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Ukiah Valley Basin Groundwater Sustainability Agency Technical Advisory Committee Meeting

Ukiah Valley Groundwater Sustainability Plan Development Update

May 13, 2020

LARRY WALKER ASSOCIATES GEI Consultants WATER MANAGEMENT LAB SCIConsultingGroup

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Outline

- State of GSP Prior to This Meeting
- Historical Trends of Groundwater Elevation
- Integrated Model Updates and Preliminary Water Budget Discussion
- Sustainable Management Criteria
  - Surface Water Depletion (introduction)
  - Subsidence

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State of GSP Prior to this Meeting

- Sustainable Management Criteria development for Water Quality
- Uncalibrated confined MODFLOW was presented along with calibrated PRMS and IDC
- SW/GW working group first two meetings were held

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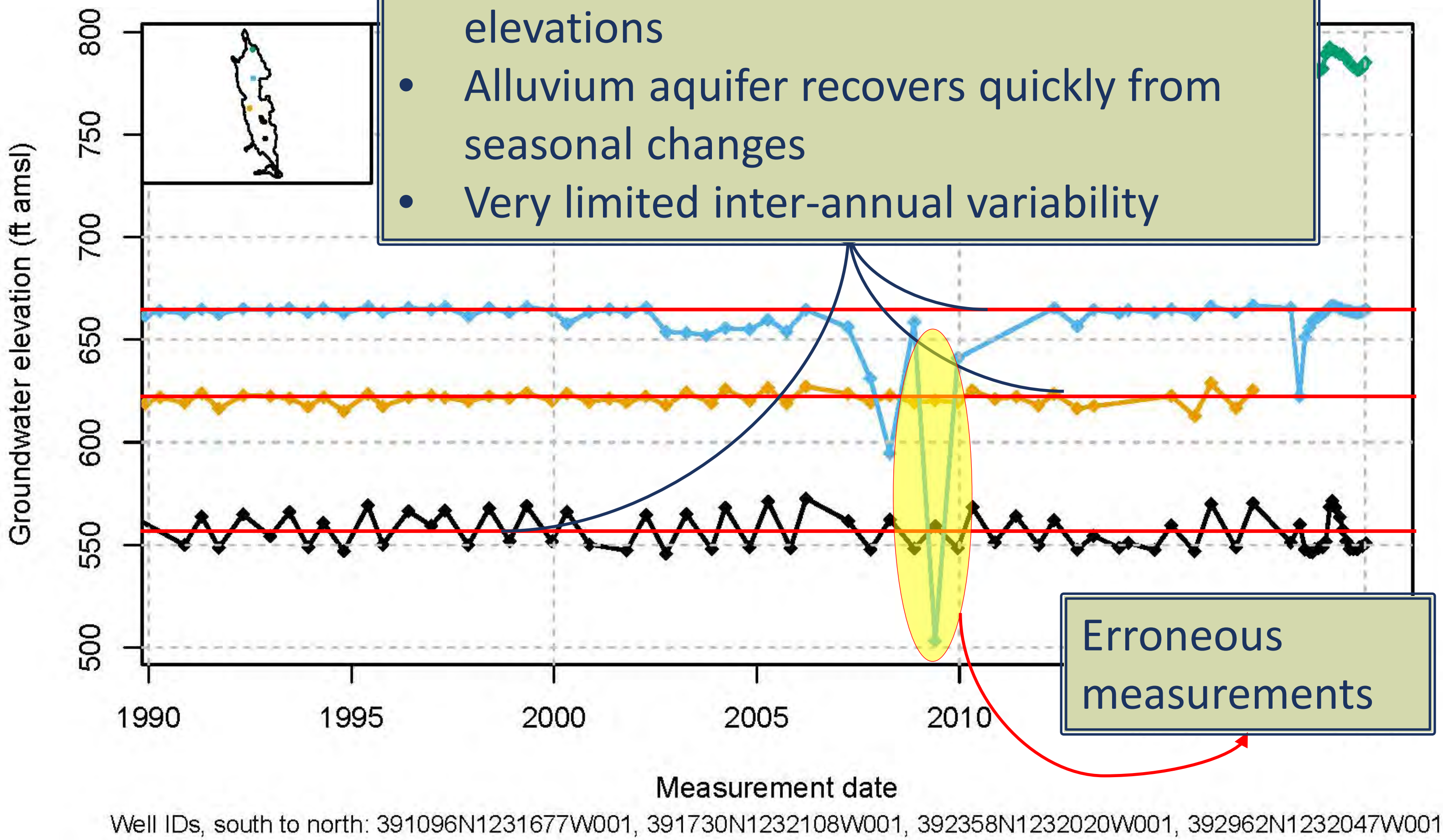
Long-term Historical Groundwater Elevations (Alluvial Aquifer)



- Relatively constant long-term historical elevations
- Alluvium aquifer recovers quickly from seasonal changes
- Very limited inter-annual variability

Erroneous measurements

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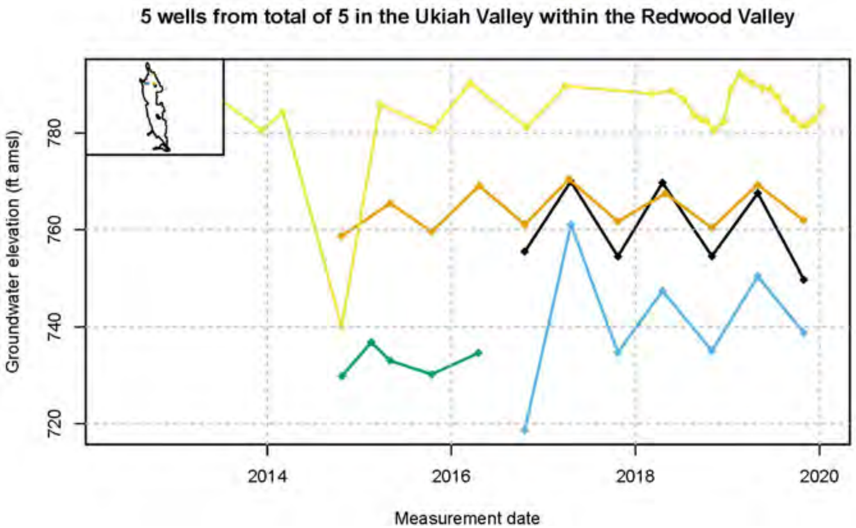
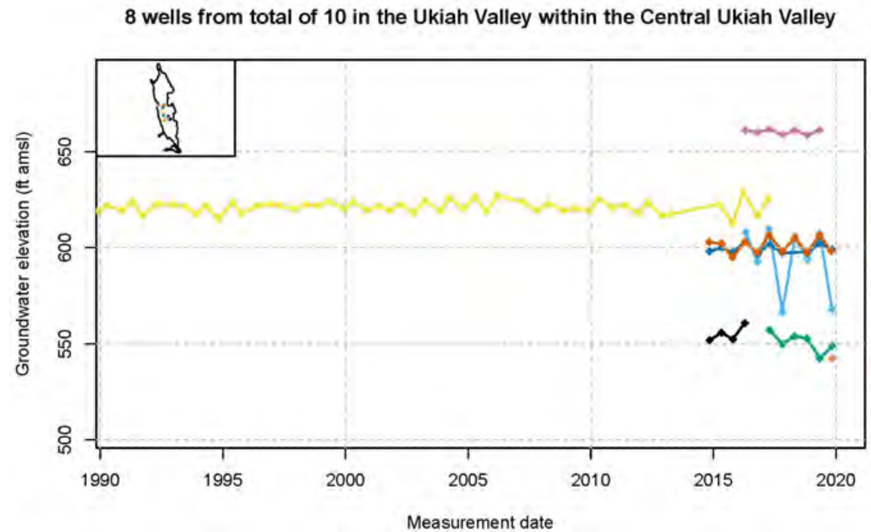
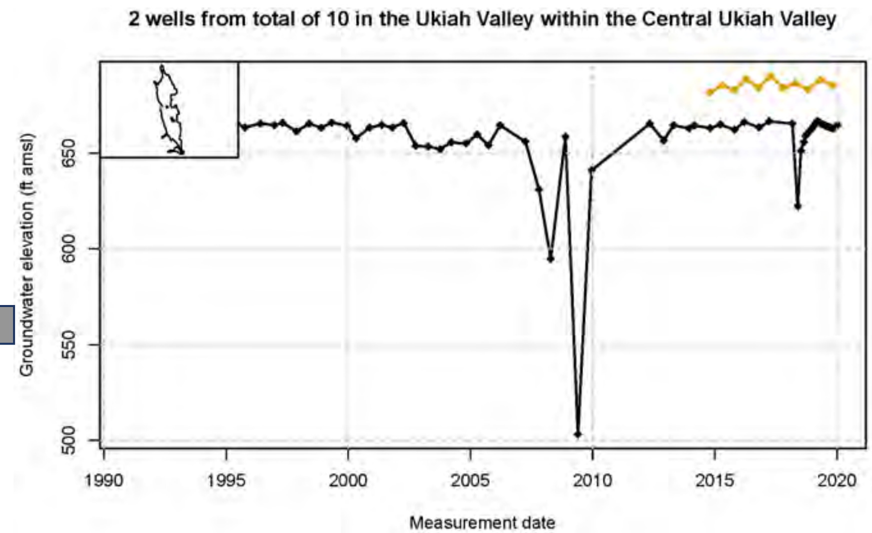
Historical Groundwater Elevations by Region for Alluvial Aquifer

Redwood Valley
Range : 718-792 ft-MSL
Seasonal Change: ~12 ft (4-17 ft)



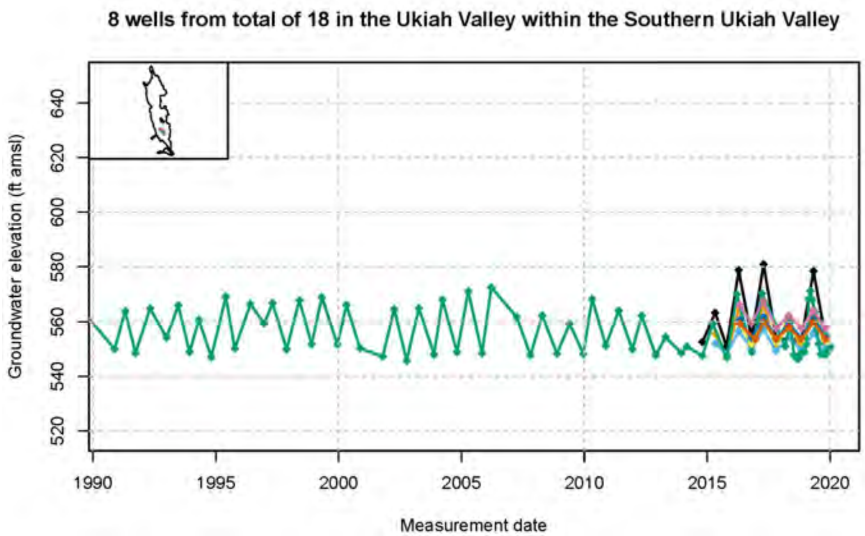


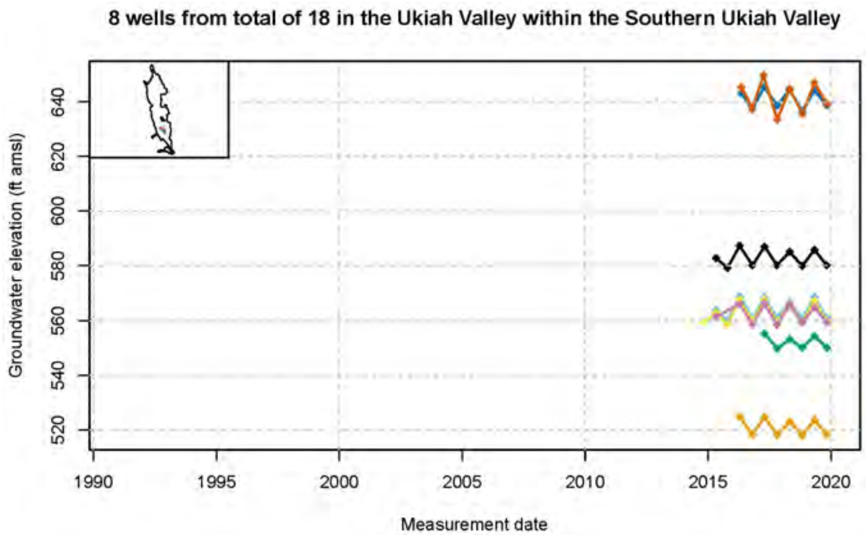


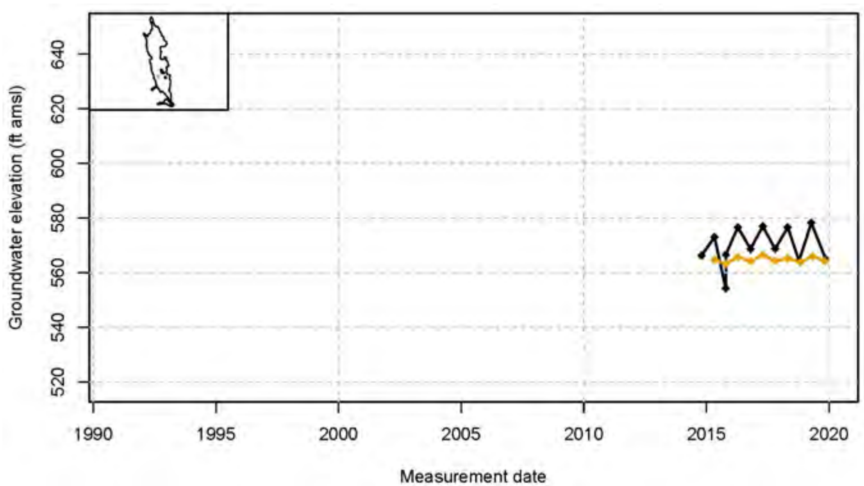
Central Ukiah Valley
Range : 542 -691 ft-MSL
Seasonal Change: ~8 ft (0-28 ft)

Historical Groundwater Elevations by Region for Alluvial Aquifer

Southern Ukiah Valley
Range : 518-650 ft-MSL
Seasonal Change: ~8 ft (1-16 ft)







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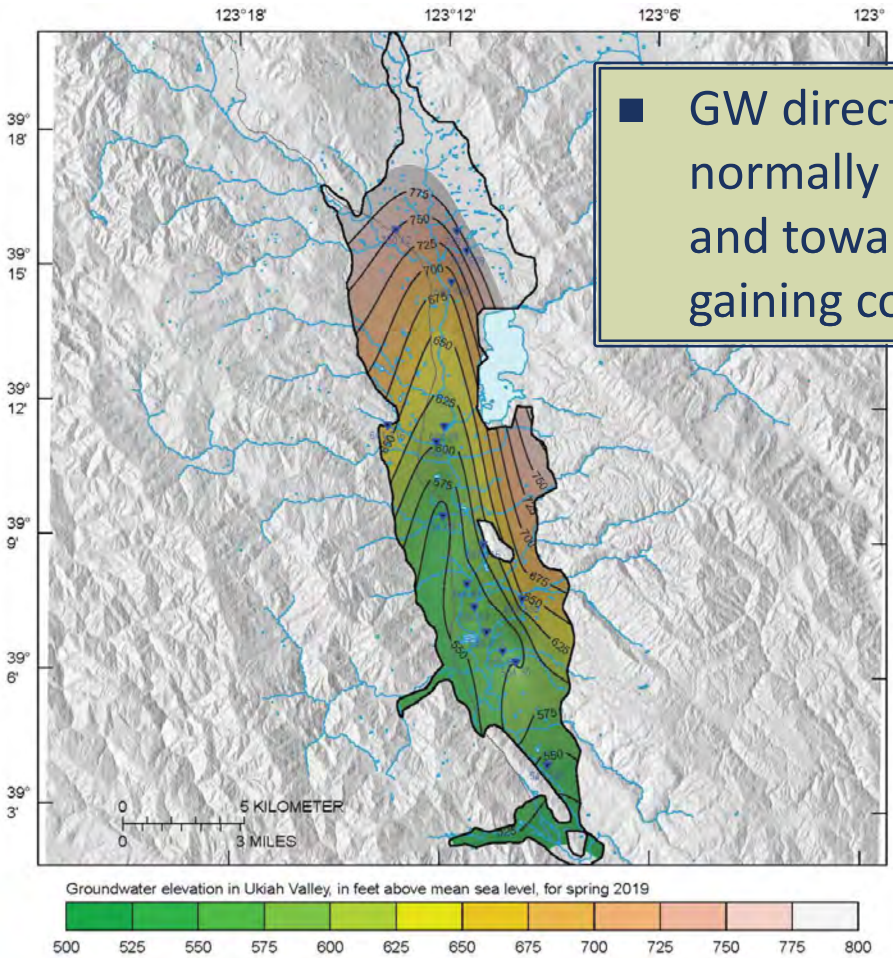
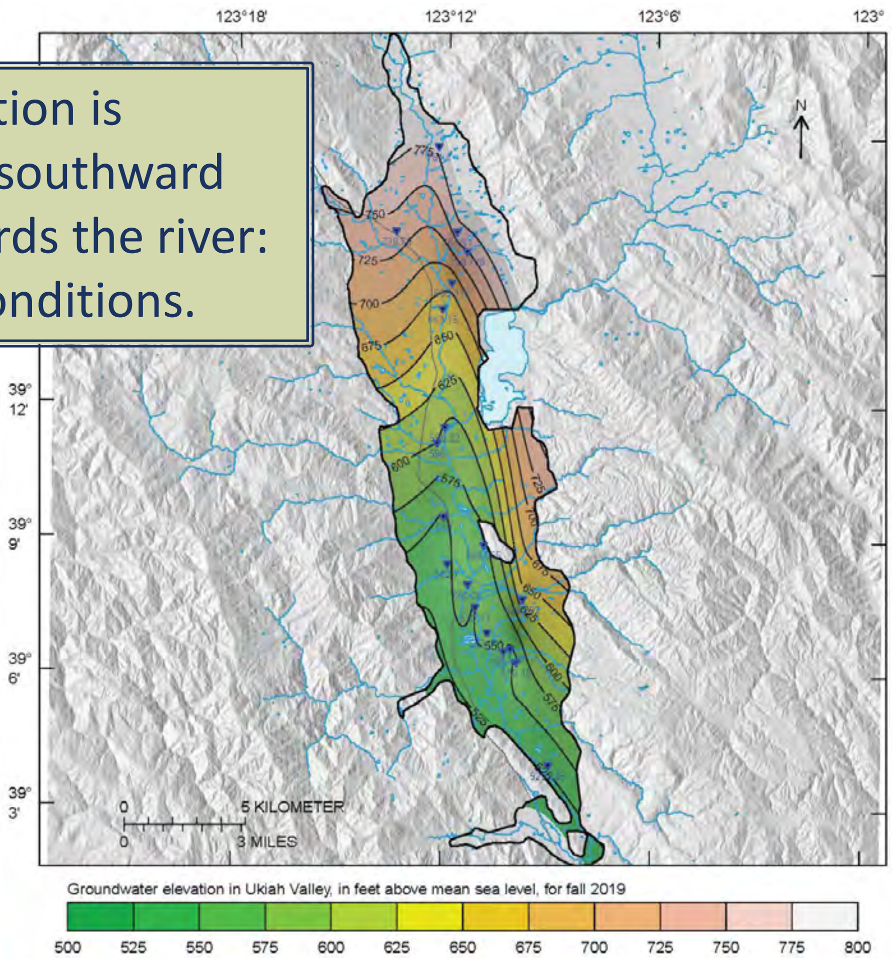
Seasonal Groundwater Elevations

- GW direction is normally southward and towards the river: gaining conditions.



Spring 2019



Fall 2019

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Questions?

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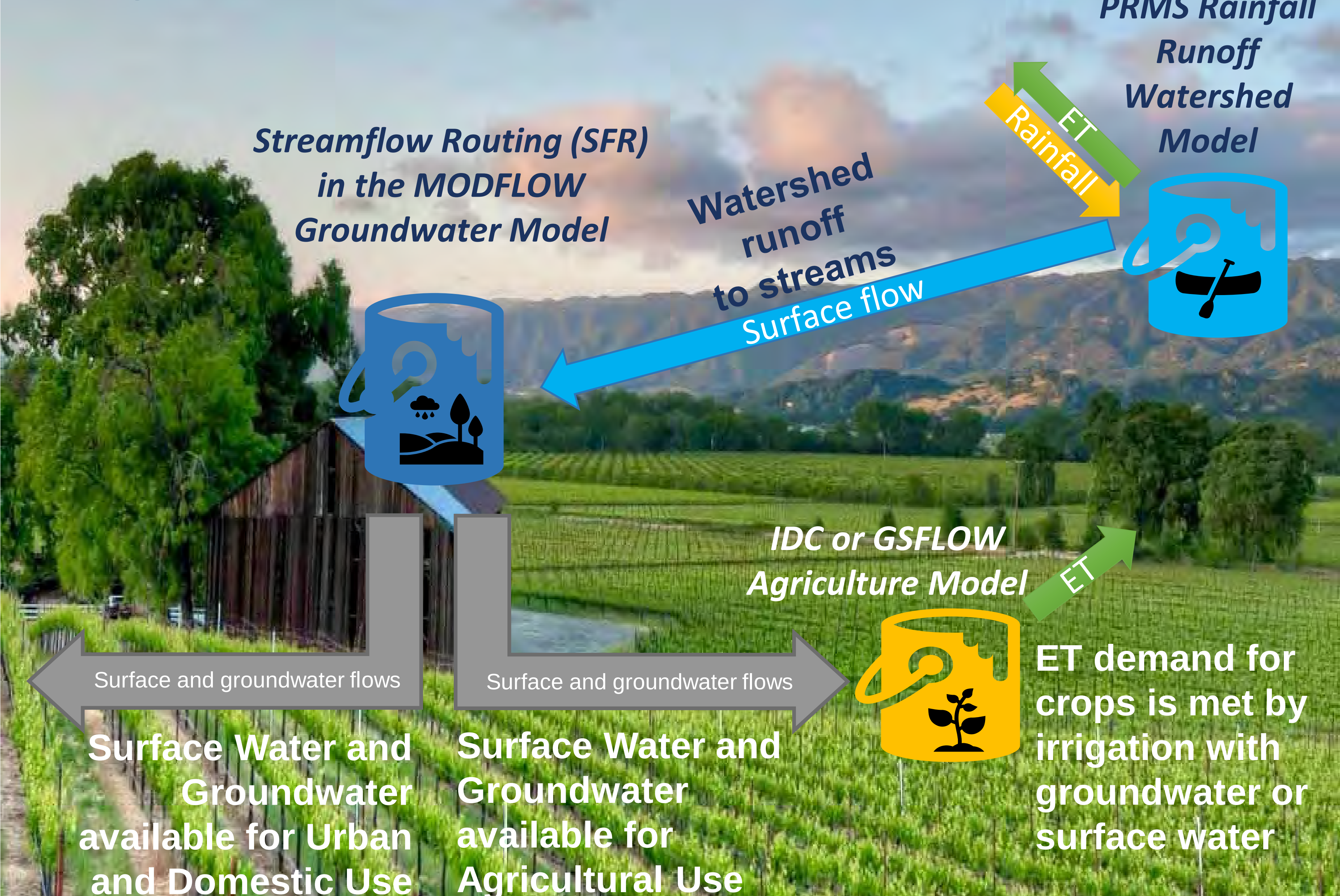
Integrated Model Updates:



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Integrated Model Updates

- PRMS updates
  - PRMS updated to newer version PRMS 5.0 compatible with GSFLOW v2.0.
  - Ponds included in PRMS. SW diversions are estimated.
  - Reservoir operation methodology developed to be incorporated into the PRMS.
  - PRMS is running with GSFLOW executable.
  - PRMS 5.0 has now the capability to model stream temperature.
- IDC updates
  - IDC calculated percolation and ET are being used to adjust MODFLOW recharge and PRMS ET.
  - IDC's role will be switched to recently released Ag Package within GSFLOW and IDC will be used to form Ag Package inputs and ground truth its results.

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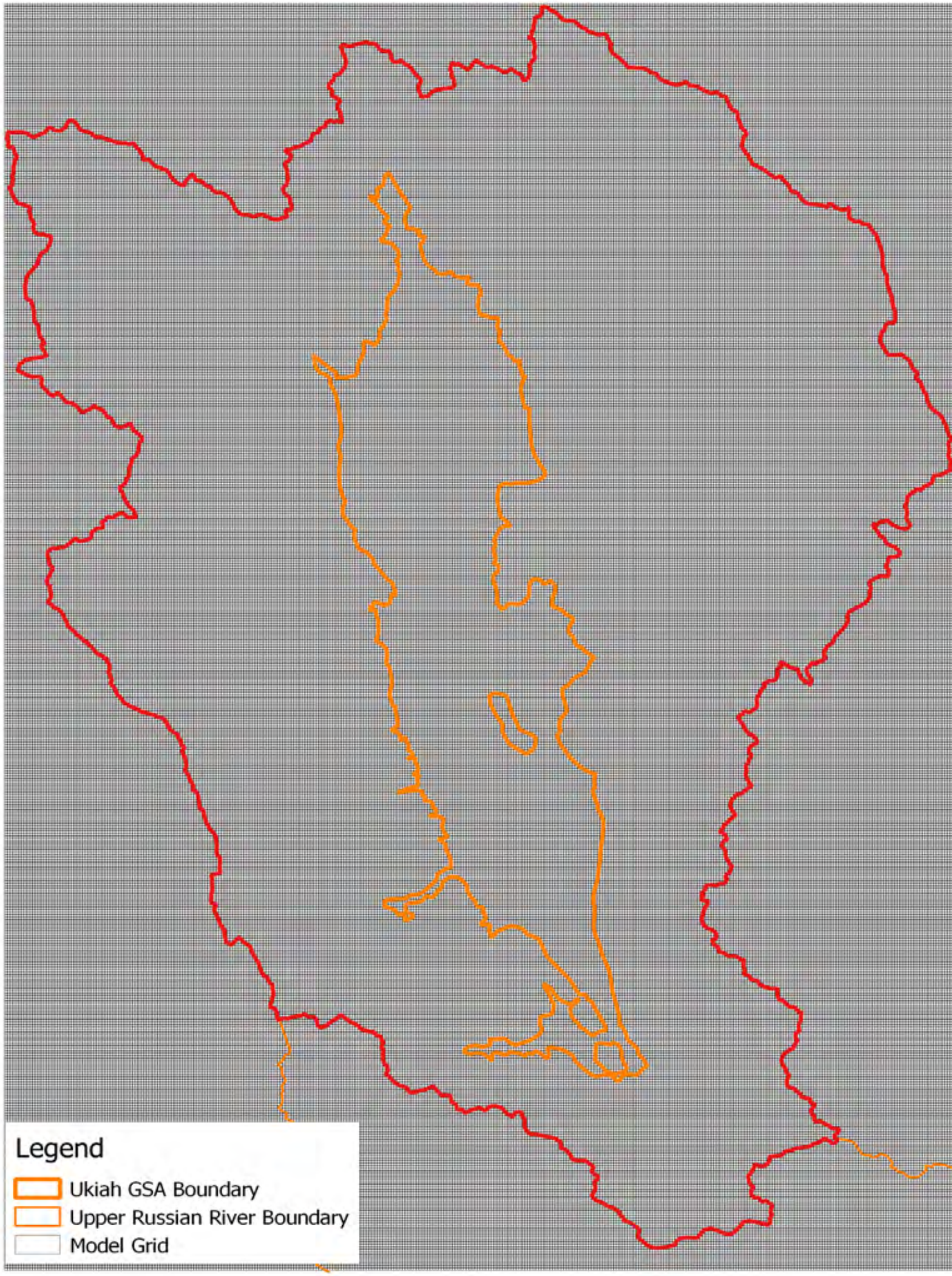
MODFLOW: Discretization

- Spatial: 100m x 100m Grid
  - Rows: 483
  - Columns: 343
  - Cells:165,669
  - Active Area: ~ 240 acres
  - Basin Area: ~ 37 acres

- Temporal:
  - From Jan 1, 1991
  - To Dec 31, 2018
  - Monthly timesteps
  - 366 timesteps



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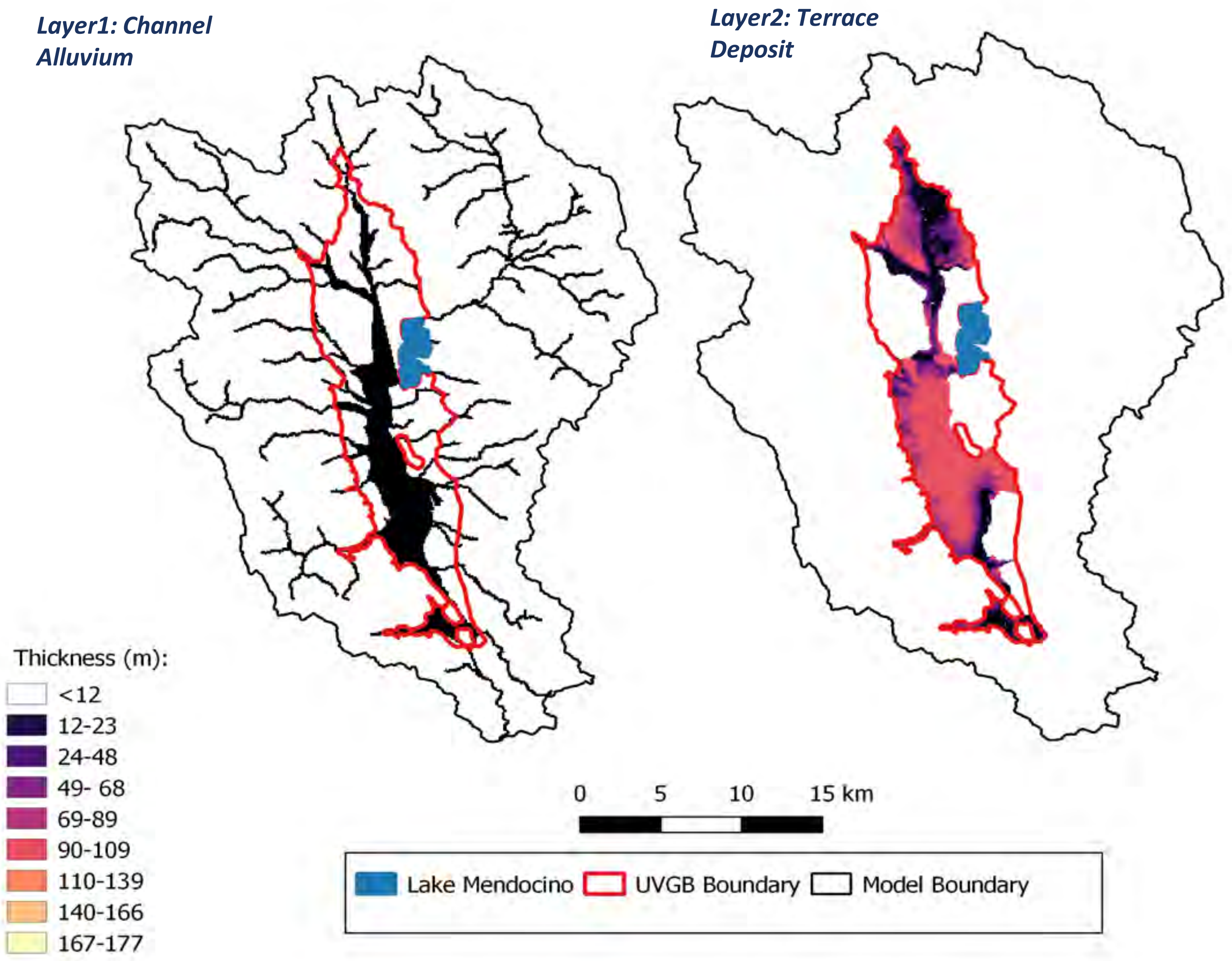
Model layers

