# Appendix 5B

Updated Water Budgets

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# 1 WATER BUDGETS

Periodic Evaluations must include updated current and projected water budgets. This appendix summarizes the estimated water budgets for the 180/400-Foot Aquifer Subbasin, including information required by the GSP Regulations and information that is important for developing an effective plan to achieve sustainability.

Water budgets provide an estimation of the total annual volume of surface water and groundwater entering and leaving the basin and the change in the volume of groundwater in storage for different time periods. Water budgets are a tool to help understand the volume of groundwater flows and how they have changed over time. Since there are no direct measures of several components of the water budget, groundwater flow models are the best available tools to use to develop water budgets. Models are periodically updated, and with each update the water budget estimates are refined. This is the third water budget produced for the 180/400-Foot Aquifer Subbasin: the first was included in the 2020 Groundwater Sustainability Plan (GSP); the second was developed in 2022 to align with the 2022 Salinas Valley GSPs and is included in GSP Amendment 1; and this third water budget was developed in 2024 for inclusion in the 2025 Periodic Evaluation.

## 1.1 Overview of Water Budget Development

The water budgets are presented in 2 subsections: (1) historical and current water budgets and (2) future water budgets. Within each subsection a surface water budget and groundwater budget are presented.

Historical and current water budgets are developed using a provisional version of the Salinas Valley Integrated Hydrologic Model (SVIHM)[1], developed by the United States Geological Survey (USGS). The SVIHM is a numerical groundwater-surface water flow model that is constructed using version 2 of the MODFLOW-OWHM code (Boyce *et al.*, 2020). This code is a version of the USGS groundwater flow code MODFLOW that estimates agricultural supply and demand through the Farm Process. Future water budgets are developed using a provisional version of the Salinas Valley Operational Model (SVOM), developed by the USGS and Monterey County Water Resources Agency (MCWRA). The SVOM is a numerical groundwater-surface water flow model constructed with the same framework and processes as the SVIHM.

[1] These data (model and/or model results) are preliminary or provisional and are subject to revision. This model and model results are being provided to meet the need for timely best science. The model has not received final approval by the U.S. Geological Survey (USGS). No warranty, expressed or implied, is made by the USGS or the U.S. Government as to the functionality of the model and related material nor shall the fact of release constitute any such warranty. The model is provided on the condition that neither the USGS nor the U.S. Government shall be held liable for any damages resulting from the authorized or unauthorized use of the model.

However, the SVOM is designed for simulating future scenarios and includes complex surface water operations in the Surface Water Operations (SWO) module.

Water budgets described in the approved 2020 GSP were developed using the best tools and methods available at the time. After the release and approval of the 2020 GSP, the USGS released provisional versions of the SVIHM and SVOM to the SVBGSA for use in developing GSPs for the Salinas Valley Basin. In 2022, the SVIHM and SVOM were used to develop the water budgets included in GSP Amendment 1 for the 180/400-Foot Aquifer Subbasin, which align with the water budgets in the 2022 GSPs of the Eastside, Langley, Forebay, and Upper Valley Subbasins. Since the development of the water budgets in 2022, the USGS released updated provisional versions of the SVIHM and SVOM. The most recent versions were used to update the water budgets for this Periodic Evaluation.

The models have not yet been publicly released by the USGS. The models and how they were used for developing the GSP are briefly described in GSP Amendment 1. Details regarding source data, model construction, and model calibration will be summarized in more detail once the model and associated documentation are publicly available from the USGS.

### 1.1.1 Water Budget Components

The water budget is an inventory of the Subbasin's surface water and groundwater inflows and outflows. Some components of the water budget can be measured, such as groundwater pumping from metered wells, precipitation, and surface water diversions. Other components are not easily measured and can be estimated using groundwater models such as the SVIHM; these include unmetered agricultural pumping, recharge from precipitation and applied irrigation, and change in groundwater in storage. Figure 1 presents a general schematic diagram of the hydrogeologic conceptual model that is included in the water budget (DWR, 2020b). Figure 2 delineates the zones and boundary conditions of the SVIHM.

The water budgets for the Subbasin are calculated within the following boundaries:

- Lateral boundaries: The perimeter of the 180/400-Foot Aquifer Subbasin within the SVIHM is shown on Figure 2.
- Bottom: The base of the groundwater subbasin is considered to be the base of the usable and productive unconsolidated sediments, or the top of the Monterey Formation (Durbin *et al.* 1978). This ranges from less than 800 feet below ground surface in the far north of the Subbasin to almost 2,600 feet deep along the Subbasin's southwestern edge. The water budget is not sensitive to the exact definition of this base elevation because the base is defined as a depth below where there is not significant inflow, outflow, or change in storage.
- Top: The top of the water budget area is above the ground surface, so that surface water is included in the water budget.

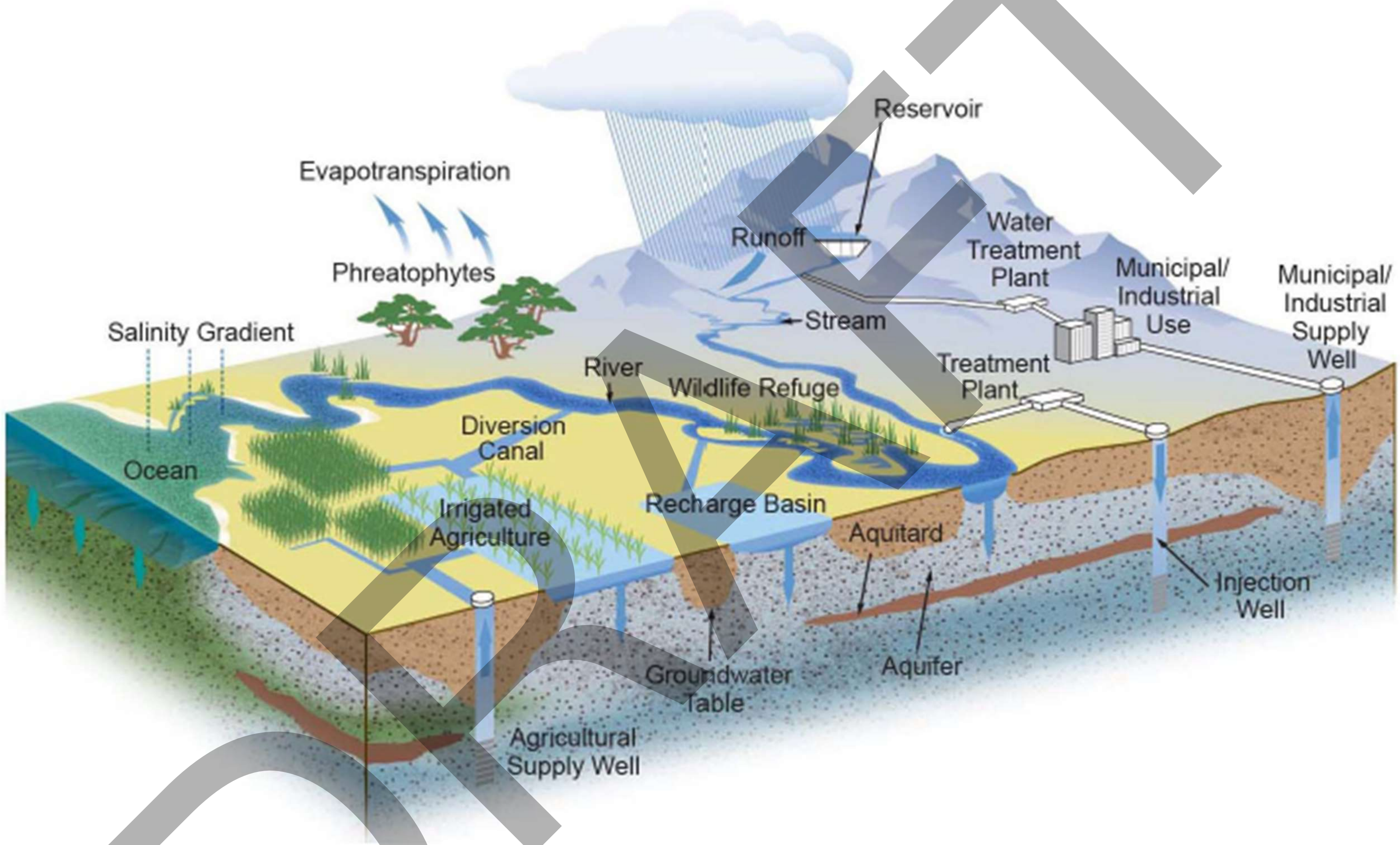


Figure 1. Schematic Hydrogeologic Conceptual Model (from DWR, 2020b)

