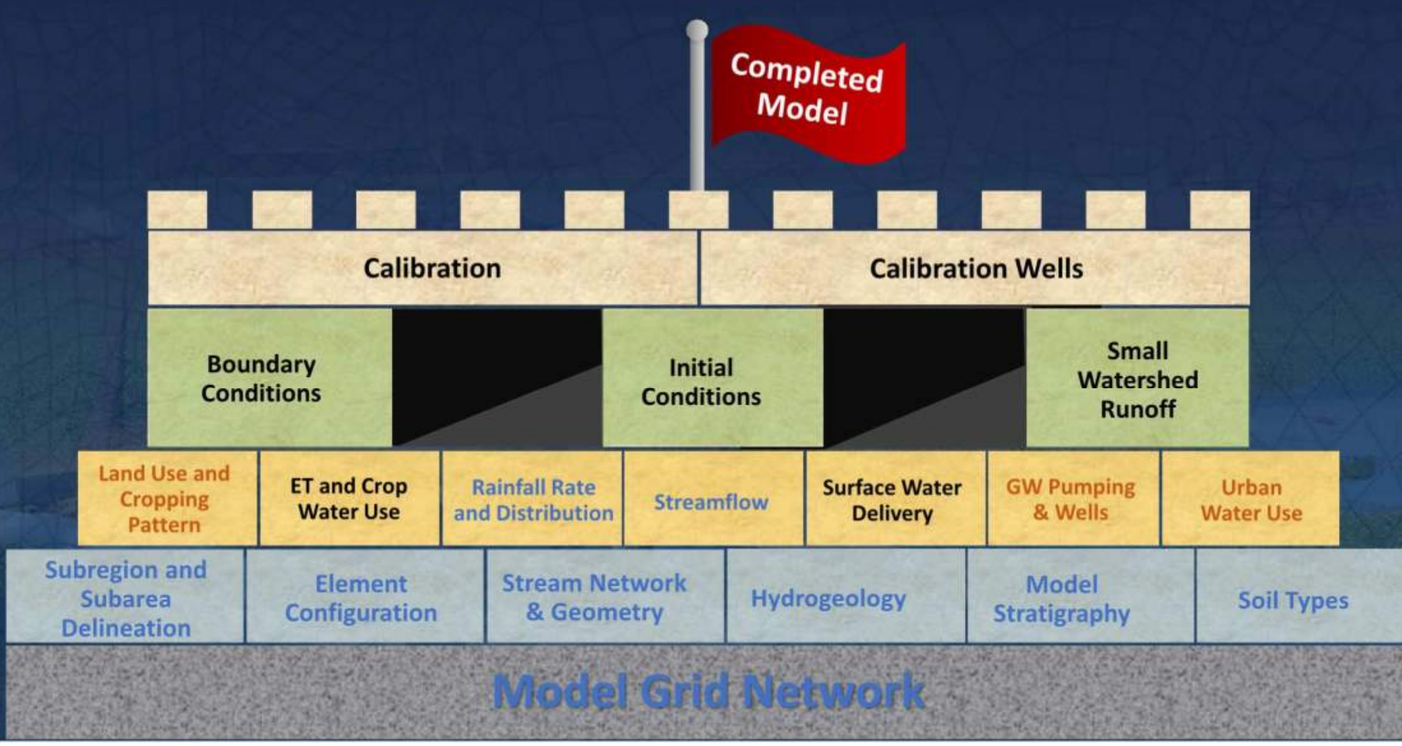
SAN JOAQUIN COUNTY CALIFORNIA

May 24, 2017

Agenda

- Introduction
- Model Crop and Other Land Use Acreage
- Model Urban Water Demand and Groundwater Pumping
- Prop 1 SGMA Groundwater Sustainability Plans Grant
- Next Meeting

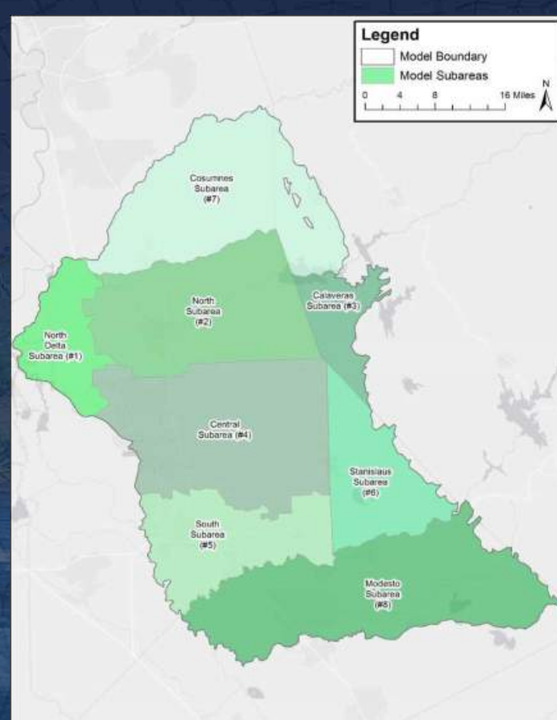
Integrated Model Construction



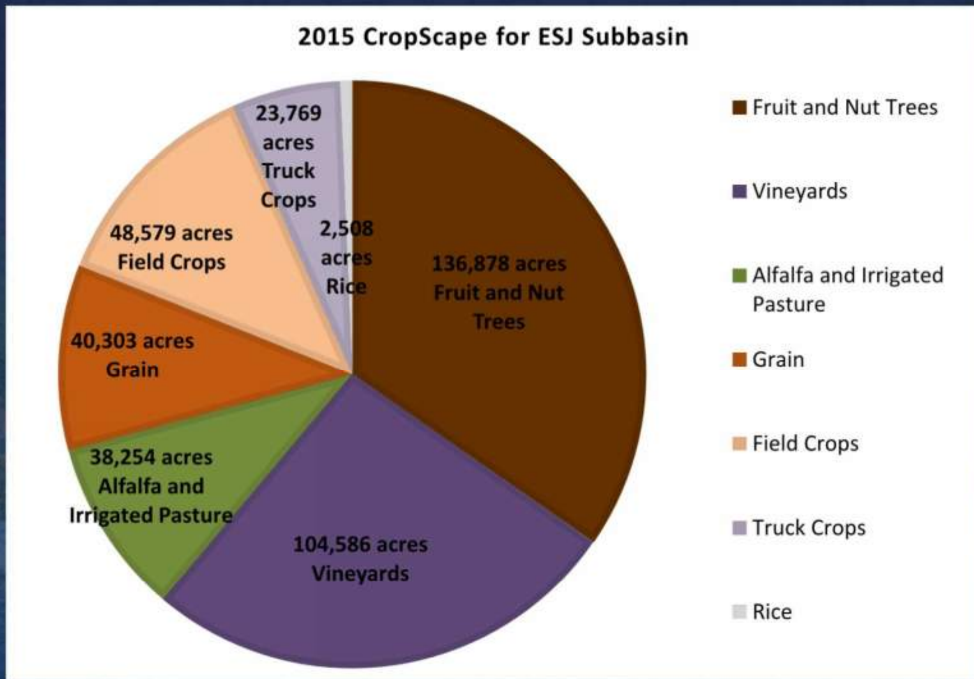
ESJ Model Trivia Part I

1. What are the neighboring Subbasins of the ESJ GW Subbasin?
   Solano, South American, Cosumnes, Tracy, Delta-Mendota, and Modesto
2. What are the geographic features of ESJ GW Subbasin at the boundaries?
   - Northern boundary: Dry Creek and County Boundary
   - Eastern boundary: Foothills
   - Southern boundary: Stanislaus River
   - Western boundary: San Joaquin River
3. What is the total gross acreage of ESJ GW Subbasin?
   772,377 acres (~1,207 square miles or ~3,126 square kilometers)
4. What is the total irrigated acres in ESJ Subbasin?
   381,907 acres (~597 square miles or ~1,546 square kilometers)

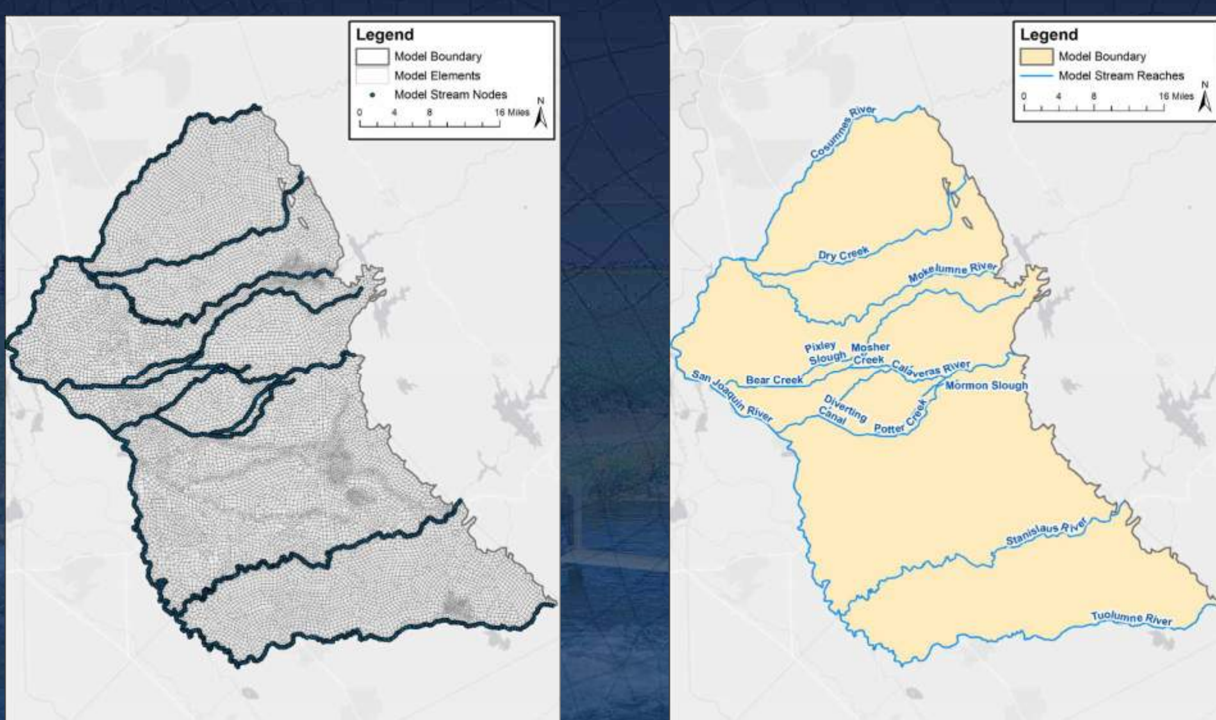
Completed Model Component: Model Boundary and Subregions



Primary Cropping Pattern in ESJ Subbasin



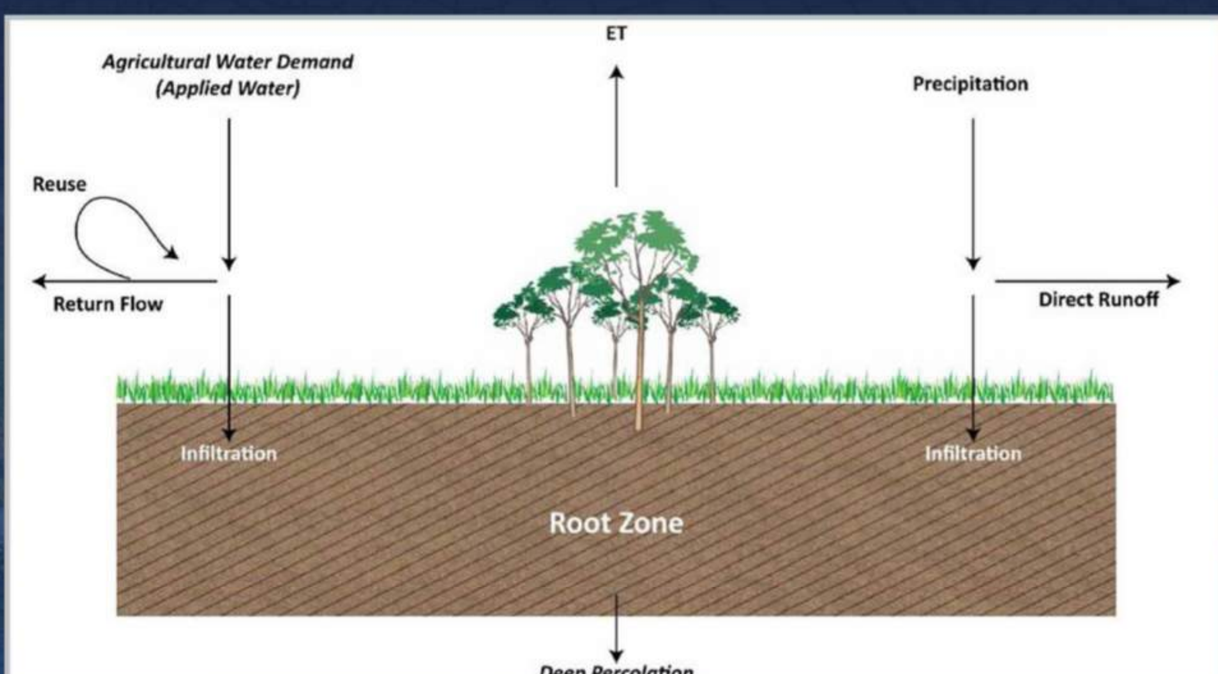
Completed Model Component: Stream Hydrology



ESJ Model Trivia Part II

1. How many elements are in the model?
   16,054 elements
2. What is the average node spacing in the model area?
   - Across Model Area: 0.37 miles
   - Along the Rivers / Water Courses: 0.28 miles
3. Why do we break up the model into elements?
   - Delineate hydrologic and jurisdictional features at local scale
   - Simulate hydrologic processes at local scale

AG Water Demand Estimation

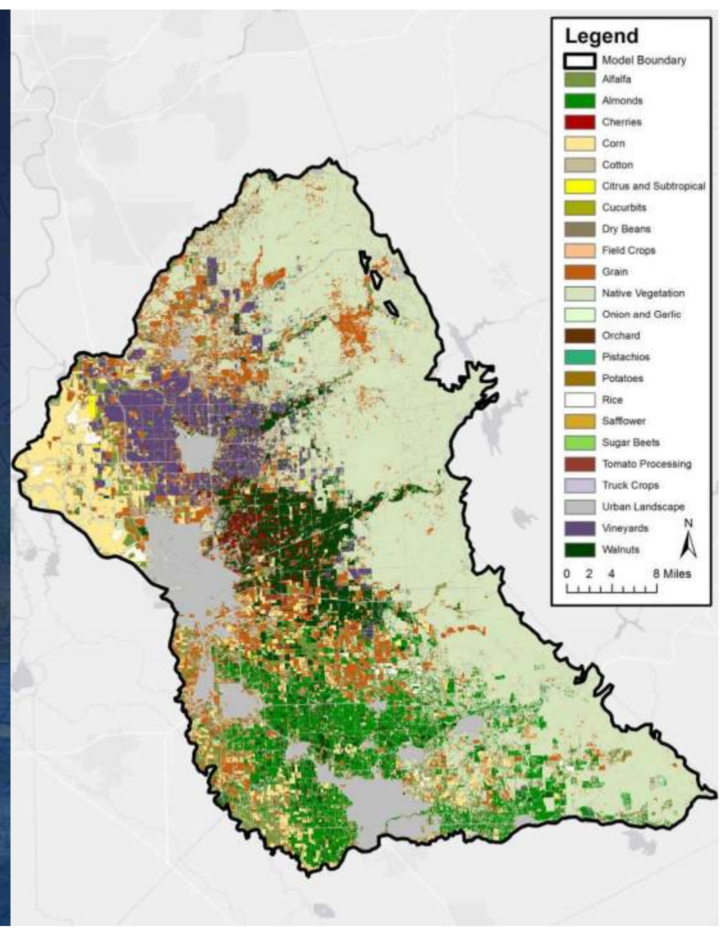


Land Use and Crop Coverage

1. DWR Land Use Surveys (Representing ~1995 Era)
   - San Joaquin County (1996)
   - Sacramento County (1993)
   - Amador County (1997)
   - Calaveras County (2000)
   - Stanislaus County (1996)
2. Remote Sensing Data:
   - USDA's CropScape
   - DWR's LandIQ Survey; 2014
3. Local Data Sources

USDA CropScape

- Satellite imagery collected during growing season
- 30 meter by 30 meter pixels
- Level of accuracy: Generally 85% to 95% for crop-specific land cover categories
- 256 land use categories

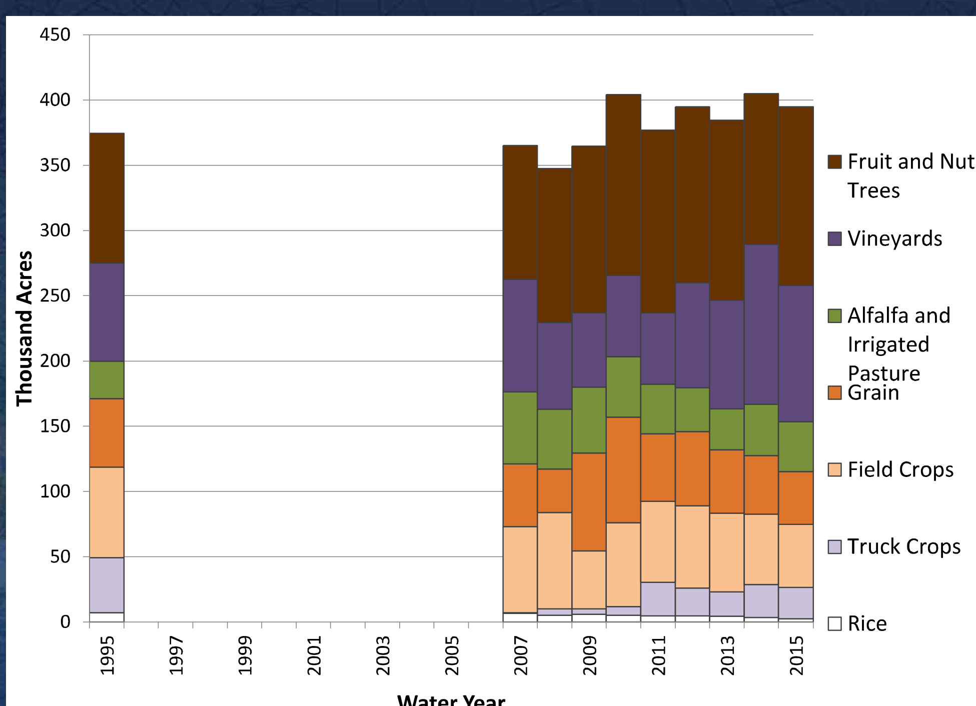


Model Land Use Types

- 23 irrigated crop categories
- 4 other land use categories
- 7 high-level categories used for verification purposes

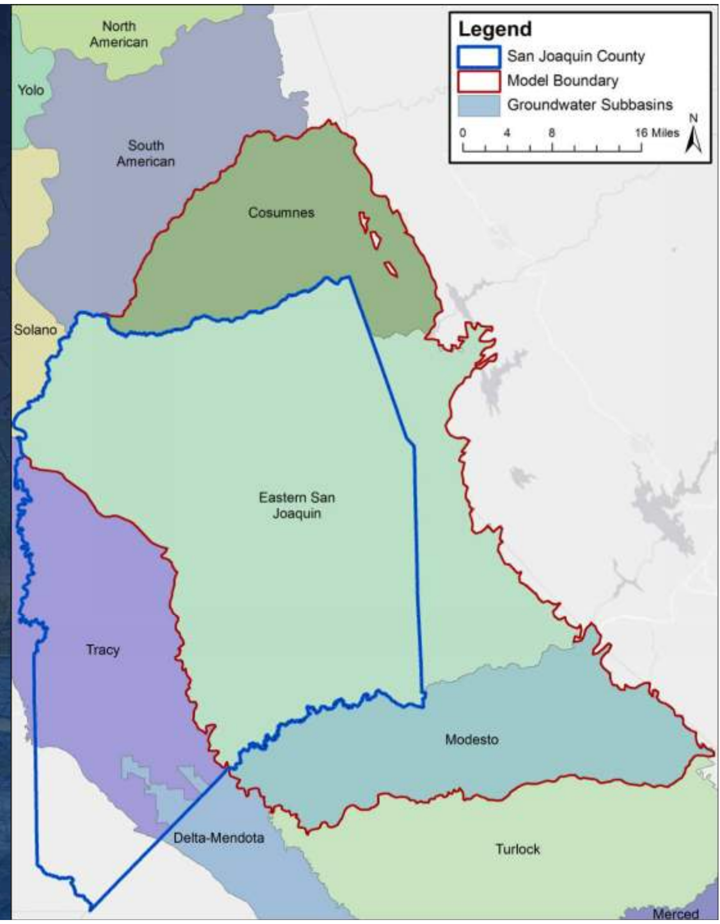
Model Crop Category	Grouped Crop Categories
Almonds Cherries Citrus & Subtropical Other Orchard Pistachios Walnuts	Fruit and Nut Trees
Vineyards	Vineyards
Alfalfa Pasture	Alfalfa and Irrigated Pasture
Grain	Grain
Corn Cotton Dry Beans Field Crops Safflower Sugar Beets	Field Crops
Cucurbits Onion & Garlic Potatoes Tomato Fresh Tomato Processing Truck Crops	Truck Crops
Rice	Rice
Urban Landscape Water Surface Riparian Vegetation Native Vegetation	Other Land Use

Primary Cropping Pattern in ESJ Subbasin



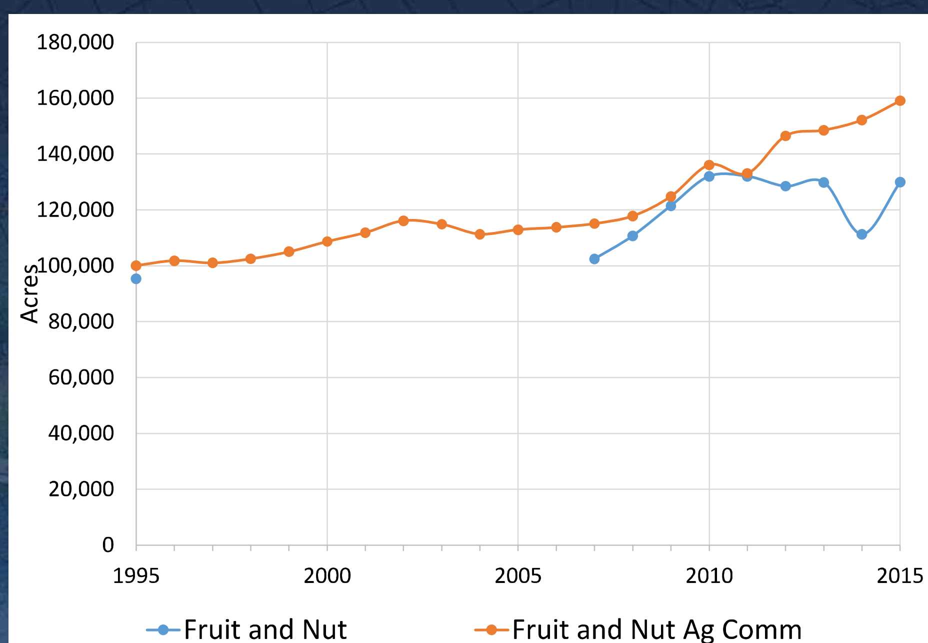
Regional Data: Comparison with Agricultural Commissioner Reports

- Ag Commissioner annual reports cover the entire county
- Model covers only the portion of the Eastern San Joaquin groundwater subbasin within the county
- Numbers not directly comparable, but can be used to glean trends



