### 3.1.2 Groundwater Pumping

Groundwater pumping within CoSANA is separated into pumping by wells and pumping by elements. The former largely includes agency-operated wells that deliver groundwater to a public water supply system, as well as groundwater contamination remediation operations where data are available by well. The latter includes estimated agricultural and domestic (including rural residential) groundwater pumping.

Where available, pumping data are specified on a monthly basis throughout the historical simulation period. Data provided typically included well locations, total depth, screen perforation depth, use (agricultural, urban, or remediation) and historical monthly pumping records. Agricultural and rural residential pumping volumes are not typically known and were estimated by the model to meet demands not satisfied through other sources (e.g., well pumping and surface water deliveries.)

## 3.2 Urban Water Demand and Supply

Urban demands are provided by the urban water purveyors for the historical model period. The monthly urban demands are directly inputted into the model for each urban purveyor.

It was assumed that an annual average of 60% of urban water is used indoors and 40% is used outdoors. CoSANA uses monthly fractions for indoor and outdoor use, with the majority of urban water demand due to indoor activities from November through March and up to 60% of urban water used outdoors for the remainder of the year. Assumed monthly fractions for City of Galt indoor and outdoor use were adjusted to better match those reported by the City of Galt.

Table 3-1 lists the number of wells by type and purveyor included in CoSANA. Figure 3-4 shows the locations of the urban pumping wells in CoSANA, including those shown in Table 3-1 and some additional smaller users including Sacramento International Airport, fish farms, and others.

**Table 3-1: Summary of CoSANA Well Pumping by Urban Purveyor**

| Purveyor | Number of Municipal Pumping Wells | Average Annual Municipal Pumping (WY 1995-2018, acre-feet) |
|---|---|---|
| California American Water Company | 135 | 39,666 |
| Cal Am (formerly Fruitridge Vista WC) | 20 | 4,220 |
| Camanche Village (Amador County WA) | 6 | 258 |
| Carmichael WD | 17 | 4,025 |
| Citrus Heights WD | 14 | 987 |
| City of Galt | 25 | 4,716 |
| City of Lincoln | 5 | 717 |
| City of Roseville | 6 | 18 |
| City of Sacramento | 68 | 20,427 |
| Del Paso Manor WD | 10 | 1,536 |
| Elk Grove WD | 17 | 5,144 |
| Fair Oaks WD | 12 | 1,262 |
| Florin County WA | 10 | 2,624 |
| Golden State WC | 33 | 9,897 |
| Orange Vale WC | 2 | 0 |
| Rio Linda Elverta CWD | 13 | 2,990 |
| Sacramento County WA | 118 | 27,510 |
| Sacramento Suburban WD | 119 | 29,905 |
| **Total Average Annual Pumping (acre-feet)** | | 155,902 |

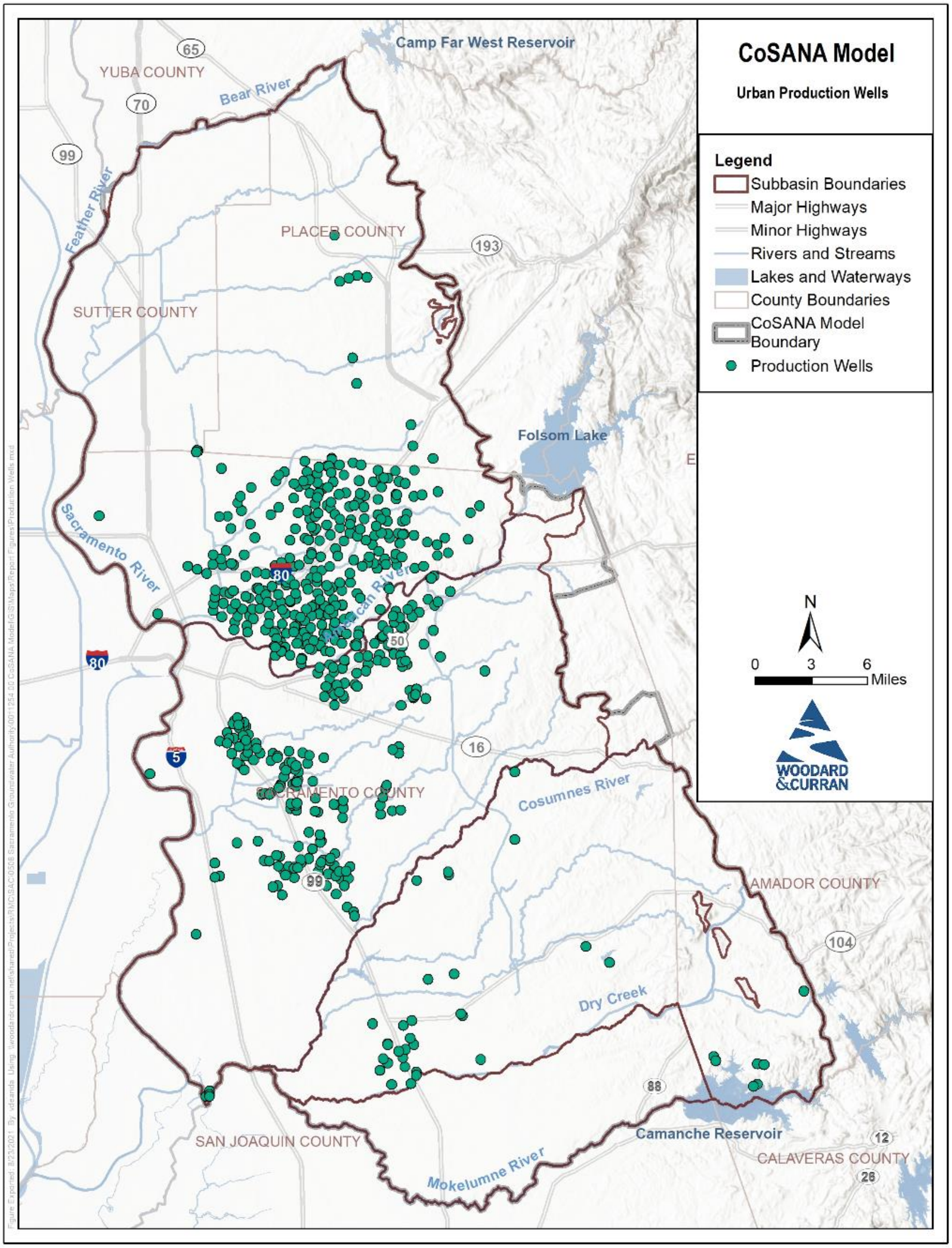



**Figure 3-4: Locations of Urban Groundwater Production Wells**

The following sections provide a brief description of water supplies for each of the urban water purveyors in each Subbasin.

## 3.2.1 North American Subbasin

This section briefly describes the urban demand and supply assumptions used in the historical CoSANA for the purveyors within the NASb. Averages presented are for the calibration period, WY 1995-2018. RWA (M. Garcia, personal communication, August 29, 2019) provided data for many of the individual entities listed below.

### 3.2.1.1 California American Water Company (Antelope)

California American Water Company (Cal Am) Antelope receives an average of 170 acre-feet per year (AFY) of surface water supplied via an intertie with Sacramento Suburban Water District (WD). Groundwater supply meets remaining demand with an average of 5,621 AFY. Data sources include SacIWRM (to 2004), RWA (service area data including surface water diversions for 2011 onwards), and Cal Am (well-by-well pumping data for 2004-2018).

### 3.2.1.2 California American Water Company (Arden)

Cal Am Arden is primarily supplied by groundwater, an average of 2,830 AFY, with approximately 2 AFY being met by surface water supplied by the City of Sacramento. Data sources include SacIWRM (to 2004), RWA (service area data including surface water diversions for 2011 onwards), and Cal Am (well-by-well pumping data for 2004-2018).

### 3.2.1.3 California American Water Company (Lincoln Oaks)

Cal Am Lincoln Oaks receives an average of 245 AFY of surface water supplied via an intertie with Sacramento Suburban WD. Groundwater supply meets remaining demand, with an average of 8,869 AFY. Data sources include SacIWRM (to 2004), RWA (service area data including surface water diversions for 2011 onwards), and Cal Am (well-by-well pumping data for 2004-2018).

### 3.2.1.4 California American Water Company (West Placer)

Cal Am West Placer service area supply includes 725 AFY of surface water sourced from Placer County Water Agency (PCWA). RWA provided data for 2011-2018. Data prior to 2011 is estimated based on annual data provided by GEI Consultants (R. Shatz, personal communication, March 5, 2020).

### 3.2.1.5 Carmichael Water District

Carmichael WD uses an average 7,155 AFY of surface water from the American River and 4,080 AFY of groundwater from district wells. Data sources include SacIWRM (to 2004) and RWA (after 2004).

### 3.2.1.6 Citrus Heights Water District

Citrus Heights WD supply includes 16,015 AFY of surface water sourced from San Juan WD and 952 AFY of groundwater from district wells. Data sources include SacIWRM (to 2004) and RWA (after 2004).

### 3.2.1.7 Del Paso Manor Water District

Supply for Del Paso Manor WD is met entirely by groundwater pumping from district wells and averages 1,549 AFY. Data sources include SacIWRM (to 2004) and RWA (after 2004).

### 3.2.1.8 Fair Oaks Water District

Fair Oaks WD supplies include an average of 11,145 AFY of surface water received from San Juan WD and 1,183 AFY of groundwater from district wells. Data sources include SacIWRM (to 2004) and RWA (after 2004).

#### 3.2.1.9 Golden State Water Company (Arden)

Golden State Water Company (WC) Arden supply includes an average of 1,169 AFY of groundwater pumping from district wells. Data sources include SacIWRM (to 2004) and RWA (after 2004).

#### 3.2.1.10 City of Lincoln

On average, 6,218 AFY of the City of Lincoln's water supply comes from surface water supplied by PCWA and Nevada Irrigation District. The remaining 739 AFY of supply is provided by groundwater production from city wells. Data for 2008-2018 was provided by the City of Lincoln. Data for 2005 to 2008 is estimated based on annual data from the City of Lincoln UWMPs (2010, 2015). Data prior to 2005 is from SacIWRM

#### 3.2.1.11 Orange Vale Water Company

Orange Vale WC on average receives 4,191 AFY of surface water sourced from San Juan WD. Data sources include SacIWRM (to 2004) and RWA (after 2004).

#### 3.2.1.12 Placer County Water Agency (City of Rocklin Retail Service Area)

PCWA serves the City of Rocklin for retail customers. Remaining portions of PCWA's service area within the model are served by other retail water purveyors or are self-supplied by groundwater. Supply to the City of Rocklin is on average 4,578 AFY, based on data from PCWA (R. Cox, personal communication, July 17, 2019) for WY 2016-2018. All demand is assumed to be met by surface water. Lacking other data sources, data from 2016 was used for previous years.

#### 3.2.1.13 Rio Linda / Elverta Community Water District

Rio Linda/Elverta CWD is primarily supplied by groundwater pumping, averaging 3,010 AFY. The remaining 5 AFY is from surface water sourced from an intertie with the City of Sacramento. Data sources include SacIWRM (to 2004) and RWA (after 2004).

#### 3.2.1.14 City of Roseville

The City of Roseville receives, on average, 27,943 AFY of surface water sourced from Folsom Reservoir, with the remaining 126 AFY of supply met by groundwater pumping from city wells. Data were provided by the City of Roseville for 1986-2018. Gaps in data existed for 1999-2000 and 2008-2009; these were filled by interpolating data from surrounding years. Data prior to 1986 is from SacIWRM. Data from the City of Roseville also included details on groundwater injection as part of the city's aquifer storage and recovery program.

#### 3.2.1.15 Sacramento Suburban Water District

Sacramento Suburban WD supply mix includes 32,396 AFY of groundwater production from district wells and 10,024 AFY from surface water sourced via intertie with PCWA and the City of Sacramento. Data sources include SacIWRM (to 2004), and RWA (after 2004).

#### 3.2.1.16 City of Sacramento

The City of Sacramento receives on average 97,488 AFY of surface water from their water treatment plants on the American and Sacramento Rivers. Remaining demand is met by groundwater production from city wells that averages 20,225 AFY. This demand is spread across both the NASb and the SASb. Data sources include SacIWRM (to 2004), and RWA (after 2004).

#### 3.2.1.17 Sacramento International Airport

The Sacramento International Airport receives on average 175 AFY from the City of Sacramento (based on data from RWA). Remaining demand of 968 AFY is assumed to be met by groundwater (based on SacIWRM demand).

#### 3.2.1.18 San Juan Water District

San Juan WD average supply is estimated to be 5,196 AFY within the model area and is met entirely by surface water from Folsom Lake. This is based on retail data for the district supplied by RWA (after 2004) and assumes that 37% of the districts retail service area is within the CoSANA boundary. Data prior to 2004 is based on SacIWRM.

#### 3.2.1.19 Sacramento County Water Agency (Arden Park Vista)

Demand for the Sacramento County Water Agency (SCWA) Arden Park Vista service area averages 3,911 AFY and is met entirely by groundwater pumping from district wells. Data sources include SacIWRM (to 2004) and RWA (after 2004).

#### 3.2.1.20 Sacramento County Water Agency (Northgate)

Supply for the SCWA Northgate service area averages 940 AFY and is met entirely by groundwater pumping from district wells. Data sources include SacIWRM (to 2004) and RWA (after 2004).

### 3.2.2 South American Subbasin

This section briefly describes the urban demand and supply assumptions used in the historical CoSANA for the purveyors located within the SASb.

#### 3.2.2.1 California American Water Company (Fruitridge - formerly Fruitridge Vista Water Company)

Cal Am Fruitridge Vista is serviced almost entirely by groundwater production from Cal Am wells. Some small surface water transfers are reported, which average to 1 AFY. Data sources include SacIWRM (to 2011), HydroDMS (2012-2013), and SCGA (2014-2018).

#### 3.2.2.2 California American Water Company (Parkway)

Cal Am Parkway receives on average 592 AFY of surface water delivered via an intertie with the City of Sacramento; the remaining 10,699 AFY is supplied from groundwater production from Cal Am wells. Data sources include SacIWRM (to 2011), RWA (service area data including surface water diversions for 2011 onwards), and Cal Am (well-by-well pumping data for 2004-2018).

#### 3.2.2.3 California American Water Company (Security Park)

Cal Am Security Park averages 31 AFY demand, met by groundwater production from Cal Am wells. Data sources include SacIWRM (to 2011), RWA (service area level data including surface water diversions for 2011 onwards), and Cal Am (well-by-well pumping data for 2004-2018).

#### 3.2.2.4 California American Water Company (Suburban Rosemont)

Cal Am Suburban Rosemont receives on average 110 AFY of surface water delivered via an intertie with the City of Sacramento, with the remaining 12,296 AFY supplied from groundwater production from Cal Am wells. Data sources include SacIWRM (to 2011), RWA (service area level data including surface water diversions for 2011 onwards), and Cal Am (well-by-well pumping data for 2004-2018).

#### 3.2.2.5 Elk Grove Water District (Service Area 1)

Supply for Elk Grove WD Service Area 1 averages 5,189 AFY and is met by groundwater production from district wells. Data sources include SacIWRM (to 2009) and Elk Grove Water District (after 2009).

#### 3.2.2.6 Florin County Water District

Florin County WD supply averages 2,623 AFY, entirely sourced by groundwater production from district wells. Data is from SacIWRM. Actual production values are not known for this area, and demand is estimated.

#### 3.2.2.7 City of Folsom

The City of Folsom has an average demand of 20,451 AFY, with 100% of its supply coming from surface water diverted from Folsom Lake. Data sources include SacIWRM (to 2011) and RWA (after 2011).

#### 3.2.2.8 Golden State Water Company (Cordova)

Golden State WC Cordova receives on average 6,287 AFY of surface water, primarily from water diverted from the American River via the Folsom South Canal. The remaining 8,977 AFY of demand is met by groundwater production from Golden State wells. Data sources include SacIWRM (to 2011) and RWA (after 2011).

#### 3.2.2.9 Rancho Murieta Community Service District

Rancho Murieta CSD supply averages to 1,833 AFY, which is fully met by surface water diverted from the Cosumnes River. This is based on data on the number of service connections and water use from the 2006 Rancho Murieta Community Services District Integrated Water Master Plan and the 2010 Update.

#### 3.2.2.10 City of Sacramento

(See North American Subbasin)

#### 3.2.2.11 Sacramento County Water Agency (Hood)

SCWA Hood service area has an average demand of 47 AFY which is supplied by groundwater production from agency wells. Data sources include SacIWRM (to 2011) and RWA (after 2011).

#### 3.2.2.12 Sacramento County Water Agency (Laguna Vineyard)

SCWA Laguna Vineyard service area (including Elk Grove WD Service Area 2) has an average supply mix of 17,340 AFY of groundwater production from agency wells, 3,314 AFY of surface water primarily sourced from the Sacramento River, and 232 AFY of recycled water. Data sources include SacIWRM (to 2011), HydroDMS (2012-2013), and SCGA (2014-2018).

#### 3.2.2.13 Sacramento County Water Agency (Mather)

SCWA Mather service area average supply mix that includes 3,958 AFY of groundwater production from agency wells, and 233 AFY surface water primarily sourced from the Sacramento River via the Vineyard Surface Water Treatment Plant. Data sources include SacIWRM (to 2011), HydroDMS (2012-2013), and SCGA (2014-2018).

### 3.2.3 Cosumnes Subbasin

This section briefly describes the urban demand and supply assumptions used in the historical CoSANA for the purveyors located within the CoSb.

#### 3.2.3.1 Amador County Water Agency (Camanche Village)

Amador County WA Camanche Village service area has an average supply of 257 AFY which is met 100% by groundwater production from agency wells. Data sources include monthly pumpage from four Camanche wells and two Camanche north shore wells, as reported by Amador County Water Agency (G. Mancebo, personal communication, April 29, 2019).

#### 3.2.3.2 Amador County Water Agency (Ione)

Amador County WA supply to the City of Ione averages 2,130 AFY which is entirely surface water. Ione supply was estimated from reported wastewater treatment plant flows and population. Data sources include treated wastewater flows from Amador Water Agency (B. Cook, personal communication, December 9, 2019) and population data from the California Department of Finance.

#### 3.2.3.3 City of Galt

The City of Galt has an average supply of 4,737 AFY, which comes entirely from groundwater production from municipal wells. Data sources include monthly pumpage from a total of 18 wells, as reported by the City of Galt (M. Clarkson, personal communication, March 22, 2019).

#### 3.2.3.4 Rancho Murieta Community Service District

(see South American Subbasin section)

### 3.2.4 Fish Farms

The 2011 South Basin Groundwater Management Plan reported that there is approximately 11,000 AFY pumping to supply water to fish farms in the Cosumnes Subbasin. This annual pumping estimate was allocated to six fish farms based on the relative area of each fish farm and the annual pumping rate was converted to monthly rates in proportion to monthly $ET_o$ rates. Inspection of aerial photos in Google Earth was used to determine when each fish farms was developed and when pumping from each fish farm was likely to have begun.

### 3.2.5 Galt Wastewater Treatment Plant Effluent

All effluent and stormwater from the City of Galt is routed to the wastewater treatment plant, where it is ultimately either released to Skunk Creek (tributary of Laguna Creek) or used for irrigation of surrounding fields. The 2011 South Basin Groundwater Management Plan (South Area Water Council, 2011) reported that the City of Galt applies an average of approximately 700 AFY to fields for irrigation. The wastewater treatment plant came online in 1983. As such, a variable monthly application rate based on an assumed monthly supply requirement was specified for 1983 through 2019.

## 3.3 Agricultural Water Demand and Supply

Agricultural water demand is the amount of irrigation water that is required to satisfy the crop evapotranspiration requirement and to meet other irrigation practices. IDC is designed to estimate the agricultural water demand for each model element through consumptive use methodology. IDC dynamically calculates crop demand at each model time step based on factors including crop type, crop evapotranspiration, rainfall, hydrologic soil type, and irrigation practices. 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. These data were compiled, analyzed, synthesized, and processed for input in CoSANA.

Precipitation, land use, evapotranspiration, and soil properties are discussed in the relevant sections in Chapter 2. The irrigation period, using data from C2VSimFG, defines irrigation as either on or off for each crop and for each month of the model simulation period. Most trees are assumed irrigated from April through October, vineyards from April through November, 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, and alfalfa. Fractions to represent return flow (i.e., irrigation flow following the model drainage pattern discussed in Section 2.5) and reuse (i.e., the fraction of applied irrigation water to be reused for irrigation) are based on data from C2VSimFG. All non-ponded CoSANA agricultural lands are assigned a 5% return flow and 1% reuse factor. Rice during the growing season is assigned an average 13% return flow and an average 9% reuse factor, with variability depending on the month of the year. Riceland when flooded for decomposition in the non-growing season is assigned an average 9% return flow and an average 6% reuse factor, also with variability depending on the month of the year. Urban landscape areas are assumed to have 0% return flow and 0% reuse.

### 3.3.1 Rural-Residential Pumping

Private groundwater pumping quantities on an individual well basis are largely unknown; therefore, private rural-residential pumping in CoSANA is estimated by IWFM on an element basis. Water demands at each relevant element are used to calculate pumping necessary to meet the urban demand estimated by IDC after water purveyor 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 domestic (i.e., rural residential) and agricultural wells. Rural residential wells used a statistical analysis of perforation interval developed for C2VSimFG. Perforation interval data were compiled by DWR using data from the CASGEM and Online System for Well Completion Reports databases. Simulated perforation intervals were assigned as the 5th and 95th percentiles of the well perforation interval data for each township/range block.

Demand for rural residential areas, or areas outside of those supplied by a public water system, was based on estimated population and water consumption outside of areas supplied by a public water system. To estimate demand in these areas, the areas themselves were isolated spatially by removing all areas served by a public water system. Population density for the rural residential areas is developed based on census tract data, and estimated per capita water use is developed for a typical household based on information from the California Water Plan (DWR, 2018b).

For the rural-residential area within the CoSb, outdoor water use was estimated from per-parcel water demand and approximate total number of rural-residential parcels. The estimated average per-parcel outdoor water demand is 2.5 AFY based on a detailed inspection of land use for 10 random parcels. Visual inspection of Google Earth aerial photographs identified approximately 3,200 rural-residential parcels, resulting in an average annual outdoor water use of 8,000 AFY. All indoor water use was assumed to return to the subsurface through septic systems and was therefore not explicitly modeled.

### 3.3.2 Agricultural Pumping

Private groundwater pumping volumes, location, and pumping depth for agricultural water supplies are largely unknown, though aggregate estimates for private pumping are often included in planning documents (e.g., AWMPs, groundwater management plans). Therefore, agricultural pumping in CoSANA is estimated by IWFM on an element basis. Water demand at each relevant element is used to calculate any additional pumping necessary to meet the agricultural demand estimated by IDC after public water system pumping and surface water has been distributed.

### 3.3.3 Agricultural Groundwater Substitution Transfers

CoSANA includes 55 agricultural groundwater substitution transfer pumping wells, shown in Figure 3-5. All agricultural groundwater substitution transfer pumping operations occur in the NASb and include Pleasant Grove Verona MWC (PGVMWC) and Natomas MWC (NMWC). South Sutter WD also operates a transfer program that is similar in many respects to a groundwater substitution transfer. Transfer pumping volumes are known for PGVMWC and NMWC on a well-by-well basis. The volume of groundwater pumped is assumed to be applied to meet agricultural demand in the respective service areas. South Sutter WD transfer wells and pumping volumes are not known, but it is assumed that a reduction in surface water deliveries to the service area creates increased pumping demand, resulting in transfer pumping operations. A summary of agricultural transfer pumping wells in CoSANA is shown in Table 3-2.

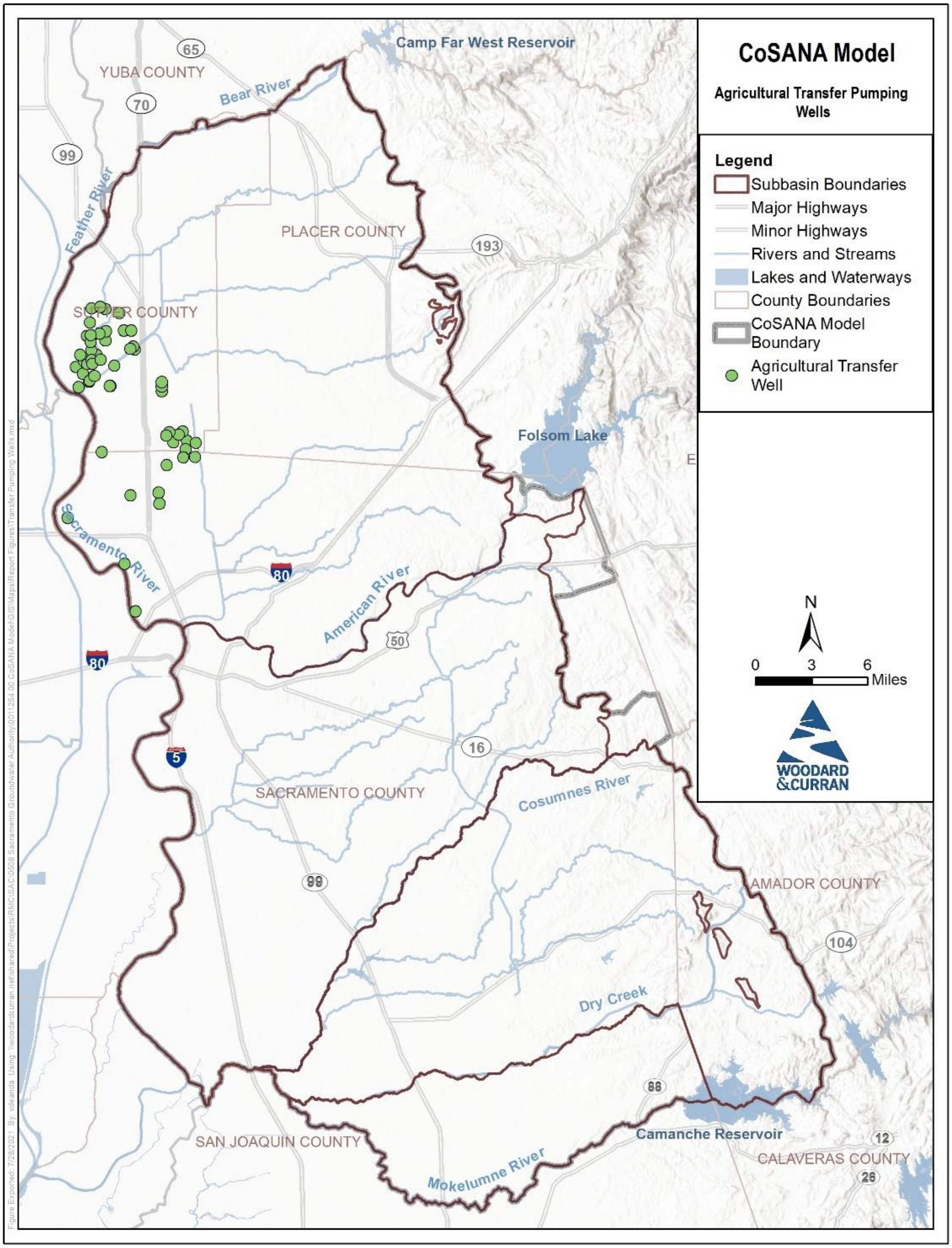



**Figure 3-5: Locations of Agricultural Groundwater Substitution Transfer Pumping Wells**

**Table 3-2: Summary of Agricultural Groundwater Substitution Transfer Pumping**

| Agency | Number of Groundwater Transfer Pumping Wells | Number of Simulated Transfer Years | Average Annual Pumping in a Transfer Year WY 1995-2018, (acre-feet) |
|---|---|---|---|
| Pleasant Grove Verona MWC | 30 | 6 | 7,668 |
| Natomas MWC | 25 | 4 | 8,412 |
| **Total Average Annual Pumping (acre-feet)** | | | 16,080 |

## 3.4 Remediation Pumping

CoSANA includes 344 remediation wells (Figure 3-6) simulating remediation operations for Aerojet/IRCTS, McClellan AFB, Mather AFB, and Kiefer landfill. Data for Aerojet and IRCTS operations were provided by Aerojet (personal communication, J. Fourie, January 16, 2020); McClellan AFB remediations data were provided by McClellan AFB (G. Yuki, personal communication, October 23, 2020) and AECOM (P. Graff, personal communication, October 10, 2020); Mather AFB data were developed based on annual reports; data for Kiefer Landfill operations were provided by Sacramento County (M. Koza, personal communication, June 11, 2020). Remediation pumping volumes by entity are shown in Table 3-3. An annual summary of remediation pumping volumes by extraction entity is provided in Appendix B. Further, annual simulated pumping volumes for the major remediation efforts in the CoSANA model area are summarized by subregion in the land and water use budgets in Appendix C.

**Table 3-3: Summary of CoSANA Remediation Operations:**

| Remediation Area (Subbasin) | Number of Groundwater Remediation Pumping Wells | Average Annual Remediation Pumping (WY 1995-2018, acre-feet) |
|---|---|---|
| Aerojet/IRCTS (NASb) | 15 | 1,970 |
| Aerojet/IRCTS (SASb) | 190 | 19,703 |
| Kiefer Landfill (SASb) | 15 | 969 |
| Mather AFB (SASb) | 4 | 207 |
| McClellan AFB (NASb) | 113 | 1,899 |
| **Total Average Annual Pumping (acre-feet)** | | 24,748 |

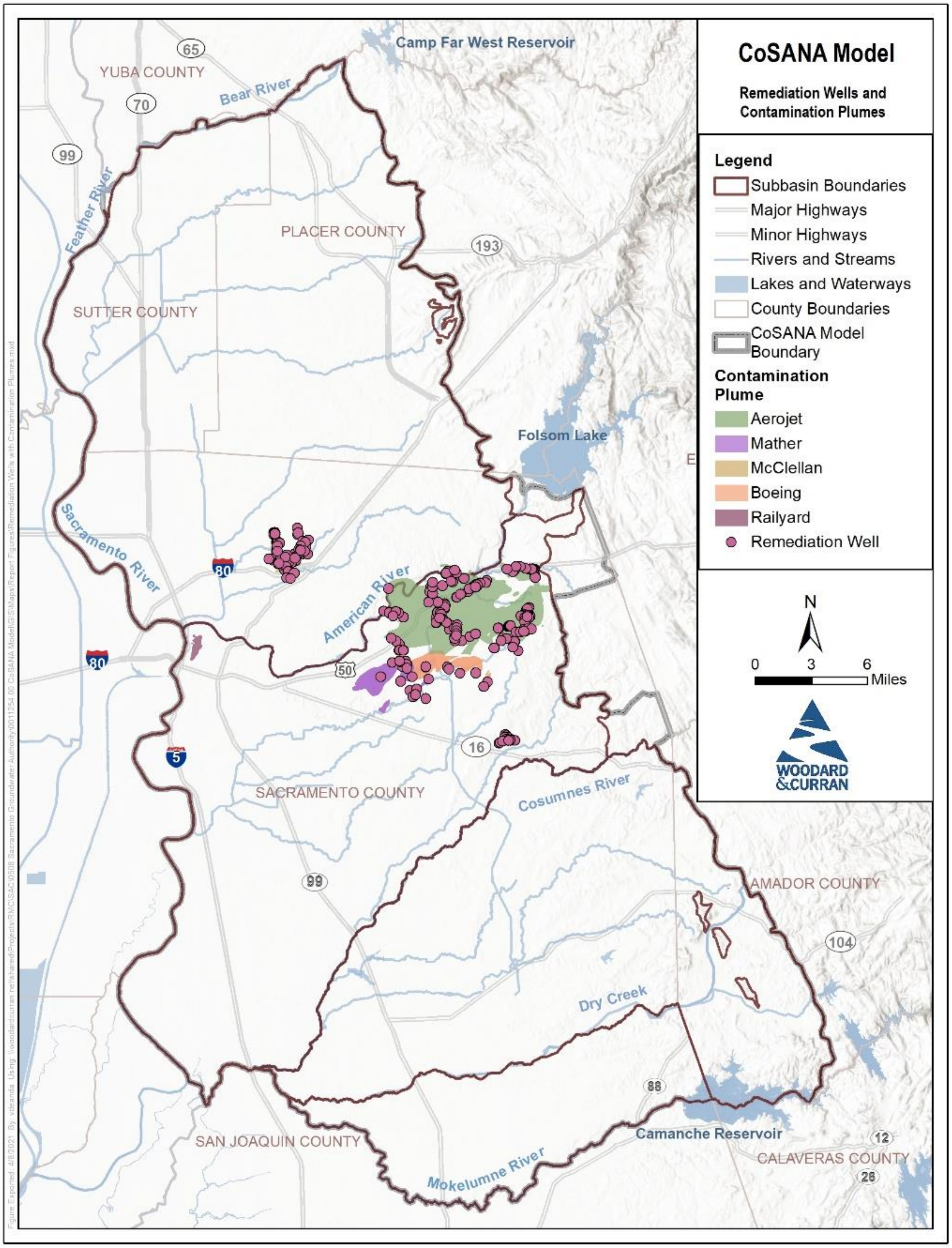



**Figure 3-6: Locations of Remediation Pumping Wells**

# 4. MODEL CALIBRATION AND SENSITIVITY ANALYSIS

CoSANA model is an integrated water resources model developed to simulate the integrated nature of the various components of the hydrologic system. Model calibration is an important part of model development, performed to meet the following objectives:

- Develop water budgets that properly represent various geographic scales, including the subbasin, GSA, and subregion scales, at both monthly and annual time scales,
- Represent the regional distribution of groundwater conditions, as well as the seasonal and long-term trends in groundwater levels at target calibration wells,
- Represent appropriate level of stream-aquifer interaction by simulating the modeled streams in such a way that the monthly and long-term streamflows at specific gaging stations properly represent the observed stream flow or stream stage data,
- Properly represent the interbasin flows across the boundaries internal to the CoSANA between the three subbasins modeled, as well as those between the neighboring subbasins outside the model area, in specific, Yuba, Yolo, Solano, and Eastern San Joaquin Subbasins.

Due to the complexities of calibrating an integrated water resources model, a hybrid approach for calibration was utilized to perform a manual calibration on initial water budgets and regional groundwater conditions and an automated calibration using PEST (Doherty, 2015) to achieve a refinement of the calibrated parameters that would result in a more accurate simulation. This calibration approach and process is similar to that used for calibration of the Central Valley's C2VSimFG, with special focus and attention to the regional and local data sets and information.

## 4.1 Calibration Goals

The goals of model calibration are to:

1. Represent the physical understanding of the model parameters within a range of reported values
2. Obtain a reasonable representation of water budgets for each of the hydrologic systems modeled (i.e., land and water use, stream flow, and groundwater budgets)
3. Achieve a reasonable general pattern of groundwater levels and flow directions
4. Optimize the agreement between simulated results and observed values for short-term seasonal and long-term trends in groundwater levels at selected calibration well
5. Optimize the agreement between simulated results and observed streamflow hydrographs or stream stage gages at selected gaging stations.

These goals are achieved through careful review of model input data and adjustments to model parameters. The model results also provide insight to key components of the groundwater basin including historical recharge, subsurface flows, gains/losses from/to streams and changes in groundwater storage.

CoSANA was calibrated to local data and knowledge, surface water flows, groundwater levels, and groundwater contours. The sources used include local knowledge (mainly gathered during the GSP Working Groups meetings), AWMPs, UWMPs, other local planning efforts, observed groundwater levels and associated contours, and observed streamflow data.

Due to uncertainty in the initial conditions, a "warm up" period is included to allow groundwater levels to stabilize. As previously noted, CoSANA includes data starting in October 1969 (WY 1970). To reduce run time, the model used for the historical calibration begins in October 1989 (WY 1990). The CoSANA calibration period begins after a five-year warm up period, in October 1994, and ends in September 2018; thus, the full period for model calibration is WY 1995 through 2018 (24 years).

## 4.2 Calibration Process

The calibration process is conducted as shown in Figure 4-1 and as described in the following subsections.

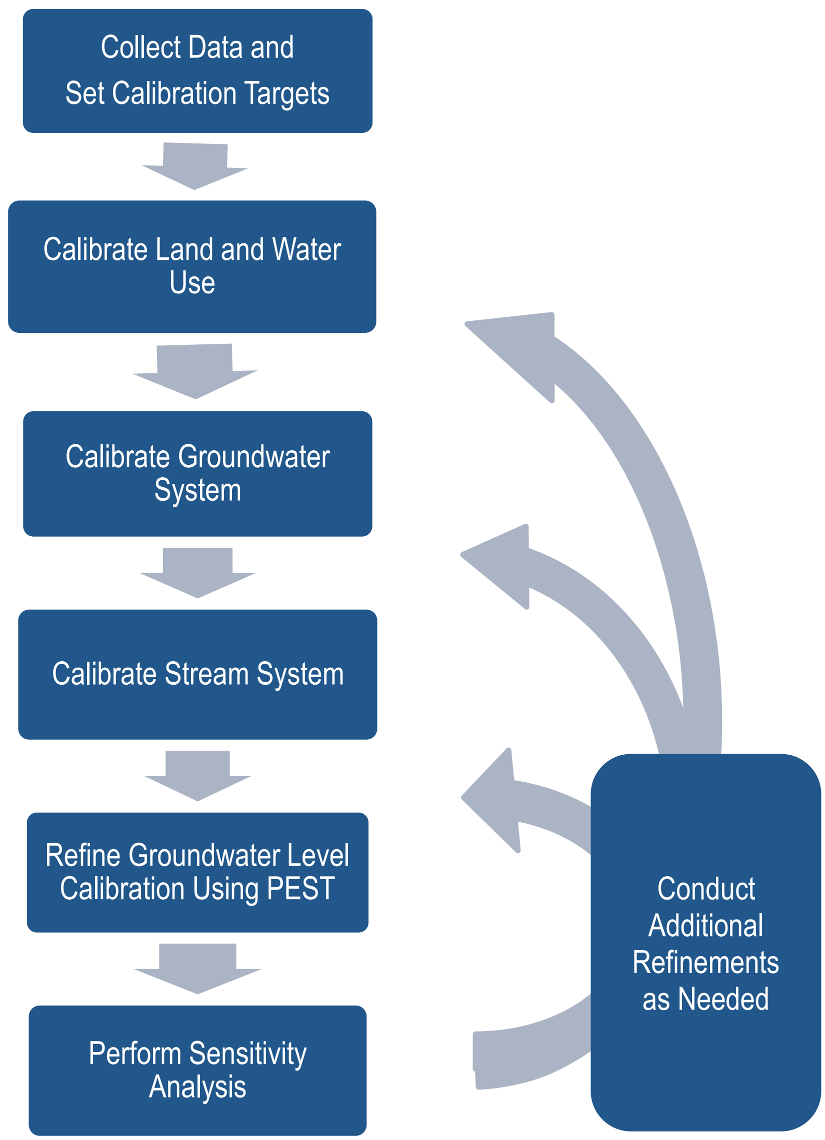



**Figure 4-1: CoSANA Calibration Process**

### 4.2.1 Water Budget Calibration

Water budgets are calibrated to improve the accuracy of the representation of the hydrologic characteristics of the groundwater basin. A water budget balances 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 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 primary budgets reviewed for calibration are the groundwater budget and the land and water use budget. Other budgets, notably the stream budget (see Appendix D), are also reviewed as part of the calibration process. After extensive budget analysis, key model datasets and parameters are adjusted, particularly groundwater aquifer parameters, to better match local budgets from local agricultural water purveyors and local planning efforts. The CoSANA water budget results are summarized in the following sections.

#### 4.2.1.1 Land and Water Use Budget

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

- Demands:
  - Demand (either agricultural or urban)
  - Surplus (if applicable)
- Supplies:
  - Groundwater pumping
  - Surface water deliveries (including recycled water deliveries)
  - Shortage (if applicable)

As part of the calibration of the land and water use budget, root zone parameters are adjusted as needed to achieve reasonable estimates of agricultural demand and to develop the components of a balanced root zone budget. IDC calibration serves as the foundation of the IWFM calibration for agricultural areas, as demand estimated often translates directly to groundwater pumping, which is the primary stress on the groundwater system. To adjust agricultural demand, element-level 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 4-2 through Figure 4-6. The IDC model was calibrated to achieve an irrigation efficiency of approximately 68% to 72%, consistent with agricultural water use values reported by irrigation districts in their AWMPs, as well as data from DWR's California Agricultural Water Use Model and California Water Plan.

The average annual water demand and supply mix used to meet the demand is summarized in Table 4-1. The average annual simulated land and water use budgets for the calibration period are presented in Figure 4-7 through Figure 4-14, showing the agricultural and urban demands and supplies in CoSANA both model wide and by subbasin. Additional detail on the Land and Water Use budget is included in Appendix C.

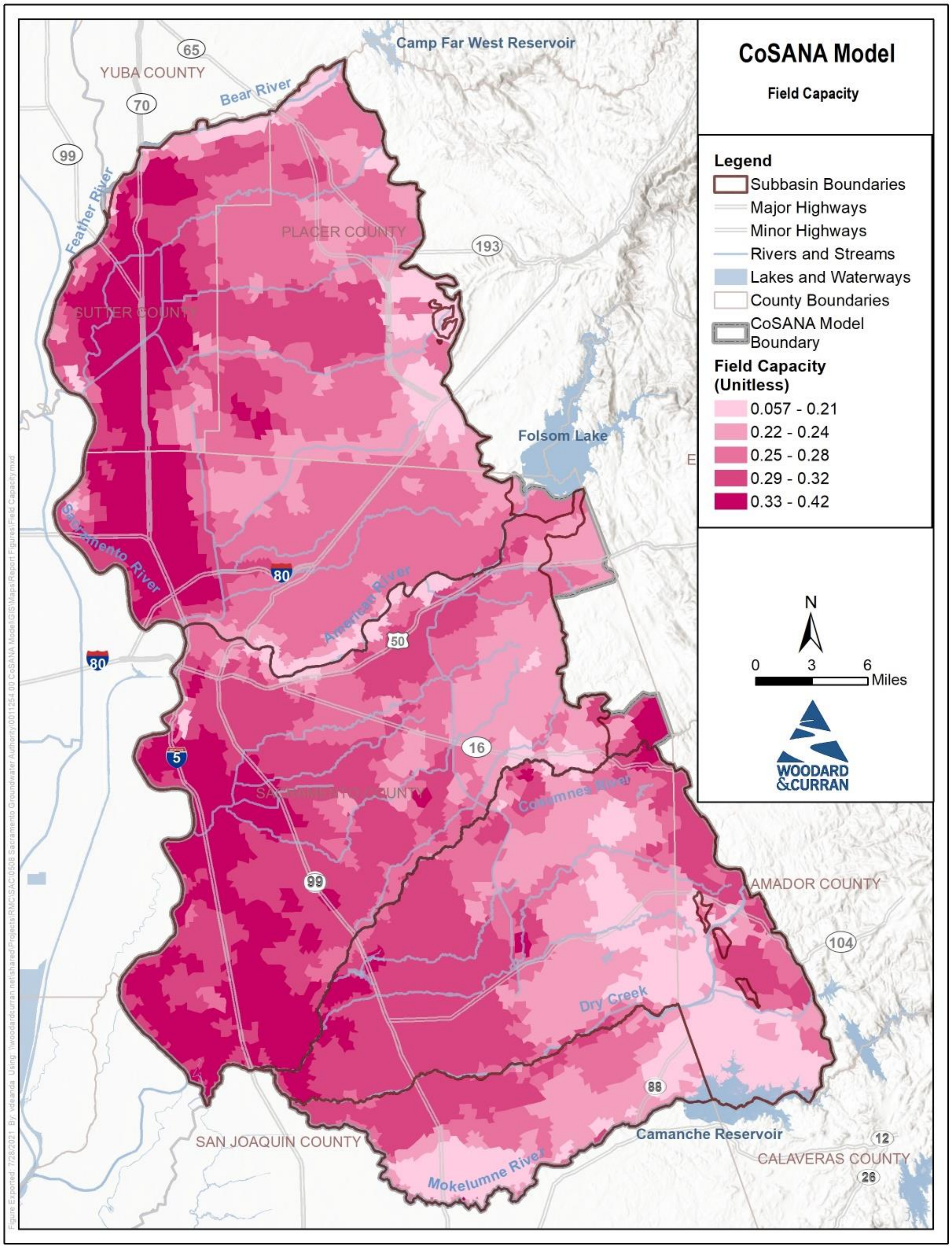



**Figure 4-2: CoSANA Field Capacity**

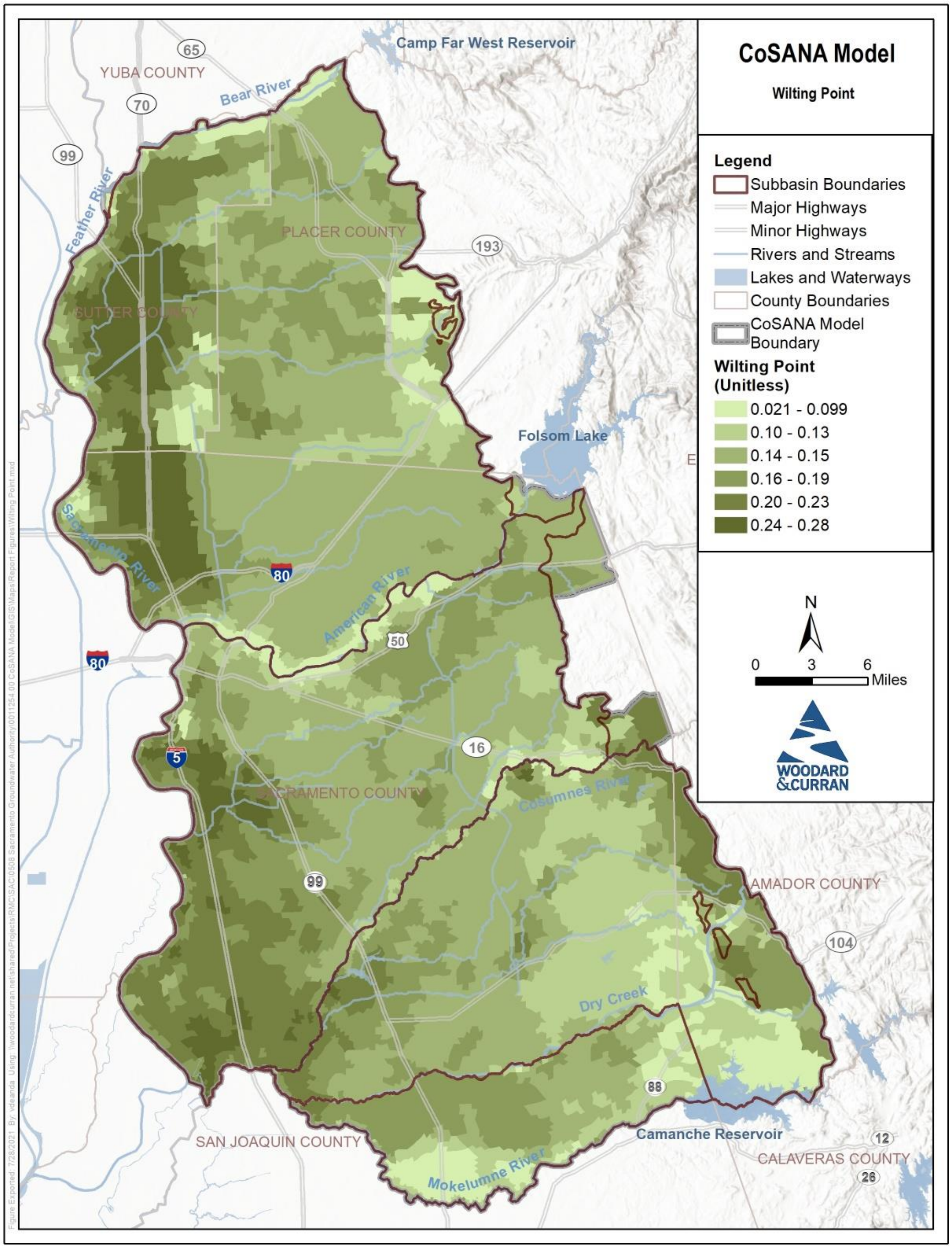



**Figure 4-3: CoSANA Wilting Point**

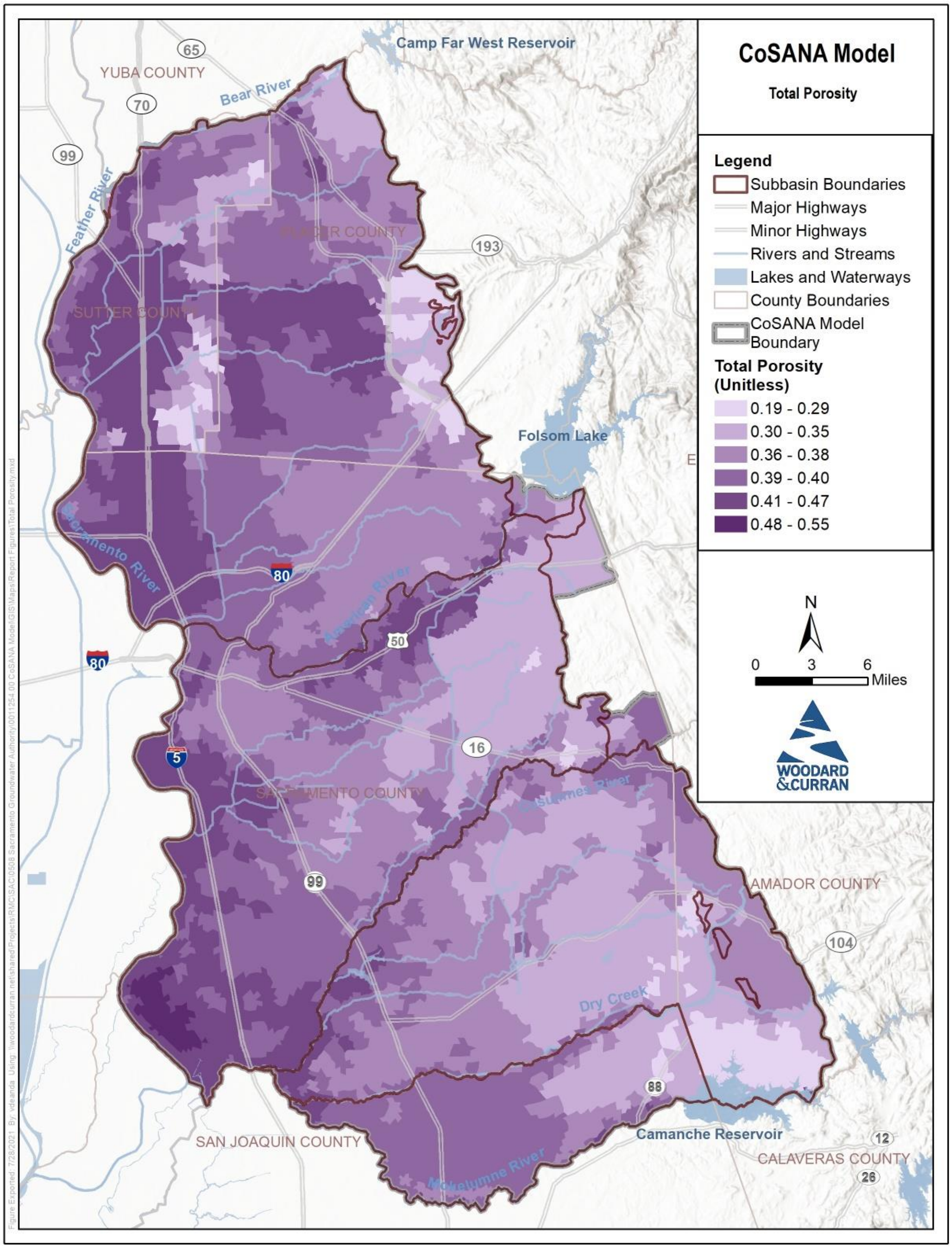



Figure 4-4: CoSANA Total Porosity

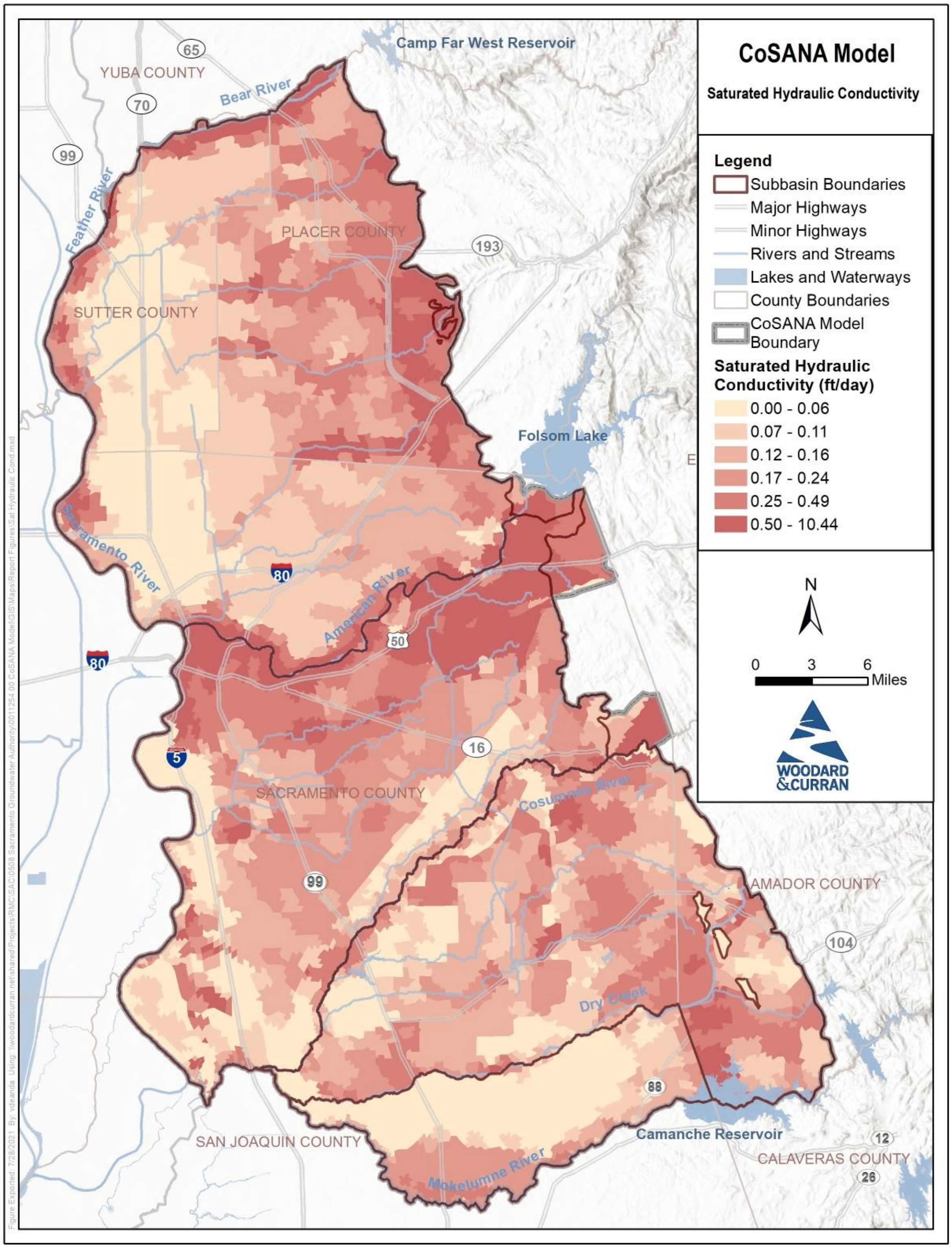



**Figure 4-5: CoSANA Saturated Soil Hydraulic Conductivity**

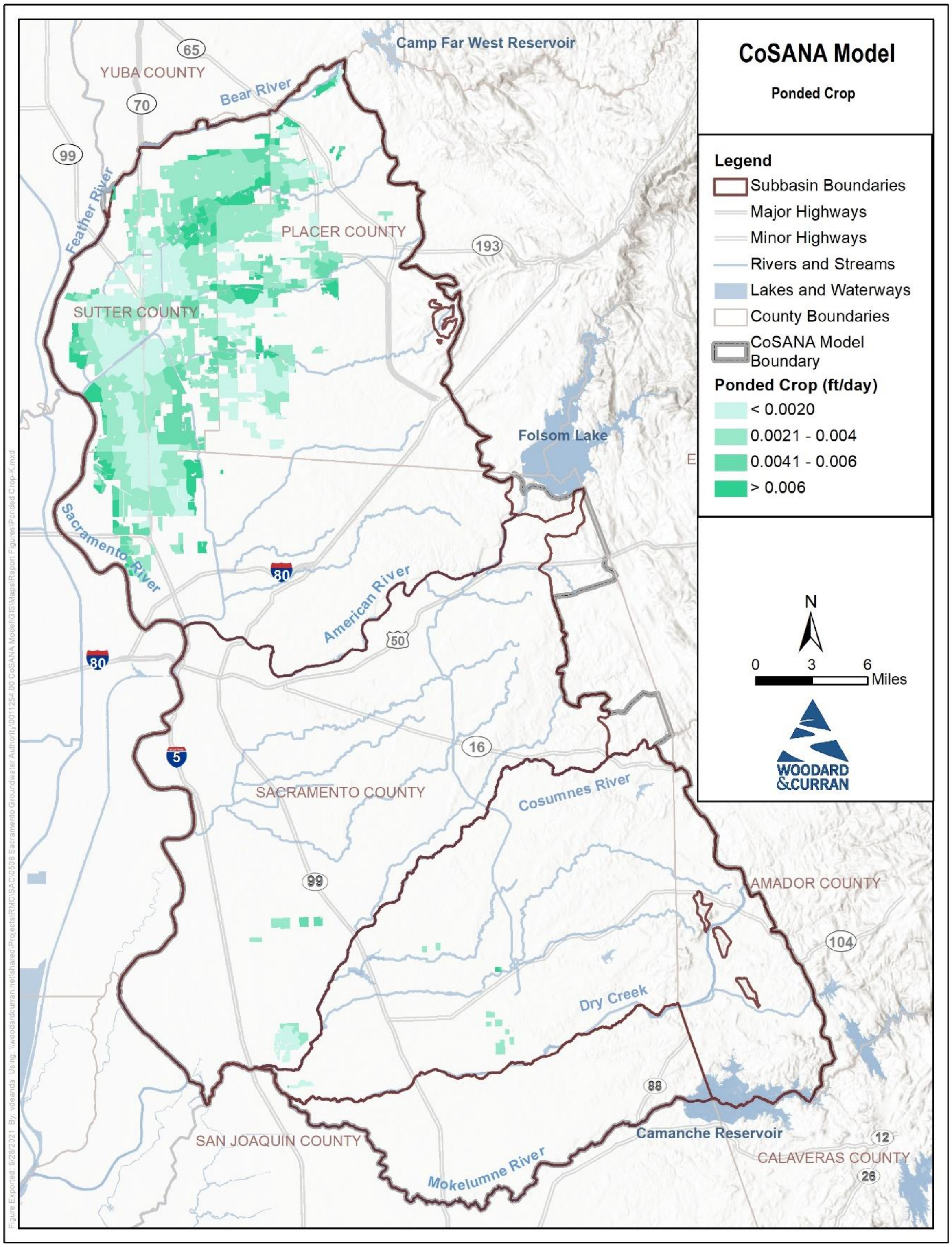
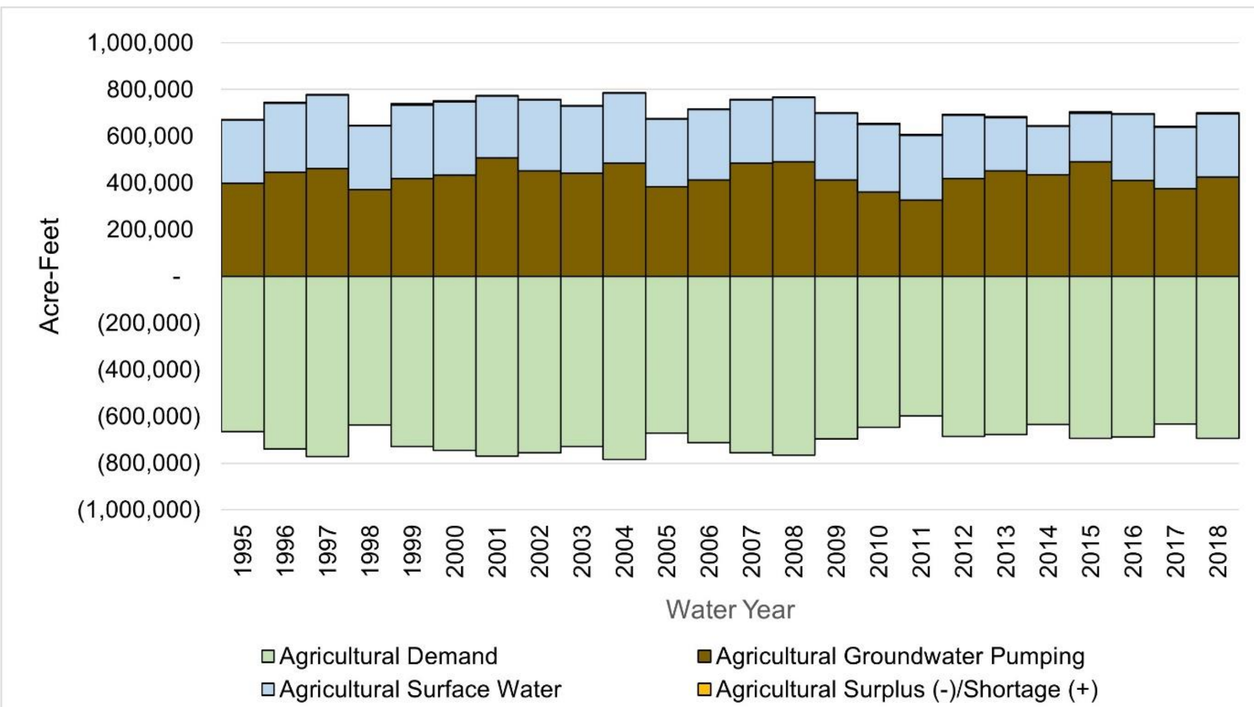



**Figure 4-6: CoSANA Ponded Crop Saturated Soil Hydraulic Conductivity**

**Table 4-1: Land and Water Use Budget Demand and Supply Mix**
**(Average Annual for the Period WY 1995-2018)**

| Subbasin | Ag. Demand (AFY) | Ag. Ground-water Use (AFY) | Ag Surface Water Deliveries (AFY) | Urban Demand (AFY) | Urban Ground-water Use (AFY) | Urban Surface Water Deliveries (AFY) | Urban Recycled Water (AFY) | Remediation Pumping (AFY) |
|---|---|---|---|---|---|---|---|---|
| NASb | 410,136 | 205,563 | 207,225 | 215,951 | 91,263 | 124,687 | 0 | 3,869 |
| SASb | 160,694 | 116,397 | 44,667 | 182,760 | 93,515 | 89,324 | 232 | 20,879 |
| CoSb | 132,690 | 107,167 | 25,576 | 26,861 | 22,881 | 2,417 | 0 | 0 |
| **Total** | **703,520** | **429,127** | **277,468** | **425,572** | **207,659** | **216,428** | **232** | **24,748** |

*Note: Small differences exist between total supplies and total demands. These shortages and surpluses are delivered and applied regardless of the demand specified in the model. Surpluses tend to result in deep percolation. Remediation pumping is not considered part of demand in the L&WU budget but is shown for information purposes. CoSANA total is a summation of the three subbasins (NASb, SASb, and CoSb) and excludes areas in the Eastern San Joaquin subbasin and areas outside of B118 subbasins.*




Note: This figure is a summation of NASb, SASb, and CoSb values and excludes areas outside of these subbasins

**Figure 4-7: CoSANA Agricultural Land and Water Use Budget**

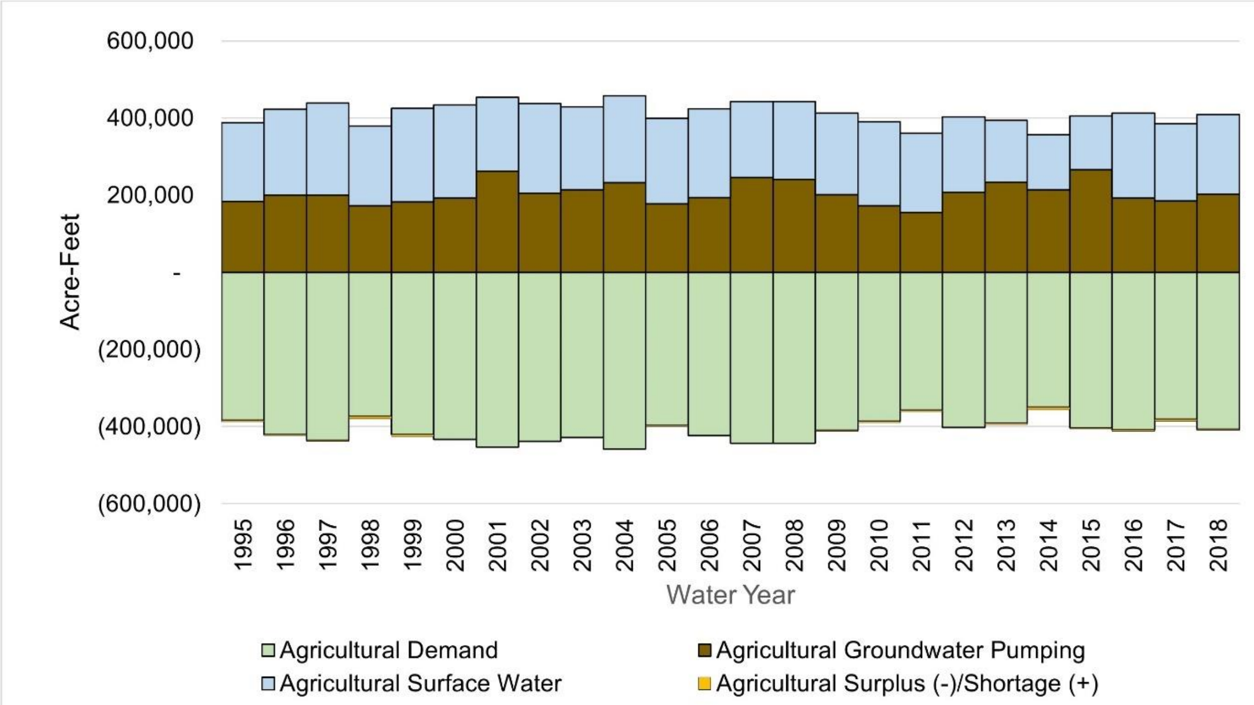



**Figure 4-8: NASb Agricultural Land and Water Use Budget**

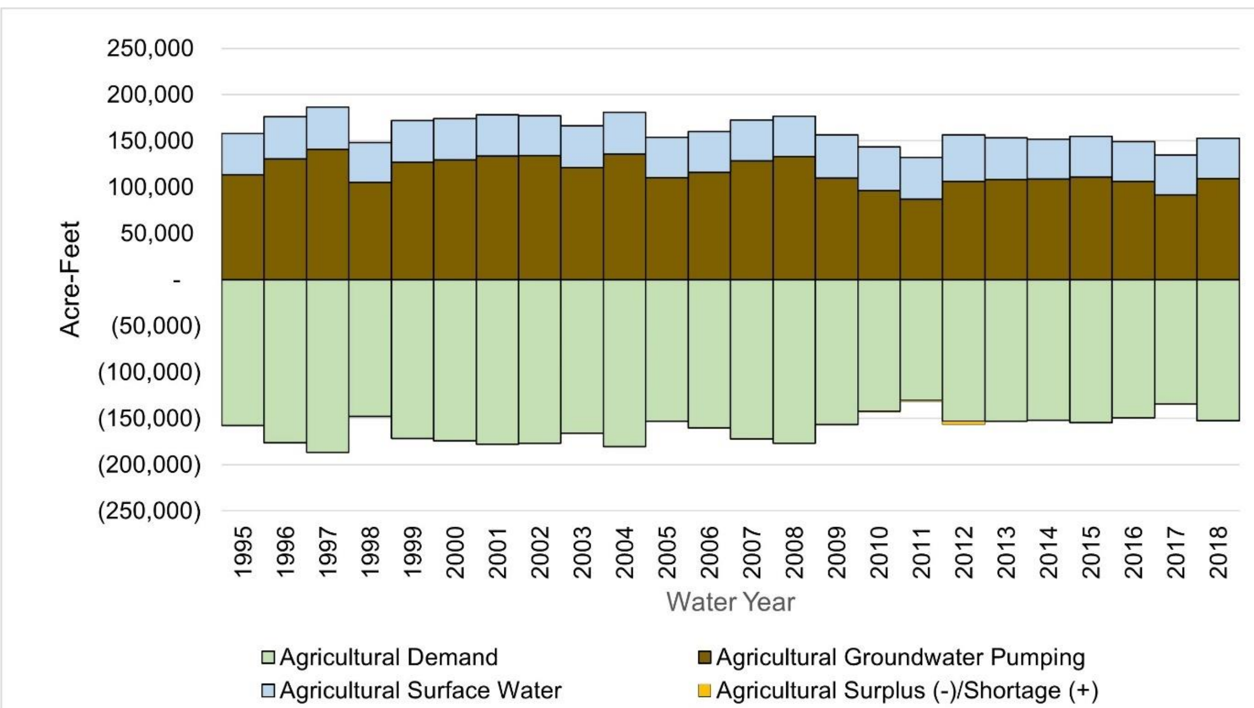



**Figure 4-9: SASb Agricultural Land and Water Use Budget**

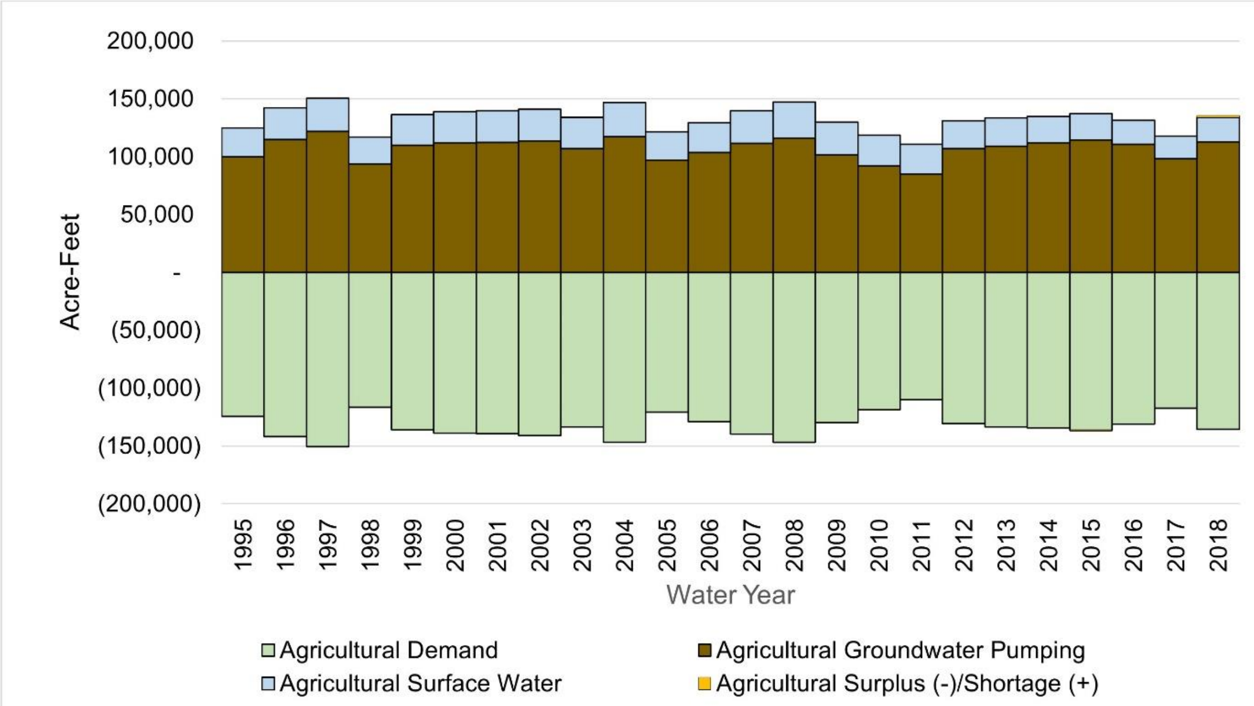
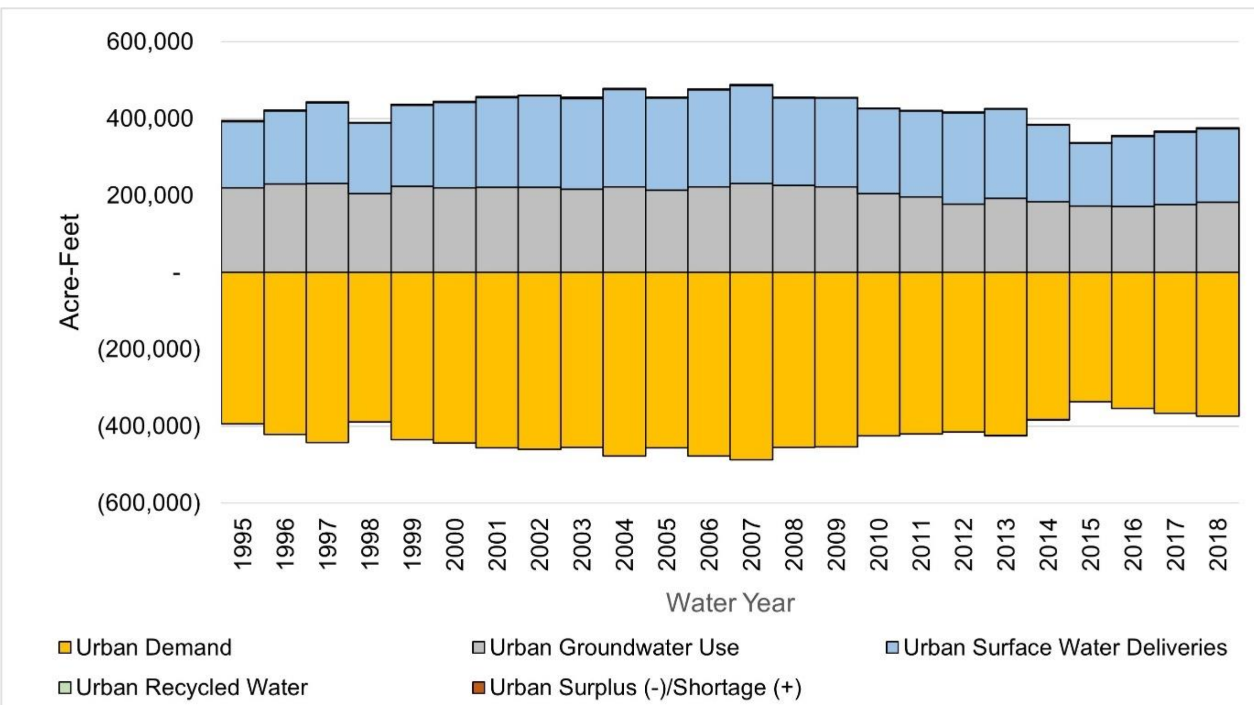



**Figure 4-10: CoSb Agricultural Land and Water Use Budget**




*Note: This figure is a summation of NASb, SASb, and CoSb values and excludes areas outside of these subbasins*

**Figure 4-11: CoSANA Model Urban Land and Water Use Budget**

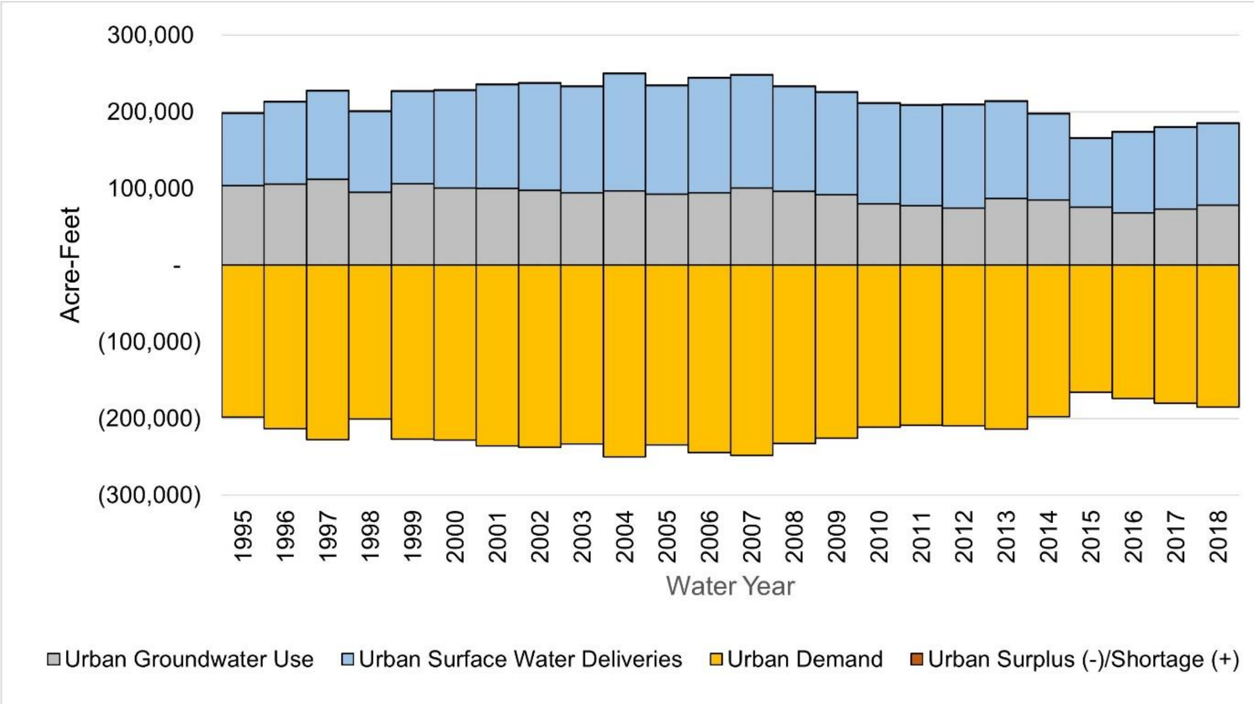



**Figure 4-12: NASb Urban Land and Water Use Budget**

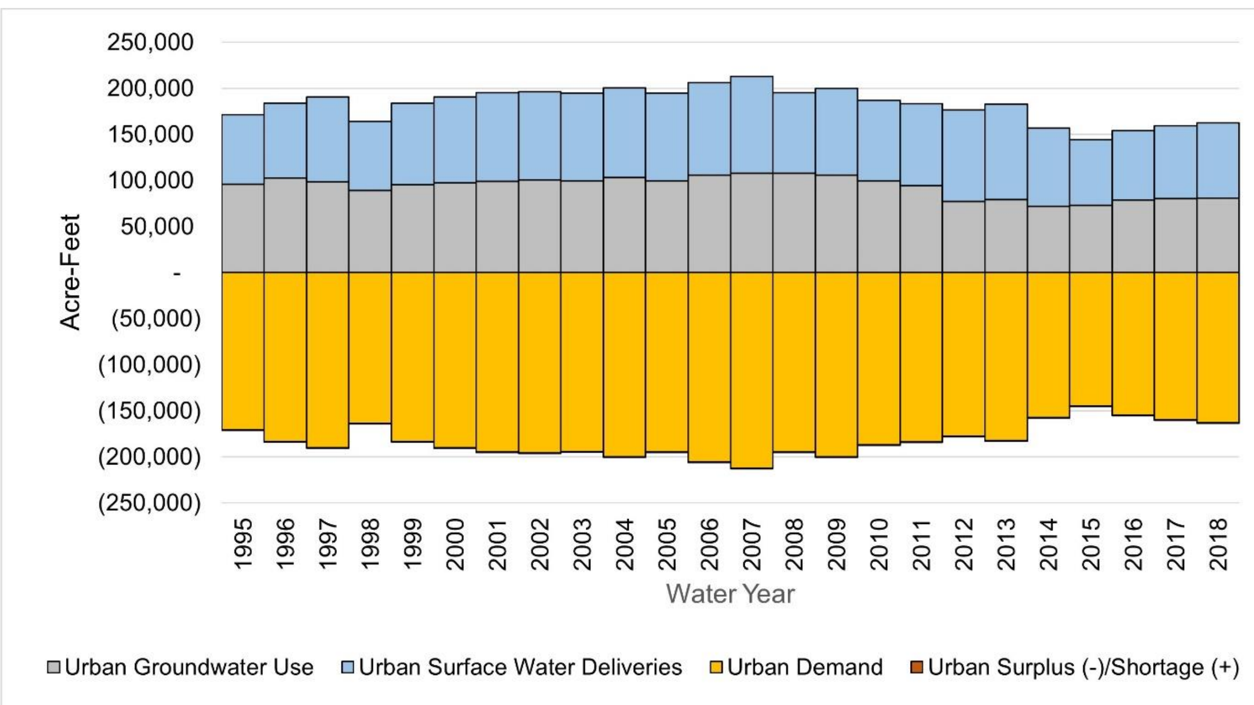
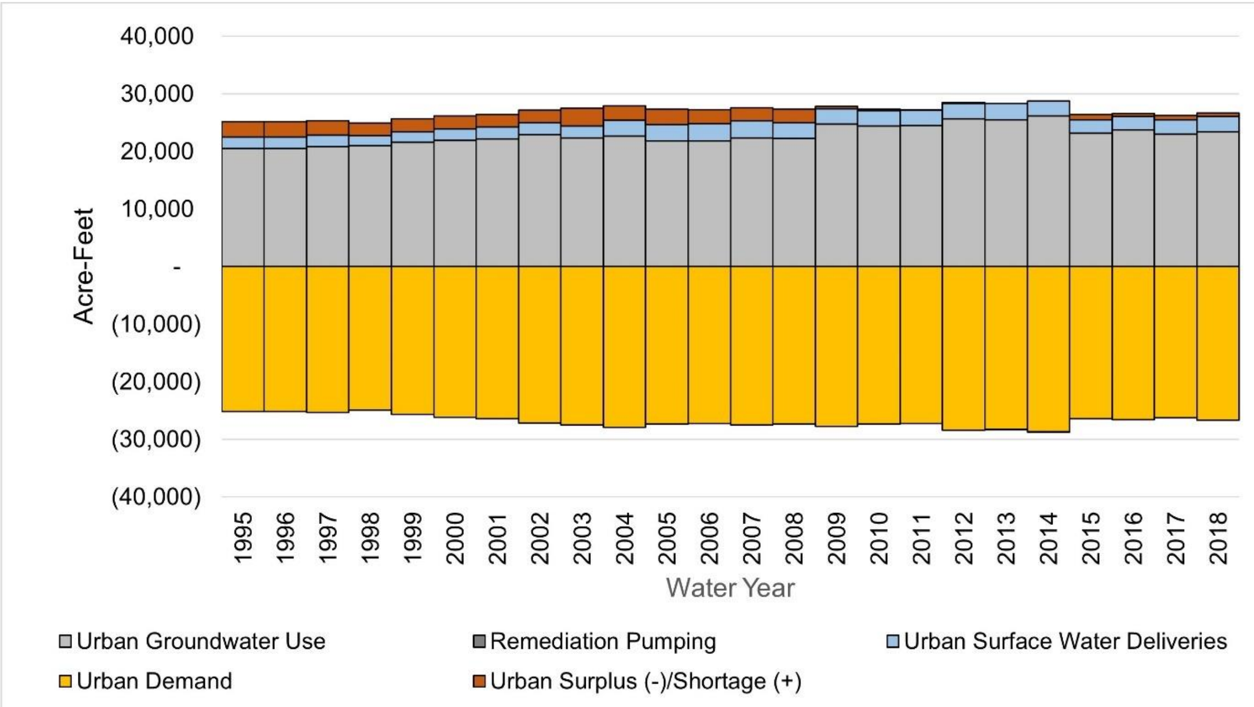



**Figure 4-13: SASb Urban Land and Water Use Budget**




*Note: Urban groundwater use is specified in the CoSb model input data set. The model-calculated surplus/shortage in urban demand is therefore not utilized to calculate the CoSb groundwater budget.*

**Figure 4-14: CoSb Urban Land and Water Use Budget**

#### 4.2.1.2 Groundwater Budget

The groundwater budget quantifies inflows and outflows from the groundwater system. 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 irrigation applied water)
  - Gain from stream (recharge due to stream seepage)
  - Recharge (from other sources such as irrigation canal seepage and recharge ponds)
  - Boundary inflow (from outside the model area)
  - Net subsurface inflow (from adjacent subregions)
- Outflows:
  - Groundwater pumping
  - Loss to stream (outflow to streams and rivers)
  - Boundary outflow (to outside the model area)
  - Subsurface outflow (to adjacent subregions)
- Change in groundwater storage (positive indicates withdrawal from groundwater storage, and negative indicates contribution to groundwater storage)

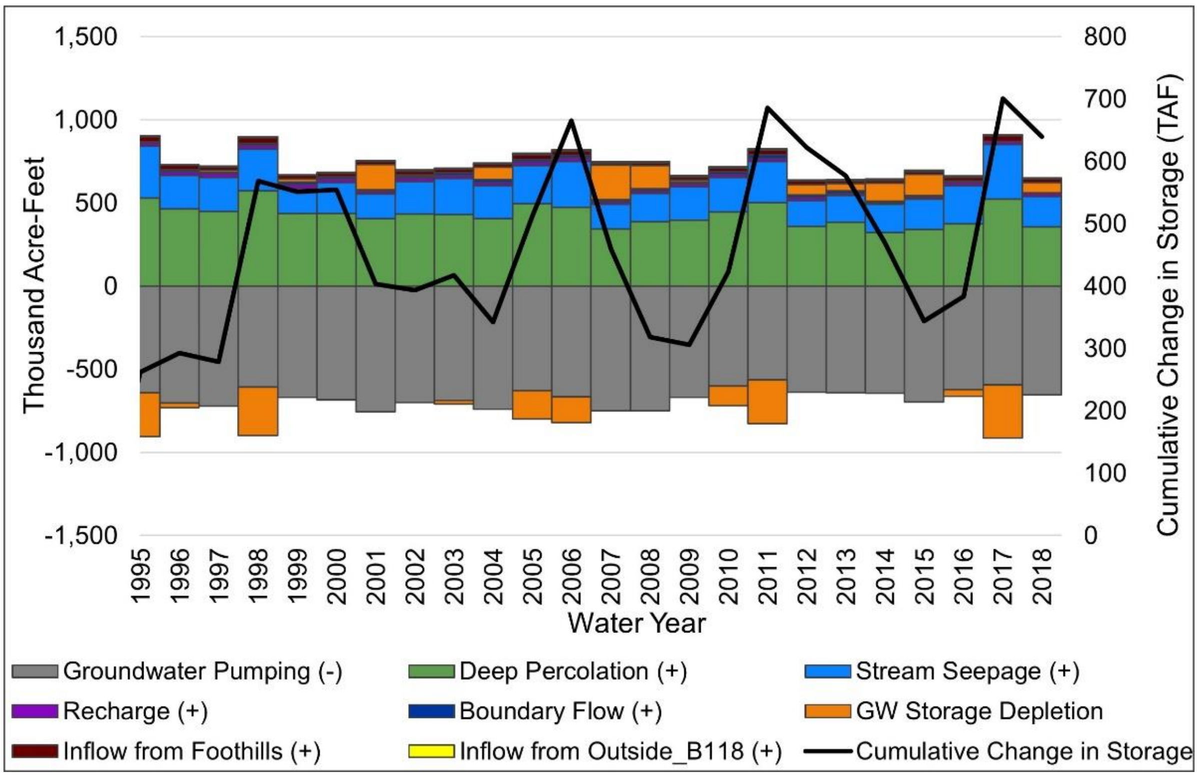
The groundwater budgets, including cumulative change in storage, are summarized in Table 4-2 and shown in Figure 4-15 through Figure 4-18 for three subbasins combined and for the NASb, SASb, and CoSb, respectively. Though results vary area to area, the primary sources of groundwater inflows are deep percolation and interaction with the model streams.

Subregion-level budgets are provided in Appendix E.

## Table 4-2: Summary of CoSANA Groundwater Budget
**(Average Annual for the Period WY 1995-2018)**

| Subbasin | Pumping (AFY) | Deep Percolation (AFY) | Gain from Stream (AFY) | Recharge from Canals (AFY) | Subsurface Inflow (AFY) | Boundary Flows (AFY) | Change in Storage (AFY) |
|---|---|---|---|---|---|---|---|
| NASb | 315,794 | 189,988 | 85,907 | 18,320 | 18,220 | 30,019 | 26,661 |
| SASb | 221,618 | 130,317 | 101,953 | 15 | -8,884 | 3,769 | 5,551 |
| CoSb | 130,048 | 108,054 | 18,977 | 0 | -2,333 | -162 | -5,510 |
| **Total** | **667,460** | **428,359** | **206,837** | **18,335** | **7,003*** | **11,302** | **26,702** |

Note: CoSANA total is a summation of NASb, SASb, and CoSb values and excludes areas outside of these subbasins.
* The model-wide subsurface inflow value includes subsurface flows to and from areas outside of the combined NASb, SASb, and CoSb area.




Note: This figure is a summation of NASb, SASb, and CoSb values and excludes areas outside of these subbasins

**Figure 4-15: CoSANA Groundwater Budget**

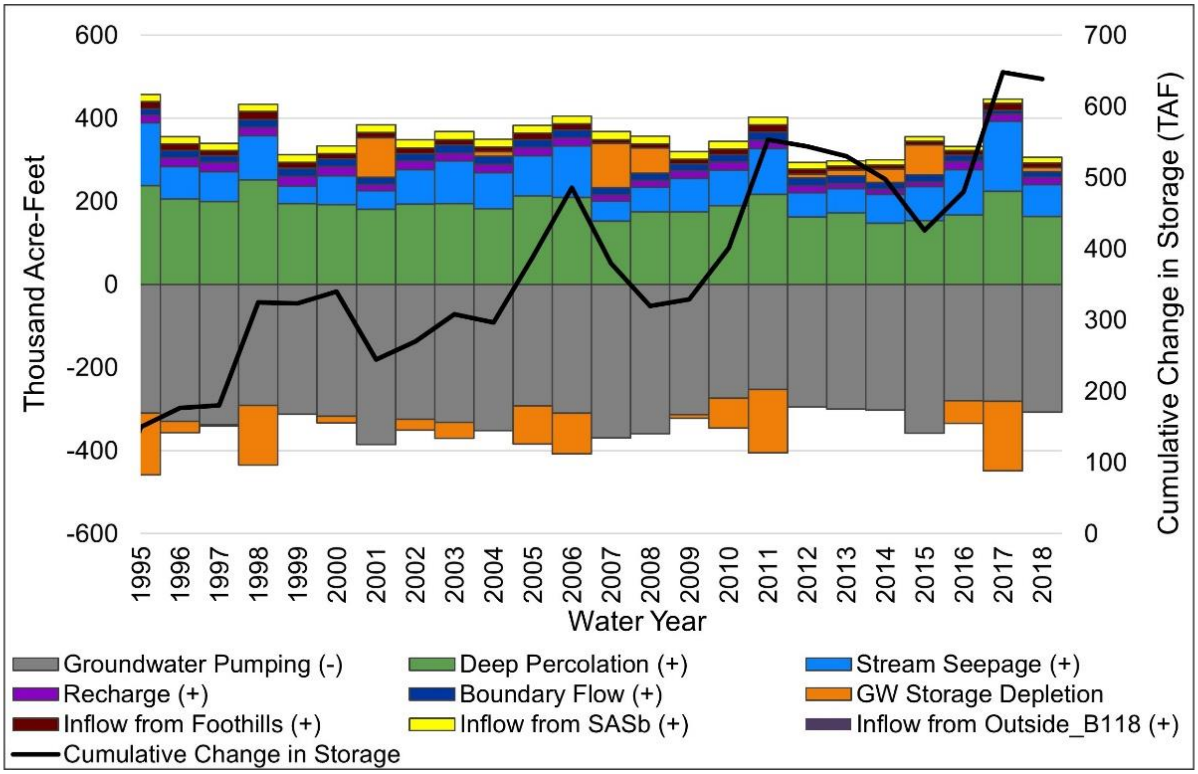



**Figure 4-16: NASb Groundwater Budget**

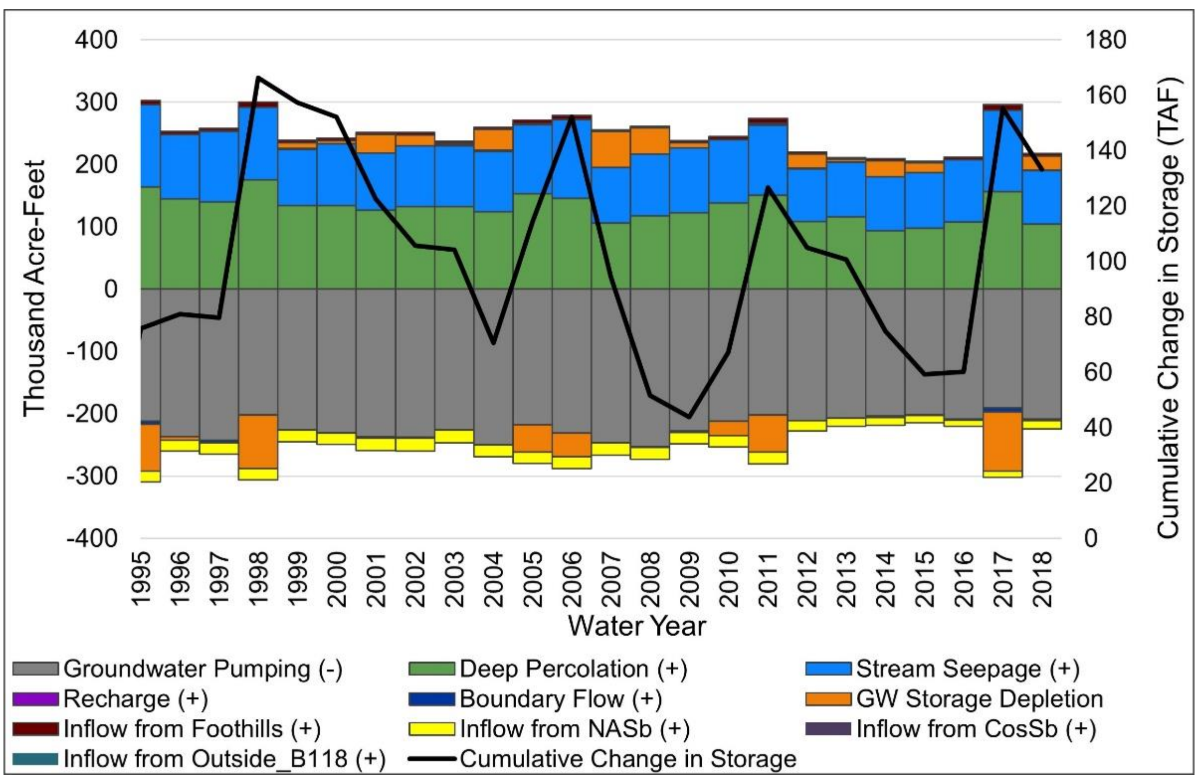



**Figure 4-17: SASb Groundwater Budget**

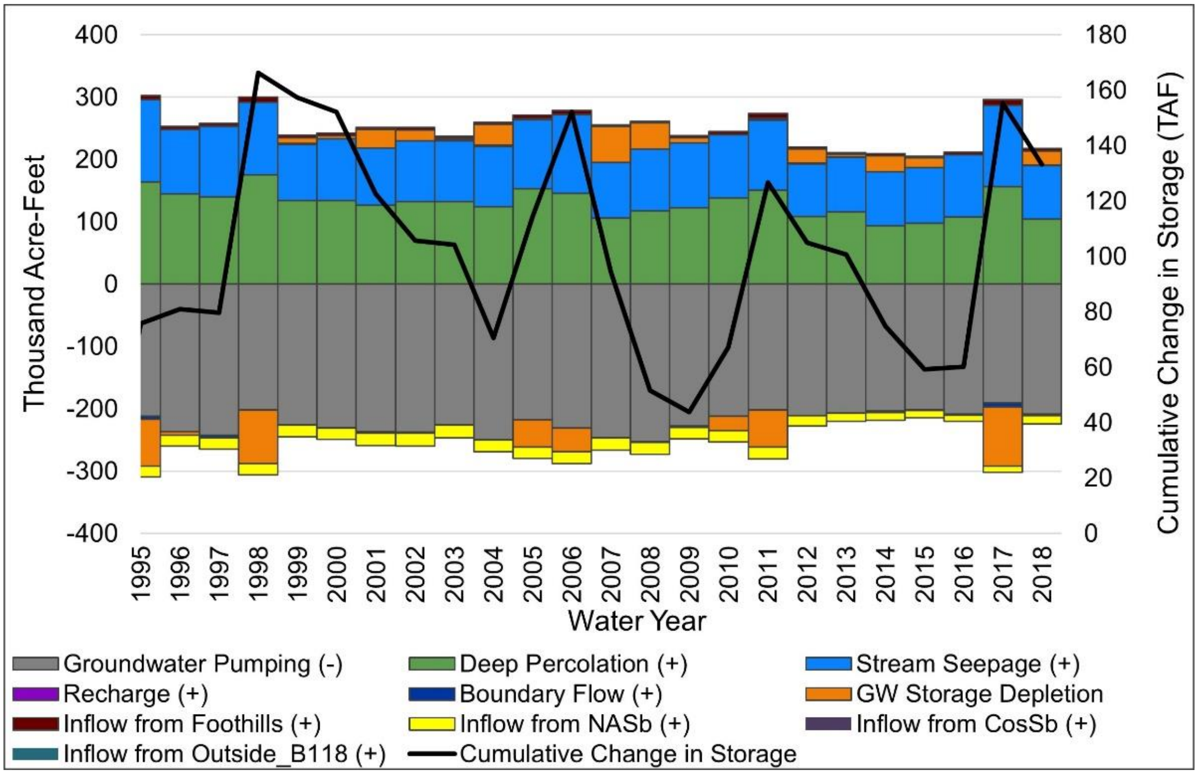



**Figure 4-18: CoSb Groundwater Budget**

### 4.2.2 Groundwater Level Calibration

Groundwater levels are calibrated to achieve acceptable agreement between the simulated and observed values (in this case, groundwater levels at the calibration wells). Within CoSANA, over 1,600 wells were evaluated for developing groundwater observation locations (calibration wells) to allow CoSANA's calibration at both a regional and local scale. Data for these wells were obtained from DWR's CASGEM program, DWR's Water Data Library, and local monitoring data from Aerojet, Elk Grove Water District, The Nature Conservancy, and the University of California - Davis. The calibration wells were selected based on their period of record, availability of observation data, spatial distribution across the model, representative nature of the data, and trends of nearby wells. After a review of the available observation data, a working set of 761 wells was selected to be used for the calibration process.

The groundwater level calibration process included both manual refinements to the model as well as automated calibration using the PEST software package. The set of 761 wells with associated observations was used to perform PEST calibration. Of the identified 761 wells, a refined subset of 403 wells that are considered representative of the long-term conditions of groundwater levels both at a local and regional scale were selected for analysis in each PEST run. The location and number of observations for the full set of 761 wells are shown in Figure 4-19, the period of record for each of these wells is shown in Figure 4-20. Maps showing the locations of each of the 403 wells in the subset and calibration hydrographs are shown in Appendix F.

With the observation data identified, a preliminary manual calibration was performed to adjust the water budgets, primarily the land and water use budgets and the small watershed budgets, to have a reasonable starting point for calibrating the aquifer parameters. 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 4.4). Input datasets were also refined where the calibration process identified issues. 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.

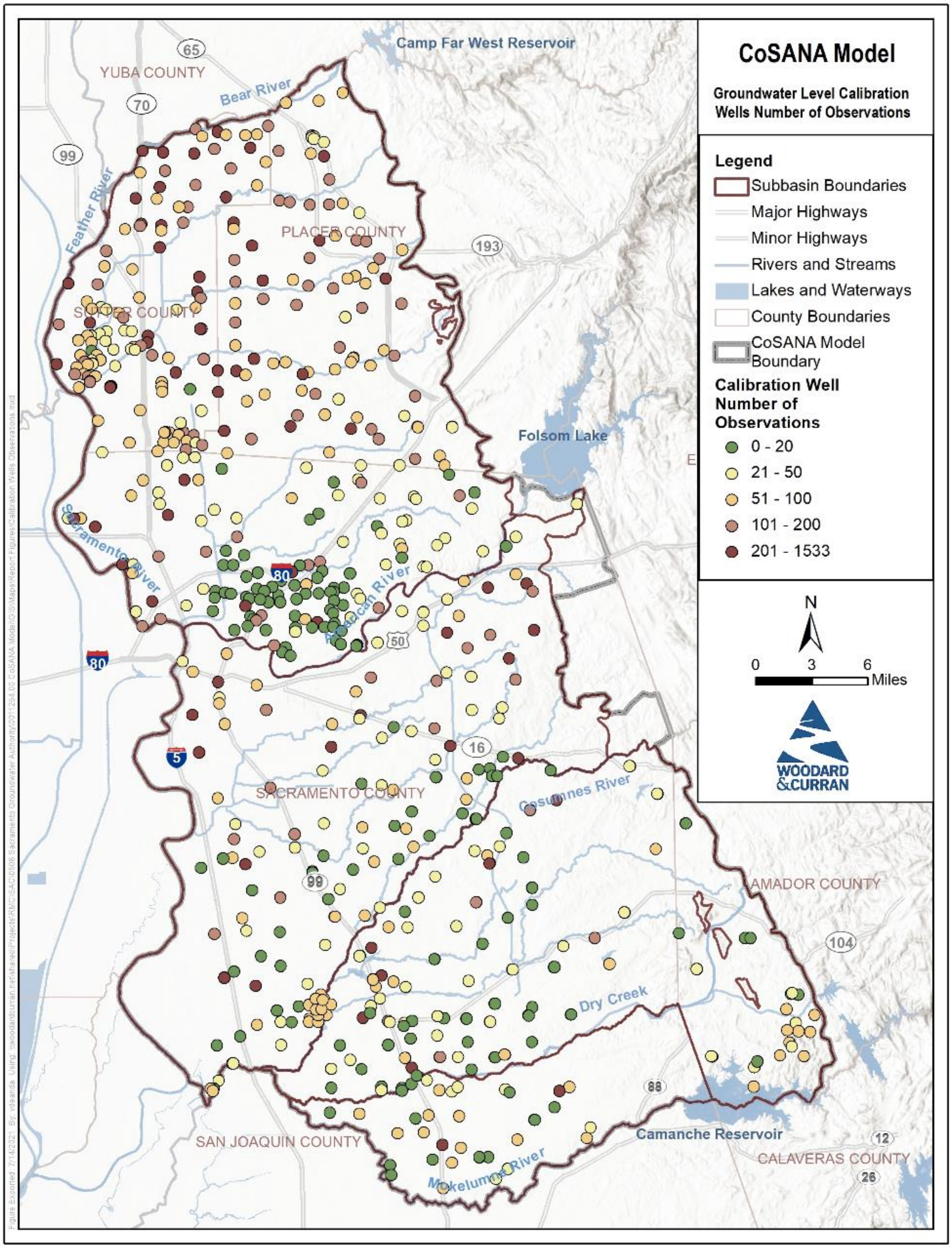



**Figure 4-19: Number of Observations for Calibration Wells**

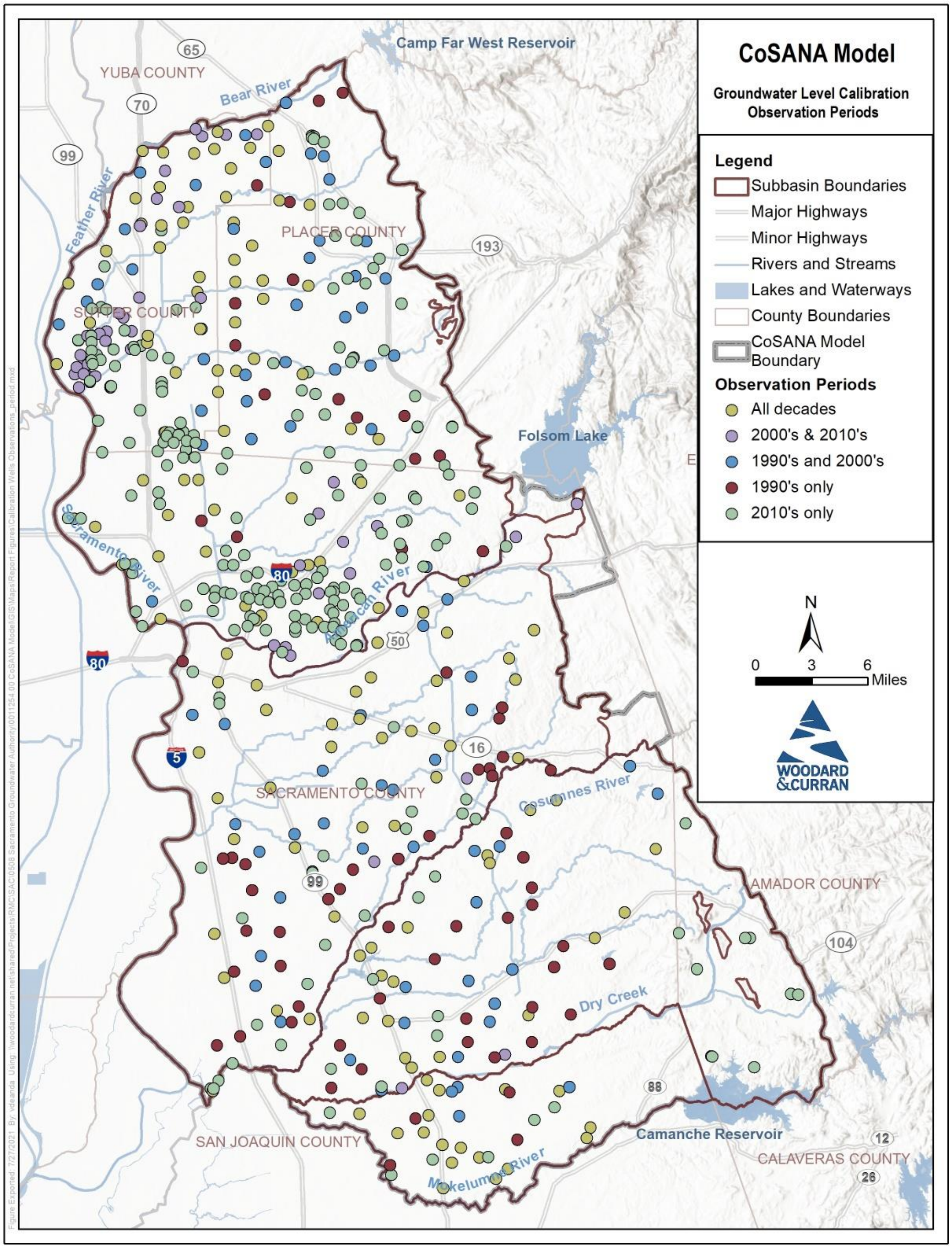



**Figure 4-20: Period of Record for Calibration Wells**

The automated parameter estimation tool, PEST, was used to assist in refinement of aquifer parameters to improve model calibration. PEST-assisted calibration is performed to interact with CoSANA via input and output files and iteratively modifies parameter values to reduce an objective function representative of the model residual error. These modifications are made within identified bounds of reasonable values for each parameter. PEST-assisted calibration focused on the aquifer parameters such as horizontal and vertical conductivities and storage parameters.

Between PEST-assisted calibration iterations, the modeling team revisited the land system and small watershed budgets and made manual adjustments where needed, until calibration goals were met.

