PILOT TESTING FOR THE GREEN RIVER FILTRATION FACILITY

PNWS-AWWA CONFERENCE

MAY 4, 2012

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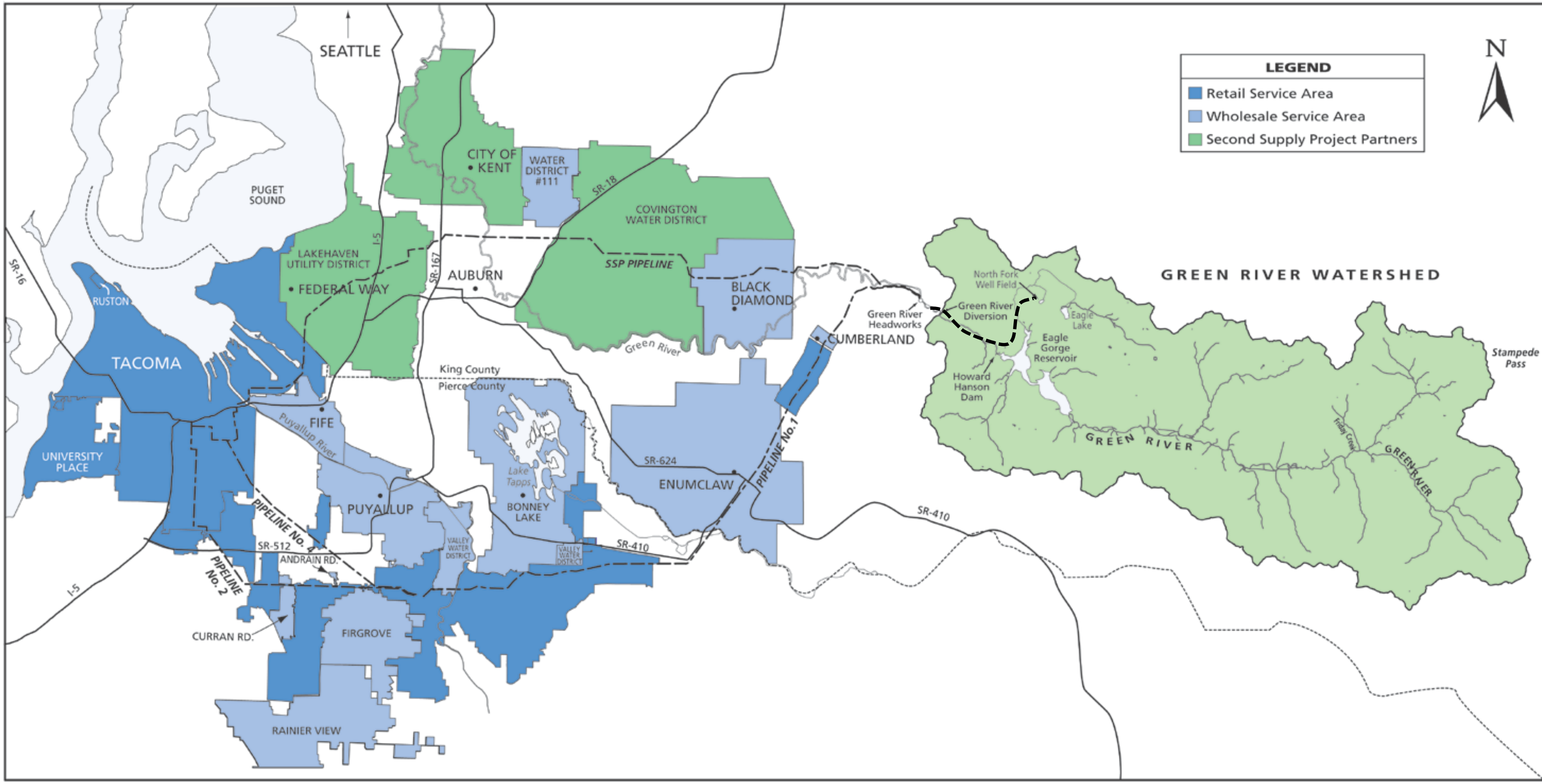
OUTLINE

- Overview of Tacoma Water and Green River Filtration Facility
- Pilot Study Goals
- Pilot Plant Overhaul
- Plant Operations and Staffing
- Study Results
- Testing of Special Conditions
- Summary and Recommendations

TACOMA WATER SYSTEM



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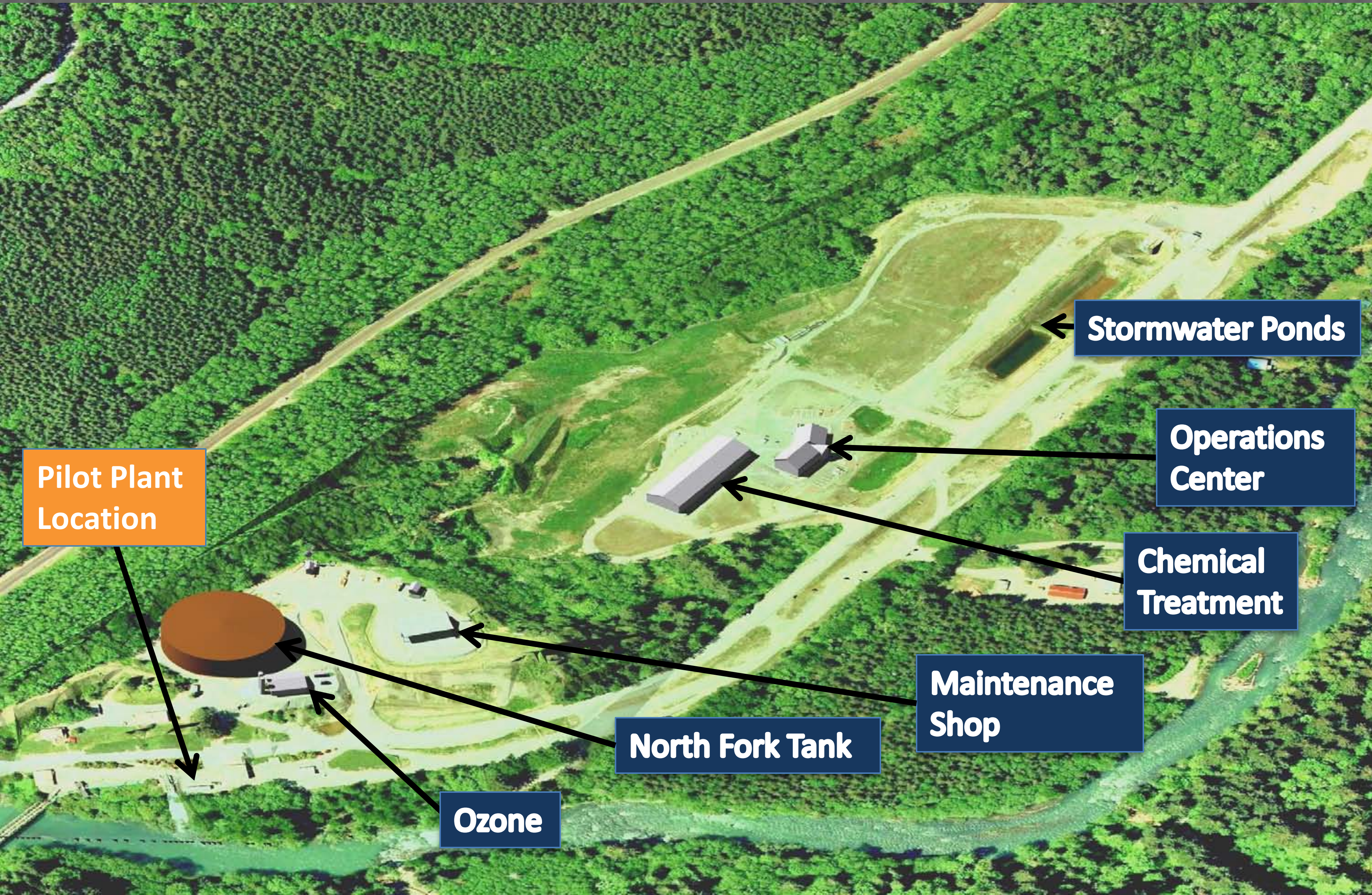
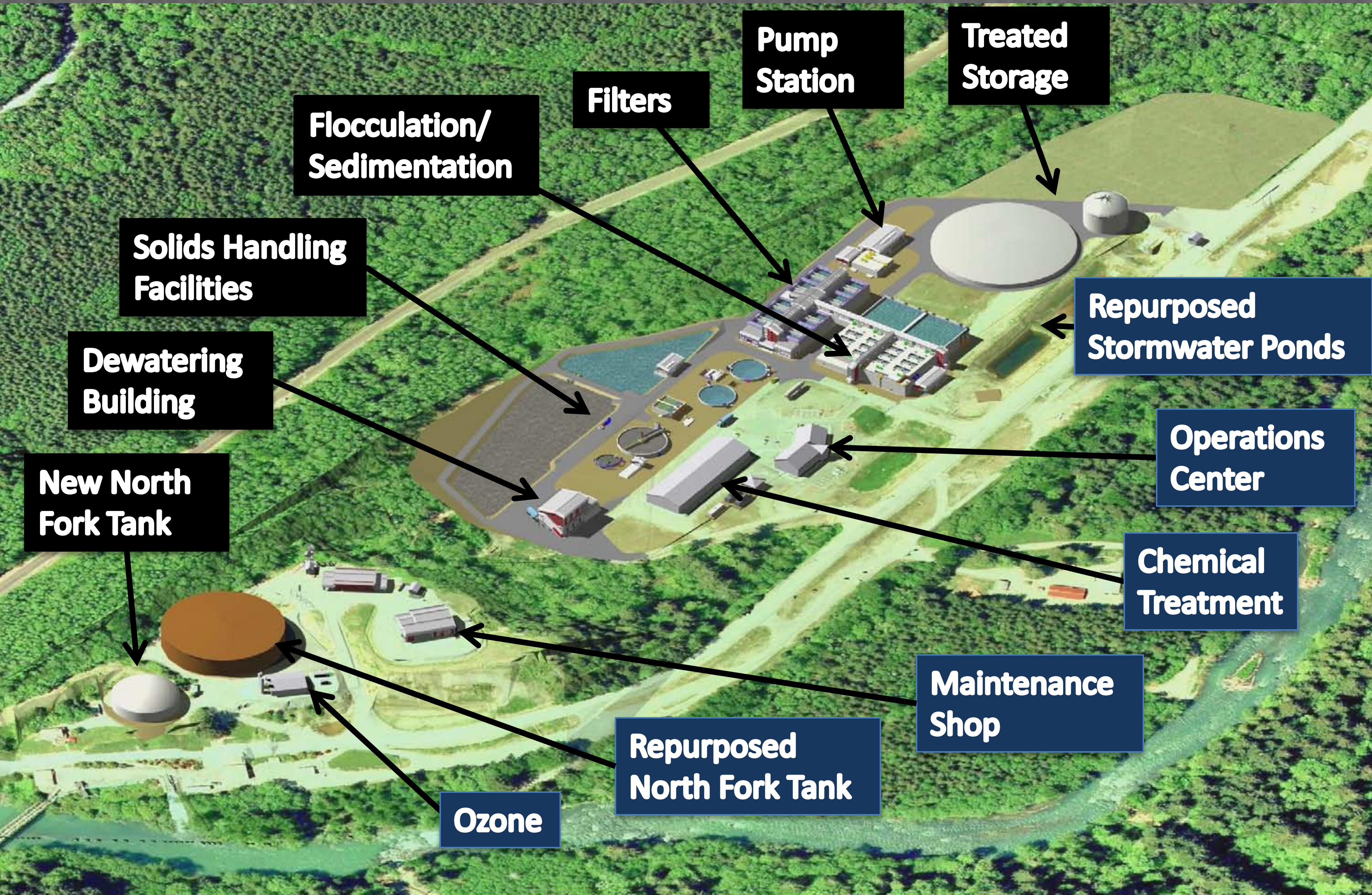
EXISTING GREEN RIVER FACILITY



GREEN RIVER FILTRATION FACILITY



PILOT STUDY GOALS

- Support DOH approval of high-rate filtration.
- Evaluate coagulant strategies.
- Optimize pretreatment for direct filtration and conventional filtration.
- Optimize filter system design.
- Develop assumptions for operating conditions in GRFF design.
- Evaluate effect of blending sources.
- Gain operational experience treating Green River under a variety of conditions.

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PILOT PLANT OVERHAUL

Look Familiar?

- Pilot Plant built for Seattle in ~1991.
- Used for Tolt Pilot Study 1991/1992.
- Used for Cedar Pilot Study 1994/1995.
- Used for Green River ozonation pilot work 2003.
- Purchased by Tacoma Water and Partners 2004.
- Began Pilot Plant overhaul 2008.

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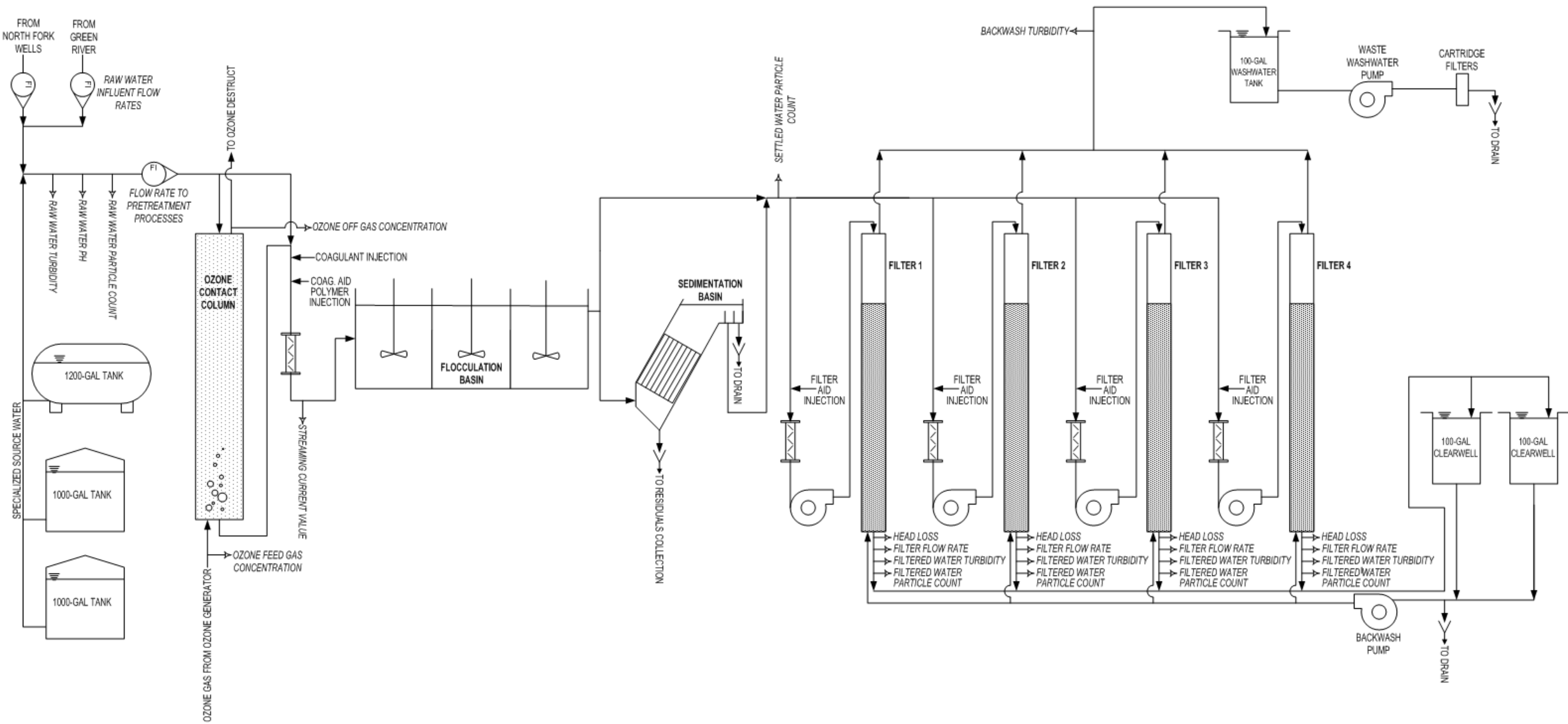
PILOT PLANT PROCESS FLOW



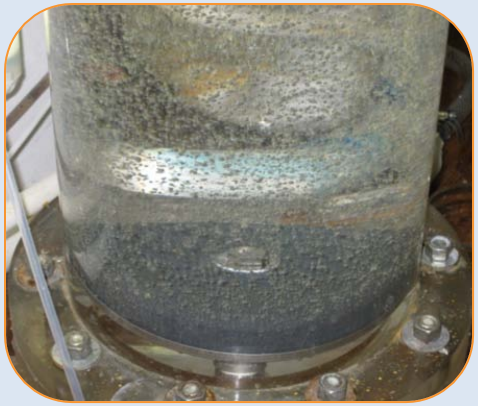
PILOT PLANT OVERHAUL

Our Starting Point

PILOT PLANT OVERHAUL – INFLUENT & OZONATION

Upgrades

- Feed from WTP conduit, river, or wellfield.
- Replaced turbidity and pH instruments.
- Replaced ozone gas analyzer.
- Replaced ozone diffuser stone.



Limitations

- High turbidity plugged instruments
- Existing ozone generation system and column.
- Bird nests in offgas duct.

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PILOT PLANT OVERHAUL – CHEMICAL INJECTION

Upgrades

- Added streaming current monitor.
- Replaced chem feed pumps.
- Increased chemical storage to allow for overnight operations.

Limitations

- Feed pump range; chemical dilution required.

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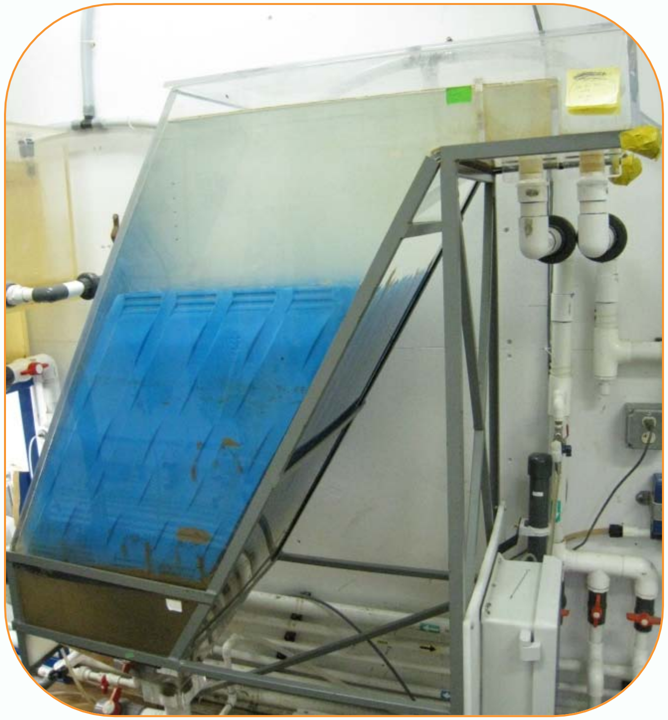
PILOT PLANT OVERHAUL – FLOCCULATION AND SEDIMENTATION

Upgrades

- Rebuilt flocculation tank.
- Rebuilt sedimentation tank.
- Replaced sedimentation tubes.

Limitations

- Touchy hydraulics.
- Ineffective pilot-scale sedimentation process.



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PILOT PLANT OVERHAUL – FILTRATION

Upgrades

- Replaced filter columns.
- Replaced filter underdrains.
- Replaced most filter turbidimeters.
- Added online filtered water particle counter.

Limitations

- 3” filter columns.

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PILOT PLANT OVERHAUL – ADDITIONAL TOOLS

Upgrades

- Replaced strip charts with data logger.
- Added new benchtop tools: jar tester and coagulant charge analyzer.

Limitations

- Still needed this tool.

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PLANT OPERATIONS AND STAFFING

- Operated from May 2009 – January 2012.
- Staffed entirely by Tacoma Water: 6 weekday pilot operators + 6 WTP operators.
- All repairs and upgrades by Tacoma Water staff.
- All data entry and analysis by Tacoma Water staff.

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PLANT OPERATIONS AND STAFFING

Benefits

- **Broad exposure to treatment processes.**
- **Experience gained will assist with full-scale design and operations.**
- **Allowed input from staff throughout the utility.**
- **Cross-sectional teamwork.**
- **Greater flexibility.**
- **Opportunities to capture more water quality events.**

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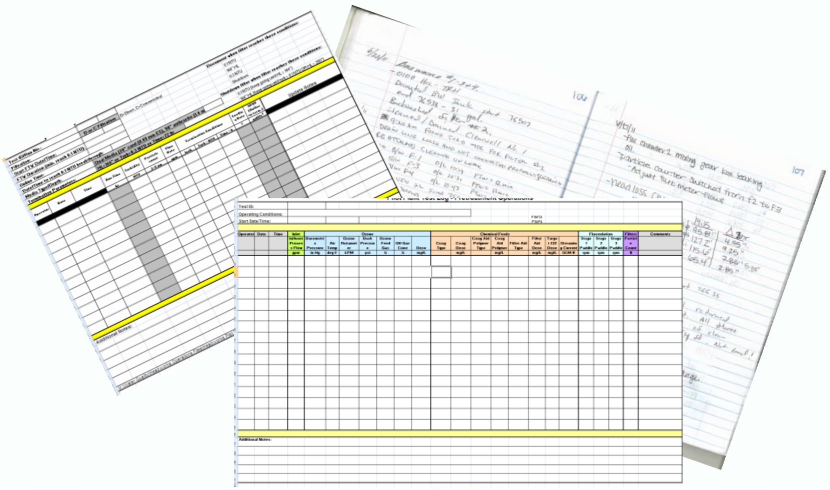
PLANT OPERATIONS AND STAFFING

Challenges

- **Large learning curve.**
- **Staff availability and priorities.**
- **Less consistency in daily operations.**
- **Every operator has their own strengths and weaknesses.**
- **All operators need to understand pilot plan and procedures.**
- **Communication critical.**
- **Documentation critical.**



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STUDY RESULTS – WATER QUALITY

Raw Water Quality

Parameter	Median	Range	Sample Size
Turbidity (NTU)	1.3	0.1 – 396[1]	Continuous
pH (pH units)	7.47	6.61 – 8.46	505
Alkalinity (mg/L as $CaCO_3$)	17.0	8.5 – 25.0	157
Temperature (°C)	11.3	1.4 – 21.1	490
Iron (mg/L)	0.06	0.002 – 1.64	434
Manganese (mg/L)	0.03	0 – 0.61	407
Color (CU)	12	0 – 1,100	159
UV254 Transmittance (%T)	92.5	29.5 – 99.5	194
Total Organic Carbon (mg/L)	1.02	0.52 – 2.14	49
Total Suspended Solids (mg/L)	1.3	0.5 – 470	67
Chlorine Demand (mg/L)[2]	0.86	0.40 – 2.0	26

[1]Includes spiked turbidity samples. [2]Measured in ozonated raw water.

STUDY RESULTS – WATER QUALITY

Filtered Water Quality

Parameter	Median	Range	Sample Size	Change from Raw Water
pH (pH units)	7.34	5.68 – 7.84	1361	-1.7%
Alkalinity (mg/L as $CaCO_3$)	16.0	2.0 – 29.0	392	-5.9%
Iron (mg/L)	0.01	0 – 0.41	1269	-85%
Manganese (mg/L)	0.01	0 – 0.13	1215	-62%
Color (CU)	1.0	0 – 64	479	-92%
UV254 Transmittance (%T)	98.1	83.9 – 100	546	+6.1%
Total Organic Carbon (mg/L)	0.80	0.25 – 2.61	227	-21%
Chlorine Demand (mg/L)	0.52	0.02 – 1.62	85	-39%

STUDY RESULTS - CHEMICALS

Chemical	Results
Aluminum Sulfate (Alum)	• Successful at lower doses for low-turbidity water. • Significant improvement with alkalinity/pH adjustment (required for higher turbidity).
Ferric Chloride	• Consumed ~1 mg/L alkalinity per 1 mg/L dose. • Severe decrease in pH. • Worse performance than aluminum-based coagulants.
Polyaluminum Chloride (PACl)/Aluminum Chlorohydrate (ACH)	• Performed well for low- and high-turbidity water. • Minimal effects on alkalinity or pH.
ACH + Alum	• Combined during high-turbidity events (based on recommendations from other utilities). • Successful performance, but required equal parts alum, and alkalinity/pH adjustment.
Cationic Polymer	• Required as coagulant aid for all coagulants. • Nonionic and anionic polymers not successful.

GRFF design:

- **PACl/ACH**
- **Optional Alum**
- **Cationic Polymer**
- **pH adjustment**
- **Alkalinity adjustment**

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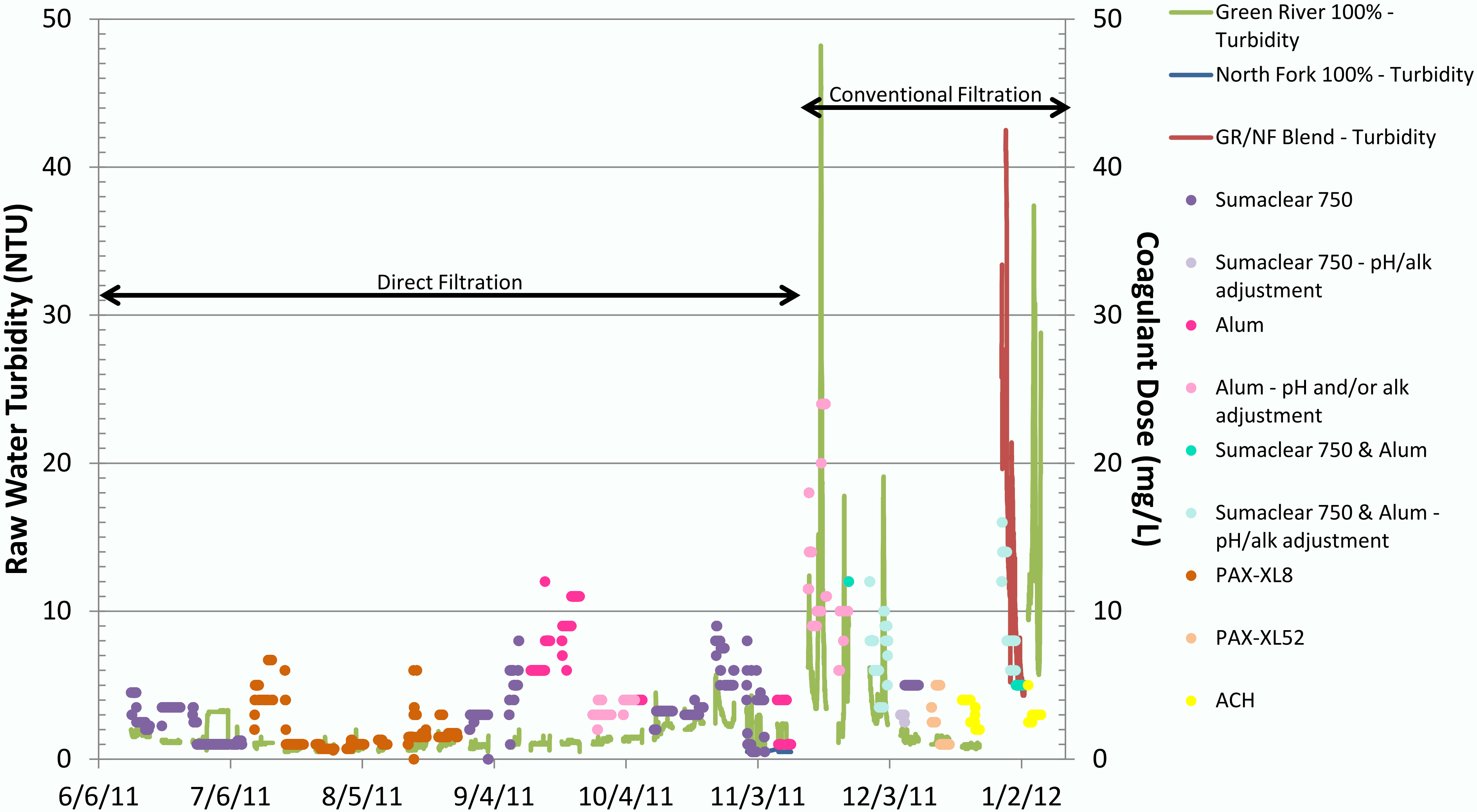
STUDY RESULTS - CHEMICALS



Raw Water Turbidity and Coagulant Dose (Phase 3)

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STUDY RESULTS – FILTRATION MEDIA

Dual Media with Deeper Sand Base Layer	• 50” 1.4-mm anthracite + 20” 0.64-mm sand. • Higher initial head loss. • Recommended due to turbidity barrier; most reliable under challenging conditions.
Dual Media with Shallower Sand Base Layer	• 60” 1.45-mm anthracite + 10” 0.75-mm sand. • Successful during optimal conditions. • Larger diameter, shallower sand failed during challenging conditions.
Dual Media with Garnet Base Layer	• 50” 1.6-mm anthracite + 20” 0.49-mm garnet. • Considered garnet to balance larger anthracite. • Very high initial head loss.
Monomedia	• 90” 1.3-mm anthracite. • Lower initial head loss; under optimal conditions, high UFRVs and long run times. • No turbidity barrier for challenging conditions.
Other Dual Media Combinations	• Tested various sizes and depths of anthracite and sand.

GRFF design:

- **Deep Bed**
- **Dual Media**
- **50” 1.4-mm anthracite + 20” 0.64-mm sand**

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STUDY RESULTS – FILTRATION RATE

Direct Filtration

- 6, 8, 10, 12, and 14 gpm/sf.
- Focus on 10 gpm/sf.
- Higher rates used to test limits of filtration process.

Conventional Filtration

- 6, 8, 10, and 12 gpm/sf.
- Focus on 6 gpm/sf.
- Higher rates used to test limits of filtration process.

GRFF design:

- **10 gpm/sf direct filtration**
- **<6 gpm/sf conventional filtration**

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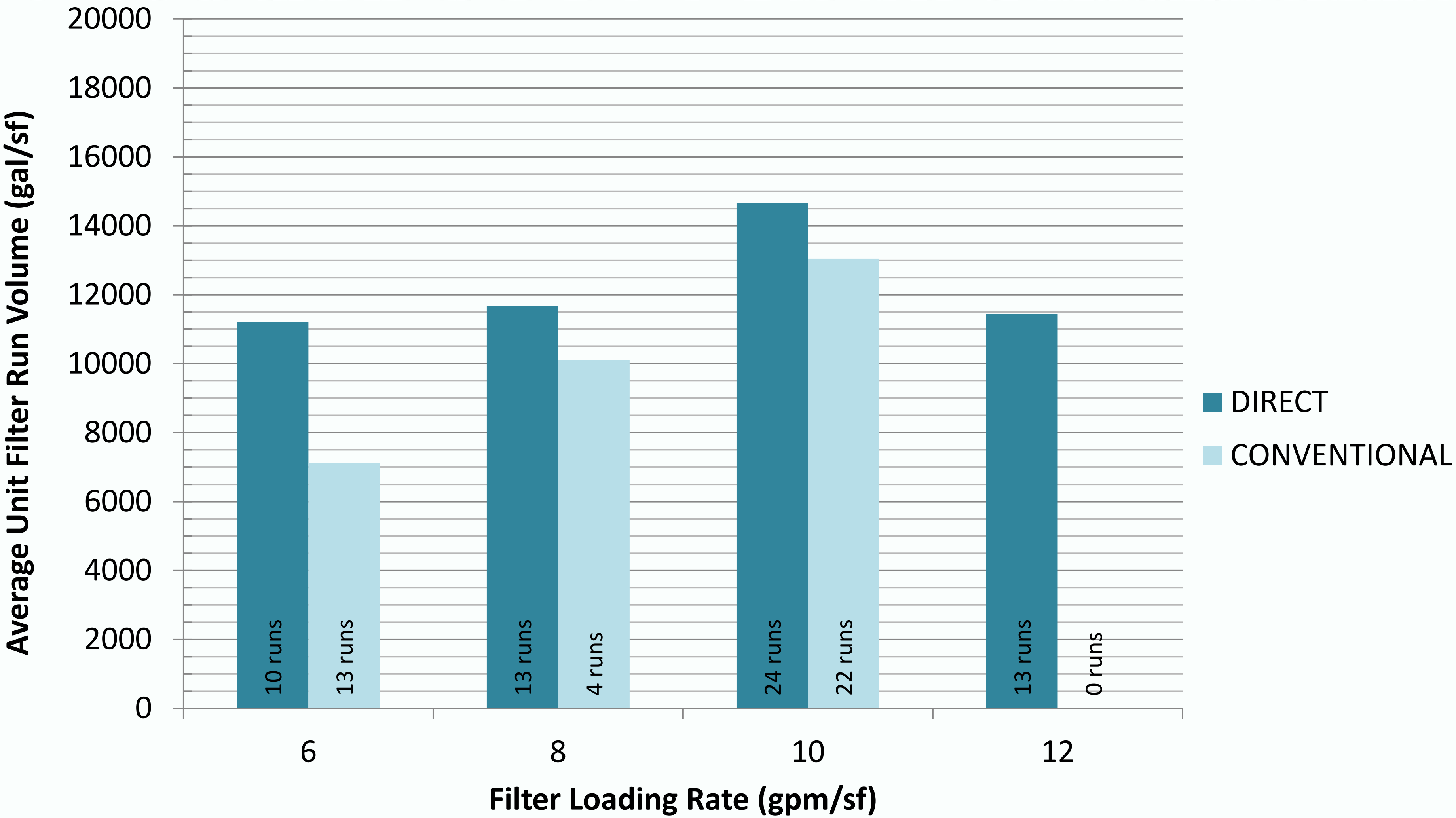
STUDY RESULTS – FILTRATION RATE



UFRV vs. Filtration Rate for Selected Media Configuration (Phase 3)

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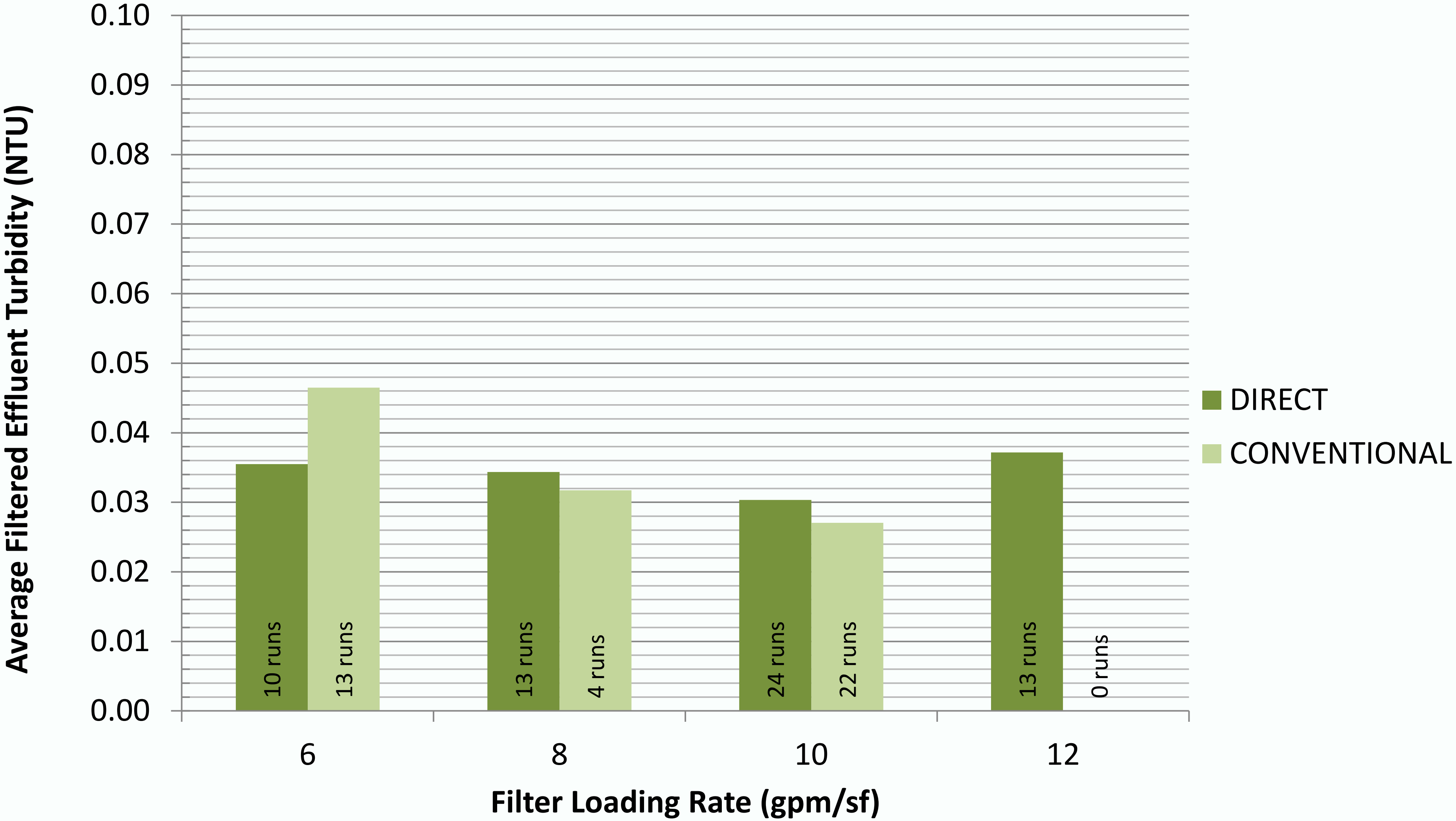
STUDY RESULTS – FILTRATION RATE



Filtered Turbidity vs. Filtration Rate for Selected Media Configuration (Phase 3)

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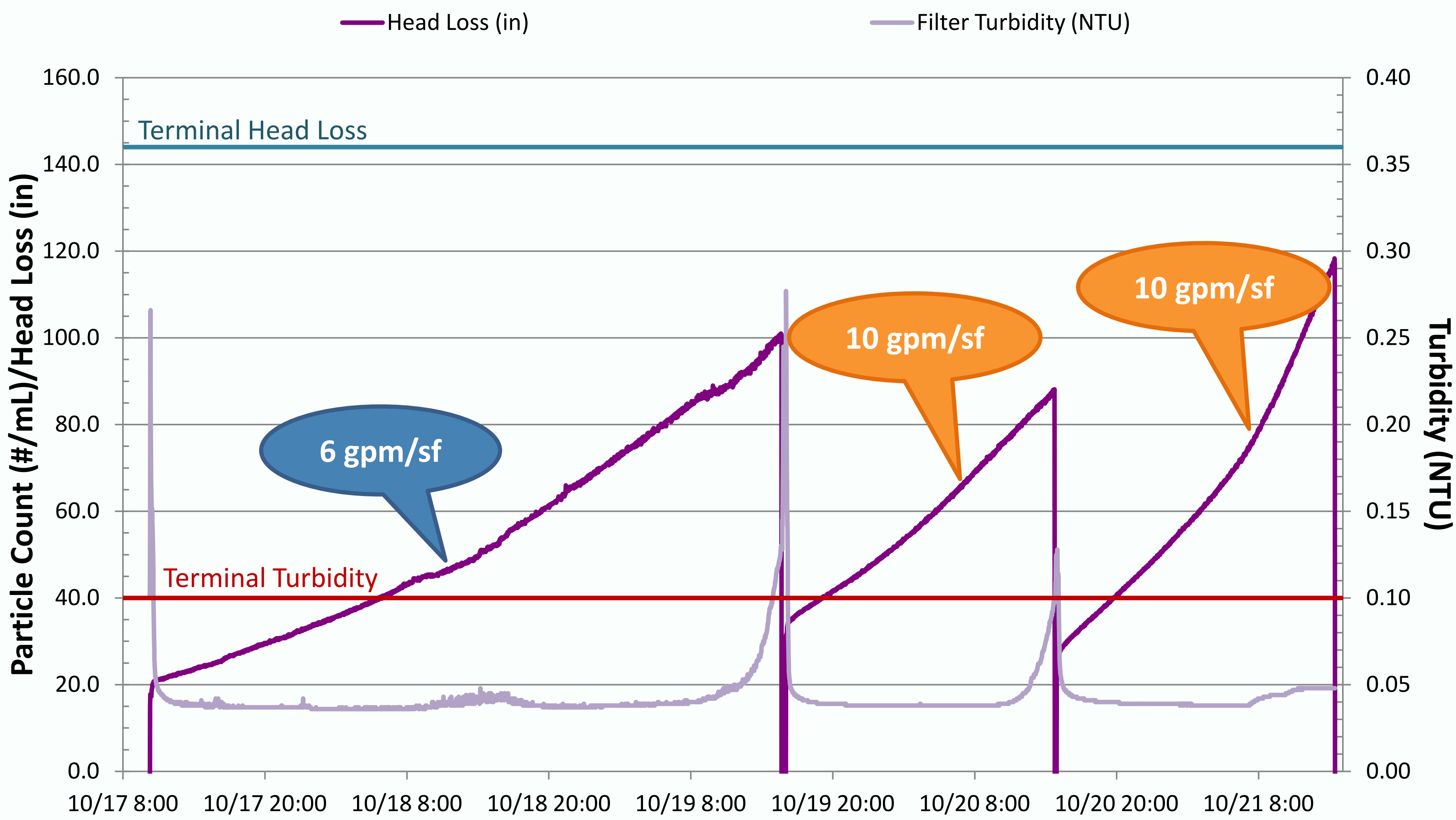
STUDY RESULTS – PARTICLE COUNTS



Example Filter Runs and Particle Counts

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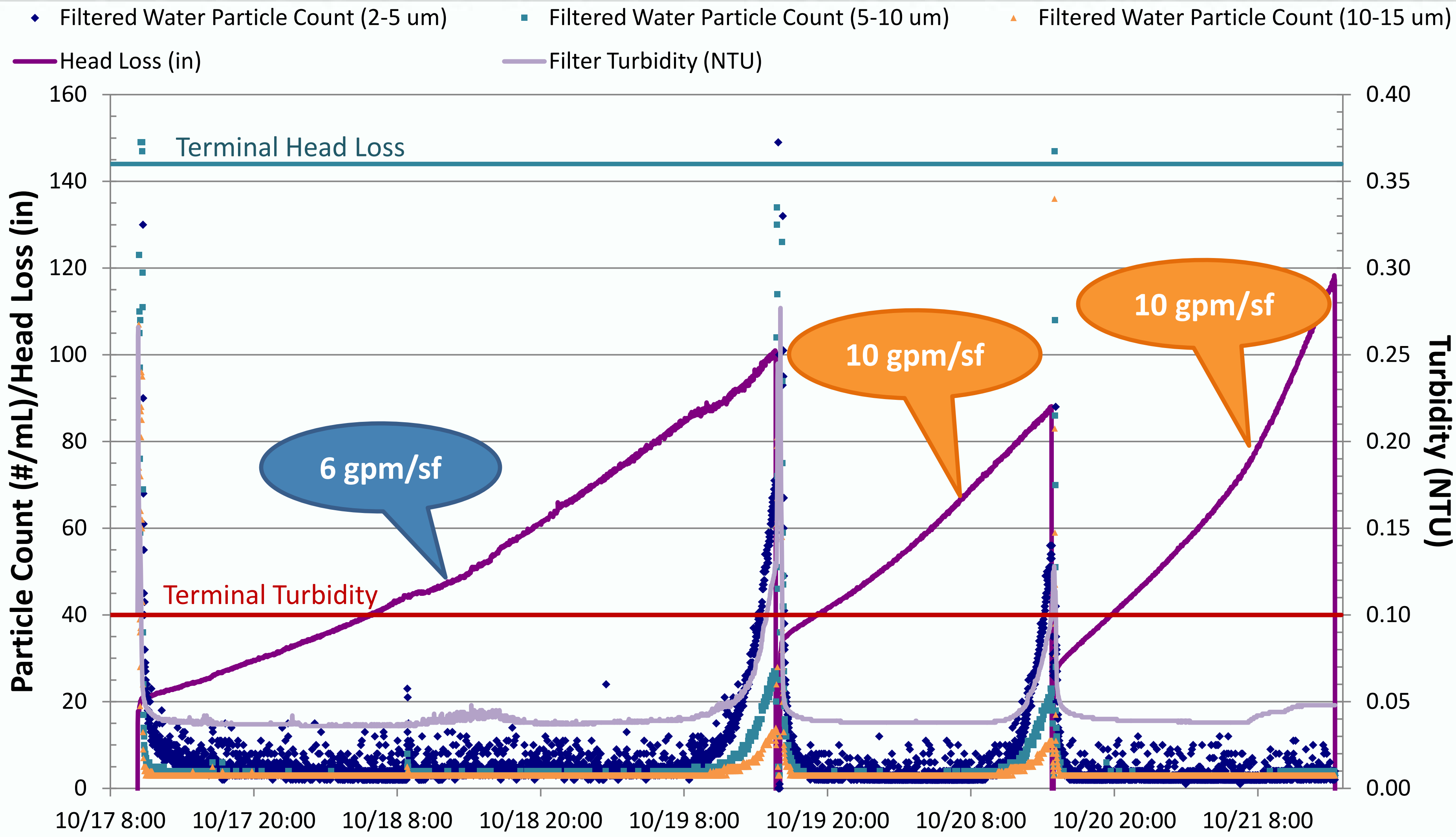
STUDY RESULTS – PARTICLE COUNTS



Example Filter Runs and Particle Counts

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SPECIAL TEST CONDITIONS

Turbidity

- Natural events
- Spiked turbidity

Algae

- Natural blooms
- Batch water from Eagle Gorge Reservoir

North Fork Wellfield

- Blending Green River and North Fork
- Transitioning between sources
- North Fork water only

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SUMMARY AND RECOMMENDATIONS

Pilot Study

- Possible to use a 20-year old pilot plant for modern study, but requires initial and ongoing upgrades.
- Primary limitations: sedimentation process and 3” filter columns.
- Internally staffed pilot study provides in-house experience and greater test flexibility, but additional challenges exist.
- Tools improve pilot operations and data quality (continuous data logger, streaming current meter, and coagulant charge analyzer).
- Particle counts can be an operational tool but variability limits use.

