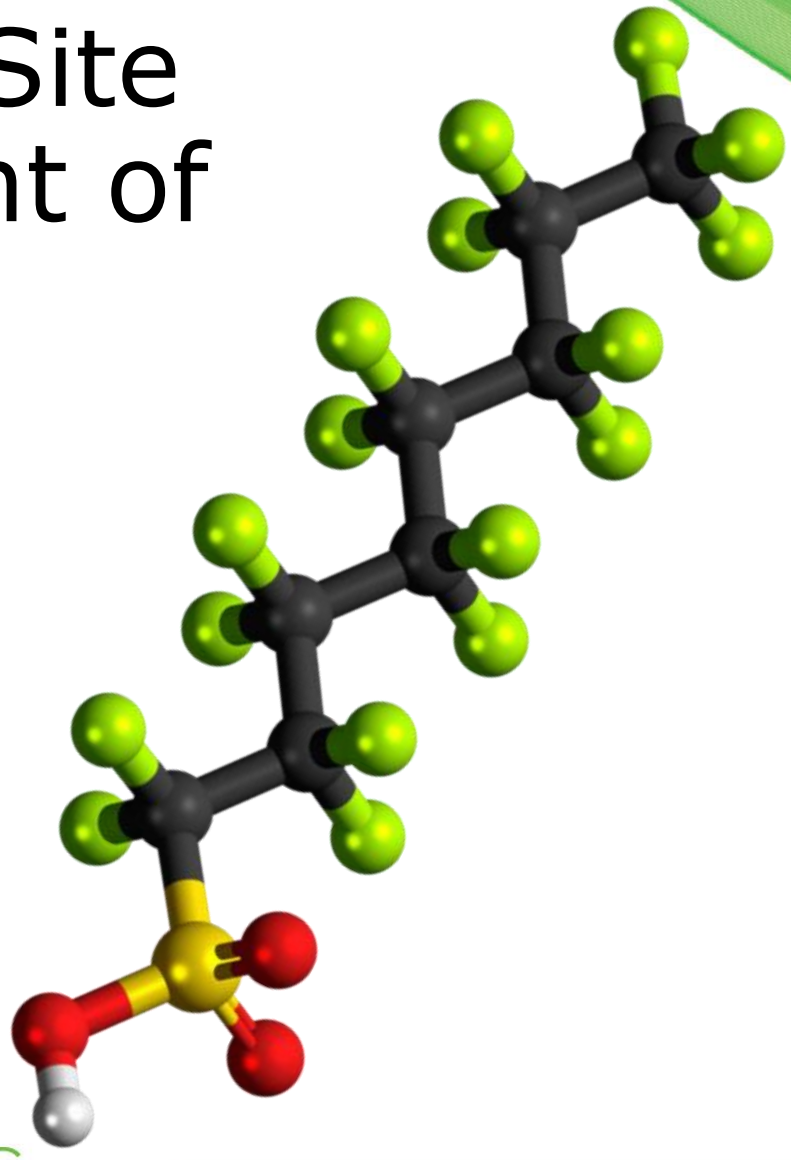
REMTEC & EMERGING CONTAMINANTS SUMMIT

OCTOBER 15-17, 2024

Lessons Learned from PFAS Site Investigations & Development of Conceptual Site Models

Chris Wenczel, P.G.
Director/Hydrogeologist
Environmental Resources Management
October 16, 2024



REMTEC & EMERGING CONTAMINANTS SUMMIT
OCTOBER 15-17, 2024

Case Study Site #1

Somewhere In The Midwest The Wind Blows & A River Flows…….

Air Dispersion, Deposition & Soil Investigation

Industrial Wastewater

Groundwater/Surface Water Interactions

Air Dispersion, Deposition Modeling & Off-site Soil Investigation - CSM Building

PFAS particulate emissions, dispersion and deposition can have far reaching impacts – soil, leaching to groundwater, groundwater discharge to surface water and/or direct deposition.

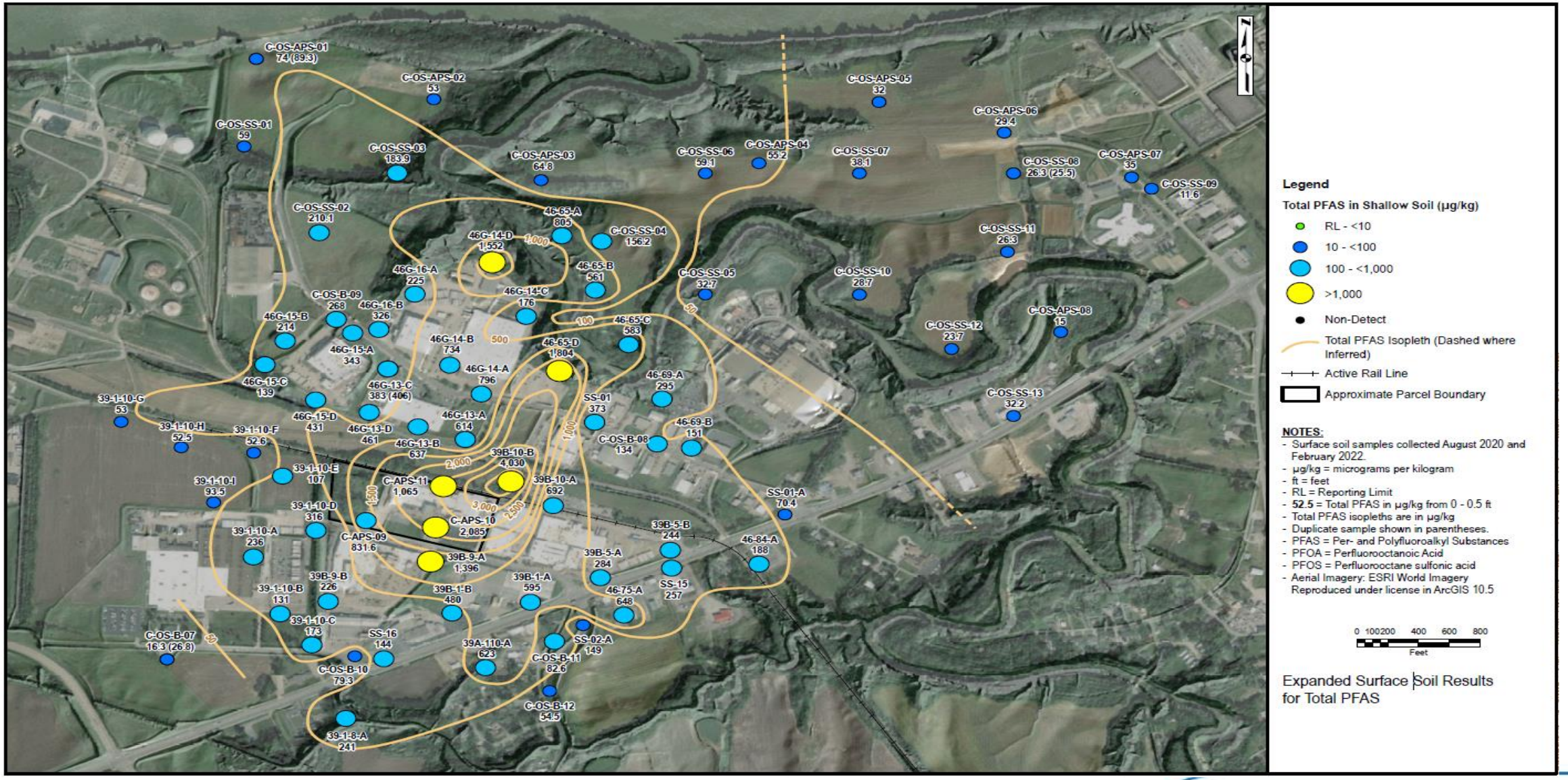
- Industrial park setting - facility releases PFAS - emitted in air discharge stacks.
- Stack testing was performed to estimate PFAS particulate mass discharge and used to perform air dispersion/deposition modeling to estimate predicted deposition rates and footprint.
- Footprint was used to plan off-site surficial soil sampling program.
- Soil sampling performed on a 500’ grid over a ~207-acre area.
- Land use within grid area: buildings, paved surface, roads, surface drainage/creeks and agricultural fields.
- Off-site access to private properties was required.

Off-site Surficial Soil Sampling Scheme For PFAS

Total PFAS In Off-site Surficial Soil

Shallow Soil Results for Total PFAS

Total PFAS In Off-site Surface Soil – Expanded Results



Legend

Total PFAS in Shallow Soil (µg/kg)

- RL - <10
- 10 - <100
- 100 - <1,000
- >1,000
- Non-Detect
- Total PFAS Isopleth (Dashed where Inferred)
- Active Rail Line
- Approximate Parcel Boundary

NOTES:

- Surface soil samples collected August 2020 and February 2022.
- µg/kg = micrograms per kilogram
- ft = feet
- RL = Reporting Limit
- **52.5** = Total PFAS in µg/kg from 0 - 0.5 ft
- Total PFAS isopleths are in µg/kg
- Duplicate sample shown in parentheses.
- PFAS = Per- and Polyfluoroalkyl Substances
- PFOA = Perfluorooctanoic Acid
- PFOS = Perfluorooctane sulfonic acid
- Aerial Imagery: ESRI World Imagery Reproduced under license in ArcGIS 10.5

0 100200 400 600 800
Feet

Expanded Surface Soil Results for Total PFAS

Summary - Air Dispersion, Deposition Modeling & Off-site Soil Investigation

- Isoconcentration plot of total PFAS in surficial soil very similar to modeled deposition footprint and prevailing wind data (wind rose).
- Grid sampling locations were adjusted to edge of paved areas to avoid penetrations.
- Increased PFAS concentrations anticipated at edges of pavement due to precipitation overwash causing PFAS-laden particulates from rooftops and paved surfaces to accumulate resulting in concentration contouring bias.
- Most all of the surrounding buildings and paved surfaces were constructed before facility began operations in 1998 and underlying soils are presumed to be non-impacted.
- Isoconcentration plot does not accurately portray acreage of PFAS-impacted soils and affected soil area/volume calculations should only consider unpaved areas.
- Is it all a result of air emissions from the target facility?

