Appendix A - Technical Collaborators Presentation Slides

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Interbasin GROUNDWATER FLOW Evaluation Project

Technical Collaborators Meeting 1

July 27, 2016

Meeting Outline

- Introductions
- Project Objectives
- Roles
- Model Inventory
- Questions for Discussion

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Project Objectives

A methodology to assess **interbasin flows**

Technical capacity
Local ownership

Methodology for **GSAs within the NSVIRWM area**

Methodology for **DWR** GSA assessments

"lessons learned" for other basins

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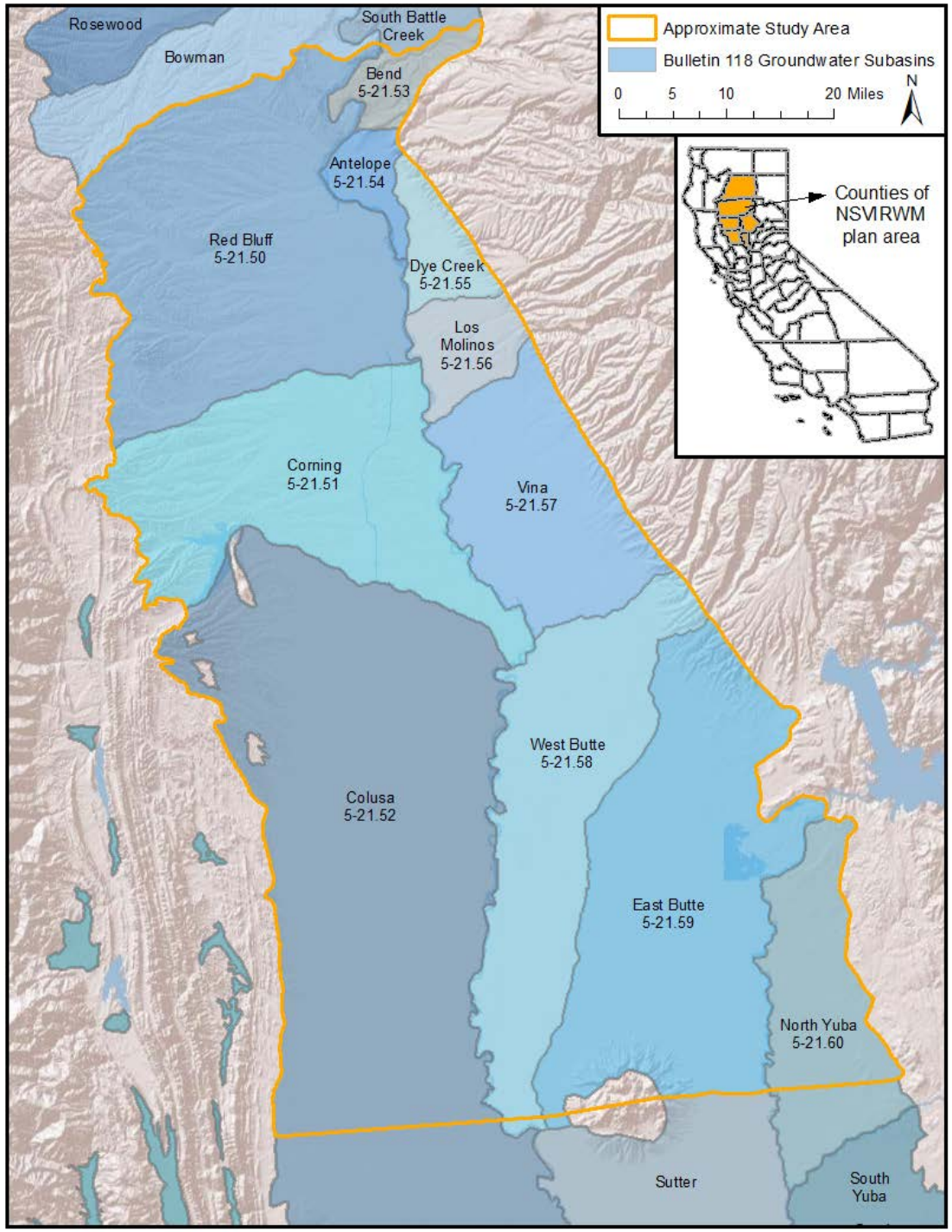
Study Area

Study Area Groundwater Subbasins:

- Red Bluff (5-21.50)
- Corning (5-21.51)
- Colusa (5-21.52)
- Bend (5-21.53)
- Antelope (5-21.54)
- Dye Creek (5-21.55)
- Los Molinos (5-21.56)
- Vina (5-21.57)
- West Butte (5-21.58)
- East Butte (5-21.59)
- North Yuba (5-21.60)



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Role of the Technical Collaborators

- Guide the
  - Identification of characteristics necessary to quantify interbasin flows
  - Development of an approach to identify model(s) or other techniques best suited for a local area
  - Application of the technique for the NSVIRWM area for this use
- Attend five Technical Collaborator meetings (July 2016-April 2017)
- Review and provide feedback on materials developed

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Project Timeline

- Jul 2016: Draft Model Inventory Memo and ***TC Meeting #1***
- Sept 2016: TC Meeting #2 (Focus on Regional Models) and Finalize Model Inventory Memo
- Jan 2017: TC Meeting #3 (Focus on Local Models)
- Feb 2017: TC Meeting #4 (Summary of Findings)
- Mar 2017: Draft Project Report
- Apr 2017: TC Meeting #5 (Comments on Draft Project Report)
- May 2017: Finalize Project Report and Present to NSVIRWM Board

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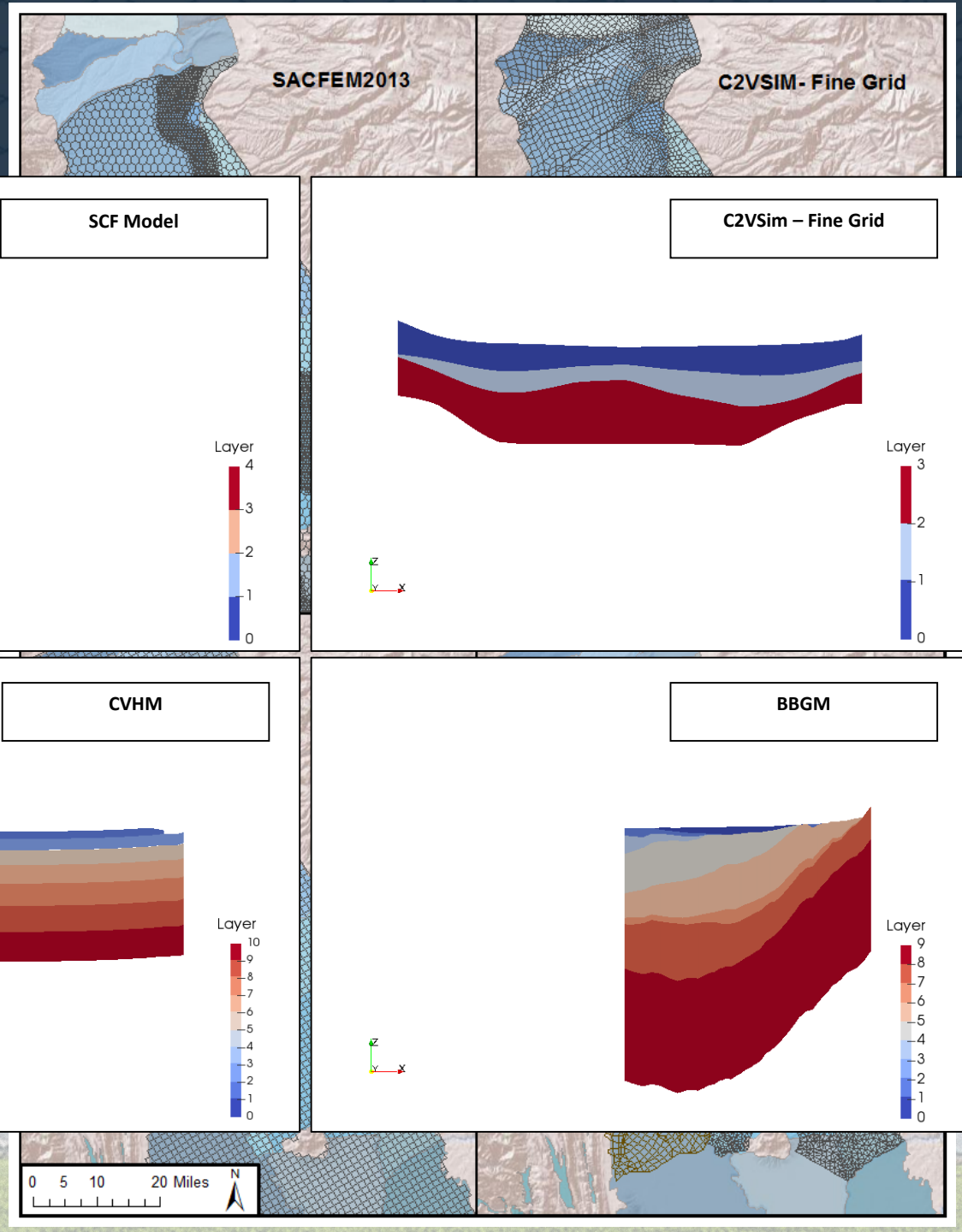
Model Inventory

- Five models identified
- Consideration of horizontal and vertical extent and discretization
- Parties responsible for development
- Agencies actively using the models



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Model Features Comparison Table (see handout)

Key Feature	C2VSim	CVHM	SACFEM2013	BBGM	SCF Model
Code Platform	IWFM	MODFLOW-FMP	IDC coupled with MicroFEM	IWFM	IGSM
Public Domain Code	Yes	Yes	Yes for IDC; MicroFEM is proprietary	Yes	Yes
Model Ownership	DWR	USGS	Reclamation	Butte County	DWR
Availability	Course grid available on DWR website and fine grid available upon request to DWR	Available on USGS website	Uncertain	Available upon request to Butte County	Available upon request to DWR
Documentation	Available on DWR website	Available on USGS website	Available online	Available on Butte County website	Available upon request to DWR
Integrated Model	Yes	Yes	Partially: two separate codes used to simulate hydrologic processes	Yes	Yes
Geographic Area	Central Valley	Central Valley	Sacramento Valley Groundwater Basin	Groundwater Subbasins in Butte County (including East Butte, West Butte, Vina, portions of North Yuba and Sutter)	Corning Subbasin and northern Colusa Subbasin
Simulation Period (Water Years)	1921 - 2009	1961 - 2003	1970 - 2010	1970 - 1999	1970 - 2000
Number of Layers	3	10	7	9	4
Geologic Formations Represented in the Model	Generalized upper unconfined aquifer, confined production zone, deep confined zone	Layers not explicitly tied to hydrogeologic units except for Corcoran Clay in the San Joaquin Valley, remainder based on sediment texture model	Layers not explicitly tied to hydrogeologic units except for portions of the Tuscan Formation	Holocene basin deposits, Alluvium, Sutter/Laguna Formation, Tehama Formation, Tuscan C/B/A Formations, older marine (Neroly, Upper Princeton Gorge, Ione)	Alluvial and basin deposits, Tehama Formation, Upper Tuscan Formation, and Lower Tuscan Formation
Agricultural Demand Estimation Method	Integrated methodology using IDC	Integrated methodology using the Farm Process	Calculated externally by IDC	Integrated methodology using IDC	Integrated methodology using IGSM Ag Demand Package
Stream-Aquifer Interaction Method	Integrated methodology using IWFM Stream Package	Integrated methodology using MODFLOW Streamflow Routing Package	Limited; fixed head boundary condition for river stages	Integrated methodology using IWFM Stream Package	Integrated methodology using IGSM Stream Package

Note: Descriptions in this table may not reflect ongoing, unpublished updates to these models.

Model Inventory

- Are there any other model applications in the NSV area that should be considered? Should any of the models we are considering be removed?
- Are there any other key features that should be included in the inventory memo?
- Are any local agencies planning to generate interbasin flow estimates without the use of a numerical model?

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Discussion

Our next two meetings will focus on regional and local models, respectively. Some questions we'll evaluate include:

- How do the models compare in their conceptual model for the region and groundwater flows between subbasins? Are any major physical features missing from the models?
- How does each model quantify the interconnectedness of adjoining subbasins? Will the information generated be sufficient for SGMA purposes?
- What updates to the models would increase confidence in their interbasin flow estimates?

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Discussion

- Could the models be used to evaluate impacts of ‘undesirable results’? Can models without the ability to explicitly simulate a process (e.g., subsidence or solute transport) still be used to help evaluate the potential for those processes?
- Does it matter if a model is in the public domain or proprietary? How will members of the public be enabled to evaluate models developed with proprietary software?
- What data gaps exist? Should common datasets be developed or hosted for the benefit of all model users/applications in a study area?

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Interbasin GROUNDWATER FLOW Evaluation Project

Technical Collaborators Meeting 2

September 6, 2016

Meeting Outline

- Recap of Meeting #1
- Overview and Discussion of Potential Project Outcomes
- Discussion of a Model Selection and Evaluation Process
- Discussion of Water Budgets and How to Compare Between Different Models
- Define the Problem of Interbasin Flow Determination When Boundary is a Stream
- Discussion of Data Gaps
- Example of Interbasin Flow Budget Generation (if time allows)

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Meeting #1 Recap

- Project objectives:
  - Local ownership of the interbasin flow evaluation process in the NSV Area
  - “Lessons learned” to DWR and others in the state
- Overview of models likely to be considered for this study
  - Regional: CVHM, C2VSim, SacFEM 2013
  - Local: Butte Basin Groundwater Model, Stony Creek Fan IGSM
- Certain tools identified as being unsuited for future use by GSAs, though they likely contain useful information that shouldn’t be lost
  - SacFEM 2013, Stony Creek Fan IGSM
- Initial discussion of project outcomes

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Project Outcomes

- Primary:
  1. Does the TC group feel comfortable identifying which regional model (CVHM or C2VSim) is most appropriate for determination of interbasin flow budget component of GSPs ***at this place and in this time?***
- Other/Secondary Outcomes:
  2. Define the most important components (e.g., simulated heads, water budget) that GSA's should focus on when evaluating which model to use
  3. Describe a process for comparing water budget information generated by different models and codes (e.g., do we need to combine terms from one model to compare outputs from another model?)

Project Outcomes

- Other/Secondary Outcomes:
  4. Describe the challenges and a process for evaluating interbasin flows where the boundary is defined by a river/stream
  5. Describe non-modeling approaches, if recommended, or why the TC does not recommend using them
  6. Describe data gaps that exist ***at this time*** in the models being considered for use. Also describe those updates that are highest priority to increase confidence in interbasin flows
  7. Describe a process for feedback between local and regional modeling efforts
  8. How can regional models be used to evaluate undesirable results

2. Important Components for Model Selection

Is the model code (e.g., IWFM, MODFLOW-OWHM) appropriate?

- Generally, no code is universally "better"
- However, the codes simulate some processes differently – do local conditions warrant a particular code?

Does the model cover my area of interest?

- Basin/subbasin of the GSA
- Adjacent, hydraulically connected basins/subbasins

Does the model include important processes and features?

- What's important will vary by area
- Rely on local knowledge and expertise
- If something is missing, can the model be updated to include it?

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2. Important Components for Model Selection (continued)

What is the status of model development?

- If the application has been "sitting on the shelf" will it require significant updates?
- If the application is under development will it be ready in time for SGMA needs?

Who is responsible for model development?

- If development is not led by the GSA, is the agency responsible for development going to continue providing support?
- Who will develop baseline and future conditions runs?

How well does the model account for local conditions (surface)?

- Is the scale of water use representation (e.g., surface water delivery, land use) sufficient relative to the GSA area?

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2. Important Components for Model Selection (continued)

How well does the model account for local conditions (subsurface)?

- Is the groundwater portion of the model based on a sound conceptual model, as will be required for SGMA?

How well is the model calibrated?

- Does the historical period of record capture periods of stress?
- What types of observations (head, stream and drain flow, stage, subsidence, head differences, etc.)?

What does the simulated water budget indicate?

- How much interbasin flow occurs?
- How does it vary temporally and spatially?
- How important is it relative to other components of the water budget?

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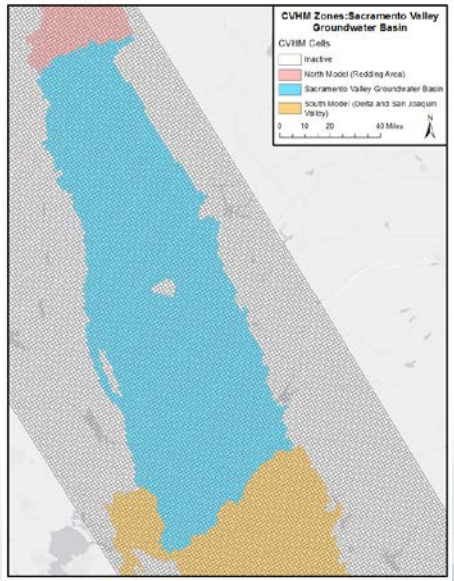
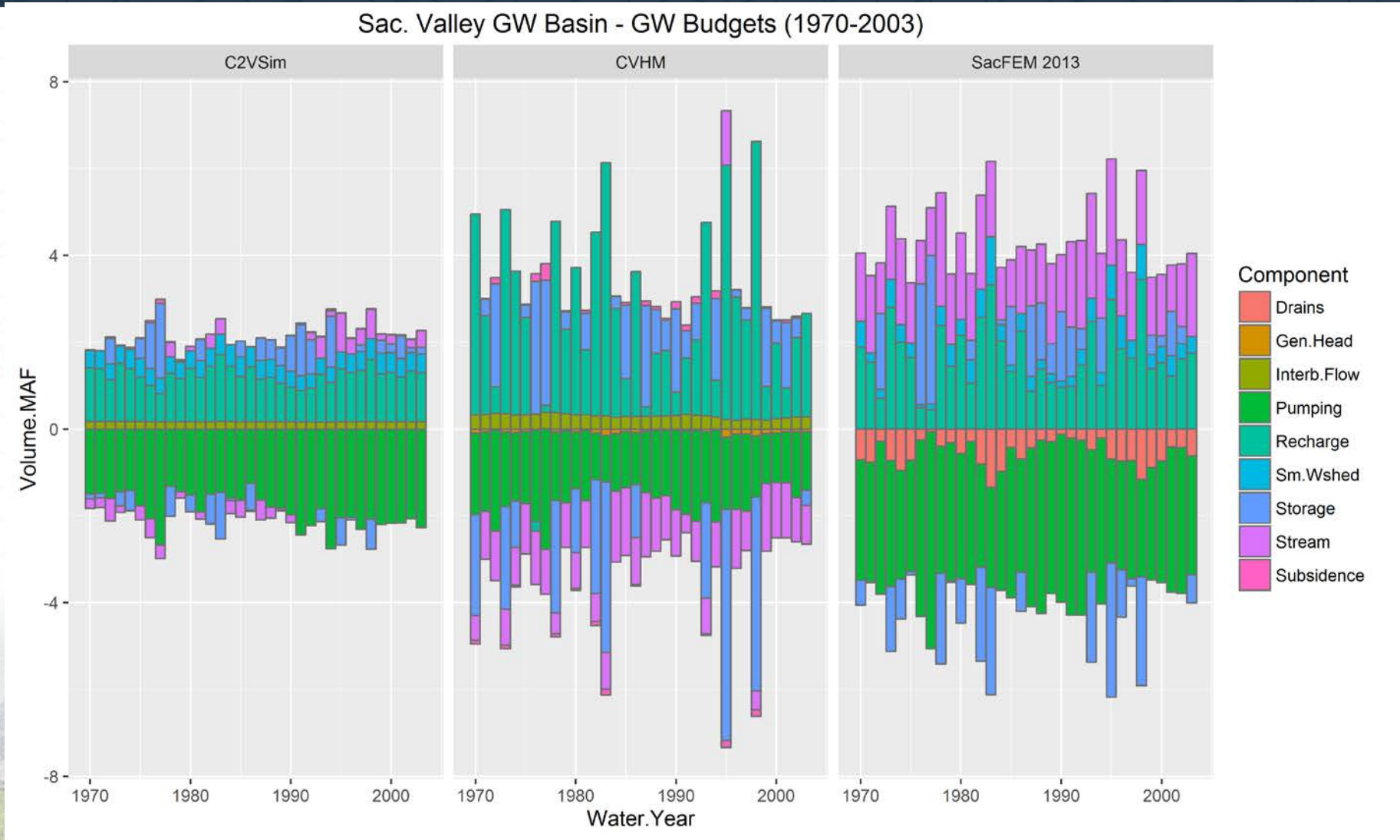
3. Process for Water Budget Comparison

- If more than one model is suitable, how should we compare them?





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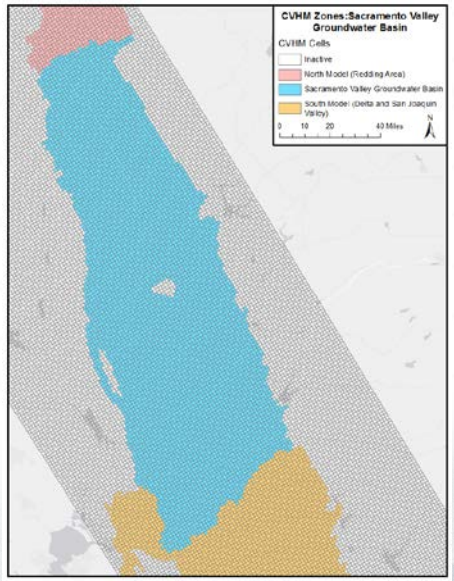

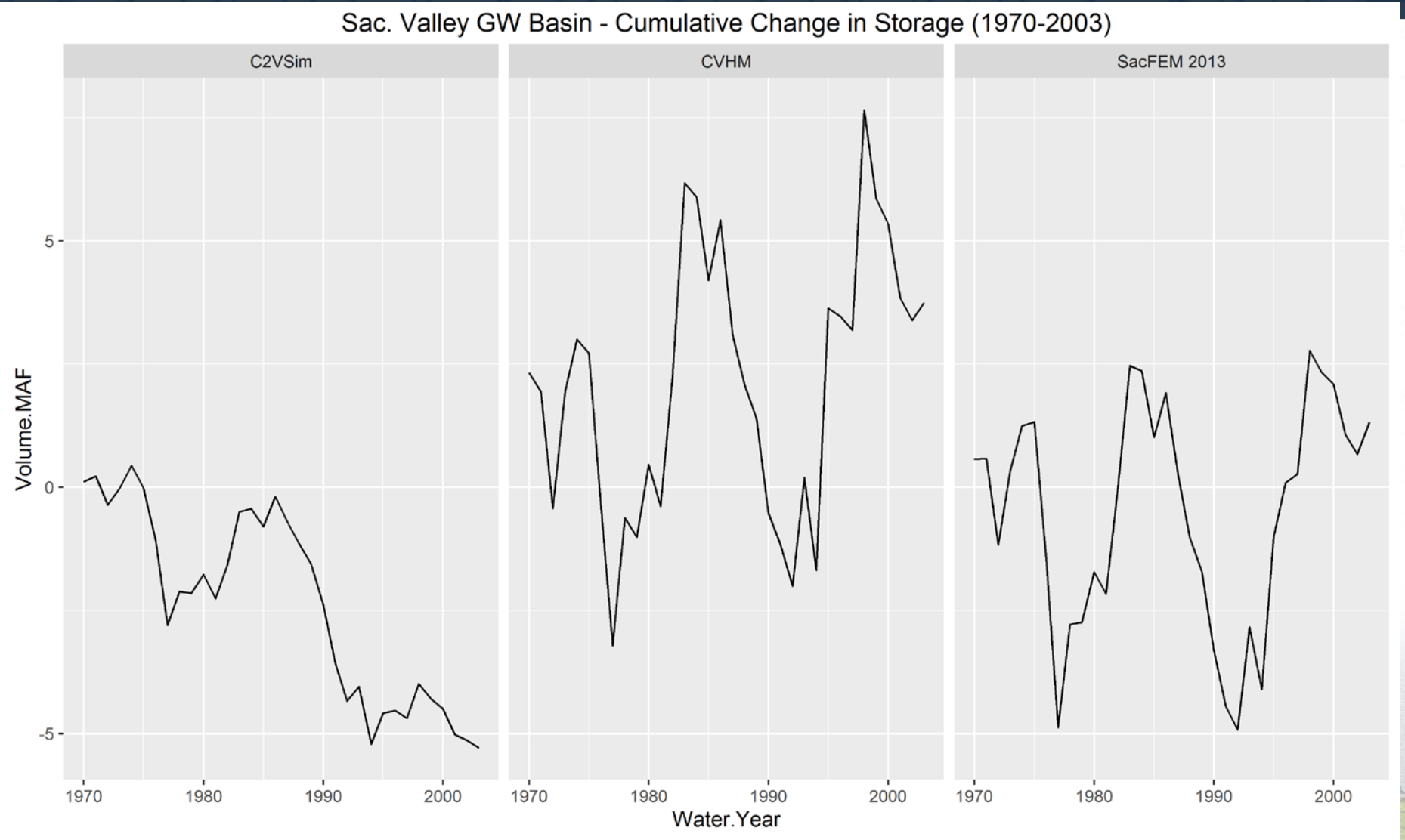

3. Process for Water Budget Comparison

- Describe best practices for comparing modeled water budgets
  - Which components are directly comparable
  - Which to aggregate
  - How to handle processes simulated by one model but not another

	C2VSim	CVHM2
Storage	GW STORAGE	STORAGE
Recharge	NET DEEP PERCOLATION + (?) DIVERSION RECOVERABLE LOSS + *(?) BYPASS RECOVERABLE LOSS*	FARM_NETRECHARGE
Pumping	PUMPING BY ELEMENT + PUMPING BY WELL	MNW2 + *FARM_WELLS*
Streams	STREAMS	STREAM_LEAKAGE
Small Watersheds	SMALL WATERSHED BASEFLOW + SMALL WATERSHED PERCOLATION	(?) SPECIFIED_FLOWS
Subsidence	SUBSIDENCE	INST_IB_STORAGE + DELAY_IB_STORAGE
Drains	*TILE DRAINS*	*DRAINS*
Interbasin Flow	FLOW FROM ZONE XXX / FLOW TO ZONE XXX	FLOW FROM ZONE XXX / FLOW TO ZONE XXX
Other Boundaries		HEAD_DEP_BOUNDS + *CONSTANT_HEAD*

Note: items in *Gray Italics* are not simulated in the Sacramento Valley GW Basin for these models

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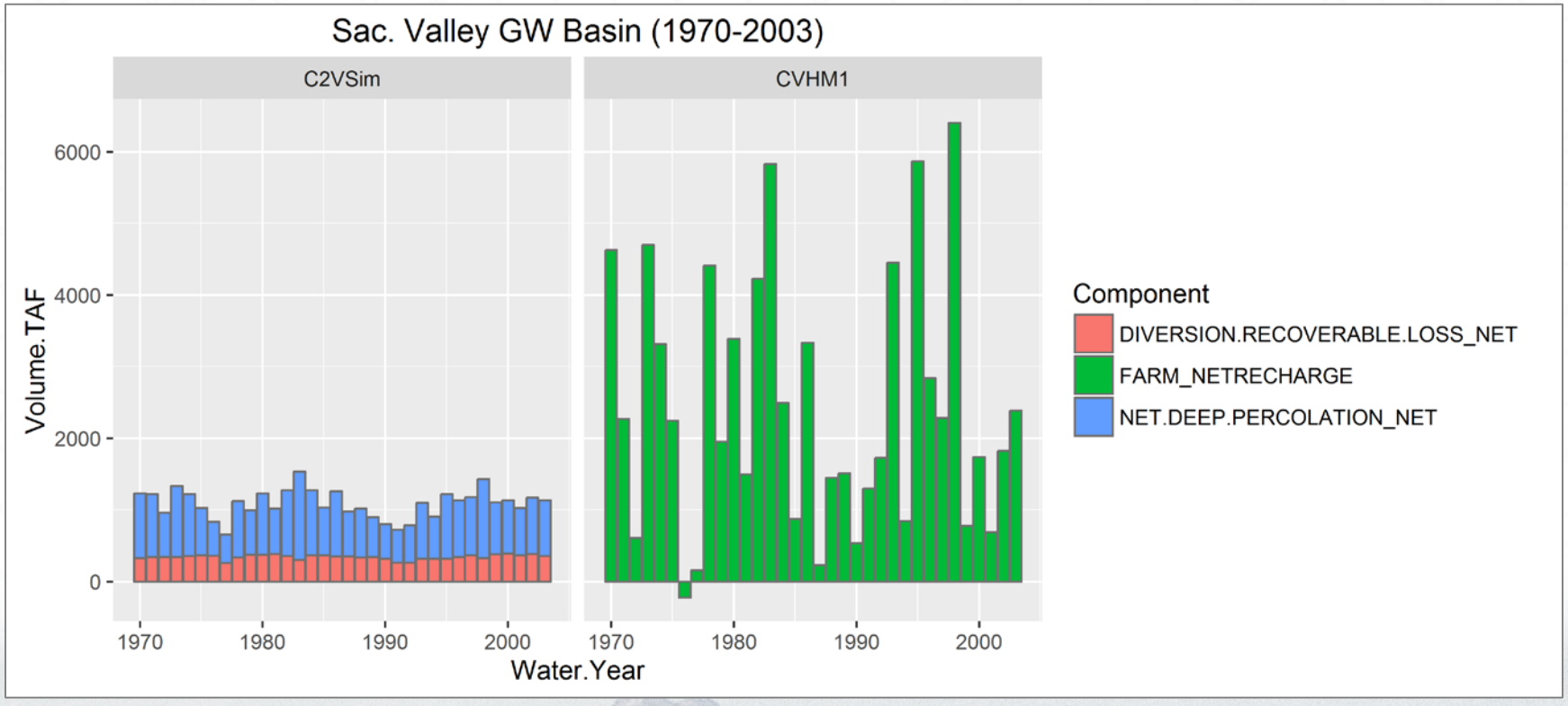
3. Process for Water Budget Comparison



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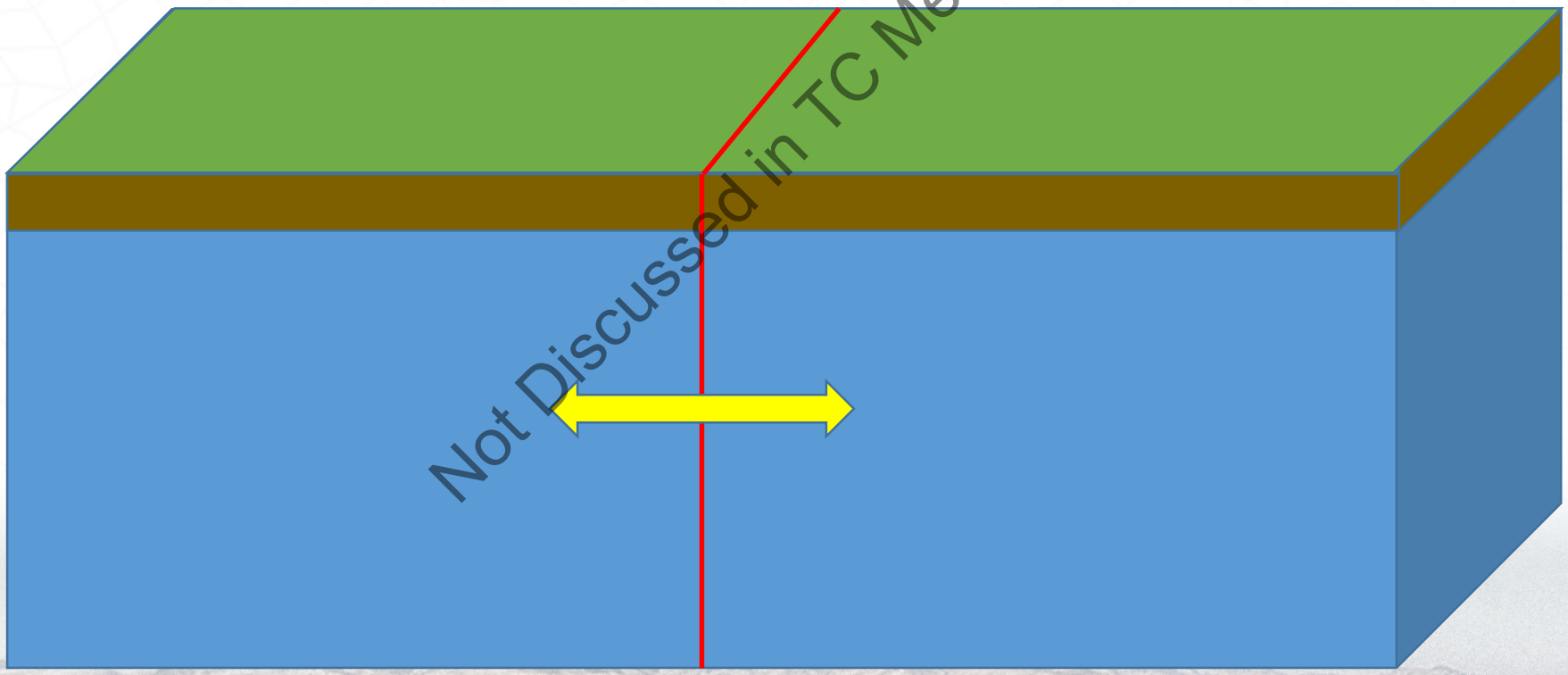
4. Evaluating Interbasin Flows Where the Boundary is Defined by a River/Stream

- Interbasin flow, generally, is the flow entering or leaving a (sub)basin from an adjacent, hydraulically connected (sub)basin



Not Discussed in TC Meeting #2

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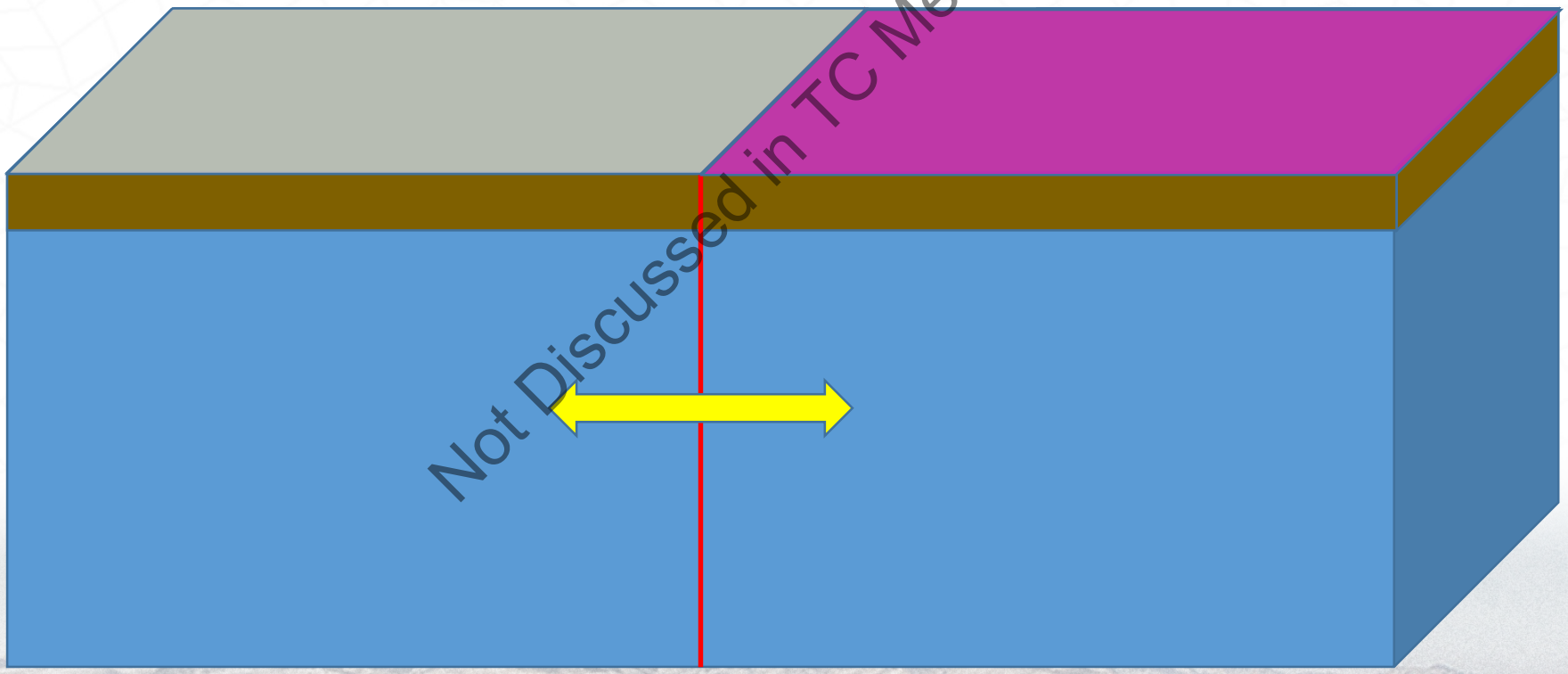

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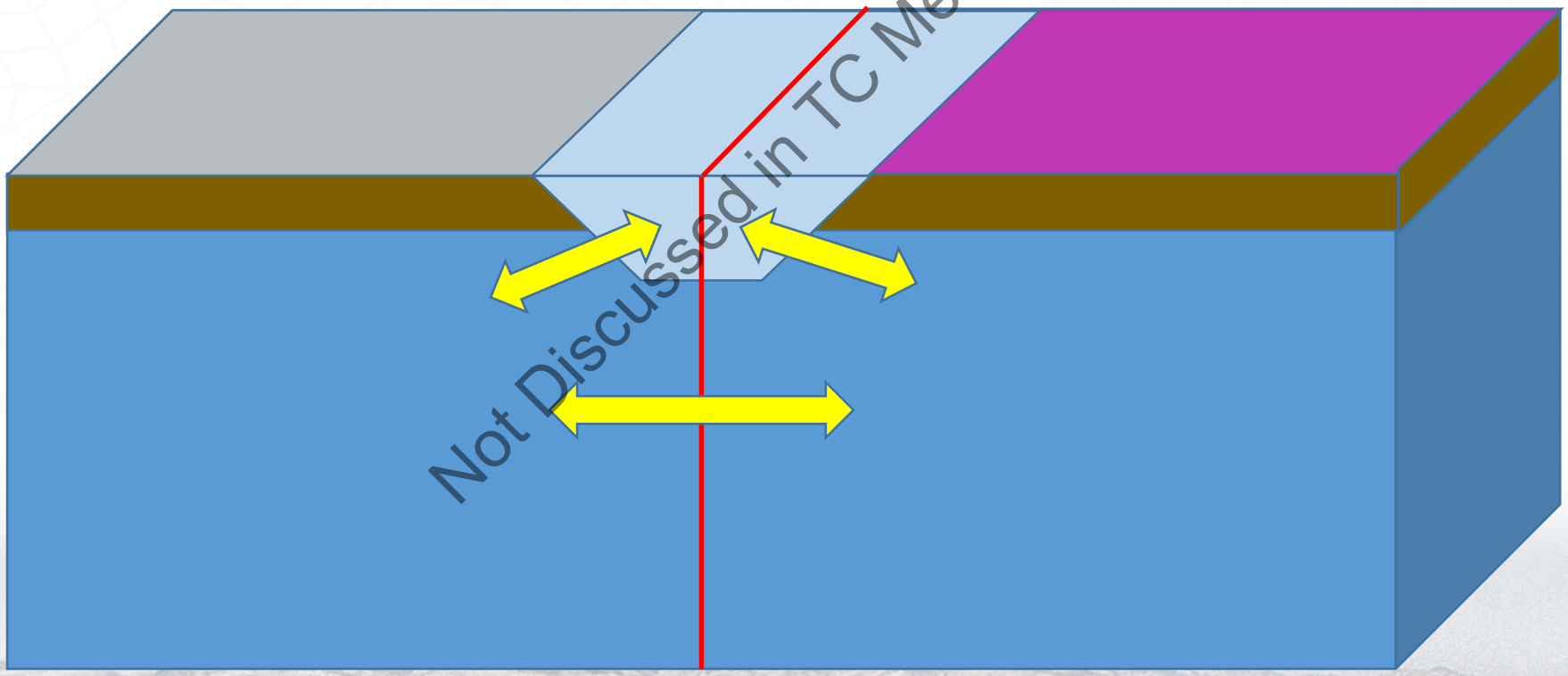
4. Evaluating Interbasin Flows Where the Boundary is Defined by a River/Stream

- Boundaries aligned with rivers and streams (as many in the state are) complicates the quantification of these flows



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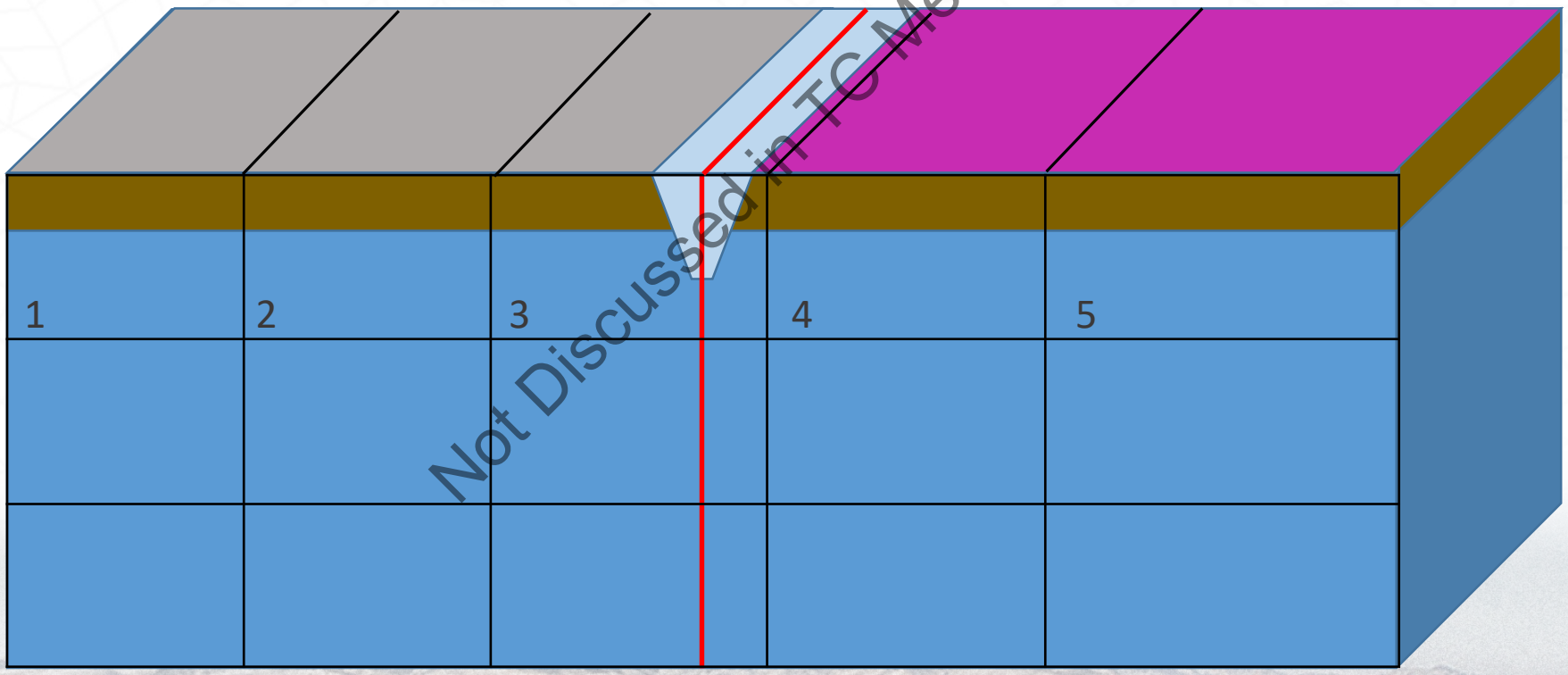

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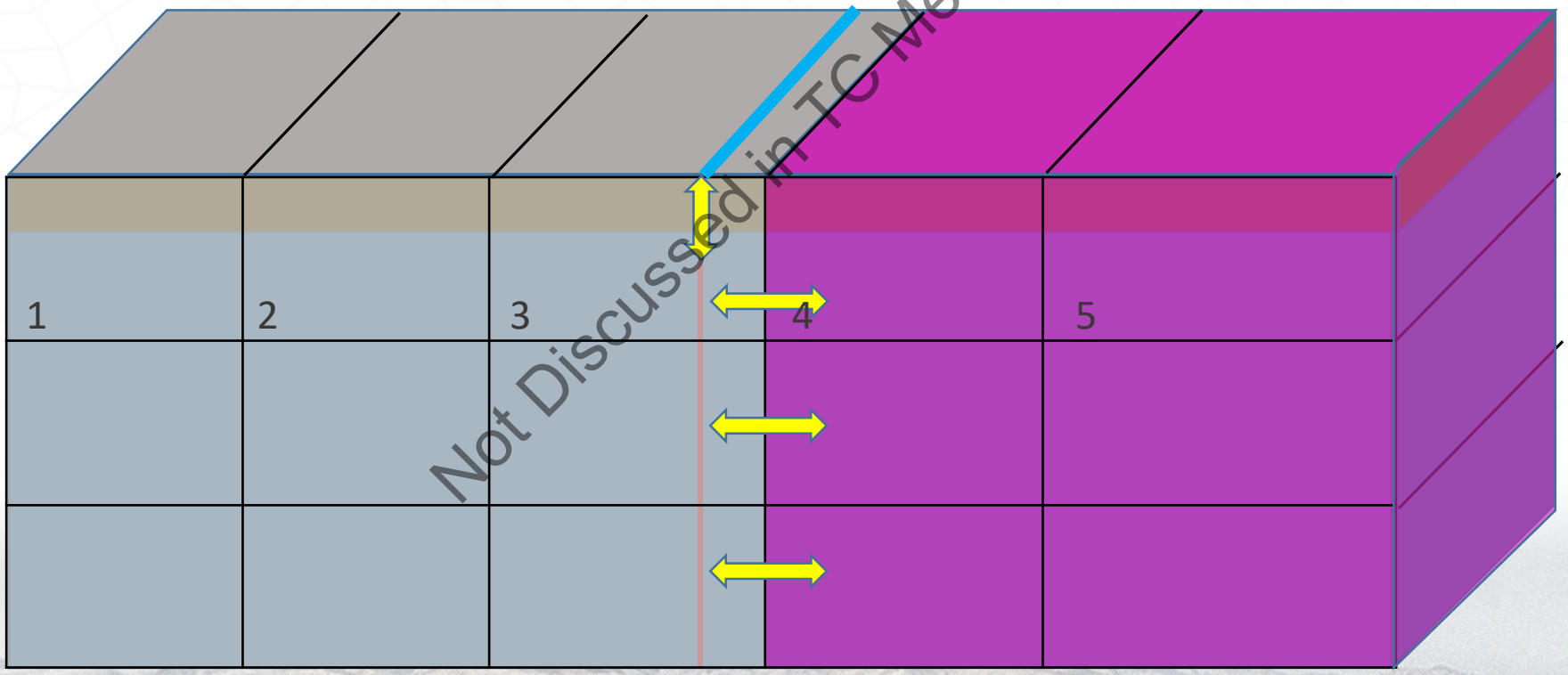

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6. Data Gaps and Needed Improvements

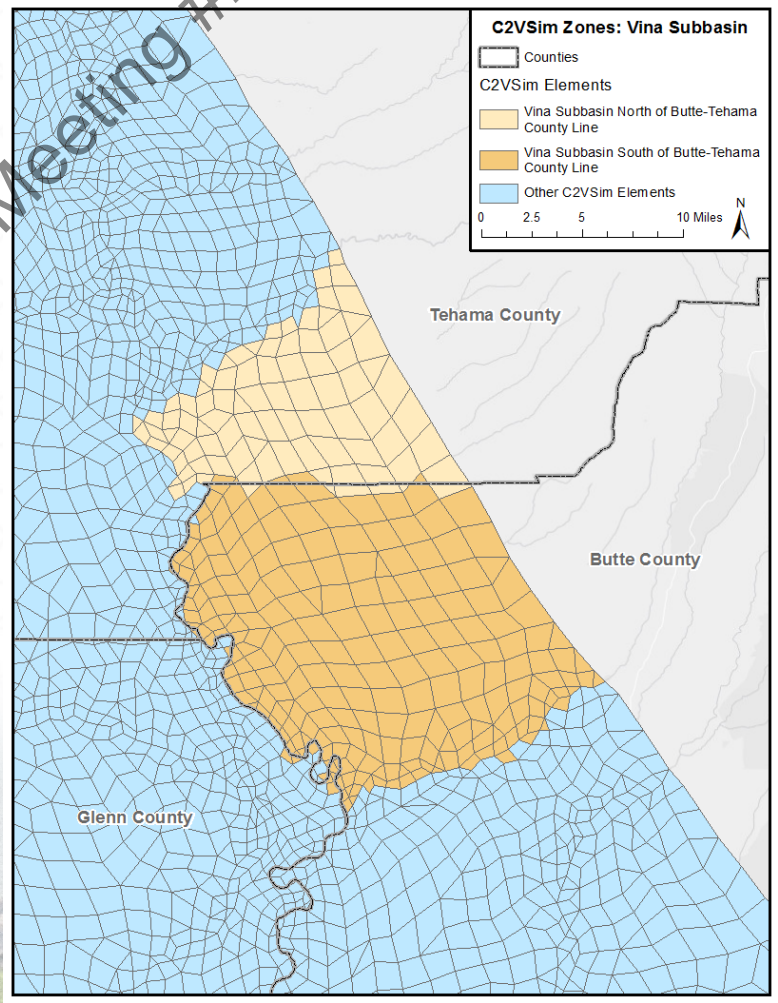
- C2VSim and CVHM are both being updated and are likely be considered by GSAs when developing interbasin components of water budgets
- What data gaps could be filled, or improvements made, to increase confidence and reliability of interbasin flow estimates
  - Model Features
  - Calibration
  - Analysis Tools
  - Documentation/Information

Not Discussed in TC Meeting #2

Example of Interbasin Flow Budget Information

- Using C2VSim
- Split Vina Subbasin into two hypothetical subbasins along county line -> North Vina and South Vina
- Budget information presented below is from the perspective of South Vina (darker orange area on figure to the left)

Not Discussed in TC Meeting #2



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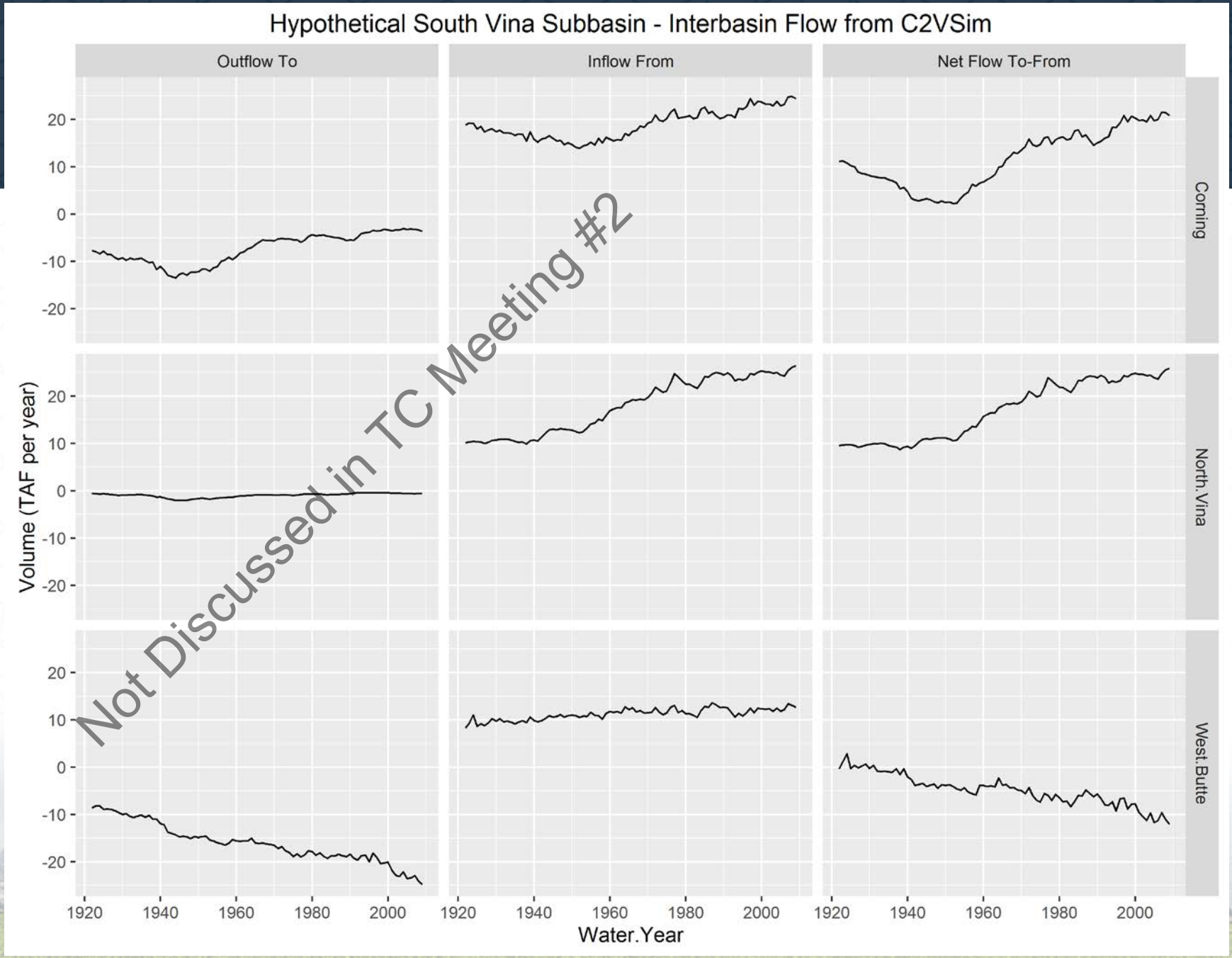
- Evaluated subsurface inflow and outflow, by layer, into/out of hypothetical South Vina Subbasin from:
  - Corning
  - North Vina
  - West Butte



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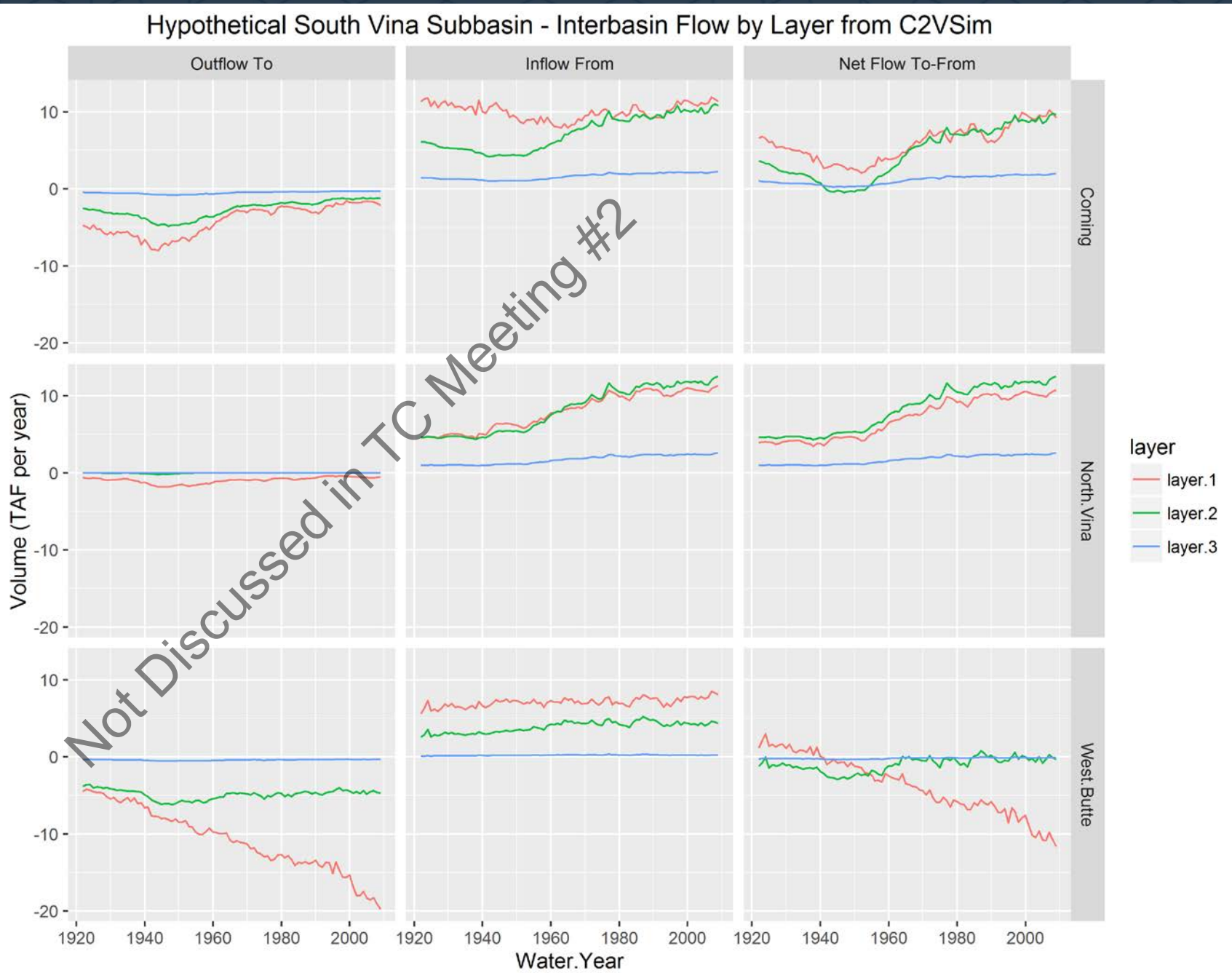
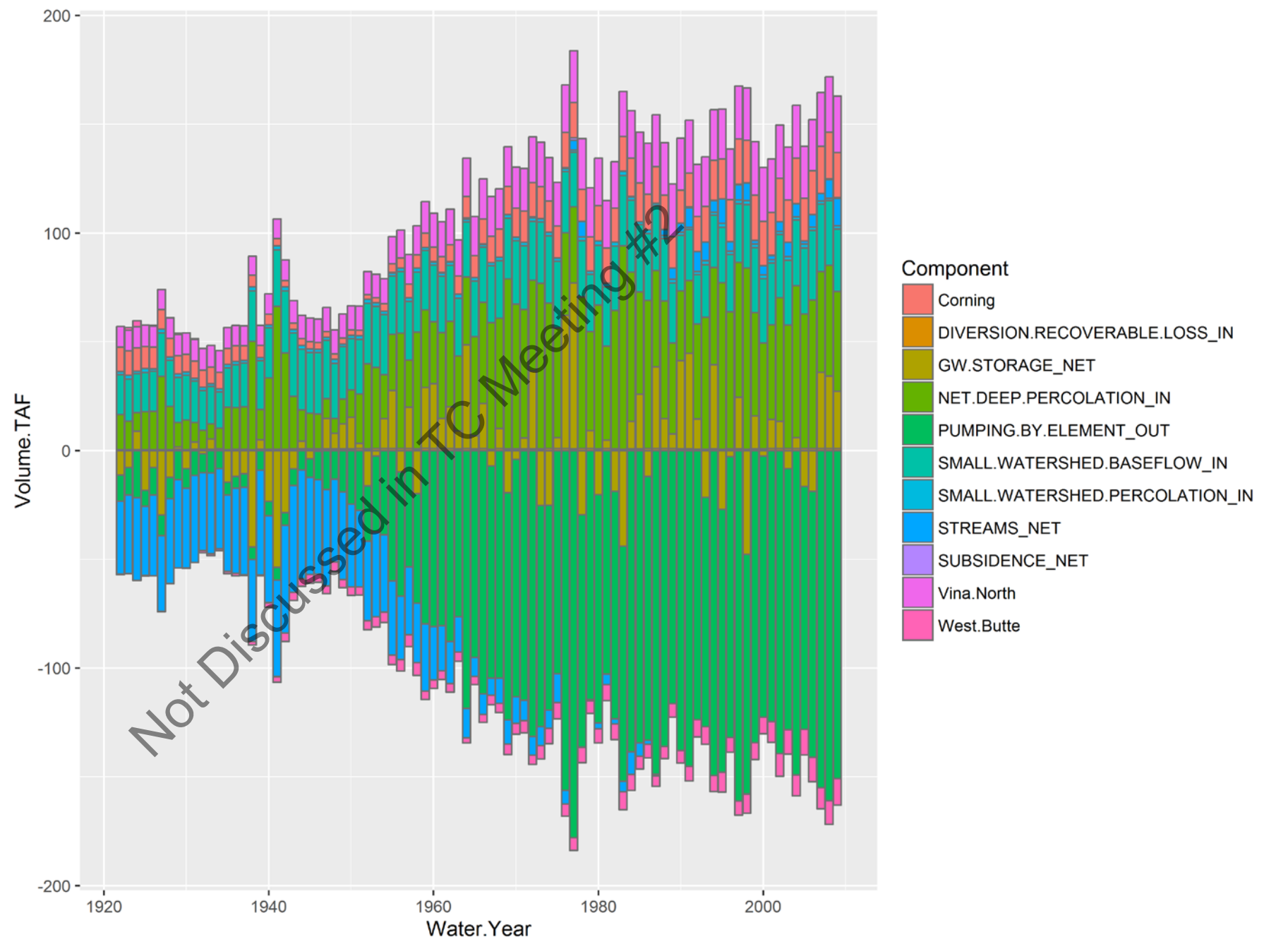