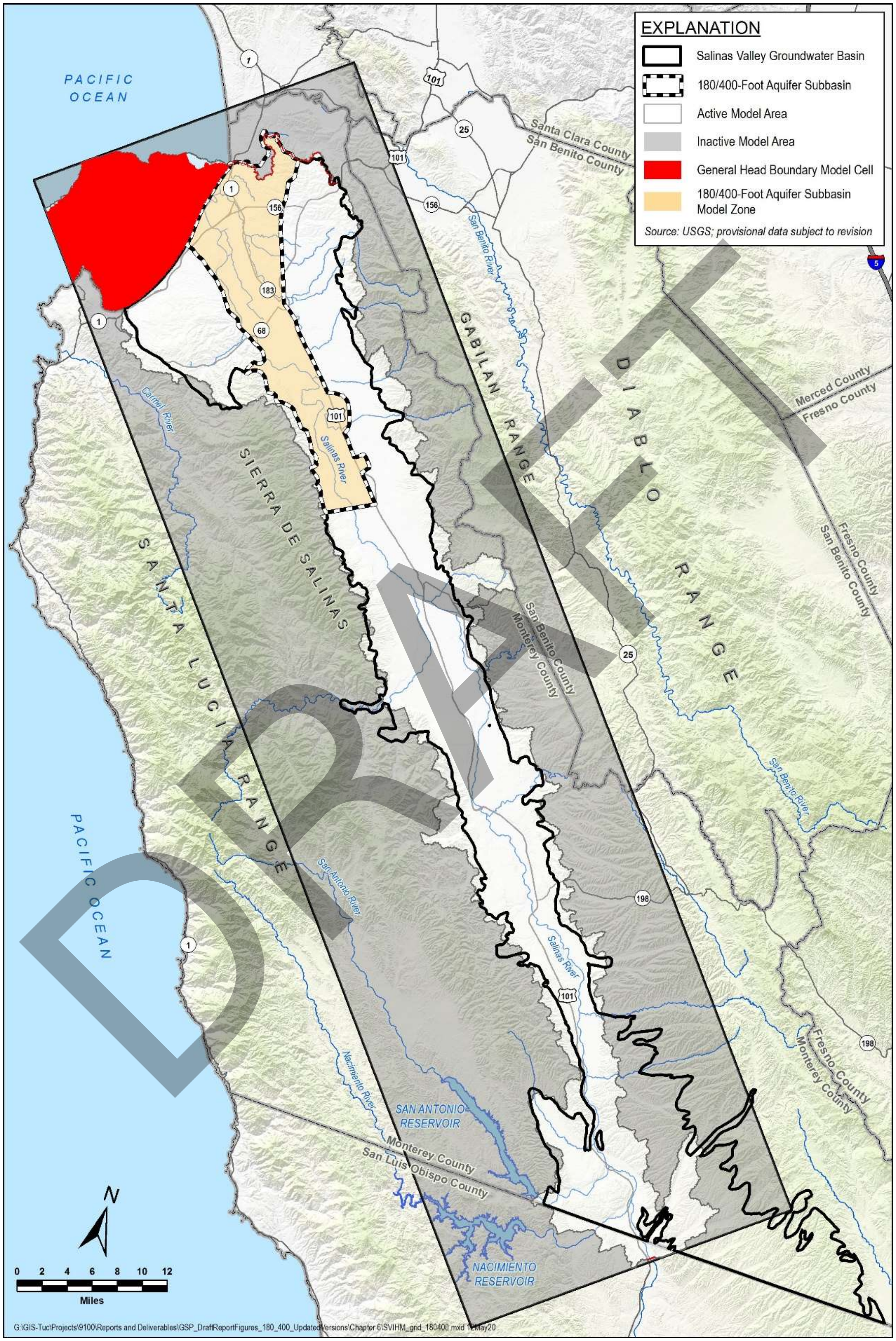


Figure 2. Subbasin Border and Boundary Conditions for the Salinas Valley Integrated Hydrologic Model

The 180/400-Foot Aquifer Subbasin water budget includes the following components:

Surface Water Budget:

- Inflows
  - Runoff of precipitation
  - Surface water inflows from streams and canals that enter (or can potentially enter) the Subbasin, including Salinas River, Chualar Creek, Quail Creek, Alisal Creek, Salinas Reclamation Canal, Santa Rita Creek, and several other smaller creeks
  - Groundwater discharge to streams
- Outflows
  - Stream discharge to groundwater
  - Stream diversions
  - Outflow to the ocean and neighboring subbasins from the Salinas River and other smaller streams

Groundwater Budget:

- Inflows
  - Deep percolation from precipitation and applied irrigation
  - Stream discharge to groundwater
  - Subsurface inflows, including:
    - Inflow from the Forebay Aquifer Subbasin
    - Inflow from the Langley Aquifer Subbasin
    - Inflow from the Eastside Aquifer Subbasin
    - Inflow from the Pajaro Valley Subbasin
    - Inflow from the Monterey Subbasin
    - Inflow from the Pacific Ocean (seawater intrusion)
    - Inflow from the surrounding watershed that are not in other DWR subbasins
- Outflows
  - Riparian evapotranspiration (ET)
  - Groundwater pumping, including municipal, industrial, and agricultural

- Groundwater discharge to streams
- Groundwater discharge to agricultural drains
- Subsurface outflows, including:
  - Outflow to the Forebay Aquifer Subbasin
  - Outflow to the Langley Area Subbasin
  - Outflow to the Eastside Aquifer Subbasin
  - Outflow to the Pajaro Valley Subbasin
  - Outflow to the Monterey Subbasin
  - Outflows to the Pacific Ocean
  - Outflow to surrounding watershed that are not in other DWR subbasins

The difference between groundwater inflows and outflows is equal to the change of groundwater in storage.

### 1.1.2 Water Budget Timeframes

Periodic Evaluations should include updated current and projected water budgets. Since newer versions of the SVIHM and SVOM are available, a historical water budget is also included.

All annual water budgets are developed for complete water years, which averages the monthly variation in the model. Selected time periods for the historical and current water budgets are summarized in Table 1 and on Figure 3. and described in Sections 1.1.2.1 and 1.1.2.2.

Table 1. Summaryof Historical and Current Water Budget Time Periods

| Time Period | Proposed Date Range | Water Year Types Represented in Time Period | Rationale |
|---|---|---|---|
| **Historical** | Water years 1980 through 2018 | Dry: 12<br>Dry-Normal: 7<br>Normal: 5<br>Wet-Normal: 3<br>Wet: 12 | Provides insights on water budget response to a wide range of variations in climate and groundwater use over an extensive period of record. Begins and ends in years with average precipitation. |
| **Current** | Water Years 2017 through 2018 | Dry: 1<br>Wet: 1 | Best reflection of current land use and water use conditions based on best available data. |

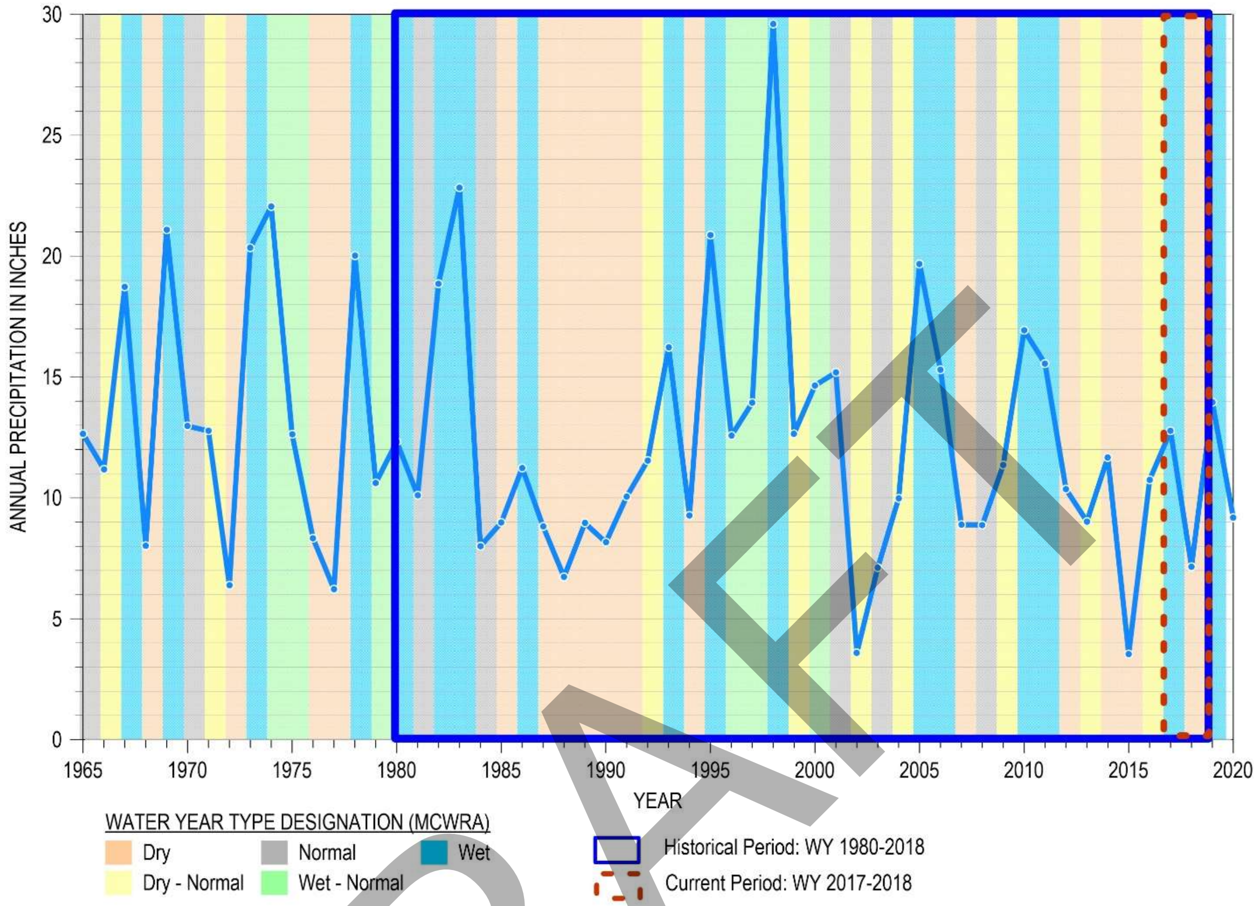


Figure 3. Climate and Precipitation for Historical and Current Water Budget Time Periods

#### 1.1.2.1 Historical Water Budgets Time Period

The historical water budget is intended to evaluate how past land use and water supply availability has affected aquifer conditions. The historical water budget helps develop an understanding of how historical conditions concerning hydrology, water demand, and surface water supply availability and reliability have impacted the ability to operate the basin within the sustainable yield.

The historical water budget is computed using results from the SVIHM groundwater flow model for the period from October 1980 through September 2018. The SVIHM simulation covers water years 1967 through 2018; however, model results for years prior to 1980 were not used for this water budget due to potential limitations and uncertainties in the provisional SVIHM. Water years 1980 through 2018 comprise a representative period with both wet and dry periods in the Subbasin (Table 1, Figure 3).

### 1.1.2.2 Current Water Budget Time Period

The current water budget is intended to allow the GSAs and DWR to understand the existing supply, demand, and change in storage under recent population, land use, and hydrologic conditions. Current conditions are generally the most recent conditions for which adequate data are available and that represent recent climatic and hydrologic conditions. Since the SVIHM includes data through 2018, the current water budget is the average of 2017 and 2018.

The current water budget is also computed using the SVIHM groundwater flow model and is based on water years 2017 through 2018. Water years 2017 and 2018 are classified as wet and dry, respectively. An average of these 2 years is reflective of recent patterns of groundwater use and surface water use. Although this period appropriately meets the regulatory requirement for using the "…most recent hydrology, water supply, water demand, and land use information" (23 California Code of Regulations § 354.18 (c)(1)), water years 2017 and 2018 may underestimate water availability because the period was preceded by multiple dry or dry-normal years.

### 1.1.2.3 Future Projected Water Budgets Time Period

The projected water budget is intended to quantify the estimated future baseline conditions. The projected water budget estimates the future baseline conditions concerning hydrology, water demand, and surface water supply over a 50-year planning and implementation horizon.

Future projected conditions are based on model simulations using the SVOM numerical flow model, using current reservoir operations rules, projected climate change scenario, and estimated sea level rise. The projected water budget represents 47 years of future conditions. Following DWR guidance on implementing climate change factors, the future water budget simulations do not simulate a 47-year projected future, but rather simulate 47 likely hydrologic events that may occur in 2070.



