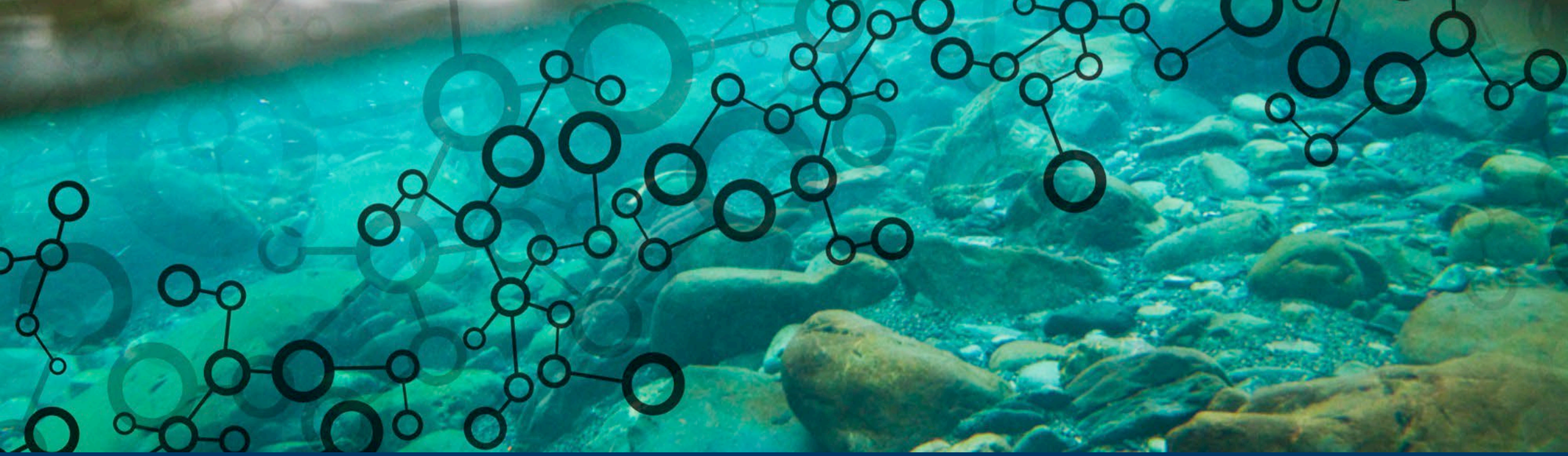
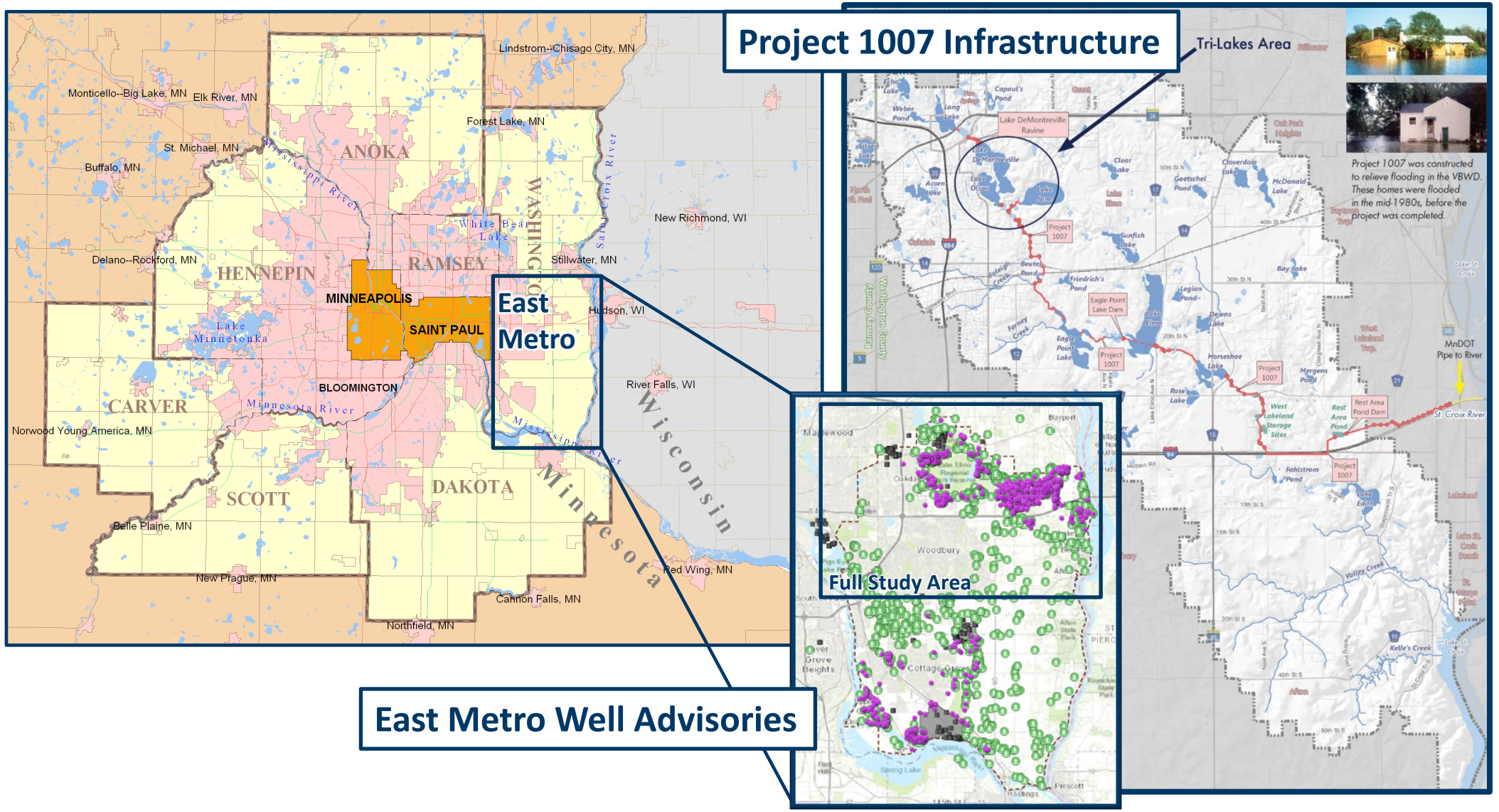


Characterization of PFAS Plumes 70 Years in the Making

MINNESOTA POLLUTION CONTROL AGENCY

Rebecca Higgins, PG
East Metro Unit, MPCA
11/7/23

Project 1007 Site Extent



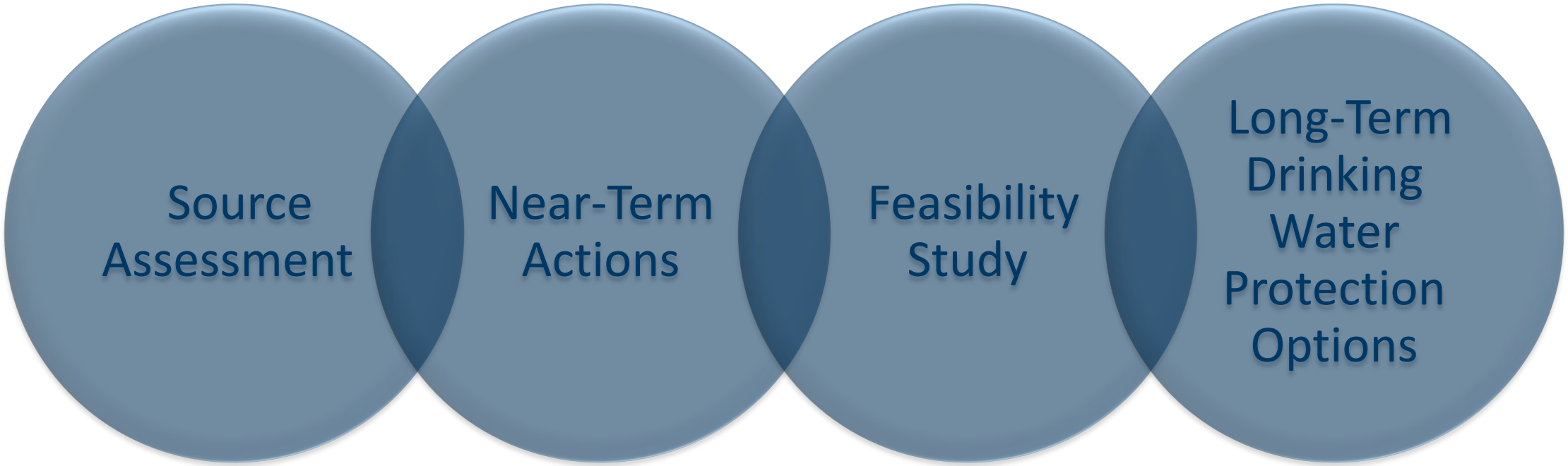
In the East Metro, approximately 1,400 public and private wells currently have drinking water health advisories.

Project 1007, constructed in 1987, is a large flood control project for the Tri-Lakes Area. It is being evaluated for its role as a conveyance system for PFAS impacts in the East Metro.

To date, the Project 1007 Study Area is >120 miles^2 in size and includes ~90 monitoring wells and over 150 surface water samples.

Project 1007 High-Level Process

"The MPCA shall conduct a source assessment and feasibility study regarding the role of the Valley Branch Water District's project known as Project 1007 in the conveyance of PFCs in the environment." - 3M Settlement



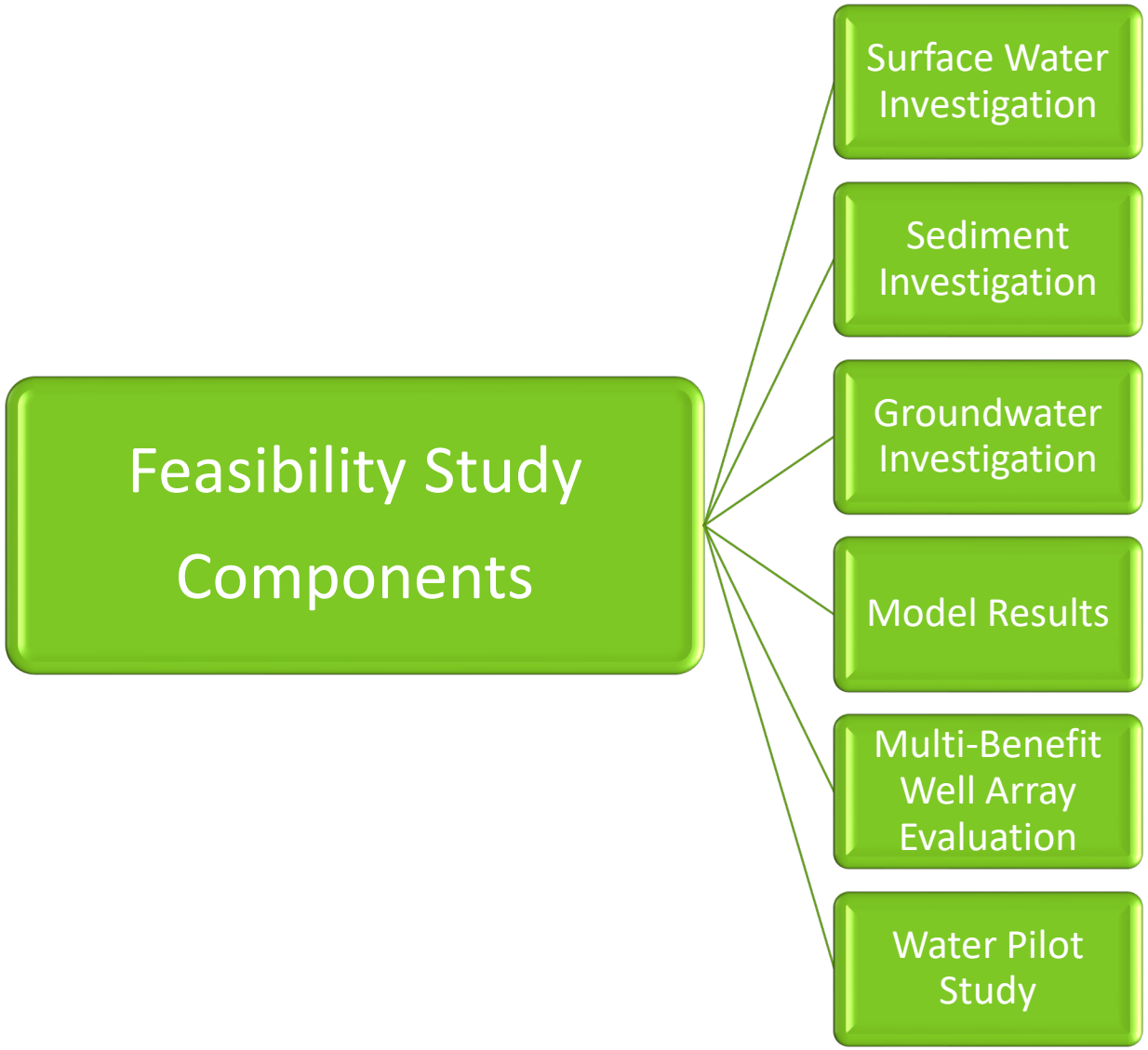
Feasibility Study Goals and Components

GOALS

Identify areas where treatment of surface water, sediment, or groundwater is required.