- ***Layer 1:*** *Has a constant thickness of 12m (39ft)*
- ***Layer 2:*** *Has thicknesses ranging from 12 to 78m (39 to 256ft)*



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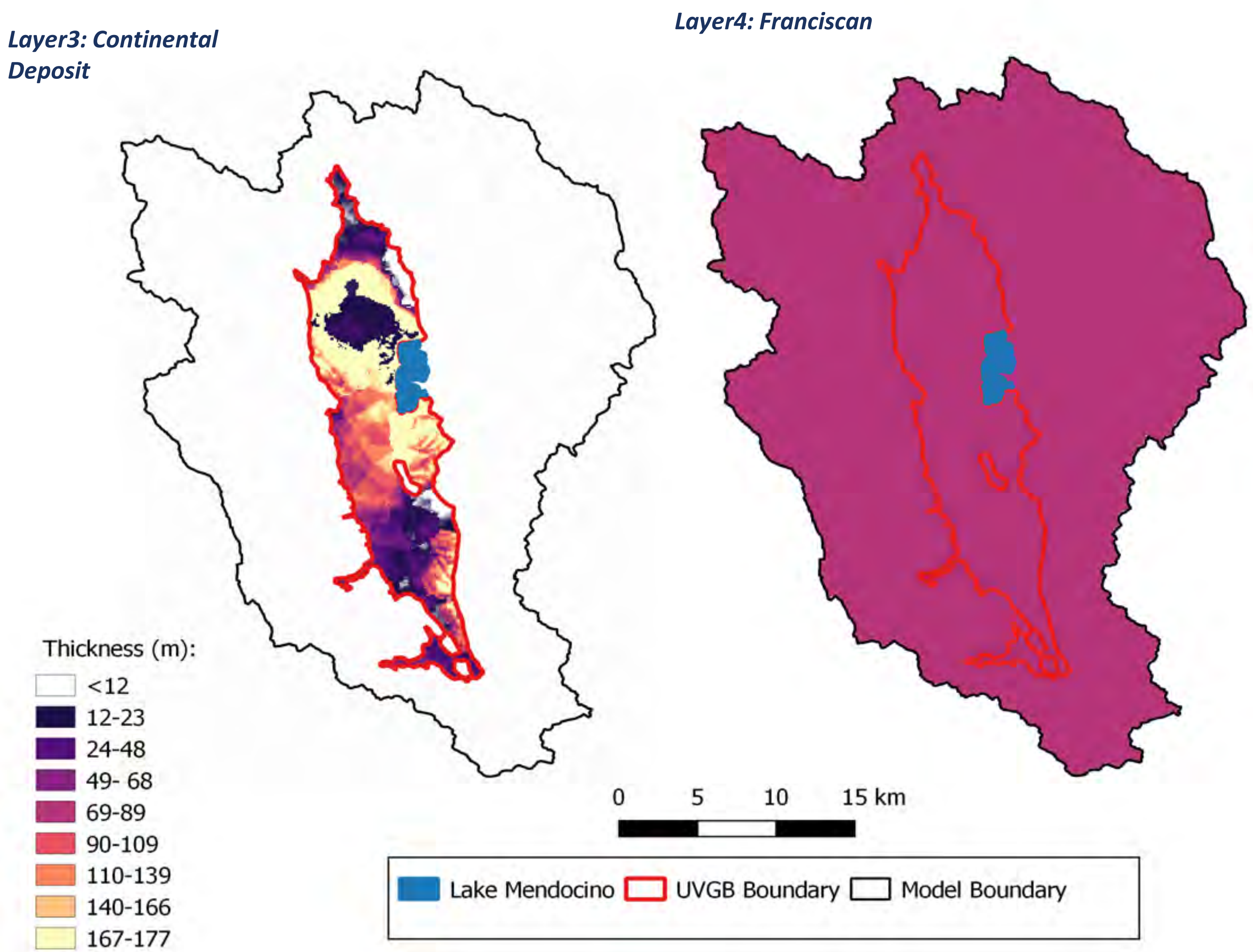
Model layers

- ***Layer 3:*** *Has thicknesses ranging from 12 to 177m (39 to 580ft)*
- ***Layer 4:*** *Has a constant thickness of 50m (160ft)*



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Model Assumptions

Model Version	Advantages	Disadvantages
Confined Layers [1,2,3]	• *Quick Run time* • *Minimal Convergence Issues*	• *No Coupling with GSFLOW*

Model Version	Disadvantages	Advantages
Unconfined Layers [1,2,3]	• *Long Run time*	• *Coupling with GSFLOW*
	• *Challenging Convergen ce Issues*	• *Add unsaturated zone flow*

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Model Hydrologic Parameters

Values before calibration from the Hydrogeological Conceptual Model (HCM) and Literature.

Aquifer Parameters	Parameters Ranges
Hydraulic conductivity:	
- Layer1: Channel Alluvium	*150 - 220 ft/day*
- Layer2: Terrace Deposit	*0.1 - 15 ft/day*
- Layer3: Continental Deposit	*0.01 - 0.51 ft/day*
- Layer4: Franciscan	*0.3×10^{-5} - 0.3×10^{-7} ft/day*
Specific Storage	
- Layer 1&2	*1×10^{-5} - 1×10^{-4}*
- Layer 3	*1×10^{-5} - 1×10^{-4}*
- Layer 4	*1×10^{-7} - 1×10^{-5}*
Specific Yield Layer 1&2&3	*1×10^{-2} - 5×10^{-2}*

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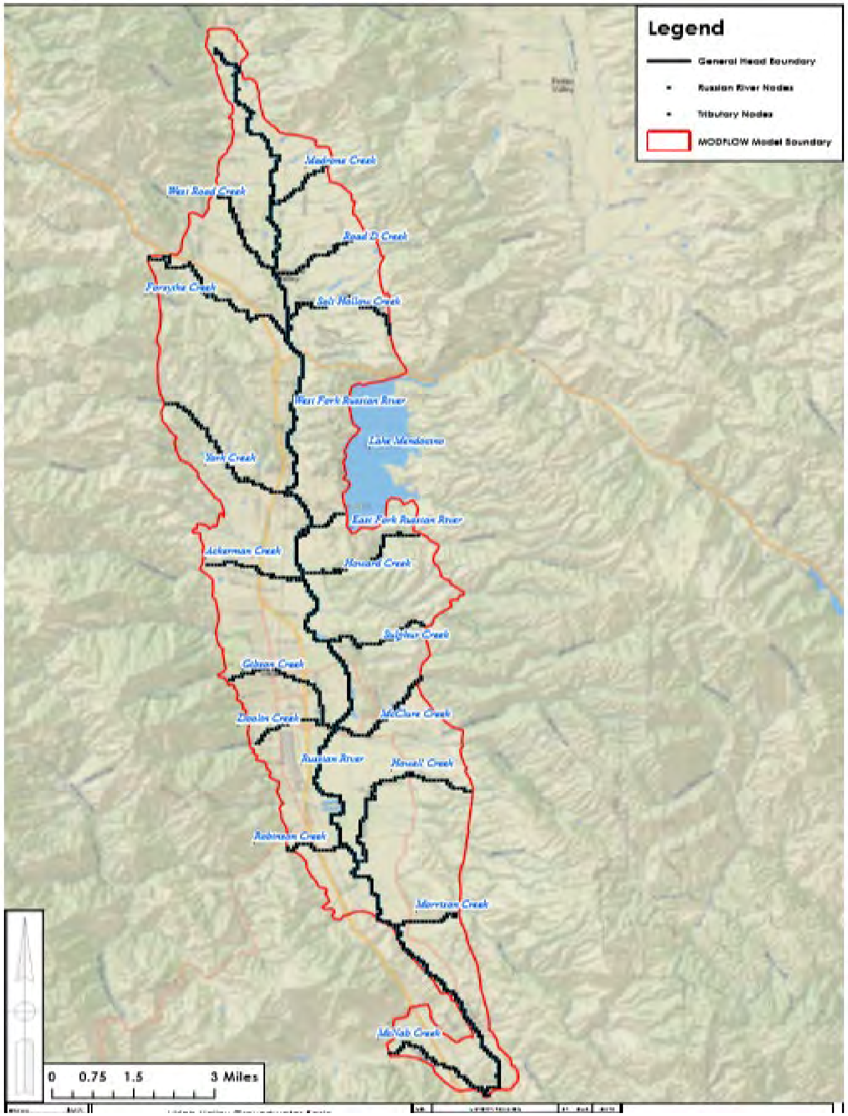
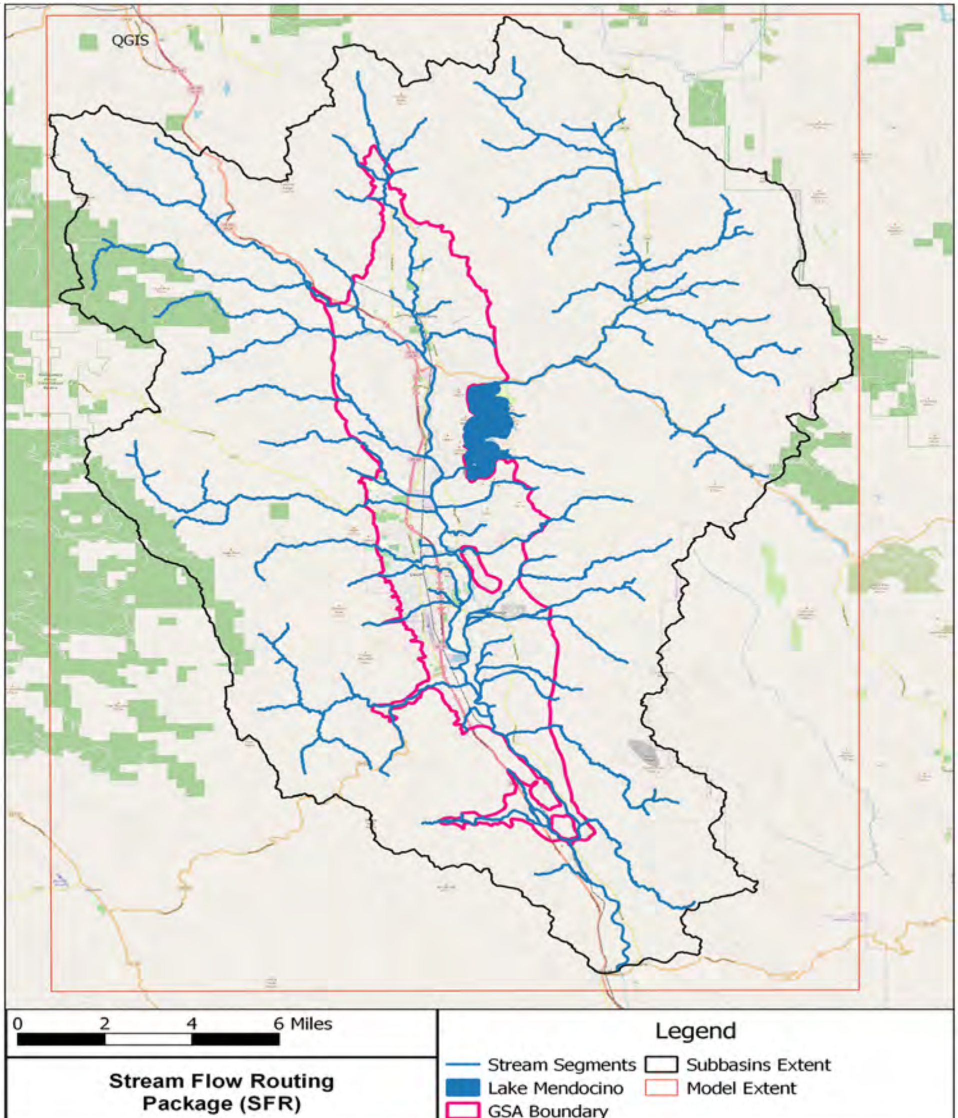
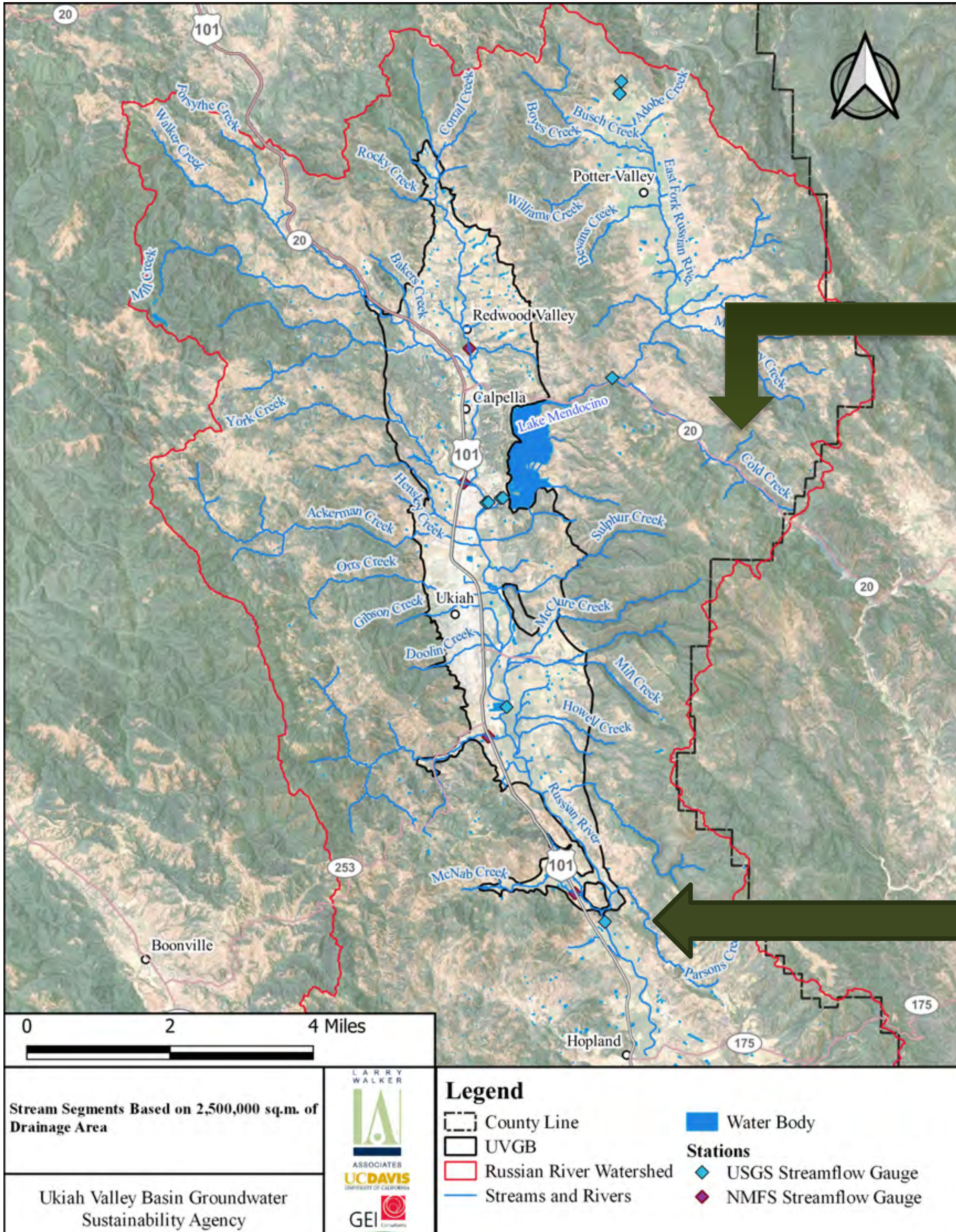
Stream Flow Routing (SFR) package

Previous Modeling Effort: River Package



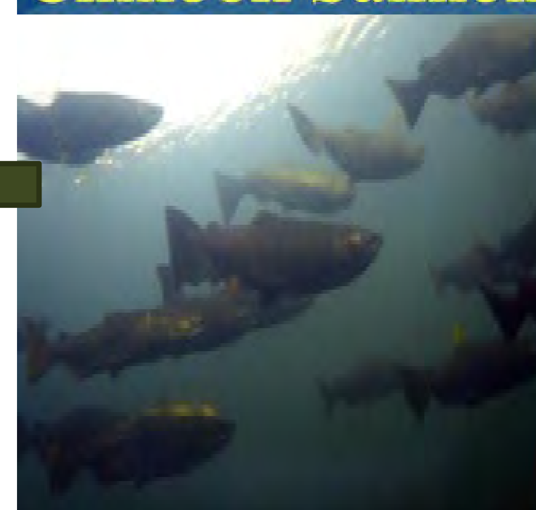
Current Modeling Effort : Stream Flow Routing Package (SFR).





Steelhead Trout

Chinook Salmon



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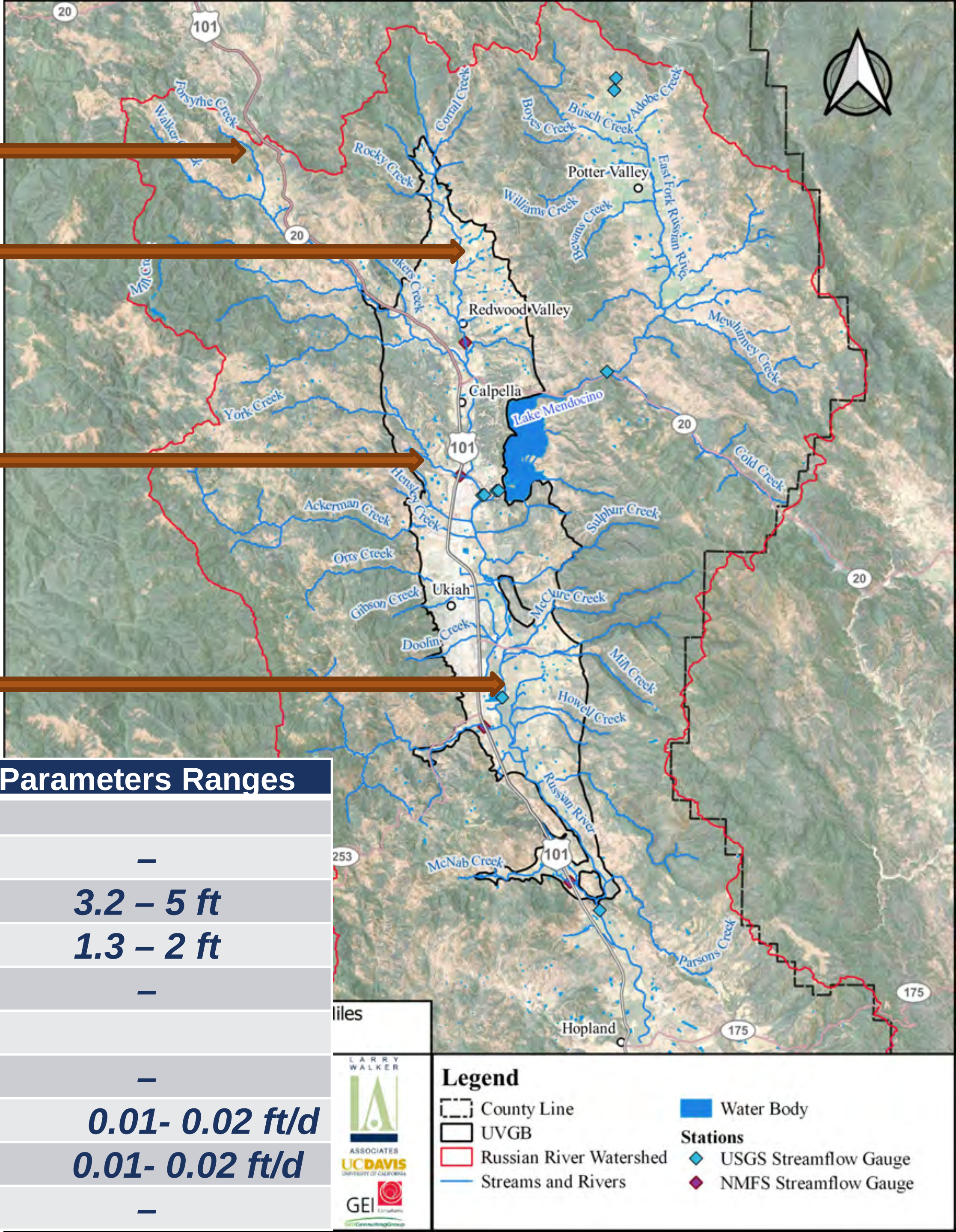
Small tributaries

Natural flows of main stem

Large tributaries

Impaired flows of main stem



Stream Parameters	Parameters Ranges
Streambed Thickness:	
- Main stem upstream of the lake	*–*
- Main stem downstream of the lake	*3.2 – 5 ft*
- Large tributaries	*1.3 – 2 ft*
- Small tributaries	*–*
Streambed Hydraulic Conductivity	
- Main stem upstream of the lake	*–*
- Main stem downstream of the lake	*0.01- 0.02 ft/d*
- Large tributaries	*0.01- 0.02 ft/d*
- Small tributaries	*–*

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Mendocino Lake Modeling

Current Model

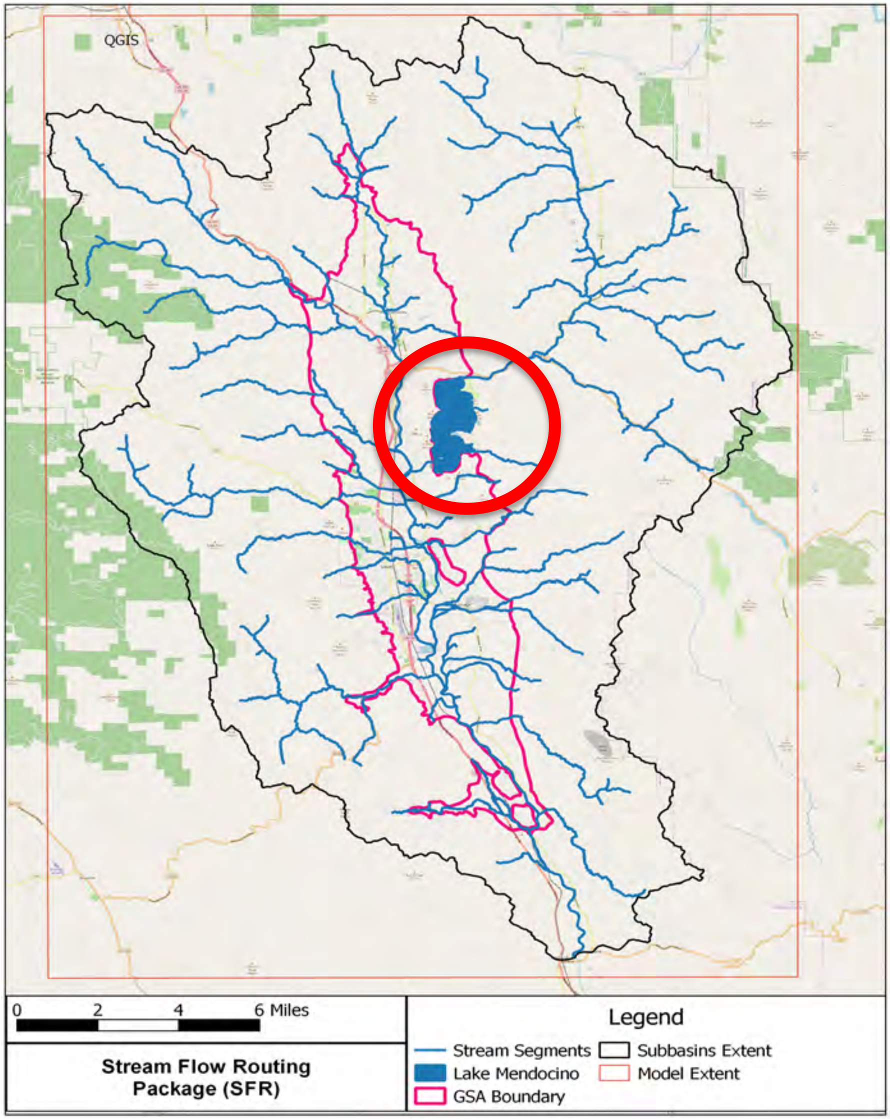
- Specified releases from the stream gage PRMS Model
  - Best way to simulate historical releases

Future Model

- *Lake package in MODFLOW*

Allow to assess and simulate different management scenarios especially :

- *Reservoir operations*



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Well (WEL) package

Well Package: defines groundwater pumping rate at a specific well location.

Municipal Wells

1. Available well supply data

Name	*Type*	*Pumping (AF/month) till December 2015*
Calpella W1	MI	2.13
Ukiah WTP	MI	0
Ukiah W2	MI	0
Ukiah W3	MI	10.59
Ukiah W4	MI	0
Ukiah W7	MI	24.59
Ukiah W8	MI	8.05
Willow/Nogard W5	MI	12.35
Willow/Nogard W6	MI	12.35
Willow/Burke W7	MI	12.35
Willow/Burke W8	MI	12.35

2. Missing well supply data

Name	*Type*	*Pumping (AF/month)*
Millview W17	MI	-
Millview W12	MI	-
Millview W16	MI	-
Masonite W6	MI	-

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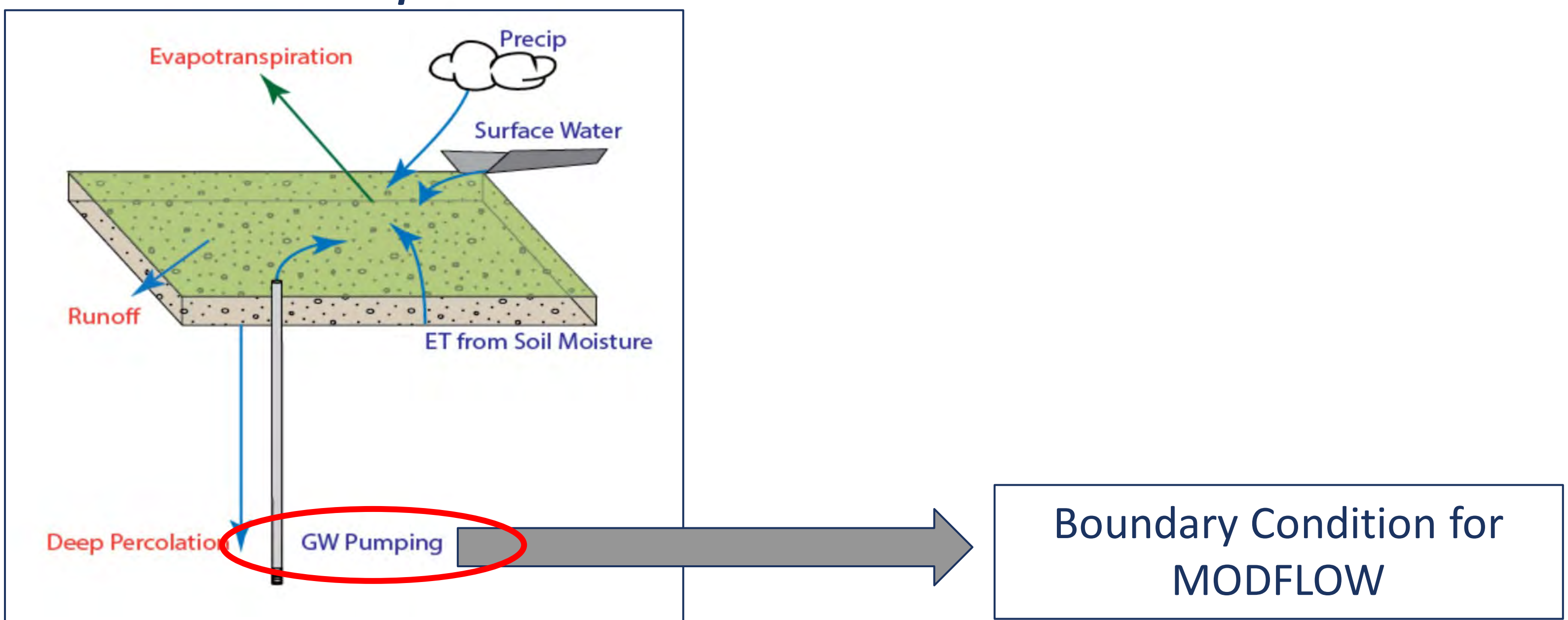
Well (WEL) package

Agricultural Wells — Demand is currently estimated from IDC at each cell with groundwater-irrigated Agriculture

… will be migrated to ***GSFLOW Ag Package*** in the future

IDC Flow Components



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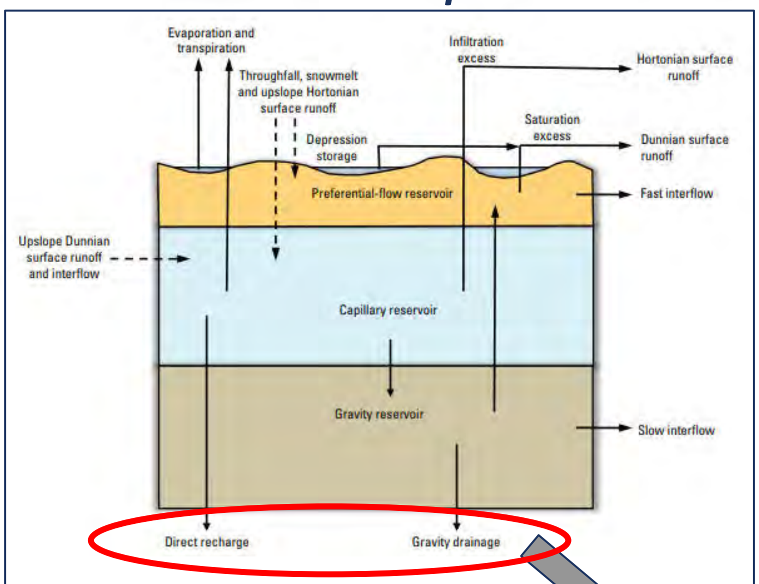
Recharge package

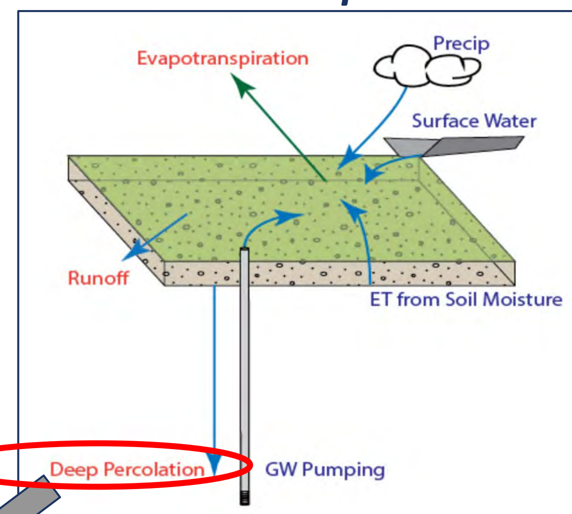
Recharge — Currently specified using PRMS results where there is no agriculture, and with IDC where there is agriculture

… will be calculated dynamically with ***GSFLOW*** in the future

PRMS Flow Components



IDC Flow Components



Boundary Condition for MODFLOW

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Questions?

MODFLOW Initial Calibration

LARRY WALKER ASSOCIATES
Science. Policy. Solutions.

Introduction to Parameters and Sensitivities

- **Parameters** are defined variables that control the flow system in a model.
  - Examples include hydrogeologic properties within the model.
- **Sensitivities** are a measurement of how important a parameter is to set of observations.
- **Observations** in groundwater models are typically hydraulic heads (water level) but including stream flow and other fluxes into or out of the system is very beneficial for a successful calibration.

