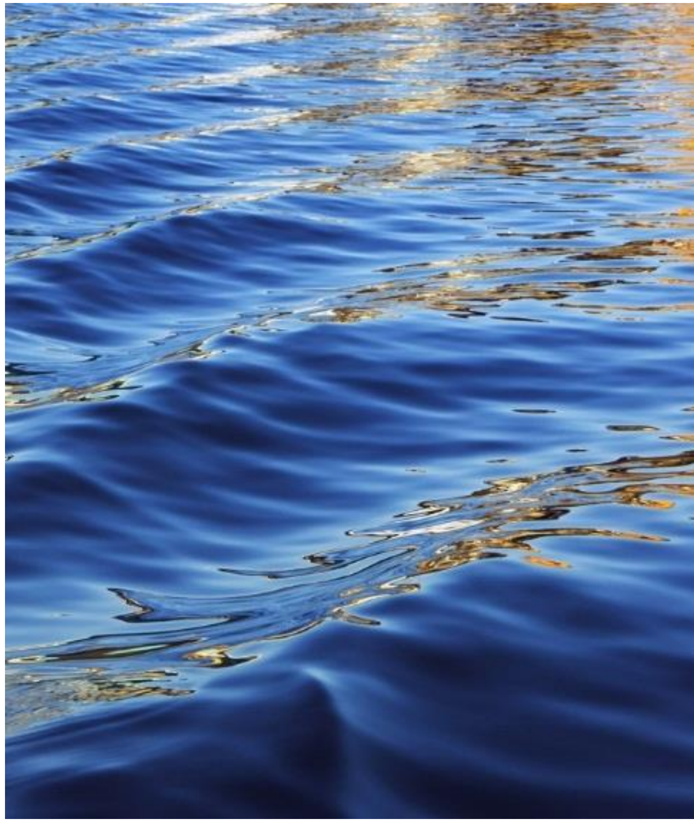
SVIHM AND SVOM MODEL WORKSHOP
6/30/2021

A PRESENTATION IN PARTNERSHIP WITH THE MONTEREY COUNTY WATER RESOURCES AGENCY AND THE UNITED STATES GEOLOGICAL SURVEY

Agenda

1. *Call to Order*
2. *Roll Call*
3. *Public comments on the agenda*
4. *SVIHM and SVOM Model Workshop*

(Introduction and Ground rules)



SVIHM and SVOM Model Workshop

- **Overview of models and how they are and will be used in the Salinas Valley**
- **Introduction to MODFLOW**

QUESTIONS (5 minutes)

- **SVIHM (Construction and Calibration)**

QUESTIONS (10 minutes)

- **SVOM**
- **SVIHM and SVOM applications**

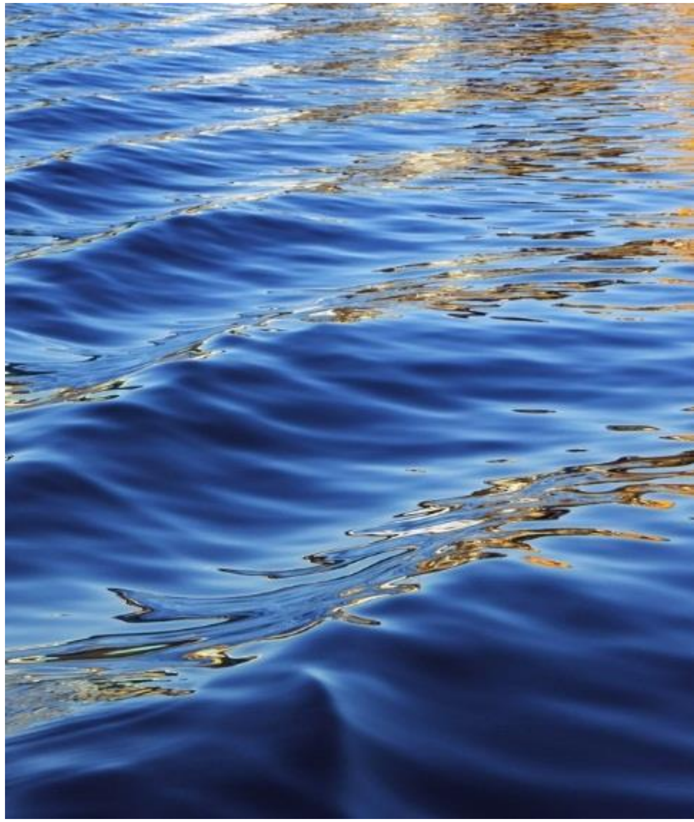
QUESTIONS (15 minutes)

Welcome and Overview of Groundwater Models

Workshop Purpose

- Review the purpose of the Salinas Valley Integrated Hydrologic Model
- Provide a technical overview of how the Salinas Valley Integrated models work
- Review how the models will be used for Salinas Valley water management
  - GSP development and implementation
- Provide opportunities for questions

Groundwater Models: what are they, and why do we model?

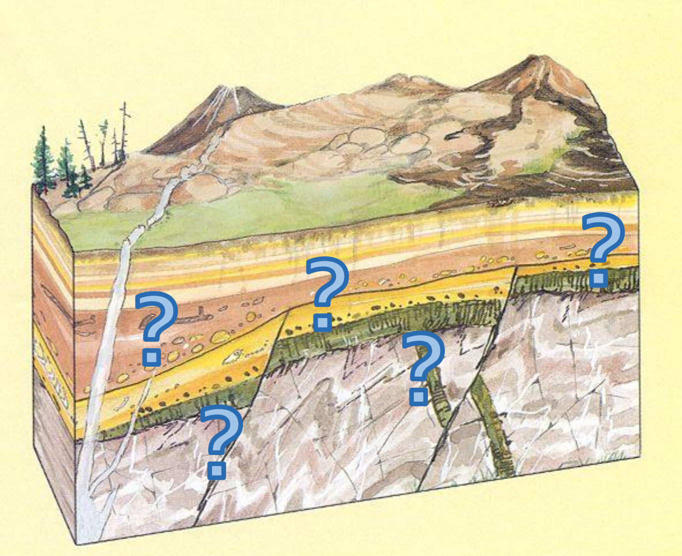


What is a model?

- Models are tools to help make decisions
- Models use accepted scientific principles to coordinate various types of data
- By coordinating and analyzing data, models reduce uncertainty and provide confidence in decisions

What is a model (2)

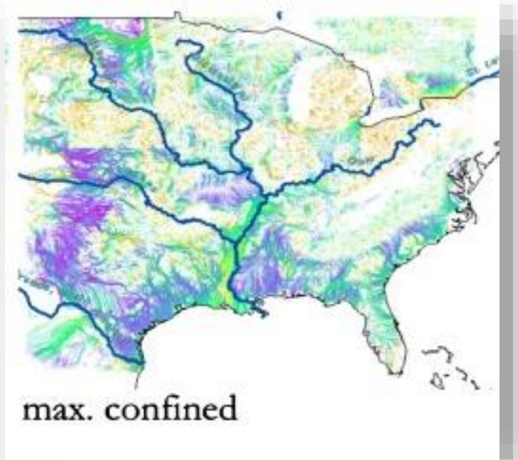
- Models **<u>approximate</u>** subsurface conditions
  - Subsurface conditions guide how models are built
  - We have imperfect knowledge of subsurface conditions, so the conditions cannot be duplicated

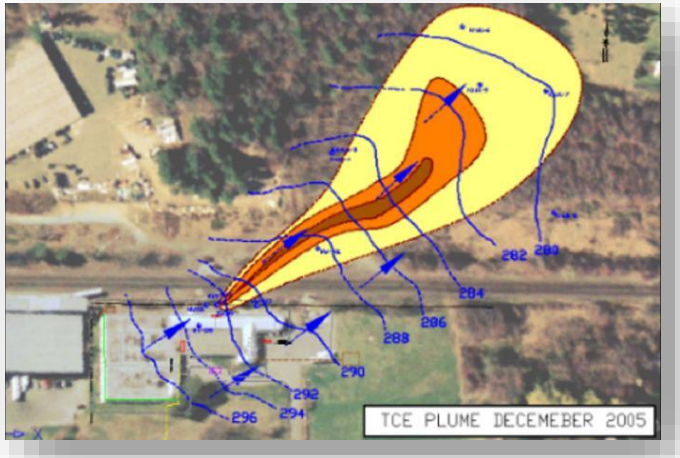


- Models do not make decisions – they guide decisions
  - Groundwater models are like climate or weather models in how they guide your decisions with uncertainty

Models Have Purposes

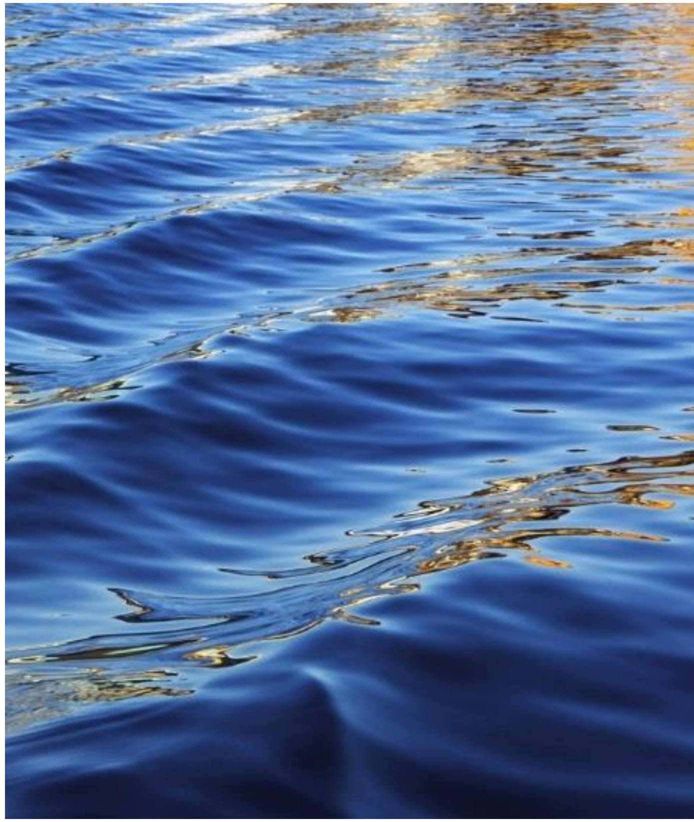
- No model is good for all purposes
- Models address scale appropriate questions:
  - City block
  - Contaminant plume
  - Groundwater basin





- The current model purpose is to develop integrated groundwater/surface water management options for the **<u>Salinas Valley</u>**
  - Not appropriate for individual parcels

SVIHM is a tool, that is supported by best available data, for guiding Valley-Wide water resource decisions



How groundwater-surface water models are and will be used in Salinas Valley: History of the models and the various applications

- Previous model development in the Salinas Valley
  - 1978 USGS: "*Two-Dimensional and Three-Dimensional Digital Flow Models for the Salinas Valley Ground Water Basin"* Timothy Durbin, et. al.
    - A Finite Element Model interacting with other hydrologic models to evaluate small stream groundwater recharge from surface-water water discharge in the Salinas River. The purpose was toward formulating plans for managing the water resources of the area.
  - 1986 Boyle Engineering: "*Salinas Valley Ground Water Model"*
    - FEGW-14: a proprietary model developed by Y. Yoon, et.al. Used to evaluate the efficiency and impact of various management options. This model was a predecessor to the SVIGSM
  - 1988 USGS: "Simulated Effects of Ground-Water Management Alternatives for the Salinas Valley, Ca" Eugene B. Yates
    - Described as a major revision of the Durbin 1978 model
    - "The purposes of this investigation were to identify and quantify the various types of flow into and out of the ground-water basin and to describe the physical process that control them."

Previous model development: The SVIGSM

- Development of the Salinas Valley Integrated Groundwater and Surface Water Model (SVIGSM) began in 1990 as Task 1.09 to develop a planning and management tool for evaluating the water resources of the basin, and was jointly funded by the Agency and the USBR.
- SVIGSM evolved from FEGW-14 and the Central Valley Groundwater-Surface Water Model
  - 1990: Begin configuration and development of SVIGSM
  - 1994: Complete initial model development and documentation
  - 1995: Began configuration for Historical Benefits Analysis
  - 1998: Historical Benefits Analysis
  - 2000: Arroyo Seco Update to the Historical Benefits Analysis
  - 2000: Began configuration for SVWP
  - 2002: SVWP EIR
  - 2005: SVWP Flow Prescription for Steelhead Trout in the Salinas River
  - 2007: Zone 2C Proposition 218 Engineer’s Report

Current model development: The SVIHM/SVOM

- Development of the Salinas Valley Integrated Hydrologic Model (SVIHM) began in 2015 when the USGS was engaged by the County to create an integrated groundwater-surface water modeling tool to evaluate the water supply of Monterey County Water Resources Agency's Zone 2C.
- After initial calibration of the SVIHM was completed, working with the Agency and our consultants, the USGS began the development of the Salinas Valley Operational Model (SVOM)

Current model applications (provisional): The SVIHM/SVOM

- Salinas Valley Basin Investigation – Monterey County
  - This project will coincide with the publication of the SVIHM and will utilize a provisional version of the SVOM
- Salinas and Carmel Basins Study – USBR, USGS, and Local Partners
  - Provisional version of the SVOM; used to evaluate climate and water supply vulnerability to 2100
- Groundwater Sustainability Plans – SVBGSA
  - SVIHM and SVOM: Provisional Use
- Interlake Tunnel – Monterey County Water Resources Agency
  - SVOM: Provisional Use
  - Including the development of a Pre-SVWP SVOM
- Winter Release Modeling – Monterey County Water Resources Agency
  - SVOM: Provisional Use

QUESTIONS

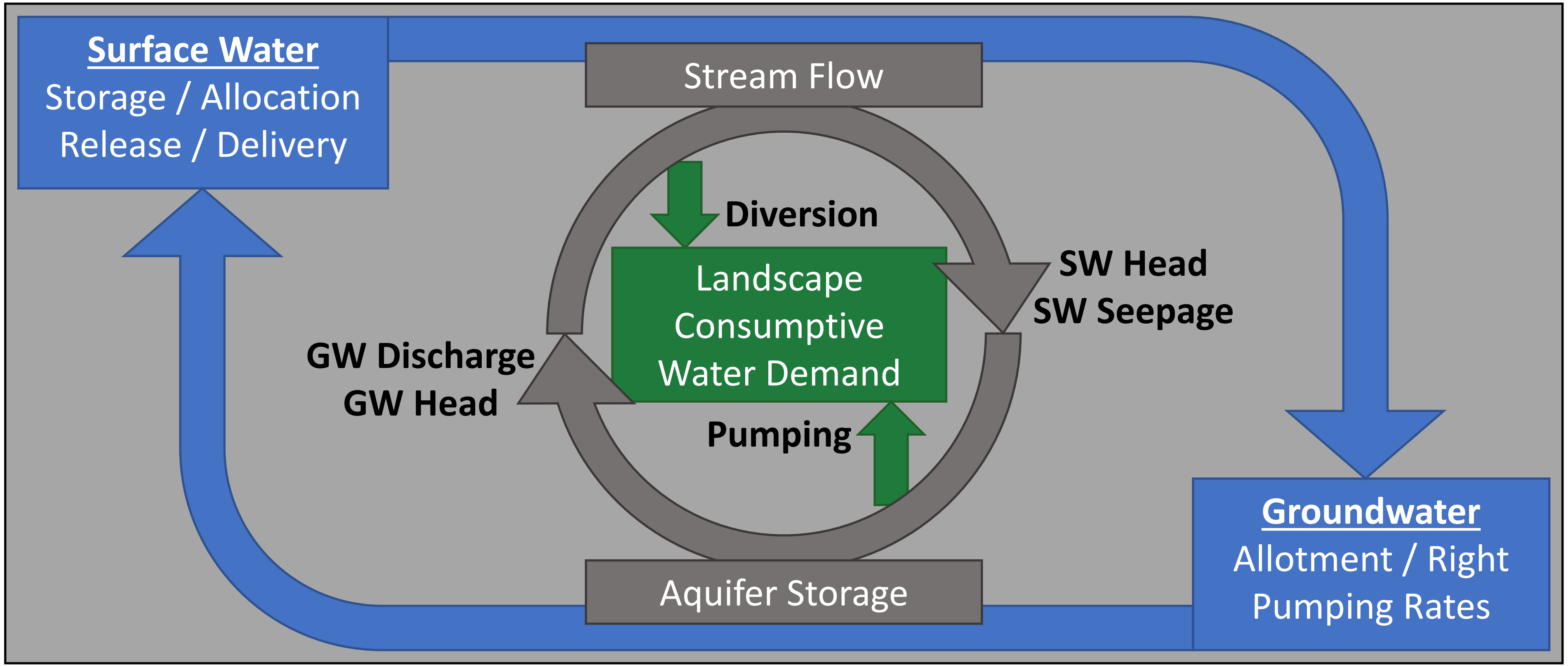
- ❖Stakeholders are hoping that the workshop will address these topics:
  - ❖Modeling subbasin to subbasin connectivity and interaction including limitations, influence of river and drought.
  - ❖Accounting for irrigation water applied, water lost via ET and water returning to the aquifer. "Does the model allow you to know the amount of water returning to the aquifer by parcel of land?"

