Tracer Study to Evaluate Passive Mixing System in A 3 Million Gallon Elevated Storage Tank

Niranjan Deshpande & Yeongho Lee (GCWW)
Mike Duer (Tideflex Technologies)

2014 Ohio WEA-AWWA Technical Conference & Expo

August 26 – 28, 2014

Columbus, Ohio

GREATER CINCINNATI WATER WORKS

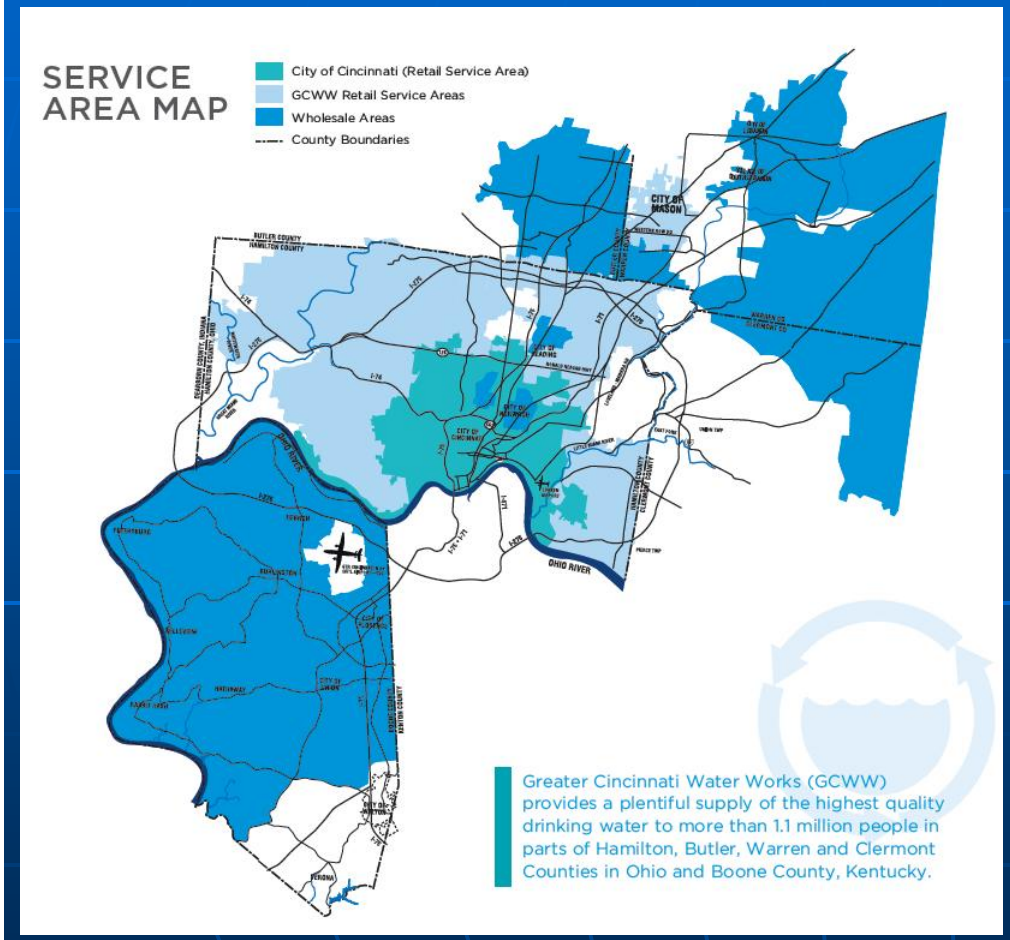
Tideflex® Technologies

One Water

Presentation Overview

- Background
- Tank Mixing System
- Tracer Study
- Tracer Study Results
- Distribution System Monitoring
- Distribution System Model
- Summary

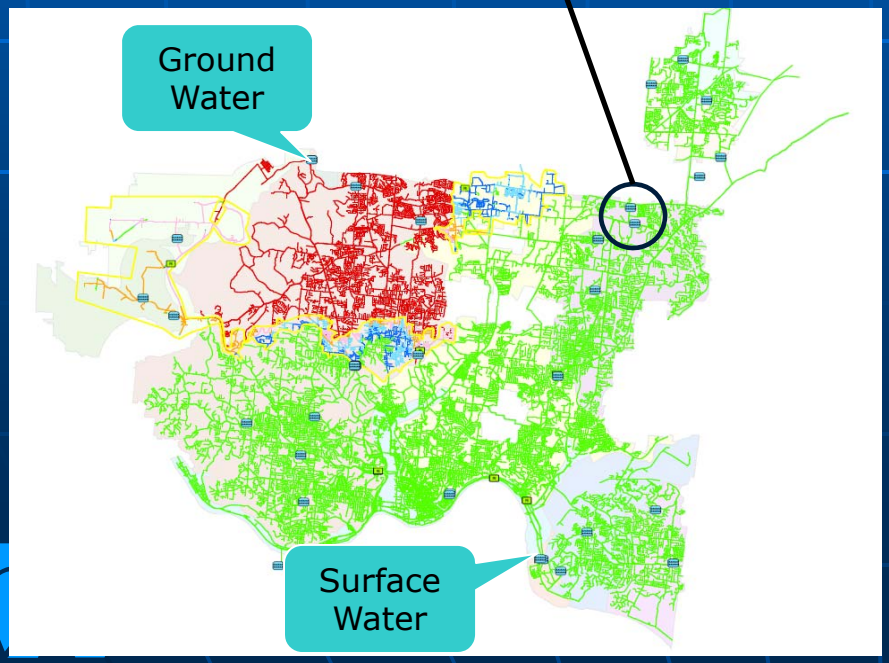
Greater Cincinnati Water Works: System Overview



- 2 Treatment plants:
  - Surface: 220 MGD
  - Ground: 40 MGD
- 3100 miles of Water main
- 11 Pressure zones
- 27 Storage tanks
- Avg. day pumpage: 120 MGD
- Customers
  - Retail
  - Wholesale

Elevated StorageTank

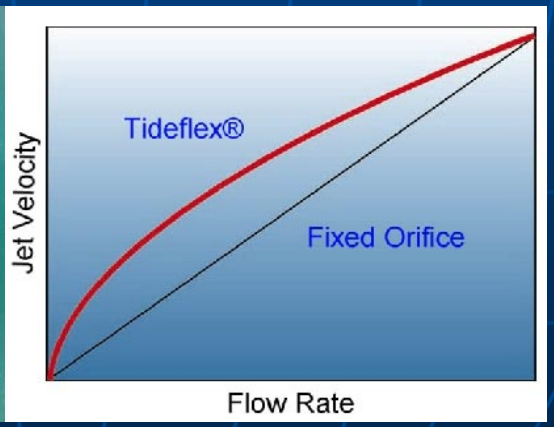
- Capacity: 3.0 MG
- Diameter: 116 ft
- Depth: 45 ft
- Separate 16” Inlet and Outlet Pipes
- Tideflex Mixing System
  - The first elevated storage tank with mixing system installed



- Used to supplement demands in the northern part of distribution system.