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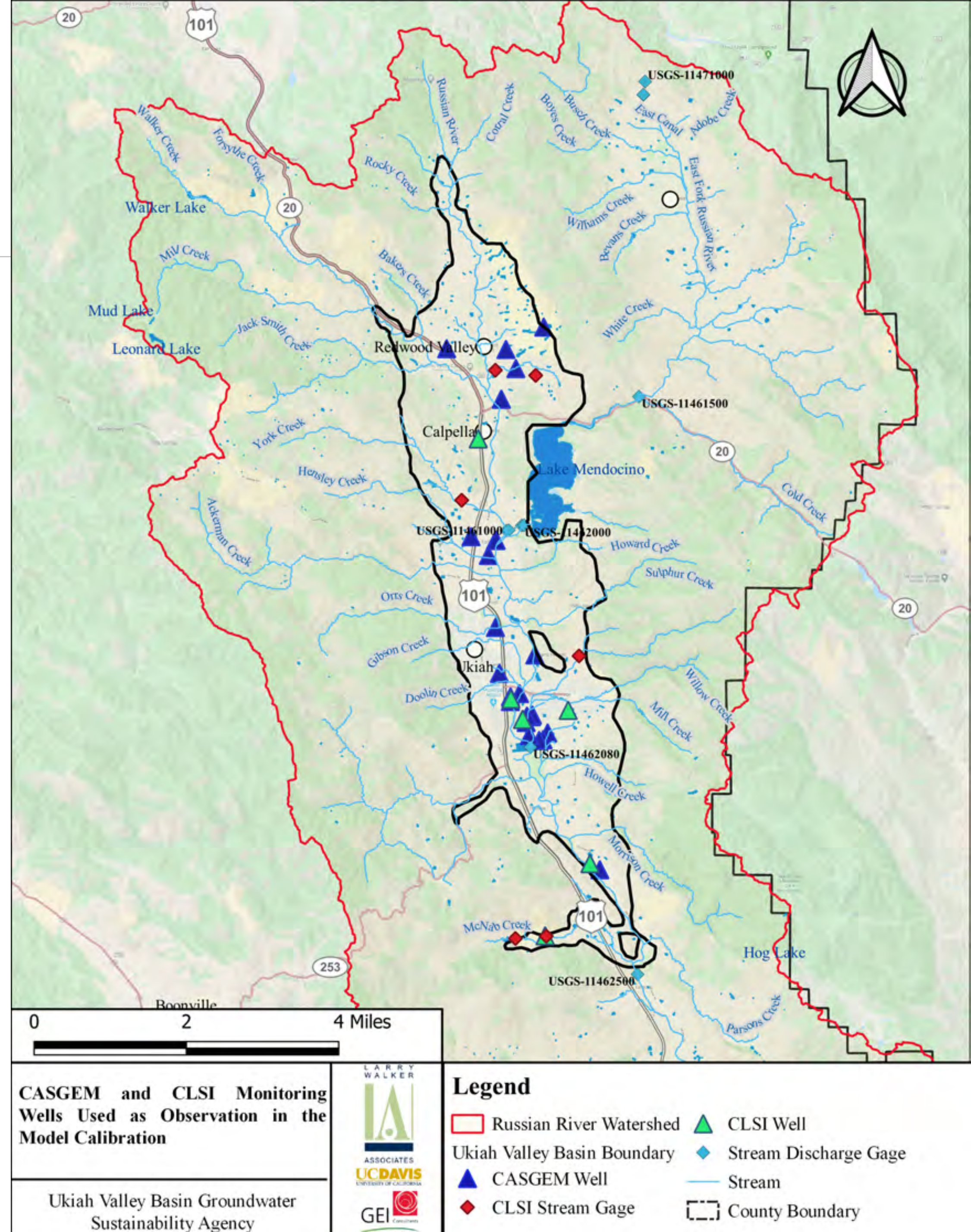
Observations

Initial sensitivity analysis and Calibration:

- 39 CASGEM wells
- 1 USGS gage (Hopland)

Subsequent Calibration:

- 39 CASGEM **+ 5 CLSI** wells
- **3 USGS + 6 CLSI** gages



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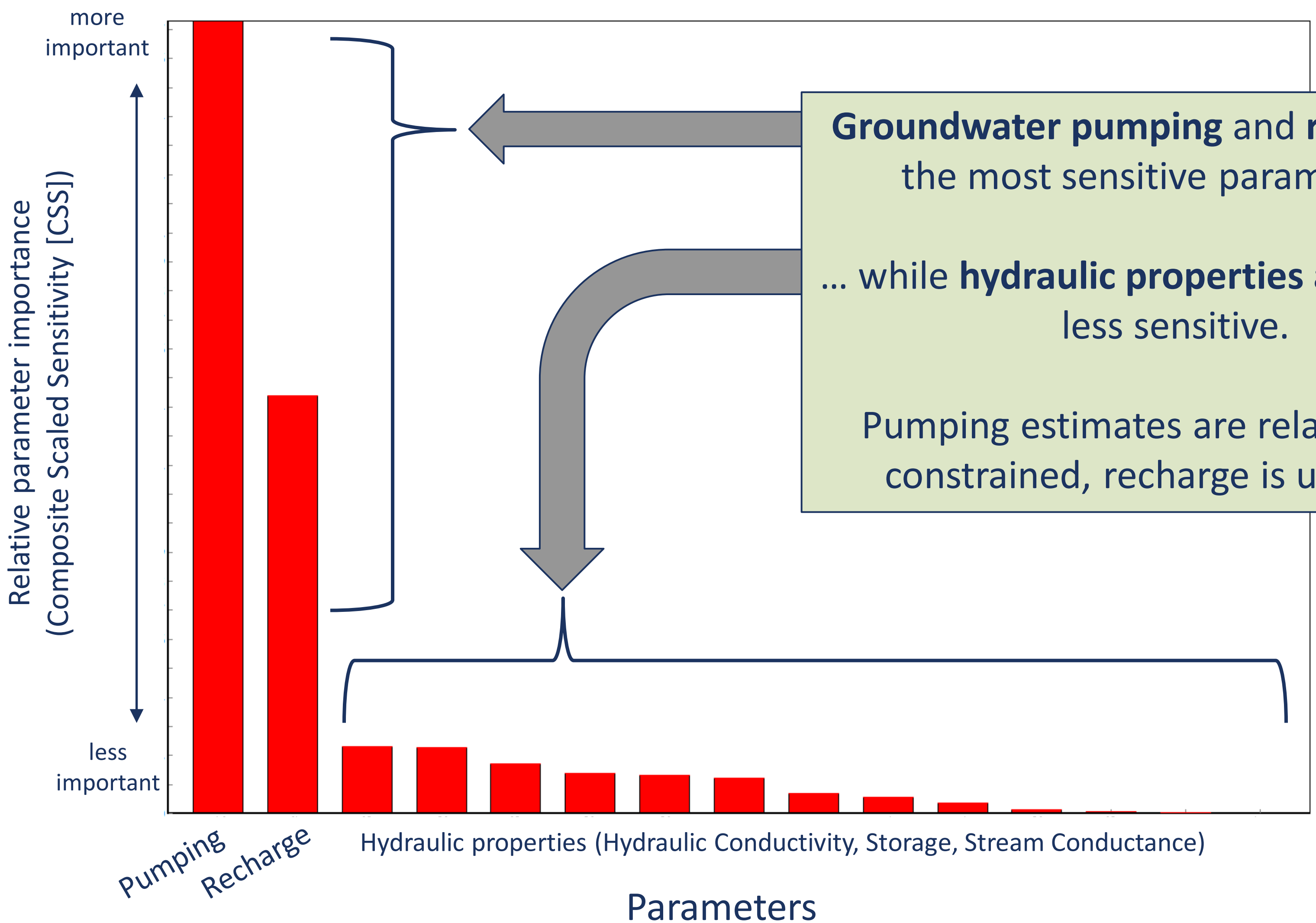
Sensitivity Results—which parameters are important?



Groundwater pumping and **recharge** are the most sensitive parameters …

… while **hydraulic properties** are relatively less sensitive.

Pumping estimates are relatively well constrained, recharge is uncertain.

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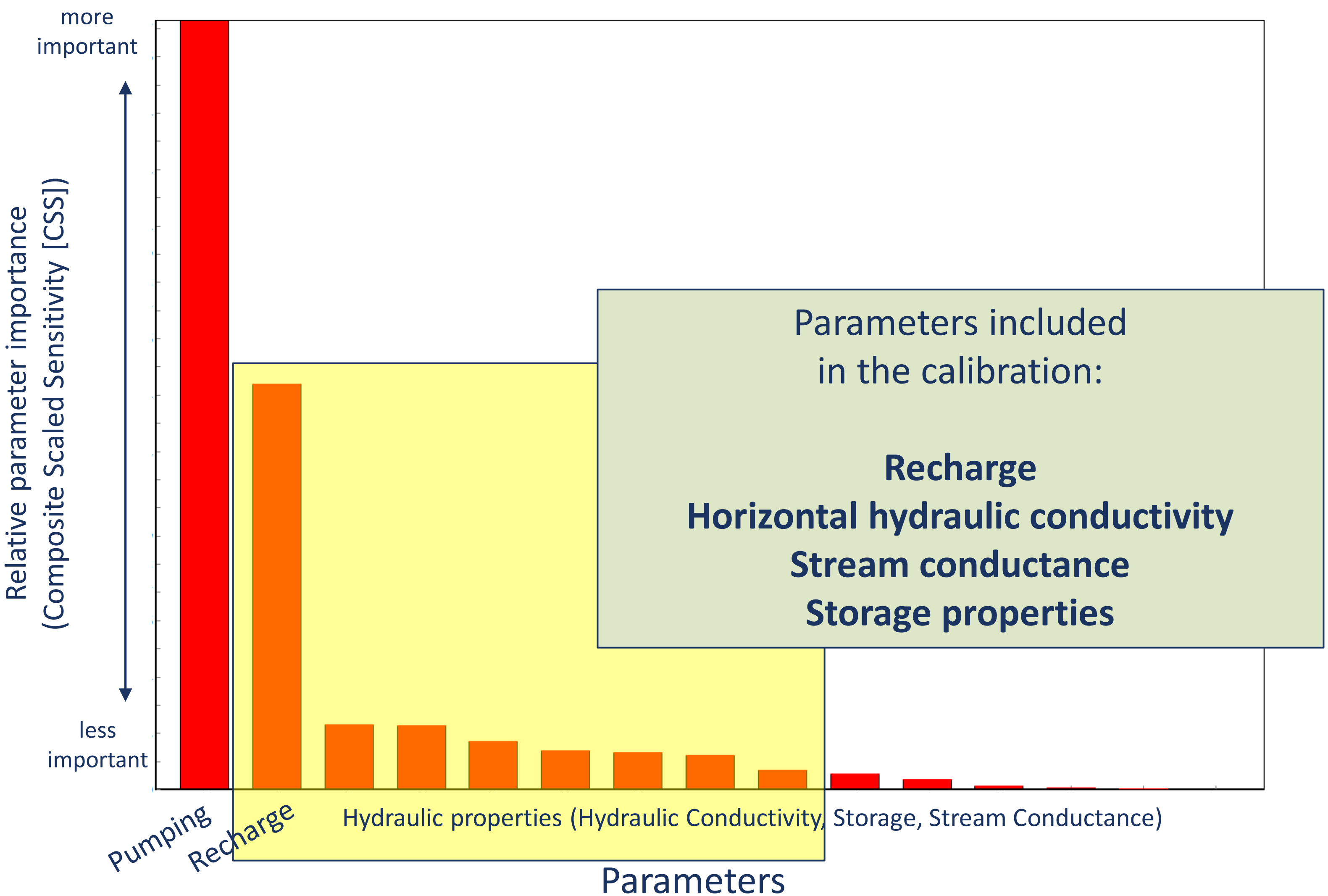
Calibration Setup—Which parameters are included?



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Initial Calibration Results—Parameter Adjustments

	Parameter	Initial value	Calibrated value	Change
Hydraulic Conductivity	Hk layer 1	196.8 ft/d	212.8 ft/d	Increase
	Hk layer 2	9.8 ft/d	0.96 ft/d	Decrease
	Hk layer 3	1.7ft/d	0.06 ft/d	Decrease
	Hk layer 4	3.3e-5 ft/d	3.3-5 ft/d	Not adjusted
Specific Storage	SS layer 1	1e-4	2e-5	Decrease
	SS layer 2	1e-4	2e-5	Decrease
	SS layer 3	1e-5	6e-6	Decrease
	SS layer 4	1e-7	1e-7	Not adjusted
Stream Conductance	Upland Strm Cond.	0.03 ft/d	0.01 ft/d	Decrease
	Lowland strm. Cond.	0.01 ft/d	3.1 ft/d	Increase
	Recharge adjustment factor	1.0 (unitless)	0.4 (unitless)	Decrease

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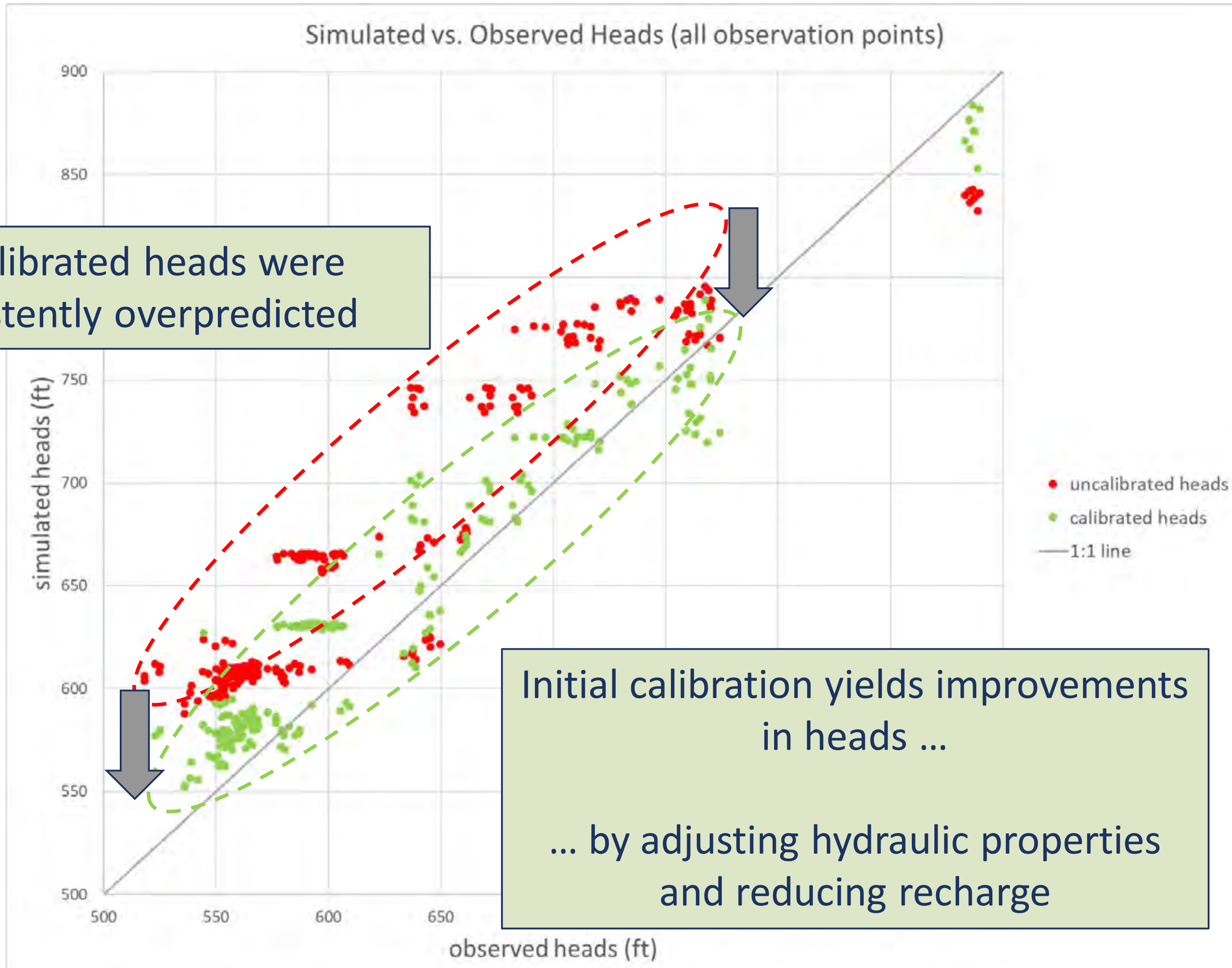
Calibration Results—Groundwater Heads



Uncalibrated heads were consistently overpredicted

Initial calibration yields improvements in heads …

… by adjusting hydraulic properties and reducing recharge

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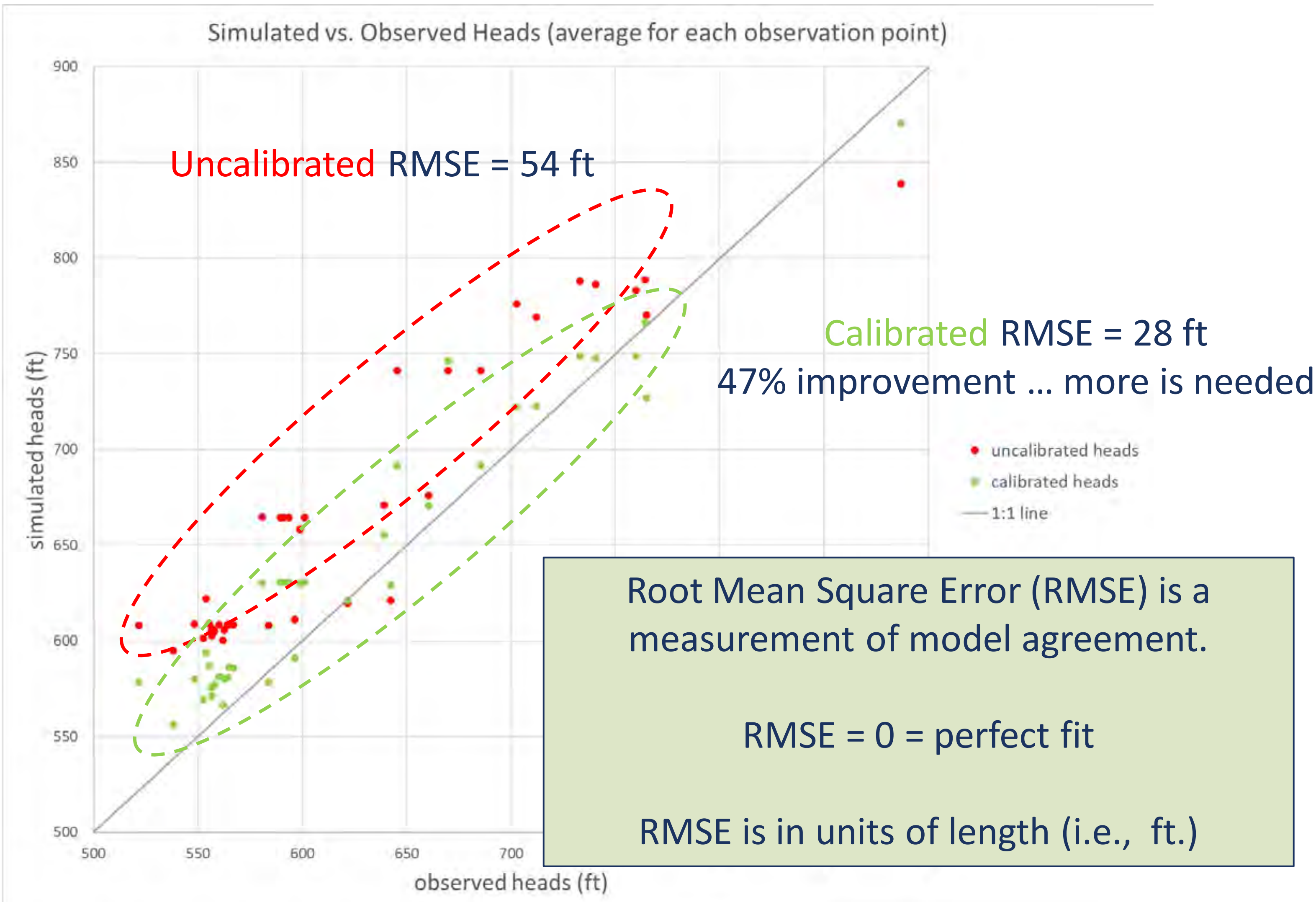
Calibration Results—Groundwater Heads



Root Mean Square Error (RMSE) is a measurement of model agreement.

RMSE = 0 = perfect fit

RMSE is in units of length (i.e., ft.)

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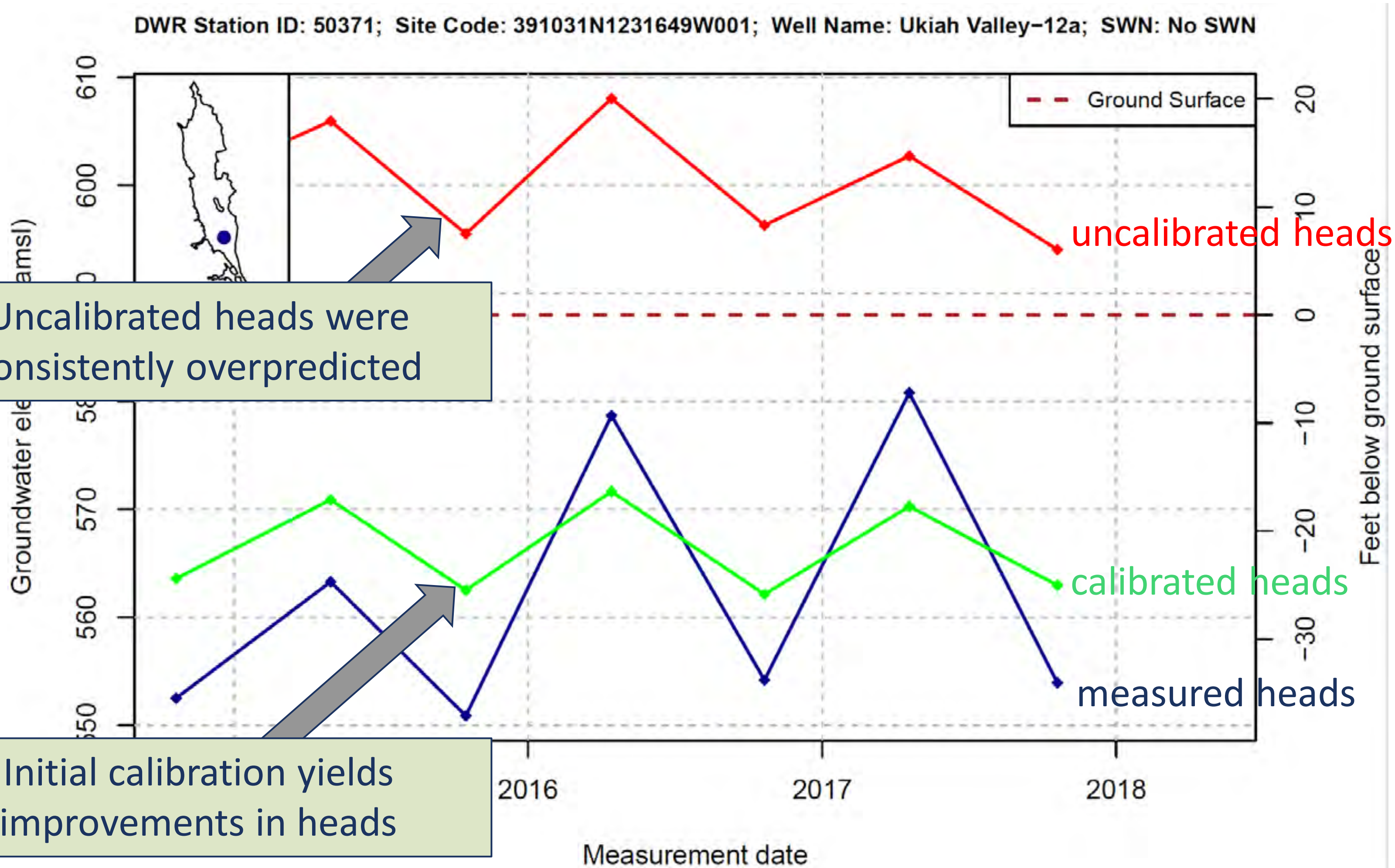

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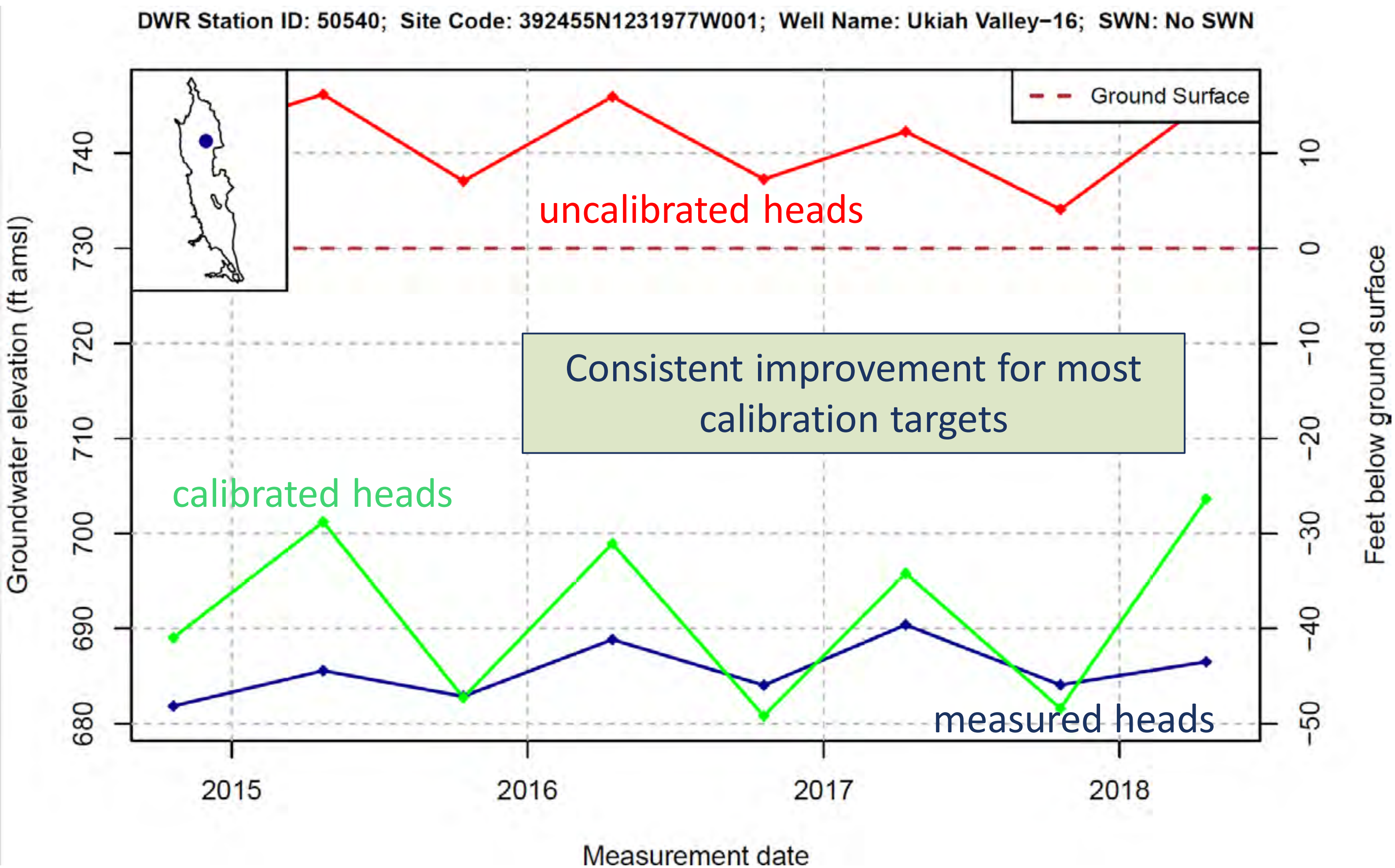

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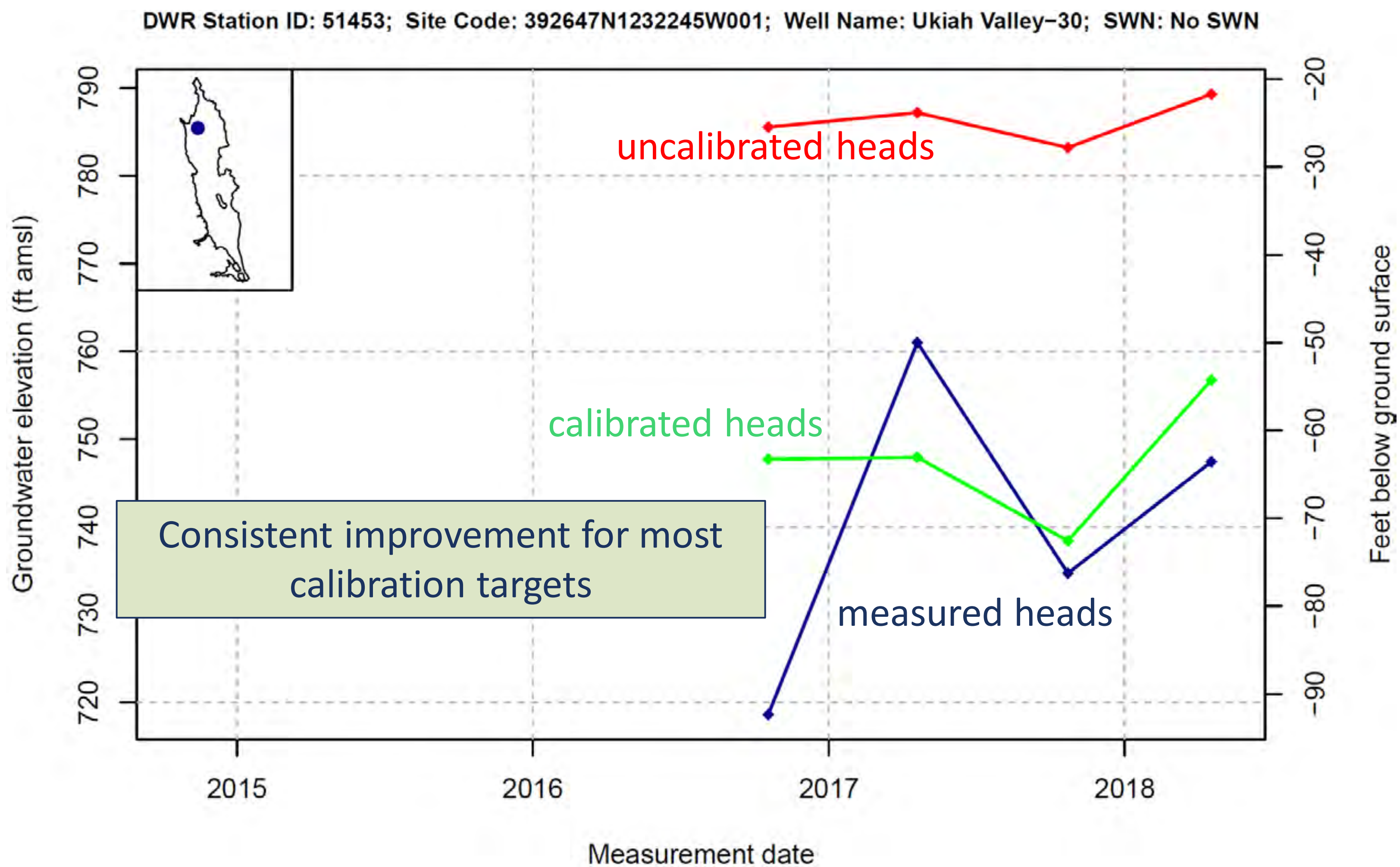
Calibration Results—Groundwater Heads



