



ABSTRACT & POWERPOINT PRESENTATION

***Recharge Performance Enhancement
through Sediment Removal: Orange County Water District
Sediment Removal Feasibility Study***

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Managed Aquifer Recharge Symposium
January 25-26, 2011
Irvine, California

Symposium Organizers:

- National Water Research Institute
- Orange County Water District
- Water Research Foundation

www.nwri-usa.org/rechargesymposium2011.htm

Recharge Performance Enhancement Through Sediment Removal – OCWD Sediment Removal Feasibility Study

**Greg Woodside (OCWD), Adam Hutchinson (OCWD), Adam Canfield (OCWD), Craig Miller (OCWD)
Scott Toland (HDR), Greg Bradshaw (HDR)**

The Orange County Water District (OCWD) in southern California operates one of the largest groundwater recharge systems in the world, utilizing over 1,000 acres of surface recharge basins. OCWD works to maximize the recharge of water from the Santa Ana River (SAR). Using a system of diversion structures, conveyance, and recharge basins, SAR water is recharged into the groundwater basin, creating a valuable water supply. During dry periods, SAR baseflow is comprised primarily of tertiary effluent from upstream treatment plants. However, during storm events SAR water is comprised mostly of storm runoff. The sediment concentration in river water varies significantly. SAR baseflow typically has a total suspended solids (TSS) concentration ranging from about 5 to 20 mg/L, while stormflow has TSS that sometimes exceeds 1,000 mg/L. This variable water quality poses a significant operational challenge. Percolation rates in recharge basins recharging SAR water decline rapidly within the initial 30 to 60 days of operation, thus reducing the amount of water OCWD is able to recharge. The decline in percolation is primarily caused by clogging of the basin bottoms and sides with silt and clay particles conveyed with the river water. Additional factors that may contribute to percolation rate decline include biological growth and chemical precipitates.

OCWD studied the feasibility of removing sediment from the recharge water prior to the water entering the recharge basins. The study was designed to assess the water quality improvement that could be achieved with sediment removal and the resultant change in percolation rate compared to untreated water. The primary functional objectives for the sediment removal strategies are: (1) to assist OCWD in optimizing the performance of existing recharge facilities, (2) to assist OCWD in recharging SAR water through subsurface recharge structures such as horizontal perforated pipes, and (3) as one approach to reaching OCWD's long-term goal of 700 cubic feet per second (cfs) winter recharge capacity and 400 cfs summer recharge capacity.

In the first part of the study, a wide collection of potential sediment removal strategies were evaluated. After screening the preliminary treatment strategies, the most favorable remaining strategies were High Rate Sedimentation, Ballasted Sedimentation, Dissolved Air Flotation, Cloth Filtration, and River Bed Filtration.

Pilot testing of these technologies commenced in January 2009 with the goal of collecting water quality data for each technology, as well as percolation rate decay through bench-top column testing and larger concrete percolation cells. Ballasted Sedimentation, Dissolved Air Flotation, Cloth Filtration, and River Bed Filtration each achieved significant sediment removal, with River Bed Filtration performing best. Although chemical treatment methods achieved significant sediment removal in most cases, they were not effective in increasing the percolation rate. This is attributed to residual treatment chemicals remaining in the water after treatment, and subsequently interacting with the sediment in the model percolation systems and reducing the sediment permeability. In terms of sediment removal efficiency and increased percolation rates, River Bed Filtration was the most effective, followed by Cloth Filter.

Recharge Performance Enhancement Through Sediment Removal

OCWD Sediment Removal Feasibility Study

Craig D. Miller, Adam Hutchinson, Adam
Canfield, Greg Woodside/OCWD
Scott Toland, Greg Bradshaw/HDR

