MONITORING OF TURBIDITY AND MODELING OF TURBIDITY RESUSPENSION IN A DRINKING WATER DISTRIBUTION SYSTEM

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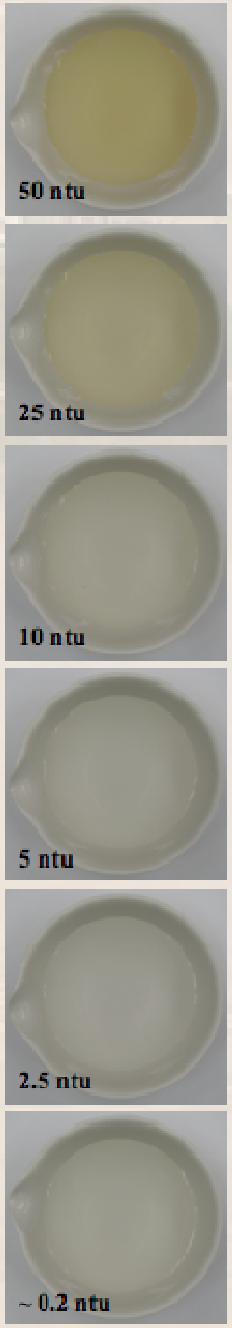
Project Objectives

- Improve the model developed by Holzem (2008) to better represent the entire distribution system to assist the utility in predicting when flushing is required.
- Determine the influence of velocity in creating a discolored water event.



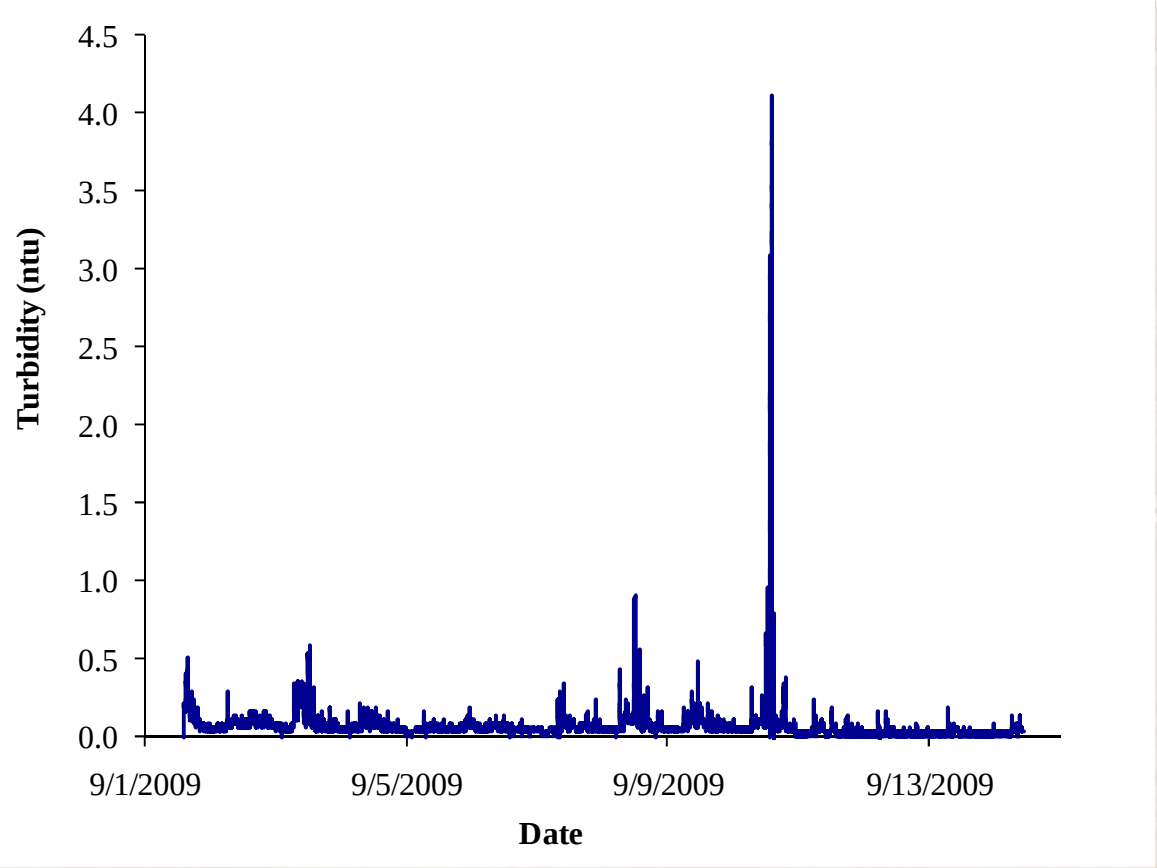
Turbidity

- A measure of the white light scattered at a 90° angle by particles in a sample, relative to the amount of light scattered by a reference suspension.
- Units of NTU (Nephelometric Turbidity Units)