Other Sources? - Industrial Wastewater Sampling Results For Total PFAS

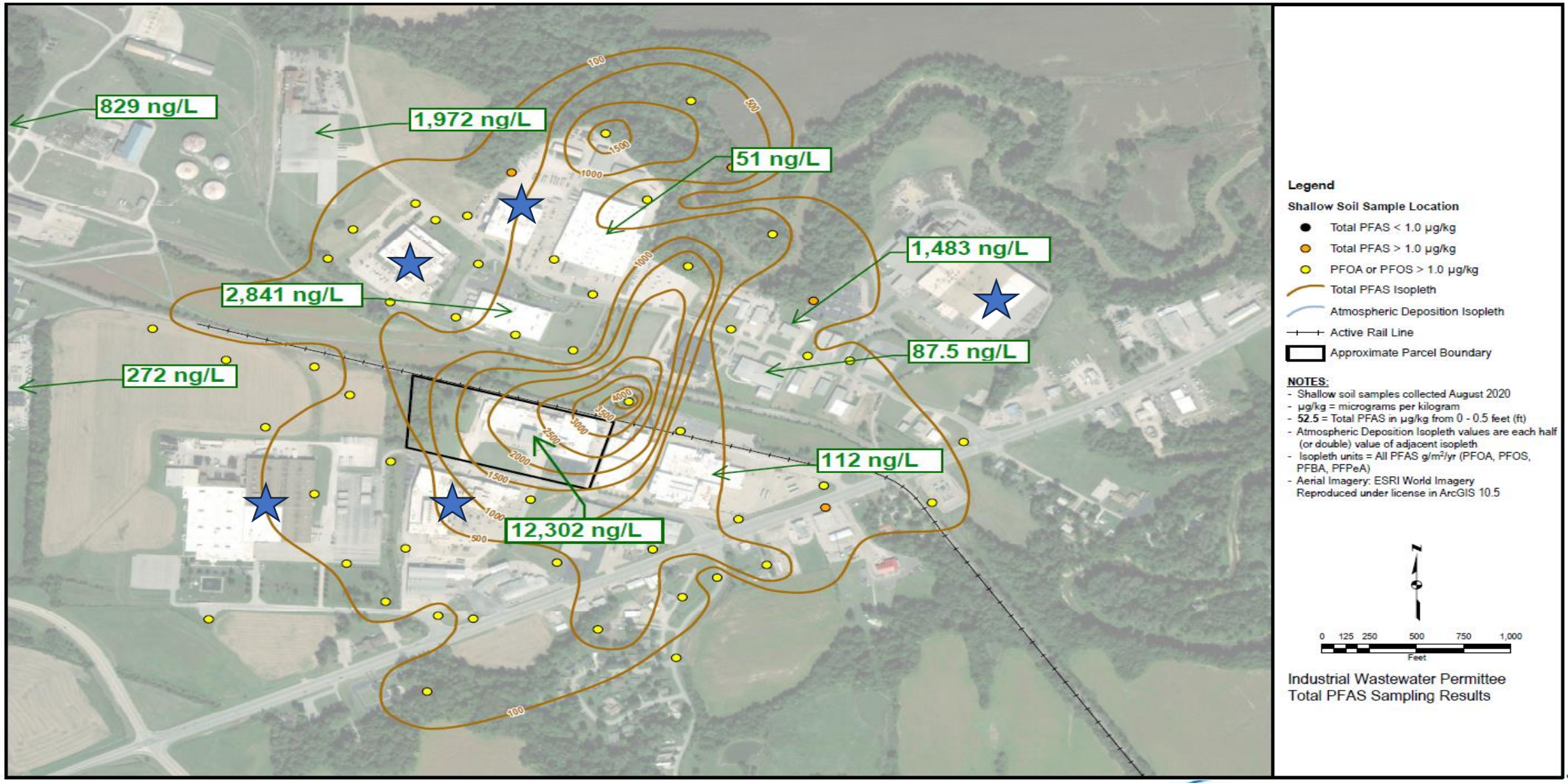
In anticipation of future POTW effluent limitation guidelines (ELGs) for PFAS that could result in increased treatment requirements, the municipality collected wastewater samples for PFAS analyses from industrial wastewater permittees to benchmark the issue.

Industrial Permittee Core Business Activity	Total PFAS ng/L
Steel and aluminum commercial vehicle wheels/wheel-end components and assemblies	13
Specialty metals and mineral products	13
Grain milling	7
Chemicals and ingredients distribution	272
Supplier of nylon polymers, co-polymers and specialty polymers	829
Hospital	24
Precision die-cast, machined, and assembled products for the automotive industry	50
Aluminum recycling	303
Paper recycling and paper products	183
Thermoplastics in a wide range of technologies, available in pellet, sheet, and film	47
Target Facility	12,302
Industrial uniform and linen provider	190
Paper, plastic, metal packaging , adhesives and coating	2,841
Cold steel bars and wire manufacturing	1,972
Polymers, thermoplastics, esters, colorants, PVC thermoplastic elastomers	1,483
Plastic colorants	88
Agricultural feed	10
Agricultural hatchery	5
Meat processing	15
WWTP Influent	91
WWTP Effluent	312
WWTP Biosolids	20,424*

* ng/kg

- Wastewater sampled for PFAS from 19 permittees including the target facility, eight other nearby industrial properties, and the POTW influent, effluent and biosolids.
- A variety of different industries are represented in the sampling.

Industrial Wastewater Sampling Results For Total PFAS



Confirmation of PFAS at surrounding facilities complicates off-site impact attribution.

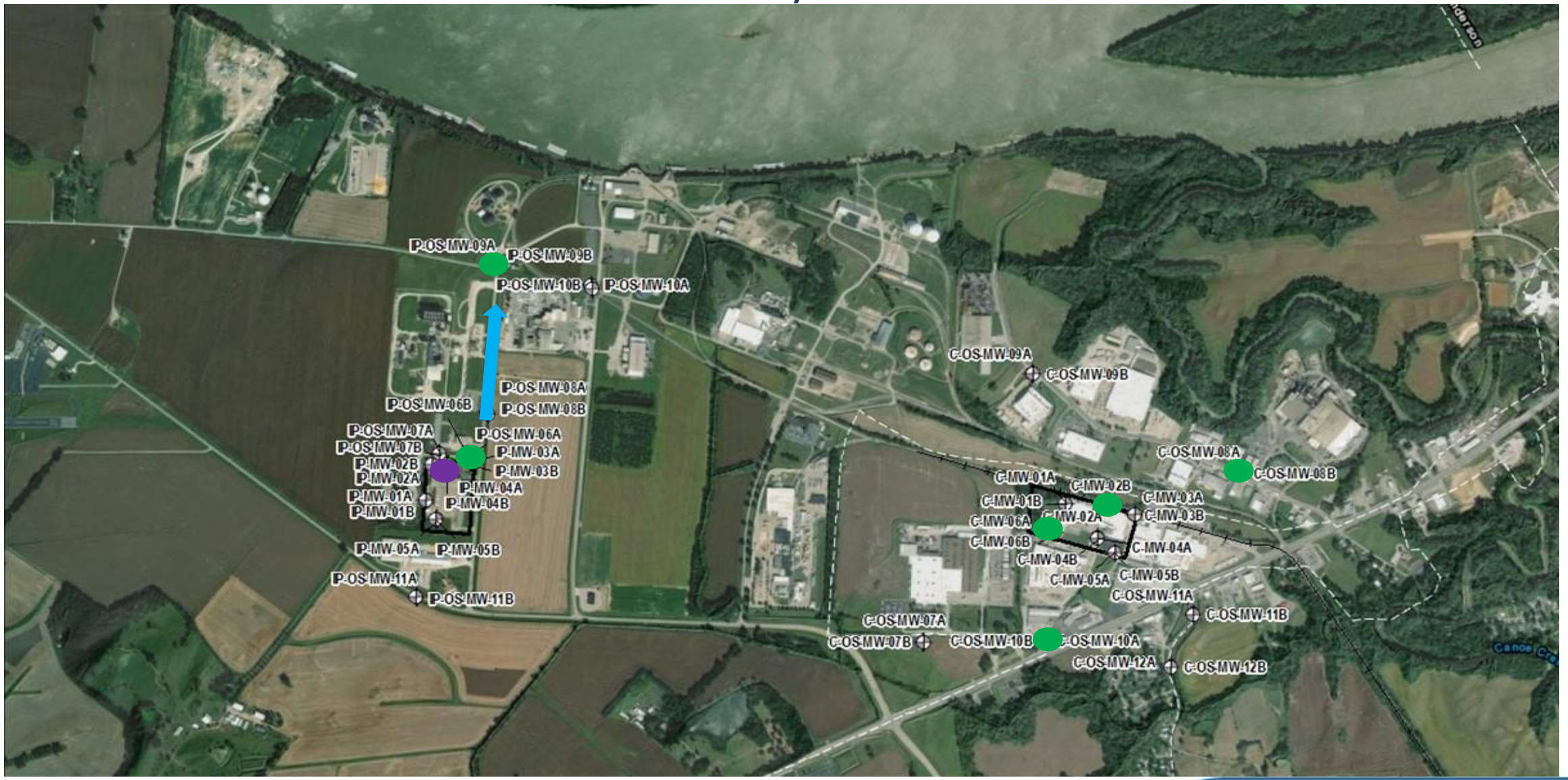
Summary - Industrial Wastewater Sampling Results For Total PFAS Summary

- Highly likely that the many operators are still unaware of PFAS in materials and/or items used at their facilities. Ongoing vetting should be occurring due to TSCA/TRI reporting requirements.
- If you look for PFAS off-site, you will find numerous sources and its presence in environmental media in residential, commercial and industrial land use settings.
- This complicates conclusive attribution of off-site PFAS impacts which become more uncertain with increasing distance from a given property. Such uncertainty cannot be ignored when evaluating off-site PFAS impacts, migration pathways and receptors.
- A POTW Influent PFAS Study as part of EPA's Effluent Limitation Guidelines (ELGs) Program Plan 15 (January 2023) intended to collect and analyze nationwide data on industrial discharges of PFAS to POTWs, as well as PFAS in POTW influent, effluent, and sewage sludge.
- It is likely that as ELGs are promulgated, POTWs will require permittees to reduce wastewater PFAS mass loading through changes in practices and/or pre-treatment.