- ❖Submitted questions:
  1. How does the SVIHM handle outlier data?
  2. Can the SVOM be run to simulate multi-year droughts or other multi-year effects (or would this be iteratively done and time-prohibitive)?
  3. When will SVOM operations rules assumptions, and parameters be referenced, documented and available?
  4. Are the operations rules a set of variables that are designed to be updated or are they programed-in?
  5. What are the known data gaps in the SVIHM?
  6. Is BCM data through 2020 utilized in the SVIHM?

Introduction to Model Tools

MODFLOW-OWHM Overview

Agricultural and Crop Model Coupled to Groundwater-Surface Water Model
(https://www.usgs.gov/software/modflow-owhm-one-water-hydrologic-flow-model)

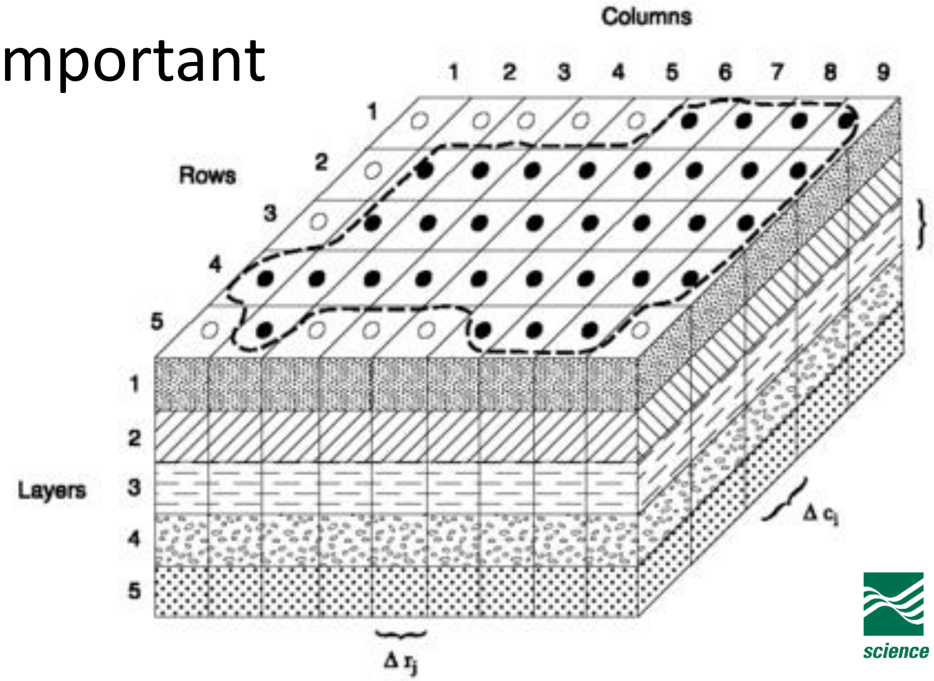


Managed hydrological flows are demand driven and supply constrained

Groundwater Model (MODFLOW)

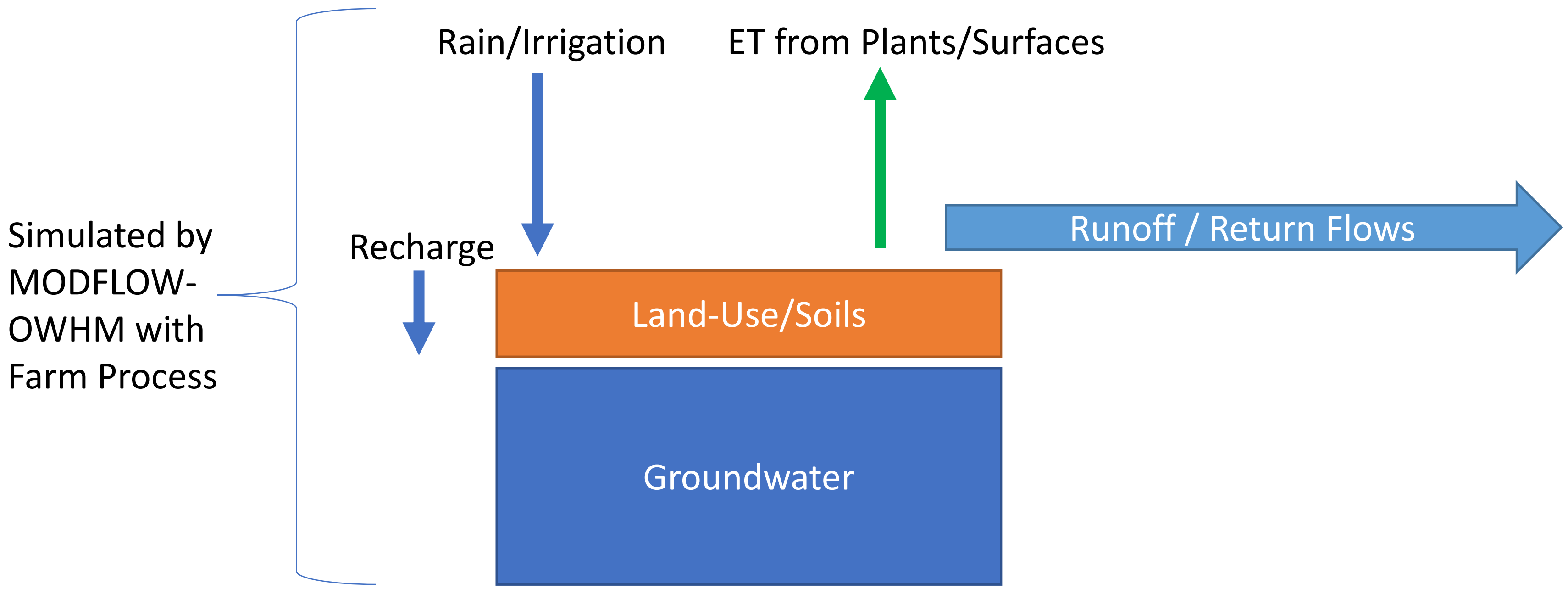
- Modular groundwater flow model (modflow; harbaugh et al. 2005) https://water.usgs.gov/ogw/modflow/
- MODFLOW-OWHM (One-Water; Boyce et al, 2020) https://www.usgs.gov/software/modflow-one-water-hydrologic-flow-model-conjunctive-use-simulation-software-mf-owhm

- Modular model allows representation of important groundwater processes
- Simulates
  - Streams
  - Lakes
  - Aquifers
  - Wells

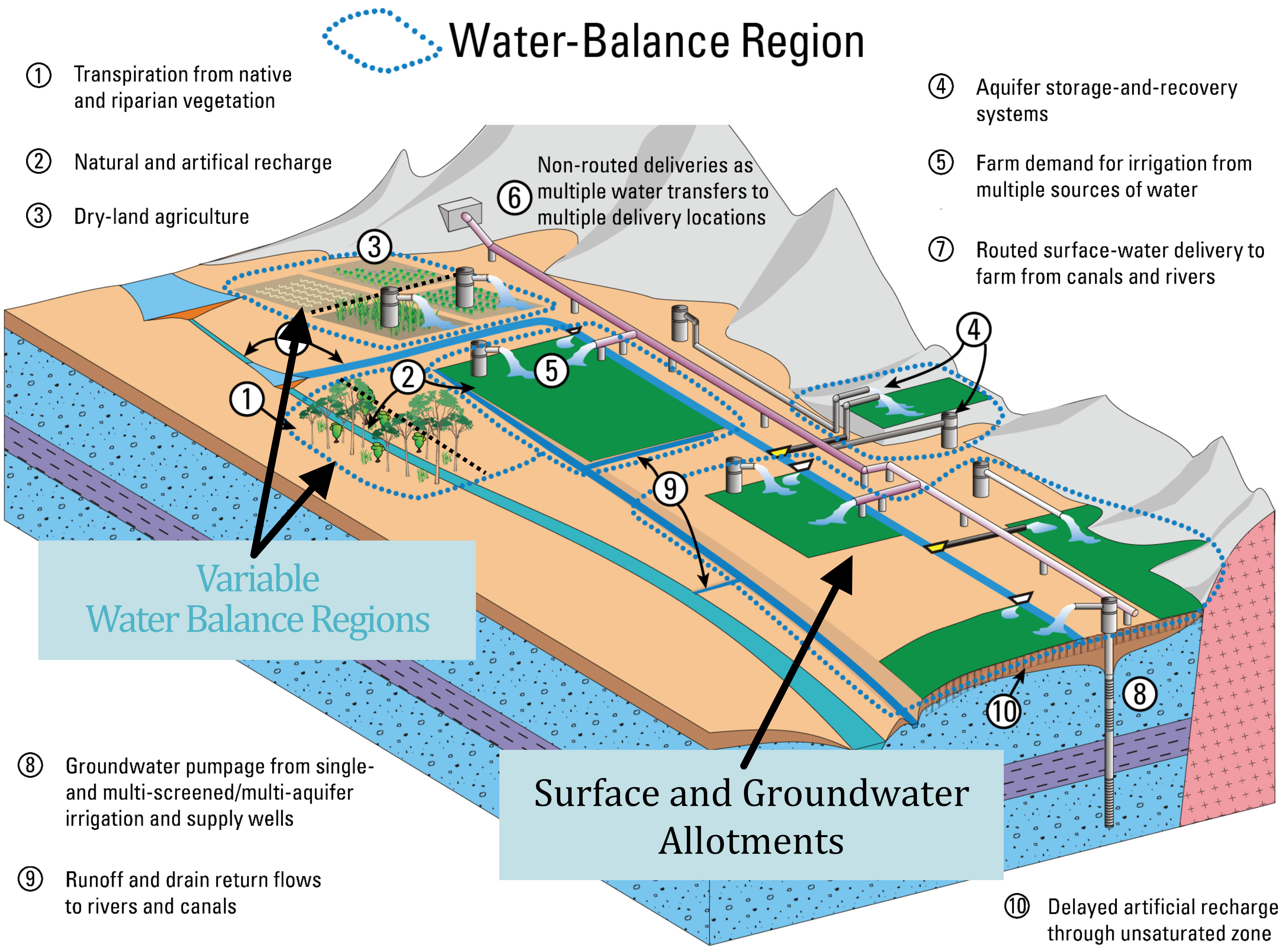


USGS science for a changing world

Crop Model (Farm Process)



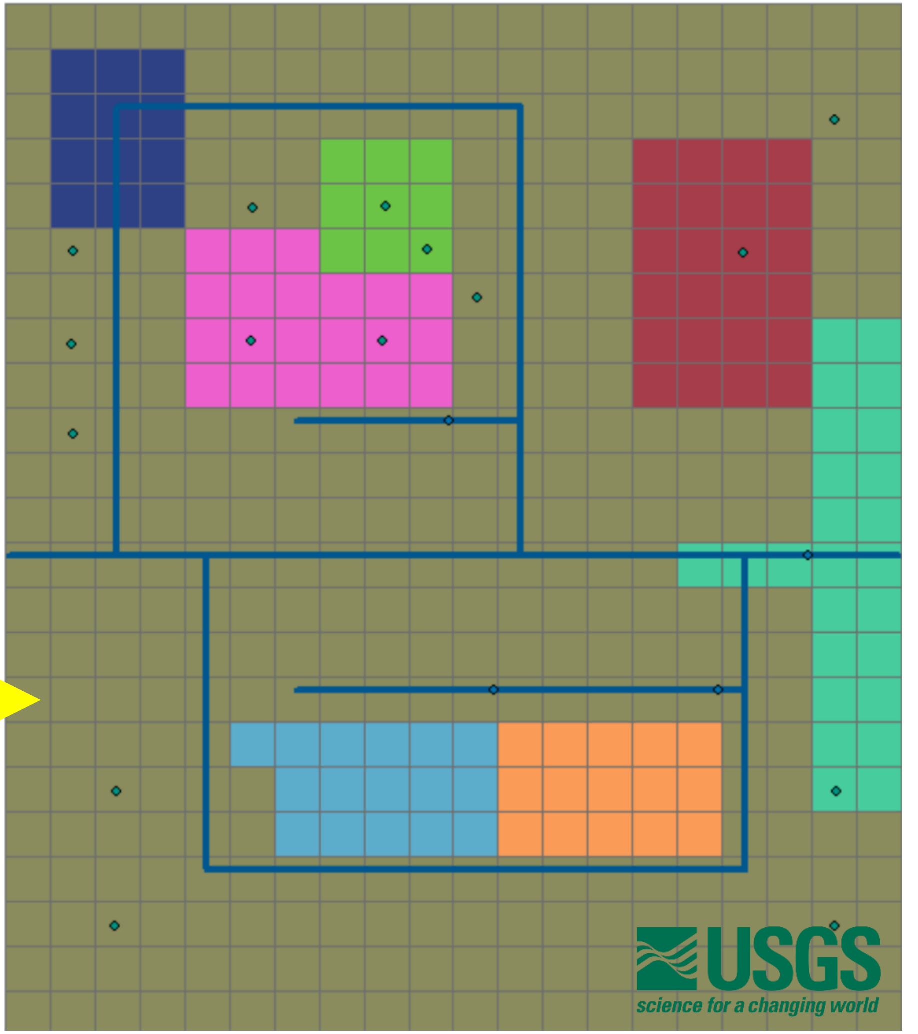
- **Uses well established methods for simulating irrigation demands**
  - Food and Agricultural Organization Crop Coefficient Method.
- **Assumes steady soil moisture**
  - reasonable for irrigated lands
- **No explicit runoff routing**
  - Runoff is generated for subareas and added directly to rivers
- **Runoff is a specified fraction of excess water after all water demands are met**
  - measured pumping and land use to train model and calibrate this fraction



