

# Appendix D. Summary of Model Update and Modifications

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## D1 INTRODUCTION

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This appendix briefly summarizes modeling work done for the GSP. A hydrologic modeling platform was developed for the Paso Robles Subbasin during the period from 2005 through 2016. This modeling platform was adapted for the GSP. Modeling work conducted for the GSP included the following activities:

- Updating the platform with recent hydrologic information
- Modifying certain components of the platform to address computational issues identified during the update process
- Adapting the water budgeting process to be consistent with the new boundary of the Paso Robles Subbasin<sup>1</sup>. Figure D-1 of the GSP shows the new Subbasin Boundary (in green); the GSP only applies to the new Subbasin area, thus, water budgets reported in the GSP do not include areas within the former Subbasin boundary that lie north of the San Luis Obispo County Line and do not include the Atascadero Subbasin. Therefore, groundwater budgets reported in the GSP are not directly comparable to previously reported groundwater budgets.

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<sup>1</sup> The Subbasin boundary was formally modified by the California Department of Water Resources on February 11, 2019. Information on the modified boundary can be found at <https://water.ca.gov/Programs/Groundwater-Management/Basin-Boundary-Modifications>.

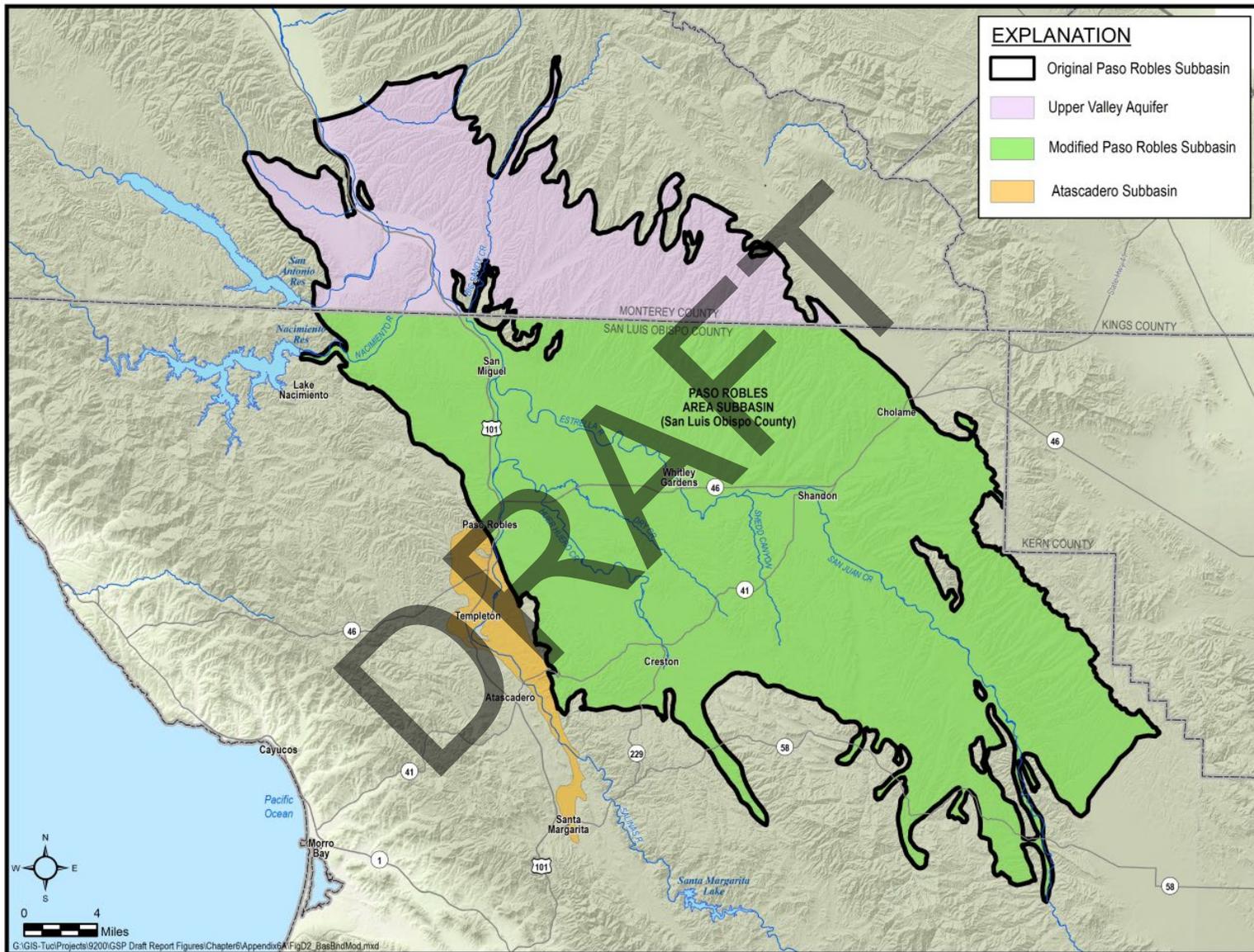


Figure D-1. Map Showing Paso Robles Subbasin Boundary

This appendix summarizes the model update process and effects of changes to the modeling platform and the change in Subbasin boundary on computed groundwater budgets, and presents a comparison between previously reported groundwater budgets and the computed groundwater budget for the GSP.

The appendix is subdivided into the following sections.

- Description of GSP Model
- Model Update
- Model Modifications
- Comparison of Groundwater Budgets

The hydrologic modeling platform includes a numerical groundwater flow model and two additional models that are used to compute groundwater model input data for streamflow, recharge, and groundwater pumping [Geoscience Support Services, Inc. (GSSI), 2014 and 2016]. The two additional models consist of a Soil Water Balance (SWB) spreadsheet model and a surface water model. The interrelationship between the groundwater model, SWB model, and surface water model are shown on Figure D-2. Hereafter in this appendix, the original hydrologic modeling platform developed by GSSI is referred to as “the GSSI model.”

