INTEGRATING SURFACE WATER MANAGEMENT AND MANAGED AQUIFER RECHARGE: CASE STUDY FROM A USACE-OCWD PARTNERSHIP

Orange County Water District's Partnership with the USACE

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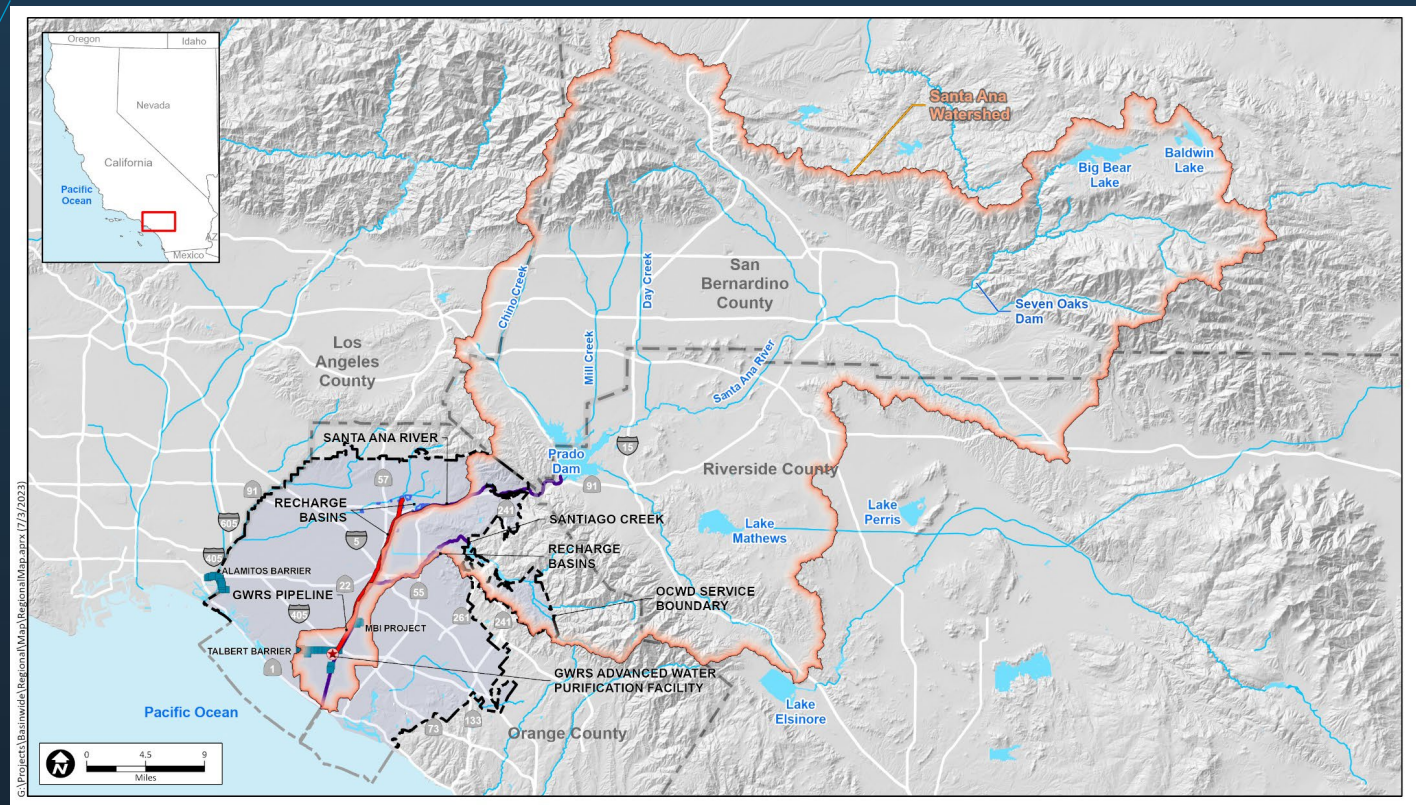
Recharge Planning Manager
Orange County Water District

The Orange County, CA groundwater basin lies at the base of the Santa Ana River watershed.



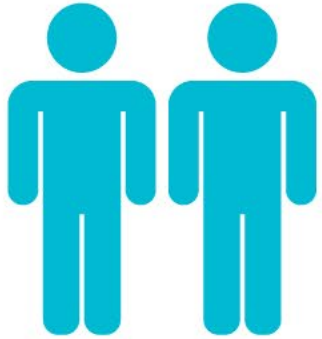
OCWD AT-A-GLANCE

Formed in **1933**

Groundwater Basin provides **85%** drinking water supply

Serve **19** cities and retail water districts in north & central OC

2.5 million people served



10 board members

Protect rights to Santa Ana River water

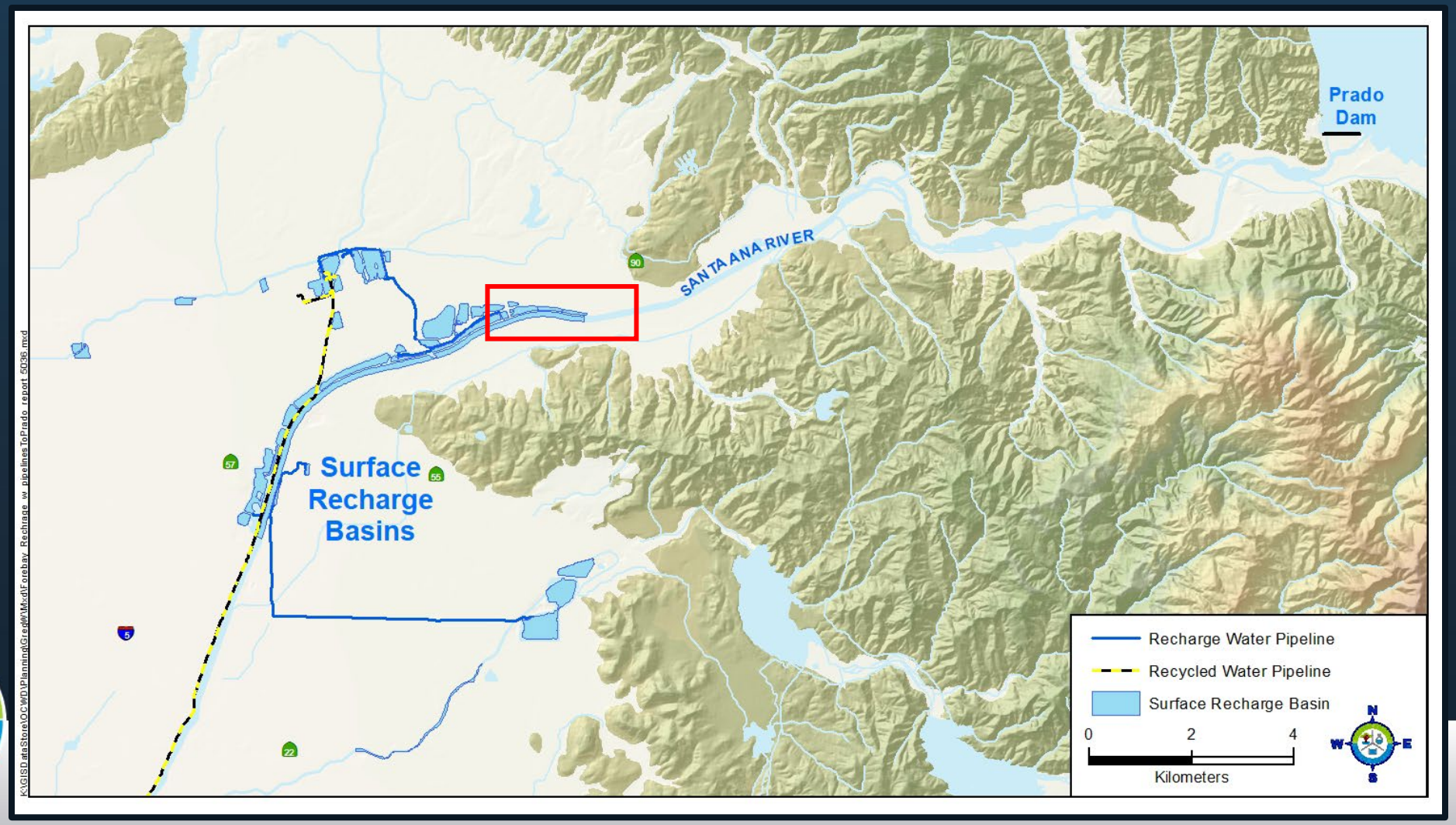
Prado Dam was constructed in 1941 to protect Orange County from flooding.

Dry most of the year.

Semi-arid region.
Avg Rainfall in OC: 14”/yr

Large riparian forest has developed behind the dam.

Since its formation in 1933, OCWD has constructed more than two dozen recharge facilities on over 1,500 acres.



First Purchase: 1936 - $27/acre

Last Purchase, 2013- $1.6M/acre

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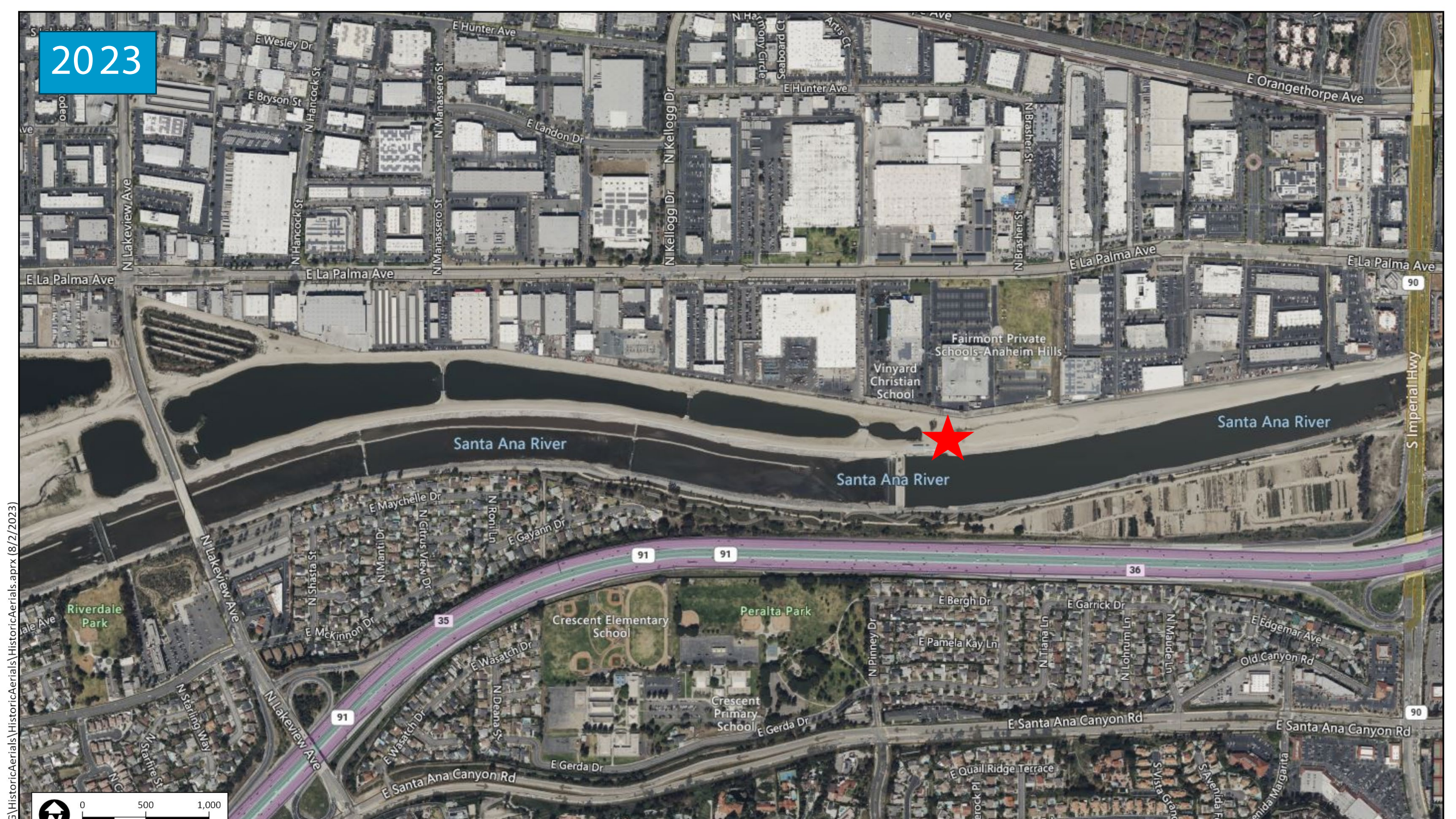

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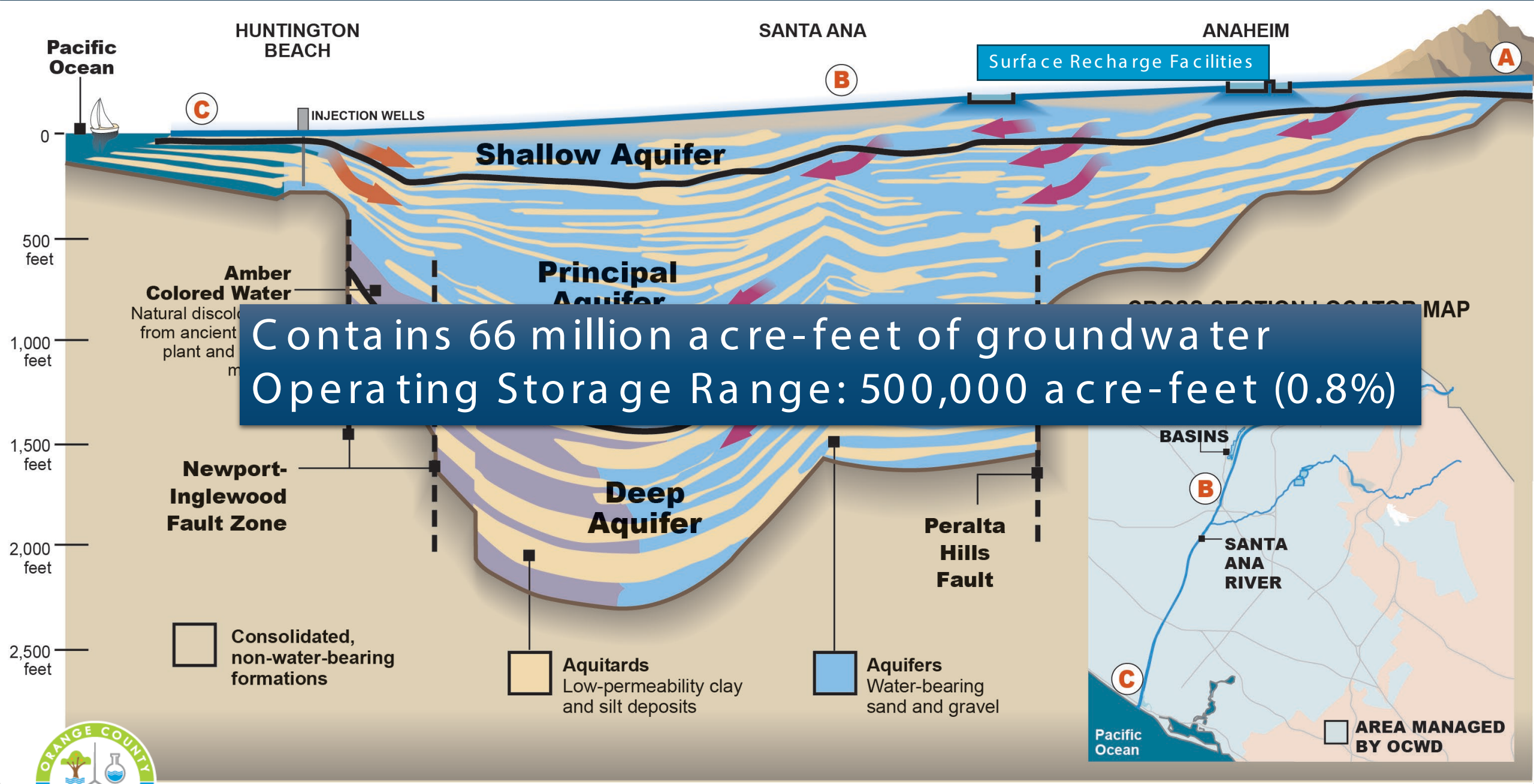


