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Engineers & Scientists

Cost Effective Water Filtration Processes for High-Quality Source Water Supplies

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Presentation Outline

- High-Quality Source Water
- Water Treatment Options
- Oxidation and Coagulation Issues
- High-Rate Treatment with Ozone
- Examples
- Summary and Conclusion

High-Quality Source Water

- Turbidity <5 NTU, >90% of time
- TOC <2 mg/L, >90% of time
- *Cryptosporidium* oocysts (LT2ESWTR)
  - <0.075 oocysts/L (“Bin 1”)
  - 0.075 - <1.0 oocysts/L (“Bin 2”)
- Aesthetics and Corrosion Control

Water Treatment Goals

- ≥3-log *Giardia* removal-inactivation credit
- ≥4-log virus removal-inactivation credit
- ≥2-log *Cryptosporidium* removal credit
- Filtered Water <0.10 NTU
- TOC < 2.0 mg/L
- THMs <64 µg/L
- HAA5 <48 µg/L
- Aesthetically pleasing treated water
- Non-corrosive treated water

Water Treatment Options

- Filtration Avoidance
  - (No Filtration Process, Disinfection only)
- Conventional Filtration
  - Coagulation, Flocculation, Gravity Clarification & Media Filtration
- Direct Filtration
  - Coagulation, Flocculation & Media Filtration
- Alternative Filtration
  - Coagulation, Media Clarification & Media Filtration
- Membrane Filtration

Filtration Avoidance

- Regulatory Requirements
  - ≥3-log *Giardia* inactivation credit
  - ≥4-log virus inactivation credit
  - ≥2-log *Cryptosporidium* inactivation credit
- Filtration Avoidance Criteria
  - Fecal and/or Total Coliforms
  - Turbidity
  - Watershed Control Program
- DBP Control
  - THMs <80 µg/L & HAA5 <60 µg/L
- Aesthetically pleasing and non-corrosive water

Pre-Treatment Options

- Gravity-based Clarification
  - Traditional Sedimentation Clarification
    - Coagulation Options
      - Settleable versus Filterable particle coagulation (dosage)
  - High-Rate Clarification
    - Ballasted Floc Clarification
    - Dissolved Air Flotation
    - Tube or Plate Settlers
- Particle capture-based
  - Buoyant and Non-Buoyant Media
- Flocculation (only) for Direct Filtration
- Other (TOC removal process)

Oxidation and Coagulation Issues

- Oxidation
  - $O_3 + 2e^- \rightarrow O_2 + O^{-2}$ (24 mg/meq)
  - $Cl_2 + 2e^- \rightarrow 2Cl^-$ (35.5 mg/meq)
- Metal Salt (coagulant) Charge Neutralization
  - $Al_2(SO_4)_3 + 14\ H_2O \rightarrow 2Al^{+3} + 3SO_4^{-2}$ (99 mg/meq)
  - $FeCl_3 \rightarrow Fe^{+3} + 3\ Cl^-$ (54 gm/meq)