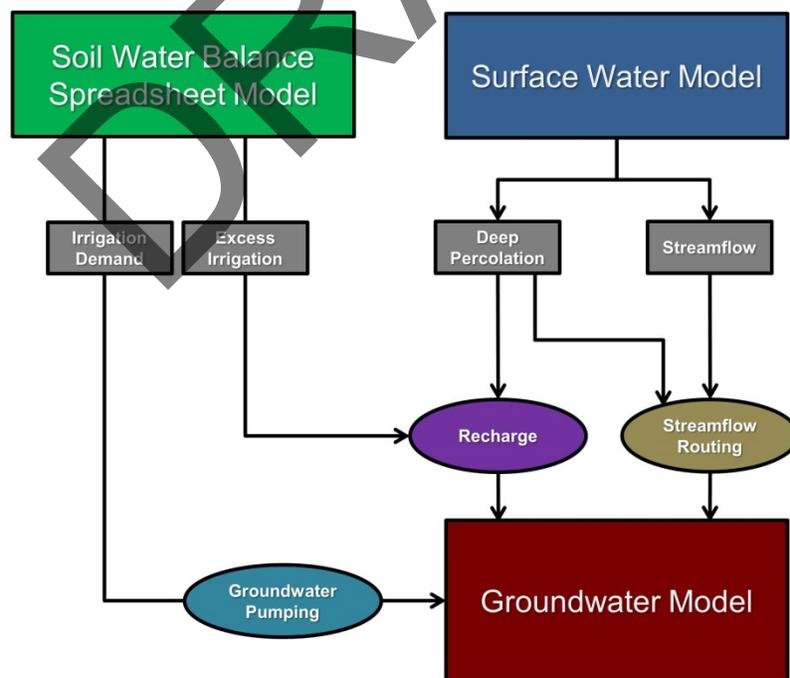


Figure D-2. Schematic for Modeling Platform

The GSSI model was updated for the GSP. The model update process included compiling hydrologic data and preparing model input files to extend the simulation time period from 2012 through 2016. Model modifications included changes to model structure, input/output processing routines, and model assumptions. Modifications were made to address issues that had a potentially significant impact on the computed water budget and groundwater storage deficit. These modifications were made to develop an updated estimate of the groundwater storage deficit that must be addressed during implementation of the GSP.

As was planned from the outset of GSP development, and to meet critical deadlines, the GSP model was not recalibrated. In lieu of recalibration, a focused comparison of model-projected and observed groundwater elevations at wells and stream flows at selected stream gages was conducted. Results of this comparison indicated that the calibration of the GSP model was similar to the GSSI model, thus, the model was considered appropriate for use on the GSP. The GSP model will be recalibrated in the future when additional hydrogeologic data are available.

## **D1.1 Overview of Differences in Computed Sustainable Yield**

Previous and current estimates of sustainable yield of the Subbasin were computed using the modeling platform. Both the model modifications and the change in Subbasin boundary influence the computed sustainable yield. Over the historical base period from 1981 through 2011, the computed sustainable yield from the 2016 GSSI model is about 89,700 acre-feet per year (AFY). This estimate of sustainable yield pertains to the original Subbasin boundary and the Atascadero Subbasin. By comparison, the computed sustainable yield for the modified Subbasin boundary from the updated GSP model is about 59,800 AFY. The difference between these two values is nearly 30,000 AFY. About 80% of this difference is due to changes in the Subbasin boundary. The remaining difference is the result of modifications made to the model components.

## D2 DESCRIPTION OF GSP MODEL

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### D2.1 Soil Water Balance Spreadsheet Model

The SWB model uses rainfall, evapotranspiration, soil, and crop data to estimate groundwater irrigation demand for crops in the Subbasin. Irrigated crops in the Paso Robles Subbasin are assigned to seven crop categories (Carollo and others, 2012), including alfalfa, nursery, pasture, citrus, deciduous, vegetables, and vineyard. For the GSP model, geospatial crop datasets compiled by the Agricultural Commissioner's Office of San Luis Obispo County were intersected with different climate zones and soil types in both the Paso Robles Subbasin and surrounding watershed. For each of the seven crop categories, existing discrete SWB models were extended in time for each unique intersection of crop acreage, climate zone, and soil type to cover the current period (2012-2016).

The underlying structure and data requirements are identical for all of the SWB spreadsheet models, except vineyards. All of the SWB models operate on a daily time step, and require daily precipitation and reference evapotranspiration rates as input. SWB models developed for vineyards also require daily minimum temperature data to estimate frost prevention groundwater pumping during March and April.

The SWB model computes daily irrigation demand rates in inches. Groundwater pumping to satisfy the irrigation demand is higher than the actual crop demand due to excess irrigation losses, which depend on assumed irrigation efficiency. The study documented by GSSI (2014) defined irrigation efficiency for each of the seven crop categories, and those efficiency values were also used in this study. The difference between groundwater pumping and crop irrigation demand is assumed to percolate past the base of the root zone, ultimately becoming groundwater recharge. This recharge is referred to as irrigation return flow in Chapter 6.

### D2.2 Surface Water Model

A surface water model was developed by GSSI (2014) for the watershed contributing to the Paso Robles Subbasin. The surface water model was developed using the Hydrologic Simulation Program – Fortran (HSPF) code. The model simulates land surface processes and surface water flow at the subwatershed scale (Bicknell and others, 2001). The surface water model simulates daily time steps, and requires daily precipitation, reference evapotranspiration, and reservoir releases as input. Historical watershed simulations developed by GSSI (2014) used land use data for 1985, 1997, and 2011 in the surface water model. The 2011 land use data were used to update the GSP model.

The surface water model simulates deep percolation of precipitation past the base of the root zone and streamflow leaving the outlet of each subwatershed. The amount of deep percolation of

precipitation computed by the surface water model was included in the recharge assigned to the groundwater model, and simulated streamflow at the subwatershed outlet was used to compute surface flow rates for stream segments simulated in the groundwater model.

## **D2.3 Groundwater Model**

The groundwater flow model for the Paso Robles Subbasin uses the MODFLOW-2005 code (GSSI, 2014 and 2016). The extent and structure of the GSSI model are based on an earlier version of the groundwater flow model developed by Fugro (2005). Groundwater inflows simulated in the model include areal recharge, subsurface inflow at the model boundaries, and streambed percolation. Areal recharge includes both recharge from precipitation and irrigation return flow. Groundwater outflows simulated in the model include subsurface flow out of the Subbasin, groundwater pumping, and riparian evapotranspiration.

