Using HRSC
to Rapidly Assess LNAPL Distribution, Optimize Well Placement, and Accelerate Remedial Design

2023 Battelle Bioremediation Symposium

May 10, 2023

Your Presenter:

Erik Gessert, P.E.

Thanks to my co-authors:

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Brennan Taylor, Terracon
Randy St. Germain, Dakota Technologies, Inc.

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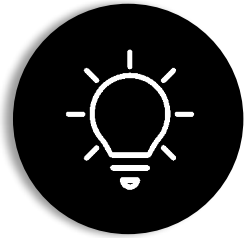
Presentation Overview

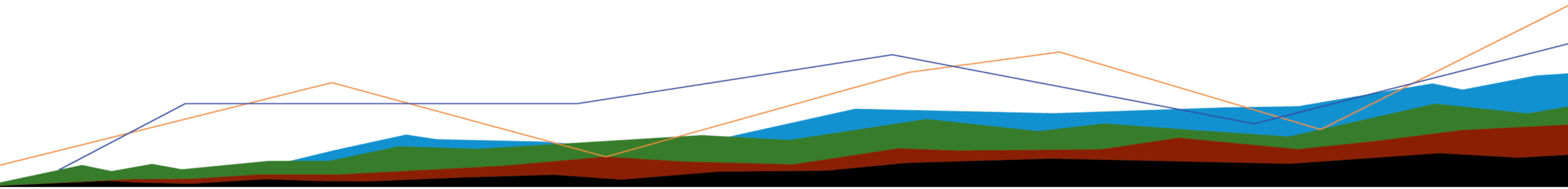
Site History and Previous Assessment

HRSC Approach and Execution

LNAPL Characteristics and Data Analysis



Summary



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Site History

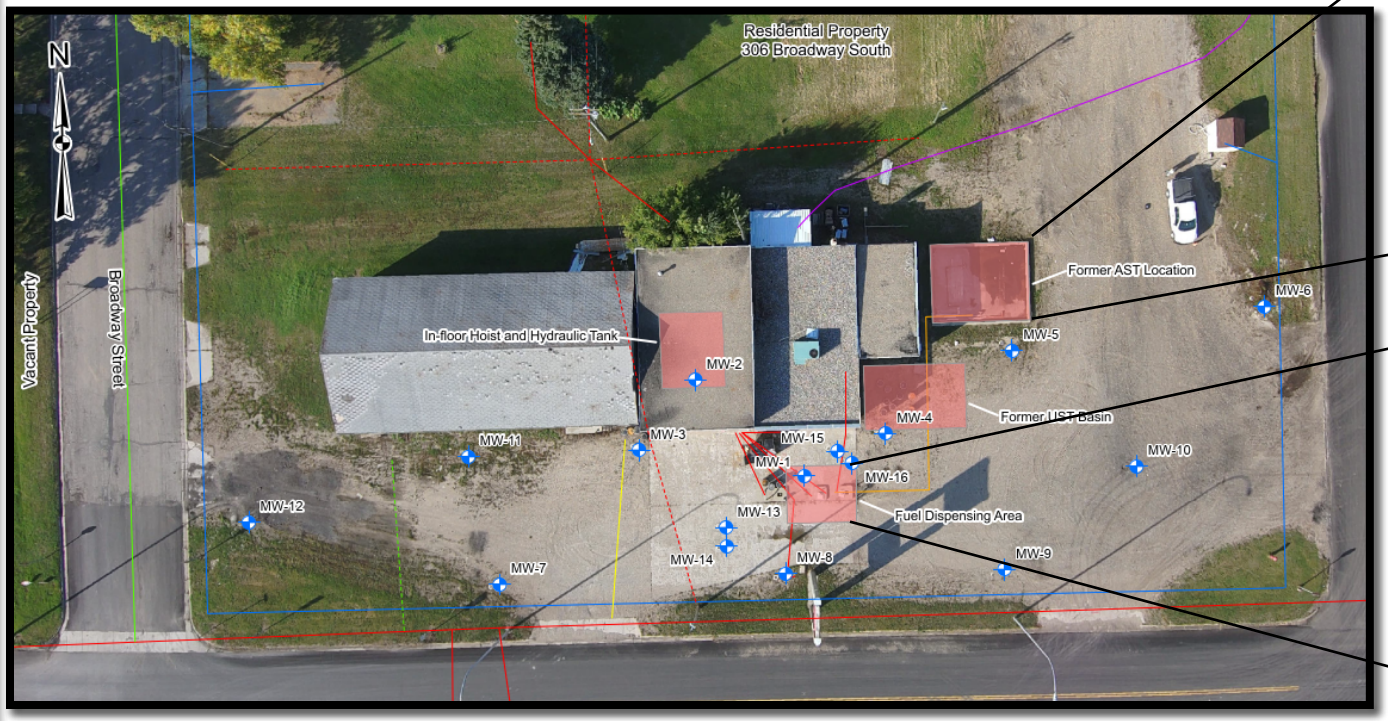
1959

North Dakota Historical Maps and Aerial Photography Map Service

2022

Terracon 2022

Site History



Plan view of the site with highlighted potential source areas.