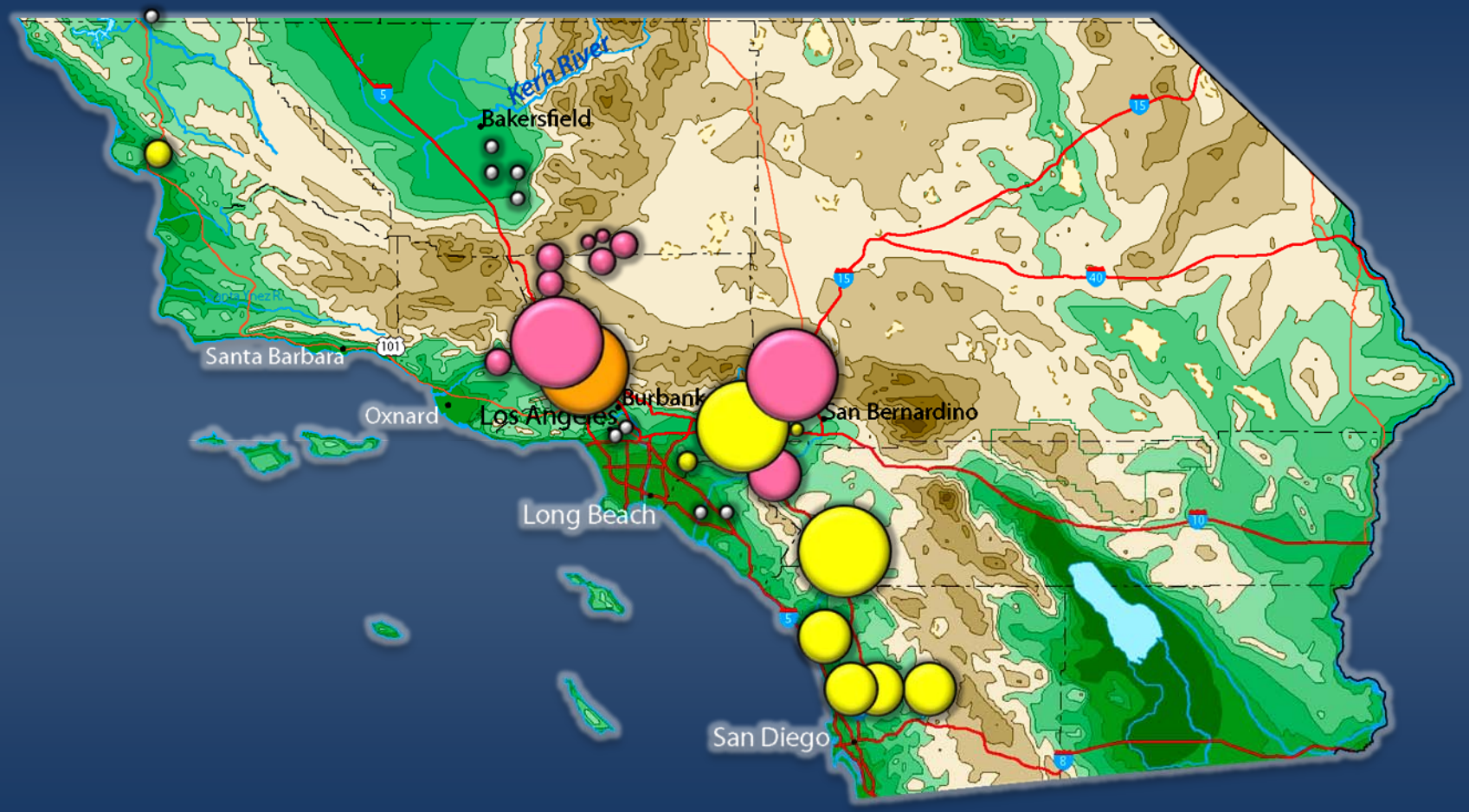
High-Rate Treatment with(out) Ozone

- Tolt WTP
  - Ozone with High-Rate Filtration
- Cedar WTP
  - Ozone and UV Disinfection
- Everett WTP
  - Chlorine oxidation with High-Rate Filtration
- Tacoma WTP
  - Ozone and UV Disinfection

Examples from Southern California

- Los Angeles Aqueduct Filtration Plant (LAAFP)
  - Owens Valley and California State Water Project sources
  - Pre-Ozone with Direct High-Rate Filtration
- Joseph Jensen Water Filtration Plant (JJWFP)
  - Treated California State Water Project source
  - Pre-Ozone with Conventional Filtration
- Lake Bard Water Filtration Plant (LBWFP)
  - Treated California State Water Project source
  - Pre-Ozone with Direct High-Rate Filtration
- Rio Vista Water Treatment Plant (RVWTP)
  - California State Water Project source
  - Pre-Ozone with Contact Clarification and High-Rate Filtration

Southern California WTPs with Ozone



LAAFP

- Water Treatment Process
  - 600 MGD capacity
  - 12,000 ppd ozone system capacity
  - Mechanical Flocculation
  - 13.5 gpm/ft^2 filtration rate

