


The Orange County Water District's Comprehensive Water Resources Management Program

**The Rosenberg International Forum on
Water Policy**

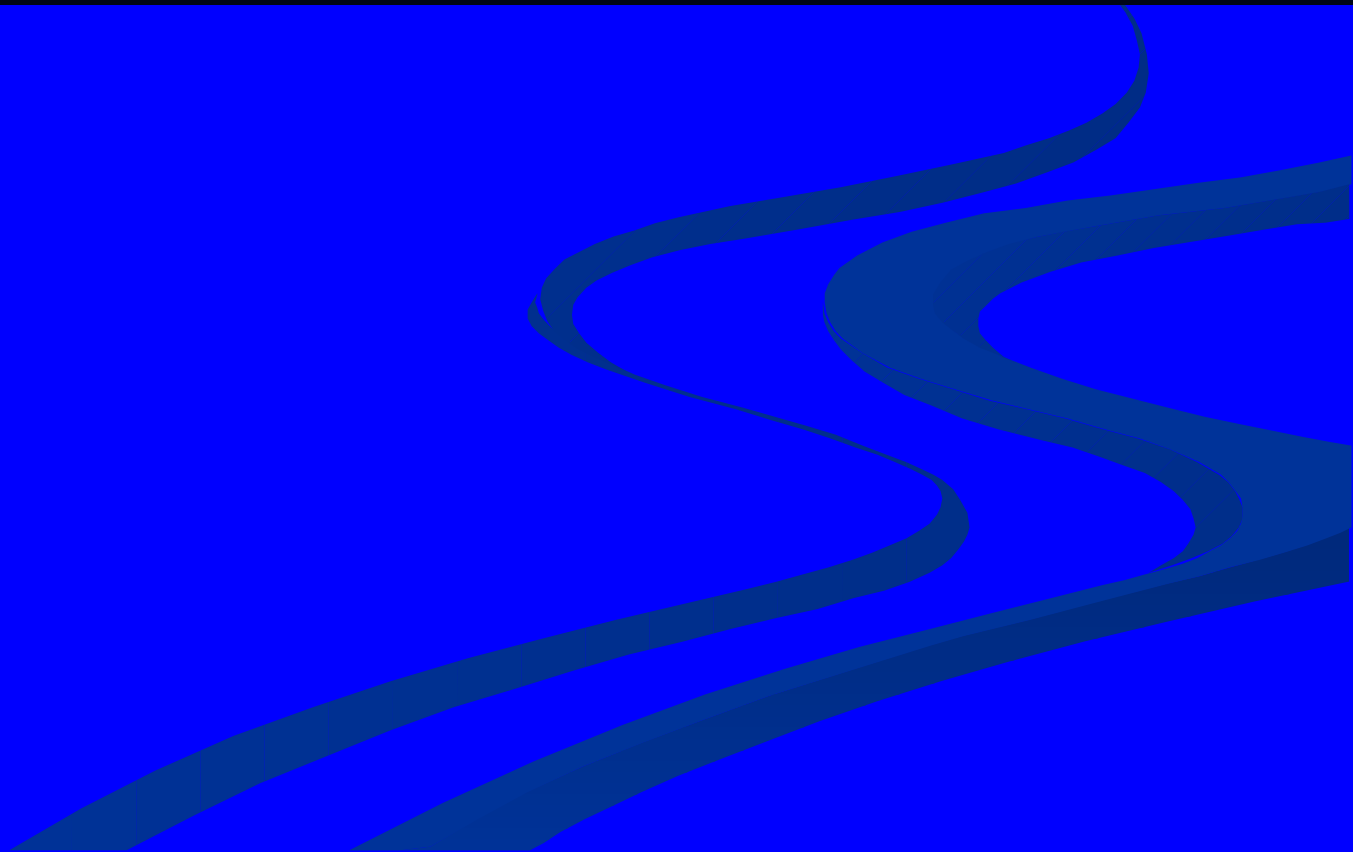
October 7-11, 2002

*William R. Mills, General Manager, Orange
County Water District (1987-2002)*

Presentation Overview

- Background on Basin and Water District
 - Challenges of the Past
 - Challenges of the 21st Century
- 
- The bottom right portion of the slide features several overlapping, wavy, horizontal bands in shades of blue and teal, creating a decorative, water-like effect.

BACKGROUND



Los Angeles
County

San Bernardino
County

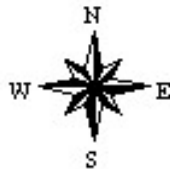
SANTA ANA RIVER
WATERSHED

Riverside
County

ORANGE COUNTY
WATER DISTRICT

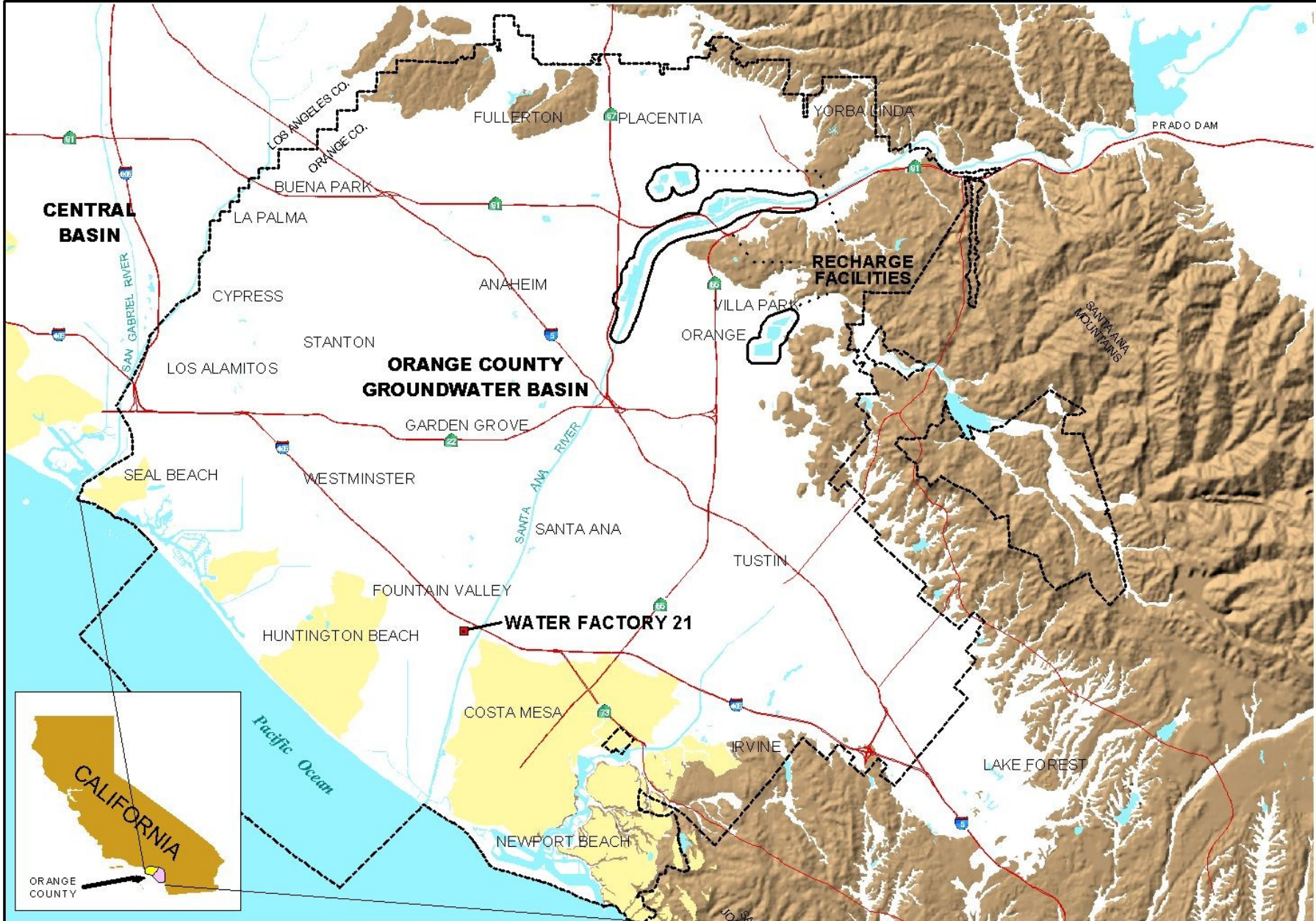
Orange
County





San Diego
County

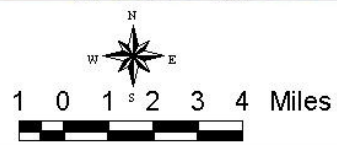


5 0 5 10 15 Miles





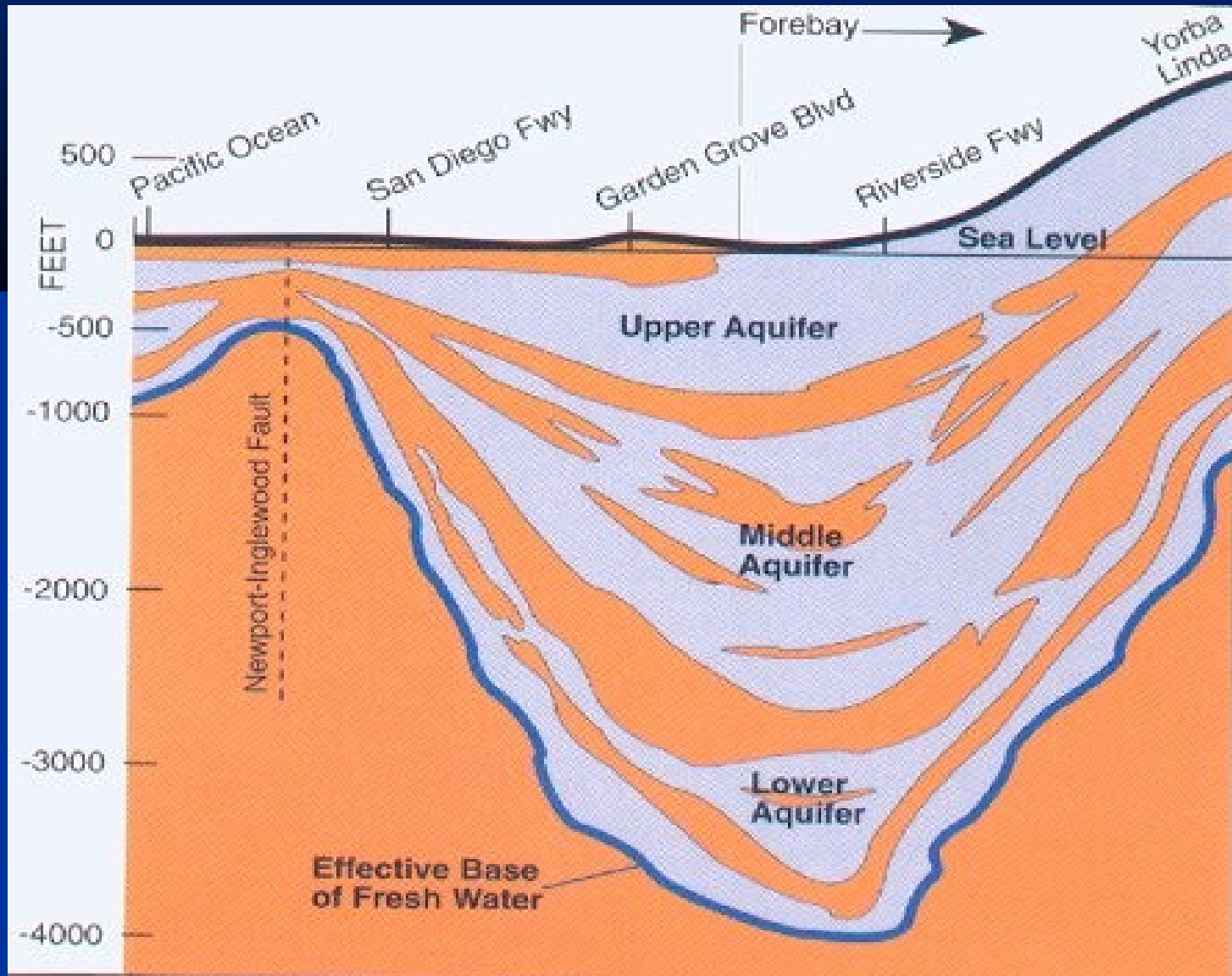
-  MAJOR HIGHWAYS
-  OCWD BOUNDARY
-  MESA
-  NON-WATER BEARING FORMATIONS



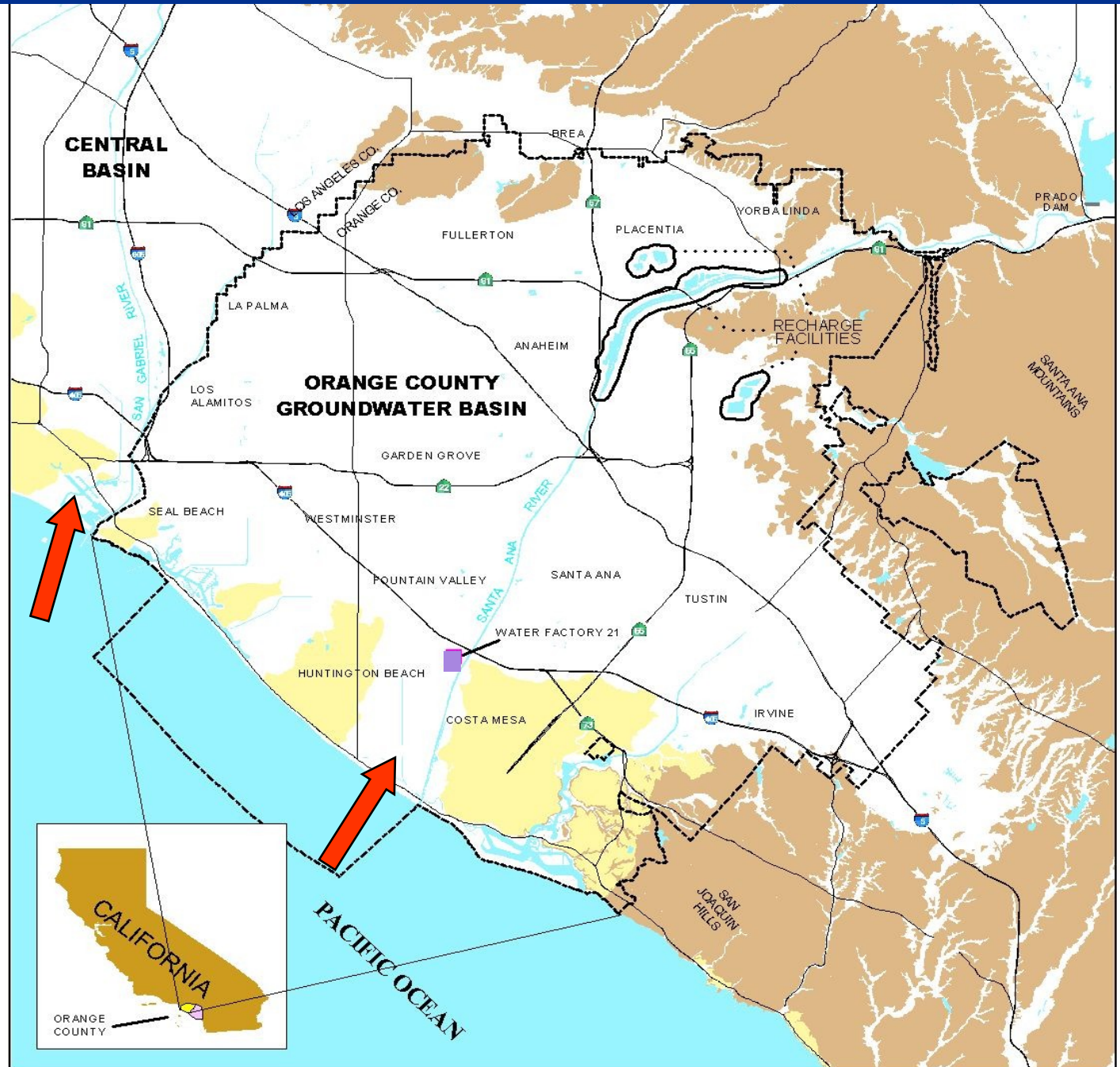
Reproduced with permission granted by THOMAS BROS. MAPS®.
© Thomas Bros. Maps. All rights reserved.

1:250,000
 11/2012
 11/2012

Orange County Groundwater Basin



**Coastal
geologic
gaps act
as
conduits
for
potential
seawater
intrusion**



Orange County Water District was Established in 1933

ORANGE COUNTY WATER DISTRICT



- Protect Santa Ana River flow
- Conserve water
- Manage groundwater basin

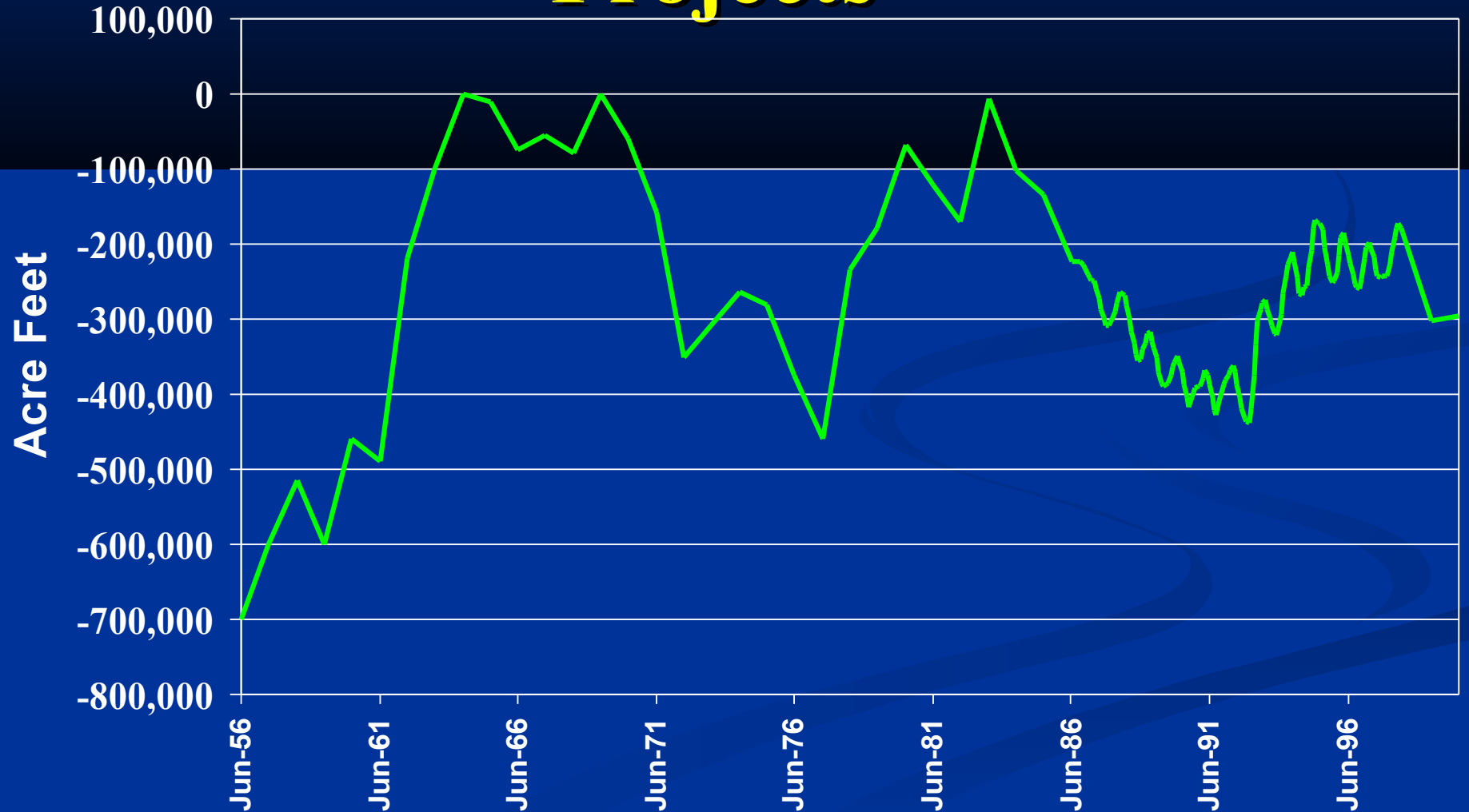
Challenges of the Past

- Controlling Basin Overdraft
- Controlling Sea Water Intrusion
- Controlling Extractions

Controlling the Overdraft

- Overdraft on Basin, Culminating in Sever Over-draft by mid-1950s
- Wells near Coast were Abandoned due to Salt Water Intrusion
- Lacked Authority to Limit Extractions
- Lacked Revenue Base to Purchase available Surplus Imported Water Supplies
- Obtained Authority to Levy a Pump Tax
- Refilled Basin

The Basin was Refilled to Allow for Sea Water Intrusion Projects

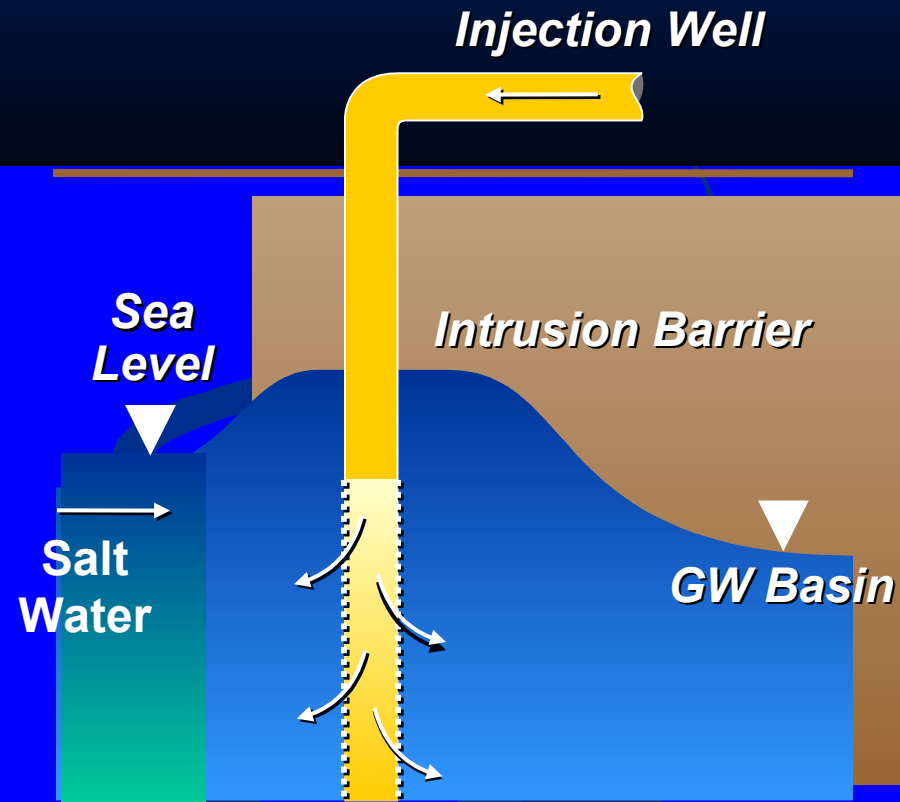


Constructing Sea Water Barriers

The background of the slide is a solid blue color. In the bottom right corner, there are several overlapping, wavy, light blue lines that create a sense of movement or depth, resembling water ripples or a stylized graphic element.