Areal recharge and subsurface inflow are computed based on excess irrigation from the SWB model and deep percolation of precipitation from the surface water model. Streambed percolation depends on both simulated water table elevation and simulated streamflow, which in turn is based on simulated streamflow from the surface water model. Agricultural groundwater pumping is specified based on irrigation demand computed in the SWB model.

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## D3 MODEL UPDATE

SGMA regulations require estimation of surface water and groundwater budgets for both a historical base period and current period. For the Subbasin, the historical base period covers Water Years (WY) 1981 through 2011 and the current period covers WY 2012 through 2016. The existing model covers only the historical base period (GSSI, 2014; GSSI, 2016). To comply with SGMA regulations for developing a current water budget, it was necessary to update the 2016 version of the GSSI model to include hydrologic data from 2012 through 2016.

Each of the three components of the modeling platform was updated to include the current period. Table D-1 lists datasets used for the model update, along with the source for each dataset.

Table D-1. Data Sources for Model Update

Dataset	Responsible Agency or Entity	Type of Data	Data Source
<b>Meteorological Data</b>			
Paso Robles Station (46730); Santa Margarita Booster Station (47933)	NOAA <sup>1</sup>	Daily precipitation	<a href="https://www.ncdc.noaa.gov/cdo-web/datatools/findstation">https://www.ncdc.noaa.gov/cdo-web/datatools/findstation</a>
San Miguel Wolf Ranch (47867)	NOAA <sup>1</sup>	Daily precipitation	<a href="ftp://ftp.ncdc.noaa.gov/pub/data/hpd/autos2/beta/">ftp://ftp.ncdc.noaa.gov/pub/data/hpd/autos2/beta/</a>
Oak Shores WWTP (201)	San Luis Obispo County	Daily precipitation	Electronic transmittal from SLO County
Paso Robles	WWG <sup>2</sup>	Daily reference evapotranspiration	Electronic transmittal
Atascadero (163)	CIMIS <sup>3</sup>	Daily reference evapotranspiration	<a href="https://cimis.water.ca.gov/WSNReportCriteria.aspx">https://cimis.water.ca.gov/WSNReportCriteria.aspx</a>
<b>Hydrologic Data</b>			
Nacimiento Reservoir	Monterey County Water Resources Agency	Daily reservoir releases	<a href="http://www.co.monterey.ca.us/government/government-links/water-resources-agency/projects-facilities/historical-data#wra">http://www.co.monterey.ca.us/government/government-links/water-resources-agency/projects-facilities/historical-data#wra</a>
San Antonio Reservoir	Monterey County Water Resources Agency	Daily reservoir releases	<a href="http://www.co.monterey.ca.us/government/government-links/water-resources-agency/projects-facilities/historical-data#wra">http://www.co.monterey.ca.us/government/government-links/water-resources-agency/projects-facilities/historical-data#wra</a>
Salinas Dam	San Luis Obispo County	Daily reservoir releases	<a href="https://wr.slocountywater.org/site.php?site_id=25&amp;site=2d50a617-2e23-4efc-a9be-e3a2c4a7100b">https://wr.slocountywater.org/site.php?site_id=25&amp;site=2d50a617-2e23-4efc-a9be-e3a2c4a7100b</a>
<b>Water Use Data</b>			
San Miguel CSD	San Miguel CSD	Monthly groundwater pumping	Excel file (Paso_Water_Use_Tables_v7.xlsx) received from GEI Consultants on 14 June 2018; data provided to GEI by San Miguel CSD
City of Paso Robles	City of Paso Robles	Monthly groundwater pumping	Excel file (Paso_Water_Use_Tables_v7.xlsx) received from GEI Consultants on 14

			June 2018; data provided to GEI by City of Paso Robles
Templeton CSD	Templeton CSD	Annual groundwater pumping	Water Supply Buffer Update, January 31, 2018
Atascadero MWC	Atascadero MWC	Annual groundwater pumping	Atascadero MWC Urban Water Management Plan
Small commercial pumping	N/A	Annual groundwater pumping	For pumping that started before 2010, projected based on historic use in 2016 model (linear regression trend). For water use that began in 2010; assume 1% annual increase through 2016.
Domestic pumping	N/A	Annual groundwater pumping	Projected based on historic use in 2016 model (linear regression trend).
Agricultural pumping	N/A	Annual groundwater pumping	Pumping based on groundwater demand from soil water-balance spreadsheets
<b>Wastewater Recharge</b>			
Wastewater recharge (all utilities)	N/A	Annual recharge to groundwater from wastewater	Projected based on rates in 2016 model (linear regression trend).
<b>Crop Data</b>			
San Luis Obispo County, 2013-2016	San Luis Obispo County	Geospatial data attributed with acreage and crop group	Electronic transmittal from SLO County
State of California, 2014	CA DWR <sup>4</sup>	Geospatial data attributed with acreage and crop group	<a href="https://gis.water.ca.gov/app/CADWRLandUseViewer/">https://gis.water.ca.gov/app/CADWRLandUseViewer/</a>

- (1) National Oceanic and Atmospheric Administration
- (2) Western Weather Group
- (3) California Irrigation Management Information System
- (4) California Department of Water Resources

## D4 MODEL MODIFICATIONS

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### D4.1 Modifications to Model Components

Groundwater budgets for the Subbasin were derived from the groundwater flow model, which depends on the SWB models and surface water model for key input data. During the model update process for the GSP model, several modifications were made to the individual models to improve two computational aspects of the model.

#### D4.1.1 Modifications to Agricultural Irrigation Routing

In the model input files developed by GSSI and provided to Montgomery & Associates (M&A) by the County of San Luis Obispo, irrigation return flow was routed to the surface water model. This irrigation return flow was treated as an external lateral surface inflow to the land surface. The surface water model combines this water with all direct precipitation that was not intercepted by the crop canopy. Some of the water accumulating at the land surface becomes streamflow. The remaining water enters the soil root zone. In the GSSI model, excess irrigation return flow water accumulating in the upper and lower soil root zones was subject to evapotranspiration. However, excess irrigation return flow represents water that has moved past the root zone, and should not be subject to evapotranspiration. Thus, irrigation return flow was inadvertently subjected to soil evaporation twice. The net effect of double-counting soil evaporation was to underestimate the quantity of water that ended up as deep percolation to groundwater.