SUMMARY AND RECOMMENDATIONS

Green River Filtration Facility Design

- PACl/ACH primary coagulant with alum as needed.
- Deep-bed dual media filtration required for Green River turbidity fluctuations.
- Filtration rates of 10 gpm/sf and higher are possible for Green River.
- Transitioning to and blending with North Fork Wellfield water presented no undue operational challenges.

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SUMMARY AND RECOMMENDATIONS

10 gpm/sf high rate filtration approved by Washington State DOH April 2012.

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ACKNOWLEDGEMENTS

Tacoma Water staff

Regional Water Supply System Partners – Lakehaven Utility District, Covington Water District, City of Kent

MWH

CH2M HILL/HDR Engineering

Washington State Department of Health

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QUESTIONS

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Improved Water for Newport, Oregon

A Small Town & the Challenges of a Huge Project

Presented by

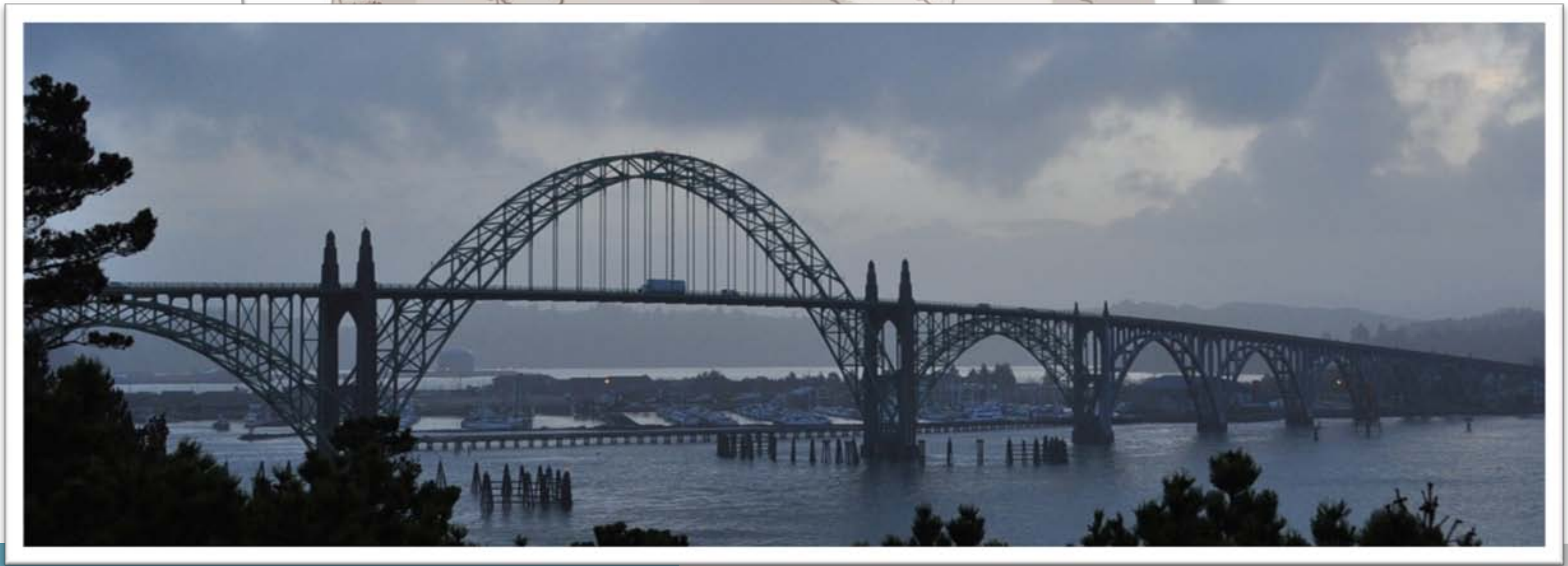
Verena Winter, P.E. HDR Engineering

Tim Gross, P.E. City of Newport, OR

HDR

Newport, OR

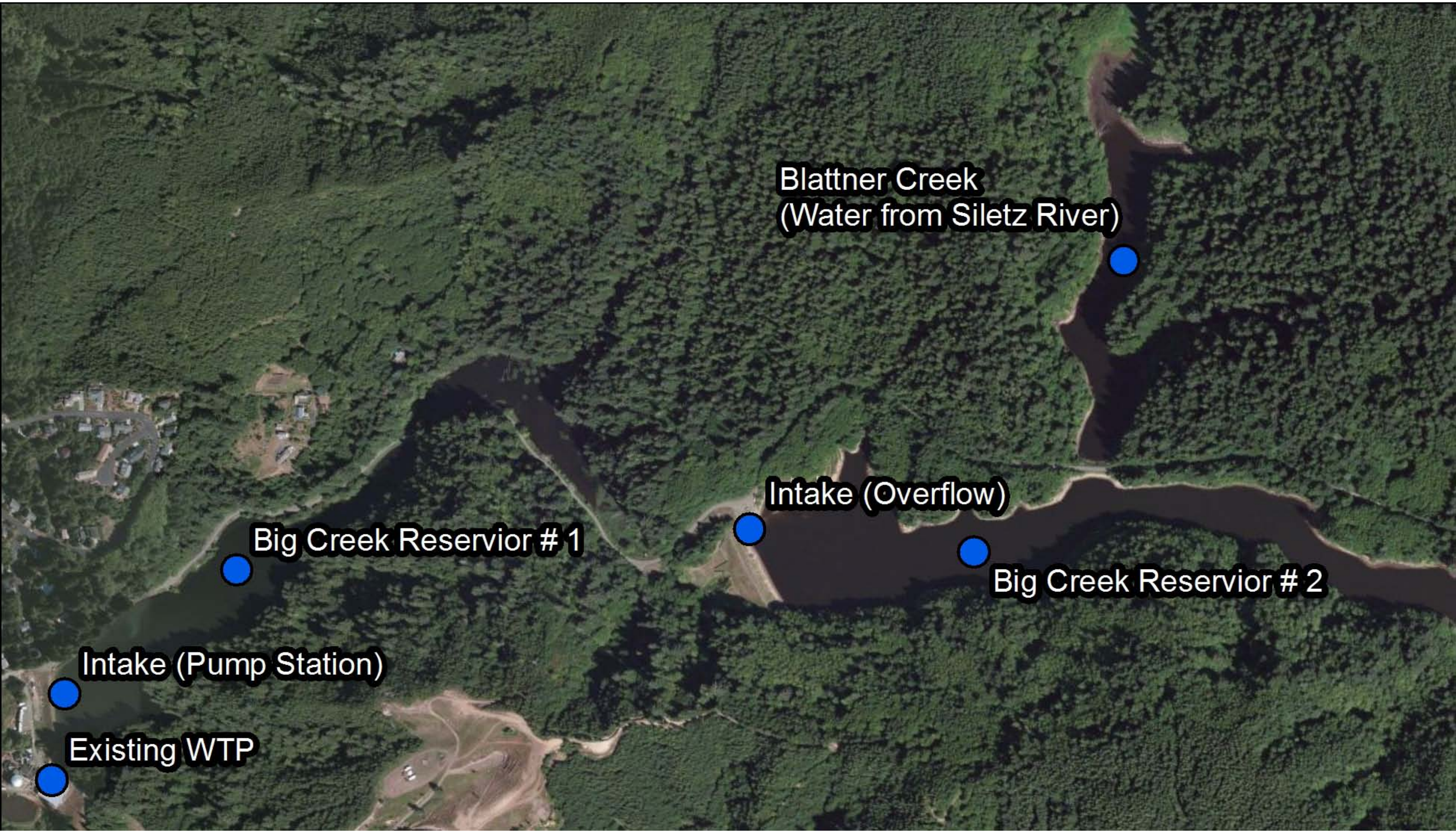

City of Newport
Salem
Eugene
Springfield
Corvallis
Lebanon
Albany
Bend
Redmond
Lincoln City
Depoe Bay
Seal Rock
Waldport
Yachats
Florence
McMinnville
Dallas
Monmouth
Independence
Oregon City
Estacada
Silverton
Stayton
Sweet Home
Brownsville
Sisters
Madras
Cottage Grove
Oakridge
Creswell
Lowell
Marcola
Vida
Mill City
Gates
Idanha
Detroit
Reedsport
Crescent Lake
Three Rivers
La Pine
Simnasho
Maupin
Warm Springs
Culver
Harlan
Alsea
Monroe
Junction City
Mapleton
Swisshome
Elkton
Drain
Dallas
Amity
Willamina
Pacific City
Beaver
Otis
Siletz
Rhododendron
Molalla
Scotts Mills
Canby
Woodburn
Elkhorn
Jefferson
Dollar
Lake Oswego
Tualatin
Newberg
Keizer
Gervais
Donald
Wamic
Eddyville
Dexter
Scottsburg
Winchester Bay
Dilley
Diston



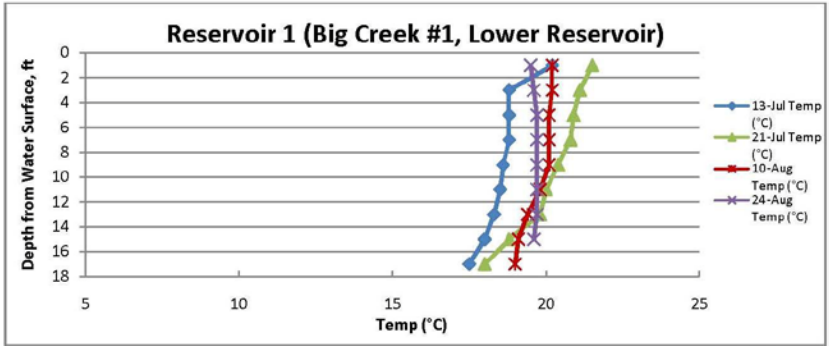
Existing Water Treatment Plant

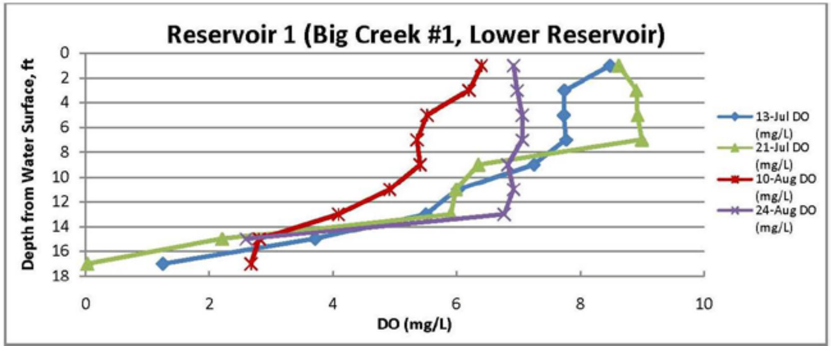
HDR

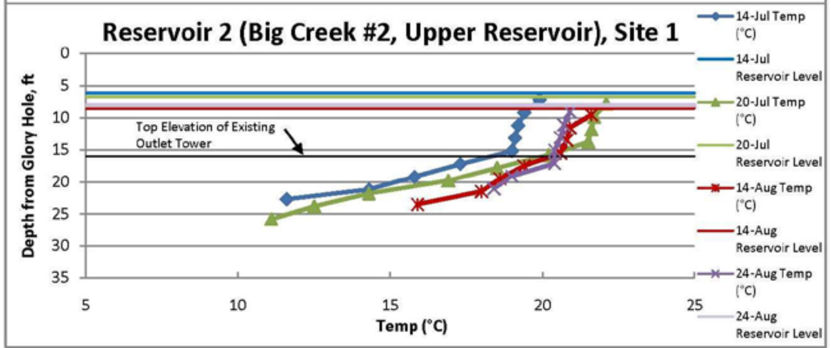
Water Source

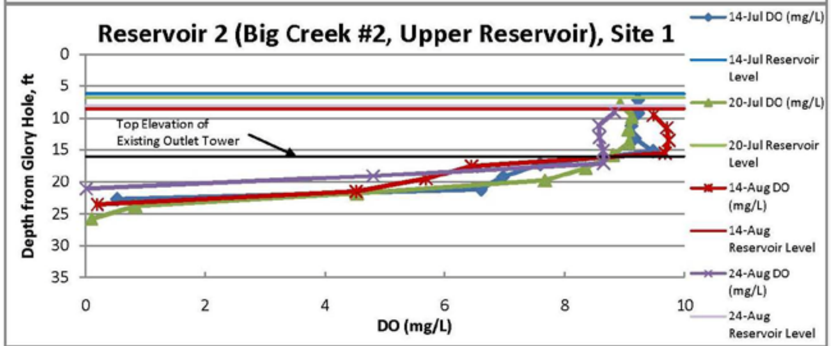


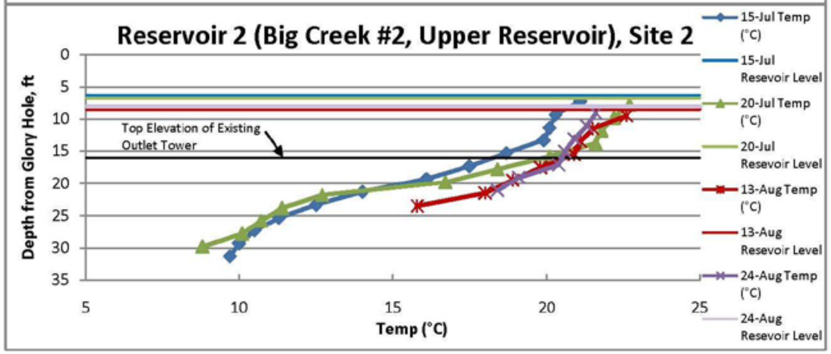
Water Quality

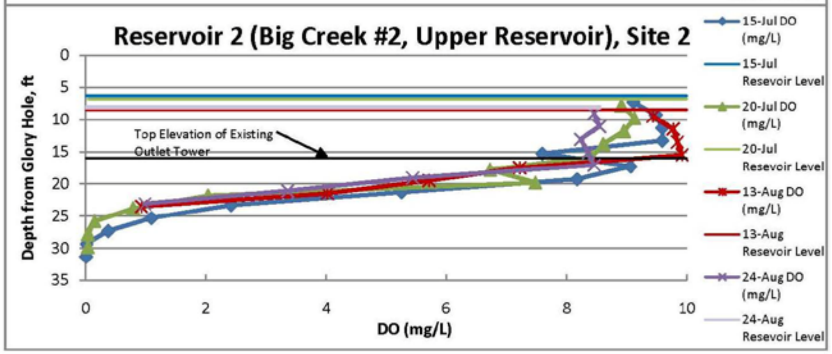




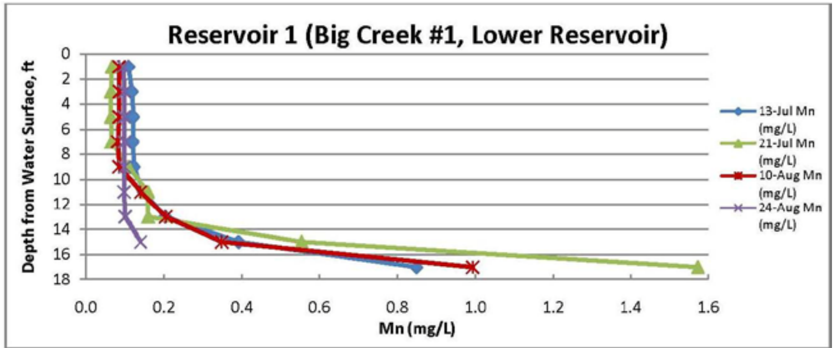


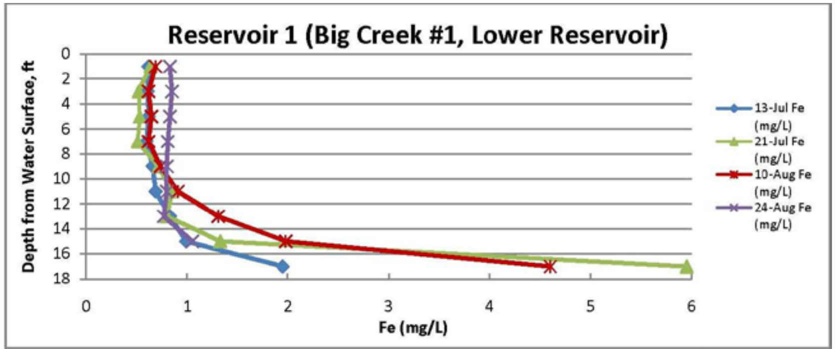


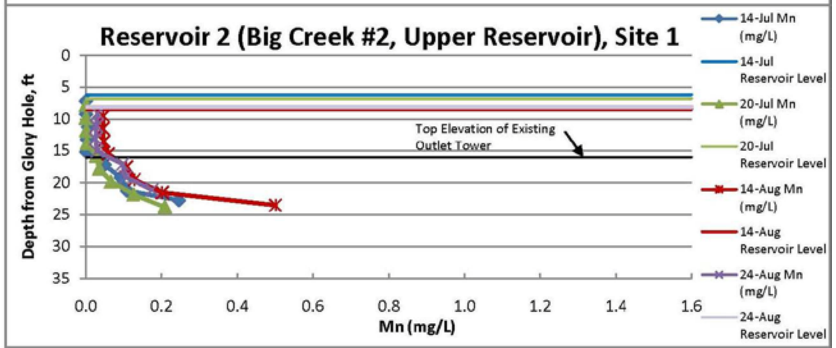


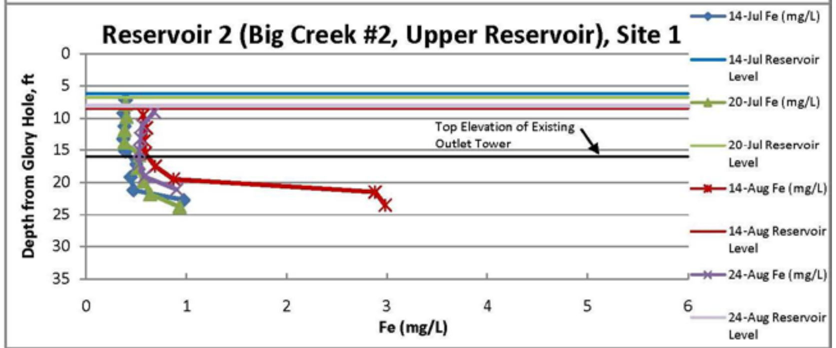


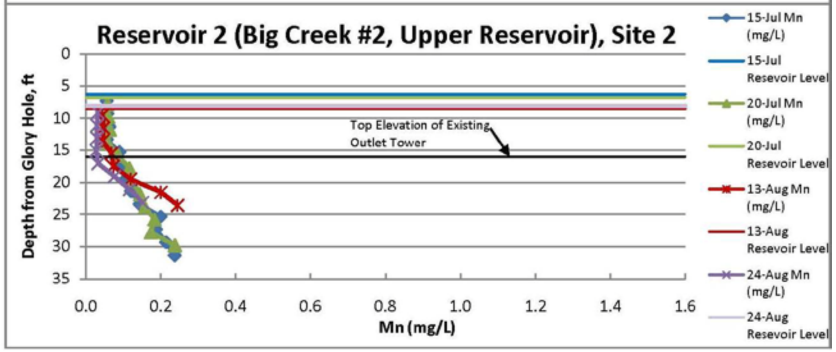
Water Quality cont…

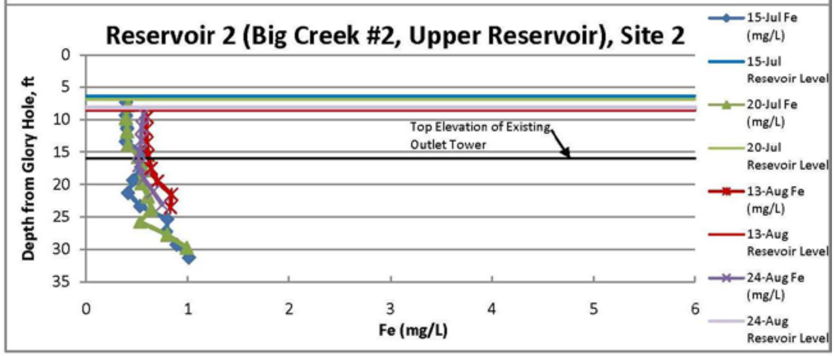












Financing

- General obligation bond $15,900,000
- Based on Master Plan estimate
- $3.5 Million additional needed
- City Council & City Finance Director pooled other resources together

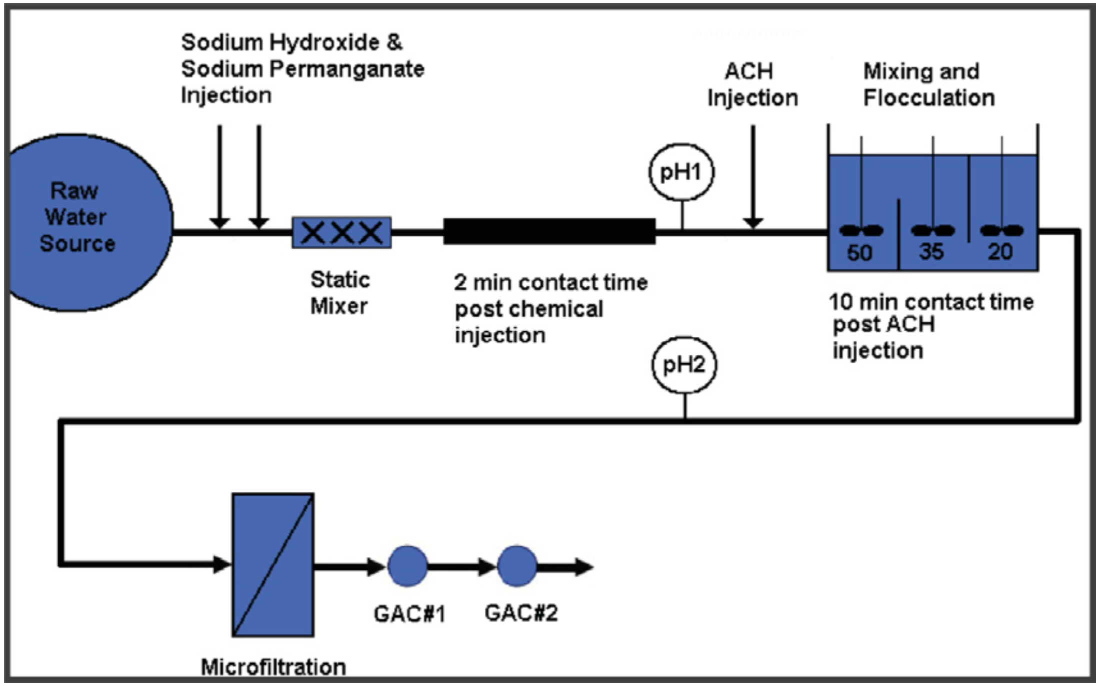
Contractor

- CM/GC (Construction Management/ General Contractor)
- Slayden Construction Group
- Involvement at 50% design
- Value Engineering to get costs down

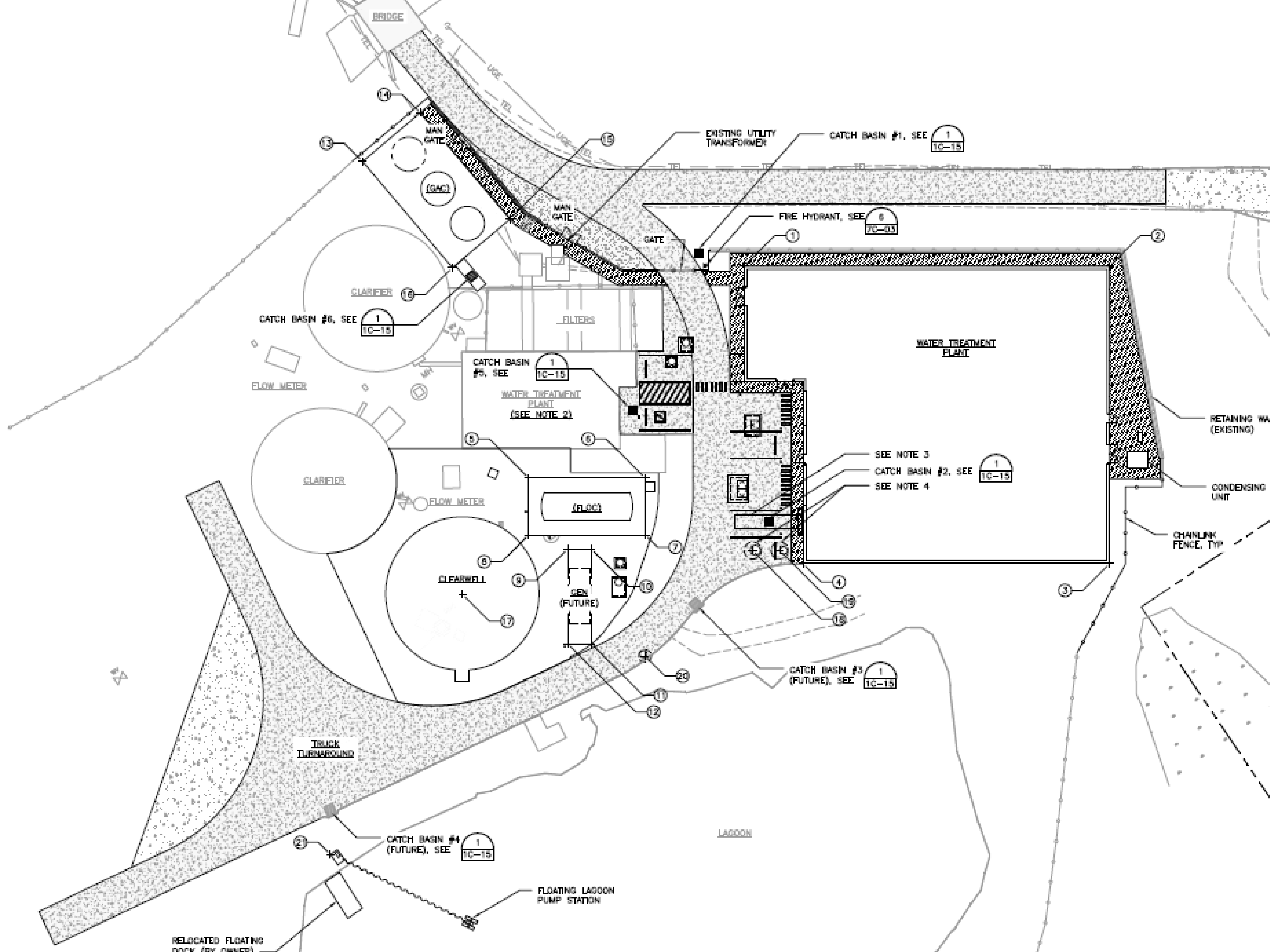
HDR

Pilot Testing

- Membrane manufacturer: Pall Corporation
- 3 month duration
- Phase 1 & 2: with pre-treatment
- Phase 3: without pre-treatment
- Mn & Fe removed with right chemical dosage
- T & O removed with GAC

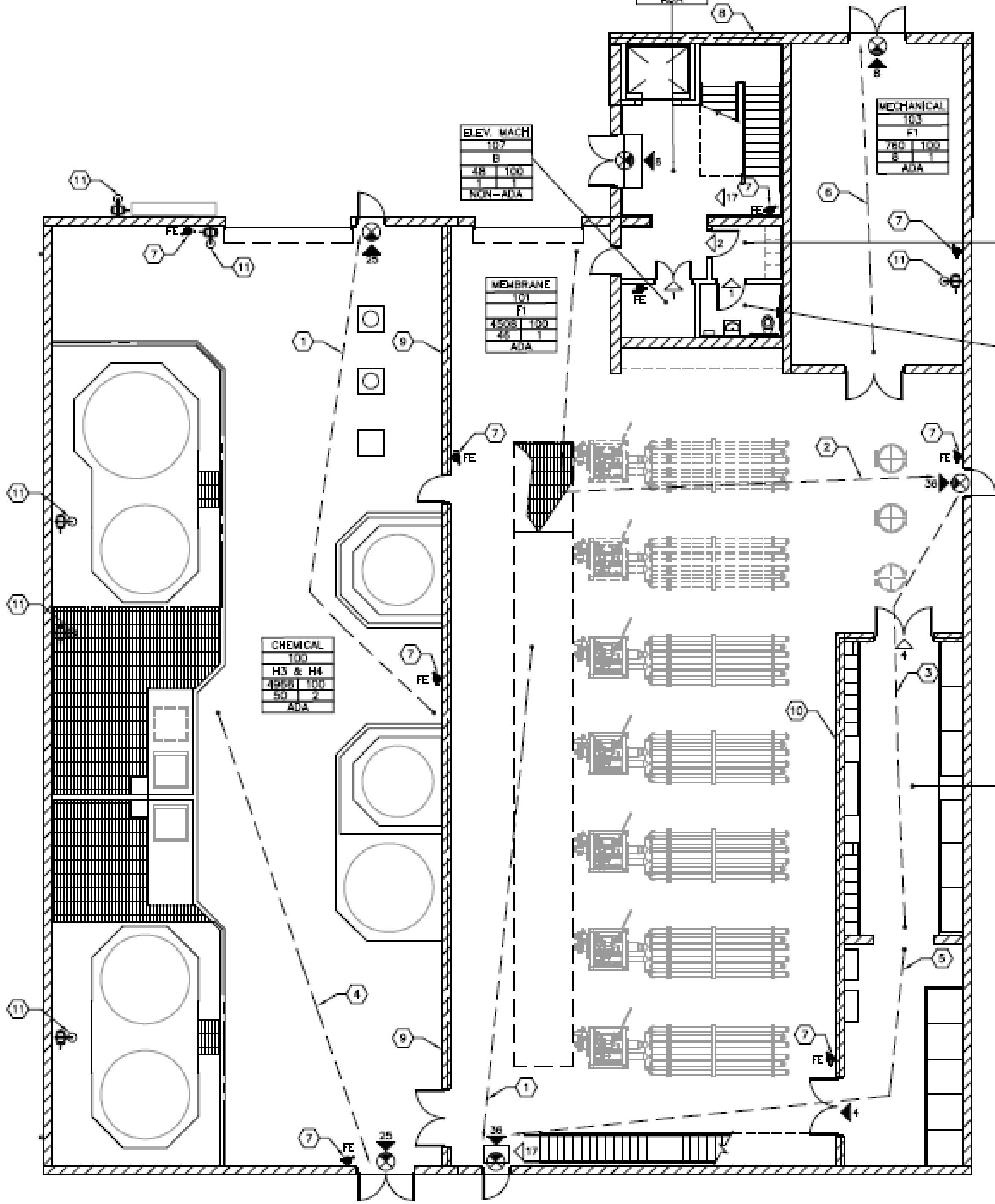


Pilot Testing cont…

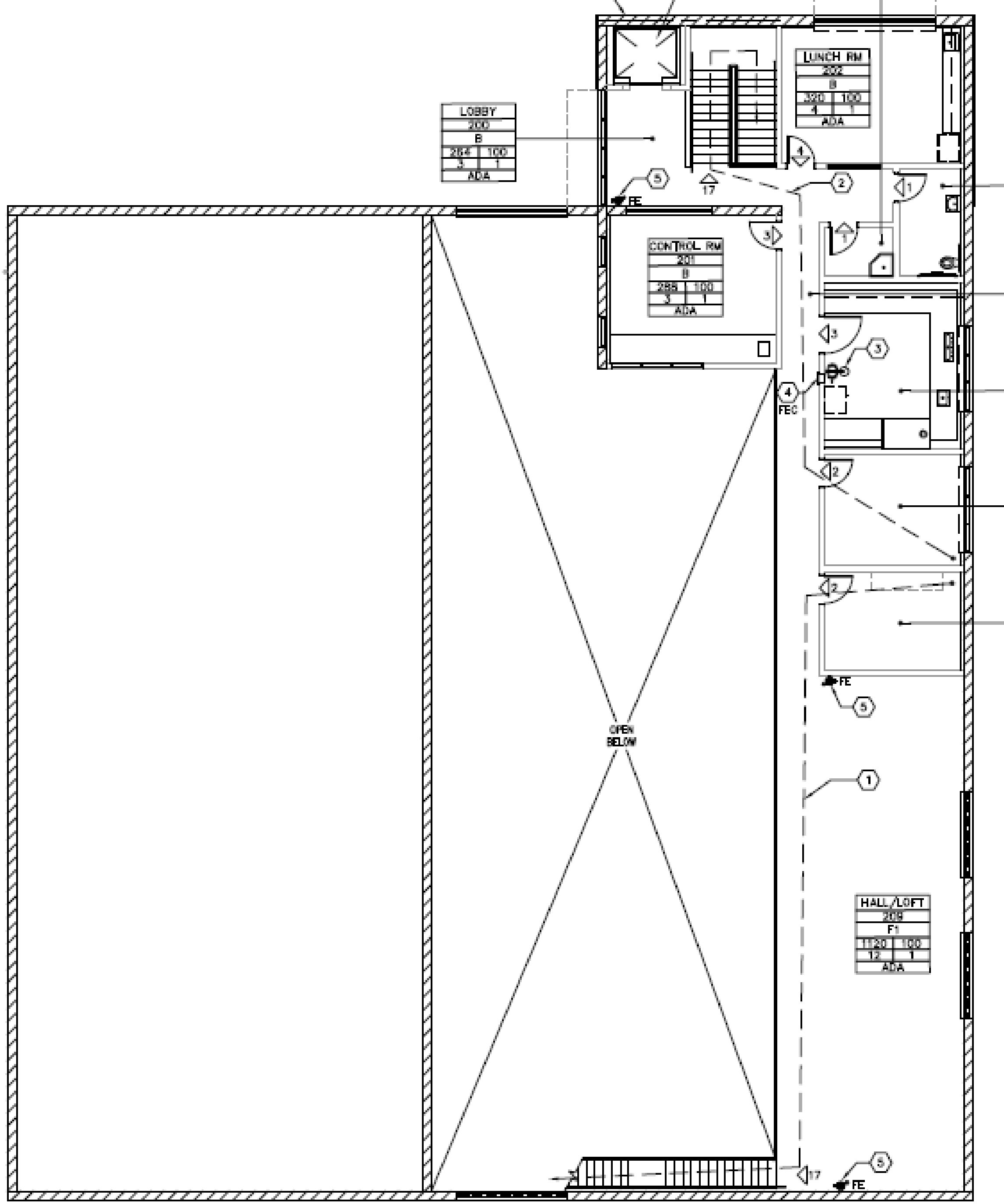


BRIDGE
MAN GATE
(GAC)
MAN GATE
EXISTING UTILITY TRANSFORMER
CATCH BASIN #1, SEE 1 1C-15
FIRE HYDRANT, SEE 6 7C-03
GATE
CLARIFIER
FILTERS
CATCH BASIN #6, SEE 1 1C-15
FLOW METER
CATCH BASIN #5, SEE 1 1C-15
WATER TREATMENT PLANT (SEE NOTE 2)
WATER TREATMENT PLANT
RETAINING WA
(EXISTING)
SEE NOTE 3
CATCH BASIN #2, SEE 1 1C-15
SEE NOTE 4
CONDENSING UNIT
CHAINLINK FENCE, TYP
CLARIFIER
FLOW METER
(FLOC)
CLEARWELL
GEN (FUTURE)
CATCH BASIN #3 (FUTURE), SEE 1 1C-15
TRUCK TURNAROUND
LAGOON
CATCH BASIN #4 (FUTURE), SEE 1 1C-15
FLOATING LAGOON PUMP STATION
RELOCATED FLOATING