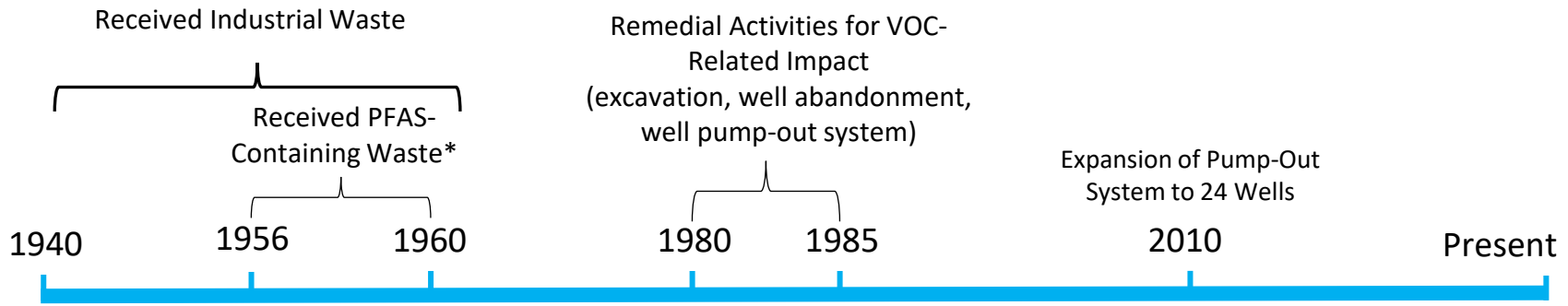
Evaluate applicable treatment options.

Recommend solutions to address PFAS impacts in surface water, sediment, and groundwater.



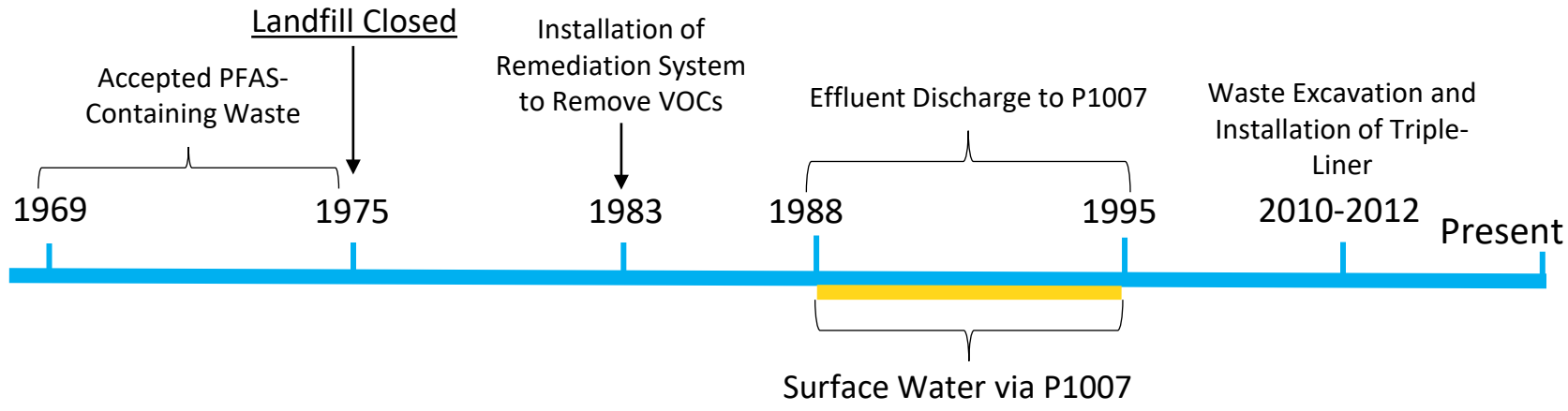
PFAS Pathways: Two Source Areas and Primary Pathways

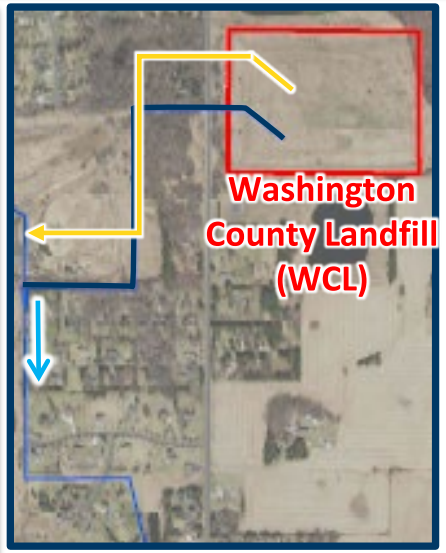
Activities at ODS



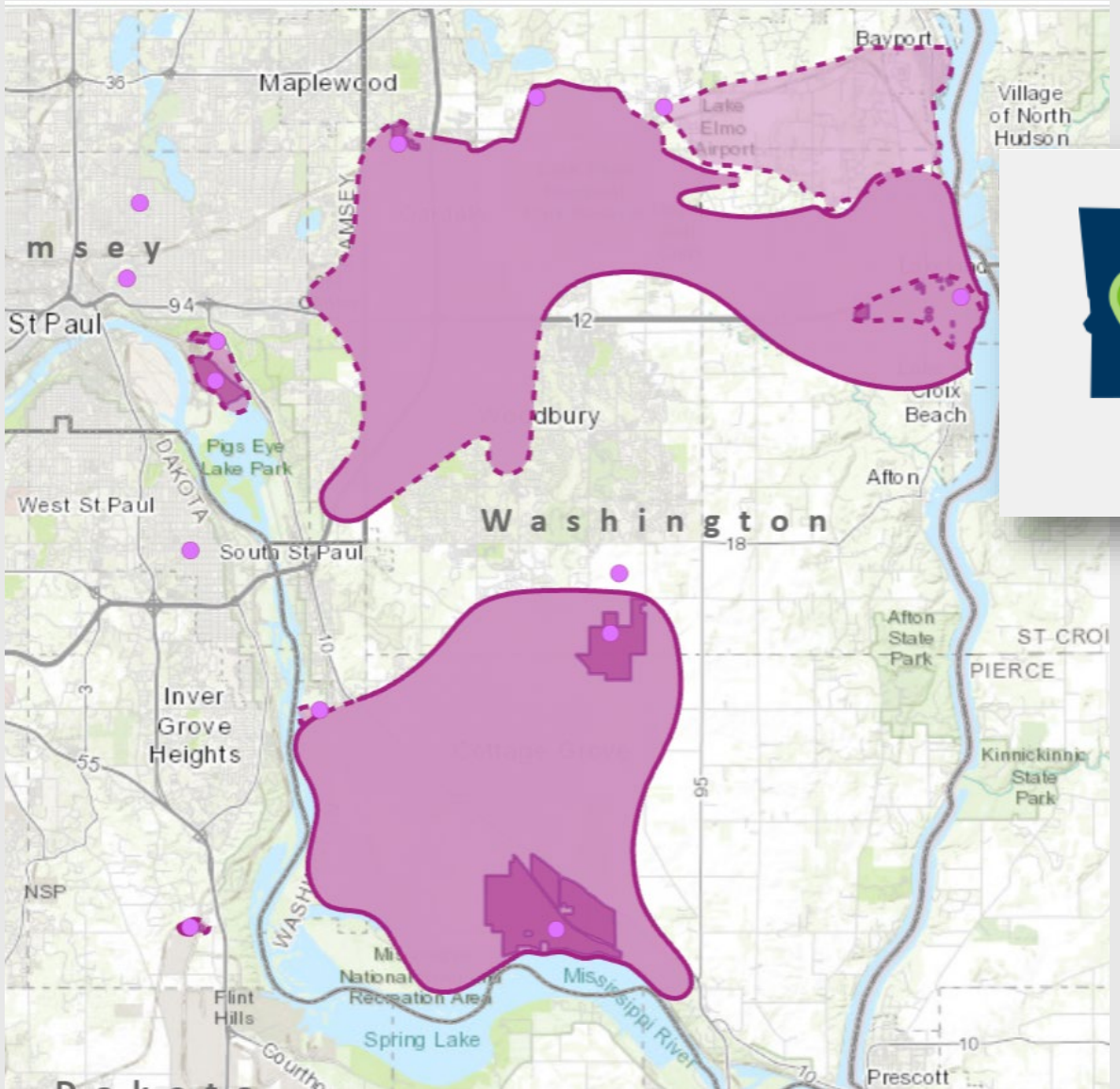
**1956-1960 is an approximate determination of the date range waste was received from 3M*

Activities at WCL





County-Wide Impacts: Groundwater Contamination Atlas



Groundwater Contamination Atlas

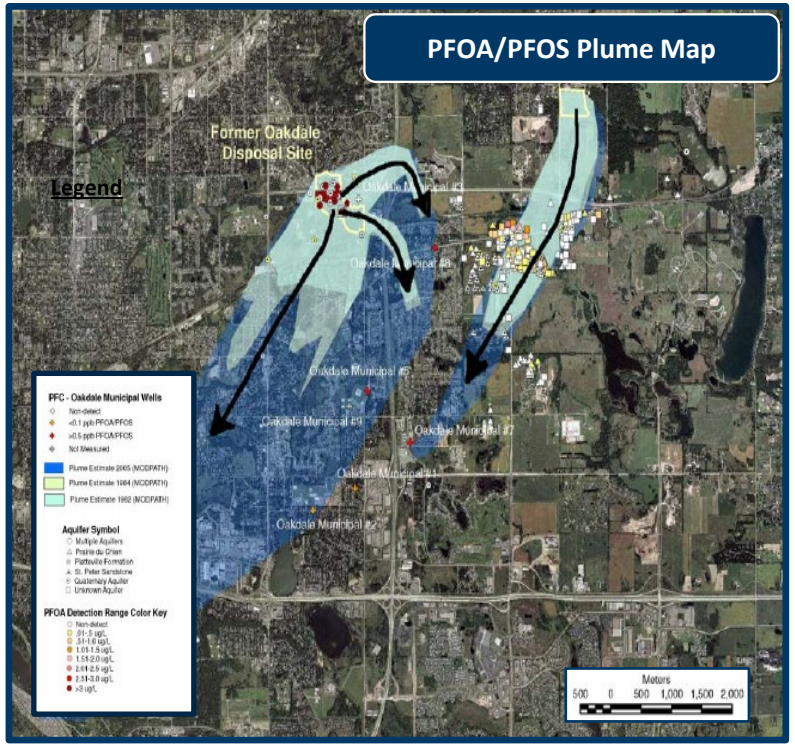
A map-based tool for learning about polluted sites around the state. Learn the story about contamination at a specific site and download groundwater sampling data.

