Tracer Study Back to Basics and the Intricacies Considered by McMinnville

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Acknowledgments

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Outline

- Reasons to have a tracer study
- Definitions
- Types of tracer studies
- Commonly used tracer constituents
- Planning a tracer study
- Performing a tracer study
- Sample and data analysis
- Reporting
- Case Study: McMinnville Water and Light Scott Norman WTP, McMinnville, OR.

Image: WRF

What is a Tracer Study?

- "Labeling" of water molecules and tracking their movement through space and time in a water plant or distribution system
- Adding a conservative (i.e., non-reactive, inert) substance into a process stream before a basin and observing the change in concentration in the effluent or path
- A methodical change in chemical addition that is observed and quantified through sampling at strategic locations and frequency
- A tracer study is <u>not</u> simply measuring a compound at a random time
- Sample collection and data analysis targets the specific purpose of the tracer study

Why would you want or need to perform a tracer study?

- Regulatory compliance to prove baffling efficiency
- New infrastructure that needs demonstration of contact time for disinfection credits
- Increase in production (higher flowrates of finished water)
- Changing the application point of the disinfectant
- Process optimization

Ultimate Goal of a Tracer Study

$$\text{Baffling Factor} = \frac{T_{10}}{TDT}$$

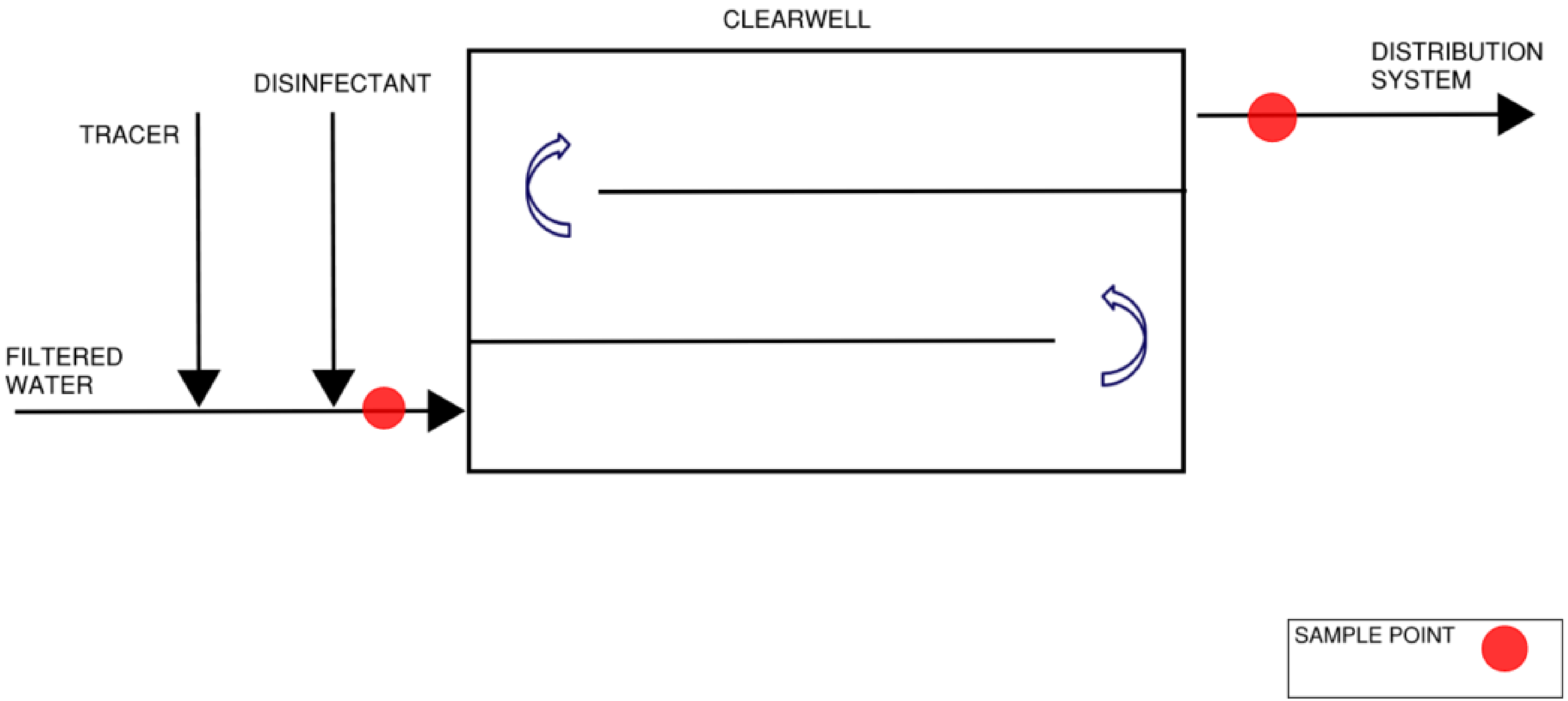
where T_{10} is the minimum contact time, and TDT is the theoretical detention time