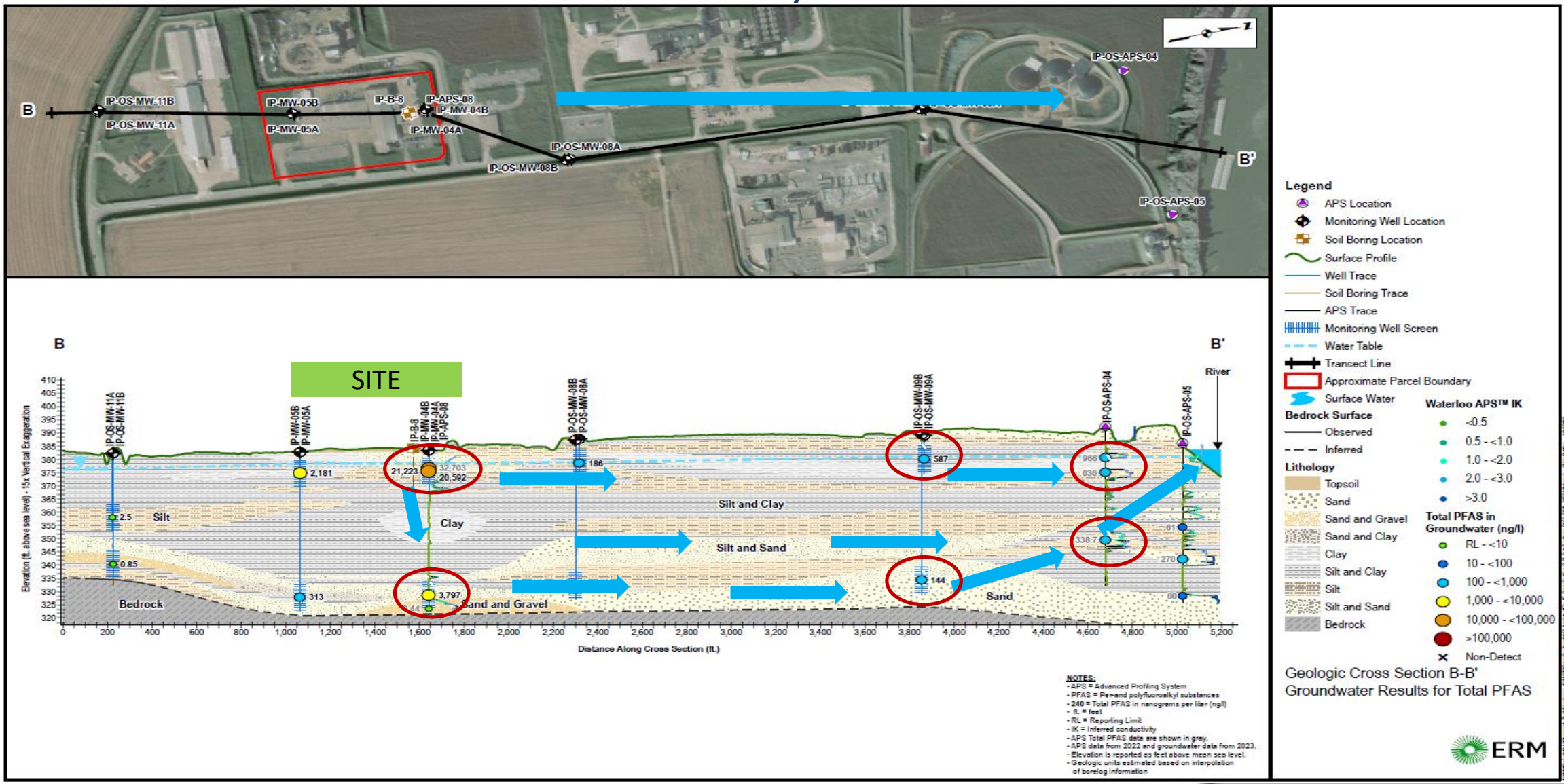
Groundwater To Surface Water Pathway Evaluation – CSM Advancement

- Second facility – approximately 3,500 feet from major river where:
  - Groundwater elevations in the deeper wells at several groundwater monitoring well pairs were typically anomalous causing difficulty in developing reasonable groundwater contour maps.
  - Groundwater sampling programs indicated PFAS impacts in groundwater extending from facility to river and preferential flow/PFAS contamination pathways were suspected based on stratigraphic profile of overburden.
- Pressure transducer study was undertaken to advance the CSM, determine if groundwater elevation anomalies could be related to changes in river stage (~25 feet annually) and confirm a preferential PFAS contamination migration pathway to river.
- Pressure transducers were deployed in the four shallow/deep well pairs with the greatest observed groundwater elevation anomalies.
- Data collected and evaluated included groundwater elevations computed from the pressure transducer data set, precipitation and river stage for September 2023 – mid-August 2024.

Groundwater To Surface Water Pathway Evaluation – CSM Advancement



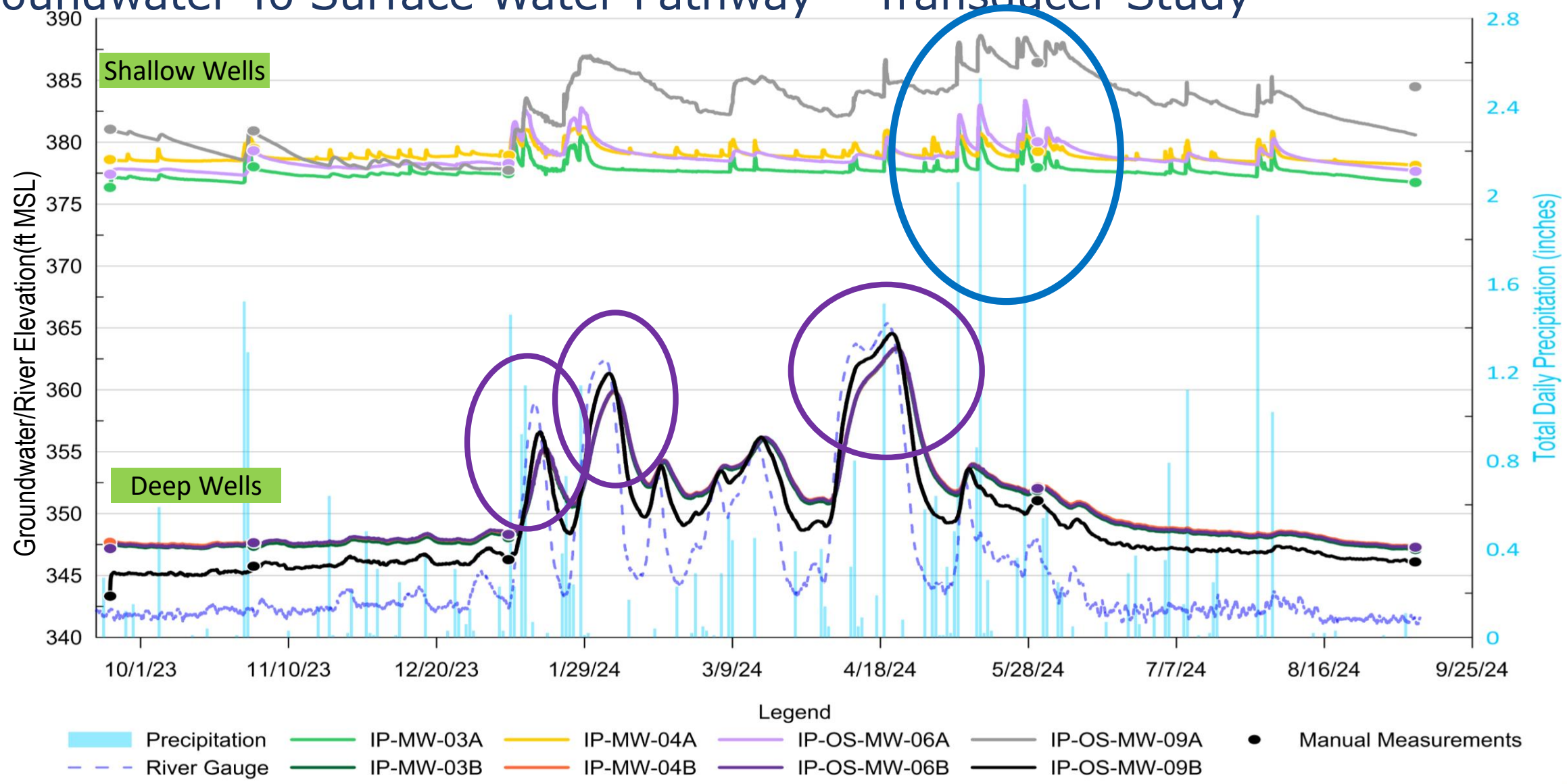
Groundwater To Surface Water Pathway Evaluation – CSM Advancement



Geologic Cross Section B-B'
Groundwater Results for Total PFAS

ERM

Groundwater To Surface Water Pathway – Transducer Study



Summary - Groundwater To Surface Water Pathway Evaluation

- Shallow wells almost immediately respond to local precipitation events while deeper wells do not directly respond.
- River responds to precipitation events and annual “wet season” (January – April) further north in the river watershed.
- Deeper wells respond to changes in river elevation and do not directly correlate to precipitation events.
- Short phase shifts between river stage peaks and groundwater elevation indicates good hydraulic connection to river, the deep well nearest the river has the shortest phase shift, while the phase shift for the group of on-site wells is longer as expected.
- Deep well heads remain higher than river elevation except for short periods of time indicating net positive discharge to the river throughout the year with only temporal periods of flow reversal/potential near-river back-flooding of vadose zone/land surfaces.
- These observations plus the distribution of PFAS in groundwater suggest a deeper preferential contaminant transport pathway to the river potential for PFAS to be discharging to the river as a primary receptor.