## 1.2 Overview of Data Sources for Water Budget Development

Table 2 provides the detailed water budget components and known model assumptions and limitations for each. A few water budget components are directly measured, but most water budget components are either estimated as input to the model or simulated by the model. Uncertainty exists in all regional models; however, the USGS and cooperating agencies selected inputs to the provisional SVIHM using best available data to reduce the level of uncertainty. Models estimate groundwater flow based on the available data; as more data becomes available and models are updated, estimates will improve. The water budgets for the 180/400-Foot Aquifer Subbasin are based on a provisional version of the SVIHM, with limited documentation of model construction. The model is in internal review at the USGS, and a final version will not be released until 2025. Nonetheless, the provisional SVIHM's calibration error is within reasonable bounds within the 180/400-Foot Aquifer Subbasin. Therefore, the model is the best available tool for estimating water budgets for the Periodic Evaluation.

As GSP implementation proceeds, the SVIHM will be updated and recalibrated with new data to better inform model simulations of historical, current, and projected water budgets. Model assumptions and uncertainty will be described in future updates after model documentation is released by the USGS.

Table 2. Summary of Water Budget Component Data Source from the Salinas Valley Integrated Hydrologic Model

| Water Budget Component | Source of Model Input Data | Limitations |
|---|---|---|
| **Surface Water Inflows** | | |
| Inflow from Streams Entering Basin | Simulated from calibrated model for all creeks | Not all creeks are gauged |
| Groundwater Discharge to Streams | Simulated from calibrated model | Based on calibration of streamflow to available data from gauged creeks |
| Overland Runoff | Simulated from calibrated model | Based on land use, precipitation, and soils specified in model |
| **Surface Water Outflows** | | |
| Streambed Recharge to Groundwater | Simulated from calibrated model | Based on calibration of streamflow to available data from gauged creeks and groundwater level data from nearby wells |
| Diversions | Simulated from calibrated model | Based on calibration of streamflow to available data from gauged creeks |
| Outflow to Streams Leaving Basin | Simulated from calibrated model for all creeks | Not all creeks are gauged |
| **Groundwater Inflows** | | |
| Streambed Recharge to Groundwater | Simulated from calibrated model | Based on calibration of streamflow to available data from gauged creeks and groundwater level data from nearby wells |
| Deep Percolation of Precipitation and Irrigation Water | Simulated from demands based on crop, acreage, temperature, and soil zone processes | No measurements available; based on assumed parameters for crops and soils |
| Subsurface Inflow from Adjacent Basins and Surrounding Watershed Other than Neighboring Basins | Simulated from calibrated model | Limited groundwater calibration data at adjacent subbasin boundaries |
| Subsurface Inflow from Ocean | Simulated from calibrated model | Seawater intrusion assumed equal to groundwater flow from the ocean across coastline |
| **Groundwater Outflows** | | |
| Groundwater Pumping | Agricultural pumping is estimated by calibrated model, based on reported land use. Simulated urban pumping is based on reported and estimated pumping. | Domestic pumping not simulated in model. |
| Groundwater Discharge to Streams | Simulated from calibrated model | Based on calibration of streamflow to available data from gauged creeks and groundwater level data from nearby wells |
| Groundwater Discharge to Drains | Simulated from calibrated model | Based on calibration of the surface water network and groundwater level data from nearby wells |
| Subsurface Outflow to Adjacent Basins and Ocean | Simulated from calibrated model | Limited calibration data at adjacent subbasin boundaries |
| Riparian Evapotranspiration | Simulated from calibrated model | Based on representative plant group and uniform extinction depth |
| **Change in Groundwater Storage** | | |
| Change in Groundwater Storage | Simulated from calibrated model | Based on calibration of groundwater levels to available measurements |

## 1.3 Historical and Current Water Budgets

Water budgets for the historical and current periods are presented below. The surface water budgets are presented first, followed by the groundwater budgets. These water budgets are based on the provisional SVIHM and are subject to change in the future. Water budgets will be updated in future periodic evaluations.

### 1.3.1 Historical and Current Surface Water Budget

The surface water budget accounts for the inflows and outflows for the streams within the Subbasin. This includes streamflows of rivers and tributaries entering and exiting the Subbasin, overland runoff to streams, and stream-aquifer interactions. Evapotranspiration by riparian vegetation along stream channels is estimated by the provisional SVIHM as part of the groundwater system and is accounted for in the groundwater budget.

Figure 4 shows the surface water network simulated in the provisional SVIHM. The model accounts for surface water flowing in and out across the subbasin boundary. For this water budget, boundary inflows and outflows are the sum of all locations that cross the Subbasin boundary. In some instances, a simulated stream might enter and exit the Subbasin boundary at multiple locations, such as Salinas River, Chualar Creek, and Natividad Creek/Reclamation Canal. The Salinas Valley Aquitard, which extends over much of the Subbasin, limits connectivity between surface water and principal aquifers where present.

Figure 5 shows the surface water budget for the historical period, which also includes the current period. Table 3 shows the average values for components of the surface water budget for the historical and current periods. Positive values are inflows into the stream system, and negative values are outflows from the stream system. Boundary stream inflows and boundary stream outflows are an order of magnitude greater than any other component of the surface water budget. The flow between surface water and groundwater in the Subbasin is generally net negative, which indicates more deep percolation of streamflow to groundwater than groundwater discharge to streams. To account for model uncertainty, surface water budget values are presented rounded to the nearest thousand acre-feet per year (AF/yr) for flows averaging more than 1,000 AF/yr and to the nearest 100 AF/yr for flows less than 1,000 AF/yr. The surface water budget does not balance perfectly due to rounding.

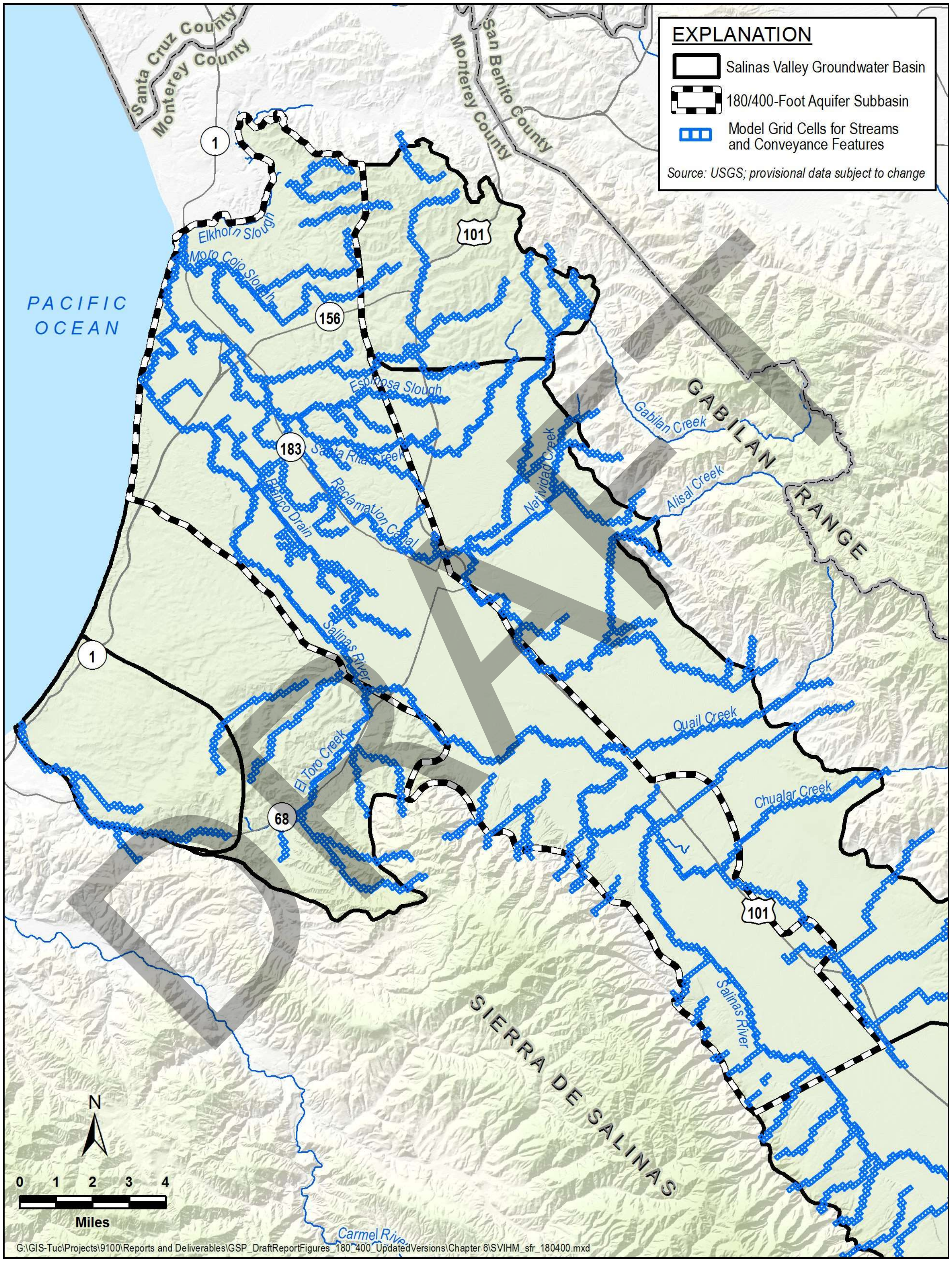


Figure 4. Surface Water Network in the 180/400-Foot Aquifer Subbasin from the Salinas Valley Integrated Hydrologic Model