OC Groundwater Basin

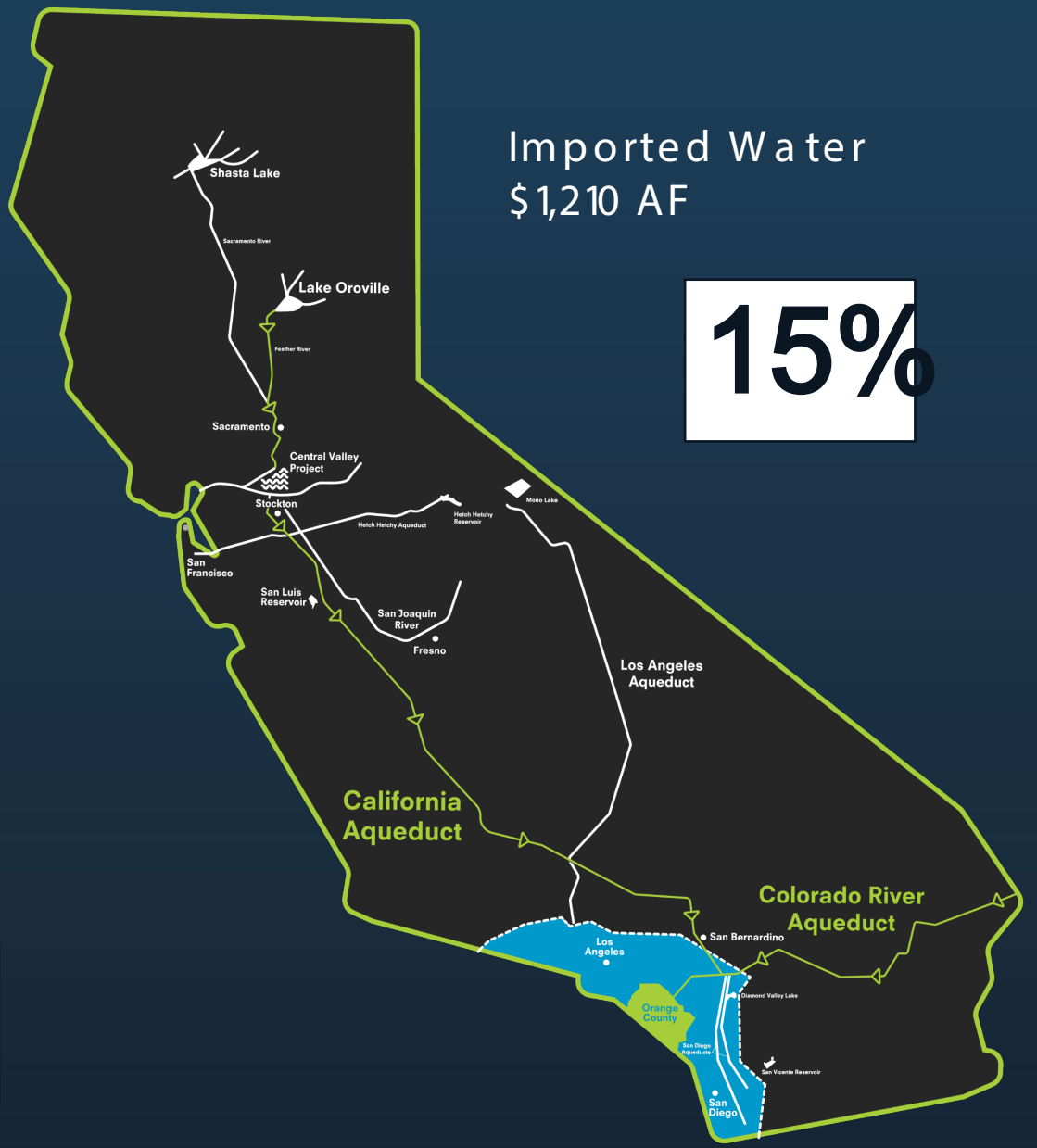
Why Managed Aquifer Recharge?

- Supply side-approach: Let's maximize what we have
  - Capture and recharge river water: base flow and storm flow
  - Purchase and recharge imported water
  - Protect the basin from seawater intrusion and replenish the basin
  - Recycle water
- Store water in the basin to get through drought periods
- Makes financial sense: Imported water is expensive alternative

Where does OC's water come from?

Groundwater
$650 AF

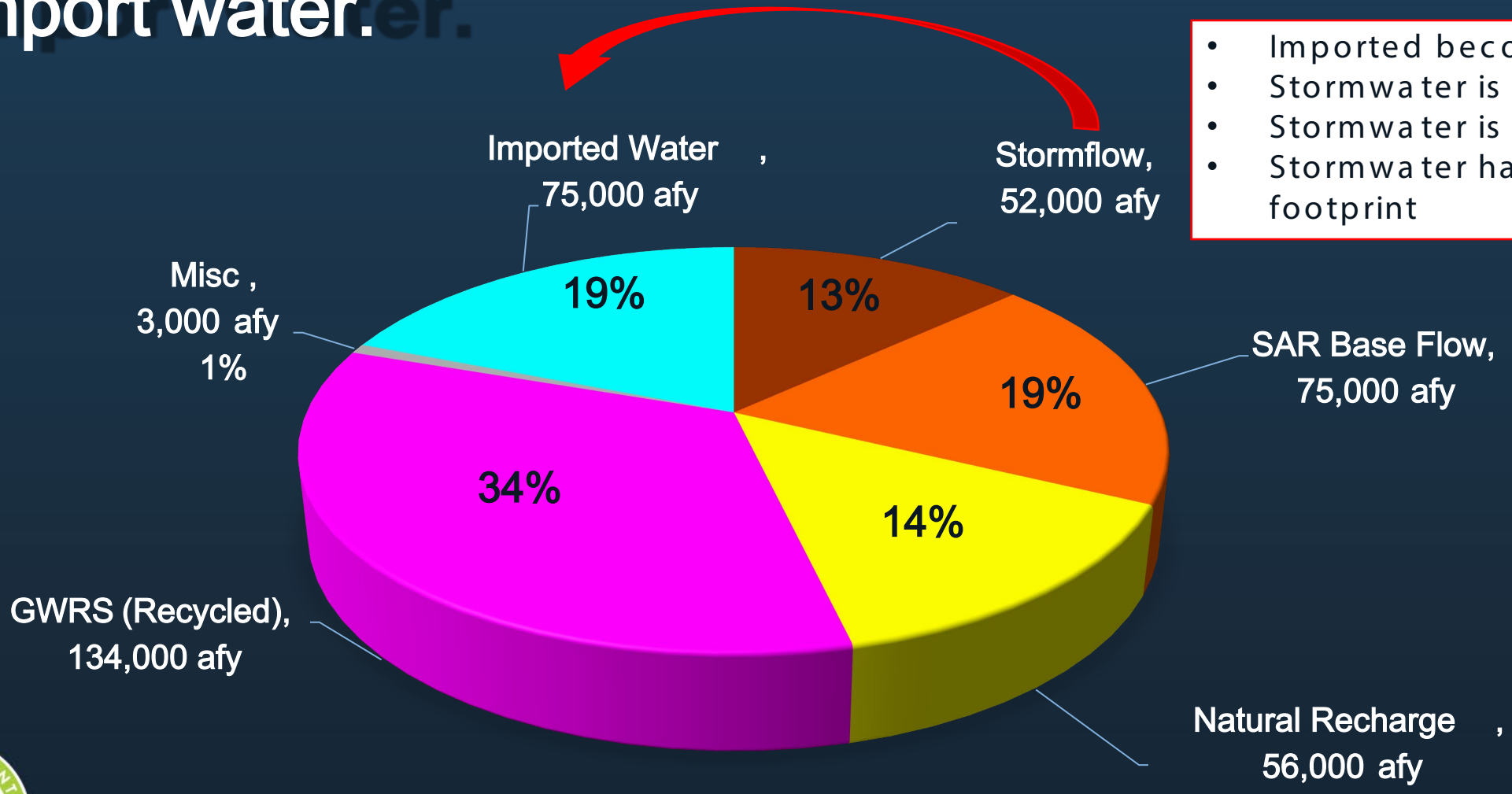
85%



Imported Water
$1,210 AF

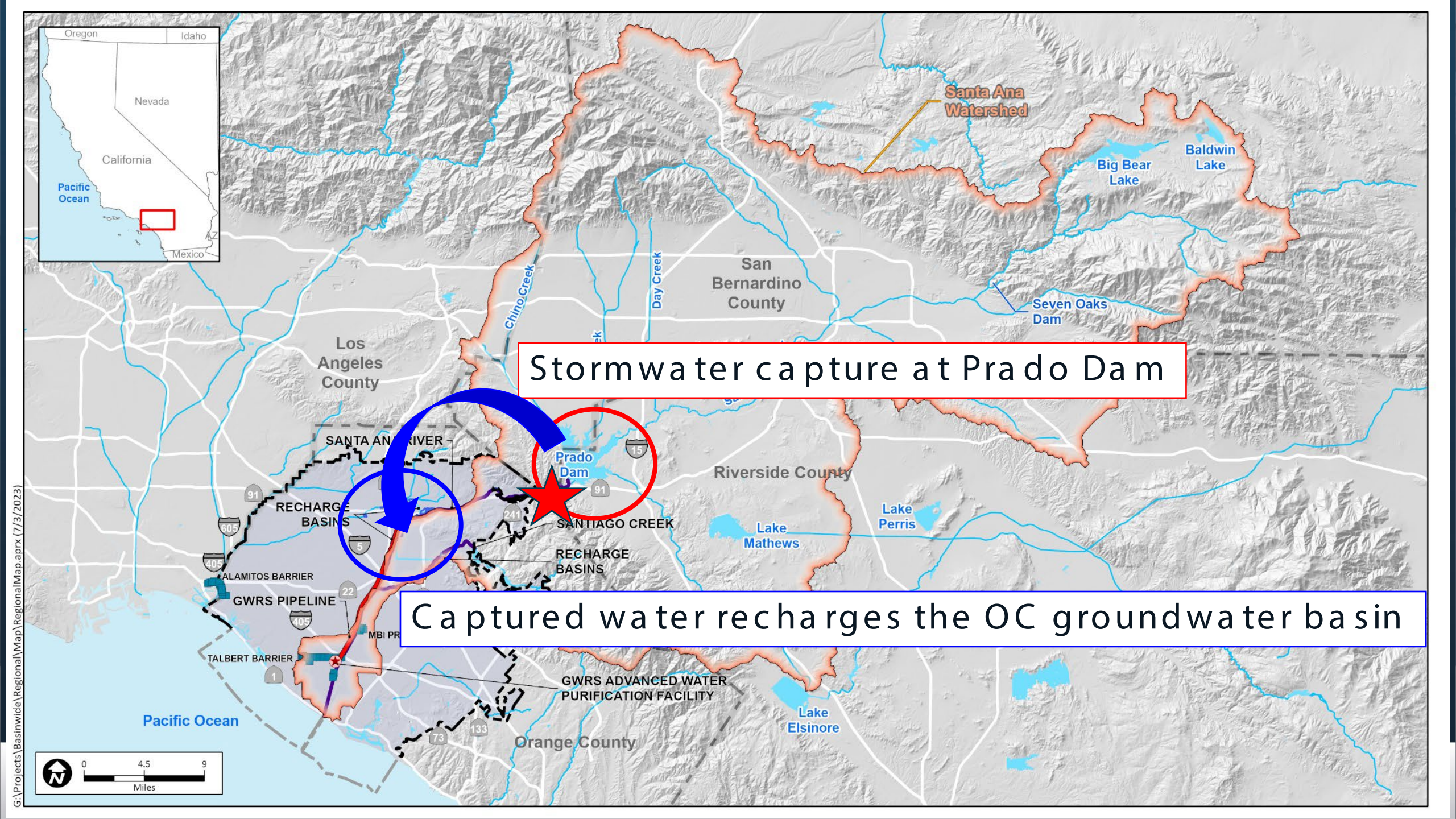
15%

Each acre - feet of storm water captured and recharged directly offsets the need to import water.



- Imported becoming less reliable
- Stormwater is local supply
- Stormwater is less expensive
- Stormwater has lower carbon footprint

Avg OCWD Service Area Water Demands: 395,000 afy


Oregon
Idaho
Nevada
California
Pacific Ocean
AZ
Mexico
Santa Ana Watershed
Big Bear Lake
Baldwin Lake
Seven Oaks Dam
San Bernardino County
Chino Creek
Day Creek
Los Angeles County
Stormwater capture at Prado Dam
SANTA ANA RIVER
Prado Dam
Riverside County
RECHARGE BASINS
SANTIAGO CREEK
Lake Mathews
Lake Perris
RECHARGE BASINS
ALAMITOS BARRIER
GWRS PIPELINE
Captured water recharges the OC groundwater basin
MBI PR
TALBERT BARRIER
GWRS ADVANCED WATER PURIFICATION FACILITY
Pacific Ocean
Lake Elsinore
Orange County
0
4.5
9
Miles
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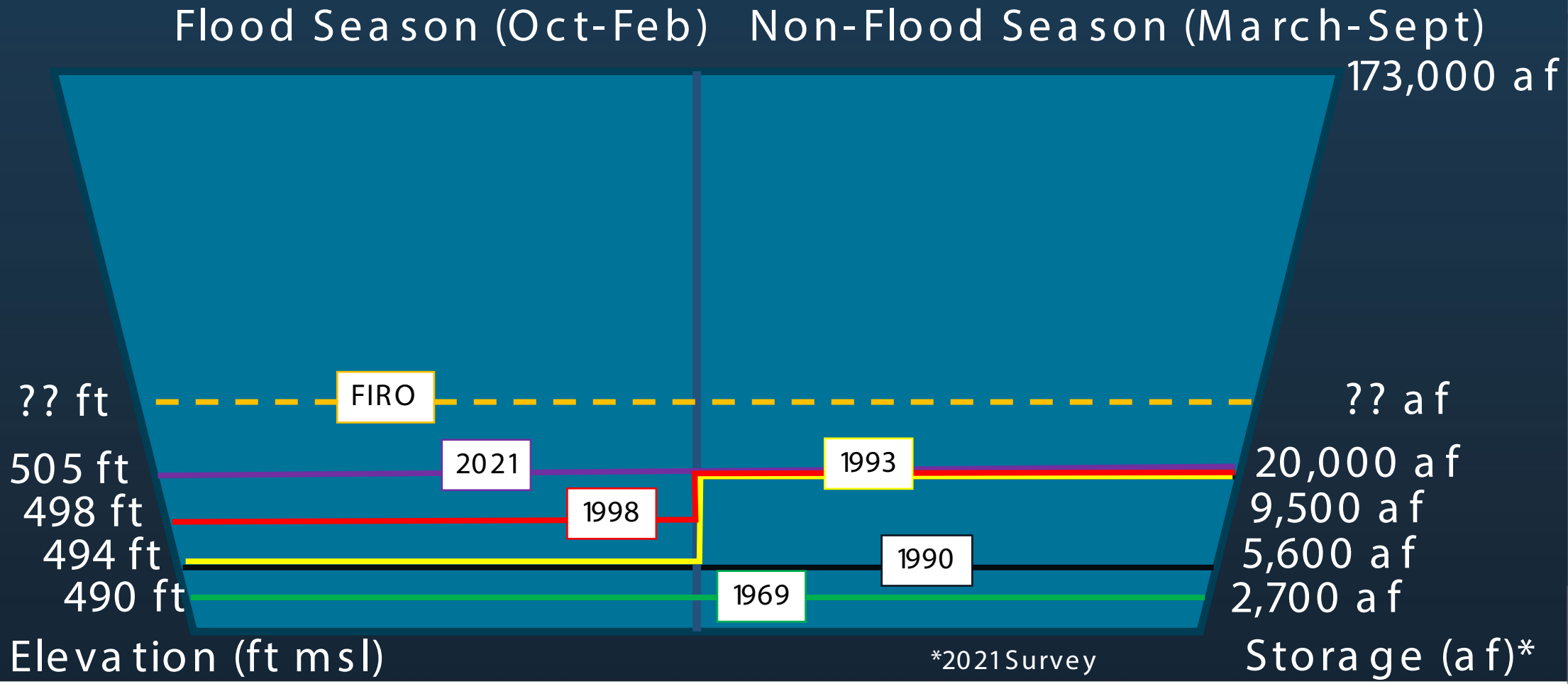
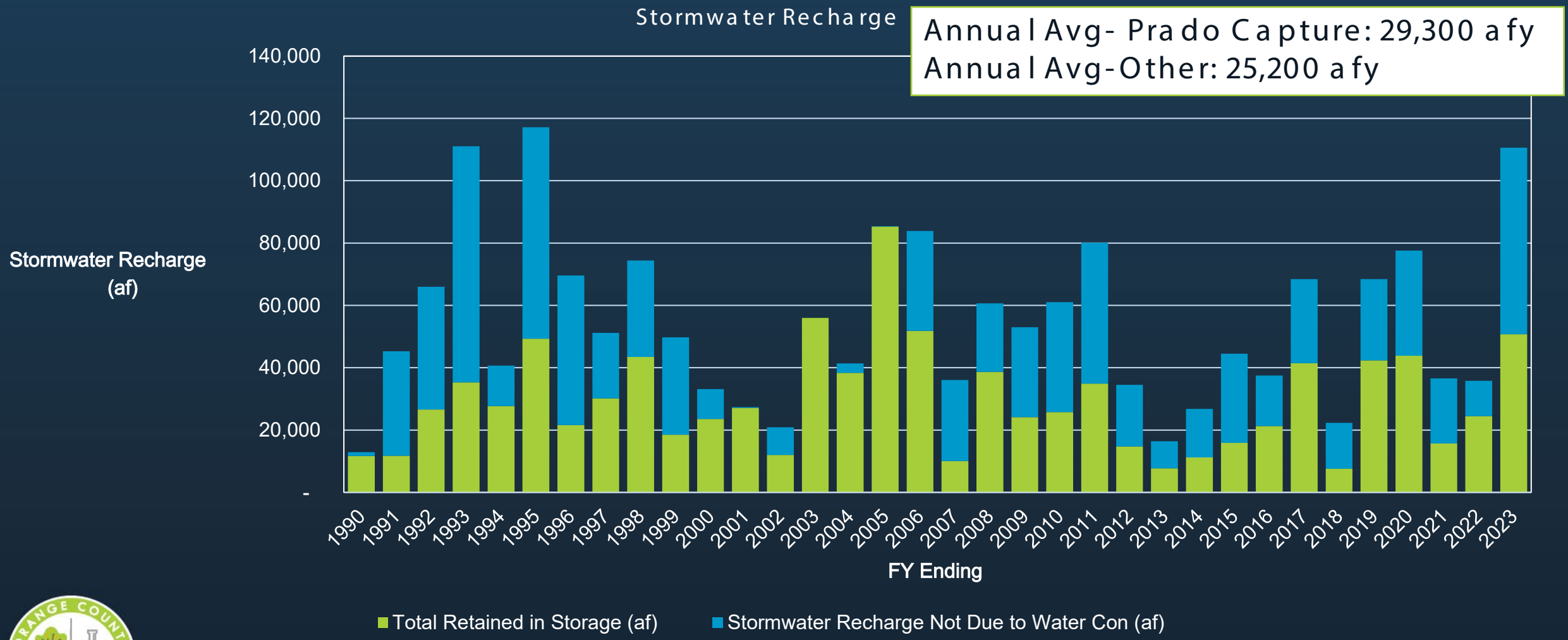
Over the years, OCWD and the USACE have worked to increase water conservation at Prado Dam.



