

May 24, 2017

## Groundwater: Pathways to Sustainability



Thomas Harter  
University of California Davis  
[ThHarter@ucdavis.edu](mailto:ThHarter@ucdavis.edu)

<http://groundwater.ucdavis.edu>



Photo: Justin Sullivan / Getty Images



Lake Mendocino, 12/2013

Jay Jasperse / SCWA



  
Do not use this water for drinking  
No utilice esta agua para beber

Jim Wilson/ The New York Times

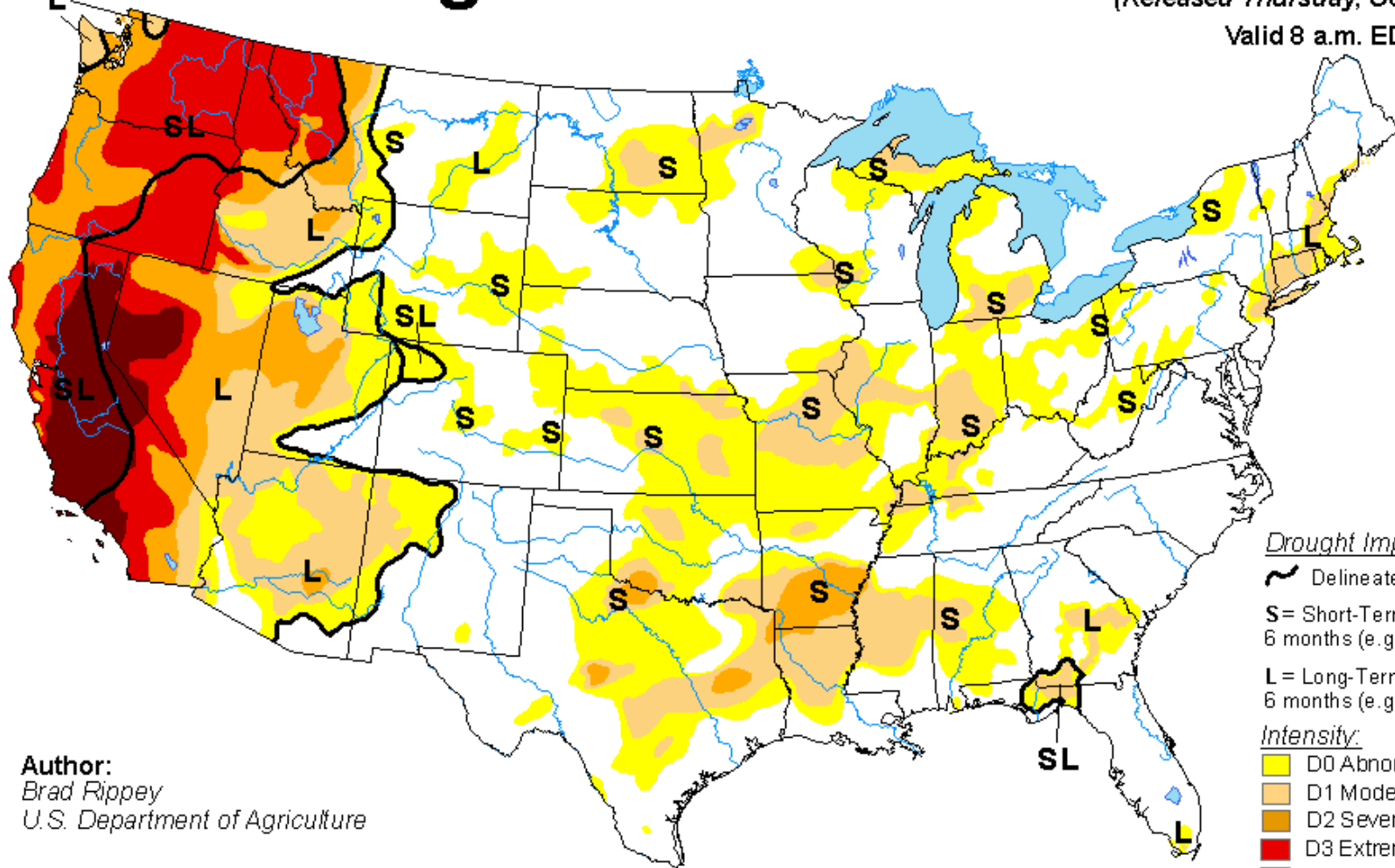


# U.S. Drought Monitor

October 27, 2015

(Released Thursday, Oct. 29, 2015)

Valid 8 a.m. EDT



Author:  
Brad Rippey  
U.S. Department of Agriculture

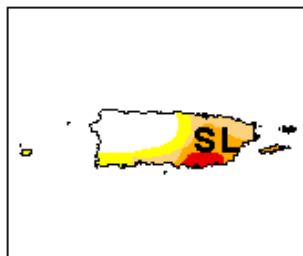
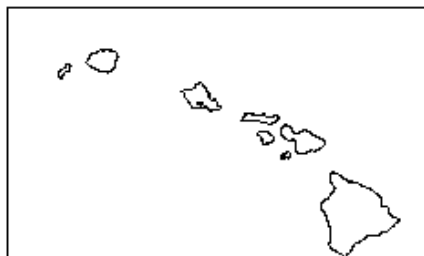
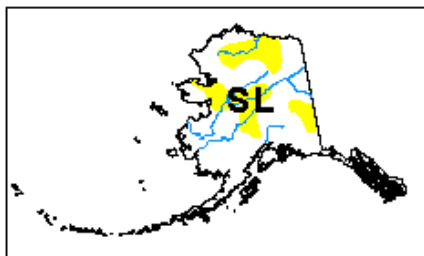
### Drought Impact Types:

- ~ Delineates dominant impacts
- S = Short-Term, typically less than 6 months (e.g. agriculture, grasslands)
- L = Long-Term, typically greater than 6 months (e.g. hydrology, ecology)

### Intensity:

- Yellow: D0 Abnormally Dry
- Light Orange: D1 Moderate Drought
- Orange: D2 Severe Drought
- Red: D3 Extreme Drought
- Dark Red: D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.



<http://droughtmonitor.unl.edu/>





sfgate.com







sfgate.com

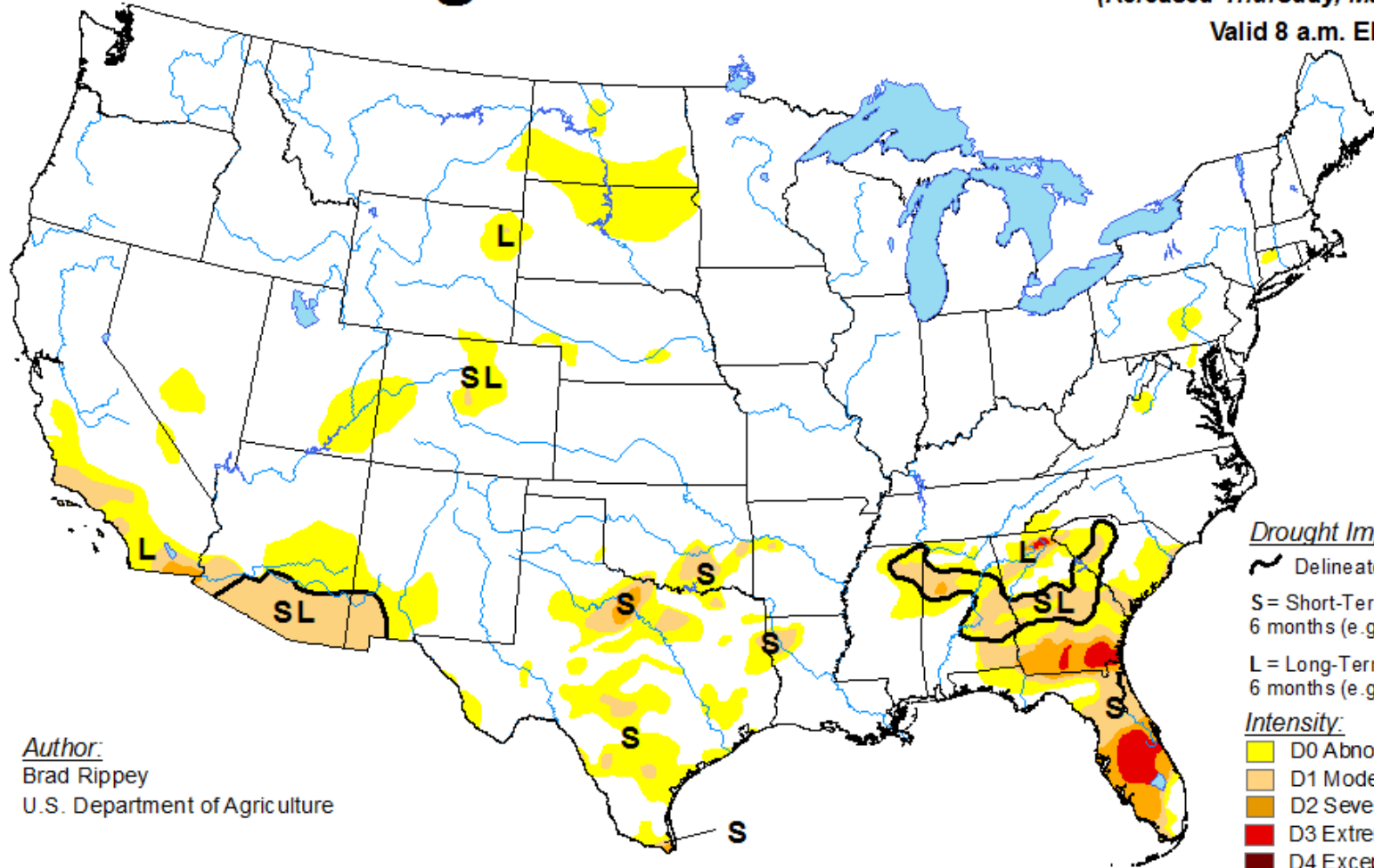
Is the Drought Over?

# U.S. Drought Monitor

May 16, 2017

(Released Thursday, May. 18, 2017)

Valid 8 a.m. EDT



### Drought Impact Types:

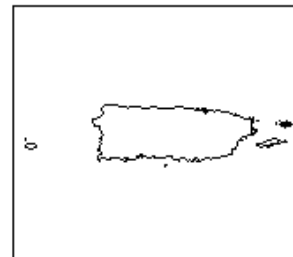
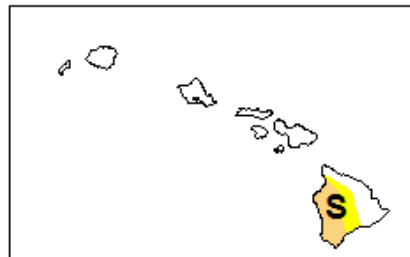
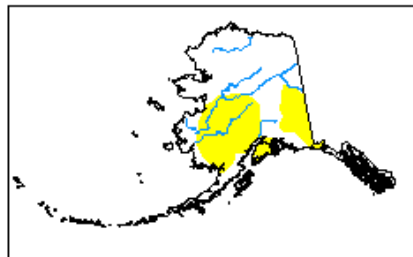
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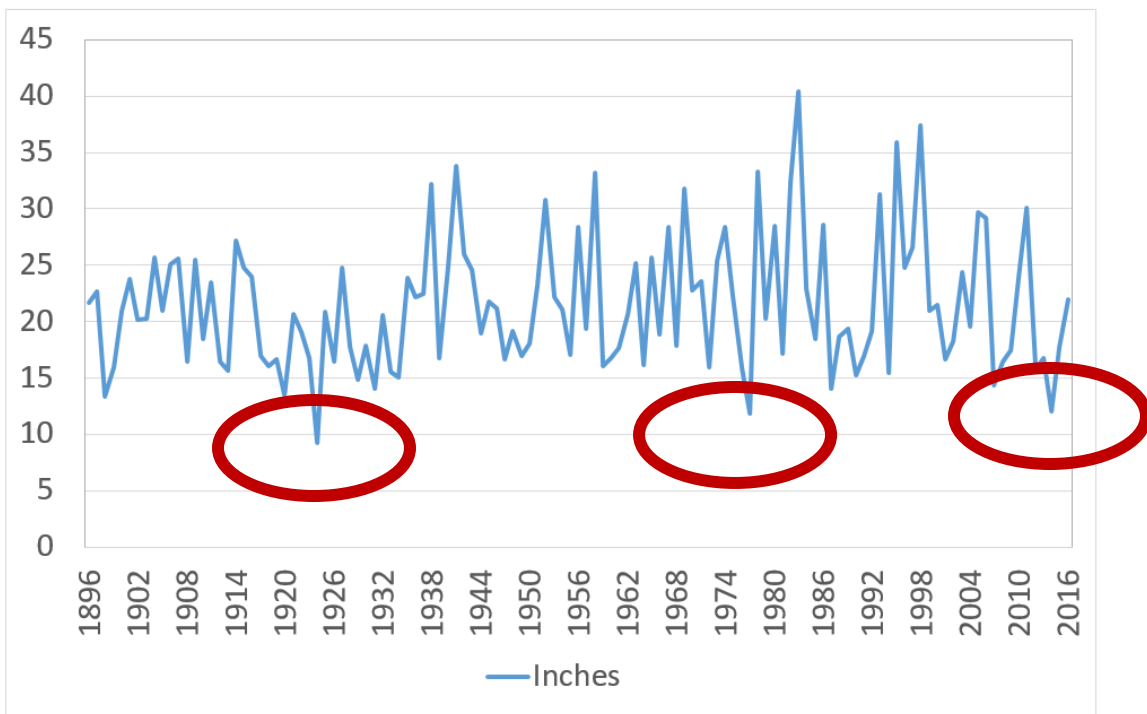
Author:  
Brad Rippey  
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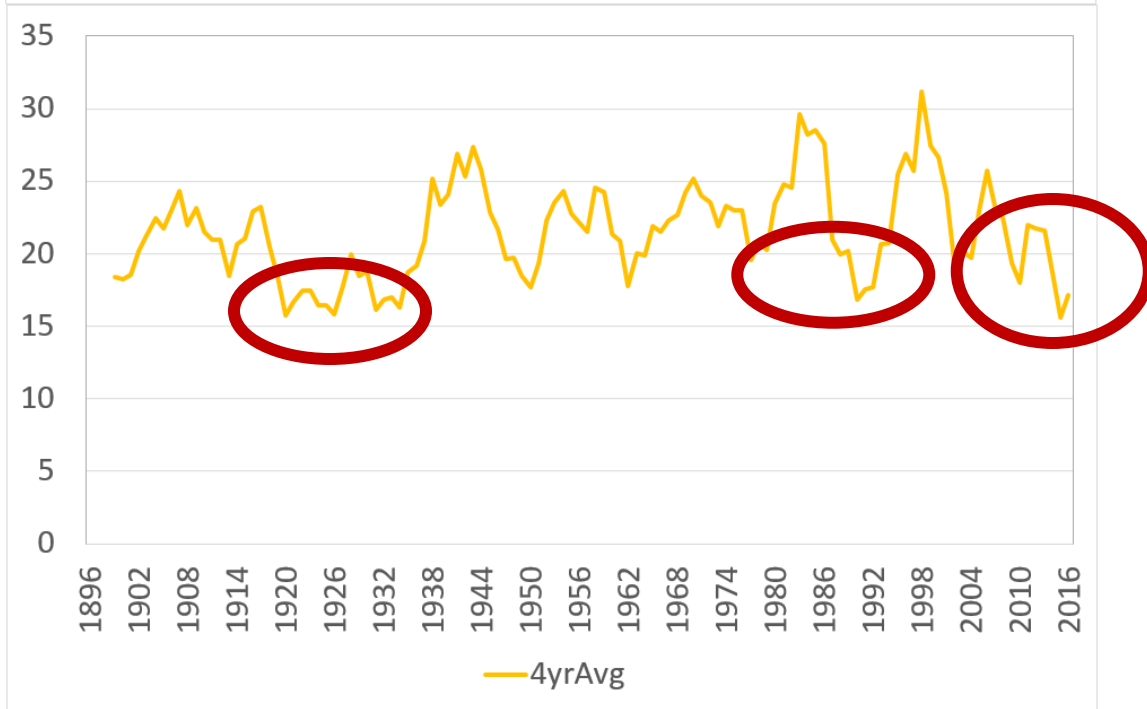


<http://droughtmonitor.unl.edu/>

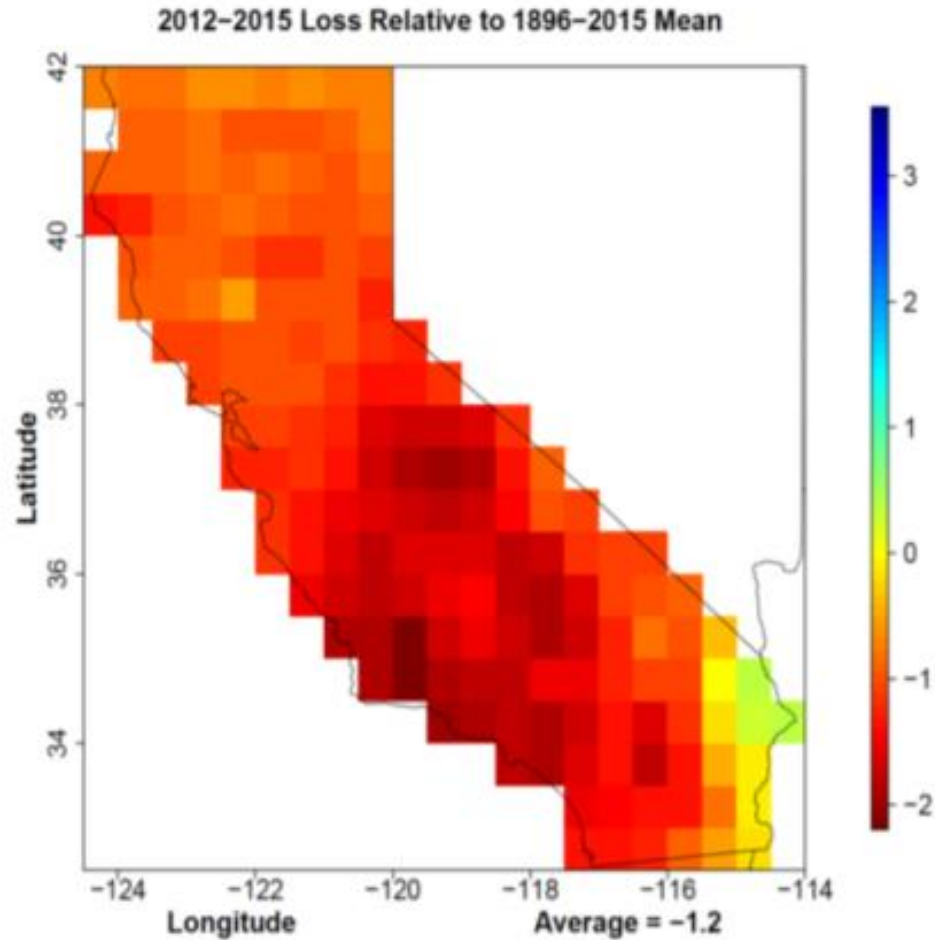
# Annual Precip [inches]



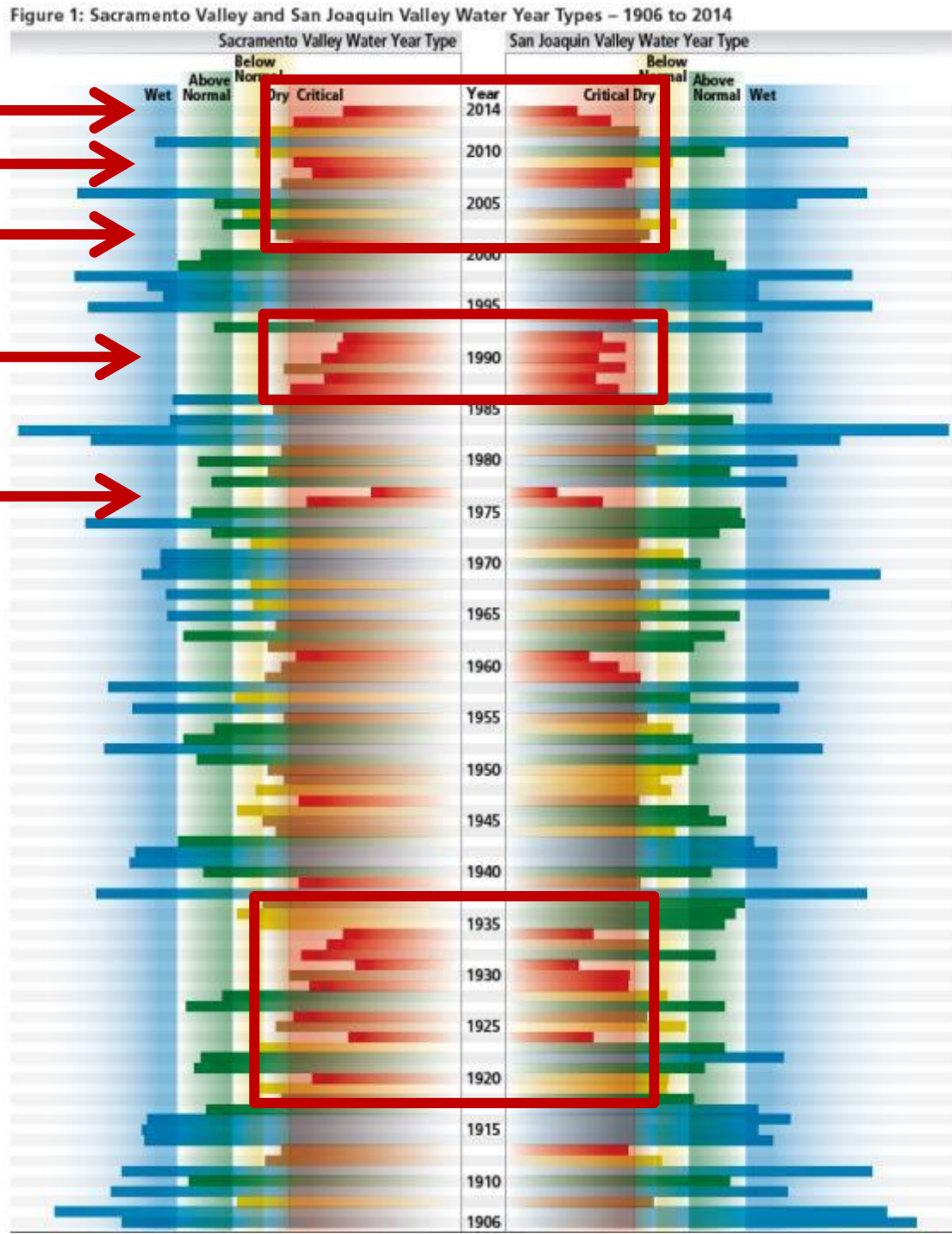
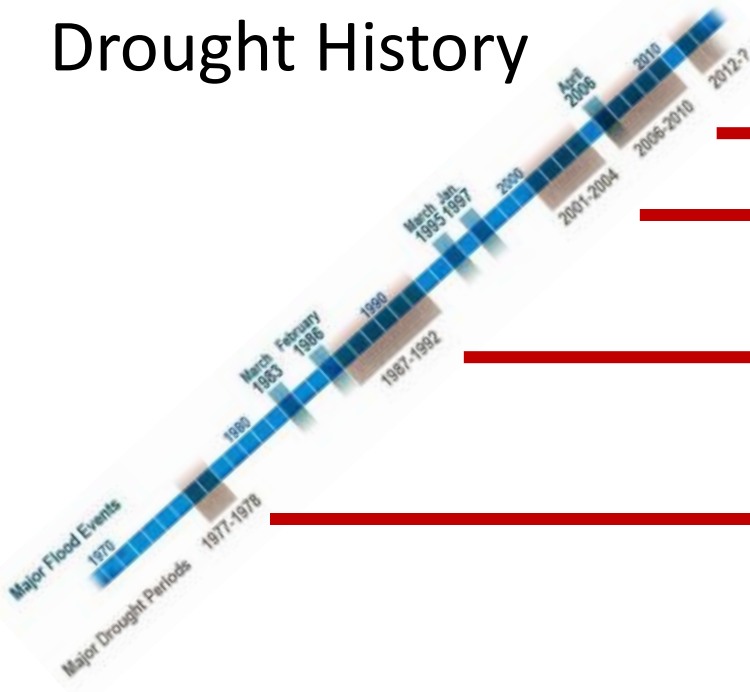
# 4-Year Precip [inches]



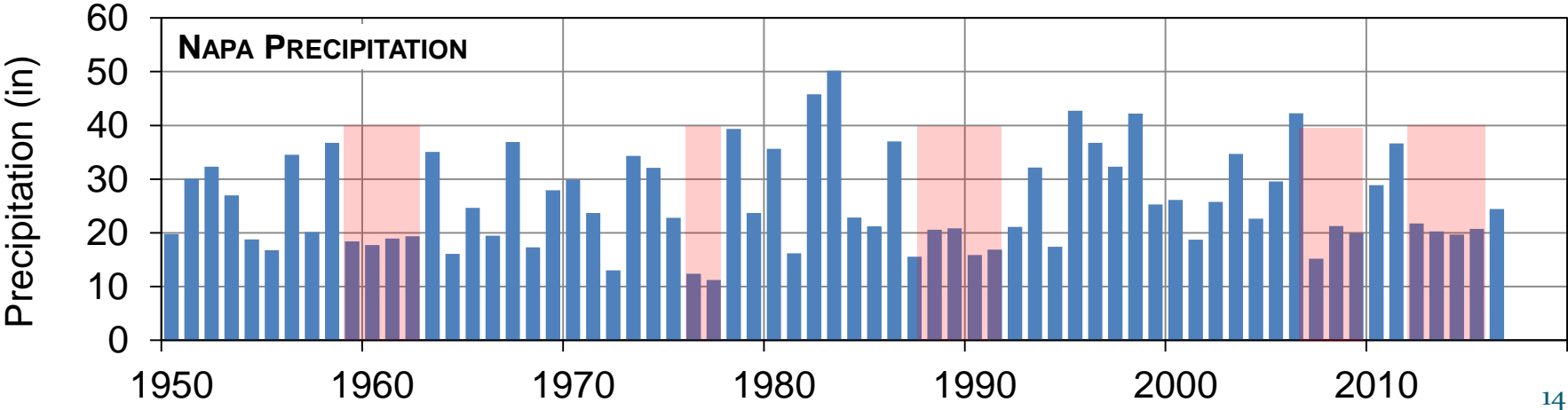
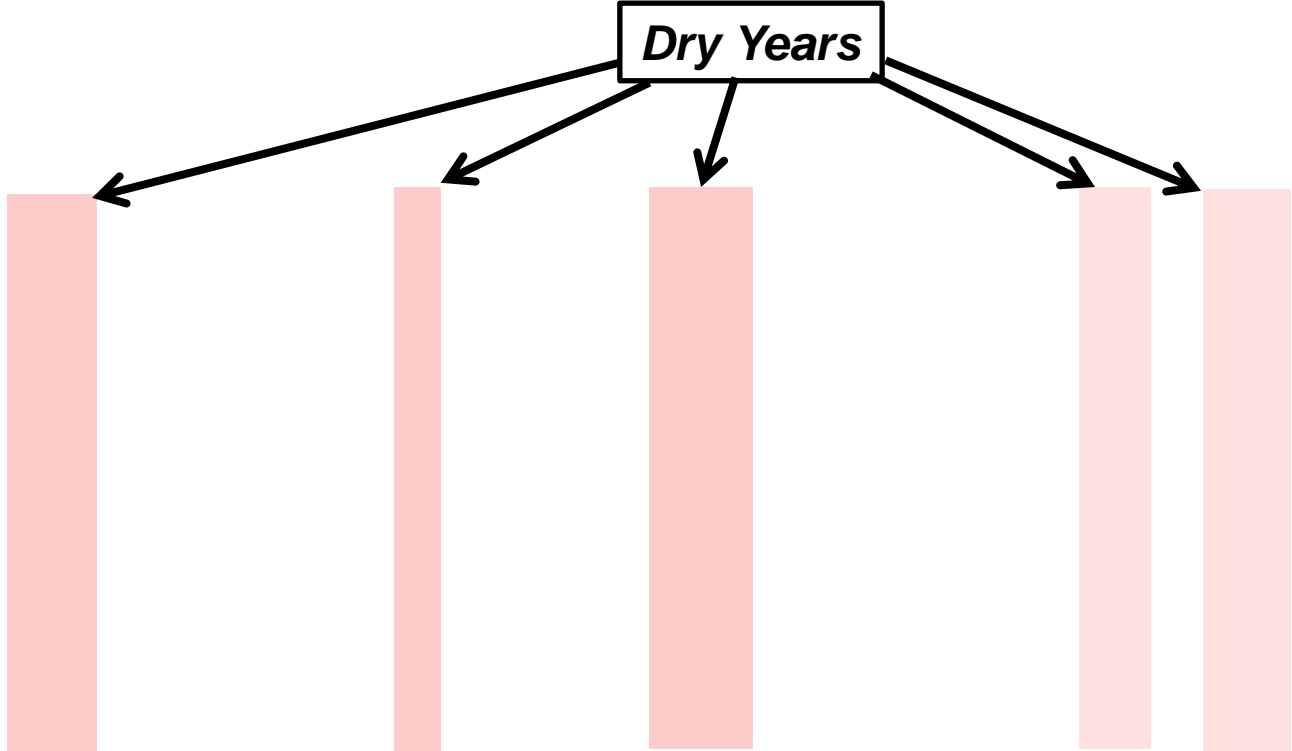
# Total Precipitation Shortfall, 2012 through 2015 [measured relative to average year precipitation]



# Drought History



# Napa Valley Precipitation

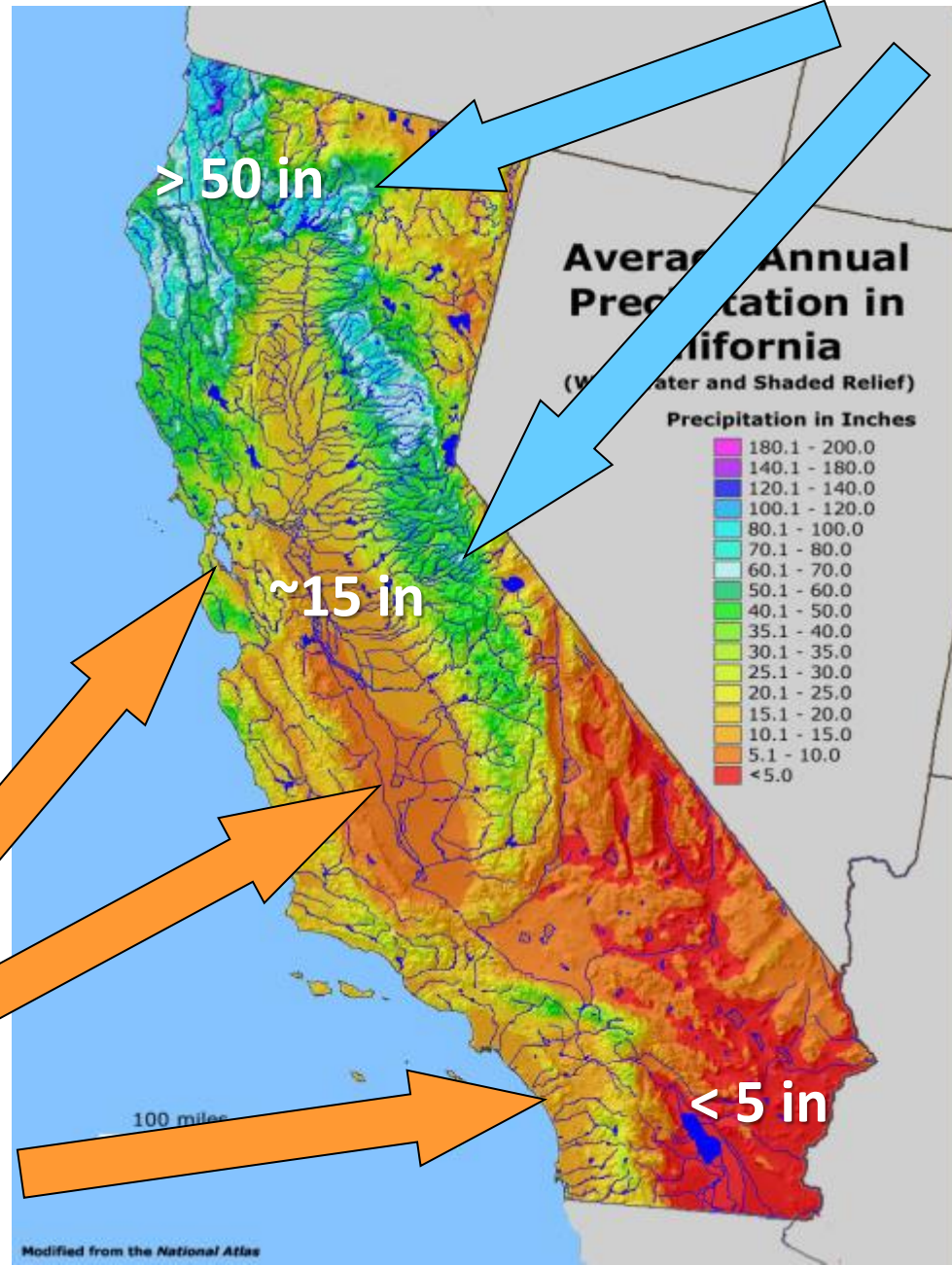


Modified From: Vicki Kretsinger-Grabert, LSCE, Report to Napa County BOS, April 2017