Search the atlas

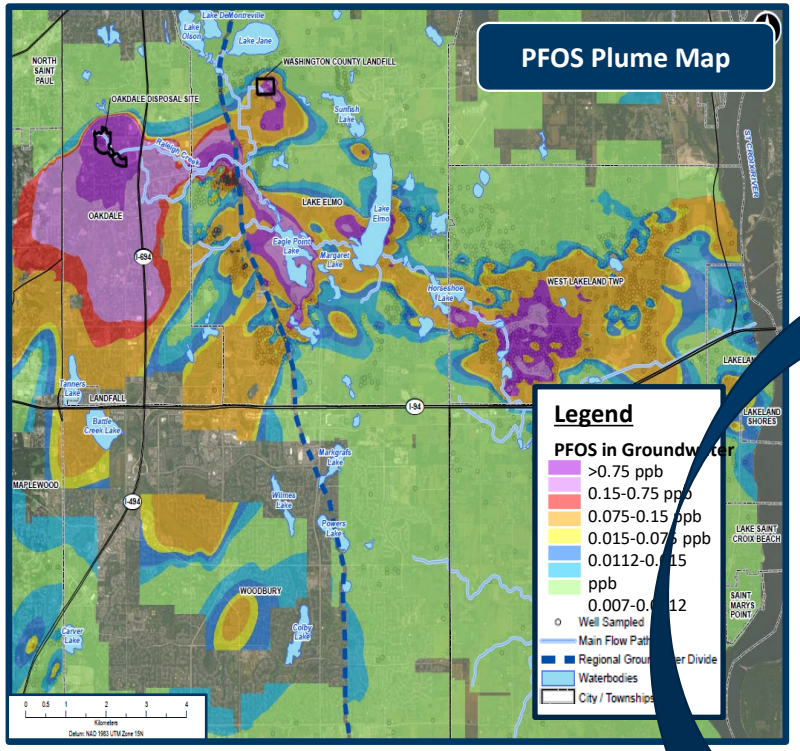
https://www.pca.state.mn.us/about-mpca/minnesota-groundwater-contamination-atlas

Evolving Conceptual Site Model
All Aquifers vs. Individual Aquifers

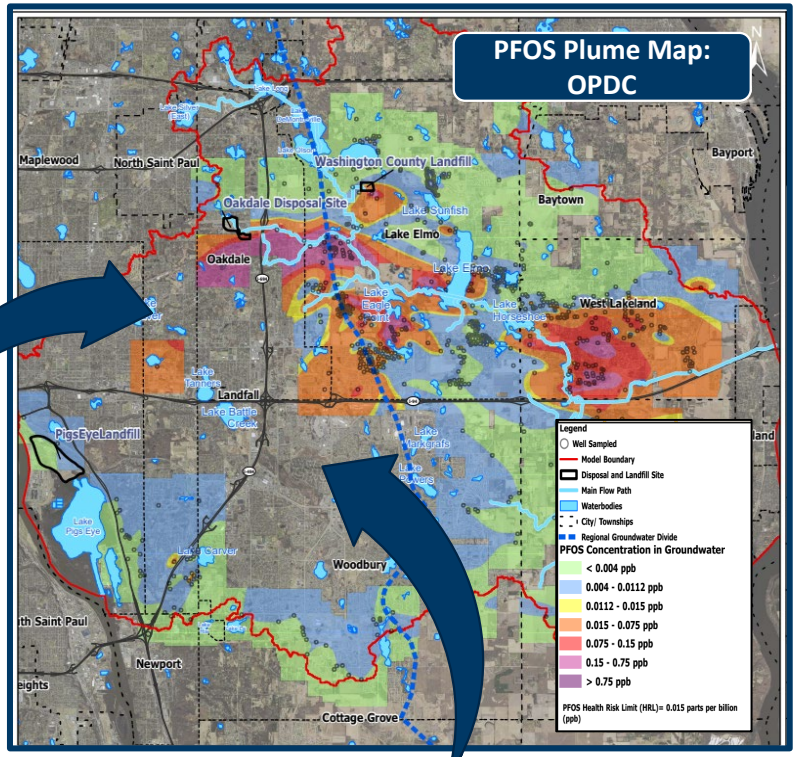
All Aquifers 2005



All Aquifers 2021

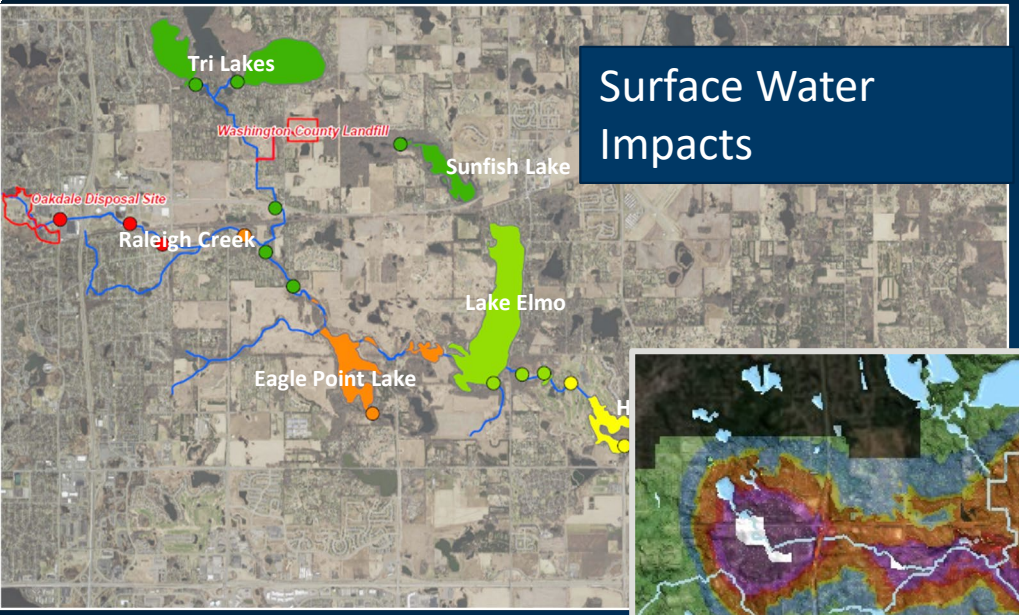


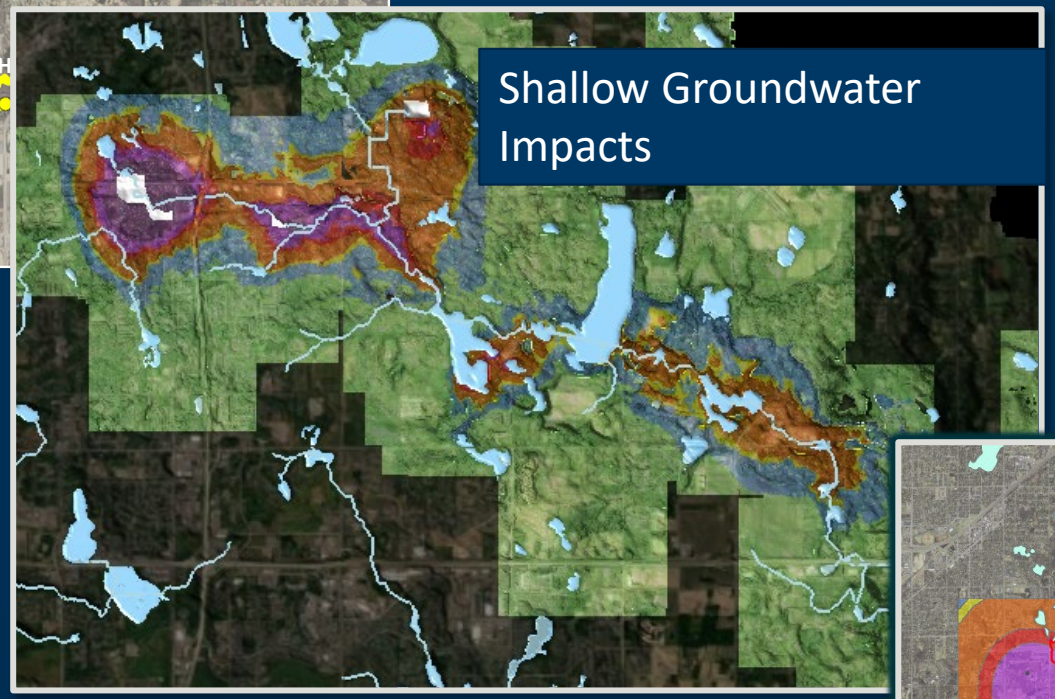
Prairie du Chien 2021

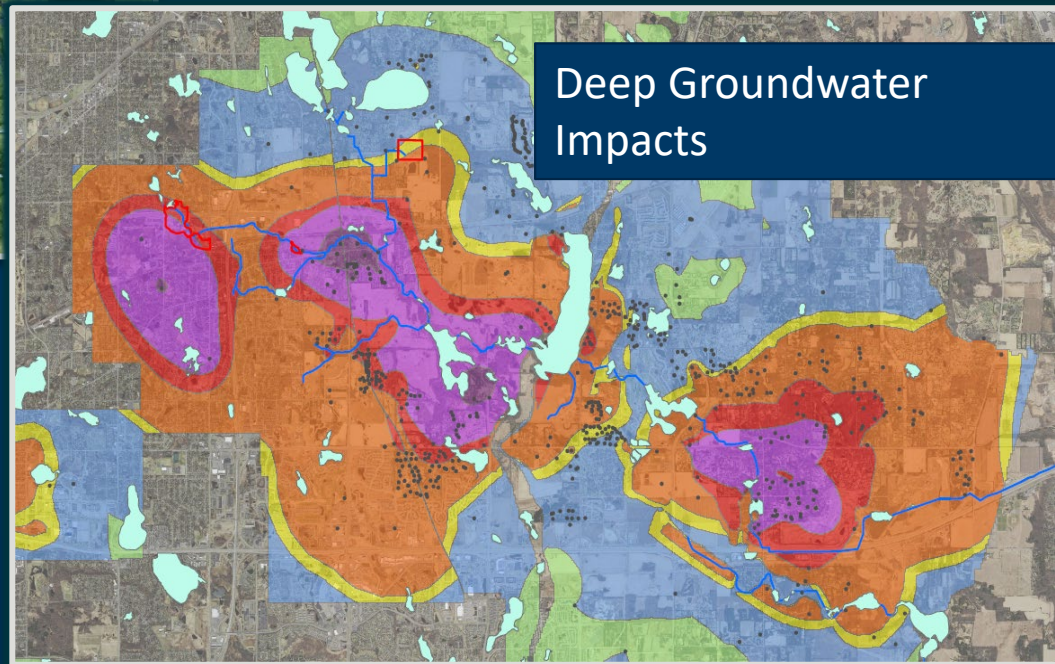


Data Gaps Remain

Project 1007 Lessons: PFAS impacts from surface waters to drinking water supply aquifers