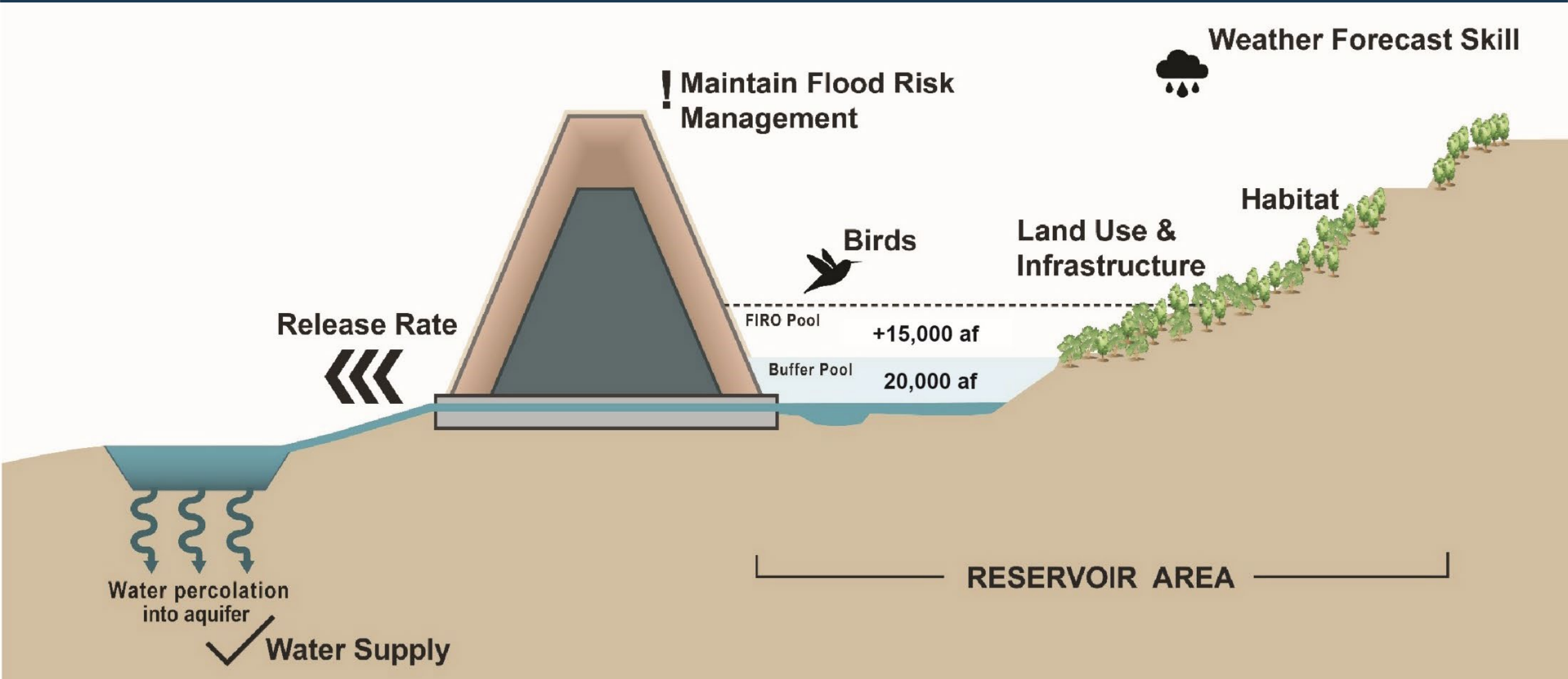
On average, 54 % of stormwater recharge is captured at Prado Dam.



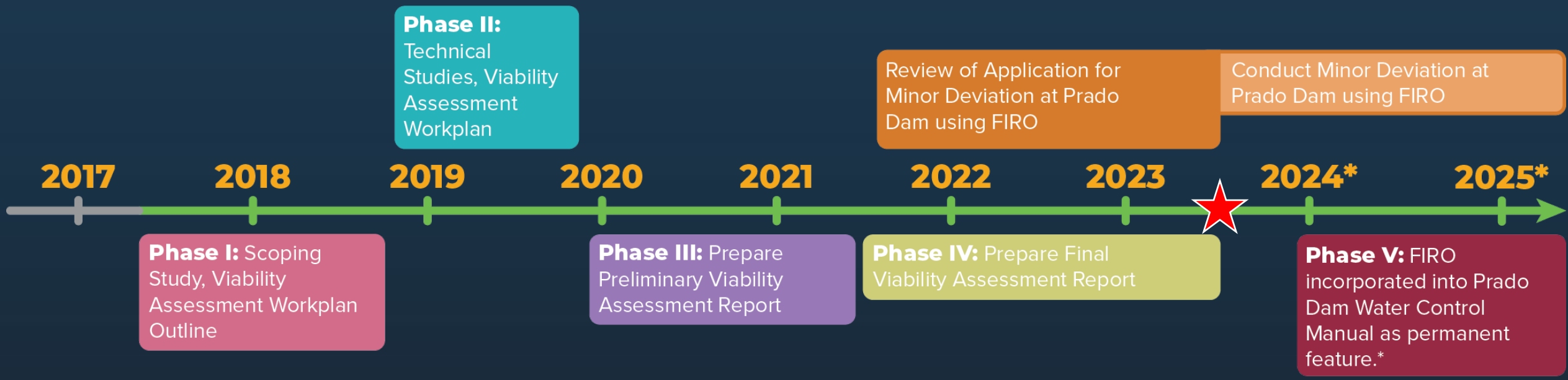
Forecast Informed Reservoir Operations (FIRO)

- Using enhanced weather forecasting and runoff estimation tools to inform future reservoir operations
- Includes growing understanding of atmospheric river (AR) storms
- **Objective:** Simultaneously optimize flood risk management, water conservation and environmental benefits
  - Without pouring a yard of concrete!

It's complicated!



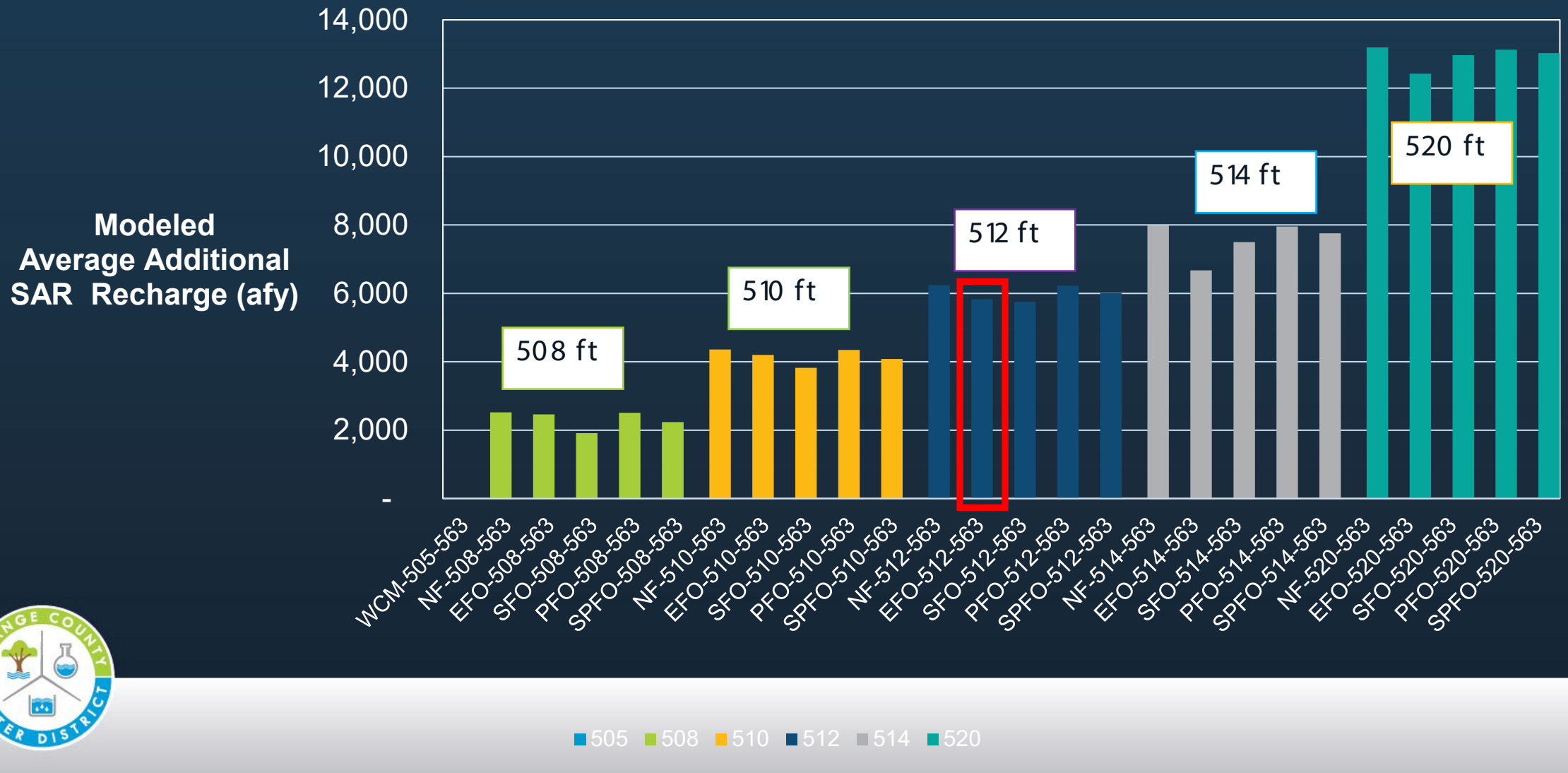
A stakeholder driven multi-phase Viability Assessment Process was used at Prado Dam (Second Pilot Location).



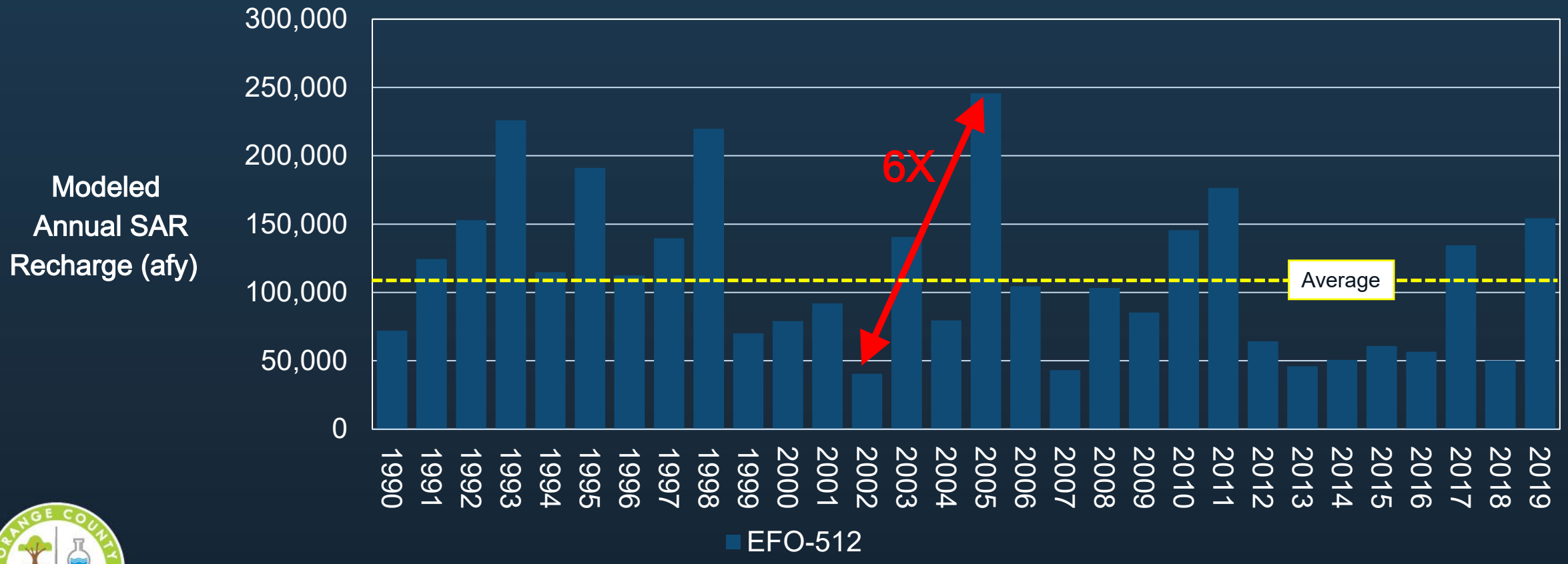
*Timeline dependent on hydrology and completion of the Santa Ana River Mainstem Project

Center for Western Weather and Water Extremes
SCRIPPS INSTITUTION OF OCEANOGRAPHY AT UC SAN DIEGO

The Prado Dam FIRO Final Viability Assessment shows great potential for additional storm water recharge.