Simulated groundwater level contours and observed values for calibration wells are shown in Figure 4-21, Figure 4-22, and Figure 4-23 for spring 1998, fall 2015, and fall 2018, respectively. Simulated groundwater level hydrographs and observations for selected wells (locations shown in Figure 4-24) are shown in Figure 4-25 through Figure 4-49. Simulated values represent the layers screened at that well, except for 7223 and 7224 which do not have screened interval information.

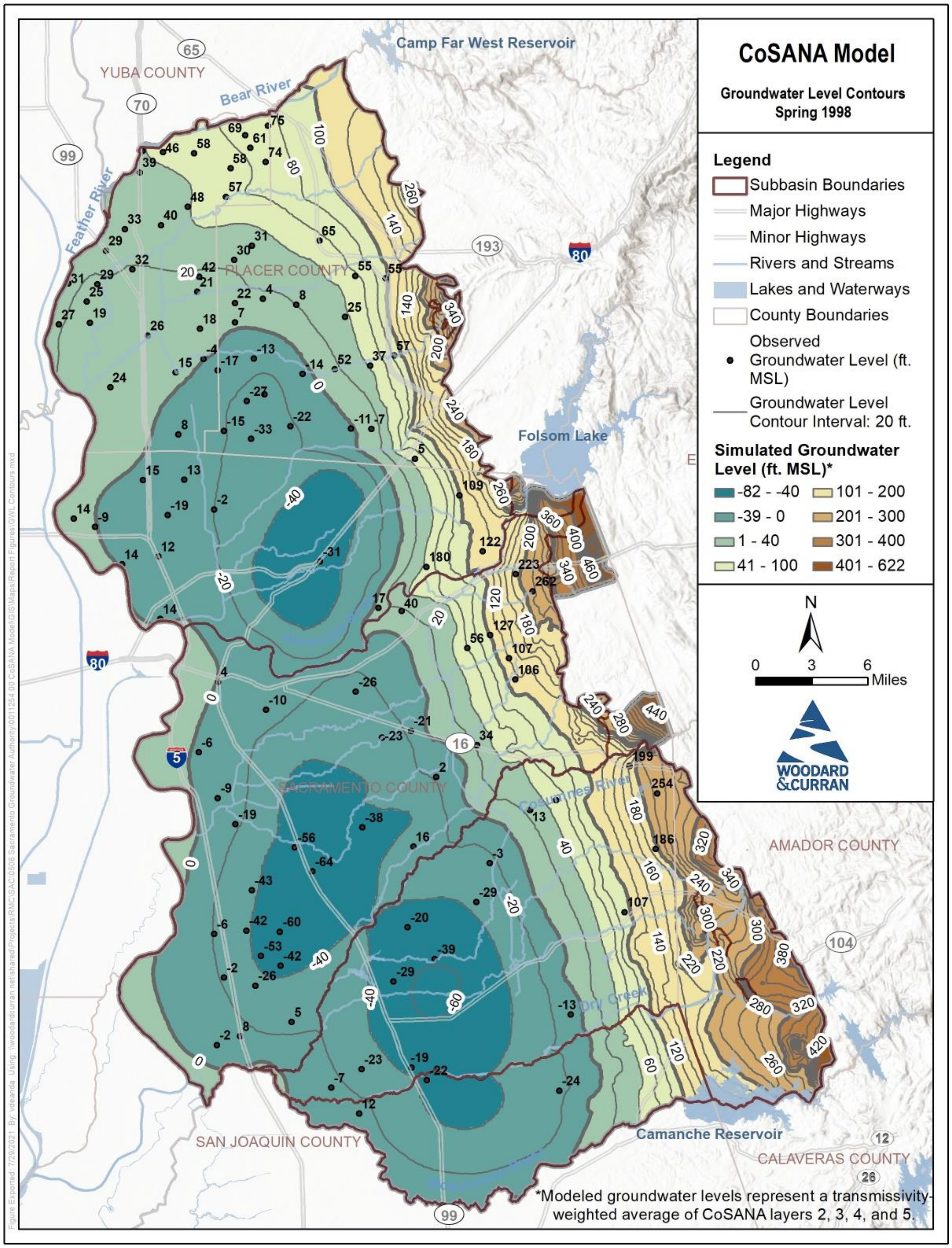



**Figure 4-21: CoSANA Groundwater Level Contours – Spring 1998 (End of Wet Period)**

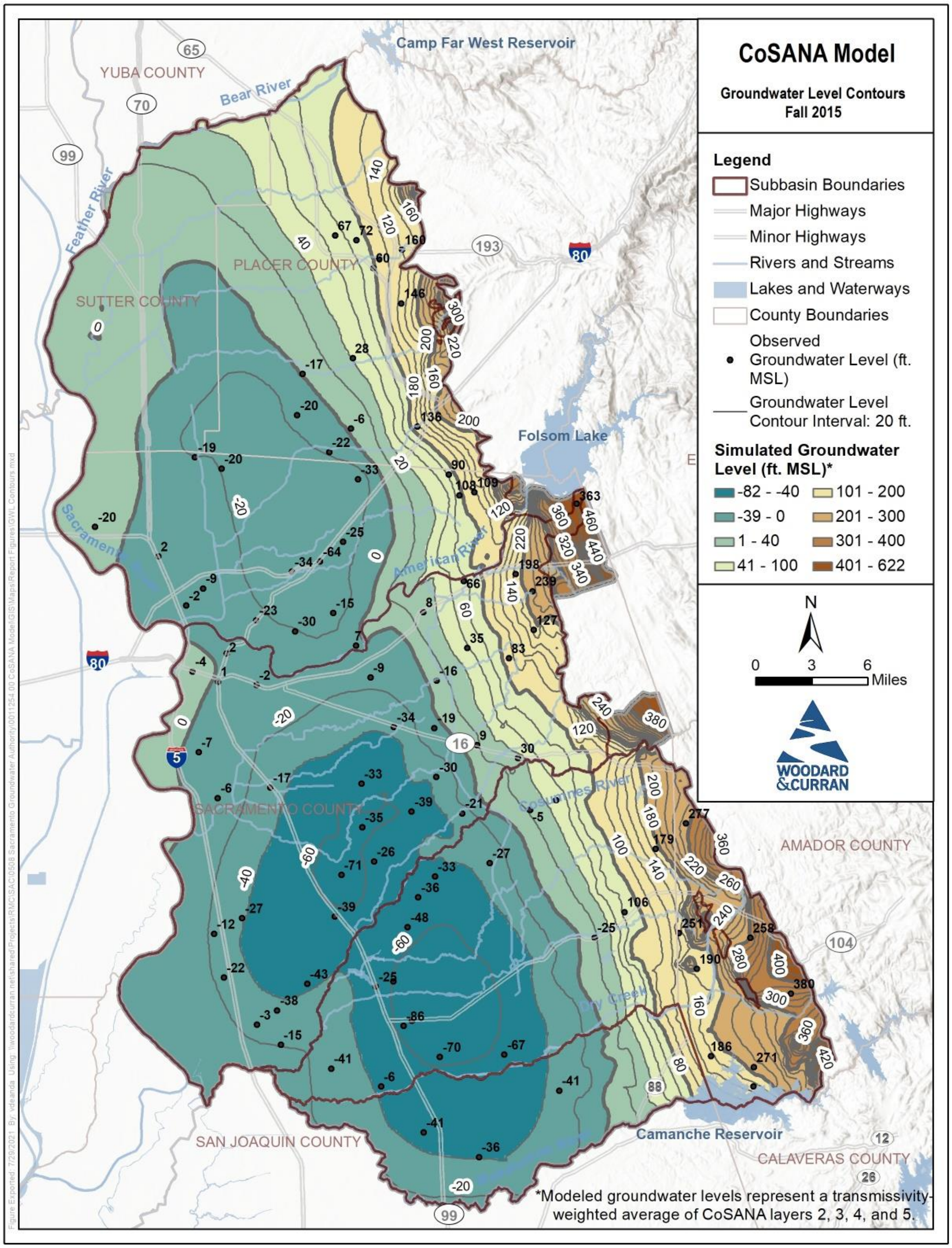



**Figure 4-22: CoSANA Groundwater Level Contours – Fall 2015 (End of Drought Period)**

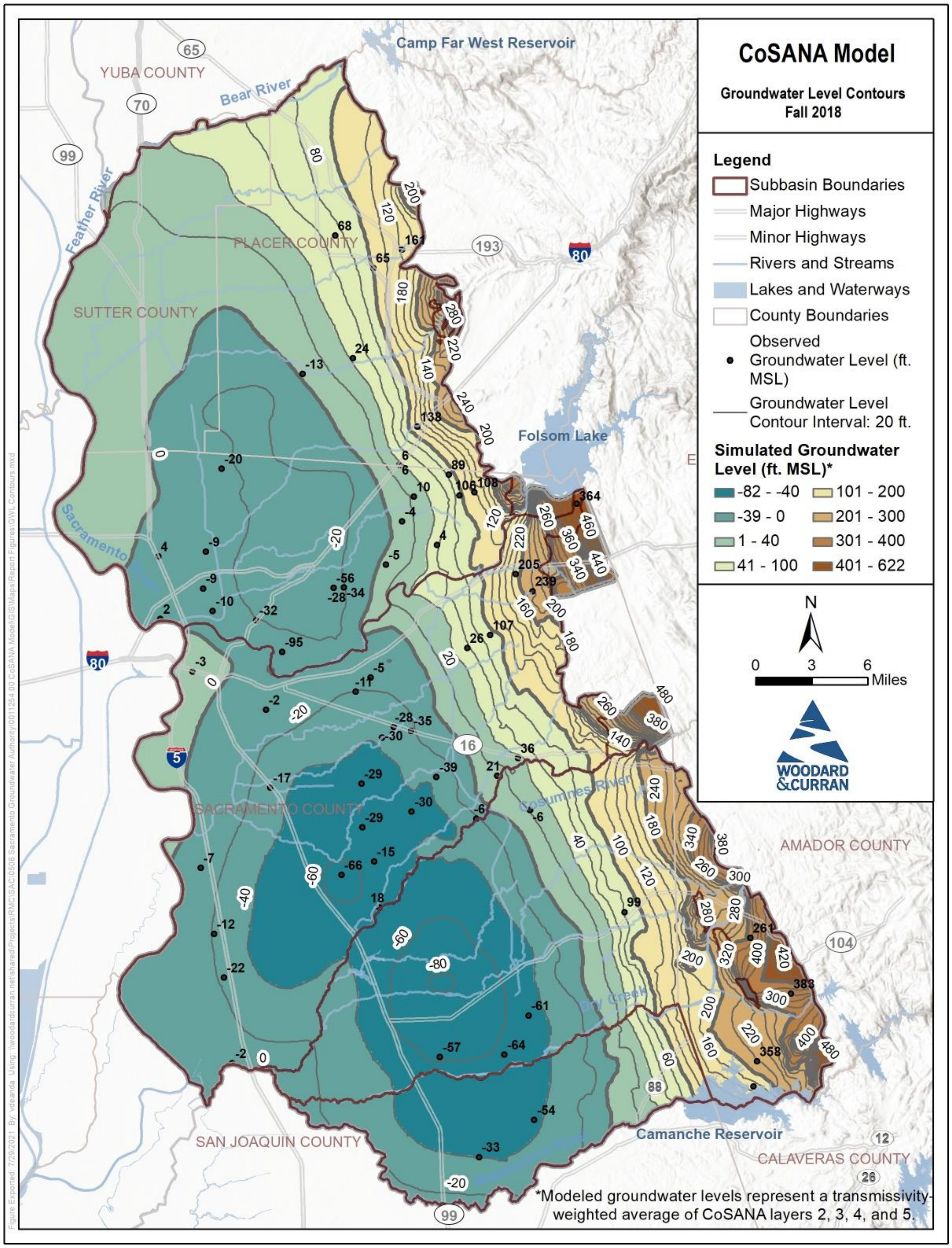



**Figure 4-23: CoSANA Groundwater Level Contours – Fall 2018 (End of Simulation)**

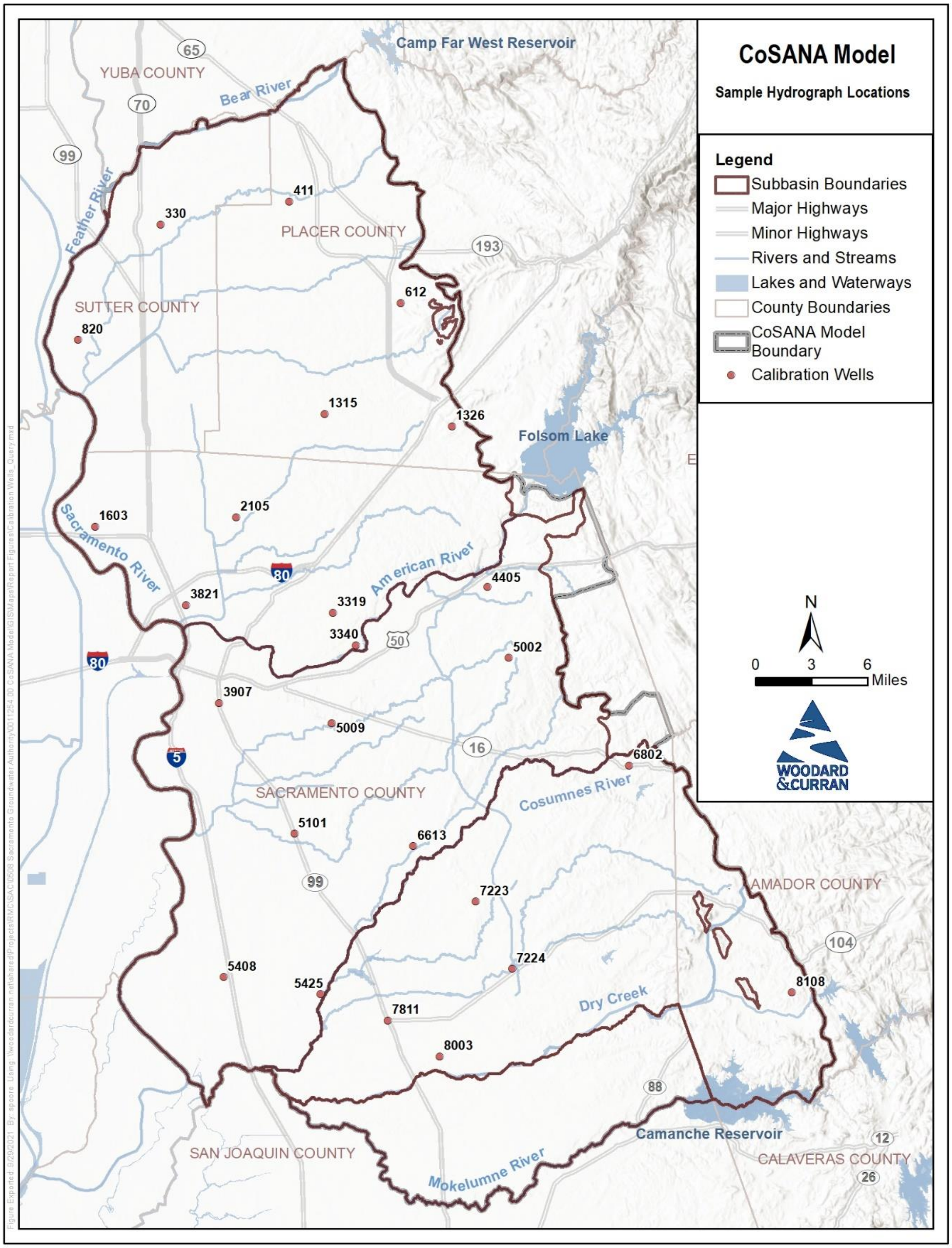



**Figure 4-24: Location of Sample Hydrographs**

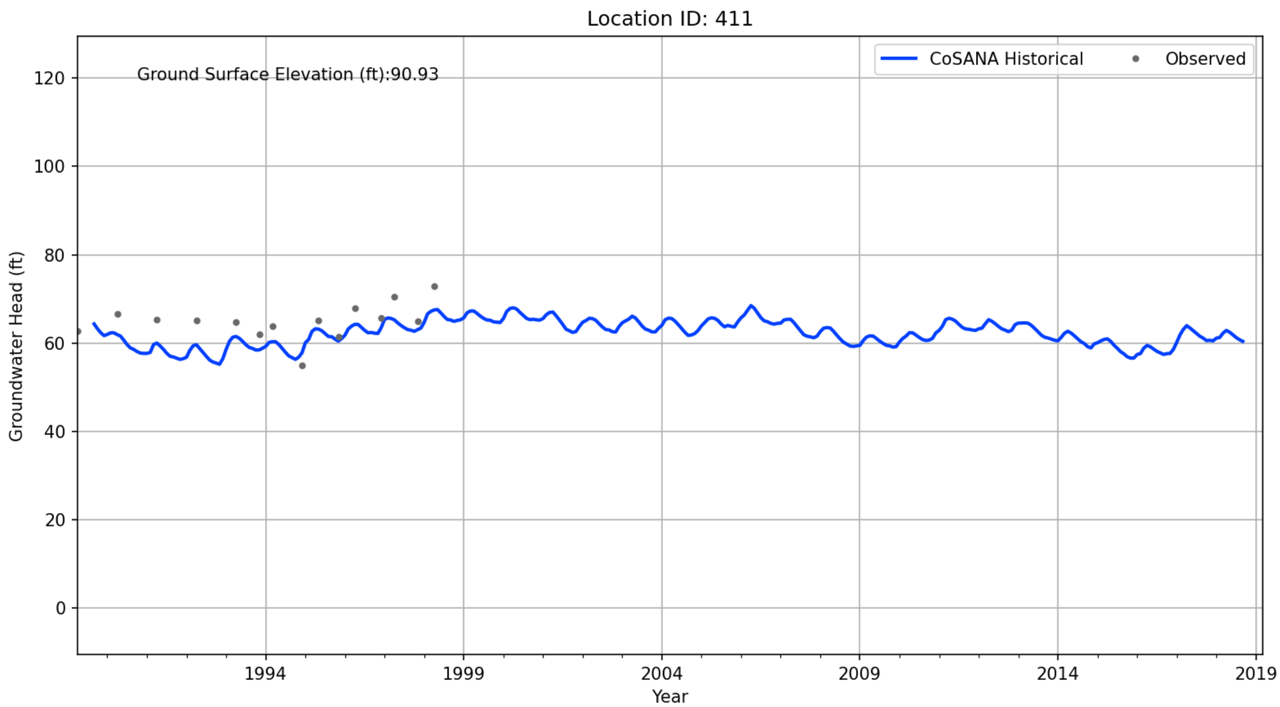



**Figure 4-25: CoSANA Groundwater Level Hydrograph – Hydrograph #1**

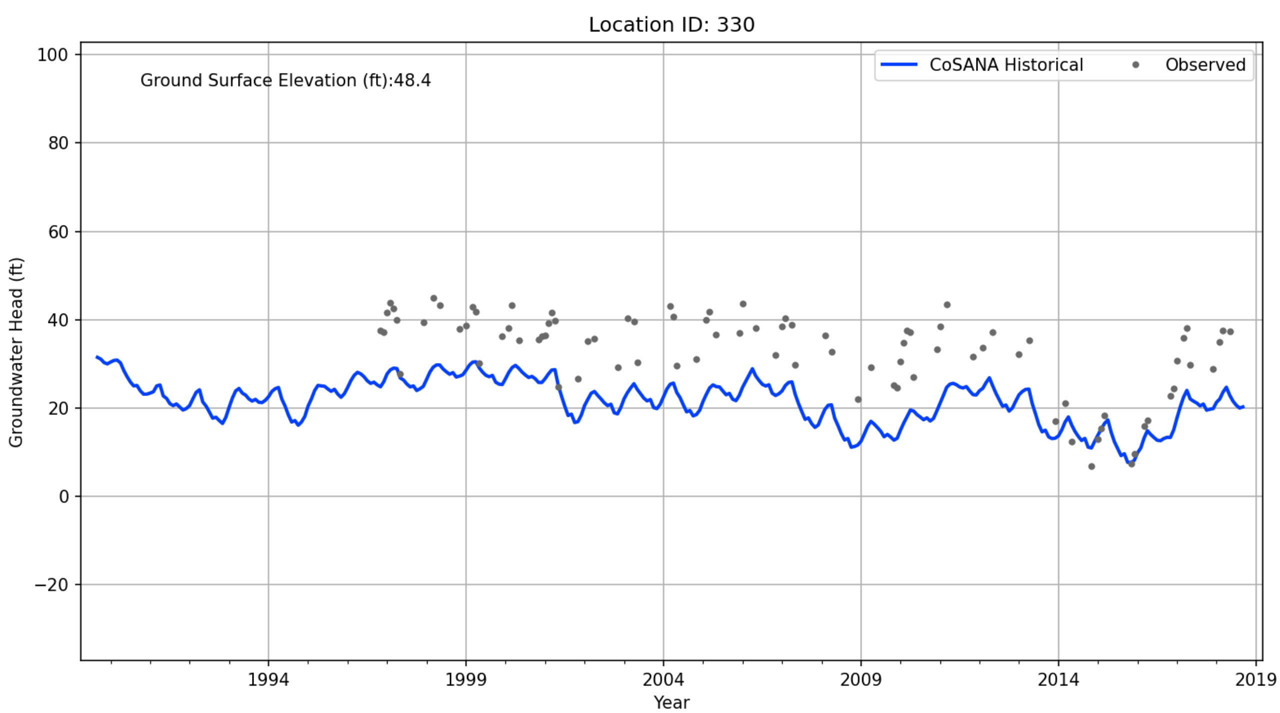



**Figure 4-26: CoSANA Groundwater Level Hydrograph – Hydrograph #2**

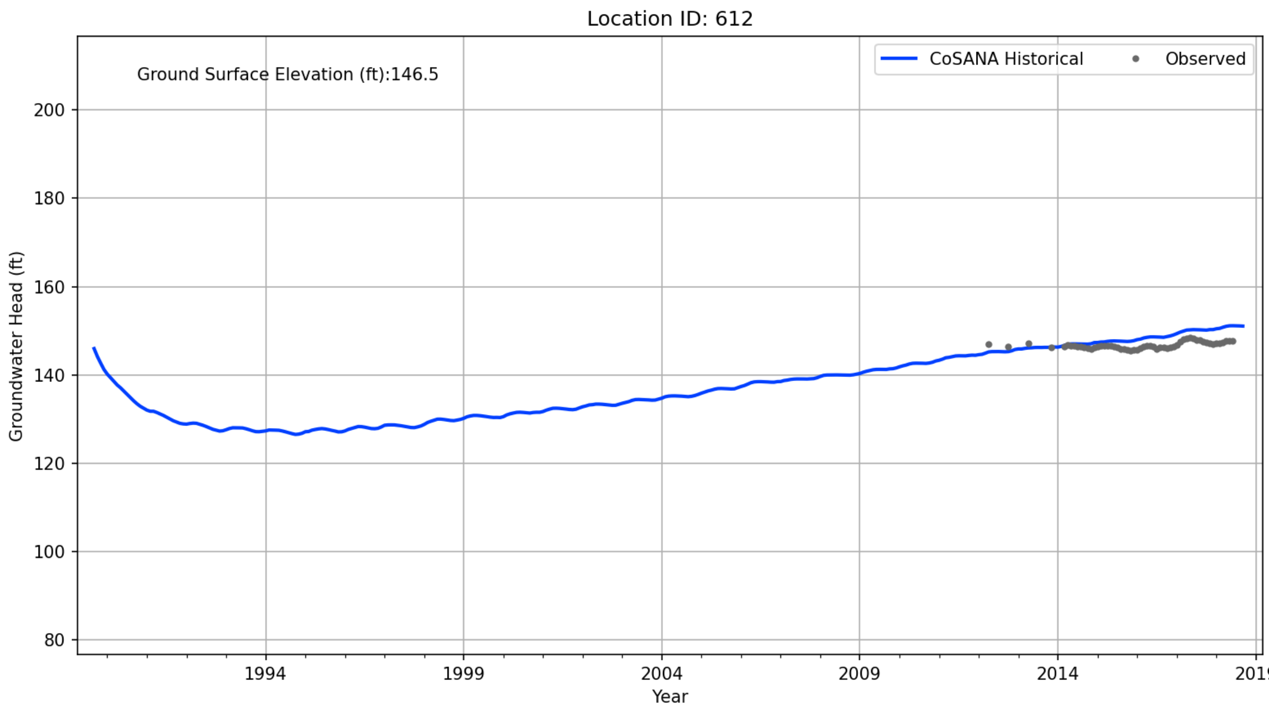



**Figure 4-27: CoSANA Groundwater Level Hydrograph – Hydrograph #3**

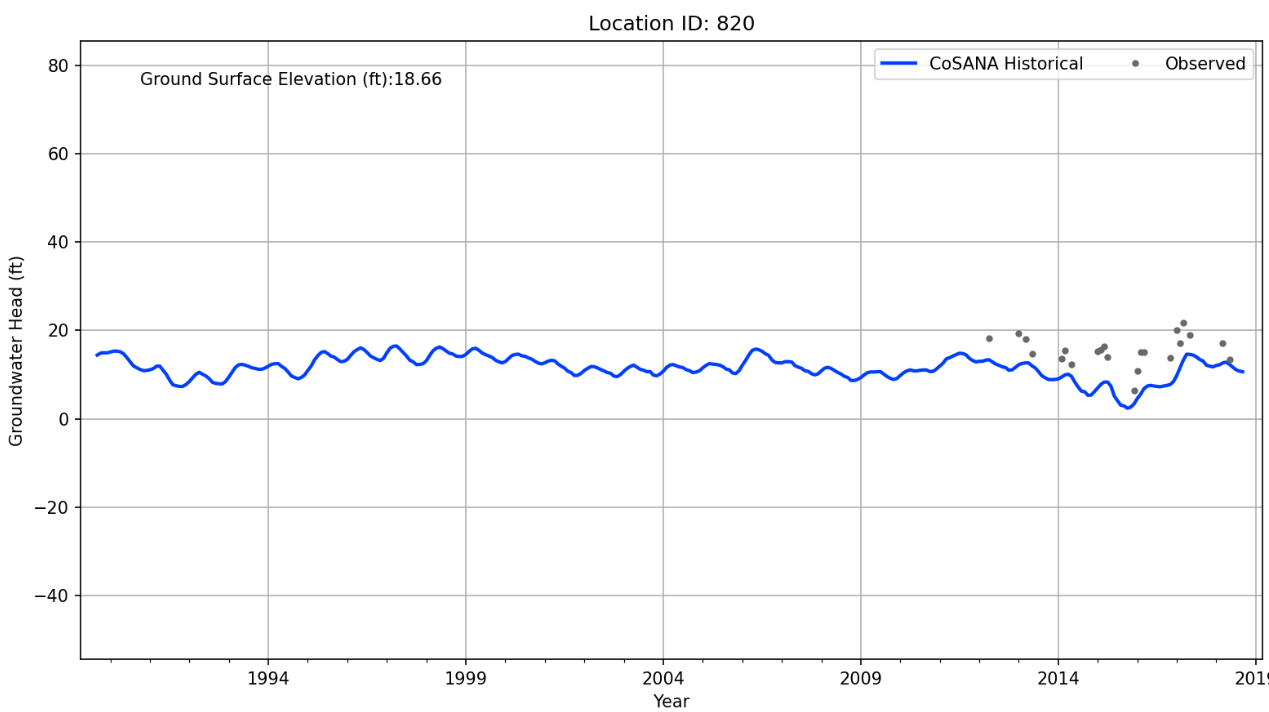



**Figure 4-28: CoSANA Groundwater Level Hydrograph – Hydrograph #4**

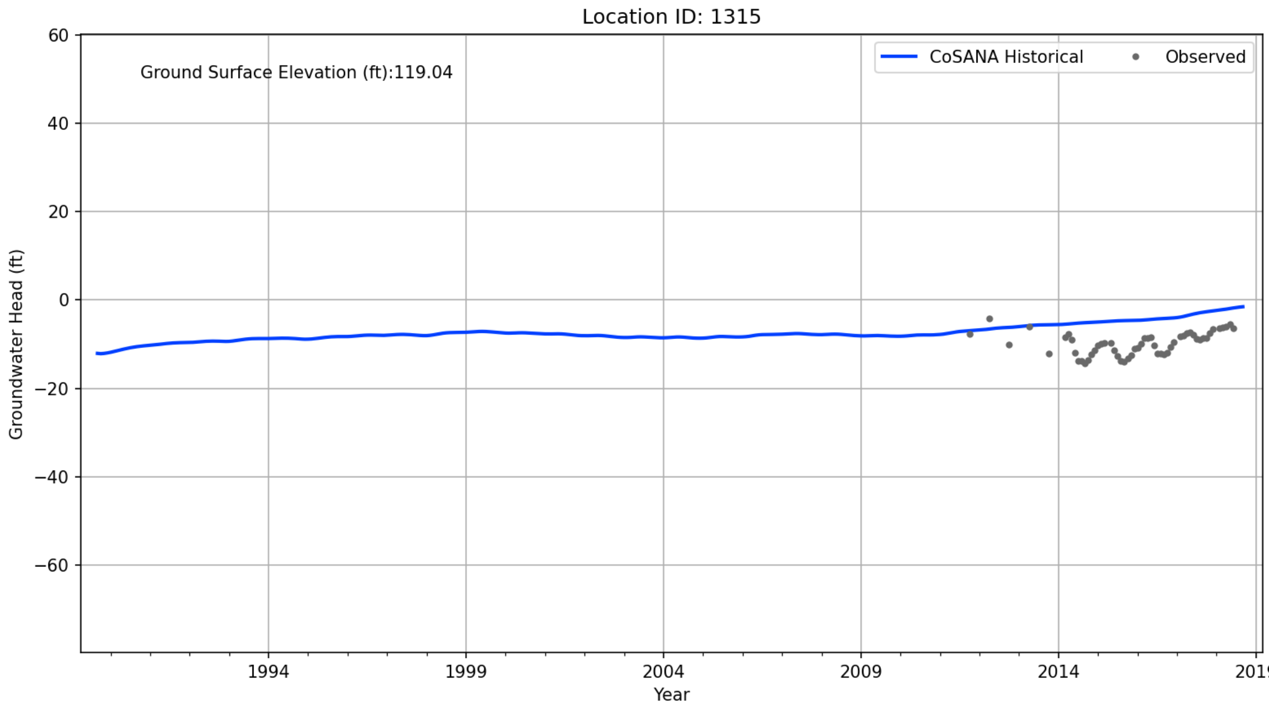



**Figure 4-29: CoSANA Groundwater Level Hydrograph – Hydrograph #5**

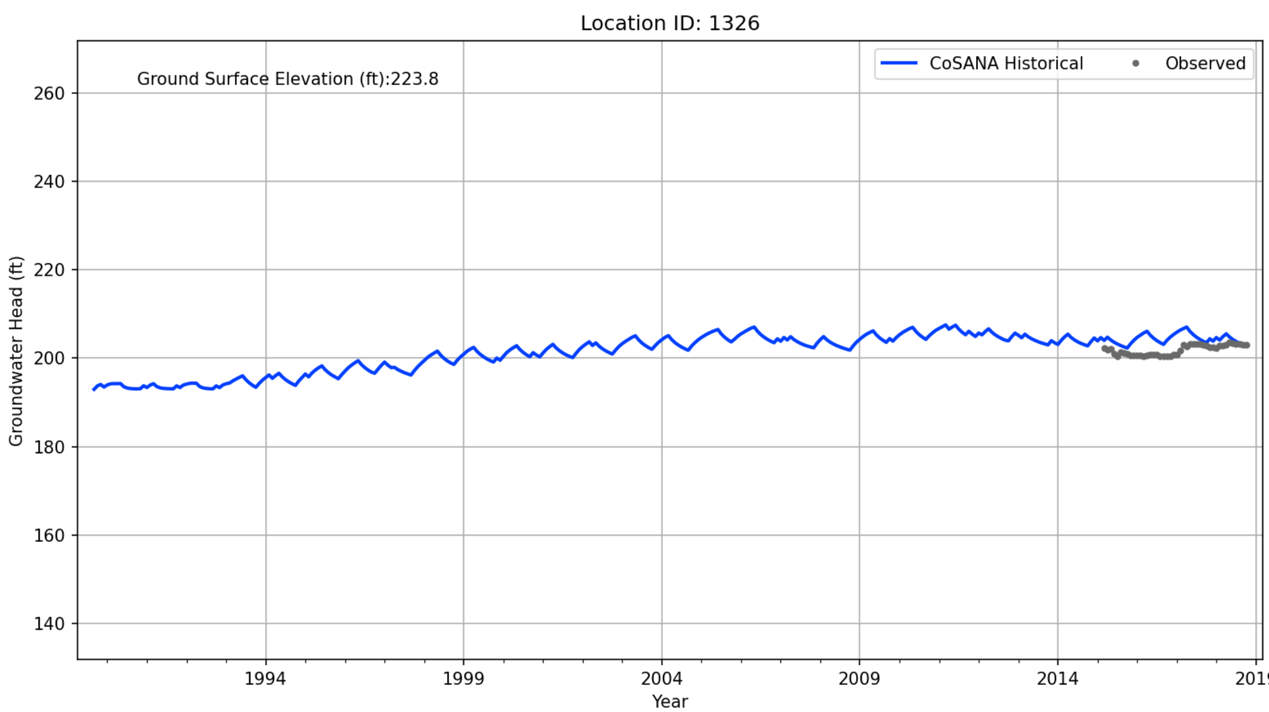



**Figure 4-30: CoSANA Groundwater Level Hydrograph – Hydrograph #6**

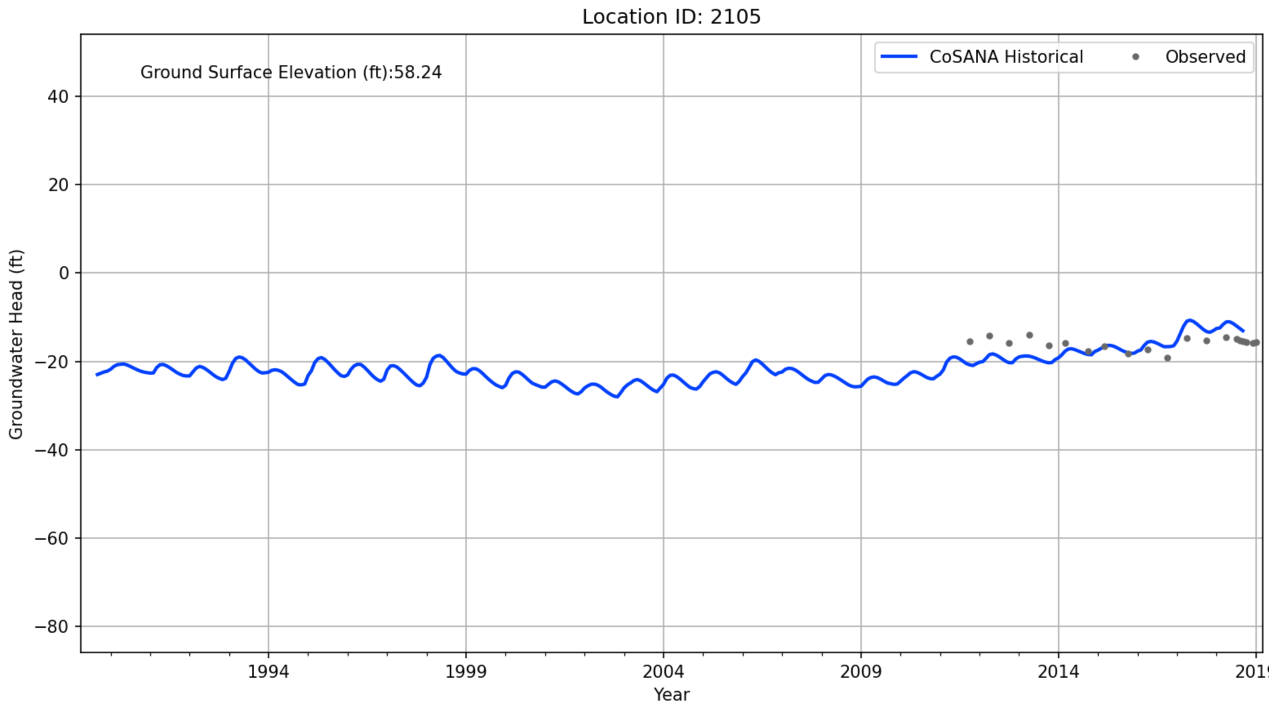



**Figure 4-31: CoSANA Groundwater Level Hydrograph – Hydrograph #7**

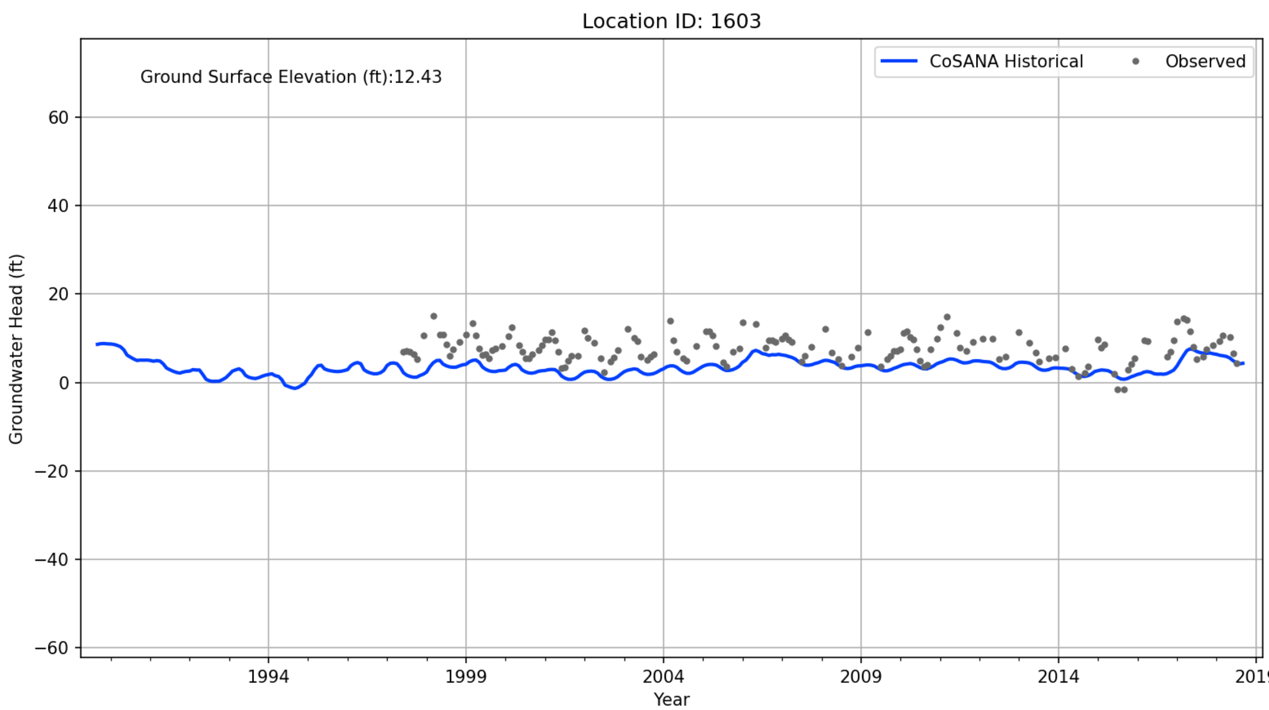



**Figure 4-32: CoSANA Groundwater Level Hydrograph – Hydrograph #8**

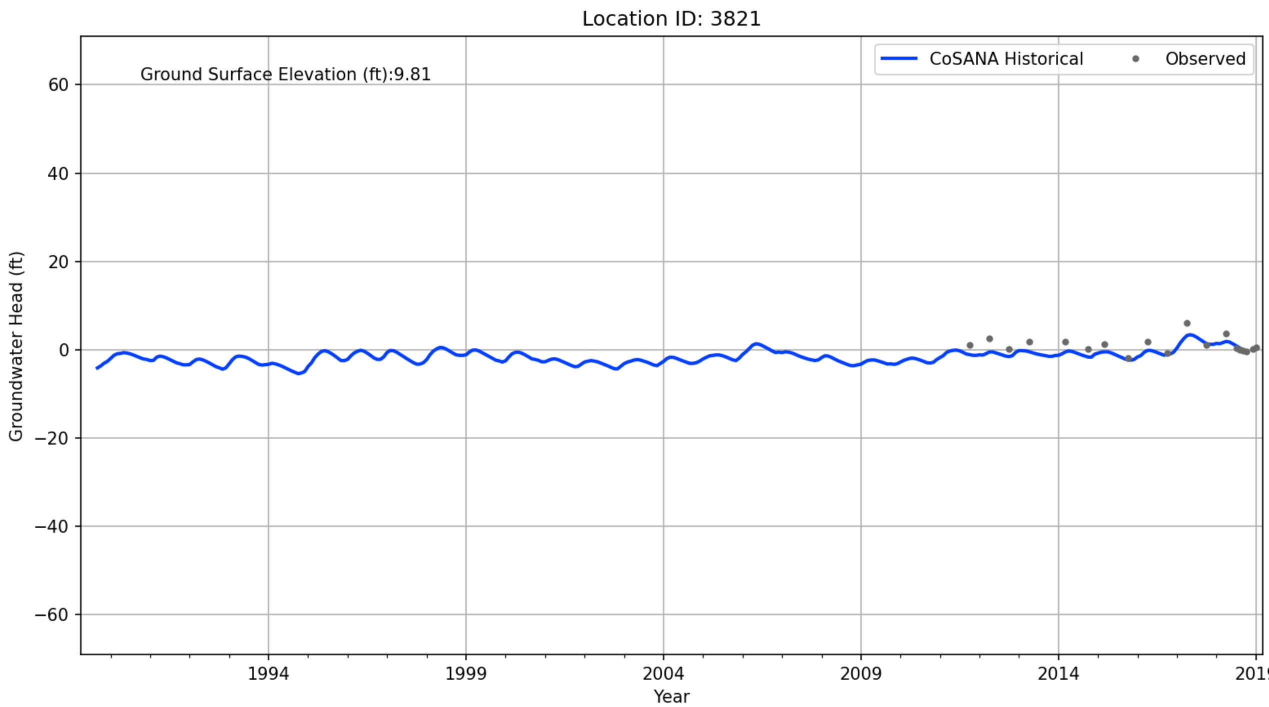



**Figure 4-33: CoSANA Groundwater Level Hydrograph – Hydrograph #9**

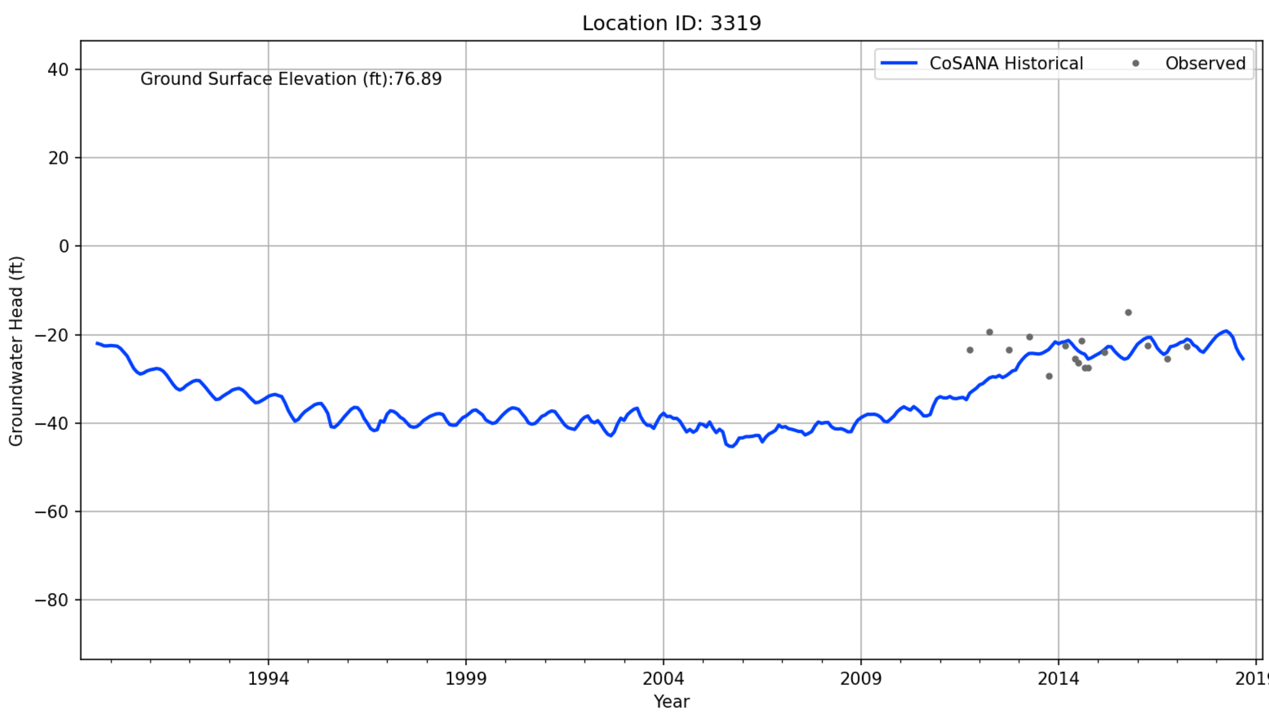



**Figure 4-34: CoSANA Groundwater Level Hydrograph – Hydrograph #10**

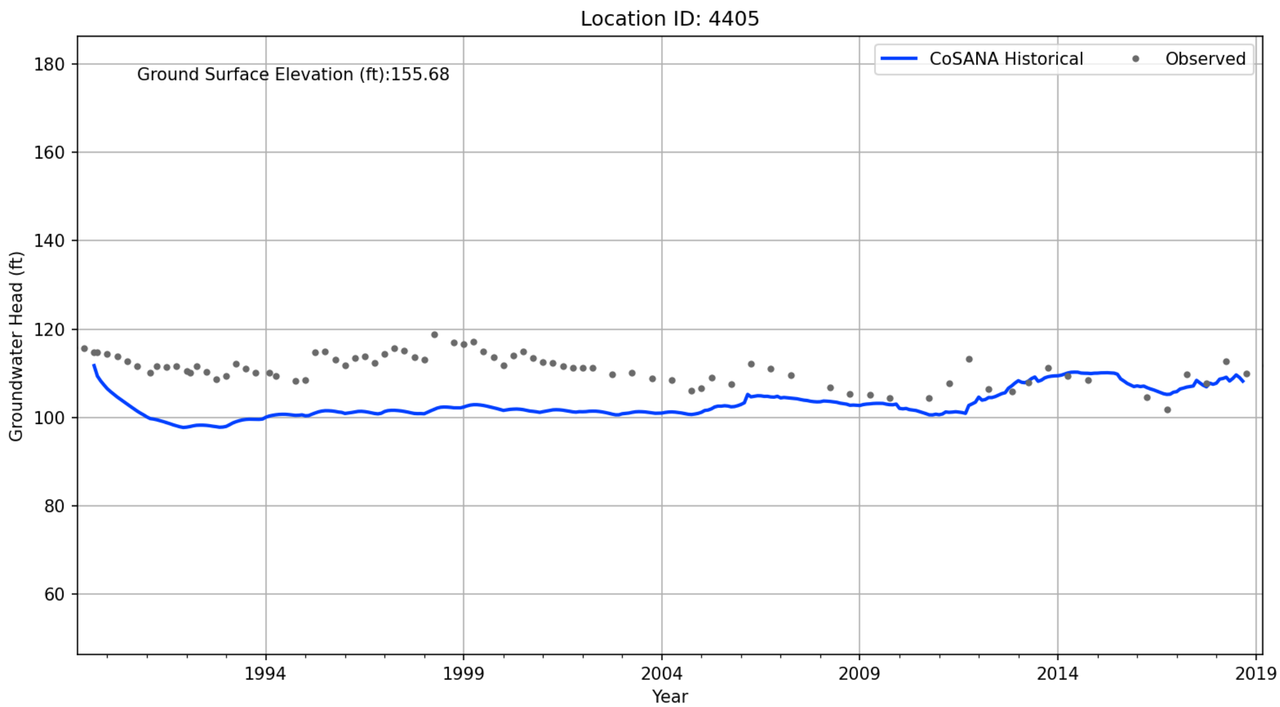



**Figure 4-35: CoSANA Groundwater Level Hydrograph – Hydrograph #11**

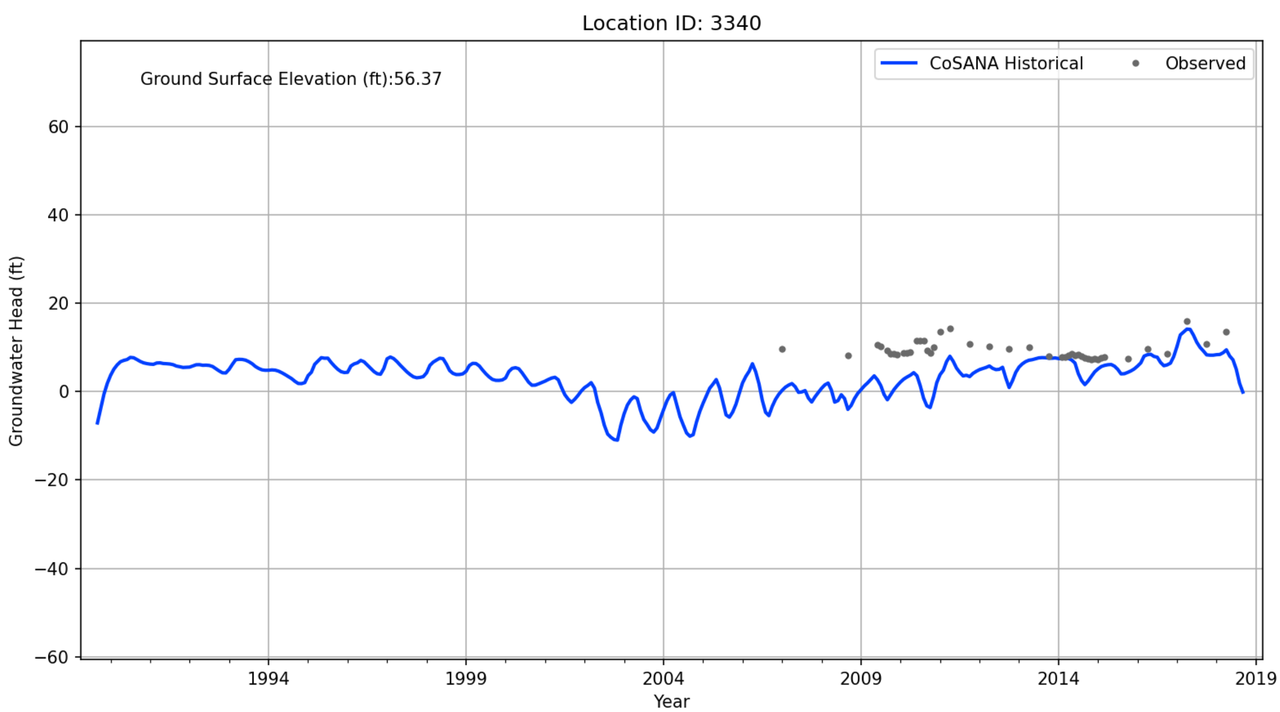



**Figure 4-36: CoSANA Groundwater Level Hydrograph – Hydrograph #12**

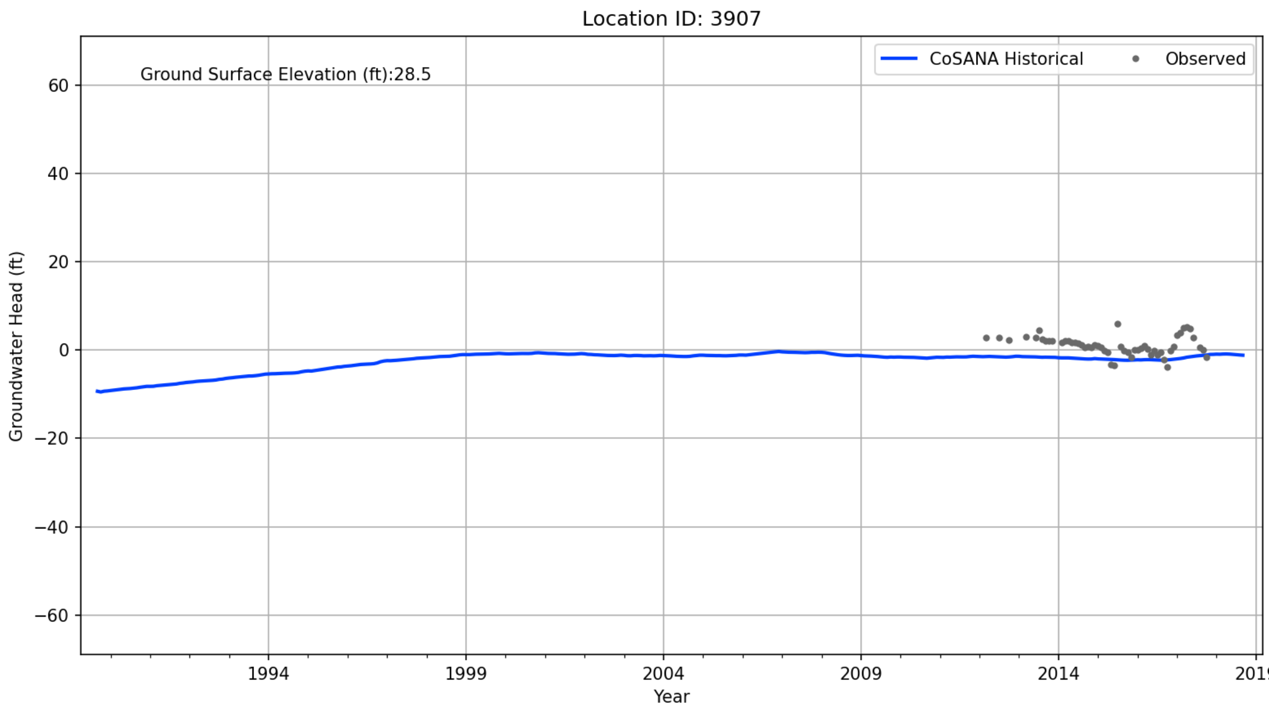



**Figure 4-37: CoSANA Groundwater Level Hydrograph – Hydrograph #13**

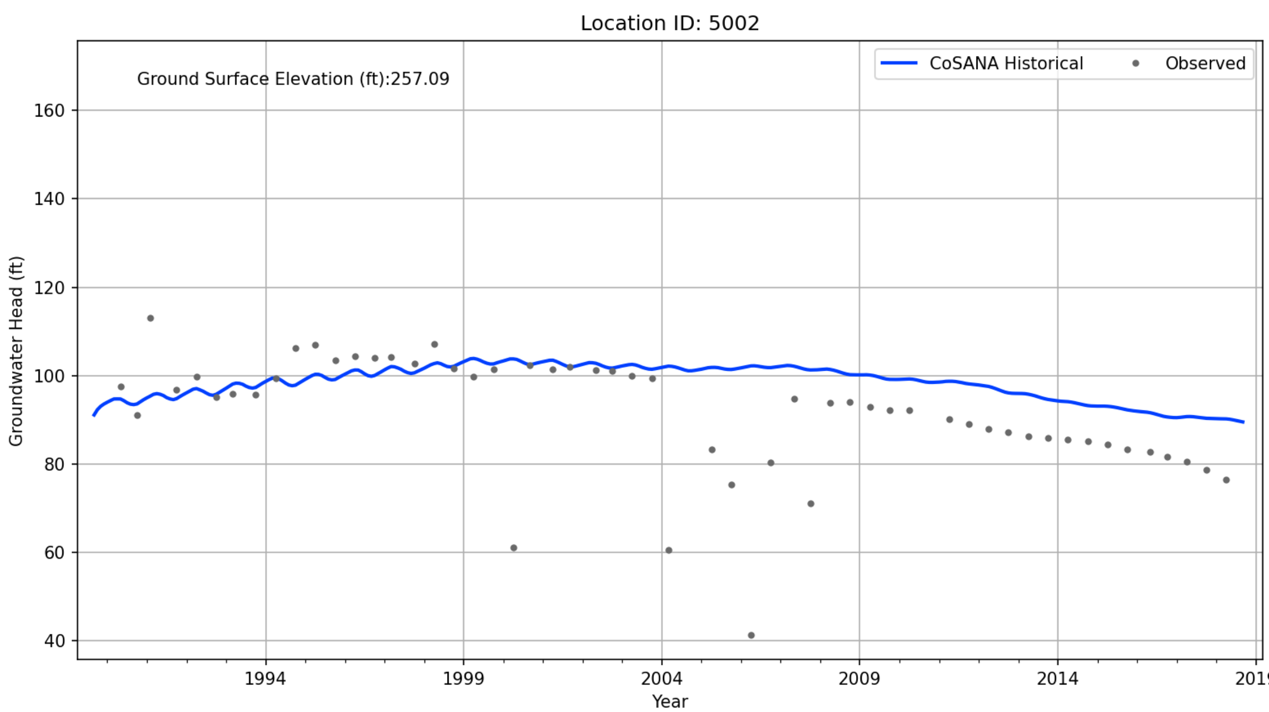



**Figure 4-38: CoSANA Groundwater Level Hydrograph – Hydrograph #14**

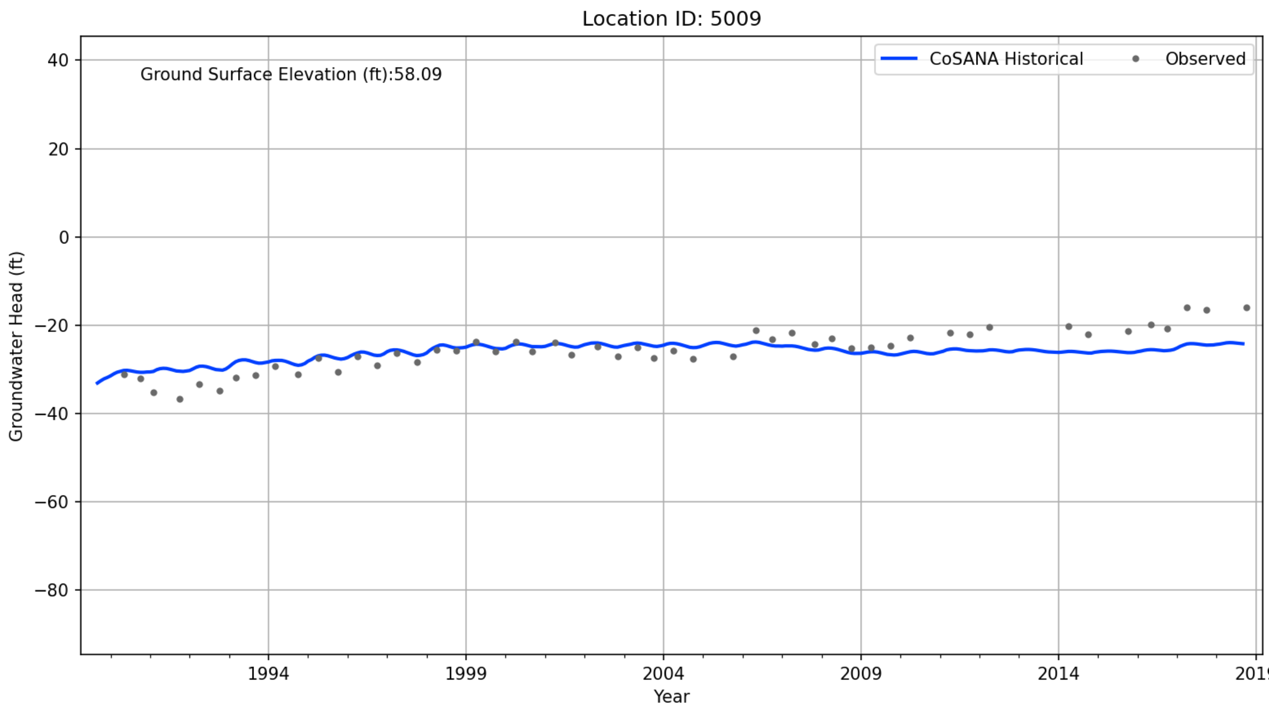



**Figure 4-39: CoSANA Groundwater Level Hydrograph – Hydrograph #15**

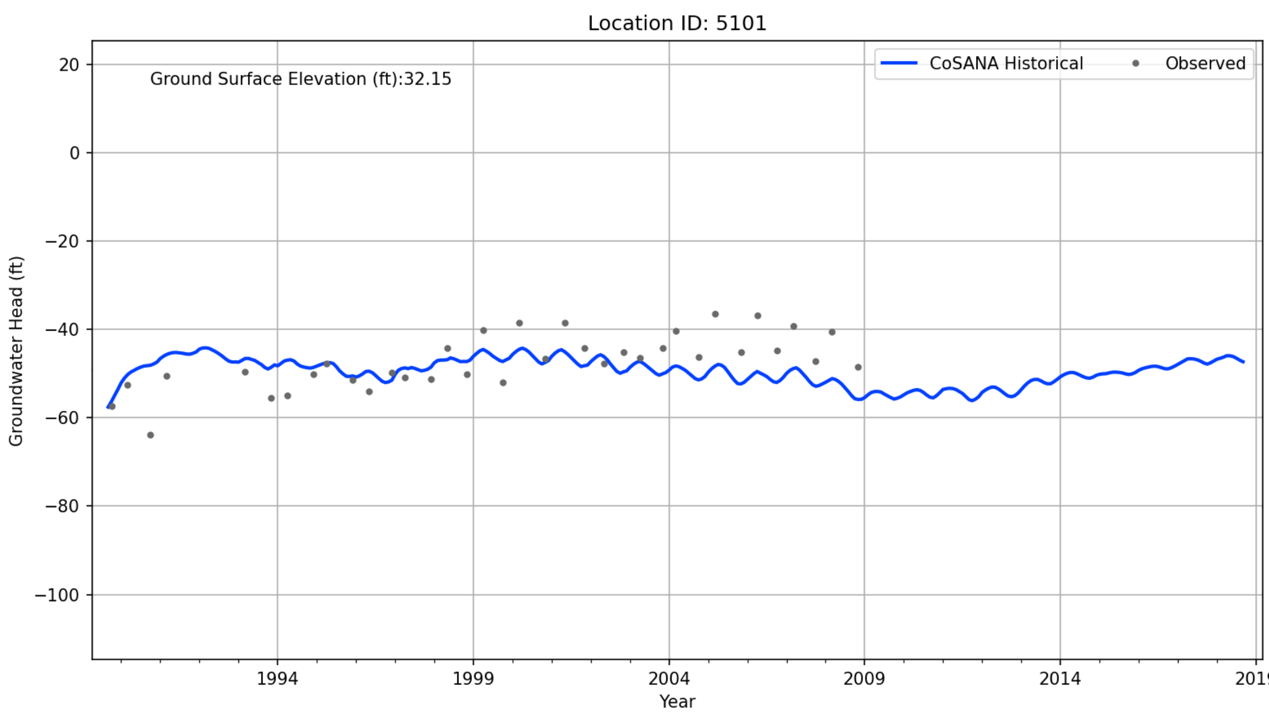



**Figure 4-40: CoSANA Groundwater Level Hydrograph – Hydrograph #16**

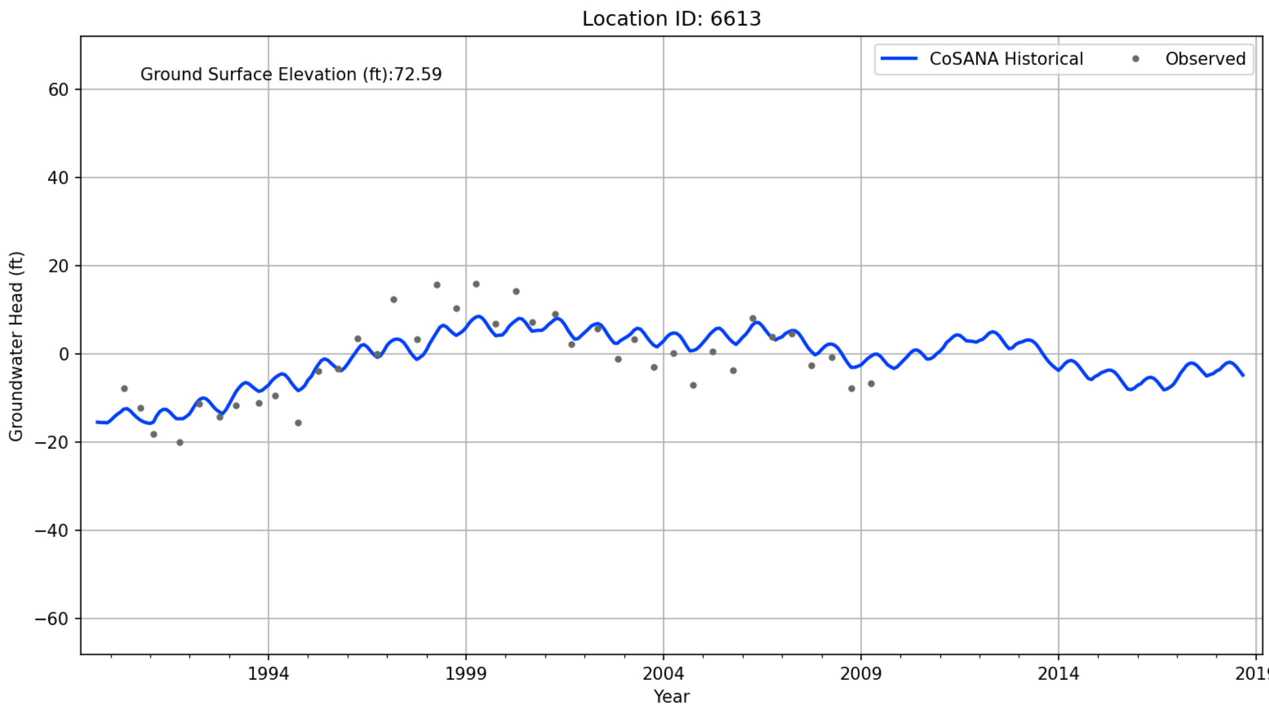



**Figure 4-41: CoSANA Groundwater Level Hydrograph – Hydrograph #17**

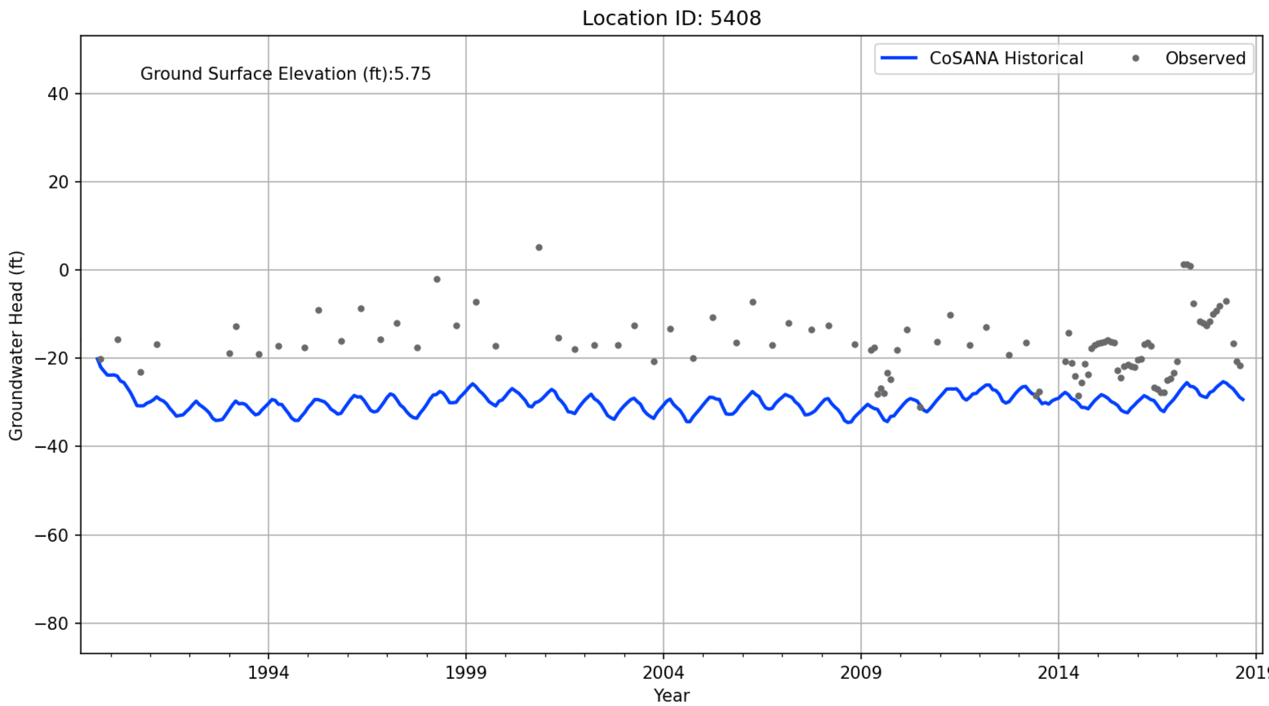



**Figure 4-42: CoSANA Groundwater Level Hydrograph – Hydrograph #18**

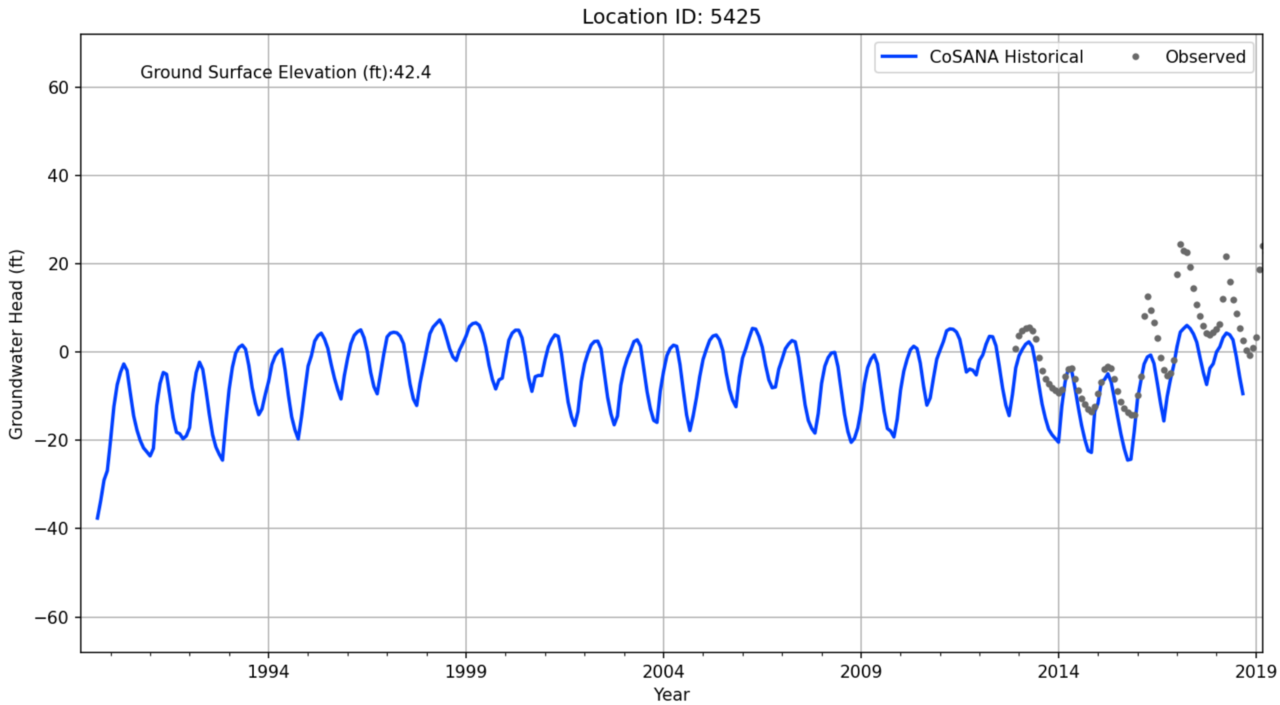



**Figure 4-43: CoSANA Groundwater Level Hydrograph – Hydrograph #19**

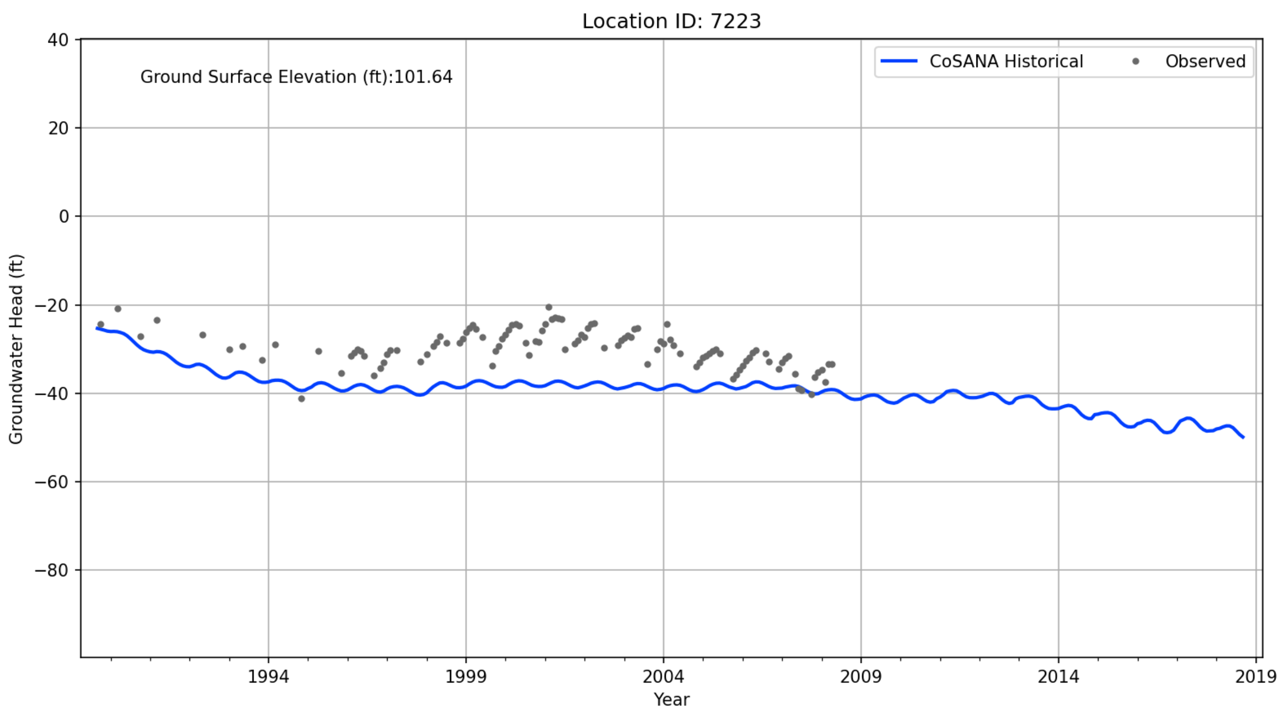



**Figure 4-44: CoSANA Groundwater Level Hydrograph – Hydrograph #20**

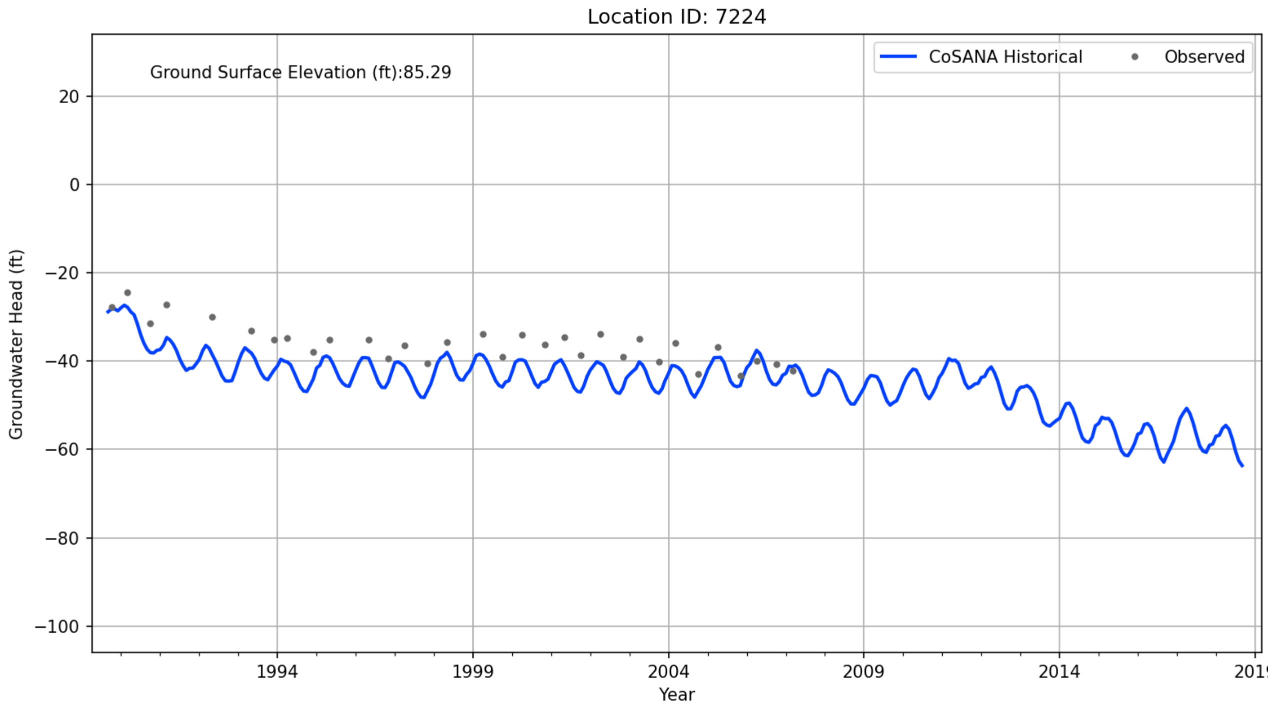



**Figure 4-45: CoSANA Groundwater Level Hydrograph – Hydrograph #21**

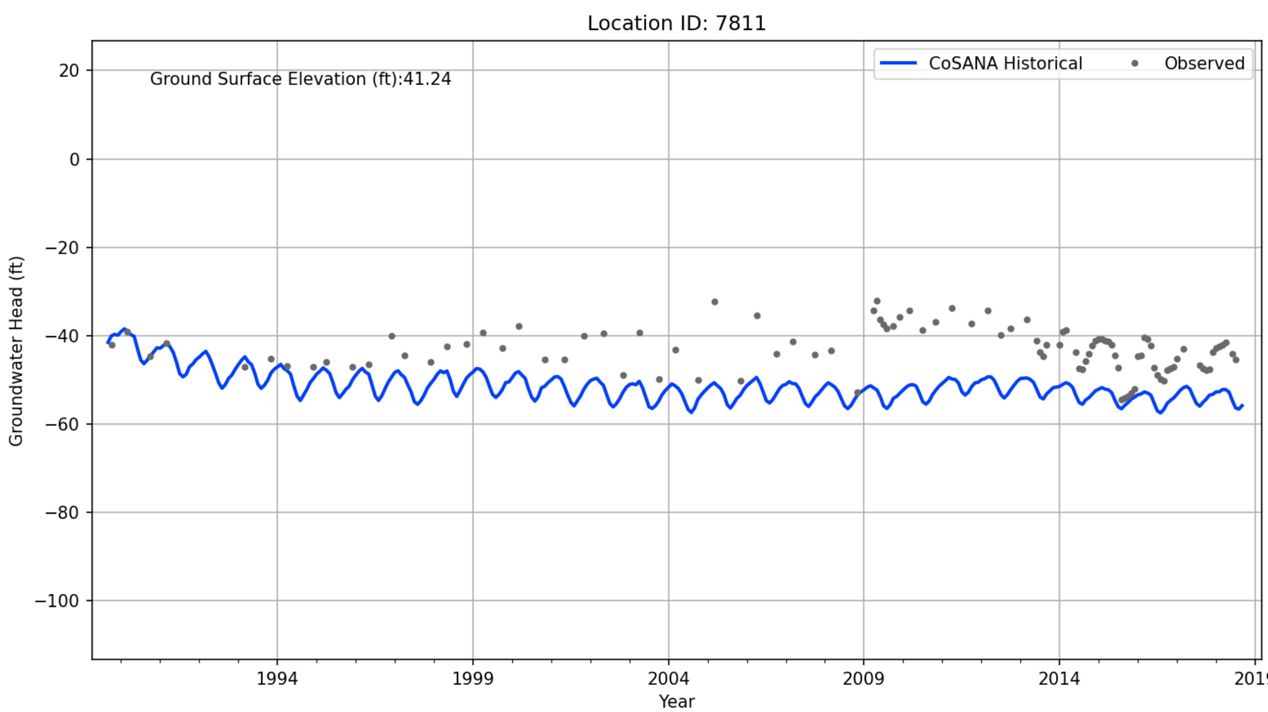



**Figure 4-46: CoSANA Groundwater Level Hydrograph – Hydrograph #22**

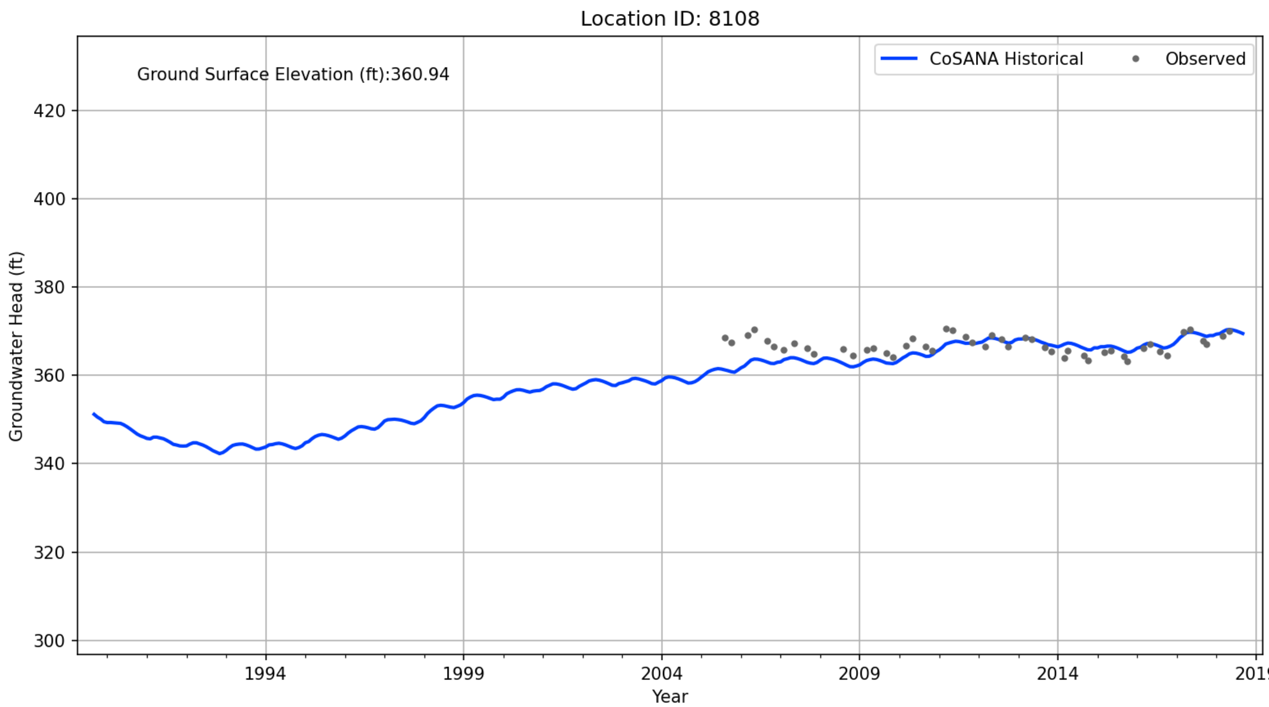



**Figure 4-47: CoSANA Groundwater Level Hydrograph – Hydrograph #23**

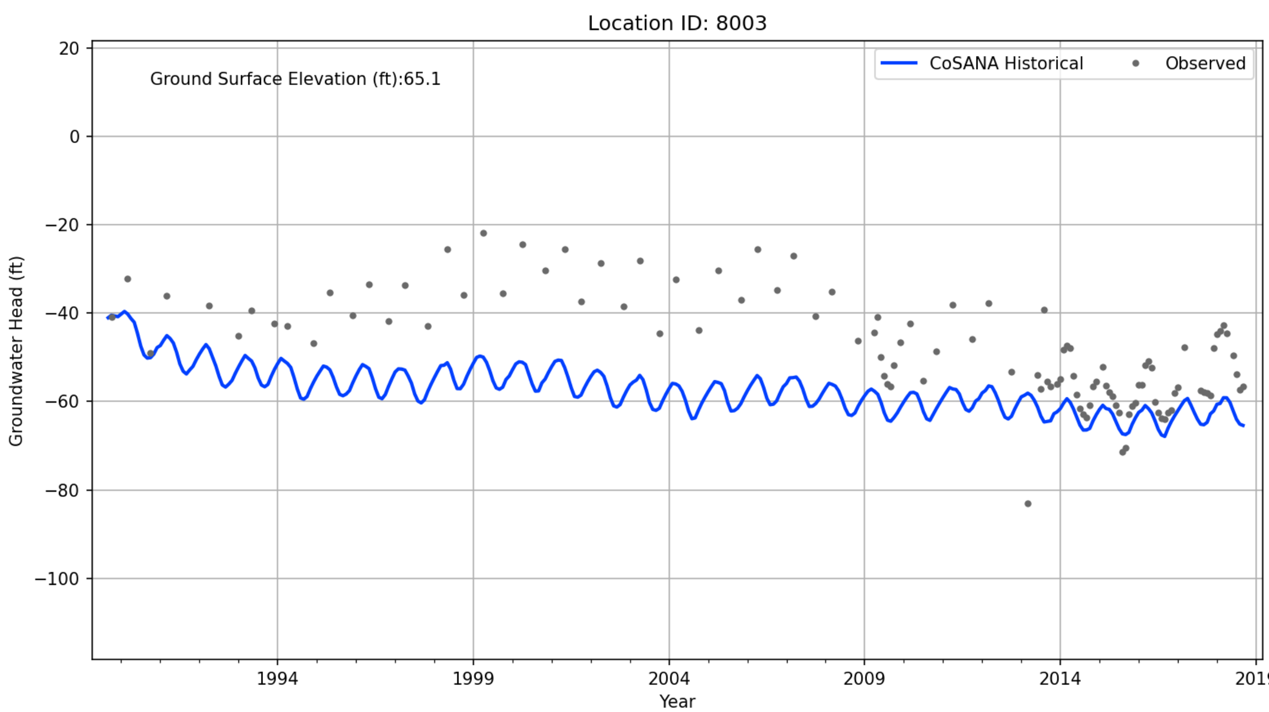



**Figure 4-48: CoSANA Groundwater Level Hydrograph – Hydrograph #24**

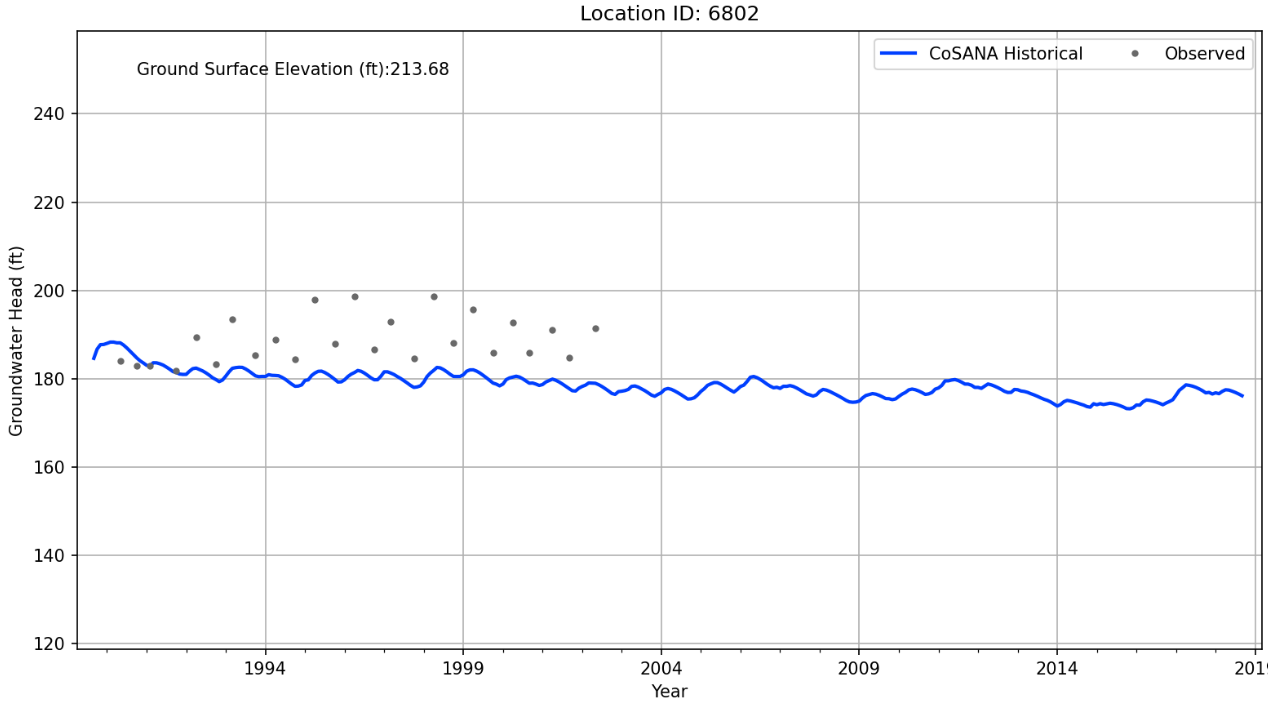



**Figure 4-49: CoSANA Groundwater Level Hydrograph – Hydrograph #25**

### 4.2.3 Streamflow Calibration

Similar to the process for groundwater levels, streamflows are calibrated to achieve reasonable agreement between the simulated and observed values (in this case, streamflows at the gaging stations). Streamflow gaging stations near the eastern boundary of the model are often used for inflow data (see Section 2.4). Other streamflow gaging stations are downstream of these inflow points and associated observed streamflow data can be compared to simulated streamflow in the calibration process. The comparison assists in modifications to parameters associated with stream aquifer interaction.

Streamflow calibration is primarily performed by comparing the simulated streamflow with local data from 15 stream gages (Table 4-3 and Figure 4-50). Data for these gages came from USGS or the California Data Exchange Center (CDEC).

**Table 4-3: Summary of CoSANA Stream Calibration Gages**

| Stream | Stream Node | Description | Agency | Station ID | Period of Record |
|---|---|---|---|---|---|
| American River | 895 | American R at H St Bridge | CA DWR | CDEC ID: HST | 1986 - Present |
| Arcade Creek | 619 | Arcade Cr at Winding Way | Sacramento County | CDEC ID: AMC | 1995 - Present |
| Arcade Creek | 625 | Arcade Cr near Del Paso Heights | USGS | 11447360 | 1995 - Present |
| Arcade Creek | 600 | Arcade Cr at Sunrise Blvd | Sacramento County Dep't Public Works | CDEC ID: ARD | 1997 - Present |
| Bear River | 49 | Bear R at Pleasant Grove Rd | CA DWR | CDEC ID: BPG | 2005 - Present |
| Cosumnes River | 1667 | Cosumnes R at McConnell, CA | USGS | 11336000 | 1941 to 1982 |
| Dry Creek (NASb) | 510 | Dry Cr at Vernon St. Bridge | City of Roseville | CDEC ID: VRS | 1995 - Present |
| Dry Creek (CoSb) | 1998 | Dry Cr near Galt | USGS | 11329500 | 1926 - 1997 |
| Feather River | 107 | Feather R near Nicolaus | CA DWR | CDEC ID: NIC | 1984 - Present |
| Laguna Creek (SASb) | 1202 | Laguna Cr near Eagles Nest Rd. | Sacramento County | CDEC ID: EGN | 1996 - Present |
| Mokelumne River | 2212 | Mokelumne R at Woodbridge | EBMUD | CDEC ID: WBR | 1997 - Present |
| Morrison Creek | 1105 | Morrison Cr at Mack Rd | Sacramento Dep't Public Works | CDEC ID: MCM | 1998 - 2009 |
| Sacramento River | 947 | Sacramento R at I St Bridge | CA DWR | CDEC ID: IST | 1984 - Present |
| Sacramento River | 1020 | Sacramento R at Freeport | USGS | 11447650 | 1948 - Present |

Streamflow calibration included refinement of the streambed hydraulic conductivity originally from C2VSim. The calibrated streambed hydraulic conductivity is shown in Figure 4-51. Simulated streamflows were compared with observed records, and exceedance charts were also used to check the model performance when simulating high and low flows at each gage location. Calibration results for the Sacramento River at Freeport are shown in Figure 4-52 and Figure 4-53. Calibration results for the Cosumnes River at McConnell are shown in Figure 4-54 and Figure 4-55 (note that stage data but not flow data are available at McConnell).

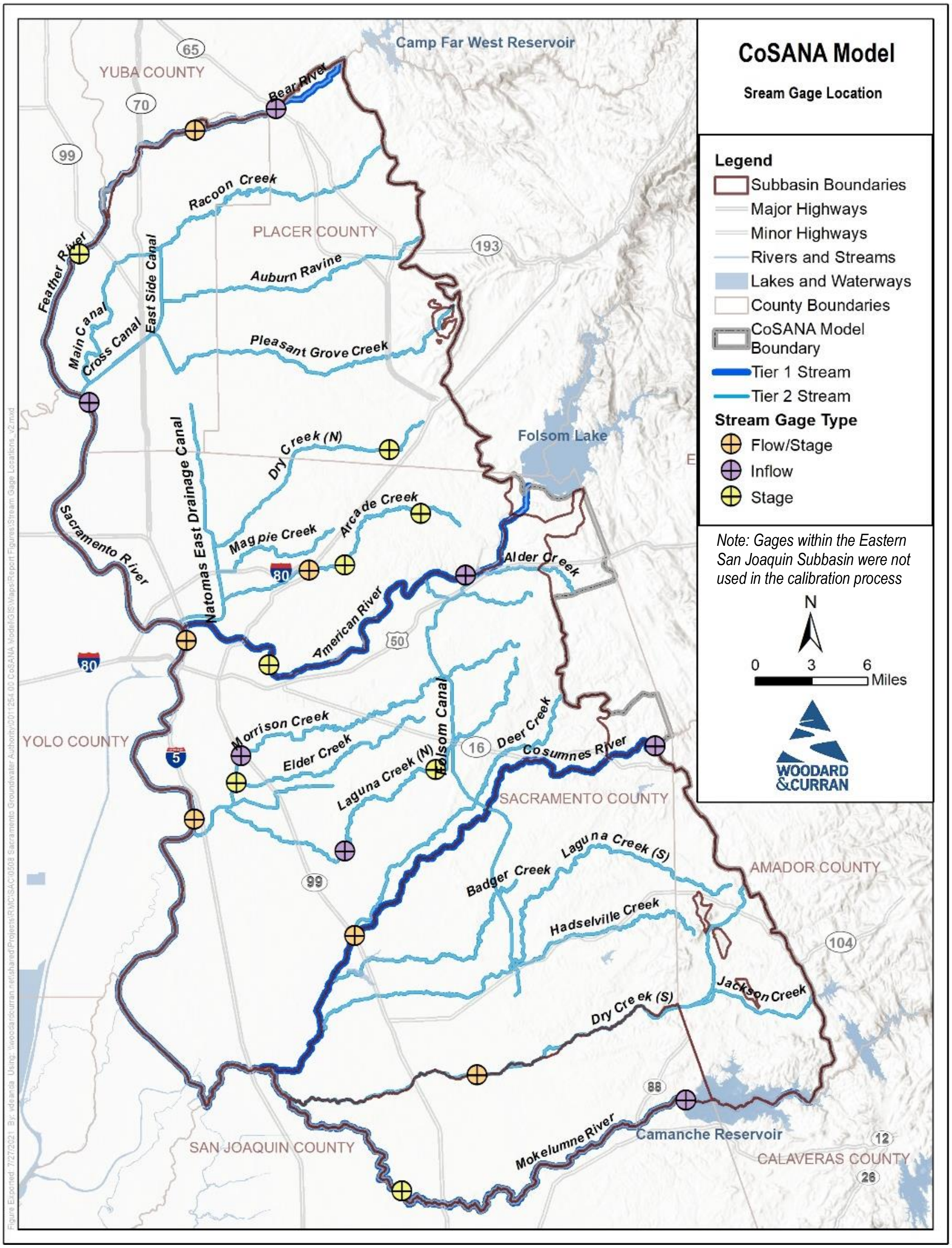



**Figure 4-50: Stream Gage Locations**

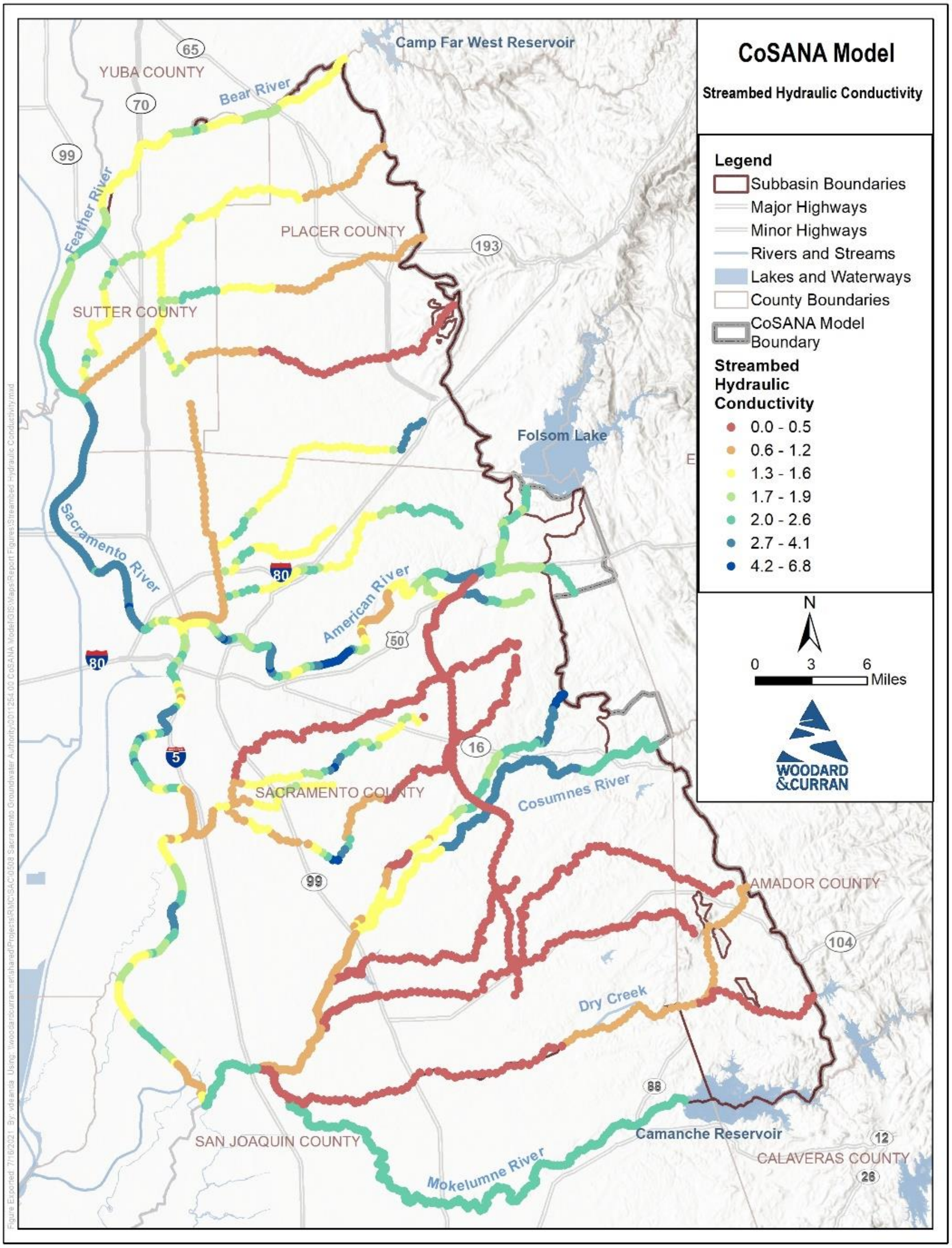



**Figure 4-51: CoSANA Streambed Hydraulic Conductivity**

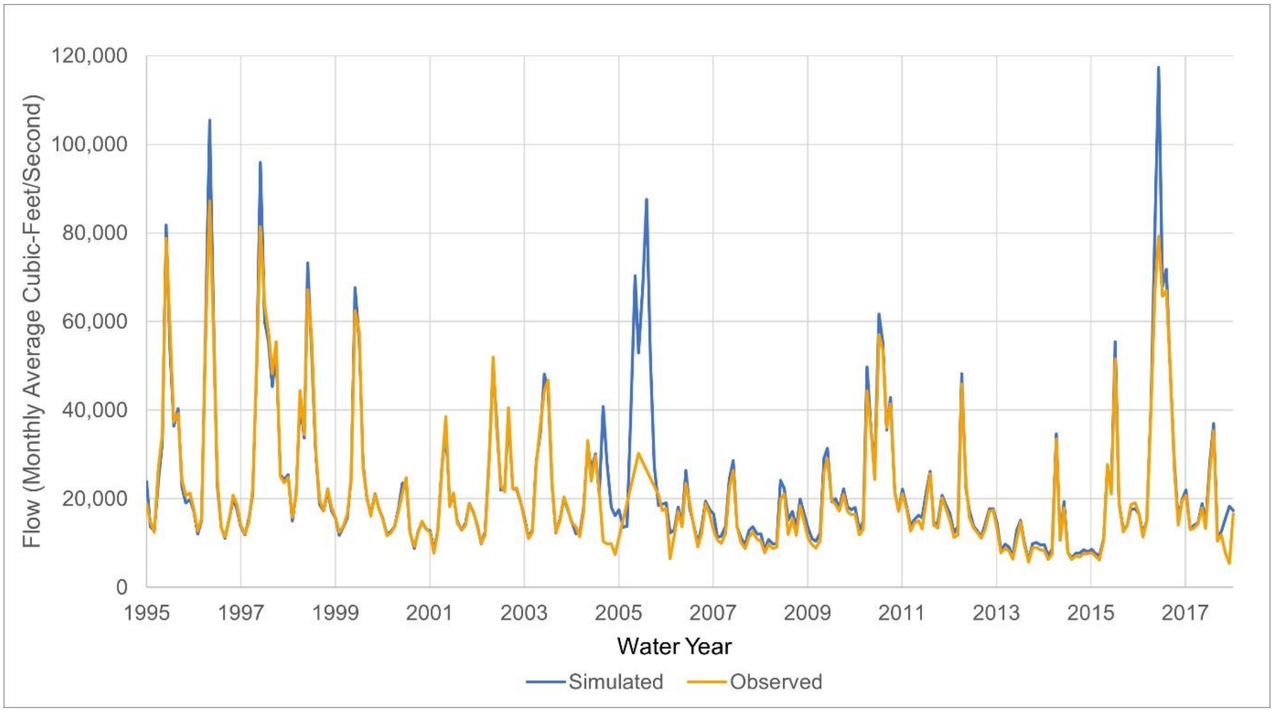



**Figure 4-52: Streamflow Hydrograph for Sacramento River at Freeport, Simulated and Observed**

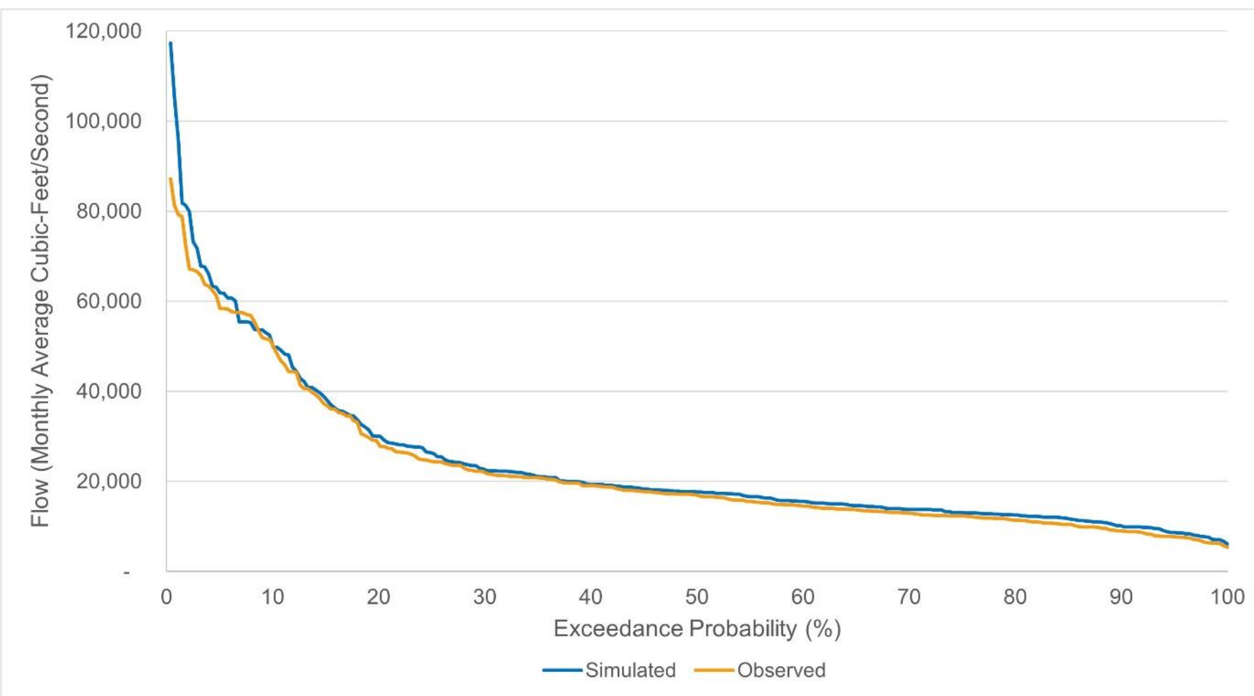



**Figure 4-53: Sacramento River at Freeport Streamflow Exceedance, Simulated and Observed**

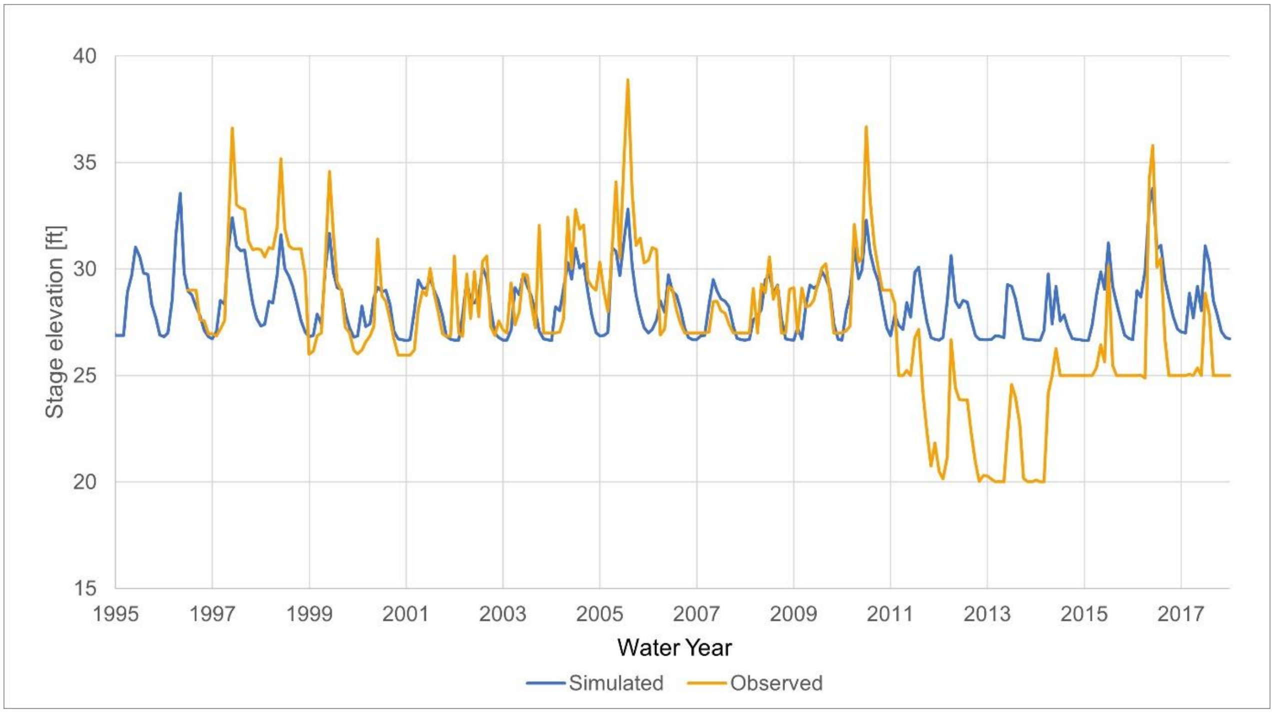
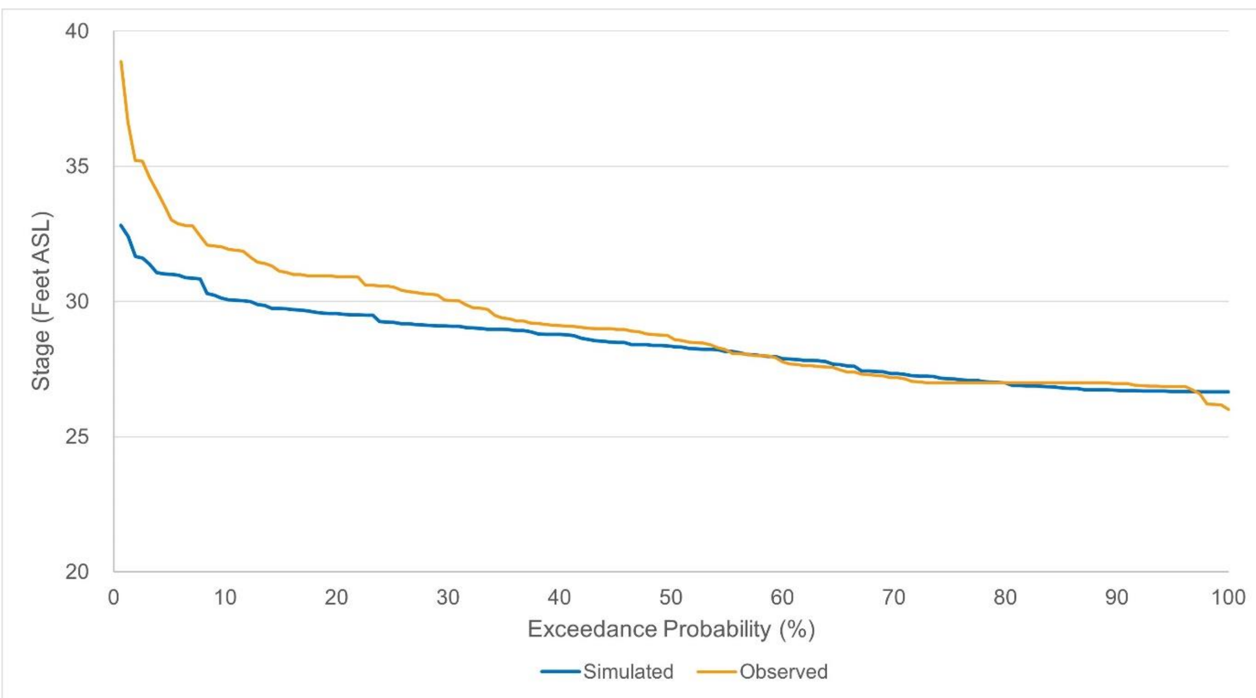



**Figure 4-54: Stage for Cosumnes River at McConnell, Simulated and Observed**




Note: due to apparent vertical datum issues (shown in Figure 4 53) the above exceedance chart shows data from only Mar-1997 to Sept-2010

**Figure 4-55: Cosumnes River at McConnell Stage Exceedance, Simulated and Observed**

### 4.2.4 Small Watershed Calibration

As discussed in Section 2.11, small watersheds are used to simulate inflows into the model from ungaged 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 4.2.2) were referenced to confirm and edit, as necessary, the various parameters of the small watersheds.