**RAIN**

Space and Time  
Disconnect  
between  
Water Supply  
and  
Water Use

**WATER USERS**

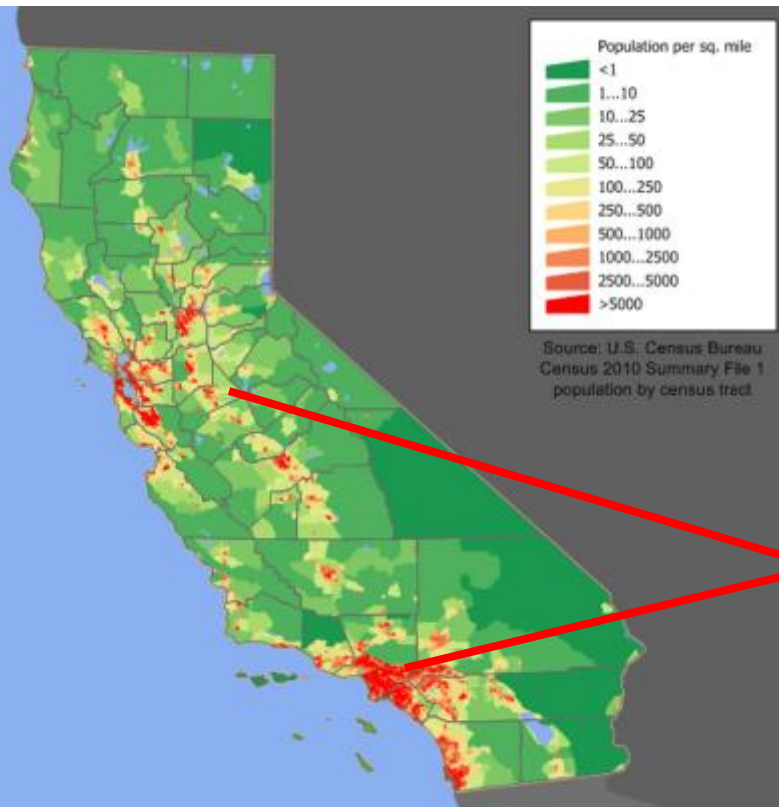
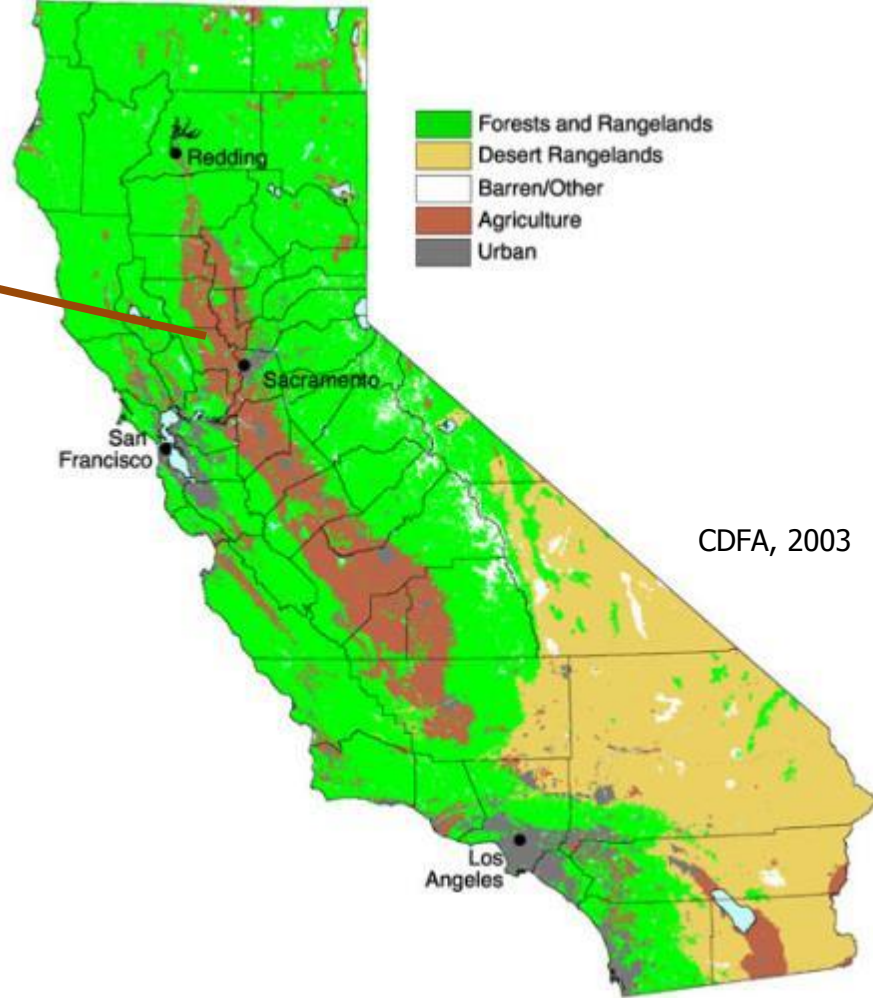


# California's Water Users

## Irrigated Agriculture

9.5 million acres  
(4 million ha)

applied water use:  
27 – 35 MAF  
(35 – 45 km<sup>3</sup>)



**Population**  
38 million people

water use:  
8 MAF (10 km<sup>3</sup>)

**Environment**  
&  
protected streams,  
wetlands:  
45 MAF (55 km<sup>3</sup>)

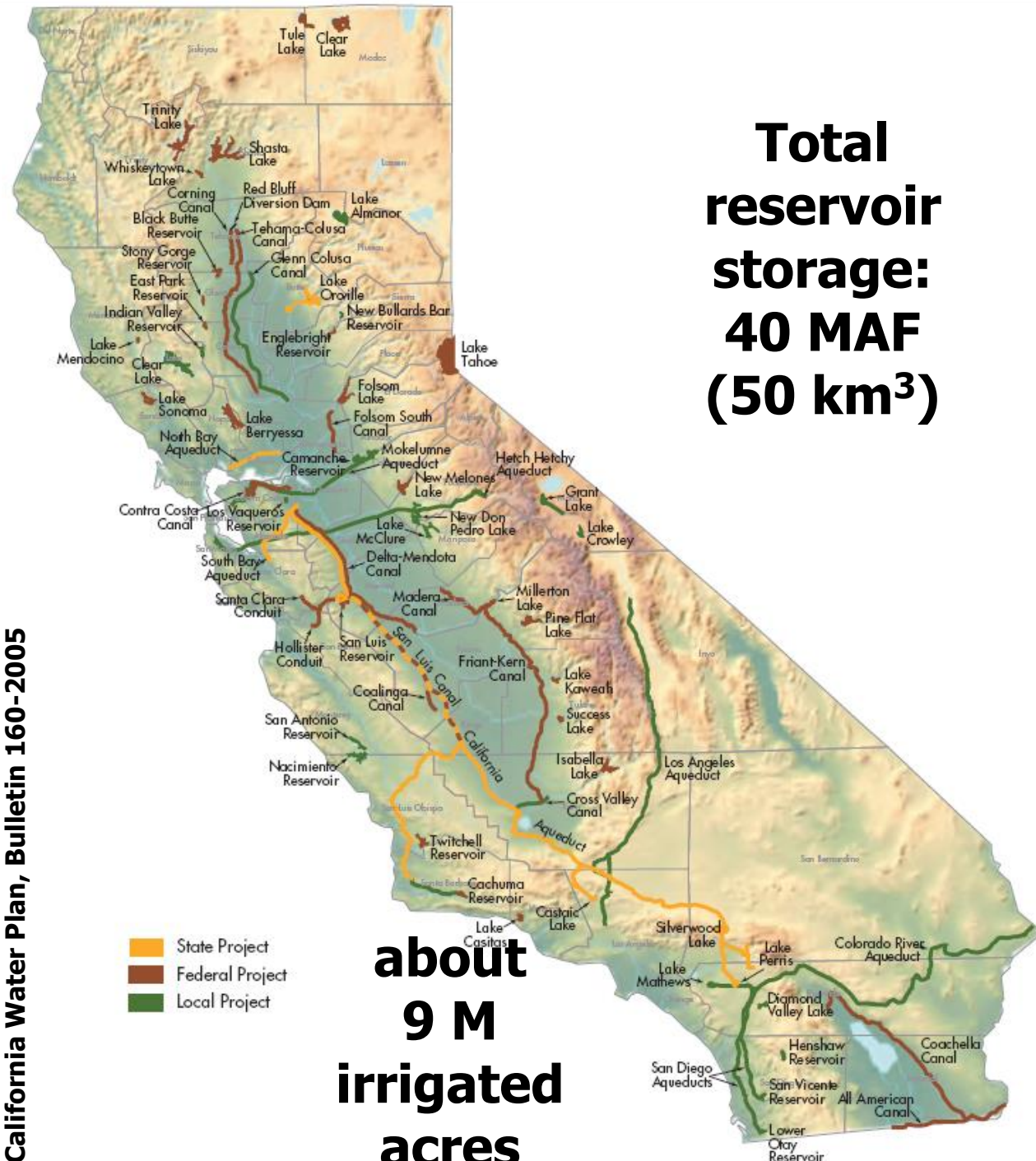
*MAF = million acre-feet*



# California Water Infra-structure:

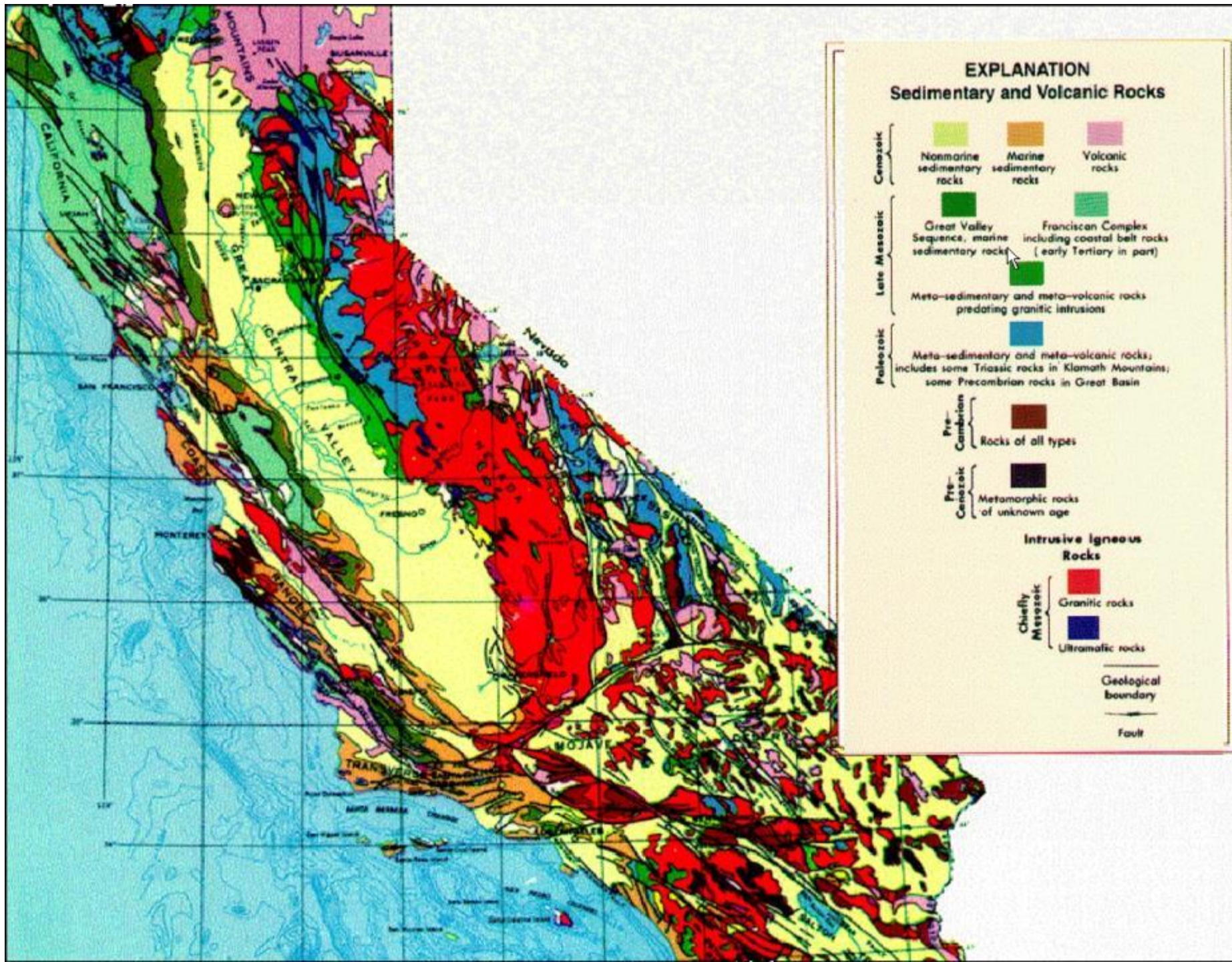
Bridging  
the Spatial  
and Temporal  
Disconnect  
between  
SUPPLY  
and  
USE

California Water Plan, Bulletin 160-2005



**Total  
reservoir  
storage:  
40 MAF  
(50 km<sup>3</sup>)**

**about  
9 M  
irrigated  
acres**

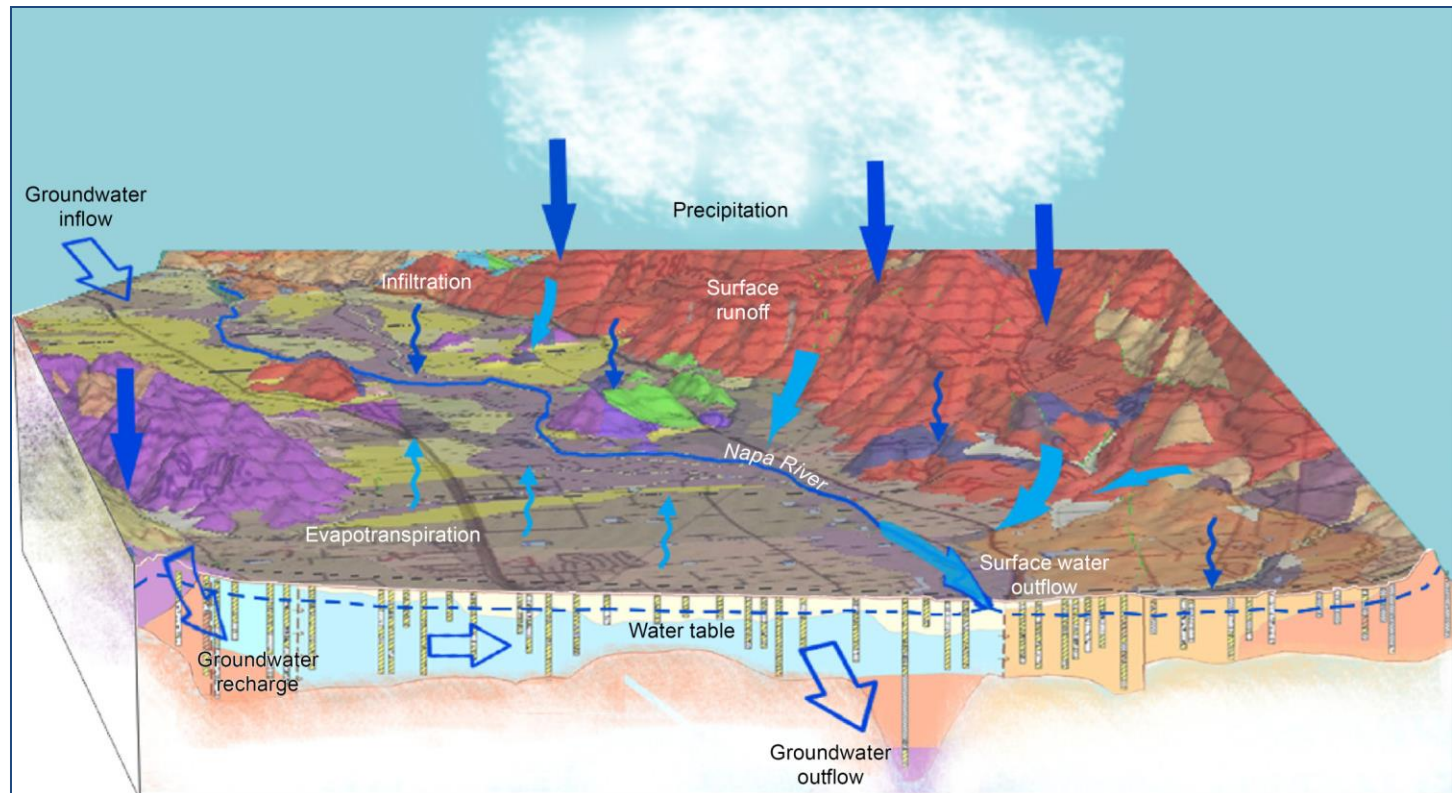


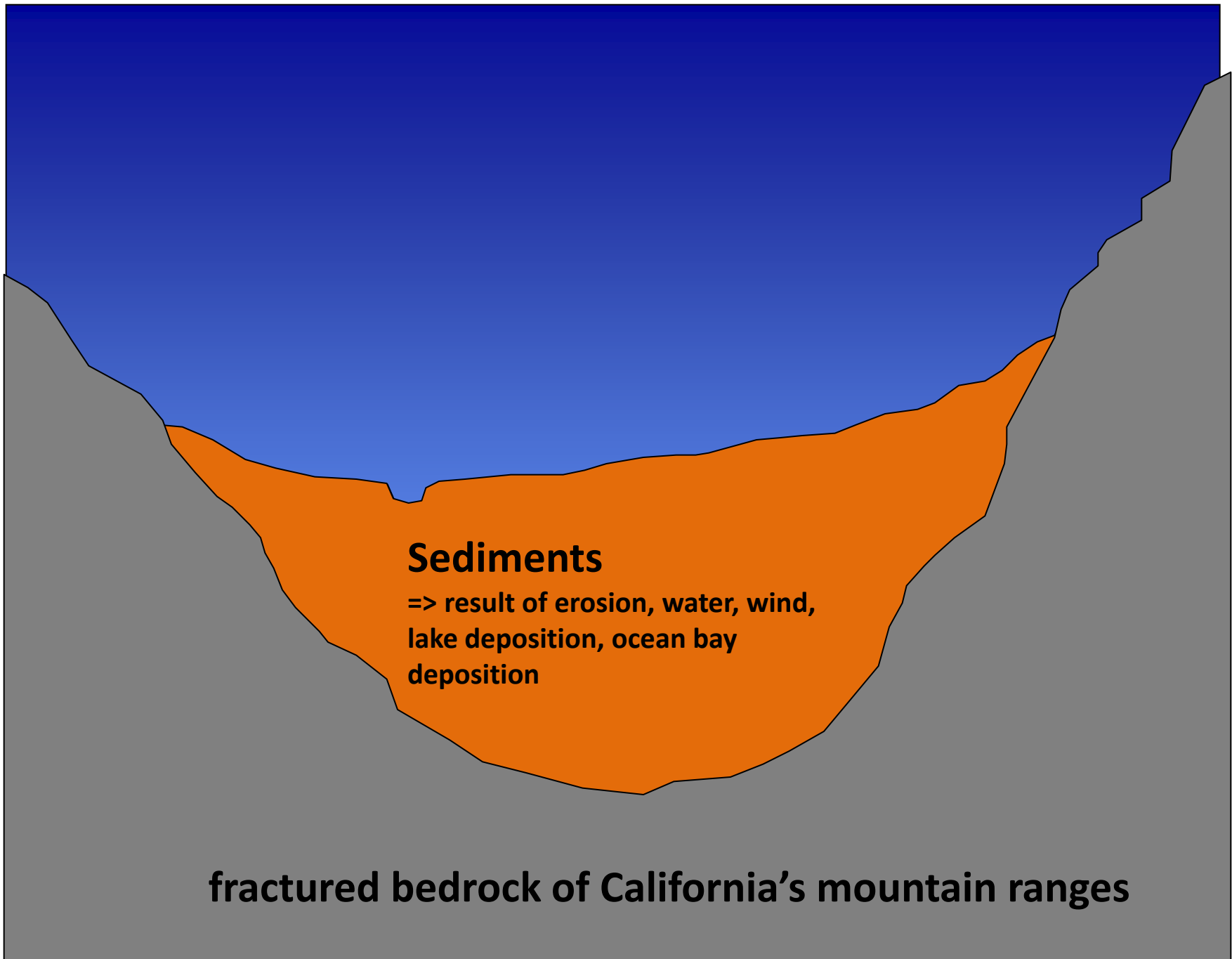
# Alluvial Groundwater Basins

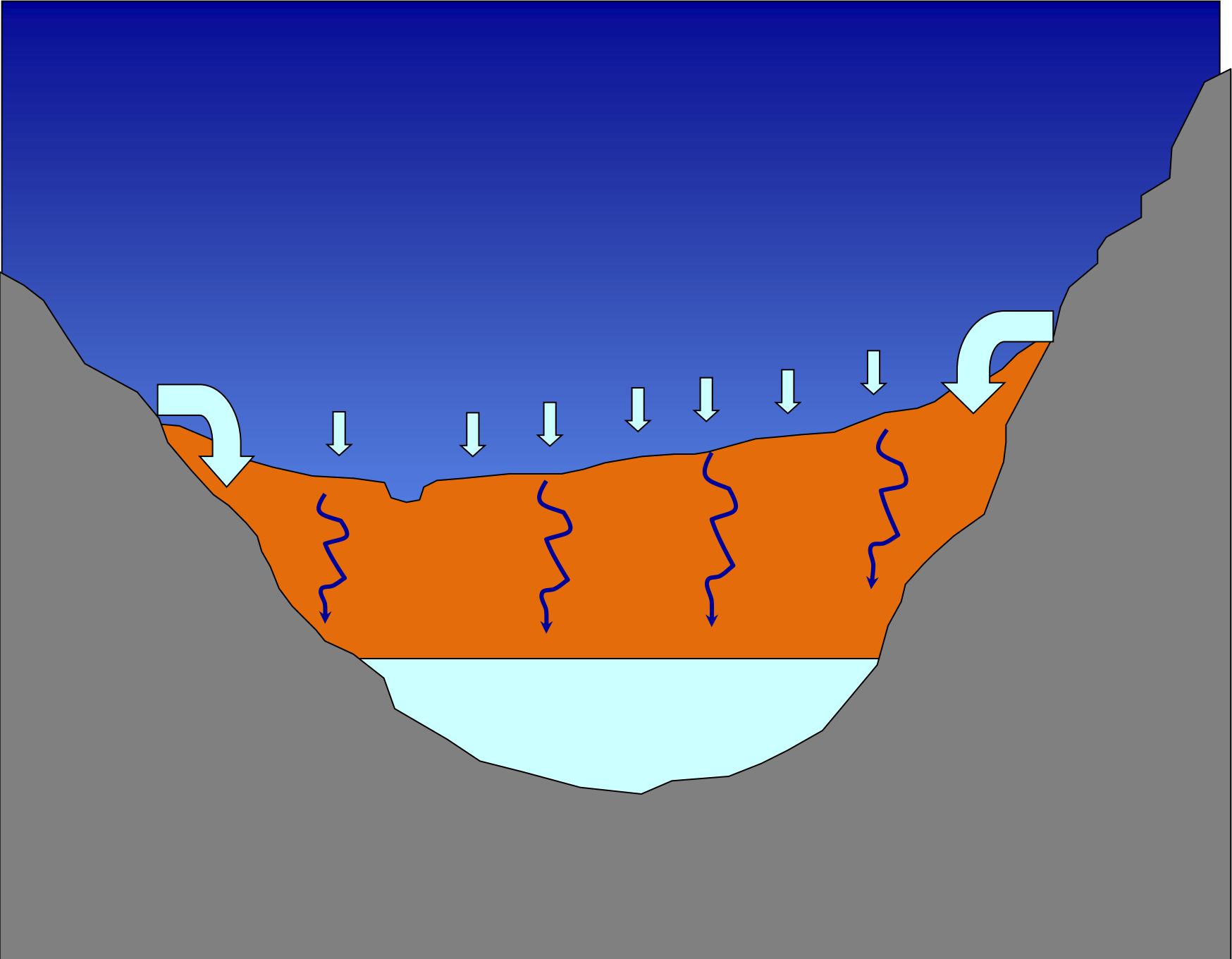


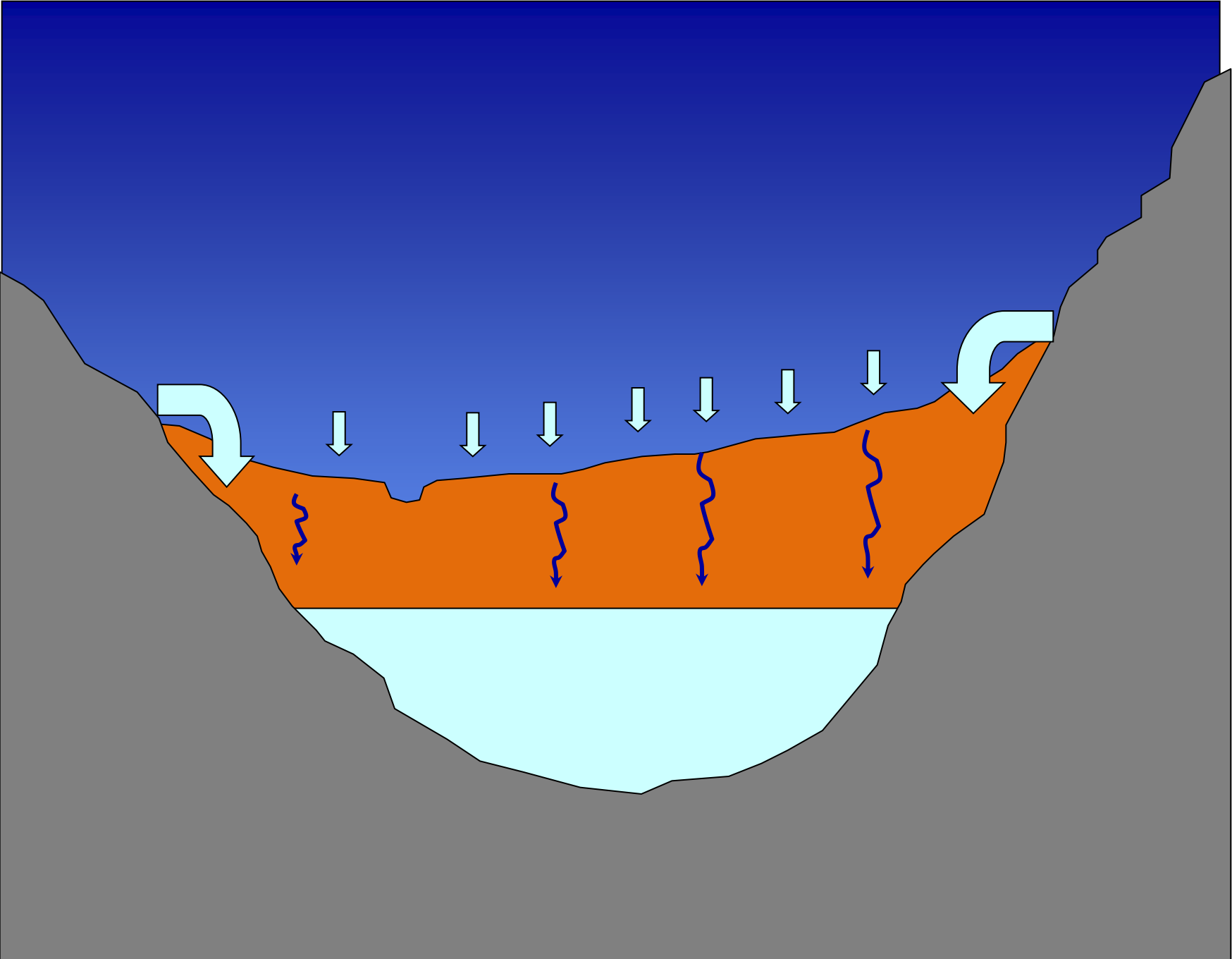
# Conceptual Model: Napa Valley

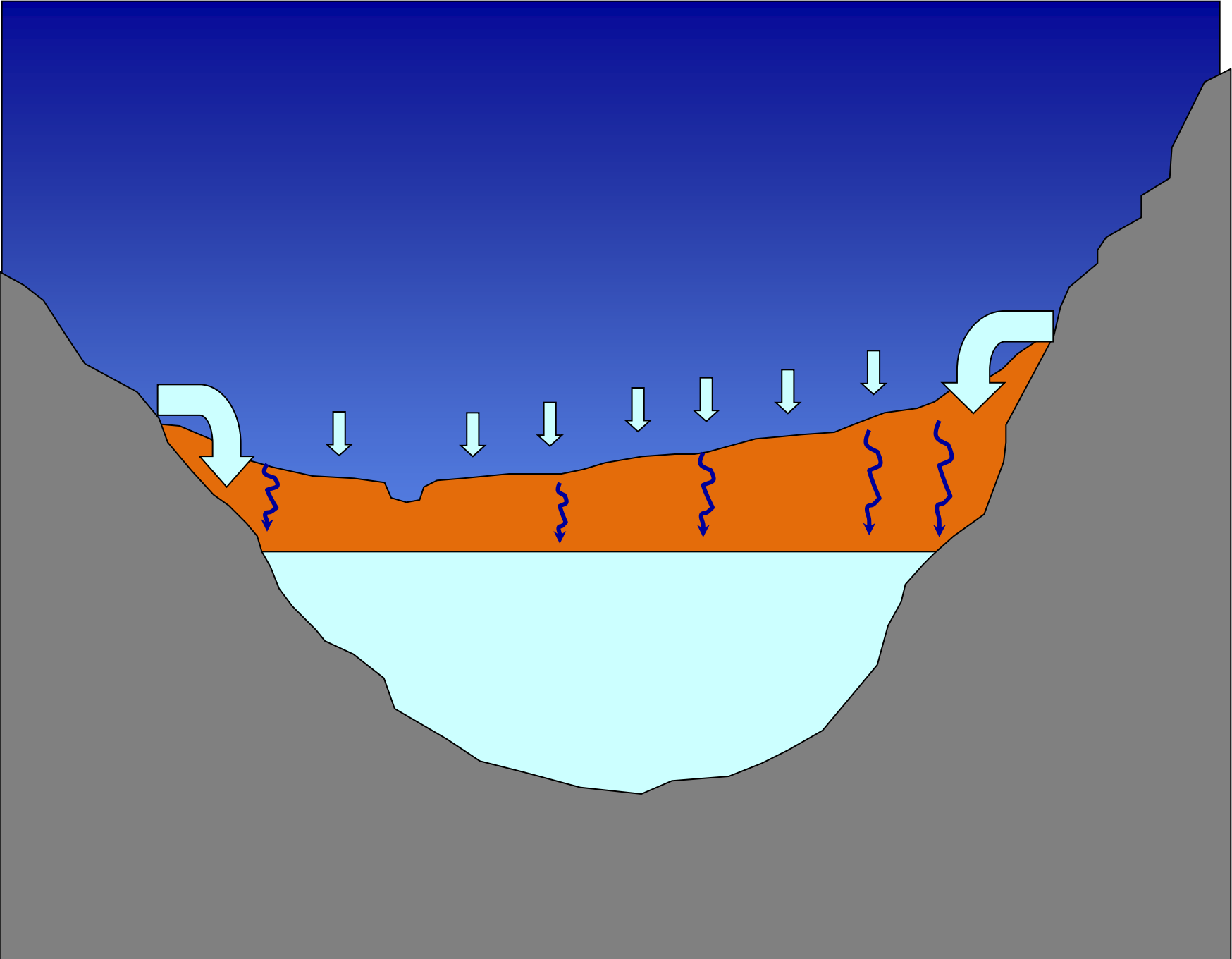
- Groundwater occurs in all four primary formations
- Precipitation and streambed infiltration primary source of groundwater recharge
- Primary groundwater discharge:
  - Pumping
  - ET
  - Baseflow
- Napa River interconnected with groundwater