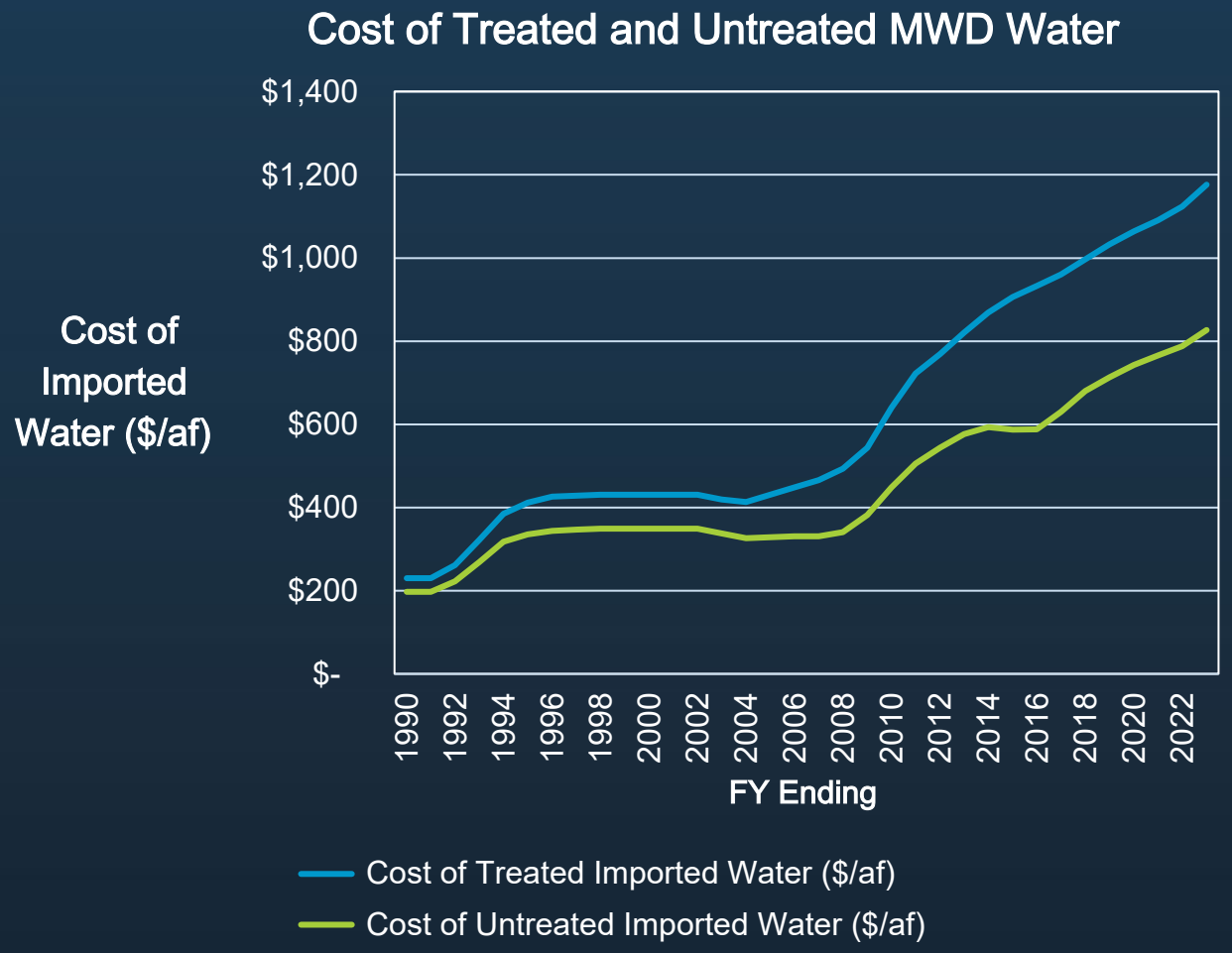


Prado Dam and FIRO are critical to capture storm water in a changing climate with most rainfall predicted to fall within a shorter window.

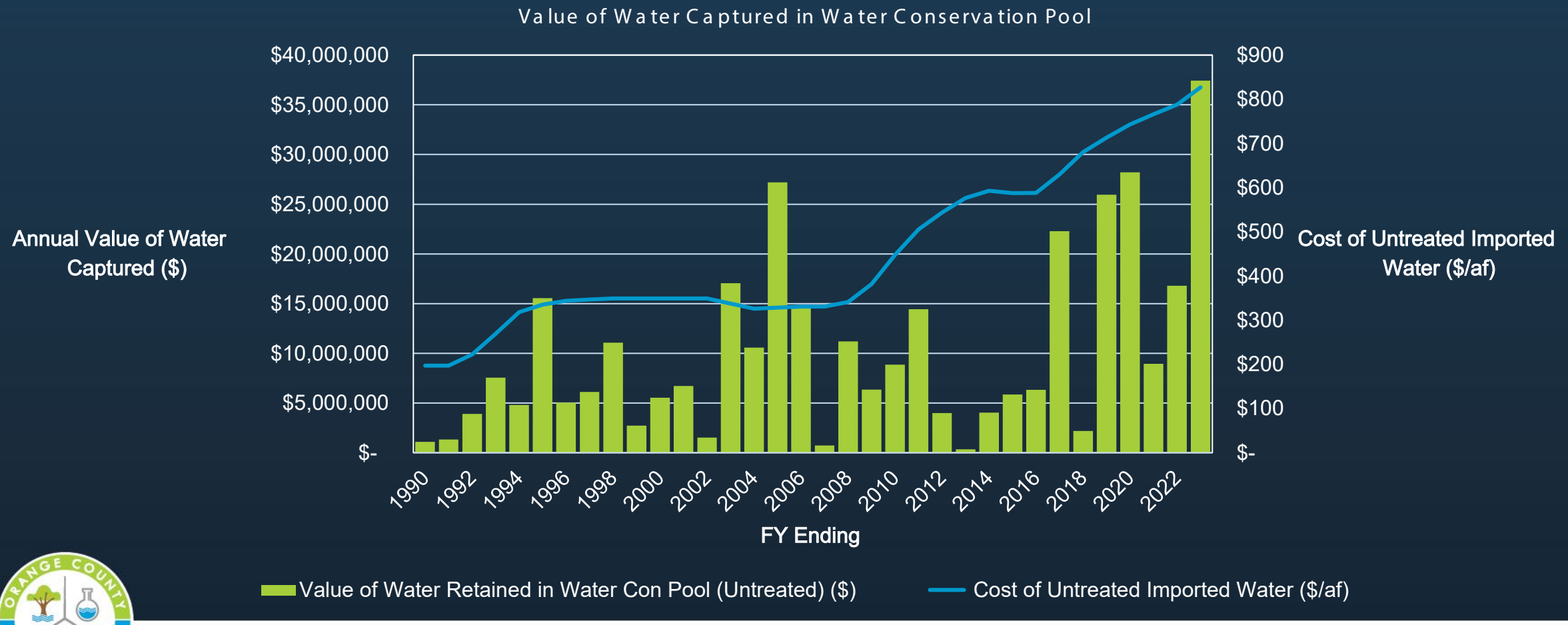


Value of Water Retained in Water Conservation Pool

- Water retained in Water Conservation Pool offsets imported water purchases
- Value based on historical MWD water rates



Since 1990, the total value of water captured is $341M using cost of untreated imported water.

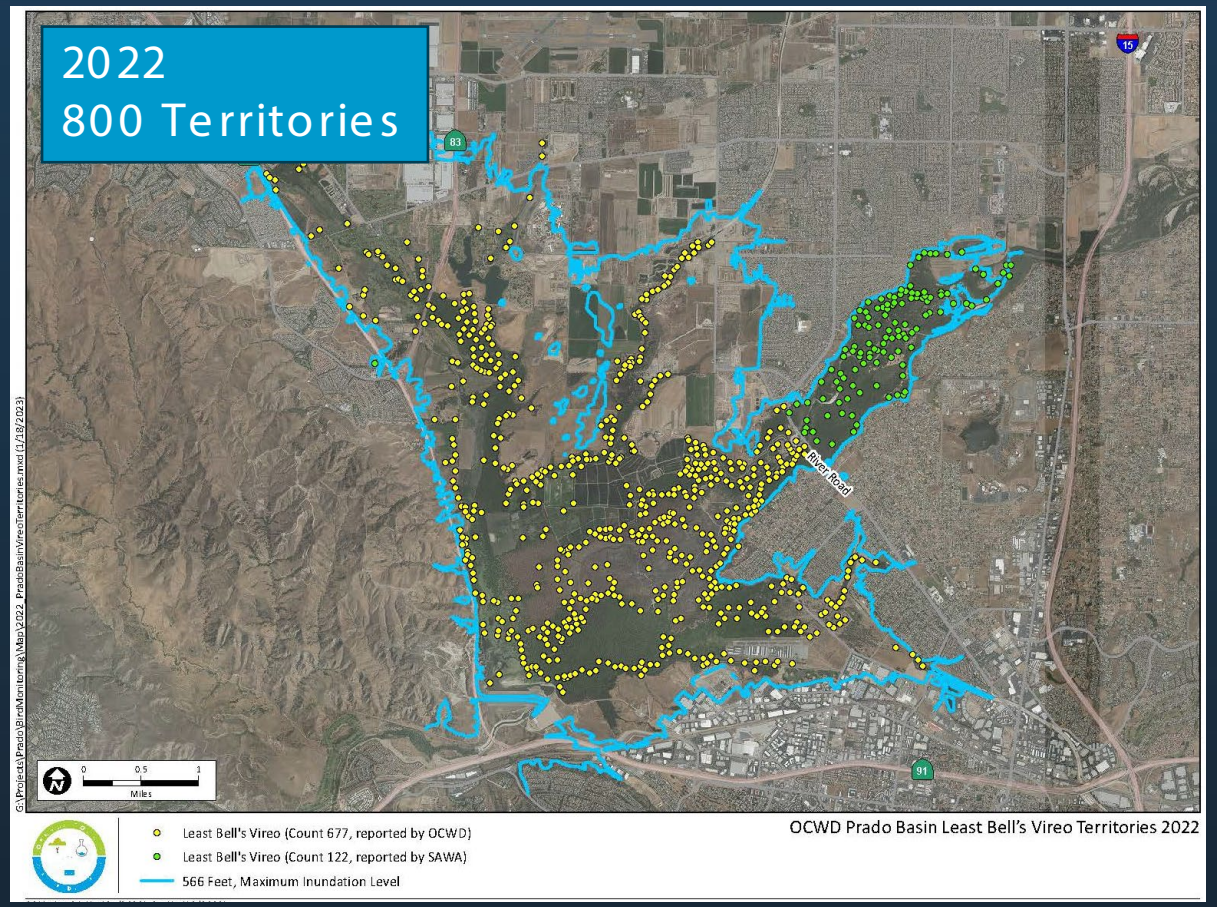


FIRO also benefits the habitat behind Prado Dam.

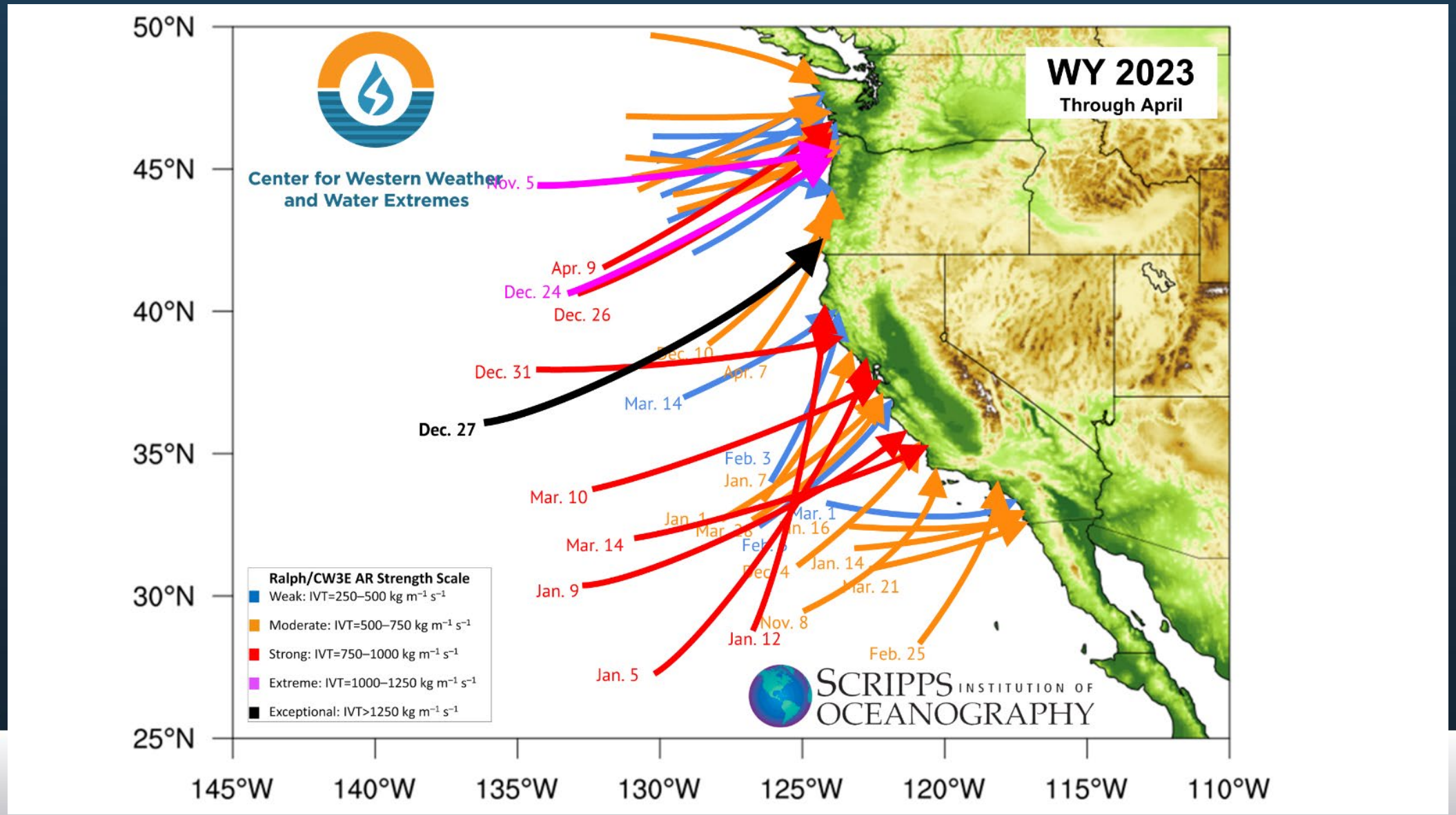
Endangered Least Bells Vireo

- Largest riparian forest in southern California
- FIRO provides additional water that will buffer a hotter/dryer future
- Least Bells Vireo is key species
- Habitat is a carbon sink that reduces OCWD's carbon footprint

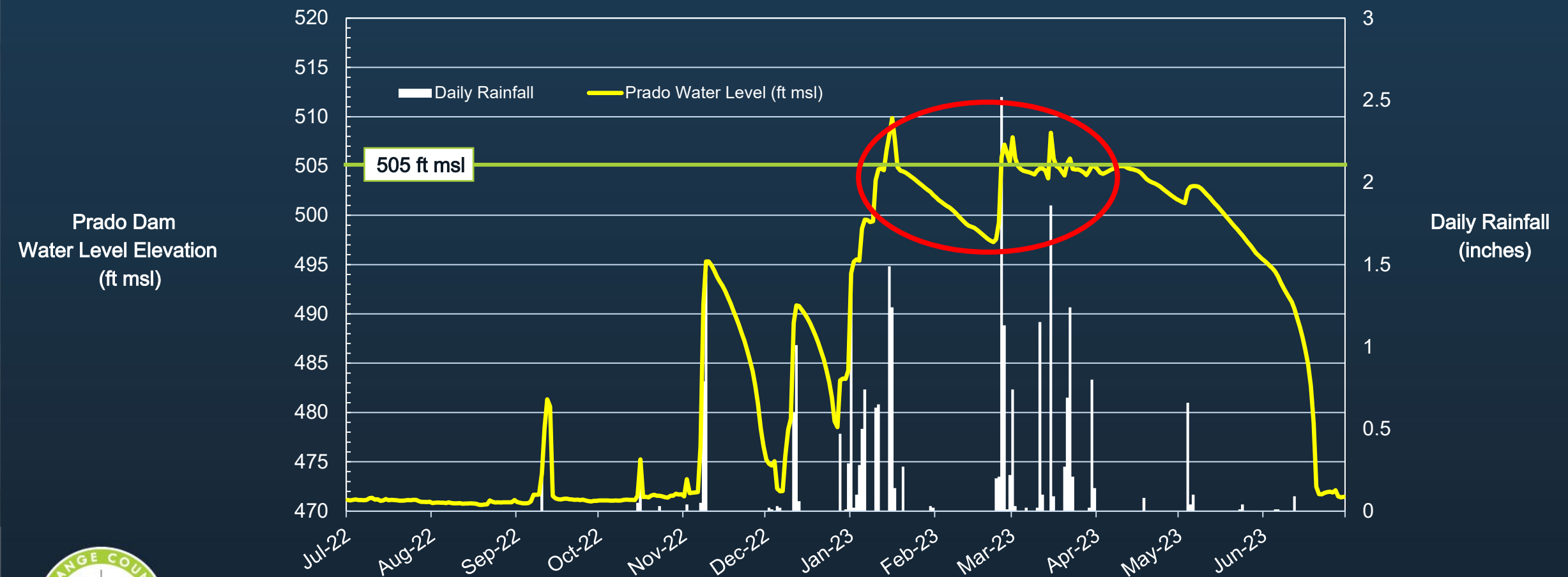
Successful Recovery of the Federally Endangered Least Bell's Vireo



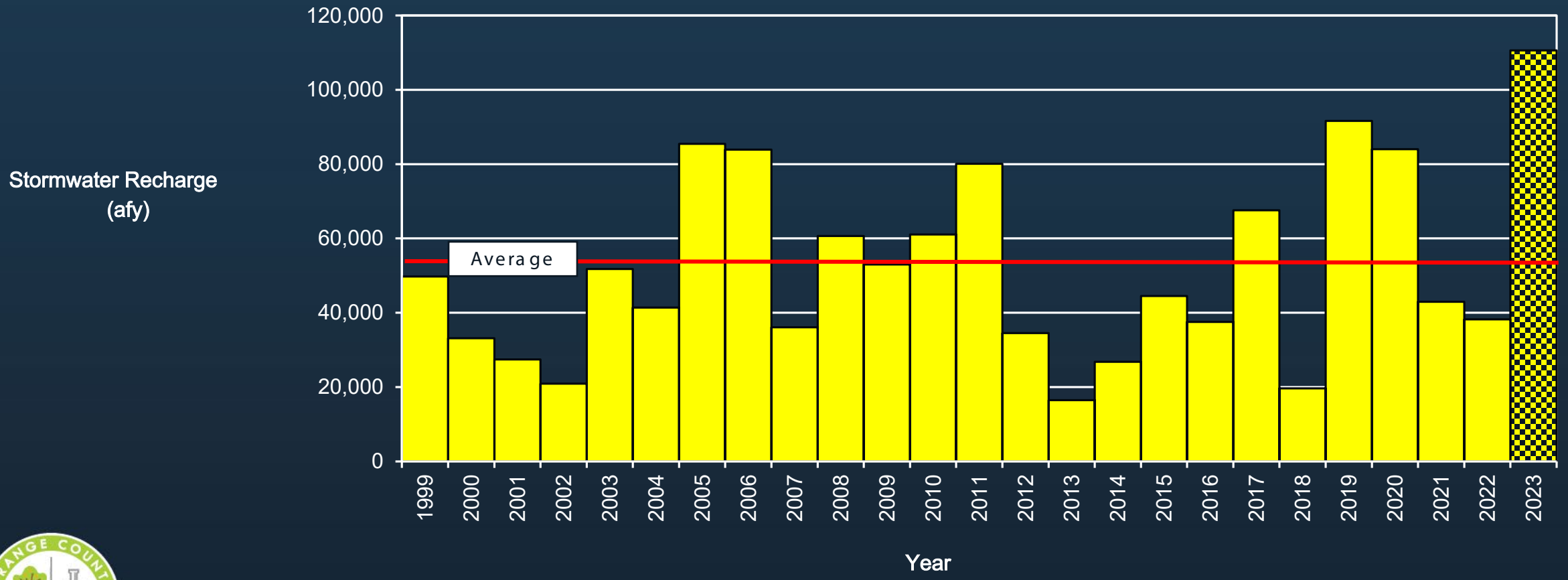
Multiple atmospheric rivers hit the SAR watershed in winter 2023.



