Technical Memorandum

Sacramento Central Groundwater Authority

Subject: **Groundwater Elevation BMO Threshold Development**

Prepared For: Sacramento County Groundwater Authority

Prepared by: Jim Blanke and Sevim Onsoy

Reviewed by: Ali Taghavi

Date: December 16, 2015

This Technical Memorandum (TM) describes the work performed for establishing groundwater elevation thresholds that define specific objectives to manage groundwater elevations according to the Basin Management Objective (BMO) Number 2 (No. 2) in the Central Sacramento County Groundwater Management Plan (GMP). The work was performed as part of Sacramento Central Groundwater Authority's (SCGA's) larger BMO Threshold Development and Recharge Mapping Project, which was partially funded by a Local Groundwater Assistance grant from the California Department of Water Resources (CDWR).

BMO No. 2 was established in the GMP with defined actions, but without fully quantified thresholds. Threshold values were based on percentages of a range of groundwater elevations, but that range of groundwater elevations was not defined in the GMP. Instead, a methodology was presented to define the groundwater elevation range, termed the bandwidth, relative to specific wells. This effort implements that methodology, adjusting for changes that have occurred in the basin from both a management and technical standpoint, to fully implement BMO No. 2. This study and the developed threshold values will be considered during the development of Groundwater Sustainability Plans, as updating the existing Groundwater Management Plan is no longer possible under the California Water Code.

Thresholds for BMO No. 2 were developed based on the procedures described in Appendix B of the GMP, with modifications where necessary reflecting the current technical and management conditions in the basin. These procedures use historical groundwater data and simulation results from the Sacramento Area Integrated Water Resources Model (SacIWRM; RMC, 2011), a regional integrated hydrologic model. The objective establishes a measureable "bandwidth" of groundwater elevations based on the maximum and minimum groundwater elevations as simulated by the (SacIWRM) 2030 Future Conditions Baseline (2030 Baseline). The 2030 Baseline was updated as part of the project to include the latest data and information, as well as the most recent management activities in the basin. The resulting bandwidths will be used in SCGA's HydroDMS, a web-based DMS which allows for SCGA staff, stakeholders, and the public to utilize the water resources data to better manage the basin based on informed decision making protocols (WRIME, 2010).

The SacIWRM was used in support of developing the groundwater elevation thresholds. SacIWRM was updated with new data to reflect both updated land and water use projections as well as an extension of simulated hydrology to incorporate water years 2005-2011 into the 2030 Baseline. A similar update was performed for the Historical Calibration simulation for quality control purposes, including verification of the calibration. Both updates focused on the SCGA area.

This TM presents the methodology used for establishing the thresholds, the major modifications made to the 2030 Baseline and Historical Calibration models and describes the key results in the following nine sections:

- Section 1, Review and Refinement of the BMO, summarizes the initial review and refinement of the BMO approach.
- Section 2, Collection of Additional Data, presents data collected for updating the 2030 Baseline and Historical Calibration simulations.
- Section 3, Update of the SacIWRM, provides an overview of the model modifications to the 2030 Baseline and the Historical Calibration simulations.
- Section 4, Updated SacIWRM Results, presents the key model results from the updated 2030 Baseline and Historical Calibration simulations through groundwater contour maps at key time periods and groundwater hydrographs at key locations.
- Section 5, Development of Groundwater Levels Bandwidth, presents the methodology used for developing the groundwater elevation bandwidths based on the analysis of the updated 2030 Baseline.
- Section 6, Merging of Polygon Grid Cells into Management Zones, presents the methodology and results for aggregating polygon cells to simplify monitoring.
- Section 7, Development of Thresholds, presents the methodology and results of identifying thresholds based on the bandwidths and application of those to the Management Zones.
- Section 8, Ground Truthing, presents a comparison of the measured groundwater elevation with the identified bandwidths.
- Section 9, Summary, presents a summary of the methodology used and the key results in the development of the groundwater elevation thresholds.

1 Review and Refinement of the BMO

The approach to developing the groundwater elevation thresholds for BMO No. 2 are contained in Appendix B of the GMP (reprinted in Appendix A of this TM for convenience). This approach was reviewed and discussed in a public meeting on July 9, 2014 with the SCGA Board and staff. The initial direction was to follow the approach in the adopted GMP, recognizing the potential for revisions to that approach during implementation.

Updates to the approach are contained in the following sections based on information learned during BMO development.

2 Collection of Additional Data

Data were collected to support groundwater model updates and definition of the BMOs. Groundwater model updates required hydrologic, land use, and water use data for historical and projected conditions. BMO definition also required information on well characteristics and groundwater elevations.

The current version of the SacIWRM covers the greater Sacramento region, generally from the Feather River in the north to the Mokelumne River in the south, and from the Sacramento River in the west to the edge of the alluvial aquifer system in the east, as shown in Figure 1. The previously developed Historical Calibration model is fully calibrated and provides a daily simulation of groundwater and surface water conditions in the model area for the period 1970-2004. In this project, the previously developed 2030 Baseline was updated with new land use and hydrologic data to extend the model period from October

2004 to September 2011. The previous 2030 Baseline represents the conditions of the basin at the 2030 level of development and repeats the 35 years of hydrologic conditions of the 1970-2004 three times for the long-term analysis of land and water use conditions. In this project, the 2030 Baseline was updated with the 2030 land use footprint and the most recent available 2030 water supply and demand projections based on the repeat of the 1970-2011 period twice. For quality control purposes, the Historical Calibration model was also updated and the calibration was verified.

The 2030 Baseline and Historical Calibration model updates required collection and analysis of new land use and hydrologic data to extend the model period to September 2011. Updates and data collection efforts under this project included model modifications within the SCGA boundary (Figure 2), although available data were incorporated outside of this area, where feasible. In the SacIWRM model, the SCGA area lies within the Central Area portion of the SacIWRM. Central Area extends generally between the American River and just south of the Cosumnes River. The SCGA and Central Area boundaries overlap closely as shown in Figure 2. Therefore, the majority of the data collection efforts primarily focused on the major water purveyors within the Central Area of the SacIWRM, including the City of Sacramento, Sacramento County Water Agency (SCWA), California American Water (CalAm), Elk Grove Water District (EGWD), Golden State Water Company (GSWC), and the City of Folsom (Figure 2). While the SCGA area was the main focus during the model update, the SacIWRM required extending the model period for the entire model area. Therefore, the simulation period and hydrology data for both the 2030 Baseline and Historical Calibration models were extended through September 2011 for the entire model domain.

Table 1 presents the collected data types and sources with a brief description. For areas outside of SCGA, the existing data in the previous models were used to extend the model period through September 2011, except where data were readily available to be incorporated.

Figure 1: SacIWRM Regional Setting and Model Subregions

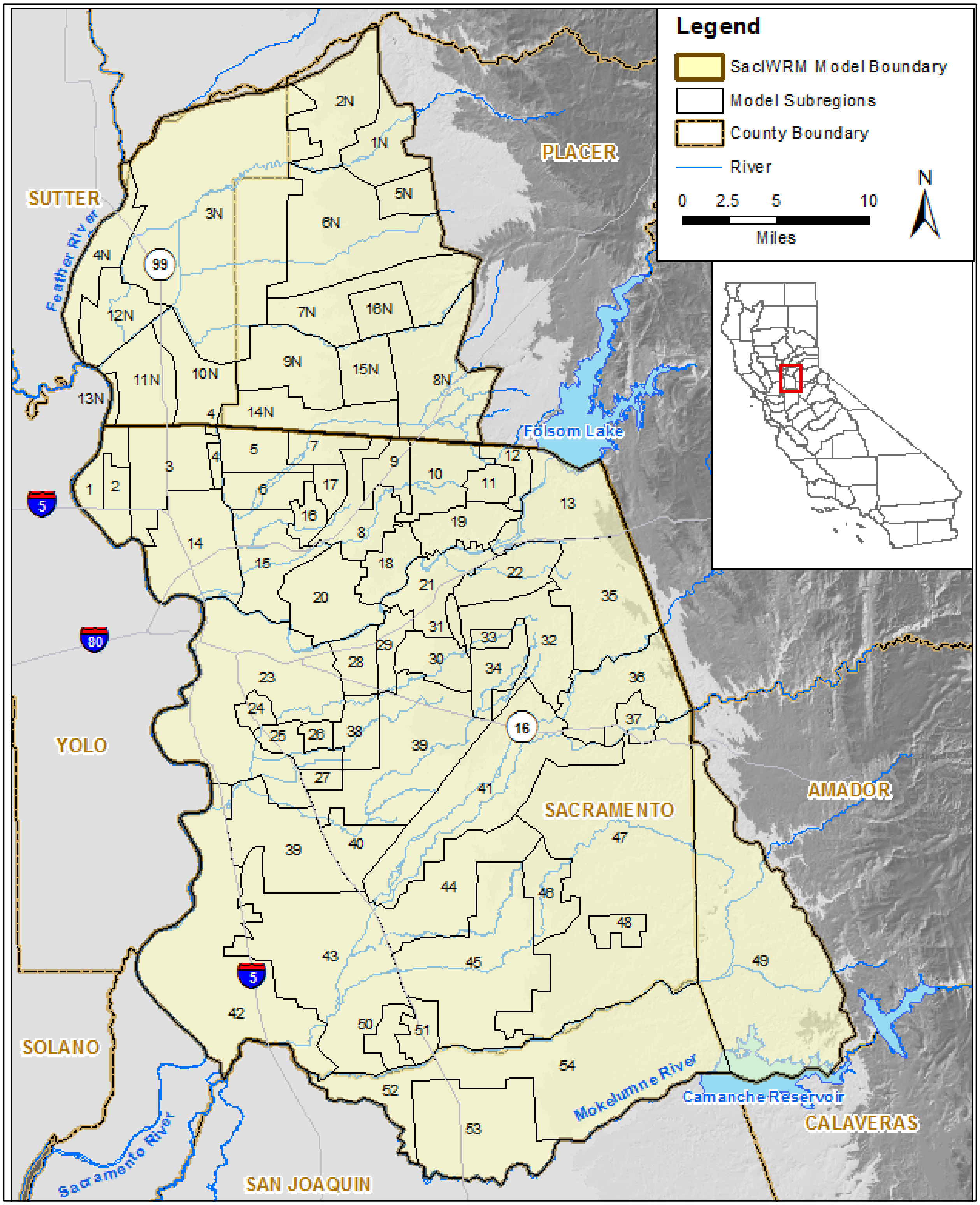


Figure 2: SacIWRM Area, SCGA Boundary, and Water Purveyors

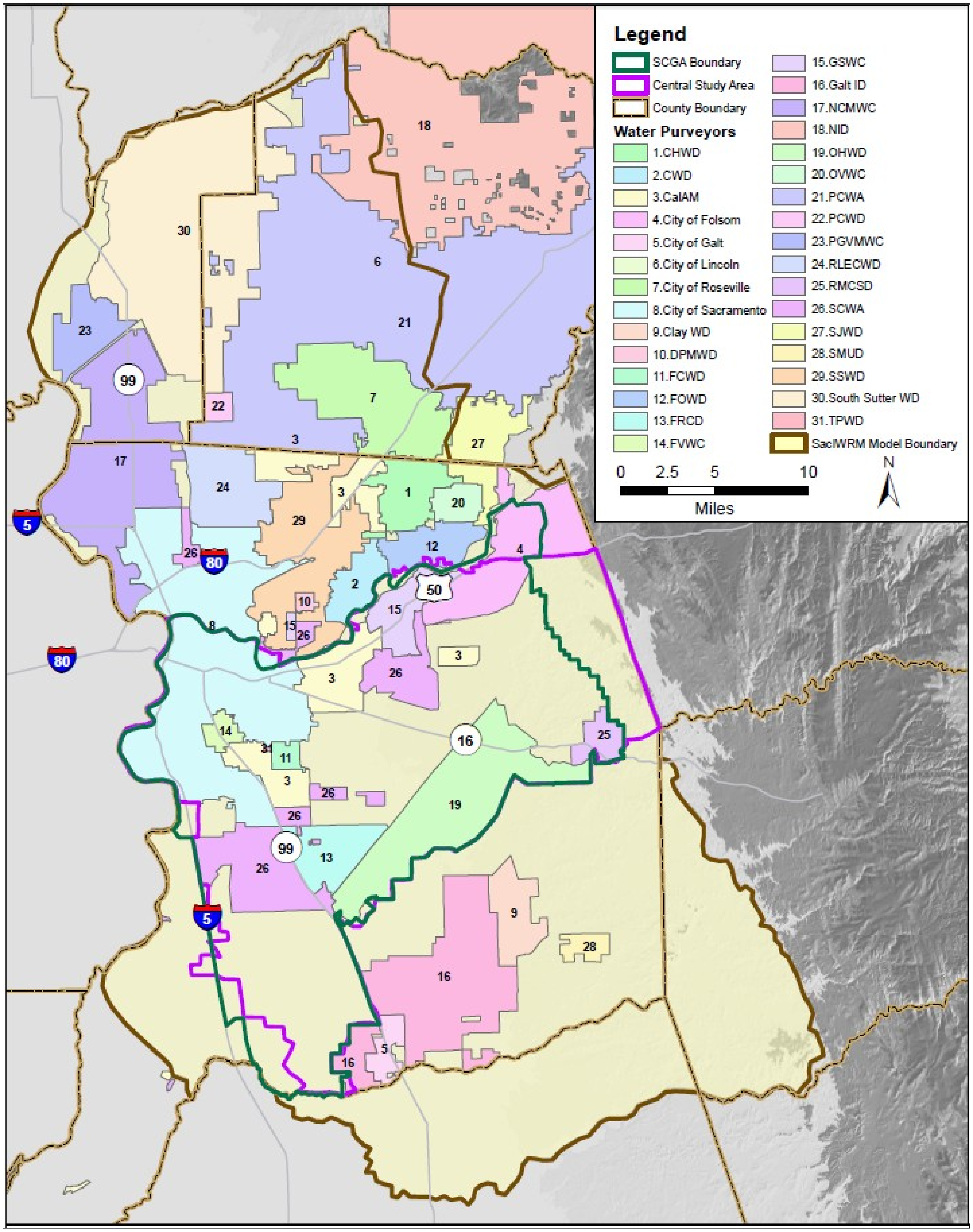


Table 1: Data Collected

Data Type	Data Source	Data Description
Precipitation	National Oceanic and Atmospheric Administration (NOAA), California Irrigation Management System (CIMIS), and California Data Exchange Center (CDEC)	Daily records from 10/1/2004 to 9/30/2011. Data gaps were filled based on available data from the nearby stations using regression analysis.
Streamflow	US Geological Survey (USGS)	Daily records from 10/1/2004 to 9/30/2011 for gages in the entire model area. Data gaps were filled with average daily records based on historical data.
Land Use and Cropping	US Department of Agriculture (USDA)	Annual land use and cropping data from 2007 through 2011 based on CropScape, covering the Sacramento and San Joaquin County portions of the model area.
2030 Future Land Use	General Plans, UWMPs, and Other Planning Documents	2030 urban footprint incorporated into the 2011 land use and cropping, focusing on the changes within the SCGA area.
Crops and Livestock Report	Sacramento County Agricultural Commissioner	2004 and 2011 reports with data for all of Sacramento County.
Urban and Agricultural Demand	Urban Water Management Plans (UWMPs) and Other Planning Documents for the SCGA Agencies	Annual data for supply and demand within the SCGA area for the 2005-2011 period. Data gaps were filled with average monthly records based on historical data.
2030 Future Urban and Agricultural Demand	UWMPs and Other Planning Documents for the SCGA agencies	2030 projections of urban demand and supply, with data for the SCGA area, plus limited data outside the SCGA area.
Surface Water Diversions	US Bureau of Reclamation (Reclamation) and State Water Resources Control Board (SWRCB)	Monthly records from 10/2004 to 9/2011 with data for the SCGA area, plus limited data outside the SCGA area. Data gaps were filled with average monthly records based on historical data.
Groundwater Pumping	SCGA Basin Management Reports	Monthly well pumping records from 10/2004 to 9/2011 with data for the SCGA area, plus limited data outside the SCGA area. Data gaps were filled with average monthly records from historical data.
Groundwater Elevation	CDWR	Monthly groundwater elevation data from 10/2004 to 9/2011 with data for the SCGA area, plus limited data outside the SCGA area. Groundwater elevation data for SCGA's California Statewide Groundwater Elevation Monitoring Program (CASGEM) wells for the full period of record.

Precipitation

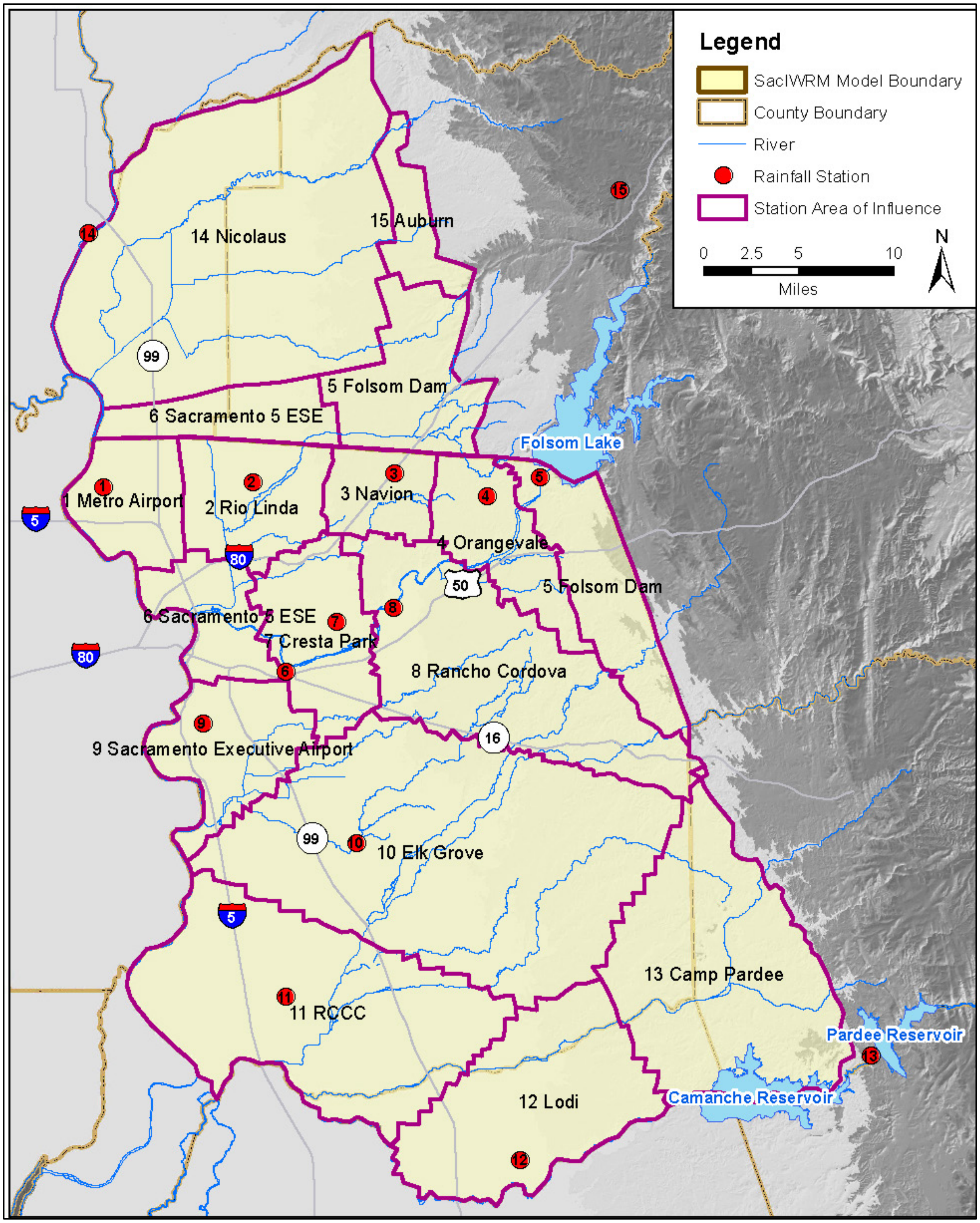
Daily precipitation records for 15 rainfall stations within the entire model area were collected and incorporated into the Historical Calibration model for the period October 1, 2004 to September 30, 2011. At the time of data collection, more recent data available beyond September 2011 were kept as part of the collected data and added into the model for potential use in future model updates. Table 2 shows the list of the precipitation data stations used in the Historical Calibration model update. The locations of the precipitation stations are shown on Figure 3. The major data sources included NOAA, CDEC, and CIMIS, as presented in Table 1. Data gaps were filled using the regression analysis that was established as part of the previous SacIWRM modeling work (RMC, 2011), based on available data from nearby stations.

