UCDAVIS
CENTER FOR WATERSHED SCIENCES

Ecosystem Management under Uncertain Hydrologic Conditions

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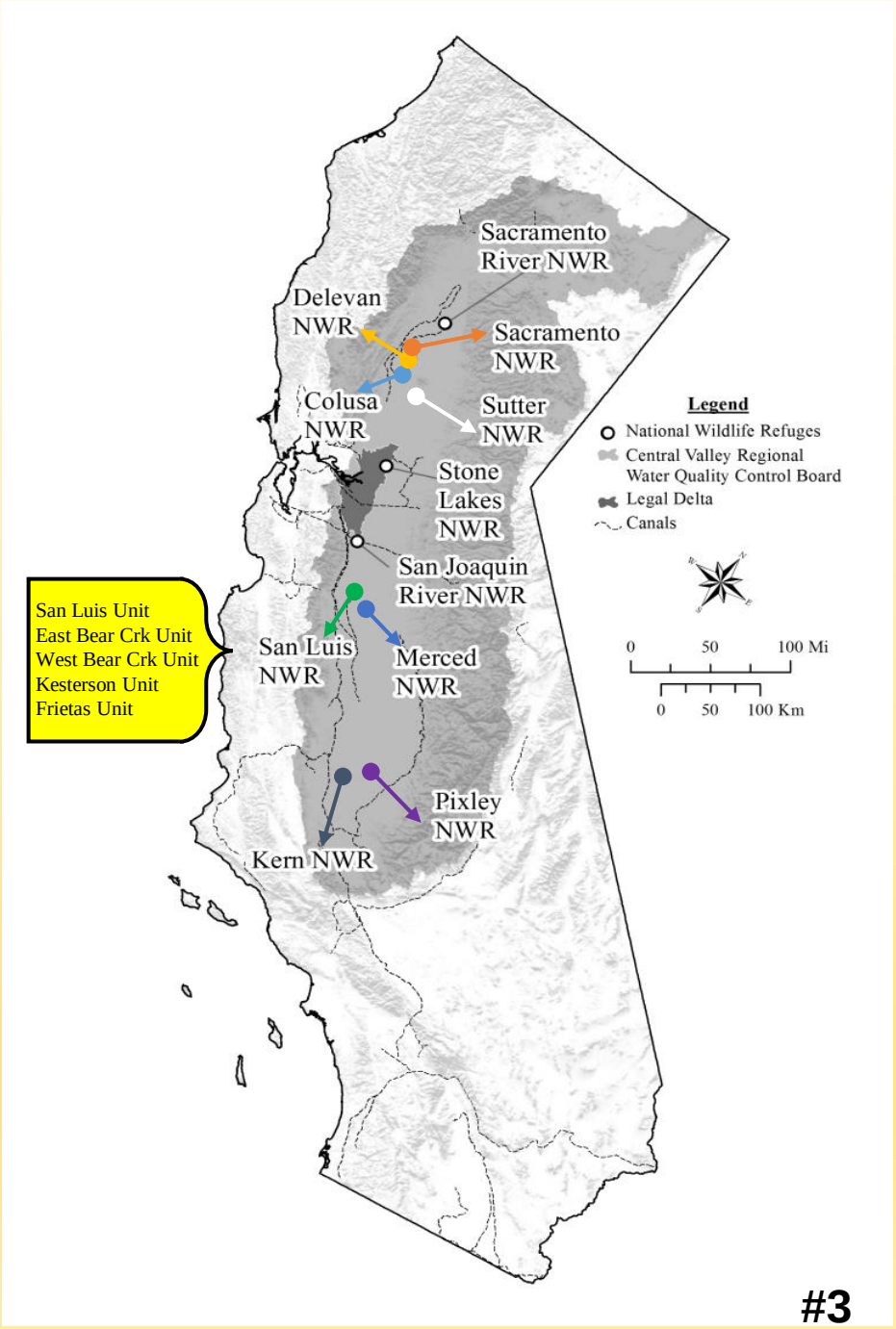
Outline

1. Study area and goals
2. Importance and relevance
3. Methods used

This is still a work in progress. We are not at a stage to start sharing results yet.

