# Extended Terminal Subfluidization Wash (ETSW)

*Applications and Lessons-Learned*

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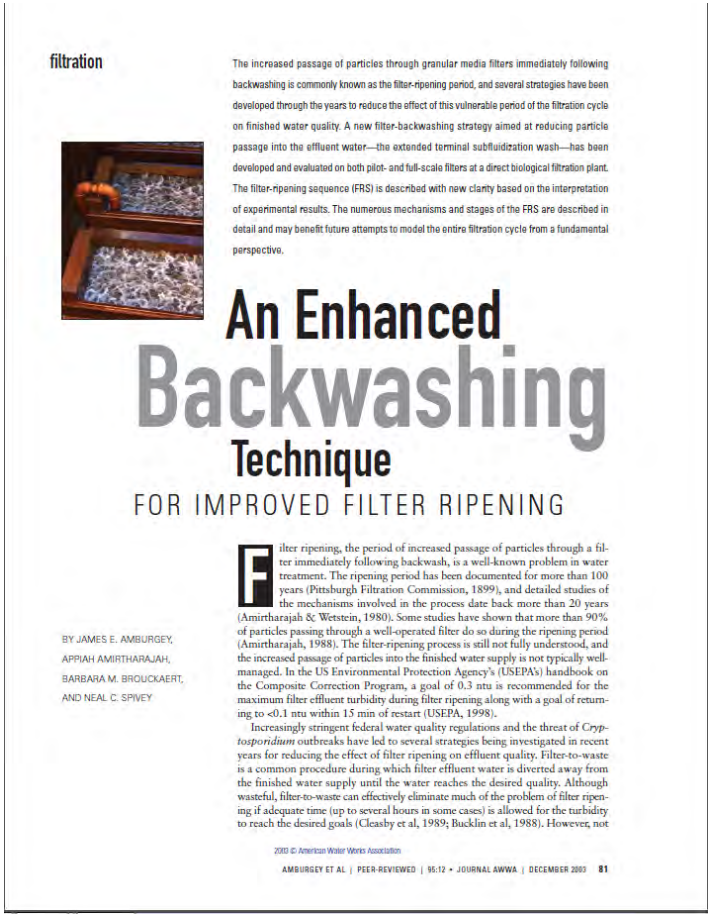
# ETSW Background & Concepts

Why?

- Some studies show that 90% of particles that pass through a well-operated filter do so during the filter ripening period.
- *Area-Wide Optimization Program backwash goal*:
  - Maximum filtered water turbidity following backwash of less than 0.30 NTU
  - Maximum backwash recovery period of 15 minutes (i.e. return to less than 0.10 NTU)

Goal:

- Remove remnant particles following backwash
- Prevent passage into finished water supply



filtration

The increased passage of particles through granular media filters immediately following backwashing is commonly known as the filter-ripening period, and several strategies have been developed through the years to reduce the effect of this vulnerable period of the filtration cycle on finished water quality. A new filter-backwashing strategy aimed at reducing particle passage into the effluent water—the extended terminal subfluidization wash—has been developed and evaluated on both pilot- and full-scale filters at a direct biological filtration plant. The filter-ripening sequence (FRS) is described with new clarity based on the interpretation of experimental results. The numerous mechanisms and stages of the FRS are described in detail and may benefit future attempts to model the entire filtration cycle from a fundamental perspective.

An Enhanced Backwashing Technique

FOR IMPROVED FILTER RIPENING

BY JAMES E. AMBURGEY, APPIAH AMIRTHARAJAH, BARBARA M. BROUCKAERT, AND NEAL C. SPIVEY

Filter ripening, the period of increased passage of particles through a filter immediately following backwash, is a well-known problem in water treatment. The ripening period has been documented for more than 100 years (Pittsburgh Filtration Commission, 1899), and detailed studies of the mechanisms involved in the process date back more than 20 years (Amirtharajah & Wetstein, 1980). Some studies have shown that more than 90% of particles passing through a well-operated filter do so during the ripening period (Amirtharajah, 1988). The filter-ripening process is still not fully understood, and the increased passage of particles into the finished water supply is not typically well-managed. In the US Environmental Protection Agency's (USEPA's) handbook on the Composite Correction Program, a goal of 0.3 ntu is recommended for the maximum filter effluent turbidity during filter ripening along with a goal of returning to <0.1 ntu within 15 min of restart (USEPA, 1998).