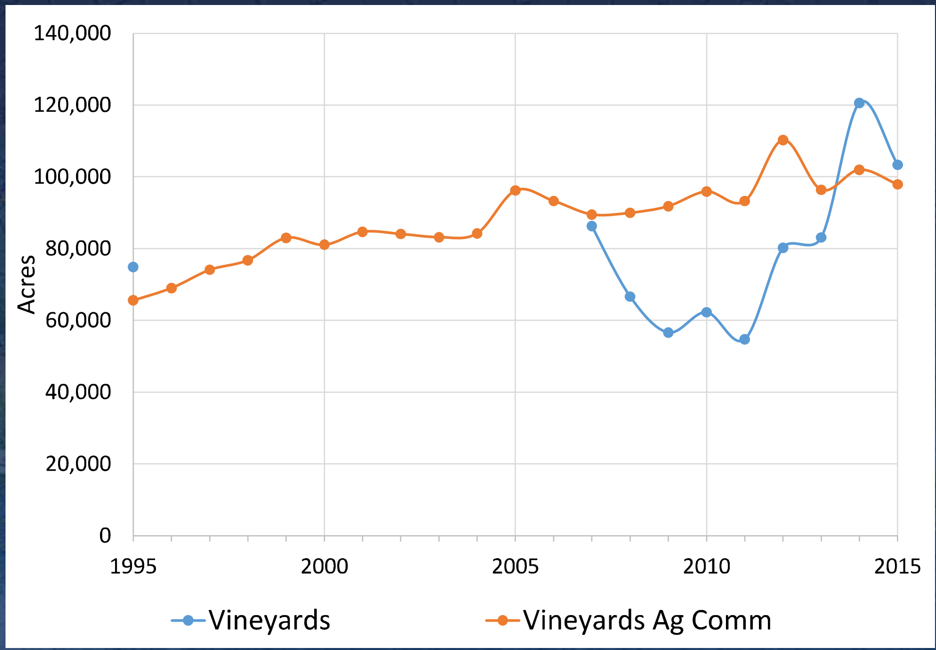
Fruit and Nut Crops

- Categories:
  - Almonds
  - Cherries
  - Citrus & Subtropical
  - Other Orchard
  - Pistachios
  - Walnuts



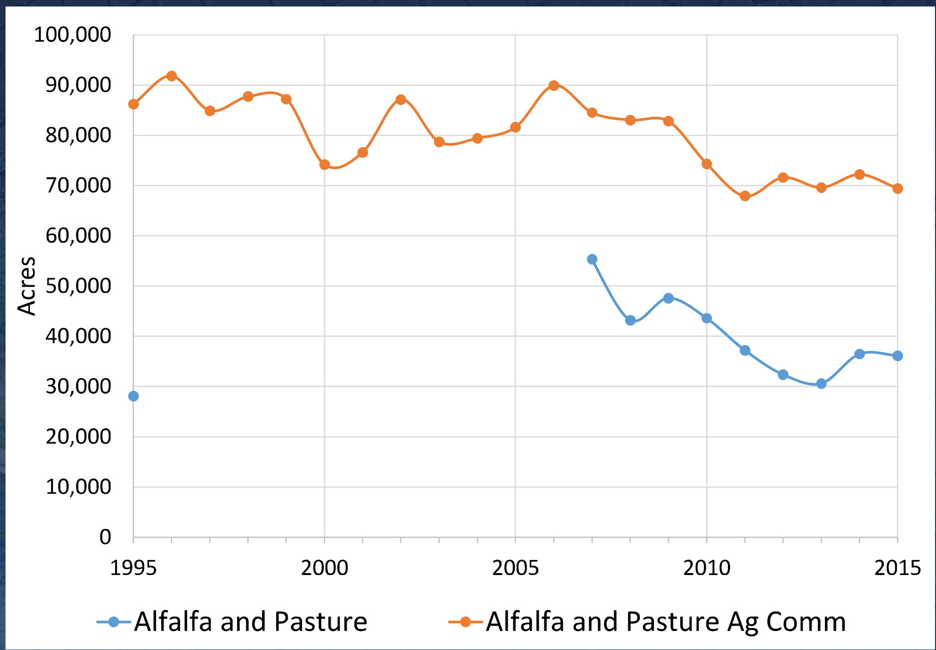
Vineyards

- Categories:
  - Vineyards



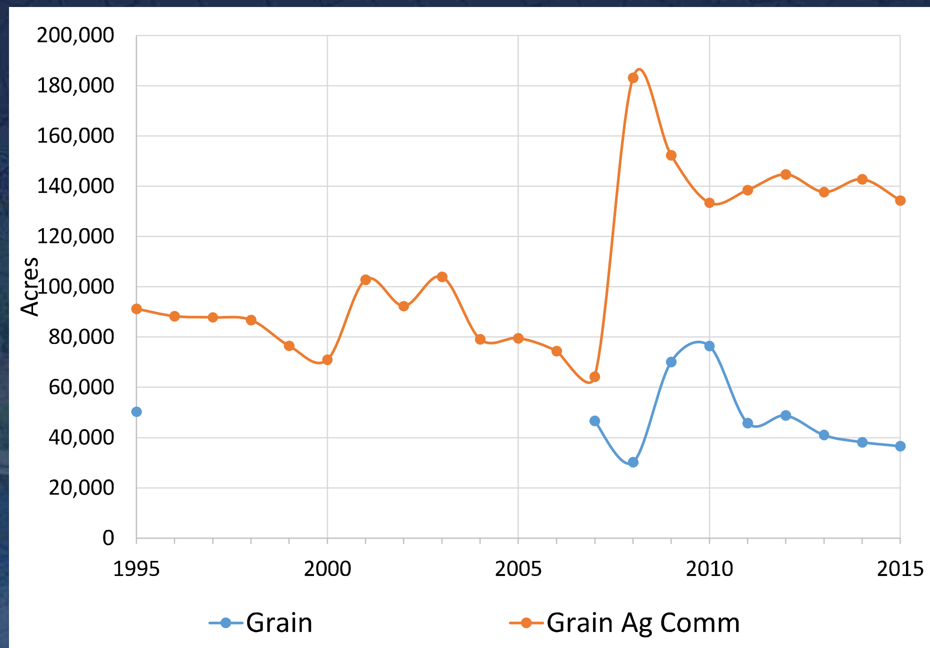
Alfalfa and Irrigated Pasture

- Categories:
  - Alfalfa
  - Pasture



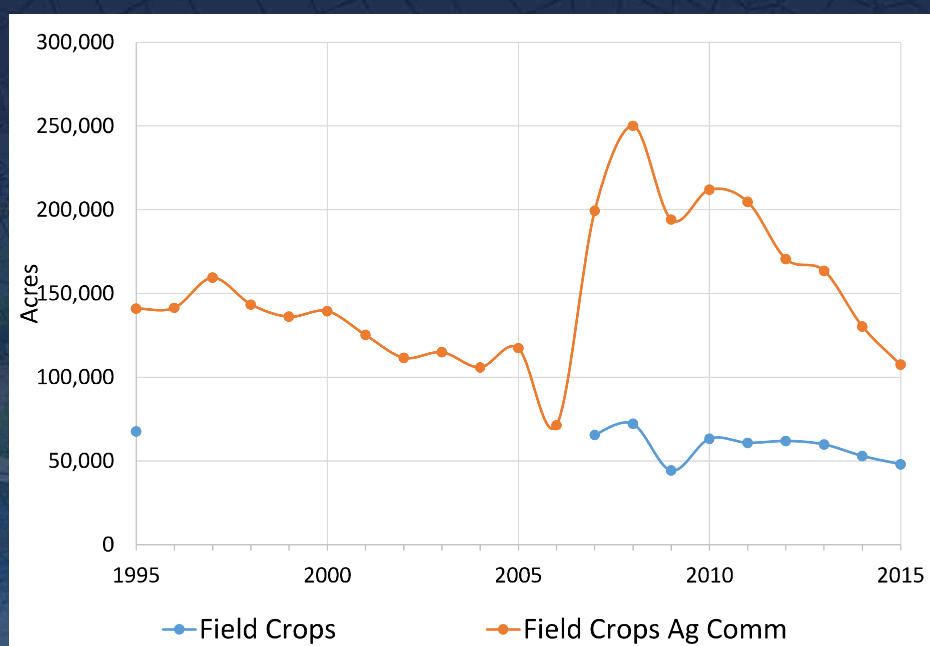
Grain

- Categories:
  - Grain
  - Silage



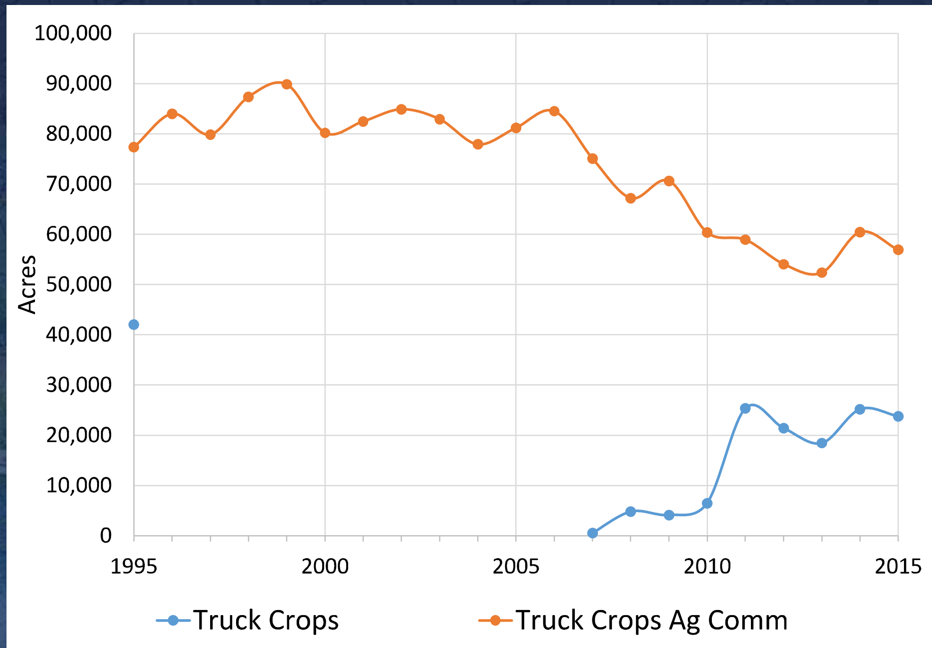
Field Crops

- Categories:
  - Corn
  - Cotton
  - Dry Beans
  - Field Crops
  - Safflower
  - Sugar Beets



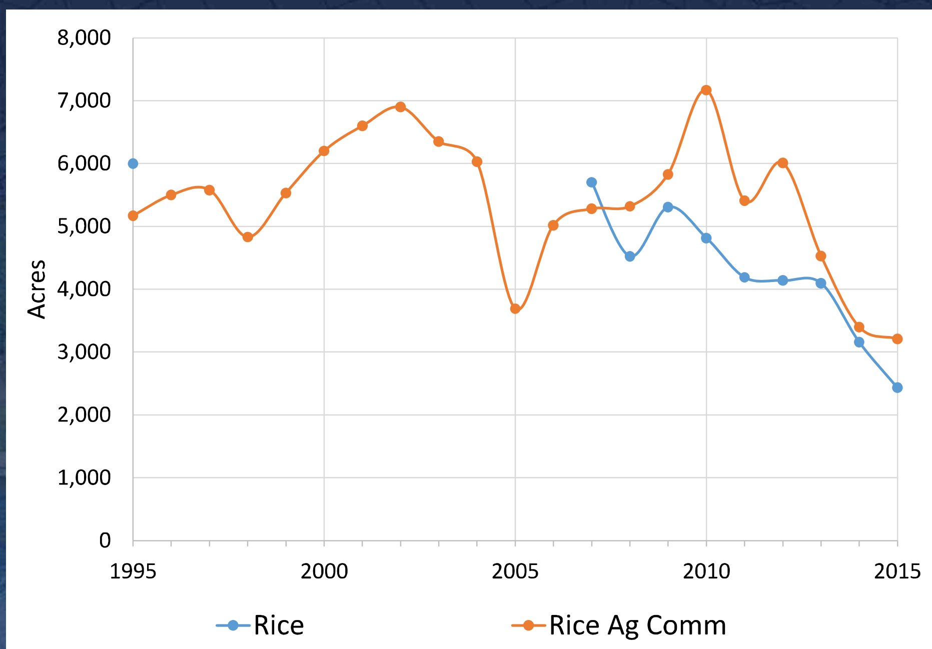
Truck Crops

- Categories:
  - Cucurbits (e.g., squash, melons, cucumbers, etc.)
  - Onion & Garlic
  - Potatoes
  - Tomato Fresh
  - Tomato Processing
  - Truck Crops



Rice

- Categories:
  - Rice

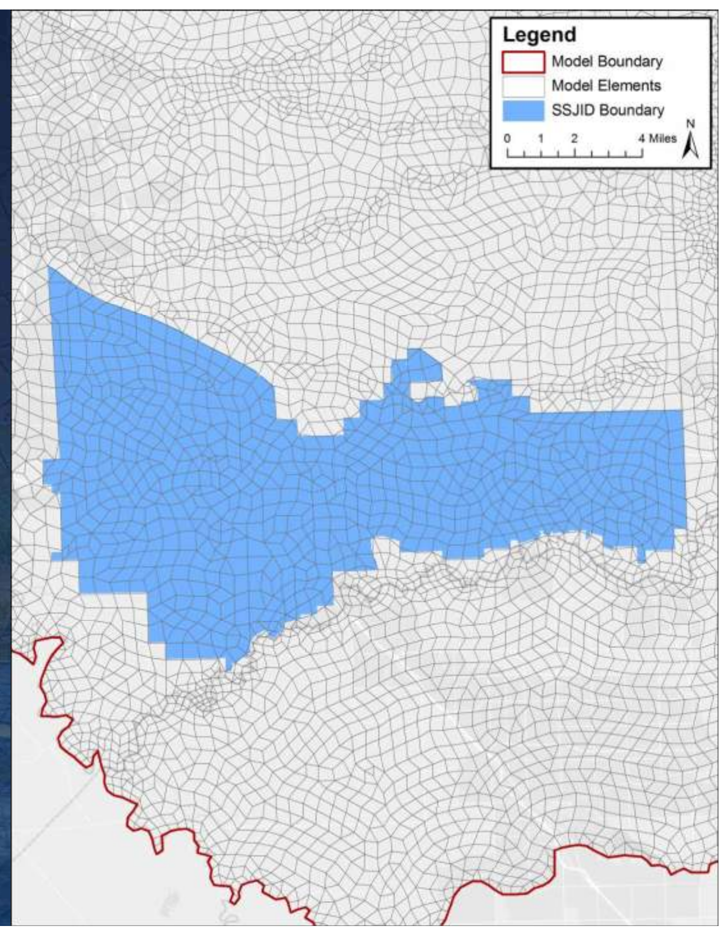


Summary

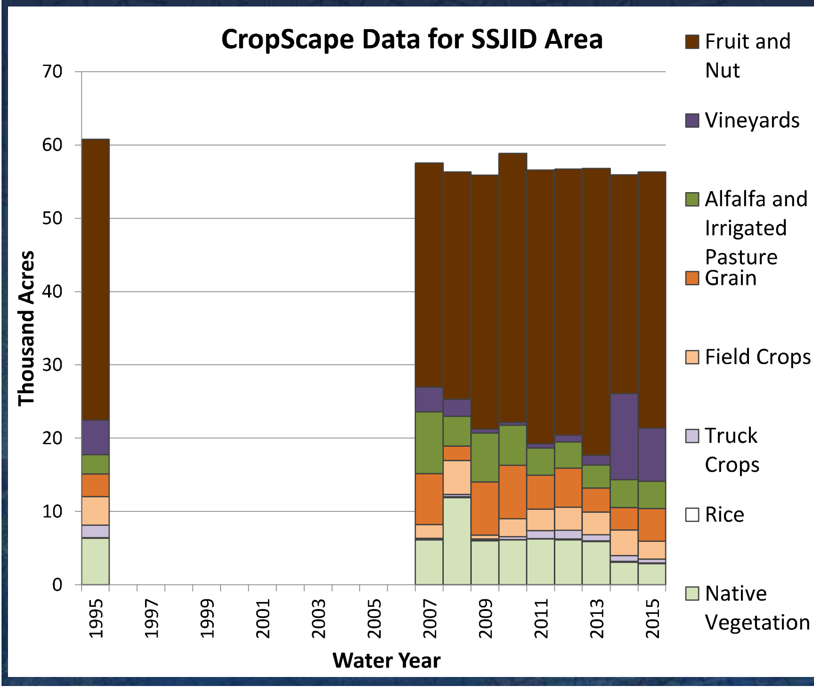
- Ag Commissioner data provides reasonable trends in the cropping pattern by major cropping categories, which can be used to modify CropScape trends
- Additional information for CropScape adjustment:
  - San Joaquin & Delta Water Quality Coalition
  - DWR's LandIQ survey
  - Local data from irrigation districts

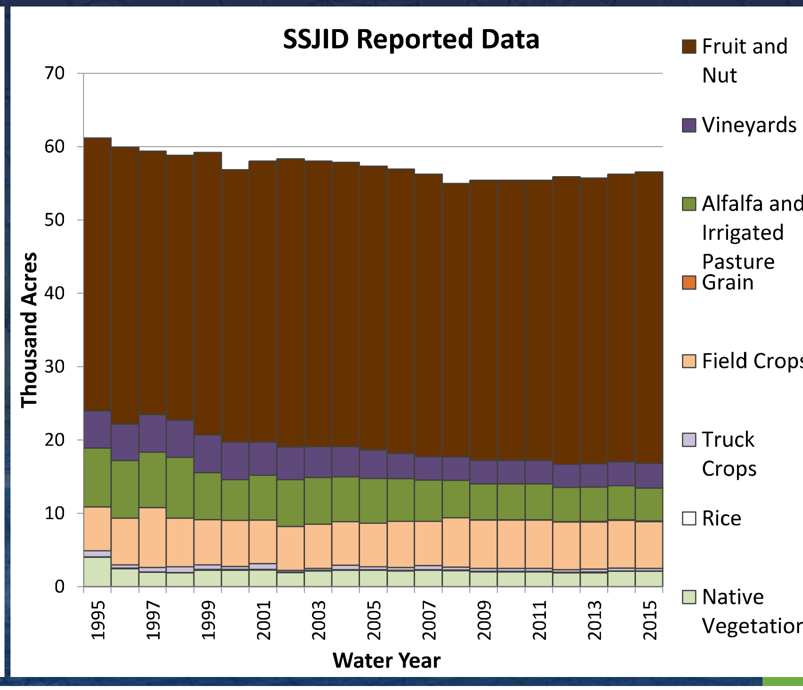
Local Data: Comparison with SSJID Acreages

- SSJID provided annual acreages by crop
- SSJID crop categories were mapped to model categories
- For CropScape years, overall agricultural area is larger for SSJID-provided acreages by average of ~3,000 acres, which may most likely be attributed to immature orchards or immature croplands

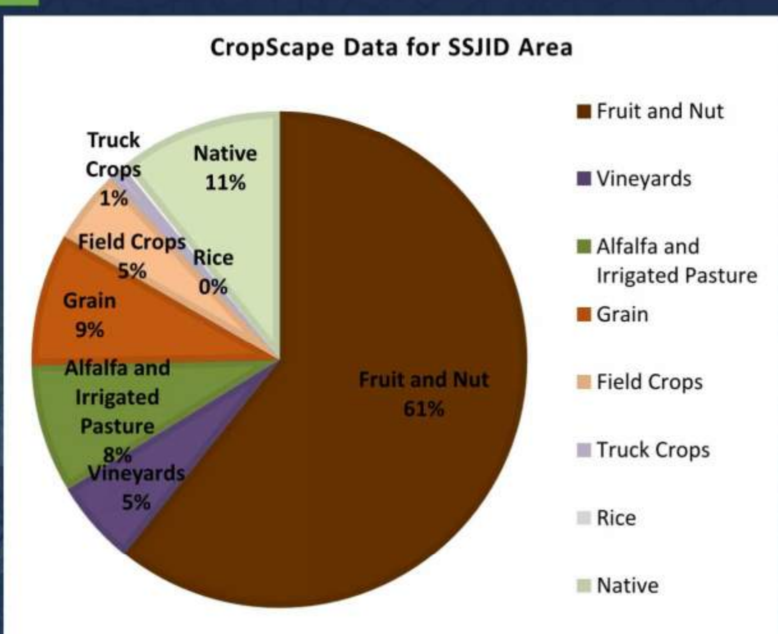


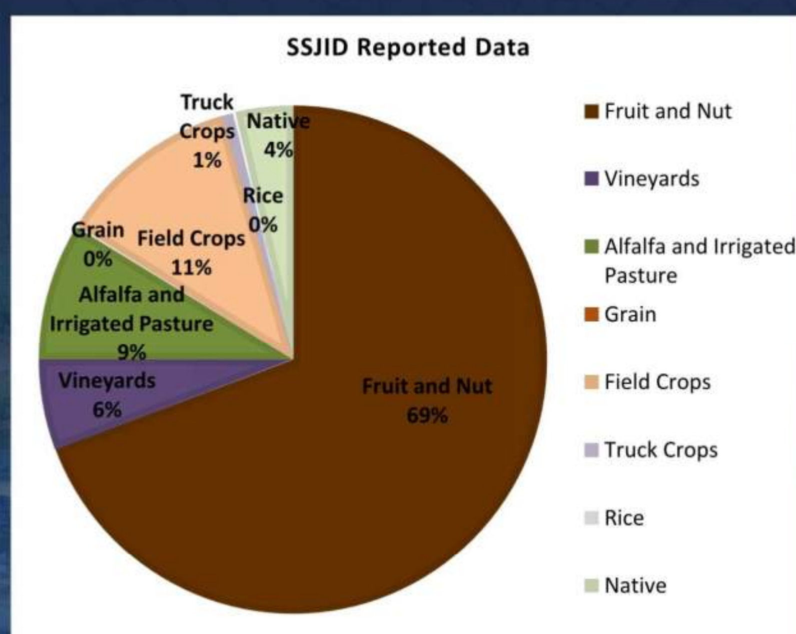
Bar Chart of Grouped Crop Categories





Comparison Pie Charts: Grouped Crop Categories





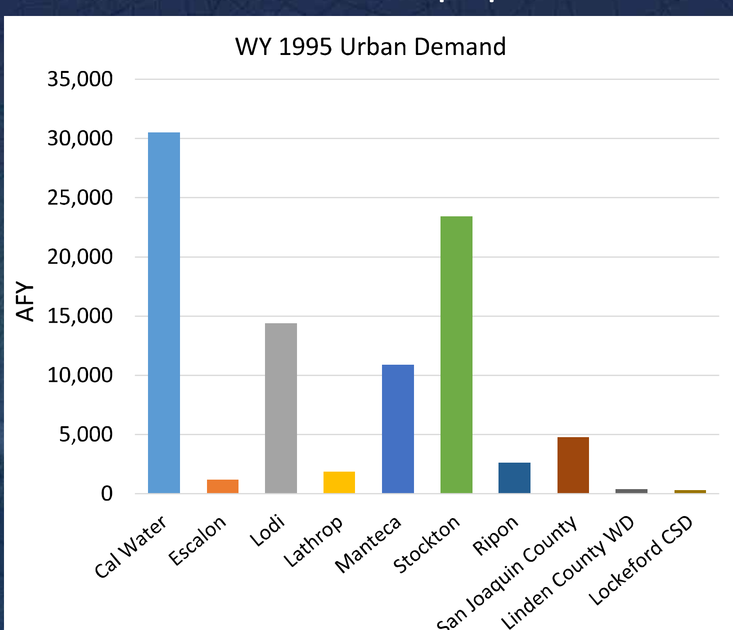
Note: Data is averaged across CropScape years (2007-2015)