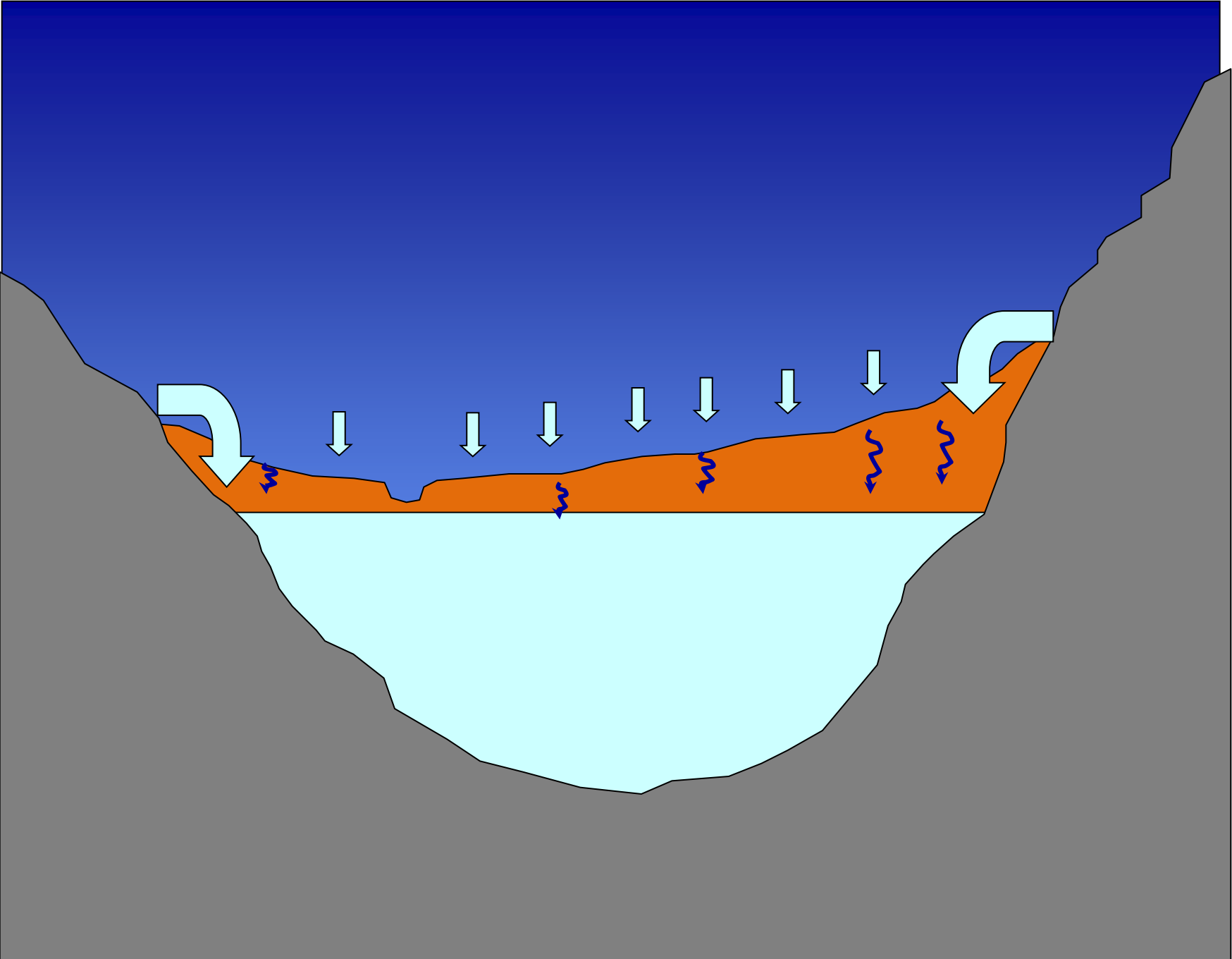




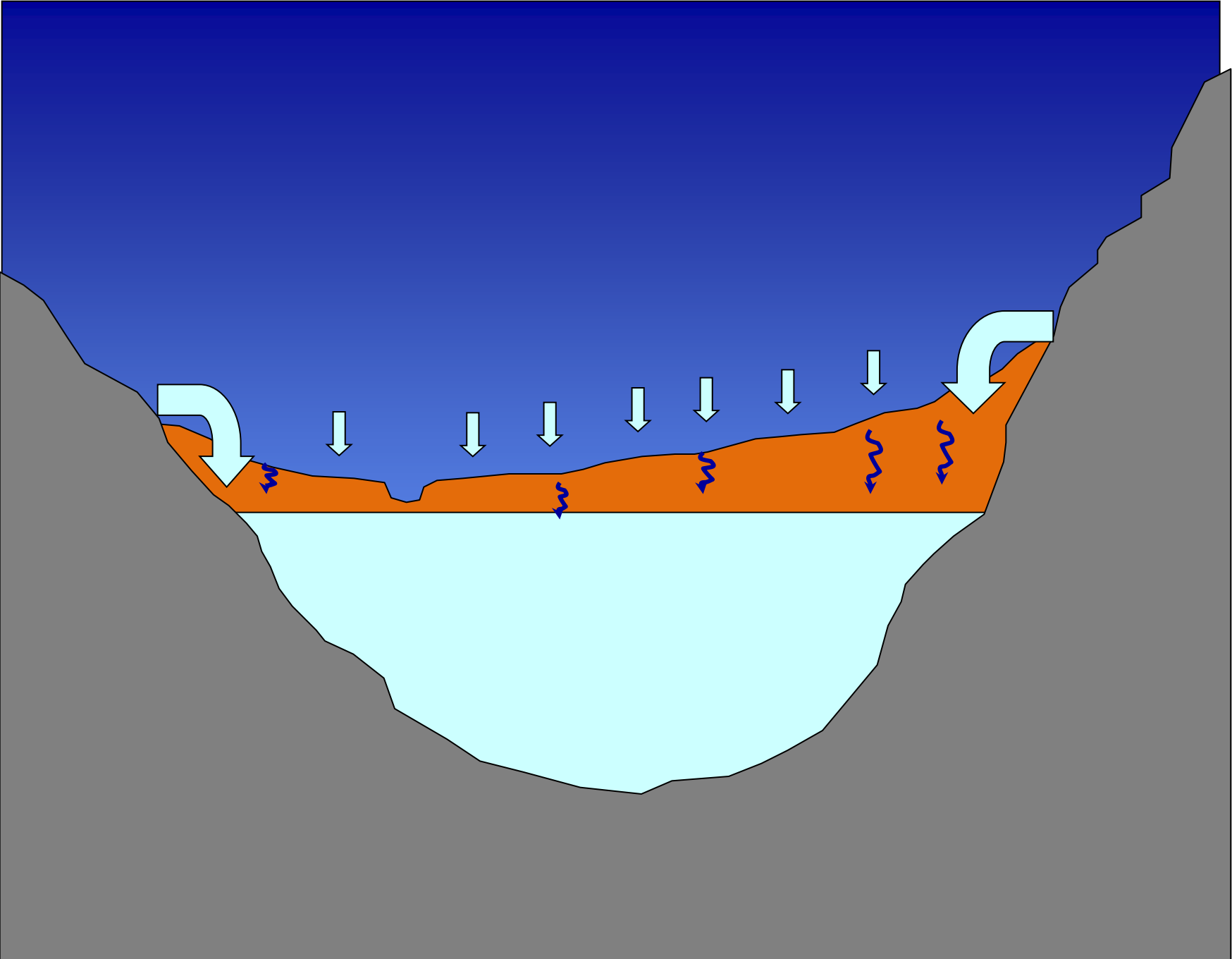


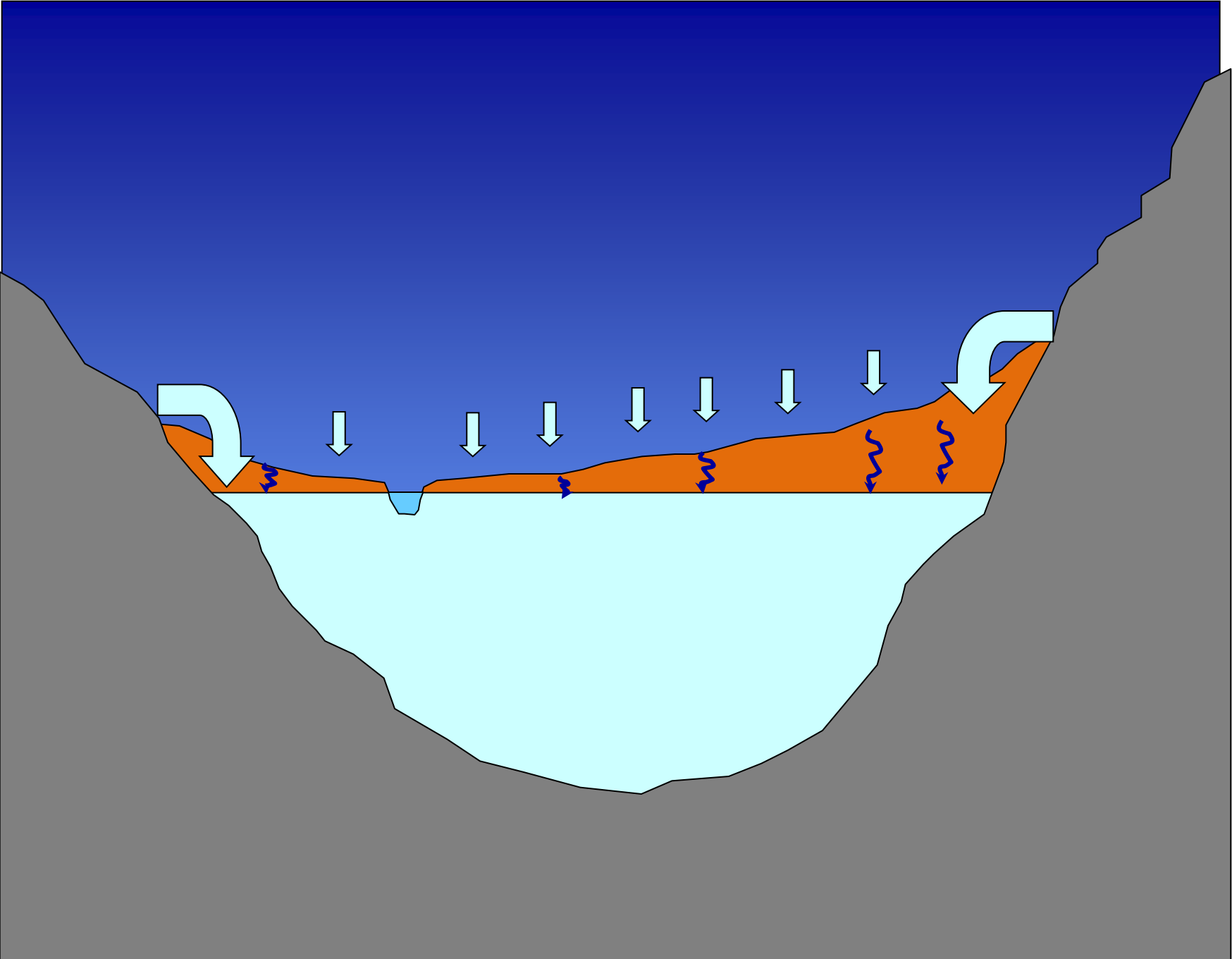


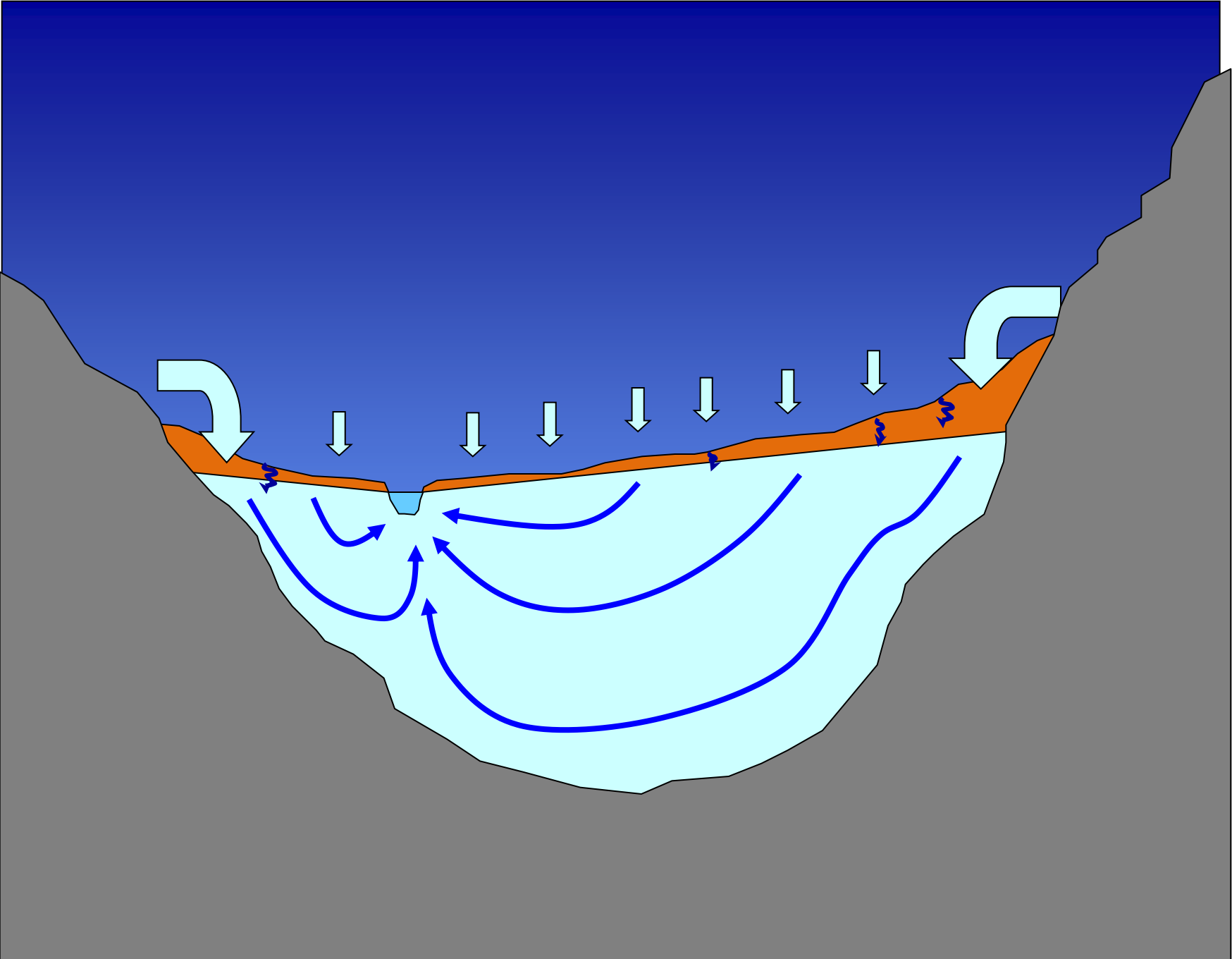






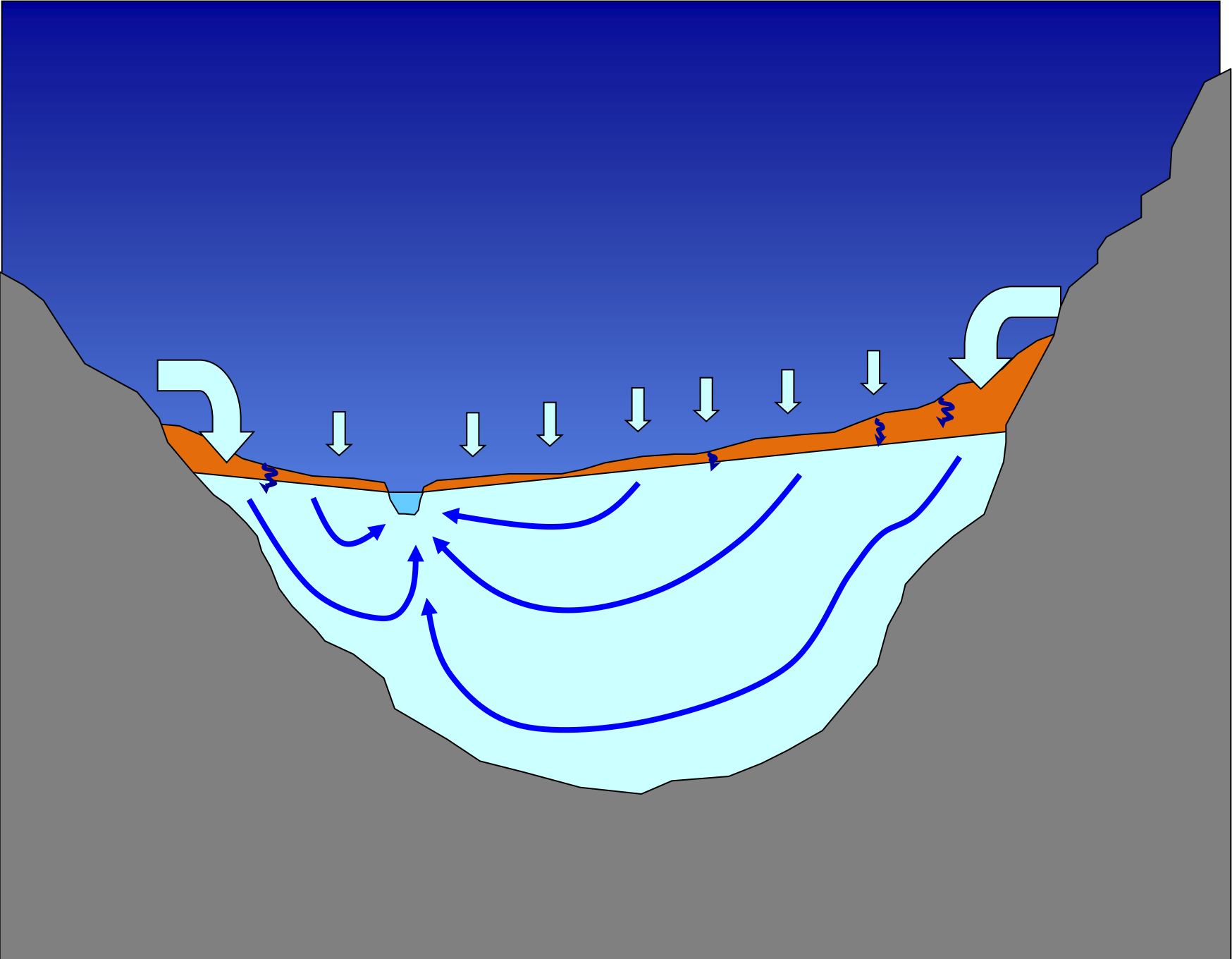




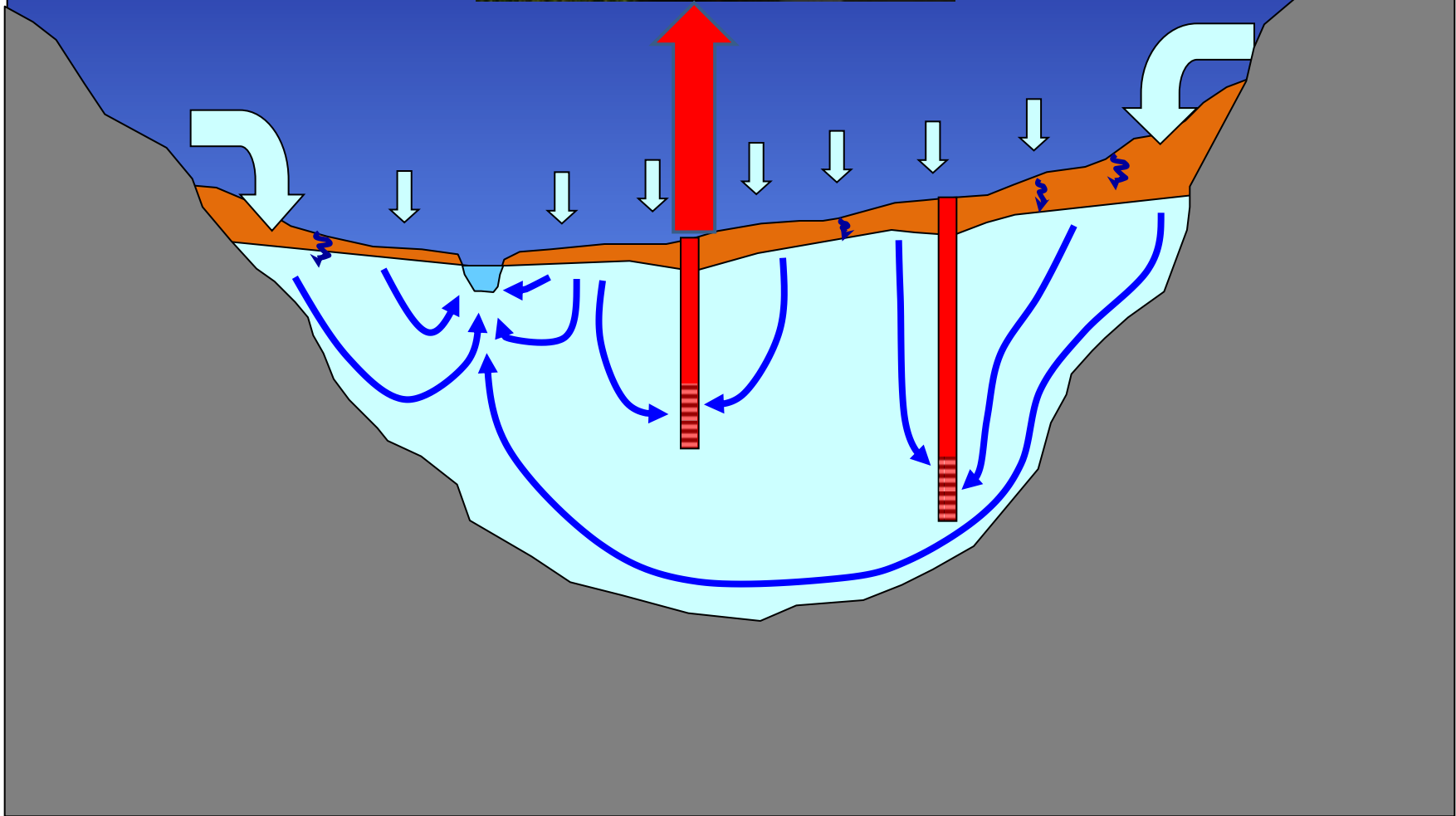


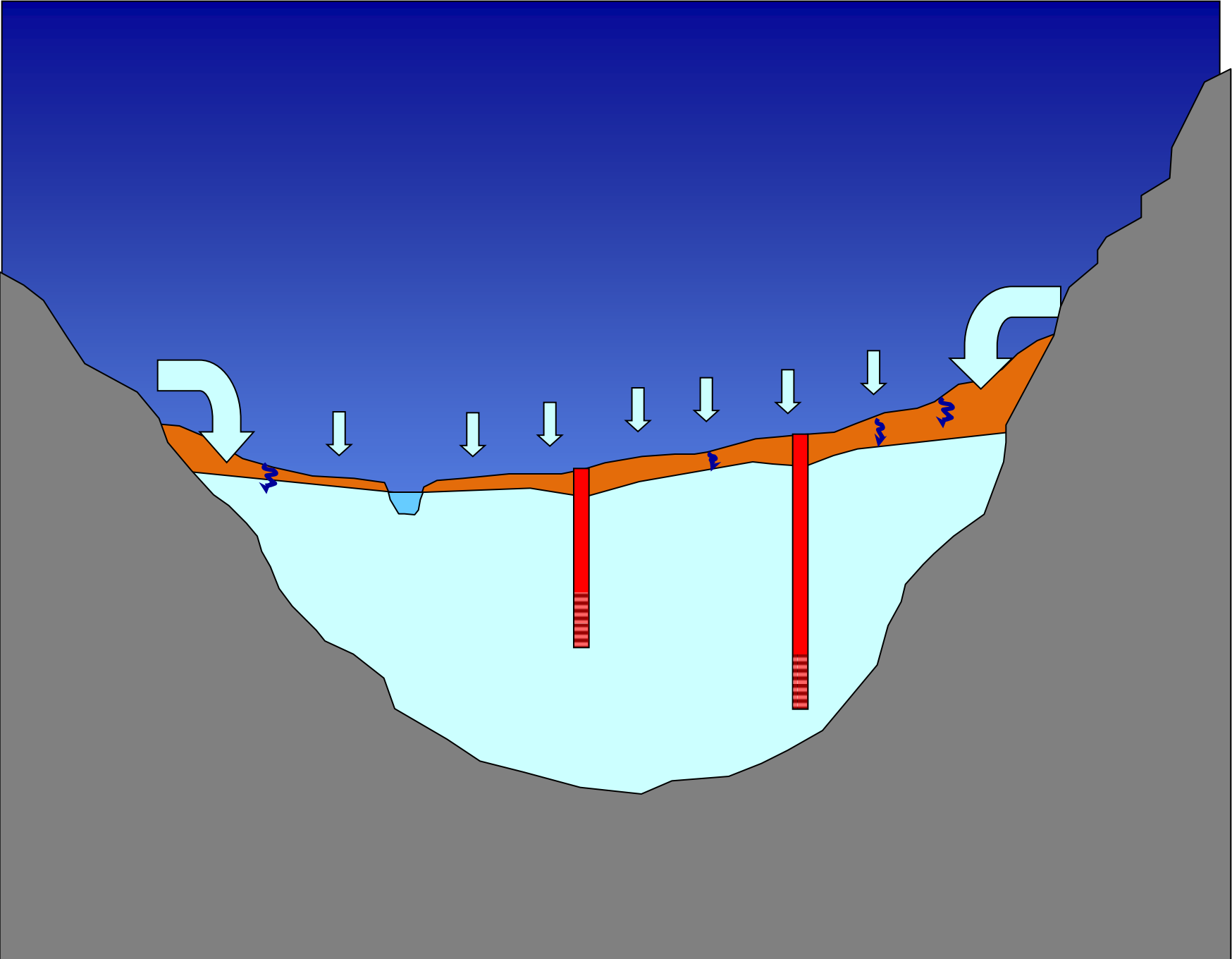


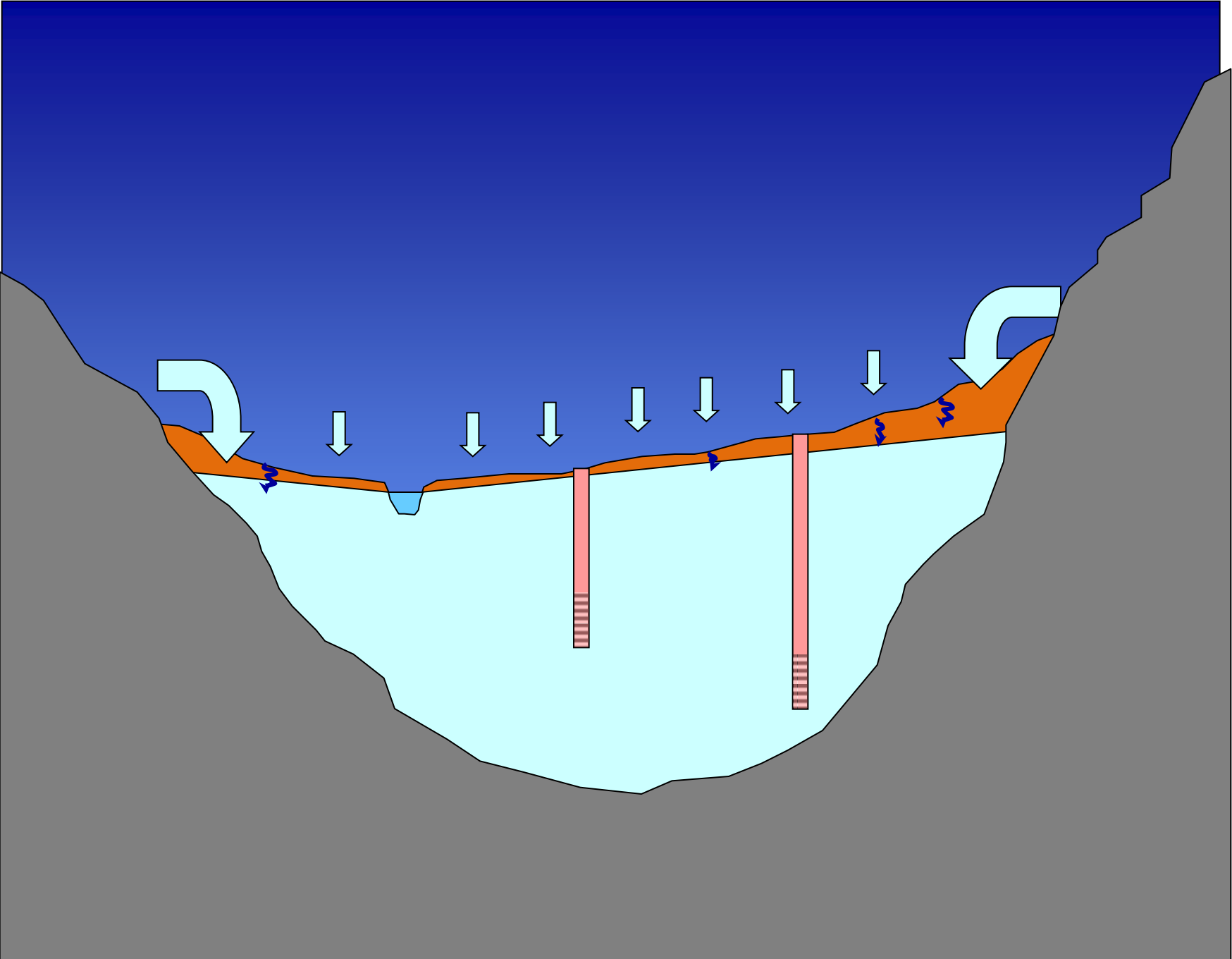


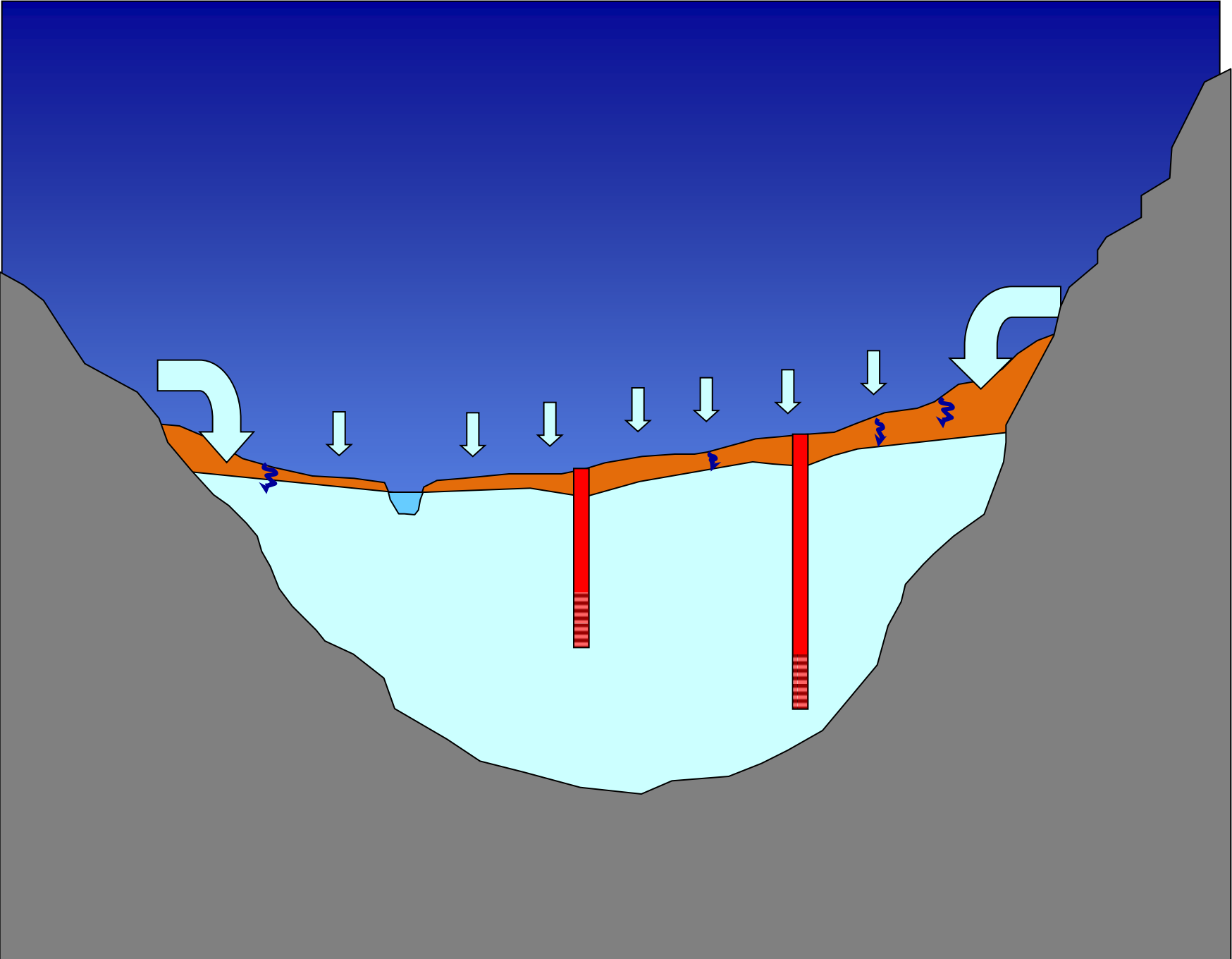


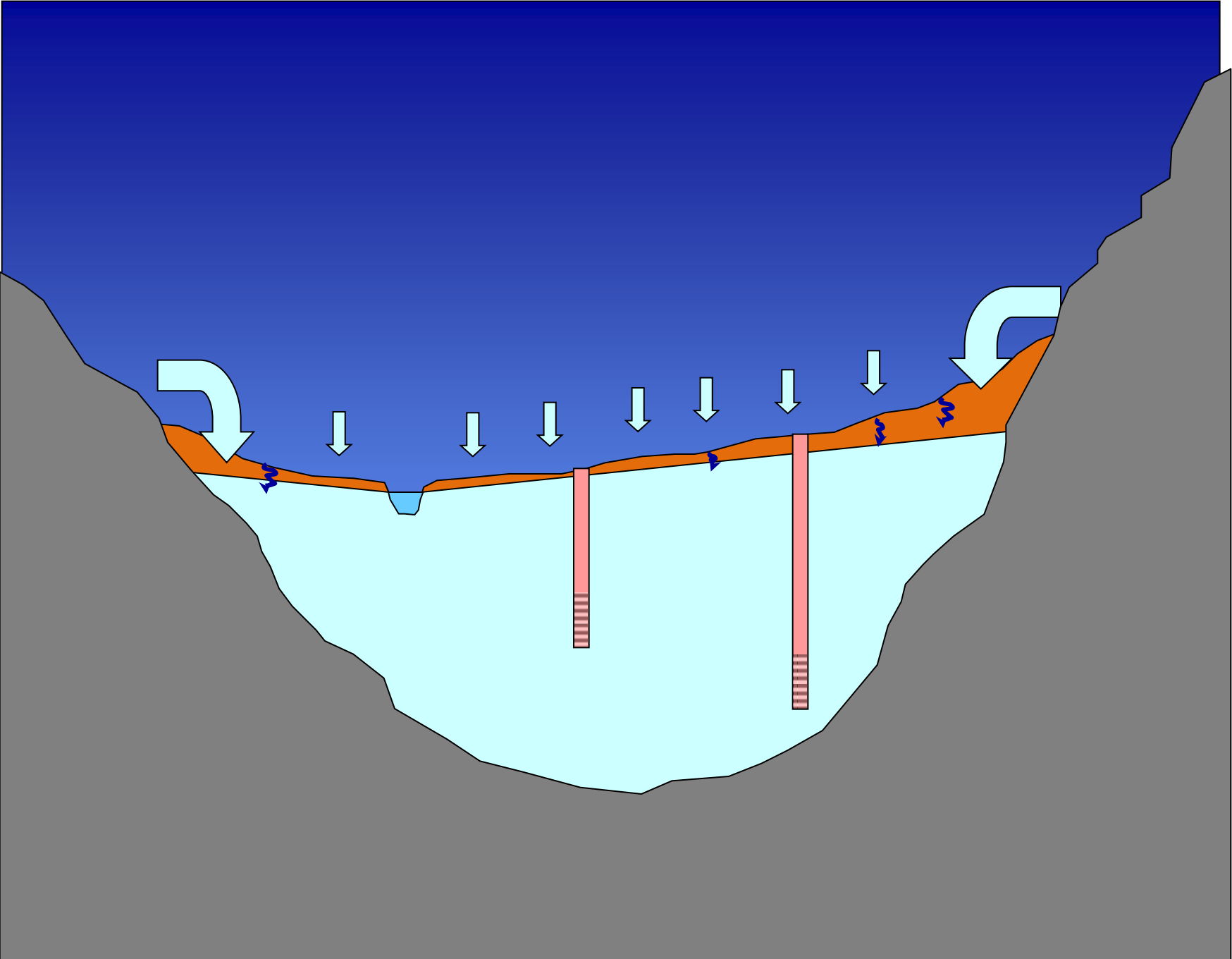


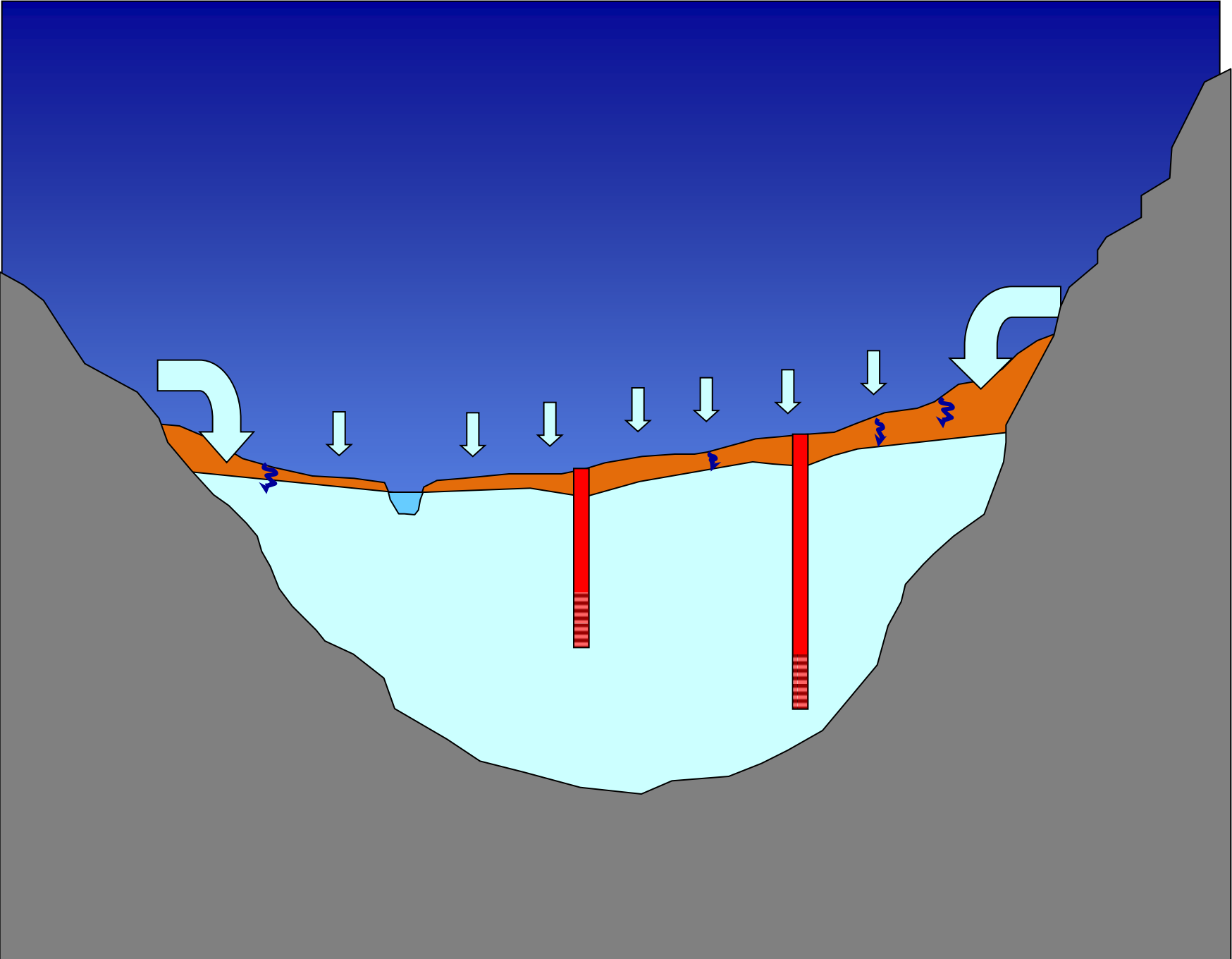