Study Area

- 12 wildlife refuges
- In Central Valley
- Managed by USFWS
- CVPIA authorized

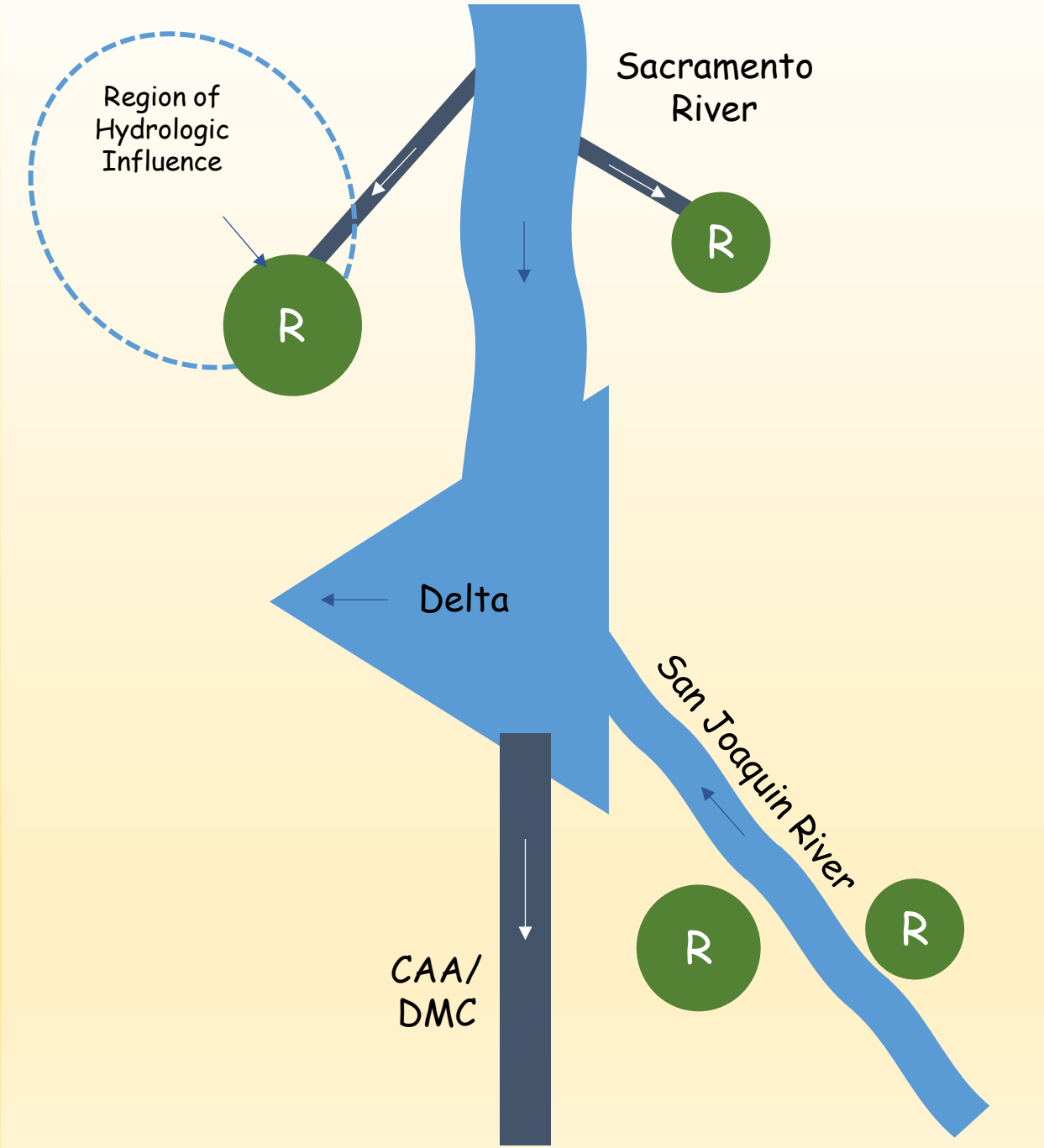


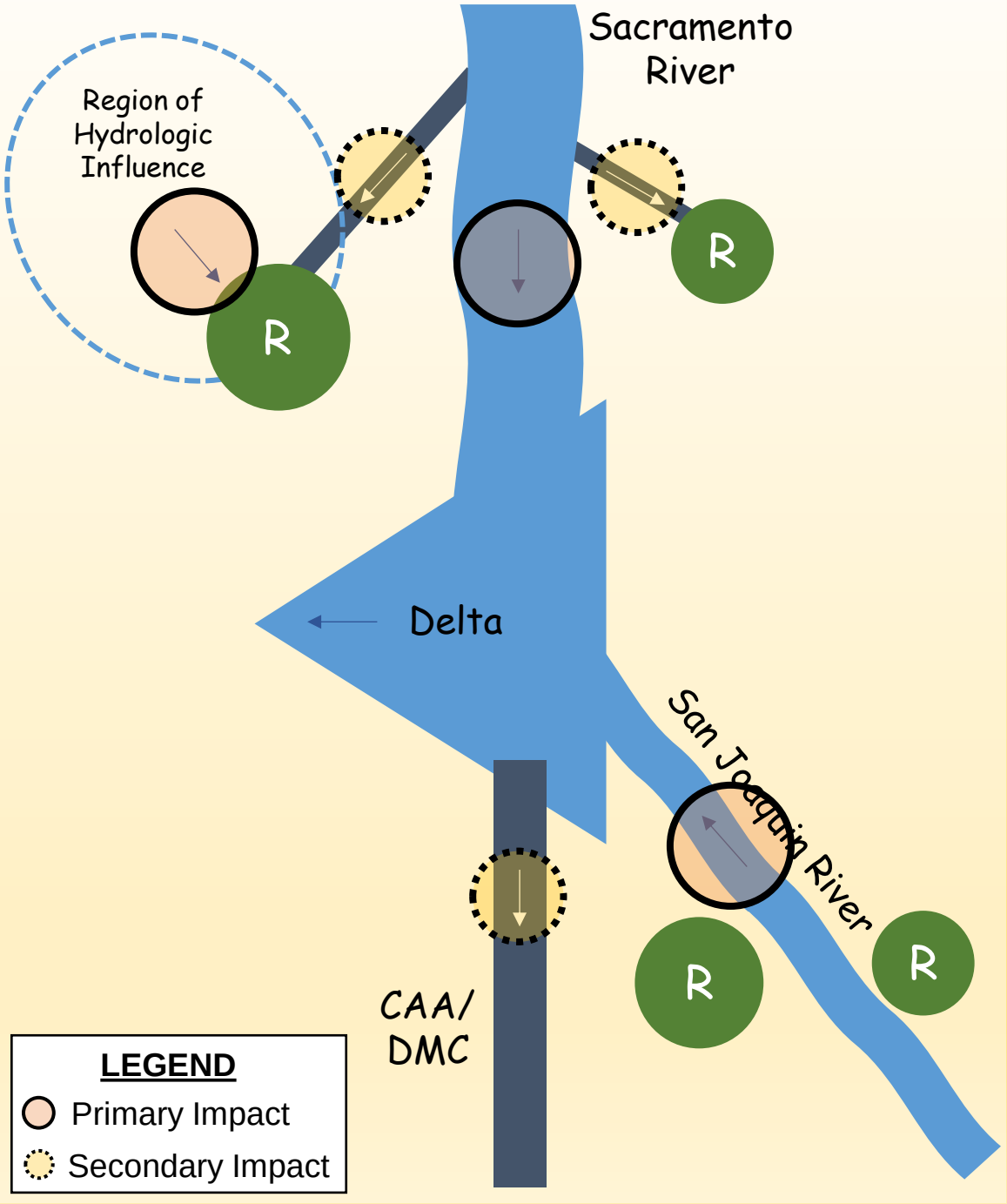
Ecological Significance

- Part of Pacific Flyway
- Provide essential food resources and resting places for migratory birds
- Home to several aquatic and wildlife species protected under ESA

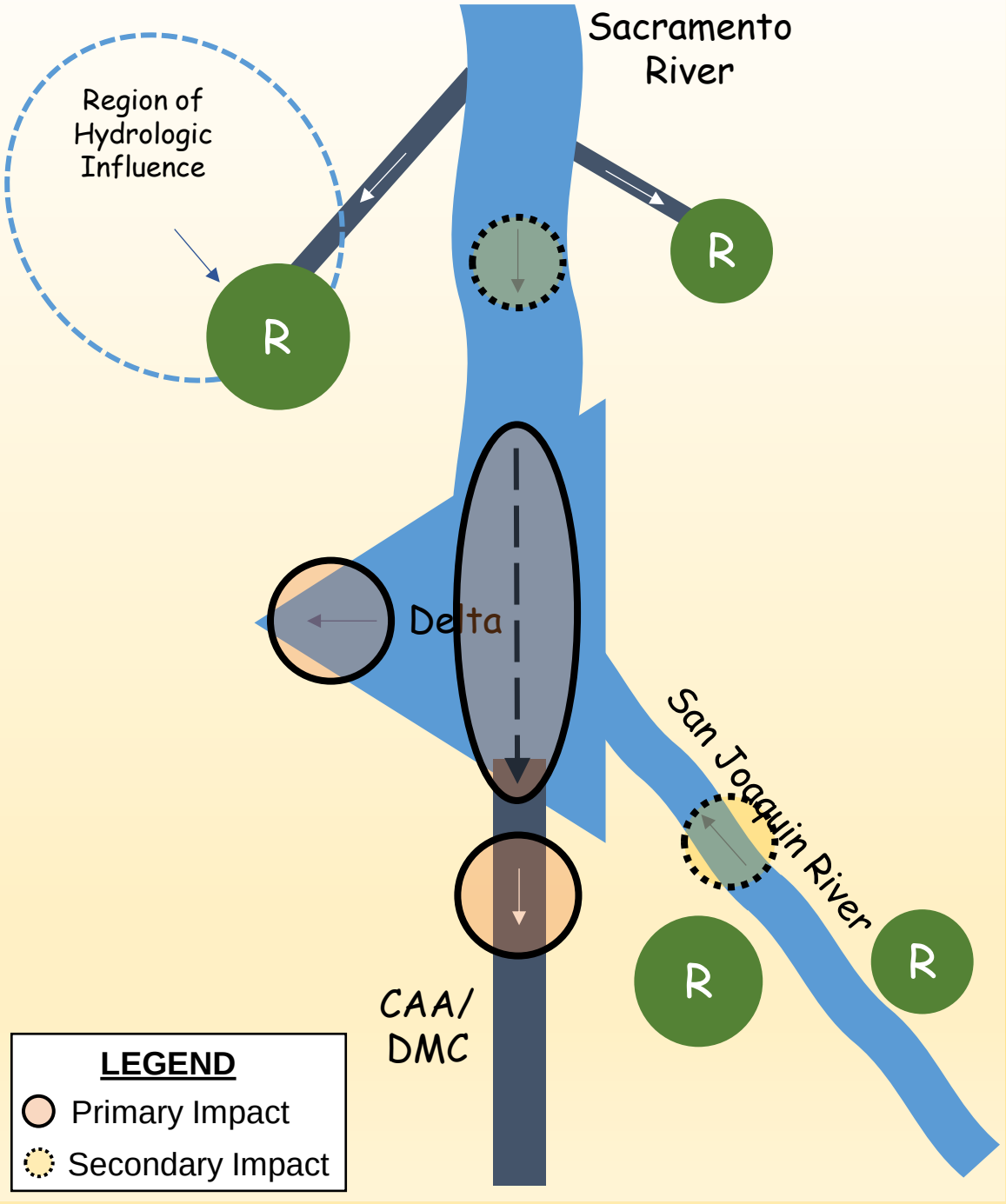
Goals

- Quantify economic and water supply impacts
- Evaluate adaptation strategies
- Develop a decision support tool


Region of Hydrologic Influence
Sacramento River
R
R
Delta
San Joaquin River
R
R
CAA/ DMC



- Two climate scenarios
- Three water management scenarios
- Water trading and other alternatives