Having multiple storms spaced out from November to May was ideal.



Stormwater recharge in 2023 was 200 % of average due to the spacing of the storms and other factors.



OCWD's Collaboration with the USACE has been crucial to sustainable groundwater basin management.

- Managed aquifer recharge is central to OC Basin management
- Prado Dam provides the best opportunity to increase storm water capture and recharge
- FIRO represents the next wave of innovation to adapt existing infrastructure to a changing climate
- The USACE is assessing the potential of using FIRO at other dams throughout the USA over the next few years

For additional information, visit the Center for Western Weather and Water Extremes website.

- CW3E.UCSD.EDU

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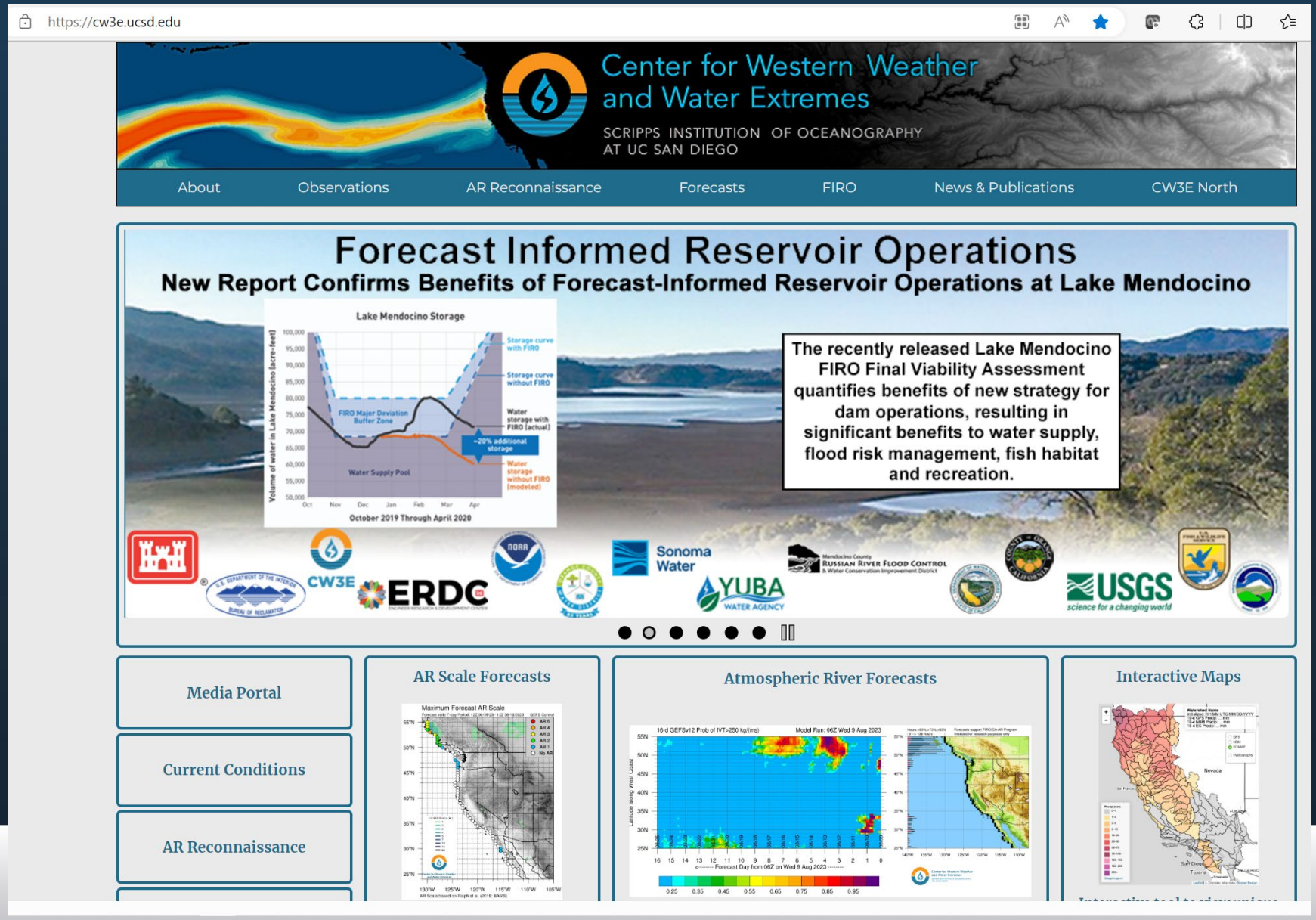
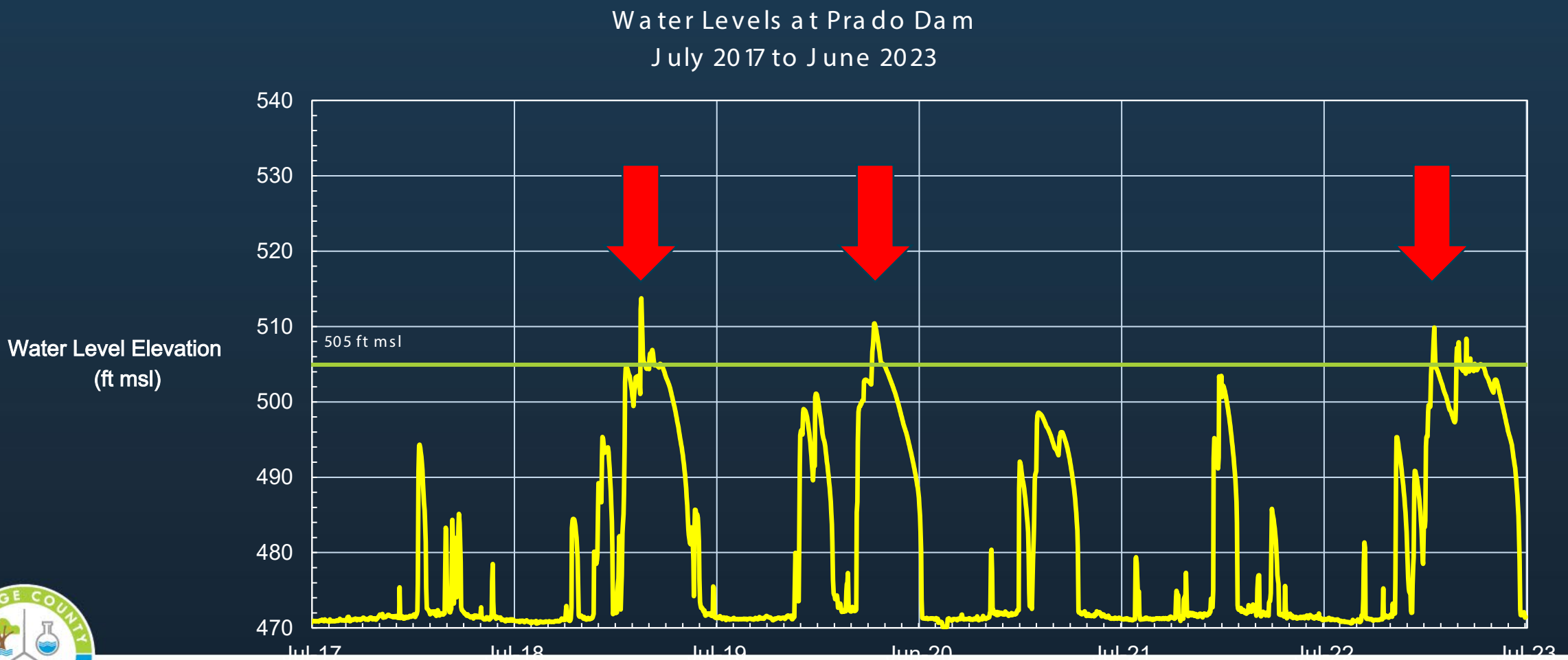
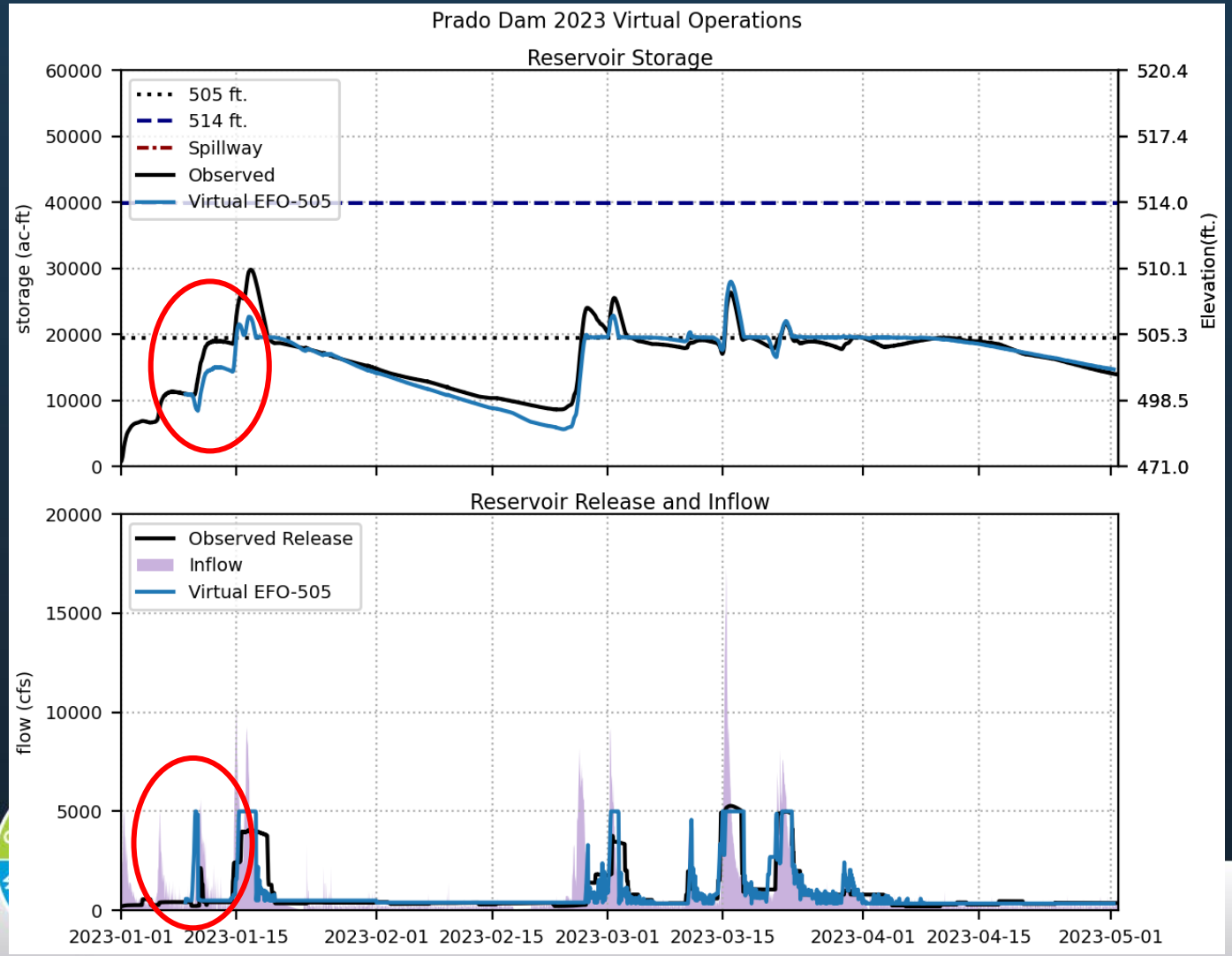


End of Presentation

FIRO will allow us to capture more water in the wet years, which occur 50 percent of the time.



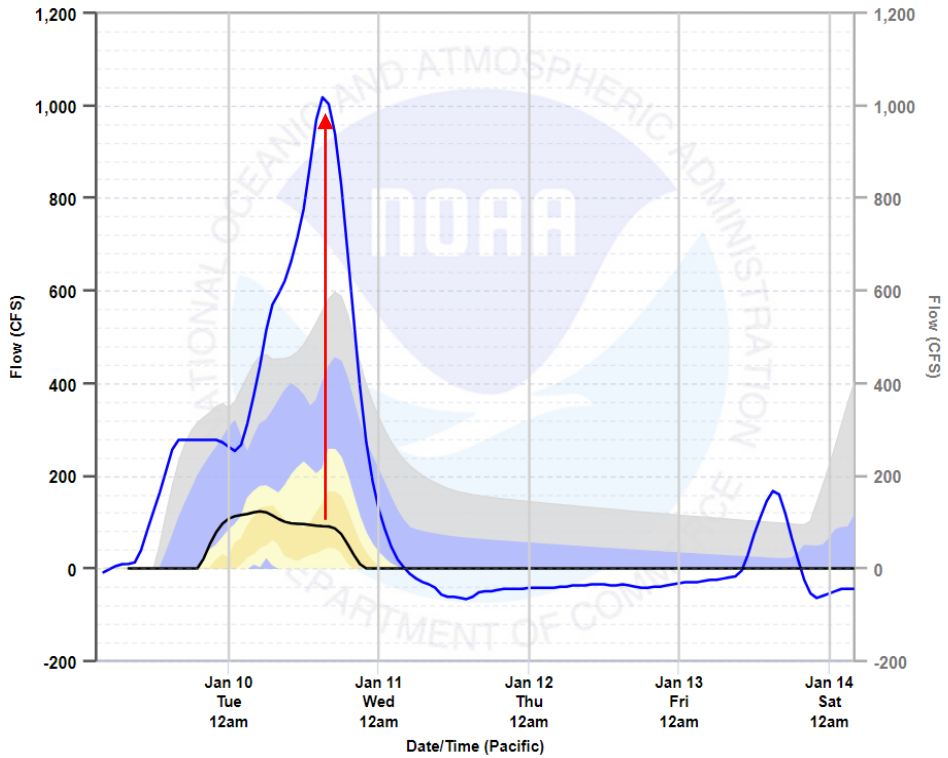
A FIRO virtual operations model was developed and tested (Think AI for FIRO).