The models were modified so that irrigation return flow calculated in the SWB models was routed to groundwater recharge in the groundwater flow model instead of routed to the surface water model. As a result, areal recharge specified in the GSP model is greater than areal recharge specified in the GSSI model.

#### D4.1.2 Modifications to Streamflow Routing Outside the Paso Robles Subbasin

In the GSSI model, subsurface inflow was computed as the sum of irrigation return flow, deep percolation of direct precipitation, and streambed percolation occurring outside the Subbasin boundaries. Streambed percolation was computed by HSPF as an outflow from each stream reach. The streambed percolation was computed using reference information from the HSPF Best Management Practices toolkit developed by the U.S. Environmental Protection Agency (GSSI, 2014).

Modifications were made to the process described above to ensure consistency in the simulated water balance. In HSPF, stream outflows and streambed percolation are routed to the next downstream stream reach. Consequently, when a stream enters the margin of the Paso Robles

Subbasin, HSPF routes all of the streamflow and streambed percolation into the stream network within the Subbasin. However, in the GSSI model, the streambed percolation water was also being added to the groundwater model as subsurface inflow. This means percolating water through streambeds in the watershed outside of the Subbasin was being double counted: as both stream inflow and subsurface inflow.

To avoid double counting the inflow, M&A modified the groundwater model input files so that subsurface inflow no longer included HSPF model-computed streambed percolation outside the Paso Robles, Atascadero, and Upper Valley Subbasins. The primary effect of this change was a reduction in subsurface inflow into the groundwater model. A secondary effect of this change was a reduction in inflow to streams inside the Subbasin boundary due to excess subsurface inflow.

Reduction in stream inflows as a result of modifications described above is due to an input processing procedure developed by GSSI (2016). Specifically, the 2016 version of the GSSI model included an empirical procedure for re-assigning computed subsurface inflow above a threshold value as surface water inflow to streams inside the Subbasin boundaries. The GSP model uses the same procedure; however, streambed percolation is no longer double counted, thus computed subsurface inflow in excess of the threshold is lower in the GSP model than compared to the GSSI (2016) model.

#### **D4.1.3 Summary of Effects of Model Modifications**

The net effect of correcting excess agricultural irrigation routing was to increase areal recharge within the Paso Robles Subbasin. The net effect of removing streambed percolation computed by the surface water model from subsurface inflow to the groundwater model was to reduce both subsurface inflow and surface water inflow to streams in the groundwater flow model. The combined effect of these two modifications was to reduce the amount of water recharging the groundwater system in the Subbasin.

### **D4.2 Change in Subbasin Boundary**

The boundary of the Paso Robles Subbasin changed between completion of the 2016 GSSI model and the GSP model update.

In 2018, the California Department of Water Resources (DWR) redefined the Paso Robles Subbasin boundary in response to two basin boundary modification requests. As a result of this modification, the Atascadero Subbasin, and all land north of the Monterey County line are no longer included in the Paso Robles Subbasin (Figure D-1). The modified Subbasin area (in green) is addressed in the GSP. Groundwater budgets for the GSP are reported for the smaller Subbasin area. Previous groundwater budgets using the 2016 GSSI model were reported for the entire original Paso Robles Groundwater Subbasin, including the Atascadero Subbasin (GSSI,

2016). Therefore, the GSP groundwater budgets are not directly comparable to the previous groundwater budgets.

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## D5 COMPARISON OF GROUNDWATER BUDGETS

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Differences between previously published groundwater budgets and the groundwater budget published in the GSP are caused by:

- Modifications made to the modeling platform components
- Changes in the Subbasin boundary

These changes have a direct effect on the computed water budget, long-term groundwater storage deficit and sustainable yield in the Subbasin.

The effect of modifying the modeling platform on groundwater storage deficit and sustainable yield can be quantified by comparing the computed water budgets from 2016 GSSI and GSP models for the same Subbasin boundary. The effect of changing the Subbasin boundary on groundwater storage deficit and sustainable yield can be quantified by comparing the computed groundwater budget of the original Paso Robles Subbasin boundary to the groundwater budget of the modified Paso Robles Subbasin boundary using either the 2016 GSSI or GSP model.

### D5.1 Effect of Model Modifications on Water Budgets

This section summarizes changes in water budget components, groundwater storage deficit, and sustainable yield that result from modifications made to the individual models of the modeling platform. Table D-2 compares annual average groundwater pumping rates by water use sector for the historical base period (1981 to 2011) specified for the original Paso Robles Subbasin boundary in the GSSI (2016) and GSP models.

Table D-2. Simulated Groundwater Pumping

Water Use Sector	Original Subbasin Boundary	
	GSSI (2016)	GSP model
Agricultural	75,900	75,800
Municipal	12,000	12,000
Rural-Domestic	2,800	2,800
Small Commercial	2,200	2,200
<b>Total</b>	<b>92,900</b>	<b>92,800</b>

Note: All values in AFY

Annual average groundwater pumping rates are nearly identical between the two models. The small increase of 100 AFY in annual average agricultural pumping in the GSP model is the result of minor modifications made to the model data processing spreadsheets.

Table D-3 compares simulated annual average inflow and outflow components of the groundwater budget for the original Paso Robles Subbasin boundary for the historical base period for the GSSI (2016) and GSP models.