The same precipitation data were also used for the updated 2030 Baseline to extend the hydrologic period.

Table 2: SacIWRM Precipitation Summary Data

Station Name	Data Source	Station ID
Metro Airport	CDEC	SMF
Rio Linda	CDEC	RLN
Navion	CIMIS	#131
Orangevale	CDEC	ORN
Folsom Dam	CDEC	FLD
Sacramento 5 ESE	NOAA	USW00023271
Cresta Park	CDEC	CRP
Rancho Cordova	CDEC	RNC
Sacramento Executive Airport	NOAA	USW00023232
Elk Grove	CDEC	ELG
Rio Cosumnes Correctional Center (RCCC/Galt)	CDEC	CRT
Lodi	NOAA	USC00045032
Camp Pardee	NOAA	USC00041428
Nicolaus 2	NOAA	USC00046194
Auburn	CIMIS	#195

Figure 3: SacIWRM, Distribution of Precipitation Stations



Streamflow

Daily streamflow records were collected for 12 locations within the entire model domain for the period from October 1, 2004 to September 30, 2011. Details and locations of the streamflow gages used in the model update are shown in Table 3 and Figure 4, respectively. For the locations in the NAR area, streamflow data were extrapolated based on the monthly averages of the historical data for Feather River, Sutter Bypass, Auburn Ravine, and Roseville Waste Water Treatment Plant (WWTP) discharge to Dry Creek. This approach was consistent with the previous model update at these locations. SMUD discharge to Laguna Creek was estimated from the SMUD diversions from Folsom based on the same approach used in the previous model.

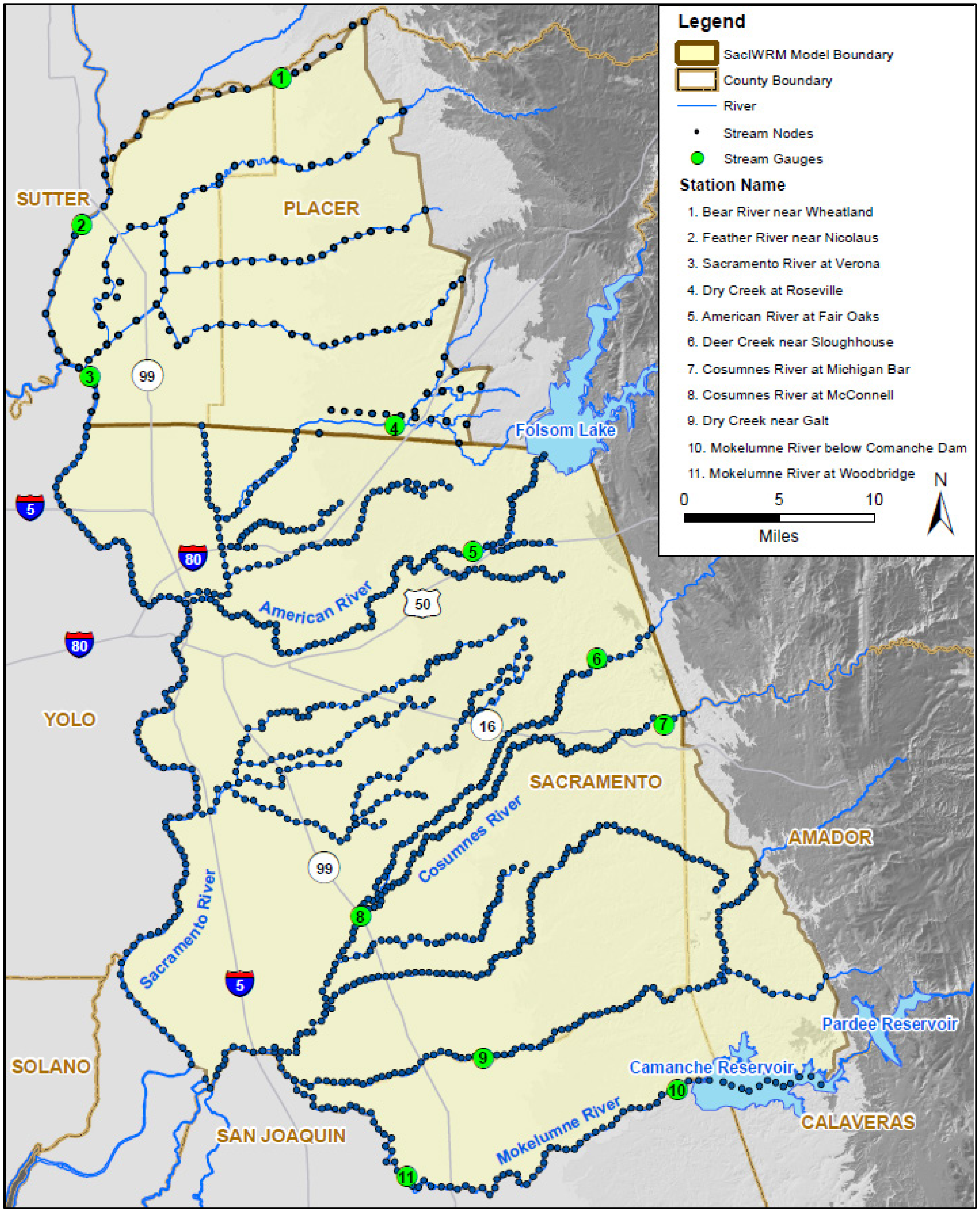
The same streamflow data were also used for the updated 2030 Baseline to extend the hydrologic period.

Table 3: SacIWRM Streamflow Summary Data

Station Name	Method Used for Data Update
American River near Fair Oaks	Daily records from USGS 11446500 gage
Cosumnes River at Michigan Bar	Daily records from USGS 11335000 gage
Dry Creek at Vernon St Bridge at Roseville	Daily records from USGS 11447293 gage
Sacramento River at Verona	Daily records from USGS 11425500 gage
Mokelumne River below Camanche Dam	Daily records from USGS 11323500 gage
Bear River (1)	Estimated based on daily records from USGS 1142400 gage
Feather River	Estimated based on average monthly records from historical data in the SacIWRM model
Sutter Bypass	Estimated based on average monthly records from historical data in the SacIWRM model
Auburn Ravine	Estimated based on average monthly records from historical data in the SacIWRM model
Roseville WWTP Effluent to Dry Creek	Estimated based on average monthly records from historical data in the SacIWRM model
Buffalo Creek (2)	Estimated based on average monthly records from historical data in the SacIWRM model
SMUD Discharge to Laguna Creek (3)	Estimated based on SMUD diversions from Folsom
Dry Creek South (4)	Not used in the model
Deer Creek near Sloughouse (4)	Not used in the model

Notes: (1) Estimated based on daily records from USGS 1142400 gage plus 110 cubic feet/second to represent the average flow of SSWD + CFWID, similar to the approach used in the previous model update.
(2) In the SacIWRM, Buffalo Creek inflow data are assumed to be Aerojet GET E/F and AR GET discharge entering Buffalo Creek at Stream Node 198. For the purposes of this update, it was estimated based on monthly averages of the historical data in the previous models. This can be updated and modified during future model updates with historical data from Aerojet, if available.
(3) SMUD discharge to Laguna Creek was estimated based on the monthly records of SMUD diversions from Folsom by multiplying diversions by 88% (12% used in plants) and 75% (25% loss to aquifer), following the same approach used in the previous model update. Constant daily discharge values were assumed based on monthly records of diversions.
(4) Not used as streamflow in the model as the model calculates this as small watershed runoff.

Figure 4: SacIWRM, Locations of Stream Nodes and Gages



Land Use and Cropping

For updating the Historical Calibration model, annual land use and cropping patterns were compiled for the years from 2007 to 2011 based on USDA's CropScape data. CropScape (USDA, 2015) is an online geospatial exploring tool with interactive visualization, geospatial queries, and dissemination. For this effort, annual Cropland Data Layers were downloaded through CropScape. The Cropland Data Layers contain satellite-derived crop information at a 30-meter resolution. The data were reclassified into the major land use and cropping classes specified in the SacIWRM model before being incorporated into the Historical Calibration model. The updated land use data cover the portion of the model that extends from the northern boundary of Sacramento County to the Mokelumne River (referred to as the SAC portion of the SacIWRM). The model defines annual crop acreage for 11 crop types, as well as urban, native vegetation, and riparian vegetation for each of the 54 subregions in the SAC area. The annual land use for urban, agricultural, and undeveloped areas are shown in Figure 5a for the SAC area and in Figure 5b for the entire model area. These figures show an overall increase in urban acreage and decrease in agricultural and undeveloped areas over time. The 2011 crop mix incorporated into the Historical Calibration model based on the CropScape data is shown in Figure 6a for the Central Area that mainly covers the SCGA boundary and in Figure 6b for the entire model domain.

For the portion of the SacIWRM in Sutter and Placer Counties (referred to as the NAR portion of the SacIWRM), the land use and cropping patterns remain the same as in the previous Historical Calibration model, but the hydrologic data (e.g., precipitation and streamflow) were extended through September 2011.

For updating the 2030 Baseline land use data, the future urban land use representative of the 2030 conditions were compiled from the existing planning documents, including the 2010 UWMPs and General Plans (City of Rancho Cordova, 2006; City of Folsom, 2008, 2014a; City of Sacramento, 2009; City of Elk Grove, 2009; Sacramento County, 2011; Cordova Hills, LLC, 2013). The CropScape 2011 data used in the Historical Calibration model were revised to incorporate the 2030 urban footprint. The major modifications from the previous version of the 2030 Baseline include the conversion of non-urban land use to urban use for the Folsom Plan Area and Cordova Hills. The non-urban land use was based on the 2011 CropScape that was used in the Historical Calibration simulation, except for the changes due to the 2030 urban footprint.

Figure 5a: Annual Land Use, Sacramento County Area (Subregions 1 to 54)

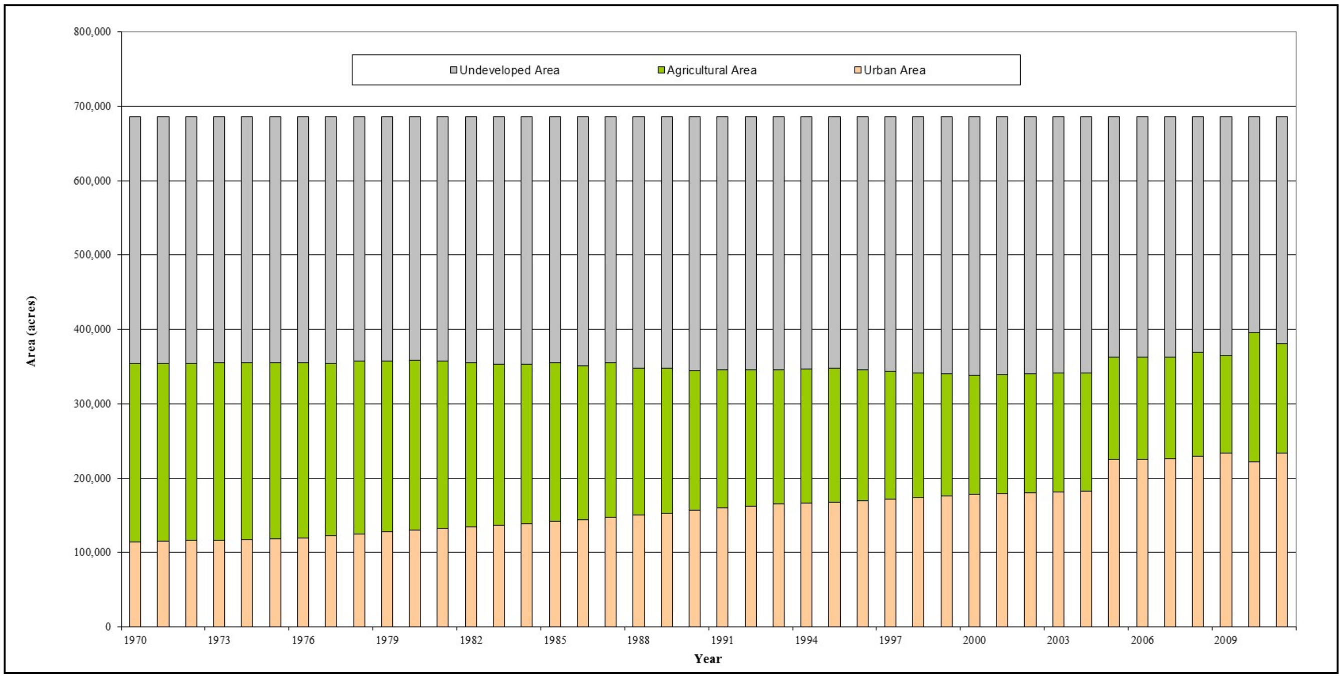


Figure 5b: Annual Land Use, Entire SacIWRM Area

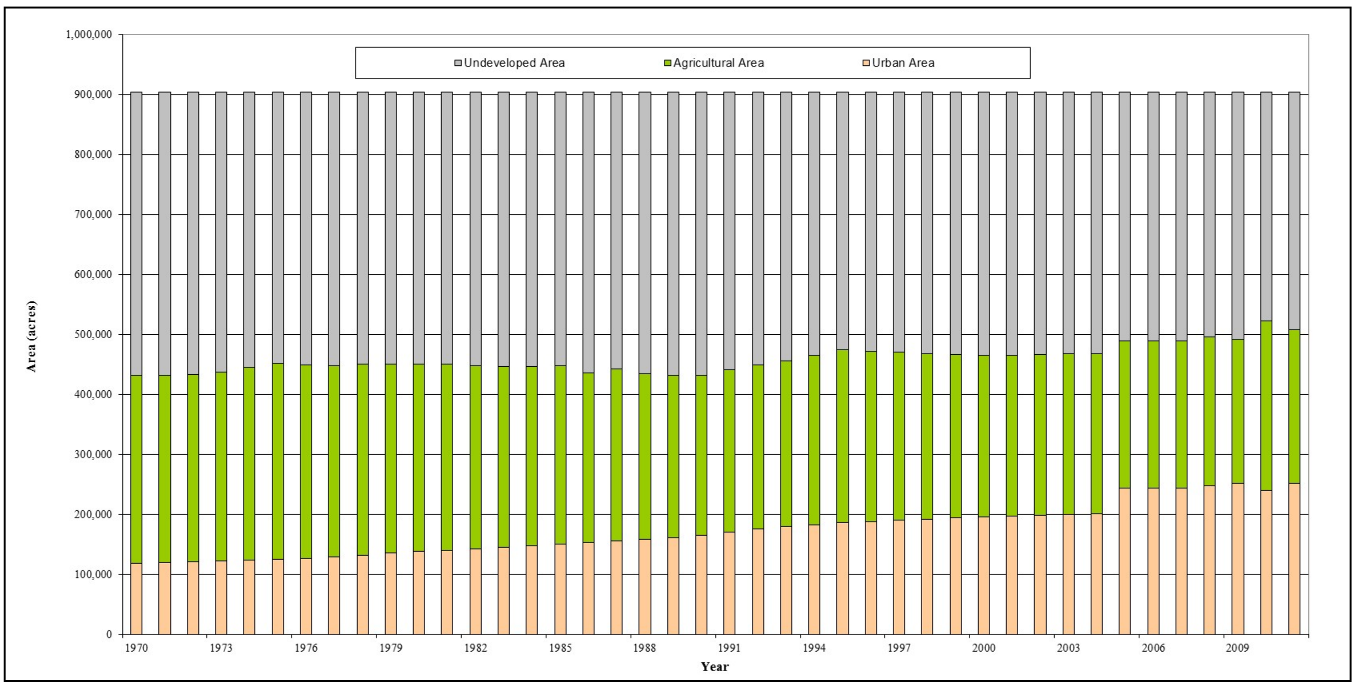


Figure 6a: 2011 Crop Mix, Central Area

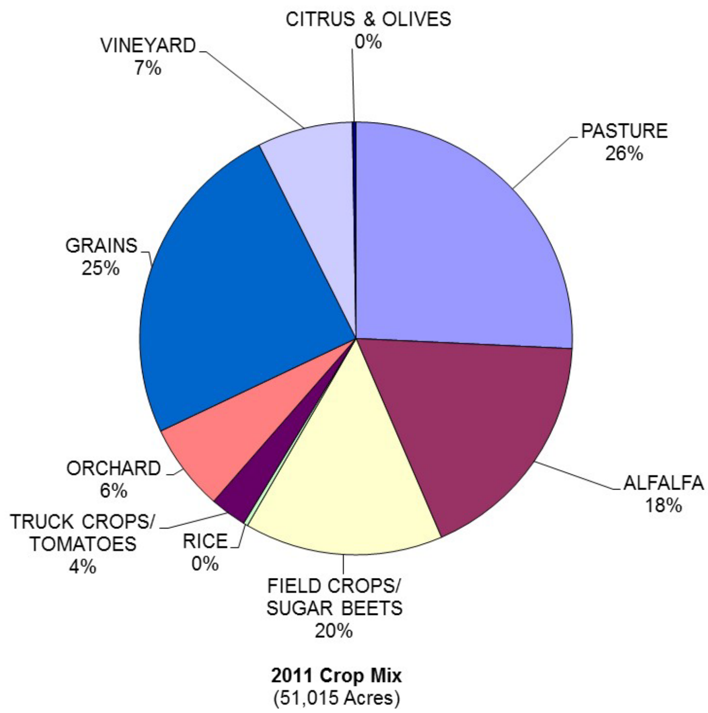
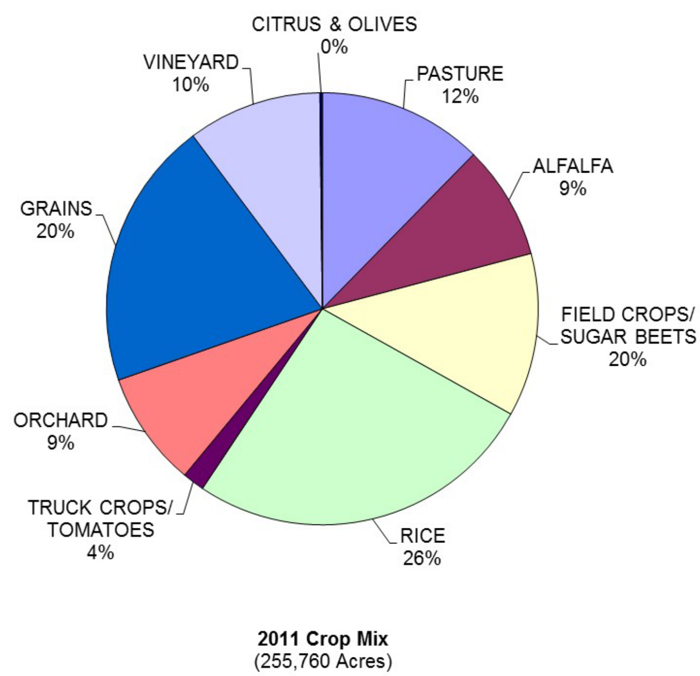


Figure 6b: 2011 Crop Mix, Entire SacIWRM Area



Crop and Livestock Report

The Sacramento County Crop and Livestock reports present crop acreages for field crops, fruits and nuts, nursery stocks, seed crops, and vegetable crops and were available for 2004 and 2011. Table 4 shows a comparison of the crop acreages for the 2004 and 2011 Crop and Livestock Reports. Data show that the agricultural acreages decreased about 6,000 acres from 2004 to 2011 with the major changes in the fruits and nuts, seed crops, and vegetable crops. While the overall intent behind the collection of this data was to compare the 2004 modeled crop acreage to 2011 crop acreage, a direct comparison of the modeled crop acreages and the acreages in the 2004 and 2011 reports is difficult, mainly because each dataset has a different classification of the major crop types and covers a different area. However, when the two datasets for the 2004 and 2011 years were compared for general trends in the SAC portion of the modeled area, both datasets show decreasing trends for rice, pasture, and field/vegetable crops and increasing trends for grains, orchards, and alfalfa.