Increasingly stringent federal water quality regulations and the threat of *Cryptosporidium* outbreaks have led to several strategies being investigated in recent years for reducing the effect of filter ripening on effluent quality. Filter-to-waste is a common procedure during which filter effluent water is diverted away from the finished water supply until the water reaches the desired quality. Although wasteful, filter-to-waste can effectively eliminate much of the problem of filter ripening if adequate time (up to several hours in some cases) is allowed for the turbidity to reach the desired goals (Cleasby et al, 1989; Bucklin et al, 1988). However, not

# ETSW Background & Concepts

How?

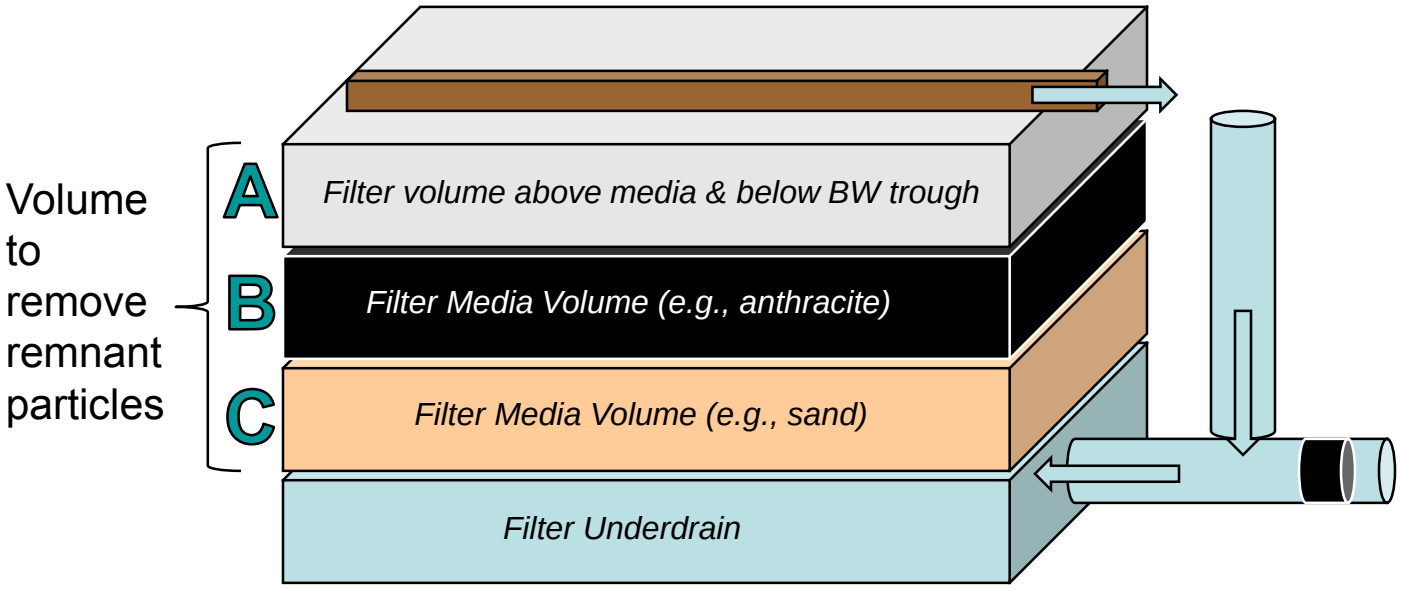
- ETSW is an extension of the normal backwash duration
- Subfluidization flow rate
- Duration sufficient to move one theoretical filter volume through filter box

# ETSW Background & Concepts

Theory:

- Incremental decrease in backwash rate allows bed to settle more slowly (fewer remnant particles dislodged)
- Media restratification – more smaller grains to the top of the bed, creating a lower porosity layer
- Most of the dislodged remnant particles removed from the filter at the low flow rate

# ETSW Measurements & Calculations




**At what flow rate?**

3 to 6 gpm/ft$^2$ (for minimal media expansion)

**How long?**

Time to replace ~ 1 bed volume of A + B + C

# *Alabama DEM Case Study*

*Courtesy of William McClimans, ADEM*

## Original Backwash Sequence:

- Air only (2 minutes)
- Air / low wash at 5 gpm/sq ft (45 seconds)
- High wash at 18.5 gpm/sq ft (160 seconds)
- 2nd low wash at 5 gpm/sq ft (165 seconds)

- Filter 1 was selected to be the test filter while maintaining Filters 2 and 3 as control filters. This changed throughout the pilot.