JJWFP

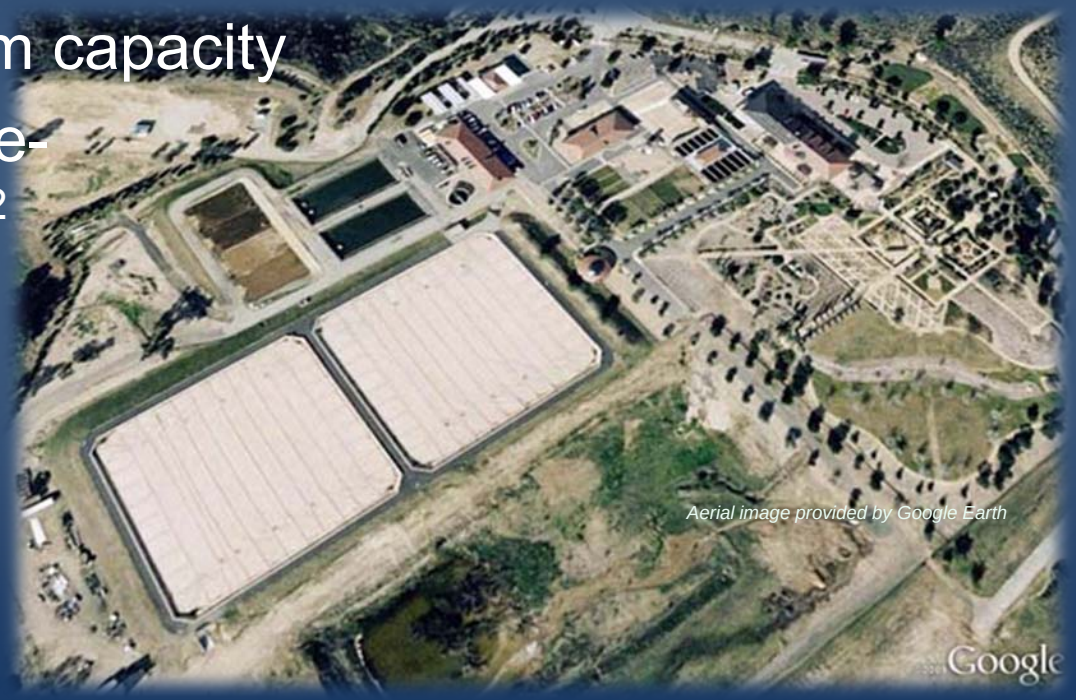
- Water Treatment Process
  - 750 MGD capacity
  - 18,750 ppd ozone system capacity
  - Coagulation, Flocculation, & Sedimentation
  - 6 gpm/ft^2 filtration rate