Influence of System Operations on Customer Tap Turbidity

Site Address:	Dates of Operation:
2926 Atwood Ave (Birrenkott's)	6/23/08 - 2/25/09
613 Hilltop Dr.	4/13/09 - 4/23/09
4237 Mandrake Rd.	5/29/09 - 6/25/09
42 Walter St.	6/25/09 - 7/10/09
4003 Hammersley Ave.	7/10/09 - 7/24/09
5217 Hammersley Rd.	7/25/09 - 8/12/09
4812 Spaanem Ave.	8/12/09 - 8/17/09
10 Schlough Ct.	8/17/09 - 8/24/09
5021 Tomahawk Trl.	8/25/09 - 8/31/09
1150 Emerald St.	9/1/09 - 9/14/09
524 Evergreen Ave.	9/14/09 - 10/5/09
2113 Oakridge Ave	10/5/09 - 10/11/09
513 Riverside Drive	10/12/09 - 10/26/09
Unit Well 7 (Sherman Ave)	11/2/09 - 2/17/10

Influence of System Operations on Customer Tap Turbidity



Typical online turbidity profile: Turbidity at 1150 Emerald Ave. from September 1 – September 14, 2009.

Influence of System Operations on Customer Tap Turbidity

Probability of a flushing causing a turbidity spike.

Hydraulic Distance to Event (ft):	Total Flush Runs:	Percentage of flushing runs that produced the spike magnitude shown (ntu):		
		> 2.5	1.0 - 2.5	Total > 1.0
0	10	60%	20%	80%
0 - 1,000	30	0%	0%	0%
1,000 - 5,000	159	< 1%	3%	3%
5,000 - 10,000	59	3%	2%	5%

Probability of a main break causing a turbidity spike.

Hydraulic Distance to Event (ft):	Total Main Breaks:	Percentage of flushing runs that produced the spike magnitude shown (ntu):		
		> 2.5	1.0 - 2.5	Total > 1.0
1,000 - 5,000	5	40%	0%	40%
5,000 - 10,000	17	18%	6%	24%

