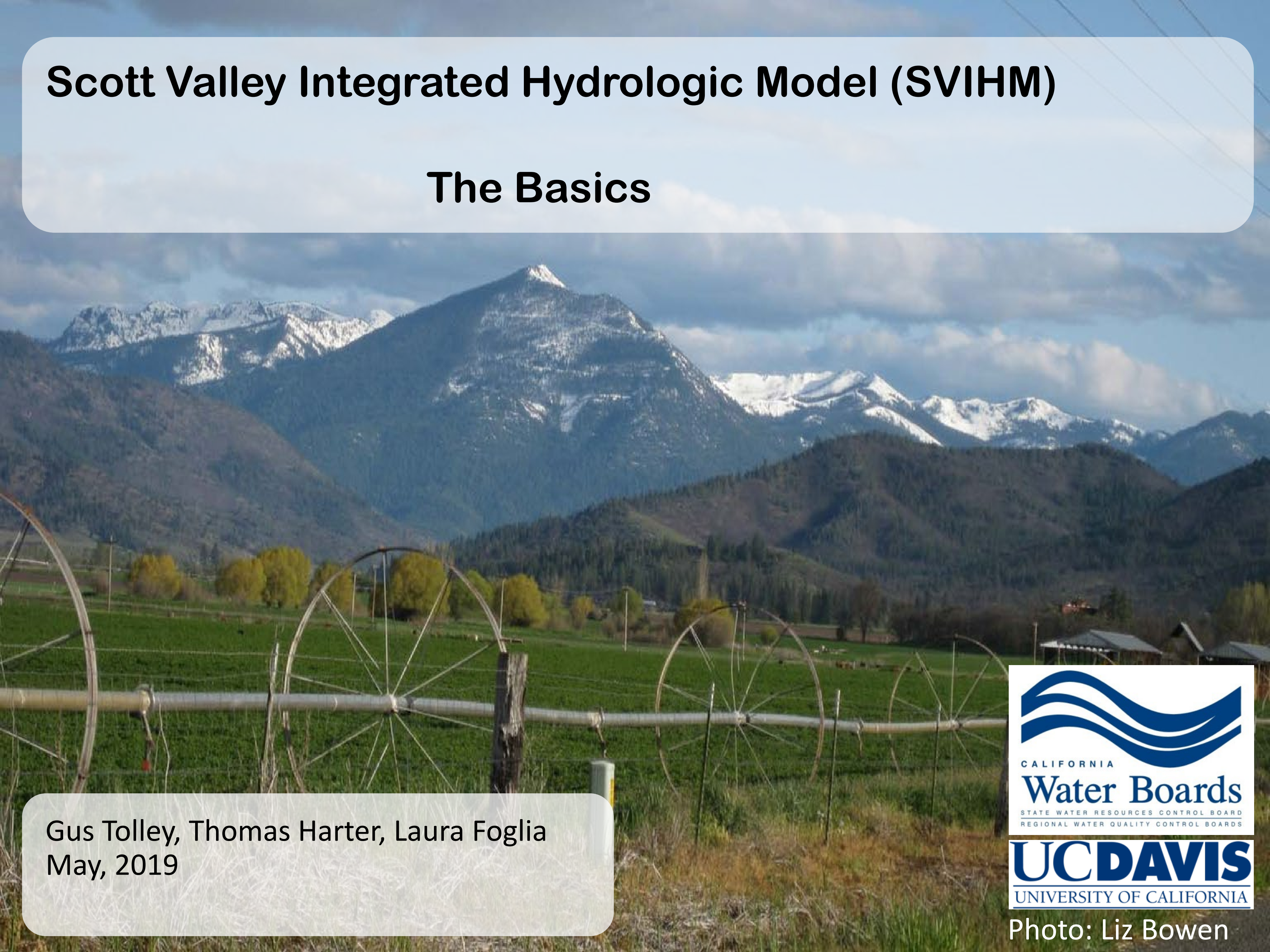
Scott Valley Integrated Hydrologic Model (SVIHM)

The Basics



Gus Tolley, Thomas Harter, Laura Foglia
May, 2019

CALIFORNIA Water Boards
STATE WATER RESOURCES CONTROL BOARD
REGIONAL WATER QUALITY CONTROL BOARDS

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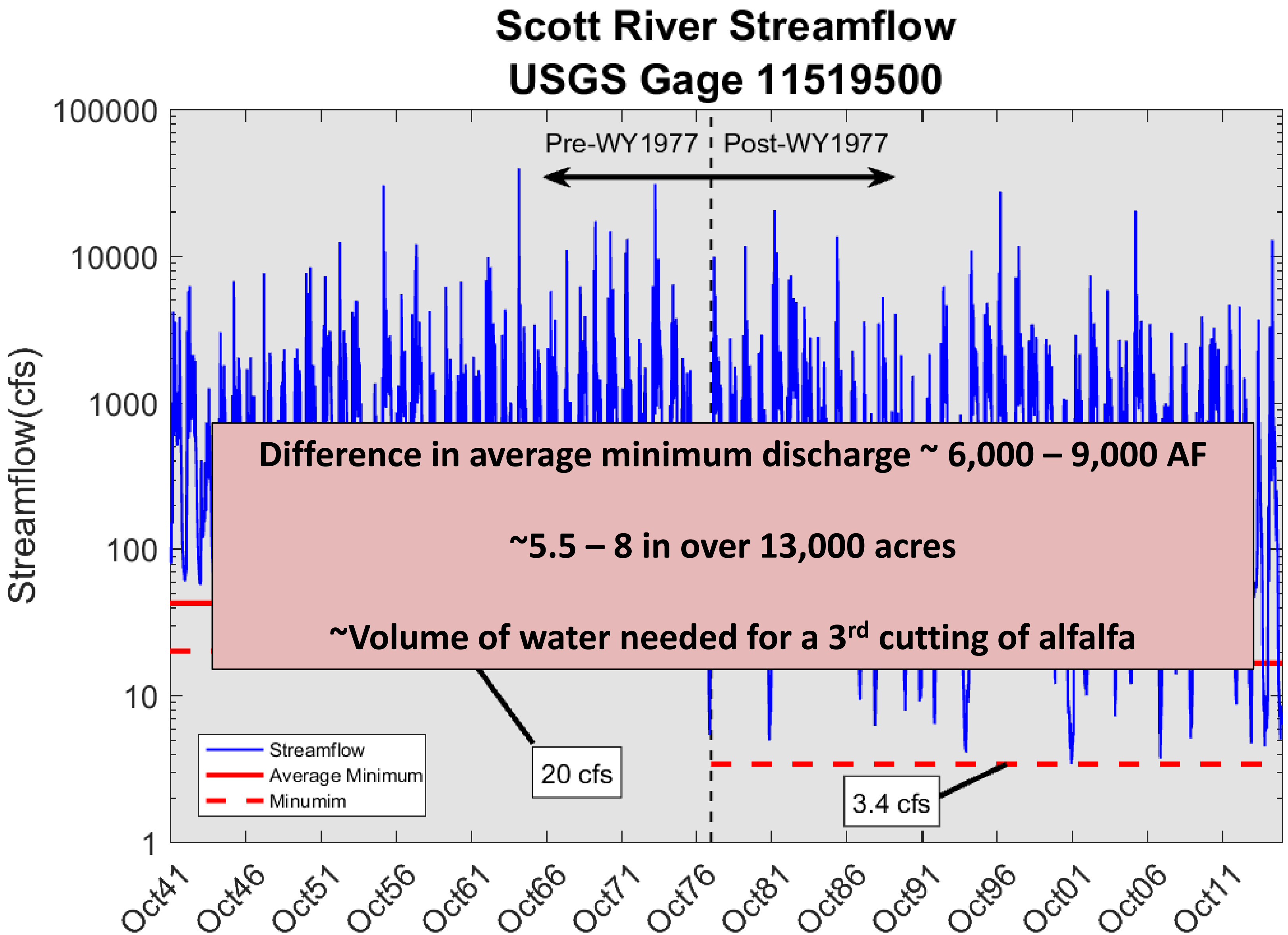
Photo: Liz Bowen

Motivation



Difference in average minimum discharge ~ 6,000 – 9,000 AF

~5.5 – 8 in over 13,000 acres

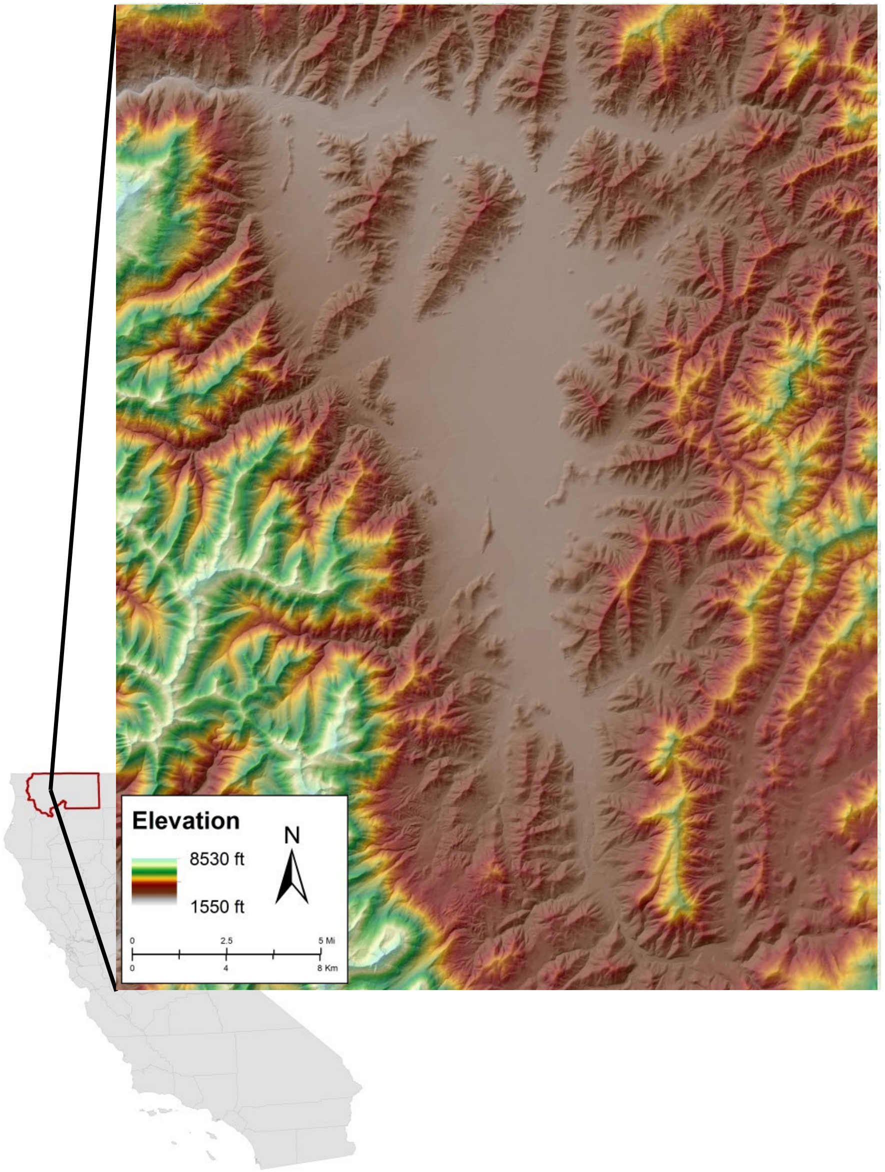
~Volume of water needed for a 3rd cutting of alfalfa

Motivation

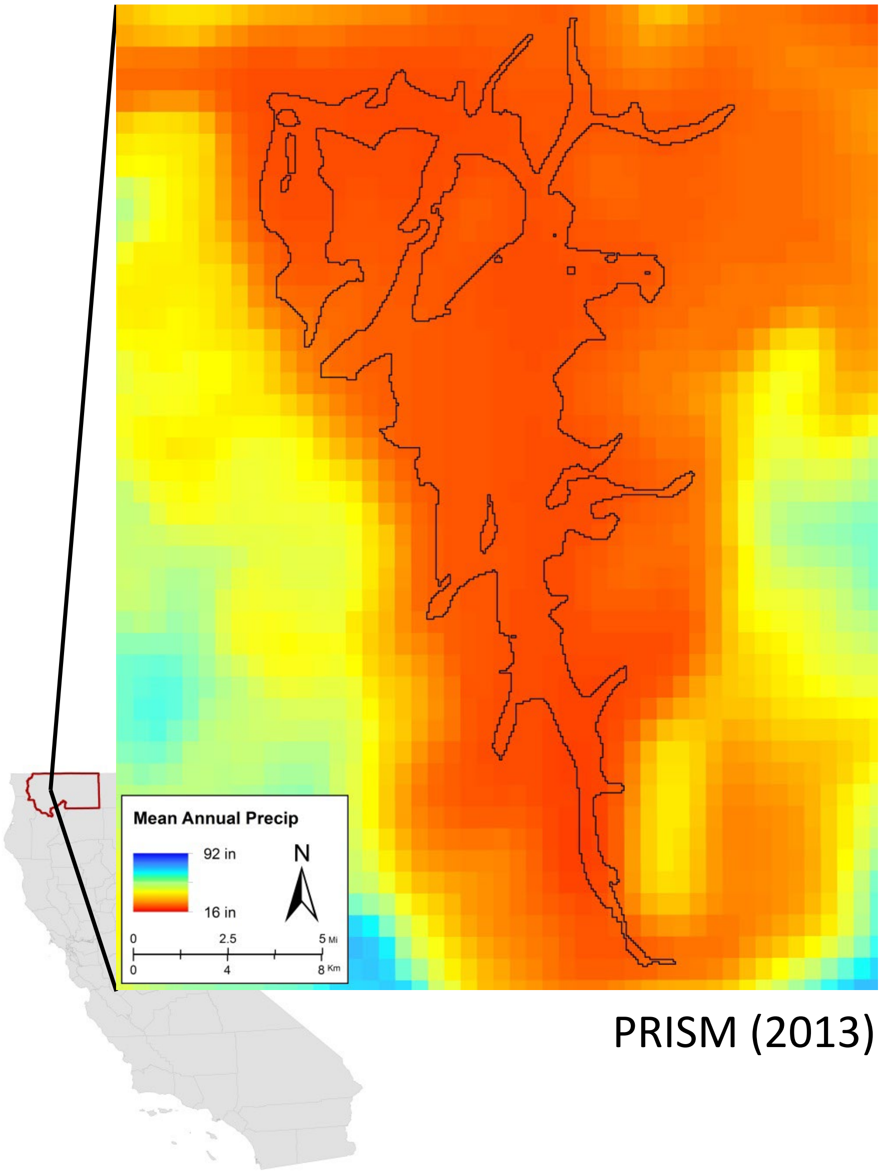
- Unforeseen consequences from move to more efficient irrigation:
  - Increased consumptive use in the valley (+ 50% for alfalfa)
  - Decreased groundwater recharge
  - Increased extractions from the aquifer
    - Streamflow depletion

- **Can we change management strategies in the basin to improve fish habitat while maintaining agricultural production in the valley?**

Study Area

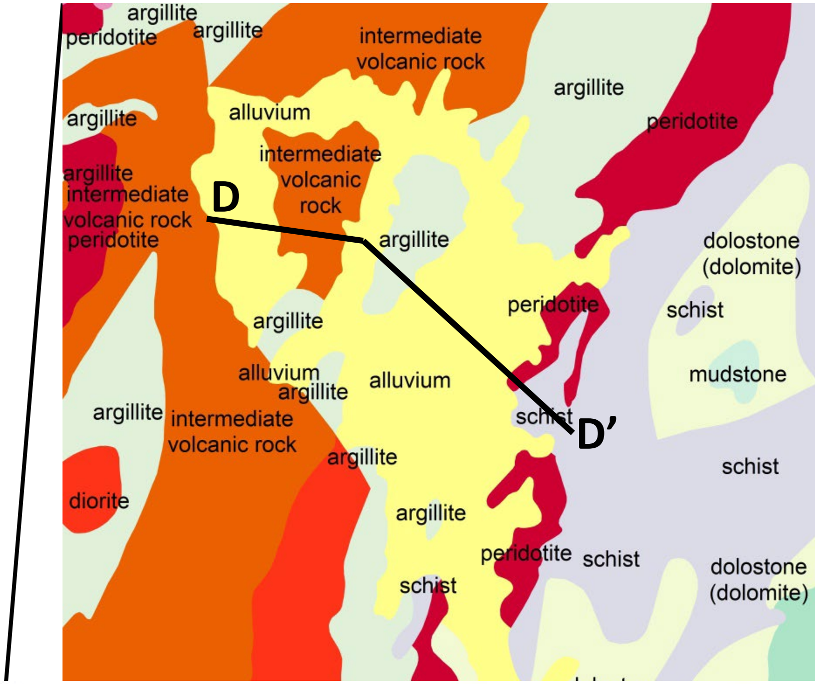


- Scott Valley
  - Watershed: 2,100 km^2 (800 mi^2)
    - Valley: 200 km^2 (77 mi^2 = 50k ac)

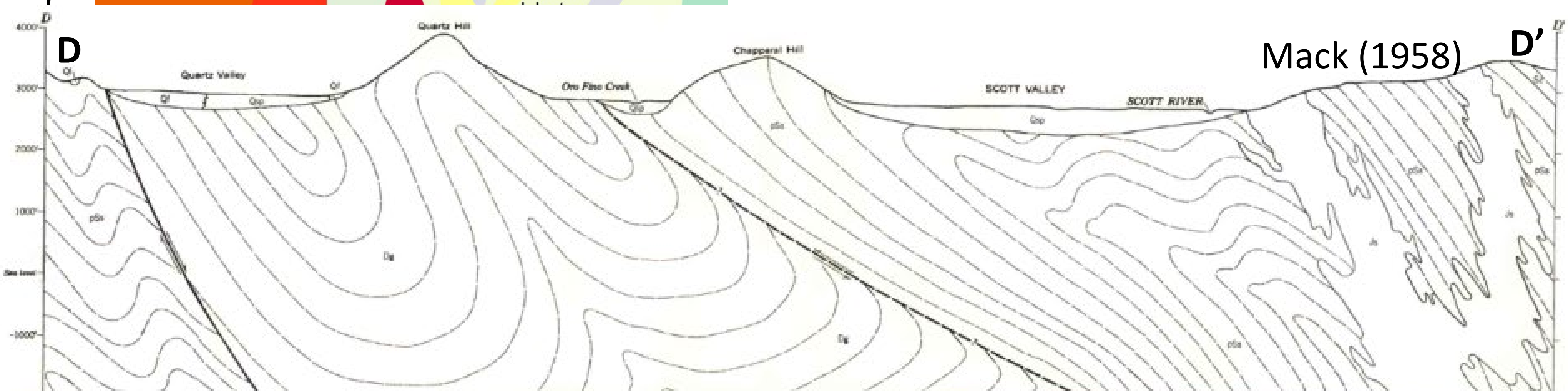


PRISM (2013)

- Scott Valley
  - Watershed: 2,100 km^2 (800 mi^2)
    - Valley: 200 km^2 (77 mi^2 = 50k ac)
  - Mediterranean Climate
    - Wet winters and dry summers

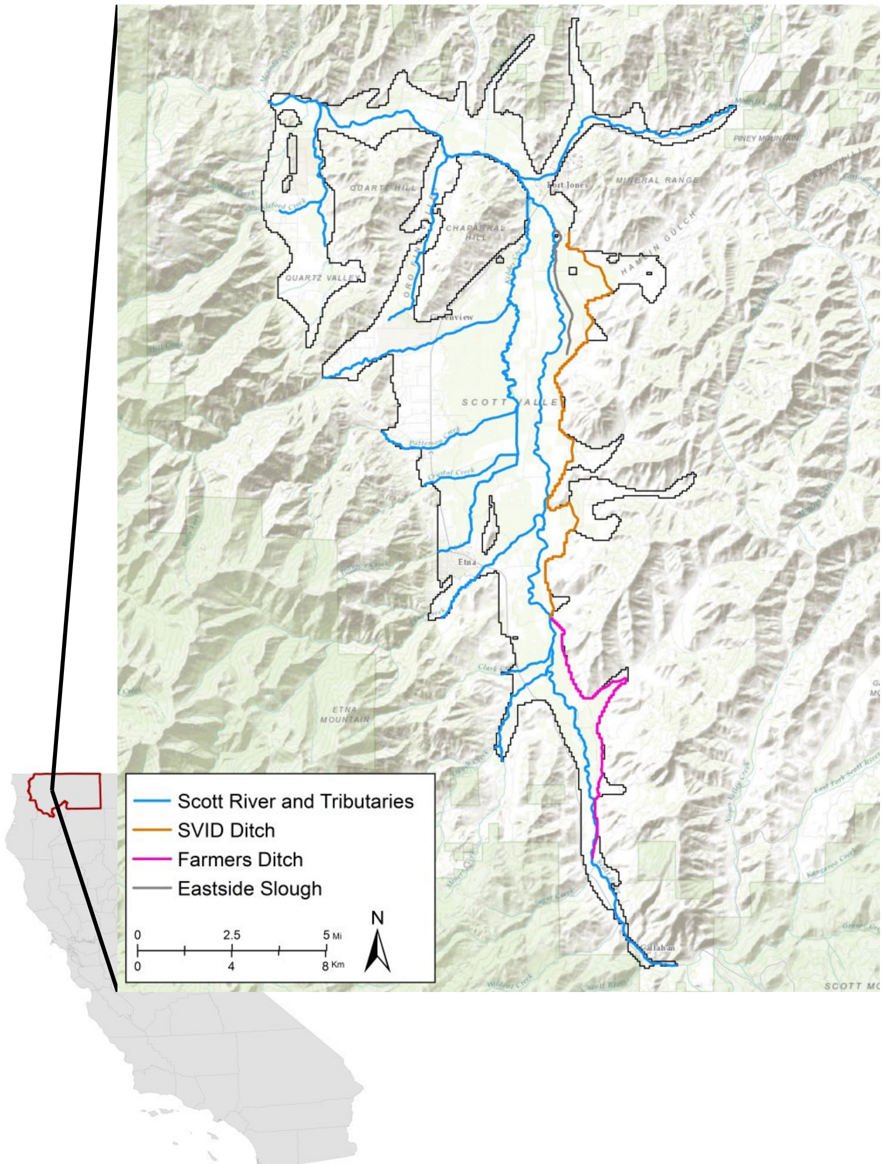


- Scott Valley
  - Watershed: 2,100 km^2 (800 mi^2)
    - Valley: 200 km^2 (77 mi^2 = 50k ac)
  - Mediterranean Climate
    - Wet winters and dry summers
  - "Bathtub" style sedimentary basin
    - Up to 76 m (250 ft) thick aquifer



DIAGRAMMATIC SECTION ILLUSTRATING STRUCTURE OF THE BEDROCK UNITS

Hydrology



- Scott Valley
  - Watershed: 2,100 km^2 (800 mi^2)
    - Valley: 200 km^2 (77 mi^2 = 50k ac)
  - Mediterranean Climate
    - Wet winters and dry summers
  - "Bathtub" style sedimentary basin
    - Up to 76 m (250 ft) thick aquifer
  - Scott River flows from south to north
    - 12 major tributary streams
    - 2 major diversion ditches

Outline

- Motivation and study area overview
- Conceptual outline and description of Scott Valley Integrated Hydrologic Model (SVIHM)
- Sensitivity analysis and calibration results
- Uncertainty analysis
- Future work

...all models are wrong...

...the ability to devise simple but evocative models is the signature of the great scientist...

...overparameterization is often the mark of mediocrity.