Case Study Site #2

There Is A River In Upstate New York

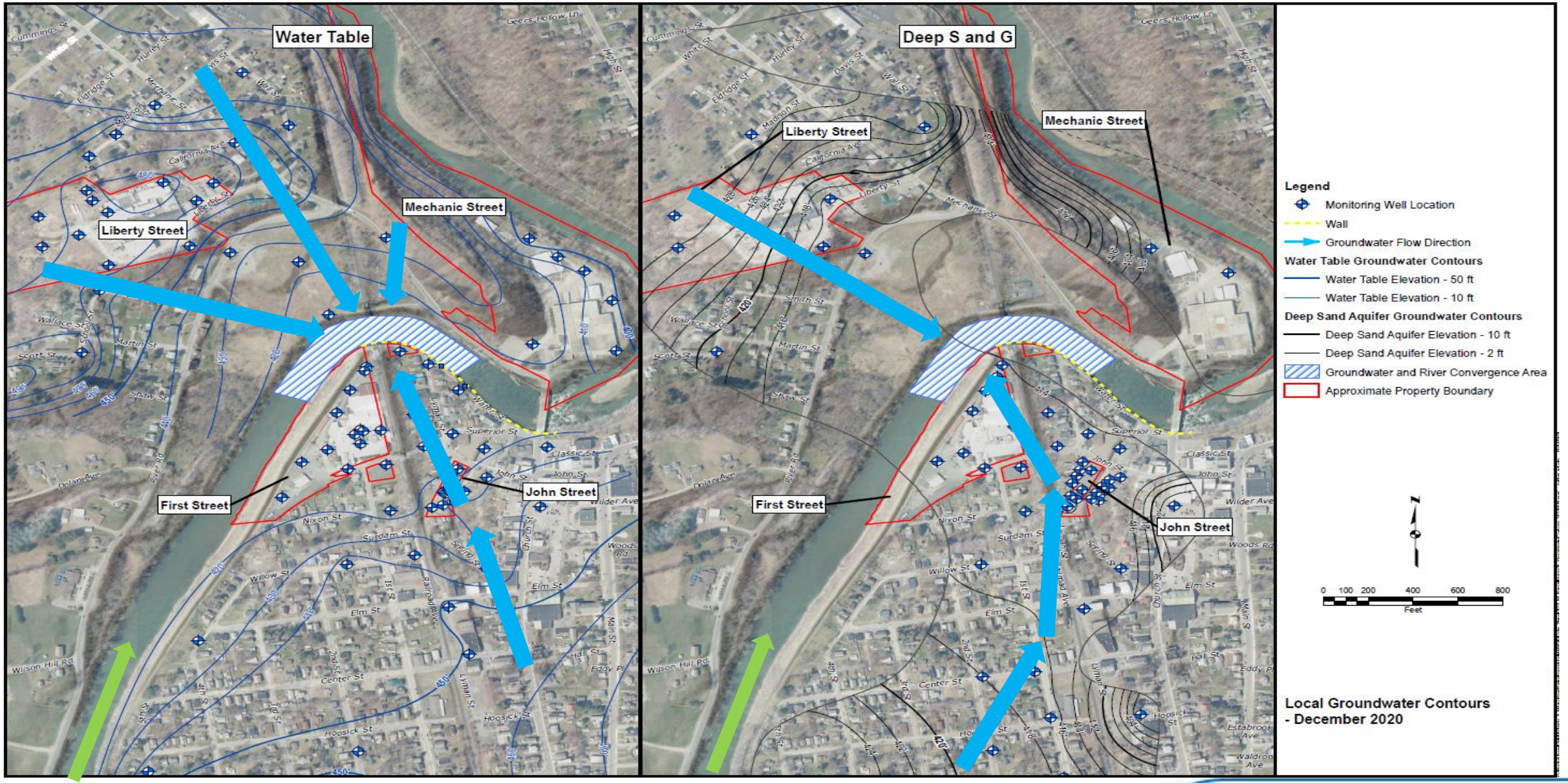
Groundwater/Surface Water Interactions

Groundwater/Surface Water Interaction Study

- A groundwater/surface water study was undertaken to advance the CSM and confirm PFAS/VOC in groundwater pathway to primary receptor relationship (river) and comparative concentrations in both media.

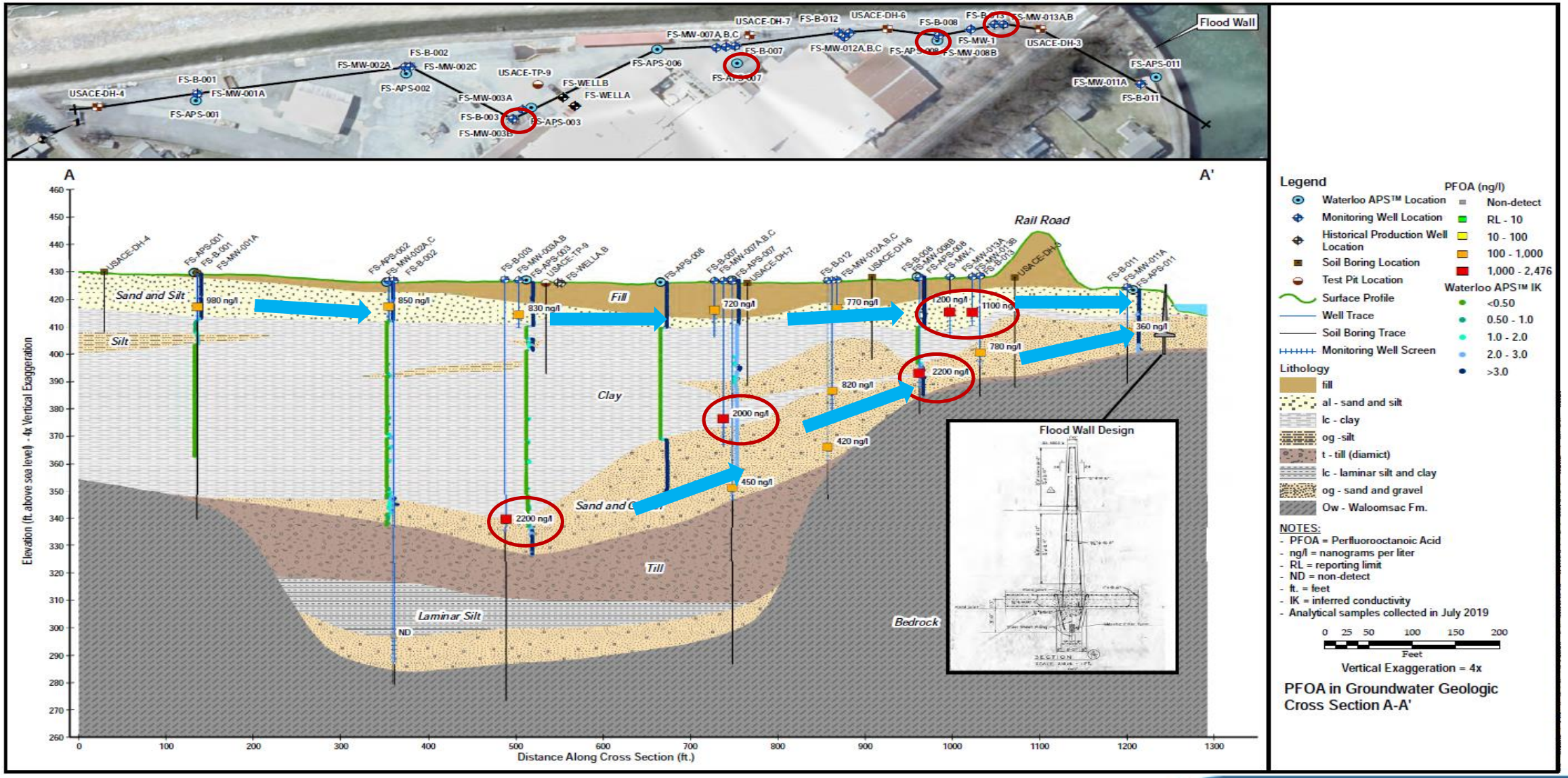
- Setting: Bedrock surface paleo-channel/shallow and deep glacial valley-fill aquifers separated by silt/clay confining unit of varying thickness.

Groundwater – Surface Water Interaction

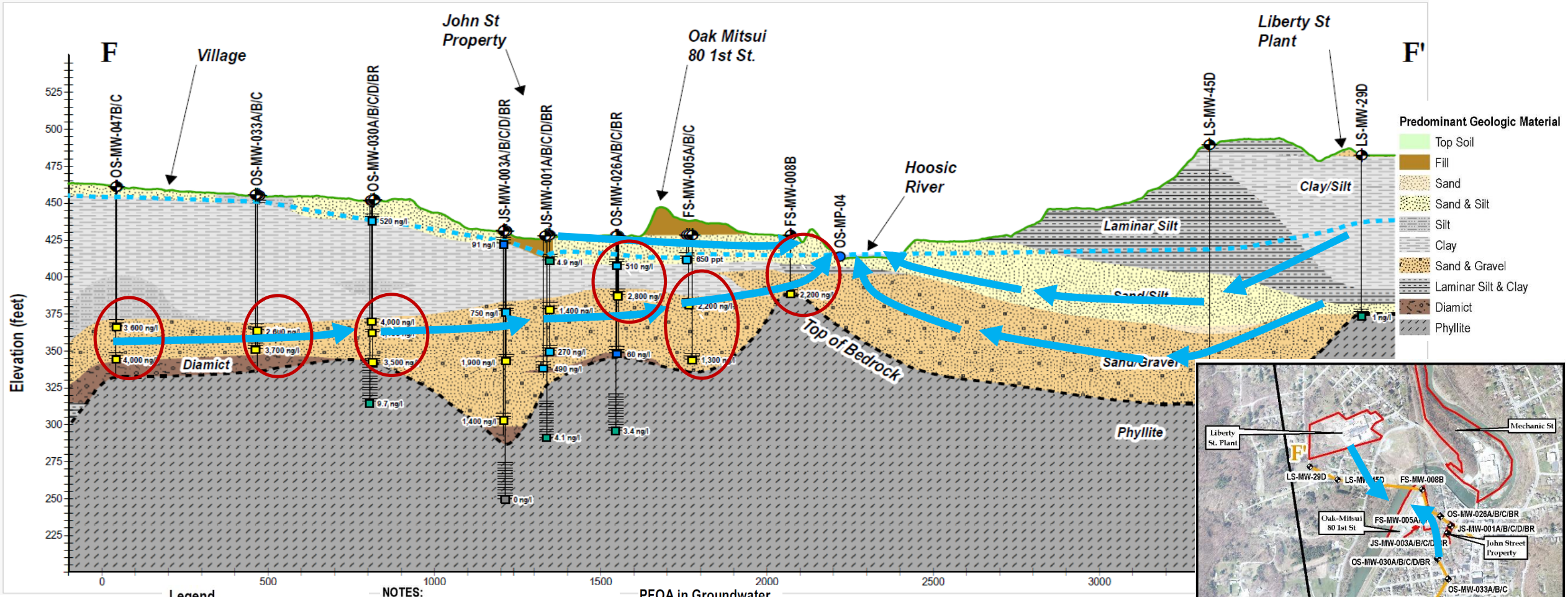


Groundwater flow patterns and PFAS/VOC in groundwater delineation suggest convergence and discharge along a bend in the river as flow boundary.