Table D-3. Comparison of Annual Average Inflow and Outflow Components

	Original Subbasin Boundary	
	GSSI (2016)	GSP model
<b>Inflow</b>		
Streamflow Percolation	53,000	39,500
Total Recharge <sup>1</sup>	50,500	51,600
Treated Wastewater Leakage	5,600	5,600
<b>Total Inflow</b>	<b>109,100</b>	<b>96,700</b>
<b>Outflow</b>		
Groundwater Pumping	92,900	92,800
Discharge to Streams and Rivers	14,300	13,200
Riparian Evapotranspiration	3,500	3,500
Subsurface Outflow <sup>2</sup>	1,600	1,600
<b>Total Outflow</b>	<b>112,300</b>	<b>111,100</b>

Notes: All values in AFY

(1) Includes areal recharge and subsurface inflow from the surrounding watershed

(2) Includes subsurface outflow in the Salinas Alluvium and Paso Robles Formation at the northern boundary of the original Paso Robles Subbasin

Total inflow in the GSP model is about 12,400 AFY lower than the GSSI (2016) model for the original Subbasin boundary. The reduction in total inflow reflects the net change in inflow caused by a reduction of 13,500 AFY in streambed percolation and an increase of 1,100 AFY in total recharge. The changes in streamflow and recharge are described in Section D-D4.1.

Table D-4 compares the computed annual average groundwater storage deficit and sustainable yield from the GSSI (2016) and GSP models, for the original Subbasin boundary and historical base period of 1981 through 2011.

Table D-4. Annual Average Groundwater Storage Deficit and Sustainable Yield

	Original Subbasin Boundary	
	GSSI (2016)	GSP model
<b>Storage Deficit</b>	<b>3,200</b>	<b>14,400</b>
<b>Sustainable Yield</b>	<b>89,700</b>	<b>78,400</b>

Note: All values in AFY

The computed annual average storage deficit for the original Subbasin boundary for the GSP model is about 11,200 AFY greater than the GSSI (2016) model. The increase in the computed storage deficit is due almost entirely to the reduction in total groundwater inflows, as shown in Table D-3. The reduction in total inflow is the result of the reduction in streamflow that resulted from modifying the model components. Consequently, the annual average sustainable yield of the original Subbasin boundary estimated using the GSP model is about 11,300 AFY lower than that computed by the GSSI model.

## D5.2 Effect of Changes in Subbasin Boundary on Water Budgets

This section summarizes changes in water budget components, groundwater storage deficit, and sustainable yield that result from the change in Subbasin boundary. The 2016 GSSI model was used for this evaluation because it does not include the effect of modifications made to the model components discussed in Section D-D5.1. Table D-5 compares annual average groundwater pumping rates by water use sector specified for both the original and modified Subbasin boundaries, for the historical base period, and for the 2016 GSSI model.

Table D-5. Simulated Groundwater Pumping

Water Use Sector	GSSI (2016) model	
	Original Subbasin Boundary	Modified Subbasin Boundary
Agricultural	75,900	65,400
Municipal	12,000	3,100
Rural-Domestic	2,800	2,500
Small Commercial	2,200	1,400
<b>Total</b>	<b>92,900</b>	<b>72,400</b>

Note: All values in AFY

Simulated annual average total pumping rate is about 20,500 AFY lower for the modified Subbasin boundary compared to the original Subbasin boundary. The total amount of groundwater pumping is lower because pumping in the Atascadero Subbasin and the portion of the original Paso Robles Subbasin located in Monterey County is no longer accounted for in the modified Subbasin. Thus, the reduction in pumping is equivalent to the amount of groundwater pumping in the Atascadero Subbasin and in the portion of the original Paso Robles Subbasin located in Monterey County.

Table D-6 compares simulated annual average inflow and outflow components of the groundwater budget for the original and modified Subbasin boundaries, the historical base period, and the 2016 GSSI model.

Table D-6. Comparison of Simulated Inflow and Outflow

	GSSI (2016) model	
	Original Subbasin Boundary	Modified Subbasin Boundary
<b>Inflow</b>		
Streamflow Percolation	53,000	36,700
Total Recharge	50,500	34,000
Wastewater Pond Leakage	5,600	3,400
Subsurface Inflow <sup>1</sup>	0	3,600
<b>Total Inflow</b>	<b>109,100</b>	<b>77,700</b>
<b>Outflow</b>		
Groundwater Pumping	92,900	72,400
Discharge to Streams and Rivers	14,300	8,100
Riparian Evapotranspiration	3,500	1,700
Subsurface Outflow <sup>2</sup>	1,600	2,500
<b>Total Outflow</b>	<b>112,300</b>	<b>84,700</b>

Note: All values in AFY

(1) Subsurface inflow from the Atascadero Subbasin

(2) Subsurface outflow from the Paso Robles Subbasin to the Upper Valley Subbasin.

### D5.2.1 Differences in Simulated Inflows

Total simulated annual average groundwater inflow is about 31,400 AFY lower for the modified Subbasin than the original Subbasin. The reduction reflects the net change in streamflow percolation, recharge, wastewater pond leakage, and subsurface inflow, as described further below.

- Simulated annual average streamflow percolation for the modified Subbasin boundary is about 16,300 AFY lower compared to the original Subbasin boundary. The lower streamflow percolation is due to reductions in the number and length of stream channels present within the modified Subbasin boundary compared to the original Subbasin boundary.
- Simulated annual average recharge for the modified Subbasin boundary is about 16,500 AFY lower compared to the original Subbasin boundary. The lower recharge is due to:
  - Smaller area within the modified Subbasin, resulting in less areal recharge from direct precipitation
  - Smaller area of irrigated fields within the modified Subbasin, resulting in less recharge from irrigation return flow

- Reduced length of contact between Subbasin and surrounding watershed, resulting in less subsurface inflow
- Simulated annual average wastewater pond leakage for the modified Subbasin boundary is about 2,200 AFY lower compared to the original Subbasin boundary. Wastewater pond leakage is lower because it does not include wastewater pond leakage within the Atascadero Subbasin.
- Simulated annual average subsurface inflow for the modified Subbasin boundary is about 3,600 AFY higher compared to the original Subbasin boundary. Subsurface inflow to the modified Subbasin includes groundwater flow from the Atascadero Subbasin into the Paso Robles Subbasin. When modeling the original Subbasin boundary, which includes both the Atascadero Subbasin and Paso Robles Subbasin, the flow between the Subbasins was an internal flow within the model and not an inflow crossing the boundary of the model.