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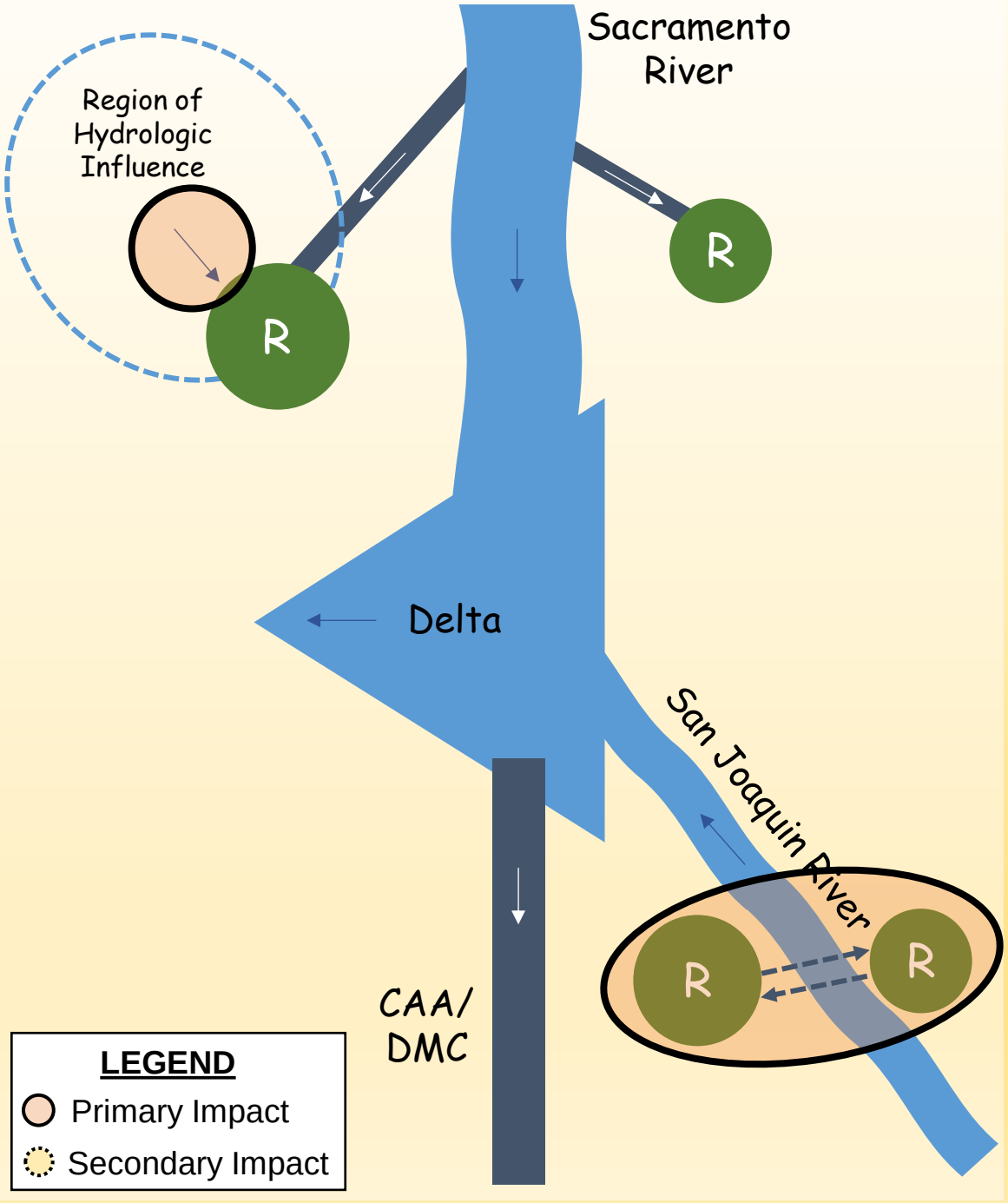
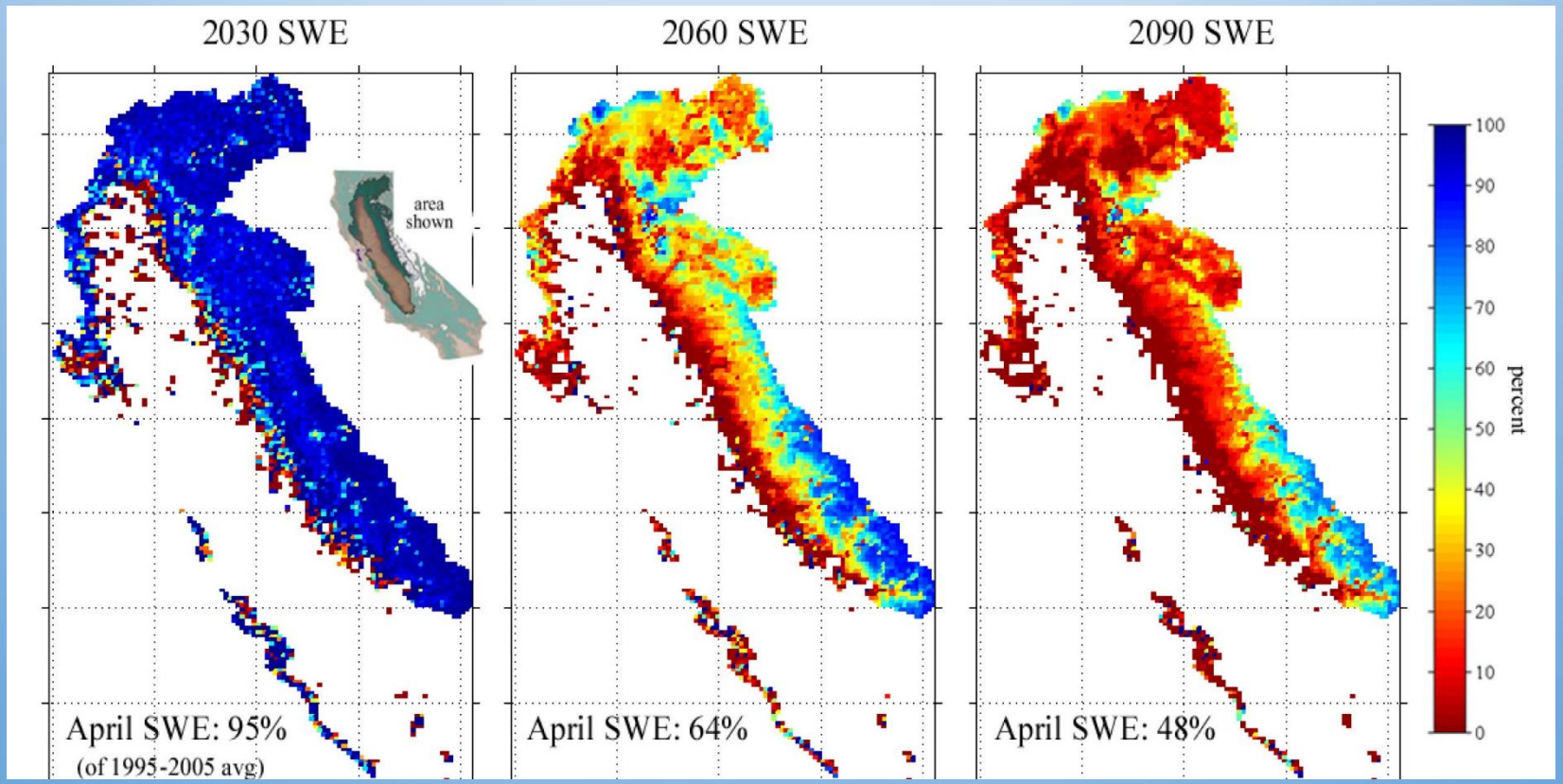


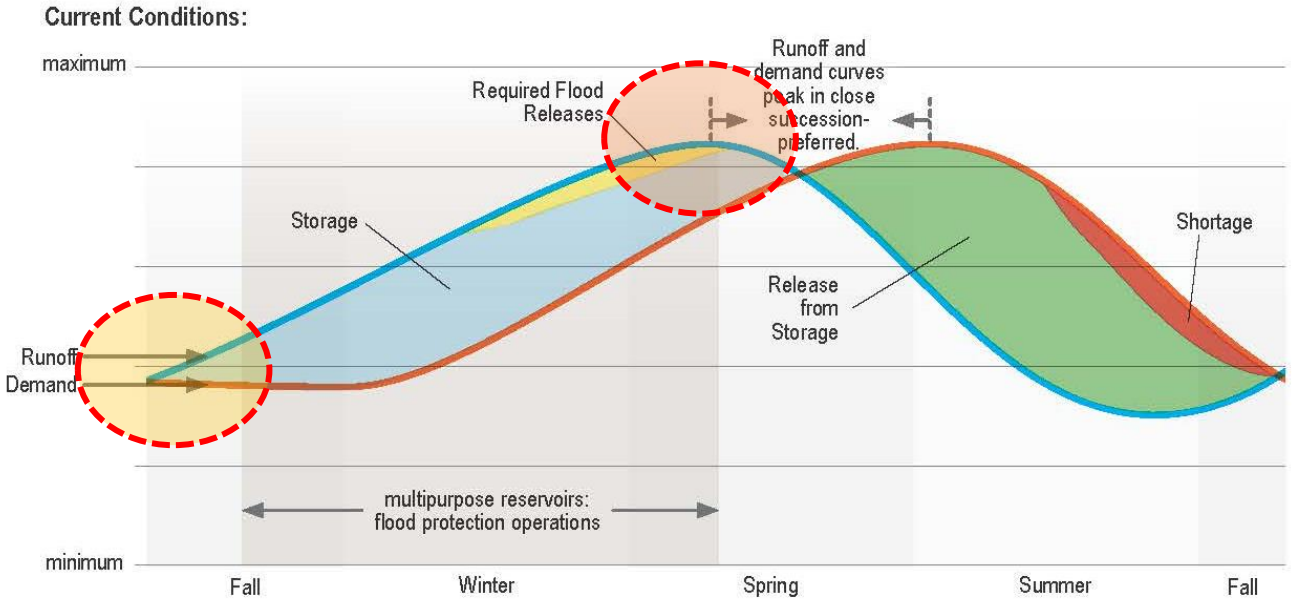
- Two climate scenarios
- Three water management scenarios
- Water trading and other alternatives

