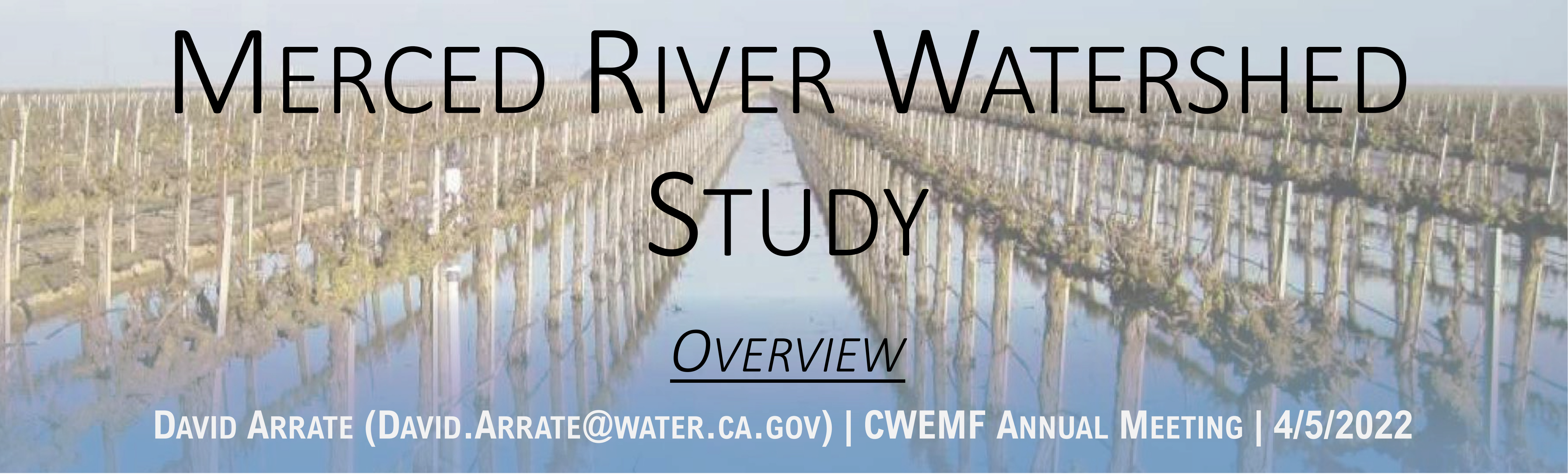


Merced River Watershed Study

Overview

David Arrate (David.Arrate@water.ca.gov) | CWEMF Annual Meeting | 4/5/2022

Department of Water Resources • State of California

ESA

MBK Engineers

Sustainable Conservation

Woodard & Curran

theEARTH GENOME
REVEALING THE POSSIBLE

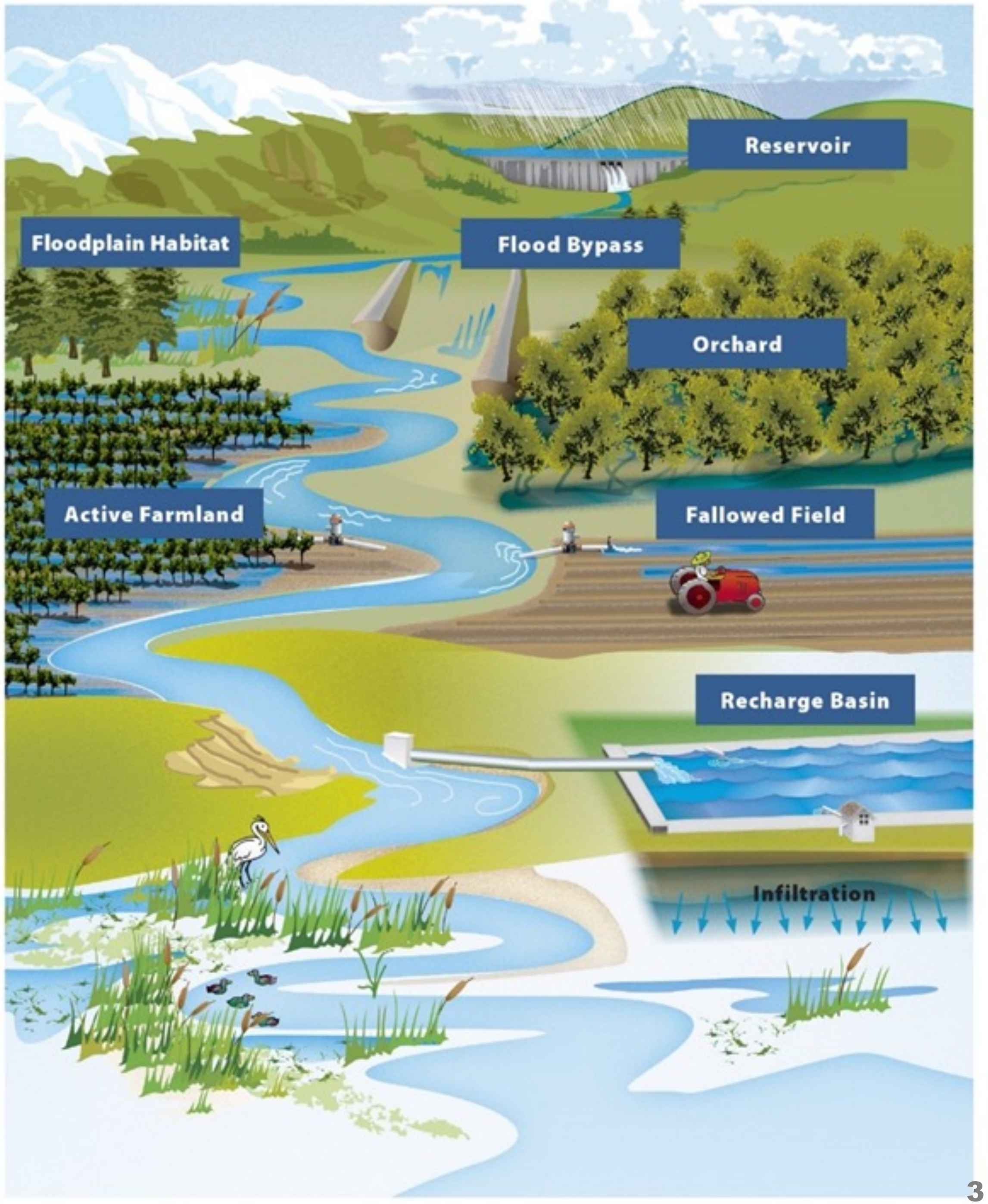
MID Merced Irrigation District
Water & Power

Session 16. Merced River Flood-MAR Study

1. Overview
2. Water Available for Replenishment and Water Supply and Flood Risk Benefits
3. In-depth Discussion of Ecosystem Effects
4. Multi-sector Performance Using Risk-based Analytics

What is Flood-MAR

- Integrated strategy to manage water resources for sustainability & climate resiliency
- Using high flows from (or in anticipation of) rainfall or snowmelt for managed aquifer recharge
- On agricultural lands, working landscapes, and natural managed lands

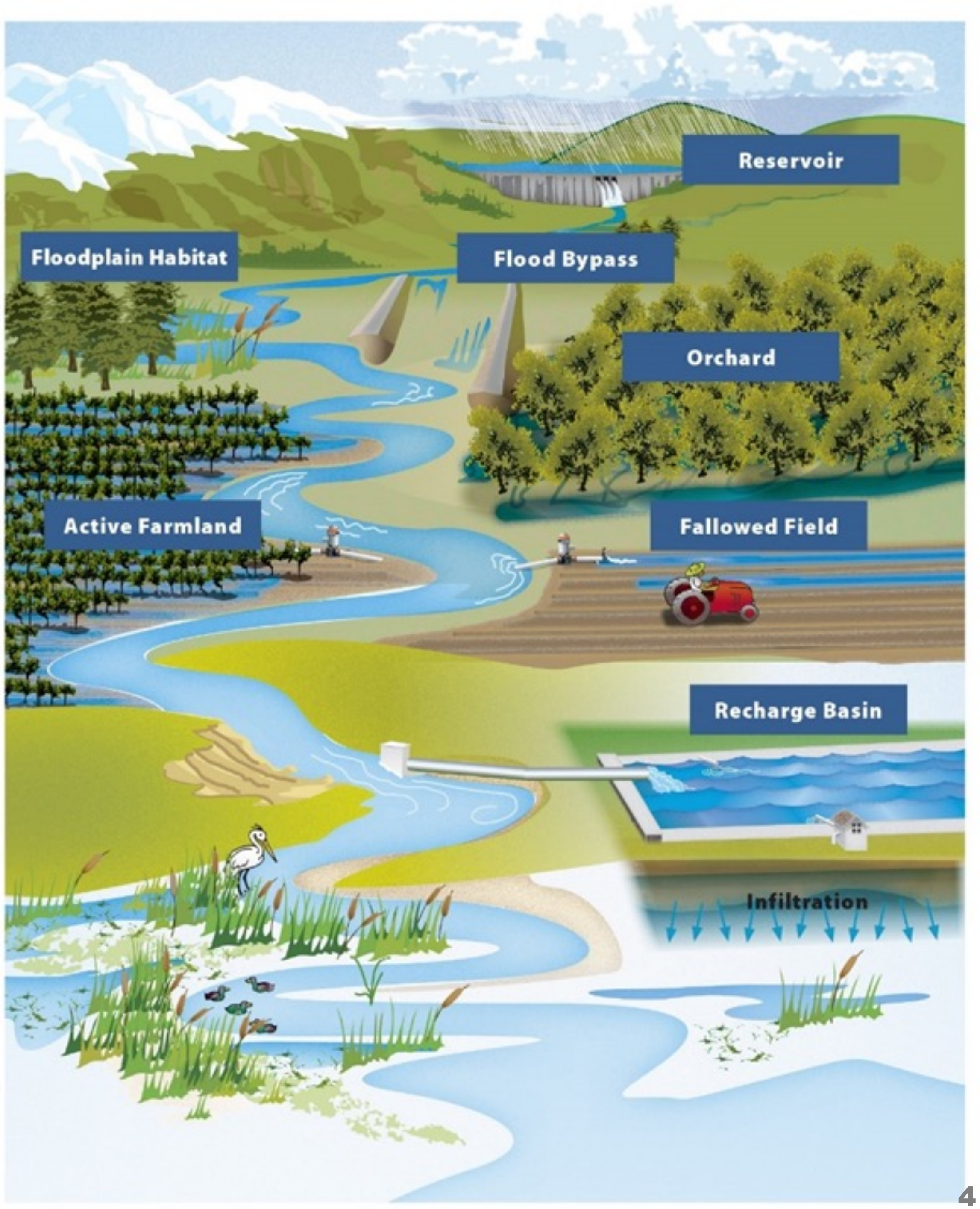


Why Flood-MAR

- Mitigate the effects of climate change
  - Shift in the runoff timing
  - Increased flood risk
  - Additional consumptive use demand

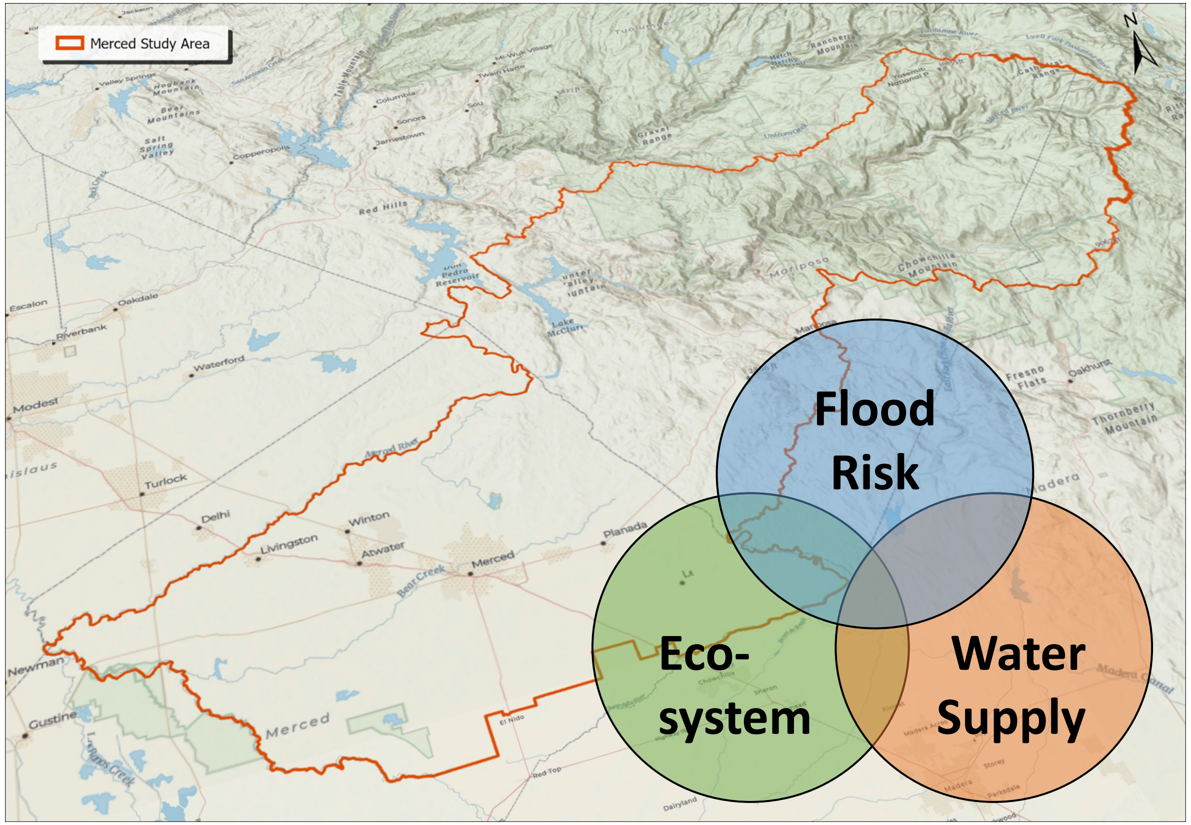
- Achieve sustainable groundwater management

- Integrates multiple water sectors



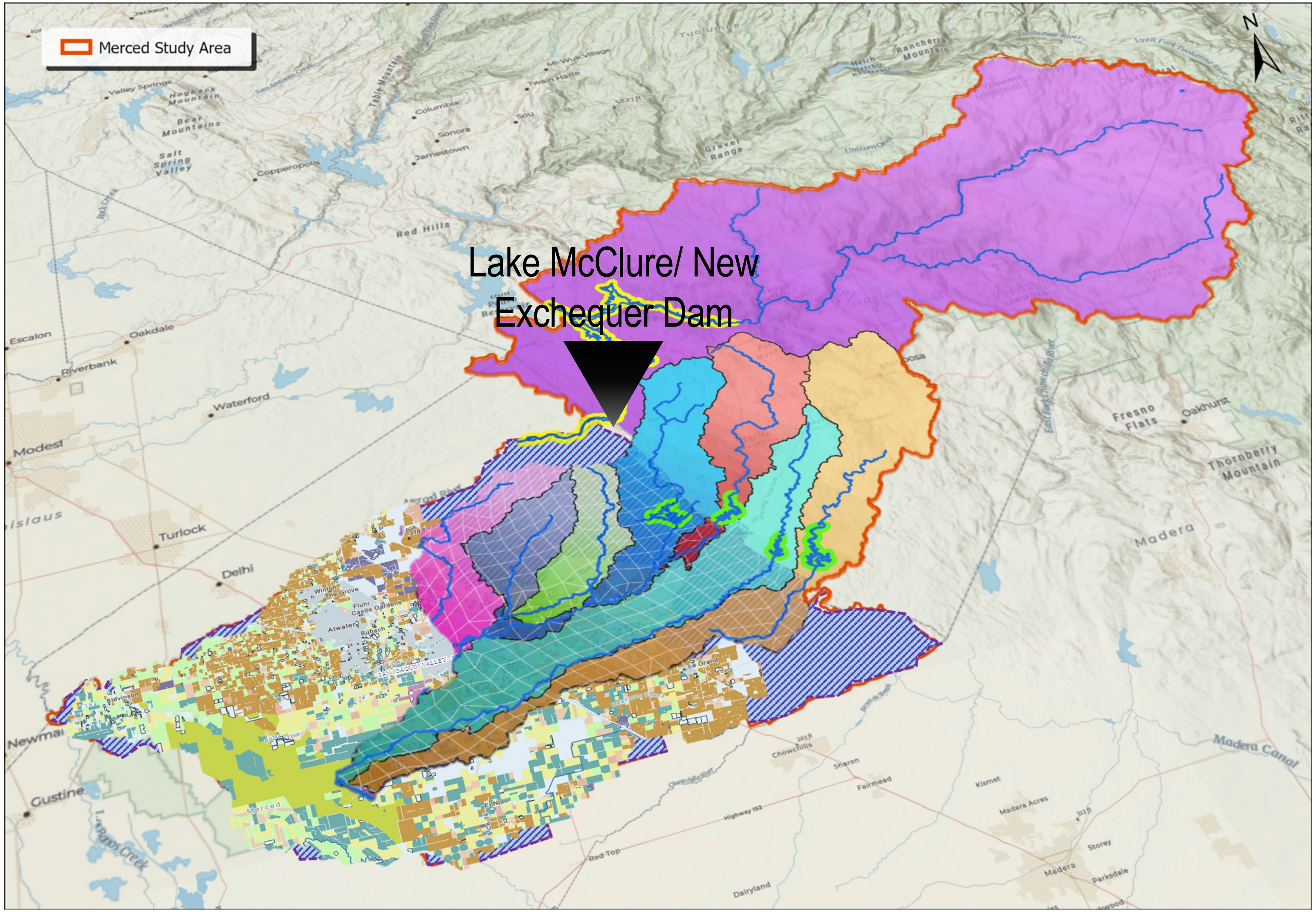
Study Purpose & Goals

- Proof of concept study
- Integrated Watershed Modeling
- Assess vulnerability and adaptation
- Evaluate multi-sector effects
- Template for future studies and projects