## D5.2.2 Differences in Simulated Outflows

Total simulated annual average outflow for the modified Subbasin boundary is about 27,600 AFY lower compared to the original Subbasin boundary. The reduction in total simulated outflow is due to changes in simulated discharge to rivers and streams, riparian evapotranspiration, and subsurface outflow, as described further below.

- Simulated annual average total groundwater pumping for the modified Subbasin is about 20,500 AFY lower than that of original Subbasin. The amount of groundwater pumping is lower because the modified Subbasin boundary does not include pumping from the Atascadero Subbasin or the portion of the original Paso Robles Subbasin in Monterey County.
- Simulated annual average discharge to streams and rivers for the modified Subbasin boundary is about 6,200 AFY lower compared to the original Subbasin boundary. The lower discharge to rivers and streams is due to exclusion of channel segments that receive groundwater discharge in the Atascadero Subbasin and portion of the original Paso Robles Subbasin in Monterey County.
- Simulated annual average riparian evapotranspiration for the modified Subbasin boundary is about 1,800 AFY lower compared to the original Subbasin boundary. The amount of riparian evapotranspiration is lower because the number and length of stream channels along which riparian vegetation are lower in the modified Subbasin compared to the original Subbasin.
- Simulated annual average subsurface outflow for the modified Subbasin boundary is about 900 AFY higher compared to the original Subbasin boundary. Similar to subsurface inflow, the higher subsurface outflow occurs because this flow crosses a

boundary (the Monterey County line) when modeling the modified Subbasin boundary, whereas, this flow is internally accounted for when modeling the original Subbasin boundary.

### D5.2.3 Differences in Simulated Sustainable Yield

Table D-7 compares the computed average annual groundwater storage deficit and sustainable yield for the original and modified Subbasin boundaries, the historical base period, and using the 2016 GSSI model.

Table D-7. Average Annual Groundwater Storage Deficit and Sustainable Yield

	2016 GSSI Model	
	Original Subbasin	Modified Subbasin
<b>Storage Deficit</b>	3,200	7,000
<b>Sustainable Yield</b>	89,700	65,400

Note: All values in AFY

The computed annual average storage deficit from the 2016 GSSI model is about 3,200 AFY for the original Subbasin. Groundwater storage deficits similar to this value have been commonly reported in the Paso Robles Subbasin in the past. For the modified Subbasin, the computed annual average storage deficit from the 2016 GSSI model is about 7,000 AFY. Therefore, the computed annual average groundwater storage deficit for the modified Subbasin is about 3,800 AFY higher compared to the original Subbasin. The increase in computed annual average groundwater storage deficit is the result of differences in the magnitude of reductions in total inflow and total outflow.

Figure D-3 shows a map of computed sustainable yields from the 2016 GSSI model. The area of the original Paso Robles Subbasin outside of the modified Subbasin (green area) has been divided into the Atascadero Subbasin and the Upper Valley Aquifer Subbasin for illustration purposes. The sustainable yield of the Upper Valley Aquifer, Paso Robles, and Atascadero Subbasins shown on Figure D-3 sum to the sustainable yield of the original Subbasin as listed in Table D-7.