Influence of System Operations on Customer Tap Turbidity

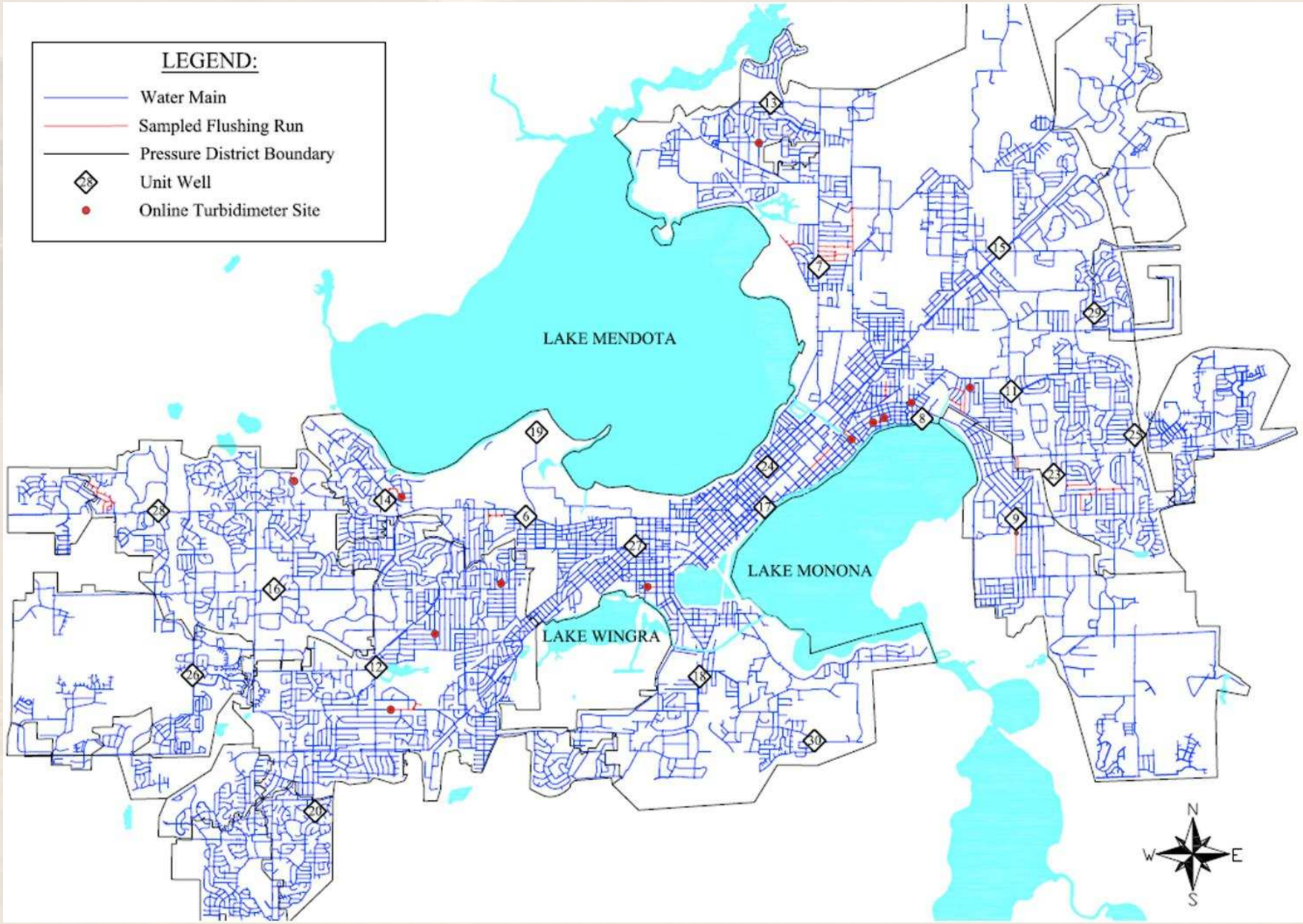
Percentage of complaints associated with a turbidity spike.

Hydraulic Distance to Event (ft):	Total Complaints:	Percentage of flushing runs that produced the spike magnitude shown (ntu):		
		> 2.5	1.0 - 2.5	Total > 1.0
0 - 2,500	20	35%	5%	40%
2,500 - 5,000	19	42%	0%	42%
5,000 - 10,000	39	36%	5%	41%

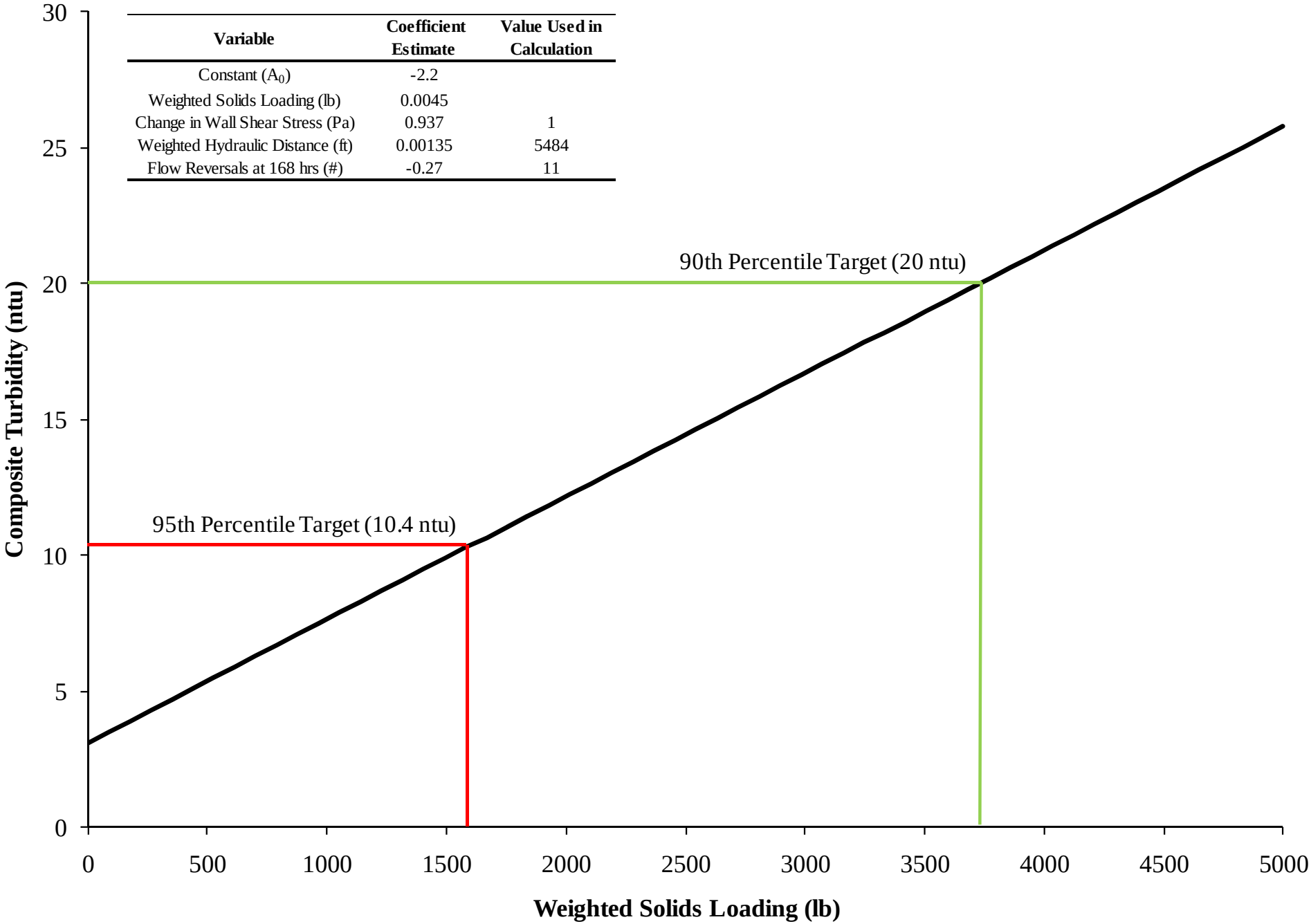
Influence of Flushing Velocity on Turbidity Resuspension