Importance

Warm-dry hydroclimatic conditions predicted



Current Conditions



Predicted Conditions

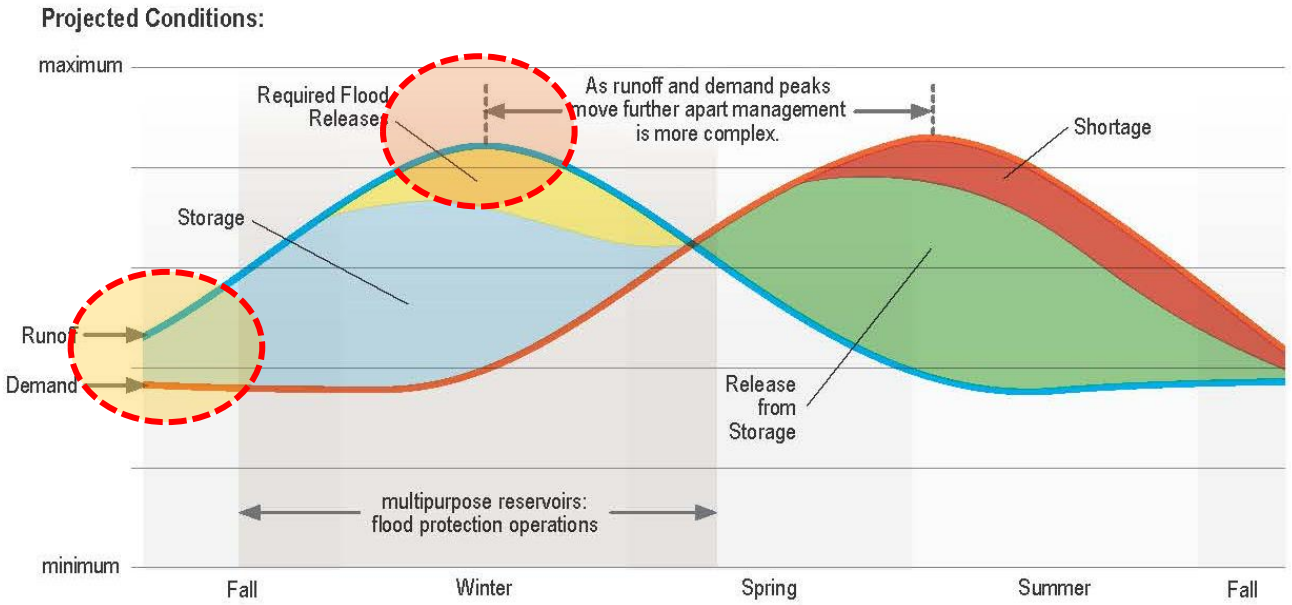
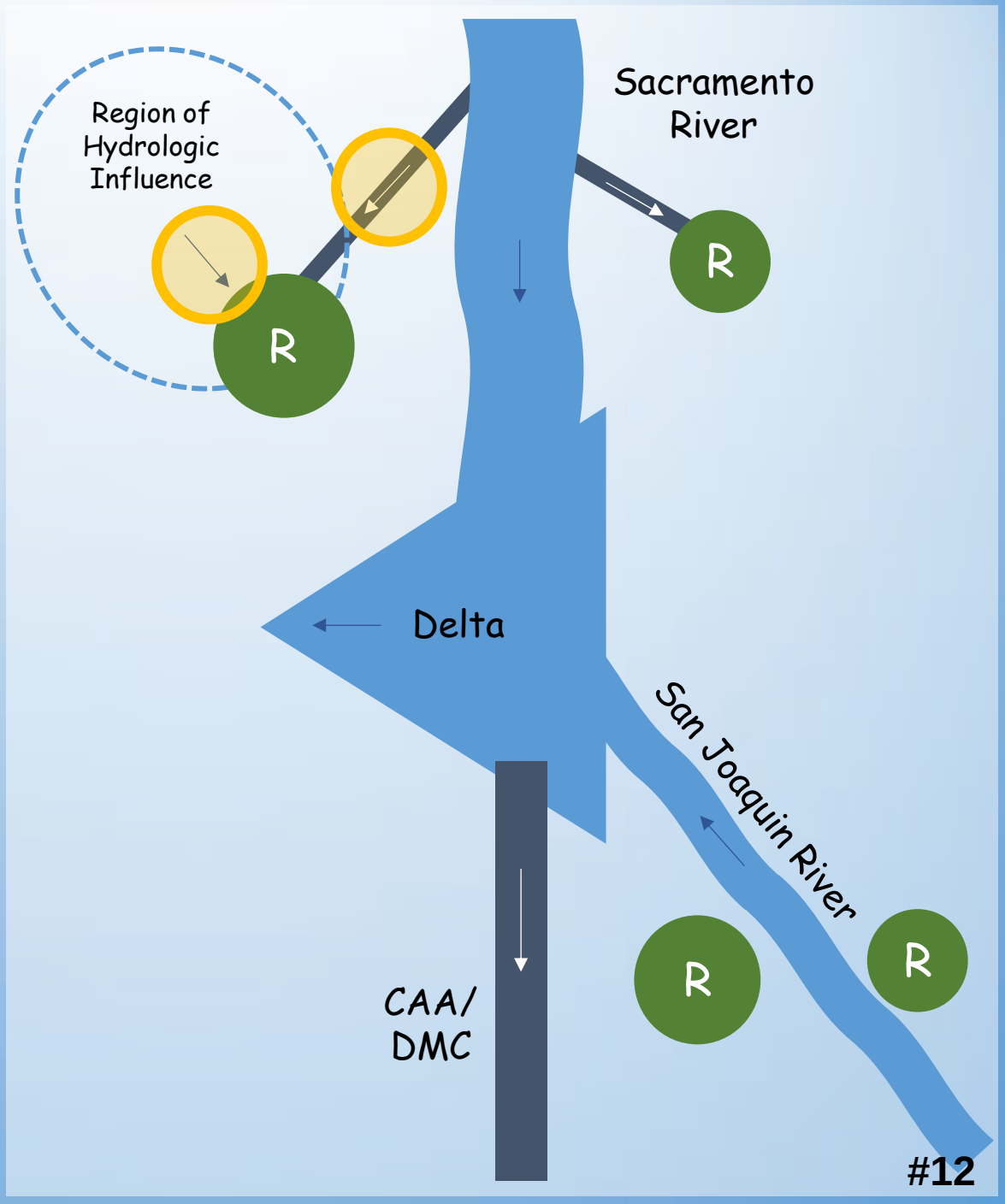


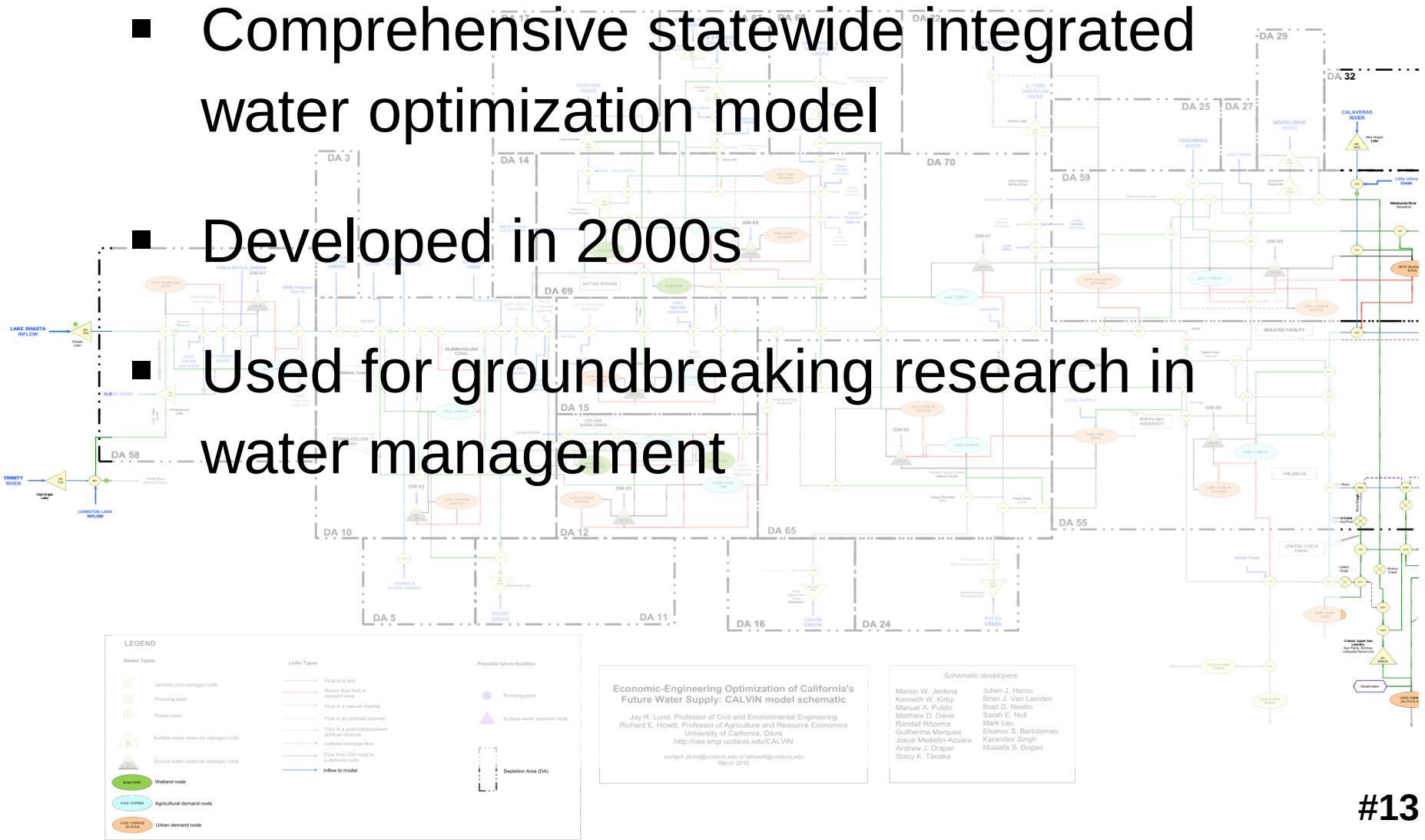
Image from California Water Plan Update 2013

- Critical to quantify impact on refuge deliveries
- Equally important to assess impact in a statewide framework



Overview of CALVIN

- Comprehensive statewide integrated water optimization model
- Developed in 2000s
- Used for groundbreaking research in water management