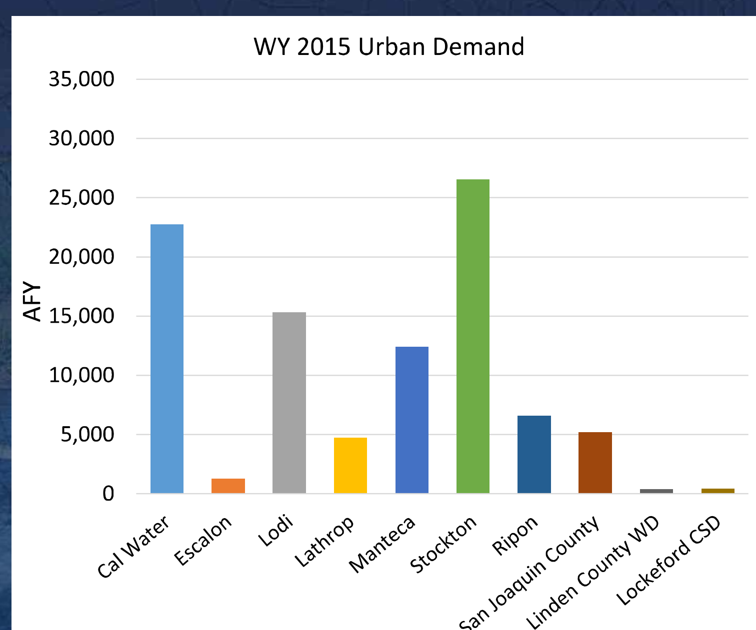
Ag Cropping Pattern: What We Need From You

- Any local crop acreages and spatial information
- Local knowledge of crop trends/types to help correct problems in CropScape data
- Any direction needed by Friday May 26, 2017; COB

Urban Water Demand

- Based on GPCD and population if water demand information unavailable





Urban Water Demand: What We Need From You

- Review of population, GPCD, and urban water use data
- Breakdown between indoor and outdoor water use
- Any direction needed by Friday May 26, 2017; COB

Next Steps

1. Complete LU/Cropping acreages
2. Complete IDC input data files
3. Complete GW pumping for urban
4. Compile and Process Surface water deliveries for urban
5. Compile and Process Surface water deliveries for agricultural use
6. Complete GW pumping for agricultural use
7. Complete pumping well construction information

Sustainable Groundwater Management Act Readiness Project

Meeting No. 7:

Integrated Water Resources Model Development Update

RMC water and environment

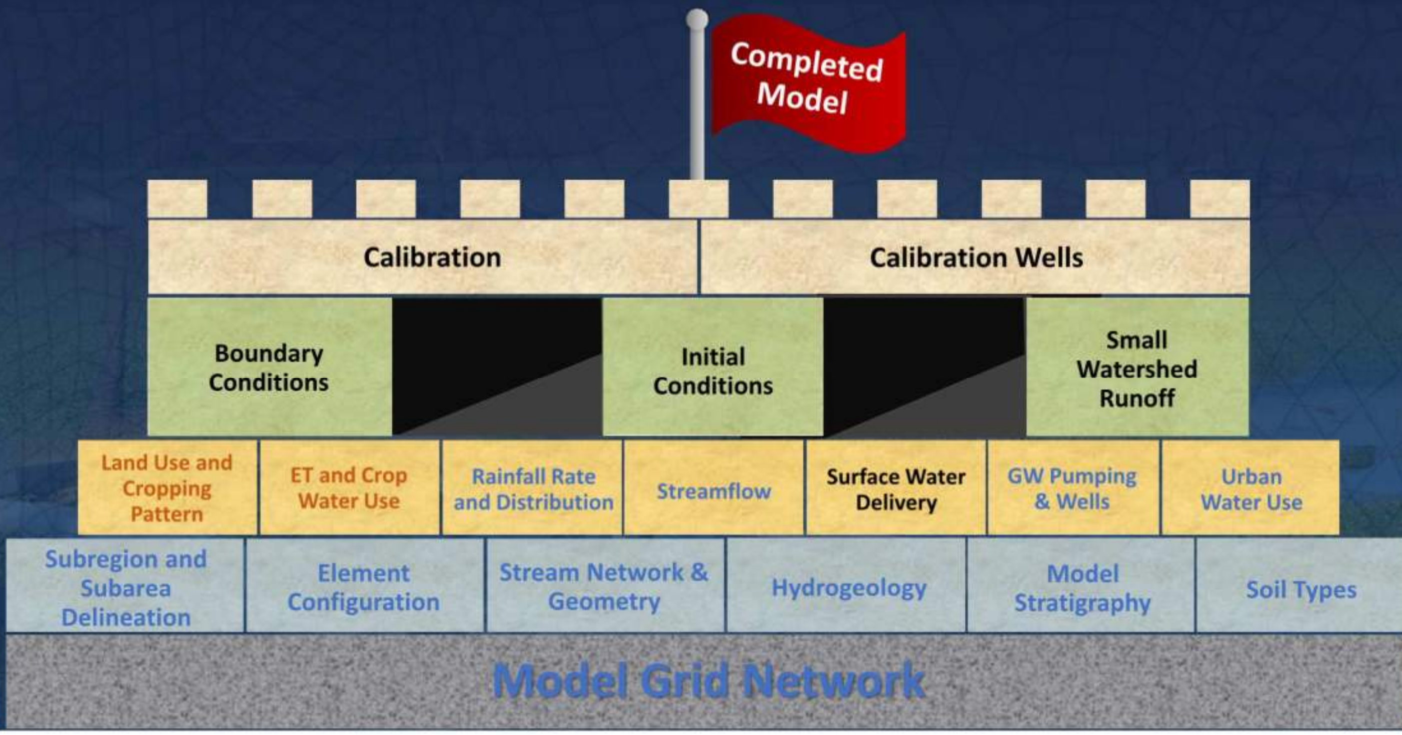
Complex Challenges | Innovative Solutions

June 28, 2017

Agenda

- Introduction
- Recap of Land Use and Cropping Patterns
- Ag Demand Estimation Methodology (IDC)
- Preliminary Ag Demand Estimates
- SJ County – GSP Work Plan
- Next Meeting

Integrated Model Construction



Model Name Examples

- Other IWFM Models:
  - MercedWRM (Merced Water Resources Model)
  - YGM (Yuba Groundwater Model)
  - BBGM (Butte Basin Groundwater Model)
  - YCIWFM (Yolo County IWFM)
- Other Models:
  - SacIGSM (Sacramento County IGSM)
  - NARIGSM (North American River Basin IGSM)
  - Stony Creek Fan (SCF) IGSM
  - KingsIGSM (Kings Basin IGSM)
  - C2VSim (California Central Valley Groundwater-Surface Water Simulation Model

IWFM
Integrated Water Flow Model

IGSM
Integrated Groundwater and Surface Water Model

Our Model Name

For your consideration…

ESJ Integrated Water Flow Model

Or

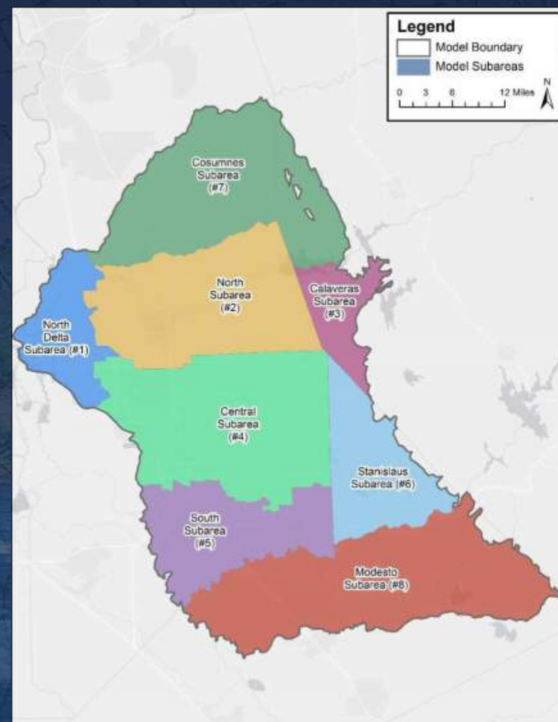
ESJ Integrated Water Resources Model

Thoughts?

ESJ Model Trivia Part I

1. How many data input subregions are in ESJ-IWFM? ESJ Subbasin?
   20 data input subregions (ESJ-IWFM) / 18 data input subregions (ESJ Subbasin)
2. How many model output subareas make up ESJ-IWFM? ESJ Subbasin?
   8 model output subareas (ESJ-IWFM) / 6 model output subareas (ESJ Subbasin)
3. How many land use categories are in ESJ-IWFM?
   27 (23 crop categories and 4 other land use types)
4. What is the gross irrigated acreage in the ESJ Subbasin in 2015?
   394,877 acres
5. What are the biggest 3 crops by acreage in the ESJ Subbasin in 2015?
   Vineyards (104,586 acres), Walnuts (71,365 acres), and Almonds (52,614 acres)

Completed Model Component: Model Subregions and Subareas



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Cucurbits Onion & Garlic Potatoes Tomato Fresh Tomato Processing Truck Crops	Truck Crops
Rice	Rice
Urban Landscape Water Surface Riparian Vegetation Native Vegetation	Other Land Use

Recap of Land Use and Cropping Patterns

1. DWR Land Use Surveys (Representing ~1995 Era)
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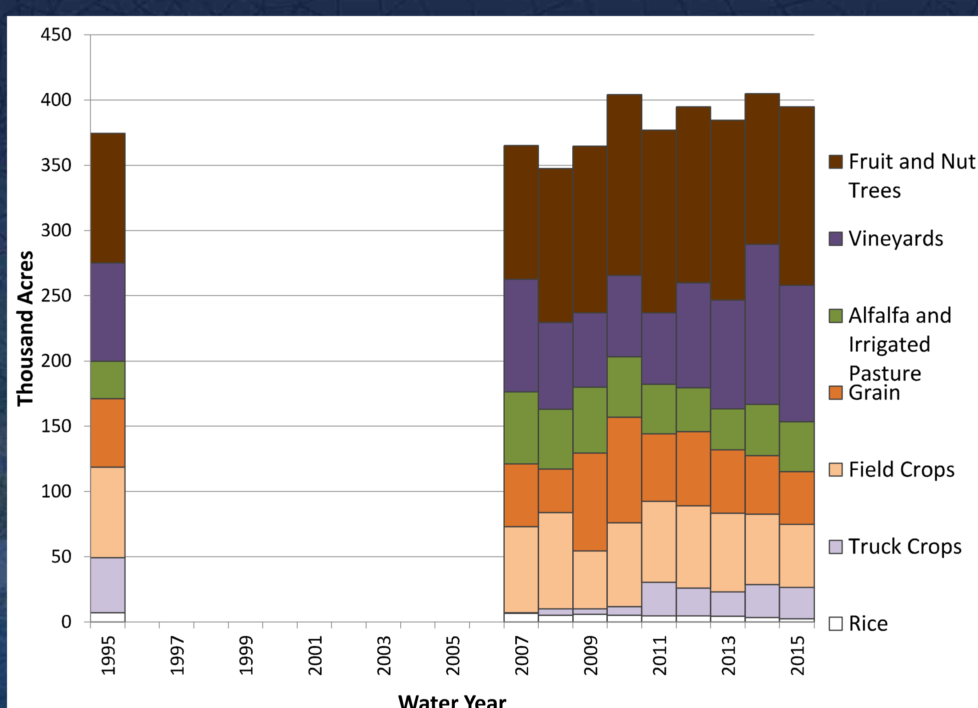
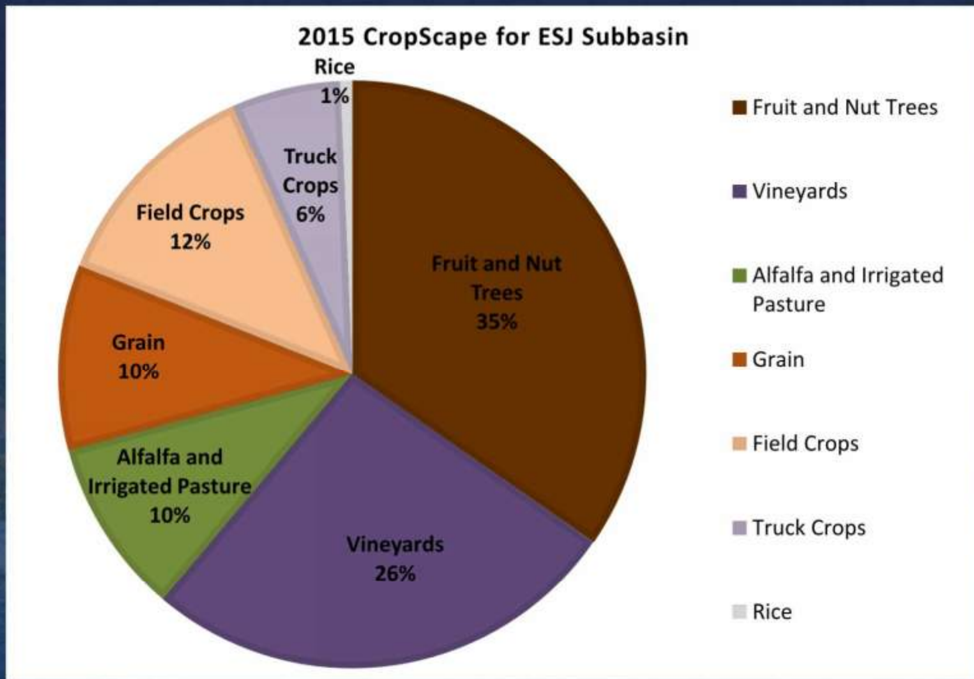
2. Remote Sensing Data:
   - USDA's CropScape
   - DWR's LandIQ Survey; 2014
3. Local Data Sources

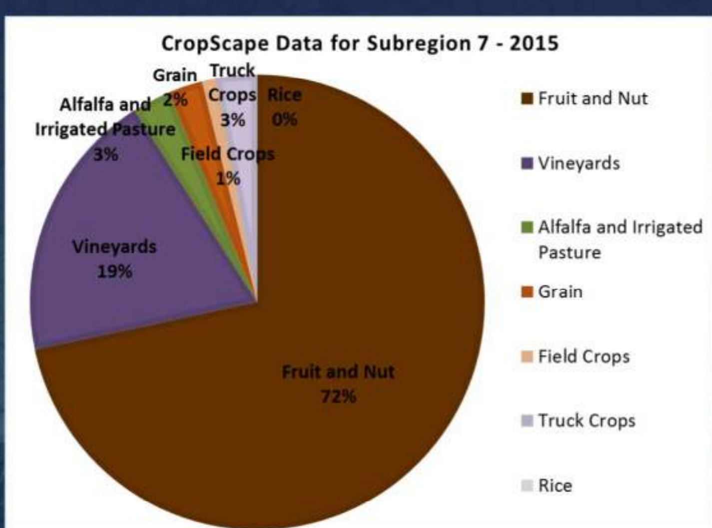
Primary Cropping Pattern in ESJ Subbasin

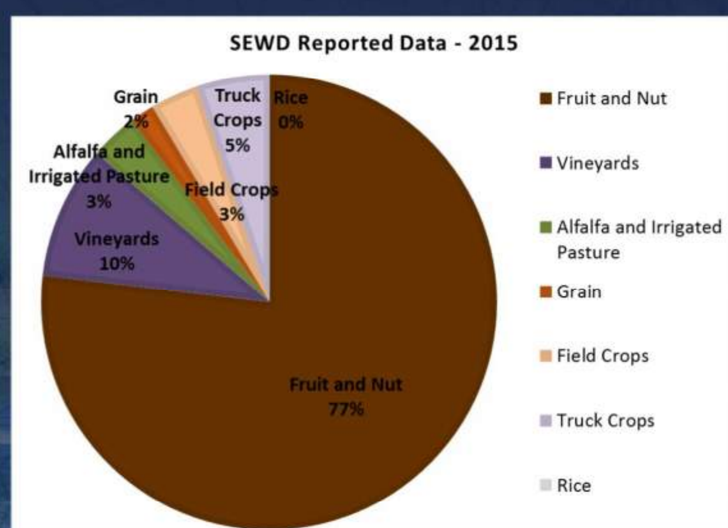


Primary Cropping Pattern in ESJ Subbasin



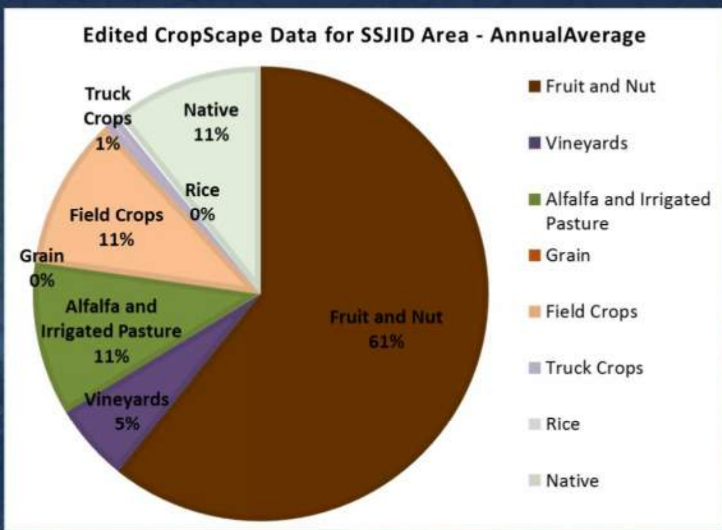
SEWD Crop Acreage Comparison

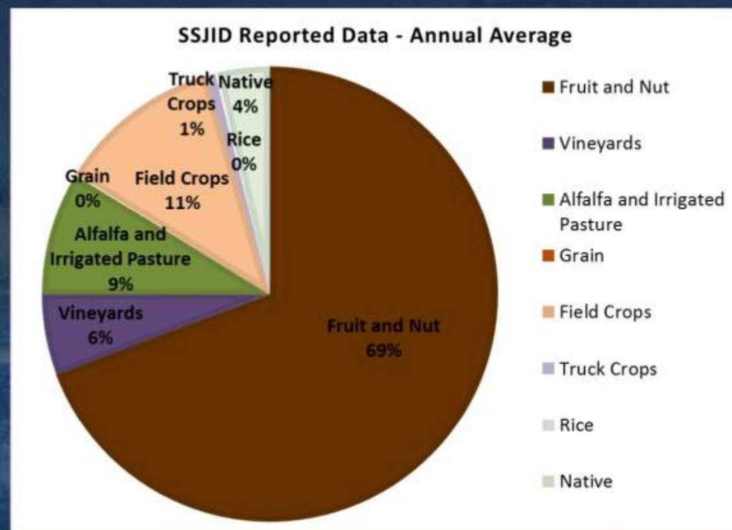




SSJID Acreage Edits

- Based on information provided by SSJID, transferred what CropScape was picking up as grain to either corn or alfalfa

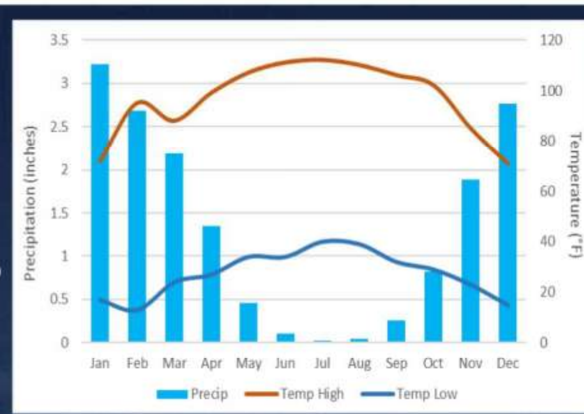




Future Land Use Edits

- Coordination with Stanisalus County model effort:
  - Jacobson James & Associates estimating end of July for updating land use data based on Ag Commissioner reports
  - Will consider edits to Stanislaus triangle and Modesto Subbasin at that time
- Incorporation of LandIQ spatial data for WY 2014
- Additional input from others

ESJ Model Trivia Part II

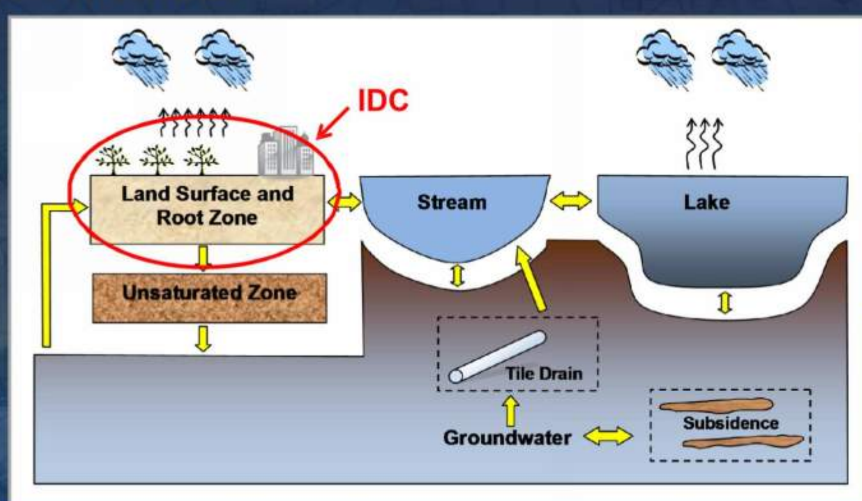


1. What does IDC stand for? What does it do?
   IWFM Demand Calculator
   IDC estimates agricultural demand
2. What is the County's average daily temperature in the past 60 years?
   Daily average temperature is 54.4°F[1]
3. What is the County's average annual precipitation in the past 60 years?
   Annual average observed precipitation is 14.7 inches[1]
4. What is the County's average monthly reference evapotranspiration in the past 30 years?
   Monthly average reference evapotranspiration is 4.2 inches[2]

1. Stockton Fire Station #4 – NCDC Weather Station
2. Manteca CIMIS Station

Ag Demand Estimation using IDC

- IWFM Demand Calculator (IDC) is a software that calculates land use based water demands and routes water through the land surface and root zone using physically-based simulation methods
- Uses methods from irrigation-scheduling-type models and applies them at regional scales
- Stand-alone executable or root zone module of Integrated Water Flow Model (IWFM) v2015



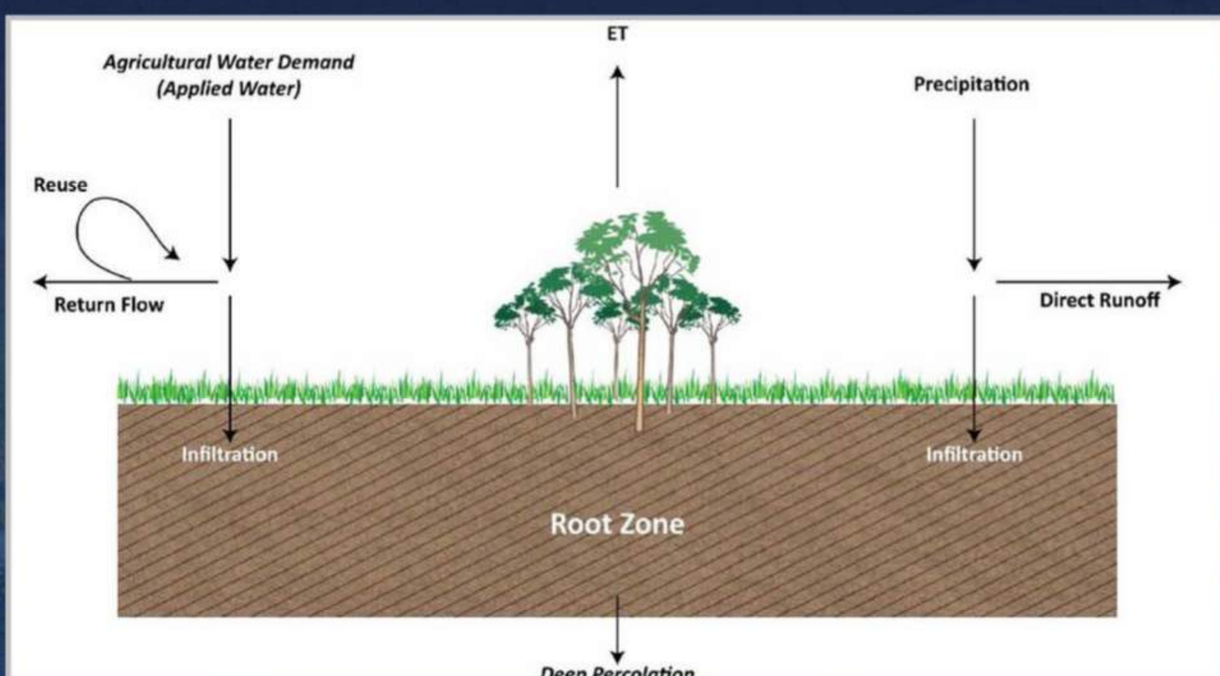
Source: IDC training workshop (Emin Can Dogrul, DWR)