Table 4: Sacramento County Crop and Livestock Reports Crop Acreages

Major Categories	Crops	2004 Acres	2011 Acres
Field Crops	Barley	1,700	-
	Beans dry	753	-
	Corn, field	26,268	26,889
	Corn, silage	13,134	9,542
	Hay, alfalfa	10,312	15,812
	Hay, grain	1,131	1,380
	Hay, other (Sudan and Clover)	3,495	2,400
	Oats	1,032	2,139
	Oats, silage	-	3,260
	Pasture irrigated	19,000	17,700
	Range	62,500	61,000
	Rice	9,851	3,478
	Ryegrass	-	2,975
	Safflower	2,955	3,197
	Sudan grass	-	1,012
	Sorghum, grain	1,100	-
	Wheat	8,114	11,252
	Misc. Field Crops	2,922	2,965
Sub-Total		***164,267***	***165,001***
Fruit & Nuts	Apples	378	301
	Cherries	415	1,197
	Grapes, wine	25,756	27,231
	Pears	6,000	5,560
	Strawberries	85	112
	Walnuts	-	785
	Misc. Fruit & Nuts	1,000	822
Sub-Total		**33,634**	***36,008***
Nursery stock	Nursery stock	732	486
Seed Crops	Clover	1,741	1,012
	Rice	1,530	-
	Sudan	3,601	960
	Misc.	347	345
Sub-Total		***7,219***	***2,317***
Vegetable Crops	Asparagus	*1,646*	-
	Peppers - All	see Misc.	-
	Pumpkins	*715*	see Misc.
	Squash	*270*	331
	Tomatoes, Fresh	-	351
	Tomatoes, Processed	*3,504*	3,203
	Misc. Vegetable Crops	*4,376*	2,706
Sub-Total		***10,511***	***6,591***
Total		**216,363**	**210,403**

Urban and Agricultural Supplies and Demand

For updating urban demand data in the Historical Calibration model, the 2010 UWMPs were reviewed for CalAm, City of Sacramento, City of Folsom, EGWD, and GSWC; the draft Zone 40 Water Supply Master Plan for SCWA; and the Integrated Water Master Plan and 2020 Compliance Plan for the Rancho Murieta Community Services District (RMCSD) (CalAm, 2011; City of Sacramento, 2011; City of Folsom, 2011; EGWD, 2011; GSWC, 2011; RMCSD 2010a and 2010b; SCWA, 2014). Annual urban demand data were compiled and distributed into monthly data using the monthly demand trends in the historical data. For areas outside of the SCGA, data in the Historical Calibration model were extended based on the monthly averages of the final five years of data in the existing SacIWRM Historical Calibration model (i.e., 1999-2004).

As a result of the land use and hydrologic data updates, agricultural demand was also updated to reflect the changes in the cropping in the updated Historical Calibration model. The agricultural water demand by subregion was calculated for the entire model area using consumptive use methodology adopted in the SacIWRM. This approach applies crop coefficients, reference evapotranspiration, precipitation, and crop types and estimates agricultural demand accordingly.

Future projected water supply and demand values for the SCGA area were compiled from planning documents, such as the 2010 UWMPs and Water Master Plans. The major documents reviewed include the 2010 UWMPs for CalAm, City of Sacramento, City of Folsom, EGWD, GSWC, and RMCSD; the draft Zone 40 Water Supply Master Plan for SCWA; and the 2020 Compliance Plan for RMCSD. Table 5 summarizes the 2030 demand and water supply projections that were incorporated into the 2030 Baseline update.

Table 5: 2030 Baseline Water Demand and Supply Projections

Model Area	Subregions	2030 Urban Demand Projections	2030 Supply Projections
CalAm (1)	25, 27, 28, 29, and 33	Total demand of 30,319 AFY (2) - Parkway – 10,622 AFY - Suburban Rosemont – 14,191 AFY - Security Park – 2,876 AFY	- Groundwater pumping projection of 23,069 AFY in Central Basin - SCWA supply of 3,178 AFY for Security Park (3) - City of Sacramento supply of 4,831 AFY for the Arden, Parkway, and Suburban areas
City of Sacramento (2)	14, 15, and 23	160,100 AFY	Total supply of 205,062 AFY - Groundwater pumping - 23,069 AFY - Surface water supply - 182,762 AFY
City of Folsom (3)	13	25,284 AFY	- Surface water supply – 46,700 AFY - Additional surface water supply of 5,421 AFY for the Folsom Plan Development
EGWD (4)	40	10,500 AFY	Total supply of 10,500 AFY - Tariff Area 1 supplied by groundwater pumping of 5,940 AFY - Tariff Area 2 supplied by SCWA at 4,560 AFY and estimated built out by 2020
GSWC (5)	21	16,932 AFY	Total supply of 24,850 AFY - Groundwater pumping – 14,850 AF - Aerojet granted water – 5,000 AFY - Surface water diversion – 5,000 AFY from the American River
SCWA (6)	30, 31, 32, 34, 38, and 39	Total demand of 63,000 AFY - North Service Area – 13,200 AFY - Central Service Area – 24,100 AFY - South Service Area – 25,700 AFY	Total supply of 63,100 AFY - Surface water supplies ranging from 15,600 AFY to 33,500 AFY - Groundwater supplies ranging from 27,800 AFY to 45,800 AFY - Recycled water supply of 1,700 AFY
RMCSD (7)	37	Total demand of 2,927 AFY, including demand reduction	- Average groundwater pumping of 334 AFY - Surface water supply of 5,179 AFY

Notes:
(1) Projections are based on the CalAm 2010 UWMP.
(2) Projections are based on the City of Sacramento 2010 UWMP.
(3) Projections are based on the City of Folsom 2010 UWMP and the 2014 Folsom Plan Area Water System Master Plan.
(4) Projections are based on the EGWD 2010 UWMP.
(5) Projections are based on the GSWC 2010 UWMP. Demand projection includes system losses and water saving reductions.
(6) Projections are based on the draft Zone 40 Water Master Plan. Supply varies based on the hydrologic water year types, except the recycled water supply of 1,700 AFY.
(7) Projections are based on the 2020 Compliance Plan and represent the demand at buildout (2030) with 2020 demand reduction compliance.

Surface Water Diversions

Monthly records of surface water diversions were compiled based on available data from Reclamation and the SWRCB for the period from October 2004 to September 2011 within the SCGA area. Data were incorporated in the Historical Calibration model to extend the model period to September 2011. Surface water diversion data outside of the SCGA area were extrapolated based on the monthly averages of the historical data in the previous model.

For the updated 2030 Baseline, the projections of the surface water supply diversions were compiled from the 2010 UWMPs and other planning documents for the major water purveyors within the SCGA area. This effort included compiling surface water supply projections for CalAm, City of Sacramento, City of Folsom, EGWD, GSWC, SCWA, and RMCSD. For the model areas outside of the SCGA, surface water diversions in the previous 2030 Baseline for the 1970-2004 hydrologic period were used to extend the model through September 2011. This included a two-step approach. First, monthly average surface water diversions were calculated by hydrologic year types (e.g., Wet, Normal, Drier, Drier and Critical, and Driest years) using the 1970-2004 data in the previous 2030 Baseline. Next, the calculated monthly averages were used for the for the 2005-2011 period based on the hydrologic year types during the seven-year period.

Groundwater Pumping

For the Historical Calibration model update, monthly groundwater pumping data for the SCGA area were obtained from the HydroDMS for the period 2005-2011, which contains data consistent with the SCGA Basin Management Reports. For wells with missing records, average monthly pumping values were assigned based on historical records in the previous Historical Calibration model to fill the data gaps. For areas outside of the SCGA, data in the Historical Calibration model were extended based on the monthly averages of the final five years of data in the simulation (i.e., 1999-2004).

Municipal well locations in the previous Historical Calibration model for the SCGA area were reviewed against the most recent well location data and adjustments were made as necessary. This resulted in adding new simulated municipal pumping wells for the City of Sacramento, SCWA, and CalAm and updating some of the existing well coordinates for GSWC. Agricultural pumping in the model area was estimated for each subregion as the agricultural demand in the subregion minus any agricultural surface water deliveries to that subregion. Since no data were available on the locations of agricultural private wells, agricultural pumping was averaged over areas with agricultural land use weighted based on crop type, using the same approach as in the previous model updates.

In the 2030 Baseline, urban pumping for the SCGA area was estimated for the entire simulation period based on the 2030 projections in the 2010 UWMPs for CalAm, City of Sacramento, City of Folsom, EGWD, and GSWC, along with the draft Zone 40 Water Supply Master Plan for SCWA and the Folsom Plan Area Water System Master Plan for the City of Folsom. The new municipal wells that were added to the Historical Calibration model were also incorporated into the updated 2030 Baseline. In addition to urban pumping, agricultural pumping was estimated to meet the agricultural demand that was calculated by the model based on the land use and hydrologic data. Similar to the Historical Calibration model, agricultural pumping was spread over agricultural land uses based on the crop type. For areas outside of SCGA, urban, agricultural, and other pumping data in the previous 2030 Baseline for the 1970-2004 period were used to extend the model through September 2011, using the same approach as with extending the surface water diversion data.

Groundwater Elevation

Measured groundwater elevation data were compiled from DWR for 10 representative calibration wells to support the modeling effort and from SCGA's CASGEM wells to support the BMO development. Table 6 presents the representative calibration wells corresponding to the model subregions and the area of the model near those wells. Figure 7 and Figure 8 show the locations of the representative calibration wells and CASGEM wells, respectively. Measured data at the selected calibration wells were compared with the model results to identify the performance of the updated Historical Calibration model and evaluate if the model reasonably represents the observed data. Based on the match between the measured and the model simulated hydrographs, recommendations were proposed for potential future model updates, as discussed in Section 4.3.

Table 6: Representative Calibration Wells within Central Area

Representative Calibration Wells	Model Area	Subregions
76	CalAm Rosemont	29
77	Aerojet	22
80	City of Sacramento Place of Use (South of American River)	23,24,25,26,27,28
100 and 109	Omochumne-Hartnell Water District	41
122	Cosumnes River West	43
189	Elk Grove	40
201	Galt ID East of Hwy 99	44,45
247	SCWA – Zone 40 East of Hwy 99	38, 39
253	Sunrise Mather Area	30,31,33,34

Figure 7: Locations of Representative Calibration Wells

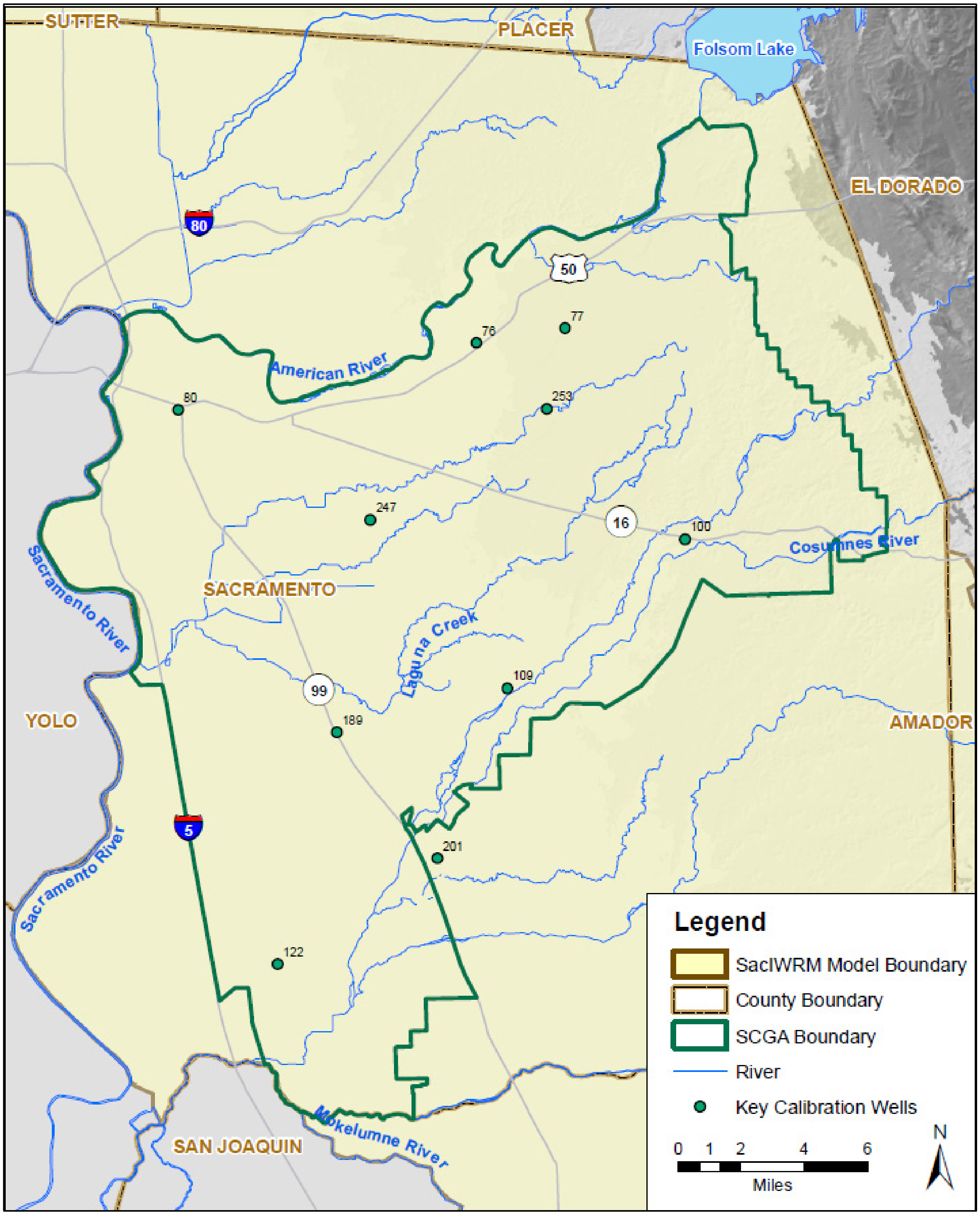
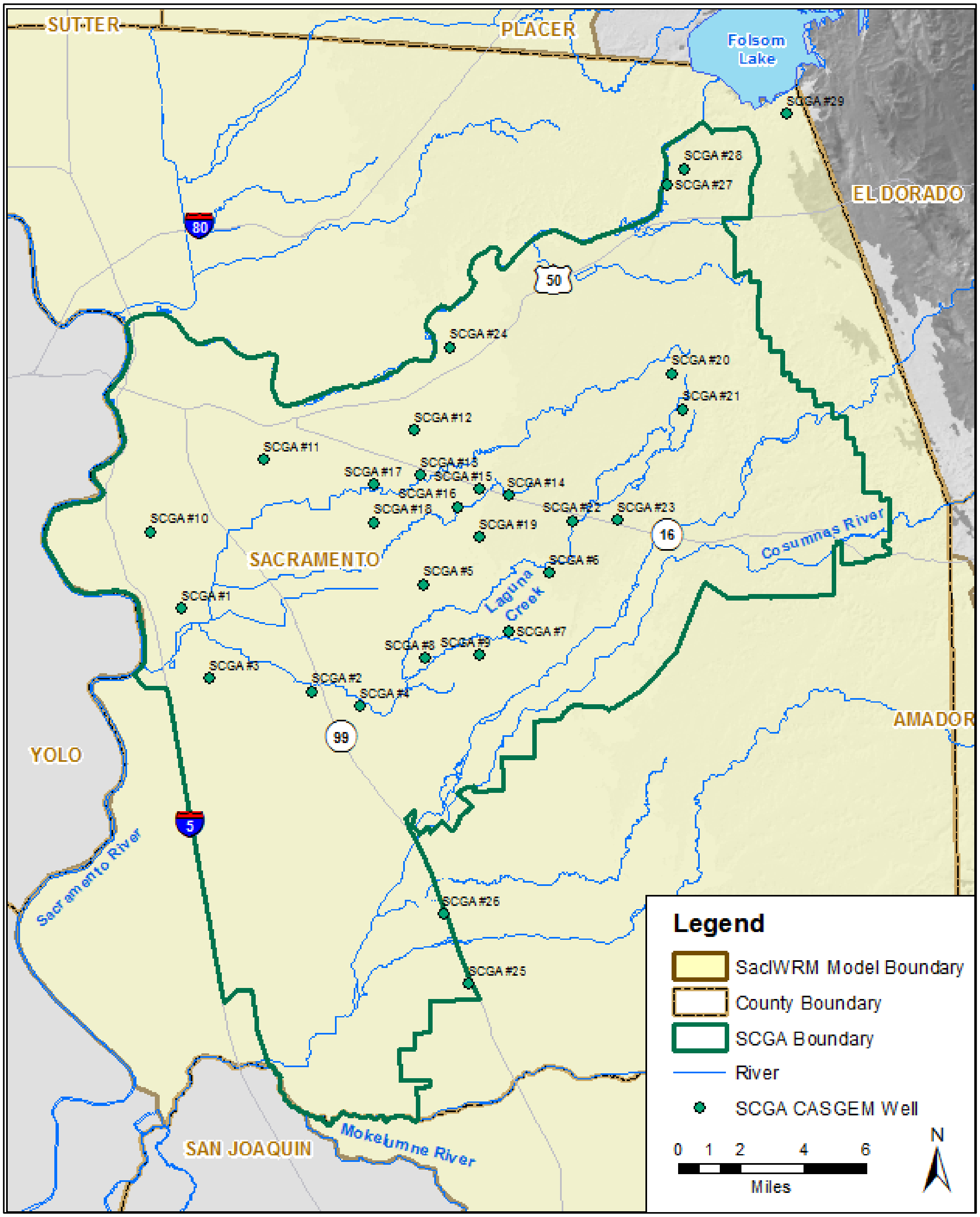


Figure 8: Locations of SCGA CASGEM Wells



3 Update of the SacIWRM

This section summarizes the major updates to the 2030 Baseline model and quality control-associated changes to the Historical Calibration model. The approach used to update the model input data is explained in the previous section. The results of changes made to the 2030 Baseline and Historical Calibration models are summarized in Section 4 based on groundwater elevation contours at key time periods and hydrographs at key locations within the SCGA area.