Water-Balance Region
① Transpiration from native and riparian vegetation
② Natural and artifical recharge
③ Dry-land agriculture
Non-routed deliveries as
⑥ multiple water transfers to
multiple delivery locations
④ Aquifer storage-and-recovery systems
⑤ Farm demand for irrigation from multiple sources of water
⑦ Routed surface-water delivery to farm from canals and rivers
Variable
Water Balance Regions
Surface and Groundwater
Allotments
⑧ Groundwater pumpage from single- and multi-screened/multi-aquifer irrigation and supply wells
⑨ Runoff and drain return flows to rivers and canals
⑩ Delayed artificial recharge through unsaturated zone

Farm Process establishes a supply and demand framework for each specified land use

Model domain



A water demand is calculated for each Land Use in each cell

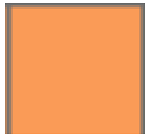
Groups of model cells are aggregated into regions with common water supply (Water Balance Subregion)

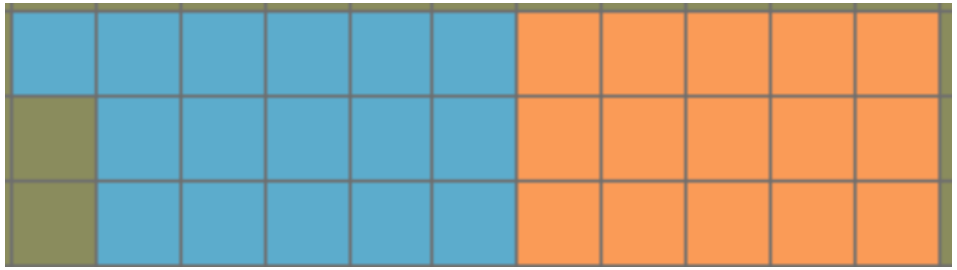
Water demands are computed for each land use (native and cultivated) in each cell

Available produced water supplies for that WBS are used to meet the total demands for the **ENTIRE** WBS

WBS (Farm)

Land Use (crop)





Simulation of Water Balance Subregions (WBS)

Within each water balance subregion (WBS):

- Demands are satisfied in a prioritized order

  Precipitation
  Shallow groundwater in root zone
  Surface water diversions
  Recycled water
  WBS associated groundwater wells

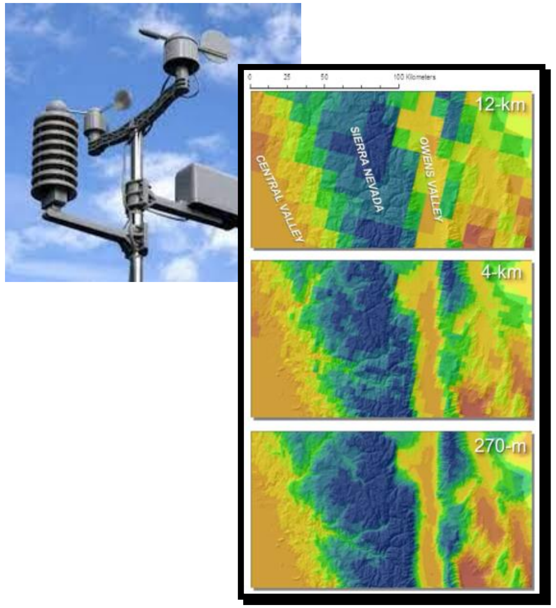
- After all water demands are met:

  Excess water remaining is partitioned into recharge and runoff for each land use in each cell
  Recharge goes into the subsurface
  Runoff is added to all streams within the WBS on a reach length weighted basis

Each WBS is distinct for its supply and demand calculations but each cell in a WBS is a part of the entire hydrologic model.

Simulating Agricultural Water Demands

Estimate Potential Evapotranspiration (PET)



Uses all available climate data in the region.

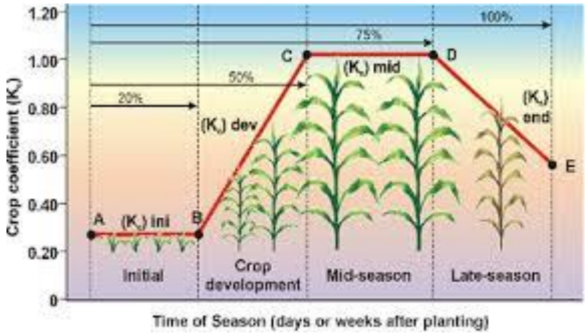
+

Crop areas from land use data

Crop properties from literature, field studies, and previous calibrated models in the region.

+

Crop Model



Consumptive Use = Crop Area*PET*Kc

=

Agricultural Applied Water Estimate

Where available, reported pumping and diversions are used to guide, evaluate, and calibrate the simulated agricultural demands

USGS science for a changing world

Model Output is available for every cell

Within the subsurface and in the stream channel:

- MODFLOW is a grid-based model that computes values for every cell
- Every flow entering, exiting, or moving **ANYWHERE** in the model can be readily quantified on a **CELL-BY-CELL** basis and **STREAM-REACH-BY-STREAM-REACH** basis.
  - Stream Infiltration/Discharge
  - Runoff
  - Pumping
  - Recharge
  - Underflow
  - Lateral and Vertical Aquifer Exchanges
- These cell-by-cell flows are aggregated in several output budget files.

Water Balance Regions (WBS) Output aggregates budgets for groups of model cells

Within the surface in the WBS:

- Every land surface (non-stream) flow is computed
- Supply and demand data are computed for each cell in each land use
- Agricultural supply, demand, consumptive use, evapotranspiration, and recharge are distributed among all cells
- All data for each WBS are reported in Farm Process budget output files
- Optional files can provide information on a land use and cell-by-cell basis.

QUESTIONS

- Stakeholders are hoping that the workshop will address these topics:
  - Modeling subbasin to subbasin connectivity and interaction including limitations, influence of river and drought.
  - Accounting for irrigation water applied, water lost via ET and water returning to the aquifer. “Does the model allow you to know the amount of water returning to the aquifer by parcel of land?”

- Submitted questions:

1. How does the SVIHM handle outlier data?
2. Can the SVOM be run to simulate multi-year droughts or other multi-year effects (or would this be iteratively done and time-prohibitive)?
3. When will SVOM operations rules assumptions, and parameters be referenced, documented and available?
4. Are the operations rules a set of variables that are designed to be updated or are they programed-in?
5. What are the known data gaps in the SVIHM?
6. Is BCM data through 2020 utilized in the SVIHM?

Construction and Calibration Salinas Valley Integrated Hydrologic Model (Historical)

General Terminology Overview

California Pesticide Use Reporting Database (CalPUR)- A comprehensive database of pesticide application and crop data collected since 1974.

MODFLOW One Water Hydrologic Model (OWHM) – A modular groundwater/surface water/agricultural/operations model based upon the MODFLOW groundwater modeling software.

MODFLOW Farm Process (FMP)- An implementation of agricultural operations and the United Nations Food and Agricultural Organization Crop Model.

Water Balance Subregion (WBS)- A water accounting subregion used to estimate and simulate agricultural supply and demand and quantify hydrologic budgets.

Surface Water Operations module (SWO)- A rigorous and flexible module to simulate complex reservoir operations, enforce simulated river flow thresholds and limits, and provide linkages between water balance subregions and reservoirs.

Nash Sutcliffe Coefficient of Model Efficiency (NS)- A metric used to quantify model performance (how well a model reproduces data).

Salinas Valley Model Suite

Basin Characteristics Model (BCM)- A 1-D climate, rainfall, and runoff model used to prepare precipitation and potential evapotranspiration input for models.

Salinas Valley Geological Model (SVGM)- A 3-D Geologic model of Salinas Valley with discrete representation of geologic structures, aquifers, confining units and textural properties of geologic materials.

Salinas Valley Watershed Model (SVWM) – A historical rainfall and runoff watershed model of the entire area that contributes flow to the Salinas river and tributaries. The SVWM is calibrated from 09/30/1948 to 12/31/2014 and updated though water year 2018.

Salinas Valley Integrated Hydrologic Model (SVIHM)- A historical integrated hydrologic model that uses estimated and measured data to simulate historical rainfall, runoff, recharge, storage, water levels, streamflow, water supply and demand for native and cultivated lands to develop comprehensive water budgets. The SVIHM is calibrated from 10/1/1967 to 12/31/2014 and updated though water year 2018.

Salinas Valley Operational Model (SVOM) – An operational baseline model that inherits, the geologic structure, hydrologic properties, and climate from the SVIHM. The SVOM assumes that current reservoir operations and 2014 land use were constant for the entire simulation from 10/1/1967 to 12/31/2014. The SVOM is used as a baseline for evaluation of potential water supply projects and to quantify project benefits.

SVIHM received substantial input from stakeholders and technical advisors

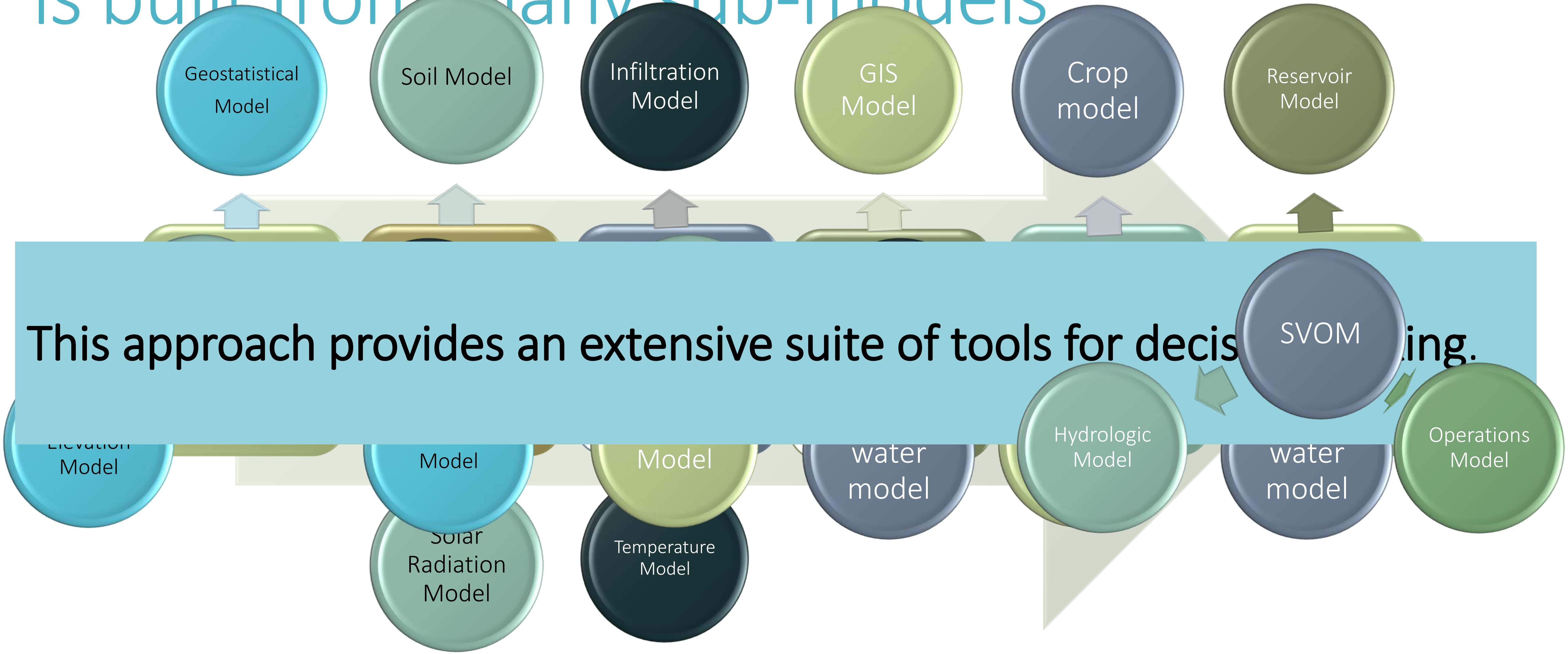
- 8 Technical Advisory Committee meetings over 2 years

Monterey One Water
Monterey Peninsula Water Management District
US Army Corps of Engineers
The Nature Conservancy
California Water Service
The Open Monterey Project
PV Water
Monterey County Water Resources Agency 1947
Grower-Shipper Association of Central California Since 1930
LandWatch Monterey County
California American Water
Salinas Valley Water Coalition
Seaside Basin Watermaster
Farm Bureau Monterey

- Stakeholder surveys and 11 meetings
- Consultations with local and national agricultural experts
- Discussions with Groundwater Sustainability Agencies

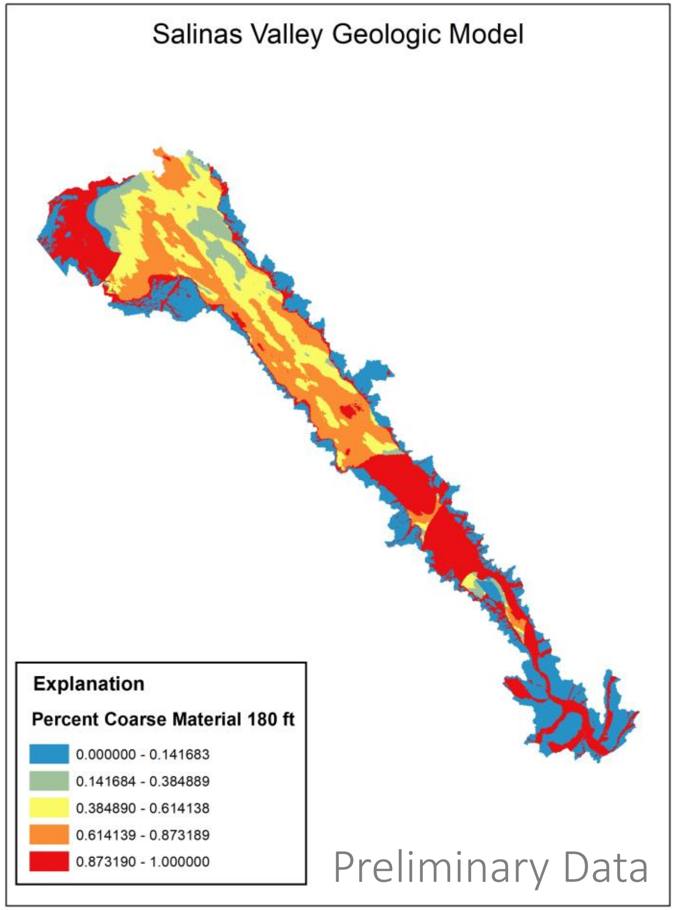
USGS
science for a changing world

Salinas Valley Integrated Hydrologic Model is built from many sub-models



This approach provides an extensive suite of tools for decis ing.

Salinas Valley Geologic Model (SVGM)



Salinas Valley Geologic Model showing percentage of coarse material distribution for the 180-ft aquifer in the Salinas Valley Integrated Hydrologic Model.