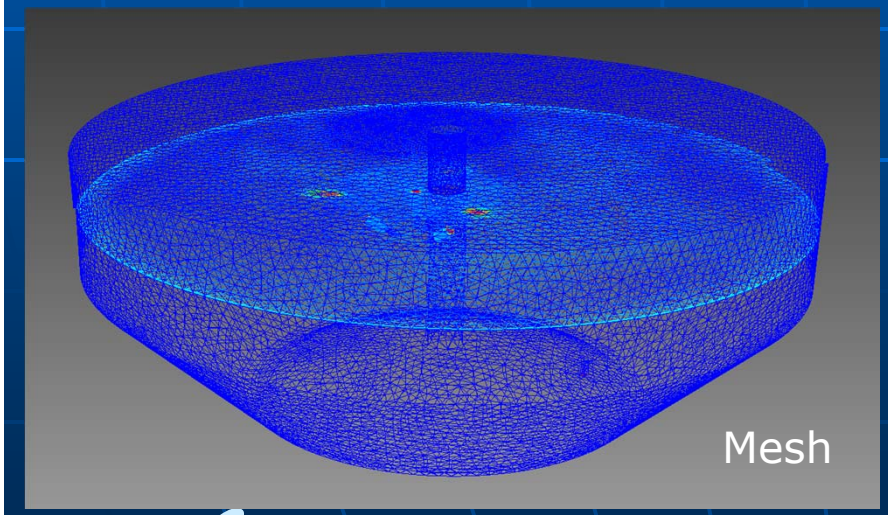
Tideflex Mixing System (TMS)

- Multiport manifold with (4) 8” variable orifice Tideflex nozzles/check valves.
- Variable orifice of Tideflex maximizes jet velocity at all flow rates
- NSF61-Certified, 30 year life, no maintenance
- Use inherent energy source of fill cycles for mixing
  > volume turnover < water age
- Extensive CFD and scale modeling, field validation
- Variable orifice maximizes jet velocity at all flow rates
- Mixing analysis model predicted complete mixing in 2.9 hours at 2.53 MGD (1,757 gpm)

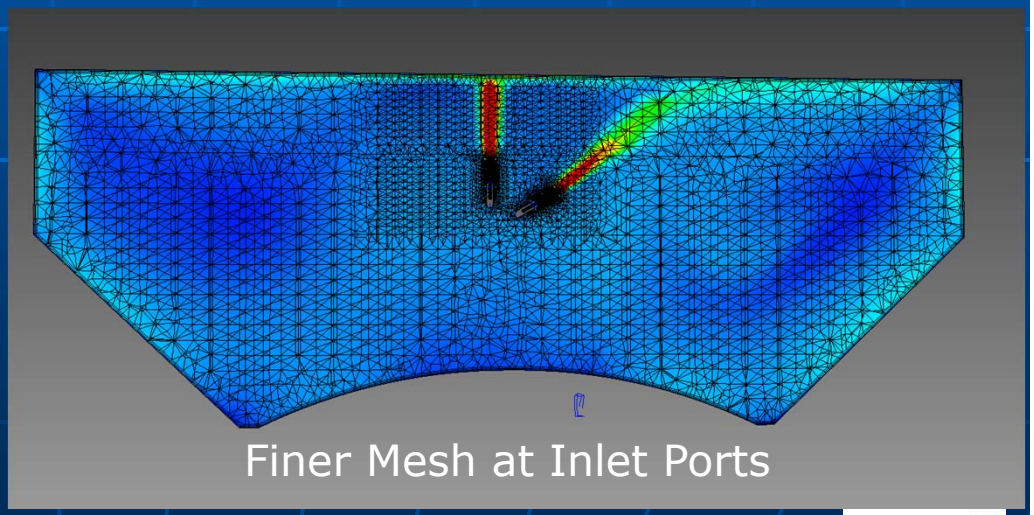


Tideflex Mixing System (TMS)

- **CFD Modeling**
- 116’ Dia. x 45’ head range, 3.0MG when full
- Fill at 1,757 gpm for 6 hours (8’ water level increase)
- Tideflex Nozzles 7.4 fps jet velocity
- Coefficient of Variation (COV) = (Std. Dev. Tracer / Mean Tracer)
- Tank is mixed when COV < 10%
- 206,972 nodes and 937,049 elements
- K-epsilon turbulence model



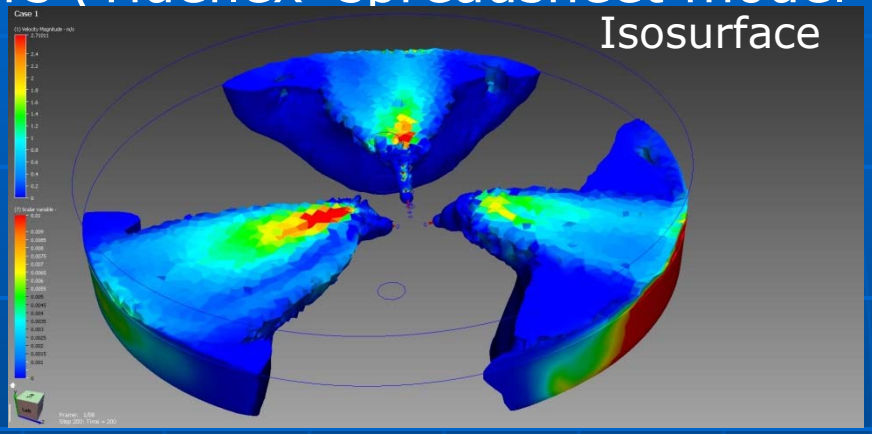
Mesh

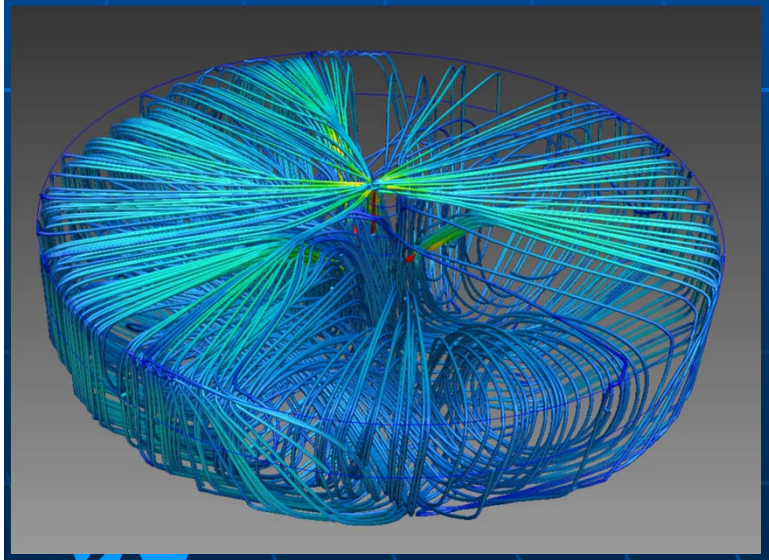


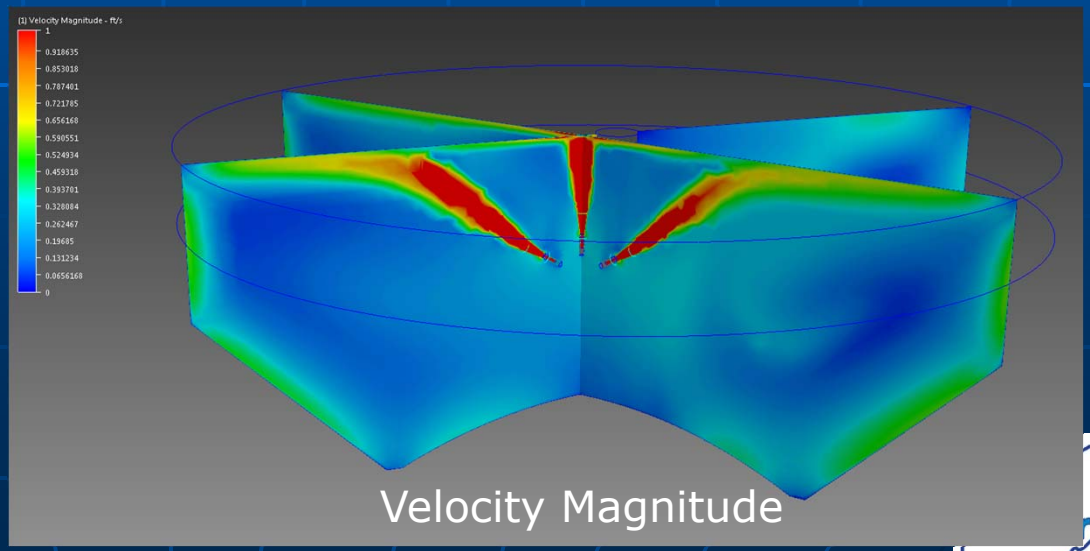
Finer Mesh at Inlet Ports

Tideflex Mixing System (TMS)