Design


ELEV. MACH
107
B
48 | 100
1 | 1
NON-ADA
MEMBRANE
101
F1
4508 | 100
45 | 1
ADA
MECHANICAL
103
F1
760 | 100
8 | 1
ADA
CHEMICAL
100
H3 & H4
4966 | 100
50 | 2
ADA
FE

Design



LOBBY
200
B
264 100
3 1
ADA
LUNCH RM
202
B
320 100
4 1
ADA
CONTROL RM
201
B
285 100
3 1
ADA
OPEN
BELOW
HALL/LOFT
209
F1
1120 100
12 1
ADA
FE
FEC

Design

- **Intake**
- Flocculation
- Auto Strainers
- Membrane Filtration
- GAC
- Disinfection

Design cont…

- Intake
- **Flocculation**
- Auto Strainers
- Membrane Filtration
- GAC
- Disinfection

Design cont…

- Intake
- Flocculation
- **Auto Strainers**
- Membrane Filtration
- GAC
- Disinfection

Design cont…

- Intake
- Flocculation
- Auto Strainers
- **Membrane Filtration**
- GAC
- Disinfection

HDR

Design cont…

- Intake
- Flocculation
- Auto Strainers
- Membrane Filtration
- **GAC**
- Disinfection

Design cont…

- Intake
- Flocculation
- Auto Strainers
- Membrane Filtration
- GAC
- **Disinfection**

Design cont…

- High Service Pumps to Distribution

Design Cont…

- 3 membrane racks with 70 modules for primary treatment
- 1 backwash rack with 50 modules allows for 95% recovery
- 1 standby rack able to do primary and backwash treatment
- Space for 2 additional racks provided for future capacity

Project Challenges

- Finances
- Water quality
- Site constrains
- Geotechnical issues – ground improvements
- Existing/new intake structure
- Dam seismic stability issues

Project Challenges

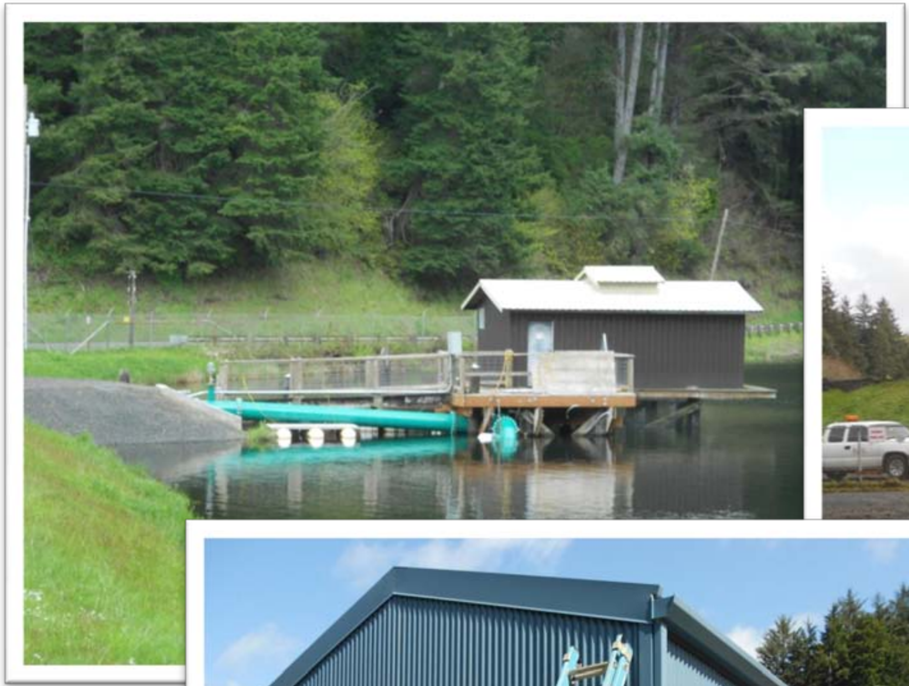
Geotechnical Issues – Ground Improvements

Project Challenges

New/Existing Intake Structure

Project Challenges Cont…

New/Existing Intake Structure



Project Challenges cont…

Dam Seismic Stability in Question

Construction Timeline

December 2009

October 2010

Construction Timeline Cont…

January 2011

March 2011

Construction Timeline Cont…

April 2011

May 2011

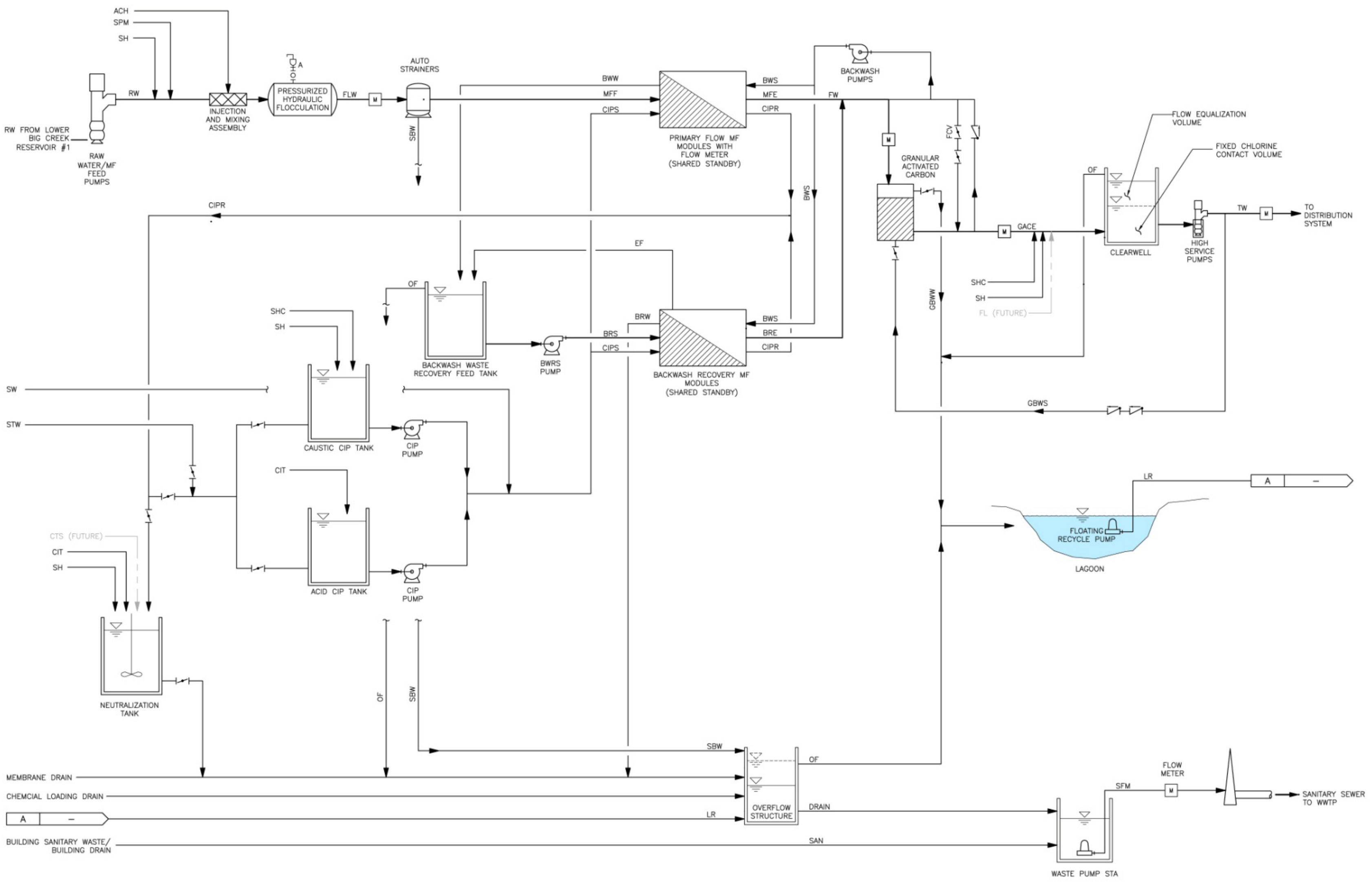
Construction Timeline Cont…

August 2011

March 2012

WHO HAS THE FIRST QUESTION

Construction Timeline Cont…



HDR

Improving Filter Performance Without Membranes – Ideas That Have Worked!

Steve Price, PE

May 4, 2012

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Presentation Agenda

The “Challenge” using existing infrastructure

Example and Filtration Forensics

Solutions that have worked

Acknowledgements

Discussion

The “Challenge”

As our infrastructure ages, we need to identify viable and proven "infra-stretching" solutions

- Many treatment plants built in the 1930s through 1960s
- Many have exceeded or are reaching the end of their original projected life
- Regulations, of course, became more stringent
  - Turbidity for entire plant
  - Turbidity for each filter, each half
  - Lower ripening turbidities
  - Better recording and reporting (more enforcement!!)
  - Particle counting, more accurate readings on turbidity breakthrough
- Focus on organics – TOC and DOC removal
- All this with the same original plant design

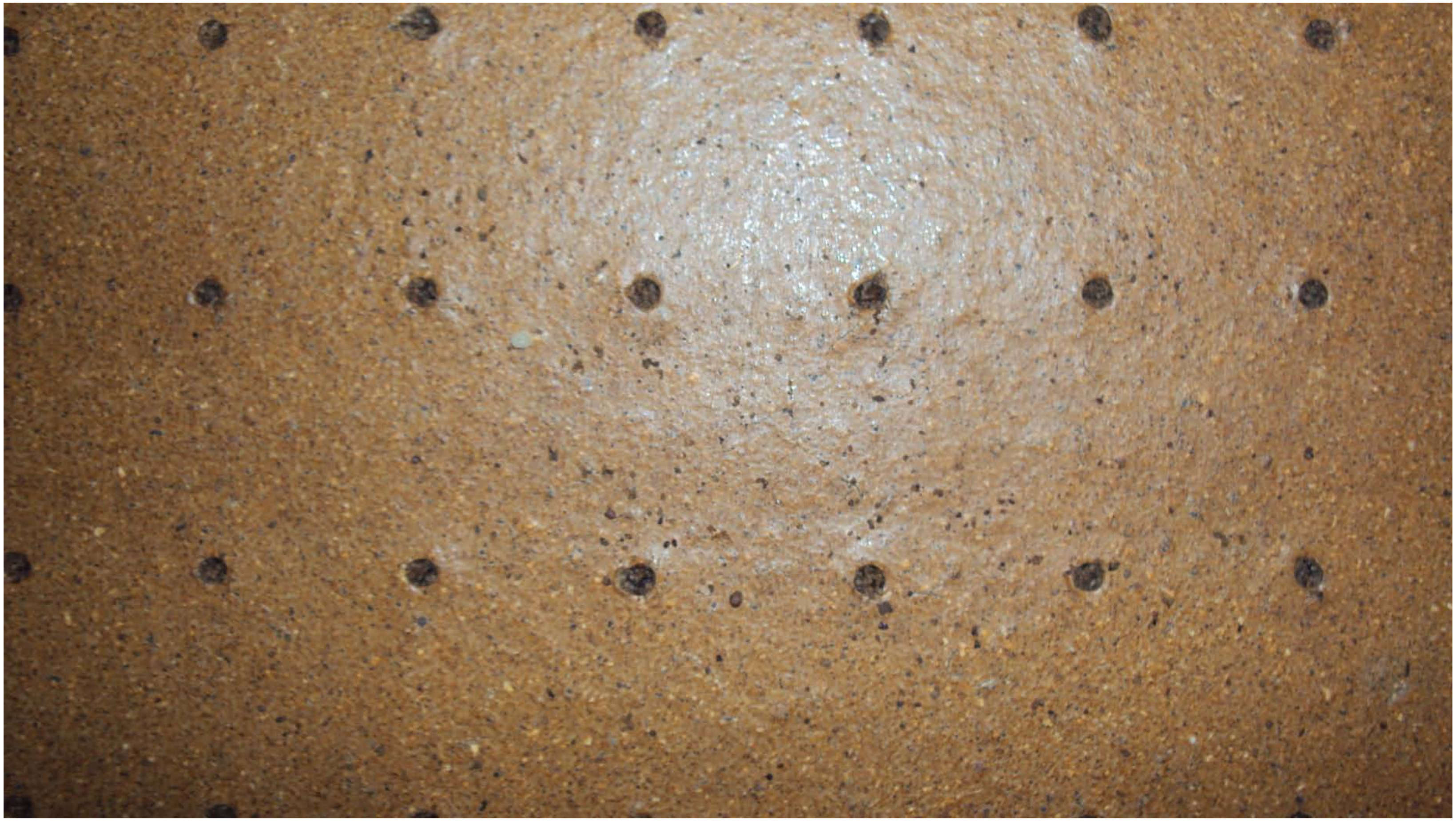
CSI: Yakima

How filter “autopsies” and forensic analysis can help identify performance variances

Autopsy – sometimes you just need to look inside!

- Softening concrete and mortar
- Opening up spaces or dislodging underdrains
- Allowing piping through the system

Sand in holes – look really close!



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Old troughs – take up a lot of surface area of the filter and starting to show aggregate

Automatic Backwash (traveling bridge) Filters – some regulators not allowing anymore

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Mudballs and ineffective surface wash cleaning

Uneven air and washwater distribution, boiling

Old, cracking media, exposed aggregate, etc..

Media migration and mounding

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Plant where utility thought they had the tepee style underdrains

Plant where utility thought they had the tepee style underdrains, continued.

More autopsy photos – look at the filter in layers

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More autopsy photos – look at the filter in layers

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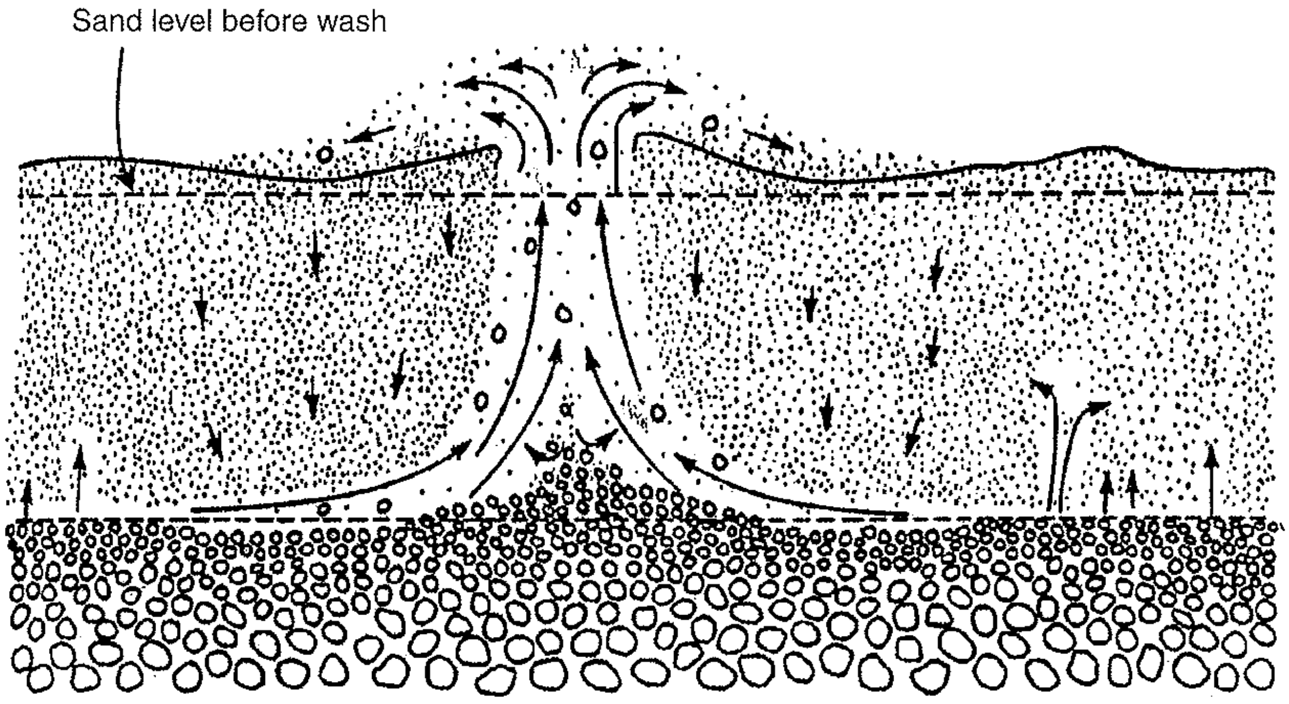
Filter "Boiling"

- Boiling is usually clearly visible during the early stages of backwash



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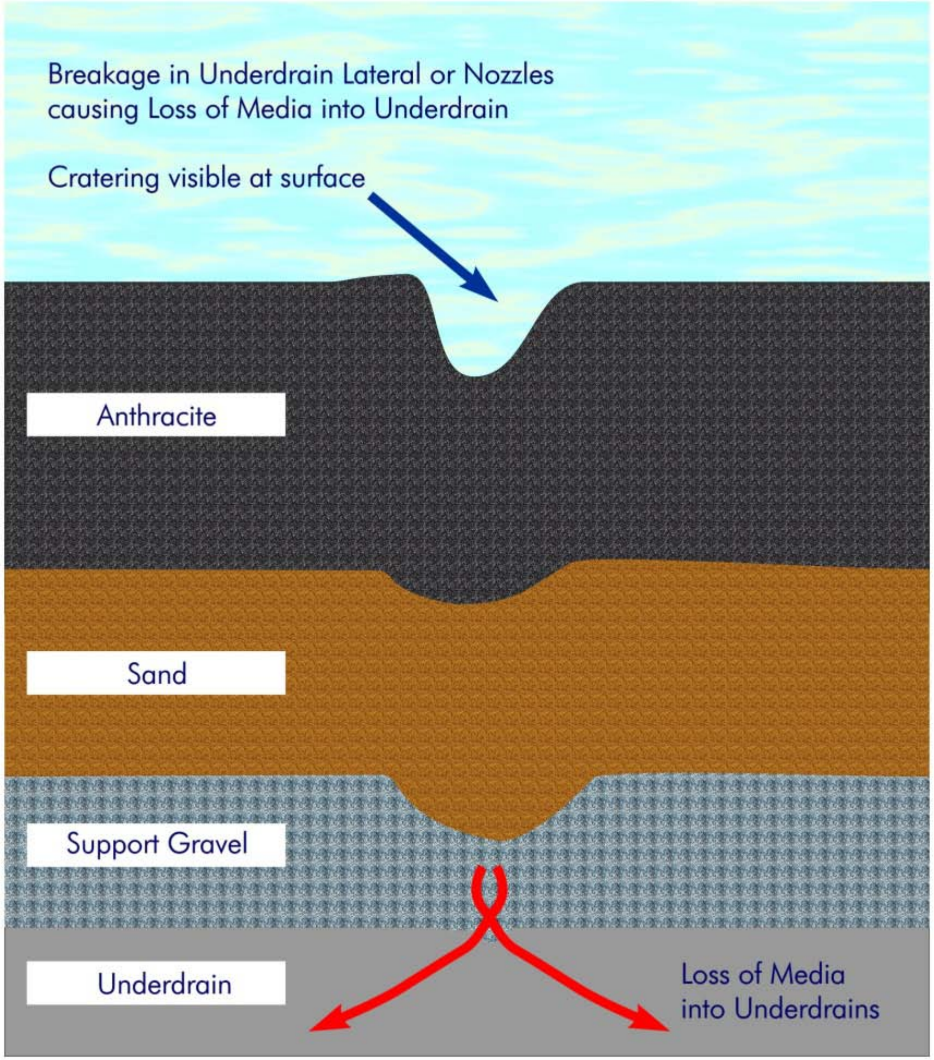
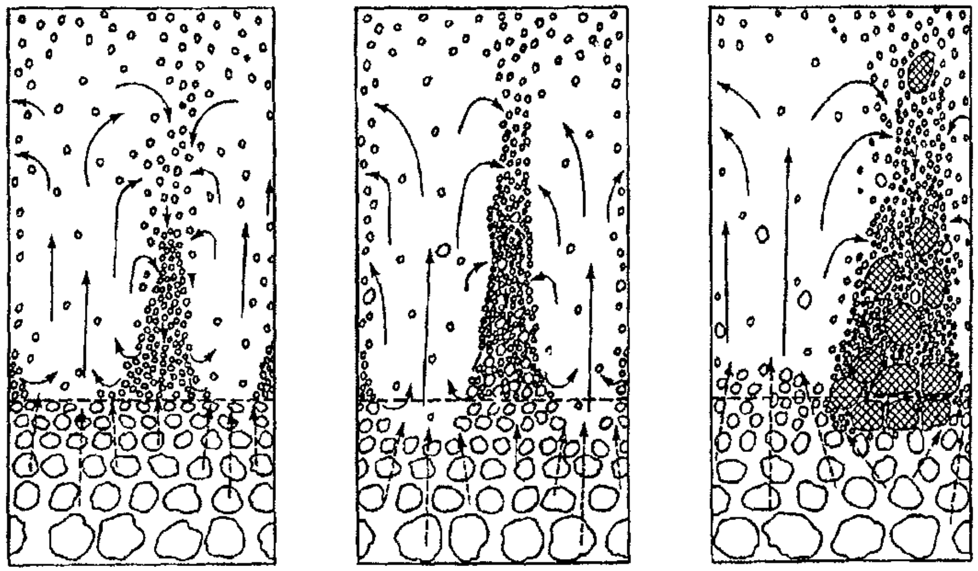
Visual Inspection - Cratering

- Cratering of filter media surface – Suggests possible damage to underdrain



Visual Inspection - Mudballs

- Insufficient Wash Velocities to remove heavier mud and silts
- Effectively blocks off filter area and increases local loading rates



(a) Newly constructed bed

(b) After several washes

(c) Mudballs forming clogged area

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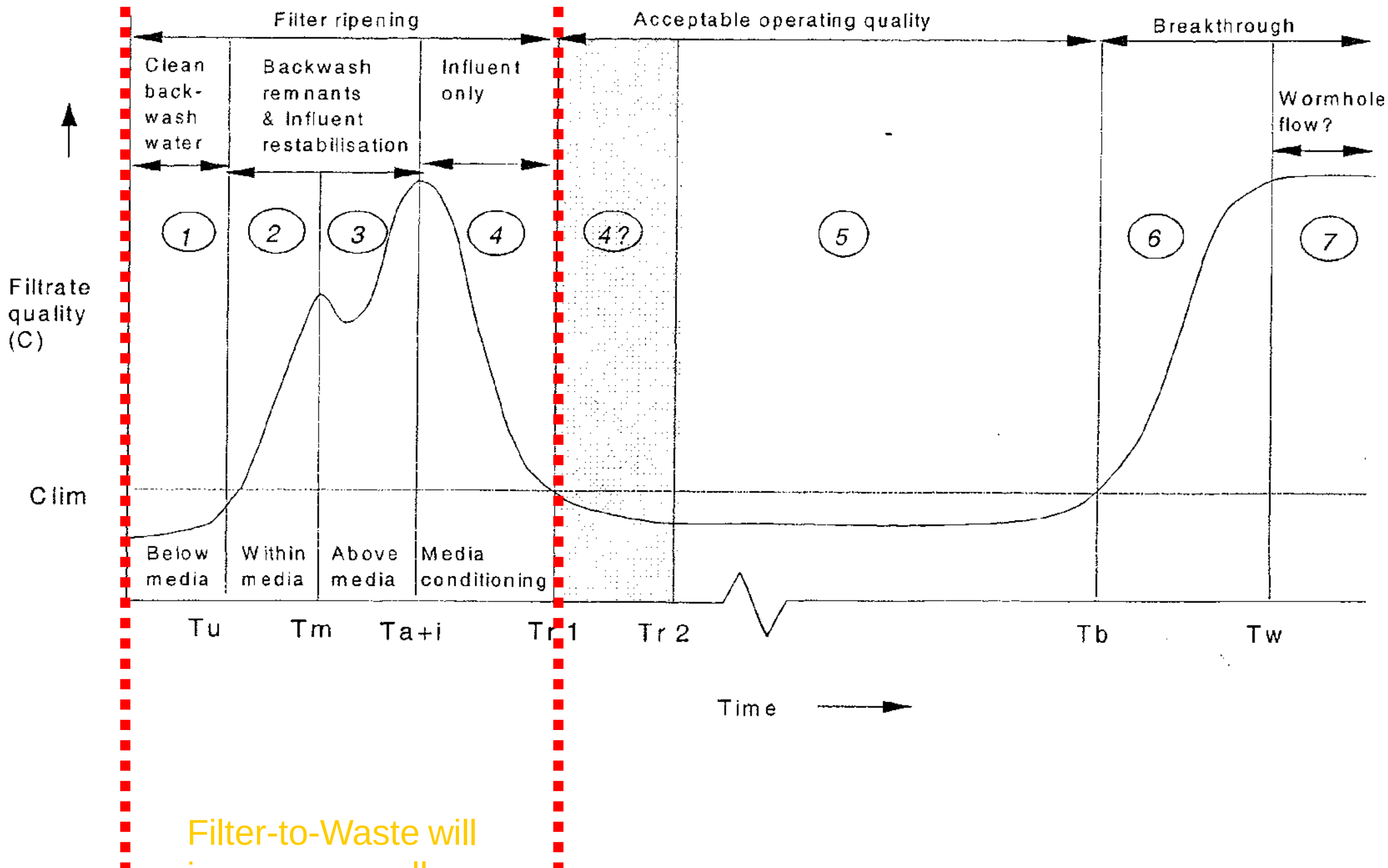
Visual Inspection – Other Issues

- “Cracking” at media surface
- Sand separation at filter walls
- Visible algae growth
- Filter media in troughs
- Has scaling or fouling changed the backwash characteristics of the media ?
- Depth of Media – Is it uniform ?
- Are the washwater troughs level ?
- Freeboard – Top of media to underside of trough
- Does surface wash effectively reach the corners ?

Look at the numbers, graphs (analogous to EKGs, blood work, etc..). Here's a typical filter run



Filter-to-Waste will improve overall filtered water quality

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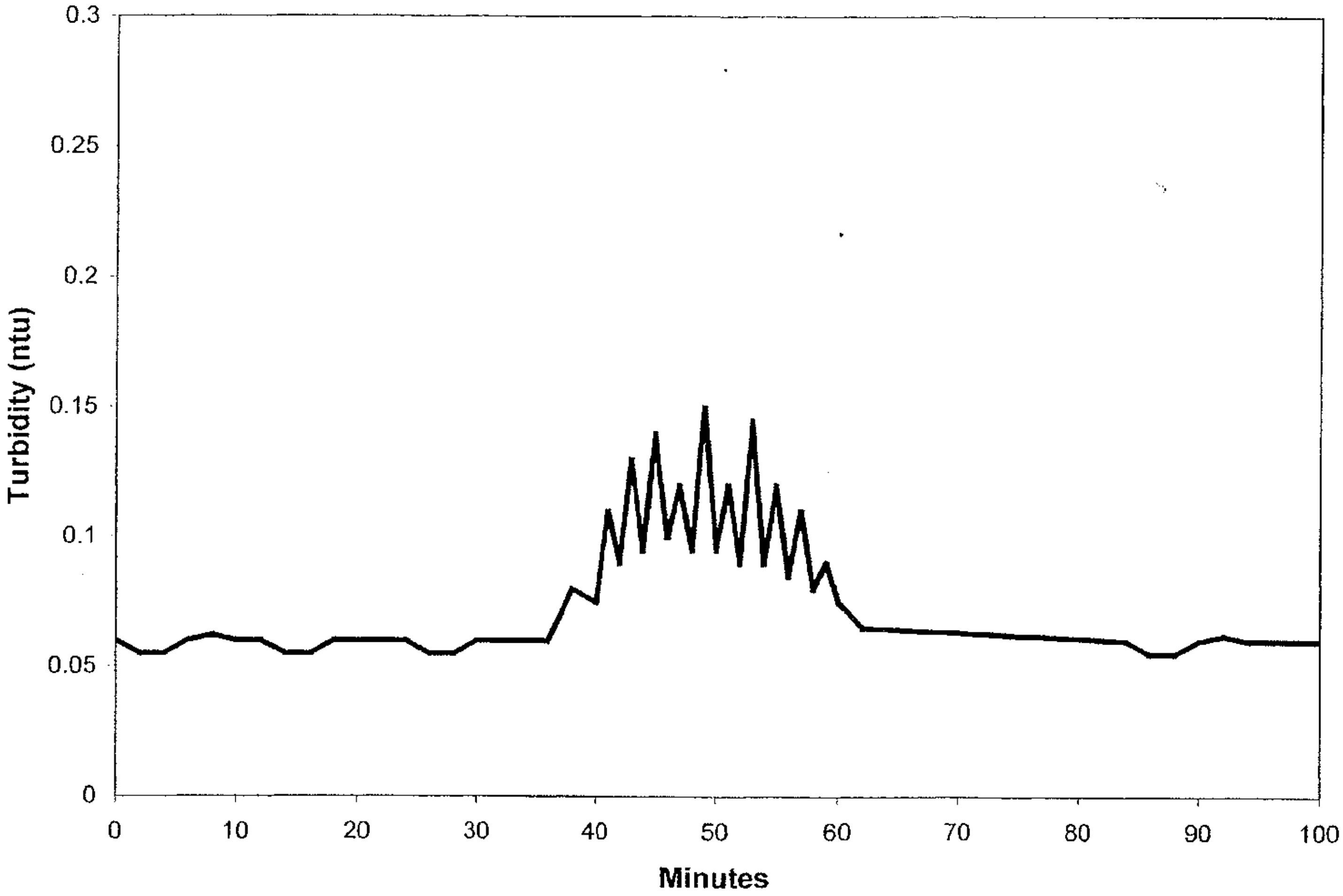
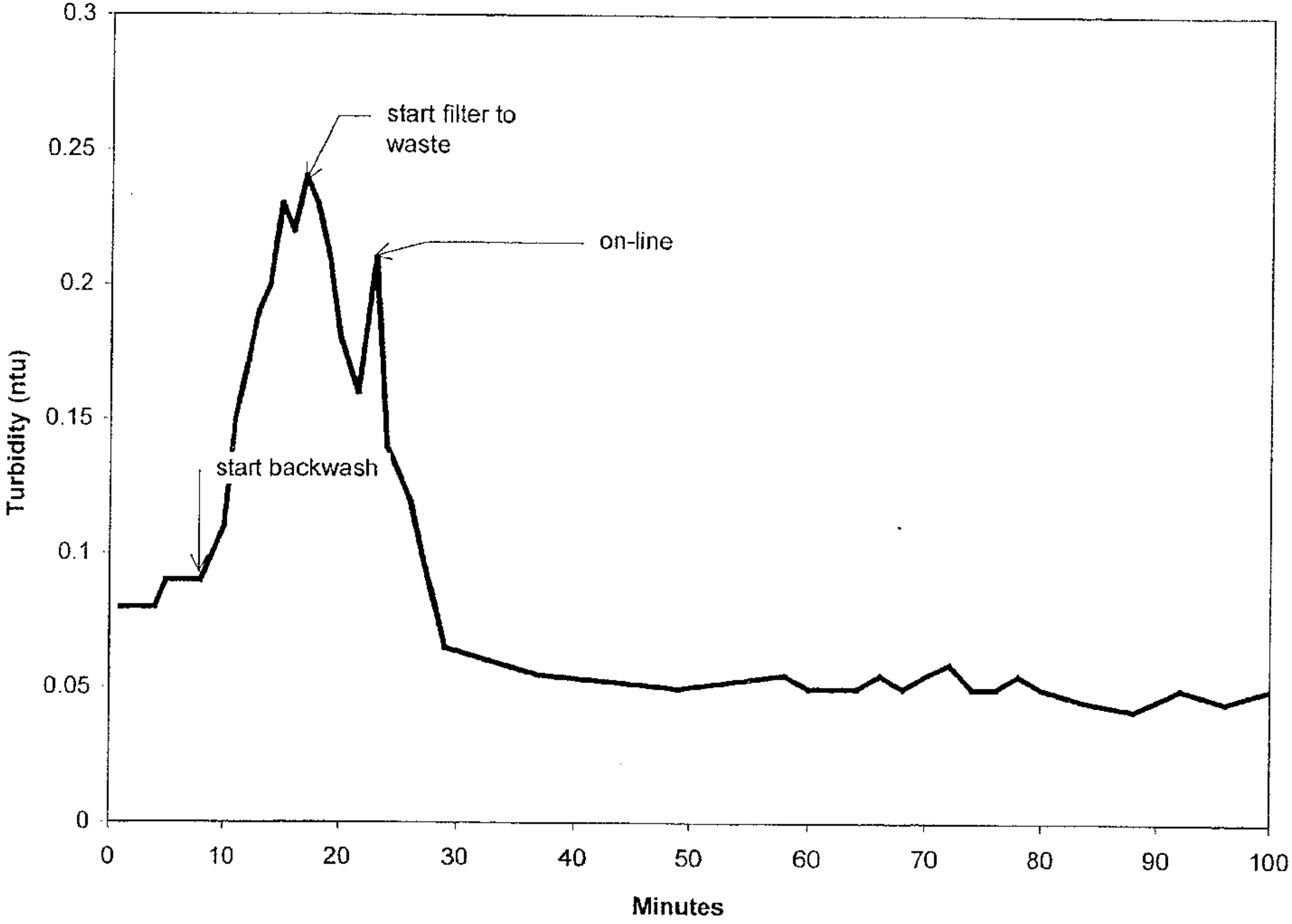
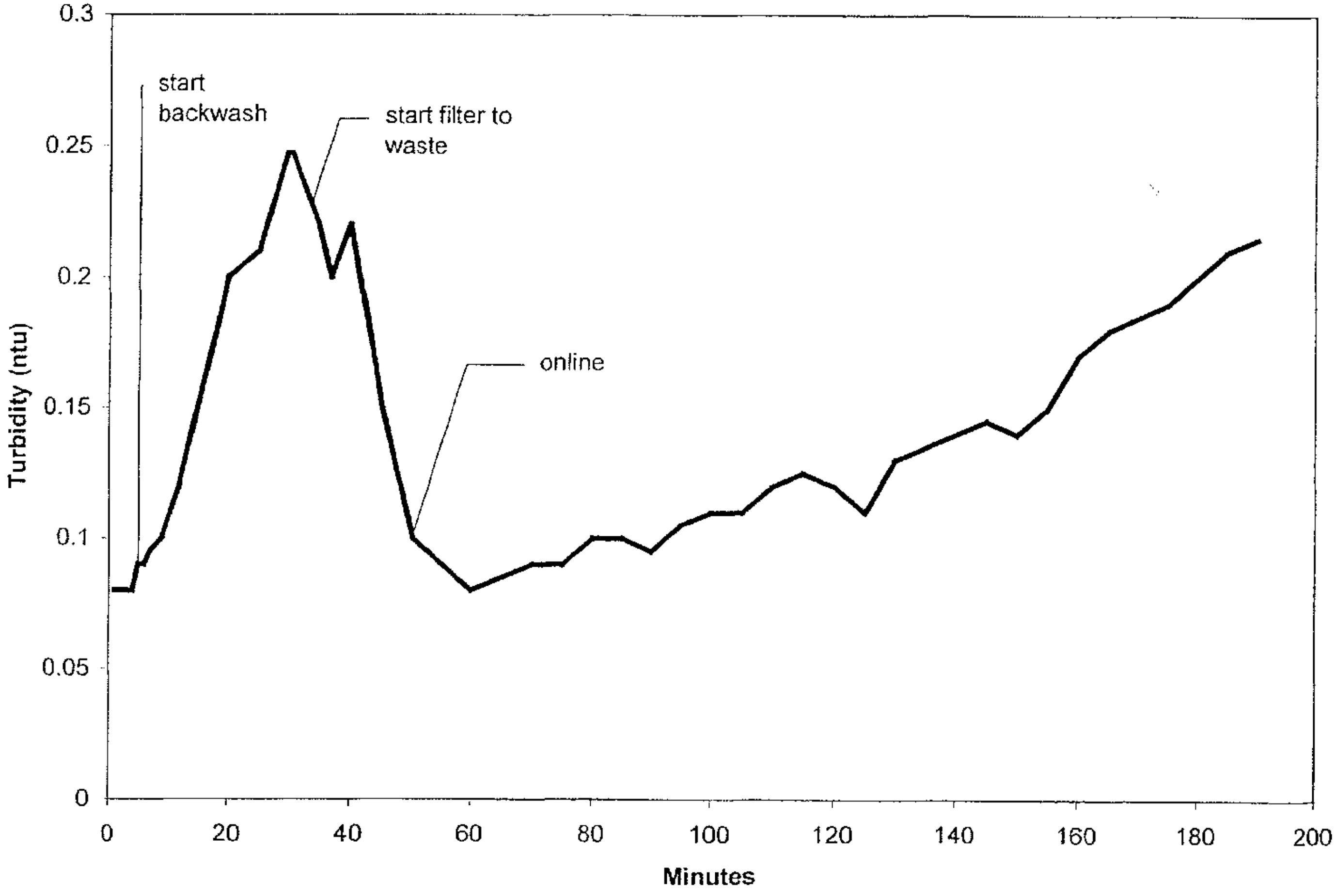
Filter Issues – Valve Hunting



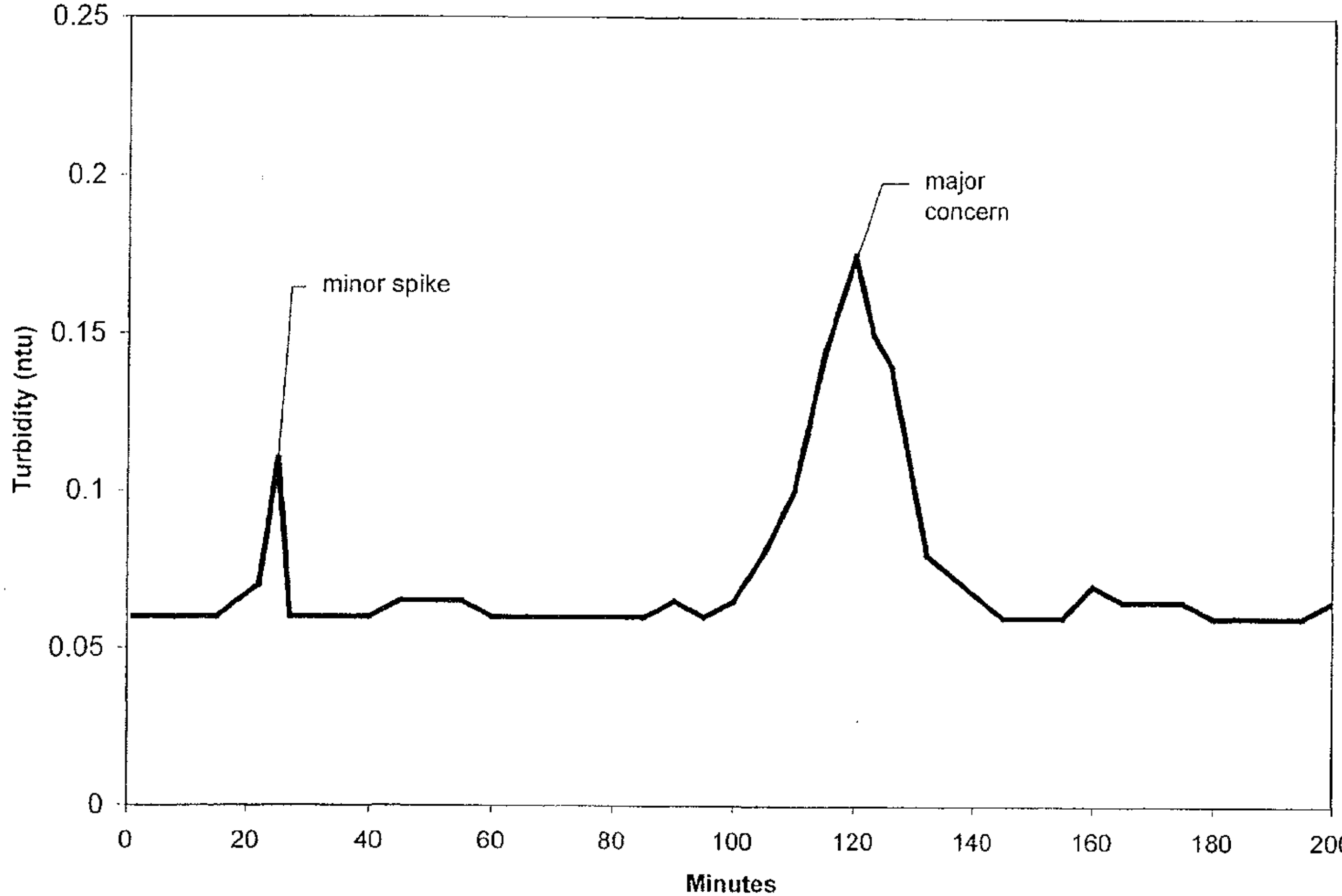
Filter Issues – Initial Turbidity Spike



Filter Issues – Effluent Turbidity “Creep”