## 1st ETSW Iteration:

- Kept waste valve open
- Washed filter for an additional 465 seconds
- Closed valve and filled filter as before

| Stage / Data | Before | After |
|---|---|---|
| Backwash | • 10,800 gallons used<br>• 9 minutes | • 15,750 gallons used<br>• 18 minutes |
| Rewash: | • 22,680 gallons used<br>• 60 minutes | • 11,340 gallons used<br>• 30 minutes |
| Turbidity spike | • 0.25 NTU after rewash | • Spike was reduced to a few minutes, all during rewash. No post-rewash spike. |
| Total | • 33,500 gallons used<br>• 75 minutes | • 27,000 gallons used<br>• 60 minutes |

## 2nd ETSW Iteration:

- Changed rewash rate on Filter #2 from 3 gpm/ft$^2$ to 2 gpm/ft$^2$ to match permitted filtration rate.
- Filter #3 is now the control filter.

| Stage / Data | Before | After |
|---|---|---|
| Backwash | • 10,800 gallons used<br>• 9 minutes | • 10,800 gallons used<br>• 9 minutes |
| Rewash: | • 22,680 gallons used<br>• 60 minutes | • 15,120 gallons used<br>• 60 minutes |
| Turbidity spike | • 0.25 NTU after rewash | • 0.45 NTU during rewash. No spike after rewash. |
| Total | • 33,500 gallons used<br>• 75 minutes | • 26,000 gallons used<br>• 75 minutes |

## 3rd ETSW Iteration:

- Changed rewash rate on Filter #1 from 3 gpm/ft$^2$ to 2 gpm/ft$^2$ to match permitted filtration rate.
- Filter #3 is now the control filter.

| Stage / Data | Before | After |
|---|---|---|
| Backwash | • 10,800 gallons used<br>• 9 minutes | • 15,750 gallons used<br>• 18 minutes |
| Rewash: | • 22,680 gallons used<br>• 60 minutes | • 3,200 gallons used<br>• 13 minutes |
| Turbidity spike | • 0.25 NTU after rewash | • None – highest turbidity at start of rewash. |
| Total | • 33,500 gallons used<br>• 75 minutes | • 18,000 gallons used<br>• 32 minutes |

## Summary:

- The WTP is saving approximately 15,000 gallons of water per backwash
- Filters returned to service in less than 15 minutes (0.10 NTU)
- ETSW can be fairly simple to implement, but filter backwash controllability needs to be assessed first.
- Potential ETSW benefits include improved filter performance, shorter FTW time, reduction or elimination of rewash turbidity spike, and water savings.
- Alabama has implemented ETSW at 15 water treatment plants, totaling approximately 600 MG/yr water savings.