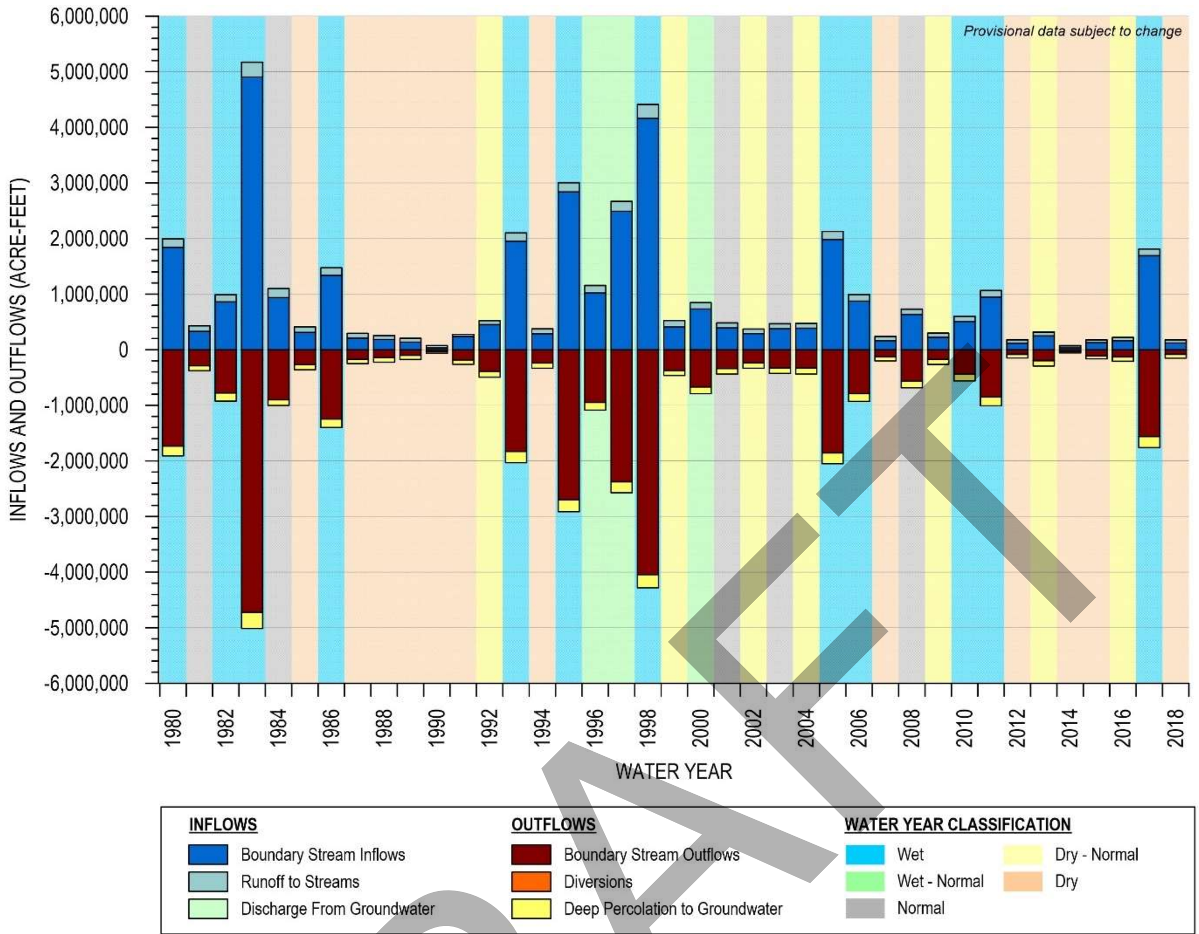


Figure 5. Historical and Current Surface Water Budget

Table 3. SVIHM Simulated Surface Water Budget Summary

| | Historical Average (WY 1980-2018) | Current (WY 2017-2018) |
|---|---|---|
| **Boundary Stream Inflows** | 896,600 | 907,100 |
| **Runoff to Streams** | 54,900 | 53,800 |
| **Direct Precipitation** | 300 | 300 |
| **Net Flow between Surface Water and Groundwater** | -120,700 | -138,100 |
| **Boundary Stream Outflows** | -830,500 | -819,300 |
| **Diversions** | -600 | -3,900 |

Values are in AF/yr

Note: provisional data subject to change.

### 1.3.2 Historical and Current Groundwater Budget

The groundwater budget accounts for the inflows and outflows to and from the Subbasin's aquifers, based on results from the SVIHM. This includes subsurface inflows and outflows of groundwater at the Subbasin boundaries, recharge, pumping, evapotranspiration, and net flow between surface water and groundwater.

Figure 6 shows SVIHM estimated annual groundwater inflows for the historical and current time periods. Total average annual inflows is about 208,000 AF/yr for the historical period and 219,000 AF/yr for the current period; however, inflows vary substantially from year to year. Table 4 provides average groundwater inflows for the historical and current periods. The dominant inflow components are deep percolation of streamflow and deep percolation of precipitation and applied irrigation. Deep percolation of streamflow is greater on average but also varies more than deep percolation of precipitation. Values of less than 50,000 to greater than 200,000 AF/yr are common for simulated deep percolation of streamflow. The most consistent groundwater flows into the Subbasin are subsurface inflows from adjacent areas. Freshwater subsurface inflows range between 22,000 and 33,000 AF/yr. For these water budgets, inflow from the ocean is counted as an inflow even though it is not usable. Seawater inflows across the coastal boundary are between 6,000 and 11,000 AF/yr. These seawater inflows are less than the change in usable storage due to seawater intrusion, as calculated in Chapter 5 of GSP Amendment 1, because the inflow represents full-strength seawater. However, the seawater mixes with fresh groundwater, and the unusable amount of groundwater is much greater than the full-strength seawater. In 2023, the SVBGSA developed a variable density groundwater model to help understand this relationship.

Figure 7 shows the SVIHM estimated groundwater outflows for the historical and current time periods. Outflows vary from year to year; however, the annual variation is dampened compared to the inflows. Table 5 provides the SVIHM estimated average groundwater outflows of the historical and current periods. The greatest groundwater outflow is pumping. Averaged over the historical period, groundwater pumping accounts for more than 60% of all groundwater outflows in the Subbasin. In the driest water years, such as 1990, it accounts for closer to 70% of the total groundwater outflows. Total average annual groundwater outflow was about 218,000 AF/yr for the historical period and about 191,000 AF/yr for the current period. All outflows are shown as negative values.

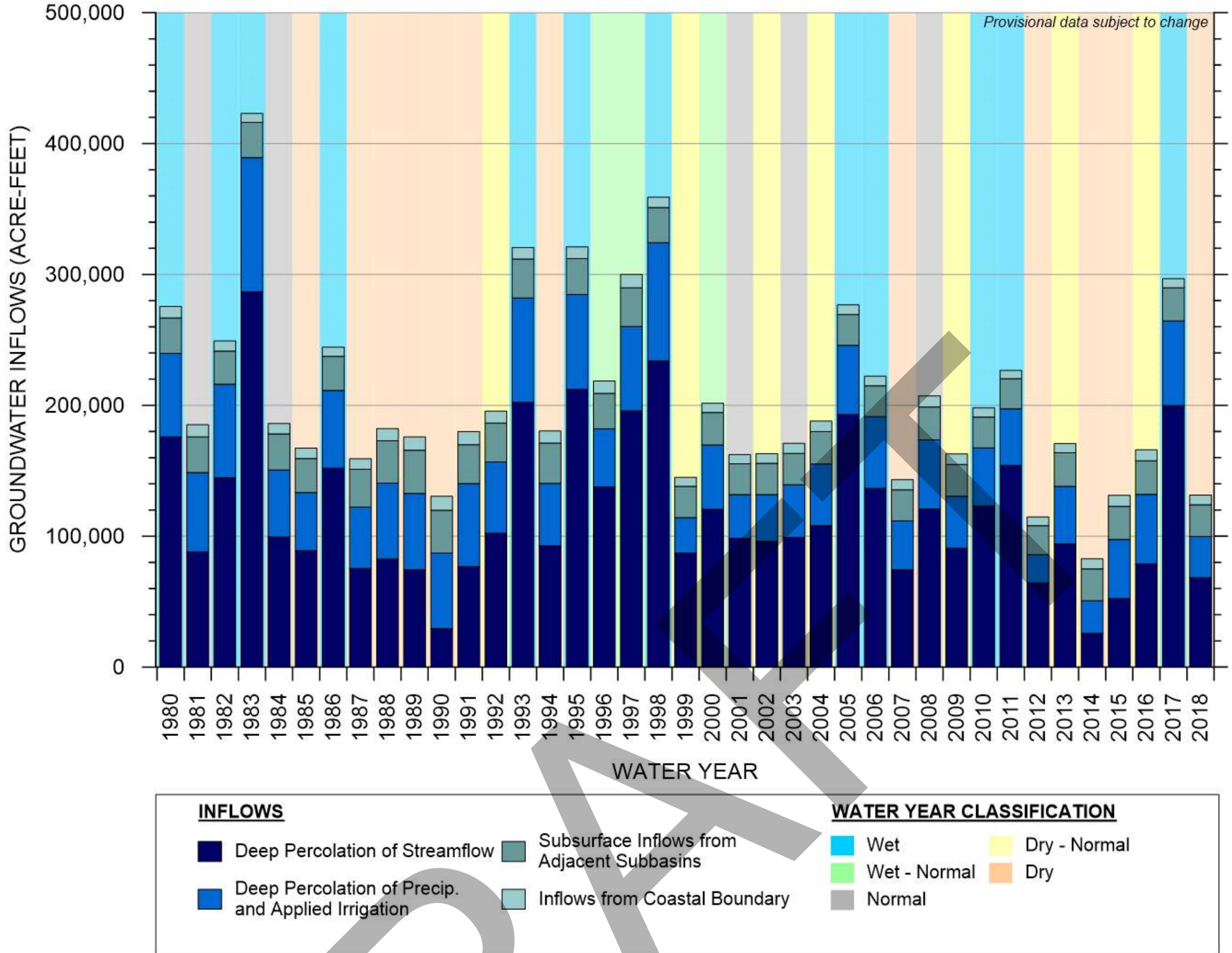


Figure 6. SVIHM Simulated Inflows to the Groundwater System



Table 4. SVIHM Simulated Groundwater Inflows Summary

| | Historical Average (WY 1980-2018) | Current (WY 2017-2018) |
|---|---|---|
| **Deep Percolation of Streamflow** | 121,100 | 138,700 |
| **Deep Percolation of Precipitation and Applied Irrigation** | 52,200 | 48,200 |
| **Subsurface Inflow from Adjacent Areas** | 26,300 | 24,700 |
| **Inflow Across Coastline** | 8,100 | 7,100 |
| **Total Inflows** | 207,700 | 218,700 |