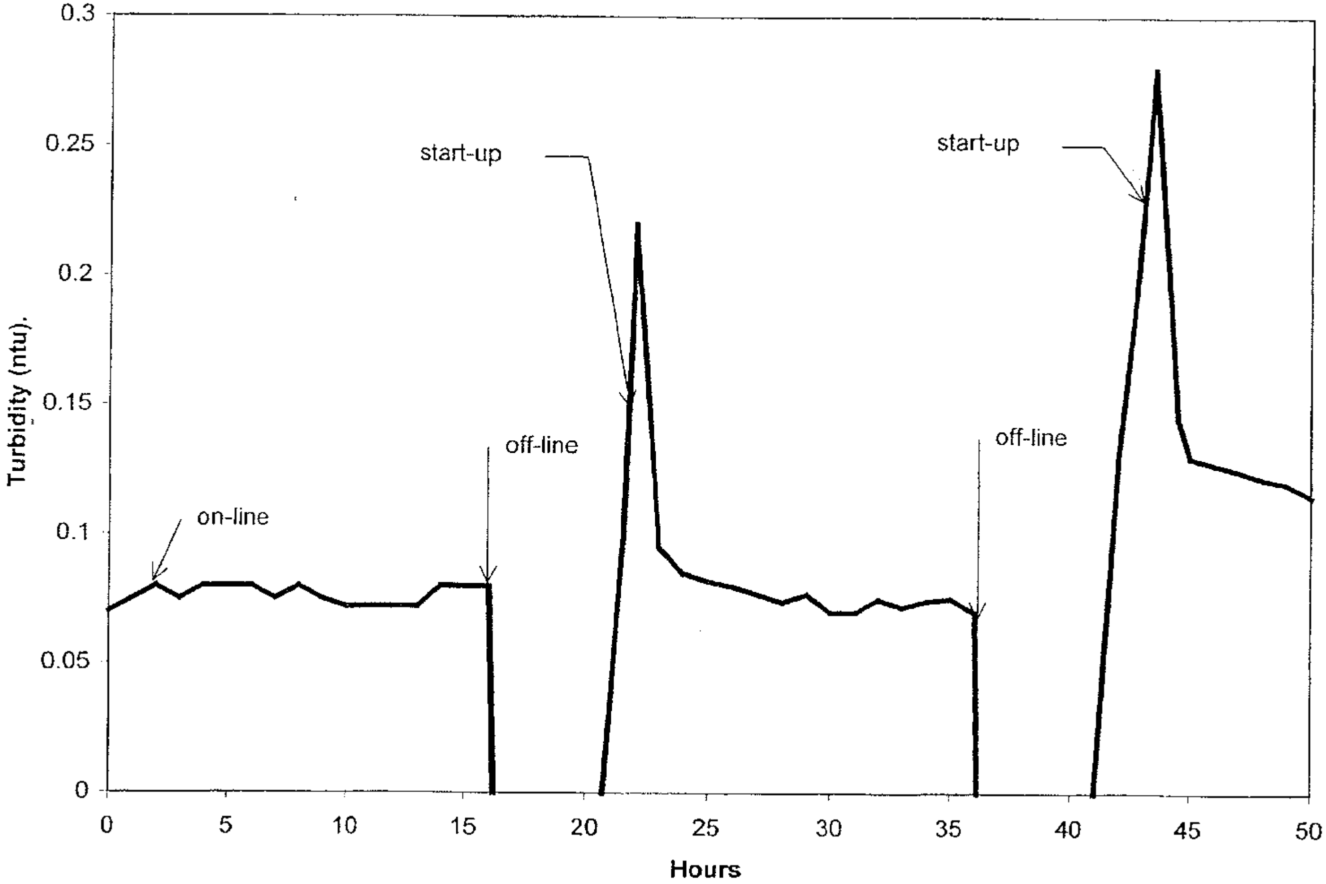


Filter Issues – Spiking during Run



Filter Issues – Hydraulic "Shock"

Need to practice filter "yoga" – want a nice and steady flow through each run



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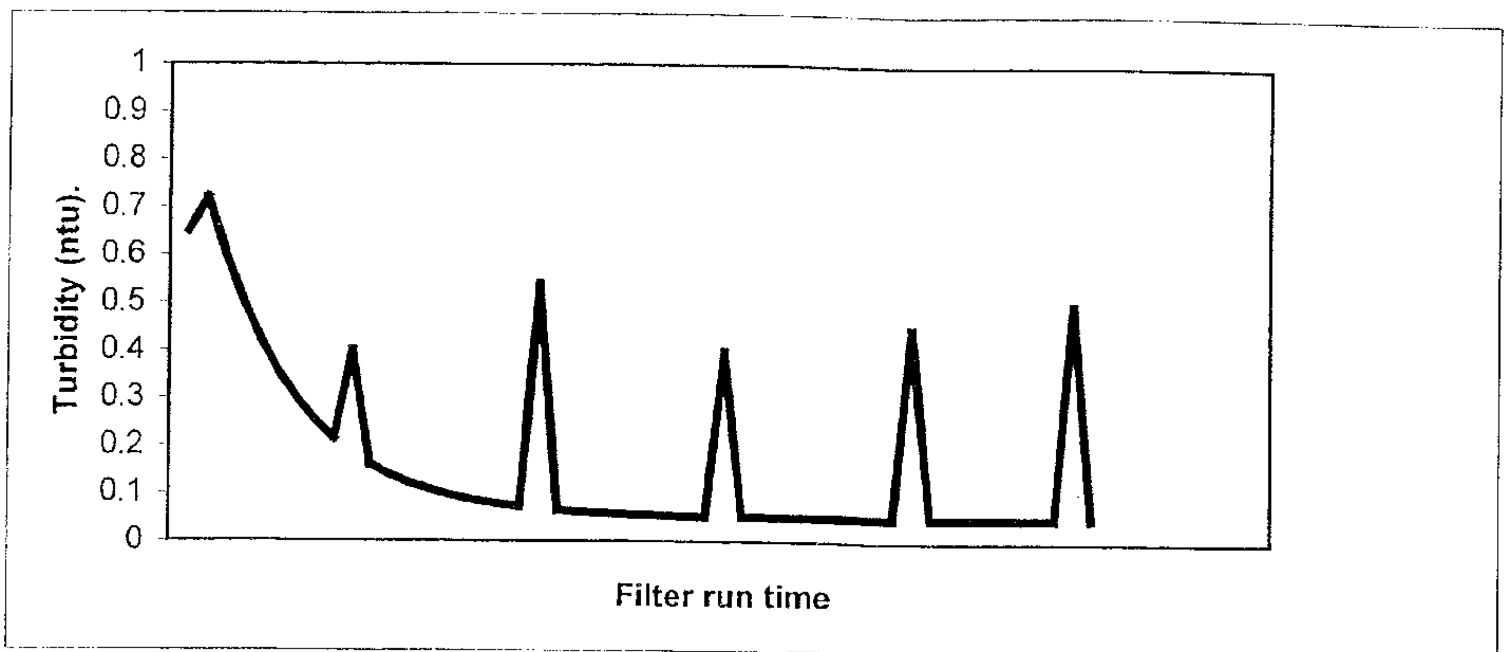
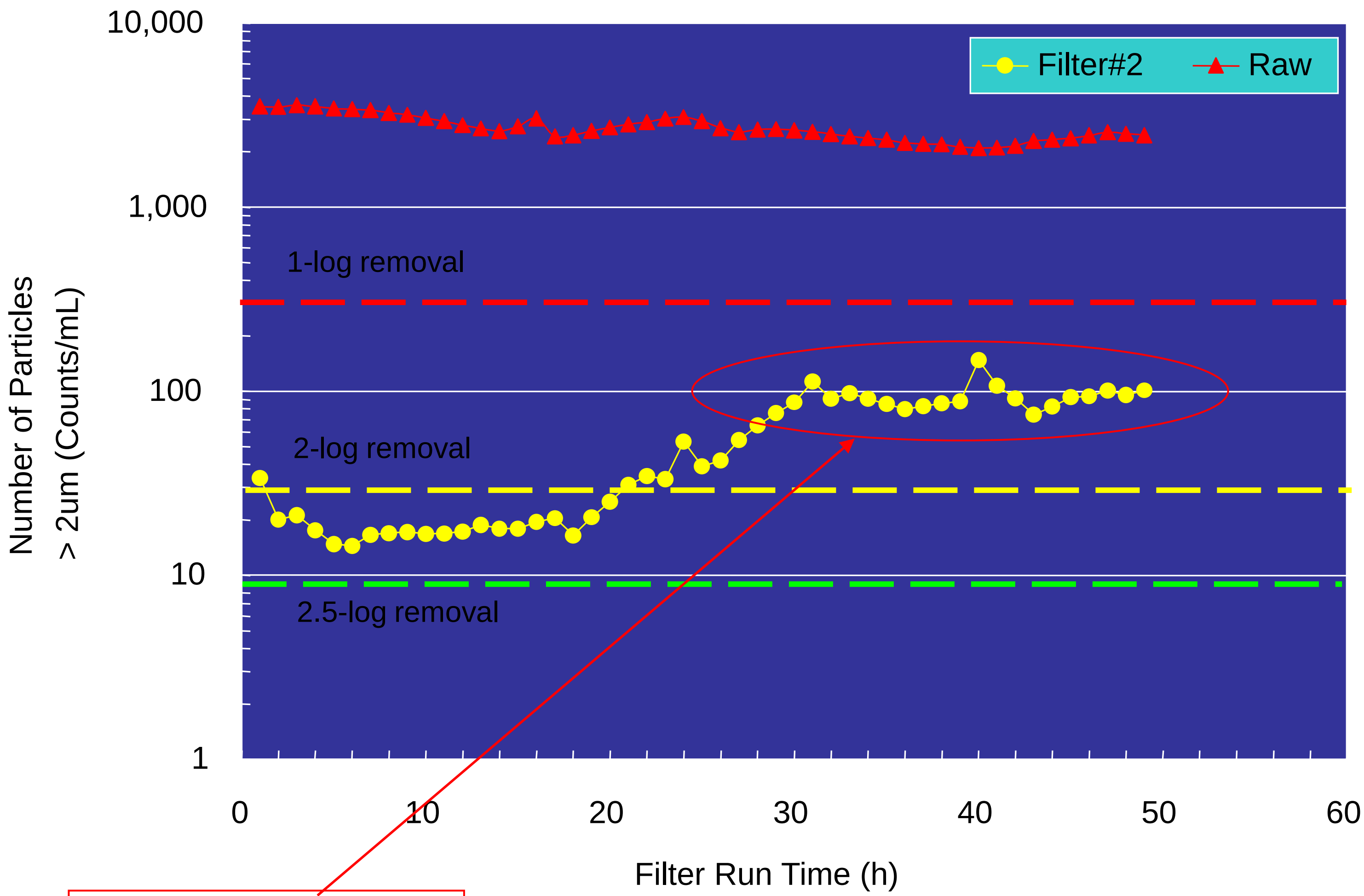
Filter Issues – Spiking during Backwash

- Backwashing of other filters increases flow to remaining filters
- Short term hydraulic shock dislodges particles



Particle Count Data is particularly sensitive for filter monitoring



Filters are at 1.5 log removal for latter part of filter run

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The Solutions that Have Worked!

Unlike with people, we can fix the patient to live better after the autopsy - air Scour and Strainers

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Media retention screens – the screen door method

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Air Scour with Header

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Trough Extensions

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Trough Extensions

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Vulcan Air Header

Air Header Above the Media Surface

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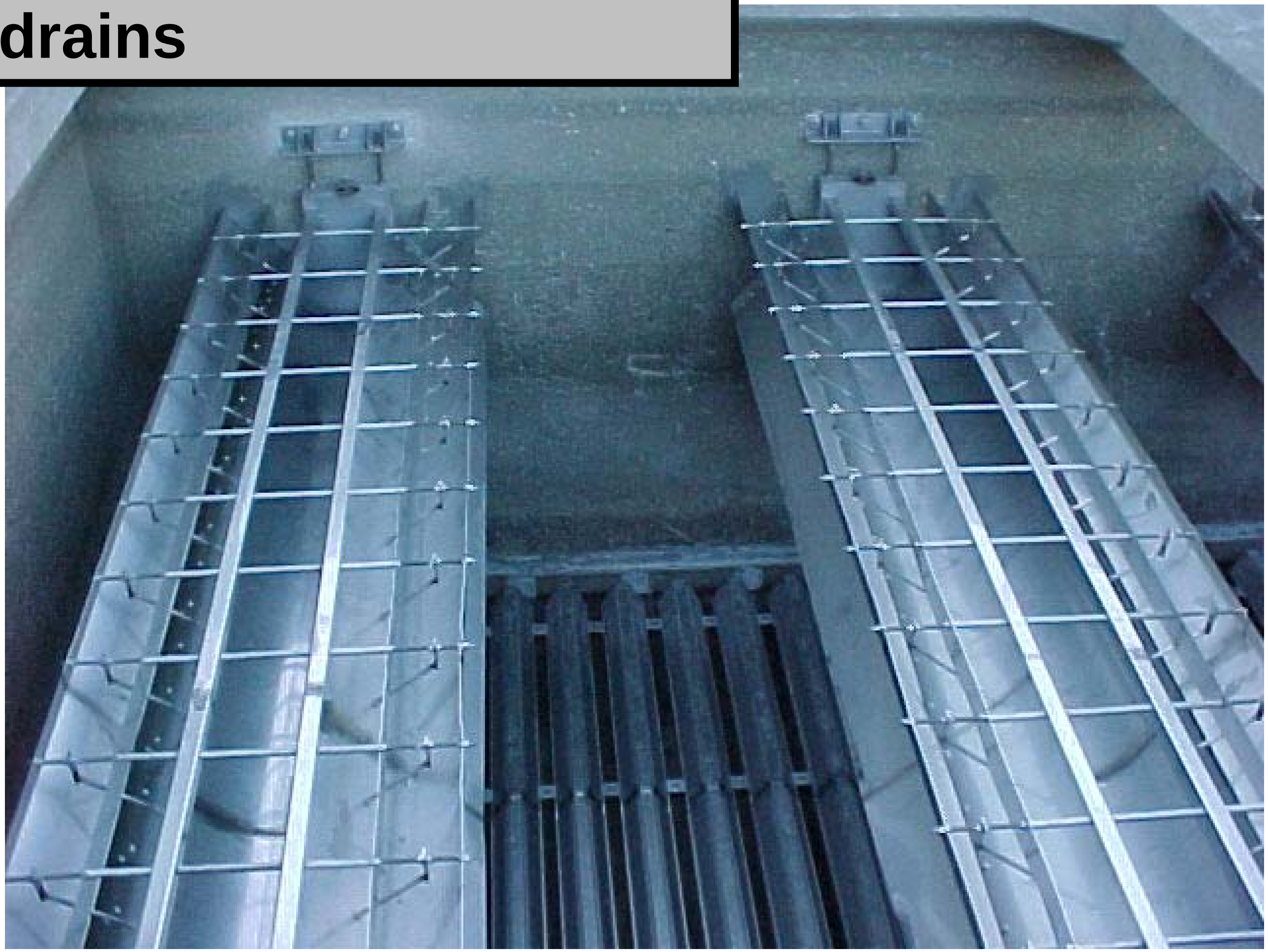
New Multi-wash troughs and underdrains



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New Multi-wash troughs

New multi-wash troughs

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Top of new underdrain lateral

Bottom of new underdrain lateral

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Sand and anthracite media in supersacks

Don’t forget about reducing solids loading on filters - New lamella plate settlers

Plate pack

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Porous Plate Cap (Leopold IMS Cap)

- From www.fbleopold.com

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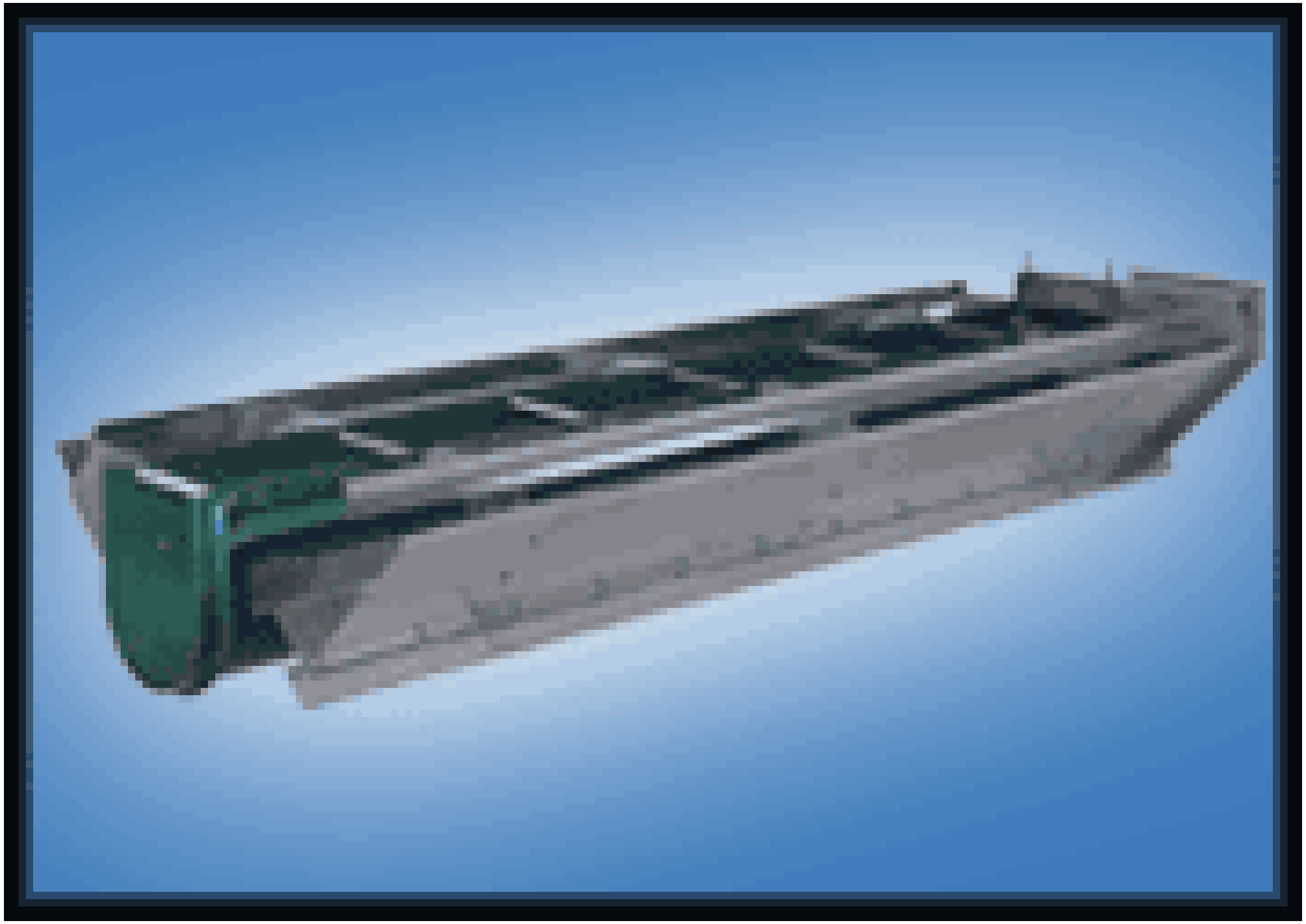
Leopold R Trough-Guard Media Baffle



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Wheeler Bottoms – repairs

- From www.robertsfiltergroup.com

AWI Phoenix Systems

- www.awifilter.com

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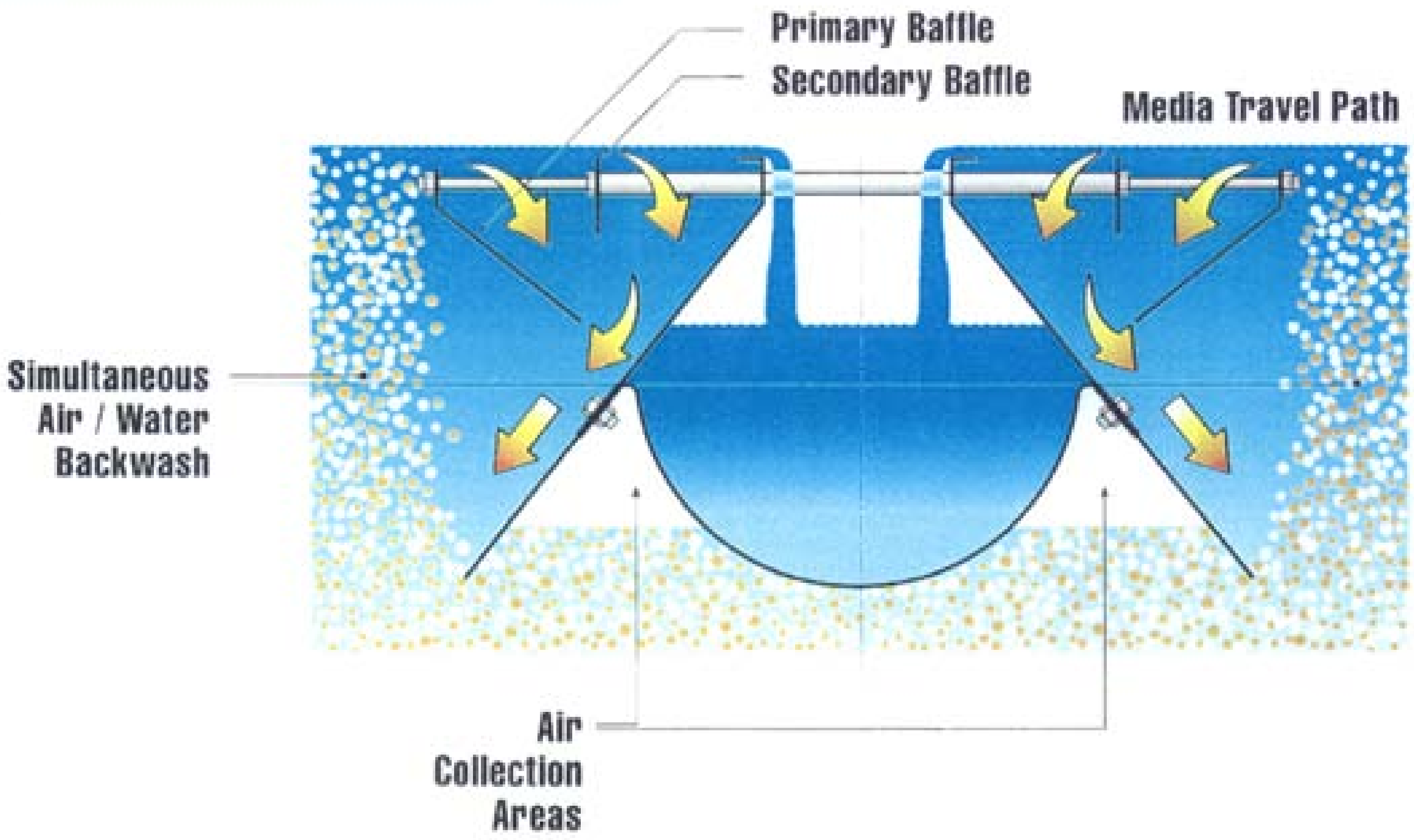
AWI Phoenix Systems

- www.awifilter.com

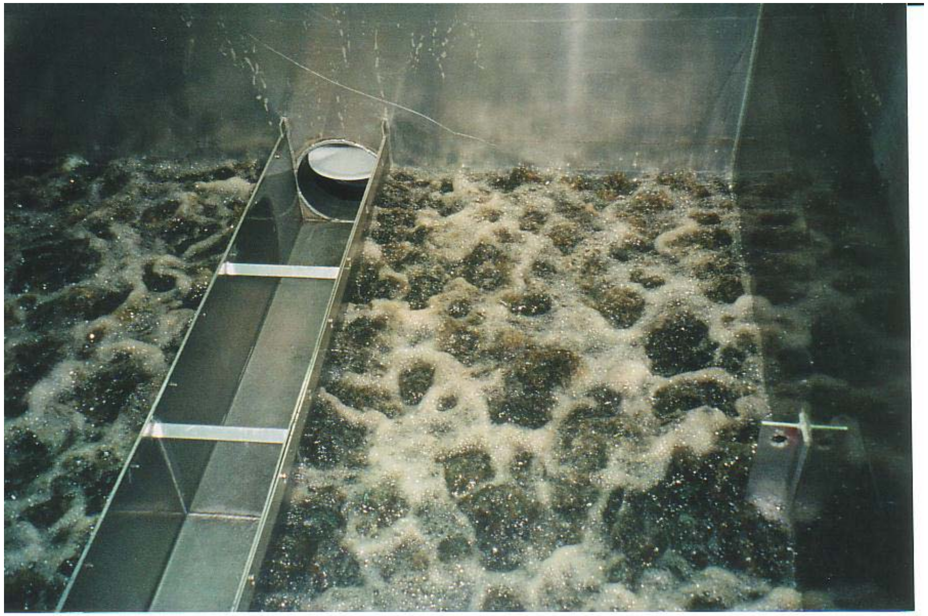
EWT ™ ScourGuard TM Filter Troughs



- www.ovivowater.com

Filter Auxiliary Cleaning

- Air Scour
  - Air flow: 0.9 – 1.5 $m^3/min/m^2$
  - Air scour provides a vigorous cleaning action, due to “collapse pulse” action (Georgia Tech work – I remember when that was groundbreaking research)



- Surface Wash
  - Generally falling out of favor,
  - Common in older filters
  - Typical Flows:
    - Fixed nozzles: 5 $m^3/m^2/hr$
    - Rotating Arms: 1.2 $m^3/m^2/hr$

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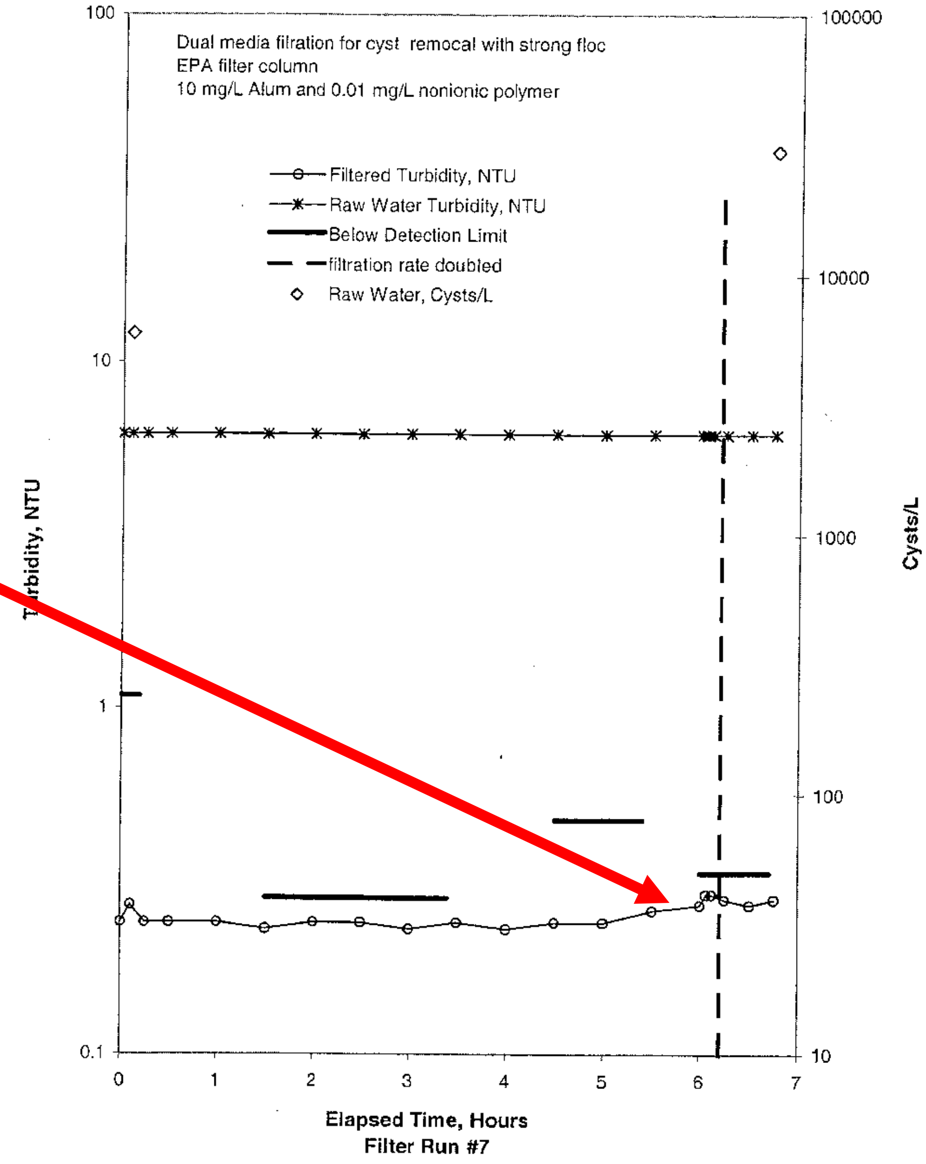
Improvement through Chemistry - Filter Aid Polymer can reduce turbidity spiking

- Note turbidity spike due to flow change



Thank You

[I got help from Alex Mofidi, Simon Breese, and Bill Clunie]

steve.price@aecom.com

Granular Media Filters
Evaluation Techniques

- Visual Inspection
- Filter Surveying
  - Filter Indices
  - Unit Filter Run Volume
  - Filter "Efficiency"
- Filter Core Sampling
- Backwash Waste Characterization
- Floc Retention Profiling
- Backwash Trough Level Check

- Remember – SAFETY FIRST

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Filter Evaluation Safety Issues

- Never walk directly on filter media
- Ensure filter is FULLY drained before entering filter box
- Beware of filter appurtenances – Wear a hard hat
- Use a safety harness where applicable, particularly during bed fluidization testing

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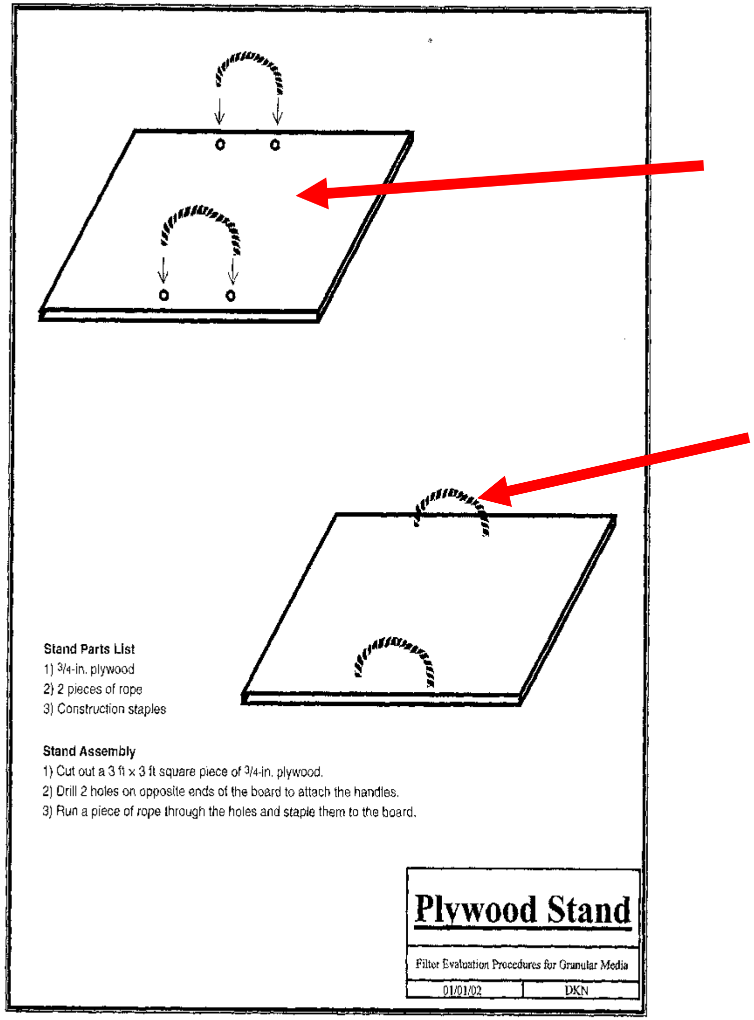
Homemade Device for Walking on Filter Media



Filter Indices

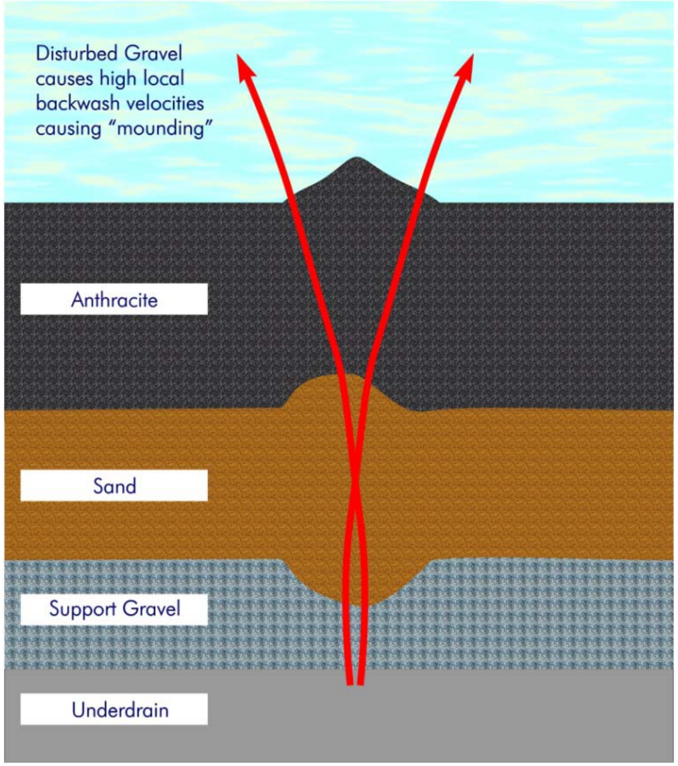
- Unit Filter Run Volume (UFRV)
  - A measure of **NET** filter production per unit filter area per filter run
  - UFRV = Filtration Rate (m/hr) x Filter Run (hr)
  - UFRV of 300 – 500 m^3/m^2 is desirable
- L/d Ratio
  - Ratio of Filter Bed Depth to Media Nominal Diameter
  - In theory filters with the same L/d should perform equally under similar conditions
  - L/d ratio > 1,000 for conventional filters, > 1,200 if using filter aid
- Filter Efficiency – Similar to UFRV, but accounts for losses as waste. Filters should typically produce 2 – 4 % as waste

Visual Observation of Filters

- The first line of defence in filter monitoring and evaluation
- Look for easy to recognize issues:
  - Media boiling during wash
  - Uneven wash distribution
  - Uneven overflow into BW troughs
  - Cratering in media surface
  - Visible mudballs
- Create a map of the filter and track observations for future mitigation

Visual Inspection - Mounding

- "Mounding" of filter media surface – Suggests possible disturbance in gravel layer – High localized flow



Detailed Filter Evaluation

- A number of techniques can be used to diagnose filter performance issues
  - Filtration Rate Checking
  - Backwash Rise Rate Checking
  - Floc Retention Profiling
  - Backwash Waste Characterization
  - Gravel profiling
  - Sieve testing of media size
  - Media bed depth checking
  - Bed Fluidization Checking
- Tests are relatively easy, and can use home-made testing equipment

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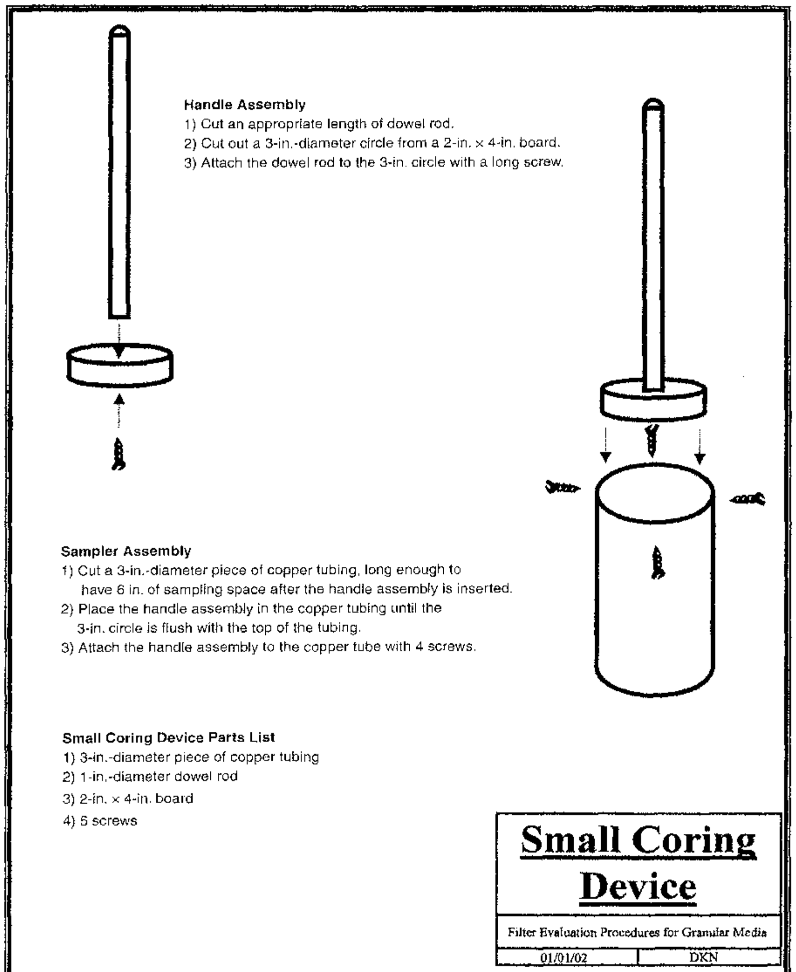
Filter Core Sampling Coring Device



- **Source:** Filter Maintenance & Operations Guidance Manual, AWWARF, 2002

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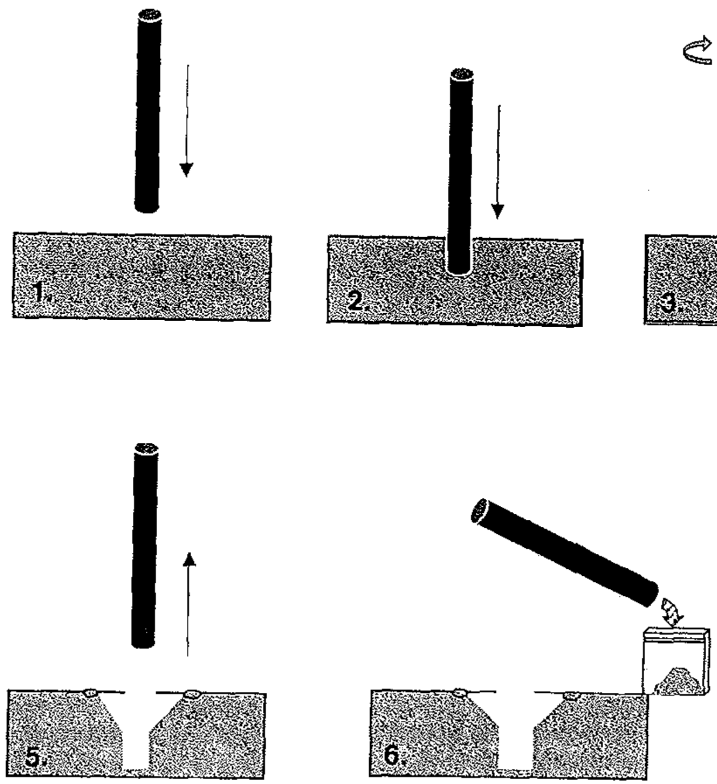
Filter Core Sampling Procedure



1. Begin by gently pushing the sampler into the media.
2. Push until the sampler is at the desired depth.
3. Gently swivel the top of the sampler to make a cone at the top of the hole.
4. Placing a hand over the top of the sampler, slowly raise it from the hole.
5. Continue to raise the sampler until it is clear of the hole.
6. Empty the contents of the sampler in the correctly labeled bag.