## Implementation issues:

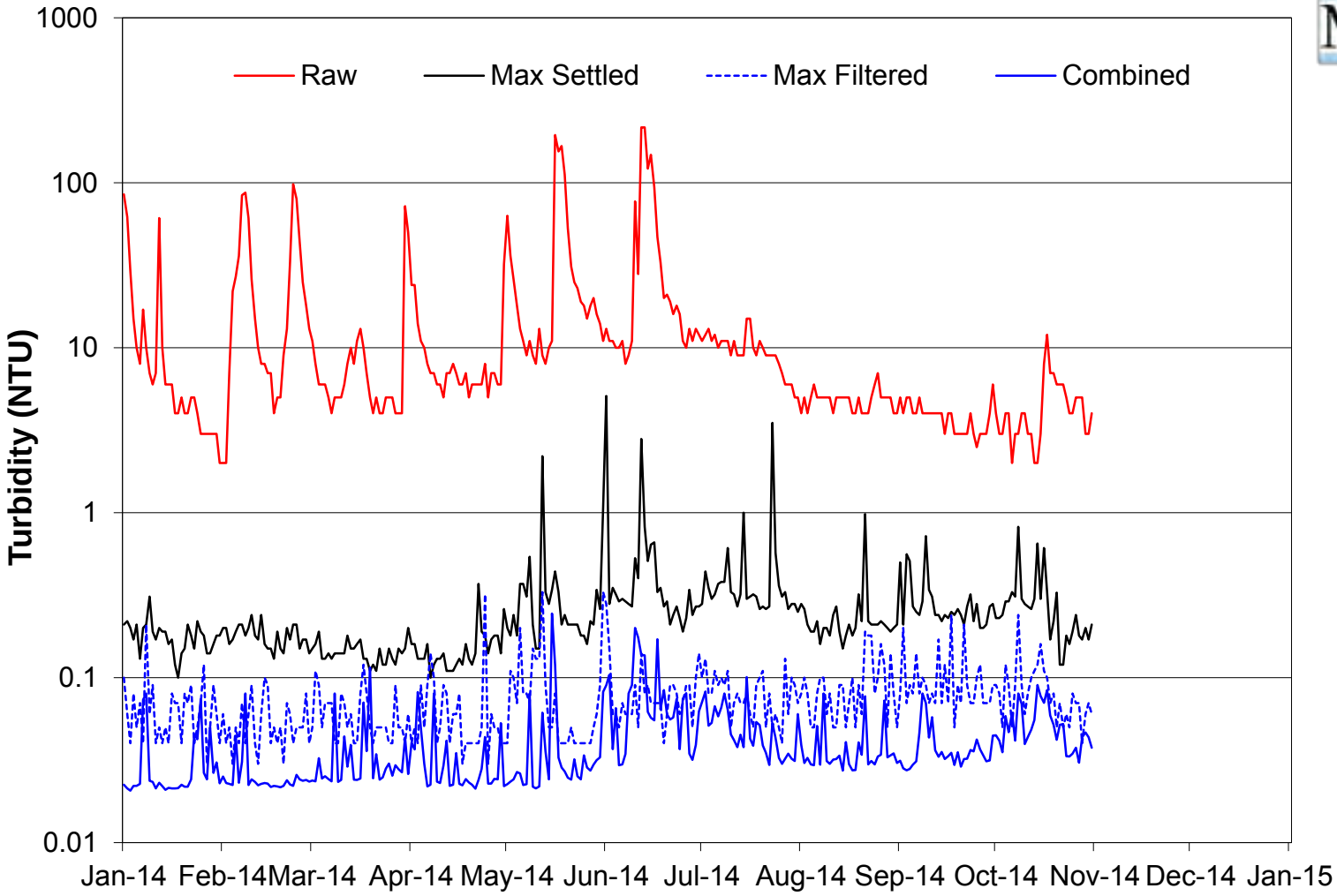
- Backwash pump must be capable of backwashing at low flow rates
- Must be able to adequately control flow rate
    - Controllable valve
    - Backwash flow meter
    - Able to see valve setting
- Some WTPs may have design issues with full implementation of ETSW due to pipe sizes