Not Discussed in TC Meeting #2

Hypothetical South Vina Subbasin Total GW Budget



Not Discussed in TC Meeting #2

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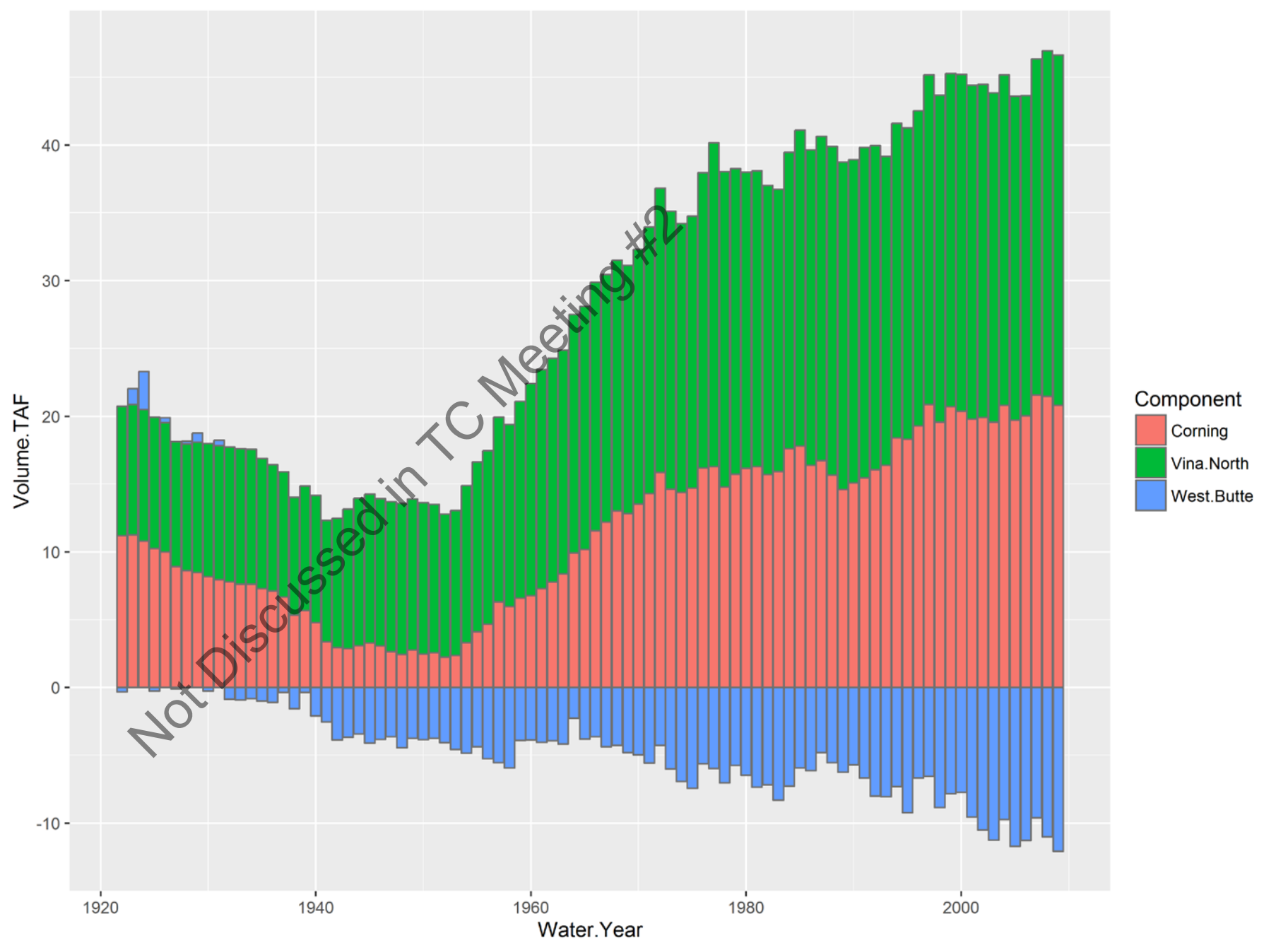
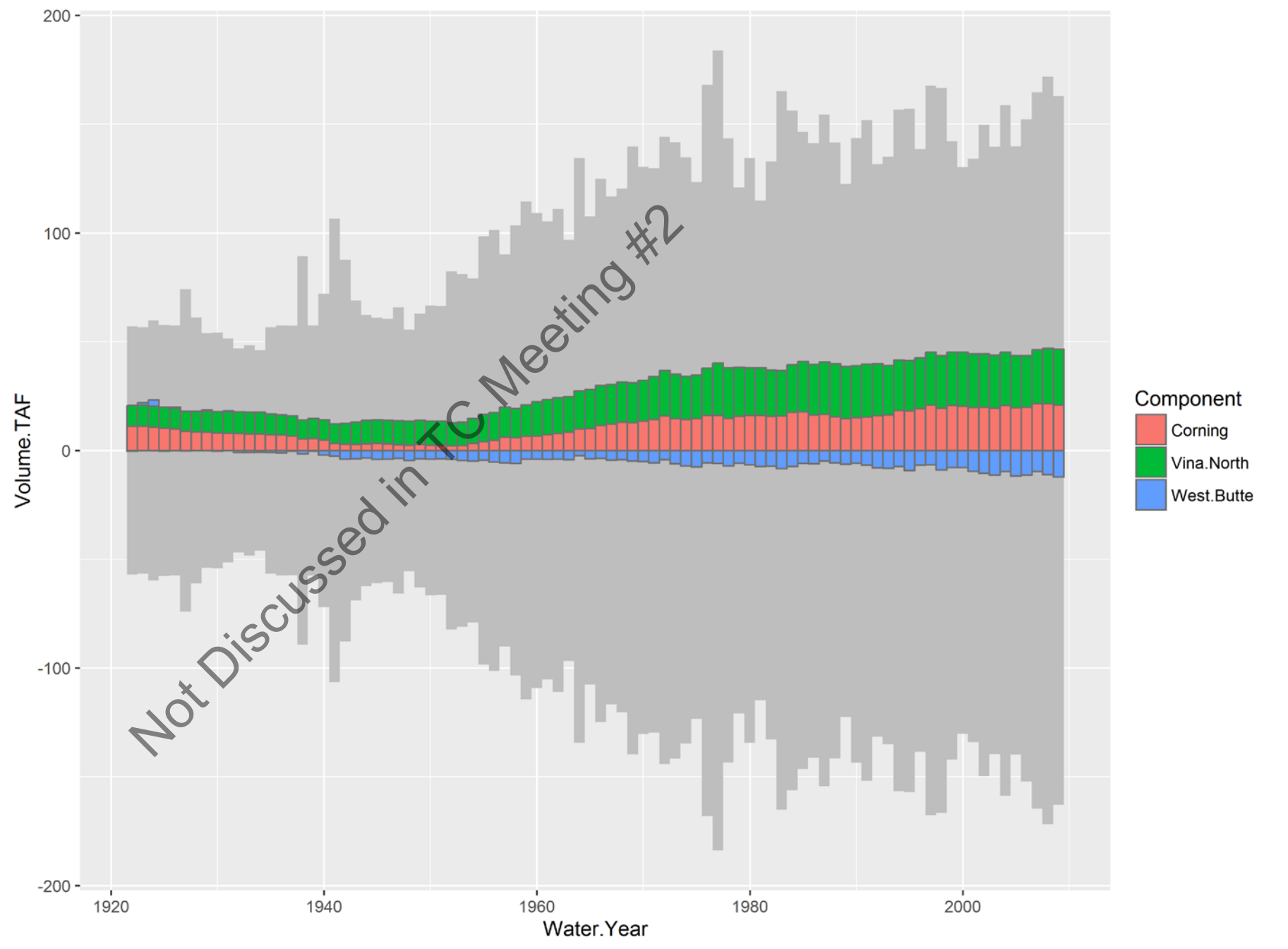
Hypothetical South Vina Subbasin Interbasin Flows



Hypothetical South Vina Subbasin Interbasin Flows Relative to Total Groundwater Budget



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Wrap Up

- Next meeting will focus on local models and how feedback between local and regional models could occur
- Deliverable for this project is the Interbasin Flow Evaluation Report
  - Scheduled to begin after completion of next meeting (Jan. 2017)
  - Report will address the project outcomes we discussed earlier
  - Next meeting will include discussion of the report outline

Not Discussed in TC Meeting #2

Thank You

Not Discussed in TC Meeting #2

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Interbasin GROUNDWATER FLOW Evaluation Project

Technical Collaborators Meeting 3

March 7, 2017

Agenda

- Recap of previous meetings
- Model comparison
  - Land use / cropping
  - Water budget
    - Ag water demand
    - Water supply
    - Recharge
    - Stream seepage
  - Surface water inflows
  - Calibration
    - Hydrographs at selected wells
- Discussion
  - Model recommendations or assistance in model recommendations

Agenda

- **Recap of previous meetings**
- Model comparison
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Meeting #1 Recap

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  - Local ownership of the interbasin flow evaluation process in the NSV Area
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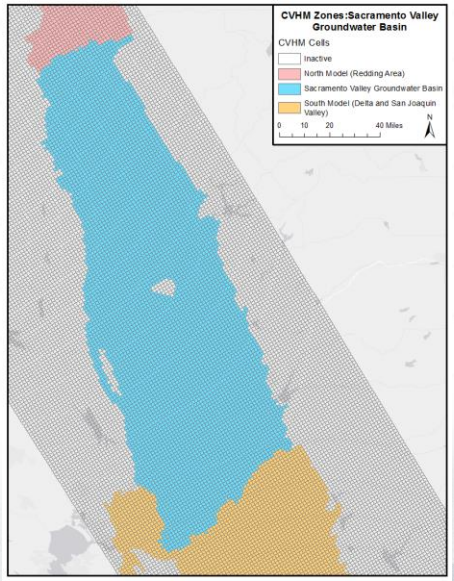
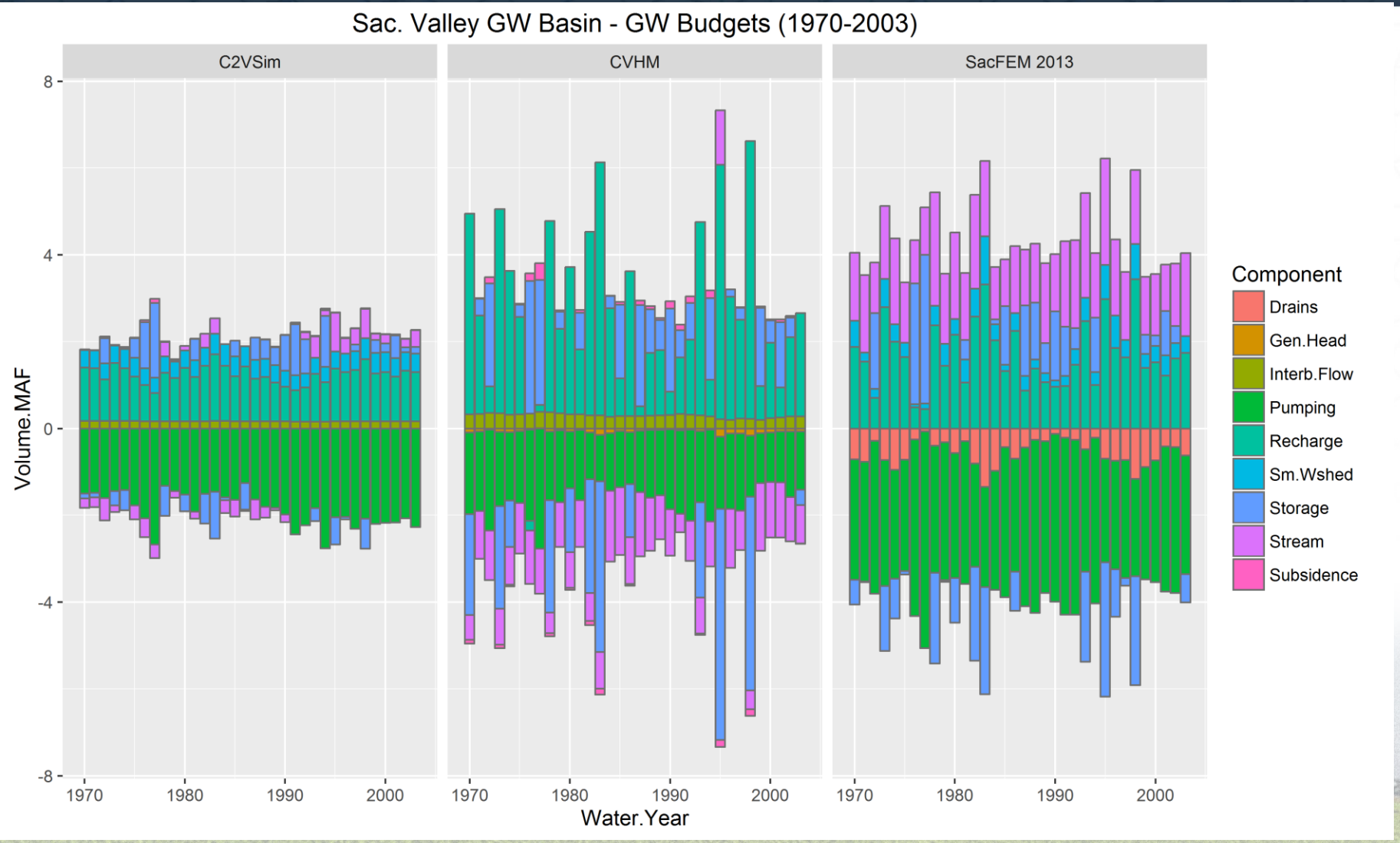
- Overview of models likely to be considered for this study
  - Regional: CVHM, C2VSim, SacFEM 2013
  - Local: Butte Basin Groundwater Model, Stony Creek Fan IGSM
- Certain tools identified as being unsuited for future use by GSAs, though they likely contain useful information that shouldn’t be lost
  - SacFEM 2013, Stony Creek Fan IGSM
- Initial discussion of project outcomes

Meeting #2 Recap

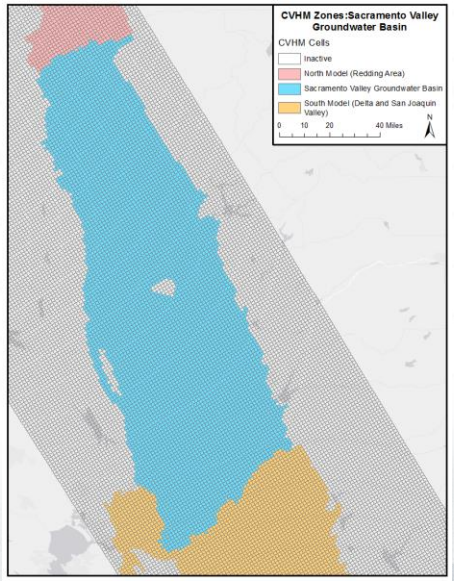
- **Model Selection:**
  - Up to GSAs to decide what model is best for what they want to do. Existing models provide bookends and a range of interbasin flows.
  - Model criteria (qualitative and quantitative) will lead evaluation of regional models
  - Define flowpath for selection, incorporating 6 Undesirable Results
- **Model Refinements:**
  - Existing models weren't designed for use in GSPs. Needs for improvement of regional models can help guide future refinement to meet needs under SGMA.
  - Local models can build off regional models
- **Model Analysis:**
  - Differences exist in definitions, methodologies, and water budgets
  - Additional information needed to guide decisions: inputs, calibration, spatially detailed water budgets

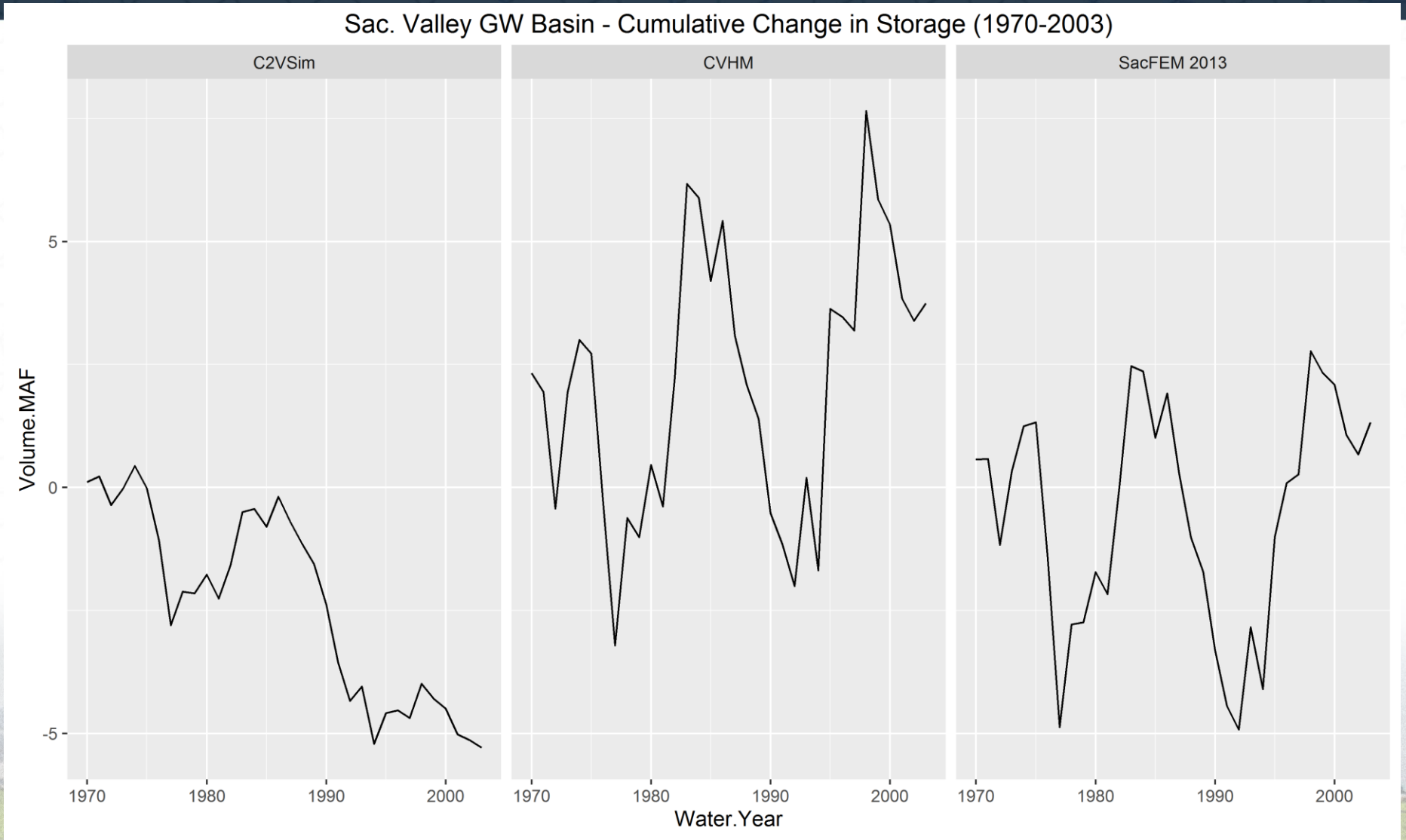
Recall: Water Budget Comparison





Recall: Water Budget Comparison





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WOODARD & CURRAN
National Experience. Local Focus.

Agenda

- Recap of previous meetings
- **Models comparison**
  - **Land use / cropping**
  - Water budget
    - Ag water demand
    - Water supply
    - Recharge
    - Stream seepage
  - Surface water inflows
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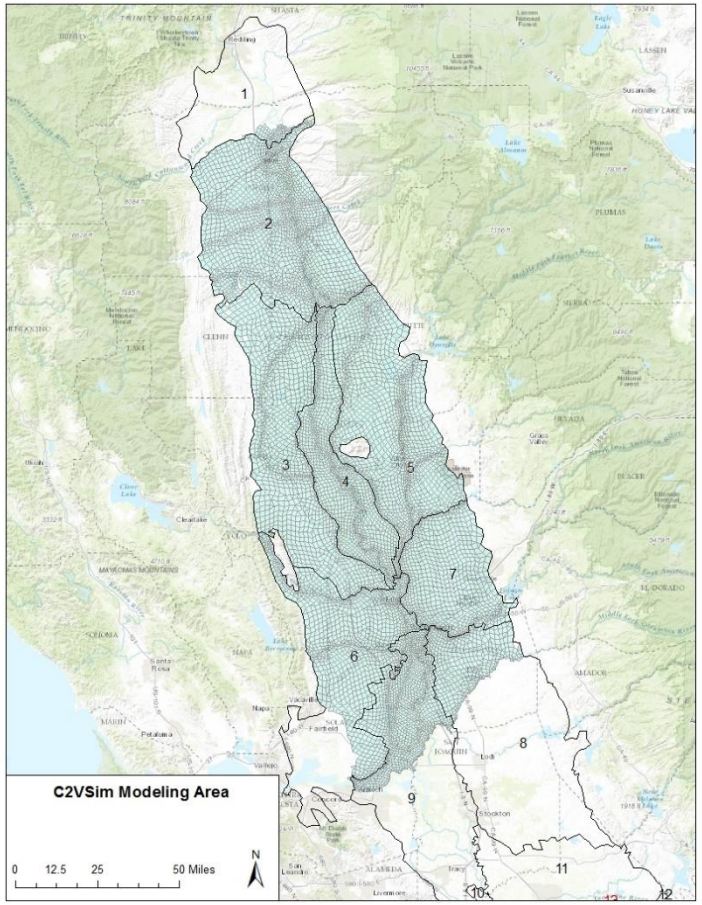
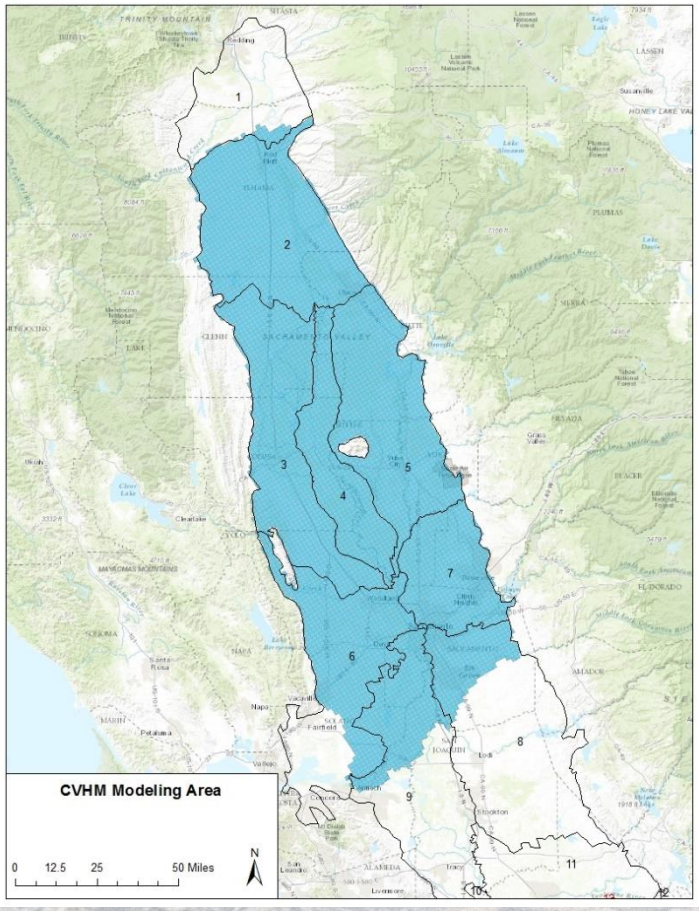
Study Area

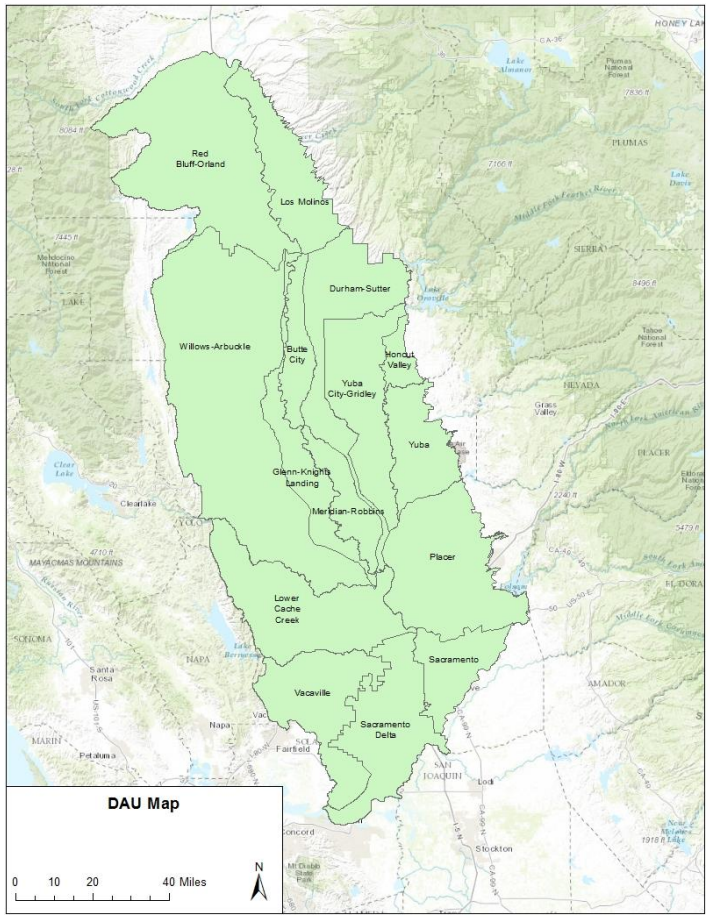
C2VSim



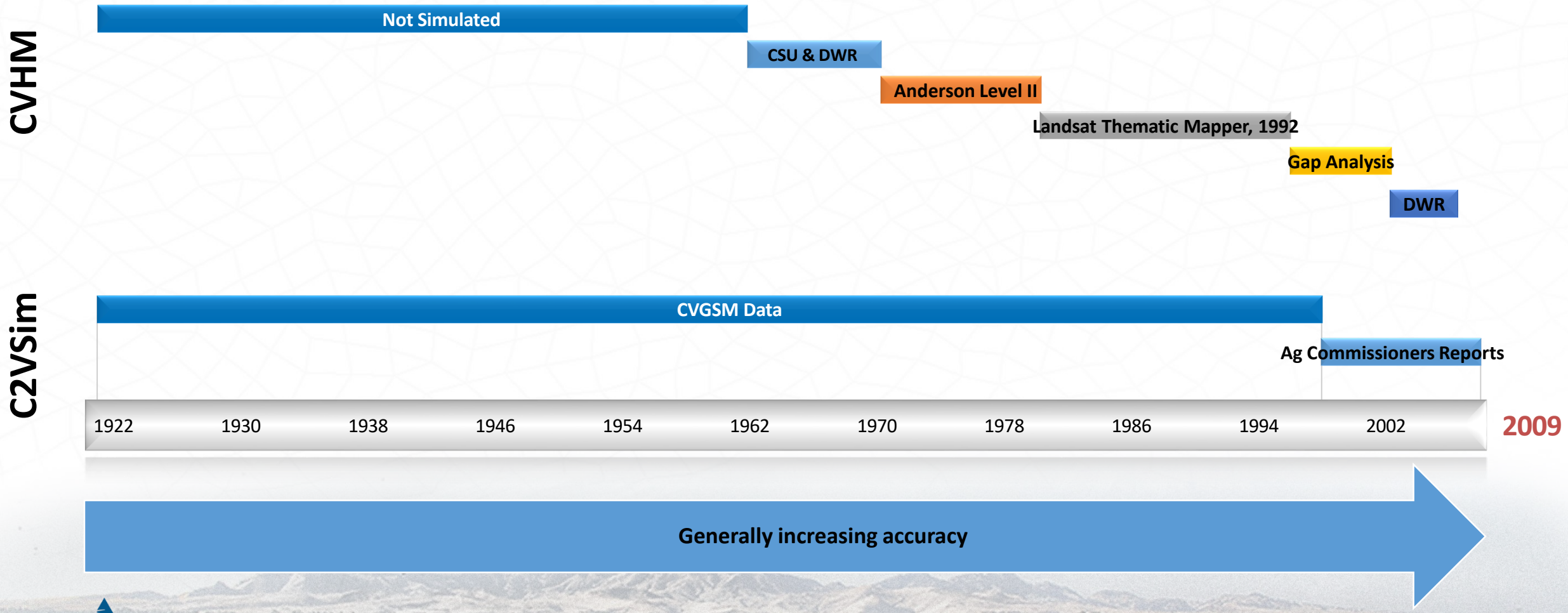
CVHM



DAU



CVHM and C2VSim Land Use Data Sources



Detailed Analysis Unit (DAU) Ag Land and Water Use Estimates

- DWR estimates applied water (AW) for 20 crop categories each year.
- AW estimates reflect:
  - Irrigation efficiencies
  - Cultural practices
    - Ponding of water in rice fields
    - Leaching of accumulated salts
    - Etc.

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Land and Water Use

Agricultural Land and Water Use Estimates

The Department of Water Resources estimates irrigated crop acreages, crop evapotranspiration (ETc), evapotranspiration of applied water (ETAW), effective precipitation (EP), and applied water (AW) for 20 crop categories each year. Data are estimated from reference evapotranspiration (ETo) or evaporation pan data (Ep), crop development over time (crop coefficients), soil characteristics, rooting depths, and the quantity and timing of precipitation. Applied water (AW) estimates reflect irrigation efficiencies as well as the water required for cultural practices such as the ponding of water in rice fields or the leaching of accumulated salts from the soil.

Data compiled by **study area** and year are available for download in spreadsheet (xls) format.

To Download Data: Expand the menu under Statewide, County, Hydrologic Region (HR), or Detailed Analysis Unit (DAU), click on a year and select "Save As...".

+ Statewide

+ Hydrologic Region (HR)

+ Planning Area (PA)

+ County

+ Detailed Analysis Unit (DAU)

Study Areas

The Department of Water Resources subdivides California into study areas for planning purposes. The largest study areas are the ten Hydrologic Regions (HR), corresponding to the State's major drainage basins. The next level of delineation are the Planning Areas (PA), which in turn are composed of multiple Detailed Analysis Units (DAU). The DAUs are often split by county boundaries, so the smallest study area used by the Department is the

Water Use Efficiency

- Land and Water Use Home
- Data Collections
  - Land Use Surveys
  - Public Water Systems Statistics Surveys
  - Statewide Irrigation Methods Surveys
- Agricultural Land and Water Use Estimates
- Agricultural Water Use Models
- California Seasonal Application Efficiency Program
- Contacts

Related Links

- CIMIS
- Desalination
- Recycling
- Urban Water Management

Follow DWR on:

RMC water and environment | WOODARD & CURRAN
National Experience. Local Focus.

Land Use Type Mapping

CVHM
Water
Urban
Native Classes
Orchards, groves, and vineyards
Pasture/hay
Row crops
Small grains
Idle/fallow
Truck, nursery, and berry crops
Citrus and sub-tropical
Field crops
Vineyards
Pasture
Grains and hay crops
Semi-agriculture
Deciduous fruits and nuts
Rice
Cotton
Developed
Cropland and pasture
Cropland
Irrigated row and field crops

C2VSim
Pasture
Alfalfa
Sugar beet
Field crops
Rice
Truck crops
Tomato
Tomato (hand picked)
Tomato (machine picked)
Orchard
Grains
Vineyard
Cotton
Citrus and Olives
Urban
Native Vegetation
Riparian Vegetation

CVHM
Water
Urban
Native Classes
Orchards, groves, and vineyards
Pasture/hay
Row crops
Small grains
Idle/fallow
Truck, nursery, and berry crops
Citrus and sub-tropical
Field crops
Vineyards
Pasture
Grains and hay crops
Semi-agriculture
Deciduous fruits and nuts
Rice
Cotton
Developed
Cropland and pasture
Cropland
Irrigated row and field crops

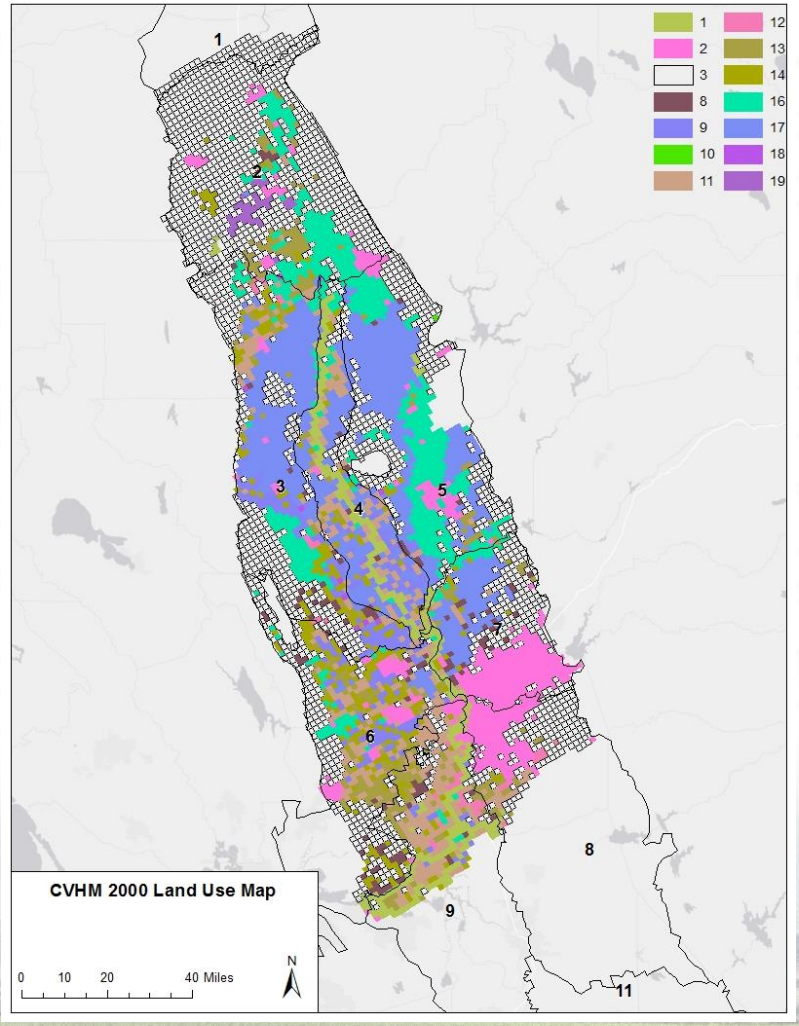
C2VSim
Pasture
Alfalfa
Sugar beet
Field crops
Rice
Truck crops
Tomato
Tomato (hand picked)
Tomato (machine picked)
Orchard
Grains
Vineyard
Cotton
Citrus and Olives
Urban
Native Vegetation
Riparian Vegetation

Land Use Type Mapping

Land Use Type Mapping

CVHM	Common	C2VSim
Water	Water	Pasture
Urban	Urban	Alfalfa
Native Classes	Native Classes	Sugar beet
Orchards, groves, and vineyards	Orchards, groves, vineyards, deciduous fruits and nuts	Field crops
Pasture/hay	Pasture/hay	Rice
Row crops	Grains and hay	Truck crops
Small grains	Truck, nursery, and berry crops	Tomato
Idle/fallow	Citrus and sub-tropical	Tomato (hand picked)
Truck, nursery, and berry crops	Field crops	Tomato (machine picked)
Citrus and sub-tropical	Rice	Orchard
Field crops	Cotton	Grains
Vineyards	Other	Vineyard
Pasture		Cotton
Grains and hay crops		Citrus and Olives
Semi-agriculture		Urban
Deciduous fruits and nuts		Native Vegetation
Rice		Riparian Vegetation
Cotton		
Developed		
Cropland and pasture		
Cropland		
Irrigated row and field crops		

Land Use Map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CVHM 2000 Land Use Map
0 10 20 40 Miles
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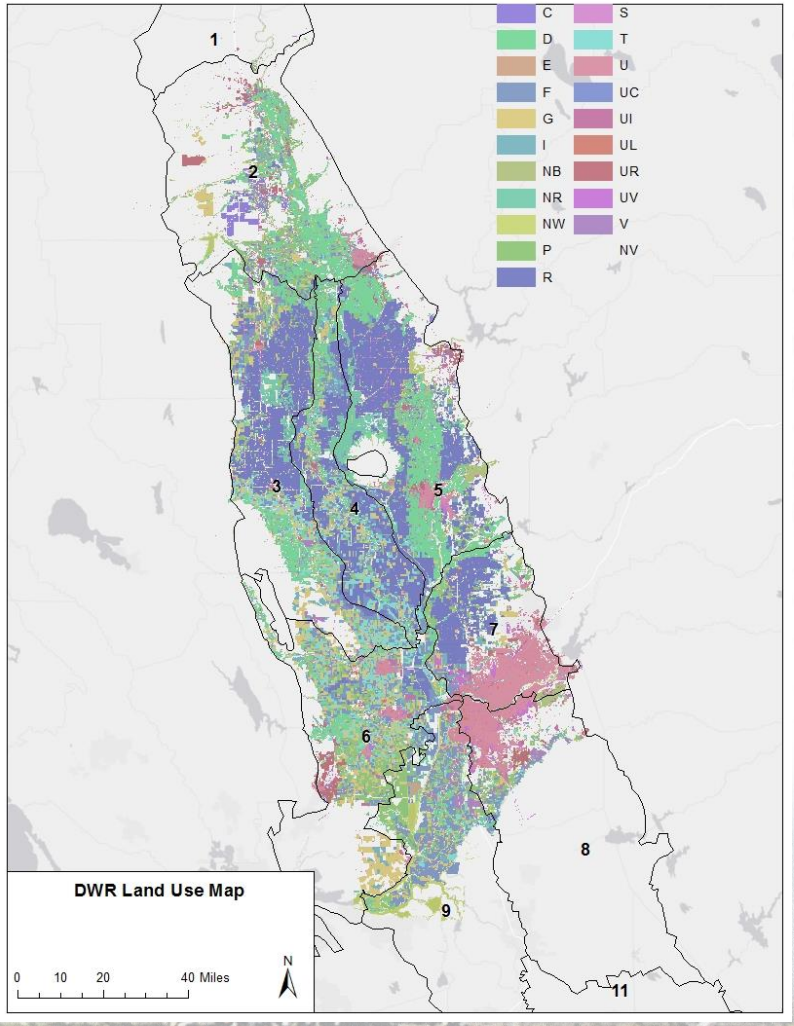
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UV
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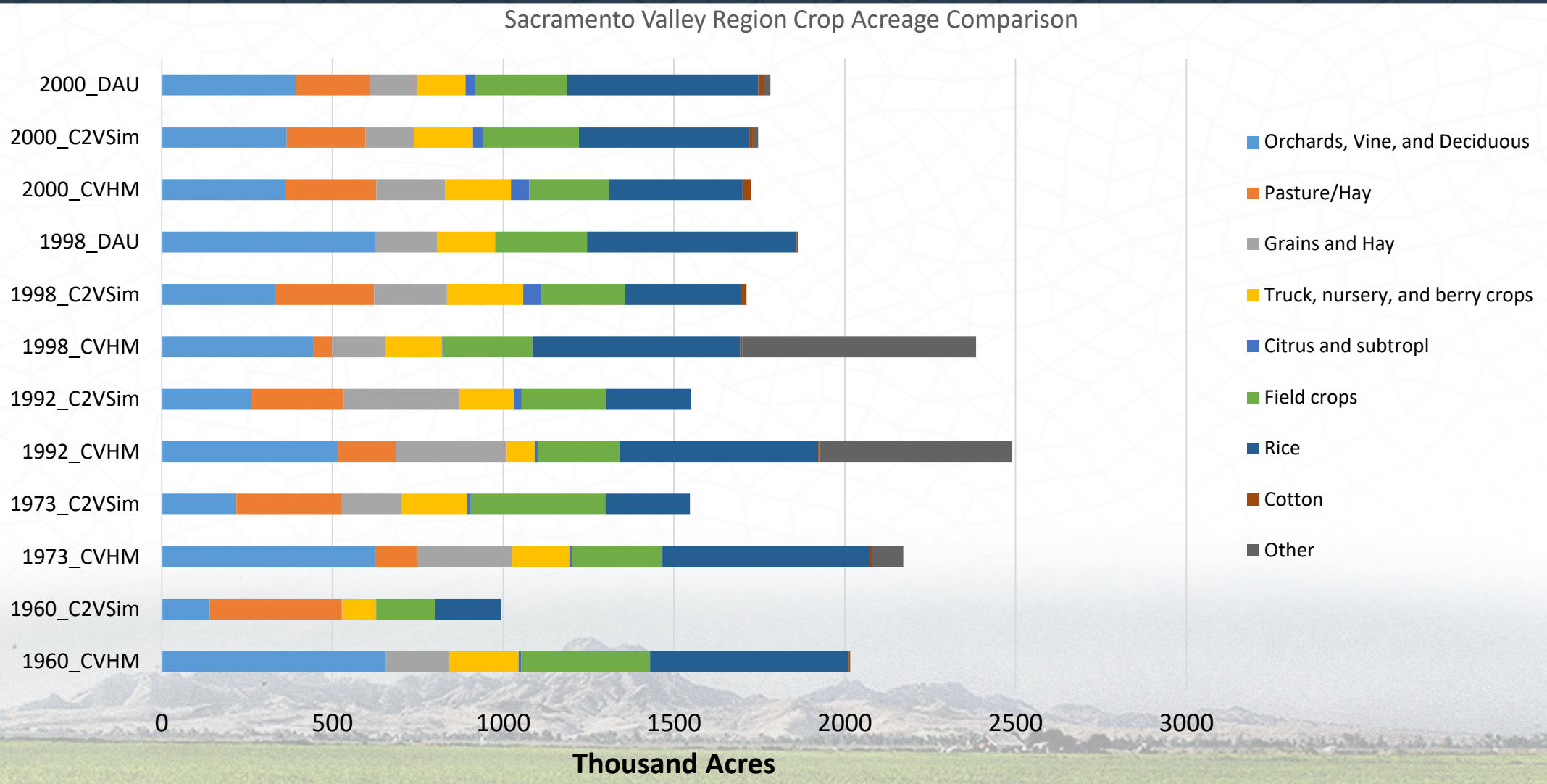
NV
DWR Land Use Map
0 10 20 40 Miles
N

Land Use/Crop Acreages for Sacramento Valley Region



Land Use/Crop Acreages for Sacramento Valley Region

CVHM	C2VSim
Orchards, groves, and vineyards	Pasture
Pasture/Hay	Alfalfa
Row Crops	Sugar Beet
Small Grains	Field Crops
Truck, nursery, and berry crops	Rice
Citrus and subtropl	Truck Crops
Field crops	Tomato
Vineyards	Grains
Pasture	Vineyards
Grain and hay crops	Cotton
Semiagricultural	Citrus and Olives
Deciduous fruits and nuts	
Rice	
Cotton	
Cropland and pasture	
Cropland	
Irrigated Row and Field Crops	

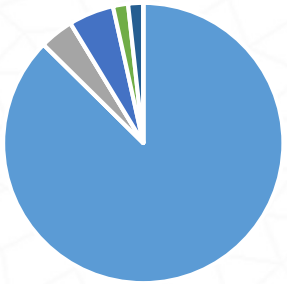
	CVHM	CVHM Ag Acreage	C2VSim	C2VSim Ag Acreage
1960	3,804	2,015	3,772	994
1973	3,804	2,171	3,772	1,547
1992	3,804	2,489	3,772	1,550
1998	3,804	2,385	3,772	1,712
2000	3,804	1,726	3,772	1,746

Units: Thousand Acres

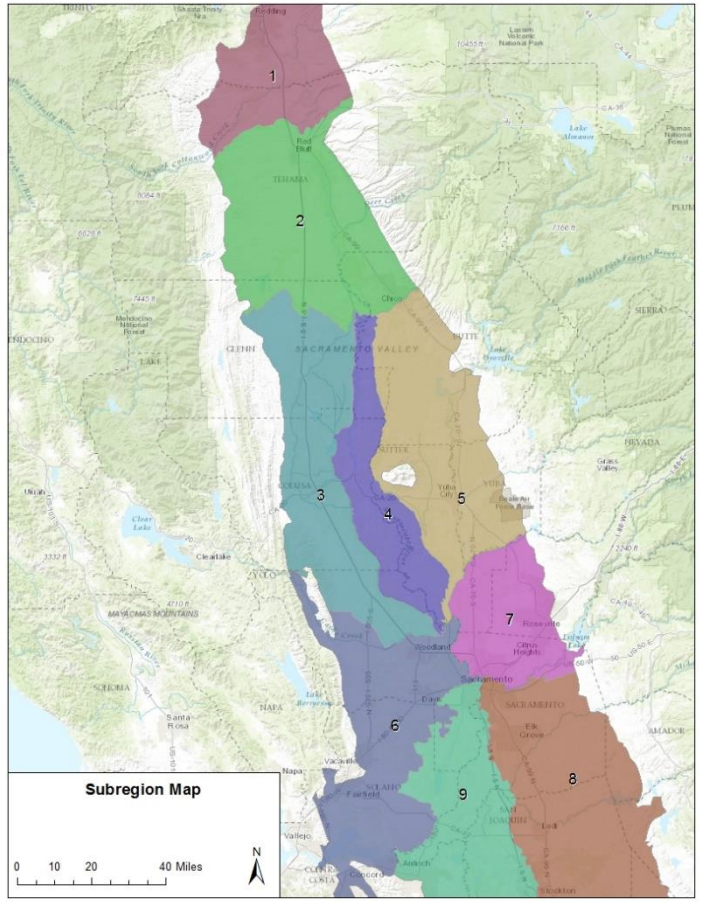
Note: Water, Urban, Native Classes, Idle/Fallow, and Developed acreages are excluded from the CVHM Ag Acreage

Agricultural Land Use
Subregion 2 - 1960

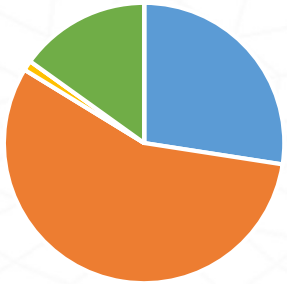
CVHM



- Orchards, Vine, and Deciduous
- Pasture/Hay
- Grains and Hay
- Truck, nursery, and berry crops
- Citrus and subtropl
- Field crops
- Rice
- Cotton
- Other

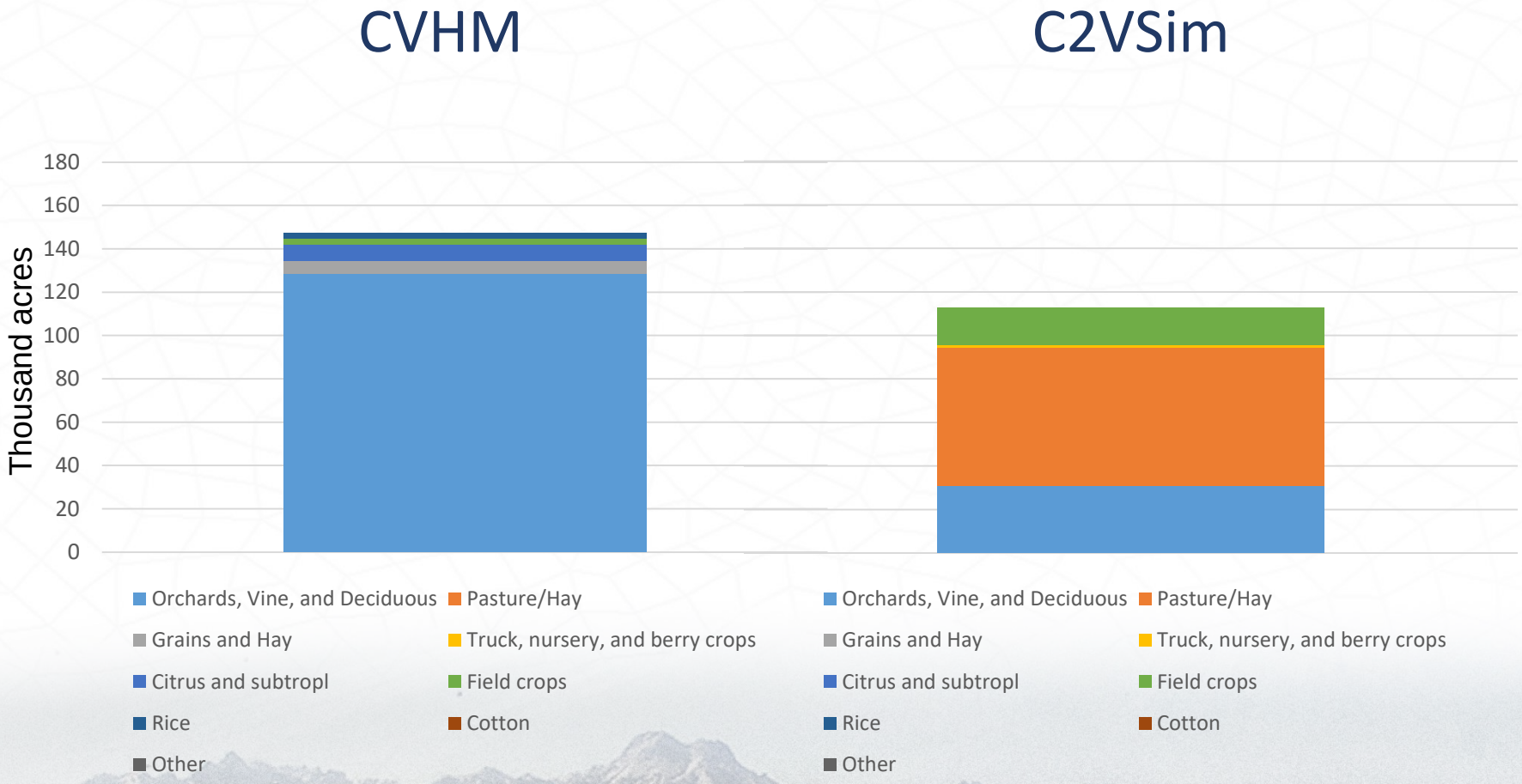


C2VSim



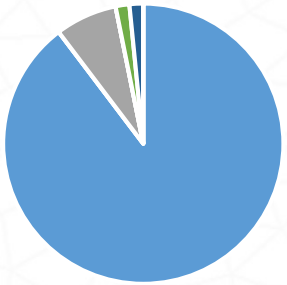
- Orchards, Vine, and Deciduous
- Pasture/Hay
- Grains and Hay
- Truck, nursery, and berry crops
- Citrus and subtropl
- Field crops
- Rice
- Cotton
- Other

Agricultural Land Use
Subregion 2 - 1960

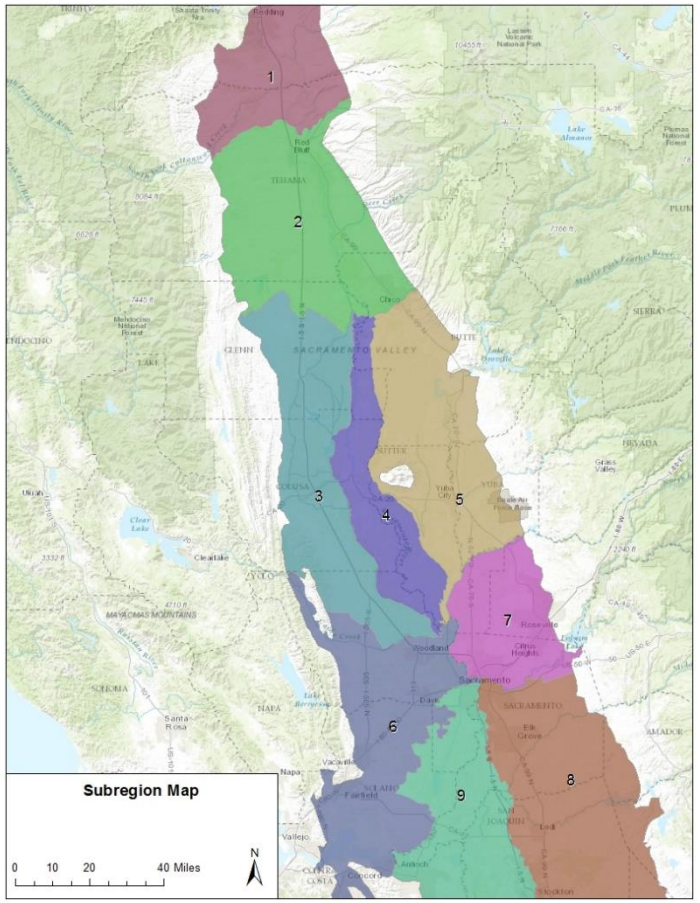


Agricultural Land Use
Subregion 2 - 2000

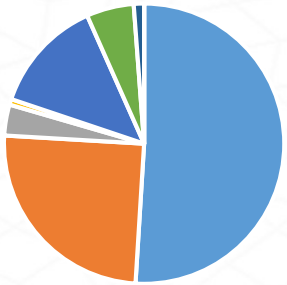
CVHM



- Orchards, Vine, and Deciduous
- Pasture/Hay
- Grains and Hay
- Truck, nursery, and berry crops
- Citrus and subtropl
- Field crops
- Rice
- Cotton
- Other

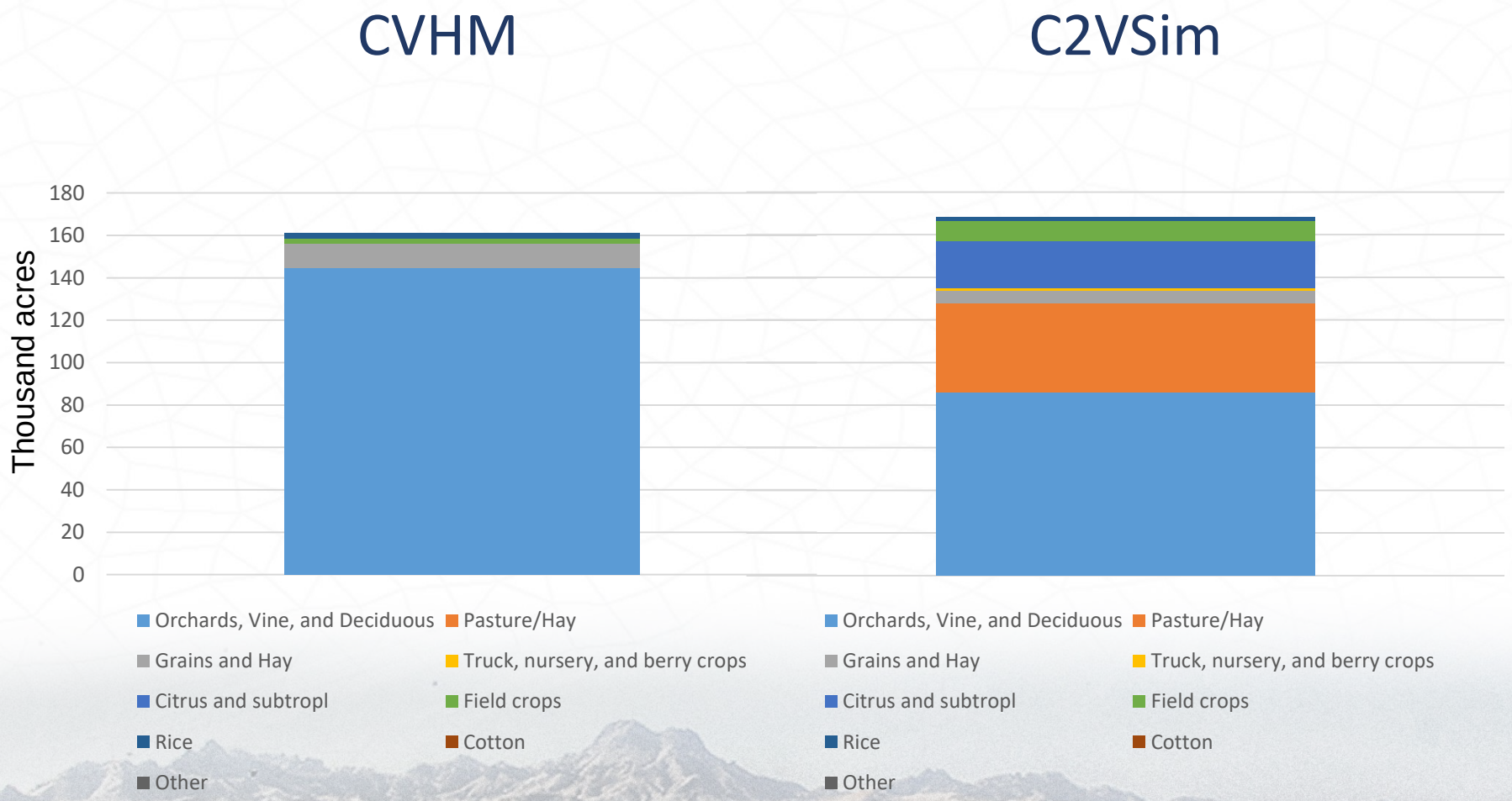


C2VSim



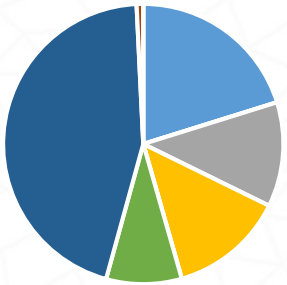
- Orchards, Vine, and Deciduous
- Pasture/Hay
- Grains and Hay
- Truck, nursery, and berry crops
- Citrus and subtropl
- Field crops
- Rice
- Cotton
- Other

Agricultural Land Use
Subregion 2 - 2000

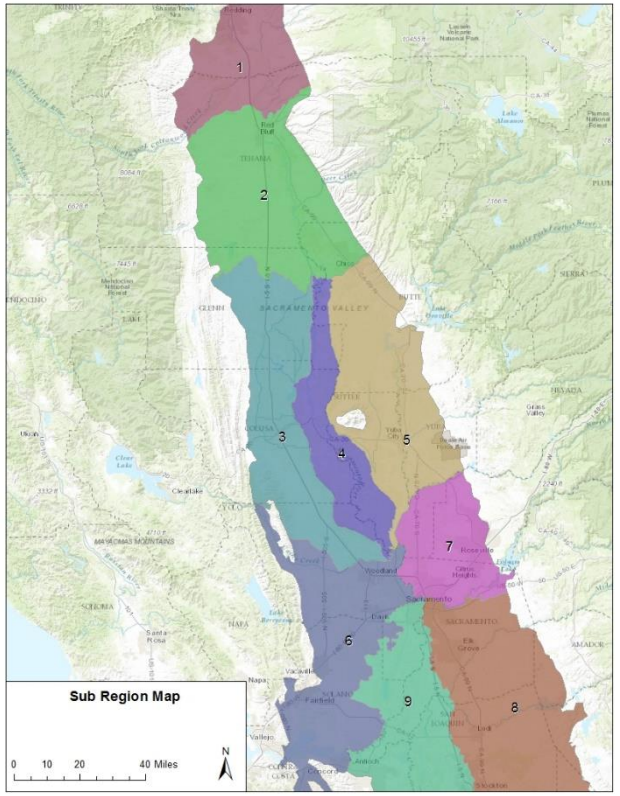


Subregion 3 - 1960

CVHM



- Orchards, Vine, and Deciduous
- Pasture/Hay
- Grains and Hay
- Truck, nursery, and berry crops
- Citrus and subtropl
- Field crops
- Rice
- Cotton
- Other



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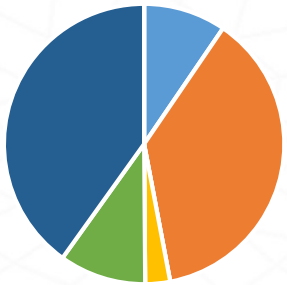
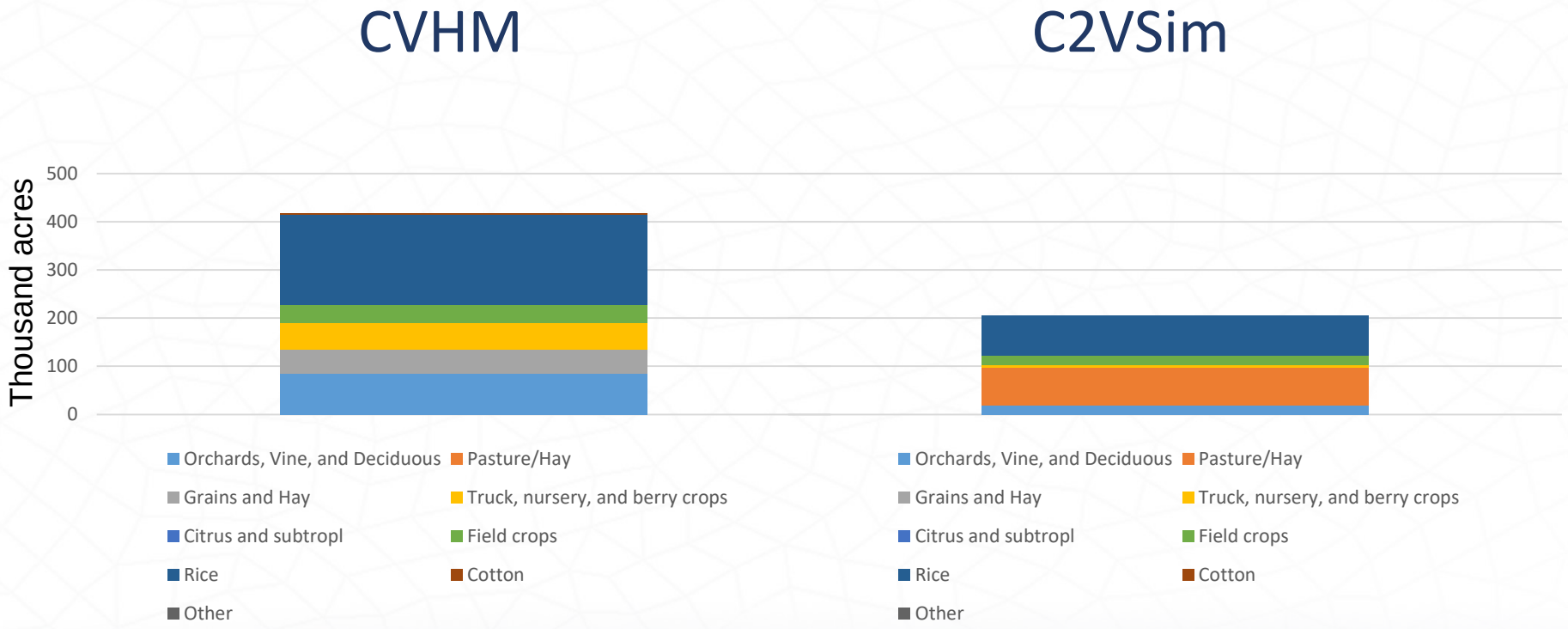