LBWFP

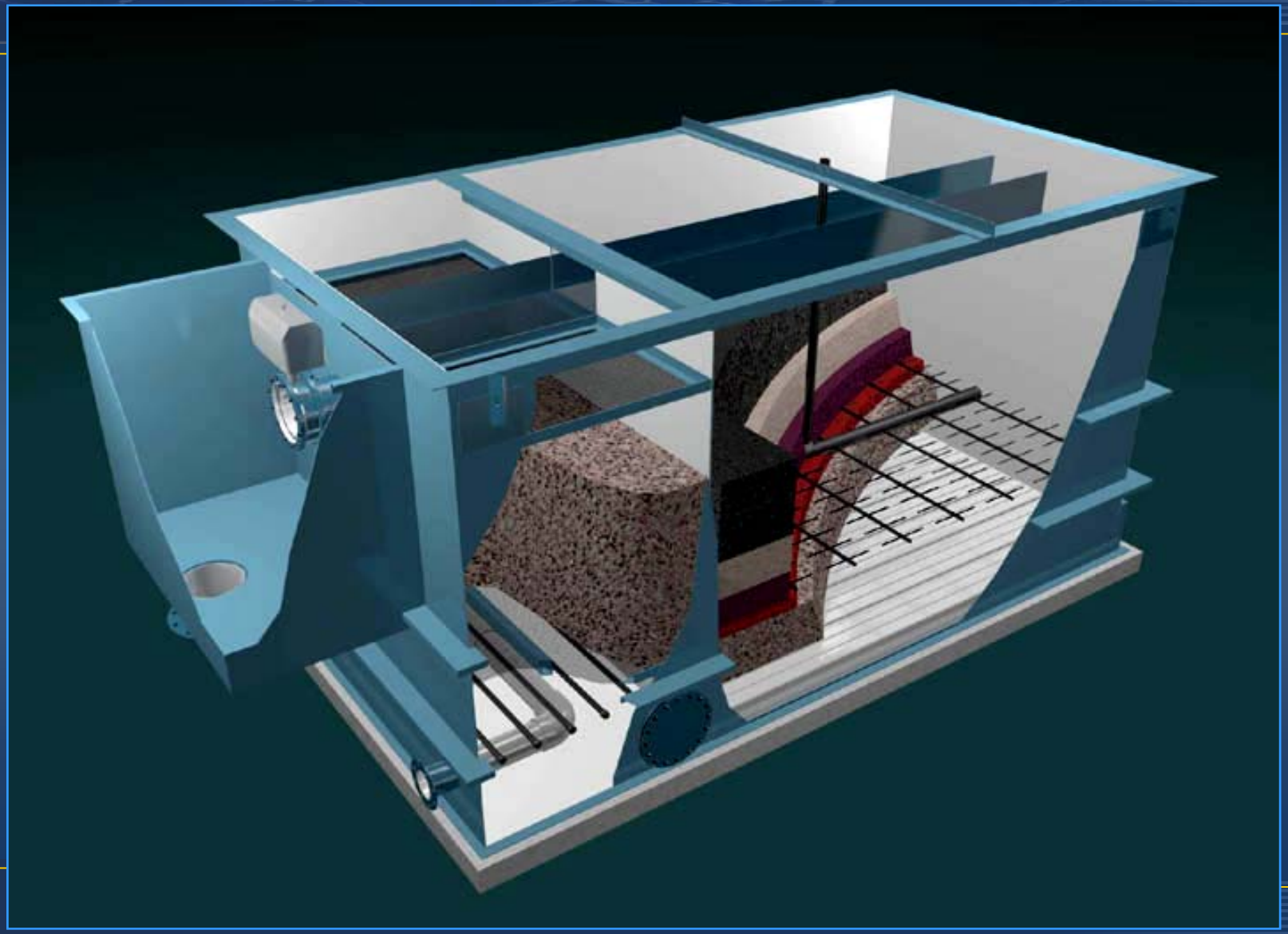
- Water Treatment Process
  - 65 MGD capacity
  - 2,000 ppd ozone system capacity
  - Hydraulic Flocculation in Pipelines
  - 9 gpm/ft^2 filtration rate

RVWTP

- Water Treatment Process
  - 36 MGD capacity (on-going expansion to 72 MGD)
  - 2,000 ppd ozone system capacity
  - Contact Clarification Pre-Treatment at 10 gpm/ft^2
  - 10 gpm/ft^2 filtration rate