Sea Water Intrusion Barrier Facilities

- Fresh water is injected along the coast
- The injected water forms a pressure ridge that blocks the landward movement of sea water



Water Factory 21: A 60 ML/d advanced waste water reclamation facility, supplies fresh water for sea water barrier



- **Since 1975 produced over 150 Mm³ of water**
- **Over 25 years of operating experience**
- **Meets all drinking water standards**

Controlling Extractions

Controlling Extractions from the Basin

- Obtained Authority to Limit Basin Extractions, but Restrictions Applied Equally to All Pumpers
- Obtained Authority to Apply an Additional Pumping Fee for Individual Pumping in Excess of Over All Pumping Allocation
- Management by Financial Incentives
- Established Program of Replenishing the Annual Over-draft each Year

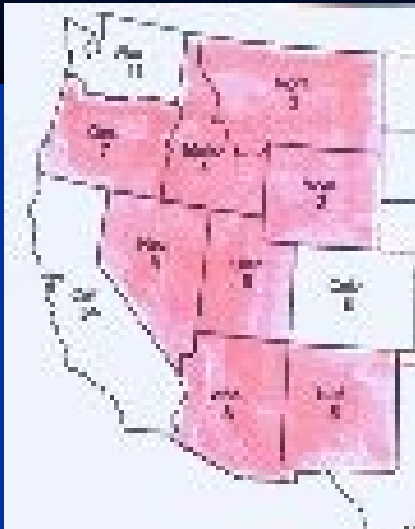
Challenges of the 21st Century

- Improving Water Reliability
- Managing Salinity of the Basin

Southern California's Imported Water



Future Water Shortages are Predicted



- Reliability of imported water challenged by legal, environmental and population issues
- Large population increases in the future
 - By 2020 — Southern California: 7 million
California: 15 million
- Projected shortages by 2020
 - Orange County predicts 200 Mm³ short fall
 - CA Department of Water Resources predicts 2,500-5,000 Mm³ shortage

The Santa Ana River ... a Reliable Resource

■ Base Flow-

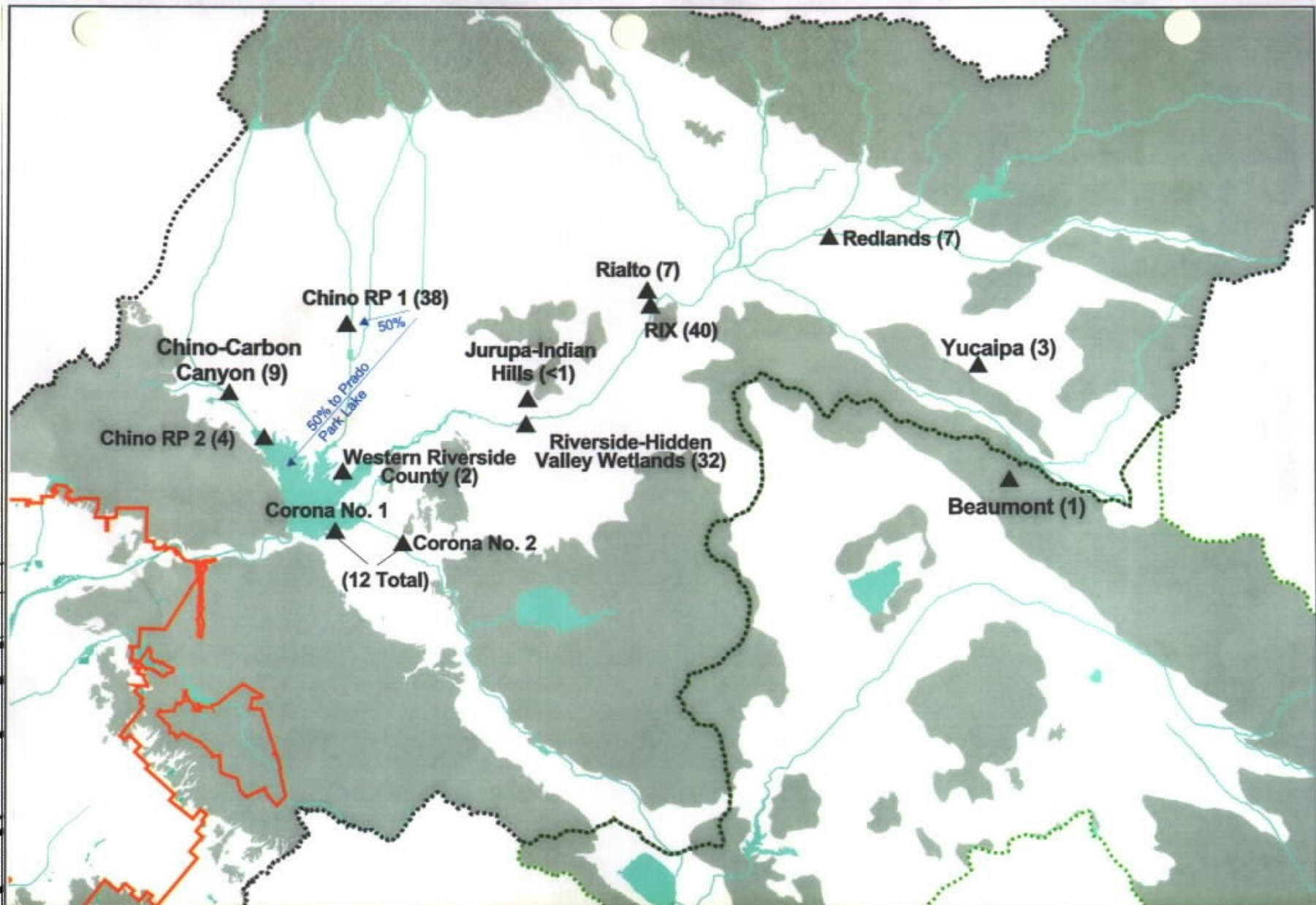
- Perennial
- Historically, Rising Ground Water
- After WW II, Became Effluent Dominated

■ Storm Flow-

- Sporadic but Increasing due to Increased Impervious Area

The Base Flow of the River now consists of Tertiary Effluent

- Currently 590 ML/d are discharged into the River Upstream of the District's Recharge System
- Population Growth Suggests a 50% Increase of the Flow by 2020, Even with Extensive Water Recycling



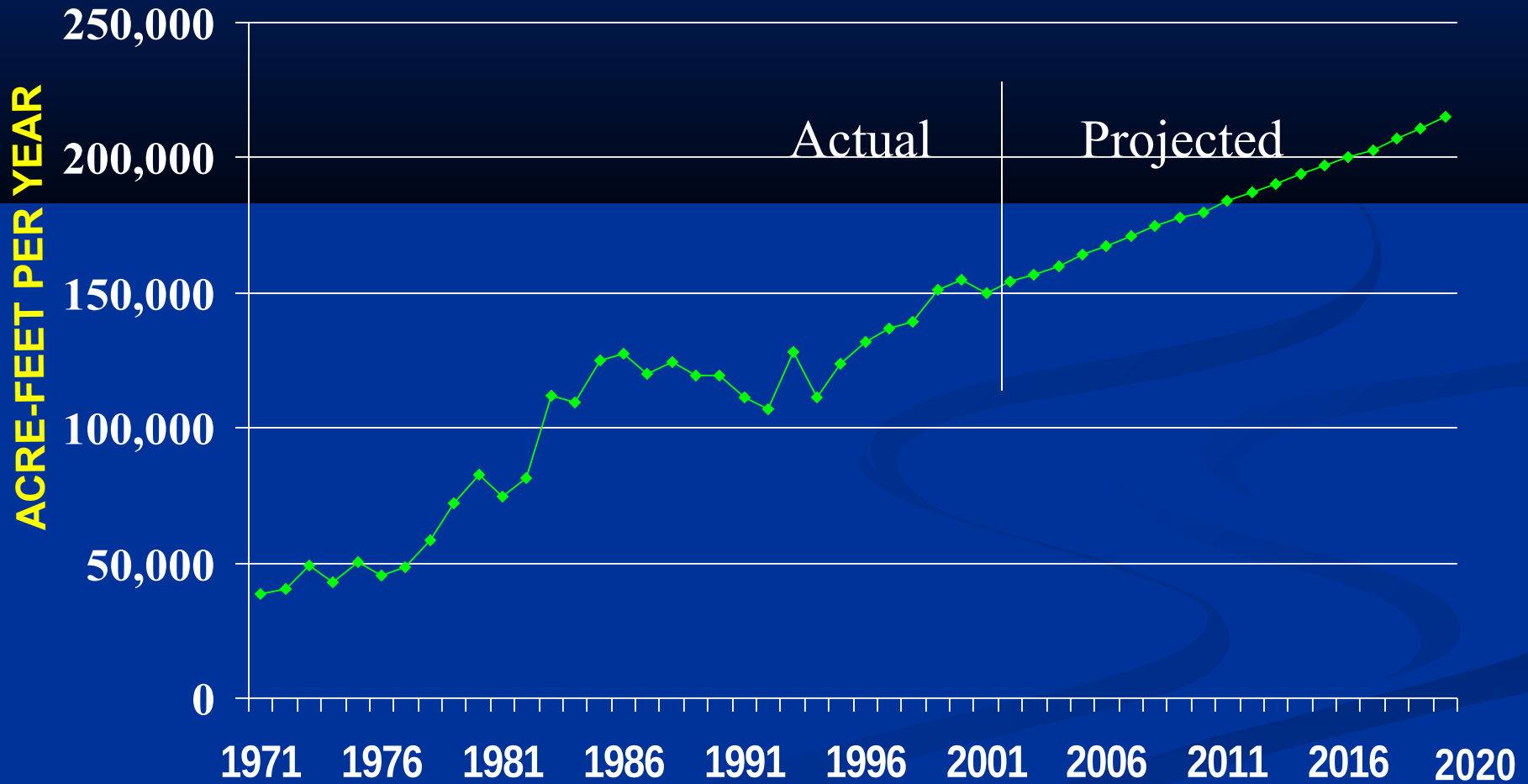
- ▲ Wastewater Facilities
 - Santa Ana River Watershed (1969 Judgment)
 - Elsinore Watershed
 - Orange County Water District Boundary
 - Water Bodies
 - Non-Waterbearing Formation
- (13) Wastewater Discharge Rate (average from 10/1/1999 to 9/30/2000; data from 1999-2000 Santa Ana River Watermaster Report)



**Figure 2-2
Wastewater Facilities and
Discharges to the
Santa Ana River**



SANTA ANA RIVER BASE FLOWS



Water Conservation at Prado Dam

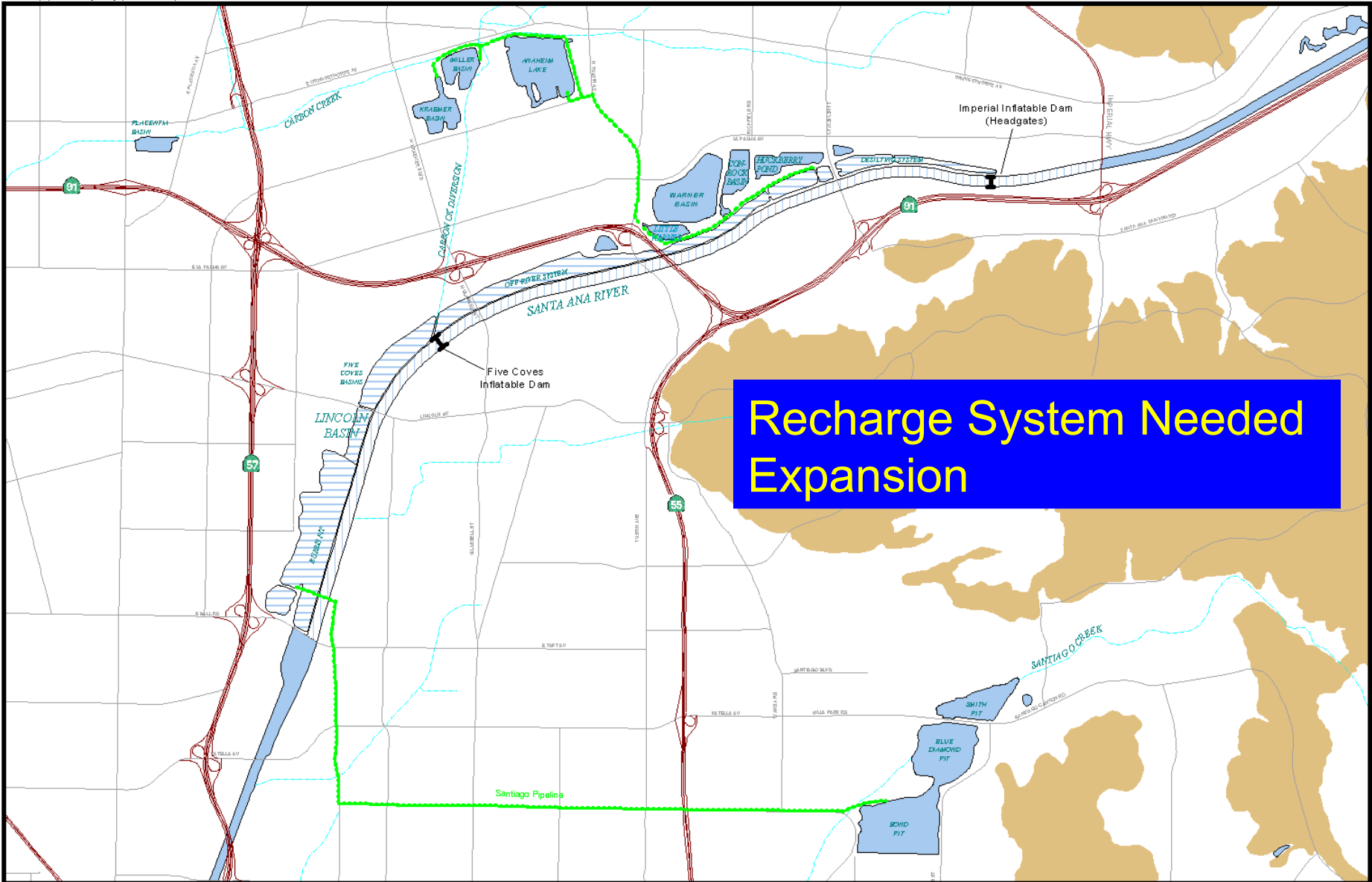





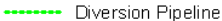
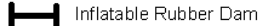
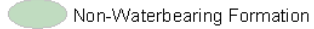
Least Bell's Vireo Population

Increase at Prado Dam

Pairs of birds





-  On River Recharge Area
-  Off River Recharge Area
-  Deep Basin Recharge Area
-  Diversion Pipeline
-  Infiltrable Rubber Dam
-  Non-Waterbearing Formation



OCWD Recharge Facilities



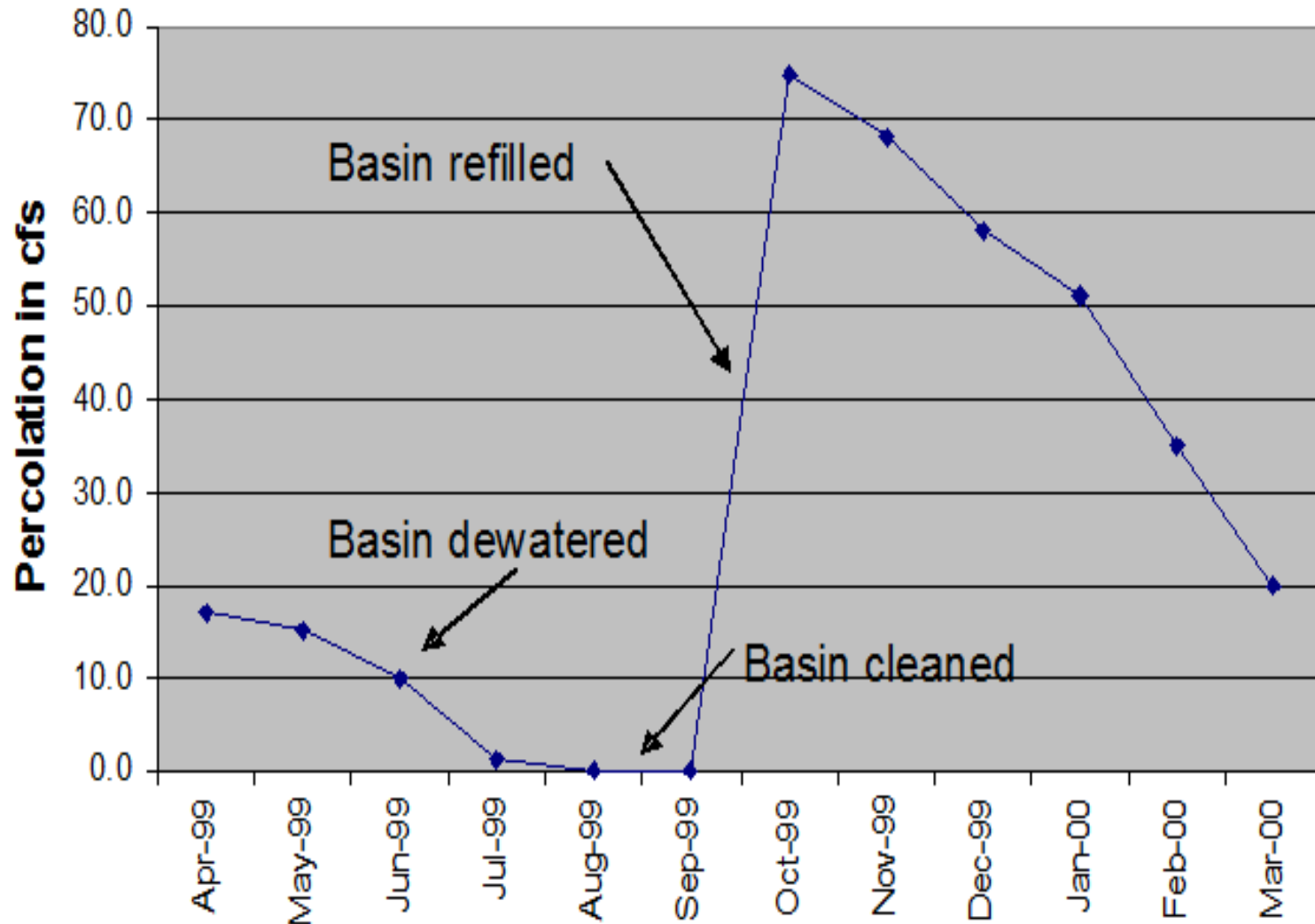
The Santa Ana River Channel



Deep Basins



Clogging of Deep Basins Became The Major Recharge Limiting Issue

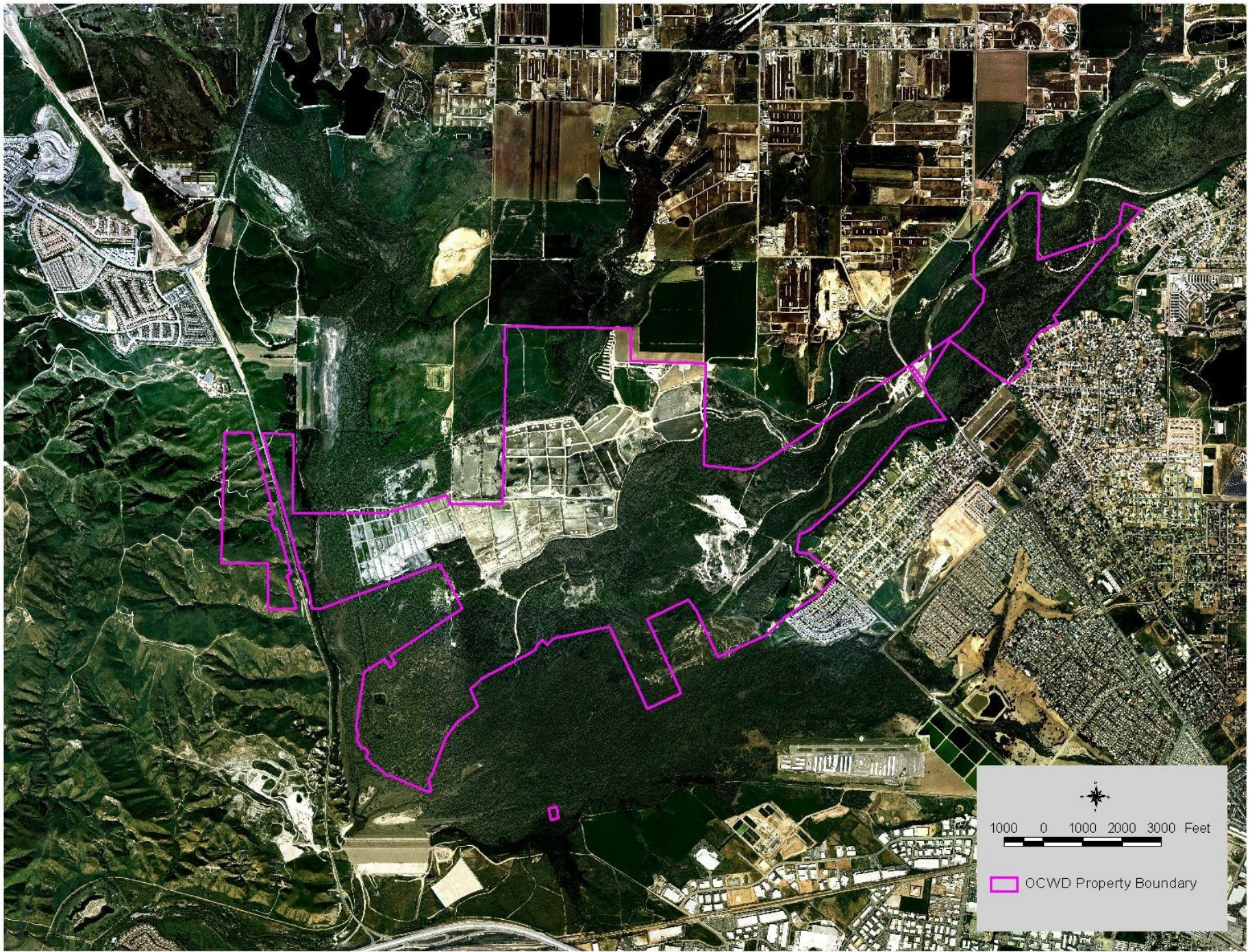


Clogging Reduction Strategies

- Nutrient Reduction in the Base Flows of the Santa Ana River
- Continuous Under Water Cleaning of the Deep Basins

Constructed Wetlands Remove Nitrogen

The background of the slide is a solid blue color. In the bottom right corner, there are several overlapping, wavy, light blue lines that create a sense of movement or water ripples.