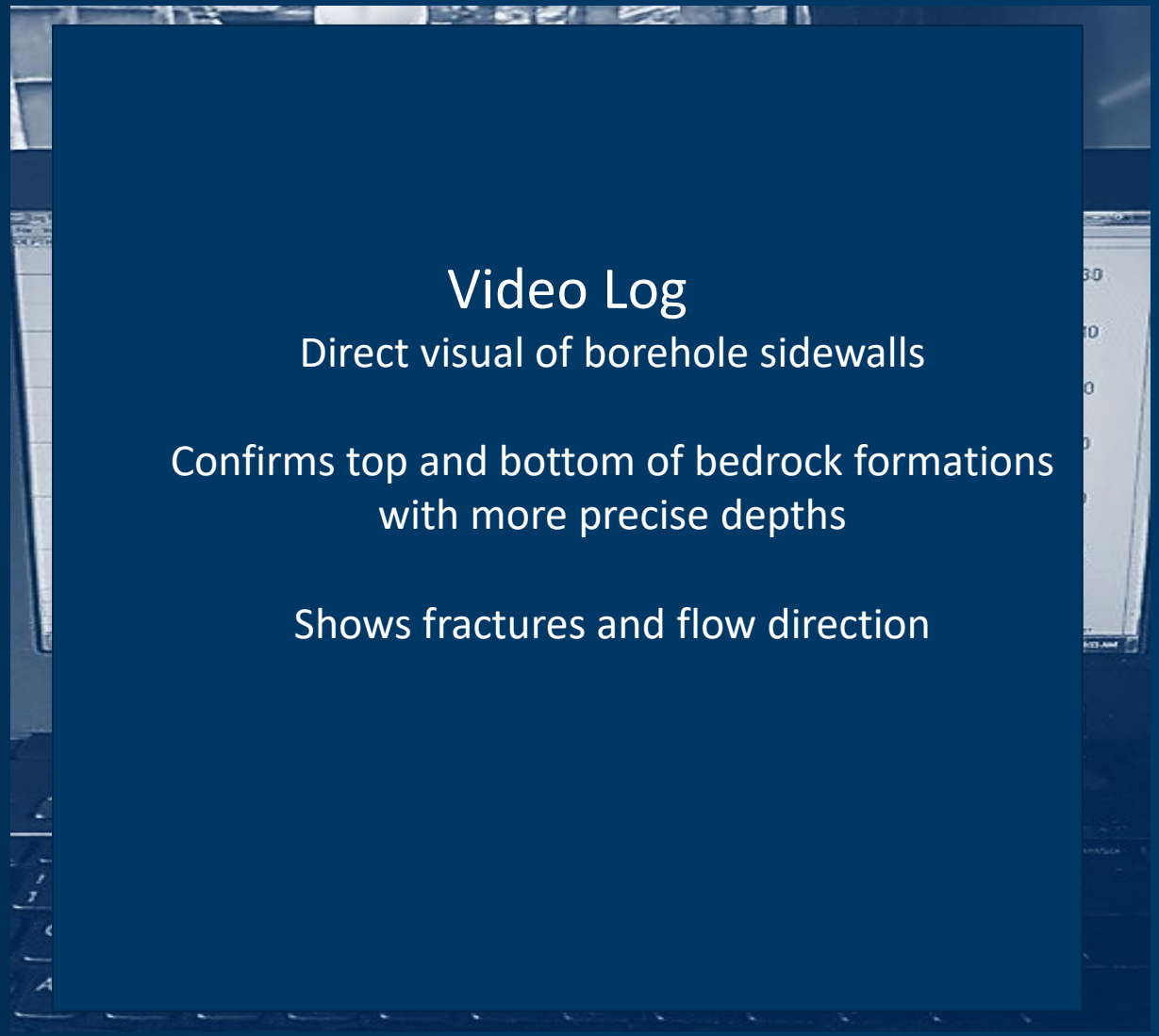




Investigation and Characterization Examples
Example #1 – Downhole Geophysics

Borehole Video and Geophysical Tools

High Resolution Data = Better Understanding of PFAS Migration



Video Log

Direct visual of borehole sidewalls

Confirms top and bottom of bedrock formations with more precise depths

Shows fractures and flow direction

Natural Gamma Log

Confirms top and bottom of bedrock formations

Caliper Log

Measures borehole diameter

Electro-Magnetic Flowmeter

Measures ambient vertical flow speed

Multi-Parameter E-Log

Measures fluid/single point/normal resistivity and temp

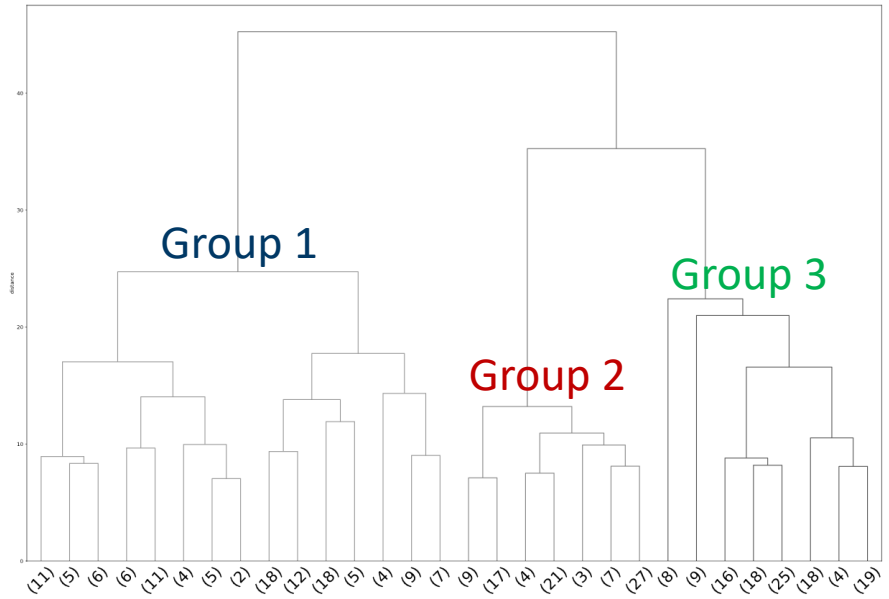
Changes in diameter, flow, and temperature can all serve to indicate significant fractures

Investigation Sample Collection Groundwater and Soil Strategy

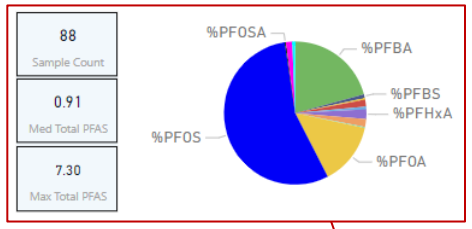
- Groundwater and soil samples in surficial glacial units *while* drilling.
- Sampling depth intervals based on soil cuttings from the adjacent deeper well.
- Groundwater samples collected at:
  - Top of the water table
  - Intervals of finer-grained and coarser-grained soils
  - Immediately above first bedrock formation
- Soil samples collected at:
  - Intervals coincident with groundwater samples
  - Zone immediately above water table and first bedrock
  - Any potential confining layers

Investigation and Characterization Examples
Example #2 – Pattern Recognition of PFAS Chemical Data

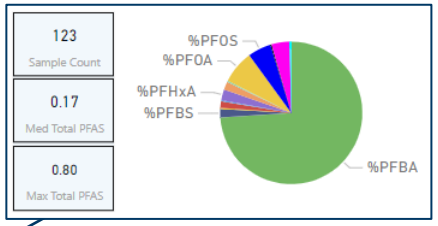
Multivariate Statistical Clustering: PFAS Signature Groups