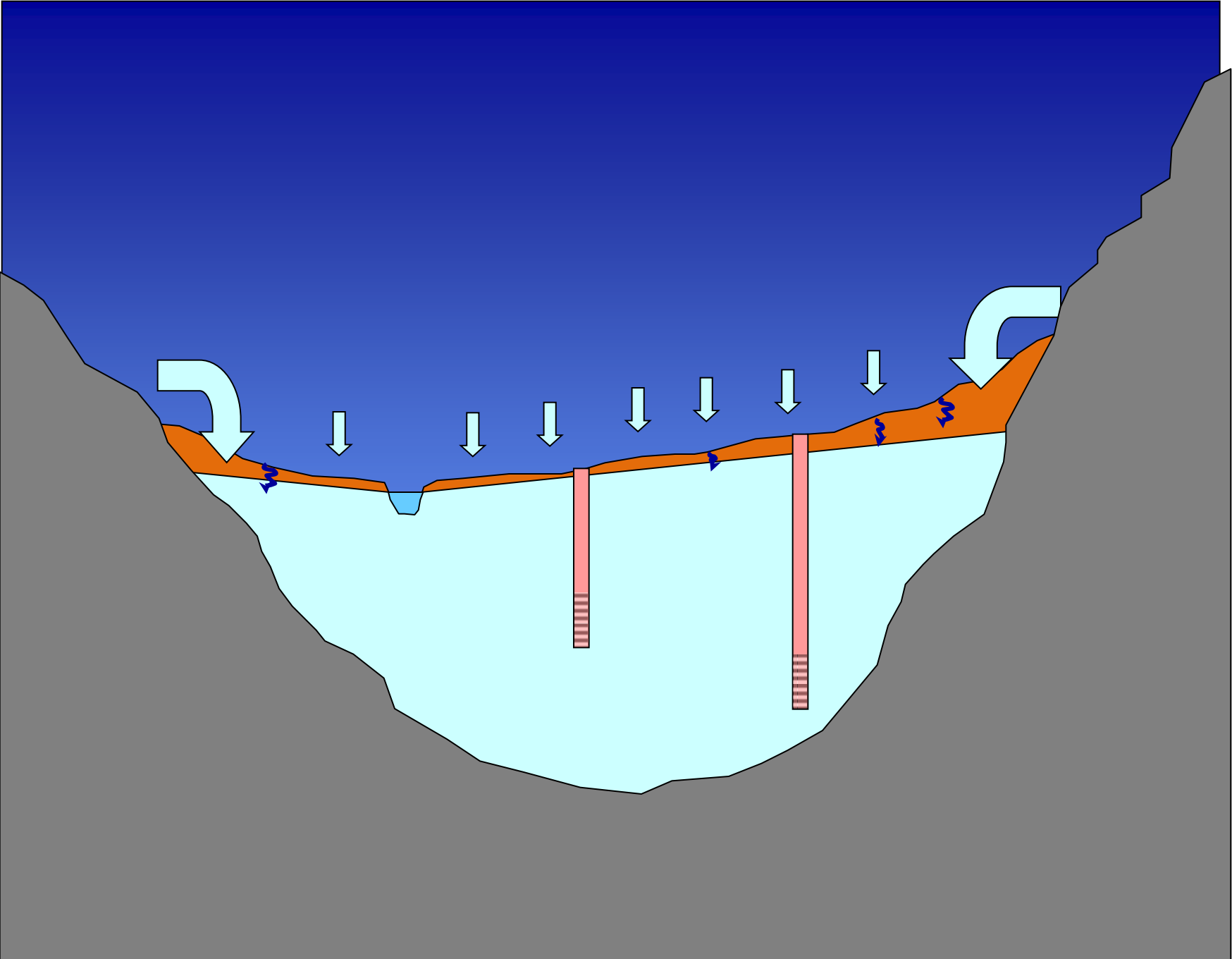


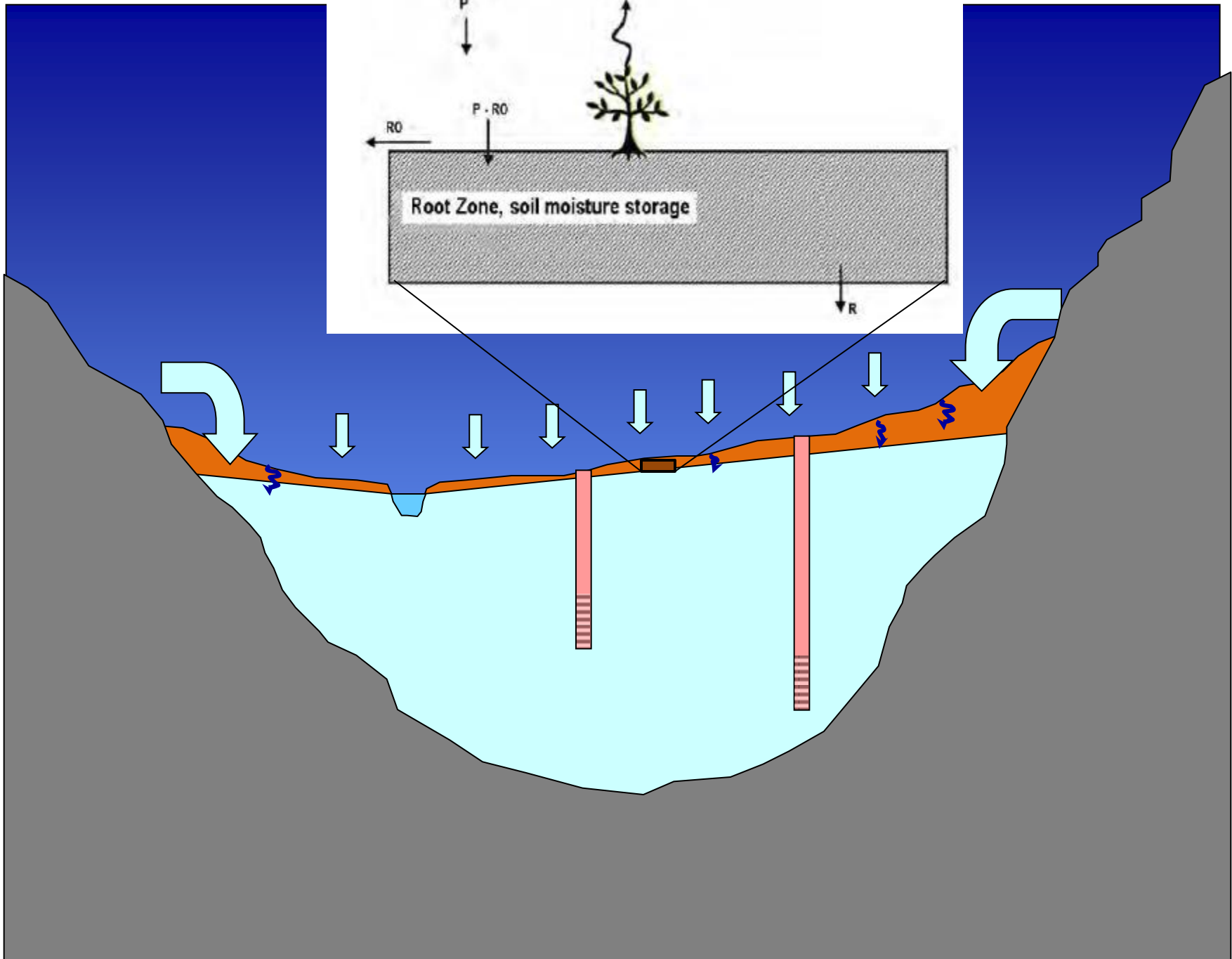




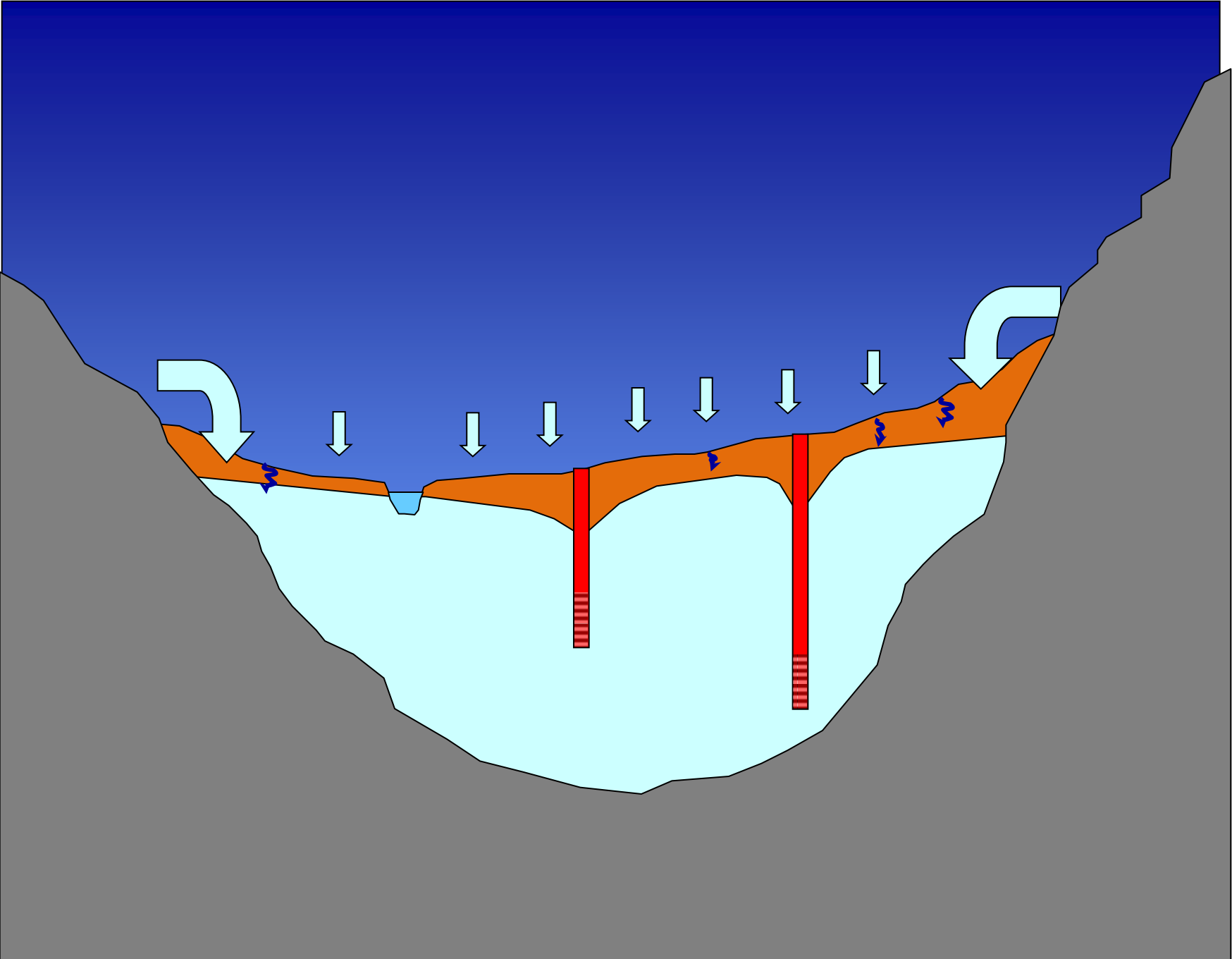


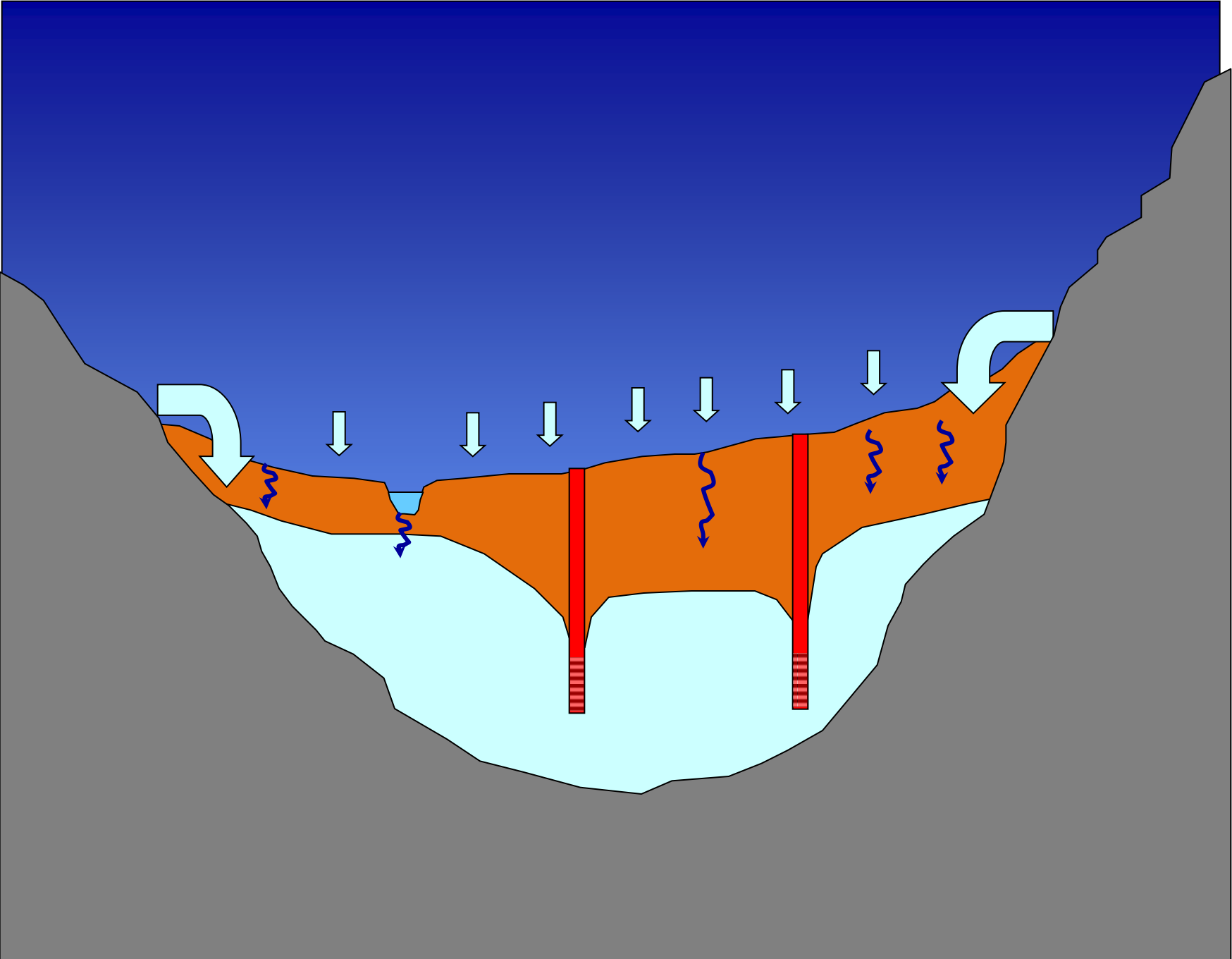


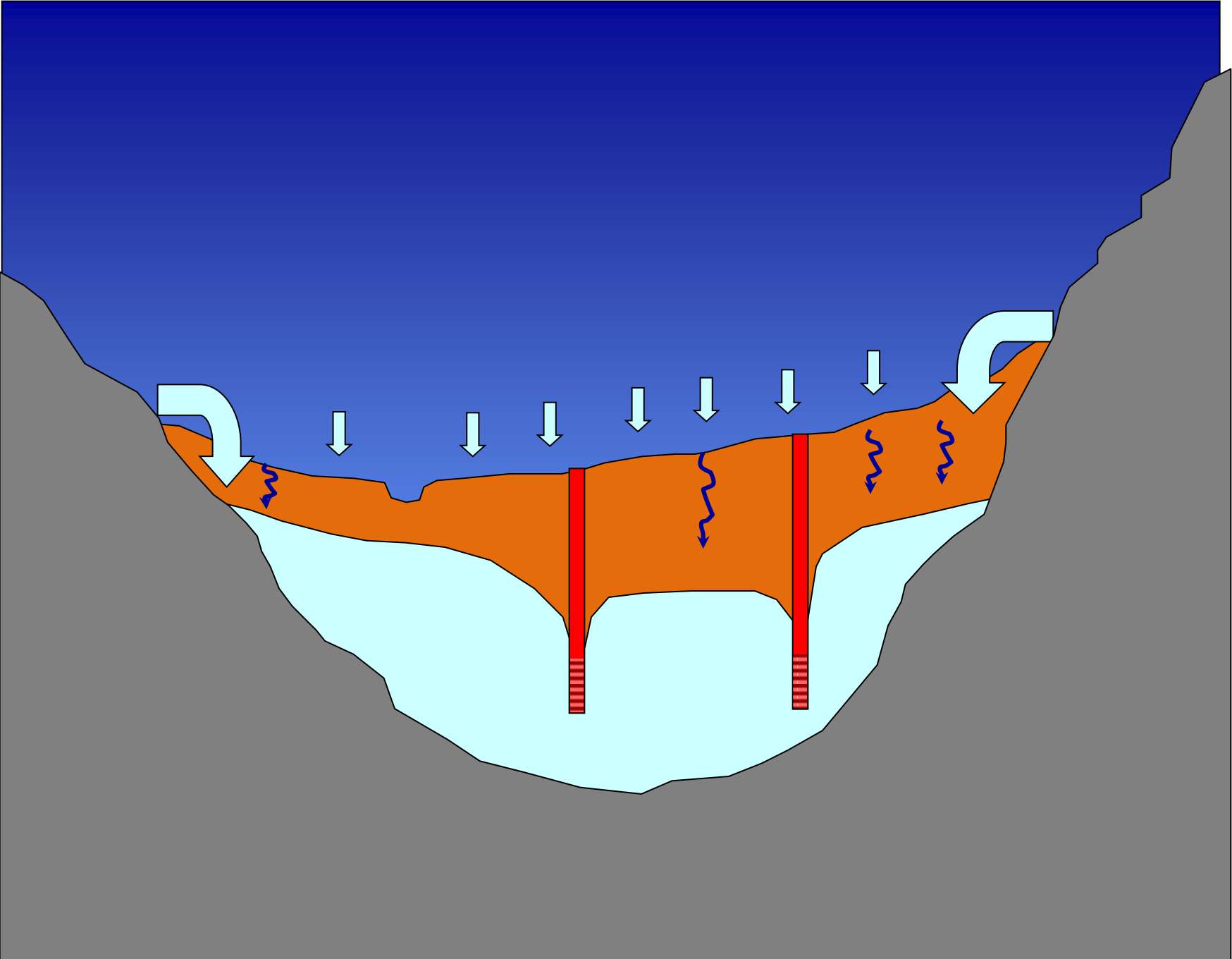


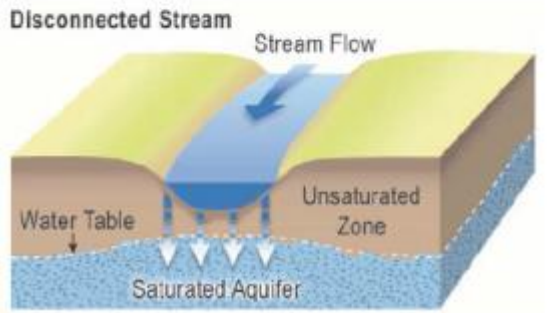
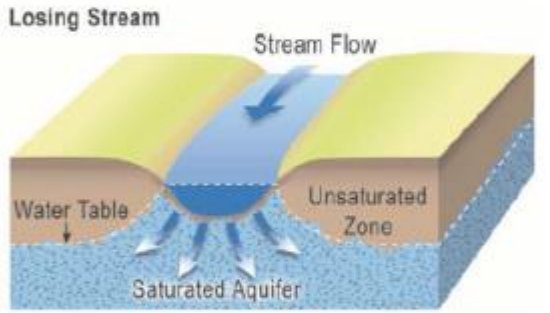
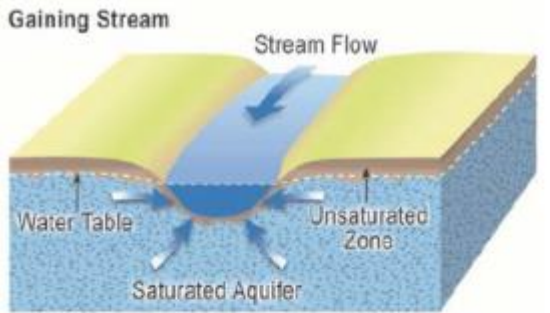
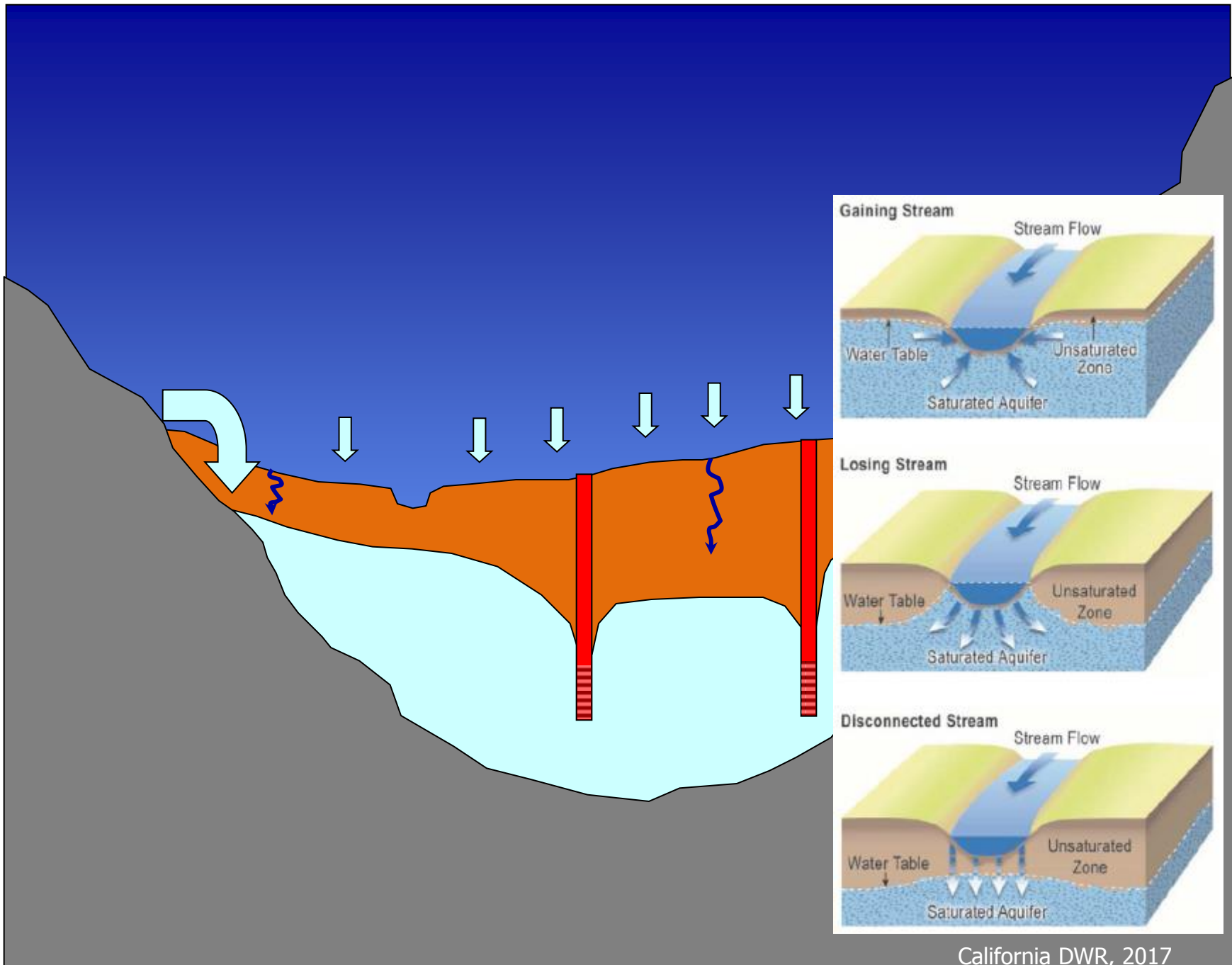












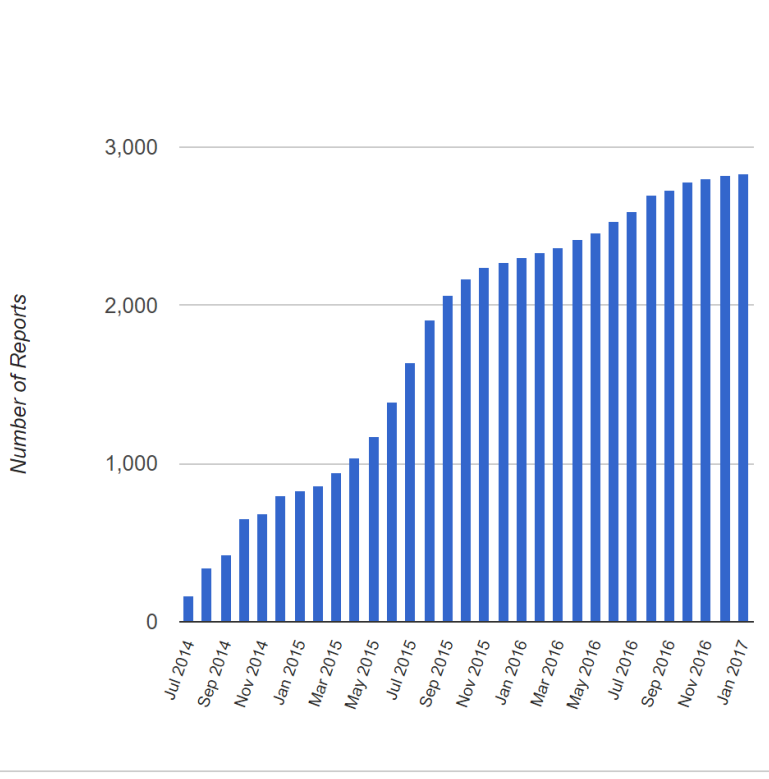
# Groundwater Banking for Environmental Flows: Scott Valley, Siskiyou County