- Provides a robust hydrogeologic framework and conceptual flow model
- 3-D Geologic texture model of entire Salinas Valley and watersheds
- Downscaled from regional scale model
- Developed subregional geologic facies
- Lithology database from Monterey County

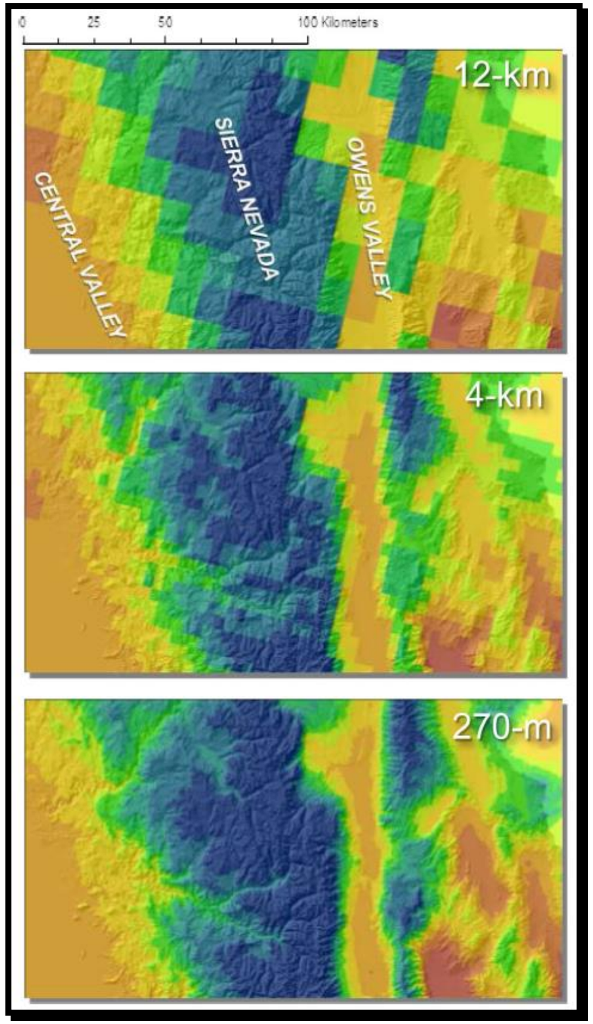
<u>Model Framework – 9 Layers with 529 ft. by 529 ft. grid cells</u>

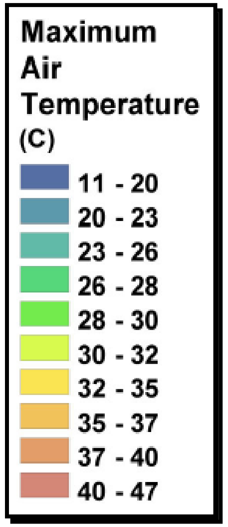
Layer 1 → Salinas Shallow/Recent Aquifer
Layer 2 → Salinas Valley Aquitard
Layer 3 → 180-Ft Aquifer
Layer 4 → Middle Aquitard
Layer 5 → 400-Ft Aquifer
Layer 6 → Deep Aquitard
Layer 7 → Paso Robles Formation
Layer 8 → Purisima/Santa Margarita Formation
Layer 9 → Composite Bedrock Aquifer

USGS science for a changing world

Basin Characteristics Model

Basin Characteristics Model (BCM) tools are used to prepare spatially distributed climate input for hydrologic models



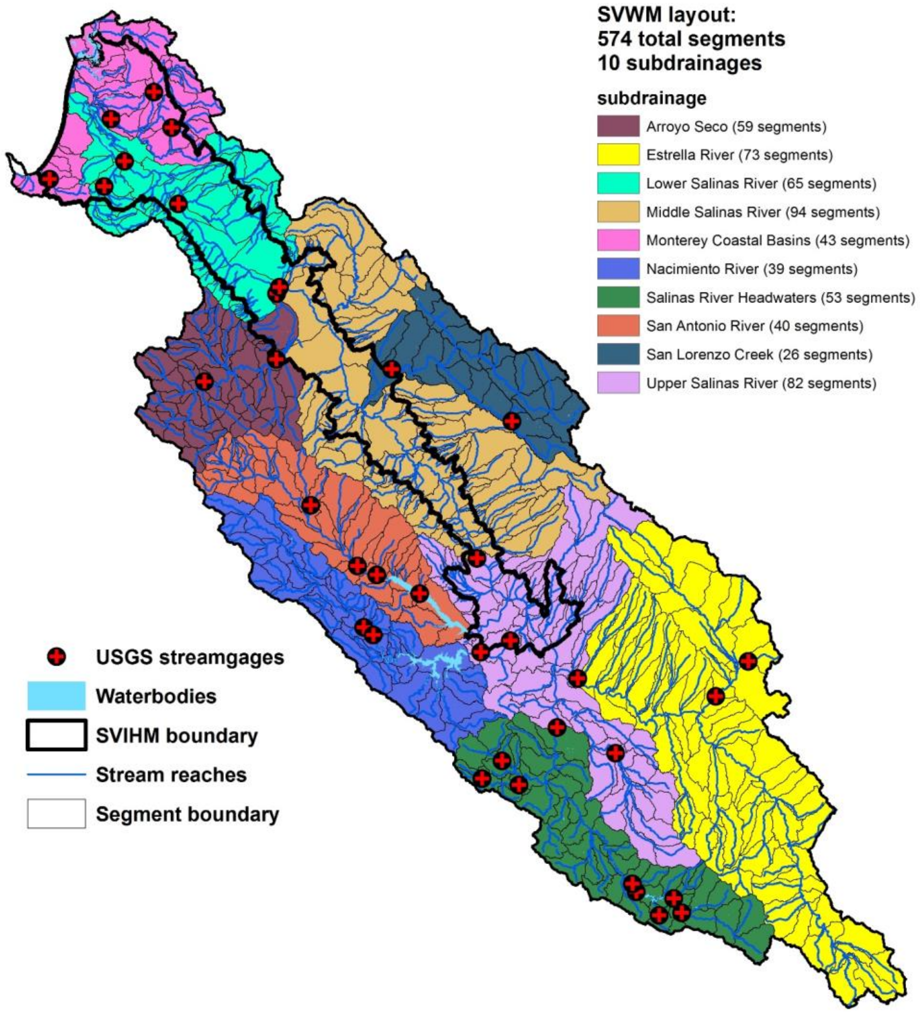


- Climate data is downscaled to 270m
    - maximum temperature (Tmax)
    - minimum temperature (Tmin)
    - Precipitation

- Potential evapotranspiration (PET) is estimated
    - Priestly Taylor
    - Bias correction to California Irrigation Management Information System (CIMIS) station data.
    - With solar radiation model that incorporates slope, aspect, and topographic shading (to define the percentage of sky seen for every grid cell) (Flint and Childs 1987).

- Downscaled using Gradient Inverse Distance Squared (GIDS) approach (Nalder and Wein, 1998)

Salinas Valley Watershed Model (SVWM)



Salinas Valley Watershed Model (SVWM) and Salinas Valley Integrated Hydrologic Model (SVIHM) showing boundaries, stream networks, stream gages, and subdrainages.

- Simulates watershed processes for the entire Salinas River Valley from Paso Robles to the coast
- Regionally downscaled climate from Basin Characteristics Model
- Provides surface inflows to integrated models from hillslopes to valley floors.
- Sediment and Contaminant transport capable

USGS
science for a changing world

SVIHM has 56 Land Use Types

Higher Frequency	Lower Frequency	Annually Stable or Native
Celery-Coastal	Carrots-Coastal	Deciduous fruits and nuts-Coastal
Celery-Inland	Carrots-Inland	Deciduous fruits and nuts-Inland
Cucumber-Melons-Squash-Coastal	Onions-Garlic-Coastal	Citrus and subtropical-Coastal
Cucumber-Melons-Squash-Inland	Onions-Garlic-Inland	Citrus and subtropical-Inland
Legumes-Coastal	Root Vegetables-Coastal	Vineyards-Coastal
Legumes-Inland	Root Vegetables-Inland	Vineyards-Inland
Lettuce-Coastal	Tomato-Peppers-Coastal	Nurseries-Outdoor-Coastal
Lettuce-Inland	Tomato-Peppers-Inland	Nurseries-Outdoor-Inland
Rotational 30-day-Coastal	Strawberries-Coastal	Nurseries-Indoor
Rotational 30-day-Inland	Strawberries-Inland	Artichokes
Crucifers-Cabbages-Coastal	Corn-Coastal	Pasture
Crucifers-Cabbages-Inland	Corn-Inland	Non-irrigated
Unspecified Irrigated Row Crops-Coastal	Field Crops-Coastal	Semiagricultural
Unspecified Irrigated Row Crops-Inland	Field Crops-Inland	Idle-Fallow
	Grain Crops-Coastal	Agricultural Trees
	Grain Crops-Inland	Golf Course Turf/Parks
	Cane-Bush Berries-Coastal	Urban
	Cane-Bush Berries-Inland	Quarries
		Water
		Riparian
		Upland Grasslands/Shrub Lands
		Woodlands
		Beach-Dunes
		Barren-Burned

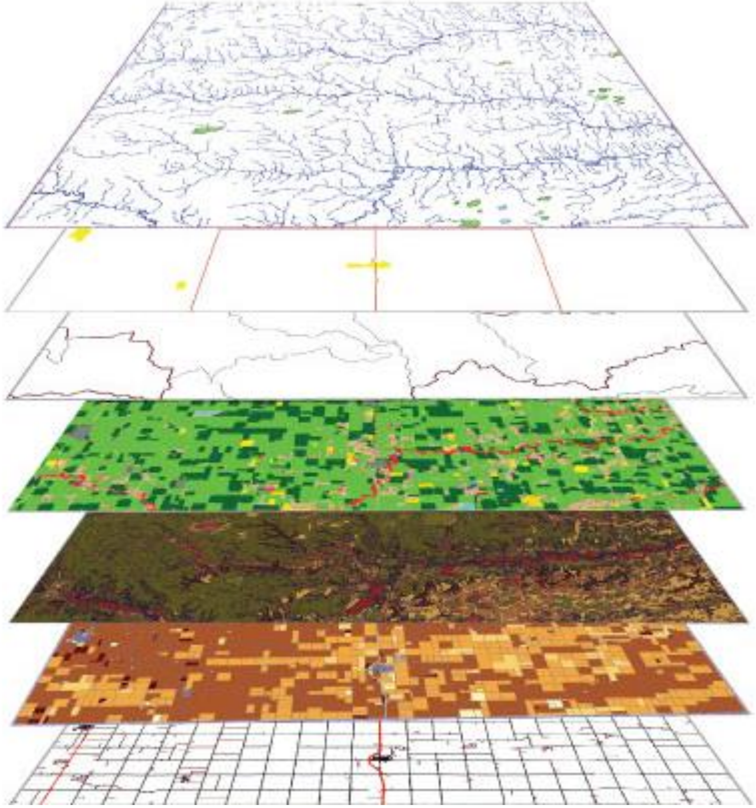
We use a tiled approach of available land use data to represent the landscape

Native and Urban areas represented by National Land Cover Database (NCLD) datasets

Riparian areas defined using aerial photography and the National Hydrography Database (NHD)

Representing agricultural development and distribution of crops and cropping patterns rely on

- Land use snapshots
- Aerial photography
- Agricultural commission data
- Stakeholder outreach activities



USGS
science for a changing world

CalPUR data provides comprehensive crop data that can vary in time.

Land use data is updated with area weighted crop types from CalPUR

Land use data preserves stable land use types (native, vineyard)

March Crop Distribution:

Crucifers 27%

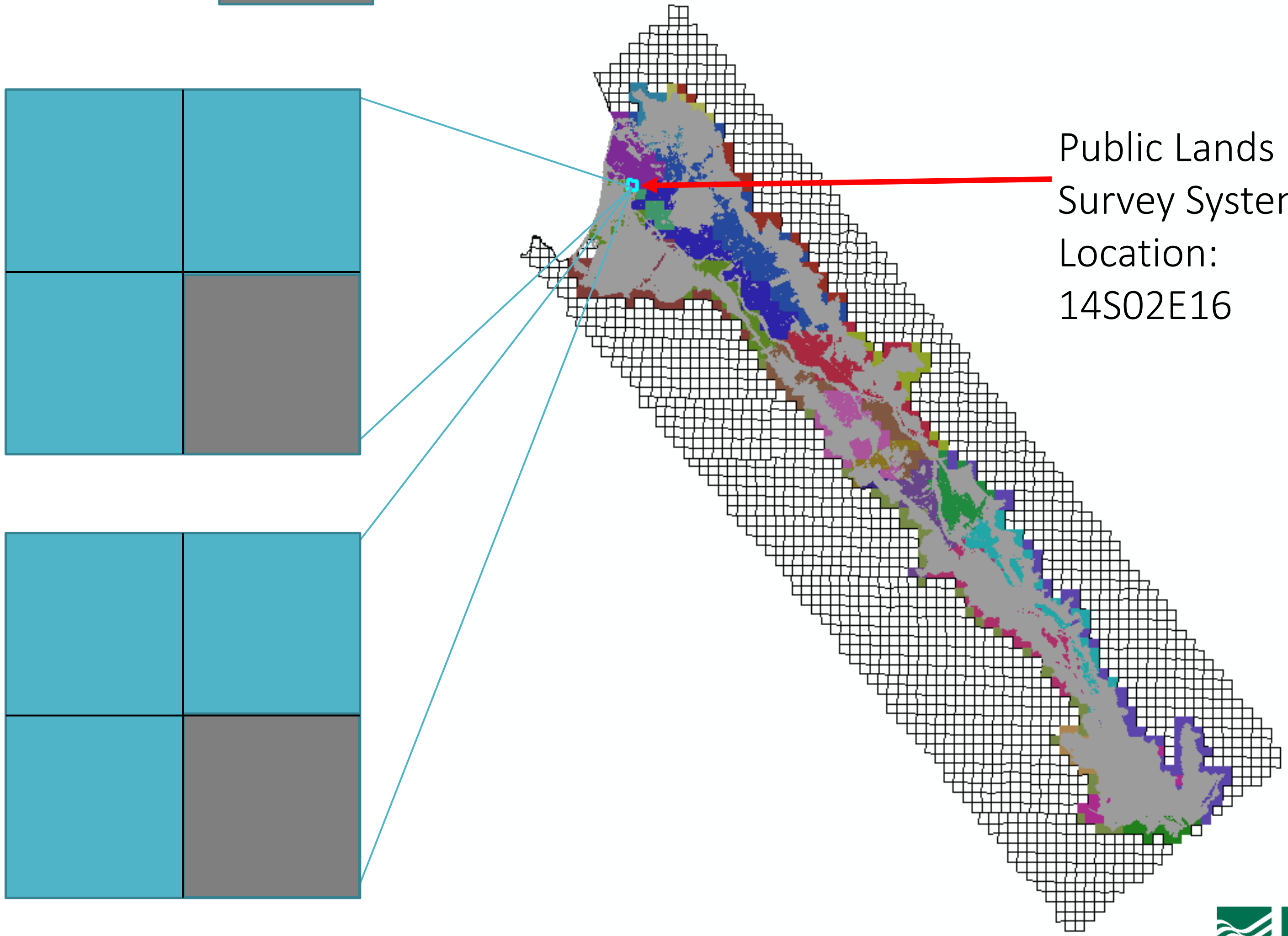
Lettuce 72%

August Crop Distribution :