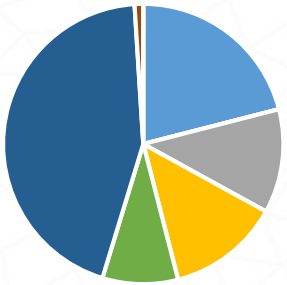
- Orchards, Vine, and Deciduous
- Pasture/Hay
- Grains and Hay
- Truck, nursery, and berry crops
- Citrus and subtropl
- Field crops
- Rice
- Cotton
- Other

Subregion 3 - 1960

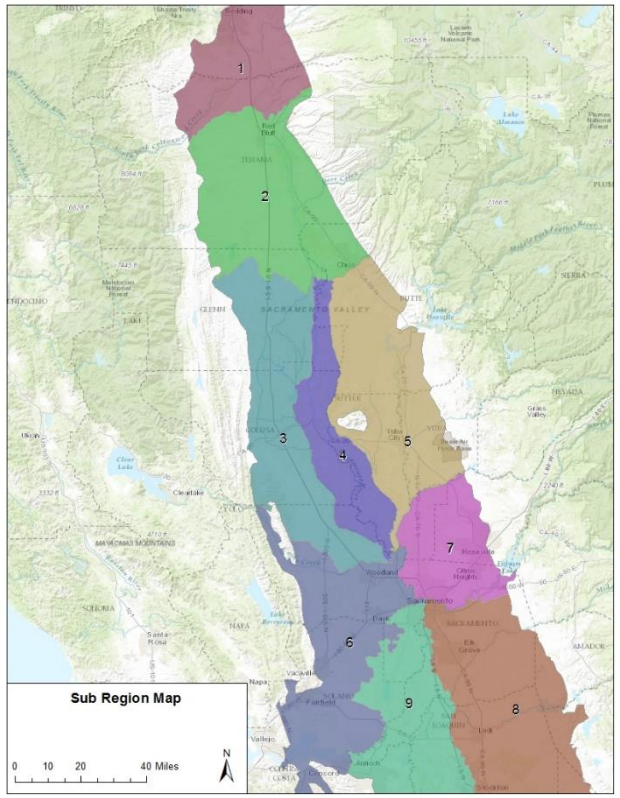


Subregion 3 - 2000

CVHM



- Orchards, Vine, and Deciduous
- Pasture/Hay
- Grains and Hay
- Truck, nursery, and berry crops
- Citrus and subtropl
- Field crops
- Rice
- Cotton
- Other



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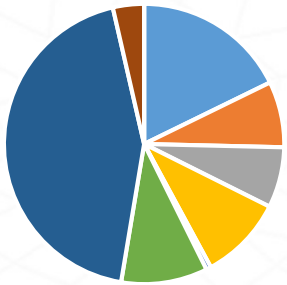
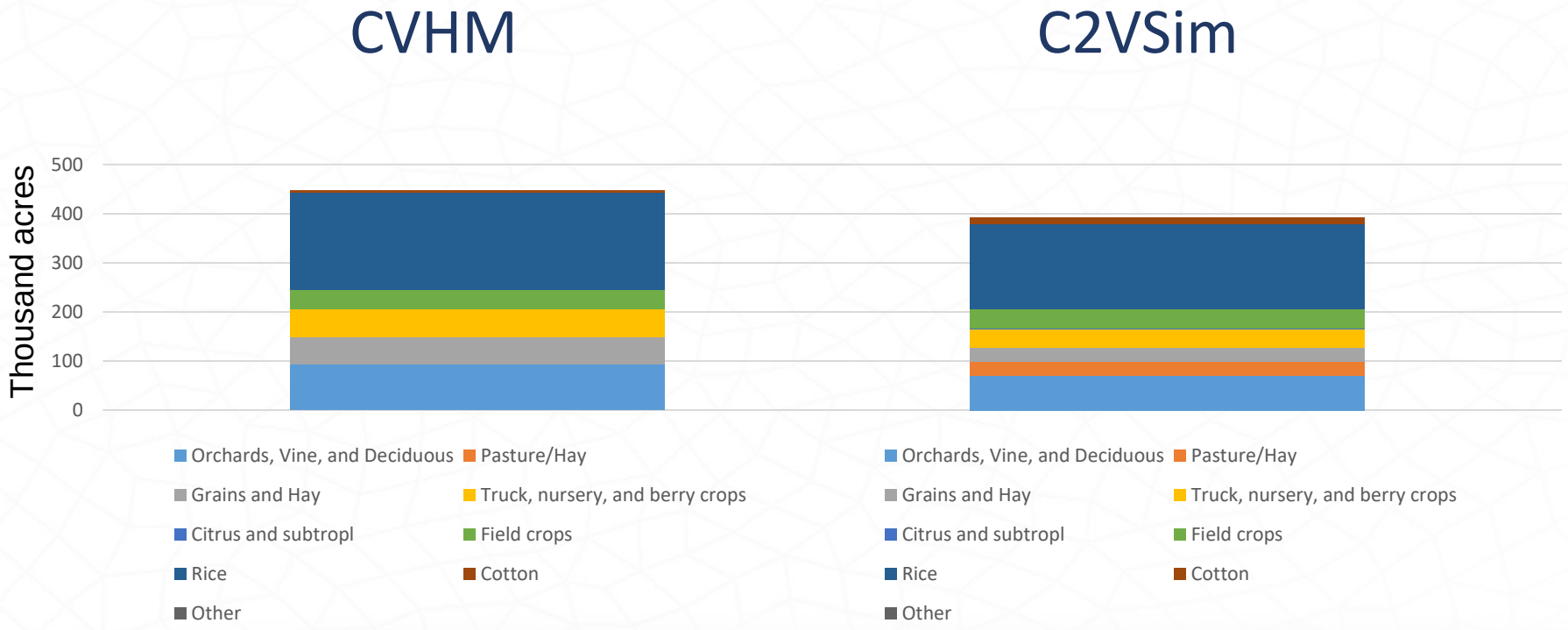


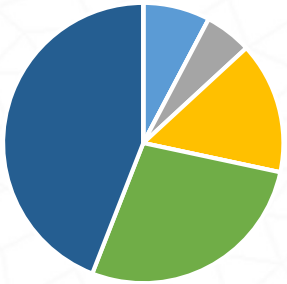
- Orchards, Vine, and Deciduous
- Pasture/Hay
- Grains and Hay
- Truck, nursery, and berry crops
- Citrus and subtropl
- Field crops
- Rice
- Cotton
- Other

Subregion 3 - 2000

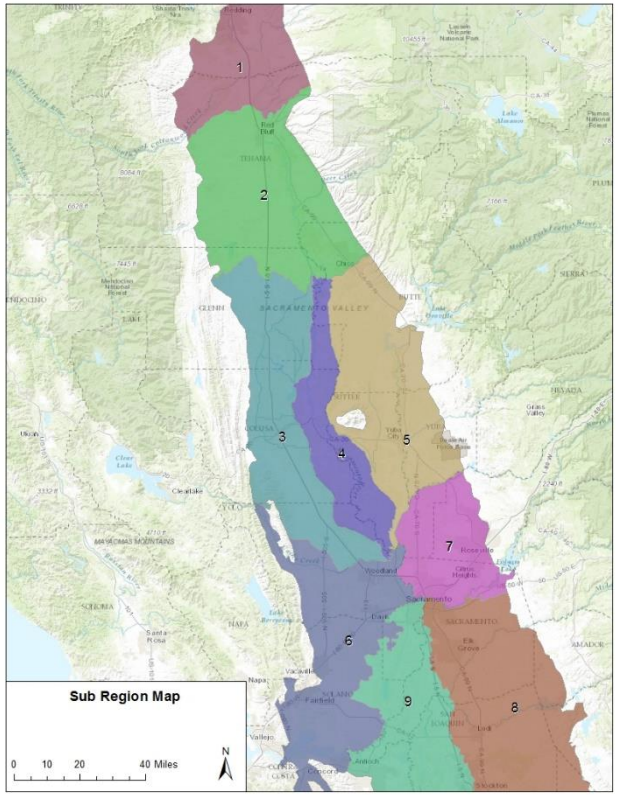


Subregion 4 - 1960

CVHM



- Orchards, Vine, and Deciduous
- Pasture/Hay
- Grains and Hay
- Truck, nursery, and berry crops
- Citrus and subtropl
- Field crops
- Rice
- Cotton
- Other



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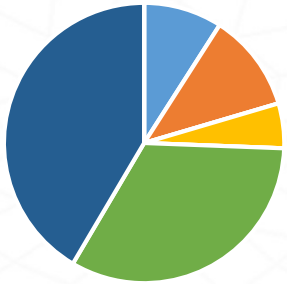
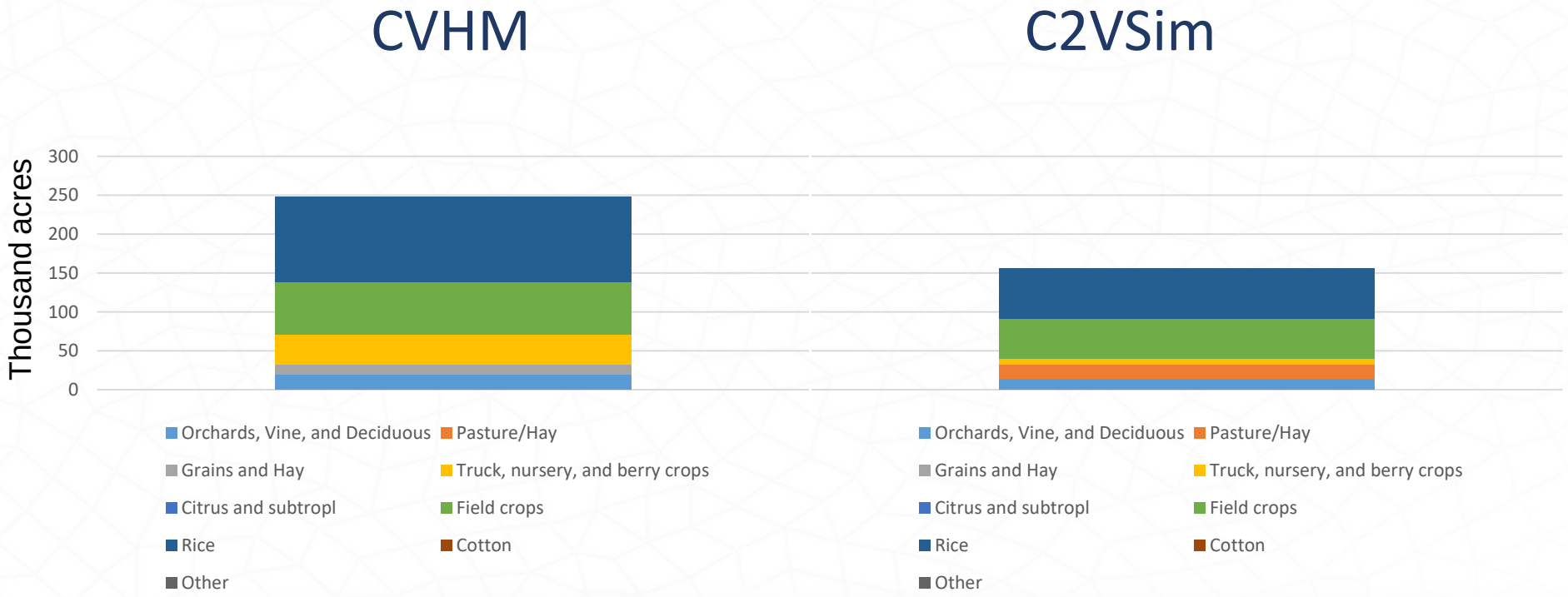


- Orchards, Vine, and Deciduous
- Pasture/Hay
- Grains and Hay
- Truck, nursery, and berry crops
- Citrus and subtropl
- Field crops
- Rice
- Cotton
- Other

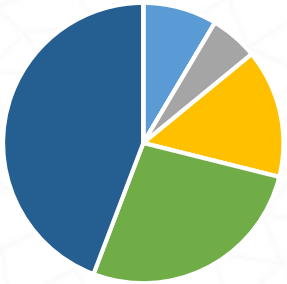
Subregion 4 - 1960



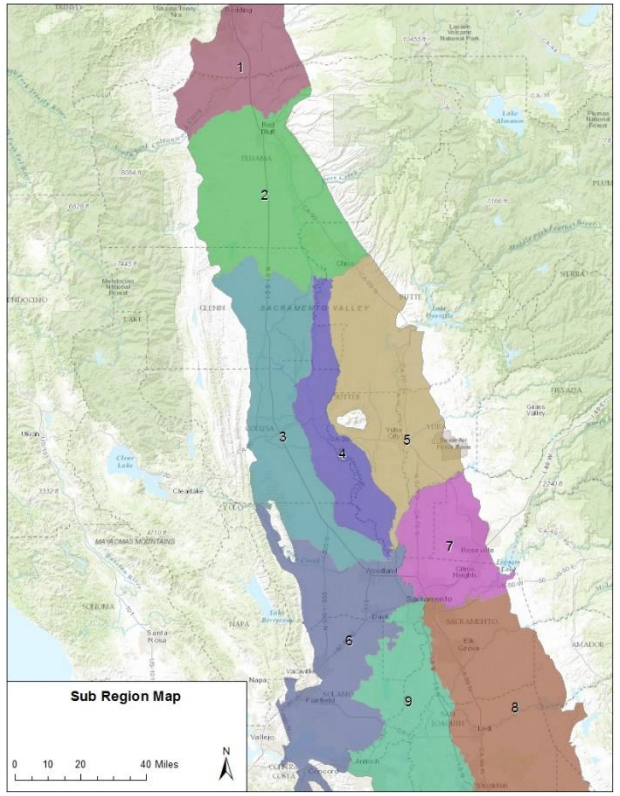
National Experience. Local Focus.

Subregion 4 - 2000

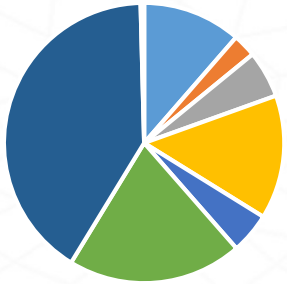
CVHM



- Orchards, Vine, and Deciduous
- Pasture/Hay
- Grains and Hay
- Truck, nursery, and berry crops
- Citrus and subtropl
- Field crops
- Rice
- Cotton
- Other

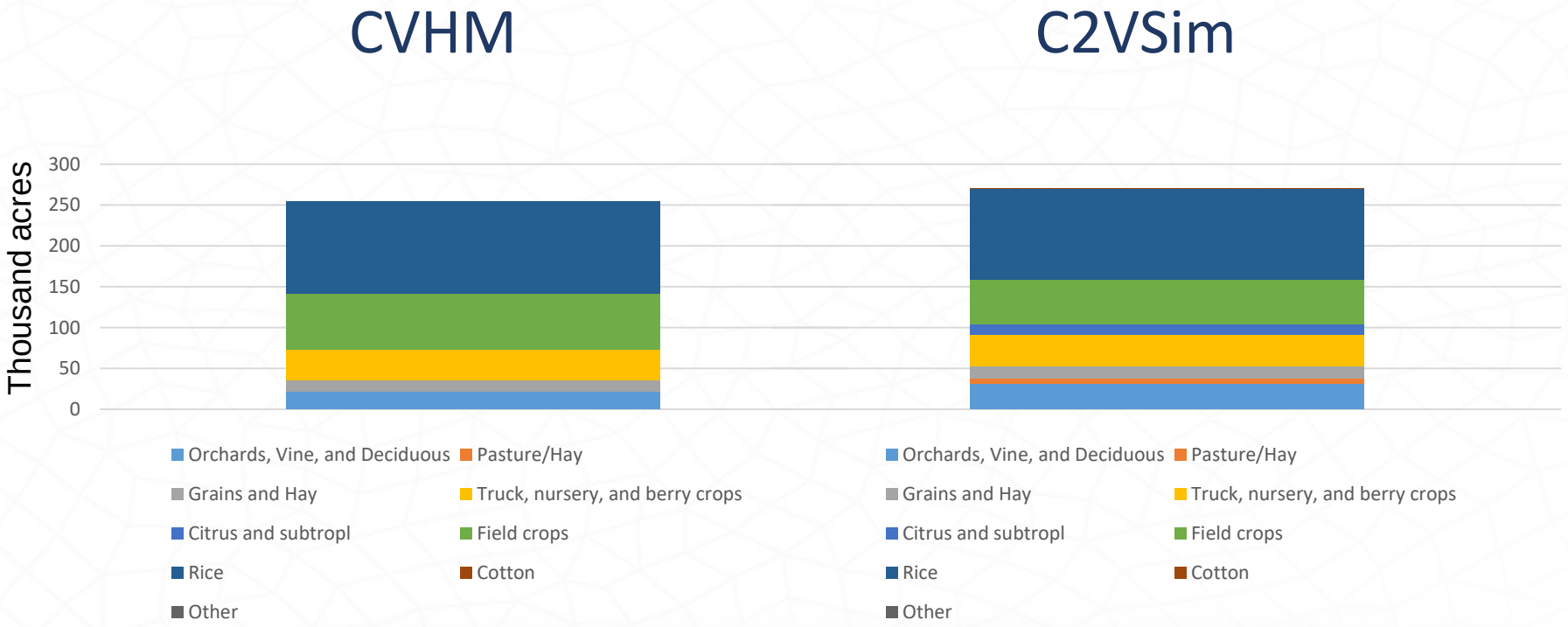


C2VSim



- Orchards, Vine, and Deciduous
- Pasture/Hay
- Grains and Hay
- Truck, nursery, and berry crops
- Citrus and subtropl
- Field crops
- Rice
- Cotton
- Other

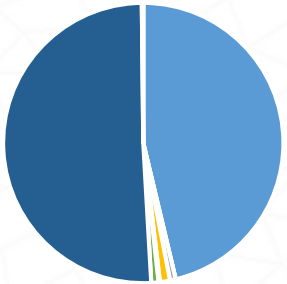
Subregion 4 - 2000



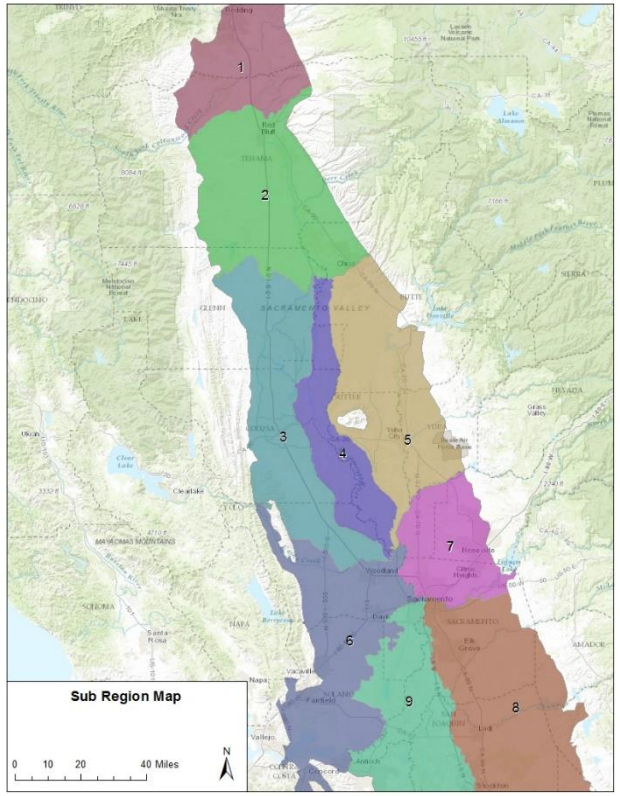
National Experience. Local Focus.

Subregion 5 - 1960

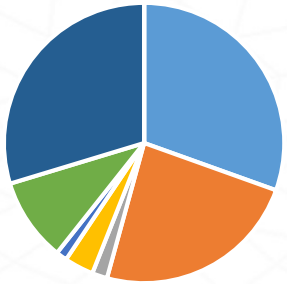
CVHM



- Orchards, Vine, and Deciduous
- Pasture/Hay
- Grains and Hay
- Truck, nursery, and berry crops
- Citrus and subtropl
- Field crops
- Rice
- Cotton
- Other

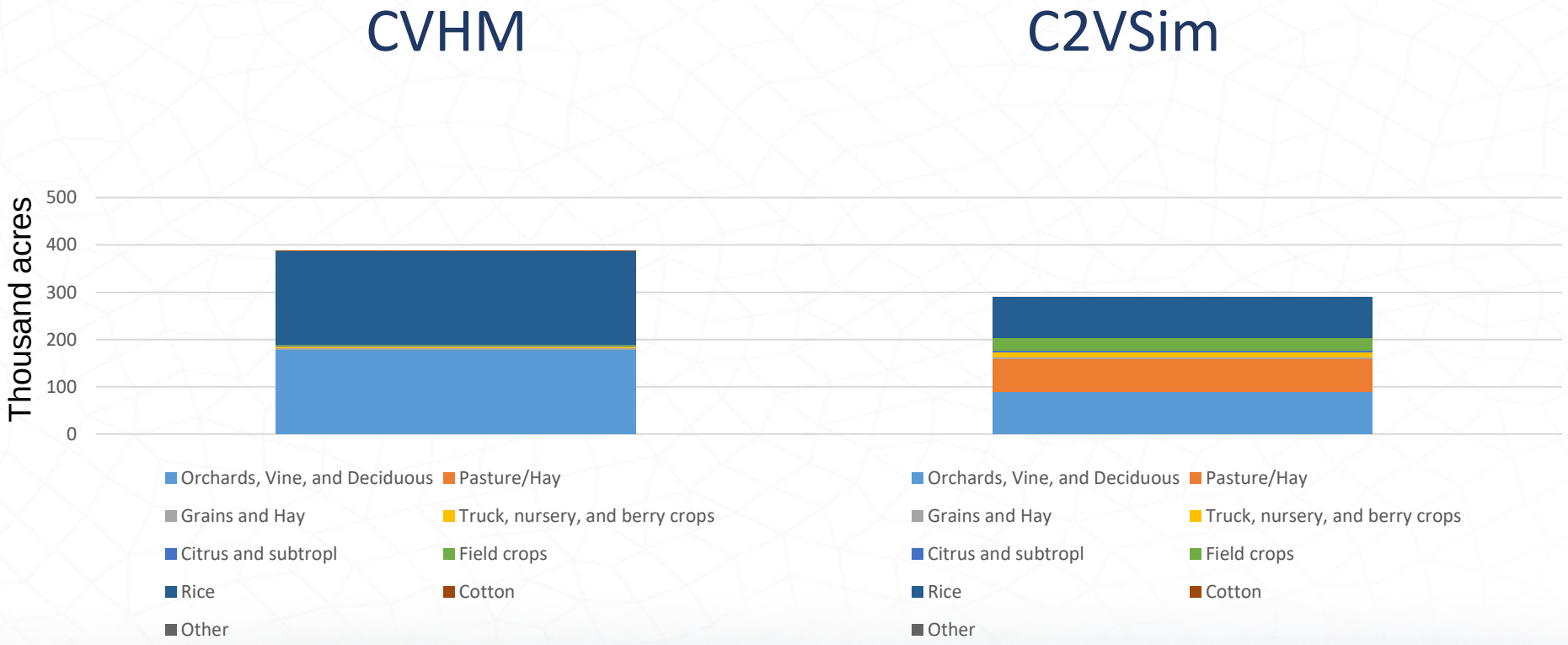


C2VSim



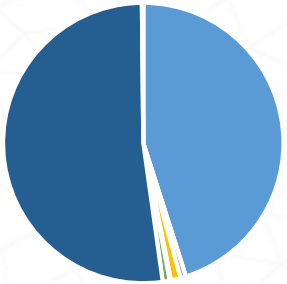
- Orchards, Vine, and Deciduous
- Pasture/Hay
- Grains and Hay
- Truck, nursery, and berry crops
- Citrus and subtropl
- Field crops
- Rice
- Cotton
- Other

Subregion 5 - 1960

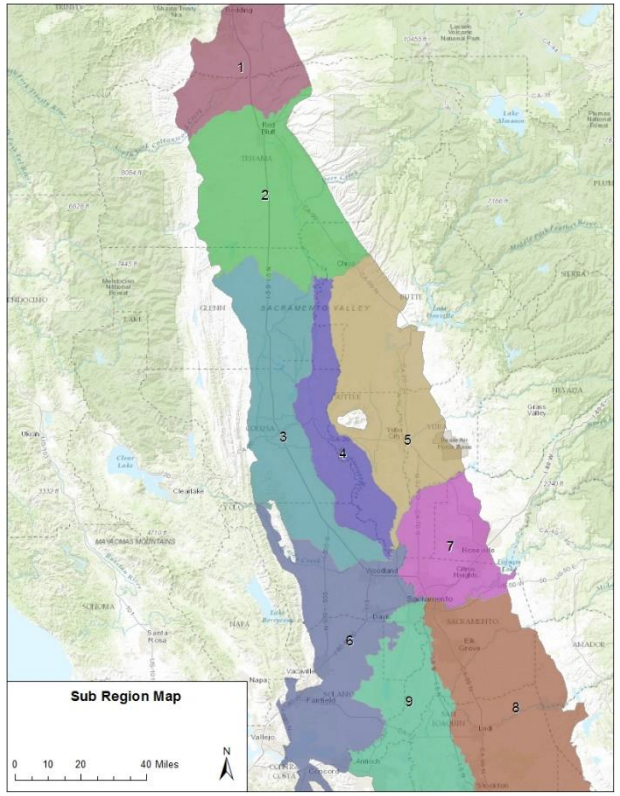


Subregion 5 - 2000

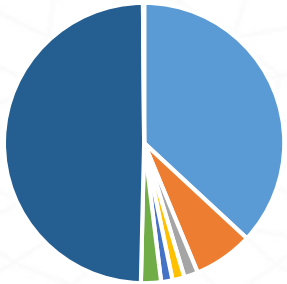
CVHM



- Orchards, Vine, and Deciduous
- Pasture/Hay
- Grains and Hay
- Truck, nursery, and berry crops
- Citrus and subtropl
- Field crops
- Rice
- Cotton
- Other

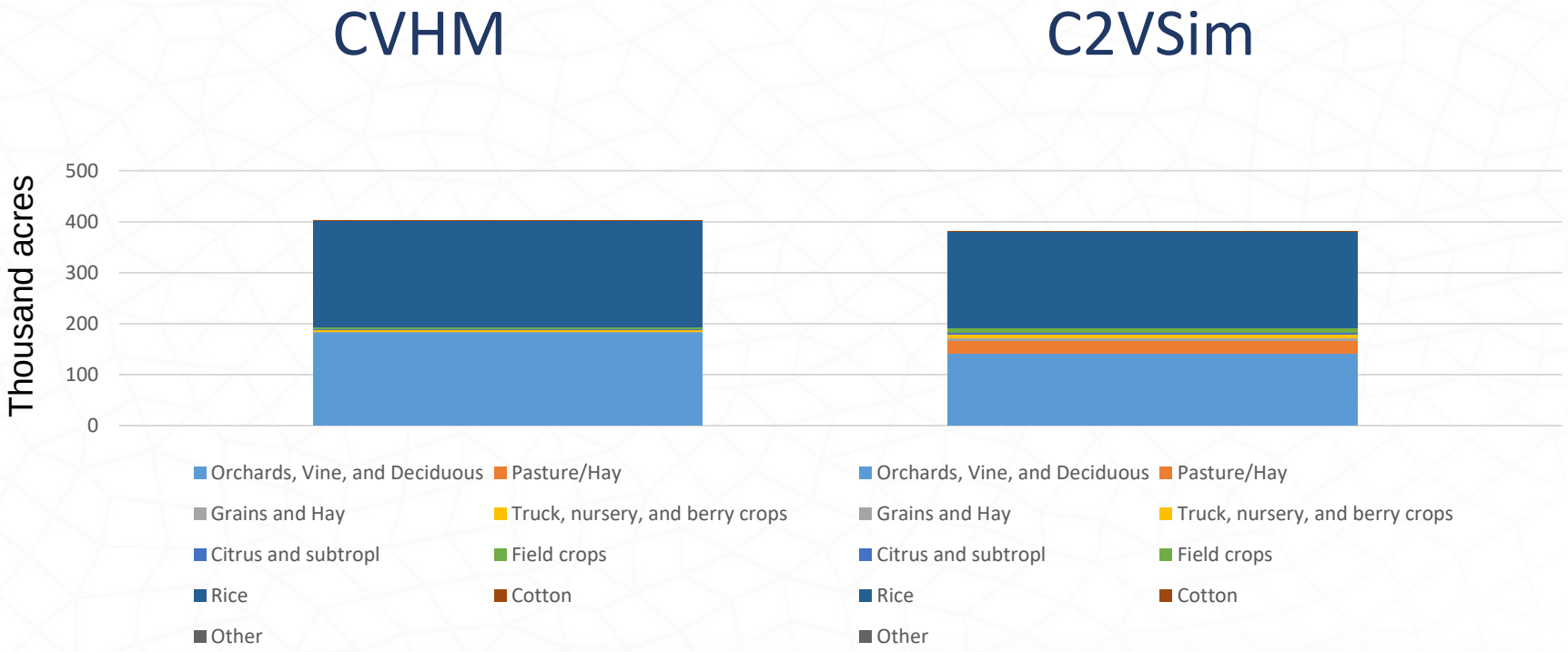


C2VSim



- Orchards, Vine, and Deciduous
- Pasture/Hay
- Grains and Hay
- Truck, nursery, and berry crops
- Citrus and subtropl
- Field crops
- Rice
- Cotton
- Other

Subregion 5 - 2000



Subregion Crop Acreage Comparison - 2000

	CVHM			C2VSim			DAU		
Subregion No.	Subregion Area	Crop Acreages	% Ag	Subregion Area	Crop Acreage	% Ag	DAU Area	Crop Acreage	%
2	745	161	22%	737	168	23%	759	174	23%
3	669	448	67%	662	393	59%	913	375	41%
4	354	255	72%	351	271	77%	350	269	77%
5	688	403	59%	687	381	55%	732	368	50%
6	503	240	48%	497	186	37%	612	259	42%
7	367	113	31%	361	123	34%	379	106	28%
8	184	61	33%	183	61	33%	142	14	10%
9	275	183	67%	276	126	46%	280	165	59%

Thousand Acres

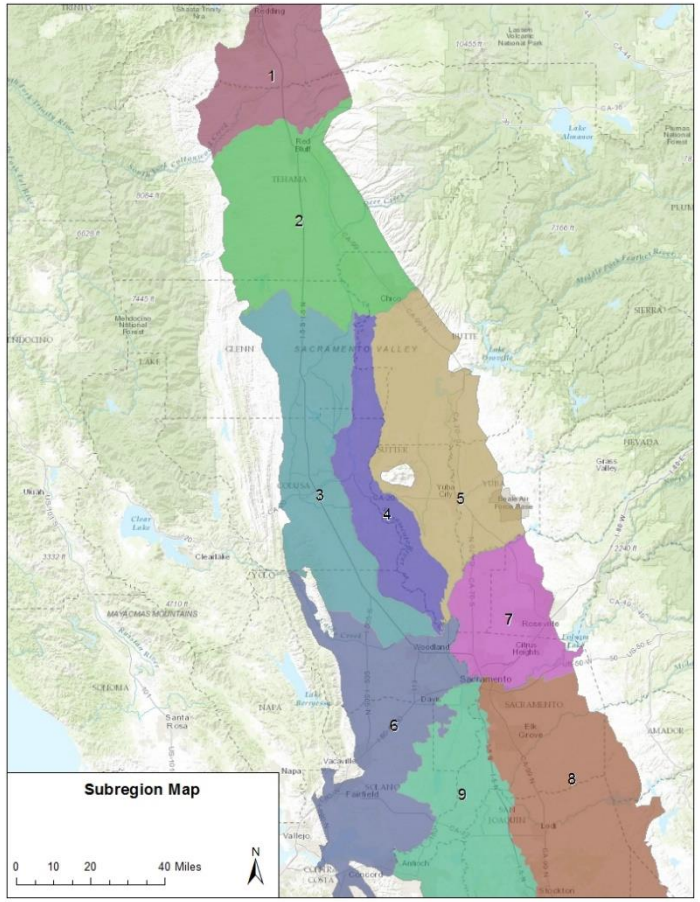
Agenda

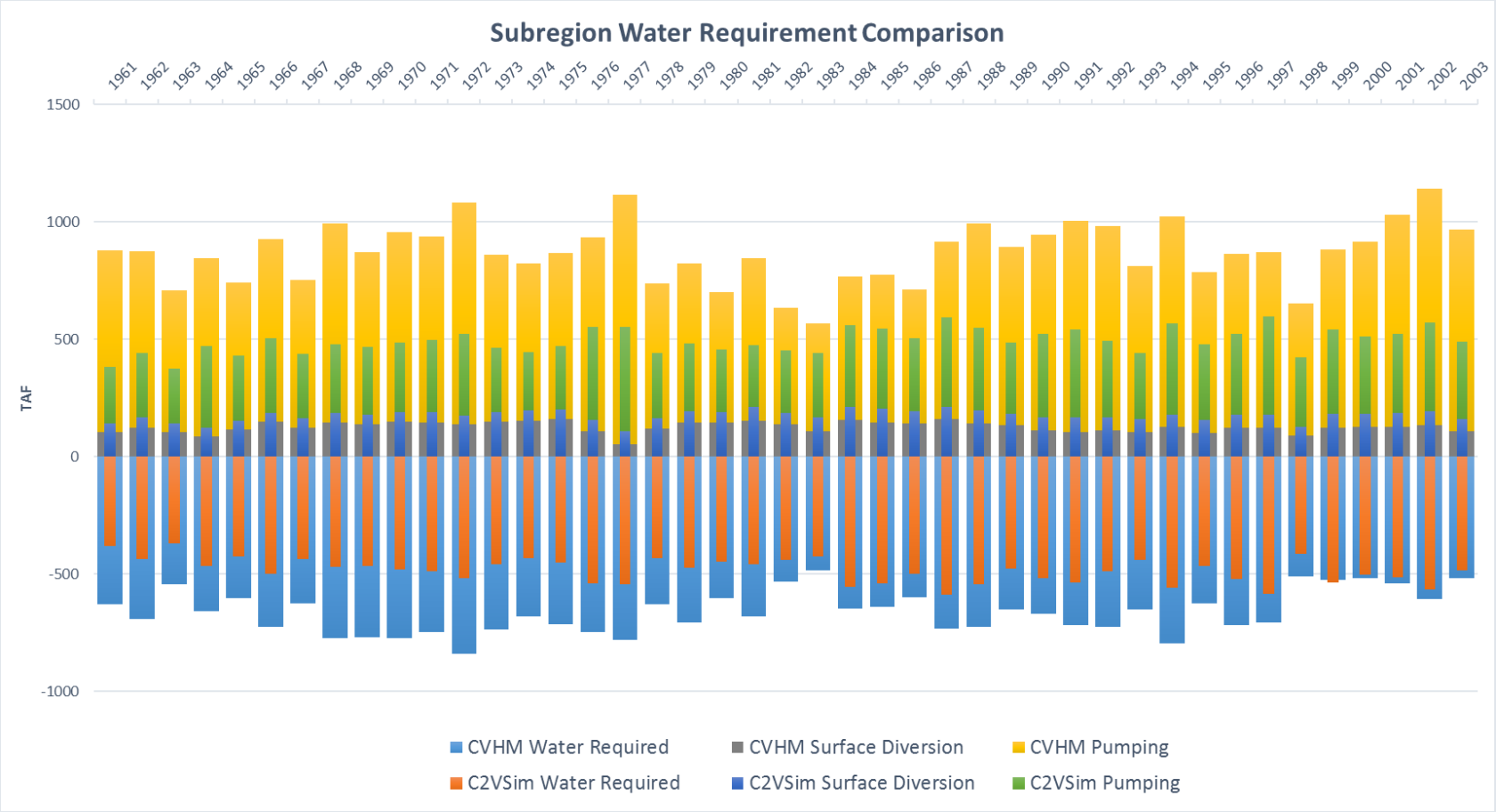
- Recap of previous meetings
- **Model comparison**
  - Land use / cropping
  - **Water budget**
    - **Ag water demand**
    - **Water supply**
    - **Recharge**
    - **Stream seepage**
  - Surface water inflows
  - Calibration
    - Hydrographs at selected wells
- Discussion
  - Model recommendations or assistance in model recommendations

Water Budget Sources

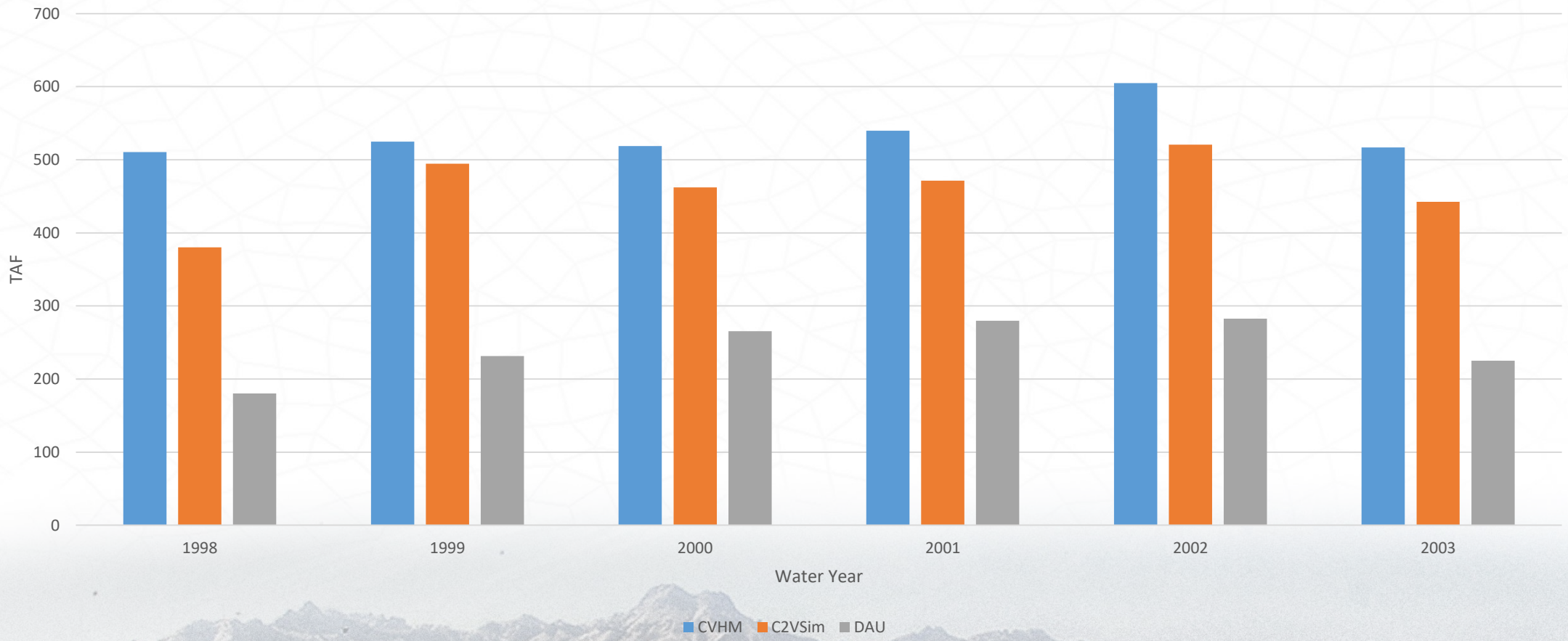
- CVHM
  - Water Required (FDS.OUT file, TFDR-FIN column)
  - Surface Water Diversion (FDS.OUT file, R-SWD-FIN and NR-SWD-FIN columns)
  - Pumping (Compq_bc.in & Compq_bc.out files, Multi Node Well and Farm Wells columns)
  - Steam Leakage (Compq_bc.out & Compq_bc.in files, Stream Leakage column)
  - Farm Recharge (Compq_bc.out & Compq_bc.in files, Net Farm Recharge column)
- C2VSim
  - Water Required (CVLandwater.BUD file, Agricultural Supply Requirement column)
  - Surface Diversion (CVLandwater.BUD file, Agricultural Diversion + Urban Diversion columns)
  - Pumping (CVLandwater.BUD file, Agricultural Pumping + Urban Pumping columns)
  - Stream Leakage (CVGround.BUD, Gain from Stream column)
  - Recharge (CVGround.BUD, Net Deep Percolation & Recharge columns)
- DAU
  - AW (applied water)

Water Budget: Subregion 2

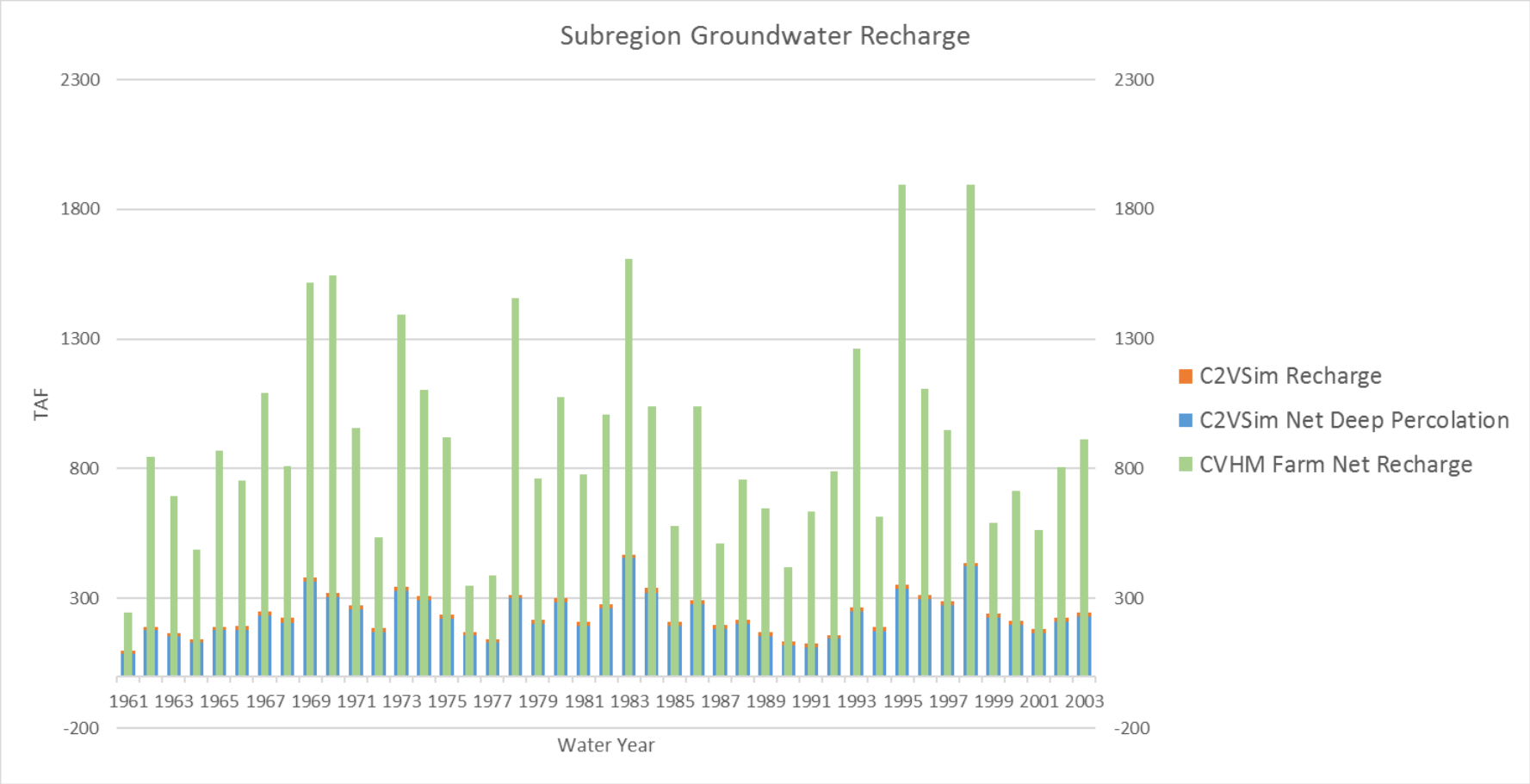




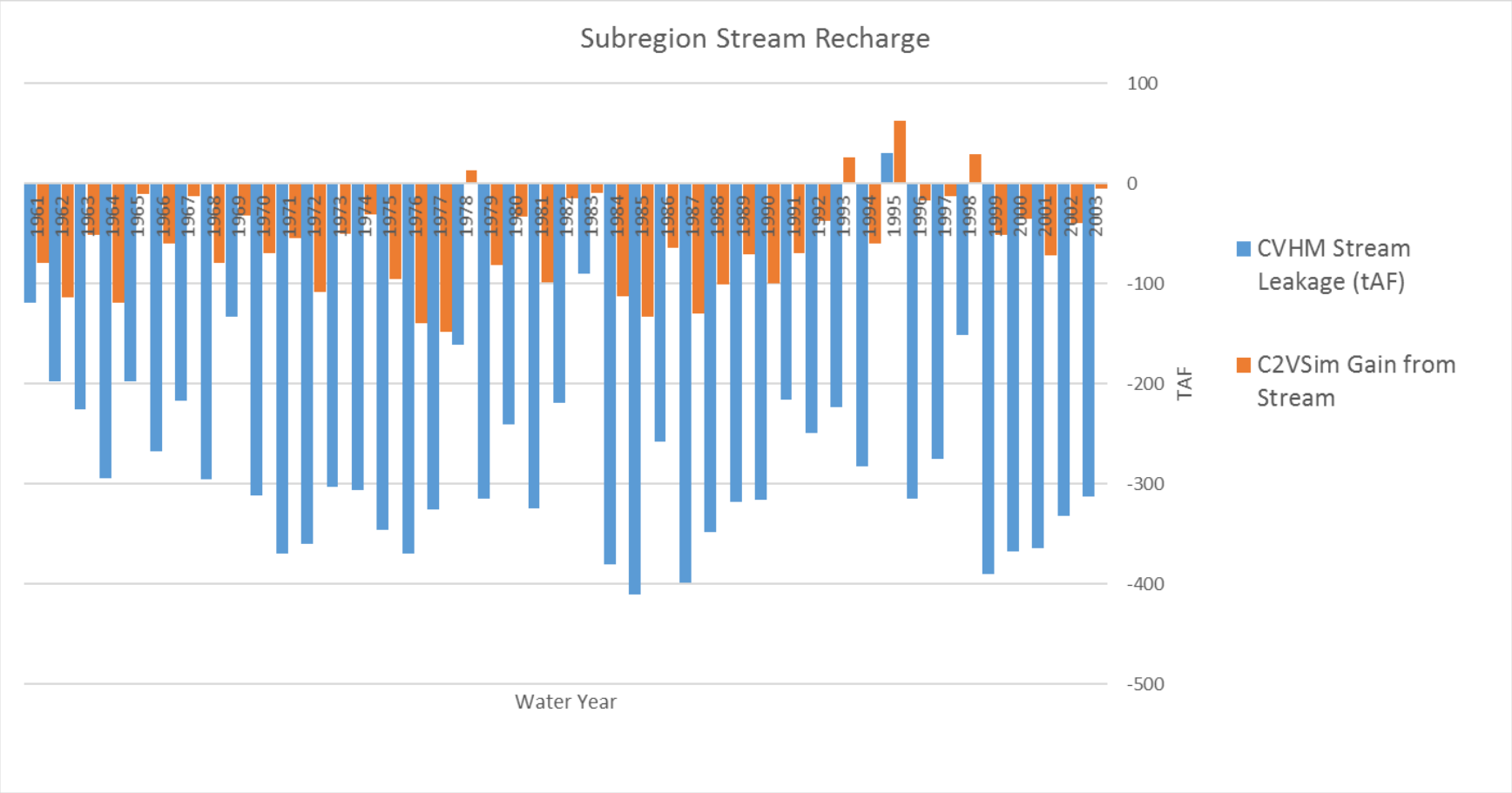
Water Budget: Subregion 2
CVHM(TFDR-FIN), C2VSim(Ag Supply Req), DAU(AW)



Water Budget: Subregion 2



Water Budget: Subregion 2



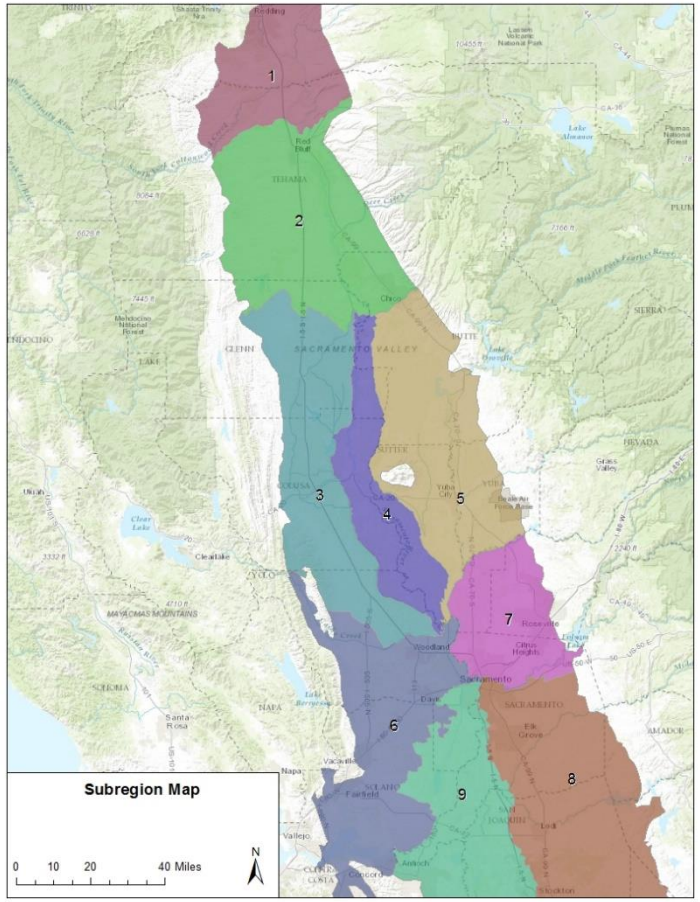
Water Budget: Subregion 2

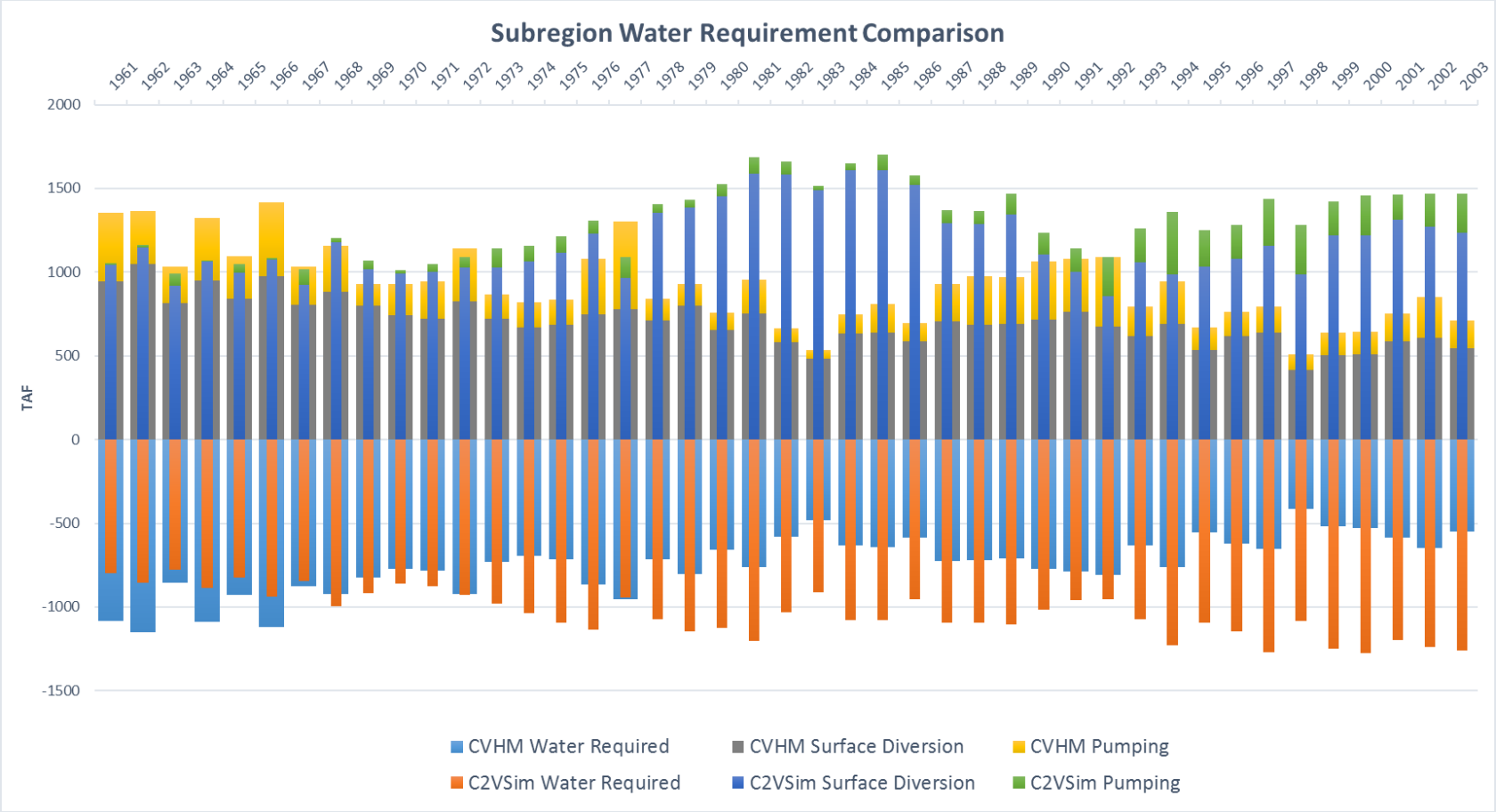
	CVHM	C2VSim
Average Water Required	663	486
Average Surface Diversion	126	174
Average Pumping	743	317