1000 0 1000 2000 3000 Feet

OCWD Property Boundary



Biomonitoring

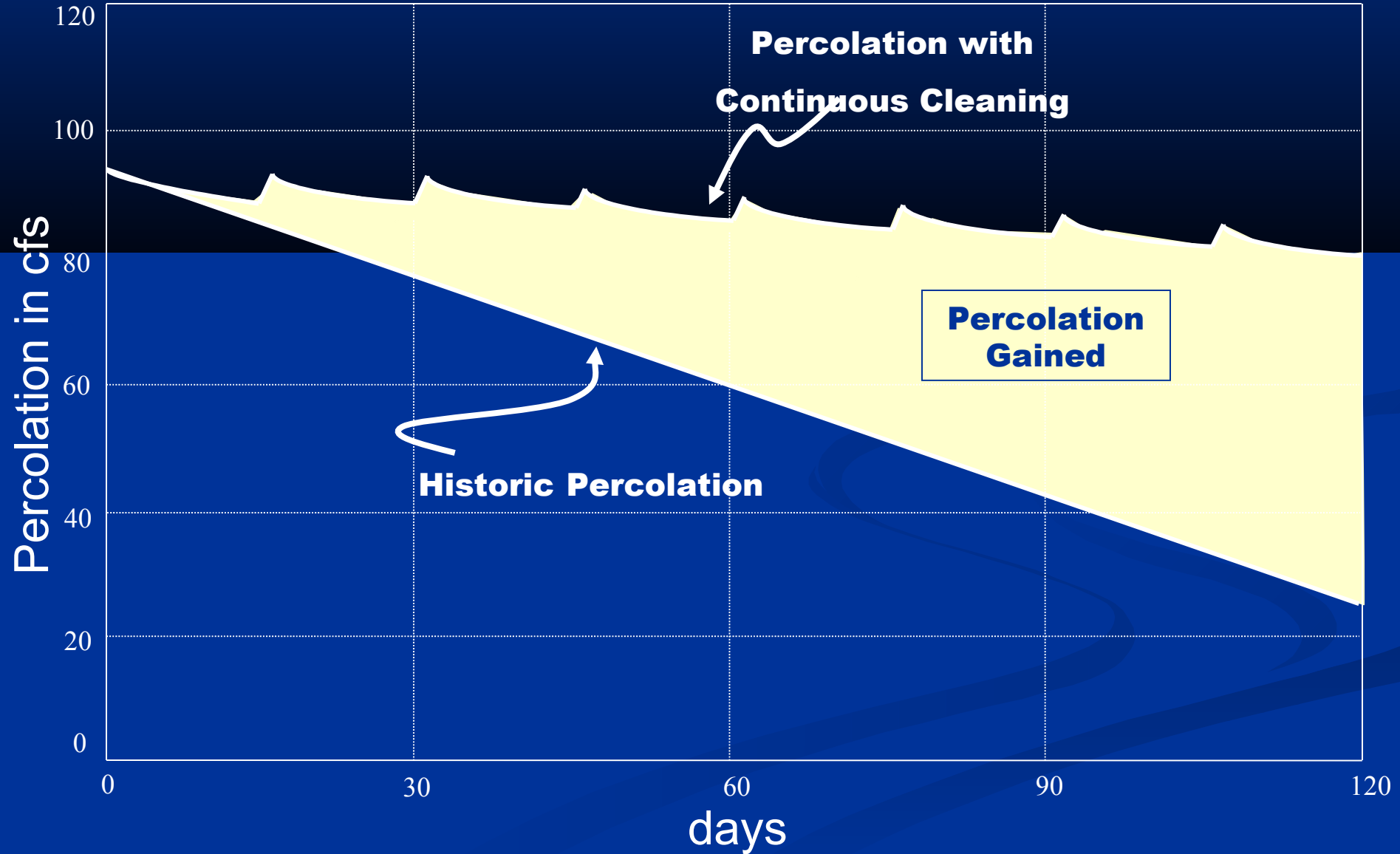




Medaka Fish are Indicators of Endocrine Disruption



A Continuous Cleaning S Could Increase the Percolation by about 50%



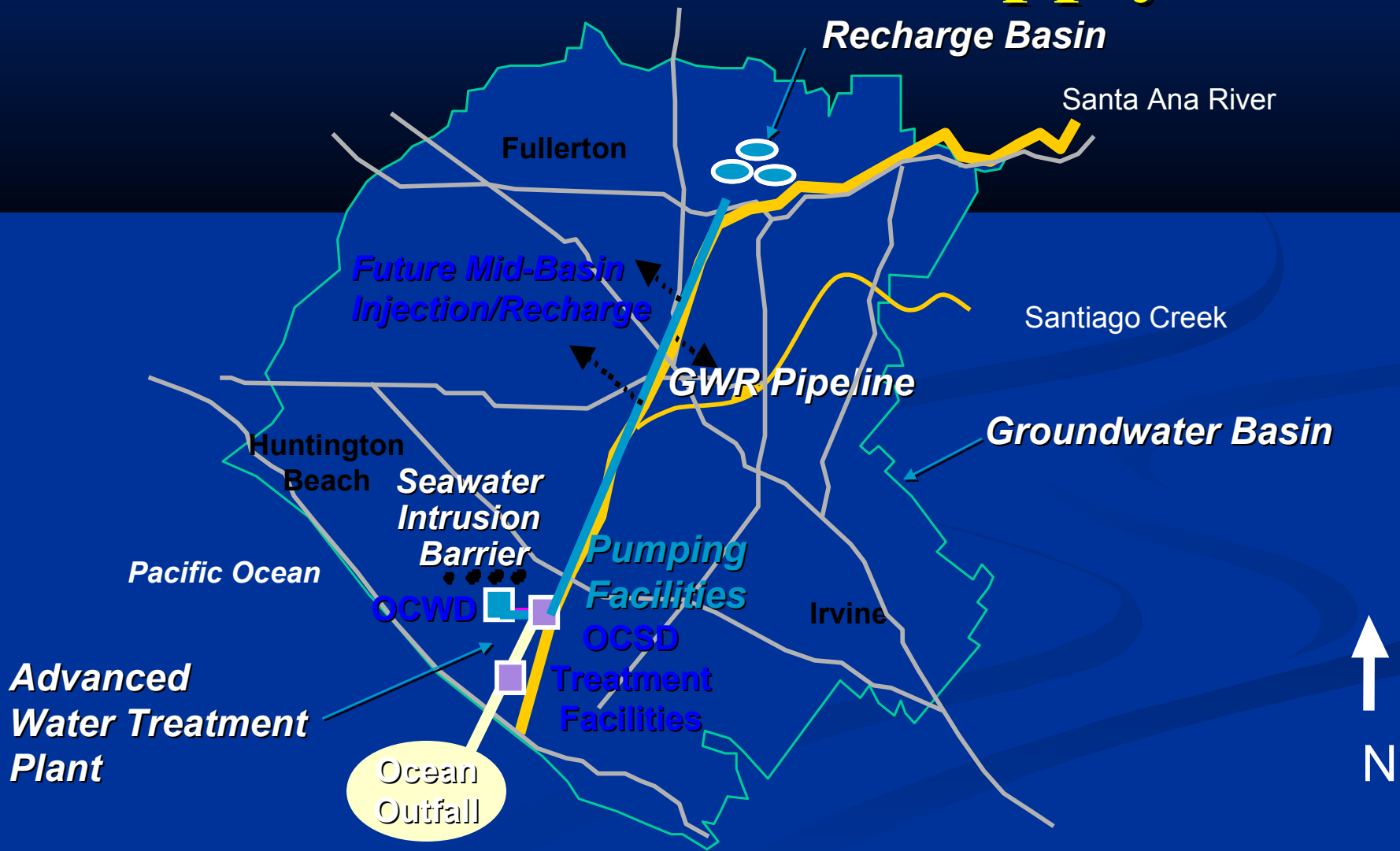
The Hardened Filter Cake Restricts Percolation



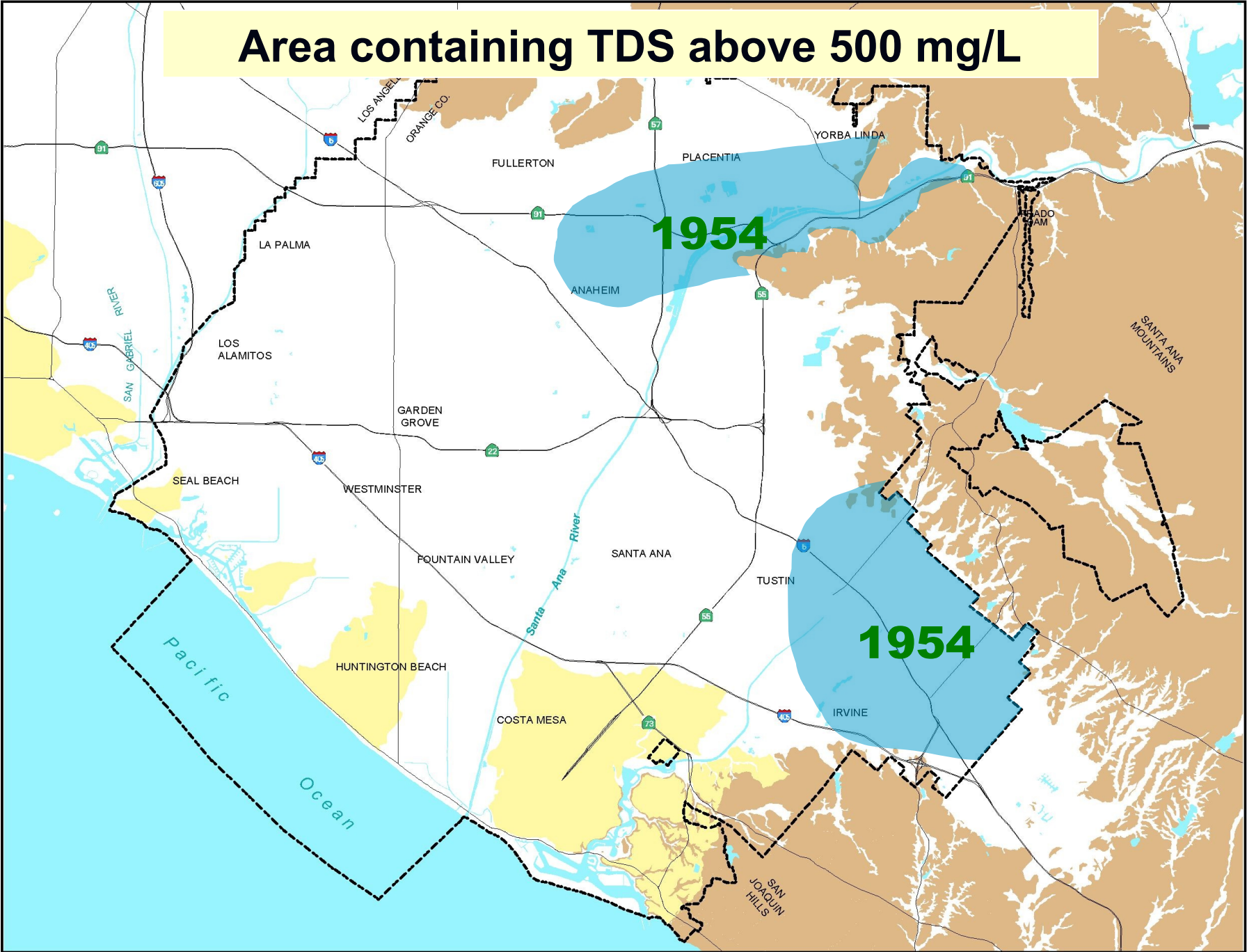
Continuous Cleaning ... The Basin Cleaning Vehicle



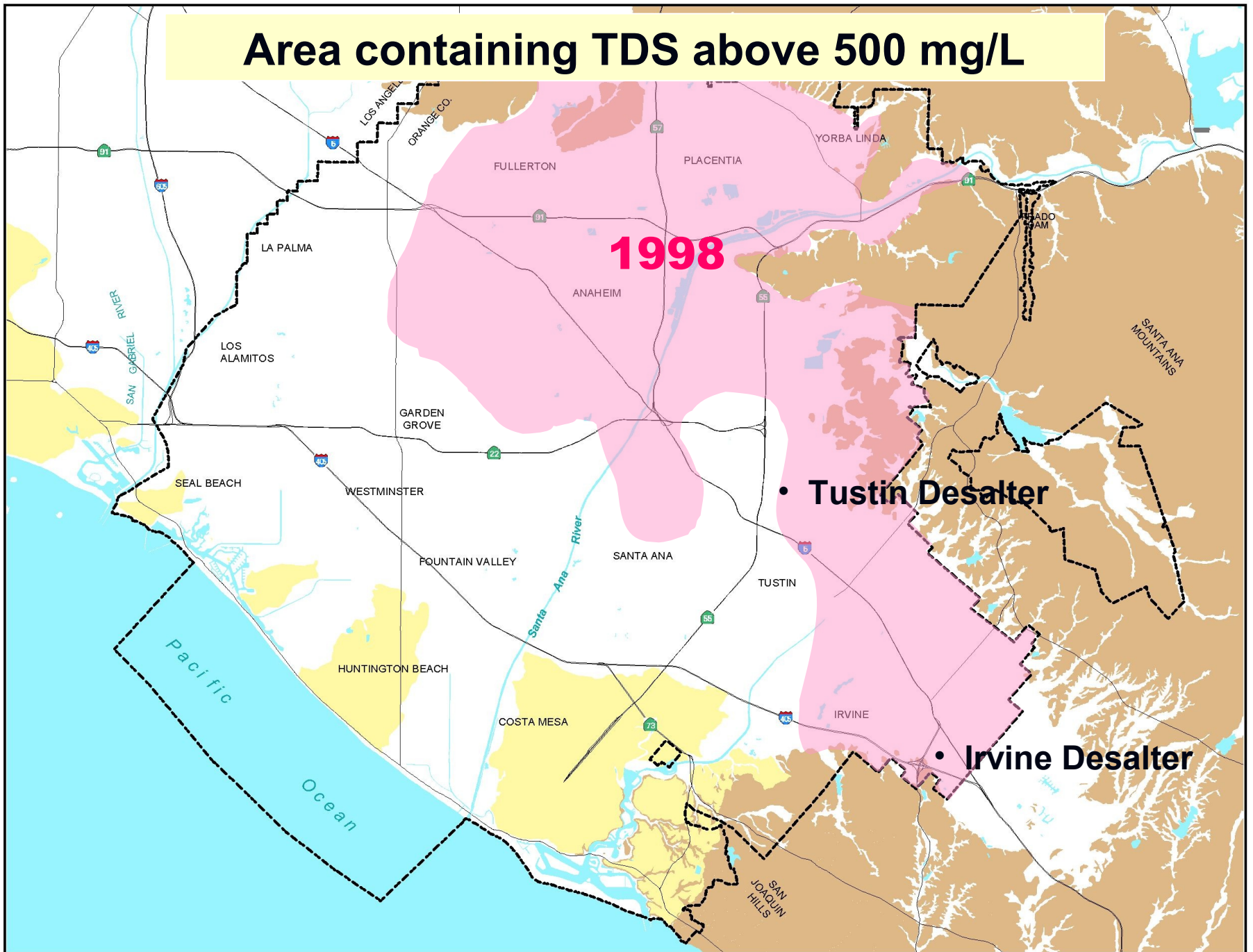
The GWR System: a 320ML/day Indirect Potable Supply



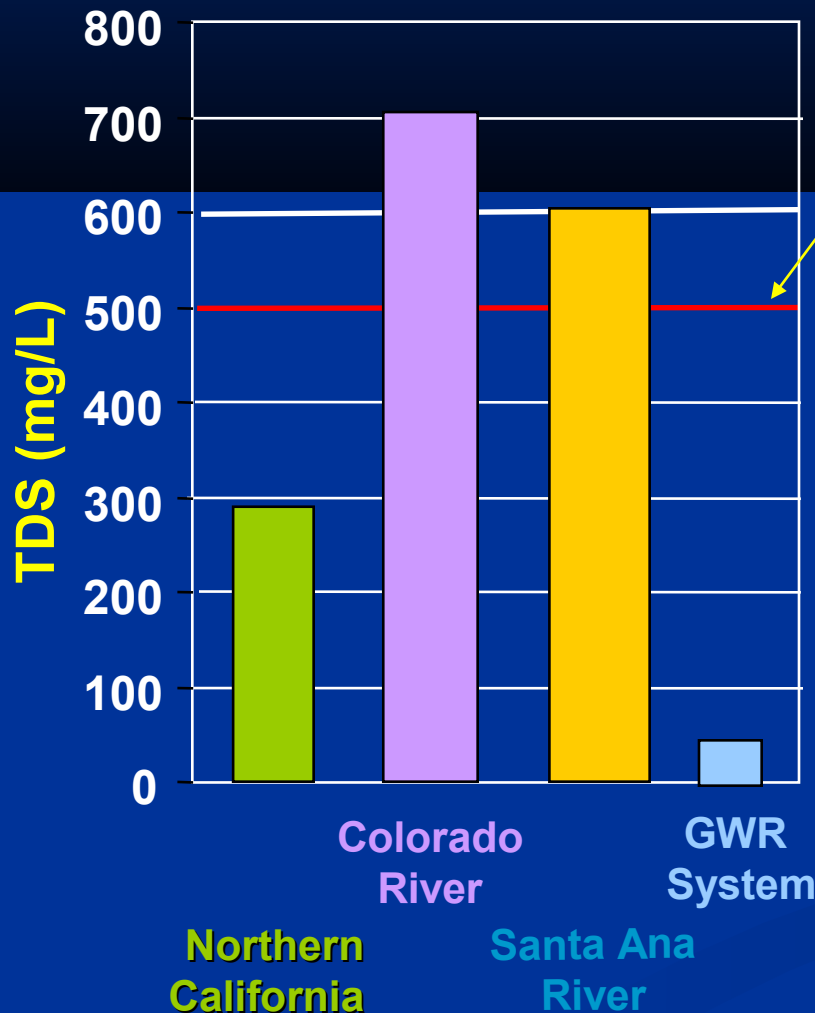
Area containing TDS above 500 mg/L



Area containing TDS above 500 mg/L



The GWR System Will Produce the Highest Quality Water in the Region

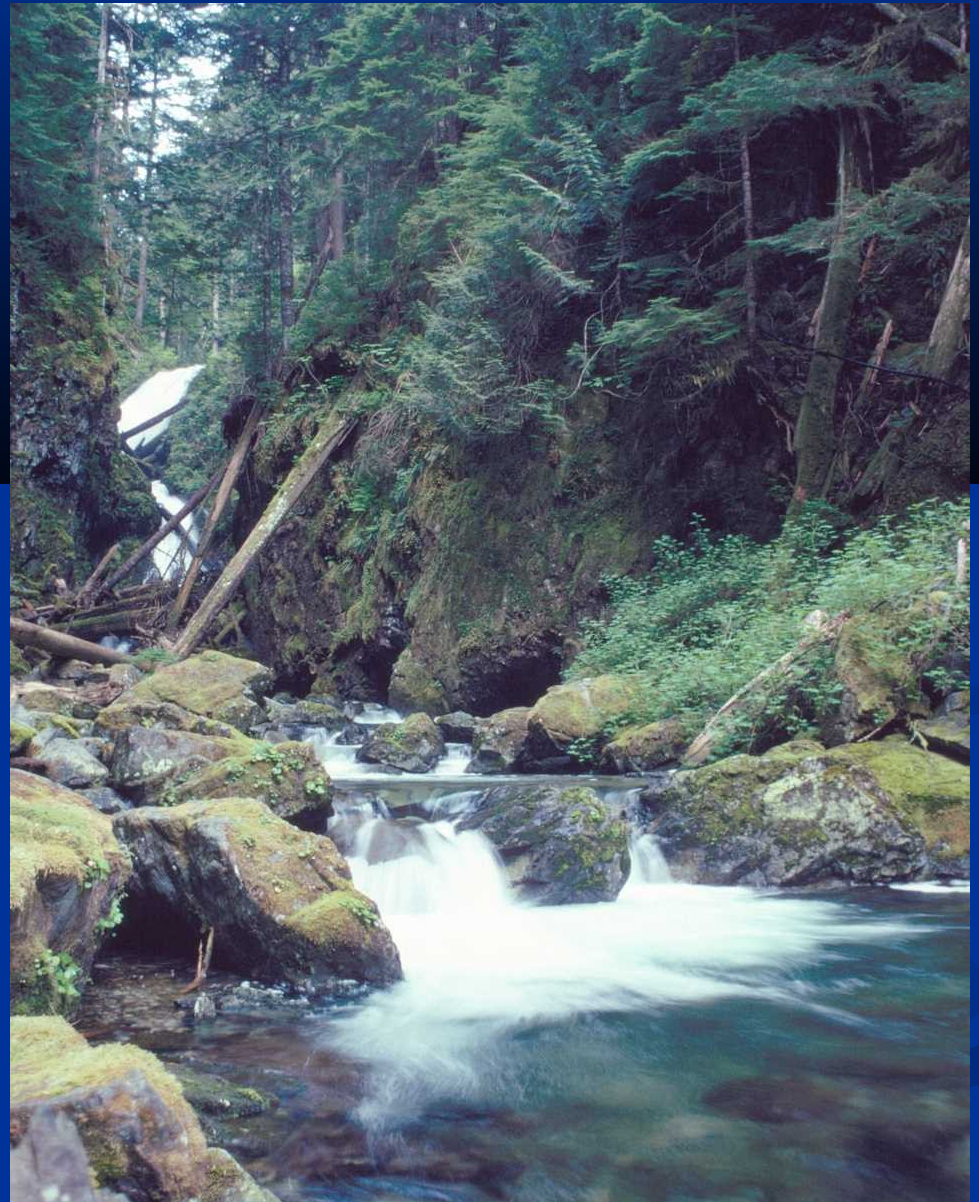


High TDS water is above 500 mg/L

- Concentration of Total Dissolved Solids in water causes significant consumer costs...water heaters, plumbing corrosion, softening, etc.
- Average TDS levels will continue to increase without this project