3.1 2030 Baseline Simulation

The previous 2030 Baseline represented basin conditions assuming the general plan build-out in the year 2030. It represented build-out land use, crop mix, urban density conditions, and water supply conditions in the basin. The 35-year hydrologic conditions of 1970-2004 were repeated three times to evaluate the long-term effects of water resources management activities on the basin. This project included a comparison of the previous 2030 Baseline simulation to the most recent general plans, UWMPs, and other planning documents to verify if the assumptions used are still representative based on the most up to date information available. This comparison resulted in modifications in the land use, urban demand, and water supply assumptions within the SCGA area. While the update focused on the SCGA area, the land use and cropping patterns were updated for the entire SAC area of the model. The non-urban land use from the 2011 CropScape data used in the Historical Calibration model was revised to incorporate the 2030 urban footprint based on the general plans and other available planning documents (City of Elk Grove, 2009; City of Folsom 2008, 2014; City of Sacramento, 2009; Cordova Hills, LLC, 2013; Sacramento County, 2011). As a result of the land use update, agricultural demand was also updated to reflect the changes in cropping and hydrologic data.

The urban demand and water supply conditions were updated primarily for the SCGA area based on the 2030 projections compiled for individual water purveyors. The primary data sources were the 2010 UWMPs and SCWA's draft Zone 40 Water Supply Master Plan, which provide the annual demand and water supply projections for 2030. For the model areas outside of SCGA, urban demand and water supply remain the same as in the previous 2030 Baseline for 1970-2004. Monthly averages of urban demand and water supply (groundwater pumping and surface water deliveries) were estimated for each hydrologic year type and used to extend the model for the 2005-2011 period.

In the updated 2030 Baseline, the 42 year hydrologic conditions of 1970-2011 were repeated twice to evaluate the long-term effects of the 2030 conditions. The initial groundwater elevations for the updated 2030 Baseline were assumed to be the September 2011 levels based on the updated Historical Calibration model output.

The changes made to the 2030 Baseline simulation are summarized in Section 4. The results of the updated 2030 Baseline with the new data were analyzed for developing the thresholds for BMO No. 2 as discussed in Sections 5 through 8.

3.2 Historical Calibration Simulation

The simulation period for the previous Historical Calibration model included the water years 1970-2004. With the current update, the model period was extended for the water years 2005-2011 by incorporating new data for land use and cropping, urban and agricultural demand, precipitation, streamflow, surface water diversions, and groundwater pumping. The model was not recalibrated, but rather the calibration was verified. Data collected are presented in Table 1 and described in Section 2. With the current update, the Historical Calibration model simulates 42 years of land use, water use, and hydrological conditions, compared to the 35 years of data in the previous model.

The updated Historical Calibration model was used to quality control the performance of the model during the extended time period. The model performance was investigated based on the comparison of the simulated and measured groundwater elevations at representative monitoring well locations within the SCGA area. The intent of this comparison was to verify that the updated Historical Calibration model reasonably represents observed conditions for the extended data period. Results of this comparison are described in Section 4.3.

4 Updated SacIWRM Model Results

The model outputs from the updated 2030 Baseline models are presented in this section based on the land and water use budget summaries, groundwater contours at key time periods and groundwater hydrographs at the representative calibration well locations. The verification process of the 2030 Baseline is also presented through comparison of historical data and simulated Historical Calibration groundwater elevations.

4.1 Land and Water Use Budget Summary

The model outputs for the land and water use budget provides key hydrologic components of the modeled area. Table 7 presents the annual simulated land and water use budget from the updated 2030 Baseline for the Central Area. The table includes agricultural and urban land use, agricultural and urban water demand, surface water supply, groundwater supply, and pumping/export volumes for remediation operations. The average total water demand in the Central Area was approximately 371,000 acre-feet per year (AFY) consisting of 117,000 AFY of agricultural demand and 254,000 AFY of urban demand. The average agricultural water use was 2.8 acre-feet per acre and the average urban water use was 1.7 acre-feet per acre.

4.2 Groundwater Elevation Contours

Groundwater contours from the 2030 Baseline are shown in Figure 9, for September 1977 hydrology, and in Figure 10, at the end of the simulation (September 2011 hydrology). Similarly, these contour maps also show a pumping depression in the Central Area, but groundwater elevations are higher in the 2030 Baseline than in the Historical Calibration model both for the September 1977 and the end of simulation (see Section 4.3). This is attributed to the reduced groundwater pumping and increased surface water supply projections under the 2030 Baseline compared to the Historical Calibration model. An exception is the pumping depression located in the central part of the SCGA area, near Florin Road and Florin-Perkins Road. This is largely due to pumping by Florin County Water District, which is projected to use exclusively groundwater. Note that no projection data was available from Florin County Water District to update the model, so the water use data remain unchanged from the previous 2030 Baseline.

4.3 Model Verification

The verification of the 2030 Baseline was performed by comparing the model simulated Historical Calibrated Model groundwater elevations to the measured data for long-term trends as well as seasonal fluctuations at 10 selected representative calibration well locations shown on Figure 7. These wells were selected as they have the most complete data for the SCGA area and were established as part of the previous calibration efforts. Figures 11a through 11j show the comparison of the simulated and observed water levels for the selected locations. Table 8 summarizes the results of comparison for each well location with response to the model matching the seasonal and long-term trends in groundwater elevations. Table 8 also includes proposed recommendations in areas where future improvements may be made to the model. Overall, the results of this calibration verification indicate that the updated Historical Calibration model reasonably simulates the long-term hydrologic responses at most of the selected representative calibration wells. It was noted that of the 10 locations analyzed, four locations show either higher or lower groundwater elevations than the observed data. As described in Table 8, the differences noted at these locations may warrant further investigations as part of future updates to the Historical Calibration model, but the verification process supports the use of the updated 2030 Baseline for development of the thresholds for BMO No. 2.

Contour maps of the simulated groundwater elevations were developed for the Historical Calibration model and 2030 Baseline for the Central Area. For both models, contours were prepared for September 1977 as a representation of a drought condition and at the end of the simulation period. Groundwater contours from the Historical Calibration simulation are shown in Figure 12 for September 1977 and in Figure 13 at the end of the simulation (September 2011). Overall, both contour maps show groundwater depressions in the Central Area but the groundwater elevations simulated for the 1977 conditions are lower than the end of the simulation. This trend is consistent with the hydrologic year types where the 1977 was the driest year and the end of simulation represents the wetter conditions from the years 2010 and 2011.

Table 7: 2030 Baseline Water Use Budget Summary for Central Area – Annual Average for 1970 - 2011 Hydrology

SUBREGION		Ag Acreage	Urban Acreage	Ag Demand	Ag Water Duty	Urban Demand	Urban Water Duty	Total Water Demand	Total Water Supply (AFY)			Remediation Operations (AFY)	
Number	Name	(Ac)	(Ac)	(AF)	(AF/A)	(AF)	(AF/A)	(AFY)	GW Pumping	SW Supply (1)	Total Supply	Pumping	Export
21	Golden State WC	76	7,296	194	2.6	16,932	2.3	17,126	7,126	10,002	17,128	3,319	3,319
22	Aerojet	32	7,374	132	4.1	5,233	0.7	5,365	0	5,233	5,233	18,122	18,122
23	City of Sac South	203	38,151	471	2.3	103,222	2.7	103,693	3,503	100,187	103,690	0	0
24	Fruitridge Vista WC	0	1,898	0	-	4,343	2.3	4,343	4,343	0	4,343	0	0
25	Cal-Am V. H. (POU)	0	4,001	0	-	8,524	2.1	8,524	6,568	1,958	8,526	0	0
26	Florin County WD	0	1,551	0	-	9,224	5.9	9,224	9,222	0	9,222	0	0
27	Cal-Am V. H. OPOU	0	1,455	0	-	3,104	2.1	3,104	2,391	714	3,105	0	0
28	Cal-Am Rosemont in POU	29	4,448	110	3.8	6,224	1.4	6,334	4,905	1,430	6,335	0	0
29	Cal-Am Rosemont outside POU	4	3,383	14	3.5	9,313	2.8	9,327	9,327	0	9,327	0	0
30	Mather Field	19	3,672	41	2.2	2,974	0.8	3,015	322	2,692	3,014	2,064	2,064
31	SCWMD Sunrise	0	940	0	-	761	0.8	761	72	689	761	0	0
32	Zone 40 East	389	6,019	899	2.3	4,876	0.8	5,775	1,360	4,414	5,774	5,773	5,773
33	Cal-Am Security Park	0	1,421	0	-	3,149	2.2	3,149	0	3,149	3,149	0	0
34	Sunrise Douglas	7	5,665	23	3.3	4,588	0.8	4,611	23	4,588	4,611	0	0
35	Foothills N. Unorganized	30	4,467	61	2.0	5,421	1.2	5,482	61	5,421	5,482	0	0
36	Foothills C. Unorganized	623	1,676	1,583	2.5	36	0.0	1,619	1,617	0	1,617	0	0
37	Rancho Murieta	204	2,527	493	2.4	2,926	1.2	3,419	493	2,926	3,419	0	0
38	SCWA in POU	112	5,157	512	4.6	7,298	1.4	7,810	5,016	2,793	7,809	0	0
39	Zone 40 West	3,042	30,262	10,830	3.6	42,502	1.4	53,332	36,612	16,722	53,334	0	0
40	Elk Grove	8	5,860	20	2.5	10,500	1.8	10,520	8,240	2,281	10,521	0	0
41	OHWD	14,175	5,786	39,565	2.8	2,062	0.4	41,627	41,321	316	41,637	0	0
43	Cosumnes River West	22,469	3,503	62,319	2.8	336	0.1	62,655	61,560	1,162	62,722	0	0
	Total Central Area	**41,422**	**146,512**	**117,267**	**2.8**	**253,548**	**1.7**	**370,815**	**204,082**	**166,677**	**370,759**	**29,278**	**29,278**

Note: (1) Surface water supply includes net import/export of groundwater to/from the subregion, in addition to imported water supply from other sources.

Figure 9: Groundwater Elevation Contour Map for September 1977 – 2030 Baseline Model

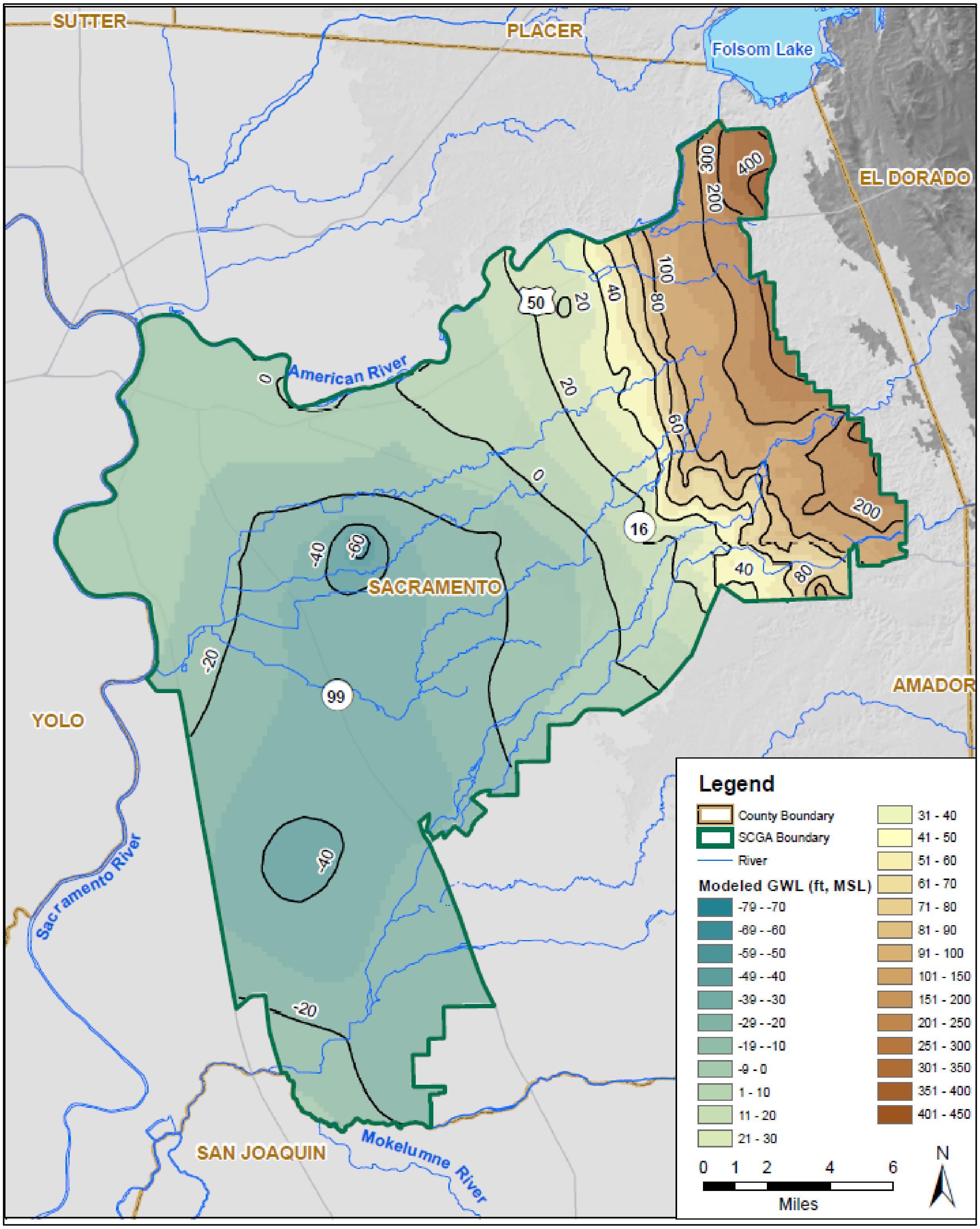


Figure 10: Groundwater Elevation Contour Map at the End of Simulation – 2030 Baseline Model