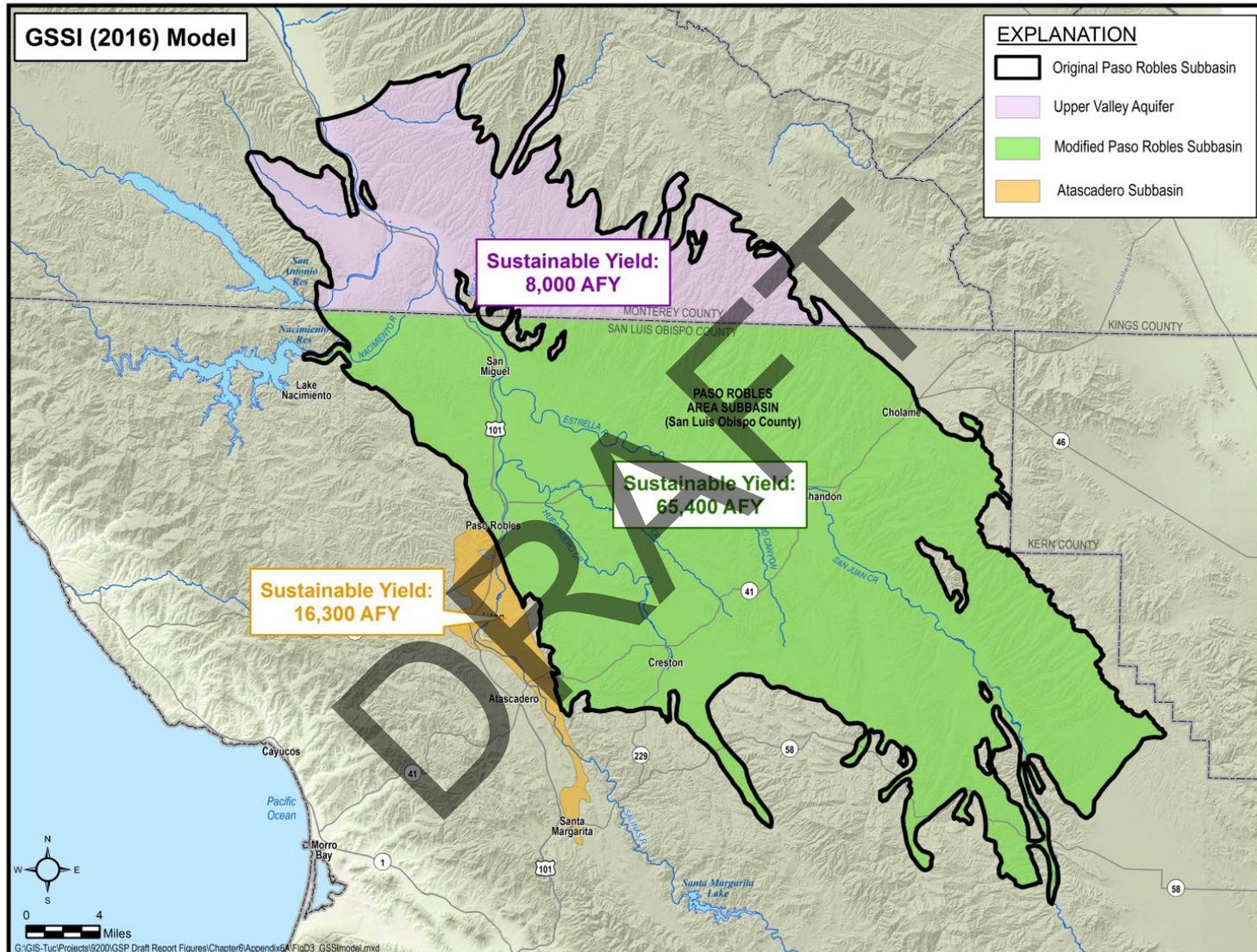


Figure D-3. Sustainable Yield Computed by GSSI (2016) Model

## D5.3 Combined Effect of Model Modifications and Changes in Subbasin Boundary on Water Budgets

This section summarizes changes in water budget components, groundwater storage deficit, and sustainable yield that result from both modifications made to model components and the change the Subbasin boundary. For this evaluation, the GSP model was used because it includes both types of changes. Table D-8 compares annual average groundwater pumping rates by water use sector specified for both the original and modified Subbasin boundaries, for the historical base period, using the GSP model.

Table D-8. Simulated Groundwater Pumping for GSP Model

Water Use Sector	GSP Model	
	Original Subbasin	Modified Subbasin
Agricultural	75,800	65,400
Municipal	12,000	3,100
Rural-Domestic	2,800	2,500
Small Commercial	2,200	1,400
<b>Total</b>	<b>92,800</b>	<b>72,400</b>

Note: All values in AFY

Table D-9 compares simulated annual average inflow and outflow components of the groundwater budget for the original and modified Subbasin boundaries, for the historical base period, using the GSP model.

Table D-9. Comparison of Simulated Inflow and Outflow for GSP Model

	GSP model	
	Original Subbasin	Modified Subbasin
<b>Inflow</b>		
Streamflow Percolation	39,500	26,900
Total Recharge	51,600	38,000
Wastewater Pond Leakage	5,600	3,400
Subsurface Inflow <sup>1</sup>	--	3,100 <sup>1</sup>
<b>Total Inflow</b>	<b>96,700</b>	<b>71,400</b>
<b>Outflow</b>		
Groundwater Pumping	92,800	72,400
Discharge to Streams and Rivers	13,200	7,300
Riparian Evapotranspiration	3,500	1,700
Subsurface Outflow	1,600 <sup>2</sup>	2,600 <sup>3</sup>
<b>Total Outflow</b>	<b>111,100</b>	<b>84,000</b>

Note: All values in AFY

(1) Subsurface inflow from the Atascadero Subbasin

(2) Includes subsurface outflow in the Salinas Alluvium and Paso Robles Formation at the northern boundary of the original Paso Robles Subbasin

(3) Subsurface outflow from the Paso Robles Subbasin to the Upper Valley Subbasin.

### **D5.3.1 Differences in Simulated Inflows**

Total simulated annual average groundwater inflow is about 25,300 AFY lower for the modified Subbasin than the original Subbasin. The reduction reflects the net change in streamflow percolation, recharge, wastewater pond leakage, and subsurface inflow, as described further below.

- Simulated annual average streamflow percolation for the modified Subbasin boundary is about 12,600 AFY lower compared to the original Subbasin boundary. The lower streamflow percolation is due to reductions in the number and length of stream channels present within the modified Subbasin boundary compared to the same for original Subbasin boundary.
- Simulated annual average recharge for the modified Subbasin boundary is about 13,600 AFY lower compared to the original Subbasin boundary. The lower recharge is due to:
  - Smaller area within the modified Subbasin, resulting in less recharge from direct precipitation
  - Smaller area of irrigated fields in the modified Subbasin, resulting in less recharge from irrigation return flow
  - Reduced length of contact between Subbasin and surrounding watershed, resulting in less subsurface inflow
- Simulated annual average wastewater pond leakage for the modified Subbasin boundary is about 2,200 AFY lower compared to the original Subbasin boundary. The amount of wastewater pond leakage is lower because the modified Subbasin does not include wastewater pond leakage within the Atascadero Subbasin.
- Simulated annual average subsurface inflow for the modified Subbasin boundary about 3,100 AFY higher compared to the original Subbasin boundary. Subsurface inflow to the modified Subbasin includes groundwater flow from the Atascadero Subbasin into the Paso Robles Subbasin. When modeling the original Subbasin boundary, which includes both the Atascadero Subbasin and Paso Robles Subbasin, the flow between the Subbasins is an internal flow within the model and not an inflow crossing the boundary of the modified Subbasin.

### **D5.3.2 Differences in Simulated Outflows**

Total simulated annual average outflow for the modified Subbasin boundary is about 27,100 AFY lower compared to the original Subbasin boundary. The reduction in total simulated outflow is due to changes in simulated discharge to rivers and streams, riparian evapotranspiration, and subsurface outflow, as described further below.

- Simulated annual average total groundwater pumping for the modified Subbasin is reduced by about 20,400 AFY compared to the original Subbasin. The amount of groundwater pumping is lower because the modified Subbasin does not include pumping from the Atascadero Subbasin or the portion of the original Paso Robles Subbasin in Monterey County.
- Simulated annual average discharge to streams and rivers for the modified Subbasin boundary is about 5,900 AFY compared to the original Subbasin boundary. The amount of discharge to rivers and streams is lower because the modified Subbasin does not include channel segments that receive groundwater discharge in the Atascadero Subbasin and portion of the original Paso Robles Subbasin in Monterey County.
- Simulated annual average riparian evapotranspiration for the modified Subbasin boundary is about 1,800 AFY lower compared to the original Subbasin boundary. The amount of riparian evapotranspiration is lower because the modified Subbasin has fewer stream channels and shorter stream channel lengths along which riparian vegetation is present than the original Subbasin.
- Simulated annual average subsurface outflow for the modified Subbasin boundary is about 1,000 AFY higher compared to the original Subbasin boundary. Similar to subsurface inflow, the higher subsurface outflow occurs because this flow crosses a boundary (the Monterey County line) when modeling the modified Subbasin, whereas, this flow is internally accounted for when modeling the original Subbasin.