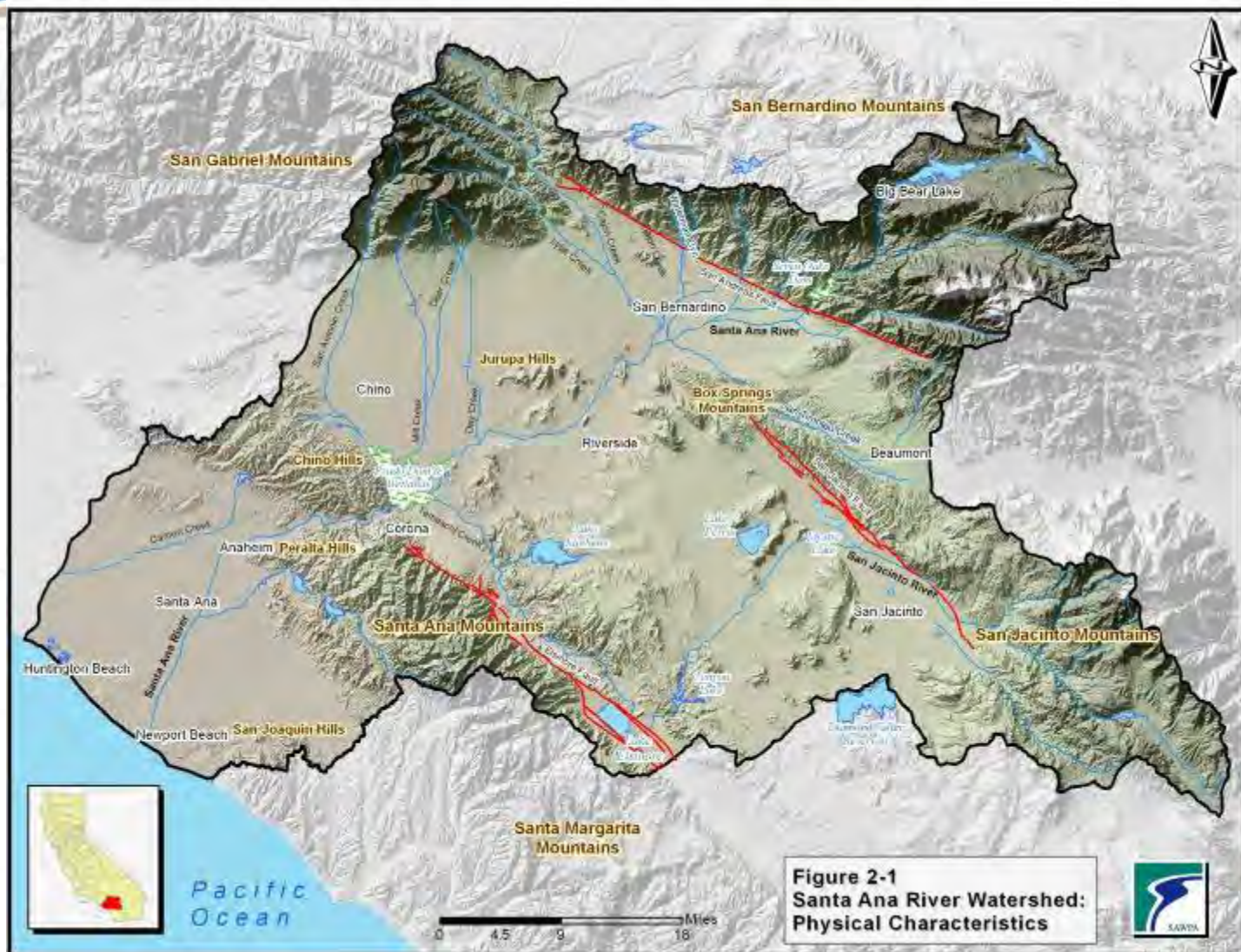


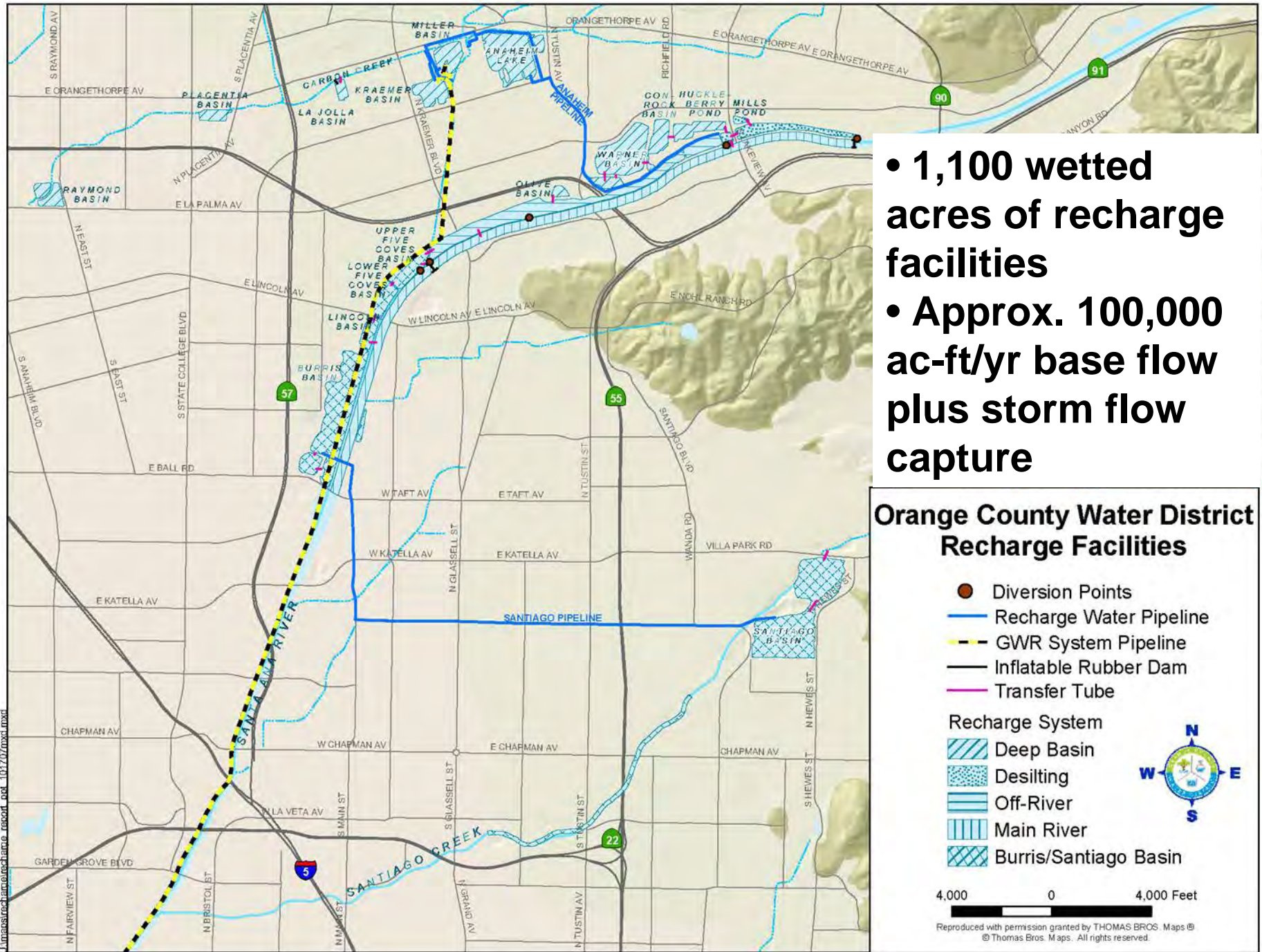
OCWD Background & Study Objectives

- Orange County Water District (OCWD) manages the large groundwater basin that provides reliable, high quality groundwater to 2.4 million customers in 20 cities and water agencies in northern and central Orange County.
- Recharging Santa Ana River (SAR) water is integral to sustaining groundwater reliability in the region.
- Specific study objectives include evaluation of sediment removal technologies to optimize recharge potential by reducing clogging.



Santa Ana River Watershed





- 1,100 wetted acres of recharge facilities
- Approx. 100,000 ac-ft/yr base flow plus storm flow capture

Orange County Water District Recharge Facilities

- Diversion Points
- Recharge Water Pipeline
- GWR System Pipeline
- Inflatable Rubber Dam
- Transfer Tube