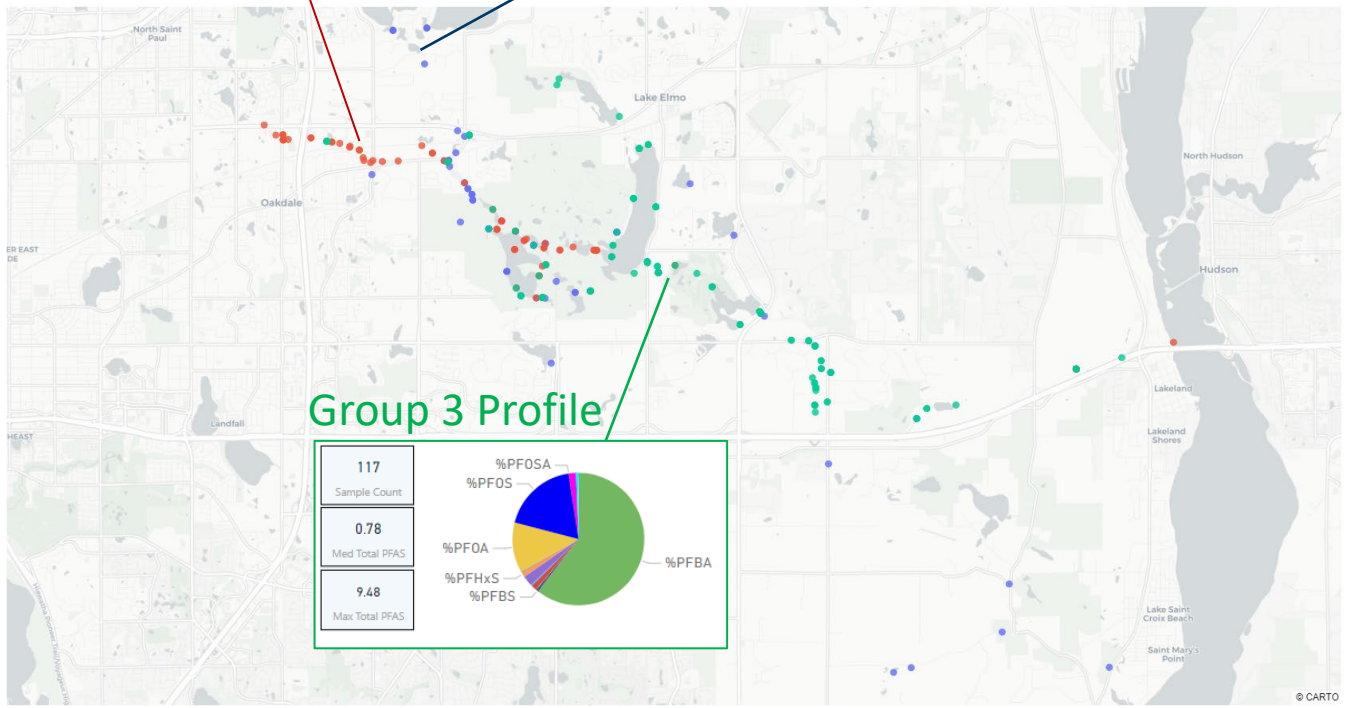


Group 2 Profile



Group 1 Profile

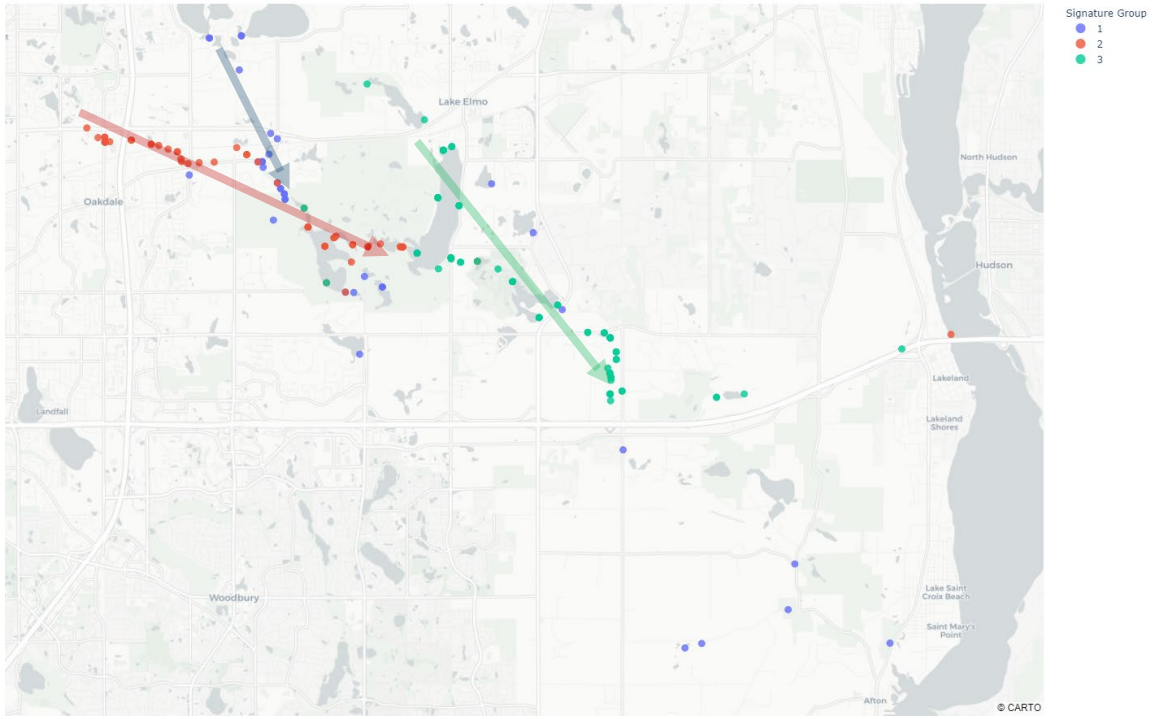




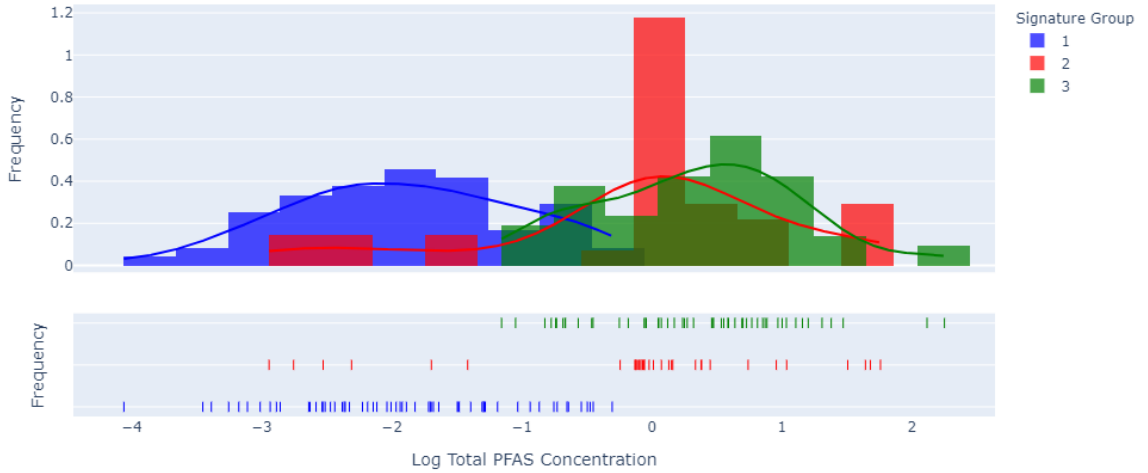
Group 3 Profile

Large-Scale Patterns

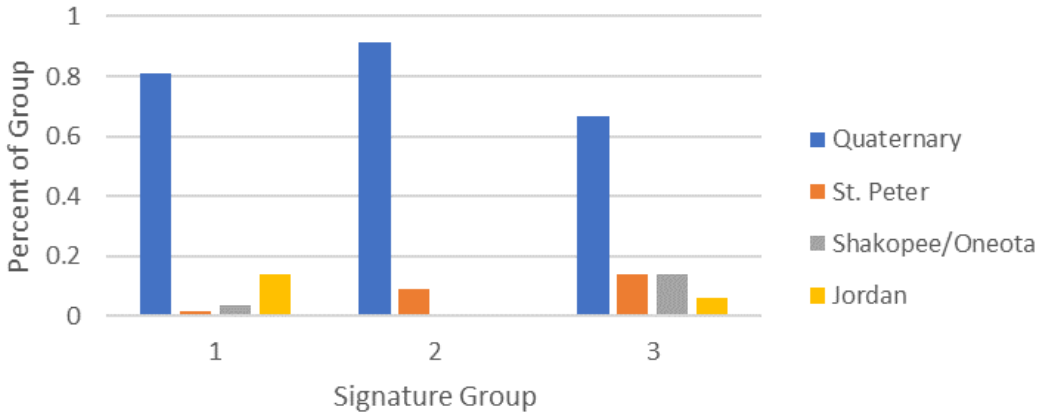
Surface Water: Potential Progression of Signatures



Log Total PFAS Magnitude by Signature Group



Aquifer Prevalence by Signature Group

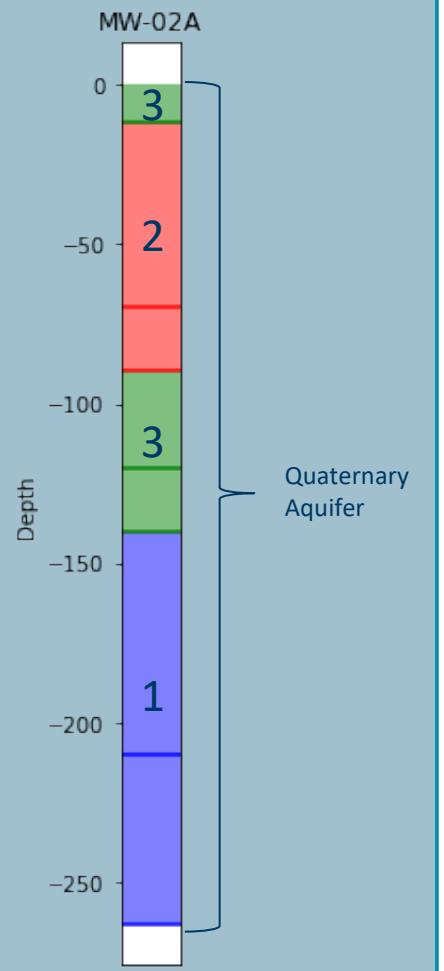


Complex Environmental Fate and Transport Behavior in Groundwater

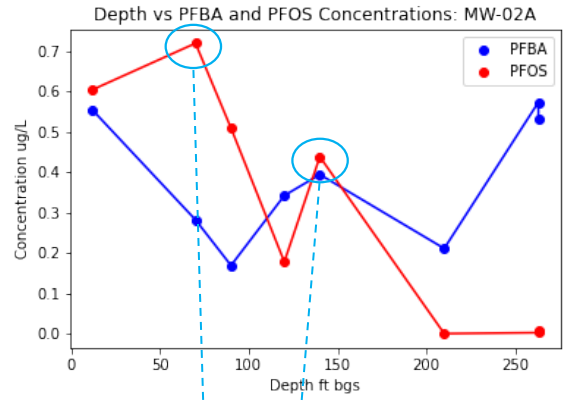
Identifying PFAS Signature Changes in Individual Wells

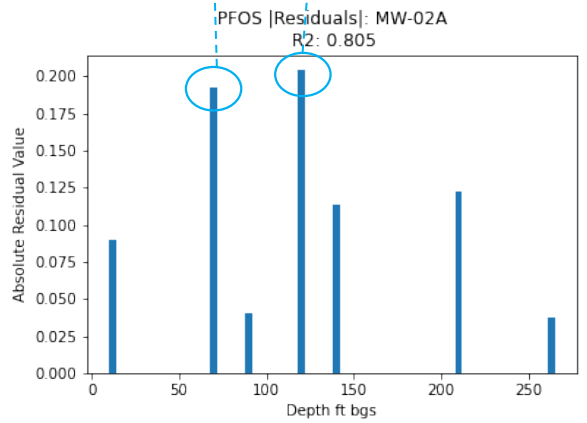
Group 2 PFOS / Group 3 PFBA+PFOS

Group 1 PFBA



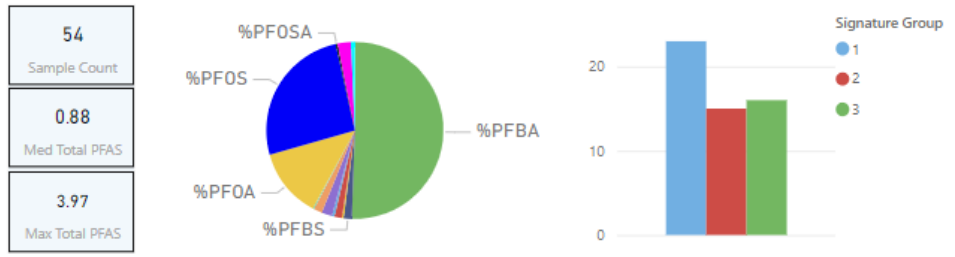
Quantifying F+T Behavior Using Regression and Residual Analysis



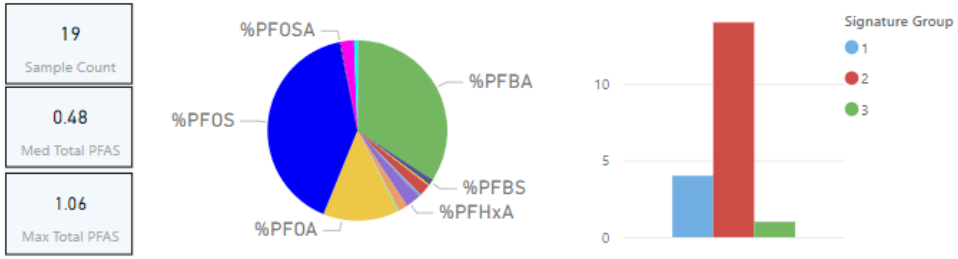


Narrowing Focus using Machine Learning
Eagle Point Lake Groundwater

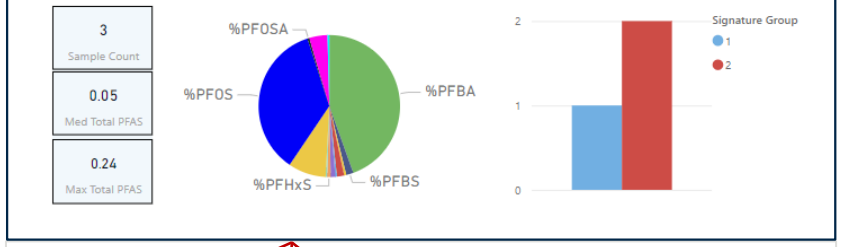
GW: Collective Eagle Point Lake PFAS Signatures

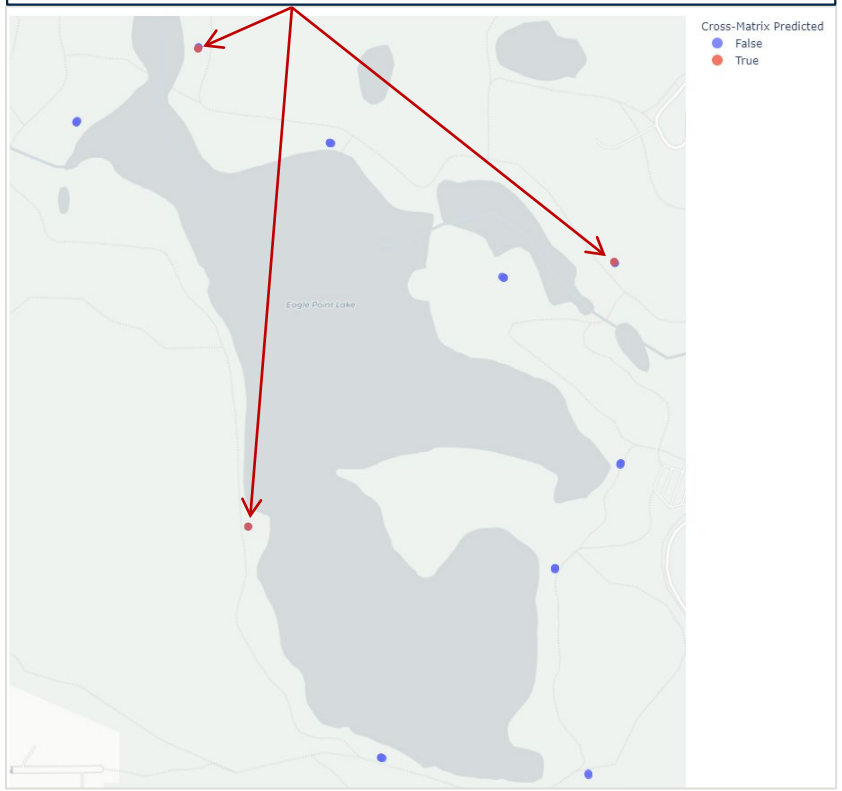


SW: Collective Eagle Point Lake PFAS Signatures

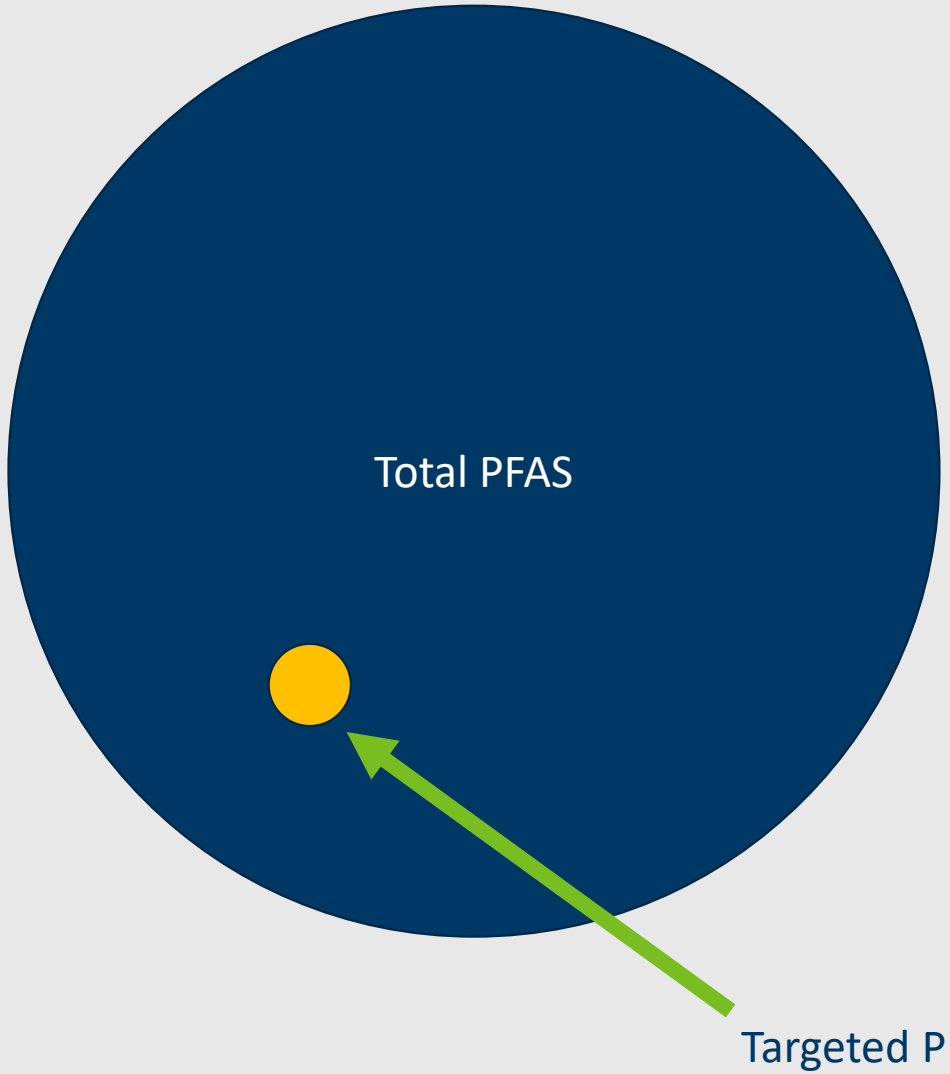


Machine Learning Model
Predicted Surface Water Signature in GW Samples





Investigation and Characterization Examples
Example #3 – Non-Targeted Analysis Pilot Project