The distribution of small watershed inflows between surface runoff, percolation, and baseflow is primarily driven by the maximum recharge rate and recession coefficients. The recession coefficient governs how much of the total water enters the system as surface water and groundwater. The maximum recharge controls the percolation from runoff. Observed groundwater hydrographs along the model boundary were used to assess how much watersheds contributed to groundwater levels with a focus on seasonal fluctuations. Parameter adjustments were implemented across the small watersheds to maintain reasonable groundwater elevations and streamflows. Additionally, some small watersheds were turned off where additional data were available to characterize the inflows.

There is considerable uncertainty in subsurface conditions and nature of hydraulic interactions between the small watersheds adjacent and upslope to the Cosumnes Subbasin. Two small watersheds adjacent to Cosumnes Subbasin were set to zero area to minimize adjacent flooding of the Foothills Subarea (flooding refers the condition when model-calculated water levels exceed land surface). As Jackson Creek is controlled by Lake Amador dam, it was instead specified as a stream inflow. The Lower Sutter Creek watershed area is the next largest contributing small watershed whose surficial geology is composed of Jurassic-age bedrock, and therefore was assumed that no baseflow or subsurface percolation to groundwater occurs from this watershed. Even with these specifications, model-calculated water budgets and groundwater levels indicated additional data and model refinements are needed to improve reliability in this portion of the Cosumnes Subbasin.

## 4.3 Calibration Statistics and Goodness of Fit

The CoSANA calibration was primarily assessed using two metrics: groundwater level trends and the correlation between simulated and observed groundwater levels. In addition to quantifiable metrics, the CoSANA calibration included comparisons and modifications to result in regional groundwater flow directions and water budgets that are consistent with available information on observed conditions and consistent with the understanding of basin conditions by stakeholders.

Statistics related to the differences between simulated and observed groundwater levels were evaluated relative to the American Standard Testing Method (ASTM) standard. 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 a range in groundwater levels of approximately 500 feet. Using 10 percent as the small fraction, the acceptable residual level would be 50 feet. The calibration exceeds that standard, as shown by the following statistics.

- 56% of observed groundwater levels are within +/- 10 feet of its respective simulated values
- 83% of observed groundwater levels are within +/- 20 feet of its respective simulated values
- 94% of observed groundwater levels are within +/- 30 feet of its respective simulated values

The residual histogram for the CoSANA is shown in Figure 4-56. Additionally, a scatter plot of simulated versus observed values is shown in Figure 4-57.

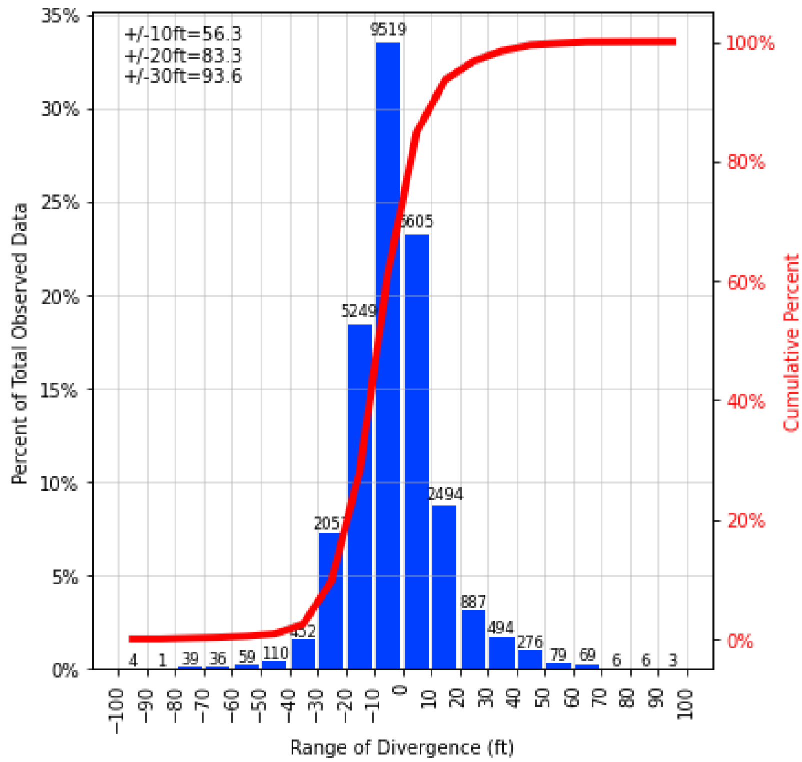
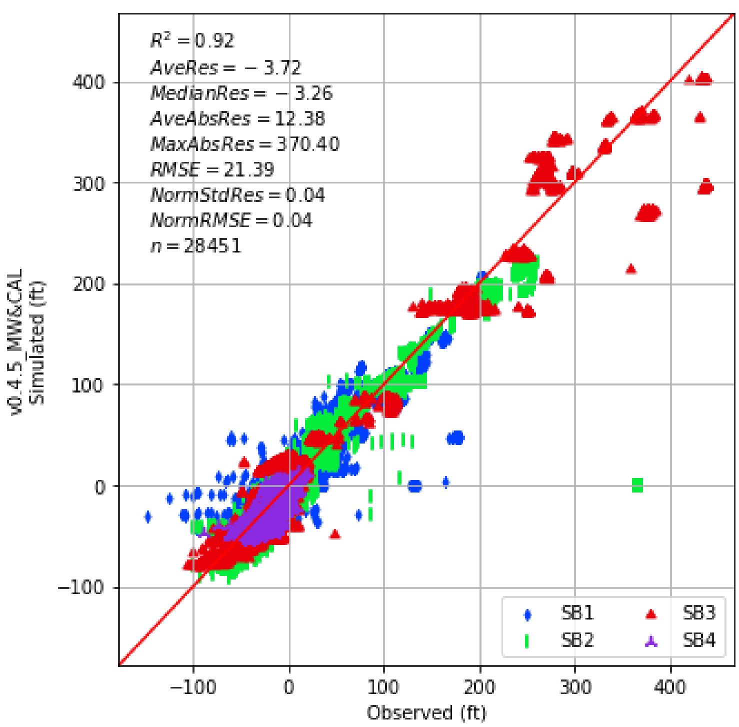



**Figure 4-56: Residual histogram for the CoSANA Model**




*Note: SB1 = NASb, SB2 = SASb, SB3 = CoSb, SB4 = Eastern San Joaquin Subbasin*

**Figure 4-57: Scatter Plot of CoSANA Simulated versus Observed Values**

## 4.4 Final Calibration Parameters

The parameters resulting from the calibration process are listed in Table 4-4. The spatial distribution of horizontal hydraulic conductivity is presented in Figure 4-58 through Figure 4-62.

**Table 4-4: Range of Aquifer Parameter Values**

| Data | | Layer 1 | Layer 2 | Layer 3 | Layer 4 | Layer 5 |
|---|---|---|---|---|---|---|
| Horizontal Hydraulic Conductivity (ft/day) | Minimum | 2.1 | 1.9 | 0.65 | 0.58 | 0.33 |
| | Average | 33.9 | 24.1 | 16.3 | 14.1 | 10.2 |
| | Maximum | 108.3 | 86.8 | 51.9 | 42.0 | 37.6 |
| Vertical Hydraulic Conductivity (ft/day) | Minimum | 0.012 | 0.0066 | 0.00045 | 0.0020 | 0.0012 |
| | Average | 0.99 | 0.73 | 0.19 | 0.42 | 0.35 |
| | Maximum | 4.6 | 5.2 | 2.0 | 2.6 | 2.3 |
| Specific Storage (1/ft) | Minimum | $2.67 \times 10^{-6}$ | $1.88 \times 10^{-6}$ | $1.54 \times 10^{-6}$ | $1.15 \times 10^{-6}$ | $9.80 \times 10^{-6}$ |
| | Average | $6.30 \times 10^{-5}$ | $6.40 \times 10^{-5}$ | $5.95 \times 10^{-5}$ | $6.09 \times 10^{-5}$ | $7.52 \times 10^{-5}$ |
| | Maximum | $4.73 \times 10^{-4}$ | $4.59 \times 10^{-4}$ | $4.68 \times 10^{-4}$ | $4.91 \times 10^{-4}$ | $4.96 \times 10^{-4}$ |
| Specific Yield (unitless) | Minimum | 0.057 | 0.068 | 0.056 | 0.073 | 0.052 |
| | Average | 0.13 | 0.12 | 0.13 | 0.13 | 0.11 |
| | Maximum | 0.24 | 0.22 | 0.24 | 0.24 | 0.22 |
| Transmissivity ($ft^2$/day) | Minimum | 0.64 | 0.067 | 0.077 | 0.25 | 0.23 |
| | Average | 2,765 | 5,128 | 9,679 | 3,489 | 1,726 |
| | Maximum | 15,005 | 24,090 | 69,562 | 17,019 | 11,078 |

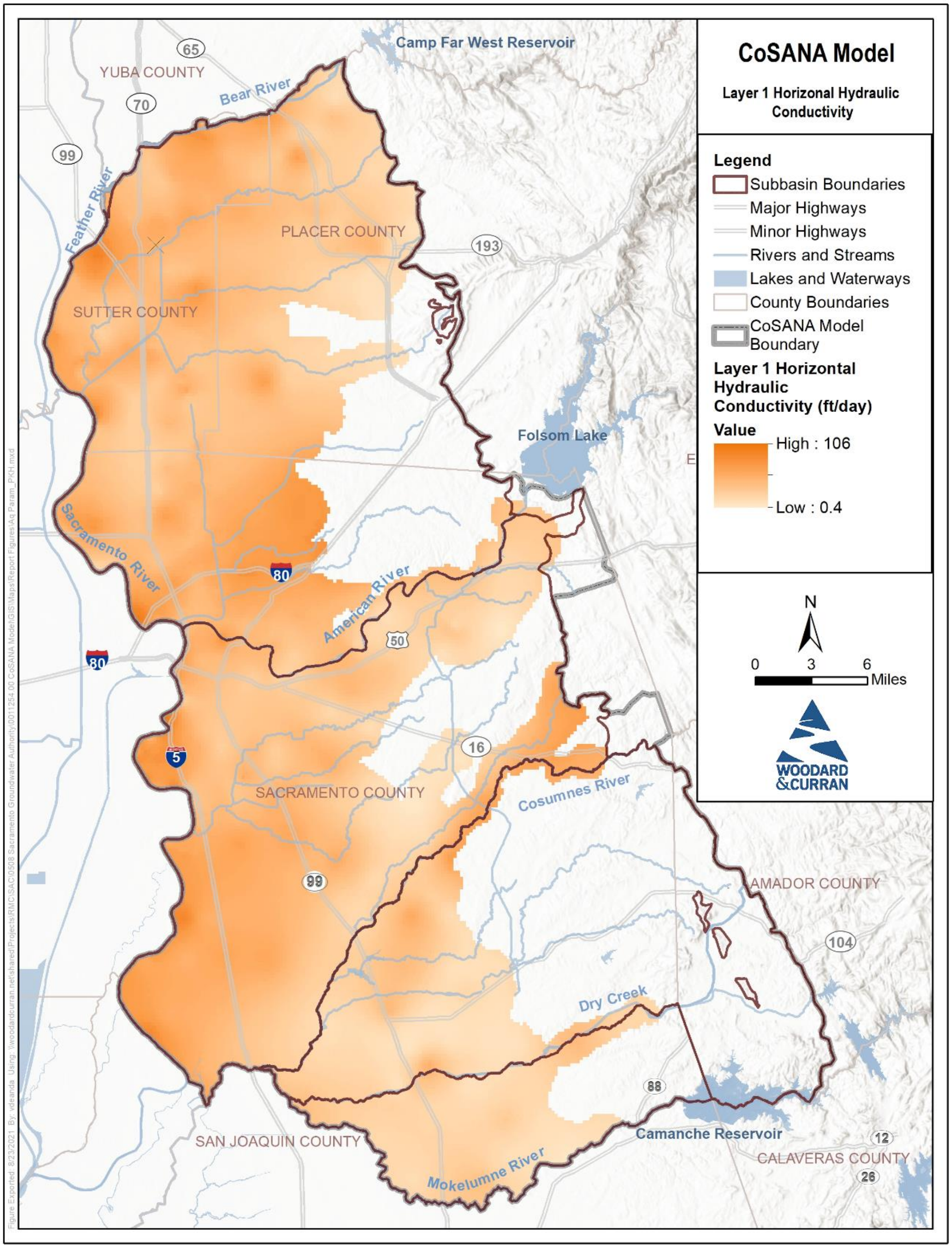



**Figure 4-58: Distribution of CoSANA Layer 1 Horizontal Hydraulic Conductivity ($K_H$)**

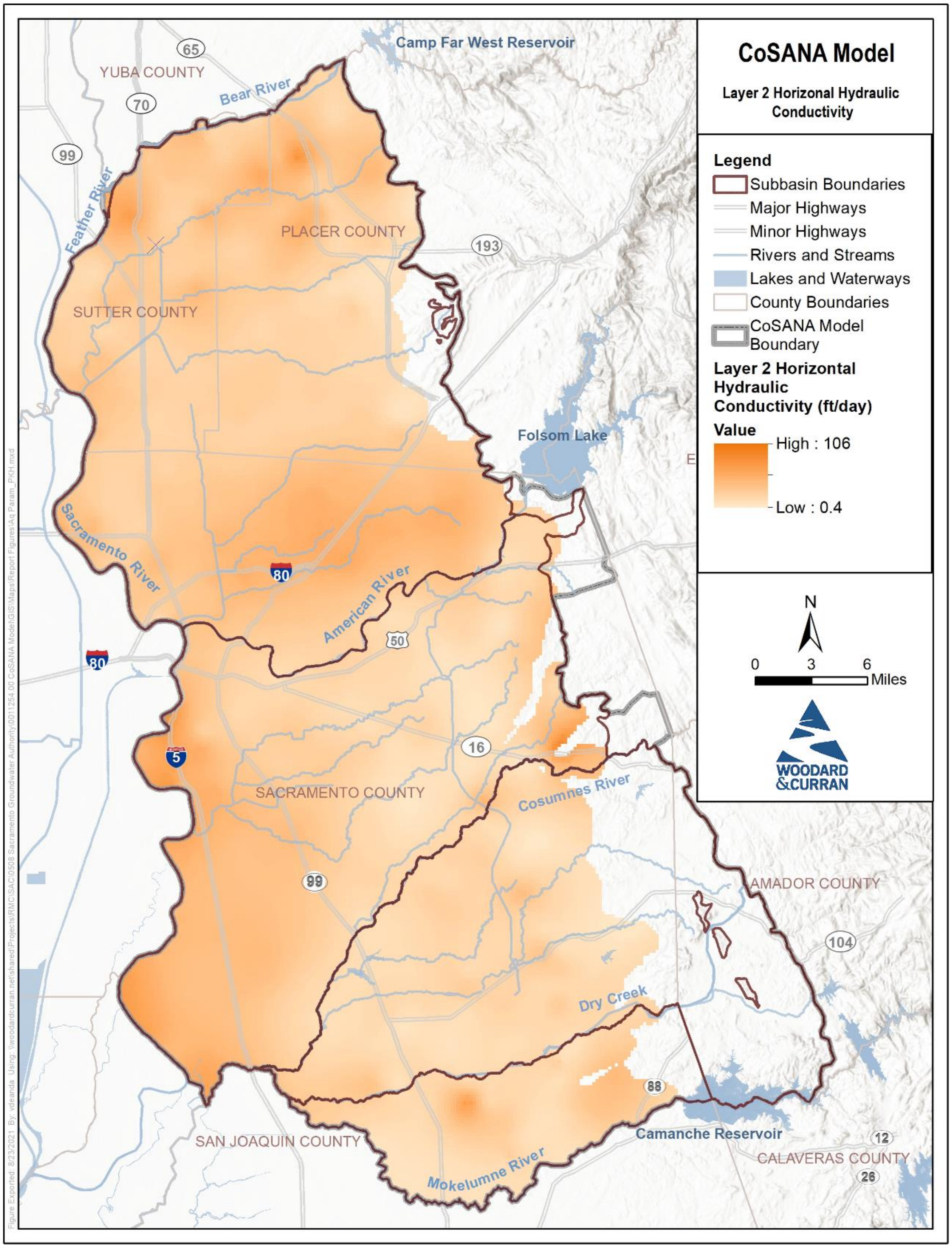



**Figure 4-59: Distribution of CoSANA Layer 2 Horizontal Hydraulic Conductivity ($K_H$)**

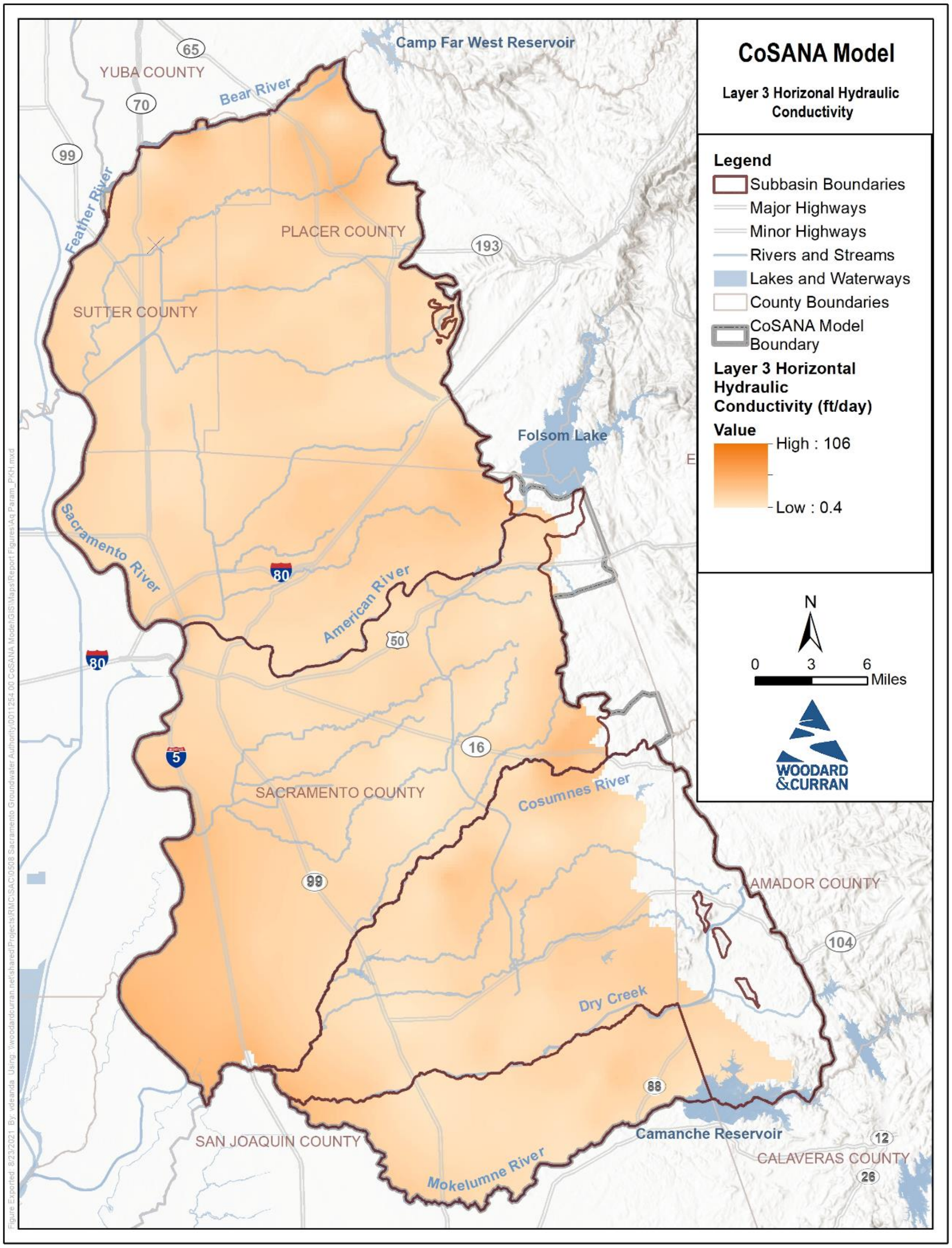



**Figure 4-60: Distribution of CoSANA Layer 3 Horizontal Hydraulic Conductivity ($K_H$)**

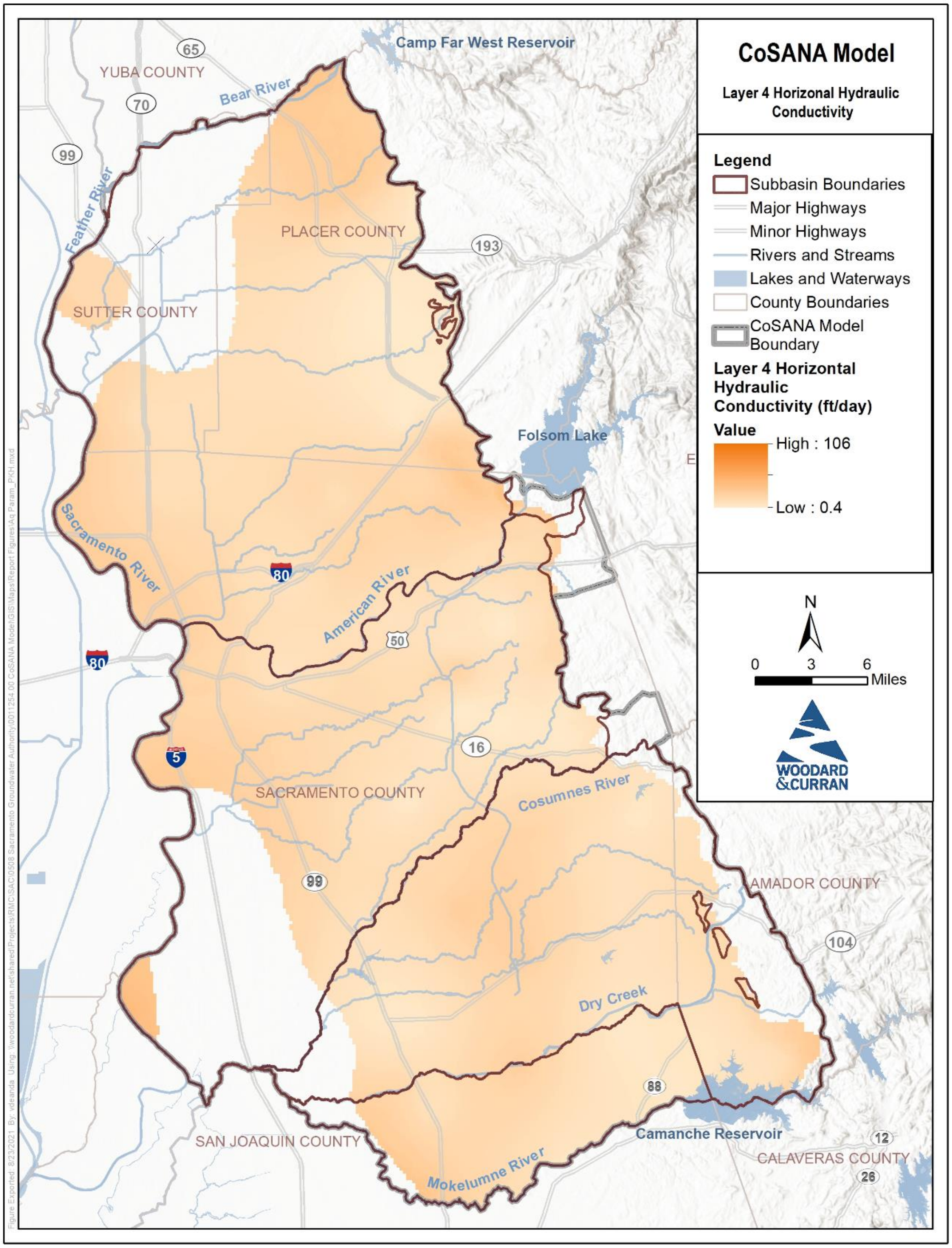



**Figure 4-61: Distribution of CoSANA Layer 4 Horizontal Hydraulic Conductivity ($K_H$)**

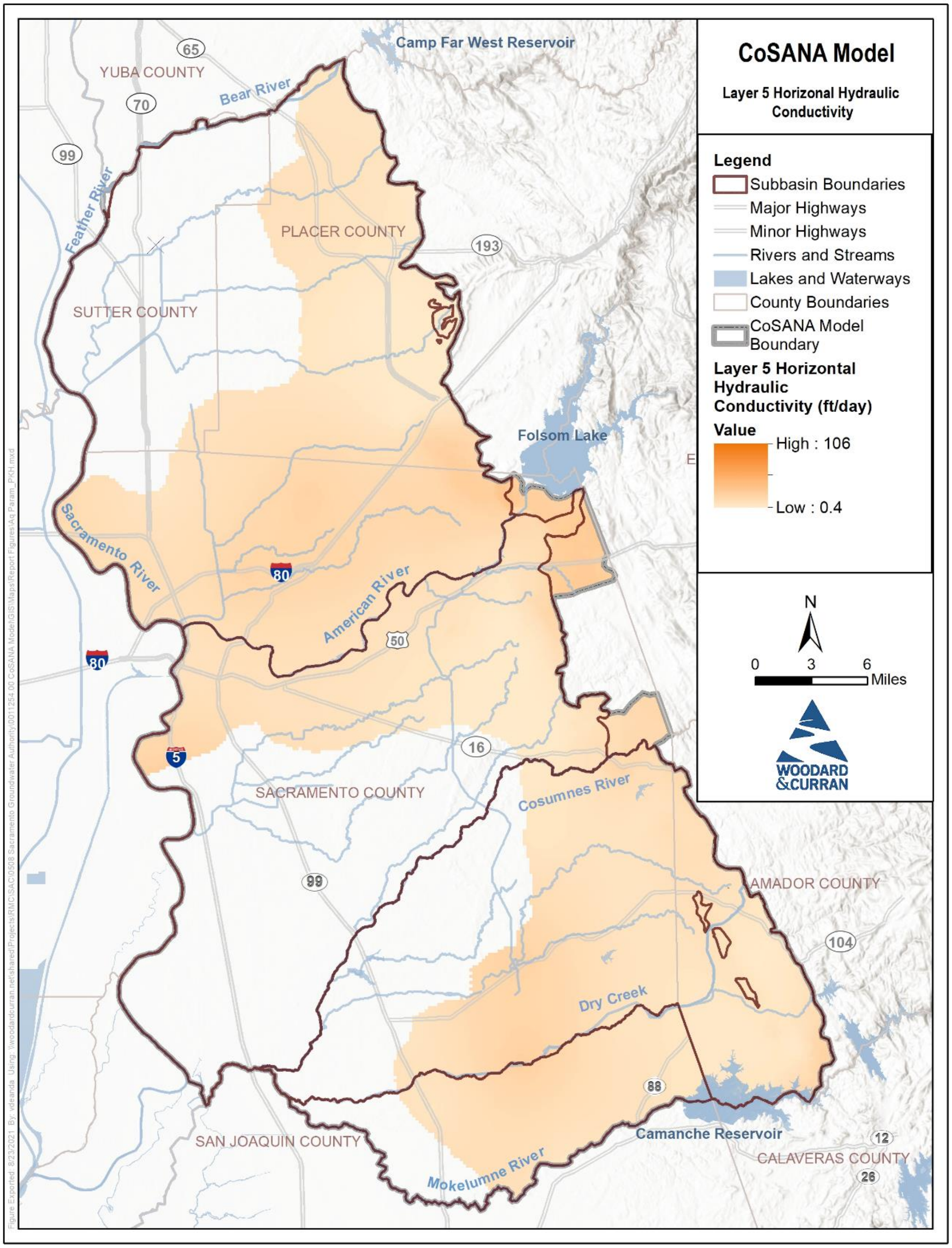



**Figure 4-62: Distribution of CoSANA Layer 5 Horizontal Hydraulic Conductivity ($K_H$)**

## 4.5 Model Features, Strengths, and Limitations

CoSANA has been developed based on years of integrated model development expertise and experience for the Sacramento area, including the SacIWRM and other groundwater planning and analysis efforts in the area. As such, the model data sets, conceptual representation of the groundwater system, the interaction with the surface water and land surface processes, and model calibration conditions are built on a strong foundation and reflect the experience and expertise of hydrologic and hydrogeologic conditions and modeling in the area. Having said that, the model has certain limitations that are outlined as follows:

### 4.5.1 Spatial Extent and Resolution

The accuracy of the model simulation is a function of spatial resolution of the data, as well as spatial discretization of the finite elements. As the spatial data such as land use or soil conditions are mapped to the elements, the size of elements reflect the accuracy of the underlying data sets as mapped. Much of the spatial data has been reviewed and verified against available statewide and local data available. The model is calibrated to target levels based on the spatial resolution in the model. However, when using the model for local scale analysis and modeling, the experienced user is encouraged to perform further validation of the underlying spatial data prior to use of the model for analysis of projects or management actions.

### 4.5.2 Temporal Scale

CoSANA includes monthly hydrologic data for the period WY 1970-2018. The model is calibrated for the period WY 1995-2018. Additionally, the model simulations are verified for the entirety of the period WY 1970-2018 for long-term trends and short -term seasonal conditions for groundwater levels and groundwater storage. The monthly time step is a reasonable one for a regional model and reflects the resolution of much of the recorded and reported data. However, the monthly time step at times may pose limitations for simulation of some of the model features, such as streamflows during high and peak flows. This is not of major concern as the regional model context and utilization of model for most long-term water supply planning needs is not affected by this limitation.

### 4.5.3 Geology and Hydrogeology

CoSANA includes an updated aquifer stratigraphy based on available maps and cross sections. CoSANA also uses the aquifer texture model used in C2VSimFG and SVSim (DWR, 2018a), which is based on the USGS aquifer texture data. The texture data is used in the model calibration and distribution of aquifer properties based on a field level set of lithologic log information. The details of the texture model affect the model performance and calibration in simulation of the various hydrogeologic conditions. The user is reminded to consider variabilities and uncertainties in the texture model as the model results are being interpreted and used for policy and planning purposes.

### 4.5.4 Land Use Data

Land use is one of the key data sets that affect water demand estimation as well as rainfall runoff, infiltration, and recharge conditions. This data set was developed based on numerous DWR county-level land use surveys, land use and cropping data available from the recent statewide DWR land use surveys, and local sources. This information was assembled, analyzed, and discrepancies were reconciled, which resulted in annual crop data by each model element. Mapping of land use data from various maps to element level within the model and temporal interpolation of land use changes between years of available data may introduce inaccuracies that need to be considered in evaluation of land use conditions at smaller spatial scales, such as parcel level, and for years in between dates of source data.

### 4.5.5 Water Demand Estimates

Water demands in the model are estimated for three user categories, urban purveyors, agricultural entities, and rural residential areas. The urban demands are based on the reported water supply and demand data from the urban purveyors. The agricultural demand estimates are based on respective model data sets and calibration of the model for each agricultural area. While care has been given to estimation of agricultural water use estimates, and the results have been shared and reviewed by the agricultural entities within the model area, inaccuracies in the source data or those mapped to the model may introduce inaccurate estimates in certain conditions. The rural residential water use estimates have also been shared and presented to the representatives of the rural residential water users at a number of public workshops. In general, the model user is encouraged to validate the estimates with additional local data and is also requested to share their findings with the model developers for future refinements of the model.

### 4.5.6 Water Supply Data

The surface water delivery data set in the model is one of the most reliable data sets as it is provided by the purveyors. However, some surface water diversions by the agricultural entities are subject to more uncertainty, which affects the model simulation results. Local entities are encouraged to review the surface water delivery data and provide feedback to the model developers as issues arise or inaccuracies are identified.

### 4.5.7 Groundwater Pumping Estimates

CoSANA includes groundwater wells for all urban purveyors and groundwater pumping rates are, with a few exceptions, provided by the urban purveyors. The model includes estimated monthly groundwater pumping by each model element for the agricultural water use and rural residential users. Agricultural groundwater pumping is estimated as the balance of agricultural demand estimates and surface water that is available to meet the demand for each element and at each model time step. The contamination remediation groundwater extractions are based on data supplied by the entity performing the remediation and are assumed to be accurate. However, these remediation systems are complex, and some details of extraction and the fate of extracted water may be missing or inaccurate. Notably, details on individual well pumping volumes and injection volumes at Mather are not known, although overall pumping and injection volumes are incorporated into CoSANA. Where data were not available, values have been estimated for the model to the best of the model development team's knowledge.

### 4.5.8 Water Budgets

CoSANA provides detailed water budgets at each model element, which, when aggregated, can provide water budgets for a selected geographic area representing a subregion, subbasin, water/irrigation district, a GSA, or other geographies. The model water budgets have been verified for major model subregions against data and information available from local sources. Additionally, the subbasin-scale model water budgets have been reviewed and verified by the respective technical staff and/or representatives of the GSAs to check the accuracy and reliability of the water budgets for GSP use. When using the CoSANA for more detailed analysis, the user is encouraged to verify the water budgets for reasonableness and consistency with local data and information.

### 4.5.9 Groundwater Flow and Levels

CoSANA has been calibrated against long-term groundwater trends and seasonal groundwater level changes at approximately 761 wells throughout the model area. The calibration process included adjustments to model input data and/or parameters to ensure that reasonable water budgets are achieved for each model subregion, and long-term simulated groundwater levels match the observed levels within acceptable tolerances. Subsequently, an automated calibration process using PEST was performed to further refine the model calibration by adjusting the aquifer hydraulic properties throughout the model domain. The process of automated calibration also used aquifer texture data for spatial distribution of aquifer parameters. Inaccuracies in observation and reported groundwater levels may influence the quality of calibration. Further, lack of detailed well construction information in many of the calibration wells limited the ability to use data at those sites to properly calibrate the model with depth.

### 4.5.10 Streamflows

CoSANA simulates streamflows many rivers and streams, including the Sacramento, American, and Cosumnes Rivers. CoSANA stream budgets have been developed and reviewed for several key stream reaches, including reaches along the major river reaches. Additional care has been given to the nature of stream-aquifer interaction to allow proper representation of the stream reaches that potentially have hydraulic connection to the groundwater system, as well as reaches that are gaining or losing. In specific, published information by various non-governmental organizations, such as TNC have been used in model calibration. The quantity and quality of data on the physical nature, extent, and rate of stream-aquifer interaction is, in general, low throughout the state. The Sacramento region and the CoSANA model area is not an exception to this lack of quality data, despite improvements over the past decades. Government agencies and non-governmental organizations are encouraged to allocate additional research to this area for better representation of the nature, extent, and conditions of stream-aquifer relationship.

## 4.6 Modeling Uncertainties

A model is a numerical representation of physical process and inherently possesses uncertainties that affect the calibration, performance, and results of the model. Integrated hydrologic models are complex models that involve simulation of complex physical systems and interrelationships and require many different types of data, each of which may be available at different temporal and spatial scales. Uncertainties in the performance of an integrated hydrologic model can arise from uncertainties in how the physical processes are conceptualized and formulated, inaccuracies in the underlying data, calibration process and eventually the assumptions used in applications of the model to evaluate projects, including projections of future conditions. The following are additional details on each of these uncertainty categories.

### 4.6.1 Structural Uncertainties

First set of model uncertainties can arise due to the structural framework of the model, which can include:

- Representation of Physical Features- In order to properly represent natural conditions, the physical and natural features need to be well understood so that they can be conceptualized in a simplified manner for development of theoretical formulations.
- Theoretical Concepts and Representation of the Natural and Physical Systems- This type of uncertainty can be attributed to the conceptualization of the physical and natural systems in the form of mathematical functions and formulas that govern the movement of groundwater and surface water systems and the interrelation of these systems. These formulas are typically referred to as governing equations for each of the hydrologic or hydrogeologic features modeled.
- Formulation, Code Development, Solution Techniques, and Assumptions- The governing equations are typically so complex that analytical solutions to these equations are either not available or are so simplified that they would add to the inaccuracies in the representation of complex hydrologic systems. Therefore, numerical solutions are employed, including finite element or finite difference techniques, which require their own set of assumptions. Computer software is used to implement the theoretical formulations.
- Model Spatial and Temporal Resolution- The governing equations representing the natural and/or physical systems are either solved at two levels:
    - Lumped solution- At this level, the formulation represents a lumped parameter system, and the solution will be for an aggregated system at the large scale. This aggregated and lumped scale can be both for the spatial and temporal scale of the problem. Lumped level solutions are typically employed in conditions where there is a lack of accurate information or where the system is small enough that further spatial or temporal breakdown of the system is not possible due to lack of data and information.

- Distributed Solution- At this level, the system is subdivided in further spatial resolution to take advantage of spatial variability in the data and information that is available at smaller scales. Additionally, the solution to the formulation of the system is also subdivided in smaller temporal scales, such as a monthly or daily time step, so that short-term and long-term variability in the data over time is properly represented in the solution.

### 4.6.2 Data Uncertainties

This category of uncertainty is related to the data and information that is used and employed in development of a model.

- Data and Information Accuracy, Data Gaps, and Estimates- Collection and compilation of data for natural and physical systems, including precipitation, streamflow, land use, cropping patterns, population, water use, crop evapotranspiration, soil conditions, groundwater levels, streamflow, surface water use, groundwater pumping, infrastructure, facilities, and operations all include a certain level of inaccuracy and uncertainty. This uncertainty is exacerbated when data gaps and inconsistencies exist. The methodology used to identify and fill data gaps can introduce levels of uncertainty.
- Data Spatial and Temporal Resolution- In addition to the above, the spatial and temporal resolution of data may contain inaccuracies and uncertainties that would affect the data that are used in the model.

### 4.6.3 Calibration Uncertainties

- Estimates of Hydrologic and Hydrogeologic Parameters- Often, data and/or information for specific parameters that are used to represent the governing equations in the model may not be available. In these circumstances, the modeler uses professional judgement, or adopts conditions from similar areas, which may introduce uncertainties and inaccuracies in model simulations.
- Calibration Approach, Target Characteristics, and Accuracy- Model calibration requires certain quality, consistency, and care, so that the model properly represents the natural and physical conditions observed in the field. In addition to the quality and uncertainties in data and methodologies, the approach employed, tools and techniques used, and experience and expertise of the model developer affects the quality of model calibration and accuracy of the results. Often, the calibration targets are prone to uncertainty or lack of information. For example, information on the depth of the screened interval, as well as pumping rate and depth at the well, whether the recorded groundwater level reflects static or pumping conditions, and whether a well is under the influence from other nearby wells or a nearby stream can have significant bearing on the approach and quality of the calibration.

### 4.6.4 Application Uncertainties

- Assumptions and Project Applications, Including Data Projections and Forecasting Methods- It is imperative that model application be defined and considered in such a way that is supported by model calibration. Assumptions on a model application to analyze a particular project can often be generalized with little knowledge of the conditions. For example, significant uncertainties exist with respect to the following data, which can affect the quality and results of the model output for planning and policy making:
  - Hydrologic conditions and rainfall patterns
  - Land use and cropping patterns
  - Population and water use
  - Water supply conditions
  - Climate change conditions

While modeling uncertainties need to be considered in use and application of models for evaluation of project conditions for potential impacts, benefits, and design of plans and facilities, the model should be considered a reasonably robust tool to support the major decisions, including GSPs, projects and management actions, and sustainability analysis.

## 4.7 Sensitivity Analysis

Sensitivity analysis is a way of investigating how sensitive certain model results are to changes in certain model parameters. A sensitive parameter is when the simulation results are greatly affected by changes in that parameter within its valid range. Conversely, an insensitive parameter means the changes in that parameter within its valid range do not affect the simulation results greatly.

Model parameters that are sensitive can be the largest sources of error and uncertainty when not precisely measured and well understood. For this reason, sensitivity analysis is an important step of the model calibration process. The sensitivity analysis serves the following purposes:

- To improve the understanding of input-output relationships
- To quantify the impact of inaccuracies in model parameters
- To evaluate the stability and robustness of the model
- To understand the overall range of accuracy of the model results

For these purposes, the following set of calibration parameters were selected for investigation under CoSANA Model sensitivity analysis:

- Aquifer horizontal hydraulic conductivity (PKH) changed globally by factors of 0.5, 0.67, 1.5, 2.0
- Aquifer vertical hydraulic conductivity (PL) changed globally by factors of 0.5, 0.67, 1.5, 2.0
- Specific yield (PN) changed globally by factors of 0.8, 1.2
- Specific storage (PS) changed globally by factors of 0.1, 0.2, 5, 10
- Streambed conductivity (CSTRM) changed globally by factors of 0.2, 0.5, 2.0, 5.0
- Small watersheds curve number (CNS) changed globally by -10, -5, 5, 10
- General head boundary condition head time series (BHTS) changed globally by -10, 10 feet

### 4.7.1 Metrics of the Sensitivity Analysis

In the process of evaluating the sensitivity of model results to certain parameter changes, the results from the sensitivity runs were analyzed for the NASb, SASb, and CoSb and compared to the calibrated model in terms of the groundwater residual statistics.

The changes to the input parameters for sensitivity analysis were made globally. Therefore, the changes in the model performance should be considered on a global scale. An improvement in the model performance based on changes in one parameter at a global scale does not necessarily mean improvements in the overall model performance and/or calibration, as the model is calibrated to a number of target parameters, only some of which may be included in the performance assessment during the sensitivity analysis. The residual statistics for this sensitivity analysis was used as the performance indicator.

### 4.7.2 Results of the Sensitivity Analysis

Figure 4-63, Figure 4-64, and Figure 4-65 present the relative change in the three groundwater level residual statistics used in the evaluation of model calibration performance for 10 sensitive parameters in NASb, SASb, and CoSb respectively. These three statistics are:

- Root mean square error (RMSE): This statistic is a measure of how spread out the residuals are.
- Average residual: This statistic measures how inaccurate simulation results are with respect to the corresponding observations on average.

- Correlation coefficient (R2): This statistic is a measure of the strength of the linear relationship between the simulated and observed pairs.

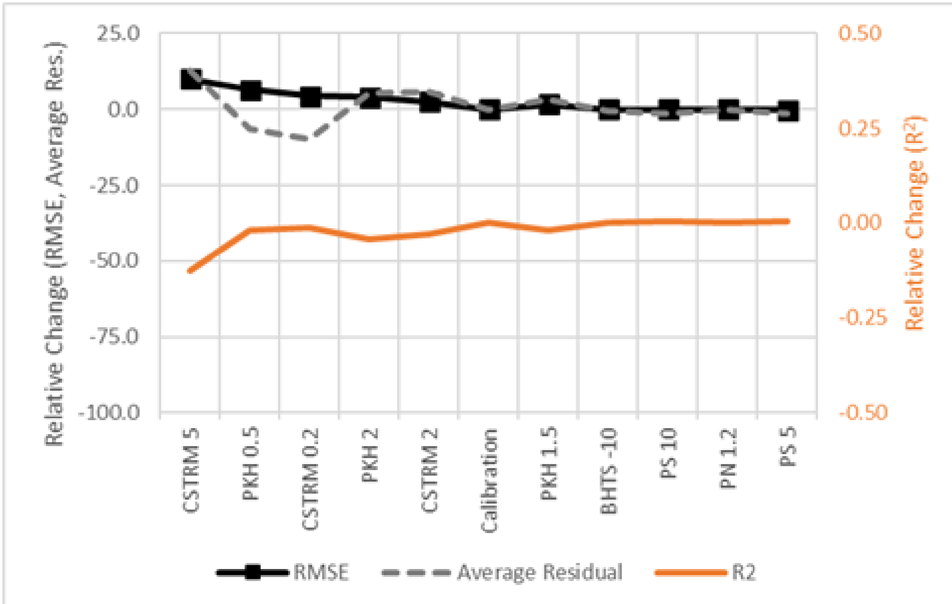



**Figure 4-63: Sensitivity of Groundwater Level Residual Statistics in NASb**

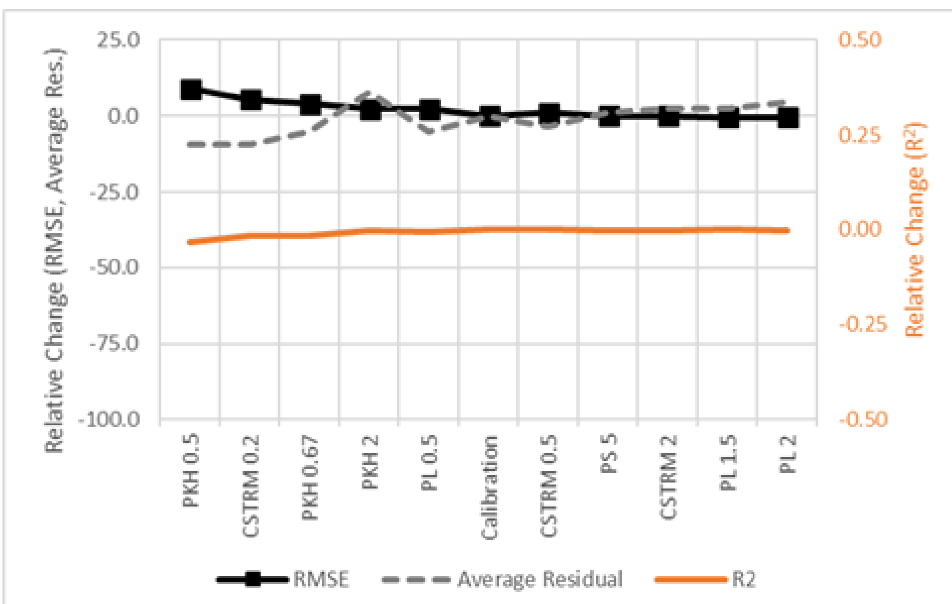



**Figure 4-64: Sensitivity of Groundwater Level Residual Statistics in SASb**

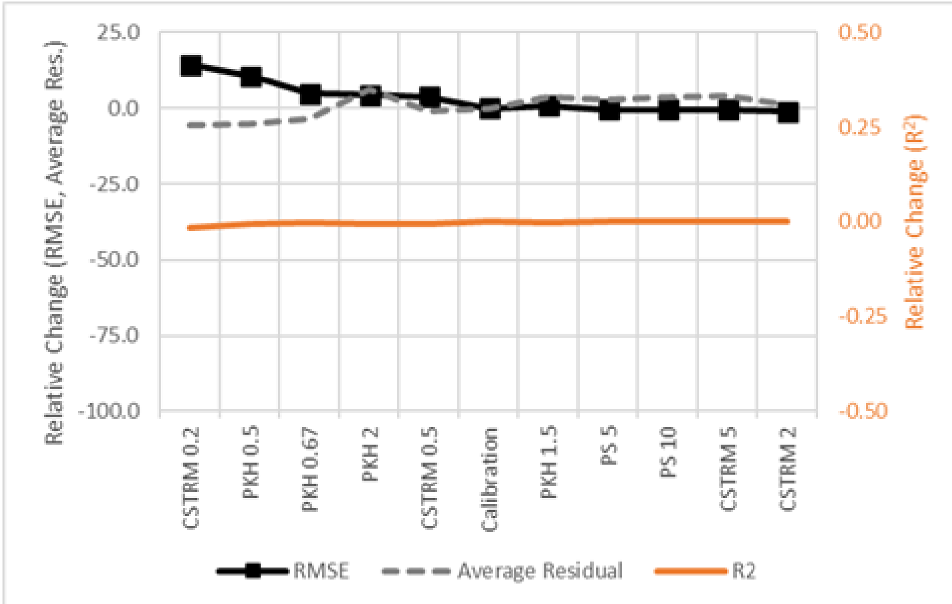



**Figure 4-65: Sensitivity of Groundwater Level Residual Statistics in CoSb**

None of the sensitivity runs resulted in a significant improvement in these statistics for any of the subbasins. This means that the model is stable and that the calibration is at or near an optimal point when global parameter changes are considered.

# 5. BASELINE CONDITIONS

Integrated hydrologic and water resources models are used to evaluate effects, benefits, and impacts of particular projects and management actions under a set of baseline conditions. These baseline conditions can represent a set of pre-established hydrologic, land and water use, water demand, water supply, and basin operational conditions. As part of the development of the GSPs for the NASb, SASb, and CoSb, three sets of baseline conditions have been defined for the CoSANA model. These represent the current, projected, and projected under climate change baseline conditions.

Following are descriptions of the assumptions and results for each of these baseline scenarios.

## 5.1 Current Conditions Baseline

The CoSANA Current Conditions Baseline (CCBL) is a representation of long-term average conditions assuming that a recent level of development and water demand persists over a long-term period of hydrologic conditions. Initial groundwater levels and soil conditions in the CCBL represent those at the end of the simulation period of the historical CoSANA (representing September 30, 2018).

### 5.1.1 Hydrology

The CCBL uses a 50-year historical hydrology from water years (WY) 1970 through 2019 (October 1, 1969 through September 30, 2019) for precipitation, evapotranspiration, and streamflow.

#### 5.1.1.1 Precipitation

Precipitation in the historical simulation, discussed in Section 2.6, uses the PRISM database for the entire period of record. The precipitation used in the historical simulation was extended through WY 2019 for use in the CCBL. The average CCBL precipitation across the entire model area is 20.2 inches, with a minimum of 7.5 inches in WY 1977 and a maximum of 38.9 inches in WY 1983.

Figure 5-1 graphically illustrates the cumulative departure of the spatially averaged rainfall within the CoSANA model area. The figure includes bars displaying annual precipitation for each water year from WY 1970 through 2019 and a horizontal line representing the long-term mean precipitation of 20.2 inches. The cumulative departure from mean precipitation is displayed as a line that highlights wet periods with upward slopes (positive departure) and dry periods with downward slopes (negative departure). More severe events are shown by steeper slopes and greater changes.

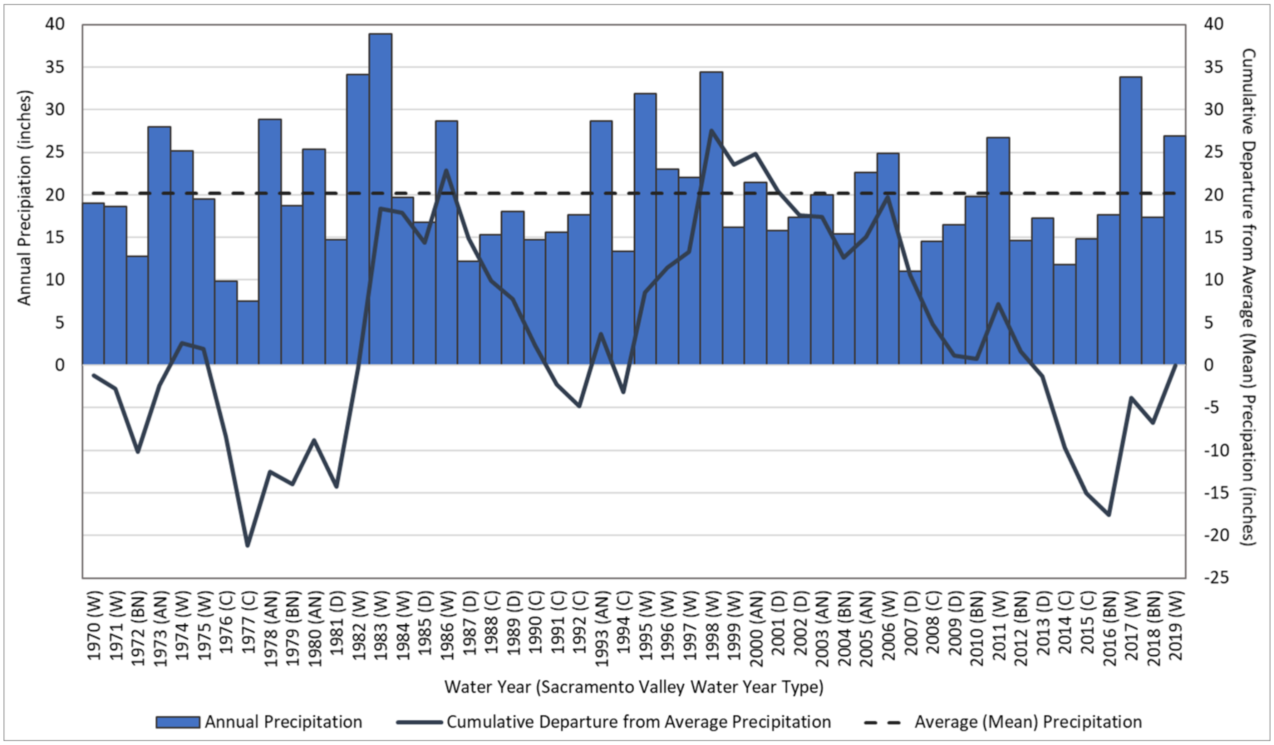



**Figure 5-1: 50-Year Historical Precipitation and Cumulative Departure from Mean Precipitation**

### 5.1.1.2 Evapotranspiration

As discussed in Section 2.8, the crop ET requirement was based on values from regional modeling (C2VSimFG) and associated CIMIS Zones 12 and 14. The ET used in the historical simulation was extended through WY 2019 for use in the CCBL.

### 5.1.1.3 Stream Inflow

As discussed in Section 2.4, stream inflows are from stream gaging stations at the upstream area of CoSANA river reaches. The stream inflow points and gaging stations are described in Section 2.4 and listed in Table 2-4. As the CCBL uses the historical hydrologic conditions as the basis for planning the baseline conditions, the stream inflows used in the historical simulation were extended through WY 2019 for use in the CCBL.

### 5.1.1.4 Hydrologic Year Types

The 50 years of the CCBL, from WY 1970 through 2019, represent a range of hydrologic conditions, as identified by the water year types in the Sacramento Valley Water Year Hydrologic Classification, which classifies water years 1901 through 2020 as Wet (W), Above Normal (AN), Below Normal (BN), Dry (D), and Critical (C) based on inflows to major reservoirs or lakes. A description of how this index is calculated and the specific data used to calculate this index is available online from CDEC at http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST. In the 50 years of hydrology used in the CCBL, there are 10 Critical years, 9 Dry years, 7 Below Normal years, 7 Above Normal years, and 17 Wet years.

To facilitate assumptions for baseline water supplies and demands, these five water year types were simplified into three water year types. Critical and Dry years are combined into one category in the baseline water year types (called Dry years), Above Normal and Below Normal years are also combined into one category (Normal years), and Wet years remain in one category (called Wet years). With this breakdown, the three baseline water year types have a distribution of 19 Dry years, 14 Normal years, and 17 Wet years. These baseline water year types (Table 5-1) are used in the remainder of the CCBL data development and results discussion.

**Table 5-1: Hydrologic Water Year Types**

| Baseline Year | Water Year | Sacramento Valley Water Year Hydrologic Classification | Baseline Year Type | | Baseline Year | Water Year | Sacramento Valley Water Year Hydrologic Classification | Baseline Year Type |
|---|---|---|---|---|---|---|---|---|
| 1 | 1970 | Wet | Wet | | 26 | 1995 | Wet | Wet |
| 2 | 1971 | Wet | Wet | | 27 | 1996 | Wet | Wet |
| 3 | 1972 | Below Normal | Normal | | 28 | 1997 | Wet | Wet |
| 4 | 1973 | Above Normal | Normal | | 29 | 1998 | Wet | Wet |
| 5 | 1974 | Wet | Wet | | 30 | 1999 | Wet | Wet |
| 6 | 1975 | Wet | Wet | | 31 | 2000 | Above Normal | Normal |
| 7 | 1976 | Critical | Dry | | 32 | 2001 | Dry | Dry |
| 8 | 1977 | Critical | Dry | | 33 | 2002 | Dry | Dry |
| 9 | 1978 | Above Normal | Normal | | 34 | 2003 | Above Normal | Normal |
| 10 | 1979 | Below Normal | Normal | | 35 | 2004 | Below Normal | Normal |
| 11 | 1980 | Above Normal | Normal | | 36 | 2005 | Above Normal | Normal |
| 12 | 1981 | Dry | Dry | | 37 | 2006 | Wet | Wet |
| 13 | 1982 | Wet | Wet | | 38 | 2007 | Dry | Dry |
| 14 | 1983 | Wet | Wet | | 39 | 2008 | Critical | Dry |
| 15 | 1984 | Wet | Wet | | 40 | 2009 | Dry | Dry |
| 16 | 1985 | Dry | Dry | | 41 | 2010 | Below Normal | Normal |
| 17 | 1986 | Wet | Wet | | 42 | 2011 | Wet | Wet |
| 18 | 1987 | Dry | Dry | | 43 | 2012 | Below Normal | Normal |
| 19 | 1988 | Critical | Dry | | 44 | 2013 | Dry | Dry |
| 20 | 1989 | Dry | Dry | | 45 | 2014 | Critical | Dry |
| 21 | 1990 | Critical | Dry | | 46 | 2015 | Critical | Dry |
| 22 | 1991 | Critical | Dry | | 47 | 2016 | Below Normal | Normal |
| 23 | 1992 | Critical | Dry | | 48 | 2017 | Wet | Wet |
| 24 | 1993 | Above Normal | Normal | | 49 | 2018 | Below Normal | Normal |
| 25 | 1994 | Critical | Dry | | 50 | 2019 | Wet | Wet |

### 5.1.2 Initial Conditions

The initial conditions for the 50-year CCBL are defined as the groundwater, surface water, and hydrologic conditions for the end of WY 2018 from the end of simulation of the CoSANA historical model. Figure 5-2 shows a map of initial groundwater levels used in the CCBL. The initial conditions for the CCBL are also used for other baseline models.

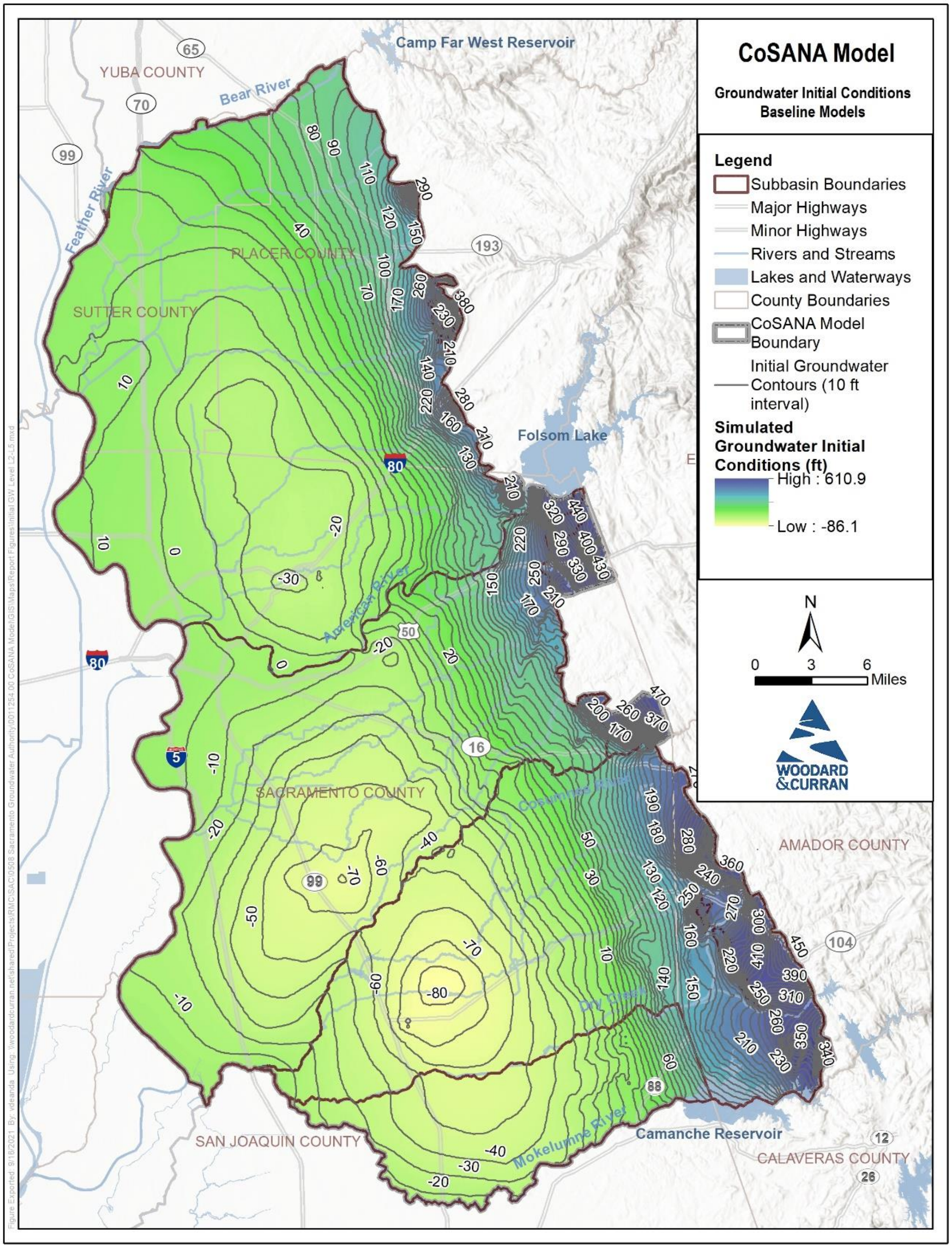



**Figure 5-2: Initial Groundwater Levels for CoSANA Baseline Models**

### 5.1.3 Boundary Conditions

CCBL boundary conditions are based on an average for each baseline water year type (normal, wet, and dry) during the last 10 years of the historical simulation (WY 2009-2018). This averaging is applied to the constrained head boundary conditions that represent Lake Camanche in the southeast corner of the model, and the general head boundary conditions that represent groundwater levels to the north, south, and west of the model boundary. Water year type averaging is not applied to the small watersheds form the eastern boundary of the model, as these are driven by hydrology (precipitation and evapotranspiration.) Further detail of how boundary conditions are applied in CoSANA are provided in Section 2.12.

### 5.1.4 Land Use

The CCBL used the land use from the last year of the historical simulation, discussed in Section 2.7. The last year of the historical simulation represents the digital land use coverage developed to represent 2015 (see Figures 15-21). As also described in Section 2.7, certain lands regarded as temporarily fallowed due to drought were represented as their typical land use for purposes of historical interpolation and for purposes of the CCBL. Minor changes to specified land use conditions were made to account for recent changes. Land use in Sutter County and Placer County was updated to incorporate recent conversions of rice fields to orchards. In the Cosumnes Subbasin, the land use was updated to incorporate recent conversion of vineyards or pasture to almonds and native land to agricultural and urban uses. A spatial representation of the CCBL land use is shown in Figure 5-3. The time-series of land use for the CoSANA CCBL is shown in Figure 5-4, highlighting the constant nature of land and water use in the baseline conditions. Figure 5-5 through Figure 5-7 show time-series of land use for the NASb, SASb, and CoSb, respectively.

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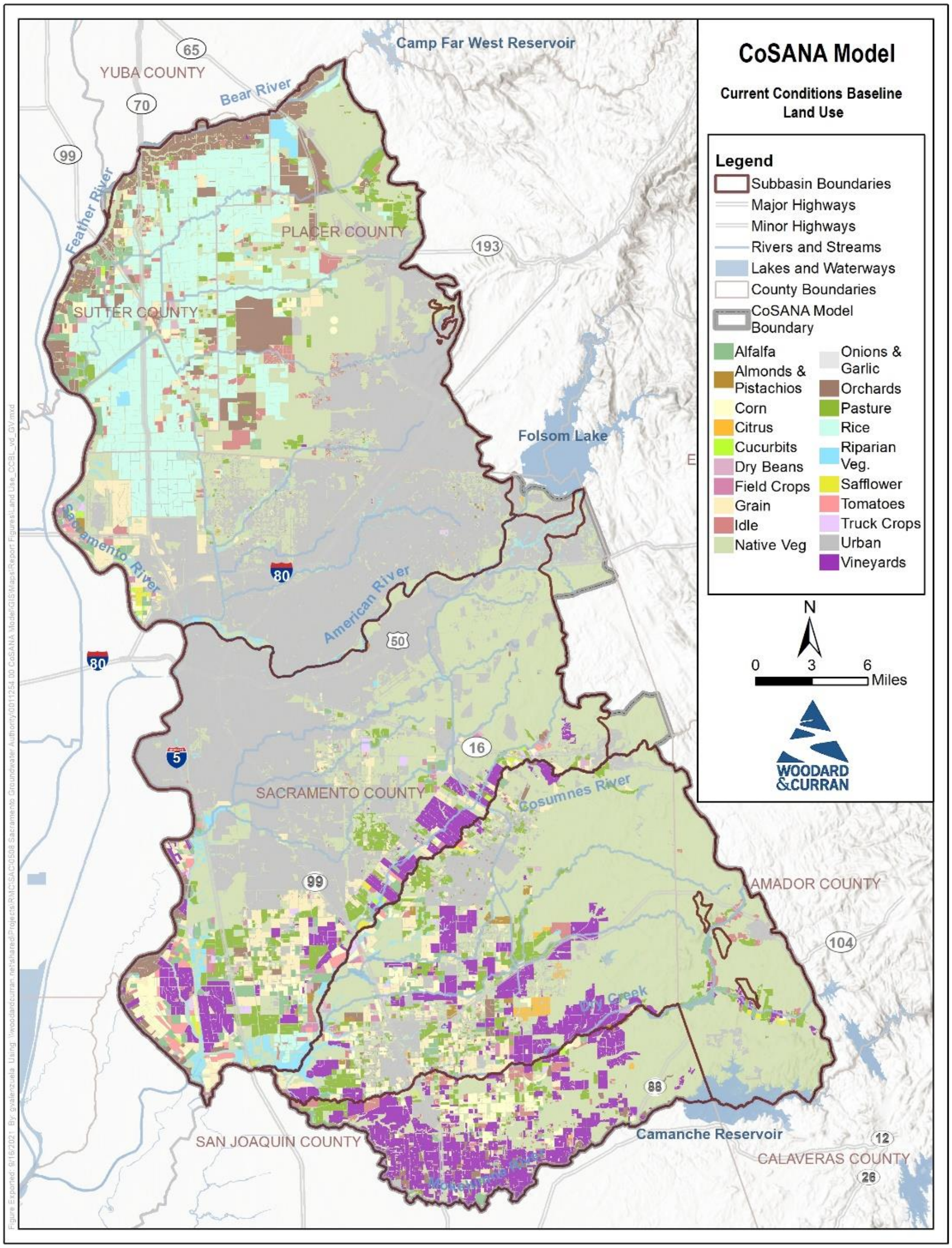



**Figure 5-3: Current Conditions Baseline Land Use**

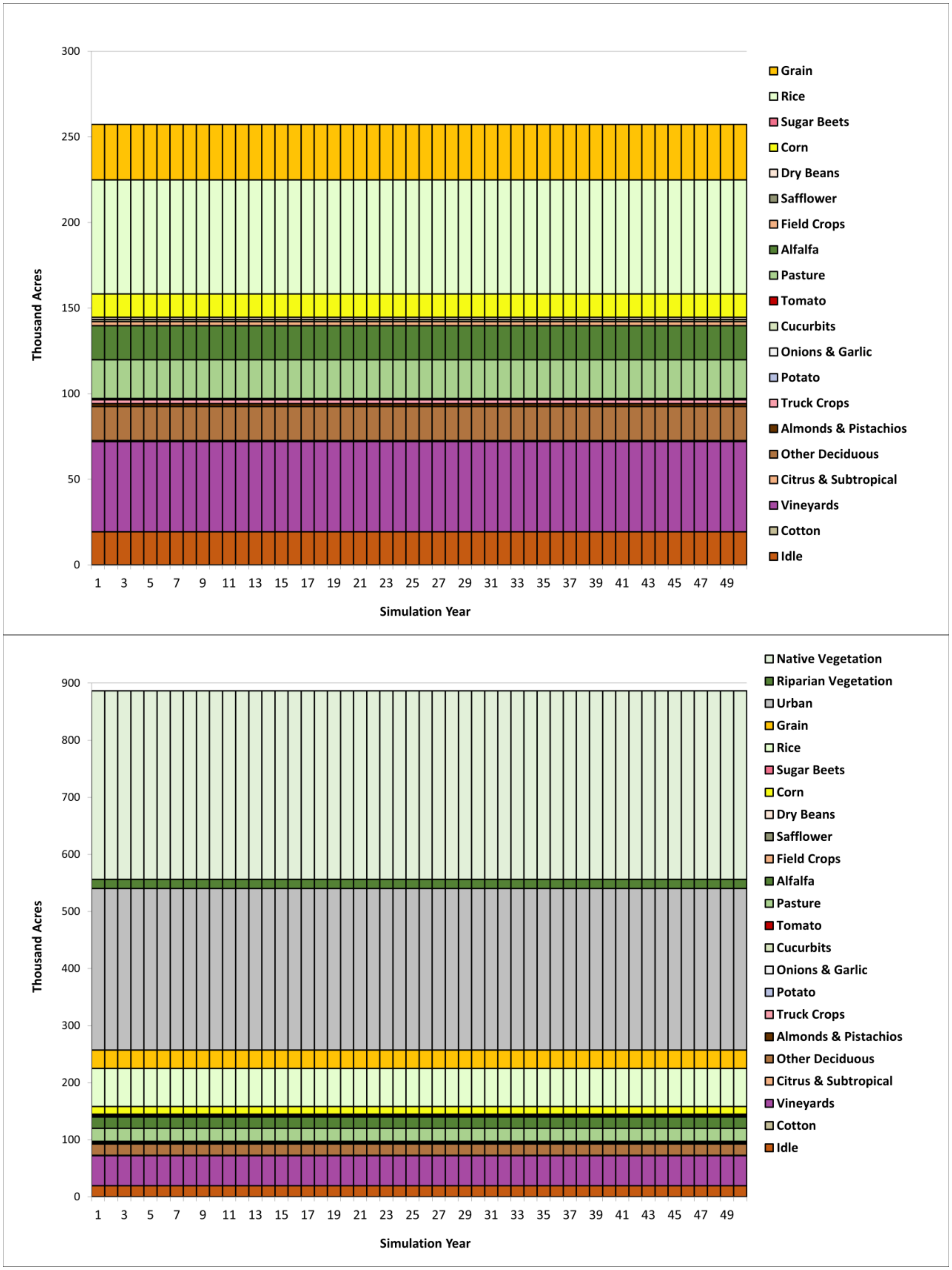
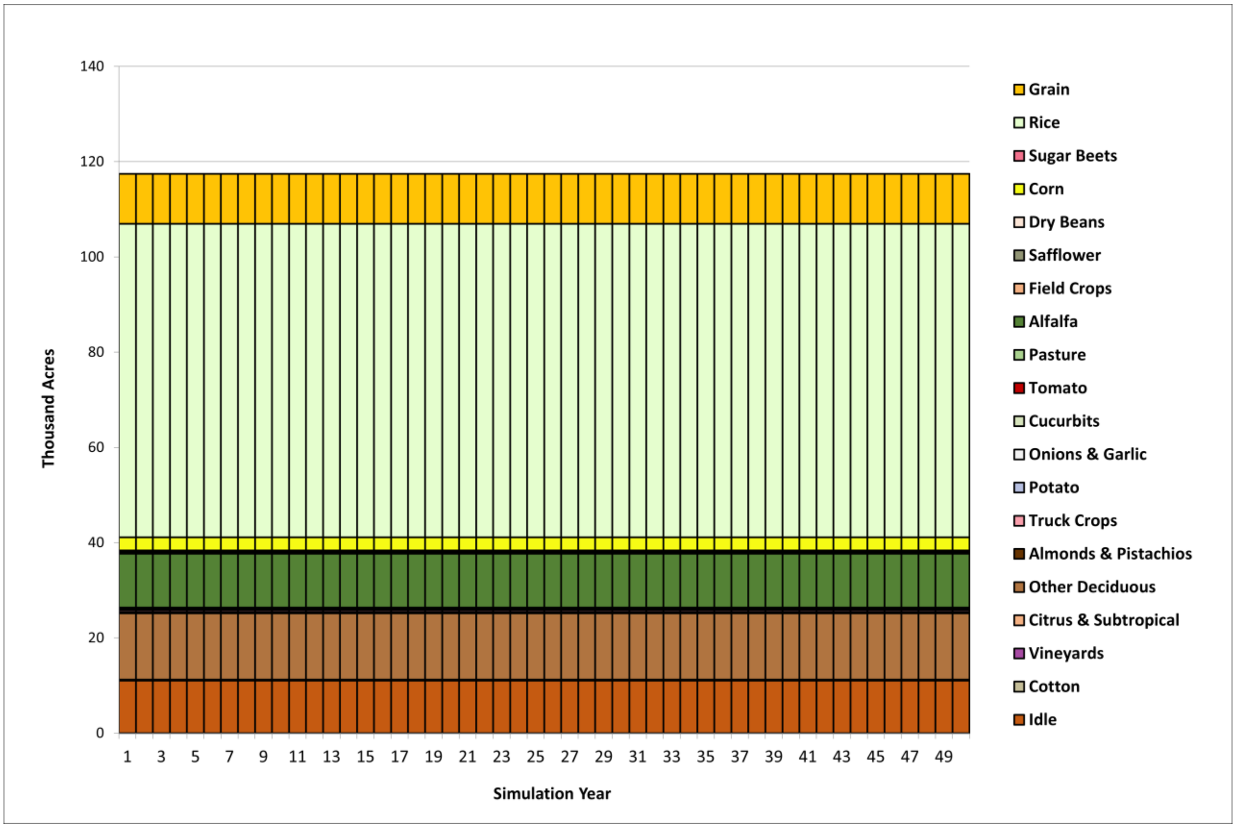



**Figure 5-4: Current Conditions Baseline Land Use for CoSANA**



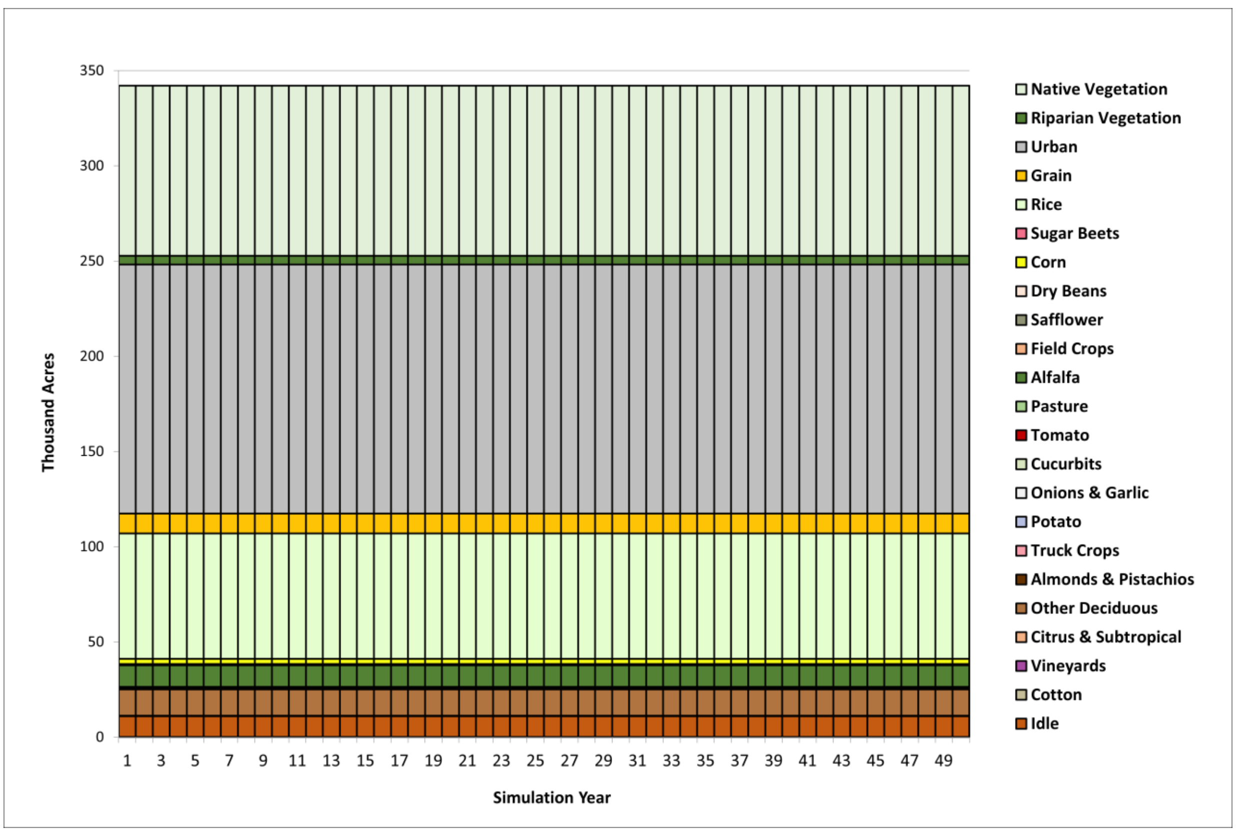
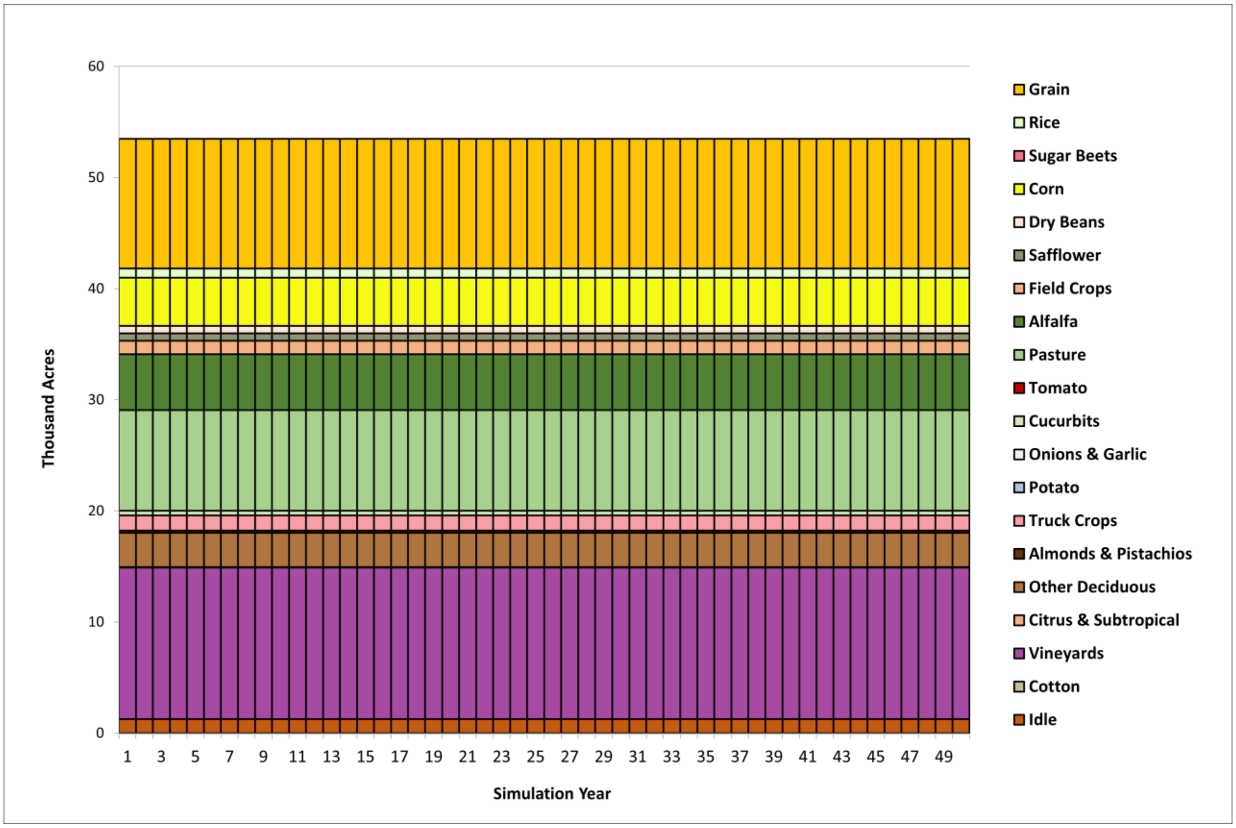




**Figure 5-5: Current Conditions Baseline Land Use for North American Subbasin**



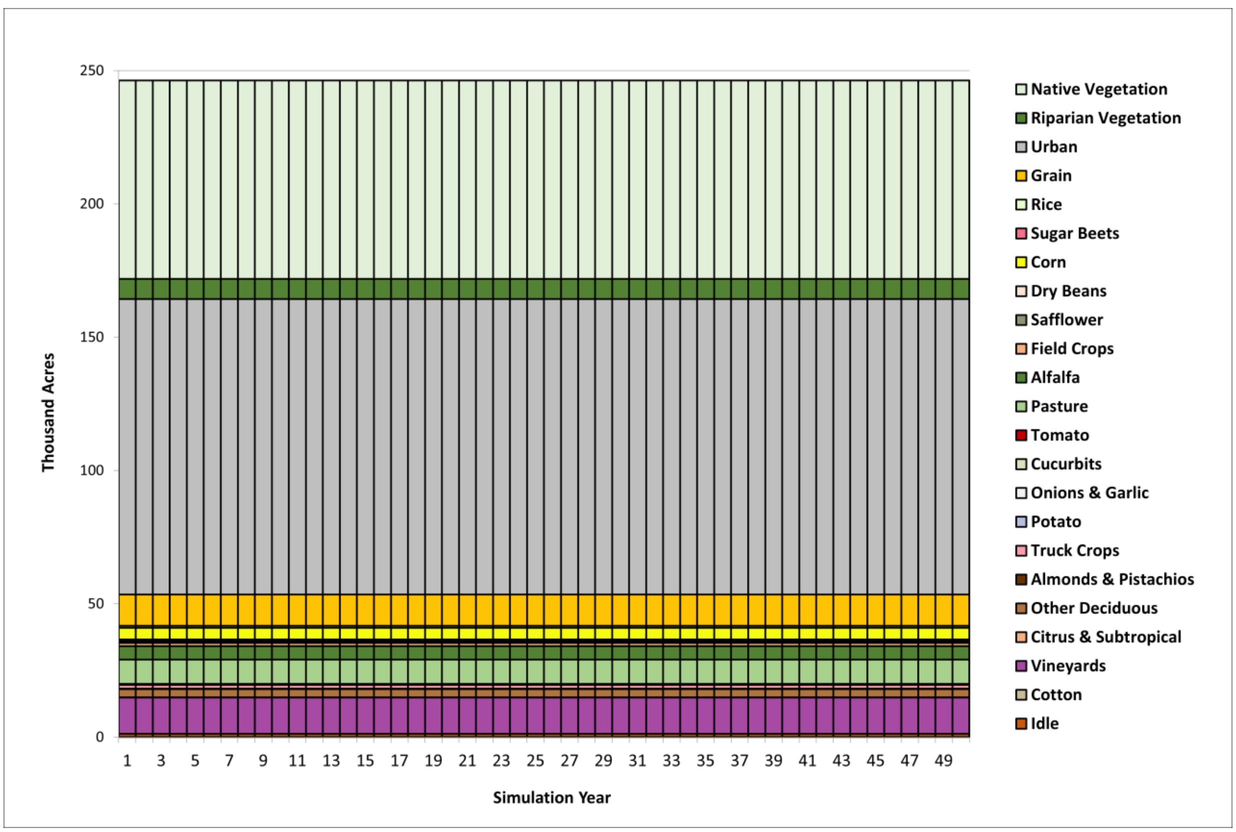
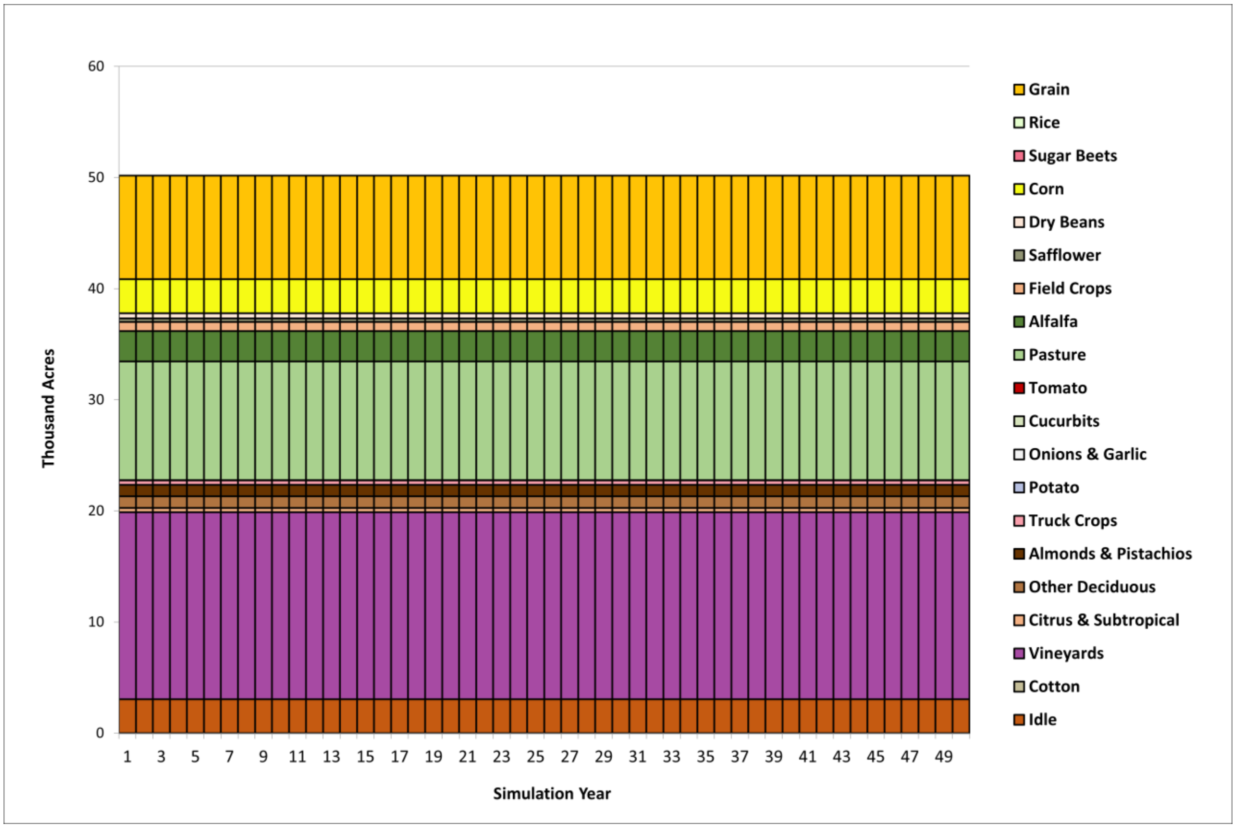




**Figure 5-6: Current Conditions Baseline Land Use for South American Subbasin**



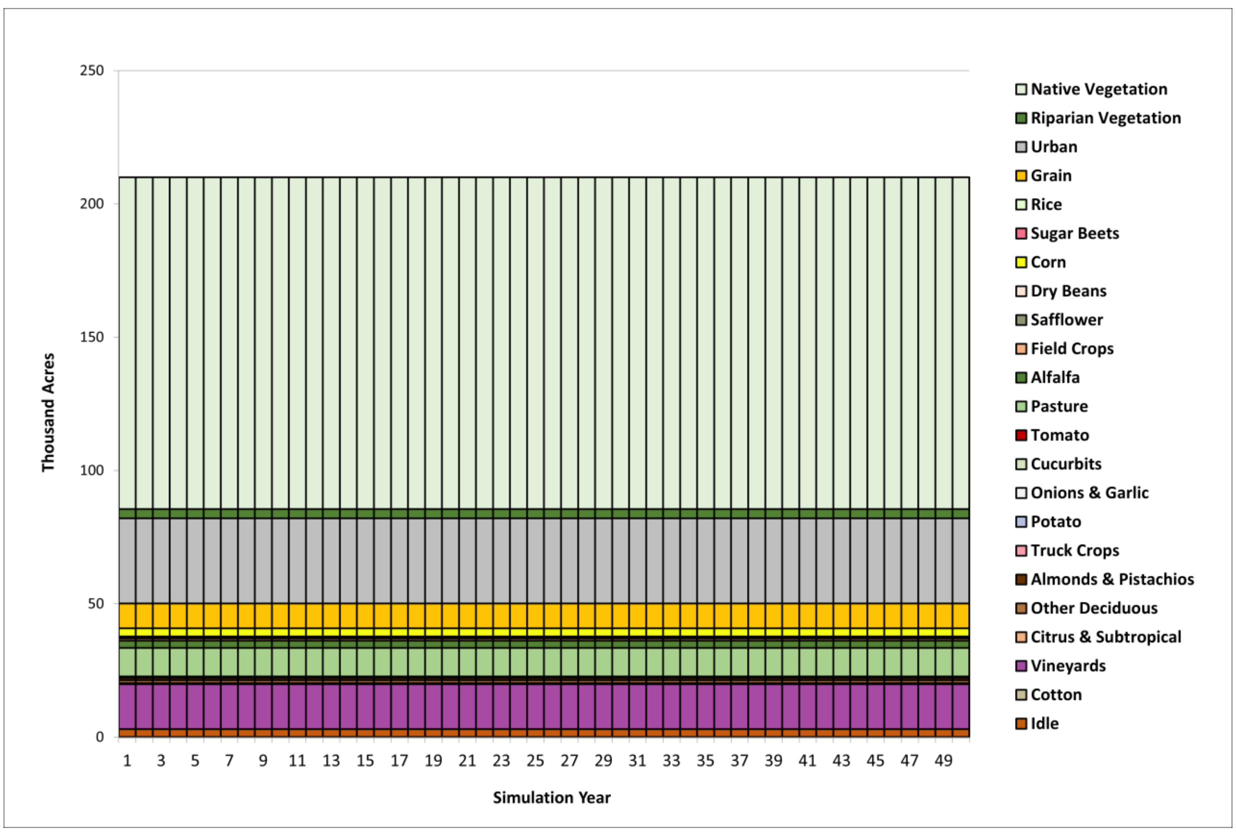




**Figure 5-7: Current Conditions Baseline Land Use for Cosumnes Subbasin**

### 5.1.5 Urban Demand and Supply

Urban demand is represented for each urban area based on supply data. Like the CoSANA historical model, each baseline assumes that urban supply (combined groundwater, surface water, and other sources such as recycled water) is equal to urban demand.

Urban water supply, including surface water deliveries, groundwater pumping, recycled water, and remediated water, are all calculated using the method described below, unless exceptions are listed in the individual purveyor sections that follow. To estimate CCBL water supply, the information for the last 10 years of the historical simulation (WY 2009 through 2018) was averaged by the three baseline water year types (normal, wet, and dry) described in Section 5.1.1.4. WY 2009 through 2018 contains four normal years (2010, 2012, 2016, and 2018), two wet years (2011 and 2017), and 4 dry years (2009, 2013, 2014, and 2015). Appendix G shows subregion/purveyor urban demand and supply for each entity for the three WY types (normal, wet, and dry). The water supply conditions for these three baseline year types were applied to the 50 years of hydrology within the CCBL.

For urban groundwater pumping, a well was assumed active in the CCBL if there was historical recorded pumping in WY 2016-2018. Average pumping by baseline year type was distributed in the CCBL to all active wells by purveyor based on their proportion of the historical simulation purveyor totals.

As previously noted, urban demand and supply were calculated using averages developed from the last 10 years of the historical simulation for all agencies except those specified otherwise in the following subsections.

#### 5.1.5.1 North American Subbasin

The following subsections present demand and supply assumptions for purveyors within the North American Subbasin whose assumptions are different from the standard methodology outlined above.

##### 5.1.5.1.1 City of Sacramento

City of Sacramento's demand was based on the last 10 years of the historical simulation. Demand varies slightly with water year types from 34,702 AFY for wet years to 35,274 AFY for dry years. Approximately 35% of the demand was assumed to be in the NASb portion of the model, based on urban area.

The City of Sacramento's current supplies include groundwater pumping and surface water supplies that vary by five water year types (as opposed to three water year types used for other purveyors) based on the City of Sacramento's 2017 Groundwater Master Plan (GWMP) (City of Sacramento, 2017). Groundwater pumping assumptions for the CCBL were consistent with the Future Conditions Baseline scenario developed in the 2017 GWMP, based on the discussions with the City of Sacramento (B. Ewart, personal communication, December 2020). Monthly pumping assumptions by each well were incorporated into the CCBL based on well locations and monthly well operations, as specified in the 2017 GWMP. Groundwater pumping in the NASb varies from 6,989 AFY during wet years to 41,841 AFY during driest years. Demand after groundwater pumping was assumed to be supplied by surface water.

The City of Sacramento also has specific wells that supply certain larger parks and green areas within the city. These irrigation wells are simulated using six representative irrigation wells that pump 2,400 AFY. Based on the locations of the irrigated parks and green areas, approximately half of the irrigation pumping was estimated in the NASb and the remaining half in the SASb.

##### 5.1.5.1.2 Sacramento County Water Agency (Arden Park Vista and Northgate)

Due to changing supply conditions over the last 10 years of the historical simulation, the SCWA service areas of Northgate and Arden Park Vista in the CCBL use groundwater pumping from WY 2018 for normal and dry baseline years and WY 2019 for wet baseline years.

##### 5.1.5.2 South American Subbasin

The following subsections present demand and supply assumptions for purveyors within the South American Subbasin whose assumptions are different from the standard methodology.

###### 5.1.5.2.1 City of Sacramento

The discussion also applies to the portion of the City of Sacramento that lies within the South American Subbasin; the portion within the NASb was discussed above in Section 5.1.5.1. Groundwater pumping in the SASb by the city varies from 1,761 AFY during wet years to 11,885 AFY during driest years, based on the Future Conditions Baseline scenario developed in the 2017 GWMP and the discussions with the City of Sacramento (B. Ewart, personal communication, December 2020). Monthly pumping assumptions by each well and by each water year type were incorporated into the CCBL based on well locations and monthly well operations, as specified in the 2017 GWMP. Demand after groundwater pumping was assumed to be supplied by surface water.

###### 5.1.5.2.2 Sacramento County Water Agency (Hood, Laguna Vineyard, and Mather)

Due to changing supply conditions over the last 10 years of the historical simulation, including construction of the Vineyard Surface Water Treatment Plant (online in WY 2011), the SCWA service areas of Hood, Laguna Vineyard, and Mather in the CCBL use surface water deliveries, groundwater pumping, recycled water, and remediated water from WY 2018 for normal and dry baseline years and WY 2019 for wet baseline years.

##### 5.1.5.3 Cosumnes Subbasin

The following subsections present demand and supply assumptions for purveyors within the Cosumnes Subbasin whose assumptions are different from the standard methodology.

###### 5.1.5.3.1 City of Galt

The average historical groundwater production for WY 2015-2018 for the City of Galt was used to estimate groundwater pumping for all CCBL years. This pumping occurs at six active wells.

###### 5.1.5.3.2 City of Ione

To estimate CCBL surface water supply to the City of Ione, the average for WY 2015-2018 was used for all CCBL years.

###### 5.1.5.3.3 Camanche Village

To estimate CCBL groundwater pumping water supply for Camanche Village from six active wells, the average for WY 2015-2018 was used for all CCBL years.

###### 5.1.5.3.4 Sacramento Municipal Utility District

The imported Central Valley Project water from the American River via the Folsom South Canal to the Sacramento Municipal Utility District (SMUD) facility uses the average for WY 2015-2018 for all CCBL years.

##### 5.1.5.4 Fish Farms

In the North American Subbasin, four wells were used to simulate 3,480 AFY of pumping for Sterling Caviar, which is located near the Sutter/Sacramento County line just east of Highway 99.

Groundwater pumping at fish farms in the South American Subbasin and Cosumnes Subbasin uses the average for WY 2015-2018 for all CCBL years.

### 5.1.6 Agricultural Demand and Supply

Agricultural demand in the CCBL is calculated within the model using land use, evapotranspiration, precipitation, and other information, as described for the historical simulation in Section 3.3.

Agricultural supply in the CCBL made of up primarily of surface water deliveries and groundwater pumping. Surface water deliveries are based on water year types (normal, wet, and dry) averages calculated using the last 10 years of the historical simulation (WY 2009-2018). Demand not met by surface water is assumed to be met by groundwater pumping, which is pumped within the associated model element, rather than coming from specific agricultural pumping wells.

#### 5.1.6.1 Rural-Residential Pumping

Rural residential pumping for the current conditions baseline is assumed to be the same as the historical model for water year 2018. Refer to Section 3.3.1 in the historical model documentation.

#### 5.1.6.2 Galt Wastewater Treatment Plant Effluent

The reclaimed water use from the Galt Wastewater Treatment Plant (WWTP) uses the average for WY 2015-2018 for all CCBL years, regardless of baseline water year type.

#### 5.1.6.3 Agricultural Groundwater Substitution Transfers

Pumping associated with agricultural water transfers occurs in three entities in the North American Subbasin: Natomas Mutual Water Company (NMWC), Pleasant Grove-Verona Mutual Water Company (PGVMWC), and South Sutter Water District. NMWC and PGVMWC participate in groundwater substitution transfers under certain conditions. South Sutter Water District is different from the other two, as they transfer water based on a hybrid approach. The water made available is released from storage in Camp Far West Reservoir. Generally, a similar volume of groundwater is pumped by private well owners within the district. This volume is not directly measured and is assumed to be slightly less than the amount released from storage. This is represented in the CCBL by delivering less surface water during dry years than normal or wet years, with averages calculated using the data from the last 10 years of the historical simulation. The groundwater pumping is calculated internally in the model and therefore automatically adjusts for years with less or more surface water.

For NMWC and PGVMWC, historical groundwater substitution transfer pumping data was provided for water years 2020 and 2021 (2019 was not a transfer year). For the CCBL estimates of groundwater substitution transfer pumping, dry year averages were calculated using historical data for WY 2012-2021. During this 10-year period, all groundwater substitution transfer pumping occurs in the five dry years (2013, 2014, 2015, 2020, and 2021). The estimated dry year transfer pumping for NMWC and PGVMWC was distributed among all transfer wells in the same proportion as in the historical data. The surface water deliveries to NMWC and PGVMWC in the CCBL are adjusted based on the amount of dry year transfer pumping.

### 5.1.7 Remediation Operations

Remediation operations for Mather, McClellan, Kiefer, and Aerojet, discussed for the historical simulation in Section 3.4, in the CCBL are held constant at the WY 2018 level of pumping for the entire CCBL. The number and location of the remediation wells is assumed to remain the same as in the historical simulation. Mather remediation pumping is set at 209 AFY, McClellan remediation pumping is set at 2,409 AFY, Kiefer remediation pumping is set at 621 AFY, and Aerojet remediation pumping is set at 32,040 AFY.

### 5.1.8 Results

This section provides a summary of the CoSANA CCBL results.

#### 5.1.8.1 Land and Water Use Budget

The land and water use budget provides details on the urban and agricultural demand and the water supply meeting the demand (groundwater pumping, surface water deliveries, recycled water, or remediation pumping). Average annual CCBL model results by groundwater subbasin are shown in Table 5-2. Annual agricultural water demand and supply by subbasin are shown in Figure 5-8 through Figure 5-10. Annual urban demand and supply by subbasin are shown in Figure 5-11 through Figure 5-13. Appendix H includes model subregion land and water use budgets for the baselines.

**Table 5-2: CCBL Average Annual Land and Water Use Budget**

| Subbasin | Ag. Demand (AFY) | Ag. Ground-Water Use* (AFY) | Ag Surface Water Deliveries (AFY) | Urban Demand (AFY) | Urban Ground-Water Use** (AFY) | Urban Surface Water Deliveries (AFY) | Urban Recycled Water (AFY) | Remediation Pumping (AFY) |
|---|---|---|---|---|---|---|---|---|
| NASb | 392,619 | 206,201 | 188,962 | 200,913 | 83,319 | 117,596 | - | 5,515 |
| SASb | 142,961 | 98,369 | 44,804 | 174,487 | 79,948 | 93,871 | 856 | 29,765 |
| CoSb | 126,838 | 105,049 | 21,458 | 27,520 | 22,825 | 2,483 | - | - |
| **Total** | **662,418** | **409,619** | **255,224** | **402,920** | **186,092** | **213,950** | **856** | **35,280** |

Note:
* Agricultural groundwater use presented in the above table may differ slightly from the values shown in the respective GSP due to minor difference in the methodology on calculation of rural residential water use.
** Urban groundwater use in the above table represents water used that originated from groundwater production but can include water that was pumped in areas outside of the respective subbasin.