IDC Background

- IDC was initially developed to…
  - Maintain consistency between C2VSim and CalSim
  - Calculate downstream water demands for CalSim under current conditions and future scenarios
- First version of IDC did not have rice and refuge simulations, had incompatible calculations for daily runs
- IDC v4.0 was developed to improve upon the initial version of IDC
- With alternative root zone routing schemes developed (v4.0, v4.1 and v3.02) IDC-2015 became a container for different root zone routing methods

Source: IDC training workshop (Emin Can Dogrul, DWR)

IDC Data



Source: IDC training workshop (Emin Can Dogrul, DWR)

Features of IDC-2015

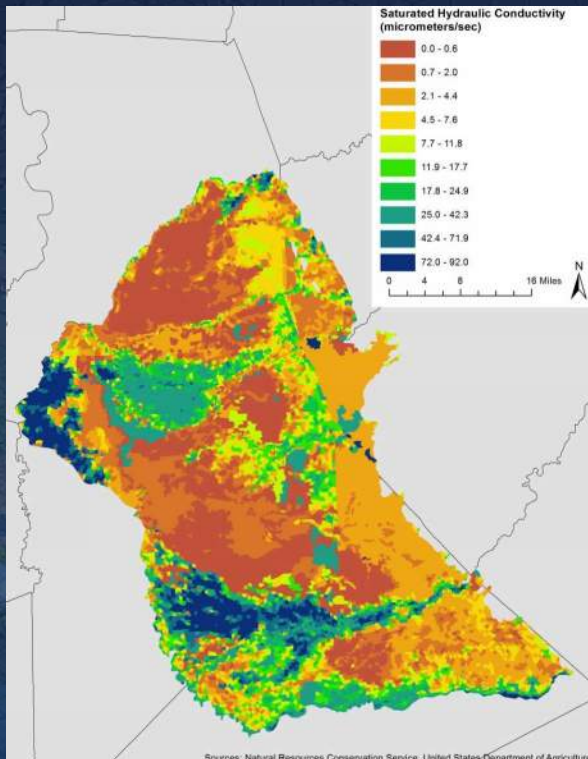
- Use of a computational grid, finite-element or finite-difference, to represent spatial distribution of land-use, climatic, soil and farm management properties; each cell can have multiple land-use types specified as time-series data
- Simulation of land surface and root zone flow processes as well as water demand computations are done at each grid cell for each land-use type
- Irrigation-scheduling-type approach at each grid cell for each agricultural crop
- Direct representation of rice fields (including simulation of flooded decomposition, non-flooded decomposition and no decomposition) and refuges (seasonal and permanent)
- Riparian vegetation access to stream flows and simulation of evapotranspiration from groundwater
- Urban water demand computation based on population and per capita water usage
- Simulation of ETAW and effective precipitation
- Simulation of re-use of irrigation return flow that takes place at a grid cell, between grid cells or between subregions
- Budget output includes soil moisture, and land and water use budgets for individual crops at each subregion

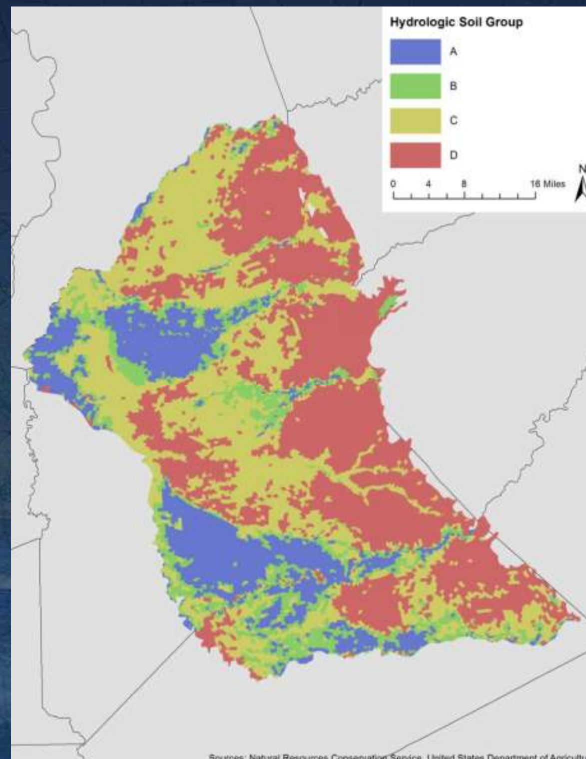
Source: IDC training workshop (Emin Can Dogrul, DWR)

Key Parameters and Data in IDC

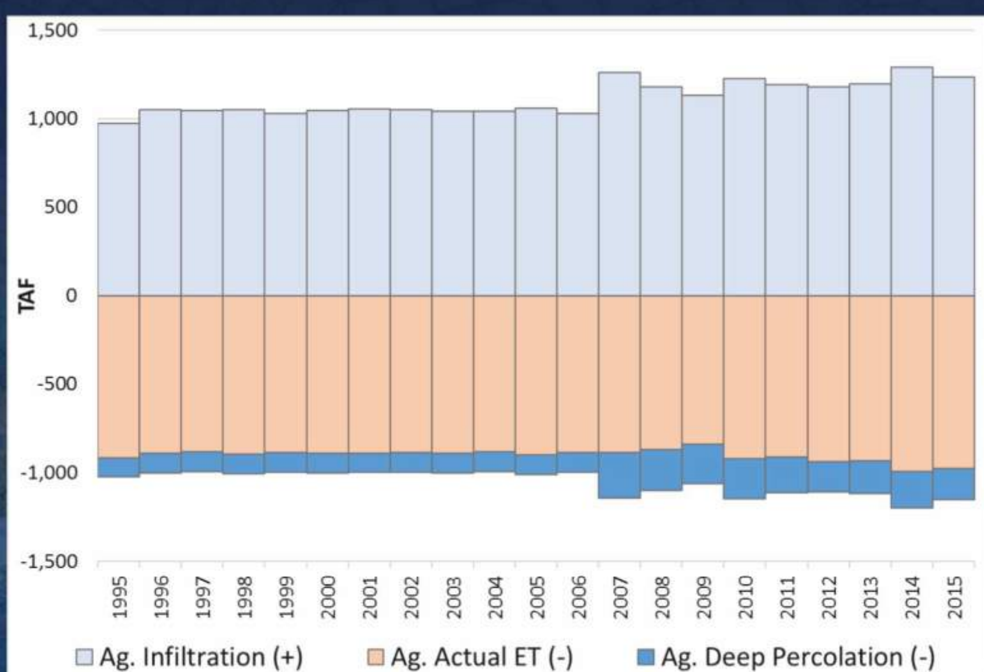
- Monthly Rainfall
- Crop Evapotranspiration, Et_c
- Return and reuse fractions
- Irrigation period
- Land use and crop acreages
- Urban population and per capita water use
- Soil Properties:
  - Hydraulic Conductivity
  - Pore Size Distribution Index
  - Others: Wilting Point, Field Capacity, Total Porosity

Root Zone Parameters

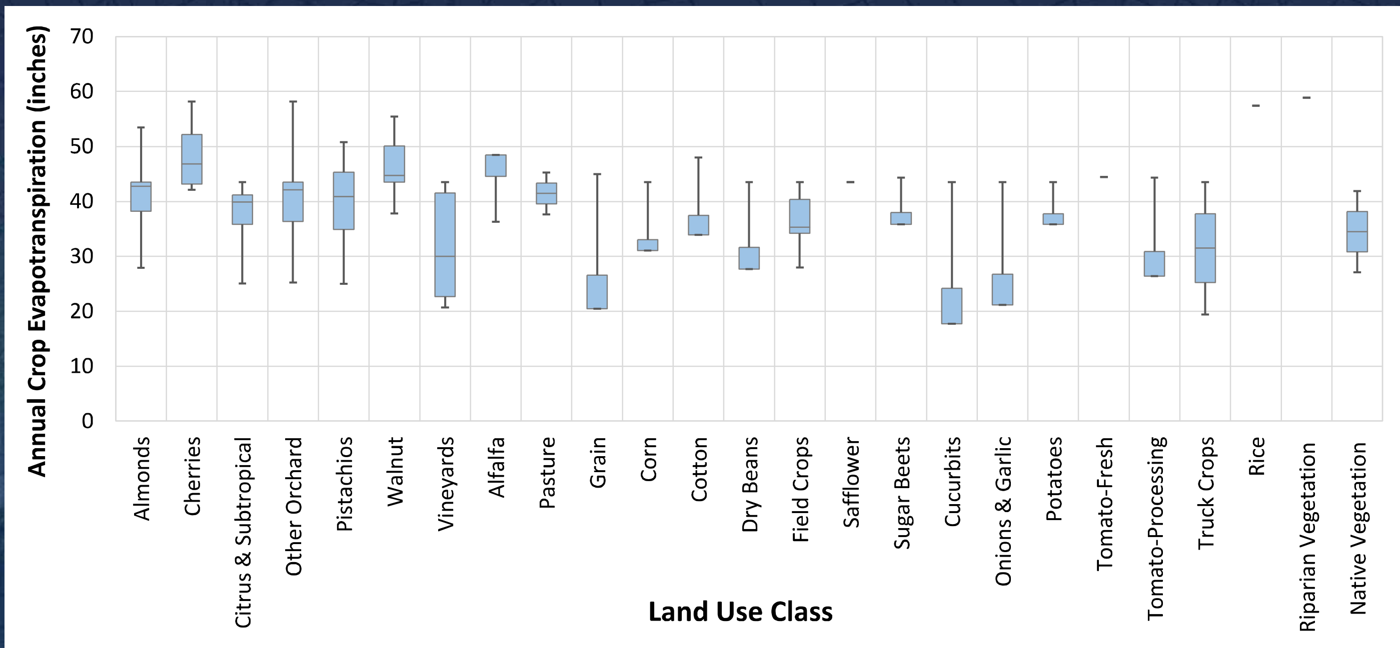




Preliminary IDC Results for ESJ Subbasin: Agricultural Root Zone Budget

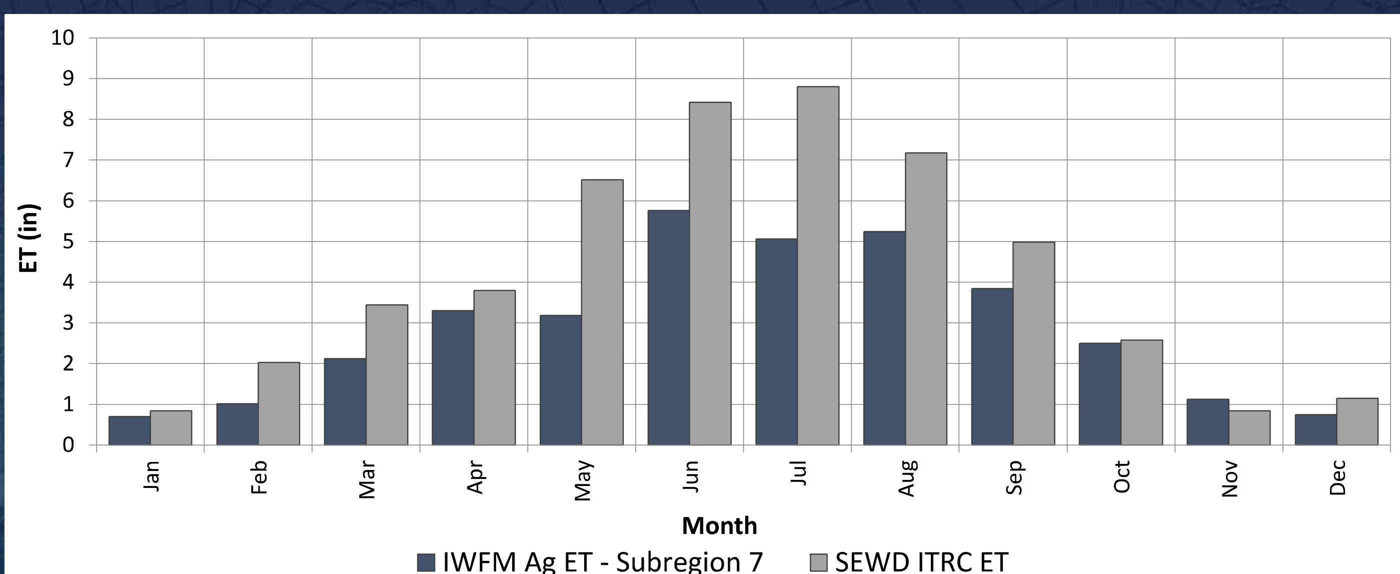


Range of Crop Evapotranspiration in Model Area



Sources: C2VSim Subregion 8 ETc, SEWD ITRC Typical Year ETc, and SSJID ITRC Average ETc

Ag Evapotranspiration Comparison



Note: ITRC includes cover crops with all tree crops (annual ET of trees with cover crops is ~10 inches higher than trees alone)

Preliminary IDC Results: Estimated Irrigation Efficiency

- Irrigation efficiency estimated as agricultural evapotranspiration (i.e., use of applied water by plants) divided by total water applied to irrigated lands

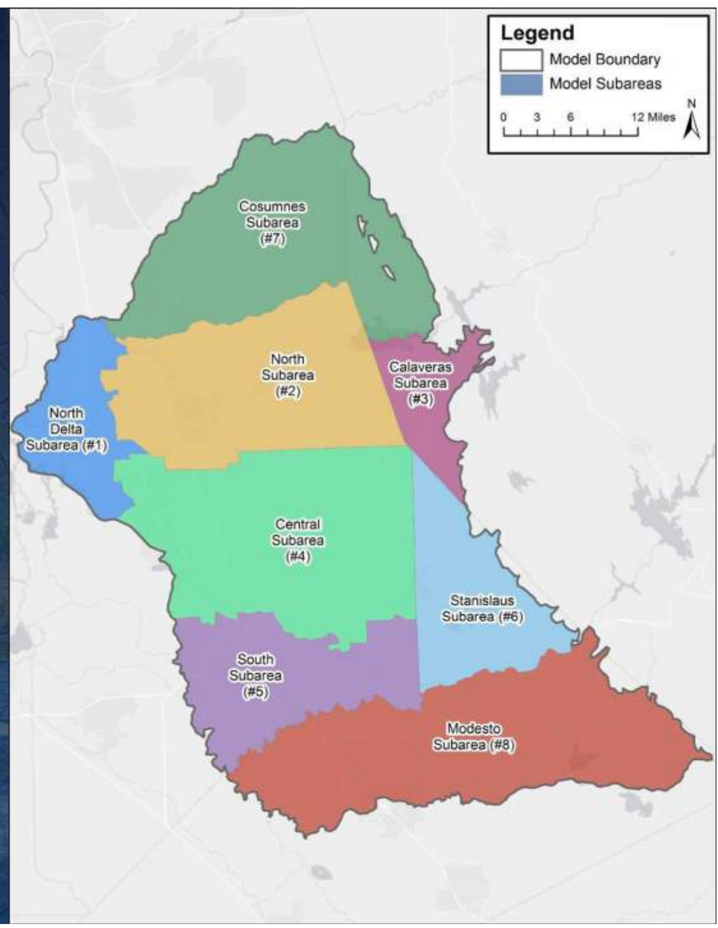
$$IE = \frac{Ag\ ET}{Applied\ Water}$$

Subarea	Name	Estimated Irrigation Efficiency
1	North Delta Subarea	73%
2	North Subarea	77%
3	Calaveras Subarea	74%
4	Central Subarea	74%
5	South Subarea	76%
6	Stanislaus Subarea	71%
TOTAL	Eastern San Joaquin Subbasin	75%

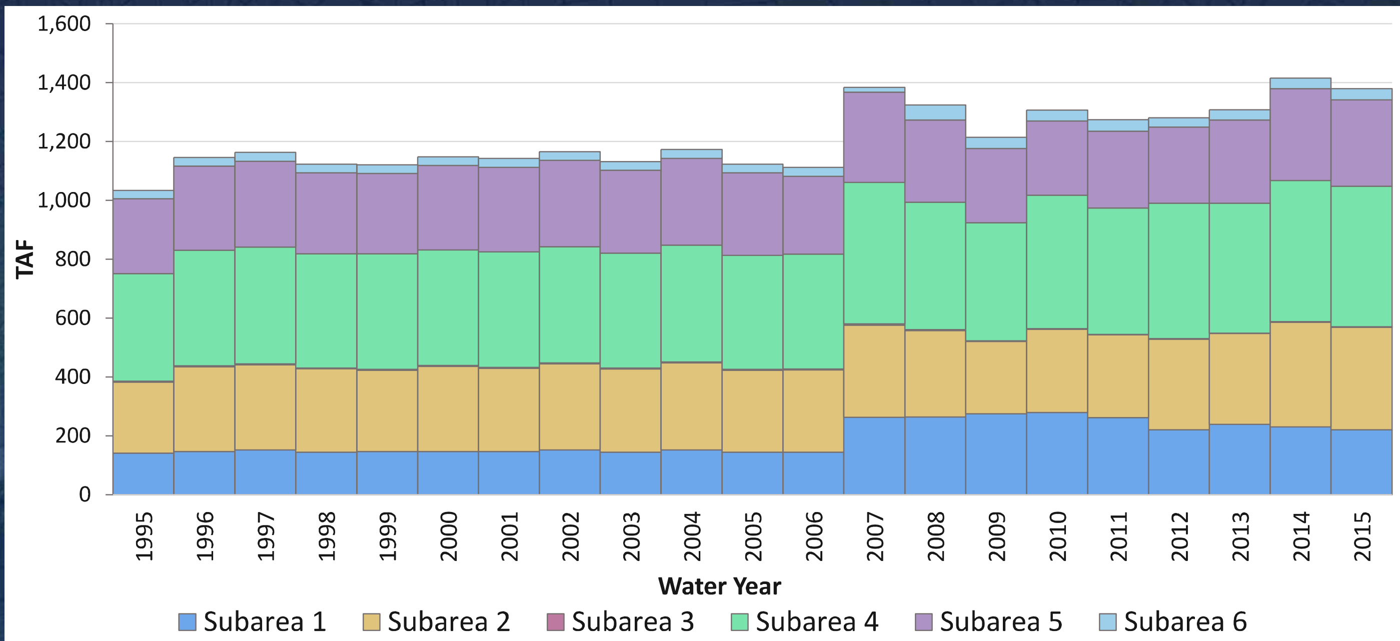
Note: Using averages from irrigation period (March-October)

Model Subareas

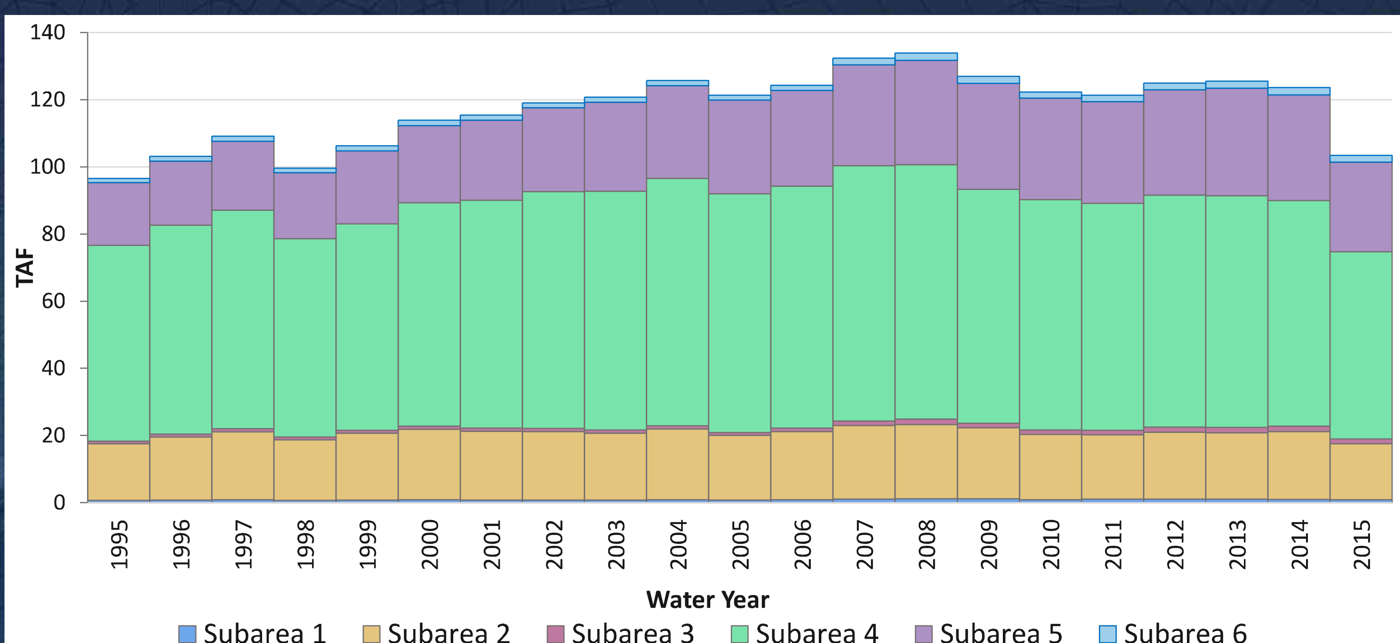
- Eastern San Joaquin Subbasin
  - Subarea 1 – North Delta
  - Subarea 2 – North
  - Subarea 3 – Calaveras
  - Subarea 4 – Central
  - Subarea 5 – South
  - Subarea 6 – Stanislaus
- Subarea 7 – Cosumnes
- Subarea 8 - Modesto