PFOA Results In Groundwater – CSM Advancement



PFOA Results In Groundwater – CSM



Results of Infrared Drone Survey

Flew and imaged the area of interest using a drone equipped with infrared and visible light wavelength camera packages during winter.

Nine Areas of Interest Identified

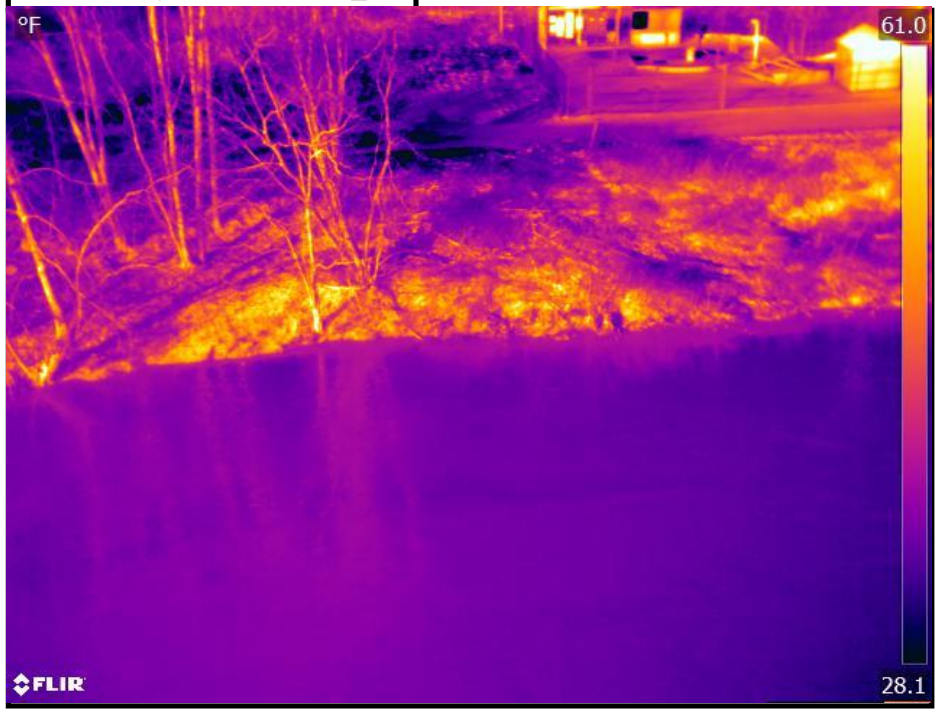
Infrared Drone Survey Results
Example of No Shoreline Temperature Contrast

Legend

Area of Detail

Cooler Warmer

Infrared Spectrum – 145_IR



Orthoimage

*Infrared temperature scale should be used for comparative purposes only and not as an absolute temperature

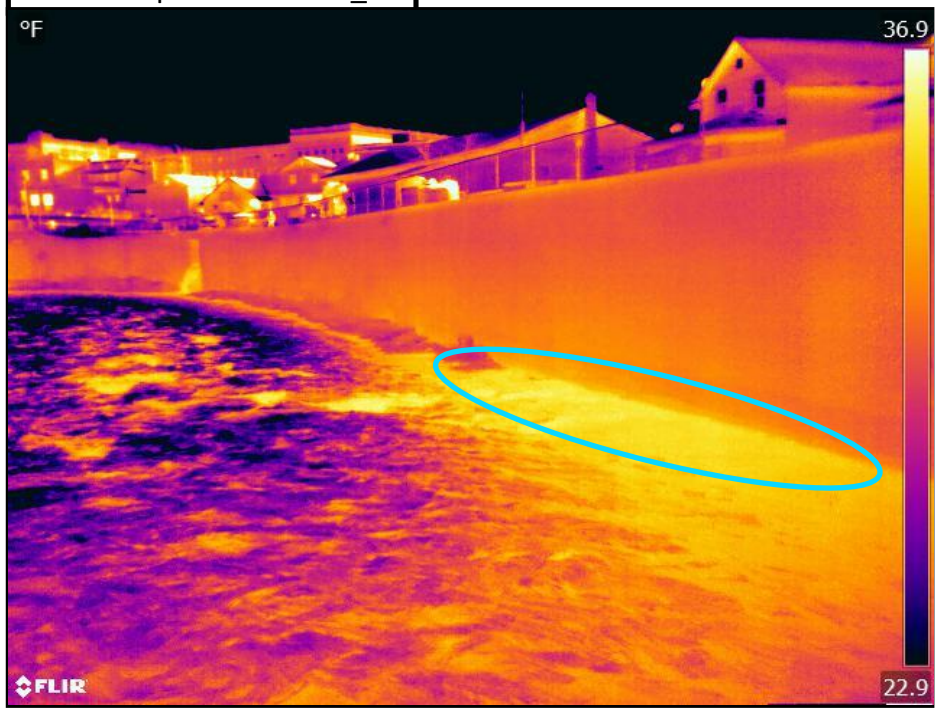
Infrared Drone Survey Results
Southeast Flood Wall

Legend

Area of Detail Area of Interest

Cooler Warmer

Infrared Spectrum – 198_IR



*Infrared temperature scale should be used for comparative purposes only and not as an absolute temperature

Orthoimage

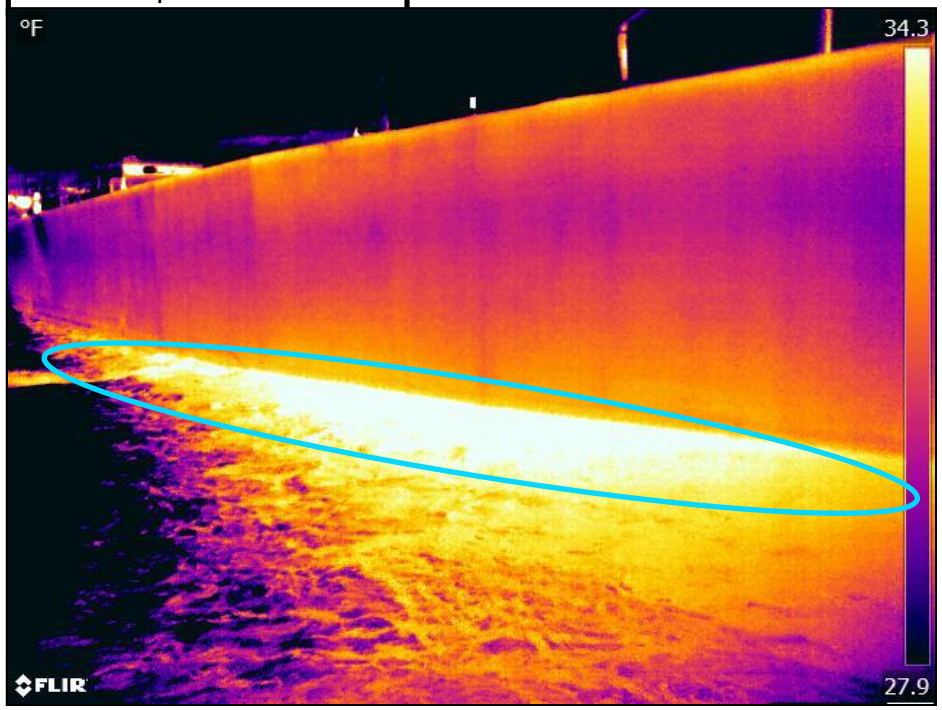
Infrared Drone Survey Results
Northeastern Flood Wall

Legend

Area of Detail Area of Interest

Cooler Warmer

Infrared Spectrum – 188 IR



*Infrared temperature scale should be used for comparative purposes only and not as an absolute temperature