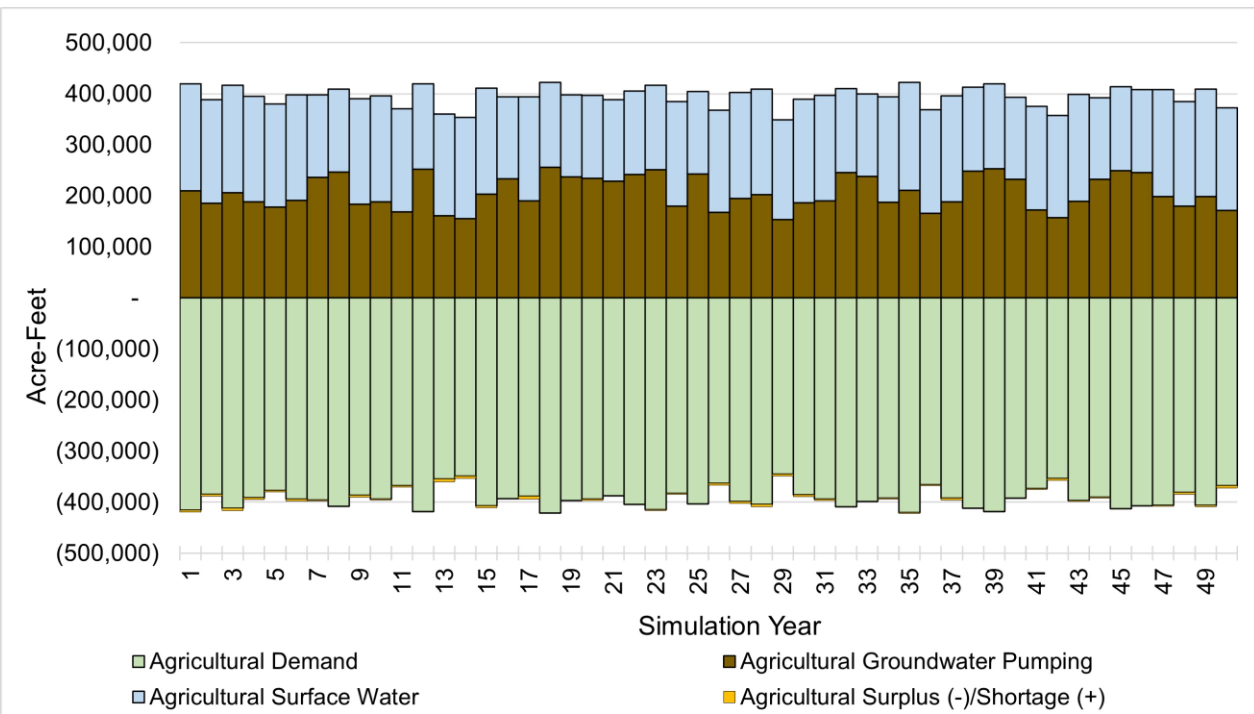



**Figure 5-8: Annual Agricultural Water Demand and Supply – North American Subbasin, Current Conditions Baseline**

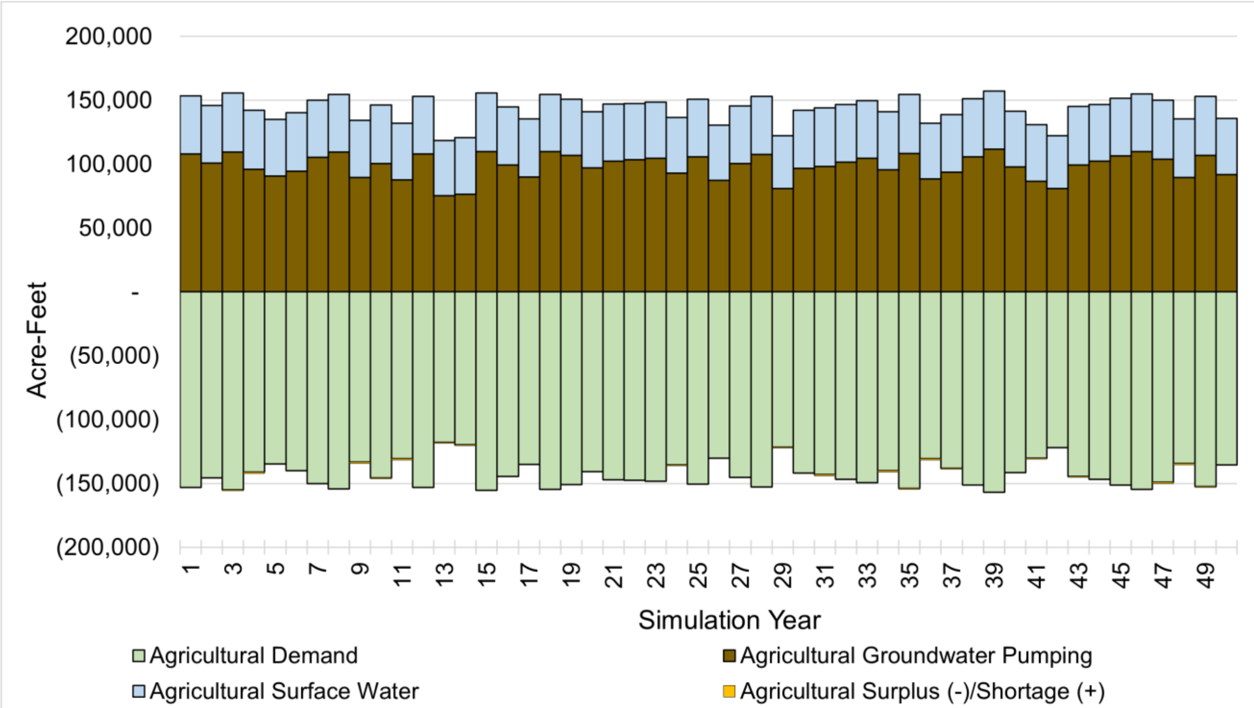



**Figure 5-9: Annual Agricultural Water Demand and Supply – South American Subbasin, Current Conditions Baseline**

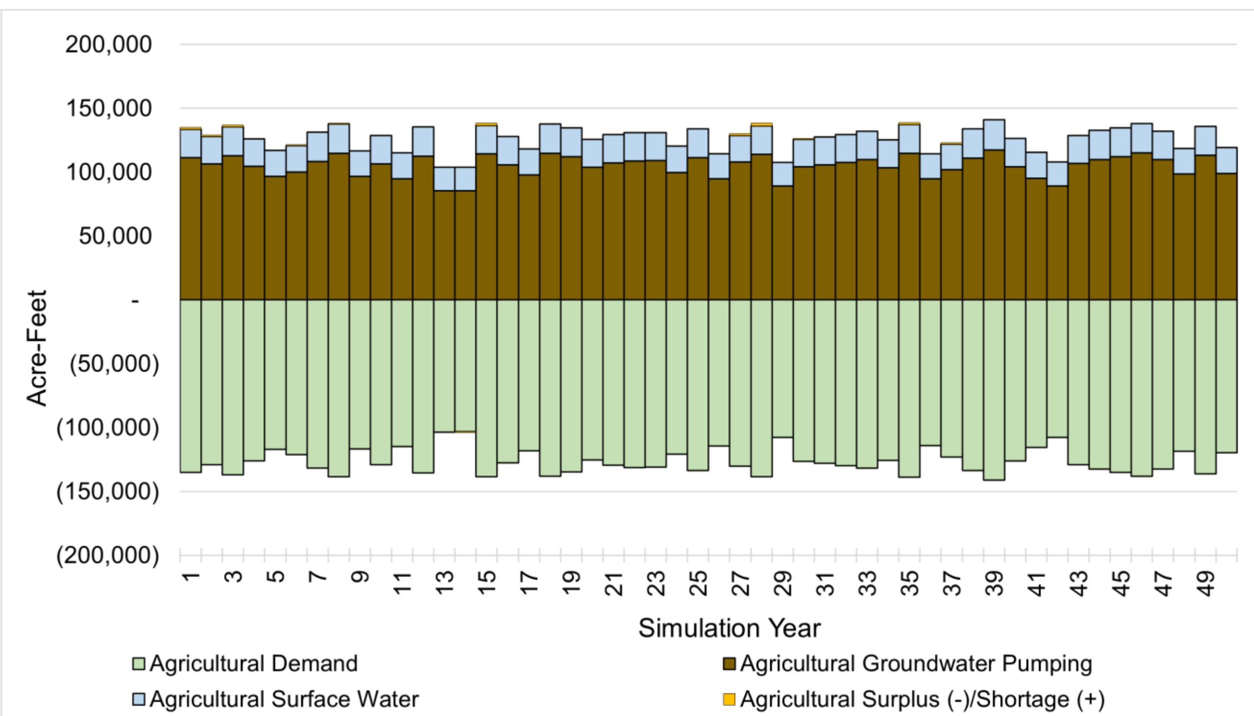



**Figure 5-10: Annual Agricultural Water Demand and Supply – Cosumnes Subbasin, Current Conditions Baseline**

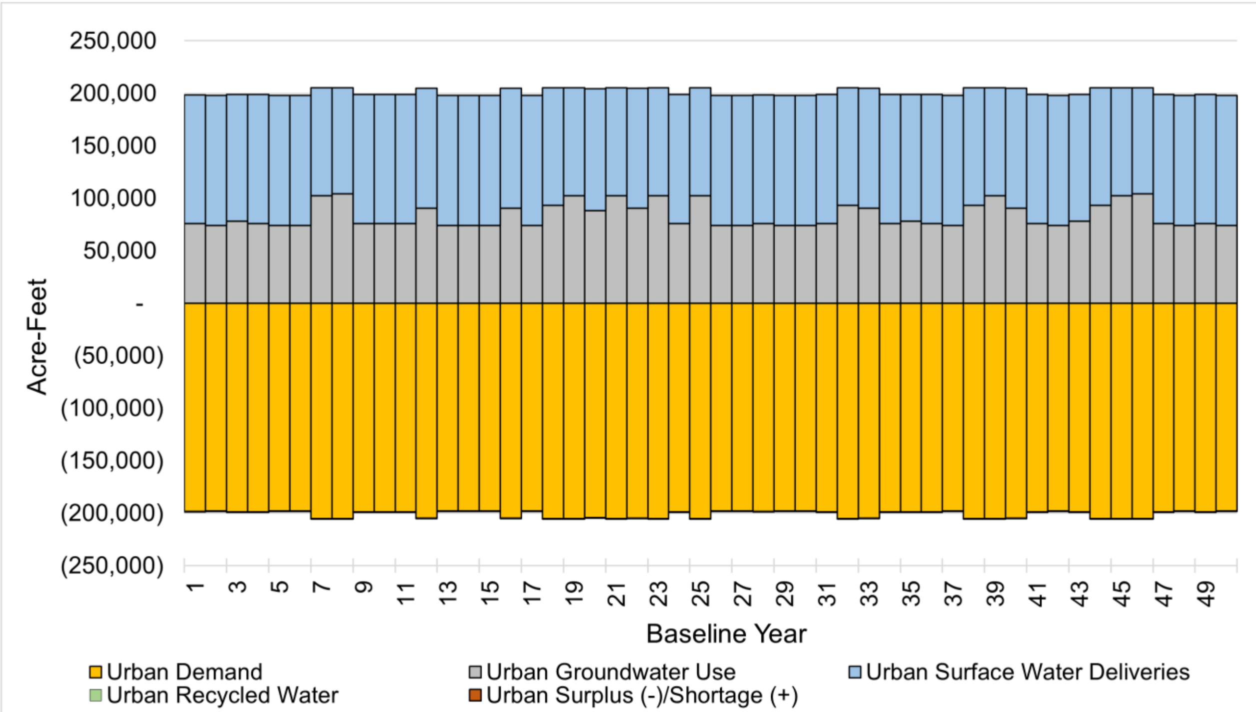



**Figure 5-11: Annual Urban Water Demand and Supply – North American Subbasin, Current Conditions Baseline**

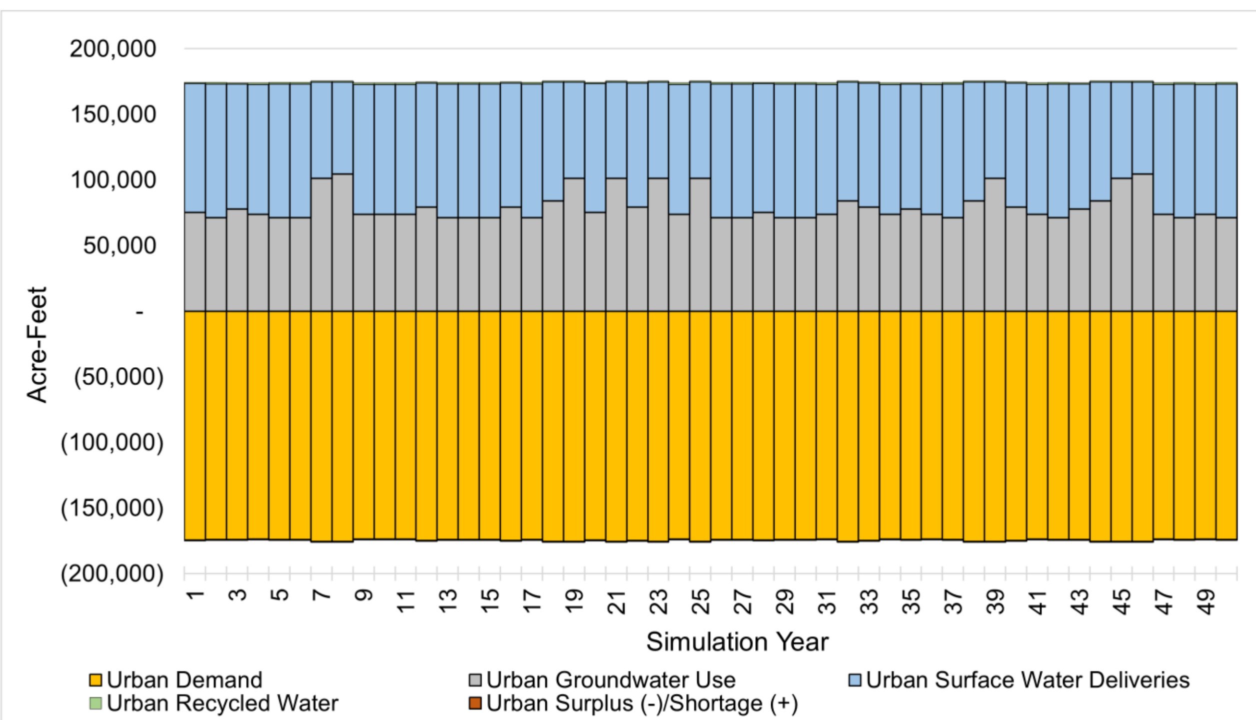
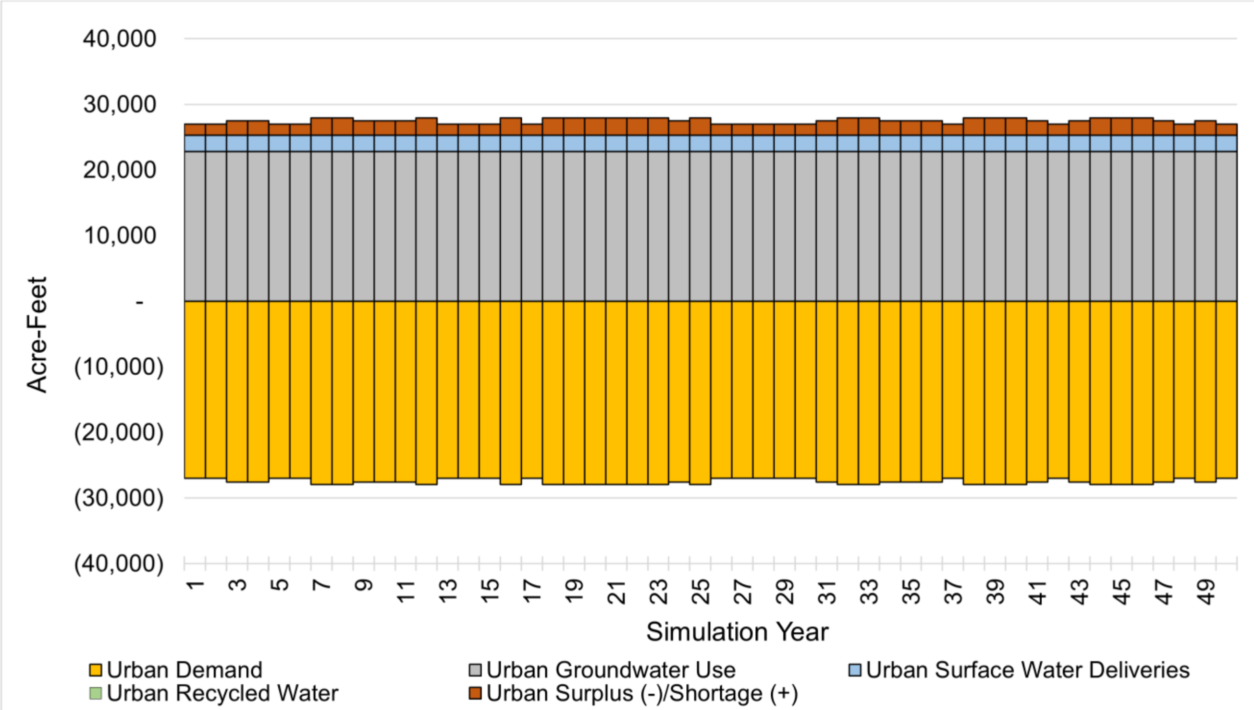



**Figure 5-12: Annual Urban Water Demand and Supply – South American Subbasin, Current Conditions Baseline**




*Note: Urban groundwater use is specified in the CoSb model input data set. The model-calculated surplus/shortage in urban demand is therefore not utilized to calculate the CoSb groundwater budget.*

**Figure 5-13: Annual Urban Water Demand and Supply – Cosumnes Subbasin, Current Conditions Baseline**

#### 5.1.8.2 Groundwater Budget

The groundwater budget provides all inflows and outflows to the groundwater aquifer system. Average annual CCBL model results by groundwater subbasin are shown in Table 5-3. Annual groundwater budgets with cumulative change in storage by subbasin are shown in Figure 5-14 through Figure 5-16. Appendix I includes model subregion groundwater budgets for the baselines. Appendix J includes a set of sample hydrographs for the baseline models.

**Table 5-3: CCBL Average Annual Groundwater Budget**

| Subbasin | Pumping (AFY) | Deep Percolation (AFY) | Gain from Stream (AFY) | Recharge from Canals (AFY) | Boundary Flows (AFY) | Subsurface Inflow (AFY) | Change in Storage (AFY) |
|---|---|---|---|---|---|---|---|
| NASb | 303,094 | 183,468 | 81,494 | 16,732 | 28,125 | 8,161 | 14,843 |
| SASb | 212,626 | 120,915 | 91,328 | 26 | 4,089 | -1,573 | 2,158 |
| CoSb | 127,875 | 109,064 | 15,575 | 0 | 1,442 | 1,559 | -233 |
| **Total** | **643,595** | **413,447** | **188,397** | **16,758** | **33,656** | **8,147** | **16,768** |

Note: Boundary Flows term includes flow between areas outside of the CoSANA model domain and baseflow from small watersheds. Subsurface Inflows includes flow between the simulated subbasins in CoSANA and areas outside of Bulletin 118 subbasins.

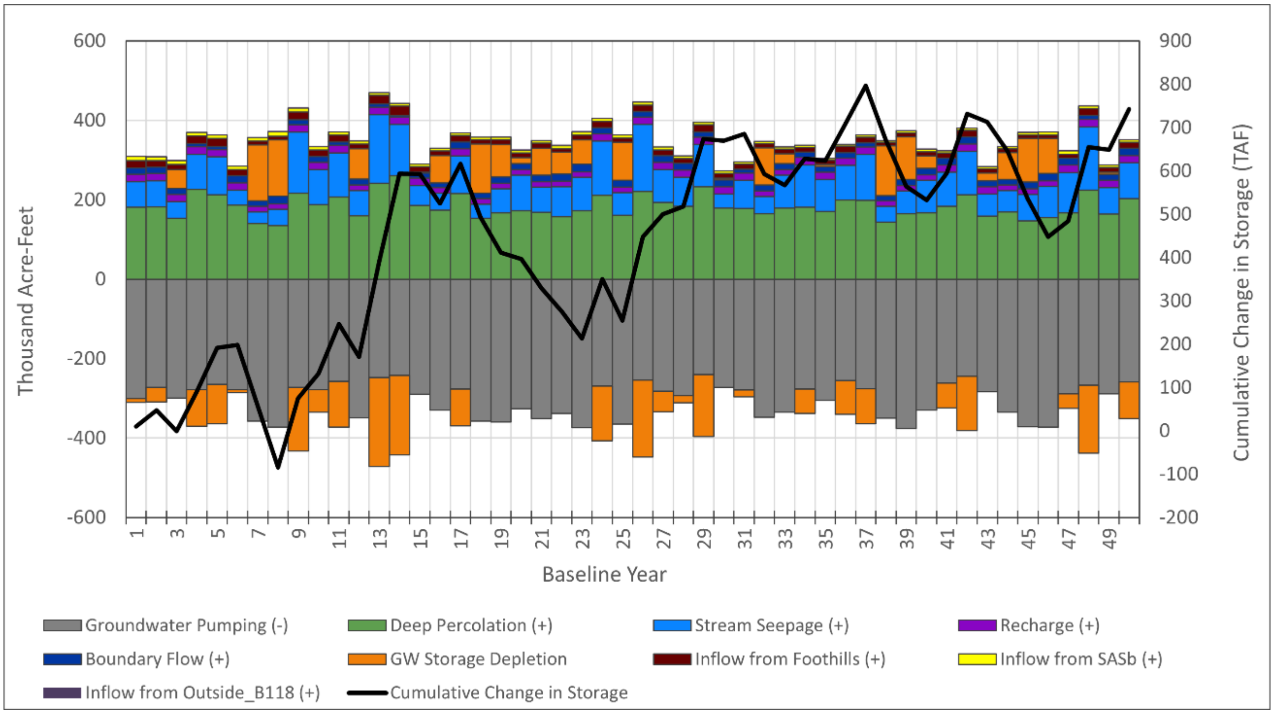



**Figure 5-14: Annual Groundwater Budget and Cumulative Change in Storage – North American Subbasin, Current Conditions Baseline**

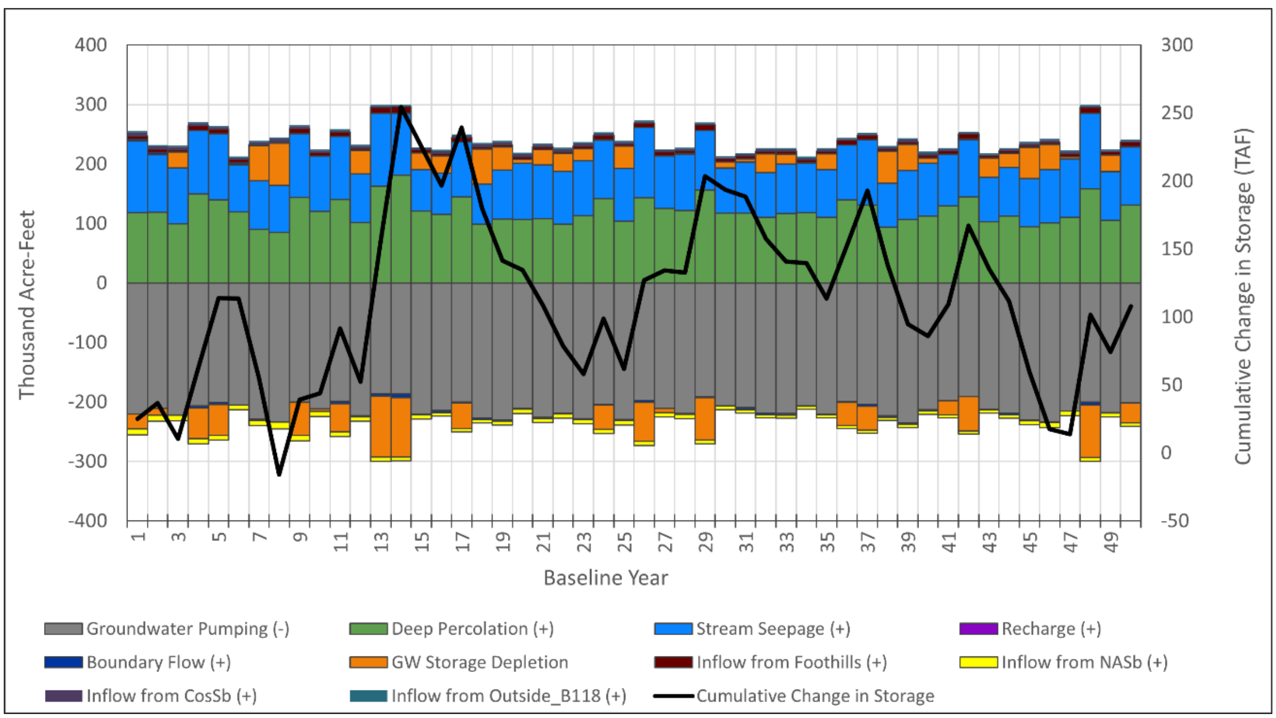



**Figure 5-15: Annual Groundwater Budget and Cumulative Change in Storage – South American Subbasin, Current Conditions Baseline**

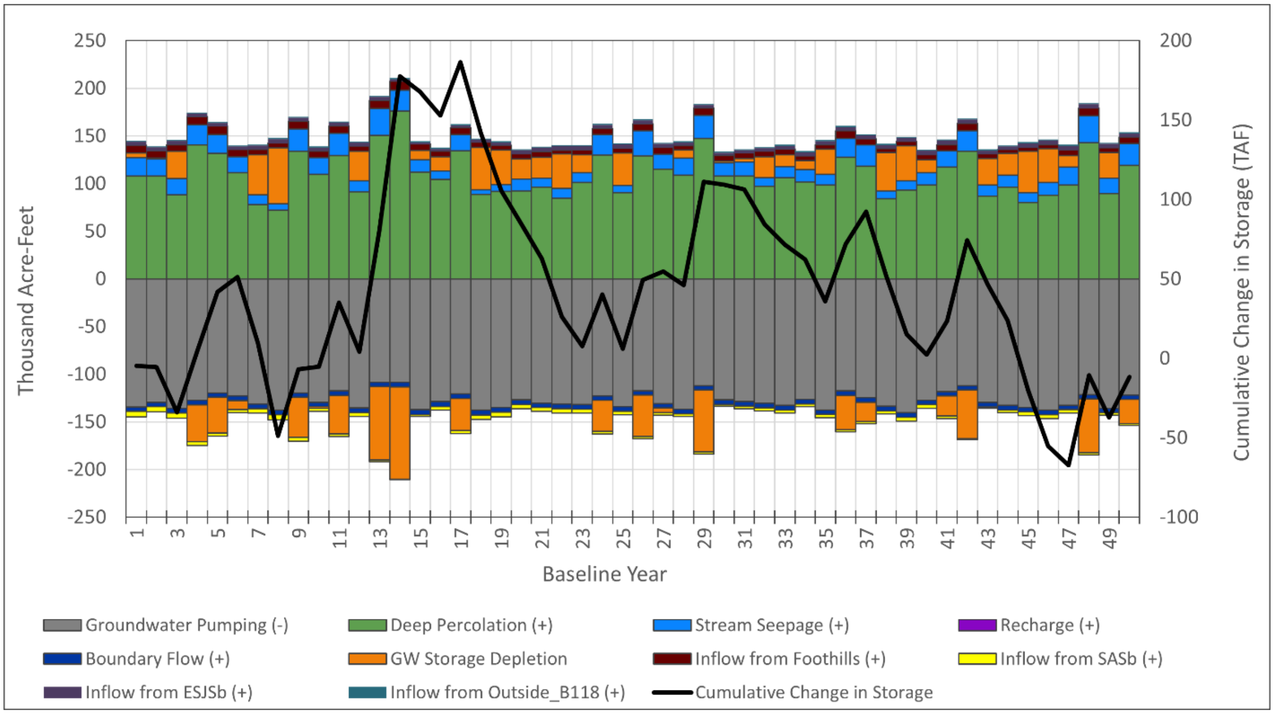



**Figure 5-16: Annual Groundwater Budget and Cumulative Change in Storage – Cosumnes Subbasin, Current Conditions Baseline**

## 5.2 Projected Conditions Baseline

The CoSANA Projected Conditions Baseline (PCBL) is a representation of the projected land and water use conditions of 2040, or the closest information available from planning documents. This section presents the key data sources and assumptions used to develop the PCBL and provides the model results. Initial groundwater levels and soil conditions in the PCBL represent those at the end of the simulation period of the historical CoSANA (September 30, 2018).

### 5.2.1 Hydrologic Period

The PCBL uses the 50-year historical hydrology from WY 1970 through 2019 (October 1, 1969 through September 30, 2019) for precipitation, evapotranspiration, and streamflow. This is the same as for the CCBL, discussed in Section 5.1. The hydrologic year types discussed in Section 5.1.1.4 are used in the PCBL to develop projected water demands and supplies.

### 5.2.2 Land Use

The PCBL incorporates the proposed new developments to reflect the 2040 land use conditions or the closest data available from planning documents. The existing land use data for 2015 conditions used in the CCBL were modified to incorporate the future projected urban footprint. The urban footprint for the proposed new developments, urban demand, and urban supply projections including the new developments were incorporated into the model, as further explained below.

Table 5-4 lists the proposed new developments incorporated into the PCBL. A total of 62 proposed new developments were identified, including 34 in the NASb, 25 in the SASb, and 3 in CoSb. In the CoSb, urban land was expanded around existing developed areas, as projected in planning documents.

The main data source for identifying the new developments in Sacramento County was information and GIS files provided by the Sacramento County Office of Planning and Environmental Review (T. Smith, personal communication, October 2020). In addition, public information available from the Sacramento Area Council of Governments (SACOG) was also collected and reviewed for identifying and confirming the developments within Placer and Sutter Counties. Placer County also reviewed the list of the new developments and provided inputs (J. Byous, personal communication, December 2020). Information was also available for many of the developments in Sutter and Placer Counties (R. Shatz, personal communication, December 2020).

The majority of the new developments in the NASb are located in Placer County near the City of Rocklin (Sunset Ranchos and Clover Valley), City of Lincoln (SUD A, SUD B, SUD C, Village 1, Village 2, Village 3, Village 4, Village 5, Village 6, and Village 7), City of Roseville (Amoruso Ranch, Creekview, HP Campus Oaks, North Area, Northwest Roseville, Sierra Vista, Sun City Roseville [or Del Webb] and West Roseville Specific Plans), and Cal-Am West Placer (Placer Vineyards Specific Plans East and West and Riolo Vineyards). Other proposed developments include the Placer Ranch and Regional University in Placer County, Sutter Pointe in Sutter County; and Grandpark Specific Plan, Elverta, Greenbrier, Panhandle, Northborough, and Upper Westside in Sacramento County.

The majority of the proposed new developments in the SASb are located within the SCWA service areas (Arboretum, Jackson Township, Laguna Ridge, Ranch at Sunridge, Rio del Oro (partially in the Cal-Am service area), Southeast Planning Area (Meridian), Sterling Meadows, SunCreek, SunRidge, Vineyards, Cordova Hills, Florin Vineyard Gap, Mather South, NewBridge, North Vineyard Station, Vineyard Springs, Lent Ranch, and West Jackson Highway Master Plan). Other proposed developments are located around or within the City of Folsom (Easton, Folsom South Area, and Glenborough), Rancho Murieta Community Service District (Rancho Murieta), and Elk Grove Water District (Triangle).

In the CoSb, urban land in the City of Galt was expanded based on 2030 projections in the City's General Plan, and areas in the vicinity of Ione ("Urban Planning Area") and Camanche Village ("Rural Residential") were expanded based on Amador County's General Plan. The footprint of the Buena Vista Rancheria was converted from native to urban.

The proposed new developments and future land use conditions are shown in Figure 5-17. The time-series of land use for the CoSANA PCBL is shown in Figure 5-18, highlighting the constant nature of land and water use in the baseline conditions. Figure 5-19 through Figure 5-21 show time-series of land use for the NASb, SASb, and CoSb, respectively.

**Table 5-4: Proposed New Developments**

| Proposed Development Name | ID | | Proposed Development Name | ID |
|---|---|---|---|---|
| Village 4 | 1 | | Greenbriar | 32 |
| SUD A | 2 | | Panhandle | 33 |
| Village 3 | 3 | | Upper Westside | 34 |
| Village 5 | 4 | | Westborough | 35 |
| SUD B | 5 | | Easton | 36 |
| Village 2 | 6 | | Glenborough | 37 |
| Village 1 | 7 | | Folsom South Area | 38 |
| Village 6 | 8 | | Rio Del Oro | 39 |
| Village 7 | 9 | | Mather South | 40 |
| SUD C | 10 | | Ranch At Sunridge | 41 |
| Sunset Ranchos | 11 | | SunRidge | 42 |
| Amoruso Ranch Specific Plan | 12 | | SunCreek | 43 |
| Clover Valley | 13 | | Cordova Hills | 44 |
| Placer Ranch | 14 | | West Jackson Highway Master Plan | 45 |
| Creekview | 15 | | Jackson Township | 46 |
| West Roseville | 16 | | NewBridge | 47 |
| North Area Specific Plan | 17 | | Arboretum | 48 |
| Sun City Roseville | 18 | | Rancho Murrieta | 49 |
| HP Campus Oaks | 19 | | Florin-Vineyard | 50 |
| Sierra Vista Specific Plan | 20 | | North Vineyard Station | 51 |
| North Area Specific Plan 2 | 21 | | Delta Shores | 52 |
| Northwest Roseville Specific Plan | 22 | | Vineyards | 53 |
| Sutter Pointe | 23 | | Vineyard Springs | 54 |
| Regional University | 24 | | Triangle | 55 |
| Riolo Vineyards | 25 | | Laguna Ridge | 56 |
| Placer Vineyards Specific Plan (east) | 26 | | Southeast Planning Area (Meridian) | 57 |
| Placer Vineyards Specific Plan (west) | 27 | | Sterling Meadows | 58 |
| Dry Creek-West Placer Community Plan | 28 | | Lent Ranch | 59 |
| Grandpark Specific Plan | 29 | | Galt Sphere of Influence | 60 |
| Elverta Specific Plan | 30 | | Camanche Village Rural Residential | 61 |
| Northborough Boundary | 31 | | Ione Urban Planning Area | 62 |

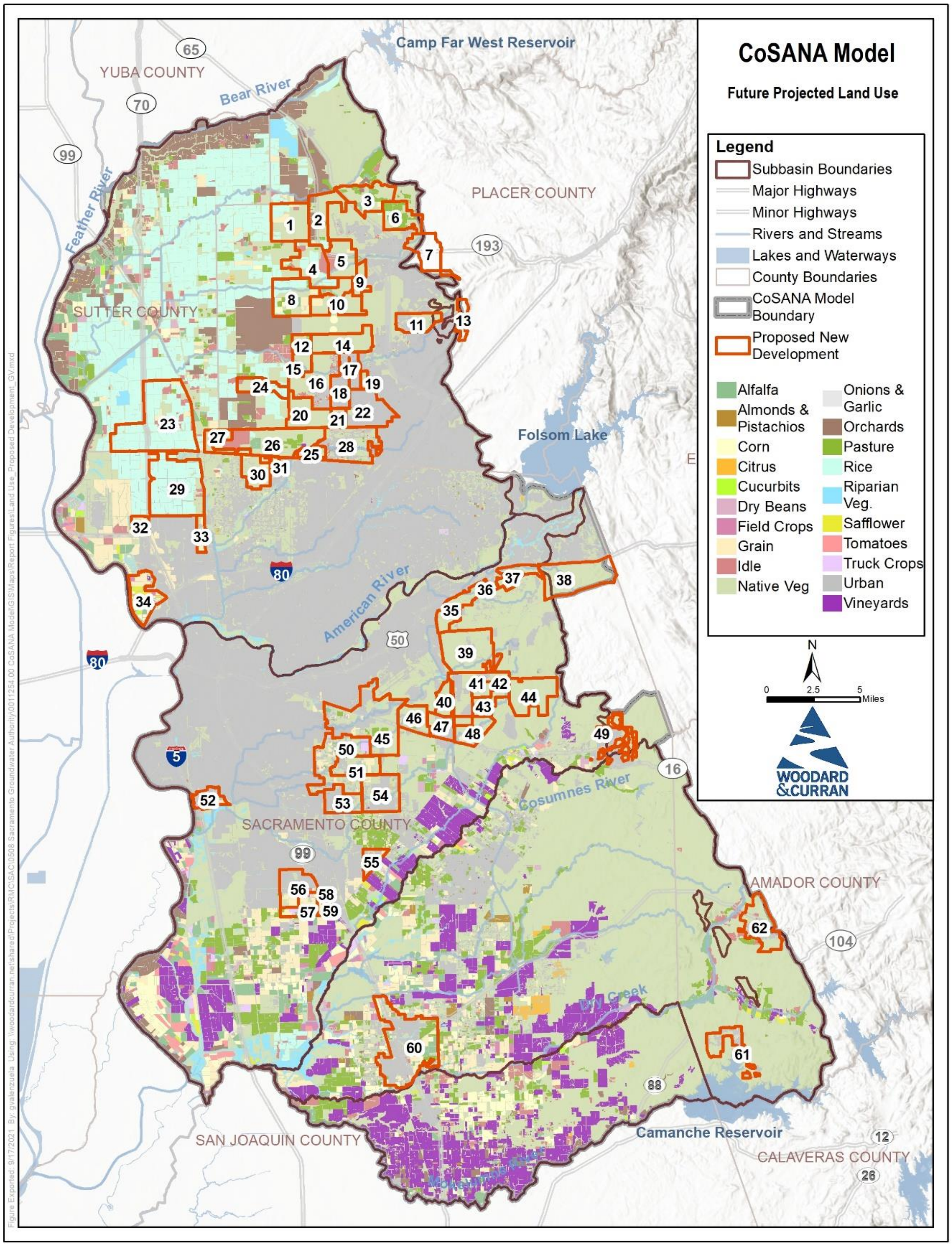



**Figure 5-17: Projected Land Use and Proposed New Developments**

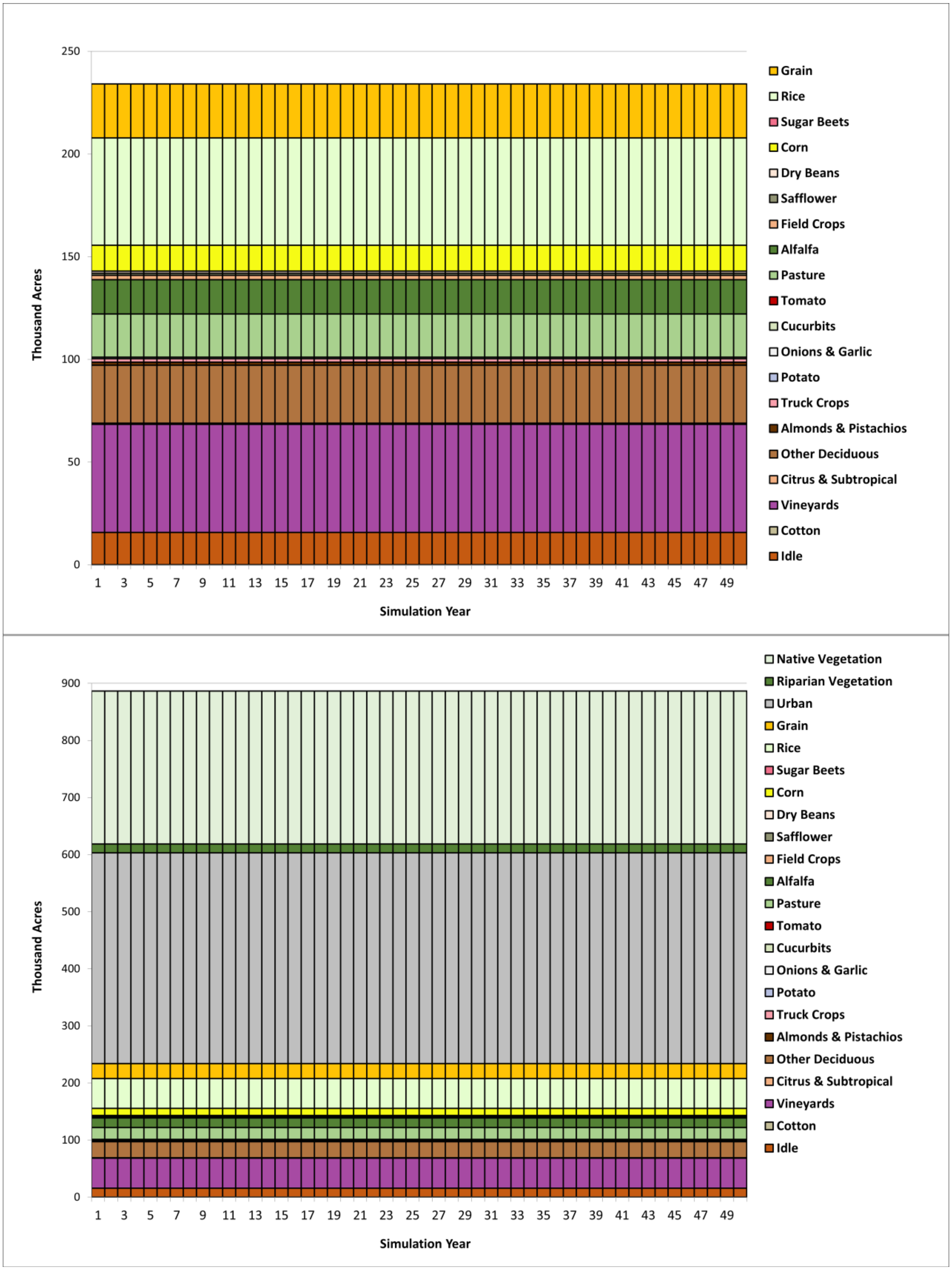
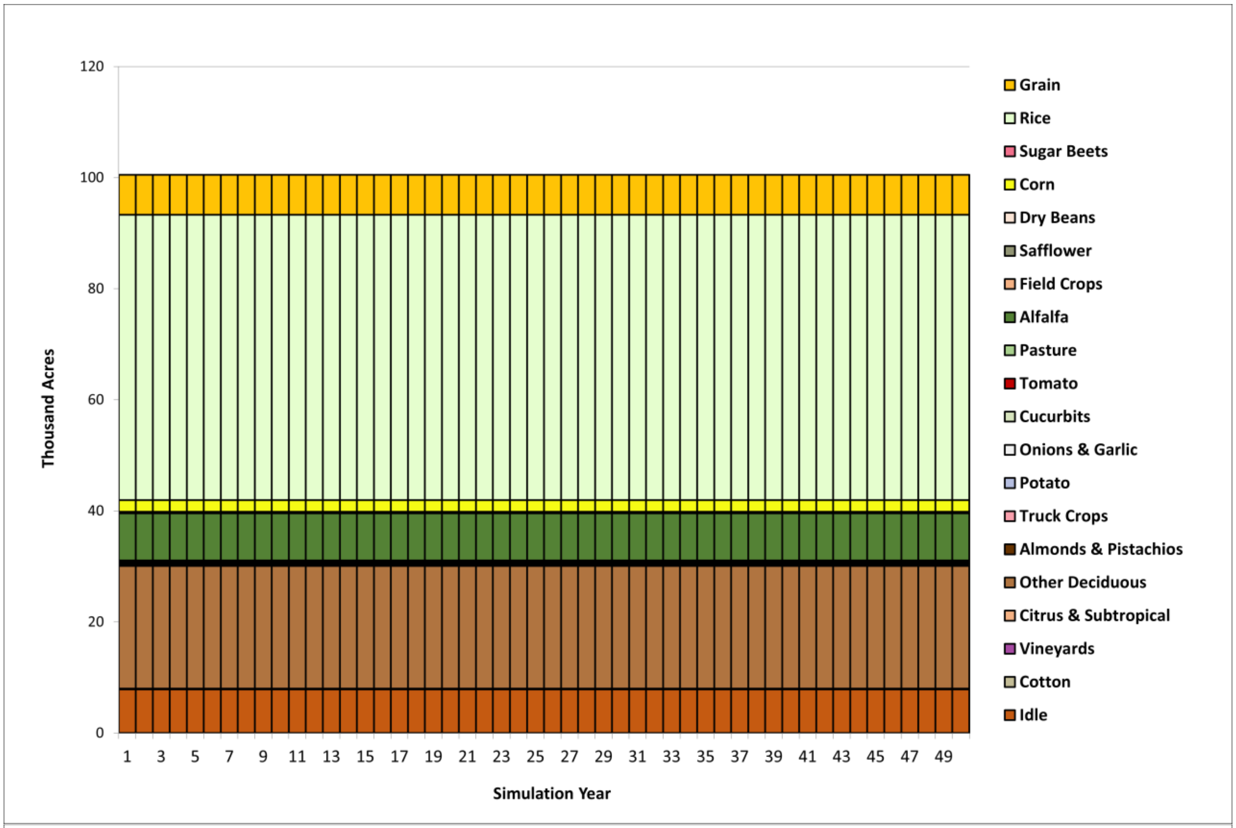



**Figure 5-18: Projected Conditions Baseline Land Use for CoSANA**



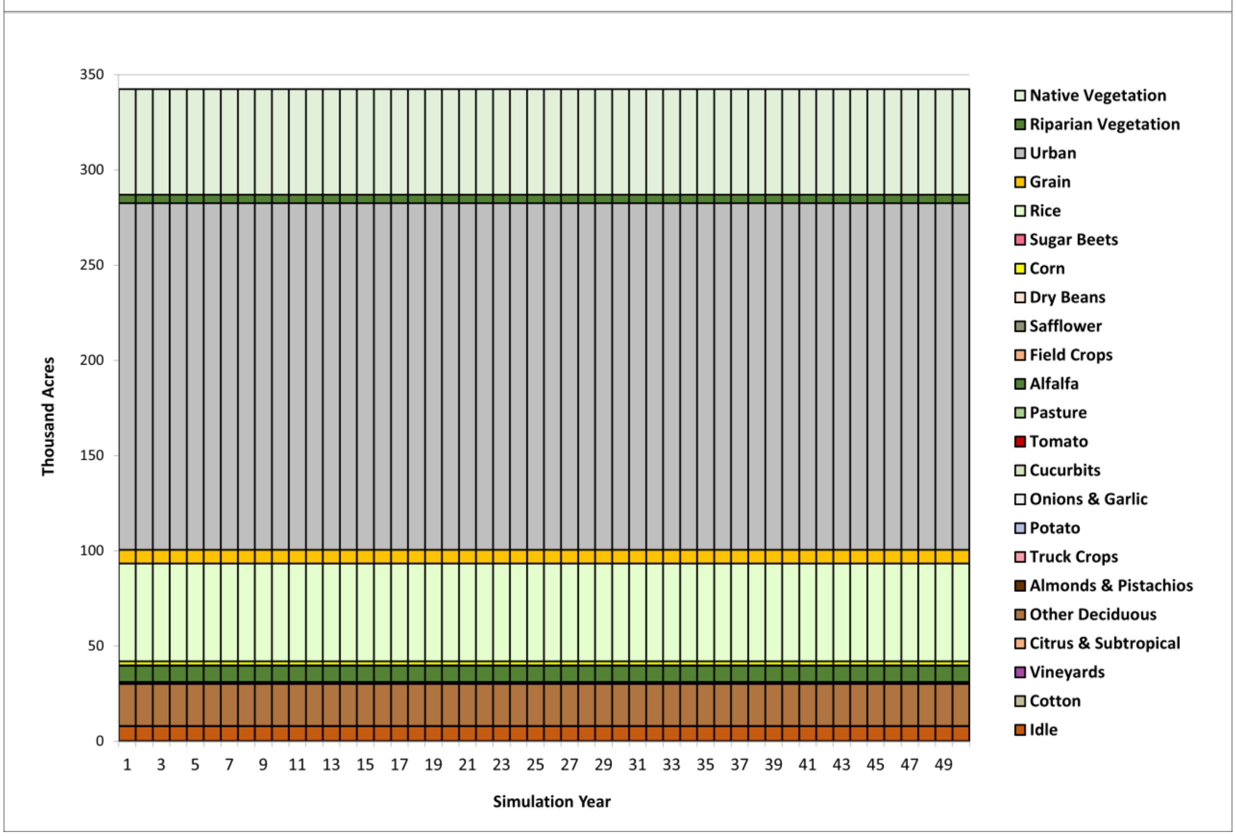




**Figure 5-19: Projected Conditions Baseline Land Use for North American Subbasin**

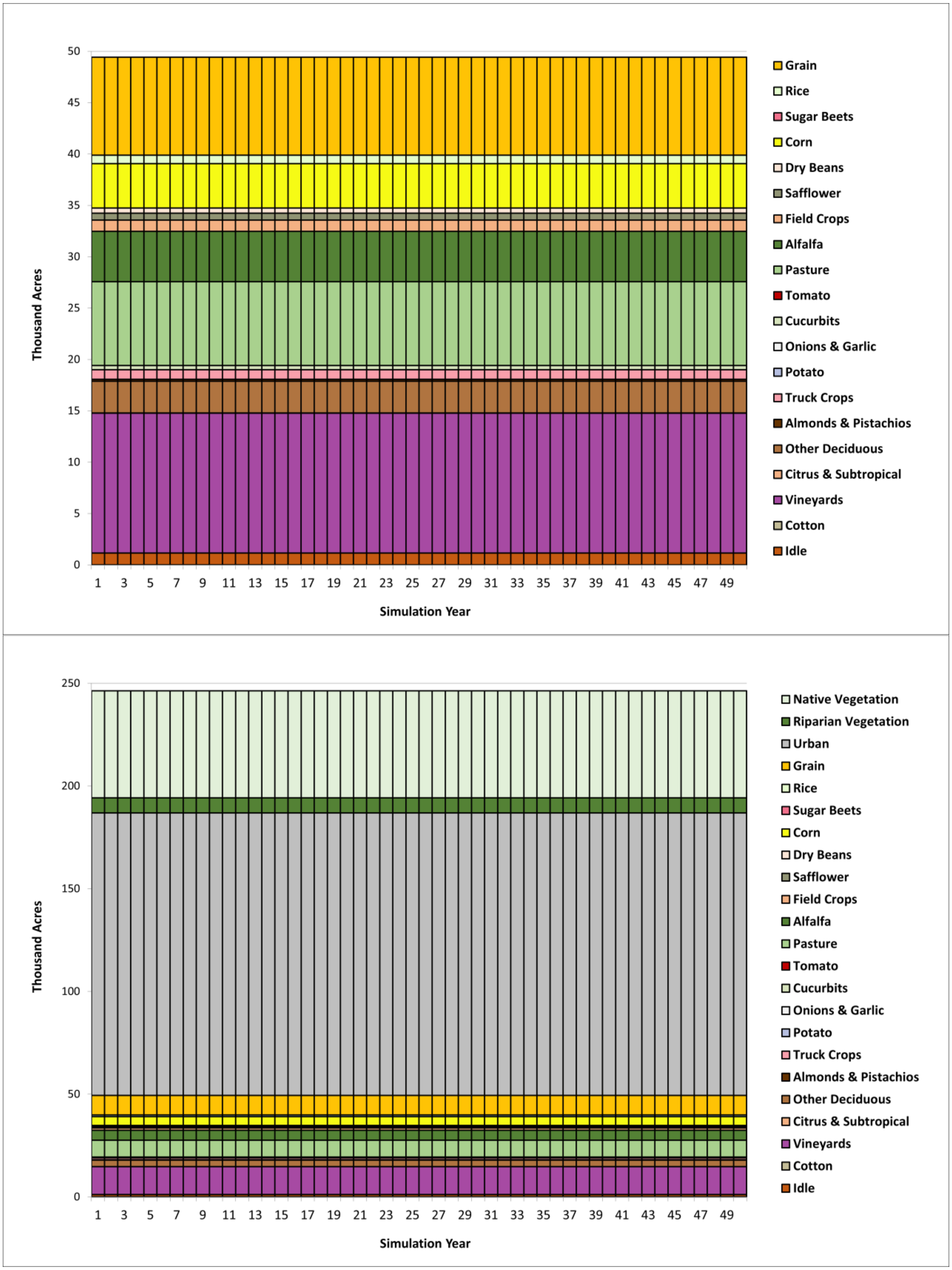



**Figure 5-20: Projected Conditions Baseline Land Use for South American Subbasin**

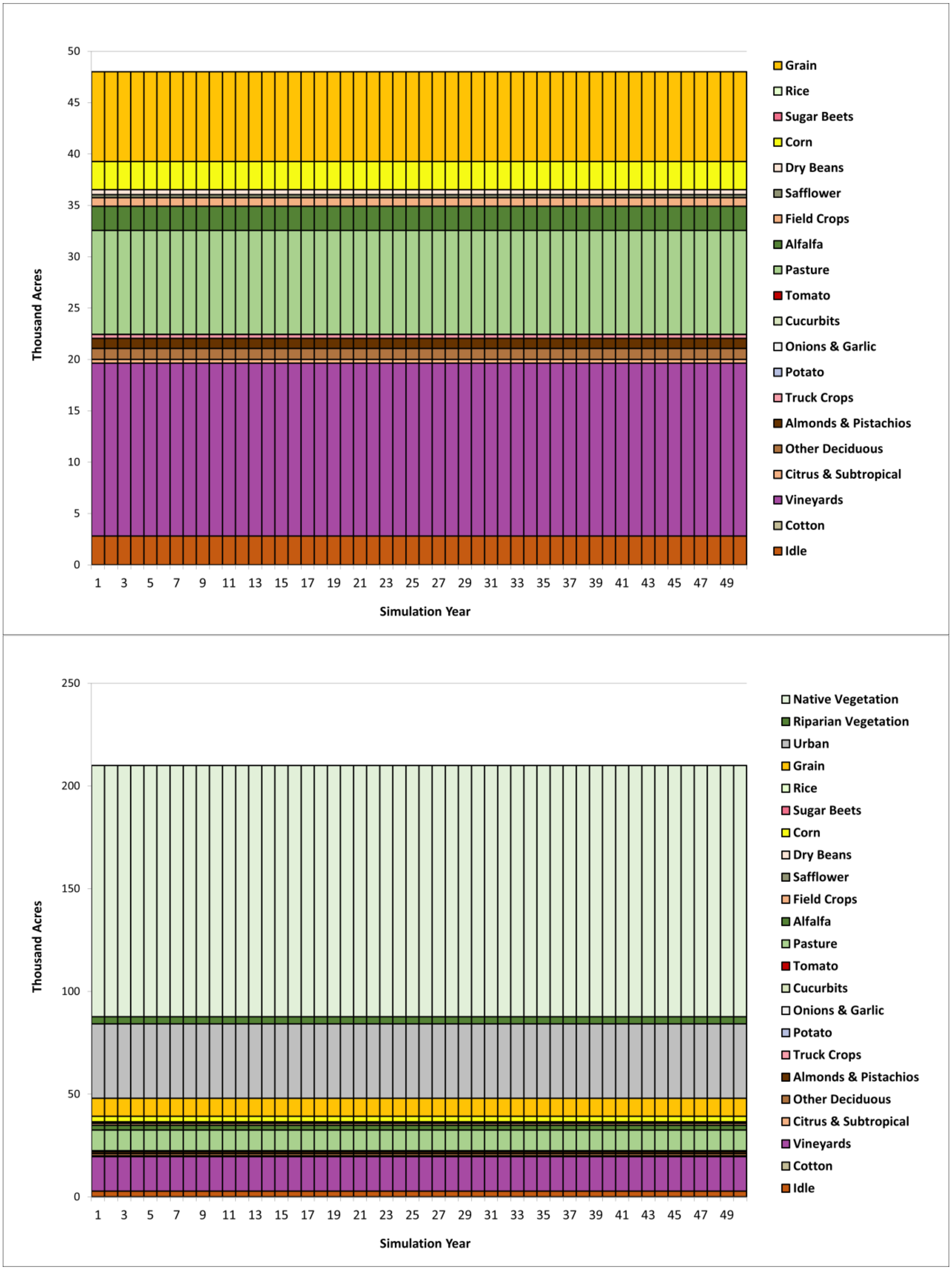



**Figure 5-21: Projected Conditions Baseline Land Use for Cosumnes Subbasin**

### 5.2.3 Urban Demand and Supply

Urban water demand in the PCBL is generally reflective of 2040 conditions. Demand and supply projections were generally available for 2040 conditions; when data for 2040 was not readily available, 2035 projections were used as the latest information. Water demand and supply assumptions are based on the 2015 UWMPs, general plans, other planning documents, or most current information provided by purveyors. Note that the 2020 UWMPs were not available at the time of model development. Appendix G presents the annual average demand and supply assumptions used in the PCBL by three water year types for each purveyor and five water year types for the City of Sacramento. Urban demand and supply projections were defined by three water year types for wet, normal, and dry conditions, using the same water year types as in the CCBL. All dry year projections were assumed to be single dry year projections based on the information available. Projections for wet years were assumed to be the same as normal conditions when wet year projections were unavailable. For the purpose of the modeling, supply was assumed to meet the demand with no surplus.

2015 UWMPs and other planning and environmental permitting documents were reviewed to estimate demand and supply sources for the proposed developments. Review of the publicly available information suggested that demand and supply projections were generally included in the purveyors' projected demand and supply estimates as reported in the 2015 UWMPs with the exception of two new developments - Sutter Pointe and Grandpark Specific Plans. Sutter Pointe and Grandpark Specific Plans were assumed to be on a mix of groundwater pumping and surface water supplies based on available documentation. It was assumed that all new developments in Placer County would be on surface water supplies.

This section briefly describes the demand and supply assumptions used in the PCBL for each purveyor. Similar to the approach in the CCBL, demand and supply information is described for purveyors grouped by the three subbasins NASb, SASb, and CoSb.

#### 5.2.3.1 North American Subbasin

This section briefly describes the demand and supply assumptions used in the PCBL within the NASb.

##### 5.2.3.1.1 Placer County Water Agency – Rocklin Retail Area

- **Demand**: The City of Rocklin's future demand of 18,942 AFY was based on the Placer County Water Agency's 2015 UWMP (Table 4-9; PCWA, 2016) with a partial demand estimated and incorporated into the PCBL to represent the portion of the City of Rocklin within the model domain. It is estimated that approximately 33% of the City of Rocklin's demand was within the model area. Demand was adjusted by water year type based on the trends seen in the CCBL, with slightly lower demand during dry years than normal and wet years.

- **Supply**: All future demand was assumed to be met by surface water.

##### 5.2.3.1.2 City of Lincoln

- **Demand**: 2040 demand projections were 20,336 AFY for normal and wet years and 20,947 AFY for dry years, based on the 2015 UWMP (Table 4-6 and Table 7-2) (City of Lincoln, 2016a).

- **Supply**: Demand was assumed to be met by 3,300 AFY of groundwater pumping, 6,063 AFY of recycled water, and the remaining demand met by surface water. These values were based on the Water Master Plan (Tables 3-10 and 3-11; City of Lincoln, 2016b) and the latest information available (R. Shatz, personal communication, December 2020). The City of Lincoln's proposed future wells to support the proposed developments were incorporated into the PCBL.

#### 5.2.3.1.3 City of Roseville

- **Demand**: The 2040 demand projection was based on the 2015 UWMP (City of Roseville, 2016) and information provided by the City of Roseville (T. Joseph, personal communication, December 2020). Demand was assumed at 56,865 AFY during normal and wet years and reduced to 46,708 AFY during dry years, which accounts for a reduction of 11,677 AFY through water conservation.

- **Supply**: Demand was assumed to be met by 5,958 AFY of recycled water in all years, based on the 2015 UWMP (Table 6-11); the remaining demand was assumed to be met by surface water and the city's aquifer storage and recovery (ASR) program. The PCBL incorporated the ASR program at buildout with 15 ASR wells operating and included well information (well IDs, well locations, and well screens) and annual extraction and injection schedules provided by the City of Roseville. With the ASR program, the city assumes no net take on groundwater supply over the long-term, based on the following ASR operations by water year types:
  - During dry years, the City of Roseville's ASR wells extract 6,907 AFY of groundwater.
  - During wet years, the City of Roseville recharges groundwater through injection of 6,200 AFY of surface water into aquifer.
  - During normal and wet years, ASR wells pump a small volume of 25 AFY for maintenance.

#### 5.2.3.1.4 California American Water Company (West Placer, Antelope, Lincoln Oaks, and Arden)

- **Demand**: A 2035 demand projection was developed for each service area based on the 2015 UWMP (Table 4-2; Cal-Am, 2016). Demand remains the same in all water year types.

- **Supply:** Supply projections by service area were based on the 2015 UWMP as follows:
  - West Placer was assumed to be all surface water provided to Cal-Am by the wholesaler, PCWA.
  - Antelope and Lincoln Oaks were assumed to be on surface water from Sacramento Suburban WD (only during normal and wet years) and groundwater pumping. The 2,000 AFY of surface water supply was assumed to be distributed as 60% to Antelope and 40% to Lincoln Oaks (2015 UWMP Table 5-9); the remaining supply comes from groundwater.
  - The City of Sacramento supply of 4,831 AFY was distributed between Arden (NASb), Parkway (SASb), and Suburban Rosemont (SASb) based on the 2015 UWMP (Table 5-9).

#### 5.2.3.1.5 Sacramento International Airport

- **Demand**: Demand was estimated based on the average of 2017 and 2018 in the CCBL.

- **Supply**: Demand was assumed to be met by surface water and groundwater, proportional to the volumes in 2017 and 2018.

#### 5.2.3.1.6 Rio Linda / Elverta Community Water District

- **Demand**: A 2035 demand projection of 7,462 AFY for normal and wet years (Table 4-2) and 8,208 AFY for dry years (Table 7-3) was assumed based on the 2015 UWMP (RLECWD, 2016).

- **Supply**: Demand was assumed to be met by groundwater, similar to the CCBL conditions (UWMP Table 6-9).

- **Proposed Development**: The PCBL incorporates the Elverta and Northborough Specific Plans, which are located outside of the RLECWD's current service area.

#### 5.2.3.1.7 Sacramento Suburban Water District

- **Demand**: A 2040 demand projection of 41,304 AFY was assumed based on the 2015 UWMP (Table 3-5) (Sacramento Suburban WD, 2016). Demand remains the same for all water year types.

- **Supply**: Demand was assumed be met by a maximum groundwater pumping of 35,000 AFY during dry years, based on the 2015 UWMP (Table 5-11); the remaining demand was assumed to come from surface water. For normal and wet years, the groundwater and surface water supply mix was assumed to be proportional to CCBL conditions.

#### 5.2.3.1.8 Citrus Heights Water District

- **Demand**: 2035 demand was assumed as 18,210 AFY for normal and wet years and 15,478 AFY for dry years, based on the 2015 UWMP (Table 4-2 and Table 7-3; Citrus Heights Water District, 2016).

- **Supply**: Demand was assumed be met by 900 AFY of groundwater pumping, with the remaining demand from San Juan WD surface water, based on the 2015 UWMP (Table 6-9).

#### 5.2.3.1.9 Orange Vale Water Company

- **Demand**: 2035 demand was assumed as 4,981 AFY for normal and wet years and 4,234 AFY for dry years, based on the 2015 UWMP (Table 4-2 and Table 7-3; Orange Vale Water Company, 2016).

- **Supply**: Demand was assumed be met by San Juan WD surface water, similar to the CCBL.

#### 5.2.3.1.10 San Juan Water District

- **Demand**: A 2040 demand projection of 19,393 AFY was assumed for retail demand, based on the 2015 UWMP (Table 4-2b; SJWD, 2016).

- **Supply**: Demand was assumed to be met by surface water, based on the 2015 UWMP (Table 6-9).

#### 5.2.3.1.11 City of Sacramento

- **Demand**: A 2040 demand projection of 161,029 AFY was assumed based on the 2015 UWMP (Table 4-2) (City of Sacramento, 2016). Demand remains the same for all water year types. Approximately 35% of the demand was assumed to be in the NASb portion of the model, based on urban area.

- **Supply**: Supply projections include groundwater pumping and surface water supplies that vary by five water year types (as opposed to three water year types used for other purveyors) based on the City of Sacramento's 2017 GWMP (City of Sacramento, 2017). Groundwater pumping assumptions were consistent with the Maximum Groundwater Use scenario developed in the 2017 GWMP, based on the discussions with the City of Sacramento. Monthly pumping assumptions by each well were incorporated into the PCBL based on well locations and monthly well operations, as specified in the 2017 GWMP. Groundwater pumping in the NASb varies from 11,553 AFY during wet years to 38,261 AFY during driest years. Demand after groundwater pumping was assumed to be supplied by surface water. The City of Sacramento also has specific wells that supply some of the larger parks and green areas within the city boundaries. These irrigation wells are simulated using six representative irrigation wells that pump 2,200 AFY. Based on the locations of the irrigated parks and green areas, approximately half of the irrigation pumping was estimated in the NASb and the remaining half in the SASb.

#### 5.2.3.1.12 Sacramento County Water Agency (Arden Park Vista and Northgate)

- **Demand**: 2045 demand projections for Arden Park Vista and Northgate were based on the Draft 2020 UWMP (Tables 4-10(b) and 4-10(c)) provided by SCWA and input from SCWA (M. Grinstead, personal communication, April 2021).
- **Supply**: Arden Park Vista and Northgate were assumed to be on groundwater, similar to the CCBL conditions.

#### 5.2.3.1.13 Del Paso Manor Water District

- **Demand**: Demand was estimated based on the average of 2017 and 2018 in the CCBL.
- **Supply**: Demand was assumed to be met by groundwater, similar to the CCBL.

#### 5.2.3.1.14 Golden State Water Company (Arden)

- **Demand**: Demand for the Arden service area was assumed to remain the same as in the CCBL conditions.
- **Supply**: Arden service area was assumed to be on groundwater, consistent with the CCBL conditions.

#### 5.2.3.1.15 Carmichael Water District

- **Demand**: A 2040 demand projection was assumed as 10,334 AFY for normal and wet years and 10,851 AFY for dry years, based on the 2015 UWMP (Table 4-6 and Table 7-2) (Carmichael Water District, 2016).
- **Supply**: Demand was assumed to be met by groundwater pumping and surface water, proportional to the CCBL conditions.

#### 5.2.3.1.16 Fair Oaks Water District

- **Demand**: A 2035 demand projection of 12,726 AFY was assumed based on the 2015 UWMP (Table 4-2) (Fair Oaks Water District, 2016).
- **Supply**: Demand was assumed to be met by groundwater pumping and surface water, proportional to the CCBL conditions.

#### 5.2.3.1.17 Sutter Pointe

- **Demand**: A demand projection of 15,786 AFY was assumed, based on the Phase 2+B proposed water supply program from the *Supplement to the Water Supply Assessment for Lakeside at Sutter Pointe* (Golden State Water Company, 2020).
- **Supply**: Demand was assumed to be met by a mixture of groundwater pumping and surface water. Groundwater pumping is assumed to meet 10,919 AFY of demand, and surface water is assumed to meet the remaining 4,867 AFY of demand.

#### 5.2.3.1.18 Grandpark

- **Demand**: A demand projection of 12,030 AFY was assumed, based on build out projections for the project (K. Giberson, pers comm. Feb 14, 2019).
- **Supply**: Demand was assumed to be met by a mixture of groundwater pumping and surface water. Groundwater pumping is assumed to meet 2,407 AFY of demand during normal and wet years, and 3,007 AFY

of demand during dry years. Surface water is assumed to meet 9,623 AFY of demand during normal and wet years, and 9,395 AFY of demand during dry years.

#### 5.2.3.2 South American Subbasin

This section briefly describes the demand and supply assumptions used in the PCBL for the purveyors located within the SASb. All new developments were assumed to be on supplies projected by the purveyors.

##### 5.2.3.2.1 City of Sacramento

- **Demand**: As described above in Section 5.2.3.1.11, a city-wide 2040 demand projection of 161,029 AFY was assumed, based on the 2015 UWMP (Table 4-2) (City of Sacramento, 2016). Approximately 65% of the demand was assumed to be in the SASb portion of the model, based on urban area.
- **Supply**: As with the NASb, supply projections include groundwater pumping and surface water that vary by five water year types (as opposed to three water year types used for other purveyors) based on the City of Sacramento's 2017 GWMP (City of Sacramento, 2017). Groundwater pumping follows the Maximum Groundwater Use scenario specified in the 2017 GWMP. Based on the specific well pumping assumptions, groundwater pumping in the SASb varies from 12,749 AFY during wet years to 43,029 AFY during driest years. Remaining demand after groundwater pumping was assumed to be supplied by recycled water (1,000 AFY) and surface water. As described above in Section 5.2.3.1.11, the City of Sacramento also has specific wells that supply some parks and green areas within the city boundaries. These irrigation wells are simulated using six representative irrigation wells that pump 2,600 AFY. Based on the locations of the irrigated parks and green areas, approximately half of the irrigation pumping was estimated in the SASb.

##### 5.2.3.2.2 California American Water Company (Suburban Rosemont, Security Park, and Parkway)

- **Demand**: As described above in Section 5.2.3.1.4 for Cal Am service areas within the NASb, demand projections reflect the 2035 conditions based on the 2015 UWMP (Tables 4-2) (Cal-Am, 2016). Demand remains the same in all water year types.
- **Supply:** Supply projections by service area were based on the 2015 UWMP as follows:
  - Security Park was assumed to be all on groundwater and served water from SCWA, similar to the CCBL conditions.
  - As described above in Section 5.2.3.1.4, surface water supply from the City of Sacramento was distributed between Arden (NASb), Parkway (SASb), and Suburban Rosemont (SASb), based on the 2015 UWMP (Table 5-9). Remaining demand is met by groundwater from Cal Am wells.

##### 5.2.3.2.3 California American Water Company (former Fruitridge Vista Water Company)

- **Demand**: A 2035 demand projection of 4,957 AFY was assumed, based on the discussions with Cal-Am.
- **Supply**: Supply projections include local groundwater pumping and surface water wholesale supply from the City of Sacramento, with 50% of demand met by groundwater and the remaining 50% of demand met by surface water.

##### 5.2.3.2.4 Golden State Water Company (Cordova)

- **Demand**: A 2040 demand projection of 19,572 AFY was assumed for the Cordova service area, based on the 2015 UWMP (Table 4-4) (GSWC, 2016).

- **Supply**: Cordova's supply projections include groundwater pumping of 9,752 AFY, 5,000 AFY of remediated water from the Aerojet Granted Water Supply, and 5,000 AFY of American River diversion from Folsom South Canal, as reported in the 2015 UWMP (Table 6-12).

#### 5.2.3.2.5 City of Folsom

- **Demand**: A 2040 demand projection was assumed as 29,923 AFY for normal and wet years and 30,819 AFY for dry years, based on the 2015 UWMP (Table 4-2 and Table 7-2) (City of Folsom, 2016).

- **Supply**: City of Folsom supply was assumed all surface water, as with the CCBL conditions.

#### 5.2.3.2.6 Florin County Water District

- **Demand**: Demand was estimated based on the average of 2017 and 2018 in the CCBL.

- **Supply**: Demand was assumed to be met by groundwater, consistent with CCBL conditions.

#### 5.2.3.2.7 Sacramento County Water Agency (Hood, Laguna Vineyard, and Mather)

- **Demand**: The 2045 demand projection for Hood was based on the Draft 2020 UWMP (Table 4-10[e]), provided by SCWA and input from SCWA (M. Grinstead, personal communication, April 2021). Demand projections for Laguna Vineyard and Mather reflect 2052 conditions based on the 2021 Zone 40 Water Supply Master Plan Amendment (Tables B-6, B-7, and B-8) (SCWA, 2021), and discussions with SCWA (M. Grinstead, personal communication, April 2021). Laguna Vineyard in the PCBL represents the South Service Area and Central Service Area; and Mather represents the North Service Area.
- **Supply**: Hood was assumed to be on groundwater, consistent with the CCBL. Supply projections for Laguna Vineyard and Mather reflect 2052 conditions based on a mix of groundwater, surface water, recycled water, and remediated water, as reported in the 2021 Zone 40 Master Plan Amendment (Tables B-6, B-7, and B-8). Recycled water of 1,700 AFY would be available in the Laguna Vineyard demand area (South Service Area) and remediated water of 8,900 AFY would be available every year.

#### 5.2.3.2.8 Elk Grove Water District

- **Demand**: A 2045 demand projection was assumed be 8,080 AFY for normal and wet years and includes demand both for Service Area 1 and Service Area 2 based on the 2015 UWMP (Table 4-6; EGWD, 2016). Dry year demand projection was assumed to 8,323 AFY based on the 2015 UWMP (Table 7-2) and was assumed to be distributed to Service Area 1 and Service Area 2 proportional to demand in normal and wet years in the two service areas.
- **Supply**: The 2015 UWMP does not break future supply projections into groundwater and surface water supplies by service areas. It was assumed Service Area 1 was served with groundwater and Service Area 2 served with a mix of groundwater and surface water by SCWA.

#### 5.2.3.2.9 Rancho Murieta Community Service District

- **Demand**: Demand for the entire service area was assumed to be 3,477 AFY based on a medium growth projection of 3,659 AFY at buildout with 20% reduction (or 2,927 AFY potable demand) and additional recycled water demand of approximately 550 AFY, based on the information available from the Rancho Murieta Community Services District's (CSD) 2010 Integrated Water Master Plan Update (Figure ES-1, Table 2-3, and Table 3-2; Rancho Murieta CSD, 2010). Approximately 32% of demand falls within the SASb based on urban area.
- **Supply**: Demand was assumed to be met by surface water for potable demand and recycled water of 550 AFY for golf course irrigation.

#### 5.2.3.3 Cosumnes Subbasin

This section briefly describes the demand and supply assumptions used in the PCBL for the purveyors located within the CoSb.

##### 5.2.3.3.1 Rancho Murieta Community Service District

Several proposed developments were identified within the Rancho Murieta CSD and incorporated into the PCBL. Note that the majority of the developments would occur outside of the three subbasins but within the model boundary.

- **Demand**: As described above in Section 5.2.3.2.9, total demand was assumed to be 3,477 AFY. Approximately 22% of the demand falls within the CoSb based on urban area, compared to 32% within the NASb. The remaining demand of 46% falls outside of the NASb, SASb and CoSb, but within the model boundary.
- **Supply**: As described above in Section 5.2.3.2.9, demand was assumed to be met by surface water for potable demand and recycled water.

##### 5.2.3.3.2 City of Galt

- **Demand**: A 2040 groundwater demand projection of 7,663 AFY was assumed based on the 2015 UWMP (Table 4-3; City of Galt, 2016).
- **Supply**: Demand was assumed to be met by groundwater with pumping distributed between six active CCBL wells proportional to their historical maximum annual yield. Dry year supply projections were assumed to be the same as normal year supplies.

##### 5.2.3.3.3 Amador County Water Agency

- **Demand**: 2040 demand projections were updated based on supply assumptions, as discussed below, and distributed to the expanded urban land use areas.
- **Supply**: Supply projections include surface water and recycled water for the City of Ione and groundwater, surface water, and recycled water for Camanche Village. CCBL City of Ione surface water supply was doubled based on the projected demand increases from the Amador Water Agency 2015 UWMP; there was no change to the recycled water use relative to the CCBL. CCBL groundwater pumping for Camanche Village from the four active wells was doubled based on expansion and development of currently vacant parcels (Dunn Environmental, 2012). CCBL groundwater pumping for Camanche North Shore from the two active wells was increased by a total of 11 AFY based on a projected maximum daily treated water demand increase from the *Camanche Area Regional Water Supply Plan Feasibility Study and Conceptual Design* (RMC Water and Environment, 2012). Specified groundwater pumping to three wells operated by the Buena Vista Rancheria are based on reported May 2019-April 2020 pumping, in which the seasonal average pumping rates were distributed to associated months.

##### 5.2.3.3.4 Sacramento Municipal Utility District

No change in demand or supply relative to the CCBL.

#### 5.2.3.4 Fish Farms

No change in demand or supply relative to the CCBL.

### 5.2.4 Agricultural Demand and Supply

Agricultural demand and supply in the PCBL is similar to the discussion in the CCBL (Section 5.1.6), with demand being driven by the land use changes in the PCBL discussed in Section 5.2.2 and much of the supply being internally calculated within the model or based on the last 10 years of the historical simulation.

#### 5.2.4.1 Galt Wastewater Treatment Plant Effluent

No change in treatment plant effluent use relative to the CCBL.

#### 5.2.4.2 Rural Residential

Refer to section 3.3.1 in the historical model report for a description of the methodology used to estimates rural residential pumping.

Rural residential demand in the PCBL version of CoSANA accounts for the urbanization of areas that would lead to a decrease in the rural residential population. It is assumed that the projected urbanization of areas previously used for agricultural purposes would result in a decline in rural residential population, and therefore demand. These areas are subsequently served by an urban water purveyor.

In the CoSb, rural residential demand was assumed to increase as a result of projected population increases. Assuming a rural residential population, and associated demand increase of 1% per year, total projected annual groundwater consumption was estimated to be 9,448 AFY and was proportionally distributed monthly as specified in the CCBL.

#### 5.2.4.3 Agricultural Groundwater Substitution Transfers

As discussed for the CCBL, two purveyors engage in agricultural groundwater substitution transfer pumping in the NASb: NMWC and PGVMWC, Additionally, South Sutter Water District operates a transfer program that behaves very similarly to a groundwater substitution transfer. South Sutter Water District uses a hybrid approach to groundwater substitution transfer pumping similar to the CCBL model. Dry year decreases of surface water deliveries from Camp Far West Reservoir are offset by an increase in groundwater pumping.

For NMWC and PGVMWC, agricultural transfer pumping was assumed to occur in 16 years of the baseline (15 of the 19 dry years and one normal year), with timing and pumping volumes based on information included in the Long-Term Water Transfer (LTWT) EIS/R (Reclamation, 2019). The estimated transfer pumping for NMWC and PGVMWC was distributed among all transfer wells in the same proportion as in the historical data. NMWC surface water deliveries are automatically adjusted to meet total agricultural demand, and PGVMWC surface water deliveries are estimated using the last 10 years of historical simulation data, reduced by the amount of agricultural transfer pumping estimated to occur in the PCBL.

### 5.2.5 Remediation Operations

Information about future remediation operations is not available, so remediation operations in the PCBL are the same as in the CCBL, discussed in Section 5.1.7.

### 5.2.6 Results

This section provides a summary of the CoSANA PCBL results.

#### 5.2.6.1 Land and Water Use Budget

The land and water use budget provides details on the urban and agricultural demand and the water supply meeting the demand (groundwater pumping, surface water deliveries, recycled water, and remediation pumping). Average annual PCBL model results by groundwater subbasin are shown in Table 5-5. Annual agricultural water demand and supply by subbasin are shown in Figure 5-22 through Figure 5-24. Annual urban demand and supply by subbasin are shown in Figure 5-25 through Figure 5-27. Appendix H includes model subregion land and water use budgets.

**Table 5-5: PCBL Average Annual Land and Water Use Budget**

| Subbasin | Ag. Demand (AFY) | Ag. Ground-Water Use* (AFY) | Ag Surface Water Deliveries (AFY) | Urban Demand (AFY) | Urban Ground-Water Use** (AFY) | Urban Surface Water Deliveries (AFY) | Urban Recycled Water (AFY) | Remediation Pumping (AFY) |
|---|---|---|---|---|---|---|---|---|
| NASb | 349,317 | 202,228 | 149,868 | 328,654 | 108,492 | 220,161 | - | 5,515 |
| SASb | 135,956 | 91,599 | 44,369 | 301,060 | 116,385 | 167,661 | 17,200 | 29,765 |
| CoSb | 121,676 | 99,886 | 21,460 | 30,168 | 28,445 | 3,943 | - | - |
| **Total** | **606,949** | **393,713** | **215,697** | **659,882** | **253,322** | **391,765** | **17,200** | **35,280** |

Note:
* Agricultural groundwater use presented in the above table may differ slightly from the values shown in the respective GSP due to minor difference in the methodology on calculation of rural residential water use.
** Urban groundwater use in the above table represents water used that originated from groundwater production but can include water that was pumped in areas outside of the respective subbasin.

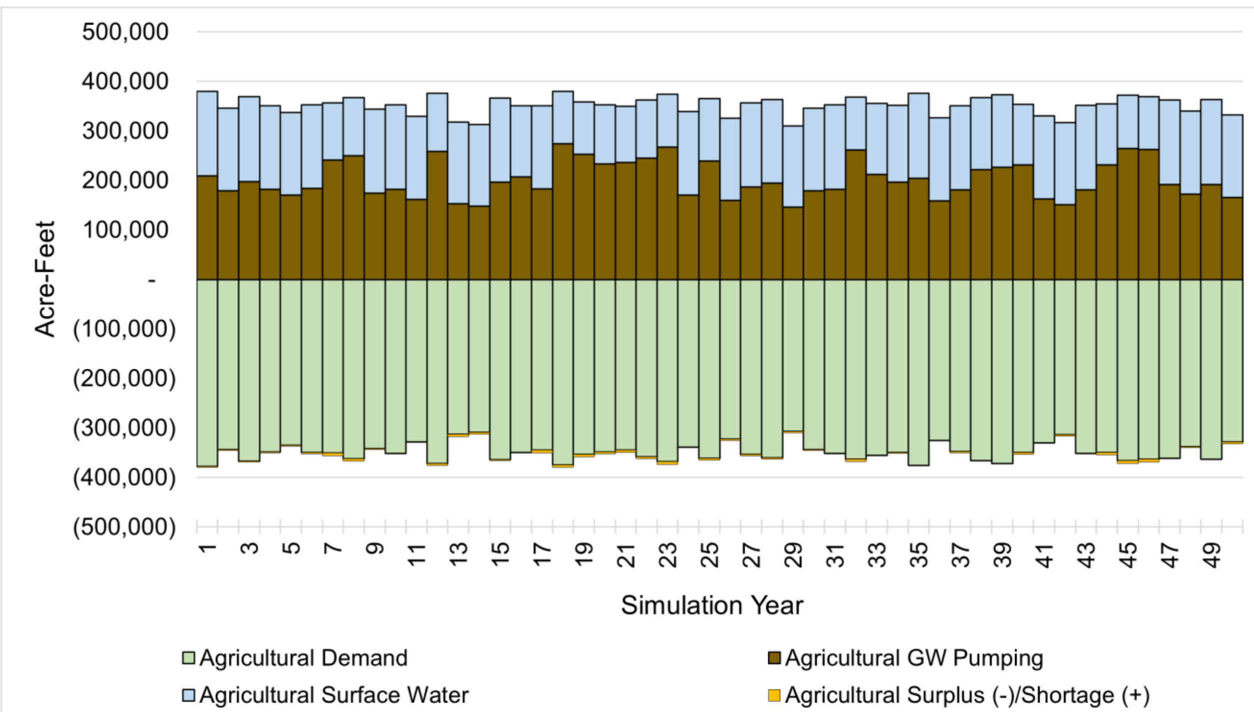



**Figure 5-22: Annual Agricultural Water Demand and Supply – North American Subbasin, Projected Conditions Baseline**

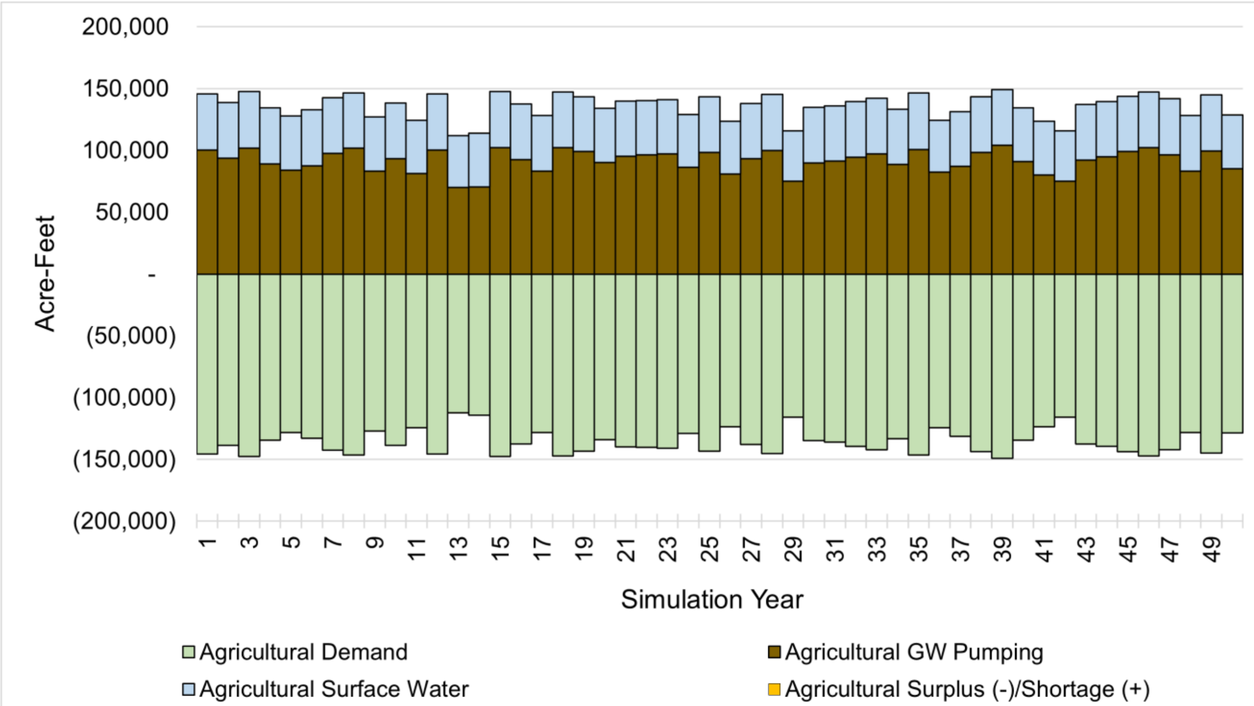



**Figure 5-23: Annual Agricultural Water Demand and Supply – South American Subbasin, Projected Conditions Baseline**

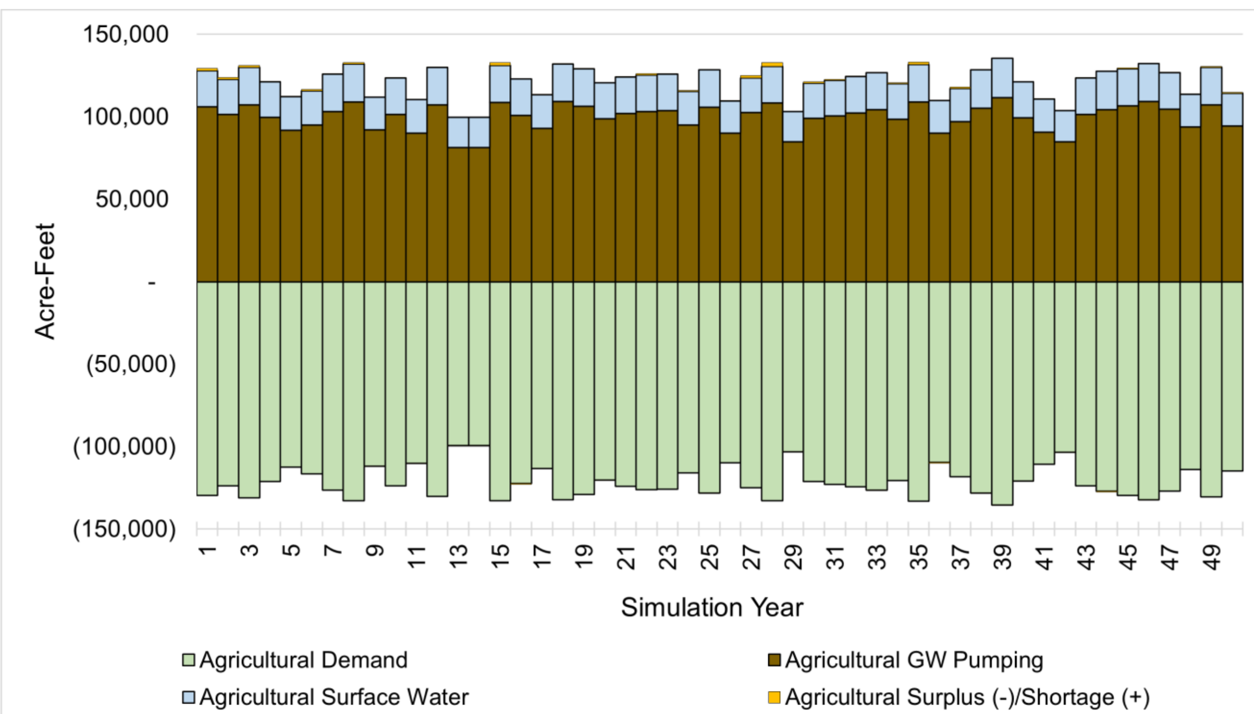



**Figure 5-24: Annual Agricultural Water Demand and Supply – Cosumnes Subbasin, Projected Conditions Baseline**

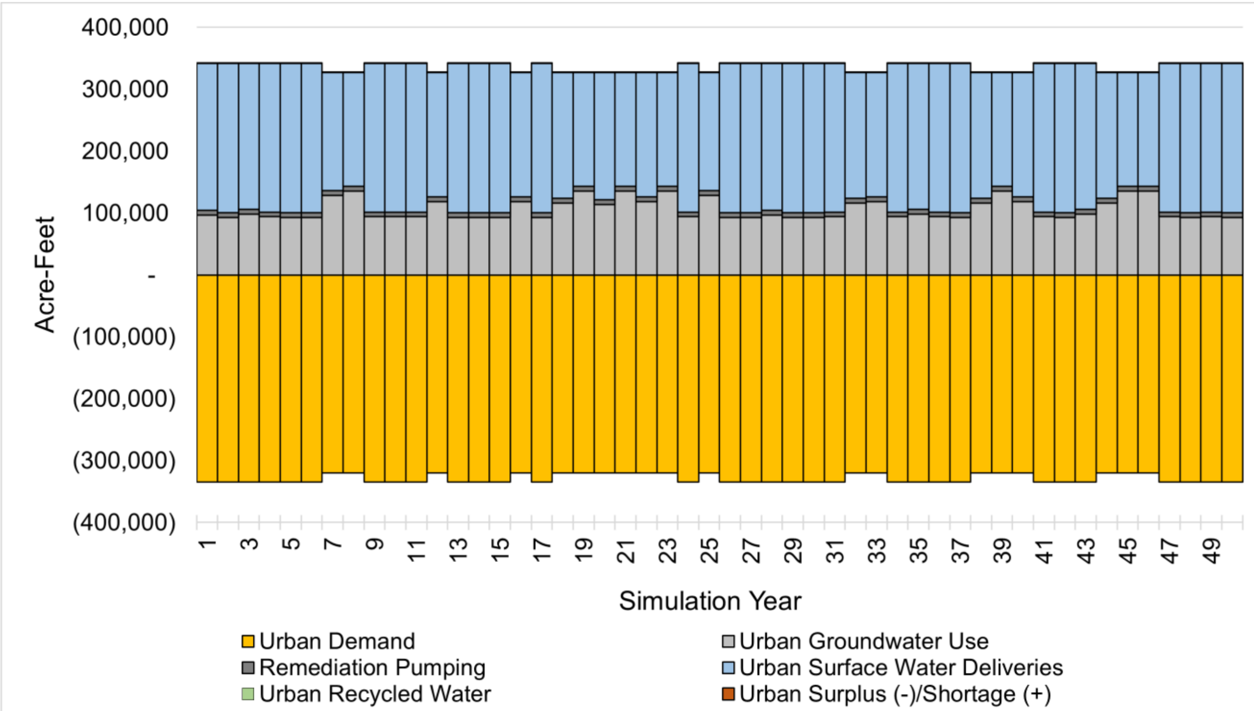



**Figure 5-25: Annual Urban Water Demand and Supply – North American Subbasin, Projected Conditions Baseline**

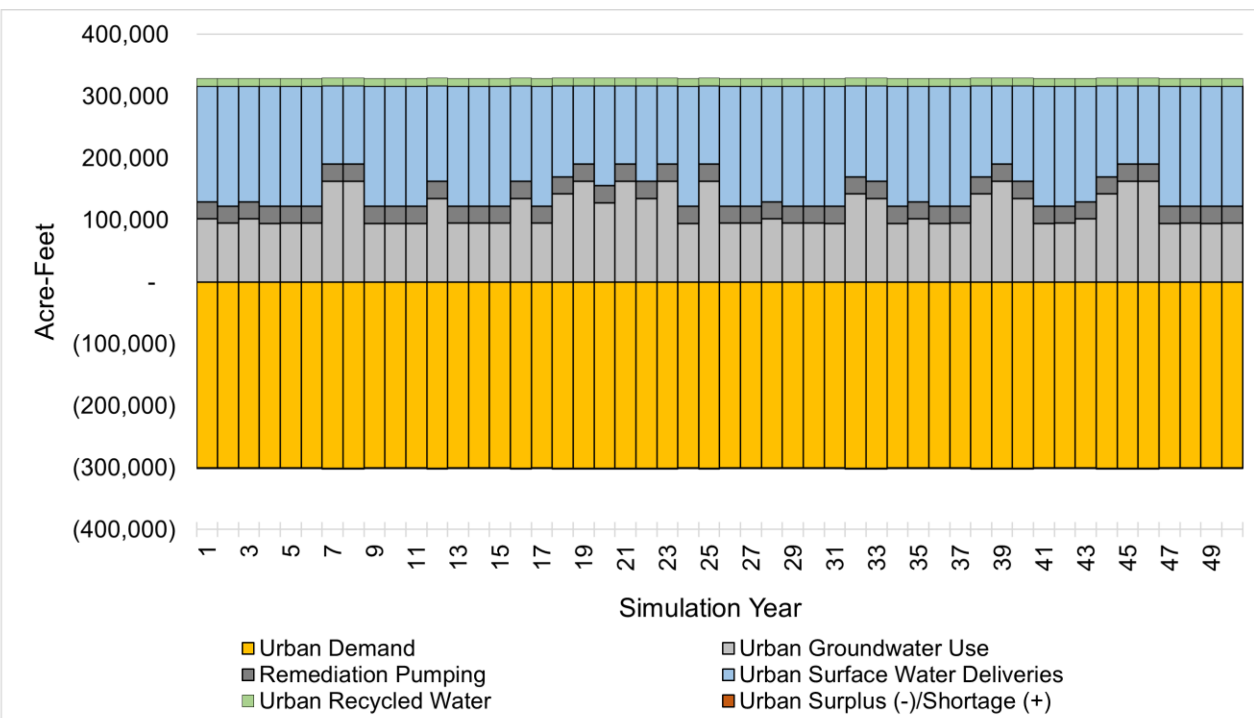
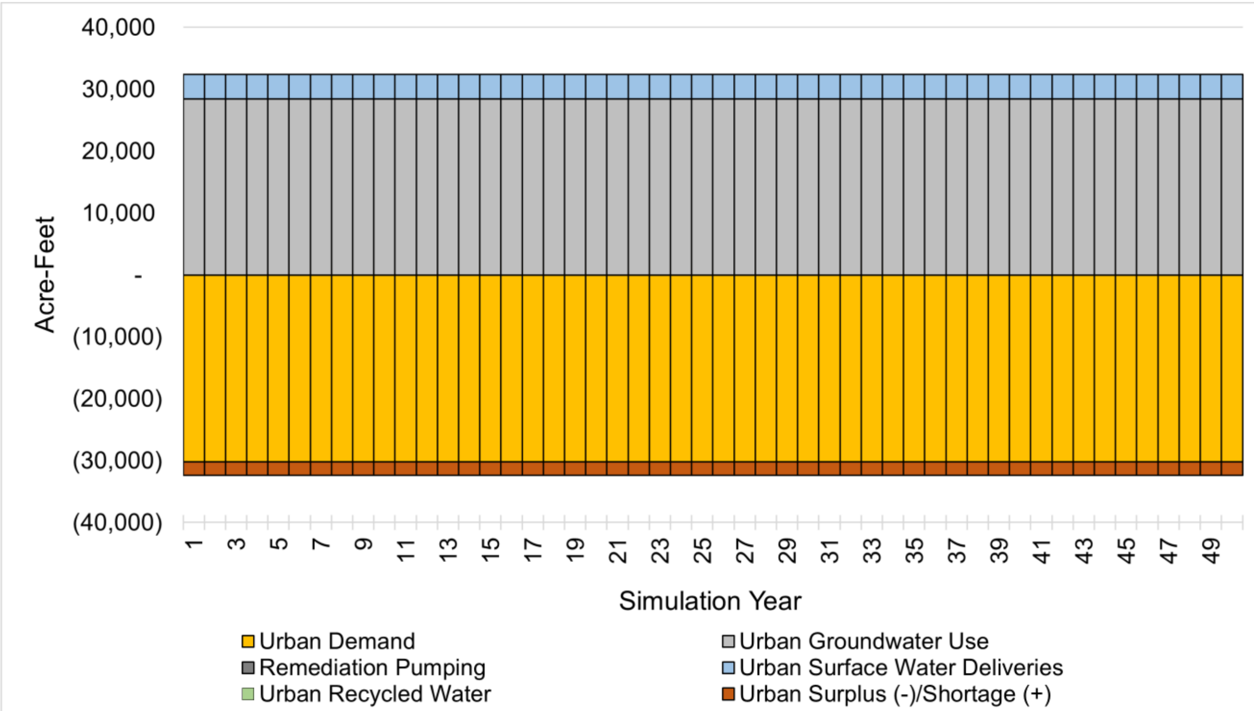



**Figure 5-26: Annual Urban Water Demand and Supply – South American Subbasin, Projected Conditions Baseline**




*Note: Urban groundwater use is specified in the CoSb model input data set. The model-calculated surplus/shortage in urban demand is therefore not utilized to calculate the CoSb groundwater budget.*

**Figure 5-27: Annual Urban Water Demand and Supply – Cosumnes Subbasin, Projected Conditions Baseline**

### 5.2.6.2 Groundwater Budget

The groundwater budget summarizes all inflows and outflows to the groundwater aquifer system. Average annual PCBL model results by groundwater subbasin are shown in Table 5-6. Annual groundwater budgets with cumulative change in storage by subbasin are shown in Figure 5-28 through Figure 5-30. Appendix I includes model subregion groundwater budgets. Appendix J includes a set of sample hydrographs for the baseline models.

**Table 5-6: PCBL Average Annual Groundwater Budget**

| Subbasin | Pumping (AFY) | Deep Percolation (AFY) | Gain from Stream (AFY) | Recharge from Canals (AFY) | Boundary Flows (AFY) | Subsurface Inflow (AFY) | Change in Storage (AFY) |
|---|---|---|---|---|---|---|---|
| NASb | 323,167 | 167,424 | 107,950 | 16,376 | 30,140 | 6,710 | 5,390 |
| SASb | 234,003 | 121,313 | 105,665 | 26 | 4,886 | 986 | -1,128 |
| CoSb | 128,332 | 107,977 | 16,494 | 0 | 1,536 | 1,030 | -1,293 |
| **Total** | **685,501** | **396,714** | **230,109** | **16,402** | **36,561** | **8,726** | **2,969** |

Note: Boundary Flows term includes flow between areas outside of the CoSANA model domain and baseflow from small watersheds. Subsurface Inflows includes flow between the simulated subbasins in CoSANA and areas outside of Bulletin 118 subbasins.

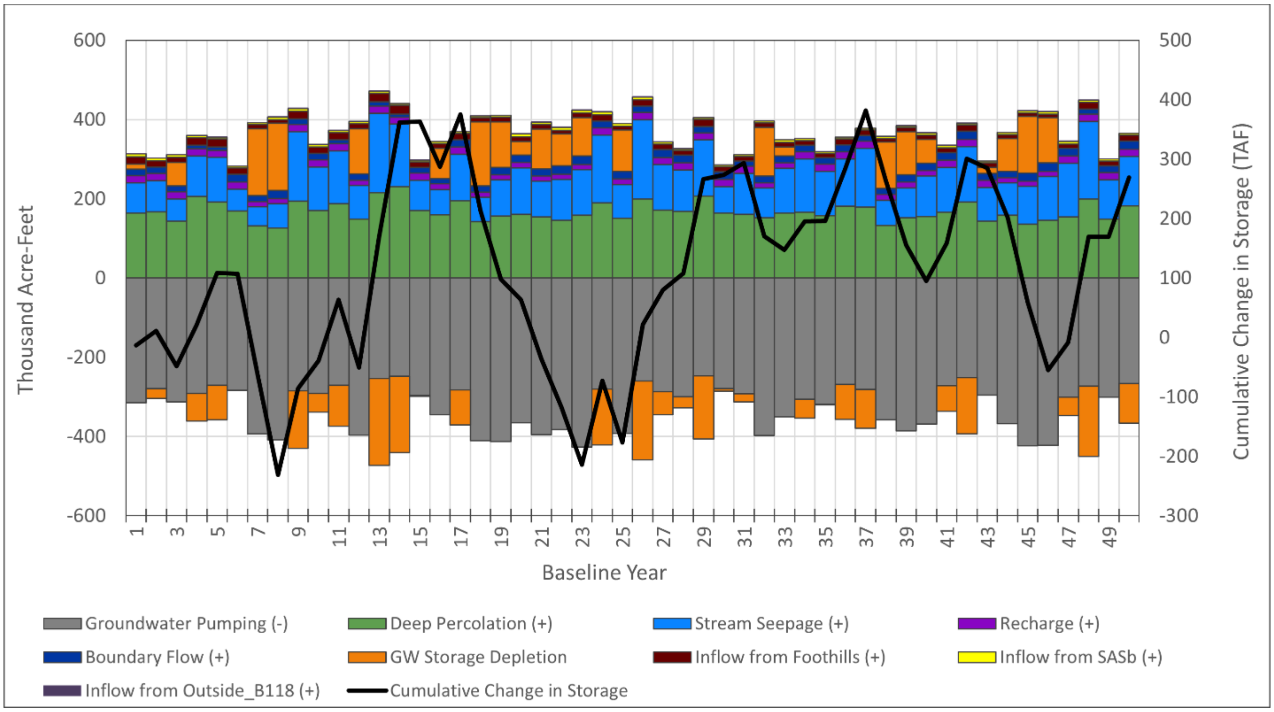



**Figure 5-28: Annual Groundwater Budget and Cumulative Change in Storage – North American Subbasin, Projected Conditions Baseline**

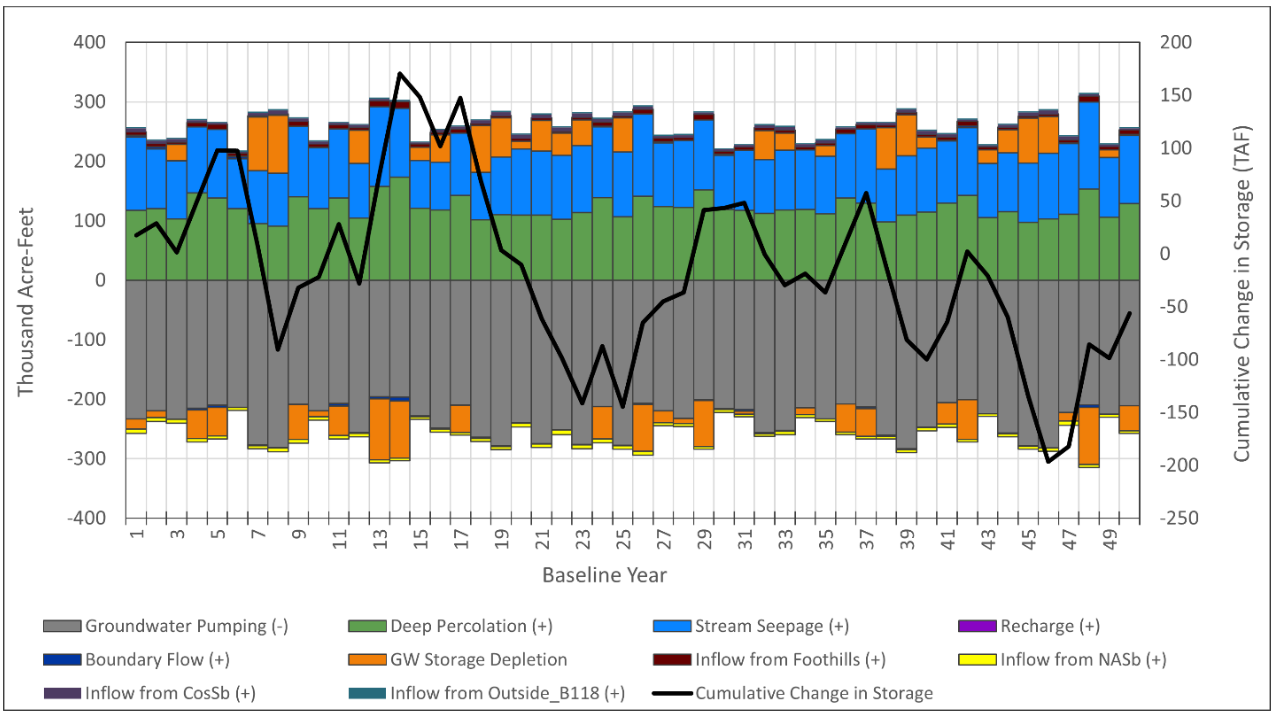



**Figure 5-29: Annual Groundwater Budget and Cumulative Change in Storage – South American Subbasin, Projected Conditions Baseline**

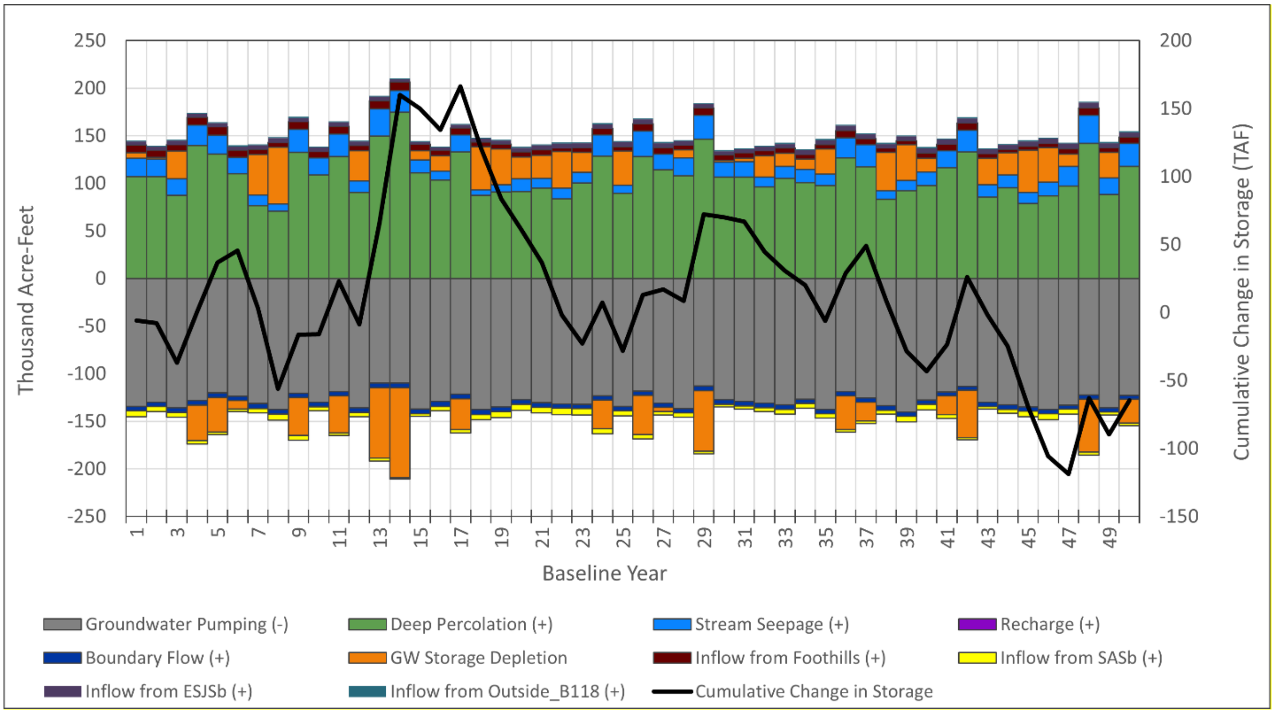



**Figure 5-30: Annual Groundwater Budget and Cumulative Change in Storage – Cosumnes Subbasin, Projected Conditions Baseline**

## 5.3 Projected Conditions Baseline with Climate Change

The CoSANA Projected Conditions Baseline with Climate Change (PCBL with Climate Change) shares many of the same inputs as the PCBL, but with additional factors to incorporate potential climate change conditions. These conditions affect the hydrologic cycle as changes in precipitation and temperature. In the CoSANA model files, the change in precipitation is incorporated by the precipitation rate and stream inflow inputs while the change in temperature is reflected by the change in evapotranspiration rate and stream inflow inputs. Changes in water use are incorporated by estimation of agricultural water demands within CoSANA based on changes in precipitation and evapotranspiration. Urban water use is assumed to remain unchanged, based on assumed changes in conservation and landscape choices.

### 5.3.1 Hydrologic Period

The hydrologic period used for the projected conditions baseline with climate change is the same as the projected conditions baseline (WY 1970 to 2019), modified according to the methodology explained below to incorporate climate change conditions.

#### 5.3.1.1 Methodology

In order to incorporate climate change conditions, precipitation, stream inflow, and evapotranspiration time series data from the projected conditions baseline are modified using the findings from the American River Basin Study (ARBS; Reclamation, in press). ARBS aims to examine the water management challenges around the American River Basin under recent changes in conditions, regulatory requirements, and the science of climate change. Towards this goal, ARBS provides regional climate change data with improved resolution that can be used with other modeling and planning studies.

ARBS used 64 downscaled climate projections with 1/16-degree grid resolution from 32 global climate models under RCP4.5 and RCP8.5 emissions scenarios. These 64 scenarios are then evaluated for three future periods (2040-2069, 2055-2084, and 2070-2099) and grouped into five climate scenarios based on percentiles of projected changes to simulate possible temperature and precipitation effects: Warm-Wet, Warm-Dry, Hot-Wet, Hot-Dry, and Central-Tendency.

The ensemble of climate models used in the study found clear trends with projected temperature changes. Precipitation trends were not found to be as consistent with around half of the projections indicating an increase in precipitation, and the other half indicating a decrease in precipitation.

Upon evaluation of these climate scenarios, the Central Tendency scenario for the 2055-2084 period, also commonly called as 2070CT conditions, was selected for groundwater sustainability planning because it was determined that it has the highest probability and likelihood to be experienced. Other climate scenarios are subject to significantly more uncertainty and less likely to occur. Additionally, to assess uncertainty and the effects of a possible extreme condition, the 2055-2084 Hot-Dry (2070HD) scenario was also simulated, with results presented in Section 5.3.7.