Preliminary IDC Results for ESJ Subbasin: Agricultural Water Demand Estimate



Preliminary IDC Results for ESJ Subbasin: Urban Water Demand Estimate



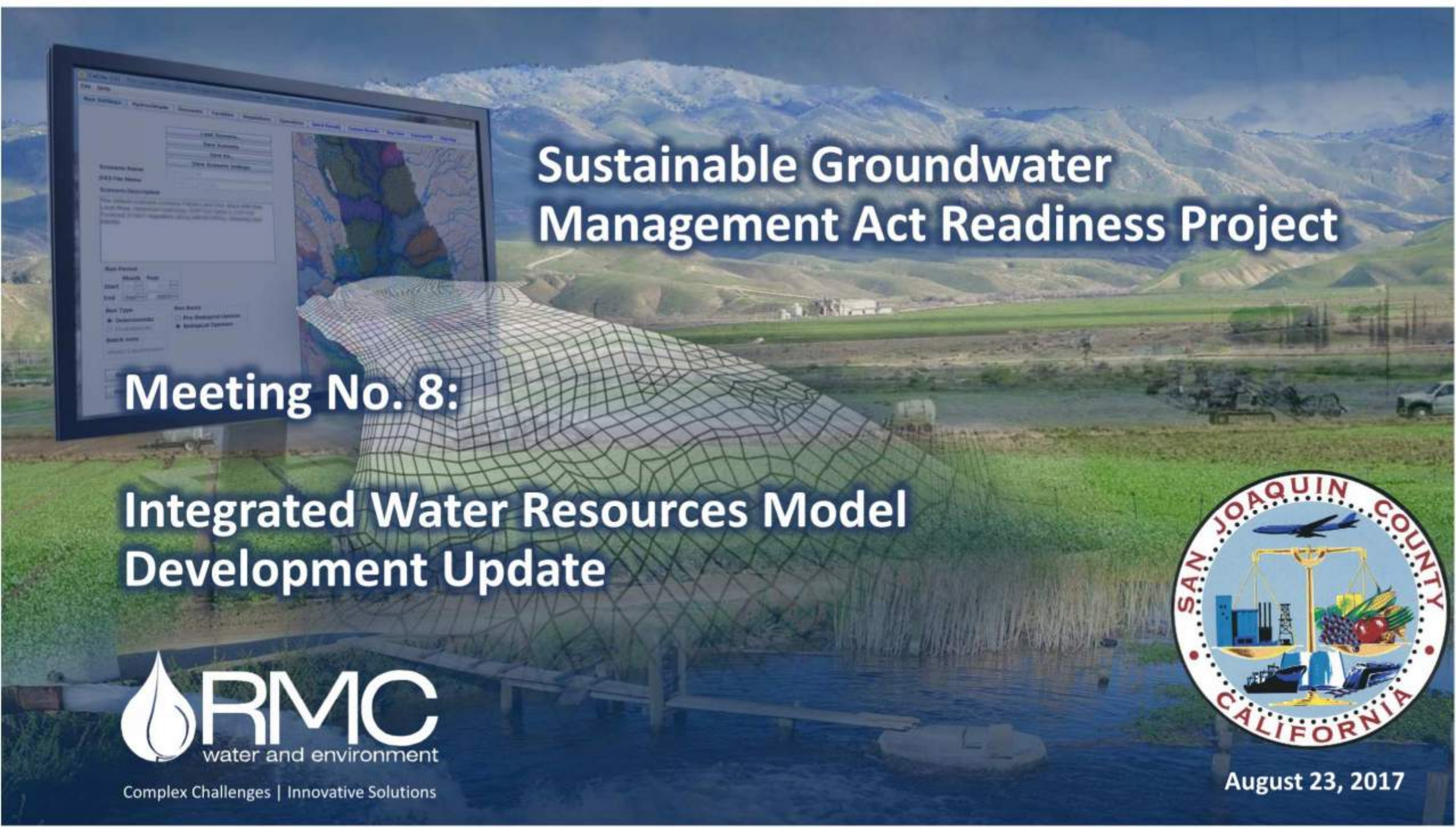
Data Request

- IDC Calibration:
  - METRIC rasters and applied water estimates
- IWFM Model:
  - SW diversions and deliveries
    - Information Provided: CCWD, Manteca, Stockton, OID, SEWD (including info on Stockton, Cal Water, CSJWCD, OID, and SSJID), SSJID, and WID (including info on Lodi and Stockton)
    - Additional Information: Breakdown of diversions by delivery for SSJID
  - Recharge
    - No Projects: Cal Water, Escalon, Lathrop, Linden County WD, Lockeford CSD, and SSJID
    - Information Provided: Lodi, OID, SEWD, and Stockton/WID
    - Need Response on Recharge Practices (if any): Manteca and Ripon

Next Steps

1. Finalize IDC and document results in a TM
2. Compile and Process Surface water deliveries for urban and agricultural use
3. Transfer completed information to IWFM input files
   - Stream flows and stream geometry
   - Well location and pumping information
   - Surface water diversion and deliveries
   - Small watersheds

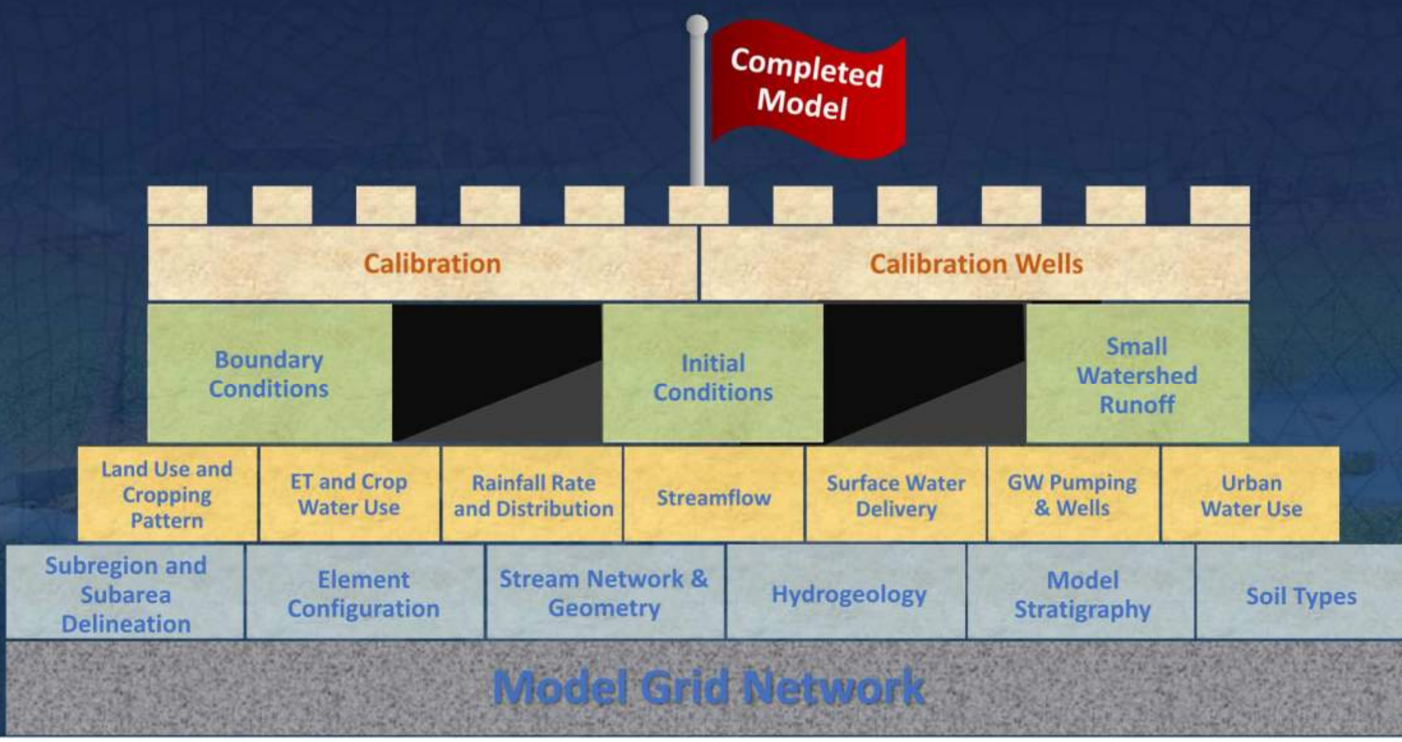
Project General Schedule



Agenda

- Introduction
- Updated Land Use and Cropping Patterns
- Preliminary Land and Water Use Budgets
- IWFM Calibration Process and Sample Hydrographs
- Next Steps

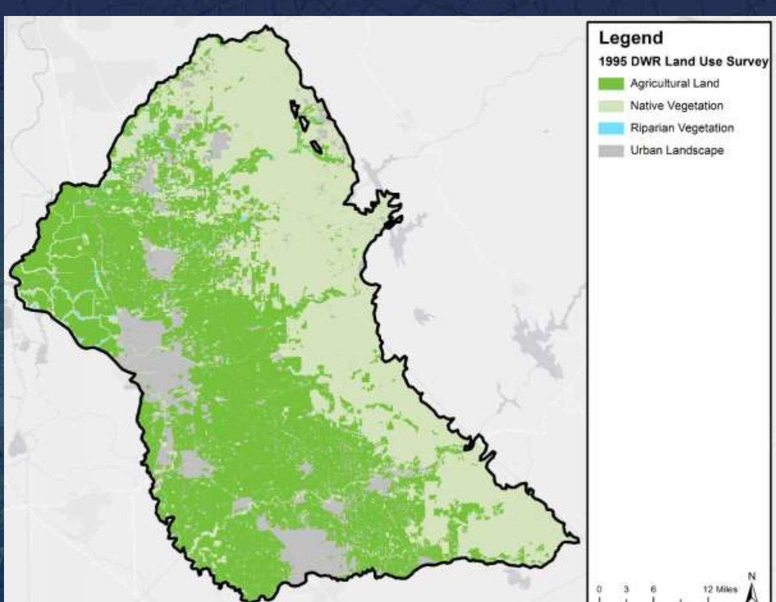
Integrated Model Construction

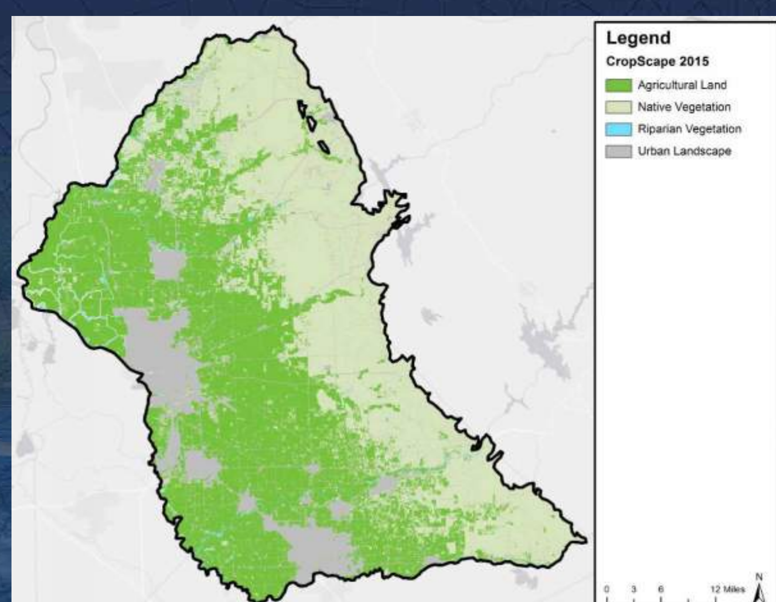


Recap of Land Use and Cropping Patterns

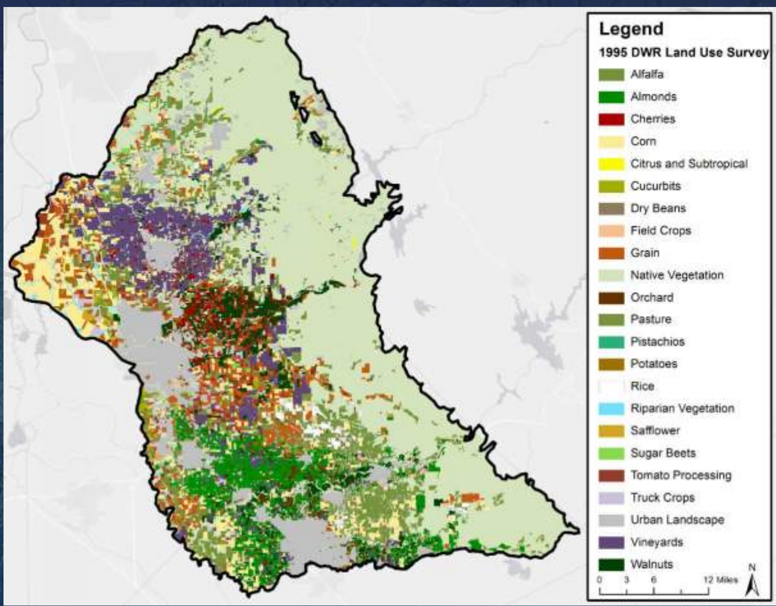
1. DWR Land Use Surveys (Representing ~1995 Era)
   - San Joaquin County (1996)
   - Sacramento County (1993)
   - Amador County (1997)
   - Calaveras County (2000)
   - Stanislaus County (1996)
2. Remote Sensing Data:
   - USDA's CropScape
   - DWR's LandIQ Survey; 2014
3. Local Data Sources

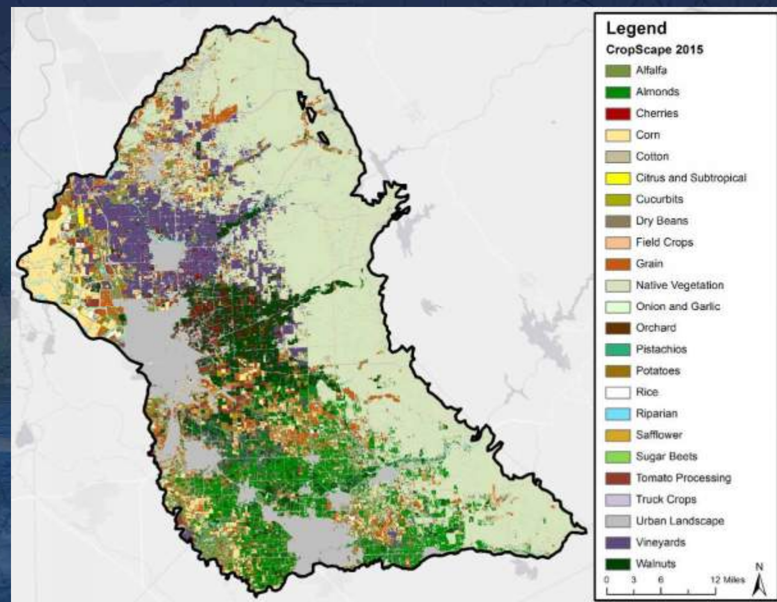
ESJ Model Area Land Use (1995 & 2015)





ESJ Model Area Cropping Pattern (1995 & 2015)



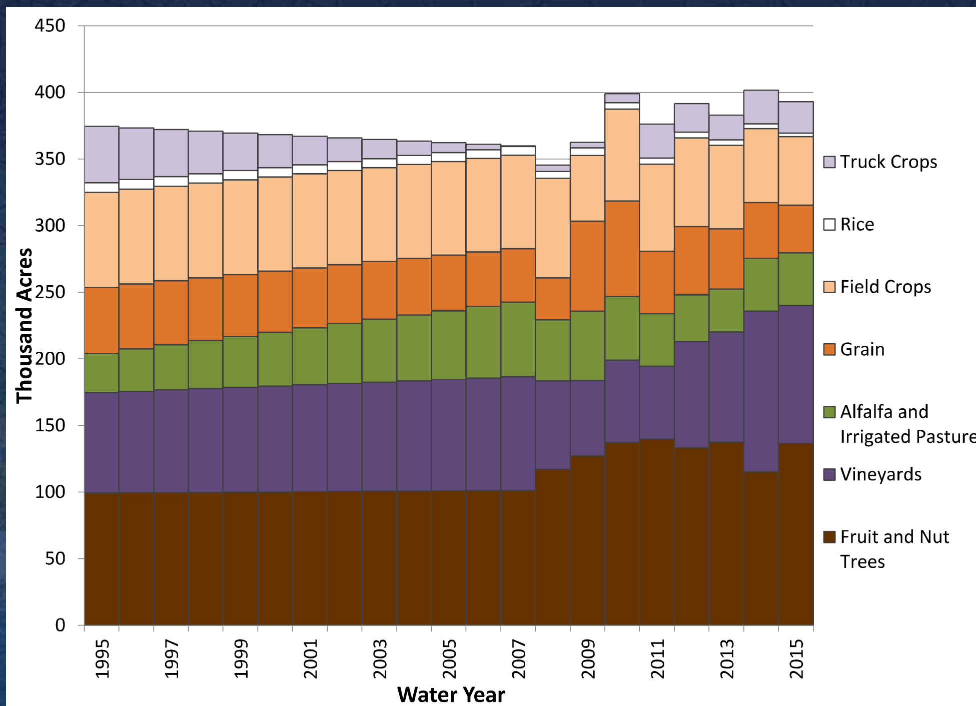


Model Land Use Types

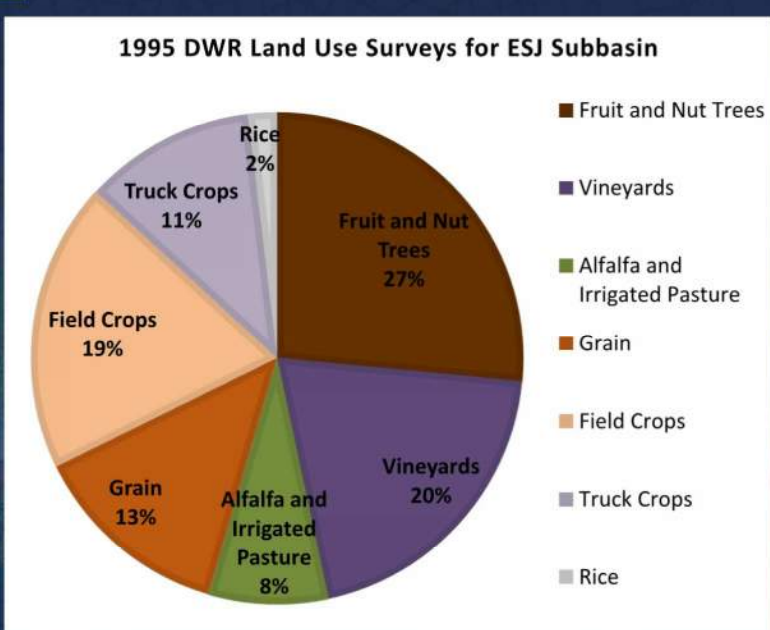
- 23 irrigated crop categories
- 4 other land use categories
- 7 high-level categories used for verification purposes

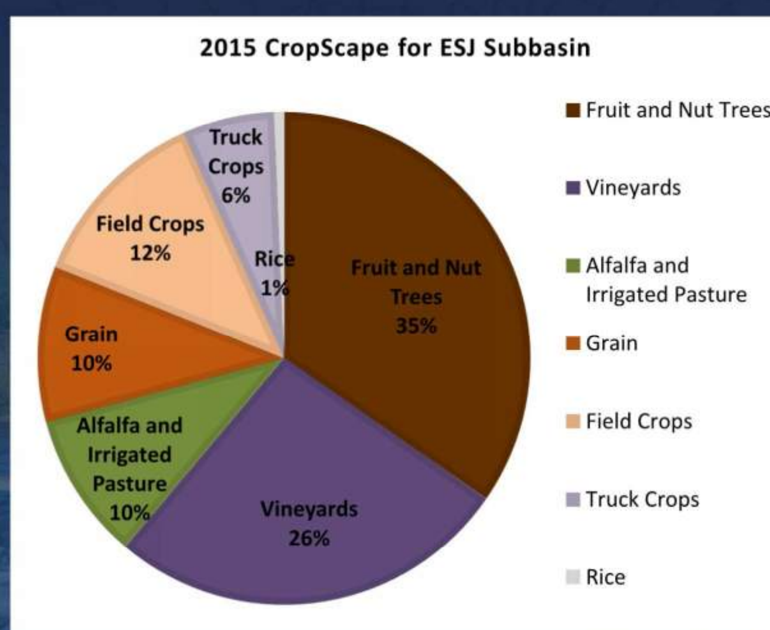
Model Crop Category	Grouped Crop Categories
Almonds Cherries Citrus & Subtropical Other Orchard Pistachios Walnuts	Fruit and Nut Trees
Vineyards	Vineyards
Alfalfa Pasture	Alfalfa and Irrigated Pasture
Grain	Grain
Corn Cotton Dry Beans Field Crops Safflower Sugar Beets	Field Crops
Cucurbits Onion & Garlic Potatoes Tomato Fresh Tomato Processing Truck Crops	Truck Crops
Rice	Rice
Urban Landscape Water Surface Riparian Vegetation Native Vegetation	Other Land Use

Primary Cropping Pattern in ESJ Subbasin



Primary Cropping Pattern in ESJ Subbasin

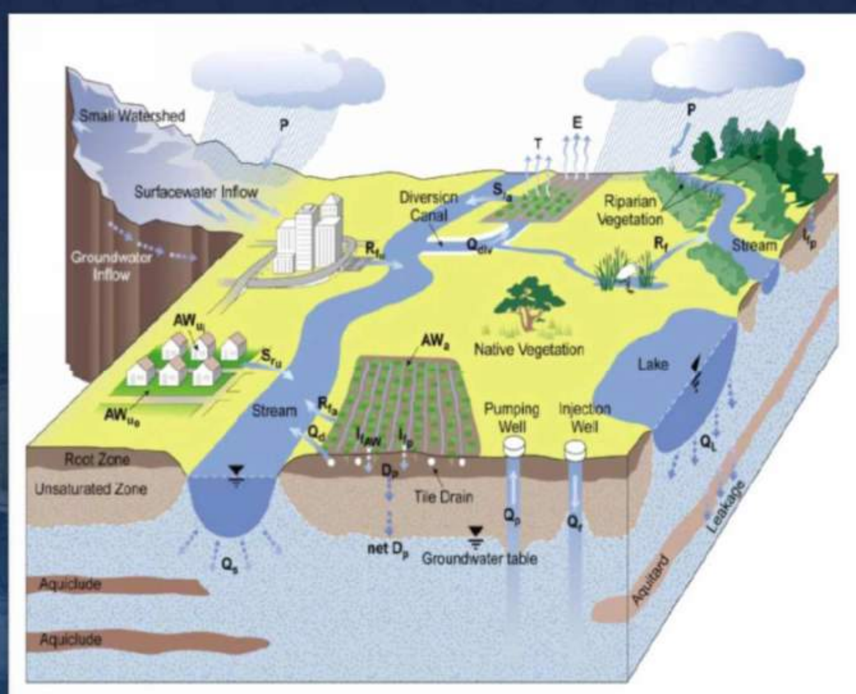




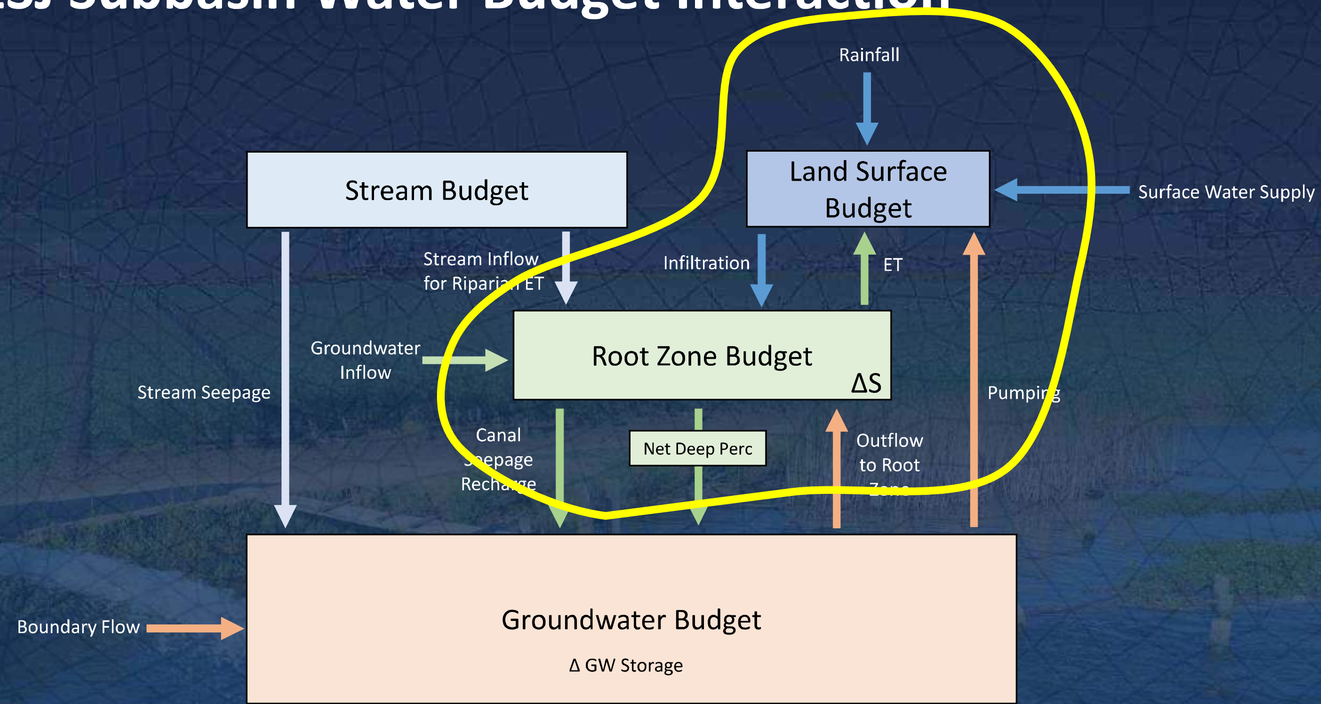
Land & Water Use Budget Components

Integrated Hydrologic Processes

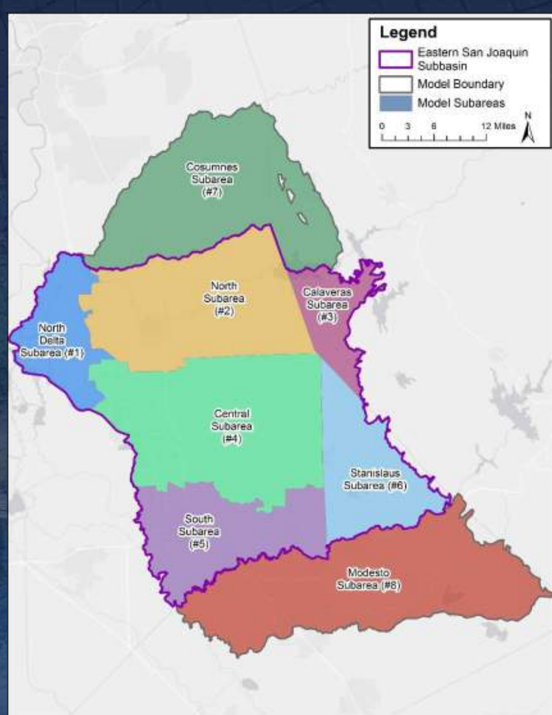
- Land Surface Processes
- Groundwater Flow
- Streamflow
- Physical Systems Integration
- Water Budgets