Recharge System

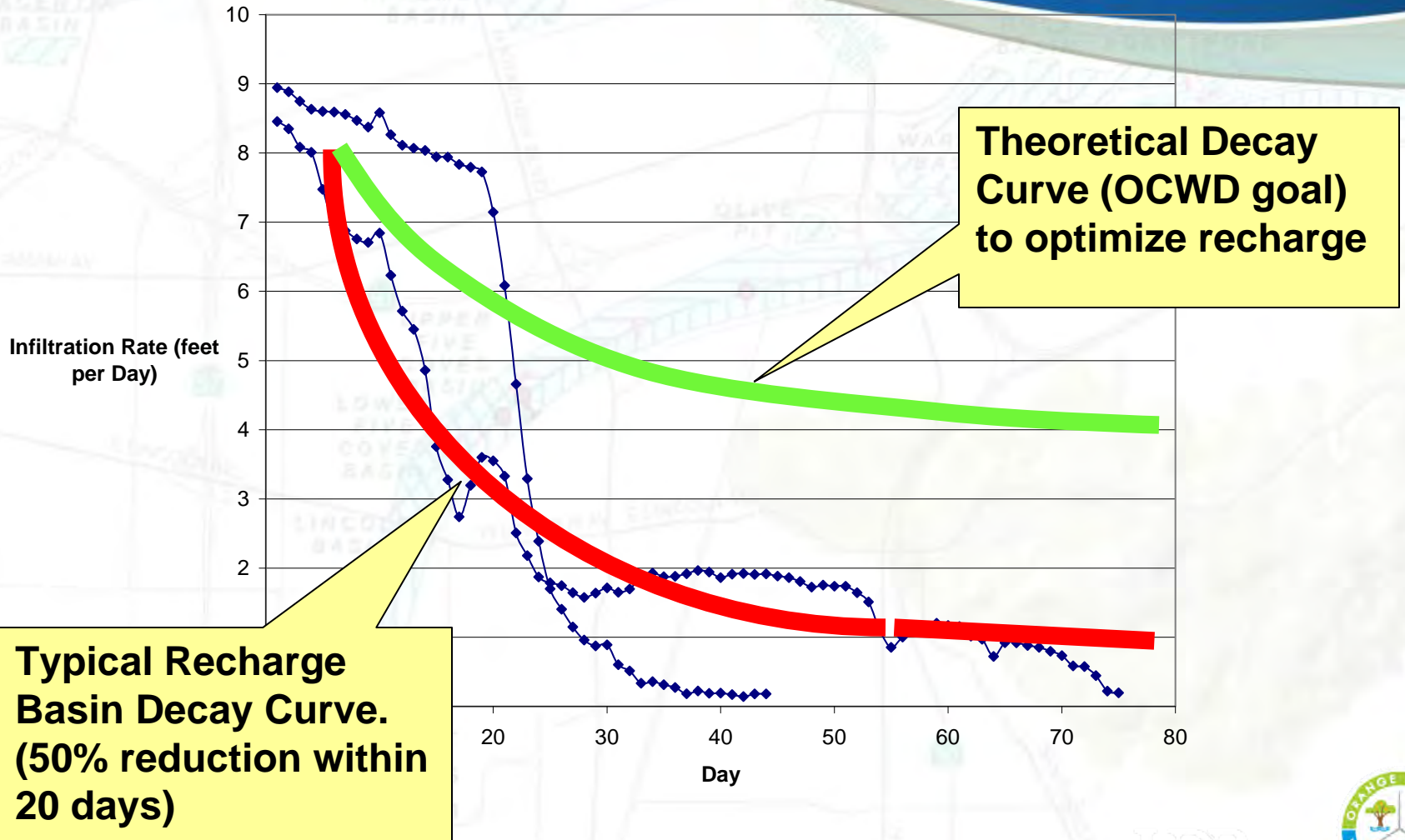
- ▨ Deep Basin
- ▨ Desilting
- ▨ Off-River
- ▨ Main River
- ▨ Burris/Santiago Basin



4,000 0 4,000 Feet

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Recharge Rate Decay



Pilot Testing Site



Warner Basin

Little Warner

Pilot Location

Conrock

Huckleberry

Weir Pond #4

Passive Pilot

**600 gpm pumped from weir pond #4 to pilot location.
Up to 2,000 gpm pumped from passive pilot (discharge to SAR w/ 40 gpm to test cells)**

Technologies Considered for Pilot Testing

- **Chemical/Physical Removal**
 - Conventional Floc-Sed
 - Ballasted Sedimentation or High Rate Clarification
 - Dissolved Air Flotation, DAF
- **Mechanical Removal**
 - Cloth Filters
- **In-River Management**
 - Passive underdrain system



IHDR

Treatment System Parameters

Floc-Sed System

- Coagulant mixing via static, inline mixer
- 2-stage flocculation
- FeCl_2 : 15 – 25 ppm
- Weir loading: 3600-7200 gpd/ft