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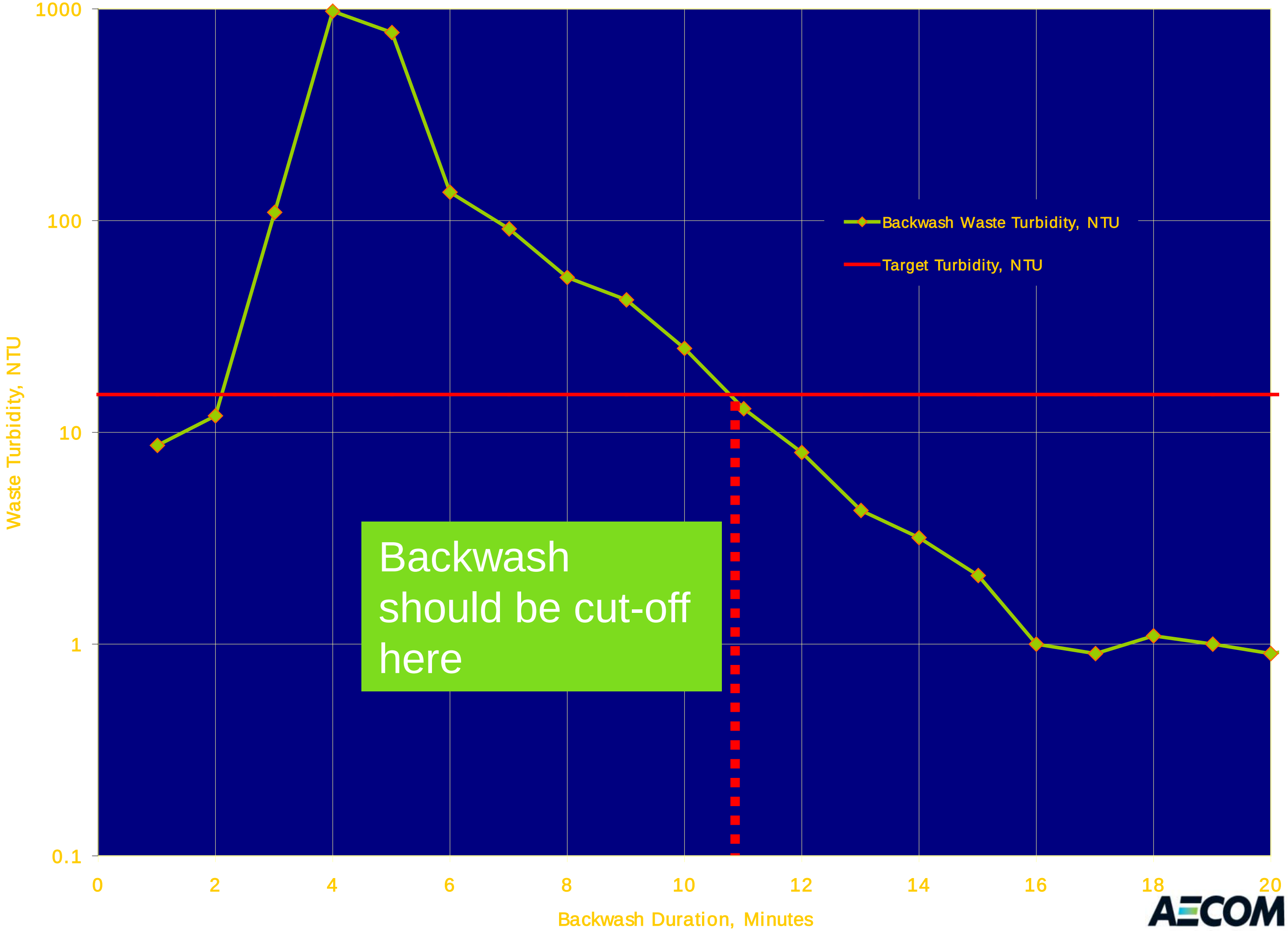
Backwash Waste Characterization

- There is such a thing as over-washing a filter !!!
- Backwash waste characterization can help assess the “right” duration
- Perform timed sampling of backwash waste to determine solids content
- Use data to asses when to terminate washing
- May allow reduction in water wastage, and residuals volumes

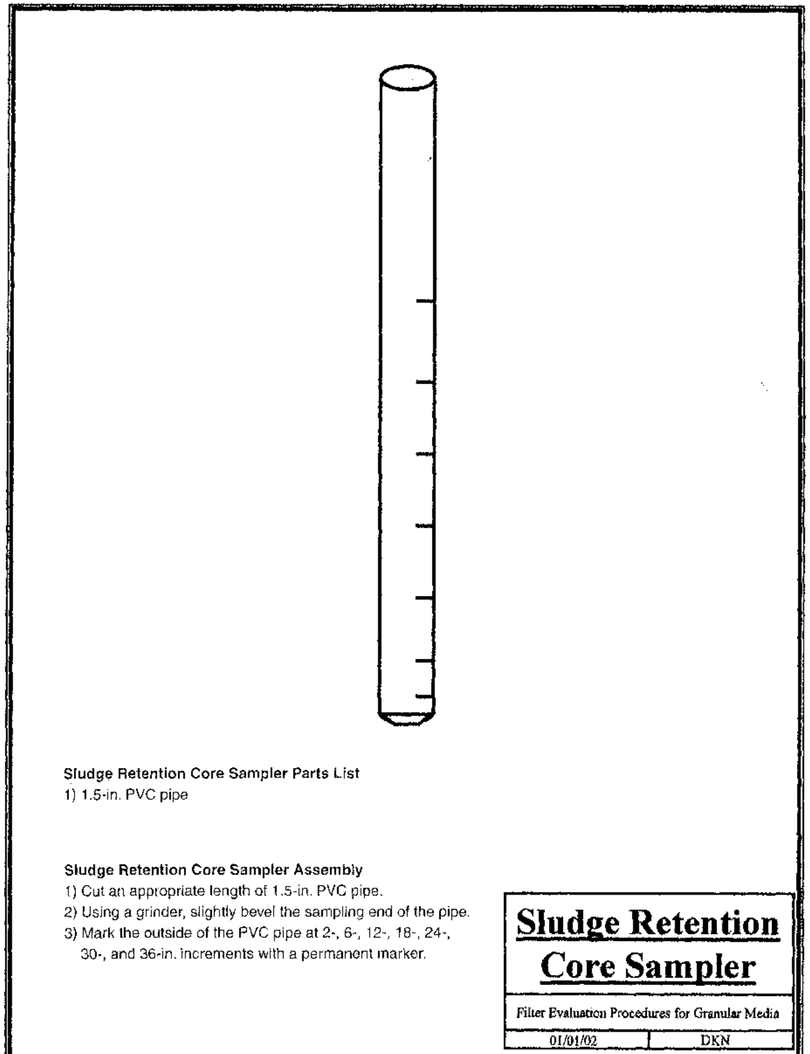
Typical Waste Evaluation



Floc Retention Profiling

- Take a core sample
- Sub-divide the core into depth fractions
- Rinse each fraction using a known volume of water, to clean solids off the media
- Measure turbidity in each fraction, before and after washing of filter
- Measures how well solids are being removed from the bed

Floc Retention Profile Sampler



- **Source:** Filter Maintenance & Operations Guidance Manual, AWWARF, 2002

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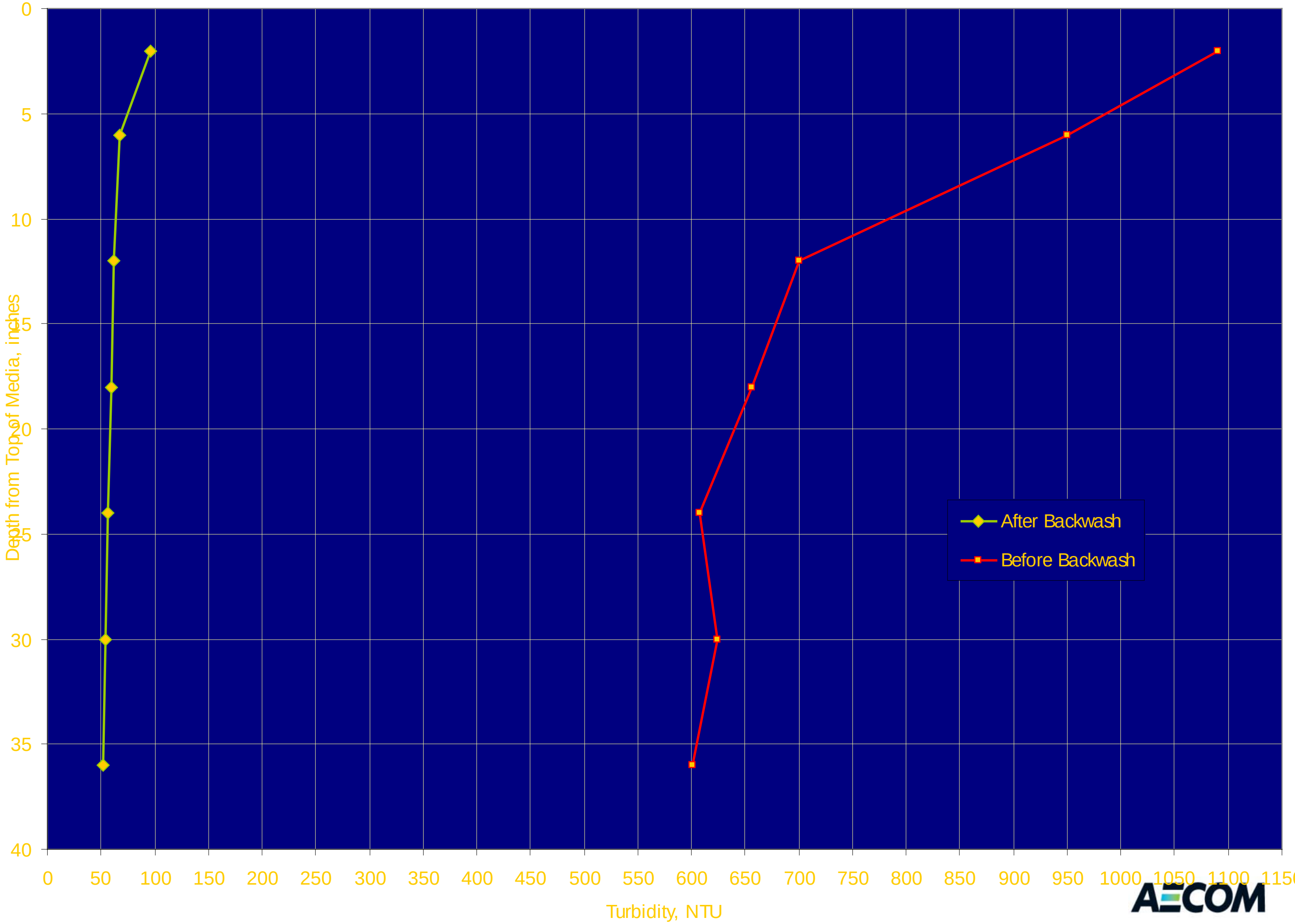
Floc Retention Profile Graph



Floc Retention Profile Results

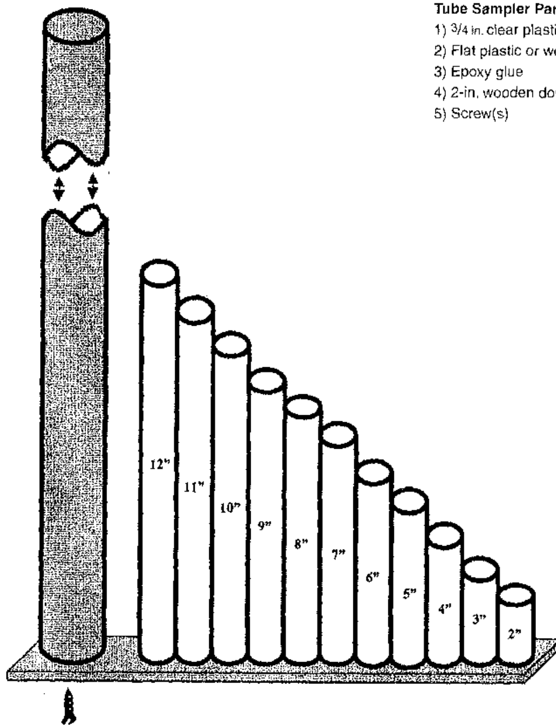
Turbidity, NTU	Filter Media Condition
0 - 30 NTU	Clean - Unripened filter – Long ripening time
30 - 60 NTU	Clean - Ripened Filter
60 - 120 NTU	Slightly dirty, Still OK
120 - 300 NTU	Dirty - Re-Evaluate Backwashing
> 300 NTU	Mudball Problems

Filter Bed Fluidization Testing Equipment

- **Source:**

Tube Sampler Parts List

1) 3/4 in. clear plastic pipe
2) Flat plastic or wooden stock
3) Epoxy glue
4) 2-in. wooden dowel
5) Screw(s)



Tube Sampler Assembly

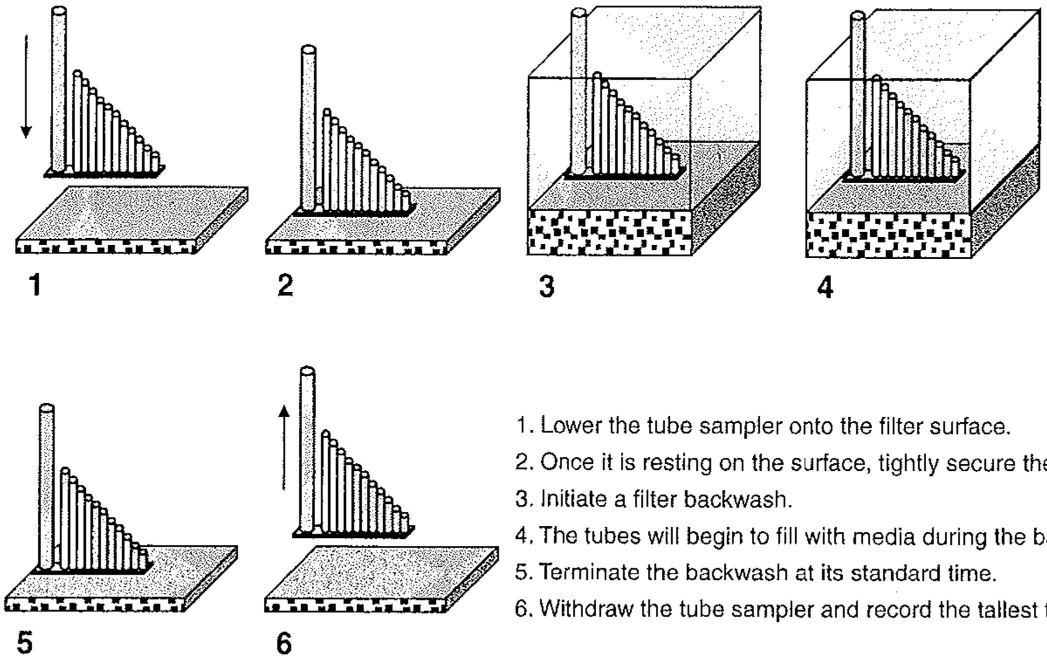
1) Cut the 3/4 in. clear plastic pipe in 1-in. increasing increments from 2 in. to 12 in.
2) Cut the plastic or wooden stock long enough to fit all 11 tubes and the 2-in. diameter handle on it.
3) Glue the clear plastic tubes to the stock and to each other.
4) Attach the 2-in. dowel to the stock with the screw(s).
5) Label the clear plastic tubes with a permanent marker.

Bed Expansion Tube Sampler

Filter Evaluation Procedures for Granular Media

01/01/02	DKN

Bed Fluidization Protocol



1. Lower the tube sampler onto the filter surface.
2. Once it is resting on the surface, tightly secure the sampler to a stationary object.
3. Initiate a filter backwash.
4. The tubes will begin to fill with media during the backwash.
5. Terminate the backwash at its standard time.
6. Withdraw the tube sampler and record the tallest tube that is full of media.

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Compare backwash rate and fluidization

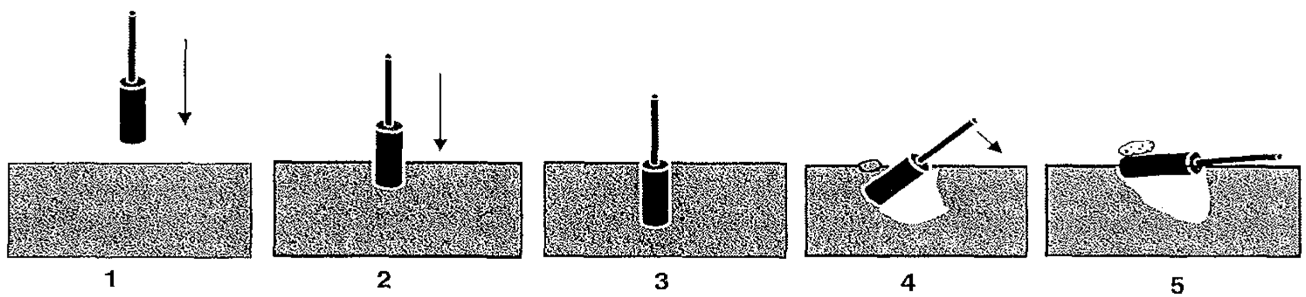
Backwash Flow Rate	Bed Expansion	Notes
Below required	< 20%	Increase backwash rate and repeat test
Below required	20 - 30%	Increase backwash rate and repeat test
Below required	> 30%	Check water temperature
Correct Flow	< 20%	Check for Polymer Buildup on Filter
Correct Flow	20 - 30%	No Action Required
Correct Flow	> 30%	Check Media Specs.
Above Required	< 20%	Check for Polymer Buildup on Filter
Above Required	20 - 30%	Check for Polymer Buildup on Filter
Above Required	> 30%	Reduce Backwash Rate and Repeat Test

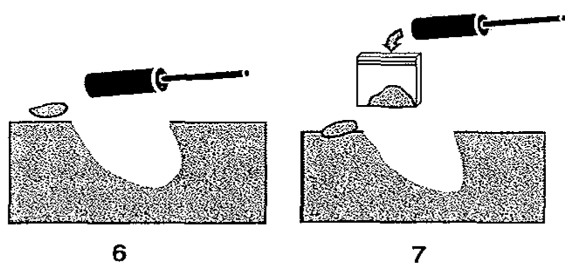
Mudball Analysis

- Used to physically determine the extent of filter mudballing due to chronic underwashing
- Collect 6" Core Samples
- **Gently** sieve the samples to separate mudballs from media
- Place mudballs into a 250 mL graduated cylinder

Percent Mudballs	Filter Condition
0 - 0.1%	Excellent
0.1 - 0.2%	Very good
0.2 - 0.5%	Good
0.5 - 1.0%	Fair
1.0 - 2.5%	Fairly Bad
2.5 - 5%	Bad
Over 5%	Very Bad

Mudball Sampling Protocol





1. Begin by placing the sampler on the surface of the media.
2. Gently push the sampler into the media.
3. Push until the top of the sampler is level with the top of the media.
4. Slowly tilt the sampler up.
5. The sampler will have some media on top of it.
6. Carefully raise the sampler and brush off the media that is on top of the sampler.
7. Empty the contents of the sampler in the correctly labeled bag.

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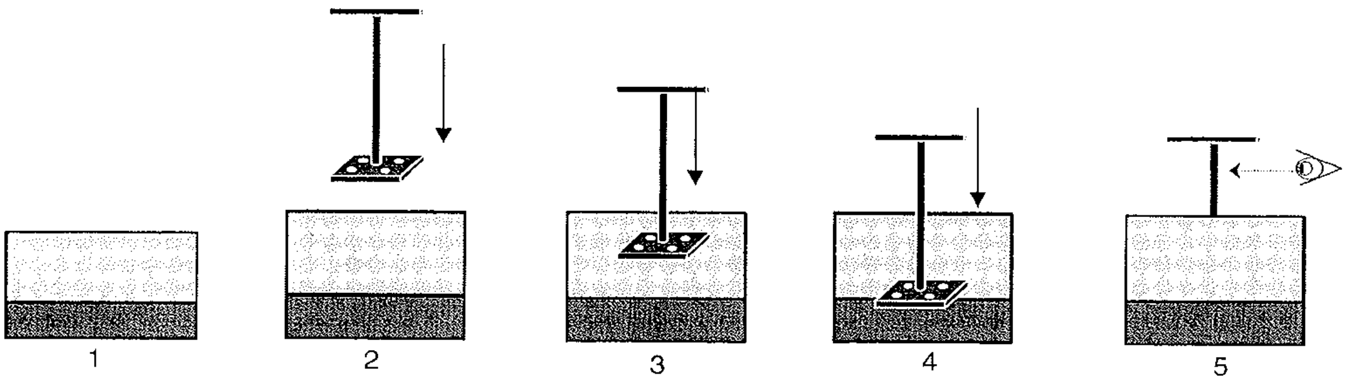
Gravel Profiling

- Manual measurement of gravel depth at various locations in the filter
- Variation should be no more than ± 25 mm



1. Determine the sampling area.
2. Begin the backwash and start to lower the punch plate into the fluidized media.
3. Continue to press the punch plate down through the media, until ...
4. ... it comes to rest on the gravel layer.
5. Take a reading off of the punch plate and move to the next location.

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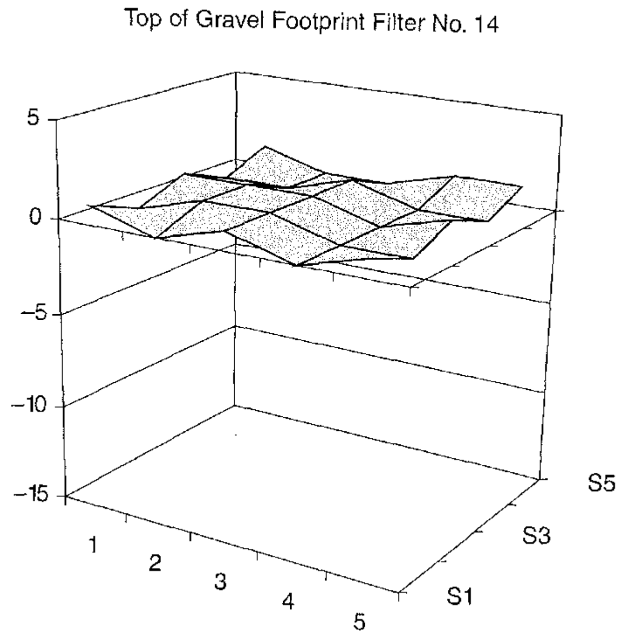
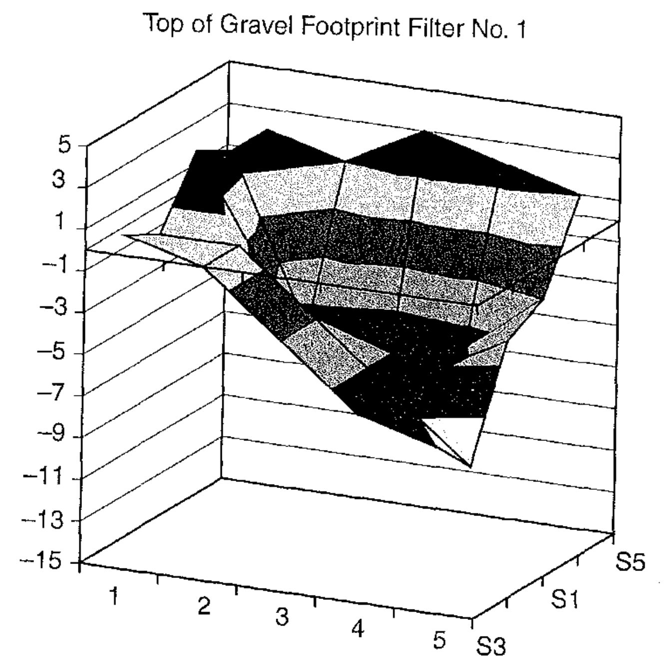
Gravel Profile Examples



Good



Severe

AECOM Pilot Filter Assembly

Granular Media Filtration

What constitutes "good" filter performance ?

- Consistently less than 0.3 NTU
- Particle counts < 50 particles/mL
- > 2-log removal of *Giardia* and *Cryptosporidium* sized particles
- Long and predictable filter runs (24+ hours) – Same for each filter
- Minimal premature particle breakthrough
- Poor performance can be difficult to rectify, but many issues can be resolved with simple fixes

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What constitutes “good” filter design ?

- Most efficient media design has largest media at the top, and the finest at the bottom
- However, backwashing immediately re-classifies bed to place the finest grains at the surface
- Therefore use multi-media to mimic this effect, with coarse grains in the top layer to trap solids, and finer layer below for polishing

What constitutes “good” filter design ?

- “Conventional” Filter Design
  - Typical Loading Rates 6 – 9 m/hr. Higher possible with pilot testing
  - Total Media Depth ≤ 1 m
  - Anthracite: ES 0.8 – 1.2 mm, UC 1.4 – 1.65
  - Sand: ES 0.45 – 0.55 mm, UC 1.4 – 1.65
- “Deep Bed” Filter Designs
  - Typical Loading Rates much higher, relying on chemical dosing to a greater extent
  - Total Media Depth 2 – 3 m
  - Anthracite: ES 0.8 – 1.2 mm, UC 1.4 – 1.65
  - Sand: ES 0.45 – 0.55 mm, UC 1.4 – 1.65

Good Filter Design Practice

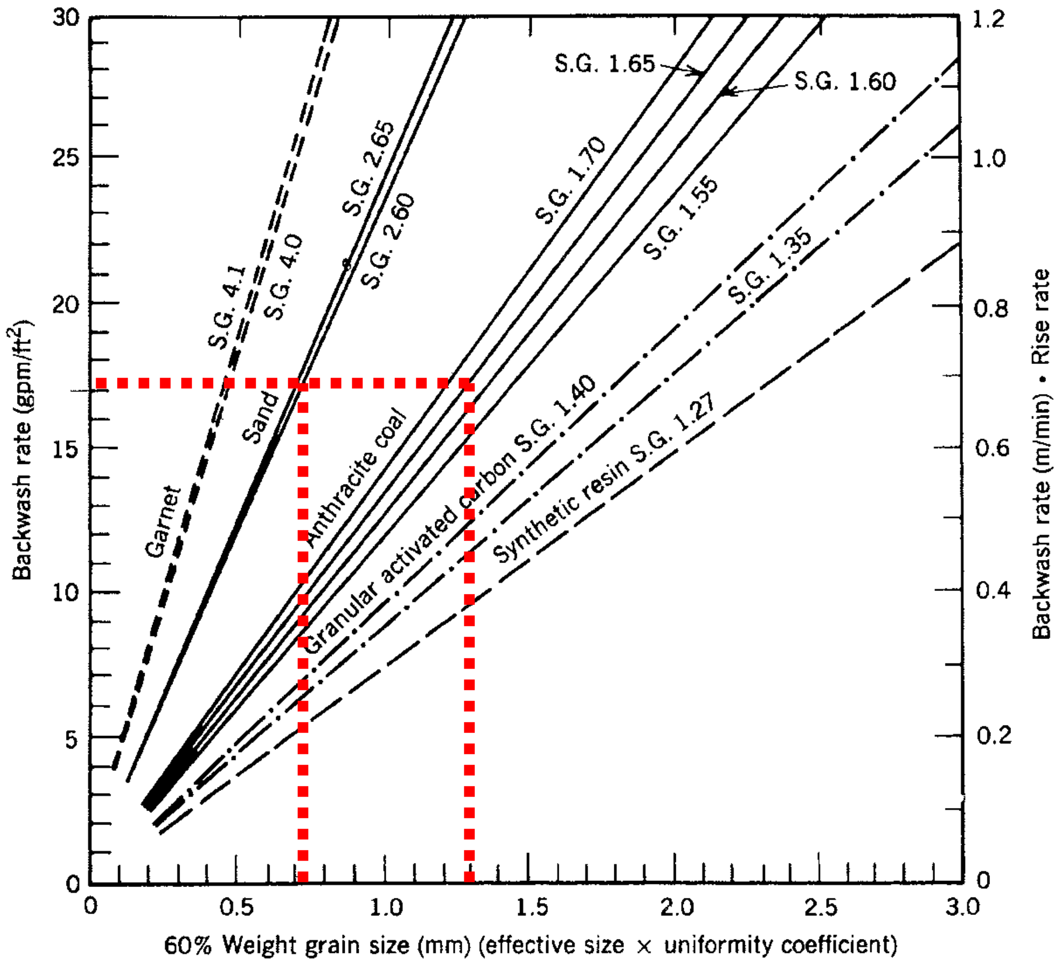
- If dual-media is used, media should be hydraulically compatible to reduce intermixing:

$$\frac{d_1}{d_2} = \left[\frac{\left(\rho_2 - \rho_{water}\right)}{\left(\rho_1 - \rho_{water}\right)} \right]^{\left(\frac{2}{3}\right)}$$

Good Filter Design Practice

- The important thing to remember is that all media should be selected to share a common fluidization velocity
- This minimizes intermixing of media layers
- Severe intermixing causes short filter runs by reducing void volume in upper layer of filter
- Note: Media characteristics can change over time:
  - Encrustations
  - Deposition
  - Physical degradation of media grains (wear)

Appropriate Backwashing Rates



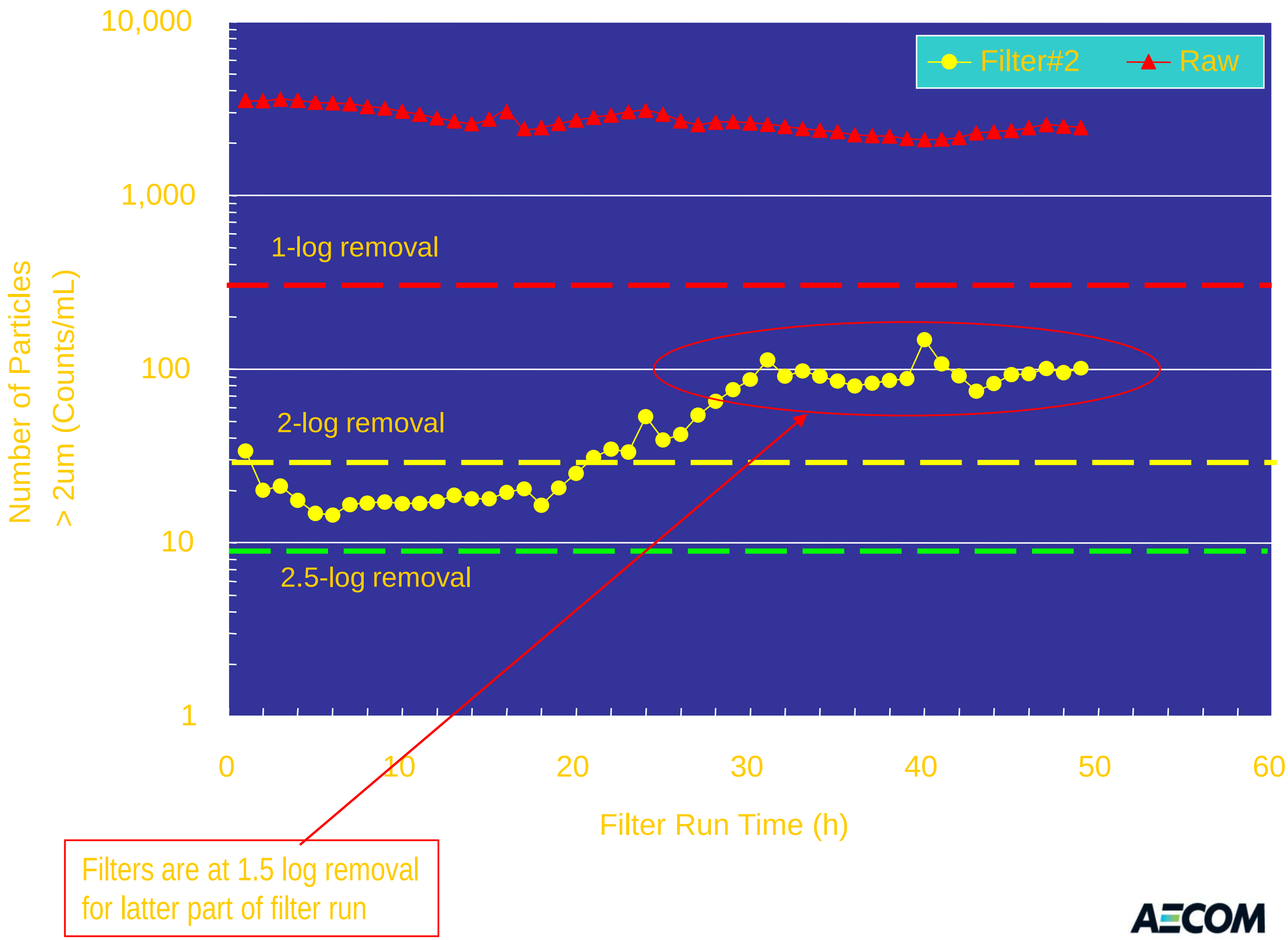
Note: Rates are at 20C, and must be adjusted for other temperatures

Granular Media Filtration

Premature Particle Breakthrough

- Increases in filtered water particle concentrations are common near the end of a filter run – Well before turbidity breakthrough
- Passage of pathogens may occur before a turbidimeter “notices”
- Particle counting may be a more appropriate trigger for backwashing than turbidity measurements

Particle Count Data is particularly sensitive for filter monitoring



Common Causes for Poor Filter Performance

- Poor clarifier performance – Excessive solids loading
- Excessive operational loading rates
- Lack of FTW capability
- Sudden changes in flow to filter – Hydraulic “shock”
- Filter media loss or upset
- Filter underdrain damage or failure
- Poor cleaning effectiveness
  - Mudballing
  - Short circuiting

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Possible Solutions for Poor Filter Performance

- Optimization of Filter Backwashing
  - Even distribution of flow
  - Selection of Appropriate Wash Rates
  - Levelling of Wash Trough Crests
  - Air Scour
  - Surface Wash
- Addition to Filter-to-Waste
- Use of filter aid polymers
- Addition of coagulant or other chemicals to backwash water

Dealing with badly fouled media

- Filters which exhibit significant fouling problems, mudballing, cracking, etc. are very difficult to rectify
- Lancing is a possible solution, but be very careful if support gravel is in place
- Replacement of the media may be the only solution

Good Filter Design Practice

- If dual-media is used, media should be hydraulically compatible to reduce intermixing:

$$\frac{d_1}{d_2} = \left[\frac{(\rho_2 - \rho_{water})}{(\rho_1 - \rho_{water})} \right]^{\left(\frac{2}{3}\right)}$$

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Good Filter Design Practice

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- Note: Media characteristics can change over time:
  - Encrustations
  - Deposition
  - Physical degradation of media grains (wear)

Seattle Public Utilities

Preparing for Murphy's Law at Water Treatment Facilities

AWWA-PNWS Conference

Yakima, WA

May 2012

Alex Chen, P.E.

Senior Water Quality Engineer

Seattle Public Utilities

Seattle Public Utilities

Agenda

- What can go wrong…

  …and how to prepare for it

- Review some actual treatment plant "hiccups" and lessons learned

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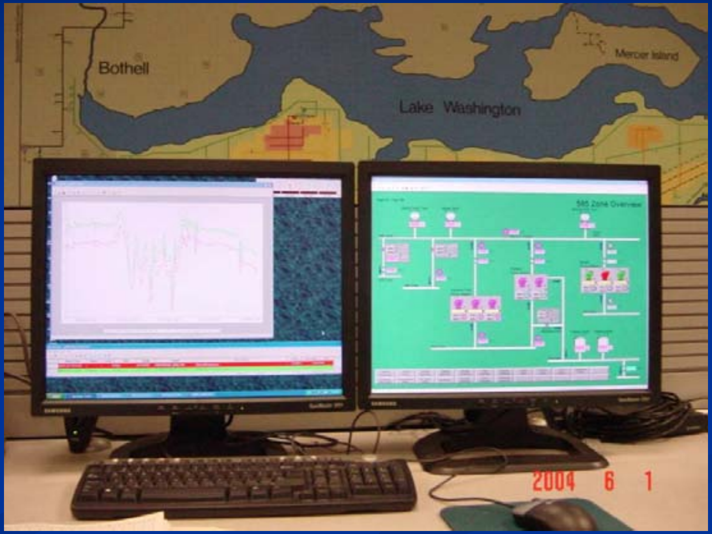
What Can Go Wrong?

- Treatment & water quality issues
- Loss of storage or piping – dewater the water system
- Too much water – flooding, overflows

Best Practices are a Good Start

- System redundancy
- Multi-barrier treatment
- Adequate safety factors
- Continuous monitoring & alarms
  - Pressures & flows
  - Key water quality parameters
- Ongoing training
- System optimization
- Computerized maintenance & diagnostics



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Planning for the Worst

- Look at highest priorities first
  - ID “single points of failure” and add redundancy
  - Hazard analysis
- Emergency response planning
  - 24/7 emergency response capabilities
- Establish lines of communication
  - Internal (Incident Command System)
  - Regulators
  - Customers
  - Media

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Some Treatment Parameters

- Pressure and flow
- Turbidity
- Chlorine residual
- Bacteriological
- pH/corrosion control
- Fluoride
- Taste and odor

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Example Prioritization (simplified)

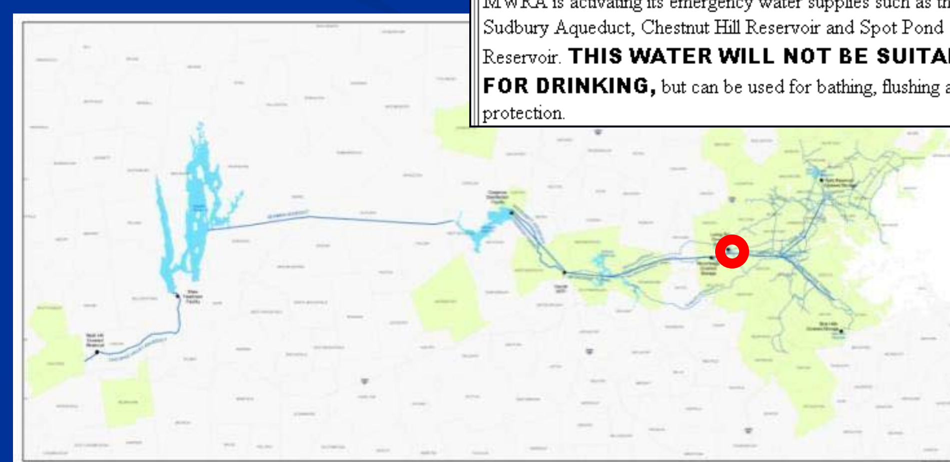
1. Water pressure and flow
2. Water quality, primary:
   - Bacteriological
   - Turbidity
   - Chlorine
3. Water quality, secondary:
   - pH
   - Fluoride
   - Taste & odor

Water service to all MWRA customer communities east of Weston has been interrupted by a major water pipe break in Weston. Due to this break, **A BOIL WATER ORDER IS BEING ISSUED FOR DRINKING WATER FOR ALL MWRA COMMUNITIES EAST OF WESTON UNTIL FURTHER NOTICE.** In addition, emergency water conservation measures are being implemented for all impacted communities. A complete list of MWRA water communities is included on this page.

Mass. Department of Public Health
MWRA Water Break - Boil Water Information

- Frequently Asked Questions PDF
- Boil Water Order Guidelines PDF
- Emergency Guidelines for Food Establishments During Boil Water Order PDF
- All Guidelines

MWRA is activating its emergency water supplies such as the Sudbury Aqueduct, Chestnut Hill Reservoir and Spot Pond Reservoir. **THIS WATER WILL NOT BE SUITABLE FOR DRINKING,** but can be used for bathing, flushing and fire protection.



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A Few Case Studies

- Not comprehensive, even for water treatment facilities…

  …but designed to spur discussion among other utilities / consultants / regulators

- Could similar events affect you?