ESJ Subbasin Water Budget Interaction

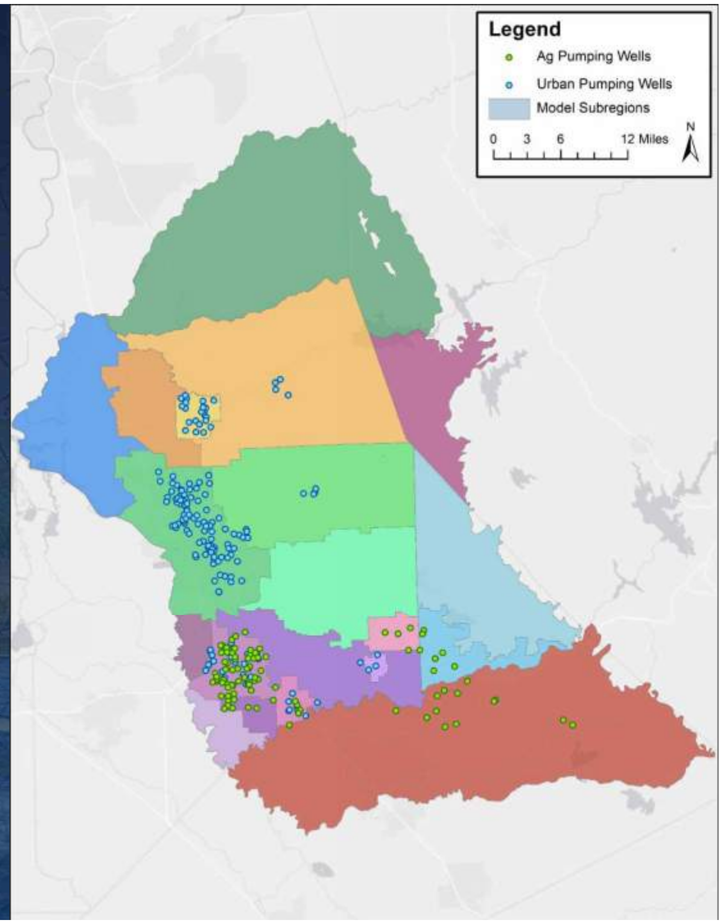


Model Area and ESJ Subbasin



Water Supply Data Sources

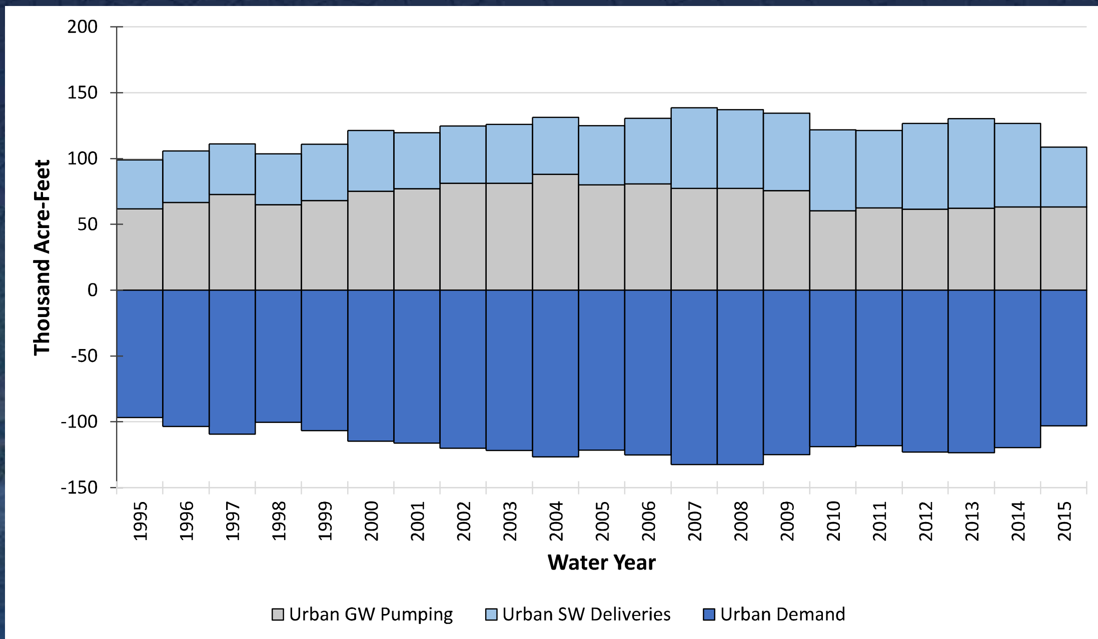
- Groundwater pumping for ag or urban purposes:
  - Cal Water
  - Escalon
  - Lathrop
  - Linden County
  - Lockeford
  - Lodi
  - Manteca
  - Ripon
  - SEWD
  - Stockton
  - Oakdale
  - SSJID



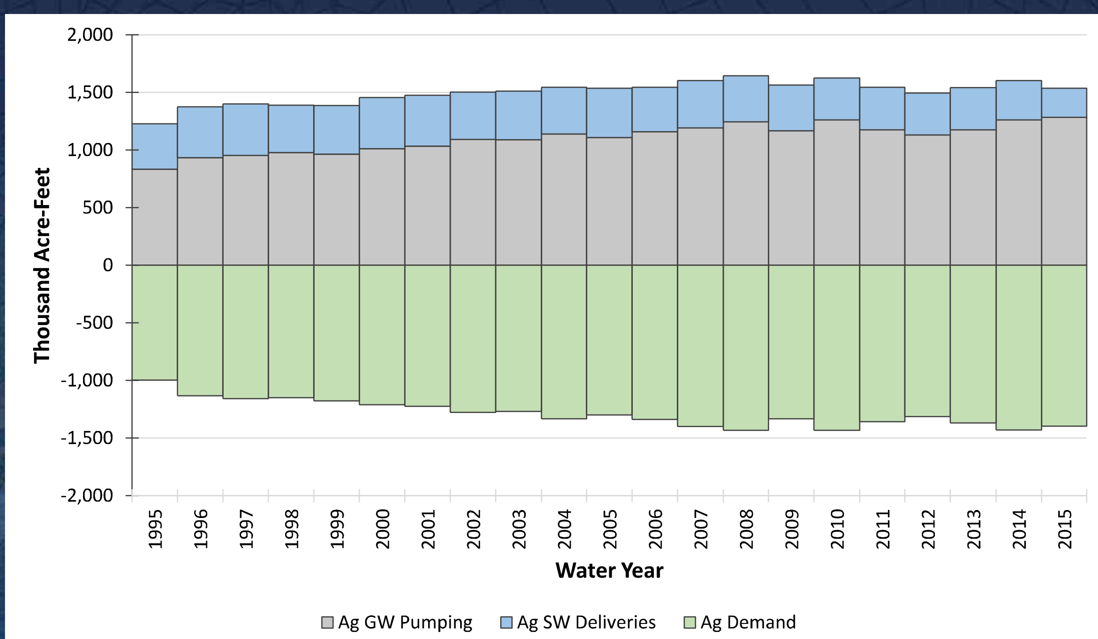
Water Supply Data Sources

- Surface water deliveries for ag or urban purposes:
  - WID
  - Lodi
  - CCWD
  - Stockton
  - SEWD
  - CSJWCD
  - Lathrop
  - Manteca
  - SSJID
  - Oakdale ID
  - Modesto ID

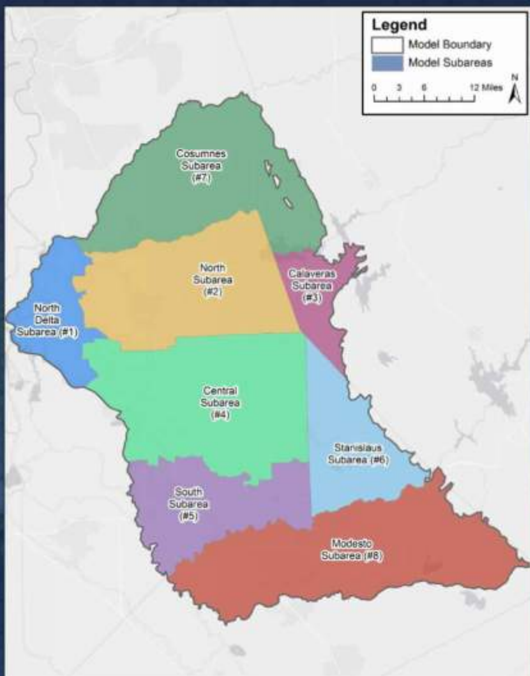
Land and Water Use Budget: ESJ Subbasin



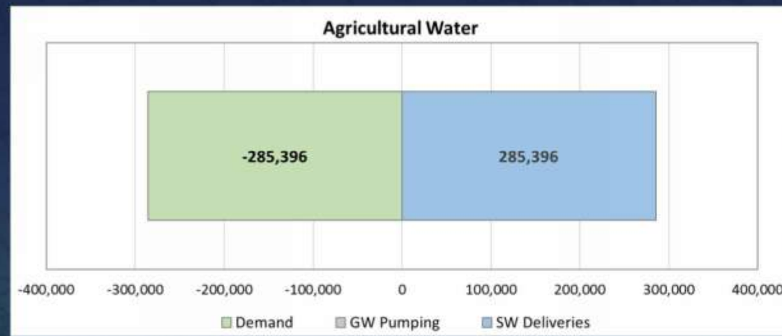
Land and Water Use Budget: ESJ Subbasin

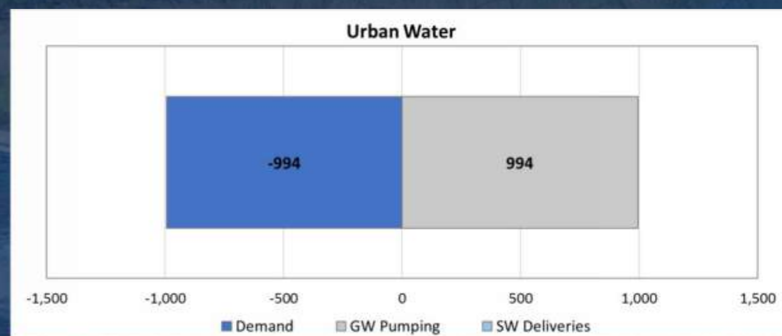


Average Annual Water Budget: Subarea 1

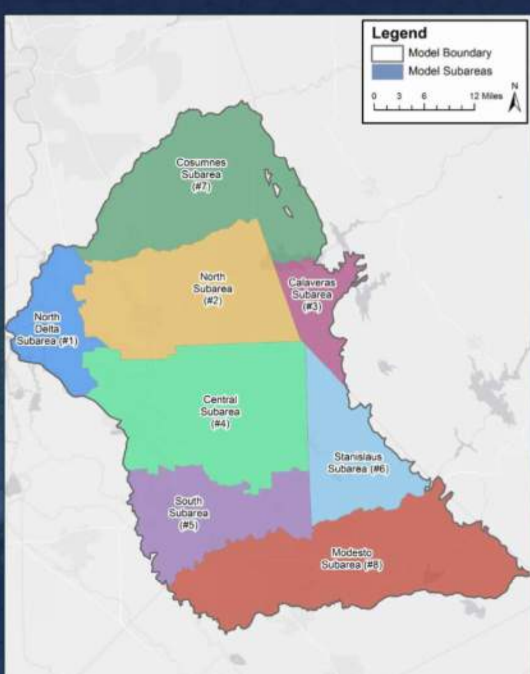


Average Annual for WY 1995-2015, Acre-Feet Per Year

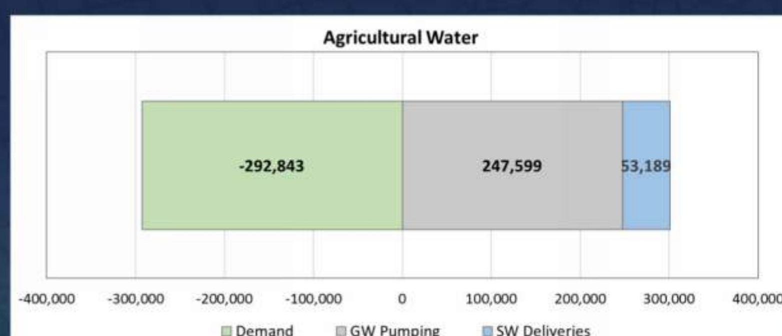


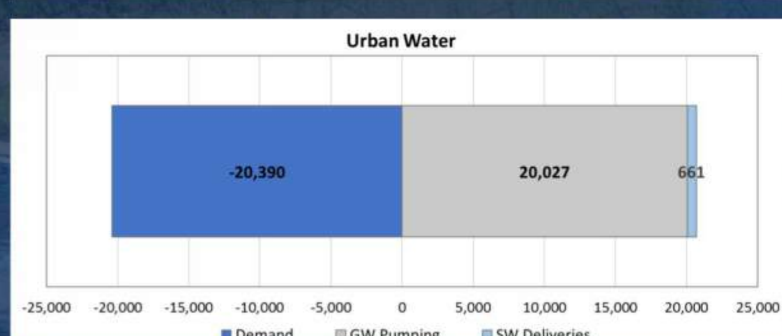


Average Annual Water Budget: Subarea 2

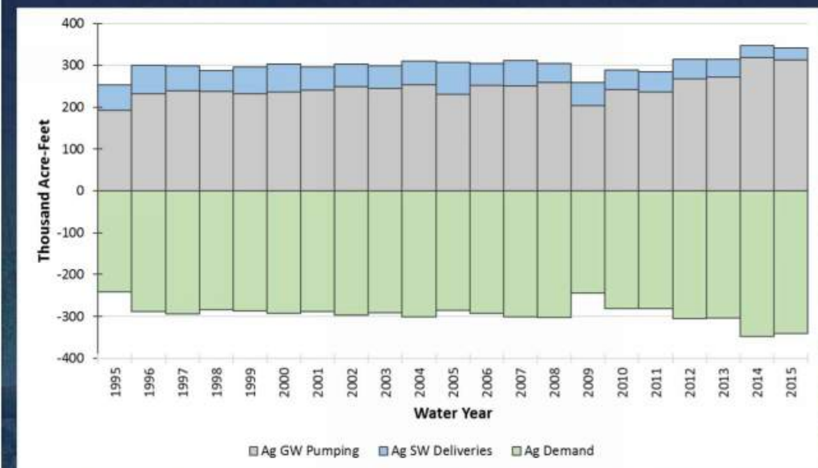


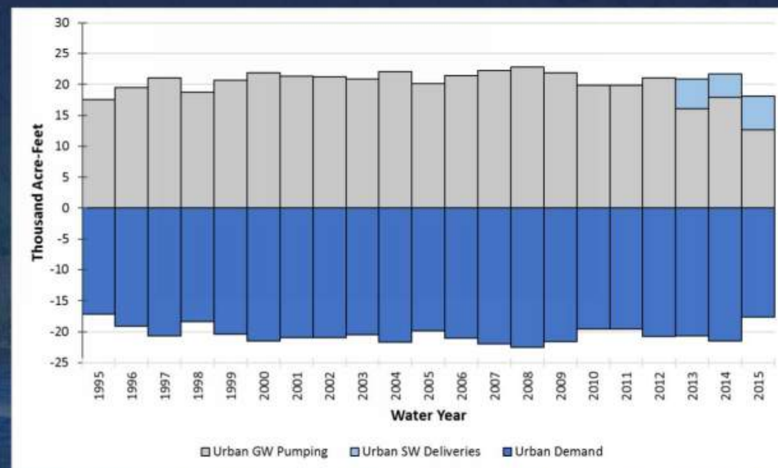
Average Annual for WY 1995-2015, Acre-Feet Per Year