Table 4-2. Baffling Factors

Baffling Condition	Baffling Factor	Baffling Description
Unbaffled (mixed flow)	0.1	None, agitated basin, very low length to width ratio, high inlet and outlet flow velocities.
Poor	0.3	Single or multiple unbaffled inlets and outlets, no intra-basin baffles.
Average	0.5	Baffled inlet or outlet with some intra-basin baffles.
Superior	0.7	Perforated inlet baffle, serpentine or perforated intra-basin baffles, outlet weir, or perforated launders.
Perfect (plug flow)	1.0	Very high length to width ratio (pipeline flow), perforated inlet, outlet and intra-basin baffles.

Source: USEPA. March 1991.

Example Generic Tracer Study: Schematic of Clearwell in WTP



Types of Tracer Studies

Pulse (Slug) Dose Method:

- One-time dose that spikes concentration momentarily
- Requires greater increase in dose (problematic for impact on water quality)

Step Dose Method

- Continuous dosing of tracer
- Most practiced for studies in WTP
- Change in concentration is much narrower
- Can use existing dosing system

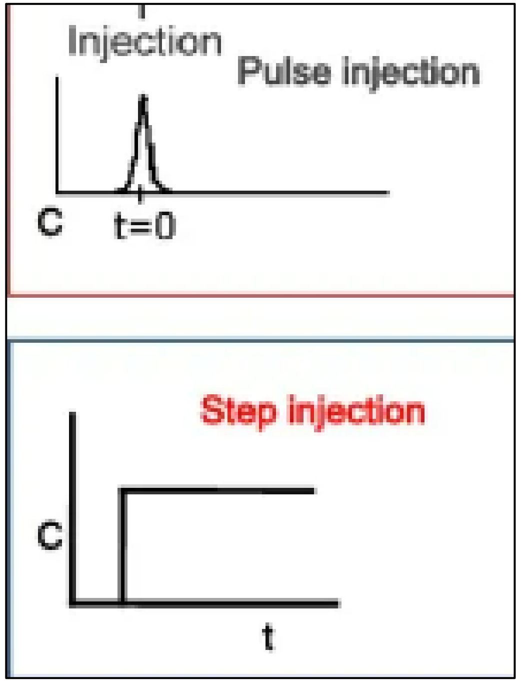


Image: Chem Reaction Eng.

Ideal Properties of a Tracer

- Non-reactive compound
- Easy to measure
- Easy to handle
- Existing plumbing and pumping
- Minimal and/or benign changes to water quality

Image: Hach

Type of Tracers

Fluoride

- Many utilities already apply therefore does not require additional plumbing
- Conservative (inert) if applied to filtered water which lends for very accurate data
- Measurements are very sensitive to temperature
- Hydrofluorosilicic acid is a very strong chemical making it very difficult to handle If not currently used at plant
- Example: - Primary MCL is 4 mg/L;
  - Secondary MCL is 2.0 mg/L,
  - Recommended value is 0.7 mg/L as fluoride
  - Tracer study dose 1.15 mg/L

Types of Tracers Continued

Conductivity

- Surrogate for Total Dissolved Solids
- Addition of dissolved solids in the form of sodium chloride, calcium chloride
- Inert (non-reactive) element so none of it is consumed through reaction which lends itself for very accurate data
- Conductivity is easily measured by handheld devices
- Impact on water quality is small and can easily remain below secondary MCL
- Example: Raw water naturally has 100 mg/L of TDS, add an additional 100 mg/L of TDS; tracer study dose of 200 mg/L (MCL is 500 mg/L)
- Benign solution to handle
- Typically requires additional plumbing beyond existing infrastructure

Types of Tracers continued

Sodium hypochlorite

- Not an inert compound so it requires establishing hypo demand of the water during the study
- Easy to dose since it is already used at the facility: dosing pumps, connections, chemical, etc.
- Easy to measure