[Box, 1976]

- **All models are wrong, but some are useful.**
- **Principle of parsimony (KISS)**

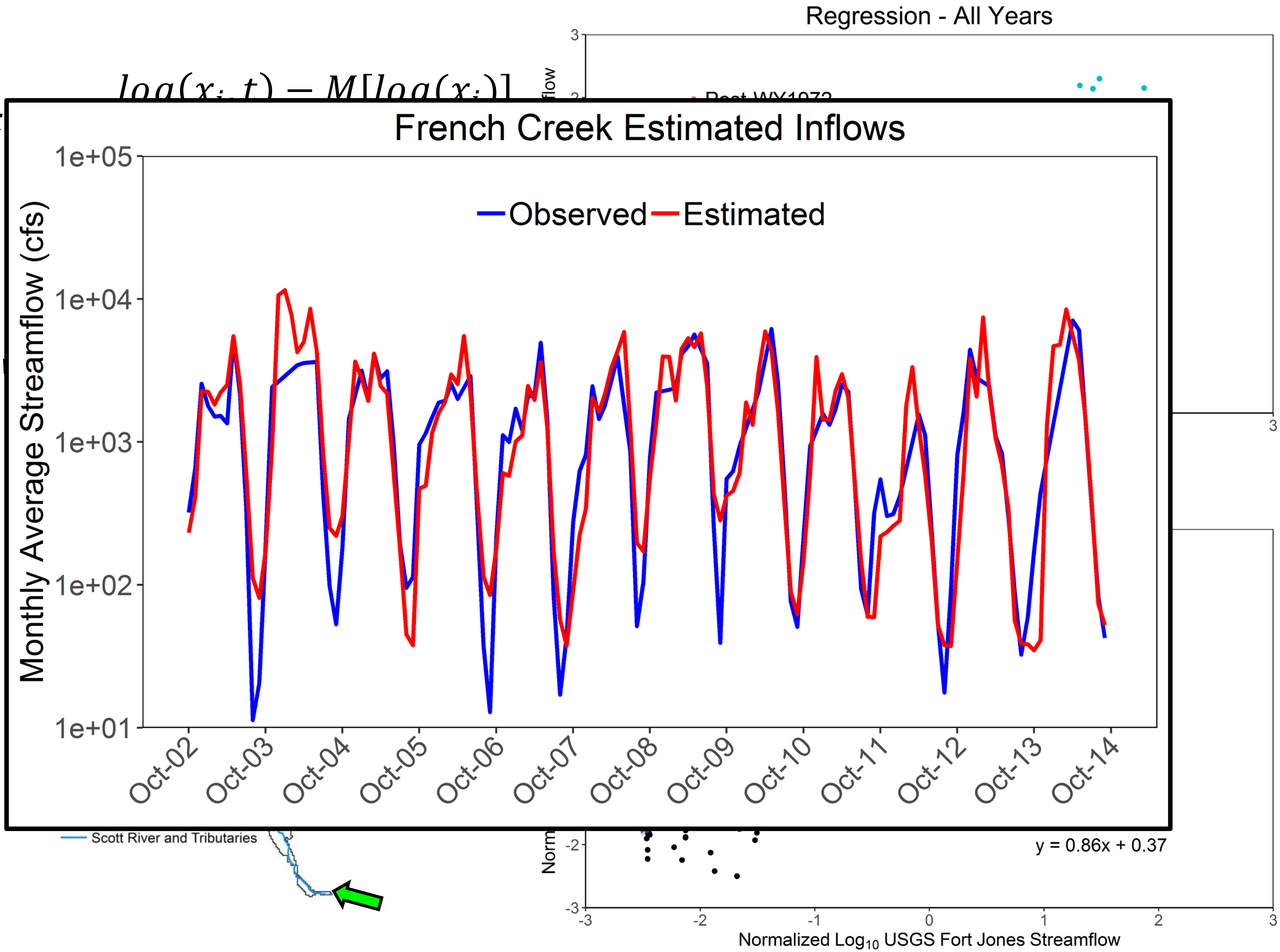
Conceptual Outline of SVIHM

Upper Watershed Model

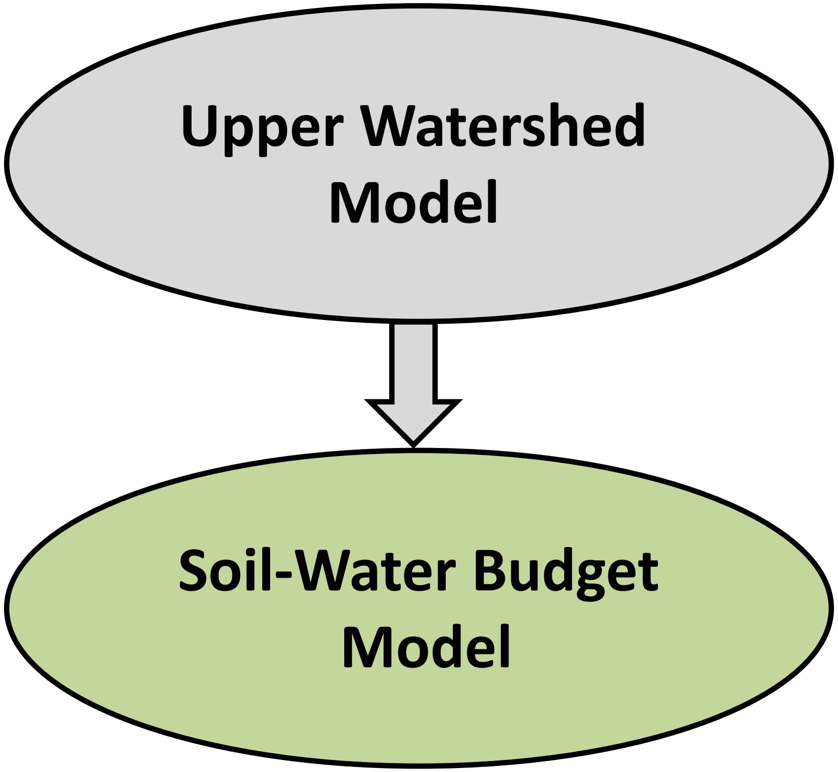
Streamflow entering Scott Valley
(Regression model)

Upper Watershed Model

$$Norm(x \quad log(x_i,t) - M[log(x_i)]$$



Conceptual Outline of SVIHM

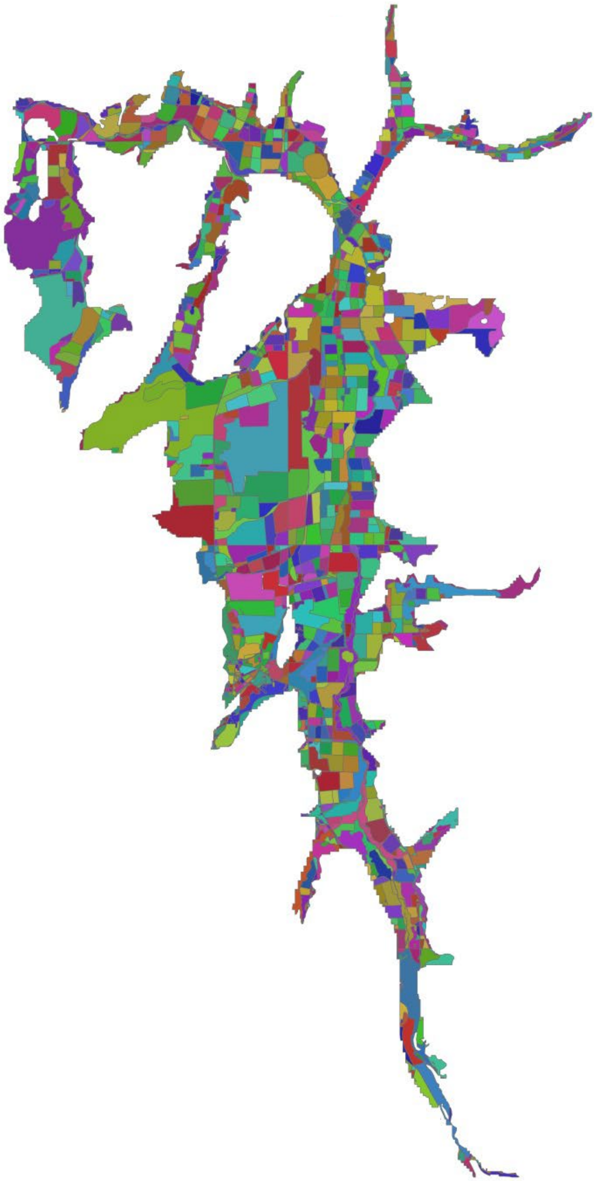


Streamflow entering Scott Valley (Regression model)

Recharge and pumping within the valley (Tipping bucket model)

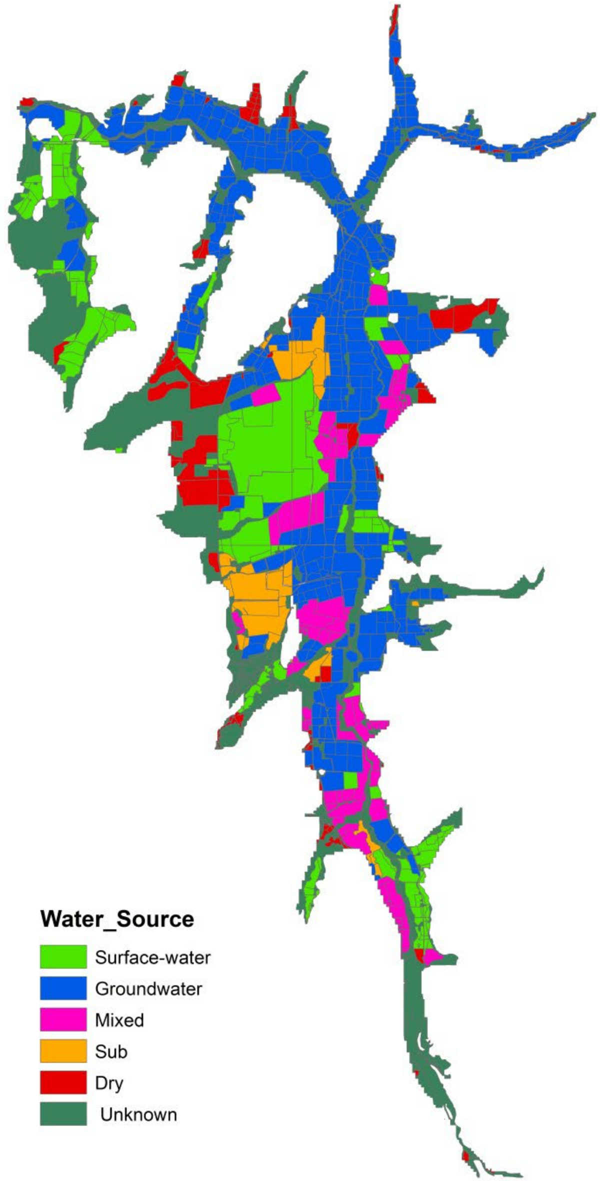
Soil-Water Budget Model

- Calculates daily water fluxes at field-scale



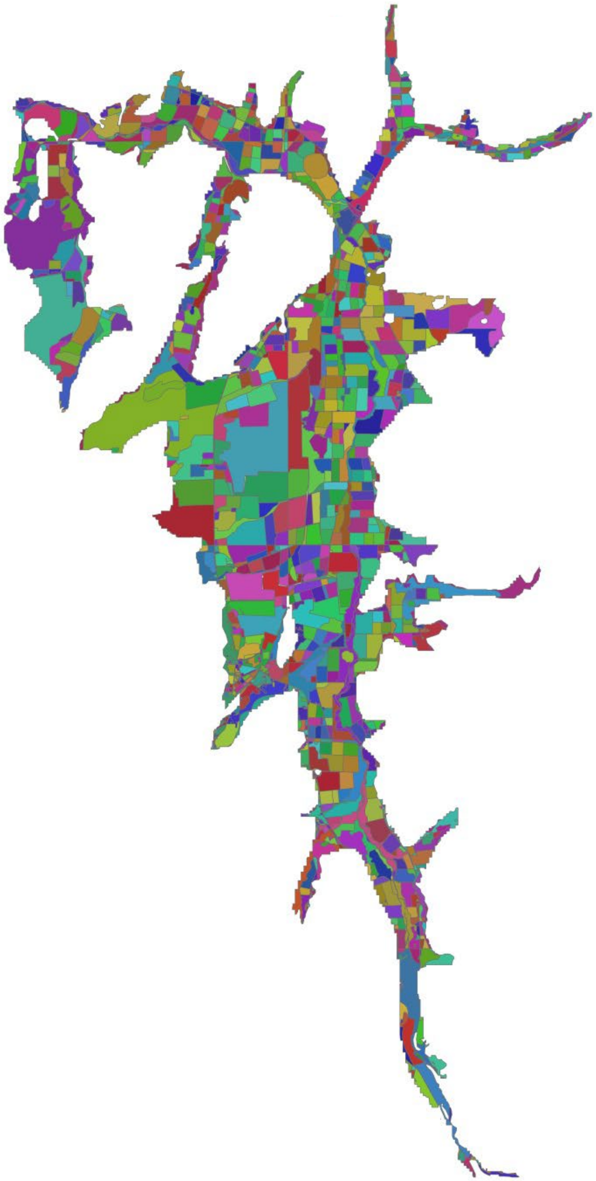
Soil-Water Budget Model

- Calculates daily water fluxes at field-scale
- Input data
  - Landuse (transient)
  - Soil properties
  - Irrigation type (transient)
  - Water source
  - Potential ET
  - Crop Coefficients (Kc)
  - Rooting depth
  - Precipitation
  - Streamflow



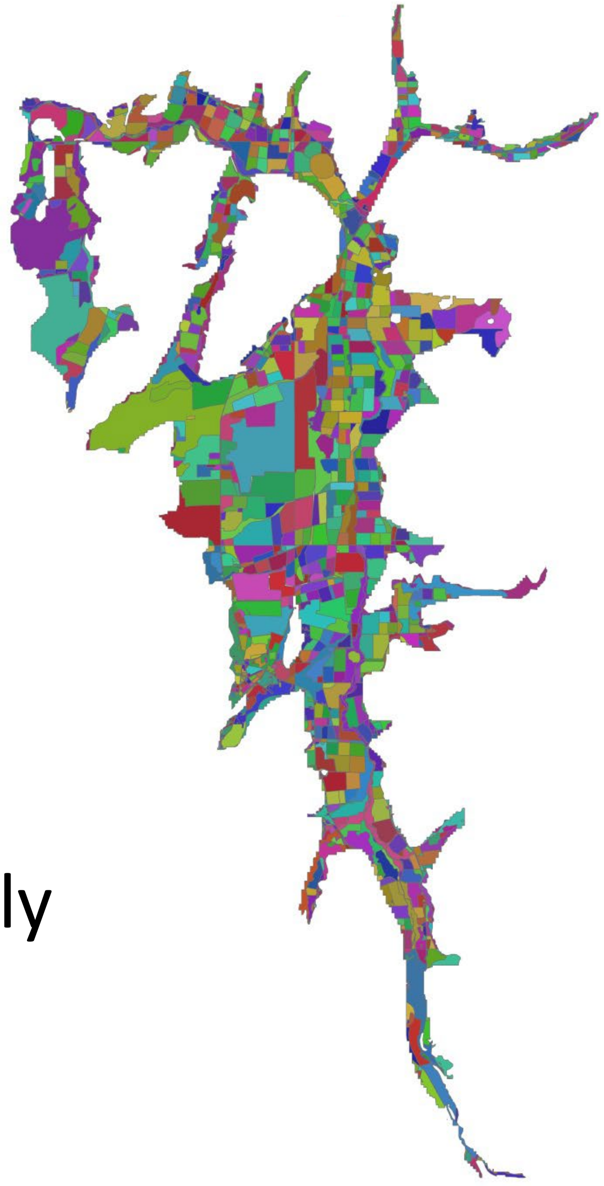
Soil-Water Budget Model Output

- Daily outputs for each field
  - Potential ET
  - Actual ET (water limited)
  - Total irrigation
  - Applied surface-water
  - Applied groundwater
  - Groundwater recharge
  - Soil water content

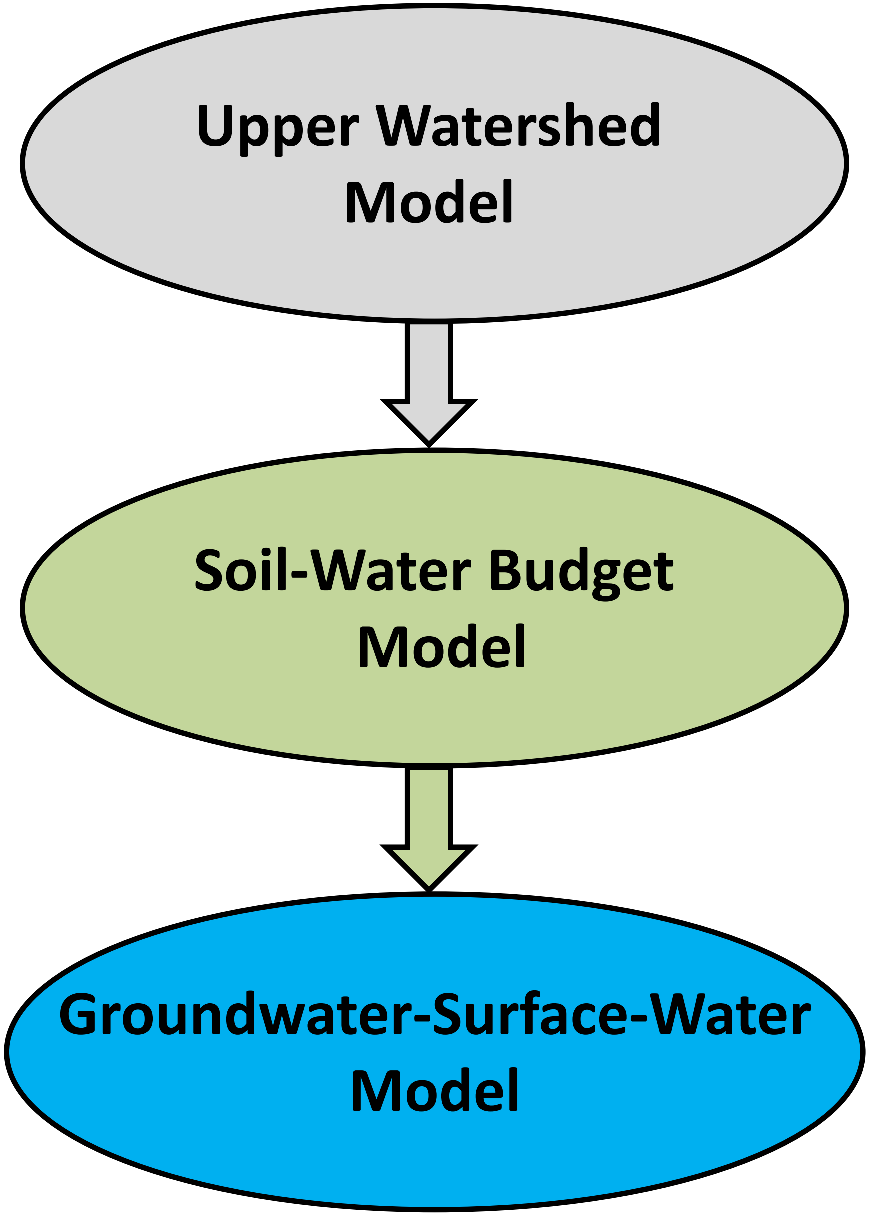


Soil-Water Budget Model Output

- Daily outputs for each field
  - Potential ET
  - Actual ET (water limited)
  - Total irrigation
  - Applied surface-water
  - Applied groundwater
  - Groundwater recharge
  - Soil water content
- Groundwater recharge and pumping are averaged to monthly values for MODFLOW model



Conceptual Outline of SVIHM



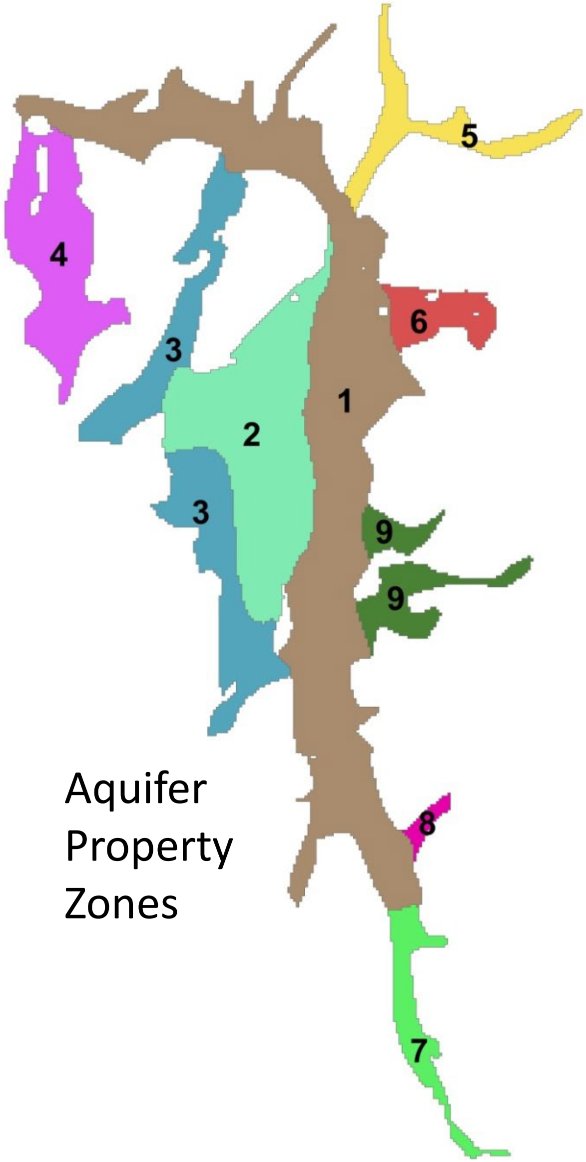
Streamflow entering Scott Valley (Regression model)

Recharge and pumping within the valley (Tipping bucket model)

Detailed groundwater levels and streamflow within the valley (MODFLOW model)

MODFLOW Model

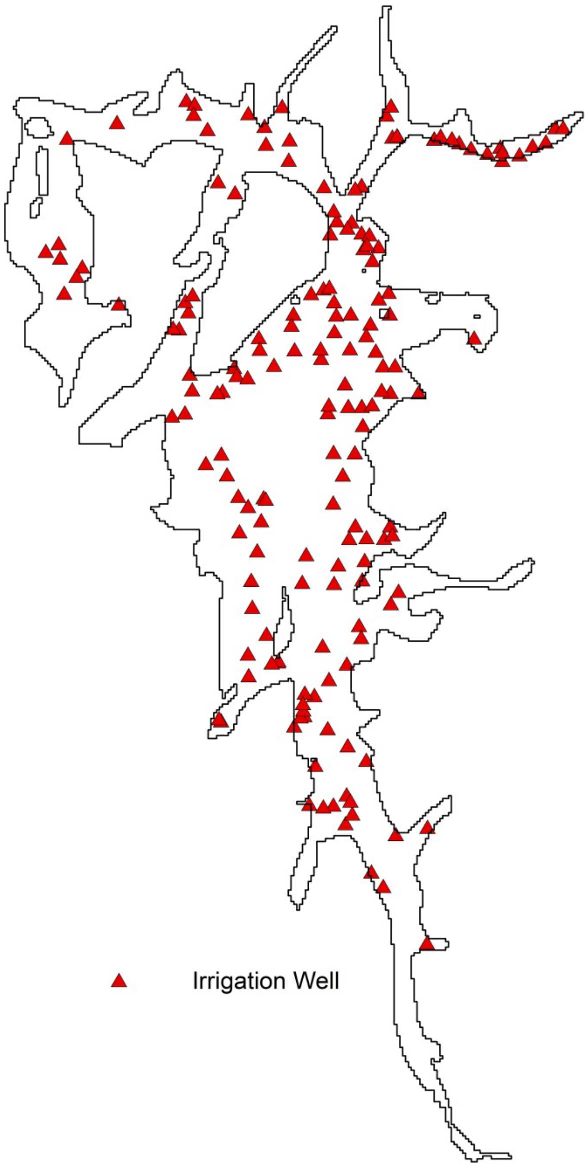
- Aquifer properties:
  - Hydraulic conductivity (vertical/horizontal)
  - Specific yield (storage coefficient)
  - Largely based on zones defined by Mack (1958)



Aquifer Property Zones

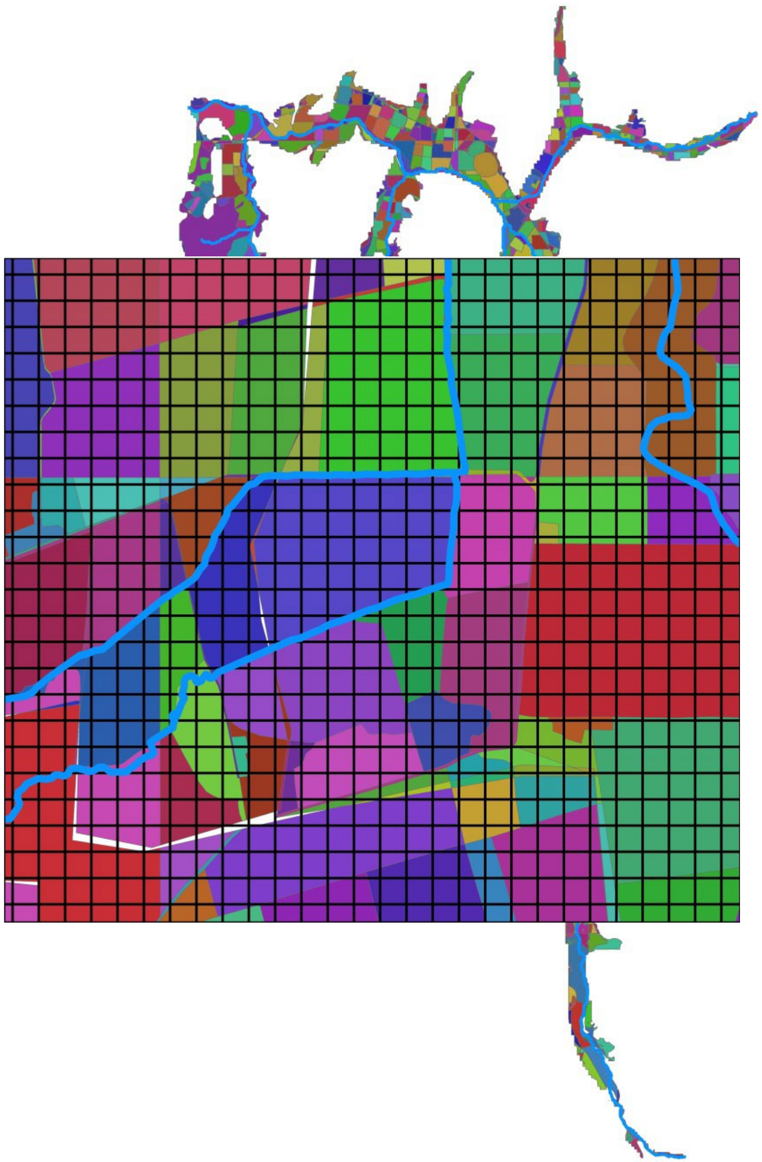
MODFLOW Model

- Daily time steps with monthly stress periods



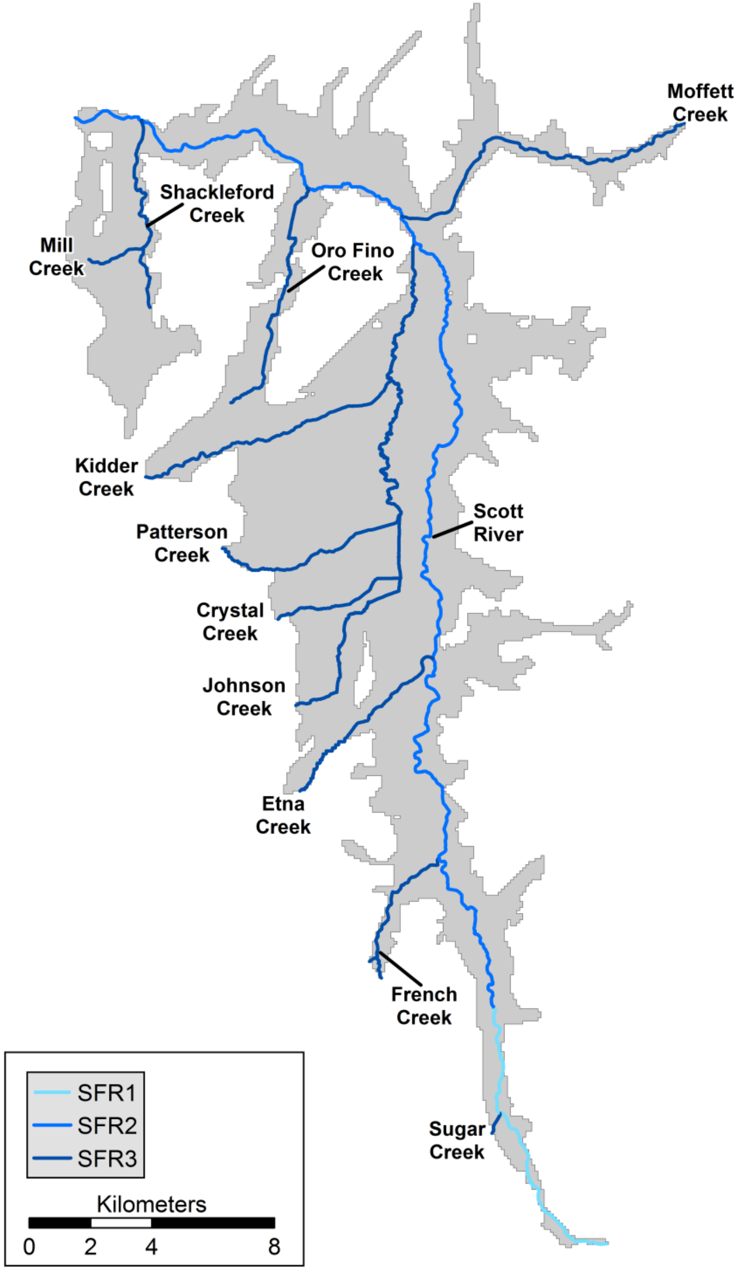
MODFLOW Model

- Daily time steps with monthly stress periods
- 100m lateral discretization



MODFLOW Model

- Daily time steps with monthly stress periods
- 100m lateral discretization
- Streamflow routing package (SFR) used to simulate Scott River and tributaries