In ARBS, the downscaled climate variables of the scenarios were then used with the Variable Infiltration Capacity (VIC) hydrology model to simulate hydrologic conditions at the land surface. VIC uses a spatial grid that covers the entire CoSANA model domain. This grid was used to resample the precipitation time series from 2070CT and 2070HD conditions to the CoSANA model grid and for the small watersheds using area weighted averaging.

ARBS uses the outputs from the VIC model to develop corresponding inputs to the operations model CalSim 3.0 that covers the entire Sacramento and San Joaquin River Basins. One of those inputs is the evapotranspiration rates for each crop type. For the PCBL with Climate Change scenarios in CoSANA, evapotranspiration time series input from the PCBL were perturbed with the perturbation factors calculated between the 2070CT and 2070HD climate change scenarios and the 2015 baseline scenario for each crop type averaged across the CoSANA domain. Additionally, stream inflow time series input at six locations (Sacramento River at Verona, Folsom Reservoir releases, Cosumnes River, Camanche Reservoir release, Bear River, and Feather River) were replaced with the simulated flows by CalSim 3.0 in ARBS.

A summary comparison table of the ARBS historical baseline hydrology and percent changes to different system components in the 2070CT and 2070HD is shown in Table 5-7.

**Table 5-7: Percent Change in Annual Climatic and Hydrologic Indicators in the American River Basin Study***

| Climate Scenario | Precipitation | Temperature (average) | Potential Evapotranspiration | Runoff |
|---|---|---|---|---|
| Historical Observations (1915-2015 average) | 38.2 inches | 54.8$^0$F | 42.8 inches | 1,458,000 AFY |
| 2070 Central-Tendency | -3% | +11% | +10% | -6% |
| 2070 Hot and Dry | -9% | +14% | +12% | -13% |

* The values are for the entire American River Basin Study area and are based on Table 2-4 in the study report.

#### 5.3.1.2 Precipitation

Annual precipitation near Sacramento International Airport and on the small watershed areas are shown in Figure 5-31 for with- and without-climate change conditions for comparison purposes. As a result of the 2070CT climate change conditions, average annual precipitation increased from 17.5 inches to 17.8 inches on the valley floor and increased from 30.6 inches to 30.9 inches on the small watersheds.

Figure 5-32 illustrates the changes in average monthly precipitation before and after climate change conditions are applied. For both the valley floor and the small watersheds, a slight shift in the distribution of precipitation can be observed.

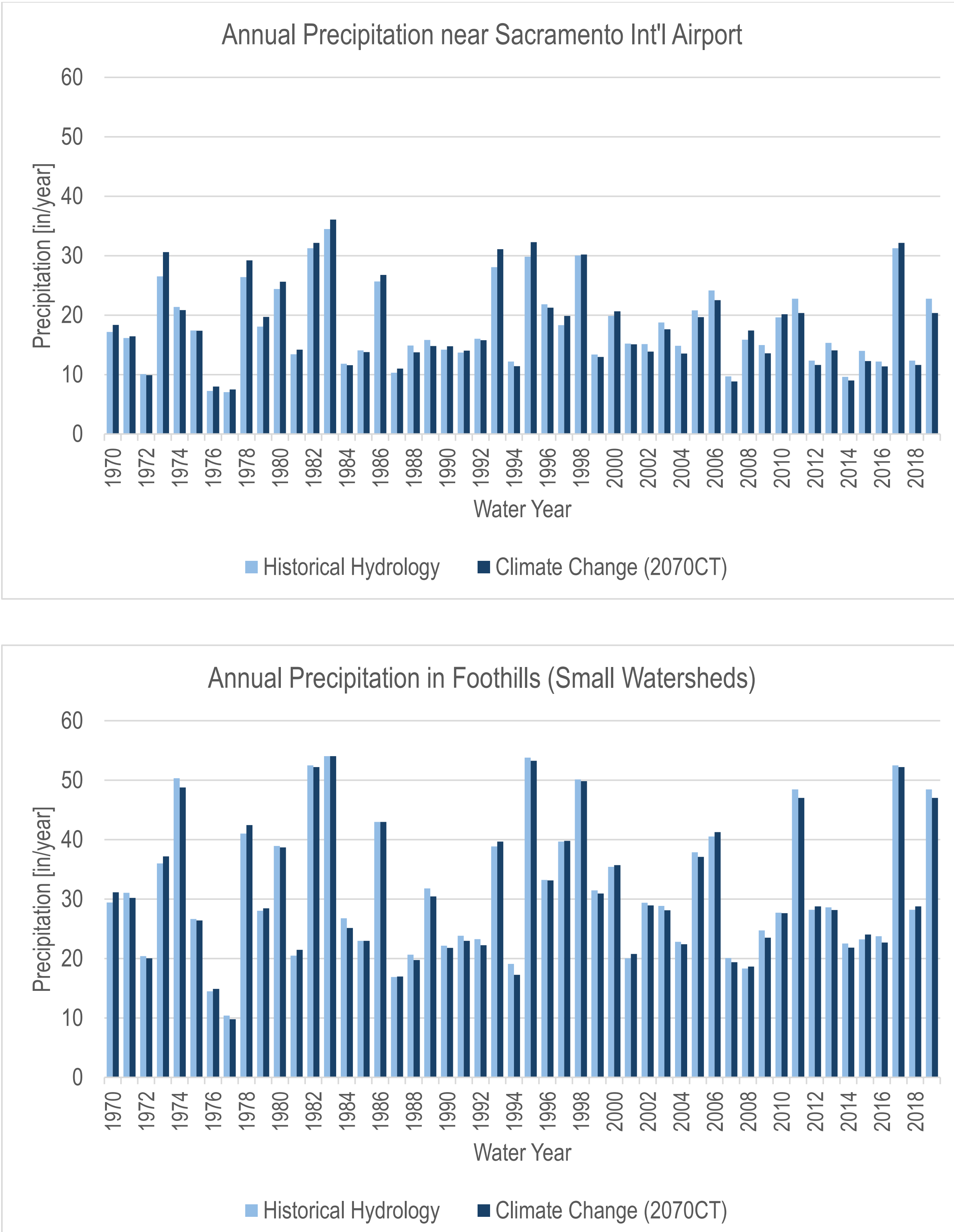



**Figure 5-31: Annual Precipitation with and without Climate Change**

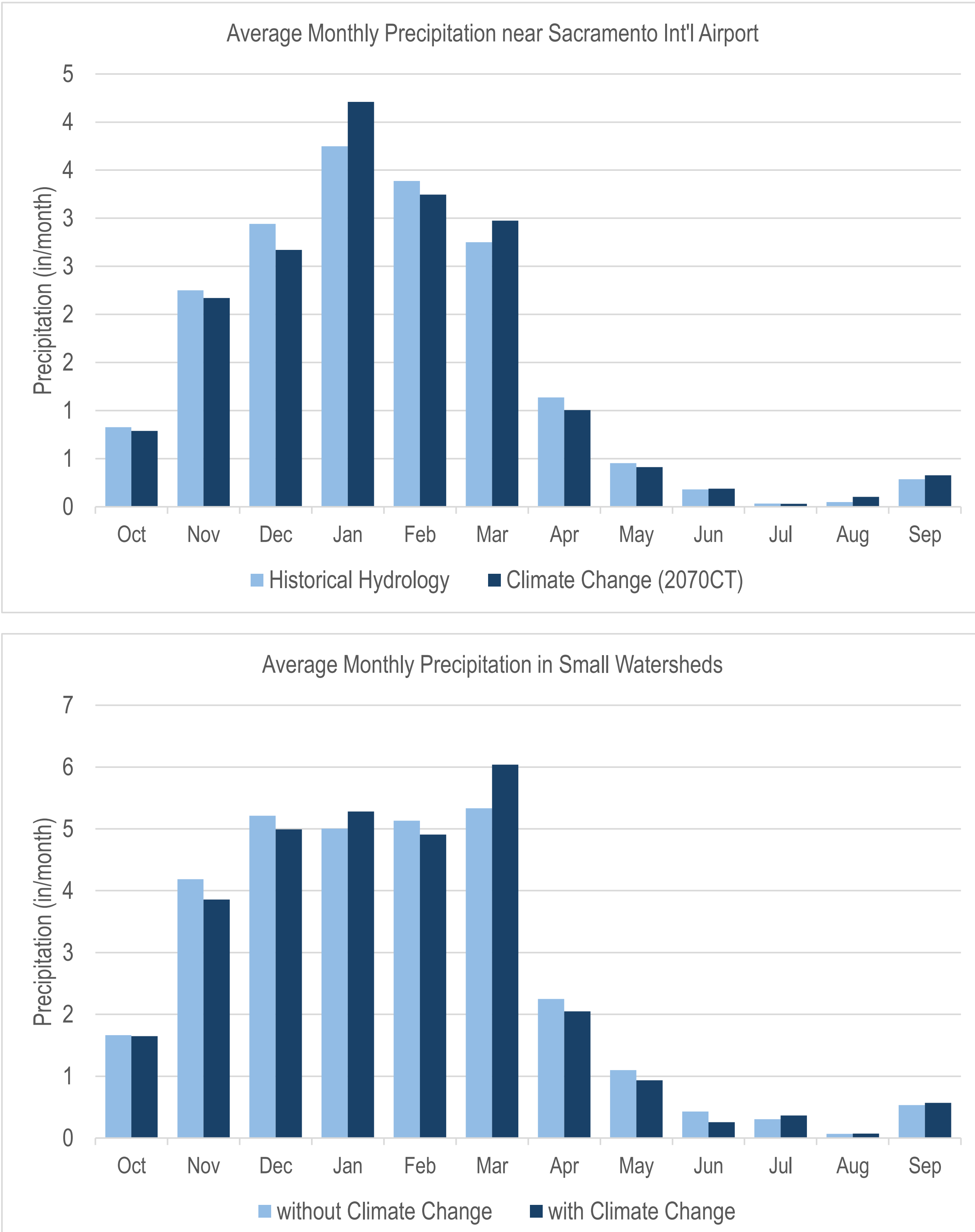



**Figure 5-32: Average Monthly Precipitation with and without Climate Change**

#### 5.3.1.3 Stream Inflow

Major stream flows entering to the CoSANA domain were modified to accommodate the climate change according to 2070CT conditions. In Figure 5-33, American River releases from the Folsom Reservoir are shown with and without climate change for comparison purposes. As a result of the 2070CT climate change conditions, average annual stream flow on the American River below Folsom Reservoir is decreased from around 3,500 cubic feet per second (cfs) to around 3,000 cfs.

Figure 5-34 illustrates the changes in average monthly stream inflow before and after climate change conditions are applied. According to this chart average flows in early winter and late spring decrease, while March flows increase.

An exceedance chart comparing the monthly Folsom Reservoir Release to American River is given in Figure 5-35 According to this chart, peak monthly flows show an increase in probability, while the probability of lower flows show a slight decrease.

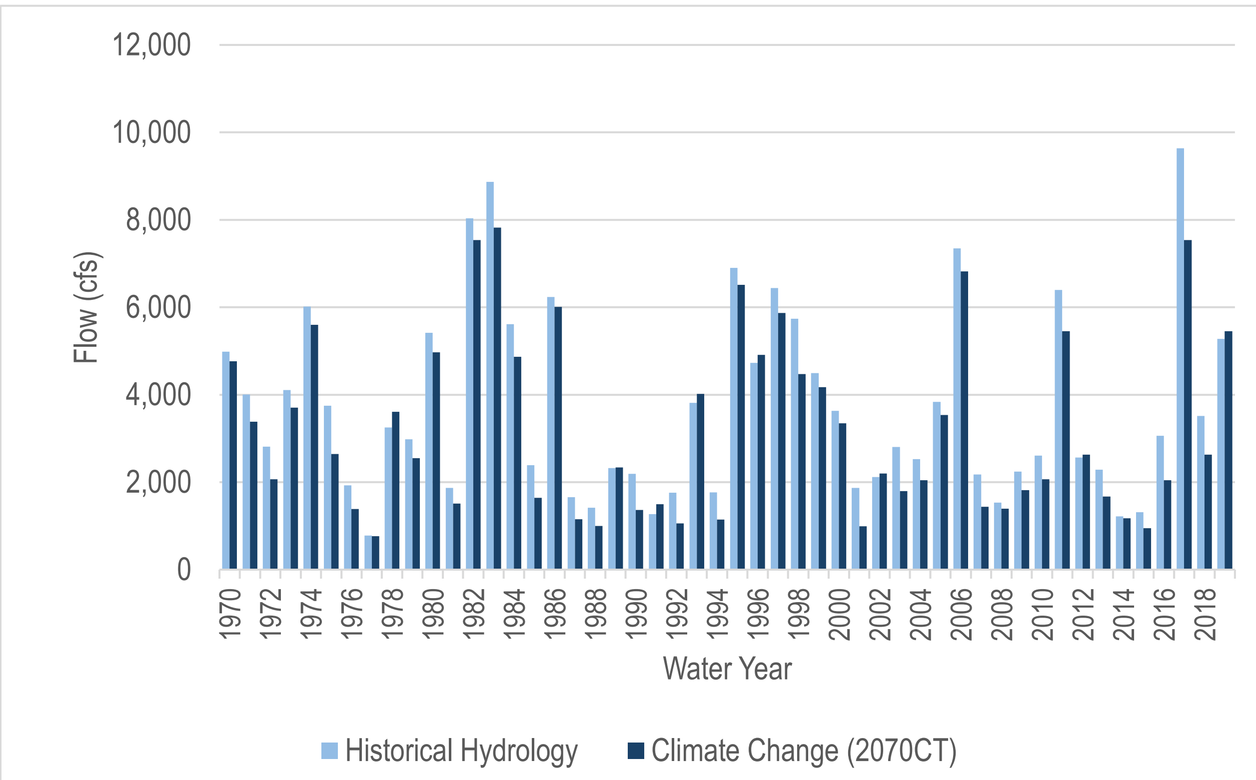



**Figure 5-33: Annual Folsom Reservoir Releases to American River with and without Climate Change**

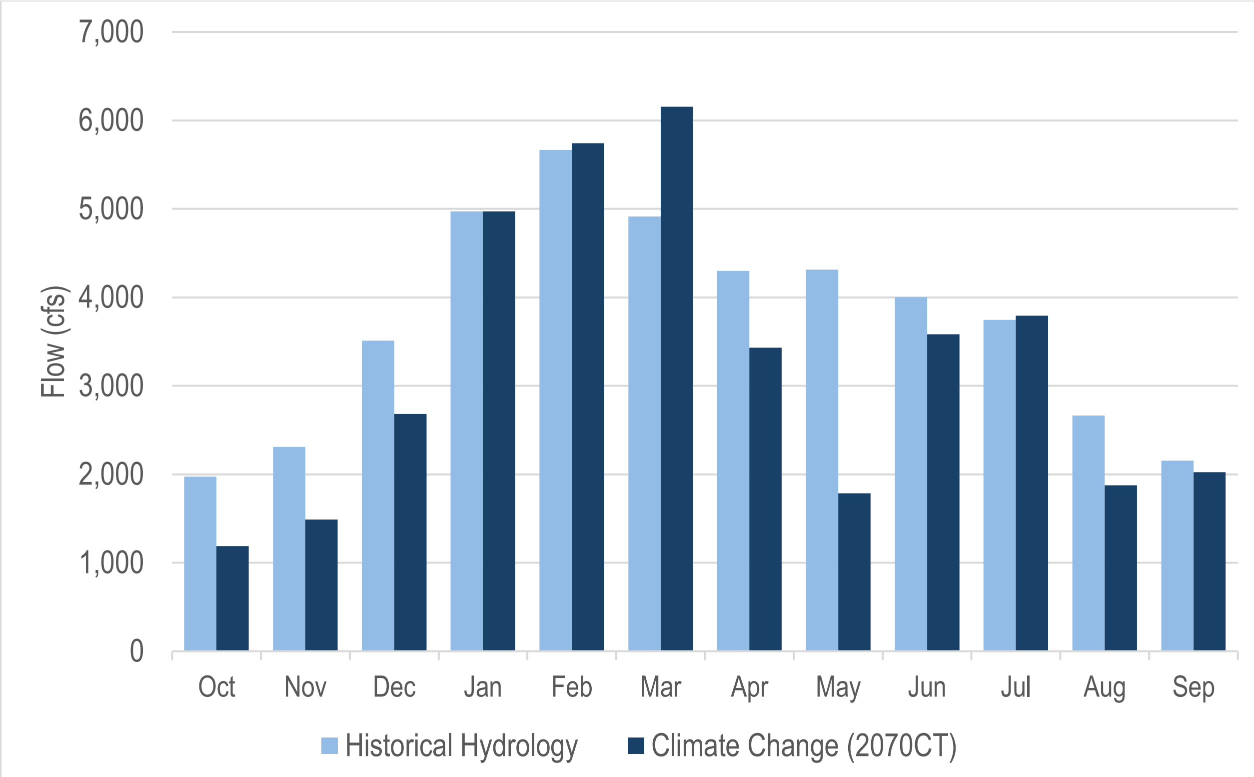



**Figure 5-34: Monthly Average Folsom Reservoir Releases to American River**

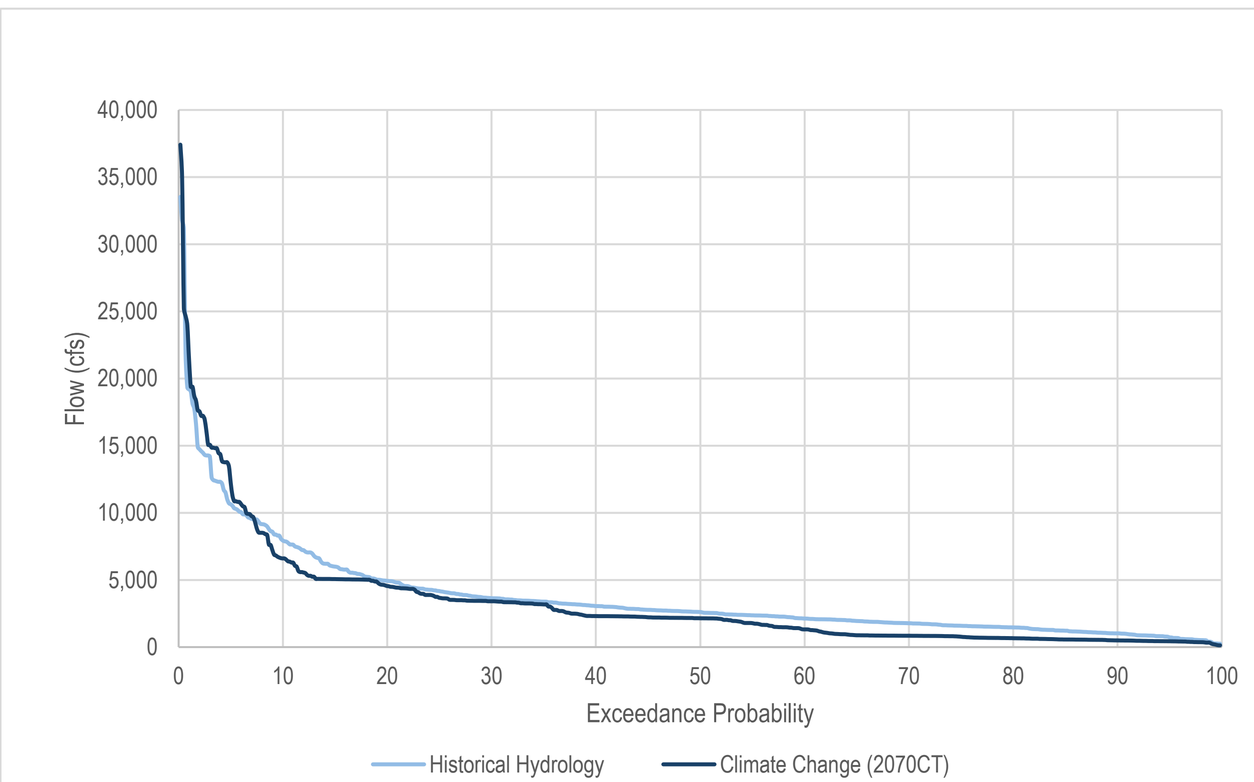



**Figure 5-35: Exceedance Chart for the Monthly Folsom Reservoir Releases to American River**

### 5.3.1.4 Evapotranspiration

Potential evapotranspiration time series data for each land cover type in CoSANA were modified to accommodate climate change according to 2070CT conditions. 2070CT conditions predict higher temperature than historical conditions which will result in higher potential evapotranspiration rates. Annual potential evapotranspiration for pasture over the valley floor is shown in Figure 5-36 for with- and without-climate change conditions for comparison purposes. Among all the land cover types defined in CoSANA, pasture was chosen here for its similarity to the reference evapotranspiration. As a result of the 2070CT climate change conditions, average annual potential evapotranspiration for pasture is expected to increase from 49.9 inches to 54.6 inches. Figure 5-37 illustrates the changes in average monthly potential evapotranspiration for pasture before and after climate change conditions are applied.

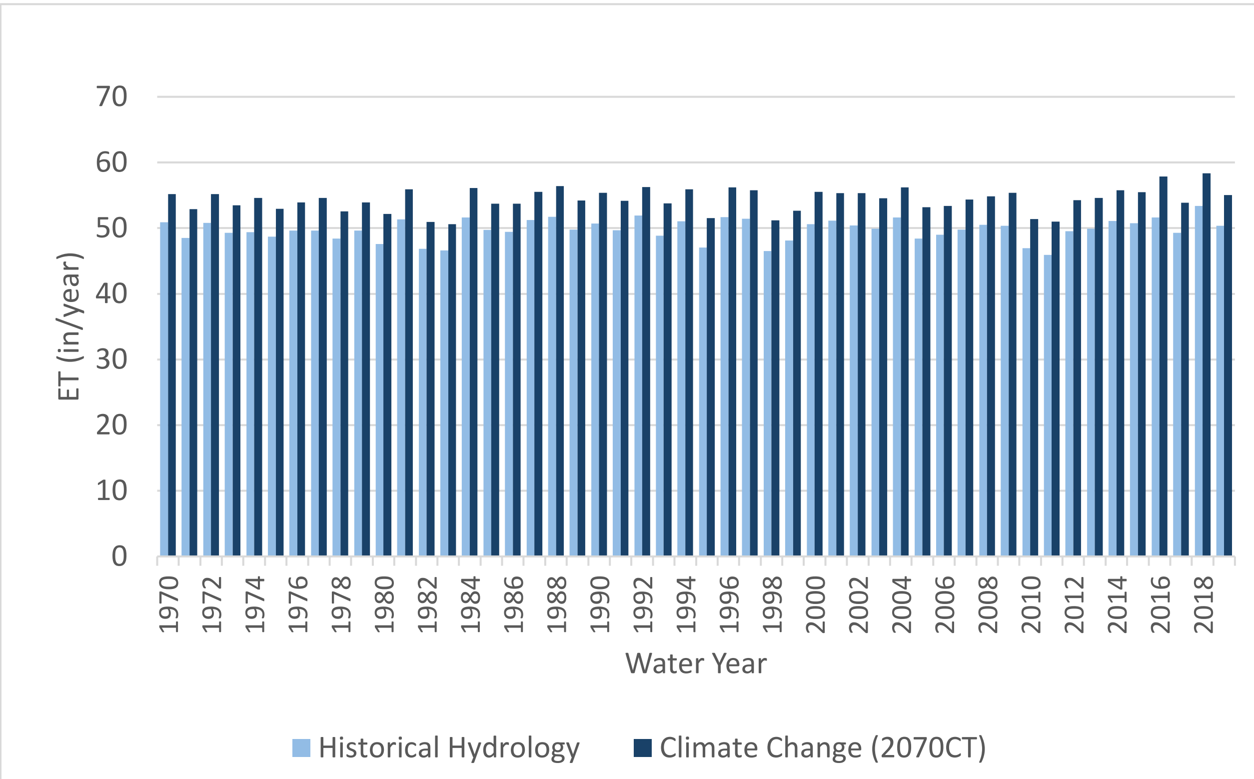



**Figure 5-36: Annual Potential Evapotranspiration for Pasture**

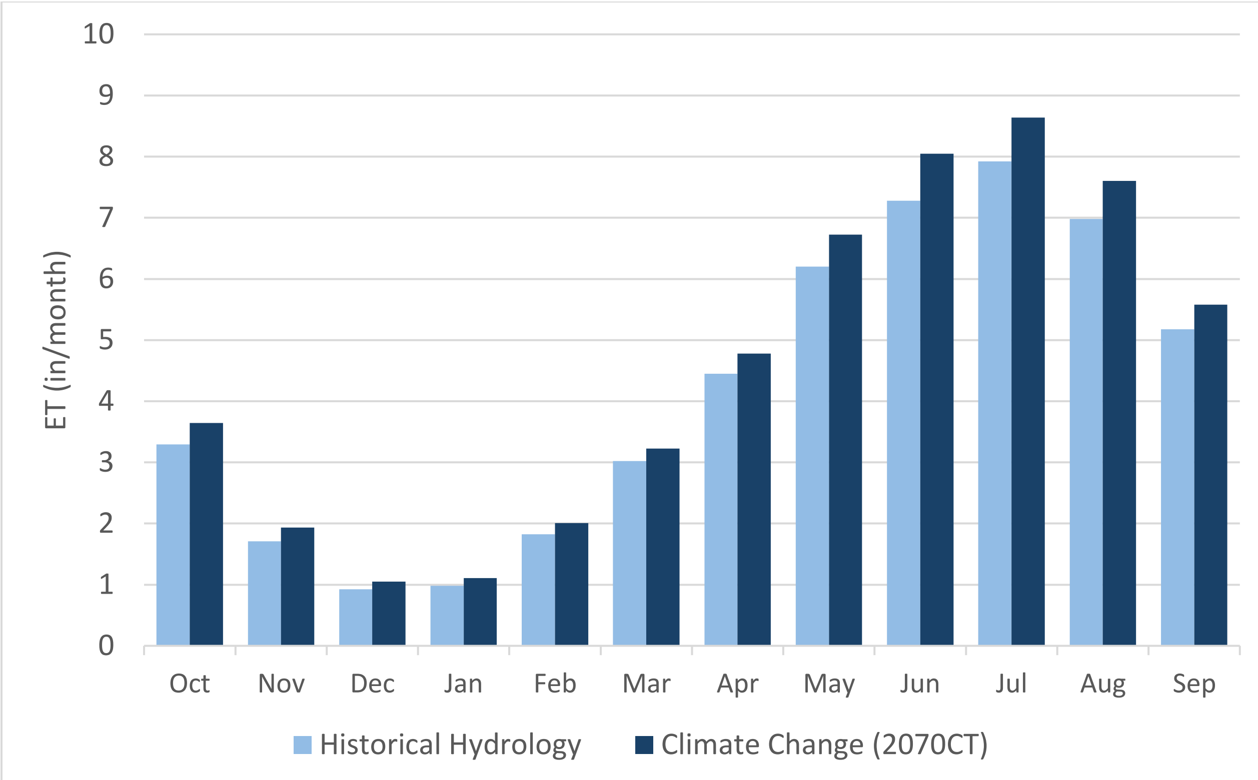



**Figure 5-37: Monthly Average Potential Evapotranspiration for Pasture.**

### 5.3.2 Land Use

The PCBL with Climate Change land use is the same as the PCBL, described in Section 5.2.2.

### 5.3.3 Urban Demand and Supply

The PCBL with Climate Change urban demand and supply is the same as the PCBL, described in Section 5.2.3. It is noted that water demands for urban landscape will increase with increasing ET under climate change, however demand and supply remain unchanged in the baseline due to likely changes in ordinances and likely changes in landscaping practices.

### 5.3.4 Agricultural Demand and Supply

The PCBL with Climate Change agricultural demand and supply is based on the PCBL, described in Section 5.2.4. The agricultural demand under the climate change conditions is impacted by the effect of climate change on the hydrology, notably evapotranspiration, which increases demands. The increased supply needed to meet this demand is typically met by additional groundwater pumping.

### 5.3.5 Remediation Operations

Information about future remediation operations is not available, so remediation operations in the PCBL with Climate Change are the same as in the CCBL, discussed in Section 5.1.7.

### 5.3.6 Results

This section provides a summary of the CoSANA PCBL with Climate Change results.

#### 5.3.6.1 Land and Water Use Budget

The land and water use budget provides details on urban and agricultural demand and the water supply meeting the demand (groundwater pumping, surface water deliveries, recycled water, and remediation pumping). Average annual PCBL with Climate Change model results by groundwater subbasin are shown in Table 5-8. Annual agricultural water demand and supply by subbasin are shown in Figure 5-38 through Figure 5-40. As discussed in Section 5.3.3, urban demand and supply for the PCBL with Climate Change are the same as the PCBL; refer to Figure 5-25 through Figure 5-27 for urban land and water use budgets. Appendix H includes model subregion land and water use budgets.

**Table 5-8: PCBL with Climate Change Average Annual Land and Water Use Budget**

| Subbasin | Ag. Demand (AFY) | Ag. Ground-Water Use* (AFY) | Ag Surface Water Deliveries (AFY) | Urban Demand (AFY) | Urban Ground-Water Use** (AFY) | Urban Surface Water Deliveries (AFY) | Urban Recycled Water (AFY) | Remediation Pumping (AFY) |
|---|---|---|---|---|---|---|---|---|
| NASb | 372,286 | 222,061 | 152,544 | 328,654 | 108,492 | 220,161 | - | 5,515 |
| SASb | 148,520 | 103,348 | 45,178 | 301,060 | 116,385 | 167,661 | 17,200 | 29,765 |
| CoSb | 132,348 | 108,831 | 22,744 | 30,168 | 28,445 | 3,943 | - | - |
| **Total** | **653,154** | **434,240** | **220,466** | **659,882** | **253,322** | **391,765** | **17,200** | **35,280** |

Notes:
* Agricultural groundwater use presented in the above table may differ slightly from the values shown in the respective GSP due to minor difference in the methodology on calculation of rural residential water use.
** Urban groundwater use in the above table represents water used that originated from groundwater production but can include water that was pumped in areas outside of the respective subbasin.

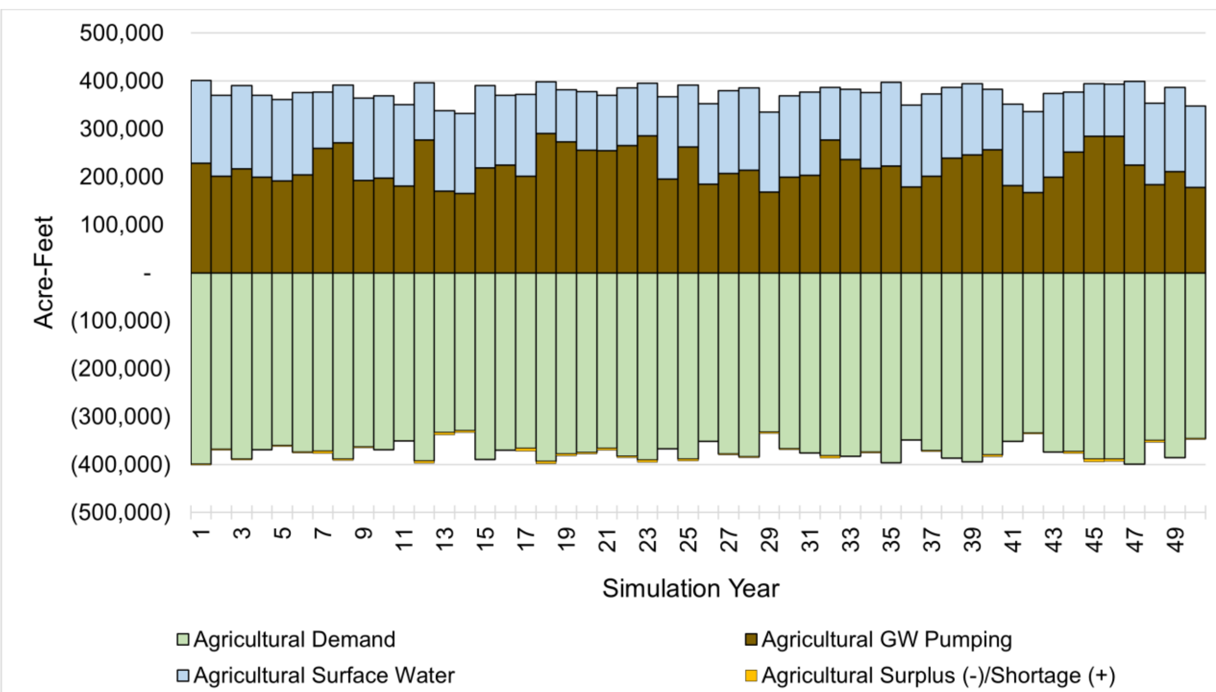



**Figure 5-38: Annual Agricultural Water Demand and Supply – North American Subbasin, Projected Conditions Baseline with Climate Change**

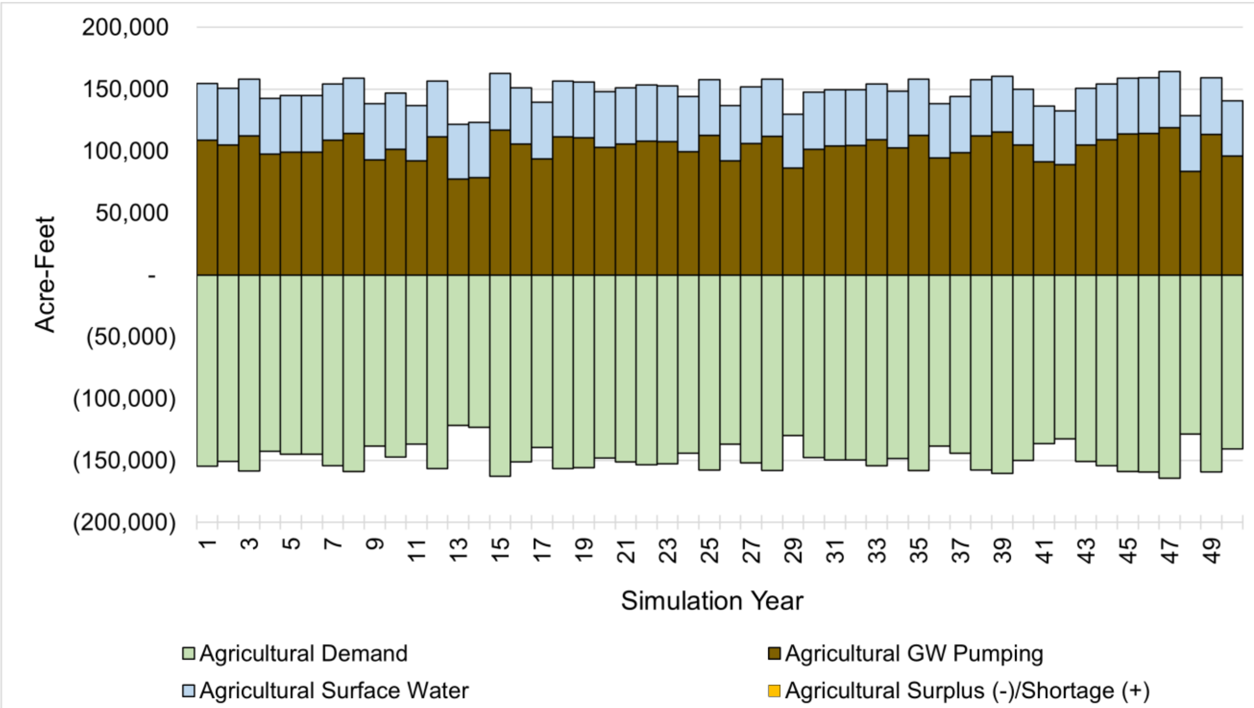



**Figure 5-39: Annual Agricultural Water Demand and Supply – South American Subbasin, Projected Conditions Baseline with Climate Change**

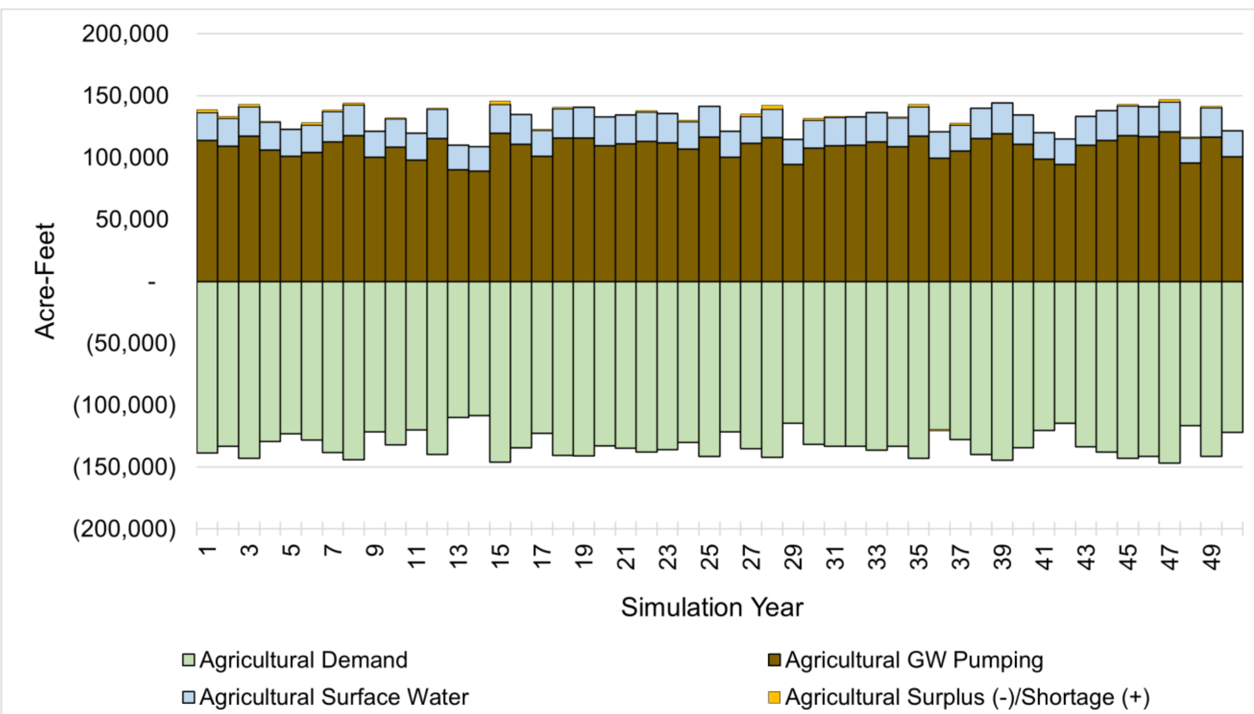



**Figure 5-40: Annual Agricultural Water Demand and Supply – Cosumnes Subbasin, Projected Conditions Baseline with Climate Change**

#### 5.3.6.2 Groundwater Budget

The groundwater budget provides all inflows and outflows to the groundwater aquifer system. Average annual PCBL with Climate Change model results by groundwater subbasin are shown in Table 5-9. Annual groundwater budgets with cumulative change in storage by subbasin are shown in Figure 5-41 through Figure 5-43. Appendix I includes model subregion groundwater budgets. Appendix J includes a set of sample hydrographs for the baseline models.

**Table 5-9: PCBL with Climate Change Average Annual Groundwater Budget**

| Subbasin | Pumping (AFY) | Deep Percolation (AFY) | Gain from Stream (AFY) | Recharge from Canals (AFY) | Boundary Flows (AFY) | Subsurface Inflow (AFY) | Change in Storage (AFY) |
|---|---|---|---|---|---|---|---|
| NASb | 343,000 | 160,987 | 122,181 | 16,401 | 32,744 | 7,228 | -3,502 |
| SASb | 245,752 | 114,730 | 118,164 | 26 | 6,198 | 411 | -6,222 |
| CoSb | 137,276 | 101,490 | 20,744 | 0 | 1,540 | 3,739 | -9,762 |
| **Total** | **726,028** | **377,207** | **261,089** | **16,427** | **40,481** | **11,378** | **-19,486** |

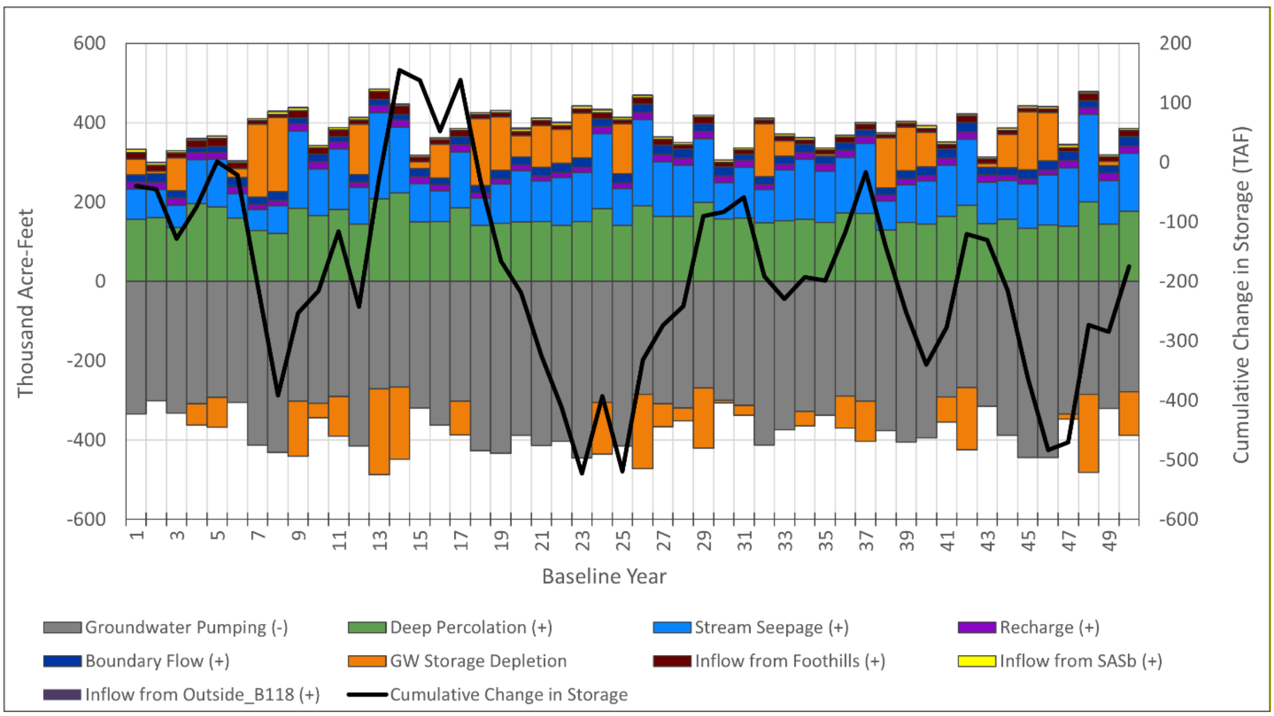



**Figure 5-41: Annual Groundwater Budget and Cumulative Change in Storage – North American Subbasin, Projected Conditions Baseline with Climate Change**

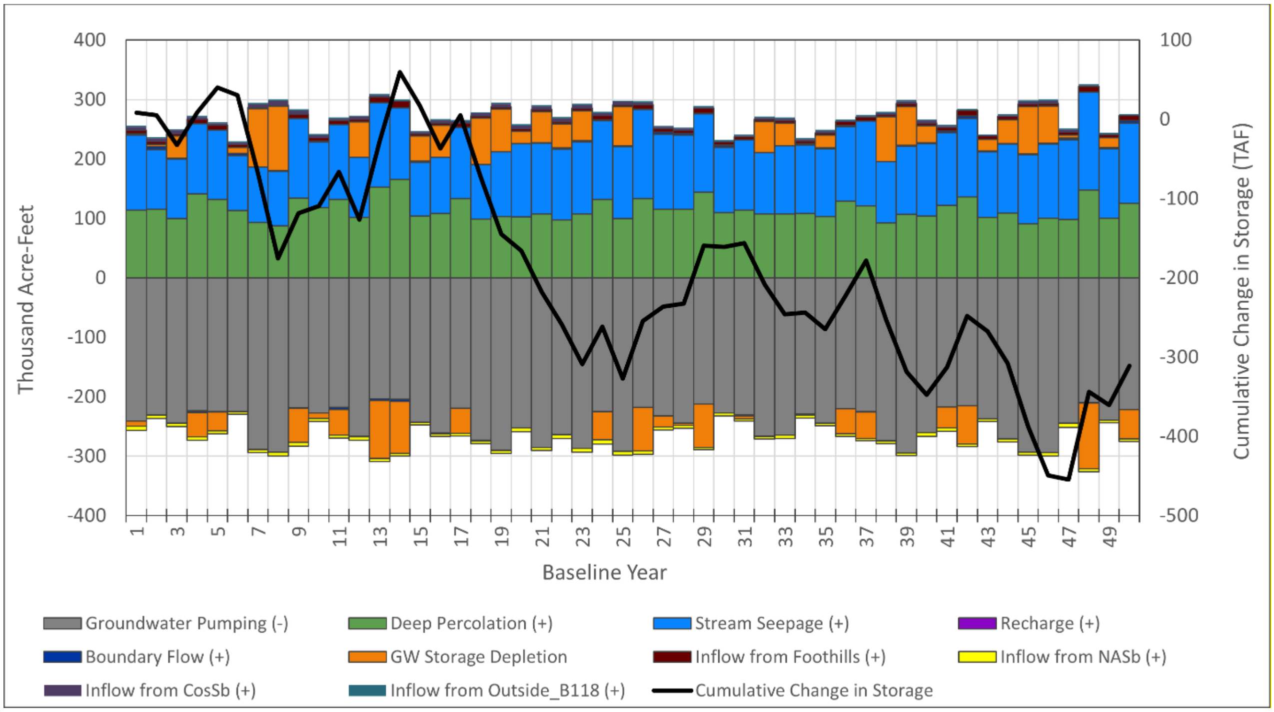



**Figure 5-42: Annual Groundwater Budget and Cumulative Change in Storage – South American Subbasin, Projected Conditions Baseline with Climate Change**

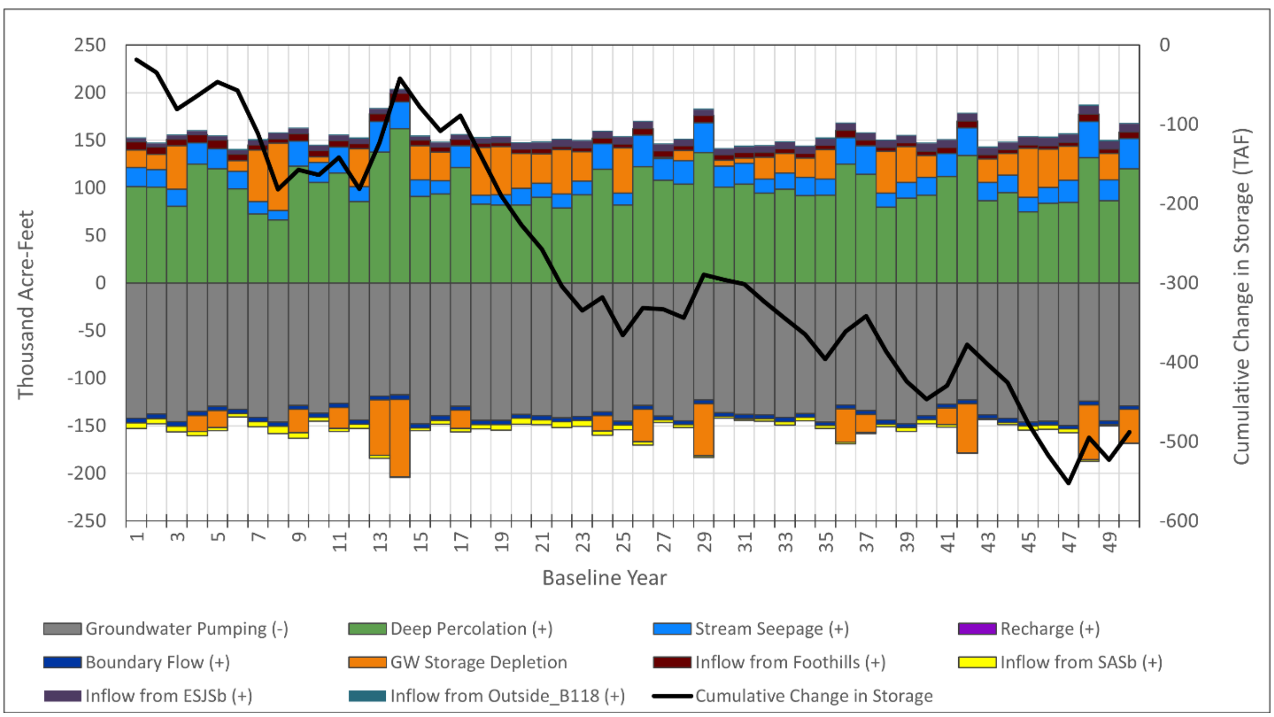



**Figure 5-43: Annual Groundwater Budget and Cumulative Change in Storage – Cosumnes Subbasin, Projected Conditions Baseline with Climate Change**

### 5.3.7 Sensitivity Analysis: Hot-Dry Scenario

The 2070HD scenario was analyzed as an extreme case to determine the potential effects of the 2070HD scenario on the groundwater and surface water systems. 2070HD simulates lower overall precipitation, and higher temperature, than the 2070CT. A comparison of groundwater budgets (summation of the 3 subbasins, does not include areas outside of NASb, SASb, and CoSb) can be seen in Table 5-10 below.

**Table 5-10: Comparison Groundwater Budgets of CoSANA Climate Change Models to the Projected Conditions Baseline**

| Model Version | Subbasin | Pumping (AFY) | Deep Percolation (AFY) | Gain from Stream (AFY) | Recharge from Canals (AFY) | Boundary Flows (AFY) | Subsurface Inflow (AFY) | Change in Storage (AFY) |
|---|---|---|---|---|---|---|---|---|
| PCBL | NASb | 323,167 | 167,424 | 107,950 | 16,376 | 30,140 | 6,710 | 5,390 |
| PCBL | SASb | 234,003 | 121,313 | 105,665 | 26 | 4,886 | 986 | -1,128 |
| PCBL | CoSb | 128,332 | 107,977 | 16,494 | 0 | 1,536 | 1,030 | -1,293 |
| **PCBL** | **Total** | **685,501** | **396,714** | **230,109** | **16,402** | **36,561** | **8,726** | **2,969** |
| PCBL+CC (2070CT) | NASb | 343,000 | 160,987 | 122,181 | 16,401 | 32,744 | 7,228 | -3,502 |
| PCBL+CC (2070CT) | SASb | 245,752 | 114,730 | 118,164 | 26 | 6,198 | 411 | -6,222 |
| PCBL+CC (2070CT) | CoSb | 137,276 | 101,490 | 20,744 | 0 | 1,540 | 3,739 | -9,762 |
| **PCBL+CC (2070CT)** | **Total** | **726,028** | **377,207** | **261,089** | **16,427** | **40,481** | **11,378** | **-19,486** |
| PCBL+CC (2070HD) | NASb | 351,979 | 155,616 | 128,609 | 16,410 | 33,728 | 7,482 | -10,179 |
| PCBL+CC (2070HD) | SASb | 250,445 | 110,570 | 122,767 | 26 | 7,058 | 614 | -9,409 |
| PCBL+CC (2070HD) | CoSb | 140,677 | 97,337 | 22,515 | 0 | 1,439 | 4,838 | -14,545 |
| **PCBL+CC (2070HD)** | **Total** | **743,100** | **363,524** | **273,892** | **16,436** | **42,224** | **12,934** | **-34,133** |

As shown in Table 5-10, the 2070HD scenario leads to an overall increase in pumping of approximately 2% above the 2070CT, this is largely due to increased evapotranspiration causing an increase in agricultural demand. Decreases in deep percolation are largely attributable to decreasing precipitation. Increases in stream seepage, boundary flows, and subsurface flows are all due to lower groundwater levels being observed in the 2070HD scenario.

# 6. SUMMARY AND RECOMMENDATIONS

## 6.1 Summary

The CoSANA model is built upon the previous SacIWRM by migrating to the IWFM platform, providing finer resolution spatially and with depth, and by refining and extending the data incorporated into the model. CoSANA provides a robust, comprehensive, defensible model for assessing water resources conditions in the Sacramento region through integrated modeling of land surface, groundwater, and surface water conditions using detailed local and regional data and the DWR-supported IWFM modeling platform. This includes simulation under historical, current, projected, and projected with climate change conditions. The tool is well calibrated and ready to be used in various water supply and management studies and includes flexibility for updates and refinements to meet future needs of the region.

CoSANA simulates historical hydrology for the water year 1970 – 2018 on a monthly time step, with a focused calibration period of water years 1995 – 2018. Model calibration is based on water budgets, regional groundwater level and flow trends, groundwater level elevations at designated calibration wells, streamflows at selected stream gaging stations, interaction between the stream and the aquifer system along major river courses, surface and subsurface flow contributions from the tributary watersheds to the east, and subsurface flow directions and rates among the three groundwater subbasins within the model.

Three baseline scenarios are developed to support SGMA activities, development of the GSPs within the three subbasins, and other potential water resources planning needs. The Current Conditions Baseline, Projected Conditions Baseline, and Projected Conditions with Climate Change Baseline allow for assessment of water budgets under respective hydrologic, land and water use, and operations conditions and also facilitate analysis of future projects and management activities. The baselines incorporate 50 years of hydrology (1970-2019) to meet SGMA requirements and to provide climatic uncertainty based on 2070 Central Tendency climate change to assess future projects and management actions. A sensitivity analysis was also performed to assess the groundwater conditions under the 2070 Hot and Dry climate conditions.

## 6.2 Recommendations

CoSANA is intended to be a living model, which would evolve over time for better and more accurate representation of the surface and groundwater systems in the greater Sacramento area. Model refinements and updates need to take place on a regular basis to ensure the most recent and best representation of the changing needs of the region and to incorporate the latest conditions, data, and modeling platforms. During the development of the model, several items were identified for future refinements to improve the capability of CoSANA:

- **Continue collaboration and engagement with local GSAs, water purveyors, groundwater users, and water managers**. Continue working with local agencies and groundwater users in the region to further understand the local operations of the groundwater system and improve representation of groundwater users in the CoSANA.
- **Collaborate with DWR.** The fine grid version of C2VSim as well as the SVSim were developed by DWR to evaluate the integrated surface water and groundwater conditions at a regional scale, and to assess surface water-groundwater interaction and stream depletions at regional scale. CoSANA, being a local scale model with significantly more detail data and information provides a much better platform for evaluation of stream-aquifer interaction for the Sacramento area. It would be important to support the DWR in increasing the accuracy of the regional groundwater conditions in the fine grid C2VSim and SVSim, so that the regional scale results and policy decisions are consistent with the analysis at the local scale. It is therefore recommended that coordination occur with DWR to provide data and information for further refinement and update of the C2VSimFG and SVSim in the CoSANA area.
- **Develop model update schedule.** In order to keep the CoSANA up-to-date and current for analysis of water resources and especially for supporting SGMA implementation, it is recommended that the model

hydrology and land and water use data be updated and used for preparation of the GSP Annual Reports on an annual basis. It is further recommended that the model be updated for other major data sets, as well as enhanced for additional features every 5 years. This 5-year update would include an update of the model calibration and would be developed for use in the 5-year GSP updates for the three subbasins in the model area.

- **Enhance representation of variability of potential evapotranspiration**. The current version of the IDC used for estimation of the consumptive use of crops in the CoSANA uses monthly potential ET values that are uniform across the model domain. Future refinements are recommended to incorporate spatial variability of ET.
- **Map Soil Survey Geographic Database (SSURGO) rootzone parameters directly to CoSANA:** CoSANA used C2VSim rootzone parameters mapped to the CoSANA grid. Due to the difference in grid resolution, this may lead to a loss of detail on the original rootzone parameters. Remapping of the rootzone parameters should be considered to improve this resolution.
- **Refine surface water deliveries in NASb/SASb:** Some surface water diversions have limited detail on the delivery area, with some of this water sent to the appropriate subregion, but not specifically to the delivery area. Additional information on delivery areas is recommended for incorporation into CoSANA, including those in OHWD, and PCWA zone 5.
- **Improve inflow estimates for tributary streams:** Tributary streams were found to have a substantial effect on simulation of groundwater levels during calibration. Improvements could include flow measurements on small streams and/or developing improved regression analyses. Some tributary streams are not connected to a small watershed or receive very little flow from the small watershed simulation (for example: Magpie Creek and Arcade Creek in NASb, Elder Creek in SASb). Finally, subsurface conditions and simulated inflows from small watersheds east of the Cosumnes Subbasin require refinement to address model-calculated water levels that are significantly above land surface (flooded conditions).
- **Improve return flow routing within IWFM and CoSANA:** IWFM allows only one location for return flows, thus surface runoff must be routed to the same stream node as urban wastewater. In much of the Sacramento region, urban wastewater is routed to the Sacramento Regional Wastewater Treatment Plant northwest of Elk Grove. However, surface runoff is typically routed to the nearest surface water course. Coordination with DWR's IWFM development team is recommended to allow flexibility to route these differently according to the physical system.
- **Improve data and simulation of Auburn Ravine flows:** Auburn Ravine has complex operations that include inflows and diversions from several different entities. Currently, CoSANA simulation of Auburn Ravine flows is based on a regression analysis that uses flows from nearby Dry Creek. Though these may represent a reasonable estimate of natural flows that could occur in Auburn Ravine, this analysis does not capture any of the operational flows that occur through the ravine. There is a streamflow gage that is installed in Auburn Ravine, but the gage does not read flows above 200 cfs and therefore cannot be used to develop model inflows. It is recommended that streamflow measurements be taken on Auburn Ravine to either provide a data series for model input or to allow for an improved regression.
- **Develop improved rating tables for major streams:** many of the major stream rating tables are based on C2VSim/SVSim (Sacramento Valley Groundwater-Surface Water Simulation Model) rating tables from a flood study. These rating tables are heavily biased towards high flows that rarely occur in the model. The lower first or second interval includes almost all of the flows observed in a 10-point rating table. This results in the model not having much stage sensitivity, which may affect groundwater / surface water interaction as well as calibration of flow and stage. It is recommended that future efforts to develop rating tables include more focus on low flow conditions that are important for water resource management.
- **Improve simulation of complex water systems:** CoSANA incorporates substantial detail on complex public water systems. In some cases, additional detail on where water is produced, how much water is

lost in transmission, and where water is used can improve the simulation and improve the ease of reporting data from the model. This is typically most relevant to larger public water systems with mixed surface water and groundwater supplies and those systems that utilize interties or perform transfers.

- **Improve data for Mather AFB remediation operations:** Pumping data was received, but well location information is not known. Incorporation of the locations of wells could improve simulation of remediation operations.
- **Improve model information and data sets on the eastern areas:** The model geologic, hydrogeologic, and land use information for the eastern areas of the model near the foothills will need to be further enhanced, once additional data are collected. Such data may include boring logs, groundwater data, or geophysical data such as from airborne electromagnetic surveys. Model calibration will need to be improved upon collection of additional groundwater level data from the representative monitoring wells on the east side.

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# APPENDIX A: MODEL SURFACE WATER DELIVERIES

| Model Diversion ID | Description | Diversion Location | Delivery Area | Use | Fraction | | | Average Annual Diversion 1995-2018 (acre-feet) | Data Source | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | RL | NL | Delivery | | | |
| 1 | North-Side Bear River Diversion - Import to Camp Far West ID for Agriculture | Import | Subregion 1 | Agriculture | 0.14 | 0.04 | 1 | 5,888 | SacIWRM | |
| 2 | Bear River Diversions - Import to South Sutter WD for Agriculture | Import | Subregion 3 | Agriculture | 0.14 | 0.04 | 1 | 93,421 | SacIWRM, MBK | |
| 3 | Auburn Ravine Diversions to South Sutter WD for Agriculture | Auburn Ravine | Subregion 3 | Agriculture | 0.14 | 0.04 | 1 | 1,529 | MBK | |
| 4 | Small Stream Diversions - Import to South Sutter WD for Agriculture | Import | Subregion 3 | Agriculture | 0 | 0 | 1 | 331 | MBK | |
| 5 | Auburn Ravine Diversions to Zone 5 - Import to Placer County Water Agency for Agriculture | Import | Subregion 4 | Agriculture | 0.14 | 0.04 | 1 | 9,998 | SacIWRM, Placer County Water Agency | |
| 6 | Hemphill Canal - Import to Nevada Irrigation District for Agriculture | Import | Subregion 5 | Agriculture | 0.07 | 0.02 | 0.25 | 19,583 | C2VSim, Nevada Irrigation District | Estimated portion of volume coming into model area |
| 7 | Auburn Ravine Diversions - Import to Nevada Irrigation District for Agriculture | Import | Subregion 5 | Agriculture | 0.07 | 0.02 | 0.25 | 3,497 | C2VSim, Nevada Irrigation District | Estimated portion of volume coming into model area |
| 8 | From PCWA/NID Intertie - Import to City of Lincoln for Urban | Import | Subregion 6 | Urban | 0 | 0 | 1 | 6,218 | SacIWRM, City of Lincoln | |
| 9 | Feather River Riparian Diversions for Agriculture | Feather River | Subregion 7 | Agriculture | 0.12 | 0.03 | 1 | 11,000 | SacIWRM | |
| 10 | Sacramento River Diversions to Pleasant Grove Verona MWC for Agriculture | Sacramento River Upstream Cross Canal | Subregion 8 | Agriculture | 0.12 | 0.03 | 1 | 14,528 | C2VSim, USBR | |
| 11 | Sacramento River Riparian Diversions below Feather River confluence for Agriculture | Sacramento River Upstream Natomas East Drain | Subregion 9 | Agriculture | 0.12 | 0.03 | 1 | 1,260 | SacIWRM | |
| 12 | Natomas Mutual Water Company USBR Diversions for Agriculture | Sacramento River Upstream Natomas East Drain | Element group representing / NMWC | Agriculture | 0.01 | 0.0033 | 1 | 61,850 | SacIWRM, Natomas Mutual Water Company | |
| 13 | NOT USED | N/A | Out of model | Agriculture | 0 | 0 | 0 | 0 | N/A | Not used |
| 14 | Folsom Diversions - Import to City of Roseville for Urban | Import | Subregion 13 | Urban | 0 | 0 | 1 | 27,943 | City of Roseville | |
| 15 | From PCWA Intertie - Import to City of Roseville for Urban | Import | Subregion 13 | Urban | 0 | 0 | 1 | 0 | N/A | Placeholder, no data |
| 16 | From PCWA Intertie - Import to Cal-Am West Placer for Urban | Import | Subregion 14 | Urban | 0 | 0 | 1 | 725 | RWA, GEI | |
| 17 | Import to Sacramento Int'l Airport for Urban | Import | Subregion 16 | Urban | 0 | 0 | 1 | 175 | SacIWRM, RWA | |
| 18 | Sacramento River Riparian Imports near Sacramento Int'l Airport | Import | Subregion 18 | Agriculture | 0 | 0 | 1 | 3,124 | SacIWRM | |
| 19 | Import to Rio Linda Elverta CWD from SSWD Intertie for Urban | Import | Element group representing / Rio Linda Elverta CWD Service Area | Urban | 0 | 0 | 1 | 5 | RWA | |
| 20 | From SSWD Intertie - Import to Cal-Am Antelope for Urban | Import | Subregion 23 | Urban | 0 | 0 | 1 | 170 | RWA | |

| Model Diversion ID | Description | Diversion Location | Delivery Area | Use | Fraction | | | Average Annual Diversion 1995-2018 (acre-feet) | Data Source | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | RL | NL | Delivery | | | |
| 21 | From SSWD Intertie - Import to Cal-Am Lincoln Oaks for Urban | Import | Subregion 24 | Urban | 0 | 0 | 1 | 245 | RWA | |
| 22 | Folsom Diversions Via SJWD Intertie - Import to Citrus Heights WD for Urban | Import | Subregion 25 | Urban | 0 | 0 | 1 | 16,015 | RWA, SacIWRM | |
| 23 | From PCWA Intertie - Import to San Juan WD for Urban | Import | Subregion 26 | Urban | 0 | 0 | 1 | 0 | N/A | Placeholder, no data |
| 24 | Total Folsom Diversions Inc. Wholesale - Import to San Juan WD for Urban | Import | Out of model | Urban | 0 | 0 | 1 | 33,020 | RWA | |
| 25 | Retail Only - Import to San Juan WD for Urban | Import | Element group representing / SAN JUAN WD RETAIL AREA | Urban | 0 | 0 | 0.37 | 14,043 | RWA, SacIWRM | |
| 26 | Sac Suburban North District Total GW Production | Import | Subregion 32 | Urban | 0 | 0 | 1 | 16,044 | RWA | |
| 27 | From SSWD Intertie - Import to San Juan WD for Urban | Import | Subregion 26 | Urban | 0 | 0 | 1 | 0 | N/A | Placeholder, no data |
| 28 | From PCWA Intertie - Import to San Juan WD for Urban | Import | Subregion 26 | Urban | 0 | 0 | 1 | 0 | N/A | Placeholder, no data |
| 29 | Folsom Diversions via SJWD Intertie - Import to Orange Vale WC for Urban | Import | Subregion 28 | Urban | 0 | 0 | 1 | 4,191 | RWA, SacIWRM | |
| 30 | Folsom Diversions Via SJWD Intertie - Import to Fair Oaks WD for Urban | Import | Subregion 30 | Urban | 0 | 0 | 1 | 11,145 | RWA, SacIWRM | |
| 31 | American River Diversions to Carmichael WD for Urban | American River | Subregion 31 | Urban | 0 | 0 | 1 | 7,155 | RWA, SacIWRM | |
| 32 | From Sac Suburban Intertie - Import to Carmichael WD for Urban | Import | Subregion 31 | Urban | 0 | 0 | 1 | 0 | N/A | Placeholder, no data |
| 33 | From CHWD Intertie - Import to Carmichael WD for Urban | Import | Subregion 31 | Urban | 0 | 0 | 1 | 0 | N/A | Placeholder, no data |
| 34 | Sac Suburban North District Imports - Import to Sac Suburban North for Urban | Import | Subregion 32 | Urban | 0 | 0 | 1 | 8,987 | RWA, SacIWRM | |
| 35 | From City of Sac Intertie - Import to Sac Suburban South for Urban | Import | Subregion 33 | Urban | 0 | 0 | 1 | 1,037 | RWA | |
| 36 | From SSWD SSA Intertie - Import to City of Sacramento for Urban | Import | Element group representing / CITY OF SACRAMENTO | Urban | 0 | 0 | 1 | 161 | RWA | |
| 37 | From PCWA - Import to City of Rocklin for Urban | Import | Element group representing Rocklin | Urban | 0 | 0 | 1 | 4,578 | Placer County Water Agency | |
| 38 | Metro Air Park - Import to Metro Air Park for Urban | Import | Subregion 17 | Urban | 0 | 0 | 1 | 0 | N/A | Placeholder, no data |
| 39 | From City of Sac Intertie - Import to Cal-Am Arden for Urban | Import | Subregion 36 | Urban | 0 | 0 | 1 | 2 | RWA, SacIWRM | |
| 40 | City of Sacramento - American River Diversions to City of Sacramento for Urban | American River | Out of model | Urban | 0 | 0 | 1 | 48,211 | RWA | |
| 41 | City of Sacramento - Sacramento River Diversions to City of Sacramento for Urban | Sacramento River Upstream Morrison Crk | Out of model | Urban | 0 | 0 | 1 | 52,300 | RWA | |

| Model Diversion ID | Description | Diversion Location | Delivery Area | Use | Fraction | | | Average Annual Diversion 1995-2018 (acre-feet) | Data Source | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | RL | NL | Delivery | | | |
| 42 | City of Sacramento - Retail SW Delivery Volumes - Import to City of Sacramento for Urban | Import | Element group representing / CITY OF SACRAMENTO | Urban | 0 | 0 | 1 | 97,195 | RWA, SacIWRM | |
| 43 | Sac Suburban South District Total GW Production - Import to Sac Suburban South for Urban | Import | Subregion 33 | Urban | 0 | 0 | 1 | 16,351 | RWA, SacIWRM | Represents total GW production for service area |
| 44 | NOT USED - Import for Agriculture | Import | Out of model | Agriculture | 0 | 0 | 0 | 470 | N/A | |
| 45 | Arcade American River Diversions to Arcade for Urban | American River Upstream Sacramento R. | Subregion 39 | Urban | 0 | 0 | 1 | 132 | SacIWRM | |
| 46 | From City of Sac Intertie - Import to Cal-Am Suburban Rosemont for Urban | Import | Subregion 40 | Urban | 0 | 0 | 1 | 85 | RWA | |
| 47 | FSC/American River Diversions - Import to Golden State Water Company Cordova for Urban | Import | Subregion 42 | Urban | 0 | 0 | 1 | 5,922 | SacIWRM, RWA | FSC operations not currently simulated |
| 48 | From Carmichael WD - Import to Golden State Water Company Cordova for Urban | Import | Subregion 42 | Urban | 0 | 0 | 1 | 366 | RWA | |
| 49 | Aerojet FSC Diversions - Import to Aerojet FSC for Urban | Import | Out of model | Urban | 0 | 0 | 1 | 1,083 | SacIWRM | FSC operations not currently simulated |
| 50 | Folsom Diversions, Estimated Prior to 1983 - Import to City of Folsom for Urban | Import | Subregion 44 | Urban | 0 | 0 | 1 | 20,451 | SacIWRM, RWA | |
| 51 | SJWD Intertie) - Placeholder No Dat - Import to City of Folsom for Urban | Import | Subregion 44 | Urban | 0 | 0 | 1 | 0 | N/A | Placeholder, no data |
| 52 | From SCWA Intertie - Import to Cal-Am Security Park for Urban | Import | Subregion 45 | Urban | 0 | 0 | 1 | 0 | N/A | Placeholder, no data |
| 53 | From City of Sac Intertie - Import to Fruitridge Vista WC for Urban | Import | Subregion 46 | Urban | 0 | 0 | 1 | 1 | RWA | |
| 54 | From City of Sac Intertie - Import to Cal-Am Parkway for Urban | Import | Subregion 48 | Urban | 0 | 0 | 1 | 592 | RWA | |
| 55 | GW Imports - Import to SCWA - Arden Park Vista for Urban | Import | Subregion 37 | Urban | 0 | 0 | 1 | 3,911 | SacIWRM, RWA, SCWA | Represents total GW production for service area |
| 56 | SW Imports - Import to SCWA - Arden Park Vista for Urban | Import | Subregion 37 | Urban | 0 | 0 | 1 | 0 | N/A | Represents total SW delivered to service area |
| 57 | RW Imports - Import to SCWA - Arden Park Vista for Urban | Import | Subregion 37 | Urban | 0 | 0 | 1 | 0 | N/A | Represents total RW for service area |
| 58 | GW Imports - Import to SCWA - Hood for Urban | Import | Element group representing SCWA - Hood | Urban | 0 | 0 | 1 | 47 | SacIWRM, RWA, SCWA | Represents total GW production for service area |
| 59 | SW Imports - Import to SCWA - Hood for Urban | Import | Element group representing SCWA - Hood | Urban | 0 | 0 | 1 | 0 | SacIWRM, RWA, SCWA | Represents total SW delivered to service area |
| 60 | RW Imports - Import to SCWA - Hood for Urban | Import | Element group representing SCWA - Hood | Urban | 0 | 0 | 1 | 0 | SacIWRM, RWA, SCWA | Represents total RW for service area |

| Model Diversion ID | Description | Diversion Location | Delivery Area | Use | Fraction | | | Average Annual Diversion 1995-2018 (acre-feet) | Data Source | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | RL | NL | Delivery | | | |
| 61 | GW Imports - Import to SCWA - Northgate for Urban | Import | Subregion 20 | Urban | 0 | 0 | 1 | 940 | SacIWRM, RWA, SCWA | Represents total GW production for service area |
| 62 | SW Imports - Import to SCWA - Northgate for Urban | Import | Subregion 20 | Urban | 0 | 0 | 1 | 0 | SacIWRM, RWA, SCWA | Represents total SW delivered to service area |
| 63 | RW Imports - Import to SCWA - Northgate for Urban | Import | Subregion 20 | Urban | 0 | 0 | 1 | 0 | SacIWRM, RWA, SCWA | Represents total RW for service area |
| 64 | GW Imports - Import to SCWA - Laguna Vineyard for Urban | Import | Element group representing SCWA - South and Central Service Areas (including Elk Grove) | Urban | 0 | 0 | 1 | 17,340 | SacIWRM, RWA, SCWA | Represents total GW production for service area |
| 65 | SW Imports - Import to SCWA - Laguna Vineyard for Urban | Import | Element group representing SCWA - South and Central Service Areas (including Elk Grove) | Urban | 0 | 0 | 1 | 3,314 | SacIWRM, RWA, SCWA | Represents total SW delivered to service area |
| 66 | RW Imports - Import to SCWA - Laguna Vineyard for Urban | Import | Element group representing SCWA - South and Central Service Areas (including Elk Grove) | Urban | 0 | 0 | 1 | 232 | SacIWRM, RWA, SCWA | Represents total RW for service area |
| 67 | GW Imports - Import to SCWA Mather for Urban | Import | Element group representing SCWA - NSA | Urban | 0 | 0 | 1 | 3,958 | SacIWRM, RWA, SCWA | Represents total GW production for service area |
| 68 | SW Imports - Import to SCWA Mather for Urban | Import | Element group representing SCWA - NSA | Urban | 0 | 0 | 1 | 233 | SacIWRM, RWA, SCWA | Represents total SW delivered to service area |
| 69 | RW Imports - Import to SCWA Mather for Urban | Import | Element group representing SCWA - NSA | Urban | 0 | 0 | 1 | 0 | SacIWRM, RWA, SCWA | Represents total RW for service area |
| 70 | North Delta WA Ag Diversions - Import to North Delta WA for Agriculture | Import | Element group representing NDWA | Agriculture | 0 | 0 | 1 | 43,072 | SacIWRM | |
| 71 | Cosumnes River diversion 1 for ag use in element group 4 within Cosumnes River South and Sac Co. 8 subregions to for Agriculture | Cosumnes River Upstream Mokolumne R. / EKI | Element group representing CosSb_4 | Agriculture | 0 | 0 | 1 | 356 | eWRIMS | |
| 72 | Cosumnes River diversion 2 for ag use in element group 4 within Cosumnes River South and Sac Co. 8 subregions to for Agriculture | Cosumnes River Upstream Laguna Crk /EKI | Element group representing CosSb_4 | Agriculture | 0 | 0 | 1 | 4 | eWRIMS | |
| 73 | Cosumnes Subbasin Subregion for Agriculture | Cosumnes River Upstream Deer Crk / EKI | Element group representing CosSb_1 | Agriculture | 0 | 0 | 1 | 752 | eWRIMS | |

| Model Diversion ID | Description | Diversion Location | Delivery Area | Use | Fraction | | | Average Annual Diversion 1995-2018 (acre-feet) | Data Source | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | RL | NL | Delivery | | | |
| 74 | East Subregion for Agriculture | Cosumnes River Upstream Deer Crk / EKI | Element group representing CosSb_3 | Agriculture | 0 | 0 | 1 | 103 | eWRIMS and Mark Stretars | |
| 75 | Cosumnes River diversion 3 for ag use in element group 4 within Cosumnes River South and Sac Co. 8 subregions for Agriculture | Cosumnes River Upstream Badger Crk / EKI | Element group representing CosSb_4 | Agriculture | 0 | 0 | 1 | 1,119 | eWRIMS | |
| 76 | Cosumnes Subbasin Subregion for Agriculture | Cosumnes River Upstream Deer Crk / EKI | Element group representing CosSb_1 | Agriculture | 0 | 0 | 1 | 1,143 | eWRIMS | |
| 77 | Cosumnes Subbasin Subregion for Agriculture | Cosumnes River Upstream Deer Crk / EKI | Element group representing CosSb_1 | Agriculture | 0 | 0 | 1 | 130 | eWRIMS | |
| 78 | Cosumnes Subbasin Subregion for Agriculture | Cosumnes River Upstream Deer Crk / EKI | Element group representing CosSb_1 | Agriculture | 0 | 0 | 1 | 307 | eWRIMS | |
| 79 | Cosumnes Subbasin Subregion for Agriculture | Cosumnes River Upstream Deer Crk / EKI | Element group representing CosSb_1 | Agriculture | 0 | 0 | 1 | 2,153 | eWRIMS | |
| 80 | Cosumnes Subbasin Subregion for Agriculture | Cosumnes River Upstream Deer Crk / EKI | Element group representing CosSb_2 | Agriculture | 0 | 0 | 1 | 354 | eWRIMS | |
| 81 | East Subregion for Agriculture | Cosumnes River Upstream Deer Crk / EKI | Element group representing CosSb_3 | Agriculture | 0 | 0 | 1 | 42 | eWRIMS | |
| 82 | Cos and S Am Subbasins for Urban | Cosumnes River Upstream Deer Crk / EKI | Out of model | Urban | 0 | 0 | 1 | 3,755 | eWRIMS | |
| 83 | Dry Creek diversion for ag use in element group 7 within Amador Co. 1 subregion for Agriculture | Dry Creek Upstream Jackson Crk | Out of model | Agriculture | 0 | 0 | 1 | 432 | eWRIMS | |
| 84 | Dry Creek diversion for ag use in element group 8 within Amador Co. 1 subregion for Agriculture | Dry Creek Upstream Jackson Crk | Out of model | Agriculture | 0 | 0 | 1 | 2,238 | eWRIMS | |
| 85 | Dry Creek diversion 1 for ag use in element group 9 within Amador Co. 1 subregion for Agriculture | Dry Creek Upstream Jackson Crk / EKI | Element group representing CosSb_9 | Agriculture | 0 | 0 | 1 | 31 | eWRIMS | |
| 86 | Dry Creek diversion 2 for ag use in element group 9 within Amador Co. 1 subregion for Agriculture | Dry Creek Upstream Jackson Crk | Element group representing CosSb_9 | Agriculture | 0 | 0 | 1 | 62 | eWRIMS | |
| 87 | Dry Creek diversion 3 for ag use in element group 9 within Amador Co. 1 subregion for Agriculture | Dry Creek Upstream Jackson Crk | Element group representing CosSb_9 | Agriculture | 0 | 0 | 1 | 3 | eWRIMS | |
| 88 | Dry Creek diversion 4 for ag use in element group 9 within Amador Co. 1 subregion for Agriculture | Dry Creek Upstream Jackson Crk | Element group representing CosSb_9 | Agriculture | 0 | 0 | 1 | 1 | eWRIMS | |

| Model Diversion ID | Description | Diversion Location | Delivery Area | Use | Fraction | | | Average Annual Diversion 1995-2018 (acre-feet) | Data Source | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | RL | NL | Delivery | | | |
| 89 | Dry Creek diversion 1 for ag use in element group 5 within Cosumnes River South subregion for Agriculture | Dry Creek Upstream Mokolumne R. / EKI | Element group representing CosSb_5 | Agriculture | 0 | 0 | 1 | 5,398 | eWRIMS | |
| 90 | East Subregion to for Agriculture | Dry Creek Upstream Mokolumne R. | Element group representing CosSb_6 | Agriculture | 0 | 0 | 1 | 413 | eWRIMS | |
| 91 | East Subregion for Agriculture | Dry Creek Upstream Mokolumne R. | Element group representing CosSb_6 | Agriculture | 0 | 0 | 1 | 59 | eWRIMS | |
| 92 | Dry Creek diversion 2 for ag use in element group 5 within Cosumnes River South subregion for Agriculture | Dry Creek Upstream Mokolumne R. / EKI | Element group representing CosSb_5 | Agriculture | 0 | 0 | 1 | 547 | eWRIMS | |
| 93 | East Subregion for Agriculture | Dry Creek Upstream Mokolumne R. | Element group representing CosSb_6 | Agriculture | 0 | 0 | 1 | 19 | eWRIMS | |
| 94 | Dry Creek diversion 3 for ag use in element group 5 within Cosumnes River South subregion for Agriculture | Dry Creek Upstream Mokolumne R. / EKI | Element group representing CosSb_5 | Agriculture | 0 | 0 | 1 | 1,748 | eWRIMS | |
| 95 | Dry Creek diversion 4 for ag use in element group 5 within Cosumnes River South subregion for Agriculture | Dry Creek Upstream Mokolumne R. / EKI | Element group representing CosSb_5 | Agriculture | 0 | 0 | 1 | 1,748 | eWRIMS | |
| 96 | Dry Creek diversion 5 for ag use in element group 5 within Cosumnes River South subregion for Agriculture | Dry Creek Upstream Mokolumne R. / EKI | Element group representing CosSb_5 | Agriculture | 0 | 0 | 1 | 1,748 | eWRIMS | |
| 97 | East Subregion for Agriculture | Badger Creek | Element group representing CosSb_15 | Agriculture | 0 | 0 | 1 | 10 | eWRIMS | |
| 98 | West Subregion for Agriculture | Badger Creek | Element group representing CosSb_12 | Agriculture | 0 | 0 | 1 | 35 | eWRIMS | |
| 99 | Laguna Creek diversion for ag use in element group 21 within Clay WD subregion for Agriculture | Laguna Creek (Cosumnes Subbasin) | Element group representing CosSb_21 | Agriculture | 0 | 0 | 1 | 301 | eWRIMS | |
| 100 | East Subregion for Agriculture | Laguna Creek (Cosumnes Subbasin) | Element group representing CosSb_11 | Agriculture | 0 | 0 | 1 | 362 | eWRIMS | |
| 101 | East Subregion for Agriculture | Laguna Creek (Cosumnes Subbasin) | Element group representing CosSb_11 | Agriculture | 0 | 0 | 1 | 3 | eWRIMS | |
| 102 | East Subregion for Agriculture | Laguna Creek (Cosumnes Subbasin) | Element group representing CosSb_10 | Agriculture | 0 | 0 | 1 | 49 | eWRIMS | |
| 103 | Jackson Creek diversion for ag use in element group 14 within Jackson ID subregion - Import for Agriculture | Import | Element group representing CosSb_14 | Agriculture | 0 | 0 | 1 | 10,558 | eWRIMS | |
| 104 | Mokelumne River diversion 1 for ag use in element group 16 within Cosumnes River South subregion for Agriculture | Dry Creek Upstream Mokolumne R. / EKI | Element group representing CosSb_16 | Agriculture | 0 | 0 | 1 | 2,376 | eWRIMS | |

| Model Diversion ID | Description | Diversion Location | Delivery Area | Use | Fraction | | | Average Annual Diversion 1995-2018 (acre-feet) | Data Source | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | RL | NL | Delivery | | | |
| 105 | Mokelumne River diversion 2 for ag use in element group 16 within Cosumnes River South subregion for Agriculture | Mokolumne River Upstream Cosumnes R. | Element group representing CosSb_16 | Agriculture | 0 | 0 | 1 | 436 | eWRIMS | |
| 106 | Mokelumne River diversion 3 for ag use in element group 16 within Cosumnes River South subregion to for Agriculture | Mokolumne River Upstream Cosumnes R. | Element group representing CosSb_16 | Agriculture | 0 | 0 | 1 | 232 | eWRIMS | |
| 107 | Mokelumne River diversion 4 for ag use in element group 16 within Cosumnes River South subregion for Agriculture | Mokolumne River Upstream Cosumnes R. | Element group representing CosSb_16 | Agriculture | 0 | 0 | 1 | 933 | eWRIMS | |
| 108 | Mokelumne River diversion 5 for ag use in element group 16 within Cosumnes River South subregion for Agriculture | Mokolumne River Upstream Cosumnes R. | Element group representing CosSb_16 | Agriculture | 0 | 0 | 1 | 4 | eWRIMS | |
| 109 | Mokelumne River diversion 6 for ag use in element group 16 within Cosumnes River South subregion for Agriculture | Mokolumne River Upstream Cosumnes R. | Element group representing CosSb_16 | Agriculture | 0 | 0 | 1 | 141 | eWRIMS | |
| 110 | East Subregion - Import for Agriculture | Import | Element group representing CosSb_19 | Agriculture | 0 | 0 | 1 | 1,263 | eWRIMS | |
| 111 | East Subregion - Import for Agriculture | Import | Element group representing CosSb_17 | Agriculture | 0 | 0 | 1 | 651 | eWRIMS | |
| 112 | East Subregion - Import for Agriculture | Import | Element group representing CosSb_18 | Agriculture | 0 | 0 | 1 | 142 | eWRIMS | |
| 113 | Diversion from unmodeled stream or spring for ag use in OHWD Cosumnes Subbasin subregion - Import for Agriculture | Import | Subregion 67 | Agriculture | 0 | 0 | 1 | 232 | eWRIMS | |
| 114 | East Subregion - Import for Agriculture | Import | Subregion 69 | Agriculture | 0 | 0 | 1 | 200 | eWRIMS | |
| 115 | Diversion from unmodeled stream or spring for ag use in Wilton subregion - Import for Agriculture | Import | Subregion 70 | Agriculture | 0 | 0 | 1 | 11 | eWRIMS | |
| 116 | Diversion from unmodeled stream or spring for ag use in Sloughhouse RCD West subregion - Import for Agriculture | Import | Subregion 71 | Agriculture | 0 | 0 | 1 | 133 | eWRIMS | |
| 117 | Diversion from unmodeled stream or spring for ag use in Galt ID East subregion - Import for Agriculture | Import | Subregion 72 | Agriculture | 0 | 0 | 1 | 10 | eWRIMS | |
| 118 | Diversion from unmodeled stream or spring for ag use in SMUD Rancho Seco subregion - Import for Agriculture | Import | Subregion 75 | Agriculture | 0 | 0 | 1 | 455 | eWRIMS | |
| 119 | Diversion from unmodeled stream or spring for ag use in Cosumnes River South subregion - Import for Agriculture | Import | Subregion 76 | Agriculture | 0 | 0 | 1 | 5 | eWRIMS | |

| Model Diversion ID | Description | Diversion Location | Delivery Area | Use | Fraction | | | Average Annual Diversion 1995-2018 (acre-feet) | Data Source | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | RL | NL | Delivery | | | |
| 120 | Diversion from unmodeled stream or spring for ag use in Amador Co. 1 subregion - Import for Agriculture | Import | Subregion 81 | Agriculture | 0 | 0 | 1 | 217 | eWRIMS | |
| 121 | Diversion from unmodeled stream or spring for ag use in Jackson ID subregion - Import for Agriculture | Import | Subregion 83 | Agriculture | 0 | 0 | 1 | 91 | eWRIMS | |
| 122 | Diversion from unmodeled stream or spring for ag use in Comanche subregion - Import for Agriculture | Import | Subregion 84 | Agriculture | 0 | 0 | 1 | 80 | eWRIMS | |
| 123 | Diversion from unmodeled stream or spring for ag use in Amador County WA subregion - Import or Agriculture | Import | Subregion 85 | Agriculture | 0 | 0 | 0 | 3 | eWRIMS | |
| 124 | East Subregion - Import to for Agriculture | Import | Element group representing CosSb_20 | Agriculture | 0 | 0 | 1 | 150 | eWRIMS | |
| 125 | Cosumnes Subbasin Subregion - Import for Agriculture | Import | Subregion 67 | Agriculture | 0 | 0 | 1 | 180 | SacIWRM | |
| 126 | East Subregion - Import for Agriculture | Import | Subregion 72 | Agriculture | 0 | 0 | 1 | 1,128 | SacIWRM | |
| 127 | Tailwater Reuse from fish farms for ag use in Clay WD subregion - Import to for Agriculture | Import | Subregion 73 | Agriculture | 0 | 0 | 1 | 150 | SacIWRM | |
| 128 | East) Subregion - Import for Agriculture | Import | Subregion 69 | Agriculture | 0 | 0 | 1 | 300 | SacIWRM | |
| 129 | Import to Ione for local surface water supply - Import for Urban | Import | Subregion 82 | Urban | 0 | 0 | 1 | 1,878 | SacIWRM | |
| 130 | Recoverable Loss from Rancho Seco Export Water to Laguna Creek - Import for Agriculture | Import | Out of model | Agriculture | 0 | 0 | 0 | 12,028 | SacIWRM | |
| 131 | NOT USED - Import for Agriculture | Import | Out of model | Agriculture | 0 | 0 | 0 | 786 | N/A | |
| 132 | Cosumnes Subbasin) Subregion to O-H for Agriculture | Folsom South Canal (South of Cosumnes R.) | Subregion 67 | Agriculture | 0 | 0 | 0.34 | 0 | SacIWRM | |
| 133 | South American) Subregion to O-H for Agriculture | Folsom South Canal (South of Cosumnes R.) | Subregion 66 | Agriculture | 0 | 0 | 0.66 | 0 | SacIWRM | |
| 134 | East Subregion to Galt ID for Agriculture | Folsom South Canal (South of Cosumnes R.) | Subregion 72 | Agriculture | 0 | 0 | 1 | 2,279 | SacIWRM | |
| 135 | Clay ID FSC diversions to Clay ID subregion to Clay ID for Agriculture | Folsom South Canal (South of Cosumnes R.) | Subregion 73 | Agriculture | 0 | 0 | 1 | 1,051 | SacIWRM | |
| 136 | SMUD FSC diversions to SMUD Rancho Seco subregion to SMUD FSC for Agriculture | Folsom South Canal (South of Cosumnes R.) | Subregion 75 | Agriculture | 0 | 0 | 1 | 14,615 | SacIWRM | |
| 137 | SCWA Freeport Diversions for Mather and Vineyard SW Supply | Sacramento River at Freeport | Out of model | Urban | 0 | 0 | 1 | 3,154 | RWA | Retail delivery handled with Divs 65, 68 |

| Model Diversion ID | Description | Diversion Location | Delivery Area | Use | Fraction | | | Average Annual Diversion 1995-2018 (acre-feet) | Data Source | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | RL | NL | Delivery | | | |
| 138 | Deer Creek diversion to SRCD to Deer Creek for Agriculture | Deer Creek | Subregion 65 | Agriculture | 0 | 0 | 1 | 29 | eWRIMS | |
| 139 | Deer Creek diversions to OHWD to Deer Creek for Agriculture | Deer Creek | Subregion 66 | Agriculture | 0 | 0 | 1 | 175 | eWRIMS | |
| 140 | Cosumnes River diversion to RMCSD area Ag to Cosumnes River for Agriculture | Cosumnes River Upstream Deer Crk / EKI | Subregion 64 | Agriculture | 0 | 0 | 1 | 570 | eWRIMS | |
| 141 | Cosumnes River diversions to OHWD to Cosumnes River for Agriculture | Cosumnes River Upstream Deer Crk / EKI | Subregion 66 | Agriculture | 0 | 0 | 1 | 1,388 | eWRIMS | |
| 142 | Not Used | Import | N/A | N/A | 1 | 0 | 1 | 0 | N/A | |
| 143 | Diversion from water stored in Loch Lane for at use, adjusted to meet demand | Import | Element group representing / CosSb_22 | Agriculture | 0 | 0 | 1 | 2,670 | eWRIMS | |
| 144 | Galt WWTP flows through Laguna Creek to Galt WWTP for Agriculture | Laguna Creek (Cosumnes Subbasin) | Element group representing / Galt WWTP | Agriculture | 0 | 0 | 1 | 700 | South Basin Groundwater Management Plan, Robertson-Bryan Inc. and WRIME, 2011 | |
| 145 | Rancho Murieta diversion from stored water to meet estimated demand. - Import to Rancho Murieta for Urban | Import | Element group representing CosSb_13 | Urban | 0 | 0 | 1 | 1,833 | RMCSD | |

RL: Recoverable Loss
NL: Non-recoverable Loss

# APPENDIX B: REMEDIATION PUMPING BY ENTITY

| Water Year | Aerojet Remediation (NASb)<br><br>(acre-feet) | Aerojet Remediation (SASb)<br><br>(acre-feet) | Kiefer Landfill Remediation<br><br>(acre-feet) | Mather Air Force Base Remediation<br>(acre-feet) | McClellan Air Force Base Remediation<br>(acre-feet) |
|---|---|---|---|---|---|
| 1995 | 0 | 14,568 | 102 | 157 | 745 |
| 1996 | 0 | 15,189 | 468 | 209 | 1,145 |
| 1997 | 0 | 14,672 | 517 | 209 | 1,157 |
| 1998 | 270 | 16,916 | 898 | 209 | 1,167 |
| 1999 | 2,018 | 14,586 | 870 | 209 | 1,032 |
| 2000 | 1,900 | 12,747 | 1,500 | 209 | 2,020 |
| 2001 | 1,672 | 13,297 | 1,339 | 209 | 1,440 |
| 2002 | 1,583 | 12,657 | 1,793 | 209 | 1,105 |
| 2003 | 1,551 | 15,267 | 1,531 | 209 | 1,098 |
| 2004 | 1,695 | 18,682 | 1,622 | 209 | 1,569 |
| 2005 | 1,953 | 17,591 | 1,333 | 209 | 1,446 |
| 2006 | 2,069 | 18,892 | 1,280 | 209 | 2,272 |
| 2007 | 2,382 | 19,568 | 1,555 | 209 | 2,838 |
| 2008 | 2,287 | 21,786 | 1,391 | 209 | 2,743 |
| 2009 | 2,093 | 21,383 | 1,321 | 209 | 2,386 |
| 2010 | 2,424 | 24,938 | 1,111 | 209 | 2,369 |
| 2011 | 2,674 | 26,618 | 1,141 | 209 | 2,406 |
| 2012 | 3,394 | 26,058 | 575 | 209 | 2,483 |
| 2013 | 2,125 | 18,808 | 488 | 209 | 2,394 |
| 2014 | 2,479 | 21,932 | 522 | 209 | 2,317 |
| 2015 | 2,689 | 20,137 | 494 | 209 | 2,213 |
| 2016 | 3,482 | 28,274 | 375 | 209 | 2,432 |
| 2017 | 3,430 | 29,362 | 422 | 209 | 2,395 |
| 2018 | 3,105 | 28,935 | 621 | 209 | 2,409 |
| **Average WY 1995-2018** | **1,970** | **19,703** | **969** | **207** | **1,899** |

# APPENDIX C: SUBREGION LAND AND WATER USE BUDGETS

**Historical Water Use Budget Summary, Annual Average for WY 1995 - 2018**

| Subregion | Description | Ag Area | Ag Demand | Ag Water Duty | Urban Area | Urban Demand | Urban Water Duty | Total Water Demand | Total Ag Water Supply (Acre-Feet/Year) | | Total Urban Water Supply (Acre-Feet/Year) | | | Total Supply (Acre-Feet/Year) | Remediation Operations | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (Acres) | (Acre-Feet) | (Acre-Feet/Acre) | (Acres) | (Acre-Feet) | (Acre-Feet/Acre) | (Acre-Feet) | GW Production | SW Deliveries | GW Use | SW Deliveries | Other Supply[2] | | Extraction | Injection |
| 1 | Camp Far West ID | 1,760 | 9,327 | 5.3 | 169 | 150 | 0.9 | 9,477 | 4,472 | 4,990 | 150 | - | - | 9,612 | - | - |
| 2 | Sutter Co. 1 | 147 | 643 | 4.4 | 2 | 1 | 0.4 | 644 | 643 | - | 1 | - | - | 644 | - | - |
| 3 | South Sutter WD GSA | 52,398 | 183,202 | 3.5 | 1,962 | 1,490 | 0.8 | 184,693 | 103,768 | 80,796 | 1,490 | - | - | 186,055 | - | - |
| 4 | Placer County WA[1] | 12,243 | 31,383 | 2.6 | 7,202 | 8,308 | 1.2 | 39,692 | 22,996 | 8,473 | 3,730 | 4,578 | - | 39,778 | - | - |
| 5 | Nevada ID | 3,168 | 11,467 | 3.6 | 482 | 397 | 0.8 | 11,864 | 6,030 | 5,770 | 397 | - | - | 12,196 | - | - |
| 6 | Lincoln[1] | 527 | 1,275 | 2.4 | 4,573 | 6,958 | 1.5 | 8,233 | 1,275 | - | 739 | 6,218 | - | 8,233 | - | - |
| 7 | RD1001[1] | 7,476 | 28,604 | 3.8 | 371 | 165 | 0.4 | 28,769 | 19,039 | 9,565 | 165 | - | - | 28,769 | - | - |
| 8 | Pleasant Grove Verona MWC | 6,813 | 23,943 | 3.5 | 99 | 45 | 0.5 | 23,988 | 12,036 | 12,633 | 45 | - | - | 24,714 | - | - |
| 9 | Sutter Co. 2 | 985 | 3,447 | 3.5 | 87 | 39 | 0.5 | 3,486 | 2,278 | 1,169 | 39 | - | - | 3,486 | - | - |
| 10 | Natomas MWC (Sutter Co.) | 11,694 | 41,428 | 3.5 | 436 | 197 | 0.5 | 41,625 | 717 | 40,744 | 197 | - | - | 41,658 | - | - |
| 11 | Sutter Co. 3 | 2,912 | 9,152 | 3.1 | 440 | 289 | 0.7 | 9,441 | 9,152 | - | 289 | - | - | 9,441 | - | - |
| 12 | Roseville SOI | 1,127 | 3,037 | 2.7 | 44 | 105 | 2.4 | 3,141 | 3,037 | - | 105 | - | - | 3,141 | - | - |
| 13 | City of Roseville | 488 | 623 | 1.3 | 16,617 | 28,069 | 1.7 | 28,692 | 623 | - | 126 | 27,943 | - | 28,692 | - | - |
| 14 | Cal Am (West Placer) | 3,223 | 6,459 | 2.0 | 2,146 | 725 | 0.3 | 7,184 | 6,459 | - | - | 725 | - | 7,184 | - | - |
| 15 | Natomas MWC (Sacramento Co.) | 13,037 | 41,942 | 3.2 | 1,357 | 2,973 | 2.2 | 44,915 | 687 | 41,291 | 2,973 | - | - | 44,951 | - | - |
| 16 | Sacramento International Airport | 946 | 893 | 0.9 | 1,621 | 1,143 | 0.7 | 2,037 | 893 | - | 968 | 175 | - | 2,037 | - | - |
| 17 | Metro Air Park | 1,643 | 1,458 | 0.9 | 37 | - | 0.0 | 1,458 | 1,458 | - | - | - | - | 1,458 | - | - |
| 18 | Sac Co. 1 | 928 | 1,896 | 2.0 | 139 | 604 | 4.3 | 2,500 | 100 | 1,796 | 604 | - | - | 2,500 | - | - |
| 19 | Sac Co. 2 | 793 | 2,636 | 3.3 | 141 | 17 | 0.1 | 2,653 | 2,636 | - | 17 | - | - | 2,653 | - | - |
| 20 | Sac County WA (Northgate 880) | 43 | 52 | 1.2 | 792 | 940 | 1.2 | 992 | 52 | - | 940 | - | - | 992 | - | - |
| 21 | Rio Linda Elverta | 630 | 905 | 1.4 | 5,873 | 8,941 | 1.5 | 9,846 | 905 | - | 8,936 | 5 | - | 9,846 | - | - |
| 22 | Sac Co. 3 | 327 | 250 | 0.8 | 214 | 335 | 1.6 | 584 | 250 | - | 335 | - | - | 584 | - | - |
| 23 | Cal Am (Antelope) | 4 | 8 | 1.8 | 2,664 | 5,790 | 2.2 | 5,798 | 8 | - | 5,621 | 170 | - | 5,798 | - | - |
| 24 | Cal Am (Lincoln Oaks) | 3 | 8 | 2.3 | 4,254 | 9,114 | 2.1 | 9,122 | 8 | - | 8,869 | 245 | - | 9,122 | - | - |
| 25 | Citrus Heights WD | 66 | 262 | 3.9 | 7,706 | 16,967 | 2.2 | 17,229 | 262 | - | 952 | 16,015 | - | 17,229 | - | - |
| 26 | San Juan WD (Placer Co.) | 41 | 18 | 0.4 | 1,130 | 1,817 | 1.6 | 1,835 | 18 | - | - | 1,817 | - | 1,835 | - | - |
| 27 | San Juan WD (Sacramento Co.) | 79 | 246 | 3.1 | 2,043 | 3,378 | 1.7 | 3,624 | 246 | - | - | 3,378 | - | 3,624 | - | - |
| 28 | Orange Vale WC | 119 | 618 | 5.2 | 2,839 | 4,191 | 1.5 | 4,809 | 618 | - | - | 4,191 | - | 4,809 | - | - |
| 29 | Lake Natoma/Mississippi Bar | 1 | 35 | 36.0 | 128 | - | 0.0 | 35 | 35 | - | - | - | - | 35 | - | - |
| 30 | Fair Oaks WD | 97 | 284 | 2.9 | 6,159 | 12,328 | 2.0 | 12,611 | 284 | - | 1,183 | 11,145 | - | 12,611 | 1,401 | - |
| 31 | Carmichael WD | 0 | 0 | 3.5 | 5,255 | 11,234 | 2.1 | 11,234 | 0 | - | 4,080 | 7,155 | - | 11,234 | 568 | - |
| 32 | Sacramento Suburban WD (North) | 154 | 74 | 0.5 | 13,736 | 25,031 | 1.8 | 25,105 | 74 | - | 16,130 | 8,902 | - | 25,105 | 1,843 | - |
| 33 | Sacramento Suburuban WD (South) | - | - | 0.0 | 7,765 | 17,388 | 2.2 | 17,388 | - | - | 16,387 | 1,001 | - | 17,388 | - | - |
| 34 | Del Paso Manor WD | - | - | 0.0 | 614 | 1,549 | 2.5 | 1,549 | - | - | 1,549 | - | - | 1,549 | - | - |
| 35 | Golden State WC Arden | - | - | 0.0 | 496 | 1,169 | 2.4 | 1,169 | - | - | 1,169 | - | - | 1,169 | - | - |
| 36 | Cal Am (Arden) | - | - | 0.0 | 640 | 2,832 | 4.4 | 2,832 | - | - | 2,830 | 2 | - | 2,832 | - | - |
| 37 | Sac County WA (Arden Park | - | - | 0.0 | 1,348 | 3,911 | 2.9 | 3,911 | - | - | 3,911 | - | - | 3,911 | - | - |
| 38 | City of Sacramento (North) | 3,522 | 4,546 | 1.3 | 17,106 | 37,754 | 2.2 | 42,300 | 4,546 | - | 6,459 | 31,296 | - | 42,300 | 56 | - |
| | ***Total NASb*** | 127,396 | 410,120 | 120 | 118,685 | 216,346 | 58 | 626,466 | 205,605 | 207,227 | 91,384 | 124,961 | - | 629,177 | 3,869 | - |
| 39 | City of Sacramento (South) | 735 | 1,230 | 1.7 | 35,588 | 79,828 | 2.2 | 81,058 | 1,146 | 84 | 13,767 | 66,193 | - | 81,190 | - | - |
| 40 | Cal Am (Suburban Rosemont) | 291 | 938 | 3.2 | 7,186 | 12,381 | 1.7 | 13,318 | 938 | - | 12,296 | 110 | - | 13,343 | 131 | - |
| 41 | Sac Co. 4 | 65 | 29 | 0.4 | 15 | - | 0.0 | 29 | 29 | - | - | - | - | 29 | - | - |
| 42 | Golden State WC (Cordova) | 72 | 76 | 1.1 | 6,310 | 15,264 | 2.4 | 15,341 | 76 | - | 8,977 | 6,287 | - | 15,341 | 4,422 | - |
| 43 | Sac Co. 5 | - | - | 0.0 | 269 | 3 | 0.0 | 3 | - | - | - | 3 | - | 3 | 7,351 | - |
| 44 | City of Folsom[1] | 53 | 55 | 1.1 | 9,505 | 20,451 | 2.2 | 20,507 | 35 | - | - | 20,451 | - | 20,487 | 3,137 | - |
| 45 | Cal Am (Security Park) | - | - | 0.0 | 171 | 31 | 0.2 | 31 | - | - | 31 | 0 | - | 31 | 48 | - |
| 46 | Fruitridge Vista WC | - | - | 0.0 | 1,894 | 4,224 | 2.2 | 4,224 | - | - | 4,387 | 1 | - | 4,388 | - | - |
| 47 | Florin County WD | 1 | 4 | 3.9 | 1,369 | 2,623 | 1.9 | 2,628 | 4 | - | 2,623 | - | - | 2,628 | - | - |
| 48 | Cal Am (Parkway) | 5 | 11 | 1.9 | 5,007 | 11,291 | 2.3 | 11,302 | 11 | - | 10,699 | 592 | - | 11,302 | - | - |
| 49 | Sac Co. 6 | 463 | 898 | 1.9 | 1,056 | 57 | 0.1 | 955 | 598 | 300 | 57 | - | - | 955 | - | - |
| 50 | Sac County WA (North/Central) | 4,080 | 11,378 | 2.8 | 12,881 | 16,425 | 1.3 | 27,803 | 11,378 | - | 14,874 | 1,435 | 92 | 27,779 | 4,819 | 207 |
| 51 | Sac County WA (South) | 3,303 | 8,188 | 2.5 | 7,996 | 11,375 | 1.4 | 19,564 | 8,188 | - | 9,397 | 1,851 | 128 | 19,564 | - | - |
| 52 | Elk Grove WD (2 - Intertie Service Area) | 639 | 1,717 | 2.7 | 2,374 | 3,430 | 1.4 | 5,147 | 1,717 | - | 2,833 | 558 | 38 | 5,147 | - | - |
| 53 | Elk Grove WD (1 - GW Service Area) | 33 | 115 | 3.5 | 2,934 | 5,189 | 1.8 | 5,305 | 115 | - | 5,189 | - | - | 5,305 | - | - |
| 54 | Cosumnes River West | 18,072 | 56,004 | 3.1 | 1,824 | 4,533 | 2.5 | 60,536 | 51,495 | 4,509 | 4,533 | - | - | 60,537 | - | - |
| 55 | RD744 | 1,294 | 2,738 | 2.1 | 102 | 60 | 0.6 | 2,798 | 702 | 2,036 | 60 | - | - | 2,798 | - | - |
| 56 | Franklin Drainage District | 2,825 | 8,515 | 3.0 | 250 | 158 | 0.6 | 8,673 | 3,180 | 5,336 | 125 | 33 | - | 8,674 | - | - |
| 57 | RD813 | 2,075 | 4,676 | 2.3 | 82 | 48 | 0.6 | 4,724 | 1,287 | 3,389 | 33 | 15 | - | 4,724 | - | - |
| 58 | RD755 | 354 | 1,497 | 4.2 | 26 | 16 | 0.6 | 1,513 | 520 | 978 | 16 | - | - | 1,513 | - | - |
| 59 | RD1002 | 4,303 | 10,037 | 2.3 | 254 | 166 | 0.7 | 10,203 | 2,889 | 7,148 | 166 | - | - | 10,203 | - | - |
| 60 | RD551 | 7,927 | 22,522 | 2.8 | 423 | 245 | 0.6 | 22,767 | 6,062 | 16,462 | 245 | - | - | 22,768 | - | - |
| 61 | RD369 | 108 | 382 | 3.5 | 37 | 23 | 0.6 | 406 | 130 | 252 | 23 | - | - | 406 | - | - |
| 62 | RD2110 | 1,401 | 2,033 | 1.5 | 52 | 28 | 0.5 | 2,061 | 409 | 1,624 | 28 | - | - | 2,061 | - | - |
| 63 | Sac Co. 7 | 306 | 680 | 2.2 | 88 | 94 | 1.1 | 773 | 176 | 504 | 94 | - | - | 773 | - | - |
| 64 | Rancho Murieta (North)[1] | 381 | 1,239 | 3.2 | 1,098 | 1,415 | 1.3 | 2,654 | 740 | 499 | 153 | 1,262 | - | 2,654 | - | - |
| 65 | Sloughouse RCD (North) | 575 | 1,318 | 2.3 | 631 | 616 | 1.0 | 1,934 | 1,290 | 28 | 584 | 31 | - | 1,934 | - | - |
| 66 | OHWD (Sth American Subbasin) | 9,592 | 24,431 | 2.5 | 2,469 | 1,970 | 0.8 | 26,401 | 23,282 | 1,517 | 1,554 | 431 | - | 26,784 | 969 | - |
| | ***Total SASb*** | 58,954 | 160,714 | 62 | 101,890 | 191,942 | 33 | 352,656 | 116,398 | 44,668 | 92,742 | 99,252 | 258 | 353,318 | 20,879 | 207 |
| 67 | OHWD (Cosumnes Subbasin) | 2,633 | 7,608 | 2.9 | 1,049 | 975 | 0.9 | 8,583 | 5,202 | 2,407 | 1,053 | - | - | 8,661 | - | - |
| 68 | Rancho Murieta (South) | 4 | 20 | 4.7 | 365 | 465 | 1.3 | 485 | 6 | 14 | - | 412 | - | 432 | - | - |
| 69 | Sloughouse RCD (East) | 8,331 | 21,515 | 2.6 | 1,303 | 1,322 | 1.0 | 22,838 | 19,813 | 1,702 | 109 | 128 | - | 21,752 | - | - |
| 70 | Wilton | 1,018 | 3,611 | 3.5 | 3,502 | 2,742 | 0.8 | 6,353 | 3,600 | 11 | 4,352 | - | - | 7,963 | - | - |
| 71 | Sloughouse RCD (West) | 4,111 | 10,694 | 2.6 | 324 | 242 | 0.7 | 10,936 | 10,562 | 132 | 8 | - | - | 10,701 | - | - |
| 72 | Galt ID (East) | 14,401 | 41,762 | 2.9 | 6,071 | 5,336 | 0.9 | 47,098 | 38,080 | 3,682 | 9,526 | - | - | 51,288 | - | - |
| 73 | Clay WD | 1,918 | 7,109 | 3.7 | 172 | 479 | 2.8 | 7,588 | 5,634 | 1,474 | - | - | - | 7,109 | - | - |
| 74 | Clay | 61 | 180 | 2.9 | 2,805 | 1,945 | 0.7 | 2,126 | 180 | - | 1,903 | - | - | 2,084 | - | - |
| 75 | SMUD Rancho Seco | 21 | 36 | 1.7 | 137 | 138 | 1.0 | 174 | - | 36 | 7 | - | - | 43 | - | - |
| 76 | Cosumnes River South | 4,405 | 12,174 | 2.8 | 191 | 315 | 1.6 | 12,488 | 9,159 | 3,046 | - | - | - | 12,205 | - | - |
| 77 | Galt ID (West) | 1,847 | 5,355 | 2.9 | 1,331 | 1,222 | 0.9 | 6,577 | 5,355 | - | 707 | - | - | 6,062 | - | - |
| 78 | Sac Co. 8 | 2,882 | 6,480 | 2.2 | 623 | 924 | 1.5 | 7,404 | 5,124 | 1,356 | 165 | - | - | 6,645 | - | - |
| 79 | City of Galt | 182 | 361 | 2.0 | 3,035 | 4,650 | 1.5 | 5,011 | 361 | - | 4,737 | - | - | 5,099 | - | - |
| 80 | Sloughouse RCD (South) | 1,034 | 2,418 | 2.3 | 320 | 497 | 1.6 | 2,915 | 2,418 | - | 56 | - | - | 2,474 | - | - |
| 81 | Amador Co. 1 | 1,812 | 3,278 | 1.8 | 1,832 | 2,530 | 1.4 | 5,809 | 1,259 | 2,018 | 0 | - | - | 3,277 | - | - |
| 82 | Ione | 153 | 425 | 2.8 | 1,109 | 2,130 | 1.9 | 2,555 | 425 | 0 | - | 1,878 | - | 2,303 | - | - |
| 83 | Jackson ID | 2,693 | 9,258 | 3.4 | 361 | 456 | 1.3 | 9,713 | - | 9,018 | - | - | - | 9,018 | - | - |
| 84 | Camanche | 63 | - | 0.0 | 133 | 164 | 1.2 | 164 | - | - | 76 | - | - | 76 | - | - |
| 85 | Amador County WA | 0 | - | 0.0 | 199 | 245 | 1.2 | 245 | - | - | 181 | - | - | 181 | - | - |
| 87 | Galt WWTP | 148 | 209 | 1.4 | 57 | 88 | 1.5 | 297 | - | 698 | - | - | - | 698 | - | - |
| | ***Total CoSb*** | 47,717 | 132,494 | 49 | 24,918 | 26,866 | 26 | 159,360 | 107,180 | 25,594 | 22,881 | 2,417 | - | 158,072 | - | - |
| 86 | Mokelumne | 34,664 | 79,056 | 2.3 | 3,200 | 4,222 | 1.3 | 83,278 | 79,056 | - | 4,222 | - | - | 83,278 | - | |
| | ***Total Other*** | 34,664 | 79,056 | 2.3 | 3,200 | 4,222 | 1.3 | 83,278 | 79,056 | - | 4,222 | - | - | 83,278 | - | - |
| | ***CoSANA Grand Total (NASb, SASb, CoSb)*** | 234,067 | 703,329 | 231 | 245,493 | 435,154 | 116 | 1,138,482 | 429,183 | 277,488 | 207,008 | 226,630 | 258 | 1,140,568 | 24,748 | 207 |