Values are in AF/yr

Note: provisional data subject to change

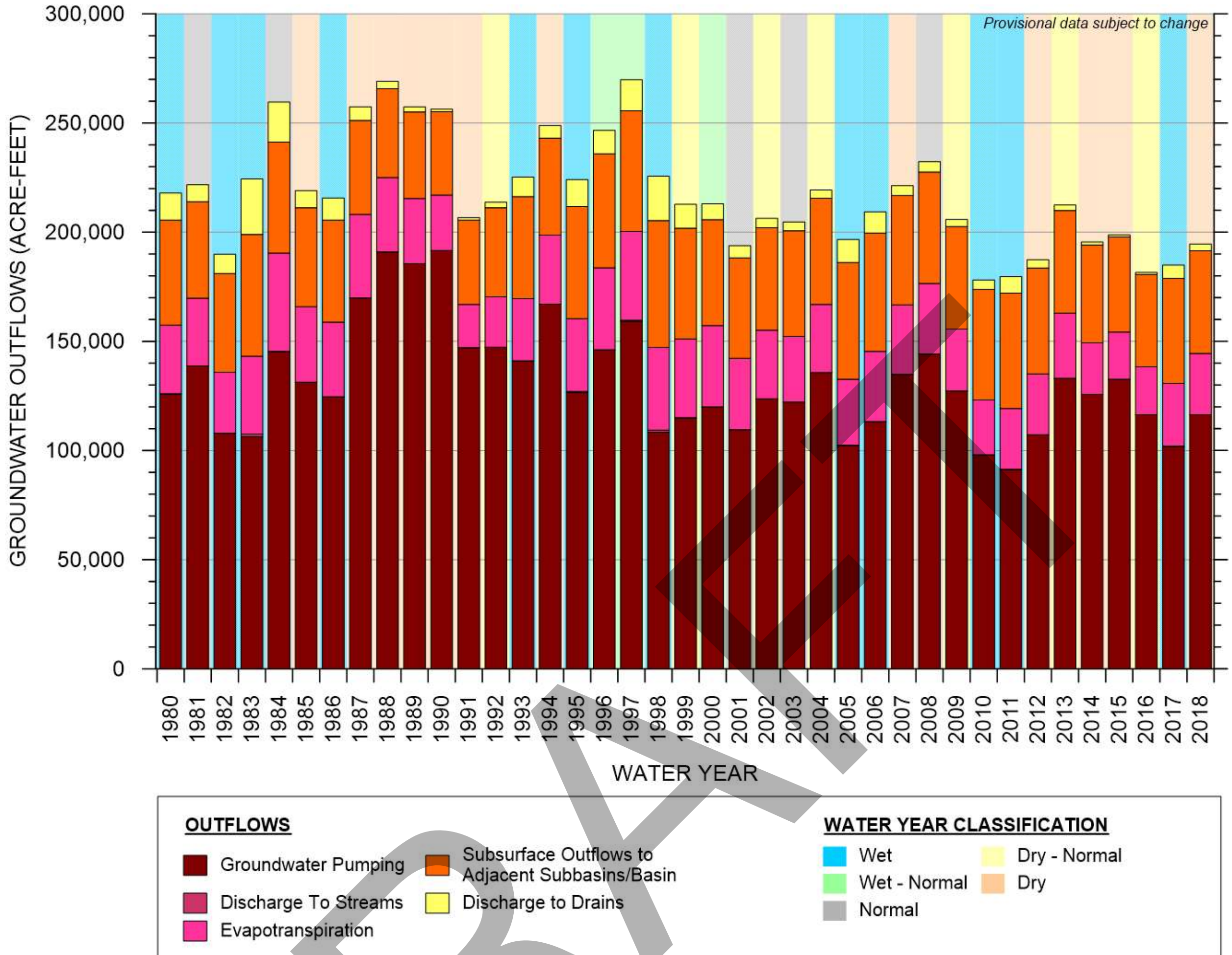


Figure 7. SVIHM Simulated Outflows from the Groundwater System

Table 5. SVIHM Simulated Groundwater Outflows Summary

| | Historical Average (WY 1980-2016) | Current (WY 2017-2018) |
|---|---|---|
| **Groundwater Pumping** | -131,400 | -109,100 |
| **Groundwater Evapotranspiration** | -31,200 | -28,500 |
| **Subsurface Outflows to Adjacent Areas** | -47,500 | -47,500 |
| **Subsurface Outflows to Ocean** | -300 | -300 |
| **Discharge to Streams** | -400 | -500 |
| **Discharge to Agricultural Drains** | -7,200 | -4,500 |
| **Total Outflows** | -218,000 | -190,400 |

Values are in AF/yr

Note: provisional data subject to change

Table 6 and Figure 8 show SVIHM simulated groundwater pumping by water use sector. More than 85% of groundwater pumping in the Subbasin is used for agricultural purposes. Groundwater pumping varies from year to year; however, total pumping in the Subbasin has generally decreased since its peak in the 1980s and 1990s. Municipal and agricultural pumping are simulated in the SVIHM; however, domestic pumping, including *de minimis* pumping, is not included in the model, including pumping that occurs from a well with a discharge pipe of less than 3 inches. The SVIHM does not simulate domestic pumping because it is a relatively small portion of overall groundwater pumping in Salinas Valley Basin, and it is not included in the 180/400-Foot Subbasin water budget. The historical average in Table 6 is not strictly comparable to the GEMS historical average because the time periods used to calculate the averages are different.

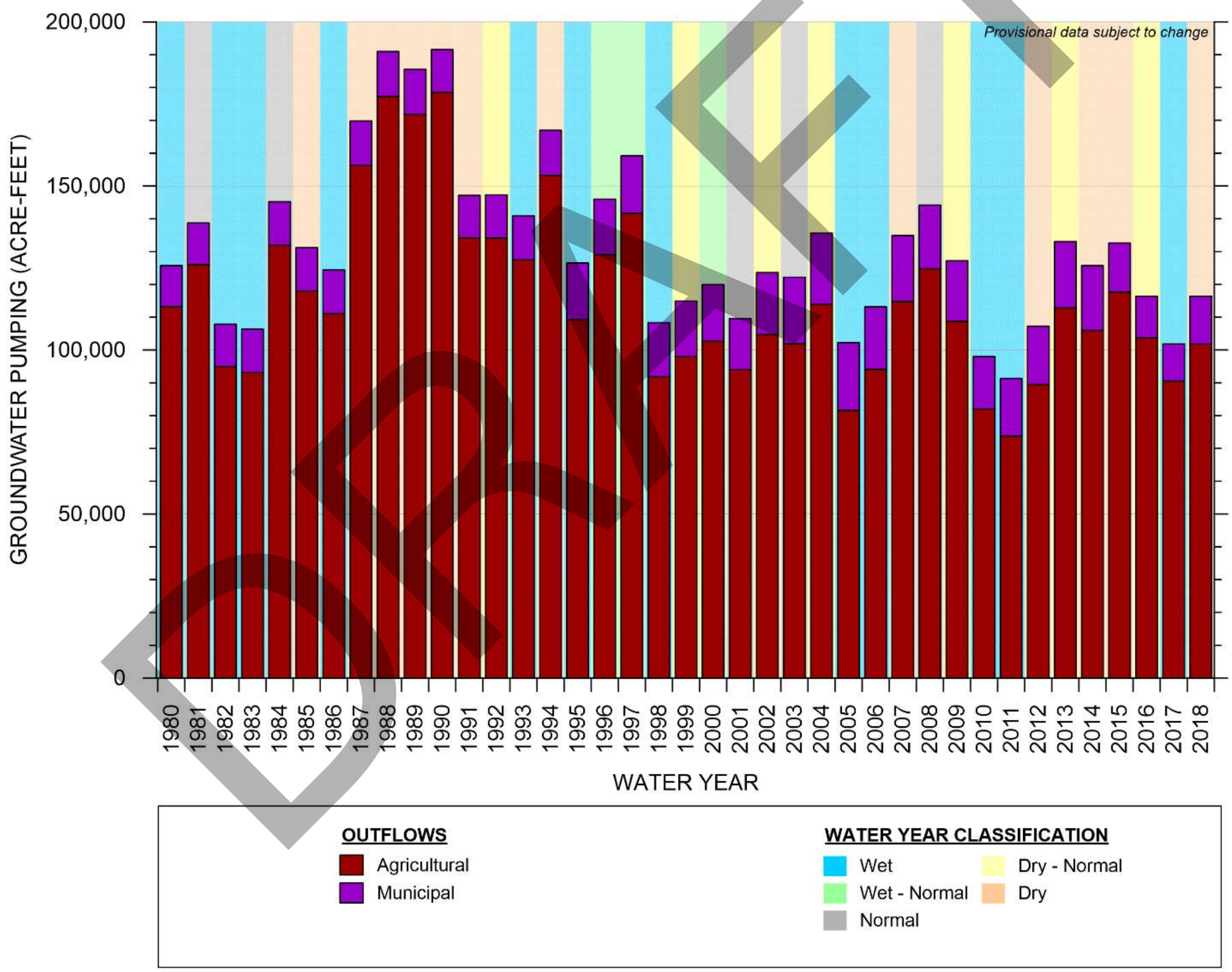


Figure 8. SVIHM Simulated Groundwater Pumping by Water Use Sector

Table 6. SVIHM Simulated and Groundwater Pumping by Water Use Sector

| | Simulated | | GEMS | |
|---|---|---|---|---|
| | Historical Average (WY 1980-2018) | Current (WY 2017-2018) | Historical Average (WY 1995-2018) | Current (WY 2017-2018) |
| **Municipal & Industrial** | -15,900 | -13,000 | -14,200 | -12,200 |
| **Agricultural** | -115,500 | -96,100 | -111,000 | -102,000 |
| **Total Pumping** | -131,400 | -109,100 | -125,200 | -114,200 |

Values are in AF/yr

Note: provisional data subject to change.

Figure 9 shows SVIHM estimated net subsurface flows entering and exiting the Subbasin by watershed and neighboring subbasin. Table 7 shows SVIHM estimated historical mean and current year subsurface flows. These results are from the SVIHM; however, modeling completed for the Monterey Subbasin with the Monterey Basin Groundwater Flow Model, which is better calibrated and more reliable than the SVIHM in the Monterey Subbasin, shows a net flow from the Monterey Subbasin into the 180/400-Foot Aquifer Subbasin of 12,300 AF/yr from 2004 to 2018. Additional efforts will be made to reconcile the discrepancies in cross-boundary flow terms between the SVIHM and Monterey Basin Groundwater Flow Model once the final SVIHM is made available by the USGS, and the water budget will be updated accordingly in future Periodic Evaluations.