MODFLOW Model

- Daily time steps with monthly stress periods
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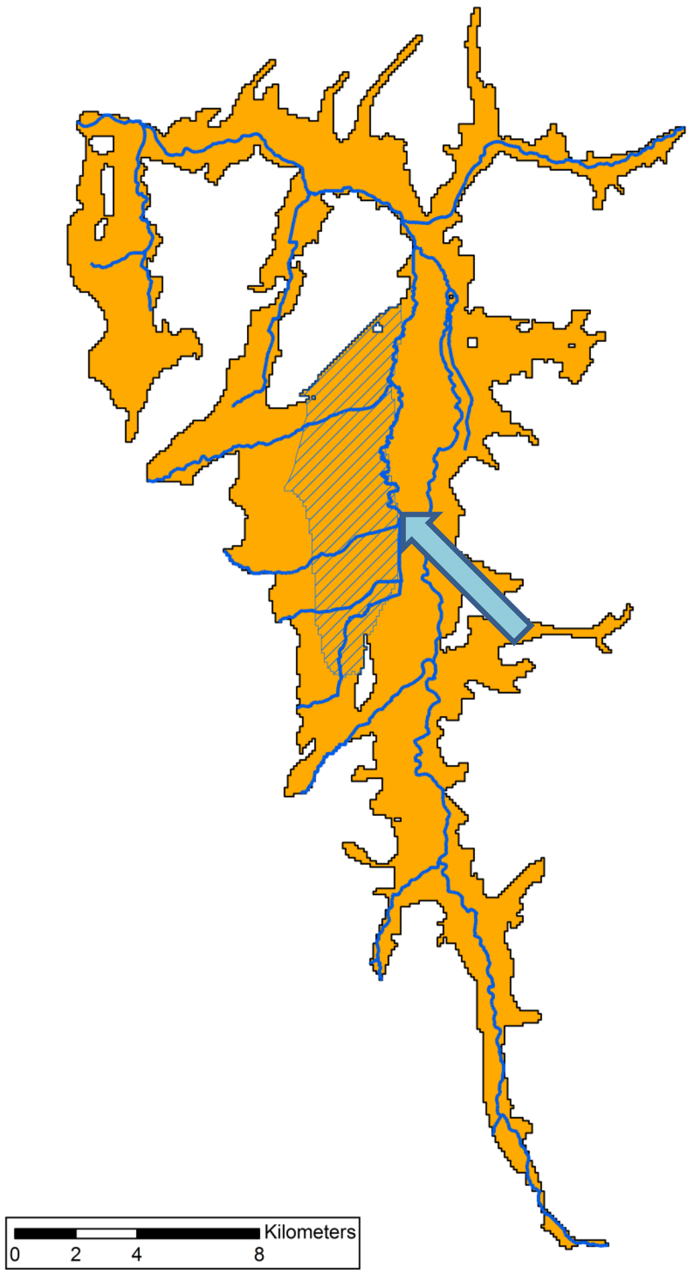
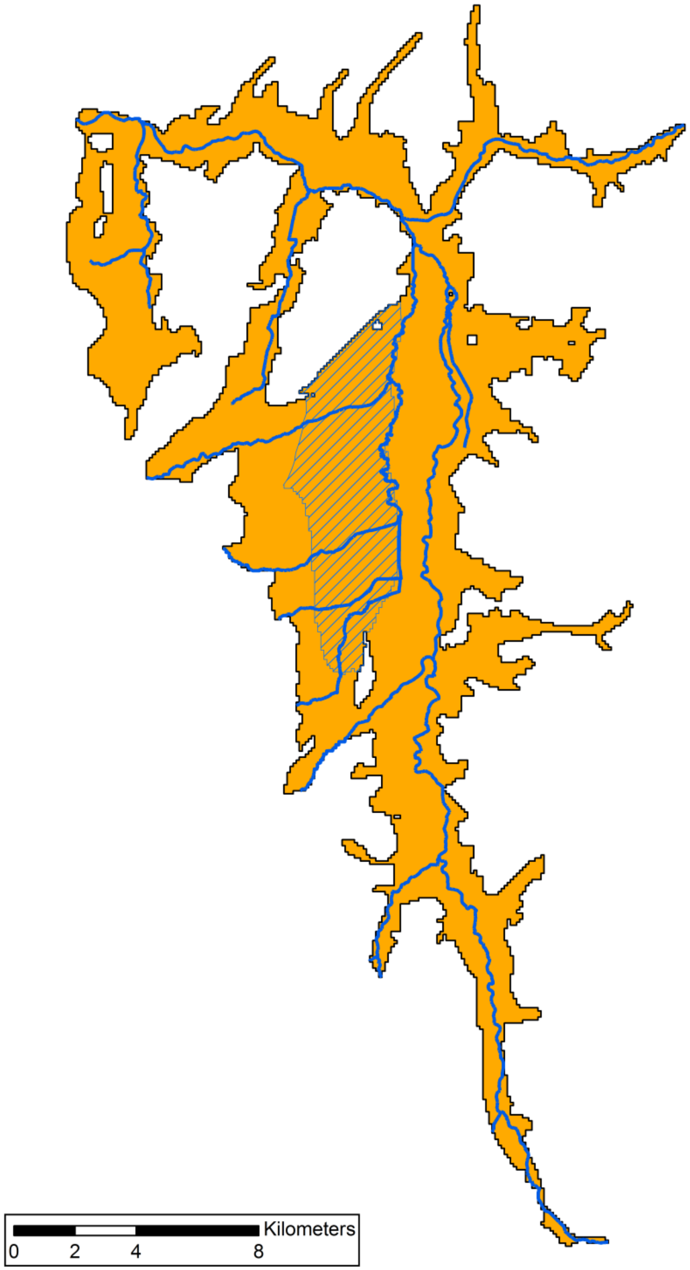
- Streamflow routing package (SFR) used to simulate Scott River and tributaries
- Discharge Zone



MODFLOW Model

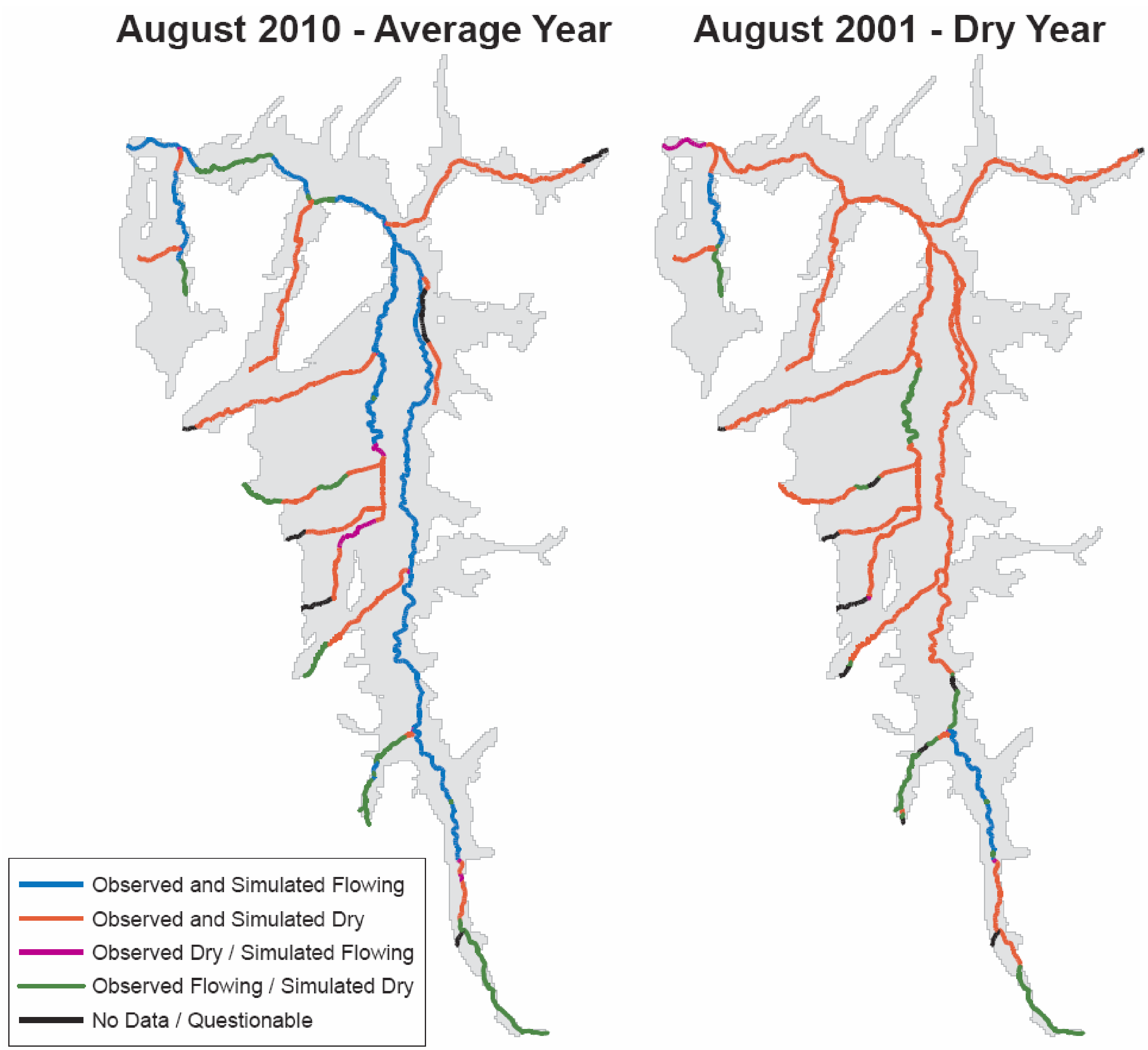
- Daily time steps with monthly stress periods
- 100m lateral discretization
- Streamflow routing package (SFR) used to simulate Scott River and tributaries
- Discharge Zone
- Oct 1, 1990 – Sep 30, 2011 simulation period



Model Development Takeaways

- SVIHM weakly couples a streamflow regression model, soil-water budget model, and MODFLOW model
- Recharge is estimated at the field scale
- Fine spatial discretization (100 m laterally)
- Groundwater heads and streamflow are solved together

Model Validation (Calibration 4)



Scott Valley Integrated Hydrologic Model (SVIHM)

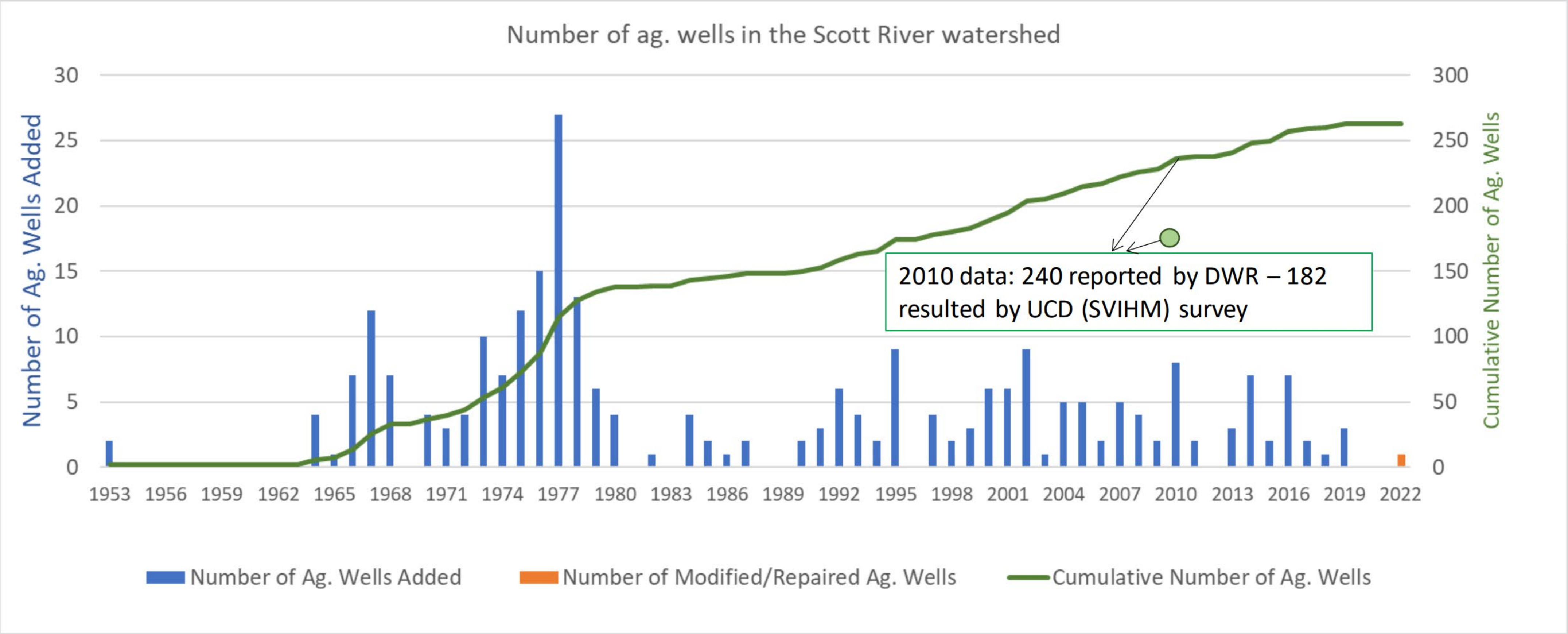
Scenario Modeling

Thomas Harter,
Claire Kouba, Leland Scantlebury, Laura Foglia

ThHarter@ucdavis.edu

https://groundwater.ucdavis.edu

Number of Agricultural Wells Drilled is **NOT EQUAL** to Groundwater Use!



Adapted from [Well Completion Reports - Datasets - California Natural Resources Agency Open Data]

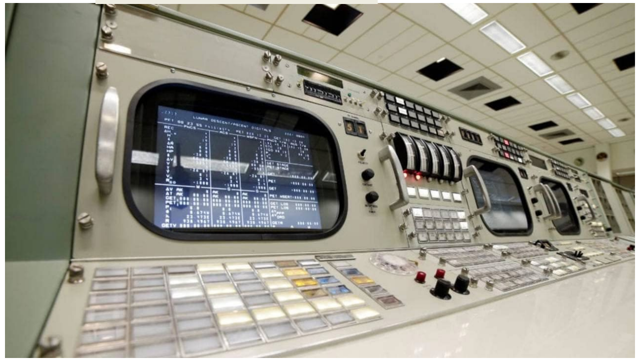
* Note: may include inactive and abandoned wells

Computer models are, of course, a standard tool to assess complex environmental links

continuous monitoring: precipitation, snow-pack, stream-gages, water levels, stream transects, …

Scott Valley Integrated Hydrologic Model

SVIHM



Foglia et al., 2013, 2018

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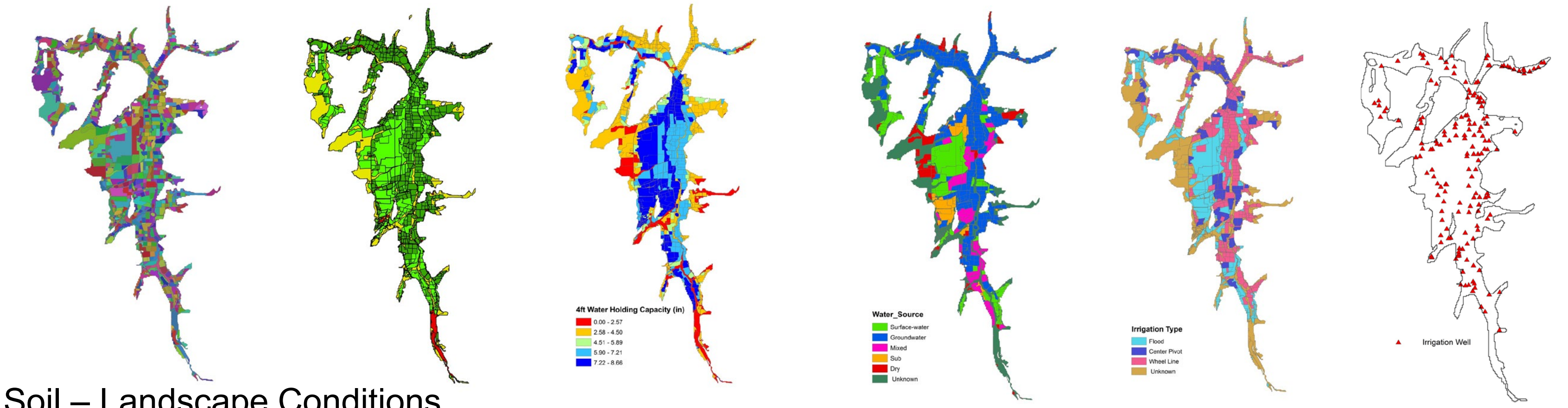
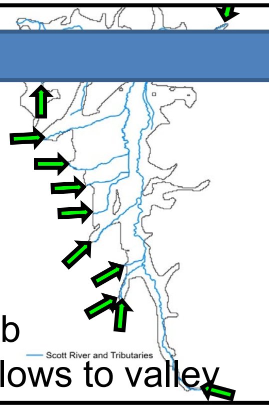
Using real world observations and a computer model to estimate flow, water levels, budgets

continuous monitoring: precipitation, snow-pack, stream-gages, water levels, stream transects, land use practices,…



Soil – Landscape Conditions

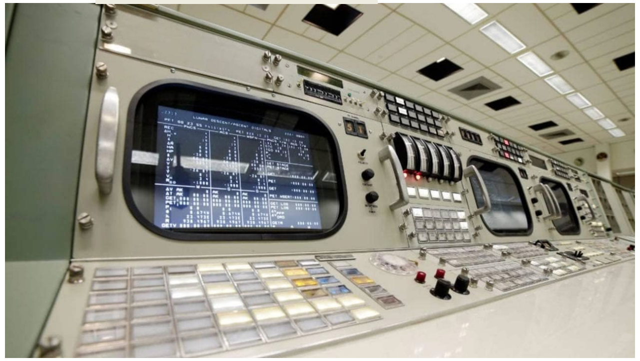
Hydro-Geologic Conditions



Trib Inflows to valley

Scott Valley Integrated Hydrologic Model

SVIHM



Foglia et al., 2013, 2018

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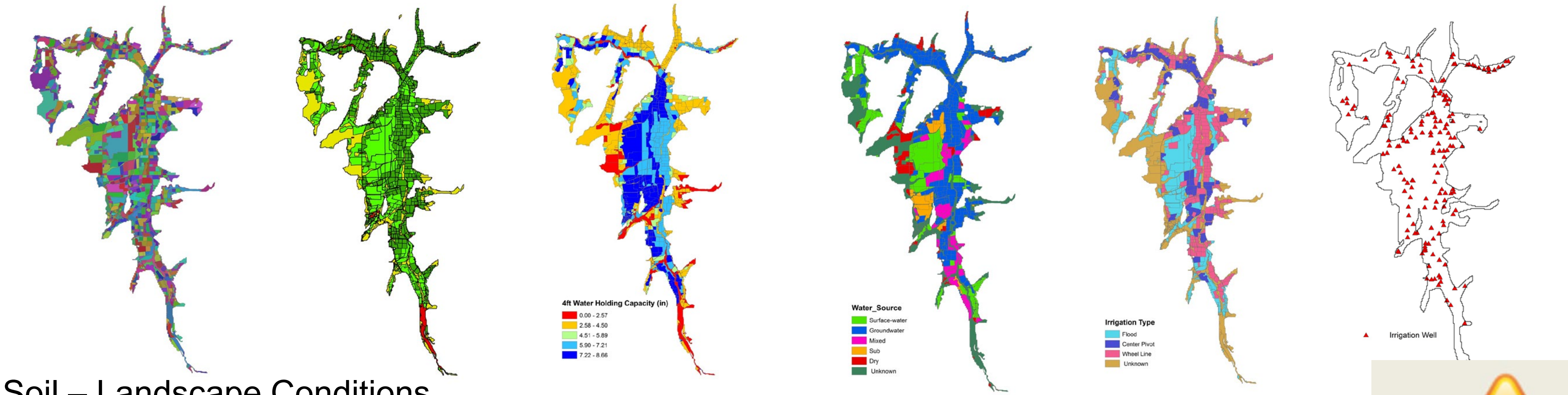
Basecase: The real history represented in a model to estimate flow, water levels, budgets

continuous monitoring: precipitation, snow-pack, stream-gages, water levels, stream transects, land use practices,…

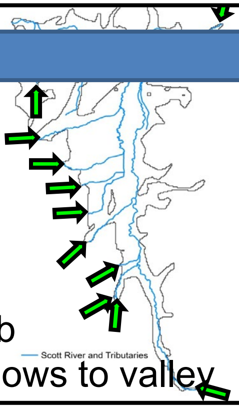


Soil – Landscape Conditions

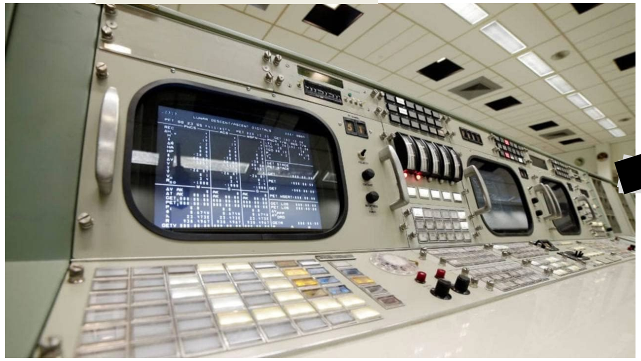
Scott Valley Integrated Hydrologic Model

SVIHM

Hydro-
Geologic
Conditions

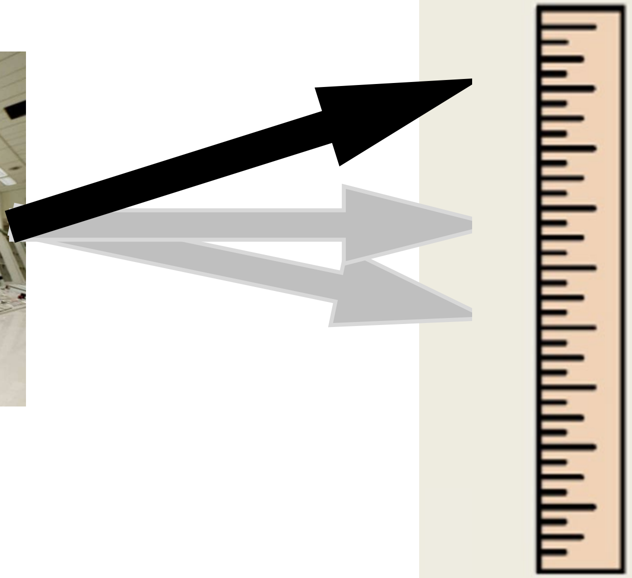


Trib
Inflows to valley



Foglia et al., 2013, 2018

Groundwater-
Surface Water
Exchange



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What is a Model Scenario?

Pretending that history had been different!

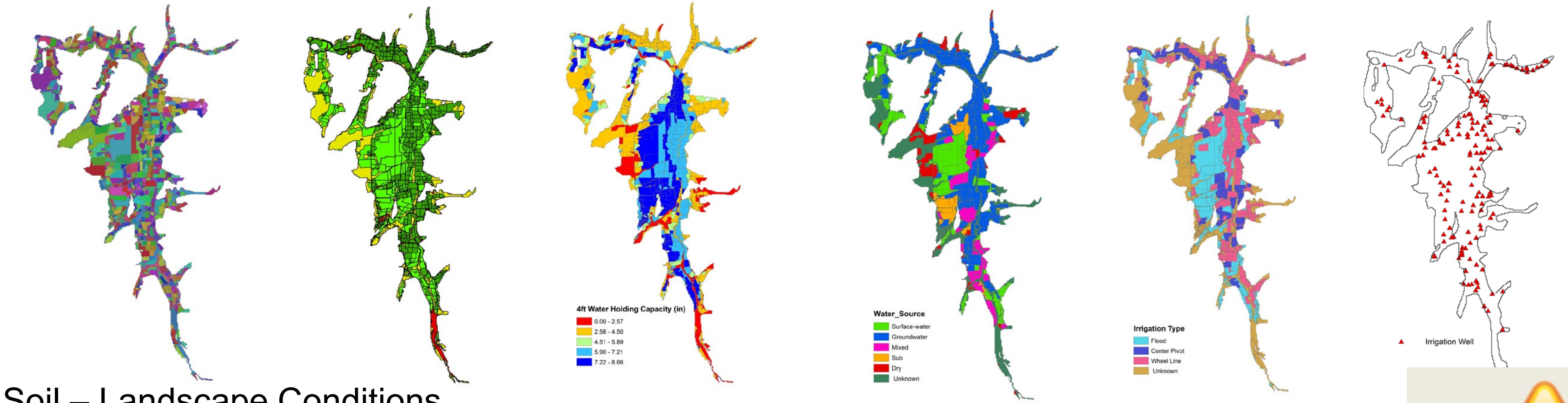
Why run a Model Scenario?