- **Computational Fluid Dynamics (CFD) Modeling**
- COV reached 10% in 2.7 hours (Tideflex' spreadsheet model predicted 2.9 hours)
- COV < 5% in 5 hours
- Complete mixing achieved
- Mixing model validated
- Compare to tracer study







Tracer Study

- Objectives
  - To evaluate the effectiveness of tank mixing system
    - Contractual requirement
  - To validate the accuracy of distribution system model
- Conducted in June 2013

Tracer Study (cont'd)

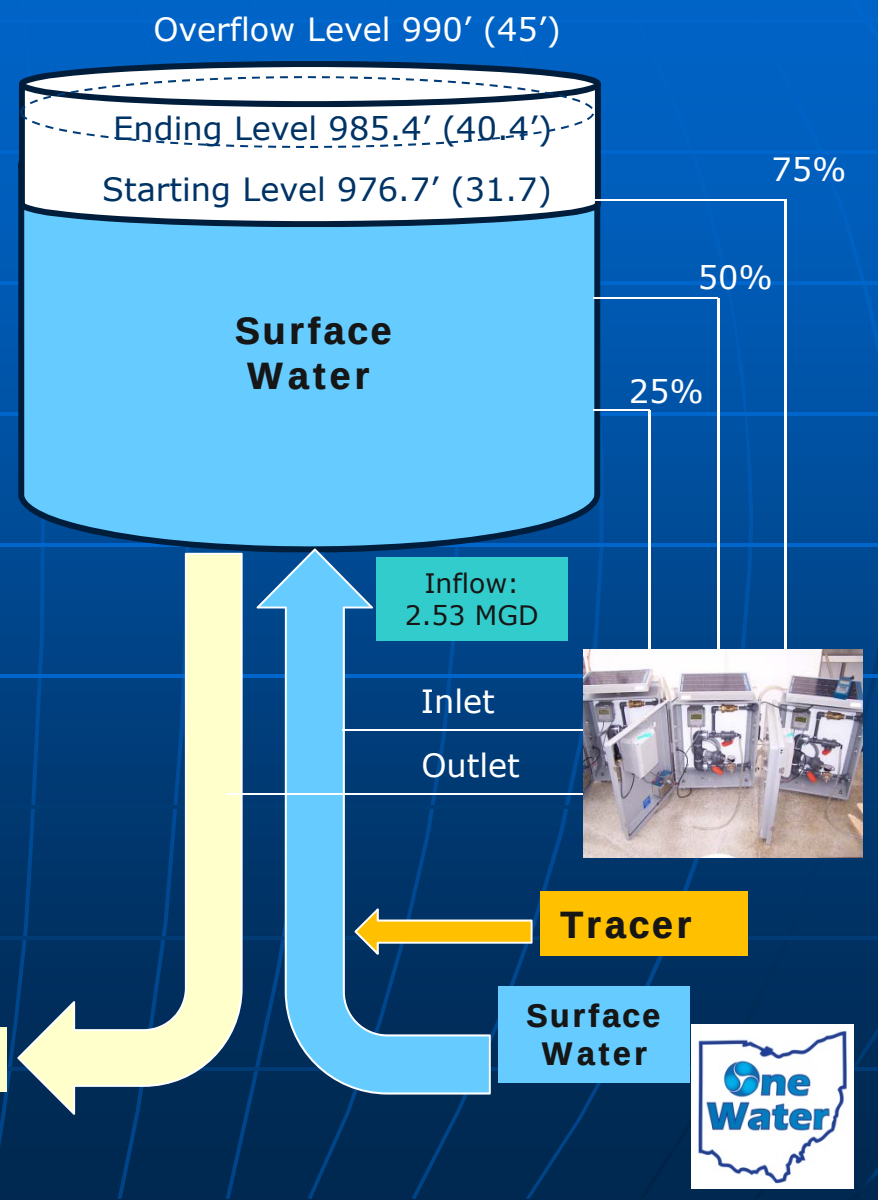
- Tracer
  - Food grade calcium chloride (32% w.t.)
  - Target chloride concentration in tank: 175 mg/L

  (Secondary MCL of chloride: 250 mg/L)

- Tracer Monitoring
  - Continuous monitoring and logging of conductivity
    - ATI Q45C4 conductivity monitor
    - ISIC data logger
  - Grab samples: chloride analysis
    - Onsite analysis by titration
    - Lab analysis by IC

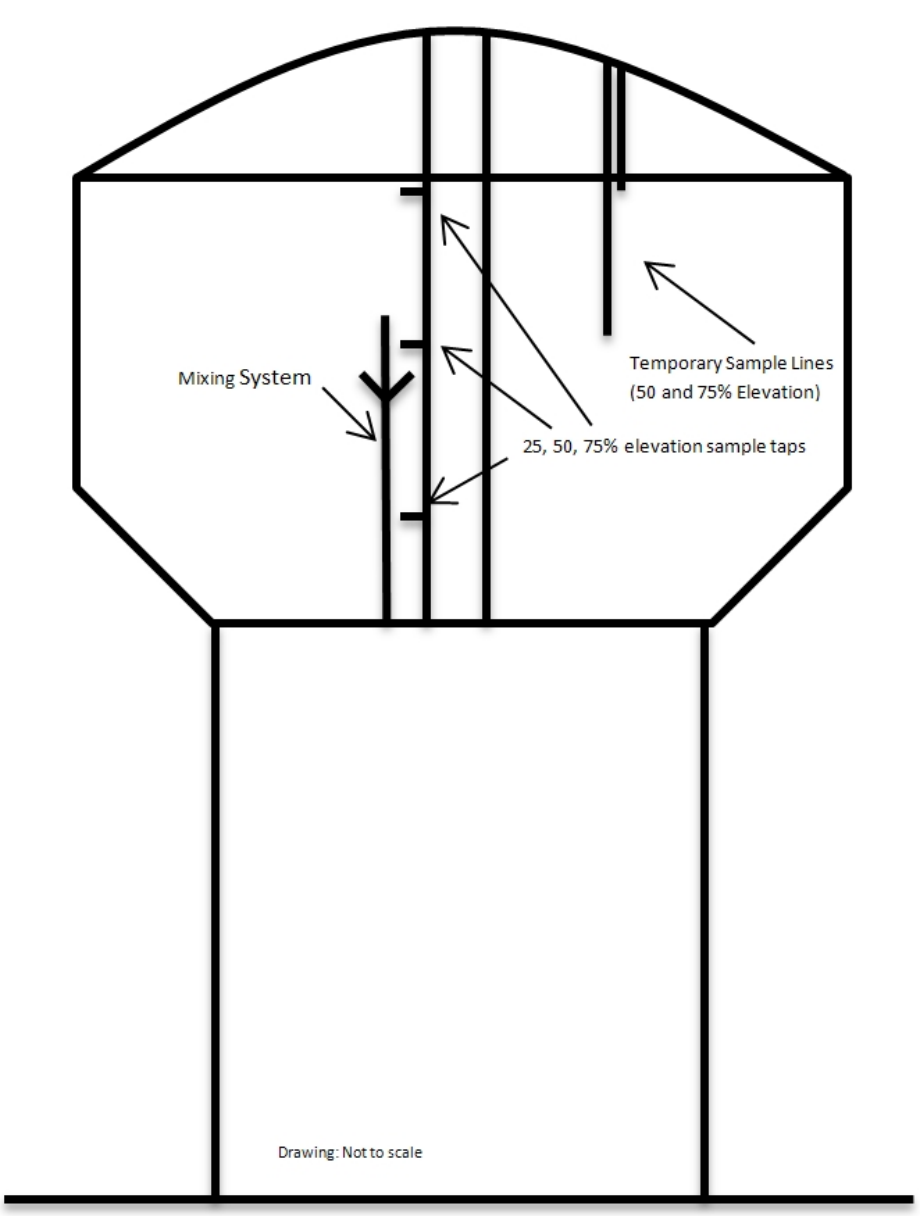
Tracer Study (cont'd)