Footnotes:
1. Subregion includes areas that fall outside of DWR B118 subbasin boundaries
2. Other Supply includes recycled water deliveries

# APPENDIX D: STREAM REACH BUDGETS

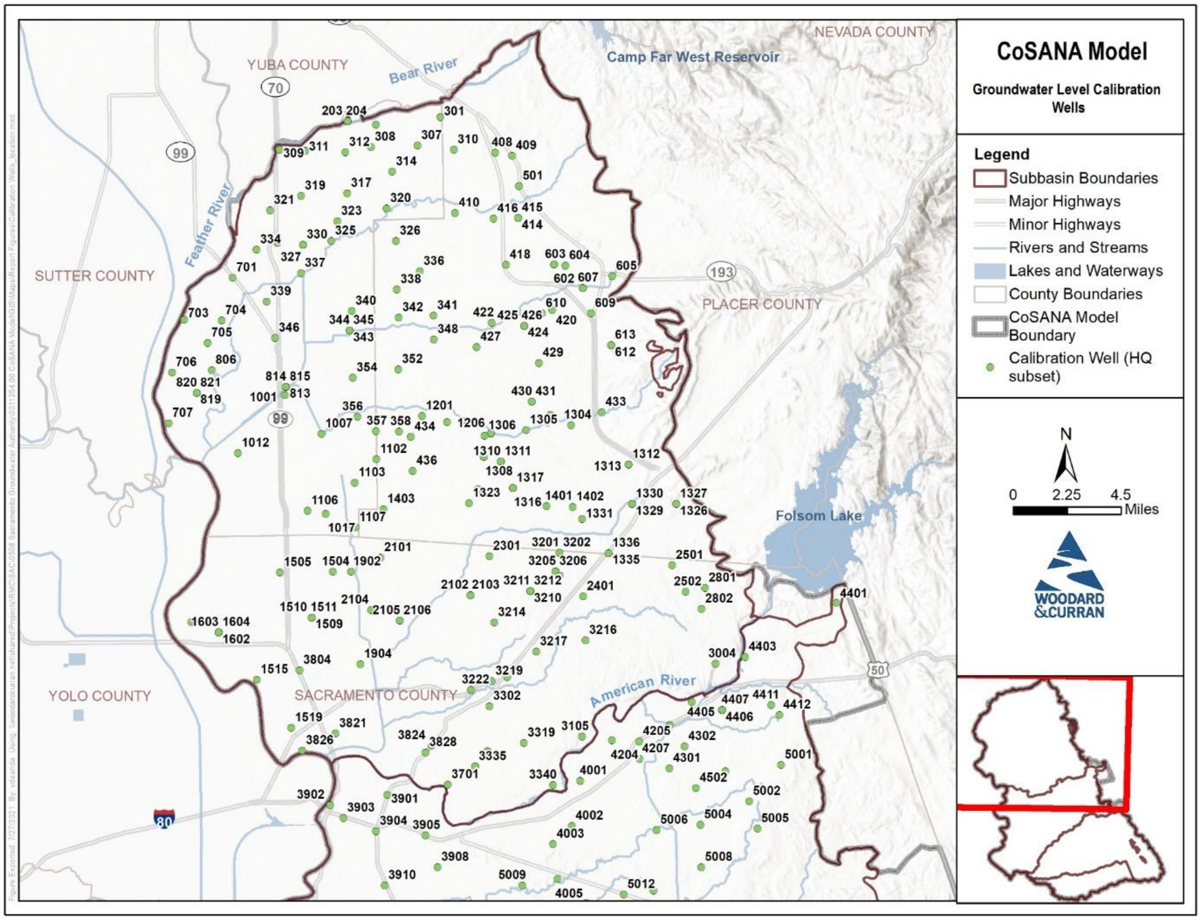
| Reach Number | Reach Description | Upstream Inflow (acre-feet) | Downstream Outflow (acre-feet) | Tributary Inflow (acre-feet) | Runoff (acre-feet) | Return Flow (acre-feet) | Gain from Groundwater (acre-feet) | Riparian ET (acre-feet) | Runoff (acre-feet) | Diversion Shortage (acre-feet) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Bear River | 325,762 | 362,711 | 1,587 | 15,179 | 3,535 | 16,654 | 0 | 0 | 0 |
| 2 | Feather River | 5,680,692 | 5,643,013 | 0 | 0 | 0 | -26,679 | 0 | 11,000 | 0 |
| 3 | Sacramento River Upstream Cross Canal | 14,471,419 | 14,512,137 | 0 | 31,663 | 8,137 | 15,455 | 0 | 14,528 | 0 |
| 4 | Racoon Creek (formerly Coon Creek) | 28,867 | 73,106 | 21,978 | 35,599 | 7,876 | -21,201 | 0 | 0 | 0 |
| 5 | East Side Canal I | 0 | 21,499 | 334 | 17,074 | 4,405 | -307 | 0 | 0 | 0 |
| 6 | Auburn Ravine | 19,365 | 26,950 | 0 | 13,451 | 3,115 | -7,449 | 0 | 1,528 | 1 |
| 7 | East Side Canal II | 48,450 | 47,304 | 0 | 0 | 0 | -1,146 | 0 | 0 | 0 |
| 8 | Pleasant Grove Creek | 28,846 | 76,604 | 386 | 38,745 | 12,405 | -3,773 | 0 | 0 | 0 |
| 9 | Pleasant Grove Creek Canal | 76,604 | 73,288 | 0 | 0 | 0 | -3,321 | 0 | 0 | 0 |
| 10 | Cross Canal 1 | 120,591 | 114,705 | 0 | 0 | 0 | -5,881 | 0 | 0 | 0 |
| 11 | Cross Canal 2 | 187,811 | 189,809 | 0 | 0 | 0 | 1,998 | 0 | 0 | 0 |
| 12 | Sacramento River Upstream Natomas East Drain | 14,701,946 | 14,624,027 | 0 | 0 | 0 | 6,551 | 0 | 84,471 | 0 |
| 13 | Natomas East Drain Upstream Dry Crk | 0 | 128,860 | 0 | 86,007 | 50,192 | -7,347 | 0 | 0 | 0 |
| 14 | Dry Creek (North American Subbasin) | 35,968 | 47,216 | 2,438 | 16,213 | 7,721 | -15,123 | 0 | 0 | 0 |
| 15 | Natomas East Drain Upstream Magpie Crk | 47,216 | 96,191 | 0 | 30,091 | 20,647 | -1,752 | 0 | 0 | 0 |
| 16 | Magpie Creek | 2,470 | 1,915 | 0 | 0 | 0 | -554 | 0 | 0 | 0 |
| 17 | Natomas East Drain Upstream Arcade Crk | 98,107 | 155,478 | 0 | 34,602 | 26,267 | -3,498 | 0 | 0 | 0 |
| 18 | Arcade Crk | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19 | Natomas East Drain Upstream Sacramento R. | 155,478 | 147,333 | 0 | 0 | 0 | -8,144 | 0 | 0 | 0 |
| 20 | Sacramento River Upstream American R. | 14,771,360 | 14,777,536 | 0 | 0 | 0 | 6,176 | 0 | 0 | 0 |
| 21 | Alder Creek | 0 | 3,728 | 999 | 0 | 0 | 2,729 | 0 | 0 | 0 |
| 22 | Buffalo Creek | 7,203 | 53,112 | 0 | 32,572 | 16,776 | -3,438 | 0 | 0 | 0 |
| 23 | American River Upstream Alder Crk | 2,747,286 | 2,754,396 | 409 | 0 | 0 | 6,700 | 0 | 0 | 0 |
| 24 | American River Upstream Buffalo Crk | 2,758,124 | 2,750,442 | 0 | 0 | 0 | -7,682 | 0 | 0 | 0 |
| 25 | American River Buffalo Crk to H St Bridge | 2,815,189 | 2,718,995 | 0 | 0 | 0 | -40,829 | 0 | 55,365 | 0 |
| 26 | American River Upstream Sacramento R. | 2,718,995 | 2,736,106 | 0 | 0 | 0 | 17,242 | 0 | 132 | 0 |
| 27 | Sacramento River Upstream Morrison Crk | 17,513,642 | 17,502,205 | 0 | 42,933 | 35,792 | -34,708 | 0 | 55,453 | 0 |
| 28 | Morrison Creek Upstream Elder Crk | 17,995 | 77,197 | 0 | 41,487 | 20,118 | -2,388 | 0 | 0 | 0 |
| 29 | Elder Creek | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 30 | Morrison Creek Upstream Beacon Crk | 77,197 | 74,208 | 0 | 0 | 0 | -2,989 | 0 | 0 | 0 |
| 31 | Beacon Creek | 0 | 57 | 0 | 0 | 0 | 57 | 0 | 0 | 0 |
| 32 | Morrison Creek Upstream Laguna Crk | 74,265 | 111,174 | 0 | 28,492 | 9,394 | -970 | 0 | 0 | 0 |
| 33 | Laguna Creek (South American Subbasin) | 8,342 | 2,940 | 0 | 0 | 0 | -5,402 | 0 | 0 | 0 |
| 34 | Morrison Creek Upstream Sacramento R. | 114,114 | 134,109 | 0 | 11,790 | 7,076 | 1,133 | 0 | 0 | 0 |
| 35 | Sacramento River Upstream Mokolumne Confluence | 17,636,315 | 17,649,814 | 0 | 38,822 | 12,907 | -38,209 | 0 | 0 | 0 |
| 36 | Deer Creek | 1,214 | 104,376 | 87,005 | 23,491 | 2,701 | -9,833 | 0 | 197 | 6 |
| 37 | Cosumnes River Upstream Deer Crk | 397,070 | 409,057 | 0 | 25,669 | 3,406 | -8,031 | 1,239 | 7,818 | 197 |
| 38 | Cosumnes River Upstream Badger Crk | 513,433 | 505,527 | 0 | 662 | 182 | -7,340 | 640 | 769 | 0 |
| 39 | Badger Creek | 0 | 6,524 | 0 | 6,425 | 486 | 199 | 579 | 0 | 45 |
| 40 | Cosumnes River Upstream Laguna Crk | 512,051 | 522,840 | 0 | 17,105 | 1,617 | -7,584 | 340 | 4 | 0 |
| 41 | Laguna Creek (Cosumnes Subbasin) | 21,012 | 96,118 | 17,138 | 52,214 | 7,685 | 1,003 | 1,544 | 1,388 | 0 |
| 42 | Cosumnes River Upstream Mokolumne R. | 618,958 | 617,231 | 0 | 8,449 | 2,085 | -10,375 | 1,817 | 68 | 0 |
| 43 | Dry Creek Upstream Jackson Crk | 30,040 | 53,117 | 0 | 19,708 | 1,448 | 4,570 | 0 | 2,649 | 75 |
| 44 | Jackson Creek | 30,295 | 36,670 | 804 | 0 | 0 | 5,570 | 0 | 0 | 0 |
| 45 | Dry Creek Upstream Mokolumne R. | 89,787 | 119,068 | 0 | 46,628 | 6,563 | -18,302 | 1,614 | 3,955 | 505 |
| 46 | Mokolumne River Upstream Dry Crk | 569,130 | 534,845 | 0 | 5,415 | 1,306 | -41,001 | 0 | 0 | 0 |
| 47 | Mokolumne River Upstream Cosumnes R. | 653,913 | 649,754 | 0 | 0 | 0 | -3,591 | 281 | 290 | 0 |
| 48 | Mokolumne River Upstream Sacramento R. Confluence | 1,266,985 | 1,278,877 | 0 | 0 | 0 | 11,894 | 0 | 0 | 0 |
| 49 | Folsom South Canal (North of Cosumnes R.) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 50 | Folsom South Canal (South of Cosumnes R.) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 51 | Hadselville Creek | 12,039 | 11,985 | 0 | 0 | 0 | -27 | 27 | 0 | 0 |

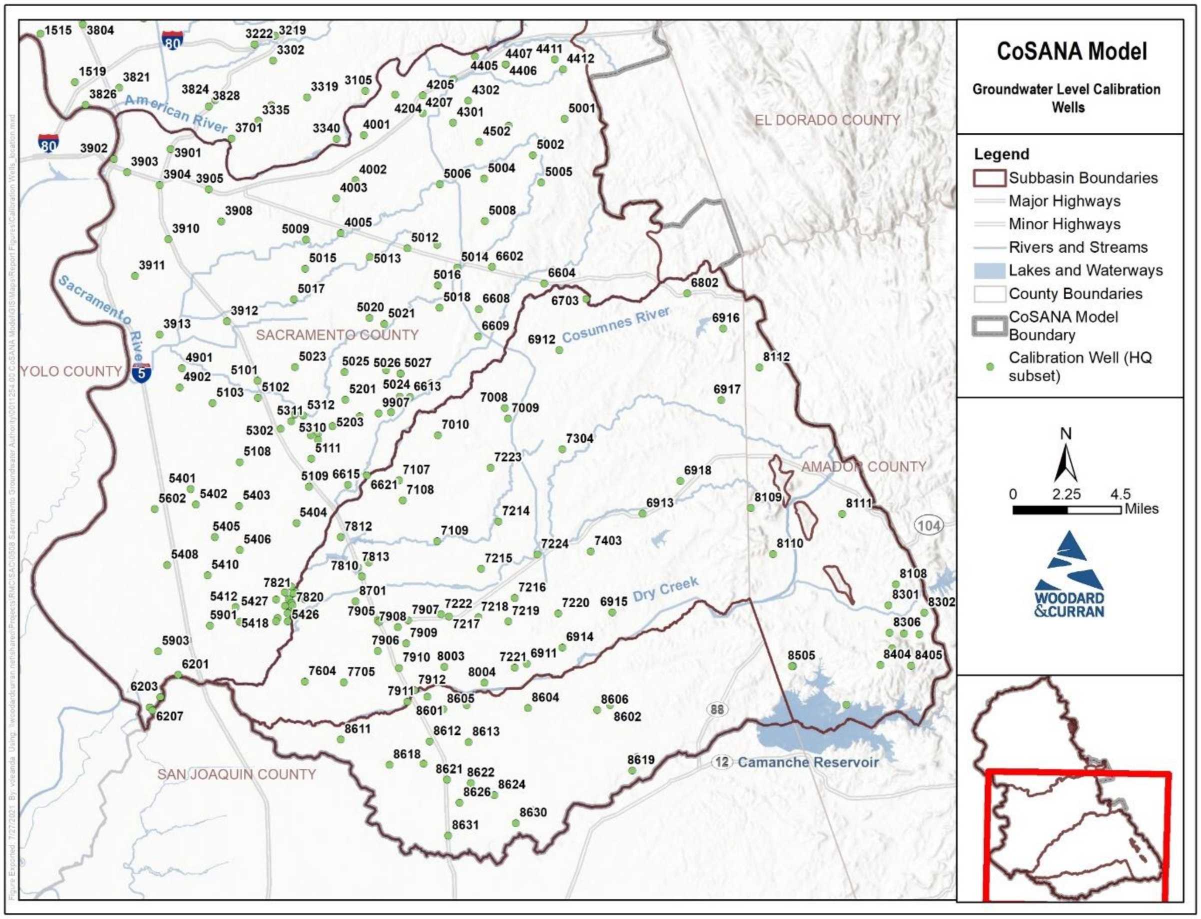
# APPENDIX E: SUBREGION GROUNDWATER BUDGETS

| Historical Groundwater Budget Summary, Annual Average for WY 1995 - 2018 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Subregion** | **Description** | **Deep Percolation** | **Gain from Stream** | **Recharge (Recoverable Loss)** | **Boundary Inflow** | **Net Subsurface Inflow** | **Pumping** |
| | | *(Acre-Feet)* | *(Acre-Feet)* | *(Acre-Feet)* | *(Acre-Feet)* | *(Acre-Feet)* | *(Acre-Feet)* |
| | ***North American Subbasin*** | | | | | | |
| 1 | Camp Far West ID | 6,135 | -5,792 | 699 | 2,385 | 1,193 | 4,622 |
| 2 | Sutter Co. 1 | 309 | 19 | 0 | 1,042 | -723 | 644 |
| 3 | South Sutter WD GSA | 53,729 | 24,620 | 11,265 | 3,832 | 12,707 | 105,258 |
| 4 | Placer County WA | 32,625 | 3,435 | 1,186 | 1,469 | -4,129 | 26,874 |
| 5 | Nevada ID | 7,990 | 850 | 1,616 | 4,455 | -8,249 | 6,426 |
| 6 | Lincoln | 6,143 | 933 | 0 | 505 | -1,859 | 1,866 |
| 7 | RD1001 | 15,990 | 3,411 | 1,148 | 741 | -1,978 | 19,204 |
| 8 | Pleasant Grove Verona MWC | 5,444 | 2,754 | 1,516 | 0 | 2,447 | 12,081 |
| 9 | Sutter Co. 2 | 1,438 | -2,571 | 140 | 1,429 | 1,889 | 2,318 |
| 10 | Natomas MWC (Sutter Co.) | 7,966 | 5,839 | 306 | 72 | -10,265 | 3,933 |
| 11 | Sutter Co. 3 | 3,321 | 938 | 0 | 0 | 5,114 | 9,441 |
| 12 | Roseville SOI | 1,287 | 1,178 | 0 | 0 | 1,043 | 3,141 |
| 13 | City of Roseville | 5,768 | 6,041 | 145 | 2,486 | -8,724 | 749 |
| 14 | Cal Am (West Placer) | 4,747 | 4,279 | 0 | 0 | -1,597 | 6,465 |
| 15 | Natomas MWC (Sacramento Co.) | 11,773 | -3,535 | 514 | 4,246 | -8,920 | 3,477 |
| 16 | Sacramento International Airport | 1,060 | 0 | 0 | 0 | 982 | 1,862 |
| 17 | Metro Air Park | 878 | 0 | 0 | 0 | 745 | 1,468 |
| 18 | Sac Co. 1 | 964 | -2,655 | 0 | 4,068 | -1,619 | 704 |
| 19 | Sac Co. 2 | 1,336 | 2,281 | 0 | 0 | -242 | 3,286 |
| 20 | Sac County WA (Northgate 880) | 77 | 603 | 0 | 0 | 238 | 846 |
| 21 | Rio Linda Elverta | 2,156 | 5,736 | 0 | 0 | 2,732 | 9,840 |
| 22 | Sac Co. 3 | 231 | 793 | 0 | 0 | -356 | 584 |
| 23 | Cal Am (Antelope) | 618 | 663 | 0 | 0 | 4,262 | 5,134 |
| 24 | Cal Am (Lincoln Oaks) | 618 | 0 | 0 | 0 | 8,459 | 8,402 |
| 25 | Citrus Heights WD | 1,760 | 0 | 0 | 476 | -292 | 1,680 |
| 26 | San Juan WD (Placer Co.) | 434 | 0 | 0 | 1,159 | -1,751 | 18 |
| 27 | San Juan WD (Sacramento Co.) | 649 | -488 | 0 | 811 | -931 | 246 |
| 28 | Orange Vale WC | 1,338 | 0 | 0 | 0 | -1,018 | 618 |
| 29 | Lake Natoma/Mississippi Bar | 1,516 | -4,959 | 0 | 30 | 3,461 | 35 |
| 30 | Fair Oaks WD | 2,910 | 5,159 | 0 | 0 | -5,449 | 2,877 |
| 31 | Carmichael WD | 1,165 | 6,118 | 0 | 0 | -1,996 | 4,906 |
| 32 | Sacramento Suburban WD (North) | 2,802 | 53 | 0 | 0 | 16,599 | 17,456 |
| 33 | Sacramento Suburuban WD (South) | 954 | 7,379 | 0 | 0 | 9,721 | 17,166 |
| 34 | Del Paso Manor WD | 84 | 0 | 0 | 0 | 1,550 | 1,549 |
| 35 | Golden State WC Arden | 45 | 0 | 0 | 0 | 956 | 931 |
| 36 | Cal Am (Arden) | 481 | 0 | 0 | 0 | 1,492 | 1,901 |
| 37 | Sac County WA (Arden Park | 237 | 991 | 0 | 0 | 1,819 | 2,896 |
| 38 | City of Sacramento (North) | 4,793 | 19,148 | 0 | 1,130 | 1,947 | 25,074 |
| | ***Total NASb*** | 191,772 | 83,222 | 18,535 | 30,336 | 19,257 | 315,980 |
| | ***South American Subbasin*** | | | | | | |
| 39 | City of Sacramento (South) | 16,041 | 15,444 | 0 | 1,403 | -28,141 | 3,252 |
| 40 | Cal Am (Suburban Rosemont) | 1,950 | 7,140 | 0 | 0 | 4,865 | 13,511 |
| 41 | Sac Co. 4 | 301 | 2,827 | 0 | 0 | -3,093 | 29 |
| 42 | Golden State WC (Cordova) | 6,644 | 14,347 | 0 | 0 | -7,641 | 13,361 |
| 43 | Sac Co. 5 | 1,939 | 0 | 0 | 0 | 5,527 | 7,351 |
| 44 | City of Folsom | 17,068 | -2,544 | 0 | 2,135 | -10,936 | 3,171 |
| 45 | Cal Am (Security Park) | 1,608 | 37 | 0 | 0 | -1,613 | 79 |
| 46 | Fruitridge Vista WC | 306 | 235 | 0 | 0 | 3,194 | 3,621 |
| 47 | Florin County WD | 158 | 0 | 0 | 0 | 2,209 | 2,315 |
| 48 | Cal Am (Parkway) | 857 | 303 | 0 | 0 | 9,845 | 10,762 |
| 49 | Sac Co. 6 | 1,228 | 3,807 | 0 | 228 | -4,544 | 655 |
| 50 | Sac County WA (North/Central) | 18,508 | 3,649 | 207 | 0 | 8,510 | 32,290 |
| 51 | Sac County WA (South) | 5,692 | 203 | 0 | 0 | 14,360 | 19,306 |
| 52 | Elk Grove WD (2 - Intertie Service Area) | 1,525 | 1,066 | 0 | 0 | 1,132 | 3,758 |
| 53 | Elk Grove WD (1 - GW Service Area) | 493 | 632 | 0 | 0 | 6,665 | 7,568 |
| 54 | Cosumnes River West | 23,325 | 11,899 | 0 | 0 | 21,878 | 56,028 |
| 55 | RD744 | 885 | 6,948 | 0 | -718 | -6,346 | 762 |
| 56 | Franklin Drainage District | 3,383 | 6,324 | 0 | -205 | -6,030 | 3,365 |
| 57 | RD813 | 1,648 | 3,037 | 0 | -91 | -3,265 | 1,320 |
| 58 | RD755 | 549 | 1,415 | 0 | -249 | -1,180 | 535 |
| 59 | RD1002 | 3,199 | 0 | 0 | 0 | -115 | 3,055 |
| 60 | RD551 | 8,934 | 6,259 | 0 | -1,397 | -7,491 | 6,307 |
| 61 | RD369 | 441 | 2,023 | 0 | -201 | -2,110 | 153 |
| 62 | RD2110 | 865 | -745 | 0 | 516 | -197 | 437 |
| 63 | Sac Co. 7 | 407 | 1,342 | 0 | 29 | -1,507 | 270 |
| 64 | Rancho Murieta (North) | 5,053 | -1,984 | 0 | 0 | -1,382 | 893 |
| 65 | Sloughouse RCD (North) | 4,971 | 93 | 0 | 2,791 | -5,805 | 1,874 |
| 66 | OHWD (Sth American Subbasin) | 11,701 | 15,439 | 15 | 64 | -969 | 25,837 |
| | ***Total SASb*** | 139,681 | 99,195 | 222 | 4,307 | -14,179 | 221,865 |
| | ***Cosumnes Subbasin*** | | | | | | |
| 67 | OHWD (Cosumnes Subbasin) | 5,590 | 5,181 | 0 | 0 | -4,272 | 6,255 |
| 68 | Rancho Murieta (South) | 1,070 | -1,843 | 0 | 0 | 768 | 6 |
| 69 | Sloughouse RCD (East) | 22,178 | 3,548 | 0 | 1,116 | -9,591 | 19,922 |
| 70 | Wilton | 4,641 | 45 | 0 | 0 | 3,051 | 7,953 |
| 71 | Sloughouse RCD (West) | 4,099 | 381 | 0 | 0 | 5,687 | 10,570 |
| 72 | Galt ID (East) | 20,192 | 1,970 | 0 | 0 | 23,121 | 47,606 |
| 73 | Clay WD | 3,514 | 1,115 | 0 | 0 | 629 | 5,634 |
| 74 | Clay | 1,051 | 3 | 0 | 0 | 733 | 2,084 |
| 75 | SMUD Rancho Seco | 473 | 0 | 0 | 0 | -666 | 7 |
| 76 | Cosumnes River South | 4,860 | 9,984 | 0 | -523 | -5,018 | 9,159 |
| 77 | Galt ID (West) | 2,736 | 776 | 0 | 0 | 2,631 | 6,062 |
| 78 | Sac Co. 8 | 4,301 | 8,367 | 0 | 0 | -7,323 | 5,289 |
| 79 | City of Galt | 1,744 | 668 | 0 | 0 | 2,623 | 5,099 |
| 80 | Sloughouse RCD (South) | 1,225 | 993 | 0 | 0 | 224 | 2,474 |
| 81 | Amador Co. 1 | 13,266 | -5,448 | 0 | 3,367 | -8,492 | 1,259 |
| 82 | Ione | 1,513 | 0 | 0 | 0 | -602 | 425 |
| 83 | Jackson ID | 8,648 | -6,775 | 0 | 507 | -2,429 | 0 |
| 84 | Camanche | 5,130 | 0 | 0 | -4,621 | -1,420 | 81 |
| 85 | Amador County WA | 1,477 | 0 | 0 | 5 | -1,559 | 176 |
| 87 | Galt WWTP | 344 | 0 | 0 | 0 | -352 | 0 |
| | ***Total CoSb*** | 108,054 | 18,964 | 0 | -149 | -2,255 | 130,062 |
| | ***Other*** | | | | | | |
| 86 | Mokelumne | 29,317 | 49,564 | 0 | 3,650 | -2,823 | 83,278 |
| | ***Total Other*** | 29,317 | 49,564 | 0 | 3,650 | -2,823 | 83,278 |
| ***CoSANA Total (NASb, SASb, CoSb)*** | | 439,507 | 201,381 | 18,757 | 34,495 | 2,823 | 667,907 |

# APPENDIX F: CALIBRATION HYDROGRAPHS

***Note:*** *hydrographs developed for this appendix use a transmissivity-weighted average of layers 2 through 5 for simulated groundwater heads.*




CoSANA Model
Groundwater Level Calibration Wells
Legend
Subbasin Boundaries
Major Highways
Minor Highways
Rivers and Streams
Lakes and Waterways
County Boundaries
CoSANA Model Boundary
Calibration Well (HQ subset)
N
0
2.25
4.5
Miles
WOODARD & CURRAN
EL DORADO COUNTY
SACRAMENTO COUNTY
YOLO COUNTY
AMADOR COUNTY
SAN JOAQUIN COUNTY
American River
Sacramento River
Cosumnes River
Dry Creek
Camanche Reservoir
80
5
104
88
12
1515
3804
3222
3219
3302
1519
3821
3826
3824
3828
3319
3105
3335
3701
3340
4001
3902
3903
3901
3904
3905
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3911
3912
3913
4002
4003
4005
4205
4204
4207
4302
4301
4405
4407
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4406
4412
4502
4901
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5014
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5016
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5111
5201
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7604
7705
7810
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7911
7912
8003
8004
8108
8109
8110
8111
8112
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8622
8624
8626
8630
8631
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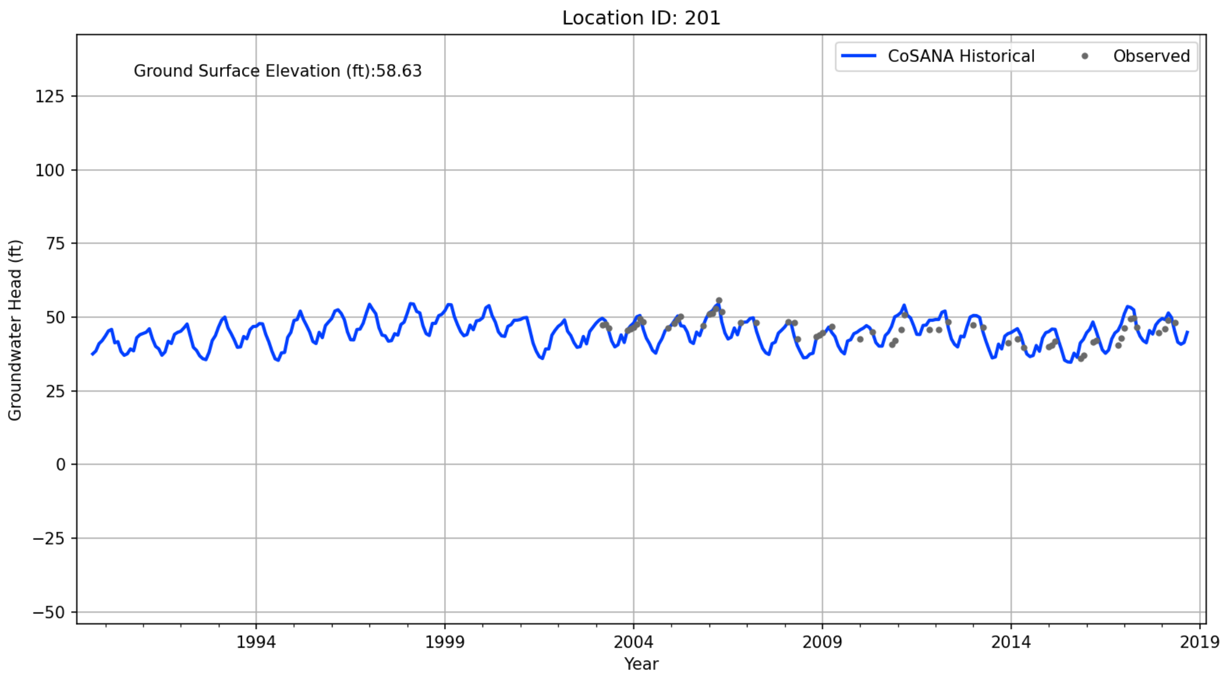
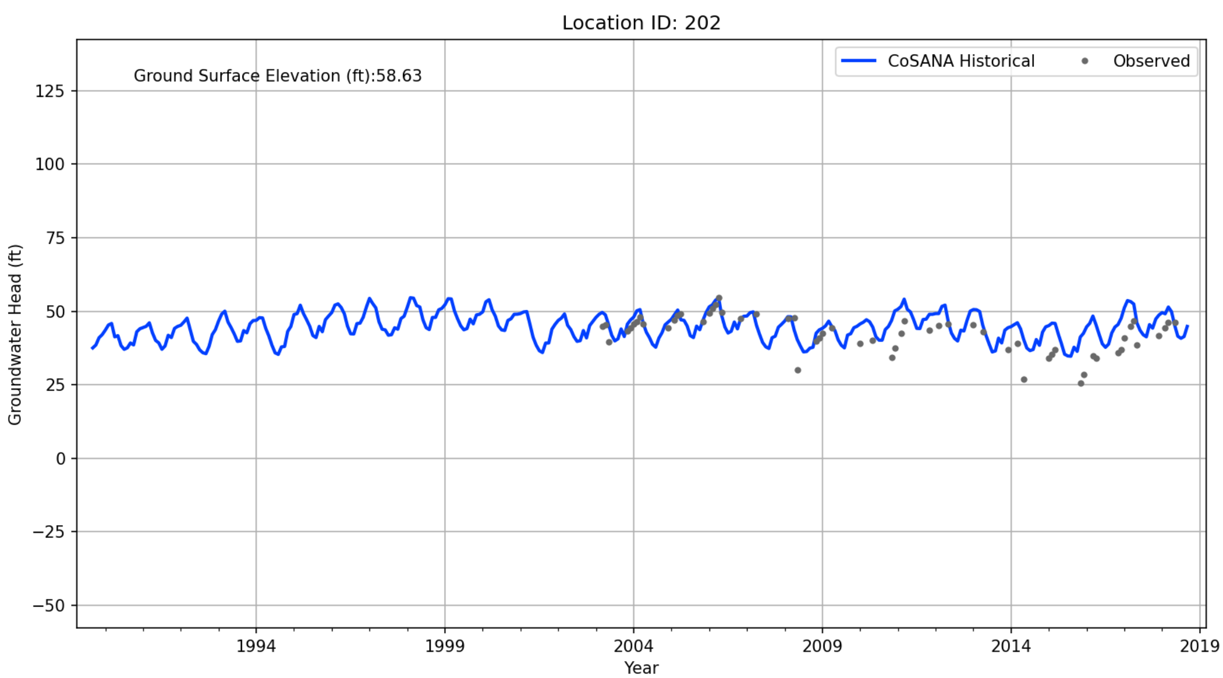
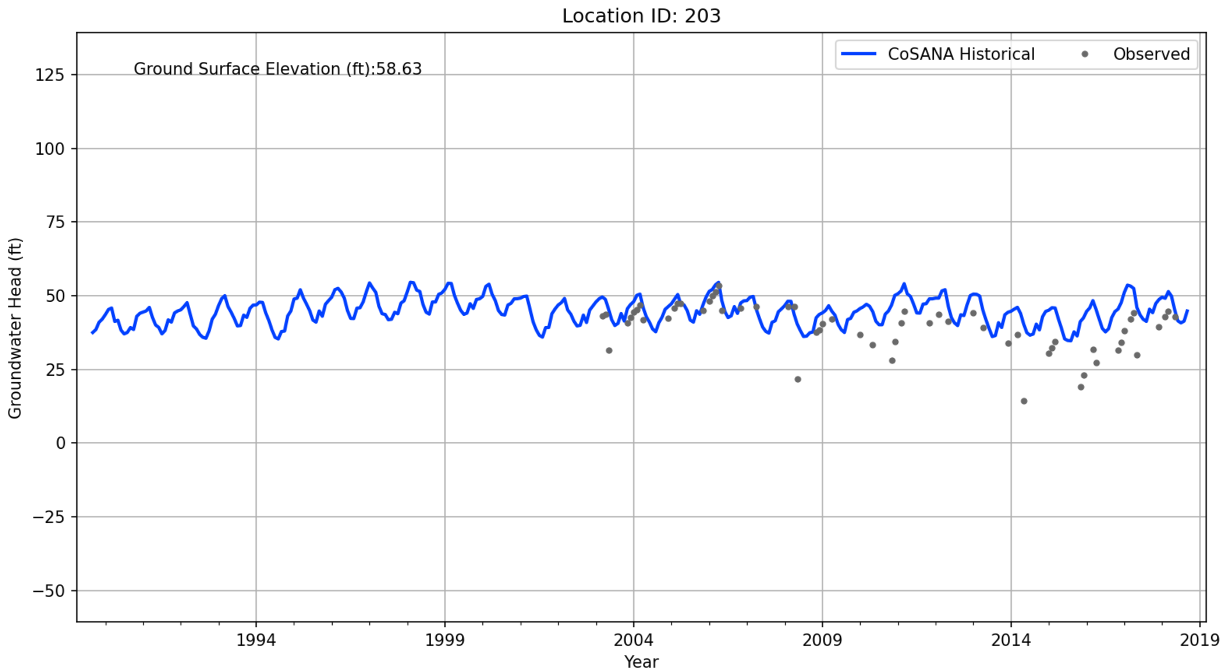
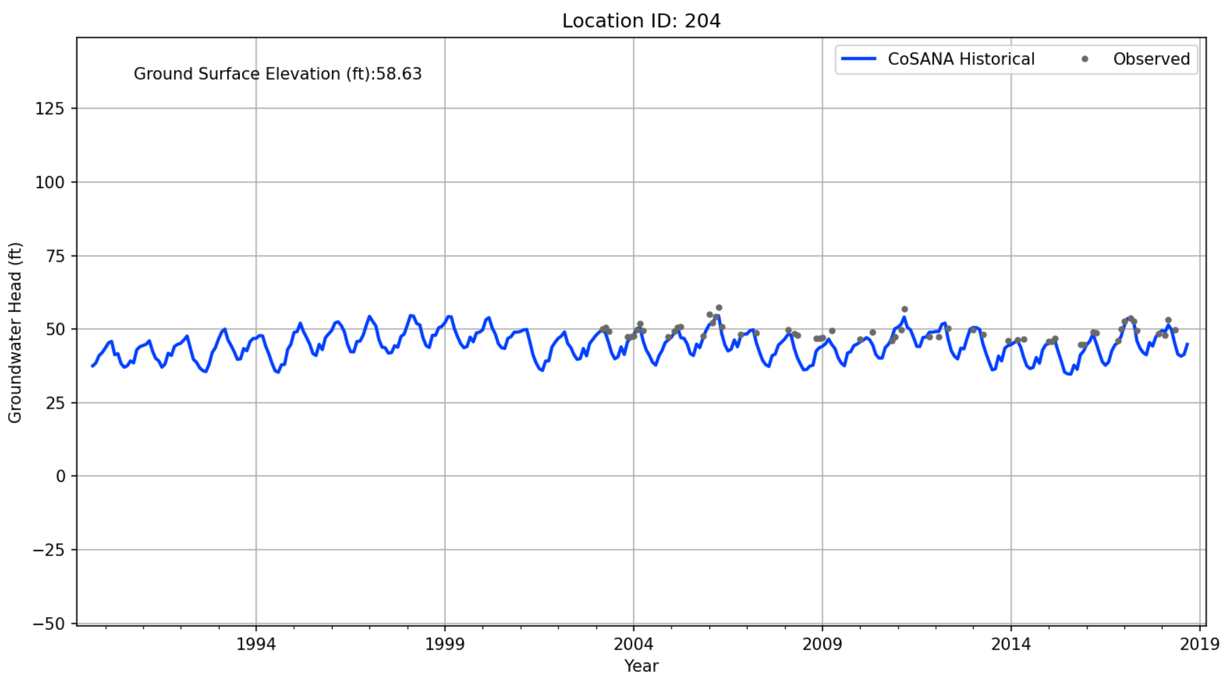
9907


Location ID: 201
Ground Surface Elevation (ft):58.63
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year


Location ID: 202
Ground Surface Elevation (ft):58.63
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year


Location ID: 203
CoSANA Historical
Observed
Ground Surface Elevation (ft):58.63
Groundwater Head (ft)
Year
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019


Location ID: 204
CoSANA Historical
Observed
Ground Surface Elevation (ft):58.63
Groundwater Head (ft)
Year
125
100
75
50
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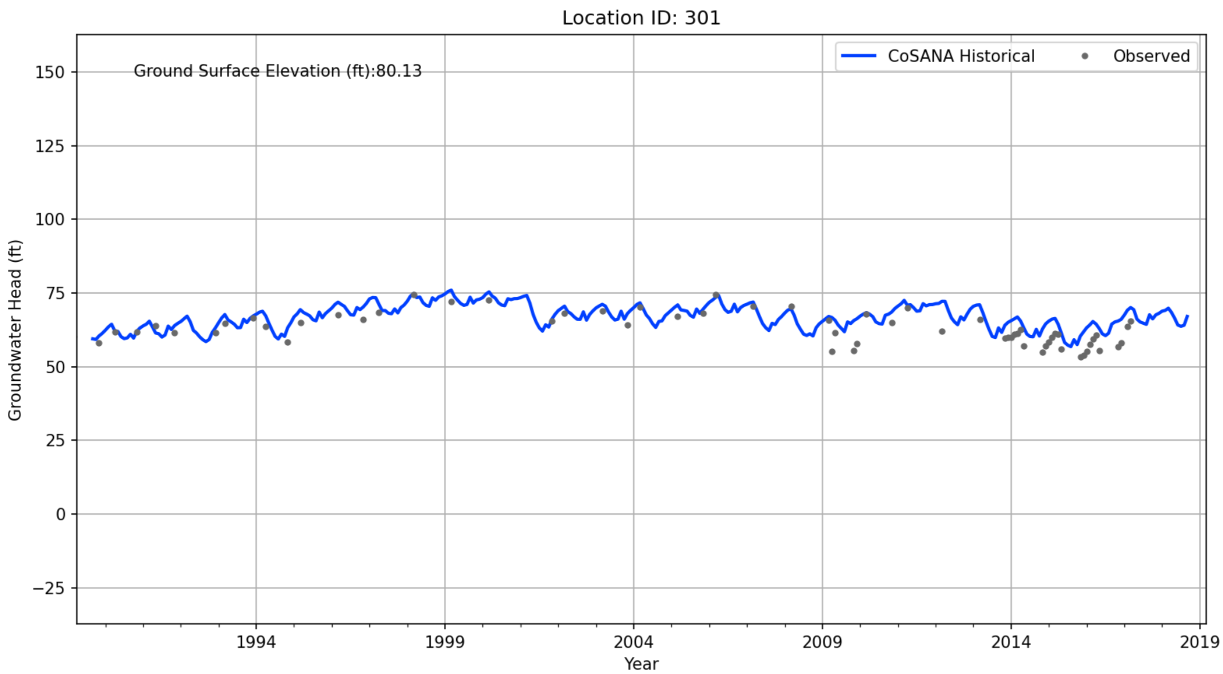
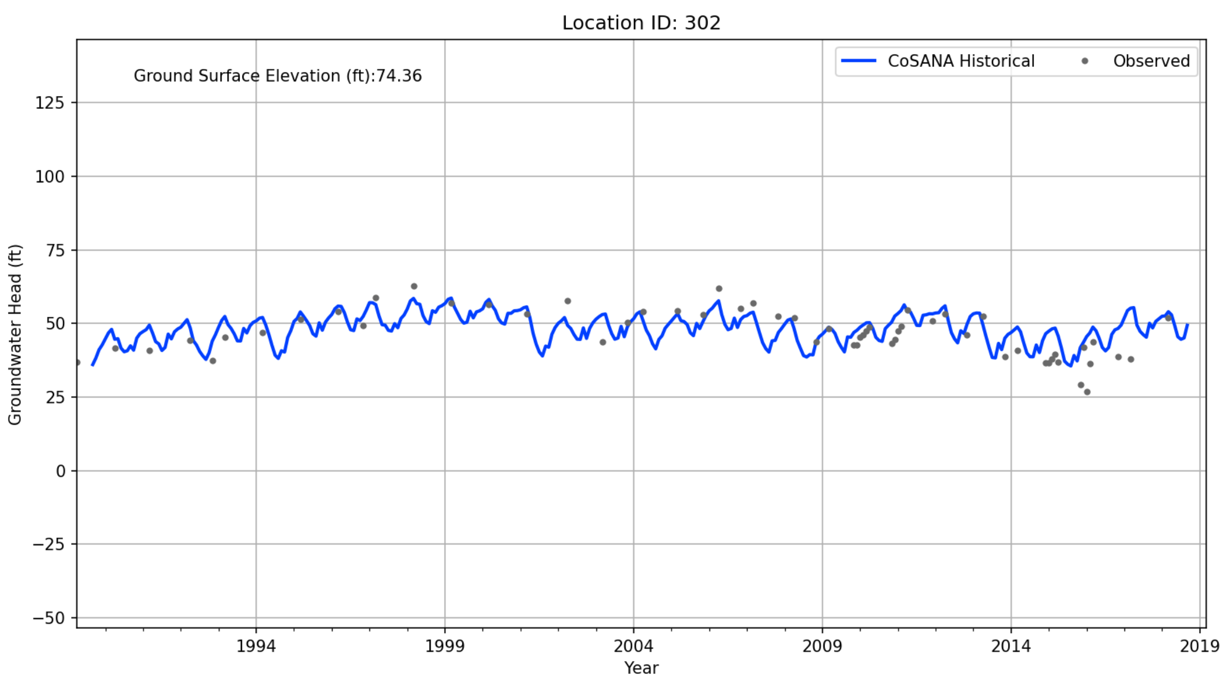
−25
−50
1994
1999
2004
2009
2014
2019


Location ID: 301
CoSANA Historical
Observed
Ground Surface Elevation (ft):80.13
Groundwater Head (ft)
Year
150
125
100
75
50
25
0
−25
1994
1999
2004
2009
2014
2019


Location ID: 302
CoSANA Historical
Observed
Ground Surface Elevation (ft):74.36
Groundwater Head (ft)
Year
125
100
75
50
25
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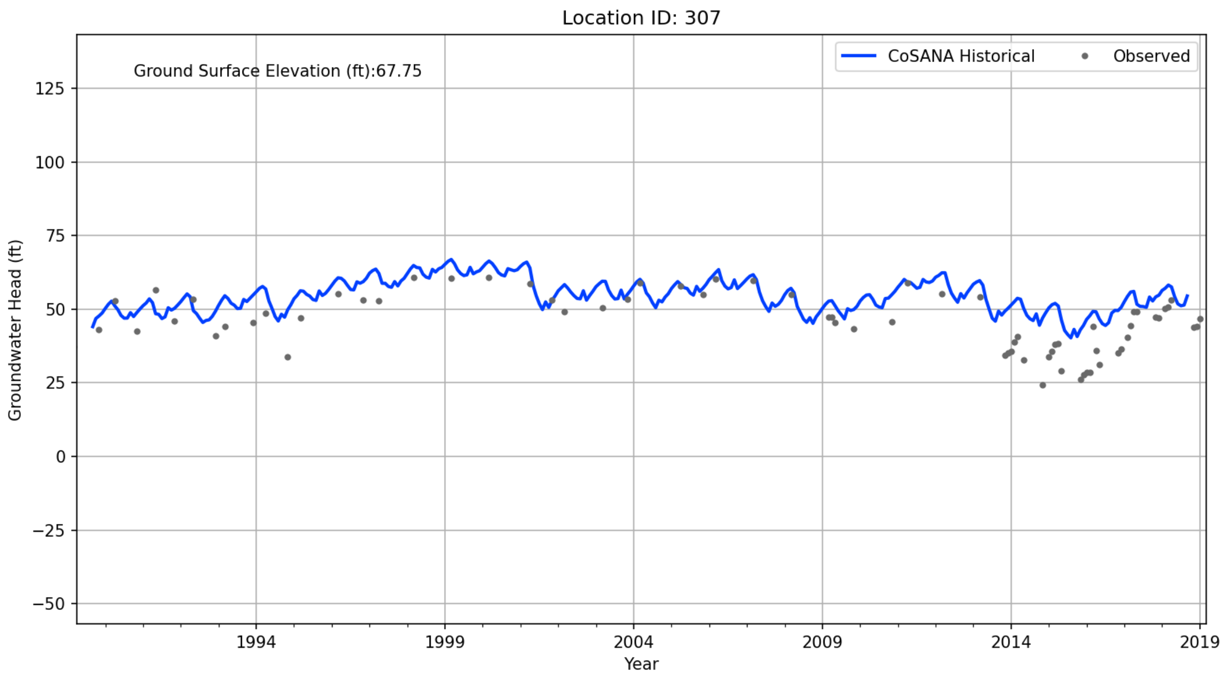
−25
−50
1994
1999
2004
2009
2014
2019


Location ID: 307
CoSANA Historical
Observed
Ground Surface Elevation (ft):67.75
Groundwater Head (ft)
125
100
75
50
25
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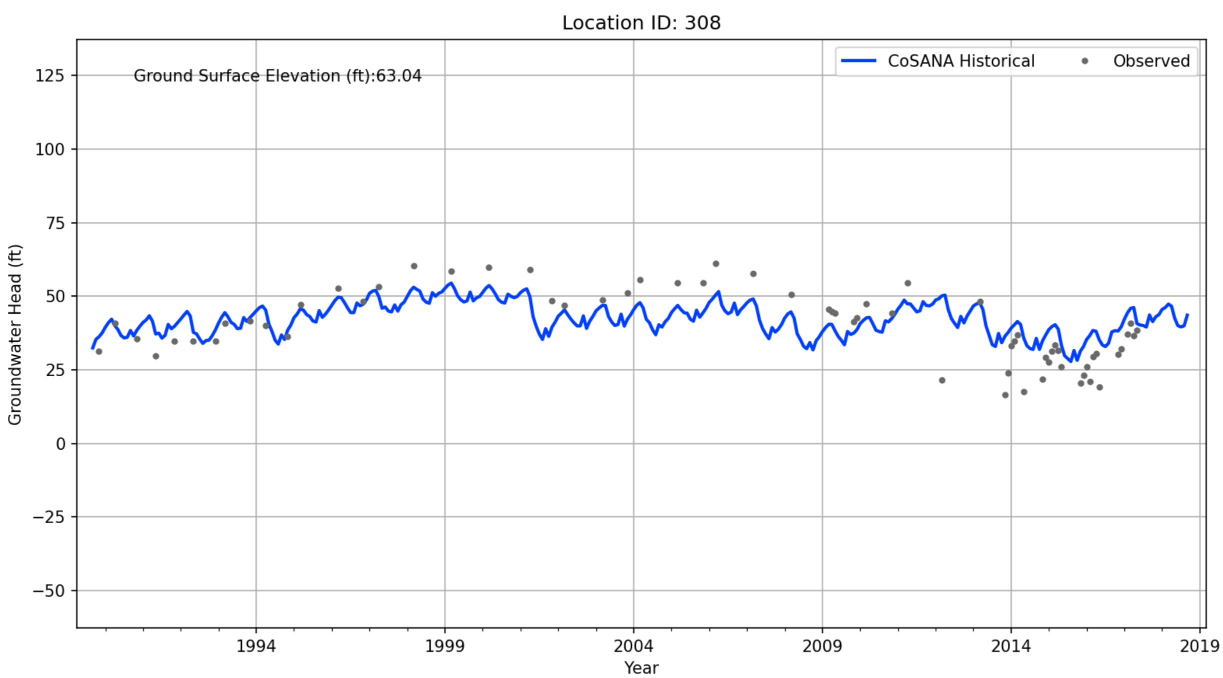
−25
−50
1994
1999
2004
2009
2014
2019
Year


Location ID: 308
CoSANA Historical
Observed
Ground Surface Elevation (ft):63.04
Groundwater Head (ft)
125
100
75
50
25
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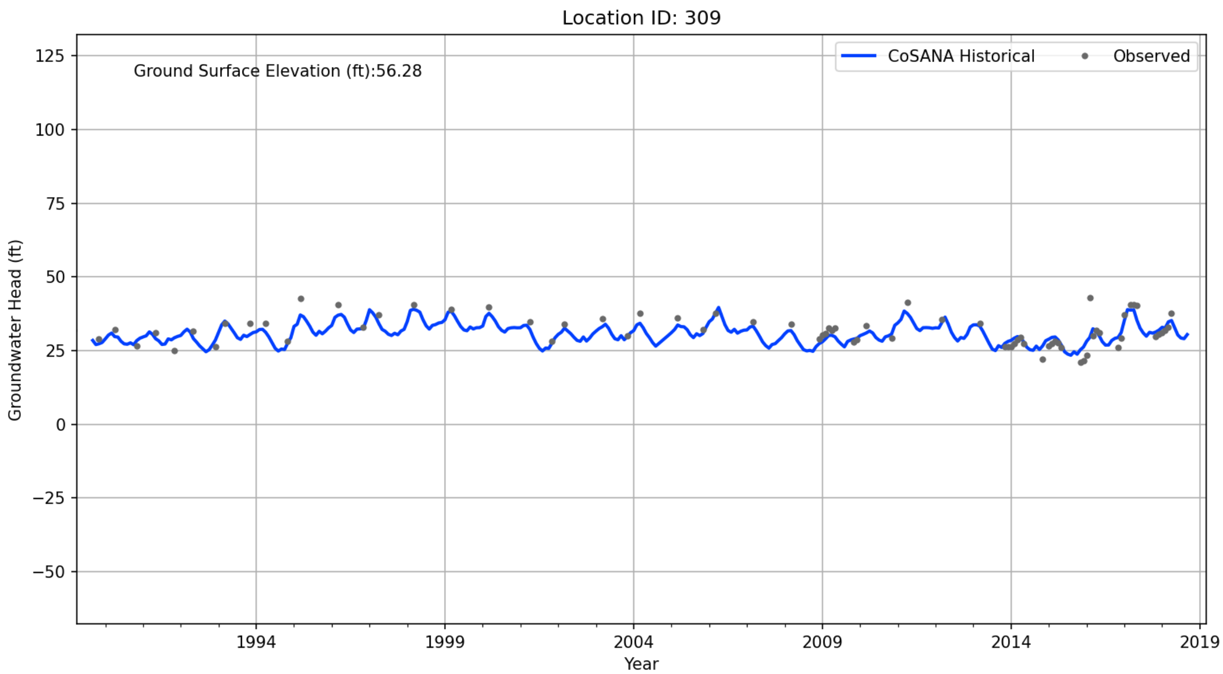
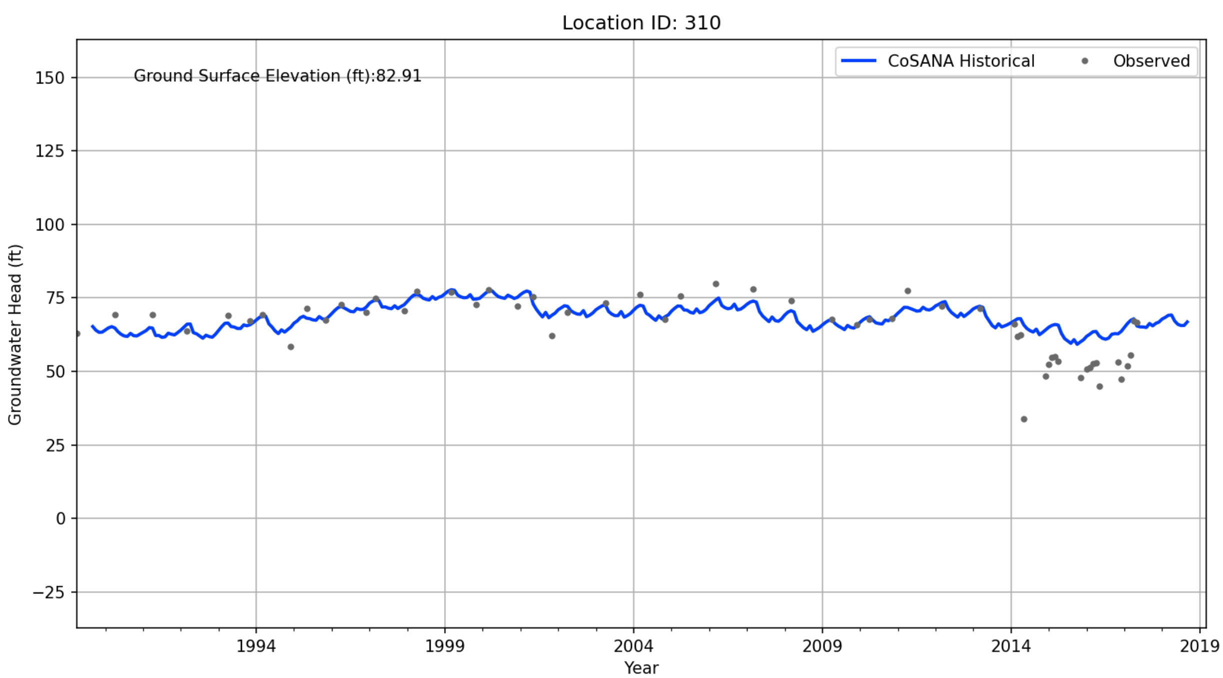
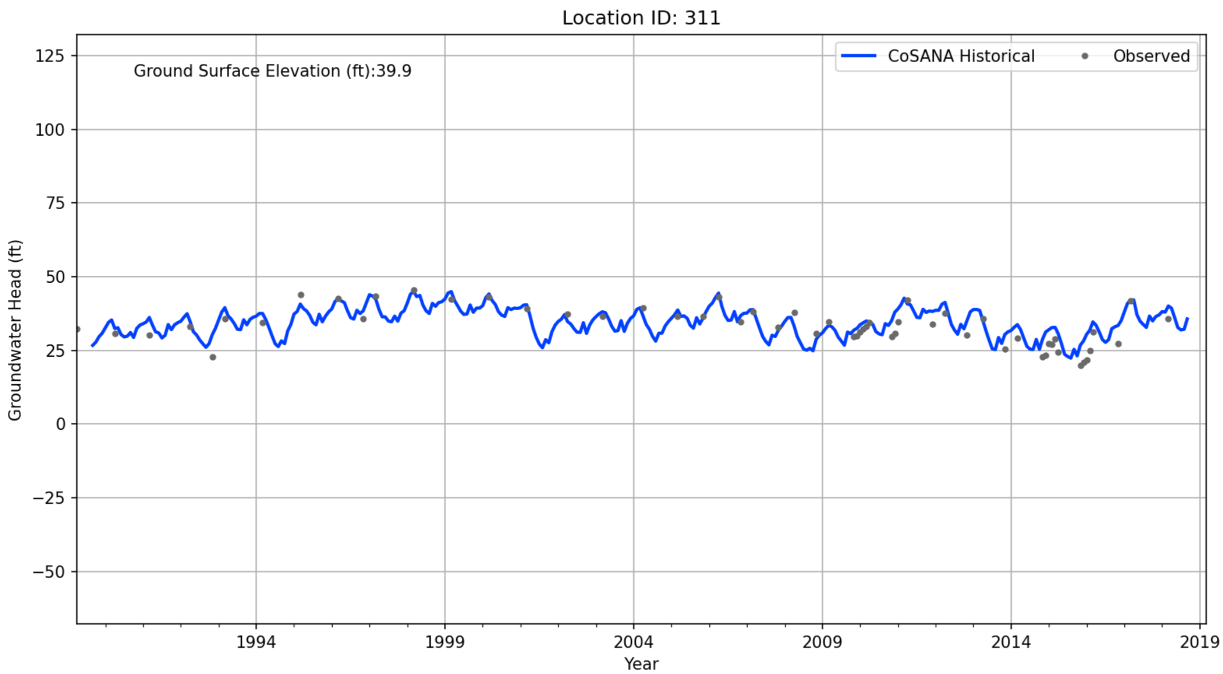
−25
−50
1994
1999
2004
2009
2014
2019
Year

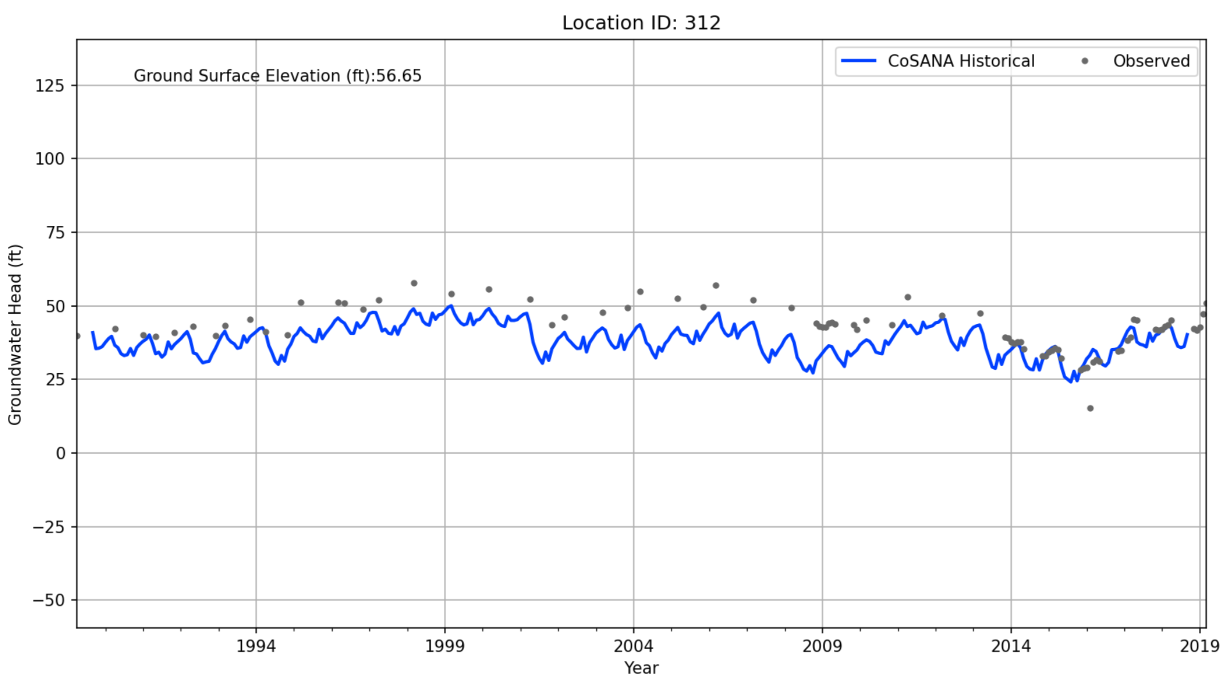


Location ID: 309
Ground Surface Elevation (ft):56.28
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

Location ID: 310
Ground Surface Elevation (ft):82.91
CoSANA Historical
Observed
Groundwater Head (ft)
150
125
100
75
50
25
0
−25
1994
1999
2004
2009
2014
2019
Year


Location ID: 311
Ground Surface Elevation (ft):39.9
CoSANA Historical
Observed
Groundwater Head (ft)
Year
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019


Location ID: 312
Ground Surface Elevation (ft):56.65
CoSANA Historical
Observed
Groundwater Head (ft)
Year
125
100
75
50
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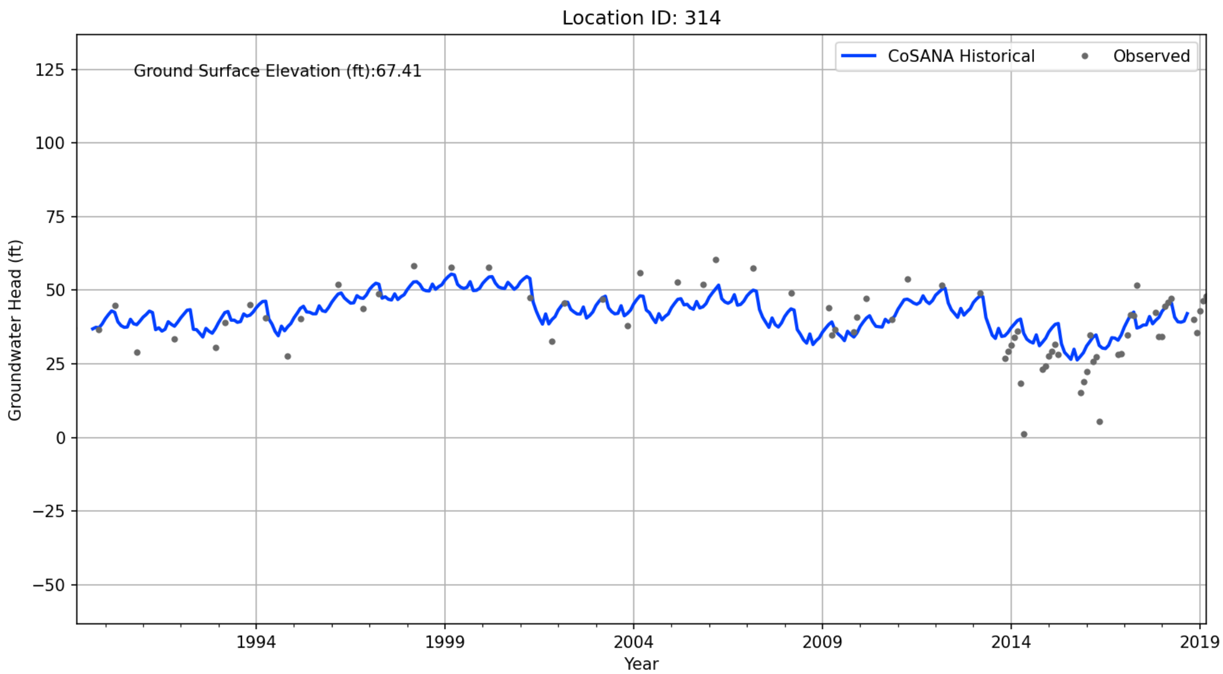
−25
−50
1994
1999
2004
2009
2014
2019


Location ID: 314
Ground Surface Elevation (ft):67.41
CoSANA Historical
Observed
Groundwater Head (ft)
Year
125
100
75
50
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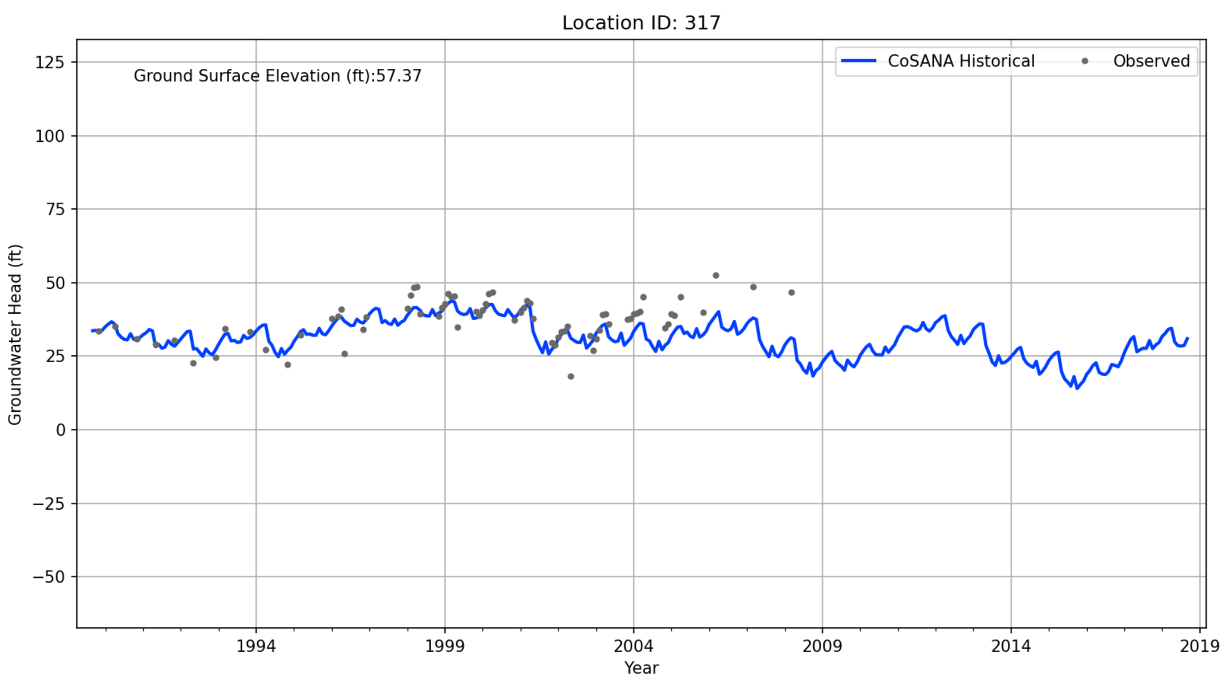
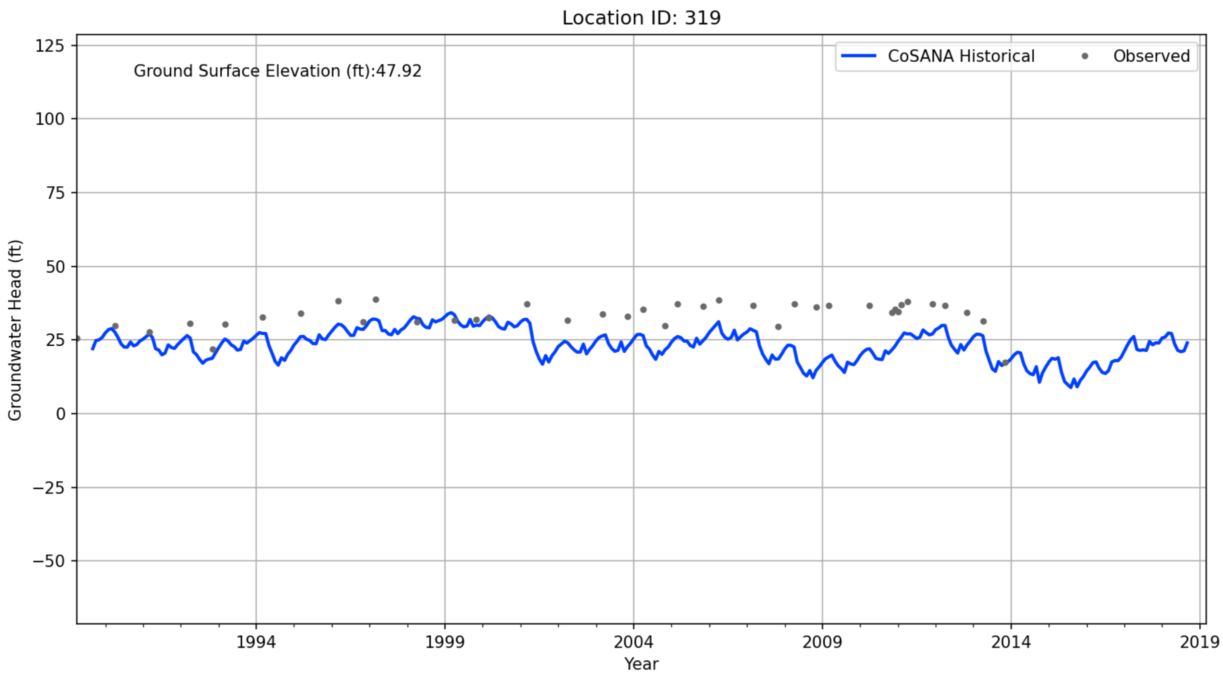
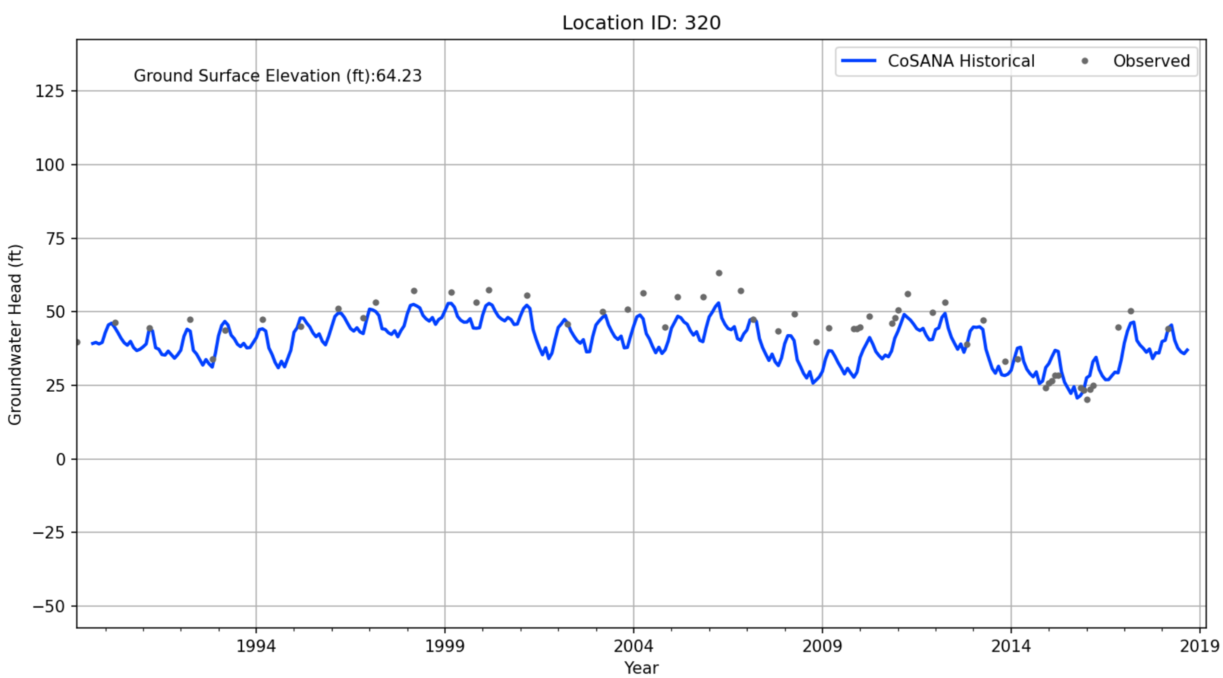
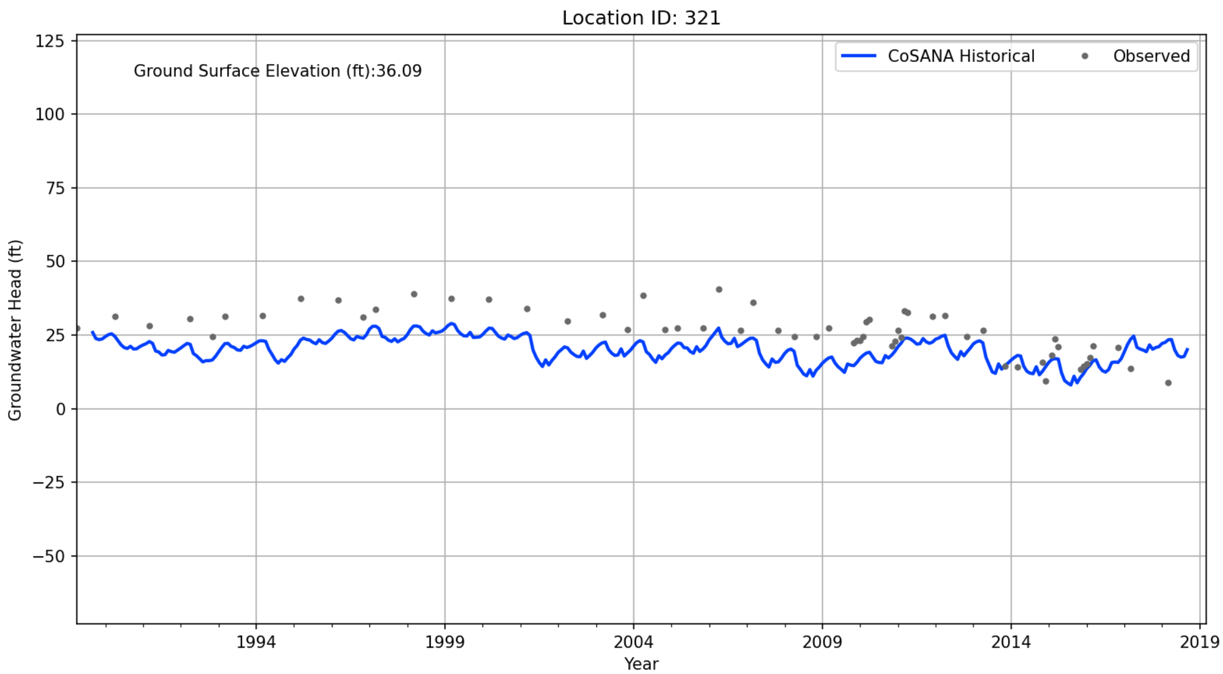
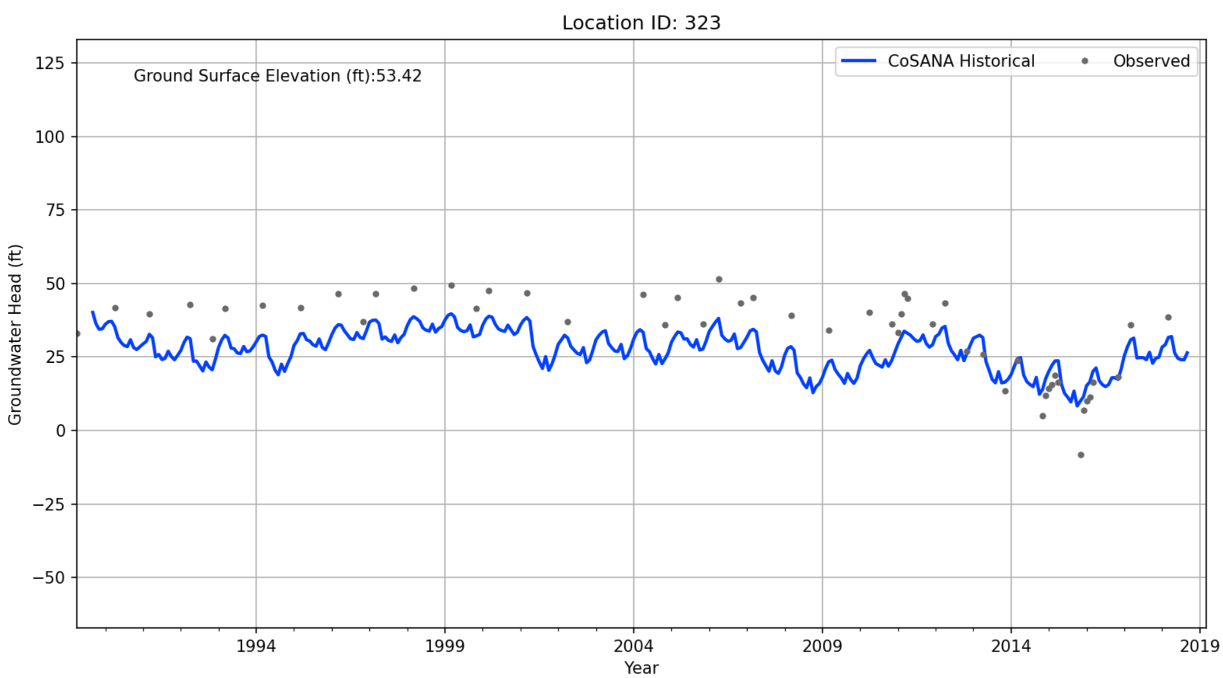
−25
−50
1994
1999
2004
2009
2014
2019

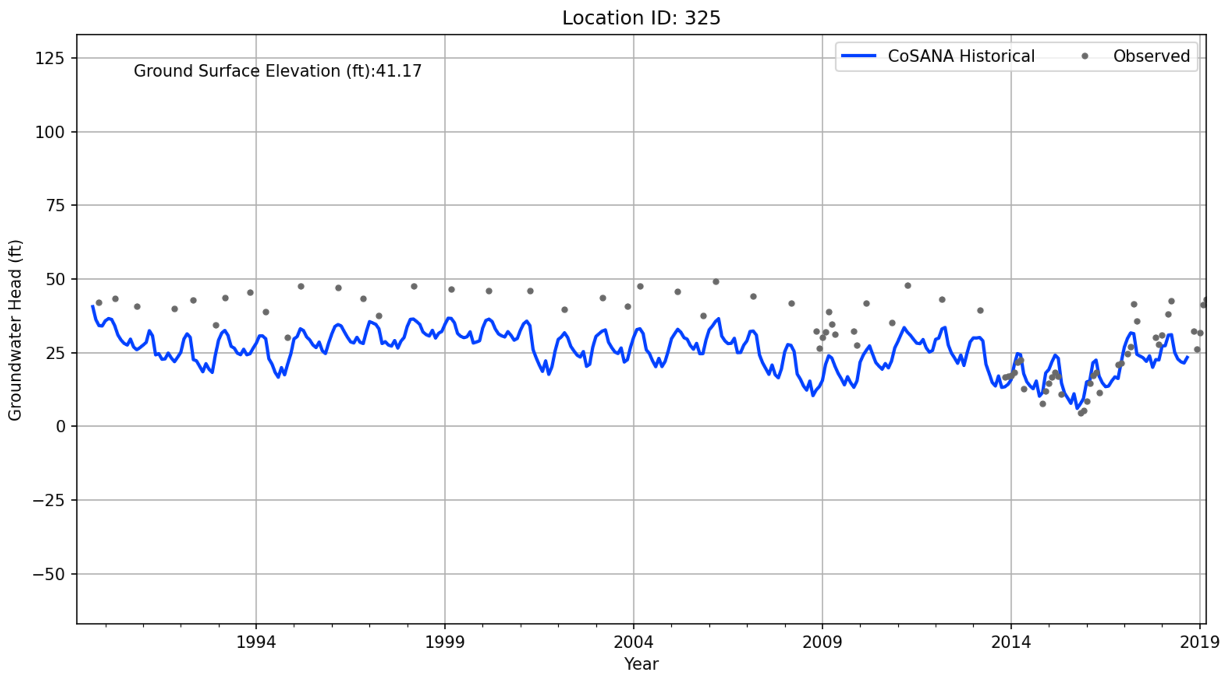

Location ID: 317
Ground Surface Elevation (ft):57.37
CoSANA Historical
Observed
Groundwater Head (ft)
Year
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019

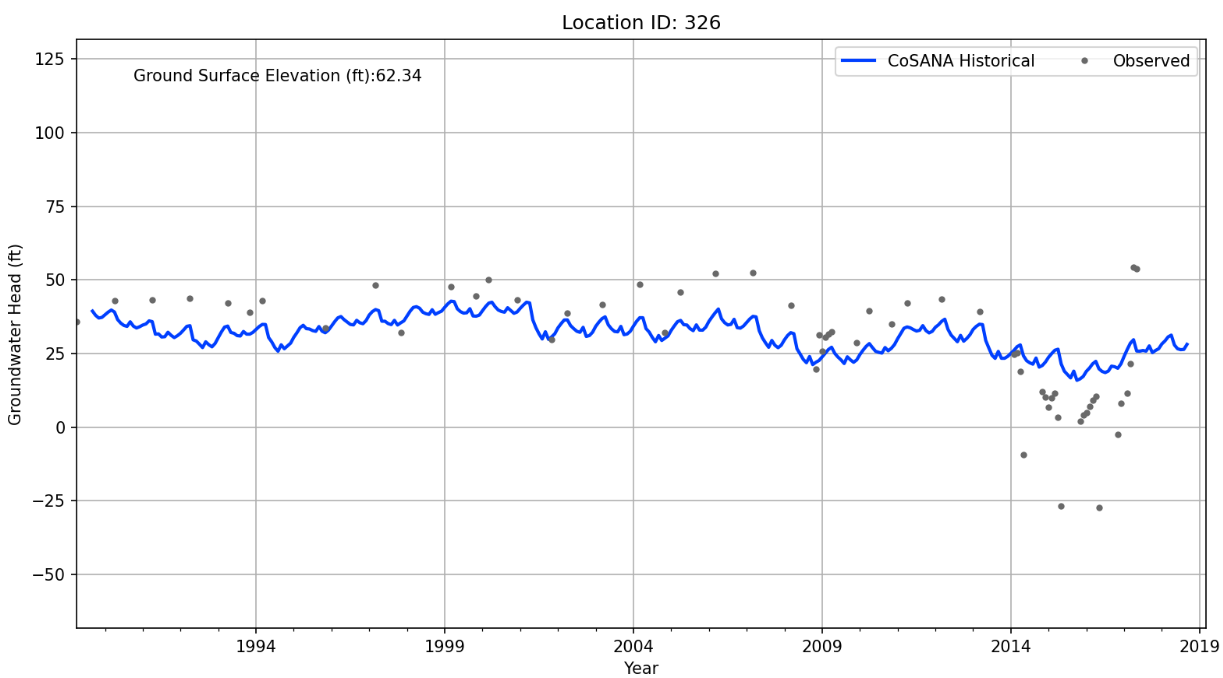

Location ID: 319
Ground Surface Elevation (ft):47.92
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

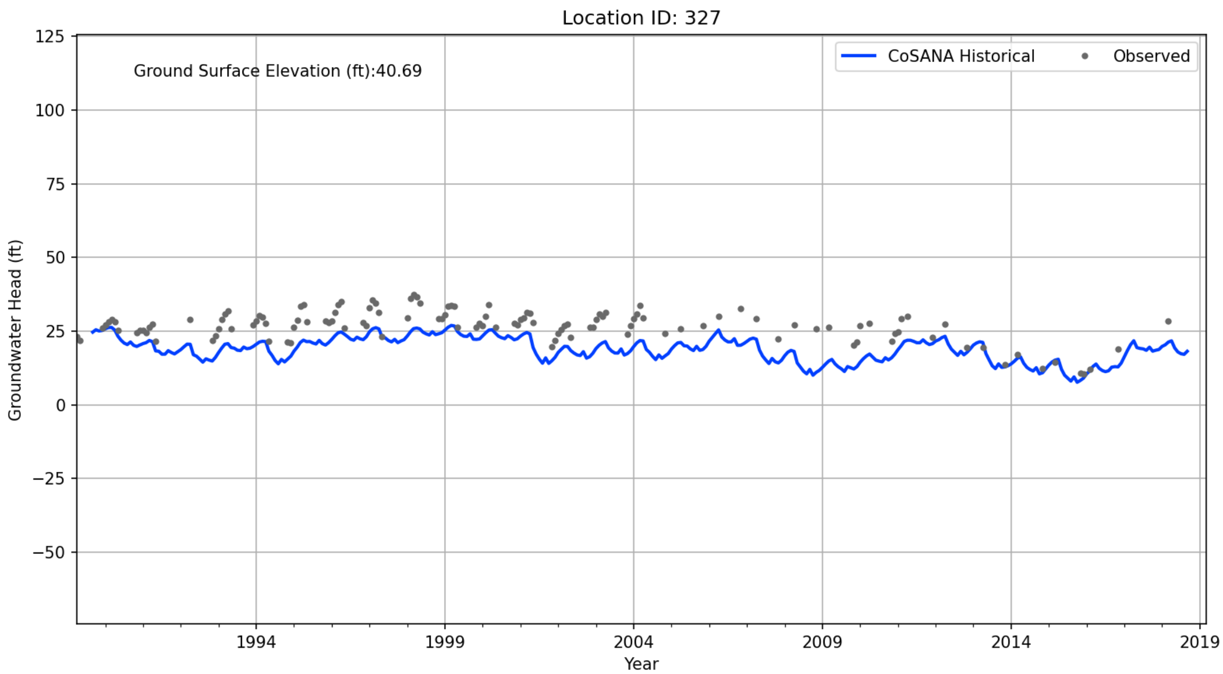

Location ID: 320
Ground Surface Elevation (ft):64.23
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

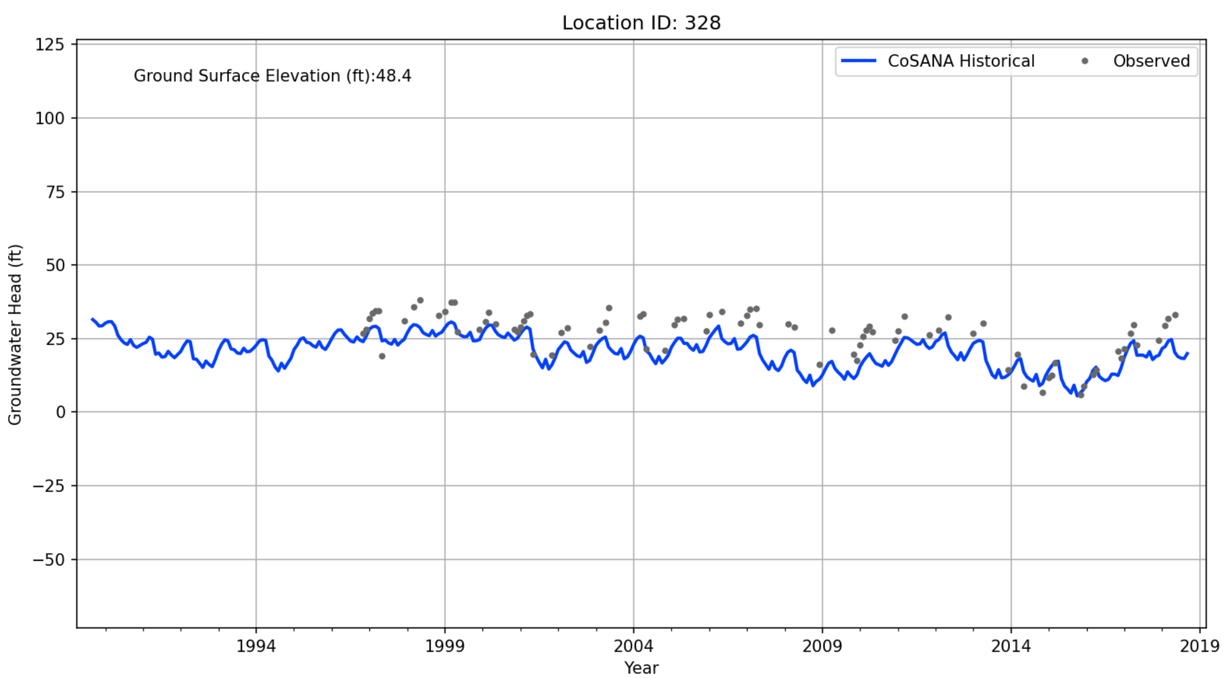

Location ID: 321
Ground Surface Elevation (ft):36.09
CoSANA Historical
Observed
Groundwater Head (ft)
Year
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019

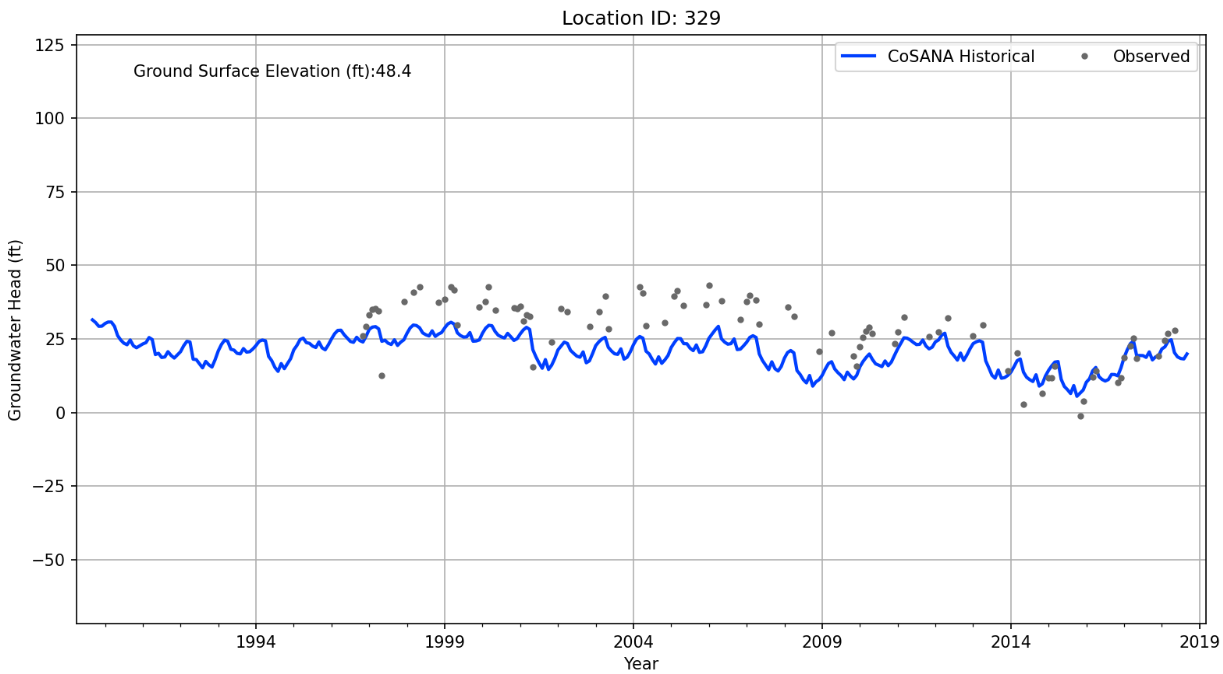

Location ID: 323
Ground Surface Elevation (ft):53.42
CoSANA Historical
Observed
Groundwater Head (ft)
Year
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019

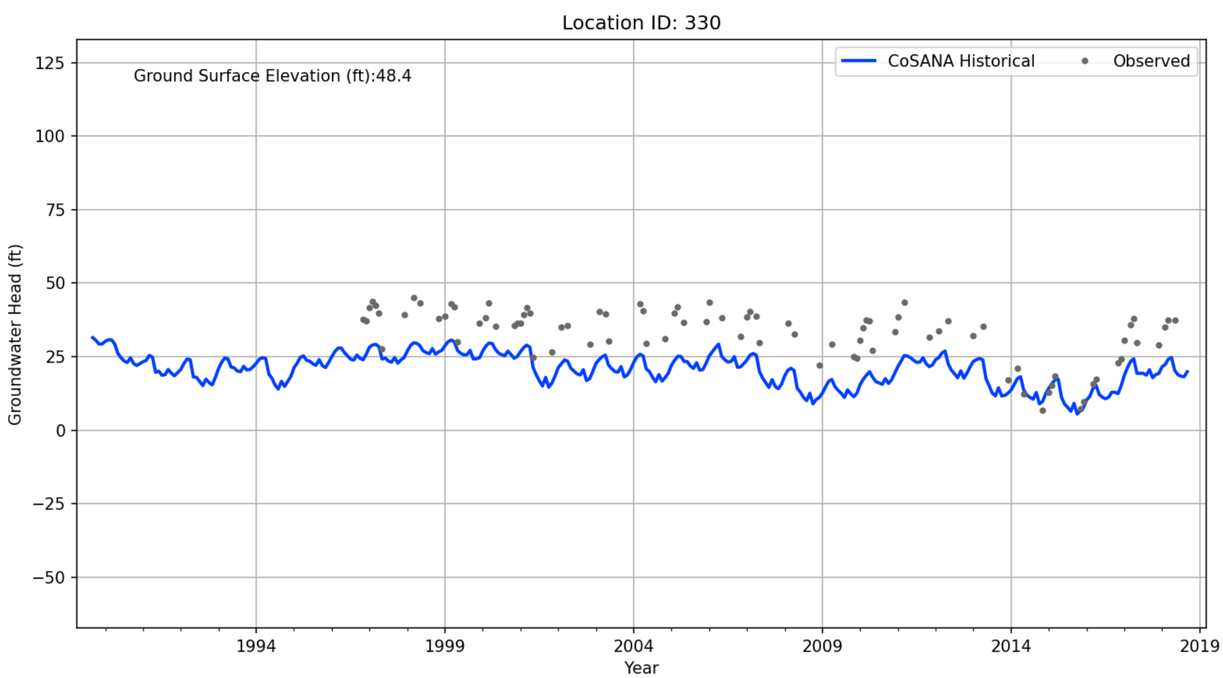

Location ID: 325
Ground Surface Elevation (ft):41.17
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

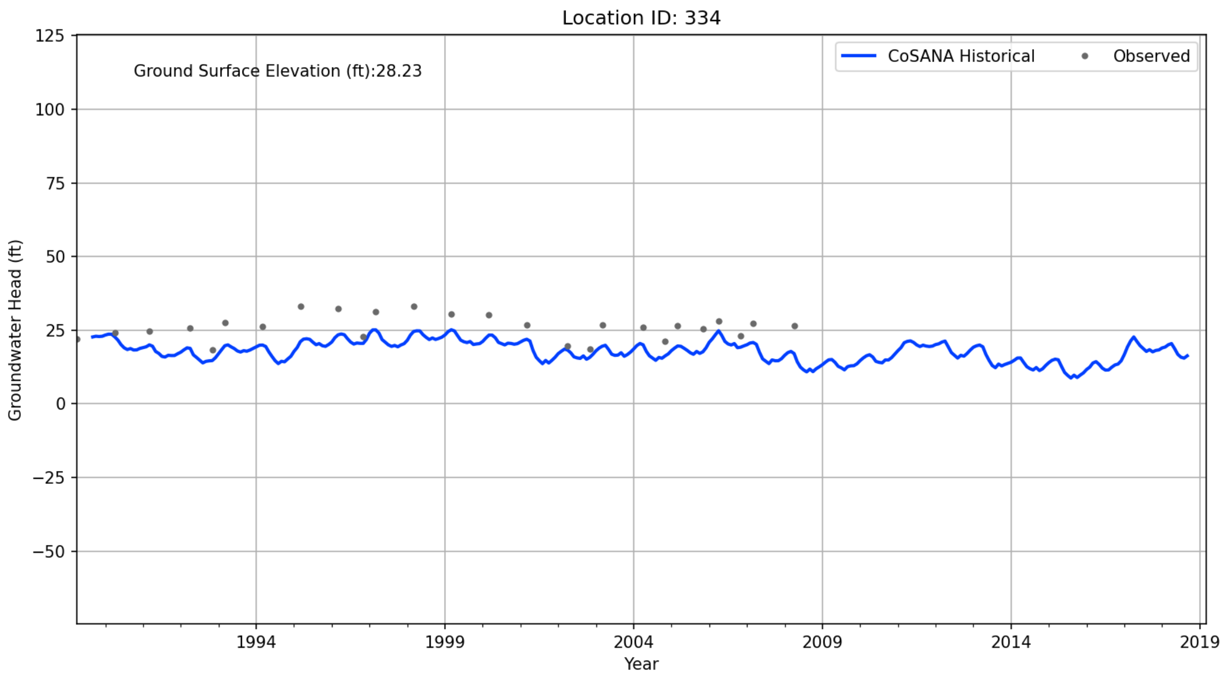

Location ID: 326
Ground Surface Elevation (ft):62.34
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

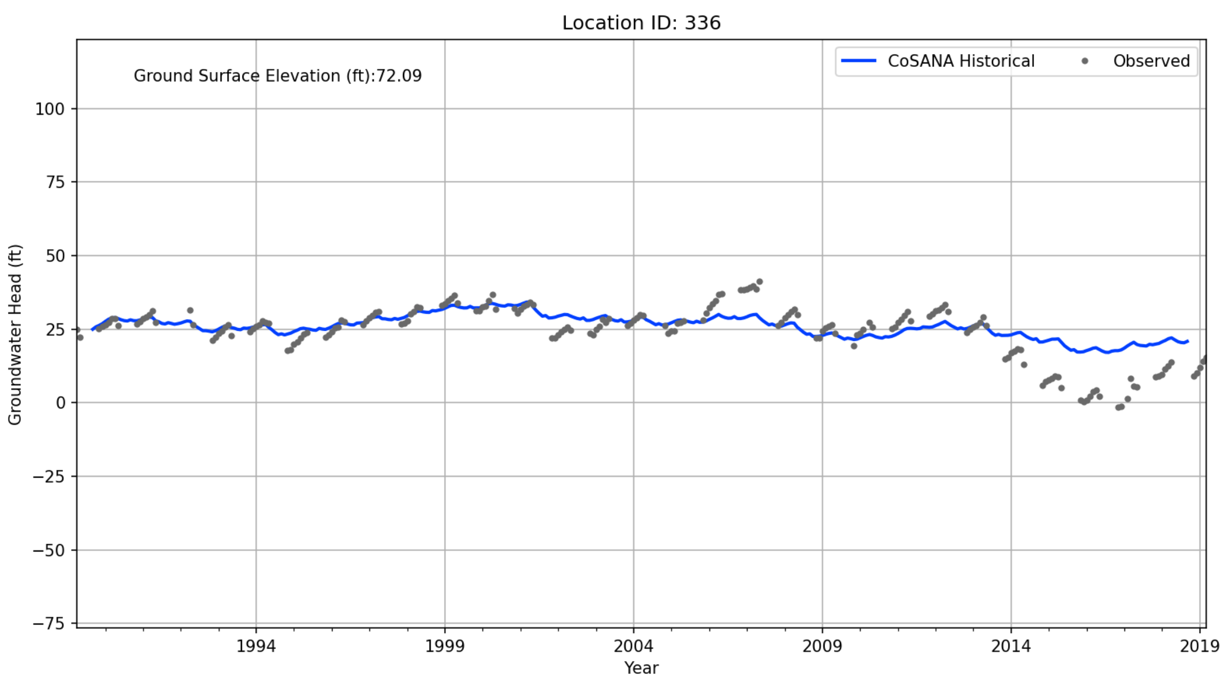

Location ID: 327
Ground Surface Elevation (ft):40.69
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

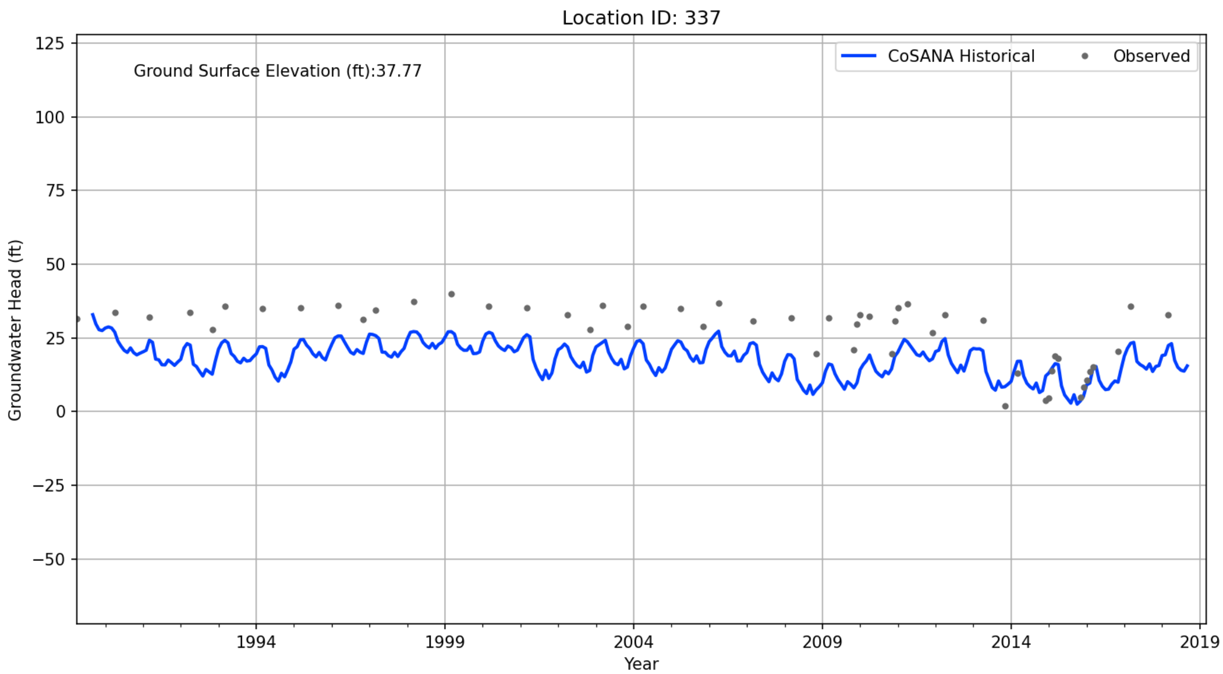

Location ID: 328
Ground Surface Elevation (ft):48.4
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year


Location ID: 329
Ground Surface Elevation (ft):48.4
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year


Location ID: 330
Ground Surface Elevation (ft):48.4
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year


Location ID: 334
Ground Surface Elevation (ft):28.23
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year


Location ID: 336
Ground Surface Elevation (ft):72.09
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year