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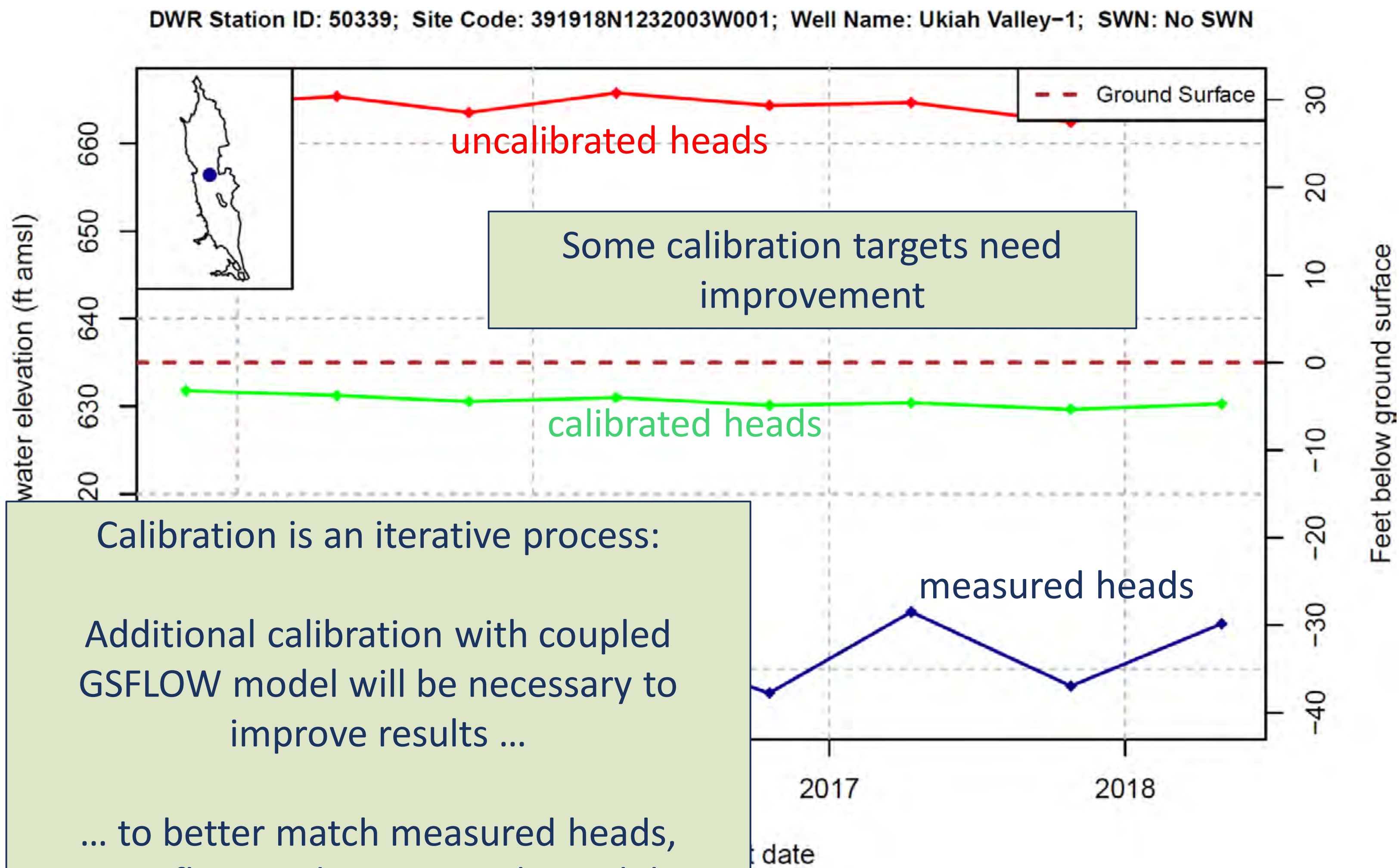
Calibration Results—Groundwater Heads



Some calibration targets need improvement

Calibration is an iterative process:

Additional calibration with coupled GSFLOW model will be necessary to improve results …

… to better match measured heads, streamflow, and interannual variability

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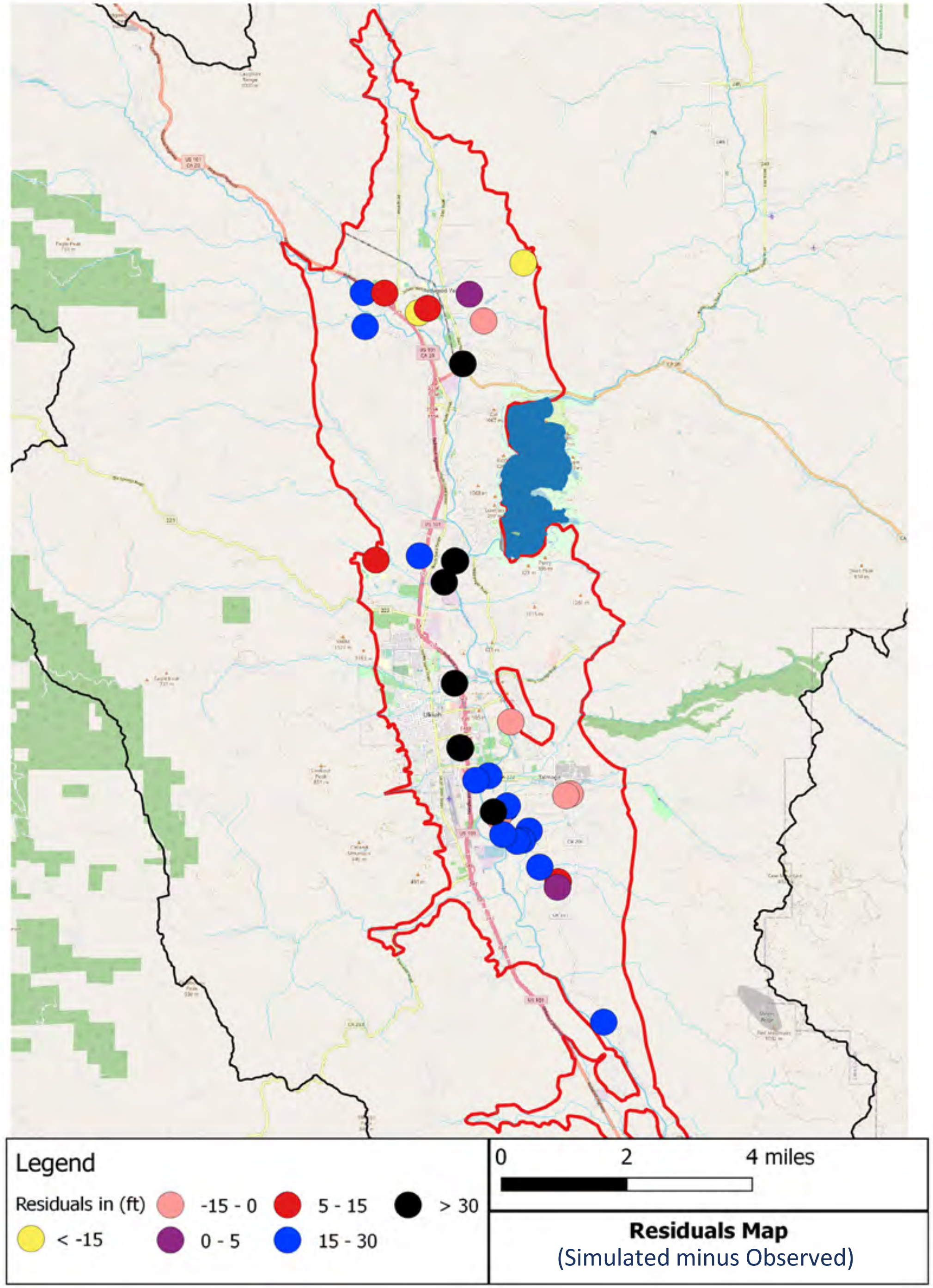
Groundwater Model Preliminary Results

- Overprediction of heads still occurring along the river corridor



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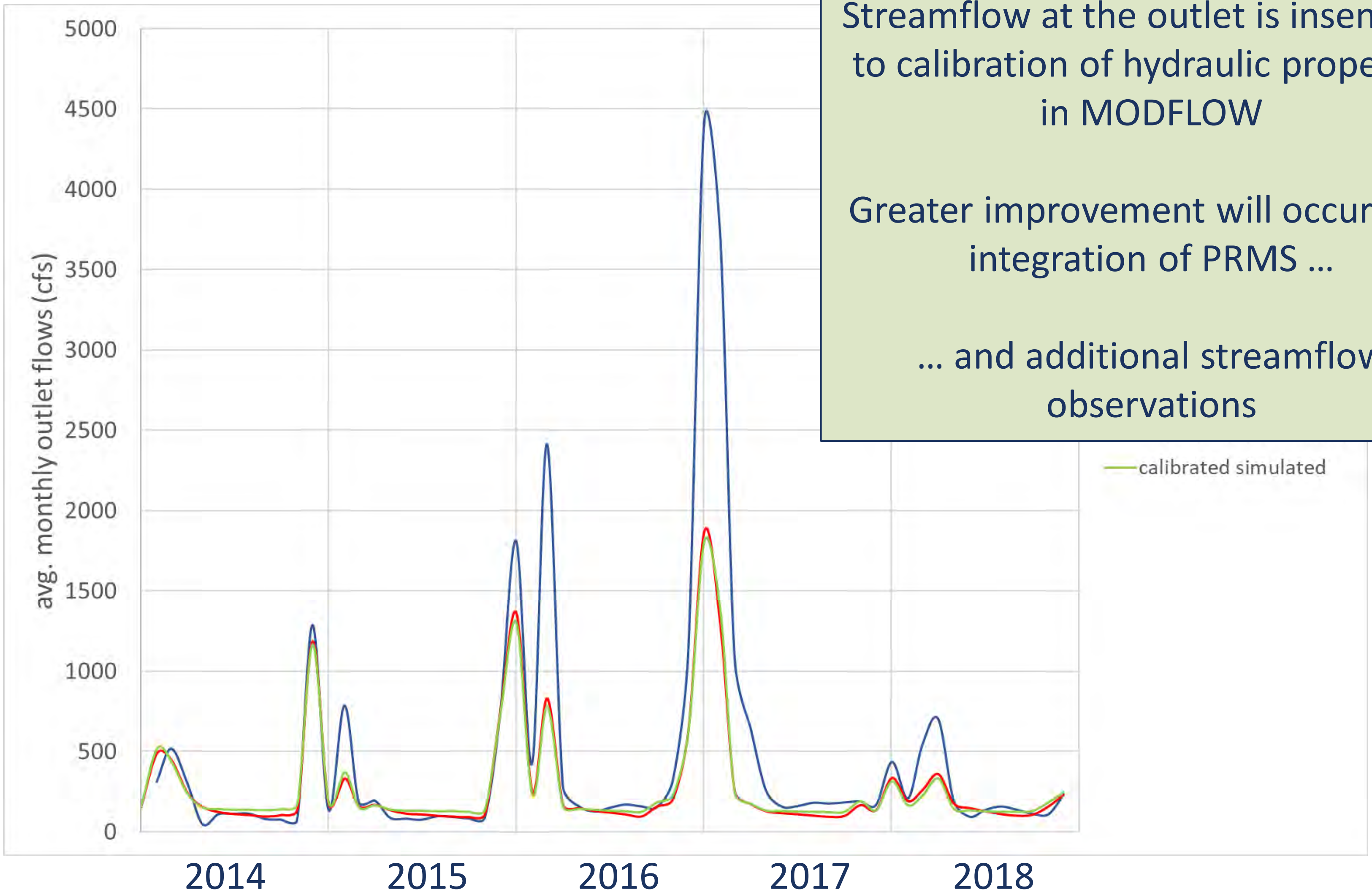
Calibration Results - Streamflow



Streamflow at the outlet is insensitive to calibration of hydraulic properties in MODFLOW

Greater improvement will occur with integration of PRMS …

… and additional streamflow observations

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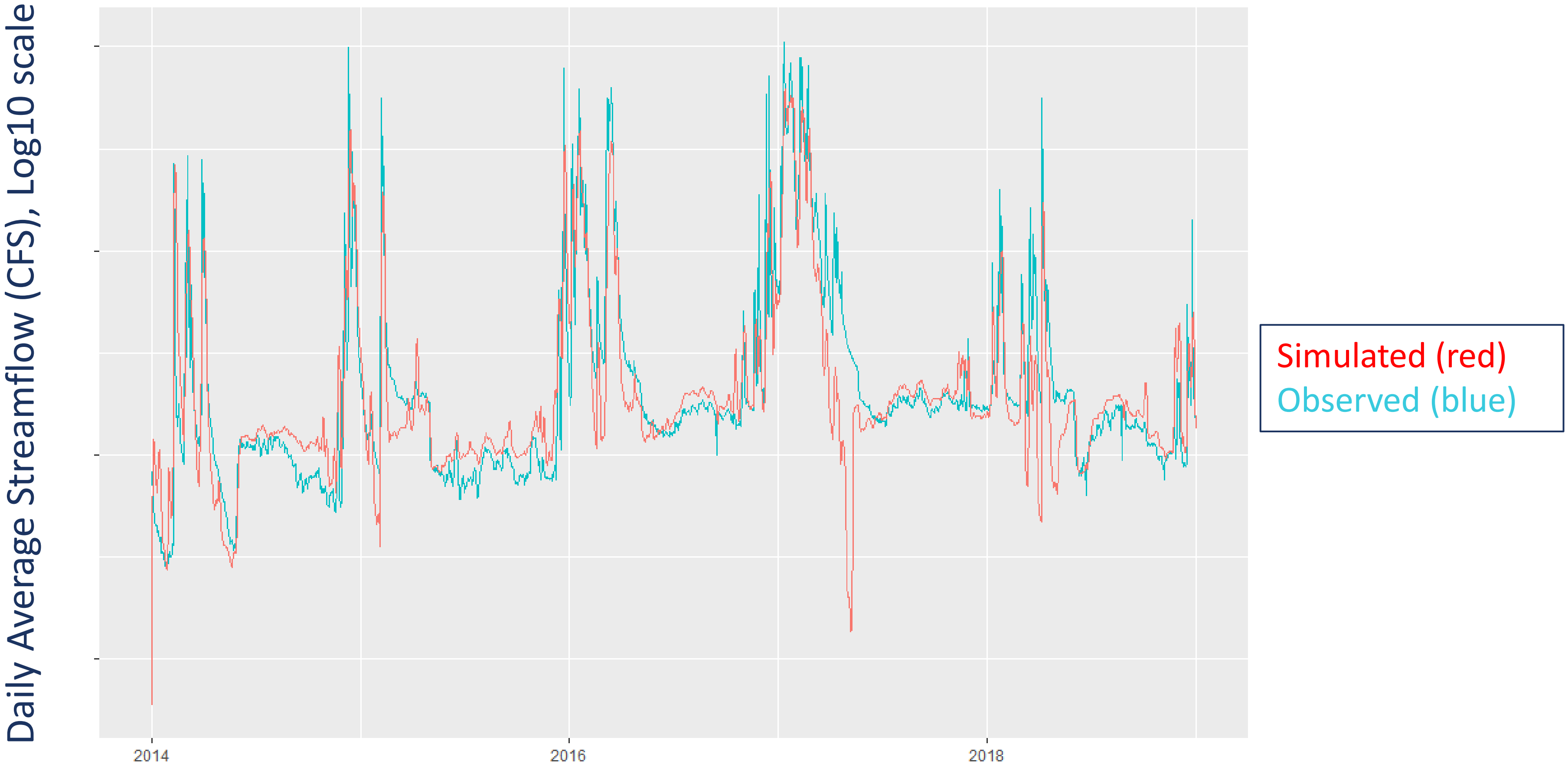
Calibration Results - Streamflow

PRMS Calibrated Streamflow shows good agreement



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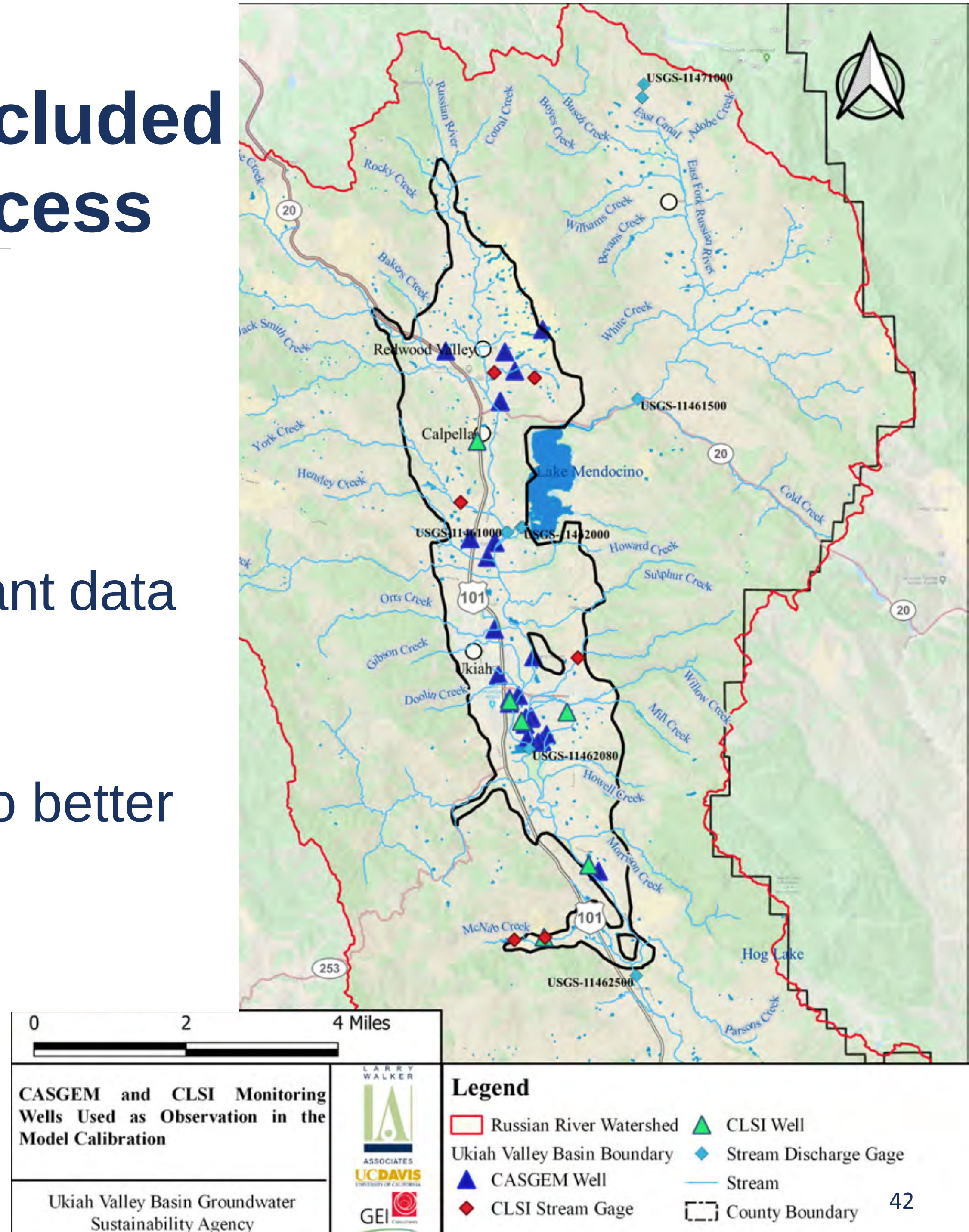
New Data to be Included in Calibration Process

- CLSI data
  - 6 tributary gages
  - 5 continuous wells
- Data helps fill important data gaps
- Tributary gage data to better understand GW/SW interactions



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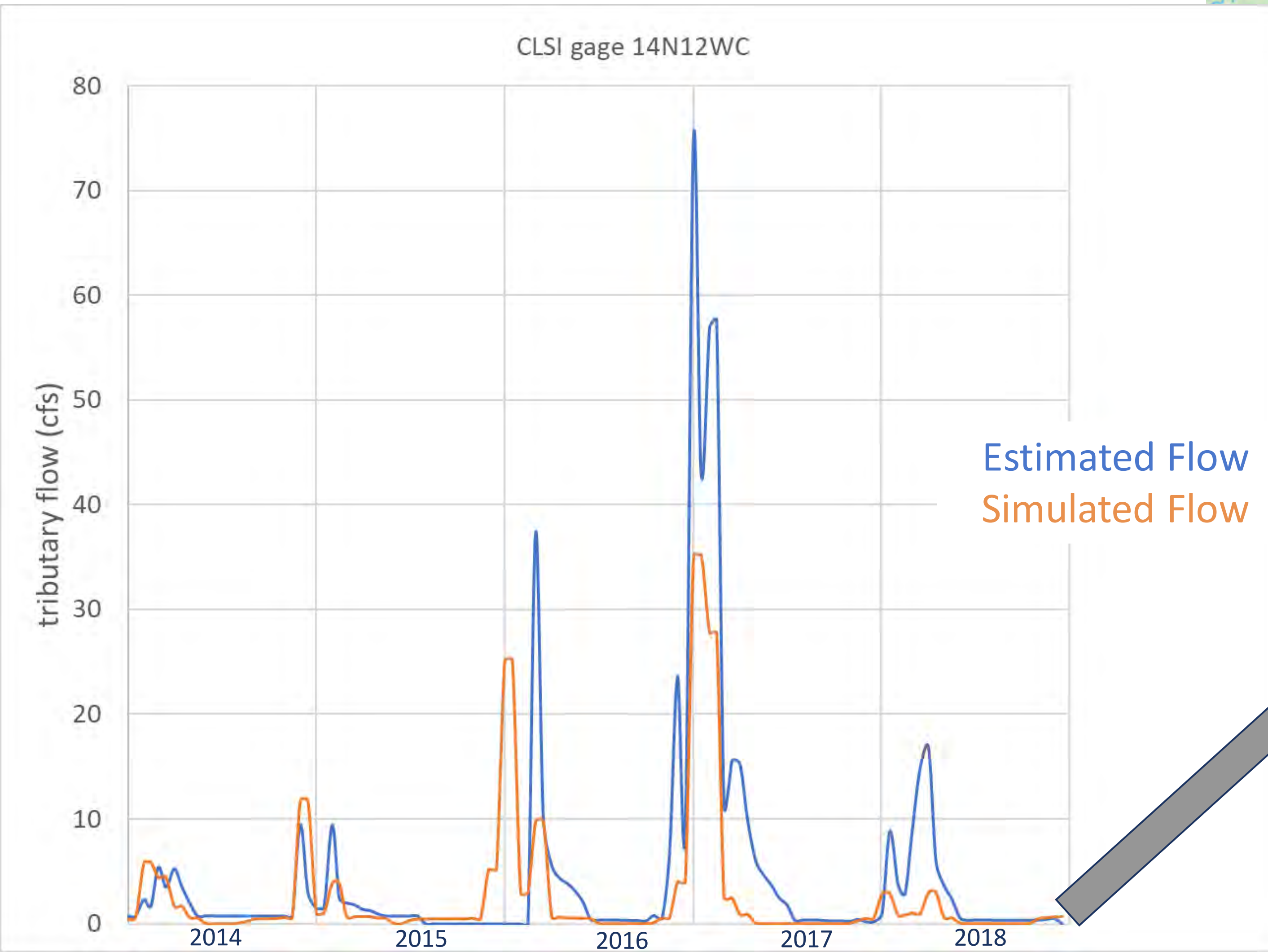

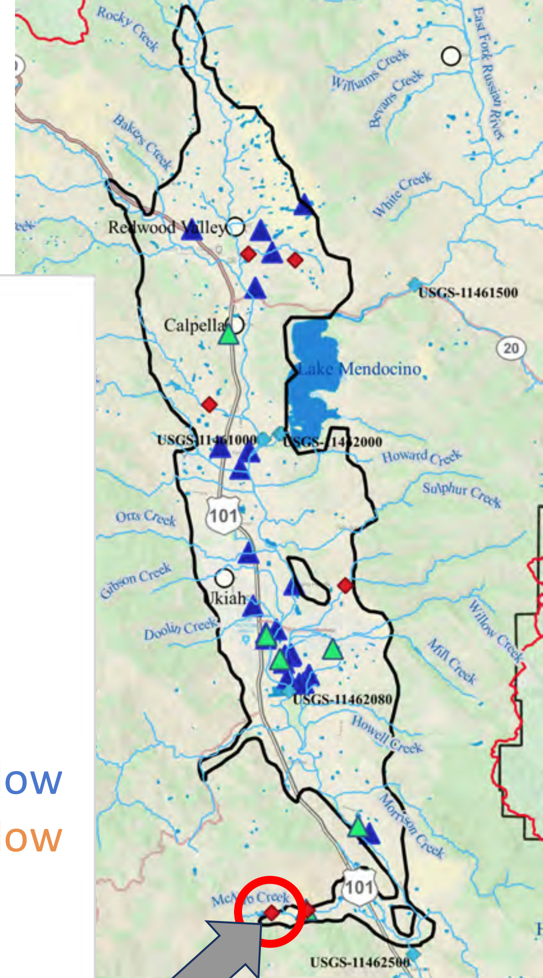

Reasonable uncalibrated agreement for some tributary gages

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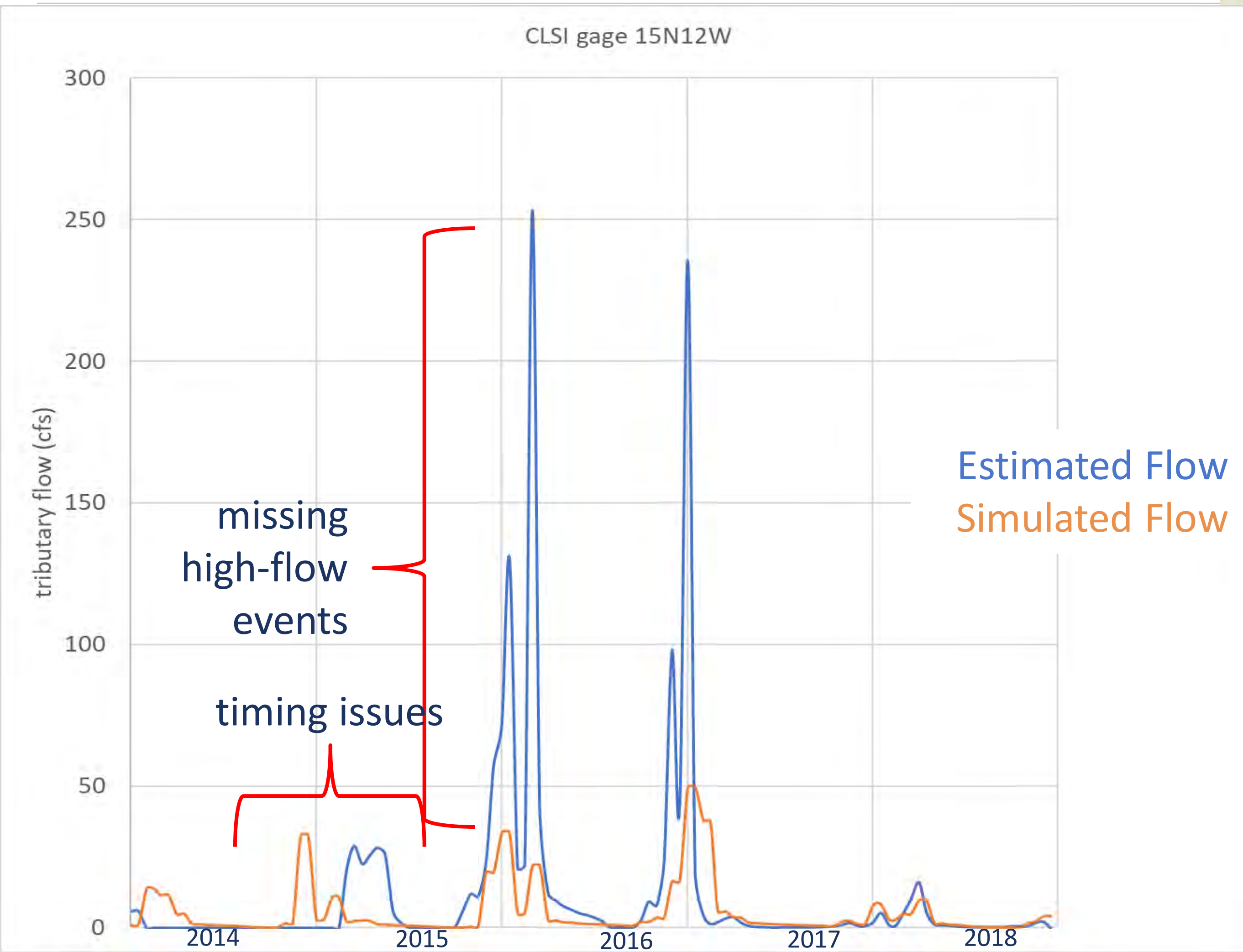