To measure **differences**

- in flows, water levels, water budgets etc
- under some different conditions (“scenario” conditions)
- if history repeated itself otherwise

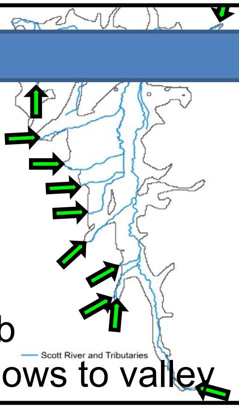
Building model **scenarios** to estimate **differences to basecase** in flow, water levels, budgets

continuous monitoring: precipitation, snow-pack, stream-gages, water levels, stream transects, land use practices,…



Soil – Landscape Conditions

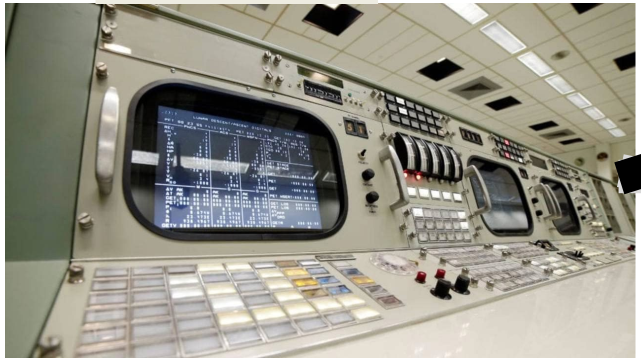
Hydro-Geologic Conditions



Trib Inflows to valley

Scott Valley Integrated Hydrologic Model

SVIHM



Foglia et al., 2013, 2018

Groundwater-Surface Water Exchange

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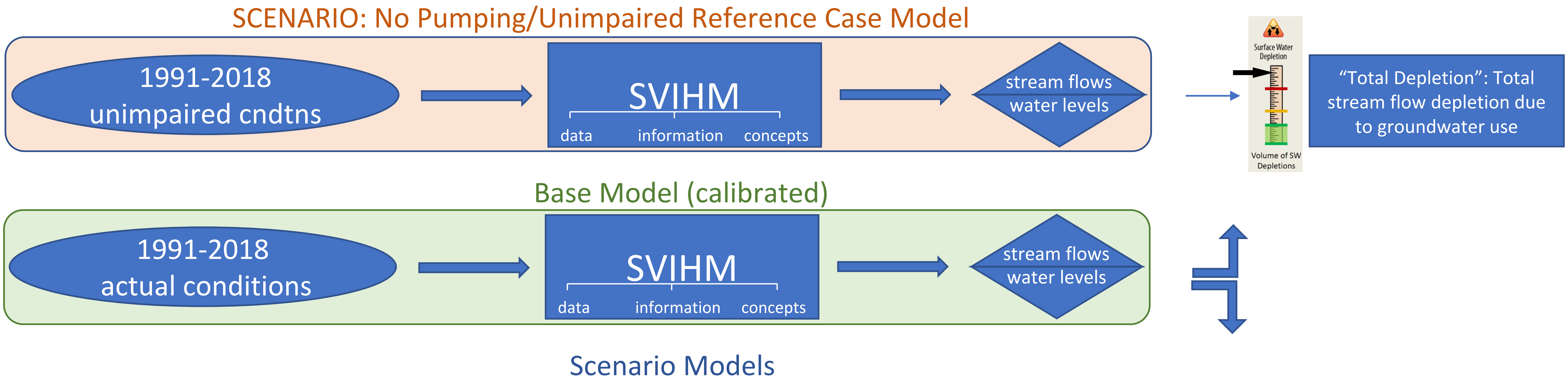
- if history repeated itself otherwise

But will the history repeat itself?

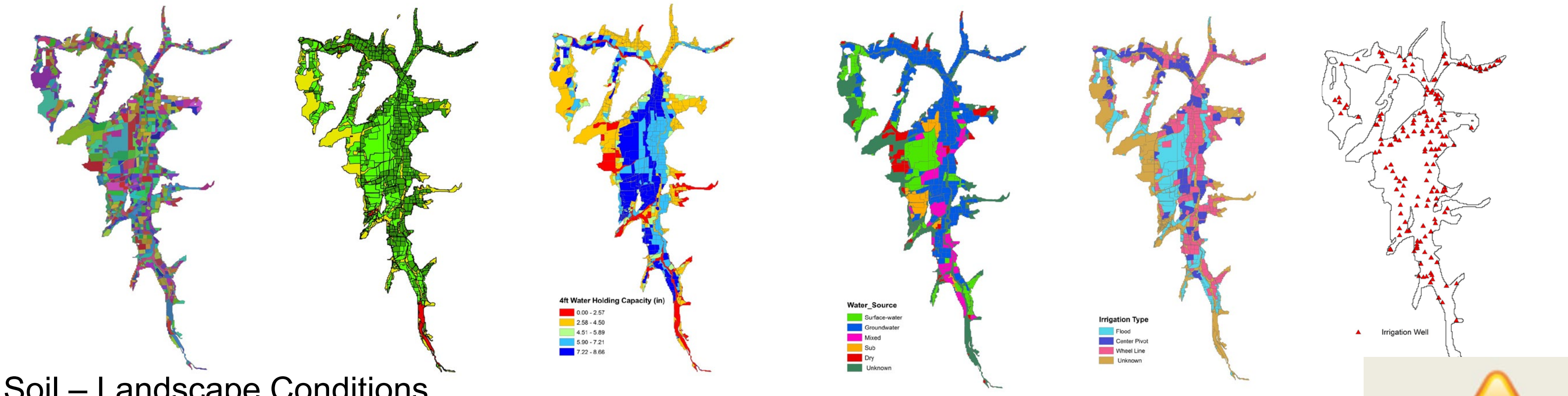
Not exactly, but perhaps similar enough.



Scott Valley Groundwater Basin, Groundwater Sustainability Plan 2022
https://sgma.water.ca.gov/portal/gsp/status

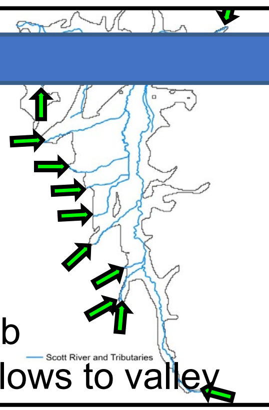
Building model **scenarios** to estimate **differences to basecase** in flow, water levels, budgets

continuous monitoring: precipitation, snow-pack, stream-gages, water levels, stream transects, land use practices,…



Soil – Landscape Conditions

Hydro-Geologic Conditions



Trib Inflows to valley

Scott Valley Integrated Hydrologic Model

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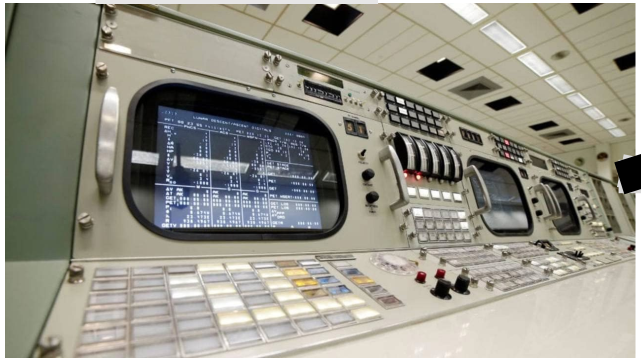
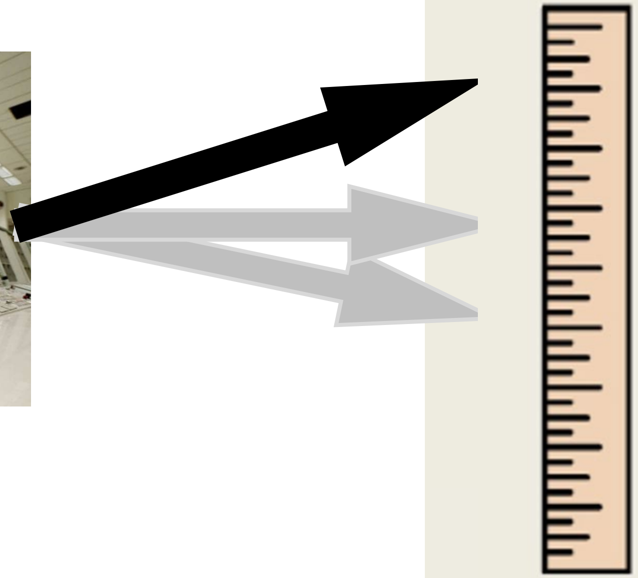


Foglia et al., 2013, 2018

Groundwater-Surface Water Exchange

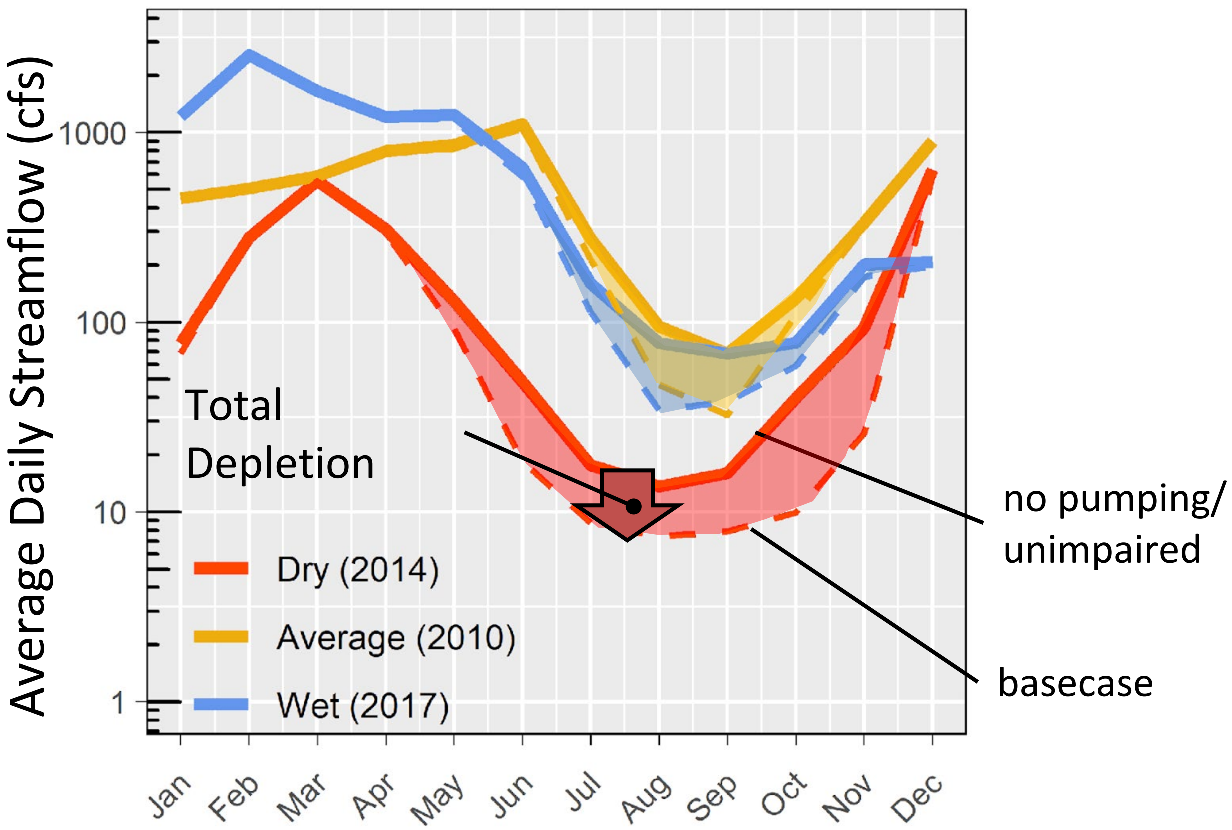


Two Model Runs Required to Quantify Depletion

Streamflow depletion due to pumping in a group of regulated wells is quantified as:

- the **difference in surface flows**…
- over the model period of 1991-2018…
- between the Basecase (estimated historical/current) conditions and the No Pumping/Unimpaired Reference case.

*Note: Areas not proportional due to log-y axis



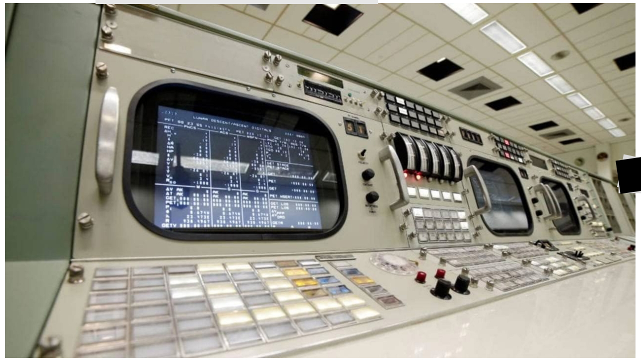
Using real world observations and a computer model to take regular "measurements"

continuous monitoring: precipitation, snow-pack, stream-gages, water levels, stream transects, …

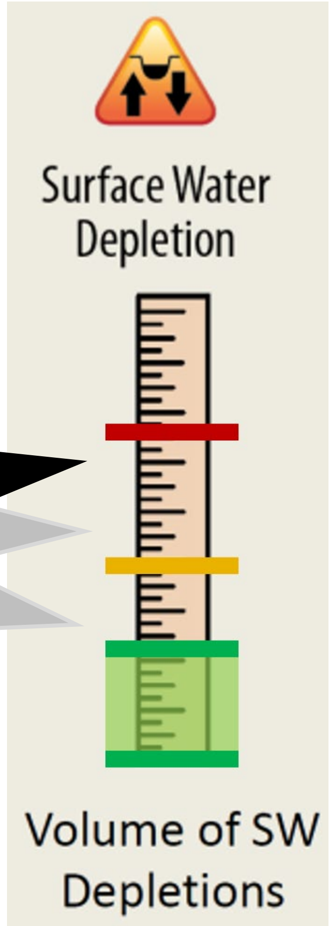
projects and management actions: implementation, monitoring of implementation

Tolley et al., 2019

SVIHM



"measurement"



- regular (annual?) update to extend simulation period to current using measured input data (stream inflow, precip, temp)
- regularly (every 5 years) recalibrated against new data, projects, research
- transparent input, model construction, public domain, peer review

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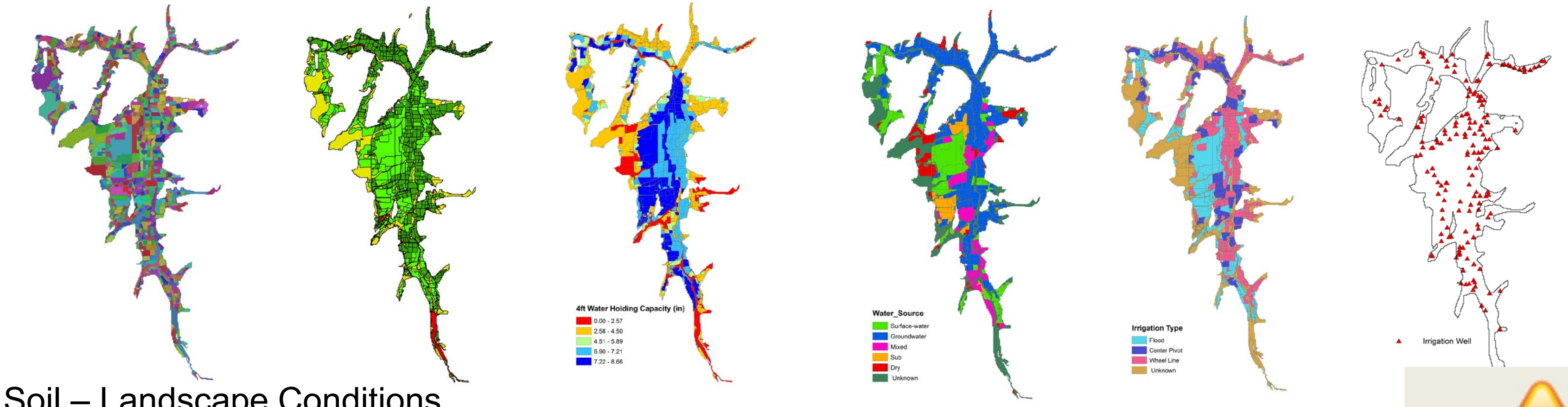
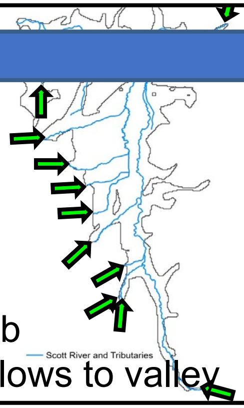
Building model **scenarios** to estimate **differences to basecase** in flow, water levels, budgets

continuous monitoring: precipitation, snow-pack, stream-gages, water levels, stream transects, land use practices,…



Soil – Landscape Conditions

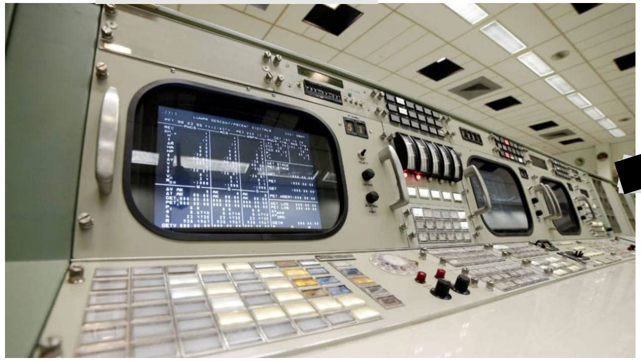
Hydro-Geologic Conditions



Trib Inflows to valley

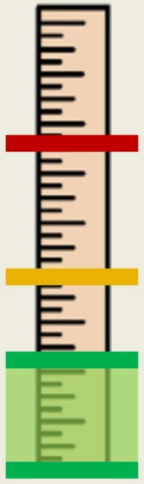
Scott Valley Integrated Hydrologic Model

SVIHM



Foglia et al., 2013, 2018

Surface Water Depletion



Volume of SW Depletions

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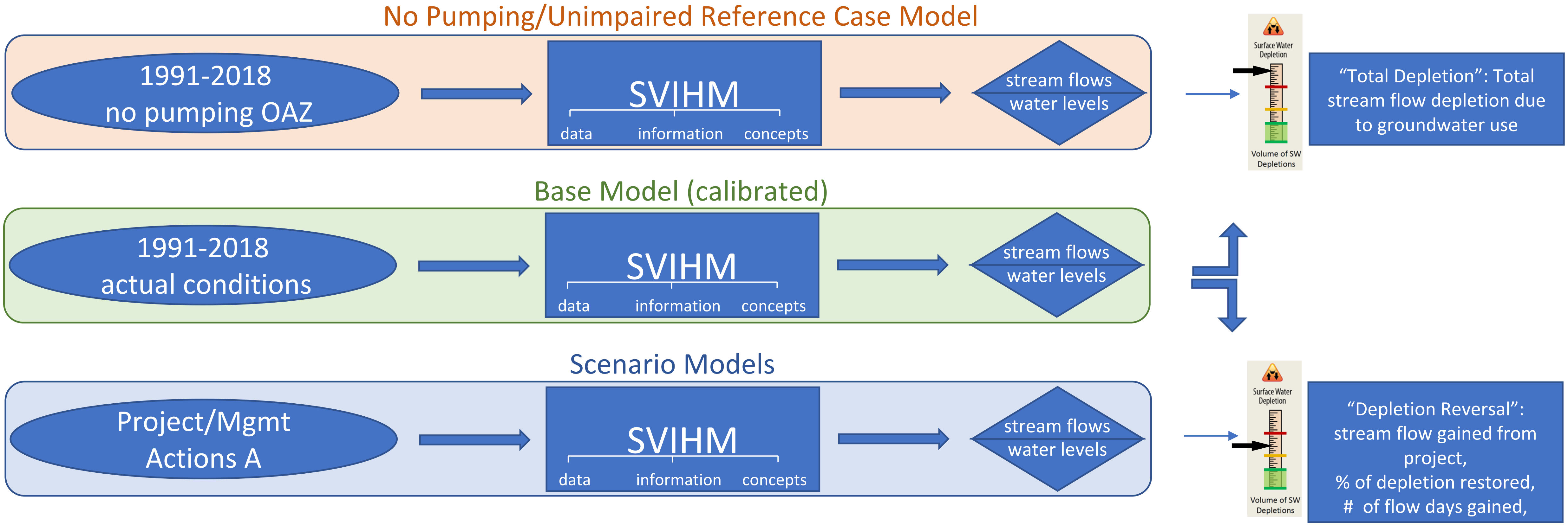
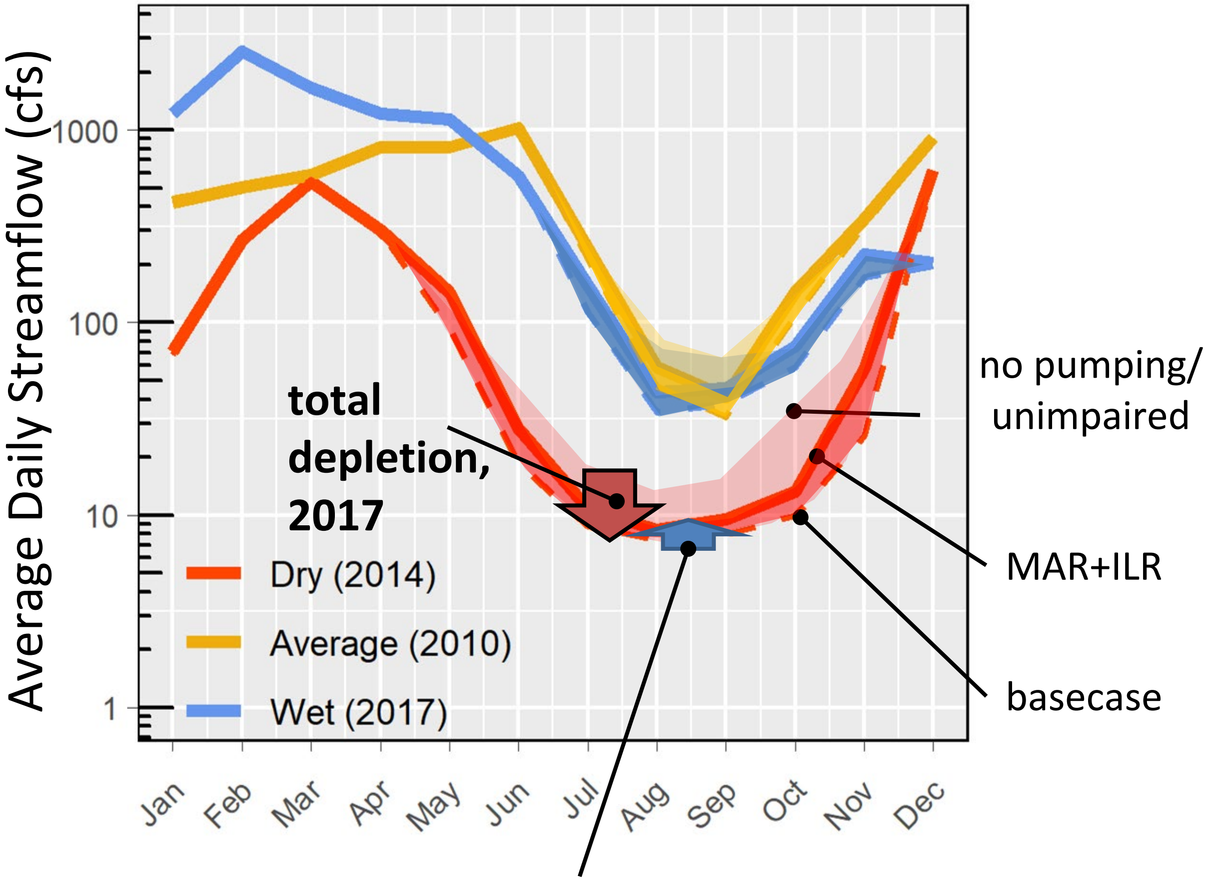


Scott Valley Groundwater Basin, Groundwater Sustainability Plan 2022
https://sgma.water.ca.gov/portal/gsp/status

A Third Model Run Required to “Monitor” Project and Management Actions

Depletion reversal is quantified for **each** scenario as the difference between the Basecase (simulated historical & current) conditions and the relevant scenario (for example, MAR+ILR).