Location ID: 337
Ground Surface Elevation (ft):37.77
CoSANA Historical
Observed
Groundwater Head (ft)
Year
125
100
75
50
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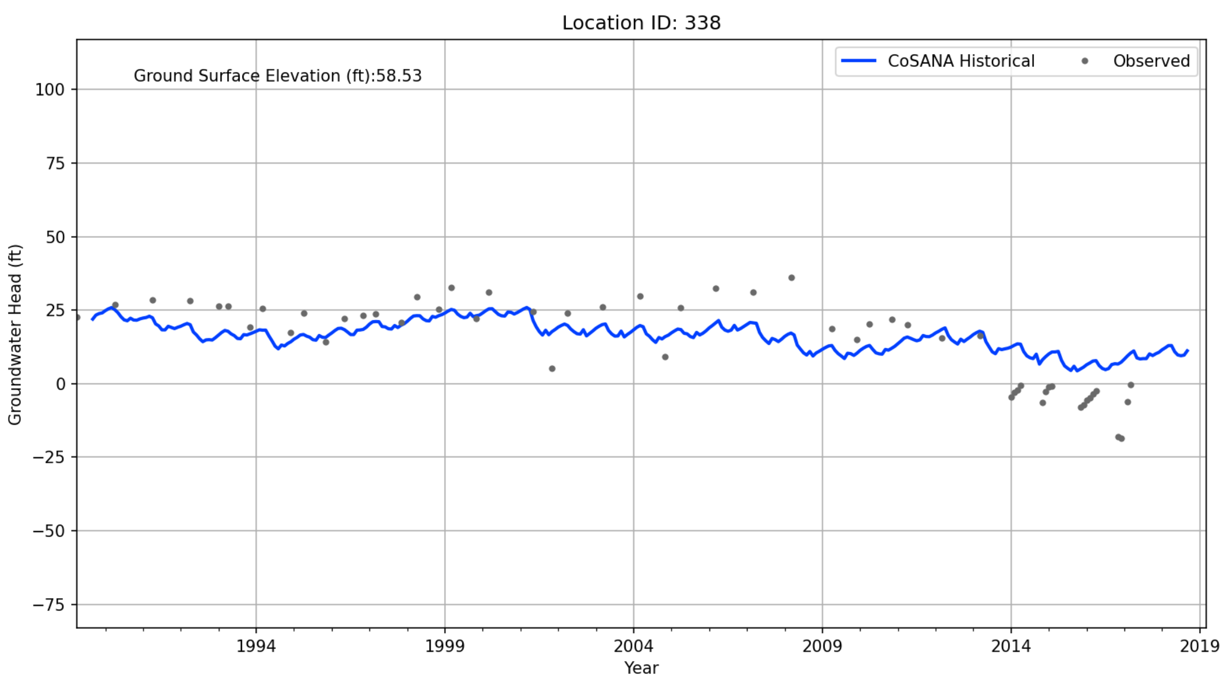
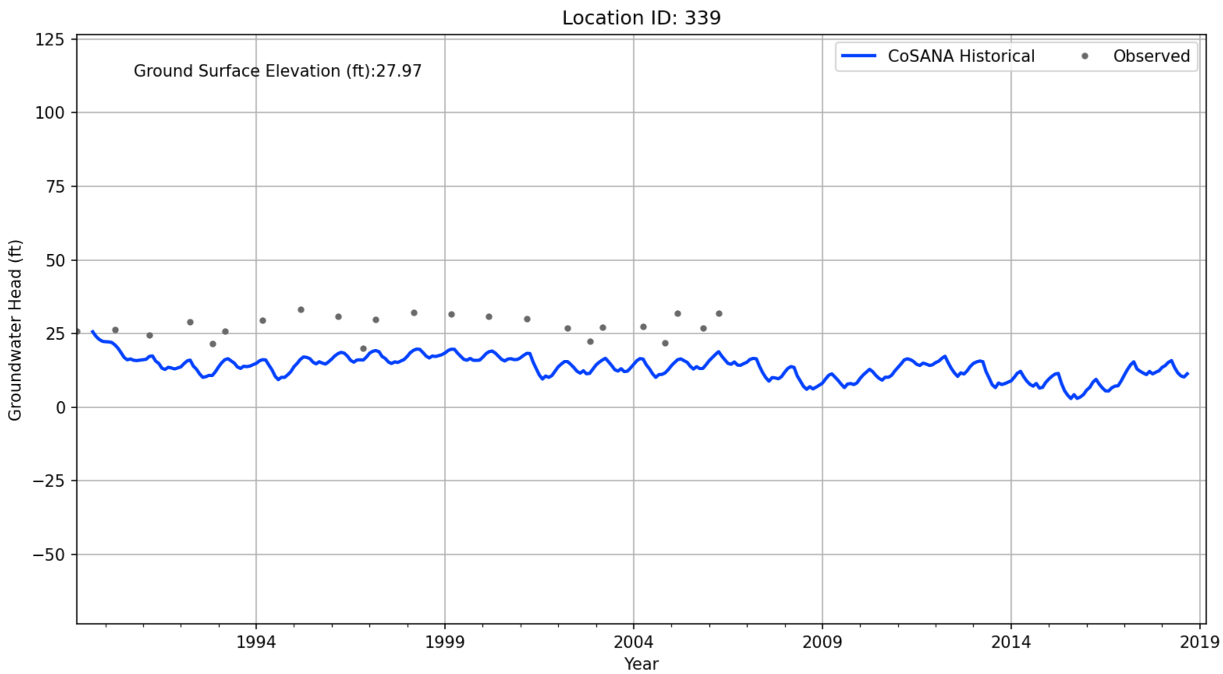
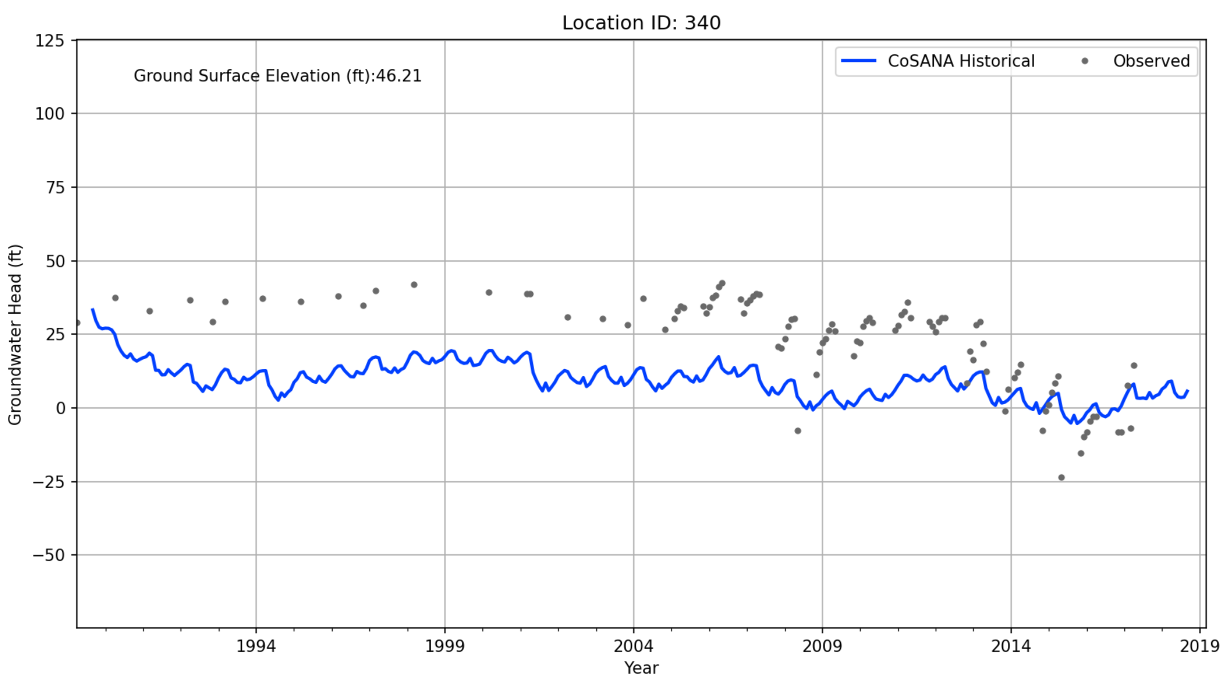
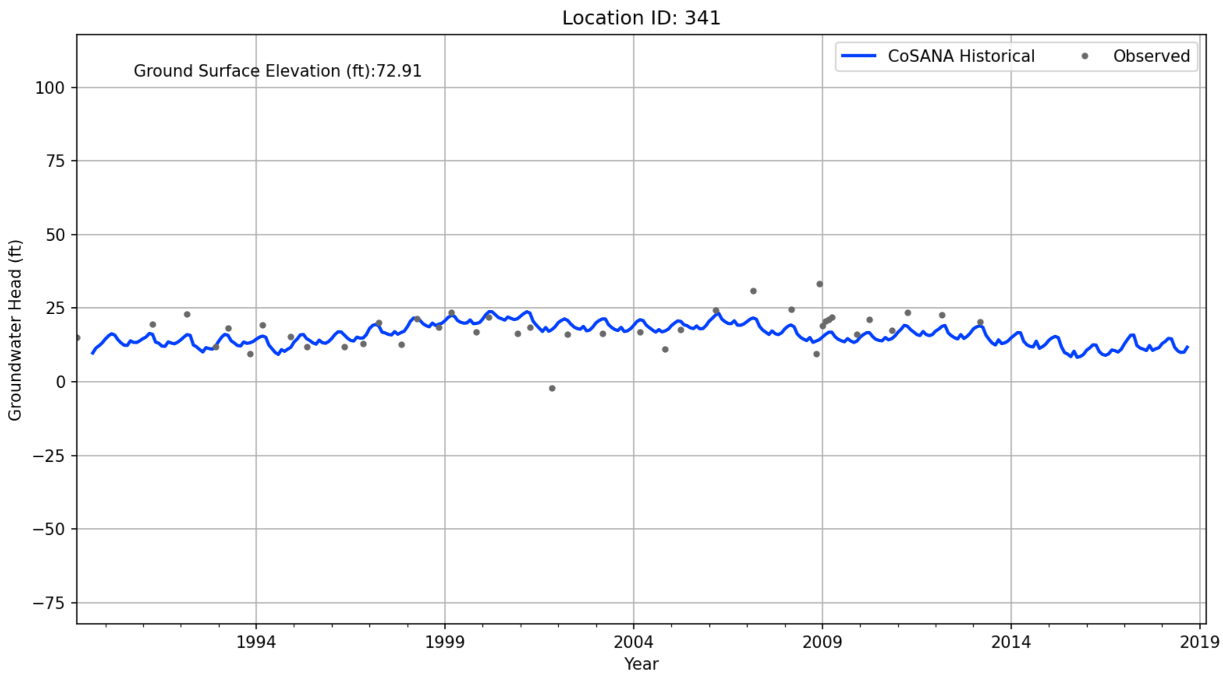
0
−25
−50
1994
1999
2004
2009
2014
2019


Location ID: 338
Ground Surface Elevation (ft):58.53
CoSANA Historical
Observed
Groundwater Head (ft)
Year
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019


Location ID: 339
Ground Surface Elevation (ft):27.97
CoSANA Historical
Observed
Groundwater Head (ft)
Year
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019


Location ID: 340
Ground Surface Elevation (ft):46.21
CoSANA Historical
Observed
Groundwater Head (ft)
Year
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019


Location ID: 341
CoSANA Historical
Observed
Ground Surface Elevation (ft):72.91
Groundwater Head (ft)
100
75
50
25
0
−25
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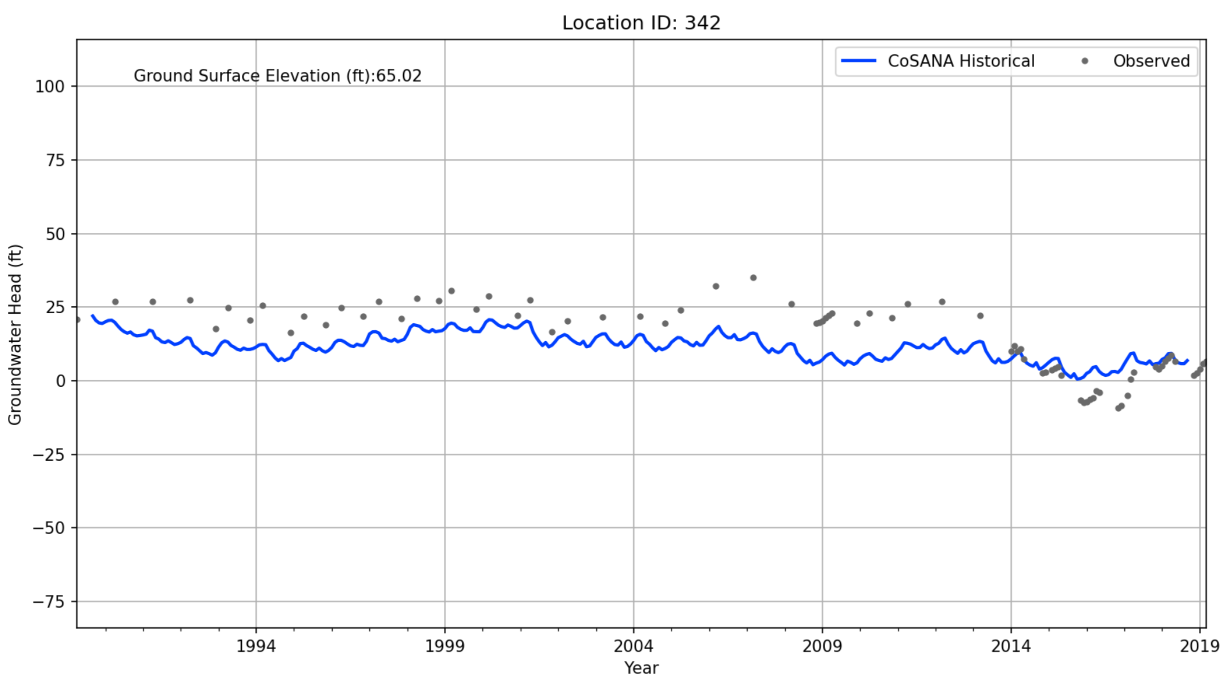
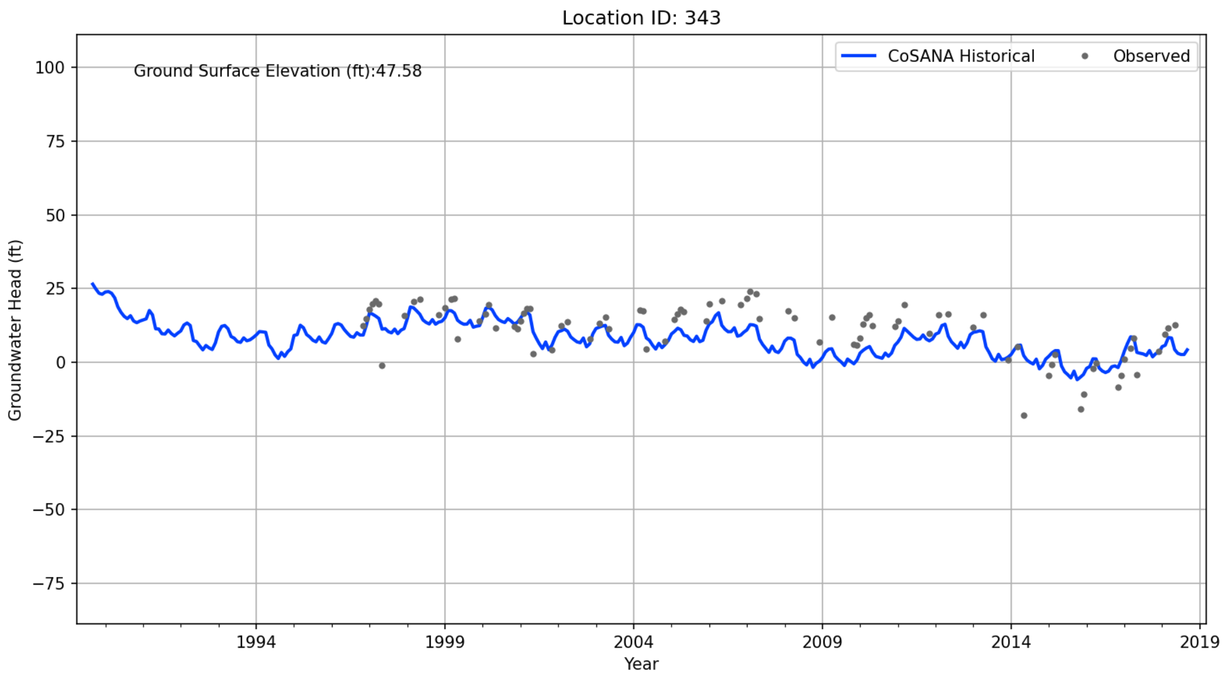
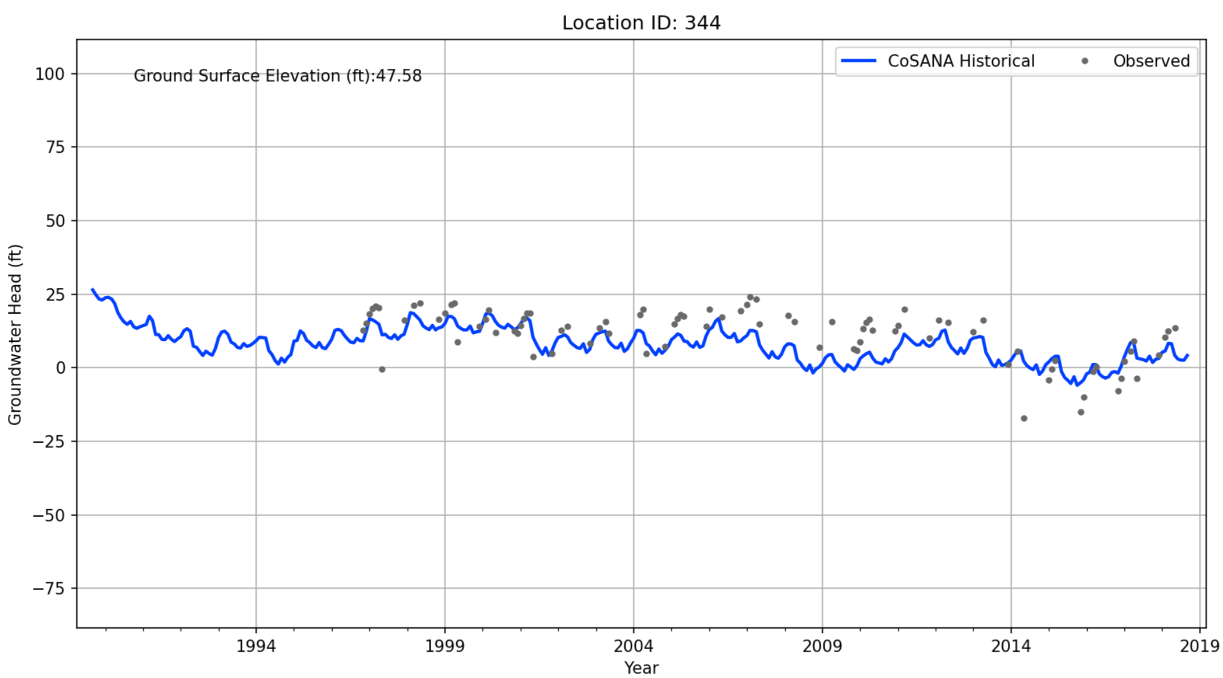
−75
1994
1999
2004
2009
2014
2019
Year


Location ID: 342
CoSANA Historical
Observed
Ground Surface Elevation (ft):65.02
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year


Location ID: 343
Ground Surface Elevation (ft):47.58
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year


Location ID: 344
Ground Surface Elevation (ft):47.58
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
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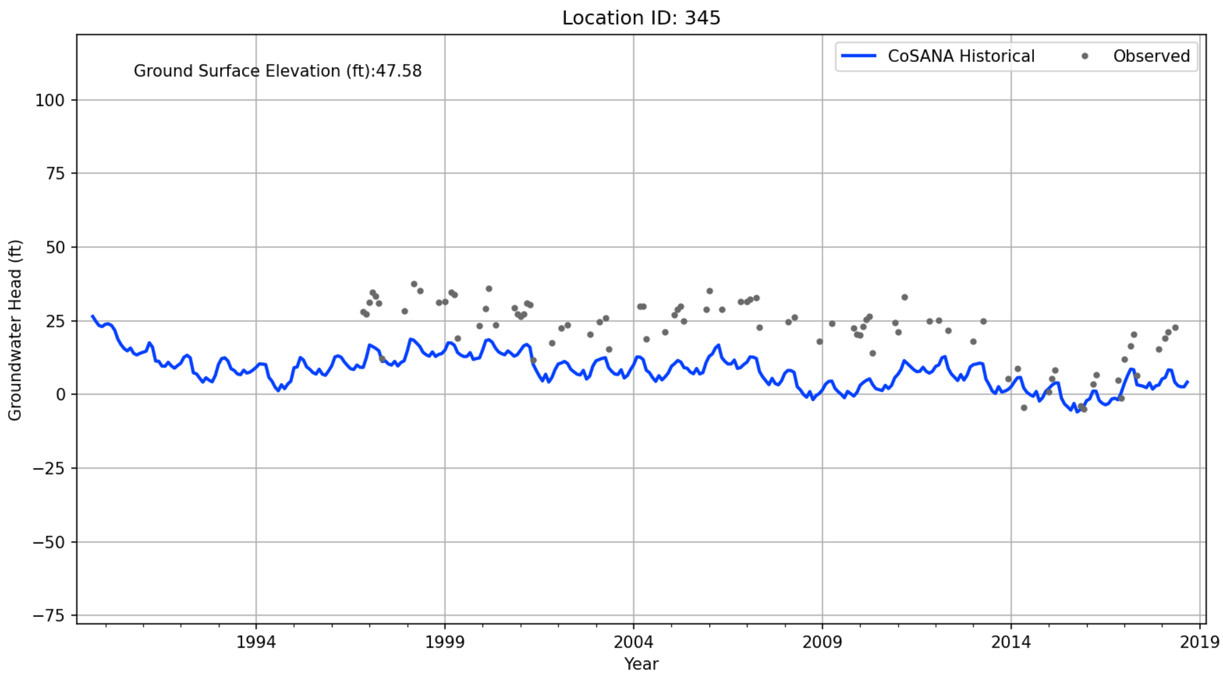
−50
−75
1994
1999
2004
2009
2014
2019
Year



Location ID: 345
CoSANA Historical
Observed
Ground Surface Elevation (ft):47.58
Groundwater Head (ft)
Year
100
75
50
25
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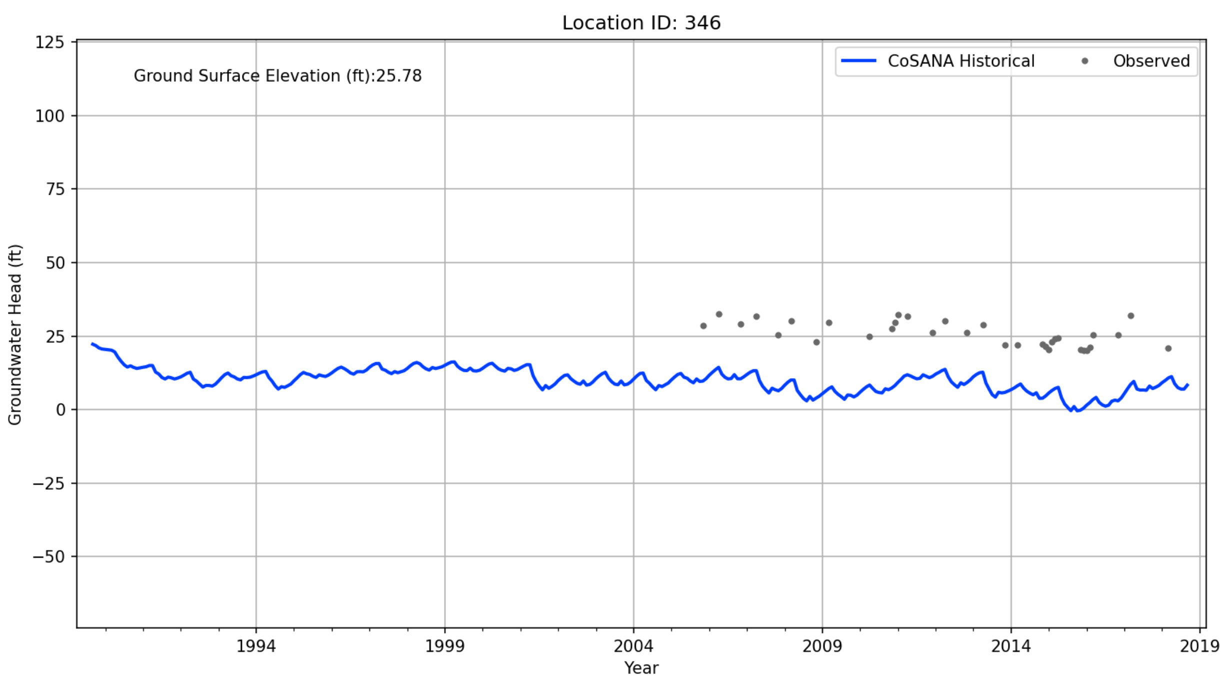
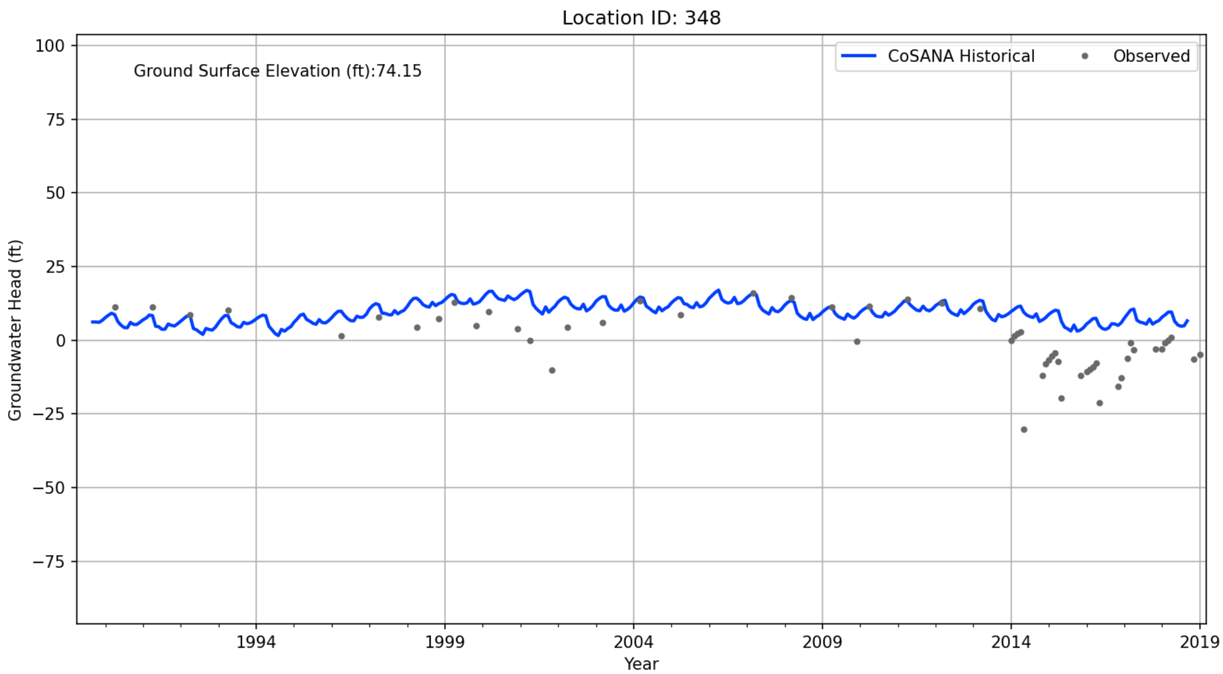
−25
−50
−75
1994
1999
2004
2009
2014
2019

Location ID: 346
CoSANA Historical
Observed
Ground Surface Elevation (ft):25.78
Groundwater Head (ft)
Year
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019


Location ID: 348
Ground Surface Elevation (ft):74.15
CoSANA Historical
Observed
Groundwater Head (ft)
Year
100
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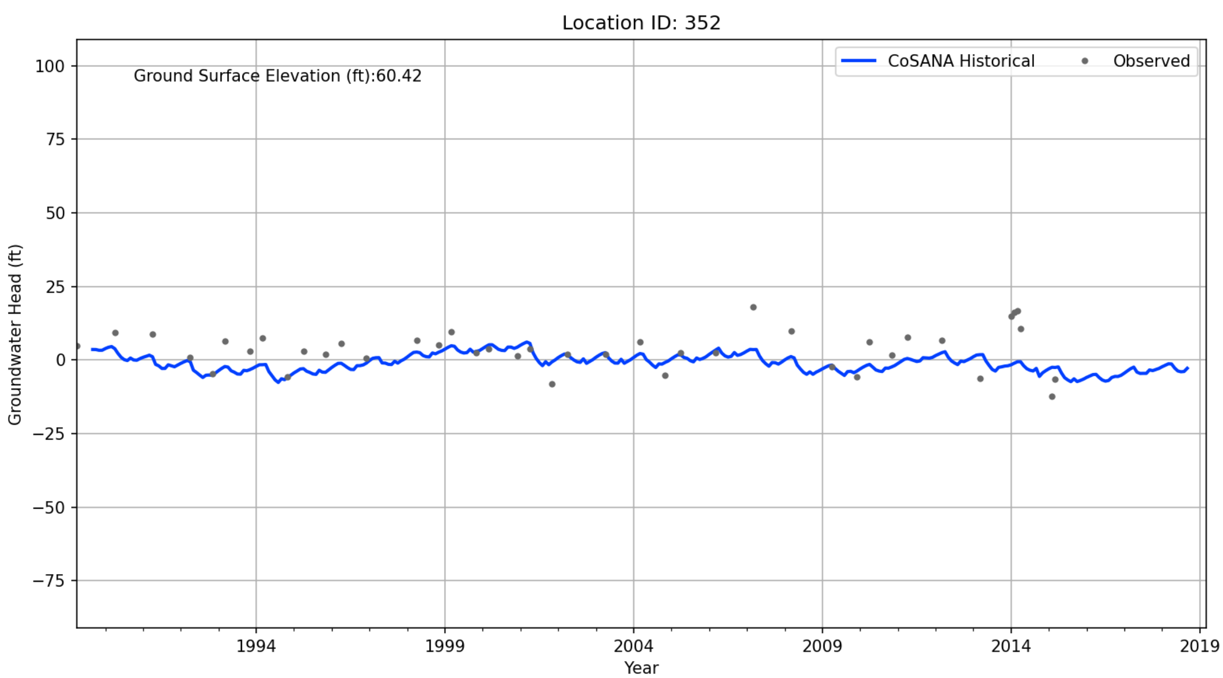
1994
1999
2004
2009
2014
2019


Location ID: 352
Ground Surface Elevation (ft):60.42
CoSANA Historical
Observed
Groundwater Head (ft)
Year
100
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1994
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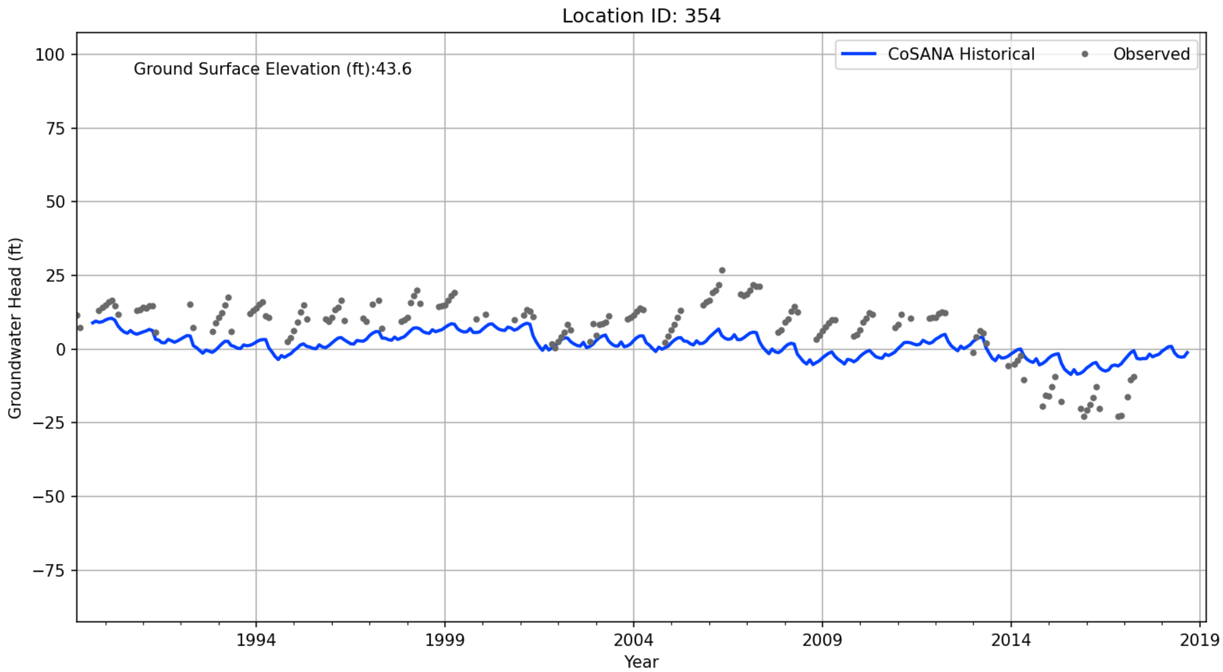
2004
2009
2014
2019


Location ID: 354
CoSANA Historical
Observed
Ground Surface Elevation (ft):43.6
Groundwater Head (ft)
Year
100
75
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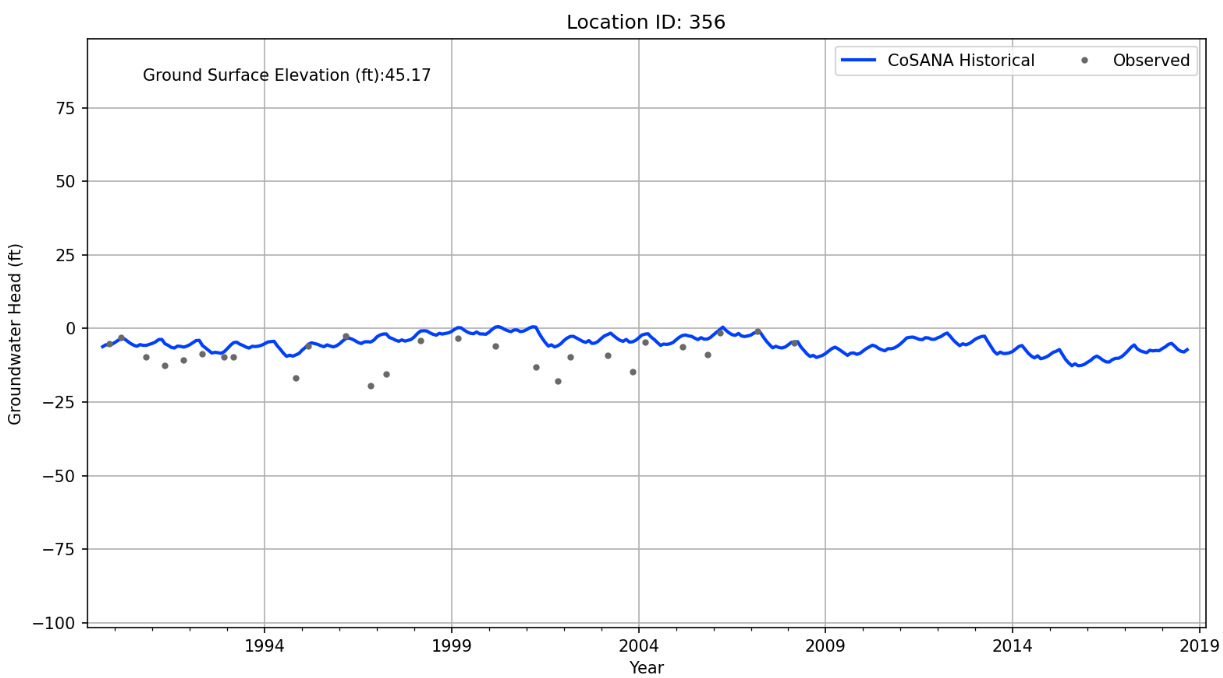
−75
1994
1999
2004
2009
2014
2019


Location ID: 356
CoSANA Historical
Observed
Ground Surface Elevation (ft):45.17
Groundwater Head (ft)
Year
75
50
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0
−25
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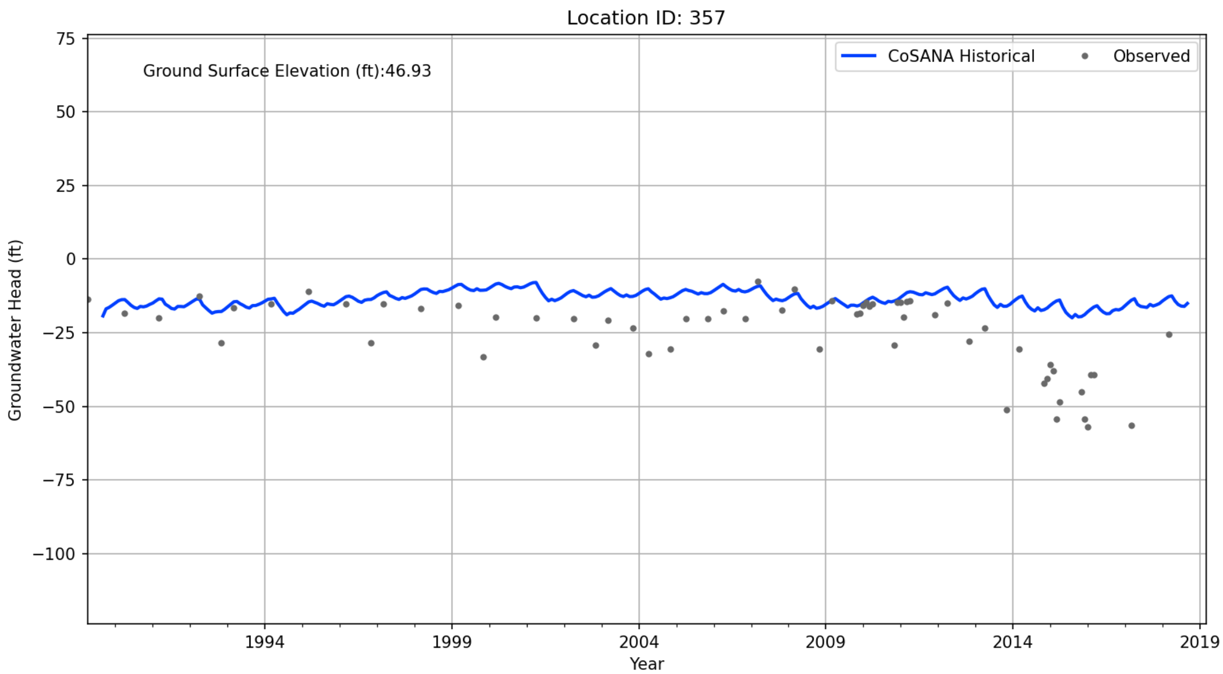
−75
−100
1994
1999
2004
2009
2014
2019


Location ID: 357
Ground Surface Elevation (ft):46.93
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
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−25
−50
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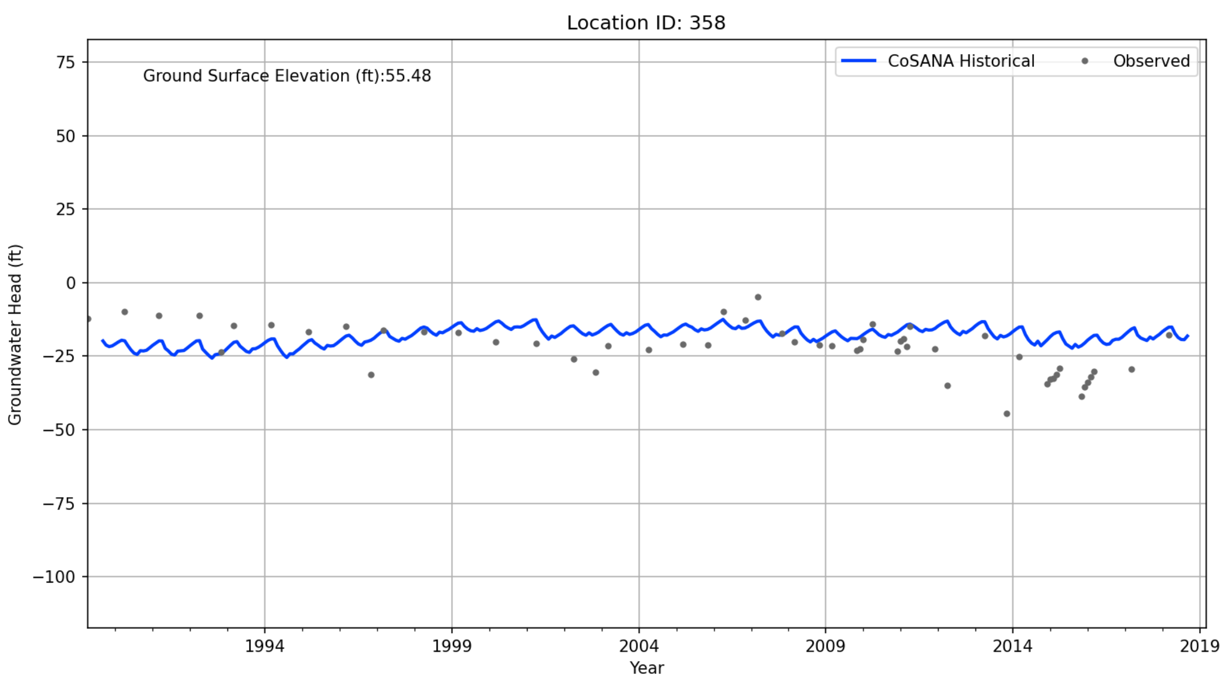
−100
1994
1999
2004
2009
2014
2019
Year


Location ID: 358
Ground Surface Elevation (ft):55.48
CoSANA Historical
Observed
Groundwater Head (ft)
75
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25
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−25
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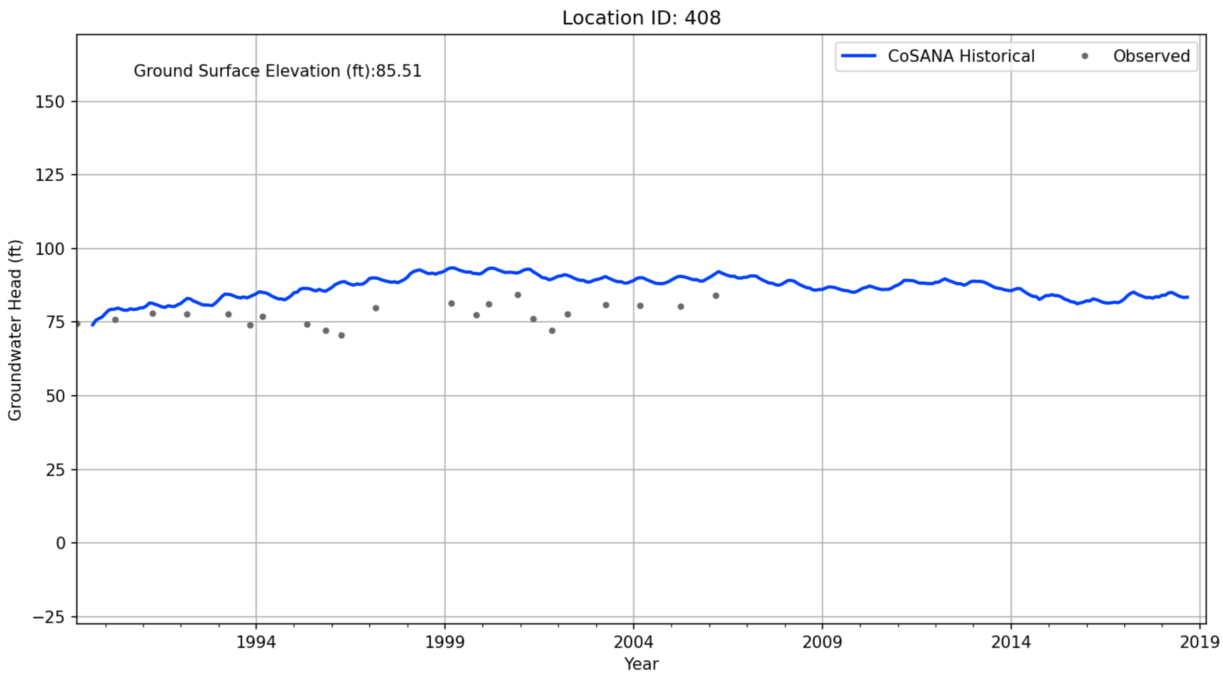
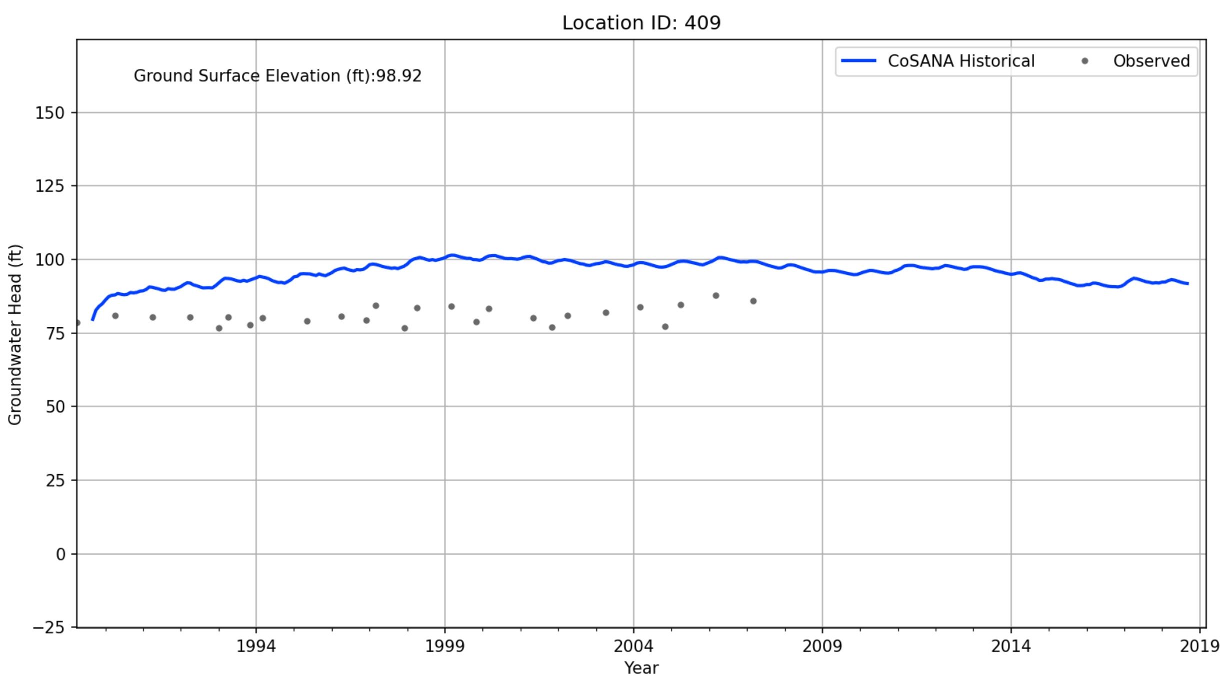
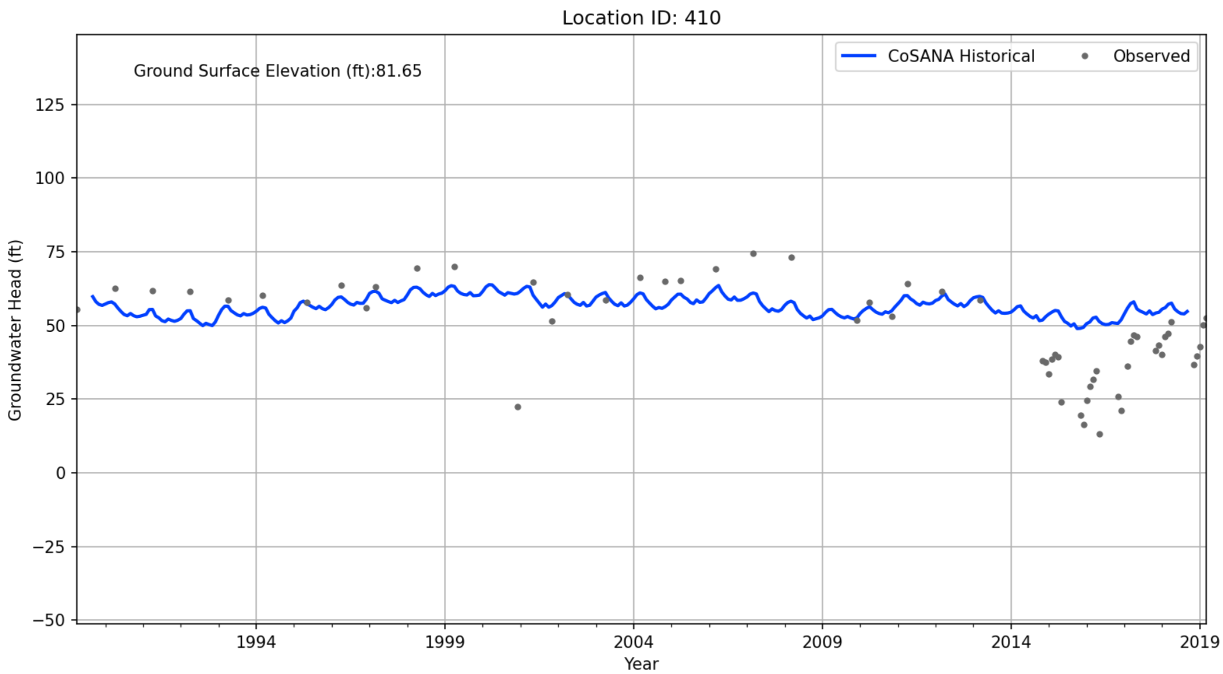
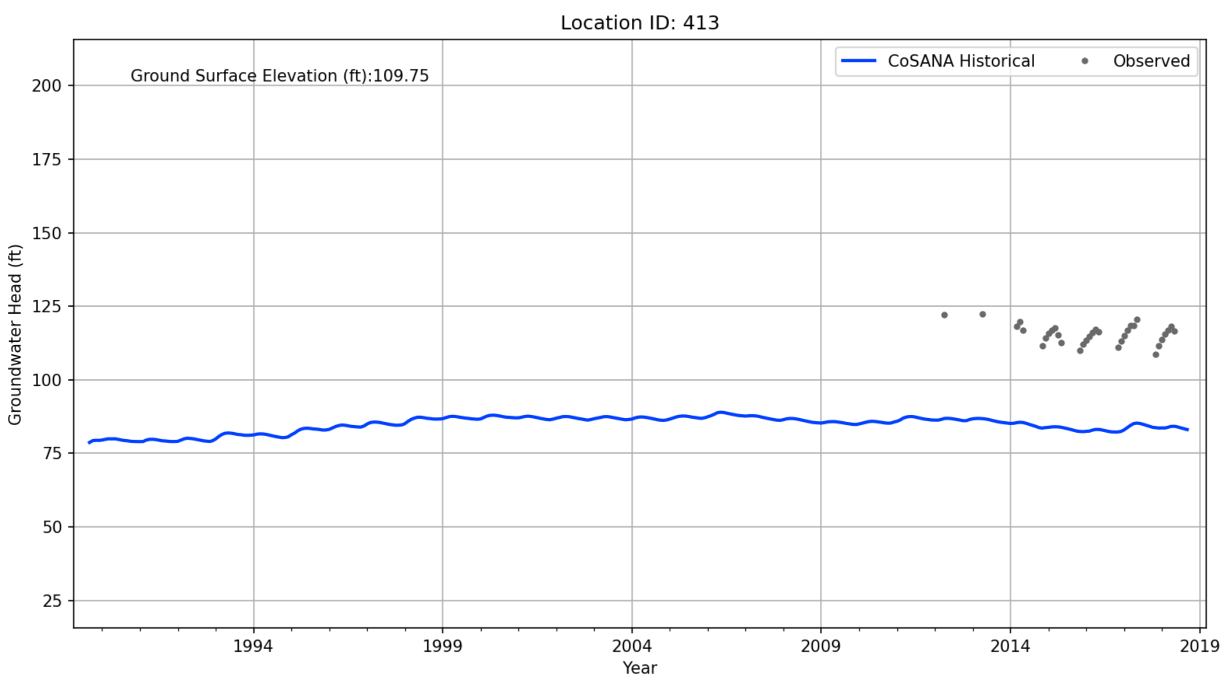
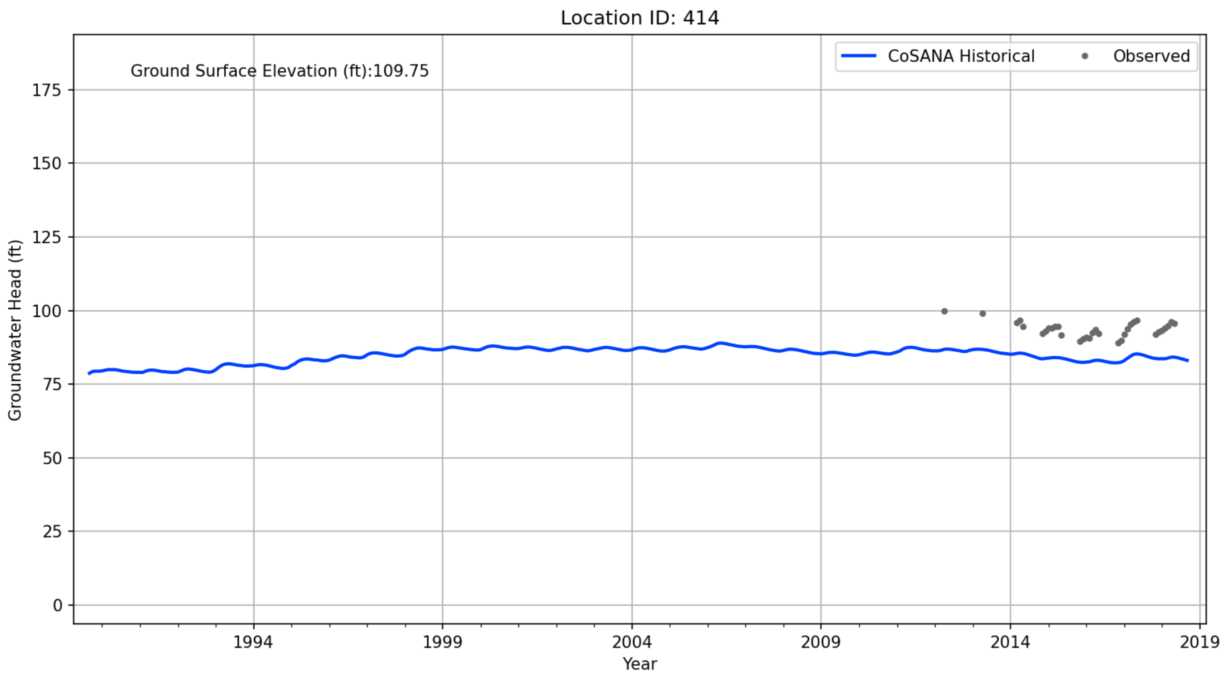
−75
−100
1994
1999
2004
2009
2014
2019
Year

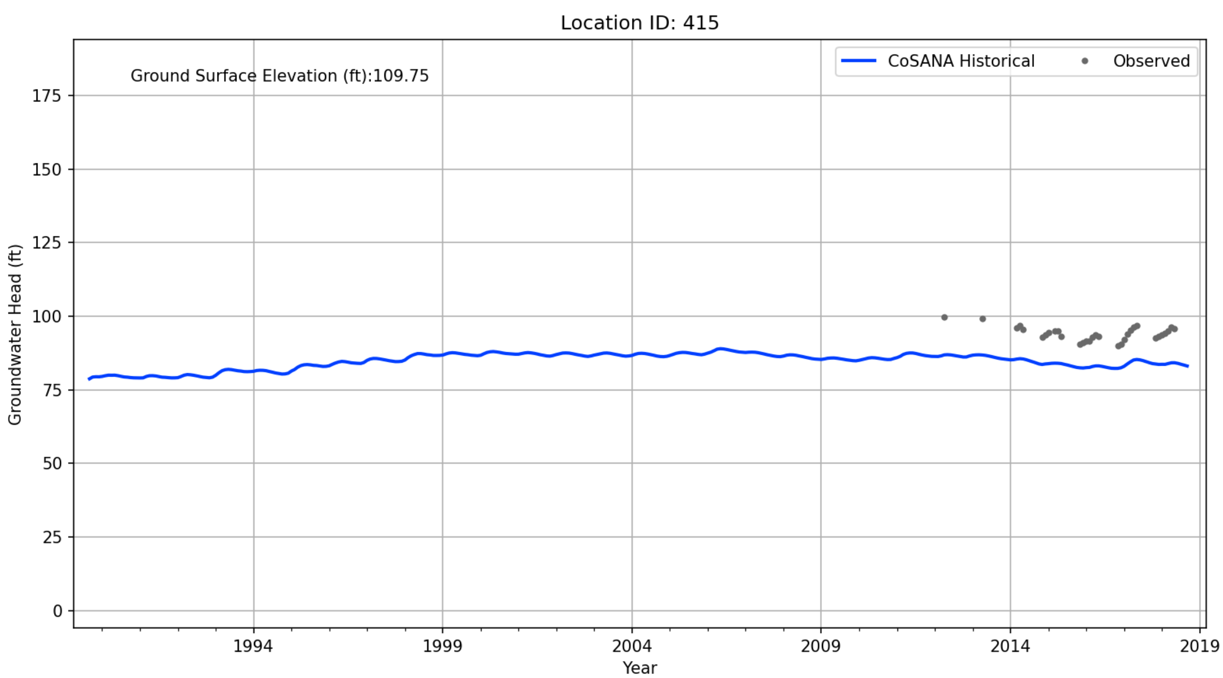

Location ID: 408
Ground Surface Elevation (ft):85.51
CoSANA Historical
Observed
Groundwater Head (ft)
150
125
100
75
50
25
0
−25
1994
1999
2004
2009
2014
2019
Year

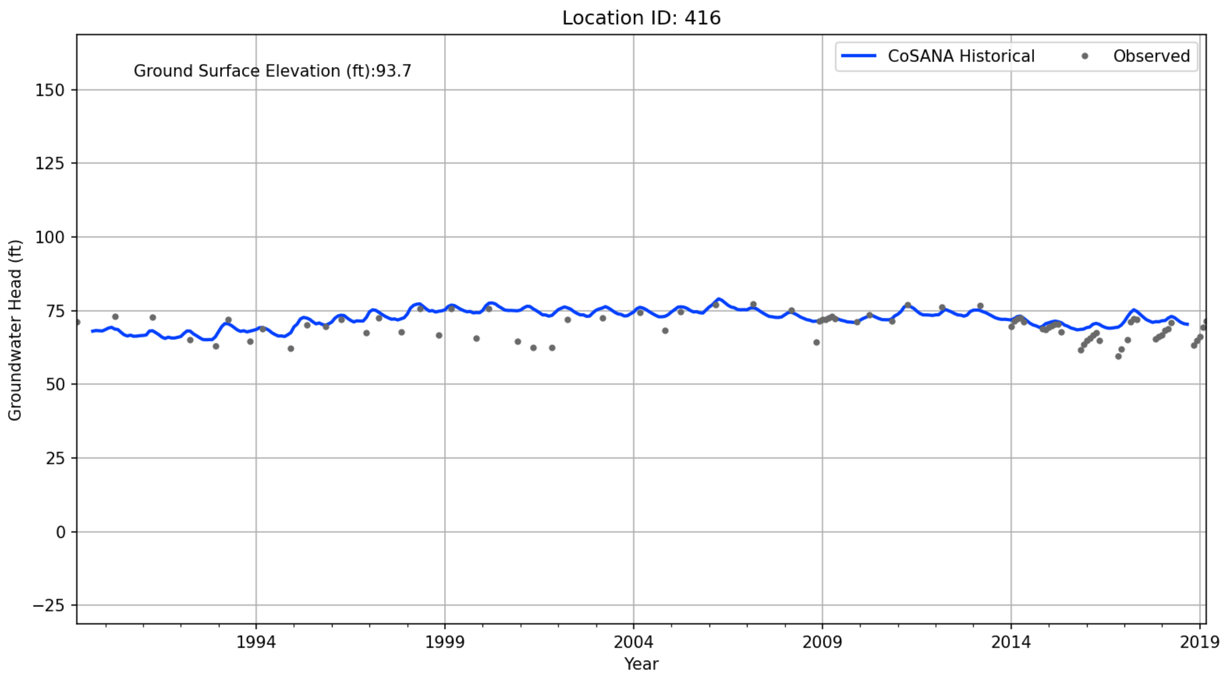

Location ID: 409
Ground Surface Elevation (ft):98.92
CoSANA Historical
Observed
Groundwater Head (ft)
150
125
100
75
50
25
0
−25
1994
1999
2004
2009
2014
2019
Year


Location ID: 410
Ground Surface Elevation (ft):81.65
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

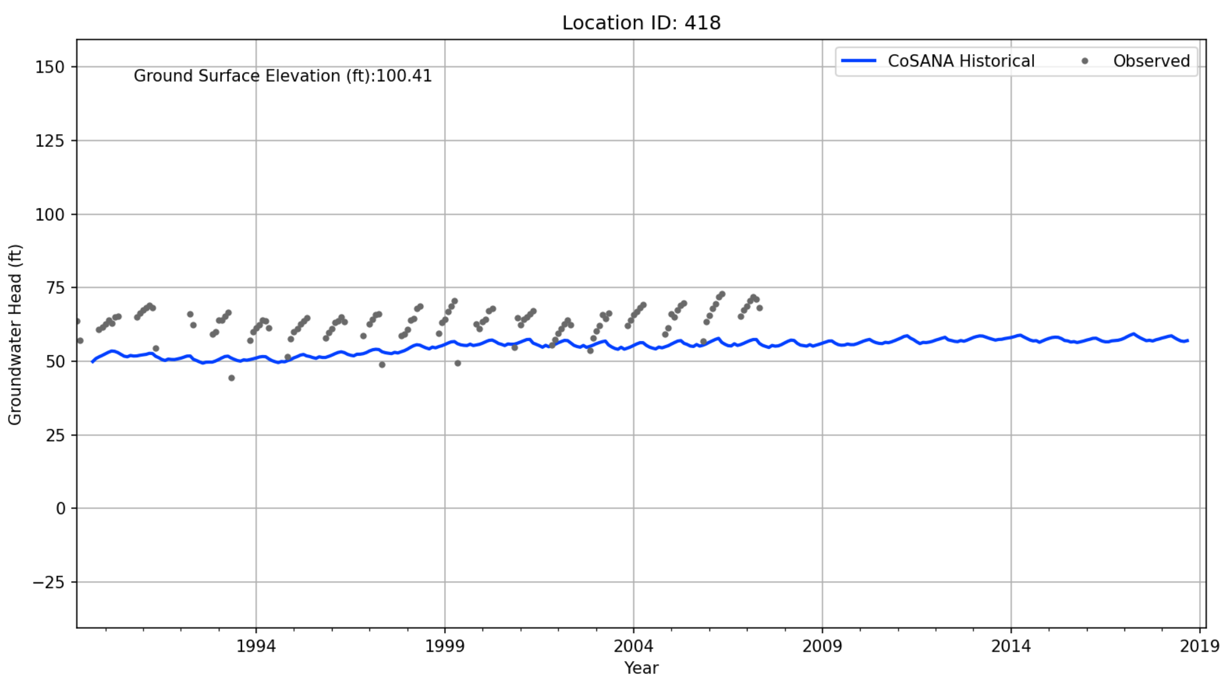

Location ID: 413
Ground Surface Elevation (ft):109.75
CoSANA Historical
Observed
Groundwater Head (ft)
200
175
150
125
100
75
50
25
1994
1999
2004
2009
2014
2019
Year


Location ID: 414
CoSANA Historical
Observed
Ground Surface Elevation (ft):109.75
Groundwater Head (ft)
0
25
50
75
100
125
150
175
1994
1999
2004
2009
2014
2019
Year

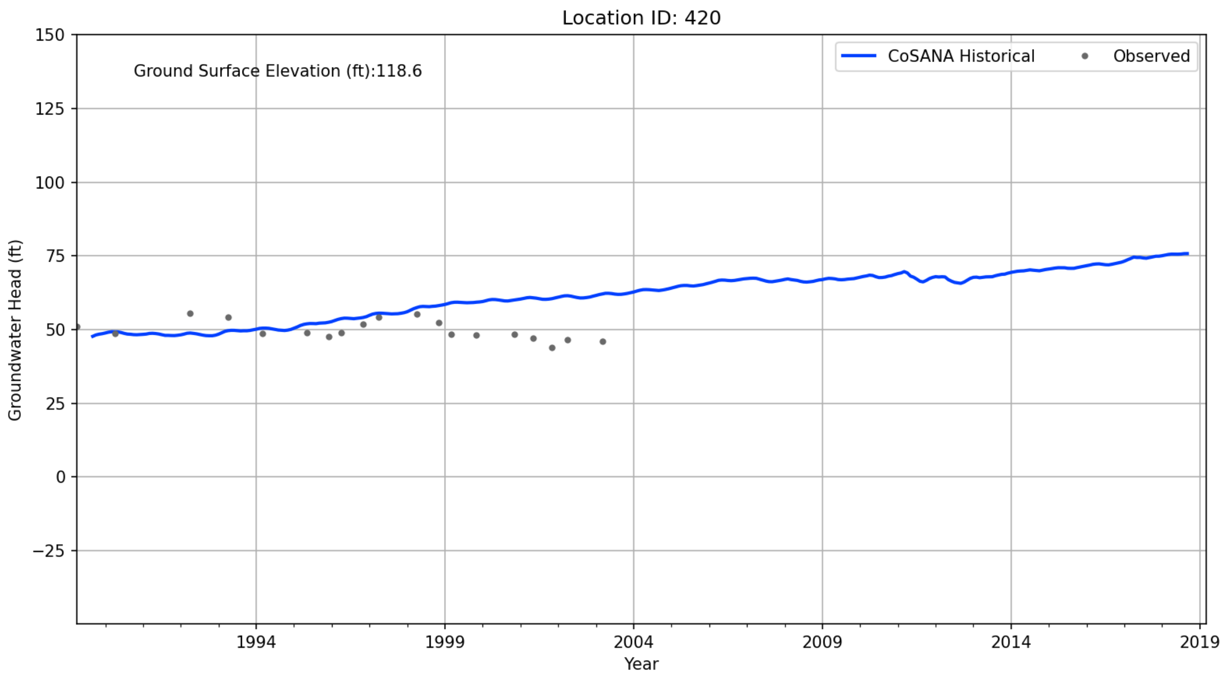

Location ID: 415
CoSANA Historical
Observed
Ground Surface Elevation (ft):109.75
Groundwater Head (ft)
0
25
50
75
100
125
150
175
1994
1999
2004
2009
2014
2019
Year

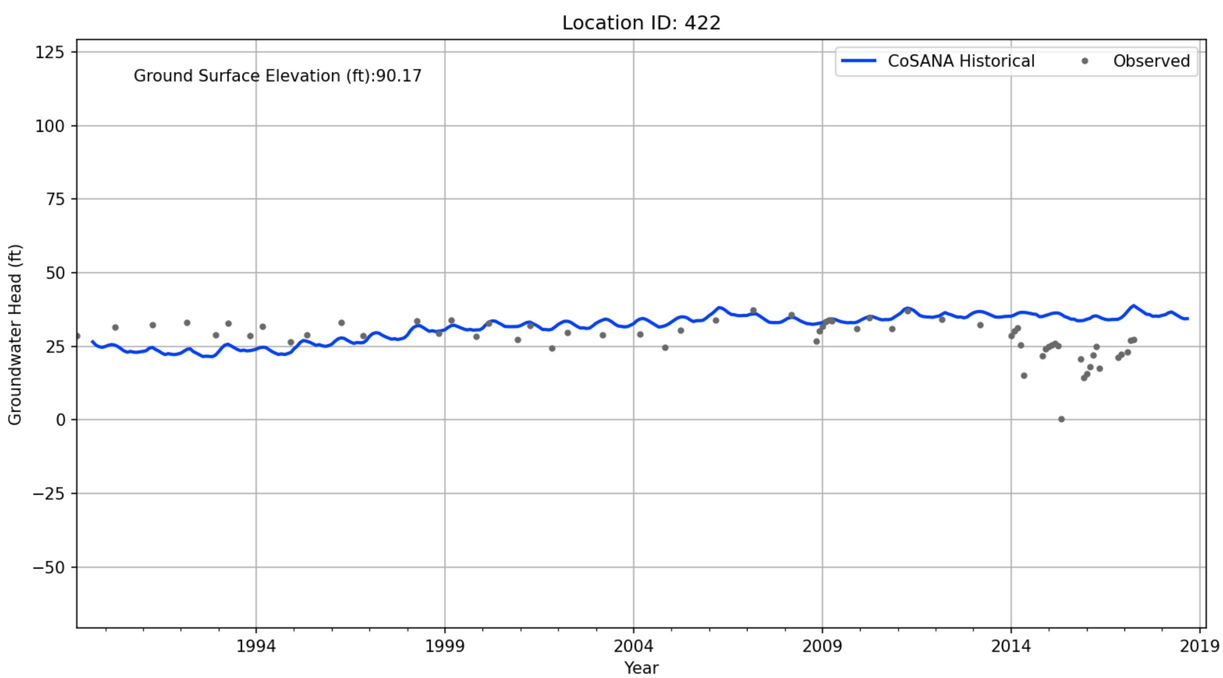


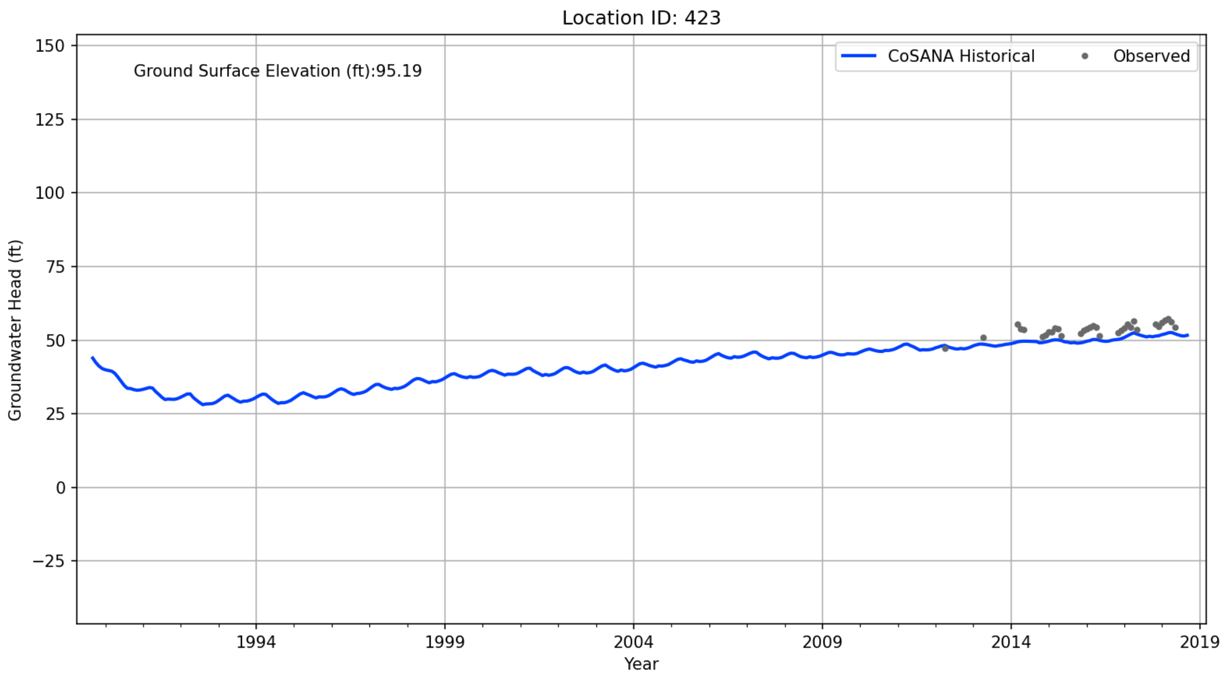
Location ID: 416
Ground Surface Elevation (ft):93.7
CoSANA Historical
Observed
Groundwater Head (ft)
150
125
100
75
50
25
0
−25
1994
1999
2004
2009
2014
2019
Year

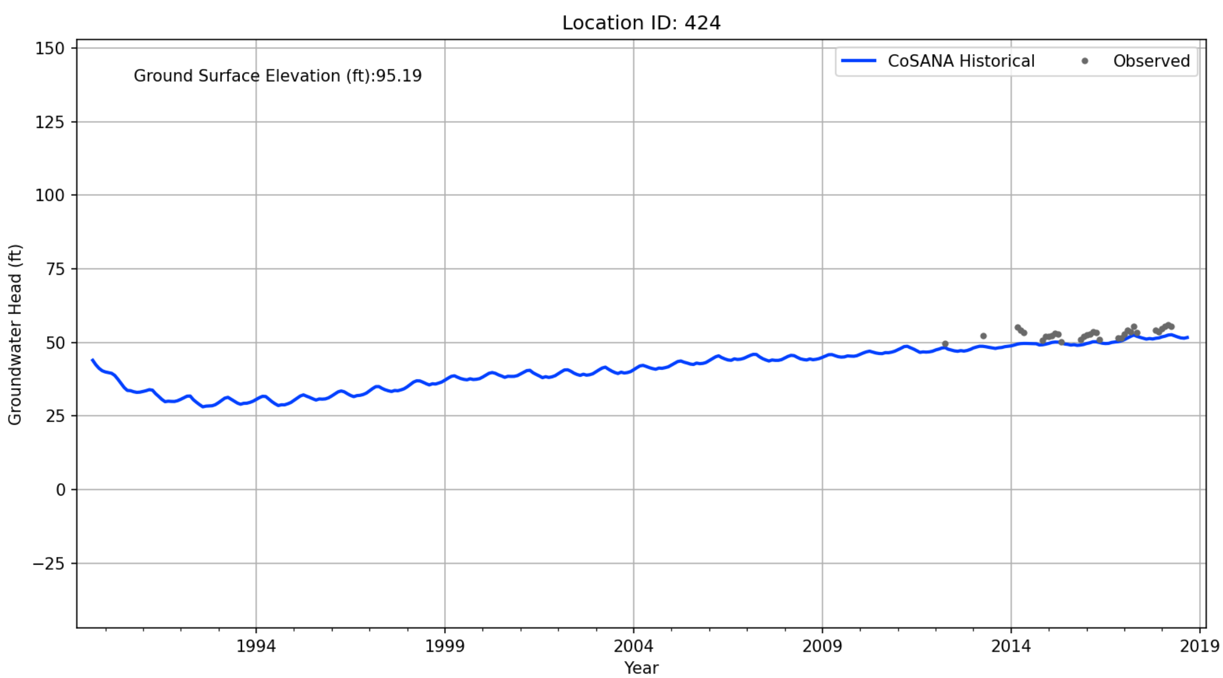
Location ID: 418
Ground Surface Elevation (ft):100.41
CoSANA Historical
Observed
Groundwater Head (ft)
150
125
100
75
50
25
0
−25
1994
1999
2004
2009
2014
2019
Year


Location ID: 420
Ground Surface Elevation (ft):118.6
CoSANA Historical
Observed
Groundwater Head (ft)
150
125
100
75
50
25
0
−25
1994
1999
2004
2009
2014
2019
Year

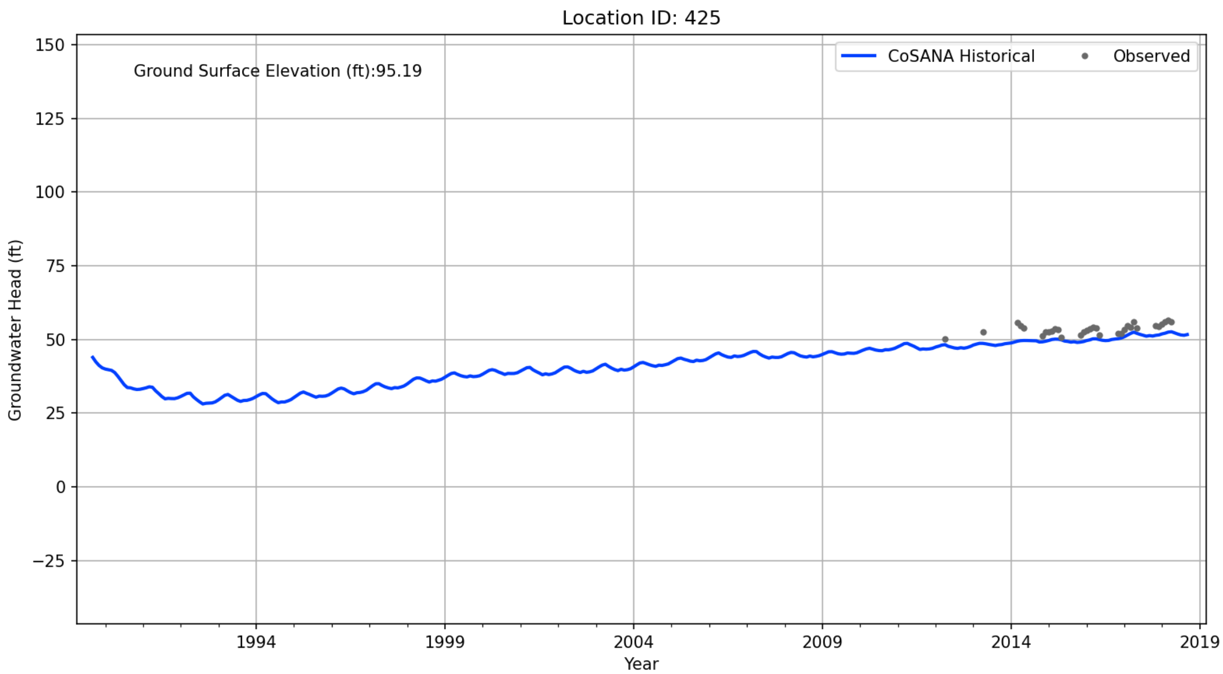

Location ID: 422
Ground Surface Elevation (ft):90.17
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year

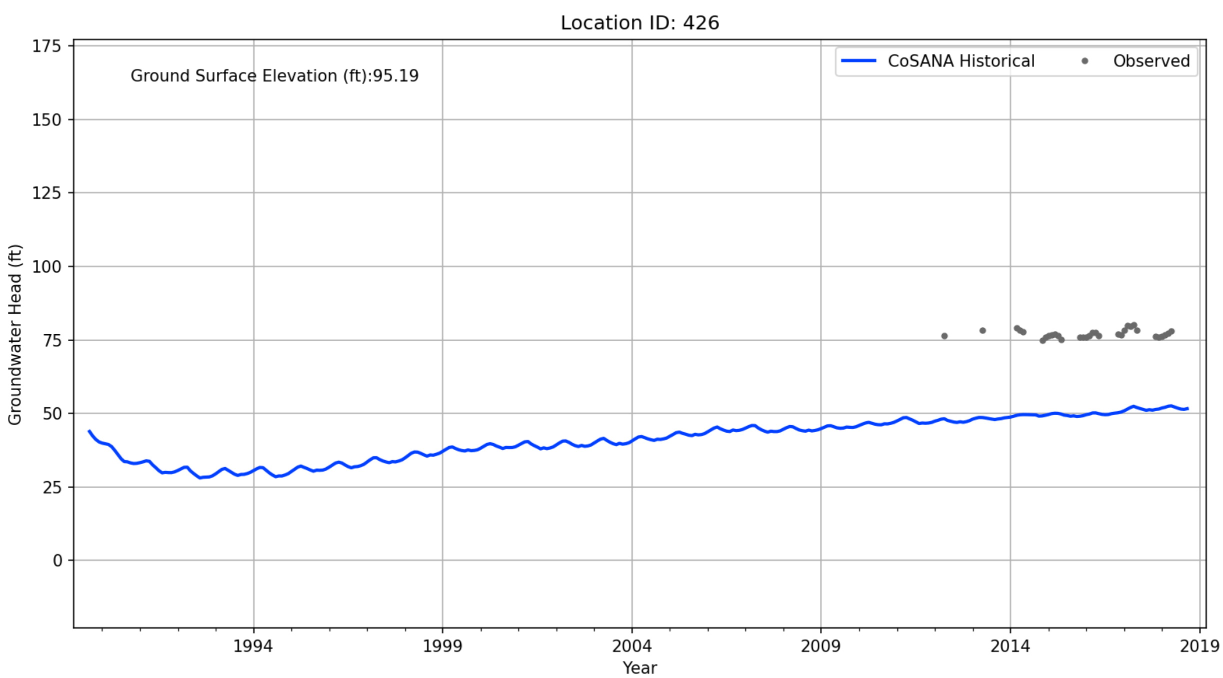


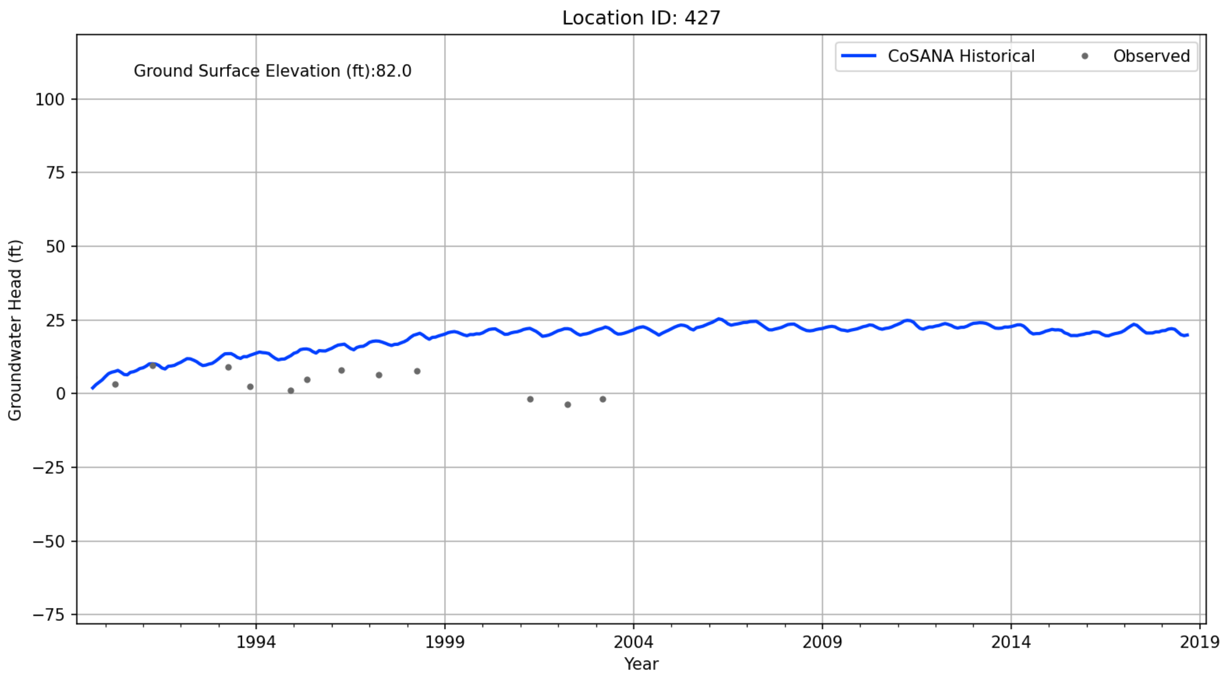
Location ID: 423
Ground Surface Elevation (ft):95.19
CoSANA Historical
Observed
Groundwater Head (ft)
150
125
100
75
50
25
0
−25
1994
1999
2004
2009
2014
2019
Year

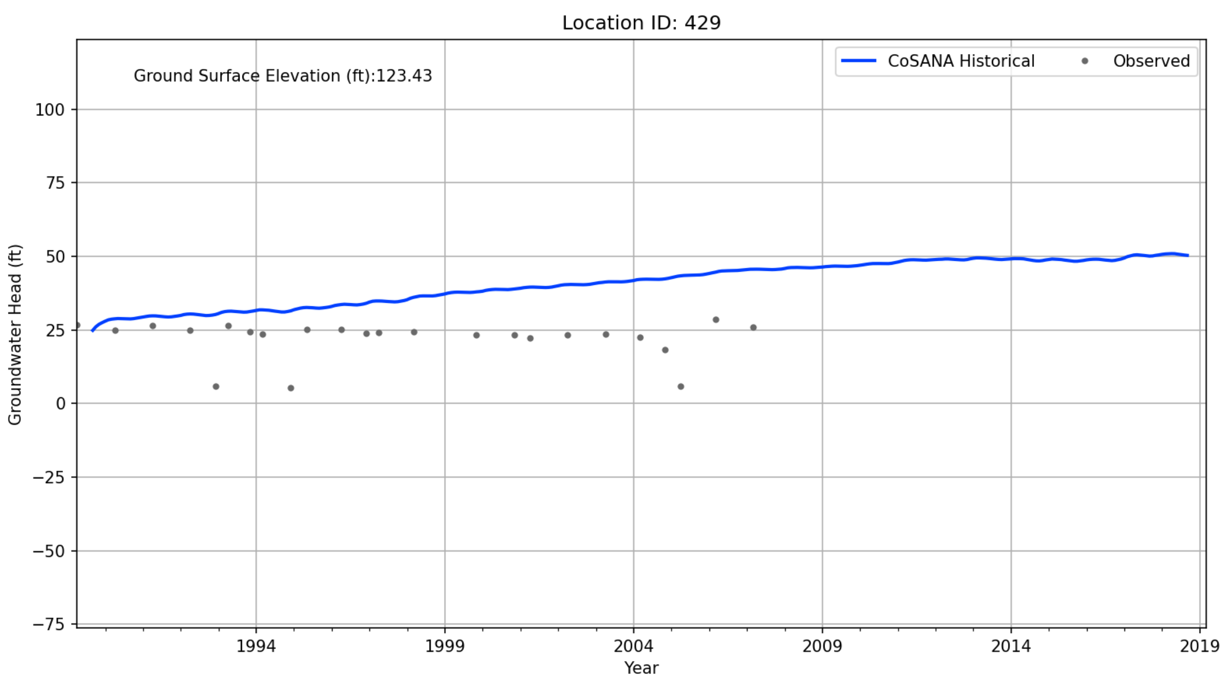



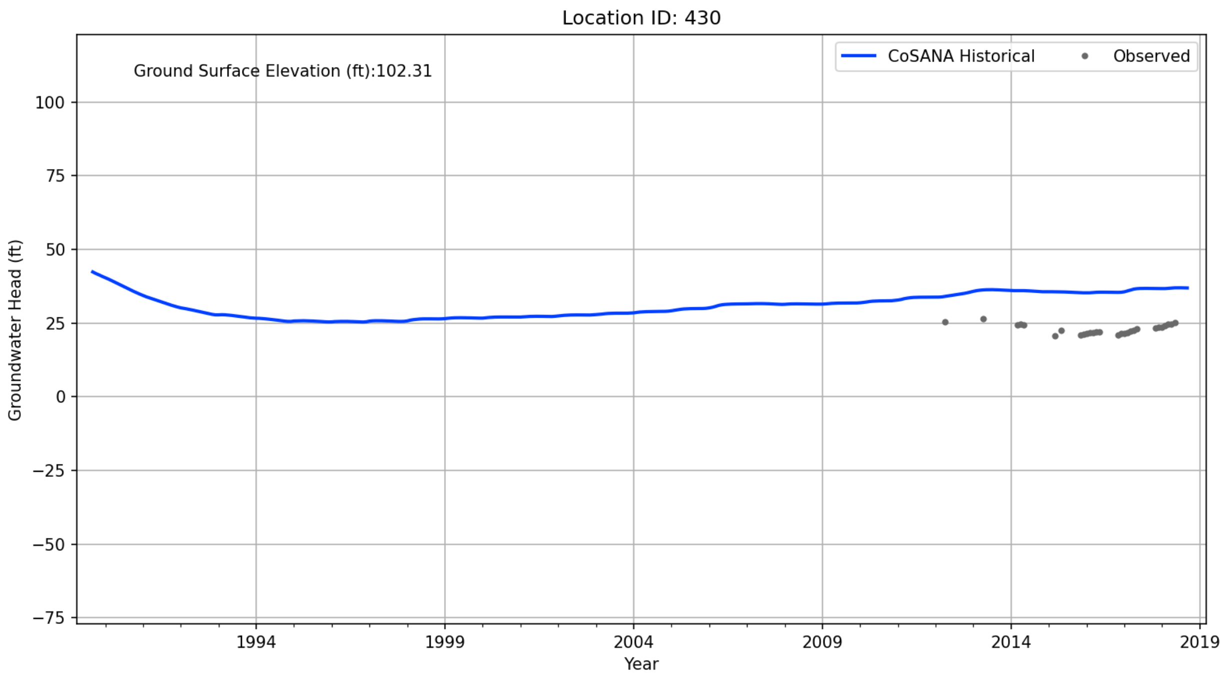
Location ID: 424
Ground Surface Elevation (ft):95.19
CoSANA Historical
Observed
Groundwater Head (ft)
150
125
100
75
50
25
0
−25
1994
1999
2004
2009
2014
2019
Year


Location ID: 425
Ground Surface Elevation (ft):95.19
CoSANA Historical
Observed
Groundwater Head (ft)
150
125
100
75
50
25
0
−25
1994
1999
2004
2009
2014
2019
Year

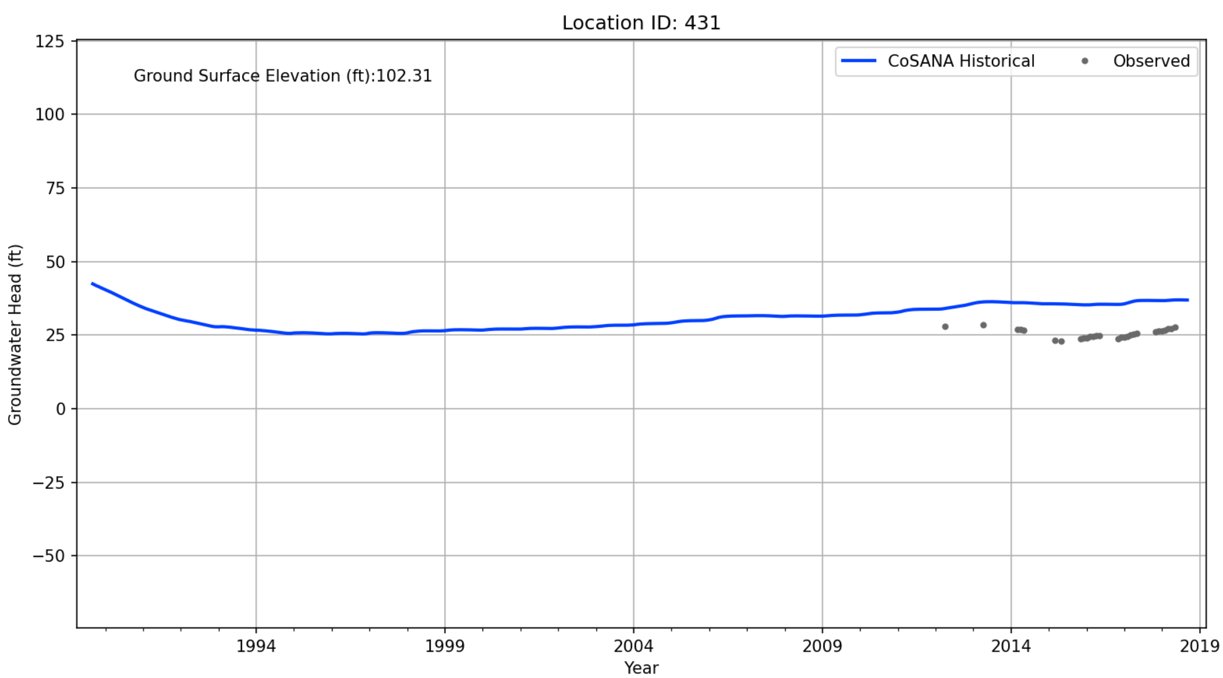

Location ID: 426
Ground Surface Elevation (ft):95.19
CoSANA Historical
Observed
Groundwater Head (ft)
175
150
125
100
75
50
25
0
1994
1999
2004
2009
2014
2019
Year


Location ID: 427
Ground Surface Elevation (ft):82.0
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

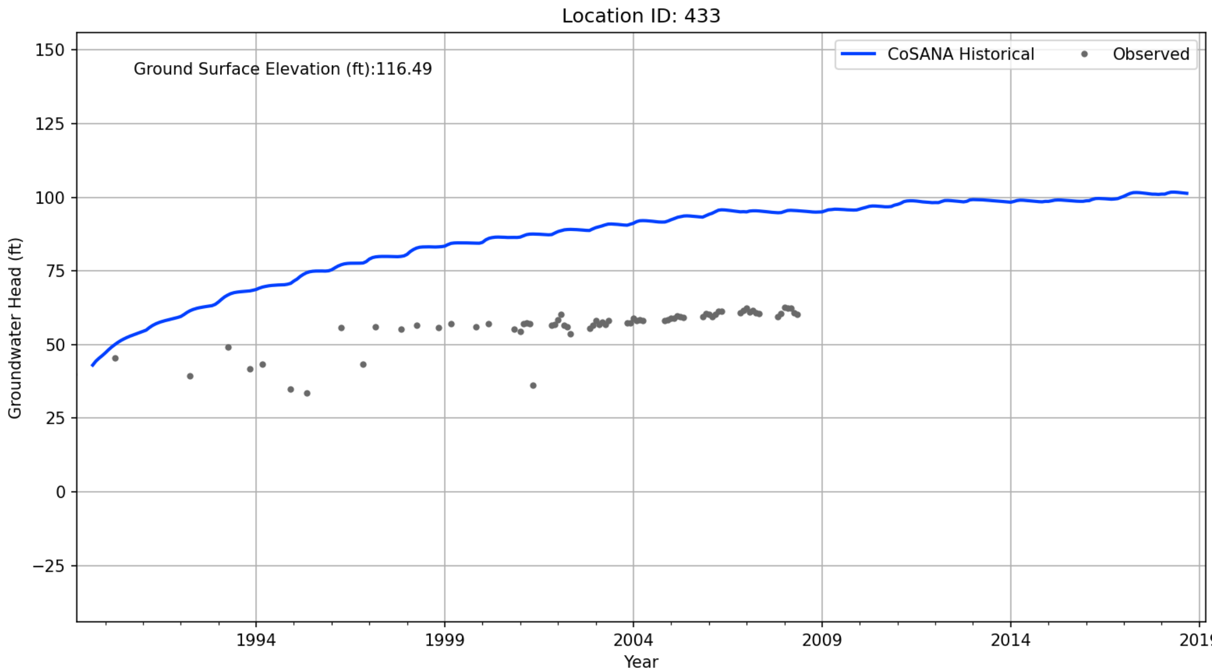

Location ID: 429
Ground Surface Elevation (ft):123.43
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

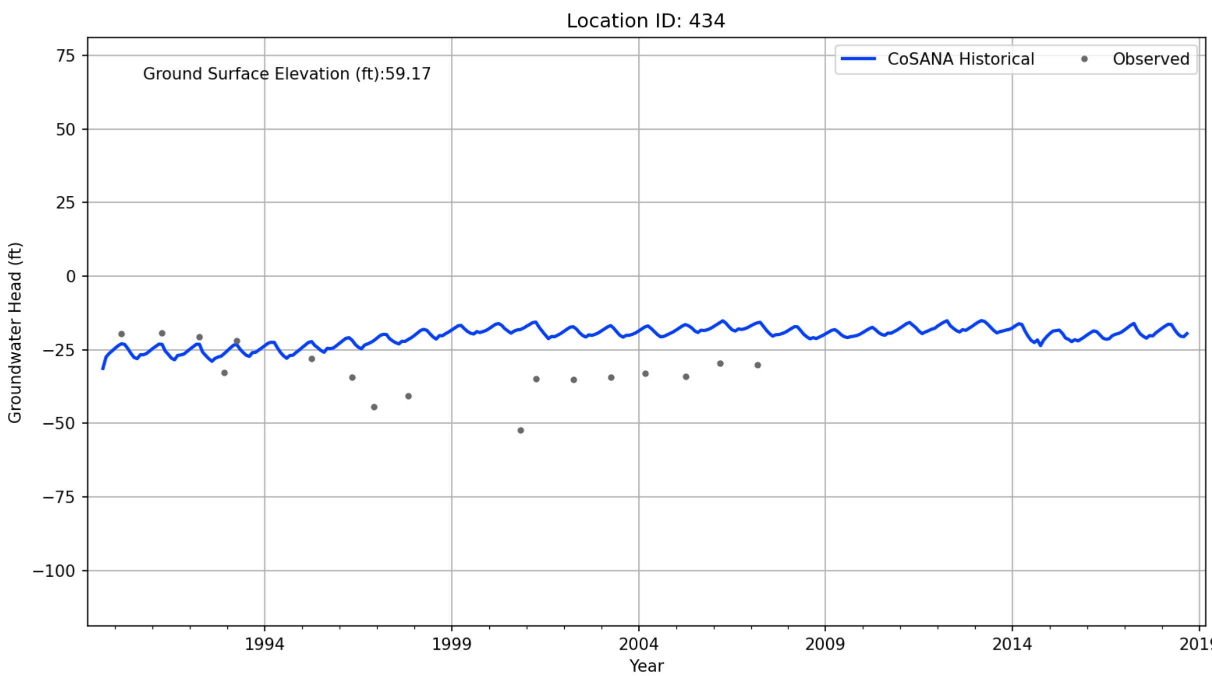


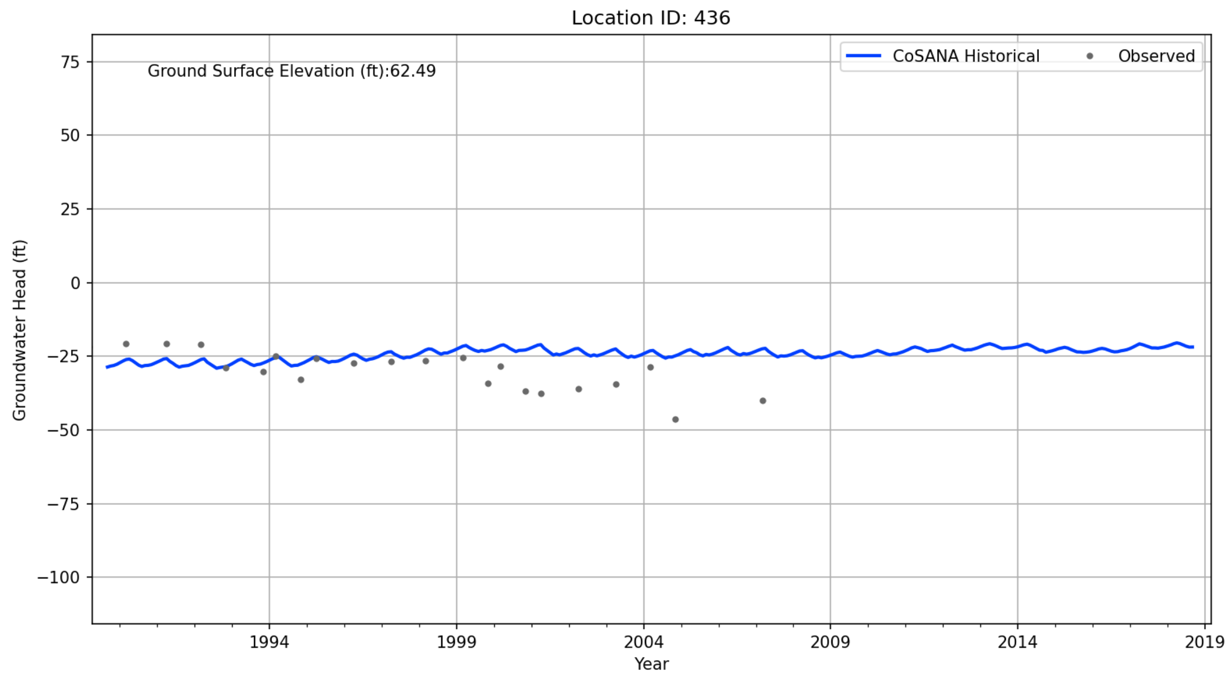
Location ID: 430
Ground Surface Elevation (ft):102.31
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

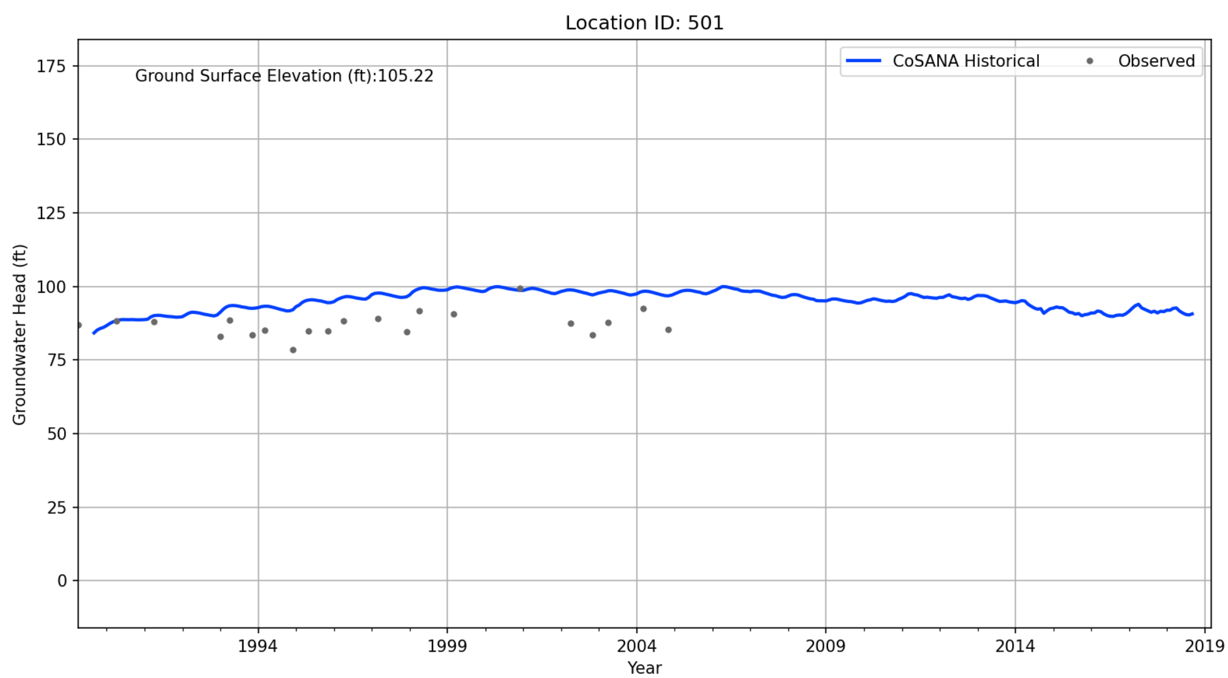
Location ID: 431
Ground Surface Elevation (ft):102.31
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year


Location ID: 433
Ground Surface Elevation (ft):116.49
CoSANA Historical
Observed
Groundwater Head (ft)
Year
150
125
100
75
50
25
0
−25
1994
1999
2004
2009
2014
2019

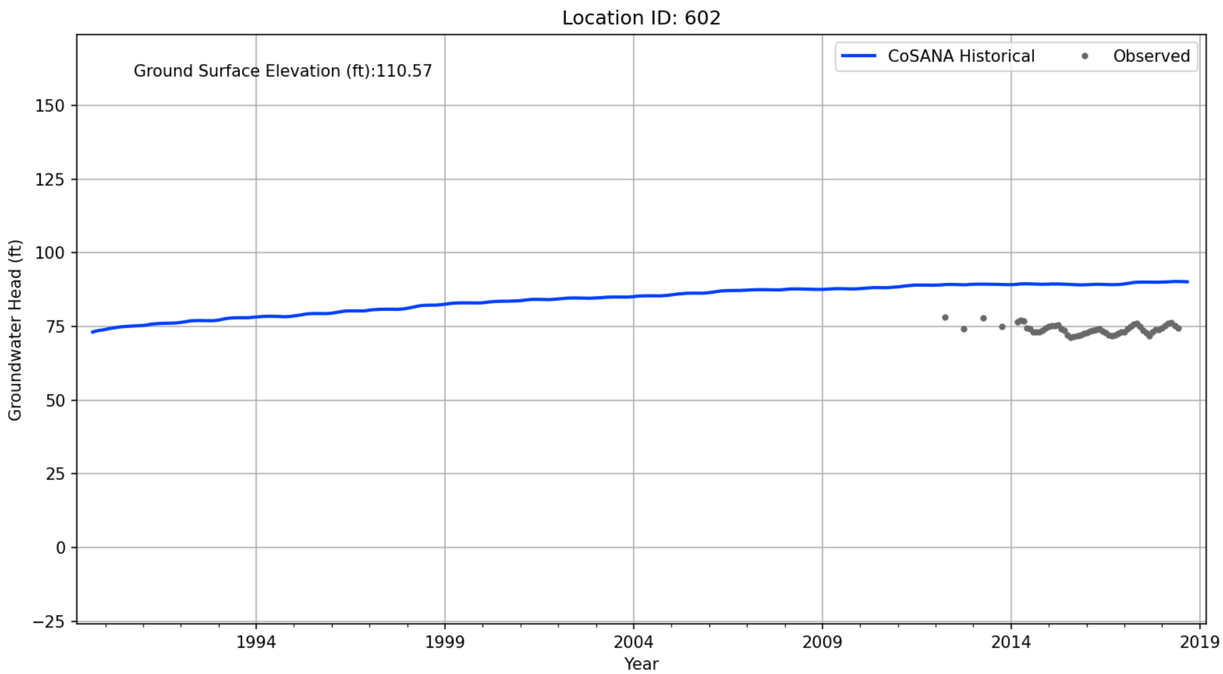

Location ID: 434
Ground Surface Elevation (ft):59.17
CoSANA Historical
Observed
Groundwater Head (ft)
Year
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019