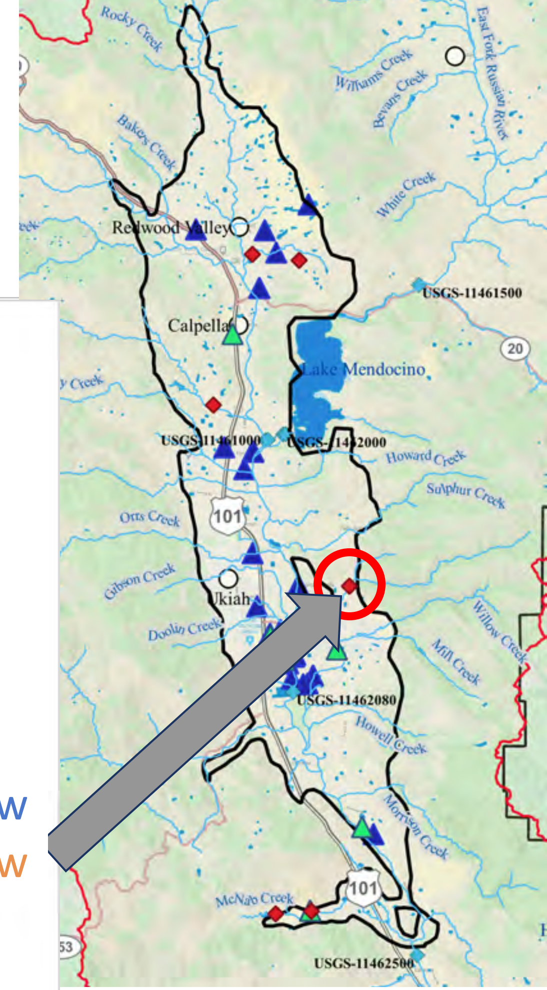

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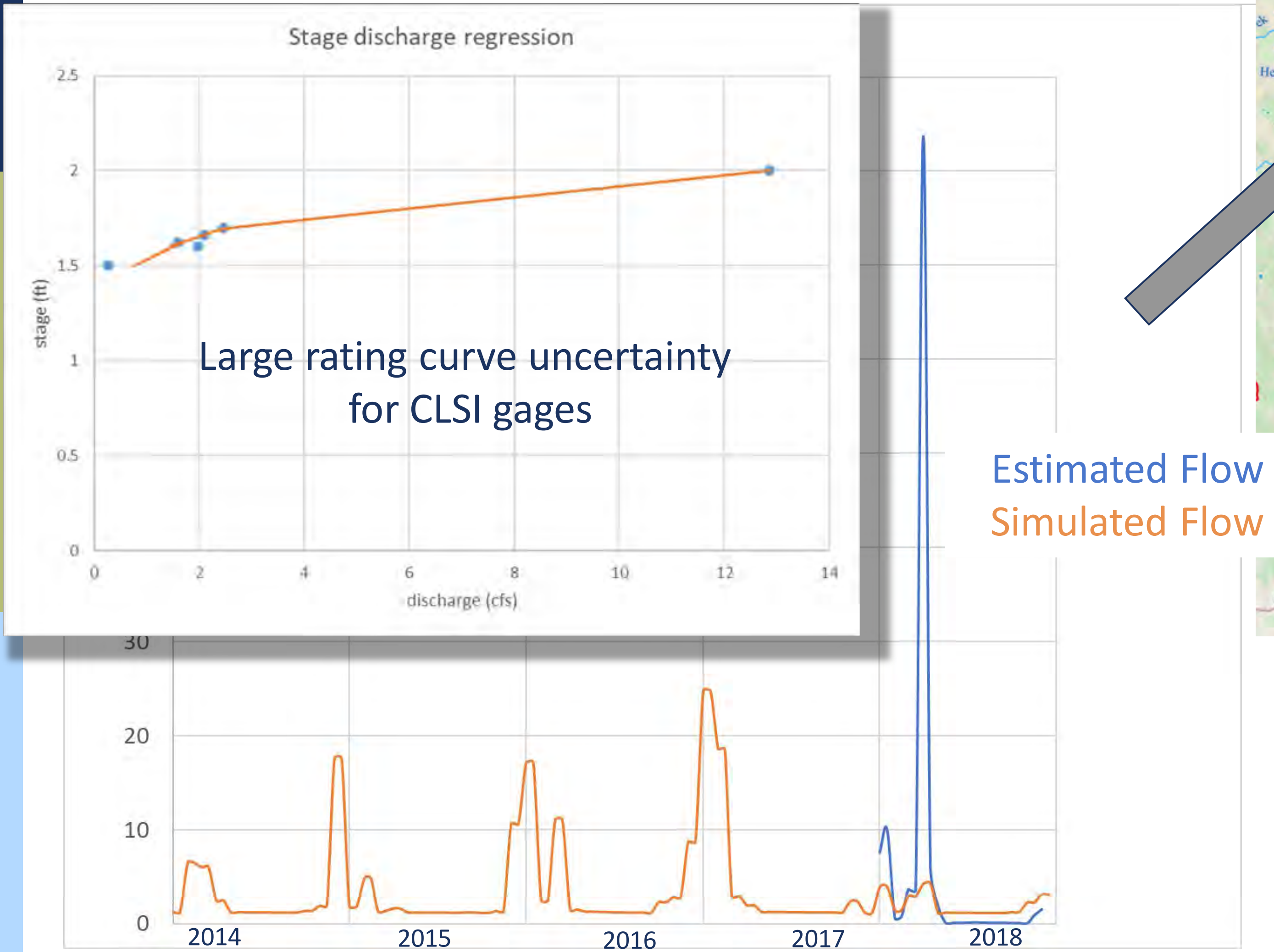

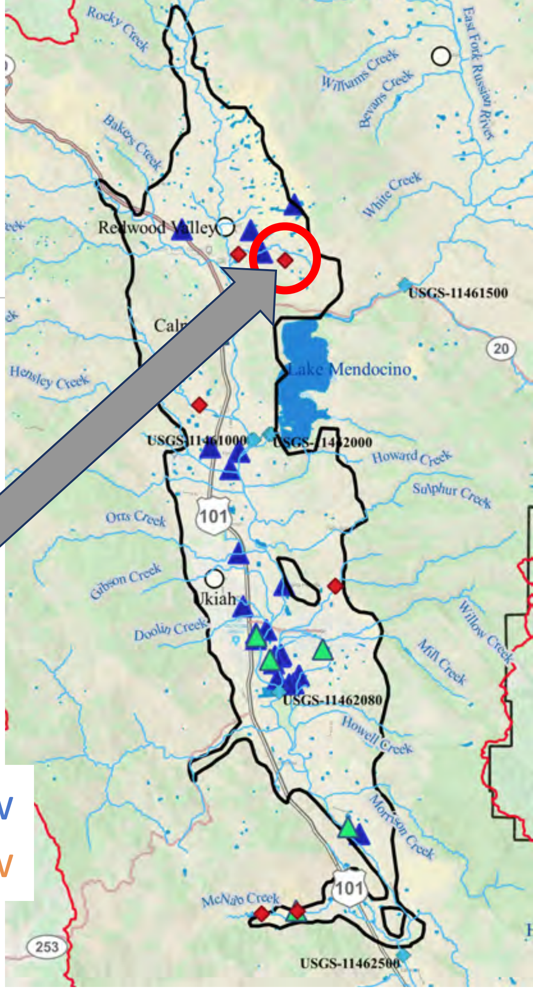

Poor uncalibrated agreement for some tributary gages

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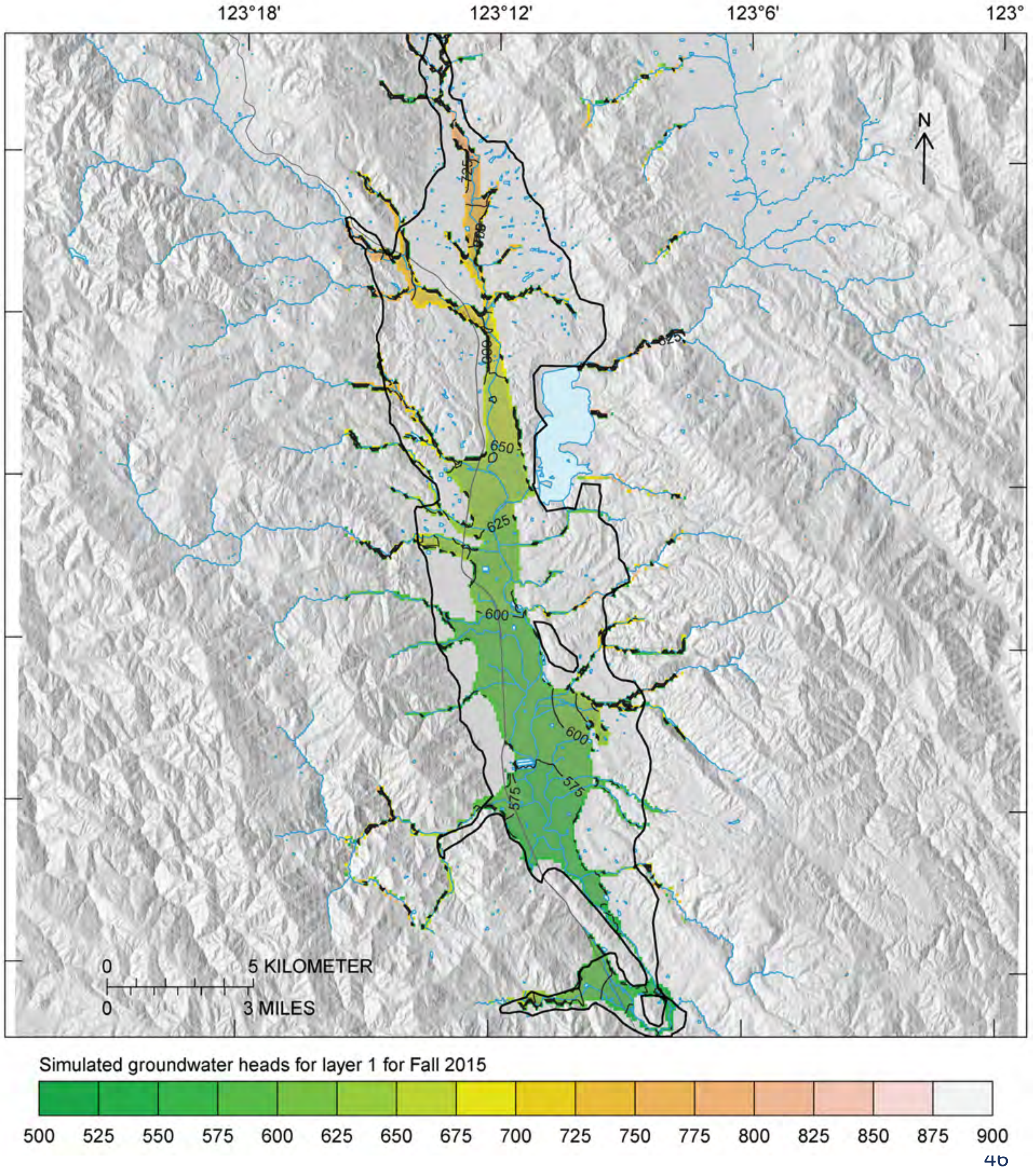
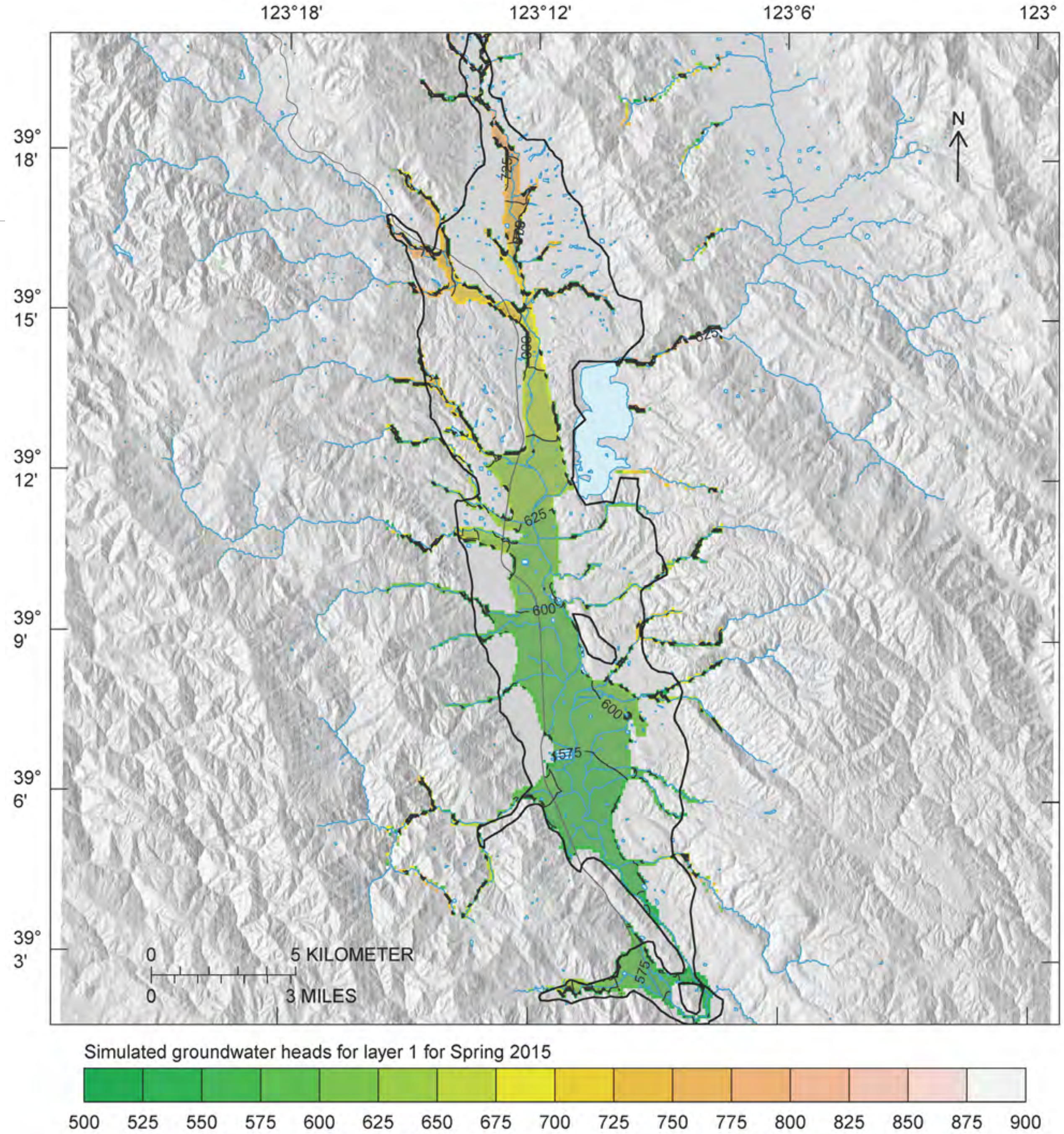
Simulated Results

Layer 1
Fall 2015



Simulated Results

Layer 1
Spring 2015



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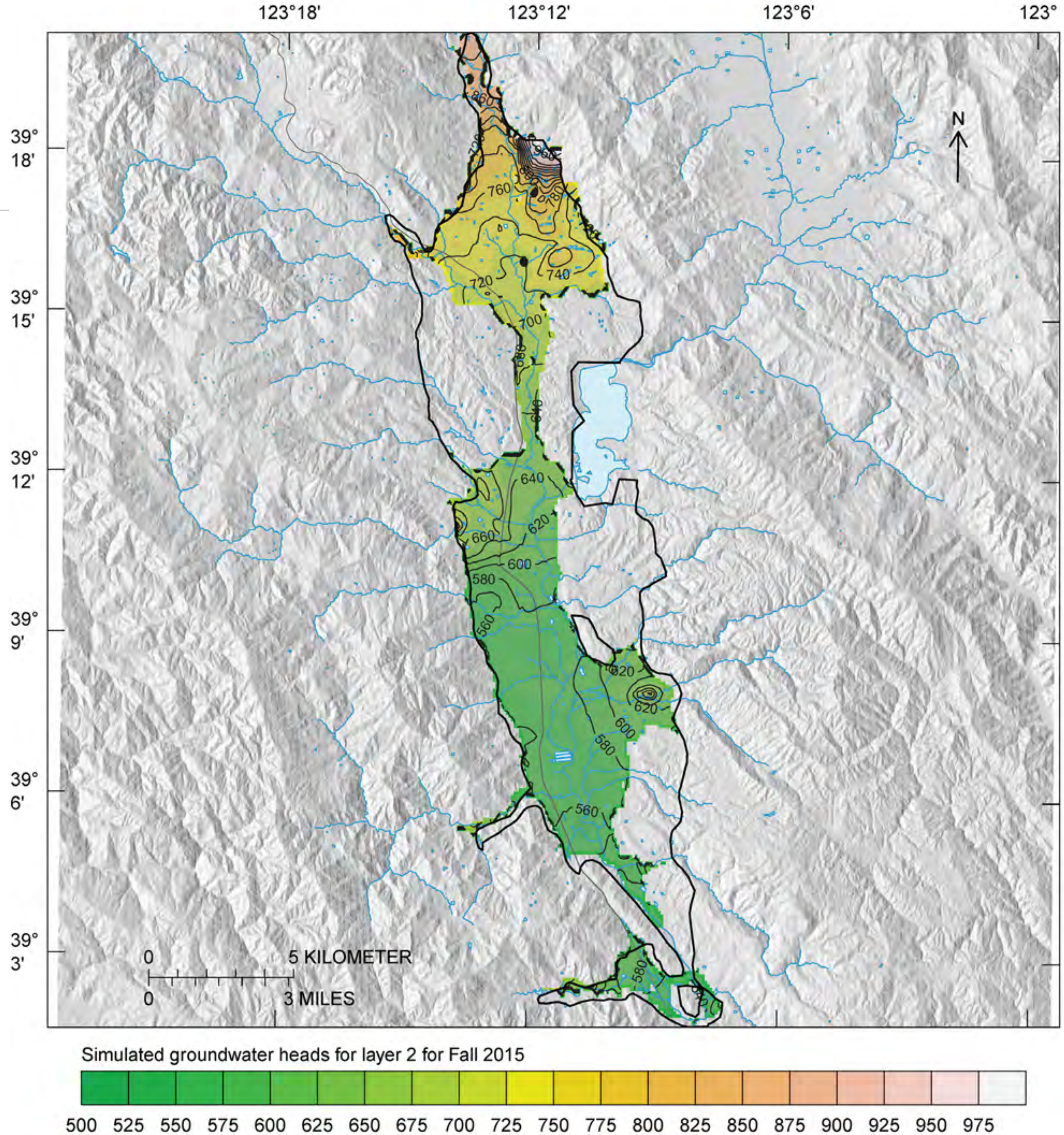
Simulated Results

Layer 2
Fall 2015



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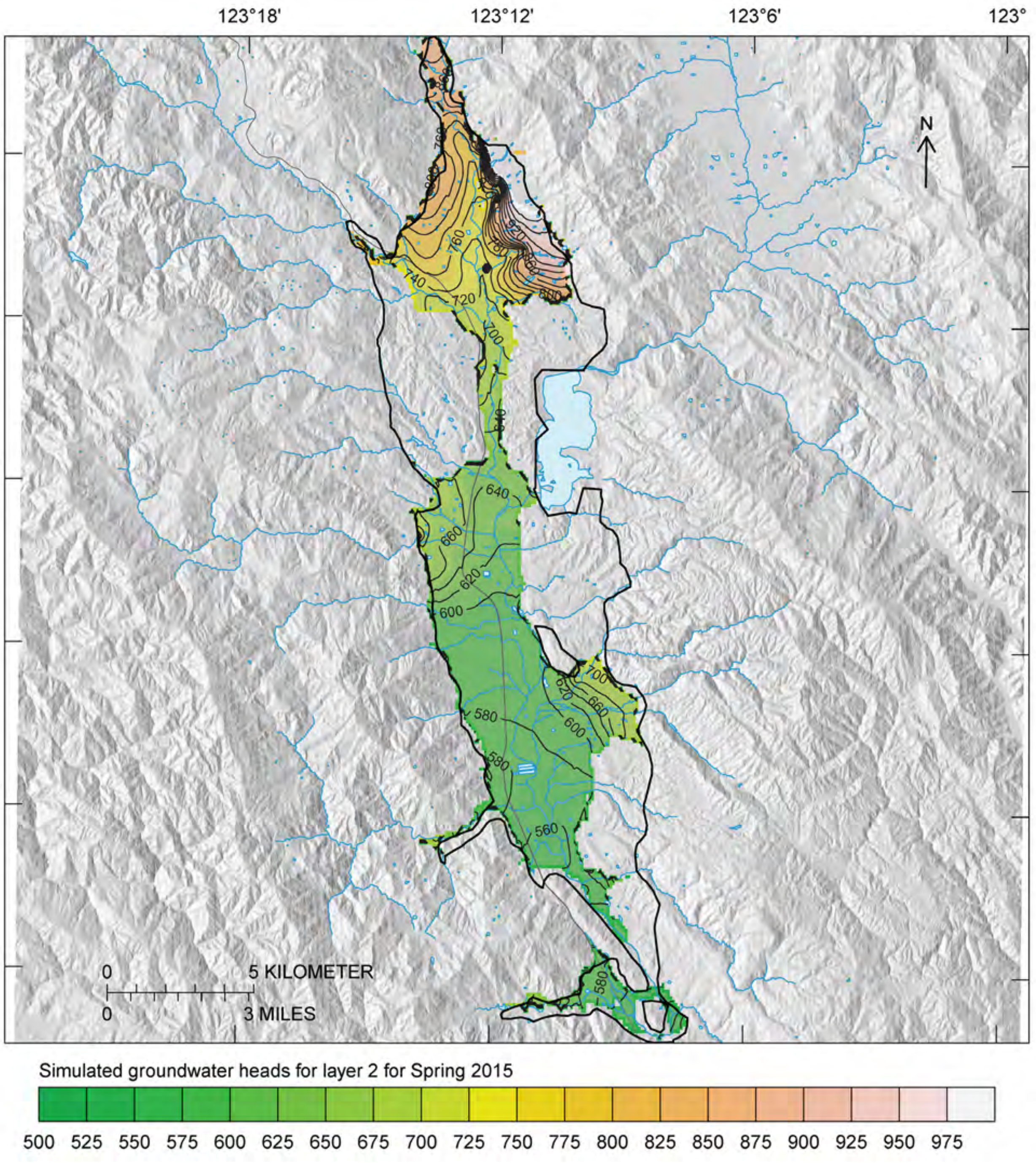
Simulated Results

Layer 2
Spring 2015



Next Steps

- Transfer to GSFLOW Model
- Implement Ag package
- Final Calibration (PRMS + MODFLOW)

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Questions?

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  - Subsidence

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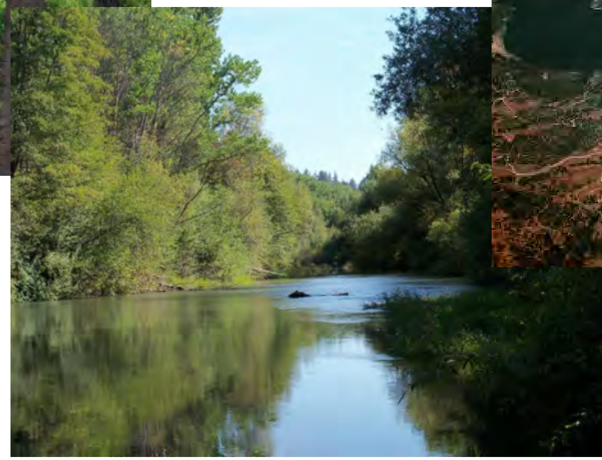

SUSTAINABLE MANAGEMENT CRITERIA – SURFACE WATER DEPLETION

LARRY WALKER ASSOCIATES
UC DAVIS UNIVERSITY OF CALIFORNIA
SCI Consulting Group
GEI Consultants

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Surface Water-Groundwater Interaction SMC

- What are surface water-groundwater interactions and why are they relevant?

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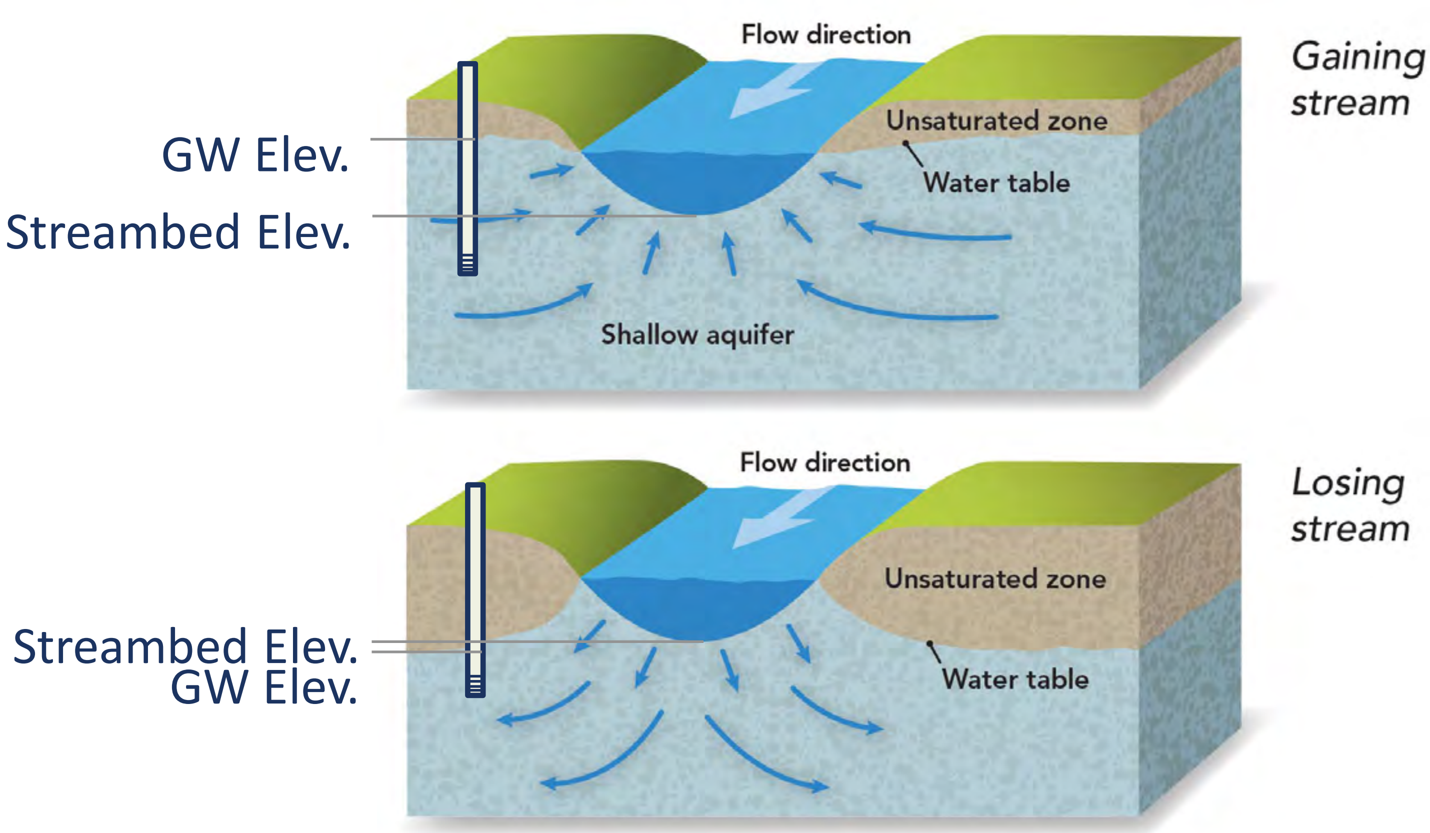
Surface Water-Groundwater Interaction SMC

How can we determine whether a stream is gaining or losing?



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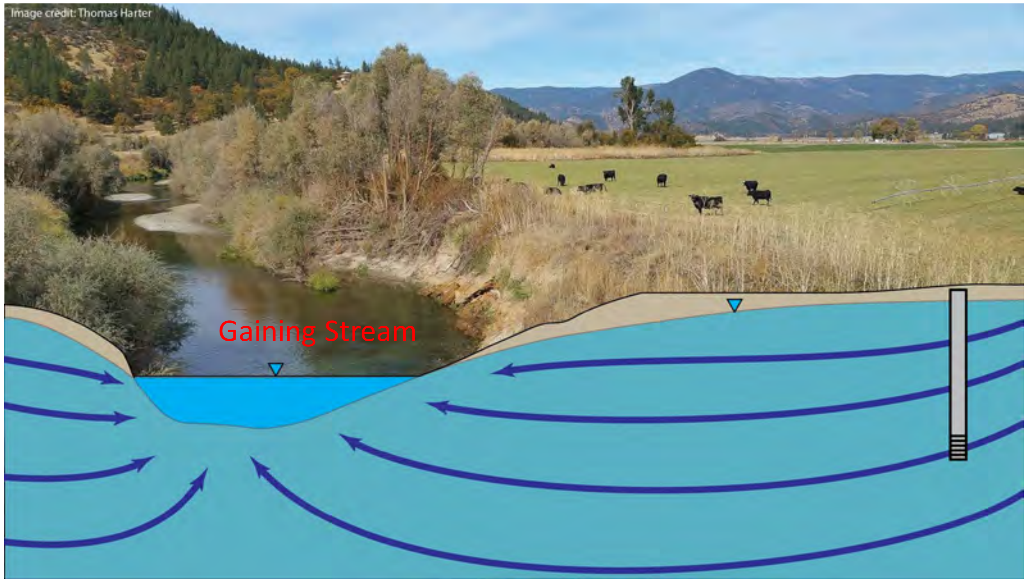
Surface Water-Groundwater Interaction SMC

How can a pumping well impact streamflow?

- Pumping can increase infiltration of surface water to the groundwater system, or reduce exfiltration of groundwater to surface water …



- … phenomena known as "Surface Water Depletion."

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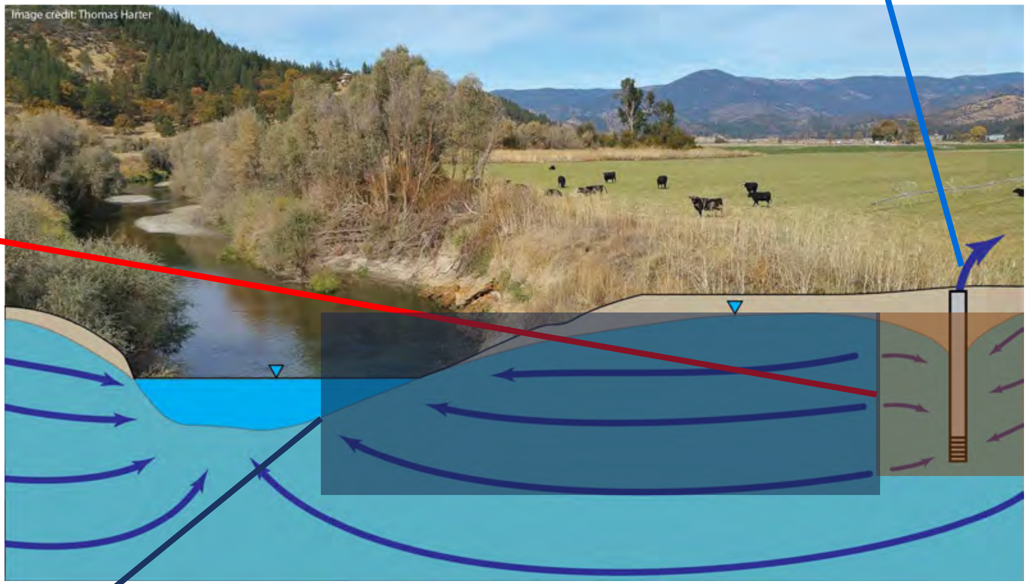
Surface Water-Groundwater Interaction SMC

How can a pumping well impact streamflow?

Groundwater pumping removes water that would have otherwise discharged to the river or riparian vegetation

“Cone of depression” is initially small. Note that its extent is unrelated to impact on stream.



Pumping creates an imperceptibly small decrease in hydraulic gradient to the river … eventually resulting in reduced discharge to the river.

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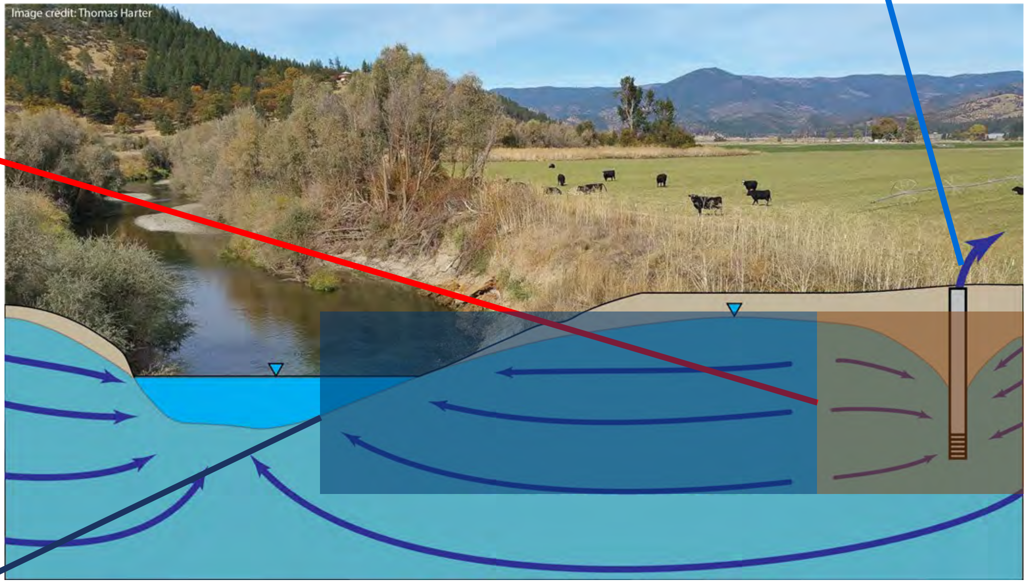
Surface Water-Groundwater Interaction SMC

How can a pumping well impact streamflow?