*Note: Areas not proportional due to log-y axis



Managed Aquifer Recharge (MAR) and In-Lieu Recharge (ILR) Depletion Reversal, 2017

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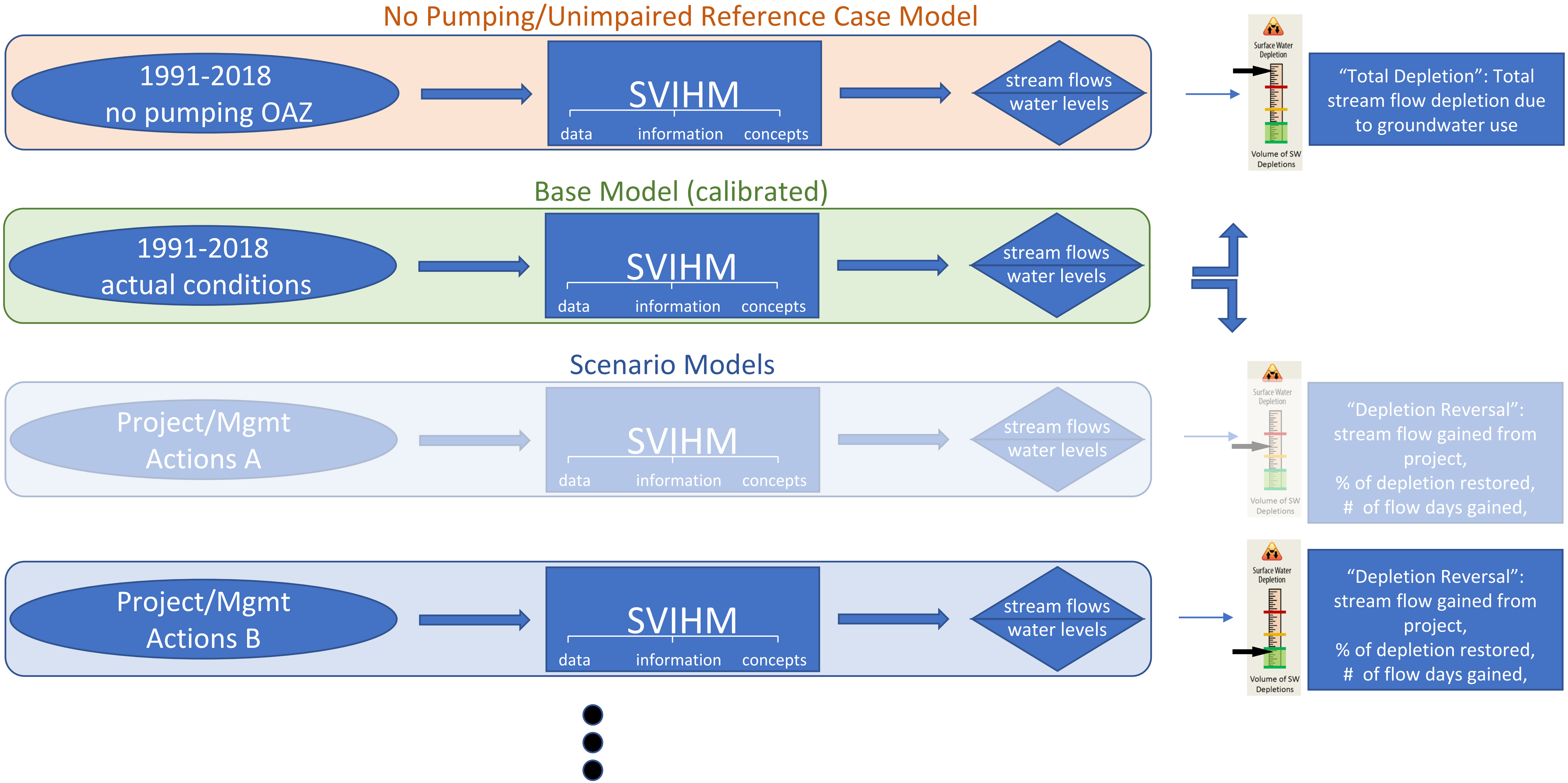


Scott Valley Groundwater Basin, Groundwater Sustainability Plan 2022
https://sgma.water.ca.gov/portal/gsp/status

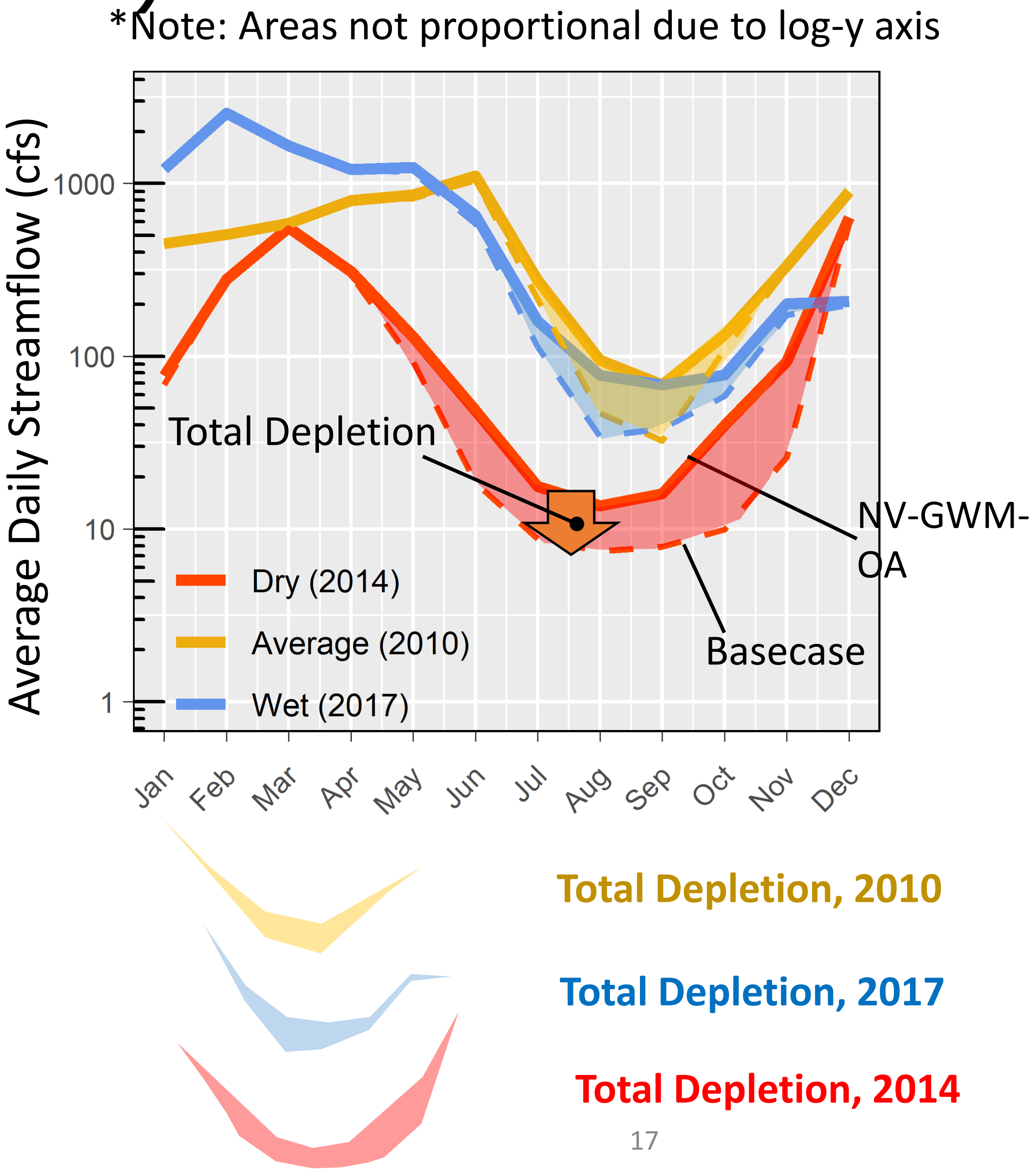
Using the No-Pumping (Unimpaired) Scenario

Total Streamflow Depletion* is quantified as:

- the **difference in flow** at the Fort Jones Gauge…
- over the model period of 1991-2018…
- between the Basecase (estimated historical/current) conditions and the No Pumping** Reference case.

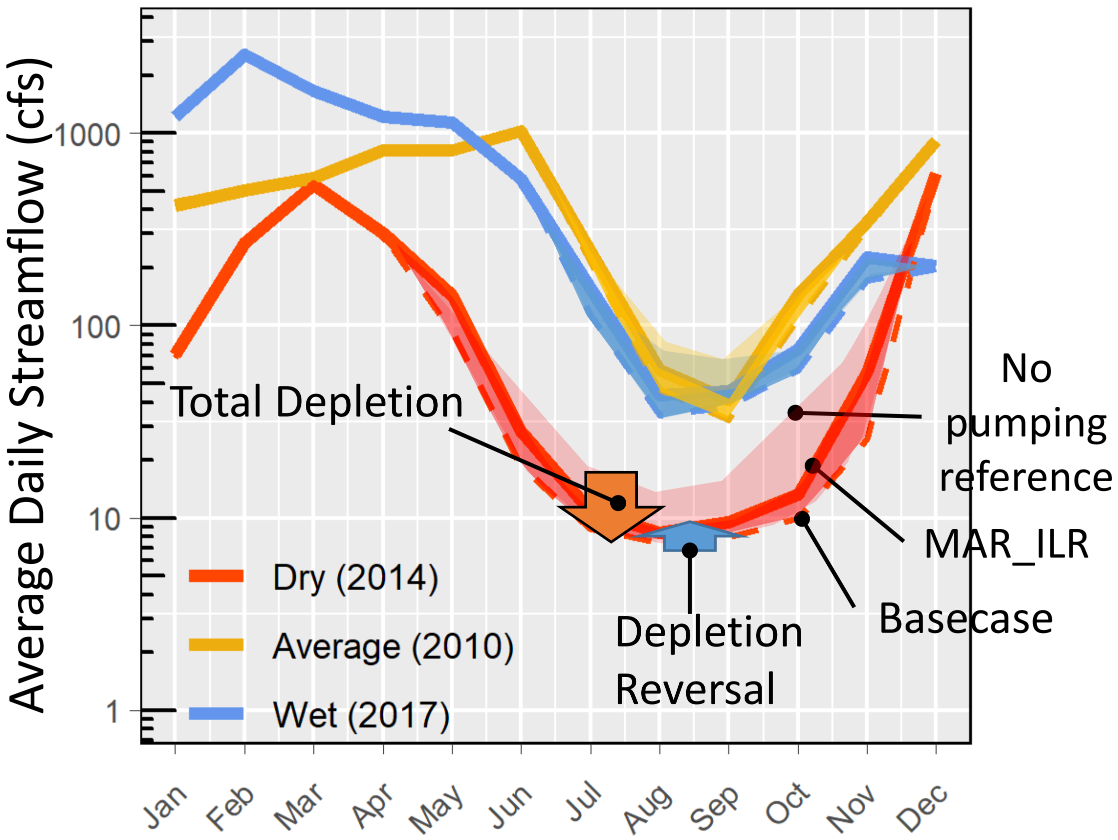
* Due to pumping in SGMA wells

** Also referred to as “Natural Vegetation on GW and Mixed-source fields Outside the Adjudicated Zone”, or NV-GWM-OA



Overlaying a Project/Management Action Scenario

*Note: Areas not proportional due to log-y axis

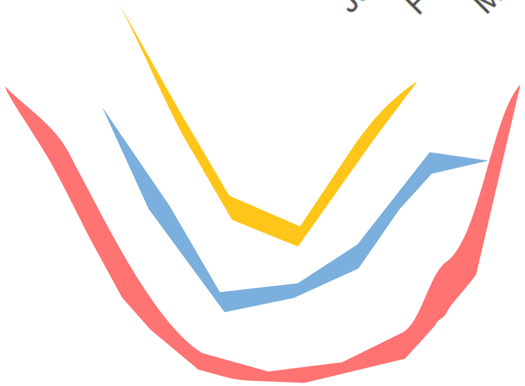


Depletion Reversal is quantified for **each** scenario as the difference between the Basecase (simulated historical & current) conditions and the relevant scenario (for example, MAR+ILR).

Total Depletion, 2010

Total Depletion, 2017

Total Depletion, 2014



MAR+ILR Depletion Reversal, 2010

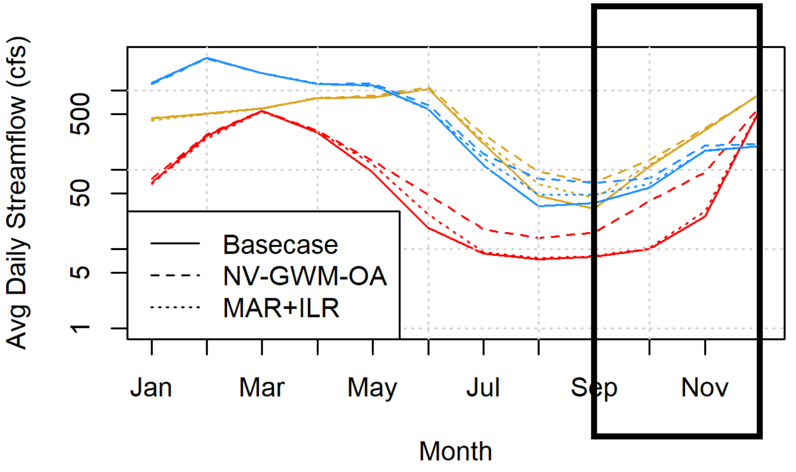
MAR+ILR Depletion Reversal, 2017

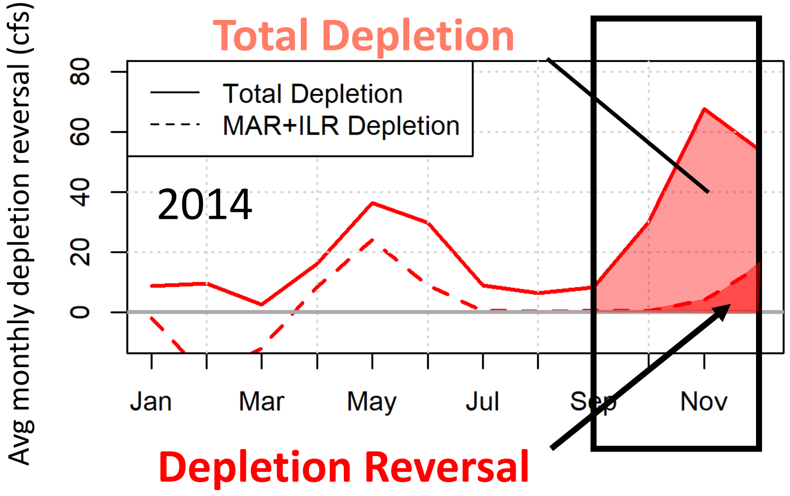
MAR+ILR Depletion Reversal, 2014

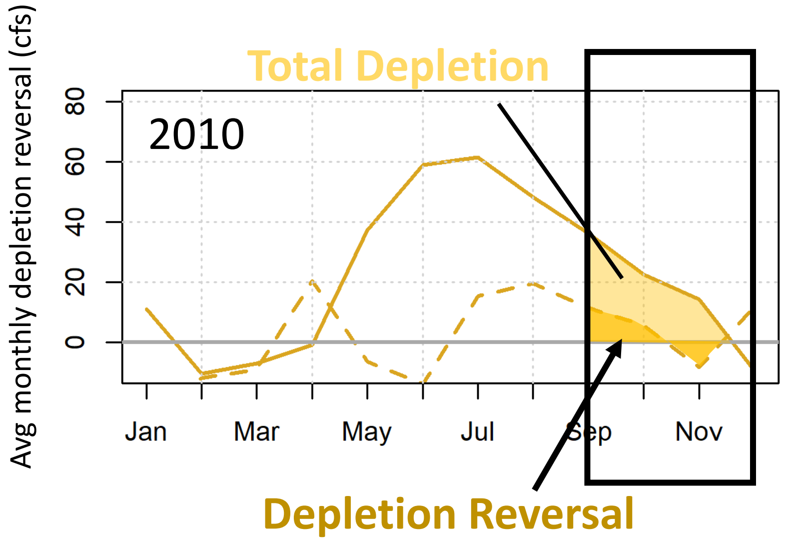
Scenario information

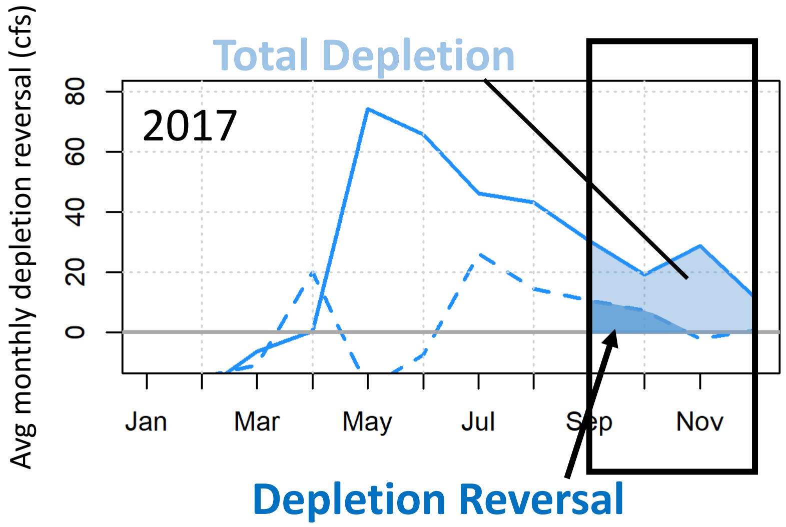
Scenario Type	Scenario ID	Scenario description
Enhanced Recharge	MAR	Divert surface water to over-irrigate fields and enhance groundwater recharge during the wet season (Dec-Mar) . Allow diversions from tributaries to continue as long as water is available (on a monthly volume basis).
	ILR	Divert surface water to irrigate fields during the growing season (Apr-Jun or Jul) in lieu of pumping groundwater. Allow diversions from tributaries to continue as long as water is available (on a monthly volume basis).
	MAR_ILR	Combination of MAR and ILR scenarios.
	Expanded MAR_ILR, 0.019	MAR and ILR on all old MAR and ILR fields and all other fields with Surface Water access. Assumed max infiltration rate of 0.019 m/day. CDFW instream flow recommendations restrict water available for MAR.
Crop change	80% Irrigation	Assumes unspecified irrigated crop change, reducing all irrigated acreage water demand by 20%.
	90% Irrigation	Assumes unspecified irrigated crop change, reducing all irrigated acreage water demand by 10%.
Irrigation Efficiency	Improve irrigation efficiency by 0.1	Effective irrigation efficiency of wheel line and center pivot on alfalfa and pasture improves by 0.1 (10%).
	Reduce irrigation efficiency by 0.1	Effective irrigation efficiency of wheel line and center pivot on alfalfa and pasture worsens by 0.1 (10%).
Irrigation schedule change	Alfalfa irrigation schedule - July 10 end date	Alfalfa irrigation ceases on July 10th of every growing season. (Basecase is Aug 31st)
	Alfalfa irrigation schedule - Aug 01 end date	Alfalfa irrigation ceases on Aug 1st of every growing season. (Basecase is Aug 31st)
	Aug 01 end date, *dry years only*	Alfalfa irrigation ceases on Aug 1st of every growing seasons in these years: 91, 92, 94, 01, 09, 13, 14, 18. (Basecase is Aug 31st)
	Alfalfa irrigation schedule - Aug 15 end date	Alfalfa irrigation ceases on Aug 15th of every growing season. (Basecase is Aug 31st)
	Aug 15 end date, *dry years only*	Alfalfa irrigation ceases on Aug 15th of every growing seasons in these years: 91, 92, 94, 01, 09, 13, 14, 18. (Basecase is Aug 31st)
Attribution - adjudicated area impacts	Natural Vegetation Outside Adjudicated area (NVOA)	Turns off pumping for wells serving all fields **outside** the adjudicated zone. Assumes that these fields, where pumping is turned off, revert to natural vegetation with a k_c value of 1.0. Assumes that all fields with 5% or more of their area overlapping with the adjudicated zone are "inside" the adjudicated zone. Increase ET extinction depth (in MODFLOW .ETS package) to 4.5 m in native vegetation areas outside the DIscharge Zone.
	Natural Vegetation, on Groundwater- or Mixed-source fields, Outside Adjudicated area (NV-GWM-OA)	Turns off pumping for wells serving fields **outside** the adjudicated zone, which have a "groundwater" or "mixed groundwater and surface water" irrigation source. Assumes that these fields, where pumping is turned off, revert to natural vegetation with a k_c value of 1.0. Assumes that all fields with 5% or more of their area overlapping with the adjudicated zone are "inside" the adjudicated zone. Increase ET extinction depth (in MODFLOW .ETS package) to 4.5 m in native vegetation areas outside the DIscharge Zone.
	Natural Vegetation Inside Adjudicated area (NVIA)	Turns off pumping for wells serving all fields **inside** the adjudicated zone. Assumes that these fields, where pumping is turned off, revert to natural vegetation with a k_c value of 1.0. Assumes that all fields with 5% or more of their area overlapping with the adjudicated zone are "inside" the adjudicated zone. Increase ET extinction depth (in MODFLOW .ETS package) to 4.5 m in native vegetation areas outside the DIscharge Zone.
	Natural Vegetation, on Groundwater- or Mixed-source fields, Inside Adjudicated area (NV-GWM-IA)	Turns off pumping for wells serving fields **inside** the adjudicated zone, which have a "groundwater" or "mixed groundwater and surface water" irrigation source. Assumes that these fields, where pumping is turned off, revert to natural vegetation with a k_c value of 1.0. Assumes that all fields with 5% or more of their area overlapping with the adjudicated zone are "inside" the adjudicated zone. Increase ET extinction depth (in MODFLOW .ETS package) to 4.5 m in native vegetation areas outside the DIscharge Zone.
	Natural Vegetation (NV)	Turns off pumping for wells serving **all irrigated fields** in the SVIHM model. Assumes that these fields, where pumping is turned off, revert to natural vegetation with a k_c value of 1.0. Assumes that all fields with 5% or more of their area overlapping with the adjudicated zone are "inside" the adjudicated zone. Increase ET extinction depth (in MODFLOW .ETS package) to 4.5 m in native vegetation areas outside the DIscharge Zone.
	Natural Vegetation on all Groundwater- or Mixed-source fields (NV-GWM)	Turns off pumping for wells serving **all irrigated fields** which have a "groundwater" or "mixed groundwater and surface water" irrigation source. Assumes that these fields, where pumping is turned off, revert to natural vegetation with a k_c value of 1.0. Assumes that all fields with 5% or more of their area overlapping with the adjudicated zone are "inside" the adjudicated zone. Increase ET extinction depth (in MODFLOW .ETS package) to 4.5 m in native vegetation areas outside the DIscharge Zone.
Reservoir	Reservoir, 30 cfs release, Shackleford	Simulates a 9 TAF reservoir on the Shackleford Creek tributary by withholding wet-season flow and releasing it during the dry season according to set operations rules.
	Reservoir, 30 cfs release, Etna	Simulates a 9 TAF reservoir on the Etna Creek tributary by withholding wet-season flow and releasing it during the dry season according to set operations rules.
	Reservoir, 30 cfs release, French	Simulates a 9 TAF reservoir on the French Creek tributary by withholding wet-season flow and releasing it during the dry season according to set operations rules.
	Reservoir, 30 cfs release, S. Fork	Simulates a 9 TAF reservoir on the South Fork tributary by withholding wet-season flow and releasing it during the dry season according to set operations rules.
100% reliable reservoir	100% reliability 30 cfs release	Simulates a 29 TAF reservoir on the Etna Creek tributary by withholding wet-season flow and releasing it during the dry season according to set operations rules.
	100% reliability 60 cfs release	Simulates a 29 TAF reservoir on the Etna Creek tributary by withholding wet-season flow and releasing it during the dry season according to set operations rules.

Quantifying the SMC









To calculate relative depletion reversal, sum the darker areas for each year and divide by the sum of the lighter areas in the Sept-Nov window.

Overall, the MAR+ILR scenario Reverses

19%

of the Sept.-Nov. Depletion for 1991-2018.

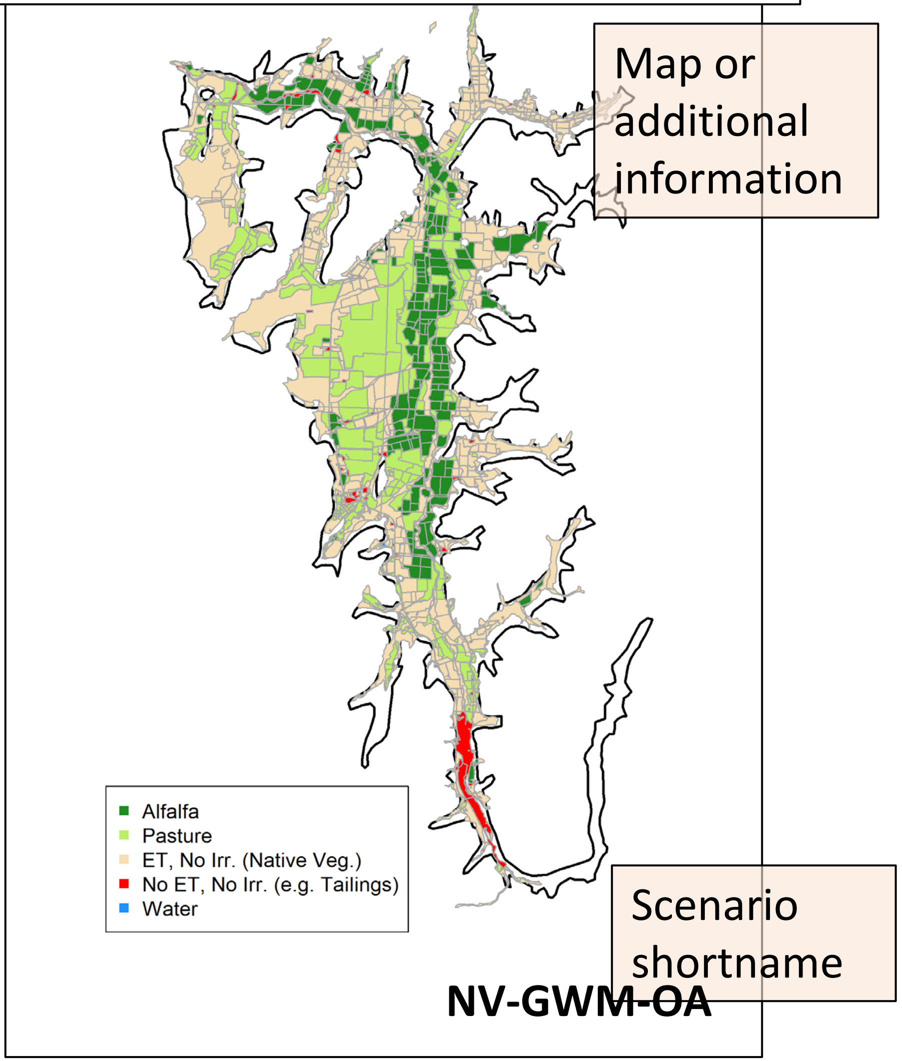
Scenario Type	Scenario ID	Scenario Depletion Reversal, Sep-Nov '91-'18 (TAF)	Relative Depletion Reversal, Sep-Nov '91-'18
Enhanced Recharge	MAR	13	10%
	ILR	12	9%
	MAR_ILR	25	19%
	Expanded MAR_ILR *(assumed max infiltration rate of 0.019 m/d)*	60	44%
Crop change	80% Irrigation demand	82	61%
	90% Irrigation demand	40	29%
Irrigation Efficiency	Improve irrigation efficiency by 0.1	5.8	4%
	Reduce irrigation efficiency by 0.1	-3.2	-2%
Irrigation schedule change	Alfalfa irrigation schedule - July 10 end date	117	86%
	Alfalfa irrigation schedule - Aug 01 end date	82	60%
	Aug 01 end date, *dry years only ('91, '92, '94, '01, '09, '13, '14, '18)*	19	14%
	Alfalfa irrigation schedule - Aug 15 end date	45	33%
Attribution - adjudicated area impacts	Natural Vegetation Outside Adjudicated area (NVOA)	171	126%
	Natural Vegetation, on Groundwater- or Mixed-source fields, Outside Adjudicated area (NV-GWM-OA)	**136**	100%
	Natural Vegetation Inside Adjudicated area (NVIA)	126	93%
	Natural Vegetation, on Groundwater- or Mixed-source fields, Inside Adjudicated area (NV-GWM-IA)	116	85%
	Natural Vegetation (NV)	287	212%
	Natural Vegetation on all Groundwater- or Mixed-source fields (NV-GWM)	233	171%
Reservoir	Reservoir, 30 cfs release, Shackleford	46	34%
	Reservoir, 30 cfs release, Etna	65	48%
	Reservoir, 30 cfs release, French	78	58%
	Reservoir, 30 cfs release, S. Fork	35	26%
100% reliable reservoir	100% reliability 30 cfs release	72	53%
	100% reliability 60 cfs release	155	114%