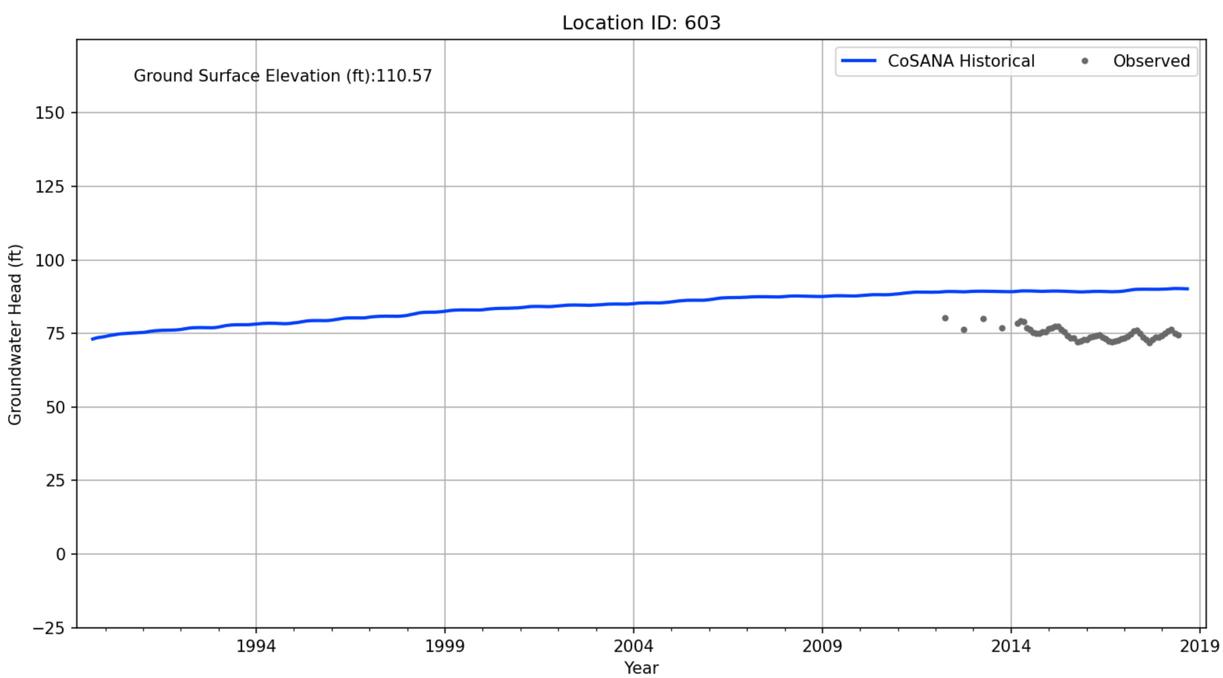


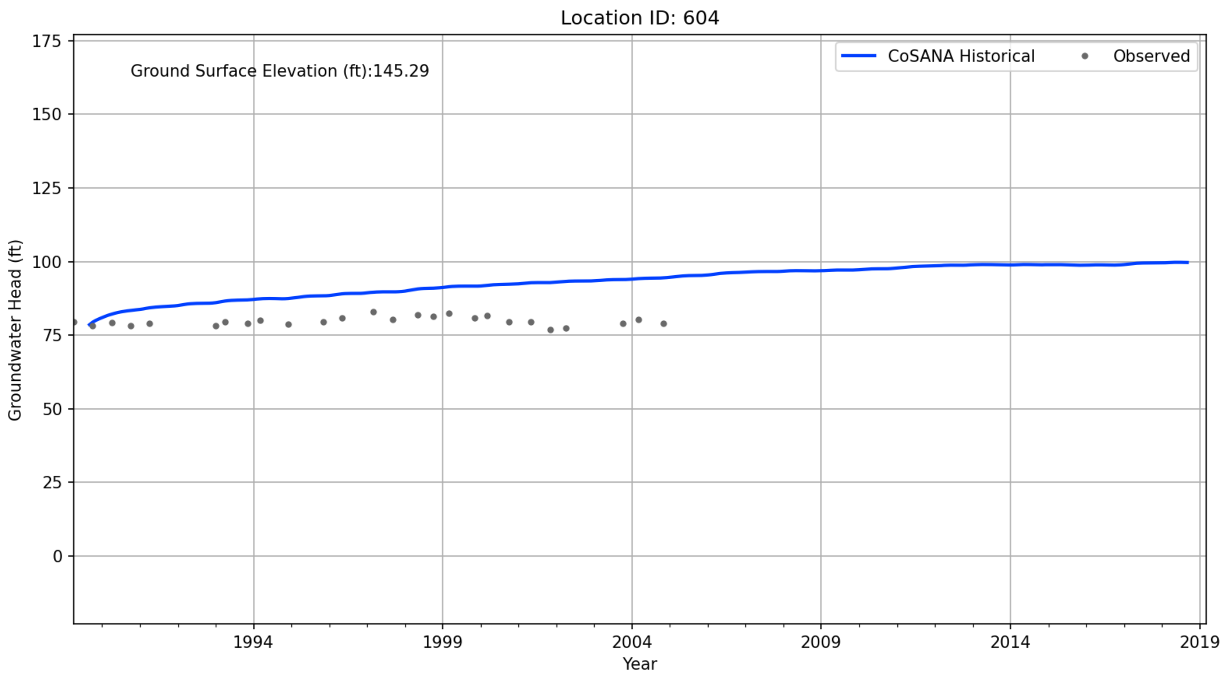
Location ID: 436
CoSANA Historical
Observed
Ground Surface Elevation (ft):62.49
Groundwater Head (ft)
Year

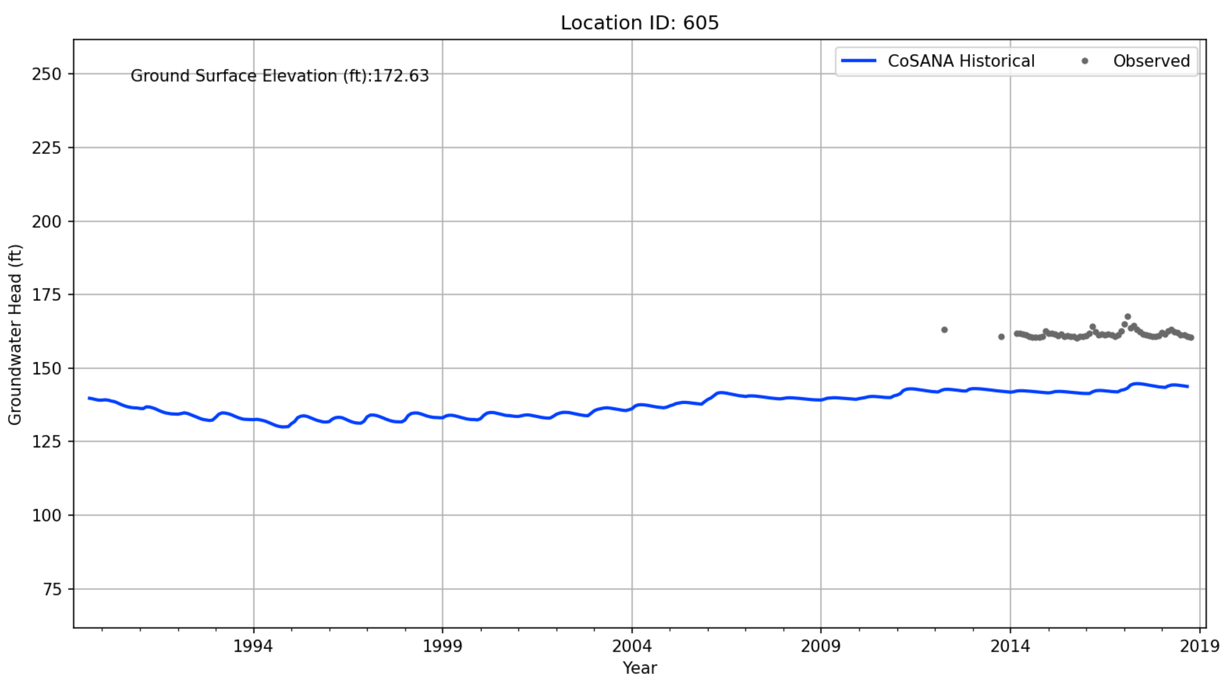



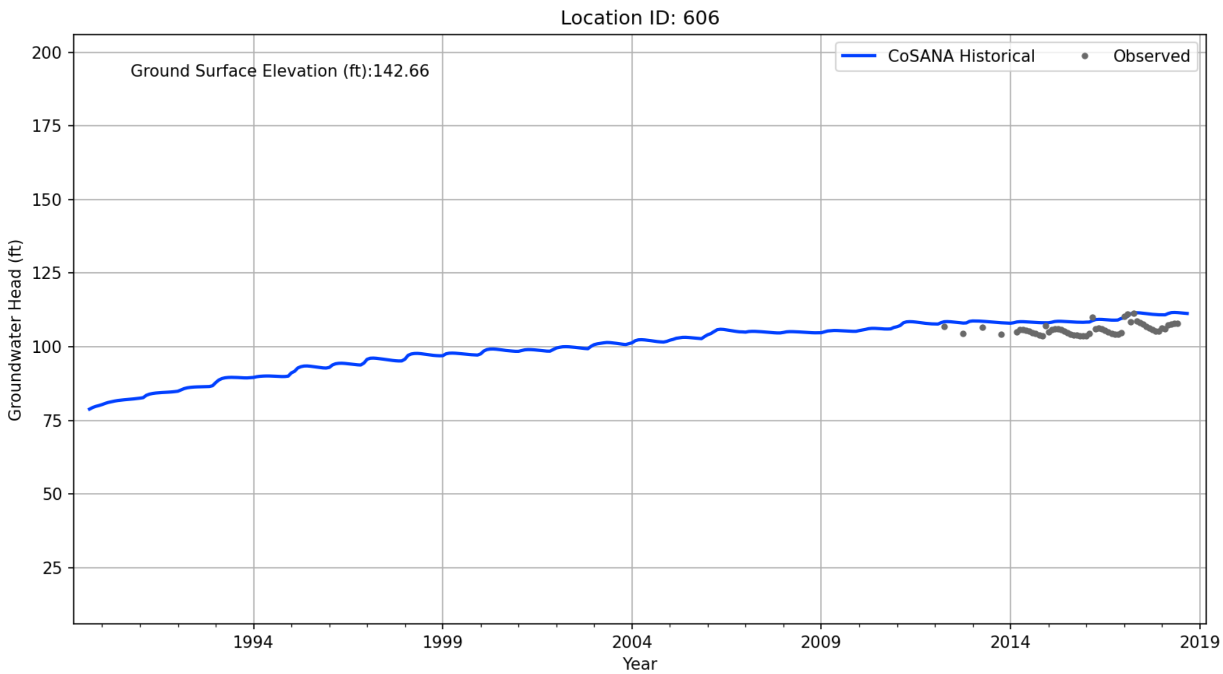
Location ID: 501
CoSANA Historical
Observed
Ground Surface Elevation (ft):105.22
Groundwater Head (ft)
Year

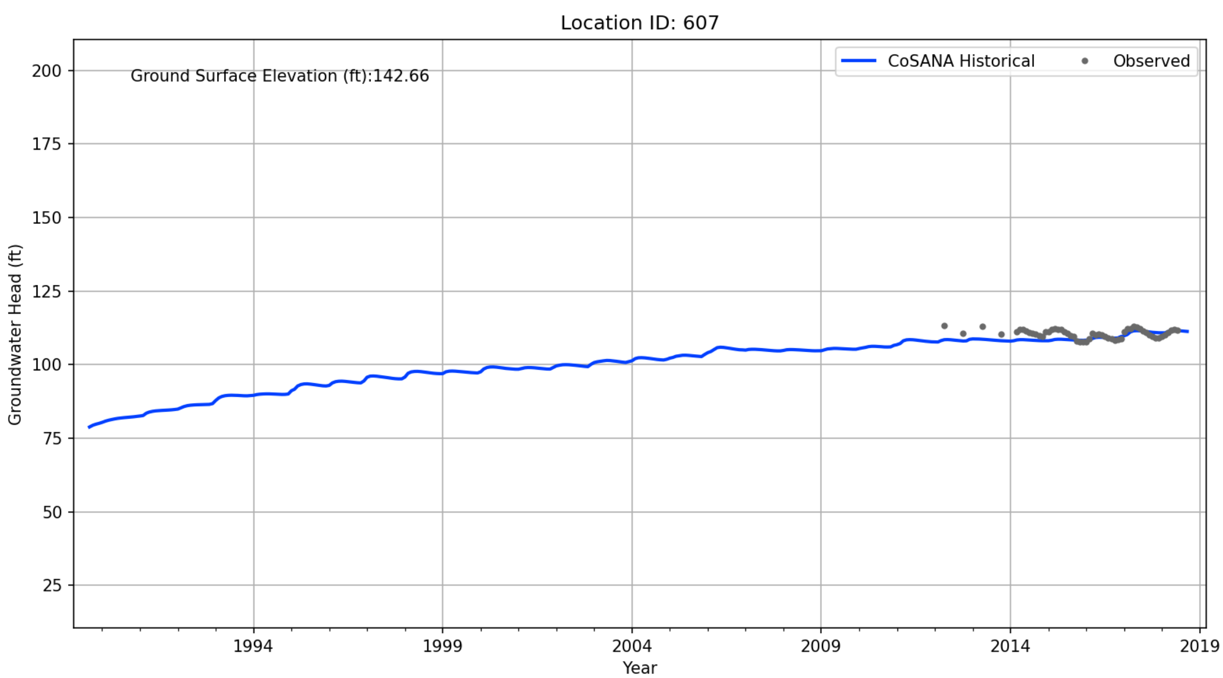

Location ID: 602
CoSANA Historical
Observed
Ground Surface Elevation (ft):110.57
Groundwater Head (ft)
150
125
100
75
50
25
0
−25
1994
1999
2004
2009
2014
2019
Year

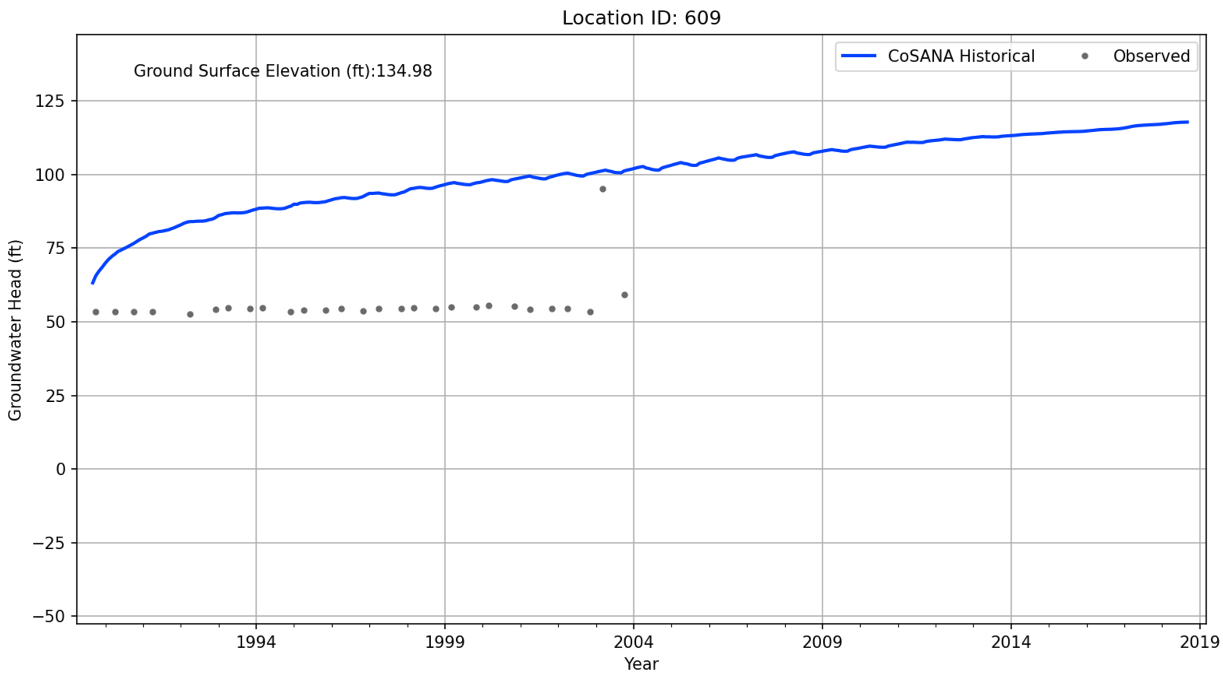

Location ID: 603
CoSANA Historical
Observed
Ground Surface Elevation (ft):110.57
Groundwater Head (ft)
150
125
100
75
50
25
0
−25
1994
1999
2004
2009
2014
2019
Year

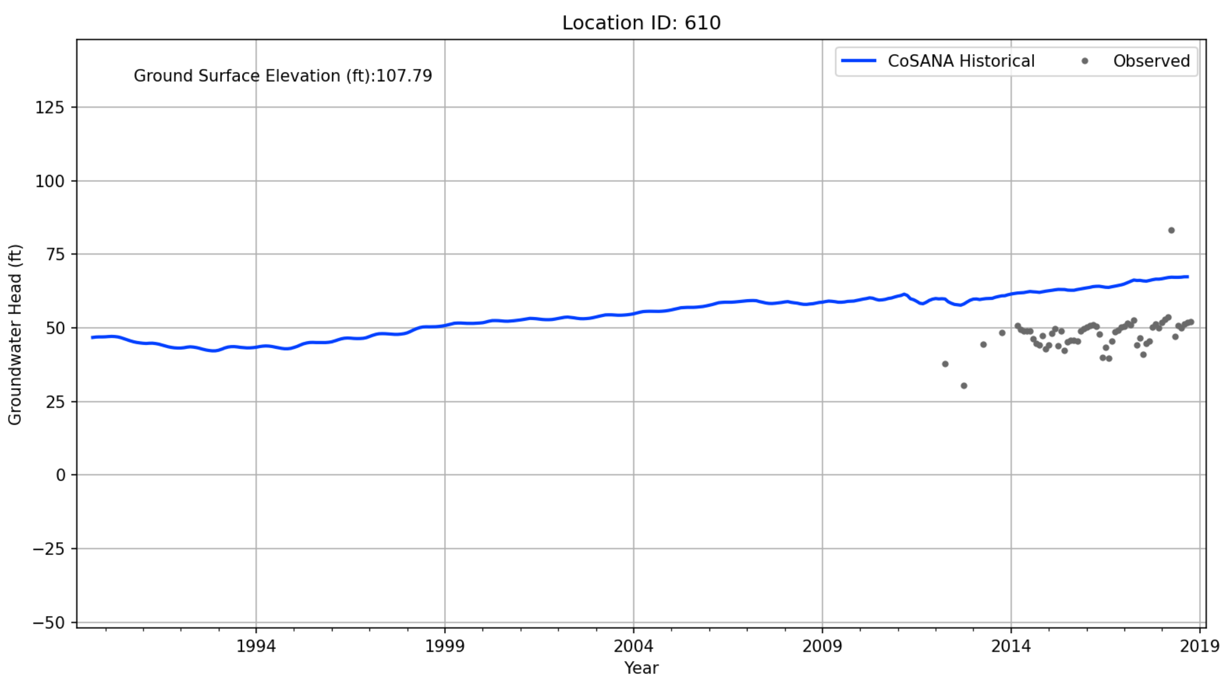

Location ID: 604
Ground Surface Elevation (ft):145.29
CoSANA Historical
Observed
Groundwater Head (ft)
175
150
125
100
75
50
25
0
1994
1999
2004
2009
2014
2019
Year


Location ID: 605
Ground Surface Elevation (ft):172.63
CoSANA Historical
Observed
Groundwater Head (ft)
250
225
200
175
150
125
100
75
1994
1999
2004
2009
2014
2019
Year


Location ID: 606
CoSANA Historical
Observed
Ground Surface Elevation (ft):142.66
Groundwater Head (ft)
200
175
150
125
100
75
50
25
1994
1999
2004
2009
2014
2019
Year


Location ID: 607
CoSANA Historical
Observed
Ground Surface Elevation (ft):142.66
Groundwater Head (ft)
200
175
150
125
100
75
50
25
1994
1999
2004
2009
2014
2019
Year


Location ID: 609
Ground Surface Elevation (ft):134.98
CoSANA Historical
Observed
Groundwater Head (ft)
Year
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019


Location ID: 610
Ground Surface Elevation (ft):107.79
CoSANA Historical
Observed
Groundwater Head (ft)
Year
125
100
75
50
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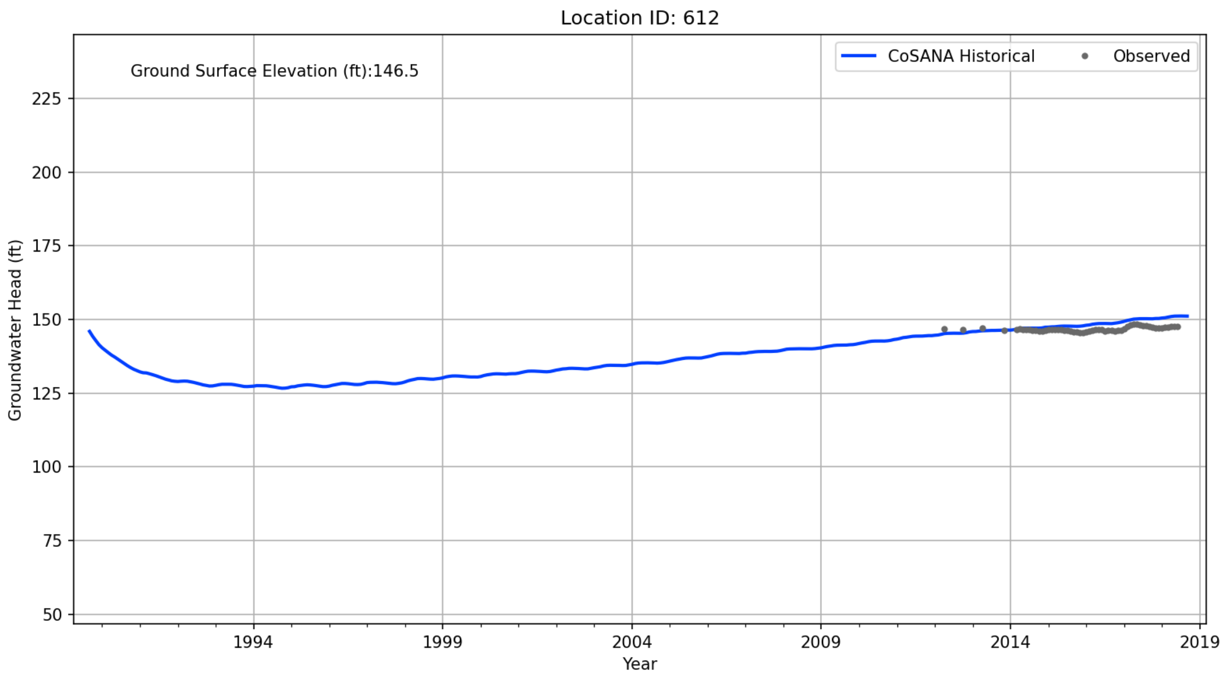
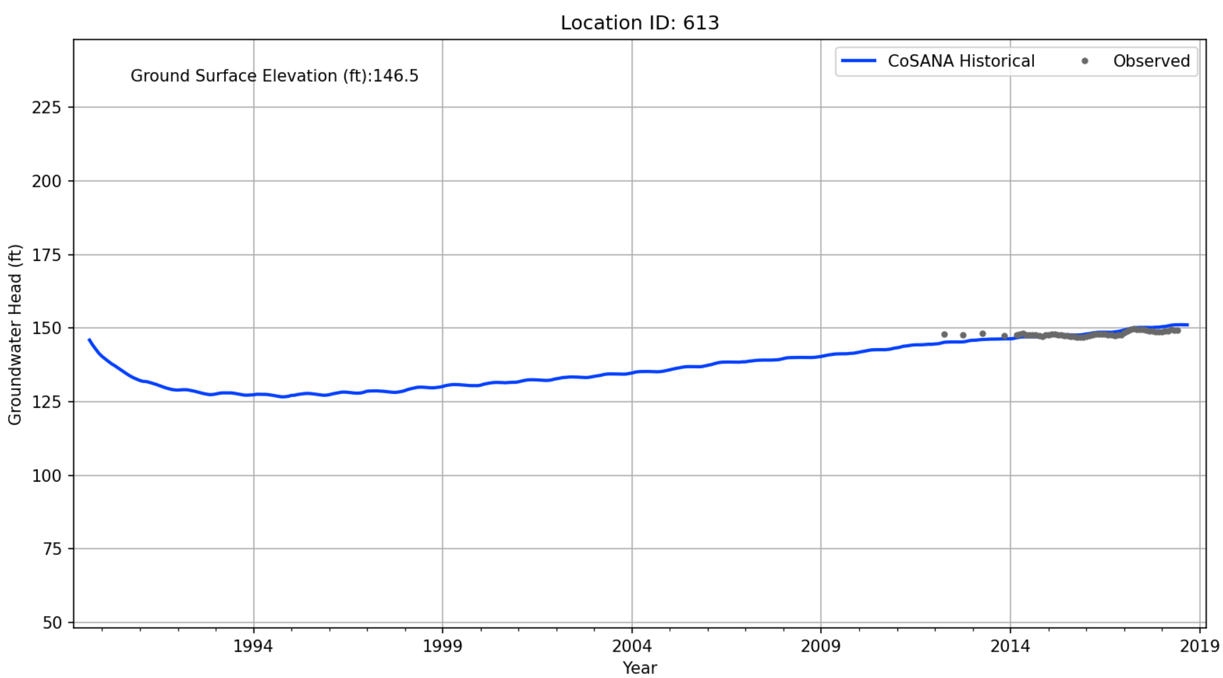
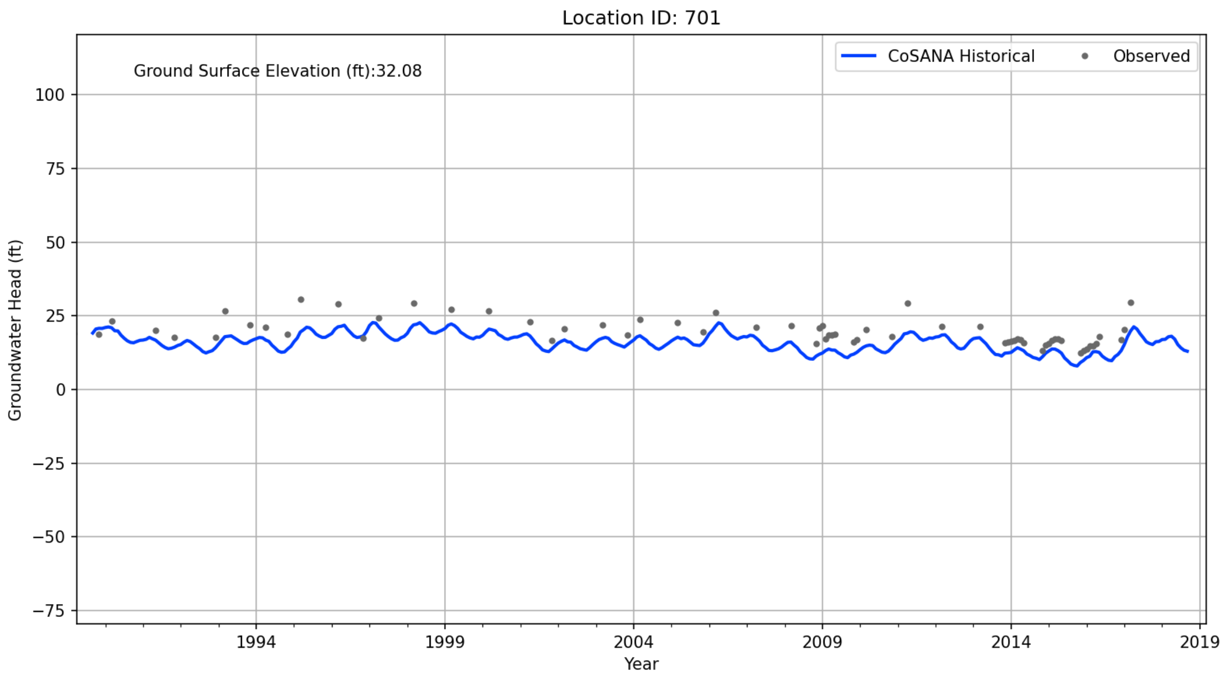
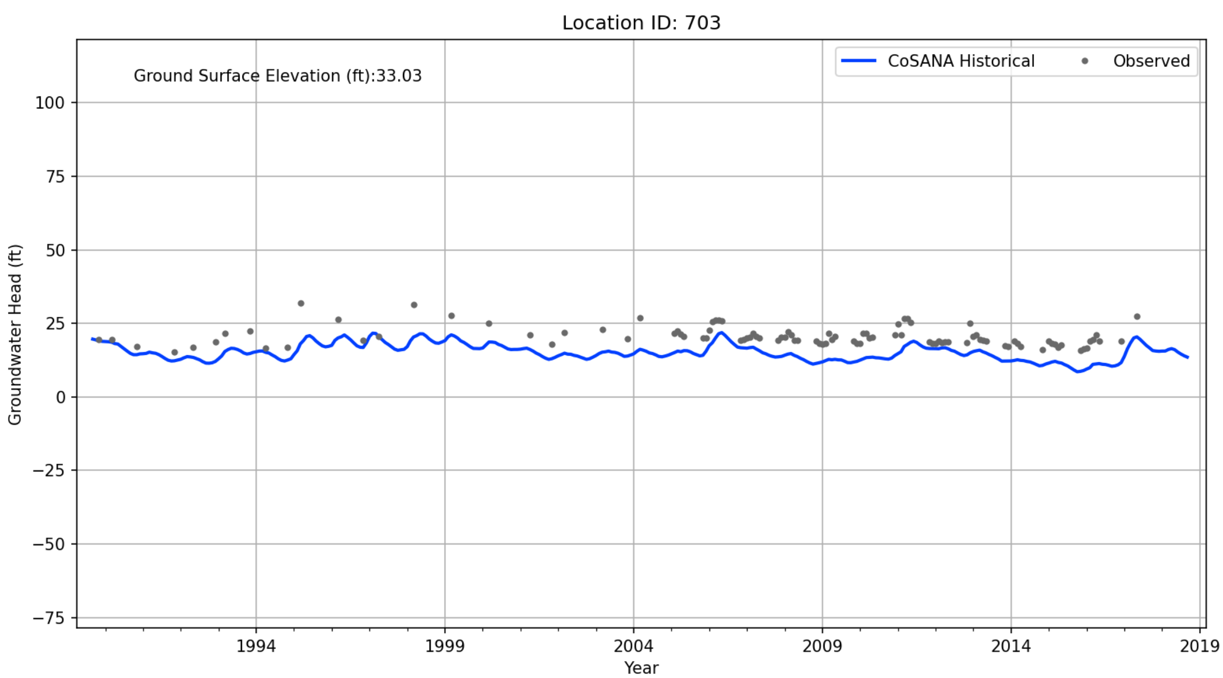
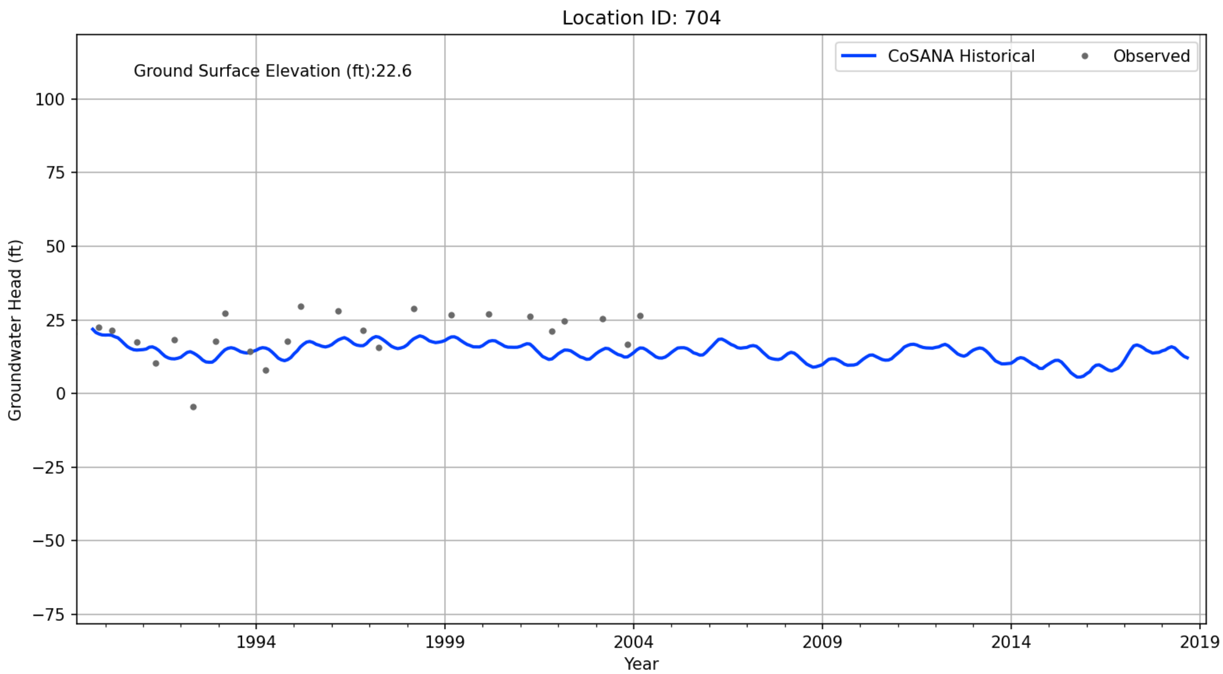
0
−25
−50
1994
1999
2004
2009
2014
2019

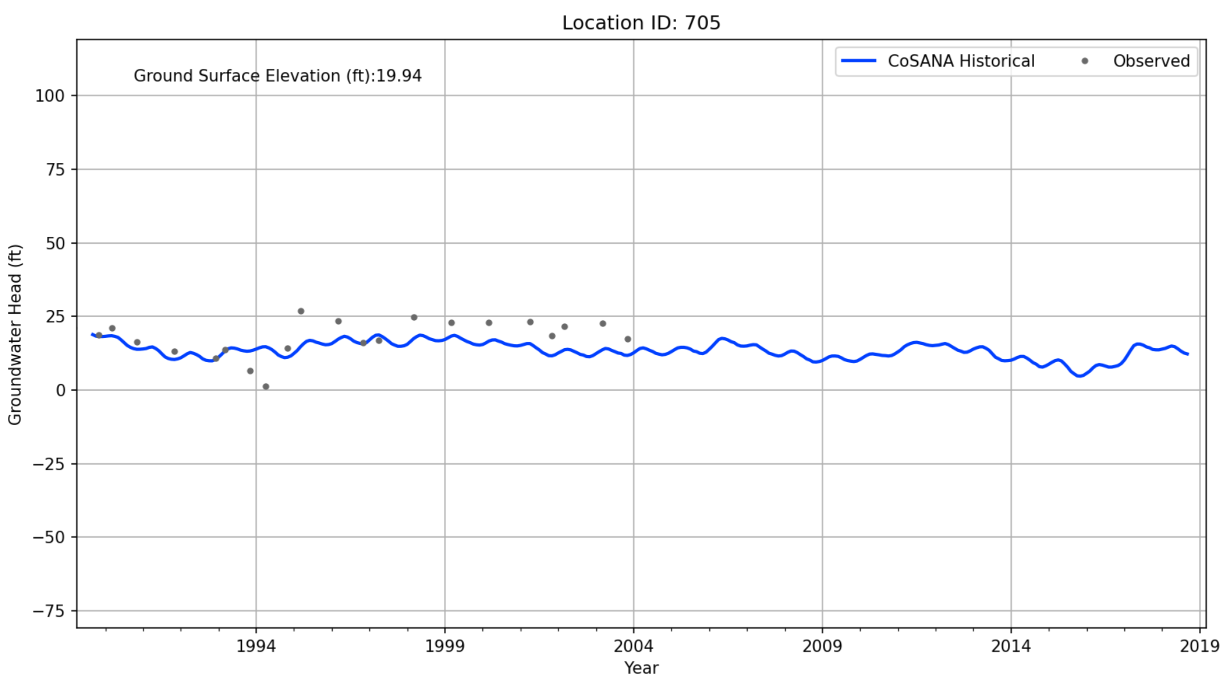

Location ID: 612
CoSANA Historical
Observed
Ground Surface Elevation (ft):146.5
Groundwater Head (ft)
225
200
175
150
125
100
75
50
1994
1999
2004
2009
2014
2019
Year

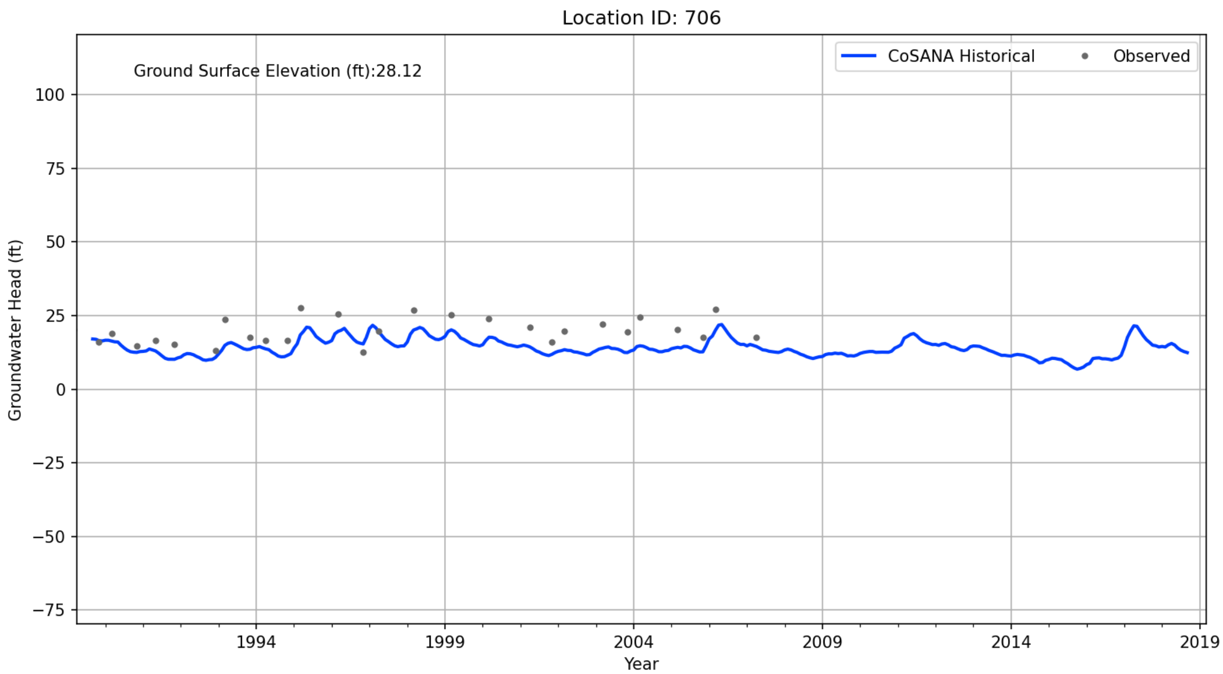

Location ID: 613
CoSANA Historical
Observed
Ground Surface Elevation (ft):146.5
Groundwater Head (ft)
225
200
175
150
125
100
75
50
1994
1999
2004
2009
2014
2019
Year

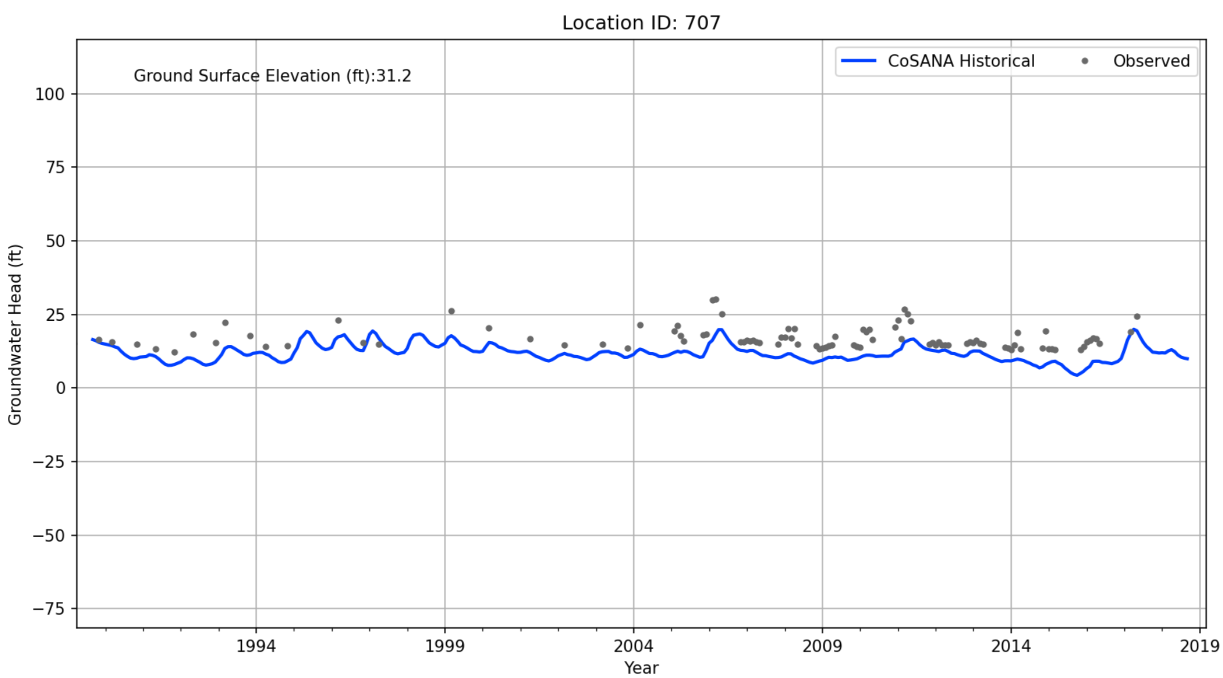

Location ID: 701
Ground Surface Elevation (ft):32.08
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

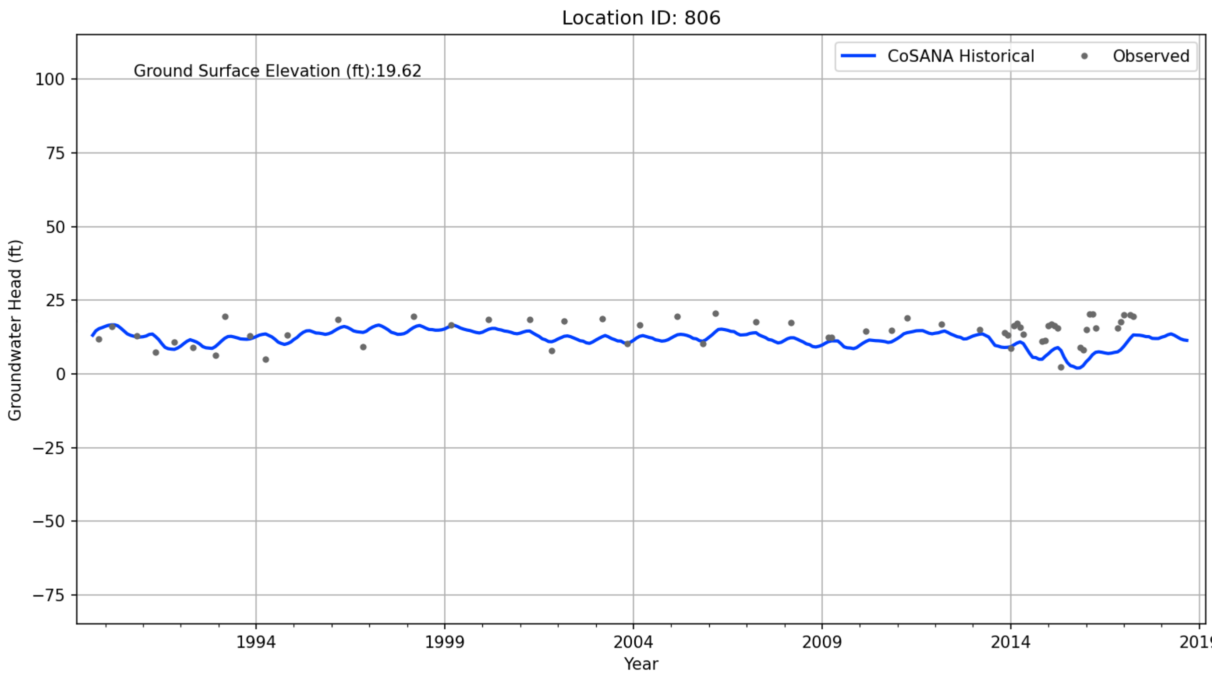

Location ID: 703
Ground Surface Elevation (ft):33.03
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

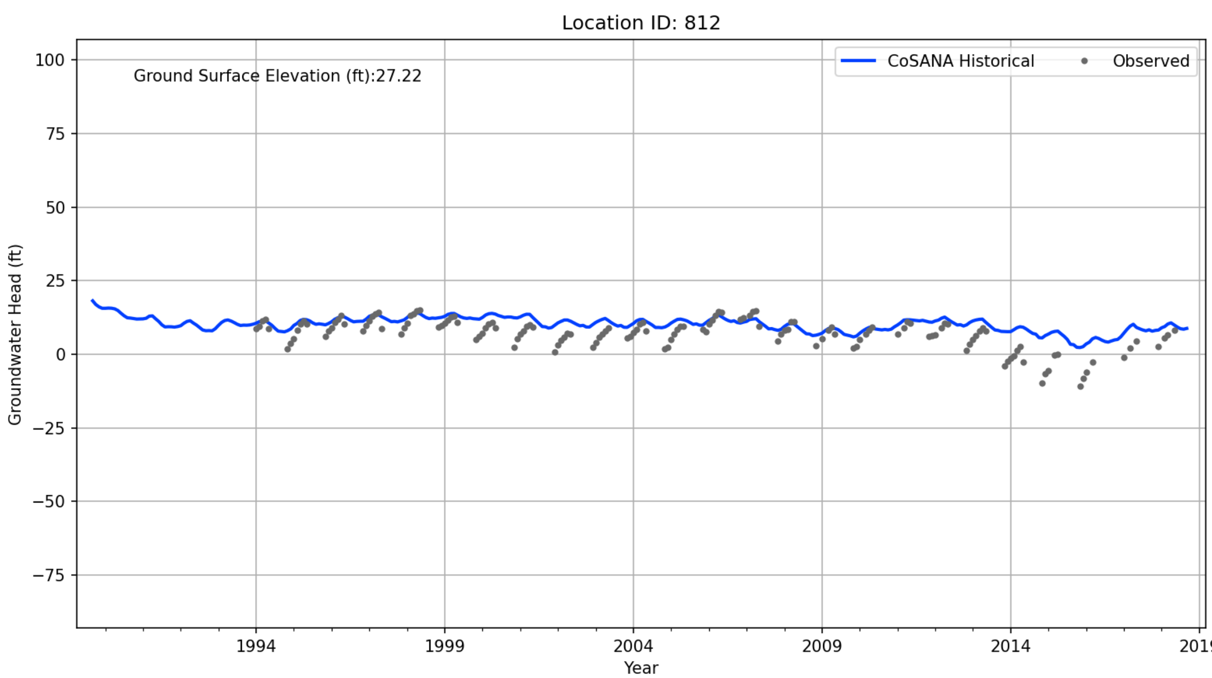

Location ID: 704
Ground Surface Elevation (ft):22.6
CoSANA Historical
Observed
Groundwater Head (ft)
Year
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019

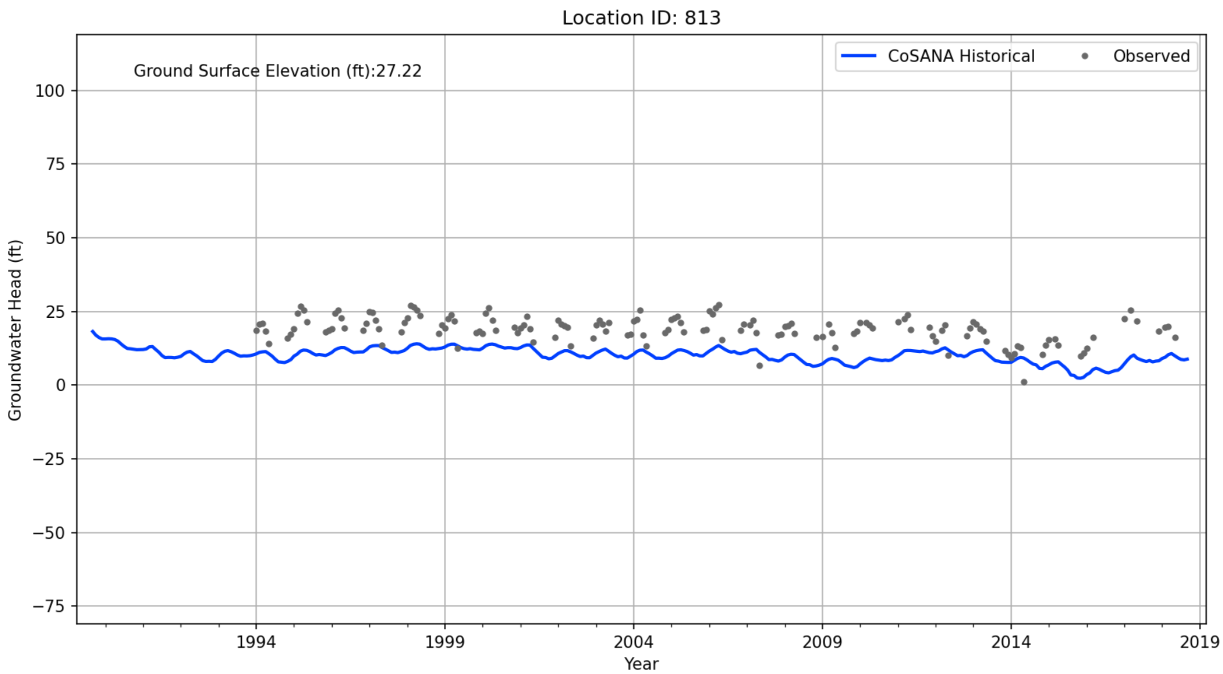

Location ID: 705
Ground Surface Elevation (ft):19.94
CoSANA Historical
Observed
Groundwater Head (ft)
Year
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019


Location ID: 706
Ground Surface Elevation (ft):28.12
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

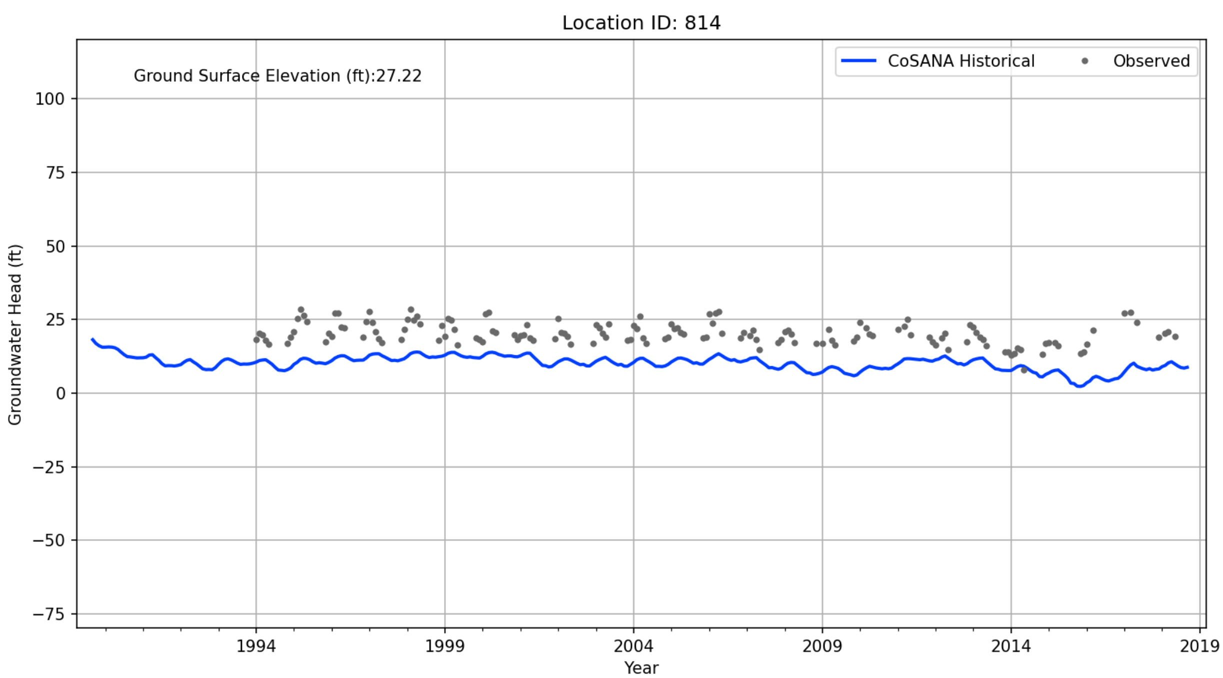

Location ID: 707
Ground Surface Elevation (ft):31.2
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year


Location ID: 806
Ground Surface Elevation (ft):19.62
CoSANA Historical
Observed
Groundwater Head (ft)
Year
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019

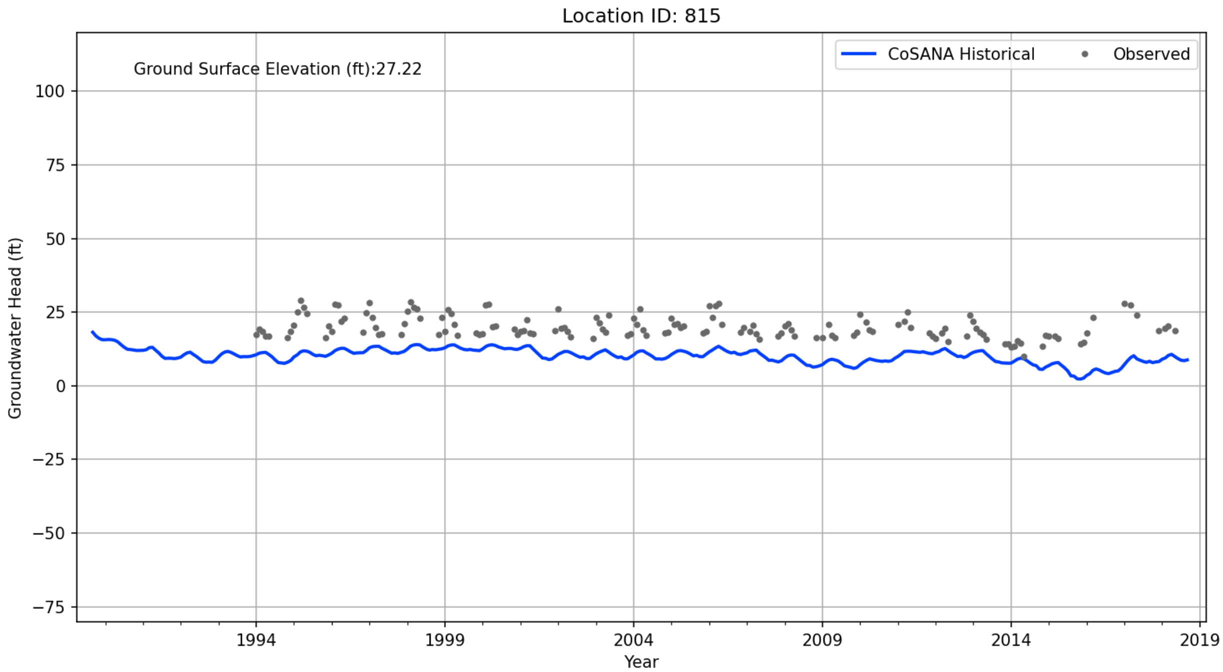

Location ID: 812
Ground Surface Elevation (ft):27.22
CoSANA Historical
Observed
Groundwater Head (ft)
Year
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019

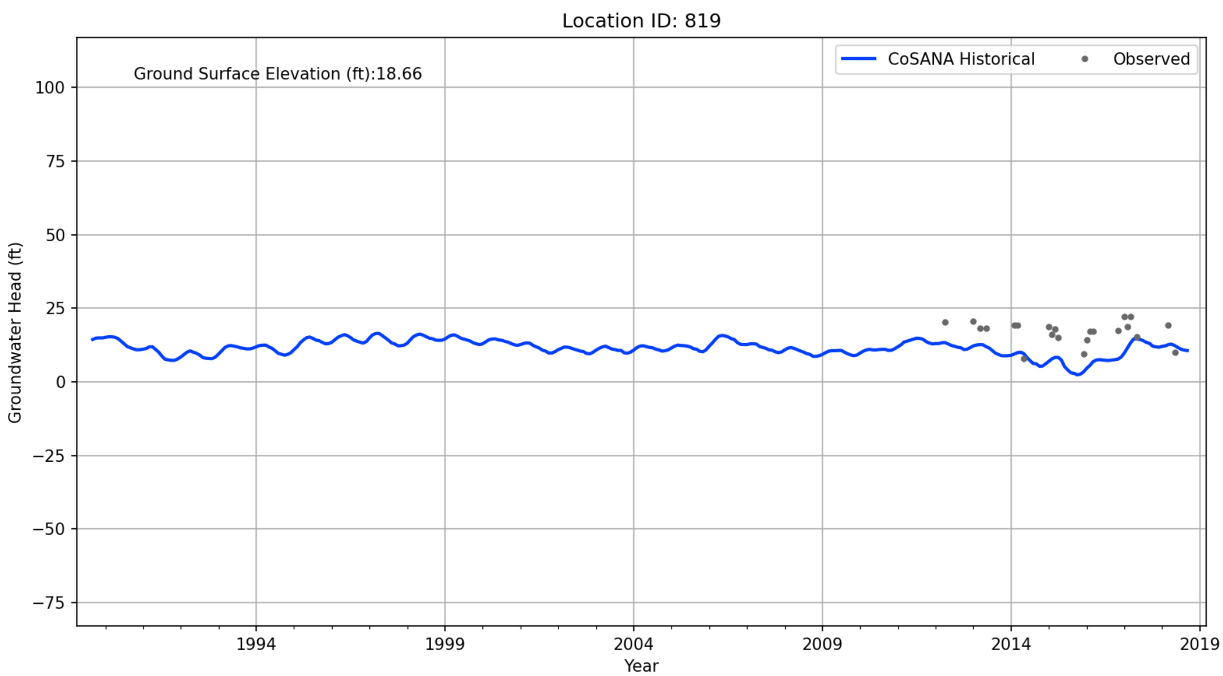


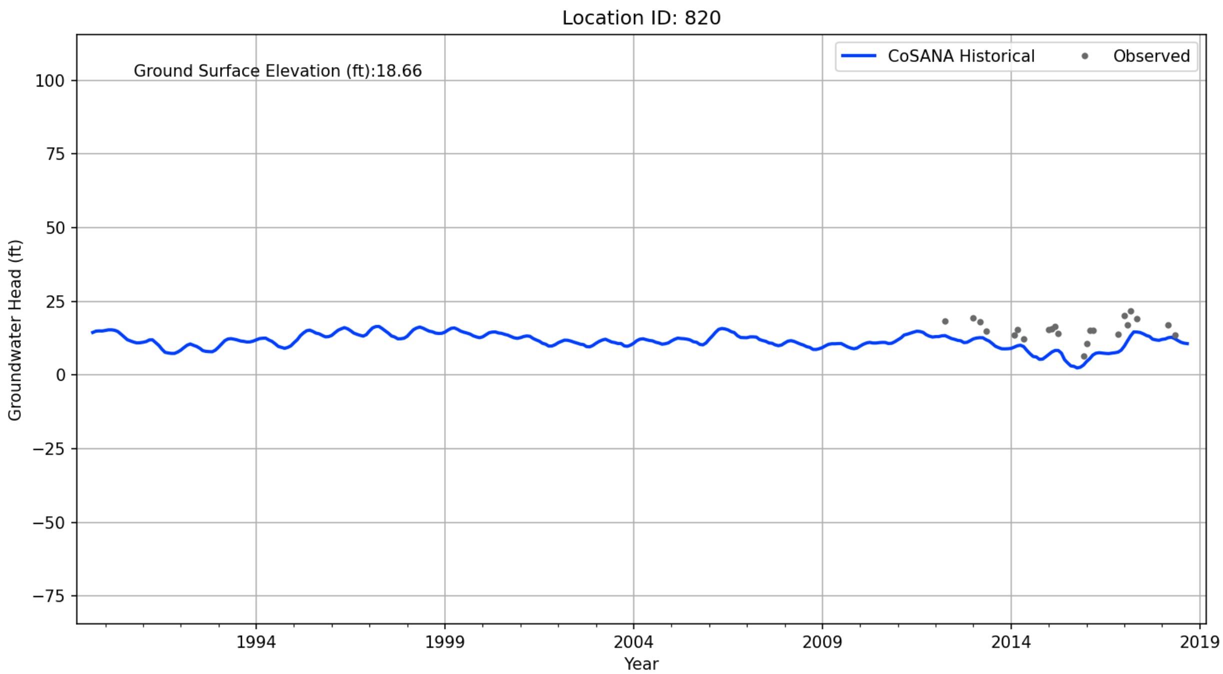
Location ID: 813
Ground Surface Elevation (ft):27.22
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

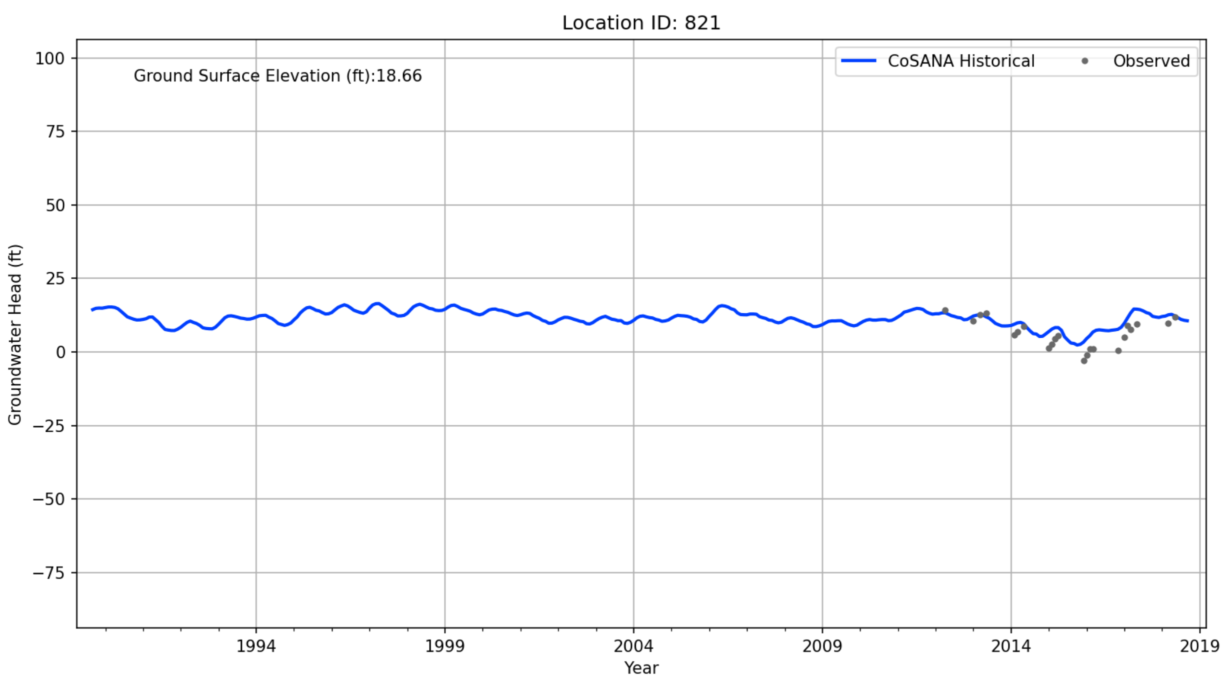
Location ID: 814
Ground Surface Elevation (ft):27.22
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year


Location ID: 815
Ground Surface Elevation (ft):27.22
CoSANA Historical
Observed
Groundwater Head (ft)
Year
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019

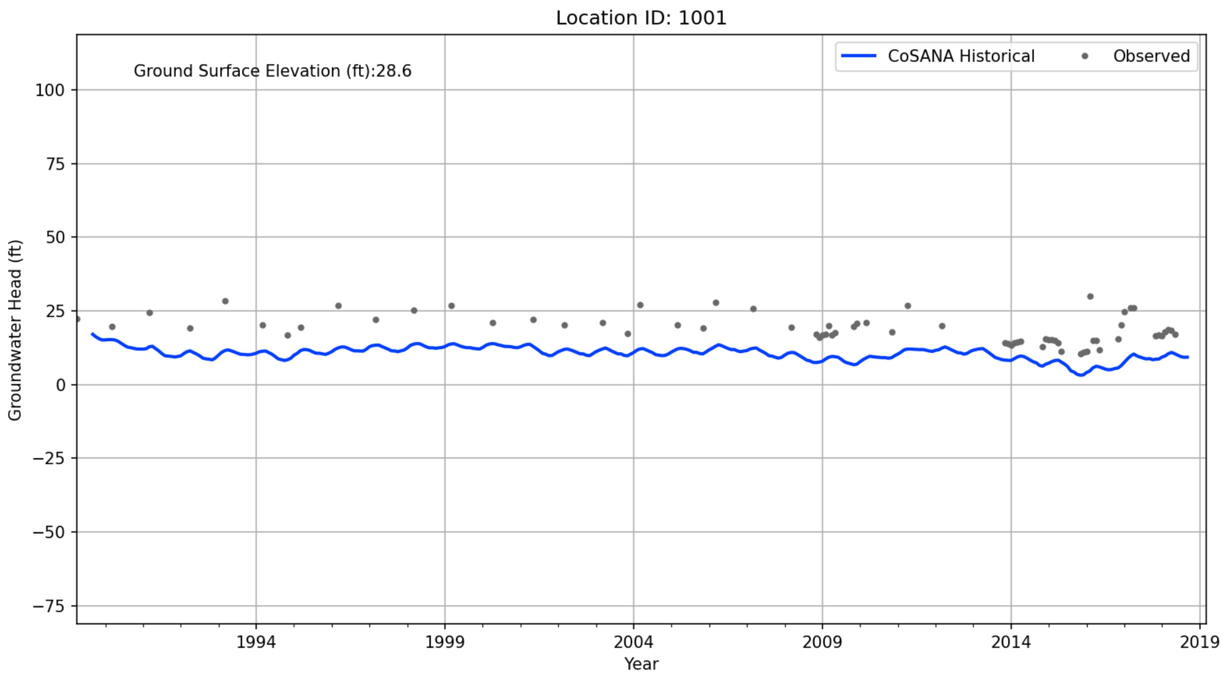

Location ID: 819
Ground Surface Elevation (ft):18.66
CoSANA Historical
Observed
Groundwater Head (ft)
Year
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019

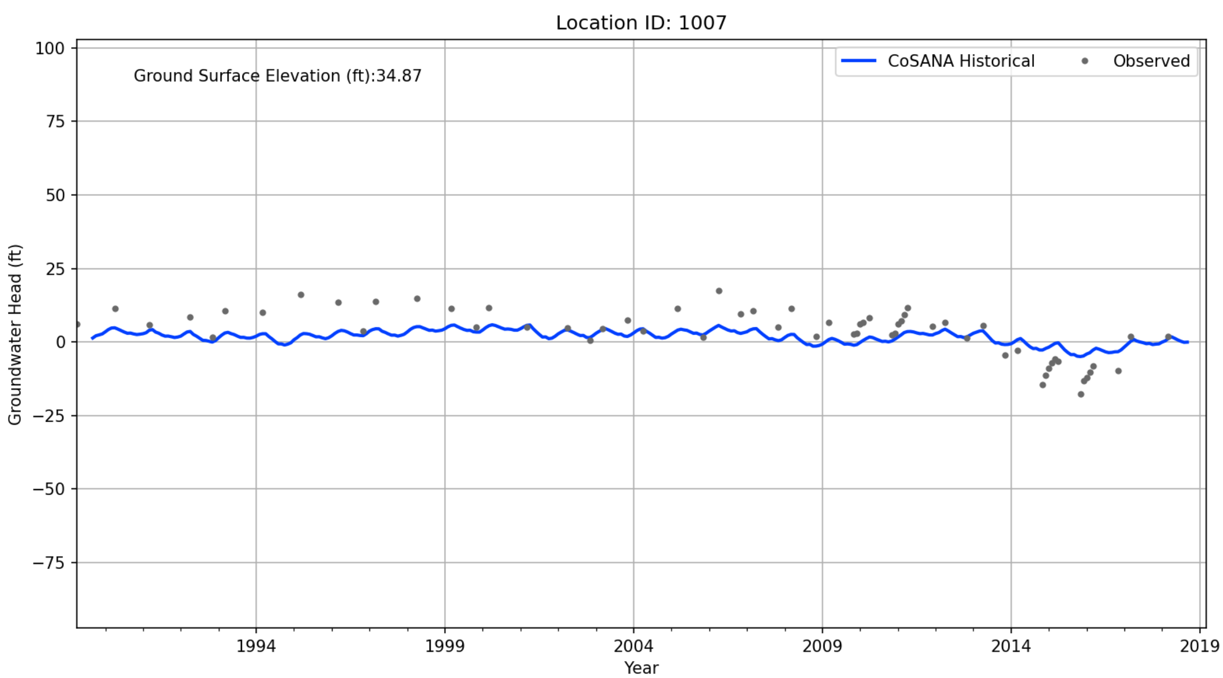


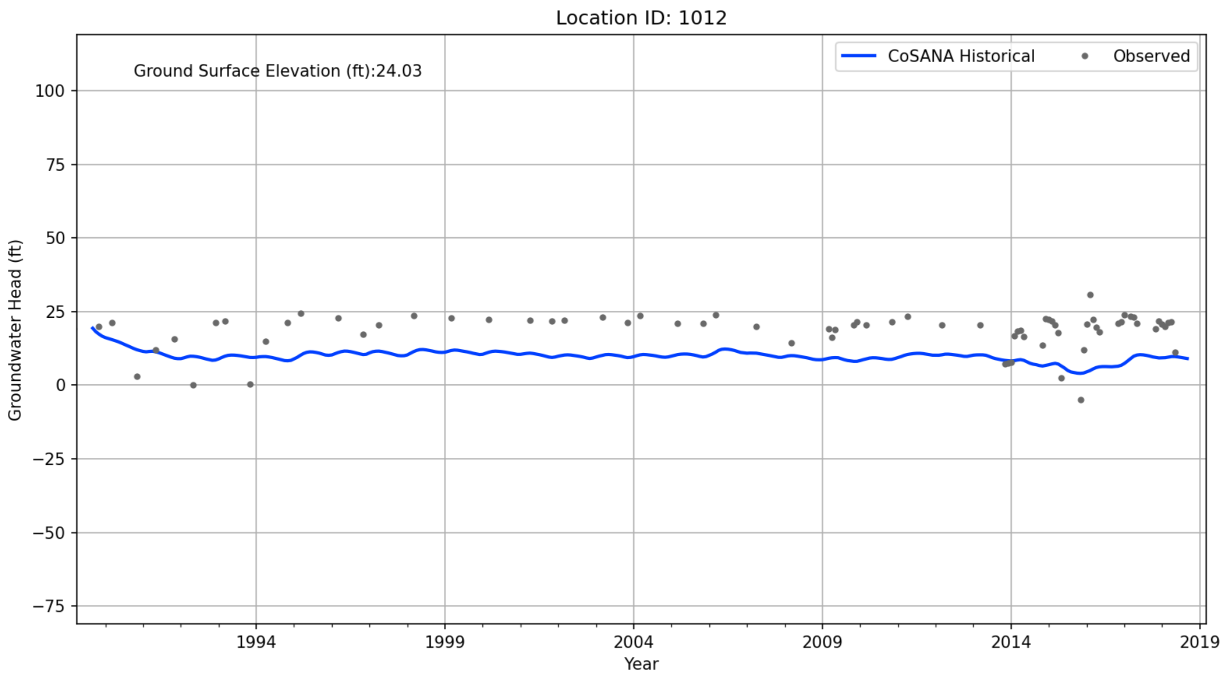
Location ID: 820
CoSANA Historical
Observed
Ground Surface Elevation (ft):18.66
Groundwater Head (ft)
Year
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019

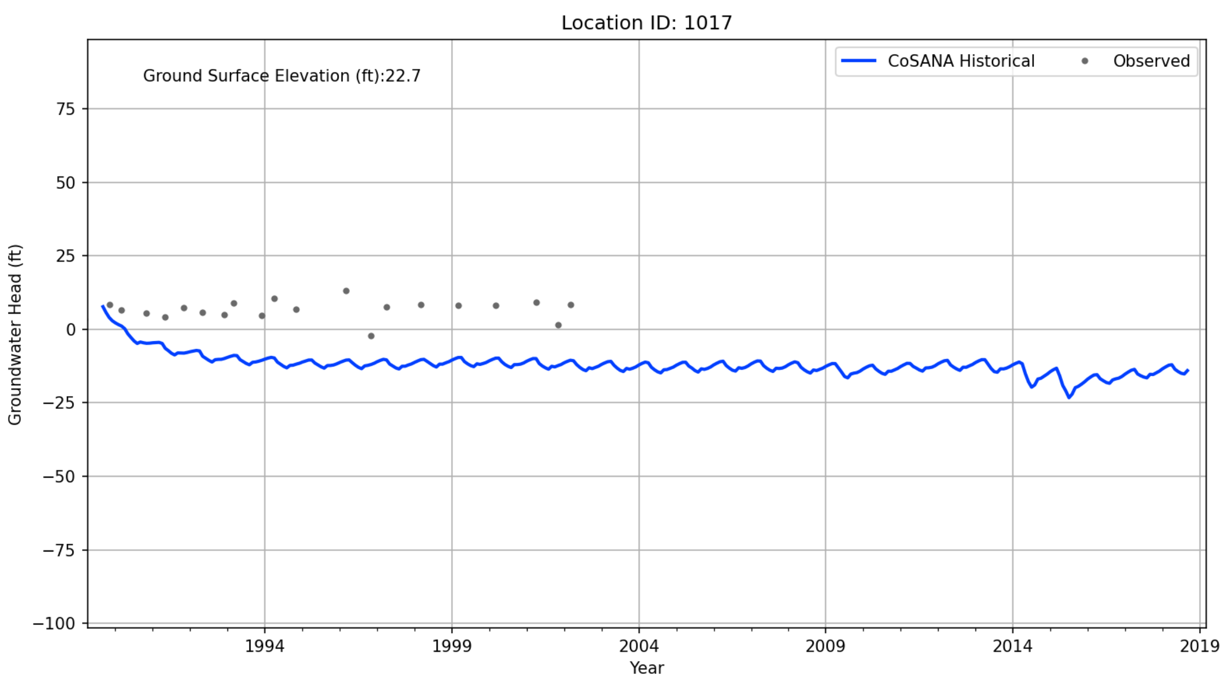



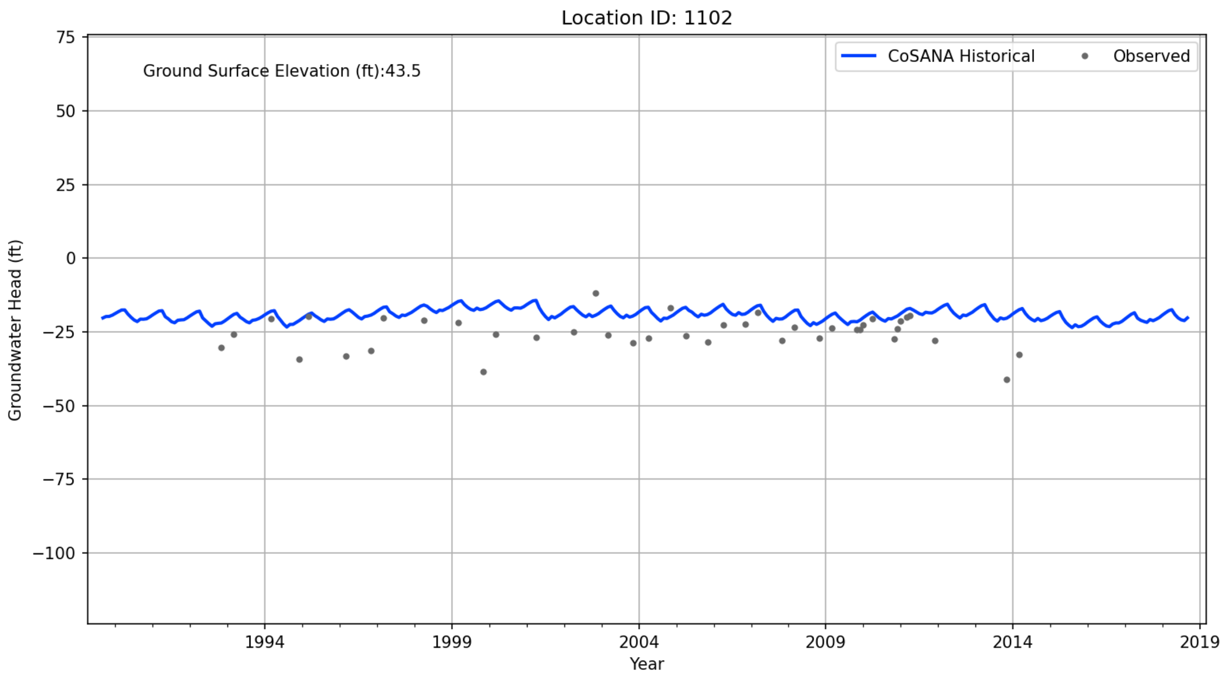
Location ID: 821
CoSANA Historical
Observed
Ground Surface Elevation (ft):18.66
Groundwater Head (ft)
Year
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019

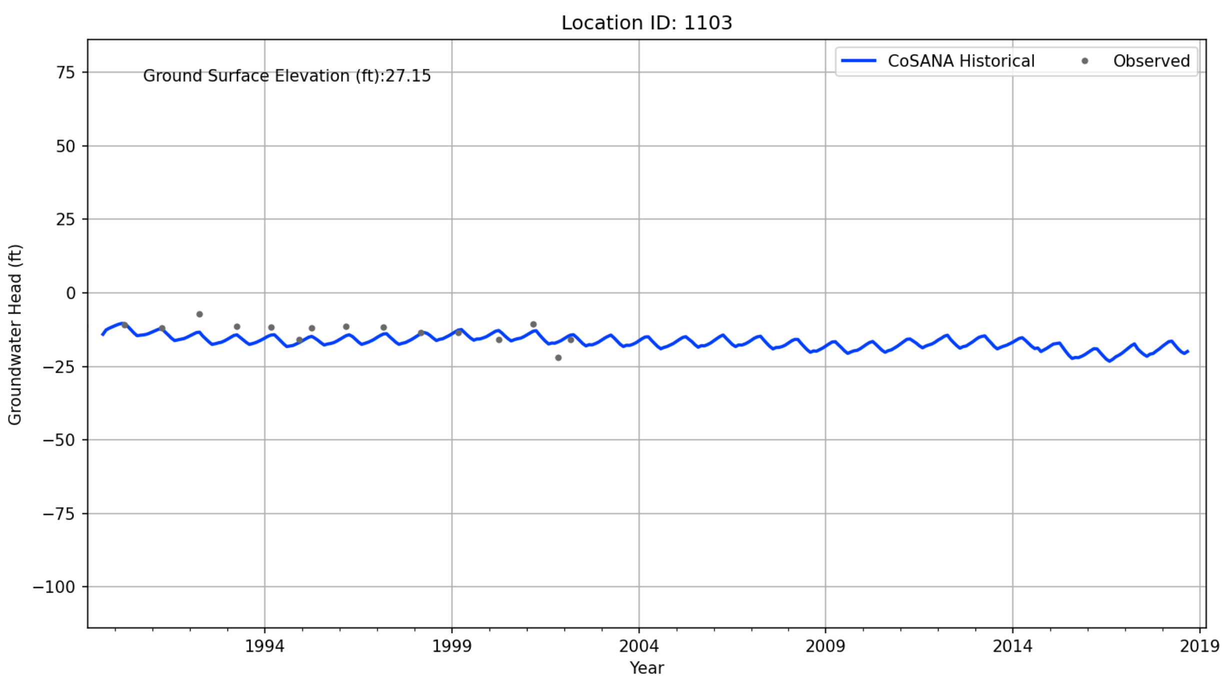

Location ID: 1001
Ground Surface Elevation (ft):28.6
CoSANA Historical
Observed
Groundwater Head (ft)
Year
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019

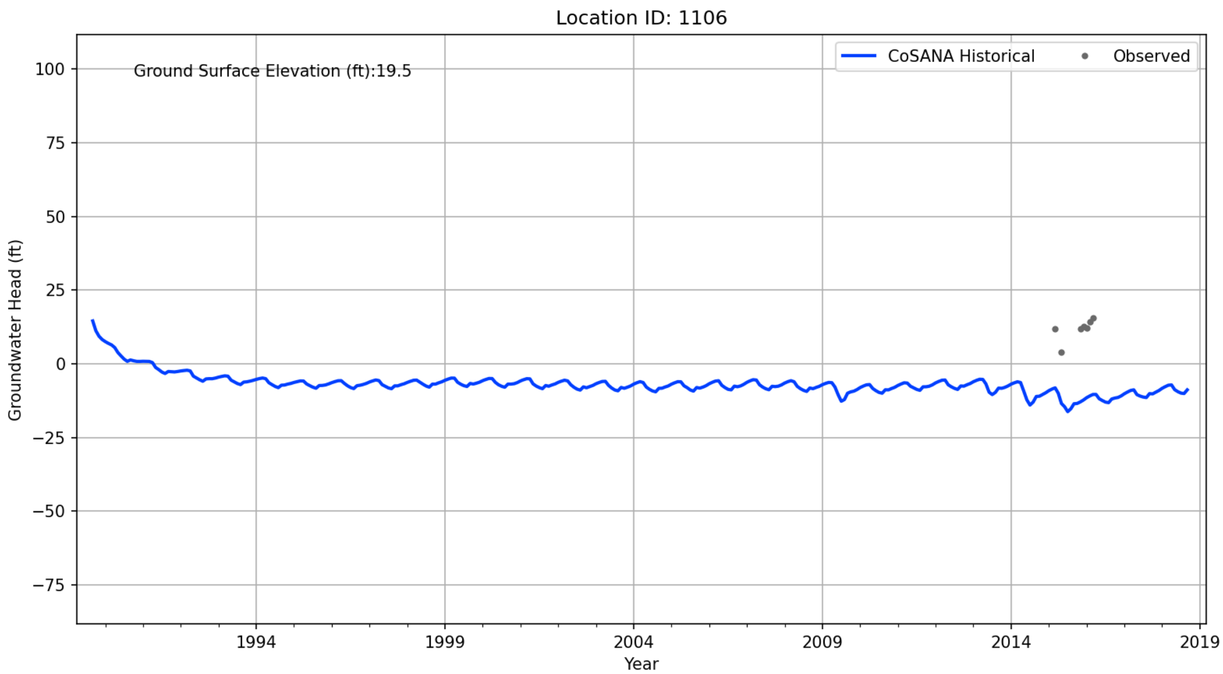

Location ID: 1007
Ground Surface Elevation (ft):34.87
CoSANA Historical
Observed
Groundwater Head (ft)
Year
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019

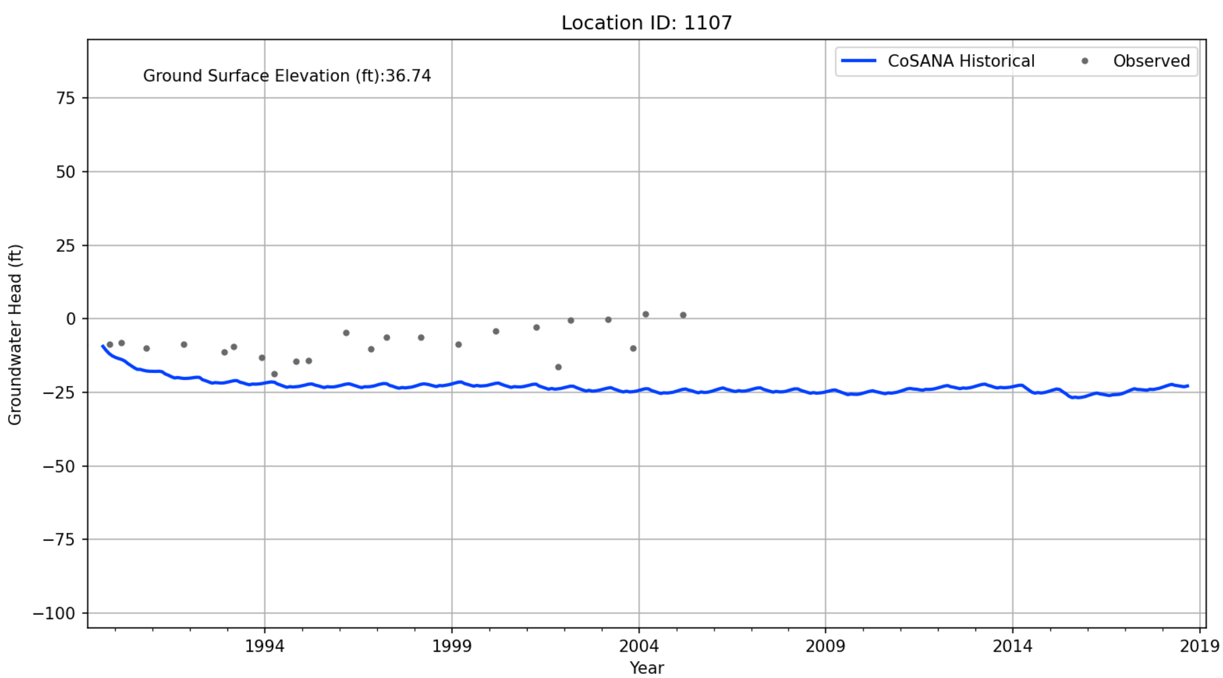

Location ID: 1012
Ground Surface Elevation (ft):24.03
CoSANA Historical
Observed
Groundwater Head (ft)
Year
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019

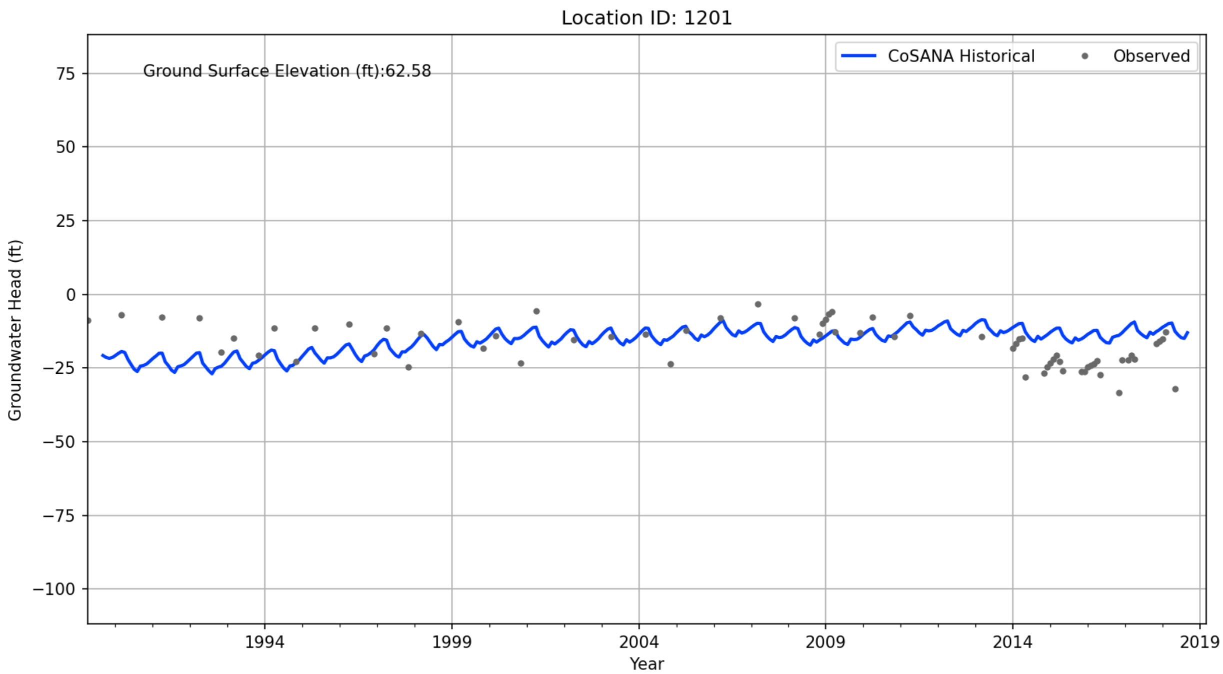

Location ID: 1017
Ground Surface Elevation (ft):22.7
CoSANA Historical
Observed
Groundwater Head (ft)
Year
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019

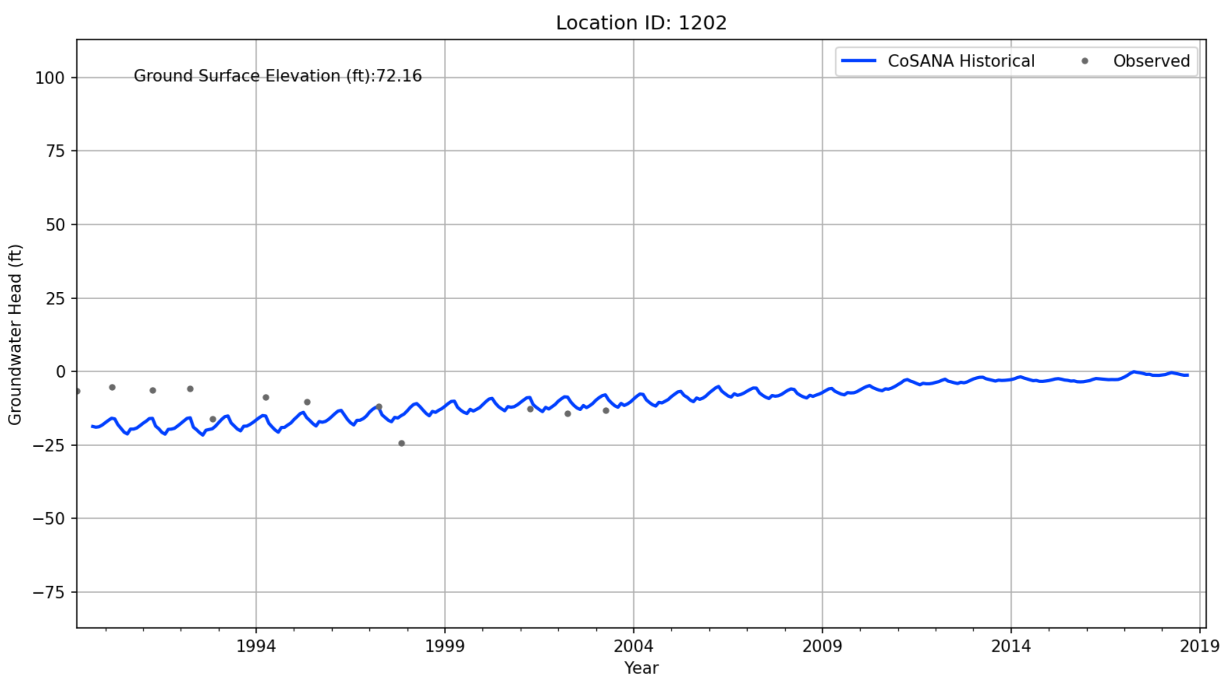

Location ID: 1102
Ground Surface Elevation (ft):43.5
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year

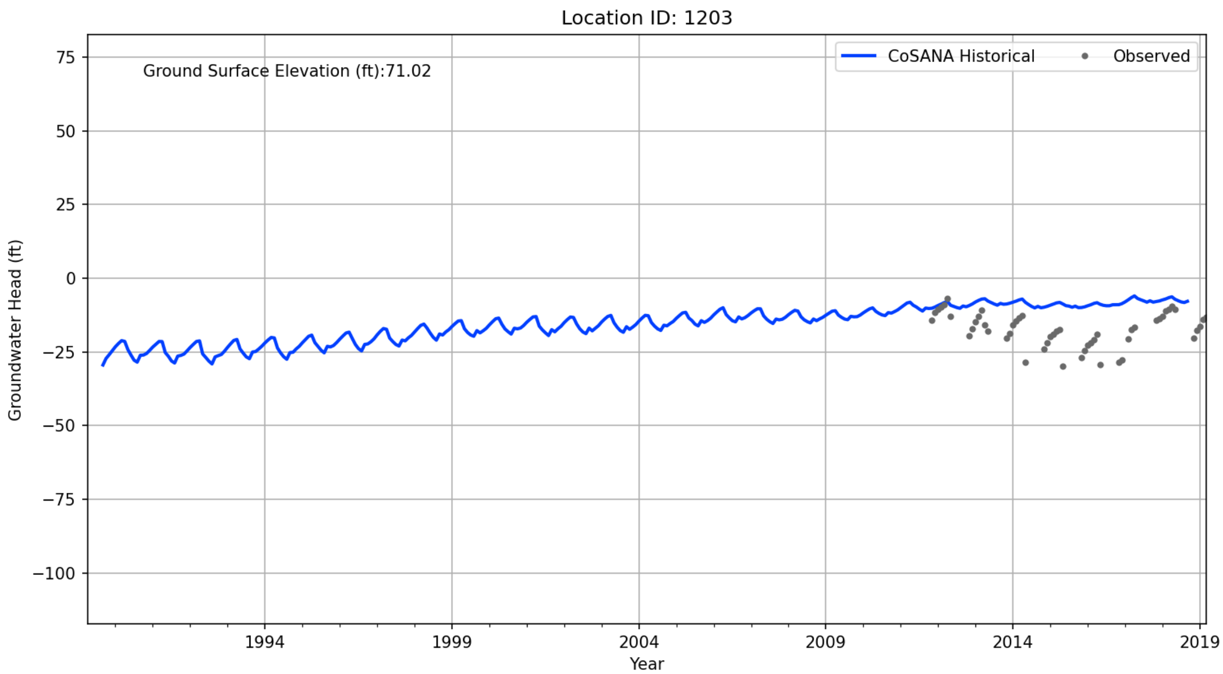

Location ID: 1103
Ground Surface Elevation (ft):27.15
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year


Location ID: 1106
Ground Surface Elevation (ft):19.5
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year

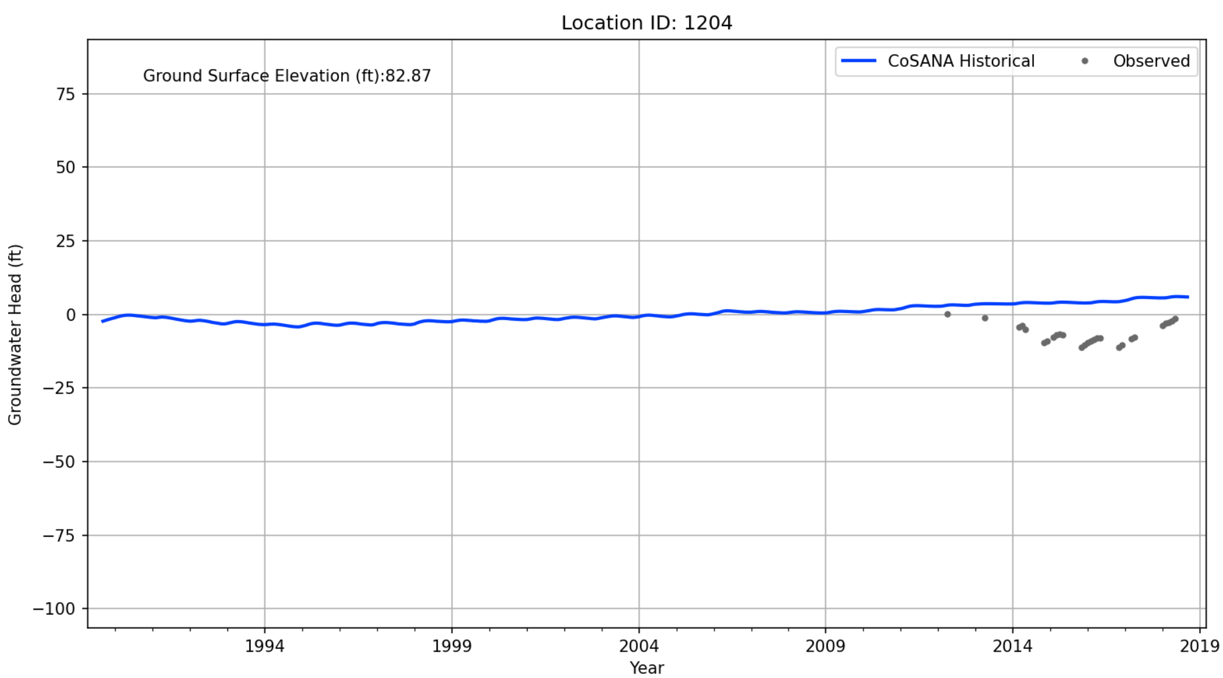

Location ID: 1107
Ground Surface Elevation (ft):36.74
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year


Location ID: 1201
CoSANA Historical
Observed
Ground Surface Elevation (ft):62.58
Groundwater Head (ft)
Year
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019

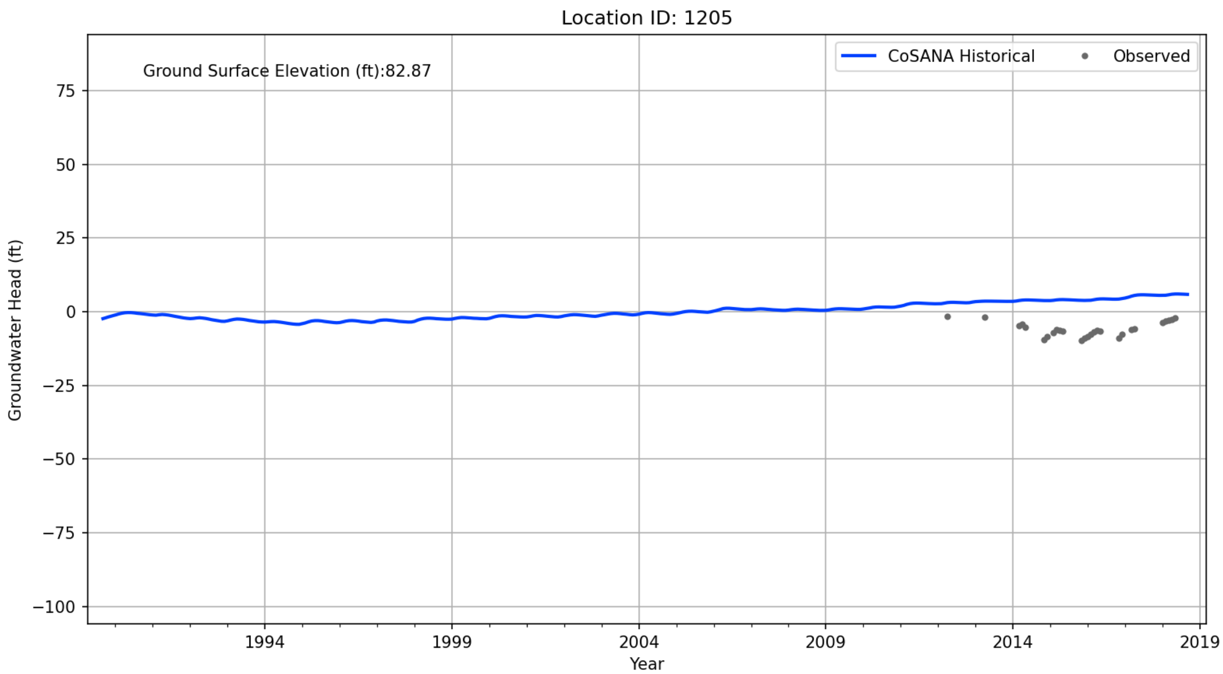

Location ID: 1202
CoSANA Historical
Observed
Ground Surface Elevation (ft):72.16
Groundwater Head (ft)
Year
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019

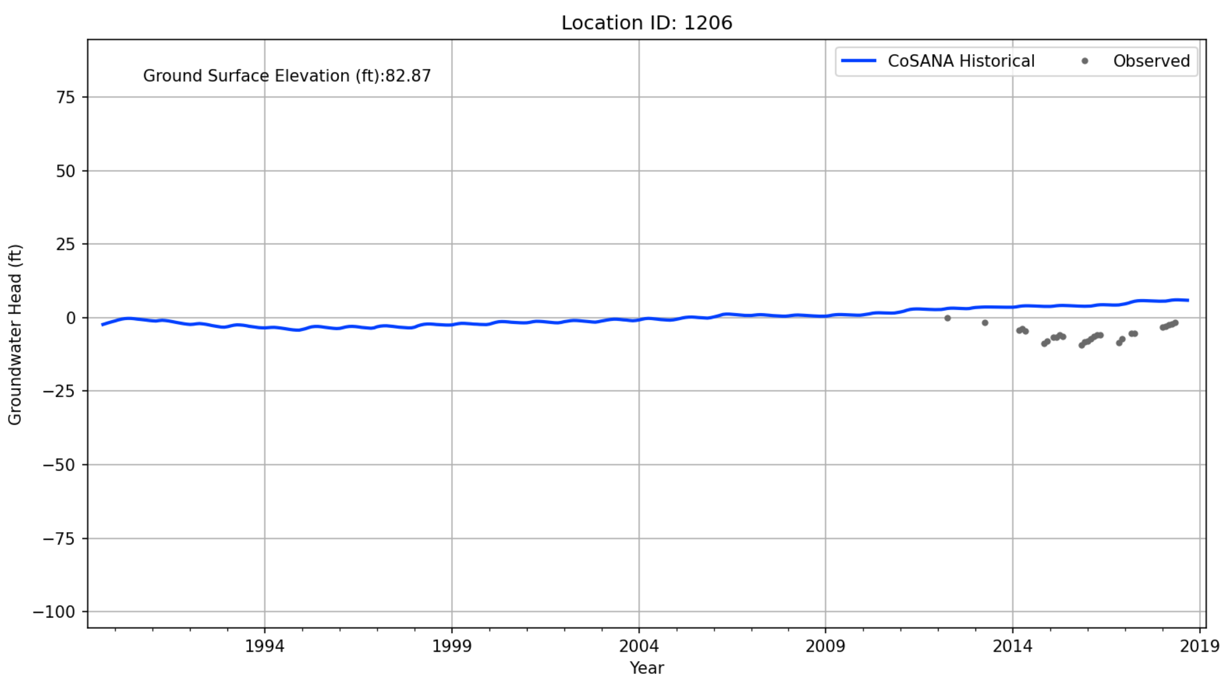


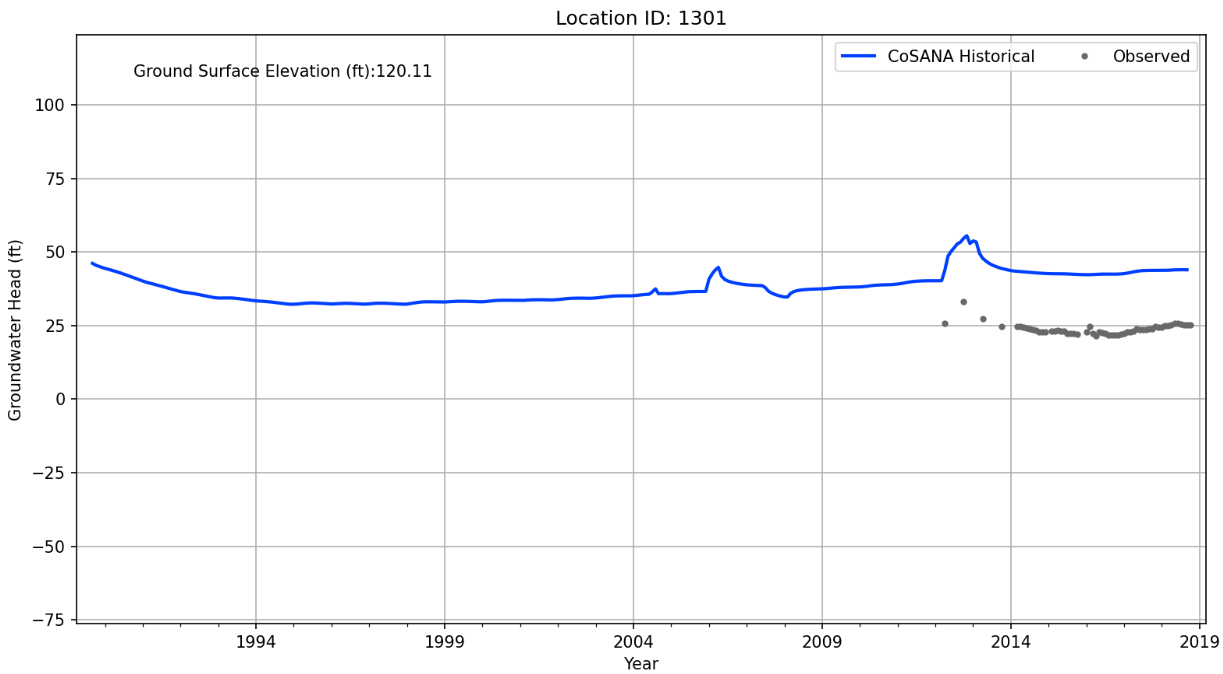
Location ID: 1203
Ground Surface Elevation (ft):71.02
CoSANA Historical
Observed
Groundwater Head (ft)
Year
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019

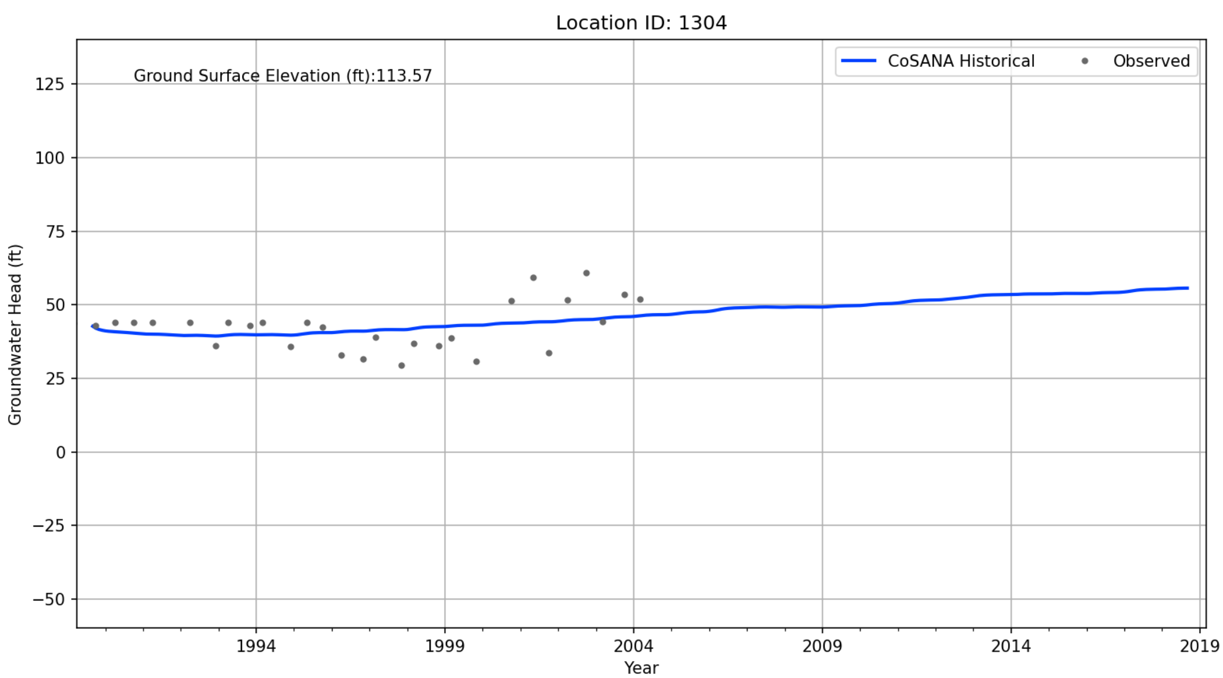



Location ID: 1204
Ground Surface Elevation (ft):82.87
CoSANA Historical
Observed
Groundwater Head (ft)
Year
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019


Location ID: 1205
Ground Surface Elevation (ft):82.87
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year


Location ID: 1206
Ground Surface Elevation (ft):82.87
CoSANA Historical
Observed
Groundwater Head (ft)
75
50
25
0
−25
−50
−75
−100
1994
1999
2004
2009
2014
2019
Year


Location ID: 1301
Ground Surface Elevation (ft):120.11
CoSANA Historical
Observed
Groundwater Head (ft)
100
75
50
25
0
−25
−50
−75
1994
1999
2004
2009
2014
2019
Year


Location ID: 1304
Ground Surface Elevation (ft):113.57
CoSANA Historical
Observed
Groundwater Head (ft)
125
100
75
50
25
0
−25
−50
1994
1999
2004
2009
2014
2019
Year