View of the site facing west.

View of the site facing northeast.

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2020 Limited Site Investigation

- Ten borings/temporary wells

- GRO in soil 139-1,760 mg/kg
- DRO in soil 356-4,790 mg/kg

- GRO in water 2,980-53,700 ug/L
- DRO in water 1,800-28,100 ug/L

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2021 Site Assessment

- 17 borings advanced; 11 converted to permanent wells
- Groundwater ranged from ~7-12 feet bgs
- LNAPL in-well measured thicknesses ranging from 0.02-4.5 feet
- Soil and GW impacts above standard throughout the assessed area
- VOCs detected above EPA VISLs in soil gas probes in store basement
- More robust assessment, but still not defined

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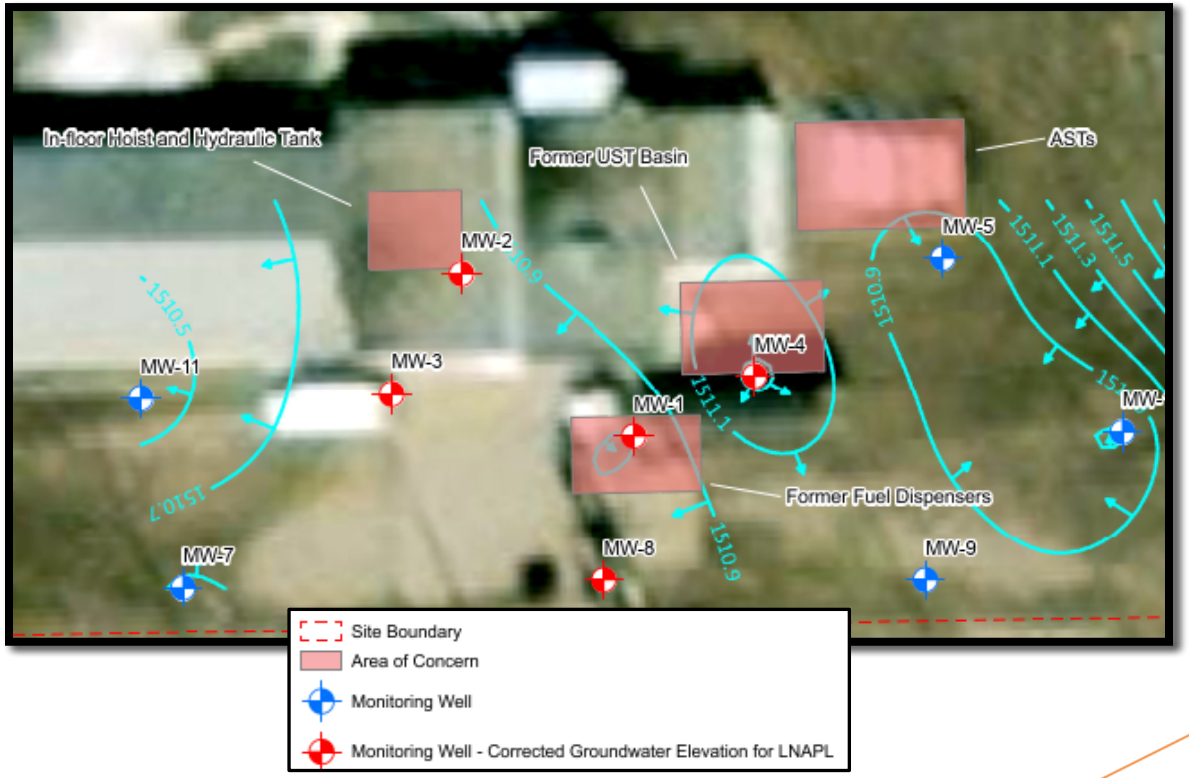
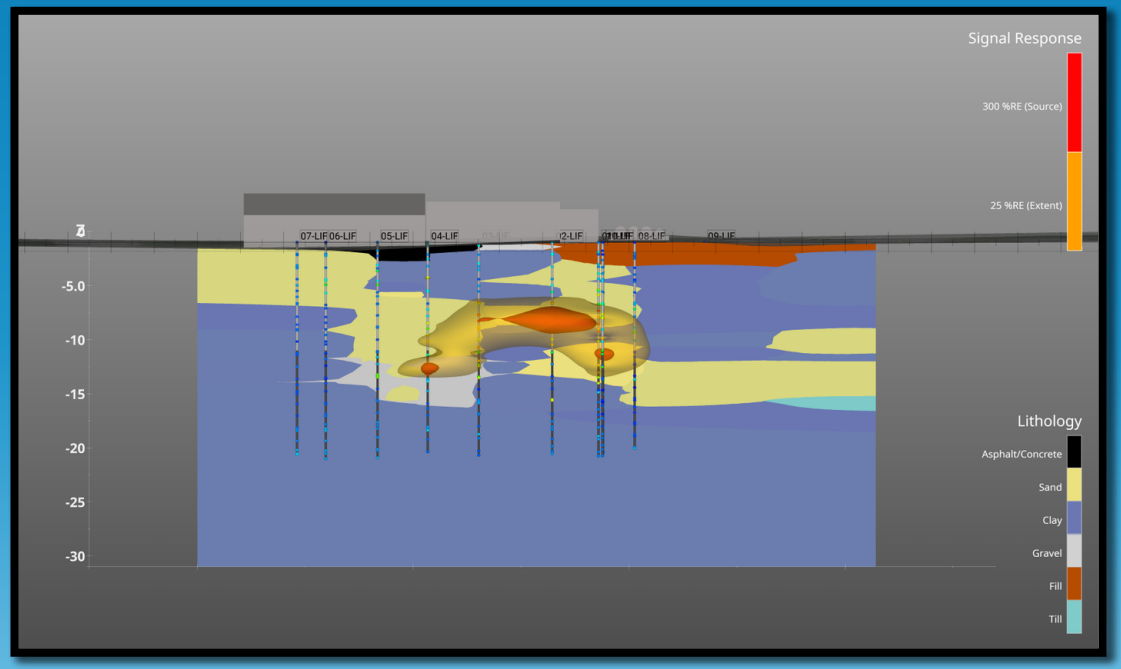
Regulatory Feedback