# *Maryland Department of the Environment Case Study*

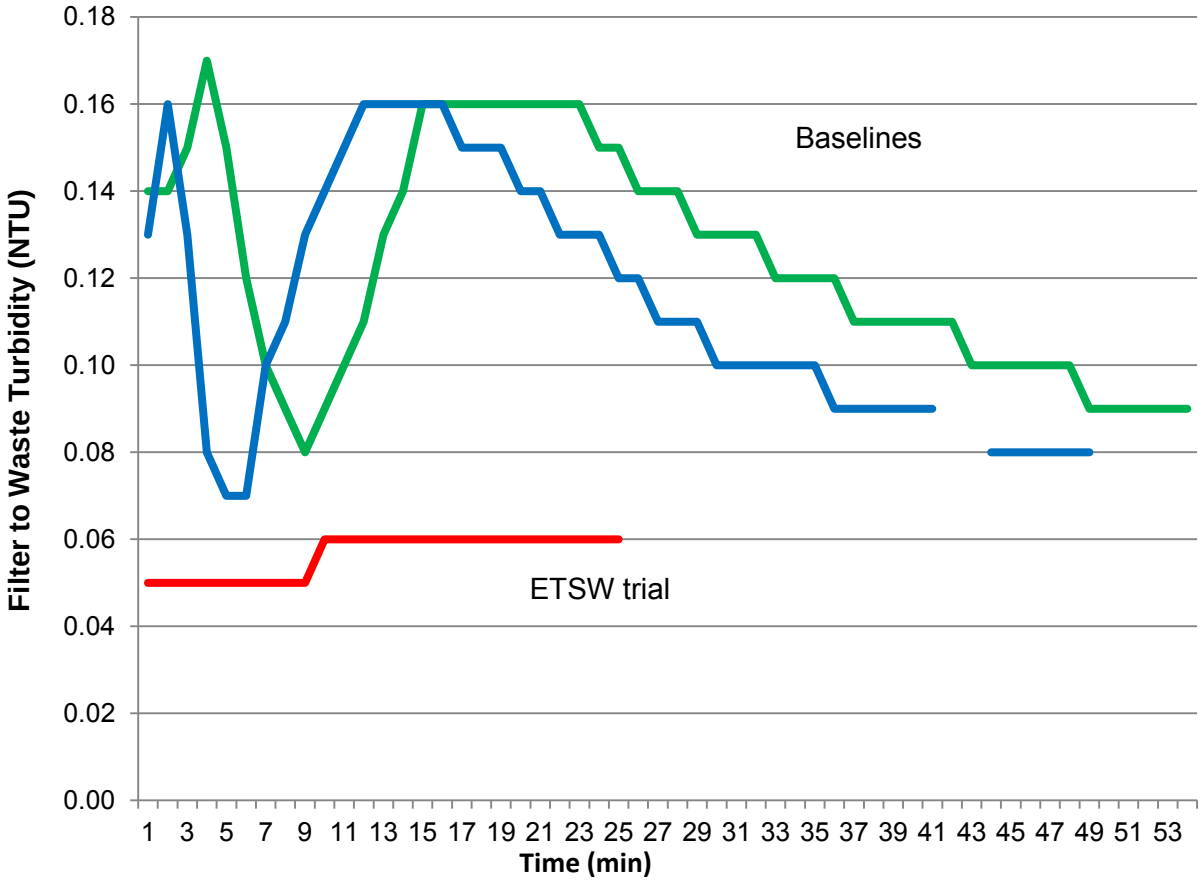
*Courtesy of Zoë Goodson, MDE*

# ETSW trial at new plant design

- Conventional plant, new in 2010
  - 6 filters, use filter-to-waste
- Some room for filter optimization, but pretty good turbidity numbers from monthly operating reports
  - Most spikes do occur immediately after backwash
- Added ETSW step at 3 gpm/sq ft, 22 min for ETSW removal of 31,119 gallons (one filter bed volume)


1000
100
10
1
0.1
0.01
Turbidity (NTU)
Raw
Max Settled
Max Filtered
Combined
Jan-14
Feb-14
Mar-14
Apr-14
May-14
Jun-14
Jul-14
Aug-14
Sep-14
Oct-14
Nov-14
Dec-14
Jan-15

## Filter turbidities during filter to waste at New Design after typical backwashes and ETSW trial backwash



# Operator's Response to ETSW:

- Impressed at how much cleaner the filter got during ETSW step compared to their typical step (low/high/low vs. low/high/ETSW)
- One operator said he had been skeptical as to how much difference there could be, but after trial "this will be our new normal"

# ETSW Benefits

| | Baseline BW | BW with ETSW added |
|---|---|---|
| Turbidity spike after return-to-service (NTU) | 0.16 | 0.06 |
| Backwash water used (gallons) | 80,600 | 90,119 |
| Time for backwash (min) | 19 | 32 |
| Filter-to-waste water used | 51,240 | 0 |
| Time for filter-to-waste (min) | 42 | 0 |
| Total water used (BW & FTW) | 161,840 | 90,119 |
| Total time (BW & FTW) | 61 | 32 |

# Case Study

*Mandy Smith*
*Connecticut Department of Health*
*Sanitary Engineer 3*

# CT DPH
# ETSW TRIAL

## 2015

Technical Review and Field Assessment Unit
Drinking Water Section
Connecticut Department of Public Health

# Bristol WTP

- 12 MGD Conventional Treatment
- 4 multimedia Filters @ 5 gpm/ft2
- No filter to waste practiced
- Raw water turbidity of 1.2-1.5 NTU