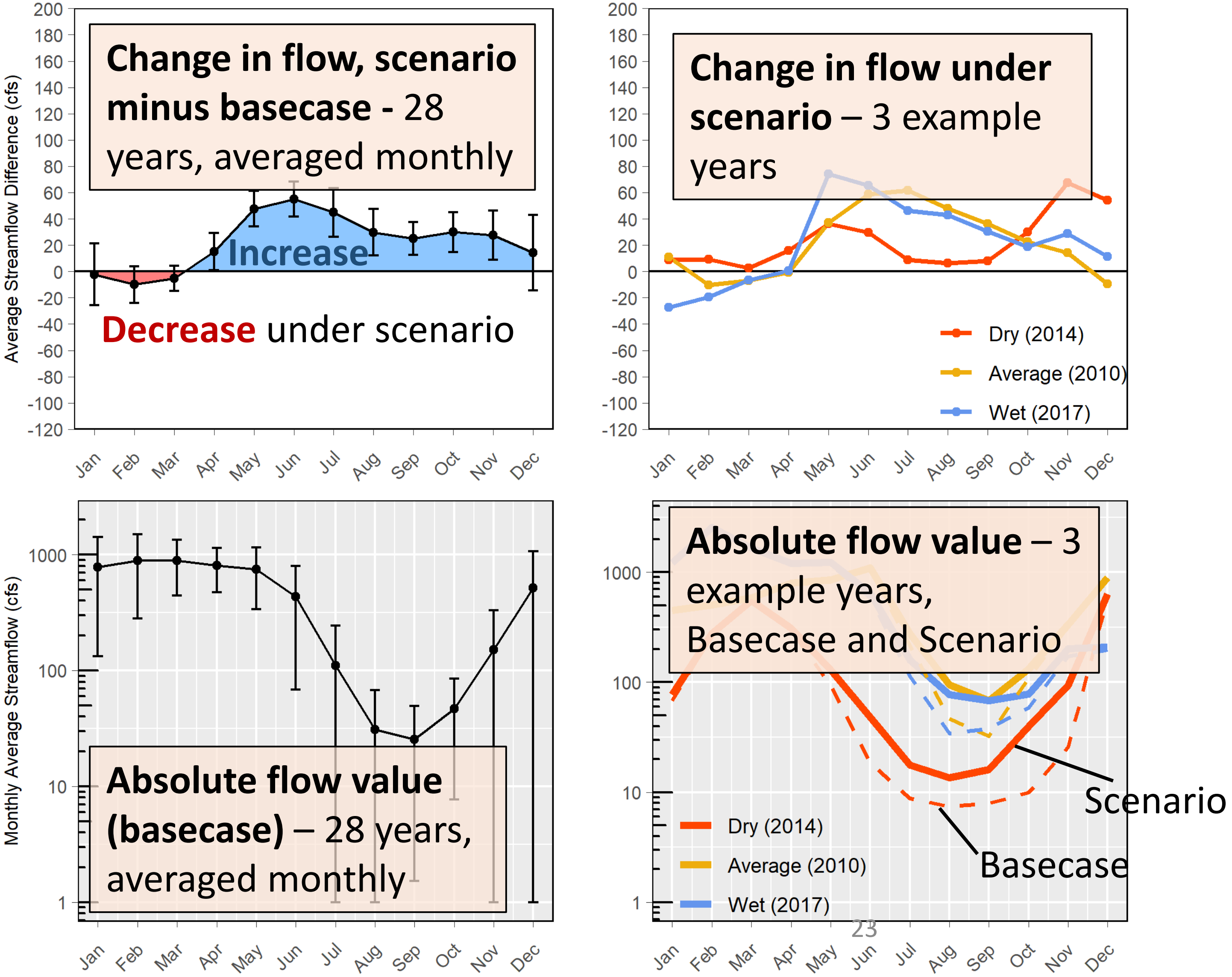
How to read and interpret graphs of scenario results

Plot Explanations

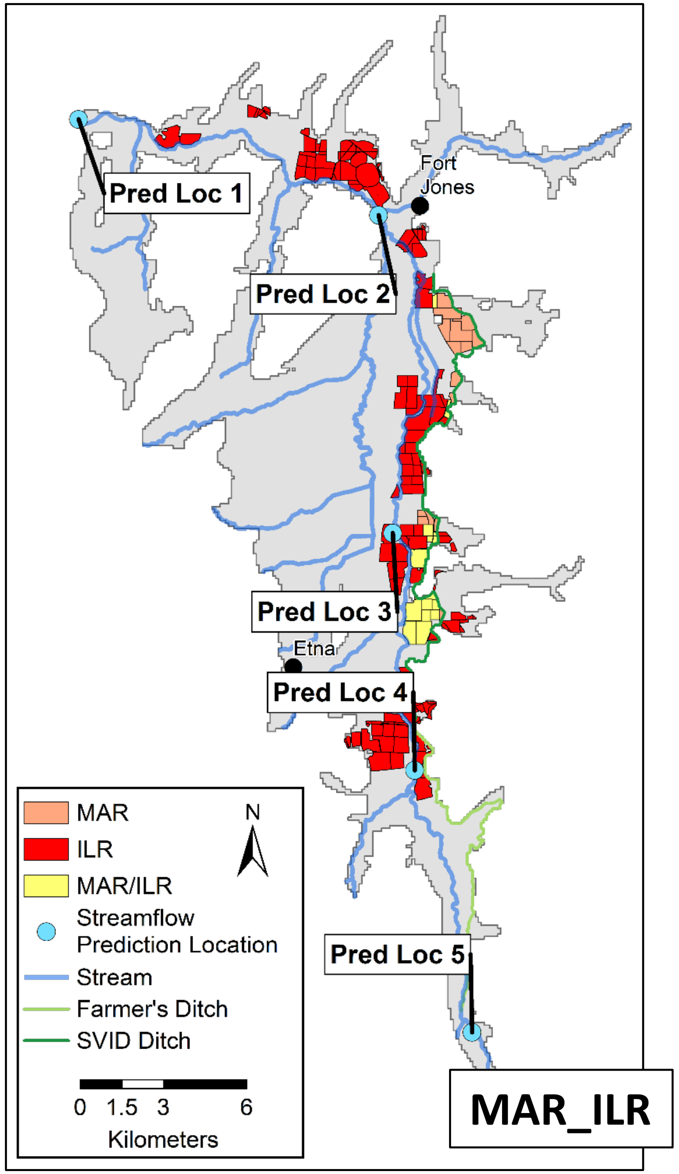
All flows and flow changes plotted are for the Fort Jones Gauge location

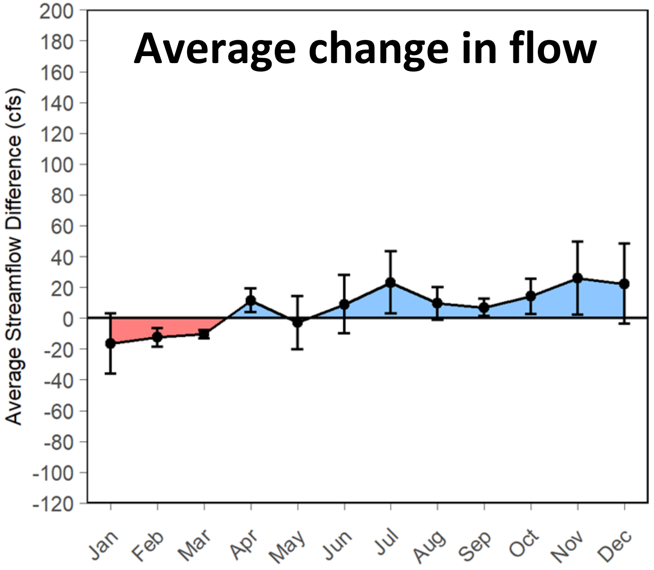
Native Vegetation on *GW and Mixed Water Source Fields* Outside Adjudication

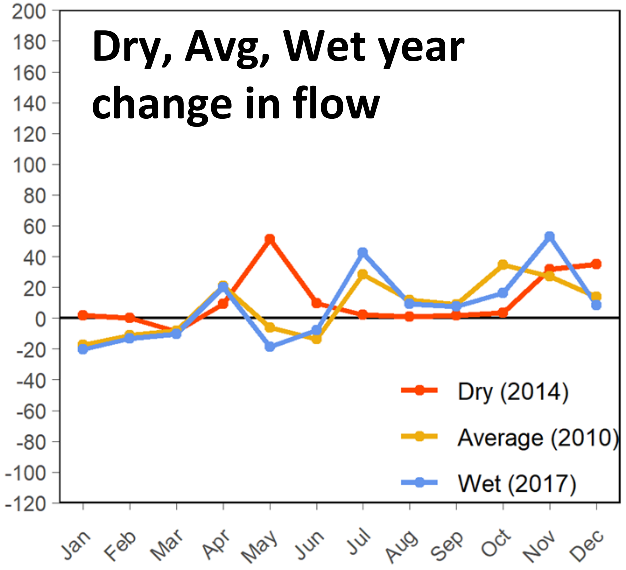


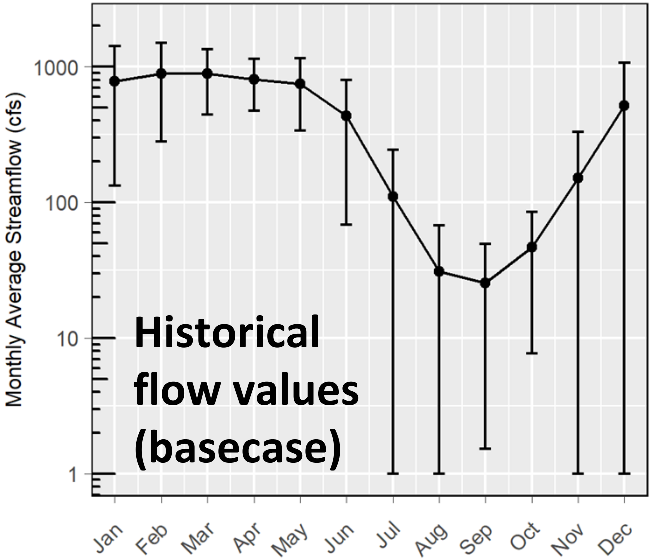


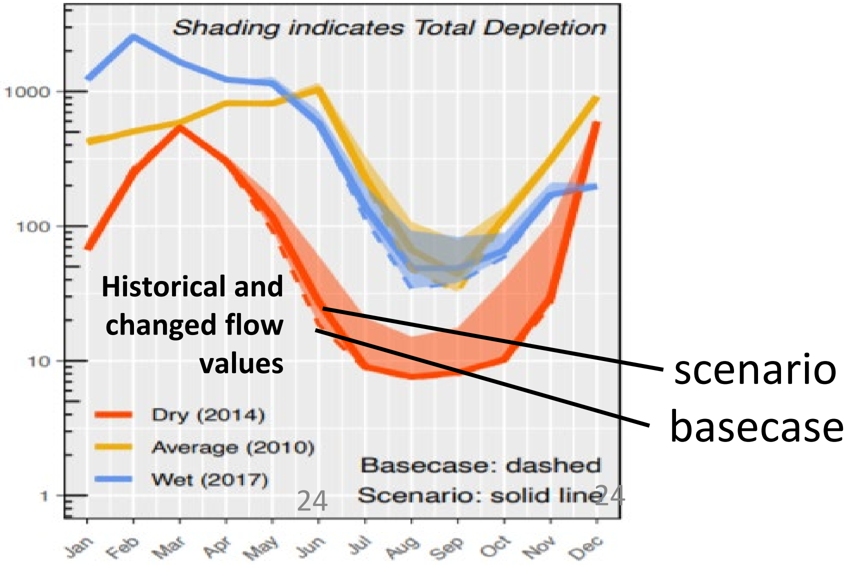
Managed Aquifer Recharge (MAR) and In-Lieu Recharge (ILR)











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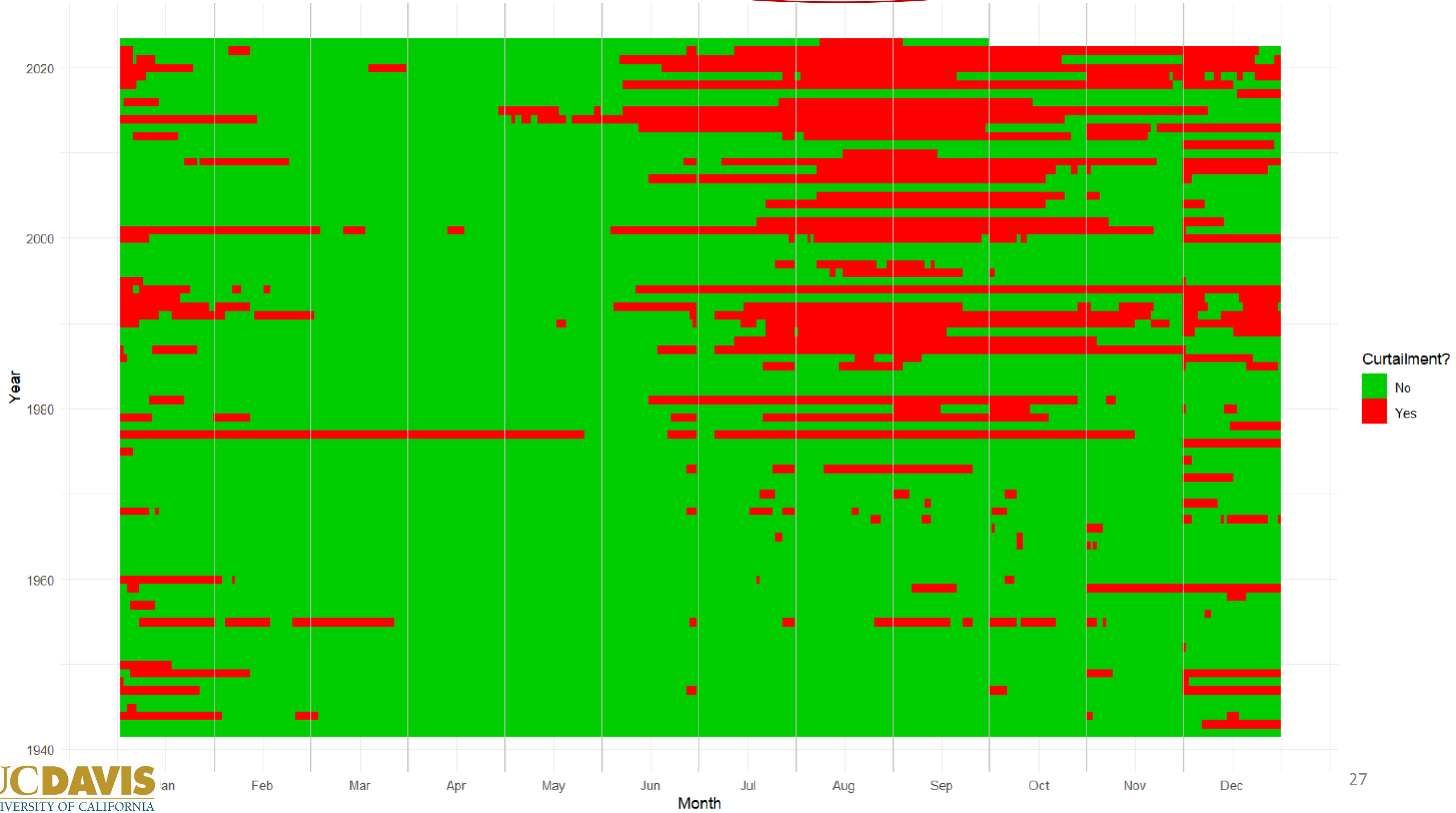
Graphs that show results for the entire year, for all years

Graphs that show results for the entire year, for all years

Timeline heatmap of “above threshold” (green) or “below threshold” Ft. Jones gage flows

Hypothetical historic curtailments in Scott Valley based on historic flows and 2021 SWRCB Emergency Flows, Pyschik and Harter, UC Davis 2023.



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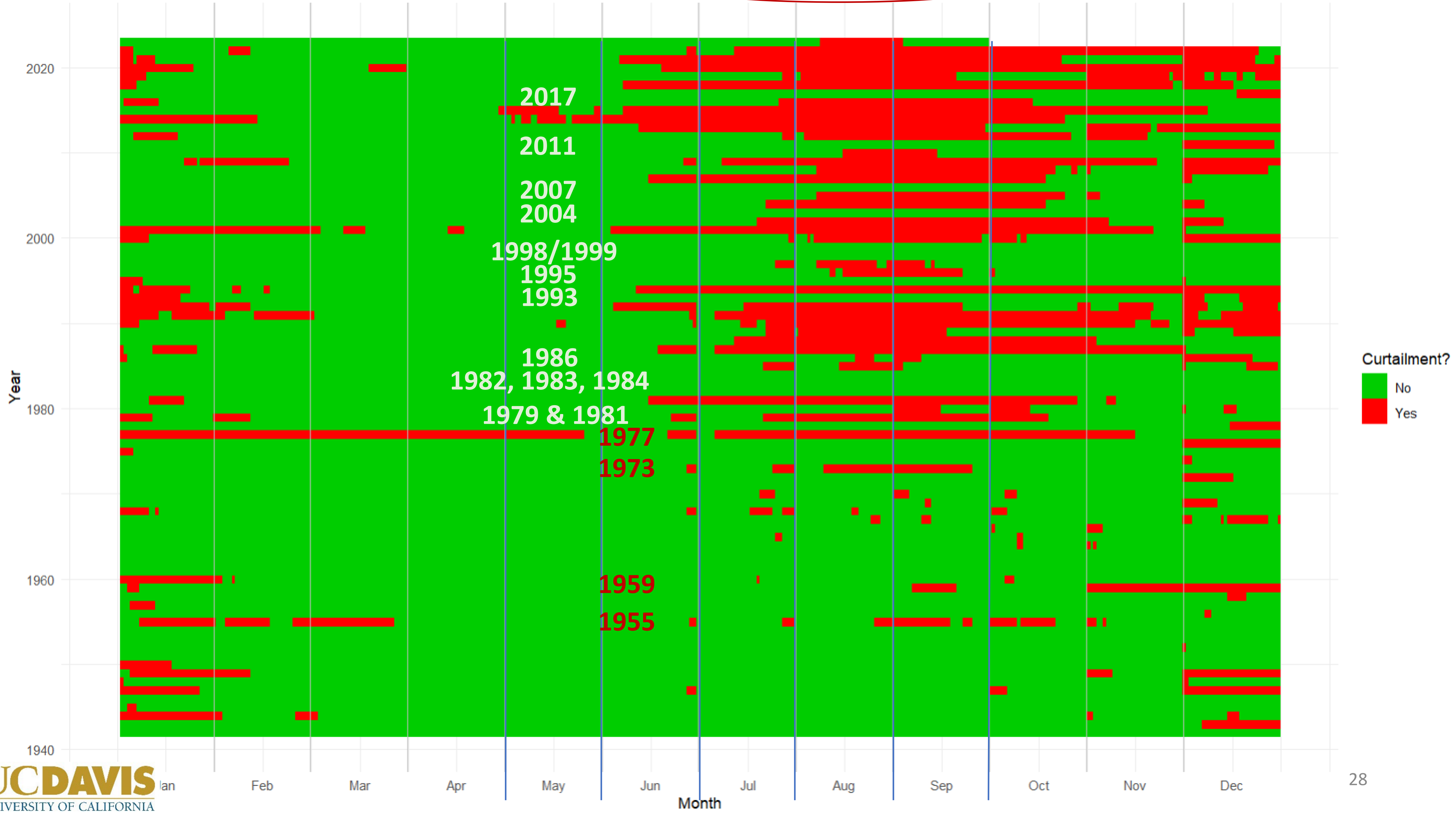

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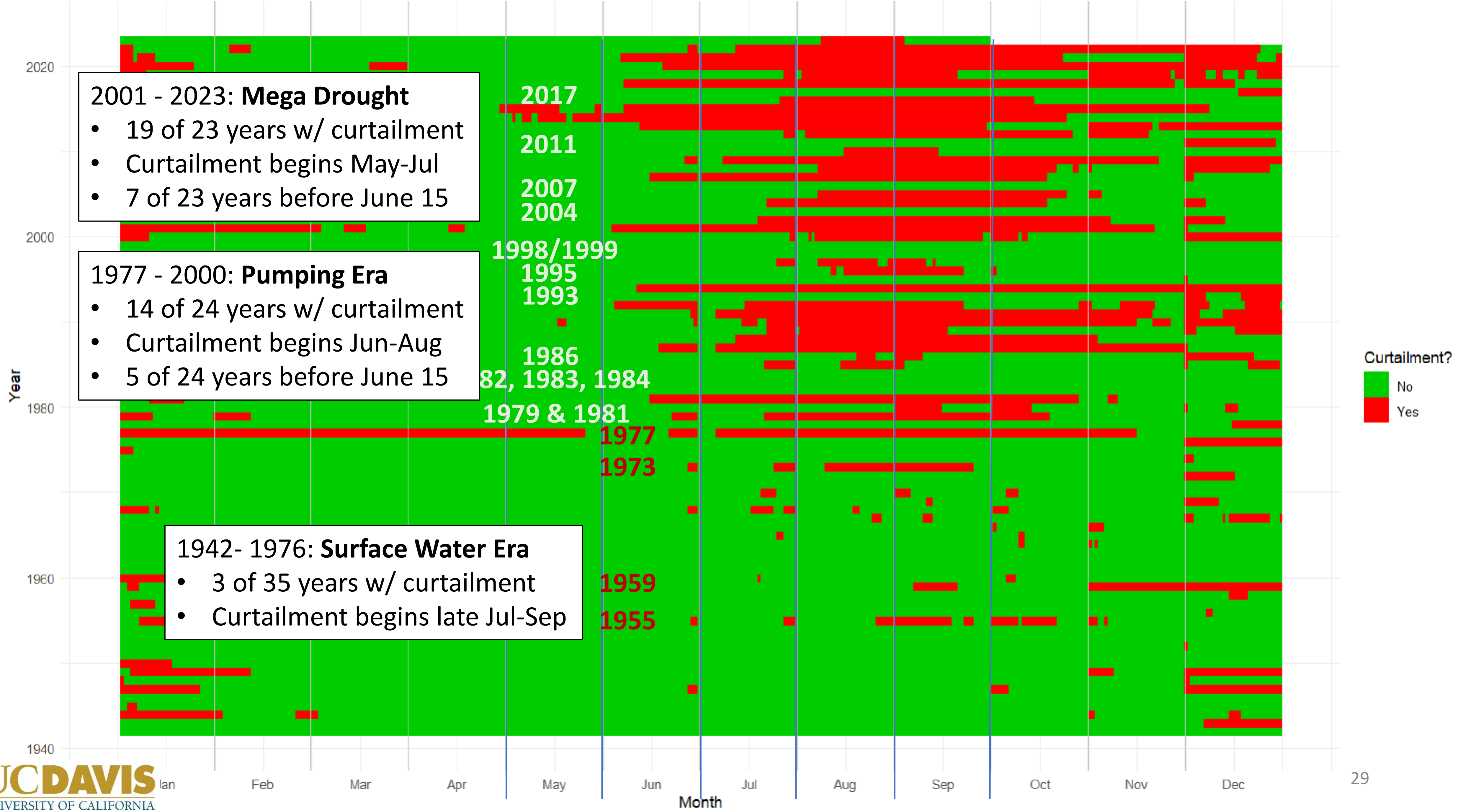

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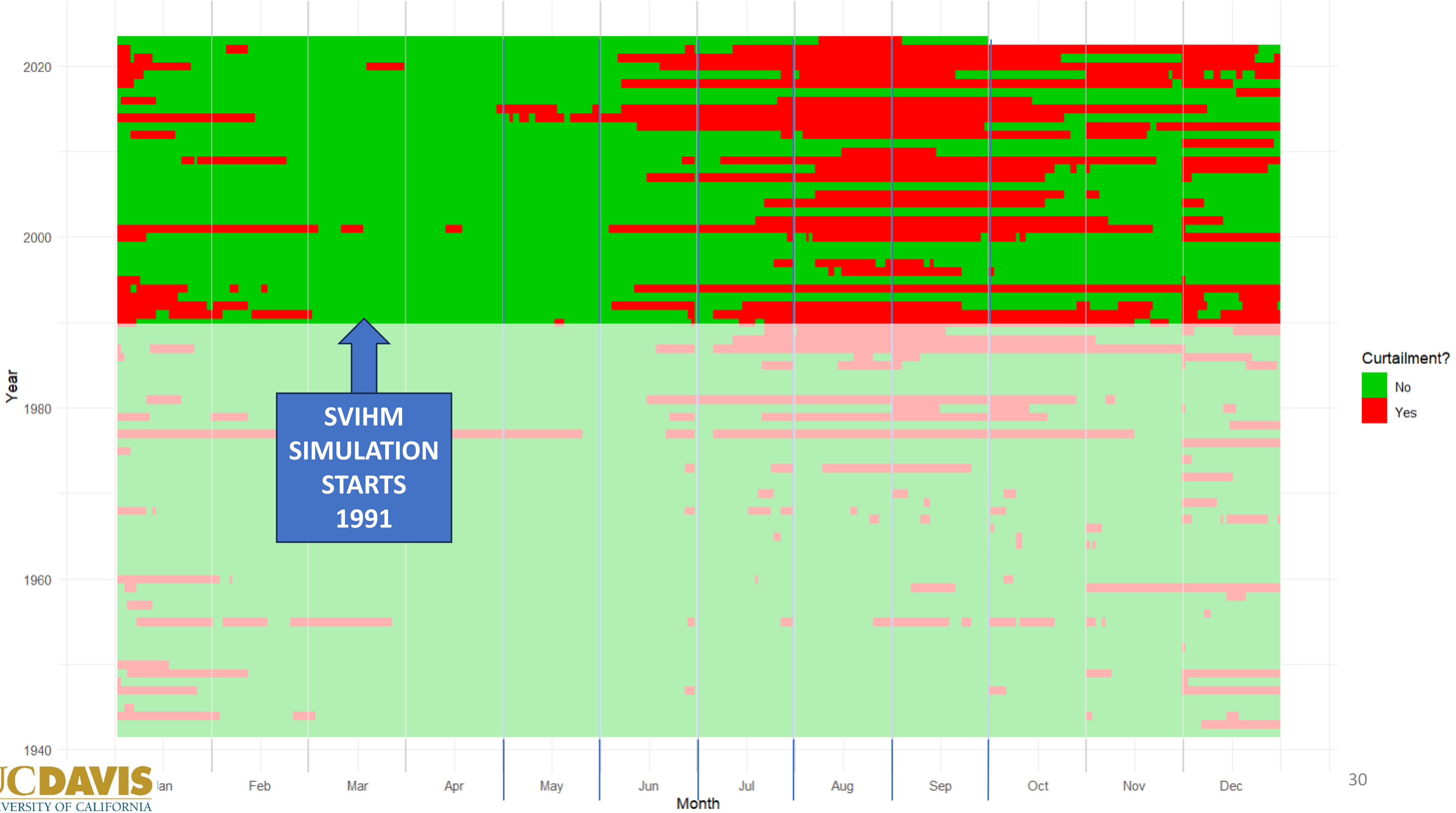