Groundwater pumping removes water that would have otherwise discharged to the river or riparian vegetation

Cone of depression may grow with time



River is still gaining, but gradually less and less than before pumping initiated

More time pumping = more impact on river

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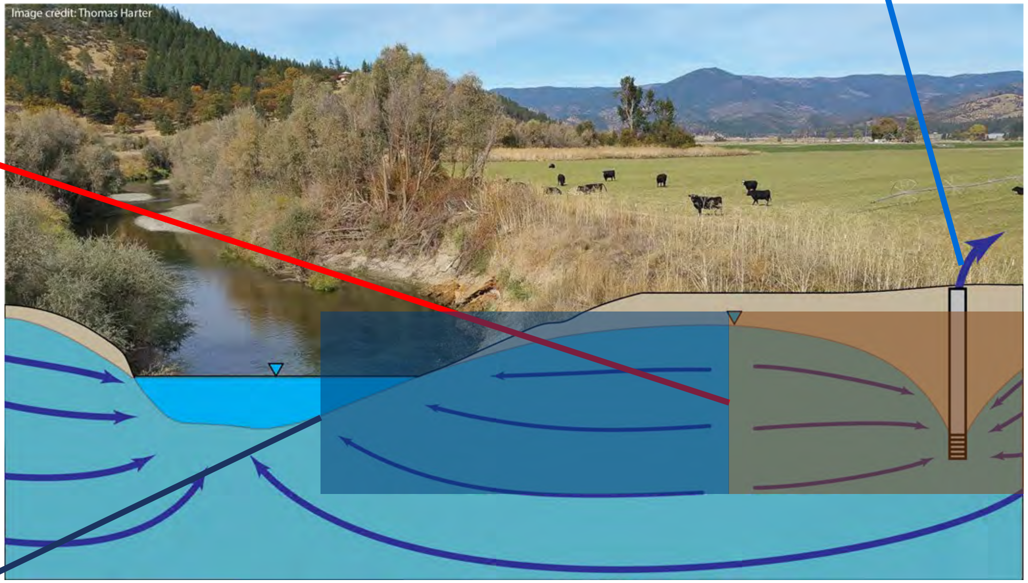

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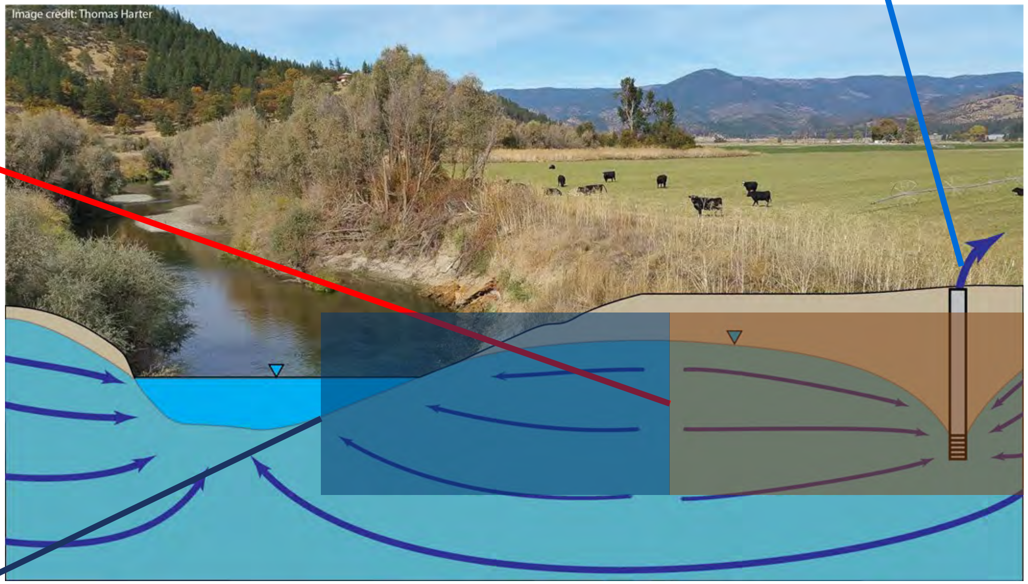

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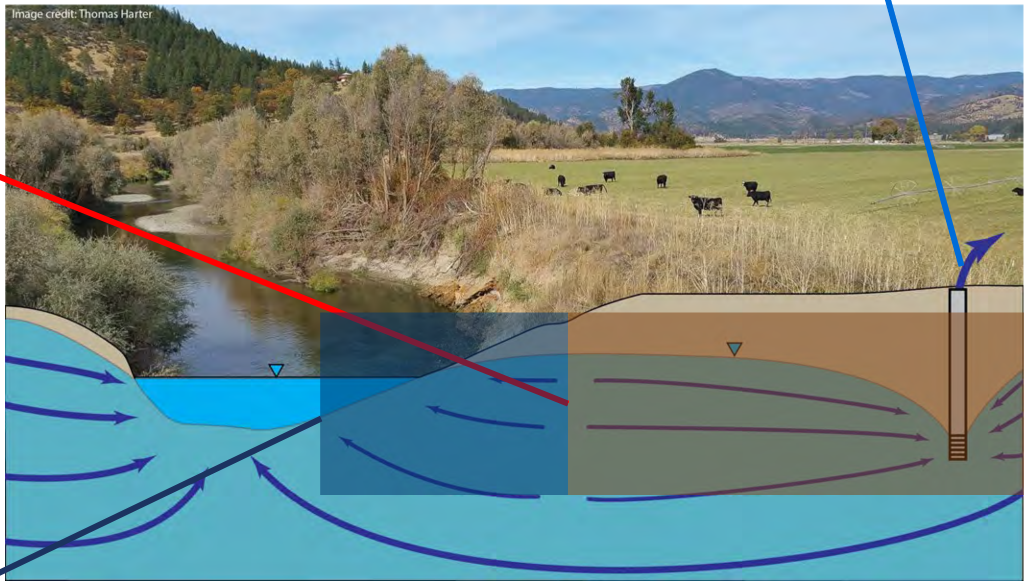

River is still gaining, but gradually less and less than before pumping initiated

More time pumping = more impact on river

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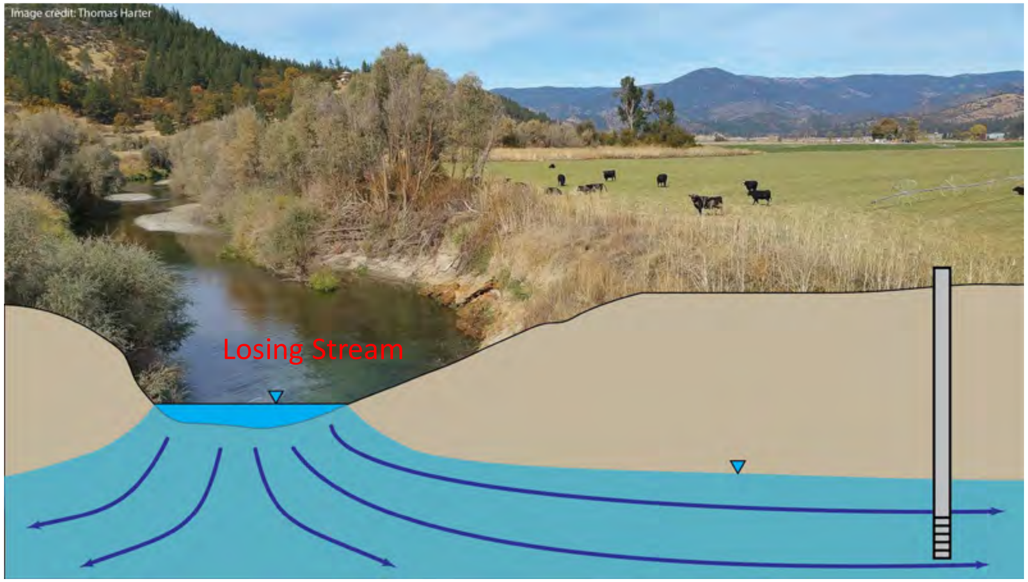
Surface Water-Groundwater Interaction SMC

How can a pumping well impact streamflow in a losing stream?

A stream segment can “gain” water and “lose” water to/from the groundwater system at different times during the year



Streams often “lose” water to the groundwater system during summer and fall months, even under natural conditions without pumping

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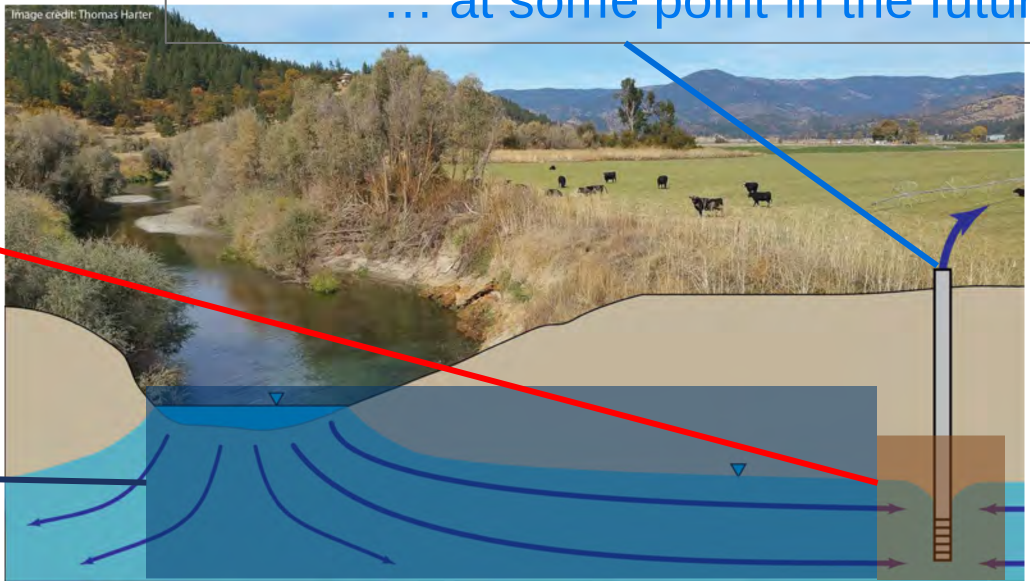
Surface Water-Groundwater Interaction SMC

Groundwater pumping removes water that would have otherwise discharged to the river or riparian vegetation
… at some point in the future

How can a pumping well impact streamflow in a <u>losing stream</u>?

Cone of depression may grow with time

River is still losing, and will lose more as the duration of pumping increases



More time pumping = more impact on river

DRAFT

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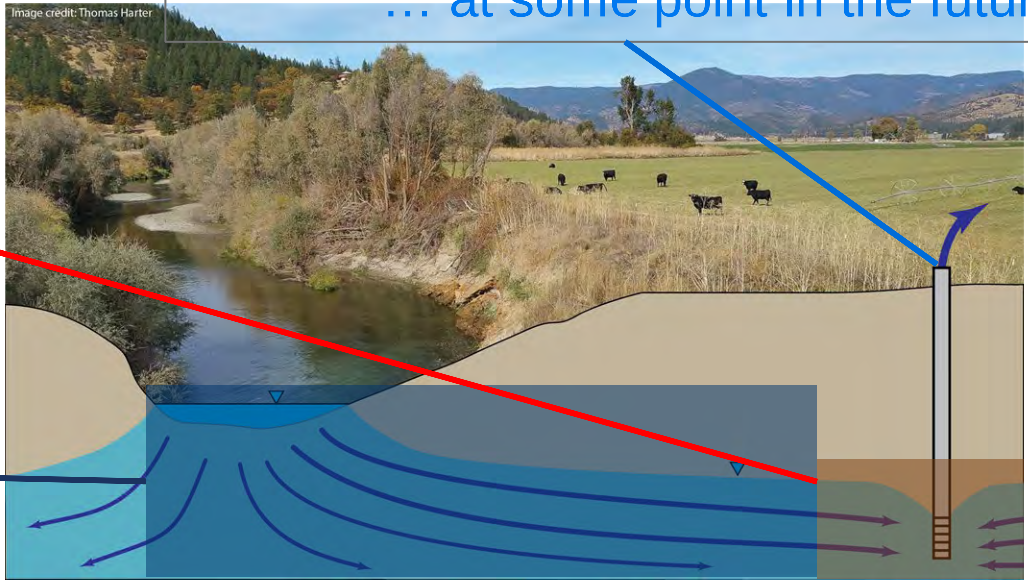

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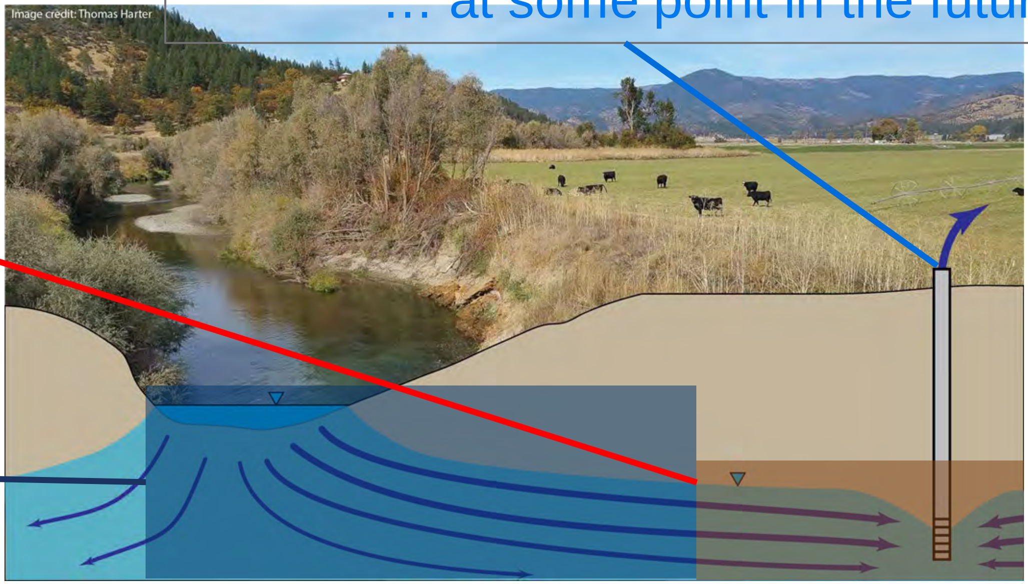
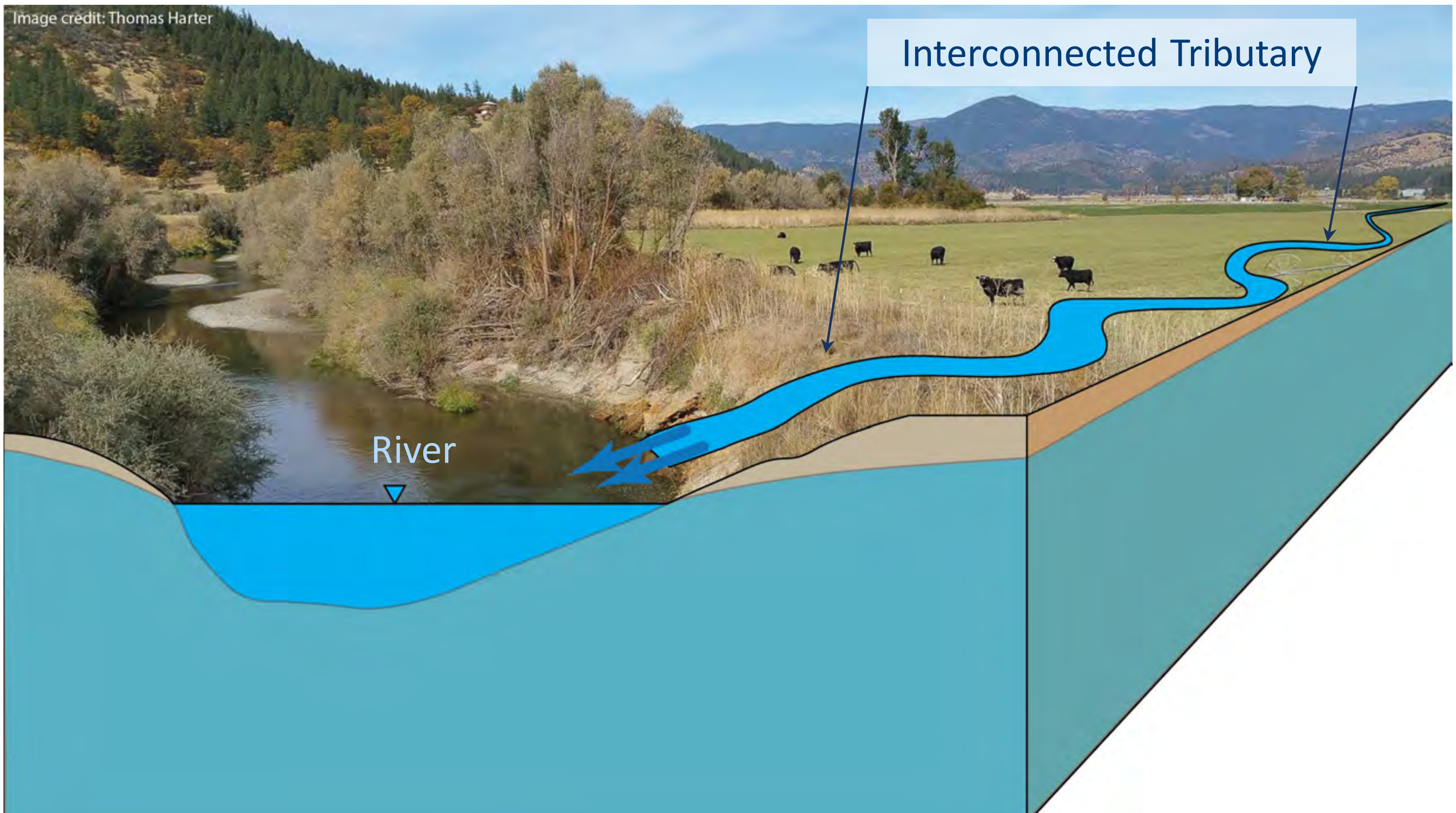


More time pumping = more impact on river

DRAFT

How is SW/GW interaction unique in UVBGSA? … River Incision

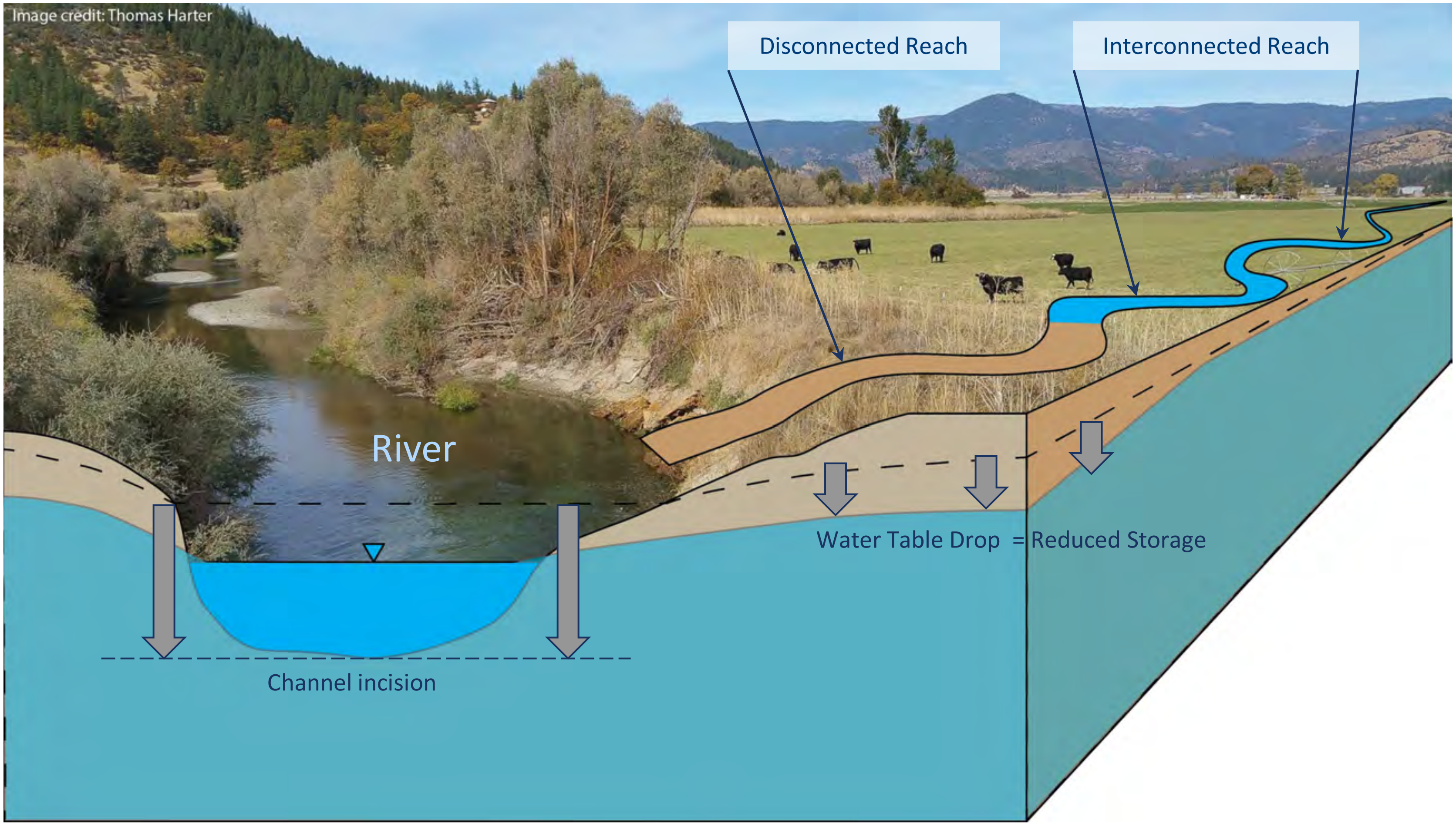
No incision → Elevated water table → Interconnected tributaries



DRAFT

How is SW/GW interaction unique in UVBGSA? … River Incision

Channel incision → Reduced water table depth → Disconnected tributaries



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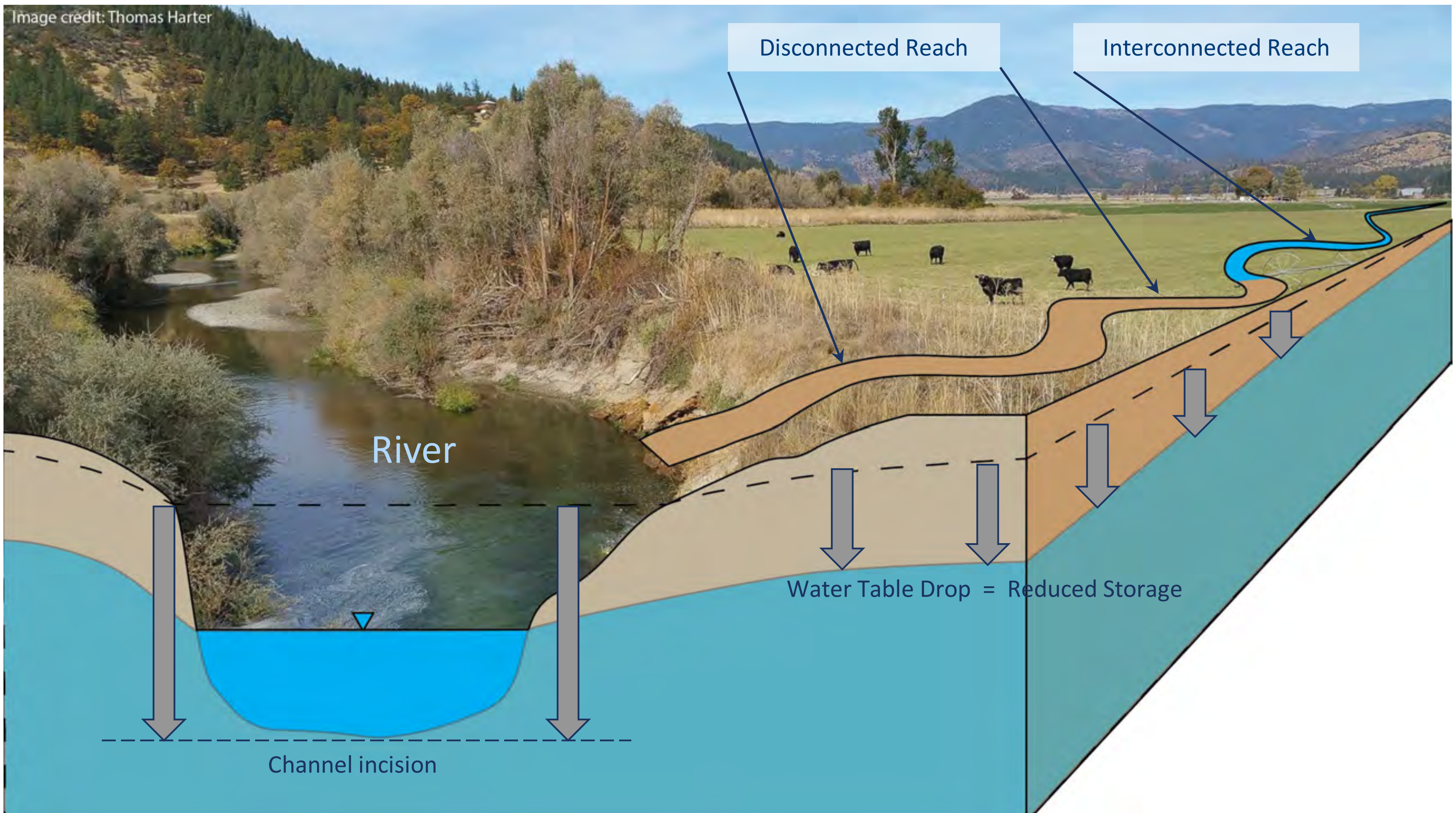

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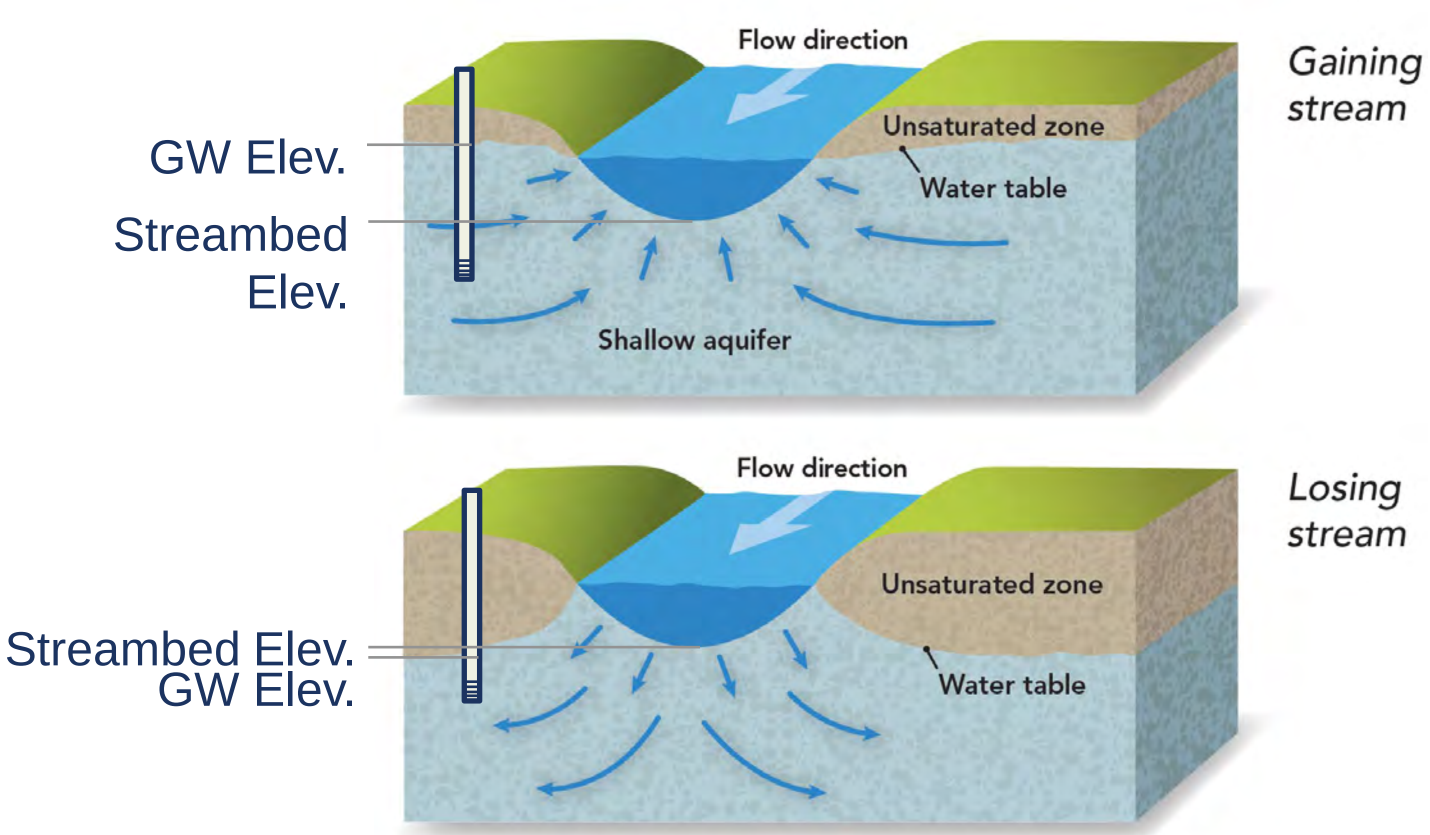
Questions on the physics of groundwater-surface water interaction?



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How are SW/GW interactions relevant to the GSP?

- § 354.28 (c)(6) Depletions of Interconnected Surface Water.

- The minimum threshold for depletions of interconnected surface water shall be the rate or volume of surface water depletions caused by groundwater use that has adverse impacts on beneficial uses of the surface water and may lead to undesirable results.

DRAFT

How are SW/GW interactions relevant to the GSP?

- The minimum threshold for depletions of interconnected surface water shall be
  - the **rate or volume**
  - of **surface water depletions** caused by **groundwater use**
  - that has **adverse impacts on beneficial uses** of the surface water
  - and may lead to **undesirable results**

This definition will determine*

*Based on the technical team's understanding at this time.

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How are SW/GW interactions relevant to the GSP?