Foglia et al., WRR 2013

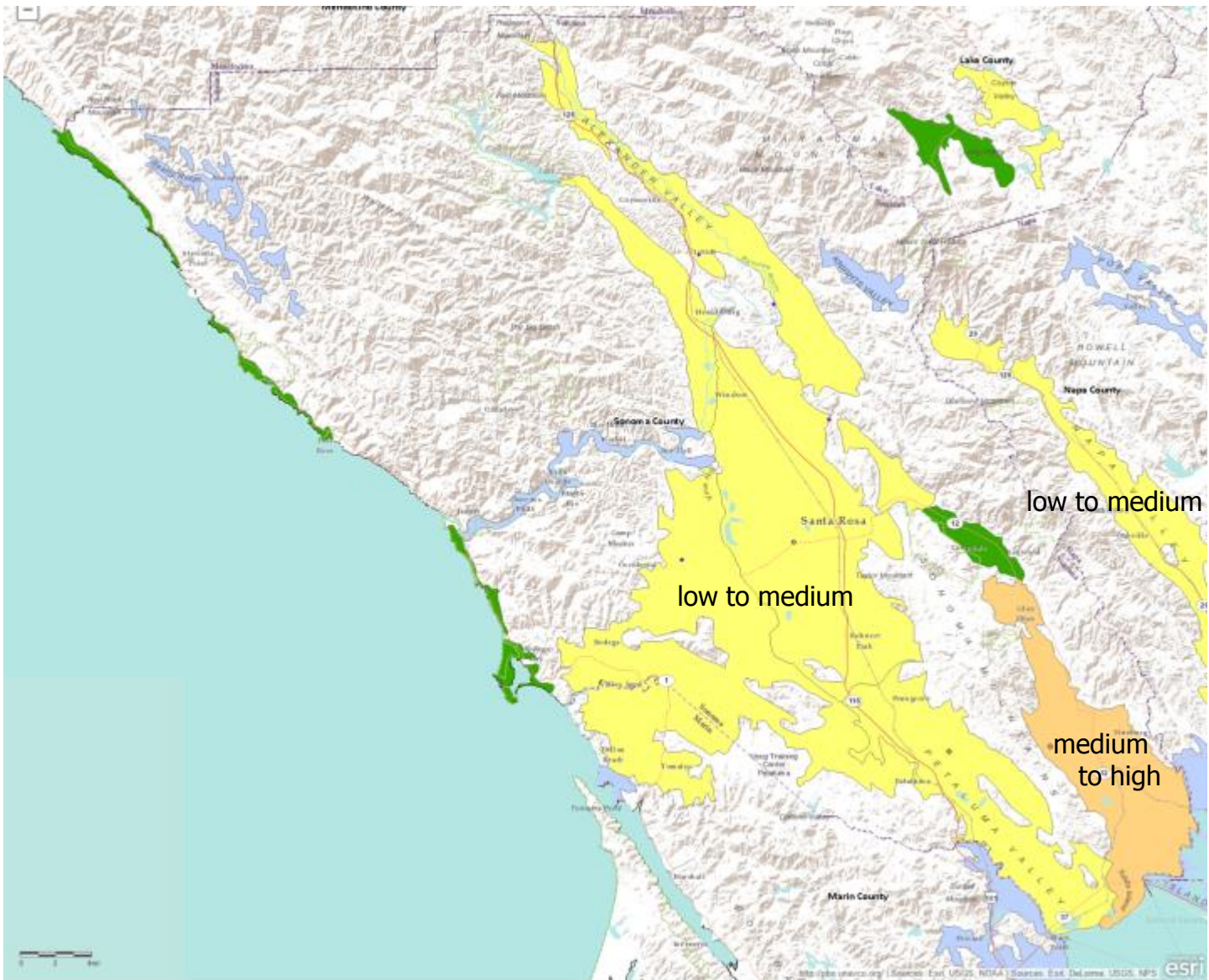
# Reported Well Outages

## July 2014 – Feb 2017



This map represents cumulative reports of household water supply shortages by county reported to the State since July 2014 through February 07, 2017. The numbers represent the total number of households reporting a dry well, creek, stream, surface or other household water supply shortages. Cumulative shortage reports include active outages, active water supply problems, resolved outages, and outages where interim solutions have been implemented. Currently only eleven counties report interim and/or permanently resolved outages. Water supply shortages for agriculture, livestock, or other non-household uses are not included in these counts. Missing information or no data for a given county does not necessarily mean that there are no household water shortages in the county only that none have been reported to the State.

# Subsidence Risk Sonoma and Napa County



modified from CA DWR, 2014

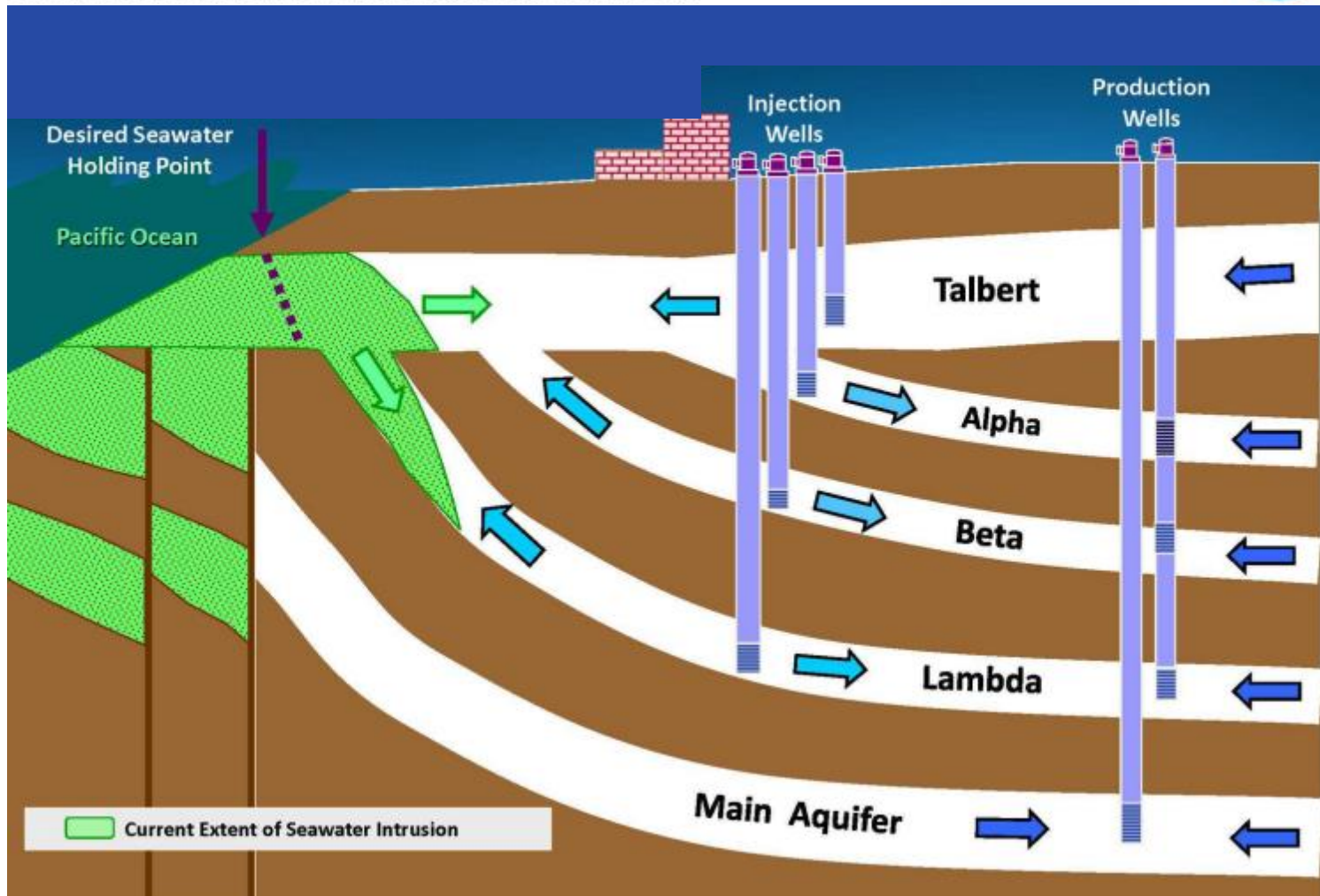
# Land Subsidence 2015-2016

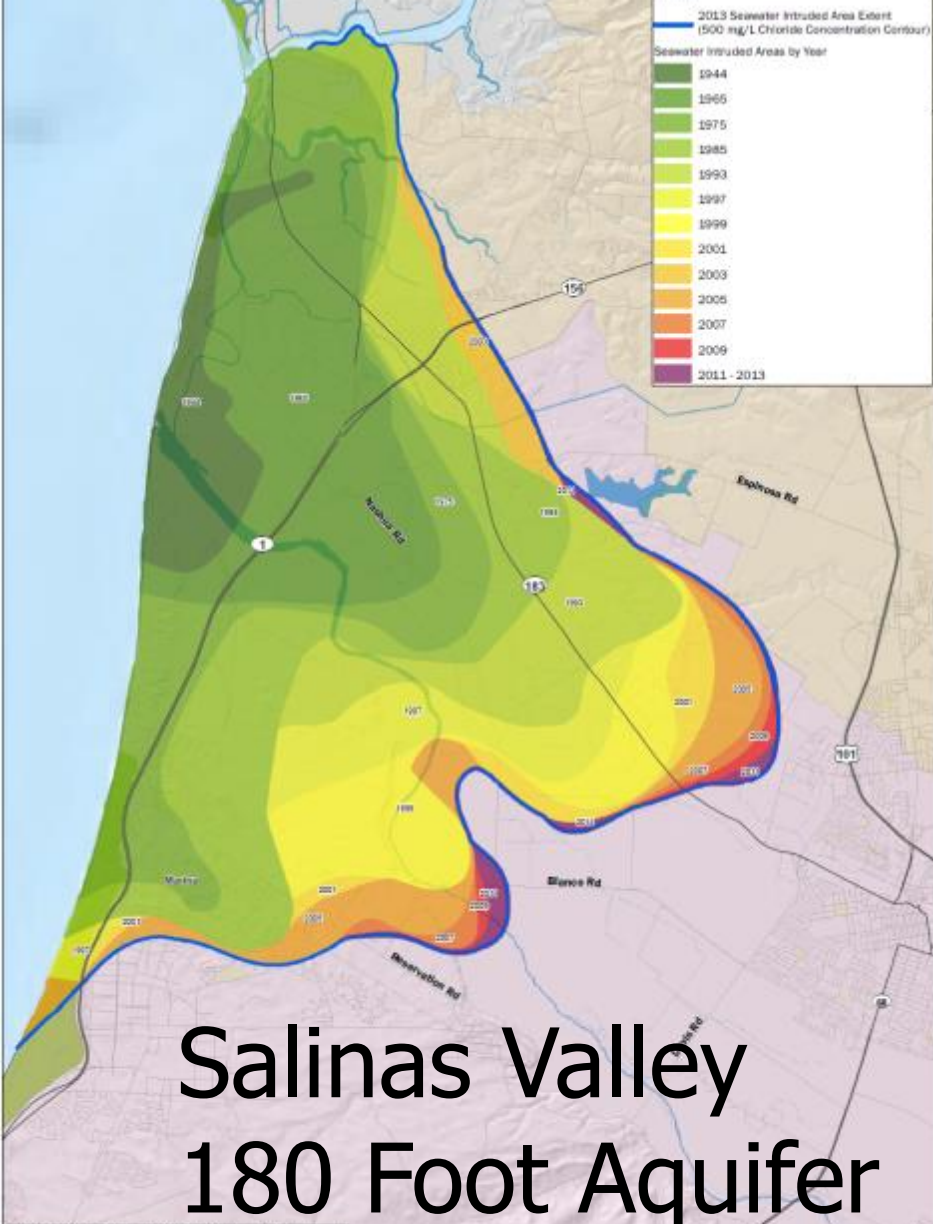




# Seawater Intrusion

## SEAWATER INTRUSION BARRIER





# Salinas Valley 180 Foot Aquifer

Note: The location and water quality data associated with groundwater wells monitored by the Monterey County Water Resources Agency are confidential per agreement between well owners and the Agency, and as such are not shown on map.

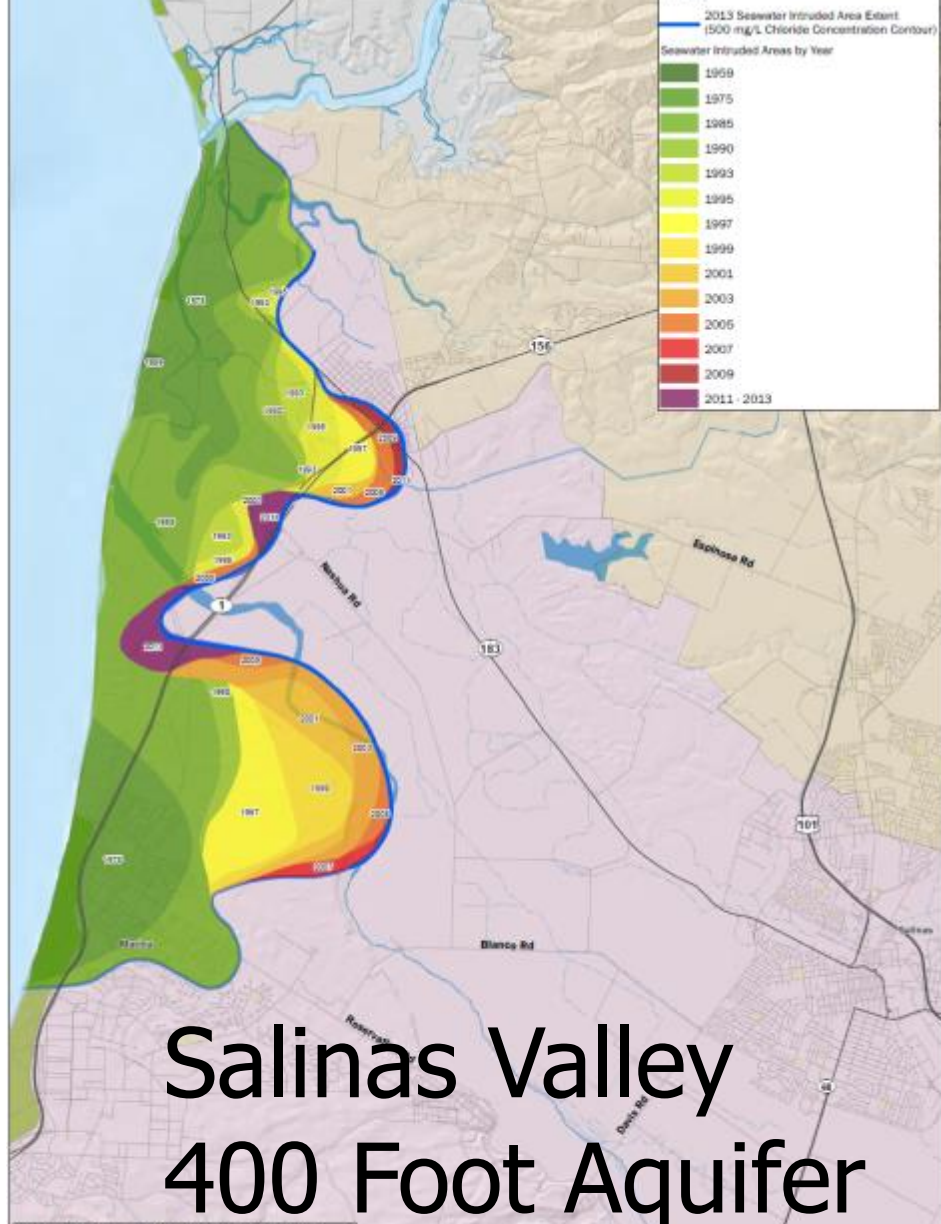
SITE: Salinas River Groundwater Basin Investigation

FILE: Pressure 180-Foot and East Side Shallow/Both Aquifer 500 mg/L Chloride Contours - 2013

DATE: 01/16/15

PROJECT: 346430

Figure 5-1



# Salinas Valley 400 Foot Aquifer

Note: The location and water quality data associated with groundwater wells monitored by the Monterey County Water Resources Agency are confidential per agreement between well owners and the Agency, and as such are not shown on map.

SITE: Salinas River Groundwater Basin Investigation

FILE: Pressure 400-Foot and East Side Deep Aquifer 500 mg/L Chloride Contours - 2013

DATE:

PROJECT:



# Sustainable Groundwater Management Act of 2014

## SEC. 2.

Section 113 is added to the Water Code, to read:

### 113.

It is the policy of the state that **groundwater resources be managed sustainably for long-term reliability and multiple economic, social, and environmental benefits** for current and future beneficial uses.

Sustainable groundwater **management is best achieved locally** through the development, implementation, and updating of plans and programs based on the best available science.

# Sustainability = No “Undesirable Results”

10721. Unless the context otherwise requires, the following definitions govern the construction of this part:

(u) “Sustainable groundwater management” means the management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results.

(w) **“Undesirable result”** means one or more of the following effects caused by groundwater conditions occurring throughout the basin (Section 10721 (w)):

(1) **Chronic lowering of groundwater levels** indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods.

(2) Significant and unreasonable **reduction of groundwater storage**.

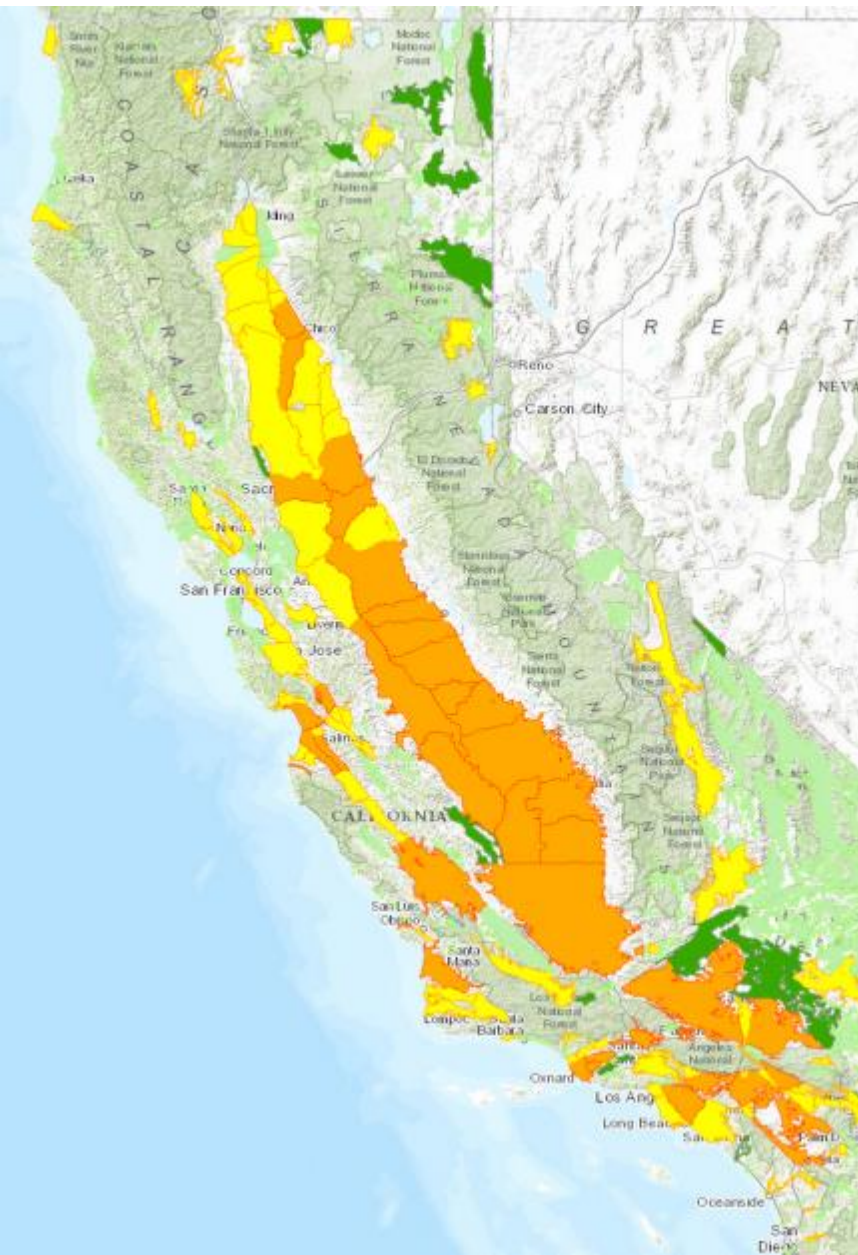
(3) Significant and unreasonable **seawater intrusion**.

(4) Significant and unreasonable **degraded water quality**, including the migration of contaminant plumes that impair water supplies.

(5) Significant and unreasonable **land subsidence** that substantially interferes with surface land uses.

(6) **Surface water depletions** that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

# Medium and High Priority Groundwater Basins



## Statewide Groundwater Basin Prioritization Summary

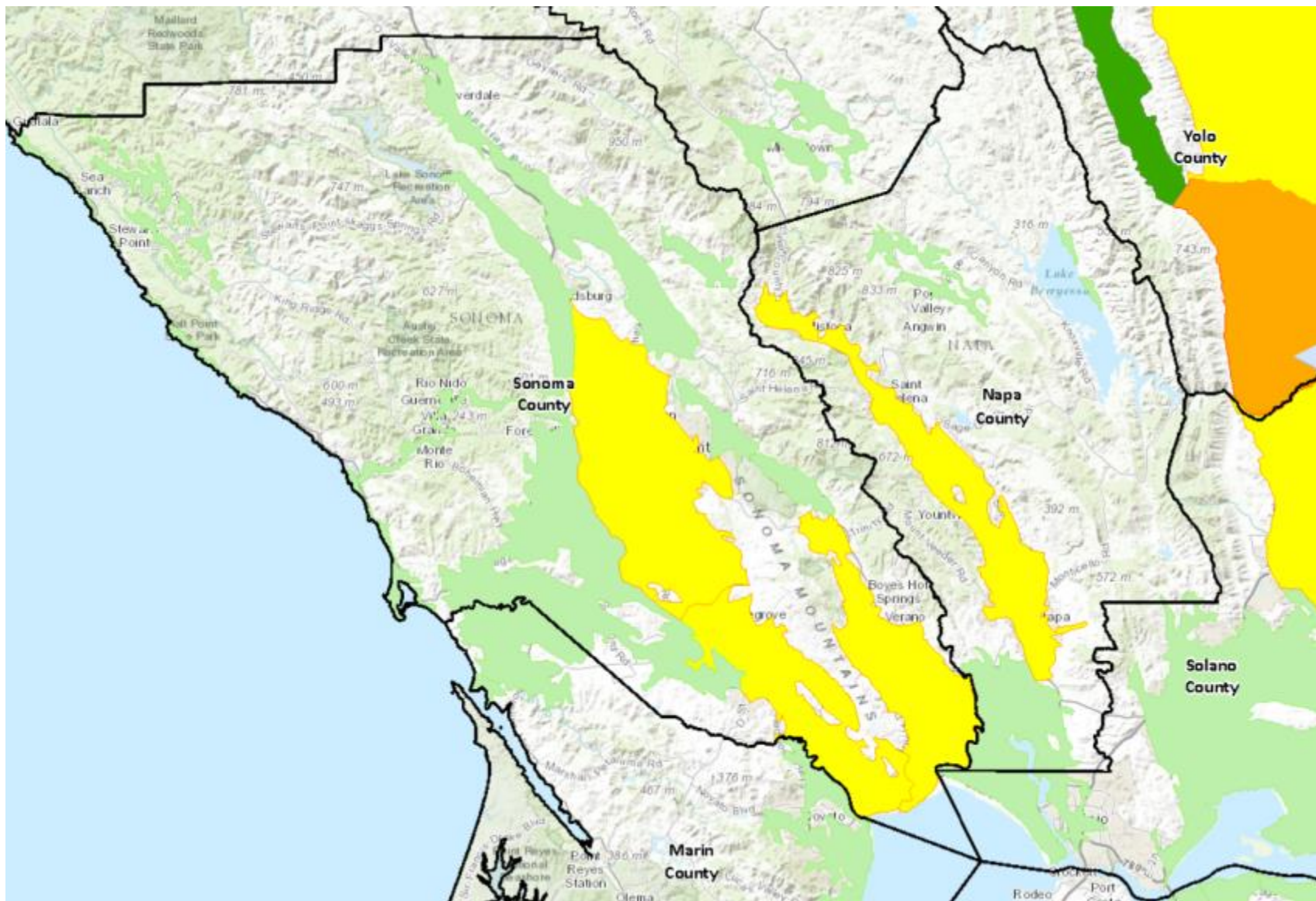
Basin Ranking	Basin Count per Rank	Percent of Total for State	
		GW Use	Overlying Population
High	43	69%	47%
Medium	84	27%	41%
Low	27	3%	1%
Very Low	361	1%	11%
<b>Totals</b>	<b>515</b>	<b>100%</b>	<b>100%</b>

Basin Prioritization results – June 2, 2014

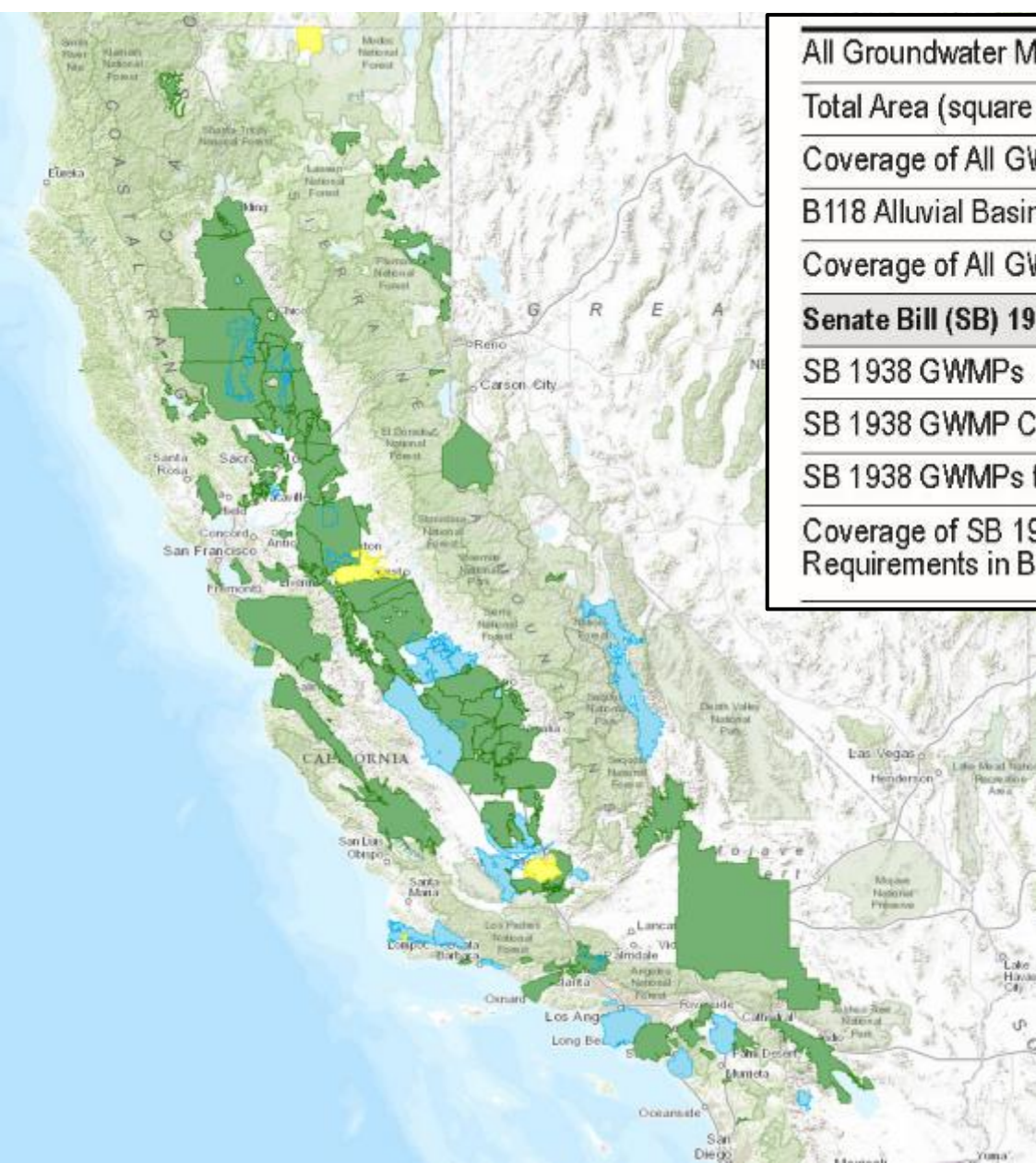
## CASGEM Groundwater Basin Prioritization



# Sonoma and Napa County: GW Basin Priority (DWR)



# Existing Groundwater Management Plans: Inventory and Assessment (No or Limited Implementation)

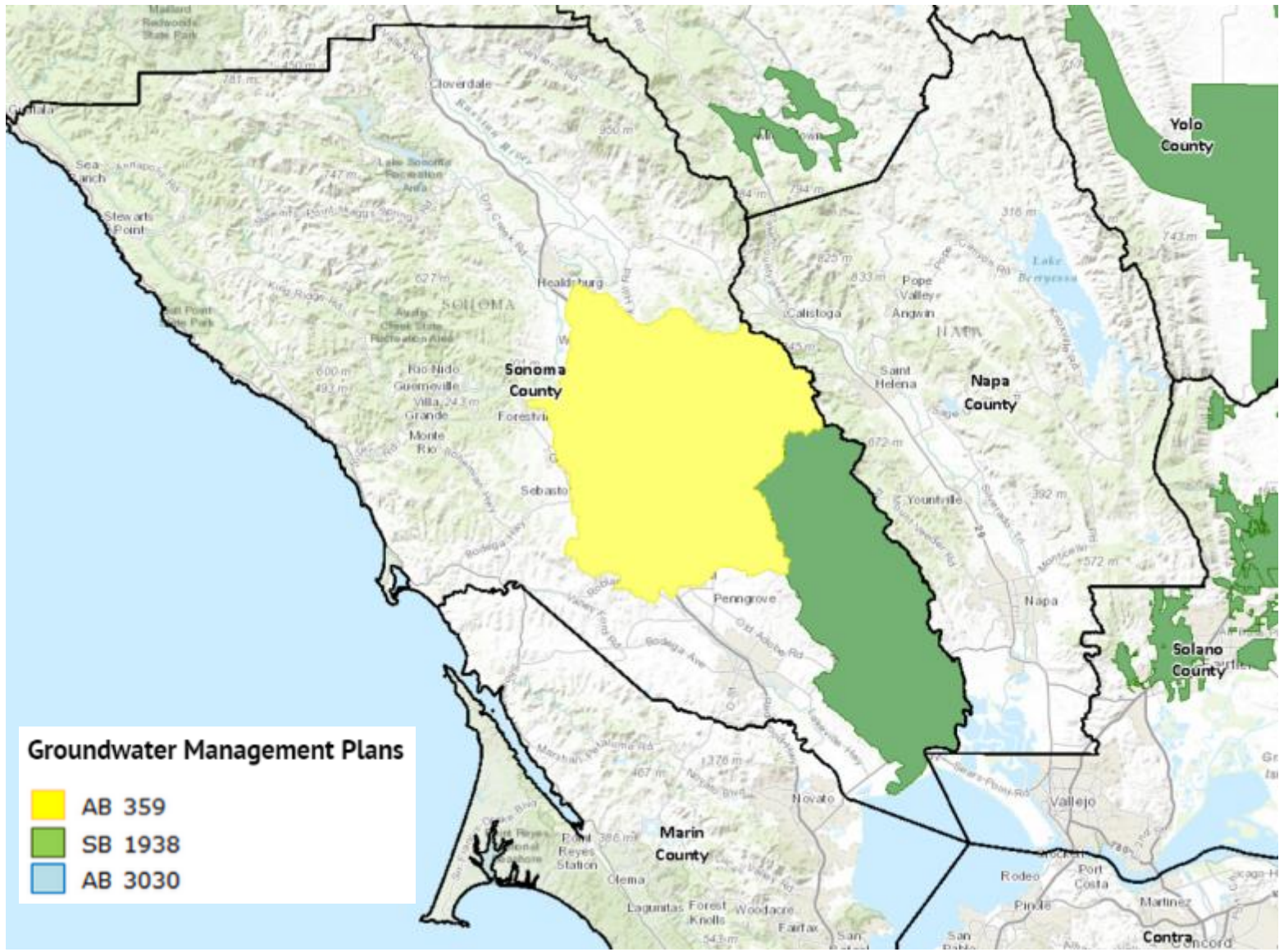


All Groundwater Management Plans (GWMP)	119
Total Area (square miles)	158,600
Coverage of All GWMPs (%)	20%
B118 Alluvial Basin Area (square miles)	61,900
Coverage of All GWMPs in B118 Basins Area (%)	42%
<b>Senate Bill (SB) 1938 GWMPs Overlaying B118 Alluvial Basins</b>	
SB 1938 GWMPs	83
SB 1938 GWMP Coverage in B118 Basin Area (%)	32%
SB 1938 GWMPs that include all CA Water Code Requirements	35
Coverage of SB 1938 GWMPs that include all CA Water Code Requirements in B118 Basin Area (%)	17%