- **December 2021** - Summary report issued
- **January 2022** - Regulatory response
  - *Workplan requested to include a map of proposed sampling locations and analytical methods.*
  - *LNAPL recovery considered likely*



2022 Workplan Development & Regulatory Collaboration

- **Client goal:** address impact and sell the property*
- **Regulatory goal:** TPH delineation, LNAPL recovery, protection of human health and the environment*
- **Terracon goal:** develop comprehensive understanding of site conditions within a reasonable timeframe/budget to meet other stakeholder goals



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2022 Workplan Development & Regulatory Collaboration

The Issues

Multiple Sources

Multiple Fuel Types

Large (+4.5') LNAPL In-Well Thicknesses

Indoor Air Vapor Intrusion Concern

Lack of COC definition in multiple media

Potential Approaches

Repeat conventional assessment approach

Implement the Triad Approach to more rapidly develop a CSM

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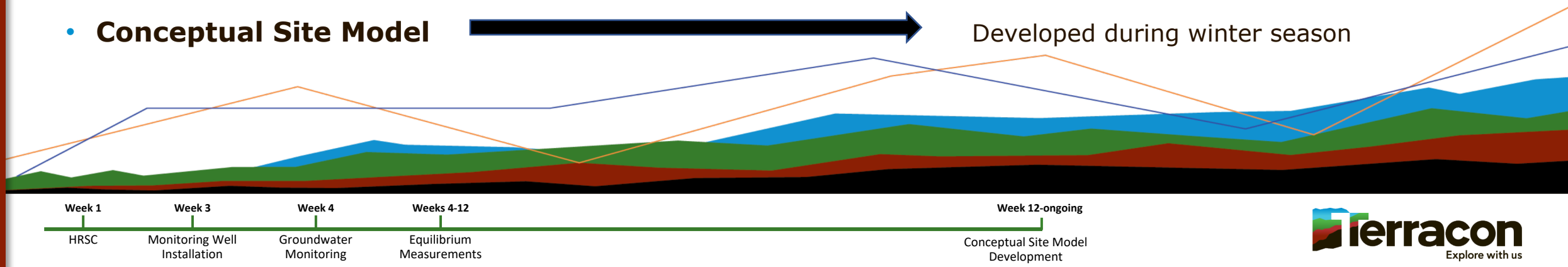
Workplan Development/Regulatory Collaboration