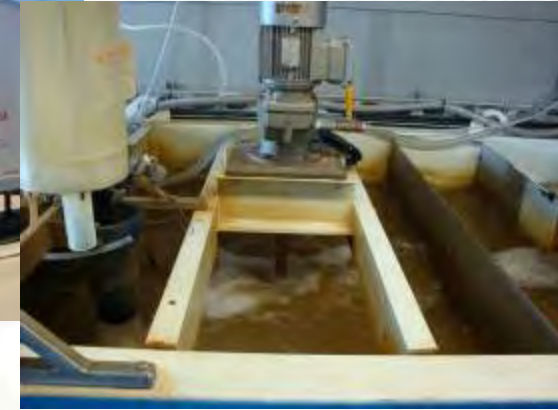
DAF (ITT Leopold)

- Flow Rate: 80 gpm
- Coagulant: Sumaclear 700, 10 – 25 ppm
- Varied small dose of cationic polymer (0-0.1 ppm) for optimization

Treatment System Parameters

HRC (Kruger Actiflo)

- Flow Rate: 130 – 202 gpm
- FeCl_2 : 55 – 75 ppm
- Varied small dose of cationic or anionic polymer for optimization



Cloth Filter (Aqua Aerobic Systems, Inc.)

- Flow Rate: 30 - 72 gpm
- 5 micron filter cloth
- Tested with and without chemical pretreatment

Passive (Riverbed Filtration) System

- Flow Rate: up to 2,000 gpm
- Dimensions: 570 ft x 190 ft
- Eight 190-ft slotted laterals
- Avg Depth: 3 – 5 ft
- Central caisson w/ 3 submersible pumps.
- Discharge to river, with 40 gpm side stream to percolation test cells & columns



Evaluation Methods

- **Turbidity and TSS**
 - Indicators of quantity of particulate and colloid solids present in the source water
- **Modified Fouling Index (MFI)**
 - Measure of plugging potential of suspended solids in the source water
- **Particle Size Distribution**
 - Used to evaluate overall particle reduction and preferential removal by size range for each technology
- **Percolation Columns and Test Cells**
 - Indicators of each treatment technology's impact on recharge potential. (Direct comparison of decay curves.)



Percolation Columns and Cells

Percolation Columns

- Columns packed with native material, then purged of air
- Perc rate measured at rate-dependant time intervals
- Data input into perc decay model

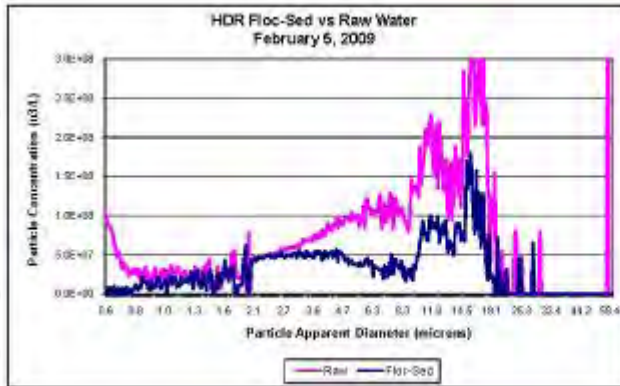


Percolation Cells

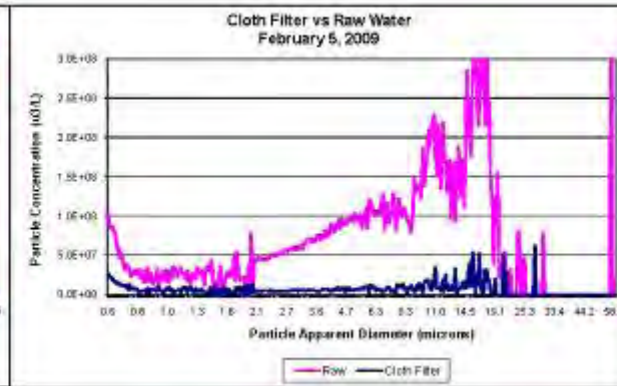
- Existing 8' x 26' concrete cells
- Retrofit with slotted underdrain and 20-inches of washed native sand
- Water introduced through perforated header and float valve
- Discharge meter