Rotational 30 Day 5%

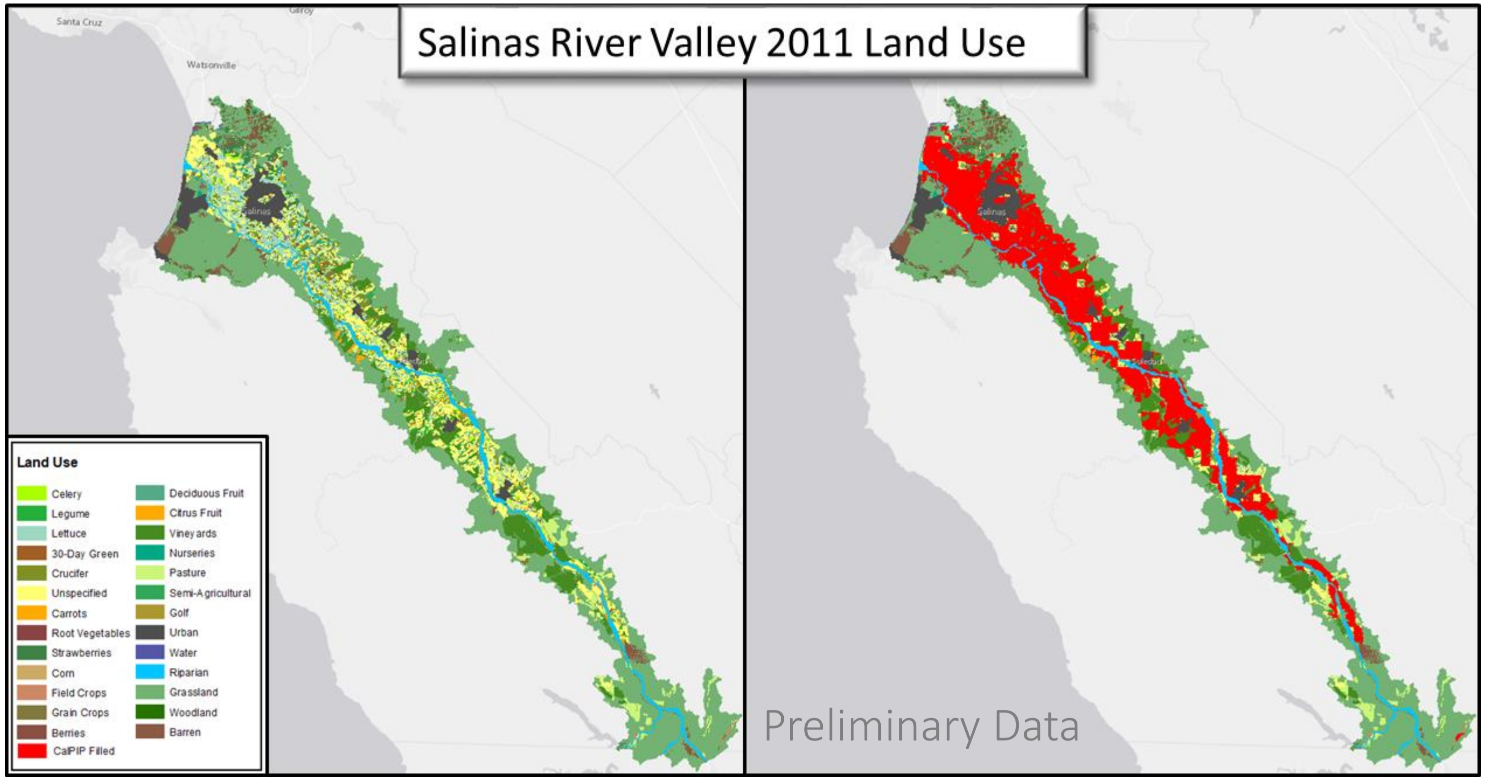
Crucifers 1%

Lettuce 94%



TWO LAND USE MAPS ARE GENERATED FOR EVERY YEAR REPRESENTING EARLY AND LATE SEASON

Cropped land use estimation is improved using pesticide data



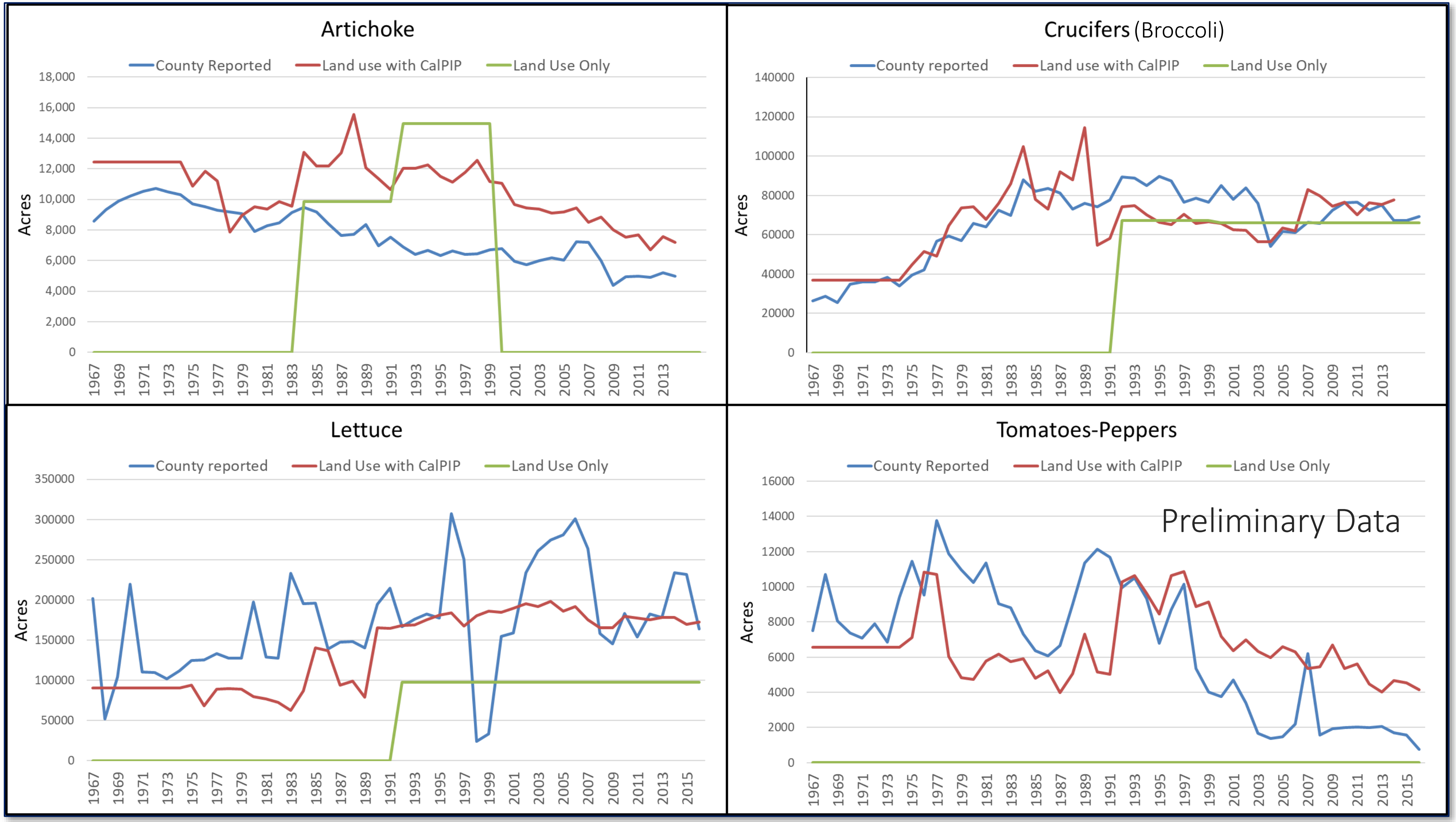
Available multi-year land use data is combined with CalPUR pesticide data to generate semi-annual land use for each model cell (~6 Acres)

This approach better represents:

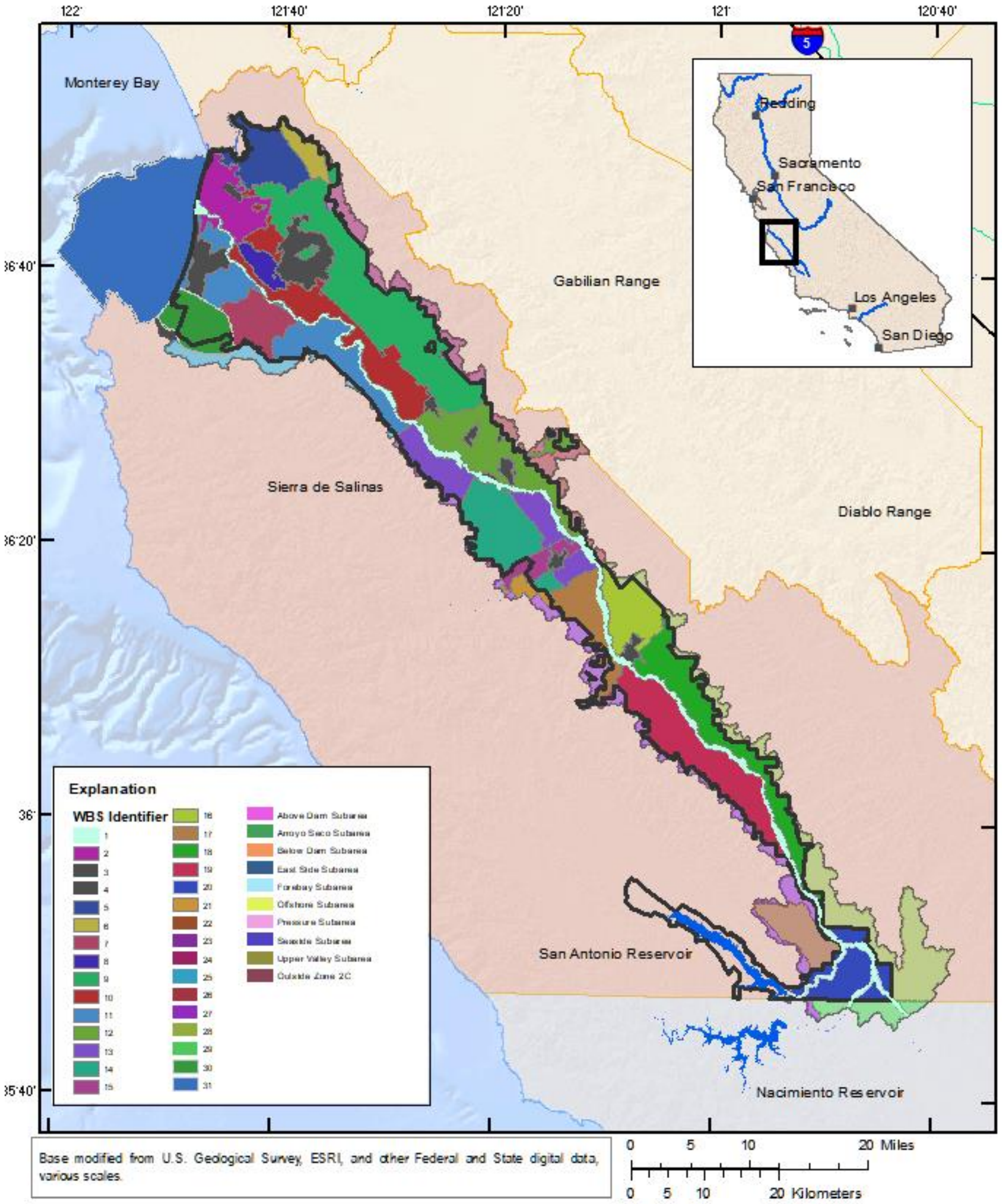
- Crop Type
- Multi-Cropping
- Crop variations

Red area shows vague crop categorization that is enhanced with additional information from pesticide database

Reproduces magnitude and variation in cropped acreage



Comparison between cropped acreage reported by Monterey County Agricultural Commissioner annual crop reports, estimated acreage with CalPUR data, and estimated acreage from land use alone.



10 Subareas were split into 30 Water Balance Regions (WBS)

- Aggregated water budget accounting areas
- Based on Zone 2C and Bulletin 118 Subareas
- Wells/Diversions in each WBS only used to meet demands in that area
- Related efforts using model may have different definitions of some subareas (e.g., SGMA GSA’s)

USGS
science for a changing world

SVIHM calibrated from 1967-2014 and updated through Water Year 2018

Includes almost 104,000 observations and reported data

- Stream flows (annual, monthly)
- Streamflow differences between stream gages (annual, monthly)
- Water Levels and drawdowns (annual, quarterly, monthly)
- Head differences (annual, quarterly, monthly)
- Reported groundwater pumpage (annual, quarterly, monthly)
- Reported diversions (annual, quarterly, monthly)

These observations representative of all historical climate conditions (drought)

All observations considered in the process, including data representing extreme values (outliers)

Opportunities for SVIHM refinement

Integrating data and improvements from other models (e.g., Seaside Basin, Sea Water Intrusion Models)

- Wells
- Groundwater extraction rates
- Boundary conditions

Comprehensive spatially distributed aquifer property assessments

- Pumping tests (permeability information)
- High resolution evaluation of paired observation wells (vertical interactions among aquifers)
- Stream aquifer connectivity (potential streamflow depletion from shallow groundwater wells near streams)

Regional scale coordination and cooperation in model development

- Subregional refinement
- Stakeholder input
- Consensus building

Opportunities to refine agricultural demands and subregional water budgets

Representation of agricultural storage ponds in the model

Aerial imagery suggests substantial storage capacity

Will improve timing and magnitude estimates of groundwater and surface water use in model

Better understanding and simulation of multi-cropping.

CalPUR land use method captures important trends but can be enhanced

More spatial information about irrigation types

Better understanding and simulation of water used for agricultural production

off-season, frost protection, field preparation, sanitation, processing, livestock, dust management

Enhancement of land use data using remotely sensed satellite data.

USGS
science for a changing world

Construction and Implementation of Salinas Valley Operational Model (Operational)

A baseline model is a tool to provide a comprehensive evaluation of a new project in a complex system

Throughout the historical period:

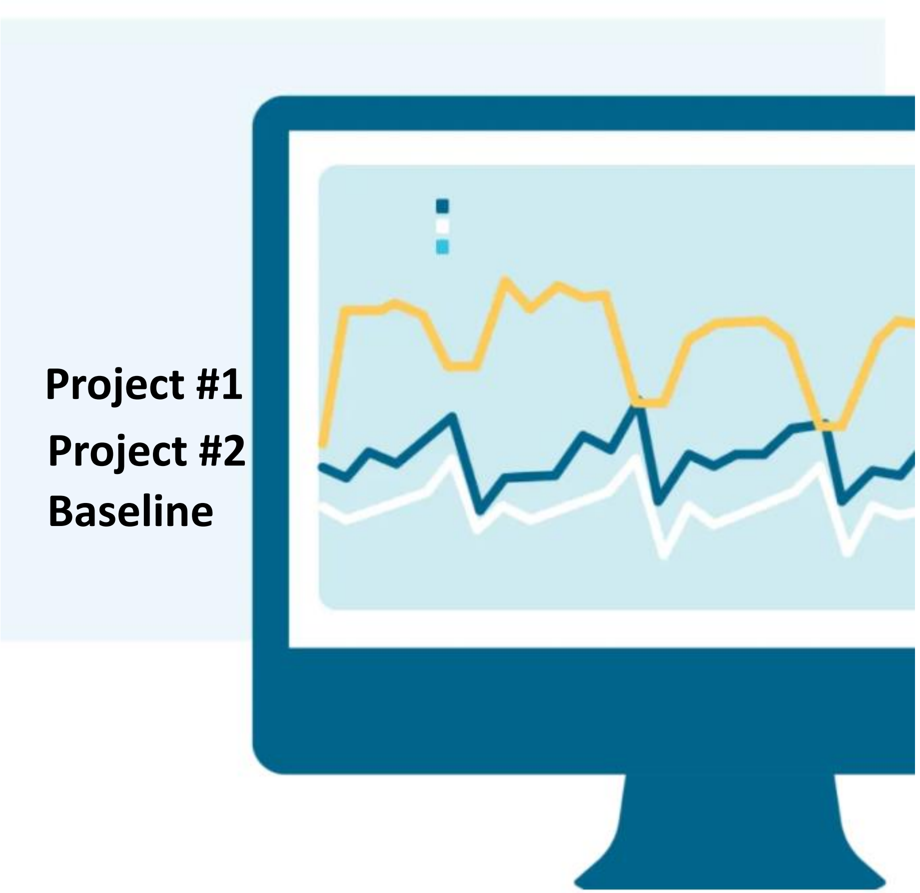
- Climate and land use are variable
- Socio-economic conditions change
- Market forces and operational behaviors change
- Water supply projects have staggered implementation

For the entire simulation period, a baseline model combines:

- Historical climate
- Recent conditions (Land Use)
- All currently implemented projects

A baseline model provides:

- A hypothetical “baseline” condition
- A metric to compare potential benefits from projects
- A method to scope project size



USGS
science for a changing world

The Salinas Valley Operational Model (SVOM) is a baseline model based on the Salinas Valley Integrated Hydrologic Model.