**If there is
magic
on this
planet,
it is in water.**

Loren Eiseley, "The Flow of the
River," *The Immense Journey*

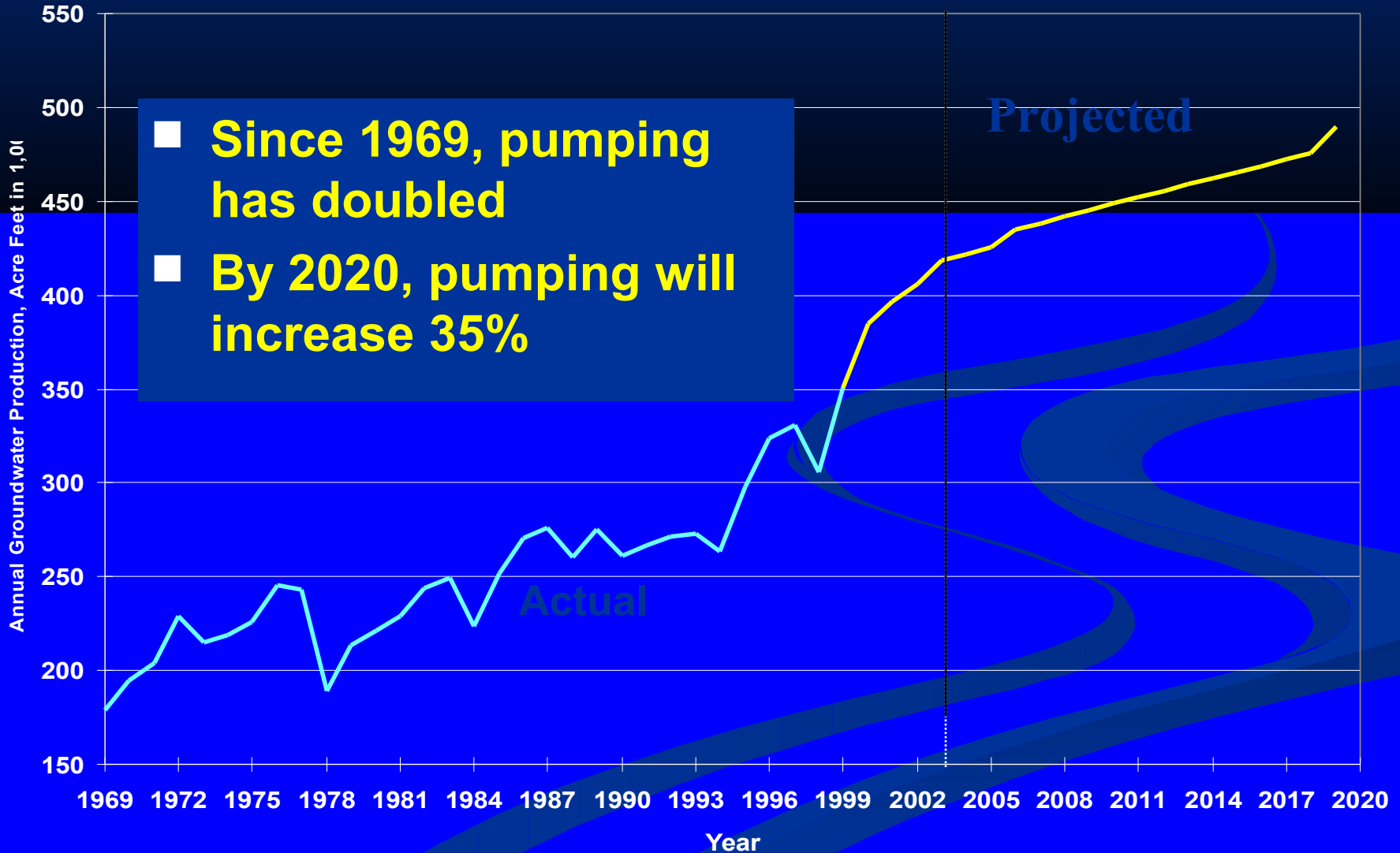




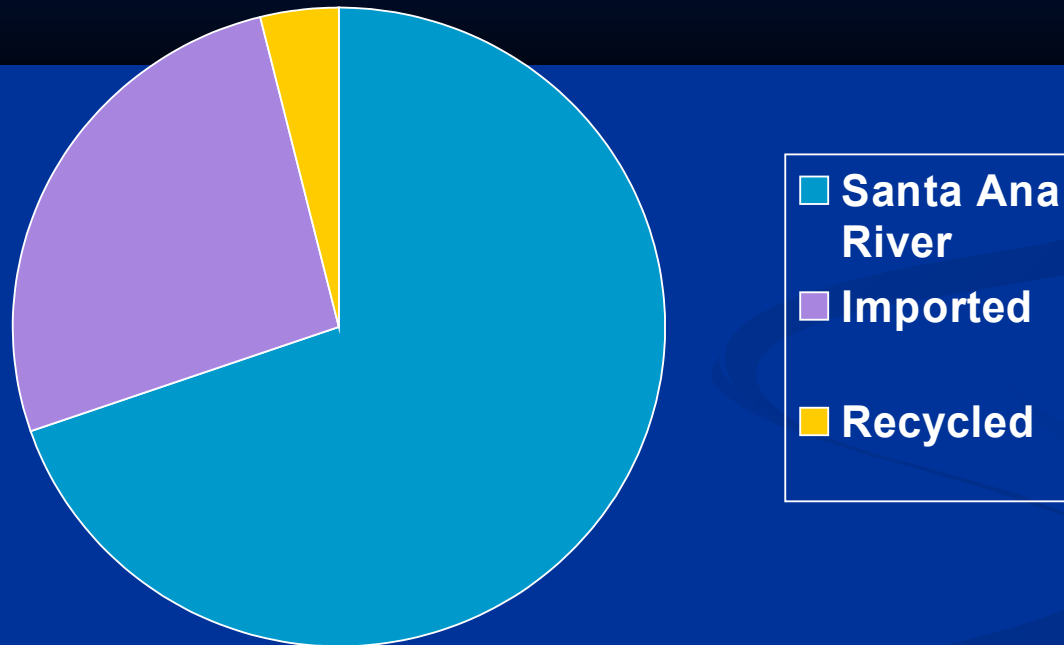
Thank You.

END OF PRESENTATION

Groundwater Provides 75% of Total Water Use



Sources of Recharge Water ... The Santa Ana River is the Largest



Base Flow is High in Nutrient Content

- Nitrogen (N) 6-10 mg/L
- BOD 5-12 mg/L
- Suspended Solids 26-118 mg/L
- Total Dissolved Solids 625 mg/L

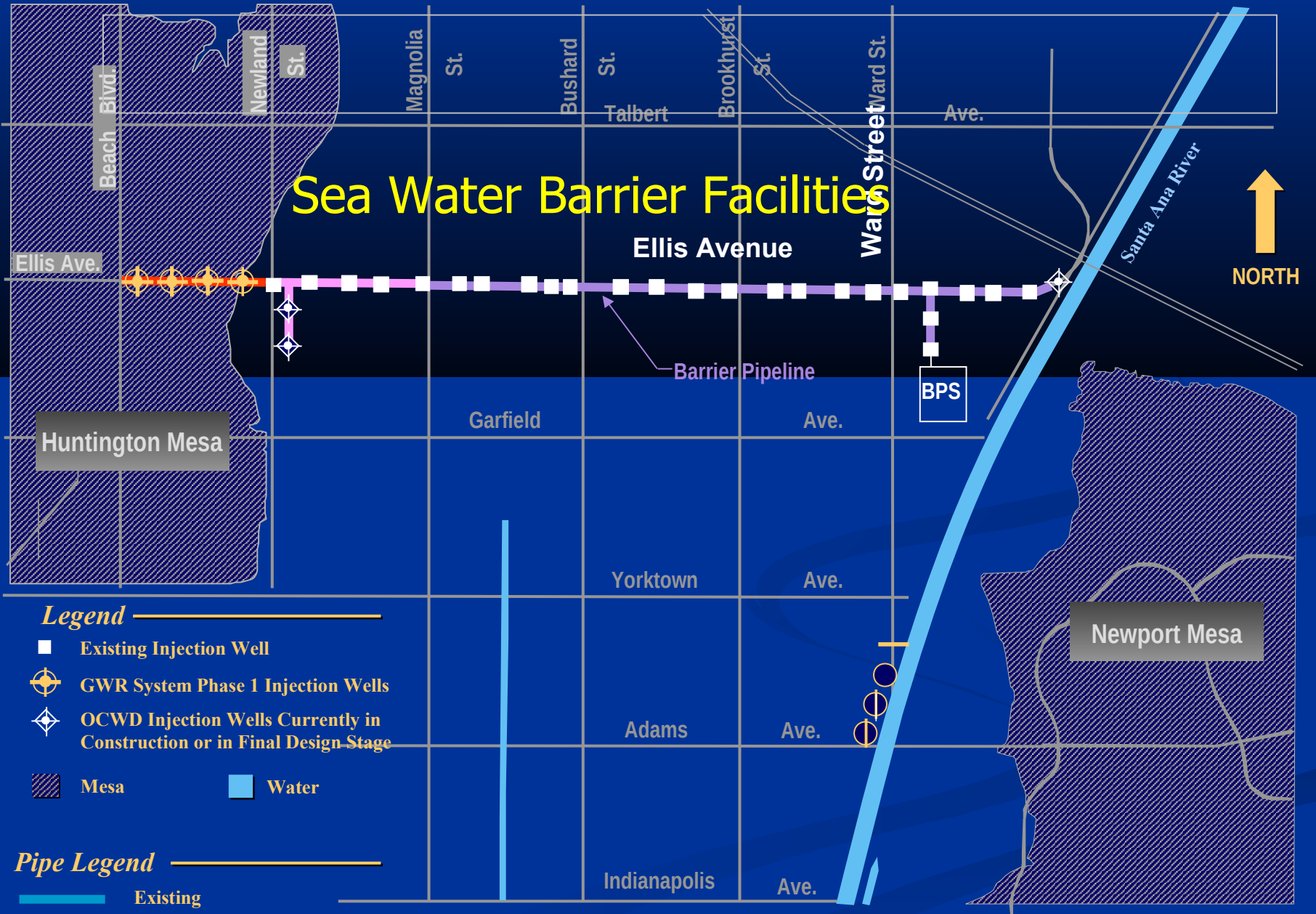
Imported Water for Groundwater Recharge

- Mainly from the Colorado River
- 2,400 Mm³ since 1954
- Annual 60-120 Mm³
- Low in Nutrients and Suspended Solids: 0.8-2.8 mg/L
- Recharge at Highest Rates
- No Co-Mingling with River Water

Recycled Water

- The OCWD Initiated Waste Water Recycling in 1975 to Provide a New Reliable Water Supply and a Source for a Sea Water Intrusion Barrier
- The Water Factory 21 was the First Recycling Plant to Provide an Indirect Potable Supply to a Drinking Water Aquifer

Sea Water Barrier Facilities



Legend

- Existing Injection Well
- ⊕ GWR System Phase 1 Injection Wells
- ⬠ OCWD Injection Wells Currently in Construction or in Final Design Stage
- ▨ Mesa
- Water

Pipe Legend

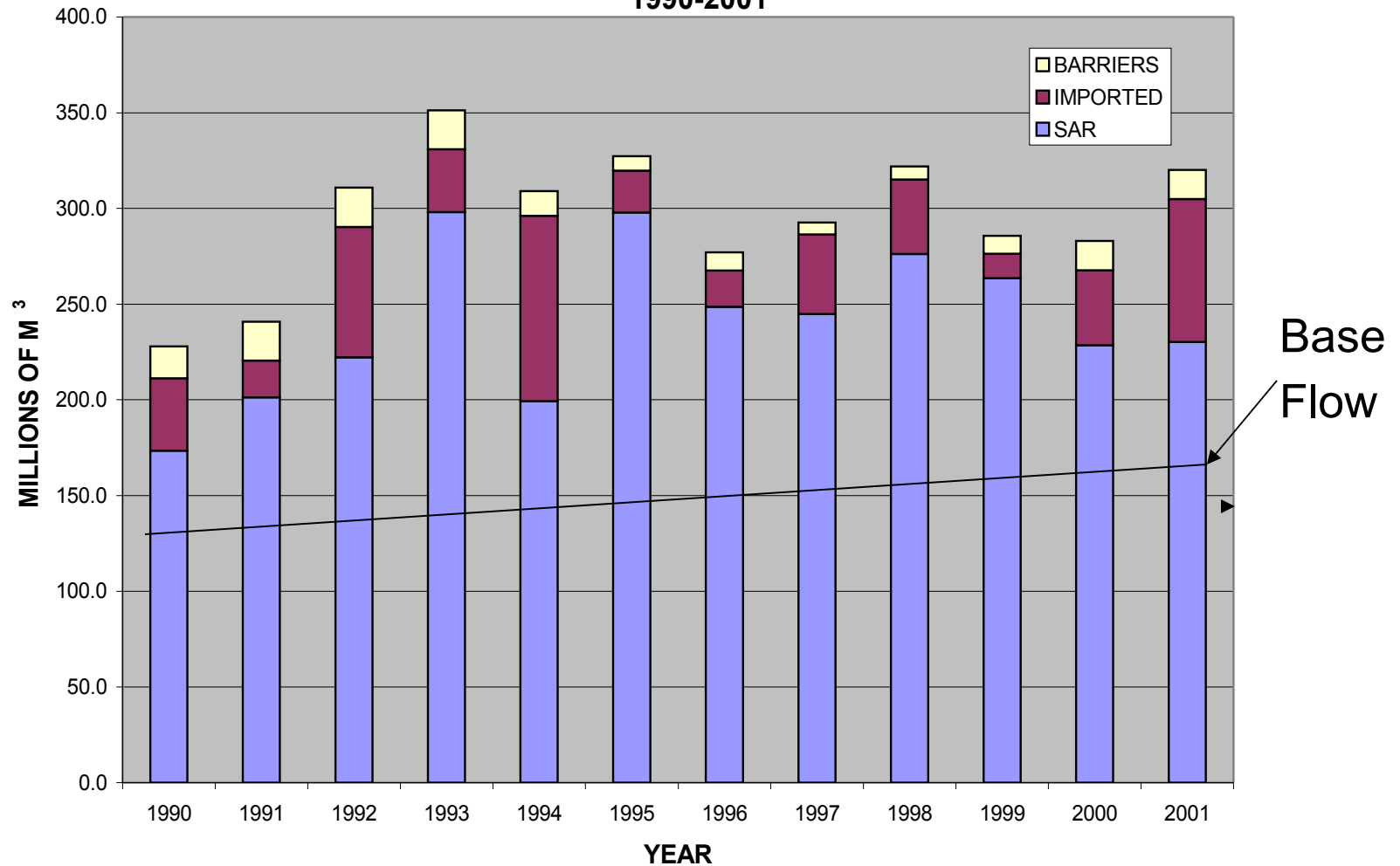
- Existing
- Phase 1
- Under Design for OCWD

Nutrient and Suspended Solids Content Varies with Source Waters

- Imported Waters
 - Low in Nutrients and Suspended Solids (SS)
- Santa Ana River- Base Flow Water
 - High in Nutrients; Moderate in SS
- Santa Ana Rivser - Storm Water
 - Low in Nutrients; High in SS
- Water Factory 21 Water
 - High in Nutrients; No SS

Since 1954 More than 7,000 Mm³ of Water have been Recharged

FIGURE 1
SOURCES OF ARTIFICIAL RECHARGE WATER
1990-2001

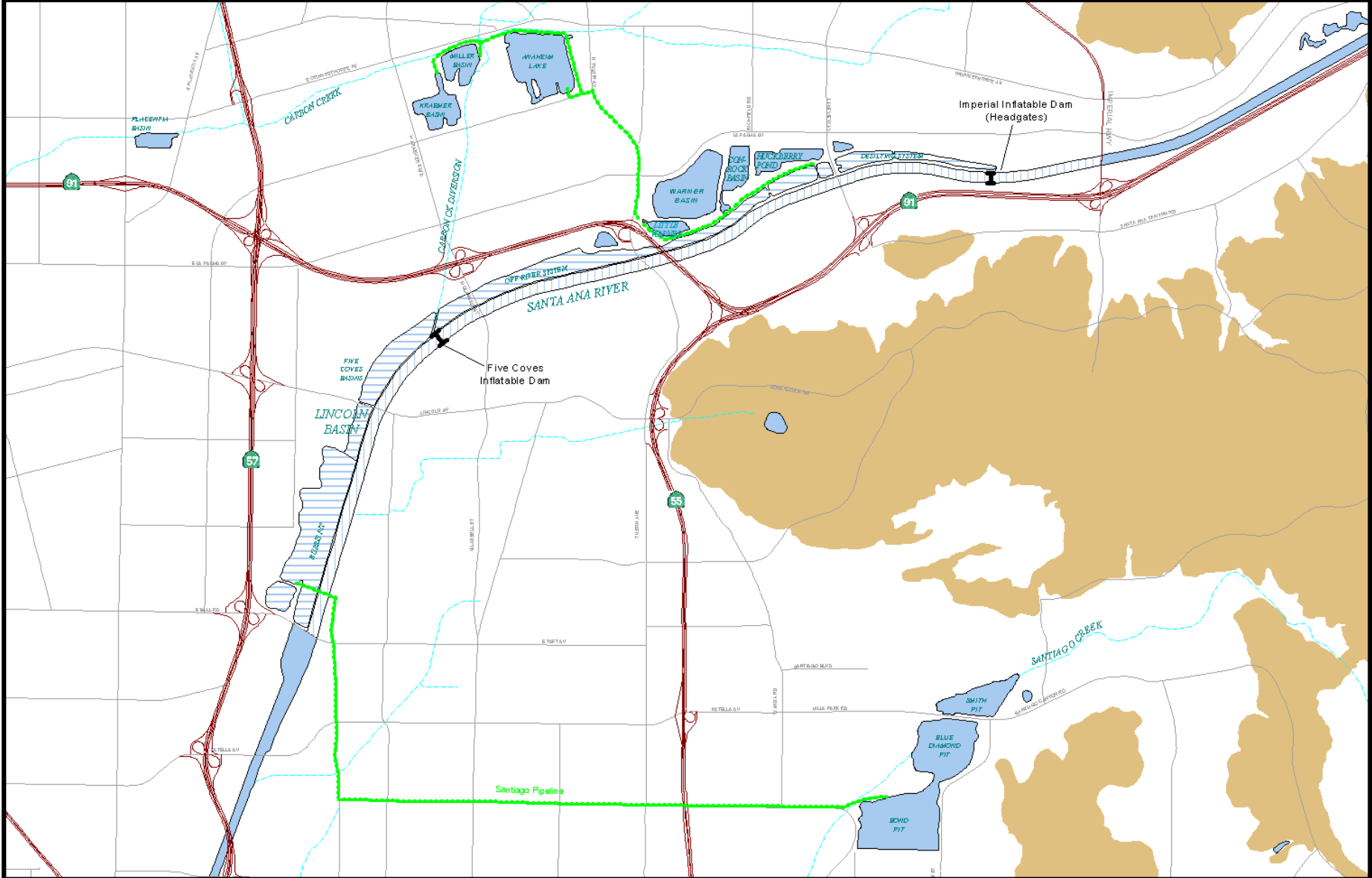





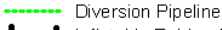


The Recharge System

Major Components of the Recharge System include:

- The Santa Ana River Channel
 - 11 km of T-Levees
- Desilting Basins
 - 5 Hrs Retention
- Deep Basins
 - ½ of Total Area
 - 25 Mm³ of Storage Volume

**Santa Ana River Channel is Divided
into an Active Flood Channel (100
Ha) and a Water Conservation
Channel (63 Ha)**



-  On River Recharge Area
-  Off River Recharge Area
-  Deep Basin Recharge Area
-  Diversion Pipeline
-  Non-Waterbearing Formation
-  Inflatable Rubber Dam



OCWD Recharge Facilities



Deep Basins

- Area- 200 Ha
- Slopes- 3:1
- Excavated for Sand and Gravel Mining
- Depth- 15 M
- Volume- 25 Mm³
- Dewatering/Piping System