Method

- Refuge representation
- Scenario runs
- Decision Support Tool

NWRs aggregated into seven nodes

Sacramento Delevan

Colusa

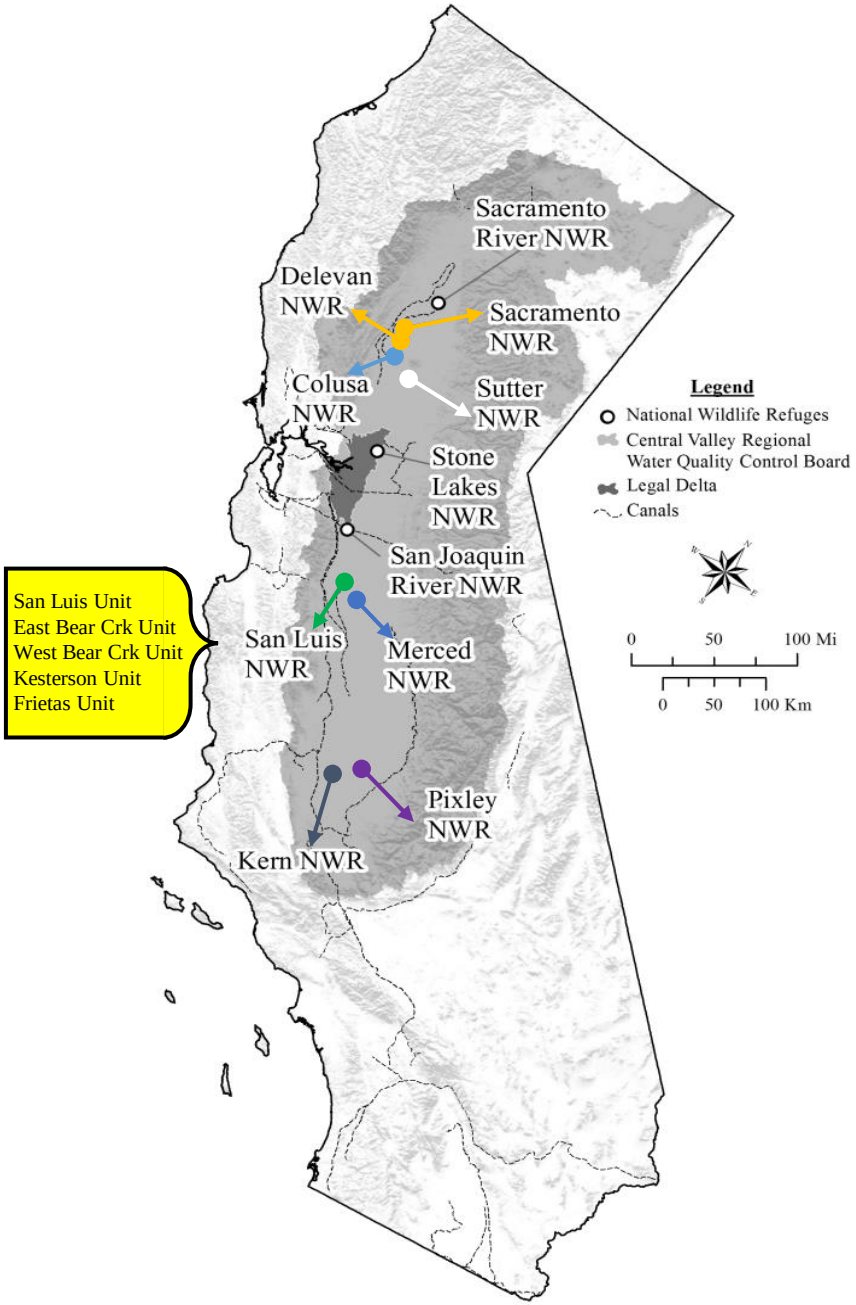
Sutter

San Luis Complex

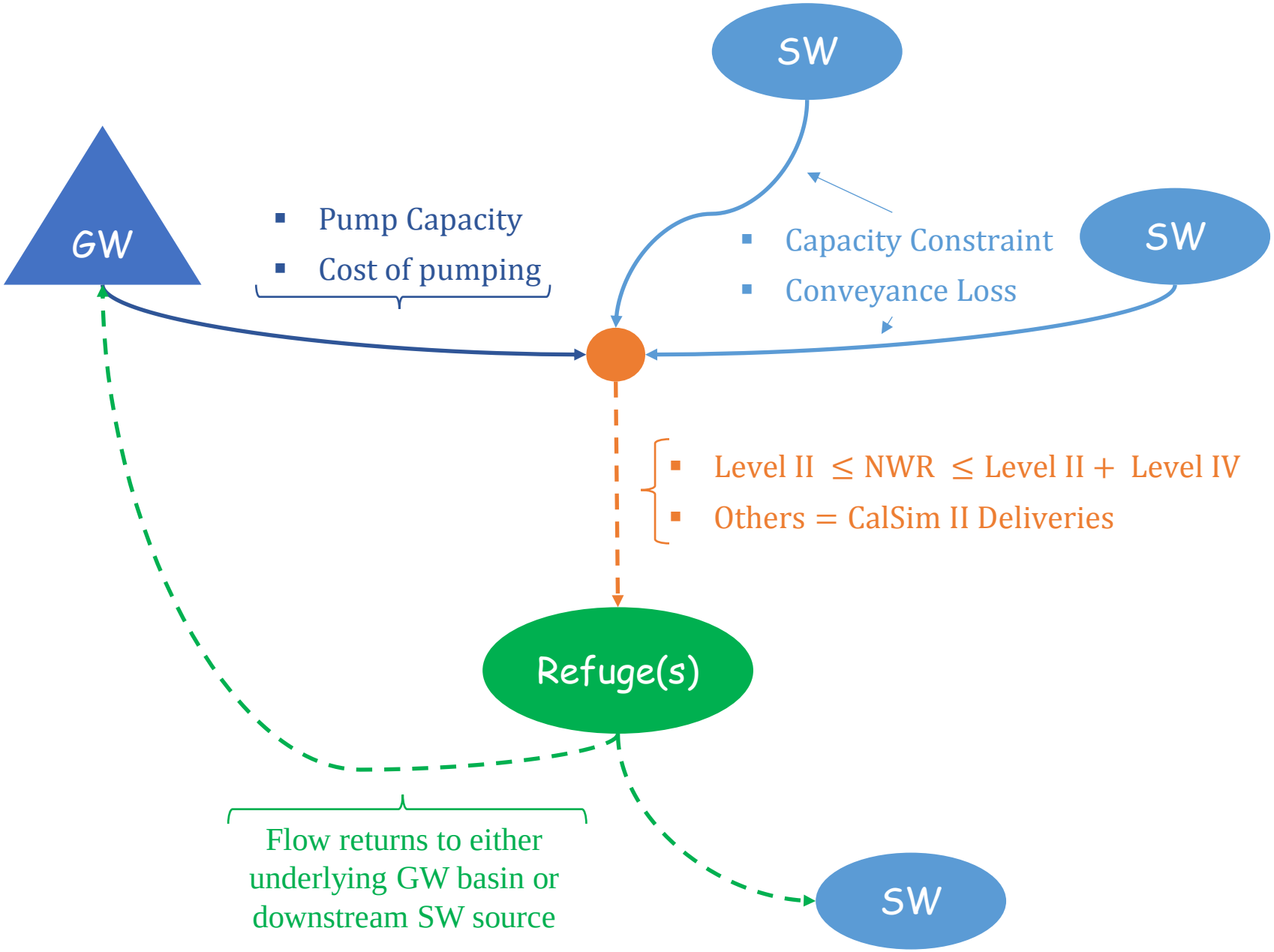
Merced

Kern

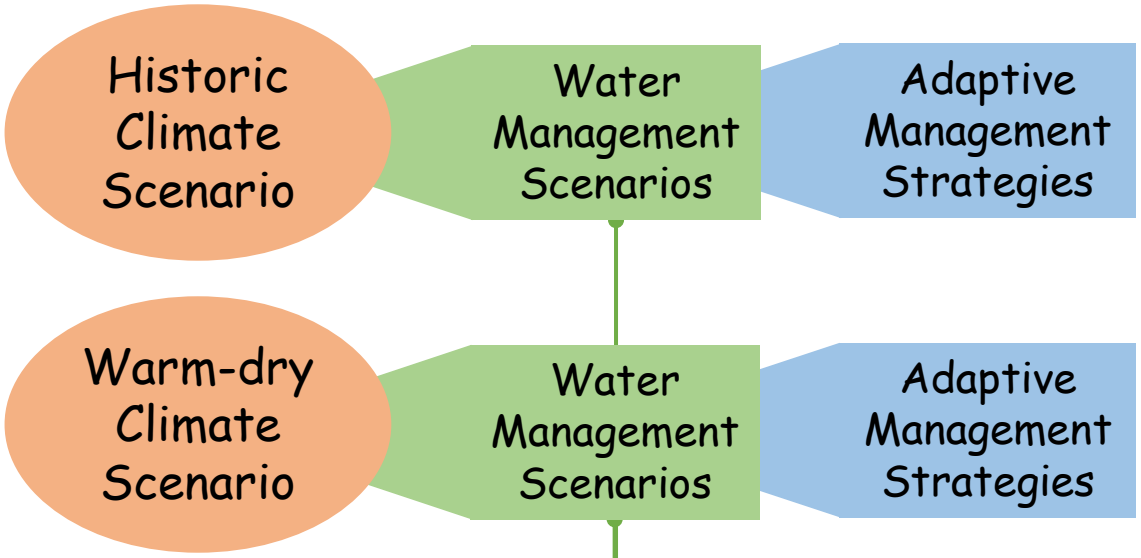
Pixley



Followed CalSim II representation for other refuges


SW
GW
Pump Capacity
Cost of pumping
Capacity Constraint
Conveyance Loss
SW
Level II ≤ NWR ≤ Level II + Level IV
Others = CalSim II Deliveries
Refuge(s)
Flow returns to either underlying GW basin or downstream SW source
SW

Scenario Runs



- Existing Water Infrastructure and Regulations
- Bay Delta Conservation Plan
- 2008/09 Biological Opinions

So far we have only examined the impact on the refuge deliveries, however, we have said nothing about improving refuge management.

Decision Support Tool

Spreadsheet based simulation-optimization tool

Designed for refuge managers and USFWS staff responsible for annual and multi-year planning

1. Select CVPIA Refuge(s) to manage collectively

Check all that apply

North of Delta
- ☐ Sacramento NWR
- ☐ Delevan NWR
- ☐ Colusa NWR
- ☐ Sutter NWR

South of Delta
San Luis NWR Complex
- ☐ San Luis Unit
- ☐ East Bear Creek Unit
- ☐ West Bear Creek Unit
- ☐ Kesterson Unit
- ☐ Freitas Unit

South of Delta
Others
- ☐ Merced NWR
- ☐ Kern NWR
- ☐ Pixley NWR

2. Select simulation scenario

Choose one

Historic Climate Conditions
- ○ existing water management infrastructure
- ○ with Peripheral Canal
- ○ with more rigorous Delta outflow requirements

Warm-Dry Climate Conditions
- ○ existing water management infrastructure
- ○ with Peripheral Canal
- ○ with more rigorous Delta outflow requirements

Simulation scenarios are based on the CALVIN model runs. Region of Hydrologic Influence (RHI) is determined for each refuge. Then, the impact of each simulation scenario on the RHI is assessed as percent change in flows compared to the base case. Finally, the percent change is applied to the "Default" Level II and Level IV deliveries.

Base case is defined as the historic conditions with existing water management infrastructure.

"Default" Level II and Level IV are defined as historic Level II and Level IV deliveries.