Types of Tracers Continued

Dyes

- Examples: Rhodamine (red)
  uranine (a.k.a. fluorescein, yellow-green)
- Aesthetic change to water
  less desirable to the public
- Measuring samples may require
  more complicated analytical equipment
- Used typically in hydrogeological studies,
  wastewater, or in plume remediation
  not in WTPs

Image: Kentucky Geological Survey

Planning for a Tracer Study

- Coordination between different departments
  - Water treatment operations
  - Distribution operations
  - Customer service
  - Engineering
- Communication to the public
- Communication with regulating agency for approval of tracer study plan prior to carrying out study
- Setting clear objectives
- Writing out protocols for sampling
- Estimating HRTs and baffling factors to determine what is expected for a T10 and use those estimates to plan sampling frequency

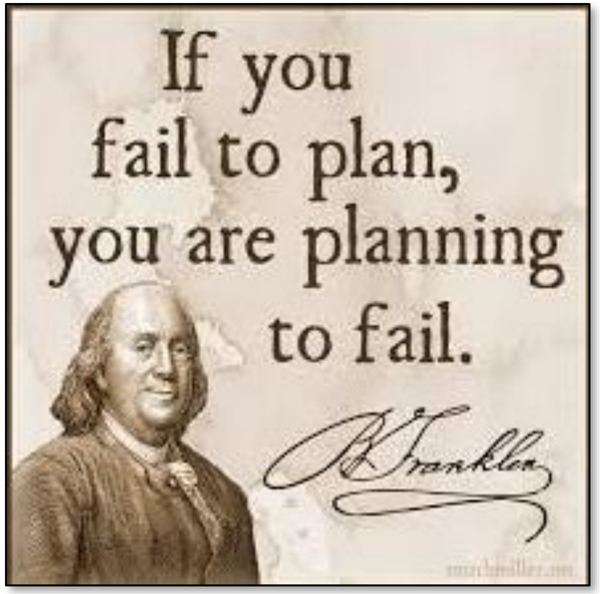
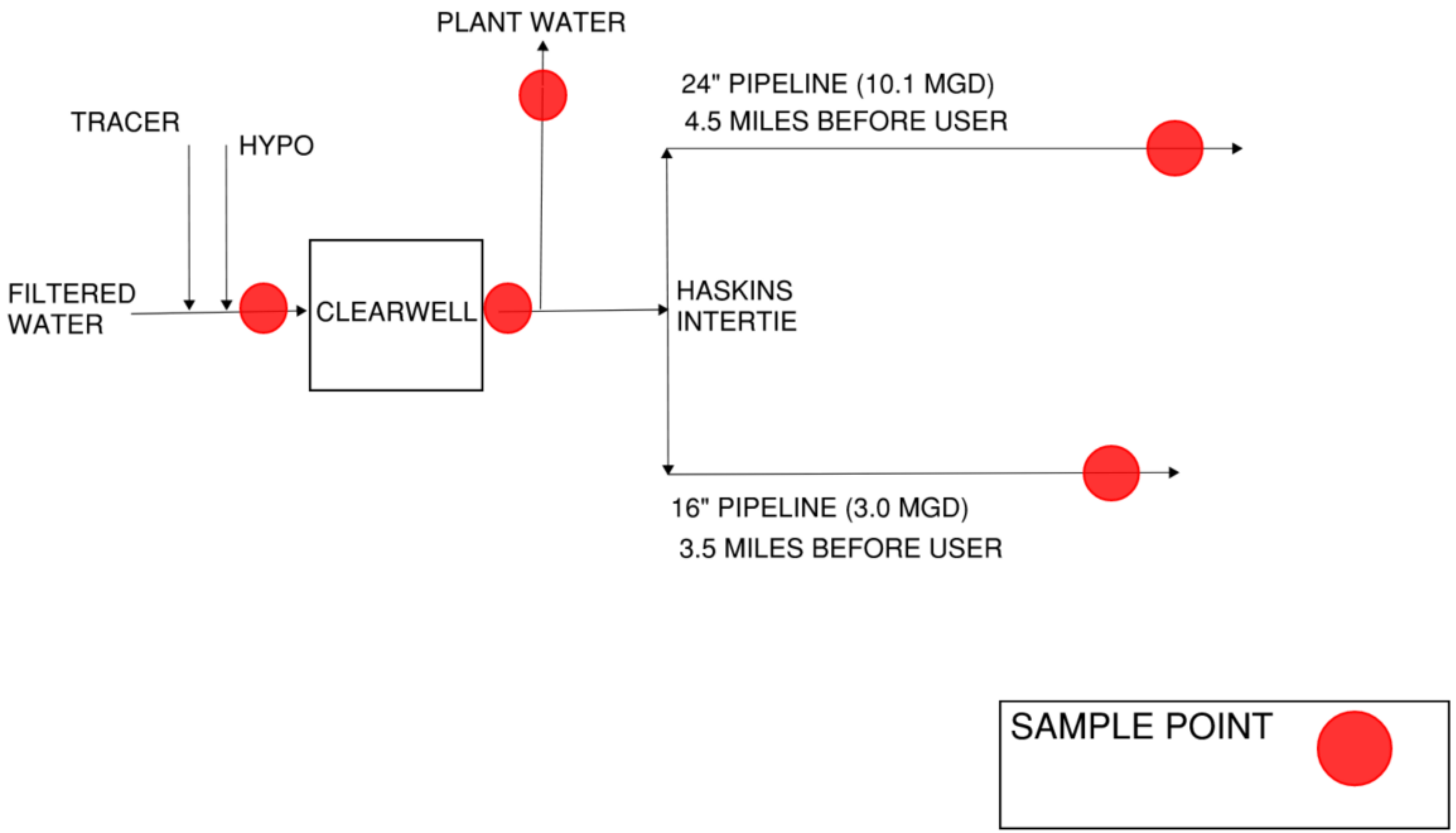