Orthoimage

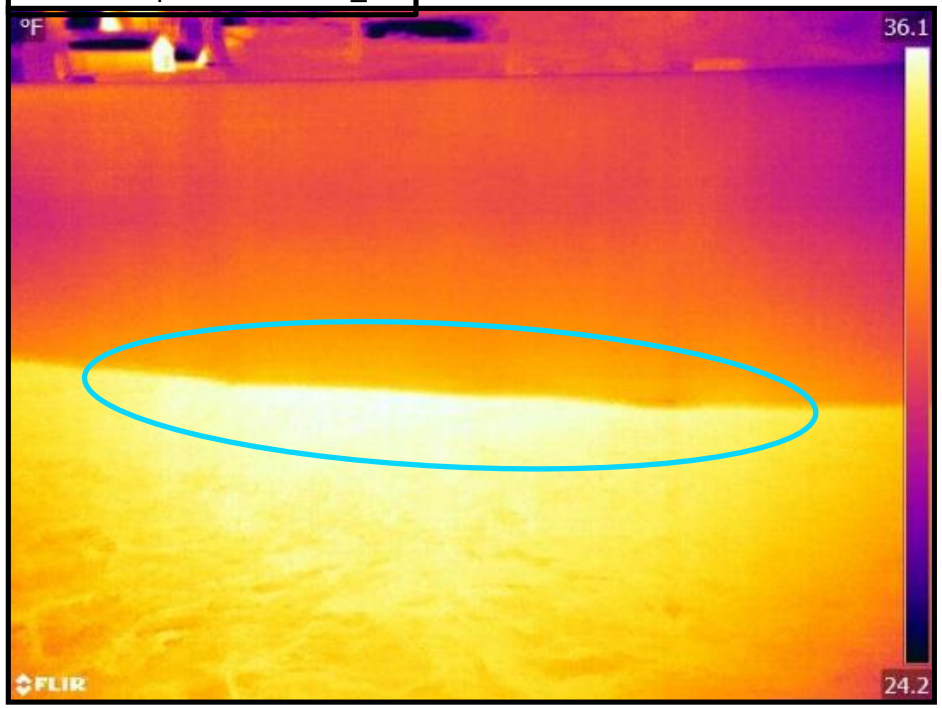
Infrared Drone Survey Results
Northeastern Flood Wall

Legend

Area of Detail Area of Interest

Cooler Warmer

Infrared Spectrum – 178_IR



*Infrared temperature scale should be used for comparative purposes only and not as an absolute temperature

Orthoimage

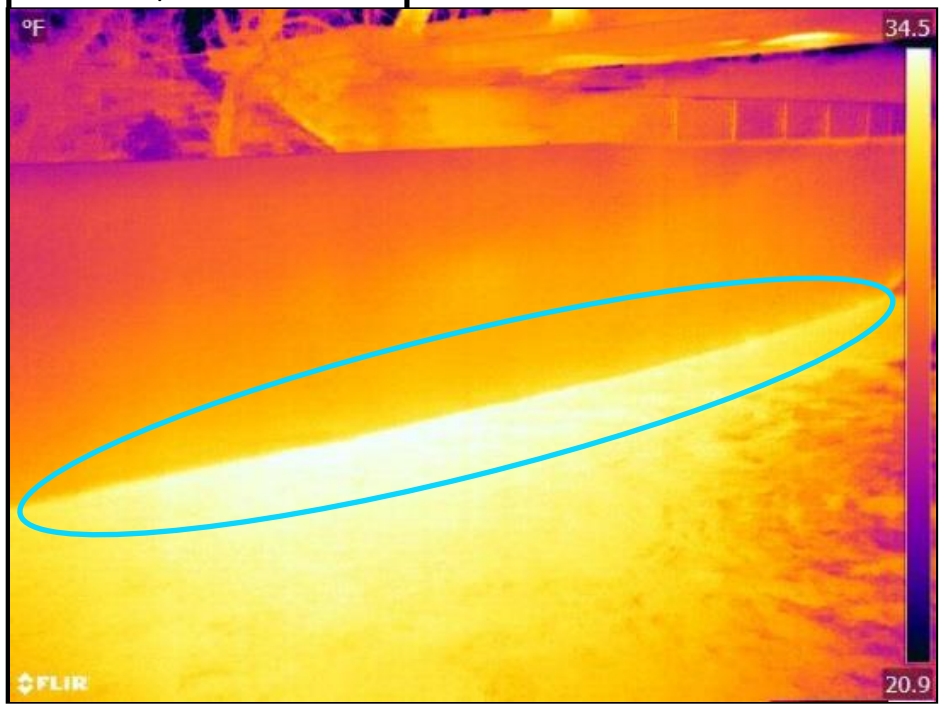
Infrared Drone Survey Results
Northern Flood Wall

Legend

Area of Detail Area of Interest

Cooler Warmer

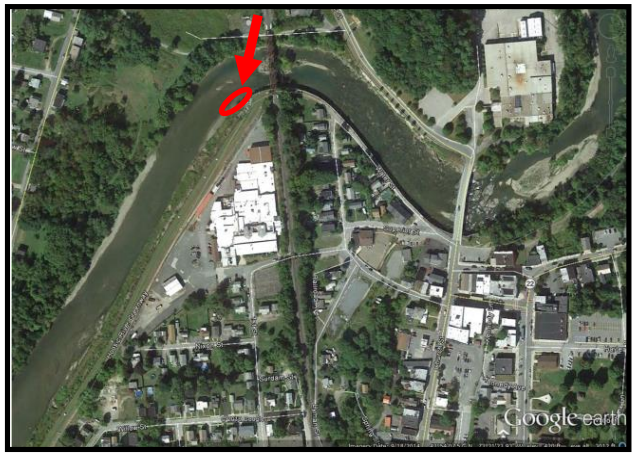
Infrared Spectrum – 175 IR



Orthoimage

*Infrared temperature scale should be used for comparative purposes only and not as an absolute temperature

Infrared Drone Survey Results
Northwestern Flood Wall

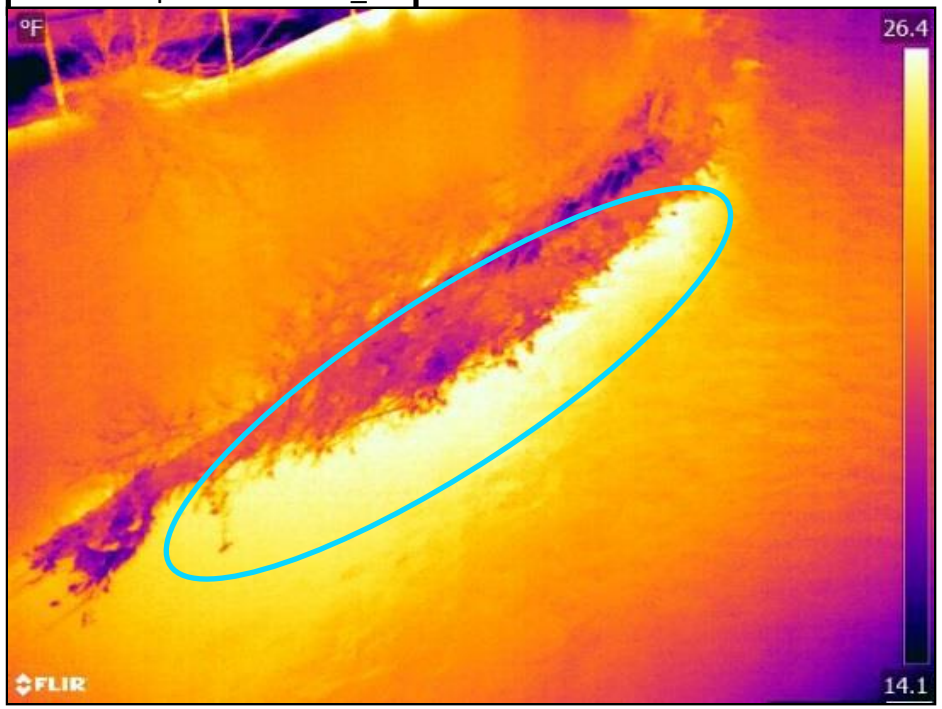


Legend

Area of Detail Area of Interest

Cooler Warmer

Infrared Spectrum – 033_IR



Orthoimage

*Infrared temperature scale should be used for comparative purposes only and not as an absolute temperature

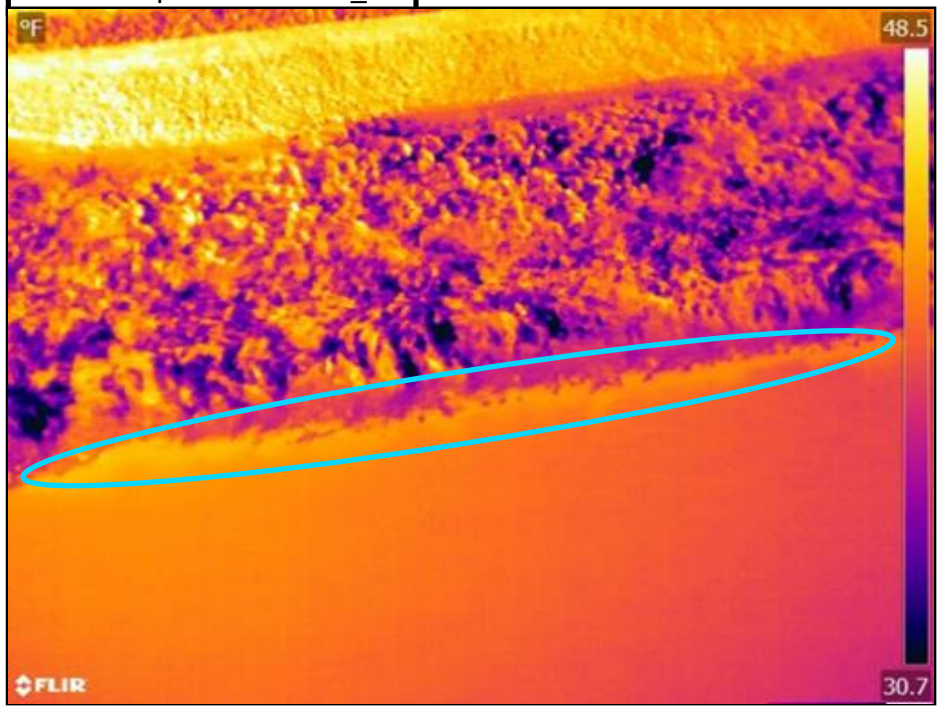
Infrared Drone Survey Results
Northern Levee