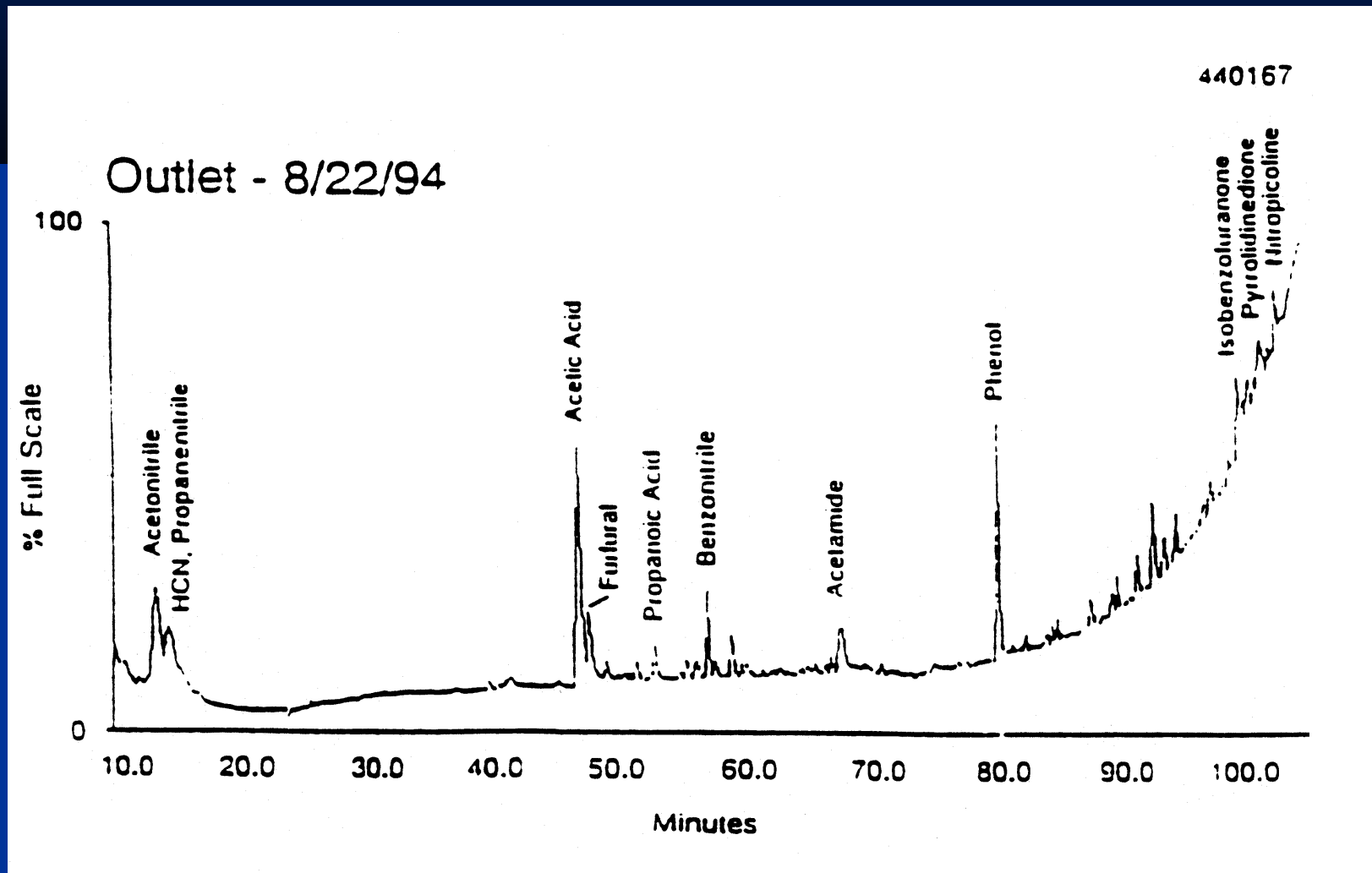
Deep Basin Clogging

- High Initial Infiltration Rates
- Rates Decline to $\frac{1}{2}$ of Initial Rate in 90-120 days
- Cleaning requires Dewatering, Draining and Scraping of Clogging Layer
- Once a Year
- Installation of High Capacity Pumps Allow Twice a Year Cleaning, Providing 40% more Annual Recharge

OCWD Wetlands at Prado Basin

- Largest Constructed Freshwater Wetlands on the West Coast, covering about 200 Ha - Construction in 1996
- Diverts 50% of Santa Ana River Water for Treatment
- Removes Large Amounts of Nitrates (~360 tons/year) from River Water to Levels Below Detection
- Long-term Goal to Provide Wetlands Treatment to All Santa Ana River Base Flows

Pyrogram of Prado Wetlands Effluent



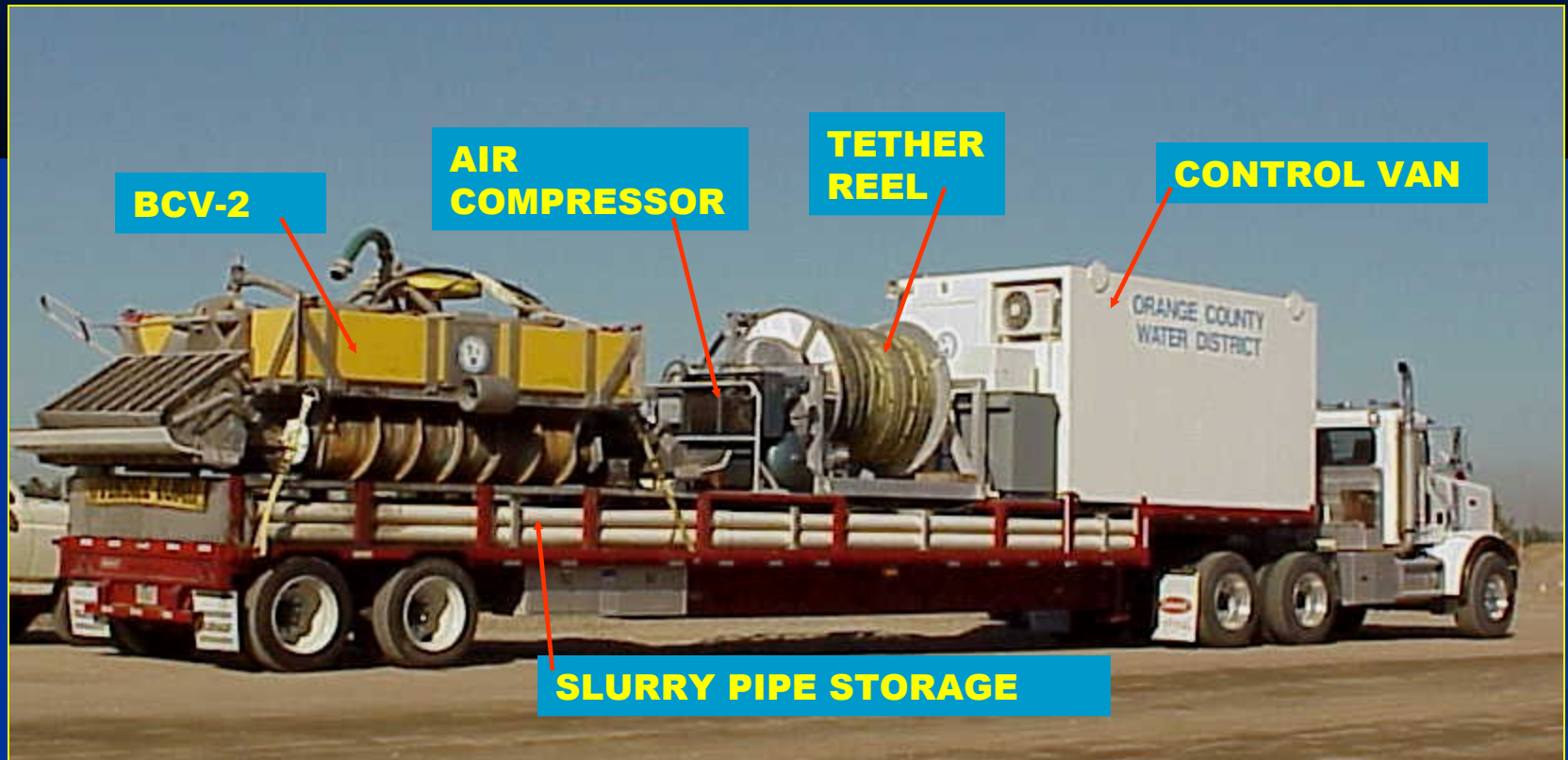
Continuous Cleaning as a Strategy

- Dewatering, Drying and Scraping Allowed only Once or Twice a Year Cleaning
- Continuous Cleaning Could Provide as much as 50% more Annual Recharge

The Basin Cleaning Vehicle (BCV) was Designed to Provide Continuous Cleaning, thus Avoiding the Dewatering and Mechanical Cleaning

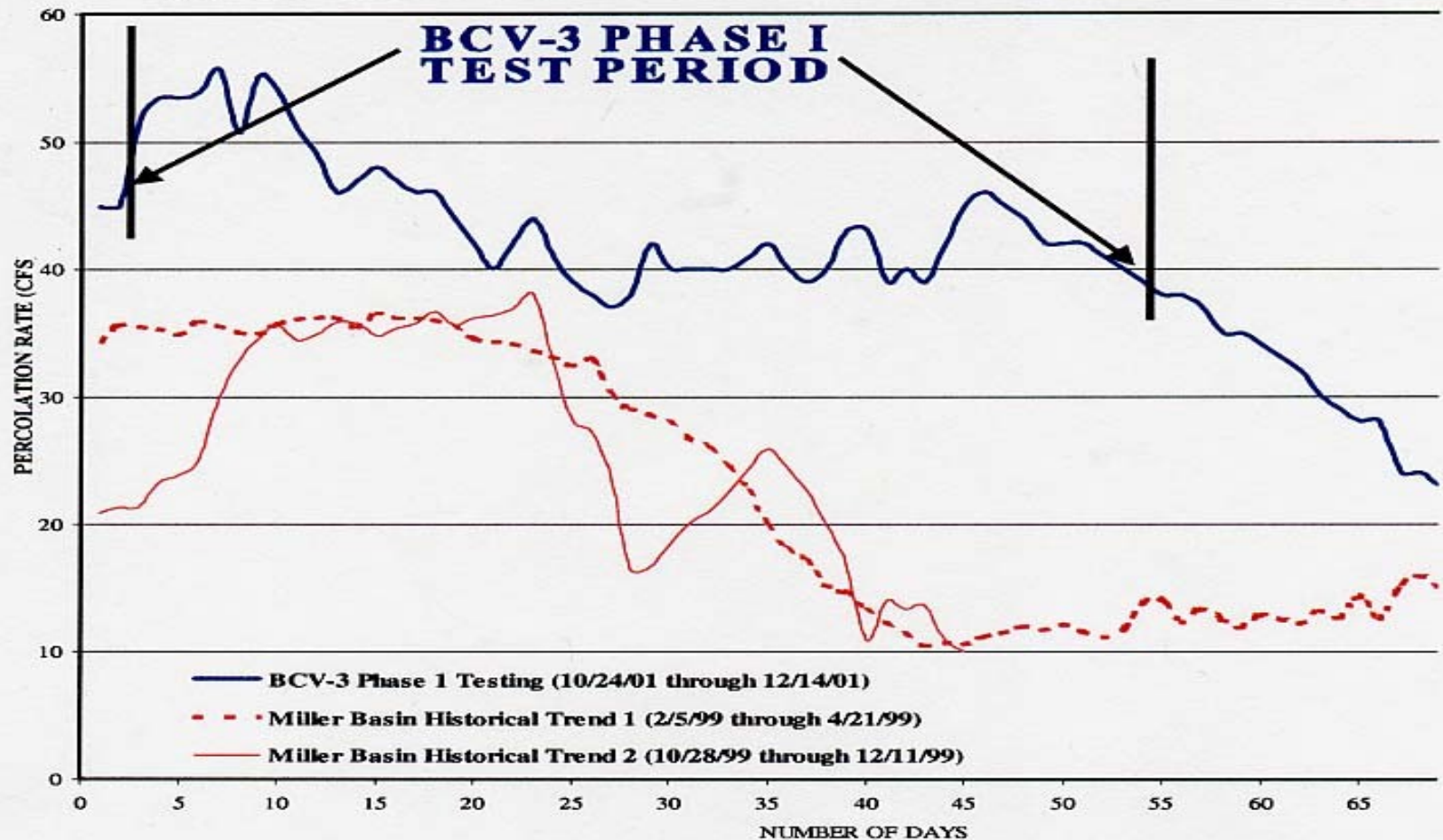


The BCV is Equipped with Support System and Designed for Automatic Operation



BCV Testing Maintained Percolation Rates

Figure 1c - IMPACT OF BCV-3 OPERATION ON PERCOLATION RATE AT THE MILLER BASIN



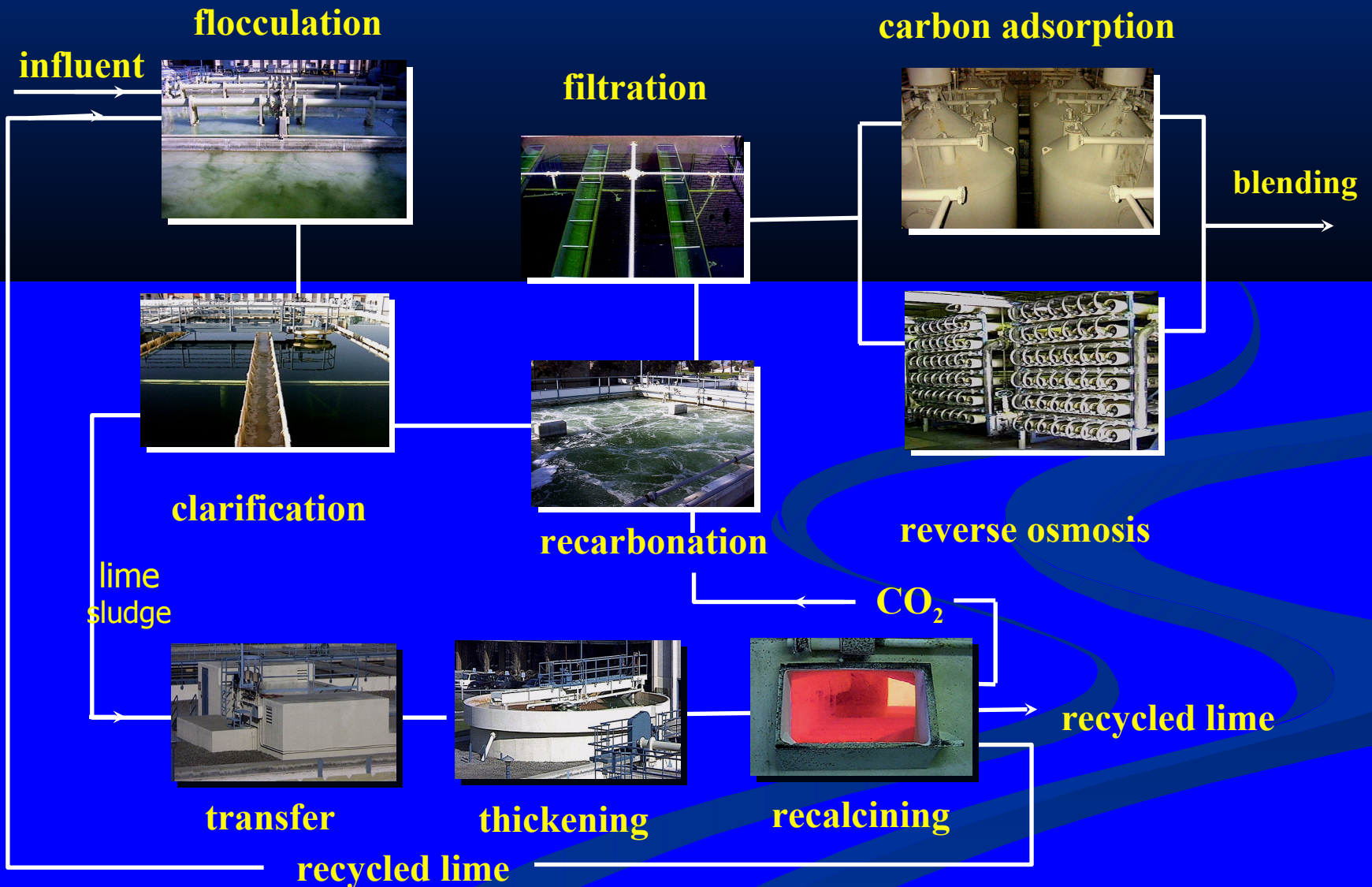
The BCV after a Hard Days Work



GWRS Treatment Technologies will Incorporate All Advances Since WF 21



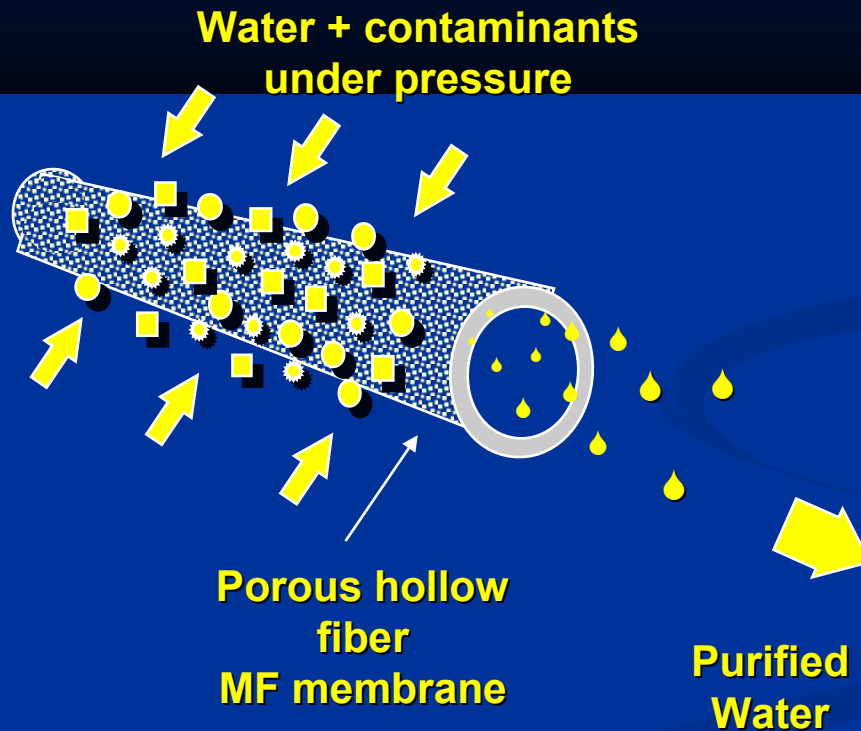
Water Factory 21



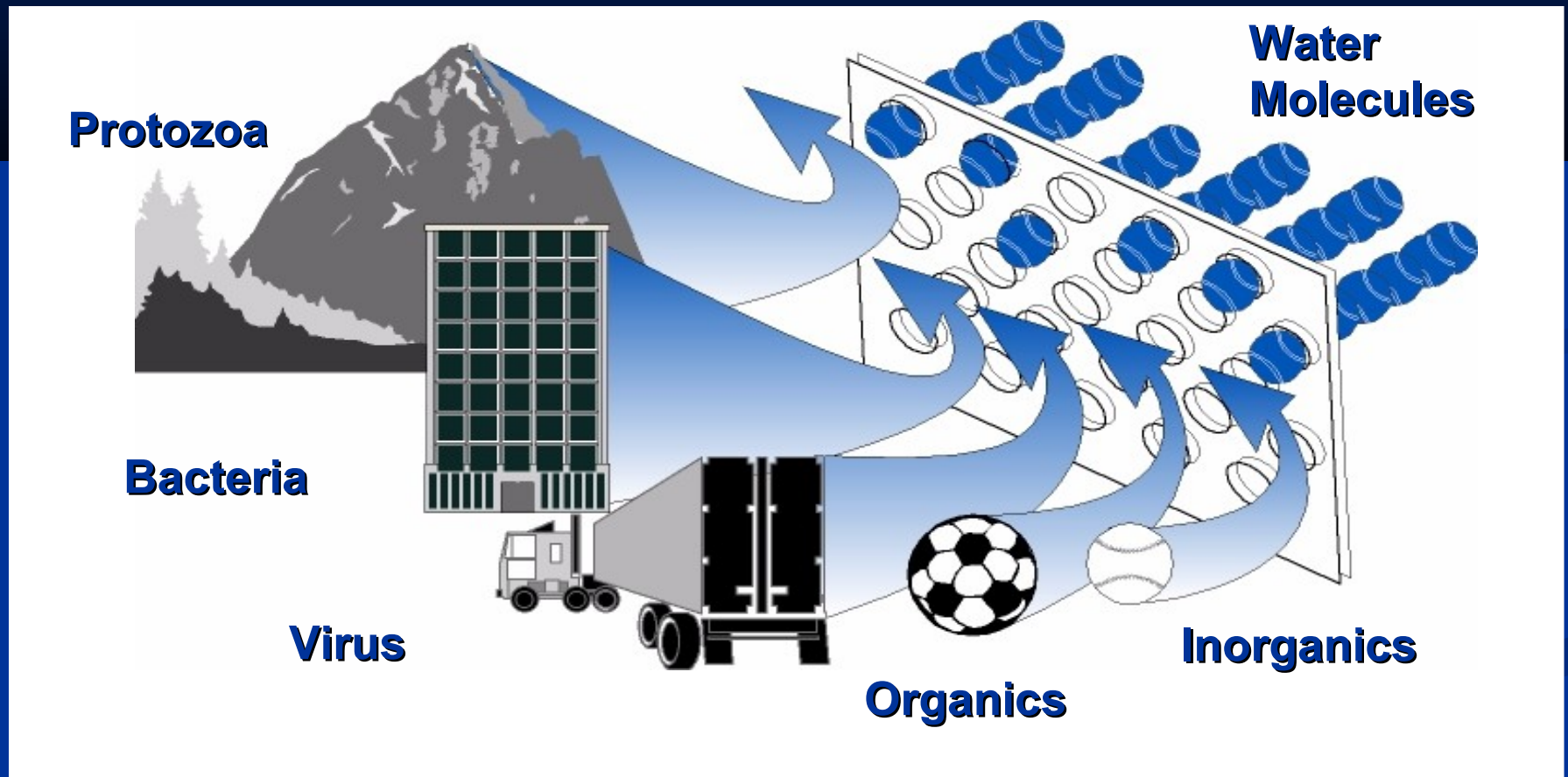
The Groundwater Replenishment System (GWRS)