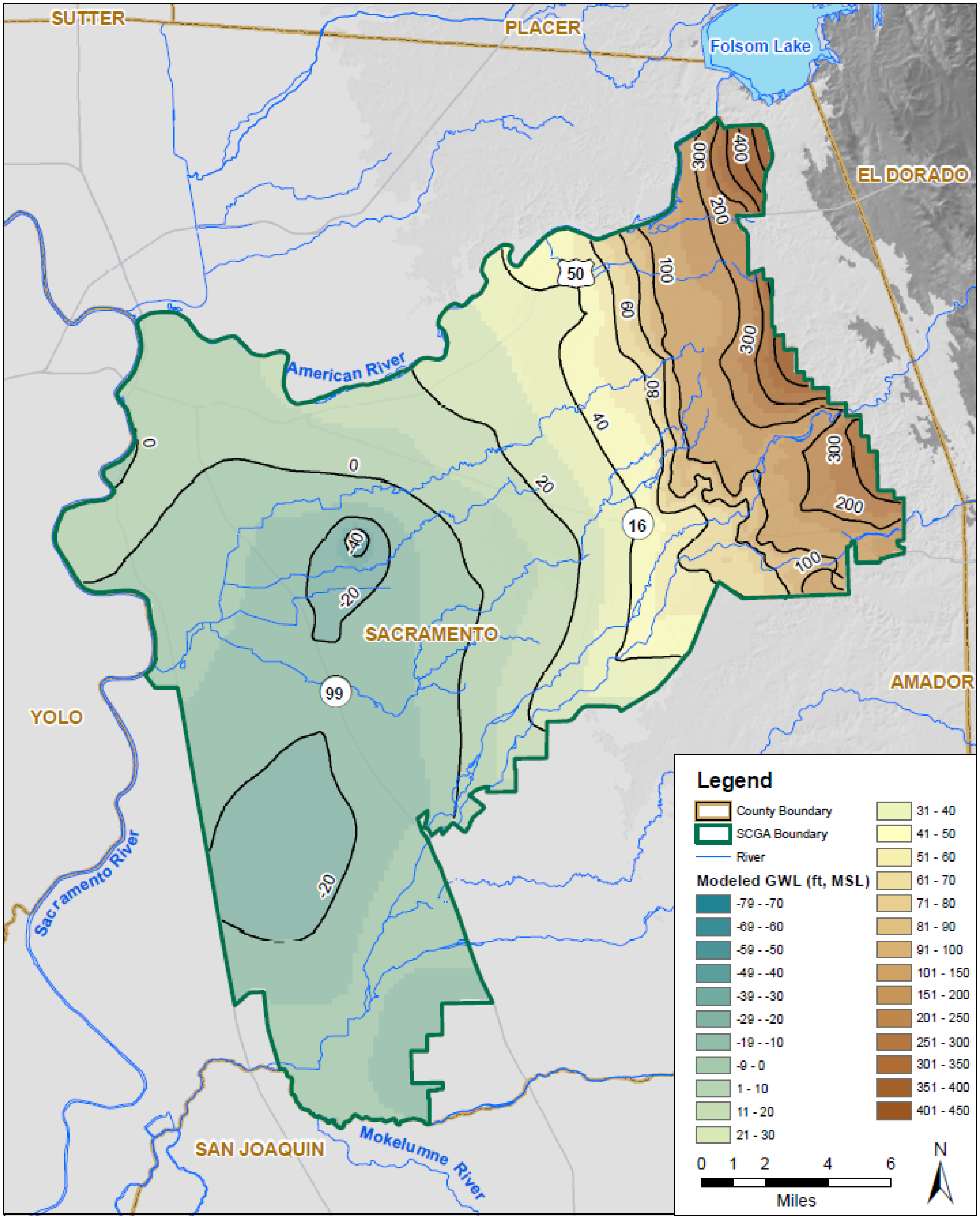


Figure 11a: Groundwater Elevation, Calibration Well 76

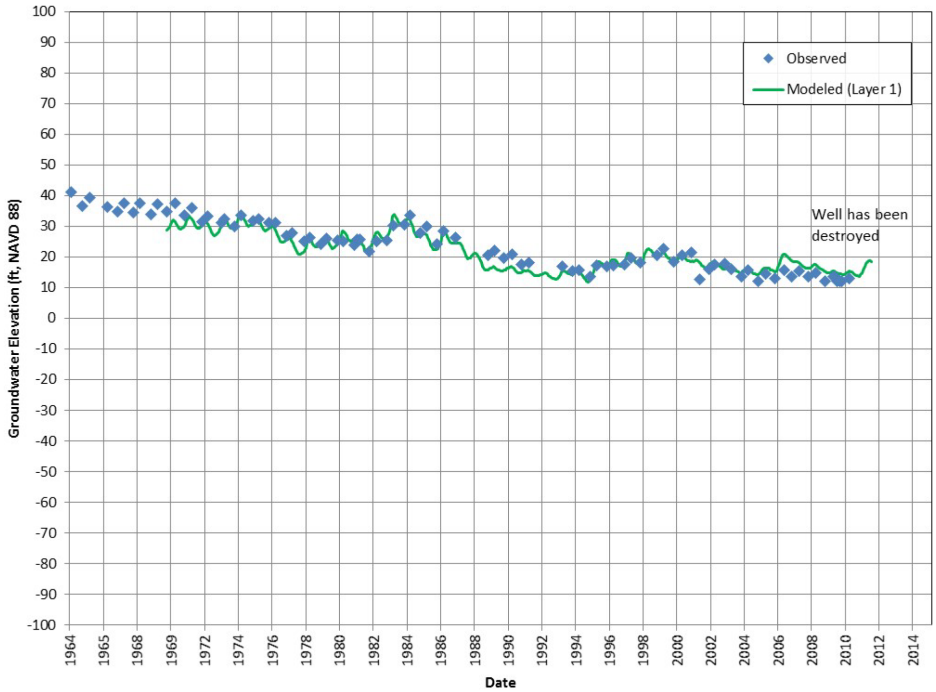


Figure 11b: Groundwater Elevation, Calibration Well 77

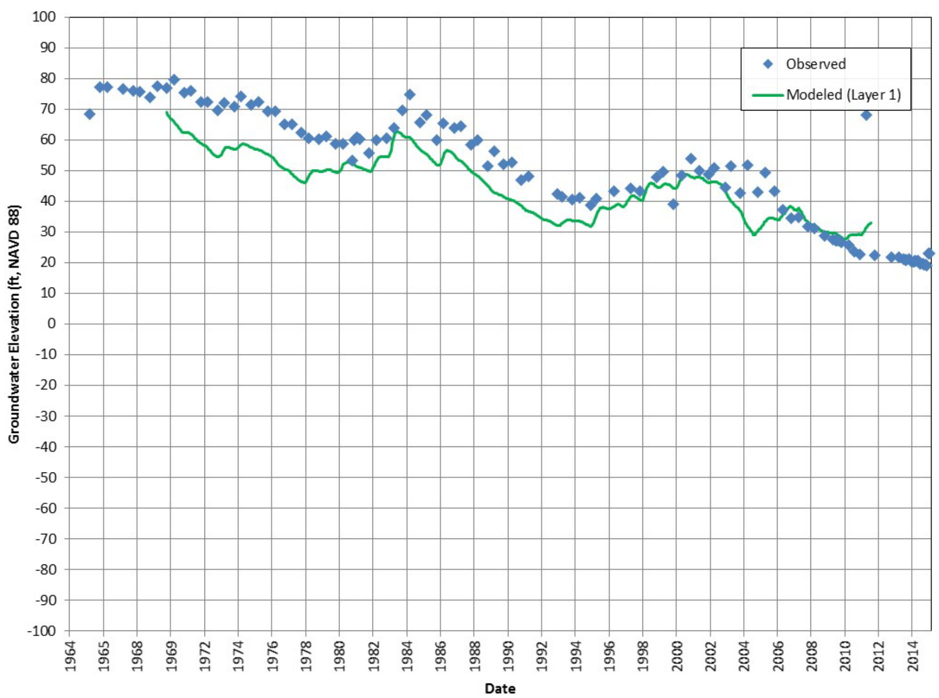


Figure 11c: Groundwater Elevation, Calibration Well 80

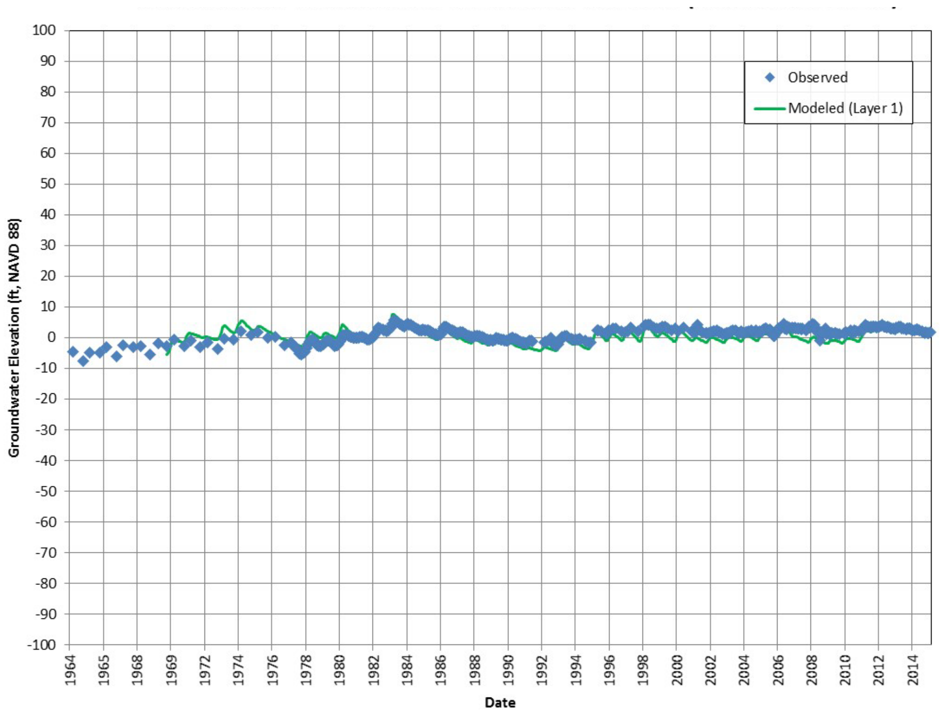


Figure 11d: Groundwater Elevation, Calibration Well 100

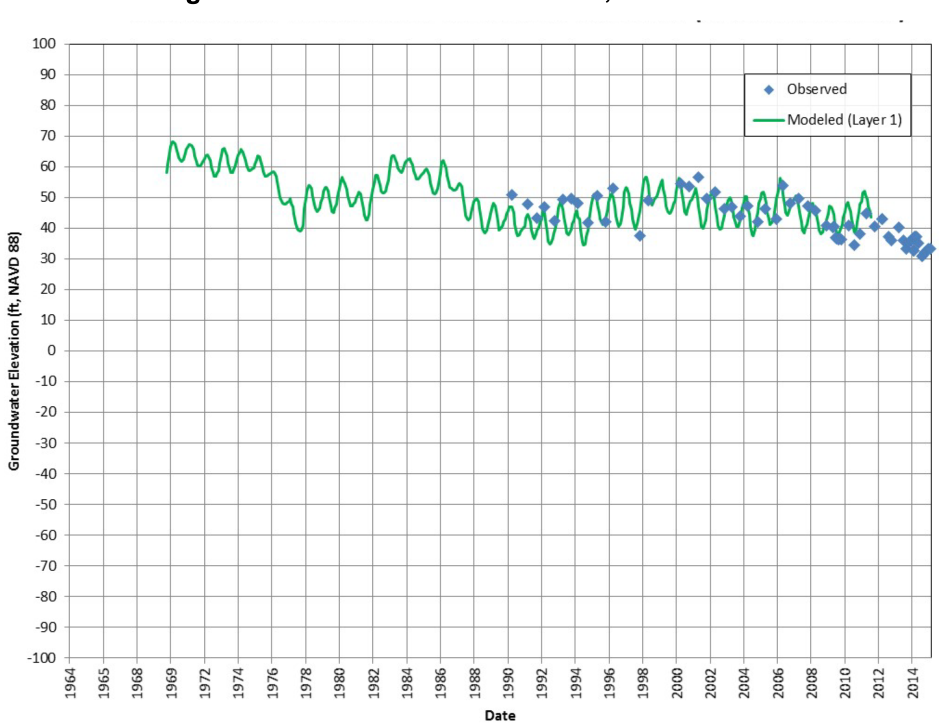


Figure 11e: Groundwater Elevation, Calibration Well 109

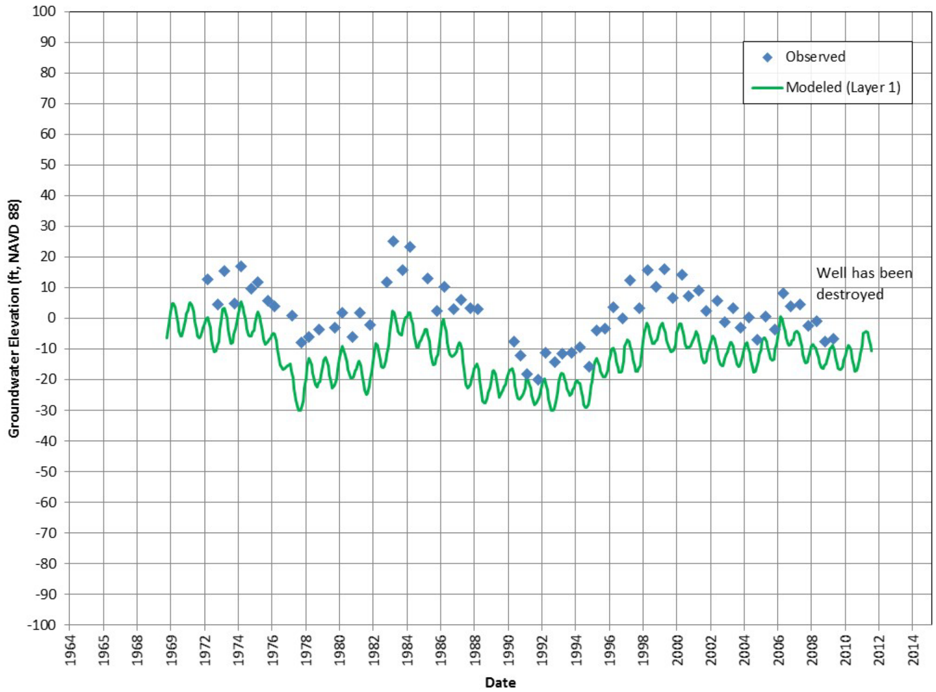


Figure 11f: Groundwater Elevation, Calibration Well 122

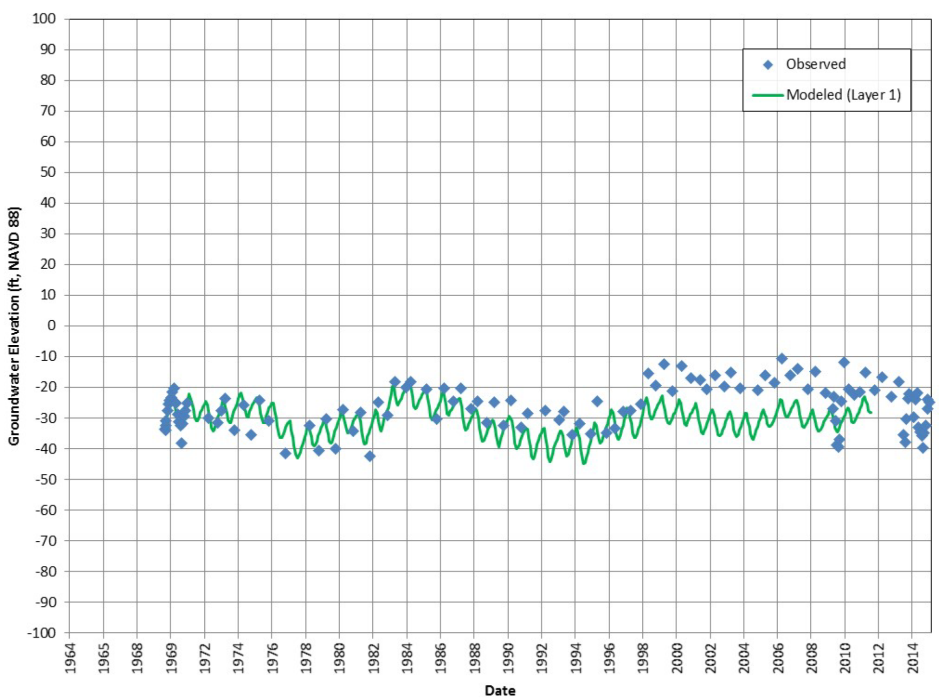


Figure 11g: Groundwater Elevation, Calibration Well 189

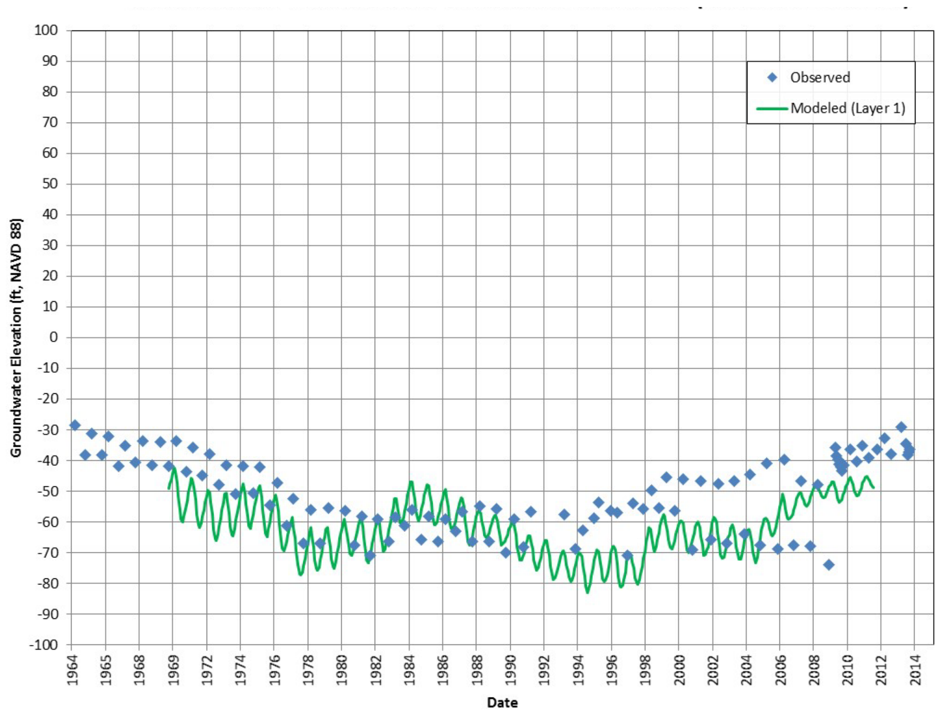


Figure 11h: Groundwater Elevation, Calibration Well 201

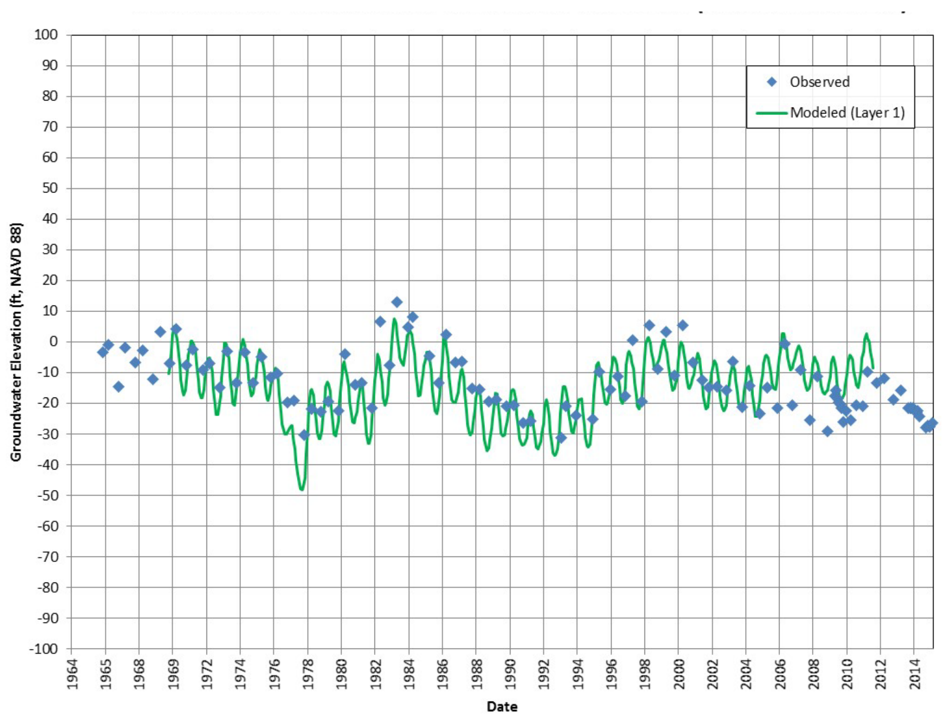


Figure 11i: Groundwater Elevation, Calibration Well 247

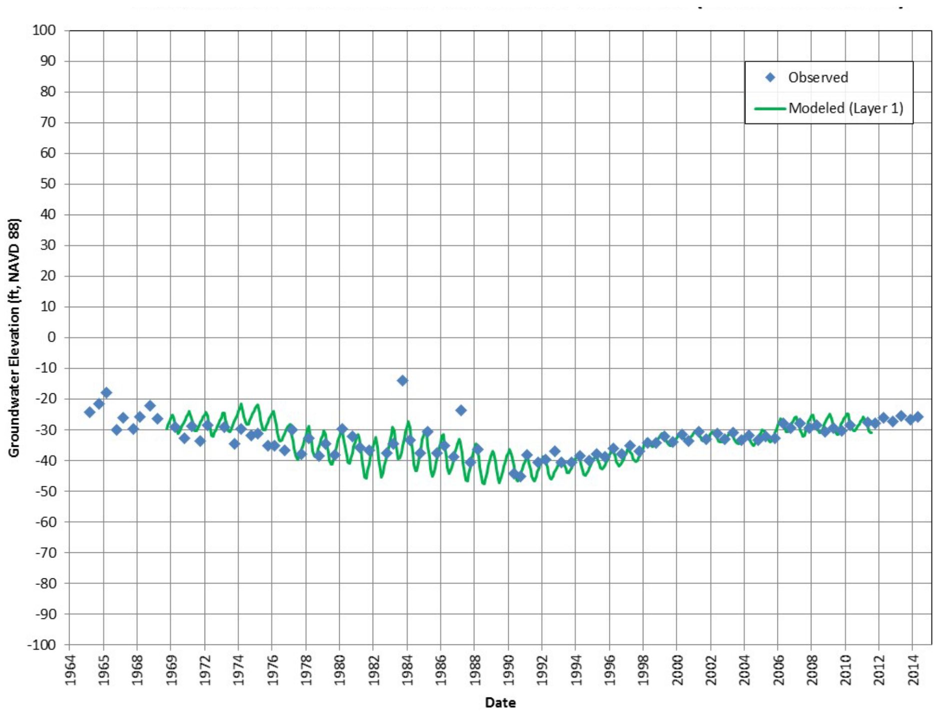


Figure 11j: Groundwater Elevation, Calibration Well 253

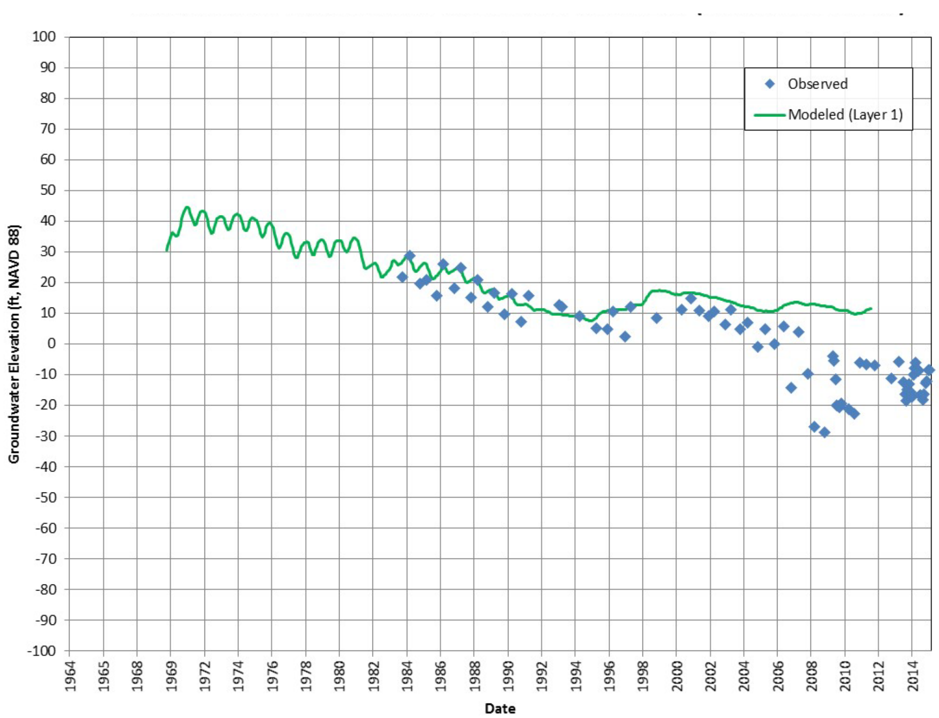


Table 8: Representative Calibration Wells and Calibration Status

Representative Calibration Well	Model Area	Sub-regions	Calibration Status
76	CalAm Rosemont	29	- Long-term water level data available, but the well is reported to be destroyed as of 2009. - Close match of seasonal and long-term trends for the extended time period
77	Aerojet	22	- Long-term water level data available - Close match of seasonal and long-term trends during 2005-2009 period - Opportunities for future refinement of simulation of lower water levels during 2010-2011 - Future calibration refinement may improve simulation results in this area - More detailed data from Aerojet remediation operations are likely needed.
80	City of Sacramento Place of Use (South of American River)	23,24,25, 26,27,28	- Long-term water level data available - Close match of seasonal and long-term trends for the extended time period
100	Omochumne-Hartnell Water District	41	- Water level data available beginning in 1990 - Generally close match of seasonal and long-term trends for the extended time period
109	Omochumne-Hartnell Water District	41	- Long-term water level data available but the well is reported to be destroyed as of 2009. - Overall trends are matched by the model simulation. - Opportunities for future refinement of simulation of higher water levels throughout the entire simulation period - Additional detail on the complex relationships between groundwater and surface water in the Cosumnes River may be required to improve simulation results.
122	Cosumnes River West	43	- Long-term water level data available - Generally close match of seasonal and long-term trends for the extended time period
189	Elk Grove	40	- Long-term water level data available - Generally close match of long-term trends - More frequent historical data collection may be necessary to capture seasonal fluctuations.
201	Galt ID East of Hwy 99	44, 45	- Long-term water level data available - Generally close match of long-term trends - Water levels are slightly lower than simulated within the extended time period. - Future calibration refinement may improve simulation results in this area. - More frequent historical data collection may be necessary to capture seasonal fluctuations.
247	SCWA – Zone 40 East of Hwy 99	38, 39	- Long-term water level data available - Close match of seasonal and long-term trends for the extended time period
253	Sunrise Mather Area	30,31,33, 34	- Water level data available beginning in 1980s - Water levels are lower than simulated within the extended time period. - Future calibration refinement may improve simulation results in this area. - More detailed data from nearby remediation operations are likely needed.