MN's PFAS Blueprint:

- First step in managing pollution is understanding which compounds occur where and at what levels.
- Existing targeted PFAS methods only look for ~20-40 individual chemicals.
- How can we use new tools to improve our understanding?
  - Non-targeted analysis

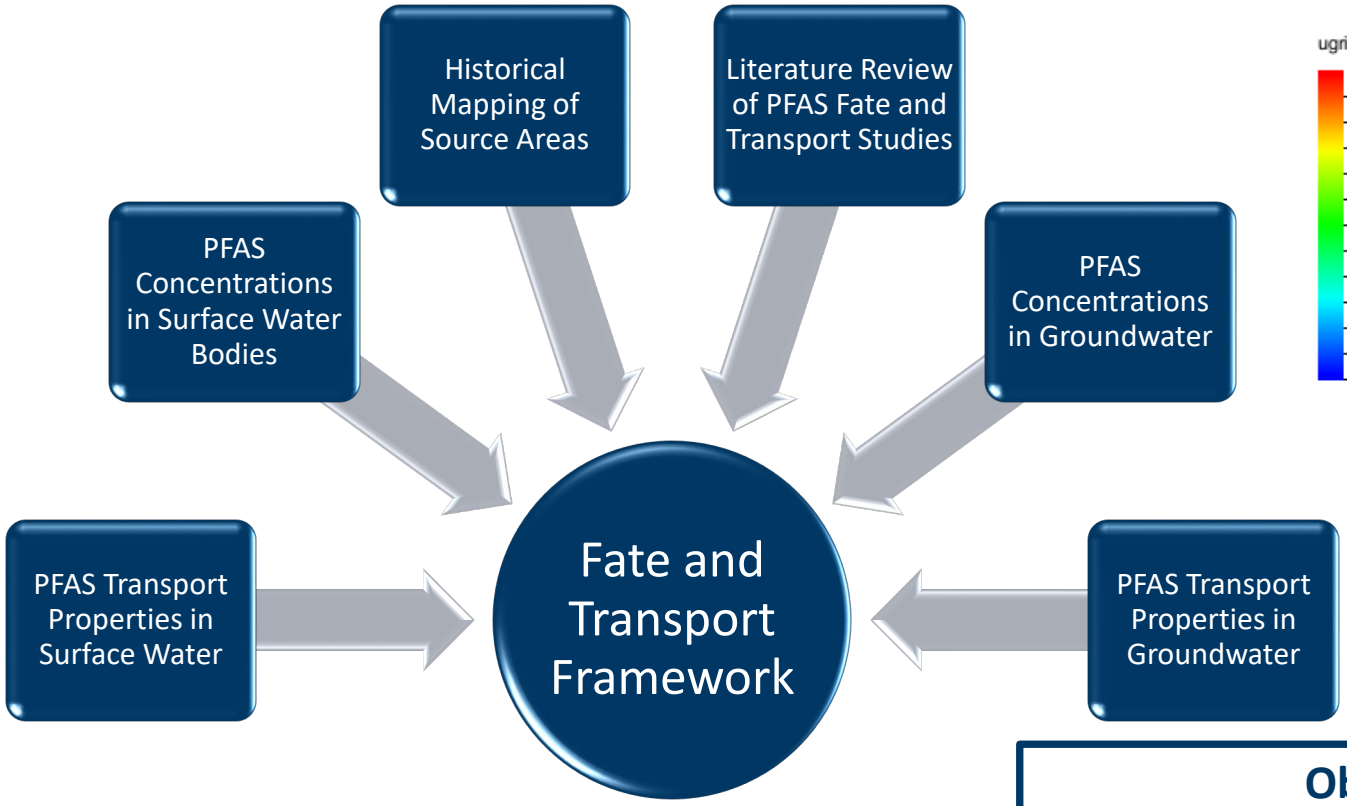
EPA collaboration: exploring the potential of NTA

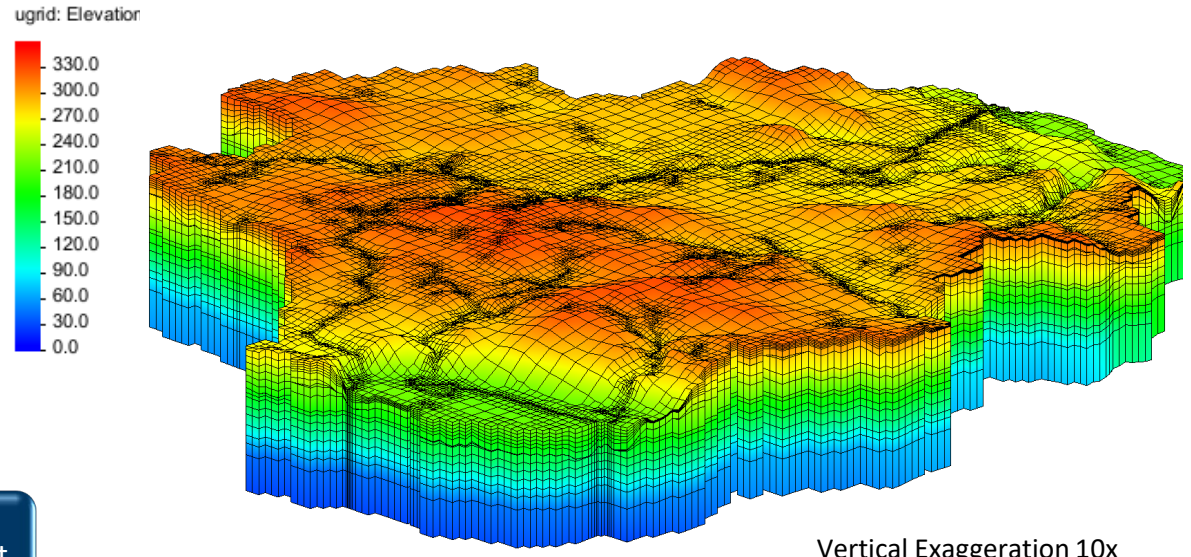
Minnesota project goals:

1. Identify new contaminants of potential interest in the East Metro PFAS contamination area
2. Examine the fate and transport behaviors of these compounds
3. Effectively communicate results to internal and external audiences

What can NTA teach us that we didn't already know?

Building Out from Characterization – PFAS Fate and Transport Model





Vertical Exaggeration 10x
(view angle: bearing 315, dip 20)

Objectives of Fate and Transport Model

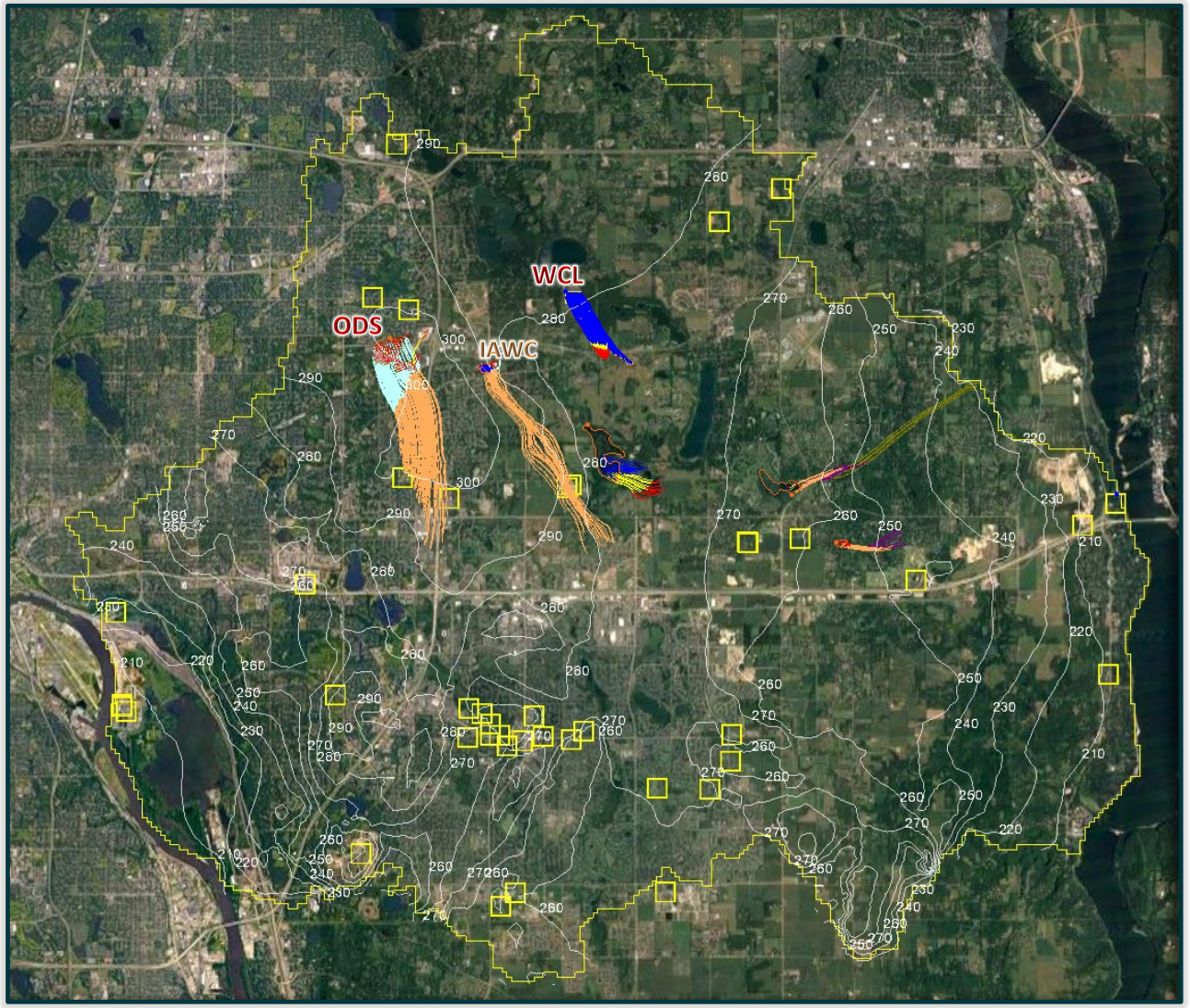
Identify Source Areas and Probably Migration Pathways to Receptors