Image: Pinterest

Case Study: McMinnville Water and Light, McMinnville, OR - Background

- Scott Norman Water Treatment Plant (WTP) is a 22 MGD conventional treatment facility enhanced coag, flocc, sed, and dual media filtration



Sampling Locations

Combined Filter Effluent (CFE)

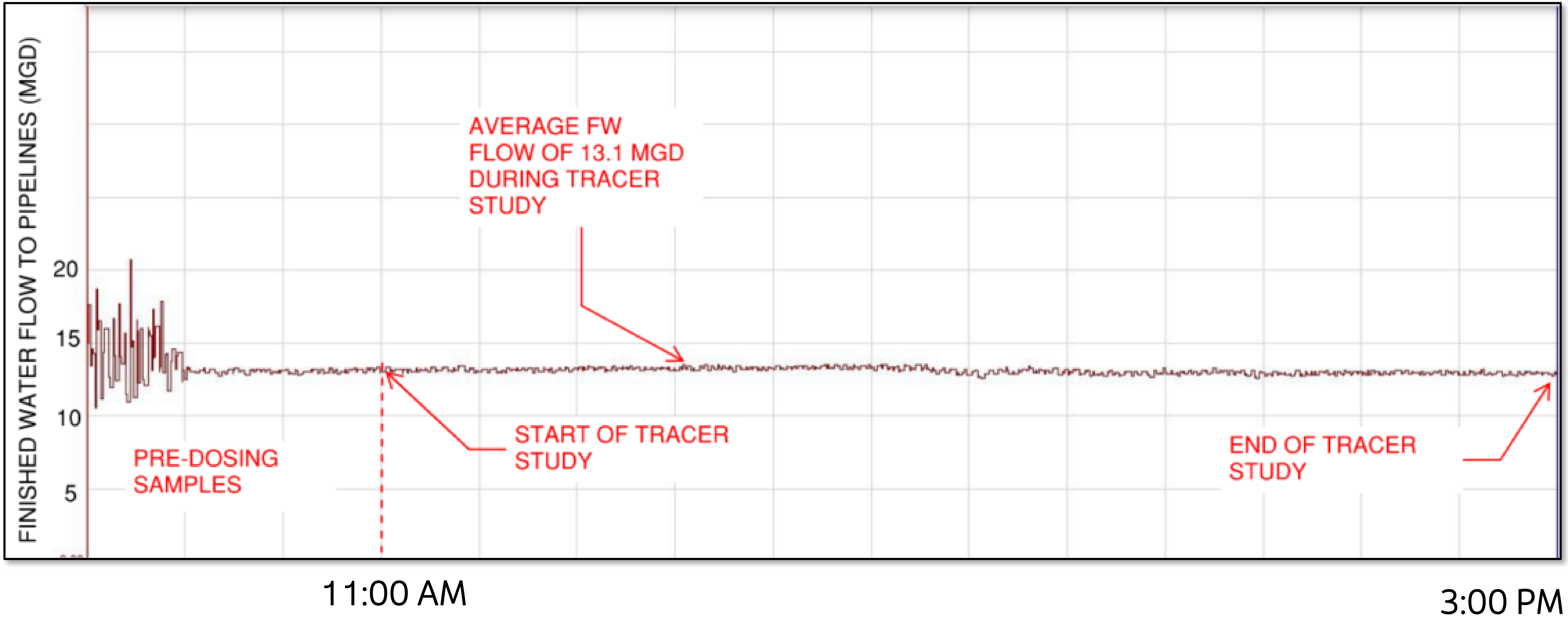
Clearwell

Ops Building

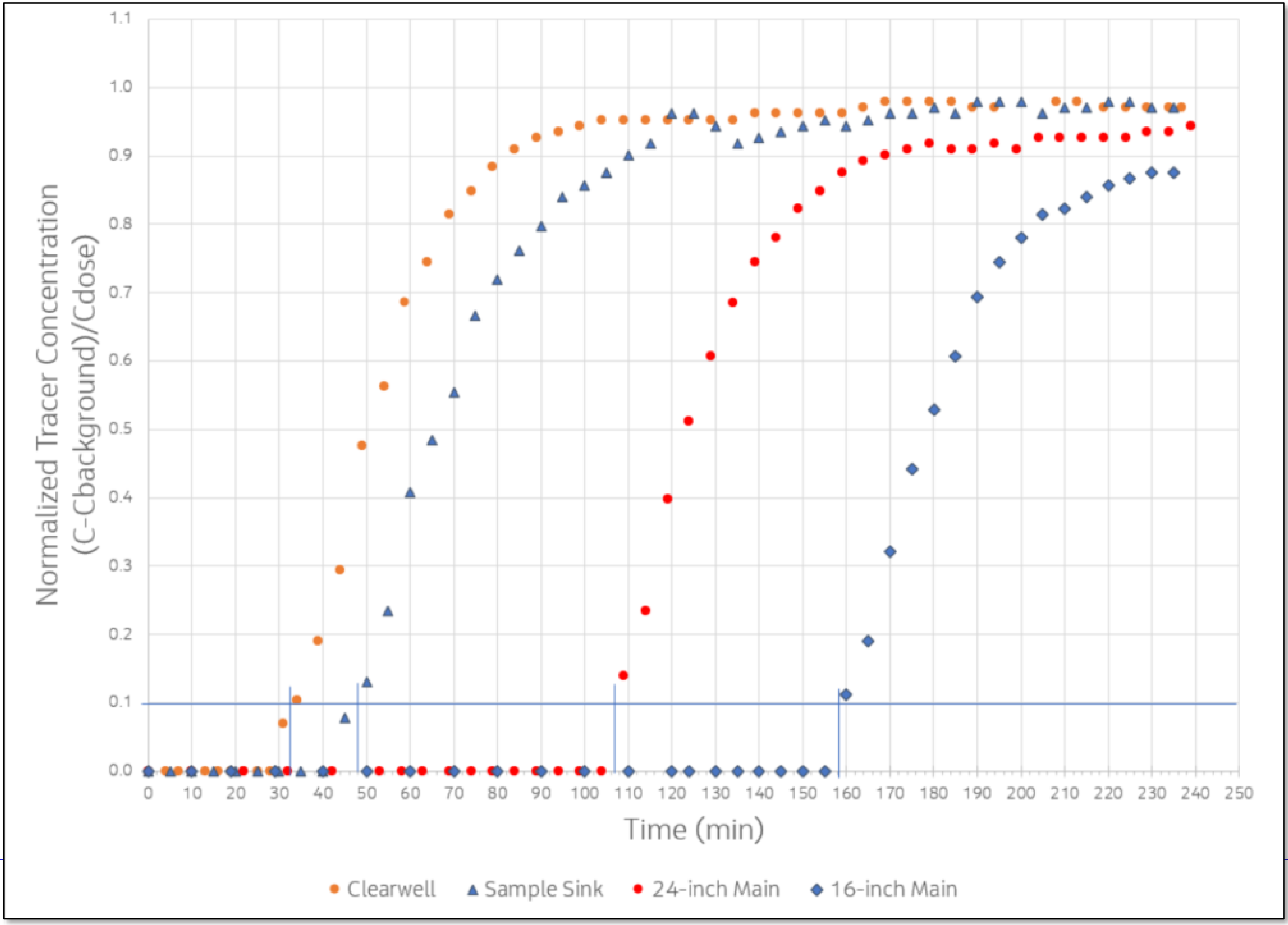
Valve at 16"