Figure 12: Groundwater Elevation Contour Map for September 1977 - Historical Calibration Model

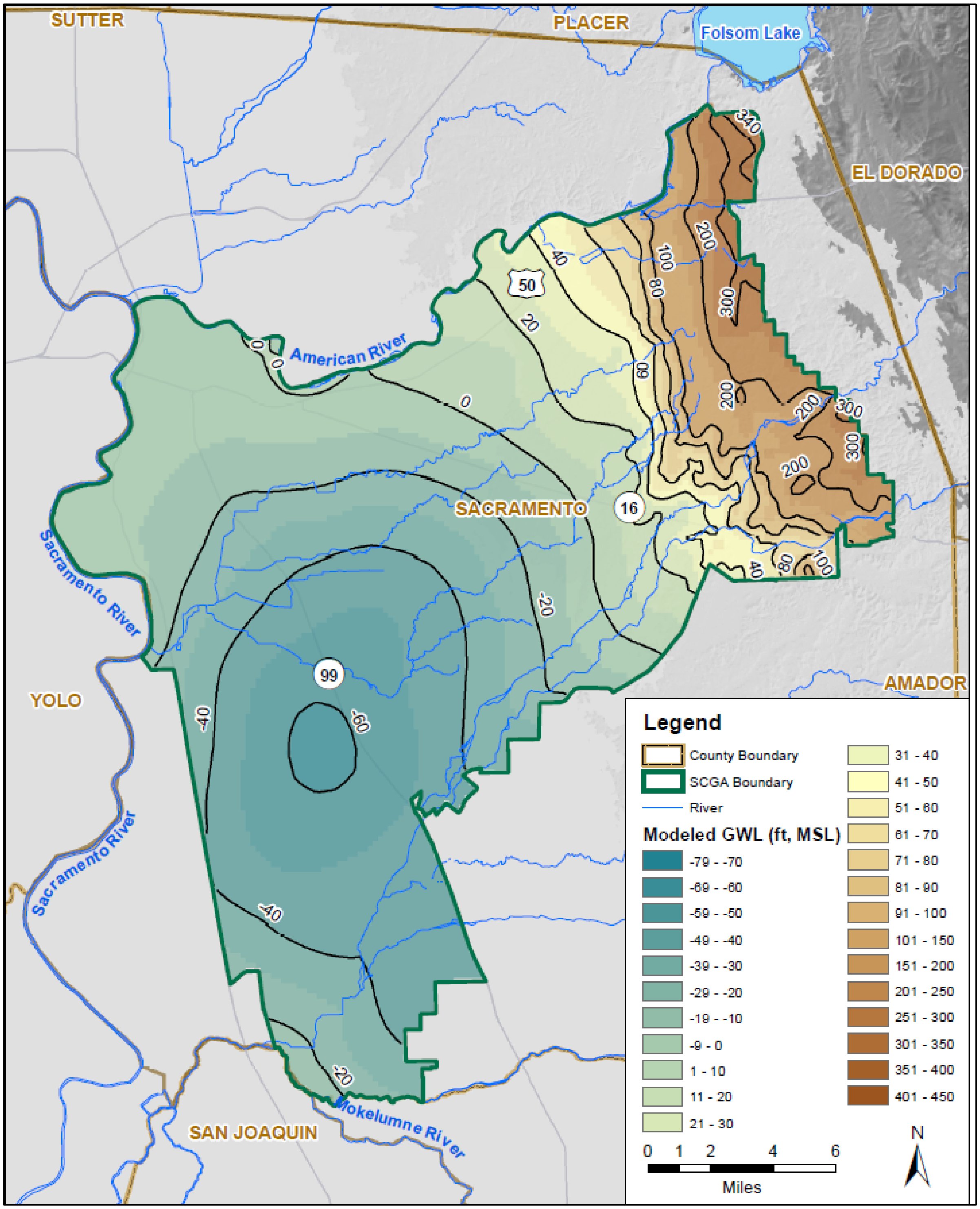
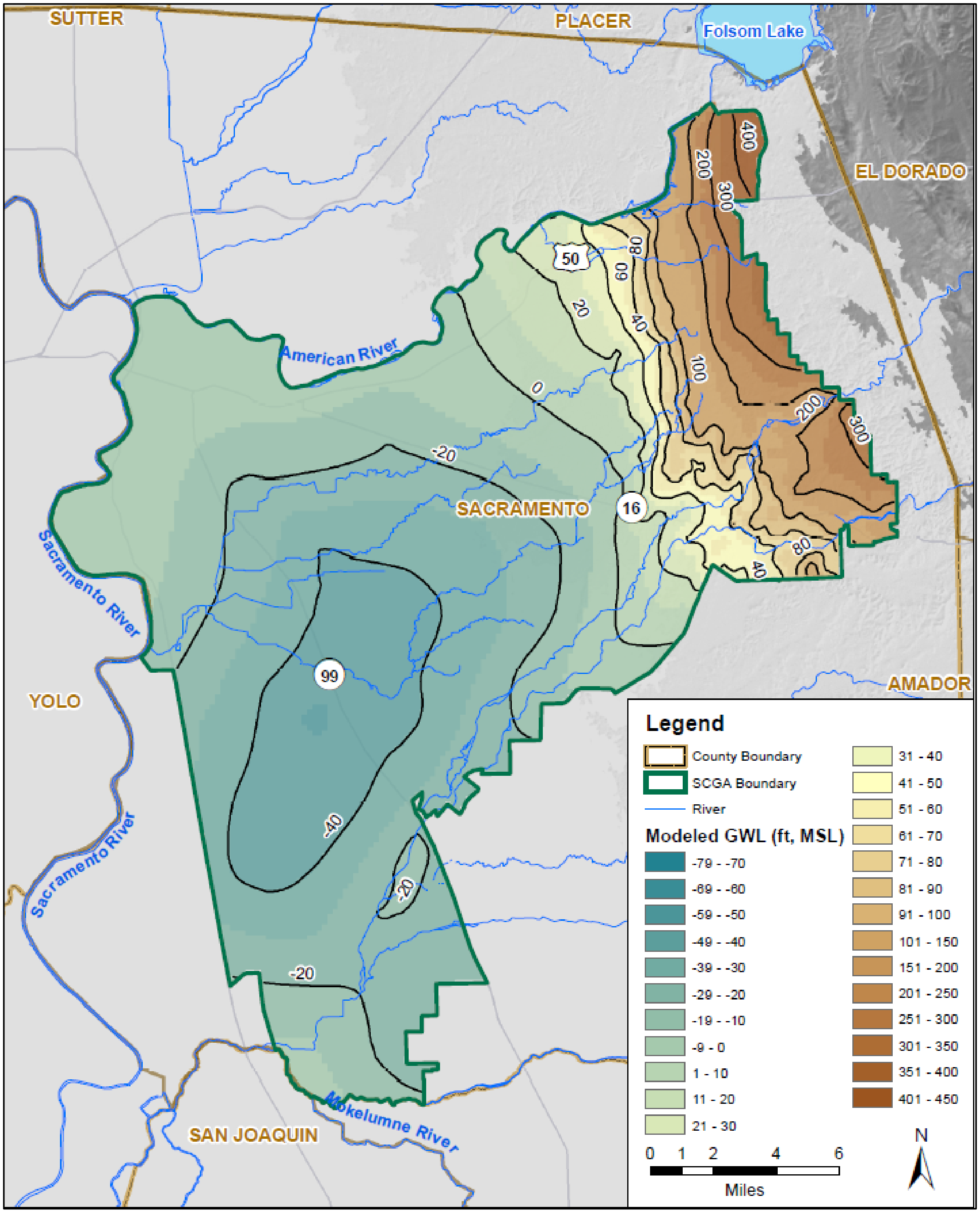


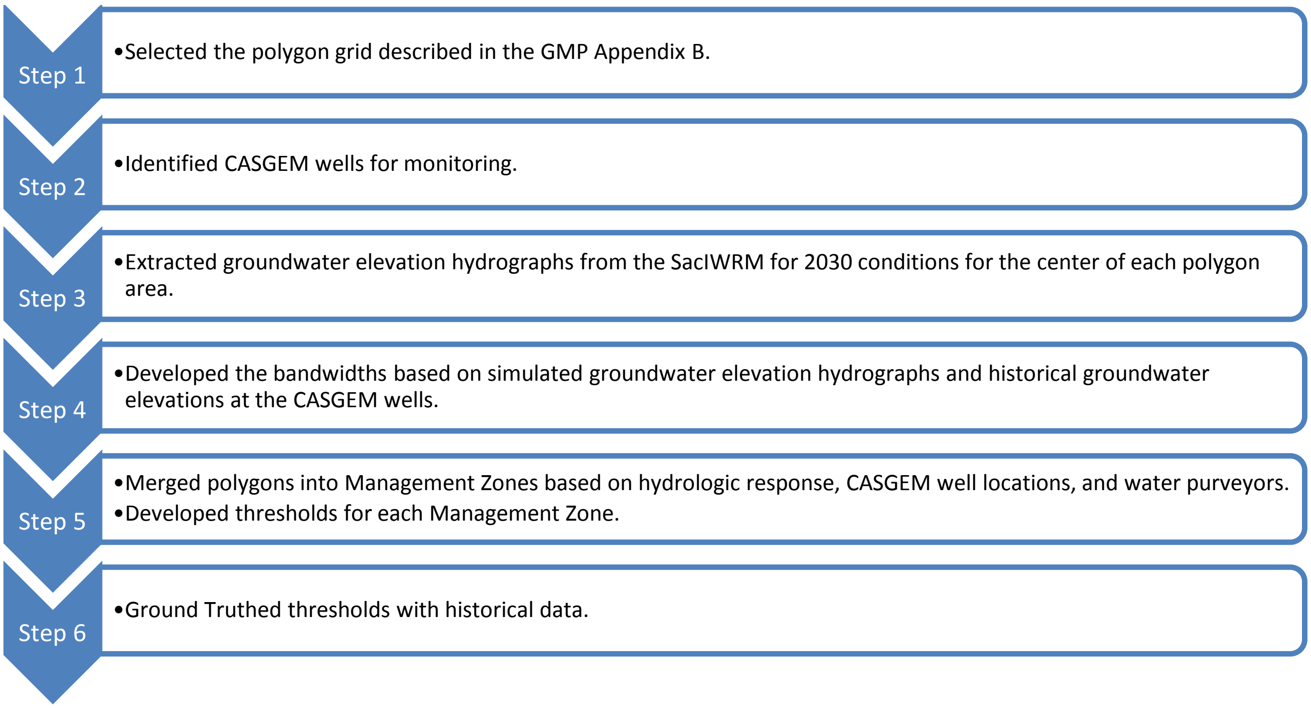
Figure 13: Groundwater Elevation Contour Map at the End of Simulation – Historical Calibration Model



5 Development of Groundwater Elevation Bandwidth

Groundwater bandwidths were initially developed based on the methodology described in Appendix B of the GMP and were then adjusted based on historical groundwater elevation data. The corresponding steps of Appendix B are presented in italics within Section 5, 6, 7, and 8. The process is summarized in Figure 14.

Figure 14: General Process for Development of Groundwater Level Bandwidths



Step 1

Step one of the GMP Appendix B methodology is to define a polygon grid for the area. The polygon grid selected, shown in Figure 15, is the same grid described in the GMP Appendix B. The grid is an extension of a similar grid used in the Sacramento Groundwater Authority Groundwater Management Plan and is comprised of hexagons, each covering 5 square miles.

Step 2

Step two of the GMP Appendix B methodology is to locate a State Monitoring Well to represent each grid area based on the period of measurement record and the quality of the data. Guidelines were provided that:

- The period of record should include 1977 to 2003
- Data gaps should not exceed 1 year in time with monitoring at least twice a year, spring and fall

If no such well existed, it was recommended that construction of a new monitoring well may be necessary.

These guidelines were modified as it was found that only 2 wells from CDWR's water level database met the criteria and as recent implementation of the CASGEM program has identified ongoing monitoring considered representative of the basin that should be utilized for this effort.

SCGA is a monitoring entity in the CASGEM program, which mandates a statewide groundwater elevation monitoring program to track seasonal and long-term trends in groundwater elevations in California's groundwater basins. CASGEM requires collaboration between local monitoring entities and CDWR to collect groundwater elevation data. SCGA developed a CASGEM monitoring plan (SCGA, 2012) in February 2012 which identified 29 wells for ongoing CASGEM monitoring. Since that time, three of these wells have been destroyed, leaving 26 CASGEM monitoring wells for ongoing monitoring.

The CASGEM monitoring wells provide good coverage of the grid area (Figure 16), as the CASGEM monitoring plan was developed to provide representative coverage of the entire area. The wells do not, however, provide one well per planning polygon. As the planning polygon are intended to be aggregated into Management Zones under Step 5, all wells were included for the following steps to provide the information necessary for aggregation.

Step 3

Step three of the GMP Appendix B methodology is to extract groundwater elevation hydrographs from the SacIWRM for 2030 conditions for the center of each polygon area. This was performed using the updated model described in Sections 2, 3, and 4. These hydrographs are shown in Appendix B of this TM and are summarized in Figure 17 by graphically displaying the variability in groundwater elevation from the mean in each of the polygons.