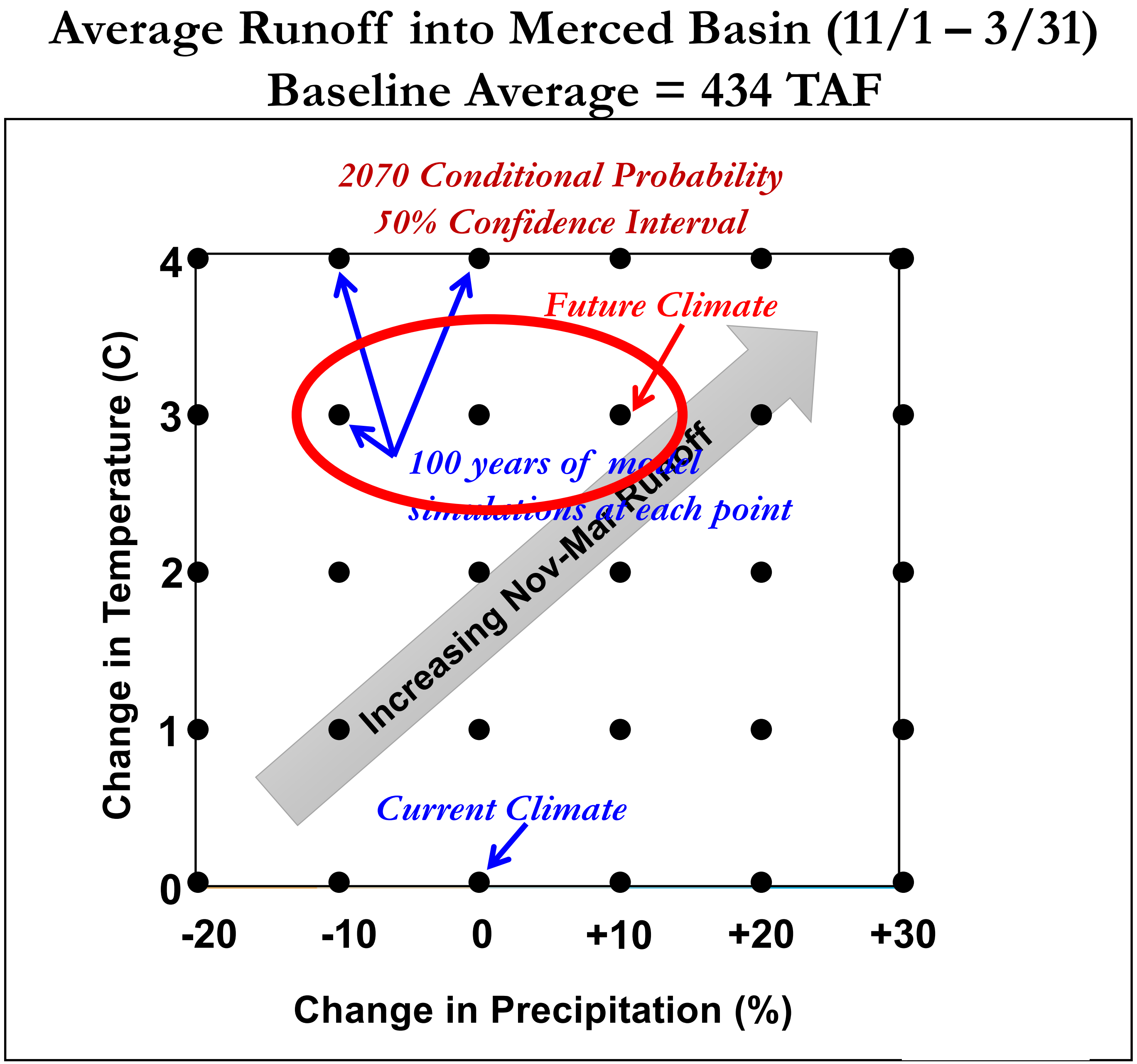
Background

- Merced watershed
- One major reservoir
- 862 miles of conveyance
  - Main Canal
  - Northside Canal
- 132,000 acres of agricultural land
  - Merced Subbasin
  - Turlock Subbasin

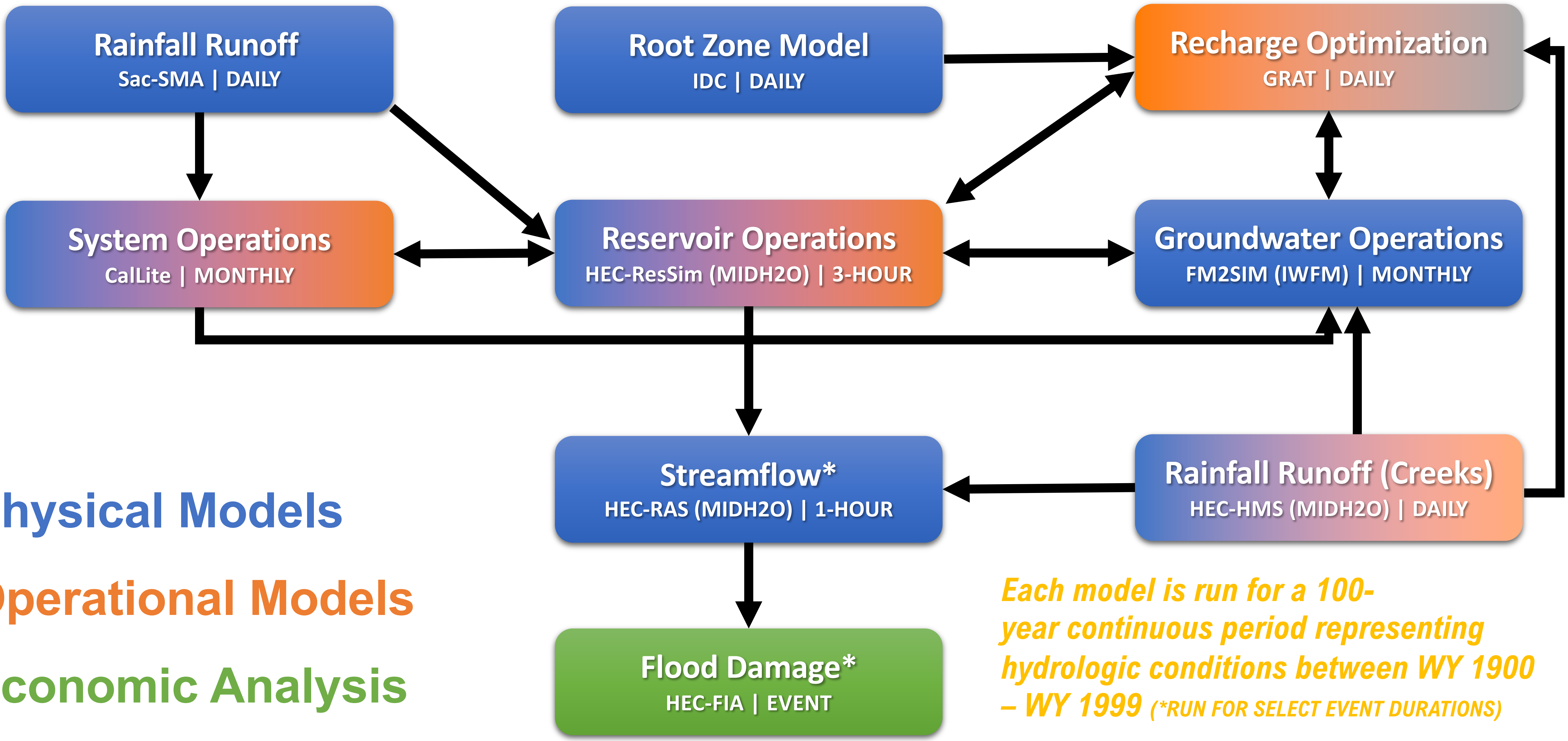


Climate Change

- 100 years of hydrology
  - 1900 to 1999
- 30 climate scenarios
  - 0° to 4° Celsius increase in temperature
  - -20% to +30% change in precipitation
- Decision scaling approach



Model Integration Flowchart



Physical Models

Operational Models

Economic Analysis

*Each model is run for a 100-year continuous period representing hydrologic conditions between WY 1900 – WY 1999 (*RUN FOR SELECT EVENT DURATIONS)*

Modeling Beyond Study Area

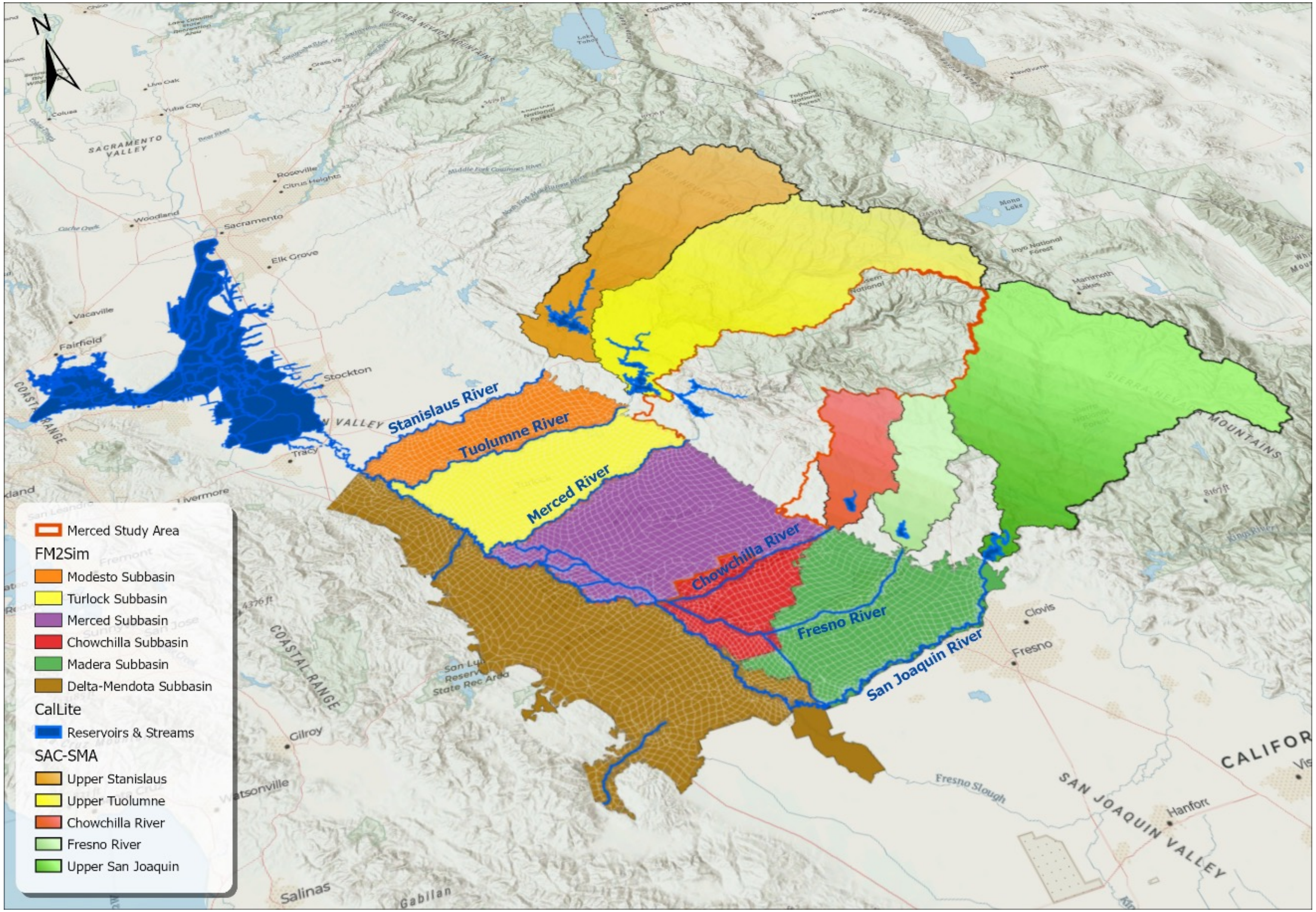
Rainfall Runoff
Sac-SMA

↓

System Operations
CalLite

↓

Groundwater Operations
FM2SIM



Watershed Scale Modeling

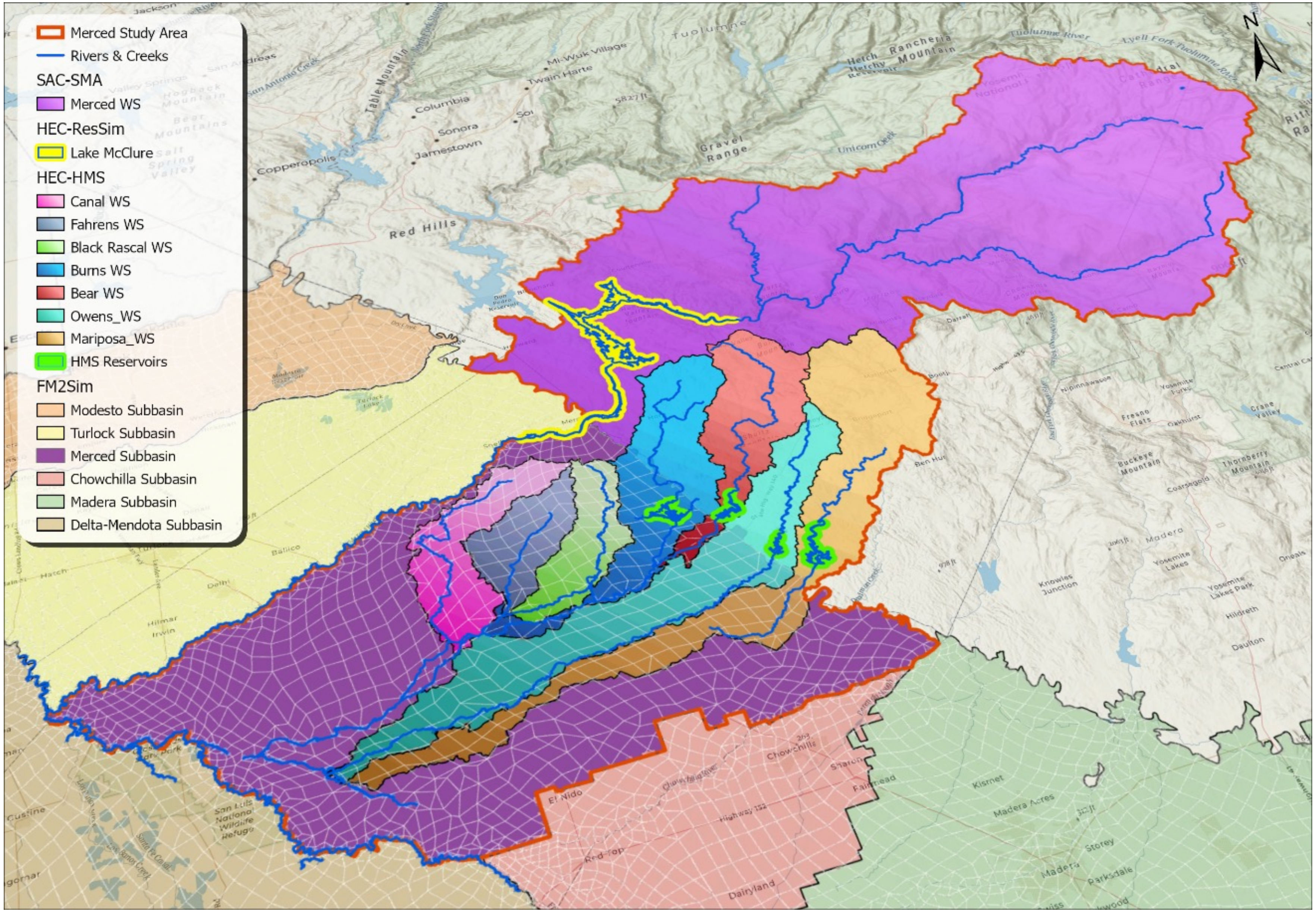
Rainfall Runoff
Sac-SMA

Reservoir Operations
HEC-ResSim (MIDH2O)

Rainfall Runoff (Creeks)
HEC-HMS (MIDH2O)