	CVHM	C2VSim
Average GW Recharge	905	242
Average Stream Recharge	-276	-58

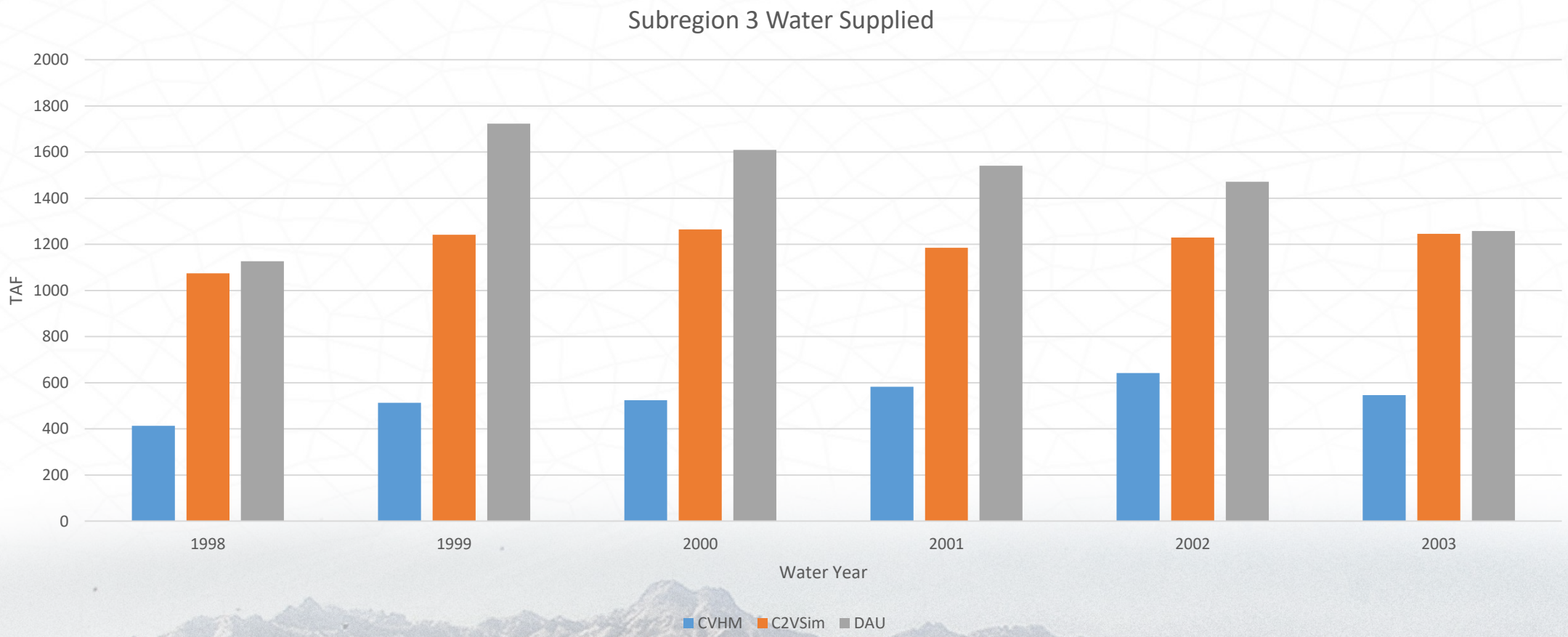
Units: TAF

Water Budget: Subregion 3

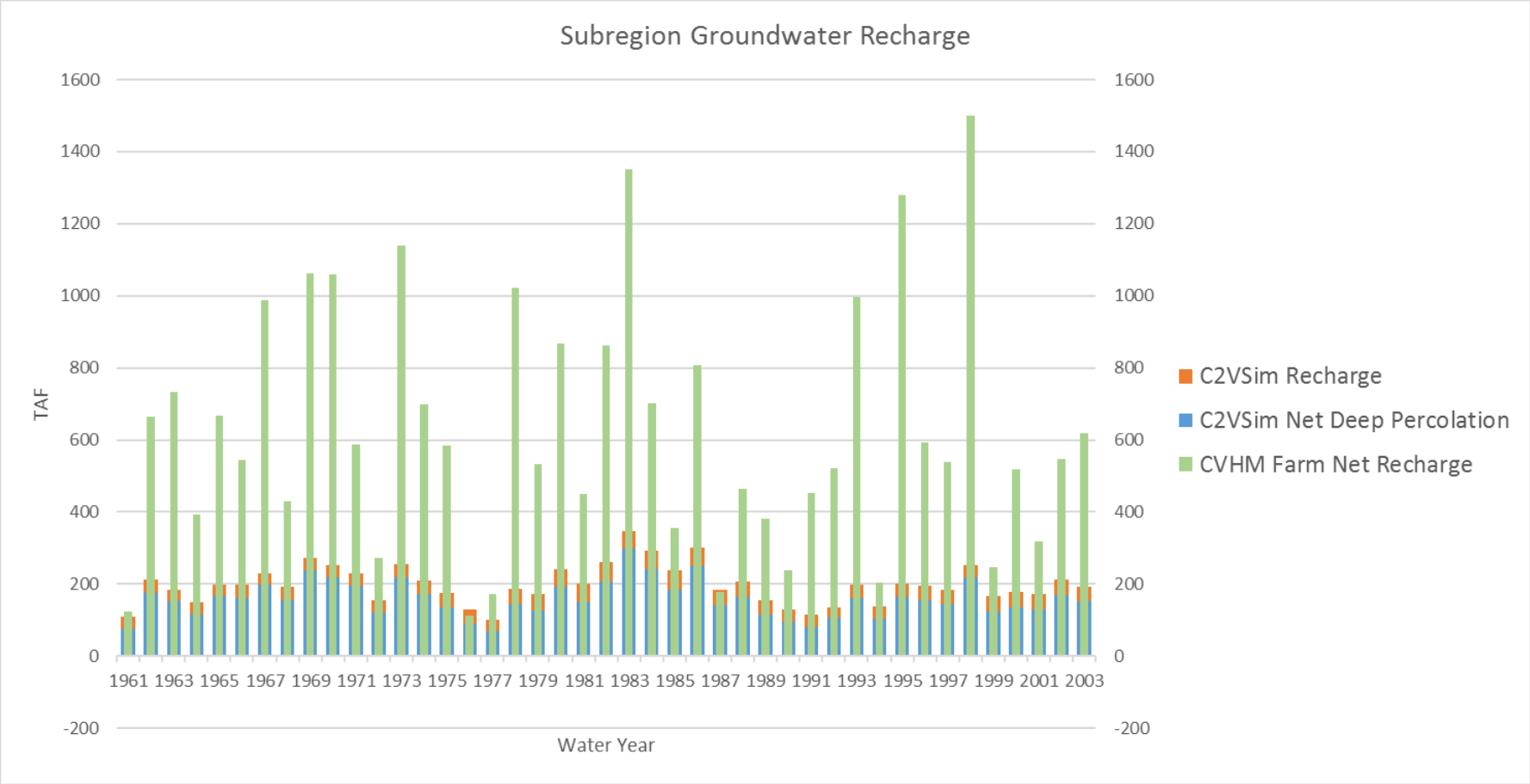




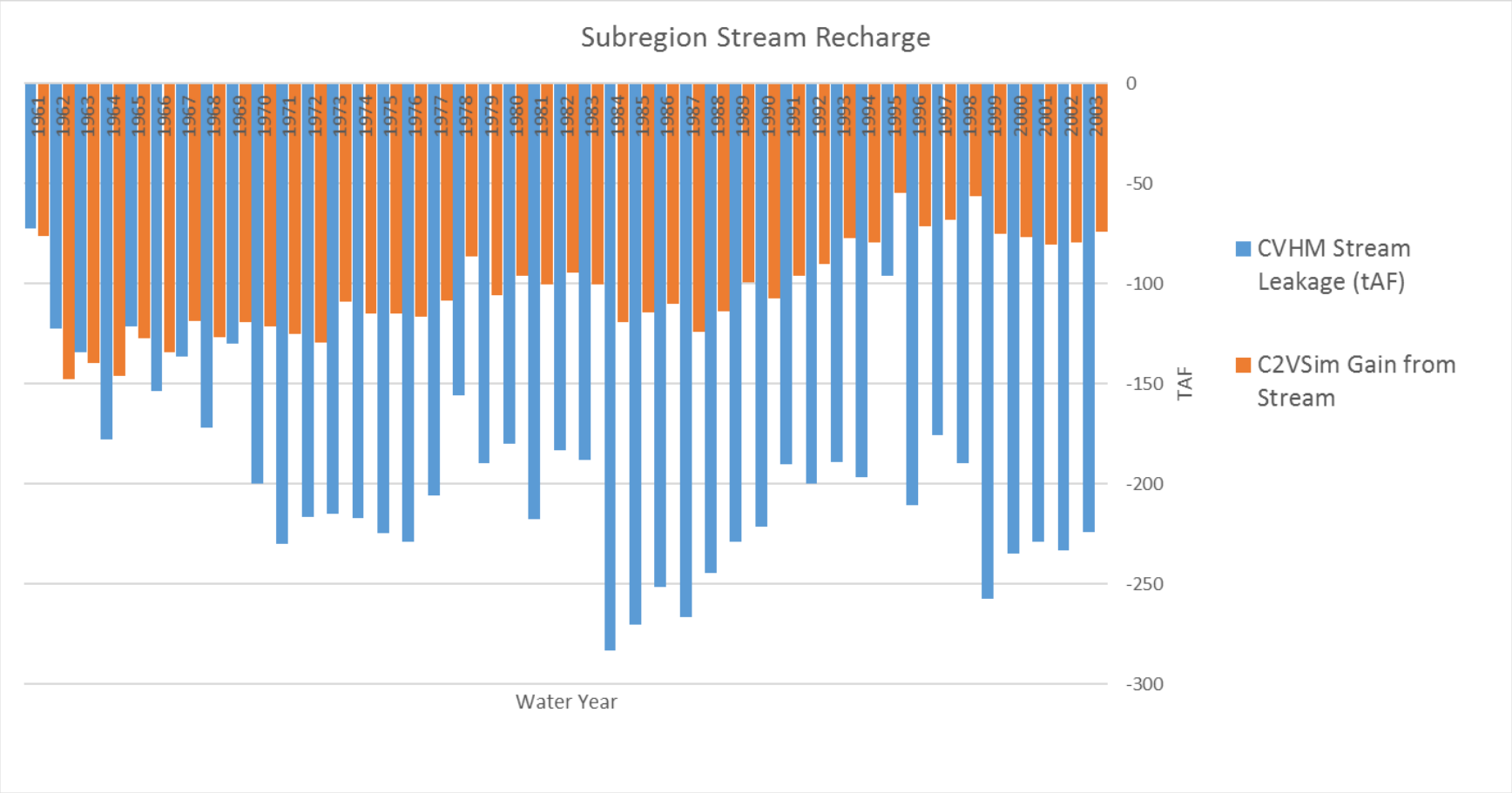
Water Budget: Subregion 3



Water Budget: Subregion 3



Water Budget: Subregion 3



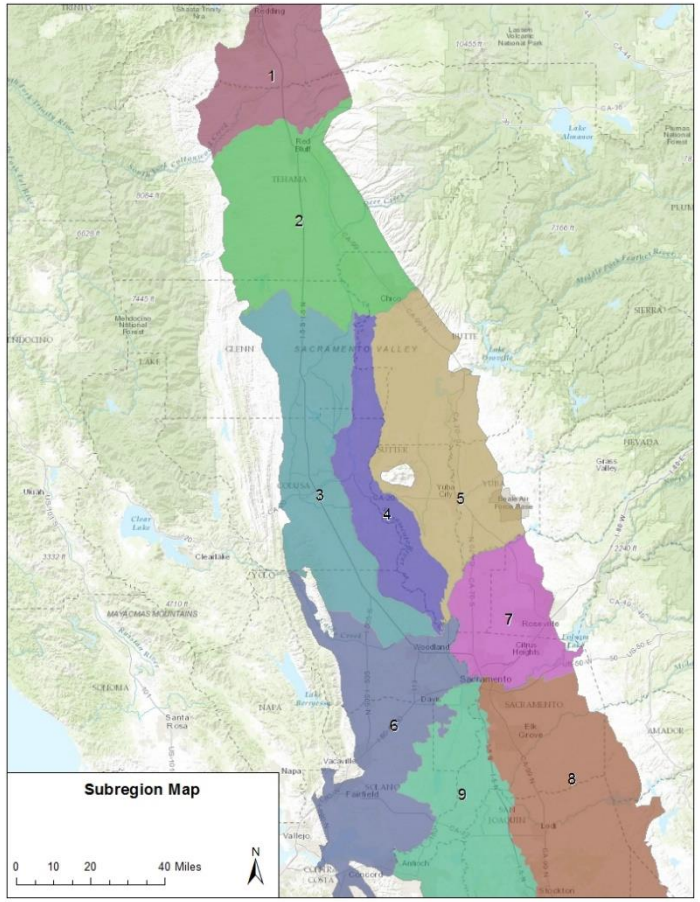
Water Budget: Subregion 3

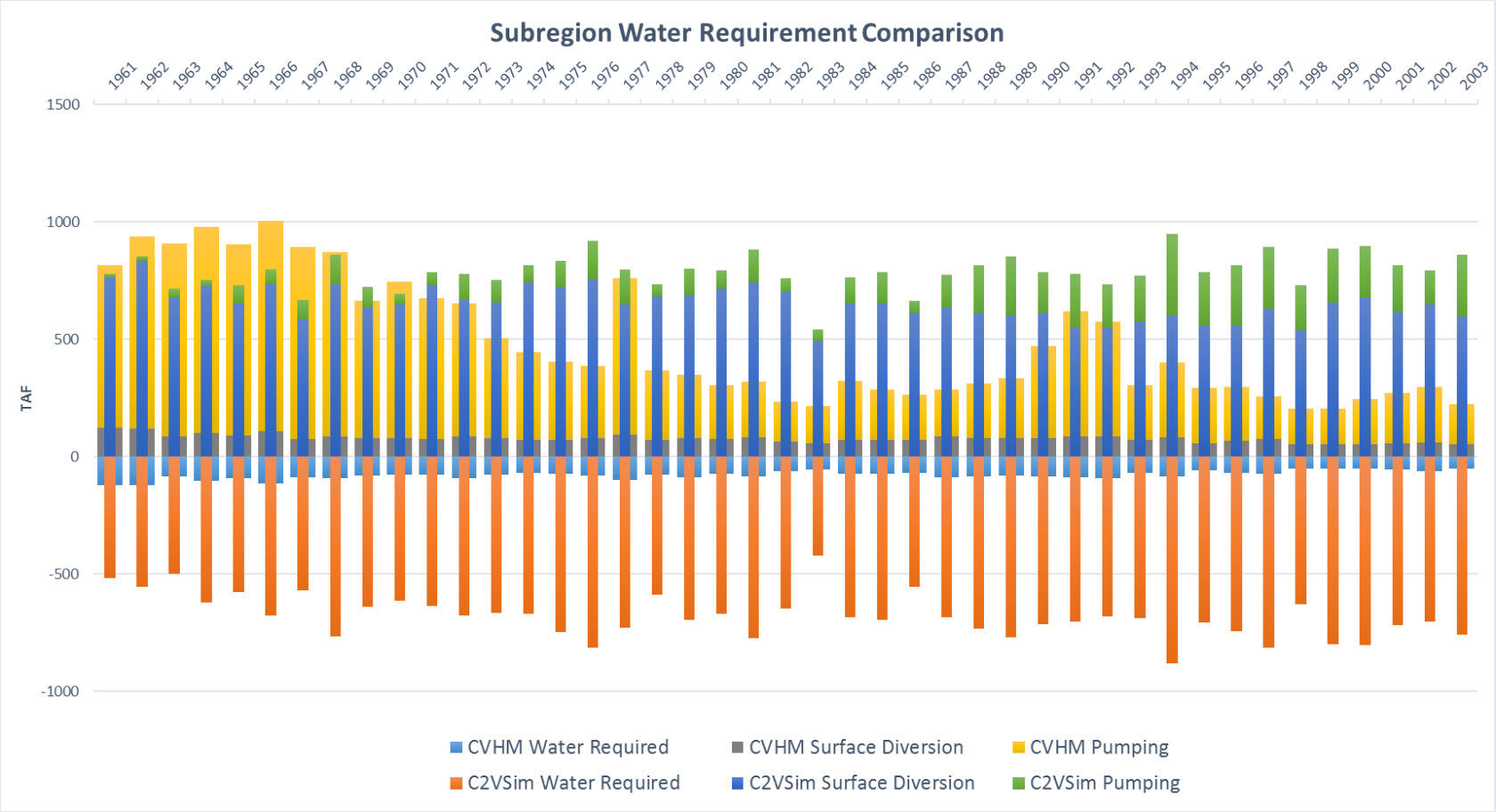
	CVHM	C2VSim
Average Water Required	747	1,037
Average Surface Diversion	703	1,181
Average Pumping	220	114

	CVHM	C2VSim
Average GW Recharge	623	198
Average Stream Recharge	-197	-103

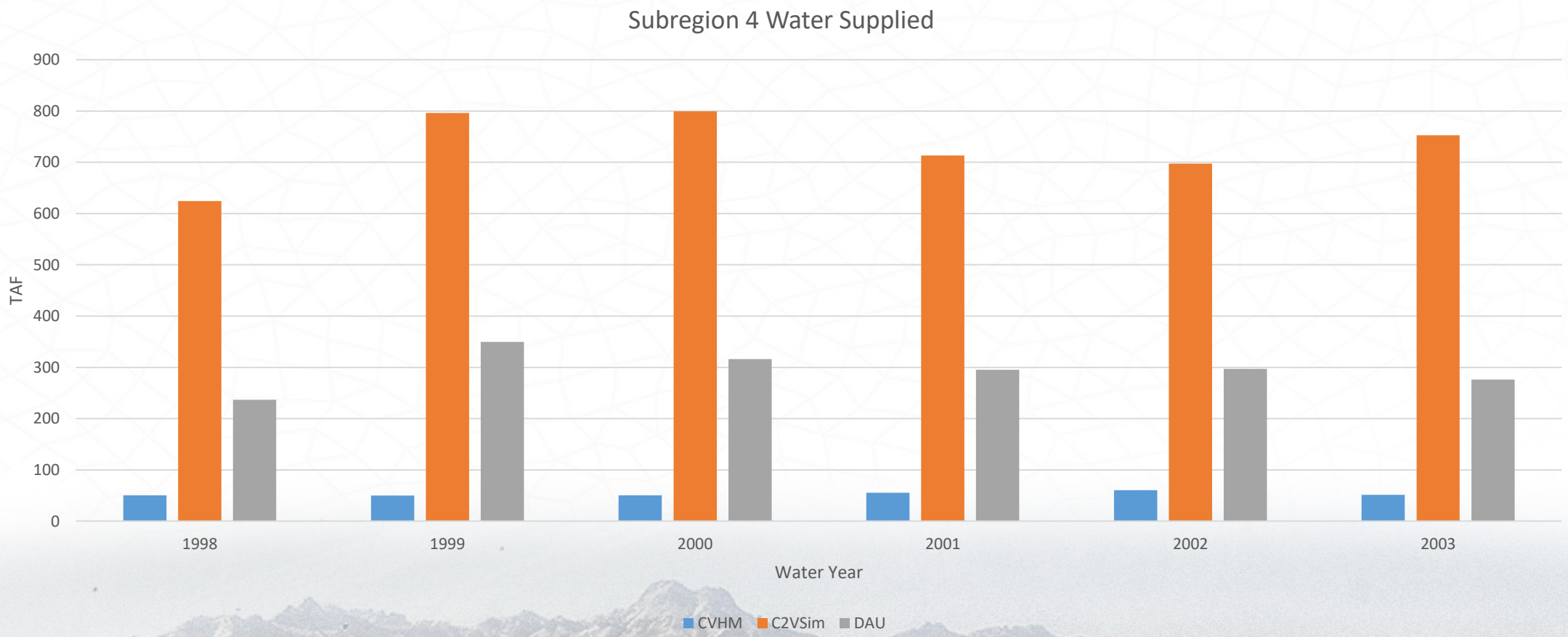
Units: TAF

Water Budget: Subregion 4

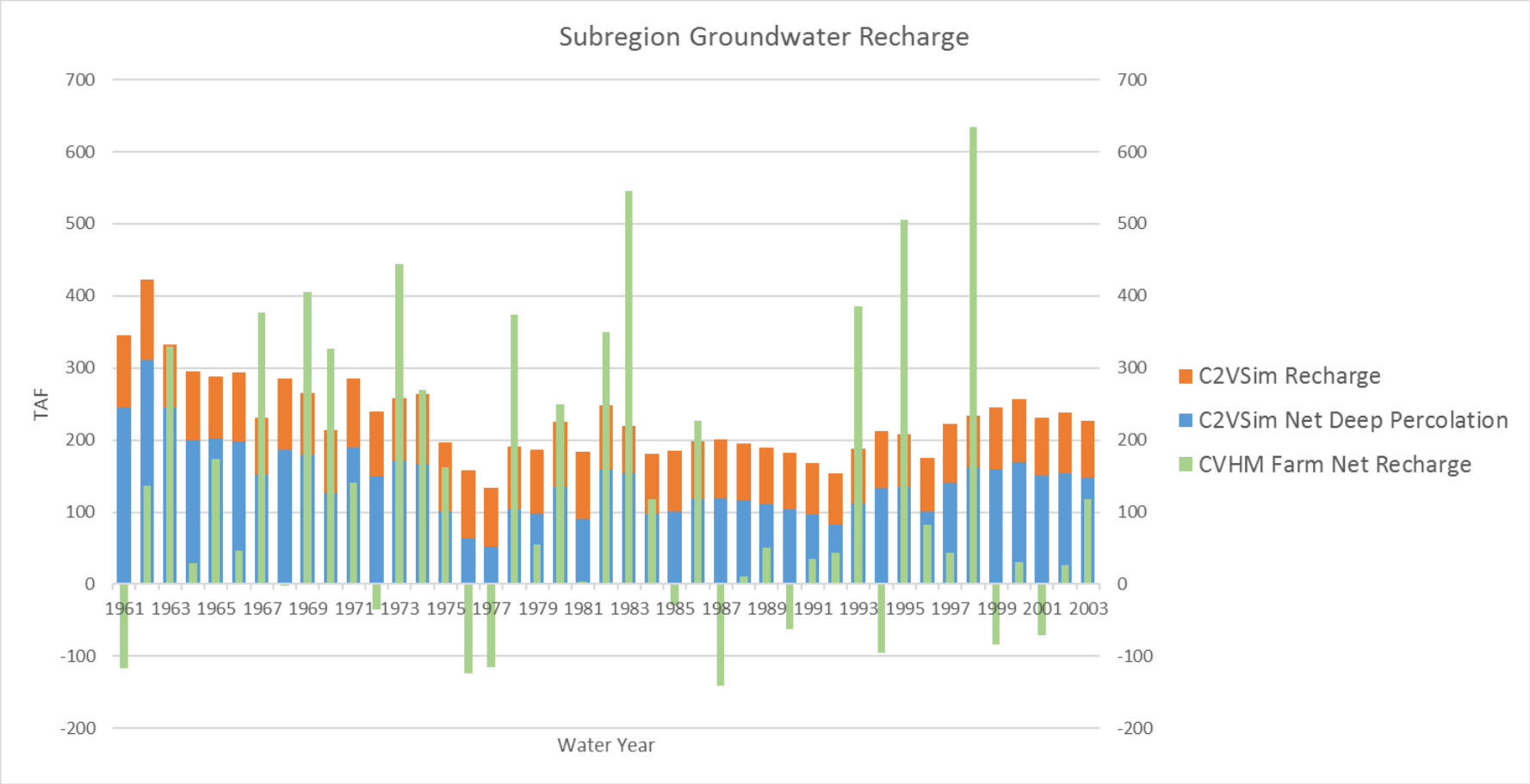




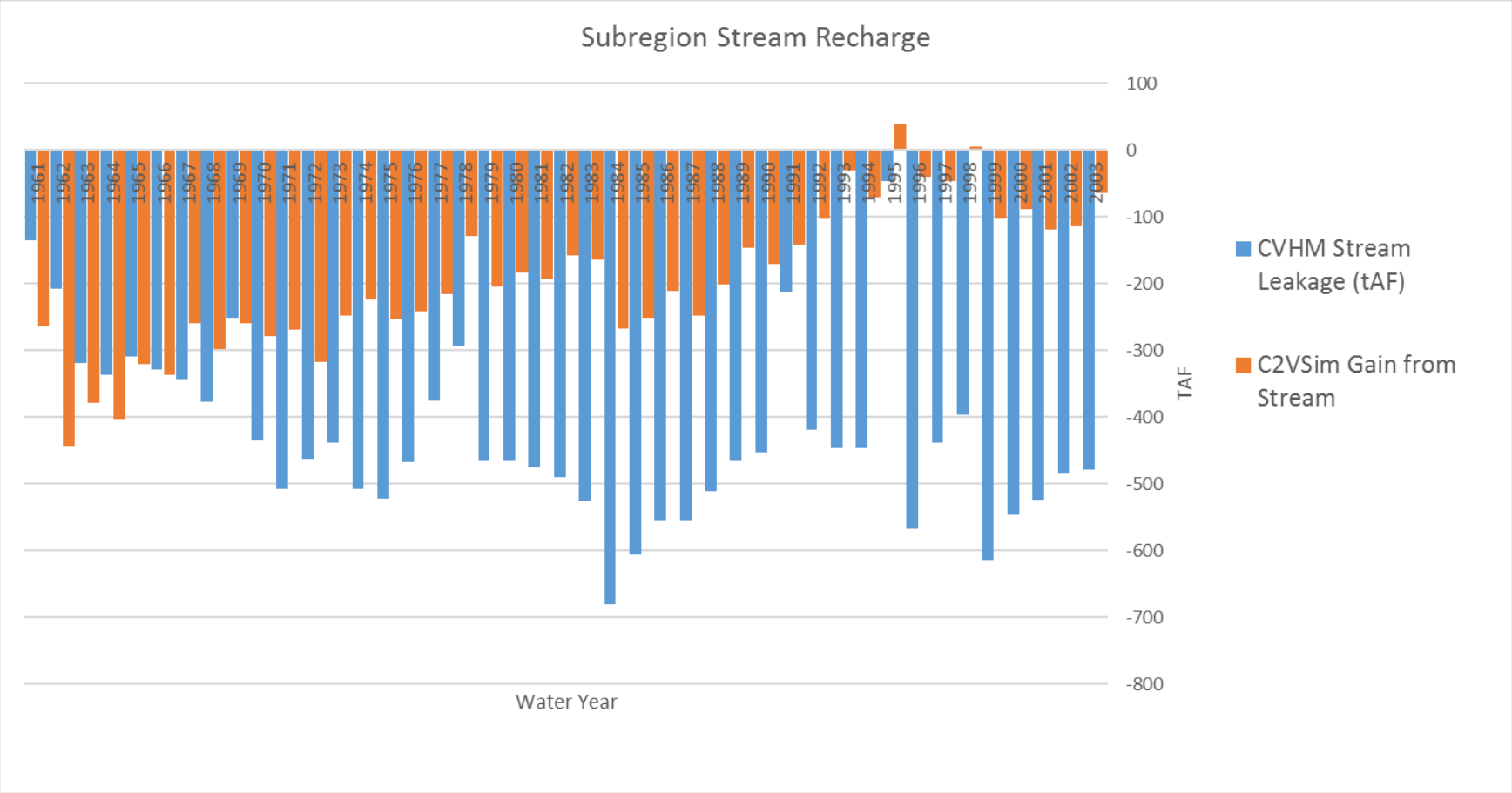
Water Budget: Subregion 4



Water Budget: Subregion 4



Water Budget: Subregion 4



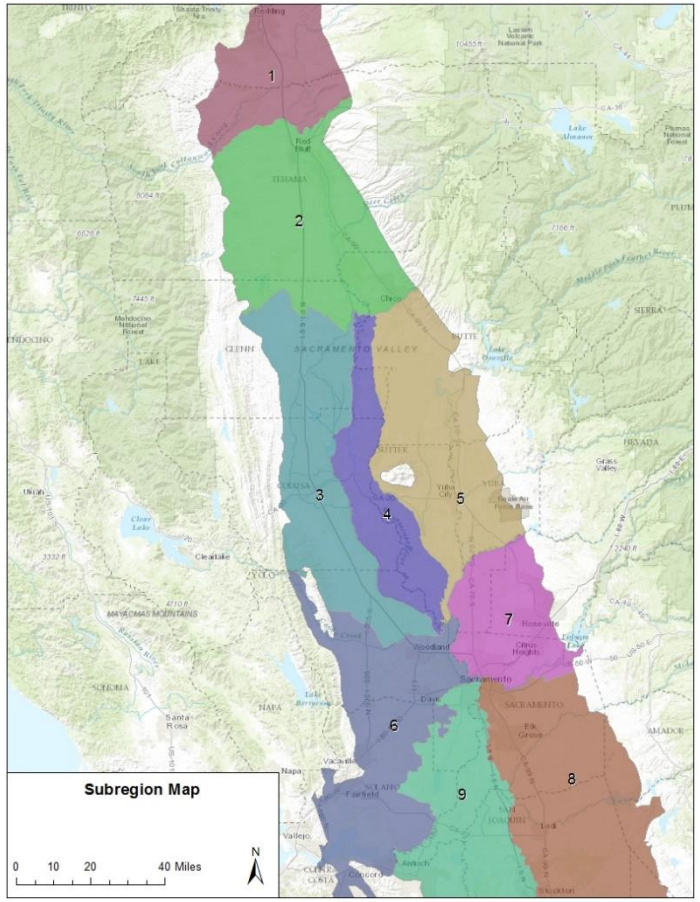
Water Budget: Subregion 4

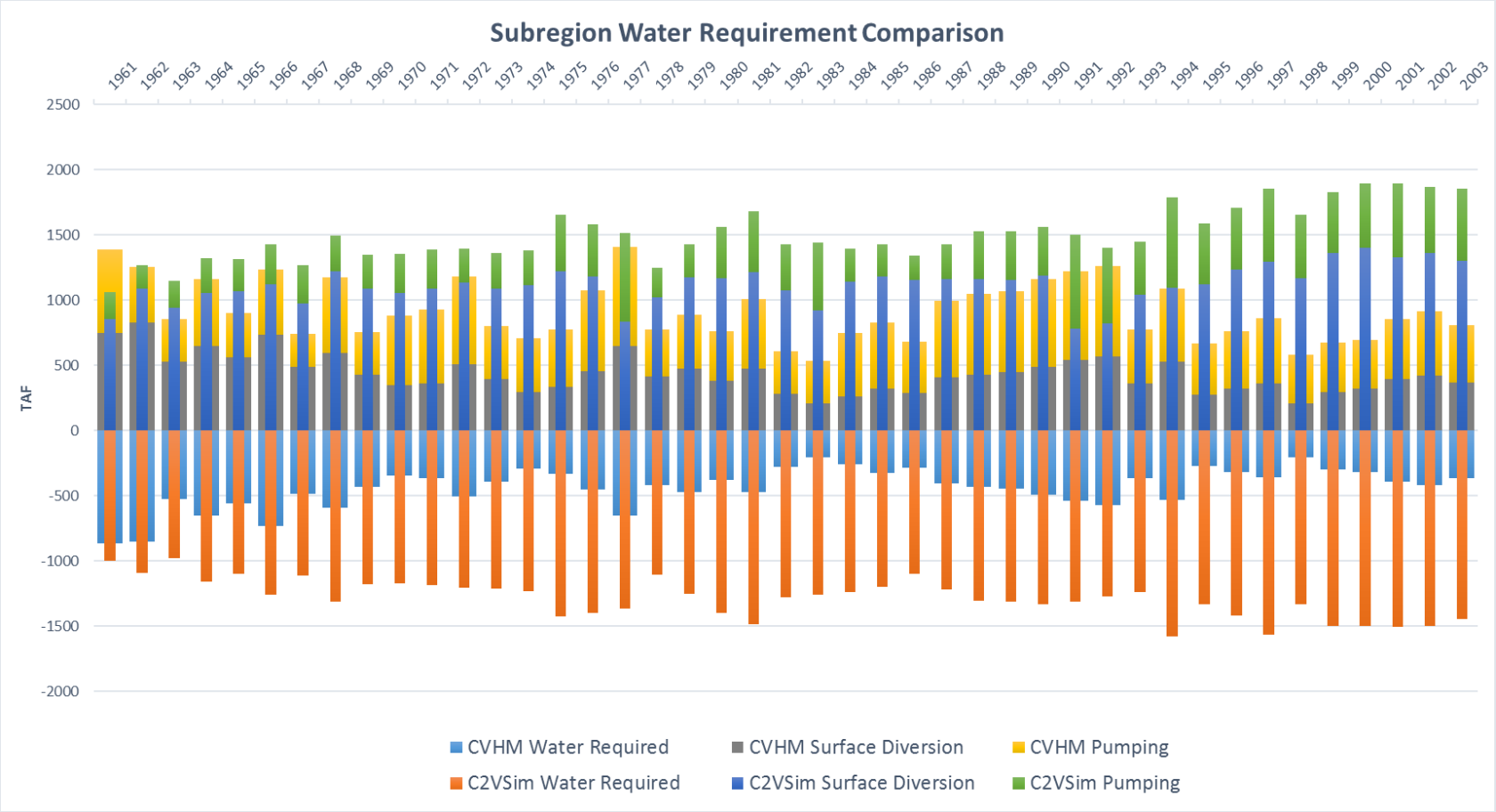
	CVHM	C2VSim
Average Water Required	79	680
Average Surface Diversion	76	652
Average Pumping	407	135

	CVHM	C2VSim
Average GW Recharge	136	229
Average Stream Recharge	-430	-196

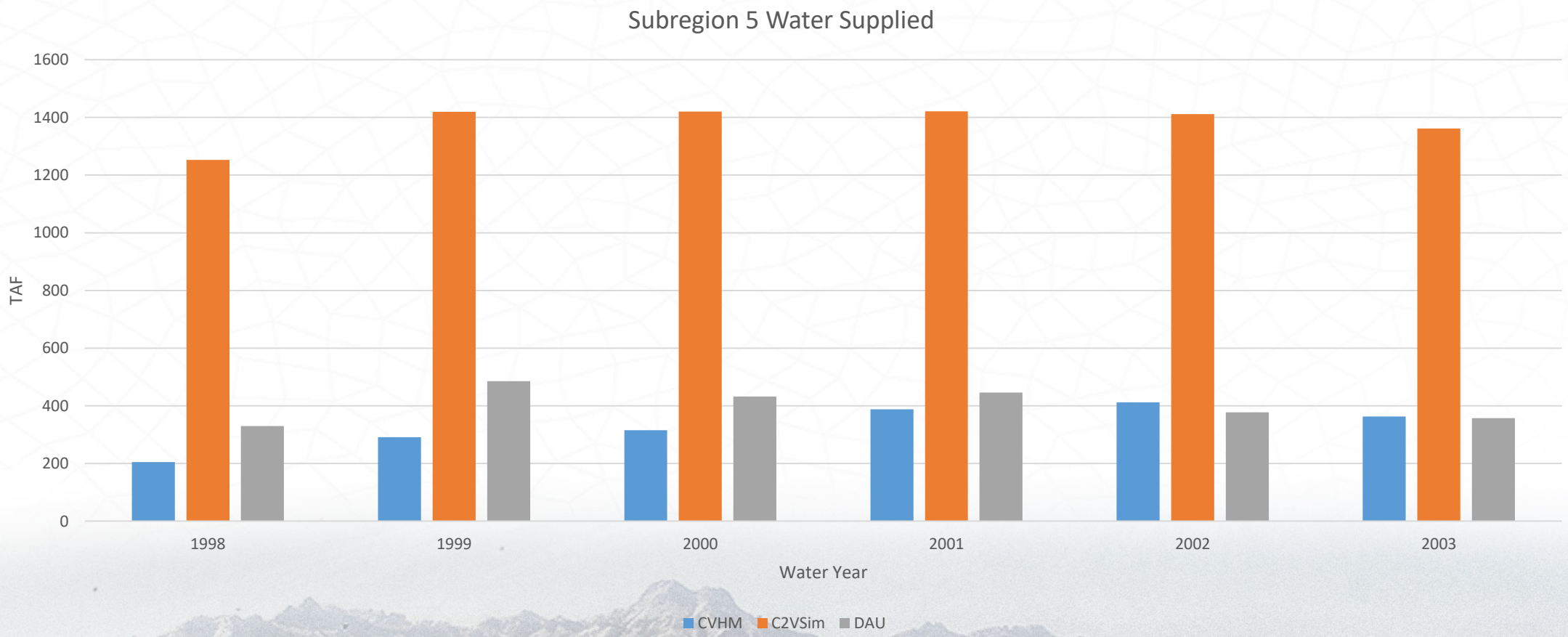
Units: TAF

Water Budget: Subregion 5

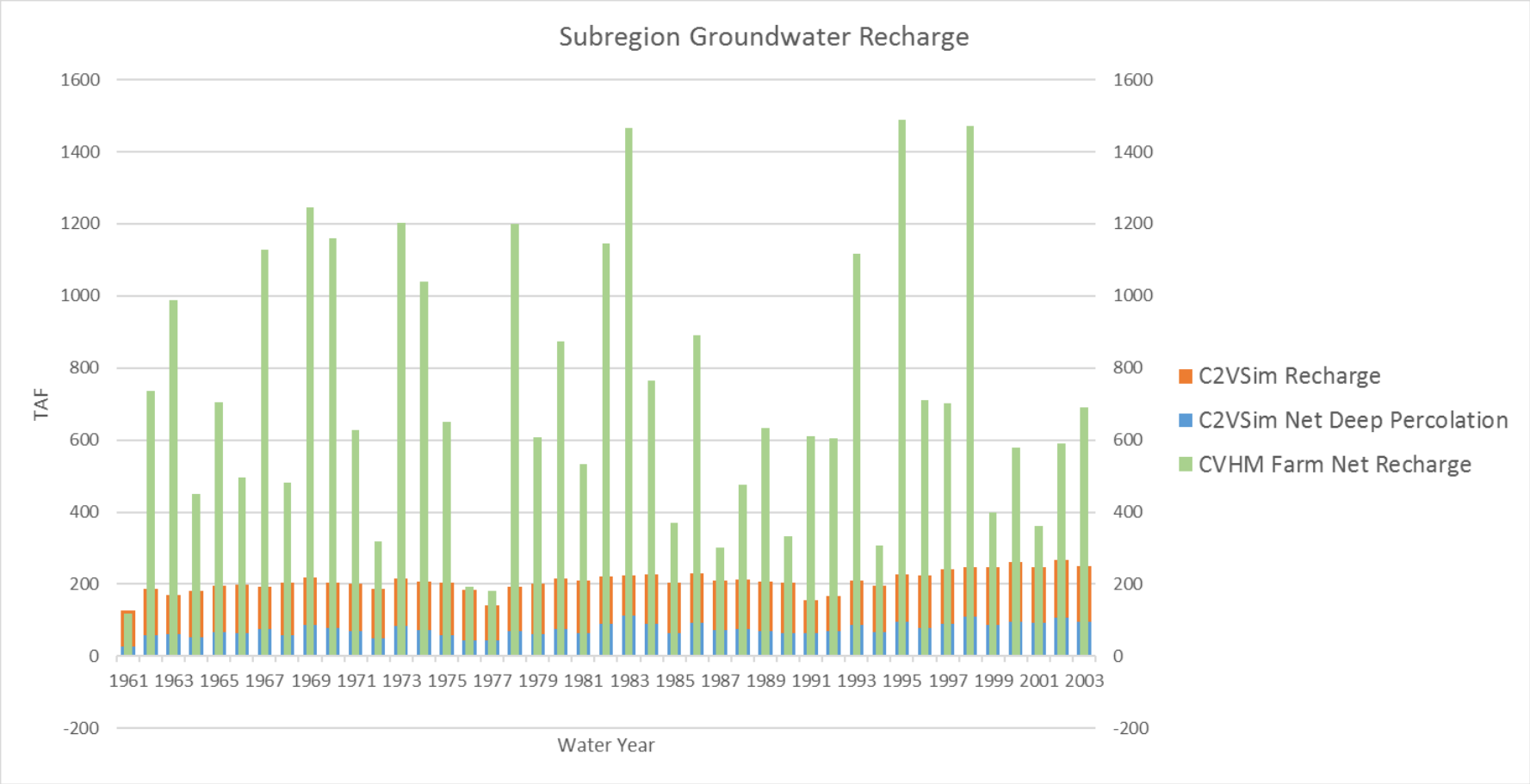




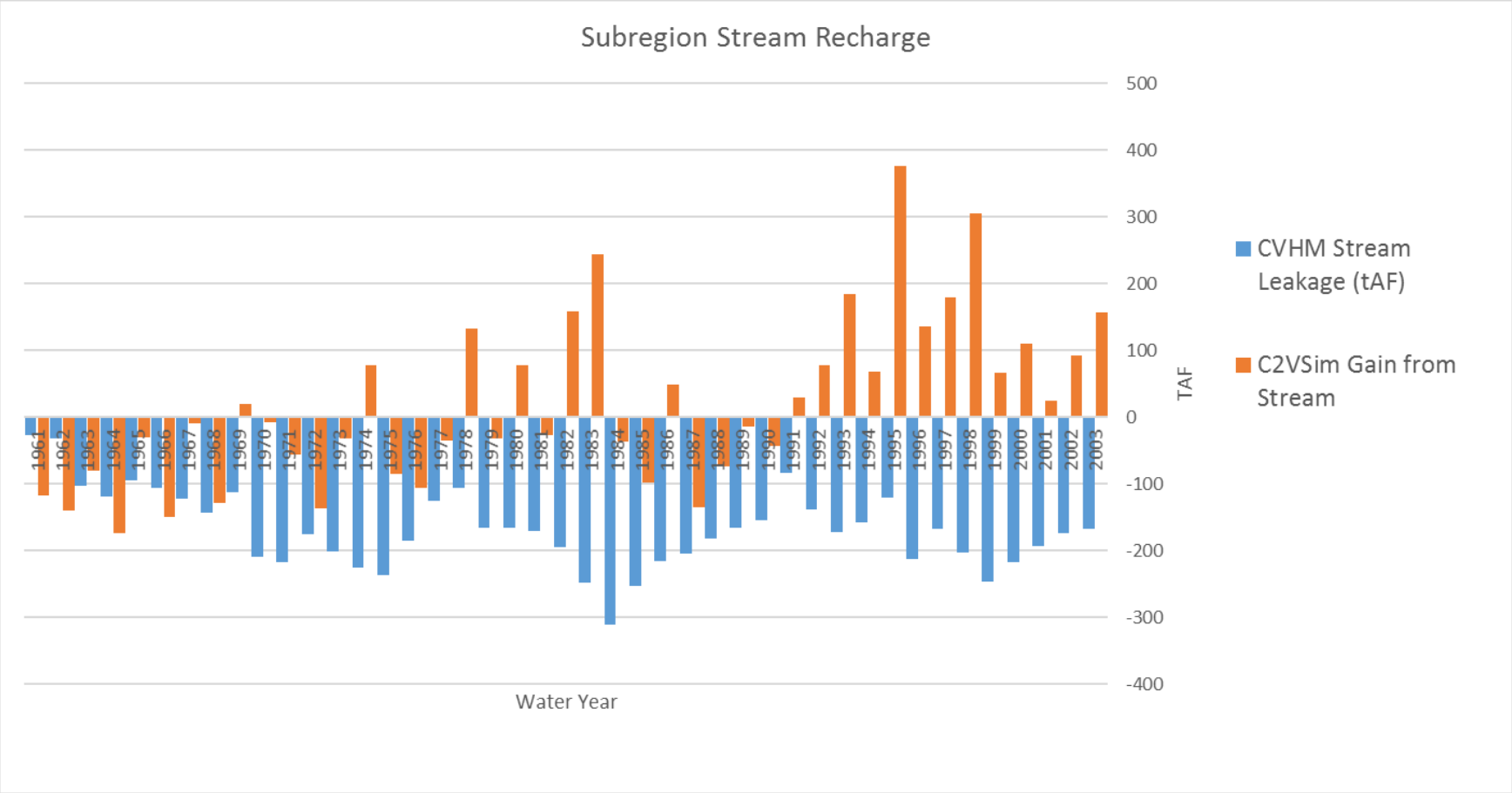
Water Budget: Subregion 5



Water Budget: Subregion 5



Water Budget: Subregion 5



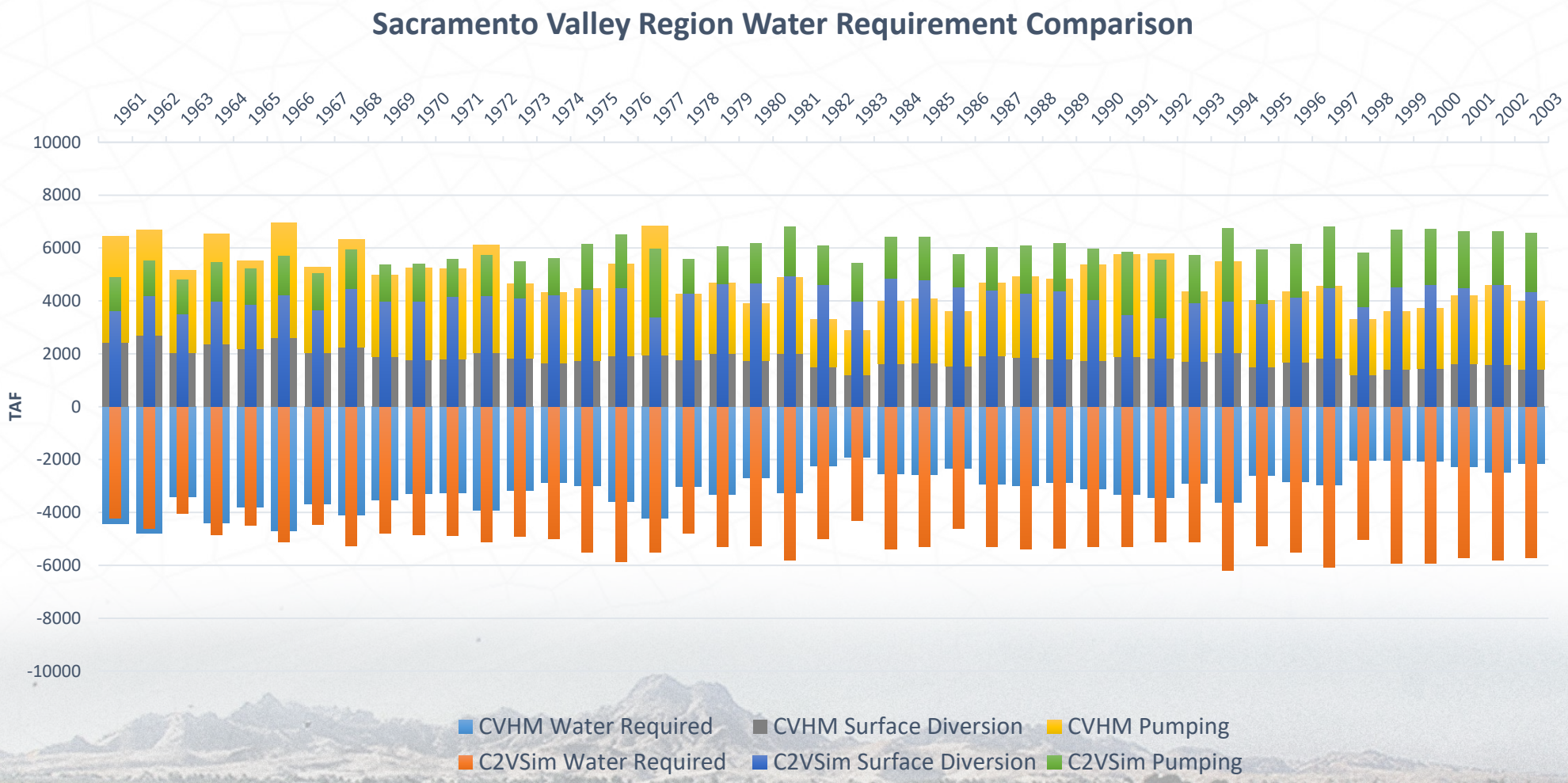
Water Budget: Subregion 5

	CVHM	C2VSim
Average Water Required	439	1,288
Average Surface Diversion	434	1,119
Average Pumping	483	382

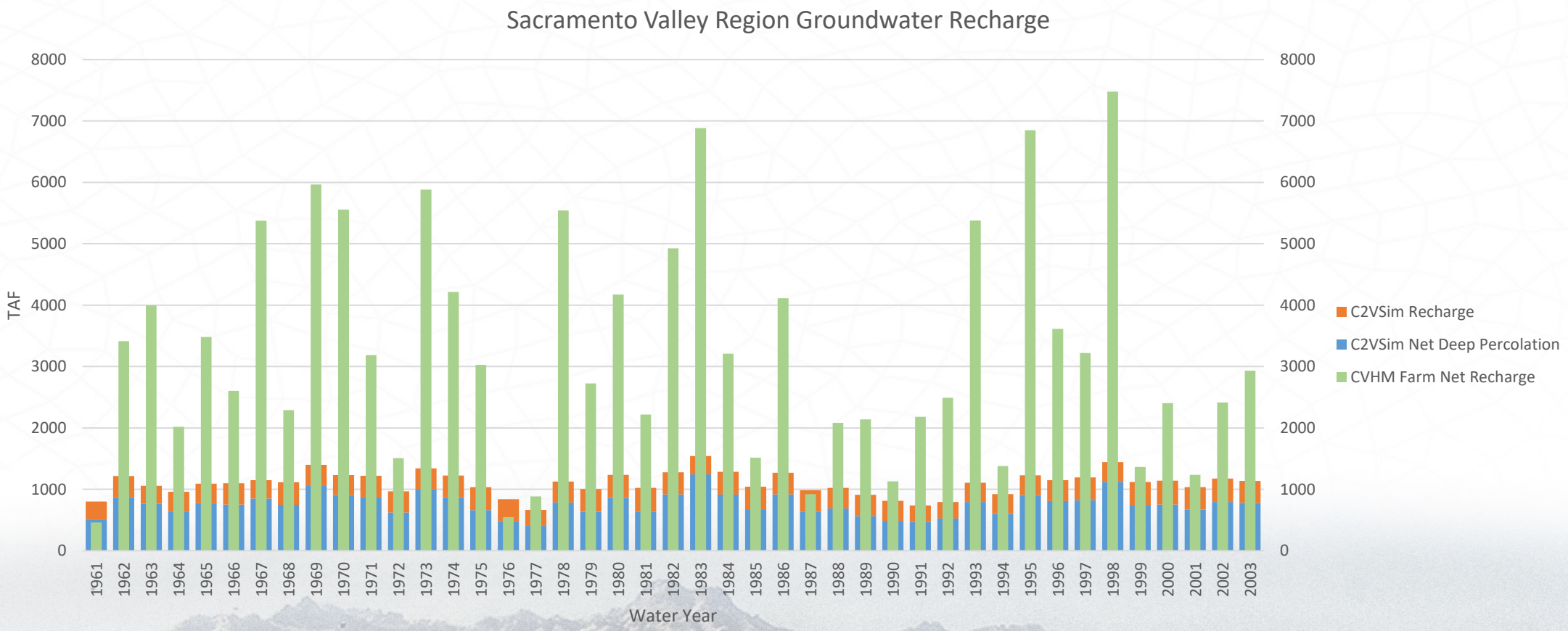
	CVHM	C2VSim
Average GW Recharge	720	207
Average Stream Recharge	-168	-19

Units: TAF

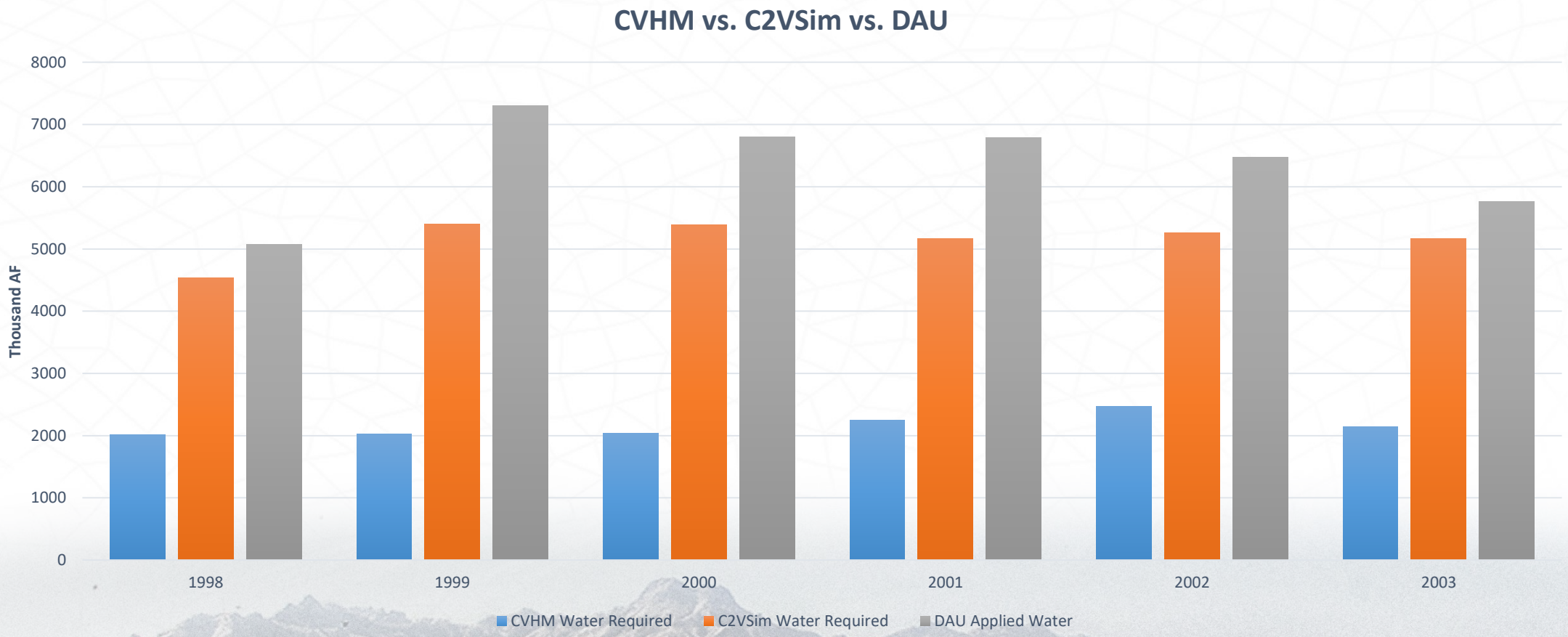
Sacramento Valley Region Agricultural Water Demand



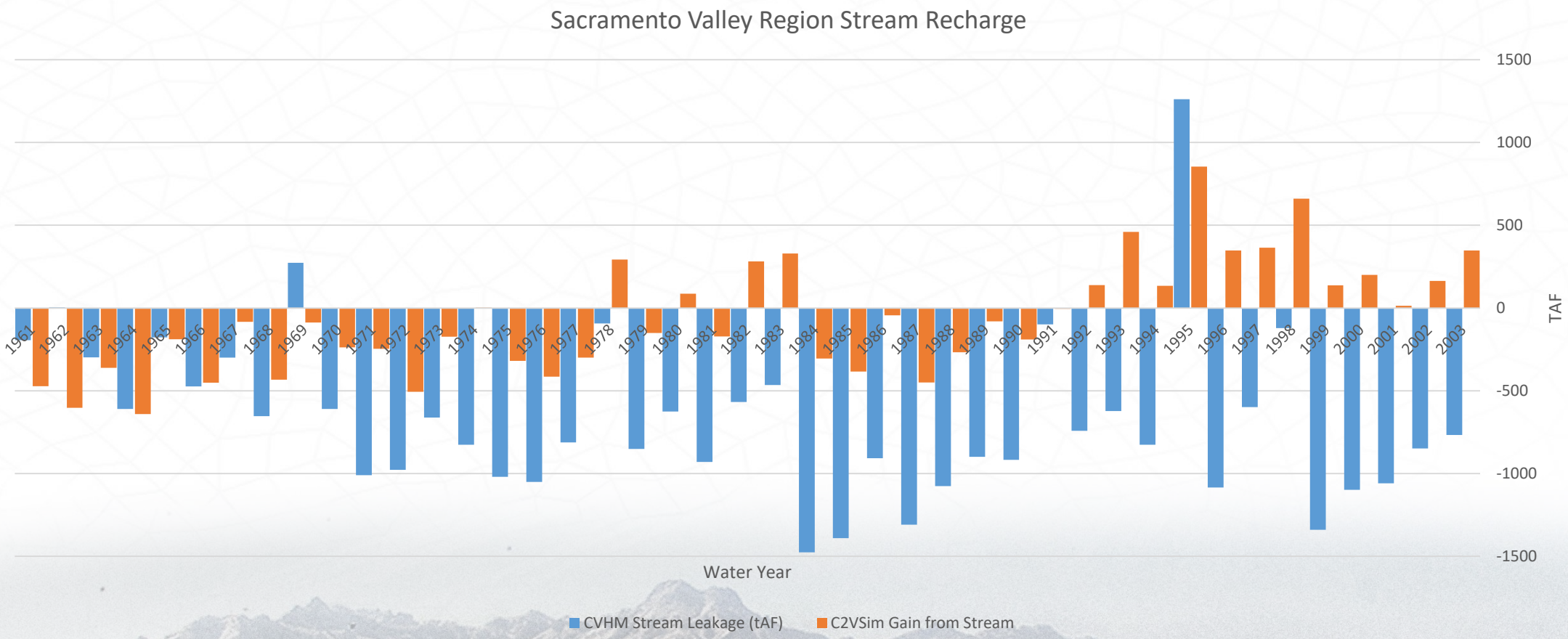
Sacramento Valley Region Groundwater Recharge



Water Budget: Sacramento Valley Region CVHM(TFDR-FIN), C2VSim(Ag Supply Req), DAU(AW)



Sacramento Valley Region Stream Recharge



Water Budget: Sacramento Valley
(Subregions 2, 3, 4, and 5)

	CVHM	C2VSim
Average Water Required	1,928	3,491
Average Surface Diversion	1,339	3,126
Average Pumping	1,853	948

	CVHM	C2VSim
Average GW Recharge	2,384	876
Average Stream Recharge	-1,021	-338

Units: TAF

Water Budget: Sacramento Valley

	CVHM	C2VSim
Average Water Required	3,130	5,190
Average Surface Diversion	1,835	4,200
Average Pumping	3,030	1,732

	CVHM	C2VSim
Average GW Recharge	3,231	1,095
Average Stream Recharge	-671	-64

Units: TAF

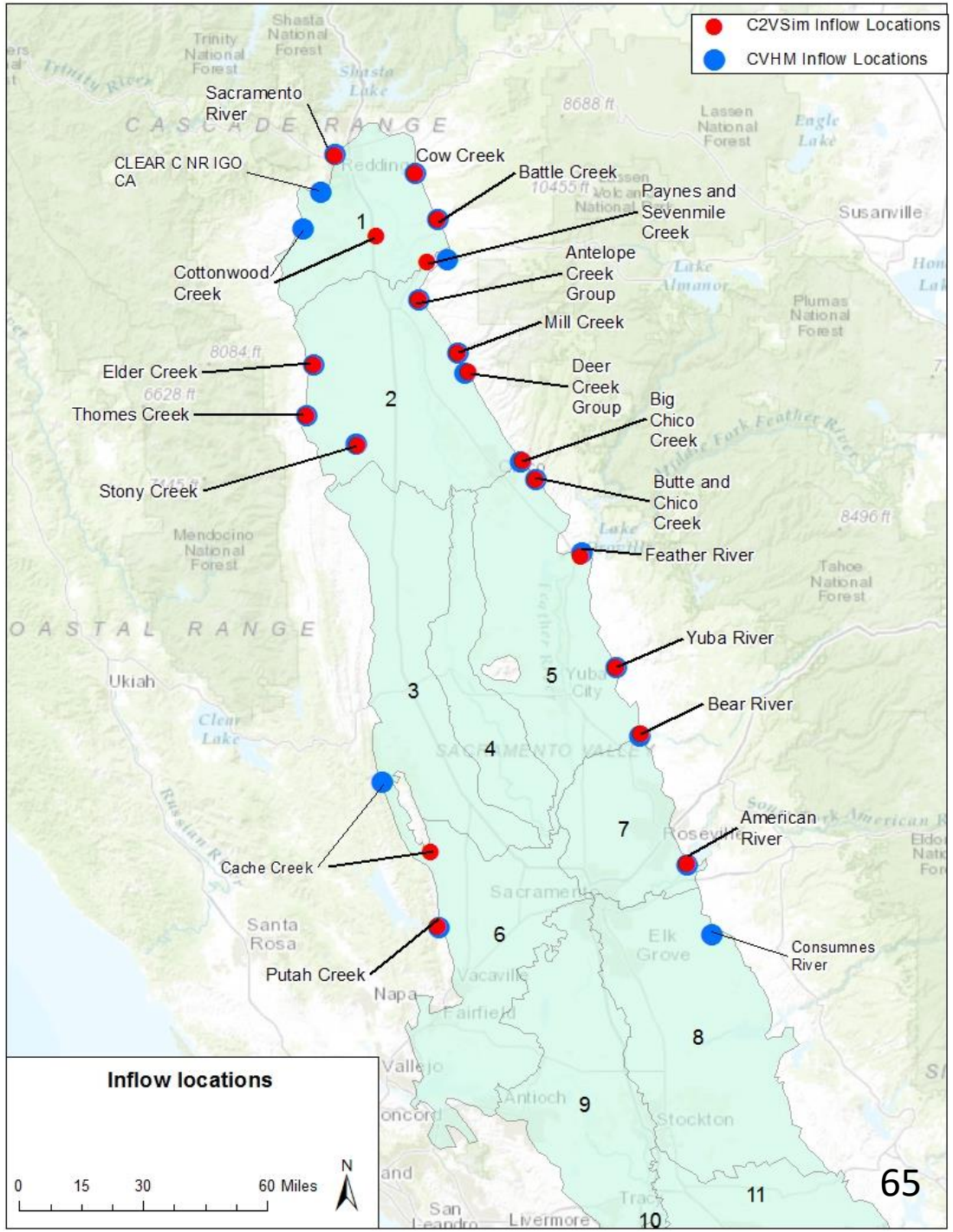
Agenda

- Recap of previous meetings
- Models Comparison
  - Land use / Cropping
  - Water Budget
    - Ag Water Demand
    - Water Supply
    - Recharge
    - Stream Seepage
  - **Surface Water Inflows**
  - Calibration
    - Hydrographs at selected wells
- Discussion
  - Model recommendations or assistance in model recommendations

Source of Data

- C2VSim
  - CVinflow.dat file (river names, and monthly inflow data 1921 to 2009)
- CVHM
  - SFR.txt file (river names, inflow location, and monthly inflow 1961 to 2003)

Stream Inflow Location



RMC water and environment
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Stream Inflow Data Comparison

Average Annual Inflow between Water Year 1962&2003					
	CVHM	C2VSim		CVHM	C2VSim
1962	15.29	14.57	1983	46.71	43.49
1963	24.05	23.34	1984	27.45	26.14
1964	14.37	12.82	1985	16.08	13.30
1965	27.27	27.06	1986	27.68	26.49
1966	16.30	15.38	1987	12.83	11.51
1967	27.54	26.69	1988	12.87	11.27
1968	16.26	14.42	1989	14.41	13.25
1969	29.15	26.99	1990	12.20	11.12
1970	28.91	27.45	1991	9.61	8.75
1971	25.25	24.16	1992	10.40	9.10
1972	15.80	14.31	1993	18.41	19.24
1973	23.38	21.73	1994	12.53	10.74
1974	38.05	36.64	1995	36.44	34.53
1975	22.10	20.59	1996	27.25	24.68
1976	13.76	12.92	1997	30.93	29.47
1977	8.52	7.51	1998	36.03	33.17
1978	19.87	18.26	1999	24.62	23.14
1979	15.46	13.40	2000	22.28	20.60
1980	24.98	24.00	2001	13.23	11.51
1981	14.66	12.43	2002	15.02	13.52
1982	36.83	34.24	2003	19.50	18.25
Units:	mAFY				

Average Stream Inflow Comparison (million AF/year) 1961-2003

River	CVHM	C2VSim	River	CVHM	C2VSim
Sacramento River	7.34	7.36	Antelope Creek Group	0.23	0.23
Clear Creek	0.13	#N/A	Mill Creek	0.23	0.23
Cottonwood Creek	0.66	0.67	Deer Creek Group	0.42	0.41
Elder Creek	0.14	0.08	Big Chico Creek	0.11	0.11
Thomes Creek	0.26	0.24	Butte and Chico Creek	0.39	0.39
Stony Creek	0.48	0.42	Feather River	4.20	3.58
Cache Creek	0.56	0.34	Yuba River	1.86	1.90
Putah Creek	0.35	0.35	Bear Creek Group	0.07	0.07
Cow Creek	0.51	0.51	American River	2.75	2.72
Battle Creek	0.37	0.37	Cosumnes River	0.40	#N/A
Paynes and Sevenmile Creek	0.06	0.06	Units:	mAFY	

Agenda

- Recap of previous meetings
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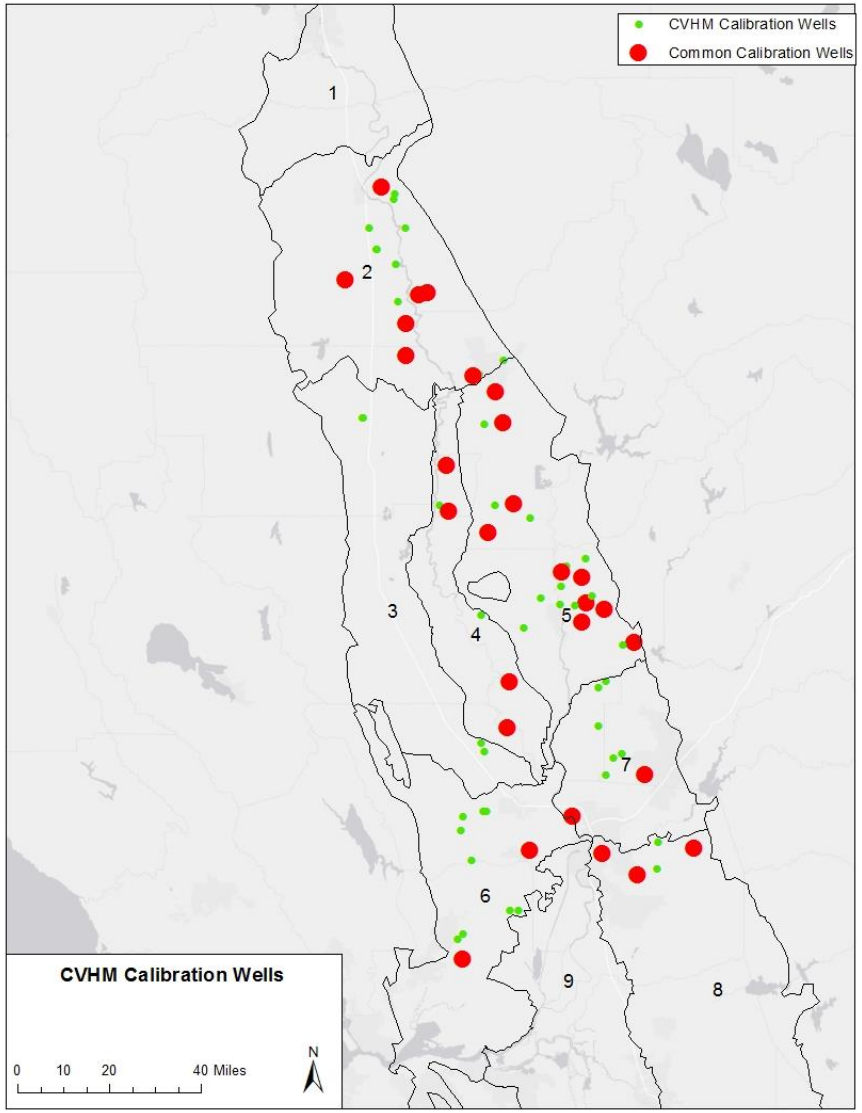
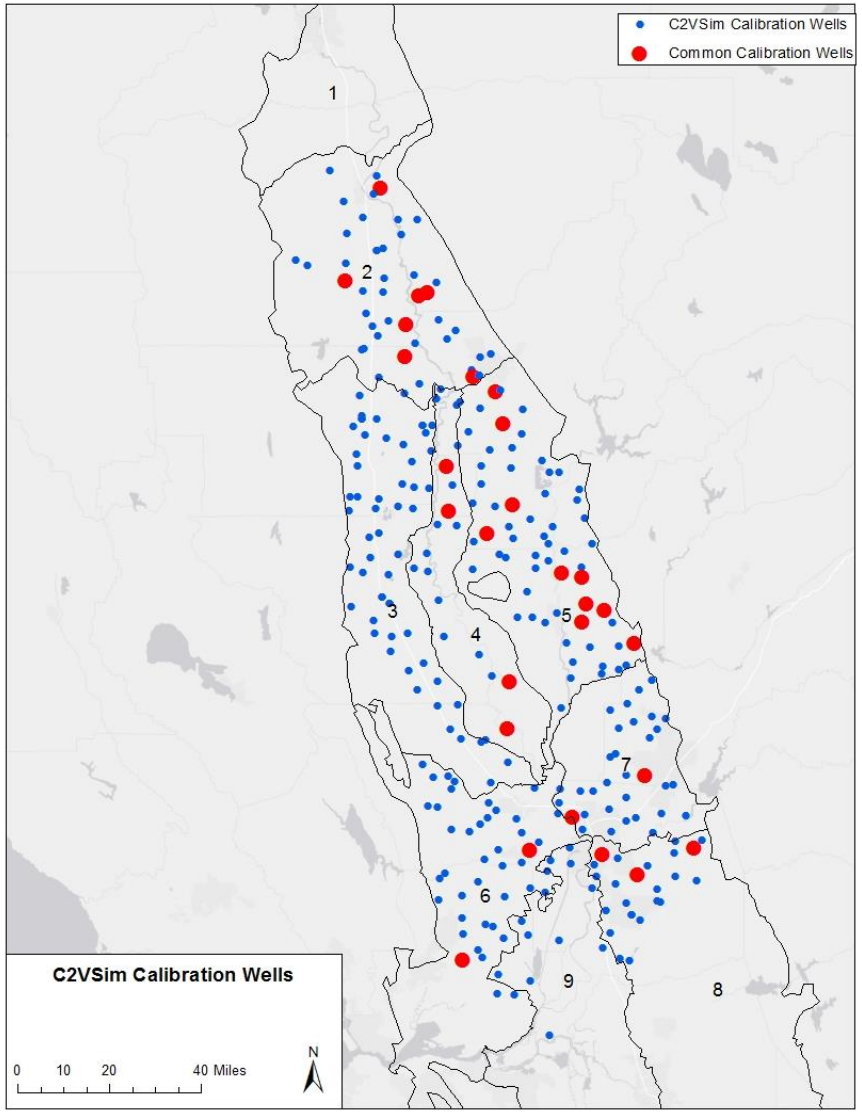
  - Water Budget
    - Ag Water Demand
    - Water Supply
    - Recharge
    - Stream Seepage
  - Surface Water Inflows
  - **Calibration**
    - **Hydrographs at selected wells**
- Discussion
  - Model recommendations or assistance in model recommendations