Figure 15: Planning Polygons

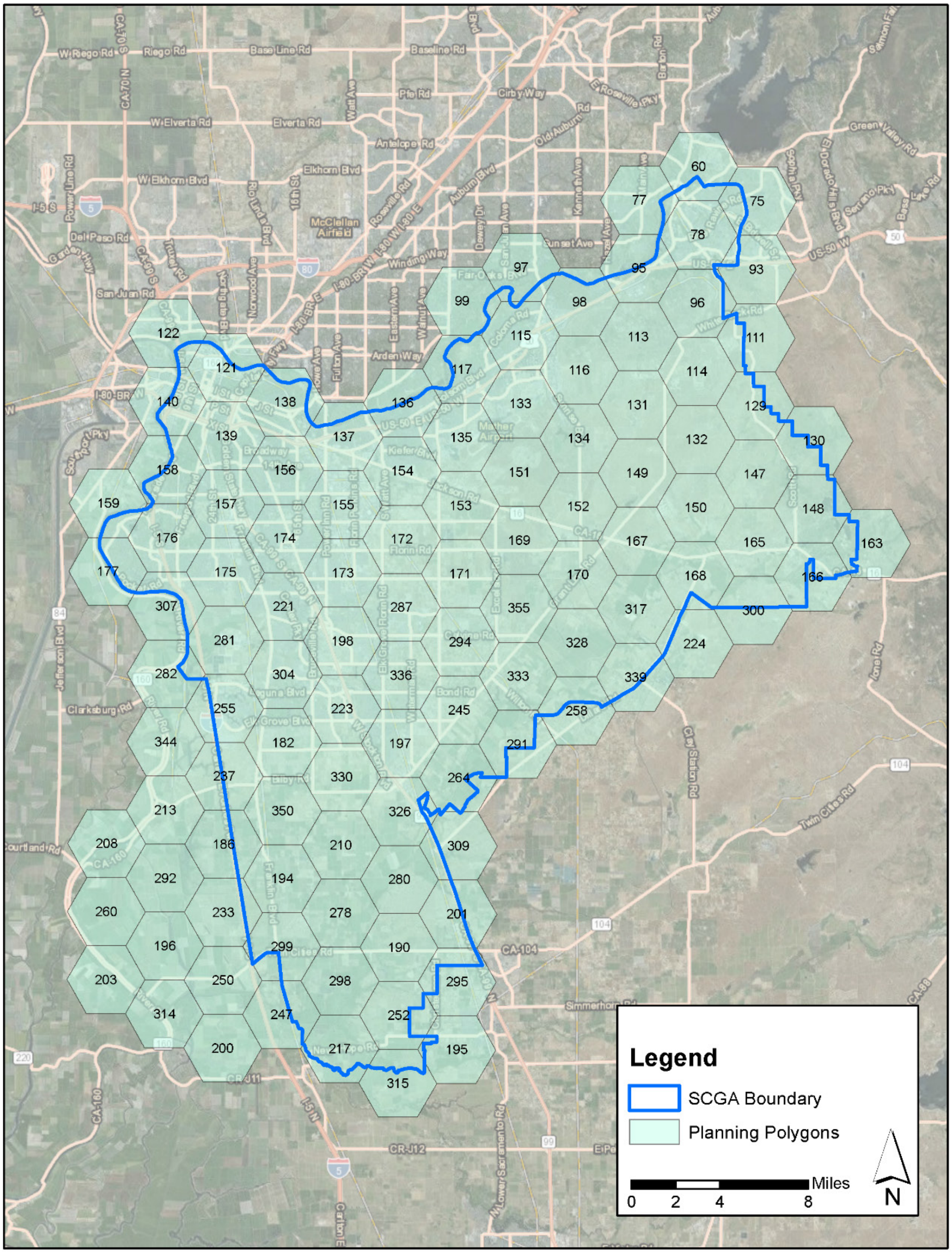


Figure 16: CASGEM Monitoring Wells and Planning Polygons

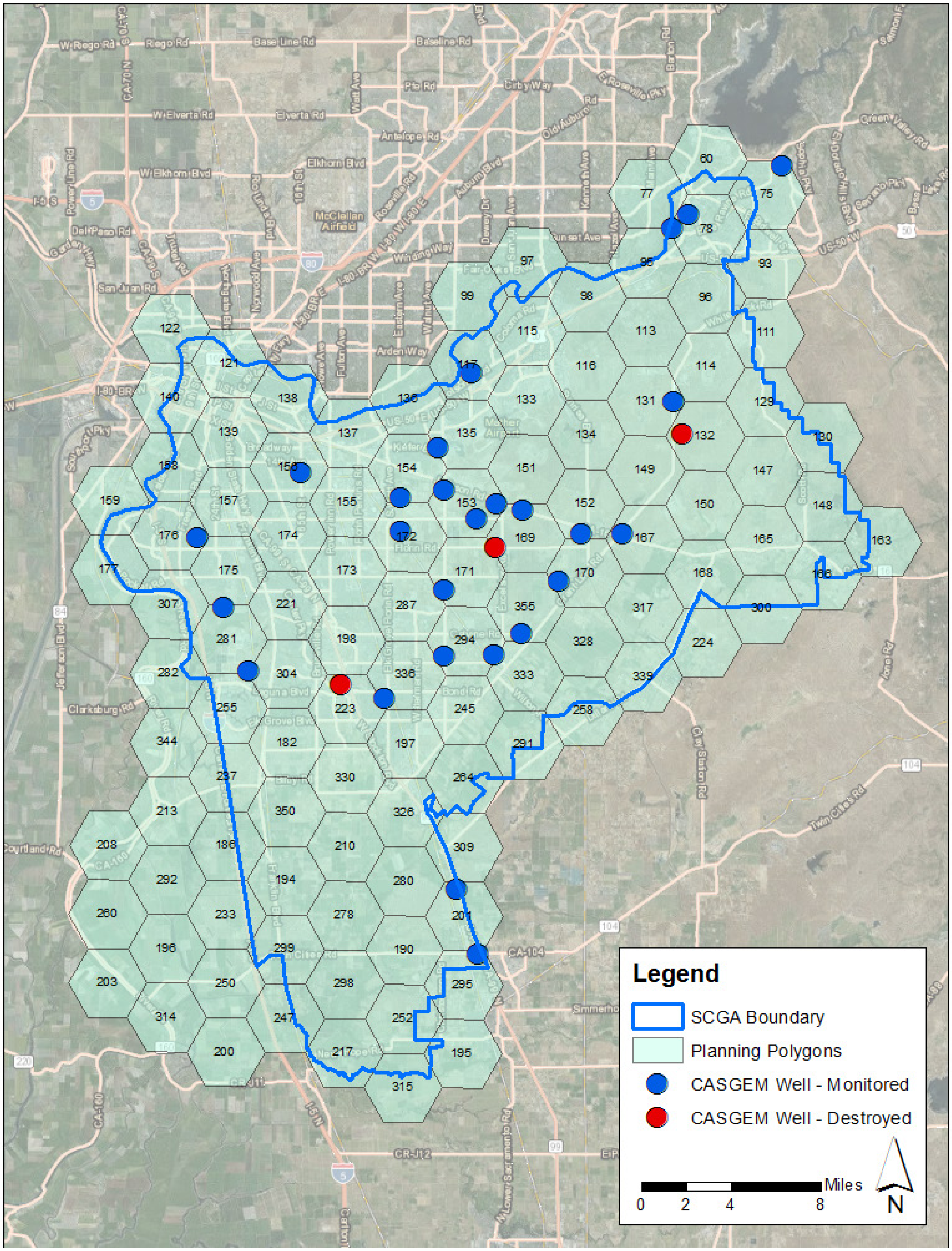
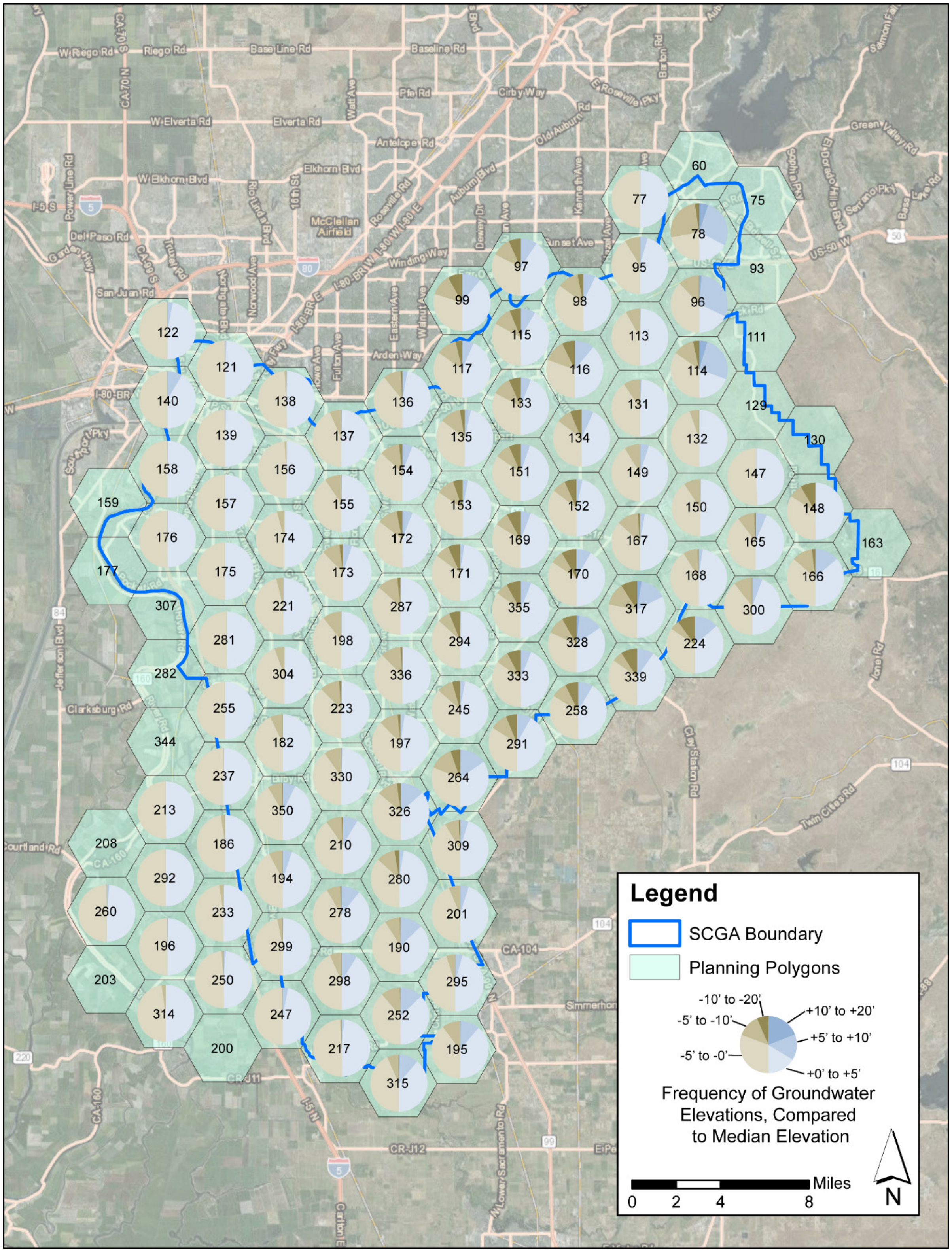


Figure 17: Groundwater Elevation Distribution about the Median, by Polygon



Step 4

Step four of the GMP Appendix B methodology is to develop the bandwidth based on the groundwater elevation hydrograph developed in Step 3. The bandwidth for each hydrograph for each planning polygon is developed by:

- Removing the first 20 years of simulated groundwater elevations, to allow for stabilization from the initial groundwater elevation conditions in the simulation
- Identifying the maximum simulated groundwater elevation and the minimum simulated groundwater elevation. The maximum elevation is defined as 0% of the range, and the minimum elevation is defined as 100% of the range. The elevations between 0% and 100% are termed the bandwidth. The bandwidth is then expanded to allow for uncertainties in the model results and in the monitoring. This adds 5% of the bandwidth to the maximum elevation and subtracts 5% from the minimum elevation.
- A refinement to the Appendix B methodology was made to further adjust the bandwidth so that historical groundwater elevations are never below the minimum elevation and so that the most recent fall elevation (generally fall 2014) is never below 75%. The additional refinement was added as historical groundwater elevations are deemed to have been suitable for meeting beneficial uses in the past and would be suitable for meeting beneficial uses in the future. Additionally, the 75% threshold adjustment is based on the current groundwater elevation conditions being considered not low enough to trigger the >75% trigger actions in the GMP.

These hydrographs and bandwidths are shown in Appendix C of this TM. Information is provided only for polygons with associated CASGEM wells, as these are the areas intended for monitoring under the BMO.

With the bandwidths, measured groundwater elevations at each well Bandwidth Status can be determined by comparing the measured groundwater elevation to the maximum (0%) and minimum (100%) elevation thresholds. For instance, Bandwidth Status could be determined from the following hypothetical situation:

- Maximum elevation threshold (0%): 50 feet above mean sea level (amsl)
- Minimum elevation threshold (100%): 10 feet amsl
- Measured groundwater elevation: 22 feet amsl

The Bandwidth Status could then be calculated as:

$$1 - \frac{(Measured\ Groundwater\ Elevation - Minimum\ Elevation\ Threshold)}{(Maximum\ Elevation\ Threshold - Minimum\ Elevation\ Threshold)} = 70\%$$

6 Merging of Polygon Grid Cells into Management Zones

Step 5

Step five of the GMP Appendix B methodology is to develop Management Zones to avoid creating a management program that is cumbersome, costly, and difficult to understand. Management Zones were defined using the approach in the GMP Appendix B, which looks at the Bandwidth Status across the basin at selected simulated time periods and groups together areas which respond similarly to the different hydrologic conditions.

Six Management Zones were identified based on similar hydrologic response and water purveyors, as listed below and shown in Figure 18:

- Confluence
- American River

- Inter-Riverine
- Upper Cosumnes River
- Lower Cosumnes River
- Sacramento River

These Management Zones differ from those contemplated in the GMP Appendix B to allow for finer detail on potential trigger actions by providing more zones, to incorporate the latest data on response to hydrologic conditions, and to allow for adequate numbers of monitoring wells within each zone. Details on the basis of selection are presented below.

Bandwidth Status for September 1977 and September 1983 are shown in Figure 19 and Figure 20, respectively, along with the Management Zones. Additionally, Figure 21 shows the Management Zones in relation to the water purveyors. The Management Zones are grouped to keep areas with similar hydrologic responses together. For instance, as shown in Figure 19 and Figure 20 and discussed in Appendix B of the GMP, areas along the American River and Cosumnes River respond more rapidly to dry (Figure 19) and wet (Figure 20) conditions. Figure 21 shows the relation to water purveyors with the Management Zone boundaries near many purveyor boundaries, which is important both due to the different supply mixes utilized by the purveyors as well as due to the need to simplify implementation of potential trigger actions that may be required within each Management Zone.