Case #1: Too Much Water (Overflow)

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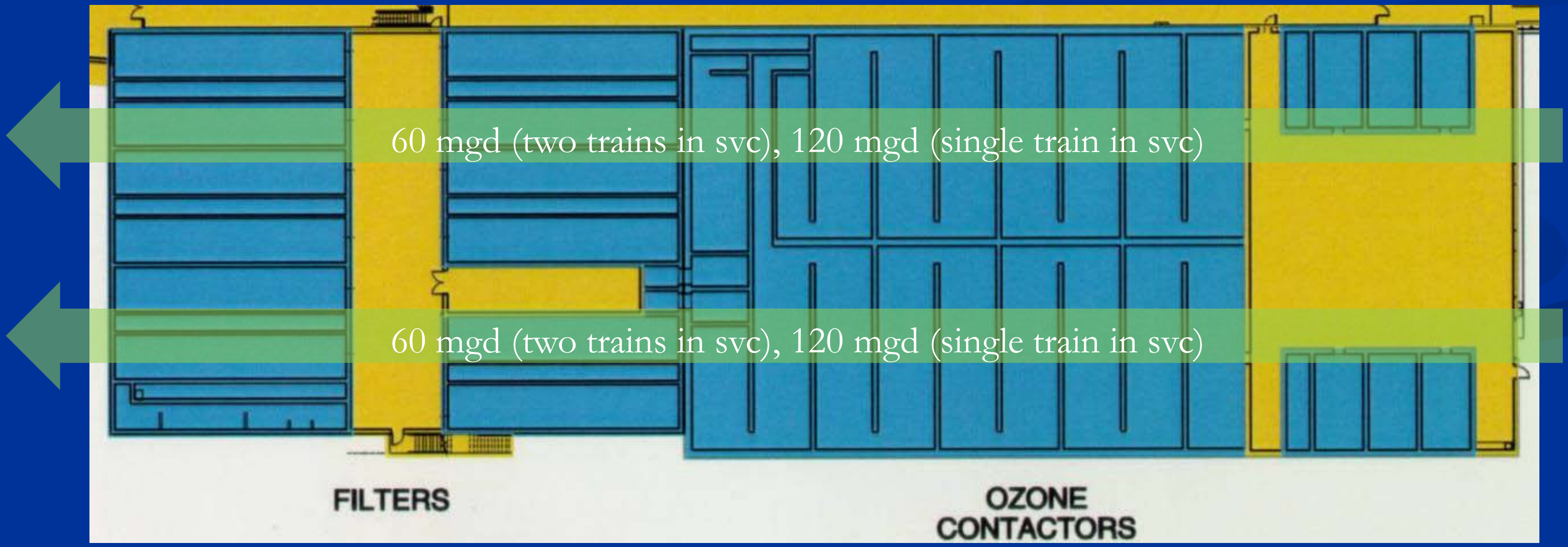
Background – Hydraulics

- Two gravity-fed trains, inlet control valves
  - Inlet valves control total flow to plant
- Originally set to deliver full flow (120+ mgd) through either train during maintenance outages
- Total overflow capacity 120 mgd



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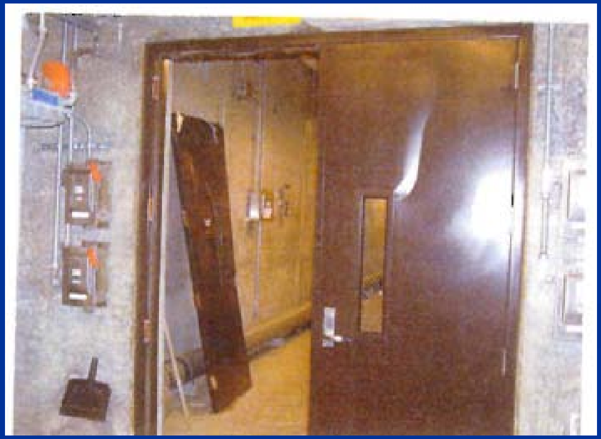
What Happened

- Inlet valves electronically controlled
- Buried conduits to actuators not properly sealed
- Operators noted intermittent issues
- One actuator flooded, commanded valve to open wide
- More than 120 mgd entered plant
- Excess water overflowed via filter-to-waste air gaps, flooded plant

Response and Follow Up - 1

- Emergency response:
  - Shut down plant
  - Increase flow from other treatment plant during shutdown
- Mop up, fix extensive electrical, piping, etc damage



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Response and Follow Up - 2

- Solution: physical stops on valve gearboxes
  - Physically limit flow through each train to 60 mgd
  - Can remove stops if needed for long-term outages

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Debrief

- Planning and design
  - Don’t count on controls as sole means of limiting anything
  - Nothing beats a physical limit
  - Try not to put equipment at or below the filter gallery
- Construction
  - Seal conduits and check contractor’s work
- Operations and maintenance
  - Pay attention to developing signs of failure
  - Plan for short-term supply arrangements if needed (redundant sources, interties)

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Case #2: Not Enough Water

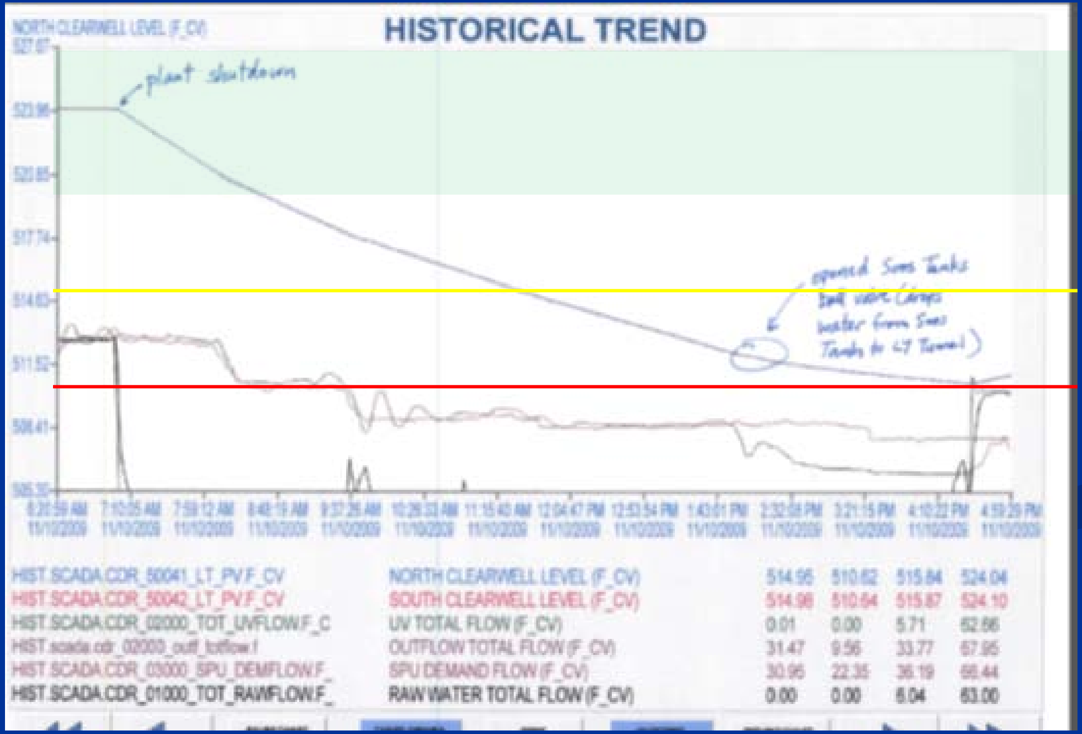
Seattle Public Utilities

Background – Hydraulics

- Treatment plant clearwells supplemented with other reservoirs at a higher elevation
  - 20 mgal storage at clearwells, always available
  - 13 mgal storage at higher reservoirs (normally used to serve water to larger customers)
  - Single manual ball valve used to access 13 mgal storage post-clearwells, in an emergency

What Happened

- Planned plant shutdown for maintenance
- At “X” clearwell level, continue to do outage work but start dropping water from elevated storage
- Ball valve didn’t open – stuck due to inactivity



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Response and Follow Up

- Call out valve crew to un-stick the valve (took several hours)
- Reduce plant demands where possible
- Continue maintenance work
  - Activities were planned to stop early if needed
  - Able to finish work before clearwells dropped to critical level
- Solution: put valve on annual exercising PM

Debrief

- Planning and design
  - Add redundancy to critical items
- Construction
  - Acceptance testing for every piece of equipment
- Operations and maintenance
  - ID critical system components
  - Exercise little-used equipment, especially if it's needed for emergency response

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Case #3: Loss of Chlorine

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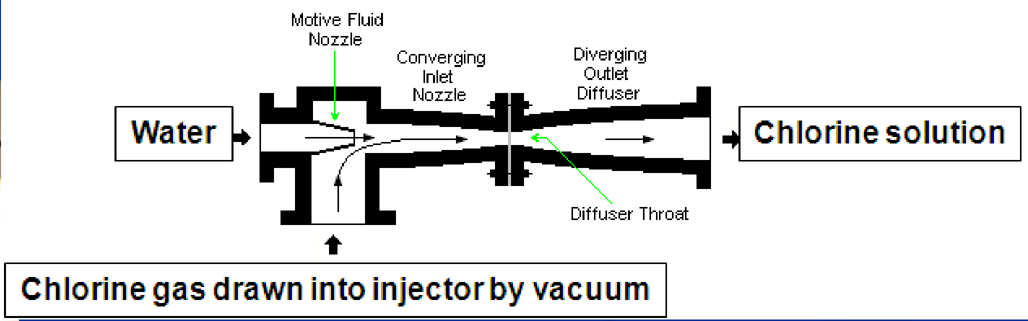
Background – Chlorine System

- Chlorine gas injectors
- Water from the domestic water system
  - Package water booster pumping system, multiple pumps with hydropneumatic tank



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What Happened

- The domestic water system failed and pumps shut down
- Operator set pumps to run in manual
  - Pumps ran briefly, then shut down
  - No chlorine without pressurized water

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Response and Follow-up - 1

- Shut down plant and draft off clearwell until domestic water system fixed
  - Lost system capacity met by other treatment plant
- Made emergency plans to:
  - Mobilize trailer of hypochlorite to manually feed hypo
  - Restart plant without chlorine and try to mix with chlorinated water in clearwells
  - Don't dewater the system

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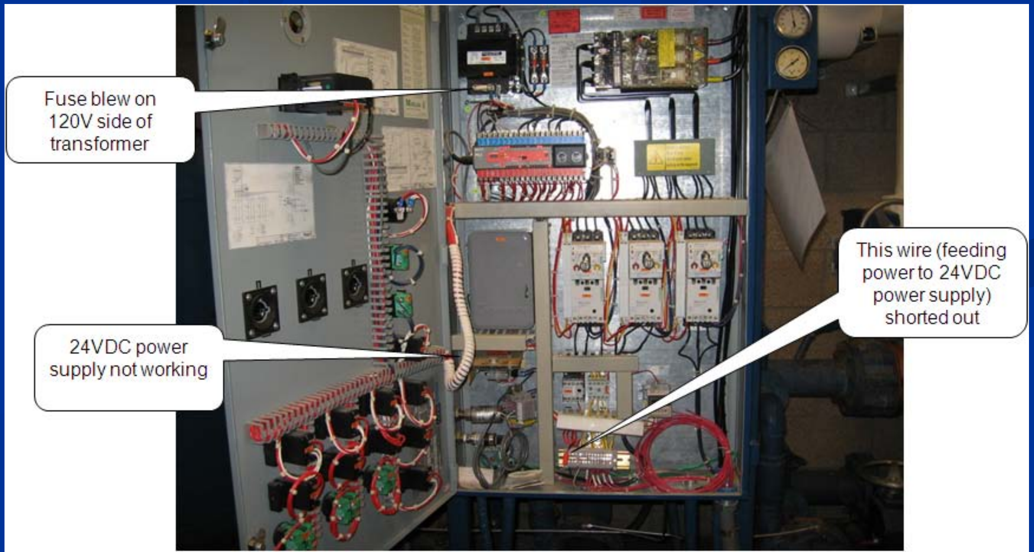
Response and Follow-up - 2

- Diagnose domestic water system problem
  - Replace blown fuse and bypass shorted-out controls
- Started up plant before clearwell got to emergency level
- Solutions:
  - Replace outdated control panel
  - Formalize backup solution(s): hypo, portable pump for injector water



Debrief

- Planning and design
  - Design alternate feed for pumped water (or more reliable feed, like elevated storage)
- Operations and maintenance
  - Identify critical single points of failure and train staff on response
  - Have backup chemicals available
  - Maintain list of critical vendors

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Case #4: Elevated Filter Turbidity

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Background – Filters

- Gravity filtration
  - Water level above filters controlled by balance of influent and effluent flow, filter effluent valves
  - Too low water level = coagulated water disturbing/scouring the surface of the filters

What Happened

- Operator allowed filter water level to get too low
  - Flow out > flow in
- Water coursed over central channel, scoured filters, disturbed media

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Response and Follow-up

- Operator shut down affected filter and verified filter level
  - Brought on another filter to replace lost flow capacity
  - No regulatory violations
- Solution: add more alarms to SCADA
  - Recurring alarm on filter level (audible once, recurring on SCADA every 3 mins until resolved)
  - Have senior operators and plant I&C tech check alarm functions periodically

] LIT-5401	LOLO	3.99 FT.	Filter 4 Level
] AIT-4069	OK	0.2857 MG/L	Basin 2 Ozone Conc 4
] AIT-4069	HI	0.3077 MG/L	Basin 2 Ozone Conc 4
] LIK-5401-L-R	CFN	RECUR	Recurring Alarm - Filter 4 Lo Level

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Debrief

- Planning and design
  - Design more automation into flow and hydraulic controls
  - Add critical alarms to SCADA design (display and/or audible)
- Operations and maintenance
  - Operator training
  - Set (and test regularly) recurring alarms for important parameters

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Case #5: SCADA/PLC Failures

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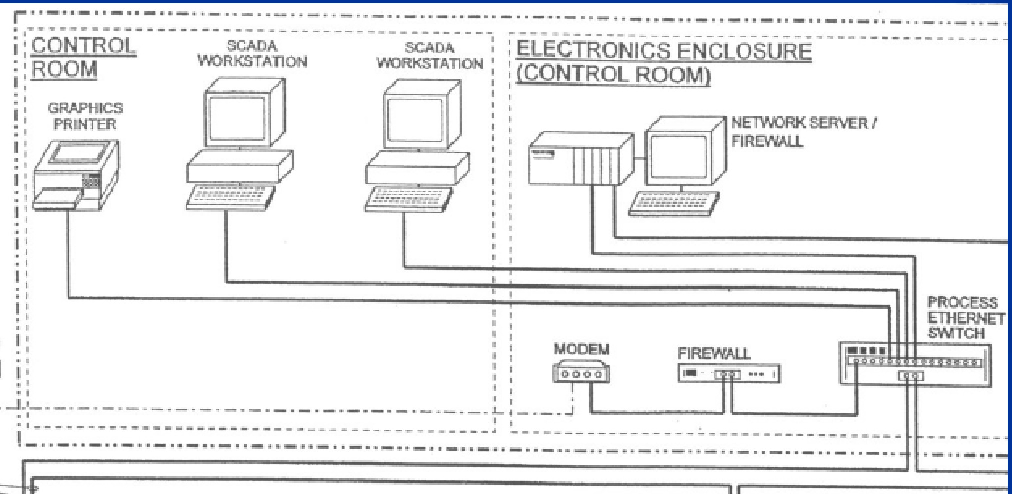
Background – SCADA/PLCs

- SCADA system used for monitoring, control and data recordkeeping
  - Data collection and control server
  - Historian server
  - HMI units for operators
- Area PLCs for process control



What Happened

- SCADA server failures (several instances)
  - No recordation of historical data
  - Operators not able to see or control from HMI
  - Loss of historical data, as much as 1+ month of history in one case
  - Able to recover most of data from backup drive(s)
- PLC failures (several instances)
  - Bad units/cable connections
  - UPS failures
  - Operators had to control plant manually

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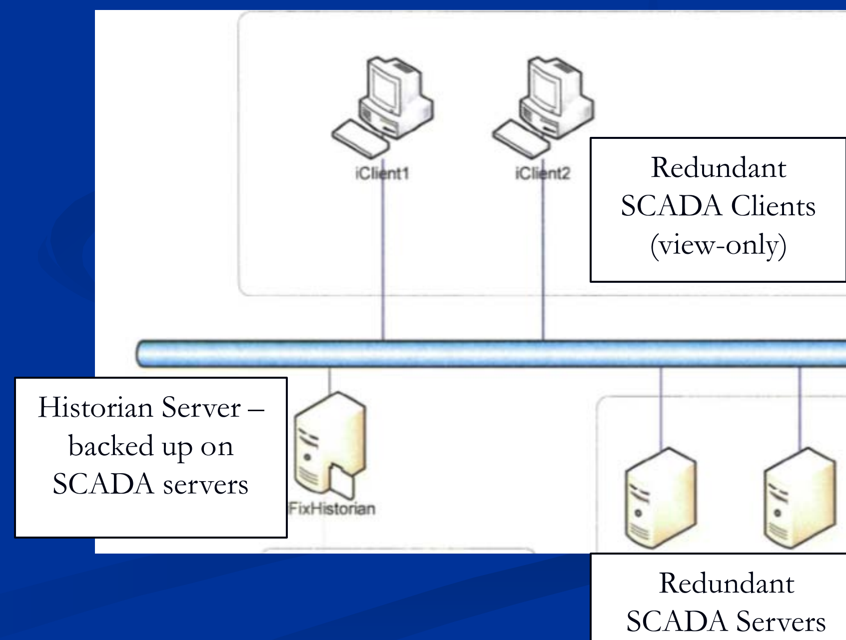
Response and Follow Up

- SCADA tech dispatched immediately
- PLC repairs
  - Power supply replaced with on-hand spare
  - UPS bypassed
  - Replaced bad cables
- Operated plant in manual
- Solutions:
  - Add redundancy in servers and PLCs
  - Review procedures for operating plant in manual
  - Stock critical spare parts



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Debrief

- Planning and design
  - Add more redundancy in SCADA system and PLCs
- Construction
  - Use high quality I&C wiring, connections
- Operations and maintenance
  - Make sure operators are trained to operate in manual mode
  - Stock critical spare parts
  - Put the SCADA/PLC techs on speed dial

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Summary

- Do your best up-front work:
  - Adopt best practices
  - Prioritize
  - Hazard analysis
  - Plan for emergencies
  - Train, train, train
- "That'll never happen…" sure can
  - Learn from your experiences
  - Talk to other utilities, so mistakes don't get repeated

Seattle Public Utilities

Questions?

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Tracer Studies and Baffling Efficiency:

Theory & Real World Challenges

Jolyn Leslie, PE
Regional Engineer
Sam Perry, PE
Water Treatment Eng.

Mission

To protect the health of the people of Washington State by ensuring safe and reliable drinking water.

Theory & Real World Challenges

"Now, this is just a simulation of what the blocks will look like once they're assembled."

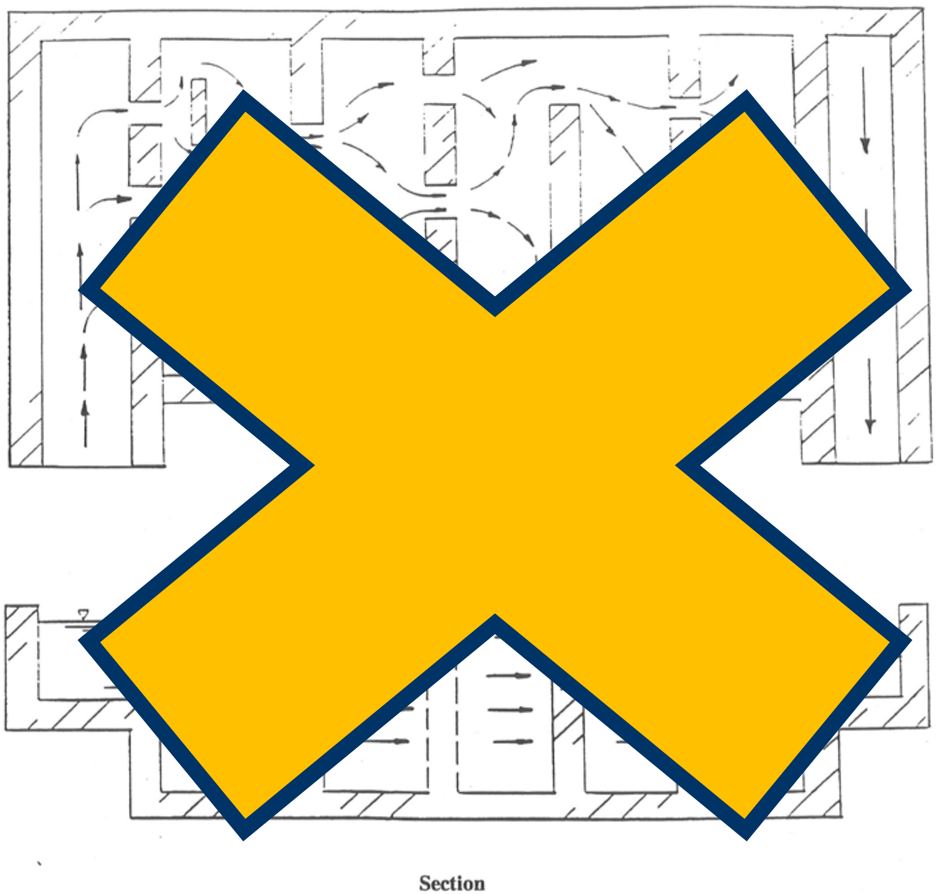
Outline of Presentation

- Brief history and definitions/nomenclature
- Tracer selection and study methods
- Tank geometry
- Sampling
- Case studies

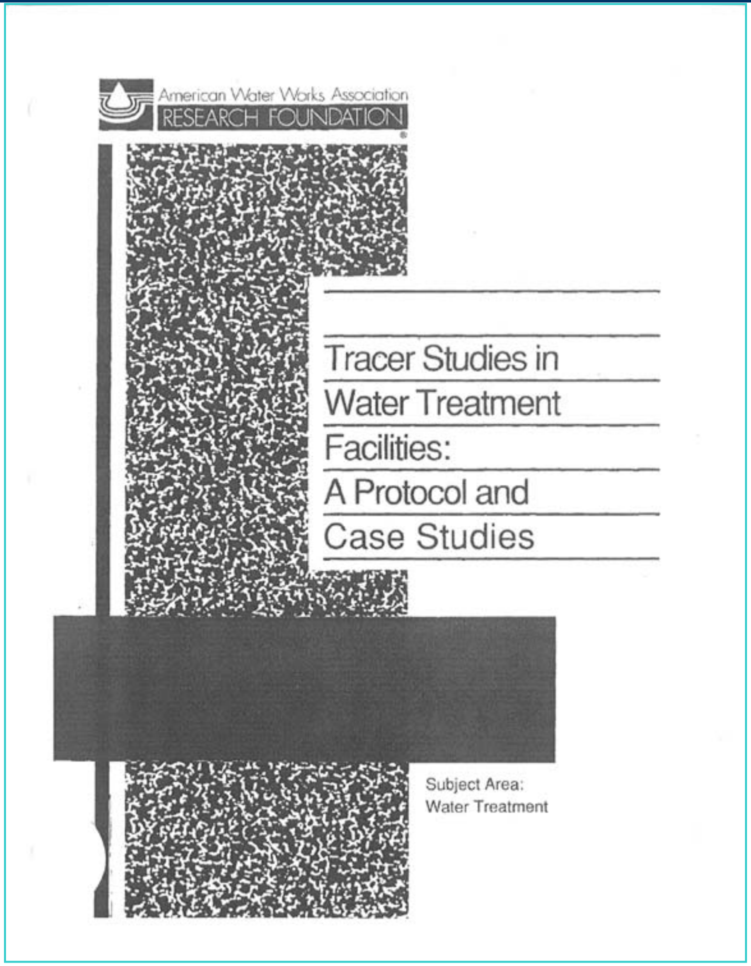
SWTR - Guidance

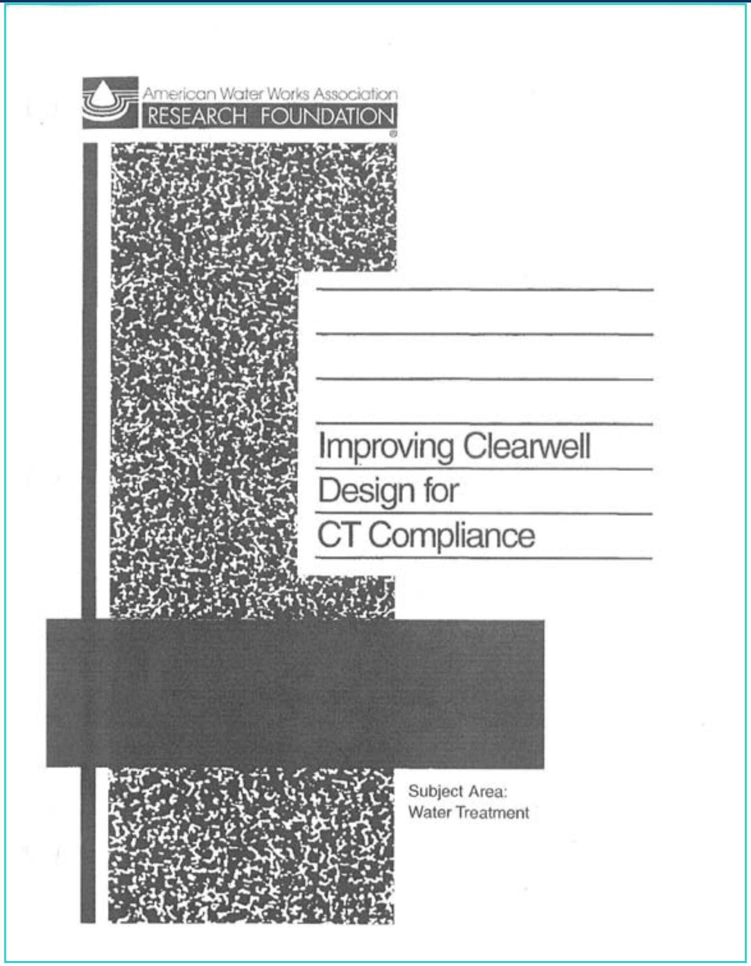
Baffling Co…	T_{10}/T	…ription
Unbaffled		Non… to width ratio, …ties.
Poor		…ed inlets and outlets, no
Average		…tlet with some intra-basin
Superior		…ne or perforated intra… perforated laundere…
Perfect Plug F…	1.0	Very high lengt… (pipeline flow), perforated inlet, outle… intra-basin baffles.

“Superior” Baffling - Really??



WaterRF - Updated References





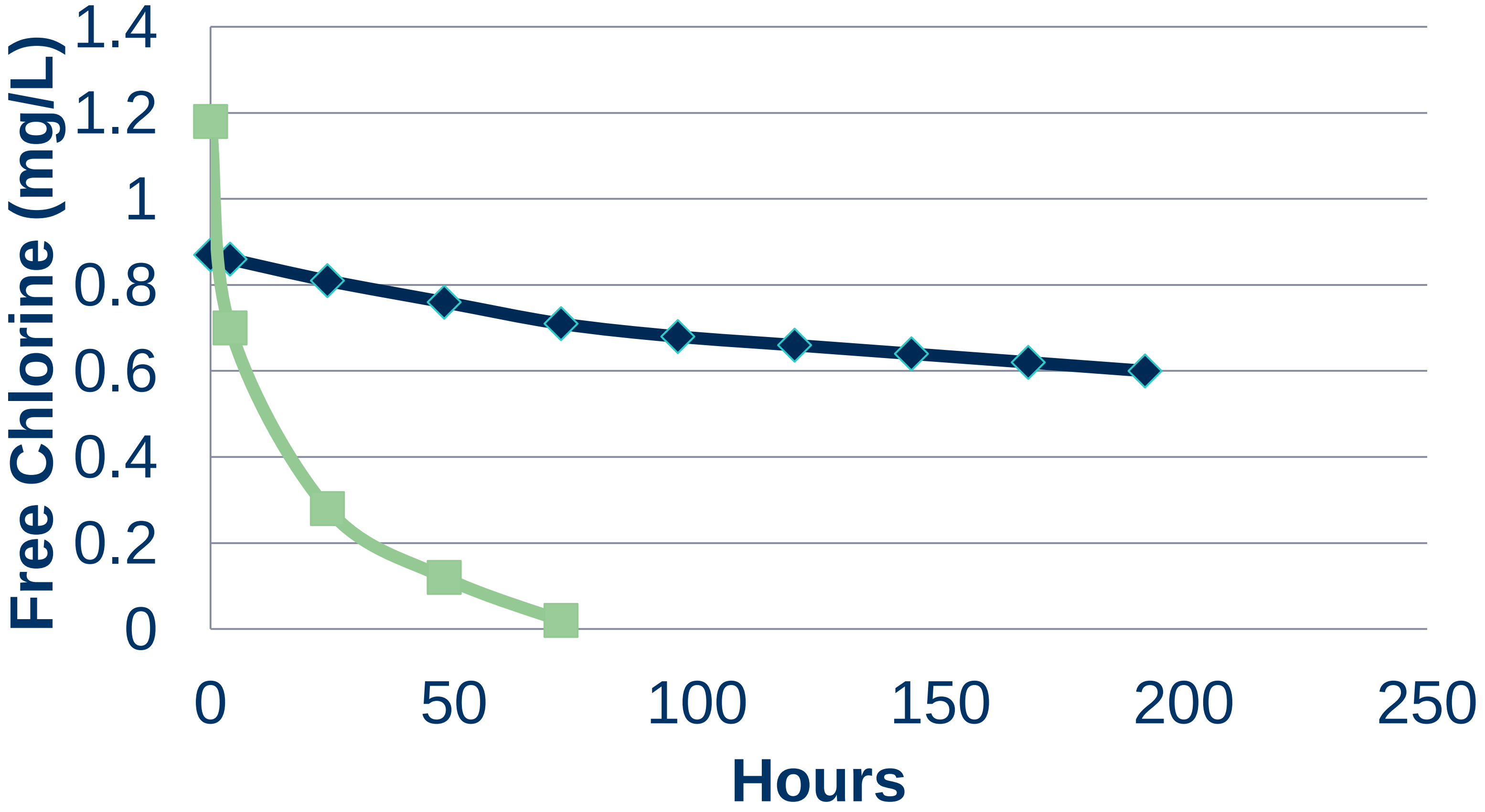
Some Definitions/Nomenclature

- HRT – Hydraulic Residence Time
  - HRT = V/Q
- RTD – Residence Time Distribution (breakthrough curve)
- BF – Baffling Factor (a.k.a. T_{10}/T)
  - BF = T_{10}/HRT
- $T_{10} = BF(V/Q)$

Tracer Selection

- Conservative (mass balance)
- ANSI/NSF 60 approved
- Easily measured
- Should mimic water
- Fluoride, Lithium, Chloride (in some limited cases, hypochlorite)

Chlorine Decay

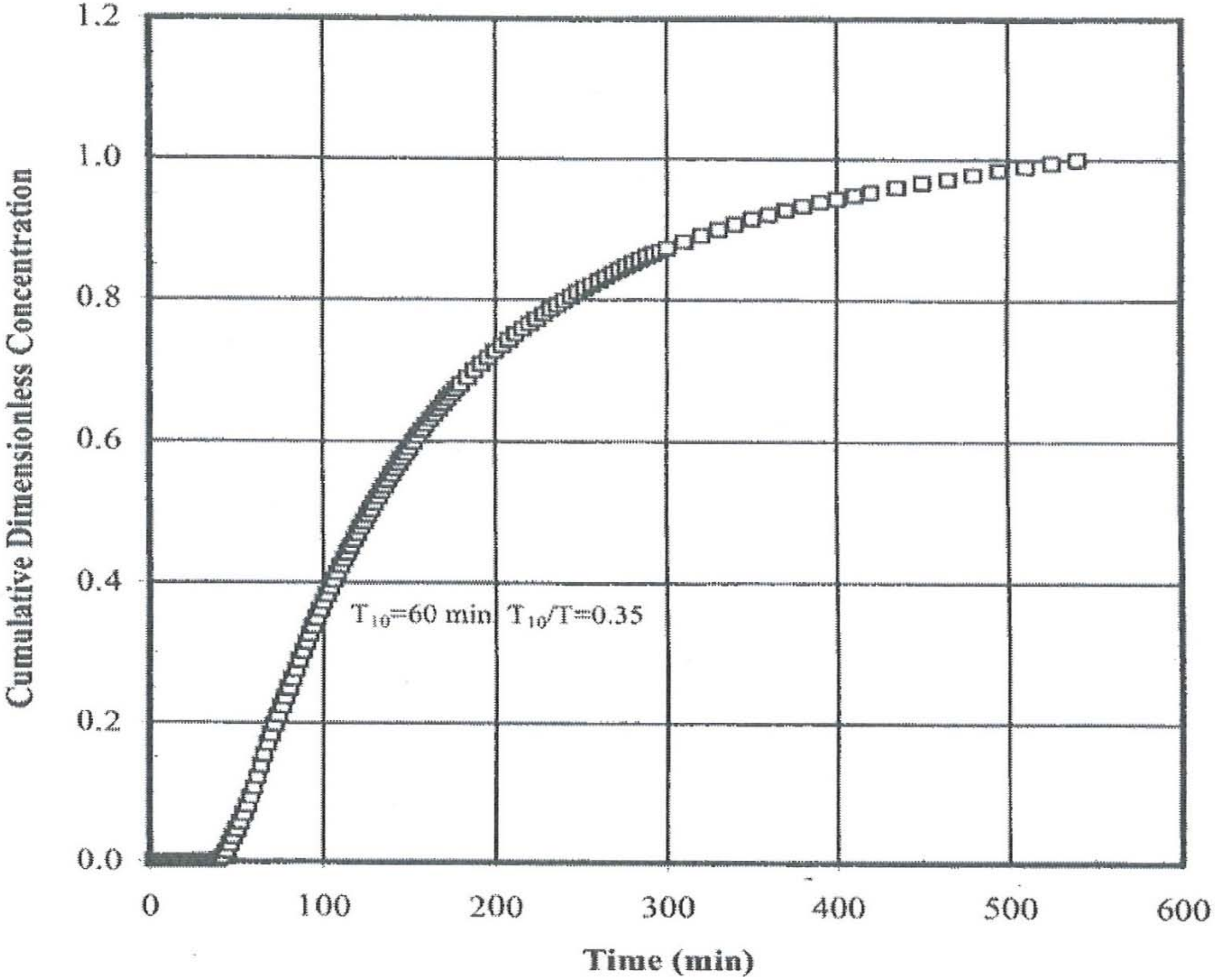


Tracer Study Methods

- Slug Dose
  - Avoid
  - Density currents
- Step Dose
  - Recommended

Example Step Dose Curve

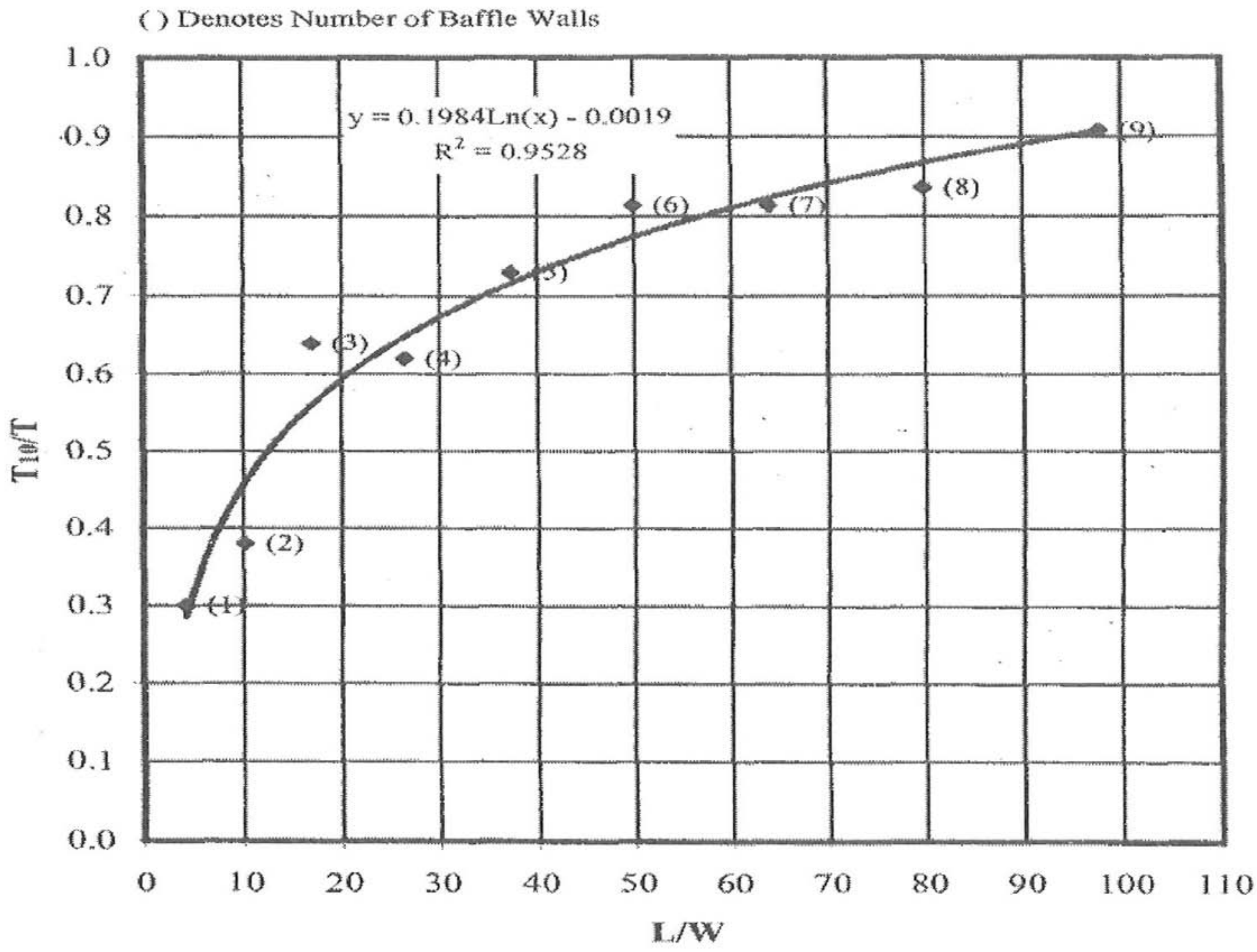
T10/T = 0.35; HRT=170 min; Test Run for three HRTs



Tank Geometry

- Inlet conditions
- Internal features, such as baffles
- Outlet features
- Length to width ratios

Baffling Factor vs. L/W Ratio



Transport of Water

- Inlet conditions
- Flow rate and residence time
- Velocity contours
- Stagnant and recirculation zones

Sampling - Challenges/Concerns

- Tracer analysis
- Sampling location
- Flow conditions
- Manpower

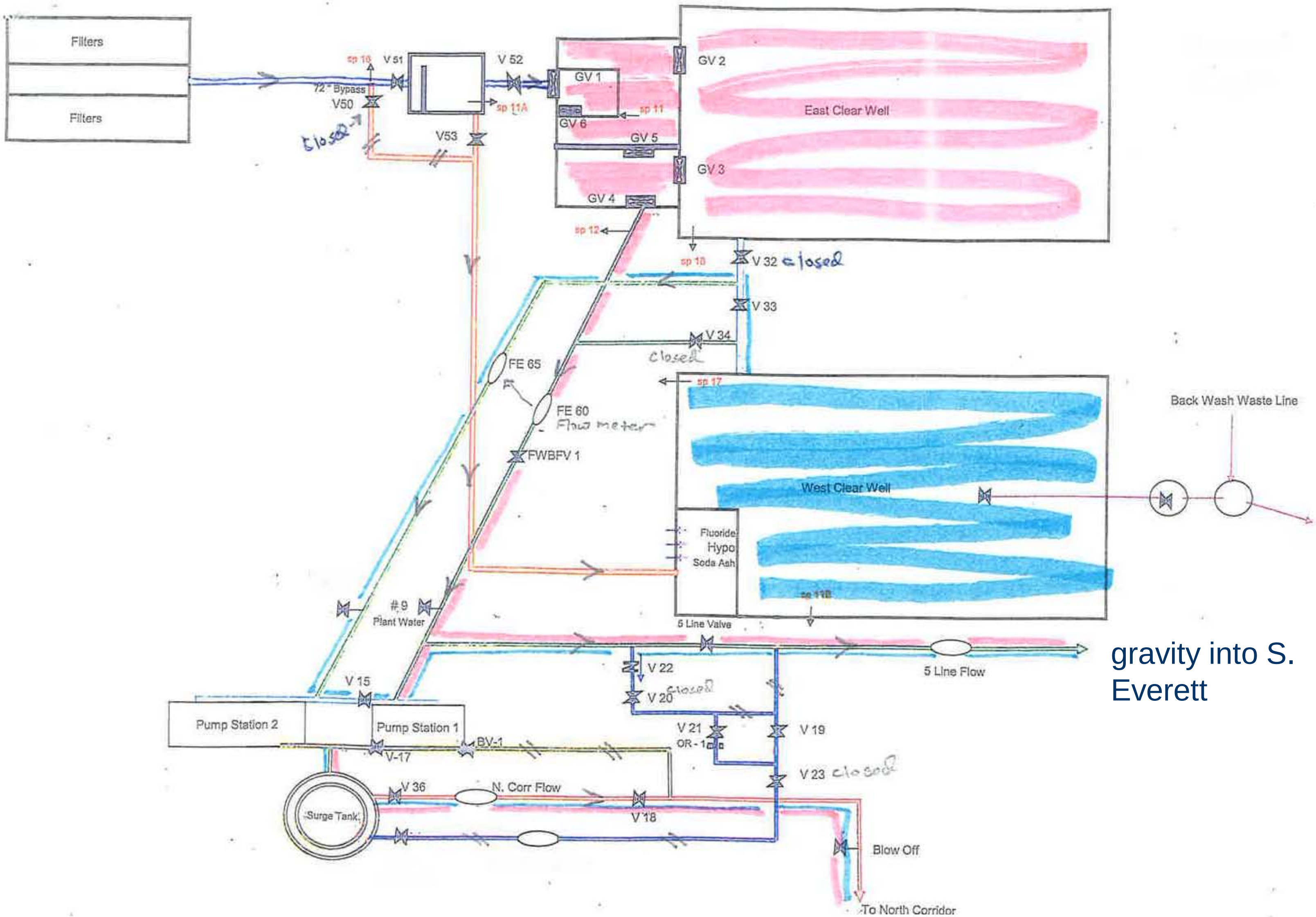
Case Studies

- Everett - new 6.75-MG clearwell
- Marysville - new 0.2-MG clearwell

Everett Tracer Study

- New 6.75-MG rectangular concrete clearwell with three linear baffles (West CW)
- Second clearwell added to existing 5-MG rectangular concrete clearwell with one linear baffle (East CW)