Multi-Phase Approach with Compressed Timeline

- **High Resolution Site Characterization** — Five Days
- **Monitoring Well Installation** — Three weeks after HRSC
- **Groundwater Monitoring** — One week after installation
- **Fluid Level Equilibrium Measurements** — Every two weeks over four months
- **Soil Gas and Indoor Air Quality Evaluation** — Concurrent with Equilibrium Measurements
- **LNAPL Transmissivity Testing** — Planned at end of Equilibrium Measurements
- **LNAPL Fingerprinting Analysis** — Planned at end of Equilibrium Measurements
- **Conceptual Site Model** — Developed during winter season



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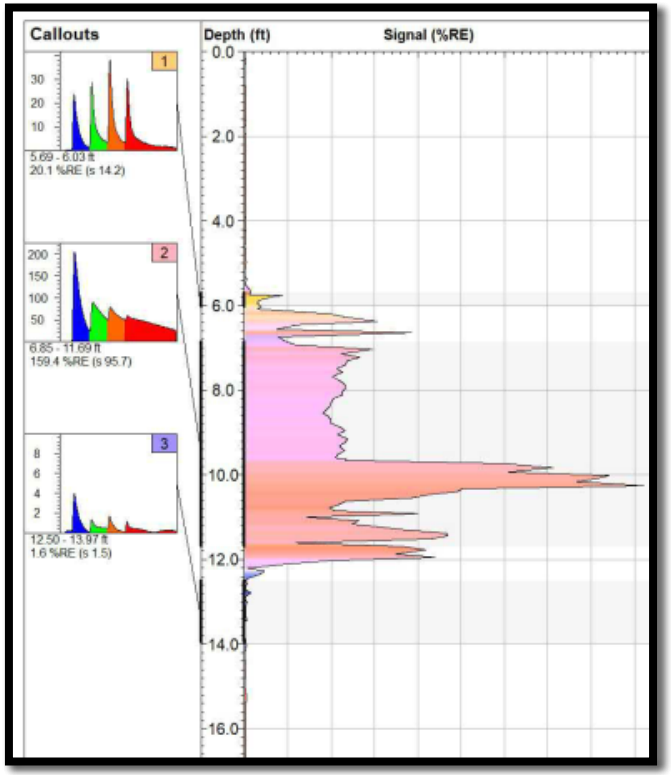
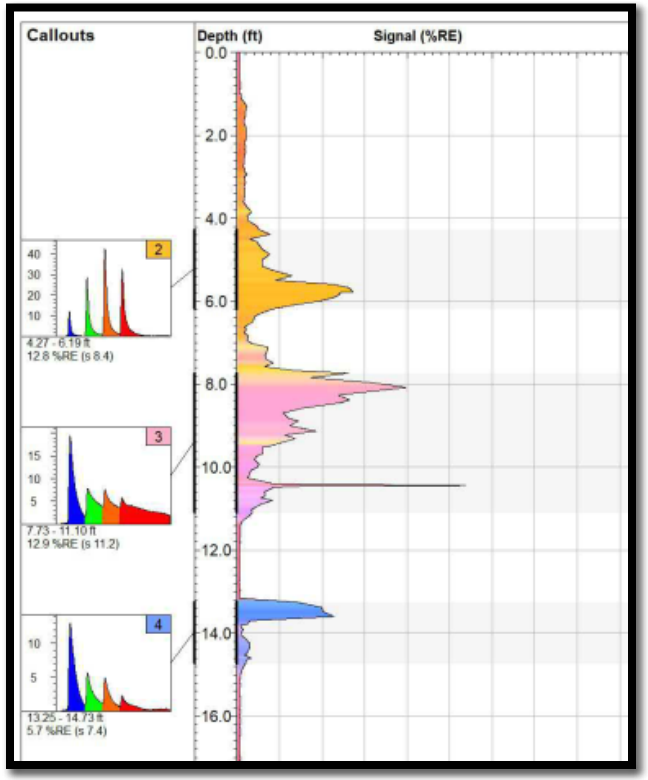
Real-Time Data – Project Setup