A New High Quality Water Supply

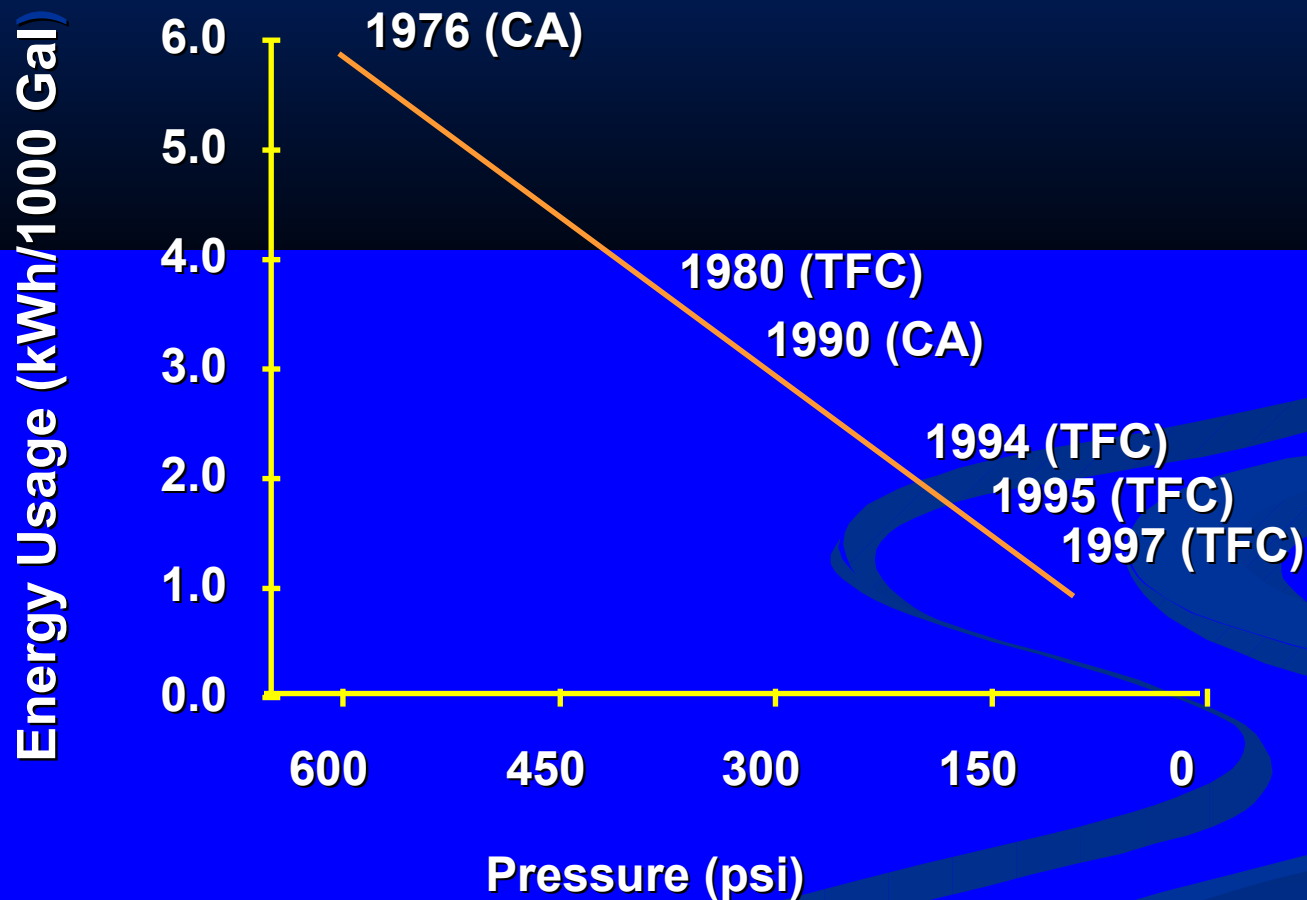
Microfiltration is an Effective Replacement for the High Lime Process



RO Membrane Is Like a Microscopic Strainer - Allows Only Water Molecules to Pass – All Water Treated by RO



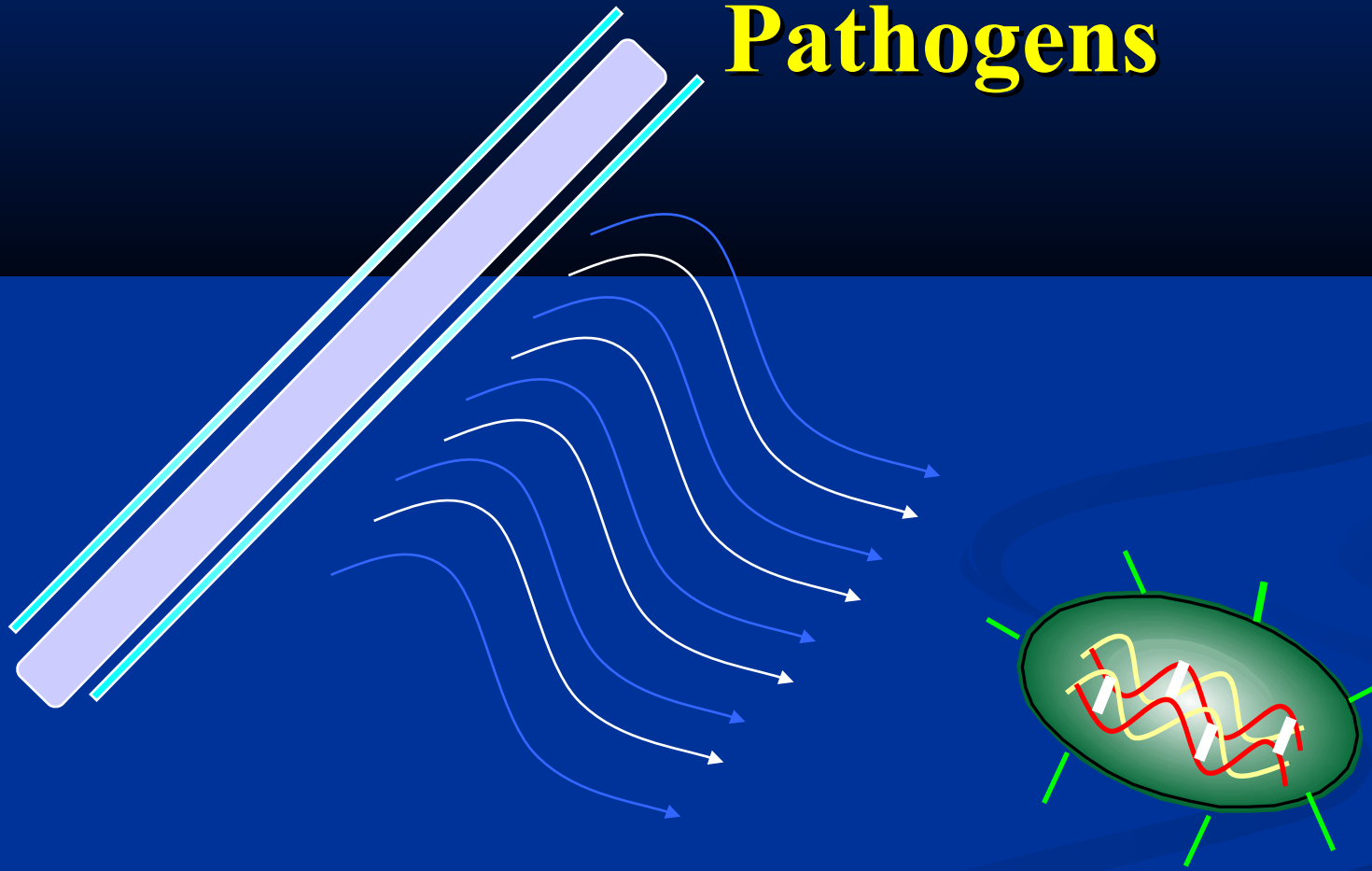
Water Factory has Led to Membrane Technology Improvements



Cellulose Acetate (CA)


Thin Film Composite (TFC)

Ultraviolet Light Disinfects through Destruction of Genetic Material of Pathogens

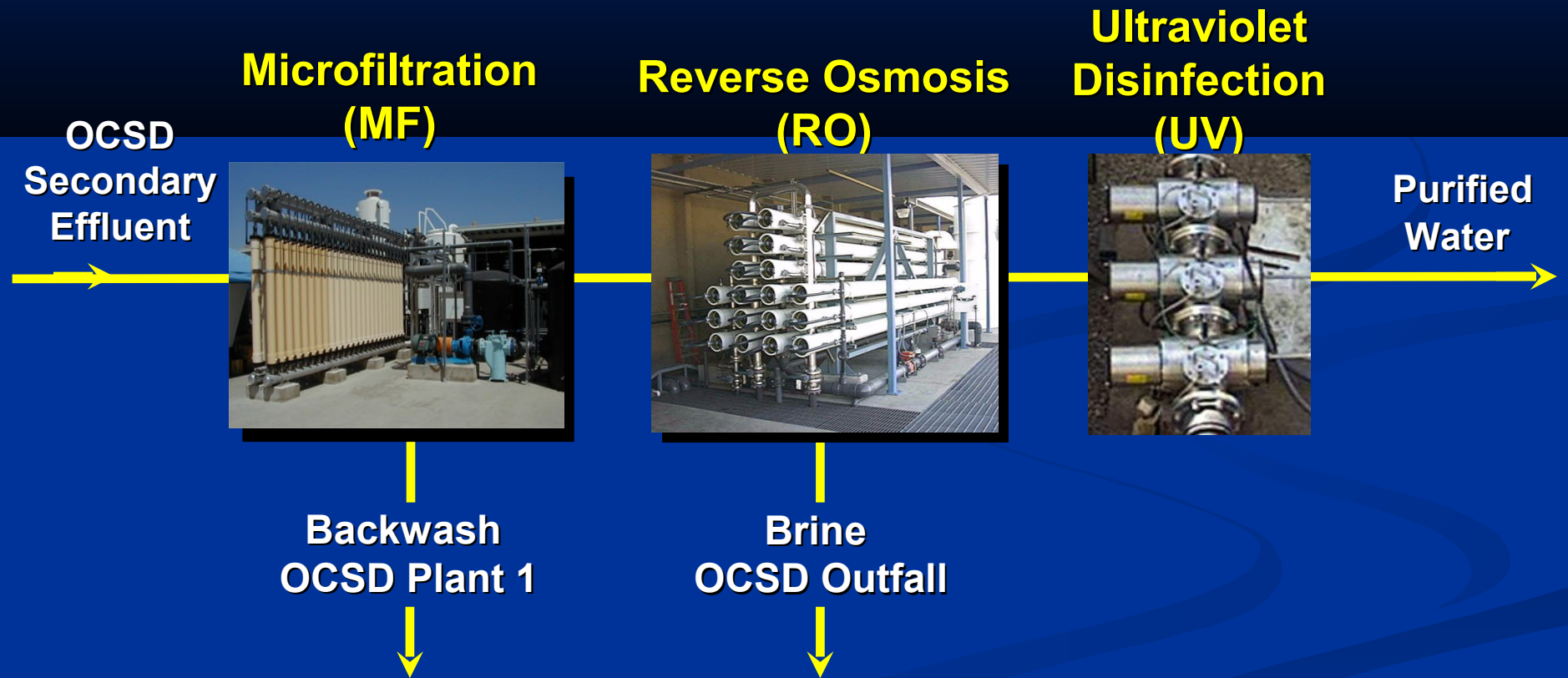


UV is Also Effective in Removing Trace Organics
and Possibly PhACs

Permitting Concerns

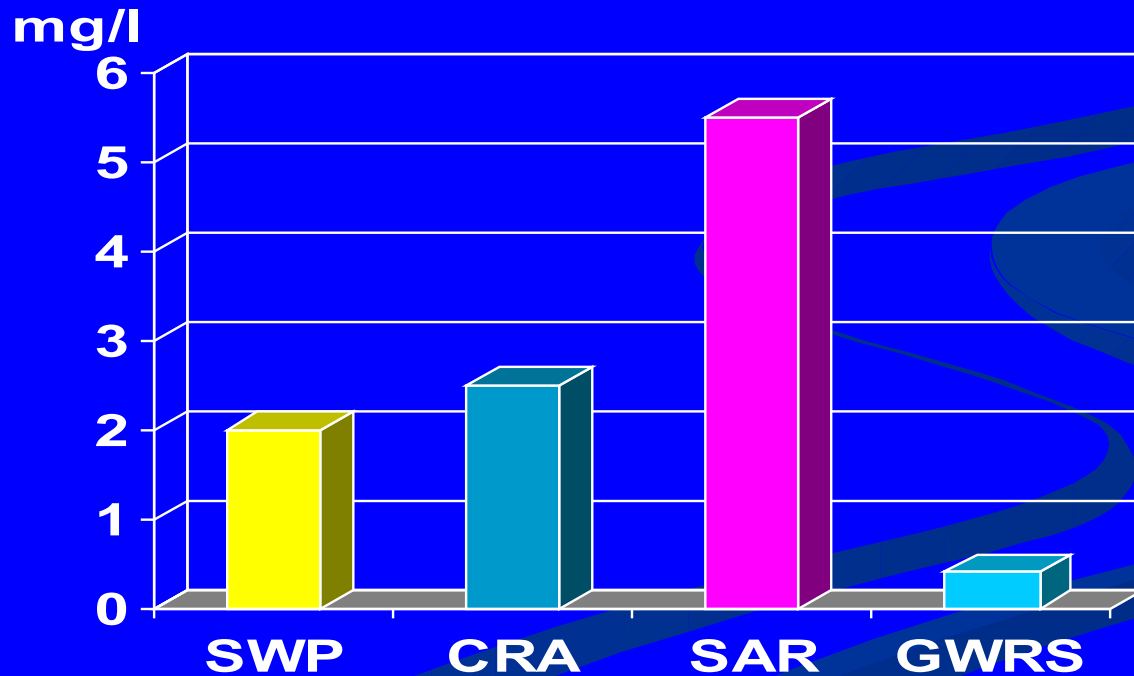
- California Department of Health has Jurisdiction over Potable Reuse Projects
 - Primary Concerns:
 - Waste Water Origin of Santa Ana River
 - Viral Transport
 - Dissolved Organic Content
 - Elimination of Blending
- 

GWR System Advanced Water Treatment Flow Diagram

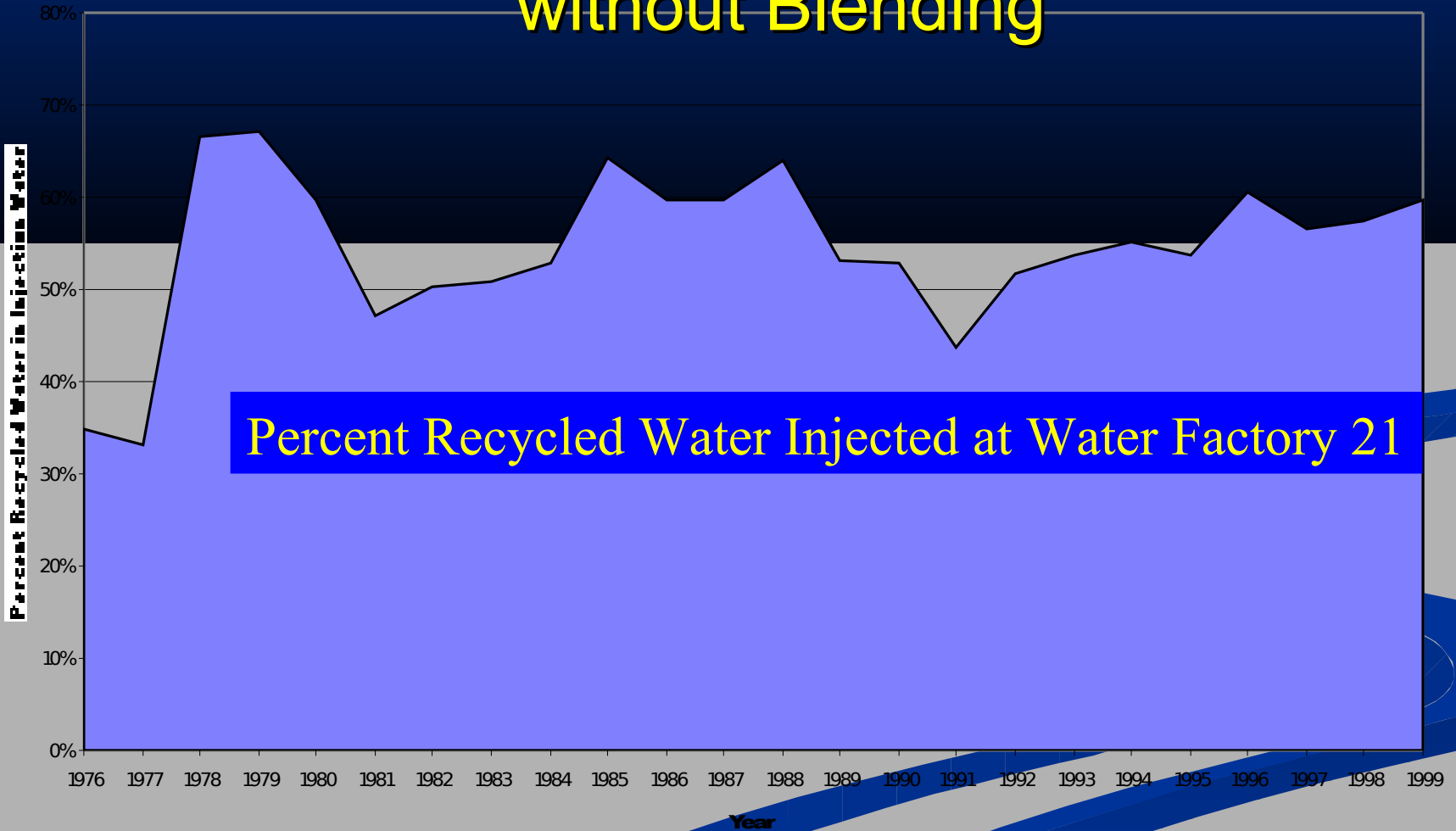


GWRS Produces Lowest Organic Content Water

Total Organic Compounds



The GWRS is Proposed to Inject without Blending



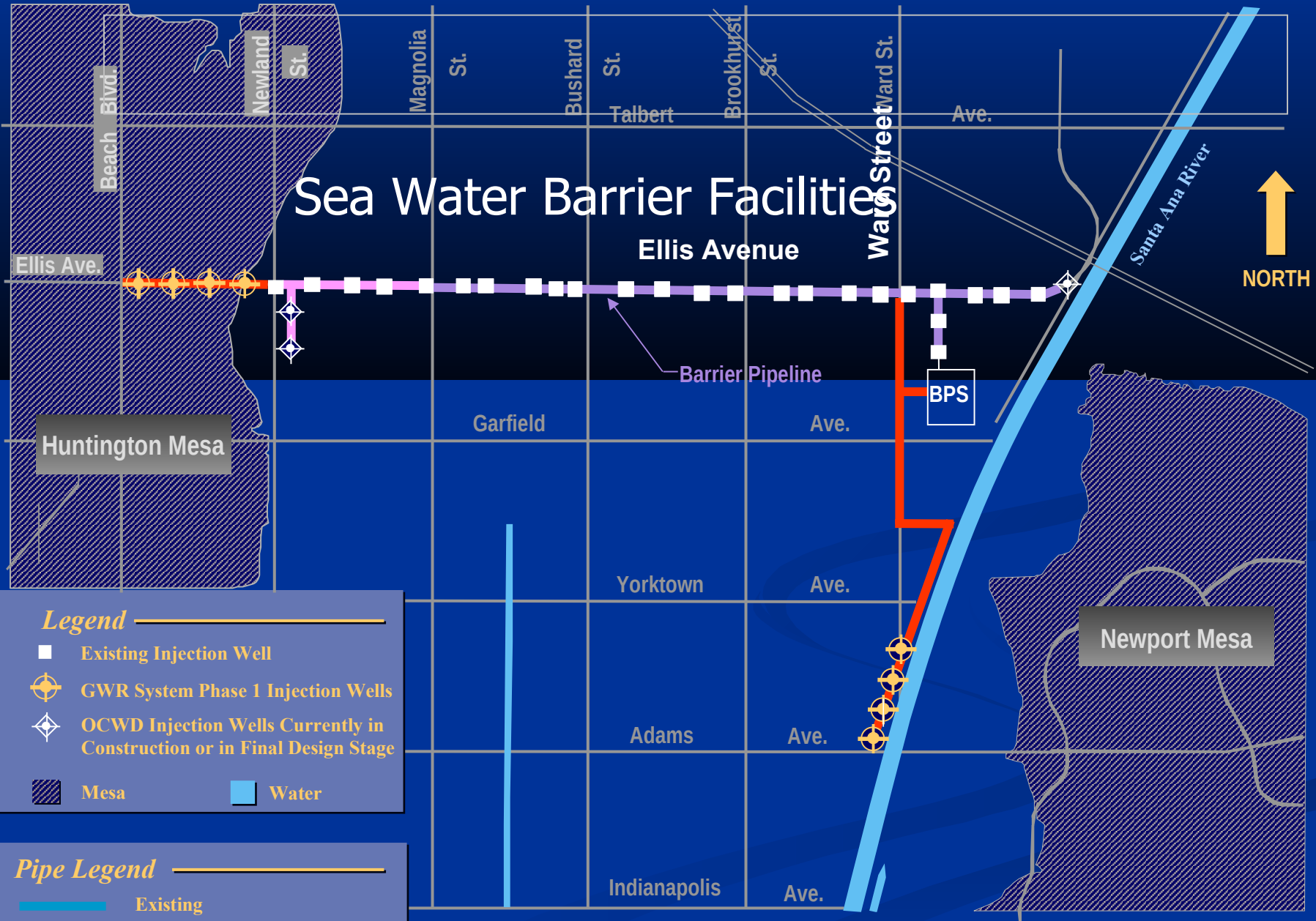
Project Approval Conditions

- Forebay Spreading
 - All RO Water/Adequate Dilution
- Costal Injection – Phased Approach
 - 0.5 mg/L TOC
 - Initial 75/25 Blend
 - 14 Month Monitoring Period
 - No Public Health Concerns, then % increase
 - TIC Analyses

Concluding Remarks

- What Is the Sustainability of the District's Recharge System?
- Will Nutrient Reduction and Continuous Cleaning of the Deep Basins be Sufficient to Maintain the Recharge Rates of the System?
- Will the GWRS and Its' Exceptional Water Quality Help Sustain the Recharge Rates?