Legend

Area of Detail Area of Interest

Cooler Warmer

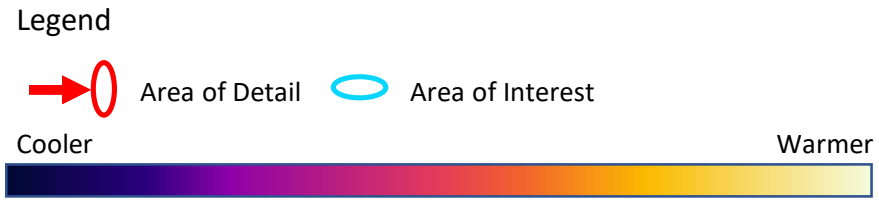
Infrared Spectrum – 049_IR

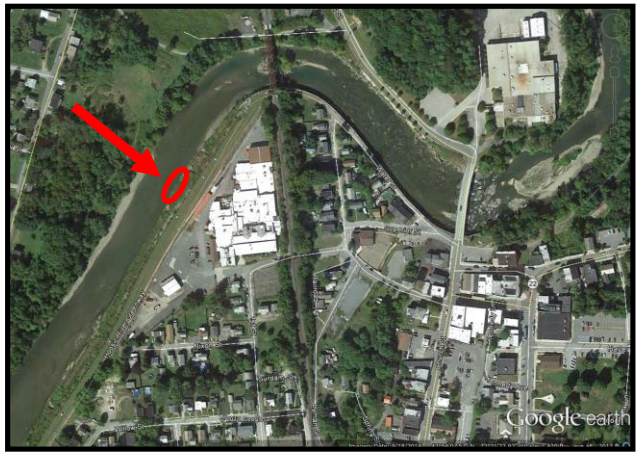


Orthoimage

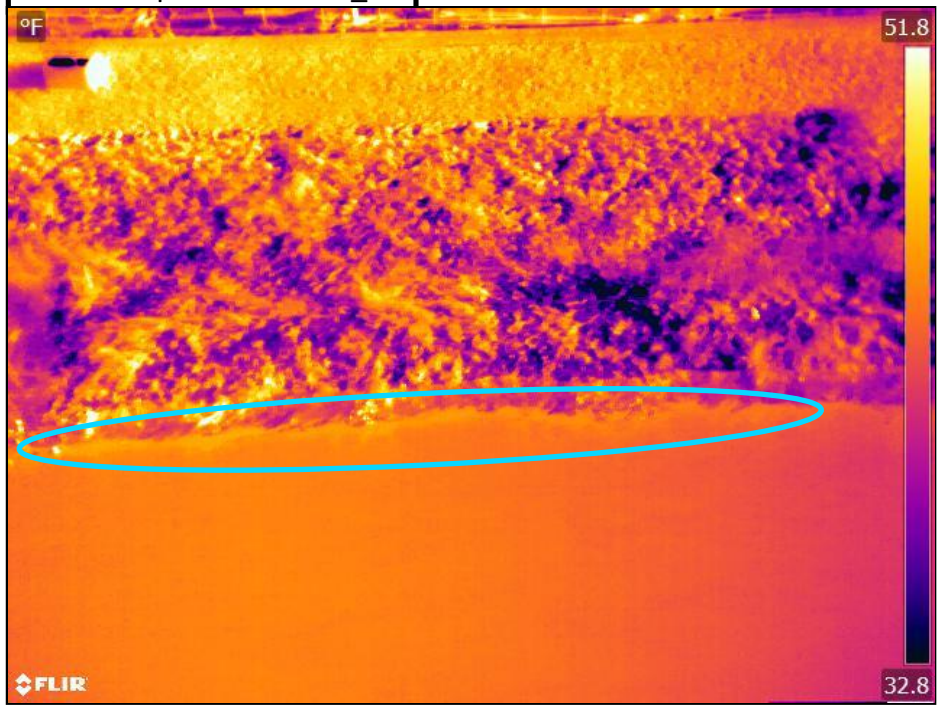
*Infrared temperature scale should be used for comparative purposes only and not as an absolute temperature

Infrared Drone Survey Results
Central Levee





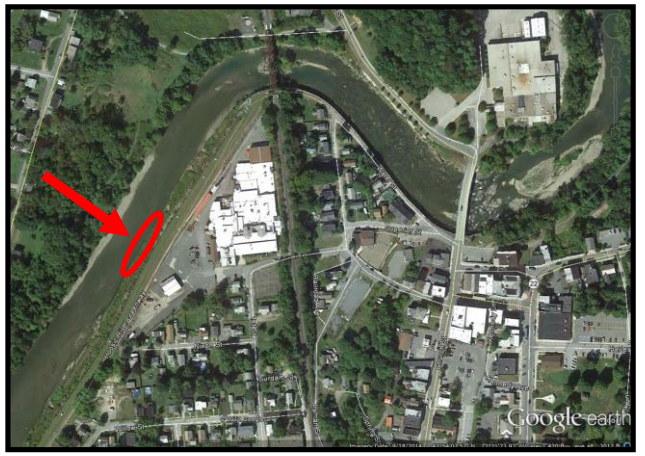
Infrared Spectrum – 064_IR



*Infrared temperature scale should be used for comparative purposes only and not as an absolute temperature

Orthoimage

Infrared Drone Survey Results
Southern Central Levee

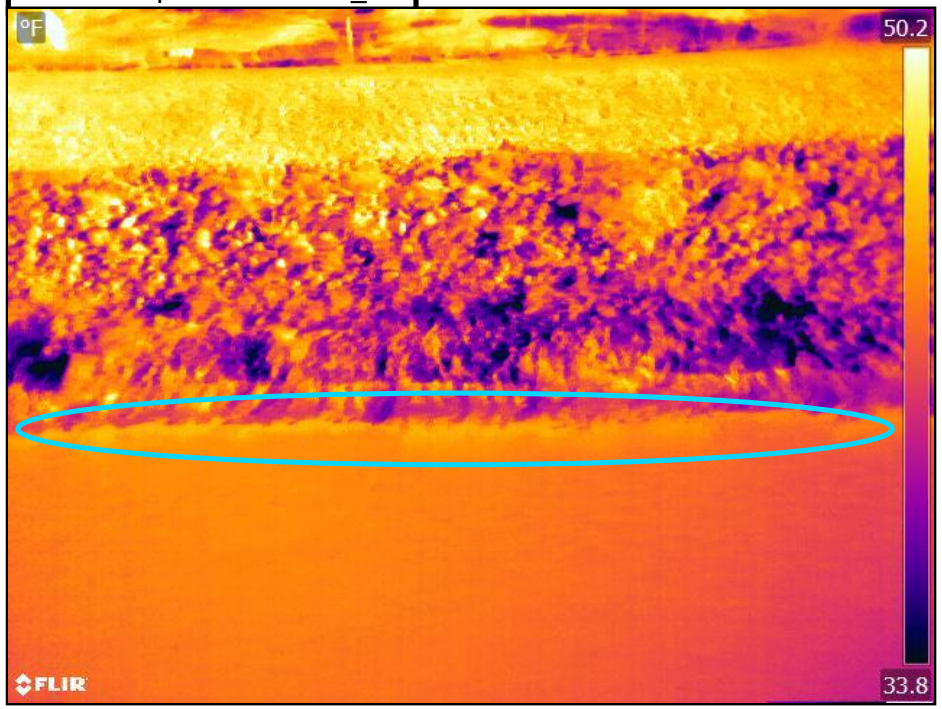


Legend

Area of Detail Area of Interest

Cooler Warmer

Infrared Spectrum – 078_IR



Orthoimage

*Infrared temperature scale should be used for comparative purposes only and not as an absolute temperature

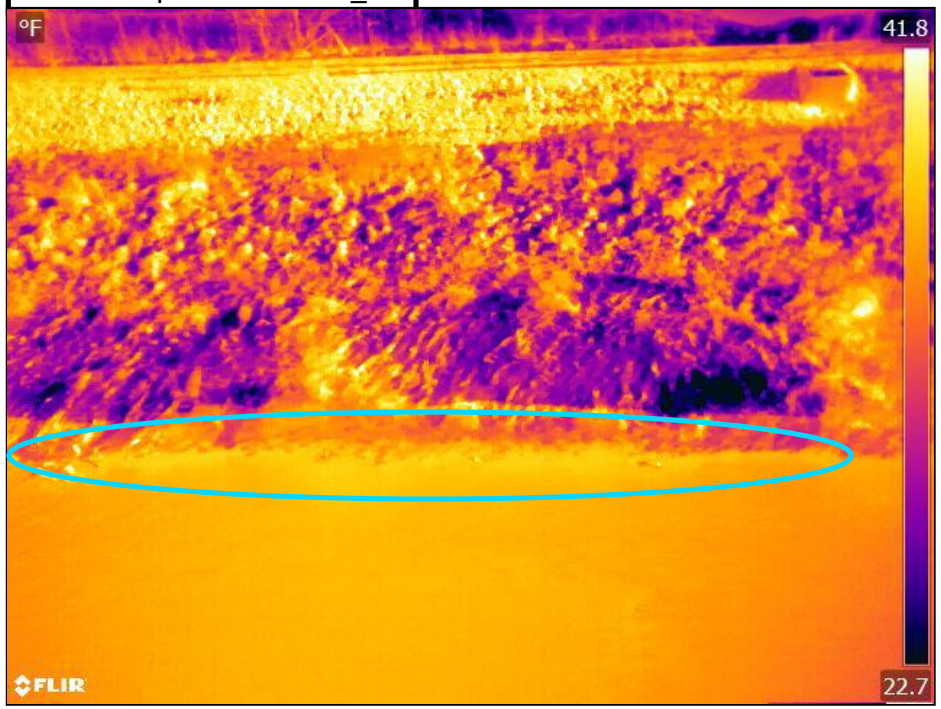
Infrared Drone Survey Results
Southern Levee