- Partnered with Dakota Technologies
- Terracon/Dakota preplanned:
  - Spatial Data
  - HRSC Data Transmittal
- Morning Kickoff Calls to Review Data and Chart Course

Real-Time Data – Technology Overview

- UVOST+HP
- MIHPT





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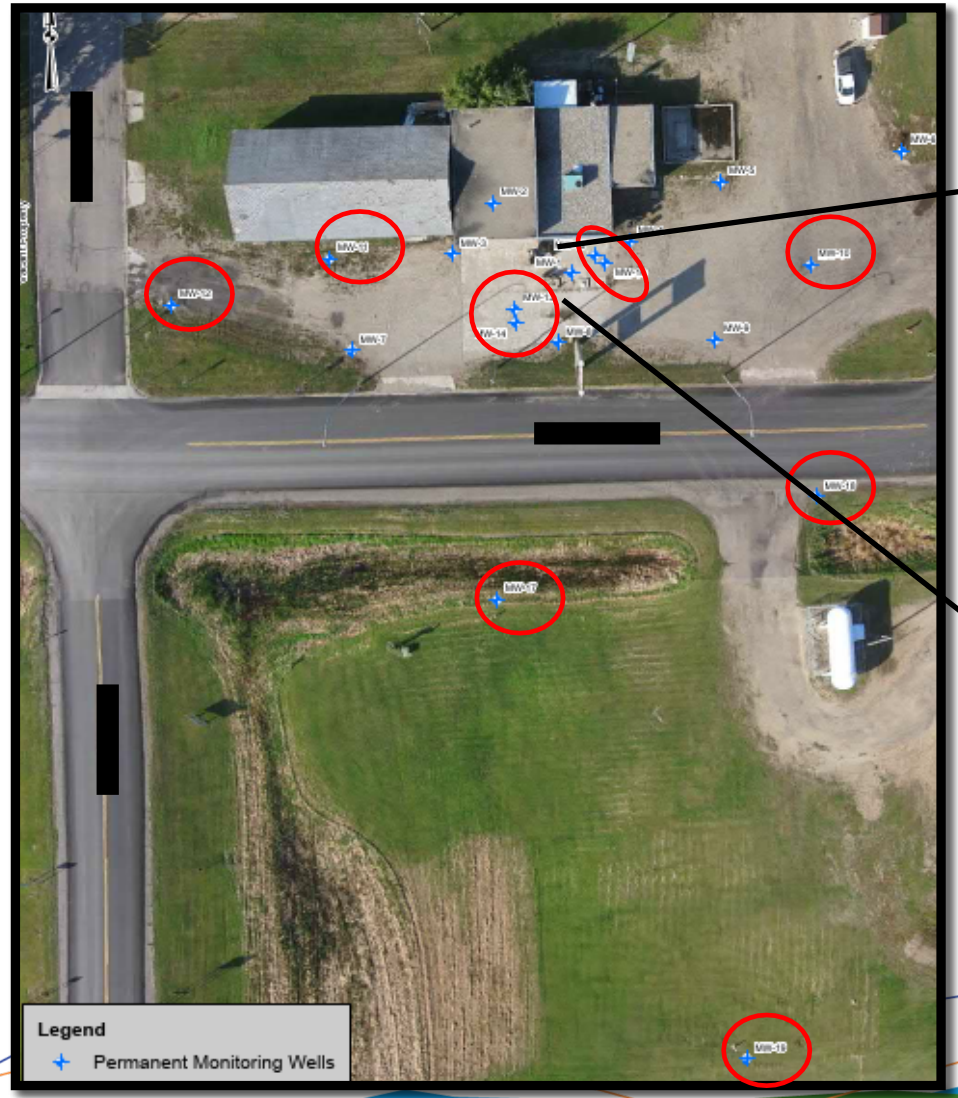
LIF Daily Live Modeling Demonstration