3. Water allocation scenario

Use arrows to define the percent allocation scenario

◀ ▶ 50%

Percent allocation scenario is used to determine:
1) Level II deliveries if using the water delivery timeseries outlined in the Drought Contingency Plan for the simulation or optimization runs, and
2) maximum and minimum constraints on the habitat acreage used to define management objectives.

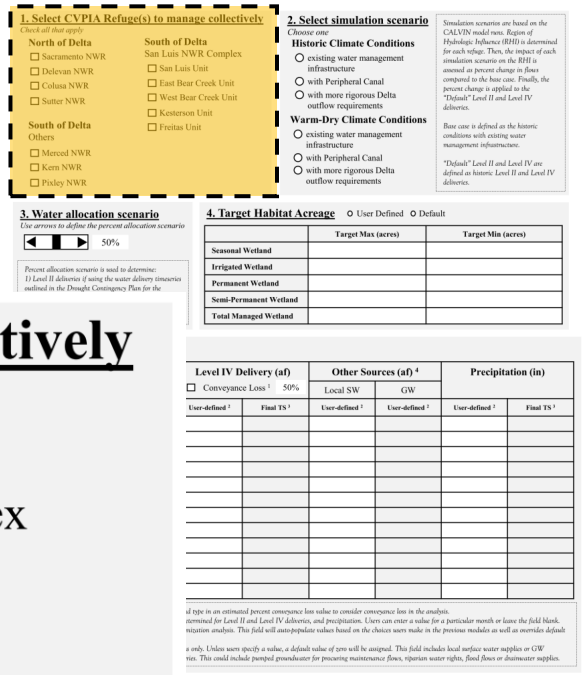
4. Target Habitat Acreage ○ User Defined ○ Default

	Target Max (acres)	Target Min (acres)
Seasonal Wetland		
Irrigated Wetland		
Permanent Wetland		
Semi-Permanent Wetland		
Total Managed Wetland		

5. Refuge Water Supply Portfolio

	Level II Delivery (af) ☐ Conveyance Loss [1] 50%		Level IV Delivery (af) ☐ Conveyance Loss [1] 50%		Other Sources (af) [4]		Precipitation (in)	
					Local SW	GW		
	User-defined [2]	Final TS [3]	User-defined [2]	Final TS [3]	User-defined [2]	User-defined [2]	User-defined [2]	Final TS [3]
Mar								
Apr								
May								
Jun								
Jul								
Aug								
Sep								
Oct								
Nov								
Dec								
Jan								
Feb								

1. *Conveyance loss: It is an on/off option. Check the box and type in an estimated percent conveyance loss value to consider conveyance loss in the analysis.*
2. *User-defined: Allow users to override any default values determined for Level II and Level IV deliveries, and precipitation. Users can enter a value for a particular month or leave the field blank.*
3. *Final TS: The final timeseries used in the simulation-optimization analysis. This field will auto-populate values based on the choices users make in the previous modules as well as overrides default values with values entered in the "User-defined" column.*
4. *"Other Source (af)": These options are user-defined options only. Unless users specify a value, a default value of zero will be assigned. This field includes local surface water supplies or GW pumping supplies in excess of Level II and Level IV deliveries. This could include pumped groundwater for procuring maintenance flows, riparian water rights, flood flows or drainwater supplies.*



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- ☐ Colusa NWR
- ☐ Sutter NWR

South of Delta

Others

- ☐ Merced NWR
- ☐ Kern NWR
- ☐ Pixley NWR

South of Delta

San Luis NWR Complex

- ☐ San Luis Unit
- ☐ East Bear Creek Unit
- ☐ West Bear Creek Unit
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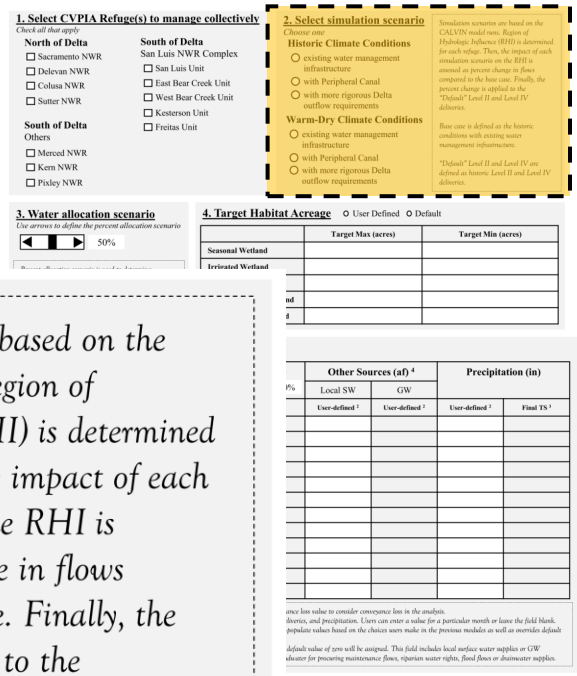
- ☐ Freitas Unit



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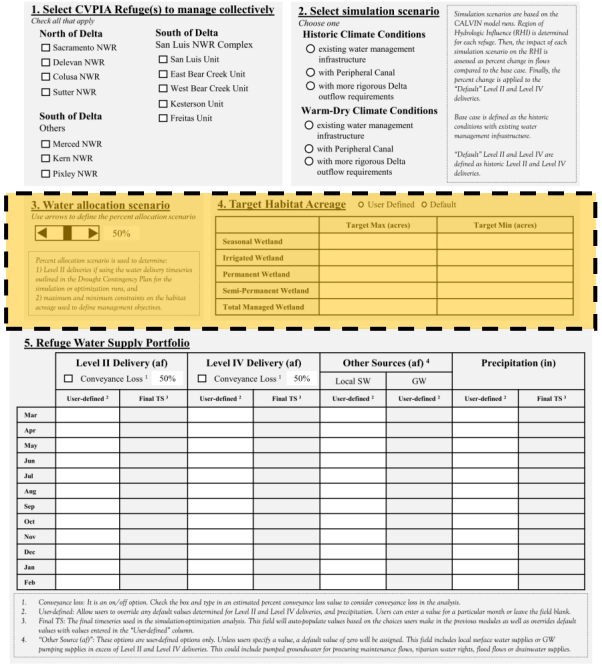

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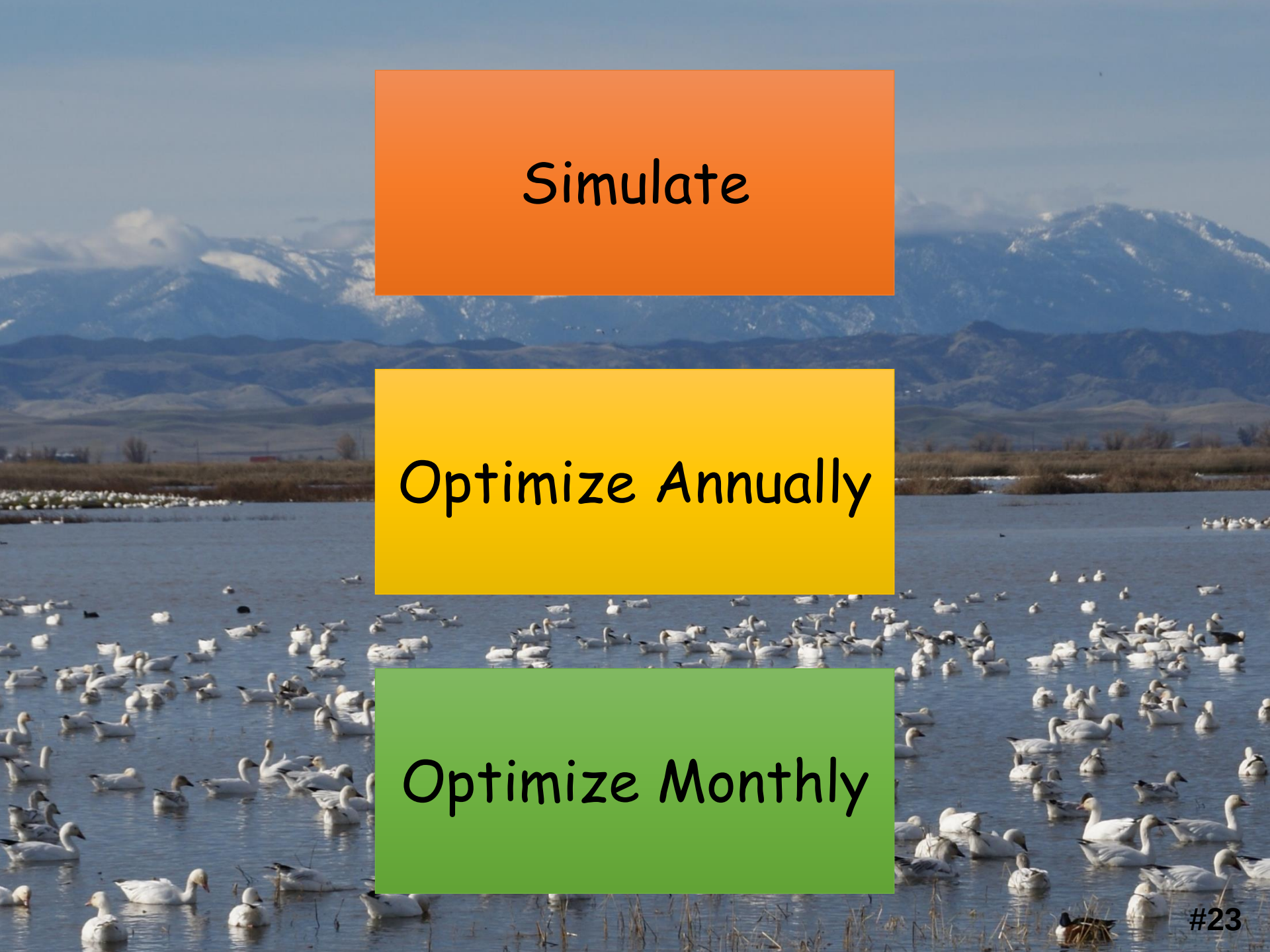
Simulate
Optimize Annually
Optimize Monthly

Optimization Objective

"The needs of wildlife and their habitats come first on refuges, in contrast to other public lands managed for multiple uses."