- Model managed reservoir using forecasted inflow
- Actual operations compared well with simulated
- 1 false alarm in January

Hourly Flow Probabilities
HANSEN DAM (HANC1)

Created: 1/9/2023 at 9:00 AM Pacific Time



Chance of Peak Flow Exceedance (CFS)

Forecast Period:
01/09/2023 4 am - 01/14/2023 4 am

2%	596
5%	545
10%	447
25%	306
50%	179
75%	49
90%	0
95%	0
98%	0

Custom Thresholds

Show: 5 Days | 10 Days

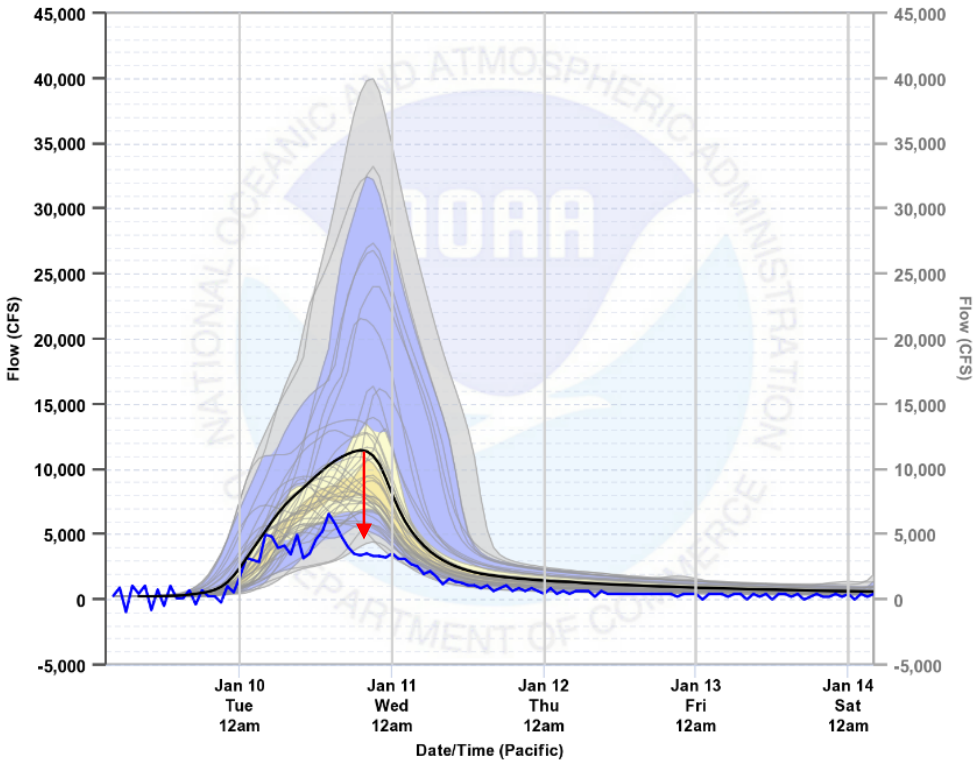
Export Image

Export Chart Data (CSV)

- [x] Observed
- [x] Official Forecast (Deterministic)
- [ ] Ensemble Mean
- [ ] Model Traces
- [x] Hourly Probabilities
  - 0-5% chance
  - 5-25% chance
  - 25-40% chance
  - 40-60% chance

Hourly Flow Probabilities
SANTA ANA RIVER - PRADO RESERVOIR (ADOC1)

Created: 1/9/2023 at 9:00 AM Pacific Time



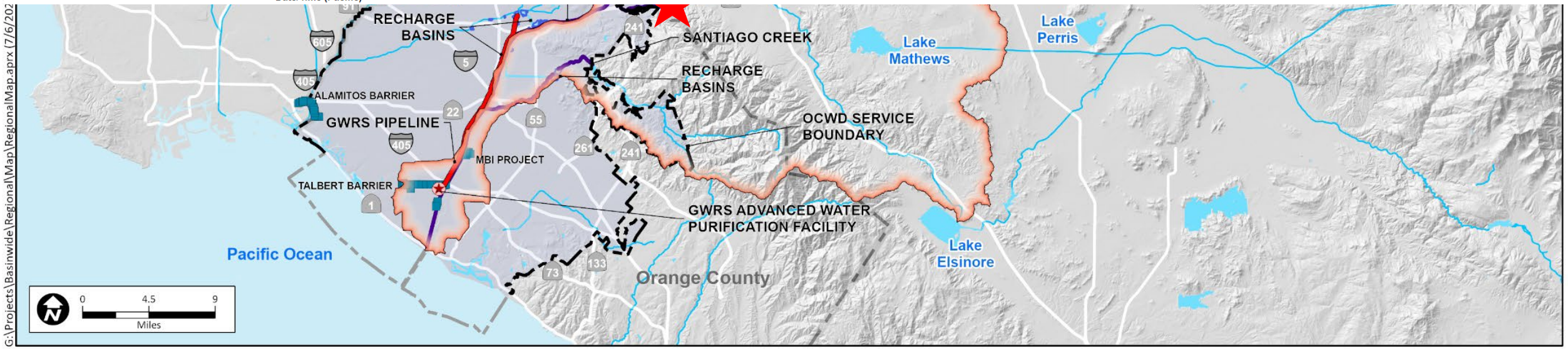
Chance of Peak Flow Exceedance (CFS)

Forecast Period:
01/09/2023 4 am - 01/14/2023 4 am

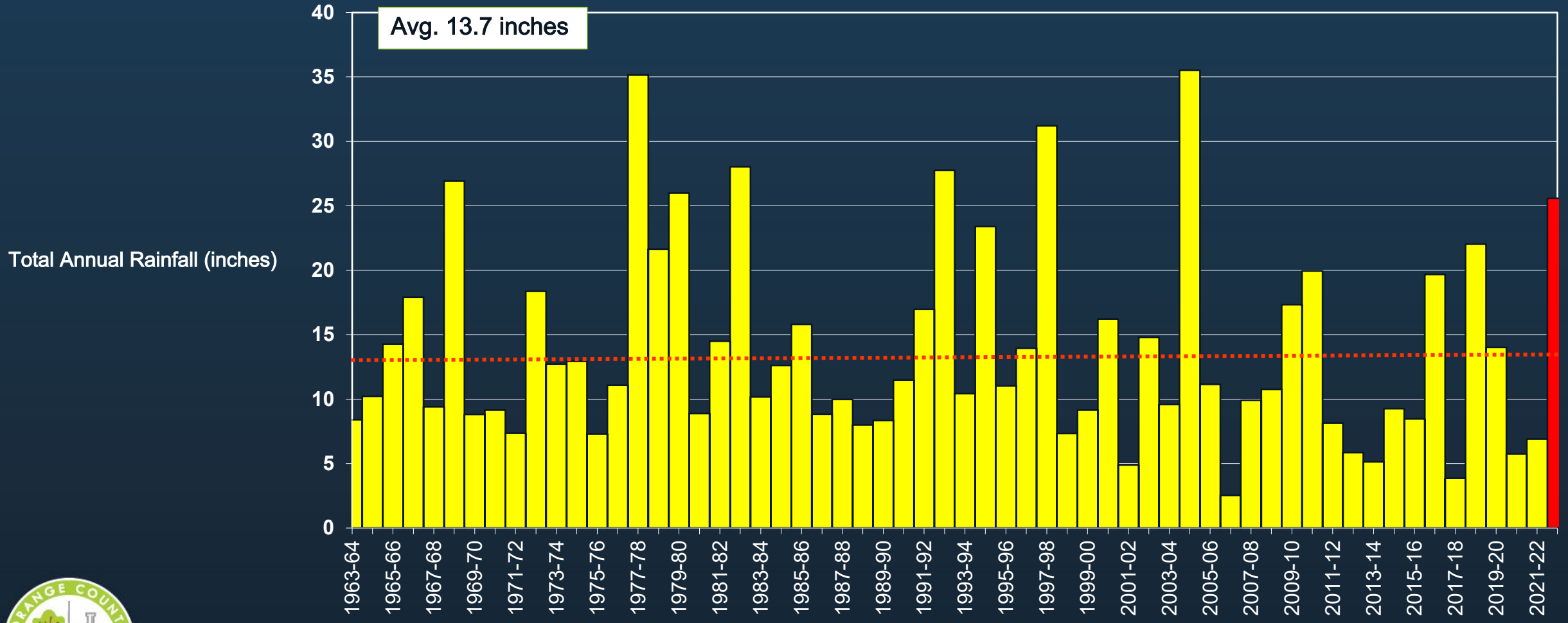
2%	39,951
5%	33,089
10%	27,154
25%	13,826
50%	9,426
75%	7,366
90%	5,875
95%	5,716
98%	4,405

- Observed
- Official Forecast (Deterministic)
- Ensemble Mean
- Model Traces

Hourly Probabilities
- 0-5% chance
- 5-25% chance
- 25-40% chance
- 40-60% chance



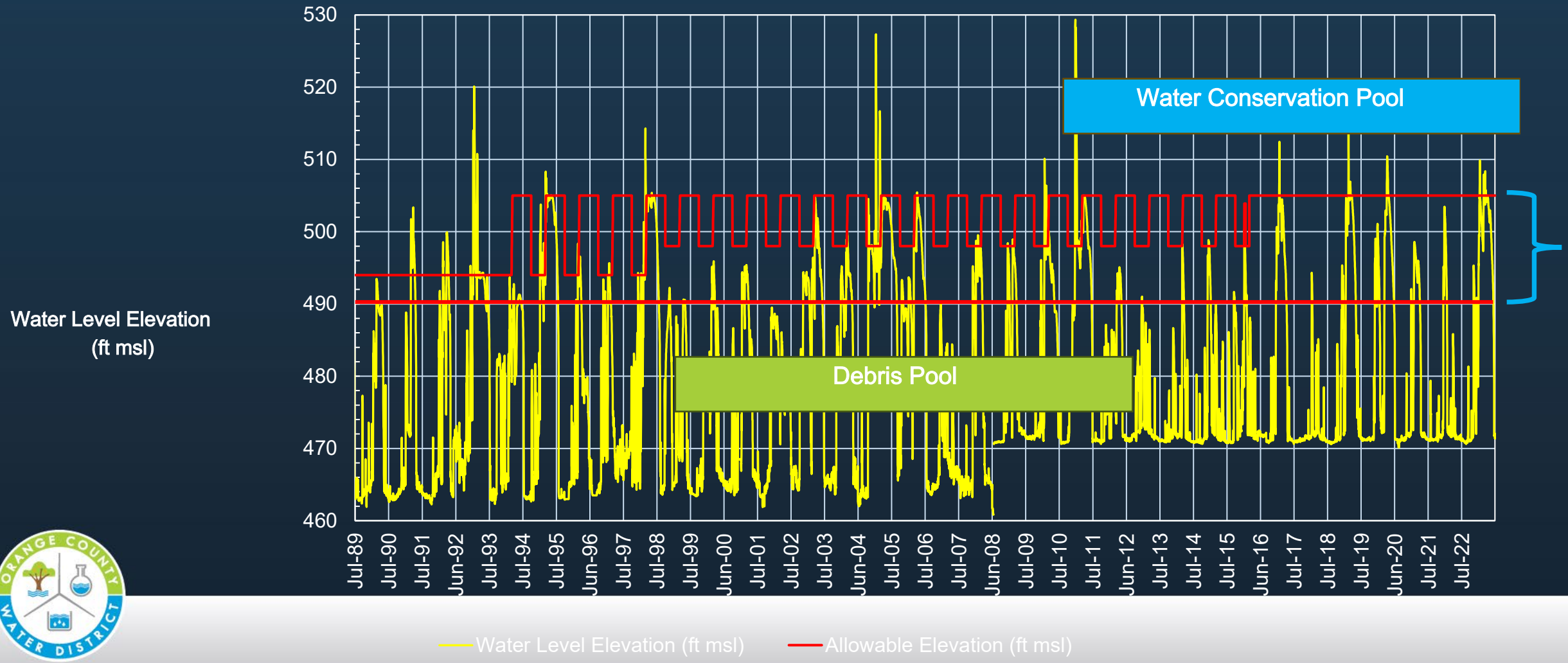
25.6 inches of rain was measured at OCWD's Anaheim Field Office, which is 187% of average.



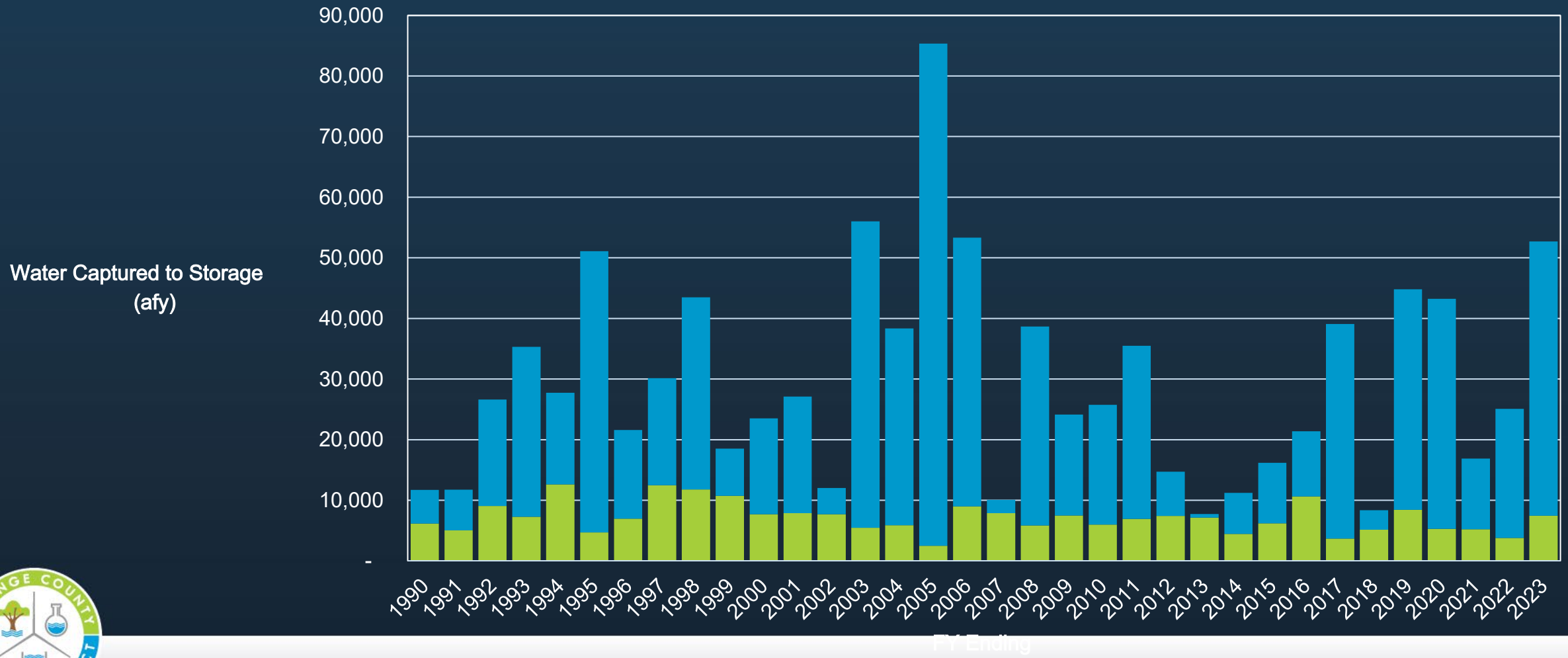

Warner, Conrock, Foster - Huckleberry, SAR, Off - River (~4,800 af)
April 2023

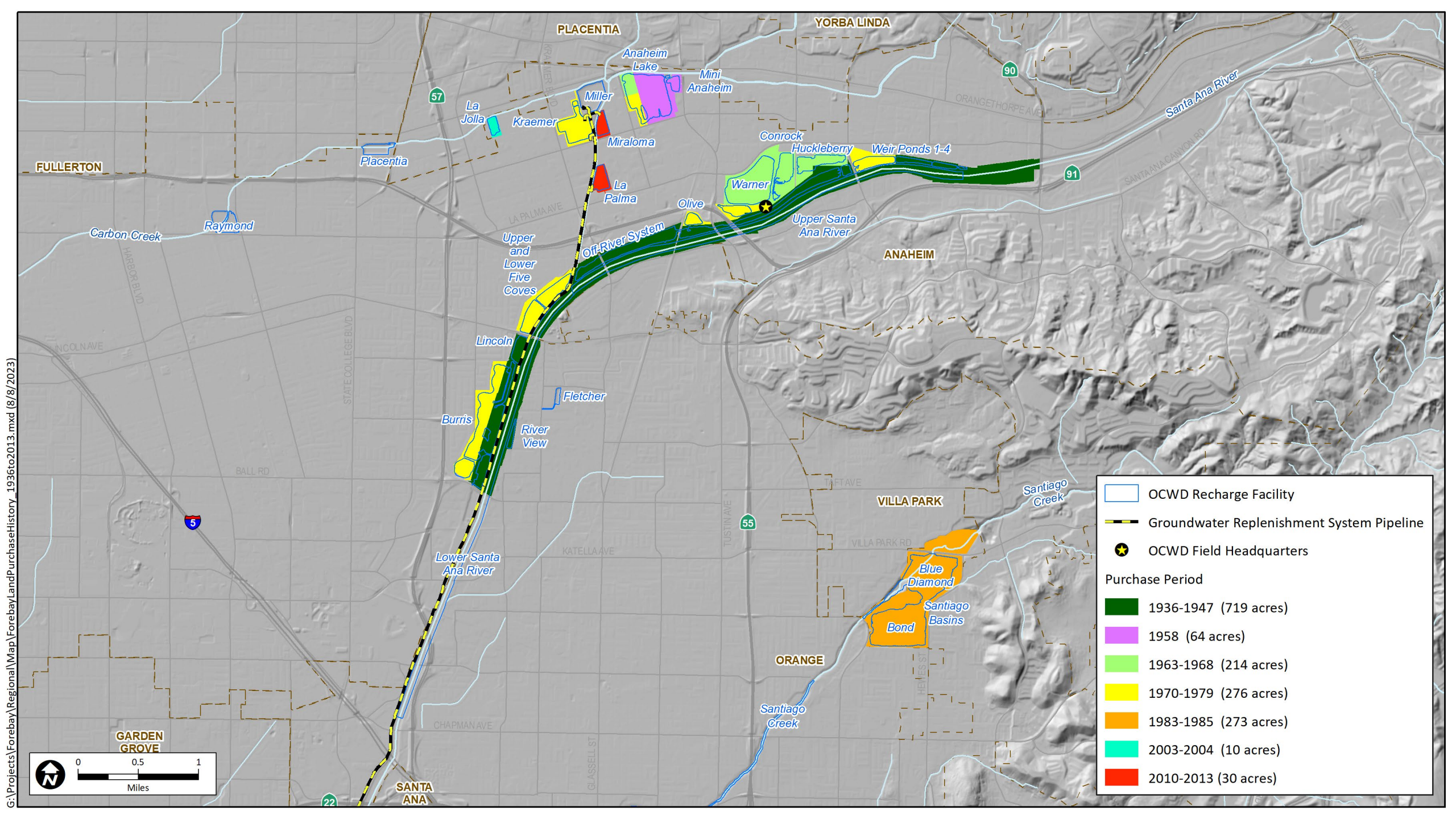
Anaheim, Miraloma, Kraemer, Miller (~3,800 af)

Prado Water Level and Water Conservation Pool Elevations: 1988 -2023



Water Retained in Water Conservation Pool ranges from 600 to 83,000 afy.