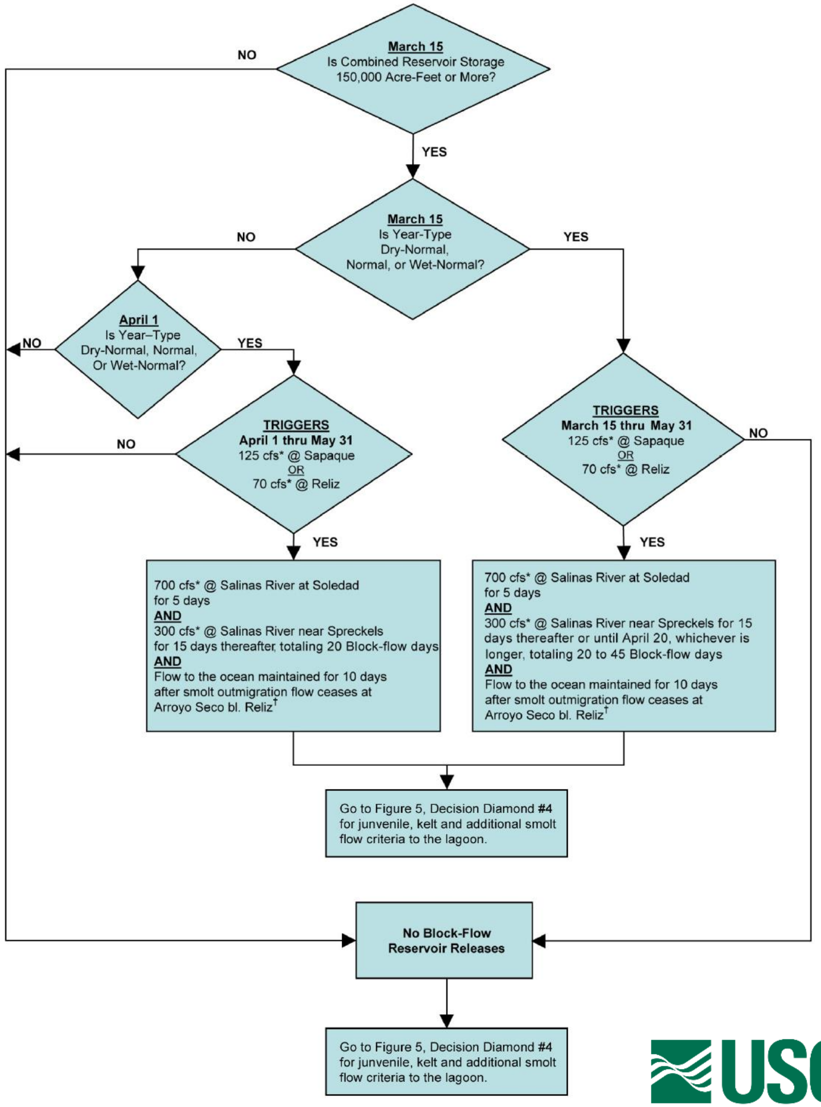
- Inherits properties for
    - Aquifer
    - Crops
- Inherits boundary conditions
    - Historical climate from 1967-2014
    - Historical extremes
    - 2014 Land Use
- Current Projects
    - Castroville Seawater Intrusion Project
    - Salinas River Diversion Facility
- Uses current reservoir operations with adherence to flow prescription and water rights

Initial application of SVOM to evaluate a proposed inter-lake tunnel.

SVOM uses the Surface Water Operations Module of MODFLOW-OWHM to implement reservoir operation rules inside the model

Reservoir operation rules:

- based on current flow prescription
- evaluated based on conditions in model
- written in human readable text files
- can be readily modified to evaluate alternatives
- are available by request



USGS
science for a changing world

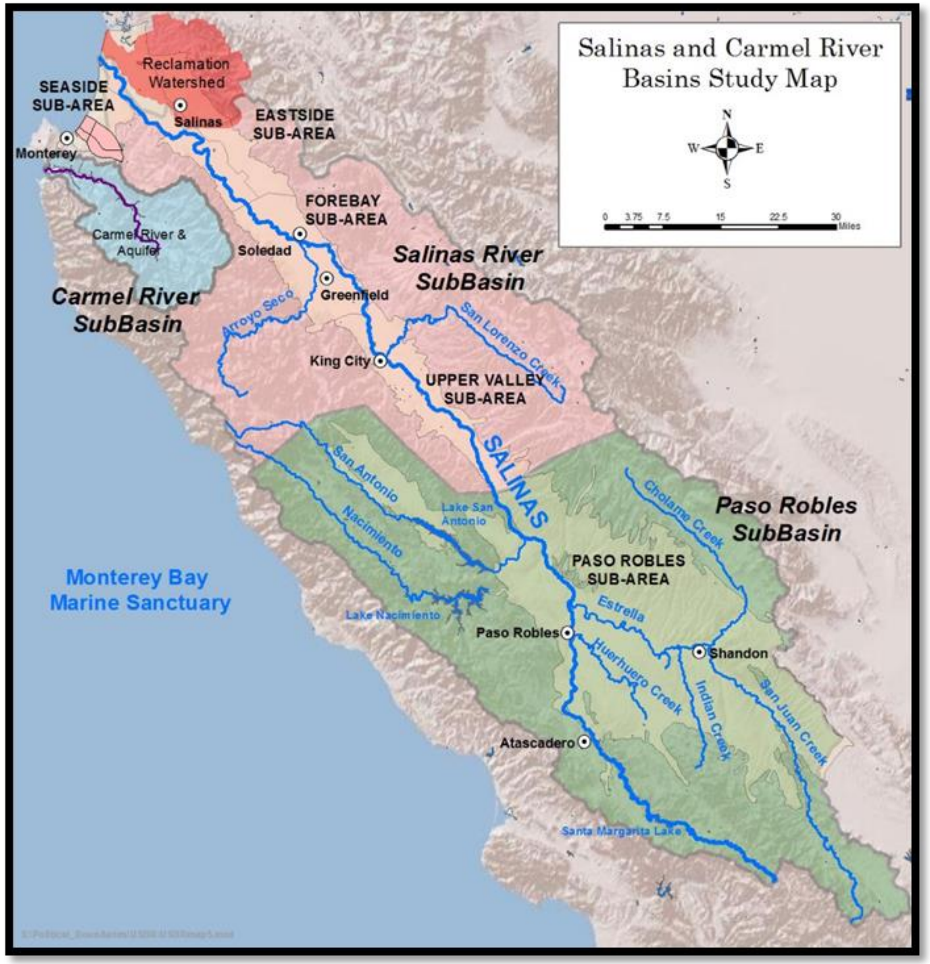
Next Steps

Estimated Timeline for Salinas Valley Model Suite Public Release (SVGM[1], SVWM[1], SVIHM[1], SVOM[2])

- **Summer/Fall 2021**
  - SVIHM Technical Review[1]
- **Winter 2021**
  - USGS Specialist Review[1]
  - SVOM Report[2]
- **Spring 2022**
  - USGS Editorial Review and Layout[1]
  - USGS Specialist Review[2]
- **Summer 2022**
  - USGS Specialist Review[2]
  - Publication[1], Model Archive[1]
- **Fall 2022**
  - Publication[2], Model Archive[2]

Related Studies

The Salinas Carmel River Basin Study is evaluating water supply strategies to 2100



Salinas and Carmel River Basins Study (Basin Study)

6 Climate forecasts

3 Socioeconomic projections

4 Water supply strategy portfolios

Climate

Land Use

Projects

Operations

Coupled Hydrologic Models

Watershed Model

- Boundary Inflows

Groundwater Model

- Changes in Aquifer Storage and Surface Water

Model Metrics

USGS
science for a changing world

USGS Collaboration with Monterey County resulted in tools and products with far reaching impact at the national and state scale.

- Substantial contributions to the development and testing of MODFLOW One Water Hydrologic Model and new features that are currently being used in a case before the Supreme Court.
- Aggregated data from SVIHM is contributing to nationwide mapping of irrigated lands
  - Validation and testing of new remotely-sensed land use characterization, irrigation estimation methods and models.
- CalPUR method that is being further developed with California Department of Water Resources with statewide mapping of irrigated lands.
- Collaborative development of:
  - model updating tools
  - model post processing tools
  - new water budget estimation methods
- SVBGSA Coordination with related efforts in the basin.

Application of the SVIHM and SVOM for the Salinas Valley Basin GSP

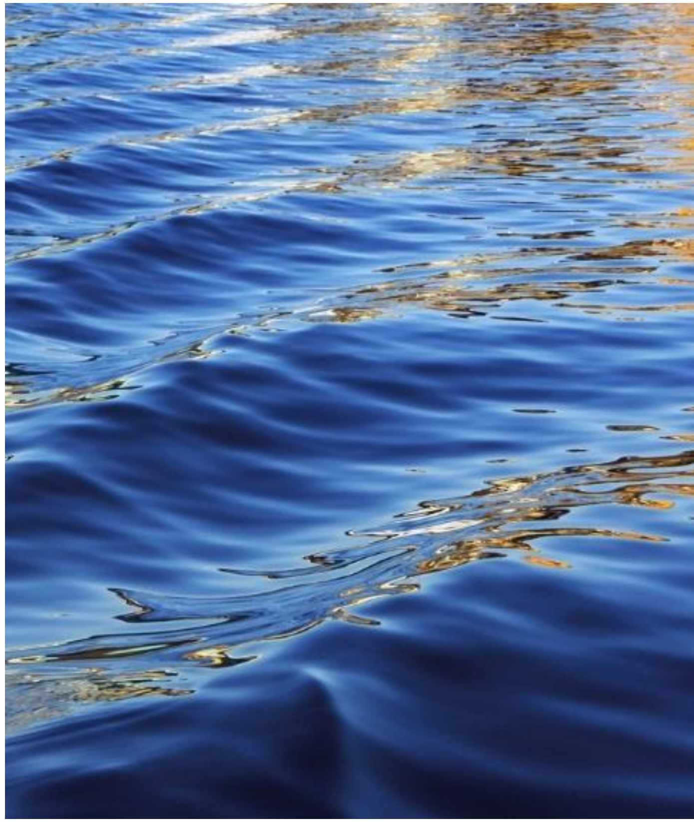
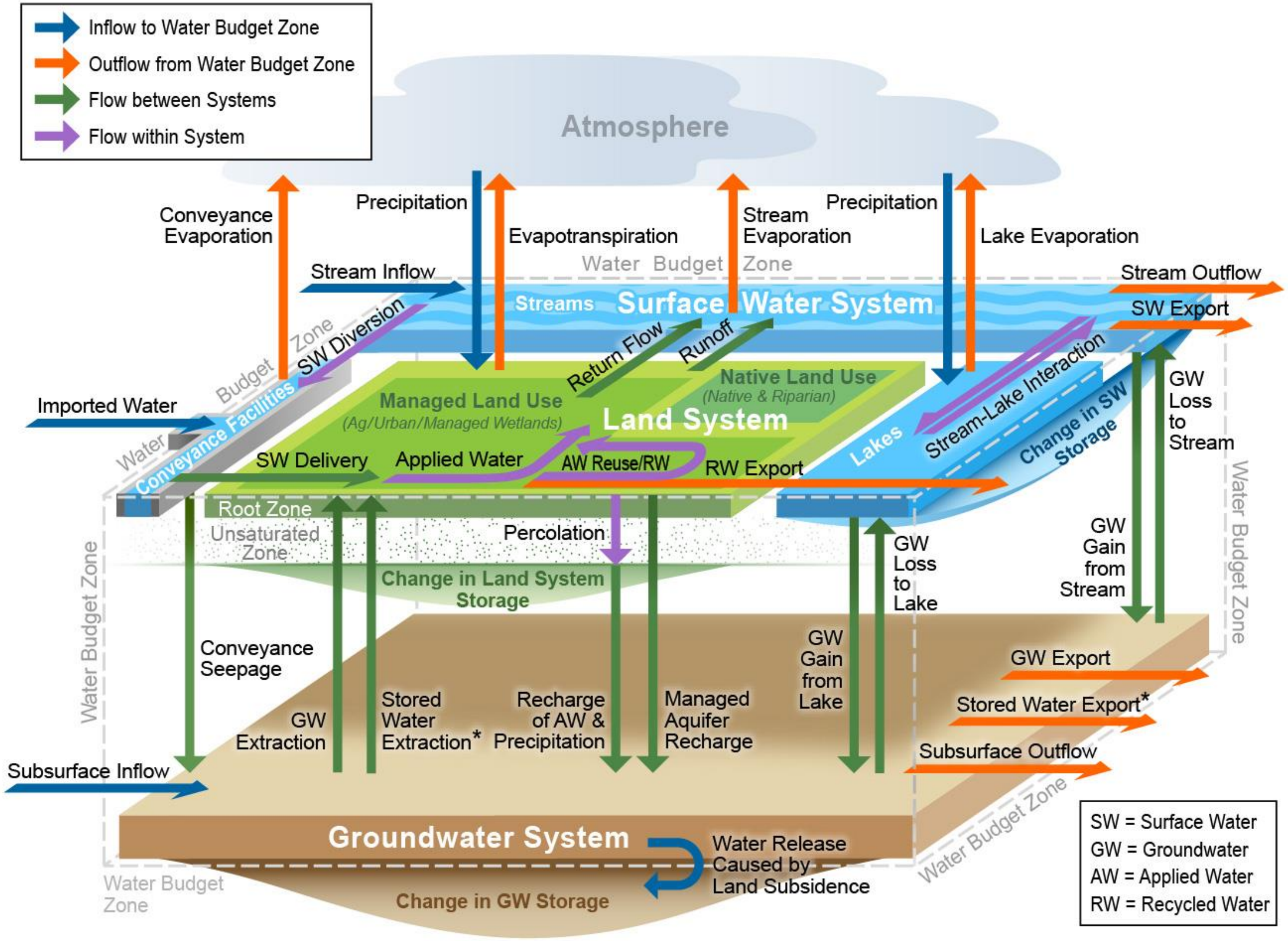