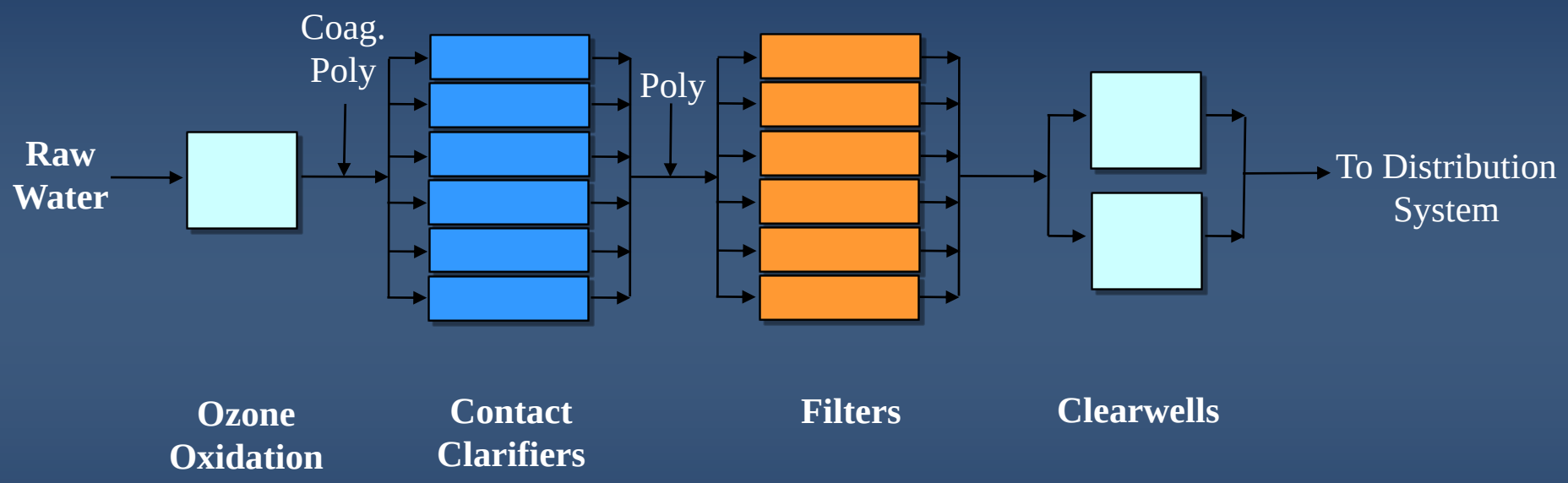
Modular CC-Filter Treatment Unit



Contact Clarifier (non-buoyant)

- Flocculation zone
- Transition zone
- Clarification zone
- Continued Flocculation
- Retention Mechanisms
  - Straining
  - Adhesion/Adsorption
  - Particle attraction
- 50 - 95 % solids removal