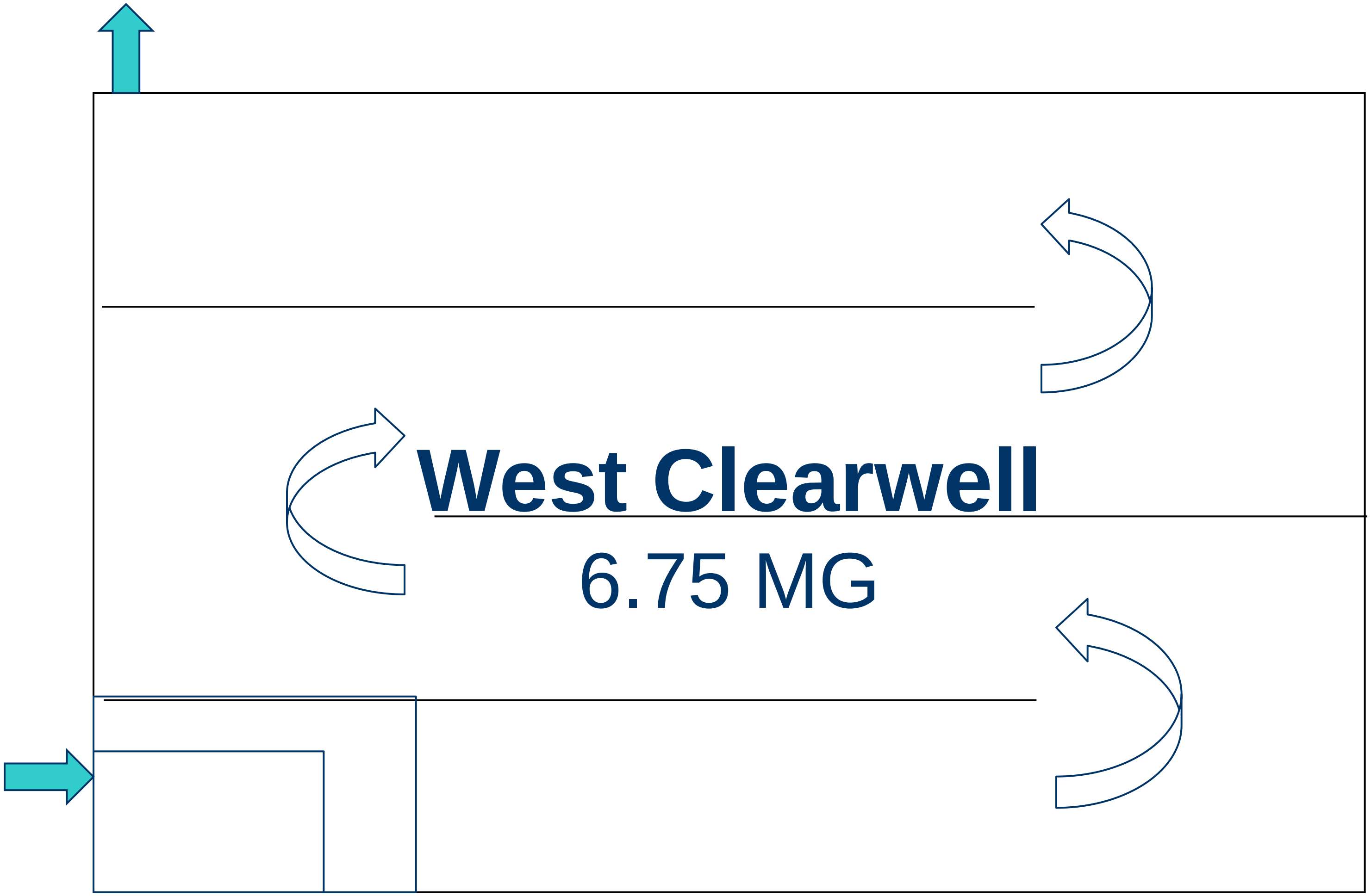
Everett Clearwell Configuration



gravity into S. Everett

Pumped to Portal 3 then gravity into N. Everett

Everett - New 6.75 MG Clearwell



Everett Tracer Study
Some Challenges

- Controlling clearwell levels and flows
- Tracer selection/sampling
- Variable baffling efficiency

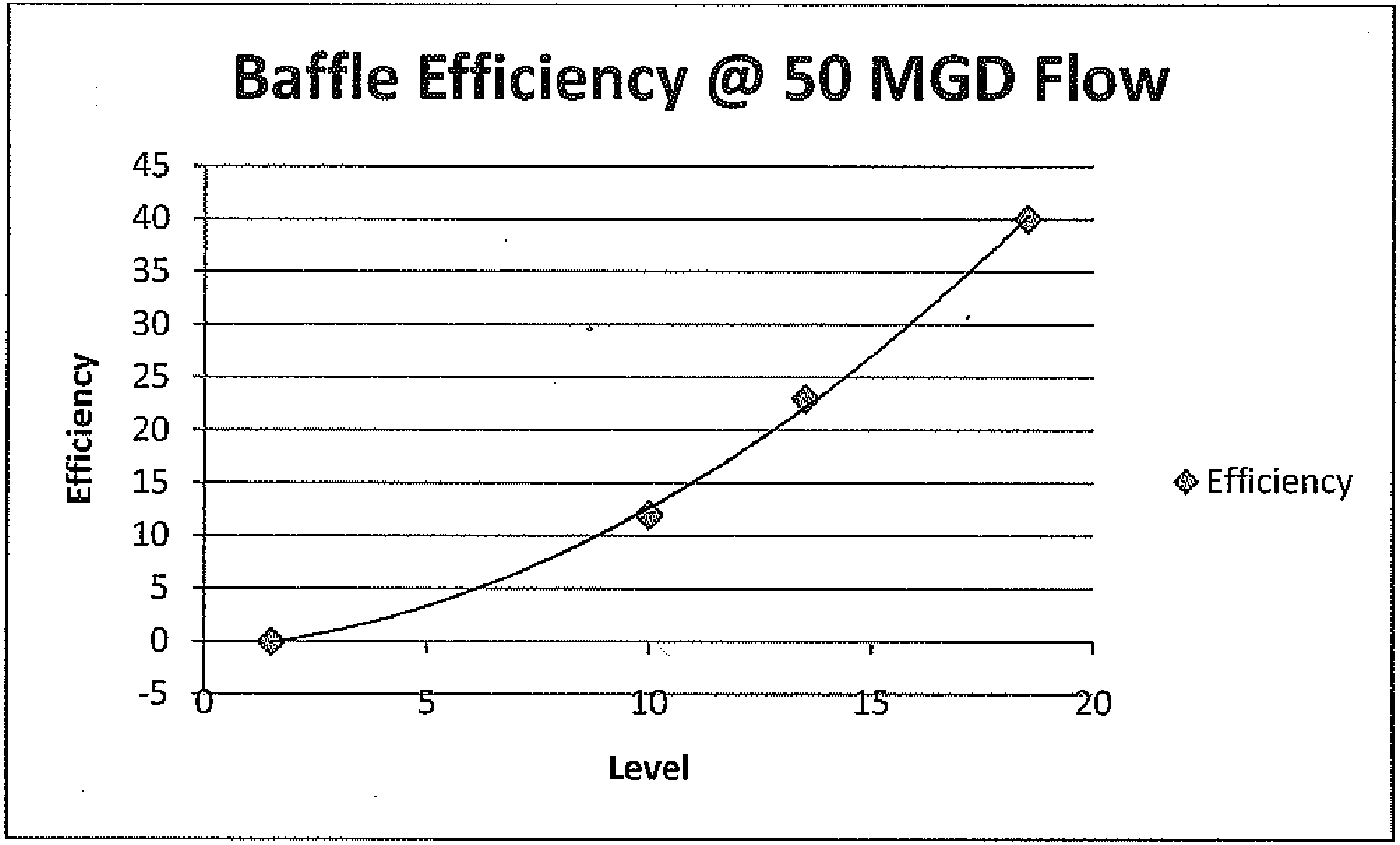
Everett - Controlling Levels and Flows

- Clearwell(s) in active use throughout tracer study
- Flows tested – 25, 50, 85, 128 MGD
- Effluent flow meter

Everett - Tracer Selection/Sampling

- Sodium hypochlorite used as tracer
  - Pre-chlorination at headworks of plant essentially eliminates chlorine demand
  - 1.0 ppm step dose
- Influent sample point
  - 10 minute lag
- At lowest flow of 25 MGD, tracer study conducted over 18 hours

Everett - Baffling Efficiency




B
A
B

Everett - Some Results

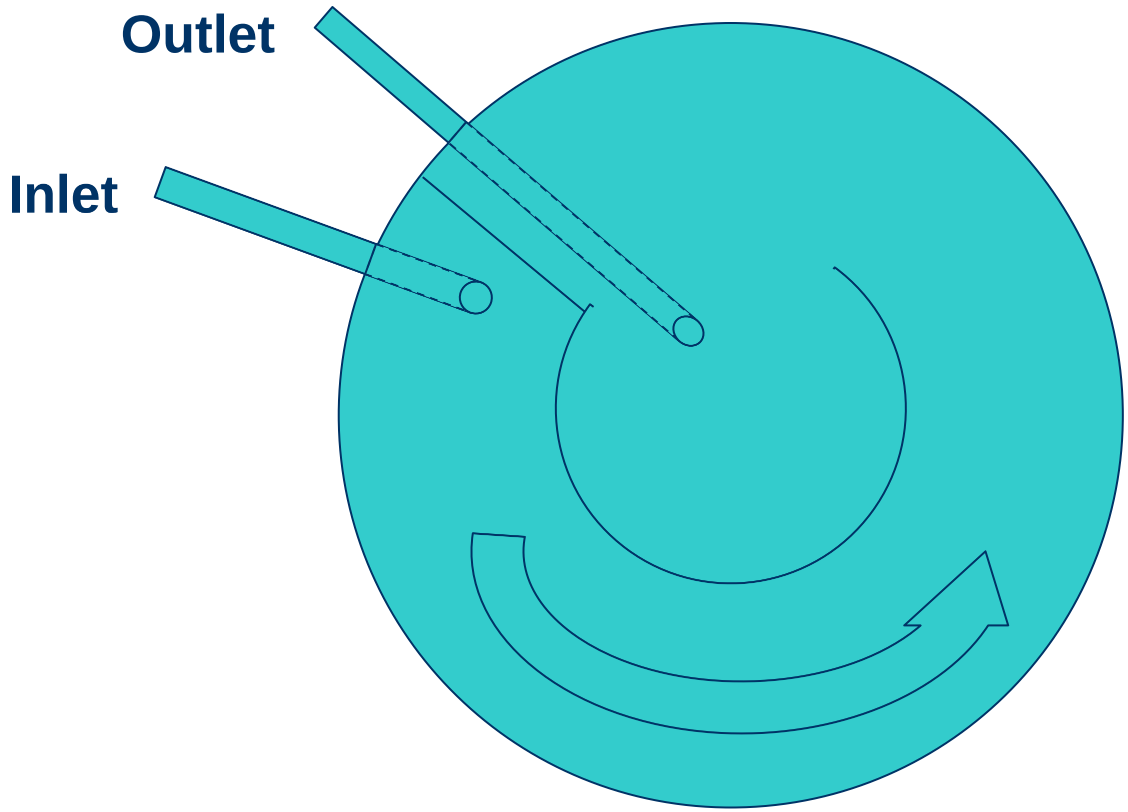
West Clearwell Tracer Study T^{10} Summary

Flow Rate	Date	T^{10}	Average T^{10} For 3 Runs
MGD		minutes	minutes
25	12/1/2009	128	105
	12/8/2009	88	
	4/8/2010	99	
50	4/22/2010	60	68
	4/27/2010	72	
	5/19/2010	72	
85	8/19/2009	56	53
	8/20/2009	52	
	8/21/2009	50	
132	9/2/2009	33	33
	9/4/2009	33	
	9/8/2009	33	

Marysville Tracer Study

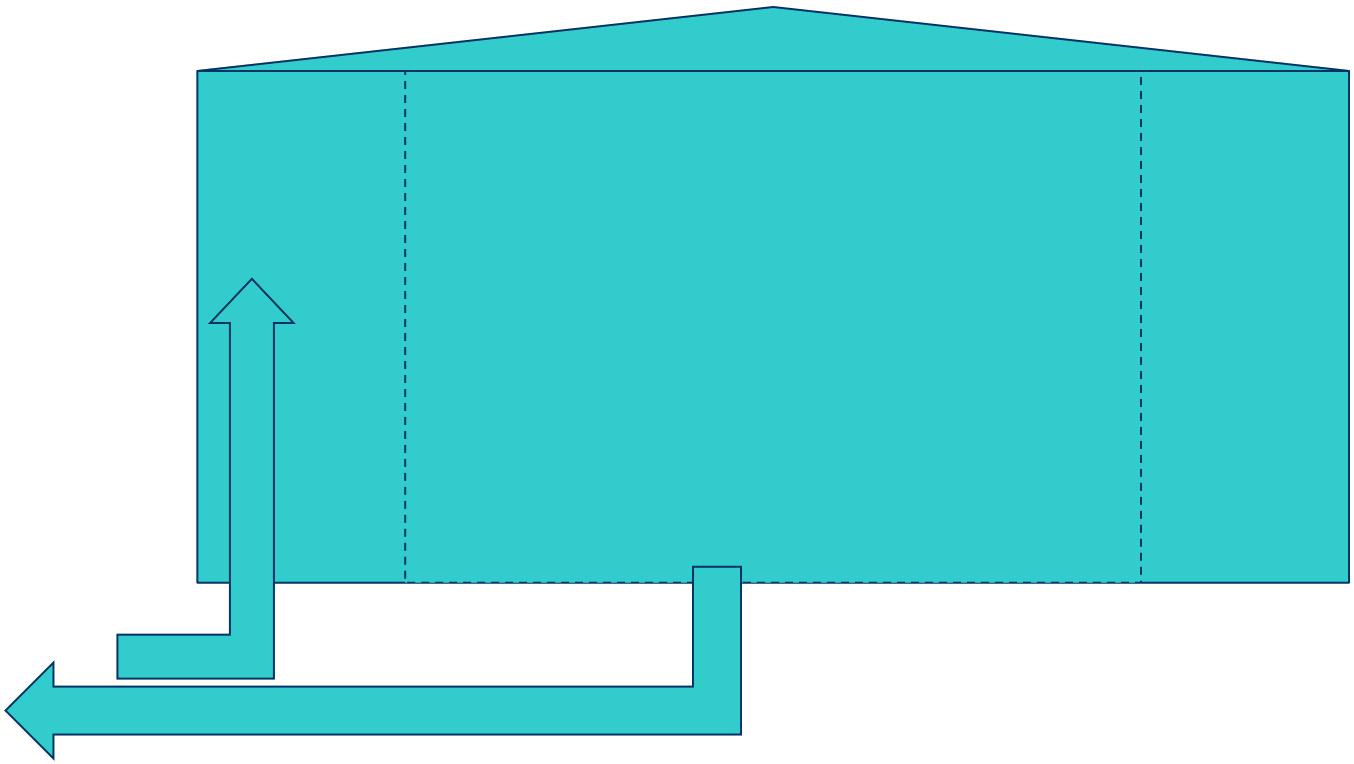
- New 0.2-MG circular welded steel clearwell with a circular baffle
- Clearwell for new Stillaguamish membrane treatment plan

Marysville Clearwell



Plan View

Marysville Clearwell



Marysville - Some Challenges

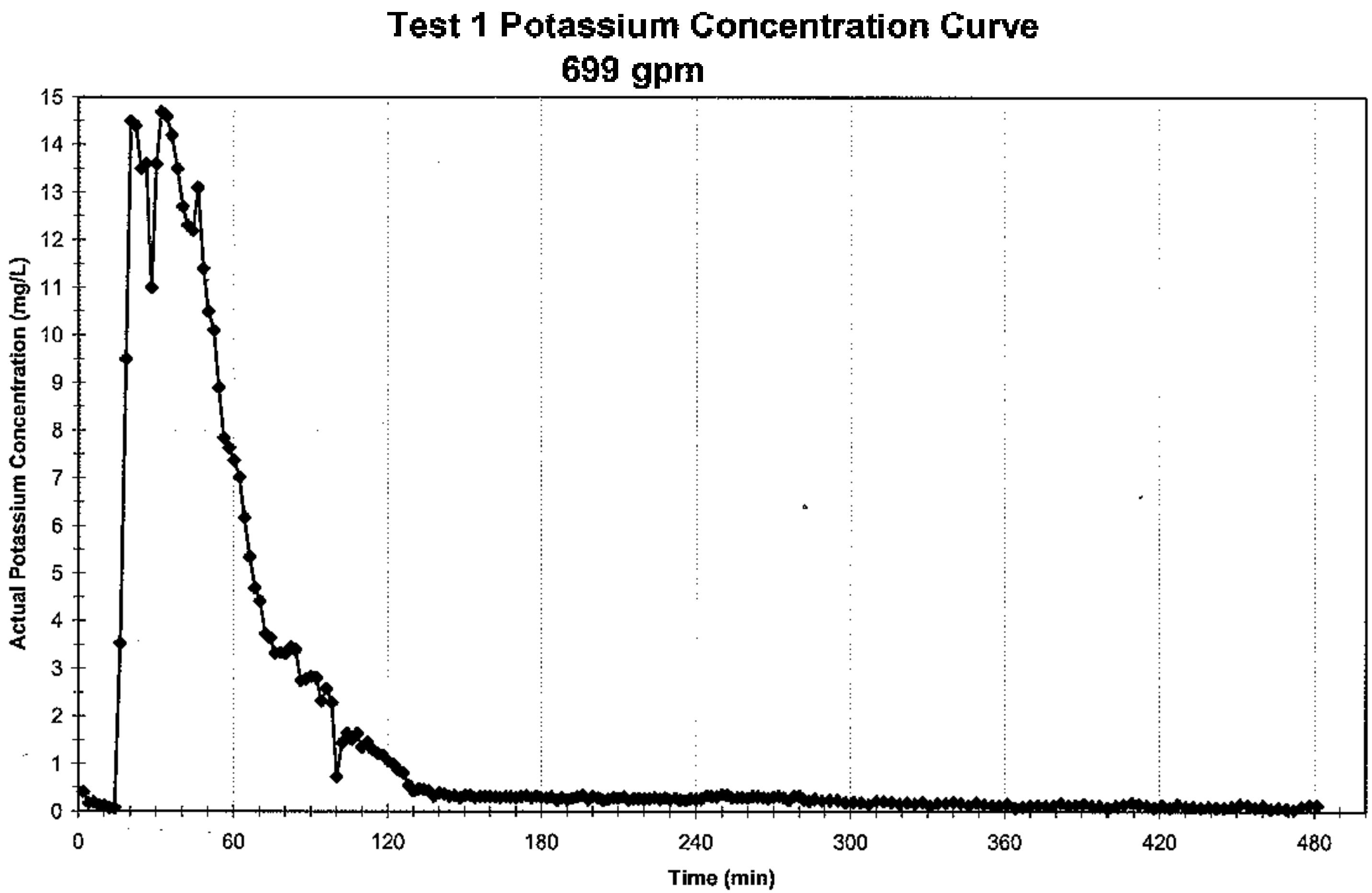
- Controlling clearwell levels and flow rates
- Tracer selection/sampling

Marysville - Controlling Levels and Flows

- Flows tested - 700, 1300, 2000 gpm
  - Influent and effluent flow rates not adequately characterized
- Routine operation of membrane plant required backpulsing several times
- Clearwell maintained approximately half full

Marysville - Tracer Selection/Sampling

- Potassium Chloride used as tracer
  - Slug dose at 63 g/l K and 79 g/l K - target 7 mg/l K at equilibrium
- 262 samples collected at lowest flow of 700 gpm (over a period of 12 hours)


Test 1 Potassium Concentration Curve
699 gpm
Actual Potassium Concentration (mg/L)
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0
60
120
180
240
300
360
420
480
Time (min)

Marysville - Density Currents

$$v = \sqrt{2\frac{\Delta\rho}{\rho}gh}$$

- Where:

  v = velocity of the density current (m/s)

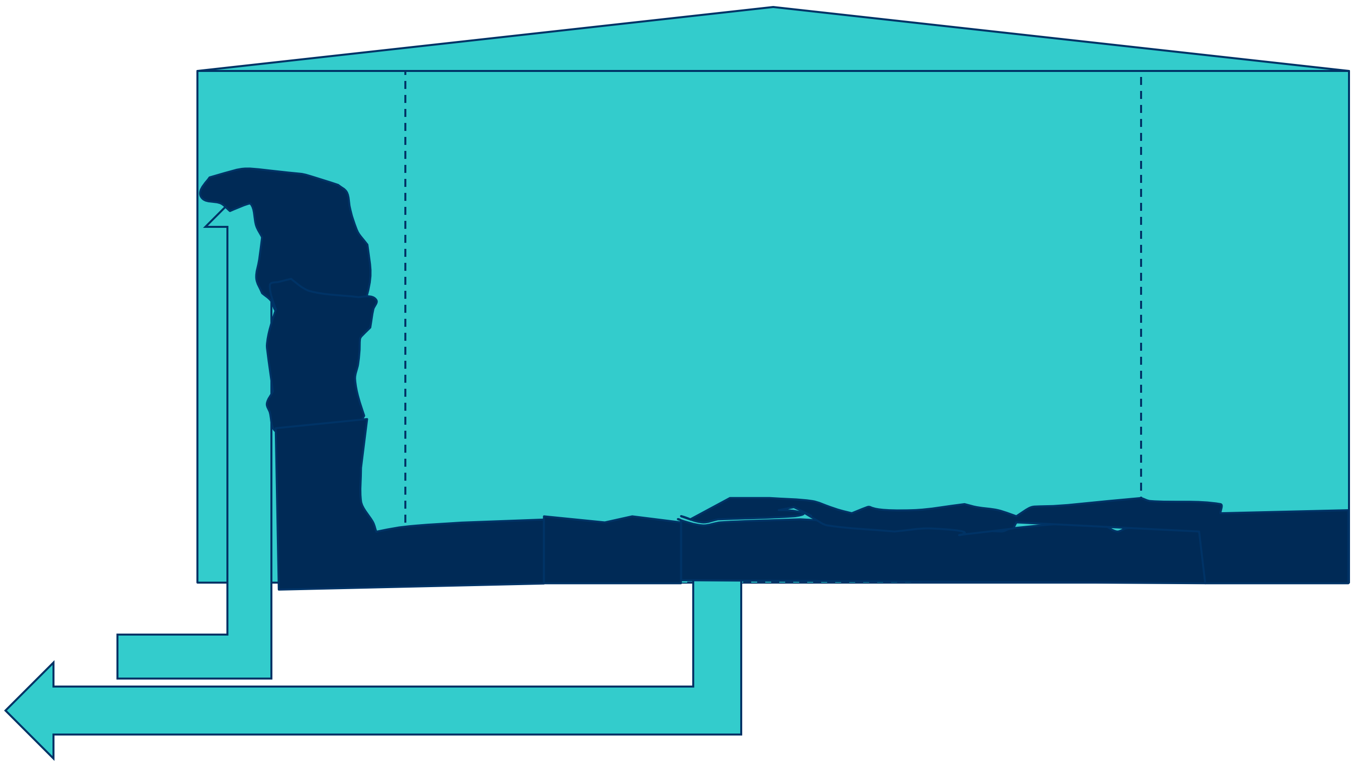
  g = gravity constant (m/s^2)

  Δρ = difference in density between the fluids (kg/m^3)

  ρ = density of water (kg/m^3)

  h = depth of the density current (m)

Marysville Clearwell - Density Current



Marysville - Some Results

Summary of Tracer Test Results

Test	Flow Rate (gpm)	Avg. Clearwell Level (in)	Clearwell Volume[a] (gal)	T_{10} (min)	HRT[a] (min)	T_{10}/T
1	699	130.9	97,515	23	139.6	0.16
2	1302	132.4	98,558	27	75.7	0.36
3	1975	131.6	98,026	26	49.6	0.52

[a] The total volume is calculated based on the average clearwell elevation observed during the individual tracer test.

For More Information

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  Sam.Perry@doh.wa.gov

Questions?

PUBLIC HEALTH
ALWAYS WORKING FOR A SAFER AND
HEALTHIER WASHINGTON

Brown AND Caldwell

Achieving Excellent Water Quality while Piloting at High Loading Rates

Lynn Williams

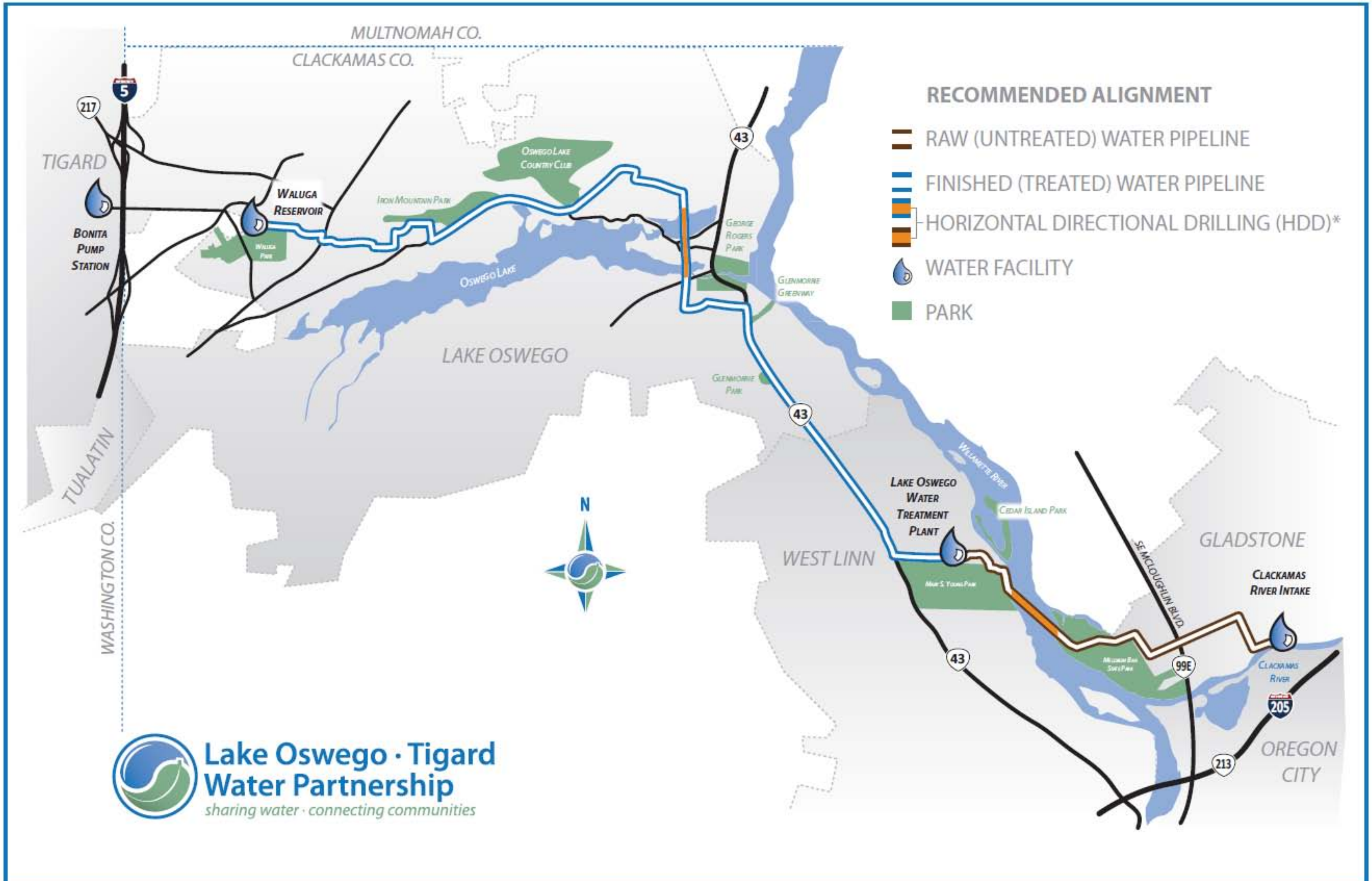
May | 2012

Lake Oswego · Tigard Water Partnership
sharing water · connecting communities

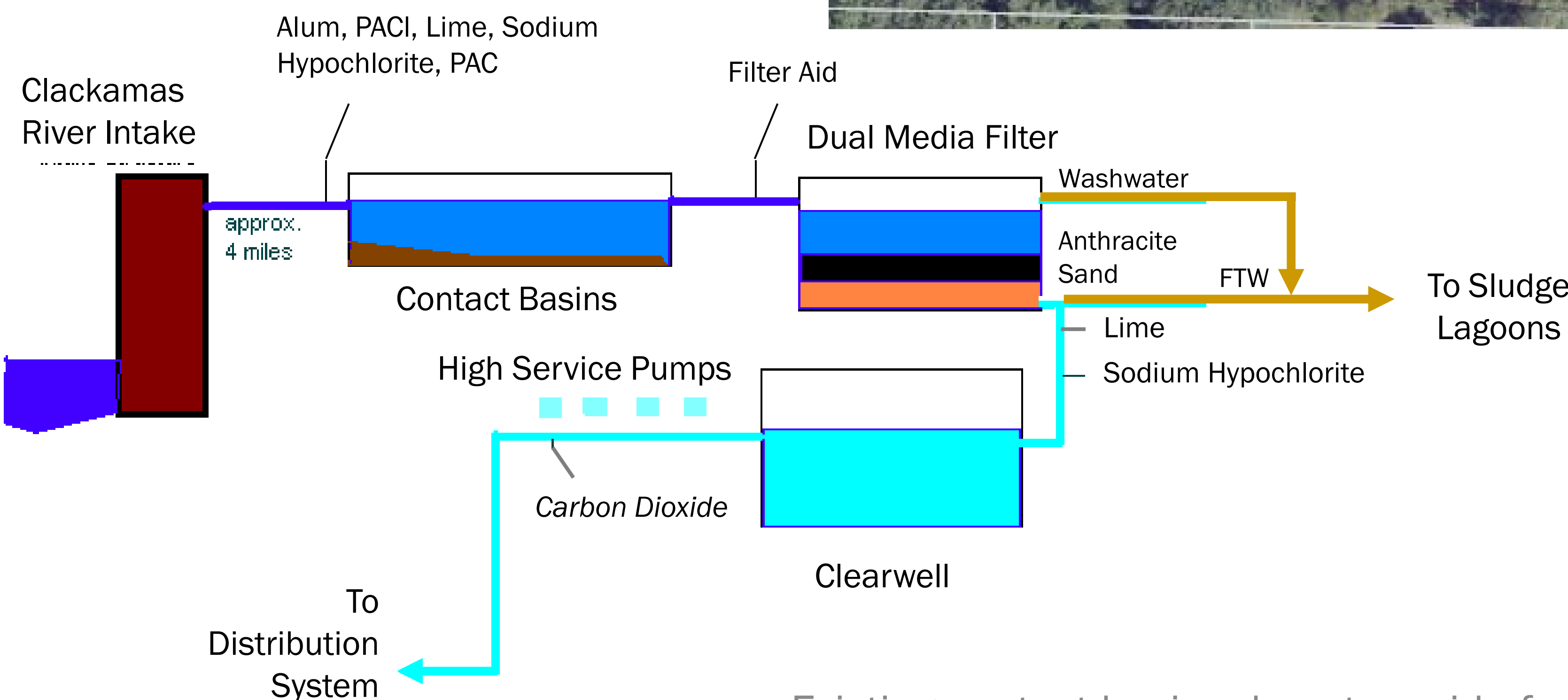
Presentation Roadmap

- Project Background
- Overview of existing LOWTP
- Pilot Study Objectives
- Pilot Equipment Description
- Pilot Study Findings
  and Recommendations

Water System Improvements

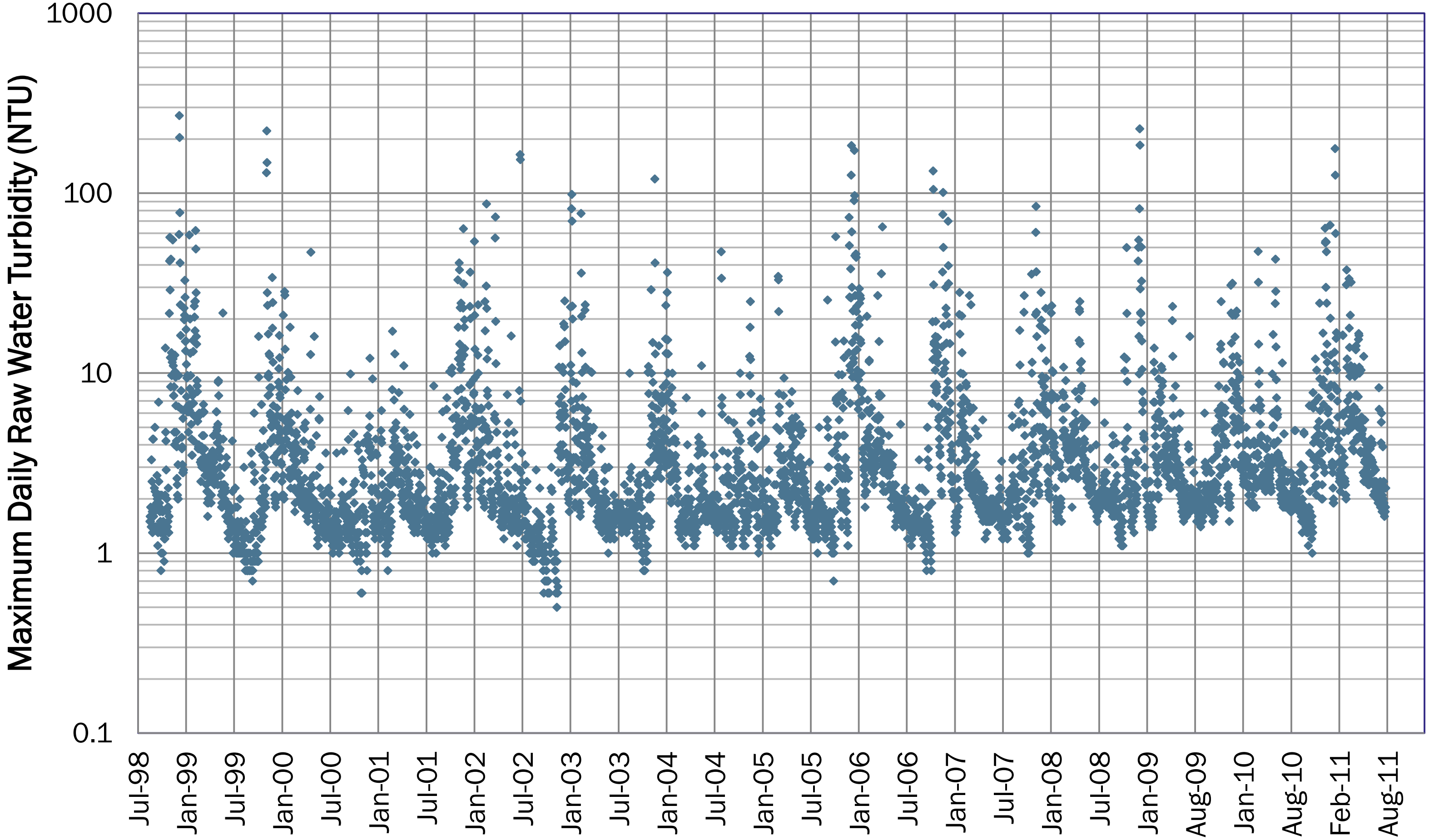


Existing Direct Filtration Plant



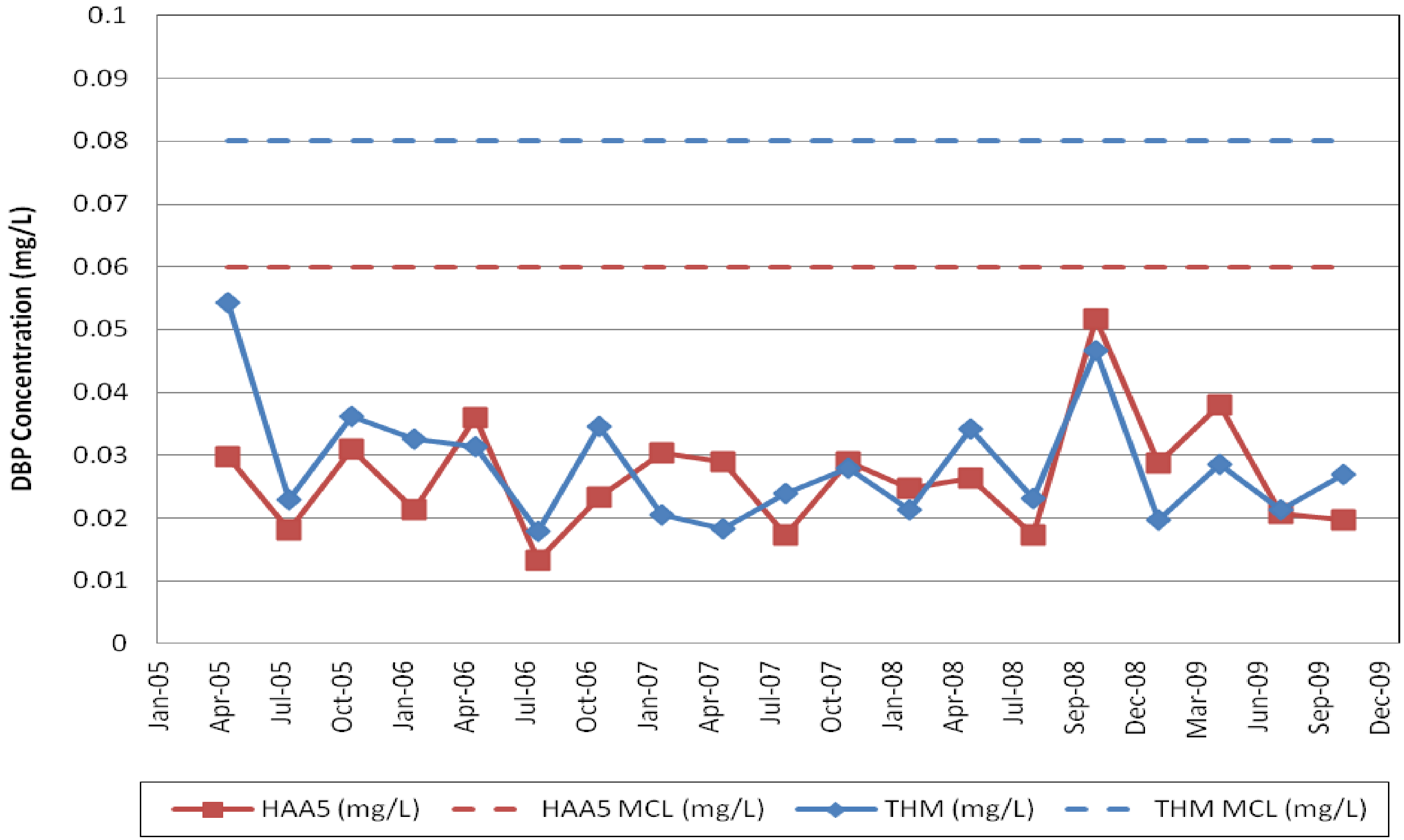
- Existing contact basins do not provide formal flocculation and sedimentation

Historical Turbidity Data



Modified from 2012 Preliminary Design Report

Historical DBP Data



Modified from 2012 Preliminary Design Report

- *Algal taste and odors issue*

Expansion Treatment Alternative

- Life Cycle Cost Evaluation
- Liquid Stream Treatment Process
  - Ballasted flocculation
  - Ozonation
  - High-rate biological filtration
- Ballasted flocculation
  - 20 gpm/sf at 38 mgd
  - 40 gpm/sf with 1 train out of service
- High-rate biological filtration loading rates
  - At 38 mgd with 6 filters at 675 sf
    - Peak day summer demand
      - 10 gpm/sf - 2 filters out of service
      - 6.5 gpm/sf – no filters out of service
    - Peak winter demand
      - 4.8 gpm/sf – 2 filters out of service
      - 3.2 gpm/sf – no filters out of service

