Hydraulic Modeling Assisting in Water Quality

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PENNSYLVANIA AMERICAN WATER
WHO WE ARE

We are the largest and most geographically diverse publicly traded water and wastewater service provider in the United States.

- We serve a broad national footprint and a strong local presence.
- We provide services to approximately 15 million people in 46 states and Ontario, Canada.
- We employ 6,900 dedicated and active employees and support ongoing community support and corporate responsibility.
- We treat and deliver more than one billion gallons of water daily.
OUR SERVICE AREA

WE SERVE

• Approx. 2.4 million people in 36 counties (19% of the population)
• 658,000 water customers
• 65,000 wastewater customers

TRANSMISSION & STORAGE

• 11,054 miles of water and sewer pipe
• 256 water storage facilities
• 359 water and wastewater pumping stations
Uses of Hydraulic Modeling

- Capital Planning
- Design
- Assist Operation
- Assist Water Quality
  - Water age
  - Chlorine residual
  - Disinfection byproduct
  - Flushing (unidirectional flushing plan, flushing location)
  - Trace study (multiple sources)
Case 1 – Water Age Simulation

SYSTEM SCHEMATIC
Planning Engineering

0.4 miles

WTP

High Service HS

Main Service HS

GROUND STORAGE
1.7 MG

GW STATION 1

GW STATION 2

MAIN GRADIENT

HIGH SERVICE GRADIENT

1.0 MG

STORAGE

3RD GRADIENT

Inlet PSV

Tank BPS

BPS

GW STATION 1

GW STATION 2

Tank BPS (Typically Used for MDD)
Case 1 – Water Age Reduction

- 3rd Gradient Optimization
  - Change tank operation level (51 feet in height)
  - Mixer
Case 1 – Water Age Simulation

Challenges:
- High demand in HS Gradient
- Plant prefers stable output
- Multiple sources in MS Gradient
Case 1 – Water Age Reduction

- HS Gradient Optimization
  - HS Elevated Tank operating level (30 feet in height)
  - Fill at night with MAIN TANK BPS

Graphs showing level fluctuations over time.
Case 1 – Water Age Reduction

- MS Gradient Optimization
  - MS Ground Tank operating level (80 ft in height)
  - Fill during daytime
Water Age – How Short is Good

Loss of Chlorine = Chlorine Decay Rate * Time (Water Age)

Chlorine decay rate = bulk liquid phase and liquid–pipe wall.

Many factors that impact chlorine decay rate
  • Rate changes constantly due to temperature, pH, constituents in water, mixing sources
  • Chloramines vs. Cl\textsubscript{2}
  • Nitrification?
Water Age – How Short is Good

• Water Age Management Solution Cycle

Managing Distribution Retention Time to Improve Water Quality—Phase I
**Case 1 Summary**

Reduce Water Age

- DO NOT over size
- Operate storage tanks in a good range
- Achieve mixing energy in tanks
- Flush effectively when needed
- Understand your system by monitoring water quality parameters and correlating results with water age
Case 2 – Trace Study and DBP Simulation

- Two Sources for the study zone
  - Purchase Water 1 – Surface Water with High DBP, minimal purchase, high flow
  - Purchase water 2 – Ground water with low DBP but limited flow of 260 gpm
- May 2017 – HAA OEL > 60 ug/L at Tank 1
- Compliance samples scheduled early July
Case 2 – Trace Study and DBP Simulation

• April 2017 Control
  • S1: ON T2 < 10.5 ft OFF T2 > 14 ft
  • T2 flow to T1: ON T1 < 30.5 ft OFF T1 > 32 ft
  • S2: ON T1 < 33.5 ft OFF T1 > 34.5 ft
  • Well blending controlled by the tank in another zone

• April 2017 Demand vs Supply
  • Customer Demand = 135 gpm
  • Well Blending = 215 gpm
  • S2 = 240 gpm S1= 110 gpm
  • S2/(S1+S2) ~ 70%

• Trace Study
  • 2-8% of S2 in Tank 1
Case 2 – Trace Study and DBP Simulation

- Proposed control should:
  - Max S2 & Min S1
  - Reduce water age of S1
  - Lower rechlorination dose
  - Max S2/S1 Ratio in T1, S2 to Tk1 instead of being consumed in system

- T2 flow: On T2 < 3 ft, Off T2 > 4 ft
- S1: On T1 < 33.5 ft, Off T1 > 34.5 ft
- S2: On T1 < 20 ft, Off T1 > 22 ft
- Well blending at max speed during Peak 8 - 4 hours at midnight
Case 2 – Trace Study and DBP Simulation

- Trace simulation: S2 60-70% in Tank #1
- HAA simulation: <40 ug/L in Tank #1
  - Assumptions: first order bulk reaction
  - Reaction rate estimated from testing results
  - Conservative HAA in S1
Case 2 Summary

• % of a source withdrawal $\equiv$ % of the source in the tank
• Trace study to optimize operation (variables)

• Purpose of WQ Modeling is to make better operational decisions, NOT to create a perfect model
Chapter 7  Water Quality Modeling
7.1  Introduction, 147
7.2  Need for Water Quality Modeling
7.3  Uses of Water Quality Modeling
7.4  Water Quality Modeling Technique
7.5  Governing Principles of Water Quality Modeling
7.6  Reactions Within Pipes and Storage
7.7  Computational Methods, 151
QUESTIONS?

THANK YOU