Sea Water Barrier Facilities



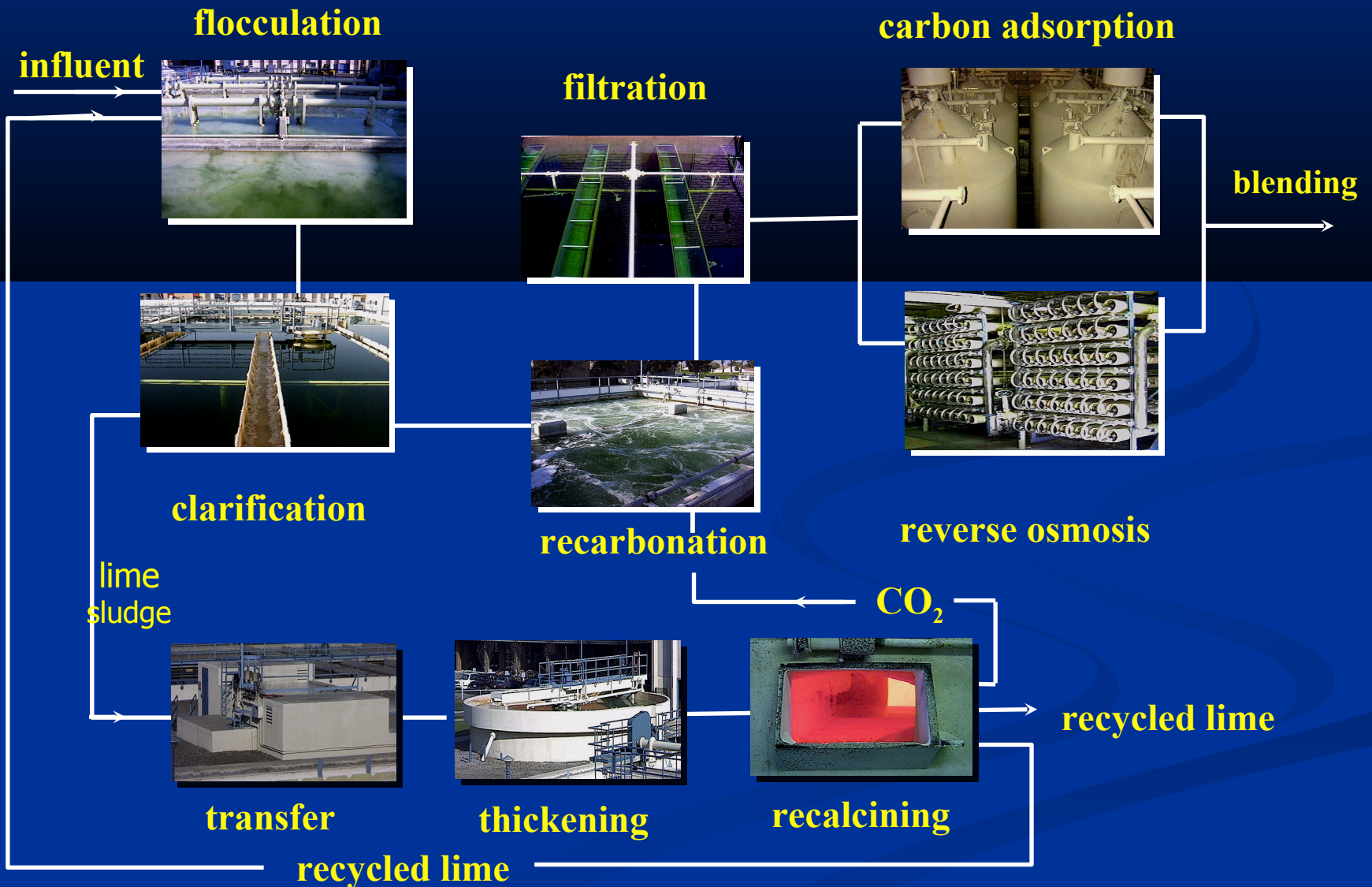
Legend

- Existing Injection Well
- ⊕ GWR System Phase 1 Injection Wells
- ⊕ OCWD Injection Wells Currently in Construction or in Final Design Stage
- ▨ Mesa
- Water

Pipe Legend

- Existing
- Phase 1
- Under Design for OCWD

Water Factory 21



Research behind the Project

- Microfiltration as a Replacement for the High Lime Process
- Underground Retention and Travel Times
- Membrane Advancements
- Contaminants of Concern

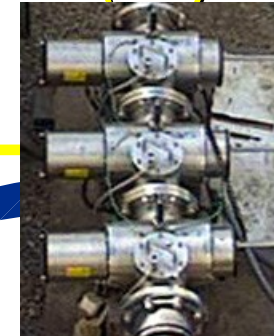
GWR System Advanced Water Treatment Flow Diagram

**Microfiltration
(MF)**

**Reverse Osmosis
(RO)**

**Ultraviolet
Disinfection
(UV)**

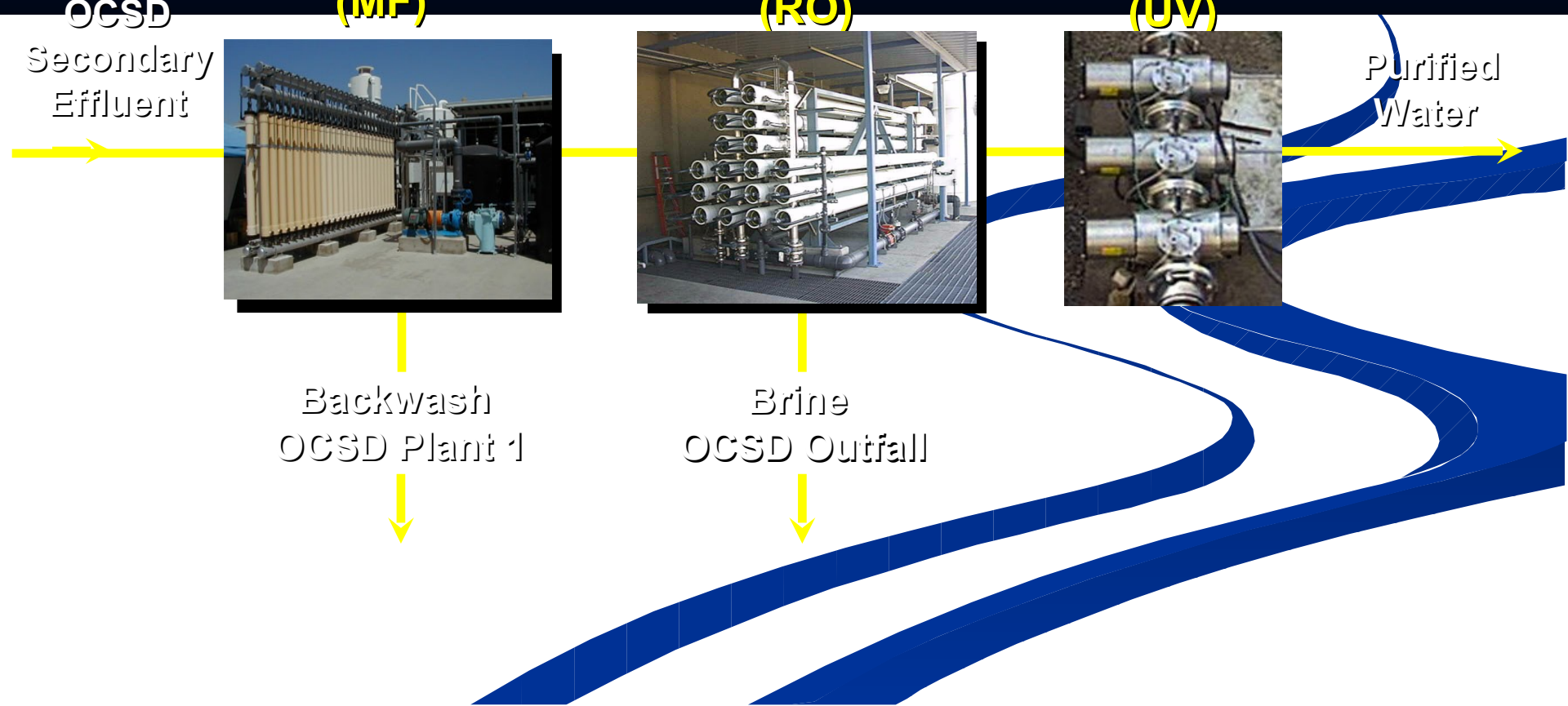
OCSD
Secondary
Effluent



Purified
Water

Backwash
OCSD Plant 1

Brine
OCSD Outfall



The GWR System Has Multiple Components



The GWR System Has Multiple Components



Future Water Shortages are Predicted

- Reliability of imported water challenged by legal, environmental and population

es

ge population increases in the future

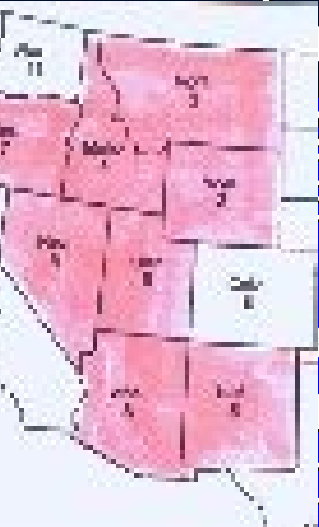
By 2020 — Southern California: 7 million

California: 15 million

ess creative solutions are found,
re will be shortages by 2020

Orange County predicts 150,000 acre-feet
short

- CA Department of Water Resources predicts 2-4 million acre-feet short

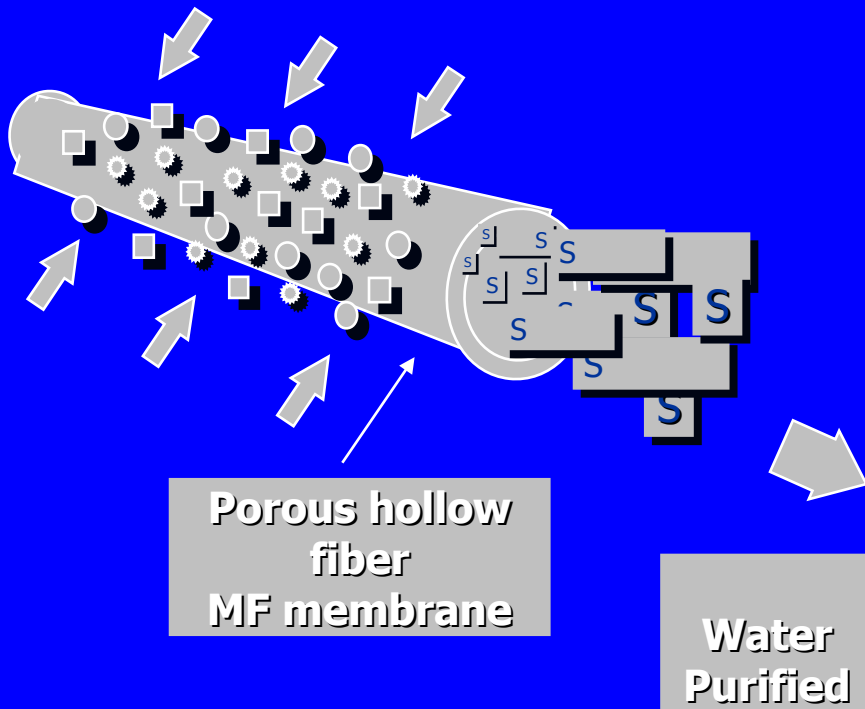


Extensive Studies Indicated that a large scale reclamation Project would meet future Challenges

- Three-phased project; first phase 80 mgd
- Uses reliable, proven high tech processes to purify treated wastewater
- Protects groundwater from seawater intrusion
- Improves quality of groundwater
- Provides safe and reliable water supply for 200,000 families
- Helps defer building another ocean outfall

Microfiltration was Found an Effective Substitute for the High Lime Process

Water + contaminants under pressure



- Less energy
- Less labor
- More flux through RO membranes
- Considerable cost reduction

GWRS Treatment Technologies will Incorporate all advances since WF 21



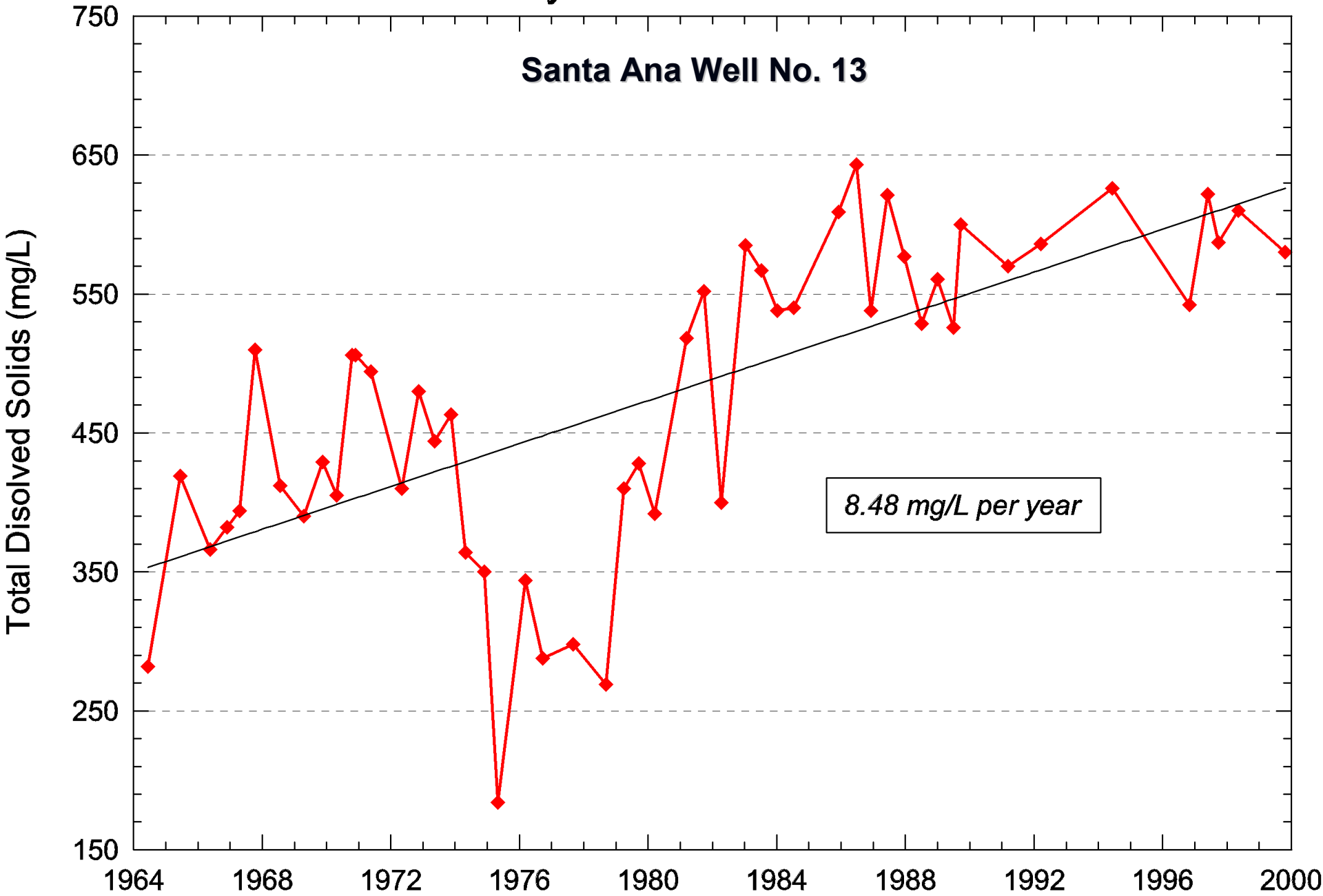
Basin Cleaning Vehicle



**NEW FIRM WATER
SUPPLIES OF LOW
SALINITY ARE NEEDED**

The background is a solid blue color. In the lower right quadrant, there is a decorative graphic consisting of several overlapping, wavy, dark blue lines that create a sense of movement or depth, resembling a stylized wave or a series of curved paths.

Groundwater quality is very good, but salinity increases are a concern



Extensive Studies Indicated that a large scale reclamation Project would meet future Challenges

- Three-phased project; first phase 300 ML/d
- Uses reliable, proven high tech processes to purify treated wastewater
- Protects groundwater from seawater intrusion
- Improves quality of groundwater
- Provides safe and reliable water supply for 200,000 families
- Helps defer building another ocean outfall

The GWR System Has Multiple Components



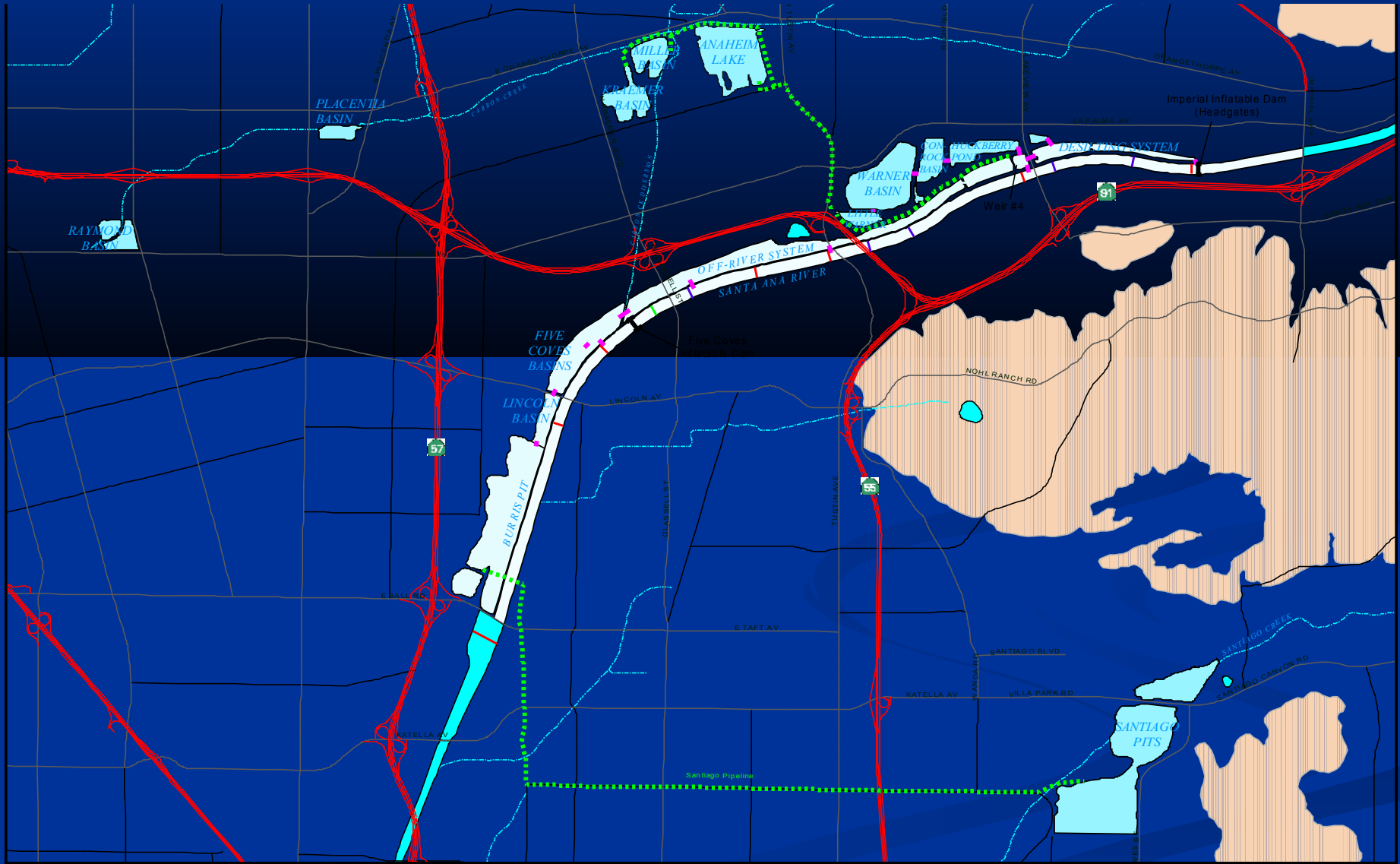
Natural Recharge Enhanced Through Deep Spreading Basins



Natural Recharge Enhanced Through Deep Spreading Basins



Forebay Recharge Facilities



Ultraviolet (UV) Doubles as Disinfectant and Destroyer of Contaminants of Concern