Legend

Area of Detail Area of Interest

Cooler Warmer

Infrared Spectrum – 088_IR



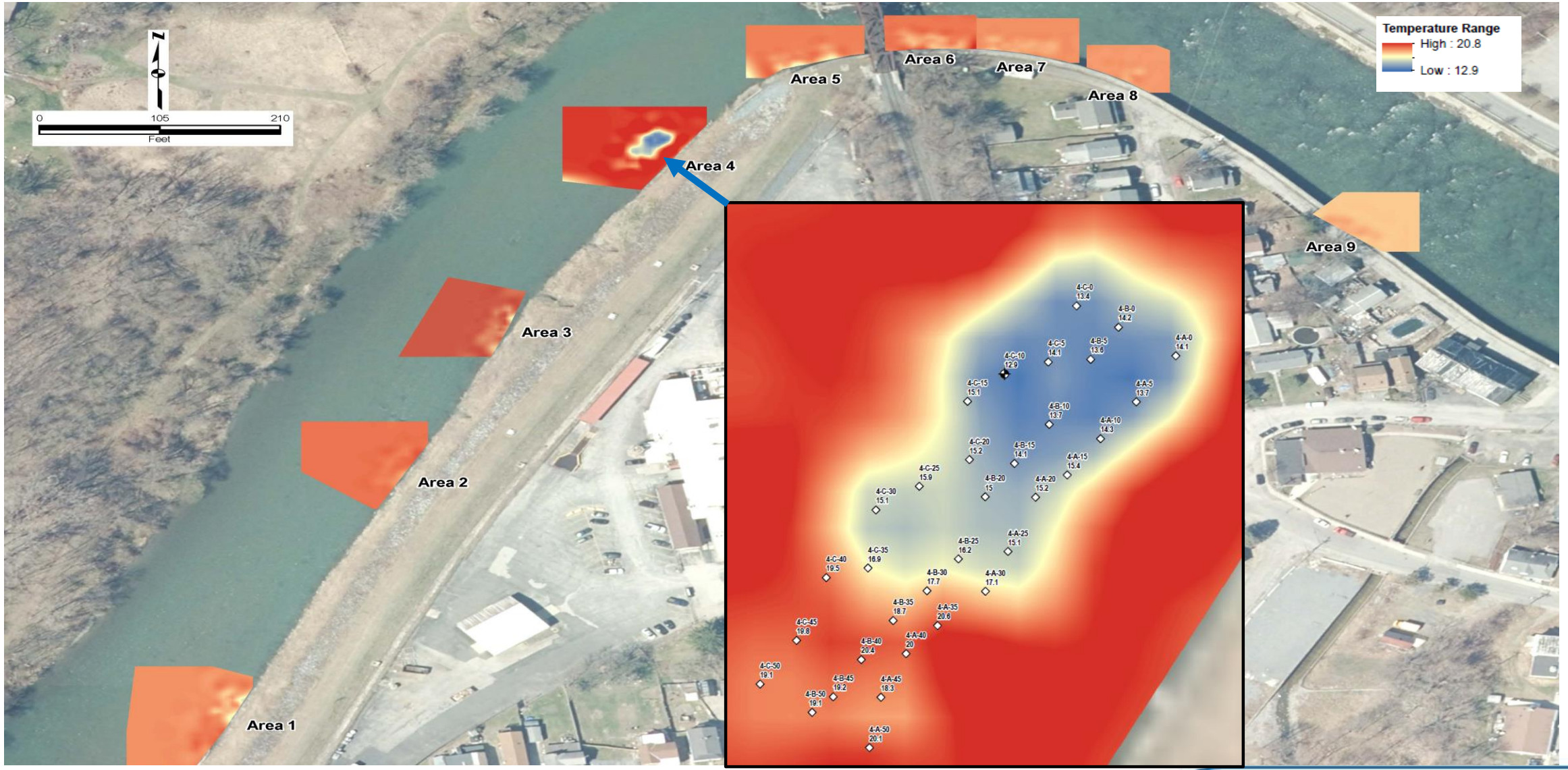
Standard Color

*Infrared temperature scale should be used for comparative purposes only and not as an absolute temperature

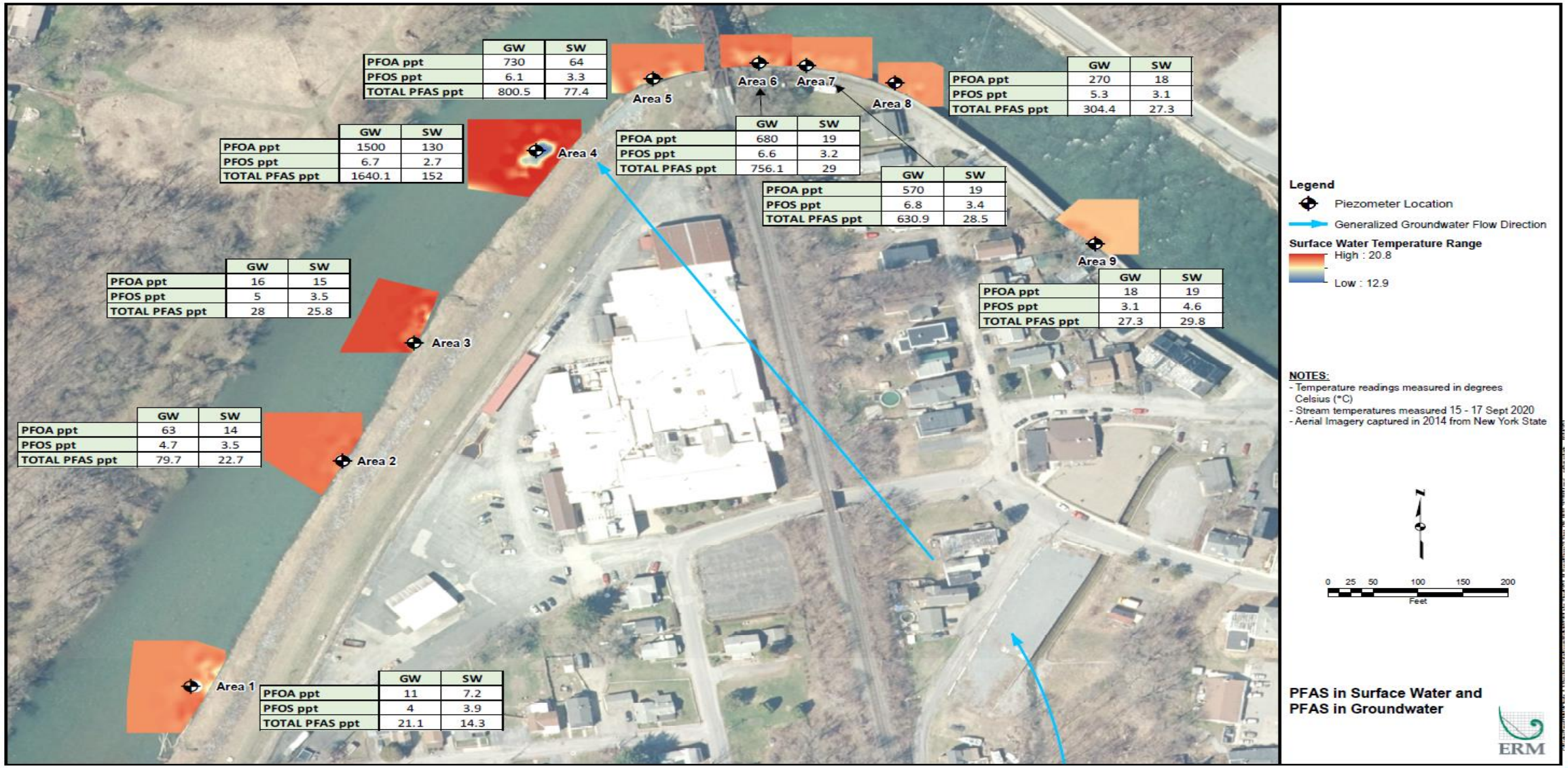
Groundwater/Surface Water Interaction Study

- Returned that summer to further investigate the areas of interest.
- Gridded the 9 candidate discharge locations and obtained pore water temperature measurements.
- Well points driven at coldest grid-point for each location to collect porewater samples from 12” below bottom.
- Sibling surface water sample collected immediately adjacent from 6” above the bottom.

Pore Water Temperature Heat Maps - Infrared Anomaly Area Nos. 1-9



PFAS Results In Groundwater & Surface Water Samples



	GW	SW
PFOA ppt	730	64
PFOS ppt	6.1	3.3
TOTAL PFAS ppt	800.5	77.4

	GW	SW
PFOA ppt	1500	130
PFOS ppt	6.7	2.7
TOTAL PFAS ppt	1640.1	152

	GW	SW
PFOA ppt	680	19
PFOS ppt	6.6	3.2
TOTAL PFAS ppt	756.1	29

	GW	SW
PFOA ppt	570	19
PFOS ppt	6.8	3.4
TOTAL PFAS ppt	630.9	28.5

	GW	SW
PFOA ppt	270	18
PFOS ppt	5.3	3.1
TOTAL PFAS ppt	304.4	27.3

	GW	SW
PFOA ppt	16	15
PFOS ppt	5	3.5
TOTAL PFAS ppt	28	25.8

	GW	SW
PFOA ppt	18	19
PFOS ppt	3.1	4.6
TOTAL PFAS ppt	27.3	29.8

	GW	SW
PFOA ppt	63	14
PFOS ppt	4.7	3.5
TOTAL PFAS ppt	79.7	22.7

	GW	SW
PFOA ppt	11	7.2
PFOS ppt	4	3.9
TOTAL PFAS ppt	21.1	14.3

Groundwater/Surface Water Interaction Study Summary

- Innovative technology was employed to complete a groundwater/surface study to advance the CSM.
- PFAS/VOC source to groundwater pathway to primary receptor relationship (river) was confirmed.
- River shoreline groundwater discharge areas are discontinuous.
- Generalized groundwater/contaminant flux calculations that assume continuous discharge surfaces would overestimate.

PFOA

- **Detected in all SW & pore water (GW) samples**
- **Pore water 7.2 to 1,500 ppt**
- **Surface water 11 to 130 ppt**

PFOS

- **Detected in all SW & pore water (GW) samples**
- **Pore water 3.1 to 6.8 ppt**
- **Surface water 3.1 to 4.6 ppt**

TVOCs

- **Detected in SW & pore water (GW) samples 5 locations**
- **Pore water 4.9 to 149.1 ppb**
- **Surface water 0.4 to 10.5 ppb**

- Effects of dilution are significant in this setting.

Questions?

Thank You!

Chris Wenczel, P.G.
Director/Hydrogeologist
Environmental Resources Management
Chris.Wenczel@erm.com