"Seasonal wetlands and other habitats at the Complex provide essential food resources and resting areas for winter residents, birds continuing south, and returning spring migrants…"

-Comprehensive Conservation Plan (USFWS, 2009)

Objective: Maximize total habitat acreage

LP Formulation

$$Max\left\{\sum_{i} HabitatAcreage_i\right\}$$

Subject to

$$WaterDemand \leq WaterSupply$$

$$MinHabitatAcreage_i \leq HabitatAcreage_i \leq MaxHabitatAcreage_{i,k}$$

Where

i = Habitat land-use types

j = Month

k = Allocation scenarios: 100%, 75%, 50%, and 25%

$$\mathbf{WaterDemand_j} = \sum_i \mathbf{HabitatAcreage_{i,t-1} * HabitatWaterDemand_{i,j}} + \sum_i \mathbf{HabitatAcreage_{i,t} * HabitatWaterDemand_{i,j}}$$

	Seasonal Wetland	Irrigated Wetland	Permanent Wetland	Semi-permanent Wetland
March	0.50	0.50	0.50	0.50
April	0.00	1.00	1.00	1.00
May	0.00	0.00	1.50	1.00
June	0.00	1.50	2.00	2.00
July	0.00	0.00	2.00	1.00
August	0.50	0.00	2.00	0.00
September	2.00	2.00	1.75	0.00
October	1.00	1.00	1.00	2.00
November	0.75	0.75	0.75	0.75
December	0.25	0.25	0.25	0.25
January	0.25	0.25	0.25	0.25
February	0.25	0.25	0.25	0.25

$$\mathbf{WaterSupply_{j,k}} = (1 - \mathbf{LossL2}) * \mathbf{L2_{j,k}} + (1 - \mathbf{LossL4}) * \mathbf{L4_{j,k}} + \mathbf{Precip_j} * \mathbf{TotalMaxAcreage_k} + \mathbf{LocalSWInflow_j} + \mathbf{GWExcessL2L4_j}$$

3. Water allocation scenario

Use arrows to define the percent allocation scenario

50%

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Feb								

$$\mathbf{MinHabAcreage_i = OR(0, User\ Defined_i)}$$

$$\mathbf{MaxHabAcreage_{i,k} = OR(MaxPercentAllocation_k * HistMaxAcreage_i, User\ Defined_i)}$$

4. Target Habitat Acreage ○ User Defined ○ Default

	Target Max (acres)	Target Min (acres)
Seasonal Wetland		
Irrigated Wetland		
Permanent Wetland		
Semi-Permanent Wetland		
Total Managed Wetland		

Major Habitat type	100%	75%	50%	25%
Seasonal Wetland	1	0.9	0.5	0
Irrigated Wetland	1	0.9	0.5	0
Permanent Wetland	1	0.5	0.25	0.2
Semi-permanent Wetland	1	0.5	0.25	0.2
Total habitat acreage (*acres*)	1	0.9	0.7	0.4

Results

- Work in progress
- Competing water demands
- Water trading will increase refuge habitat and reduce scarcity

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REFERENCES

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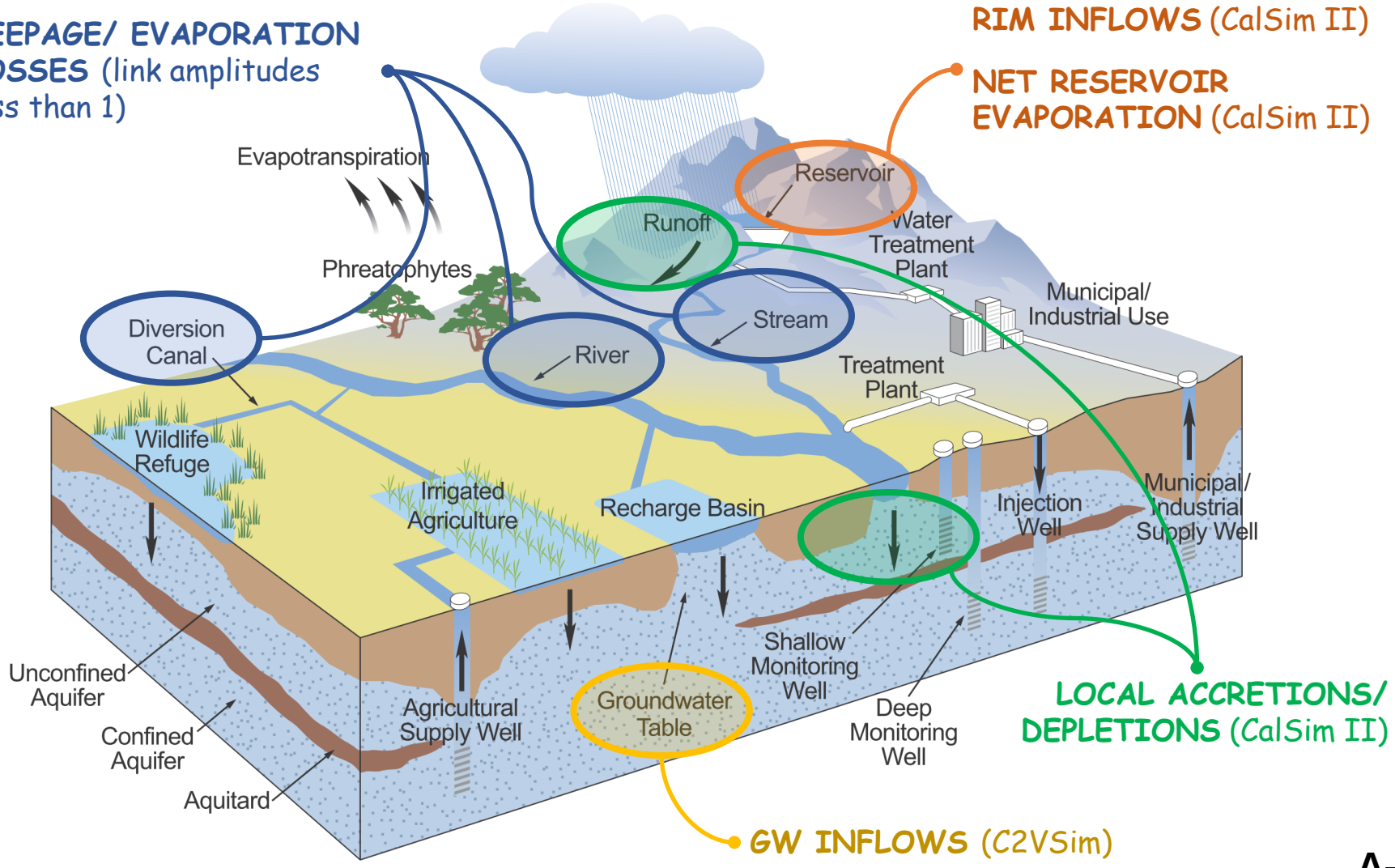
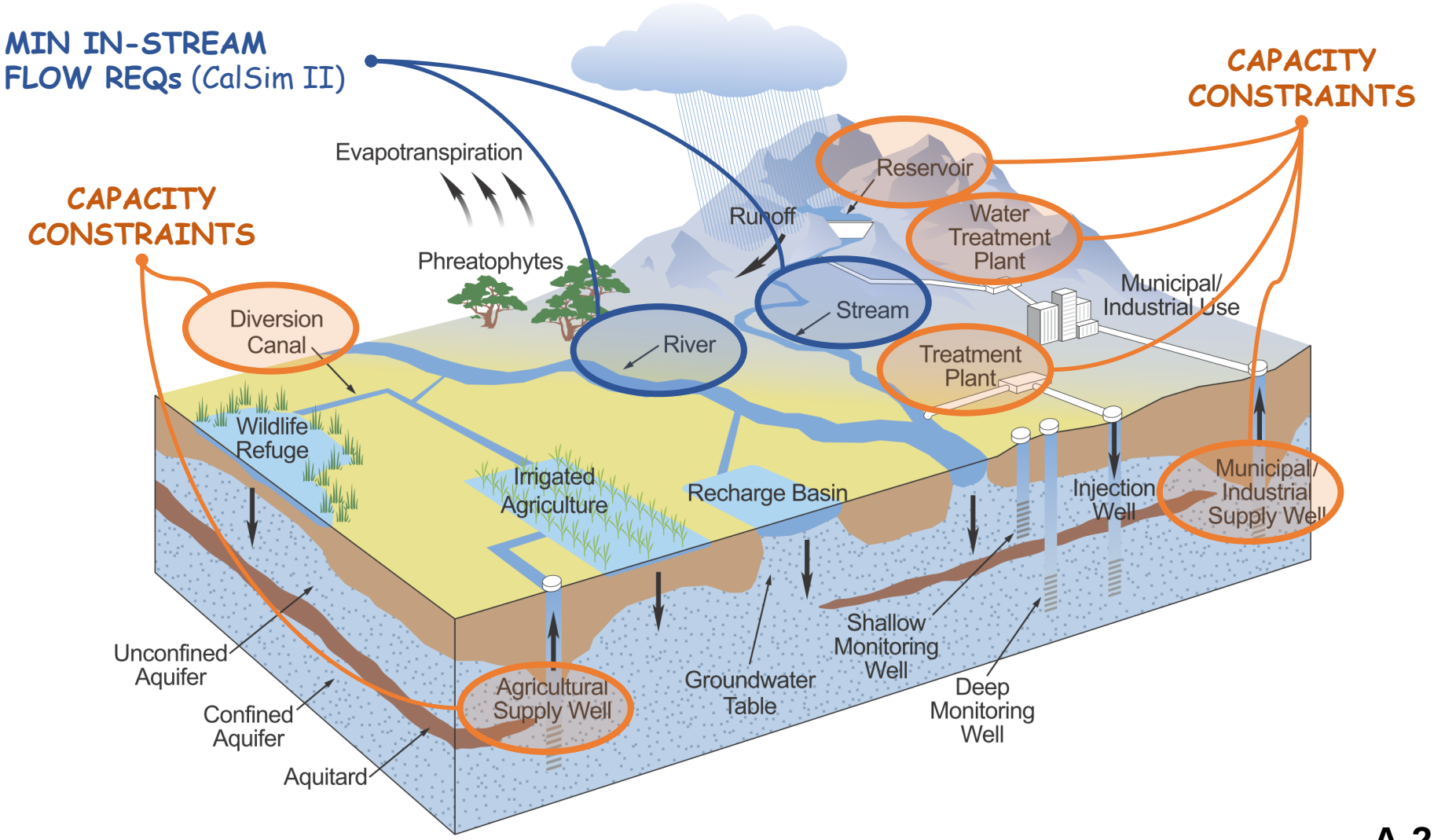
Null S.E., Viers J.H. & Mount J.F. (2010). *Hydrologic Response and Watershed Sensitivity to Climate Warming in California's Sierra Nevada.*