Valve at 24-inch

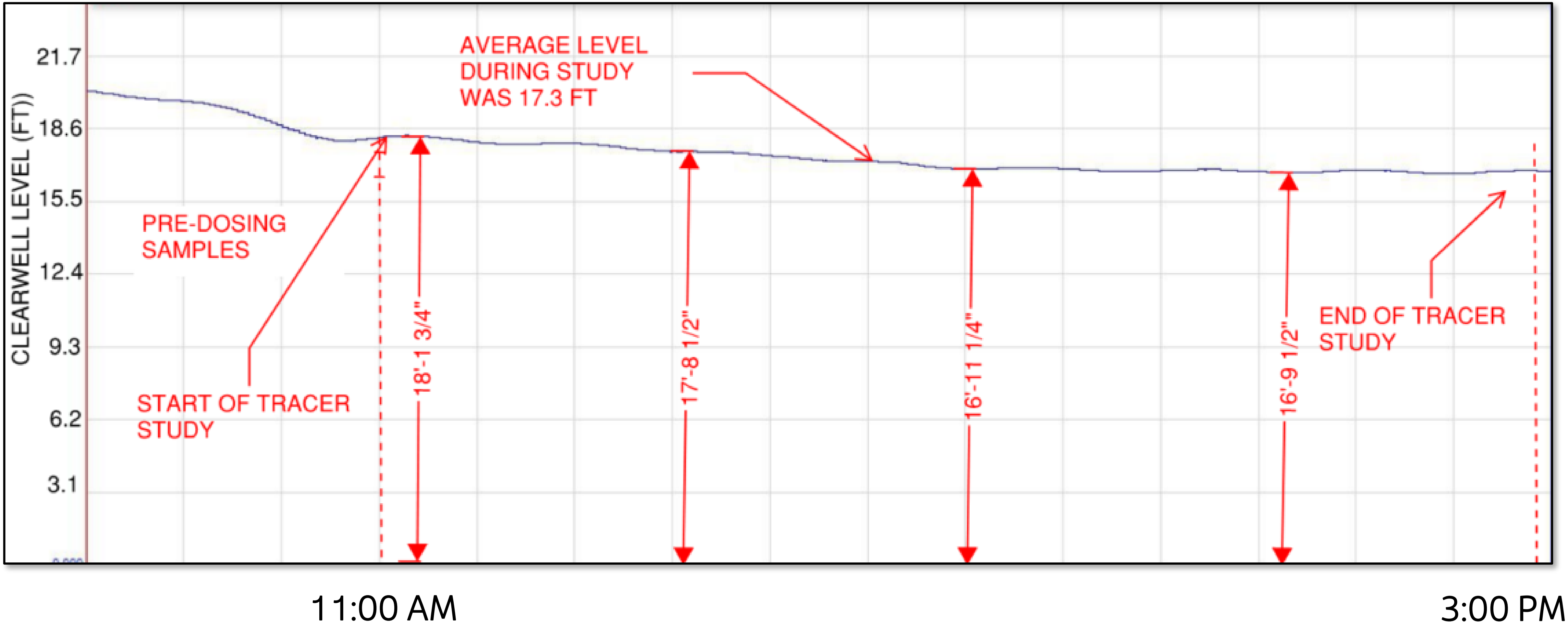
Finished Water Flowrate out of Clearwell During Tracer Study



McMinnville W&L – Tracer Study August 2023



Clearwell Level During Tracer Study



McMinnville Tracer Study – Baffling Factors

13.1 MGD Tracer Study Calculations		
Location	T_{10} (min)	Baffling factor for Segment
Clearwell	33	0.77
Operations Building: Lab Sample	48	0.9-1
Operations Building: Potable Water;	71	0.9-1
24-inch Main	107	0.9
16-inch Main	158	0.8

Conclusion

- Different tracer substances available
- Setting up a test plan is critical
- Defining objectives early on
- Sampling points through system make life easier
- Communication through internal departments, primacy agency, and public
- Tracer studies provide a greater understanding of treatment and distribution system
- Lessons learned

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Thank You!
Questions

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