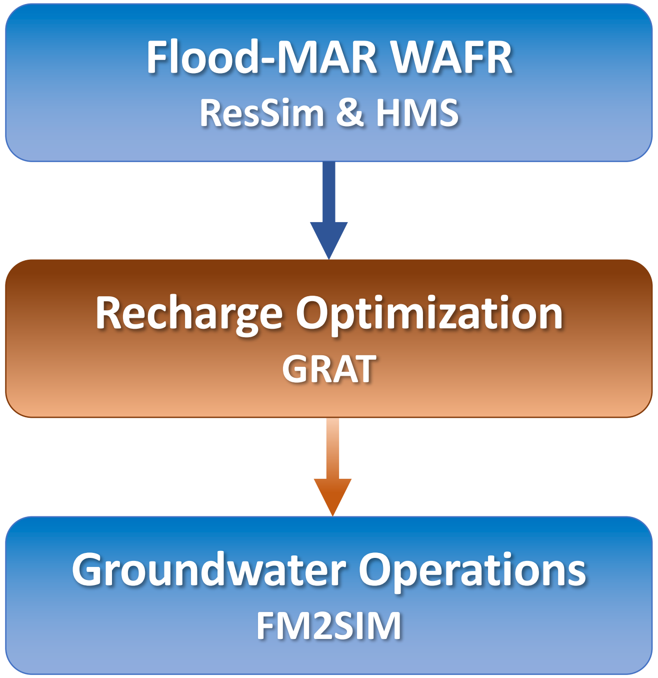
Recharge Optimization
GRAT

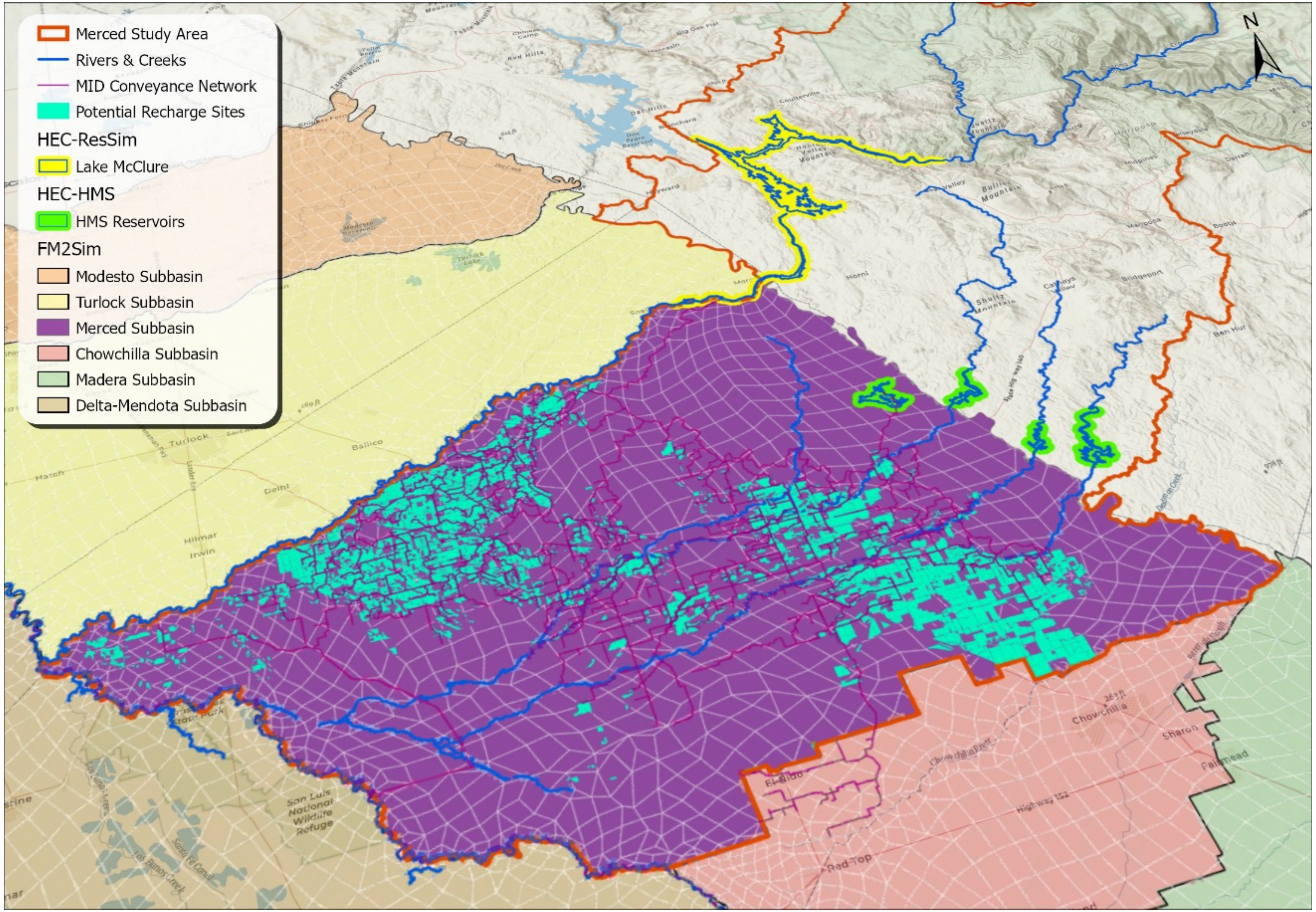
Groundwater Operations
FM2SIM



Watershed Scale Modeling

Potential Recharge Sites





Watershed Scale Modeling

Reservoir Operations
HEC-ResSim (MIDH2O)

↓

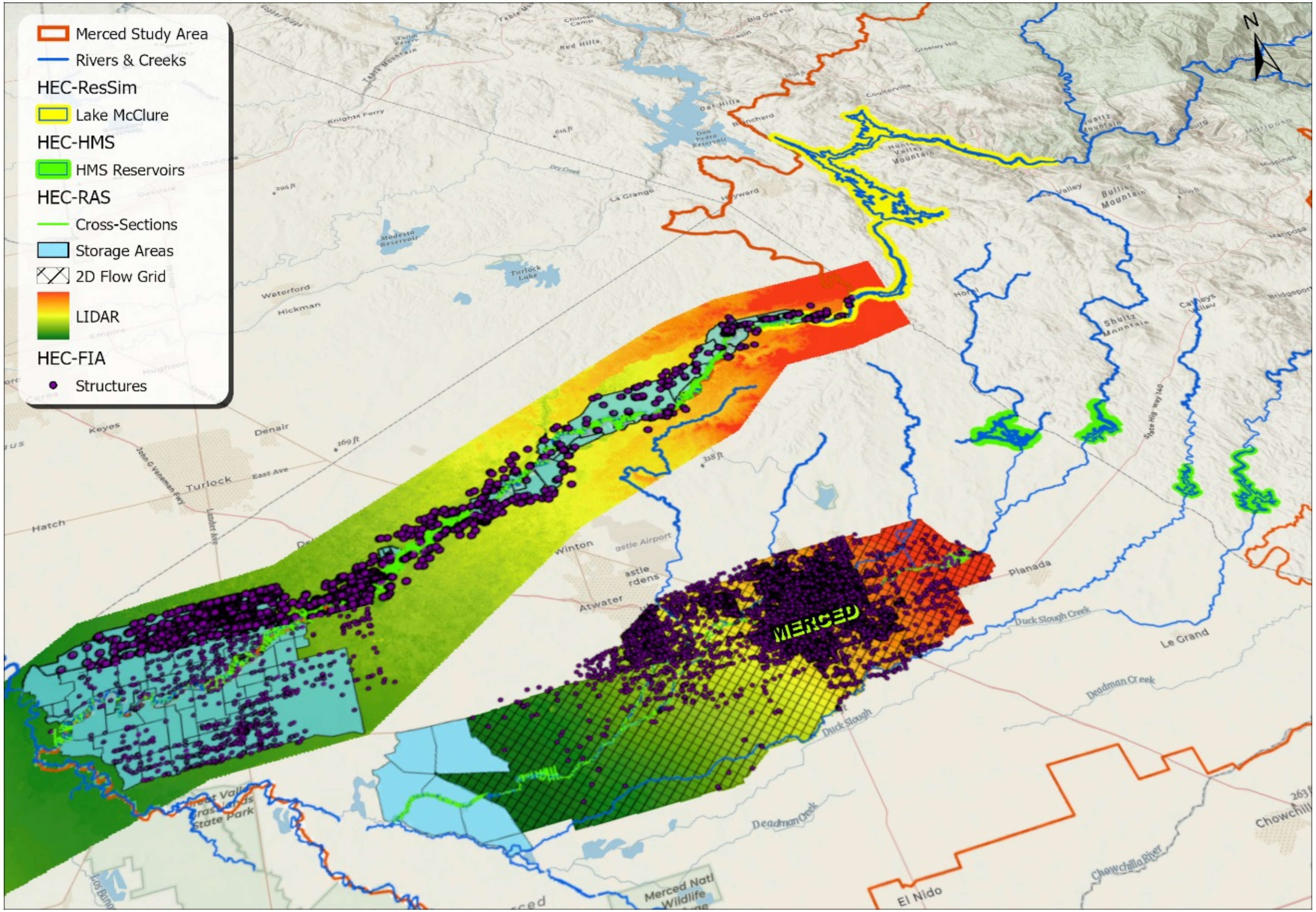
Rainfall Runoff (Creeks)
HEC-HMS (MIDH2O)

↓ ↓

Streamflow
HEC-RAS (MIDH2O)

↓

Flood Damage
HEC-FIA



Results → Metrics → Sector Performance

	Watershed Conditions	Upper Watershed Runoff
		Applied Demand
		Water Available For Recharge (WAFR)
	Water Supply/ Groundwater (GW)	GW Pumping
		Δ GW Storage
		Δ GW Levels in Disadvantaged Communities
	Water Supply/ Surface Water (SW)	Lake McClure Storage
		SW Deliveries
	Flood Risk	Merced River Flood Conditions
	Ecosystem	GDE Habitat
		Merced River Salmonid Habitat
		Shorebird Habitat

FLOOD-MAR IMPLEMENTATION SCENARIOS

	Existing Infrastructure	Reservoir Reoperation	Management Emphasis	Infrastructure Improvements	
High Flows	✓	✗	✗	✗	**Level 1 x 3**
High Flows + Res. Reop.	✓	✓	✓	✗	**Level 2 x 3**
High Flows + Res. Reop. + Infrastructure	✓	✓	✓	✓	**Level 3 x 3**

Flood-MAR uses water that is physically available in the system.
Physically available ≠ legally available.
Opportunity for local, state, and federal partnerships.

Level 1 = Existing Infrastructure + High Flows

	Initial	Intermediate	Robust
Time Window	December to March	November to March	November to March
Protective Threshold	90^{th} Percentile Daily Flow	90^{th} Percentile Monthly Flow	500 cfs
Diversion Amount	Up to minimum of 20% of total flow or available conveyance capacity	Up to available conveyance capacity	Up to available conveyance capacity
Recharge Location	Canal-Only	Canal & On-Farm	Canal & On-Farm
		PRESENTED TODAY **"L1 Interm."**	

*Water Available For Recharge (WAFR)**

based on SWRCB's Streamlined Permitting Guidelines

**Lesser of instream flows available after meeting the downstream uses or flows above the protective flow threshold. Downstream uses include (1) environmental and applied water demands along the Merced River and local creeks, and (2) Sacramento-San Joaquin Delta regulatory requirements related to water quality, salinity, and flow.*

Level 2 & 3 Flood-MAR Scenarios

LEVEL 3

LEVEL 2

Water Available For Recharge (WAFR)	PRESENTED TODAY "L3 FIRO-MAR" **FIRO-MAR**	**Hybrid-MAR**	PRESENTED TODAY "L3 RP-MAR" **Recharge Pool-MAR**
High Flow Diversion Criteria	Same as Level 1 Intermediate *instream flows available after meeting the downstream uses above the 90th percentile monthly flow between November and March*		
Reservoir Operations	• Forecast Informed Reservoir Ops (FIRO)	• Recharge Pool • FIRO	• Recharge Pool
Primary Management Objective	• Flood Control • Ecosystem Management	• Flood Control • Aquifer replenishment for DAC's and subsidence mitigation • Ecosystem management	• Flood Control • Aquifer replenishment for water supply
Secondary Management Objective	• Aquifer replenishment for water supply	• Aquifer replenishment for water supply	• Ecosystem Management
Infrastructure Improvement	• Field turnout capacity • Off-channel habitat	• Field turnout capacity • Conveyance capacity	• Field turnout capacity • New recharge basins

Merced River Watershed Study

Water Available for recharge, Water Supply, And Flood Risk

David Arrate (David.Arrate@water.ca.gov) | CWEMF Annual Meeting | 4/5/2022

Session 16. Merced River Flood-MAR Study

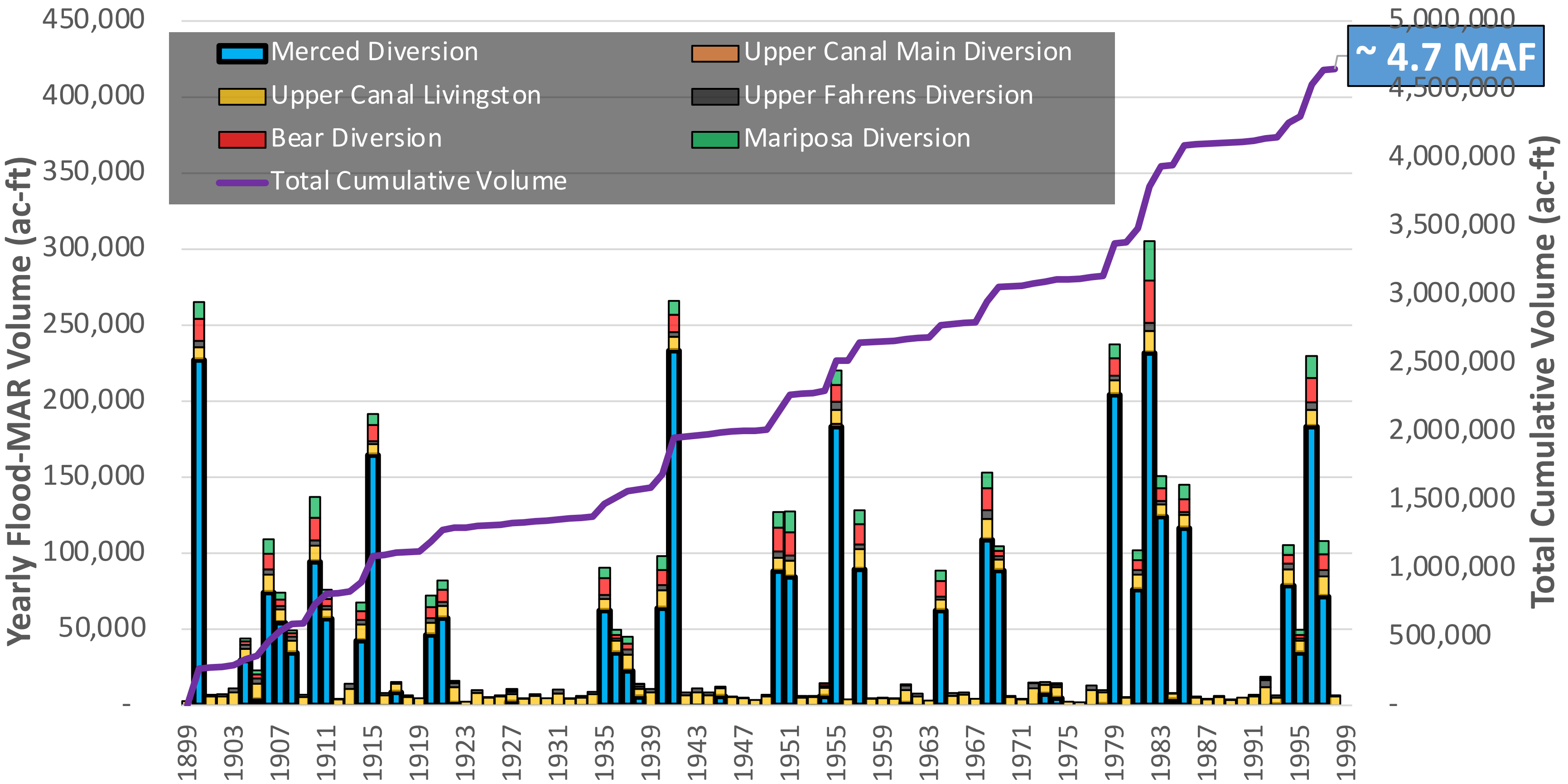
1. Overview
2. Water Available for Recharge, Water Supply and Flood Risk Benefits
3. In-depth Discussion of Ecosystem Effects
4. Multi-sector Performance Using Risk-based Analytics

SOURCE: Reservoir Operations Model (HEC-ResSim)

How much is (physically) available for recharge?

Preliminary Results – Subject to Change

- 2/3 from Merced River and 1/3 from local creeks.
- Major rivers systems are a substantial but an intermittent supply source of water for recharge.
- Local creeks provide a more reliable supply of water for recharge.