- Study Conditions
  - Selected "worst case" condition for mixing
    - Tank initially at 75% capacity
    - Fill time- 6 hours
    - Large starting volume
- Tank Operation during the Test
  - Tracer injection/tank fill period: ~6.5 hours
  - Starting tank volume: 2.00 MG (31.7 ft depth)
  - Ending tank volume: 2.63 MG (40.4 ft depth)
  - Tank fill rate: ~2.53 MGD



Concerns

- Mixing system located directly under sample taps
- Temporary sample lines added at 50 and 75% elevations
- Conductivity monitored on temporary sample lines as well.



Tracer Study (cont'd)

- Monitoring Locations
  - Tank – inlet, outlet, 25%, 50%, temp 50%, 75%, and temp 75% tank levels
  - Distribution system – 40 locations, monitors connected to selected hydrants (32) and 8 facilities

Tracer Study (cont'd)

Tracer Study (cont'd)

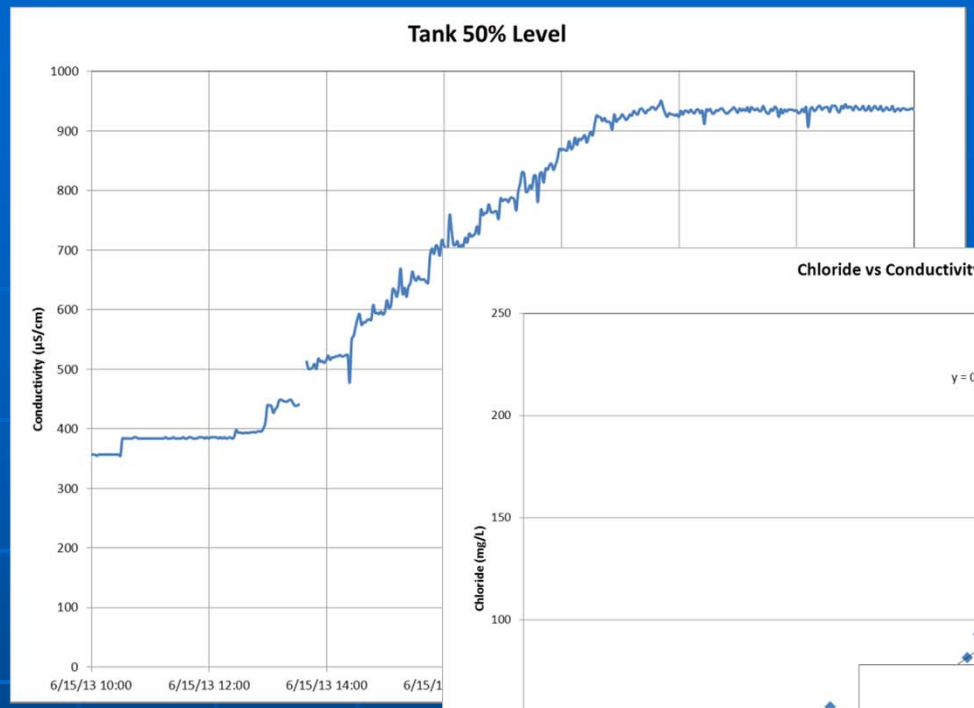
- How to evaluate tank mixing system?
  - Continuously monitor conductivity data
  - Create correlation curve between conductivity and chloride
  - Convert conductivity data into chloride data
  - Calculate COV (coefficient of variation) for each time step using 25%, 50%, and 75% levels and tank effluent chloride data

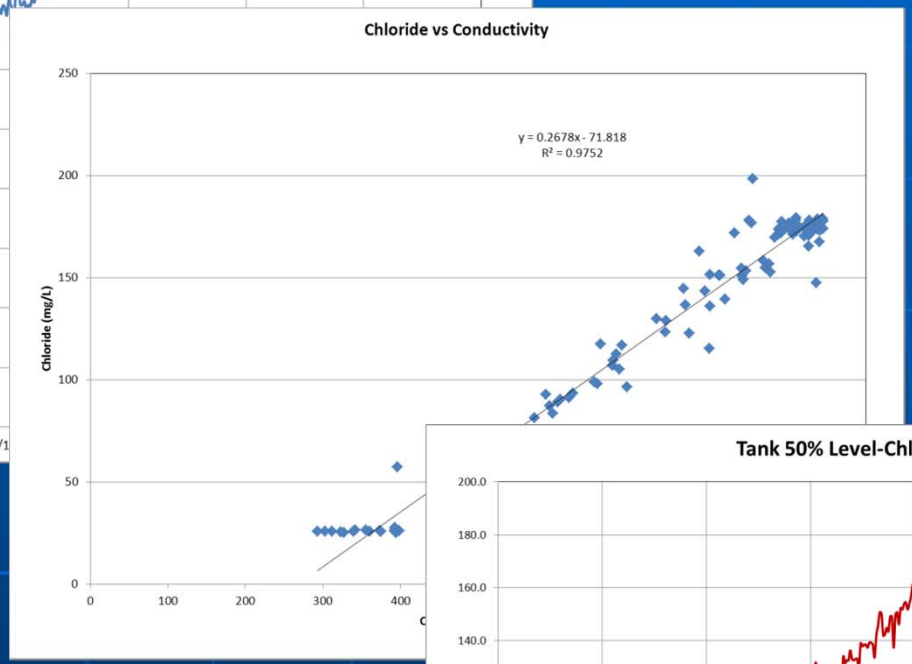
$$COV = \frac{Standard\ Deviation\ of\ Tracer\ Concentration}{Mean\ Tracer\ Concentration}$$

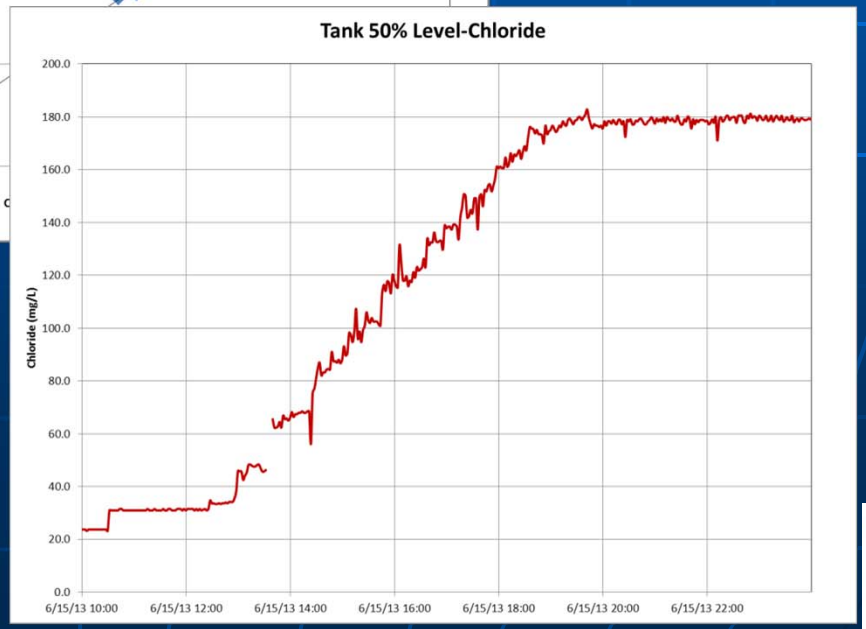
  - Criteria of complete mixing: COV<10% while the tank is draining

(Reference: Scale-Model Studies of Mixing in Drinking Water Storage Tanks, J.EE, ASCE, Vol. 125, No. 8, August 1999.)