Sampling Technique:

- Flushed in 4 velocity stages: (1.4, 3.0, 4.5 ft/s, full open)
- Turbidity (every 30 – 60 seconds)


LEGEND:
Water Main
Sampled Flushing Run
Pressure District Boundary
Unit Well
Online Turbidimeter Site
LAKE MENDOTA
LAKE MONONA
LAKE WINGRA
N
W
E
S

Variable	Coefficient Estimate	Value Used in Calculation
Constant (A_0)	-2.2	
Weighted Solids Loading (lb)	0.0045	
Change in Wall Shear Stress (Pa)	0.937	1
Weighted Hydraulic Distance (ft)	0.00135	5484
Flow Reversals at 168 hrs (#)	-0.27	11



Flushing Frequency

Pumping volume (millions of gallons) to meet solids loading targets by unit well for a change in velocity of 1.5 ft/s

Unit Well:	95th Percentile	90th Percentile	2009 Annual Pumpage
Unit Well 6	14,200	29,500	193
Unit Well 7	310	640	193
Unit Well 8	150	360	43
Unit Well 9	116,000	206,600	486
Unit Well 11	23,100	49,500	433
Unit Well 12	52,300	111,900	453
Unit Well 13	1,700	3,900	665
Unit Well 14	81,000	197,800	716
Unit Well 15	4,500	9,500	552
Unit Well 16	22,200	54,400	303
Unit Well 17	870	2,000	225
Unit Well 18	3,200	9,000	307
Unit Well 19	560	1,100	431
Unit Well 20	47,900	129,400	451
Unit Well 23	1,100	1,900	214
Unit Well 24	730	1,400	454
Unit Well 25	2,900	6,000	568
Unit Well 26	1,200	3,100	974
Unit Well 27	720	1,500	398
Unit Well 28	470	1,200	132
Unit Well 29	9,000	17,200	334
Unit Well 30	360	900	644

Conclusions

- The analysis of turbidity spike events and customer complaints support using a customer turbidity target of 2.5 ntu.
- The Turbidity Resuspension Model may be used to prioritize when to flush each area to avoid discoloration due to a velocity event of various magnitudes.

Recommendations

- The monitoring of online turbidity within the distribution system should continue to help quantify the turbidity at a customer's tap due to hydraulic disturbances within the distribution system.
  - Areas with high main break rates
  - Multiple turbidimeters to quantify the size of an event

- The MWU should flush each unit well before it meets the volume targets outlined in the flushing frequency table to avoid customer complaints.


Questions