## Groundwater Management Plans

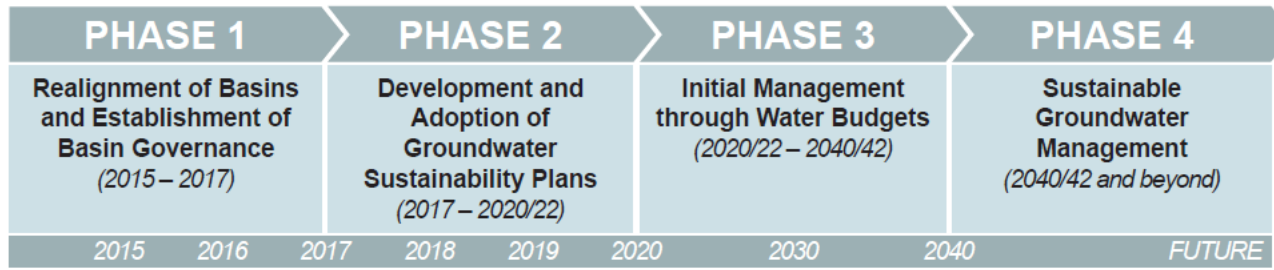
- AB 359
- SB 1938
- AB 3030

# Sonoma and Napa County: Existing Groundwater Management Plans



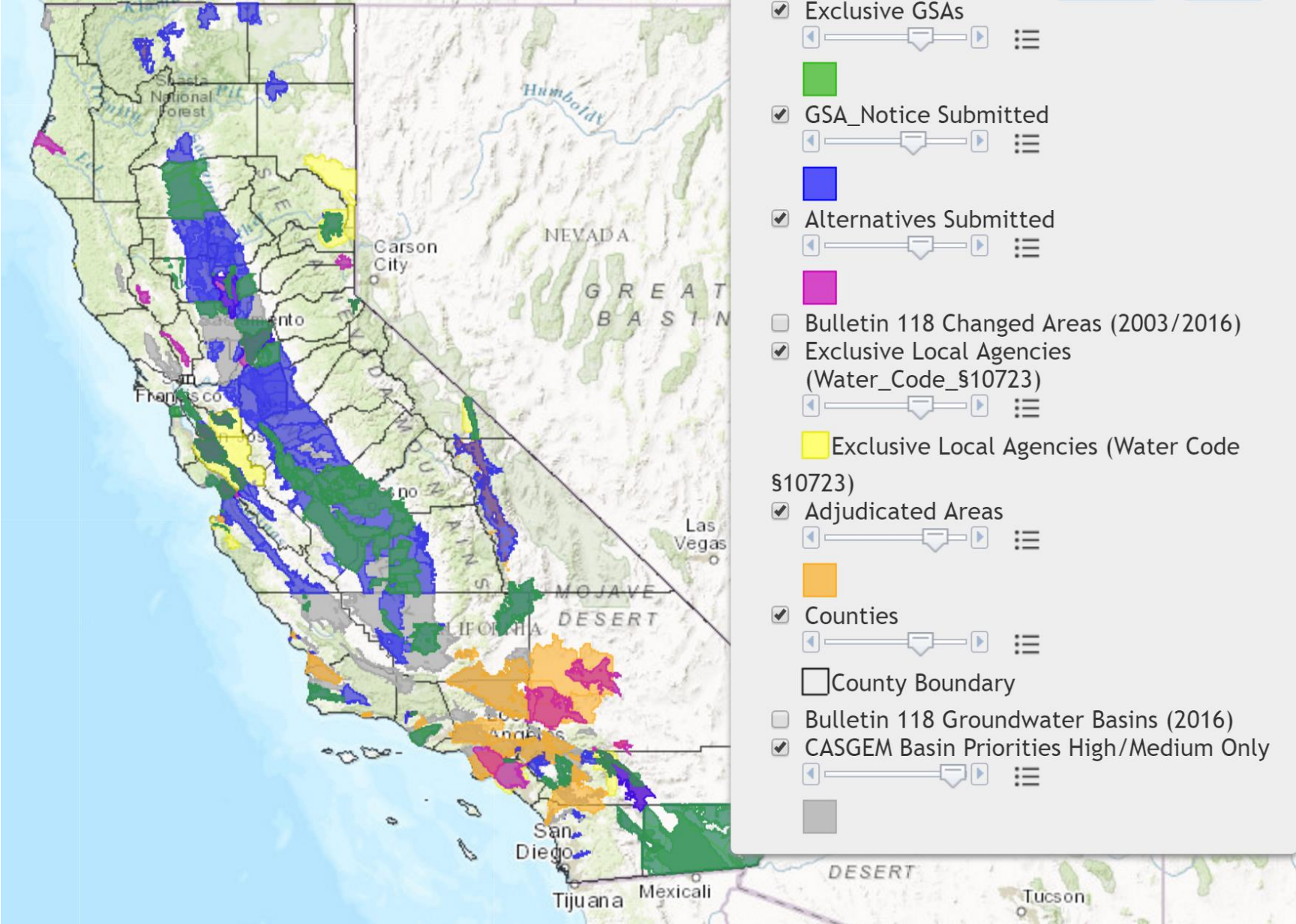


# So What Exactly Will Happen?

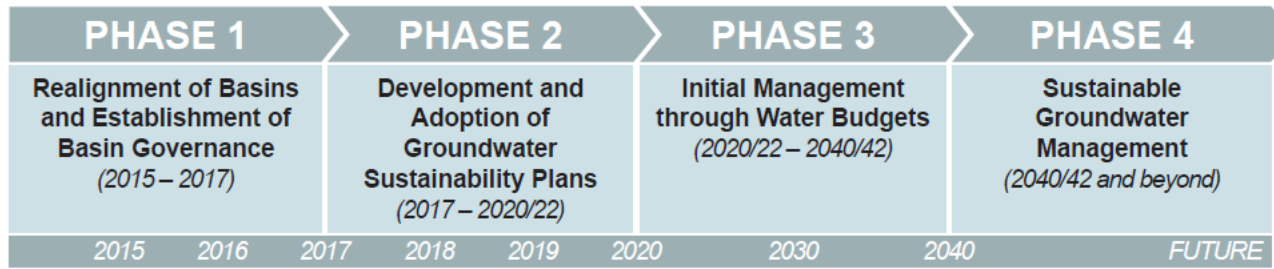


- **First Step: forming a Groundwater Sustainability Agency (GSA)**
  - By June 2017

# Map of Current GSAs and Other Groundwater Jurisdictions

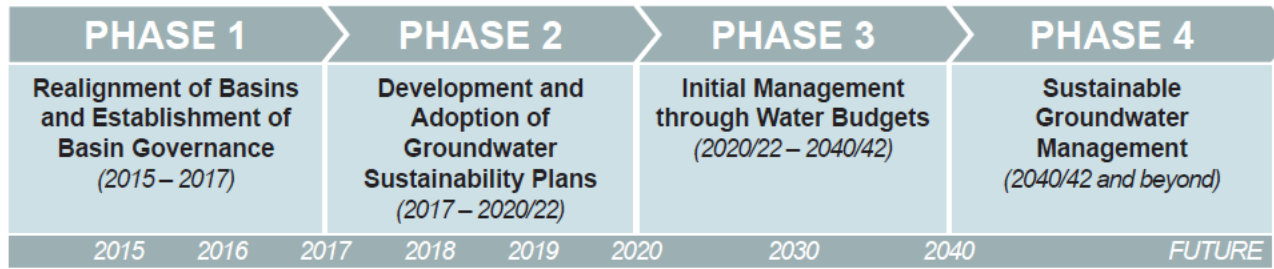


# So What Exactly Will Happen?



- First Step: forming a Groundwater Sustainability Agency (GSA)
  - By June 2017
- **Second Step: developing a Groundwater Sustainability Plan (GSP)**
  - Within 5 years of GSA formation

# So What Exactly Will Happen?



- First Step: Forming a Groundwater Sustainability Agency (GSA)
  - By June 2016
- **Second Step: Developing a Groundwater Sustainability Plan (GSP)**
  - Within 5 years of GSA formation

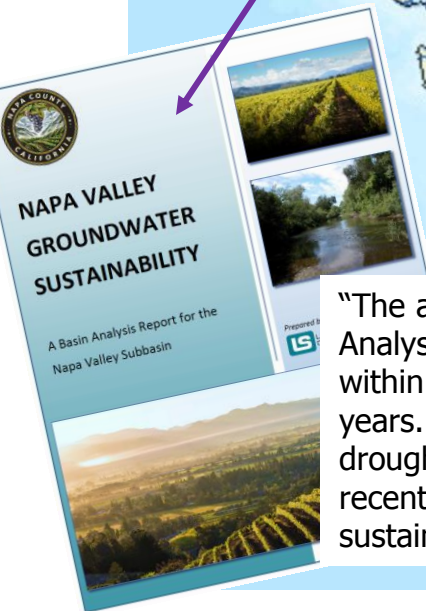
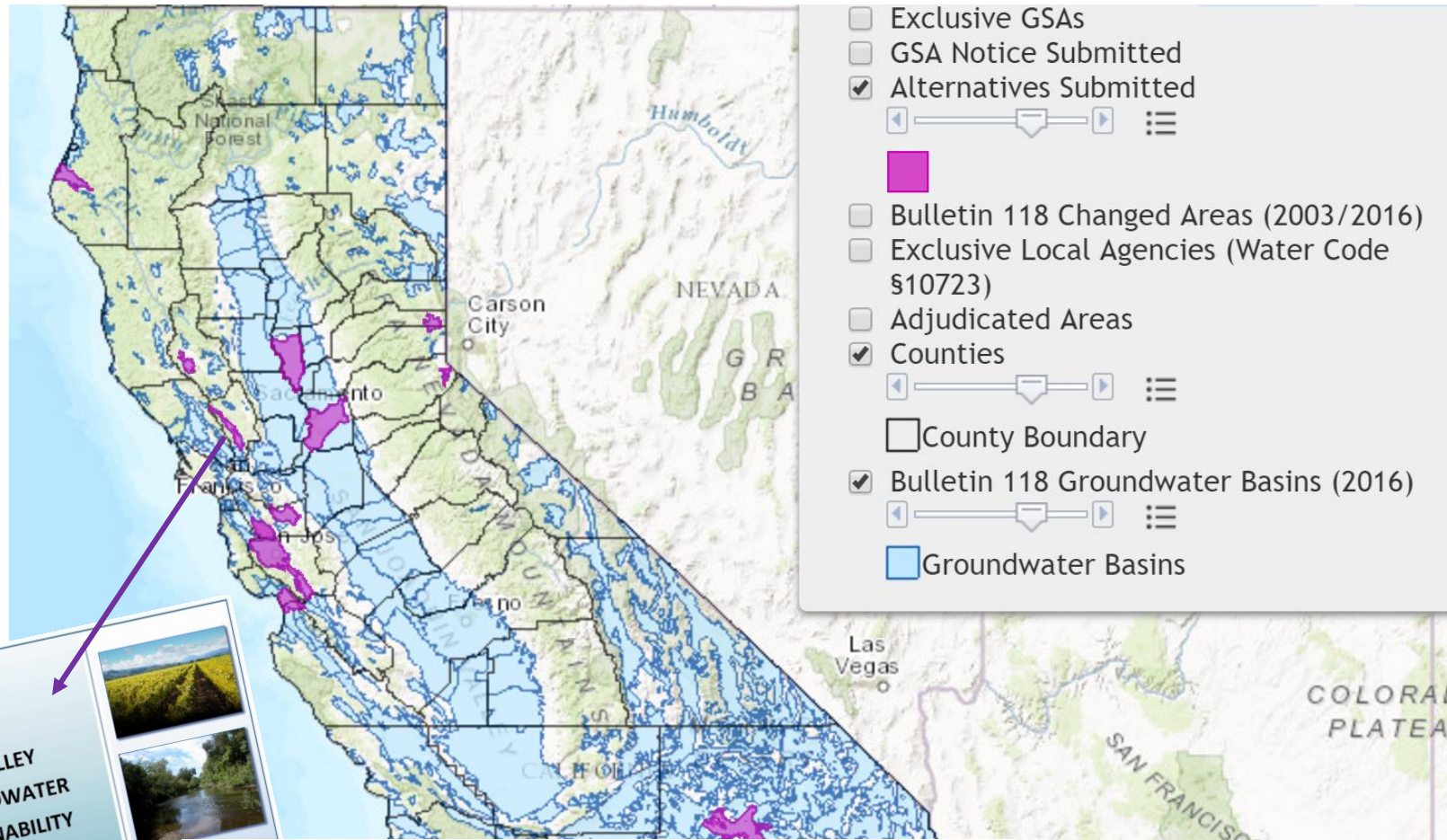
**if groundwater management already sustainable:**

**“Alternative Plan” by December 2016  
(functional equivalent of a GSP)**

# “Alternative Plans” submitted by 12/2016 deadline



# “Alternative Plans” submitted by 12/2016 deadline



“The analyses presented in the Napa Valley Subbasin Basin Analysis Report demonstrate that the basin has operated within its sustainable yield over a period of more than 20 years. Stable groundwater levels observed during recent drought conditions (from 2012 through 2015) suggest that recent rates of groundwater pumping have not exceeded the sustainable yield of the Subbasin.”

# Measure of Groundwater Sustainability: Sustainability Indicators

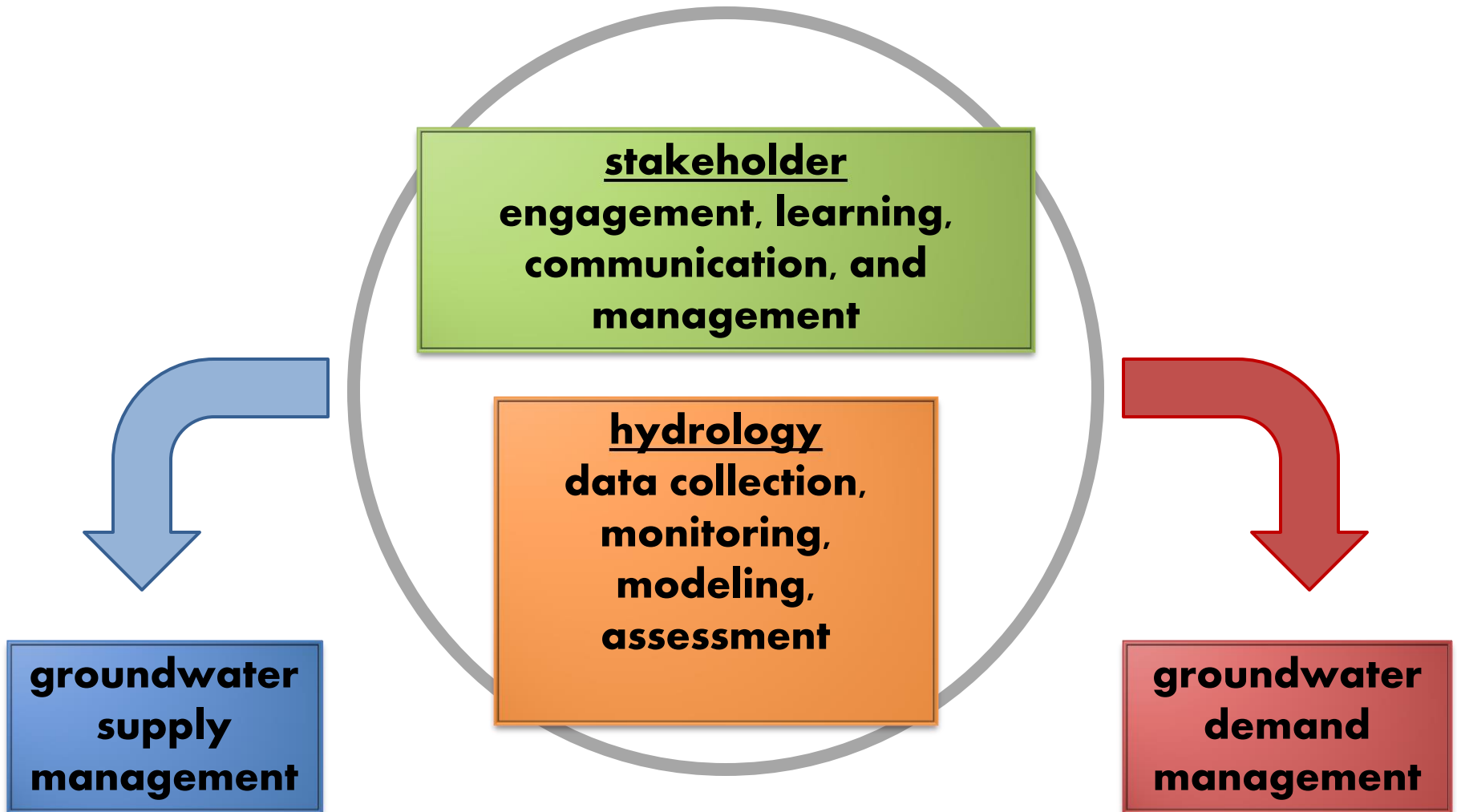


California Department of Water Resources, 2016

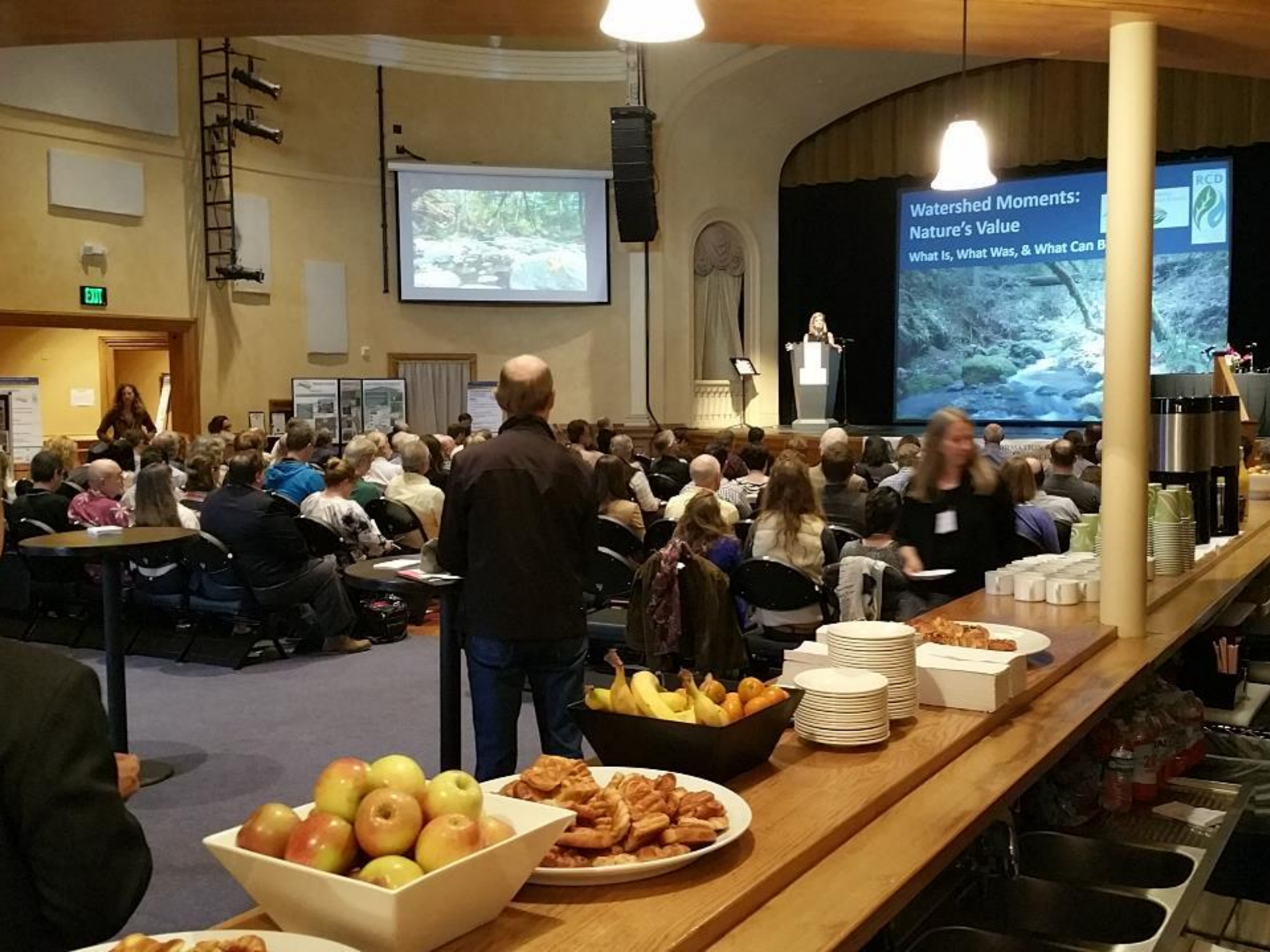
Goal of the GSP:

 maintain sustainability indicators in good status

# Getting There: GSAs plan & implement GSPs







**Watershed Moments:  
Nature's Value**  
What Is, What Was, & What Can Be



EXIT

# Monitoring and Assessment

Groundwater Sustainability Agencies have *discretionary* authority to:

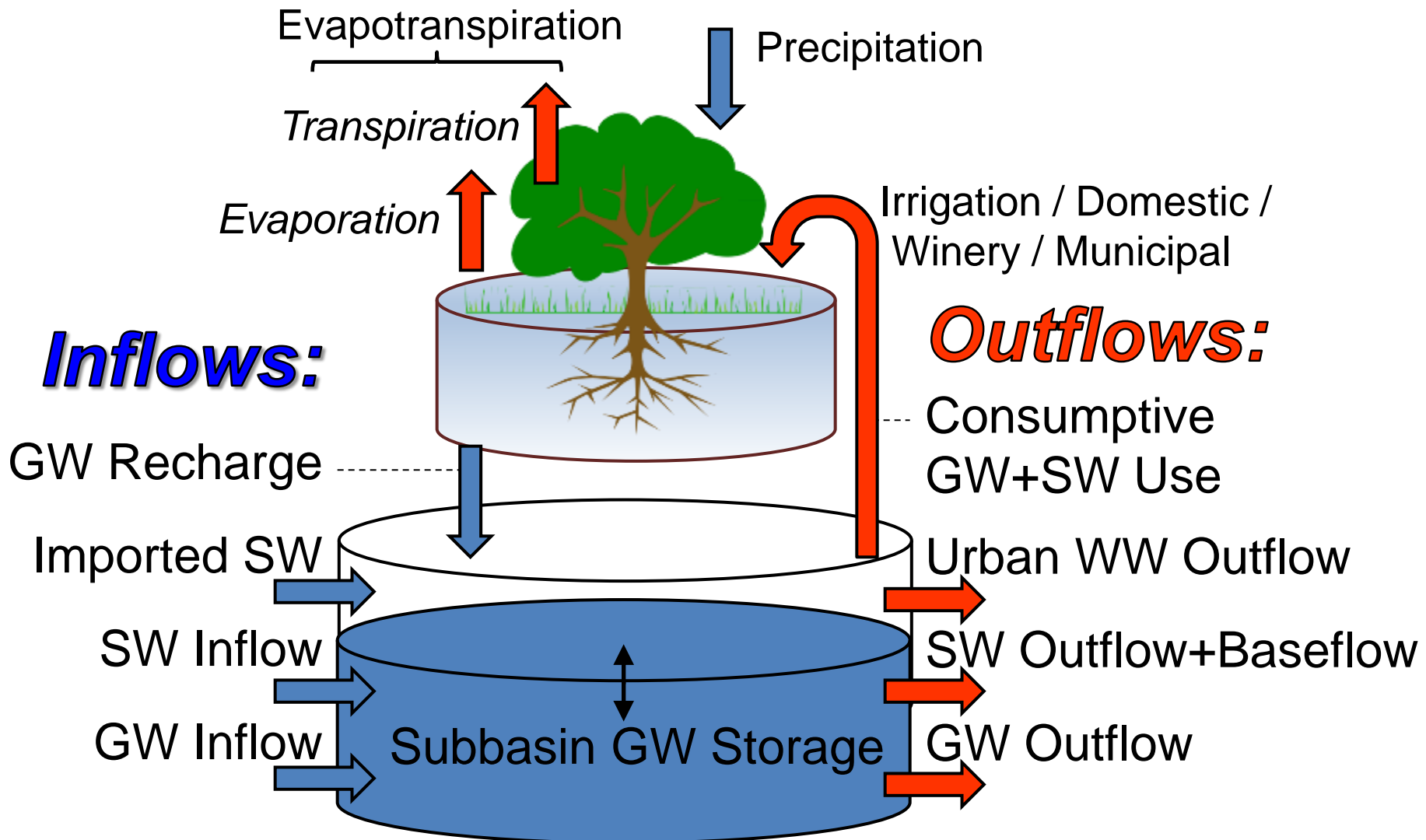
- Conduct studies
- Register & monitor wells
- Set well spacing requirements
- Require extraction reporting
- Regulate extractions
- Implement capital projects
- Assess fees to cover costs

Some exemptions for smaller private well owners

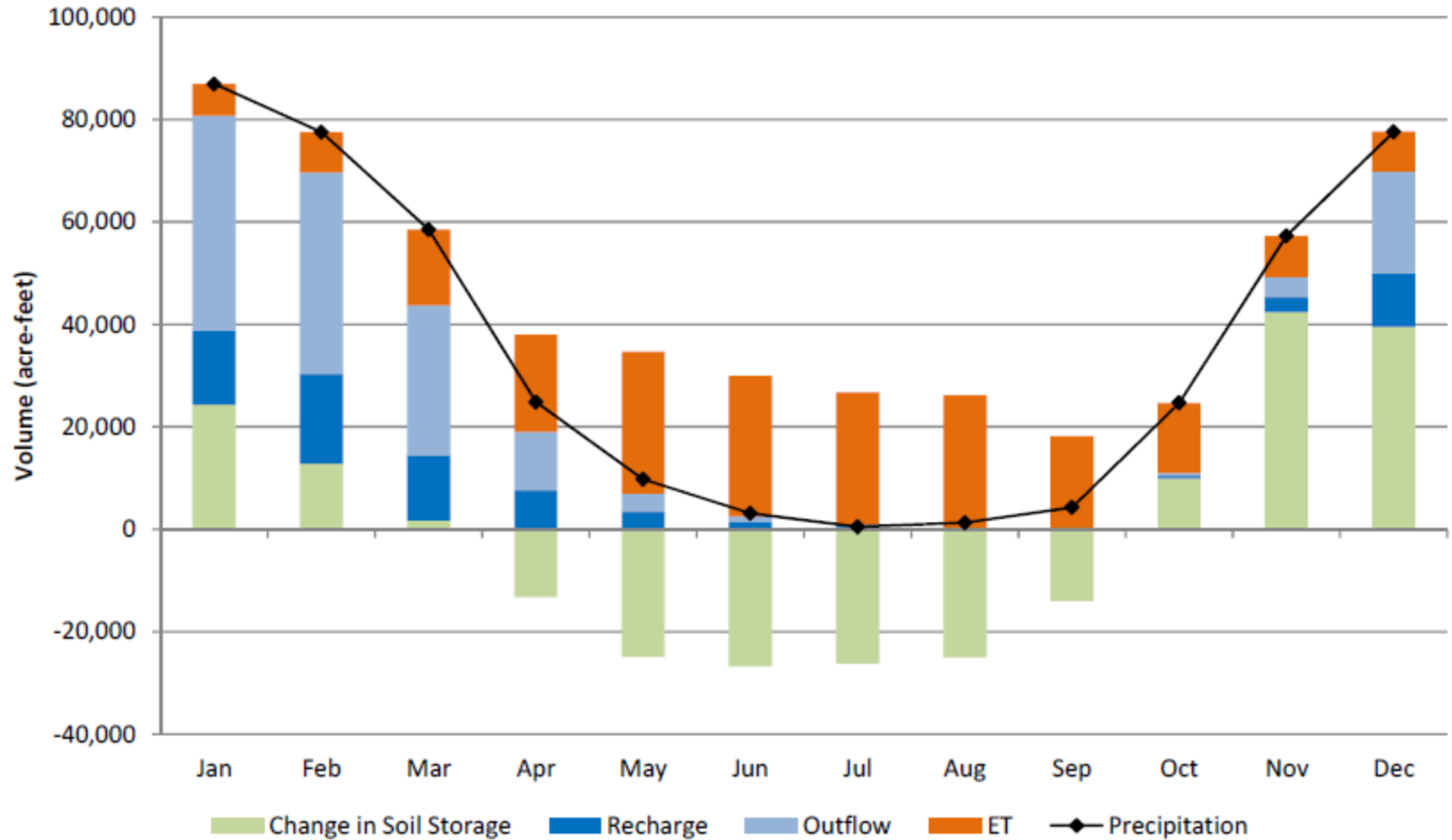


# Subbasin Water Budget Components

$$\text{Inflows} - \text{Outflows} = \Delta S \text{ Change in GW Storage}$$



# Dynamics of the Soil Root Zone Water Budget: Napa River Watershed



# Groundwater Pumping Napa Valley Subbasin

Groundwater Use	2012 – 2015 Avg. Acre- Ft/Yr
Vineyard Irrigation	12,263
Other Ag Irrigation	448
Unincorporated Residential (indoor use)	371
Semi-Ag, Residential, and Commercial Unincorporated Areas, Irrigation	2,885
Unincorporated Wineries	1,222
Municipal	317
Total Average Groundwater Pumping 2012 - 2015	17,506

Modified From: Vicki Kretsinger-Grabert, LSCE, Report to Napa County BOS, April 2017

# Water Budget

Est. Inflows (1988-2015)	Avg. Annual Ac-Ft/Yr
<i>Upland Runoff</i>	<i>145,000</i>
GW Recharge	69,000
Imported SW Deliveries	17,000
Uplands Subsurface Inflow	5,000

Est. Outflows (1988-2015)	Avg. Annual Ac-Ft/Yr
<i>SW Outflow and Baseflow</i>	<i>176,000</i>
Net GW Use	13,000
Net SW Use	14,000
GW Subsurface Outflow	19,000
Urban Wastewater Outflow	8,000

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**Net Avg. Annual Change in Subbasin Storage ~ 6,000 Acre-Ft/Yr**  
**(uncertainty in individual budget components; *italicized more uncertain*)**

*Modified From: Vicki Kretsinger-Grabert, LSCE, Report to Napa County BOS, April 2017*