Figure 18: Management Zones

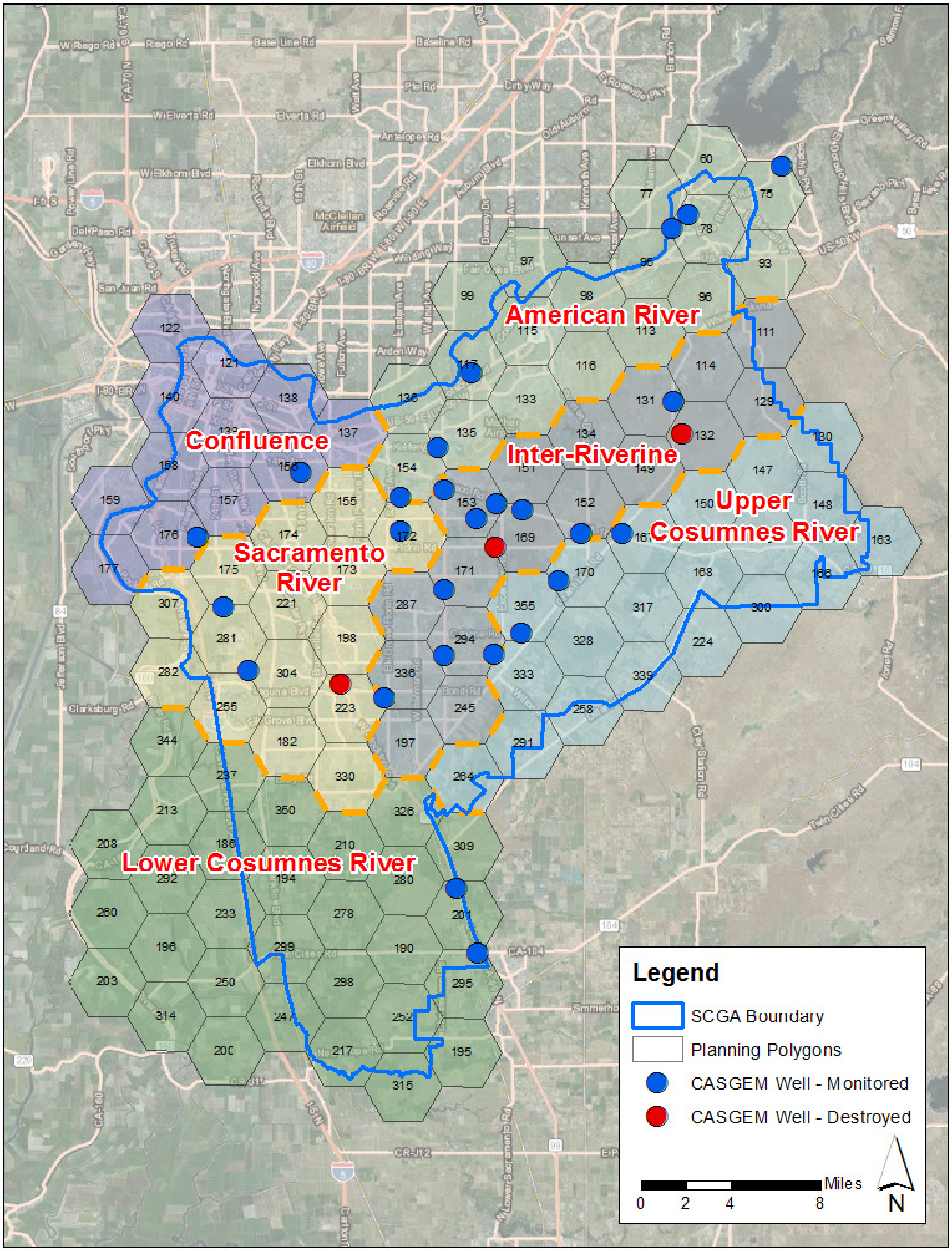


Figure 19: Bandwidth Status, Simulated September 1977 Conditions

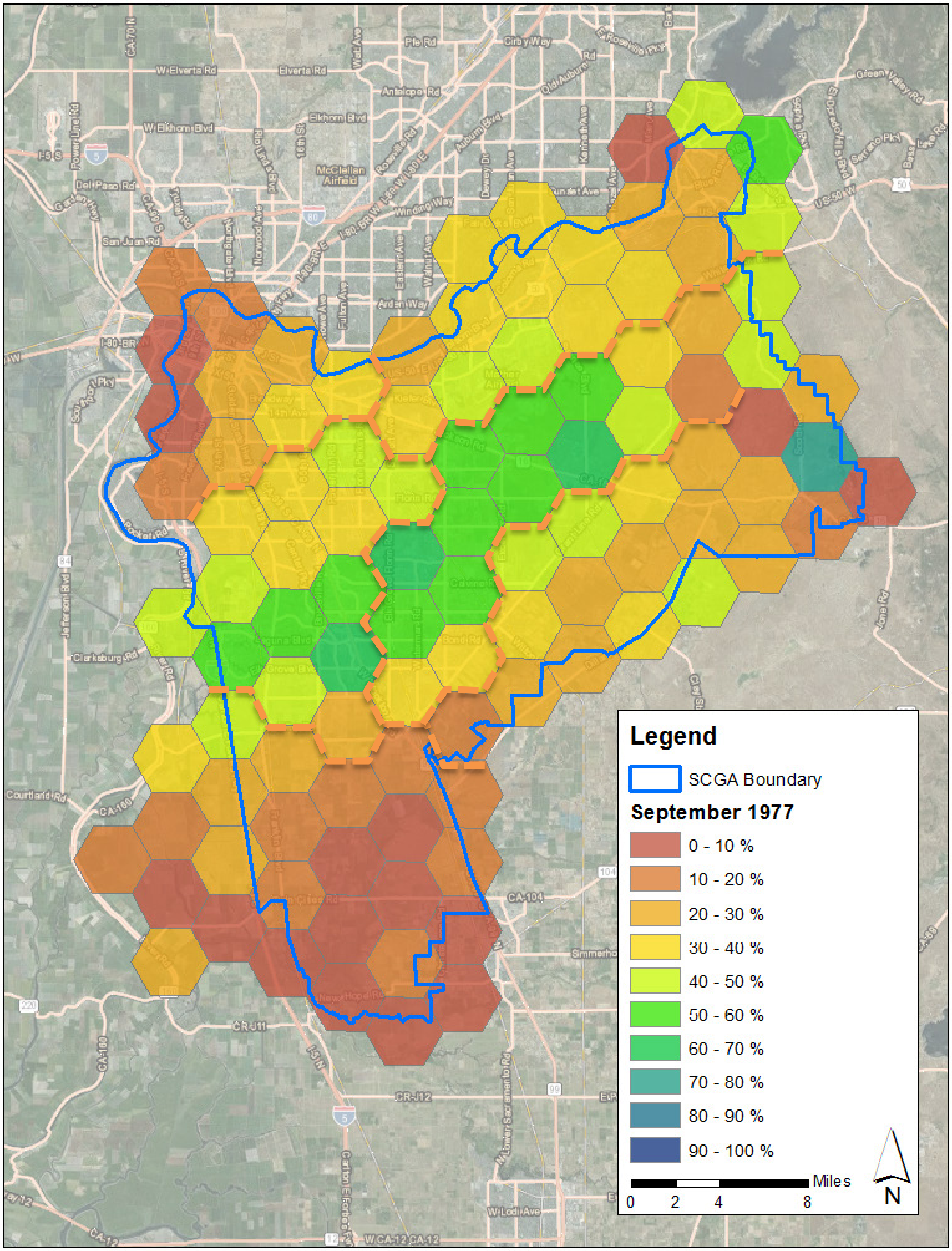


Figure 20: Bandwidth Status, Simulated September 1983 Conditions

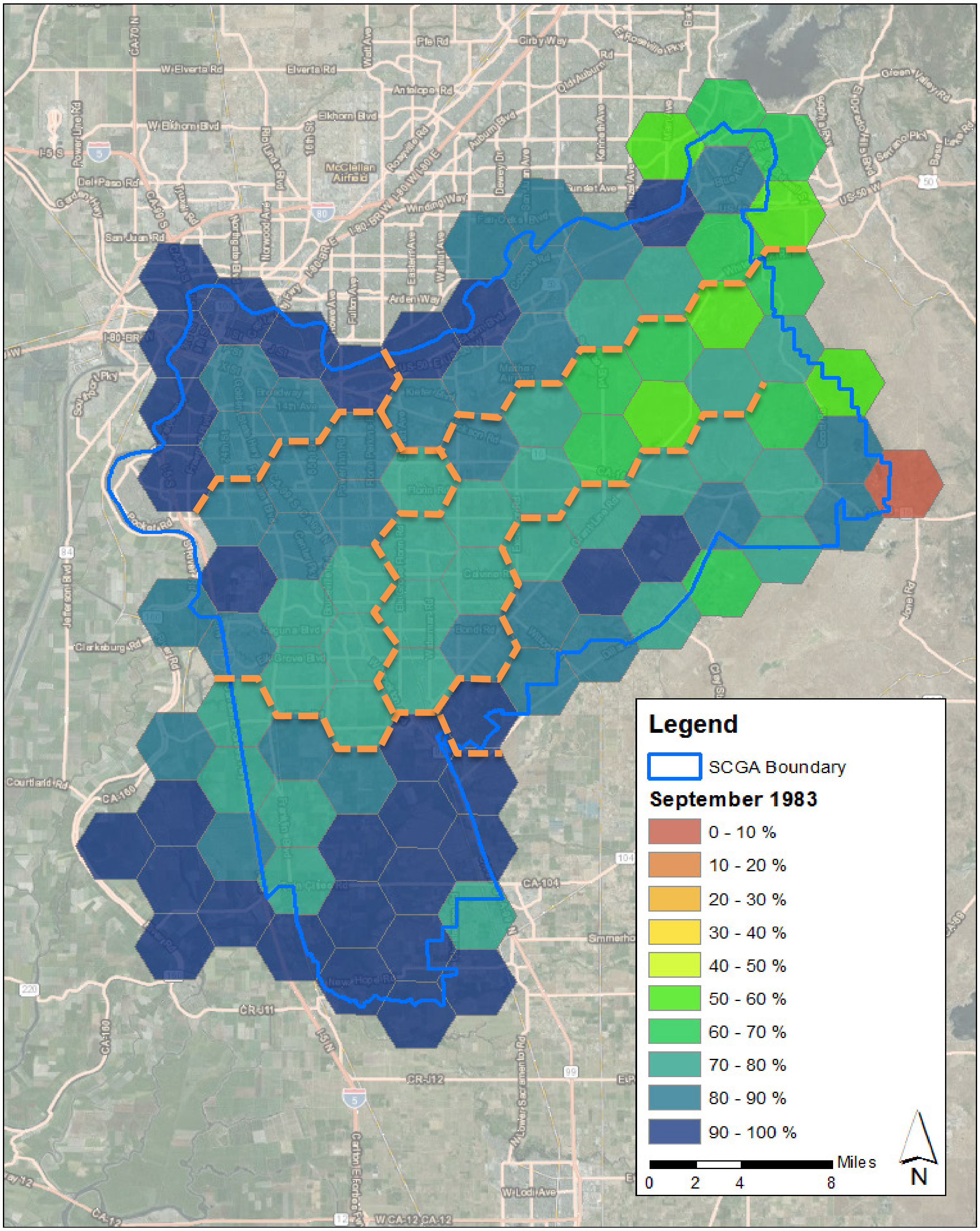
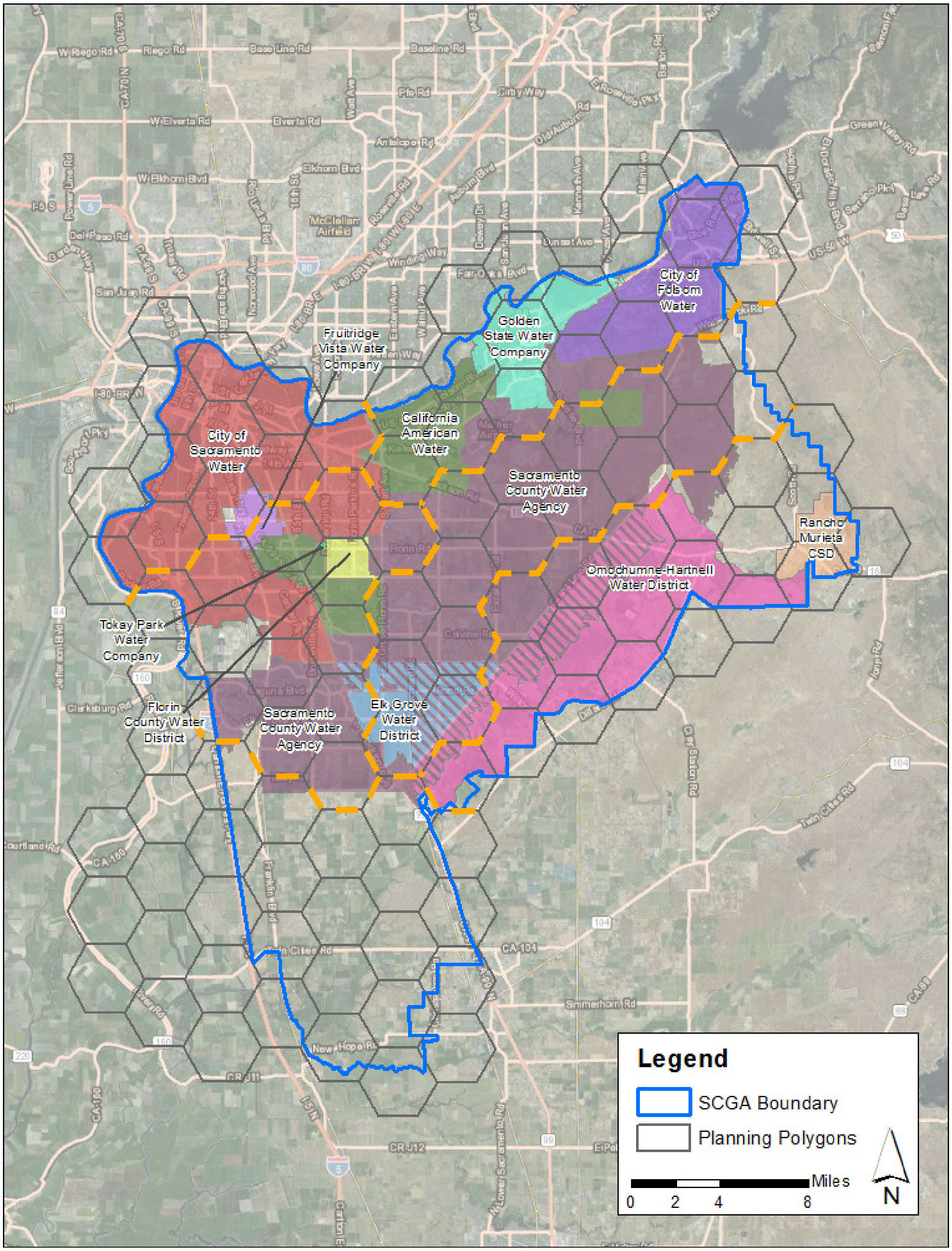


Figure 21: Management Zones and Water Purveyors



7 Development of Thresholds

Thresholds for each Management Zone were developed based on an averaging process of CASGEM wells within each Management Zone. For a selected time period, the Bandwidth Status within each Management Zone can be determined by first identifying the Bandwidth Status for each identified CASGEM well within the Management Zone and then averaging those percentages to arrive at the final Bandwidth Status for the Management Zone. Note that six CASGEM wells are excluded from the process, SCGA #2, SCGA #19, and SCGA #21 have been destroyed and SCGA #27, SCGA #28, and SCGA #29 are located on the edge of the basin with a very thin aquifer that is difficult for the model to simulate accurately. Table 9 provides for each Management Zone the associated CASGEM wells and their respective upper and lower thresholds.

Table 9: Thresholds for CASGEM Wells, by Management Zone

Management Zones and Associated CASGEM Well	Upper Threshold	Lower Threshold
Confluence Management Zone – Average of Bandwidth Status of the following two wells		
SCGA #10	6.66	-21.89
SCGA #11	10.42	-26.95
American River – Average of Bandwidth Status of the following three wells		
SCGA #12	35.13	-56.80
SCGA #17	19.90	-36.69
SCGA #24	45.53	16.20
Inter-Riverine – Average of Bandwidth Status of the following 11 wells		
SCGA #4	-14.11	-47.86
SCGA #5	9.08	-49.10
SCGA #8	9.91	-50.80
SCGA #9	9.91	-50.80
SCGA #13	21.88	-44.80
SCGA #14	23.63	-59.10
SCGA #15	25.00	-54.90
SCGA #16	21.88	-67.70
SCGA #20	128.56	40.07
SCGA #22	68.71	-35.67
Upper Cosumnes River – Average of Bandwidth Status of the following three wells		
SCGA #6	52.40	-56.70
SCGA #7	22.11	-58.90
SCGA #23	66.11	-7.80
Lower Cosumnes River – Average of Bandwidth Status of the following two wells		
SCGA #25	-5.09	-58.40
SCGA #26	12.92	-51.29
Sacramento River – Average of Bandwidth Status of the following four wells		
SCGA #1	3.07	-18.73
SCGA #3	0.78	-40.25
SCGA #18	-4.84	-45.19

8 Ground Truthing

Step 6

Step six of the GMP Appendix B methodology is to apply historical groundwater elevation data to the bandwidths. Two periods were compared, fall 1977 and fall 2014, with resulting percentages shown in Table 10. Fall 1977 data, while limited, showed BMO Bandwidth Status of between 75% and 100% encroachment for Confluence, Lower Cosumnes River, and Sacramento River; between 50% and 75% for American River; and between 25% and 50% for Inter-Riverine and Upper Cosumnes River. Fall 2014 data showed BMO Bandwidth Status of between 50% and 75% encroachment for all Management Zones except for the Confluence and Sacramento River Management Zones, which were in the 25% to 50% range. These values are considered appropriate for management, recognizing that existing management strategies, notably full utilization of the Vineyard Surface Water Treatment Plant, have not yet been fully realized. Fall 2014 Bandwidth Status is presented graphically in Figure 22.

Figure 22: Bandwidth Status, Fall 2014 Groundwater Elevation Data

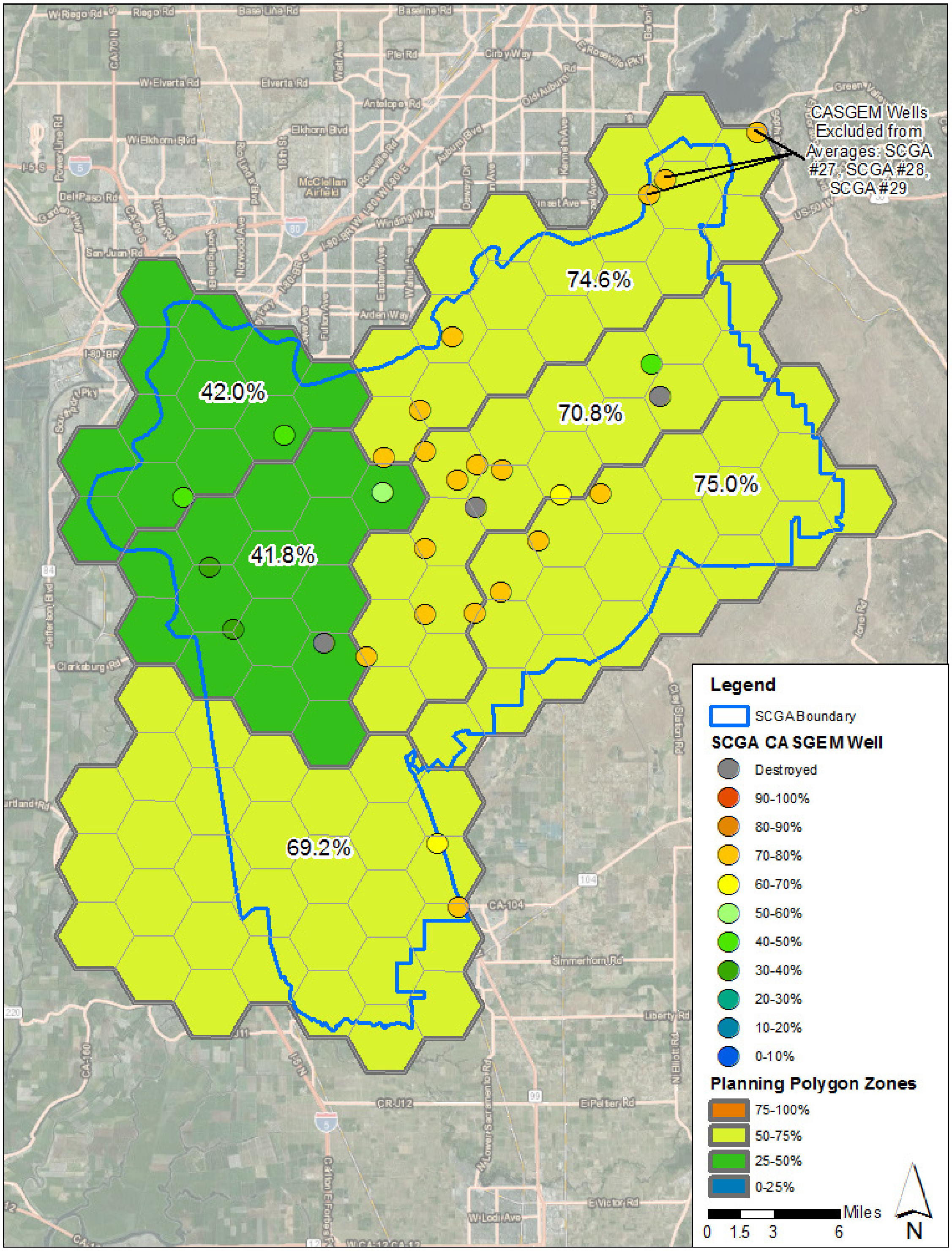


Table 10: Bandwidth Status for Management Zones, Fall 1977 and Fall 2014

Management Zones and Associated CASGEM Well	Fall 1977	Fall 2014
Confluence Management Zone	***82.5%***	***42.0%***
SCGA #10	96.9%	43.6%
SCGA #11	73.5%	40.3%
	n/a	
American River	***64.6%***	***74.6%***
SCGA #12	42.8%	n/a
SCGA #17	86.4%	74.2%
SCGA #24	n/a	74.9%
Inter-Riverine	***40.0%***	***70.8%***
SCGA #4	n/a	75.0%
SCGA #5	n/a	74.9%
SCGA #8	n/a	71.6%
SCGA #9	61.8%	75.0%
SCGA #13	n/a	74.9%
SCGA #14	n/a	n/a
SCGA #15	n/a	75.0%
SCGA #16	n/a	75.0%
SCGA #20	10.7%	49.2%
SCGA #22	47.6%	66.7%
Upper Cosumnes River	***33.0%***	***75.0%***
SCGA #6	n/a	75.0%
SCGA #7	n/a	75.0%
SCGA #23	33.0%	75.0%
Lower Cosumnes River	***90.1%***	***69.2%***
SCGA #25	90.1%	73.2%
SCGA #26	n/a	65.3%
Sacramento River	***90.1%***	***41.8%***
SCGA #1	n/a	33.0%
SCGA #3	100%	38.1%
SCGA #18	81.9%	54.1%

Footnote:
n/a: data not available

9 Summary

Groundwater elevation bandwidths were developed to support Basin Management Objective (BMO) No. 2 in the Central Sacramento County Groundwater Management Plan (GMP). The work was performed as part of Sacramento Central Groundwater Authority's (SCGA's) larger BMO Threshold Development and Recharge Mapping Project, which was partially funded by the California Department of Water Resources (CDWR).

The SacIWRM was used in support of developing the groundwater elevation thresholds. SacIWRM was updated with new data for the water years 2005-2011 for the 2030 Baseline. A similar update was performed for the Historical Calibration simulation for quality control purposes. While additional modeling needs were noted, including the need to update the model to the north and south of SCGA, the calibration verification of the Historical Calibration simulations showed the 2030 Baseline was suitable for use in development of the thresholds.

Thresholds were developed for existing CASGEM monitoring wells to monitor conditions across six Management Zones: Confluence, American River, Inter-Riverine, Upper Cosumnes River, Lower Cosumnes River, and Sacramento River. The CASGEM wells are part of the existing SCGA CASGEM monitoring program and are monitored twice a year. Bandwidths were developed for each CASGEM well based on the minimum and maximum groundwater elevation simulated by the SacIWRM Future Conditions Baseline, plus a 5% buffer, and based on the minimum and maximum historical groundwater elevations. If necessary, the minimum threshold was reduced so that the fall 2014 percentage would be no greater than 75%.

The wells were divided into Management Zones based on groundwater response to different hydrologic conditions, with areas of relatively rapid response along major rivers separated from areas of more damped response away from major rivers. Management Zone Bandwidth Status, the value to be utilized in BMO compliance, is then developed by averaging the Bandwidth Status for each associated CASGEM well within the Management Zone.

The resulting values were ground-truthed to determine the values associated with historical groundwater elevation data. Fall 2014 data showed BMO Bandwidth Status of between 50% and 75% encroachment for all Management Zones except for the Confluence and Sacramento River Management Zones, which were in the 25% to 50% range.

This study and the developed threshold values will be considered during the development of Groundwater Sustainability Plans, as updating the existing Groundwater Management Plan is no longer possible under the California Water Code.

10 References

California American Water, 2011. 2010 Urban Water Management Plan Sacramento District. October.

City of Folsom, 2008. Folsom Plan Area Specific Plan Proposed Land Use Plan.

City of Folsom, 2011. 2010 Urban Water Management Plan, June.

City of Folsom, 2014a. City of Folsom General Plan. Public Review Draft. April.

City of Folsom, 2014b, Folsom Plan Area Water System Master Plan. October.

City of Sacramento, 2009. Sacramento 2030 General Plan. March.

City of Sacramento, 2011. 2010 Urban Water Management Plan, October.

Elk Grove Water District, 2011. 2010 Urban Water Management Plan, June 22.

City of Elk Grove, 2009. City of Elk Grove General Plan. Prepared by the City of Elk Grove Planning.

City of Rancho Cordova, 2006. Rancho Cordova General Plan. June.

Cordova Hills, LLC, 2013. Cordova Hills Master Plan. March.

Golden State Water Company, 2011. 2010 Urban Water Management Plan, July.

Rancho Murieta Community Services District, 2010a. 2010 Integrated Water Master Plan Update. October.

Rancho Murieta Community Services District, 2010b. 2020 Compliance Plan. September.

RMC Water and Environment (RMC), 2011. Sacramento Area Integrated Water Resources Model (SacIWRM) Model Development and Baseline Scenarios. Prepared for Sacramento Groundwater Authority, Sacramento Central Groundwater Authority, and South Area Water Council. October.

Sacramento Central Groundwater Authority (SCGA), 2012. Sacramento Central Groundwater Authority Groundwater Elevation Monitoring Plan. February.

Sacramento County, 2011. Sacramento County General Plan of 2005-2030. November.

Sacramento County Water Agency (SCWA), 2014. Admin Draft Zone 40 Water Supply Master Plan. November.

United Stated Department of Agriculture (USDA), 2015. CropScape – NASS CDL Program. Accessed online at http://nassgeodata.gmu.edu/CropScape/.

WRIME, 2010. Comprehensive Update of SCGA's Data Management System. December.

Appendix A

Appendix B of the Central Sacramento County Groundwater Management Plan

Appendix B

SacIWRM Future Conditions Baseline Groundwater Hydrographs at the Center of Each Polygon

Appendix C

Bandwidths