	Merced River	Upper Canal Livingston	Upper Canal Main	Upper Fahrens	Bear Creek	Mariposa Creek	Total
Flood-MAR Volume (ac-ft)	3,172,623	699,062	11,614	182,012	312,394	271,572	4,649,278
Percentage of Volume	68%	15%	<1%	4%	7%	6%	100%
Max Yearly Diversion (ac-ft)	233,300	14,253	2,092	5,655	27,667	25,742	305,077

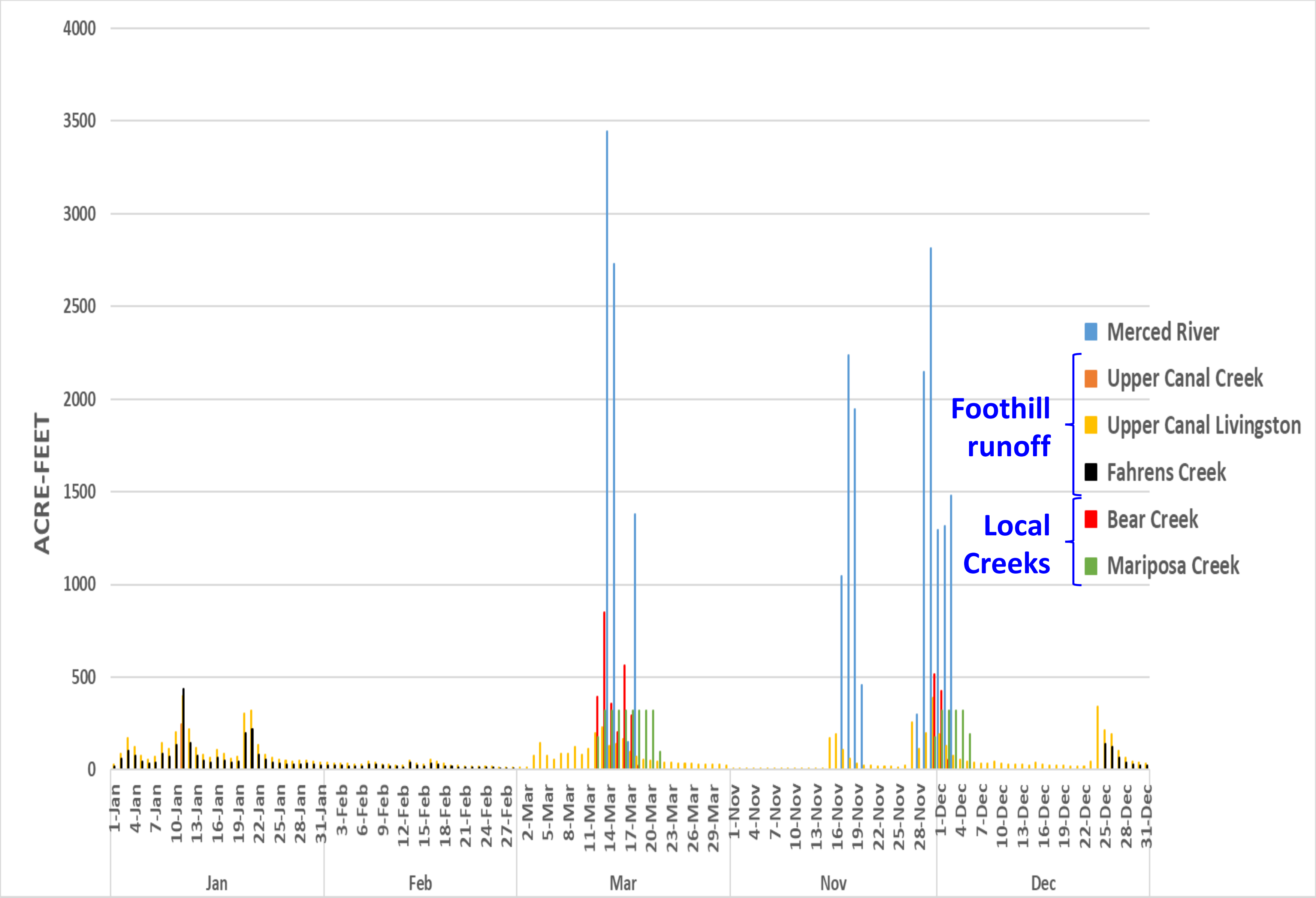
Foothill runoff 19%   Local Creeks 13%

SOURCE: Reservoir Operations Model (HEC-ResSim)

When is it available?

Preliminary Results – Subject to Change

- Year-to-year variation in supply sources is also reflected in the daily variability.
- Some of this variability can be managed by reoperating reservoirs

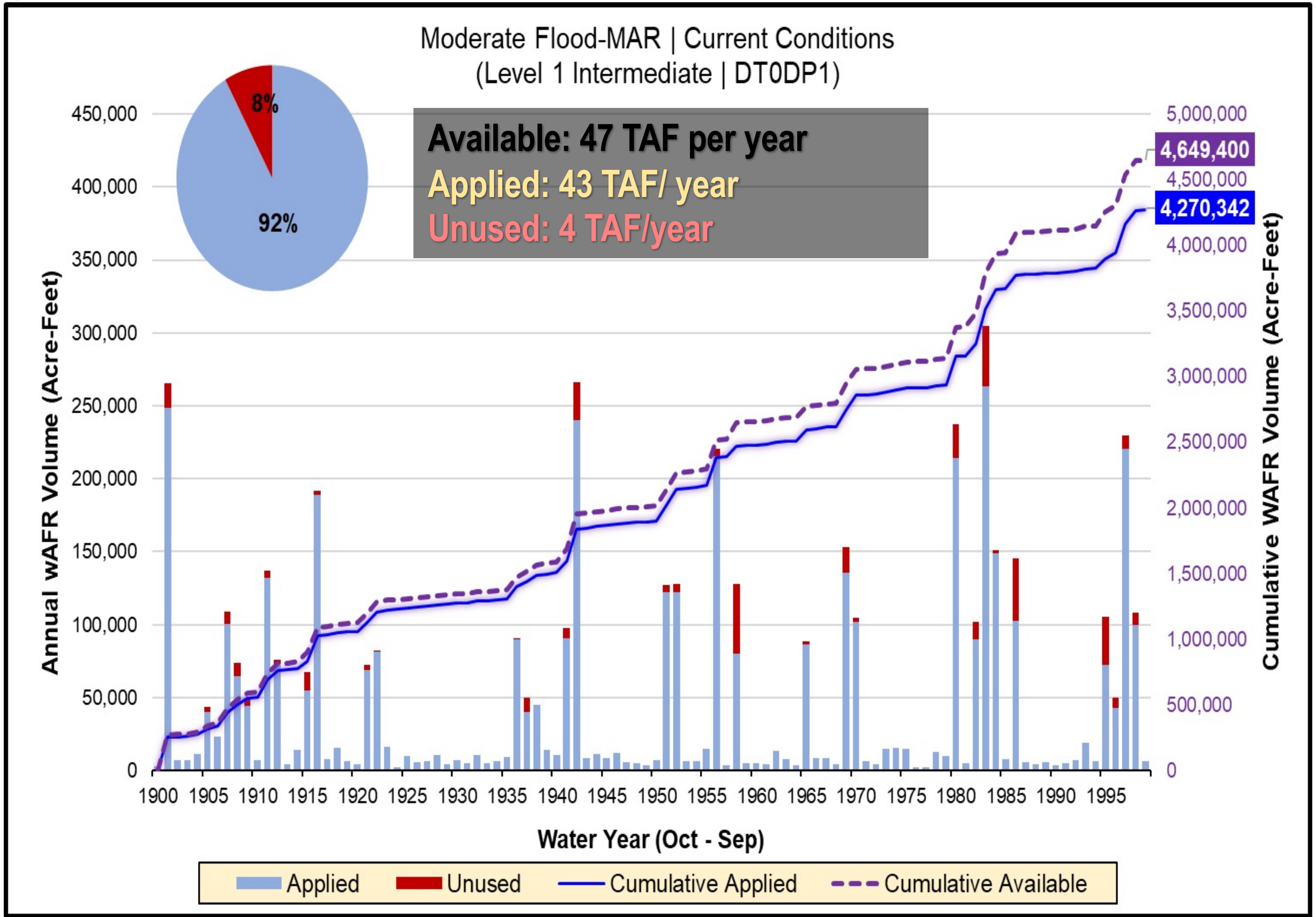


SOURCE: Recharge Optimization Model (GRAT)

Can we use it all?

Preliminary Results – Subject to Change

- Almost all of the available water can be put to use.
- ~10% left unused, on average
    - too much water over a small period of time – limited by delivery capacity
    - too late in the season – limited land available for recharge

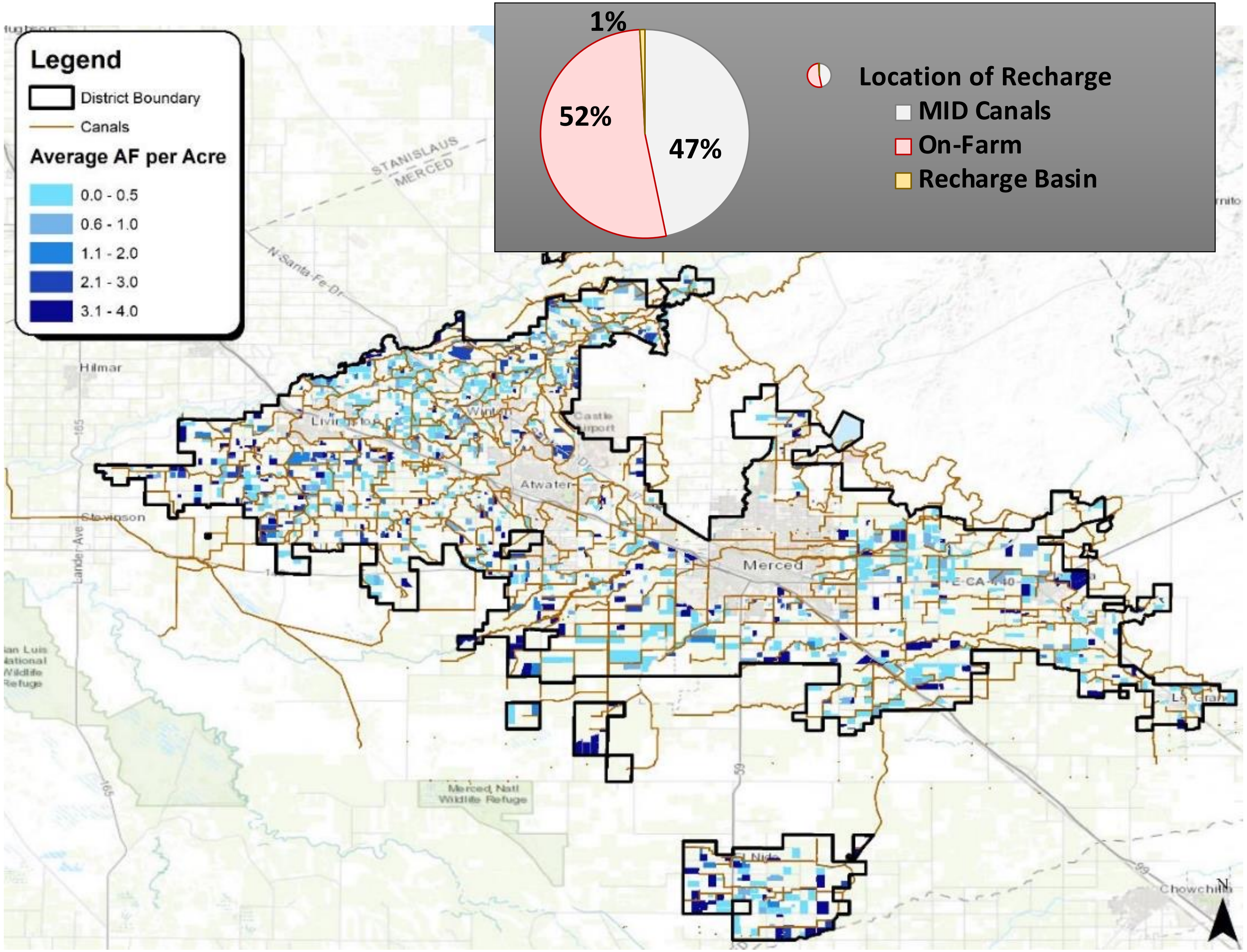


Where to put it?

Preliminary Results – Subject to Change

- Canal network
- "Available" agricultural land based on crop compatibility calendar
- Fields with good drainage, higher depth to GW, and outside Corcoran Clay layer are prioritized.**

***Additional criteria can be added to further refine field selection or prioritization.*



System Performance

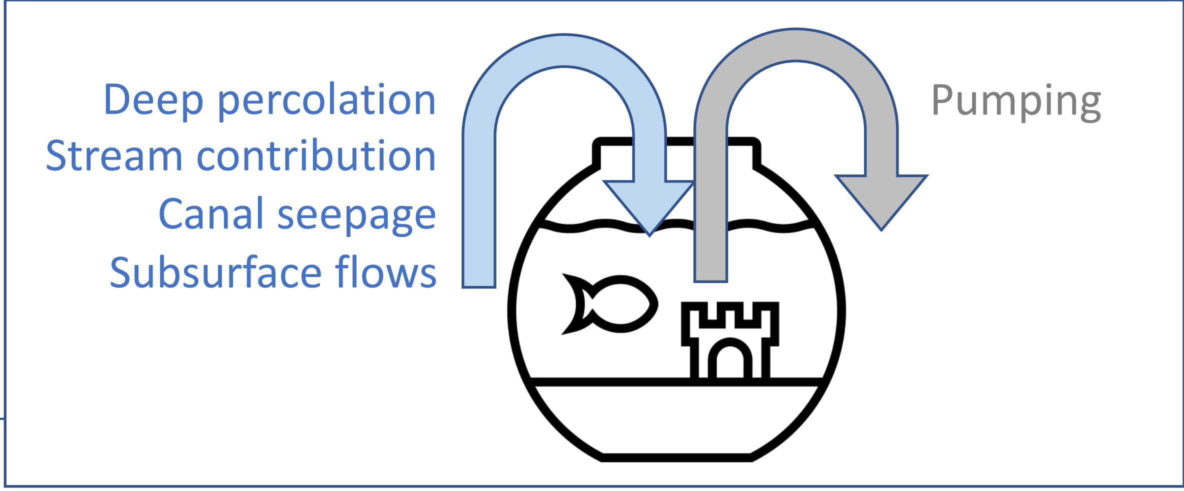
Performance Indicator: Decline | No significant change | Improvement

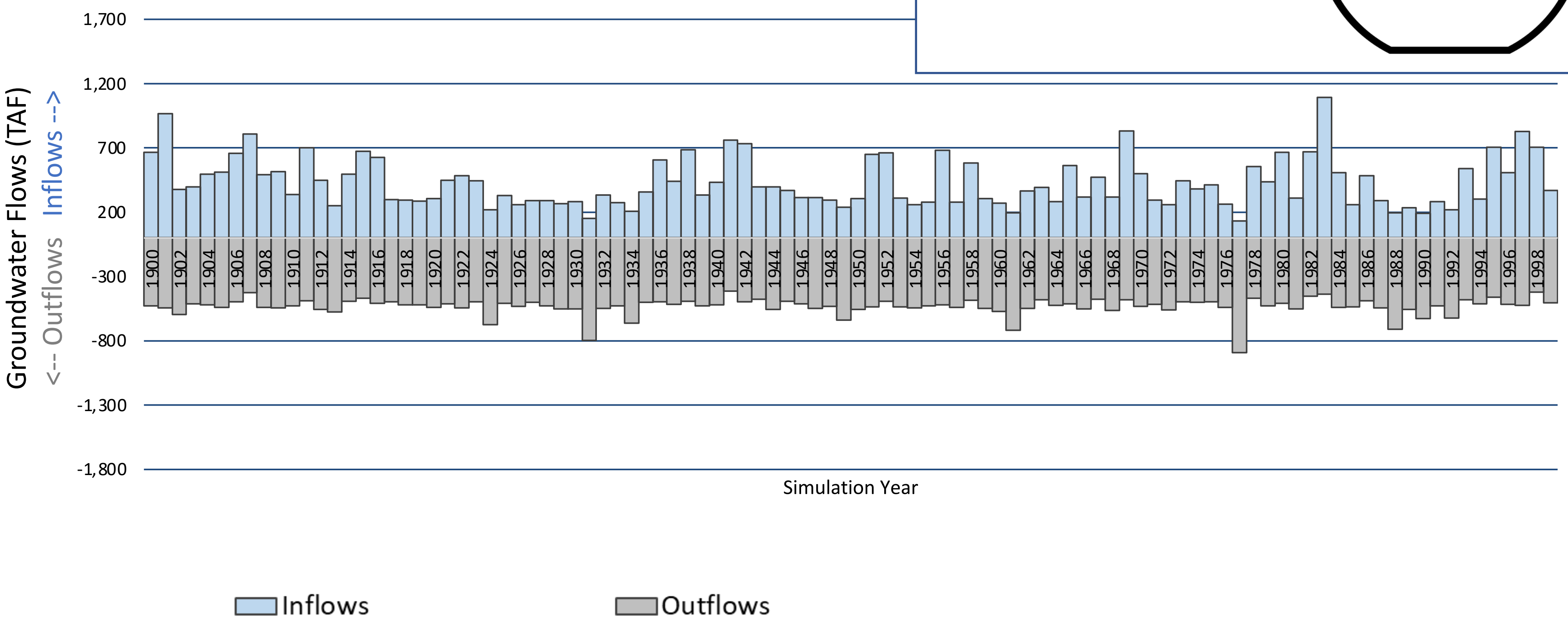
Preliminary Results – Subject to Change

Performance evaluated with respect to Baseline Current Conditions | *Performance evaluated with respect to Baseline DT3DP1.1 Scenario*

				VULNERABILITY		ADAPTATION PERFORMANCE		
				BASELINE		DT3DP1.1		
				CURRENT	DT3DP1.1	L1 INTERM.	L3 FIRO-MAR	L3 RP-MAR
Watershed Conditions	Upper Watershed Runoff	Oct – Sep	*TAF/ year*	1,123	**1,277**	1,277	1,277	1,277
		Nov – Mar	*TAF/ season*	434	**688**	688	688	688
		Apr – Oct	*TAF/ season*	689	**589**	589	589	589
	Applied Demand	Agricultural Demand (Oct – Sep)	*TAF/ year*	800	**854**	854	854	854
	Water Available For Recharge	Available (Nov – Mar)	*TAF/ season*	--	--	**90**	**119**	**151**
		Applied (Nov – Mar)	*TAF/ season*	--	--	**79 (88%)**	**111 (93%)**	**145 (96%)**