Model Calibration
Source of Data

- C2VSim
  - Cvprint.dat (wells names and locations)
  - CVGWhyd.out (monthly simulated groundwater levels)
- CVHM
  - HYDMOD.txt (wells names and locations)
  - Hydro2.gwh (monthly simulated groundwater levels)
- Ground Surface Elevations
  - Google Earth

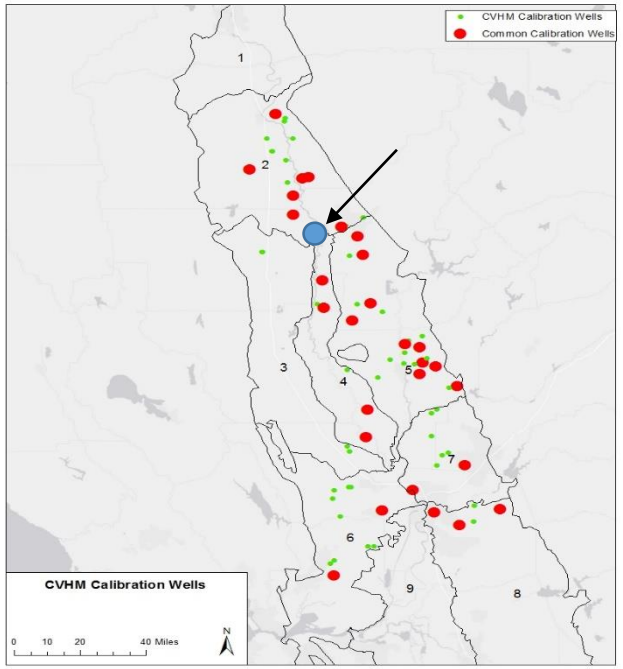
Model Calibration

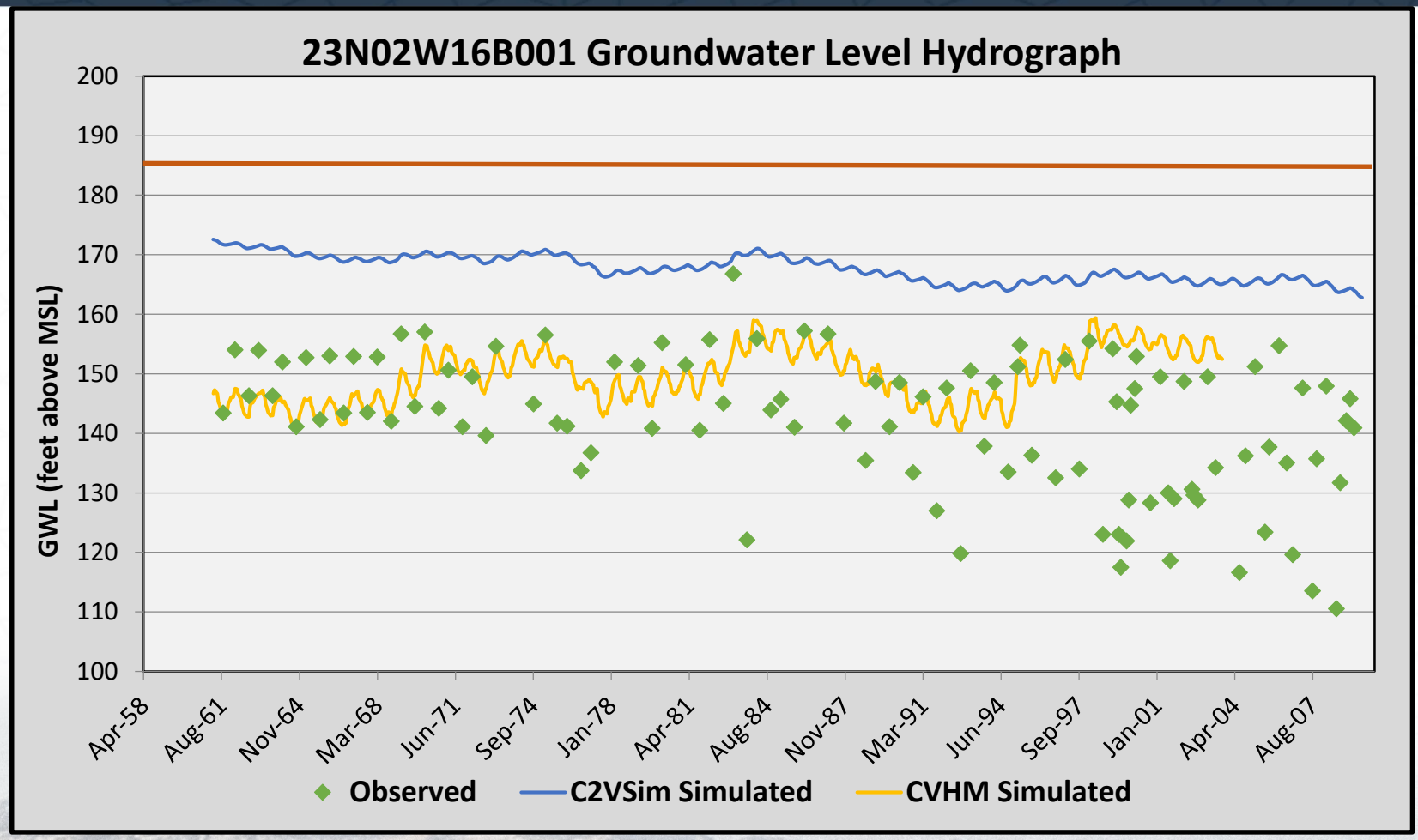




Model Calibration

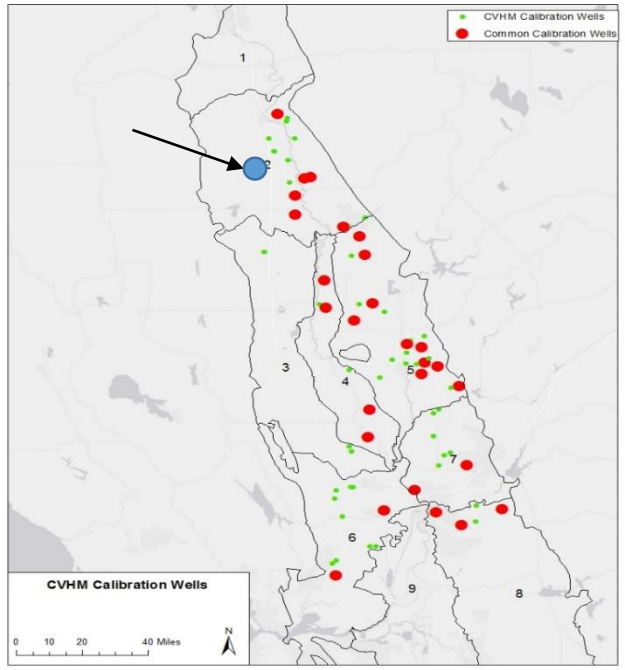
- Active Irrigation
- Shallow (100 – 120 ft)

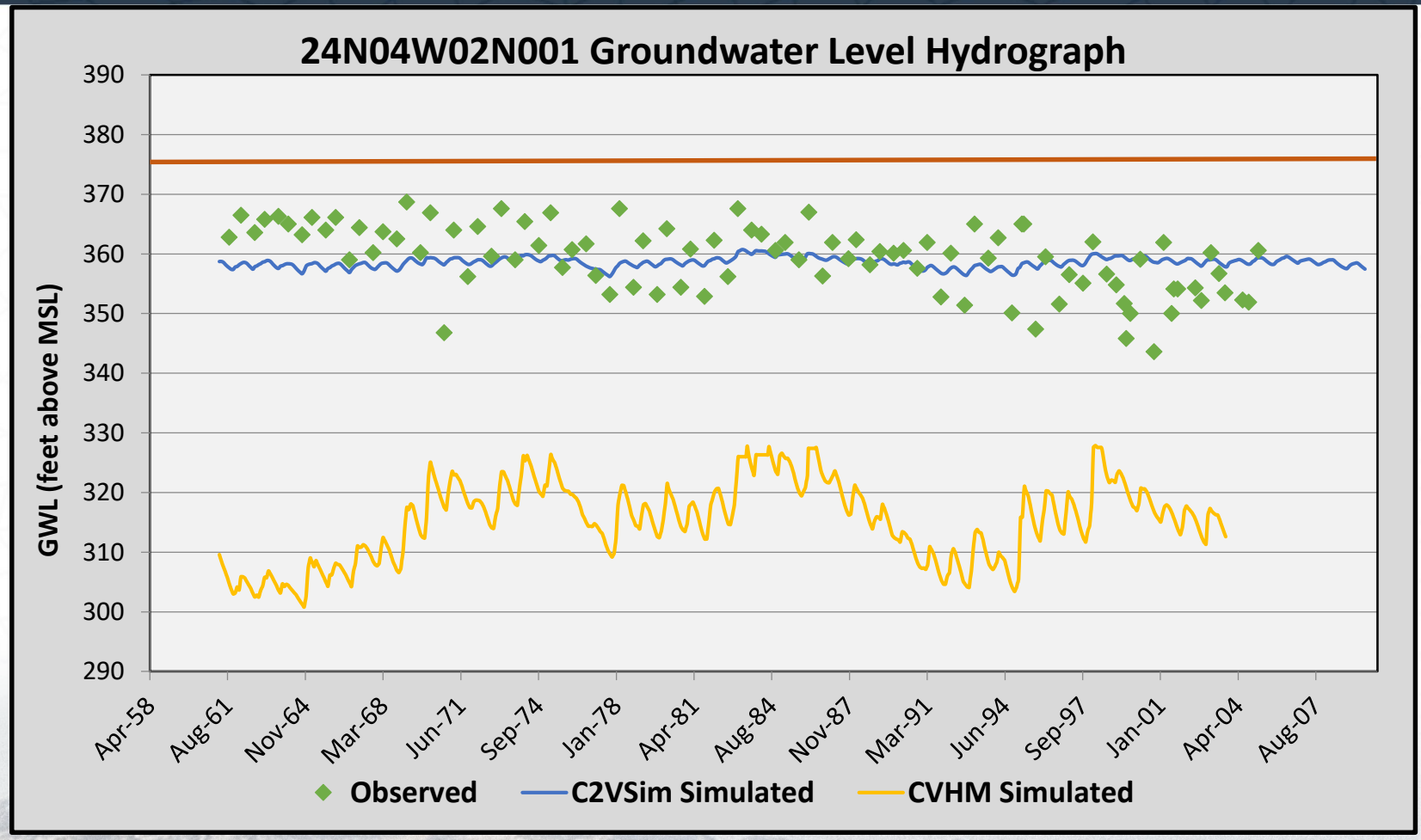




Model Calibration

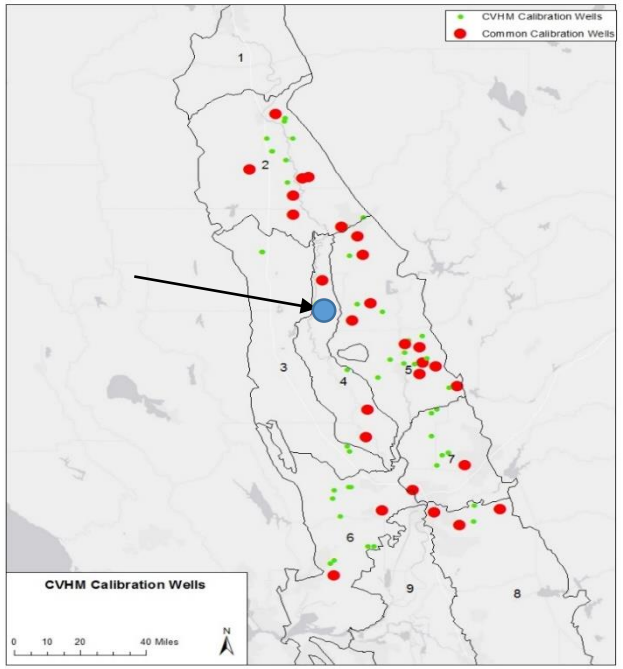
- Inactive Residential
- Shallow (30 – 90 ft)

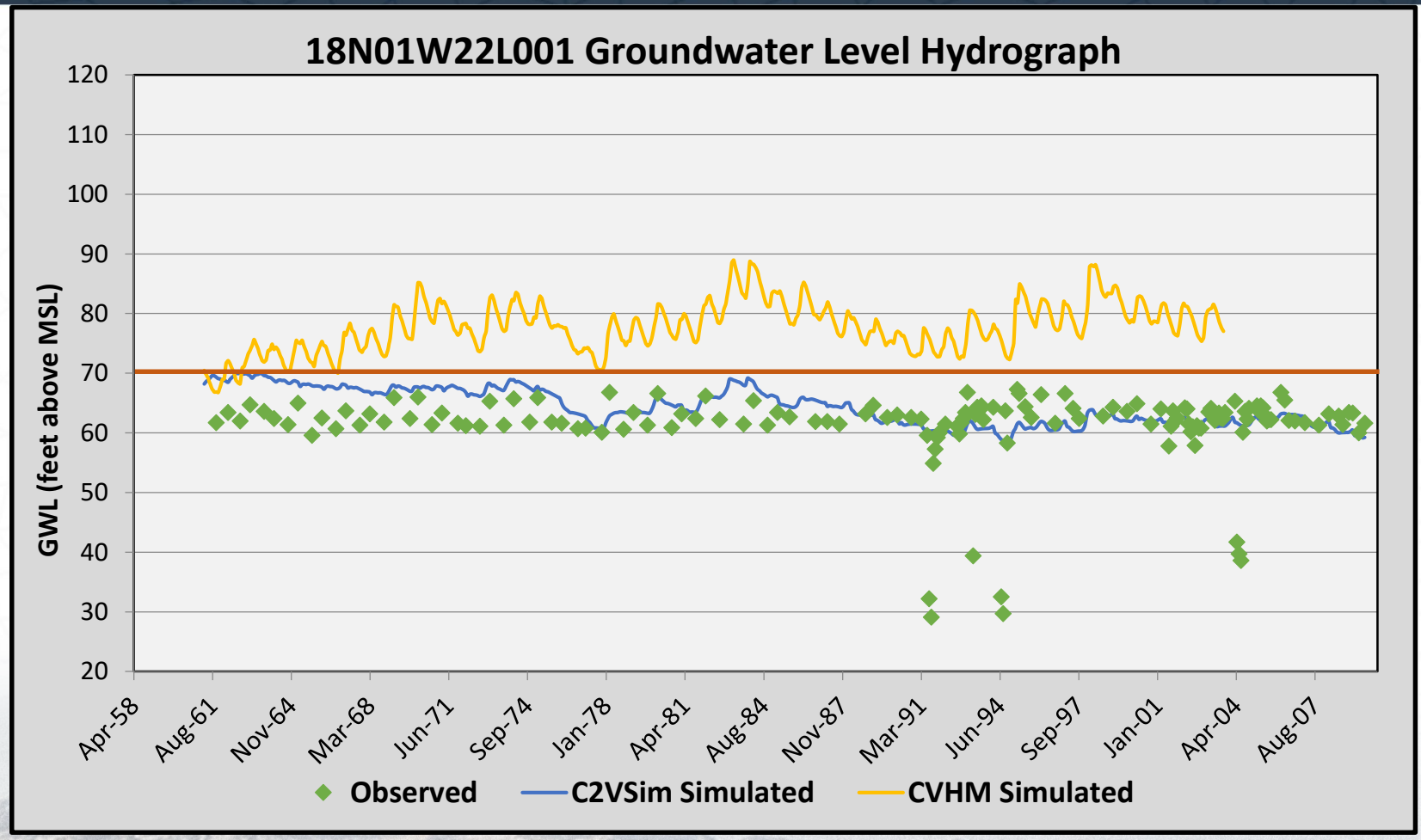




Model Calibration

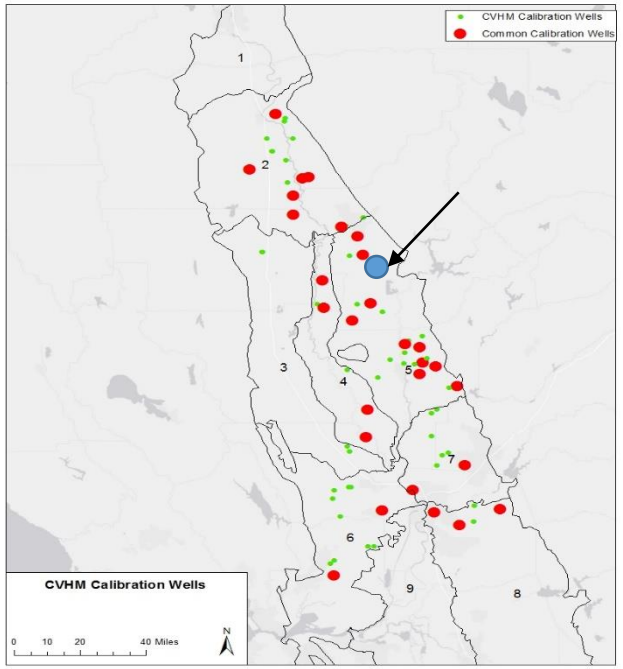
- Active Irrigation
- Shallow (76 – 92 ft, 108 – 124 ft)

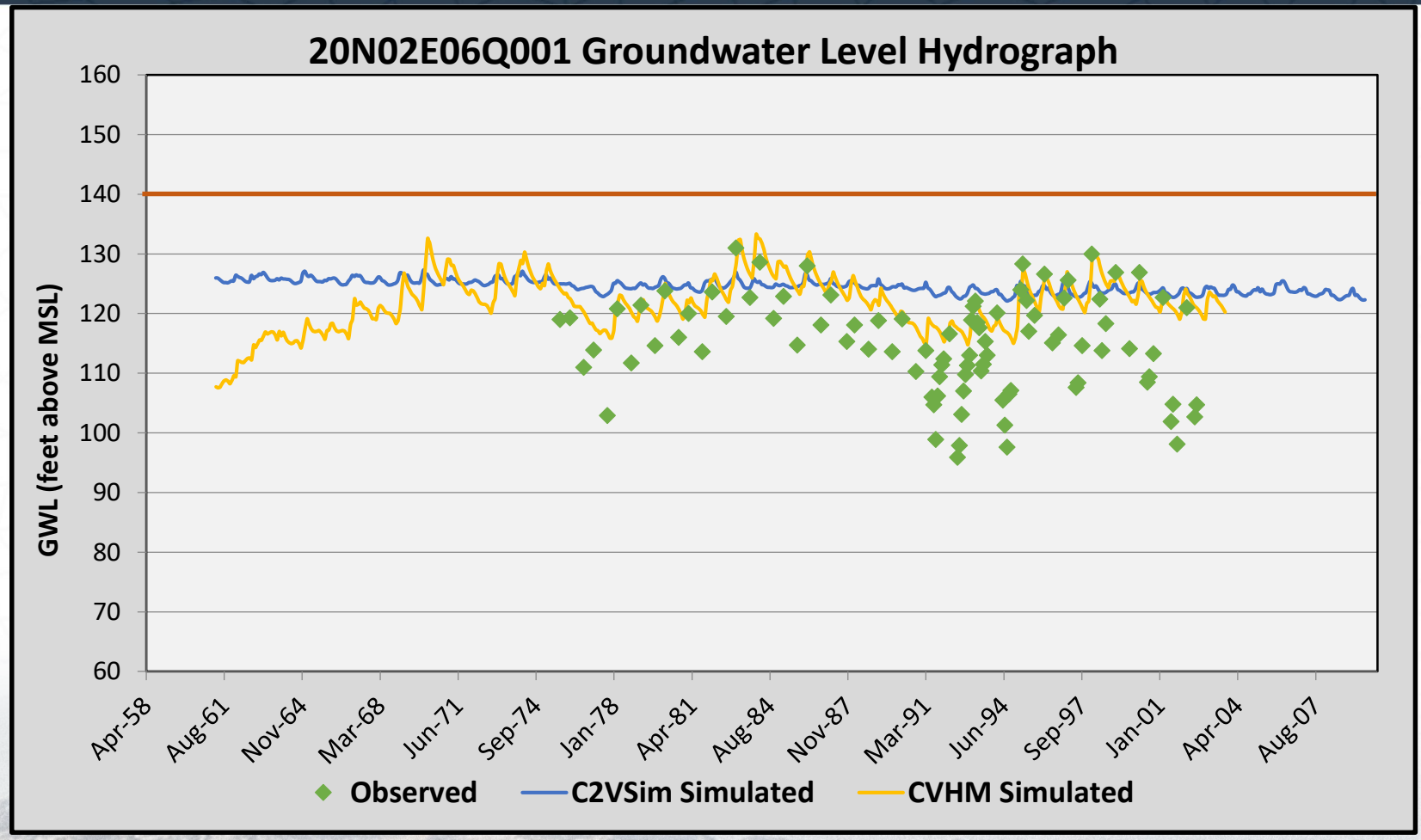




Model Calibration

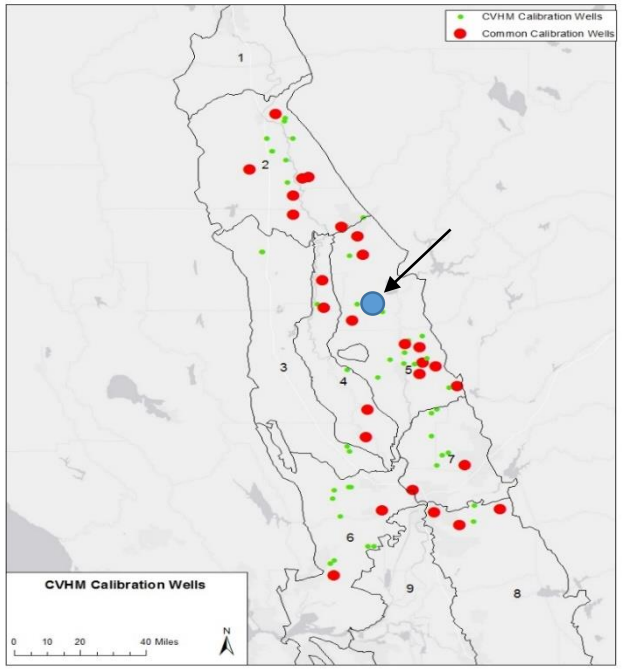
- Active Irrigation
- Shallow (10 – 44 ft)

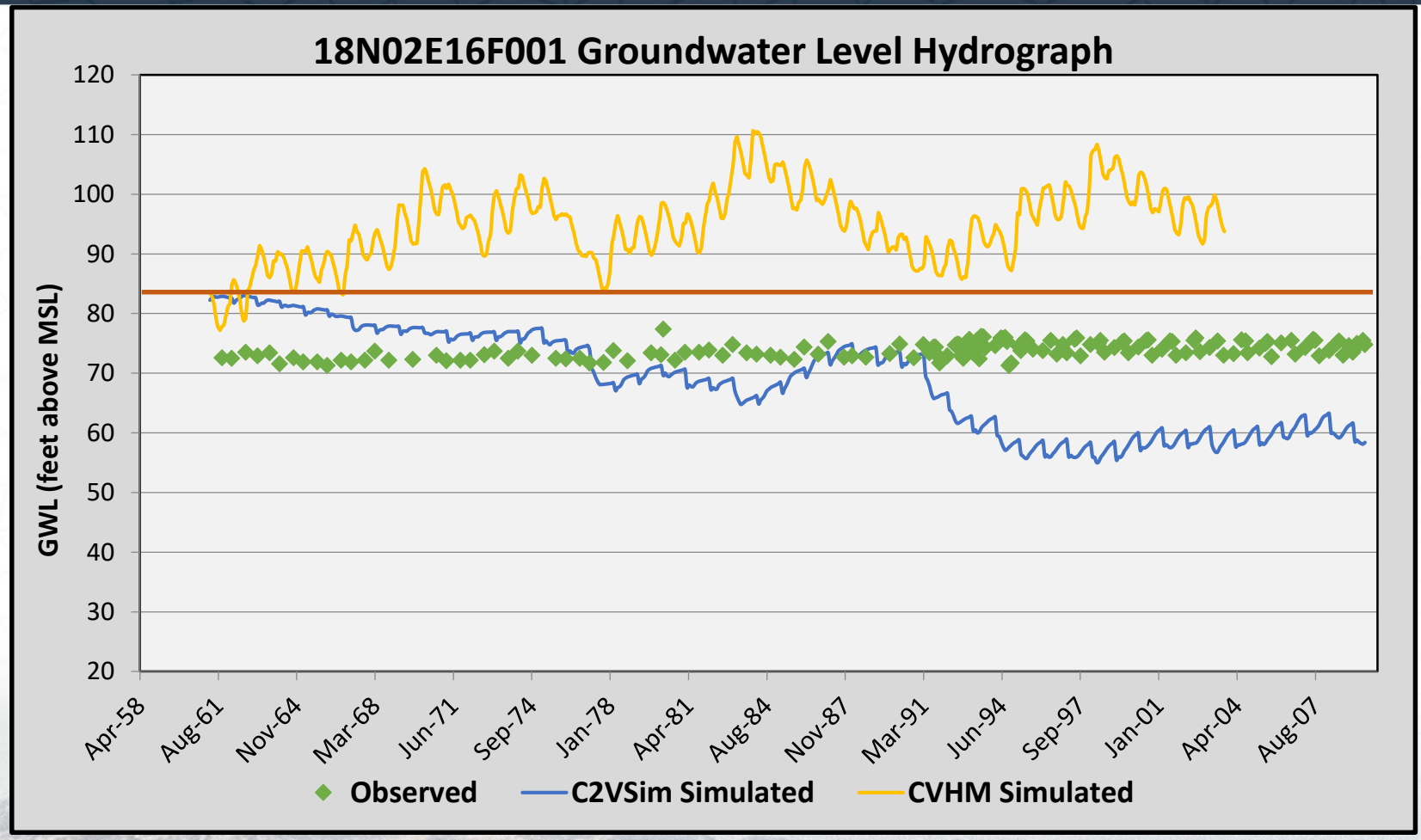




Model Calibration

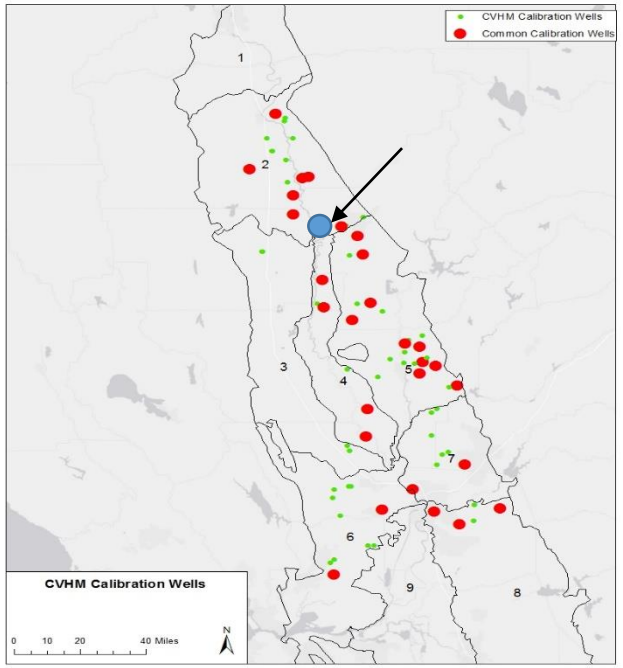
- Active Irrigation
- Shallow (20 – 60 ft)

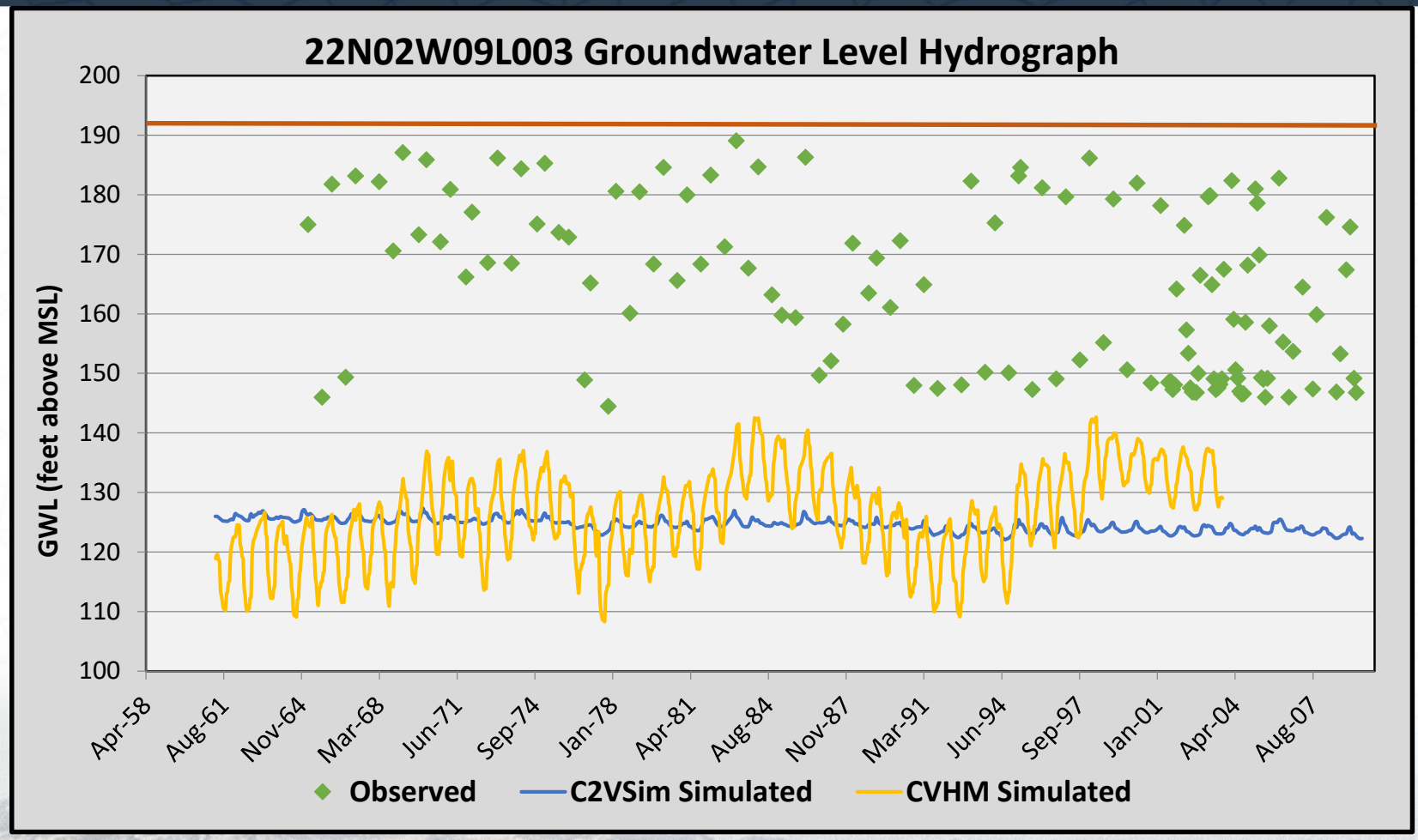




Model Calibration

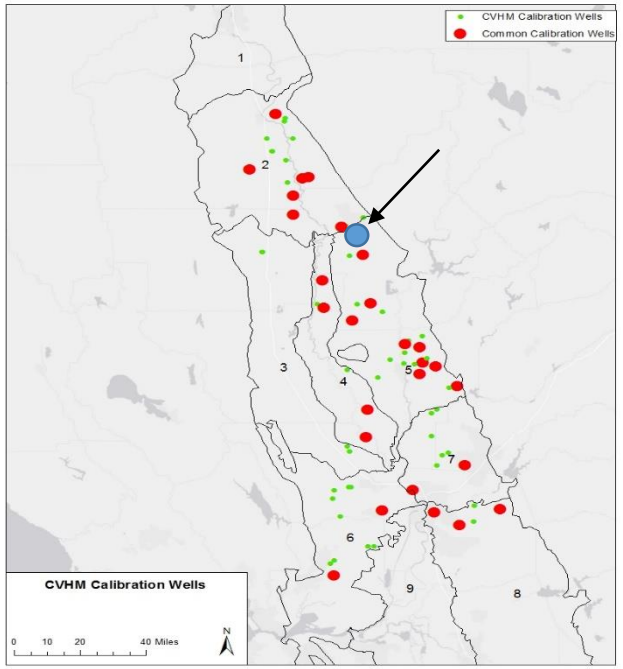
- Active Irrigation
- Intermediate

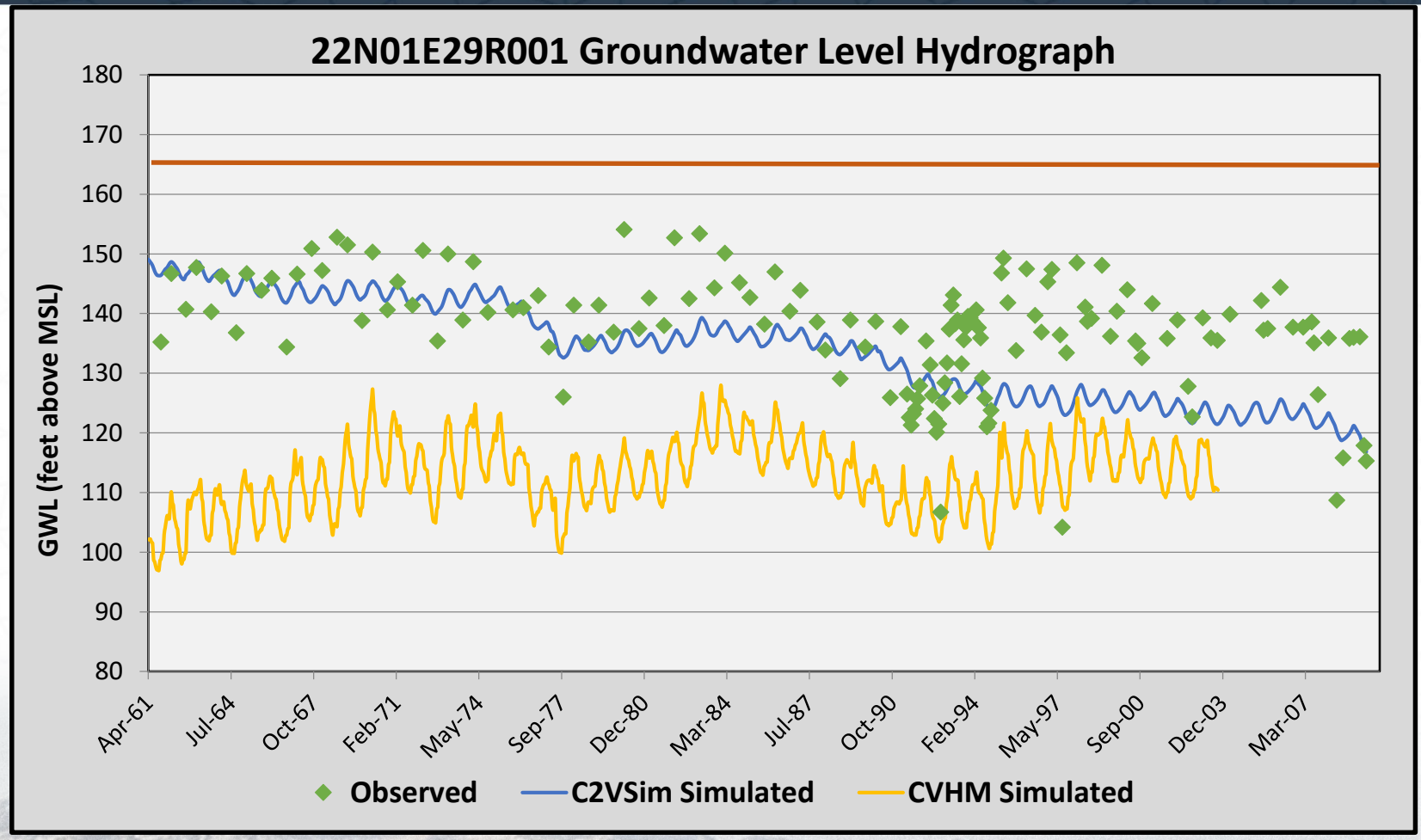




Model Calibration

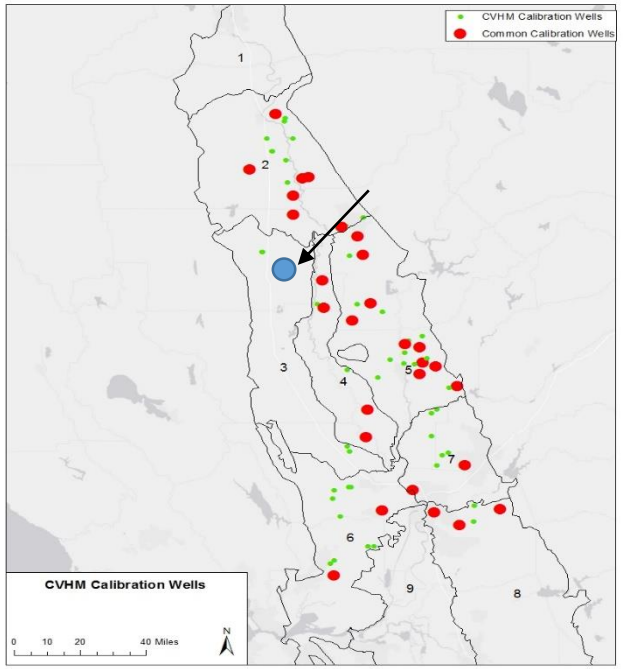
- 22N01E28J001 was used for CVHM
- Observation
- Intermediate (460 – 559 ft)

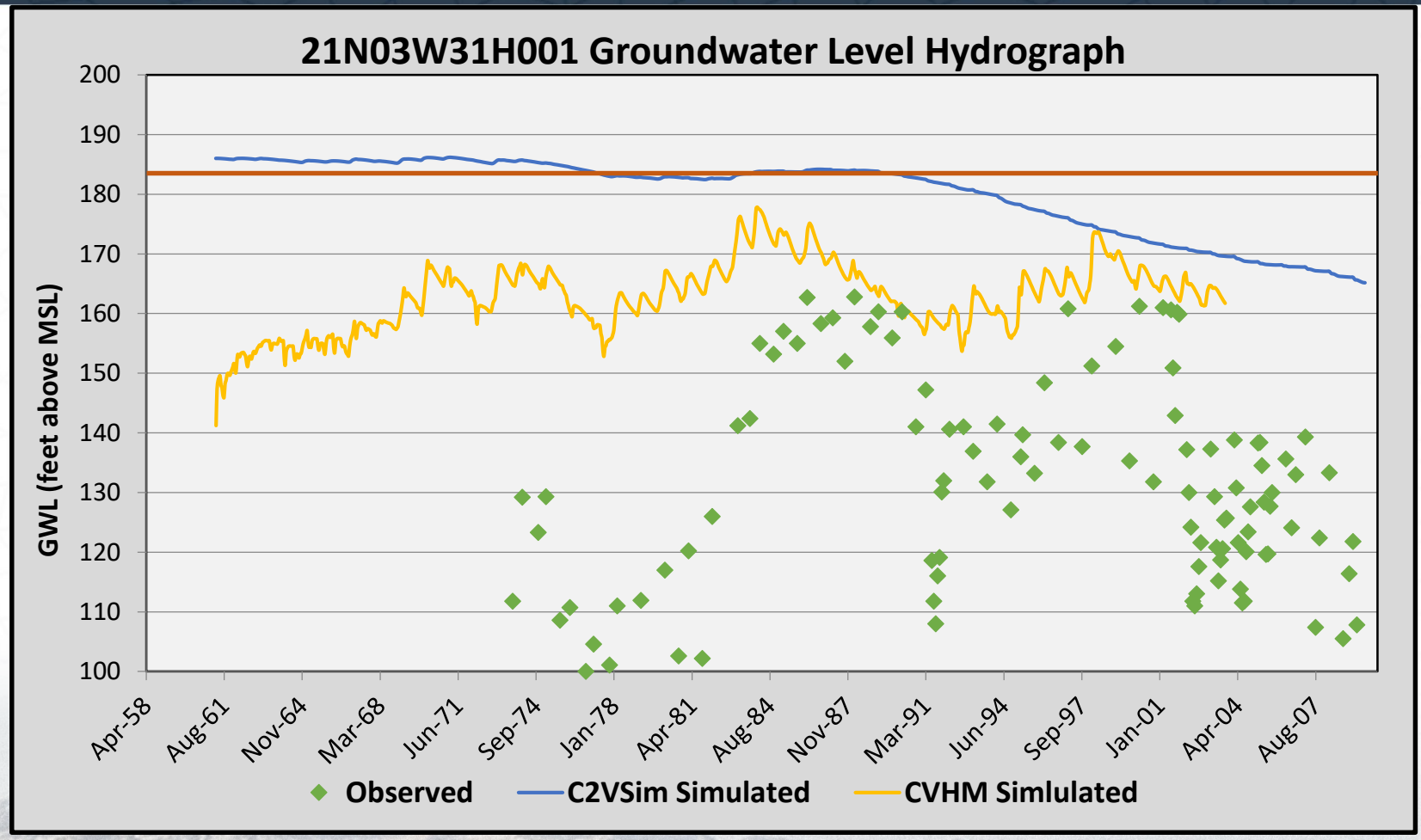




Model Calibration

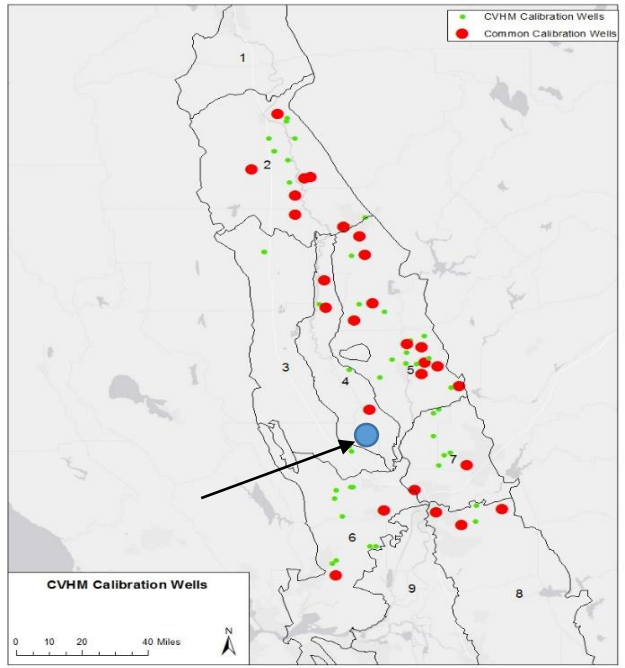
- 21N03W31R002 was used for CVHM
- Inactive, unknown type
- Intermediate (270 – 410 ft)

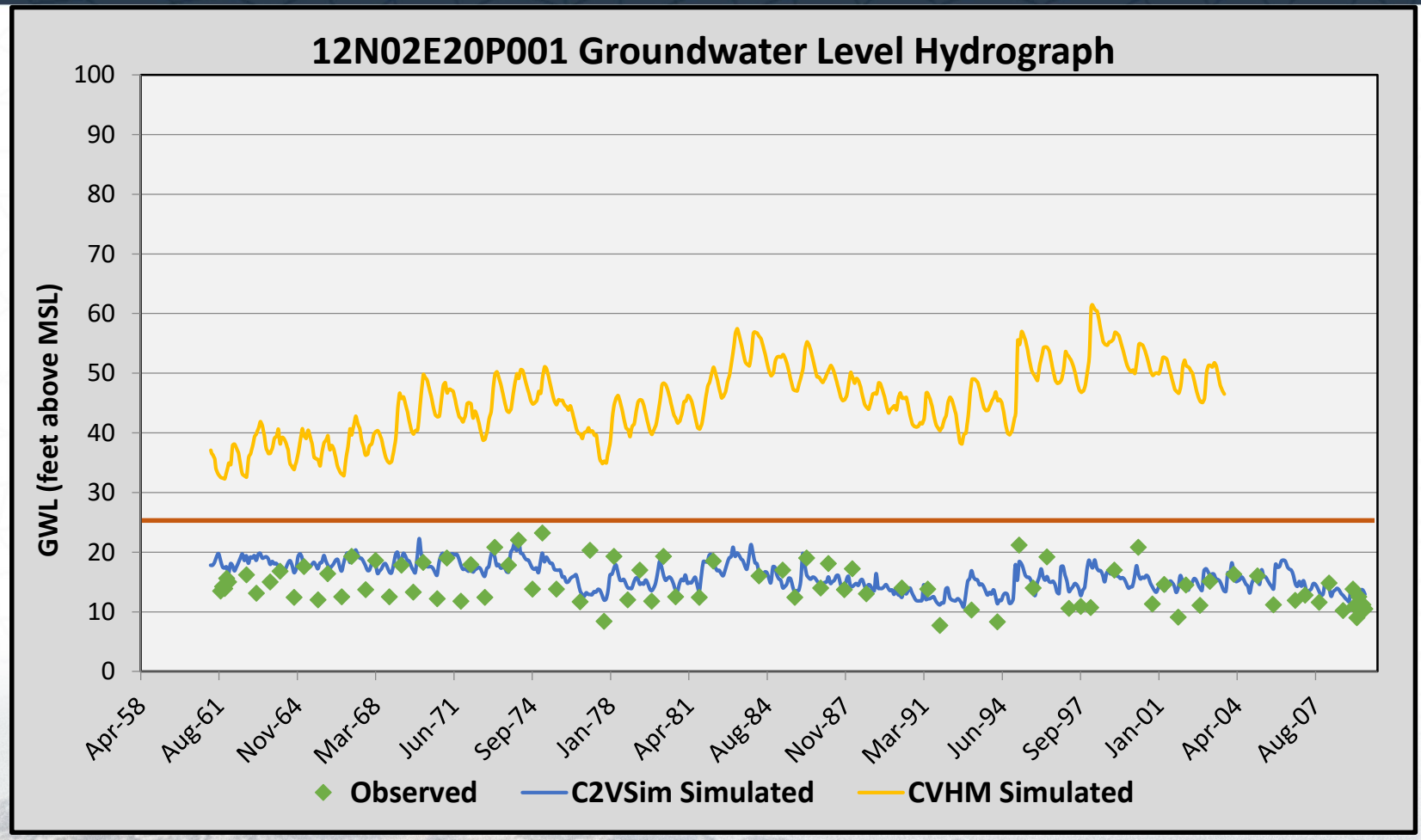




Model Calibration

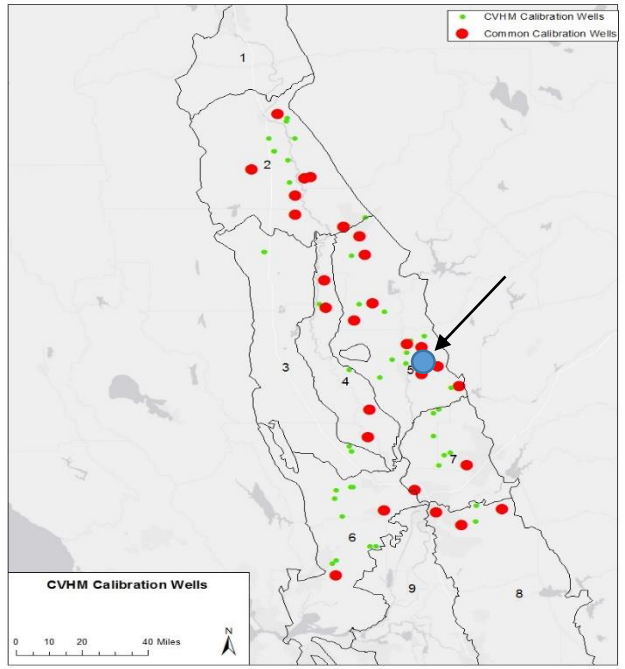
- Active, unknown type
- Intermediate (Total Depth – 500 ft)

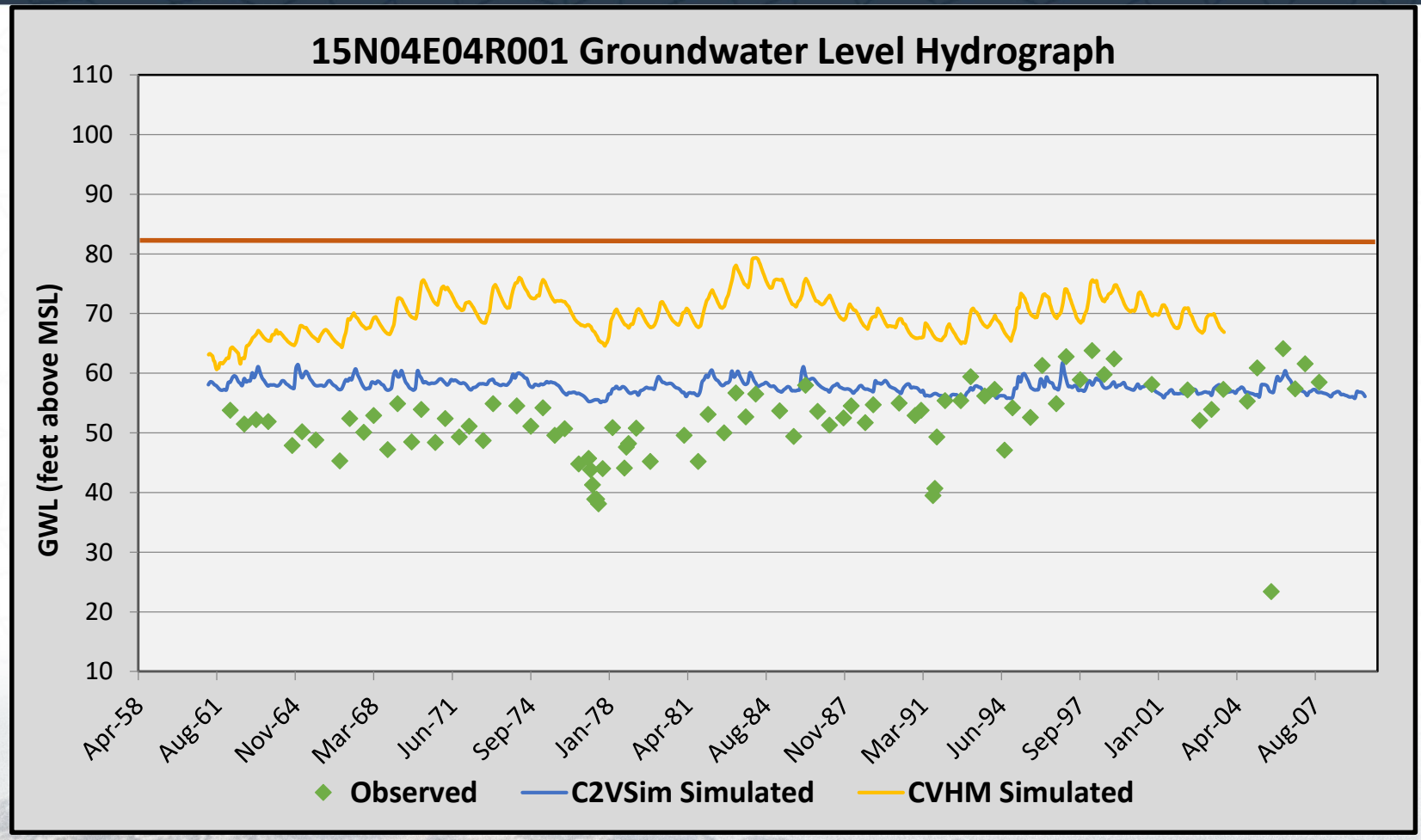




Model Calibration

- Active Irrigation
- Intermediate (Total Depth 400 ft)





Agenda

- Recap of previous meetings
- Models Comparison
  - Land use / Cropping
  - Water Budget
    - Ag Water Demand
    - Water Supply
    - Recharge
    - Stream Seepage
  - Surface Water Inflows
  - Calibration
    - Hydrographs at selected wells
- **Discussion**
  - **Model recommendations or assistance in model recommendations**

Model recommendations or assistance in model recommendations?

- Can we provide a recommendation?
  - Of a model?
  - Of an approach?
  - Of focus areas?
- How do you see a GSA coming to a conclusion on model selection?

Thank you.

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Interbasin GROUNDWATER FLOW Evaluation Project

Technical Collaborators Meeting 4

April 13, 2017

Agenda

- Recap of previous meetings
- Report approach and contents

Meeting #1 Recap

- **Project objectives:**
  - Local ownership of the interbasin flow evaluation process in the NSV Area
  - "Lessons learned" to DWR and others in the state
- **Overview of models** likely to be considered for this study
  - Regional: CVHM, C2VSim, SacFEM 2013
  - Local: Butte Basin Groundwater Model, Stony Creek Fan IGSM
- Certain **tools** identified as being unsuited for future use by GSAs, though they likely contain useful information that shouldn't be lost
  - SacFEM 2013, Stony Creek Fan IGSM
- Initial discussion of **project outcomes**

Project Objectives

A methodology to assess **interbasin flows**

Technical capacity
Local ownership

Methodology for **GSAs within the NSVIRWM area**

Methodology for **DWR** GSA assessments

"lessons learned" for other basins

Meeting #2 Recap

- **Model Selection:**
  - Up to GSAs to decide what model is best for what they want to do. Existing models provide bookends and a range of interbasin flows.
  - Model criteria (qualitative and quantitative) will lead evaluation of regional models
  - Define flowpath for selection, incorporating 6 Undesirable Results
- **Model Refinements:**
  - Existing models weren't designed for use in GSPs. Needs for improvement of regional models can help guide future refinement to meet needs under SGMA.
  - Local models can build off regional models
- **Model Analysis:**
  - Differences exist in definitions, methodologies, and water budgets
  - Additional information needed to guide decisions: inputs, calibration, spatially detailed water budgets

Meeting #3 Recap

- **Land Use Classifications**
  - Due to varying aggregation methods, CVHM and C2VSim have a different number of land use categories, further groupings were completed for comparative purposes.
  - The group recommends local agencies should review both models in their subregion as early records show significant differences.
- **Water Budget Comparison**
  - Budget component definitions should be reviewed for consistency across two models.
  - Large scale updates and calibrations for both models are currently underway and may address existing issues.
- **Recommendations**
  - Modeling needs are outstripping capacity, additional support and data are needed.
  - The committee recommends to USGS and DWR to formally request specific updates to each model based on local expectations and to formally document model differences.

Report Approach

- High level summary of approach and results
- Easily digestible
- Suitable for decision makers and stakeholders
- 10-20 pages
- More detailed technical information in appendices or by reference
- Executive summary to be considered

Report Approach – TC Participation

- Google Docs – Allowing TC member to provide early input
  - Initial direction / bullets,
  - Identification of appendices, and/or
  - Initial review and comment
- Entire document – All TC members
  - Review and comment

Report Outline

- Executive Summary (tentative)
- Introduction
- Inventory of Groundwater Models
- Assessment of Regional and Local Models
- Conclusions and Recommendations

Introduction

- Motivation
- Project Goals
- Interbasin Flows
- NSVIRWM Region
- Use of Information
- Technical Collaborators

Introduction

- Motivation
- Project Goals
- Interbasin Flows
- NSVIRWM Region
- Use of Information
- Technical Collaborators

Volunteers
Familiarity with NSV
Familiarity with SGMA

Inventory of Groundwater Models

- No subsections
- Briefly summarizes the existing TM
- TM to be included in the appendix

Inventory of Groundwater Models

- No subsections
- Briefly summarizes the existing TM
- TM to be included in the appendix

<u>Volunteers</u>
Familiarity with models

Assessment of Regional and Local Models

- Terminology
- Effective Accounting of Interbasin Flows
- Water Budget Comparison
- Calibration
- Baselines
- Role of Local Models
- Issues with Non-Modeling Approaches
- Guidance on Selecting a Model for Addressing SGMA Needs

Assessment of Regional and Local Models

- Terminology
- Effective Accounting of Interbasin Flows
- Water Budget Comparison
- Calibration
- Baselines
- Role of Local Models
- Issues with Non-Modeling Approaches
- Guidance on Selecting a Model for Addressing SGMA Needs

Questions
How to present existing analysis?

Assessment of Regional and Local Models

- Terminology
- Effective Accounting of Interbasin Flows
- Water Budget Comparison
- Calibration
- Baselines
- Role of Local Models
- Issues with Non-Modeling Approaches
- Guidance on Selecting a Model for Addressing SGMA Needs

Questions

If leaving to locals, can we provide things like land use and water budget equivalents?

Assessment of Regional and Local Models

- Terminology
- Effective Accounting of Interbasin Flows
- Water Budget Comparison
- Calibration
- Baselines
- Role of Local Models
- Issues with Non-Modeling Approaches
- Guidance on Selecting a Model for Addressing SGMA Needs

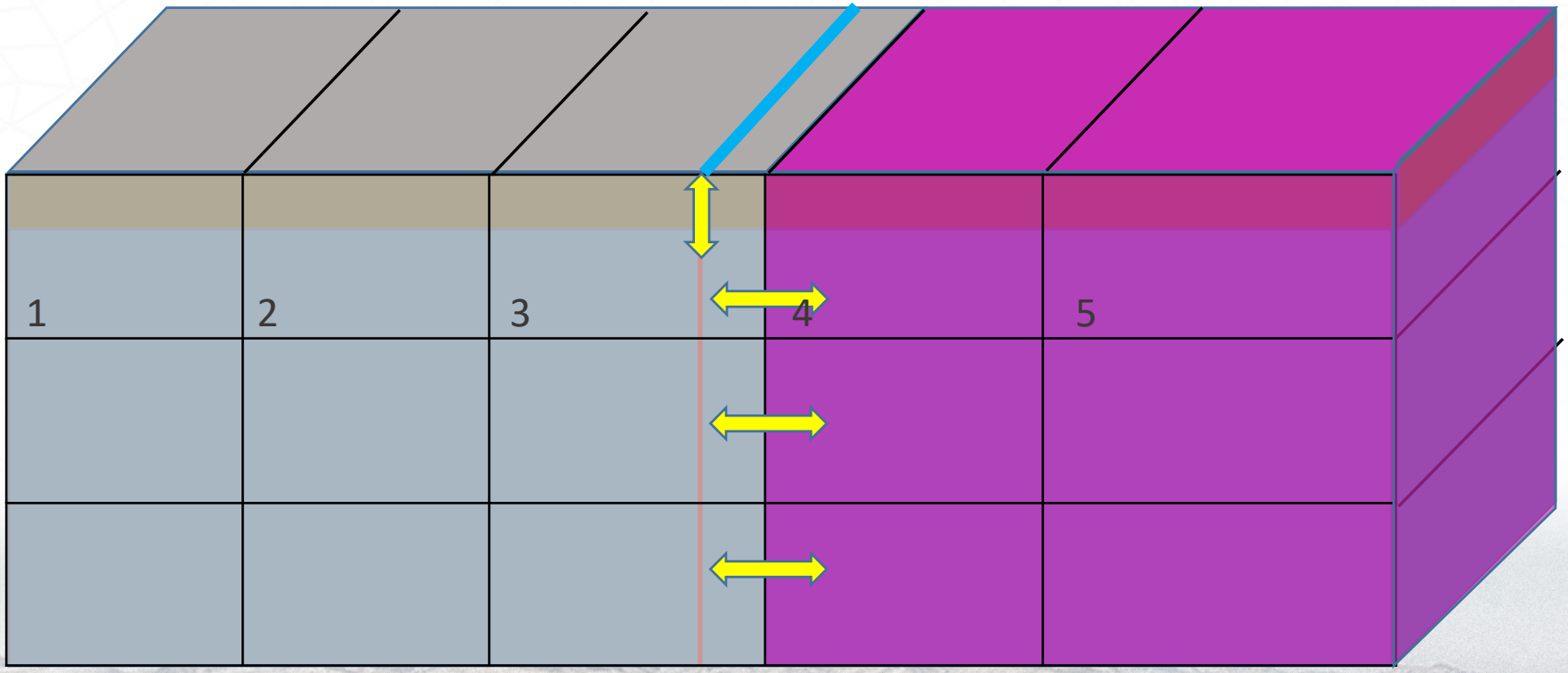
Questions

Appendix materials here will be critical. What do we include?

- Stream budget block diagrams
- Vina example
- etc.