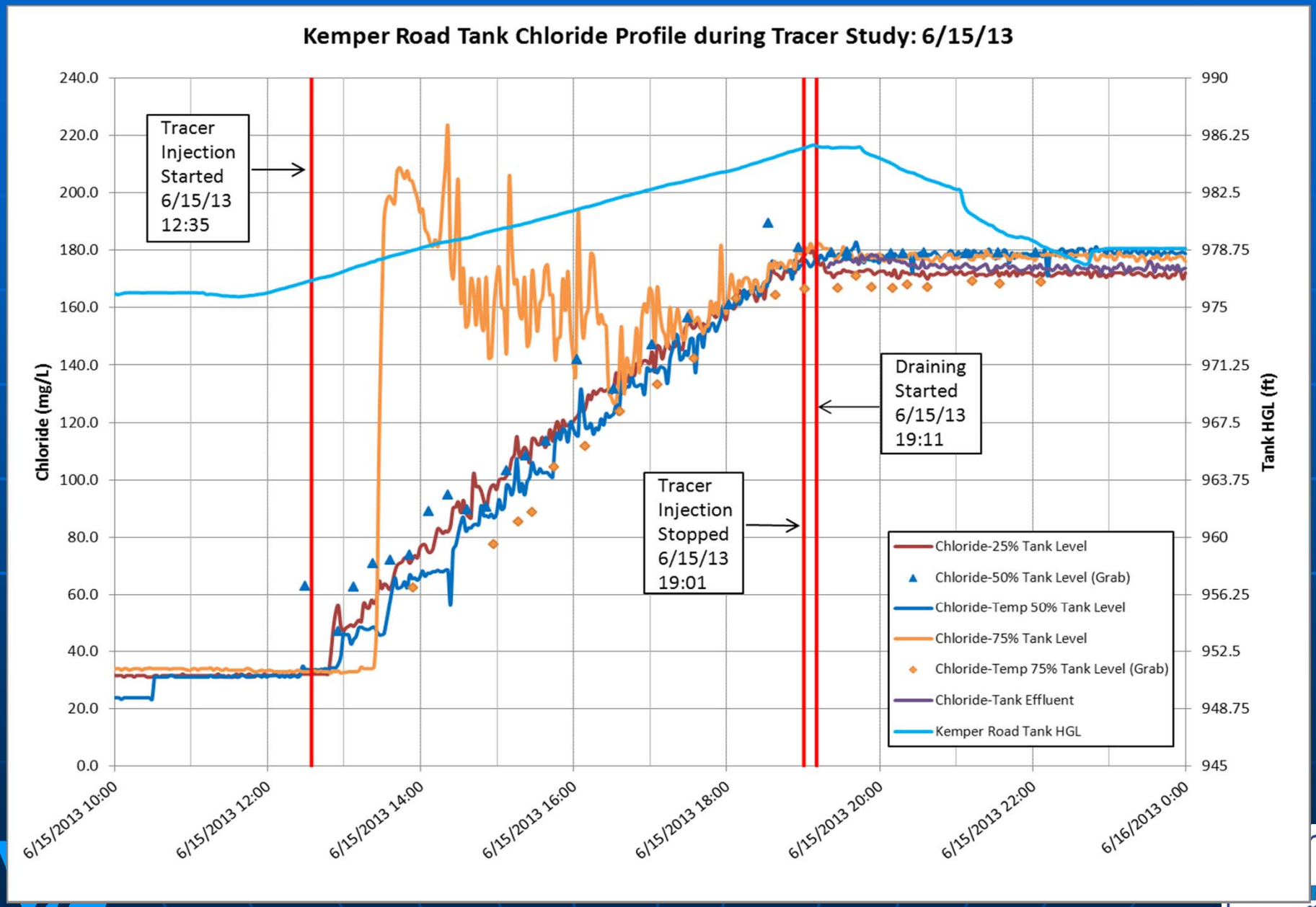
Tracer Study Results



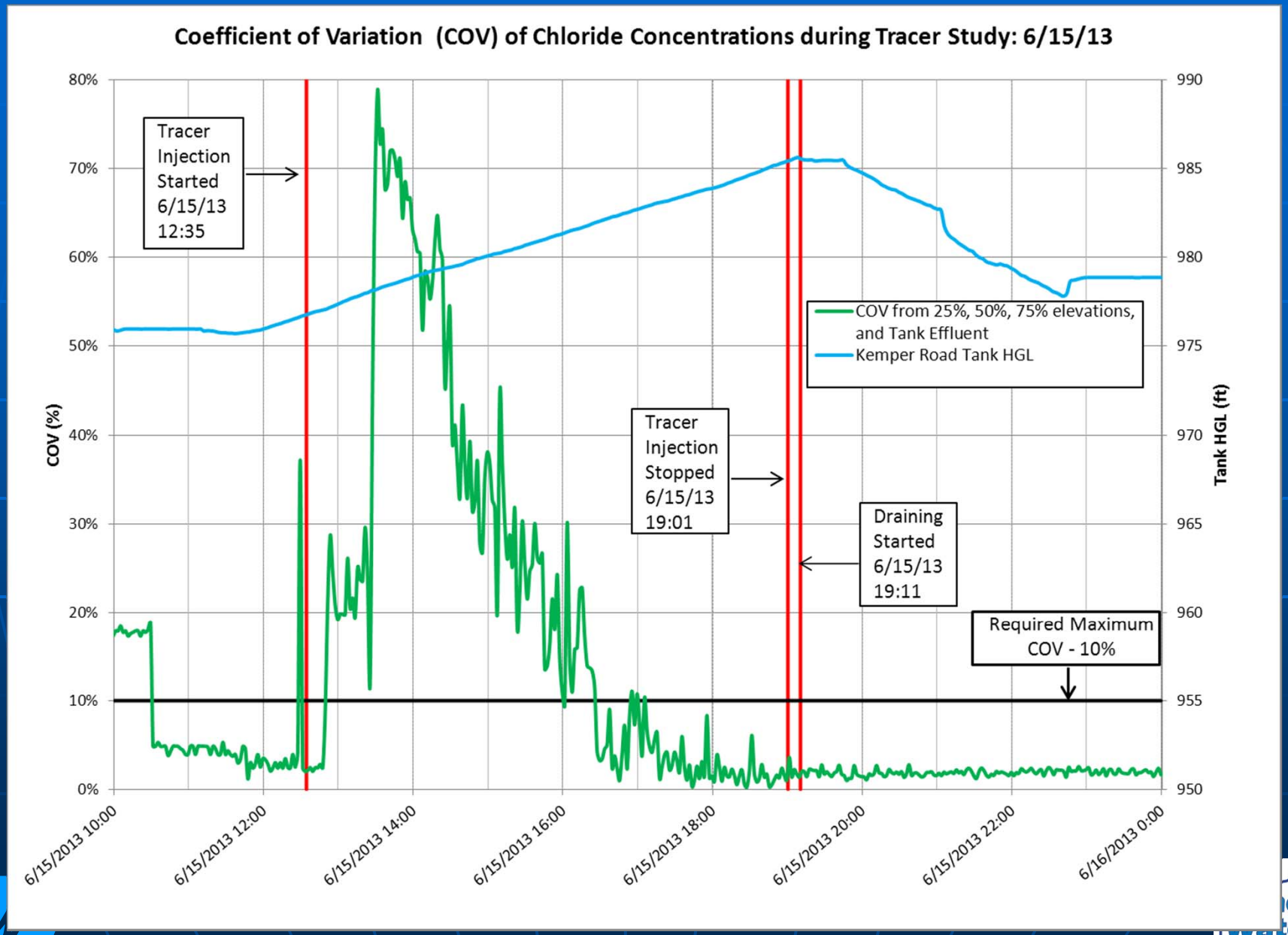