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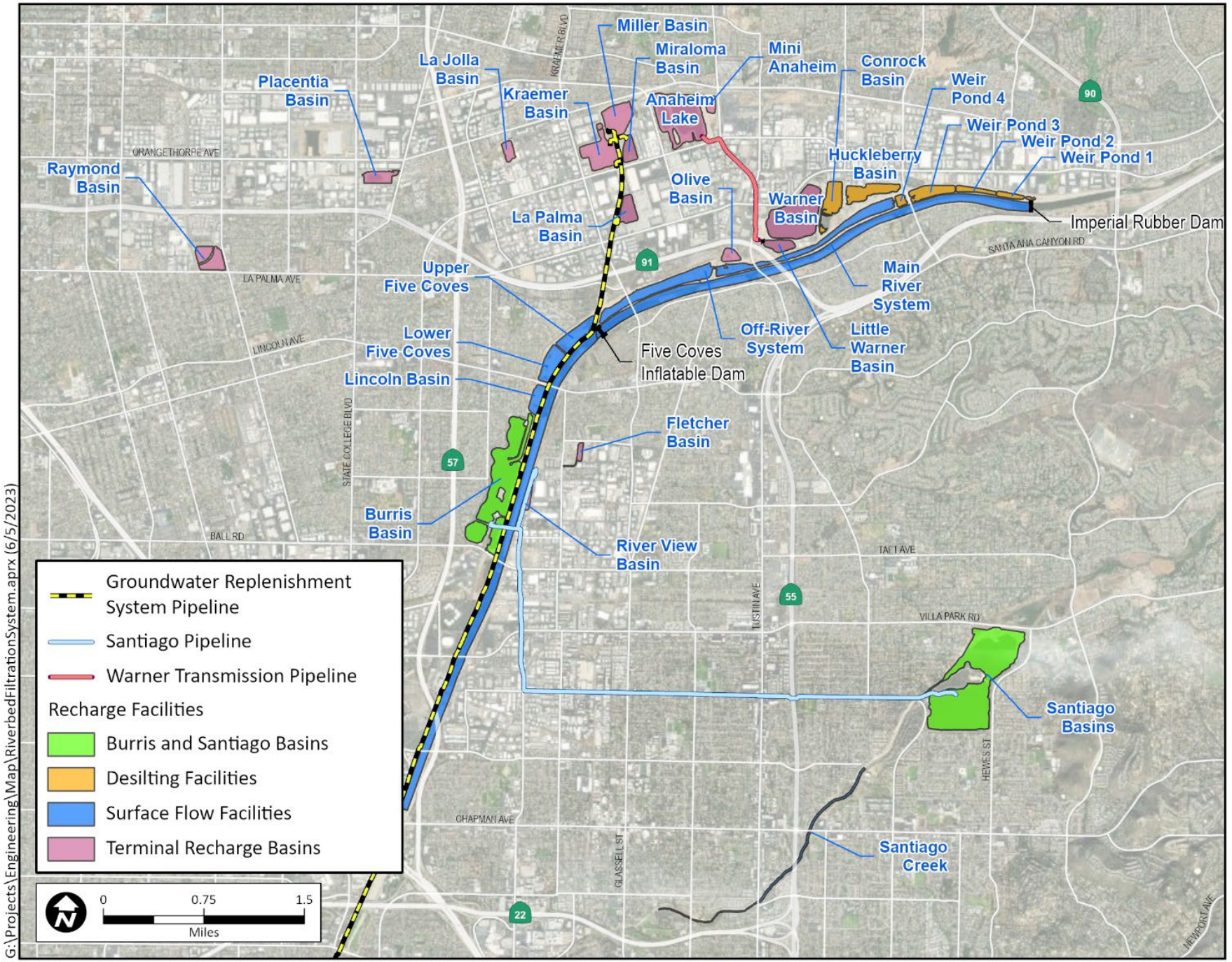


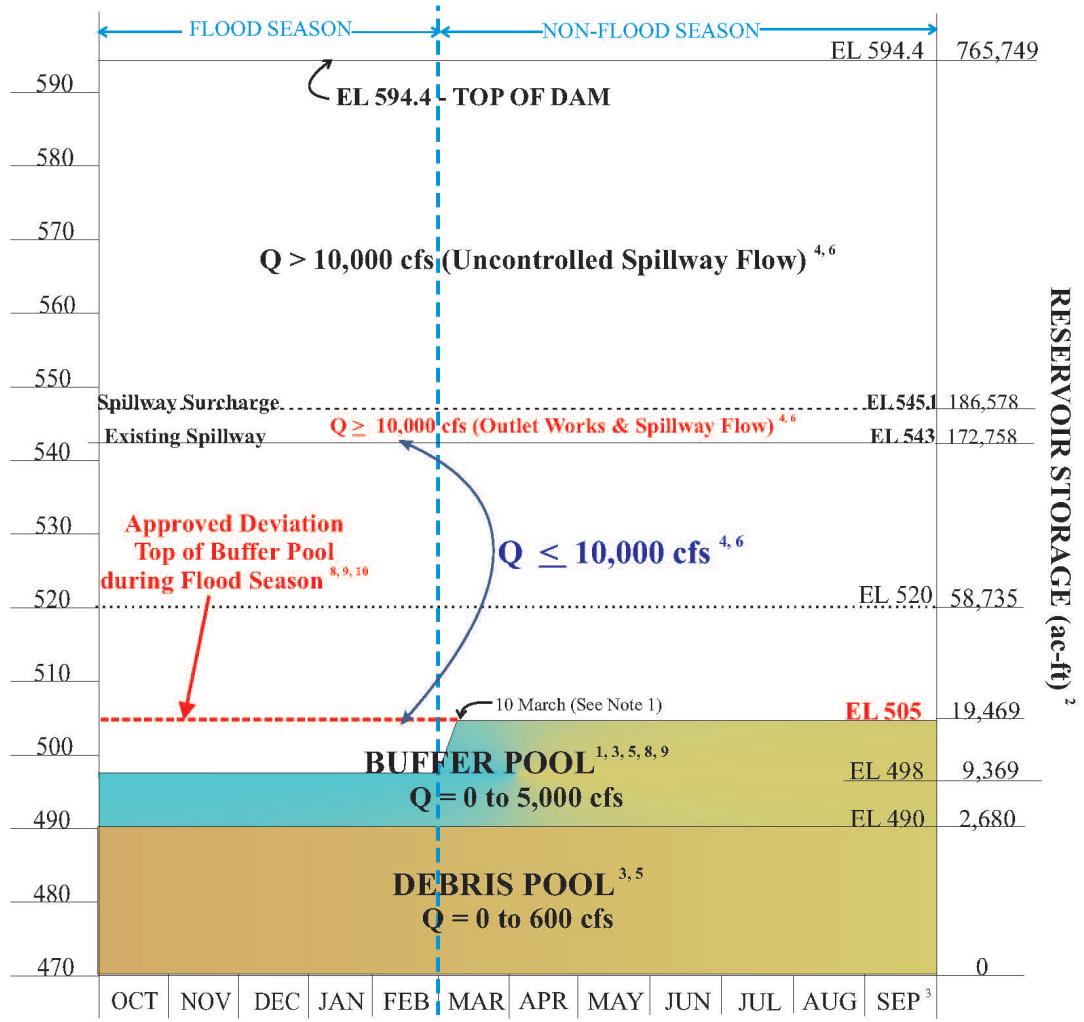
Captured stormwater recharges the groundwater basin.

OCWD Surface Recharge System

- **25 facilities**
- **1,500 acres**
- **1,100 “wet” acres**
- **26,000 af storage**

Sign up for Tour on September 19

Upd



Prado Dam Release Ranges - Using New Outlet Works

Pertinent Pool Elevations (ft, NGVD29)	Recommended Plan of Discharge Description
DEBRIS POOL 470 - 490	At the start of a runoff event, a debris pool is built to settle out floating debris to limit their being drawn into the outlet works. Discharge from within this pool range varies (0-600 cfs), but generally accommodates the OCWD's downstream spreading capacity without waste to the Pacific Ocean. Flow may also be shut off temporarily to facilitate construction.
BUFFER POOL Flood Season* and Non-Flood Season ** EL 490-505	Discharge range (0 - 5000 cfs). The buffer pool range is borrowed flood risk management space to temporarily store water for water conservation. The top of buffer pool elevation during flood season while the approved multi-year (5-year) Deviation is in place, can be maximized up to EL 505. Upon signing of the Record of Decision (ROD) to approve change to water conservation, it will permanently be allowed to maximize the buffer pool up to EL 505 during both flood and non-flood seasons (see Note 9).
FLOOD RISK MANAGEMENT POOL EL 505-520	Discharge (≤ 10,000 cfs). The resulting maximum reservoir release will depend on anticipated inflow and downstream conditions. Maximum discharge is maintained until the pool elevation recedes back down to/below the top of buffer pool elevation.
FLOOD RISK MANAGEMENT POOL 520 - 543 ***	Discharge (≤ 10,000 cfs). The resulting maximum reservoir release will depend on anticipated inflow and downstream conditions. Maximum discharge is maintained until the pool elevation recedes back down to/below the top of buffer pool elevation. If hydrologic conditions warrant, or if dam safety is a concern, discharge through the outlet works may exceed 10,000 cfs.
SPILLWAY SURCHARGE POOL 543 - 545.10 ***	Discharge (> 10,000 cfs) Combined controlled discharge through outlet works and uncontrolled discharge over the spillway. Existing dam safety concern with the unmodified spillway. Controlled outlet discharge may be maximized (>10,000 cfs) to minimize the duration of spillway flow.
UNCONTROLLED SPILLWAY DISCHARGE 545.10 - 594.4 ***	Discharge (> 10,000 cfs) Combined controlled discharge through outlet works and uncontrolled discharge over the spillway. Existing dam safety concern with the unmodified spillway. Controlled outlet discharge may be maximized (>10,000 cfs) to minimize the duration of spillway flow.

Footnotes:

* Flood season is defined 1 OCT through 29 FEB. Within this time period, if flood risk management discharge is not warranted, then water conservation releases are made, coordinated with OCWD, while the pool elevation does not exceed top of approved buffer pool elevation. The entire buffer pool is under Corps control and can be evacuated any time for any reason. Discharge for water conservation will vary depending on OCWD diversion capacity. Discharge may also be shut off temporarily to accommodate downstream maintenance or channel inspections, as needed.

** Non-flood season is defined 1 MAR through 30 SEP. Within this time period, if flood risk management discharge is not warranted, then water conservation releases are made, coordinated with OCWD, while the pool elevation does not exceed top of approved buffer pool elevation. The entire buffer pool is under Corps control and can be evacuated any time for any reason. Also, while the pool elevation remains above elevation 498, a running average discharge of 350 cfs is required. Discharge may also be decreased to 50 cfs or shut off temporarily (with coordination with SPL's ERB) to accommodate downstream maintenance or channel inspections, as needed.

*** The decision of release magnitude will depend on storm and runoff conditions, as well as conditions of the reservoir and channels in the Santa Ana River watershed and how flood risk management objectives can best be met. Releases could exceed 10,000 cfs to either prevent/minimize the occurrence of spillway flow, or if there are dam safety concerns. Coordination with District Chain of Command and SPD will be made prior to implementing a discharge exceeding 10,000 cfs.

NOTES:

1. The top of buffer pool in during flood season is normally up to elevation 498 ft and at 505 ft during non-flood season. Beginning 1 March, the reservoir pool is gradually increased to transition from EL 498 ft to EL 505 ft by March 10. Discharge from Prado to accommodate OCWD's spreading capacity varies, maximizing up to 600 cfs during both flood and non-flood seasons.
2. Storage Data based on Reservoir Surveys completed in 2008, 2013, and 2015. Area and Storage Capacity Tables provided in Exhibit B of the IWCM.
3. Maintenance activities typically scheduled during summer months (i.e., July, August, September). Reservoir should be drained by end of August, if possible.
4. Maximum outlet discharge capability is up to 30,000 cfs. Above elevation 520 ft, releases may be increased to the maximum possible discharge to prevent/minimize spillway flow, or due to dam safety concerns.
5. During non-flood season, discharge is subject to minimum release requirements (running average 350 cfs) while the pool elevation remains above elevation 498.
6. If discharge will exceed 10,000 cfs, a dam safety team must be on site to evaluate impacts to the dam and outlet works. Discharge greater than 10,000 cfs will be also be coordinated with SPD.
7. All elevations cited are in feet, NGVD 1929.
8. **The Multi-Year Deviation Request changes ONLY the top of buffer pool elevation from 498 to 505 during flood seasons. All other operating conditions specified for the IWCP remains the same.**
9. **Upon signing of the Record of Decision (ROD), the Prado Basin Feasibility Study alternative to change the water conservation operation, which is the same operating plan as the approved multi-year (5-year) Deviation plan, the Deviaiont in place will then be permanently implemented as part of this IWCP.**
10. **The signed ROD will be subsequently added to this IWCM for reference.**

PRADO DAM
SANTA ANA RIVER BASIN, CALIFORNIA
INTERIM WATER CONTROL MANUAL

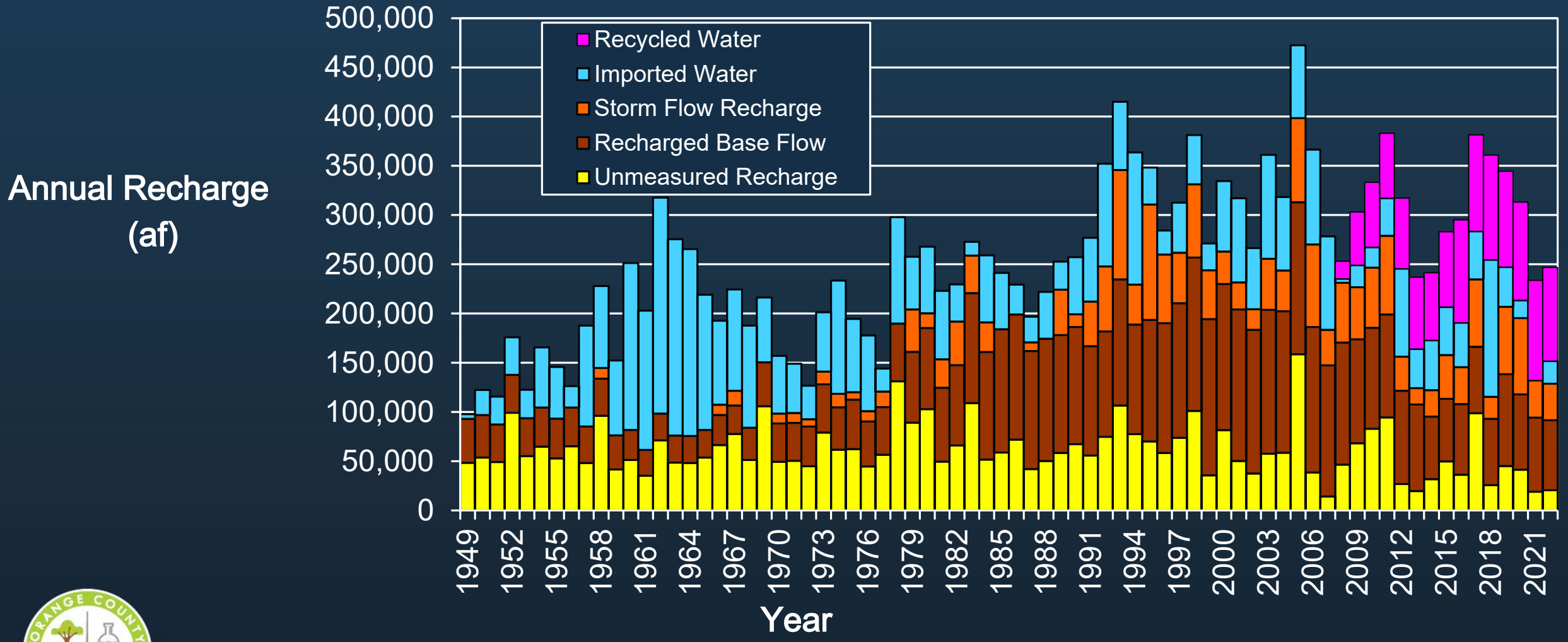
INTERIM WATER CONTROL PLAN (IWCP - April 2021)