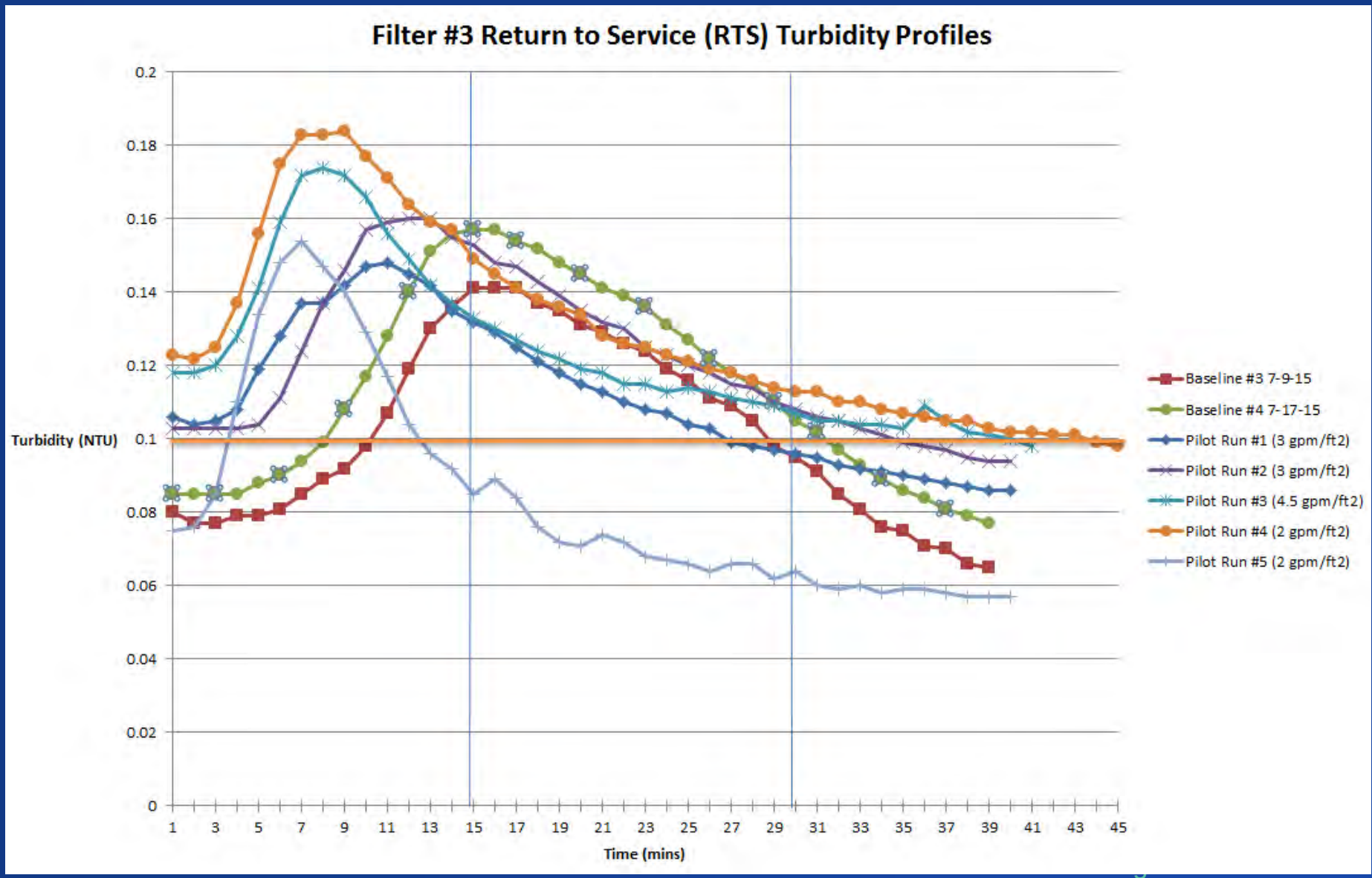
# Baseline BW Operations

| | | |
|---|---|---|
| Surface Wash | 5 minutes | (overlaps with low wash) |
| Low Wash | 2 minutes | @ 3.5 MGD or 6.0 gpm/ft2 |
| High Wash | 10 minutes | @ 8.0 MGD or 13.5 gpm/ft2 |
| Low Wash | 2 minutes | @ 4.0 MGD or 6.7 gpm/ft2 |
| Totals | 17 minutes | ~53,000 gallons |

# ETSW Strategy

- Winter and Summer Pilot Studies
- Replace final low wash with ETSW wash at lower rates until one filter bed volume (approximately 23,000 gallons) has been removed.
- Trial Rates/duration
  - 2 gpm/ft2 for 28 minutes
  - 3 gpm/ft2 for 19 minutes
  - 4.5 gpm/ft2 for 12 minutes