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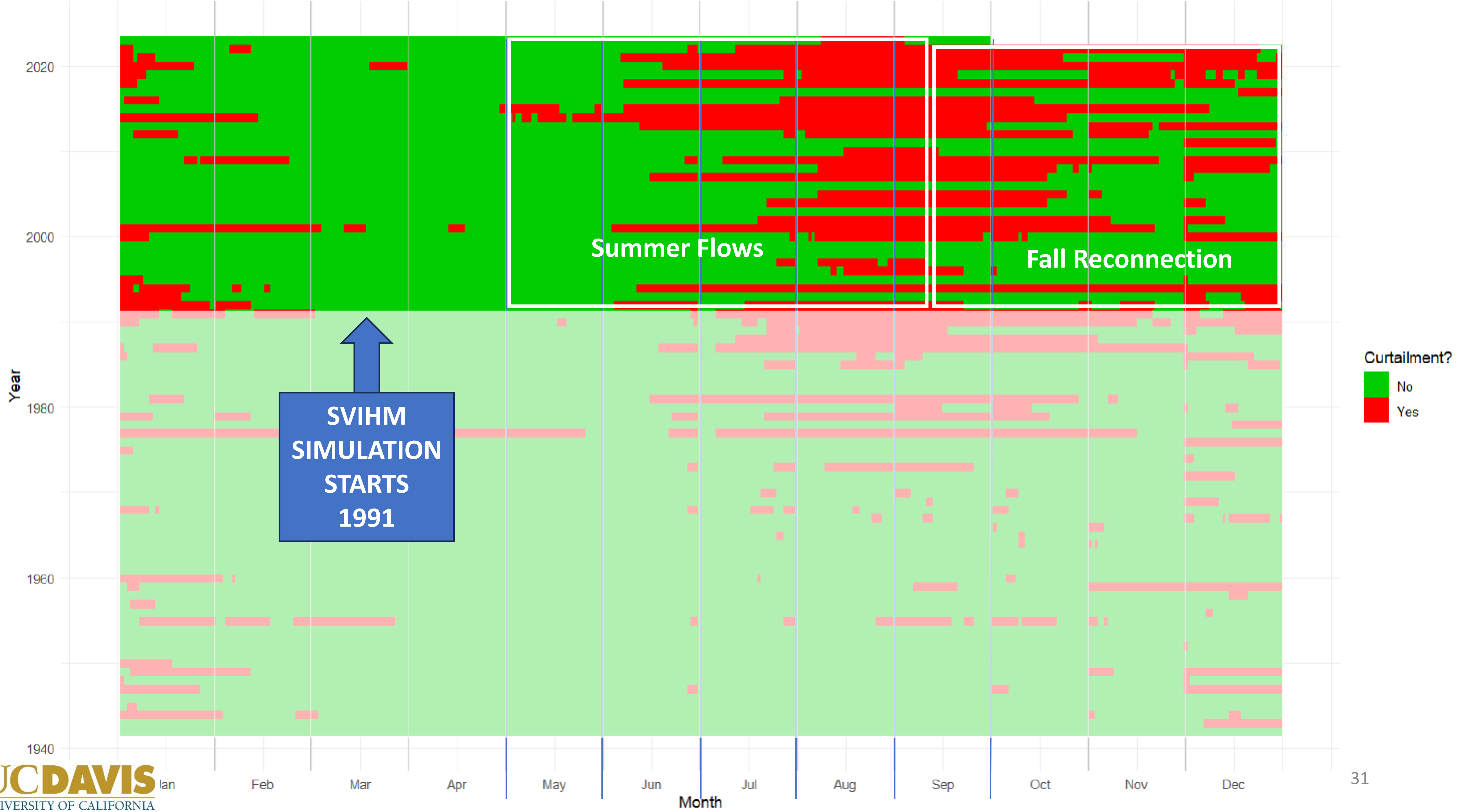

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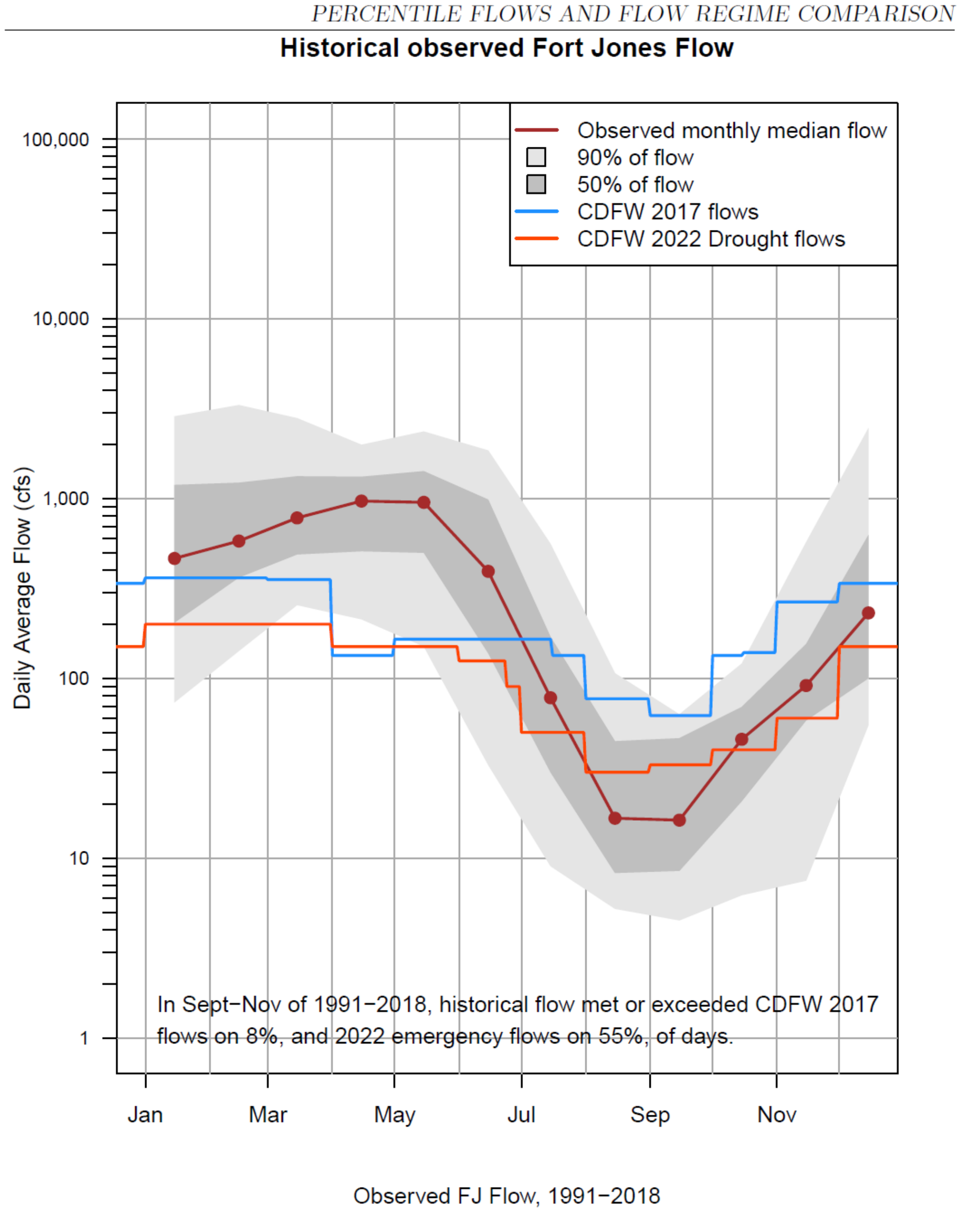
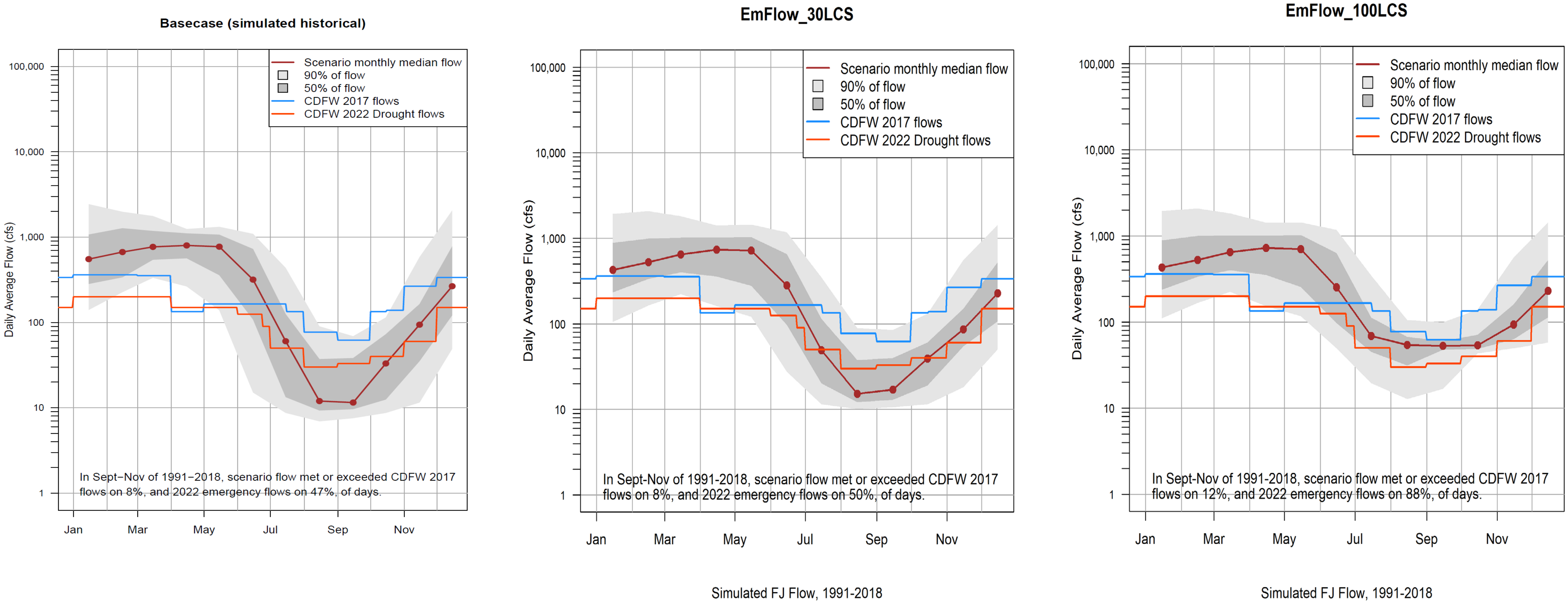
Summary of the **range of flows observed** in a given month at the Fort Jones gage

- Each month of 1991 – 2018:
  - January: range of average flow among 28 Januaries
  - February: range of average flow among 28 Februaries
  - ….
- Dark red line with dot: 14 years have flows above, 14 years have flows below (by month)
- Dark-shaded grey area: in half of years (14 years), monthly average daily flow was within this range (7 below the red line with dots, 7 above the red line with dots)
- Light-shaded grey area: 5 or 6 years were in this range (5 or 6 in the lower one, 5 or 6 in the upper one)
- Extreme years (1 in 10):
  - one or two years among the 28 falls below the lower the grey-shaded area and
  - one year or two years among the 28 that falls above the upper grey-shaded area
- Proposed in-stream flows:
  - Blue: CDFW 2017 instream flow table
  - Red: CDFW 2022 drought instream flow table
  - Red (in the GSP): USFS water right (similar to CDFW 2022)



Percentile Statistics of Monthly Fort Jones Gage Flow (from simulations)



- 1 in 4 years has flows in the lower light grey zone
- 1 in 20 years has flows that fall *below* the light grey zone

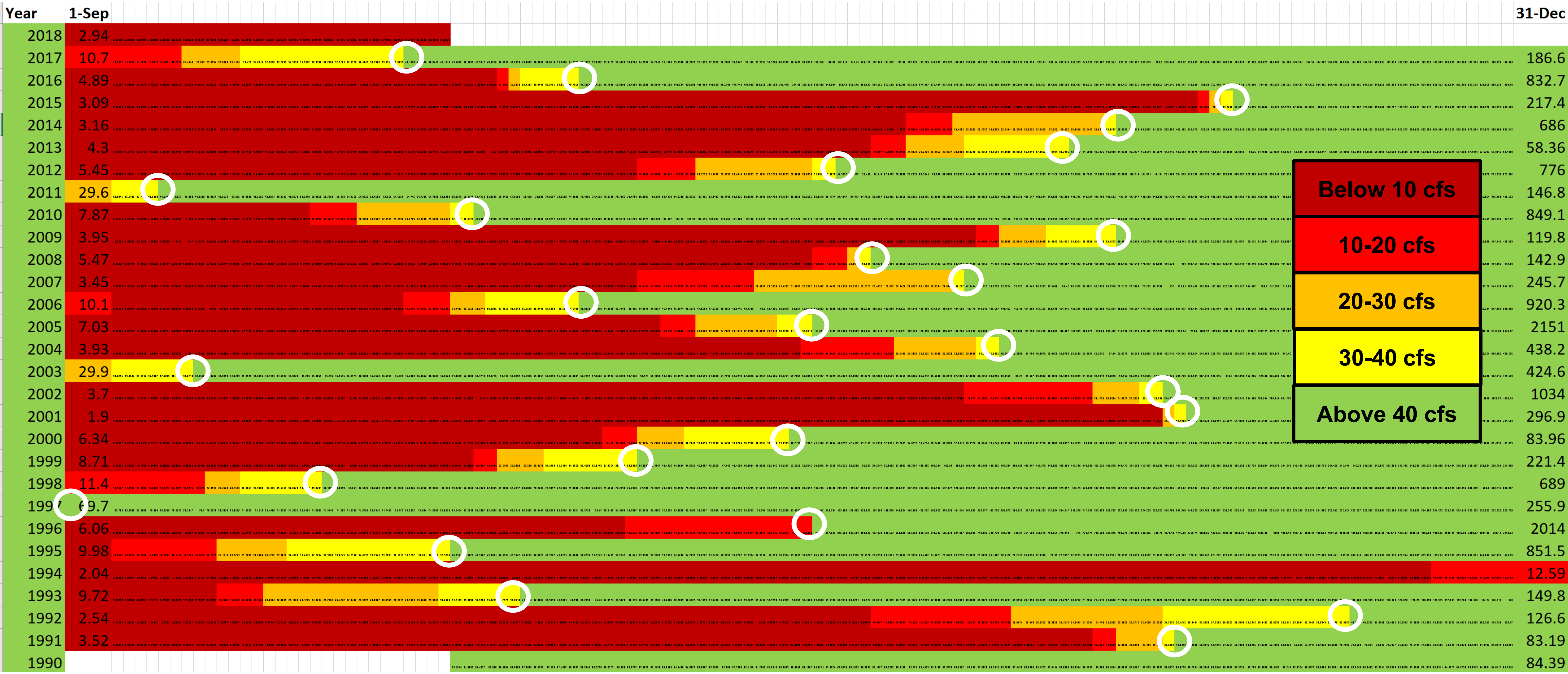
Looking specifically at **fall flow reconnection timing**

Fall Season Timeline Heatmap of Forth Jones Gage Flows:

Green = Good. Colored = below threshold

Trying to represent this in a more informative way:

Identify the day of the year when flows are above threshold



Trying to represent this in a more informative way:

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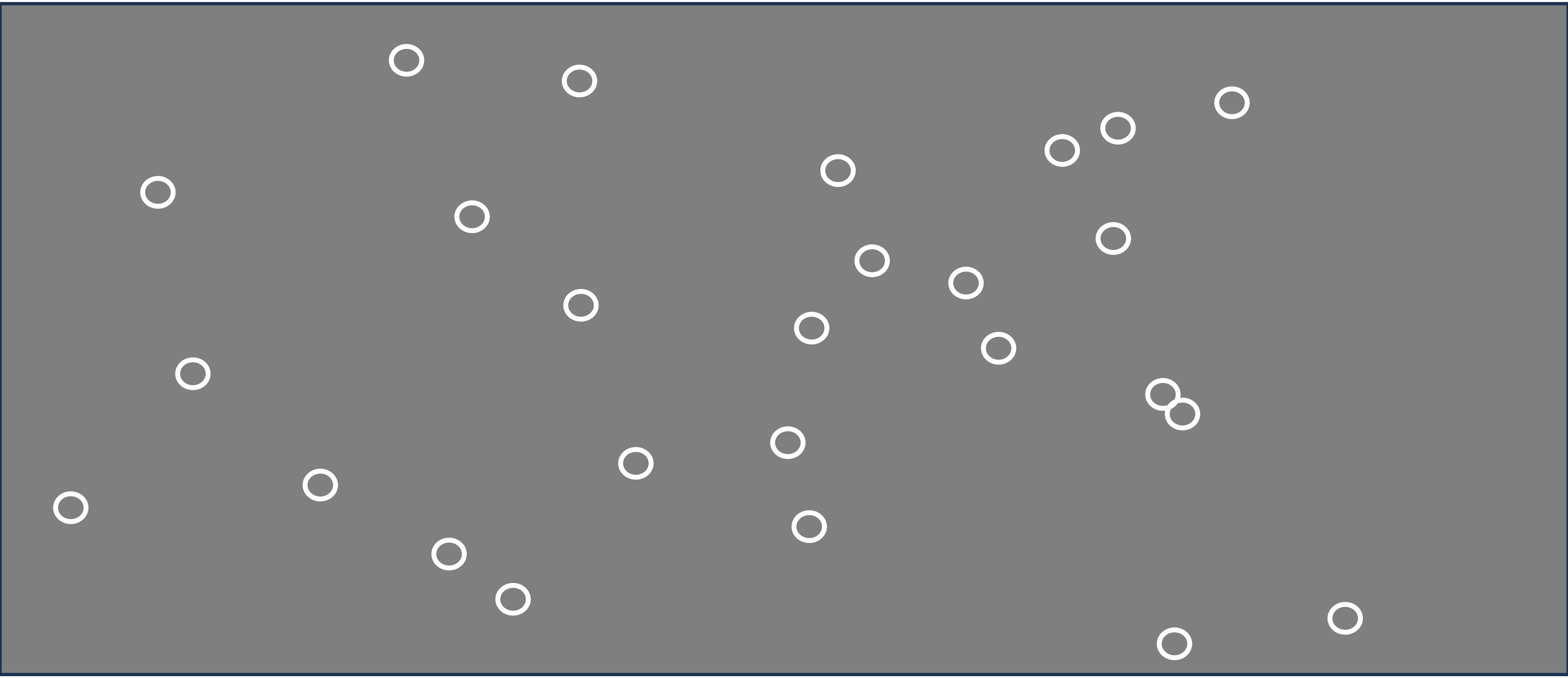
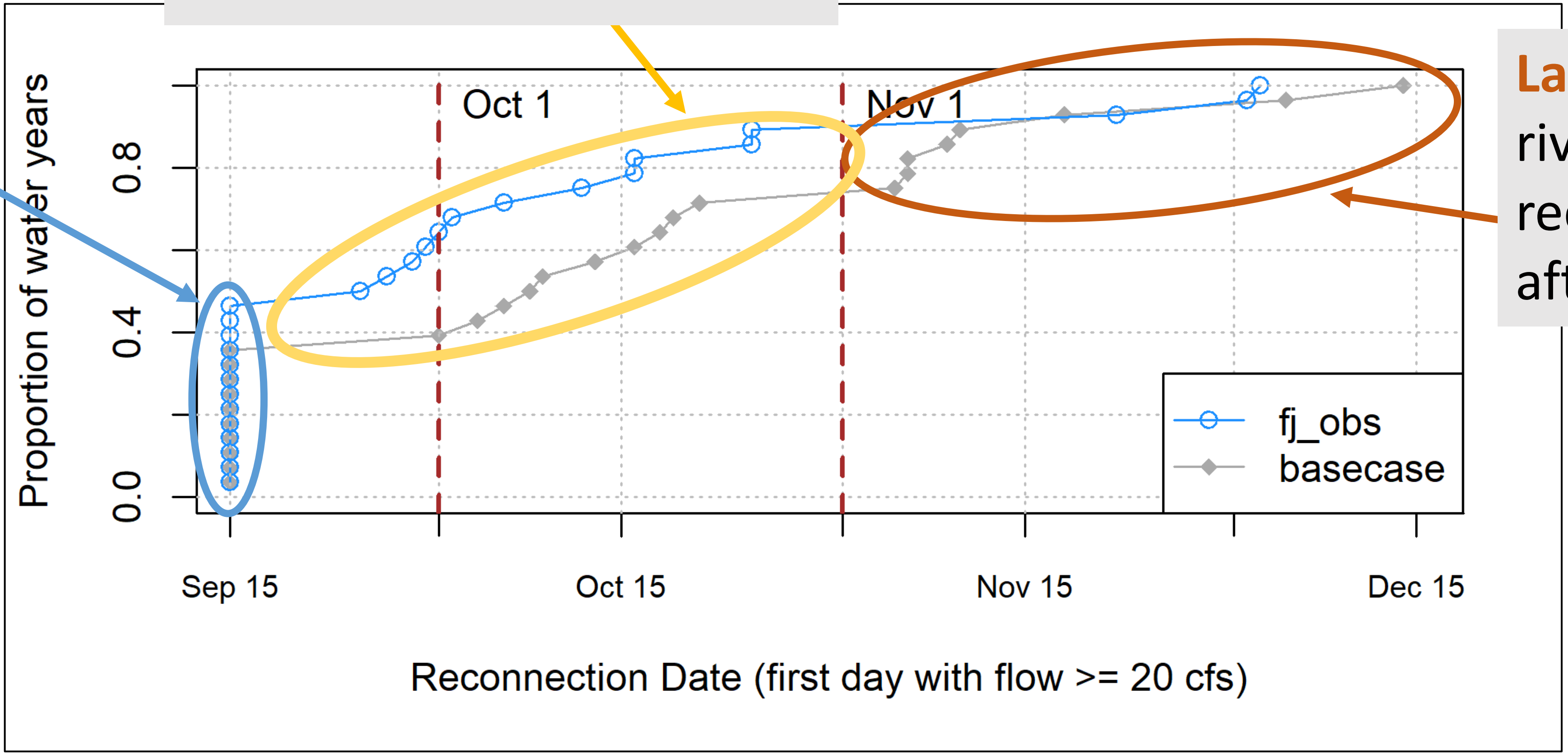


...and now **sort those points**:
from bottom to top = **early to late**

Intermediate years – river reconnected Sept. 15 – Nov. 1

Early years – river reconnected on or before Sept. 15



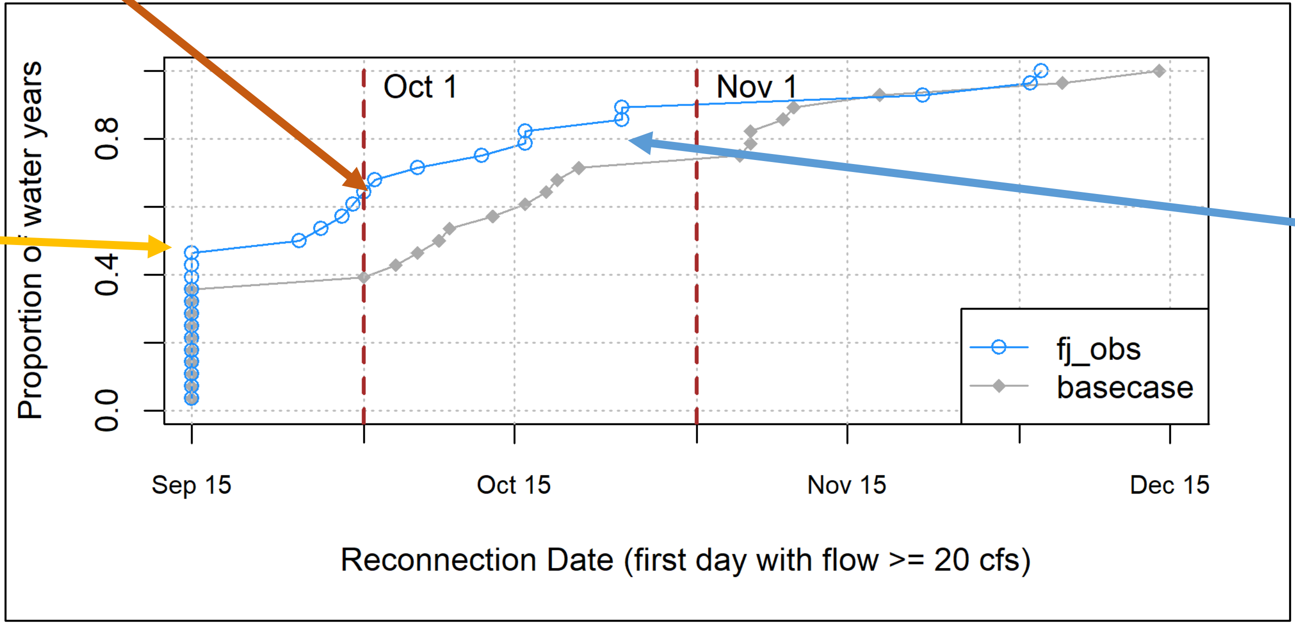
Late years – river reconnected after Nov 1

“Reconnection date distribution” graph

How to read this graph: In the years 1991-2018, the FJ gauge “reconnected”* **on or before Oct. 1** in ~**63%** of years.