Tracer Study Results (cont'd)



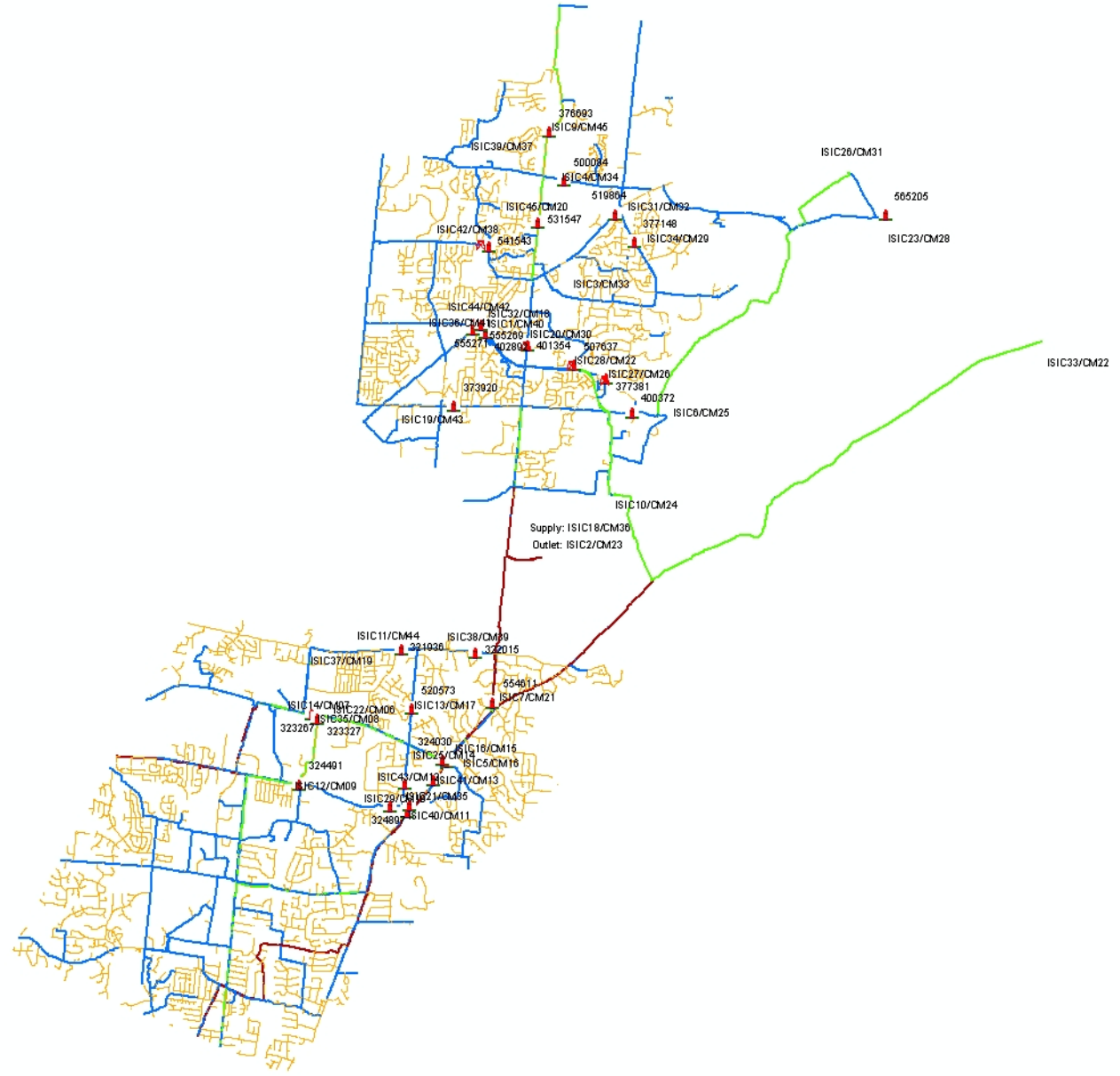
Tracer Study Results (cont'd)