Identify Hydrologic Conditions That May Modify Migration Pathways

Identify Anthropogenic Activities That May Modify Migration Pathways

Develop Numeric Modelling Tool to Support Future Plume Capture

Particle Tracking: 30 Years Time

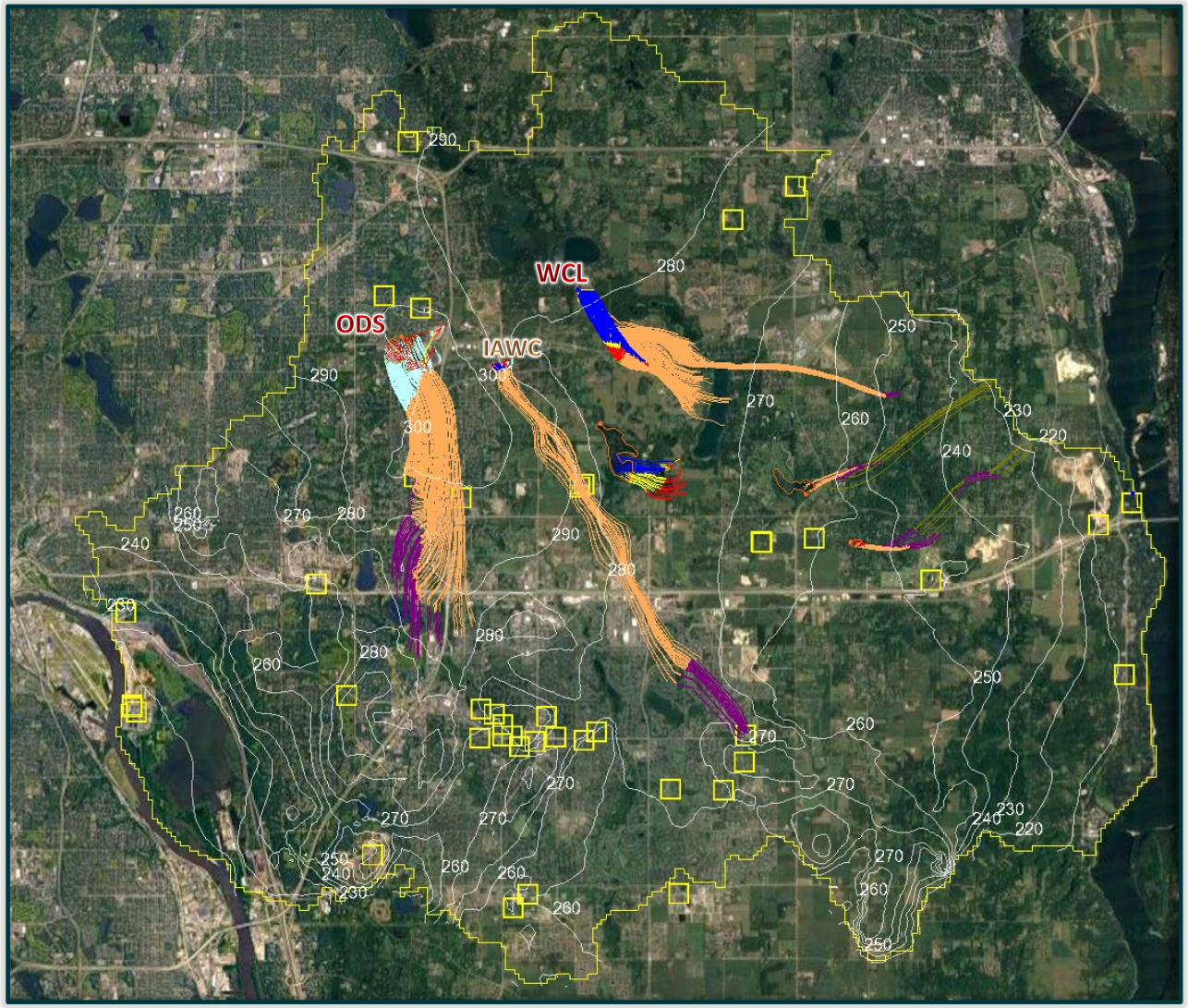


Pathline Color Corresponding Aquifer

- Quaternary Aquifer
- Decorah Shale
- Shallow Fractured Bedrock
- Platteville Aquifer
- St Peter Aquifer
- PDC Aquifer
- Jordan Aquifer
- St Lawrence and Deeper

Particles were released from the Oakdale Disposal Site (ODS), Washington County Landfill (WCL), Ideal Avenue Wetland Complex (IAWC), Eagle Point Lake, Horseshoe Lake, and West Lakeland Storage Pond.

Particle Tracking: 50 Years Time



Pathline Color Corresponding Aquifer

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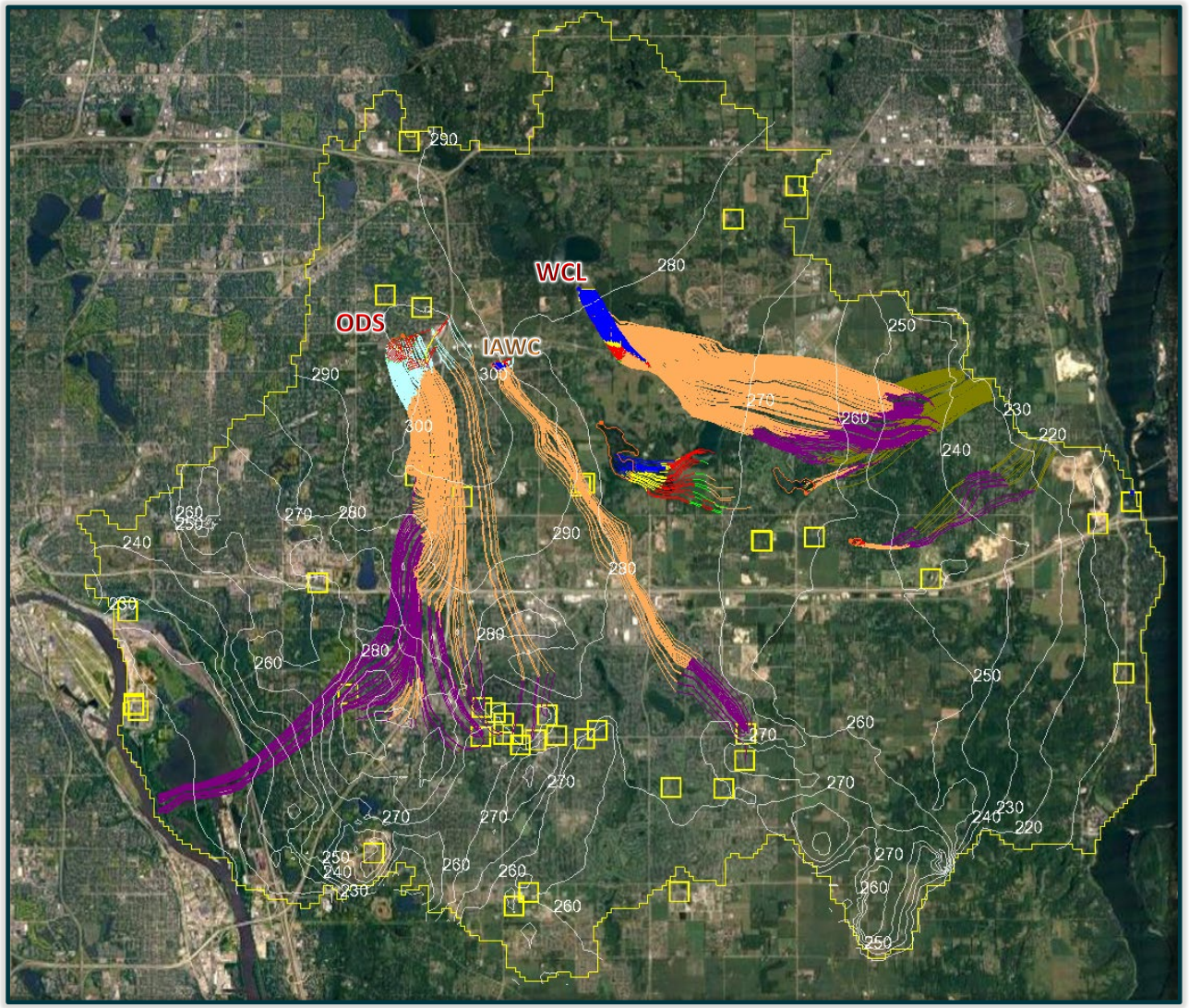
- Decorah Shale
- Shallow Fractured Bedrock
- Platteville Aquifer
- St Peter Aquifer
- PDC Aquifer
- Jordan Aquifer
- St Lawrence and Deeper

Particles were released from the Oakdale Disposal Site (ODS), Washington County Landfill (WCL), Ideal Avenue Wetland Complex (IAWC), Eagle Point Lake, Horseshoe Lake, and West Lakeland Storage Pond.