Representative Particle Size Distribution

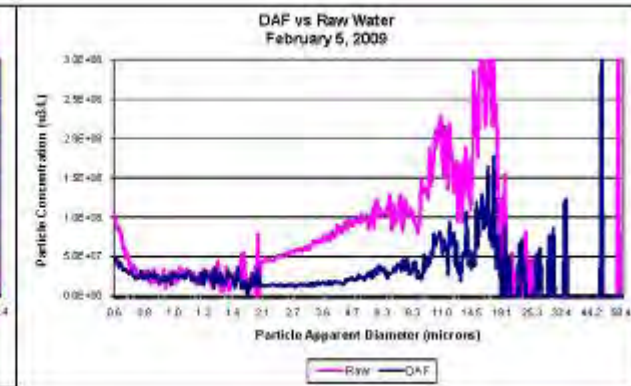
Floc-Sed, 2/5/09



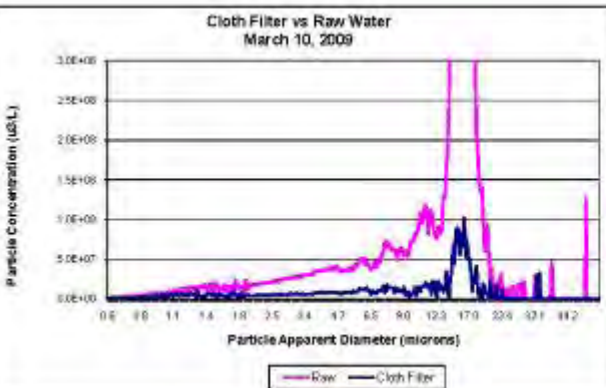
Cloth Filter, 2/5/09



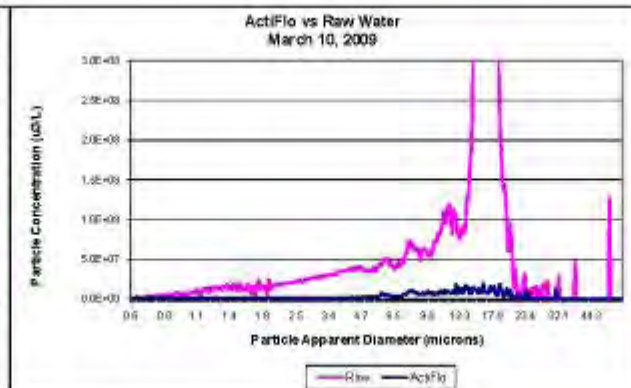
DAF, 2/5/09



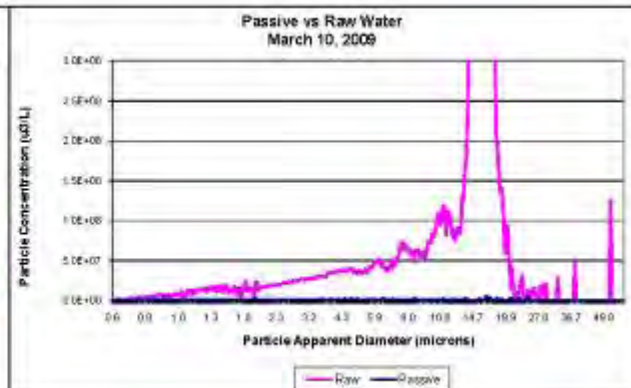
Cloth Filter, 3/10/09



HRC, 3/10/09



Passive, 3/10/09



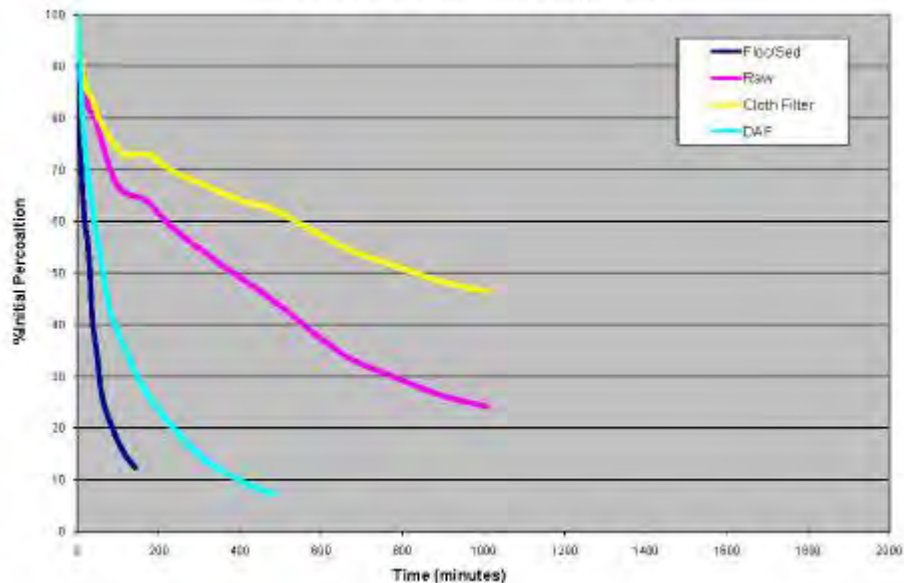
Representative Percolation Column Data