# Groundwater Level Monitoring Network



**Napa Co., 98  
(including  
10 SW/GW)**

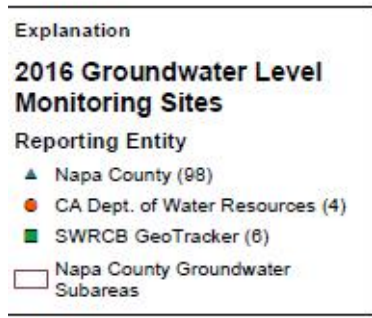


**DWR, 4**

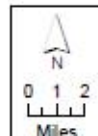
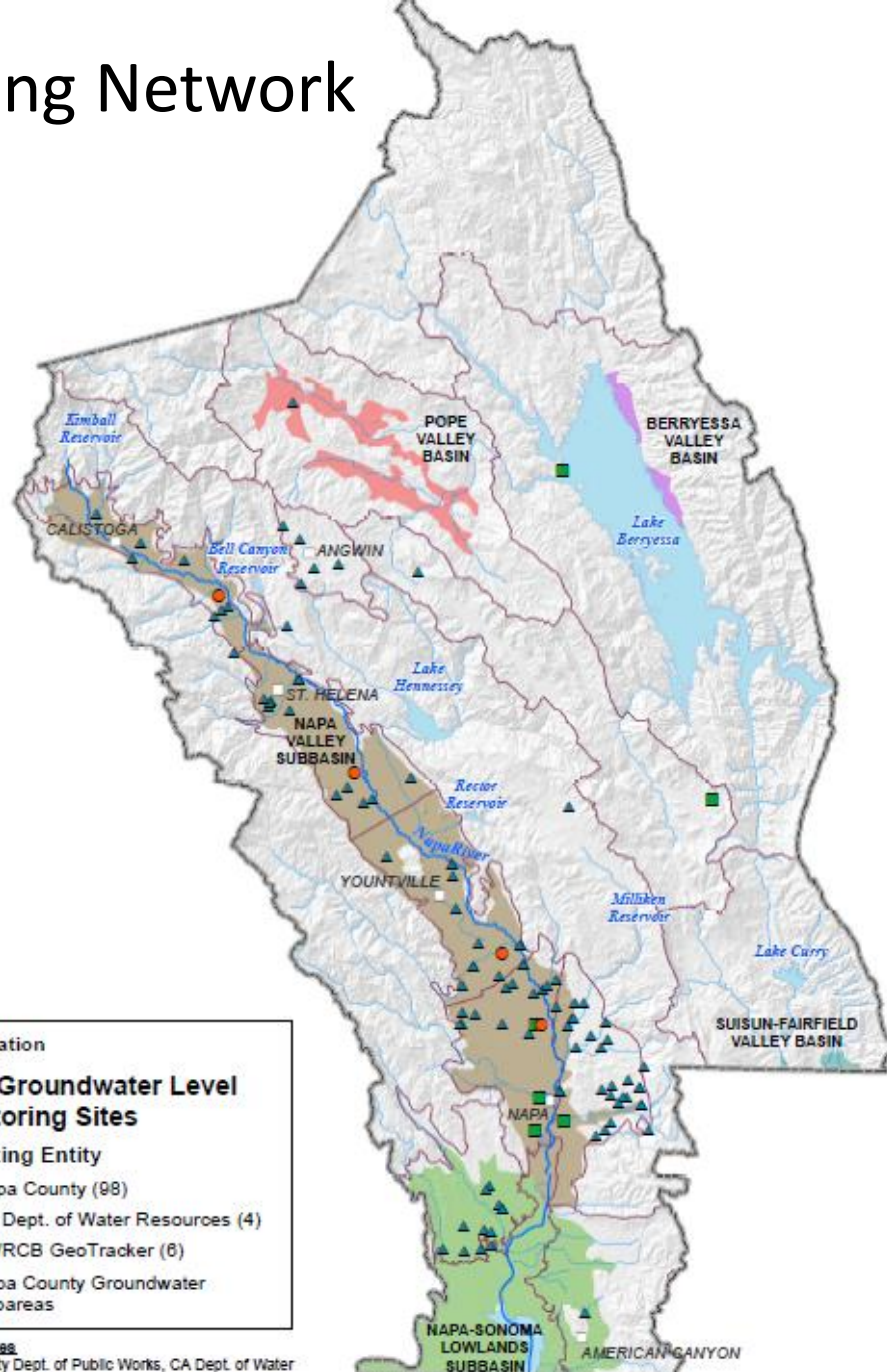


**GeoTracker, 6**

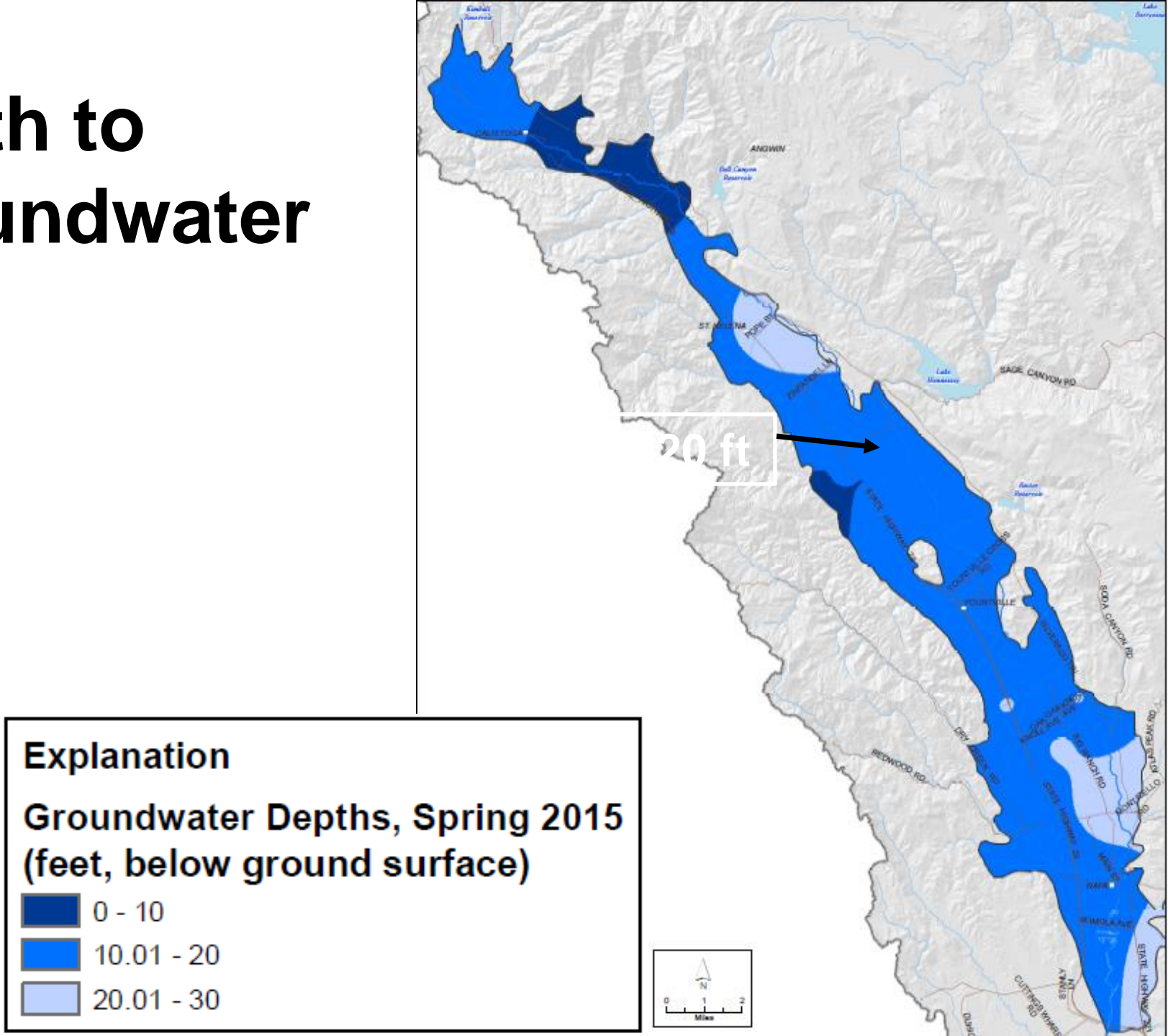
**Total Wells  
= 108 Sites**



Data sources  
Napa County Dept. of Public Works, CA Dept. of Water

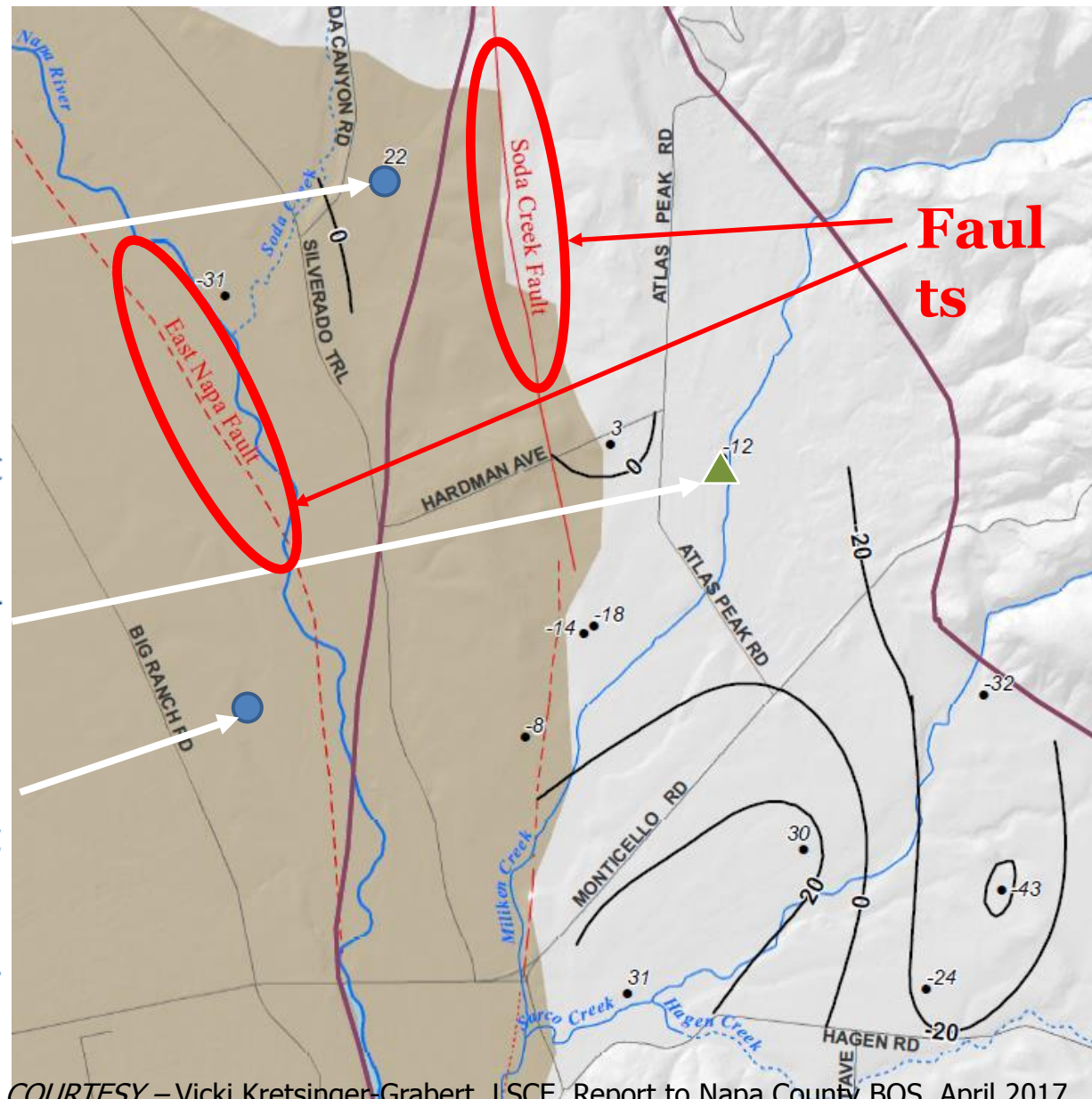
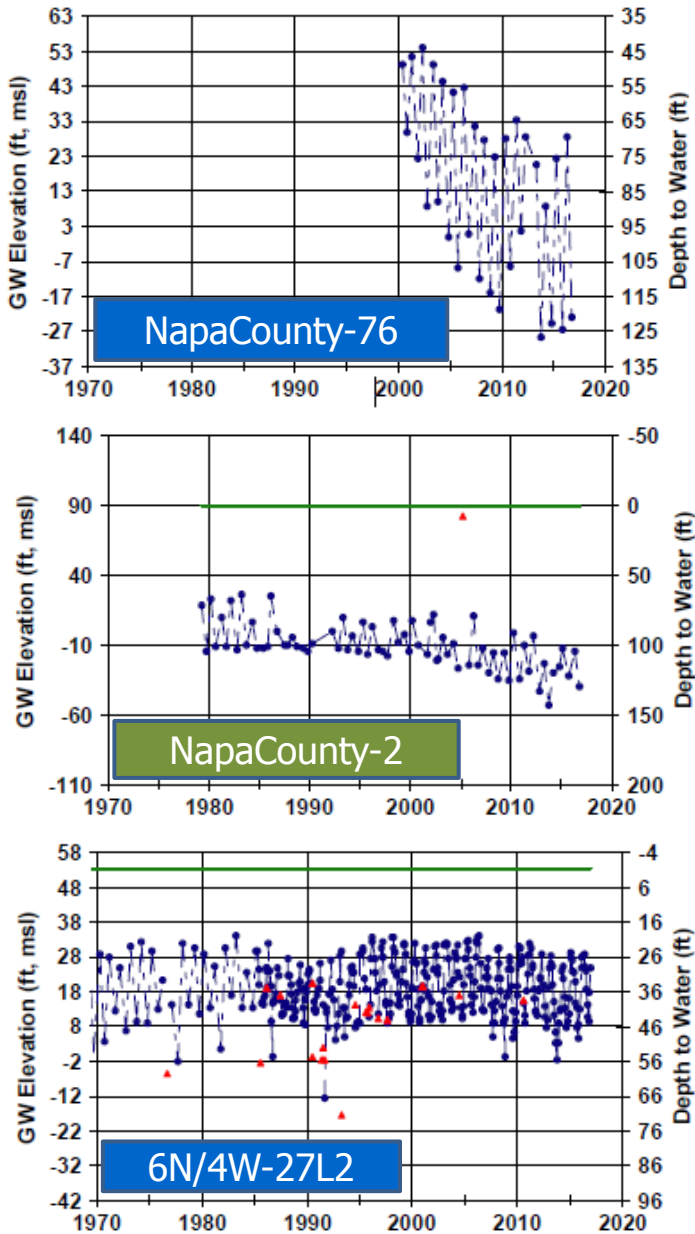


# Depth to Groundwater





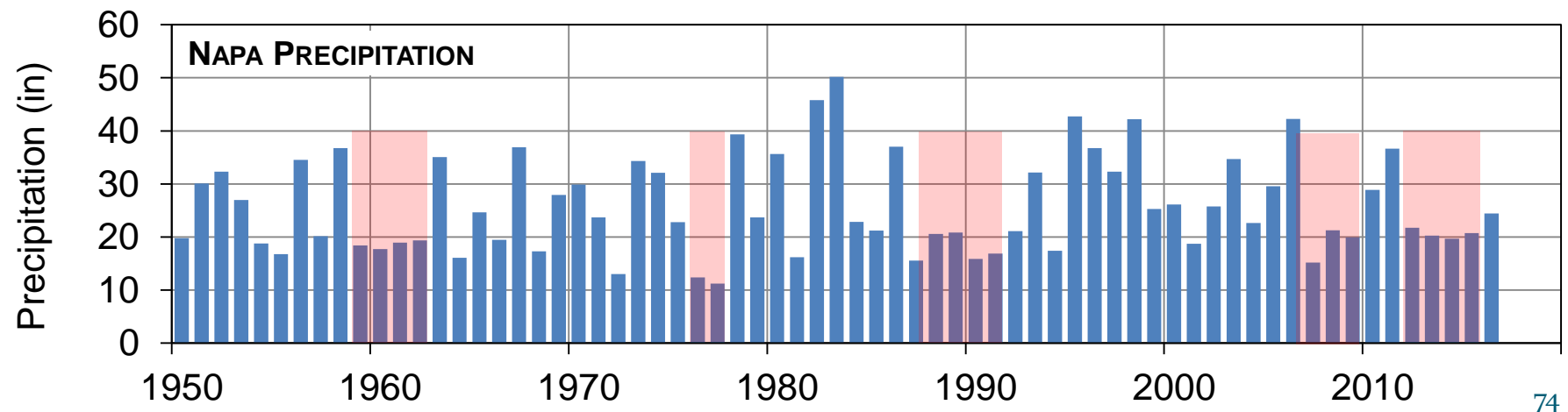
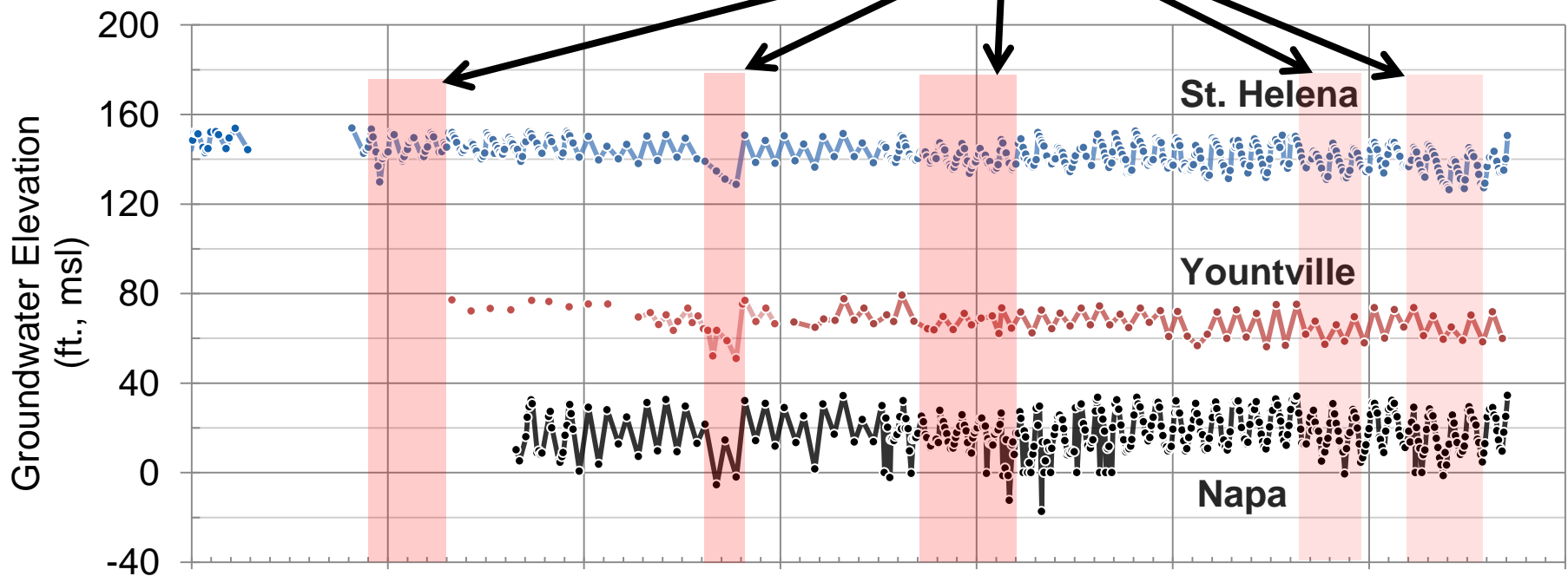
# NV Subbasin, Northeast Napa Area & MST



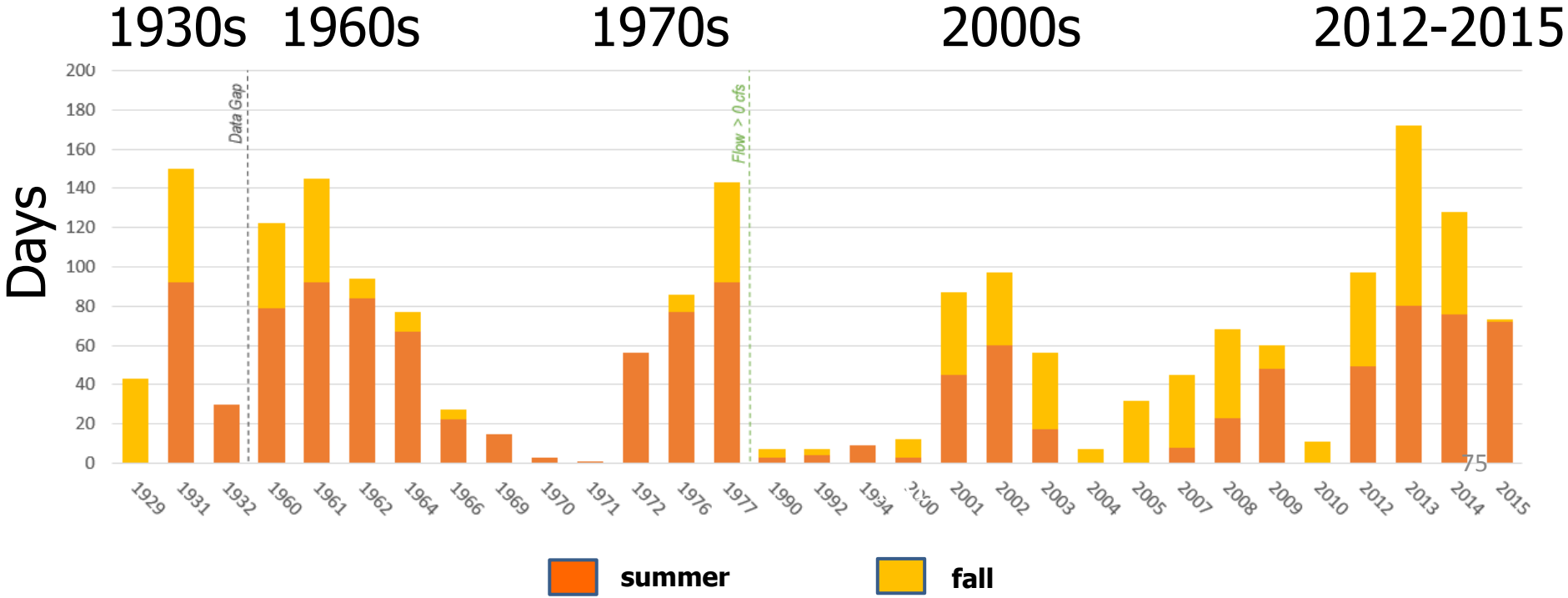
COURTESY – Vicki Kretsinger-Grabert, LSCE, Report to Napa County BOS, April 2017

# Groundwater Conditions: Napa Valley Subbasin

Dry Years



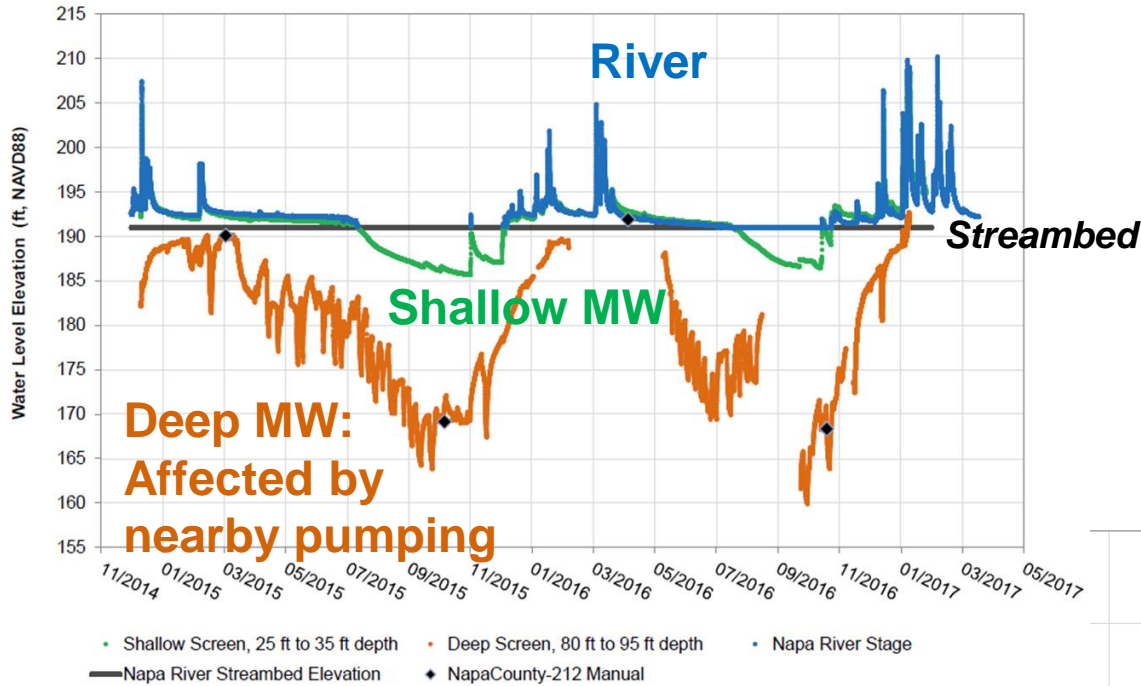
# Napa River: No. of Days with No Flow [years with perennial flow not shown]



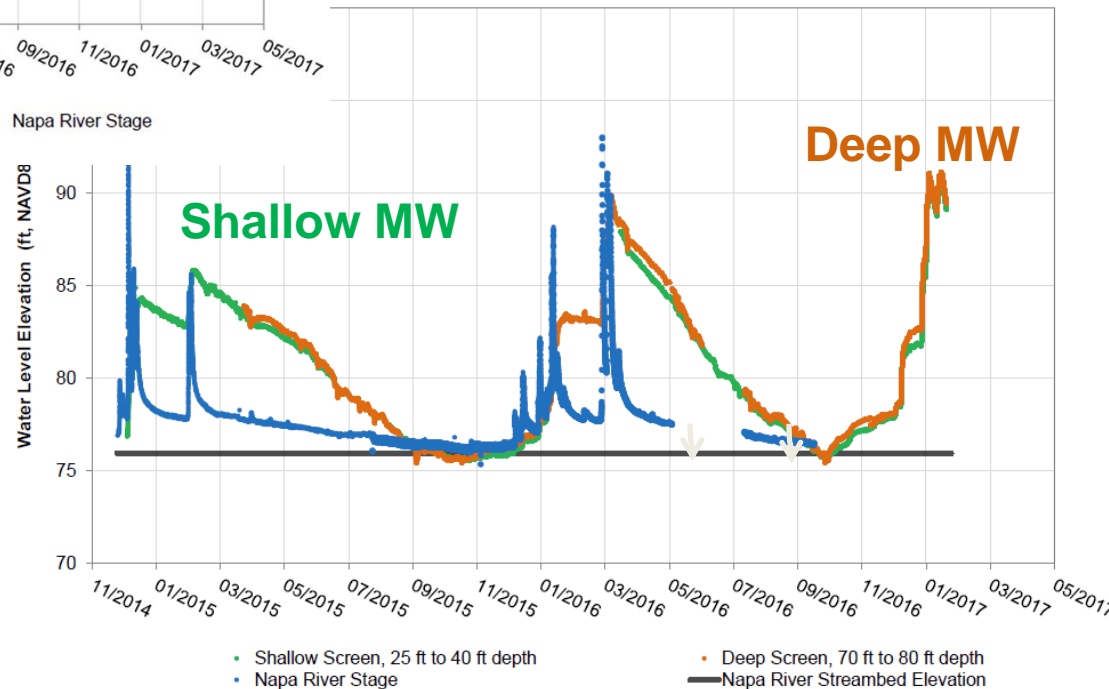
Modified From: Vicki Kretsinger-Grabert, LSCE, Report to Napa County BOS, April 2017

# Groundwater – Stream Interaction: Monitoring Sites

## St. Helena SW/MW Site



## Yountville SW/MW Site



- Healthy

**Health Maintenance**

- Nutrition
- Exercise
- Relationships/social engagement
- Monitoring & Assessment

- Sustainable Groundwater

**Groundwater Management**

- Adaptive supply management
- Adaptive demand management
- Stakeholder engagement
- Monitoring & Assessment

M

E

TRIGGER(s)

- Ill

**Treatment Mode**

- Medication / therapy
- Additional monitoring & Doctor's assessment

- Reversible undesirable impacts

**Extraordinary Measures**

- Supply enhancement / demand reduction
- Additional monitoring & assessment

T

R

THRESHOLD(s)

- Critically ill

**Emergency Mode**

- Emergency Room
- Surgery

- Major undesirable impacts

**Emergency Mode**

- SGMA Chapter 11
- Probationary Status

I

C

- Death

- Groundwater unusable/unavailable

• Healthy

**Health Maintenance**

- Nutrition
- Exercise
- Relationships/social engagement
- Monitoring & Assessment

• Sustainable Groundwater

**Groundwater Management**

- Adaptive supply management
- Adaptive demand management
- Stakeholder engagement
- Monitoring & Assessment

**"Measurable Objective"**

E

TRIGGER (s)

• Ill

**Treatment Mode**

- Medication / therapy
- Additional monitoring & Doctor's assessment

• Reversible undesirable impacts

**Extraordinary Measures**

- Supply enhancement / demand reduction
- Additional monitoring & assessment

T

R

**"Minimum Threshold"**

• Critically ill

**Emergency Mode**

- Emergency Room
- Surgery

• Major undesirable impacts

**Emergency Mode**

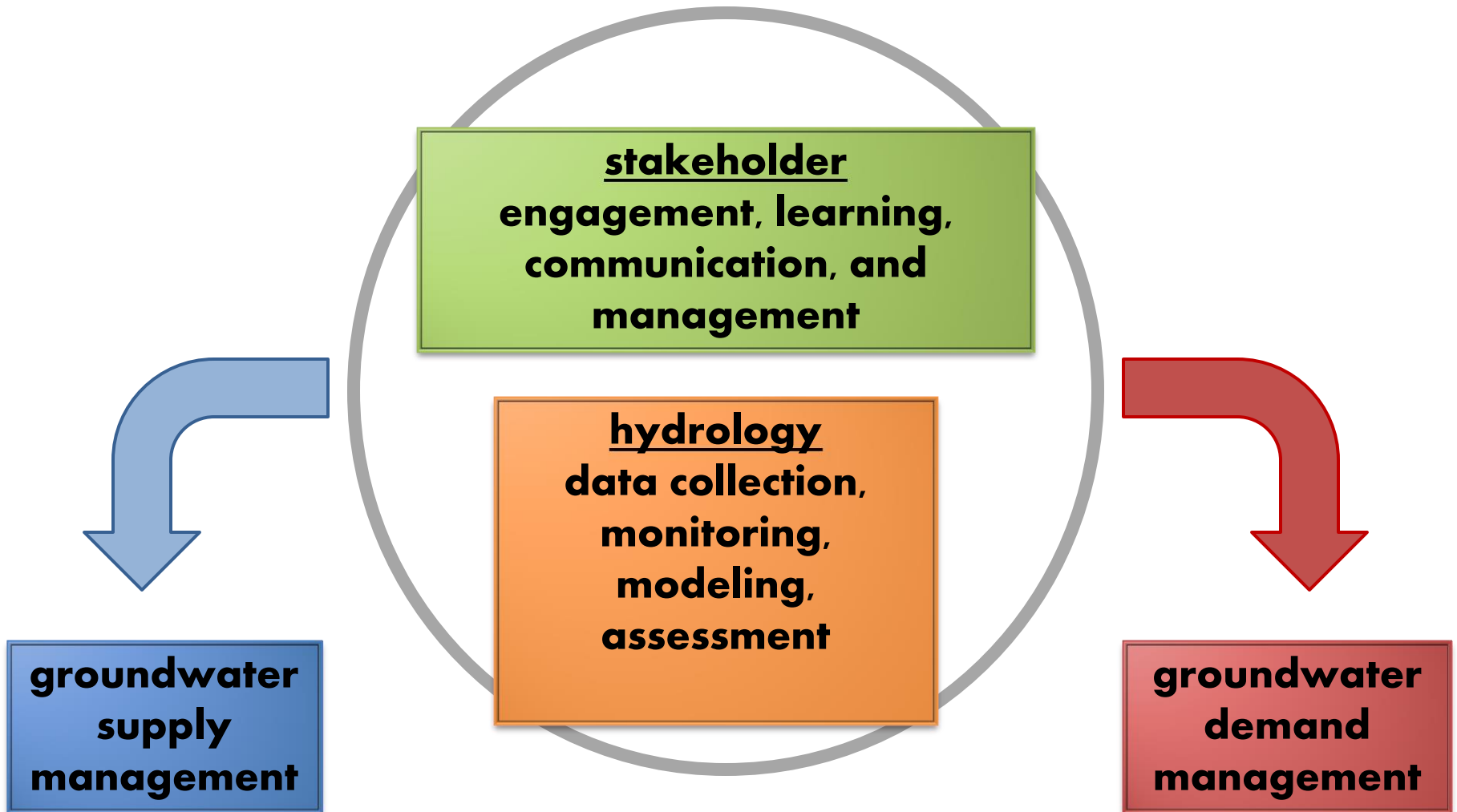
- SGMA Chapter 11
- Probationary Status

C

• Death

• Groundwater unusable/unavailable

# Getting There: GSAs plan & implement GSPs



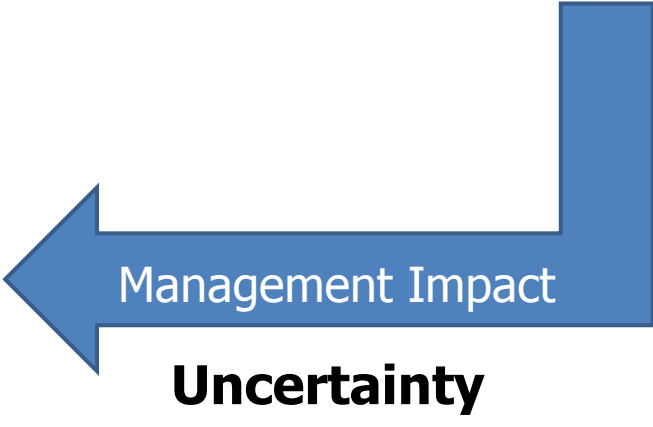
# Models Useful to Define Relationship between Measurable Objectives (MO) and Management Practices

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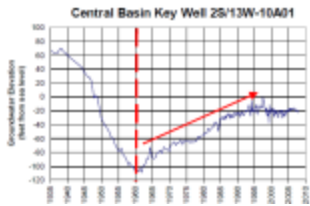