Evaluating Interbasin Flows Where the Boundary is Defined by a River/Stream

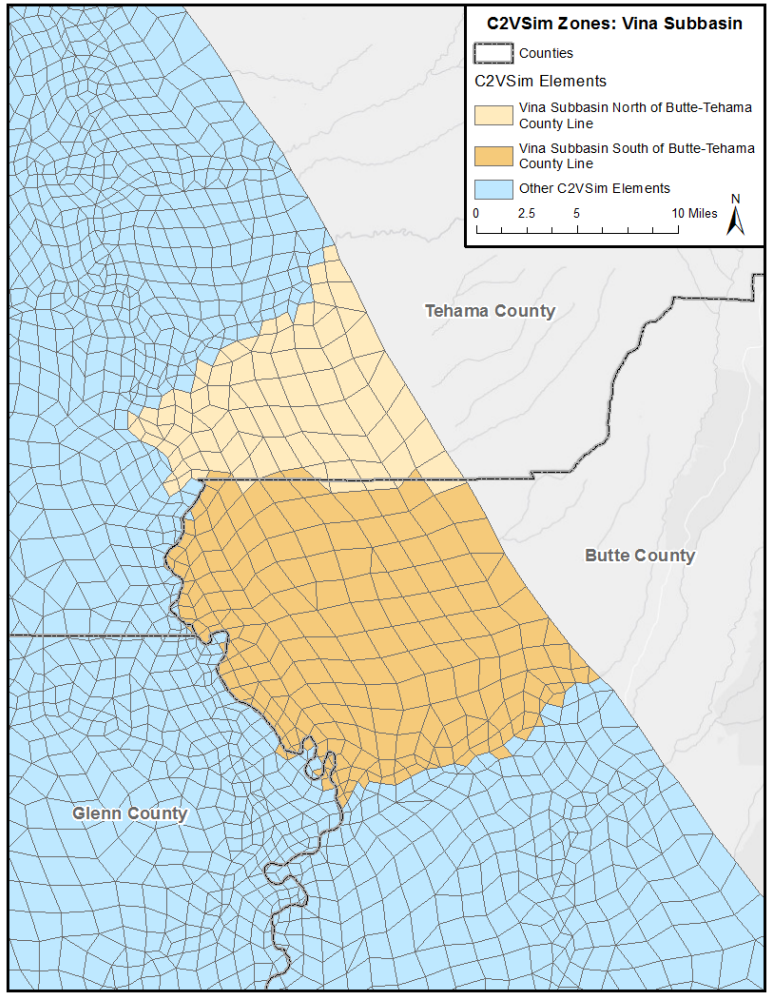
- Boundaries aligned with rivers and streams (as many in the state are) complicates the quantification of these flows



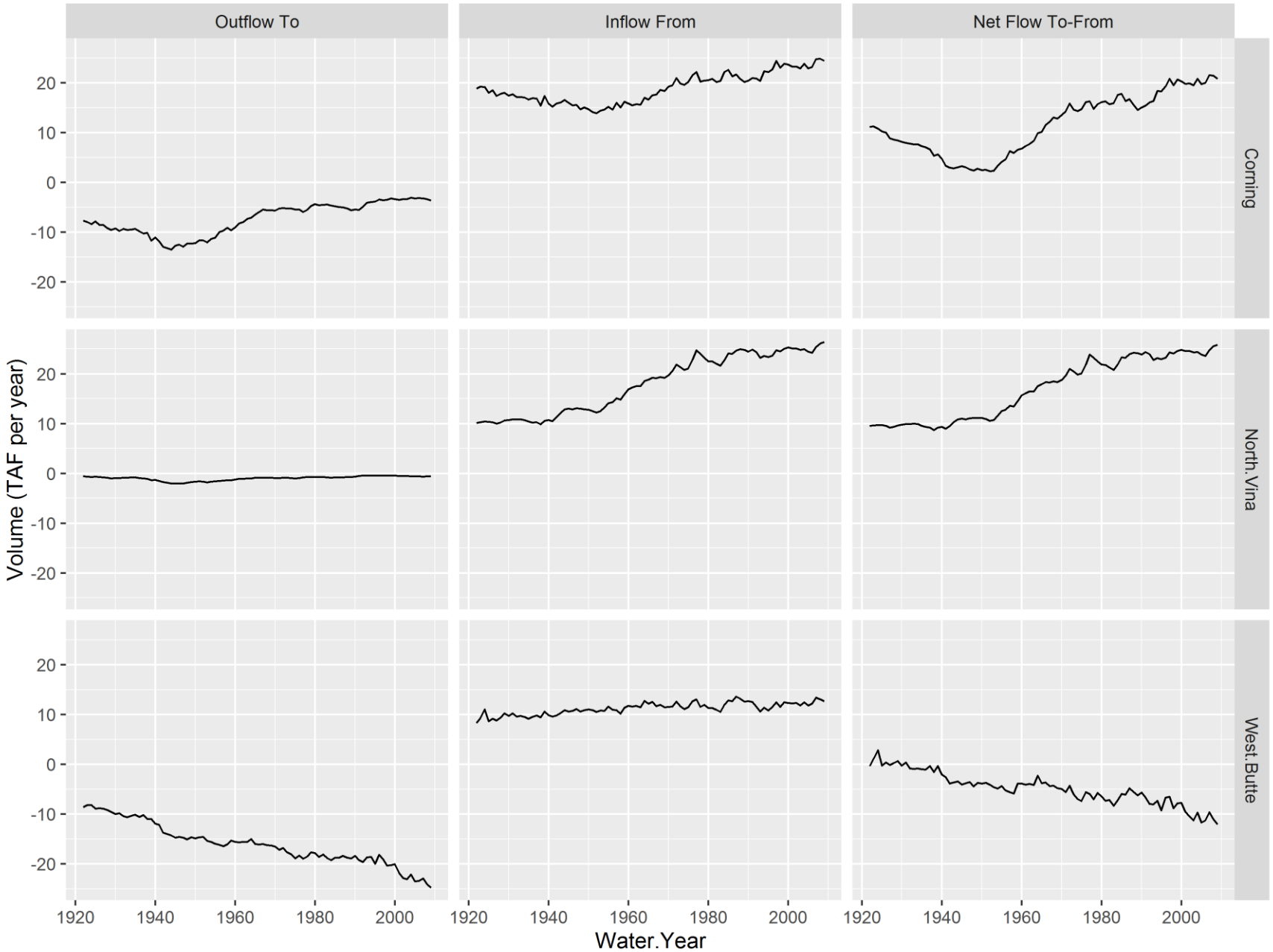
$Q_{str} = 0$

Example of Interbasin Flow Budget Information

- Using C2VSim
- Split Vina Subbasin into two hypothetical subbasins along county line -> North Vina and South Vina
- Budget information presented below is from the perspective of South Vina (darker orange area on figure to the left)



- Evaluated subsurface inflow and outflow, by layer, into/out of hypothetical South Vina Subbasin from:
  - Corning
  - North Vina
  - West Butte



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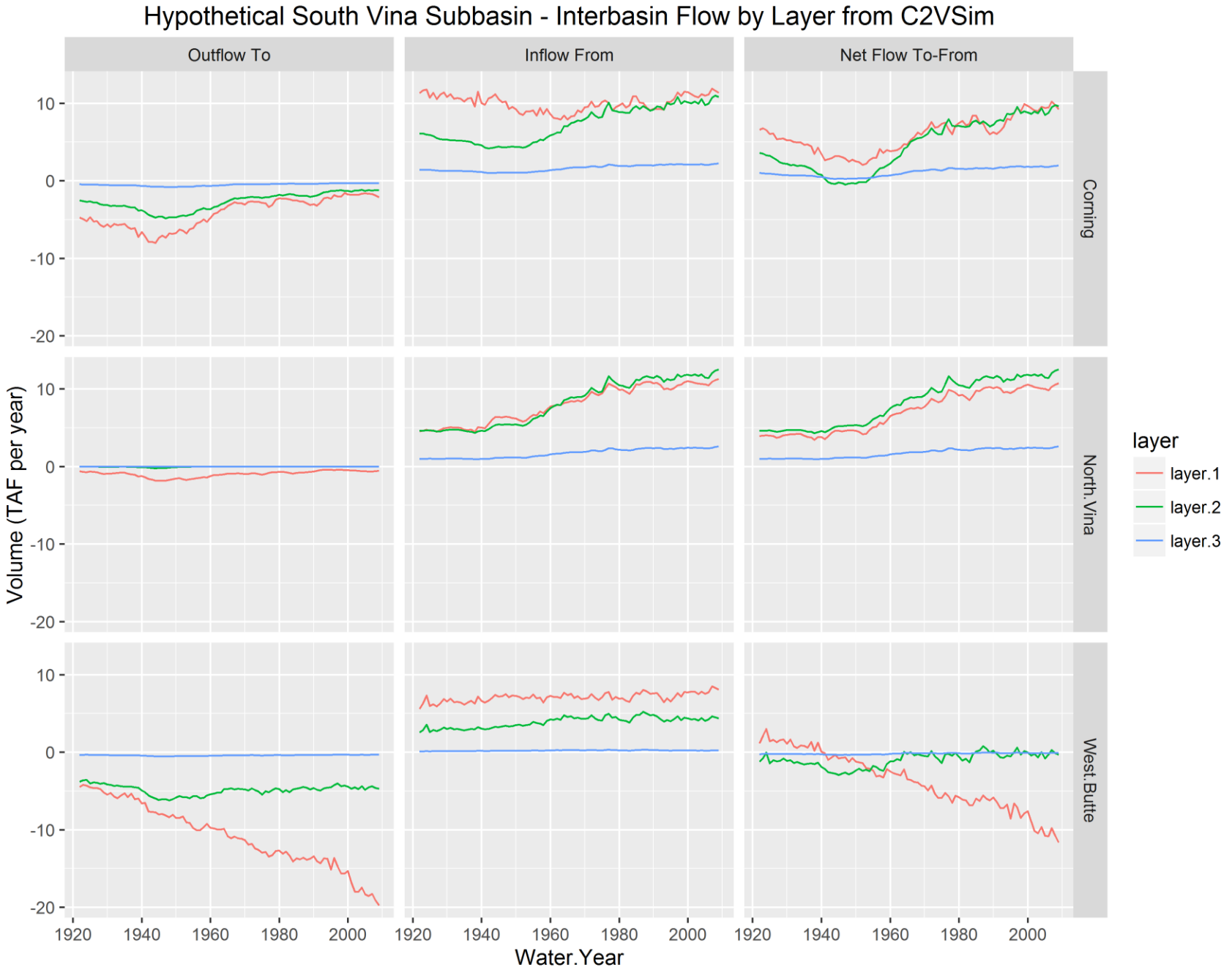
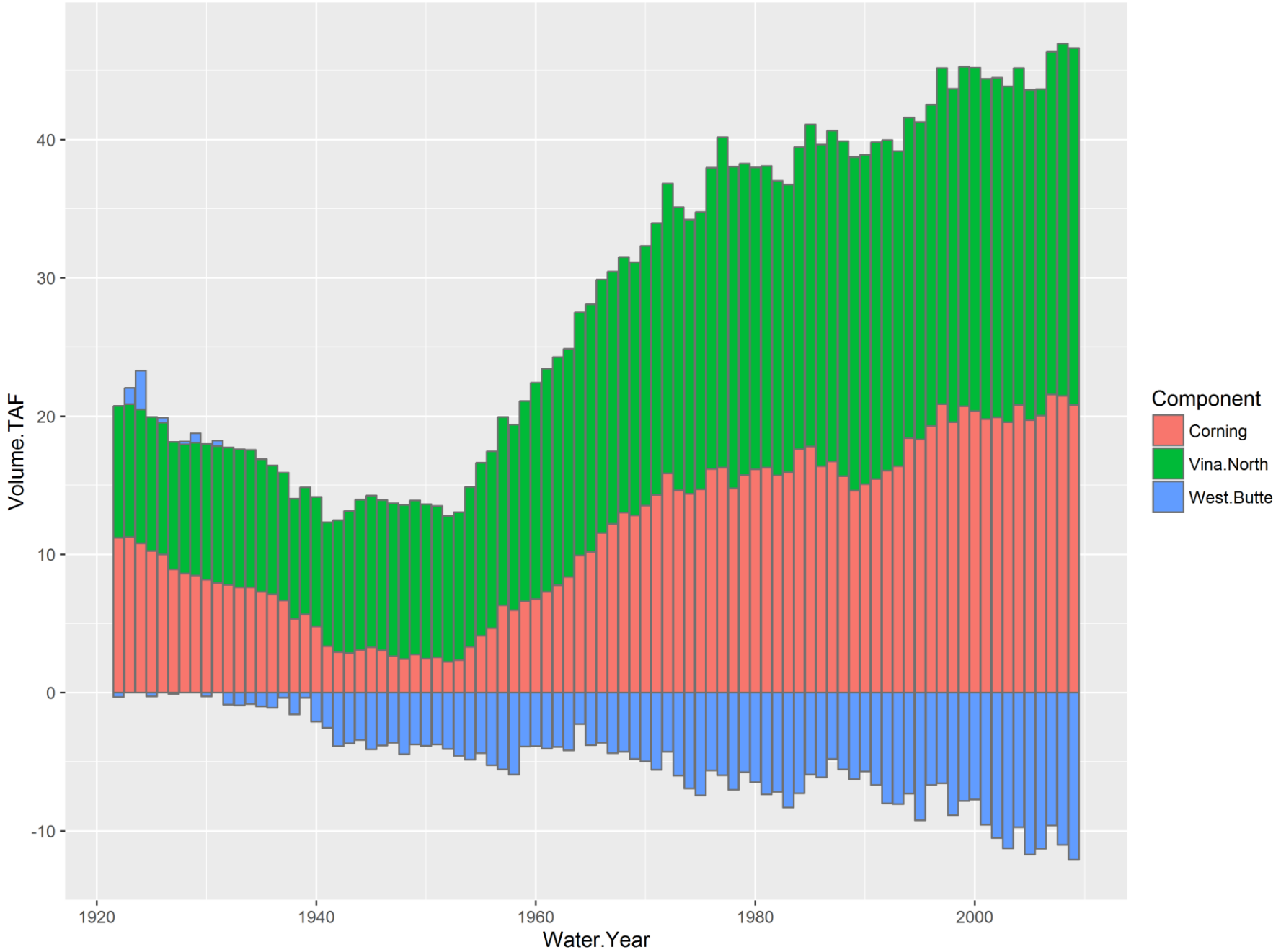


Hypothetical South Vina Subbasin Total GW Budget

Hypothetical South Vina Subbasin Interbasin Flows



Hypothetical South Vina Subbasin Interbasin Flows Relative to Total Groundwater Budget

Assessment of Regional and Local Models

- Terminology
- Effective Accounting of Interbasin Flows
- Water Budget Comparison
- Calibration
- Baselines
- Role of Local Models
- Issues with Non-Modeling Approaches
- Guidance on Selecting a Model for Addressing SGMA Needs

Volunteers
Modelers

Conclusions and Recommendations

- North Valley Specific
- General Technical Issues (Statewide Application)
- Recommendations for DWR and USGS (Expectations and Desires of Local Agencies for Available Models)

Conclusions and Recommendations

- No qualified or unqualified model recommendation
- No model was developed with SGMA in mind and all models require some kind of refinement to be truly suitable for use in SGMA

Conclusions and Recommendations: North Valley Specific

- NSV-specific data gaps
- NSV-specific needs for refinements for C2VSim and CVHM.
- Utilizing data from SacFEM and Stony Creek Fan models
- Use of local models like Butte Basin
- Consideration of future models, such as SVSim, and updated regional models in the NSV

Conclusions and Recommendations: General Technical Issues (statewide application)

- Overall approach (TC, needs assessment, model ID, model analysis, model selection)
- Specific technical approaches within analysis and selection
  - Process for evaluating multiple modeling tools (water budgets, gw heads)
  - Process for comparing water budgets (which components, and reconciling terminologies/differing approaches)
  - Approach for streams at the boundary for comparing boundary flows in the water budgets.
- Approach to boundaries of GSPs using different models

Conclusions and Recommendations: Recommendations for DWR and USGS

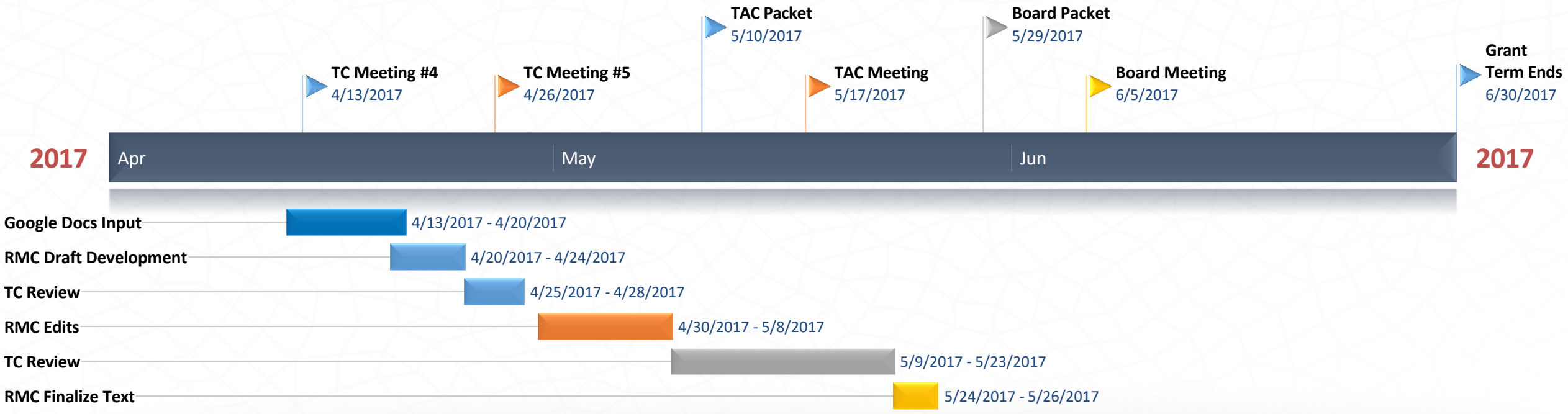
- Enhance the utility, reliability, and ultimately acceptability of the models for SGMA use
- Specific needs
  - Standard data inputs (eg land use refinements)
  - Comparable water budgets
  - Tools for extracting water budgets for specific GSA area
  - Tools for extracting simulated heads at given locations
  - Guidance for using the models by GSAs with respect to each of 6 undesirable results

Conclusions and Recommendations

- North Valley Specific
- General Technical Issues (Statewide Application)
- Recommendations for DWR and USGS (Expectations and Desires of Local Agencies for Available Models)

Volunteers
Anyone/Everyone

Next Steps / Schedule



Discussion

Next Steps / Schedule

Early input provided April 20 (Google Docs)
Draft text provided April 24
TC Meeting #5 Wednesday April 26, 10 am-noon
TC review by April 28
Revised document by May 8
May 17 TAC (May 10 TAC packet)
TC review May 9-23
Incorporate comments, May 23 – May 26
Board meeting June 5 (May 29 Board packet)
Grant term ends June 30

Next Steps / Schedule

Early input provided April 20 (Google Docs)
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Interbasin GROUNDWATER FLOW Evaluation Project

Technical Collaborators Meeting 5

April 26, 2017

Agenda

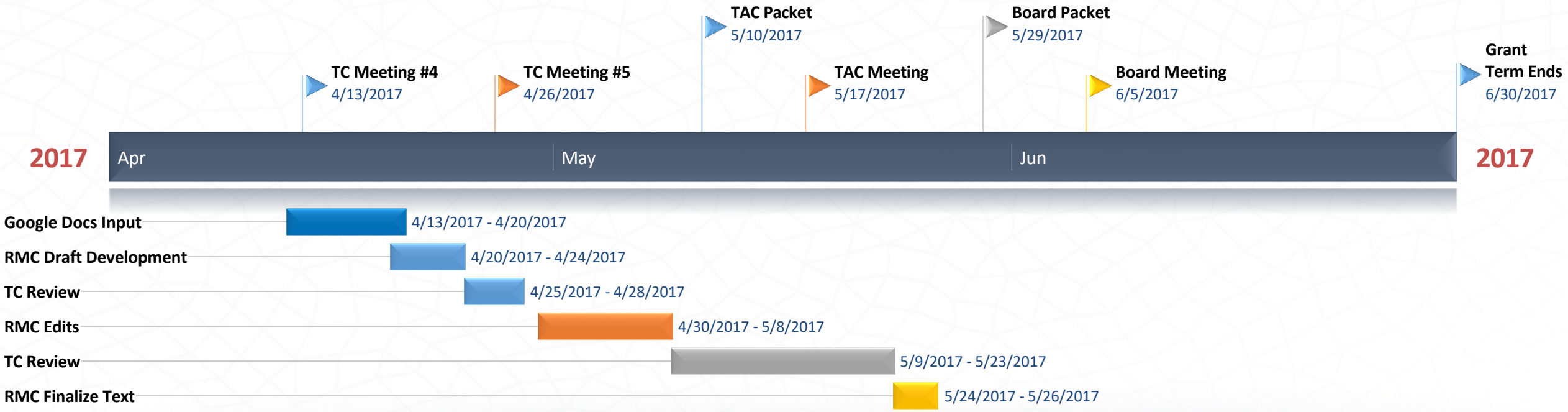
- Recap of previous meeting
- Report discussion
- Next Steps

Meeting #4 Recap

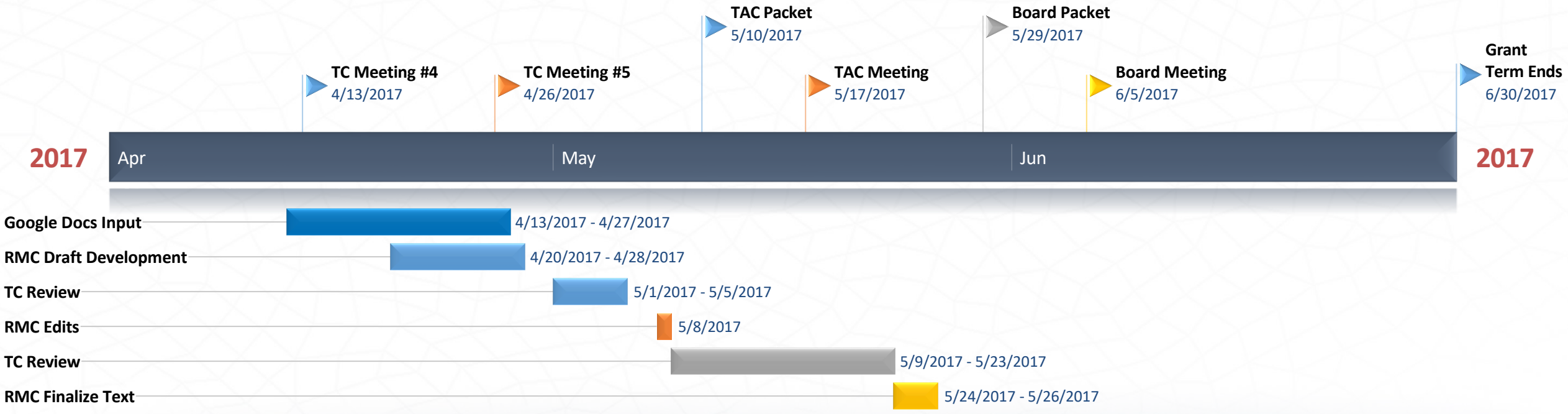
- **Report Outline**
  - Aim to have a concise, high level report with technical analysis in appendices
    - Executive Summary
    - Introduction
    - Inventory of Groundwater Models
    - Assessment of Regional and Local Models
    - Conclusions and Recommendations
    - Appendices
  - All TC members may contribute via Google Document link
- **Discussion Highlights**
  - No model recommendation. No model was developed with SGMA in mind and all models require refinement to be truly suitable for use in SGMA.
    - Model uncertainty and risk
    - Tabulated model differences/methodologies
  - Relative differences between scenarios more useful than absolute values
  - Have specific recommendations for approach by sustainability indicator (matrix)
- **Conclusions and Recommendations**
  - Specific recommendations geared toward North Sacramento Valley, statewide application, and DWR/USGS

Report Discussion

Next Steps / Schedule



Next Steps / Schedule



Appendix B - Technical Collaborators Meeting Summaries

Meeting Summary

Interbasin Groundwater Flow Evaluation Project

Subject: Technical Collaborators Meeting #1
Prepared By: Craig Altare
Date/Time: July 27, 2016
10:00am-12:00pm
Location: RMC Water and Environement
1545 River Park Drive, Suite 425
Sacramento, CA 95815

Meeting Attendance

• Technical Collaborators: ○ Grant Davids (Davids Engineering) ○ Steve Phillips (USGS) ○ Ali Taghavi (RMC) ○ Claudia Faunt (USGS) ○ Mary Randall (DWR) ○ Oscar Serrano (Colusa Indian Community Council, NSVIRWM TAC) ○ Ben Pennock (Glenn Colusa ID, NSVIRWM TAC) ○ Bill Ehorn (DWR, NSVIRWM TAC) ○ Vickie Newlin (Butte County, NSVIRWM TAC Chair) ○ Allan Fulton (UC Cooperative Extension, NSVIRWM TAC) ○ Steffen Mehl (CSU Chico) ○ Christina Buck (Butte County) ○ Peter Lawson (CH2M Hill) ○ Charlie Brush (DWR) ○ Thomas Harter (UC Davis, on phone)	• Other: ○ Jim Blanke (RMC) ○ Craig Altare (RMC) ○ Sara Miller (RMC)

Meeting Objectives

- Kick off the Interbasin Groundwater Flow Evaluation Project
- Familiarize Technical Collaborator (TC) members with the motivation for the Project
- Inform TC Members of models being considered for interbasin groundwater flow evaluation for the North Sacramento Valley Integrated Regional Water Management (NSVIRWM) area
- Solicit feedback from TC members on draft Tech Memo, e.g. additional models or methods to consider
- Discuss Project timelines

Discussion Summary

1. Project objectives:
    a. Develop methodology to assess interbasin flows for GSAs in the NSVIRWM area

   b. Develop methodology to assess interbasin flows for DWR GSA assessments
   c. Develop "lessons learned" for other basins
2. Draft Model Inventory Tech Memo:
   a. 5 models: 3 regional (C2VSim, CVHM, SACFEM2013) and 2 local (BBGM, SCF Model)
      i. Code platforms:
         1. IWFM (C2VSim, BBGM)
         2. MODFLOW-FMP (CVHM)
         3. MicroFEM with IDC (SACFEM2013)
         4. IGSM (SCF Model)
   b. Other methodologies/models to discuss?
      i. Use field observations for verification
      ii. Sacramento Valley Simulation Model (SVSim) – add to inventory to track it, even though all of the details aren't available
      iii. Age dating/GAMA (Christina Buck mentioned Jean Moran at Lawrence Livermore and Claudia Faunt mentioned USGS studying Fresno area)
3. Suggestions for study:
   a. Members of the TC noted that SACFEM2013 (propriertary and not fully integrated MicroFEM code) and SCF Model (IGSM is predessessor to IWFM and not maintained) are not the path forward, but may contain useful information that could be retained for future efforts.
   b. Considerations when analyzing regional and local models:
      i. Focus on assumptions behind data rather than model numbers
      ii. Consider how differences in discretizations may drive differences in model results
      iii. Consider where boundaries are drawn (e.g., subbasin boundaries usually at streams), especially with regards to differences in finite element (IWFM, MicroFEM, and IGSM), and finite difference (MODFLOW-FMP) models
         1. If keep analysis boundaries at streams, likely need to subtract the stream reach budget from interbasin flows for CVHM
      iv. Include analysis of how different models simulate boundary inflows
      v. For regional models, look at northern Sacramento Valley basin-wide water budgets and how they compare in magnitude
      vi. Consider including an appendix listing the different terminology used for water budget components in each model and how they compare
      vii. Stay closer to a current time period (last ~20 years)
      viii. Consider hydrogeology and how it is implemented in the models (e.g., consider focusing on Tuscan Formation and above, or on primary production zones)
      ix. Most important to compare magnitudes and flow directions across boundaries
      x. Suggestion to focus on one or two boundaries for analysis (consider with/without streams, wet/dry periods, east-west/north-south flow, etc.)
         1. Butte-Tehama County line across Vina subbasin
         2. Tehama-Glenn County line within Stony Creek Fan

Action Items

1. Thomas Harter to send IWFM v.s. MODFLOW-FMP peer review to group
2. Grant Davids to send study comparing C2VSim and CVHM that determined interbasin flow magnitudes often accounted for up to 20% of total water budget
3. RMC to revise draft Tech Memo:
    a. Add to table:
        i. General level of calibration, if possible focusing on the Sacramento Valley
        ii. Stress period and time step for each model
    b. Add information for the upcoming Sacramento Valley Simulation Model (SVSim)
4. Next meeting (September 2016) will focus on regional models
    a. Look at region-wide water budgets and two boundaries (one across a stream and one away from a stream). Boundary water budgets to focus on C2VSim and CVHM.
    b. Continue discussion regarding end products that will be most helpfulto the NSV region and to others throughout the State.

Meeting Summary

Interbasin Groundwater Flow Evaluation Project

Subject: Technical Collaborators Meeting #2
Prepared By: Craig Altare
Date/Time: September 6, 2016
10:00am-12:00pm
Location: RMC Water and Environment
1545 River Park Drive, Suite 425
Sacramento, CA 95815

Meeting Attendance

• Technical Collaborators: ○ Charlie Brush (DWR) ○ Christina Buck (Butte County) ○ Grant Davids (Davids Engineering) ○ Bill Ehorn (DWR, NSVIRWM TAC) ○ Claudia Faunt (USGS) ○ Allan Fulton (UC Cooperative Extension, NSVIRWM TAC) ○ Thomas Harter (UC Davis) ○ Peter Lawson (CH2M Hill) ○ Steffen Mehl (CSU Chico) ○ Vickie Newlin (Butte County, NSVIRWM TAC Chair) ○ Ben Pennock (Glenn Colusa ID, NSVIRWM TAC) ○ Steve Phillips (USGS) ○ Mary Randall (DWR) ○ Oscar Serrano (Colusa Indian Community Council, NSVIRWM TAC) ○ Ali Taghavi (RMC)	• Other: ○ Jim Blanke (RMC) ○ Craig Altare (RMC) ○ Sara Miller (RMC)

Meeting Objectives

- Primary: Obtain feedback from the Technical Collaborators (TC) regarding project outcomes:
  - What types of recommendations does the group feel comfortable committing to?
  - Based on that, what are the action items for the TC and consultants?
- Secondary:
  - Bring members of the TC up to speed on regional modeling tools, the water budget information they generate, current status, and applicability to determination of interbasin flows in the NSV

Discussion Summary

1. Recap of TC Meeting #1:
   a. Project objectives: local ownership of interbasin flow evaluation process in the NSV Area and "lessons learned" to DWR and others in state

   b. SacFEM and Stony Creek Fan not suited for use by GSAs, but still contain useful information

2. Project Outcomes:
   a. Discussion question posed: Does the TC group feel comfortable identifying which regional model (CVHM or C2VSim) is the most appropriate for determination of interbasin flow budget components of GSPs *at this place and in this time*?
      i. "At this time"- Consultants would need model and time to develop GSP well before GSPs due in 2022 (estimated about 2017-2018 with preliminary model development work beginning now)
      ii. Consensus: Up to GSAs to decide what model is best for what they want to do. These models provide bookends and a range of interbasin flows.
   b. TC group could provide input for model development as CVHM and C2VSim continue updating
      i. Since the regional models were never developed for use by GSAs for GSPs, the TC group could recommend improvements to meet the needs of GSAs that may be able to implemented in the models by 2018.
         1. Develop criteria of what would want model to have
      ii. Regional models were never intended for anything other than regional answers. Local models use regional models to develop boundary conditions.
   c. Summary: Model criteria (i.e., qualitative and quantitative components of model that augment the work of GSAs and for GSPs) will lead evaluation of regional models and may help modelers with ideas for how to better support GSPs and GSAs
      i. Criteria would help other GSAs (i.e., evaluate now so others don't have it) and enhance defensibility of modeling for GSPs (i.e., list of criteria met by model). Look at improvements in data and data gaps.
3. Components of Model Selection:
   a. Presentation of flowpath of things considered by water manager to determine model to use
      i. Add to criteria: How well does model work for projects planned?
      ii. Add information about 6 undesirable results from GSP
      iii. May need to be tweaked depending on different critical criteria in each area (e.g., stream-aquifer interaction important in NSV Area)
   b. Discussion:
      i. DWR will do technical evaluation of tools (e.g., model) that go into GSPs. If interbasin flow values from two adjacent basins are largely off, the basins will have to work together to resolve the issue.
      ii. GSAs are only held to sustainability factors and not to the model (model is just how sustainability factors were evaluated and how determined what projects will help)
      iii. Ranges of numbers are a reality that people will have to get used to
4. Regional Model Results for Sacramento Valley Groundwater Basin:
   a. Groundwater budget results across entire Sacramento Valley Groundwater Basin may only come out to a difference between models of about 1-2 AF for each acre
   b. Summary of budget components:
      i. Drains—SacFEM's groundwater discharge to land surface

            1. Add to discharge to streams (i.e., reduces stream component of groundwater budget)
        ii. General head—CVHM only (in Delta area)
        iii. Interbasin flows—coming from north or going to south, SacFEM doesn't have (only has a boundary condition at Delta for outflow)
        iv. Recharge—ET from groundwater taken out of recharge component in CVHM (i.e., reason for negative farm net recharge)
        v. Small watershed—not in 2009 version of CVHM
    c. Beauty of SGMA is that locals define the surface water system and then use groundwater stratigraphy from CVHM or C2VSim. This iterative process lets locals improve the regional models with accurate local surface water data.
    d. Boundary conditions between the models are different and drive the differences in results
5. Direction for Analysis and Next Meeting:
    a. Next meeting in January
    b. Have defined data gaps and specifics about what models may improve (i.e., criteria ideas)
    c. Focus on local models and subbasin-scale water budgets in order to help hammer out criteria
    d. Develop framework for report

Meeting Summary

Interbasin Groundwater Flow Evaluation Project

Subject: Technical Collaborators Meeting #3
Prepared By: Dominick Amador
Date/Time: March 7, 2017
10:00am-12:00pm
Location: RMC, a Woodard and Curran Company
1545 River Park Drive, Suite 425
Sacramento, CA 95815

Meeting Attendance

• Technical Collaborators: ○ Grant Davids (Davids Engineering) ○ Ali Taghavi (RMC) ○ Claudia Faunt (USGS) ○ Oscar Serrano (Colusa Indian Community Council, NSVIRWM TAC) ○ Ben Pennock (Glenn Colusa ID, NSVIRWM TAC) ○ Vickie Newlin (Butte County, NSVIRWM TAC Chair) ○ Allan Fulton (UC Cooperative Extension, NSVIRWM TAC) ○ Steffen Mehl (CSU Chico) ○ Christina Buck (Butte County) ○ Peter Lawson (CH2M) ○ Charlie Brush (DWR)	• Other: ○ Jim Blanke (RMC) ○ Reza Namvar (RMC) ○ Dominick Amador (RMC)

Meeting Objectives

Obtain feedback from the Technical Collaborators (TC) regarding project outcomes:

- Review of C2VSim and CVHM model input and output.
  - Note any discrepancies in model classifications or budgetary definitions during comparison.
  - Note any additional areas of needed review or refinement to the analysis.
- Determine general recommendations for local agencies looking to use a regional model in support of SGMA and GSA governance.
- Based on meeting discussions, what are the action items for the TC and consultants?

Discussion Summary

Model Comparison

1. Land Use / Cropping Patterns
    a. CVHM operates with 22 land use categories, compared to the 17 of C2VSim. To directly compare the two models, categories were aggregated into 12 common groups.
        i. Claudia and Charlie have offered to assist classification mapping as some of the miscellaneous categories may be misrepresented (ex: developed and semi-agricultural) in the initial analysis.
        ii. Earlier years show greater degrees of model differences, particularly in 1960 and 1992 where CVHM has nearly 1,000,000 acres of additional irrigated cropland. The group notes that this may be caused by methodology, and recommends that calibration is weighted towards later years in the simulation.
    b. Subregional Comparison
        i. Individual subregions should be reviewed by local agencies to determine which model may better represent their area with greater accuracy.
        ii. The group recommends that local agencies look at the total consumptive use, applied water, and surface water diversions rather than only land use. Differences in crop classifications may not make significant changes to the water budget.
2. Water Budget
    a. Initial review of comparative water budgets show significant differences; additional review should be undertaken to ensure that budgetary item definitions are comparative.
        i. Water Demand Required – Claudia indicated that the CVHM ET demand includes ET from precipitation, ET from groundwater, and ET from applied water (Claudia to verify), whereas C2VSim is ET from applied water as read from the L&WU budget.
    b. Subregional water budgets and calibration:
        i. C2VSim Calibration – In IWFM 3.02 stream nodes are given a subregional delineation and all flows from stream-groundwater interaction are applied in that specific subregion. Because of this, certain subregions with large streams on the boundary are showing inaccurate stream seepage depending on the nodal classification. C2VSim is currently being updated to the IFWM 2015 framework, where this will no longer be an issue.
        ii. CVHM Calibration - Subregion 3 is not calibrated very well and has very high water levels, this may be the reason for lower surface water diversions (GCID delivers 800 TAF of and CVHM only shows 700 TAF for the entire subregion).
        iii. CVHM Calibration – CVHM is calibrated more towards storage changes over time and capturing trends rather than matching groundwater elevations.
        iv. Groundwater calibration analysis should take into consideration the scale of the model element and the variation in ground surface elevation and water surface elevation within that model element. These factors can result in what appears to be a mismatch in measured versus simulated groundwater elevations.
        v. There is a fundamental need for consistency between model budget components and there needs to be additional coordination between DWR and USGS about their modeling efforts.
        vi. Models need to be able to be upgraded or fine-tuned at a local level.

Recommendations

1. Regional models are a good starting point for local refinement but even though local agencies would like to be able to pick up either model and use it as-is for their water budgets, the group does not recommend this approach.
    a. Local agencies should look specifically at their area and review both models for accuracy.
    b. Regional models were not developed or calibrated for use in GSA governance.
    c. If local stakeholders want something that can be used off-the-shelf they need to provide additional data and coordinate with the DWR and USGS. This process may include changes to reporting units within the models (e.g. subbasins).
2. The committee recommends that they develop a recommendation to USGS and DWR to formally request specific updates to each model based on local expectations.
    a. SGMA - Develop a guideline on how to use these regional models to address the six SGMA parameters and how a numerical model would assess those conditions.
    b. Cost - The DWR and/or State Board should develop guidelines for expected cost and investment into the refinement of groundwater models to meet SGMA and GSA requirements.
3. Areas for review and additional discussion on the regional models
    a. Development – Modeling needs are outstripping capacity. C2VSim and CVHM were not designed for local SGMA use, and there needs to be development support to allow them to grow into this new capacity.
    b. Model Differentiation – As there are large differences in the regional models within the Sacramento Valley, there needs to be some formal explanation as to why the two models vary to such a degree.
    c. Processing Tools – More materials should be available for a lay-person to understand models and their output, specifically relating to budget output. Review additional utilities that can provide large benefit for minimal effort, potentially a comparison tool for model output.

Action Items

1. Claudia and Charlie to coordinate on an aggregated land use classification for model comparison.
2. Claudia and Charlie to review water budgets to ensure equivalent definition of budgetary items.
3. Everyone to send Jim final thoughts, recommendations, comments, concerns, and questions.
4. Jim to begin develop draft documentation of project findings for discuss at next meeting.

Meeting Summary

Interbasin Groundwater Flow Evaluation Project

Subject: Technical Collaborators Meeting #4
Prepared By: Sara Miller
Date/Time: April 13, 2017
10:00am-12:00pm
Location: RMC Water and Environment
1545 River Park Drive, Suite 425
Sacramento, CA 95815

Meeting Attendance

• Technical Collaborators: ○ Grant Davids (Davids Engineering) ○ Steve Phillips (USGS) ○ Mary Randall (DWR) ○ Ben Pennock (Glenn Colusa ID, NSVIRWM TAC) ○ Bill Ehorn (DWR, NSVIRWM TAC) ○ Vickie Newlin (Butte County, NSVIRWM TAC Chair) ○ Allan Fulton (UC Cooperative Extension, NSVIRWM TAC) ○ Christina Buck (Butte County) ○ Charlie Brush (DWR) ○ Thomas Harter (UC Davis) ○ **Phone** Peter Lawson (CH2M Hill) • Absent: ○ Ali Taghavi (RMC) ○ Claudia Faunt (USGS) ○ Oscar Serrano (Colusa Indian Community Council, NSVIRWM TAC) ○ Steffen Mehl (CSU Chico)	• Other: ○ Jim Blanke (RMC) ○ **Phone** Reza Namvar (RMC) ○ Sara Miller (RMC)

Meeting Objectives

- Receive input from TC on the content of the draft report and on TC participation during the drafting of the report

Discussion Summary

Recap of Previous TC Meetings

1. Meeting #1
    a. Project Objectives:
        i. Local ownership of the interbasin flow evaluation project in the NSV Area (a methodology to assess interbasin flows)

        ii. "Lessons learned" to DWR and others in the state
    b. Overview of models to be considered for this study and decision that some tools are unsuited for future use by GSAs, though still contain useful information that should be preserved (SacFEM 2013, Stony Creek Fan IGSM)
2. Meeting #2
    a. Model selection- Existing models provide bookends and a range of interbasin flows. Model criteria will lead evaluation of regional models
    b. Model refinements- Existing regional models weren't designed for SGMA and need improvement
    c. Model analysis- Differences exist in definitions, methodologies, and water budgets
3. Meeting #3
    a. Analysis of land use classifications and water budget comparisons between CVHM and C2VSim
    b. Recommendations: Specific updates for CVHM and C2VSim

Report Approach

4. Aim to have a concise, high level report with executive summary and technical analysis included in appendices
5. All TC members may contribute to report via Google Document link
6. Target audiences include local agencies (county supervisors, etc.), DWR and USGS, and possibly consultants
7. No model recommendation. No model was developed with SGMA in mind and all models require refinement to be truly suitable for use in SGMA.
    a. Model uncertainty and risk: Acknowledge and deal with uncertainties in model results/GSPs. Need work to get models better over time (i.e., feed information up and down from state to local models and vice versa).
        i. Ultimate goal of model is to evaluate how well a project will do (and with what uncertainty risk) (i.e., sensitivity analysis)
    b. Both C2VSim and CVHM coming out with updates soon, though differences highlighted during TC meetings will remain in updated versions. Updated model releases: SVSim by end of 2017, C2VSim CG by summer 2017 and FG likely early 2018, and CVHM waiting on MODFLOW release (likely summer 2017)
    c. Tabulated model differences/methodologies in report
    d. To minimize conflict in numbers, consider using same model as neighboring subbasins
8. Example of interbasin flows across county line (Vina subbasin) included in appendix to provide an example of how to look at data and will focus on the differences between interbasin flows
9. Relative differences between scenarios more useful than absolute values
10. Include specific recommendations (for local agencies) for approach by sustainability indicator (represent information in a matrix)
11. Conclusions and Recommendations
    a. Specific recommendations geared toward North Sacramento Valley, statewide application, and DWR/USGS
    b. Northern Sacramento Valley highlights:
        i. Significant foothill groundwater use
        ii. Consider:

1. Compare local surface layer model (i.e., water budget model) to C2VSim/CVHM
2. Local groundwater model (e.g., Butte basin)
3. SVSim conceptual model and texture model

iii. Don't mix and match groundwater model/local data
iv. Interbasin flows driven by pumping, climate, crop, transfers, etc.
v. 5 sustainability indicators (salt water intrusion not an issue)

c. Statewide application highlights:
   i. Model differences vs. absolute numbers (risk tolerance/adaptive management, sensitivity analysis)
   ii. Model status- CVHM (late summer), C2VSim (FG early 2018, CG summer), SVSim (late 2017)
   iii. Consider how to deal with disagreement in models (e.g. boundaries)
   iv. Water budgets by water year type
   v. How to include information from existing tools (e.g. G-C ID)
   vi. USGS natural recharge model
   vii. Consider what model your neighbor is using

d. Recommendations for DWR/USGS highlights:
   i. Support funding- legislature, justification (local needs and support of 2 models)
   ii. Provide a workplan
   iii. Continuous updating and long-term improvement
   iv. Linkage with local models- Process for local data submittal and for inclusion in models or SGMA group
   v. Groundwater/surface water interaction- Update gage surveys for stage to minimize uncertainty

Project Schedule

1. Last TC meeting (Meeting #5) in 2 weeks on April 26, 2017
2. Complete TC review of report by late May
3. Report presented to NSV IRWM board meeting on June 5, 2017
4. Project continues through June 30, 2017 to allow for final edits after board meeting

Meeting Summary

Interbasin Groundwater Flow Evaluation Project

Subject: Technical Collaborators Meeting #5
Prepared By: Dominick Amador
Date/Time: April 26, 2017
10:00am-12:00pm
Location: RMC Water and Environment
1545 River Park Drive, Suite 425
Sacramento, CA 95815

Meeting Attendance

• Technical Collaborators: ○ Charlie Brush (DWR) ○ Christina Buck (Butte County) ○ Bill Ehorn (DWR, NSVIRWM TAC) ○ Allan Fulton (UC Cooperative Extension, NSVIRWM TAC) ○ Thomas Harter (UC Davis) ○ Peter Lawson (CH2M Hill) ○ Vickie Newlin (Butte County, NSVIRWM TAC Chair) ○ Ben Pennock (Glenn Colusa ID, NSVIRWM TAC) ○ Steve Phillips (USGS) ○ Mary Randall (DWR) ○ Ali Taghavi (RMC) ○ **Phone -** Claudia Faunt (USGS) ○ **Phone -** Oscar Serrano (Colusa Indian Community Council, NSVIRWM TAC) • Absent: ○ Grant Davids (Davids Engineering) ○ Steffen Mehl (CSU Chico)	• Other: ○ Jim Blanke (RMC) ○ Reza Namvar (RMC) ○ Dominick Amador (RMC)

Meeting Objectives

- Receive input from TC on the content of the draft report.

Discussion Summary

Recap of Previous TC Meetings

1. Report Outline
    a. Aim to have a concise, high level report with technical analysis in appendices
    b. All TC members may contribute via Google Document link
2. Discussion Highlights

   a. No model recommendation. No model was developed with SGMA in mind and all models require refinement to be truly suitable for use in SGMA.
   b. Relative differences between scenarios more useful than absolute values.
   c. Have specific recommendations for approach by sustainability indicator (matrix).
3. Conclusions and Recommendations
   a. Specific recommendations geared toward North Sacramento Valley, statewide application, and DWR/USGS

Report Discussion

4. How to handle multiple models
   a. It is important for local agencies to acknowledge that differing models may show conflicting results but this does not mean that a specific model is incorrect.
   b. The DWR and USGS are currently working together to develop common terminology across modeling platforms, particularly as it pertains to model output.
   c. The committee recommends that the DWR and USGS develop water budgets for each published version of their regional models to assist with local agency consumption.
5. Uncertainty in groundwater modeling
   a. Model development and future updates carry a degree of variance and may change local water budget components.
      i. Most modeling updates are due to improvements in available data rather than changes numerical processes.
      ii. The committee encourages open communication between local agencies and model developers. Sharing high-quality data will improve accuracy and lower the costs of needed refinement.
   b. Local agencies should acknowledge that there is a degree of uncertainty associated with any modeling effort, and plan accordingly.
      i. The committee recommends that the report include a section on uncertainty analysis; what it is, why it is important, and when it should be done. Particularly highlighting how uncertainty should feed into basin management.
      ii. Modeling the groundwater system and working towards sustainability is an iterative process and agencies should utilize adaptive management practices.
6. Local modeling efforts
   a. Coordination between local agencies and the DWR/USGS may be needed to understand the interaction between conflicting models, particularly when simulating boundary conditions.
      i. Charlie recommends the use of boundary flows rather than general head boundary conditions. Models using similar heads can have significant variance in flow and when calibrating to specified flow, it is important to include simulated heads in the analysis.
      ii. Due to the nature of conflicting modeling results, local Groundwater Sustainability Plans (GSPs) should account for levels of uncertainty when developing their management practices and plan for an iterative process through adaptive management.
7. Comments on the Project Report were discussed and will be considered.

Schedule Adjustments

8. 04/28/2017 The current phase of commenting and direct editing of the report though Google Documents will be completed by the Technical Collaborators.
9. 05/05/2017 RMC to have incorporated all suggested comments for further review by the Technical Advisory Committee (TAC).
10. 05/19/2017 Christina will summarize all TAC comments and provide them to RMC by close of business.
11. 05/27/2017 RMC to review and address additional comments suggested by the TAC and provide a draft report to the Technical Collaborators for review and consideration.

Appendix C - Inventory of Groundwater Models Technical Memorandum

Technical Memorandum

Interbasin Groundwater Flow Evaluation

Subject:	**Inventory of Groundwater Models**
Prepared For:	Butte County Department of Water and Resource Conservation
Prepared by:	Sara Miller and Craig Altare, P.G.
Reviewed by:	Jim Blanke, P.E., P.G., C.Hg.
Date:	September 21, 2016
Reference:	

This Technical Memorandum (Tech Memo) contains an inventory of numerical hydrologic models capable of simulating interbasin groundwater flow in the Northern Sacramento Valley Integrated Regional Water Management (NSVIRWM) plan area.

1 Study Area

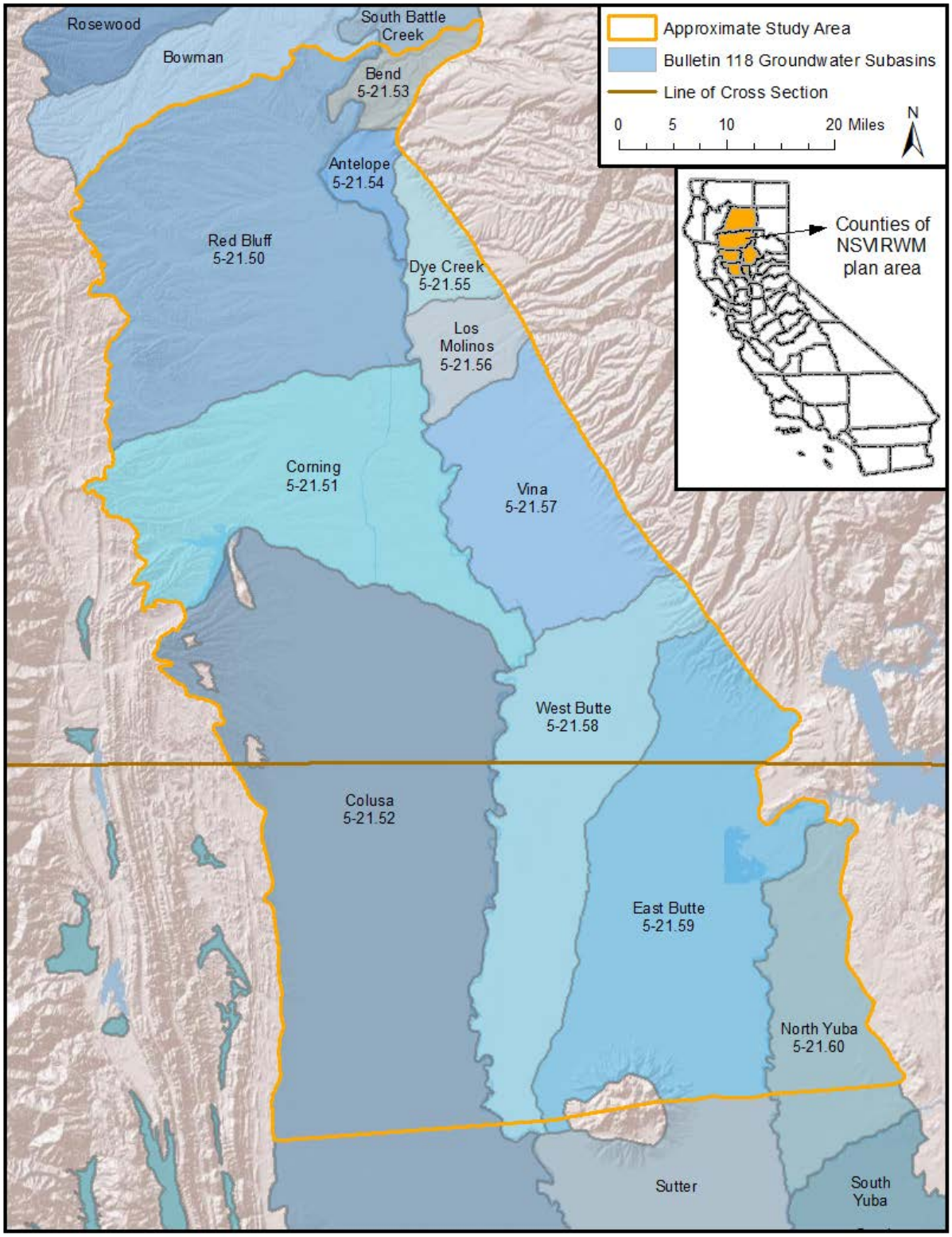
The NSVIRWM plan area is made up of six counties—Butte, Colusa, Glenn, part of Shasta, Sutter, and Tehama—in the northernmost part of California's Central Valley (inset in Figure 1). A portion of the NSVIRWM Area constitutes the study area and includes the area bounded to the north, west, and east by the extent of the Sacramento Valley Groundwater Basin and to the south by the Sutter Buttes. Eleven groundwater subbasins (all part of the Sacramento Valley Groundwater Basin) underlie the study area and are the focus of interbasin flows in the study:

1. Red Bluff (5-21.50)
2. Corning (5-21.51)
3. Colusa (5-21.52)
4. Bend (5-21.53)
5. Antelope (5-21.54)
6. Dye Creek (5-21.55)
7. Los Molinos (5-21.56)
8. Vina (5-21.57)
9. West Butte (5-21.58)
10. East Butte (5-21.59)
11. North Yuba (5-21.60)

These groundwater subbasins are shown in Figure 1. All of the subbasins, except for Bend, were categorized as either being medium or high priority under the California Statewide Groundwater Elevation Monitoring (CASGEM) program in June 2014. None of the subbasins were designated as critically overdrafted by the Department of Water Resources (DWR) as of January 2016.

Figure 1 also shows the approximate bounds of the study area. The study area contains all of the subbasin connections for the subbasins listed above (e.g., Corning–Red Bluff, Corning–Los Molinos, Corning–Vina, Corning–West Butte, Corning–Colusa, etc.).

Figure 1: Groundwater Subbasins in Study Area



2 Interbasin Groundwater Flow and the Sustainable Groundwater Management Act

The 2014 Sustainable Groundwater Management Act (SGMA) established new requirements for groundwater management of medium and high priority groundwater basins or subbasins (referred to hereafter collectively as basins). All critically overdrafted basins (i.e., none of the study area subbasins) must have Groundwater Sustainability Plans (GSPs) by January 31, 2020; all other medium and high priority basins must complete GSPs by January 31, 2022.

In the GSP regulations[1], DWR recognizes that groundwater conditions in one basin may be affected by groundwater management practices in adjacent, hydrologically-connected basins. Each GSP must demonstrate that management activities within a basin will have no adverse impacts on sustainable management of adjacent basins. Therefore, it is important that agencies planning to develop and execute GSPs understand the hydrologic connections between adjacent groundwater basins and how different groundwater models deal with subsurface flows across those boundaries.

Article 8 of the GSP regulations describes interbasin agreements, which are optional interagency agreements for hydrologically connected basins. These interbasin agreements are to include an estimate of groundwater flow across basin boundaries developed using consistent and coordinated data, methods and assumptions; estimates of stream-aquifer interactions at the boundary; and a common understanding of the hydrogeology and hydrology of the basins. Though they are optional, it is likely that DWR will view them favorably when evaluating the interaction of multiple GSPs in adjacent basins.

3 Models Selected to Evaluate Interbasin Groundwater Flow

The first task in the Interbasin Groundwater Flow Evaluation Project is an inventory of numerical hydrologic models capable of simulating interbasin groundwater flow. The models are generally categorized as either regional or local. For this study, regional models are those covering at least an entire Bulletin 118 groundwater basin. Examples include the California Central Valley Groundwater-Surface Water Simulation Model (C2VSim), Central Valley Hydrologic Model (CVHM), and Sacramento Valley Finite Element Groundwater Model (SACFEM2013), all of which cover the Sacramento Valley Groundwater Basin at a minimum. Local models are those simulating only a portion of a groundwater basin, for example several subbasins within and adjacent to a given county. Examples of local models include the Butte Basin Groundwater Model (BBGM) developed by Butte County and the Stony Creek Fan Model (SCF Model) developed by DWR. The horizontal extent of the active domain for each of the models in the study area is shown in Figure 2. Cross sections through all models except SACFEM2013 are shown on Figure 3 (see Figure 1 for line of section). Each cross section shown on Figure 3 uses a consistent camera origin and focal point, which results in a consistent perspective and vertical axis for each pane of the figure. This allows for comparison between models (e.g., to show that the BBGM extends to a greater depth than the other models included for comparison).

A brief description of each model described above is provided below, including the historical calibration period, horizontal and vertical extent and discretization, and modeling code and packages used. Each description includes details on model features relevant to the simulation of interbasin groundwater flow and a summary of those features are shown on Table 1 for all the models. Note that this inventory report is not an exhaustive review and comparison of each model. However, we have included references to the most recent development information and reports for each model. Also note that this analysis focuses on models

[1] http://www.water.ca.gov/groundwater/sgm/pdfs/Proposed_GSP_Regs_2016_05_10.pdf

that are complete as of the time this memo was developed. DWR is developing a new model of the Sacrament Valley, named the Sacramento Valley Simulation Model (SVSim), but it is not complete. SVSim is being developed to evaluate water transfer projects in the Sacramento Valley, and will be more refined than the fine grid version of C2VSim, both in terms of horizontal and vertical discretization and input datasets.

Figure 2. Groundwater Model Grids

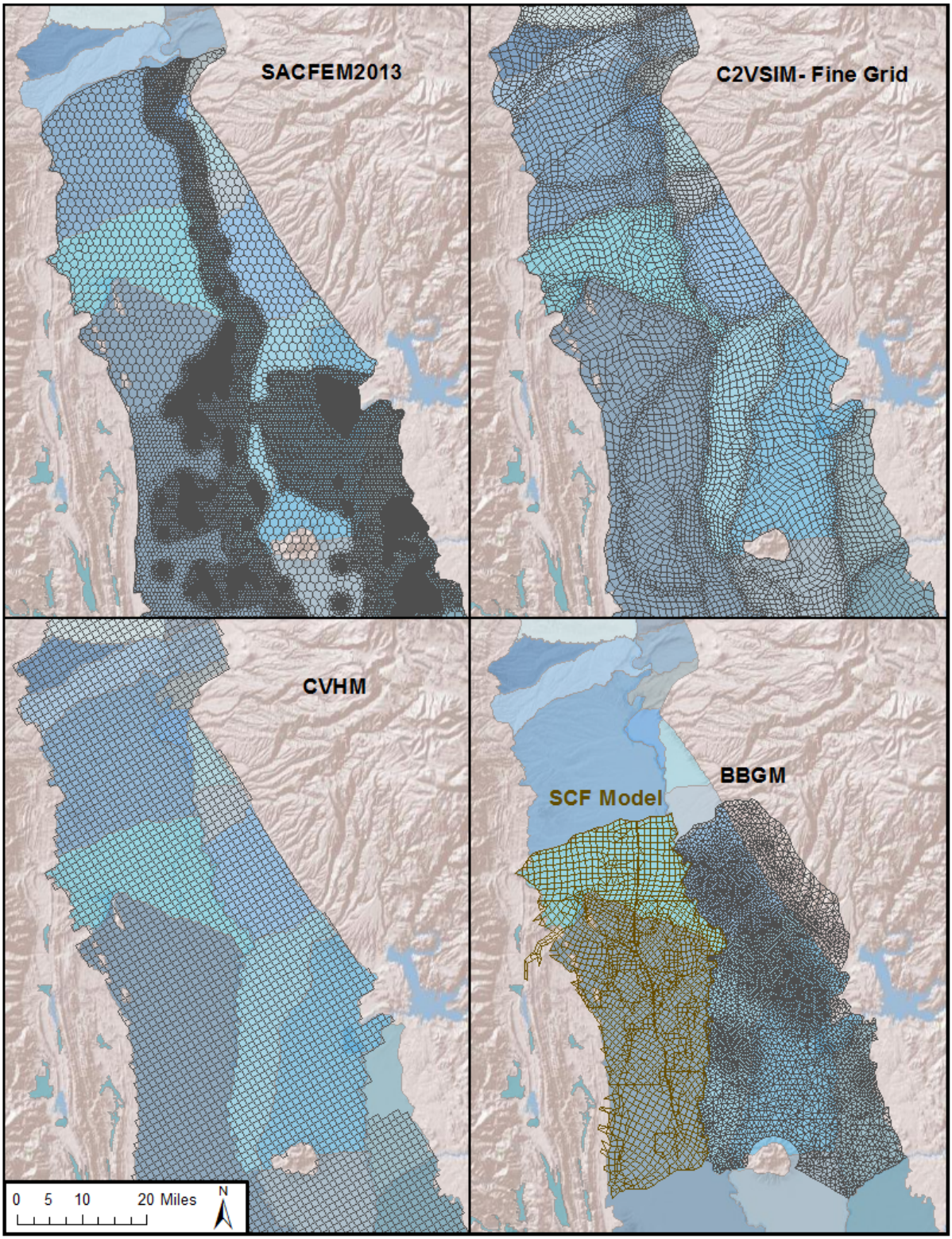
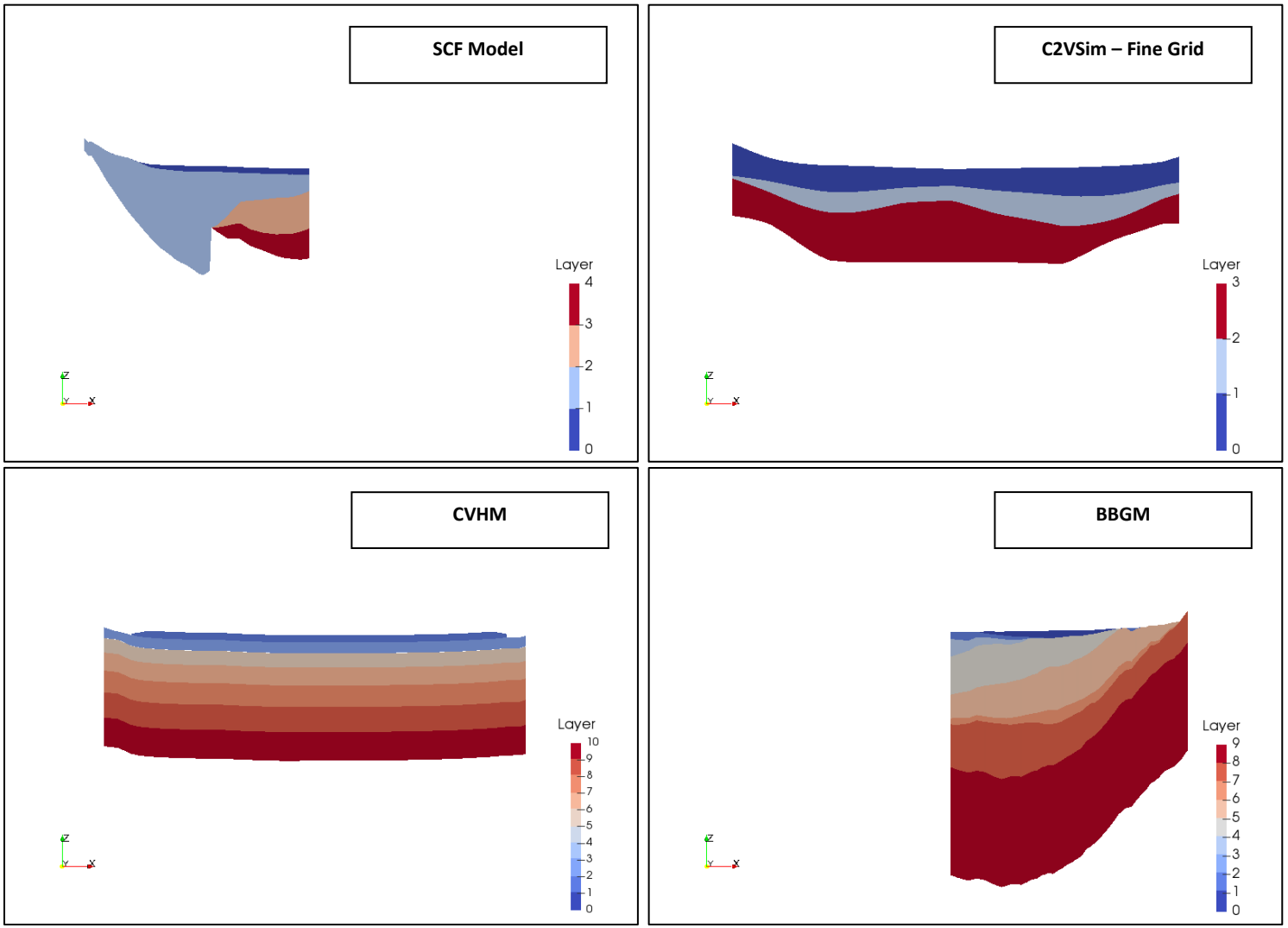


Figure 3. Model Cross Sections



Note: See Figure 1 for line of section. Viewing direction is to the north. Camera origin and focal point are the same for each figure, resulting in a consistent vertical scale for each pane of the figure

Table 1: Study Area Model Components

Key Feature	C2VSim	CVHM	SACFEM2013	BBGM	SCF Model
Code Platform	IWFM	MODFLOW-FMP	IDC coupled with MicroFEM	IWFM	IGSM
Public Domain Code	Yes	Yes	Yes for IDC; MicroFEM is proprietary	Yes	Yes
Model Ownership	DWR	USGS	Reclamation	Butte County	DWR
Availability	Course grid available on DWR website and fine grid available upon request to DWR	Available on USGS website	Uncertain	Available upon request to Butte County	Available upon request to DWR
Documentation	Available on DWR website	Available on USGS website	Available online	Available on Butte County website	Available upon request to DWR
Integrated Model	Yes	Yes	Partially: two separate codes used to simulate hydrologic processes	Yes	Yes
Geographic Area	Central Valley	Central Valley	Sacramento Valley Groundwater Basin	Groundwater Subbasins in Butte County (including East Butte, West Butte, Vina, North Yuba, and portions of Sutter)	Corning Subbasin and northern Colusa Subbasin
Simulation Period (Water Years)	1921 - 2009	1961 - 2003	1970 - 2010	1970 - 2014	1970 - 2000
Number of Layers	3	10	7	9	4

Key Feature	C2VSim	CVHM	SACFEM2013	BBGM	SCF Model
Geologic Formations Represented in the Model	Generalized upper unconfined aquifer, confined production zone, deep confined zone	Layers not explicitly tied to hydrogeologic units except for Corcoran Clay in the San Joaquin Valley, remainder based on sediment texture model	Layers not explicitly tied to hydrogeologic units except for portions of the Tuscan Formation	Holocene basin deposits, Alluvium, Sutter/Laguna Formation, Tehama Formation, Tuscan C/B/A Formations, older marine (Neroly, Upper Princeton Gorge, Ione)	Alluvial and basin deposits, Tehama Formation, Upper Tuscan Formation, and Lower Tuscan Formation
Agricultural Demand Estimation Method	Integrated methodology using IDC	Integrated methodology using the Farm Process	Calculated externally by IDC	Integrated methodology using IDC	Integrated methodology using IGSM Ag Demand Package
Stream-Aquifer Interaction Method	Integrated methodology using IWFM Stream Package	Integrated methodology using MODFLOW Streamflow Routing Package	Limited; fixed head boundary condition for river stages	Integrated methodology using IWFM Stream Package	Integrated methodology using IGSM Stream Package
Note: Descriptions in this table may not reflect ongoing, unpublished updates to these models.					