# Summer ETSW Pilot Data



# Summer Pilot Study

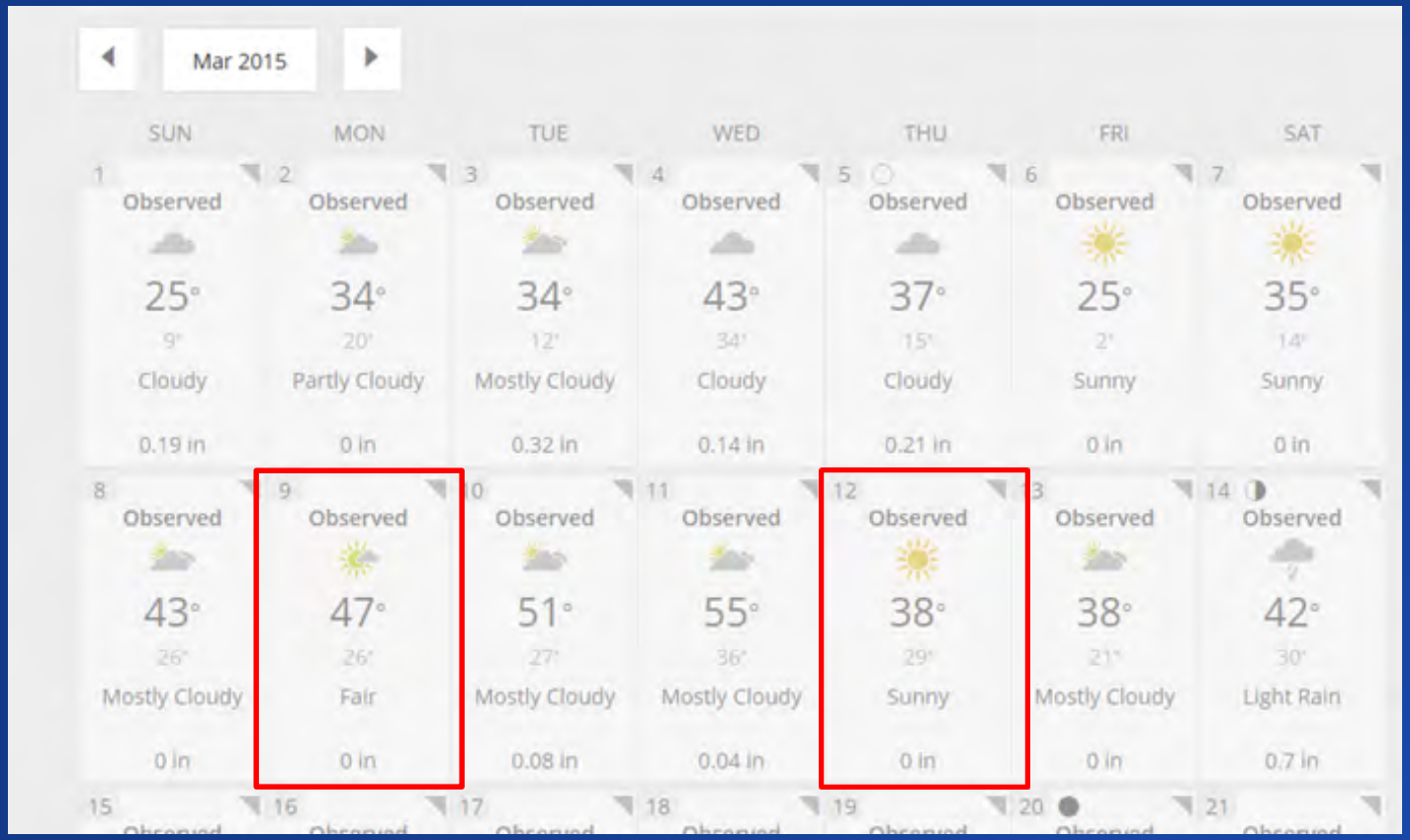
| | Baseline BW | BW with ETSW added |
|---|---|---|
| Turbidity Spike after return to service (NTU) | 0.15 | 0.15-0.18 |
| Backwash water used (gallons) | 53,000 | 80,000 |
| Time for Backwash (min.) | 17 | 27-43 |
| Time to Get Under 0.1 NTU (min.) | 30 | 13-40 |
| | | |

# Pilot Study Variables

- Pilot study was conducted operating bw in manual mode vs. by SCADA
- Spray down the walls at different point
- Average filter turbidities slowly rose during course of summer pilot study
- Alum dosage was changed prior to last pilot test run