Groundwater storage will continue to decline under business as usual





Preliminary Results – Subject to Change

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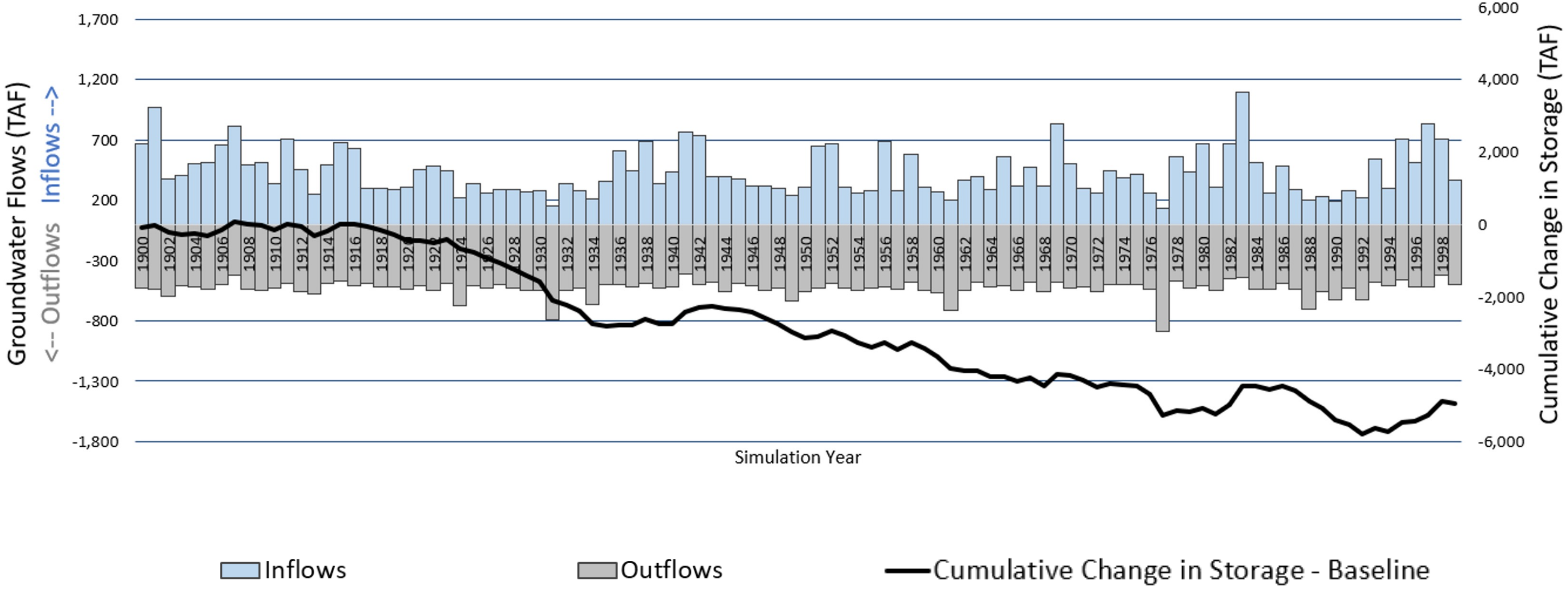
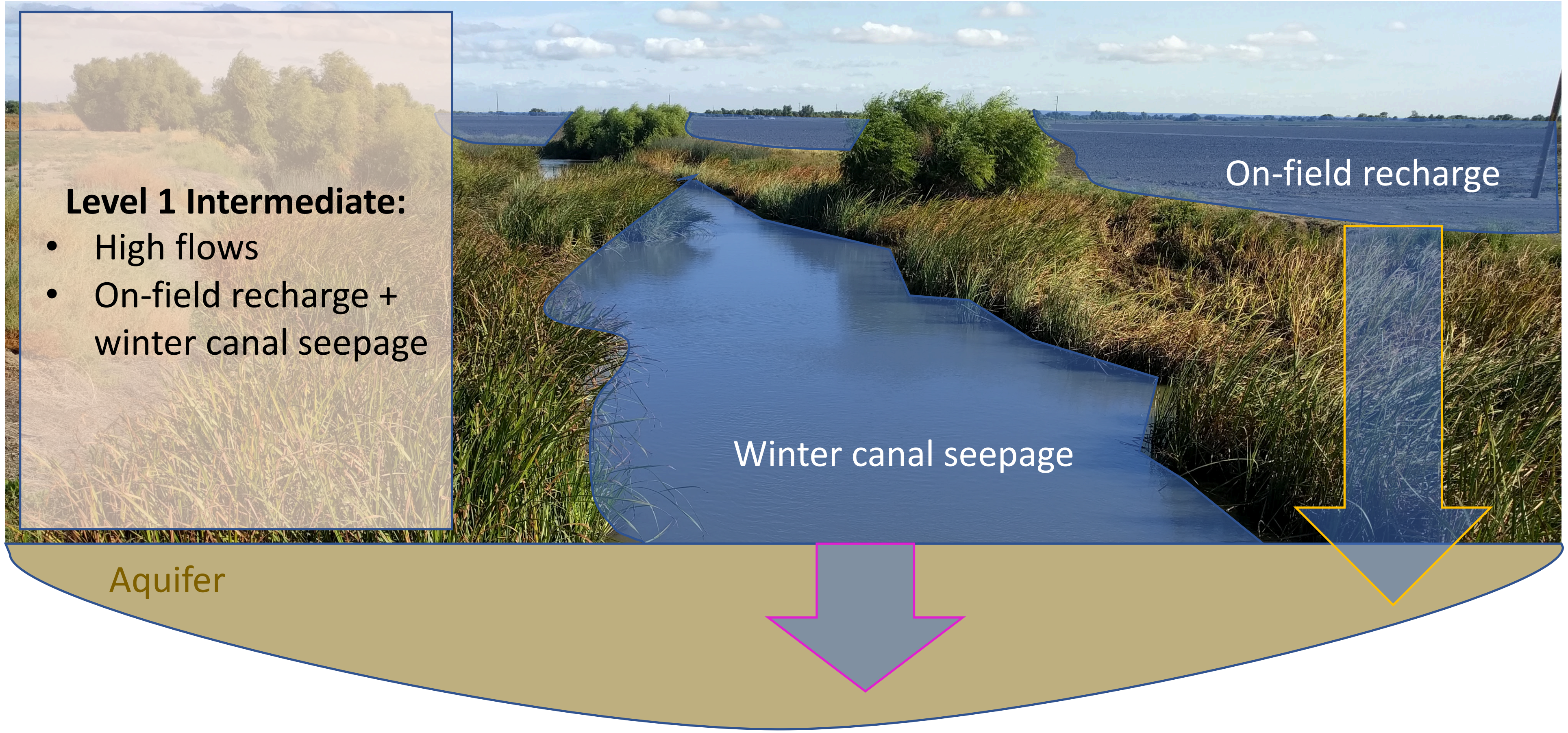


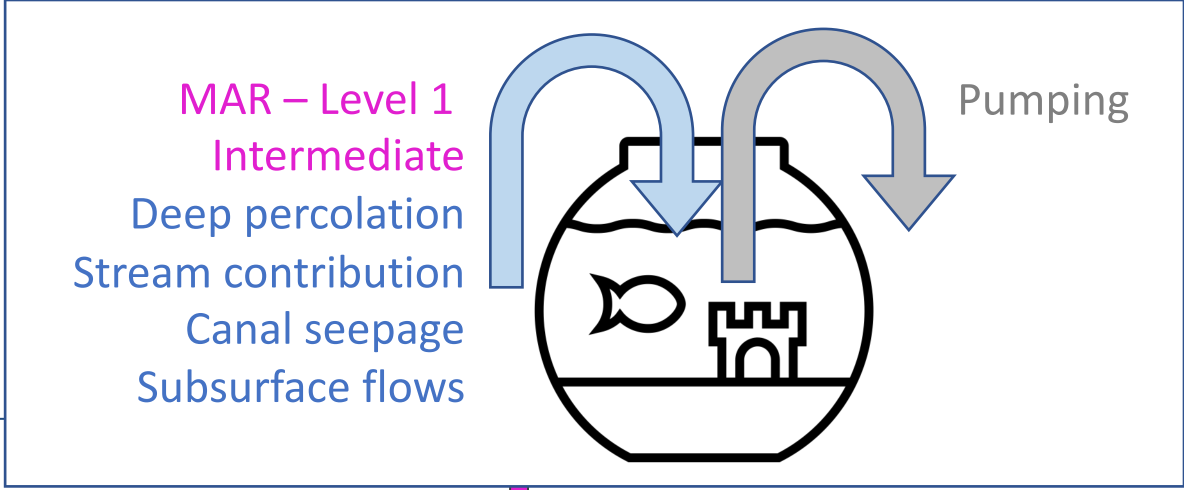
Preliminary Results – Subject to Change

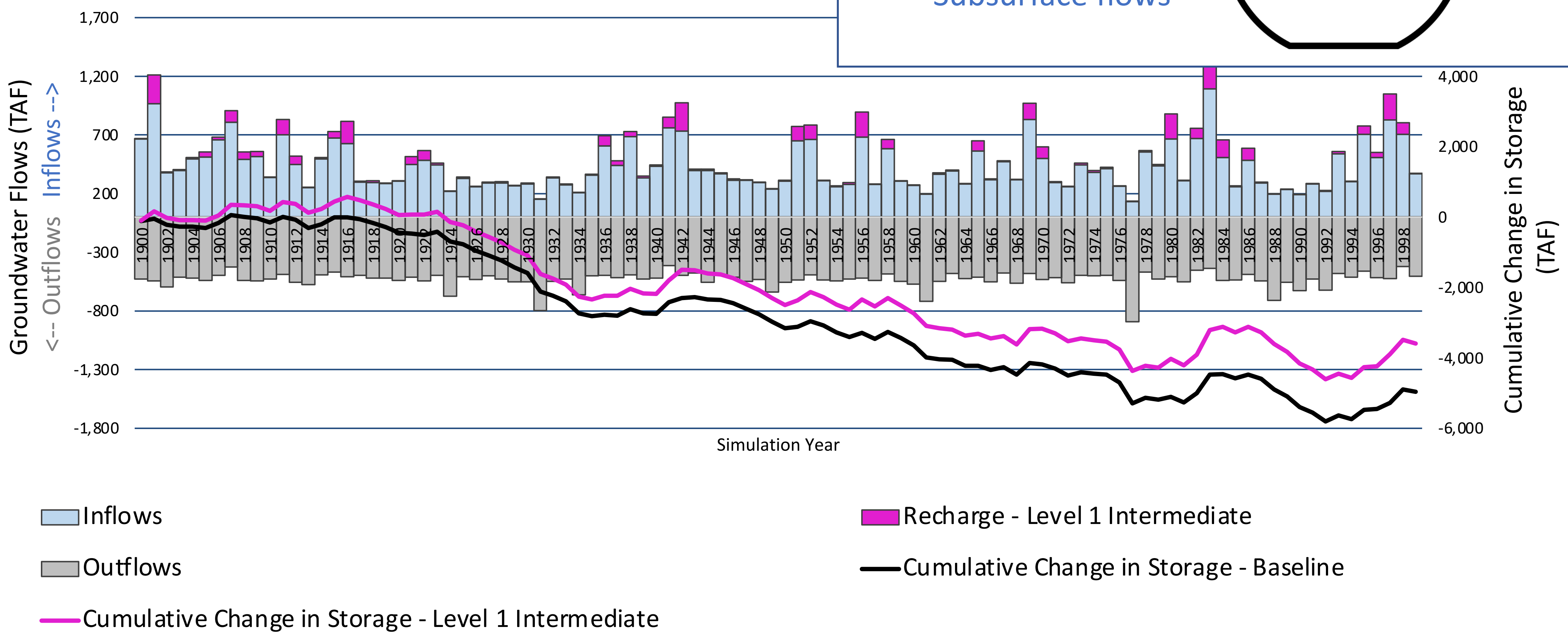
Recharge through canals and agricultural fields

Existing Infrastructure	Reservoir Reoperation	Management Emphasis	Infrastructure Improvements
✓	✗	✗	✗



Flood-MAR increases groundwater storage



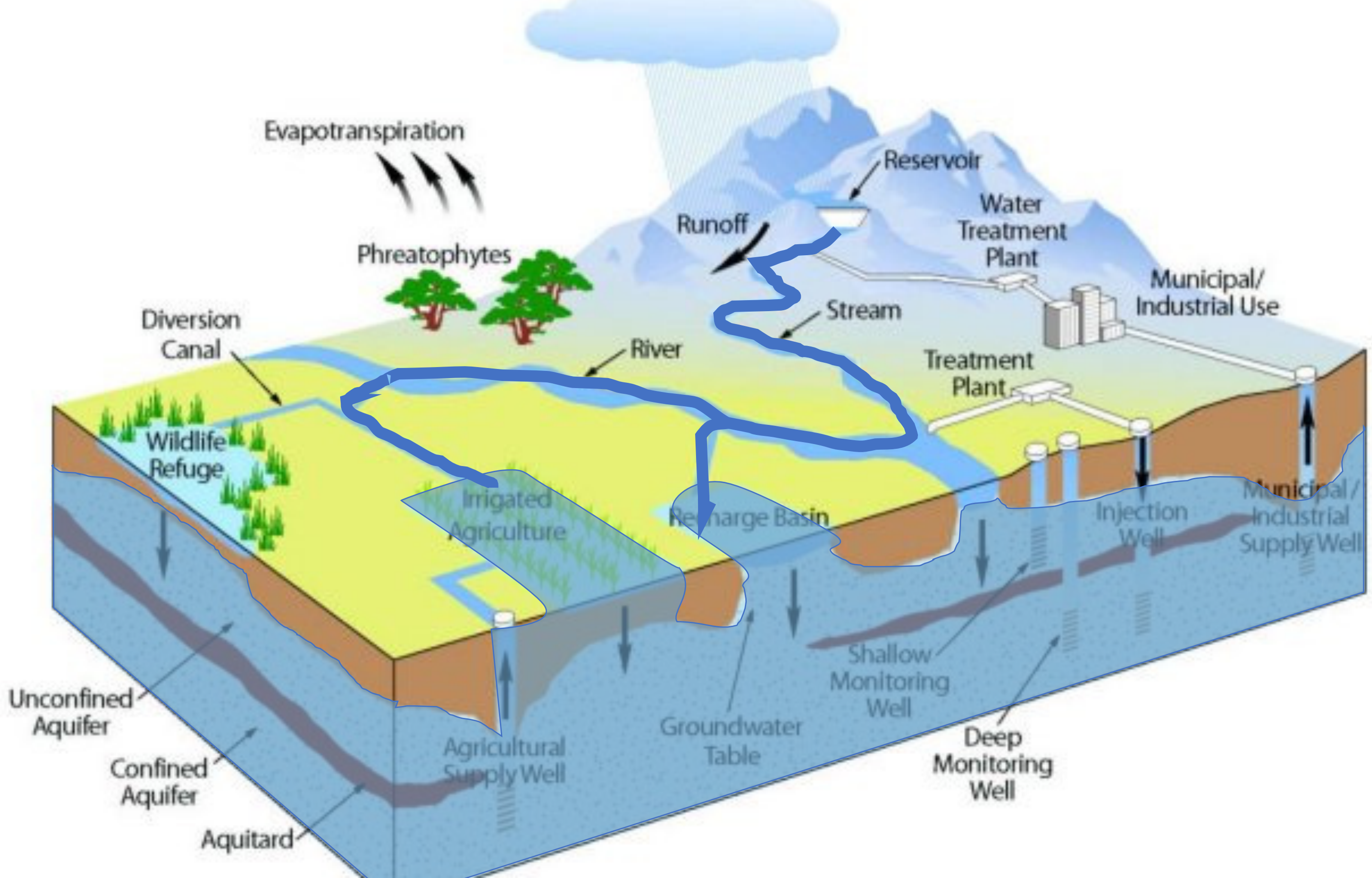


Preliminary Results – Subject to Change

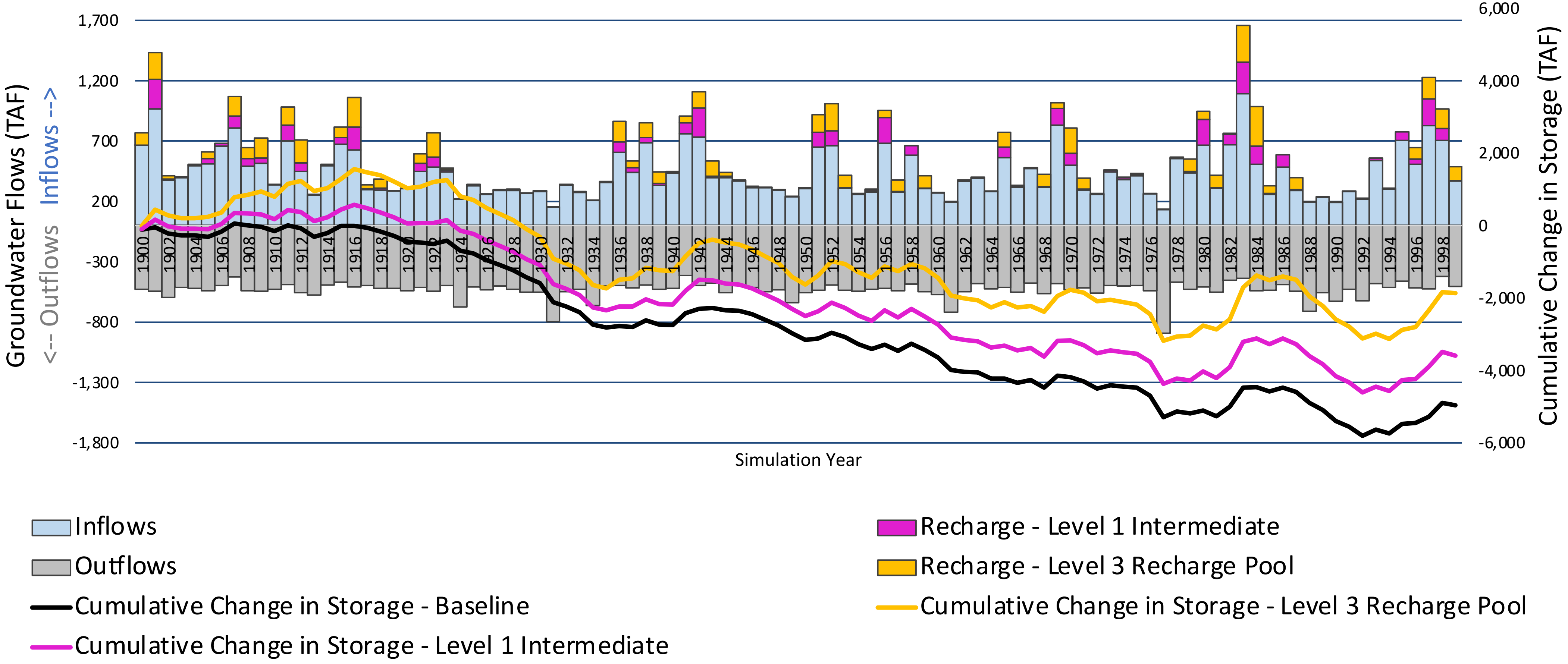
Recharge through canals and agricultural fields