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

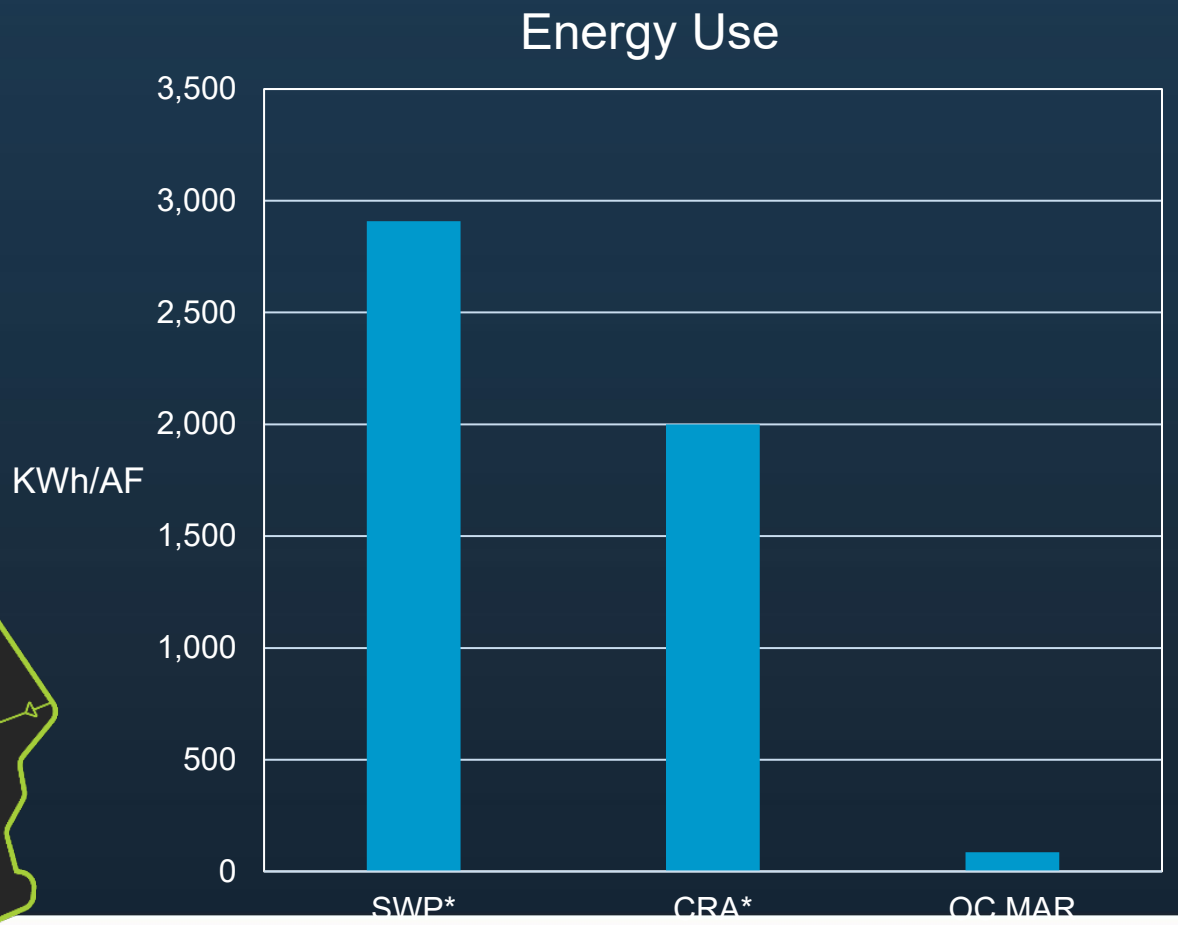
This Diagram Supersedes the 2003 IWCP Diagram (Plan A)

Plate 7-01

Since 1949, 11 million acre-feet of imported and Santa Ana River base flow have been recharged.



The energy to convey imported water to the region is 20 to 30 times more than storm water recharge.

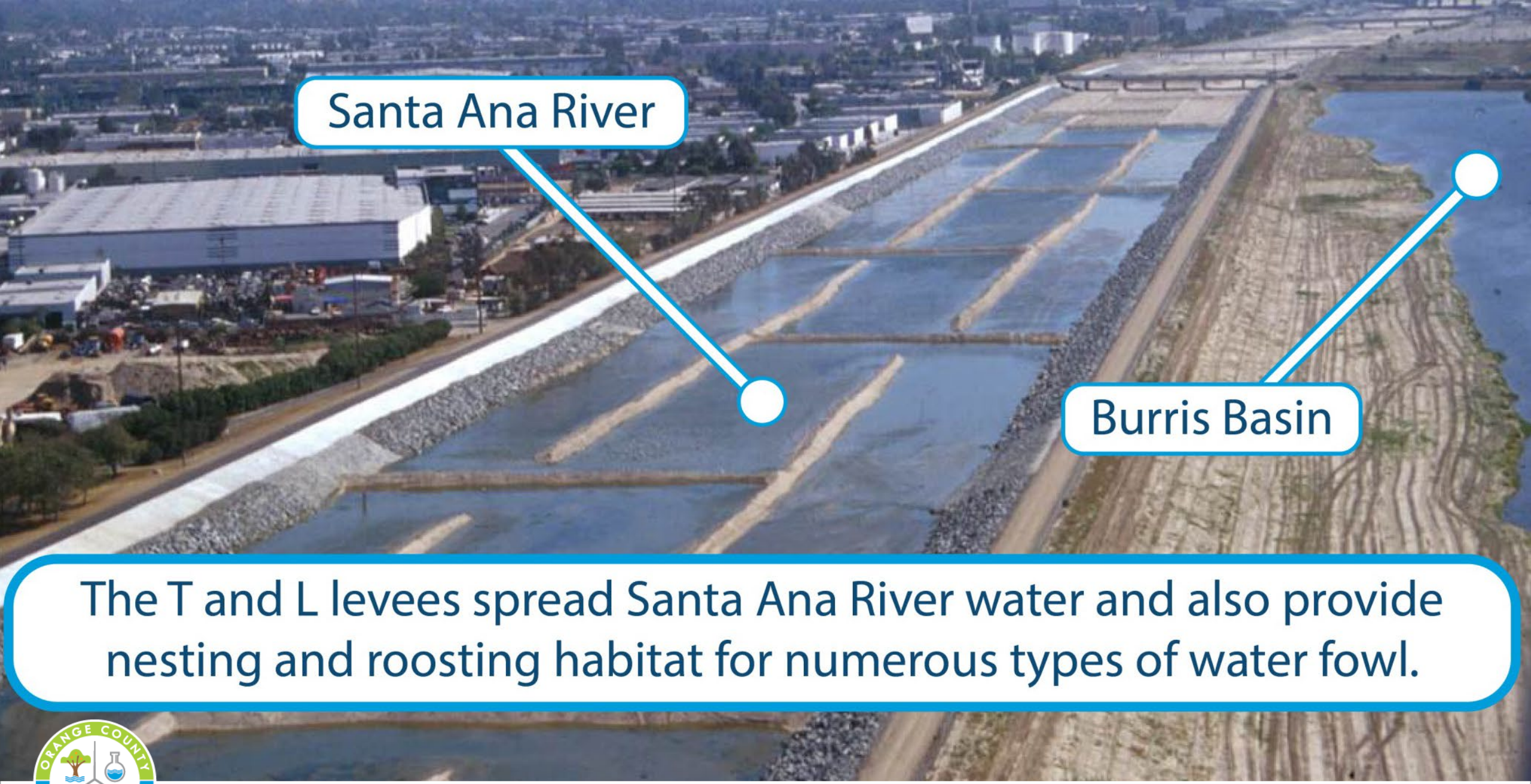


*2020 MWD UWMP, https://www.mwdh2o.com/media/21641/2020-urban-water-management-plan-june-2021.pdf

Santiago Basins (~14,000 af)

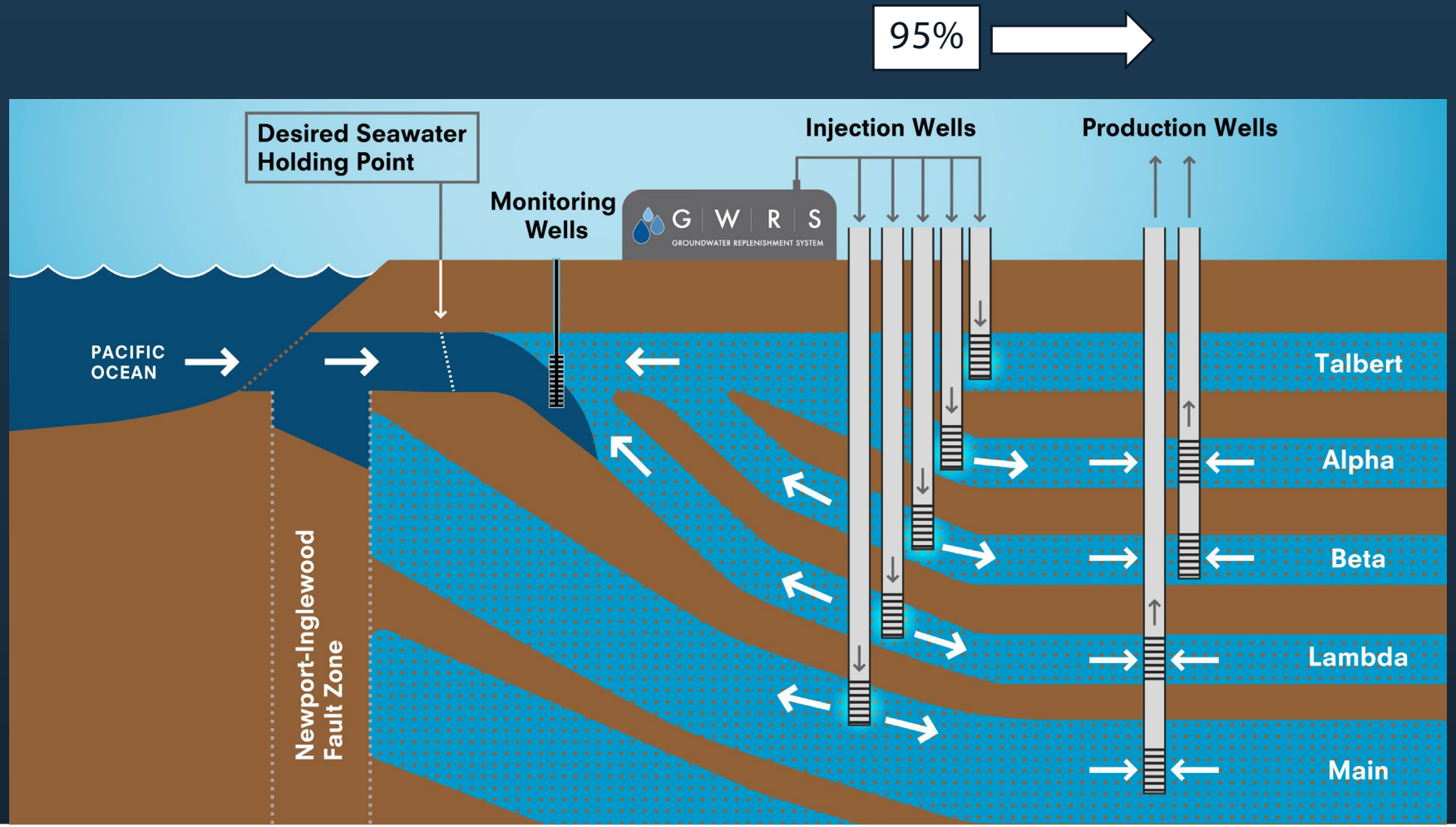
July 2022

March 2023



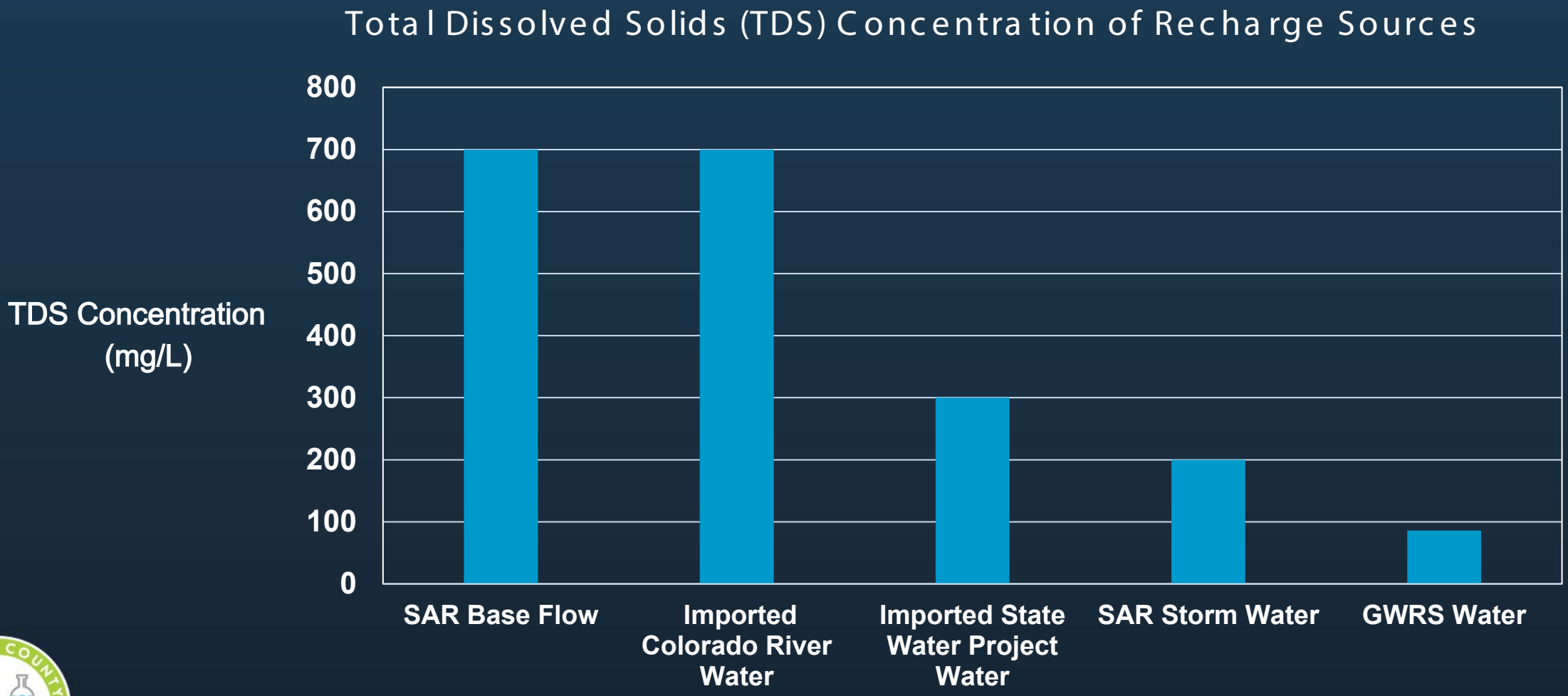
The T and L levees spread Santa Ana River water and also provide nesting and roosting habitat for numerous types of water fowl.

The seawater intrusion barrier, built in 1975, serves to protect and replenish the basin.



Seawater Intrusion Barrier (1975)

Diverse Recharge Portfolio = Diverse Water Quality



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