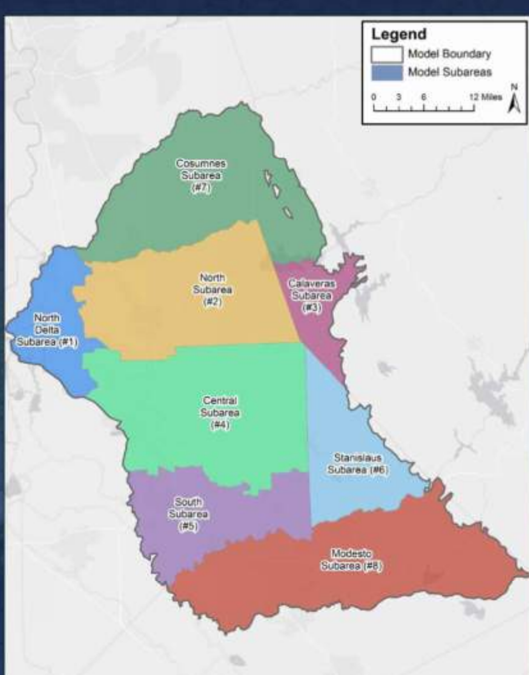


Annual Water Budget: Subarea 2

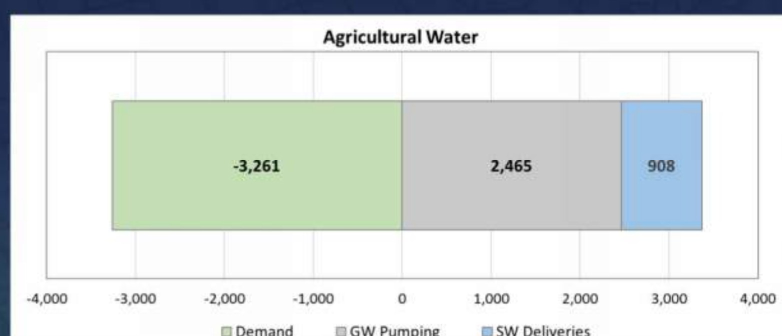


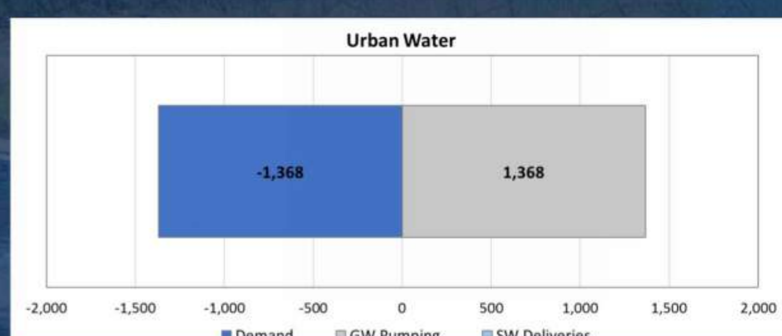


Average Annual Water Budget: Subarea 3

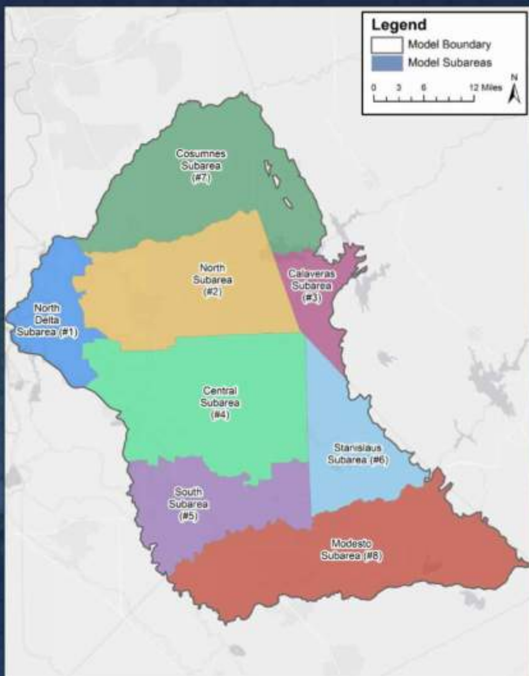


Average Annual for WY 1995-2015, Acre-Feet Per Year

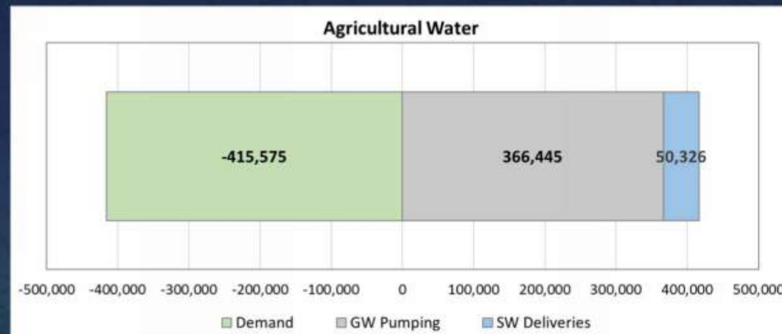


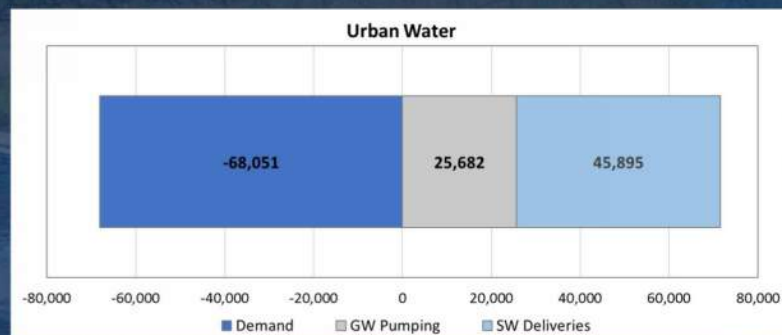


Average Annual Water Budget: Subarea 4

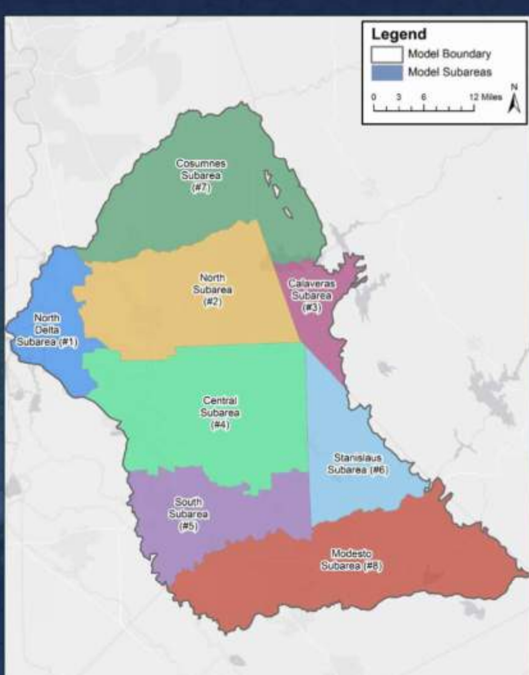


Average Annual for WY 1995-2015, Acre-Feet Per Year

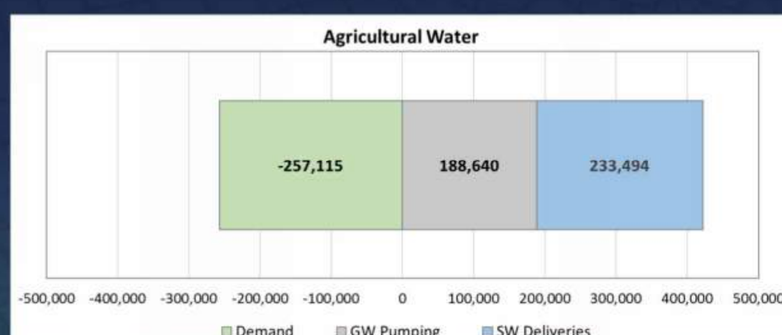




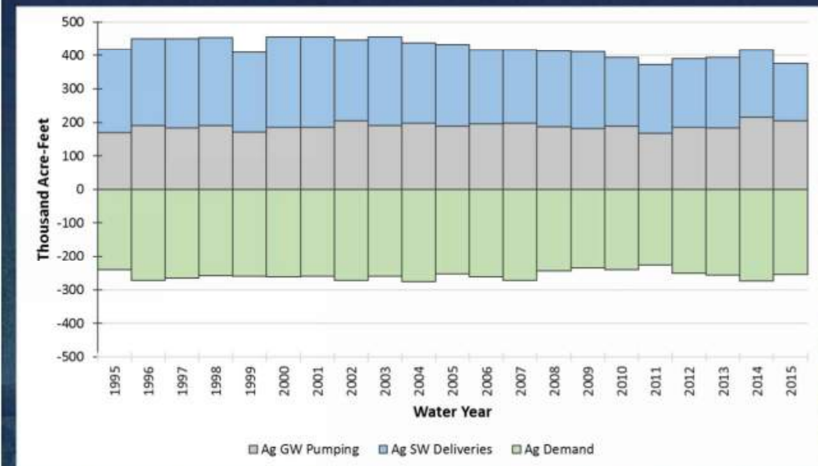
Average Annual Water Budget: Subarea 5

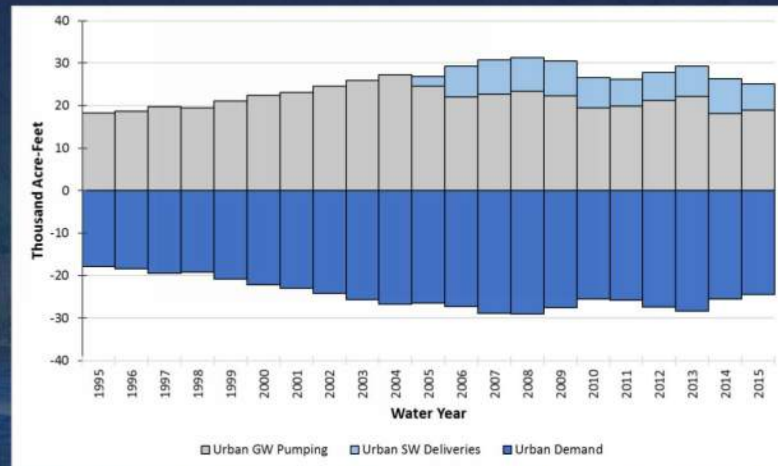


Average Annual for WY 1995-2015, Acre-Feet Per Year

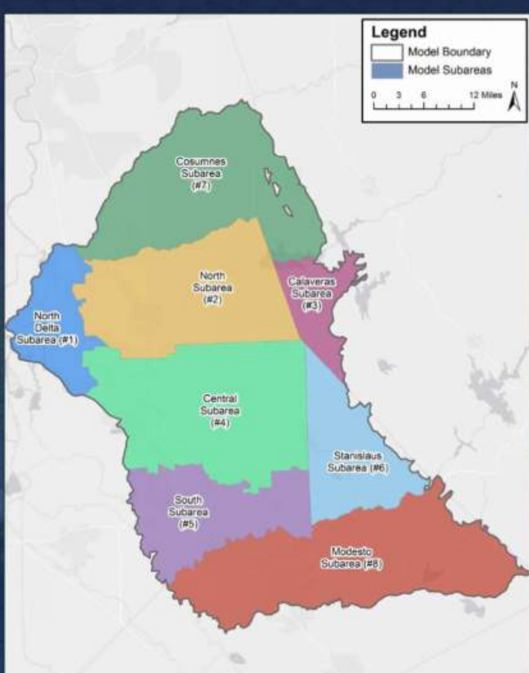


Annual Water Budget: Subarea 5

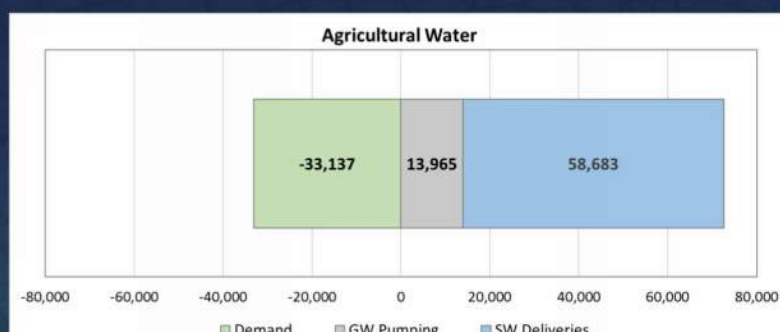


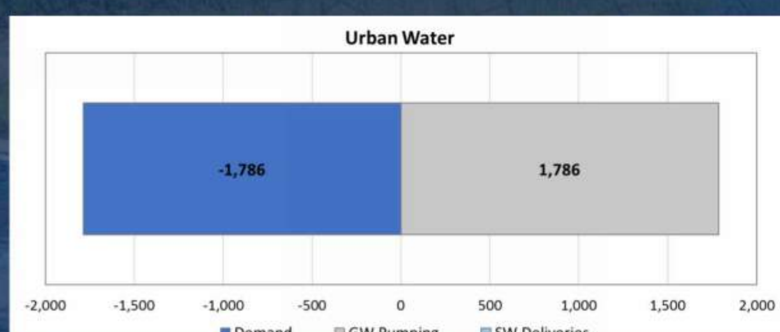


Average Annual Water Budget: Subarea 6



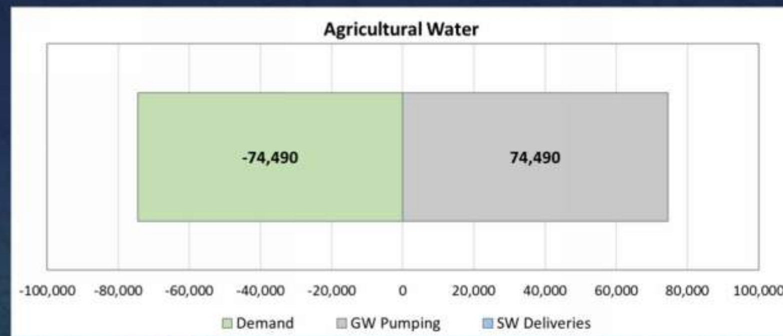
Average Annual for WY 1995-2015, Acre-Feet Per Year

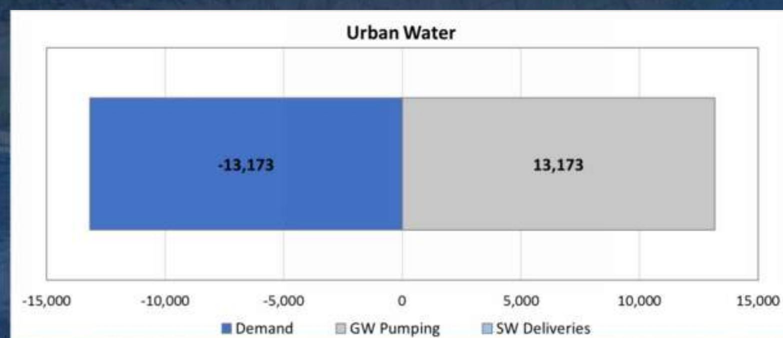




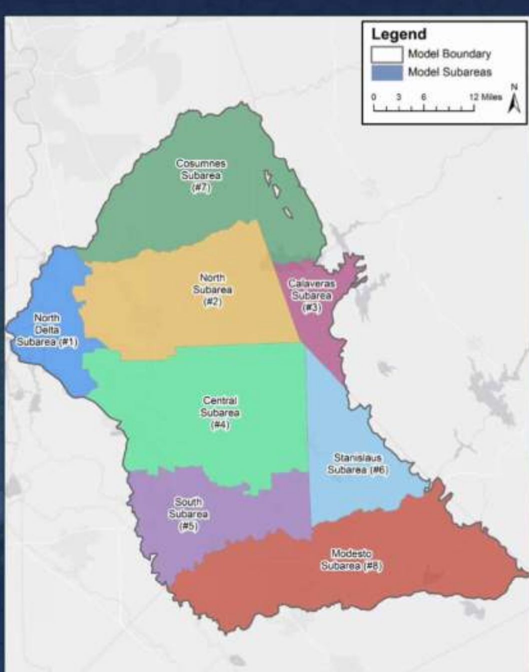
Average Annual Water Budget: Subarea 7

Average Annual for WY 1995-2015, Acre-Feet Per Year

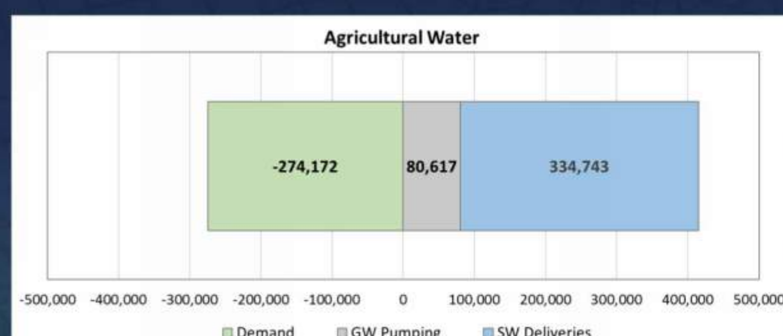


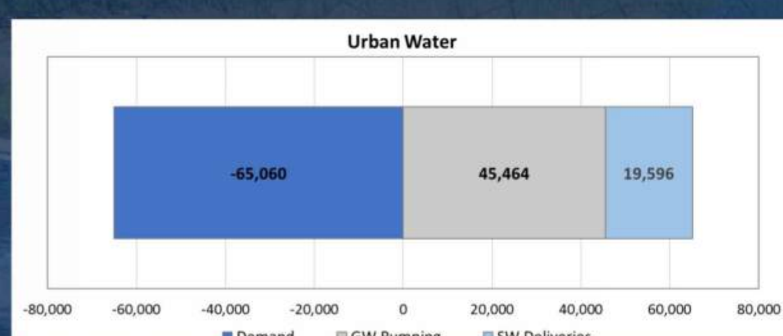


Average Annual Water Budget: Subarea 8

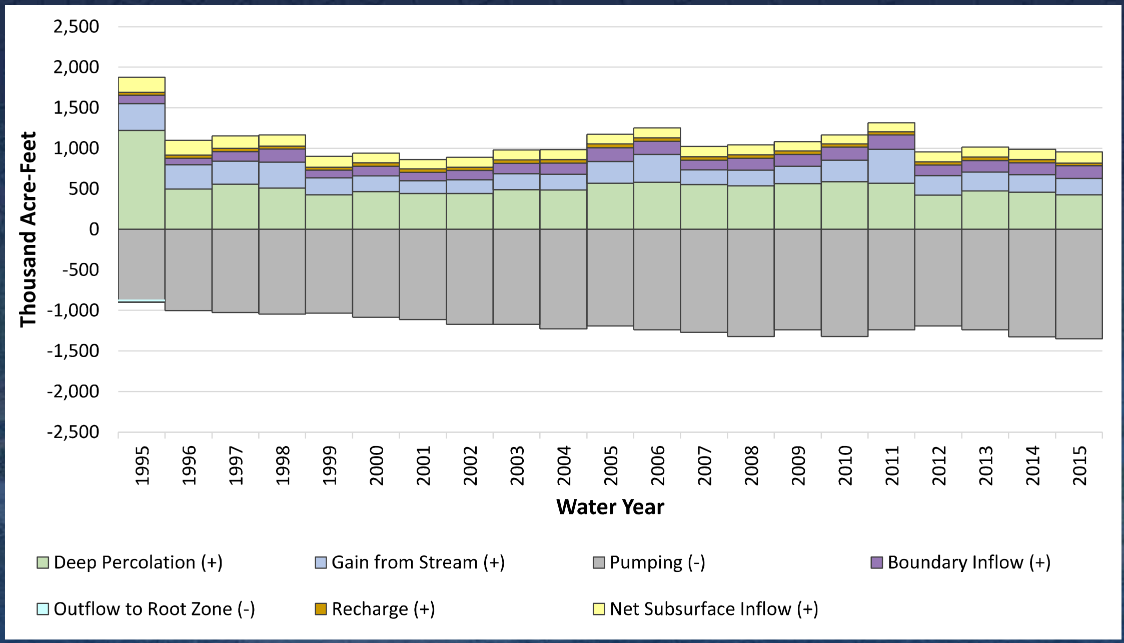


Average Annual for WY 1995-2015, Acre-Feet Per Year





Groundwater Budget: ESJ Subbasin

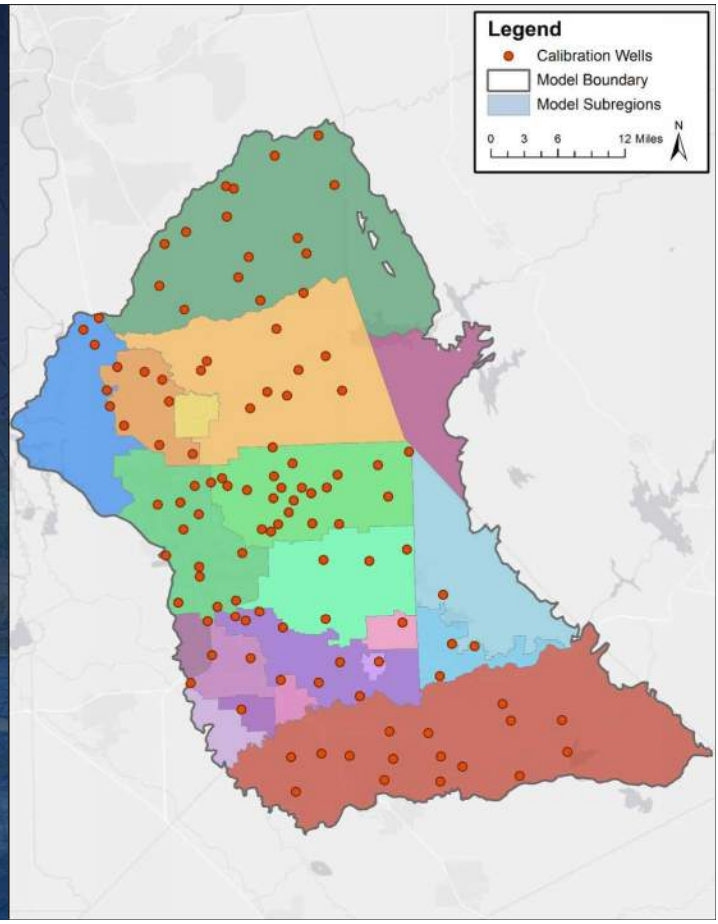


Calibration Process

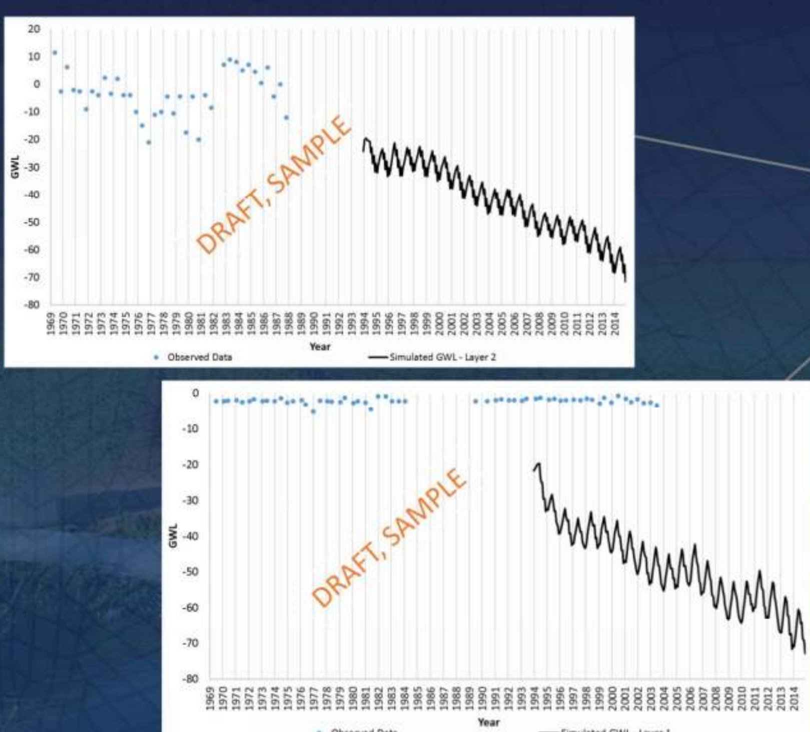
- Identify:
  - Target calibration wells
  - Target streamflow gaging stations
- Review observed data and set calibration targets
- Calibrate model by adjusting model parameters to attain reasonable match between modeled and opbserved data for:
  - Water budgets for each component of the hydrologic cycle modeled
  - GW levels at select wells
  - Streamflows at select gaging stations
- Compare calibration performance with calibration targets
- Conduct additional refinements as necessary

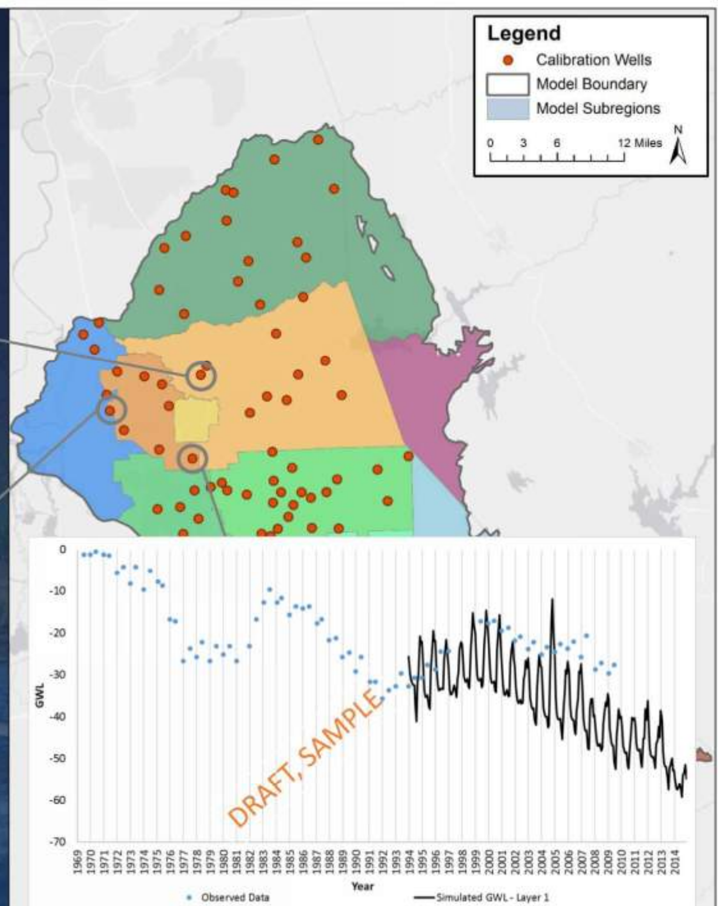
Preliminary Calibration Wells

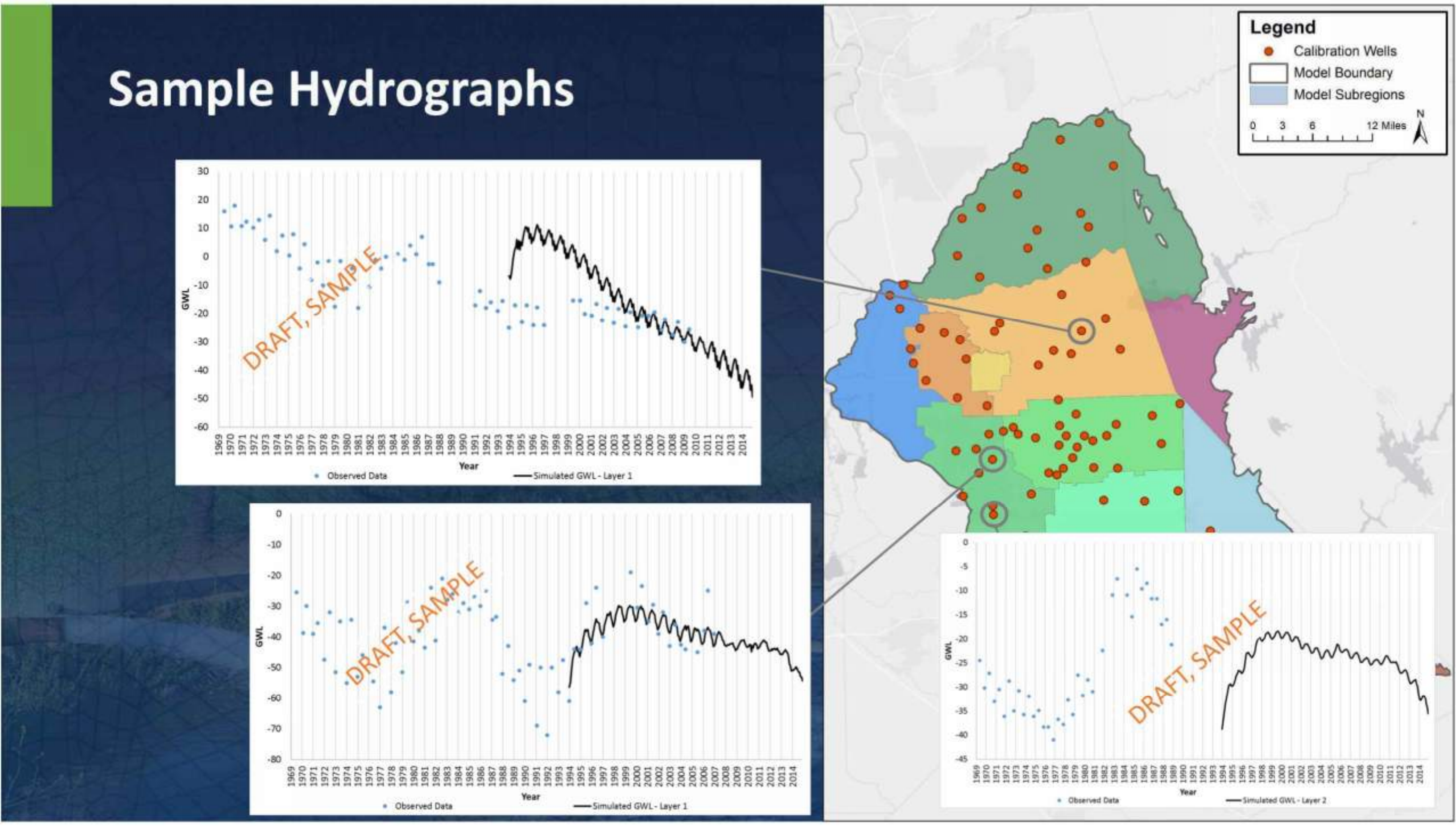
- Correspond to calibration wells in other models:
  - C2VSim-FG
  - San Joaquin-Stanislaus IGSM & DynFlow