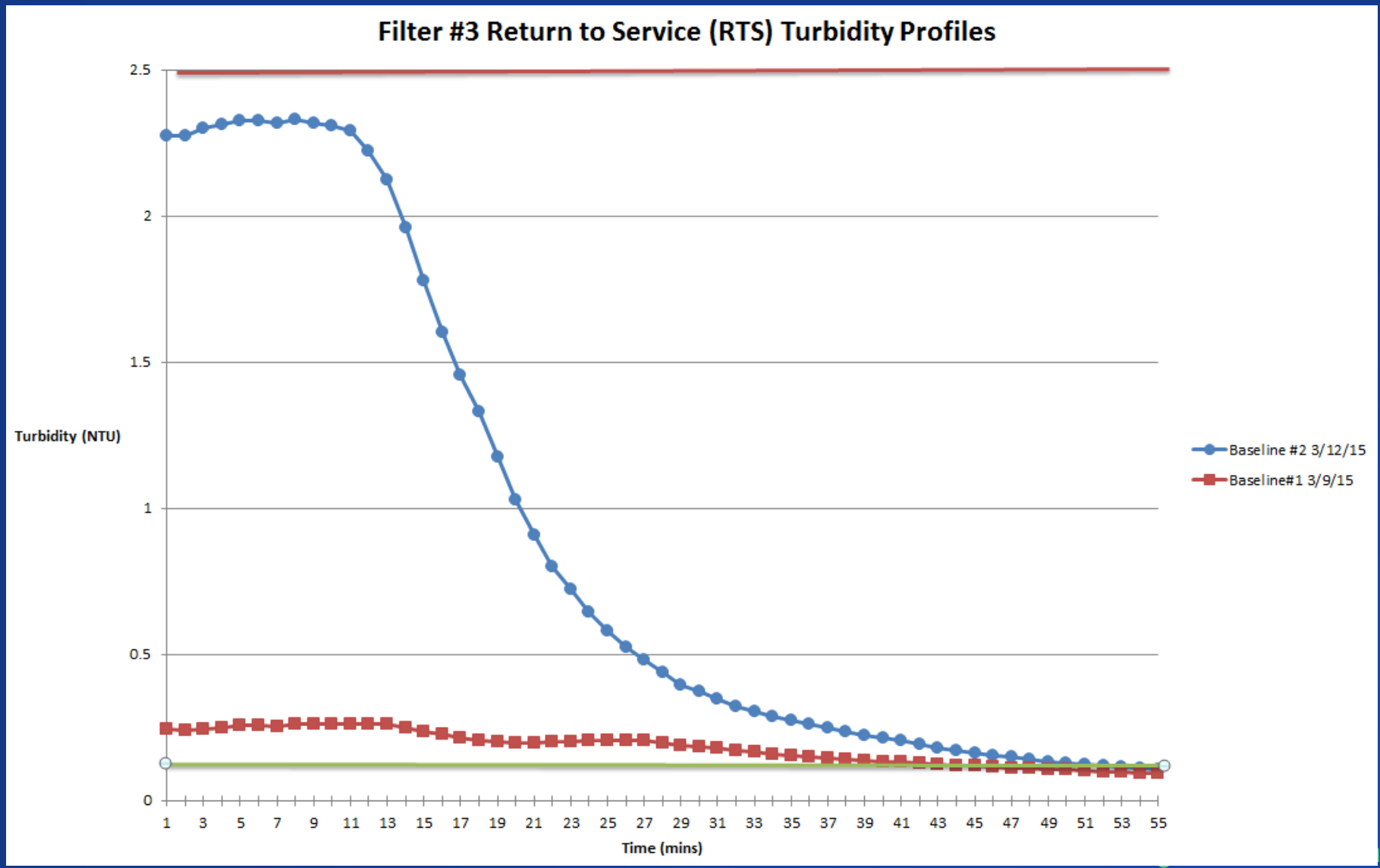
# Winter Pilot Study

- Coldest February on Record in Hartford daily average of 16.1° F



# Winter Pilot Study

- Baseline Problems:



# Stop the Study!

- Take Filter #3 offline immediately
- Begin Troubleshooting:
- Filter #3 turbidimeter readings from pipe gallery did not match SCADA computer in control room – Data Capped at 1NTU
- Started to see elevated turbidities in other filters during BW
- Look at backwash pipe manifold and twin 100,000 gallon backwash tanks – what's that noise?

# What Happened?

- 2’ thick ice layer formed in backwash tanks due to cold temperatures
- Quick thaw caused the ice layer to break away from tank sidewalls and was scraping the sides of the backwash tanks, essentially washing the filters with turbid water
- Last backwash tank inspection about 5 years old
- Previous optimization activities doubled filter run times from 32 hours to 64 hours

# Winter Follow Up

- Modified backwash protocol utilizing wet well supply until each backwash tank was isolated, drained, rid of ice and power washed
- Corrected SCADA data capping issue
- Warmer temps led into the Summer Pilot Study, will try to conduct Winter Pilot Study again this winter
- Also working on summer and winter backwash turbidity profile

# Lessons Learned

- This Pilot Study left us with more questions than answers
- Current low wash is already near the ETSW range
- As background turbidities rose, pilot runs were worse – coincidence?
- Conduct 2 trials at each rate good idea
- One study can lead to another!

# Thank You!

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