Existing Infrastructure	Reservoir Reoperation	Management Emphasis	Infrastructure Improvements
✓	✓	✓	✓

Level 3 Recharge Pool:
- Reservoir reoperation
- Managed for in-basin water supply retention
- Higher intensity on-field recharge + winter canal seepage



Potential to store more water in the aquifer system



Preliminary Results – Subject to Change

System Performance

Performance Indicator: Decline | No significant change | Improvement

Preliminary Results – Subject to Change

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Performance evaluated with respect to Baseline DT3DP1.1 Scenario

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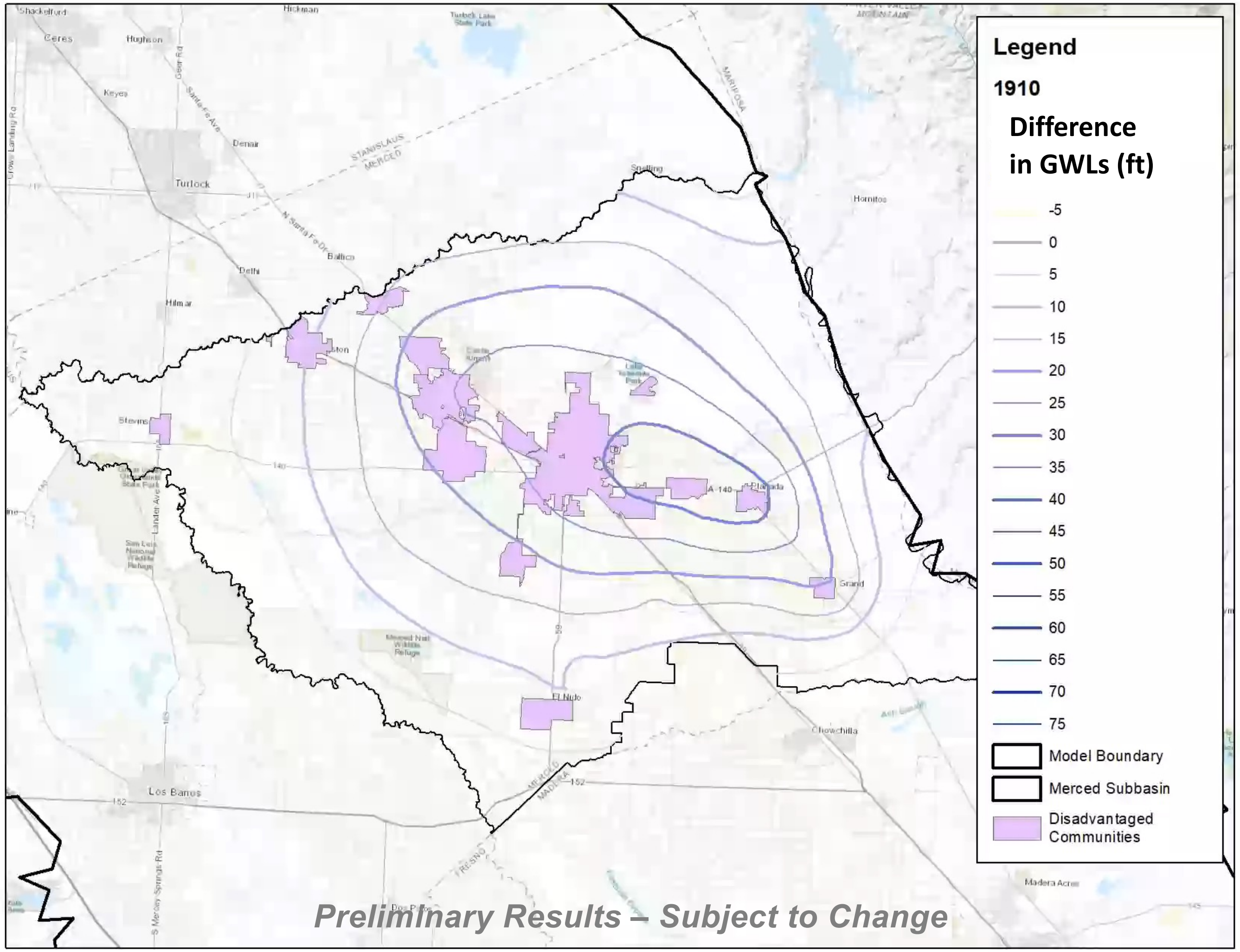
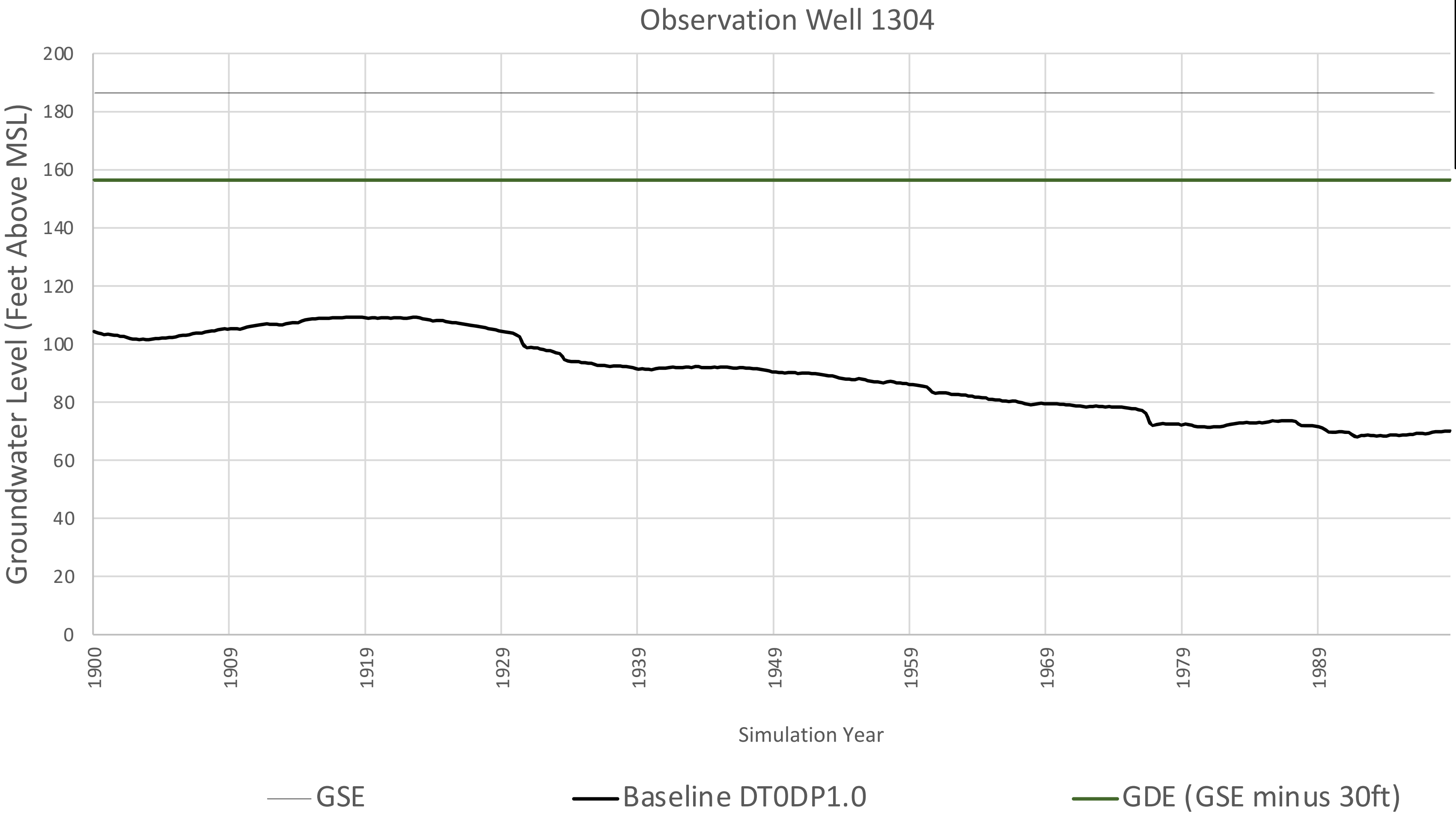
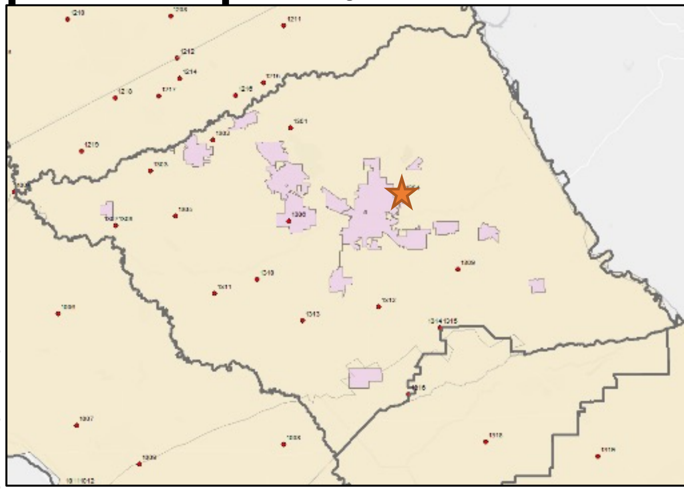
Water Supply/ Groundwater (GW)	GW Pumping	Oct – Sep	*TAF/ year*	466	499	499	501	506
	Δ GW Storage	Change in basinwide GW storage	*TAF/ year*	-50	-60	-35	-32	-15

Flood-MAR increases groundwater levels in Disadvantaged Communities



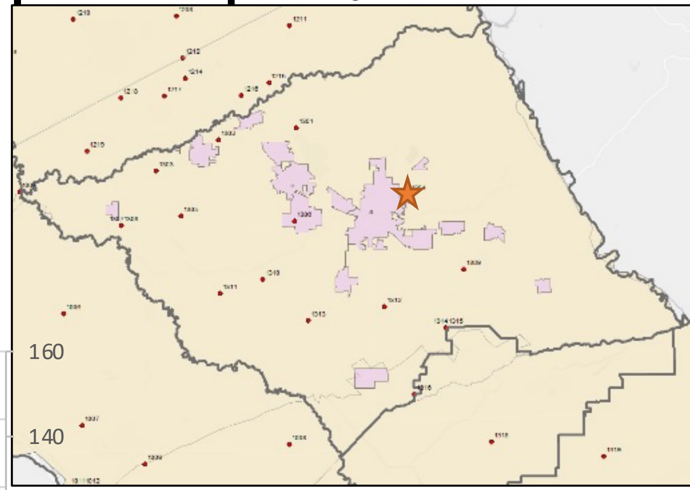
Flood-MAR Increases Groundwater ... DACs