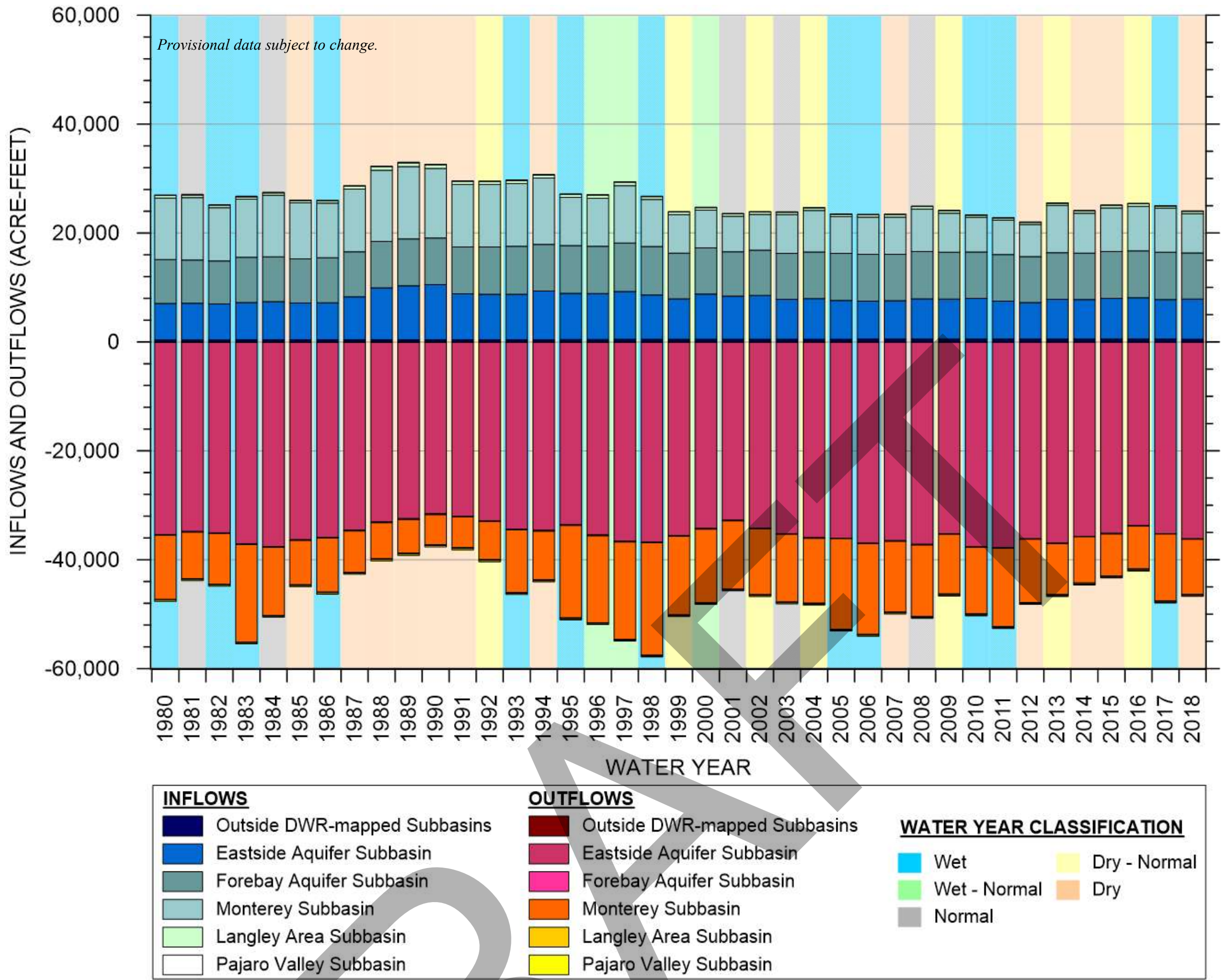


Figure 9. SVIHM Simulated Subsurface Inflows and Outflows from Watershed Areas and Neighboring Basins/Subbasins

Table 7. SVIHM Simulated Net Subbasin Boundary Flows

| | Historical Average (WY 1980-2018) | Current (WY 2017-2018) |
|---|---|---|
| **Eastside Aquifer Subbasin** | -27,500 | -28,300 |
| **Forebay Aquifer Subbasin** | 8,400 | 8,500 |
| **Monterey Subbasin** | -2,500 | -3,500 |
| **Langley Area Subbasin** | 300 | 200 |
| **Pajaro Valley Subbasin** | -300 | -100 |
| **Outside Areas** | 400 | 400 |

Values are in AF/yr

Note: provisional data subject to change

Change in Salinas Valley groundwater storage can be due to groundwater level changes or seawater intrusion. The water budget inflows and outflows listed above only relate to the change in storage due to groundwater level changes. However, total change in usable groundwater storage is estimated with the sum of change in usable storage from continued migration of the seawater intrusion front and the change in storage from groundwater level changes outside of the seawater intruded area. Each component is discussed separately below.

A negative change in groundwater storage due to groundwater level changes indicates groundwater storage depletion associated with groundwater level declines; while a positive value indicates groundwater storage accretion associated with groundwater level rise. Averaged over the historical period, the preliminary SVIHM estimates that the 180/400-Foot Aquifer Subbasin is in overdraft by 10,100 AF/yr. Model results represent storage loss from all aquifer layers, including shallow sediments. However, this simulated overdraft contains significant variability and uncertainty due to the preliminary calibration of the provisional SVIHM version used for this Periodic Evaluation. Figure 10 shows considerable variability in change in storage from one year to the next. In water year 1983, inflows exceeded outflows by more than 200,000 AF, while in 1990 outflows exceeded inflows by more than 100,000 AF. The current period represents a snapshot in time showing variability within the model simulation and is not necessarily representative of actual current conditions. Based on the simulated results from the SVIHM, this Periodic Evaluation considers 10,100 AF/yr as the historical average annual decline in storage due to change in groundwater elevations.

Seawater intrusion degrades groundwater quality, making the groundwater unusable for most municipal or agricultural uses. Seawater that flows into the basin mixes with fresh water and renders it unusable, typically when the chloride concentration is above 500 mg/L. Therefore, the 500 mg/L chloride isocontour is considered the limit of usable groundwater in storage. Groundwater within the 500 mg/L isocontour is a mix of fresh groundwater and seawater, and it represents the extent of the non-usable groundwater interface at a given time.

Change in usable storage from seawater intrusion in the 180/400-Foot Aquifer Subbasin is calculated from MCWRA's annual seawater intrusion maps, since the SVIHM does not specifically simulate seawater intrusion. Mapped contours indicate that the rate of loss of usable groundwater storage is greater than the simulated groundwater flow rate across the coastal boundary. This is because the simulated rate of groundwater flow across the coastal boundary represents the amount of full-strength seawater entering the Valley, but much more groundwater than the full-strength seawater is unusable as it mixes with fresh water. The loss of groundwater in storage due to seawater intrusion in the 180/400-Foot Aquifer Subbasin is estimated to be 12,600 AF/yr, based on isocontours from 1995 through 2019.

Furthermore, the change in groundwater storage calculated by the SVIHM is not comparable to, and should not be equated with, the calculated change in usable groundwater in storage. The

SVIHM water budget is an accounting of all flows across the subbasin boundaries, not an estimate of usable groundwater.

### 1.3.3 Historical and Current Groundwater Budget Summary

The main groundwater inflows into the Subbasin are: (1) deep percolation of precipitation and irrigation water, (2) subsurface inflow from adjacent DWR groundwater basins and subbasins, and (3) stream recharge. Groundwater pumping is the predominant groundwater outflow. The smaller outflow terms are subsurface outflows to adjacent subbasins, evapotranspiration, discharge to streams, and flows to agricultural drains.

Figure 10 shows the entire groundwater water budget from the SVIHM, including annual change in groundwater storage. Changes in groundwater storage are strongly correlated with changes in deep percolation of precipitation and stream flows. For example, 1983 and 1998 were comparatively very wet years and represent the greatest increases in deep percolation and, correspondingly, the greatest increases in groundwater storage over the historical period. Estimated cumulative change in groundwater storage has steadily declined over time with slight increases in response to wet periods.

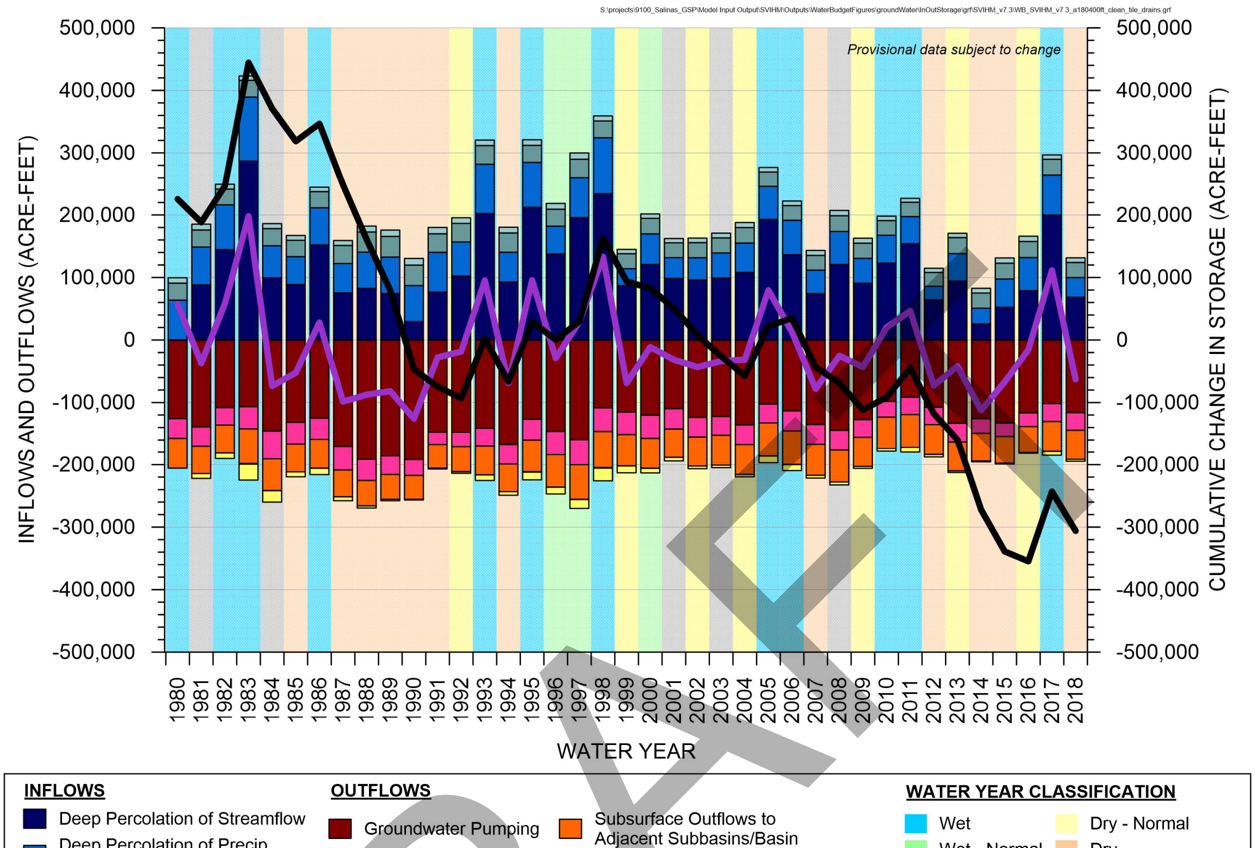


Figure 10. SVIHM Simulated Historical and Current Groundwater Budget



The SVIHM estimated the average historical annual decline in storage due to change in groundwater levels to be 10,100 AF/yr.