- NDMA eliminated
- 1,4 Dioxane eliminated, with peroxide addition

Utilizes Two Existing Recharge Basins

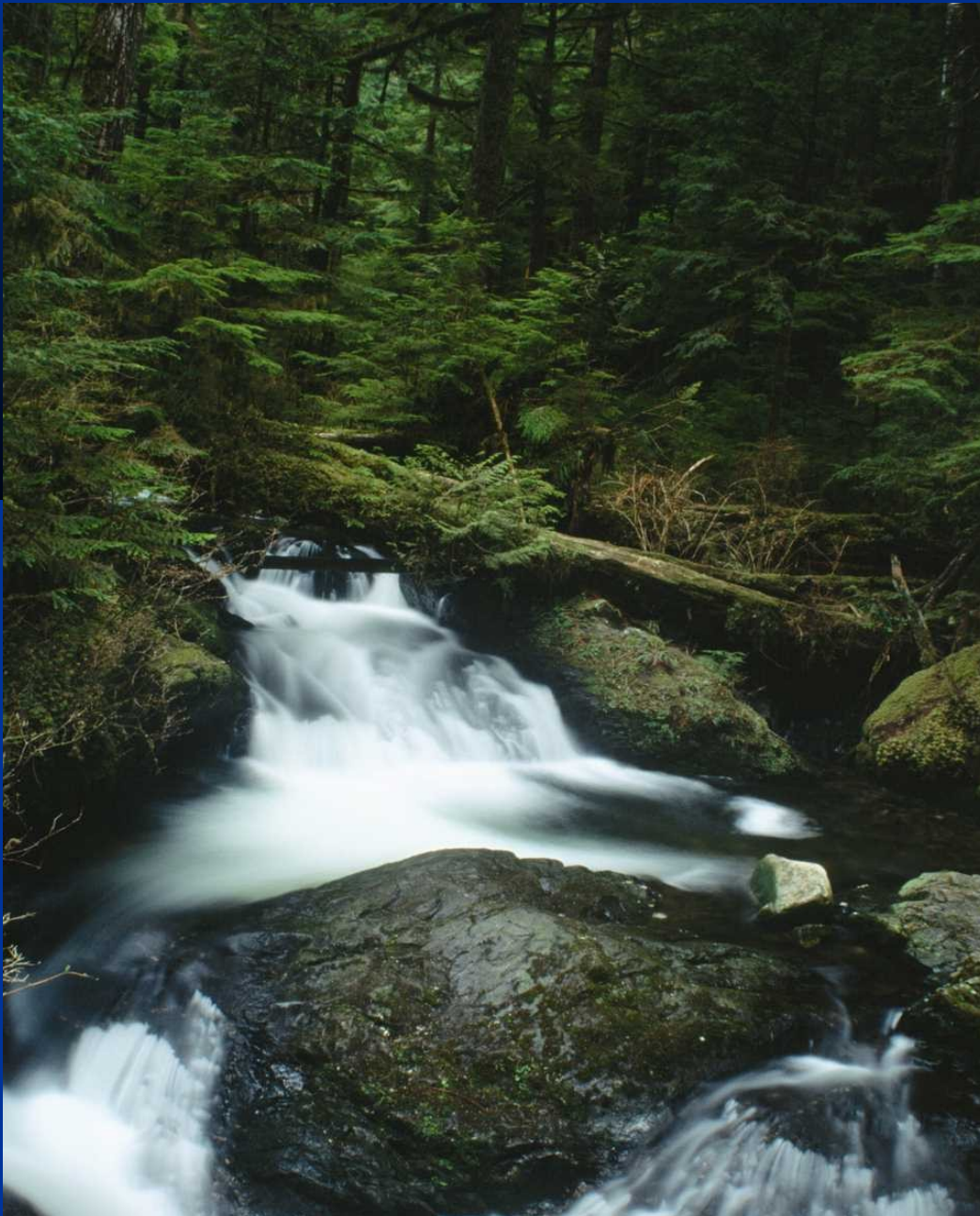
- Kraemer Basin has high, sustained recharge capacity
- Utilize Miller Basin during Kraemer Basin cleaning operations
- New pipelines to both Kraemer and Miller Basins





If there is
magic
on this
planet,
it is in water.

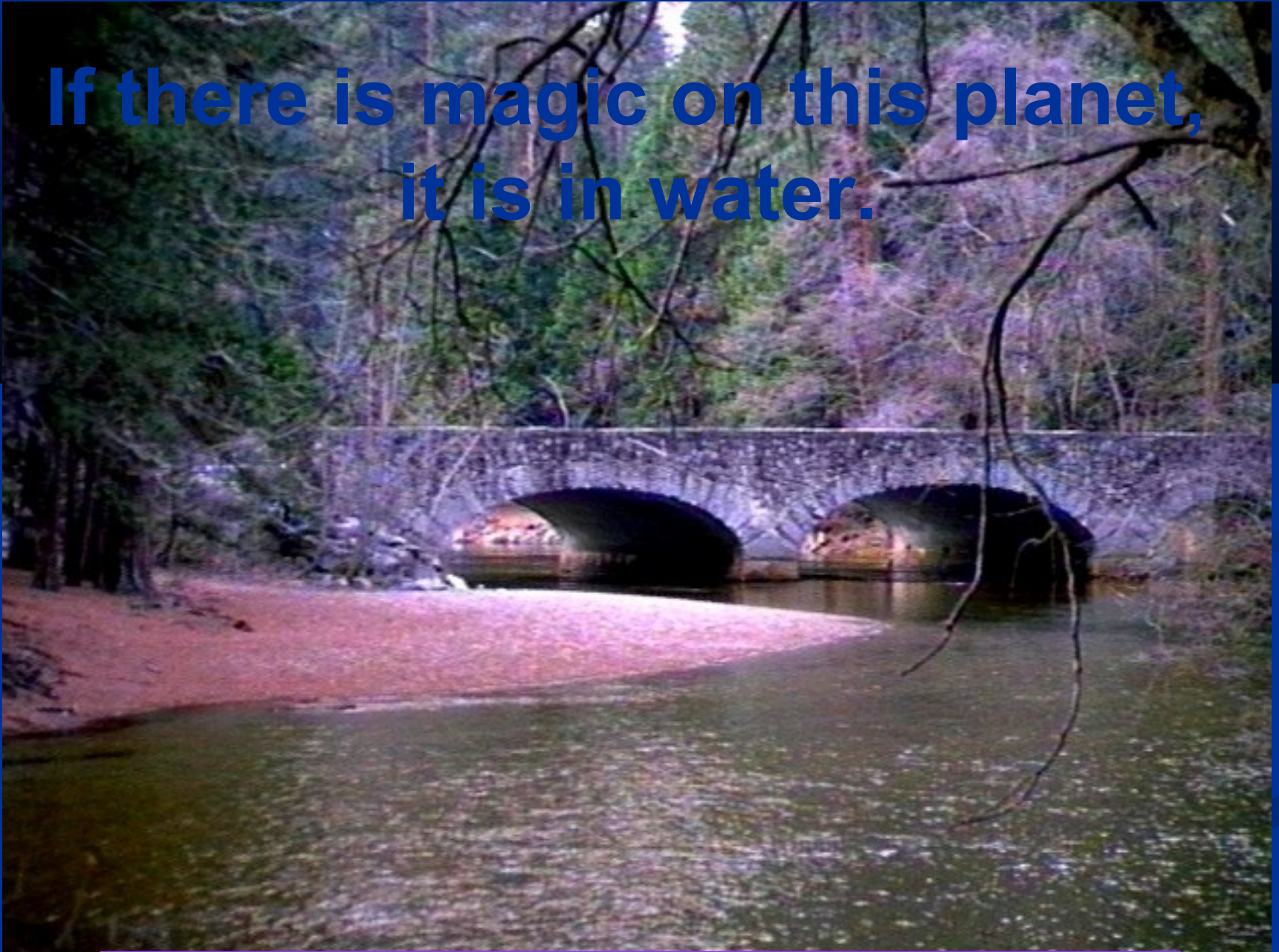
Loren Eiseley, "The Flow of the River,"
The Immense Journey



If there is
magic
on this
planet,
it is in water.

Loren Eiseley, "The Flow of the River," *The Immense Journey*

If there is magic on this planet,
it is in water.

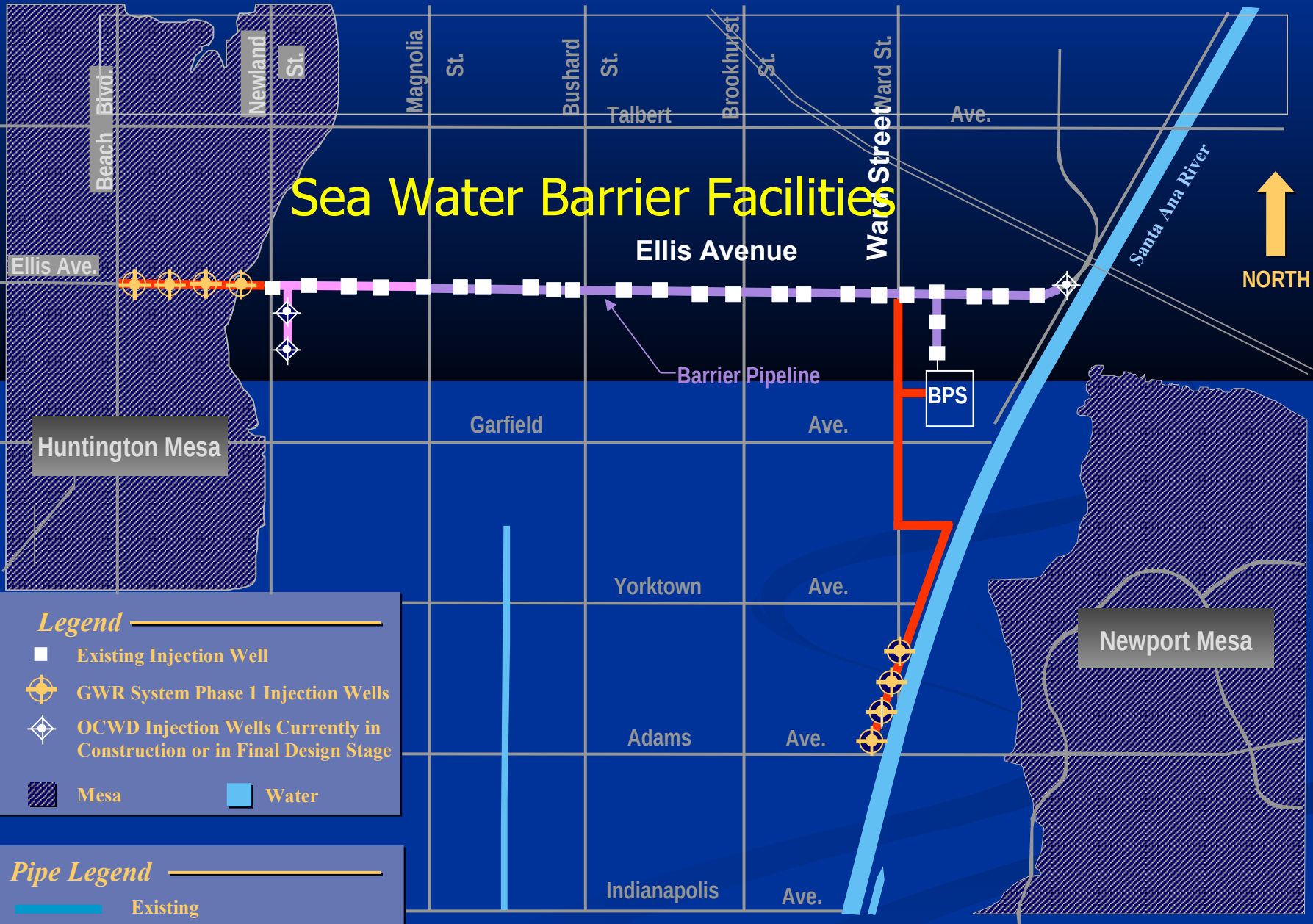


Loren Eiseley, "The Flow of the River," *The Immense Journey*

Basin Management

- **Only non-adjudicated basin in Southern California**
- **Basin managed by these tools:**
 - ✓ **Set level of groundwater use Basin Production Percentage (BPP) currently 75% of demand**
 - ✓ **Replenishment Assessment (RA)**
 - ✓ **Fee for going over 75% that makes cost of water equal to imported water**

Sea Water Barrier Facilities




Legend

- Existing Injection Well
- ⊕ GWR System Phase 1 Injection Wells
- ◇ OCWD Injection Wells Currently in Construction or in Final Design Stage
- ▨ Mesa
- Water

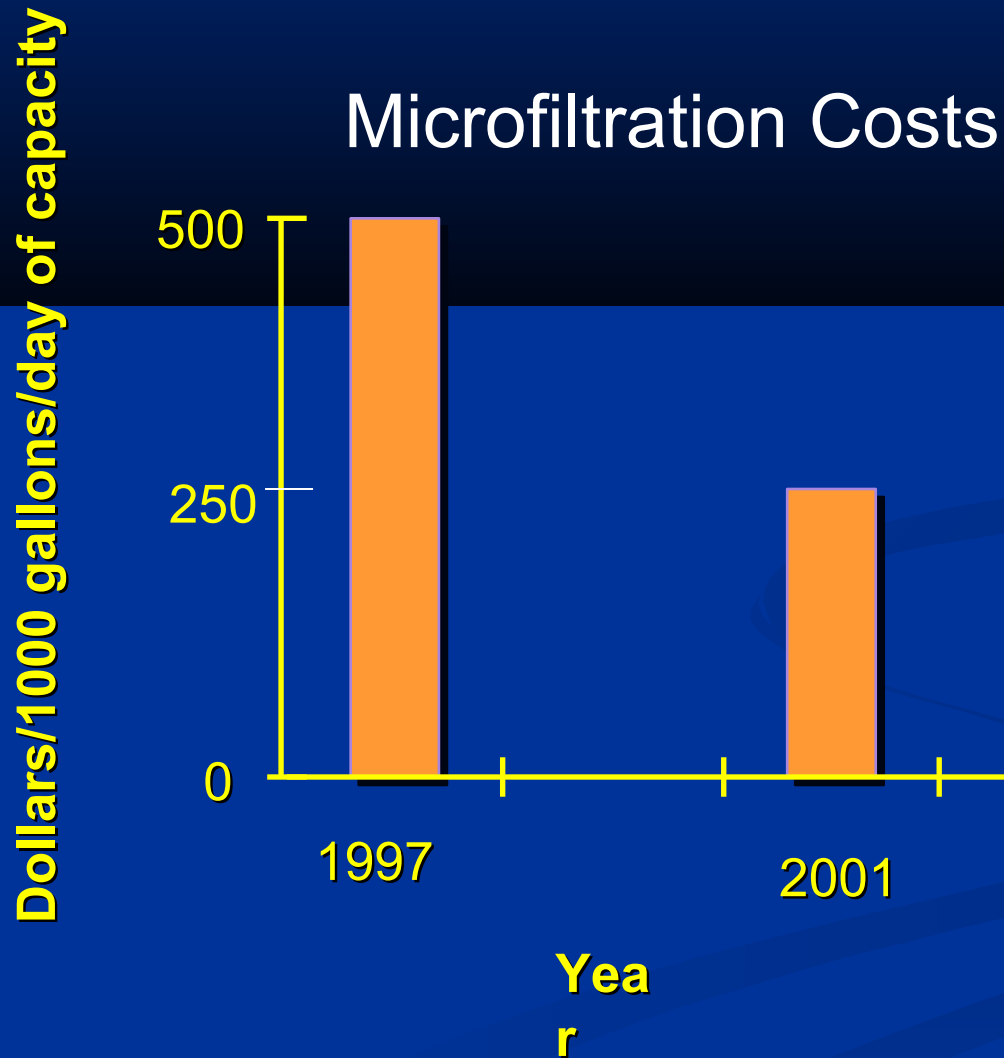
Pipe Legend

- Existing
- Phase 1
- Under Design for OCWD

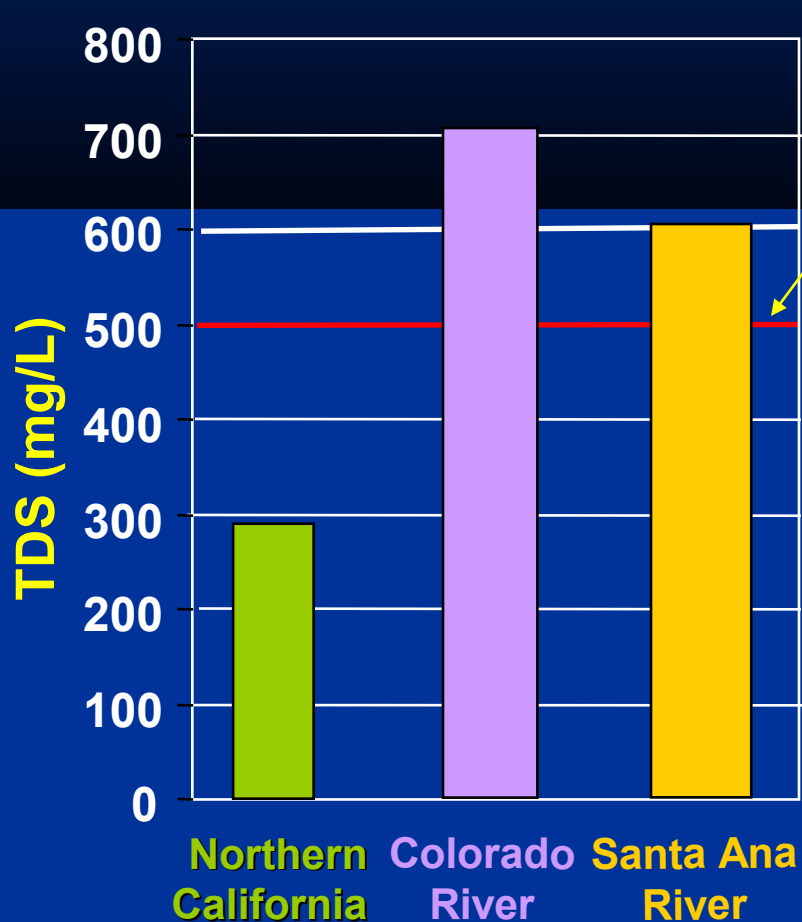
Research behind the Project

- Microfiltration as a Replacement for the High Lime Process
 - Underground Retention and Travel Times
 - Membrane Advancements
 - Contaminants of Concern
- 

The GWR System will drive down membrane filtration costs



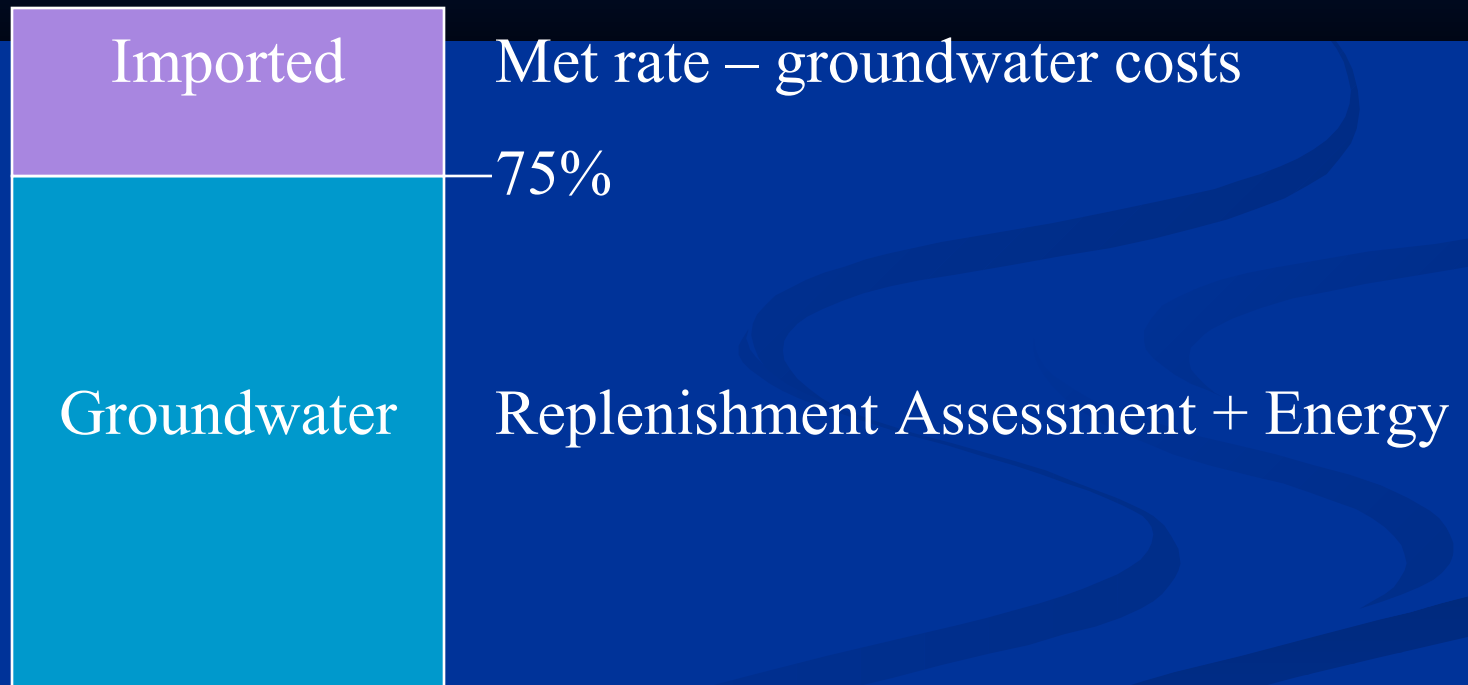
All Available Sources of Recharge Water are high in Dissolved Salts



Secondary Public Health Standard for TDS - 500 mg/L

- Concentration of Total Dissolved Solids in water causes significant consumer costs...water heaters, plumbing corrosion, softening, etc.
- Basin TDS levels will continue to increase due to adverse salt imbalance

How the Basin Equity Assessment Controls Pumping



Constructed Wetlands Provide Nutrient Removal



Flows are Increasing, Per Unit of Rainfall, due to Increased Impervious Areas

- Increased Impervious Areas
 - Currently 29 %; Future 34%
- First Annual Runoff:
 - Urban Contaminants ... nutrients, pesticides and herbicides
 - Dairy Animal Wastes ... 300,000 Dairy Animals

The SAR River Channel is Frequently Cleaned by Storm Flows



Deep Basins Provide for Storm Flow Capture and Subsequent Recharge