3.1 C2VSim

C2VSim[2] is a regional numerical hydrologic model covering the approximately 20,000 square miles (i.e. 12.8 million acres) of California's Central Valley. C2VSim was originally developed in 1990 for DWR, U. S. Bureau of Reclamation, and the State Water Resources Control Board as the Central Valley Groundwater and Surface water Model (CVGSM). The model was upgraded in 2005 to the public domain IWFM platform and was renamed C2VSim. IWFM, also developed by DWR, is an open source finite element simulation code that supports triangular and quadrilateral elements. C2VSim has been used in numerous applications, including planning studies, climate change assessments, improved understanding of stream–groundwater flows, groundwater storage investigations, ecosystem enhancement scenarios, infrastructure improvements, and Delta flows specific studies. IWFM and C2VSim are both specifically designated as useful in developing water budgets for SGMA compliance, though other models or codes may be used.

There are two versions of C2VSim maintained by DWR, a coarse-grid version (C2VSim-CG) and a fine-grid version (C2VSim-FG). C2VSim-CG is publically available for download from DWR, while C2VSim-FG is under refinement and calibration. Both versions are currently being updated through 2015.

[2] http://baydeltaoffice.water.ca.gov/modeling/hydrology/C2VSim/index_C2VSIM.cfm

This Tech Memo will focus on the fine-grid version of C2VSim; all references to C2VSim hereafter refer to C2VSim-FG.

C2VSim currently contains monthly historical stream inflows, surface water diversions, precipitation, land use, and crop acreages from October 1921 through September 2009. C2VSim dynamically calculates crop water demands; allocates contributions from precipitation, soil moisture, and surface water diversions; and calculates groundwater pumping required to meet the remaining demand. The model simulates the historical response of the Central Valley's groundwater and surface water flow system to historical stresses.

The C2VSim grid has more than 32,000 elements and 30,000 nodes, with an average element area of approximately 400 acres. The C2VSim model grid, which covers the entire Central Valley, is shown for the study area in Figure 2. C2VSim is vertically discretized into 3 aquifer layers and 1 aquiclude with a generalized upper unconfined aquifer, a confined production zone, and a deep confined zone. Additional details of C2VSim are provided in Table 1.

3.2 CVHM

CVHM[3] is a regional model developed by the U.S. Geological Survey (USGS) to simulate historical hydrology and groundwater conditions of California's Central Valley. Some applications have included simulating land subsidence, determining groundwater availability in the Central Valley, and evaluating the effect of climate change on streamflow, demands, and other hydrology. CVHM utilizes USGS' open source MODFLOW code plus the Farm Process Package, Stream Flow Routing, Basin Characteristics Model, Subsidence, and Flow Barriers modules and simulates conditions from October 1961 through September 2003. CVHM, like C2VSim, accounts for historical stream inflows, surface water diversions, precipitation, land use, and crop acreages. USGS developed a Central Valley sediment texture model to account for the heterogeneous distributions of fine and coarse grained materials that control groundwater flow. Although not yet released, USGS is reportedly updating CVHM to simulate recent conditions and to use a new simulation code, MODFLOW-One Water Hydrologic Model (OWHM).

CVHM contains about 20,000 elements with a uniform cell size of 640 acres (i.e., 1 square mile) and covers approximately 20,000 square miles (12.8 million acres) of the Central Valley. The subsurface is simulated using 10 layers. Additional details of CVHM are provided in Table 1.

3.3 SACFEM2013

SACFEM2013[4] is a regional model that uses the proprietary MicroFEM model for simulation of groundwater flow and the IWFM Demand Calculator model (IDC) for simulation of land surface processes. SACFEM2013, originally developed in 2008, links the groundwater model with the surface water budget and root zone model (i.e., IDC model) to estimate deep percolation and agricultural pumping on a node by node basis from October 1969 through September 2010. SACFEM2013 was primarily developed as a tool to estimate the impact of conjunctive water management projects on surface water and groundwater resources within the Sacramento Valley. RMC performed a peer review of SACFEM in 2011[5]. SACFEM2013 was used to evaluate water transfers to mitigate Central Valley Project supply shortages for

[3] http://ca.water.usgs.gov/projects/central-valley/central-valley-hydrologic-model.html

[4] SACFEM2013: Sacramento Valley Finite Element Groundwater Flow Model User's Manual, February 2015. Prepared for U.S. Bureau of Reclamation by CH2M HILL and MBK Engineers, Inc.

[5] Technical Memorandum: Peer Review of Sacramento Valley Finite Element Groundwater Model (SACFEM), October 2011. Prepared for U.S. Bureau of Reclamation by WRIME, Inc. (now RMC).

the Long-Term Water Transfers Environmental Impact Statement/Environmental Impact Report (EIS/EIR) in 2014[6]. It was also reviewed as a part of the Review and Comments for the EIS/EIR.

SACFEM2013 covers the entirety of the Sacramento Valley Groundwater Basin (i.e., almost 6,000 square miles) and contains about 150,000 nodes and over 300,000 elements. Spacing between the nodes is as large as 3,300 feet and as small as 410 feet. The subsurface is simulated using 7 layers. Additional details of SACFEM2013 are provided in Table 1.

3.4 BBGM

BBGM[7] is a local model that uses the public domain IWFM code to simulate surface water and groundwater conditions in Butte County and selected surrounding areas from October 1970 through September 2014. Applications have included evaluating project feasibility, determining water budgets by model subregion, estimating changes to surface water availability, modeling climate change effects and system vulnerabilities, and assessing the effects of changing future demands. The model is a successor to the earlier Butte Basin Water Users Association Groundwater Model developed using the FEMFLOW3D code. Butte County staff and their consultants are currently updating the BBGM to utilize a newer version of IWFM. The update will allow for representation of additional complexity, including elemental land use distributions and details of water use for ponded crops (e.g., water use changes associated with laser levelling of rice fields).

The boundaries of the model are Deer Creek to the north, Sacramento River to the west, the Sutter Buttes and Yuba River to the south, and foothills to the east. The model covers about 1,200 square miles with nodes spaced between 2,500 and 5,000 feet that form over 7200 elements. The average element size is 112 acres and the model has 9 layers. BBGM contains portions of the Sacramento Valley Groundwater Basin—the Vina, West Butte, East Butte, Sutter, and North Yuba subbasins. Additional details of BBGM are provided in Table 1.

3.5 SCF Model

The SCF Model[8] is a local model developed for DWR and local program sponsors in 2003 to study Stony Creek Fan, a geologic feature in Glenn and Tehama Counties. The model has been used to evaluate changes in land and water use and make assumptions about the availability of water supply. The SCF Model is a comprehensive hydrologic model that simulates the surface water and groundwater flow systems using the public domain Integrated Groundwater-Surface Water (IGSM) code, which is a predecessor code to DWR's IWFM. The historical simulation period of the SCF Model is from 1970 through 2000. An extensive geologic analysis was conducted to develop model layering and parameters. The model simulates conditions in the Corning and northern Colusa groundwater subbasins, and includes the Tehama, Upper, and Lower Tuscan Formations. The calibration period of the model has not been updated since 2003 and we are not aware of any ongoing efforts to update this model.

At its largest points, the model extends about 30 miles from west to east and about 70 miles from north to south to cover an area of about 1,000 square miles covering the Corning groundwater subbasin and a portion

[6] http://www.usbr.gov/mp/nepa/nepa_projdetails.cfm?Project_ID=18361

[7] https://www.buttecounty.net/waterresourceconservation/Groundwater.aspx

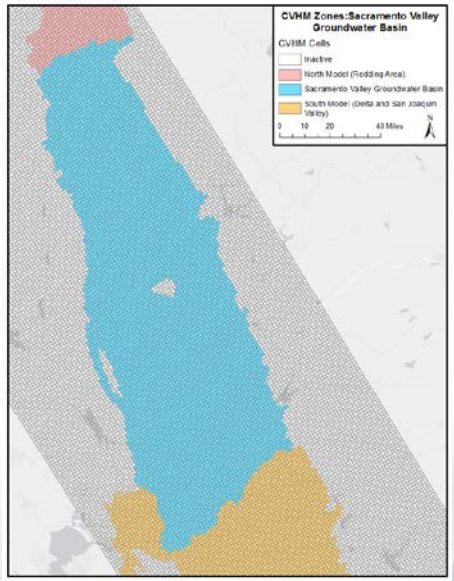
[8] Stony Creek Fan Integrated Groundwater and Surface Water Model (SCFIGSM): Model Development and Calibration Baseline Analysis, Volume 3 of 4, May 2003. Prepared for Glenn-Colusa Irrigation District, Orland-Artois Water District, and Orland Unit Water Users' Association by WRIME, Inc. (now RMC) in coordination with DWR.

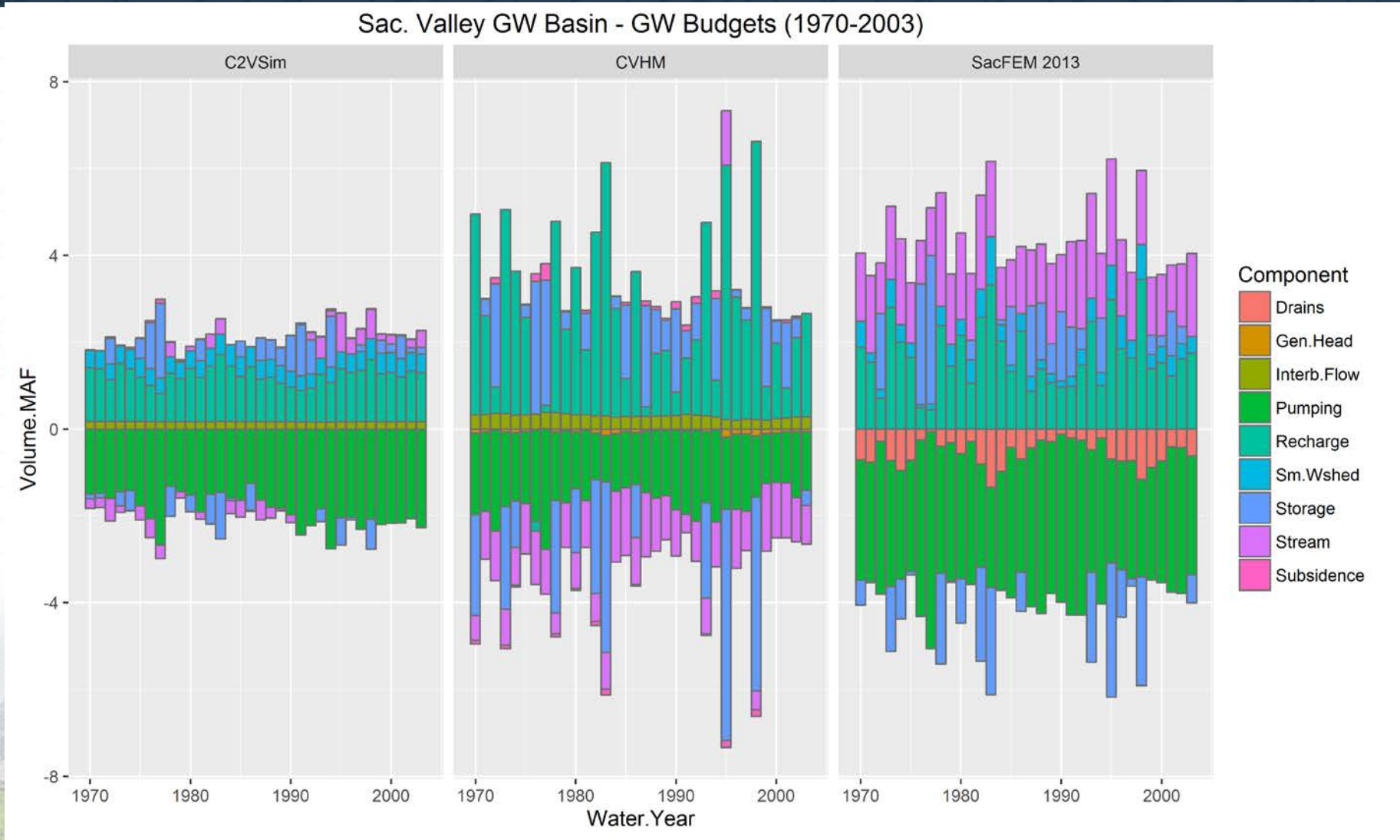
of the Colusa subbasin (i.e., approximately the same portion within the study area). The SCF Model grid is made up of over 2,000 elements and approximately 1,800 nodes. The subsurface is modeled using 4 layers. Additional details of the SCF Model are provided in Table 1.

Appendix D - Water Budget Assessment

3. Process for Water Budget Comparison

- If more than one model is suitable, how should we compare them?

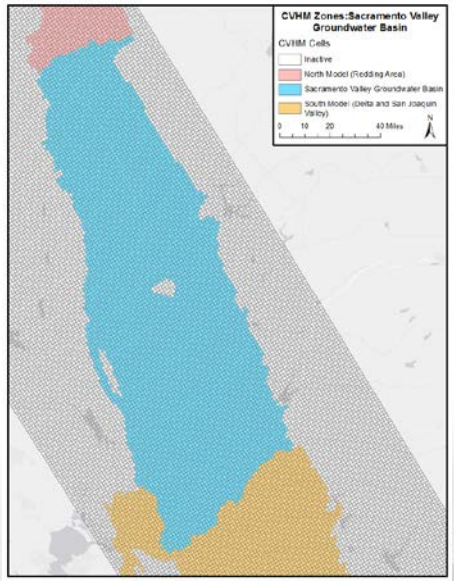


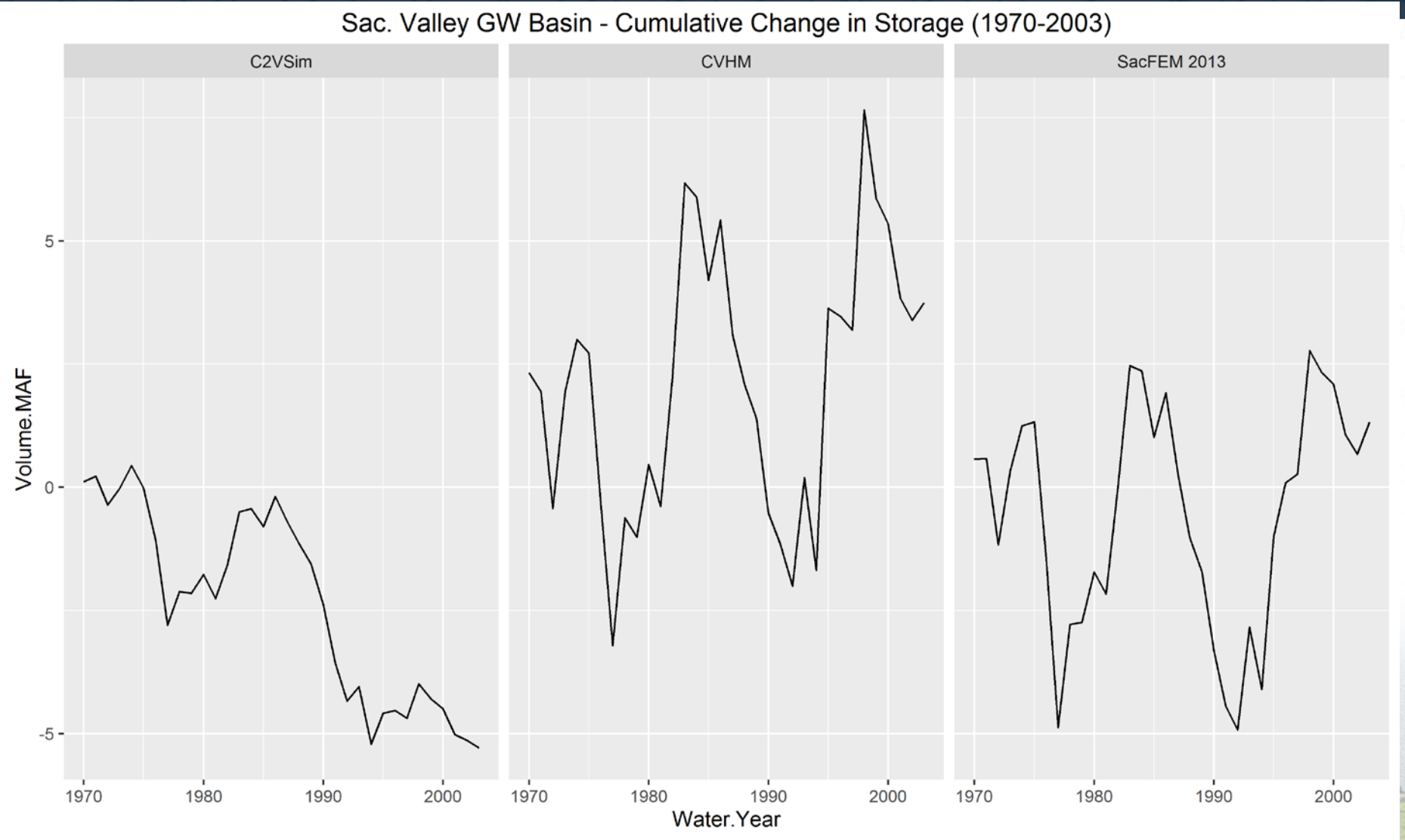


RMC water and environment

3. Process for Water Budget Comparison

- If more than one model is suitable, how should we compare them?





3. Process for Water Budget Comparison

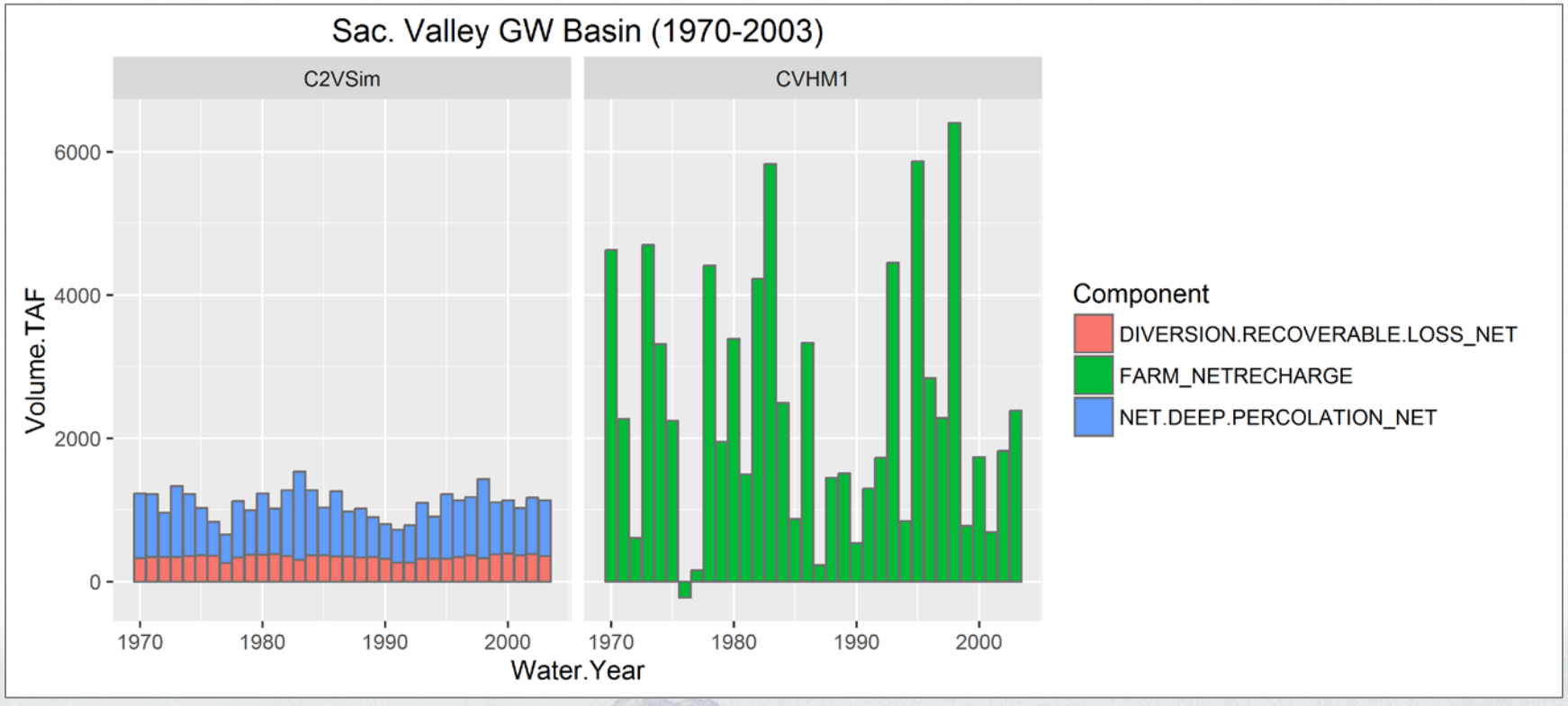
- Describe best practices for comparing modeled water budgets
  - Which components are directly comparable
  - Which to aggregate
  - How to handle processes simulated by one model but not another

	C2VSim	CVHM2
Storage	GW STORAGE	STORAGE
Recharge	NET DEEP PERCOLATION + (?) DIVERSION RECOVERABLE LOSS + *(?) BYPASS RECOVERABLE LOSS*	FARM_NETRECHARGE
Pumping	PUMPING BY ELEMENT + PUMPING BY WELL	MNW2 + *FARM_WELLS*
Streams	STREAMS	STREAM_LEAKAGE
Small Watersheds	SMALL WATERSHED BASEFLOW + SMALL WATERSHED PERCOLATION	(?) SPECIFIED_FLOWS
Subsidence	SUBSIDENCE	INST_IB_STORAGE + DELAY_IB_STORAGE
Drains	*TILE DRAINS*	*DRAINS*
Interbasin Flow	FLOW FROM ZONE XXX / FLOW TO ZONE XXX	FLOW FROM ZONE XXX / FLOW TO ZONE XXX
Other Boundaries		HEAD_DEP_BOUNDS + *CONSTANT_HEAD*

Note: items in *Gray Italics* are not simulated in the Sacramento Valley GW Basin for these models

RMC water and environment

3. Process for Water Budget Comparison

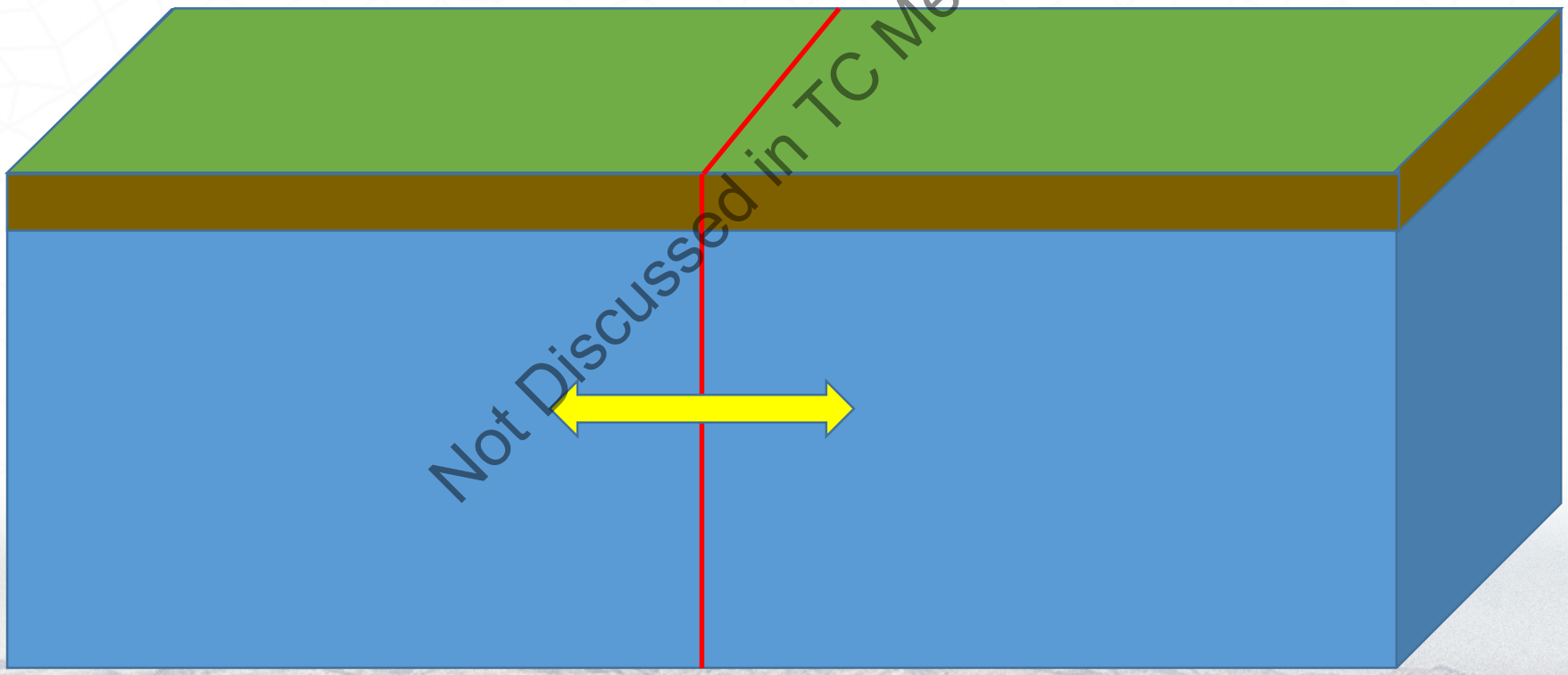


RMC water and environment

Appendix E - Interbasin Groundwater Flow Assessment

4. Evaluating Interbasin Flows Where the Boundary is Defined by a River/Stream

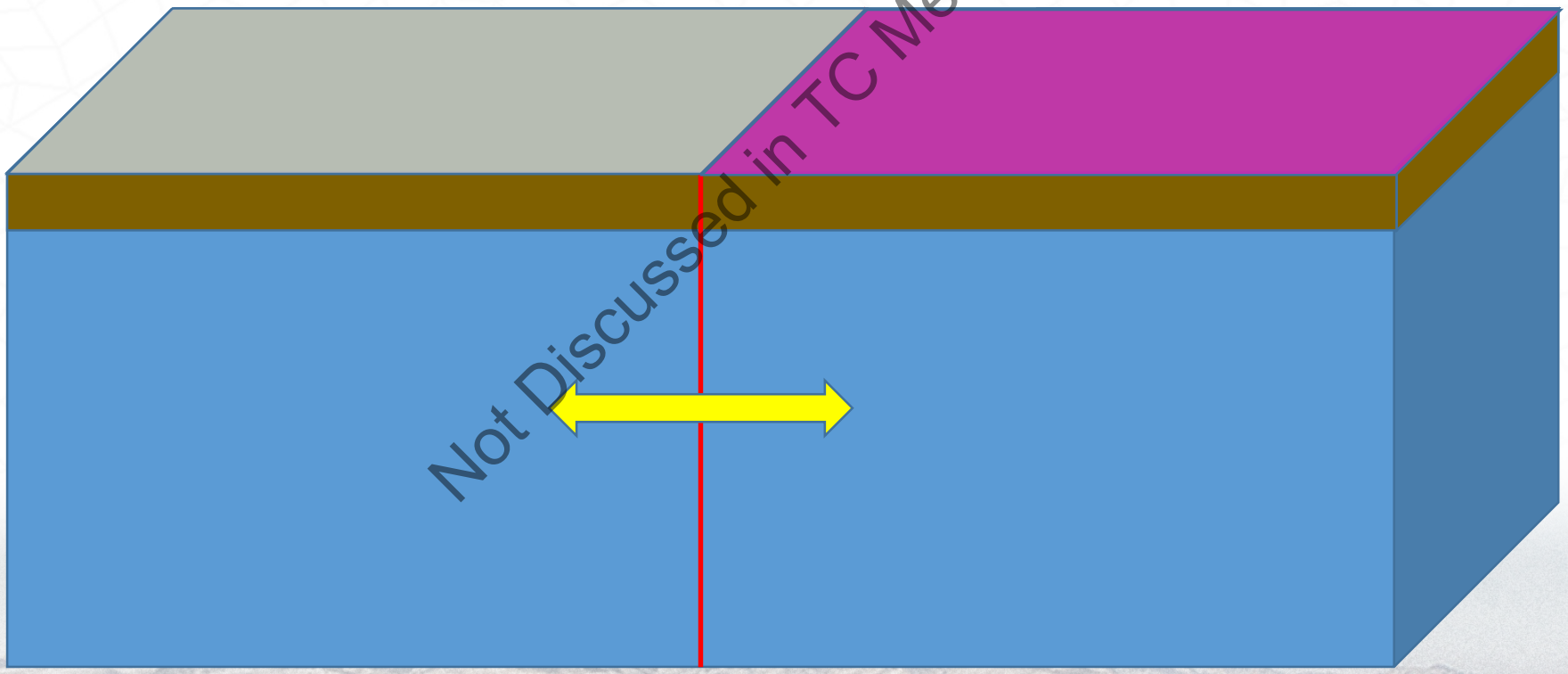
- Interbasin flow, generally, is the flow entering or leaving a (sub)basin from an adjacent, hydraulically connected (sub)basin



Not Discussed in TC Meeting #2

RMC water and environment

4. Evaluating Interbasin Flows Where the Boundary is Defined by a River/Stream

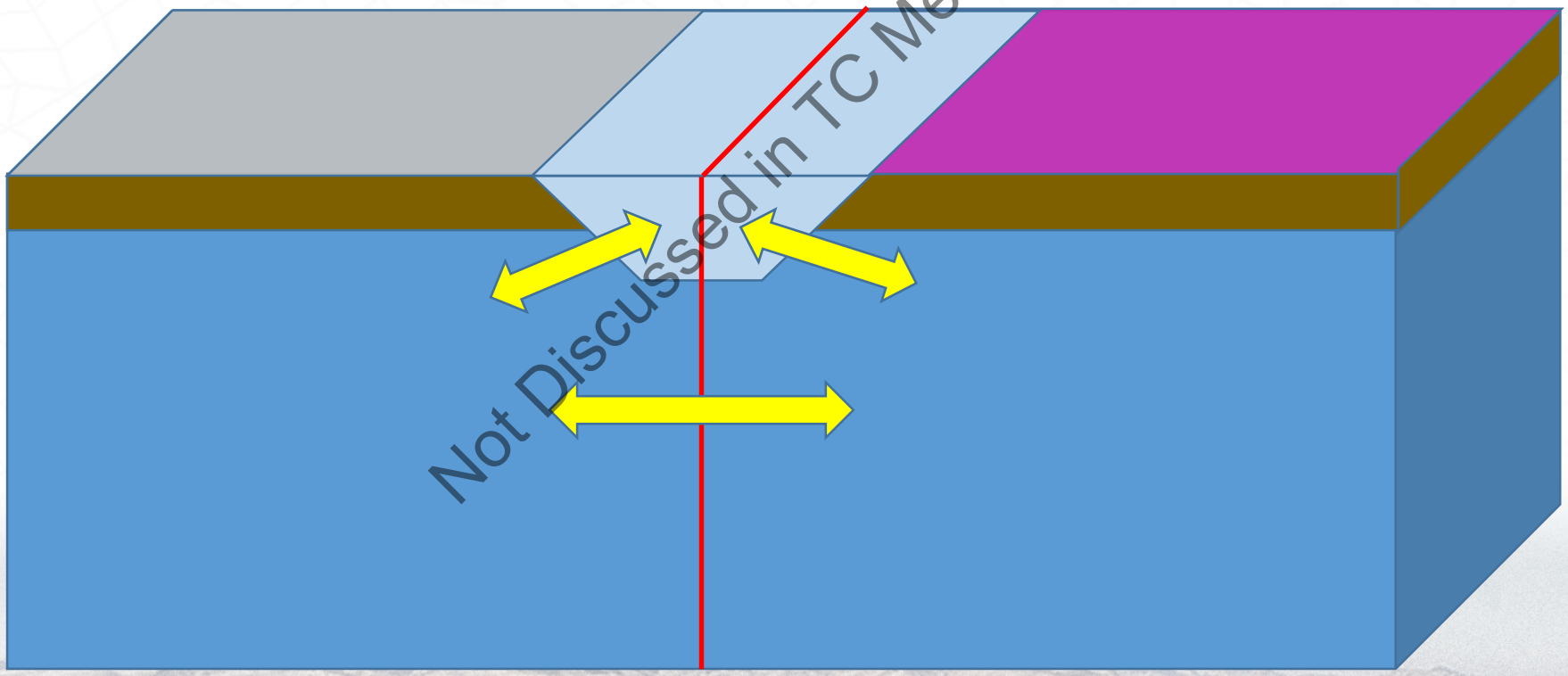


Not Discussed in TC Meeting #2

RMC water and environment

4. Evaluating Interbasin Flows Where the Boundary is Defined by a River/Stream

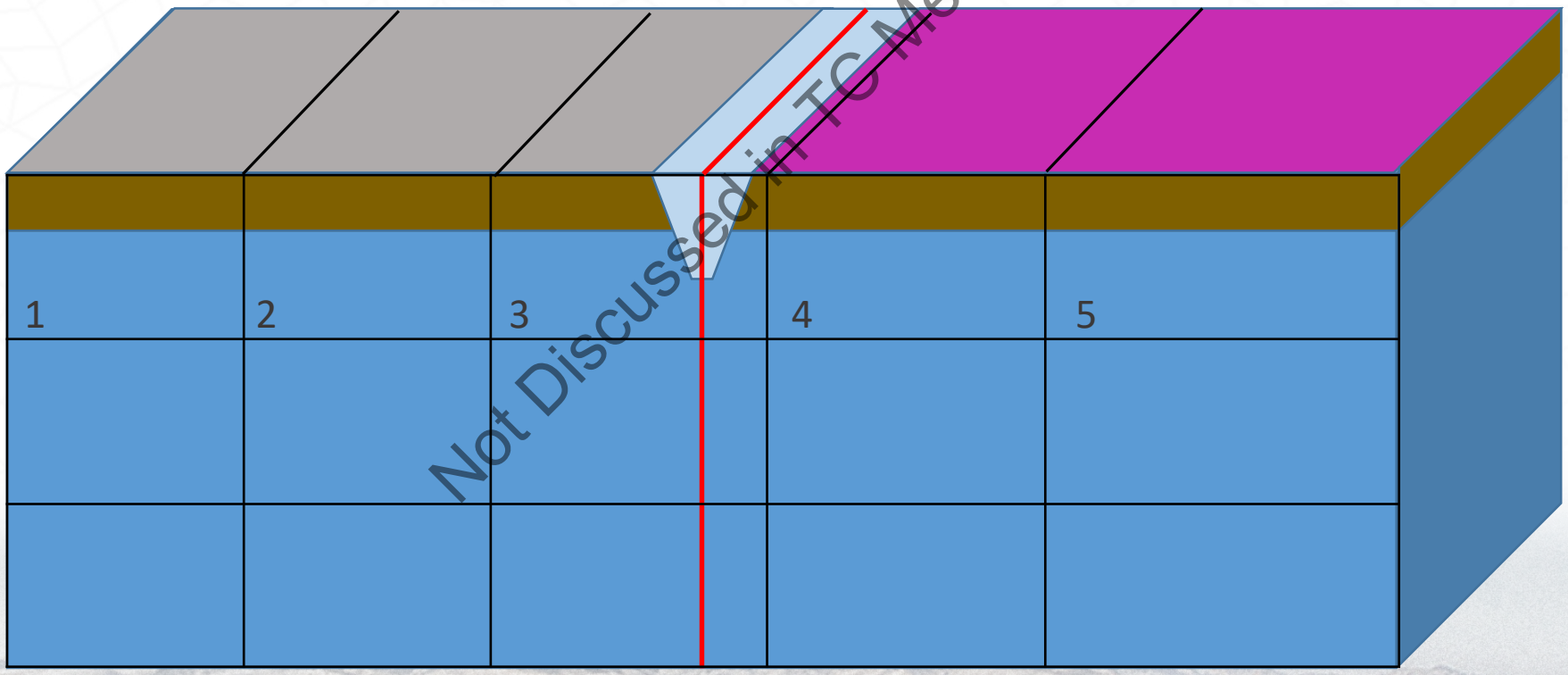
- Boundaries aligned with rivers and streams (as many in the state are) complicates the quantification of these flows



Not Discussed in TC Meeting #2

RMC water and environment

4. Evaluating Interbasin Flows Where the Boundary is Defined by a River/Stream



Not Discussed in TC Meeting #2

RMC water and environment

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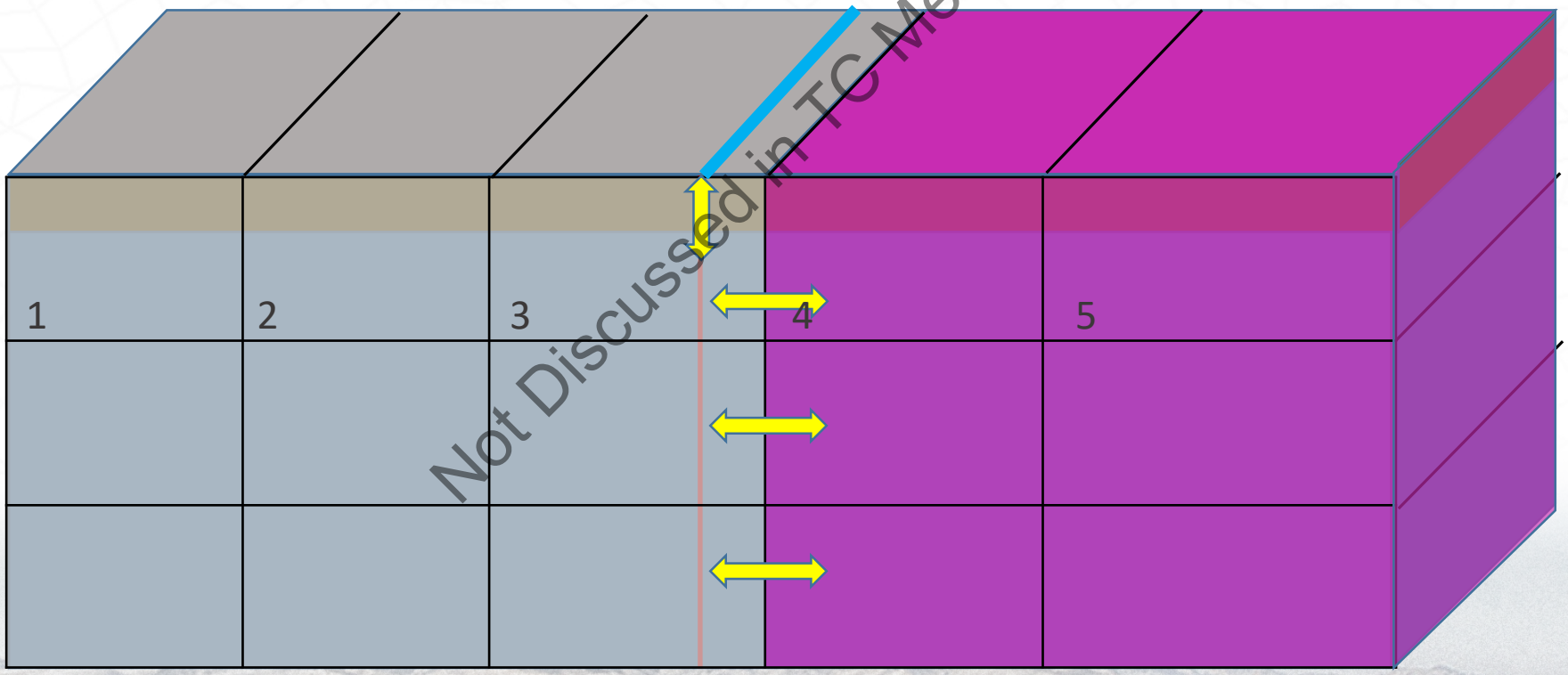
Not Discussed in TC Meeting #2

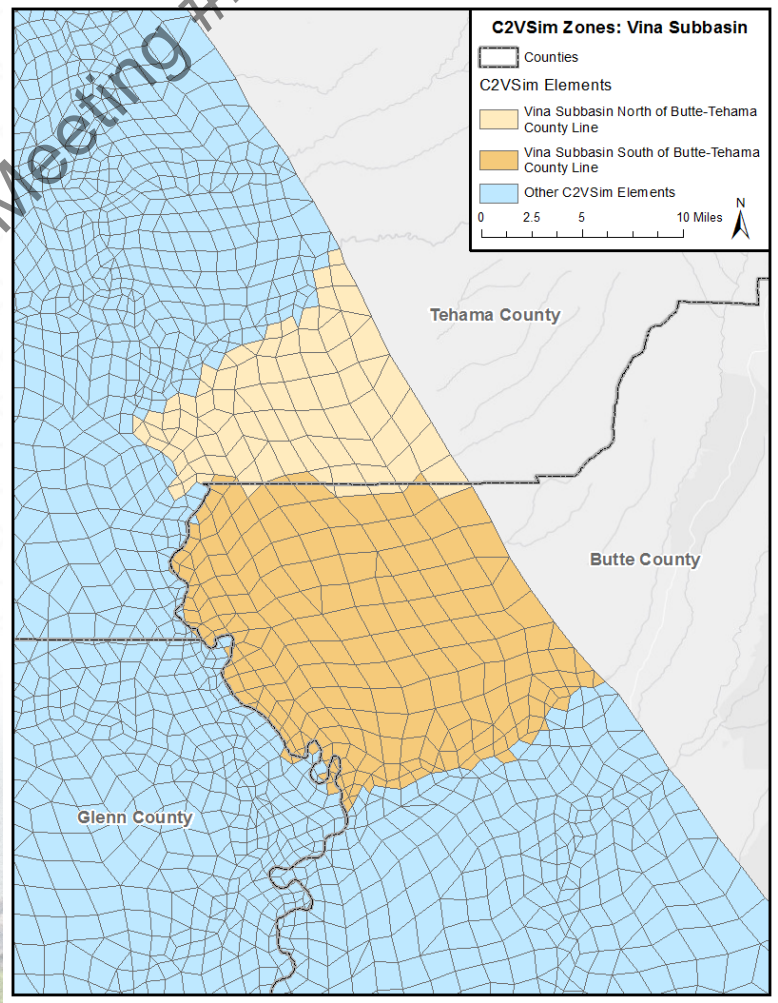


$Q_{str} = 0$

Example of Interbasin Flow Budget Information

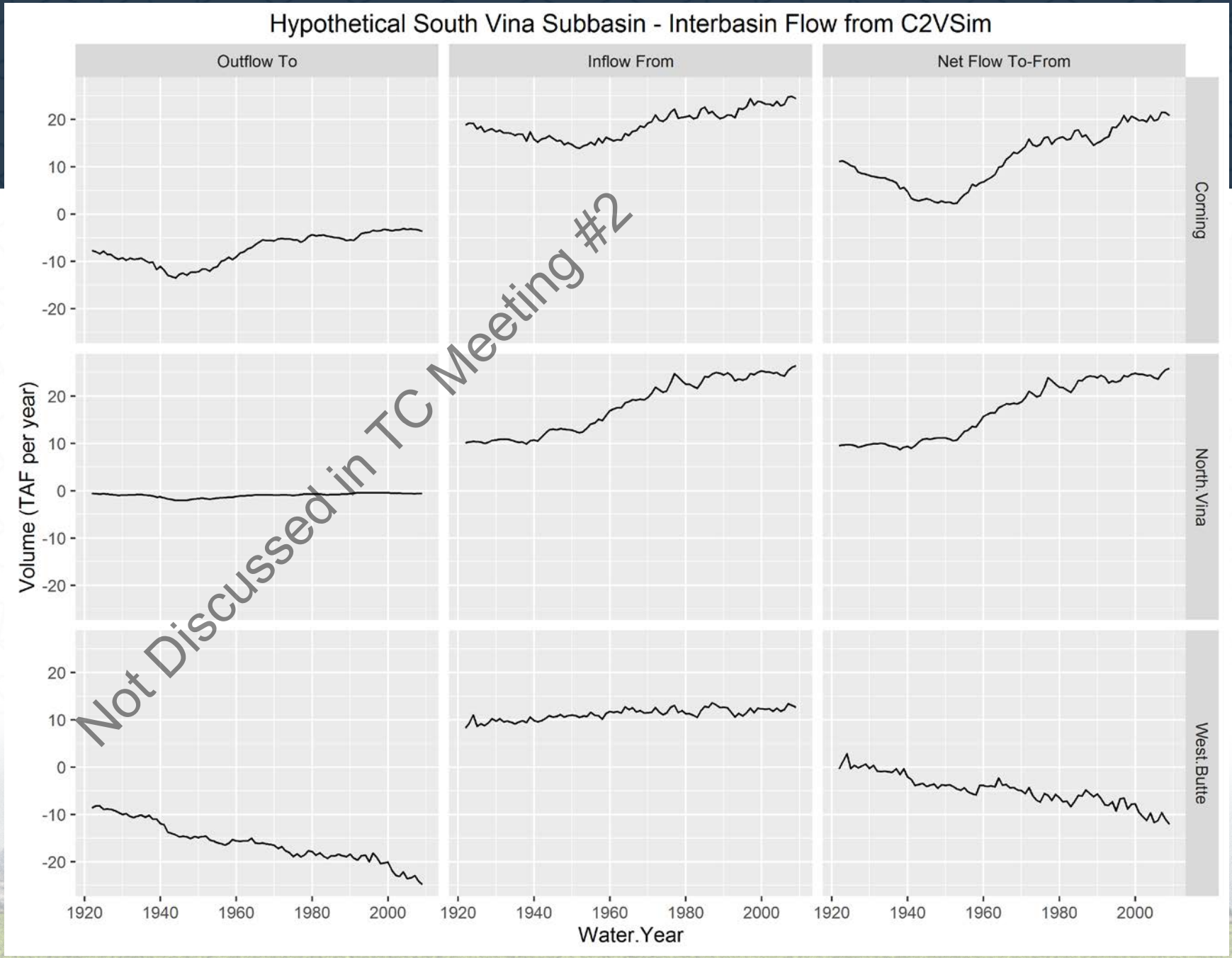
- Using C2VSim
- Split Vina Subbasin into two hypothetical subbasins along county line -> North Vina and South Vina
- Budget information presented below is from the perspective of South Vina (darker orange area on figure to the left)

Not Discussed in TC Meeting #2



RMC water and environment

- Evaluated subsurface inflow and outflow, by layer, into/out of hypothetical South Vina Subbasin from:
  - Corning
  - North Vina
  - West Butte



RMC water and environment

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  - Corning
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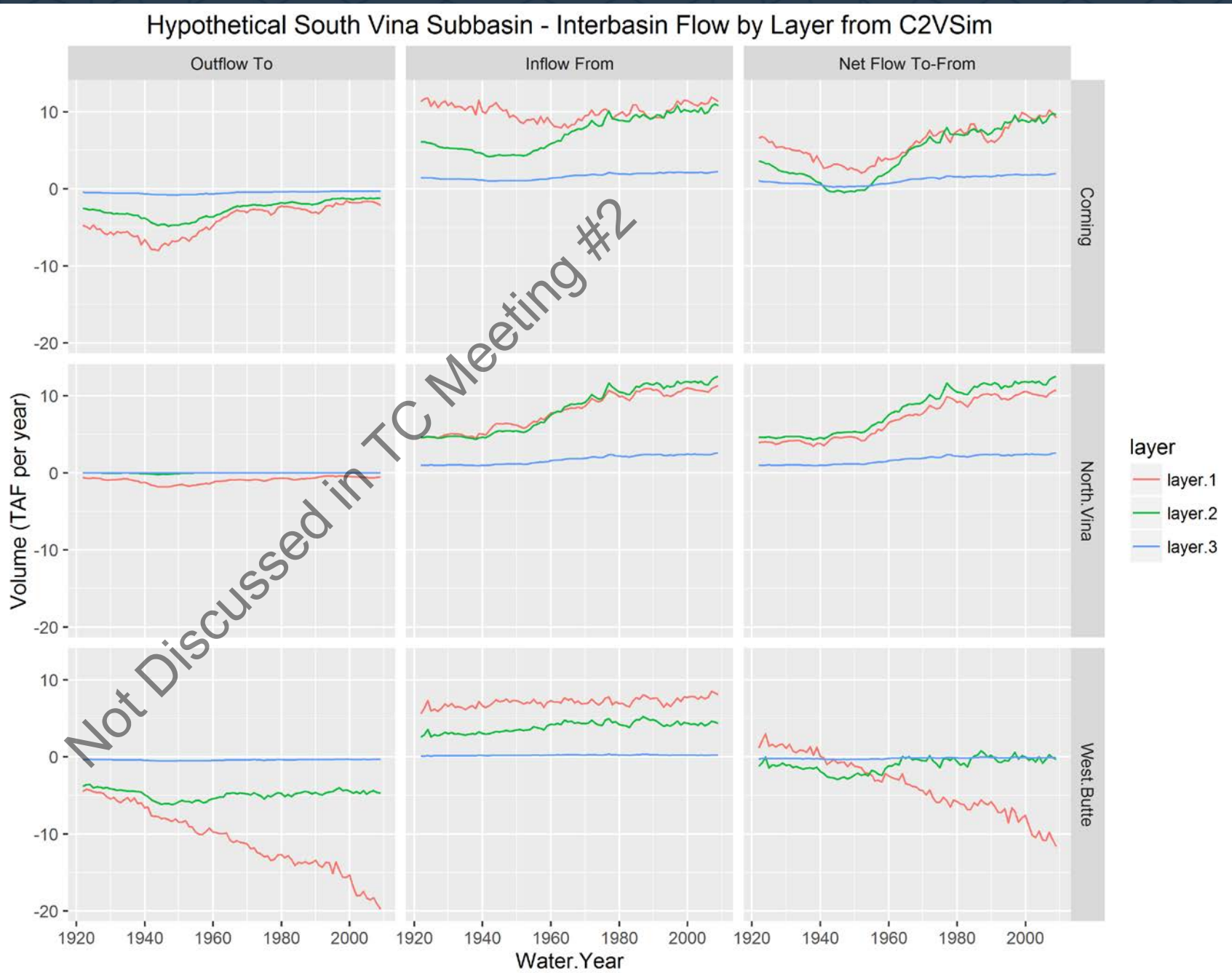
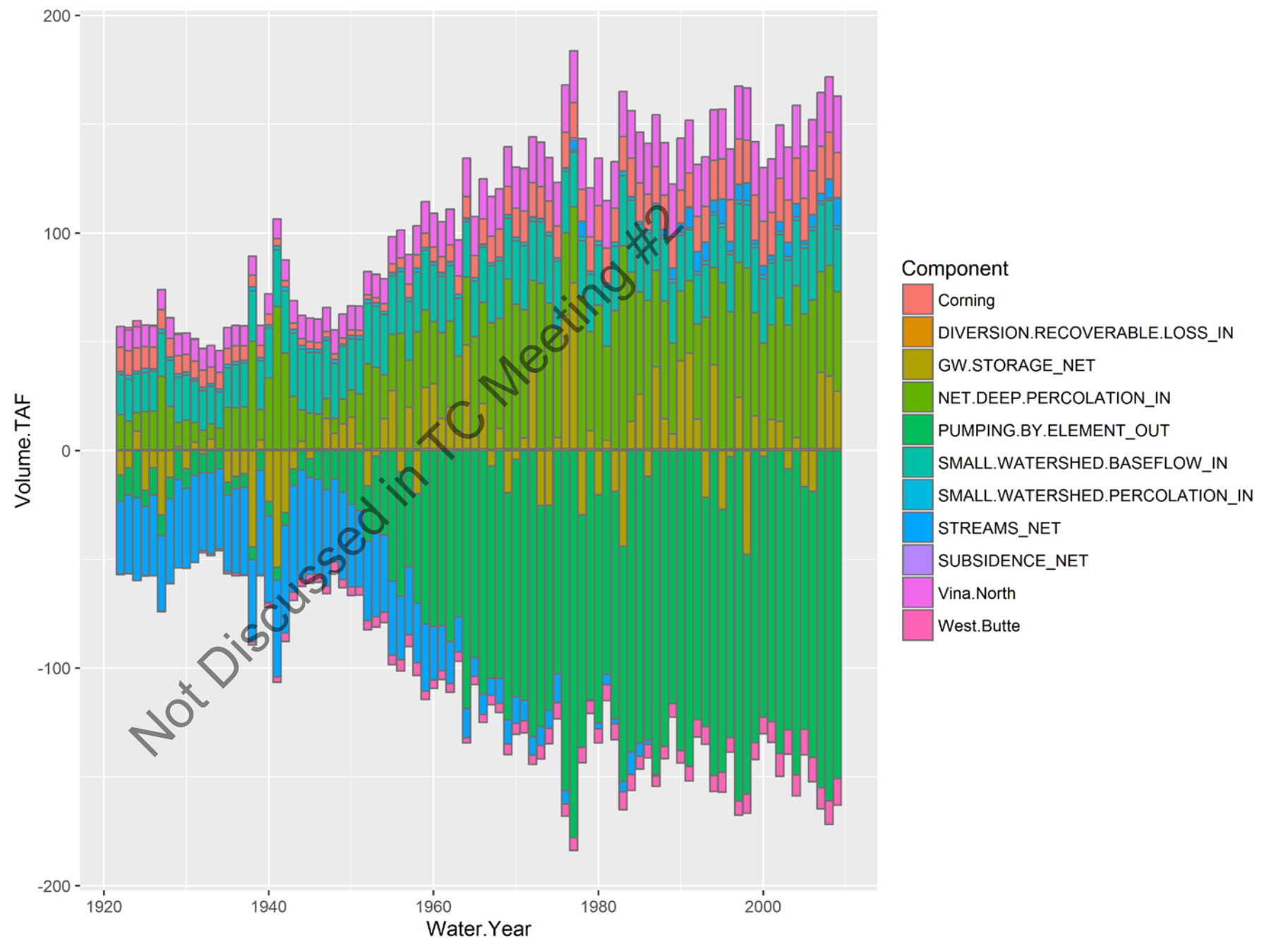
  - West Butte



Not Discussed in TC Meeting #2

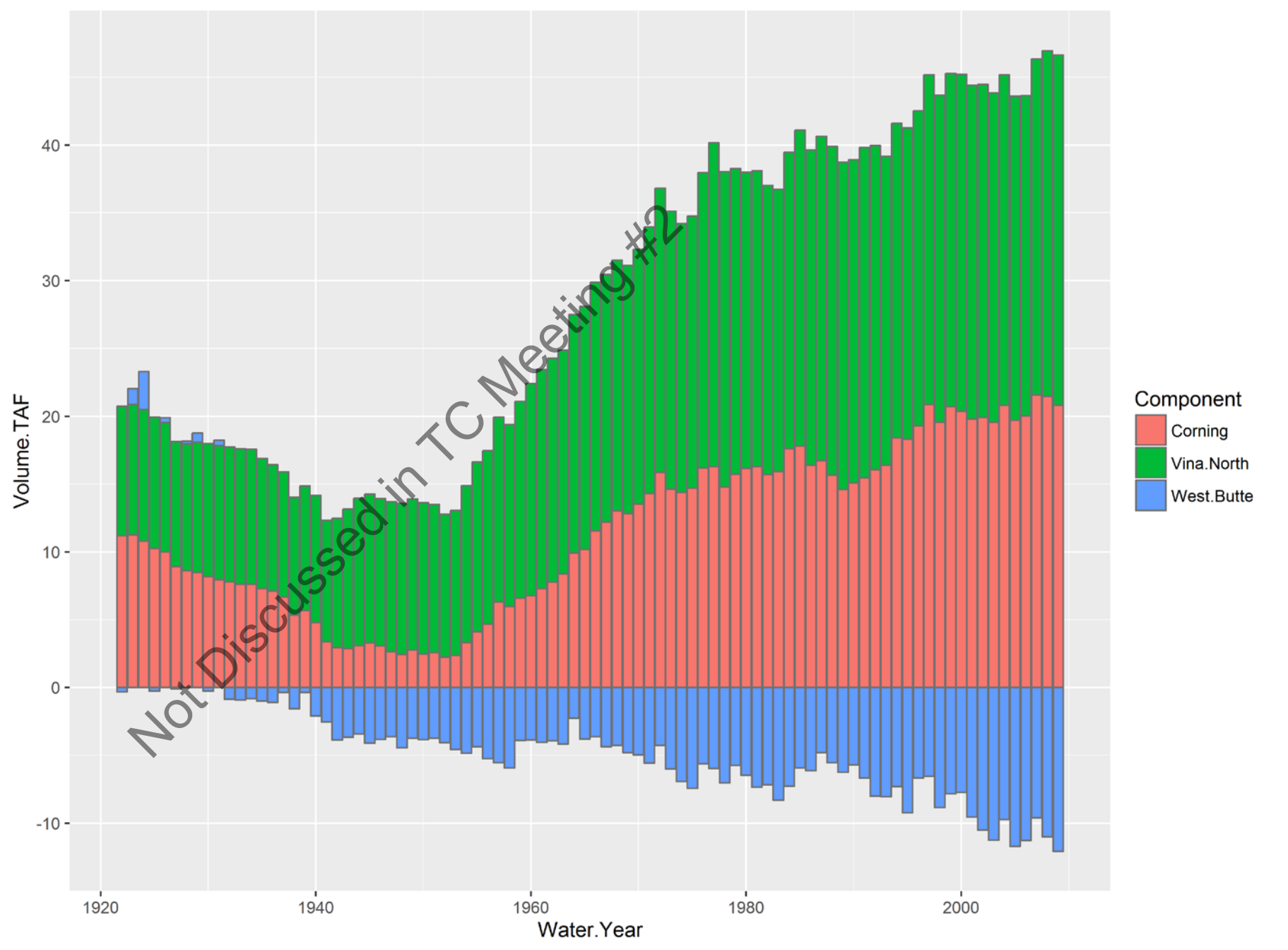
Hypothetical South Vina Subbasin Total GW Budget