A comparison of the historical and current groundwater budgets is shown in Table 8. The values in the table are based on the inflows and outflows presented in previous tables. Negative values indicate outflows or depletions. Historical average decline in usable storage (overdraft) is 10,100 AF/yr. Inflow across coastline is shown in Table 8 as an inflow because it is represented in the models as seawater flow into the Subbasin at the coastline; however, seawater intrusion into the Subbasin contributes to the loss in usable storage. The SVIHM does not account for water quality. When factoring loss of usable storage due to seawater intrusion, the total loss of usable storage is considerably higher than if only loss of storage due to groundwater levels alone was considered. This table is informative in showing the relative magnitude of various water budget components; however, these results are based on a provisional model and will be updated in future periodic evaluations.

Table 8. Summary of Groundwater Budget

| | Historical Average (WY 1980-2018) | Current (WY 2017-2018) |
|---|---|---|
| **Net Inflows** | | |
| **Net Stream Exchange** | 120,700 | 138,200 |
| **Deep Percolation of Precipitation and Applied Irrigation** | 52,200 | 48,200 |
| **Net Coastal Inflow** | 7,800 | 6,900 |
| **Net Outflows** | | |
| **Groundwater Pumping** | -131,400 | -109,100 |
| **Net Flow from Adjacent Subbasins/Basin** | -21,200 | -22,800 |
| **Flow to Drains** | -7,200 | -4,500 |
| **Groundwater Evapotranspiration** | -31,200 | -28,500 |
| **Net Change In Storage (overdraft)** | | |
| **Change in Storage due to Groundwater Levels** | -10,100 | 28,700 |

Values are in AF/yr

Note: provisional data subject to change. This groundwater model does not factor in loss of usable storage due to seawater intrusion. The water budget does not balance exactly due to a combination of model error and presenting rounded water budget components.

## 1.3.4 Historical and Current Sustainable Yield

The historical and current sustainable yields reflect the amount of Subbasin-wide pumping reduction needed to balance the water budget, resulting in no net decrease in storage of usable groundwater. The sustainable yield has been estimated as:

Sustainable yield = pumping + change in storage due to groundwater levels + change in storage due to seawater intrusion

Table 9 provides an estimate sustainable yield based on results from the SVIHM and observed seawater intrusion. The simulated change in groundwater storage is used for this calculation, as well as the observed seawater intrusion estimate previously described, which is related to the change in volume of usable water rather than flow across the coastline. These values are the likely range of the sustainable yield of the Subbasin. As previously described in Section 1.3.3, historical average loss of storage due to water levels is 10,100 AF/yr. The total estimated historical loss of storage for the Subbasin is 22,700 AF/yr, which is the sum of storage loss due to seawater intrusion (12,600 AF/yr) and net storage loss due to groundwater level changes (10,100 AF/yr). Using this estimate of loss in storage and based on the historical average water budget, the best estimate of sustainable yield for the Subbasin is 108,700 AF/yr. In addition to the inherent uncertainty that exists in all numerical models, this estimate is based on results from a provisional version of the SVIHM. Sustainable yield estimates will be refined and improved in future periodic evaluations.

Table 9. Historical Sustainable Yield within the 180/400 from Simulated Pumping, Change in Storage, and Mapped Seawater Intrusion Areas

| | Historical Average (WY 1980-2018) |
|---|---|
| **Total Subbasin Pumping** | 131,400 |
| **Change in Storage due to Groundwater Levels** | -10,100 |
| **Change in Storage due to Seawater Intrusion** | -12,600 |
| **Estimated Sustainable Yield** | 108,700 |

Values are in AF/yr

Note: Pumping is shown as positive value for this computation. Change in storage and pumping values are based on the SVIHM and seawater intrusion is based on mapped areas of intrusion, as previously described in the text.

## 1.4 Projected Water Budgets

An updated version of the SVOM was used to develop the 2070 projected water budget. The projected water budgets shows anticipated conditions by the end of the 50-year GSP planning and implementation horizon if current management and land use continues. It may be used to help plan projects and management actions, along with other tools and analyses. These future baseline conditions include hydrology, water demand, and surface water supply over 51 years of potential future conditions. Following DWR guidance on incorporating climate change, the projected water budget is the average of 51 simulated likely hydrologic years that may occur in 2070.

The SVOM model used to develop the 2070 projected water budget simulates future hydrologic conditions with a central tendency climate change scenario applied. The assumptions for the climate change scenario are based on data provided by DWR (2018). The projected water budget is based on a provisional version of the SVOM and will be updated in future periodic evaluations.

### 1.4.1 Assumptions Used in Projected Water Budget Development

Model information and assumptions summarized in this section are based on provisional documentation on the model. Additional information will be provided in the USGS model report, when released. These assumptions are not policy decisions regarding management that should occur, but rather are intended to provide a reasonable projected water budget that represents what may occur independent of new projects and management actions. Future modeling may be used to understand the projected water budget under different assumptions.

The SVOM simulations used to develop the projected water budget simulations include the following assumptions:

- Land Use: The land use is assumed to be static, including crop types and water demands, aside from a semi-annual change to represent crop seasonality. The annual pattern is repeated every year in the model. Land use specified in the model by USGS reflects the 2017 land use.
- Agricultural Pumping: The SVOM derives agricultural pumping through a USGS modeling process called the Farm Process, whereby agricultural demand is driven by evapotranspiration, crop type, and crop coefficient, and it is met through available precipitation, surface water and recycled water where available, and groundwater extraction for the remaining quantity needed. Since land use is held constant and the climate change scenario includes a warmer future, agricultural demand and groundwater pumping is higher than in the historical water budget.
- Municipal and Industrial Pumping: Urban growth is assumed to be static to remain consistent with land use assumptions. If urban growth is infill, this assumption may result in an underestimate of net pumping increases and an underestimate of the Subbasin's future overdraft. If urban growth replaces agricultural irrigation, the impact may be minimal because the urban growth will replace existing agricultural water use.
- Reservoir Operations: The reservoir operations reflect MCWRA's current operational rules. In the SVOM, Nacimiento and San Antonio Reservoir receive inflow based on the precipitation and runoff in the watershed model, and releases are made according to the operational rules.
- Stream Diversions: The SVOM explicitly simulates only 2 stream diversions in the Salinas Valley Basin: Clark Colony and the Salinas River Diversion Facility (SRDF). The Clark Colony diversion is located along Arroyo Seco and diverts stream water to an agricultural area nearby. The SRDF came online in 2010 and diverts water from the Salinas River to the Castroville Seawater Intrusion Project (CSIP) area. Clark Colony diversions are repeated from the historical record to match the water year. SRDF diversions are made throughout the duration of the SVOM whenever reservoir storage and streamflow conditions allow during the period from April through October. For purposes of the projected water budgets, SRDF diversions are specified at a rate of 18 cubic feet per second.
- Recycled Water Deliveries: Recycled water has been delivered to the CSIP area since 1998 as irrigation supply. The SVOM includes recycled water deliveries throughout the duration of the model.

Modifications were made to the SVOM to incorporate anticipated climate change, in accordance with recommendations made by DWR in their *Guidance for Climate Change Data Use During Groundwater Sustainability Plan Development* (DWR, 2018). The following datasets were modified to account for projected climate change in 2070:

- Regional climate data including precipitation and potential evapotranspiration
- Streams flows along the margins of the model
- Direct precipitation and evapotranspiration on the San Antonio and Nacimiento Reservoirs
- Streamflow into the San Antonio and Nacimiento Reservoirs
- Sea level

Additional modifications include modifying SRDF diversions and CSIP supplemental wells maximum pumping capacity to be more in line with reported values.

*Climate Data*

DWR provided climate change datasets that were derived by taking the historical interannual variability from 1915 through 2011 and increasing or decreasing the magnitude of events based on projected changes in precipitation and temperature from general circulation models. These datasets of climate projections for 2070 conditions were derived from a selection of 20 global climate projections recommended by the Climate Change Technical Advisory Group as the most appropriate projections for California water resources evaluation and planning. Years after 2011 were adapted based on SVOM climate scenarios and the climate change adjustments for similar hydrologic years.

*Streamflow*

DWR provided monthly adjustment factors for unimpaired streamflow throughout California. For the Salinas Valley, these factors are provided for each major watershed, and streamflows along the margins of the Basin are modified by them. As with the climate data, climate change factors were extended beyond 2011 through using the factors on similar hydrologic years.

*Sea Level*

DWR guidance recommends using a single static value of sea level rise for each of the climate change scenarios (DWR, 2018). For the 2070 scenario, the DWR-recommended sea level rise value of 45 centimeters is used.

### 1.4.2 Projected Surface Water Budget

Average projected surface water budget inflows and outflows for the 2070 water budget are quantified in Table 10. As with the current water budget, the boundary stream inflows and outflows are much greater than the other components.

Table 10. SVOM Projected Average 2070 Surface Water Inflow and Outflow Components with Climate Change

| Projected Climate Change Timeframe | 2070 |
|---|---|
| **Boundary Stream Inflows** | 891,100 |
| **Runoff to Streams** | 46,300 |
| **Direct Precipitation** | 300 |
| **Net Flow between Surface Water and Groundwater** | -112,900 |
| **Boundary Stream Outflows** | -819,500 |
| **Diversions** | -5,300 |

Values are in AF/yr

Note: provisional data subject to change

### 1.4.3 Projected Groundwater Budget

Average projected groundwater budget inflows for the 2070 climate change assumptions are quantified in Table 11. The biggest contributors to groundwater inflows are deep percolation of stream flow and deep percolation of precipitation and applied irrigation.

Table 11. SVOM Projected Average 2070 Groundwater Inflow Components with Climate Change

| Projected Climate Change Timeframe | 2070 |
|---|---|
| **Deep Percolation of Stream Flow** | 130,100 |
| **Deep Percolation of Precipitation and Applied Irrigation** | 71,600 |
| **Inflow from Eastside Aquifer Subbasin** | 8,600 |
| **Inflow from Forebay Aquifer Subbasin** | 8,400 |
| **Inflow from Monterey Subbasin** | 9,900 |
| **Inflow from Langley Area Subbasin** | 400 |
| **Inflow from Pajaro Valley Subbasin** | 200 |
| **Inflow from Surrounding Watersheds** | 500 |
| **Inflow Across Coastline** | 8,300 |
| **Total Inflows** | 238,000 |

Values are in AF/yr

Note: provisional data subject to change

Average annual SVOM projected groundwater budget outflows for the 2070 water budget are quantified in Table 12. As in the historical and current water budgets, the greatest outflow is groundwater pumping. Negative values are shown in Table 12 to represent outflows. Groundwater pumping is 12% greater than the historical water budget, which is mainly due to the warmer climate change assumptions driving higher evapotranspiration to maintain the same crops. This water budget does not represent any policy decisions regarding future pumping, but rather estimates future pumping and other inflows and outflows if current urban pumping and agricultural land use is maintained in the future.