- § 354.28 (c)(6) Depletions of Interconnected Surface Water. **(cont.)**
- The minimum threshold established for depletions of interconnected surface water shall be supported by the following:
  - (A) The location, quantity, and timing of depletions of interconnected surface water.
  - (B) A description of the groundwater and surface water model used to quantify surface water depletion. …

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SW/GW interactions discussion topics

- Possibly tailor in-stream flow studies to local conditions
  - Correlating flow conditions with data from spawning surveys data or juvenile surveys
- Possibly define measurable objectives as functional flows, rather than constant flow rate
- Relate flow rates (at Hopland gage? elsewhere?) to tributary connectivity
  - Has this been done?
- **What does the model tell us about SW-GW interaction?**

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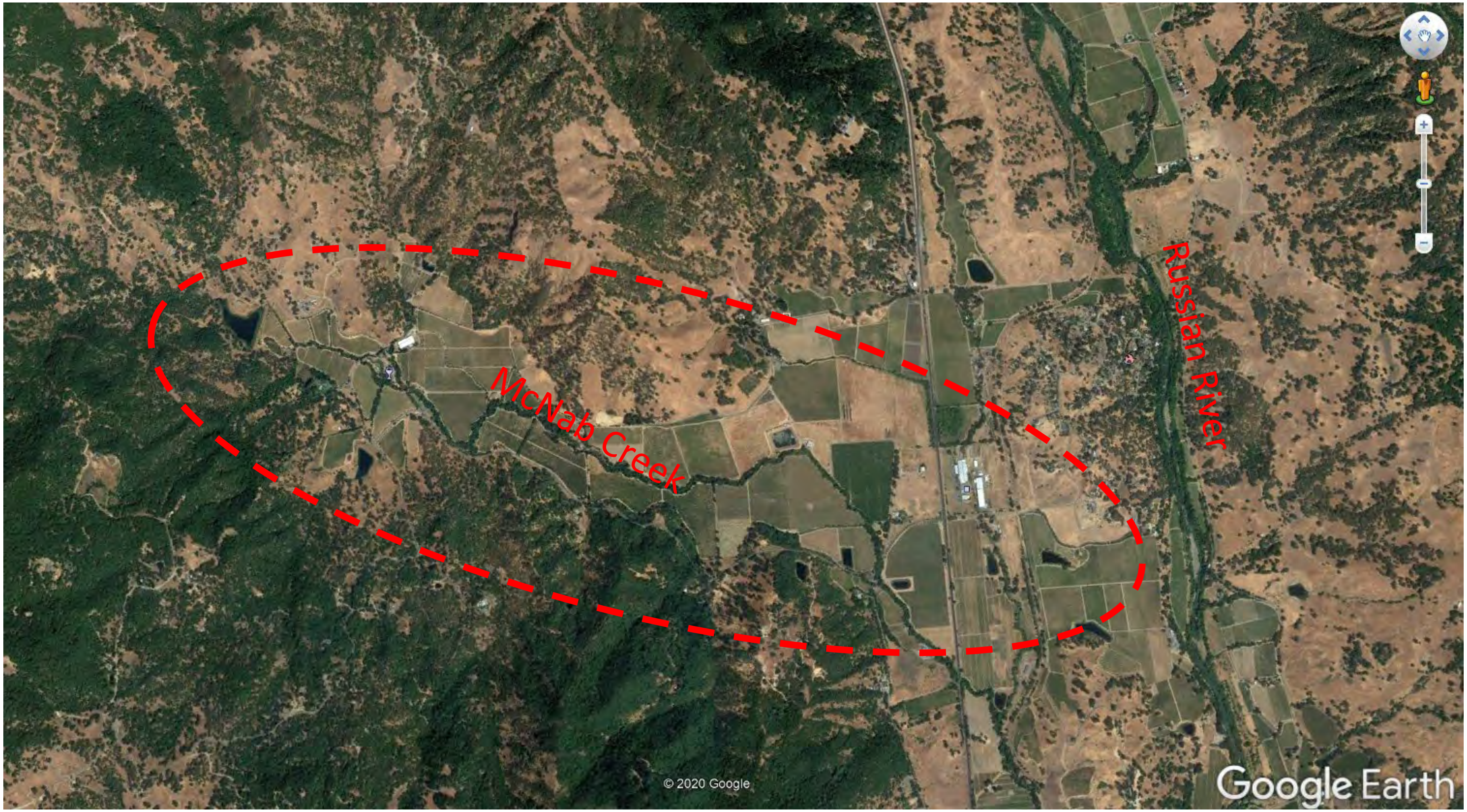
Example using historical data from McNab Creek and adjacent monitoring well

15-minute stream gage + monitoring well head data since 2012



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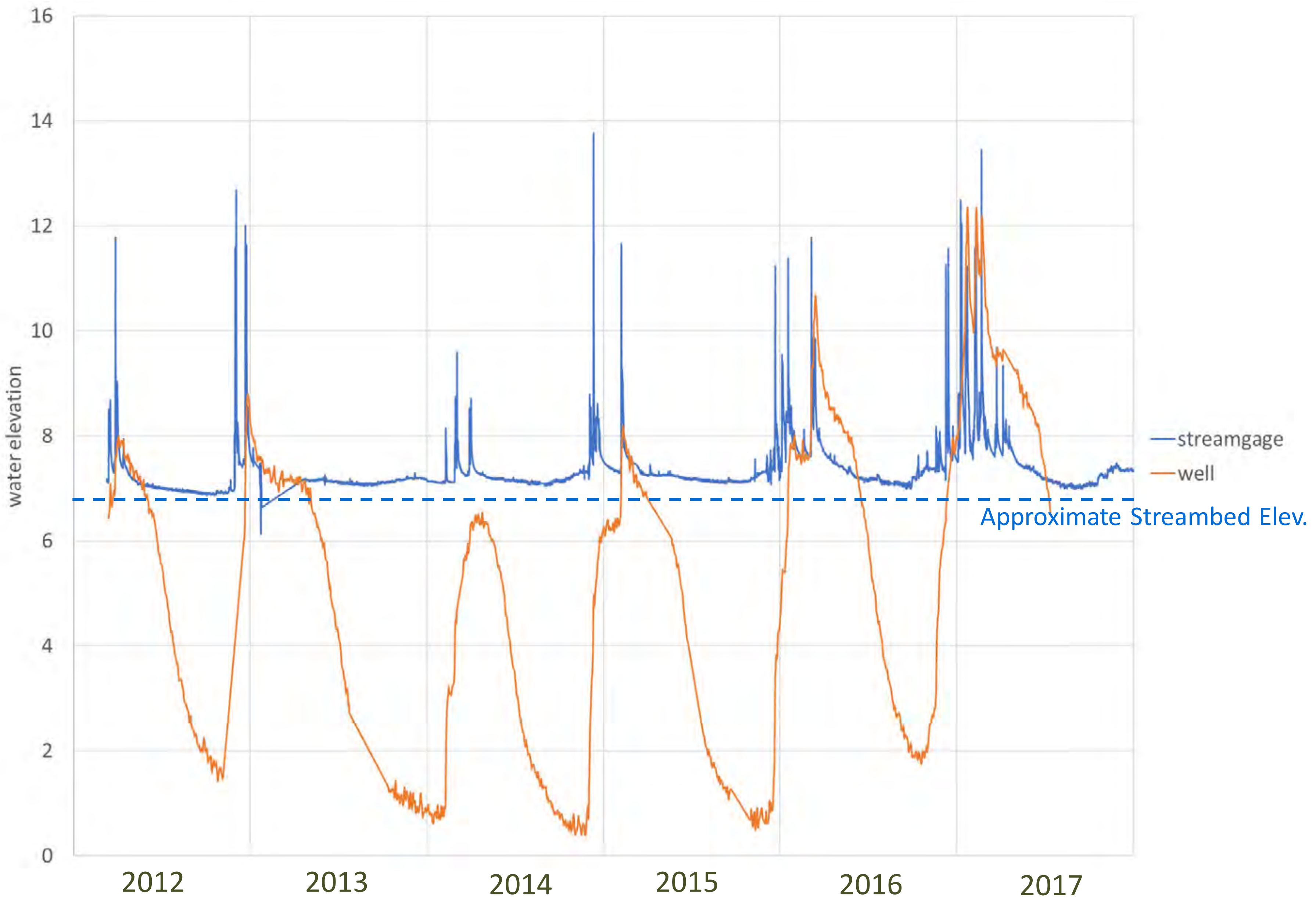

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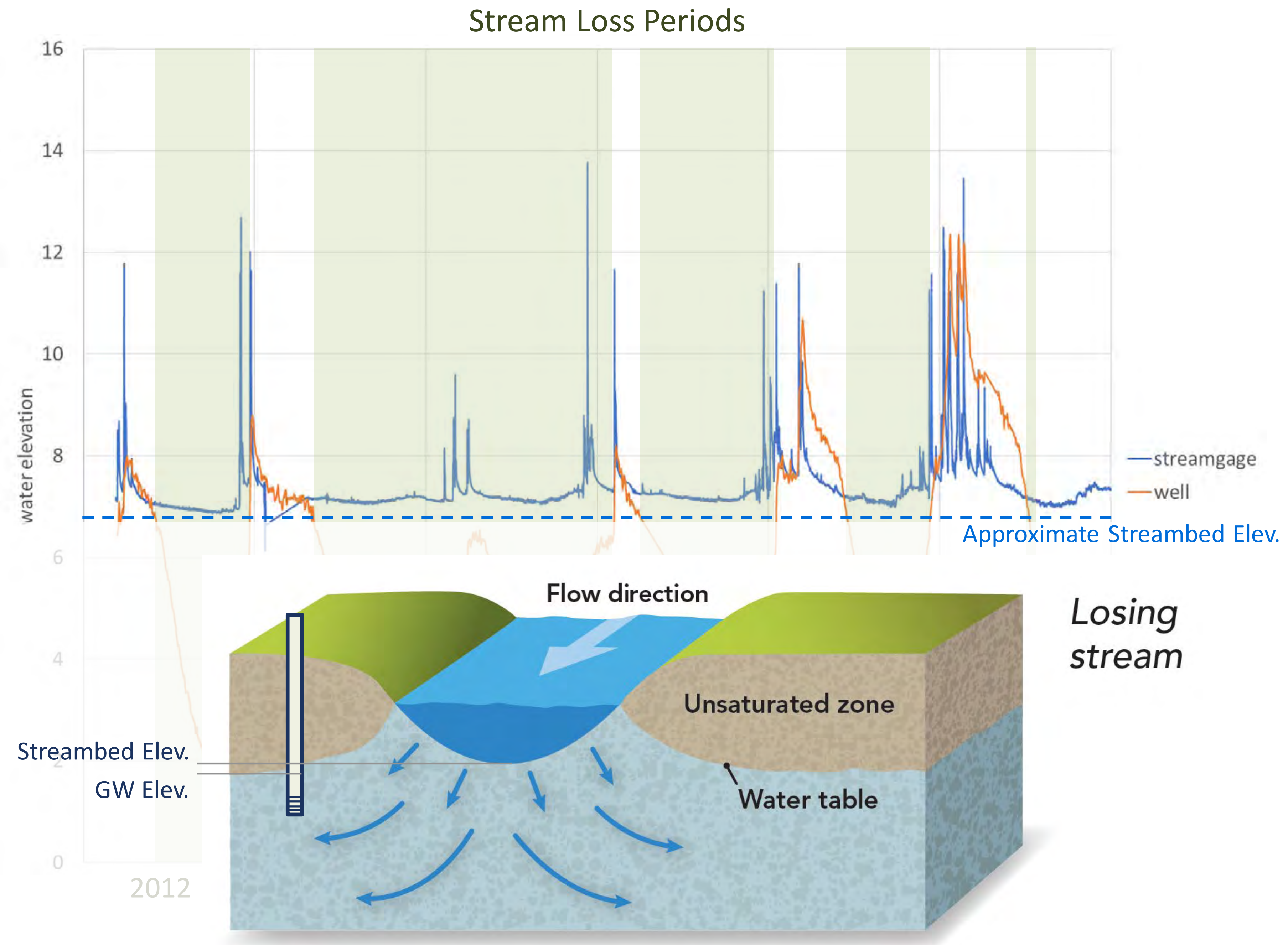

Stream Loss Periods
16
14
12
10
8
6
4
2
0
water elevation
2012
streamgage
well
Approximate Streambed Elev.
Flow direction
Losing stream
Unsaturated zone
Water table
Streambed Elev.
GW Elev.

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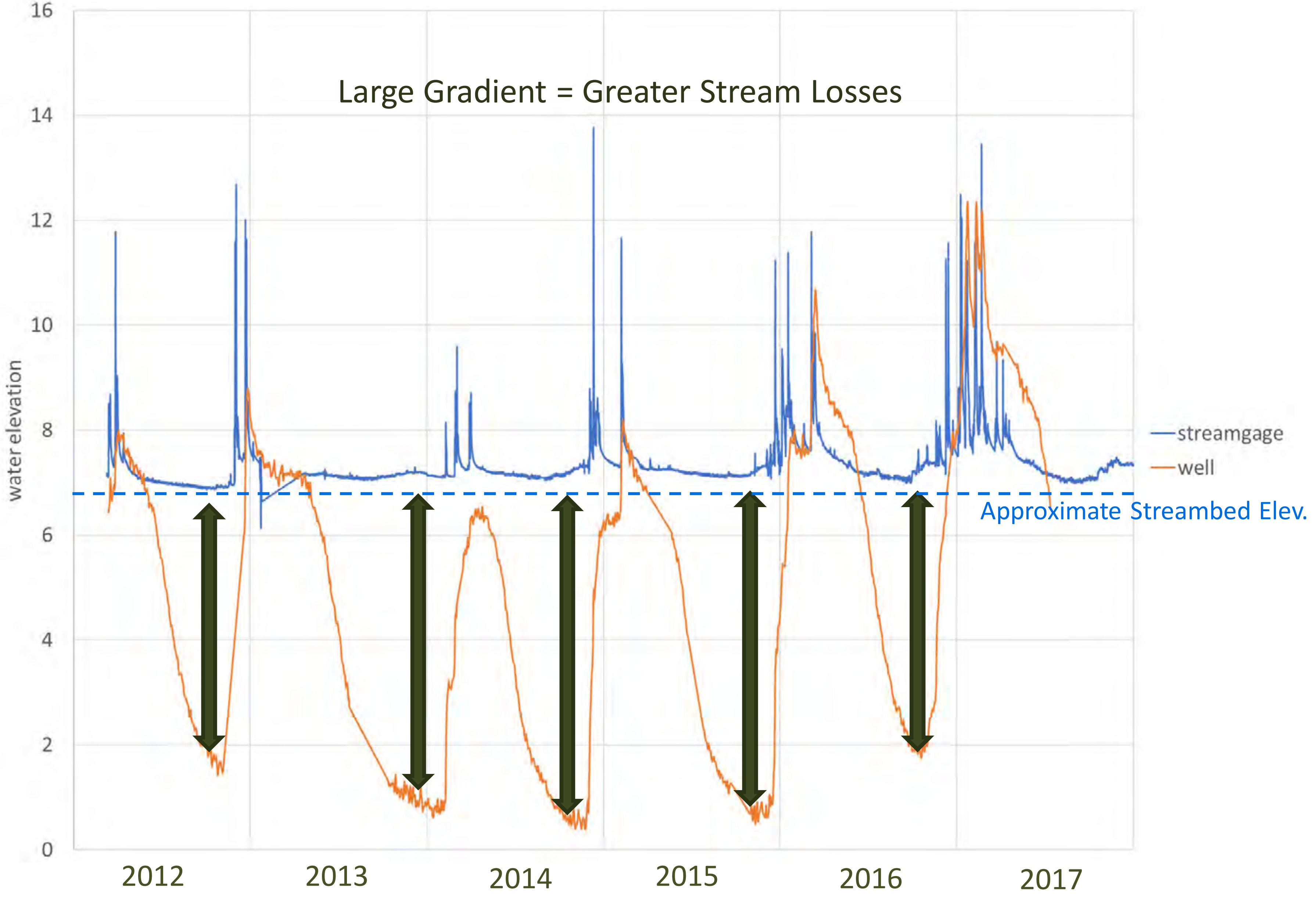
Magnitude and direction of gradient affects loss/gain volumes



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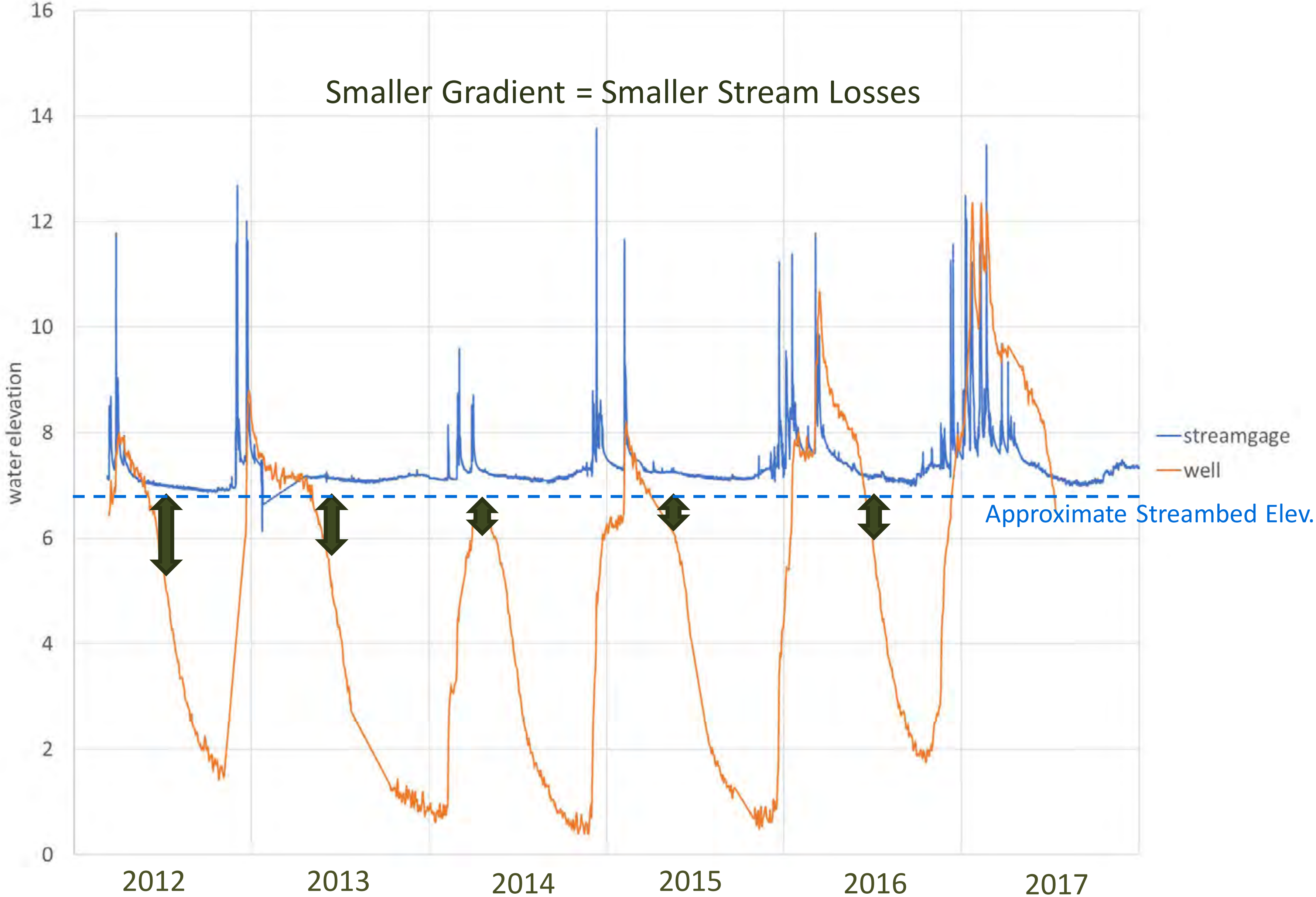

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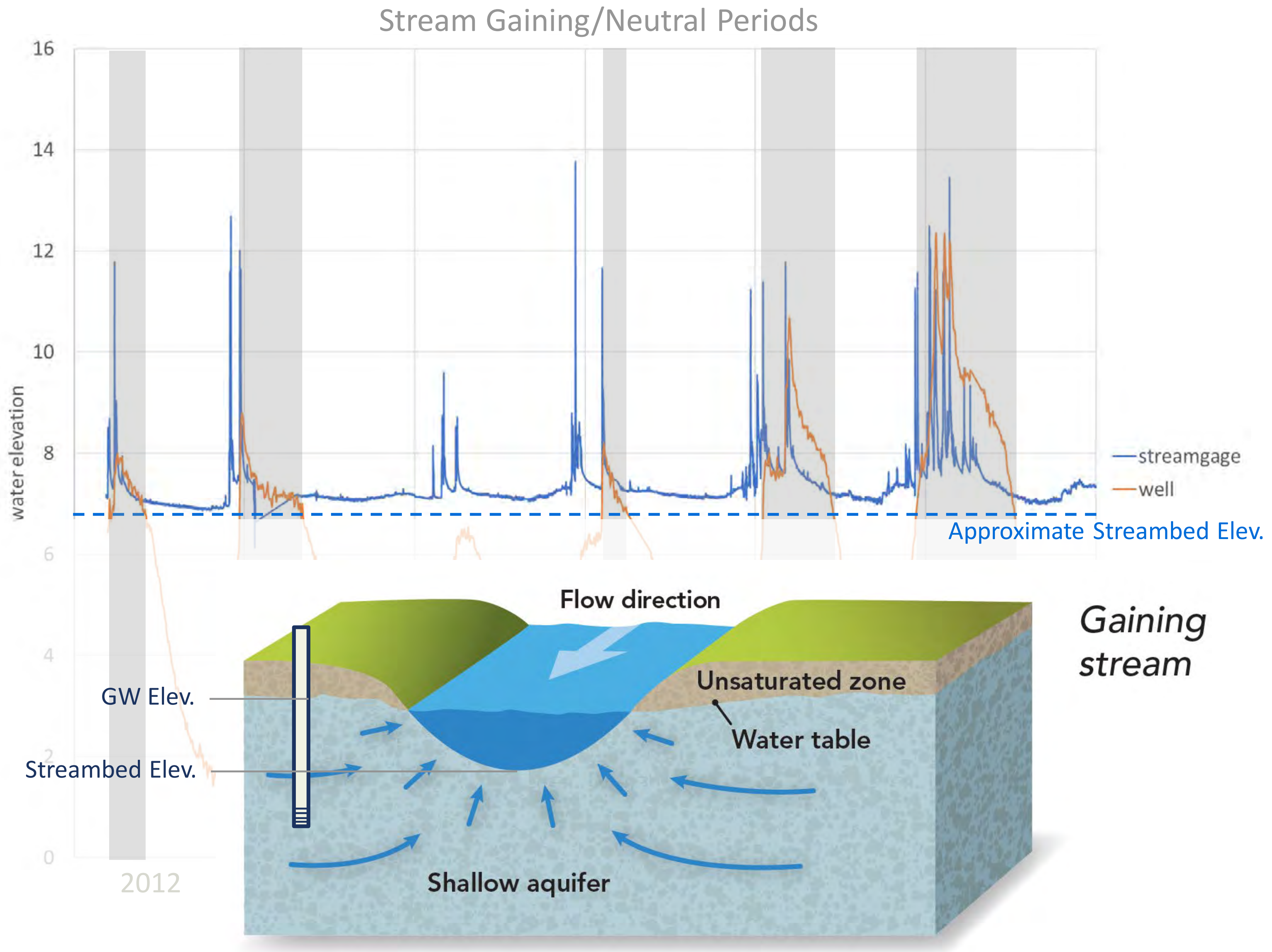
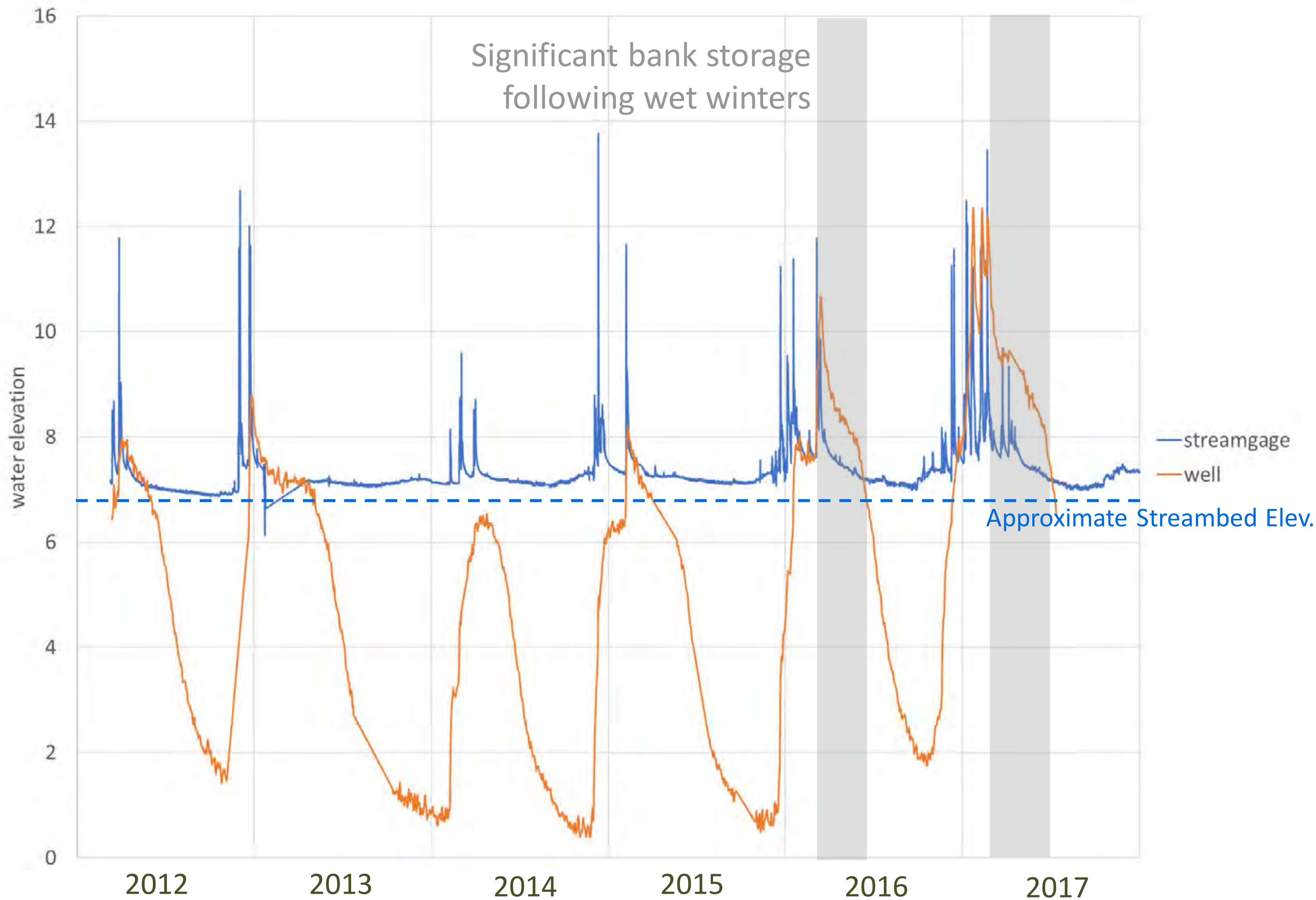


Stream Gaining/Neutral Periods
16
14
12
10
8
6
4
2
0
water elevation
2012
streamgage
well
Approximate Streambed Elev.
GW Elev.
Streambed Elev.
Flow direction
Unsaturated zone
Water table
Shallow aquifer
Gaining stream

DRAFT

Magnitude and direction of gradient affects loss/gain volumes



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Key Tasks

- Get informed on all aspects of SW beneficial uses
- Options for defining:
  - Measurable Objectives
    - for stream discharge/depletion and GDEs
    - “healthy” basin condition
  - Undesirable Results
    - “Significant and unreasonable” depletion of surface water
  - Minimum Thresholds→ avoid undesirable results
  - **What are the key questions that will help define the above?**

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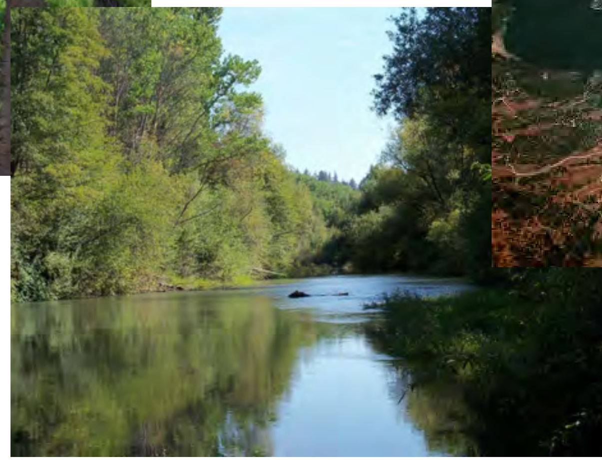
QUESTIONS ON SW-GW INTERACTION?

LARRY WALKER ASSOCIATES

Science. Policy. Solutions.

DRAFT



SUSTAINABLE MANAGEMENT CRITERIA – SUBSIDENCE

Subsidence of the land surface is an *undesirable result for SGMA*

- Lowering groundwater levels
- Reduction in storage
- Seawater intrusion
- Degraded water quality
- Land subsidence
- Surface water depletion

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DRAFT

Subsidence data available for Mendocino Co.

InSAR satellite-derived subsidence data product is the only known dataset for Mendocino Co. to use for GSPs

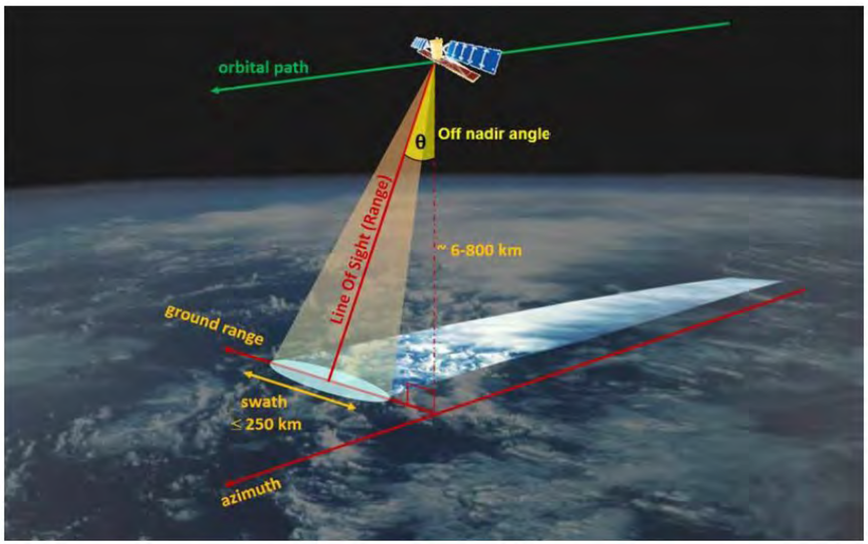
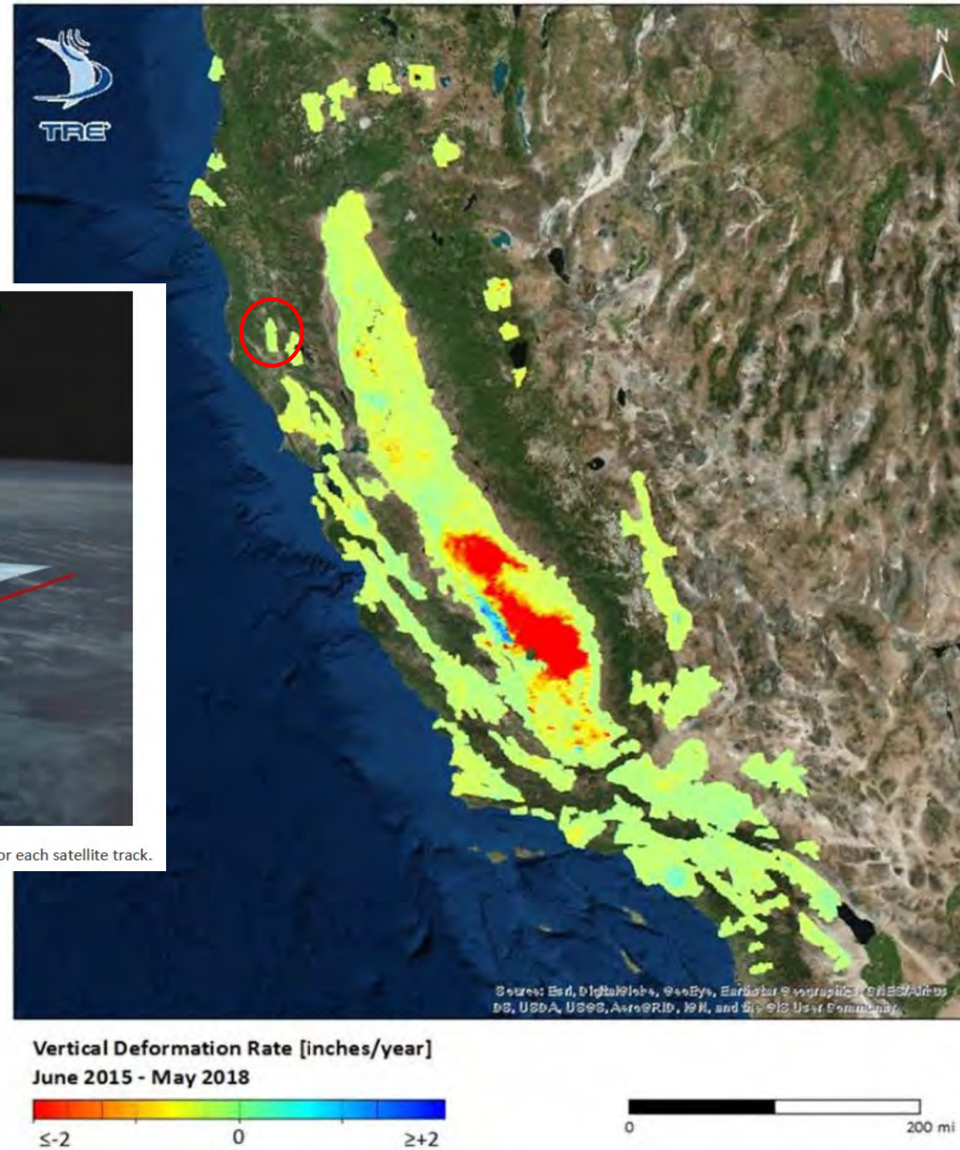


Figure 4: Schematic of the SAR satellites acquisition geometry. The Line of Sight (LOS) θ angle is different for each satellite track.