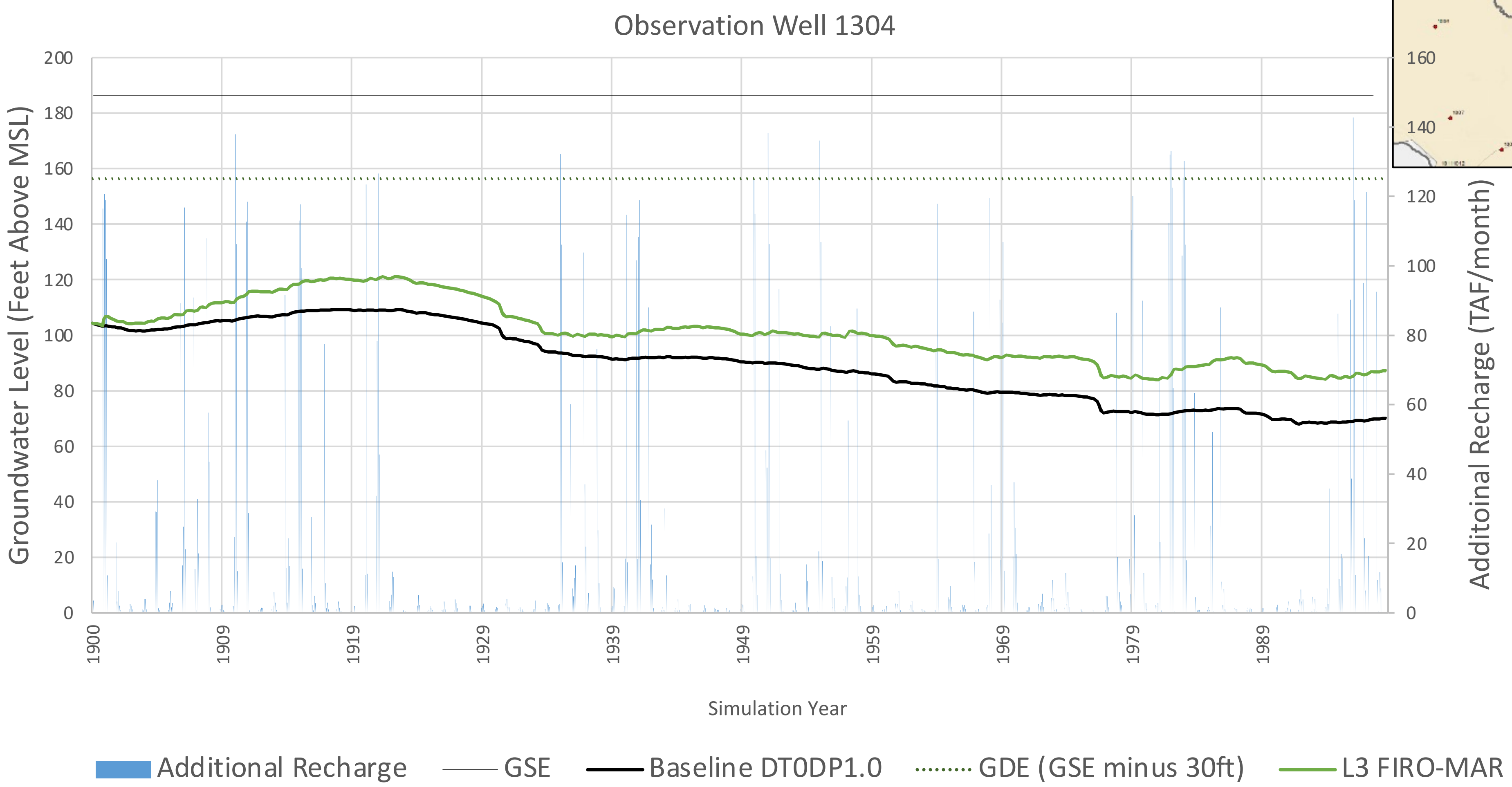




Preliminary Results – Subject to Change

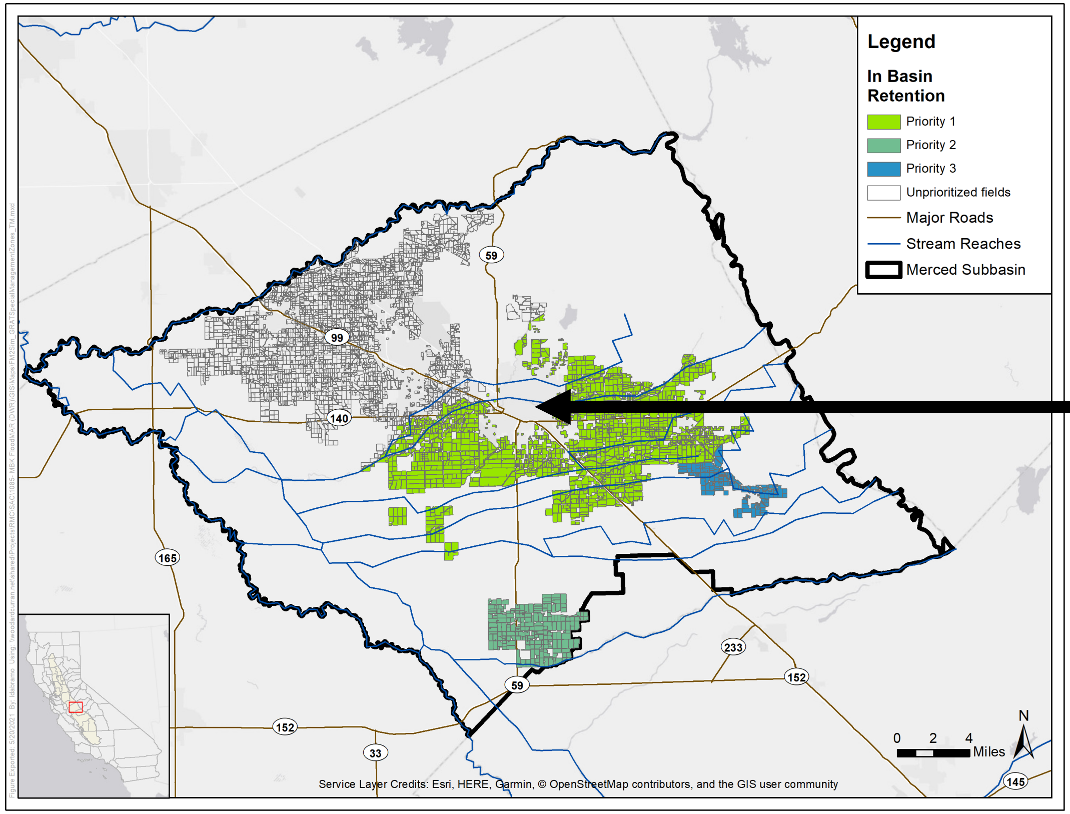
Flood-MAR Increases Groundwater
DACs





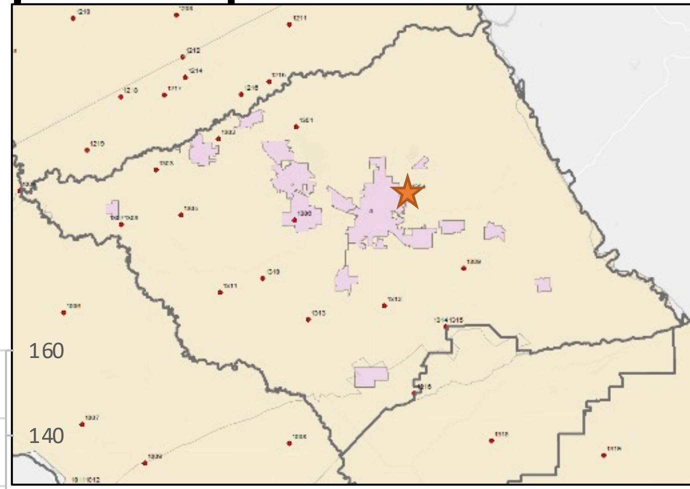
Preliminary Results – Subject to Change

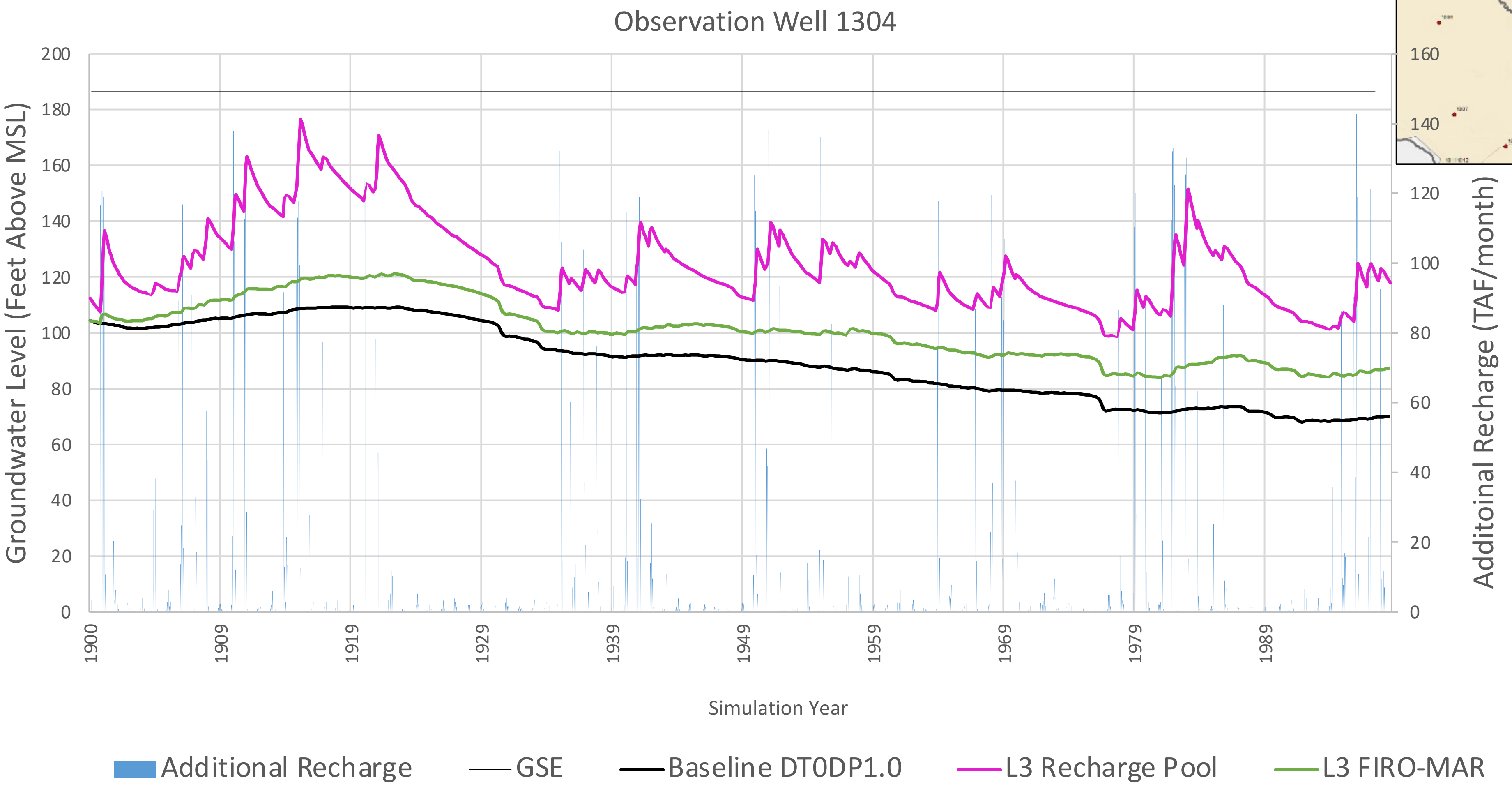
Existing Infrastructure	Reservoir Reoperation	Management Emphasis	Infrastructure Improvements
✓	✓	✓	✓



- Prioritizing fields adjacent to City of Merced Disadvantaged Community

Flood-MAR Increases Groundwater
DACs





Preliminary Results – Subject to Change

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Performance Indicator: Decline | No significant change | Improvement

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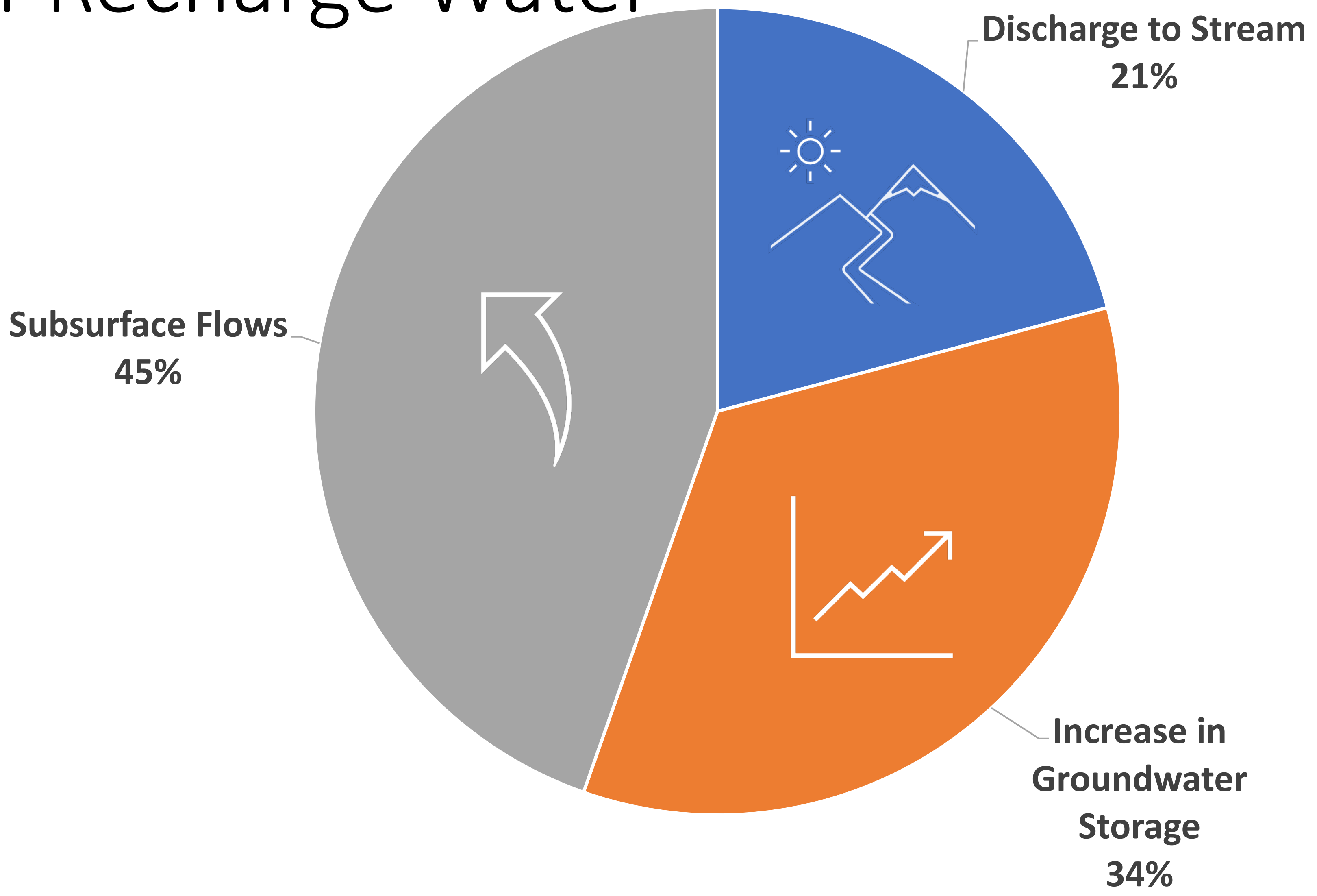
	Δ GW Storage	Change in basinwide GW storage	*TAF/ year*	-50	**-60**	**-35**	**-32**	**-15**
	Δ GW Levels	Aquifer east of Corcoran Clay layer	*Feet/ year*	-0.6	**-0.8**	**-0.2**	**-0.1**	**0.3**

- WHERE you recharge matters and can support management objectives

Fate of Recharge Water



Preliminary Results – Subject to Change

Climate Vulnerability – Surface Water & Flood Risk

Performance Indicator: Decline | No significant change | Improvement

Preliminary Results – Subject to Change

VULNERABILITY

				CURRENT	DT3DP1.1
				BASELINE	
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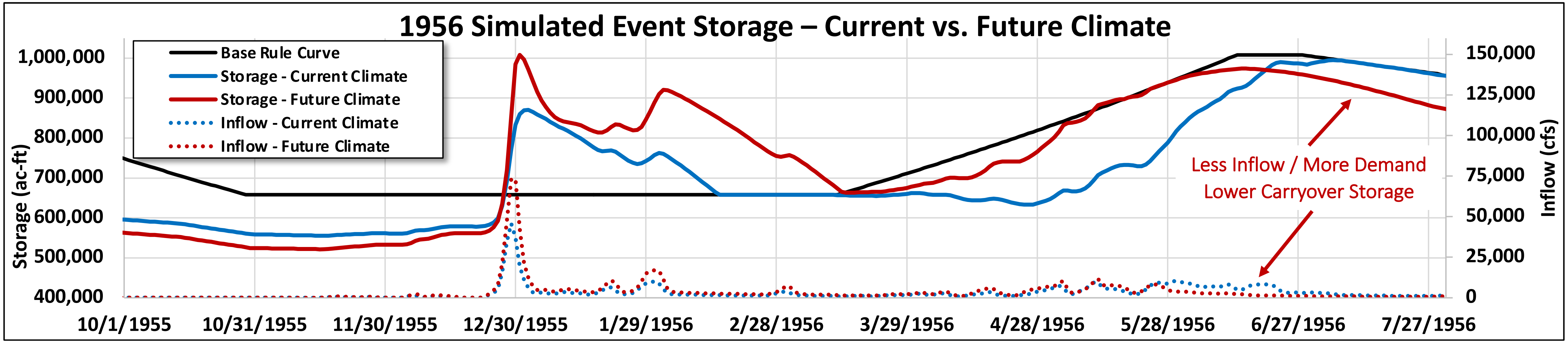
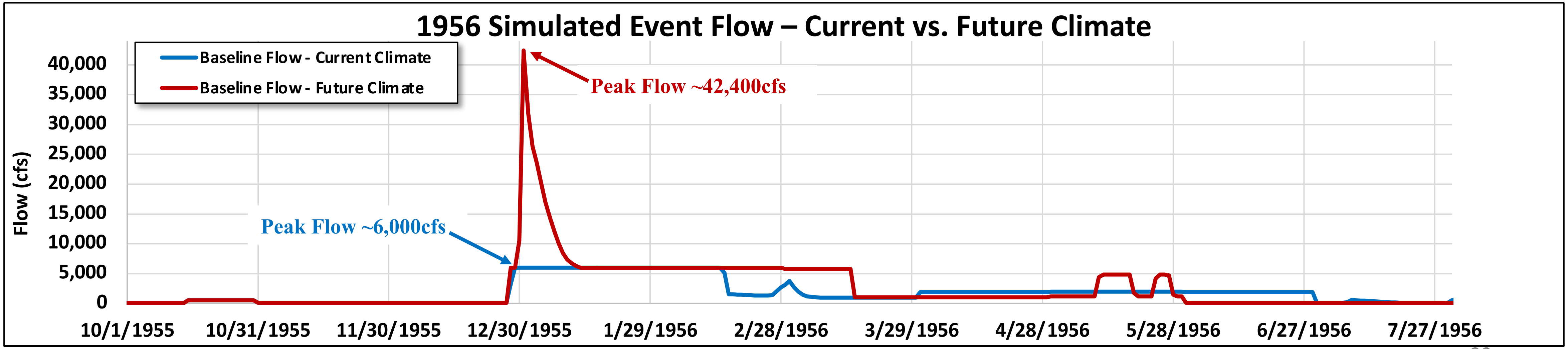
	Δ GW Storage	Change in basinwide GW storage	*TAF/ year*	-50	-60
	Δ GW Levels	Aquifer east of Corcoran Clay layer	*Feet/ year*	-0.6	-0.8
Water Supply/ Surface Water (SW)	Lake McClure Storage	End of October Storage	*Avg. TAF*	518	474
		# Years allocation ≤ 80%	*Years*	7	7
	Deliveries	Oct – Sep	*TAF/ year*	355	372
Flood Risk	Merced River Flood Conditions	100-year max simulated flow	*cfs*	6,004	42,412
		# Years with flows > 7300 cfs	*Years*	0	9

Climate Vulnerability (1956 Event)