Stewart I.T., Cayan D.R. & Dettinger M.D. (2005). *Changes toward earlier streamflow timing across western North America.* Journal of Climate.

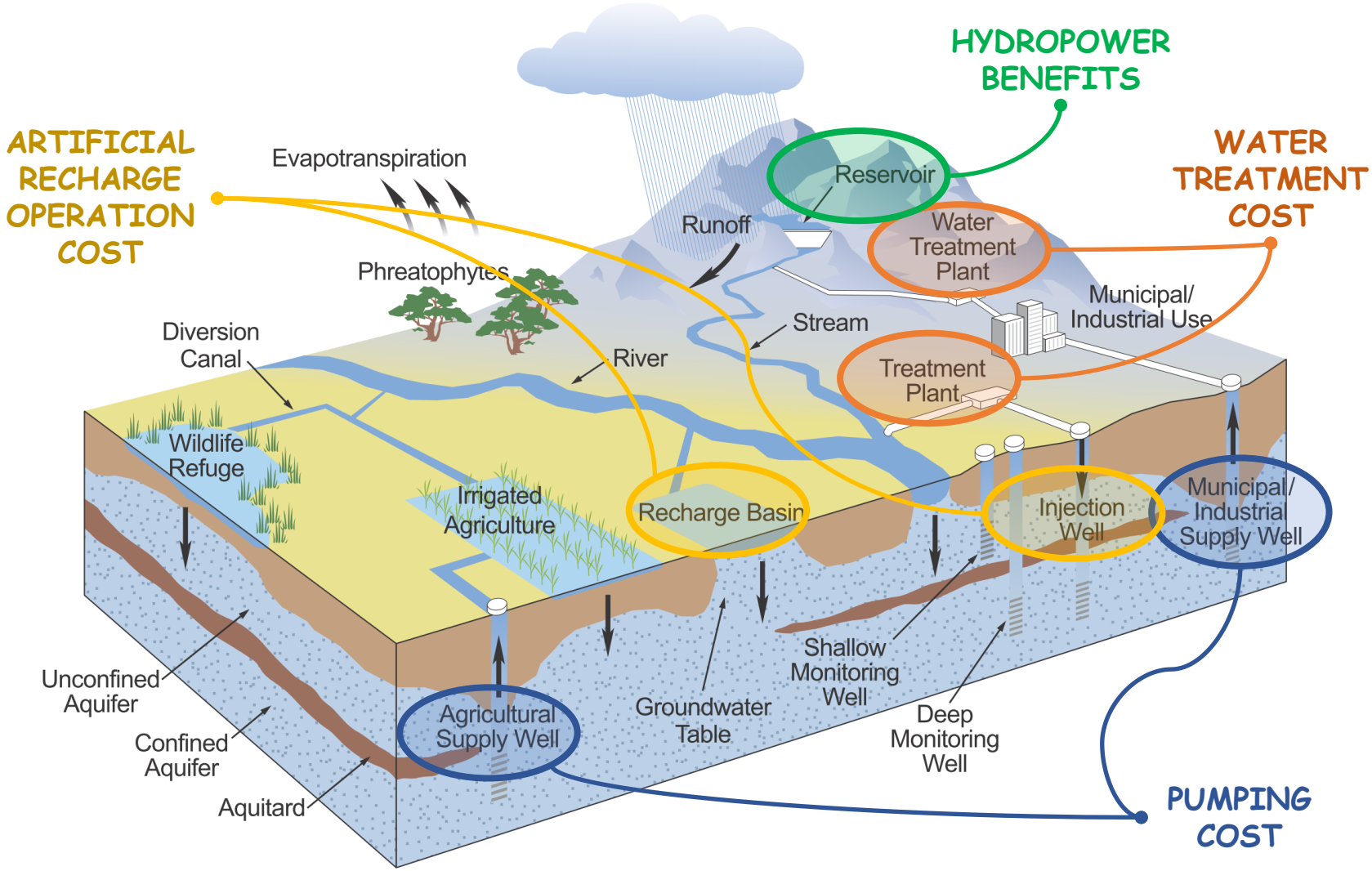
CALVIN Hydrology



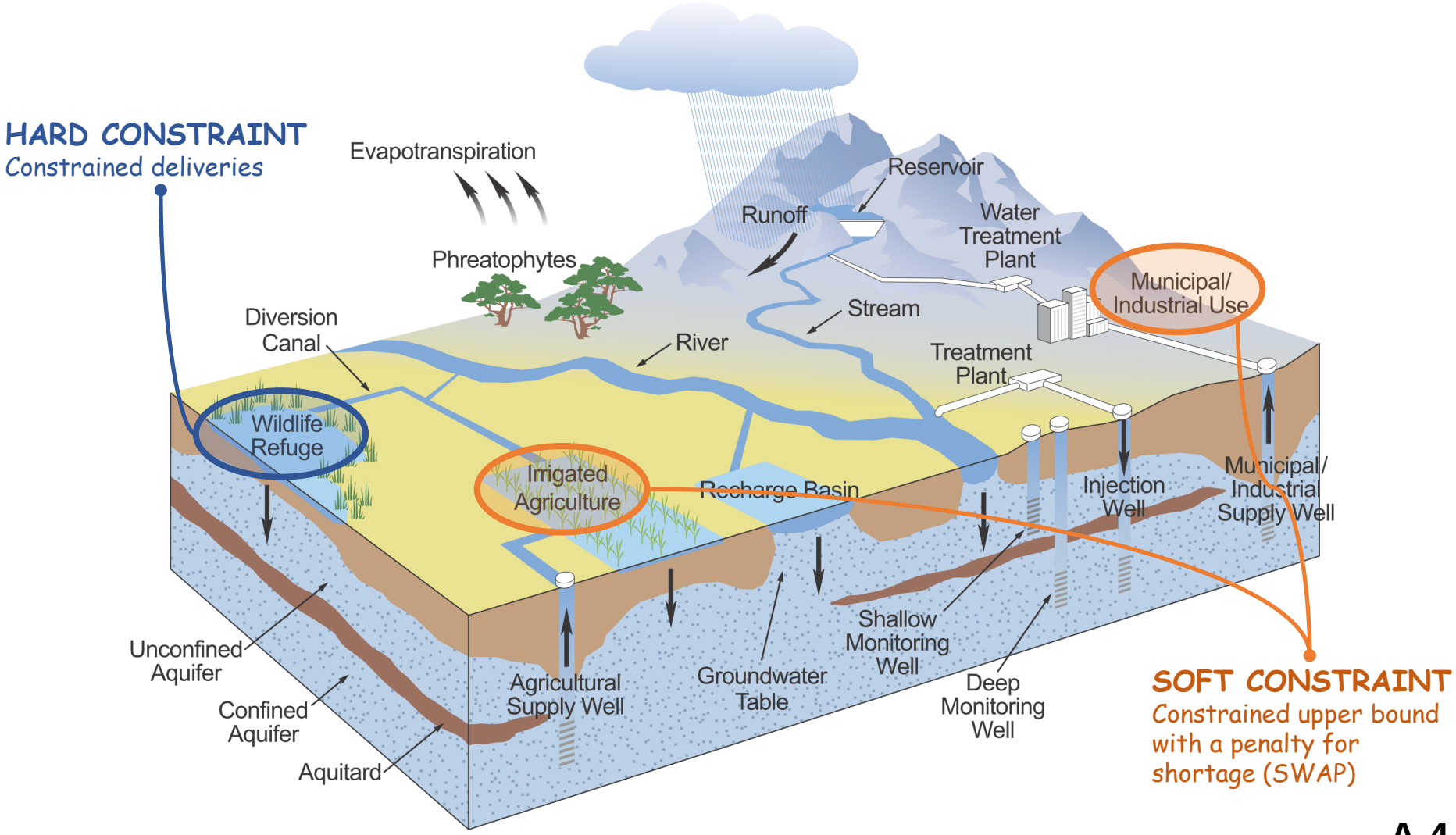
CALVIN Constraints



CALVIN Operating Costs



CALVIN Demands



CALVIN Outputs

In addition to flow, delivery, and reservoir and GW storage timeseries…