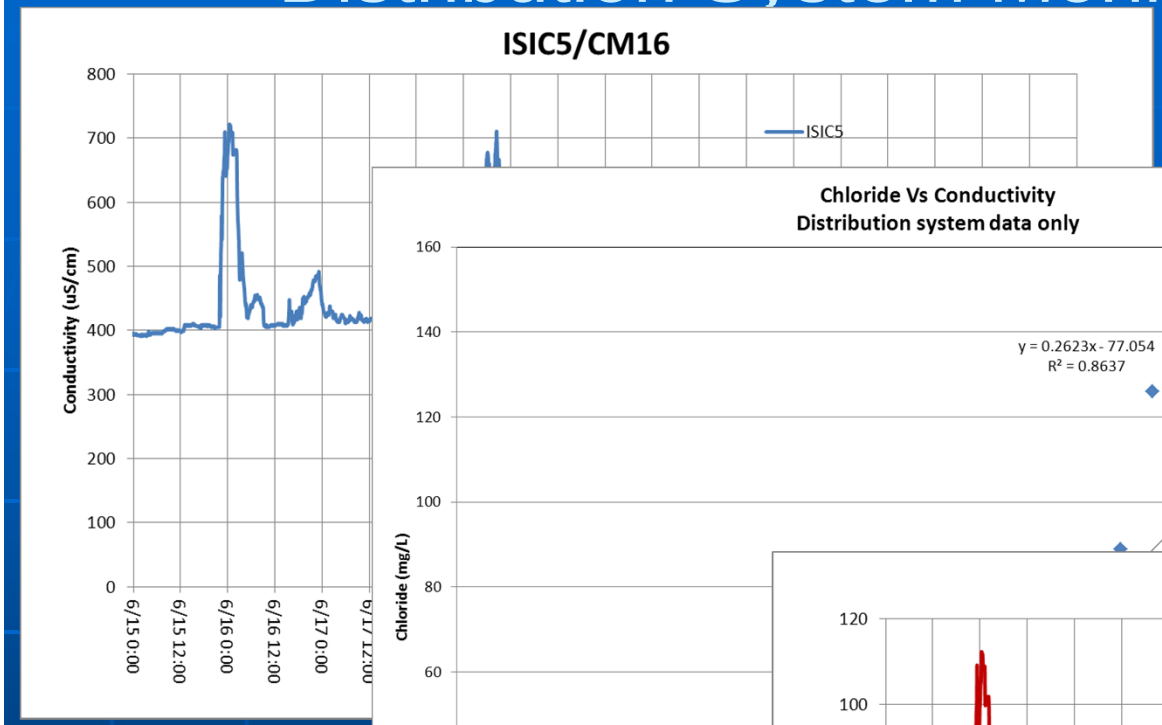
Distribution System Monitoring

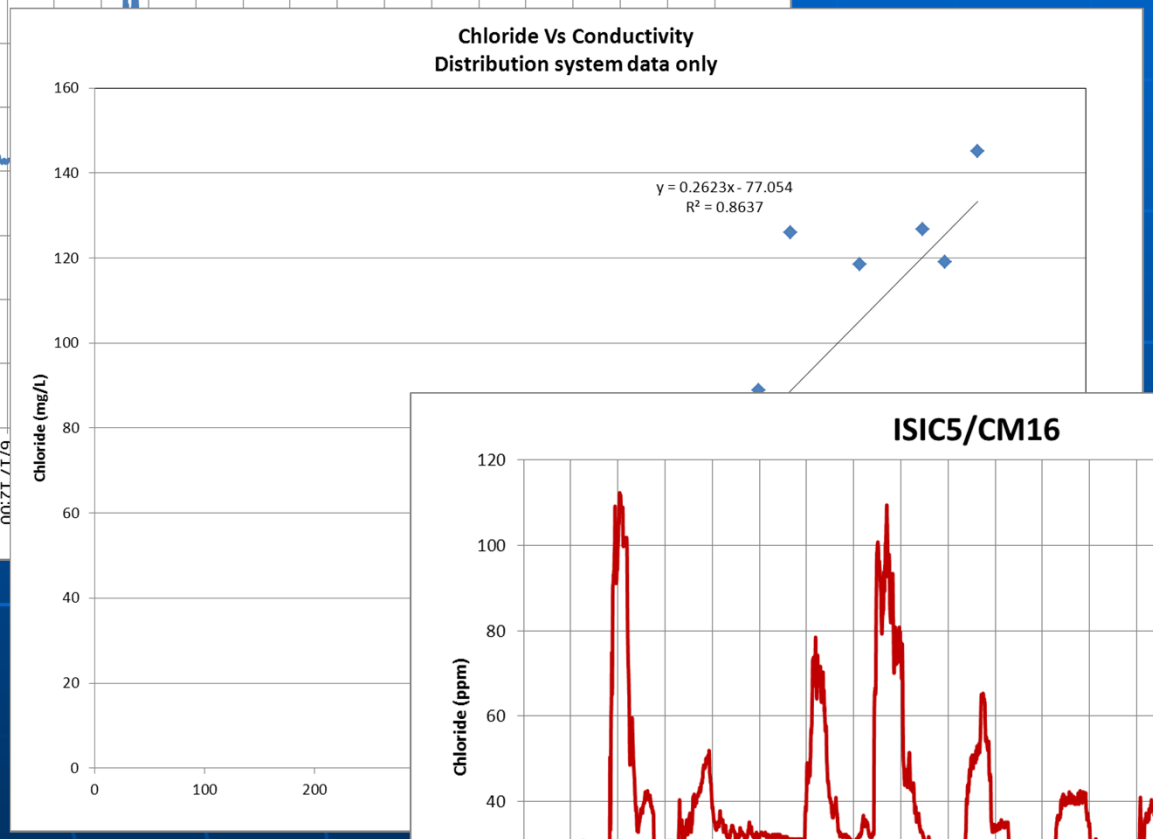
- Source trace modeling
- Conductivity monitored at Hydrants and GCWW facilities
- 32 hydrants monitored in distribution system
- 8 GCWW facilities
- Grab sampling

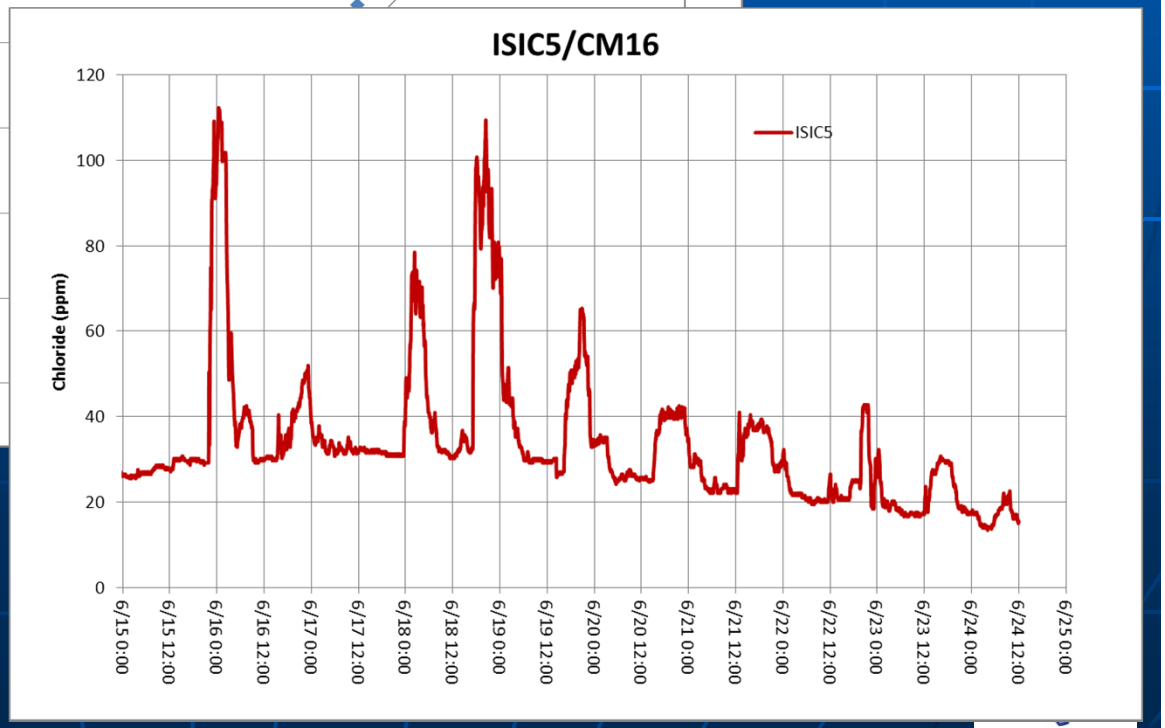
Distribution System Monitoring (cont'd)



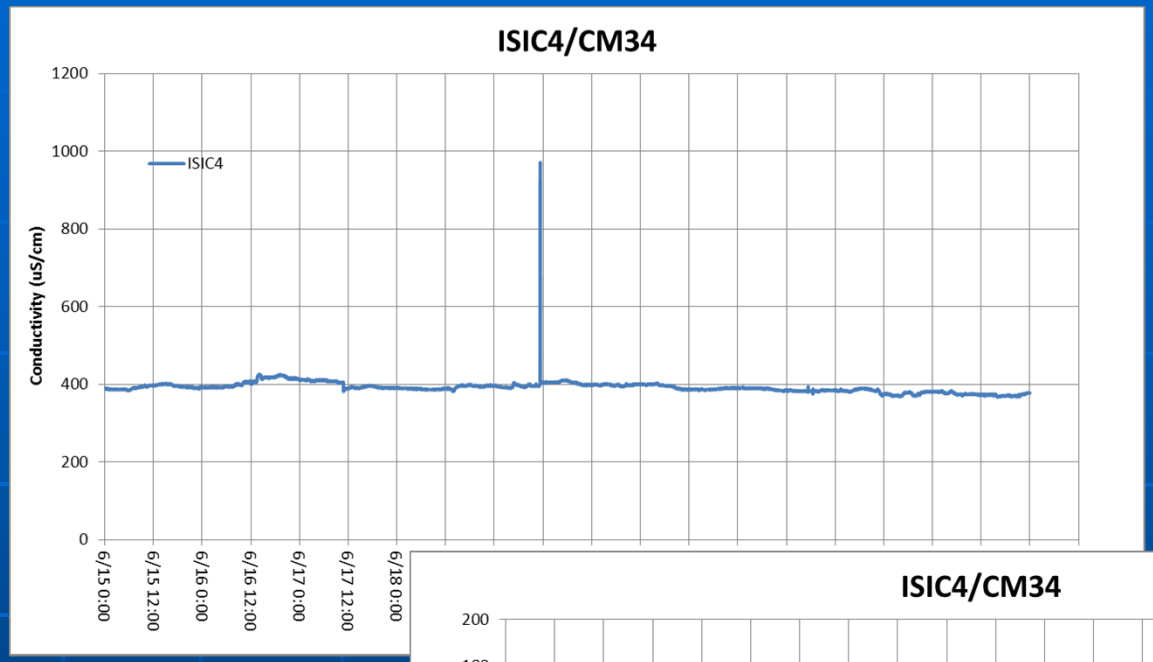
Distribution System Monitoring (cont'd)