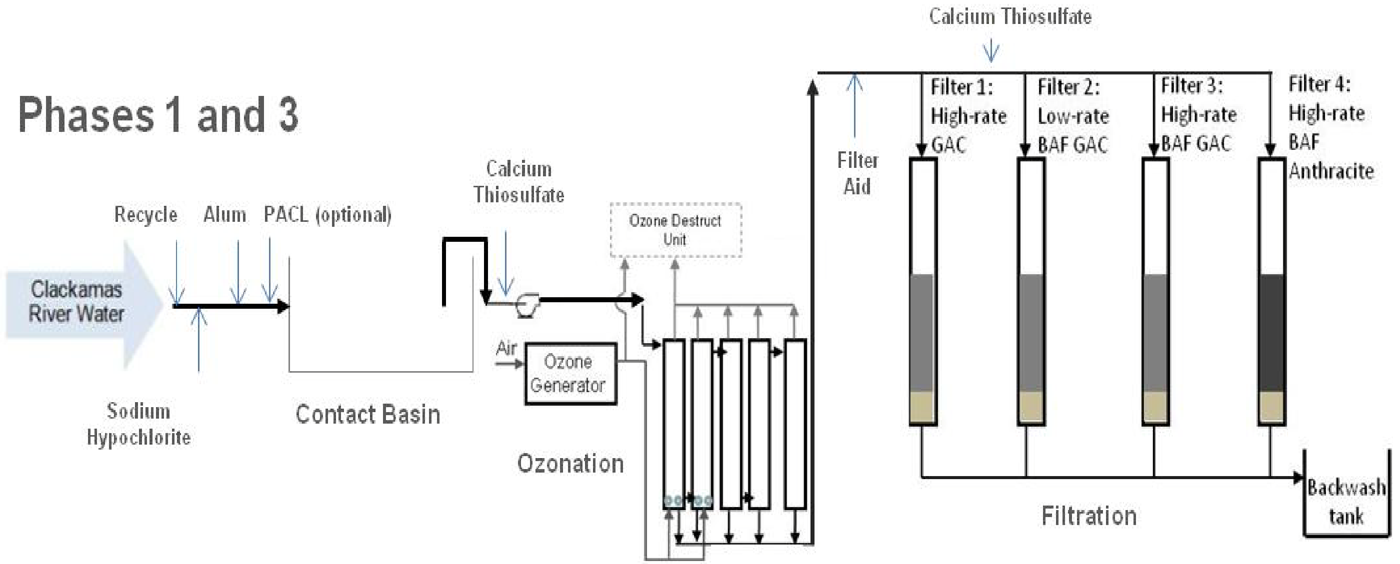
Objectives

- Validate design parameters for final detailed design
- Optimize filter media configuration
- Evaluate the benefits of intermediate ozonation
- Familiarize operations staff with future processes and equipment
- Public education/outreach opportunity

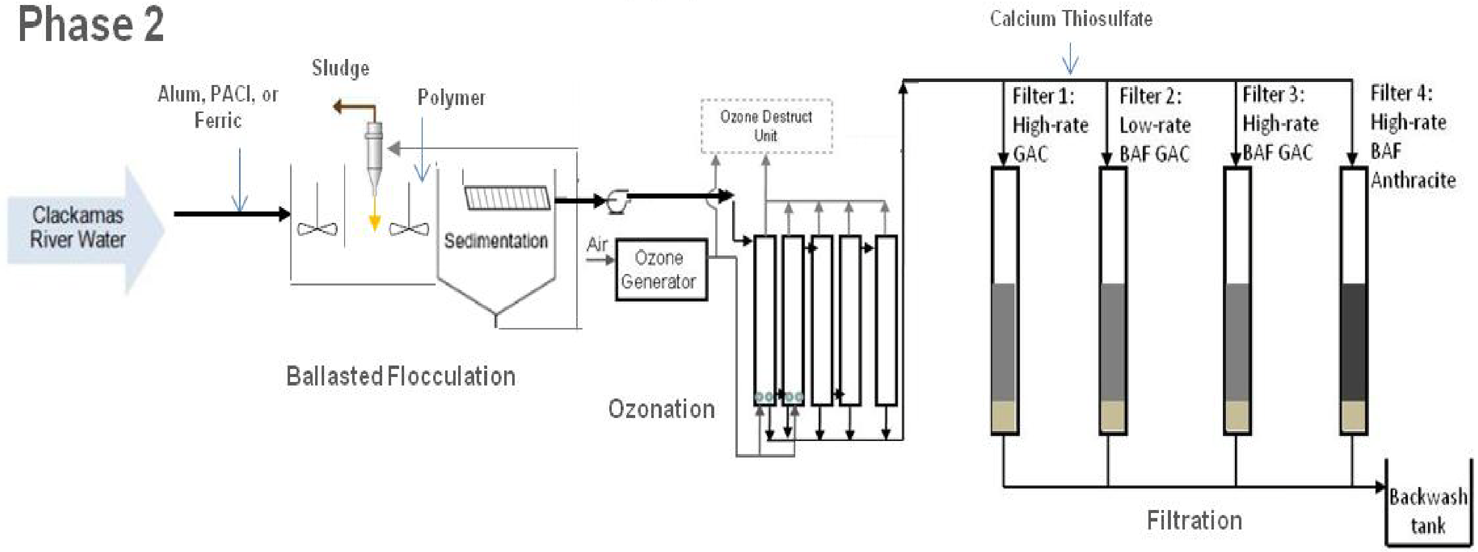
Pilot Operations Overview

Phase	Season	Condition Captured	Pilot Setup	Operation
1	Summer/fall	High temperature water, taste and odor events	Prechlorinated existing contact basin water + ozonation + high-rate filtration	Continuous
2	Fall	Higher turbidity and organic loads	Ballasted flocculation + ozonation + high-rate filtration	Start/Stop
3	Winter/Spring	Higher turbidity, colder temperatures	Prechlorinated existing contact basin water + ozonation + high-rate filtration	Continuous

Pilot Plant Configuration

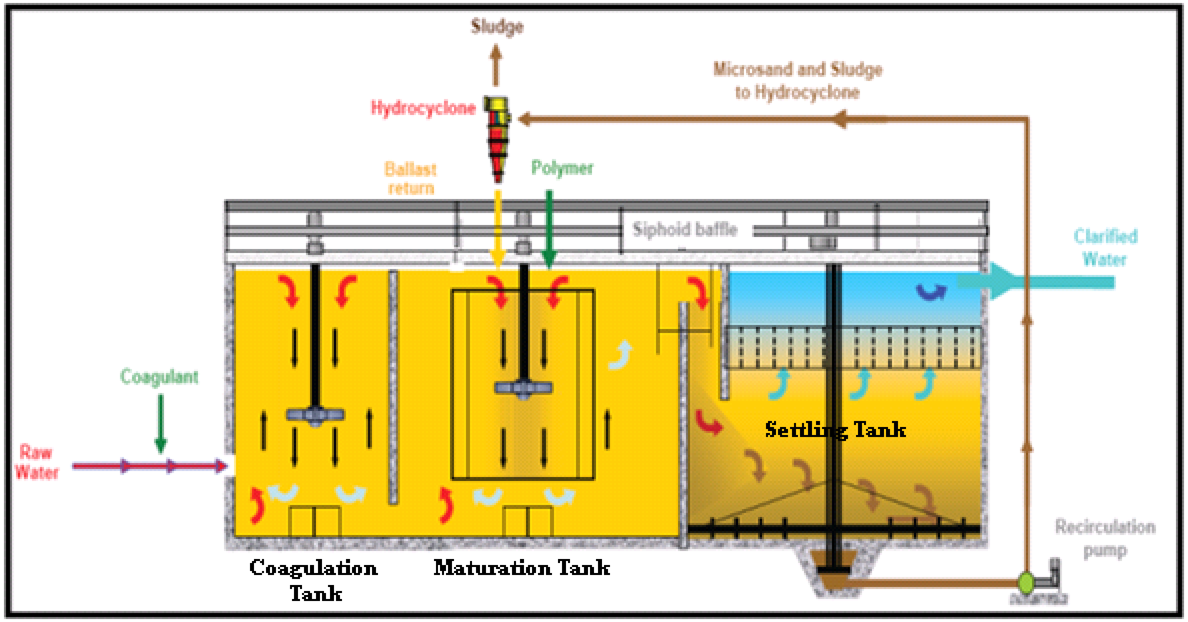


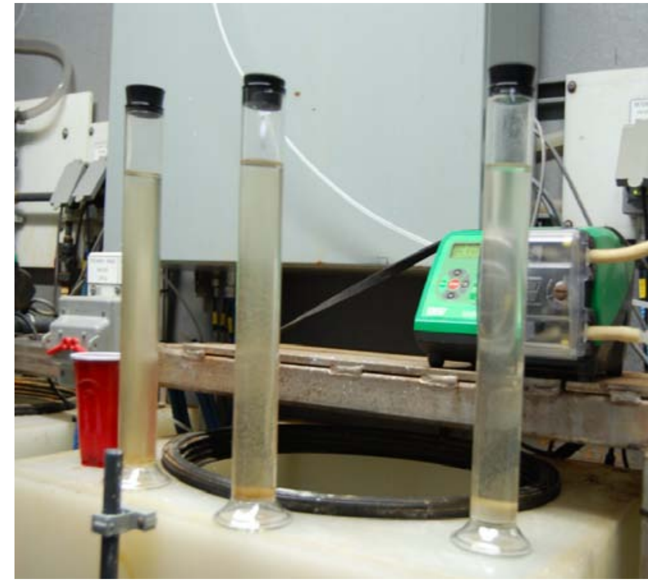
Continuous Operation



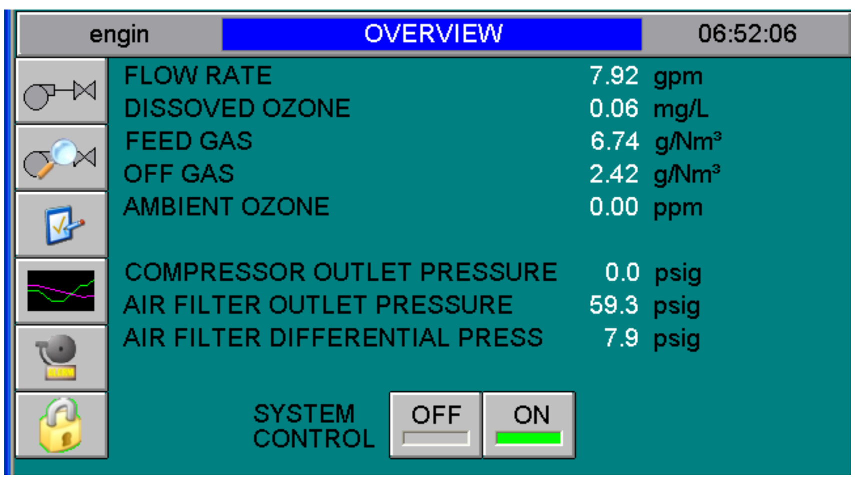
Start-Stop Operation

ACTIFLO® Process

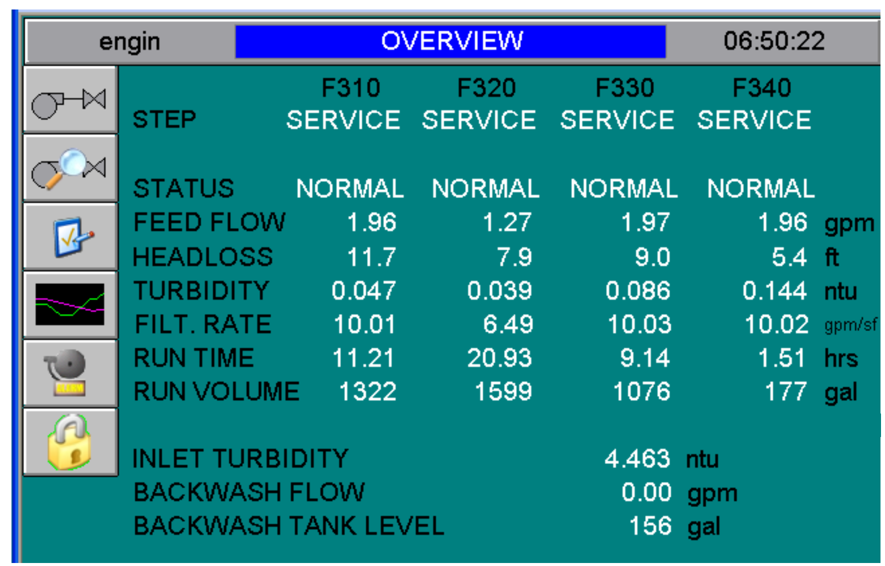




Ozonation Process



Filtration Process



Water Quality and Performance Goals and Benchmarks

Parameter	Location	Goal	Condition
Turbidity	Settled water	0.5-2.0 NTU	95% of time
	Settled water	≤ 5.0 NTU	99% of time
	Individual FE	≤ 0.15 NTU	95% of time
Particle Count	Individual FE	<50 particles/mL, 5 - 15µm range 2.0-log removal, 3 - 5 µm range 2.5-log removal, 5 - 15 µm range	95% of time
TOC	Individual FE	≥ 50% removal	99% of time
MIB/geosmin	Individual FE	≤ 3 ng/L	95% of time
THM	SDS	≤ 0.04 mg/L	
HAA5	SDS	≤ 0.03 mg/L	
Bromate	Filter influent	≤ 0.008 mg/L	
UFRV goals			
Minimum UFRV	Individual Filter	5,000 gal/sf-run	95% of time
Desired UFRV	Individual Filter	10,000 gal/sf-run	

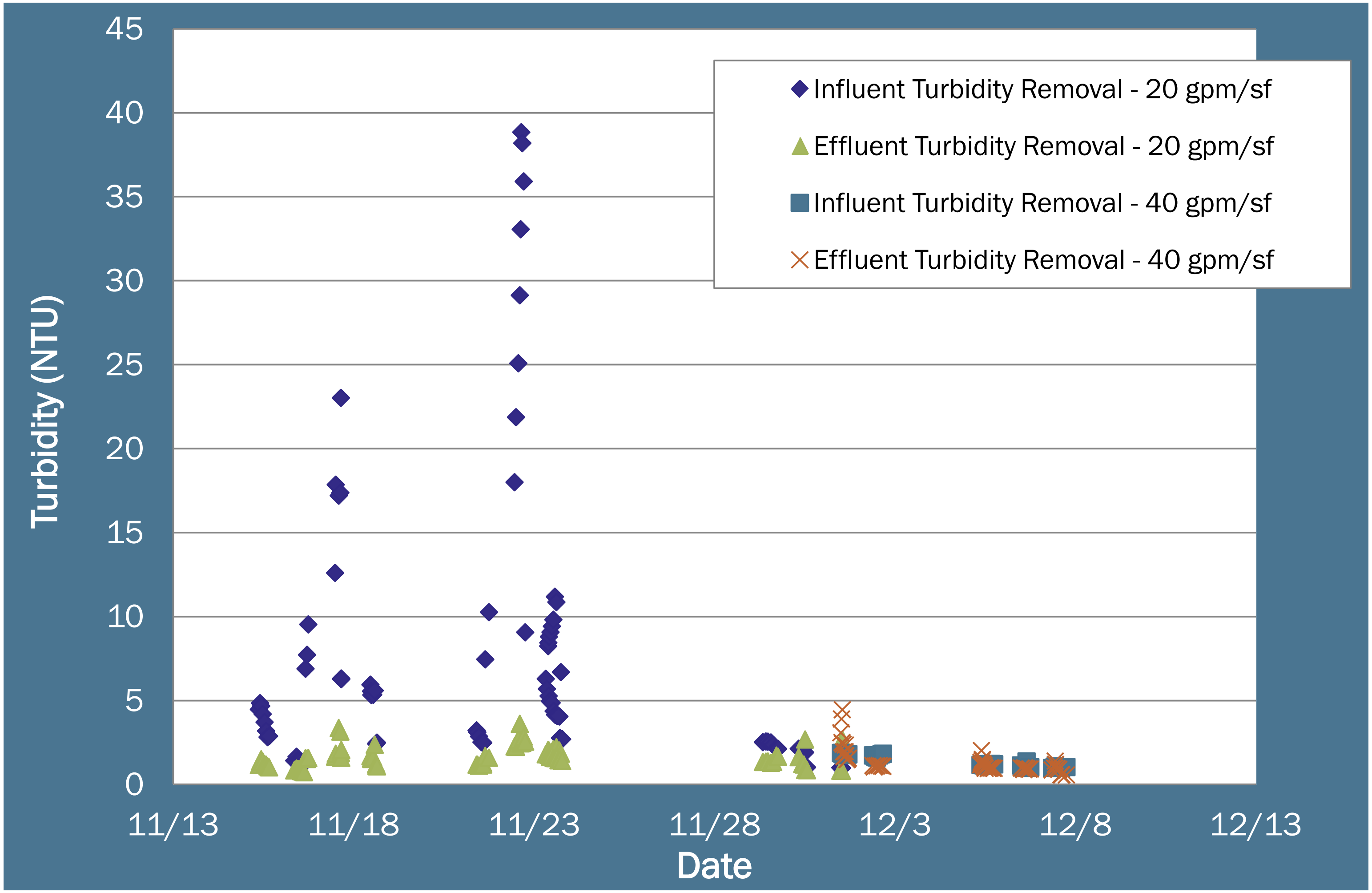
Water Quality Testing

- Continuous
  - Applied Ozone Dose
  - Ozone Offgas Concentration
  - Ozone Residual
  - Flow
  - Headloss
  - Turbidity
  - Particle Counts

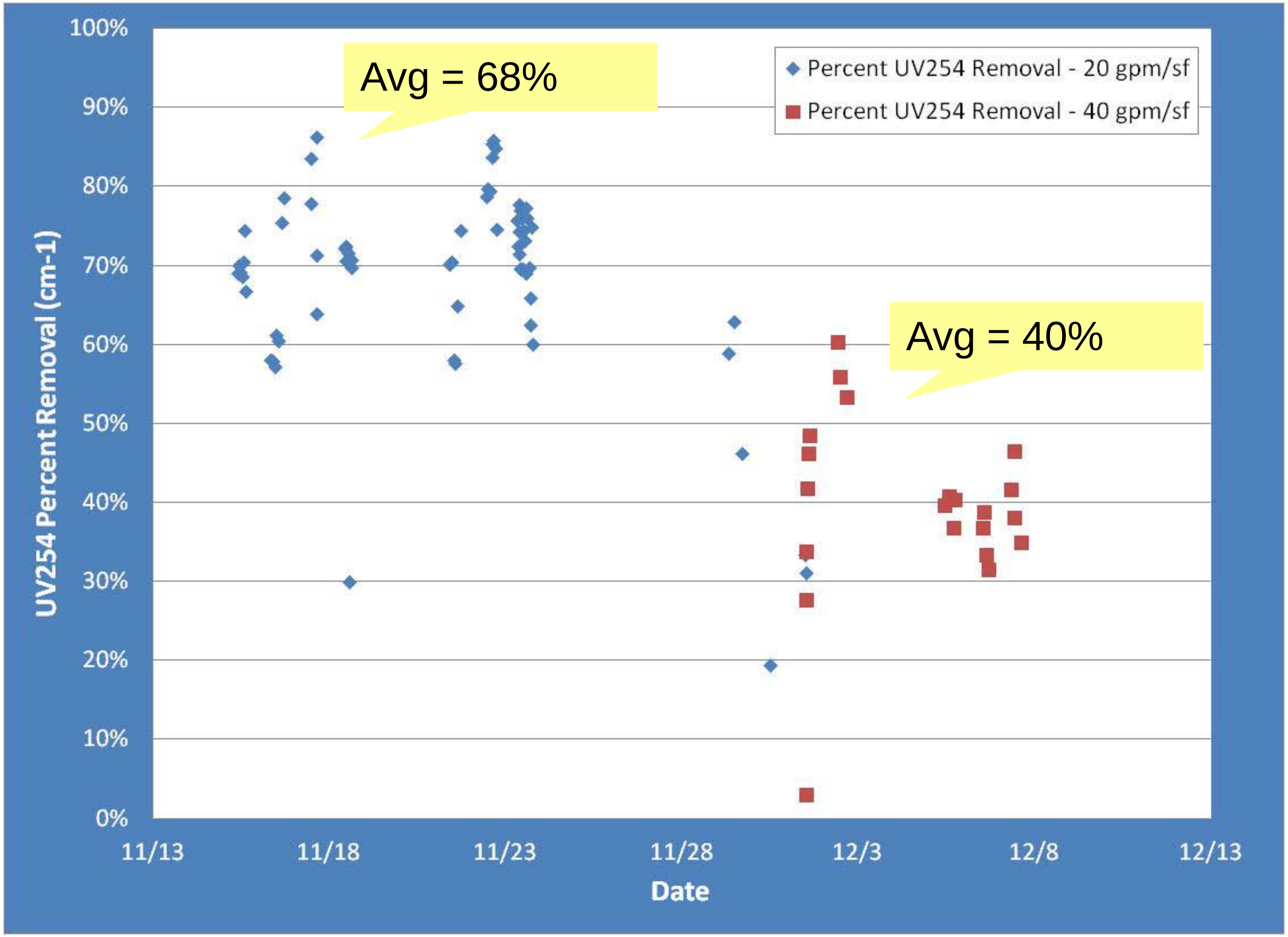
- Comprehensive testing
  - TOC, DOC
  - BDOC and AOC
  - Taste and odor compounds
  - DBP precursors – UV_{254}/SUVA
  - THMs/HAAs
  - Bromide/bromate
  - Nitrate
  - Emerging contaminants

Pilot Study Findings

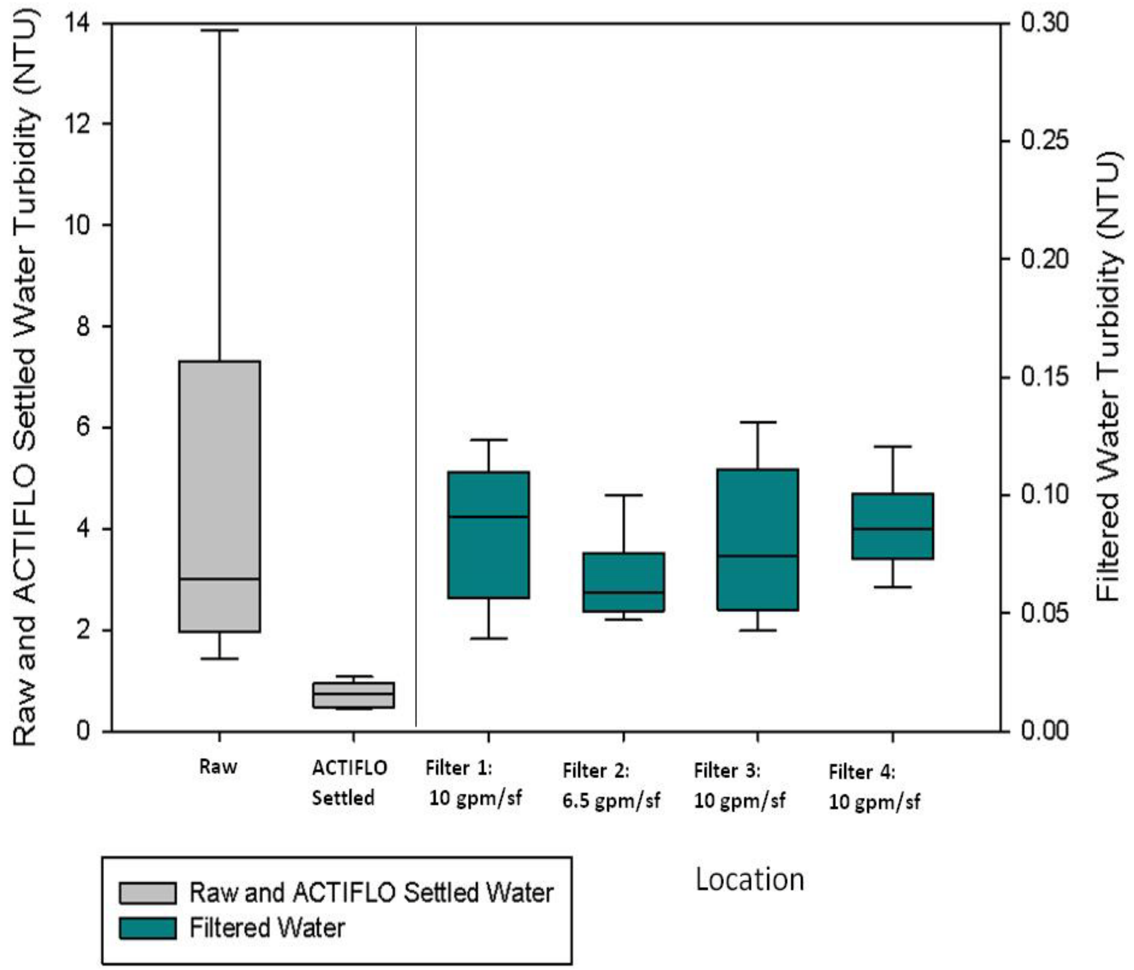
Actiflo® Performed Well Under Turbidity Spikes



ACTIFLO® Performance – Organics Removal



ACTIFLO Effectively Removed Turbidity, No Filter Aid Used

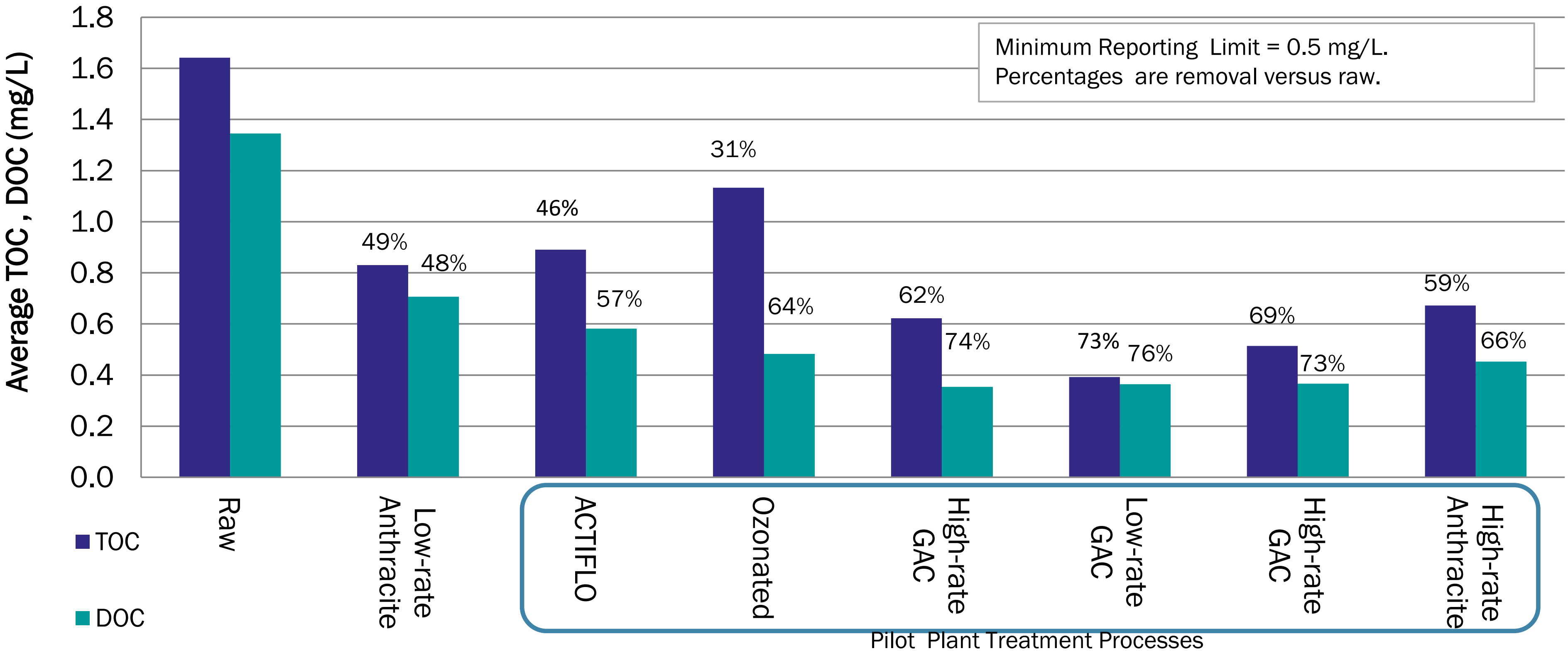


Filter Performance

- GAC filters outperformed anthracite filter
- High filter production efficiency: 97 to 98 percent
- ACTIFLO performance improved productivity

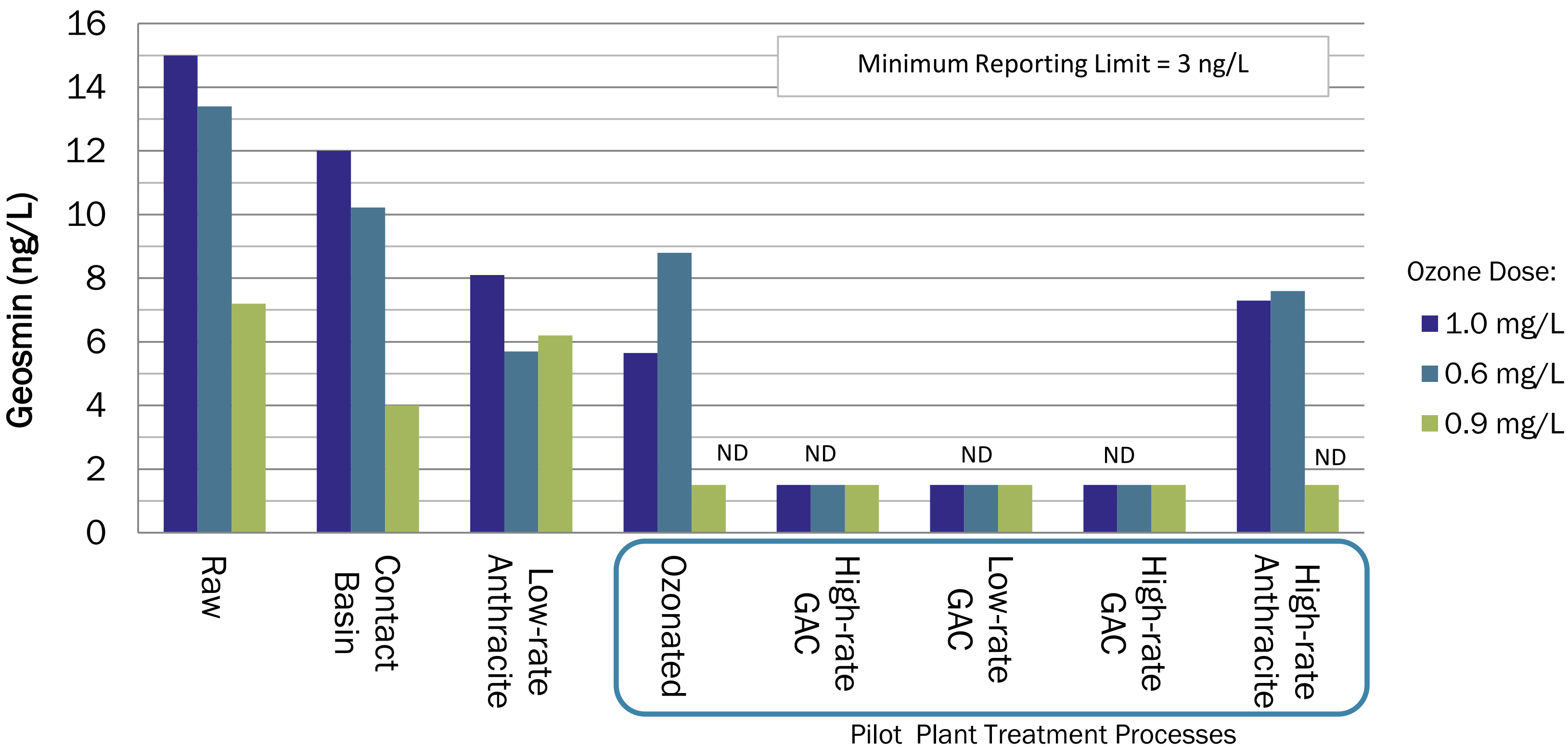
Unit filtration rate (gpm/sf)		Filter 1: High-rate GAC	Filter 2: Low-rate GAC	Filter 3: High-rate GAC	Filter 4: High-rate Anthracite
		10	6.5	10	7.8
Average UFRV (gal/sf-run)	Phase 1: Without ACTIFLO	7,300	6,900	7,000	5,200
	Phase 2: With ACTIFLO	8,900	8,200	6,000	5,200

Phase 2 - Organics Removal During ACTIFLO Operation



Taste and Odor Sampling

- MIB was non-detect for all samples



Bromate Should Not Be a Concern

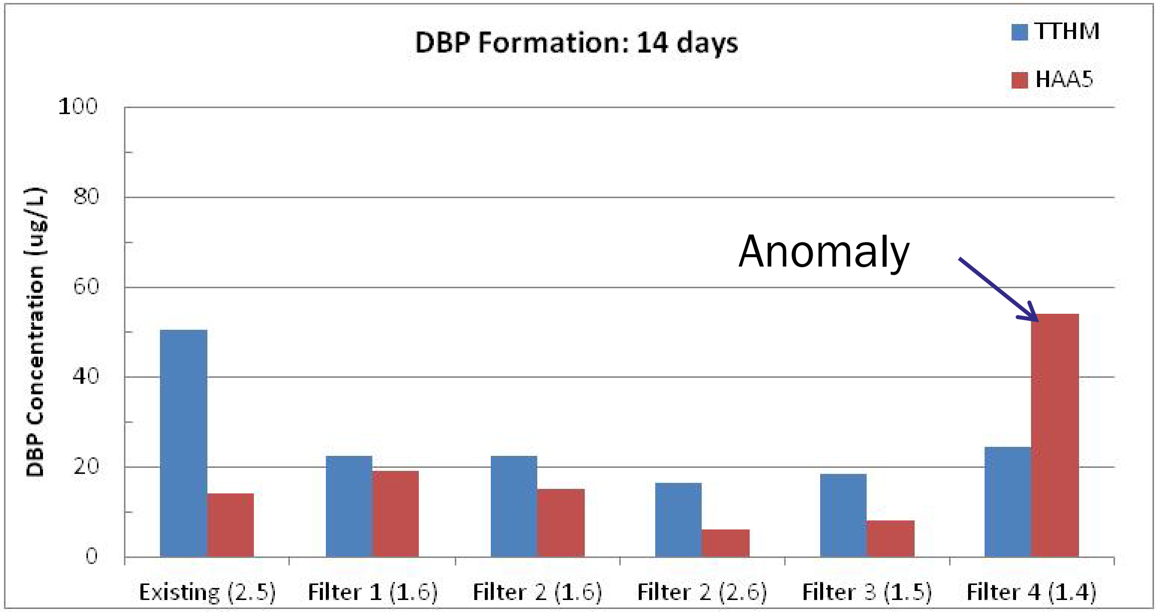
Date	Raw water bromide concentration (ug/L)	Applied ozone dose (mg/L)	Ozonated water bromate concentration (ug/L)
9/27/2011	6	1.0	ND
9/28/2011	5.25	0.6	ND
10/5/2011	8.3	0.9	ND
11/29/2011	ND	1.0	ND

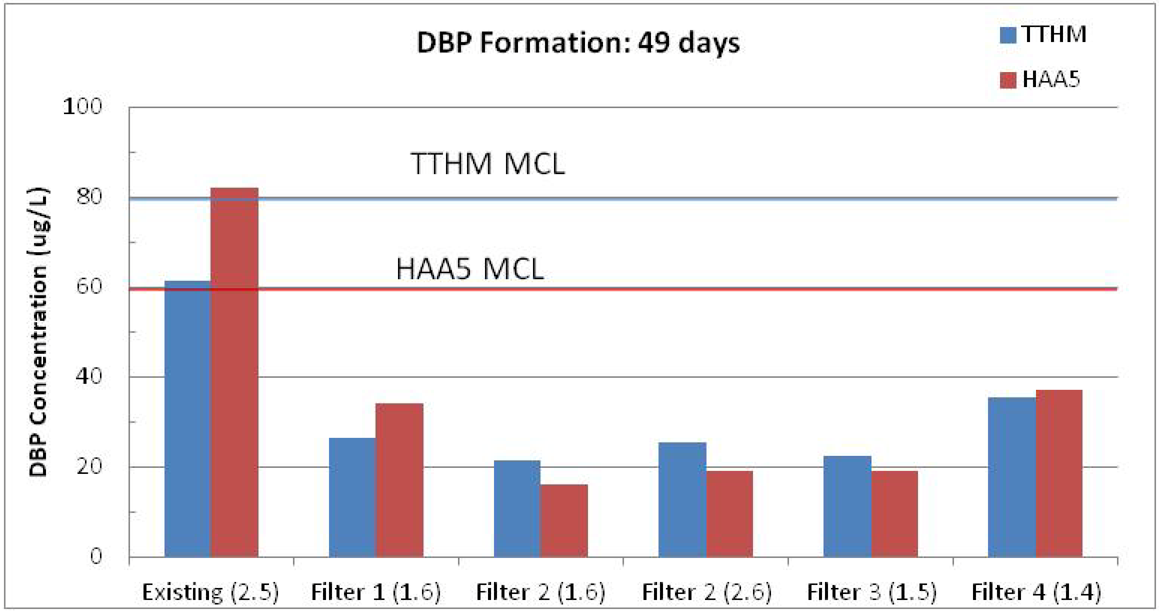
Note: Minimum Reporting Limit = 5 ug/L

Phase 2: Chlorine Residual and DBP Testing

- Samples taken from pilot and existing filters with ACTIFLO
- Dosed with free chlorine in batch reactors
- Samples stored at room temperature
- Measured:
  - Chlorine residual
  - pH
  - Temperature

DBP Testing Results





Recommendations

- Ballasted flocculation:
  - Design for 20 gpm/sf
  - Rated to 40 gpm/sf (one unit out of operation)
- Ozone:
  - HRT = 9 min
  - Design for maximum of 2 mg/L transfer dose
- Filtration:
  - GAC media
  - Design for 6 deep bed media filters – 10 gpm/sf
  - Filter aid necessary, type and dose require further optimization

Conclusions

- Ballasted flocculation, ozonation, and high-rate biological filtration will provide an affordable water treatment process
- Proved high loading rates
- Maintains smaller footprint on existing WTP site
- Provides aesthetic benefits
- Address future regulations

Acknowledgements

- Lake Oswego-Tigard Water Partnership
  - Kari Duncan, Lake Oswego WTP Manager
  - Dave Prock, Lake Oswego –Tigard Water Partnership Deputy Project Manager
  - Lake Oswego WTP Operators
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  - Pete Kreft
  - Jude Grounds
- Brown and Caldwell – Program Manager
  - Bill Persich
  - Nick Wobbrock
  - Melissa Hassler
  - Corianne Hart
- Kruger Operations Staff
- Willamette River WTP Staff

Questions? Comments?

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Mini water plant to test new huge plant

Test machinery will give information to make new plant safe, cost-effective

By CLIFF NEWELL
Staff Reporter

Everyone knows how big the Lake Oswego-Tigard Water Partnership is. Some day it will produce up to 32 million gallons of drinking water a day.

But the project is starting out small. Two key parts of a miniature water plant — ozonation and filtration units — were installed on Sept. 6 at the city of Lake Oswego's water treatment plant in West Linn.

The main reason the little plant is necessary is that the state requires pilot studies.

But the mini water plant will set the stage for the major plant by providing a huge amount of information that will be used to assure that the new operation provides plentiful, safe water in the most cost-effective way.

"Our operators will get invaluable experience," said Lynn

"This won't be like a wrecking ball. It's more like microsurgery. The sequence must be very tight."

— Jane Heisler, on refining the design of an expanded water treatment plant

and see how best to remove taste, odors and contaminants."

The mini plant will treat 250,000 gallons of water a day through March 2012. The new processes for reducing byproducts will be compared to the processes now used at the existing plant.

"We will have seven months to fully understand the water quality characteristics of three seasons,"

...d. "We'll have a report ... spring. It will allow the ...nd plant staffs to under- ... the new plant will

...ER PLANT, page A3

STAFF PHOTO / VERN UYETAKE

Lynn Williams and Tyler McCune show off part of the pilot filtration unit at the West Linn water treatment facility.

Water plant:

Continued from page A1

improve water quality."

Knowledge gained will be money saved. Williams estimates the pilot project will result in the water partnership saving millions of dollars in the future.

Even before the pilot project begins, the city of Lake Oswego is working to get West Linn's Robinwood neighborhood ready for the new water treatment plant. Heading this effort is communications director Jane Heisler, who has jumped from one huge public works project — the Lake Oswego Interceptor

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