Diagram of Generalized Interrelated Water Budget



- Land system
- Surface Water system
- Groundwater system

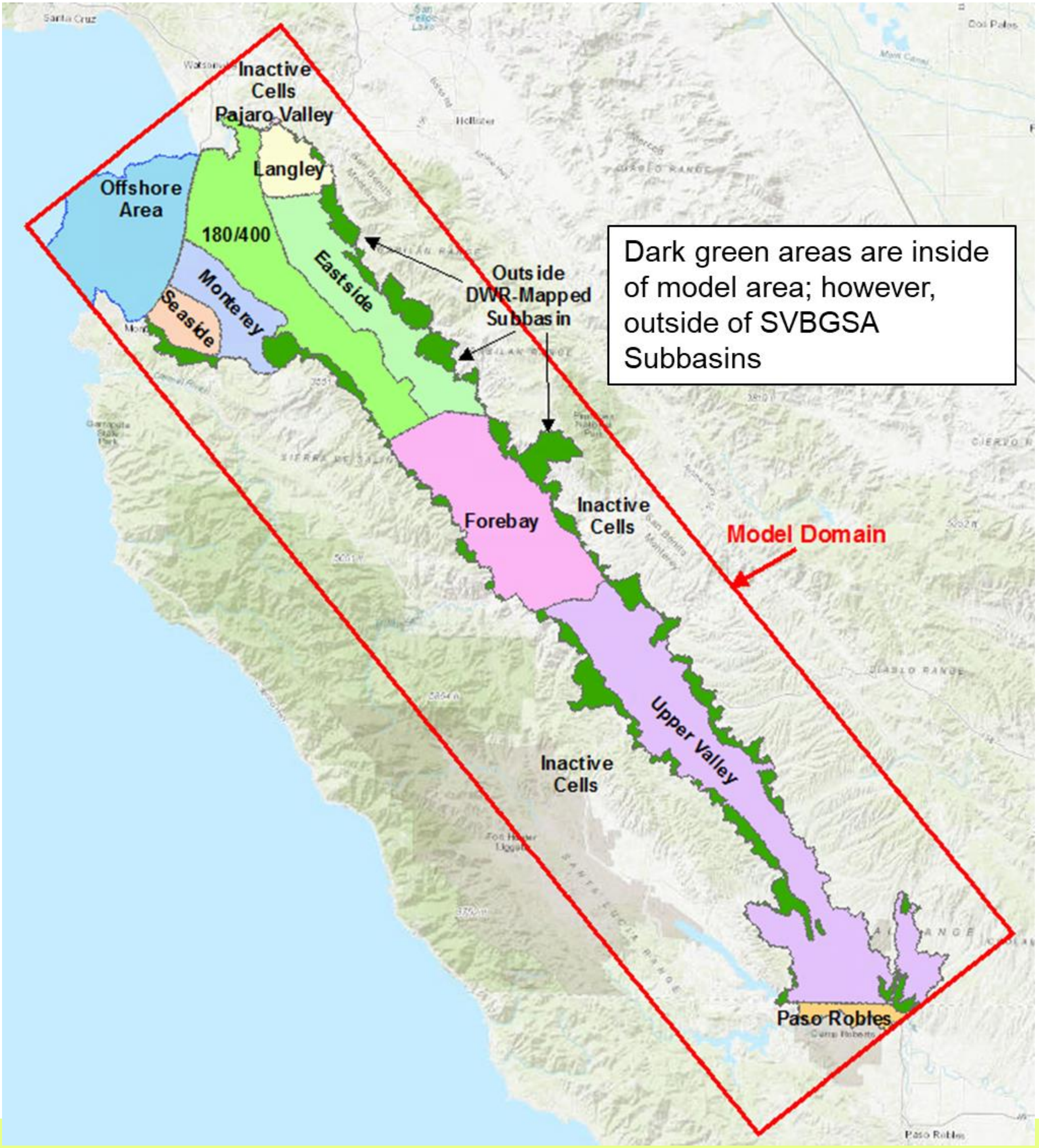
From: Handbook of Water Budget Development, California Department of Water Resources, draft 2020

Benefits of Using the SVIHM and SVOM for GSP Analysis

- The models integrate different types of data and models, such as the watershed and land use models, to produce a single water budget that is internally consistent
- Produces consistent water budgets for the Subbasins
- Able to assess impacts from various programs and projects in holistic manner
- SVOM is setup to estimate future pumping and necessary reservoir releases

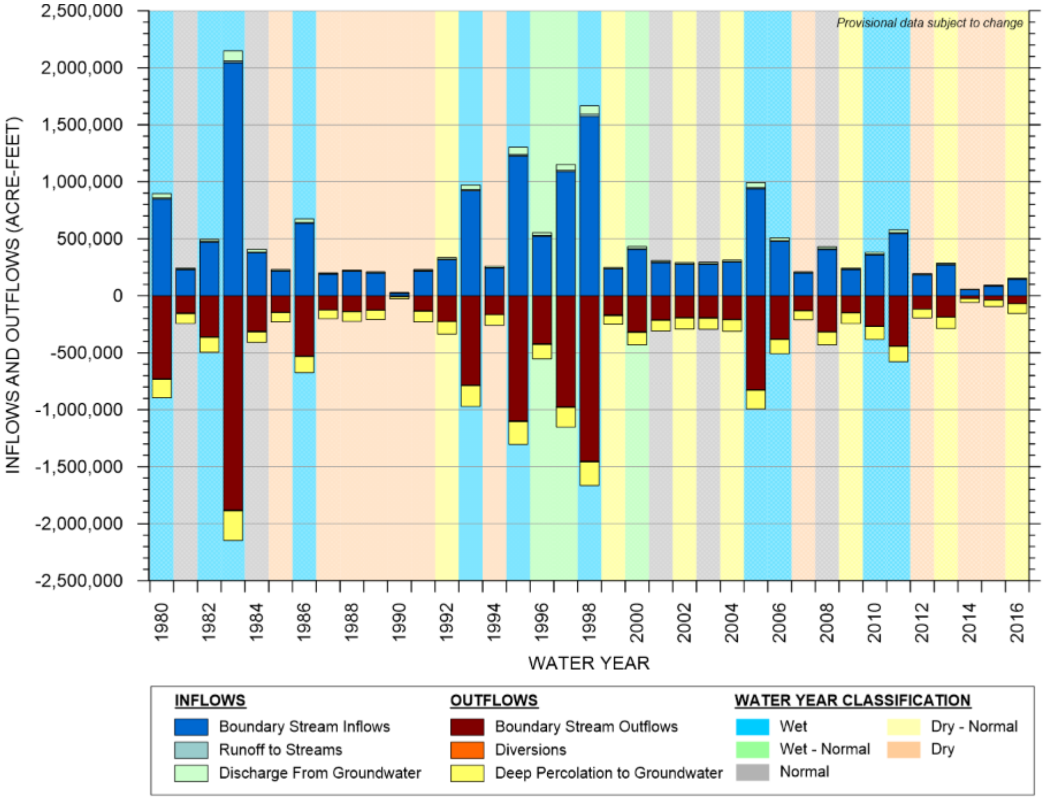
Water Budgets

- Water budgets are developed for each subbasin's GSP by grouping model results by zones
- The Salinas Valley Basin is divided into zones in the model to represent GSP subbasins, management areas, and other areas
  - Every model grid cell is assigned a zone number based on its location
- Model results are extracted from various model output files and processed for each zone based on the assigned zone number

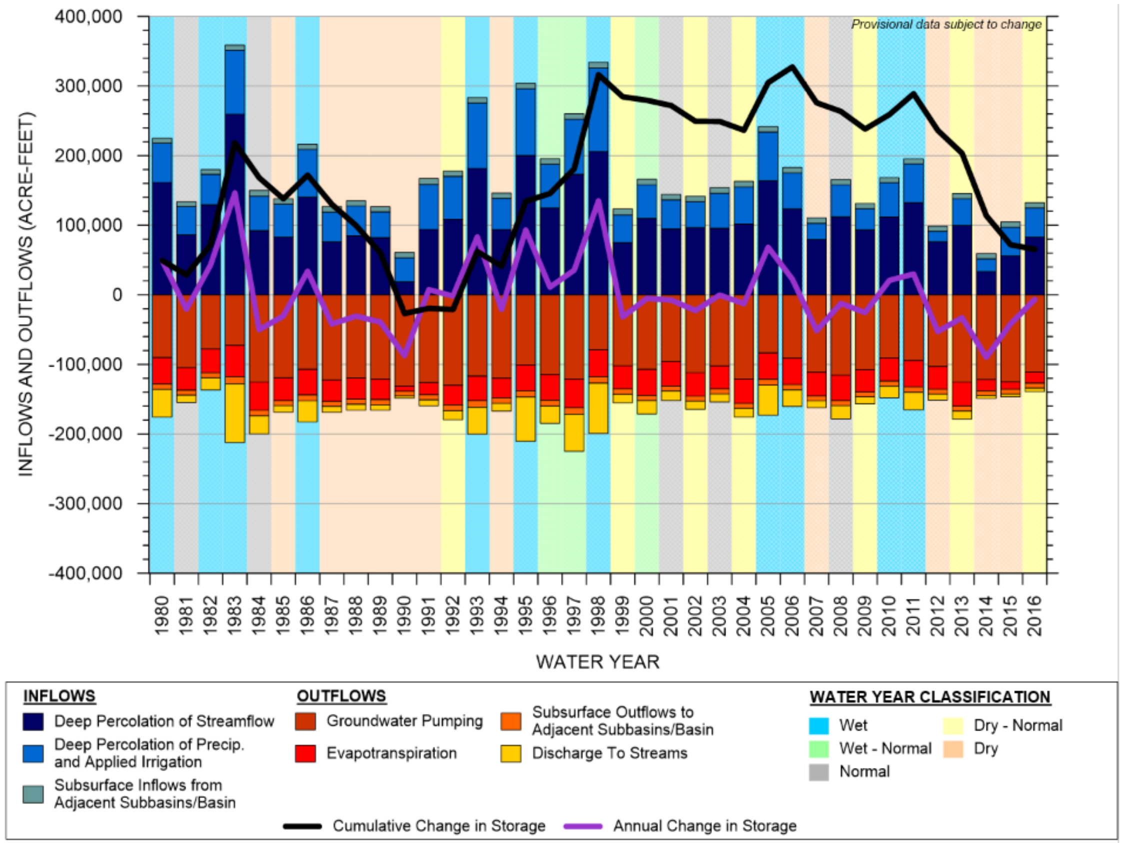


Example of Historical Water Budgets: Forebay Subbasin GSP (draft)

Surface Water Budget



Groundwater Budget



Climate Change Approach

- DWR provides Change Factors for climate (precip and ET) and streamflow for projected 2030 and 2070 climate conditions (from VIC model)
- Change factors are multiplied by Baseline climate and streamflow inputs
- Sea level rise of 15 and 45 cm assumed for 2030 and 2070 climate conditions

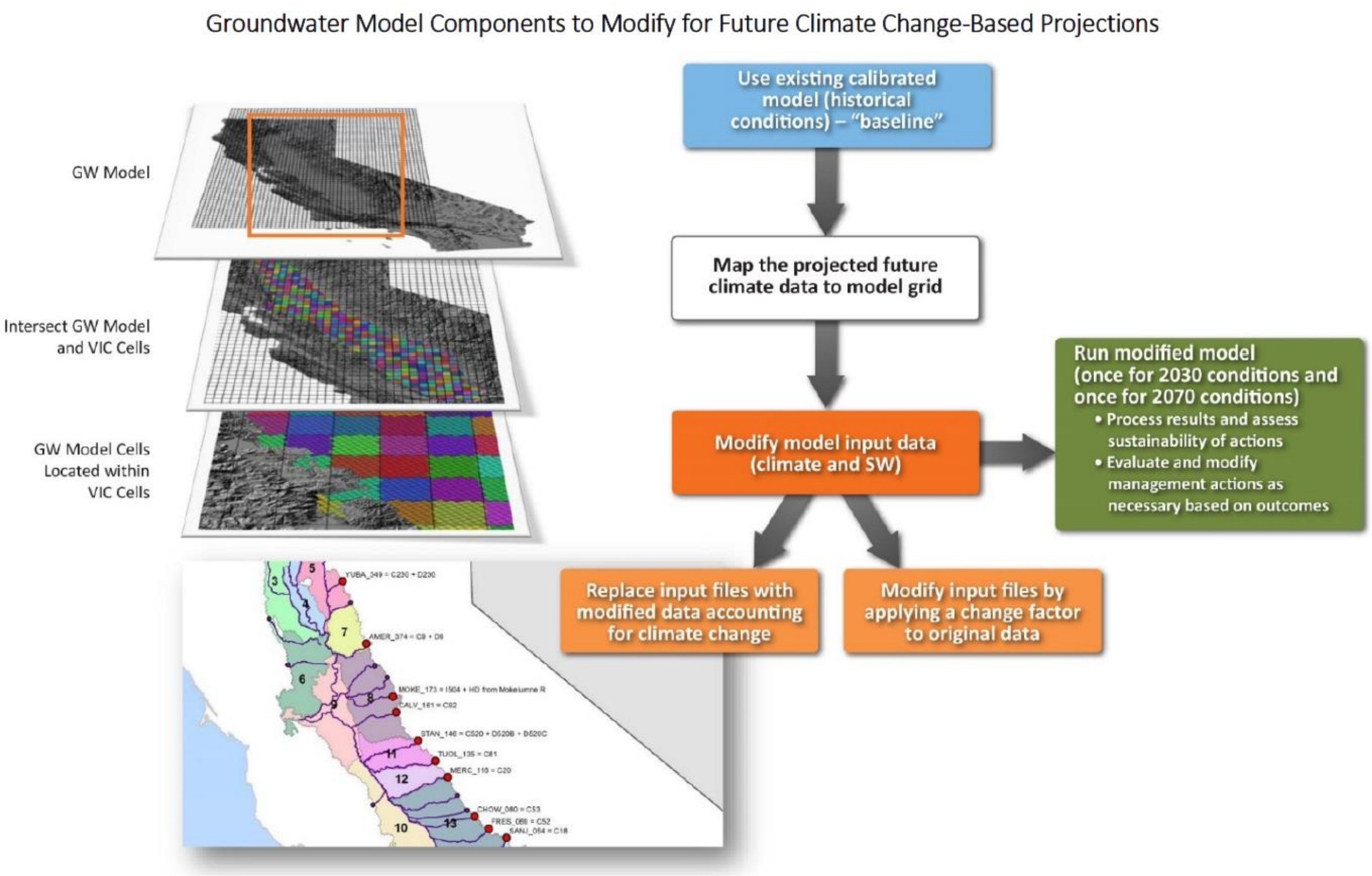


Image source: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/Resource-Guide-Climate-Change-Guidance_v8_ay_19.pdf

Sustainable Yield

- Sustainable yield estimates are calculated using simulated results from the SVIHM and SVOM
  - Groundwater pumping
  - Change in groundwater storage
  - Seawater intrusion
- Estimates are adjusted based on GEMS pumping data
- For certain areas, a range of sustainable yields is estimated to address uncertainties in model results

Projects

- Certain potential projects are simulated using the SVOM
- Integrated structure of the model allows for a holistic assessment of impacts of a project, including any impacts on other subbasins
- Results of Project simulations are evaluated as the differential from the Baseline (no projects)
- These model simulations are used to gain an understanding of the potential groundwater benefits. However, the projects are still conceptual and need to be refined further in order to do a benefits assessment.

Limitations and Uncertainty

- Adjustments to simulated water budget components are made for certain areas to address uncertainties in the models
  - For example, domestic pumping (“de minimis”) is assumed to be very small in the Salinas Valley Basin and is not simulated in the SVIHM and SVOM
    - However, domestic pumping accounts for a substantial portion of total pumping in in Langley Aquifer Subbasin. Thus, domestic pumping was estimated for this subbasin and the simulated water budget was adjusted accordingly.

We did not have time to answer all questions during the workshop. Answers are provide here and were added after the workshop.