Week 1 & 7 Examples

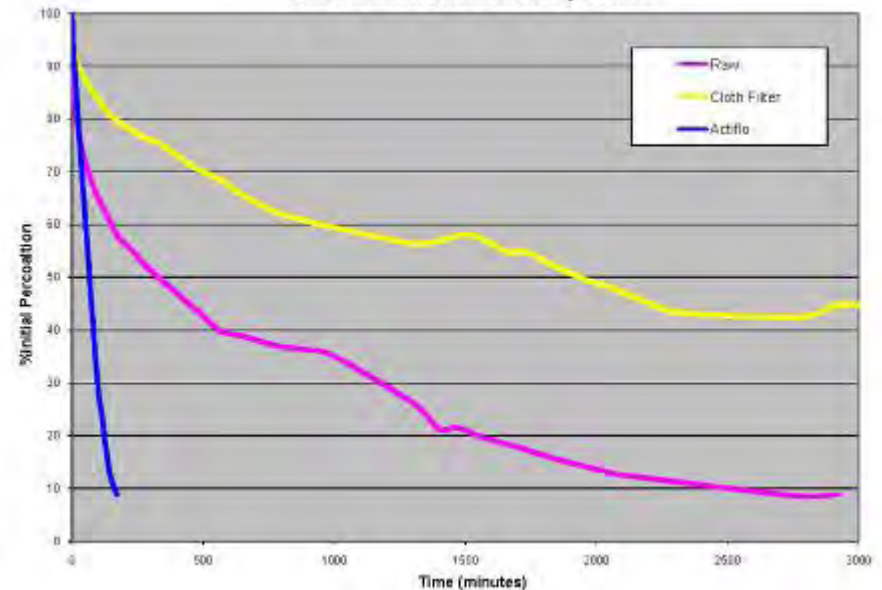
In General,

- Cloth Filter (without chemical pretreatment) typically performed better than raw water
- No improvement by Cloth Filter when chemical pretreatment was used
- Other physical/chemical processes resulted in faster percolation rate decay
- Single passive system test (week 8 – not shown) performed better than raw water and cloth filter