**Groundwater Sustainability Plan**

- Stakeholder engagement
- Monitoring & Assessment
- Adaptive supply management
- Adaptive demand management



THRESHOLD (s)





# Monitoring for Sustainability Indicators



**Napa Co., 98  
(including  
10 SW/GW)**

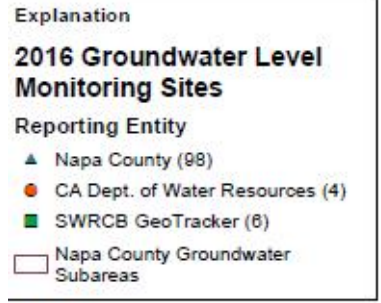


**DWR, 4**

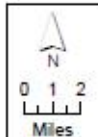
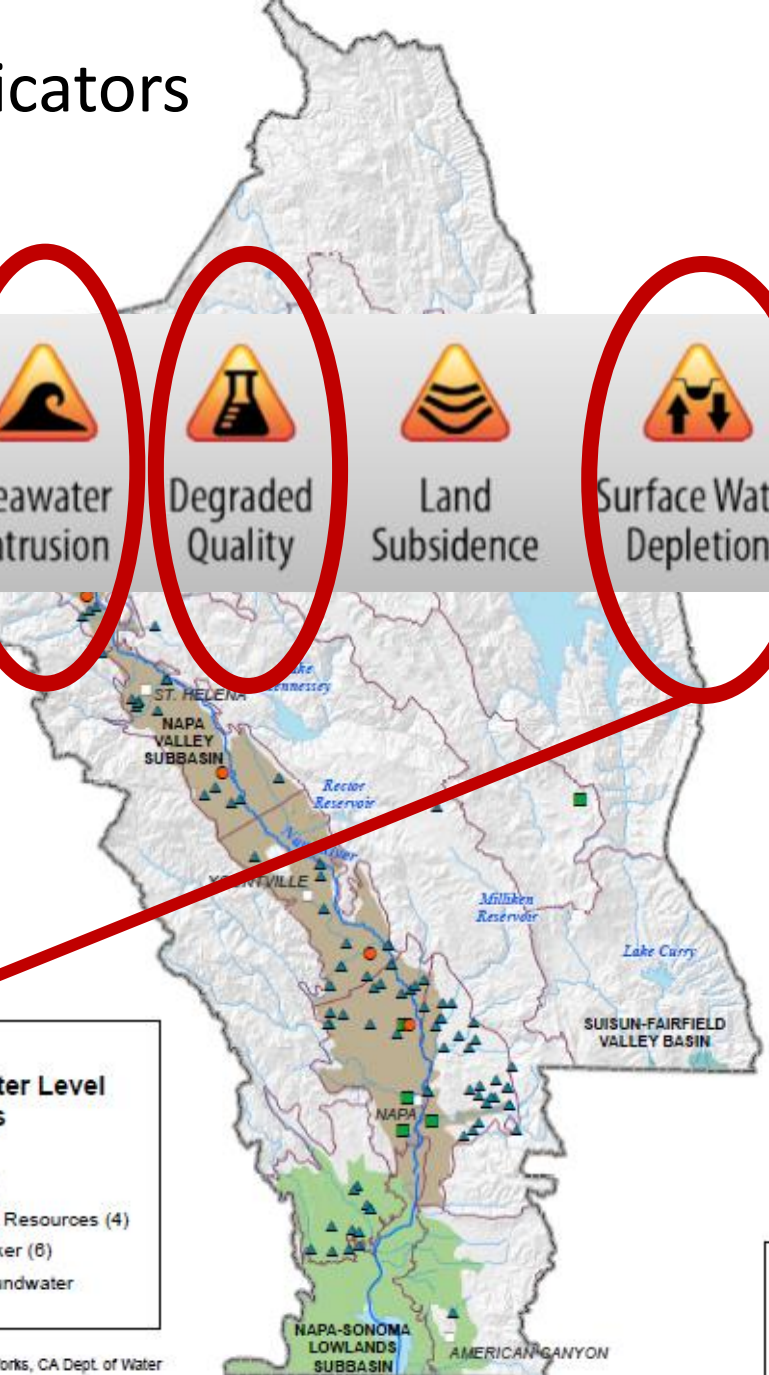


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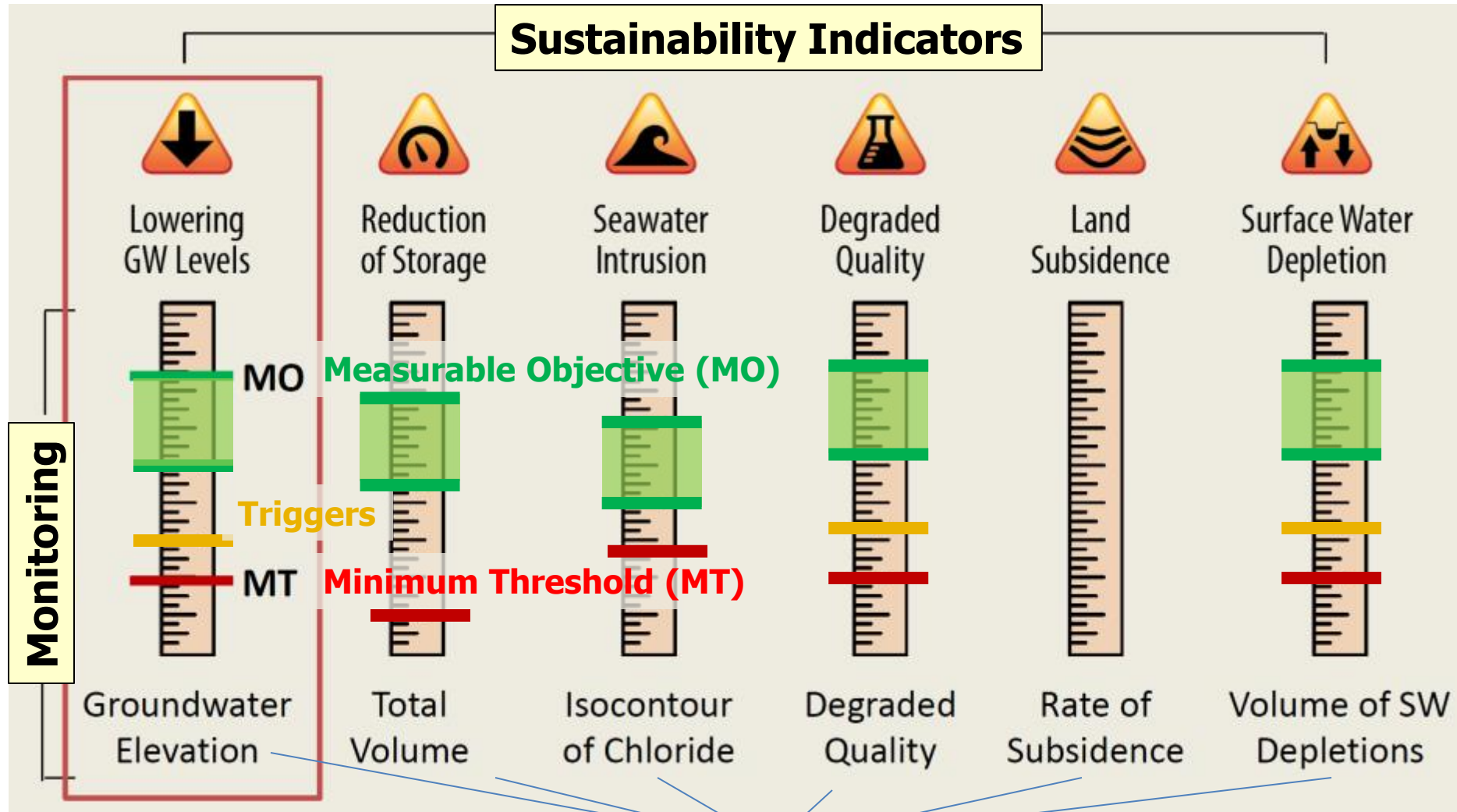
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**Data sources**  
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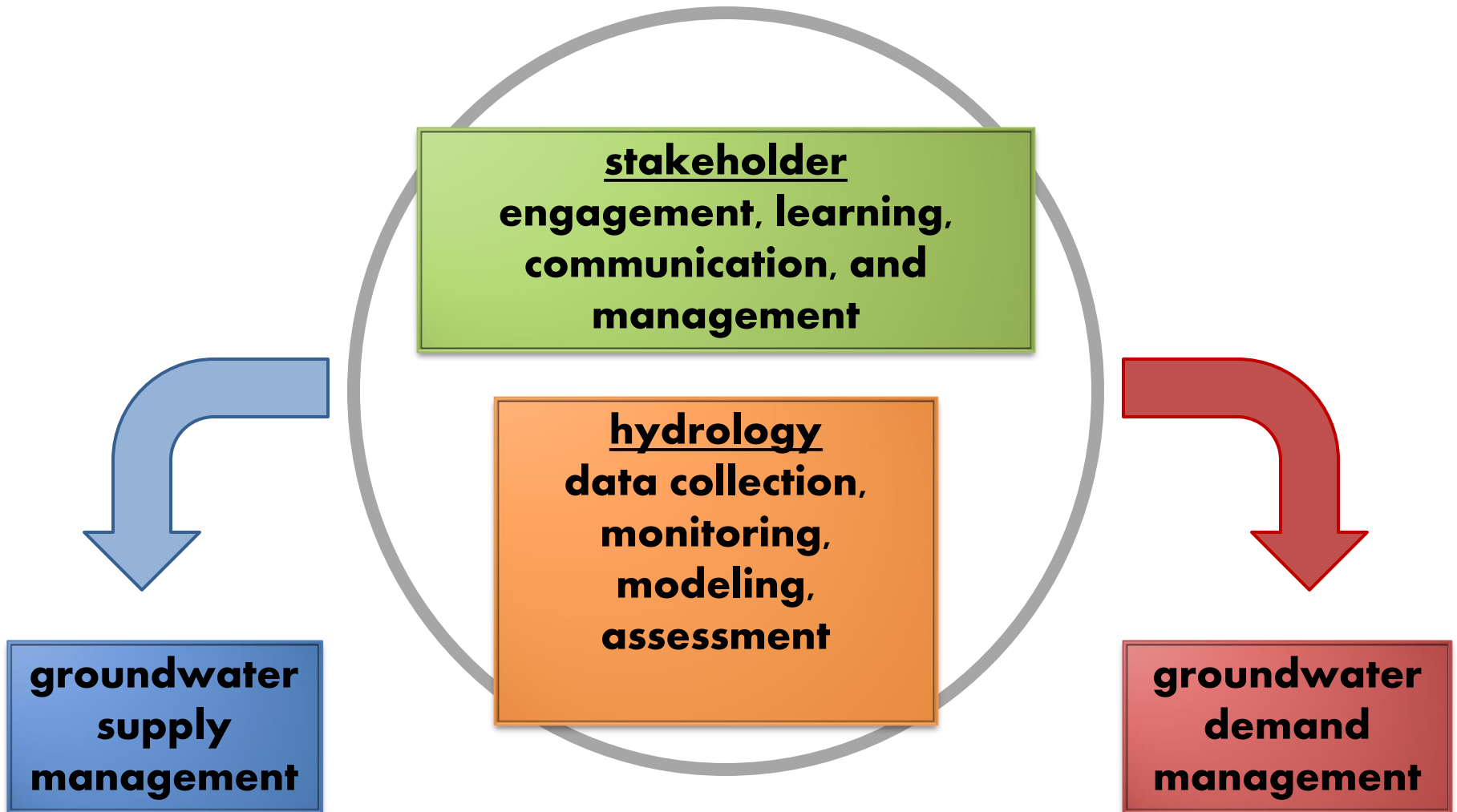
# GSP: Monitoring and Managing Sustainability



[generalized examples of what to monitor]

modified from Ca DWR 2016

# Getting There: GSAs plan & implement GSPs



# Recycled Water Reuse - Pajaro Valley -



Photo: Californian Salinas



**Pajaro Valley**  
Water Management Agency

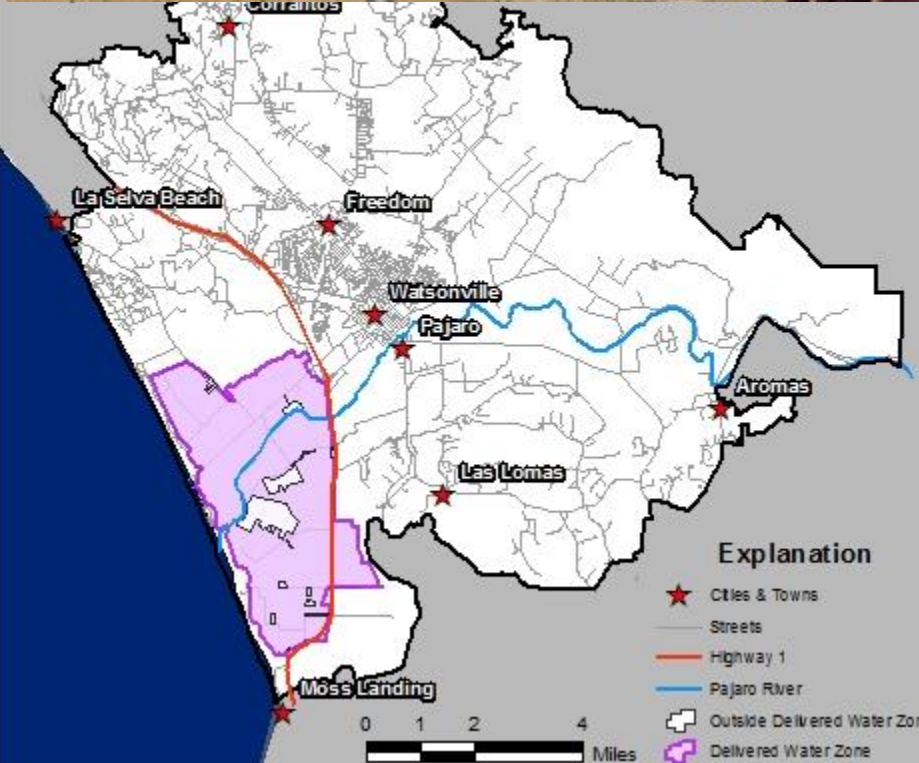


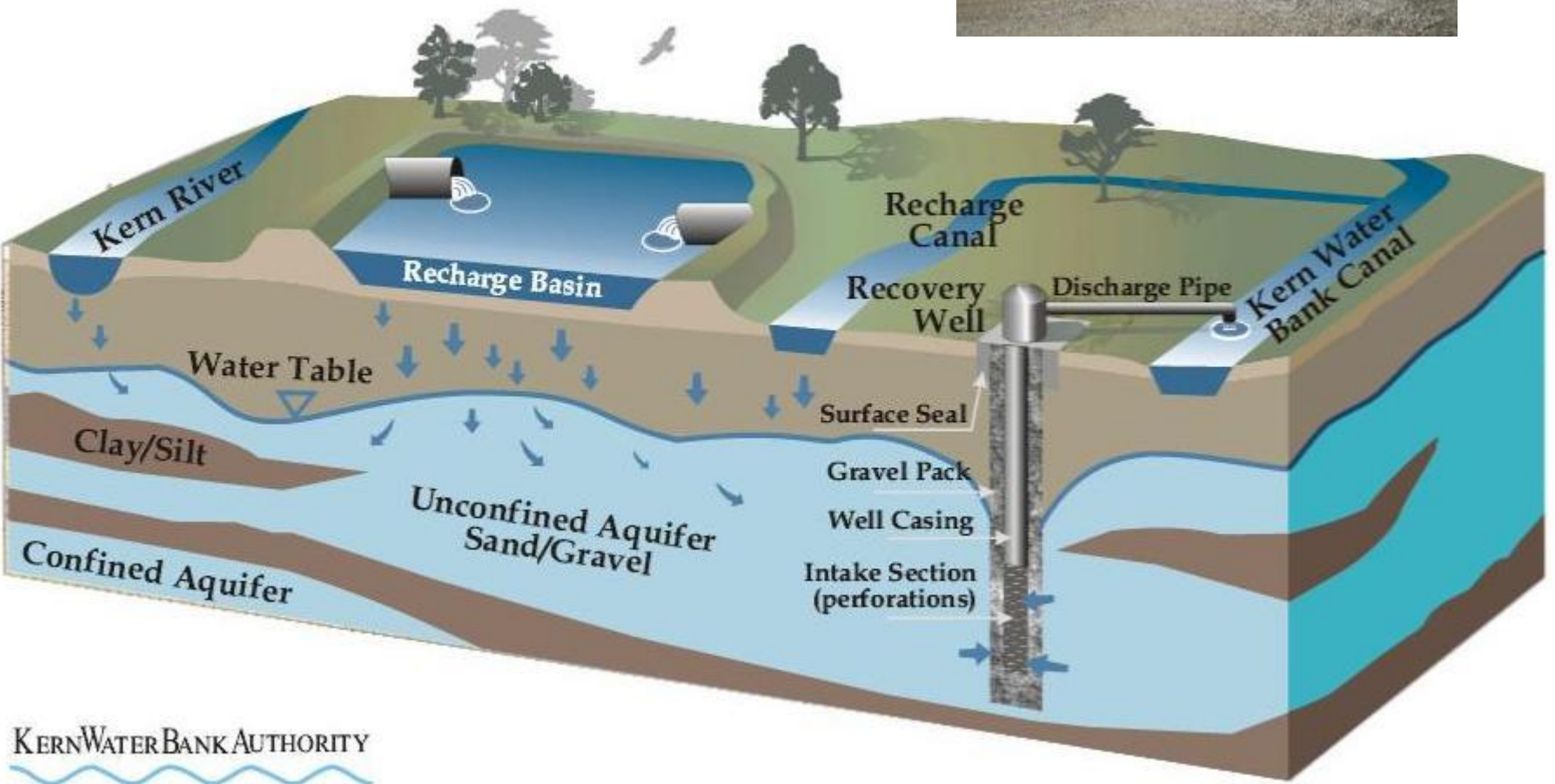
Photo: J.D. Hillard

# Water Banking



From: Ted Johnson, WRD 2013

Yuba River Infrastructure, such as this water discharge pipe, allow water districts and agencies to manage surface water and groundwater within the same hydrologic area as a single resource, using one source to balance the other when surface water or groundwater levels are low. This can reduce water diversions and groundwater pumping, enhance local supply, and increase the amount of water available for transfer.



# On Farm Winter Groundwater Recharge



# Managed Aquifer Recharge Near a Stream





# Managed Aquifer Recharge Near a Stream



# Managed Aquifer Recharge Near a Stream



# Managed Aquifer Recharge Near a Stream



# Managed Aquifer Recharge Near a Stream



# Managed Aquifer Recharge Near a Stream



# Managed Aquifer Recharge Near a Stream



# Managed Aquifer Recharge Near a Stream



# Managed Aquifer Recharge Near a Stream





# Managed Aquifer Recharge Near a Stream



# Managed Aquifer Recharge Near a Stream



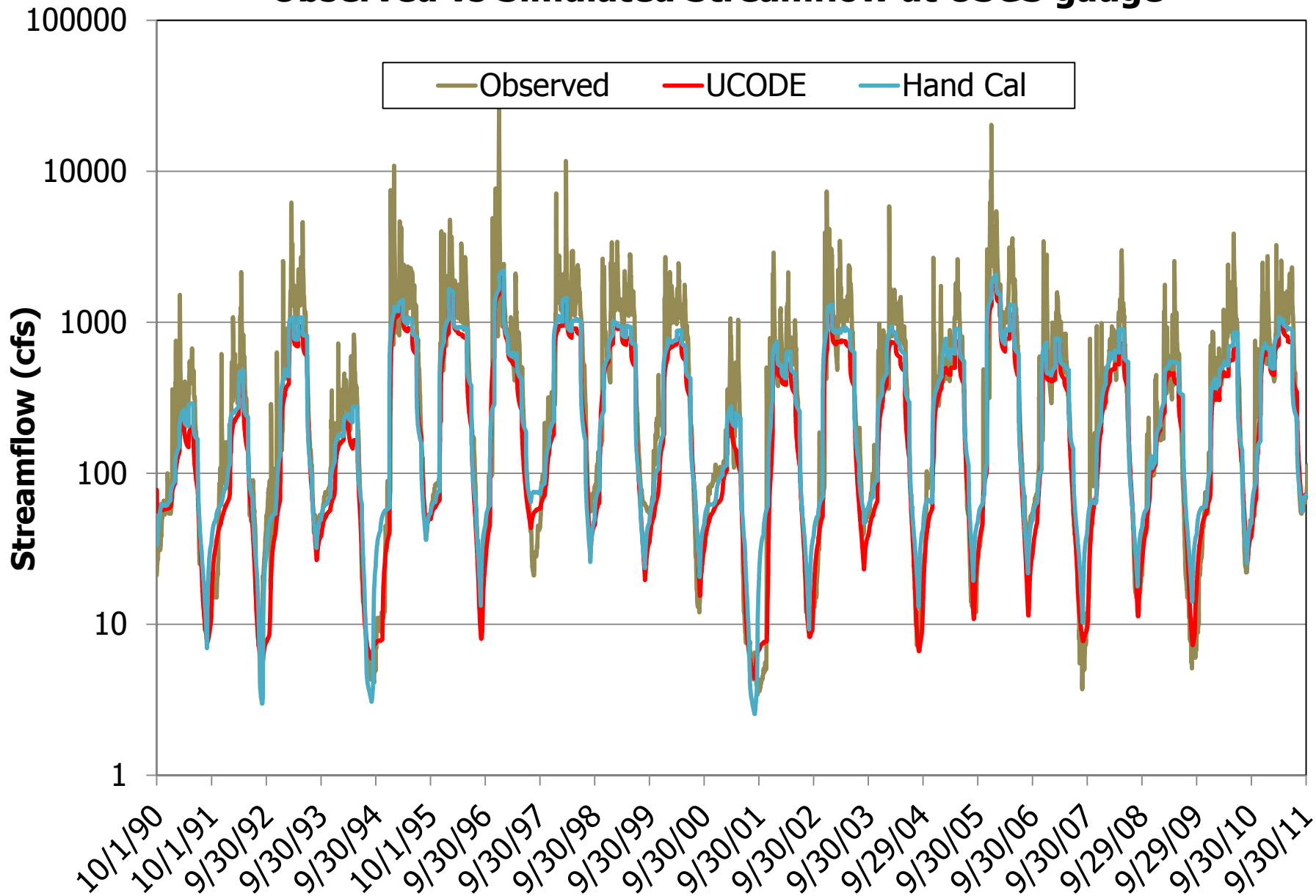
# Managed Aquifer Recharge Near a Stream



# Managed Aquifer Recharge Near a Stream

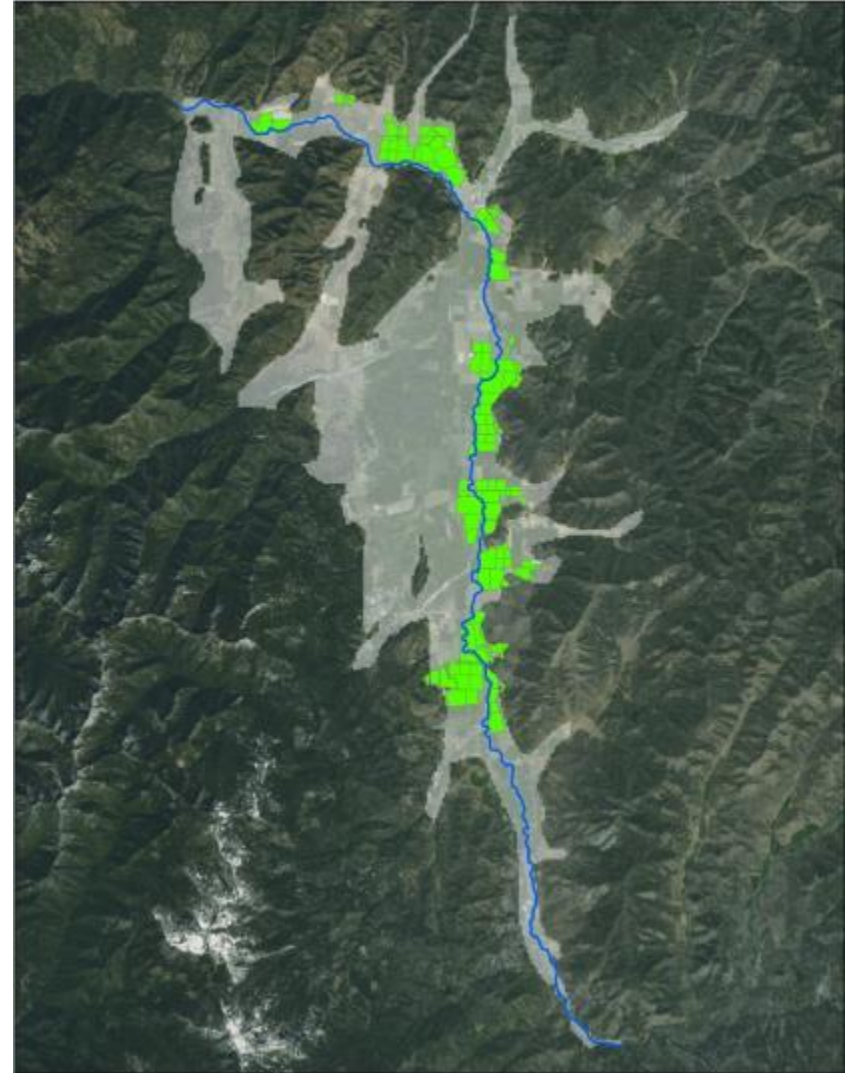


# Calibrated Groundwater-Surface Water Model: Observed vs Simulated Streamflow at USGS gauge

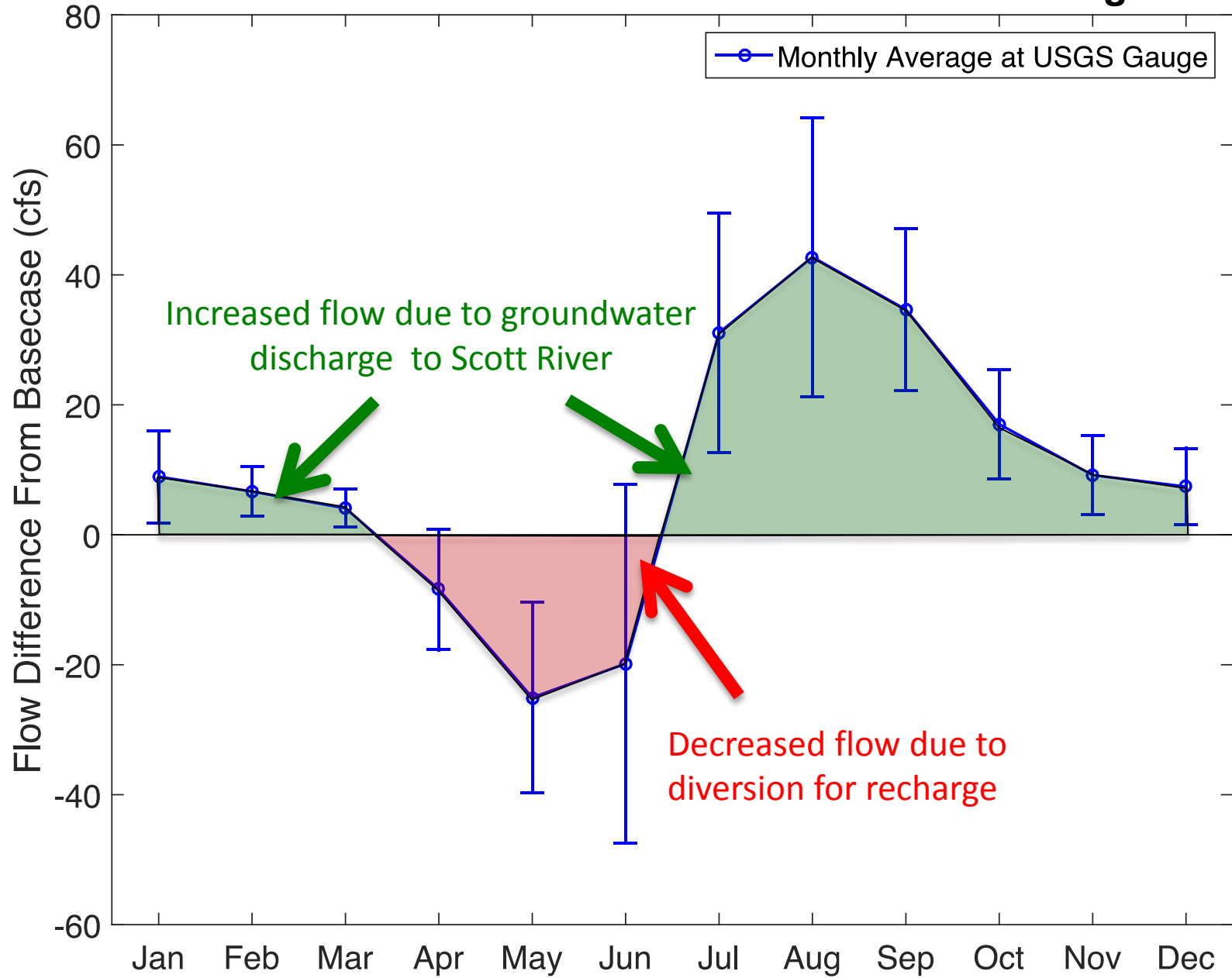


# Evaluate Project Scenarios with Numerical Model: Example: In-Lieu Recharge

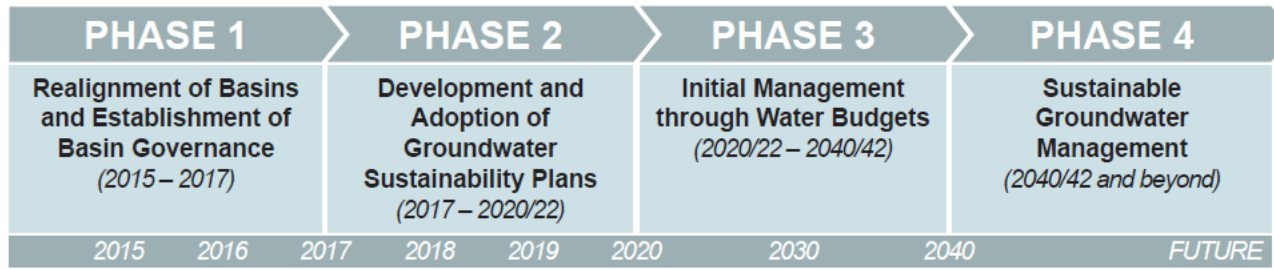
- Use surface water instead of groundwater when available on selected fields
  - ~5,900 acres
- Apply additional irrigation prior to start of growing season on selected fields
  - 33% increase
- Delays portion of groundwater pumping until later in the summer



# Flow Difference From Basecase - In Lieu Recharge



# So What Exactly Will Happen?



- First Step: forming a Groundwater Sustainability Agency (GSA)
  - By June 2017
- Second Step: developing a Groundwater Sustainability Plan (GSP)
  - Within 5 years of GSA formation
- **Third Step: implementing Groundwater Sustainability Plan**
  - **achieve sustainable management no later than 2042**
  - DWR may grant up to two 5-year extensions upon showing of good cause and progress



# Role of the State: **Carrot**

- Department of Water Resources has a key role:
  - Technical assistance and funding (Prop 1: \$100 million for SGMA)
  - Regulation
    - Groundwater basin boundary adjustments
    - Minimum guidelines for appropriate GSP
  - Control
    - Review and approve GSPs
    - Review implementation

# Role of the State: Carrot & Stick

- Department of Water Resources has a key role:
  - Technical assistance and funding (Prop 1: \$100 million for SGMA)
  - Regulation
    - Groundwater basin boundary adjustments
    - Minimum guidelines for appropriate GSP
  - Control
    - Review and approve GSPs
    - Review implementation
- State Water Resources Control Board:
  - Enforcement where local control fails (after 2017)
    - “probationary status”
    - Public hearing and 180 days to fix the problem
  - After 180 days: SWRCB poses as interim GSA
    - Groundwater extraction reporting mandatory
    - Possibly temporary control of groundwater extraction
    - Development and implementation of interim GSP
  - When locals are ready: get authority back from state

# Online Resources

- <http://groundwater.ucdavis.edu/sgma>
- <http://groundwater.ucdavis.edu/calendar>
- <http://www.water.ca.gov/groundwater/casgem/> (California DWR groundwater level monitoring program)
- <http://www.water.ca.gov/waterconditions/drought/#> (California DWR drought information)
- [http://www.waterboards.ca.gov/gama/geotracker\\_gama.shtml](http://www.waterboards.ca.gov/gama/geotracker_gama.shtml) (California groundwater quality information)
- [http://groundwater.ucdavis.edu/links\\_California/](http://groundwater.ucdavis.edu/links_California/) (miscellaneous groundwater information sources)
- Contact Dr. Thomas Harter at [ThHarter@ucdavis.edu](mailto:ThHarter@ucdavis.edu)