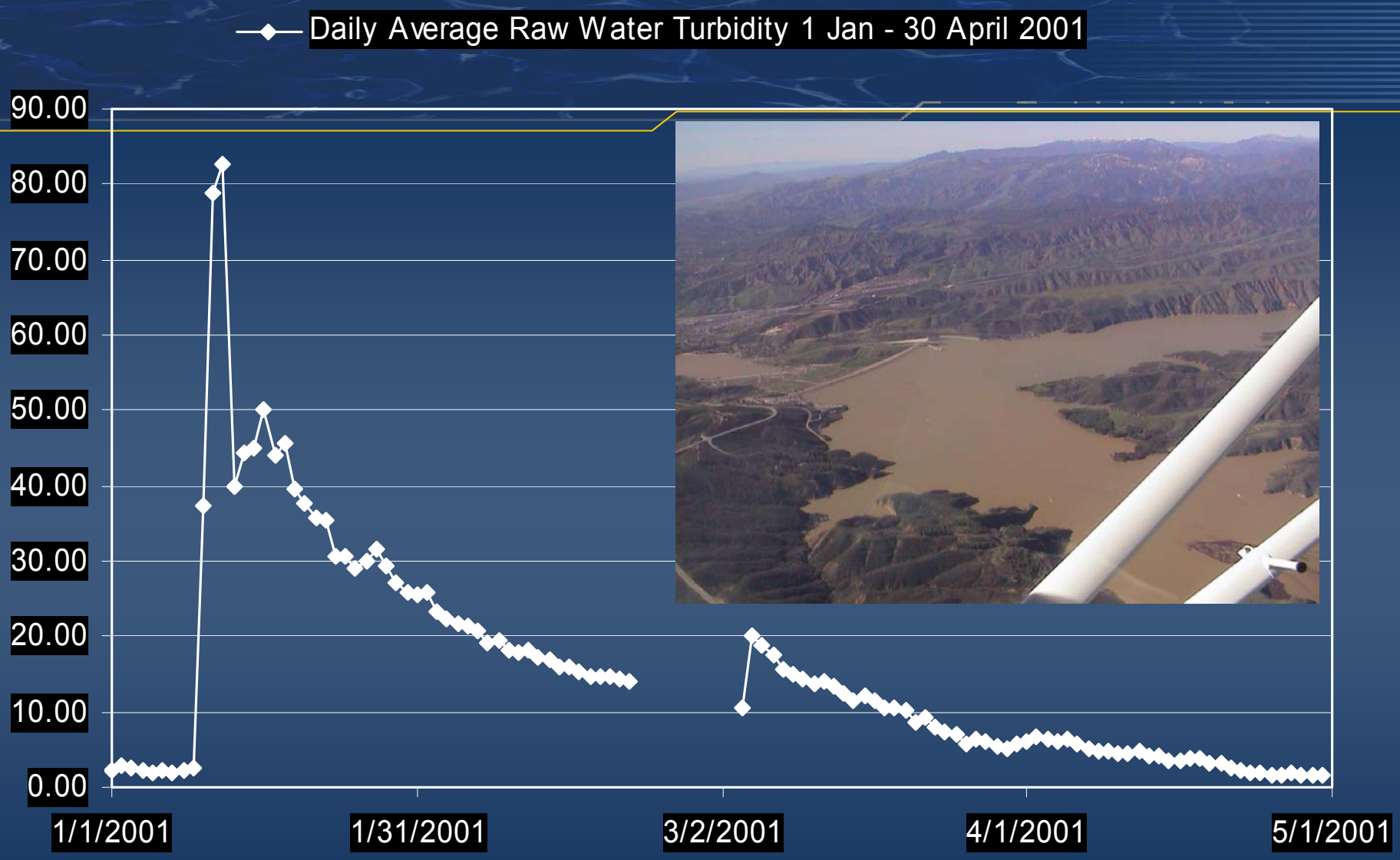
RVWTP Schematic Diagram



RVWTP Contact Clarifiers

RVWTP Operating Experience

- Normal Operation
  - Source Water Turbidity 1 – 5 NTU, >90% of time
  - Coagulant ($FeCl_3$) dosage 0.75 – 1.0 mg/L
  - Coagulant Aid 0.4 mg/L and Filter Aid 0.2 mg/L (Cat-poly)
  - Clarified Water Turbidity 0.1 – 0.5 NTU
  - Filtered Water Turbidity <0.05 NTU
  - UFRVs >100,000 gallons/ft^2
- Unusual Operating Conditions
  - High Turbidity Source Water
    - February - March 1998: 10 – 30 NTU for 20 days
    - January - March 2001: 10 – 100+ NTU for 60 days
  - Significant Increase in Solids Production


Daily Average Raw Water Turbidity 1 Jan - 30 April 2001
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1/1/2001
1/31/2001
3/2/2001
4/1/2001
5/1/2001

High-Turbidity Source Water Event

- Coagulant Dosage, Treatment Process Performance, Operational Issues and Experience
  - JJWTP (Conventional Filtration @ 6 gpm/ft^2)
  - LAAFP (Direct Filtration @ 13.5 gpm/ft^2)
  - RVWTP (Contact Clarification – Filtration @ 10 gpm/ft^2)
- Solids Production and Handling
  - Washwater and solids handling systems overwhelmed by water and solids at all three WTPs
    - 160 ft^3 sludge with 425+ pounds of dry solids per MG treated
  - RVWTP – On-Going Expansion includes more robust washwater and solids handling facilities
  - Similar WW Improvements project on-going at JJWTP

Optimal Water Treatment when Filtration Avoidance isn't Feasible

- Ozone oxidation (and disinfection) with
  - High-Rate Contact Clarification-Filtration or
  - High-Rate Direct Filtration
- Provide Efficient Treatment Process
  - Media filtration effective in removing TOC
- Wash Water Handling System
  - Design for High Raw Water Turbidity Events
  - Provide Robust Washwater/Solids Handling System

Summary and Conclusion

- Advantages:
  - Ozone improves coagulation efficiency
    - Addresses taste and odor challenges
  - Particle capture-based processes produce less residuals (solids) than sedimentation-based processes
- Limitations:
  - Direct Filtration suitable when source water <15 NTU
  - Contact Clarification-Filtration best when <25 – 50 NTU

Questions?