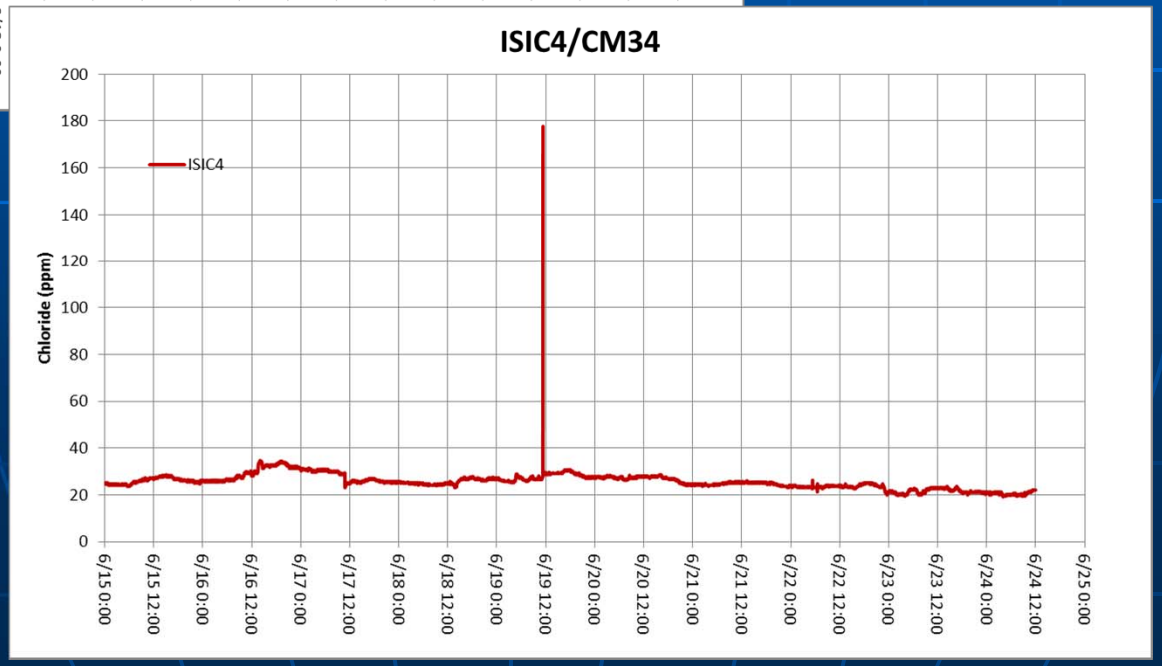




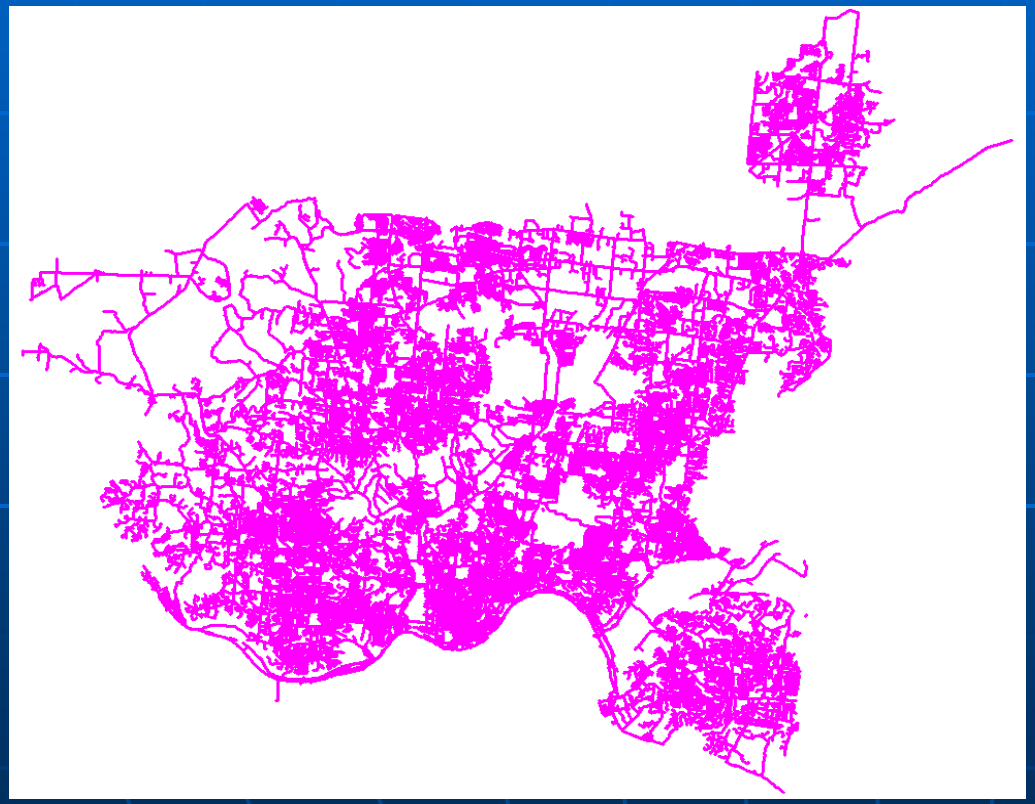


Distribution System Monitoring (cont'd)





All Pipes Distribution System Model



- Built from System-Wide GIS Data
- Includes all pipes ≥2” in diameter
- Links: 200,000
- Hydraulic Calibration
- Chlorine Calibration
- Master Planning, WQ Analyses, and Operational Modeling

Model Set Up

- Demand
  - Summer week demand
- Field Data Input
  - SCADA Data:
    - Tank initial levels
    - Pump/valve on/off time
    - Flow patterns for flow control valves
    - Wholesale customer demand
  - Tracer Study Data:
    - Tank effluent tracer concentration
- Model Simulation
  - Tracer as a non-reactive chemical
  - Hydraulic time step: 60 minutes
  - Water quality time step: 2 minute
  - Simulation period: 2 weeks

Summary

- Tracer study is a valuable method
  - To directly evaluate the effectiveness of tank mixing system.

- Tracer study confirmed that the passive tank mixing system installed in the 3 MG storage tank does provide complete mixing of water in the tank.

Acknowledgement

- GCWW Staff
  - Lab Techs
  - Valve Operators
  - Operators
  - Electricians
- CB&I Federal Services (Formerly Shaw Environmental)


Thank you!