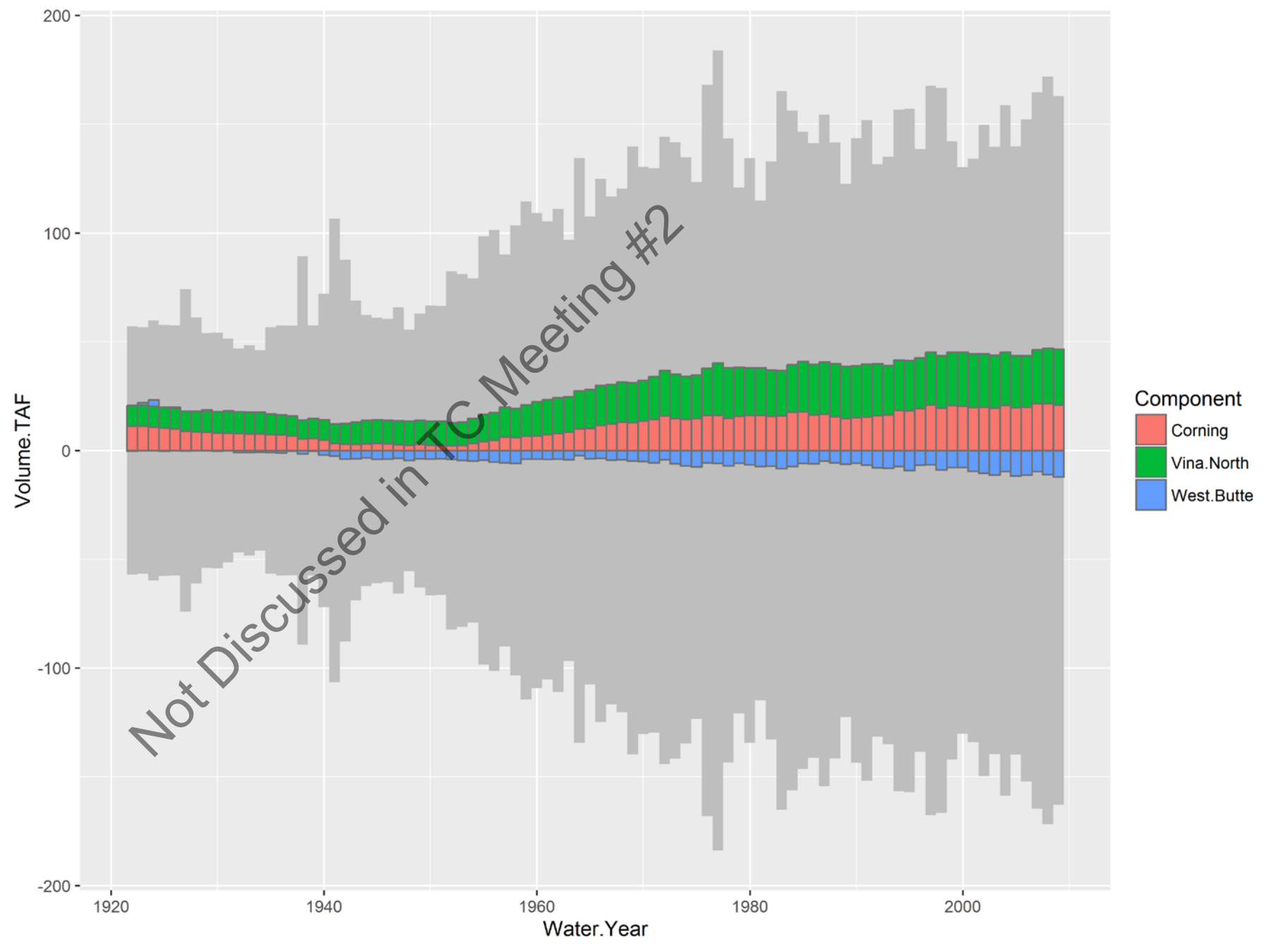
Not Discussed in TC Meeting #2

RMC water and environment

Hypothetical South Vina Subbasin Interbasin Flows



Hypothetical South Vina Subbasin Interbasin Flows Relative to Total Groundwater Budget



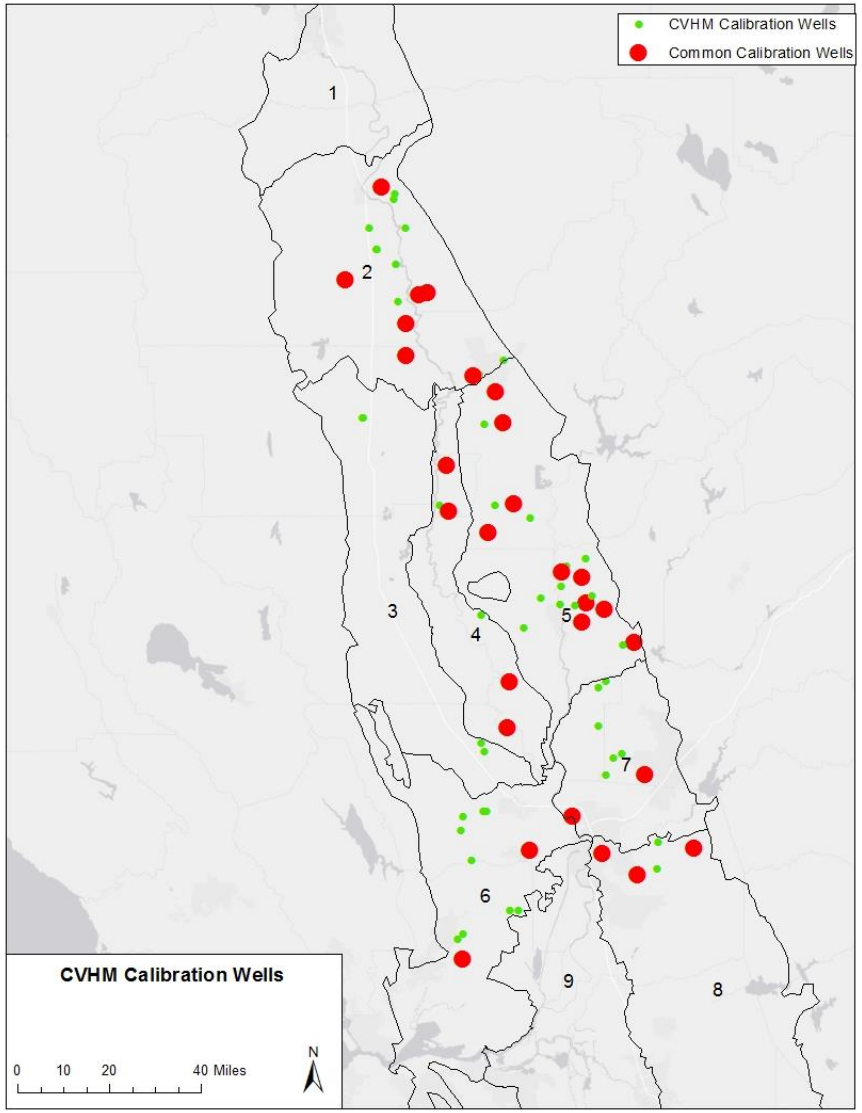
RMC water and environment

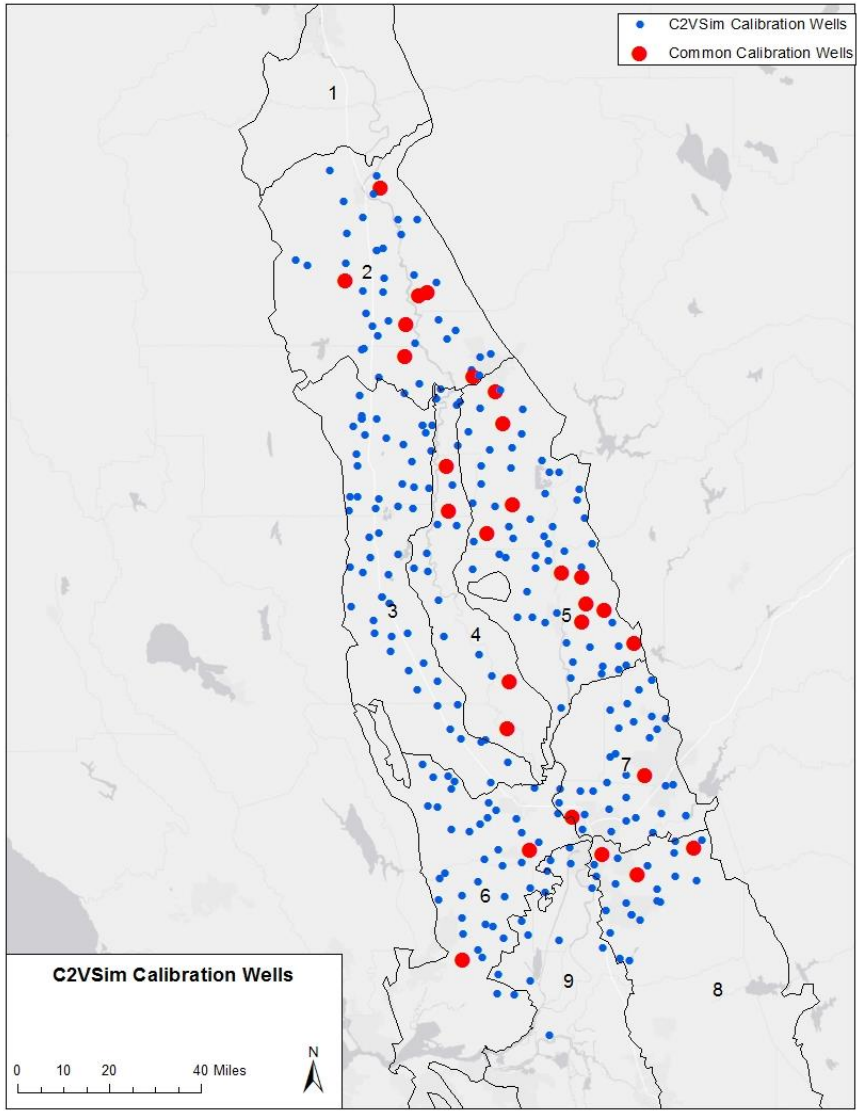
Appendix F - Model Calibration Hydrographs

Model Calibration
Source of Data

- C2VSim
  - Cvprint.dat (wells names and locations)
  - CVGWhyd.out (monthly simulated groundwater levels)
- CVHM
  - HYDMOD.txt (wells names and locations)
  - Hydro2.gwh (monthly simulated groundwater levels)
- Ground Surface Elevations
  - Google Earth

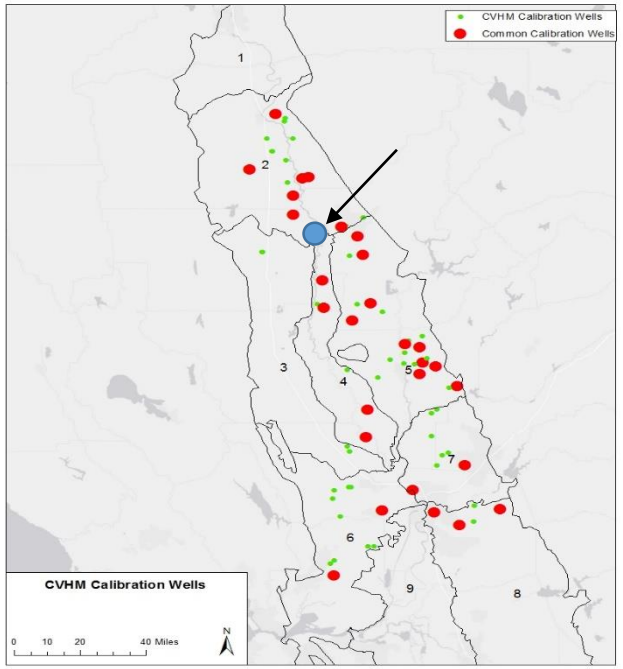
Model Calibration

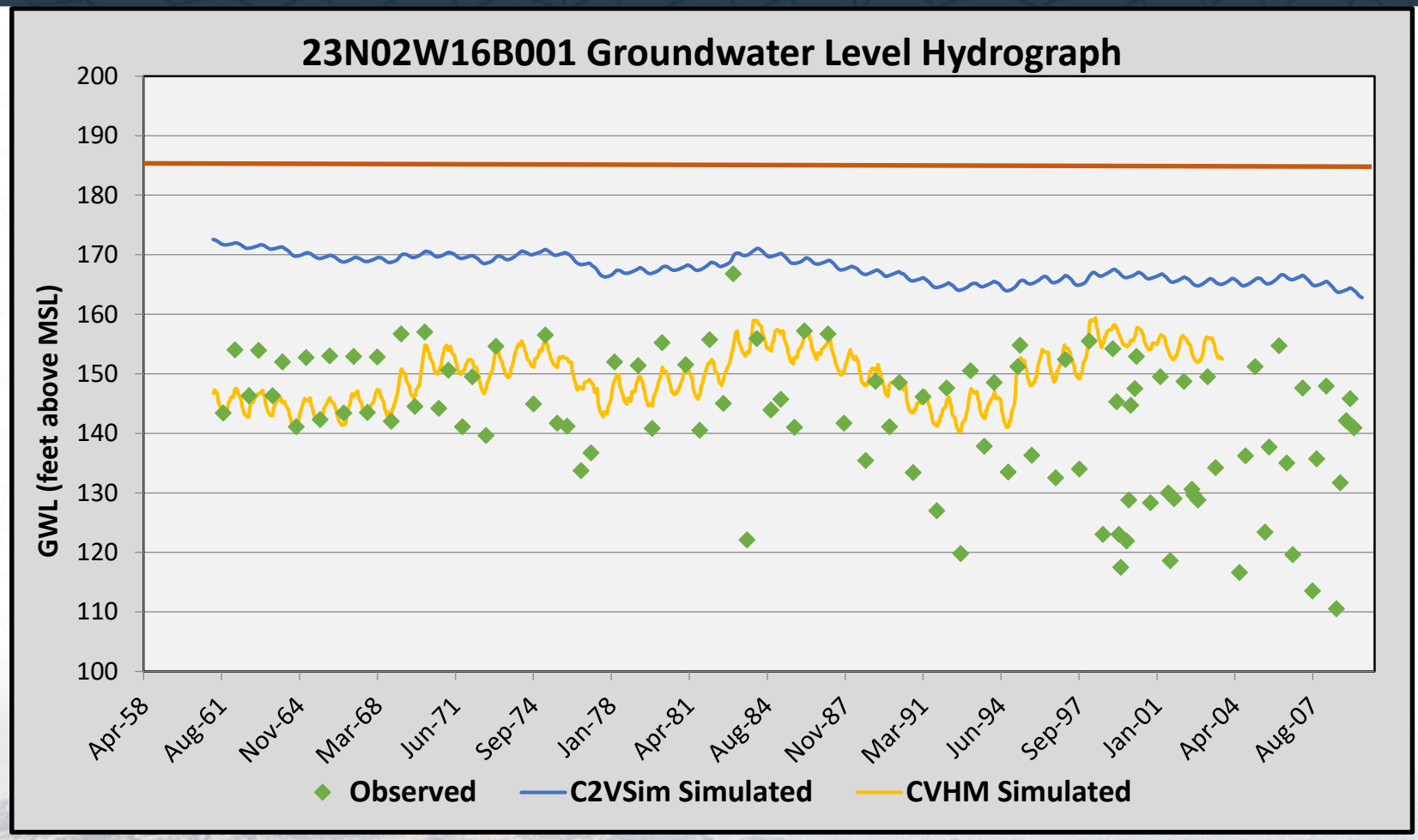




Model Calibration

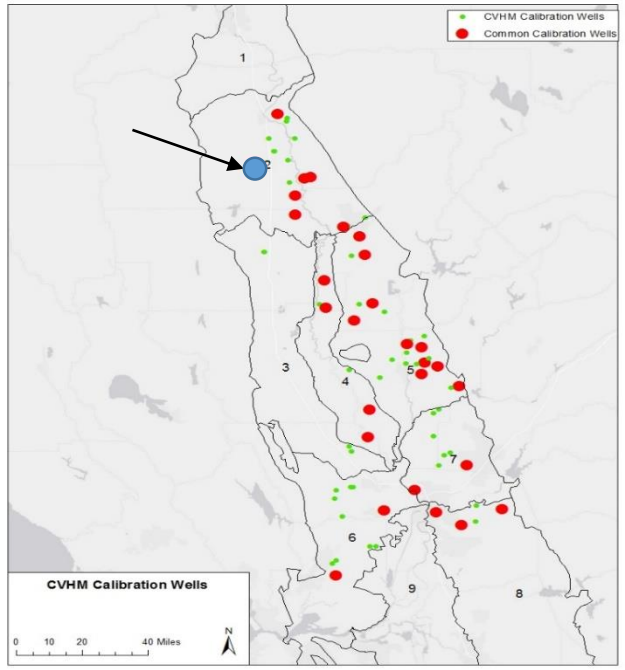
- Active Irrigation
- Shallow (100 – 120 ft)

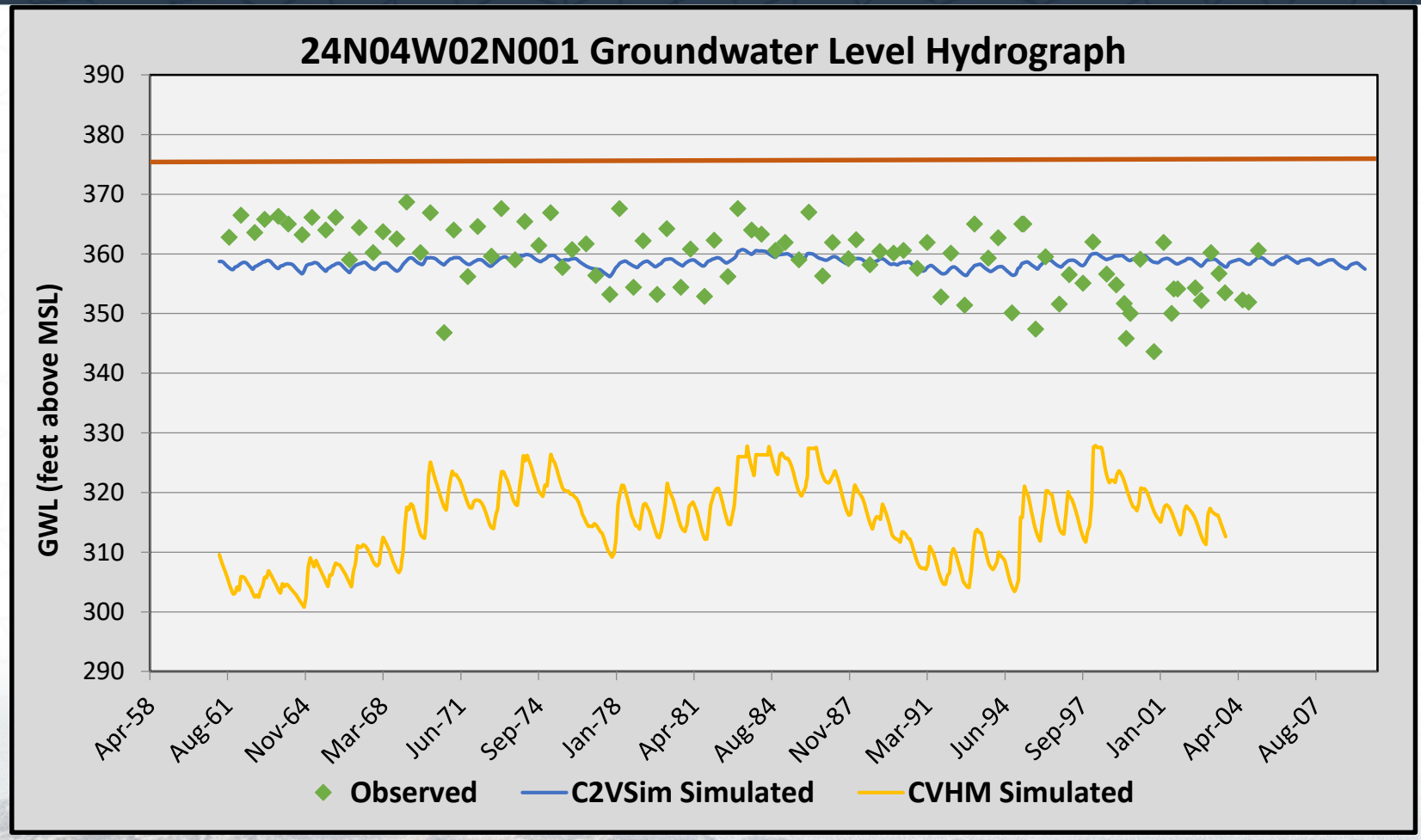




Model Calibration

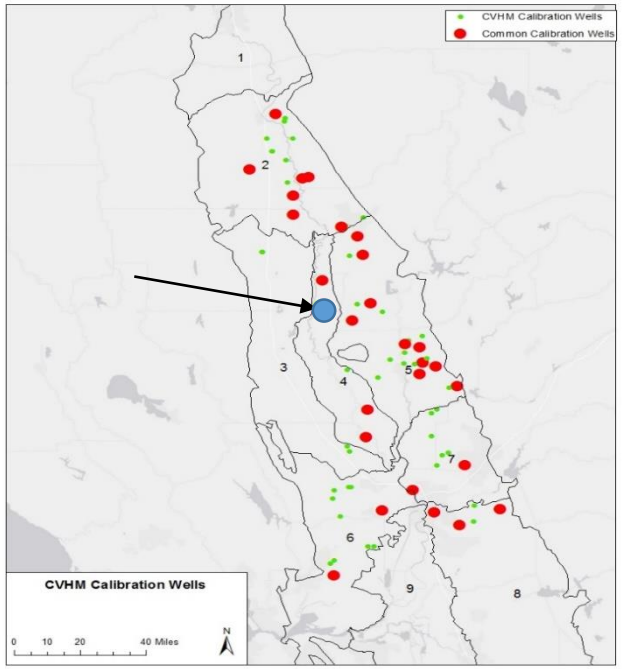
- Inactive Residential
- Shallow (30 – 90 ft)

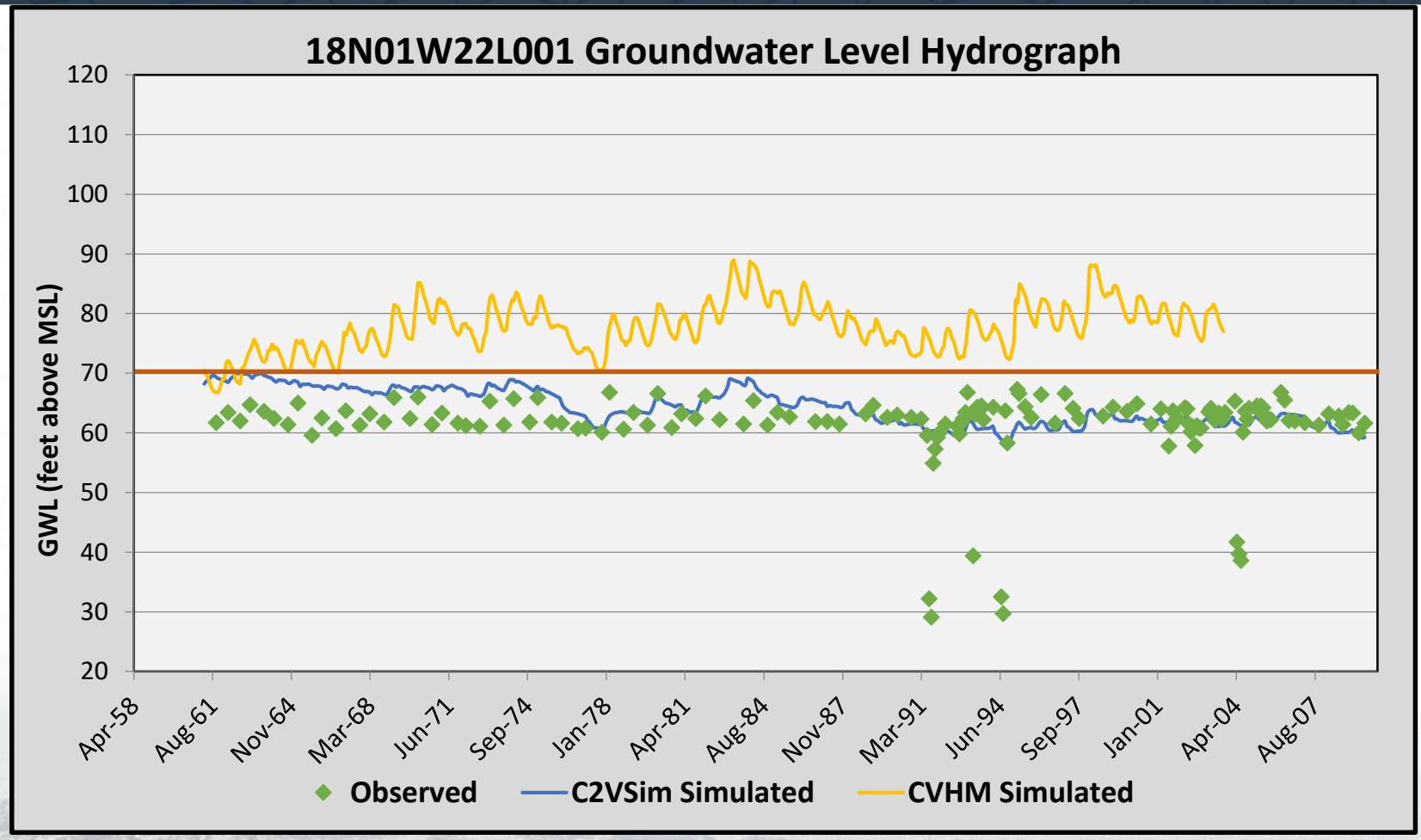




Model Calibration

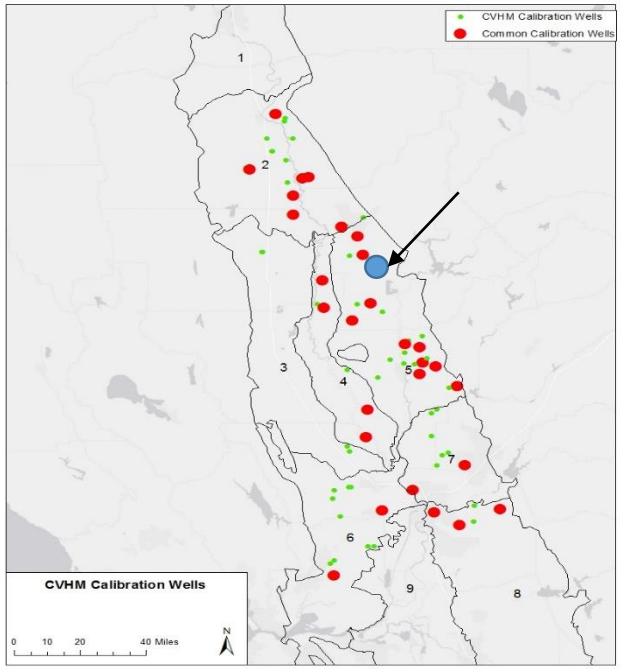
- Active Irrigation
- Shallow (76 – 92 ft, 108 – 124 ft)

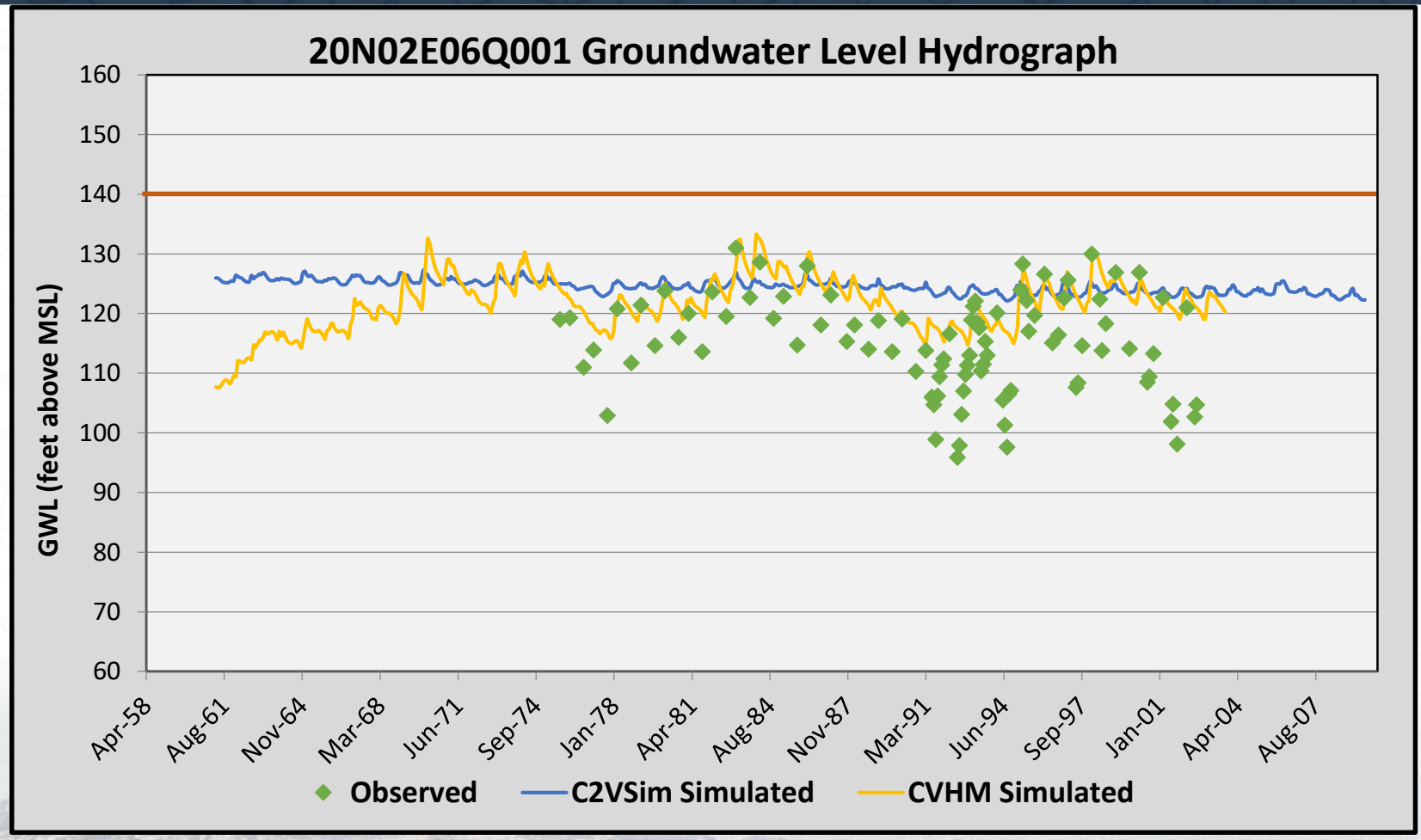




Model Calibration

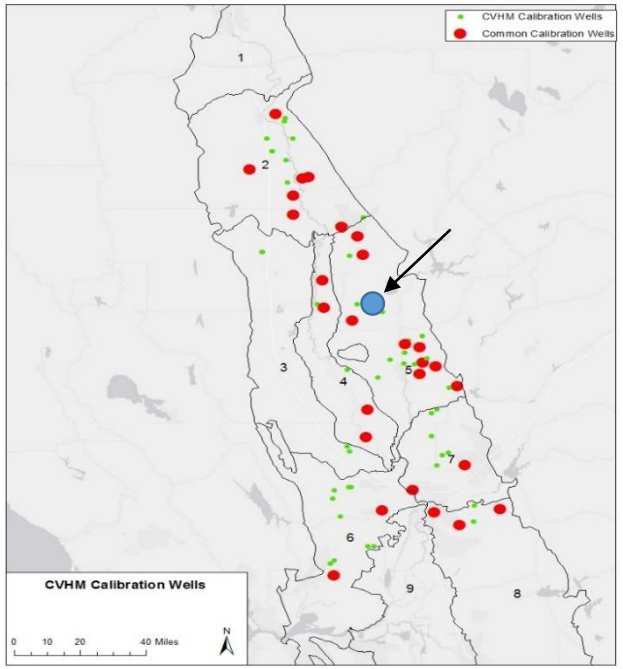
- Active Irrigation
- Shallow (10 – 44 ft)

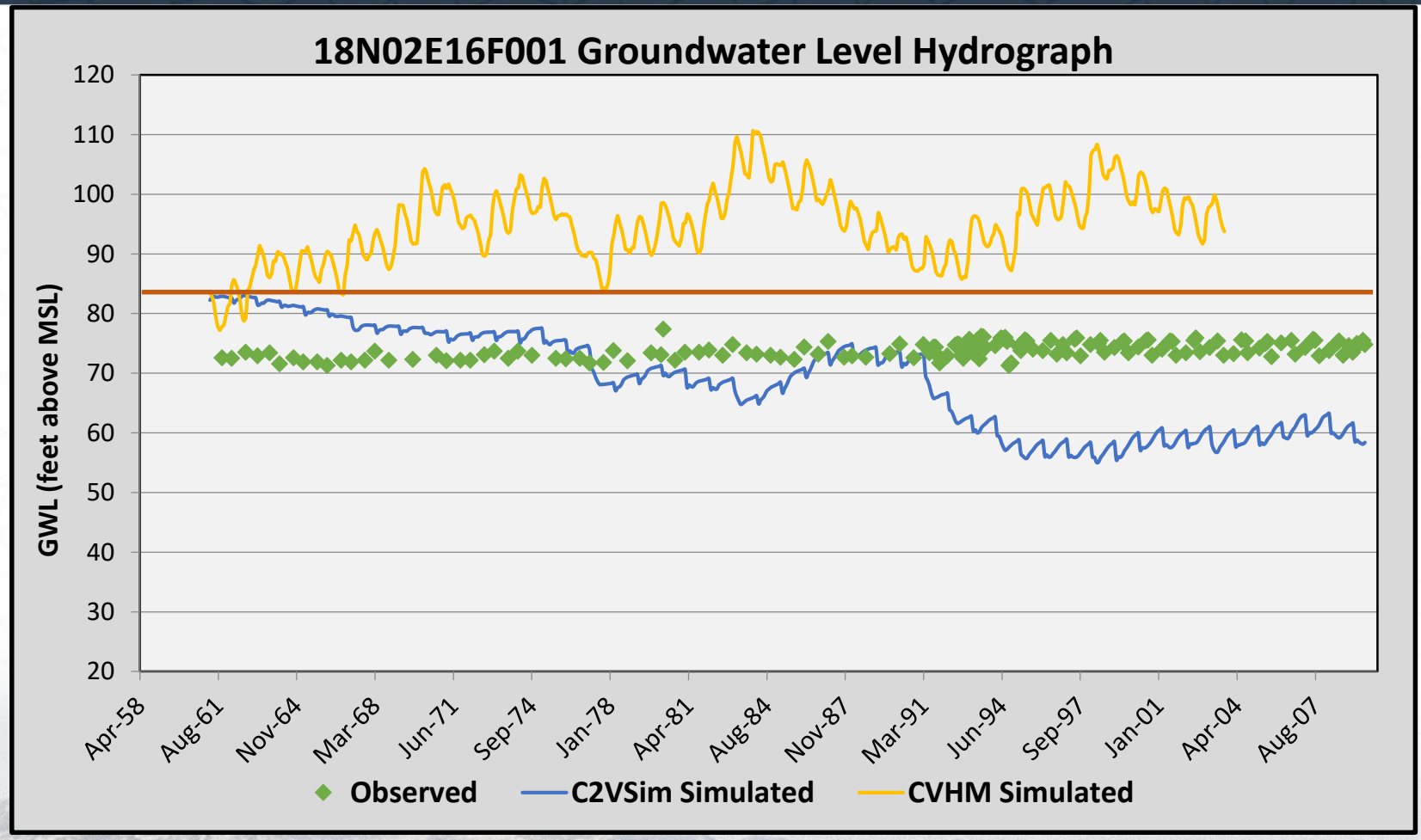




Model Calibration

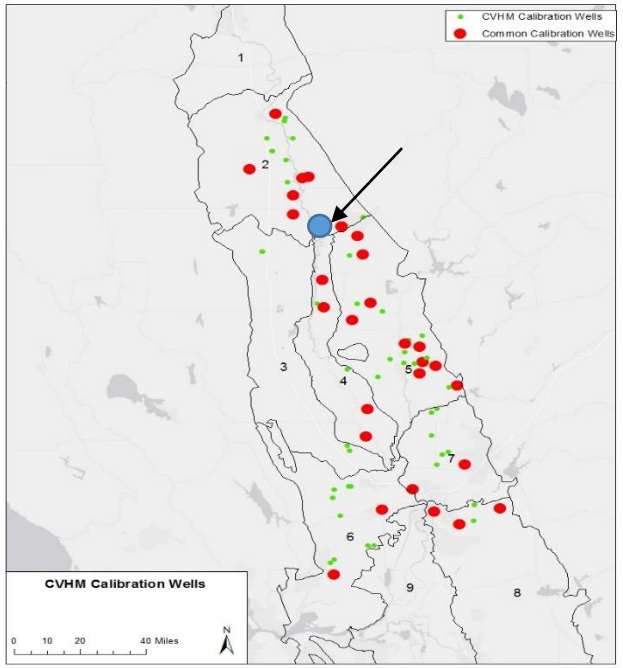
- Active Irrigation
- Shallow (20 – 60 ft)

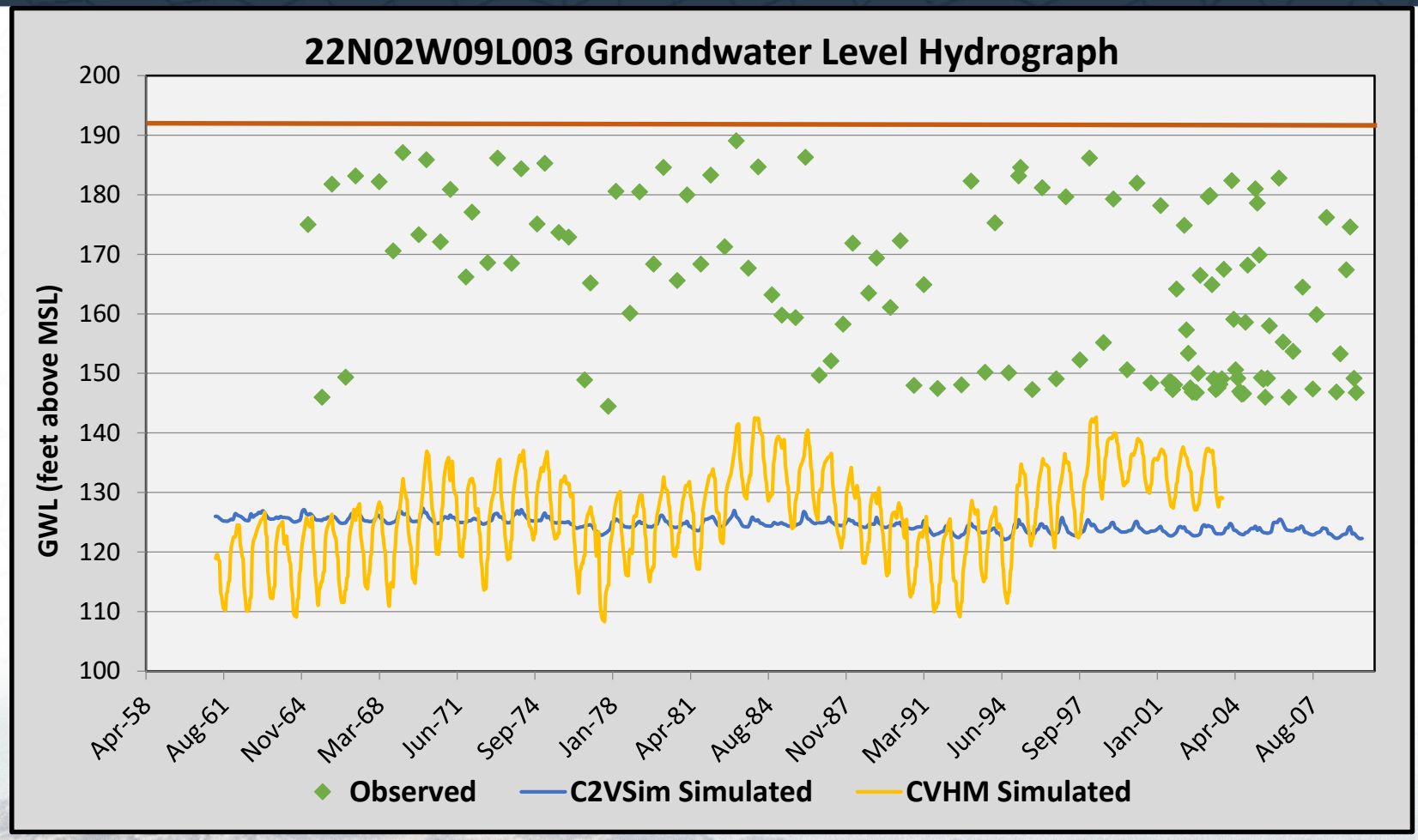




Model Calibration

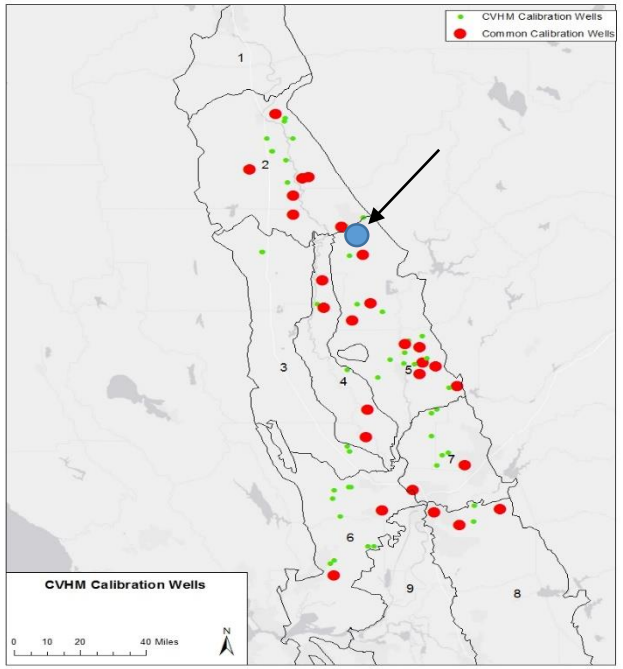
- Active Irrigation
- Intermediate

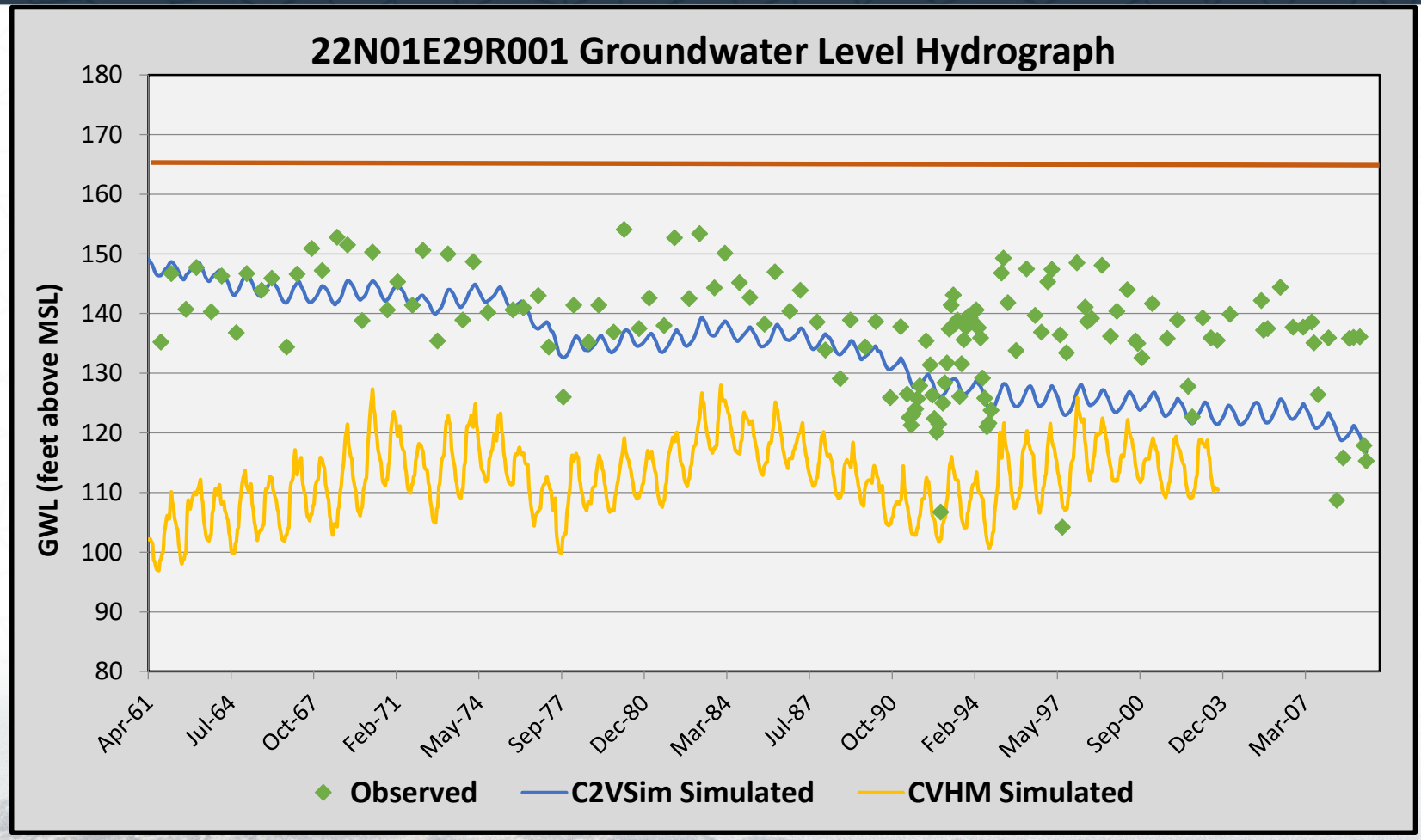




Model Calibration

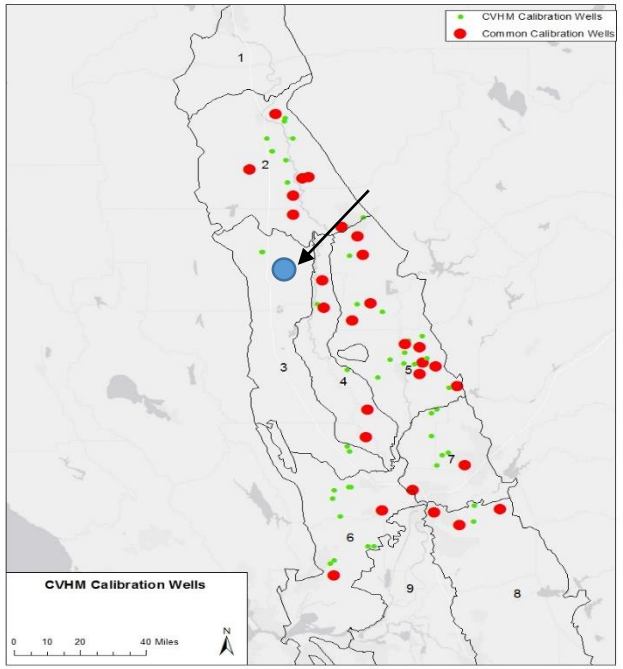
- 22N01E28J001 was used for CVHM
- Observation
- Intermediate (460 – 559 ft)

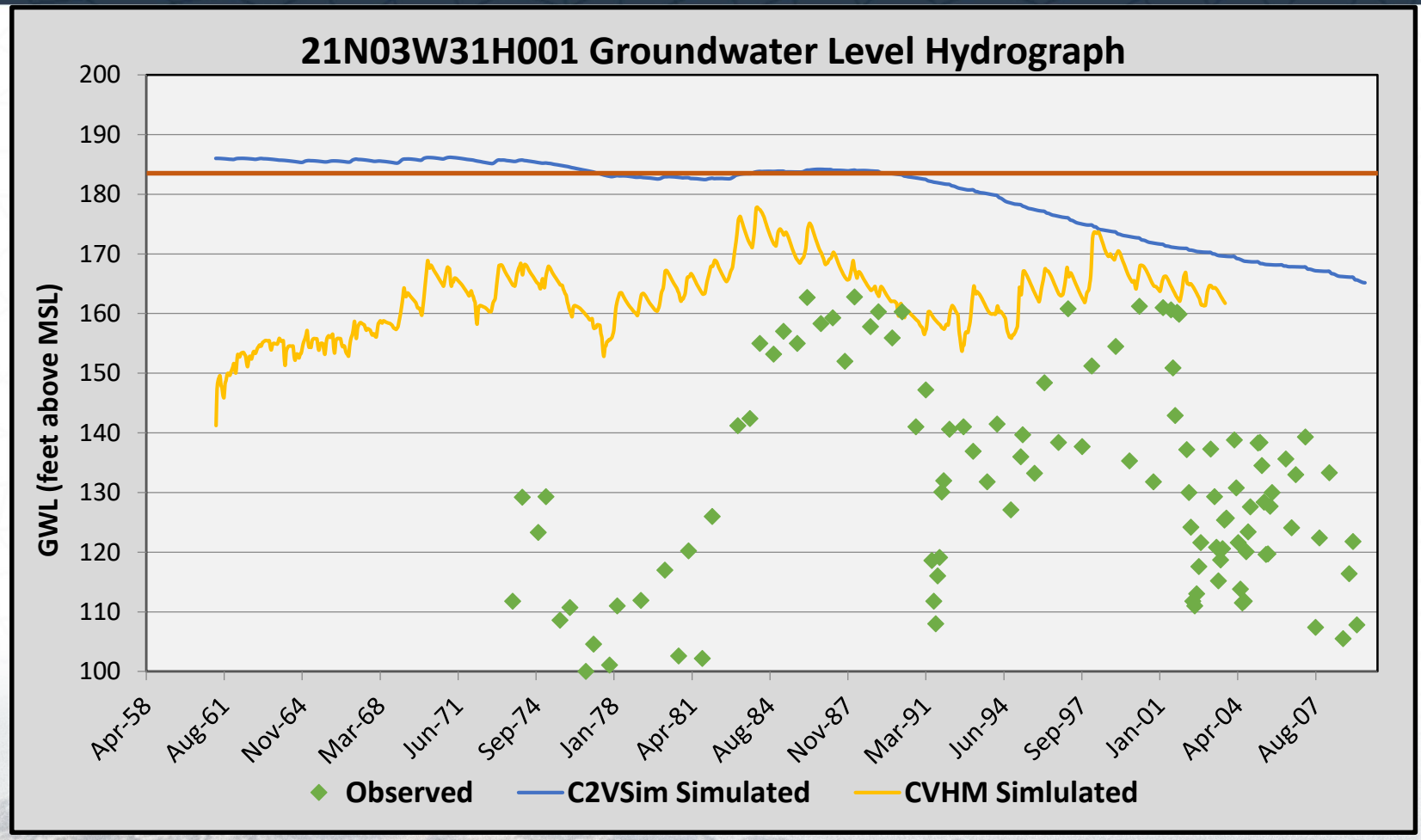




Model Calibration

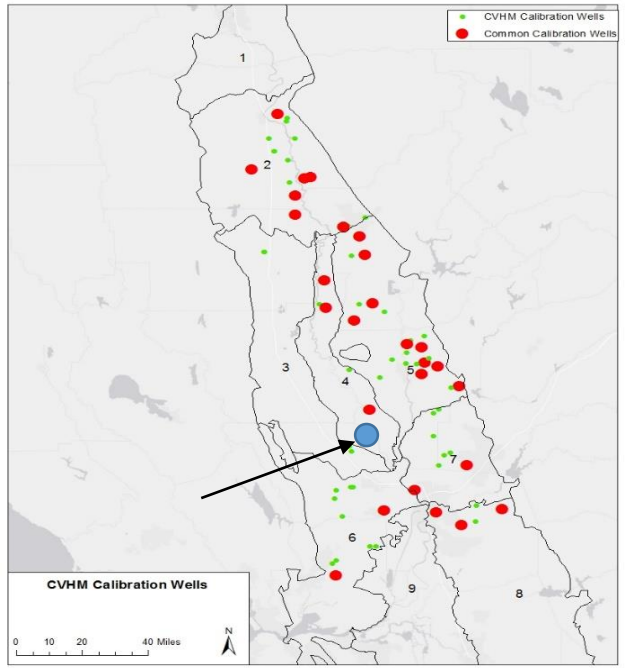
- 21N03W31R002 was used for CVHM
- Inactive, unknown type
- Intermediate (270 – 410 ft)

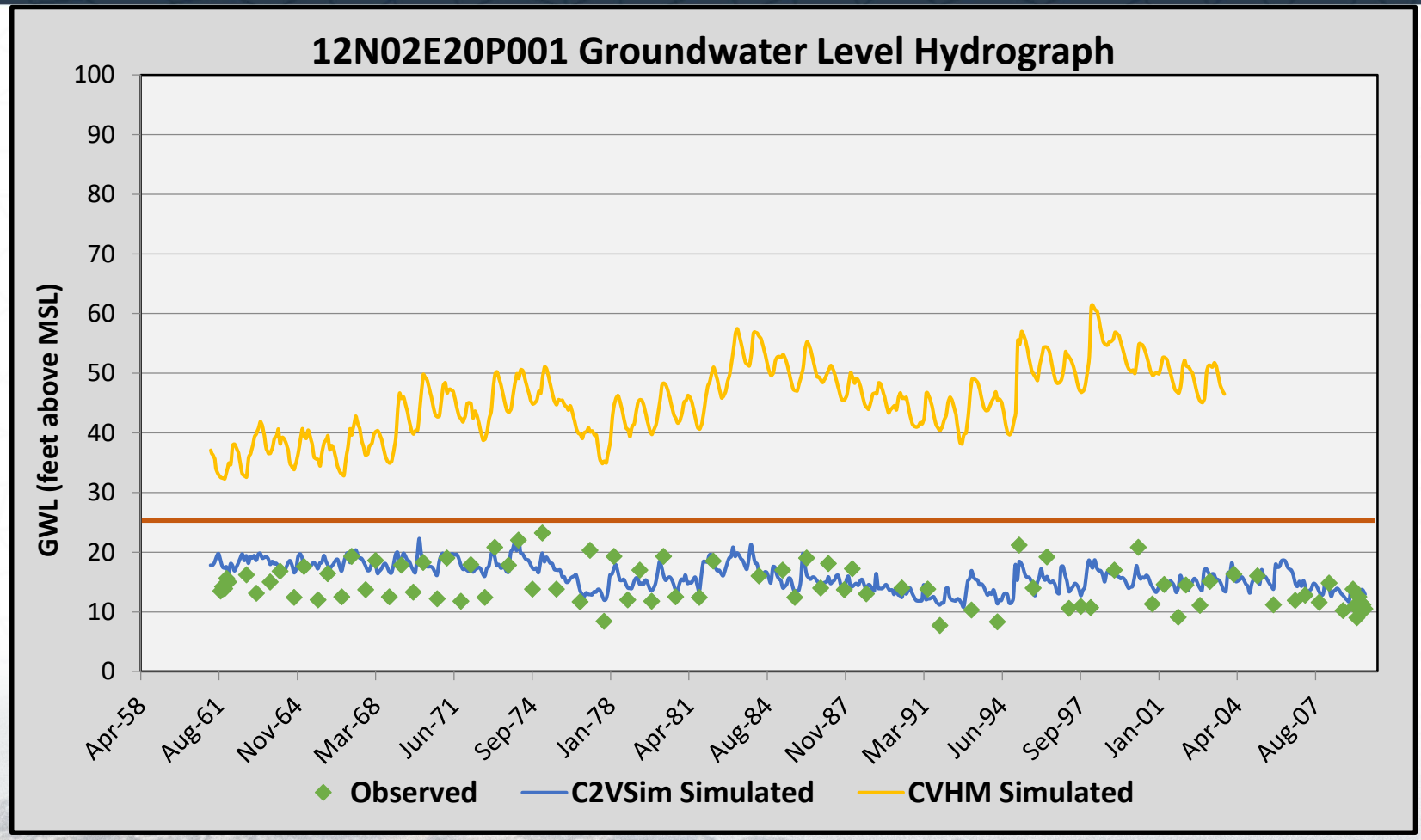


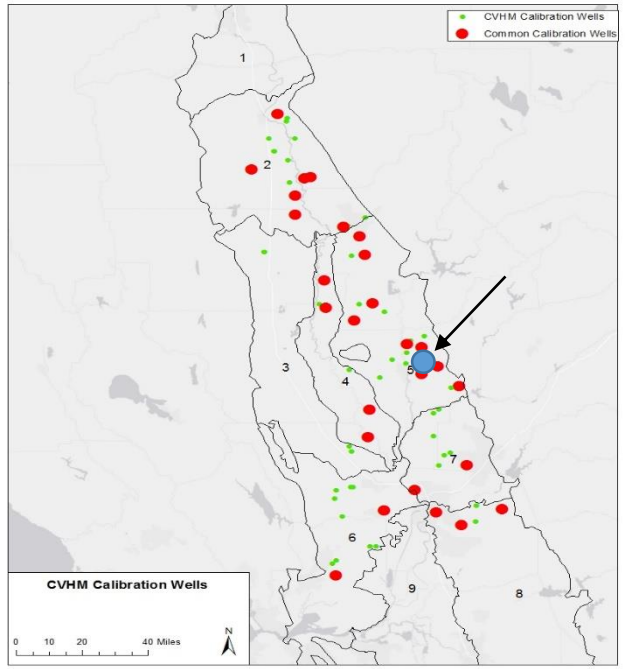
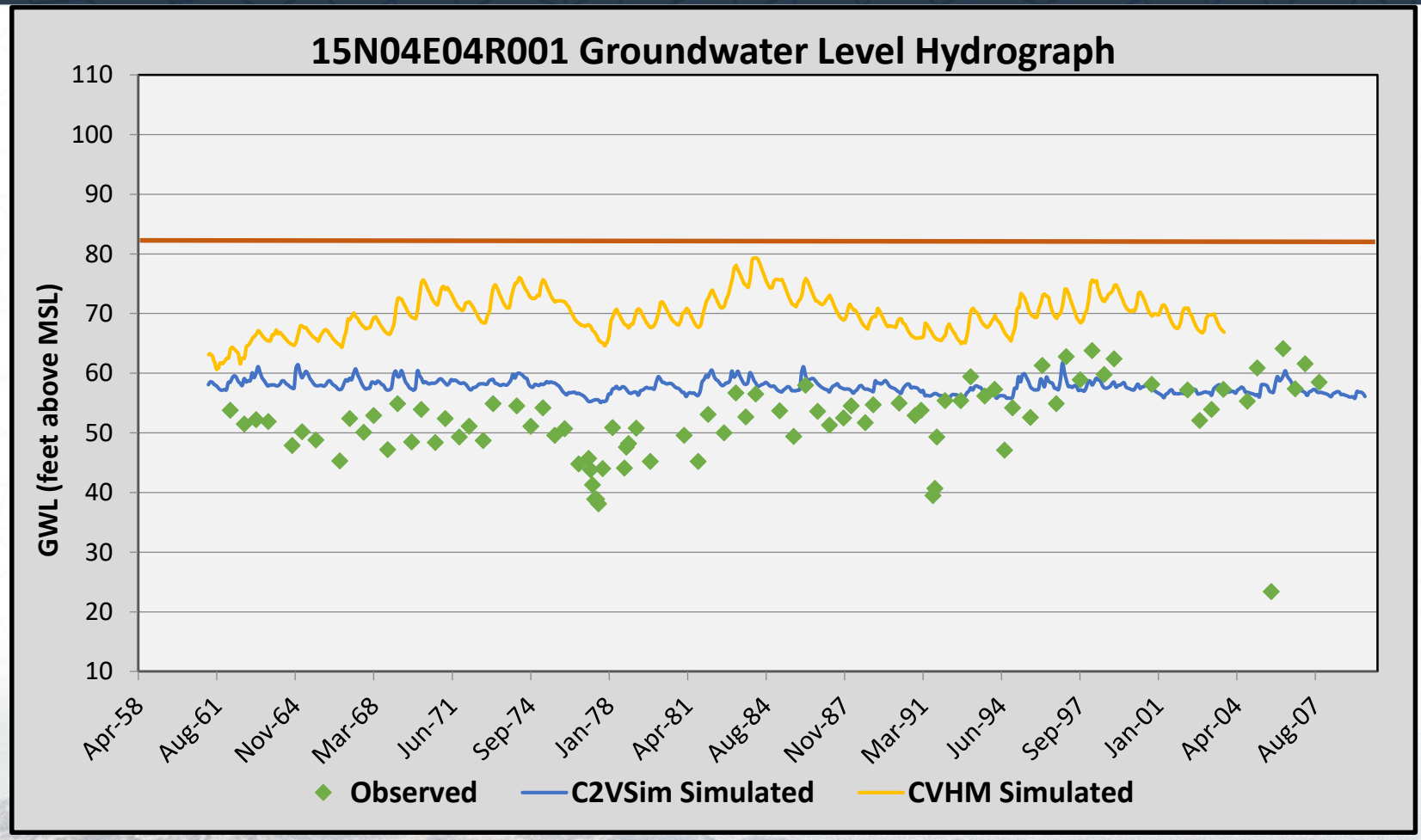


Model Calibration

- Active, unknown type
- Intermediate (Total Depth – 500 ft)





Model Calibration

- Active Irrigation
- Intermediate (Total Depth 400 ft)