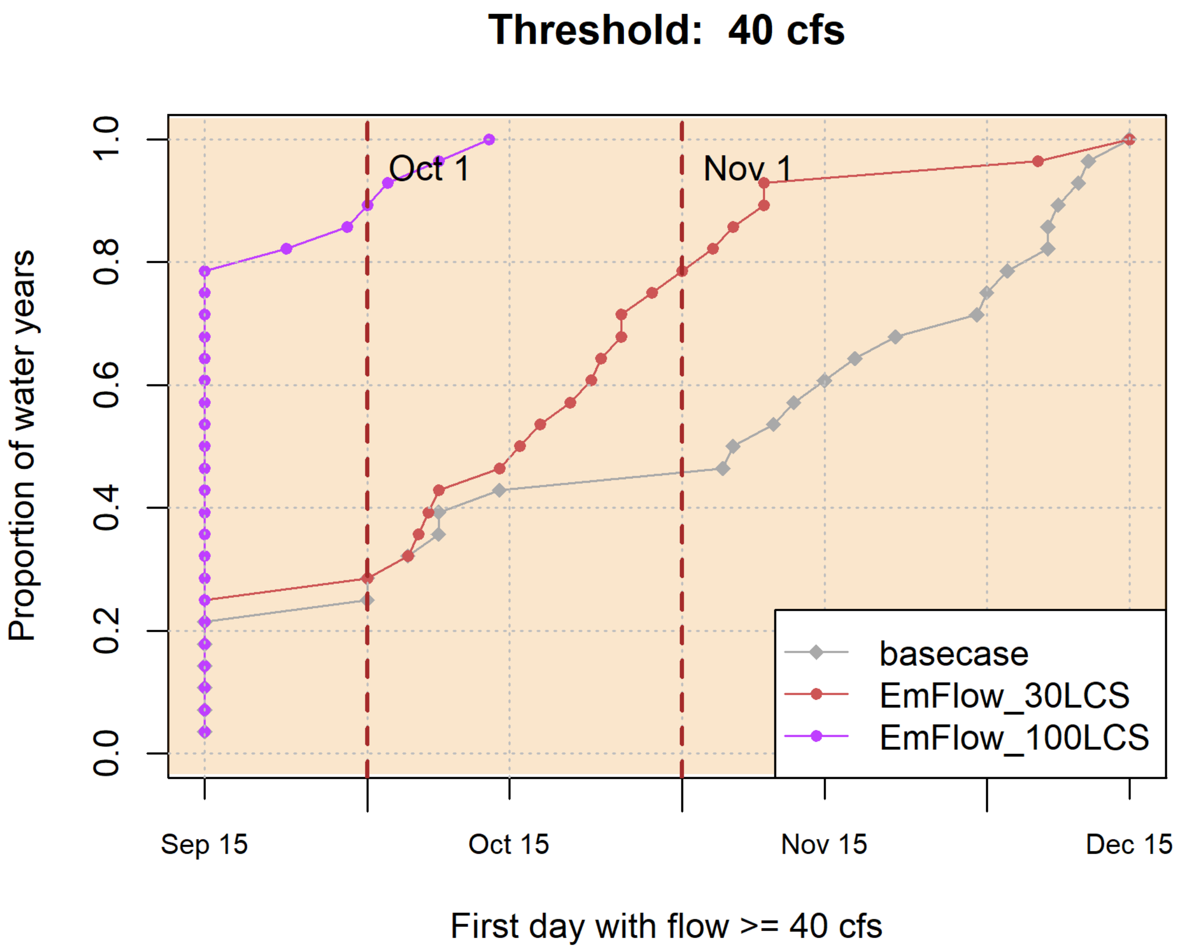
* flow gauge measured flow > 20 cfs

Notes on model performance:
The basecase simulates 10 years reconnecting before Sept 15 **(early years)**; in the observed record it’s 13 years.



Notes on model performance:
The discrepancies between the observed and simulated basecase distributions are another reason to think of scenario results as “relative change” rather than an exact prediction of future conditions.

Fall Reconnection Date, 1991-2018
– sorted early to late



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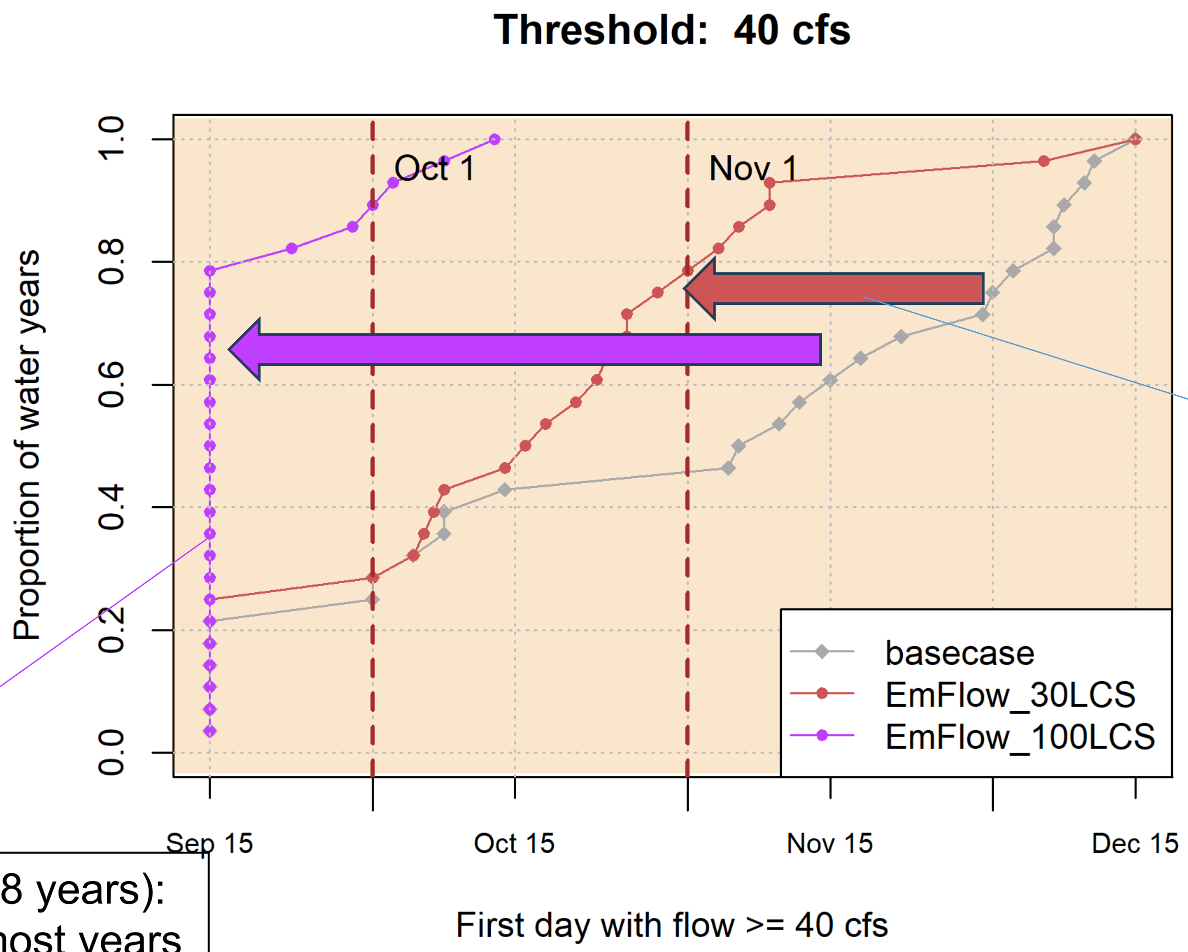
Fall Reconnection Date, 1991-2018 – sorted early to late



2022-like curtailment:
1 month earlier in all but the driest years

Full curtailment (in 20 of 28 years):
No loss of connection in most years

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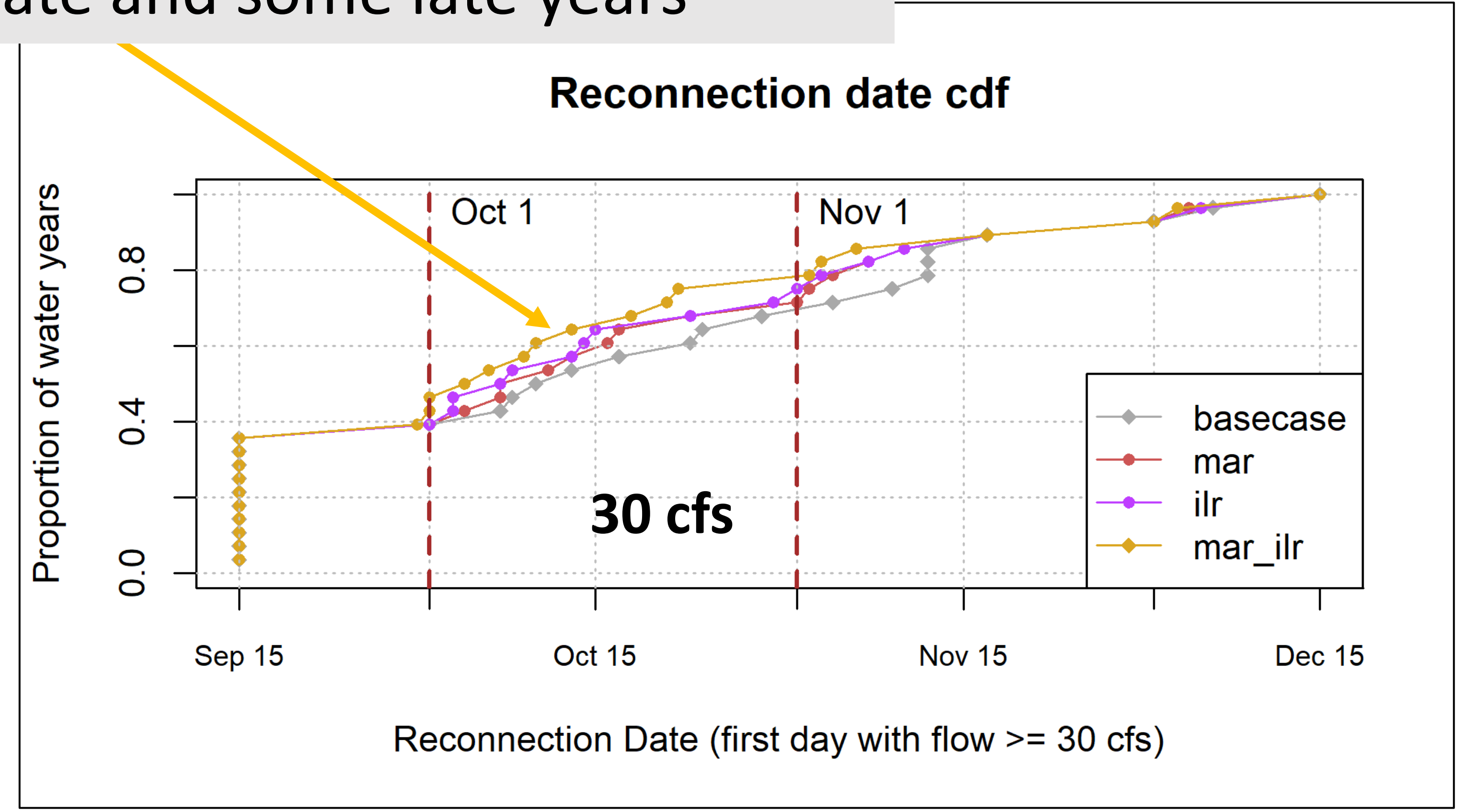
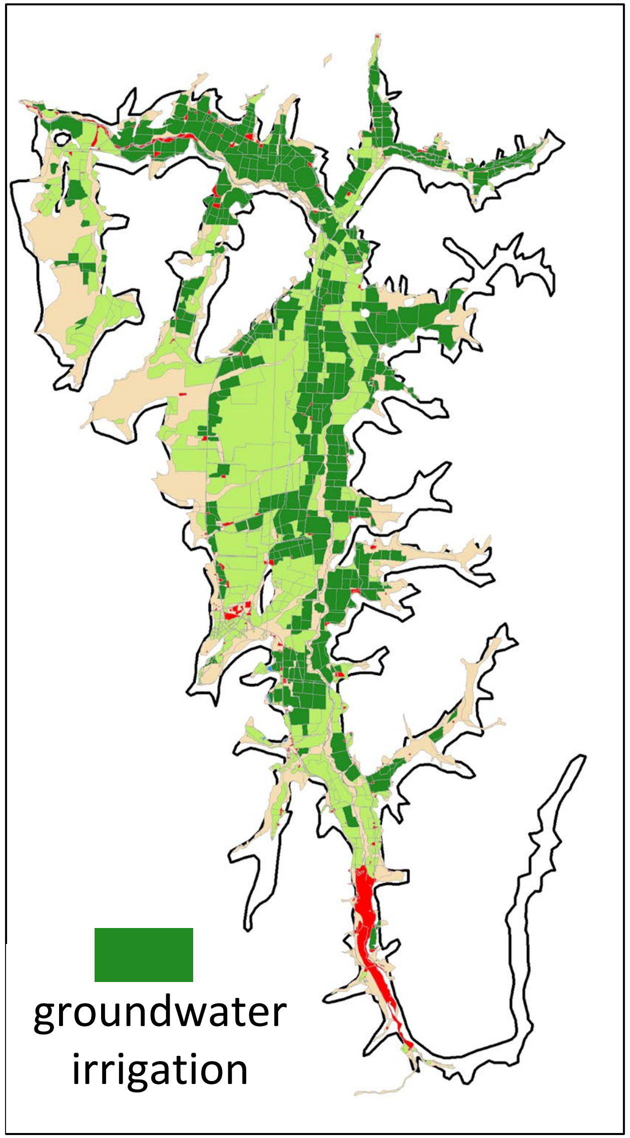
“Reconnection date distribution” graphs

Using them to explore an scenario option

MAR+ILR: Aim for a gain of 7-10 days in intermediate and some late years



Groundwater Irrigation Terminates on August 1 (annually)



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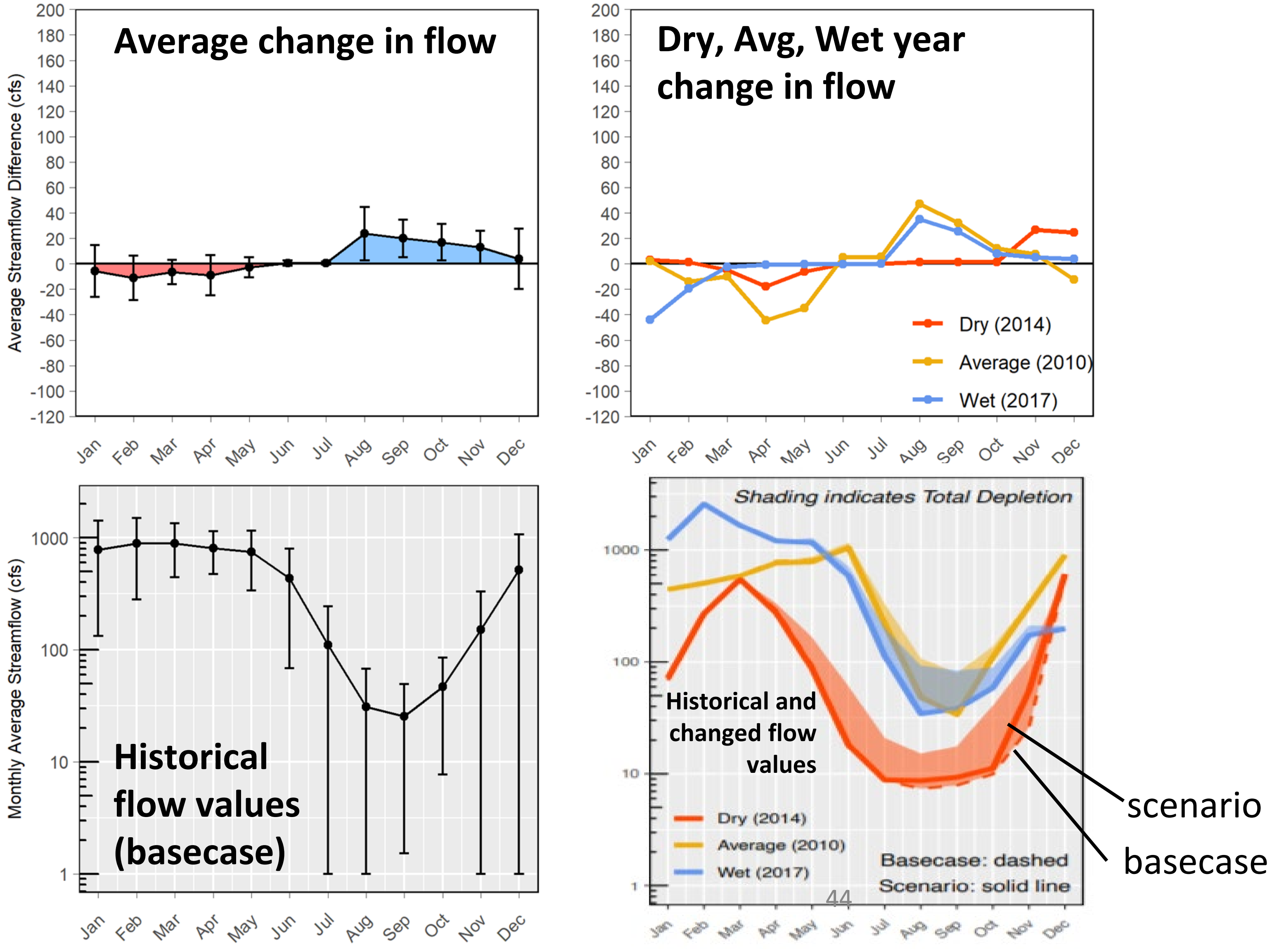

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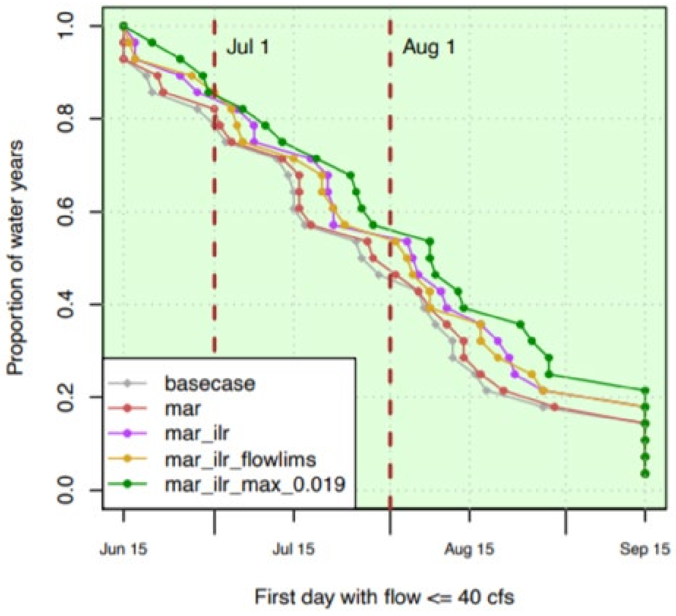
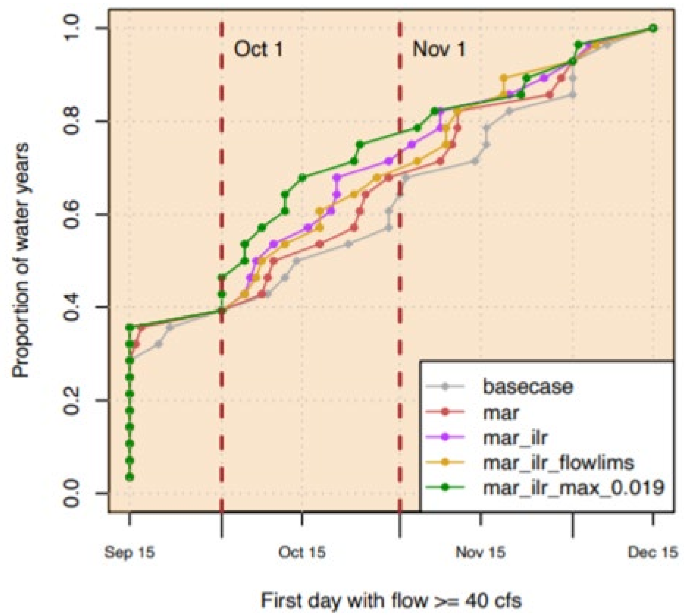
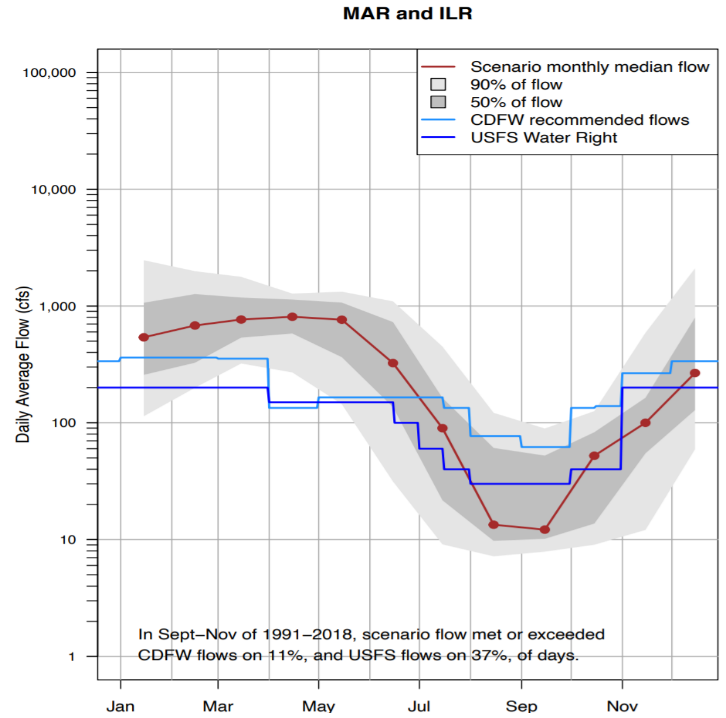
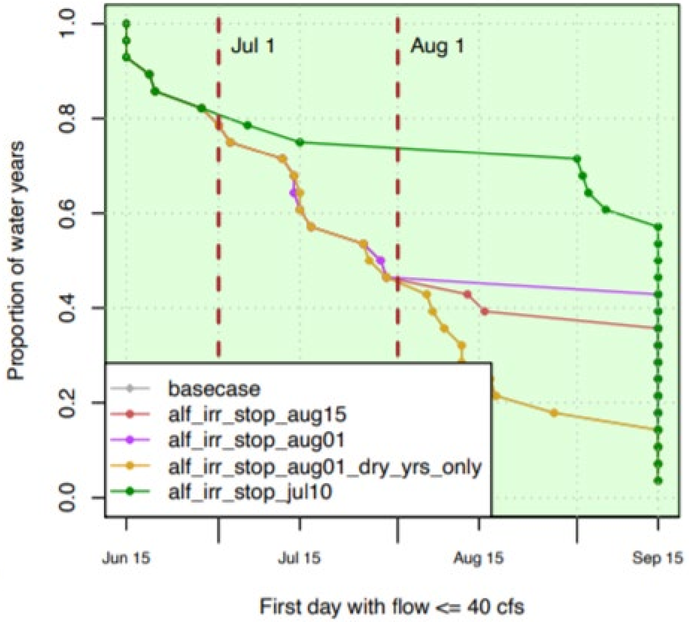
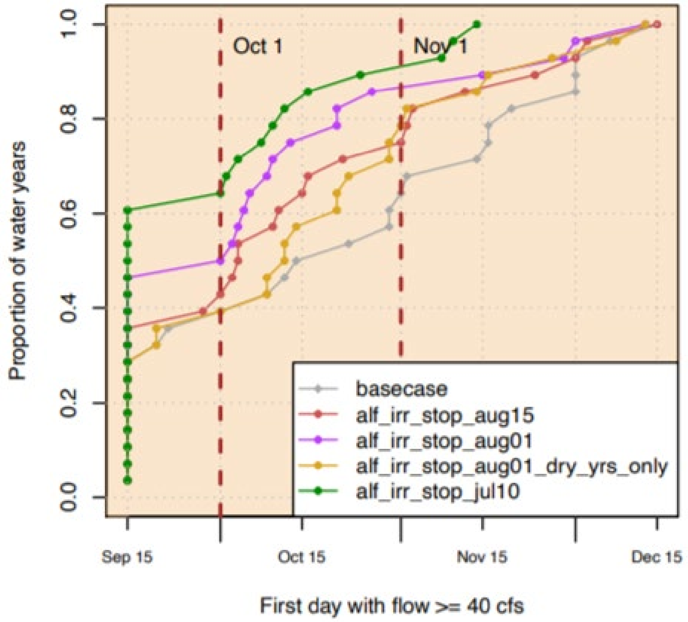
Statistical Analysis:
Disconnection Reconnection, By-Month-Ranges

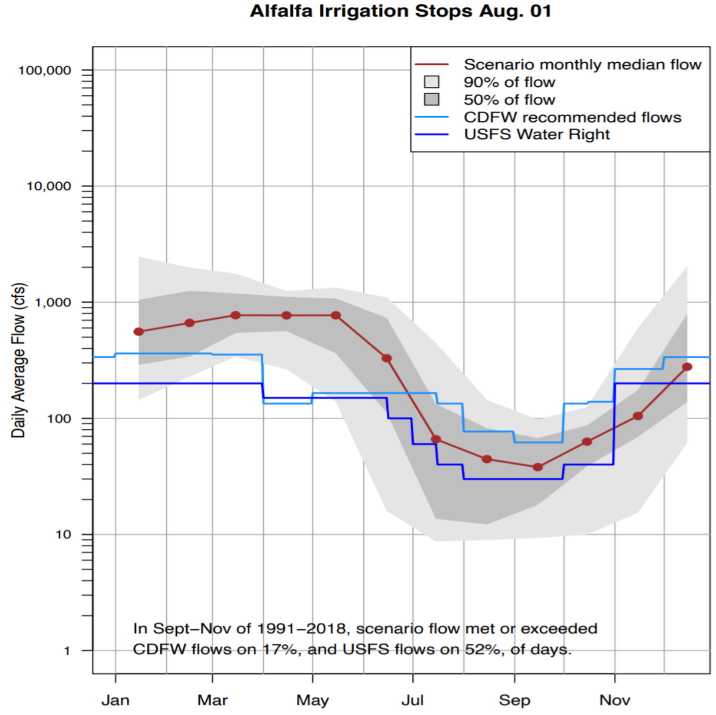












Scott Valley Groundwater Sustainability Plan, 2022

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