Preliminary Results – Subject to Change





Level 1 = Existing Infrastructure + High Flows

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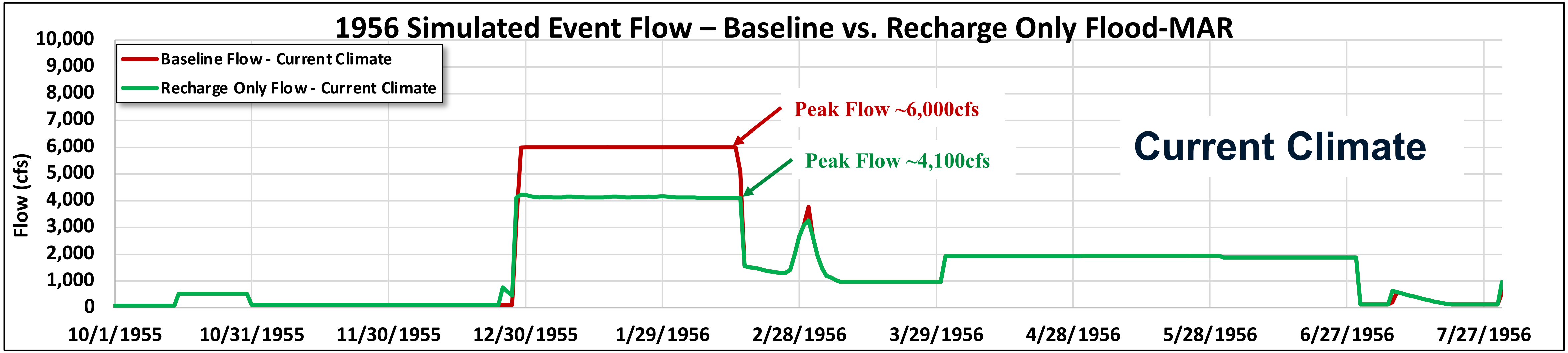
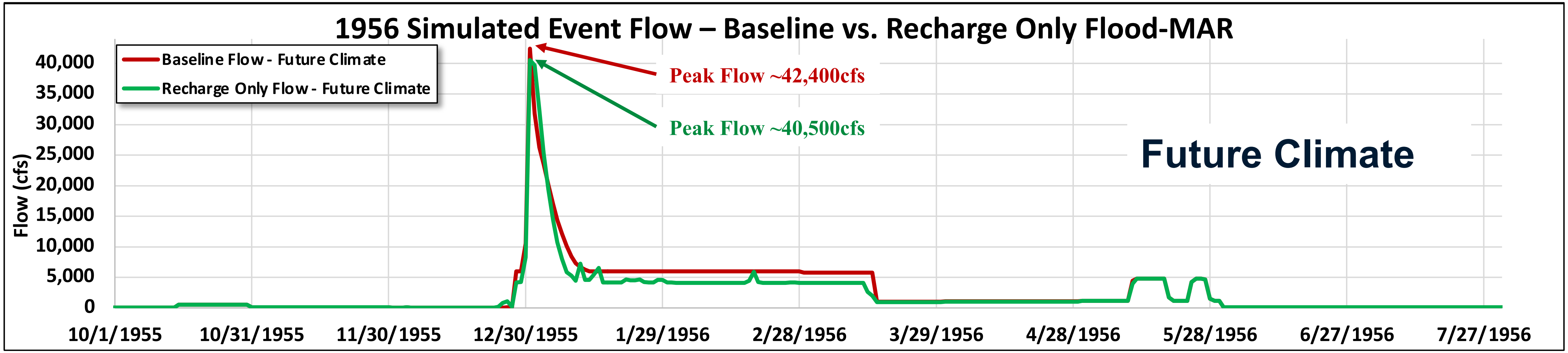
Diversion Amount	Up to minimum of 20% of total flow or available conveyance capacity	Up to available conveyance capacity	Up to available conveyance capacity
Recharge Location	Canal-Only	Canal & On-Farm	Canal & On-Farm
		PRESENTED TODAY **"L1 Interm."**	

L1 Intermediate - Recharge using High Flows

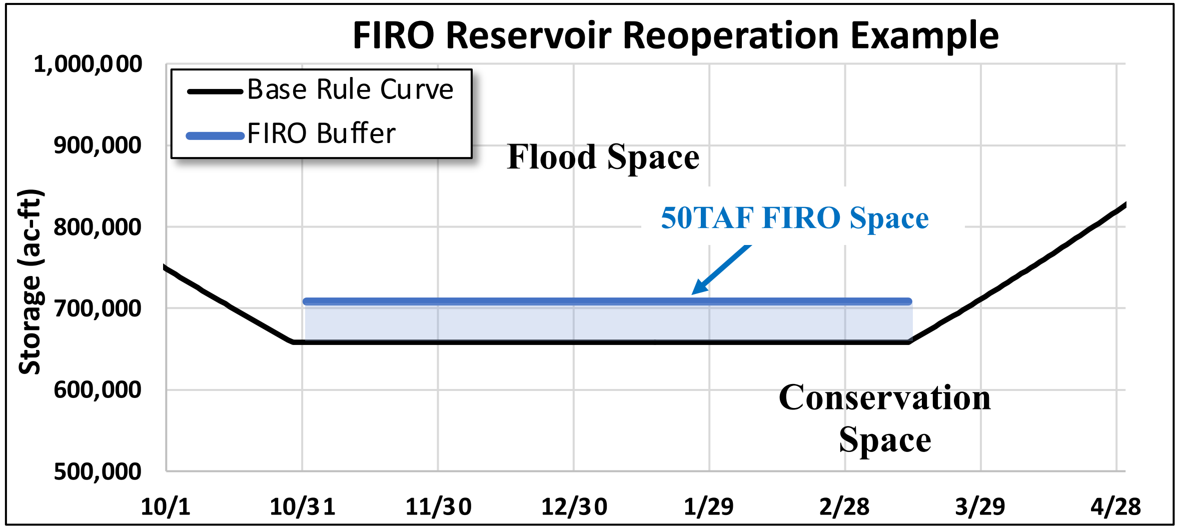
Preliminary Results – Subject to Change





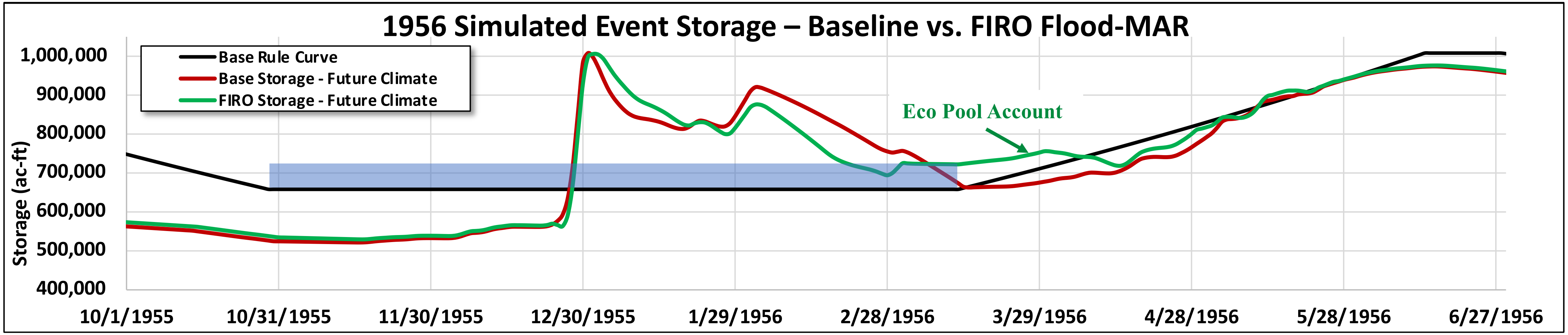
Reservoir Reoperation – L3 FIRO-MAR

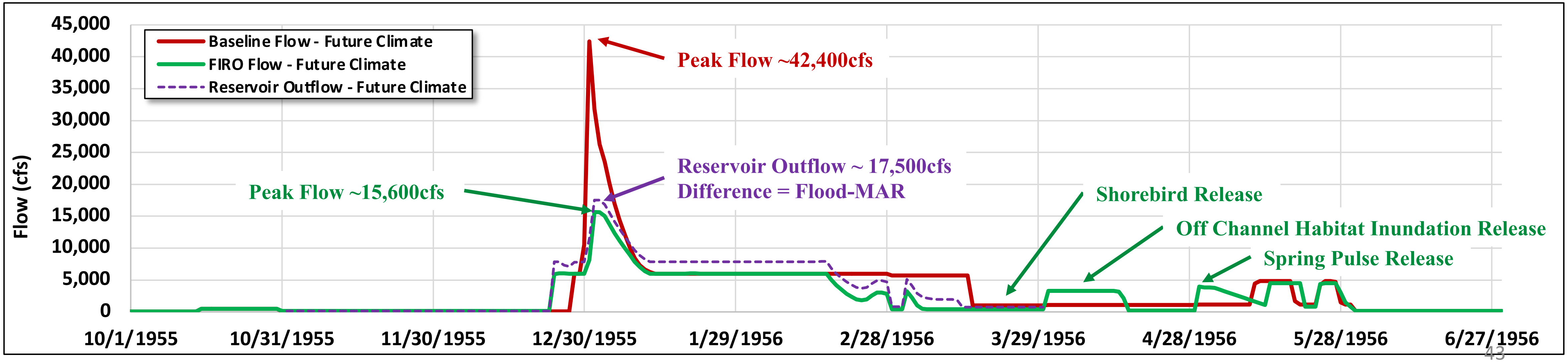
- Increases flood release capacity (6,000 +1,900cfs)
- FIRO Operations (5-day forecast period)
- 50 TAF Buffer above flood rule curve
- Eco Pool Operations
  - ✓ Eco Pool Account (reshaping flood control and snowmelt releases)
  - ✓ Shorebird release
  - ✓ Off channel habitat inundation release
  - ✓ Spring pulse release
- Increased minimum flow release



L3 FIRO-MAR – Future Climate (1956 Event)

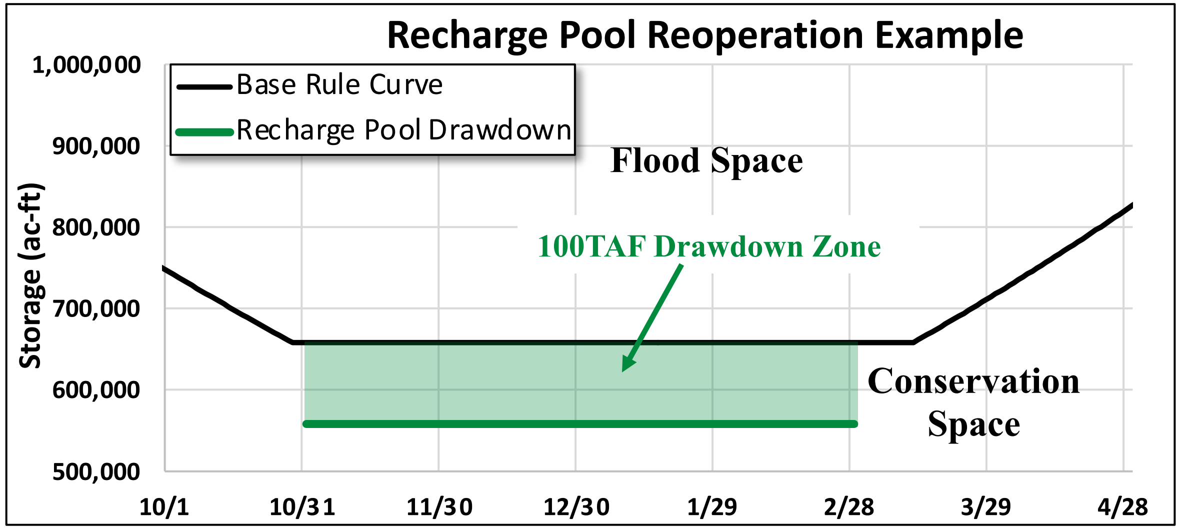
Preliminary Results – Subject to Change





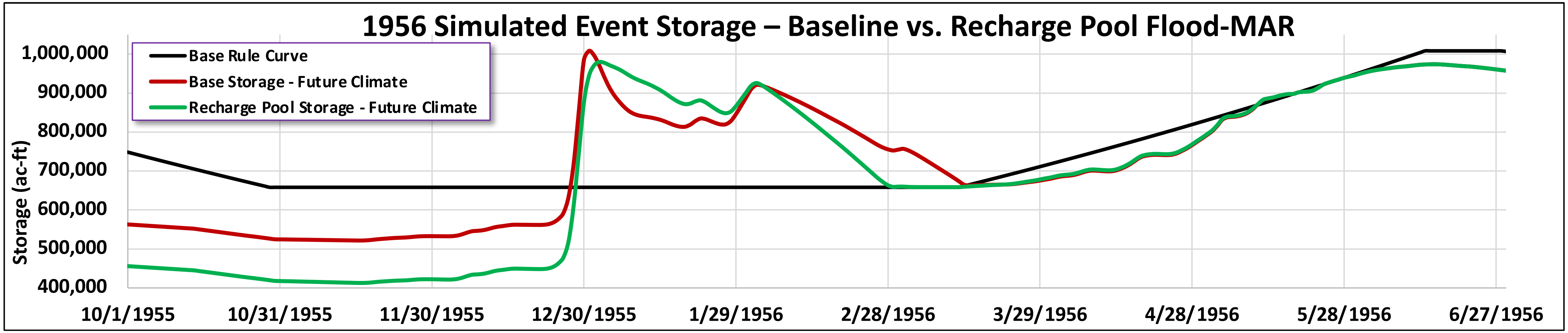
Reservoir Reoperation – L3 RP-MAR

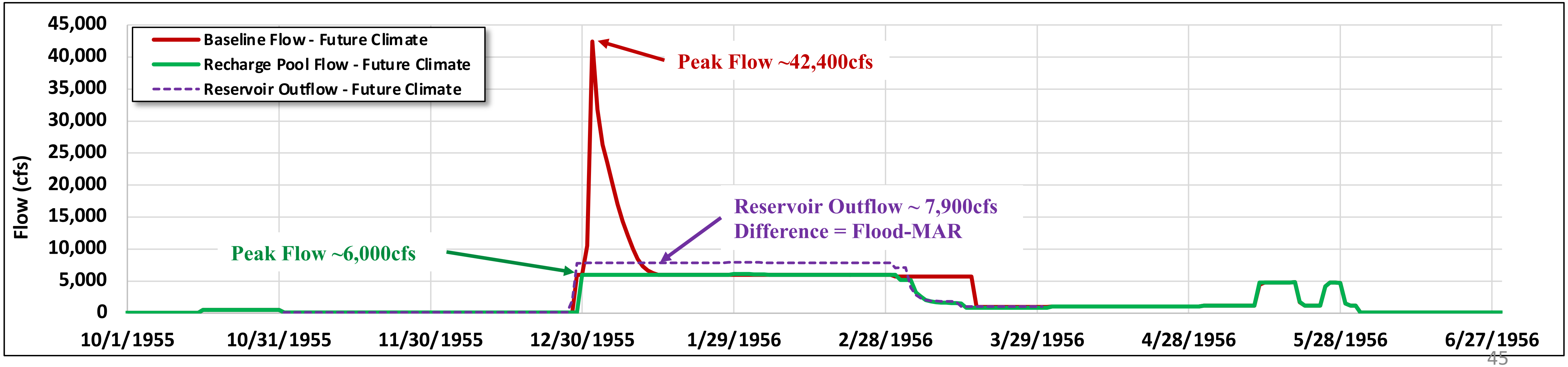
- Increases flood release capacity (6,000 +1,900cfs)
- Draws storage down to 100TAF below TOC
  - ➢ Releases up to available Main Canal capacity
- Tracks the cumulative storage deficit created by Recharge Pool releases
- The deficit is refilled when:
  - ➢ Delta is in excess conditions
  - ➢ Reservoir would've spilled during baseline operations



L3 RP-MAR – Future Climate (1956 Event)

Preliminary Results – Subject to Change





System Performance

Performance Indicator: Decline | No significant change | Improvement

Preliminary Results – Subject to Change

Performance evaluated with respect to Baseline Current Conditions

Performance evaluated with respect to Baseline DT3DP1.1 Scenario

				VULNERABILITY		ADAPTATION PERFORMANCE		
				CURRENT	DT3DP1.1 BASELINE	DT3DP1.1 L1 INTERM.	DT3DP1.1 L3 FIRO-MAR	DT3DP1.1 L3 RP-MAR
Watershed Conditions	Upper Watershed Runoff	Oct – Sep	*TAF/ year*	1,123	1,277	1,277	1,277	1,277
		Nov – Mar	*TAF/ season*	434	688	688	688	688
		Apr – Oct	*TAF/ season*	689	589	589	589	589
	Applied Demand	Agricultural Demand (Oct – Sep)	*TAF/ year*	800	854	854	854	854
	Water Available For Recharge	Available (Nov – Mar)	*TAF/ season*	--	--	90	119	151
		Applied (Nov – Mar)	*TAF/ season*	--	--	79 (88%)	111 (93%)	145 (96%)
Water Supply/ Groundwater (GW)	Δ GW Pumping	Oct – Sep	*TAF/ year*	466	499	499	501	506
	Δ GW Storage	Change in basinwide GW storage	*TAF/ year*	-50	-60	-35	-32	-15
	Δ GW Levels	Aquifer east of Corcoran Clay layer	*Feet/ year*	-0.6	-0.8	-0.2	-0.1	0.3
Water Supply/ Surface Water (SW)	Lake McClure Storage	End of October Storage	*Avg. TAF*	518	474	474	472	435
		# Years allocation ≤ 80%	*Years*	7	7	7	8	9
	Deliveries	Oct – Sep	*TAF/ year*	355	372	372	369	367
Flood Risk	Merced River Flood Conditions	100-year max simulated flow	*cfs*	6,004	42,412	40,552	15,660	8,774
		# Years with flows > 7300 cfs	*Years*	0	9	9	1	2

Key Study Messages

1. Study results communicate to different water sectors
2. Common hydrology and integrated modeling facilitate consistent exploration of effects and tradeoffs across all sectors
3. Study is designed to showcase, not optimize, the multi-sector benefits and outcomes
4. Adaptation strategies address both existing and future vulnerabilities
5. Study focuses on water physically available
6. Recharge schedule can be safely designed around the existing land uses and ag practices
7. Flood-MAR builds water supply resilience
8. Intentional recharge can help achieve different management objectives and benefits
9. Climate change will likely increase flood risk
10. Flood-MAR could help reduce flood risk and reservoir reoperations could provide the most flood risk reduction benefits

QUESTIONS?

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