Table 12. SVOM Projected Average 2070 Groundwater Outflow Components with Climate Change

| Projected Climate Change Timeframe | 2070 |
|---|---|
| Groundwater Pumping | -147,300 |
| Flows to Drains | -8,600 |
| Flow to Streams | -2,200 |
| Groundwater Evapotranspiration | -36,800 |
| Outflow to Eastside Aquifer Subbasin | -35,700 |
| Outflow to Forebay Aquifer Subbasin | -200 |
| Outflow to Monterey Subbasin | -11,400 |
| Outflow to Langley Area Subbasin | -200 |
| Outflow to Pajaro Valley Subbasin | -600 |
| Outflow to Surrounding Watersheds | -100 |
| Outflow Across Coastline | -300 |
| Total Outflows | -243,400 |

Values are in AF/yr

Note: provisional data subject to change

The SVOM projects average annual overdraft from groundwater levels to be 2,300AF/yr for 2070. It does not account for loss of usable storage due to seawater intrusion; however, seawater intrusion is included in the projected sustainable yield. Average annual loss of groundwater storage due to changes in groundwater levels is less in the projected water budget than in the historical water budget, even though there is no change in land use. Loss of annual groundwater storage is likely due primarily to the applied climate change assumptions. The DWR climate change scenario generally includes warmer and wetter conditions, which has greater precipitation and streamflow and increases agricultural groundwater pumping due to higher evapotranspiration. While the model includes increased precipitation from climate change, it does not account for the frequency and magnitude of storm events. If storm events concentrate precipitation within short periods, more water may run off than infiltrate. Regarding future recharge, more analysis needs to be done.

Combining Table 11 and Table 12 yields the SVOM projected net groundwater inflow and outflow results for the 2070 water budget with climate change. These flows are shown in Table 13. Negative values indicate outflows or depletions. Projected average annual overdraft in 2070 due to groundwater levels is estimated to be 2,300 AF/yr. Inflow across the coastal boundary is shown as an inflow in the table because it represents seawater flow into the Subbasin in the model. Water budget estimates will be refined in the future with improved versions of the model.

Table 13. Average SVOM Projected Annual Groundwater Budget with Climate Change Conditions

| | 2070 |
|---|---|
| **Net Inflows** | |
| **Net Stream Exchange** | 127,900 |
| **Deep Percolation of Precipitation and Applied Irrigation** | 71,600 |
| **Net Coastal Inflow** | 8,000 |
| **Net Outflows** | |
| **Groundwater Pumping** | -147,300 |
| **Net Flow from Adjacent Subbasins/Basin** | -20,200 |
| **Flow to Drains** | -8,600 |
| **Groundwater Evapotranspiration** | -36,800 |
| **Net Change In Storage (overdraft)** | |
| **Change in Storage due to Groundwater Levels** | -2,300 |

Values are in AF/yr

Note: provisional data subject to change. The water budget does not balance exactly due to a combination of model error and rounded water budget components.

SVOM projected groundwater pumping by water use sector is summarized in Table 14. Because the model assumes static urban growth, future municipal and industrial pumping may result in underestimates of net pumping increases and the Subbasin's future overdraft. The 2070 model simulations predict that agriculture will account for about 90% of pumping. Similar to the SVIHM, domestic pumping is not included in the SVOM future projections simulation since it is a minimal part of the Subbasin's pumping.

Table 14. SVOM Projected Annual Groundwater Pumping by Water Use Sector

| | 2070 | Historical Average (WY 1980-2018) |
|---|---|---|
| **Municipal & Industrial** | -14,800 | -15,900 |
| **Agricultural** | -132,500 | -115,500 |
| **Total Pumping** | -147,300 | -131,400 |

Values are in AF/yr

Note: provisional data subject to change

### 1.4.4 Projected Sustainable Yield

Projected sustainable yield is the long-term pumping that can be sustained once all undesirable results have been addressed. However, it is not the amount of pumping needed to stop undesirable results before sustainability is reached. The SVBGSA recognizes that depending on the success of various proposed projects and management actions there may be some years when pumping must be held at a lower level to achieve necessary rises in groundwater elevation. The actual amount of allowable pumping from the Subbasin will be adjusted in the future based on the success of projects and management actions.

Average annual change in usable storage is due to both groundwater level change and seawater intrusion that renders the area within the 500 mg/L chloride isocontour generally unusable. This projected water budget estimates this through combining the change in groundwater storage due to groundwater levels from the SVOM 2070 simulation with the historical average annual change in storage due to seawater intrusion changes. The historical average annual change in storage is considered the most reasonable estimate for the future, assuming extraction continues.

To retain consistency with the historical sustainable yield, projected sustainable yield has been estimated as:

Sustainable yield = pumping + change in storage due to groundwater levels + change in storage due to seawater intrusion

The variable density Seawater Intrusion Model will be used to further evaluate the Subbasin-side pumping reductions and/or other projects and management actions that will be necessary to prevent additional net decreases in storage of usable groundwater from seawater intrusion. The SWI Model and/or the SVOM will be used to refine estimates of projected sustainable yield accordingly in future Periodic Evaluations. For this sustainable yield discussion and associated computations, groundwater pumping outflows are reported as positive values, which is opposite of how the values are reported in the water budget tables. The projected sustainable yield value will be updated in future periodic evaluations as more data are collected and additional analyses are conducted and the SVOM improved.

Although the sustainable yield values provide guidance for achieving sustainability, simply reducing pumping to within the sustainable yield is not proof of sustainability. Sustainability must be demonstrated through the Sustainable Management Criteria (SMC). Table 15 provides estimates of the future sustainable yield. As described for the historical sustainable yield, data indicate that the Subbasin has historically been in overdraft (on the order of 22,700 AF/yr decline in groundwater storage). The estimated total projected loss of storage for the Subbasin is 14,900 AF/yr, which is the sum of storage loss due to seawater intrusion (12,600 AF/yr) and net storage loss due to groundwater level changes (2,300 AF/yr). Using this estimate of loss in storage, the projected sustainable yield for the Subbasin is 132,400 AF/yr, based on the projected average water budget. This is higher than the historical sustainable yield in part due to greater groundwater recharge in the future associated with the applied climate change assumptions. In addition to the inherent uncertainty that exists in all numerical models, this estimate is based on results from a provisional version of the SVOM. Sustainable yield estimates will be refined and improved in future periodic evaluations.

Table 15. Projected Sustainable Yields for the 180/400 Subbasin Derived from GEMS, Observed Groundwater Levels, and Mapped Seawater Intrusion Areas

| | 2070 Projected Sustainable Yield | Historical Average (WY 1980-2018) |
|---|---|---|
| **Total Subbasin Pumping** | 147,300 | 131,400 |
| **Change in Storage due to Groundwater Levels** | -2,300 | -10,100 |
| **Change in Storage due to Seawater Intrusion** | -12,600 | -12,600 |
| **Estimated Sustainable Yield** | 132,400 | 108,700 |

Values are in AF/yr

Note: Pumping is shown as positive value for this computation. Change in storage value is based on observed groundwater measurements and seawater intrusion is based on mapped areas of intrusion, as previously described in the text for historical water budgets.

Table 15 includes the adjusted estimate of historical sustainable yield for comparison purposes. Although the sustainable yield values provide guidance for achieving sustainability, simply reducing pumping to within the sustainable yield is not proof of sustainability. Sustainability must be demonstrated through the SMC. The sustainable yield value will be modified and updated as more data are collected and more analyses are performed.

### 1.4.5 Uncertainties in Projected Water Budget Simulations

Models are mathematical representations of physical systems. They have limitations in their ability to represent physical systems exactly and due to limitations in the data inputs used. There is also inherent uncertainty in groundwater flow modeling itself, since mathematical (or numerical) models can only approximate physical systems and have limitations in how they compute data. However, DWR (2018) recognizes that although models are not exact representations of physical systems because mathematical depictions are imperfect, they are powerful tools that can provide useful insights.

There is additional inherent uncertainty involved in estimating water budgets with projected climate change based on the available scenarios and methods. The DWR recommended 2070 central tendency scenarios that are used to develop the projected water budgets with the SVOM provide a dataset that can be interpreted as the most likely future conditions. There is an approximately equal likelihood that actual future conditions will be more stressful or less stressful than those described by the recommended scenarios (DWR, 2018).

As stated in DWR (2018):

> *"Although it is not possible to predict future hydrology and water use with certainty, the models, data, and tools provided [by DWR] are considered current best available science and, when used appropriately should provide GSAs with a reasonable point of reference for future planning."*

## 1.5 Subbasin Water Supply Availability and Reliability

Water is not imported into the 180/400-Foot Aquifer Subbasin. However, a significant portion of the Subbasin's recharge is derived from reservoir releases that regulate Salinas River streamflow. The historical water budget incorporates years when there was little availability of surface water flow and groundwater elevations declined as a result. Figure 5 shows that when Salinas River flows were low, deep percolation to groundwater was also low. Declines in groundwater levels during these years contributed to chronic groundwater storage loss and seawater intrusion during the historical period. The projected water budgets are developed with the SVOM, which is based on historical surface water flows and groundwater conditions, and therefore projected water budgets incorporate reasonable fluctuations in water supply availability. MCWRA plans to revise the Habitat Conservation Plan (HCP) for the Salinas River, which may change the current reservoir release schedule. A revised reservoir release schedule could influence the reliability of groundwater recharge.



## 1.6 Uncertainties in Water Budget Calculations

As previously described, the level of accuracy and certainty is highly variable between water budget components. A few water budget components are directly measured, but most water budget components are either estimated inputs to the model, simulated by the model, or adjusted to account for model errors and limited calibration to storage loss and seawater intrusion. Additional model uncertainty stems from an imperfect representation of natural condition and is reflected in model calibration error. However, inputs to the models are carefully selected by the USGS using best available data, the model's calculations represent established science for groundwater flow, and the model calibration error is within acceptable bounds. Therefore, the models are the best available tools for estimating water budgets. The model results are provisional and subject to change in future periodic evaluations after the models are released by the USGS.

The following list groups water budget components in increasing order of uncertainty.

- Measured: metered municipal, agricultural, and some small water system pumping
- Simulated primarily based on climate data: precipitation, evapotranspiration, irrigation pumping
- Simulated based on calibrated model: all other water budget components

Simulated components based on calibrated model have the most uncertainty because those simulated results encompass uncertainty of other water budget components used in the model in addition to model calibration error.