Particle Tracking: 100 Years Time



Pathline Color Corresponding Aquifer

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- Decorah Shale
- Shallow Fractured Bedrock
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- St Peter Aquifer
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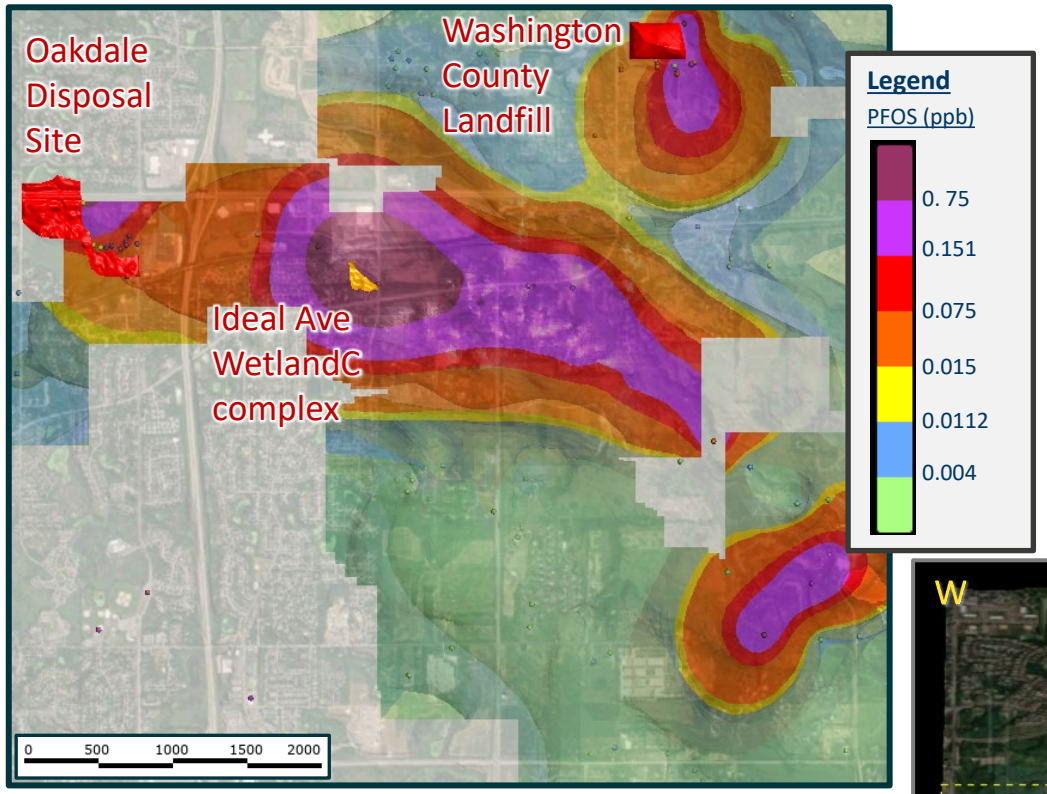
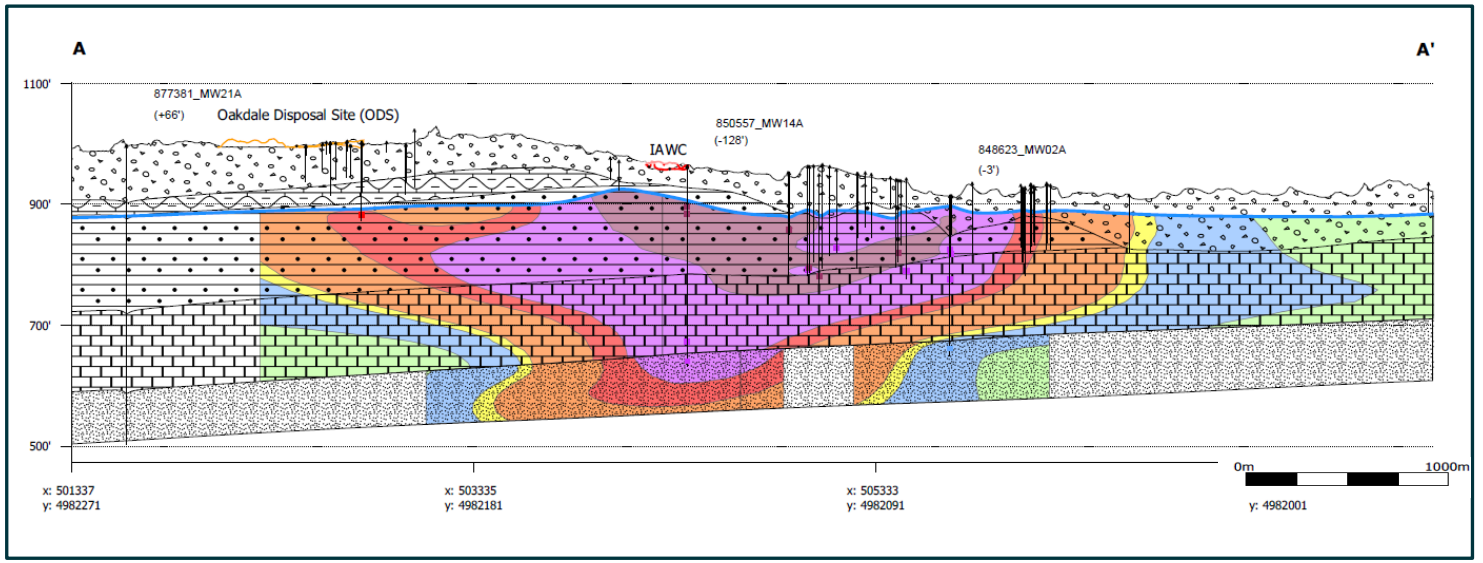
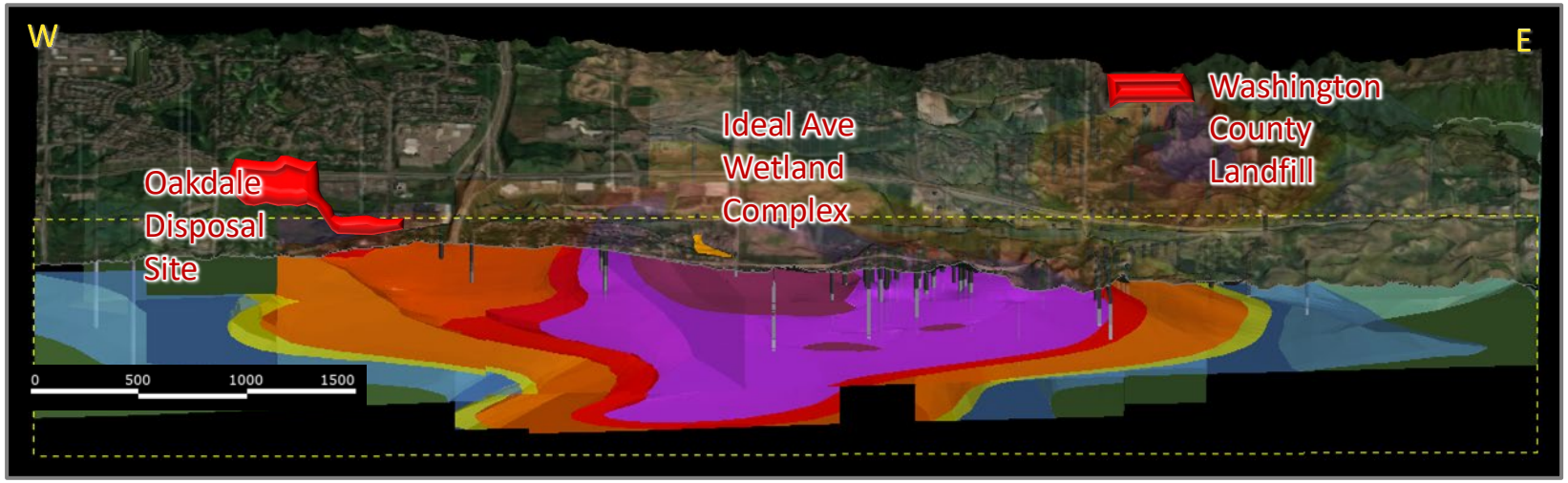
- Jordan Aquifer
- St Lawrence and Deeper

Particles were released from the Oakdale Disposal Site (ODS), Washington County Landfill (WCL), Ideal Avenue Wetland Complex (IAWC), Eagle Point Lake, Horseshoe Lake, and West Lakeland Storage Pond.

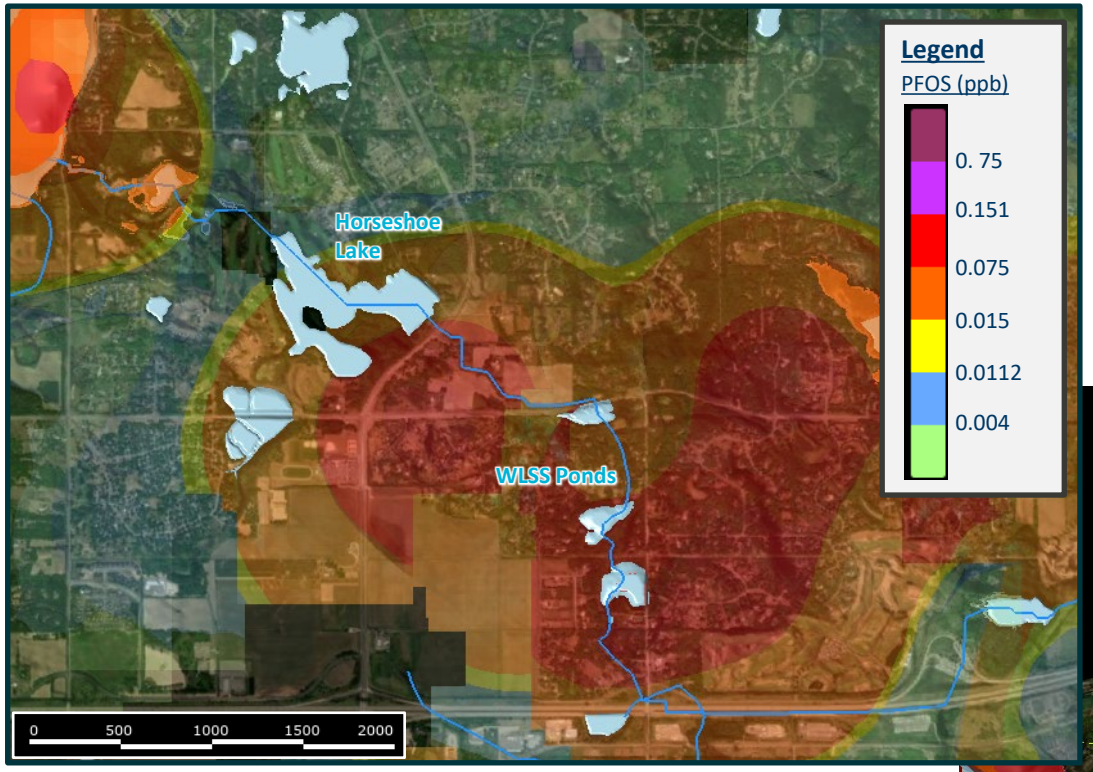
3D Visualization Leapfrog: Ideal Avenue Wetland Complex Secondary Source Mass

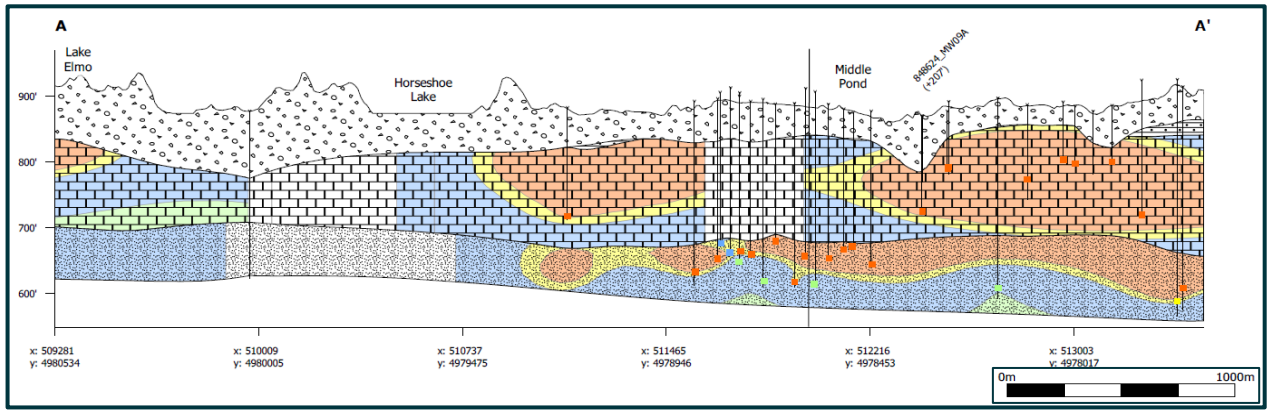


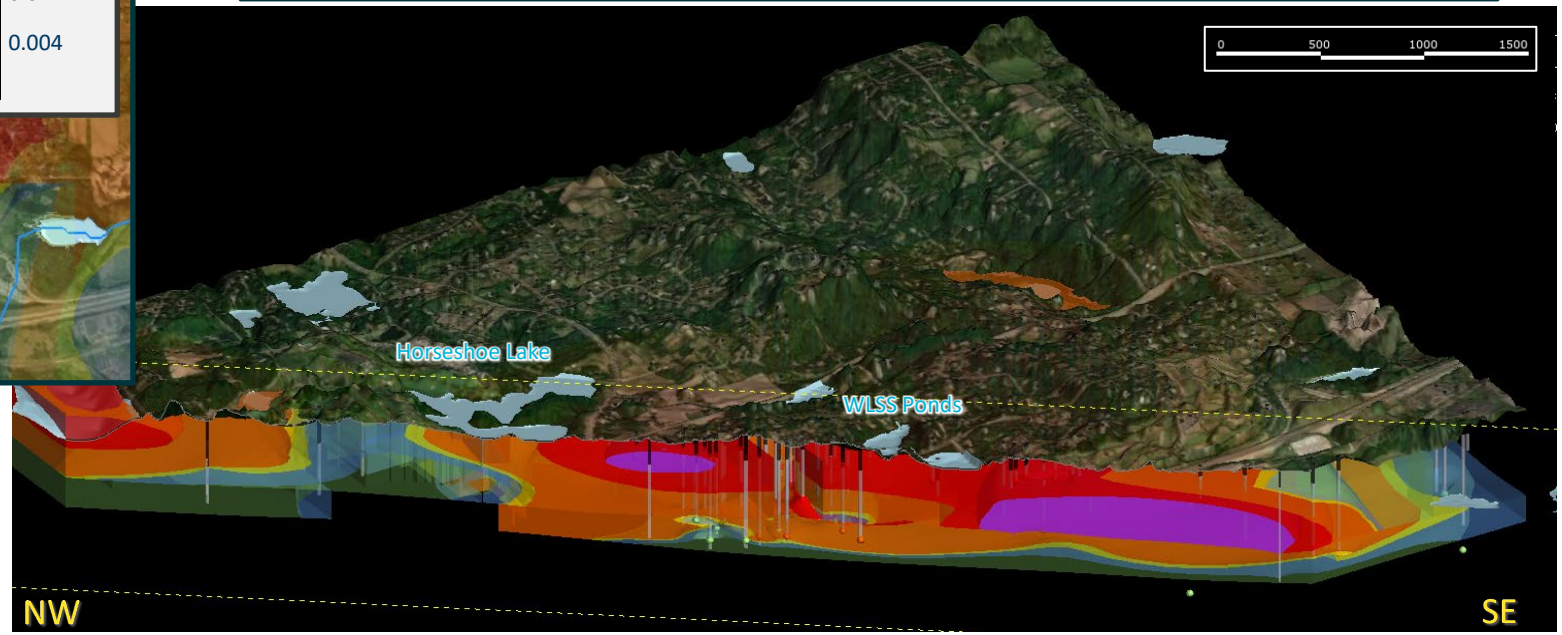




Model 3D Visualization: West Lakeland Infiltration







Project 1007 Partners:

DNR, MDH, MGS, UofM, VBWD, EPA ORD, East Metro Cities, Washington County, Met Council and Settlement Work Groups

Consultant: AECOM

Laboratory: AXYS SGS