Question 1: *SVIHM was calibrated to conditions post-1967, when the Basin was fully developed in terms of pumping, reservoir operations, and other projects. These conditions include flow from the Pressure Area to the East Side Area and extensive seawater intrusion. Has the model been used to simulate a surrogate of pre-development conditions, to see if the model can reproduce conditions that are thought to have existed in the past? Such conditions would include, for example, flow from the East Side to the Pressure Area, minimal seawater intrusion, and heads that look reasonable relative to the land surface. If this has not been done, how can the modelers and stakeholders have confidence that the model can correctly simulate current and future conditions, and the magnitude of flows between subareas/subbasins, both pre- and post-development? – Bob Abrams*

Answer: Hydrologic models are representations of complex systems. Models are very useful tools for evaluation of potentially different conditions that may have existed in the past or could exist in the future. However, models are most reliable when they use measured data. The SVIHM was developed with a specific aim of simulating contemporary water budgets, hydrology, land use, agriculture, and reservoirs since water year 1967. It provides a rigorous representation of valley-wide hydrologic processes based on calibration to over 100,000 measurements. Defining model input for pre-development periods is a substantial undertaking with sparse data. Pre-development models are a tool that can be used to evaluate potential conditions that are thought to have existed in the past. However, developing model input data based on conditions that were thought to exist has substantial uncertainty. Likewise, forecasting how society, market forces, municipal ordinances, and climate change will alter the hydrologic system in the future also has substantial uncertainty. This does not mean that pre-development and forecast models do not have merit. However, the best model for making decisions today will be based on measured historical data. We cannot judge the suitability of a calibrated contemporary model for decision making today based on conditions that were thought to exist before or its ability to forecast things that have not happened yet. A model should be evaluated based on how well it reproduces measured data and known conditions. A pre-development model could be developed in the future, but it was not a part of the current scope of work for Monterey County's Basin Investigation.

We did not have time to answer all questions during the workshop. Answers are provide here and were added after the workshop.

Question 2: *Regarding the issue of growers pumping water from within the basin to outside of the basin -- Howard stated that the model pumping boundary is for Zone 2A. The extraction reporting ordinance only applies to zones 2 and 2a -- the county never modified it to include zone 2x (I believe this is correct?) So since Zone 2C is larger than Zone 2A , could the model mapping be showing the pumping within zone 2a but that some it may be utilized outside of zone 2a in zone 2c? This may be why some believe there are large irrigated acres outside of the 'basin' using water from inside the 'basin'. – Nancy Isakson*

Answer: There may be other potentially relevant jurisdictional or legal context for this question that is outside the scope of this model study. From the model perspective, we can describe how water is simulated within the model domain. The model supply and demand calculations are based upon the MCWRA benefit region Zone 2A. However, the complete model domain includes much of the hydrologically defined groundwater basin and extends beyond the Zone 2A boundary. Delivered water supplies in the model are based upon reported water use within Zone 2A. Any delivered water supply (wells, diversions) is provided by sources within the Zone 2A area and is only used to meet agricultural water demands within Zone 2A. Any agriculture that may be defined outside of Zone 2A in the model can only access naturally provided water to meet its demands (for example, rain or shallow groundwater). At this time no wells are defined outside Zone 2A in the model. Water budget can be computed for areas outside the Zone 2A region. In this way, the potential demands for these regions can be evaluated. However, the model does not deliver water from Zone 2A to meet those demands.

We did not have time to answer all questions during the workshop. Answers are provide here and were added after the workshop.

Question 3: *Publication of the Baseline model will be available sometime in the Fall of 2022 (eight or more months after the submission of the GSP's in the Eastside, Forebay and Upper Valley); does this publication time frame apply to the Operational Model? – Bill Lipe*

Answer: The Salinas Valley Model Suite (SVMS) is a comprehensive solution to address the needs of the Monterey County Basin Investigation and support the proposed Interlake Tunnel benefit analysis. The SVMS includes the geological texture model (SVGM), the Salinas Valley Watershed Model, the Salinas Valley Integrated Hydrologic Model (SVIHM), and the Salinas Valley Operational Model (SVOM). All these related models are to be published and released to the public. Every effort is being made publish the model within the estimated timeline and to ensure the model is complete and includes the best representation of the hydrologic system. The models will be released to the public and hosted on a public website. Any use of model data before that time is provided only to meet immediate needs and is subject to revision.

The Sustainable Groundwater Management Act (SGMA) was implemented after the model project was started. Every effort has been made to align the model results with the SGMA process. The model is a comprehensive and valuable tool that can be used to inform these efforts, evaluate strategies to reach sustainability, and estimate potential project benefits. However, the model is not intended to be the arbiter of sustainability efforts in the basin. The model is intended to be the best unbiased representation of the Salinas Valley hydrology using the best available data. Models are one tool within a toolbox. A variety of tools and data are available that can be leveraged for sustainability evaluations. These data have been applied to develop Groundwater Sustainability Plans. Many of the same data used in these other tools are used in the model.

We did not have time to answer all questions during the workshop. Answers are provide here and were added after the workshop.

Question 4: *Will publication of the Baseline model (and/or the Operational Model), include a technical manual for the model that includes not only inputs/outputs, but actual processing rules, functions, source code, tables and metadata throughout the model? – Bill Lipe*

Answer: All cooperative science projects that receive substantial federal investment, as our cooperative science program for the Salinas Valley, are required to be open source, and rigorously reviewed for technical sufficiency, documented, and publicly released. The models were constructed using published open source modeling software, with separate and complete documentation that is already available. The hydrologic model is MODFLOW One Water Hydrologic Model (MODFLOW-OWHM). The software can be downloaded in its entirety here, https://code.usgs.gov/modflow/mf-owhm. You can also find helpful information on this webpage https://www.usgs.gov/software/modflow-one-water-hydrologic-flow-model-conjunctive-use-simulation-software-mf-owhm. The download includes a report describing the software as well as the source code.

The operational model uses the Surface Water Operations Module whose implementation is based on a wealth of prior publications:

Ferguson, I.M.., Llewellyn, D., Hanson, R.T., and Boyce S.E., 2016,
User guide to the surface water operations process—An integrated approach to
simulating large-scale surface water management in MODFLOW-based hydrologic models:
Denver, Colo., Bureau of Reclamation Technical Memorandum no. 86-68210–2016-02, 96 p.

(cont.)

We did not have time to answer all questions during the workshop. Answers are provide here and were added after the workshop.

Question 4: *Will publication of the Baseline model (and/or the Operational Model), include a technical manual for the model that includes not only inputs/outputs, but actual processing rules, functions, source code, tables and metadata throughout the model? – Bill Lipe*

Answer (continued):

Ferguson, I.A., and Llewellyn, D., 2015, Simulation of Rio Grande project operations in the Rincon and Mesilla Basins: Summary of model configuration and results: Bureau of Reclamation Technical Memorandum 86–68210–2015–05, 56 p.

Hanson, R.T., Ritchie, A.B., Boyce, S.E., Galanter, A.E., Ferguson, I.A., Flint, L.E., Flint, A., and Henson, W.R., 2020, Rio Grande transboundary integrated hydrologic model and water-availability analysis, New Mexico and Texas, United States, and northern Chihuahua, Mexico: U.S. Geological Survey Scientific Investigations Report 2019–5120, 186 p., https://doi.org/10.3133/sir20195120. (see pages 7-9)

The reservoir operations rules are human readable text files that follow the current mandated operational rules for conservation, water supply, flood mitigation, and water rights. These data just translate public documents with flow charts and figures into text that the model can read in. These are available from MCWRA upon request, both in the form used in the model and in public documents.

The Salinas Valley Model Suite reports will include a complete description of implementation of the Salinas Valley models and a model archive of the published model versions. This is the fundamental standard of all USGS cooperative science projects. Specifically, the Salinas Valley Operational Model report will include a description of the adaptations to the Salinas Valley Historical model to generate a baseline reservoir operations model, describe reservoir model implementation, and document implementation of rules.

We did not have time to answer all questions during the workshop. Answers are provide here and were added after the workshop.

Question 5: *The MCWRA has been promising the baseline model for many years now; so, how long has the "Technical Review" been underway and will they be able to honor the Fall 2022 commitment.– Bill Lipe*

Answer: Every effort is being made to publish the models within the estimated timeframe. However, it is important to note that the initial model scope was to address specific concerns about historical conditions for the Monterey County Basin Investigation. Since the start of project, the models have been refined with better representation of GEMS well network wells and updated with 4 additional years of critical climate, land use, water supply, and reservoir storage, that represent drought recovery between 2014 and 2018. These data allow for (1) better representation of stakeholder conservation efforts that are essential for evaluation of water budgets and potential sustainability projects (2) a longer duration for evaluation of the CSIP and SRDF operations evaluation, (3) many updates to model input data sets to better represent the GEMS well network.

A comprehensive 51-year climate, surface and groundwater, agricultural and reservoir operations model of the entire Salinas Valley is a substantial effort that warrants and benefits greatly from a sufficient technical review. This review provides a rigorous basis for further tool development and refinement and scenario testing.

The technical review has been enhanced by use and further development of the Salinas Valley Model Suite in two regional projects, (1) the WaterSMART water supply vulnerability study cooperatively funded in partnership with the US Bureau of Reclamation and (2) the Interlake Tunnel project. The WaterSMART Study includes forecast and analysis framework to evaluate conditions to 2100 for multiple possible climates, socio-economic growth scenarios, projects, and conservation strategies in the Salinas Valley and region. The Interlake Tunnel benefit analysis facilitated the operational model development which (cont.)

We did not have time to answer all questions during the workshop. Answers are provide here and were added after the workshop.

Question 5: *The MCWRA has been promising the baseline model for many years now; so, how long has the "Technical Review" been underway and will they be able to honor the Fall 2022 commitment.– Bill Lipe*

Answer (continued): will benefit future project evaluations for years to come. These applications of the model allowed for more rigorous review of model input data, better implementation of important processes, and improved representation of land use.

The Salinas Valley Model suite development has leveraged a unique opportunity to benefit multiple projects for stakeholders throughout the entire Salinas valley. Although the technical review and model development has taken longer than anticipated, the value-added information and consistent analysis framework for these concurrent studies benefits both stakeholders and the models. As presented at the Model Workshop, the SVIHM is expected to be submitted for USGS Specialist Review in Winter 2021.

We did not have time to answer all questions during the workshop. Answers are provide here and were added after the workshop.

Question 6: *Can you confirm the management area within the Forebay, mentioned in the presentation, is the Arroyo Seco GSA? - Bill Lipe*

Answer:

USGS: The water accounting regions in the model are based upon the DWR Bulletin 118 boundaries or MCWRA subareas, not the jurisdictional regions of specific groundwater sustainability agencies.

SVBGSA: Yes, the water budget tools account for the Arroyo Seco Cone Management Area that will be managed by the ASGSA. The GSP water budget chapter includes a section for the ASGSA water budget.

We did not have time to answer all questions during the workshop. Answers are provide here and were added after the workshop.

Question 7: *Today's preamble in to the slide deck about the simulation not being a realistic portrayal of what will come and is likely inaccurate (which I view as them shielding themselves, not the SVBGSA, from potential liability) and since the public cannot truly analyze the model being used until well after the GSP's for all basins in the Salinas Valley Basin are submitted (i.e. the black box, source code, formulas, tables, metadata), nor may the Public potentially have access to the operational model that potential projects will use (with some modeling already being done for the Interlake Tunnel by MCWRA in a separate silo outside the GSA); all that said in context to, why should the public trust it at all? - Bill Lipe*

Answer:

The opening statement was not intended to cast the model as un-realistic or inaccurate—just to provide some limitations about models and data in general. This is especially relevant for models and data that are under technical review. All models, data, and measurements have uncertainty because we cannot measure everything, at every time, everywhere. Models are the best way to represent a complex system to gain insights not attainable by looking at individual data points alone. The initial statement was intended to relay that the model is under review and that changes to the model during this process are inevitable. For example, we uncovered some data were missing. These missing data led to underrepresentation of some pumping in the model. That error has been fixed. This correction may alter a few budget numbers for a few years from the prior version of the model by 5-10% but the model now is MORE accurate than before. This is an example of how models are improved during the technical review process. It is also important to note that the model was developed for the Monterey County Basin Investigation. Although model output can be helpful for evaluation of budgets and sustainability strategies that is not its purpose.

(cont.)

We did not have time to answer all questions during the workshop. Answers are provide here and were added after the workshop.

Question 7: *Today's preamble in to the slide deck about the simulation not being a realistic portrayal of what will come and is likely inaccurate (which I view as them shielding themselves, not the SVBGSA, from potential liability) and since the public cannot truly analyze the model being used until well after the GSP's for all basins in the Salinas Valley Basin are submitted (i.e. the black box, source code, formulas, tables, metadata), nor may the Public potentially have access to the operational model that potential projects will use (with some modeling already being done for the Interlake Tunnel by MCWRA in a separate silo outside the GSA); all that said in context to, why should the public trust it at all? - Bill Lipe*

Answer: (continued)

Finally, regarding concerns about public trust of the model. The data and methods are all public record. The source code, operational rules, and model software are all publicly available, see question 4 above for references. The Salinas Valley models were developed with substantial stakeholder involvement with public updates and expert input. The model input has been using publicly available data that are provided by the stakeholders or public agencies.

To enumerate this further:

1) agricultural crop information is based upon known and documented agricultural practices, other published models, a crop model funded by the UN Food and Agricultural Organization and literature-based values and field measurements by University of California,
2) land use estimation is developed from national, county, and state land use data that constrained with knowledge from a public database of reported pesticide use and the agricultural commission reports, (cont.)

We did not have time to answer all questions during the workshop. Answers are provide here and were added after the workshop.

Question 7: *Today's preamble in to the slide deck about the simulation not being a realistic portrayal of what will come and is likely inaccurate (which I view as them shielding themselves, not the SVBGSA, from potential liability) and since the public cannot truly analyze the model being used until well after the GSP's for all basins in the Salinas Valley Basin are submitted (i.e. the black box, source code, formulas, tables, metadata), nor may the Public potentially have access to the operational model that potential projects will use (with some modeling already being done for the Interlake Tunnel by MCWRA in a separate silo outside the GSA); all that said in context to, why should the public trust it at all? - Bill Lipe*

Answer: (continued)

3) climate data are developed using publicly funded climate stations and the published Basin Characteristics Model for California that was funded by the California department of water resources (https://pubs.er.usgs.gov/publication/tm6H1 ,
4) data for streamflow and reservoir releases comes from stream gages and agency reports,
5) stakeholder reported agricultural diversions and pumping constrain water use in the model,
6) reported municipal water supply is specified,
7) geologic framework that is used to define with aquifer extents and characterize aquifers is based upon borehole data from Monterey County and refinement of an existing published geologic model of the region, and
8) reservoir operations are human readable text file implementations of publicly available documents

The only thing that is not yet available is monthly aggregated input data (derived from public sources) and model output data that is undergoing review. We hope that the substantial and consistent use of public information, stakeholder engagement activities, simulation method transparency, rigorous expert input and review, and subsequent public release and hosting of the model data, documentation, and model input by an independent federal science agency is sufficient to build public trust.

We did not have time to answer all questions during the workshop. Answers are provide here and were added after the workshop.

Question 8: *During the SVIHM and SVOM model workshop Dr. Henson from USGS discussed the availability of SVOM operations logic. Was he referencing these rule files that you shared last year? If so, have they been updated?*

Answer: There may have been slight modifications to facilitate implementation of water rights. These rule files are publicly available from MCWRA upon request.