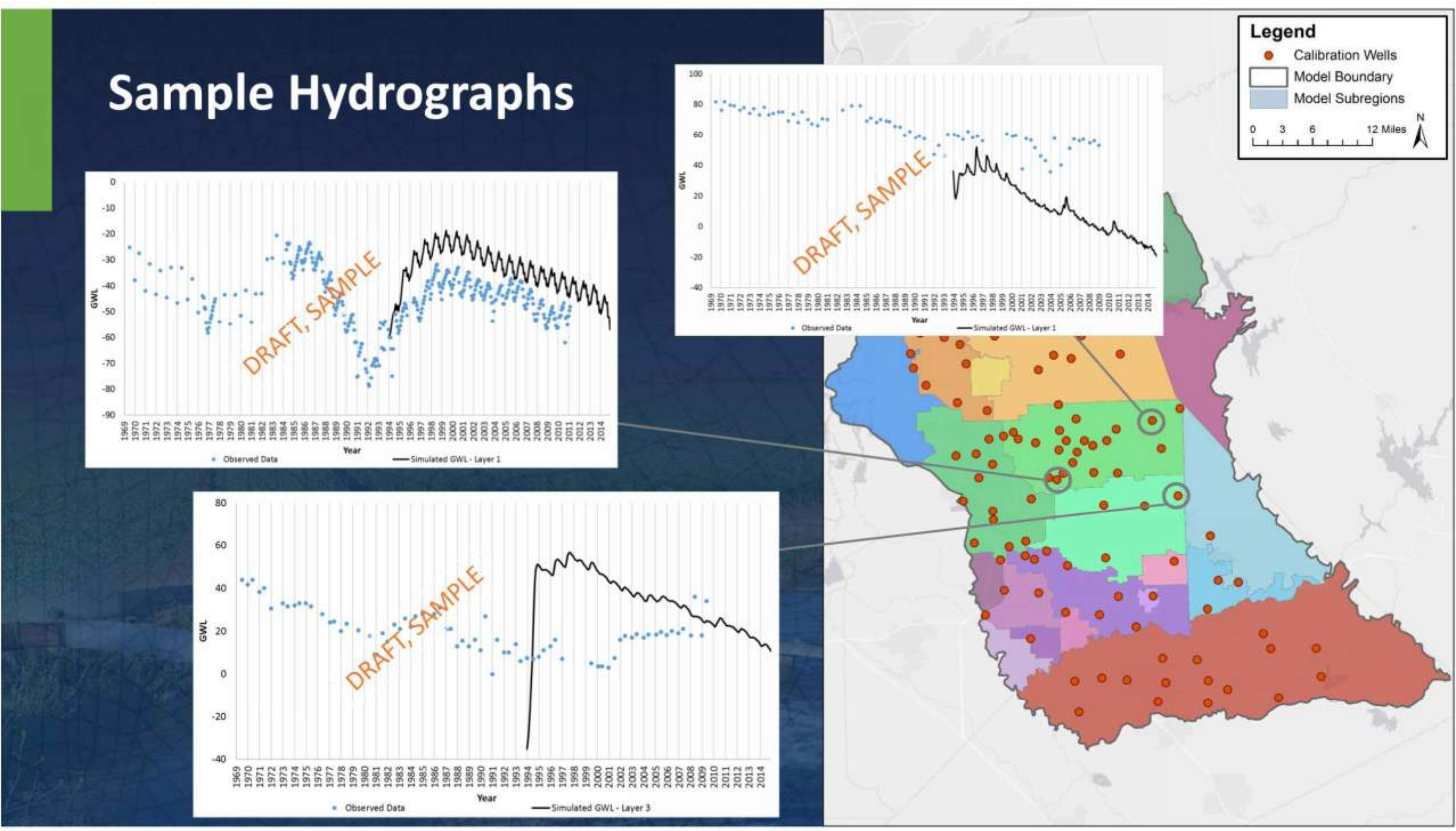
Sample Hydrographs







Sample Hydrographs
Legend
Calibration Wells
Model Boundary
Model Subregions
0 3 6 12 Miles
N
GWL
Year
Observed Data
Simulated GWL - Layer 1
Simulated GWL - Layer 2
DRAFT, SAMPLE



Sample Hydrographs
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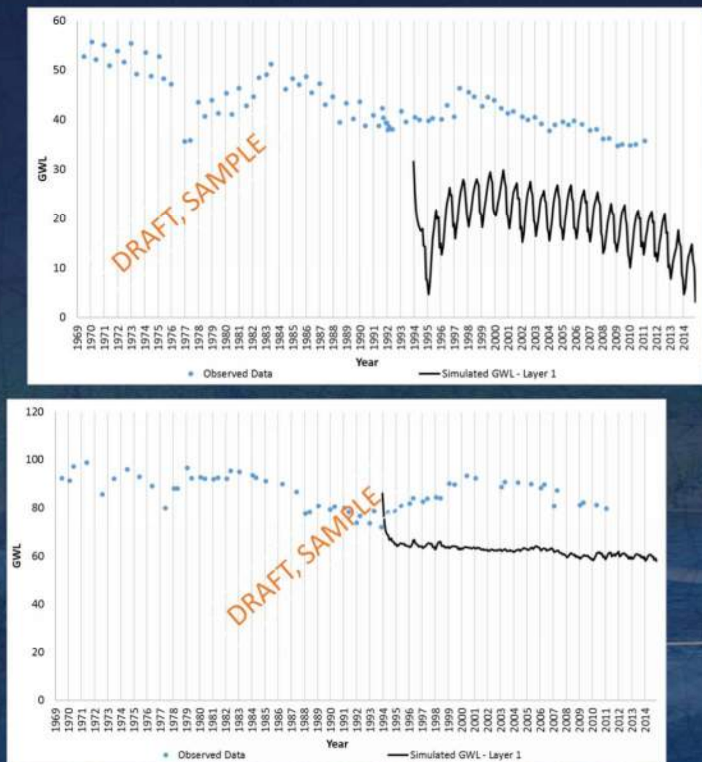
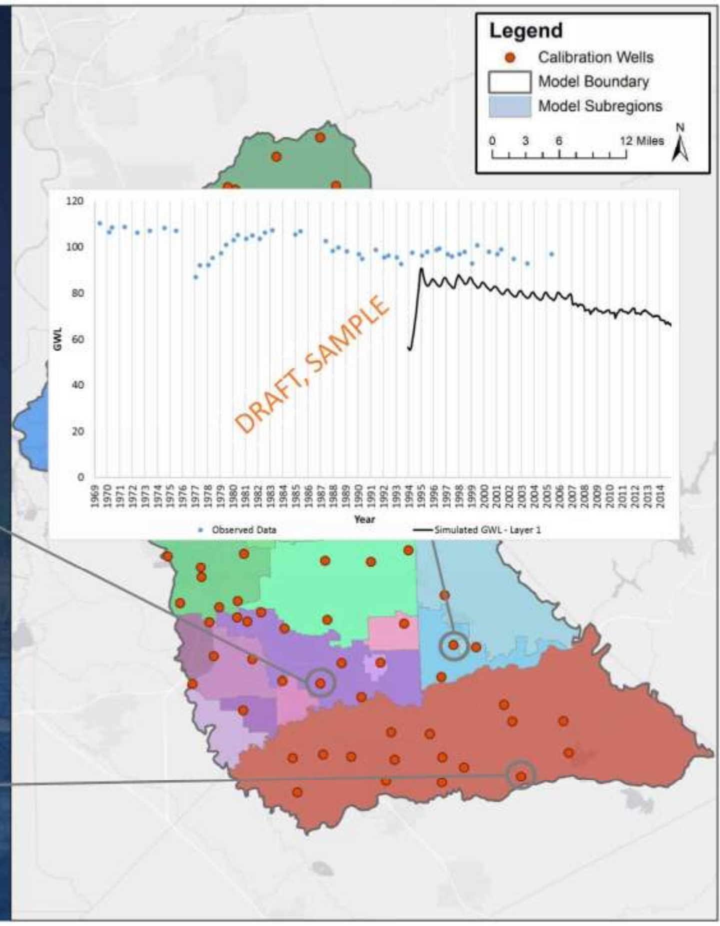




Model Applications Next Steps …

Model Objectives: Historical Conditions

Basin Characteristics

Historical, Current and Projected Levels of Development

GW & SW Conditions

Stream-Aquifer Interaction

Model Objectives: Projected Conditions

Projected Conditions

IRWM, GWMP
SGMA

Storm water and Recycled Water Opportunities

Groundwater Banking

Groundwater Sustainability

Hydro-Economic Evaluations

Water Availability

Urban Water Supply

Project Beneficiary Assessment

Next Steps

1. Finalize IDC and document assumptions, data sources, and results
2. Finalize IWFM datasets and parameters
3. Calibrate IWFM

Project General Schedule

Sustainable Groundwater Management Act Readiness Project

ESJ Water Resources Model (ESJWRM) IDC Workshop

RMC water and environment

WOODARD & CURRAN

National Experience. Local Focus.

San Joaquin County California

April 25, 2018

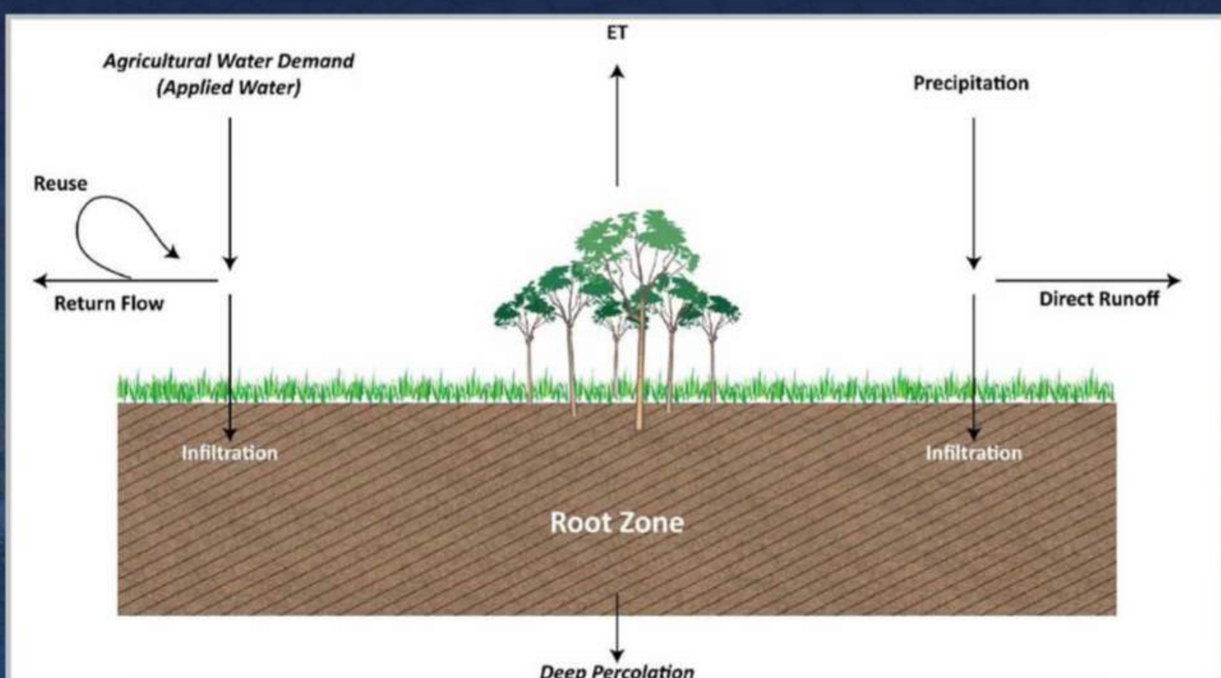
Agenda

- Introduction
- Review IDC
- Review IDC data
- Review IDC results

Stakeholder Collaboration

- Cal Water
- Calaveras County Water District
- Escalon, City of
- Lathrop, City of
- Lockeford Community Services District
- Lodi, City of
- Manteca, City of
- North San Joaquin Water Conservation District
- Oakdale Irrigation District
- San Joaquin County
- South San Joaquin Irrigation District
- Stanislaus County
- Stockton, City of
- Stockton East Water District
- Woodbridge Irrigation District

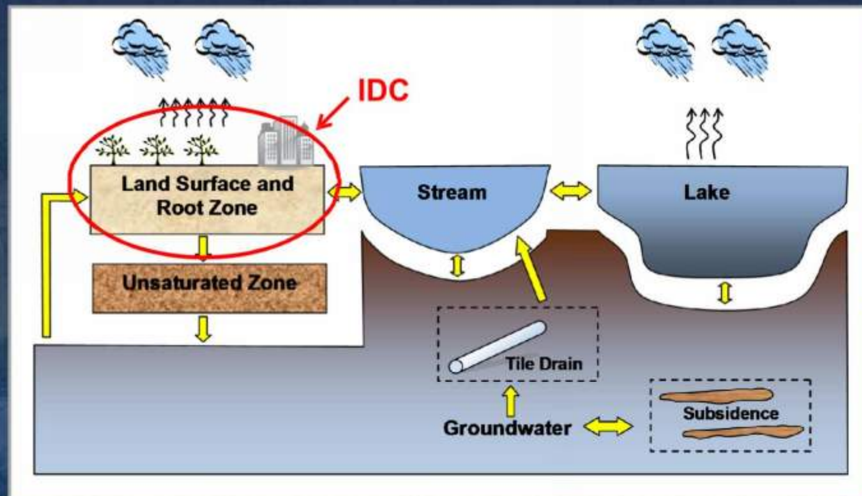
IWFM Demand Calculator: IDC



Source: IDC training workshop (Emin Can Dogrul, DWR)

Ag Demand Estimation using IDC

- IWFM Demand Calculator (IDC) is a software that calculates land use based water demands and routes water through the land surface and root zone using physically-based simulation methods
- Uses methods from irrigation-scheduling-type models and applies them at regional scales
- Stand-alone executable or root zone module of Integrated Water Flow Model (IWFM) v2015



Source: IDC training workshop (Emin Can Dogrul, DWR)

IDC Background

- IDC was initially developed to…
  - Maintain consistency between C2VSim and CalSim
  - Calculate downstream water demands for CalSim under current conditions and future scenarios
- First version of IDC did not have rice and refuge simulations, had incompatible calculations for daily runs
- IDC v4.0 was developed to improve upon the initial version of IDC
- With alternative root zone routing schemes developed (v4.0, v4.1 and v3.02) IDC-2015 became a container for different root zone routing methods

Source: IDC training workshop (Emin Can Dogrul, DWR)

Features of IDC-2015

- Use of a computational grid, finite-element or finite-difference, to represent spatial distribution of land-use, climatic, soil and farm management properties; each cell can have multiple land-use types specified as time-series data
- Simulation of land surface and root zone flow processes as well as water demand computations are done at each grid cell for each land-use type
- Irrigation-scheduling-type approach at each grid cell for each agricultural crop
- Direct representation of rice fields (including simulation of flooded decomposition, non-flooded decomposition and no decomposition) and refuges (seasonal and permanent)
- Riparian vegetation access to stream flows and simulation of evapotranspiration from groundwater
- Urban water demand computation based on population and per capita water usage
- Simulation of ETAW and effective precipitation
- Simulation of re-use of irrigation return flow that takes place at a grid cell, between grid cells or between subregions
- Budget output includes soil moisture, and land and water use budgets for individual crops at each subregion

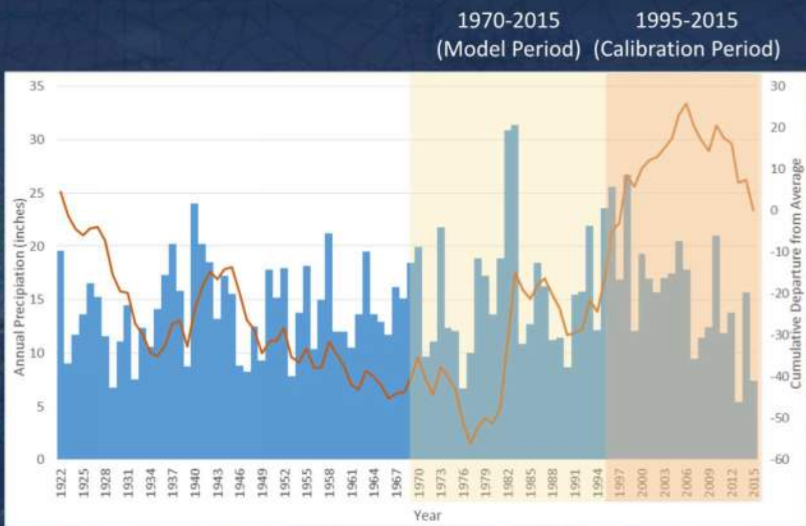
Source: IDC training workshop (Emin Can Dogrul, DWR)

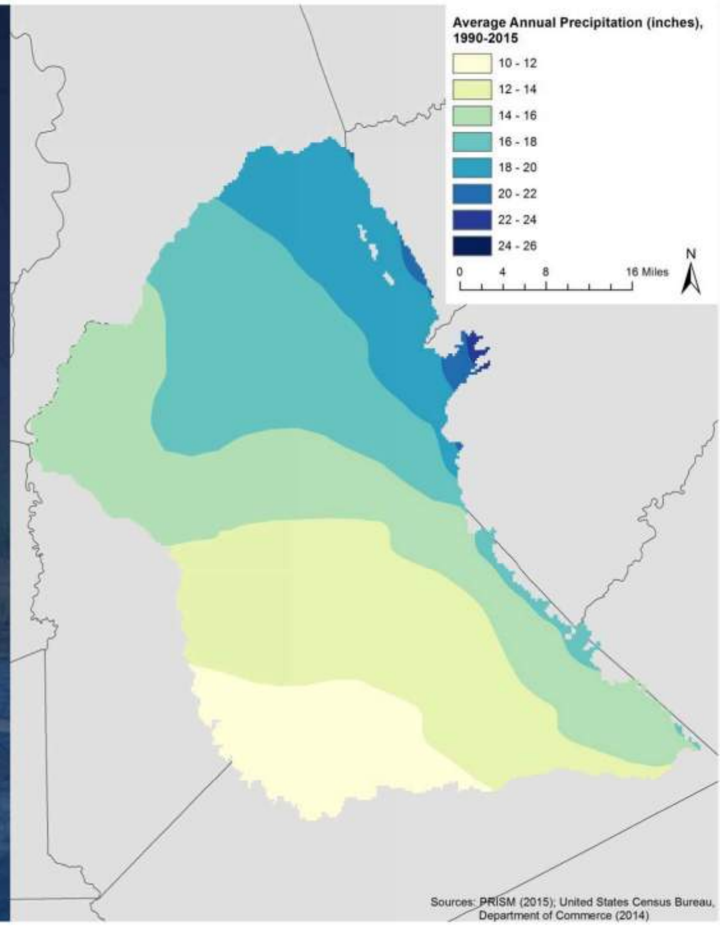
Key Parameters and Data in IDC

- Monthly Rainfall
- Crop Evapotranspiration, Et_c
- Return and reuse fractions
- Irrigation period
- Land use and crop acreages
- Urban population and per capita water use
- Soil Properties:
  - Hydraulic Conductivity
  - Pore Size Distribution Index
  - Others: Wilting Point, Field Capacity, Total Porosity

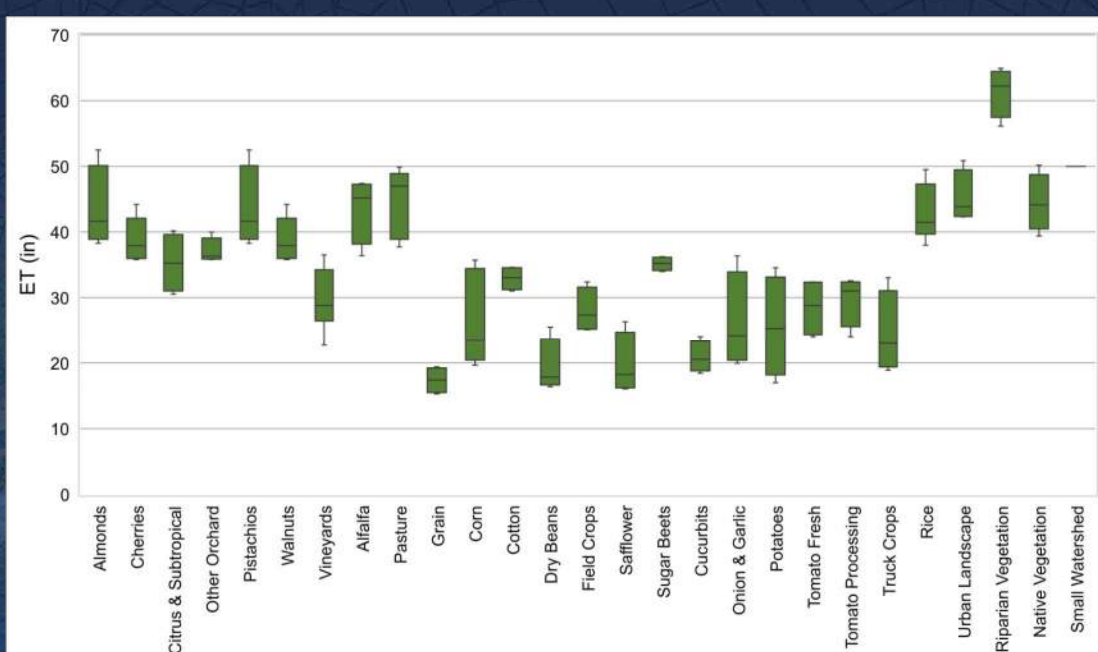
Precipitation

- Source of Data: PRISM for entire model period (1970-2015)





Crop Evapotranspiration, ET_c



Recap of Land Use and Cropping Patterns

1. DWR Land Use Surveys (Representing ~1995 Era)
   - San Joaquin County (1996)
   - Sacramento County (1993)
   - Amador County (1997)
   - Calaveras County (2000)
   - Stanislaus County (1996)
2. Remote Sensing Data:
   - USDA's CropScape
   - DWR's LandIQ Survey; 2014
3. Local Data Sources

ESJWRM:

- 23 irrigated crop categories
  - Form 7 high-level categories used for verification purposes
- 4 other land use categories

Model Crop Category	Grouped Crop Categories
Almonds Cherries Citrus & Subtropical Other Orchard Pistachios Walnuts	Fruit and Nut Trees
Vineyards	Vineyards
Alfalfa Pasture	Alfalfa and Irrigated Pasture
Grain	Grain
Corn Cotton Dry Beans Field Crops Safflower Sugar Beets	Field Crops
Cucurbits Onion & Garlic Potatoes Tomato Fresh Tomato Processing Truck Crops	Truck Crops
Rice	Rice
Urban Landscape Water Surface Riparian Vegetation Native Vegetation	Other Land Use

ESJ Model Area Land Use (1995 & 2015)