Week 1 Column Percolation Decay vs Time



Week 7 Column Percolation Decay vs Time



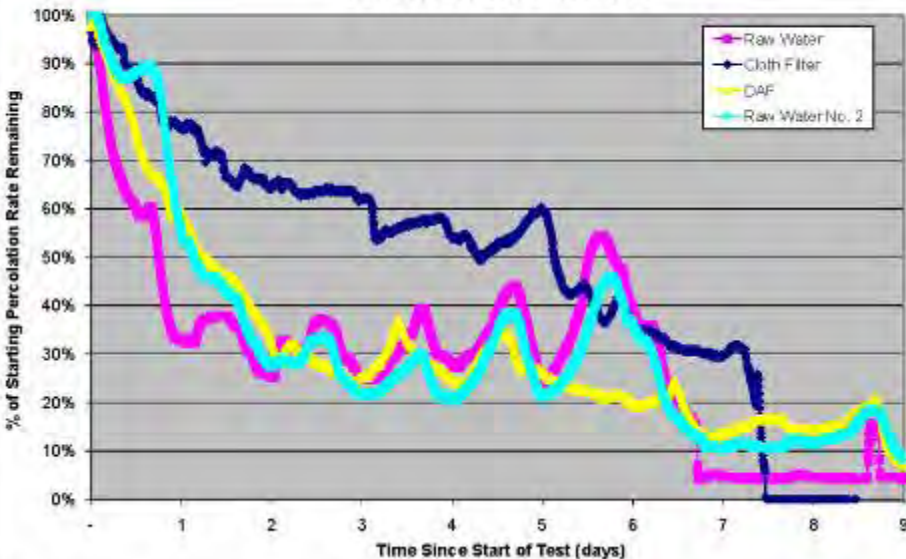
Representative Percolation Cell Data

Round 2 & 4 Examples

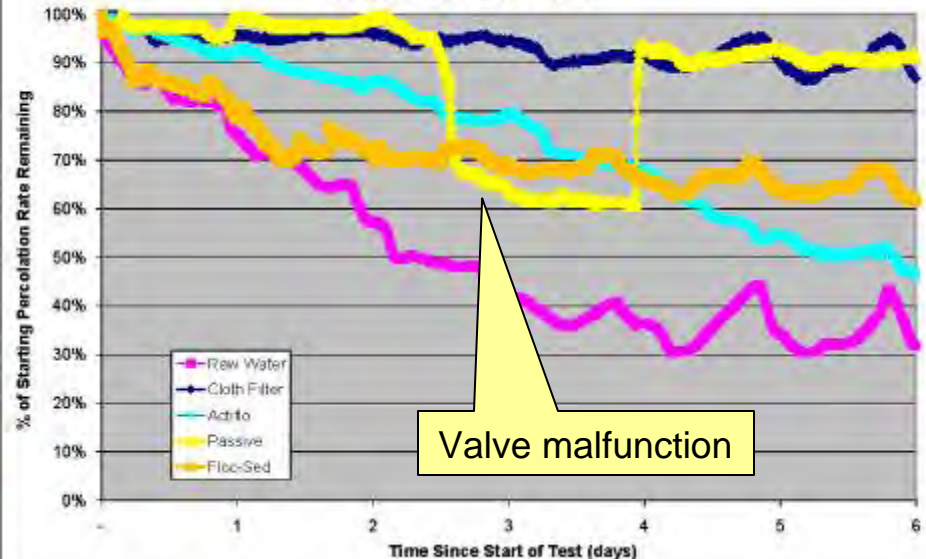
In General,

- Passive and Cloth Filter (without chemical pretreatment) typically performed better than raw water
- No improvement by Cloth Filter when chemical pretreatment was used.
- No improvement by other physical/chemical processes.
- (Round 2 percolation rates impacted by daily temperature variation.)

Percolation Cell - Round 2



Percolation Cell - Round 4



Comparison of Select Evaluation Methods

Better Performance ←



Worse Performance

Turbidity (NTU)				
Passive (0.9 – 1.0)	HRC (1.2 – 1.8)	DAF (1.8 – 37*)	Cloth (2.5 – 50*)	Floc-Sed (7.4 – 104*)
TSS (mg/L)				
Passive. ND	HRC, (ND-3.2)	DAF, (4.5 – 37)	Cloth (ND – 50)	Floc-Sed (16-79)
MFI (s/L ²)				
Passive, 11-28	HRC, (115-370)	Cloth, (69 – 500)	DAF (740-1860)	F-S (1300-6000)
Percolation Cell (Days to 50% initial flow)				
Passive >5 - >10	Cloth 4 - >10	HRC 4.5 - 6	DAF 1.1 - 2	Floc-Sed No data
Percolation Column (Minutes to 50% initial flow)				
Passive 3470	Cloth 125 - 2000	HRC 30-140	DAF 20-70	Floc-Sed 18-50
Particle Size Distribution (extent of overall removal)				
HRC	Passive	Cloth	DAF	Floc-Sed

Weighted Performance Ranking

Evaluation Method	Weighting Factor	Desilting Technology Ranking				
		Passive	Cloth	HRC	DAF	Floc-Sed
WQ (Turbidity, TSS)	1	5	2	4	3	1
MFI	2	5	4	3	2	1
Percolation Cell	2	5	4	3	2	1
Column Test	4	5	4	3	2	1
Particle Size Distribution	1	4	3	4	2	1
Score:		49	37	32	21	10



HDR

Major Conclusions

- Two technologies suitable for additional evaluation
 - Passive System (Riverbed filtration)
 - Cloth Filter
- Processes involving chemical addition should not be further investigated

Additional Conclusions

- Turbidity or TSS removal is partial but not comprehensive predictor of percolation performance
- Evaluations of technologies should include demonstration-level testing at field conditions
- Longer term testing required to address additional issues related to long term operation
 - Biological activity (benthic zone)
 - Inorganic fouling
 - Raw water quality variability
 - Sustainability and operability of technology



Riverbed Filtration Demonstration Project



Cloth Filter Demonstration Project



- 5 – 8 cfs capacity unit matches Riverview Basin percolation rate

End