Data available from mid 2015-2018

Additional 2018-2019 data expected by April 2019



InSAR land surveying and mapping services in support of the DWR SGMA program
Technical Report - May 2019

Figure 13: Vertical deformation rate map over the AOI. The sMP are colour coded according to their annual deformation rate (inches/year) within the common period (June 2015 – May 2018).

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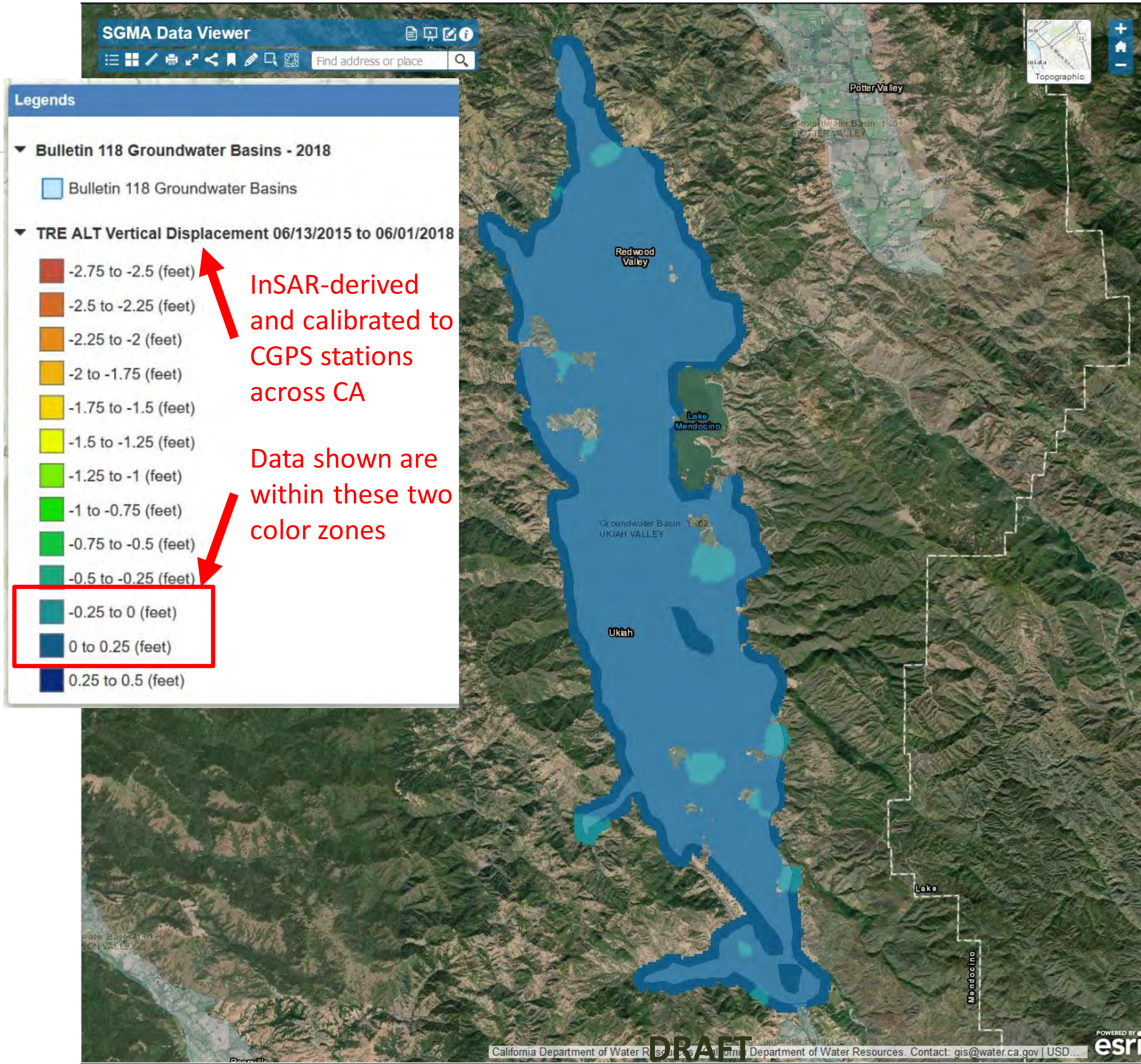
Subsidence data available for Mendocino Co.



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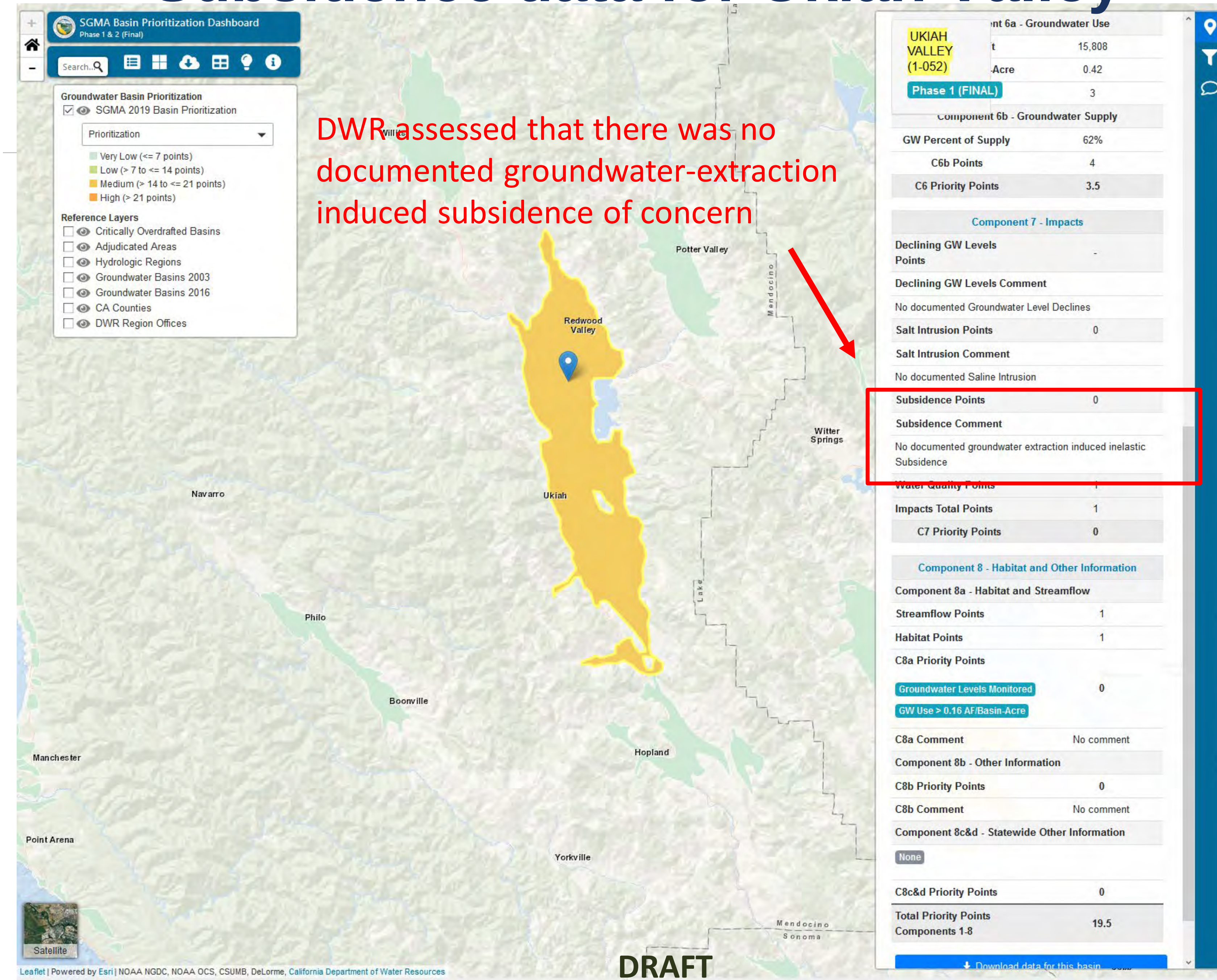
Subsidence data for Ukiah Valley

DWR assessed that there was no documented groundwater-extraction induced subsidence of concern



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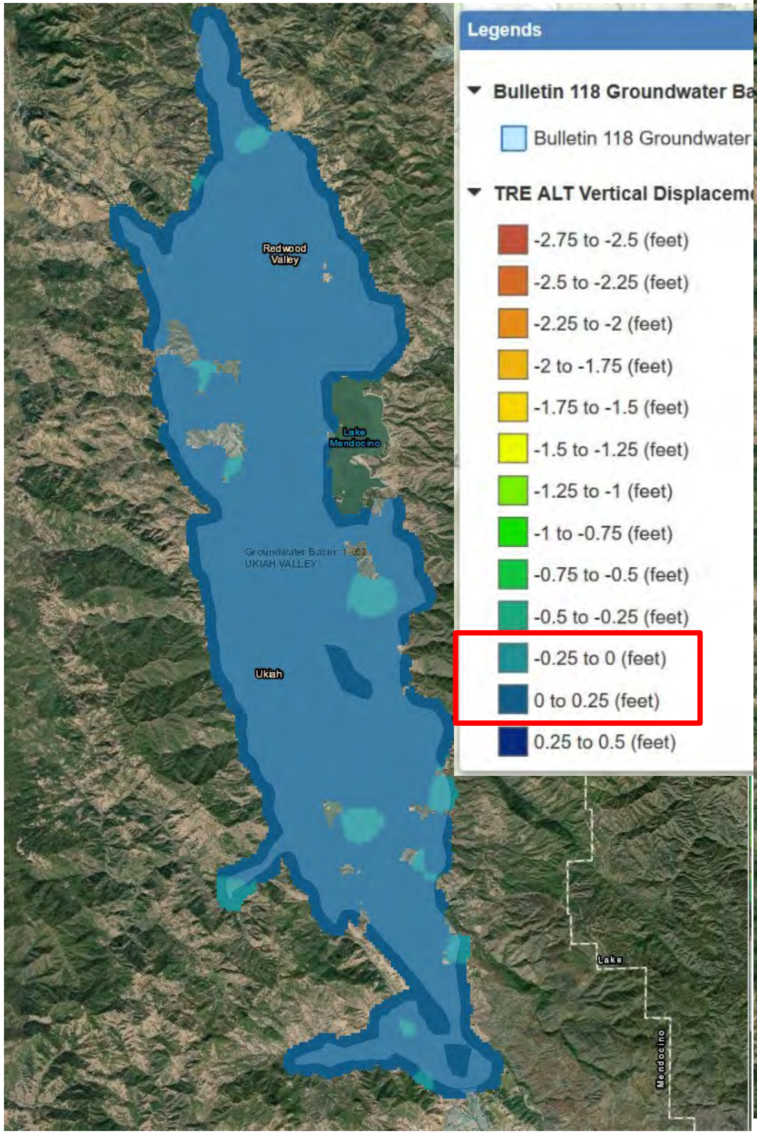
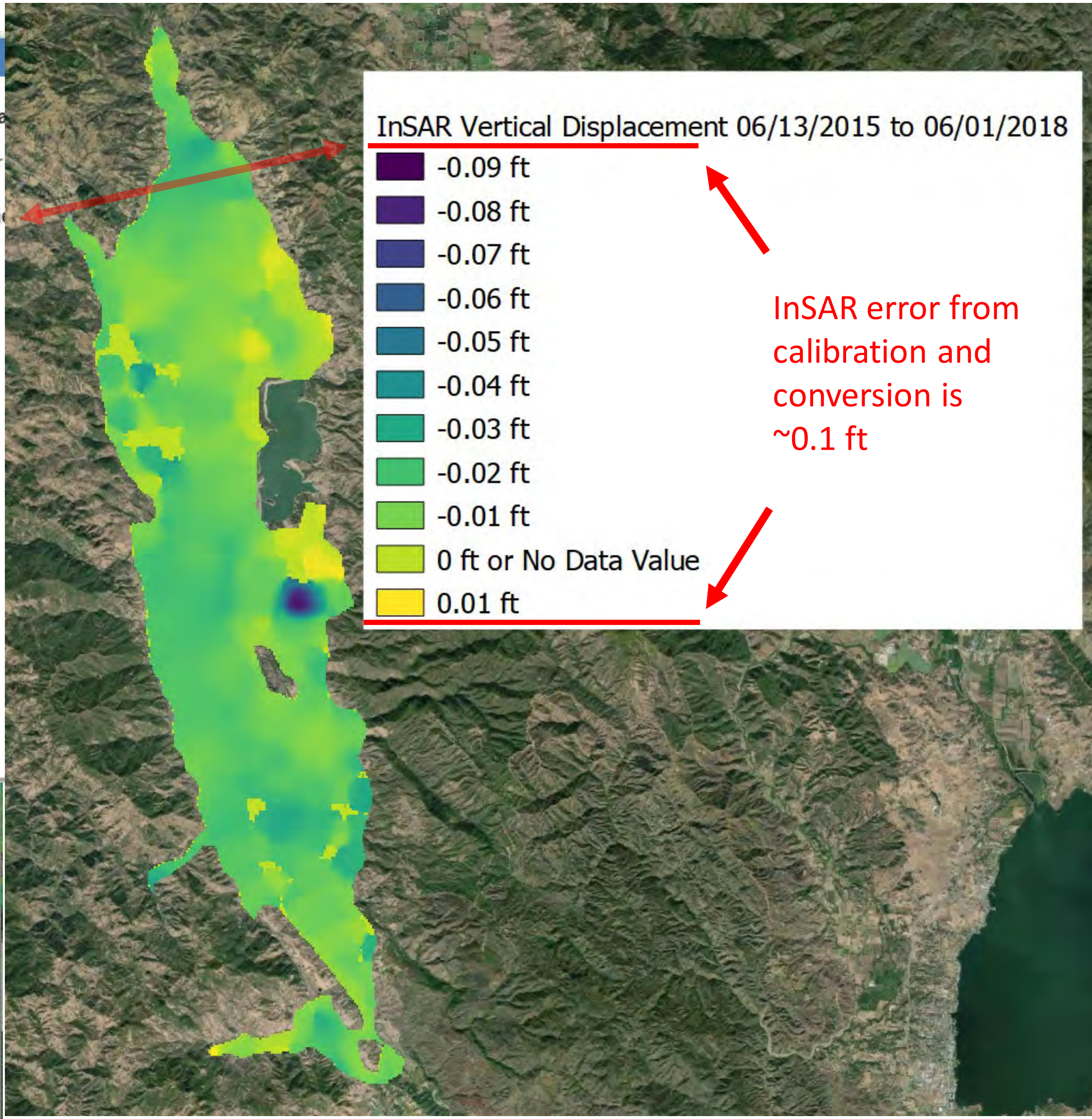
DRAFT

Subsidence data for Ukiah Valley 2015-2018





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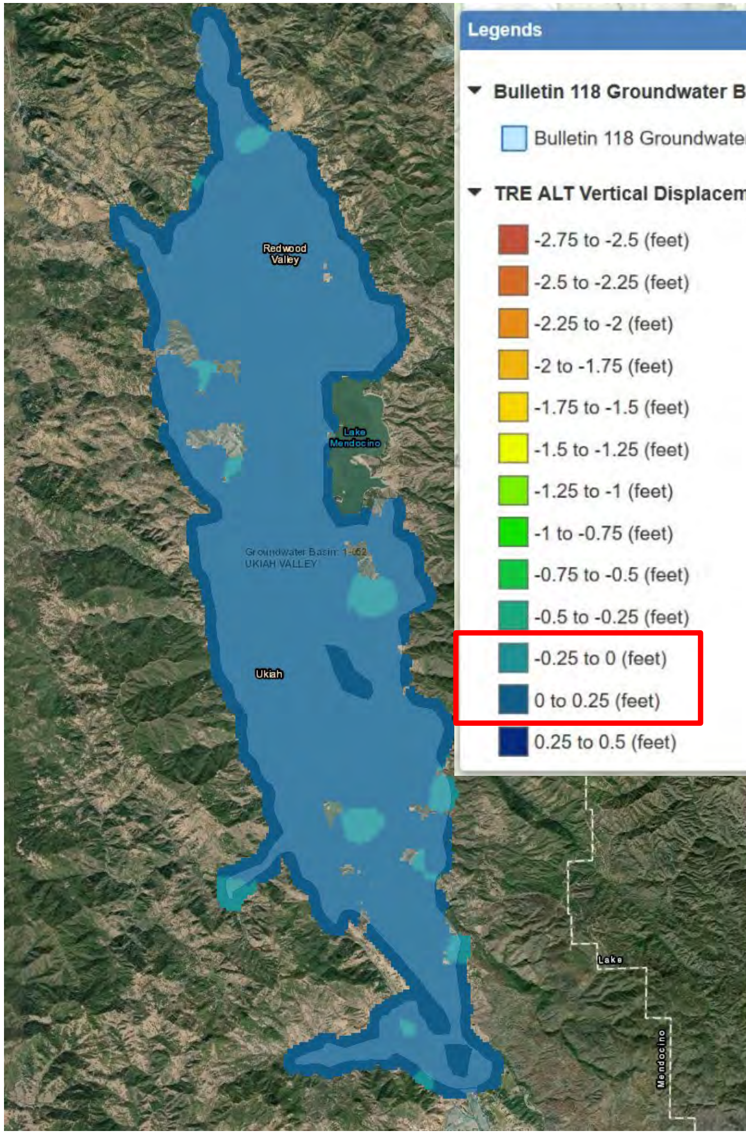
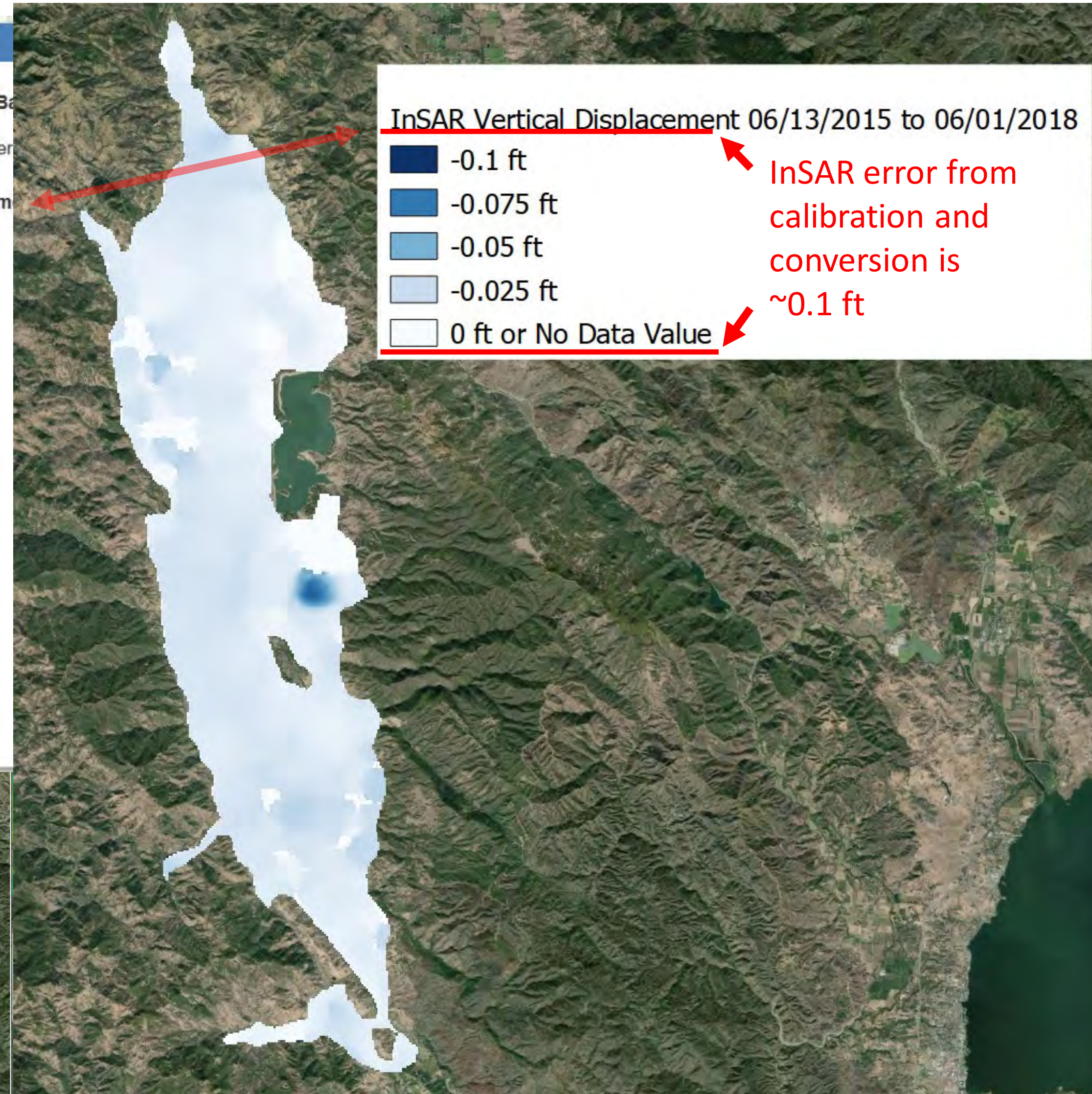




Data display largely noise considering the range of both the data and the error are equivalent

DRAFT

DRAFT

Questions?

Thank you!

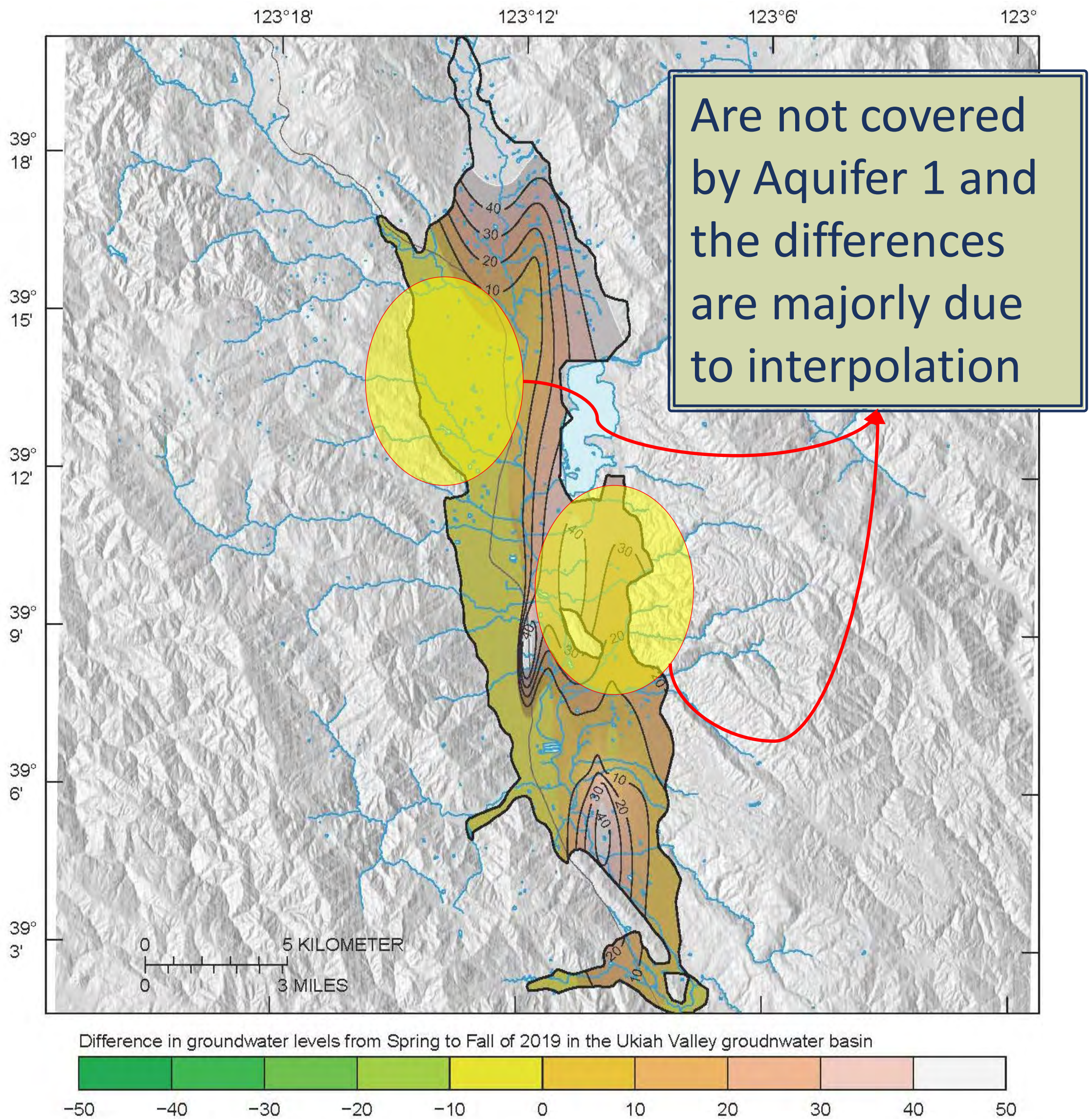
DRAFT

Seasonal Change in Groundwater Elevations

2019:

Spring Head-Fall Head

- Similar pattern were shown for 2017-2019.
- It seems west of the river and east of the river have different responses to the change in season. That change in season may be due to the difference in land use.
- North of Redwood Valley is very dependent on climate variability.



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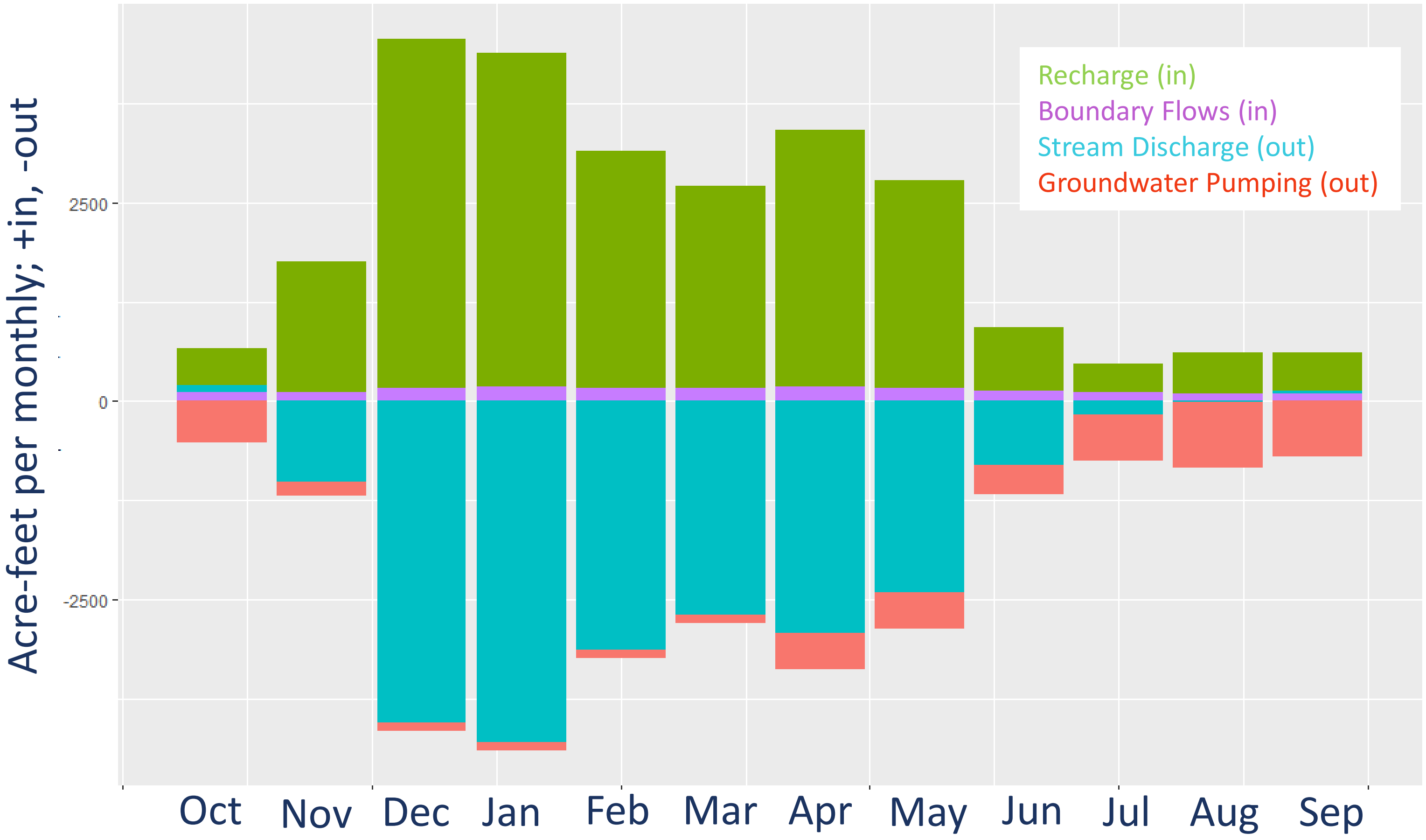
Calibration Results—Water Budget

Uncalibrated Monthly Groundwater Budget for a “Typical” Water Year (GSA Area)



DRAFT

Calibration Results—Water Budget

Calibrated Monthly Groundwater Budget for a “Typical” Water Year (GSA Area)