### **D5.3.3 Differences in Computed Sustainable Yield**

Table D-10 compares the computed average annual groundwater storage deficit and sustainable yield for the original and modified Subbasin boundaries, the historical base period, and for the GSP model.

Table D-10. Average Annual Groundwater Storage Deficit and Sustainable Yield

	GSP Model	
	Original Subbasin	Modified Subbasin
<b>Storage Deficit</b>	14,400	12,600
<b>Sustainable Yield</b>	78,400	59,800

Note: All values in AFY

The computed annual average storage deficit from the GSP model is about 14,400 AFY for the original Subbasin boundary. For the modified Subbasin, the computed annual average storage deficit from the GSP model is about 12,600 AFY. Therefore, the computed annual average groundwater storage deficit for the modified Subbasin boundary is about 1,800 AFY lower compared to the original Subbasin boundary. The decrease in computed annual average groundwater storage deficit is the result of differences in the magnitude of reductions in total inflow and total outflow.

Figure D-4 shows a map of computed sustainable yields from the GSP model. The area of the original Paso Robles Subbasin outside of the modified Subbasin (green area) has been divided into the Atascadero Subbasin and the Upper Valley Aquifer Subbasin for illustration purposes. The sustainable yield of the Upper Valley Aquifer, Paso Robles, and Atascadero Subbasins shown on Figure D-4 sum to the sustainable yield of the original Subbasin as listed in Table D-10.

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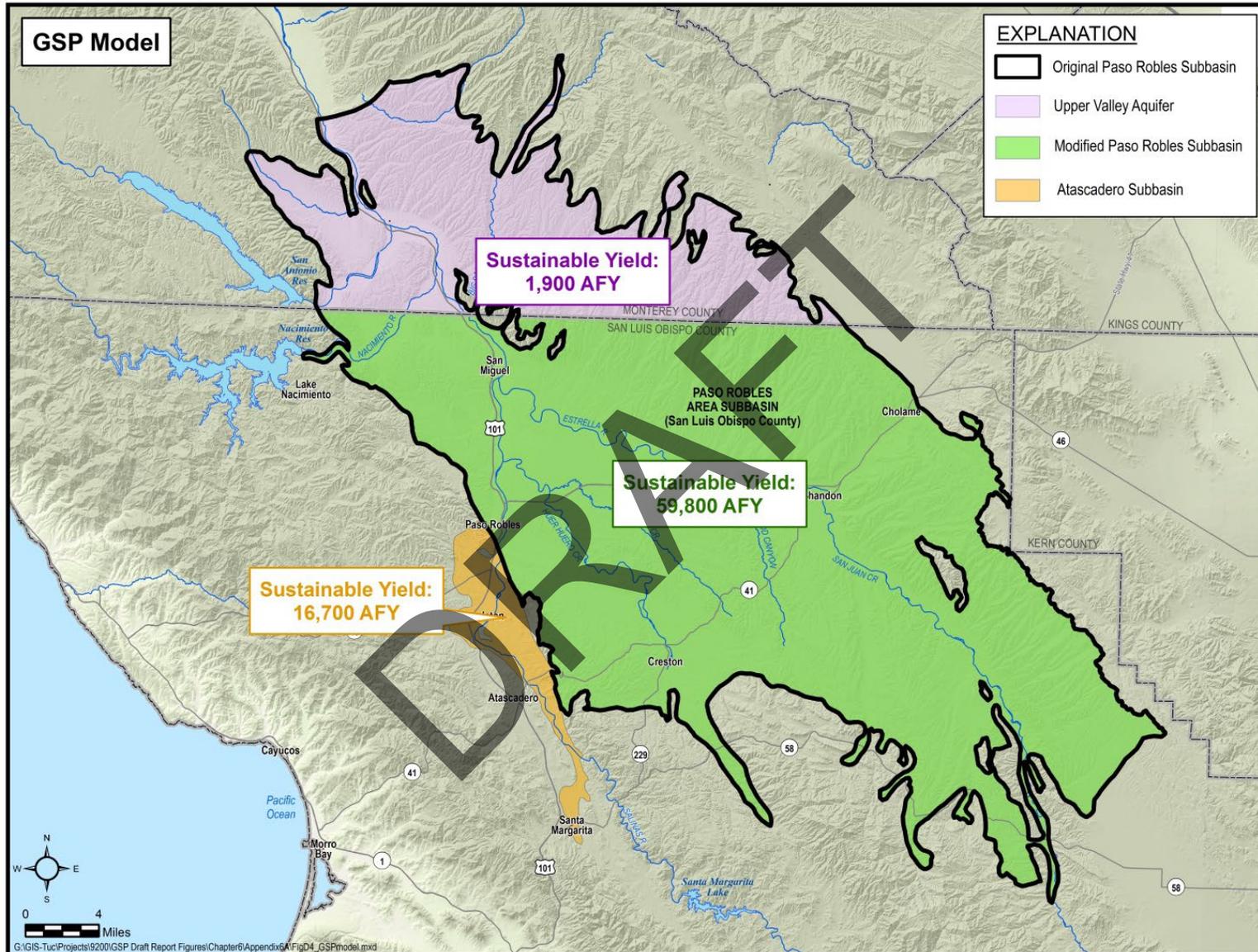


Figure D-4. Sustainable Yield as Computed by GSP Model

## D6 CONCLUSIONS

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Both the model modifications and the change in Subbasin boundary influence the computed sustainable yield. Over the historical base period, the computed sustainable yield for the original Subbasin boundary from the 2016 GSSI model is about 89,700 AFY. By comparison, the computed sustainable yield for the modified Subbasin boundary from the updated GSP model is about 59,800 AFY. The difference between these two values is nearly 30,000 AFY. Most of this difference is due to changes in the Subbasin boundary. The computed sustainable yield from 2016 GSSI model for the modified Subbasin boundary is 65,400 AFY; a reduction of about 24,300 AFY from the sustainable yield of the original Subbasin. The change in Subbasin boundary accounts for about 80% of the reduction in reported sustainable yields. The remaining difference is the result of modifications made to the model components.

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