Correlation Borings

Sample ID	Depth (feet)	Date Collected	TPH by EPA Method 8015D	TPH-DRO	TPH-GRO	Motor Oil Range
North Dakota Action Levels[1]				100	100	100
USEPA Residential RSLs[2]				NE	NE	NE
USEPA Industrial RSLs[2]				NE	NE	NE
LIFCB-2	6-8	07/29/2022		8,320	664	436
	8-10	07/29/2022		4,170	585	215
	14-16	07/29/2022		87.1	379	22.5
LIFCB-4	2-4	07/29/2022		468	18.8	940
	8-10	07/29/2022		219	663	26.7
	10-12	07/29/2022		1,560	1520	107
LIFCB-7	2.5-5	07/28/2022		166	<7.5	425
	5-7.5	07/28/2022		34.1	32.4	90.1
	7.5-10	07/28/2022		<11.7	<7.0	<11.7
LIFCB-8	6-8	07/28/2022		1,910	688	104
	12-14	07/28/2022		12.1	<8.7	15.0
LIFCB-9	10-15	07/28/2022		<12.2	<7.1	<12.2
	16-18	07/28/2022		<12.5	<9.0	16.7
	18-20	07/28/2022		<12.7	<6.9	12.8
LIFCB-11	6-8	07/29/2022		2,260	445	332
	8-10	07/29/2022		4,360	1,370	235
	10-12	07/29/2022		790	1,040	60.0
LIFCB-12	4-6	07/29/2022		2,990	404	7,180
	8-10	07/29/2022		2,990	1,030	170
	12-14	07/29/2022		117	305	19.7
LIFCB-15	0-2	07/28/2022		738	132	1,640
	4-6	07/28/2022		961	20.4	2,240
	8-10	07/28/2022		<11.7	<6.2	<11.7
	10-12	07/28/2022		<12.8	<7.3	<12.8
LIFCB-16	4-6	07/29/2022		2,980	167	10,000
	8-10	07/29/2022		2,030	1,570	104
	10-12	07/29/2022		1,000	1,680	59.7
	12-14	07/29/2022		220	527	14.2

Monitoring Well Placement



Week 1 — HRSC

Week 3 — Monitoring Well Installation

Week 4 — Groundwater Monitoring

Weeks 4-12 — Equilibrium Measurements

Week 12-ongoing — Conceptual Site Model Development

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Groundwater Analytical Data

Sample ID	Date Collected	Date Received by Lab	TPH by EPA 8015	TPH-GRO	TPH-DRO	Motor Oil Range	Oil and Grease by EPA 1664B HEM	Oil and Grease	BTEX by EPA 8260D	Benzene	Ethylbenzene	Toluene	Total Xylenes	Fluid Levels	Depth to Groundwater (TOC)	Depth to Product (TOC)	Product Thickness
North Dakota Regulatory Guidance[1]				500	500	500		NE		5	NE	NE	NE		ft	ft	ft
USEPA MCLs[2]				NE	NE	NE		NE		5	700	1,000	10,000				
MW-1	09/20/2021	NA		-	-	-		-		-	-	-	-		10.44	9.60	0.84
	08/30/2022	NA		-	-	-		-		-	-	-	-		11.17	6.72	4.45
MW-2	09/20/2021	NA		-	-	-		-		-	-	-	-		10.92	9.95	0.97
	08/30/2022	NA		-	-	-		-		-	-	-	-		8.40	7.69	0.71
MW-3	09/20/2021	NA		-	-	-		-		-	-	-	-		9.52	9.50	0.02
	08/31/2022	09/02/2022		11,000	3,500	360		<17200		957	617	20.1	133		7.15	-	-
MW-4	09/20/2021	NA		-	-	-		-		-	-	-	-		12.90	8.37	4.53
	08/30/2022	NA		-	-	-		-		-	-	-	-		9.23	6.00	3.23
MW-5	09/20/2021	09/22/2021		<100	92	-		-		<1.0	<1.0	<1.0	<3.0		9.34	-	-
	08/31/2022	09/02/2022		240	910	450		<17200		55.4	9.6	<1.0	<3.0		6.93	-	-
MW-6	09/20/2021	09/22/2021		<100	<49	-		-		<1.0	<1.0	<1.0	<3.0		6.81	-	-
	08/30/2022	09/02/2022		<100	190	250		<17200		<1.0	<1.0	<1.0	<3.0		5.68	-	-
MW-7	09/20/2021	09/22/2021		<100	130	-		-		<1.0	<1.0	<1.0	<3.0		8.27	-	-
	08/30/2022	09/02/2022		<100	410	260		<17200		<1.0	<1.0	<1.0	<3.0		5.97	-	-
MW-8	09/20/2021	NA		-	-	-		-		-	-	-	-		10.25	9.10	1.15
	08/30/2022	NA		-	-	-		-		-	-	-	-		8.21	6.71	1.50
MW-9	09/20/2021	09/22/2021		2,230	850	-		-		694	58	6.3	71.1		9.67	–	–
	08/31/2022	09/02/2022		1,040	860	280		<17200		211	35	2.3	11.0		7.50	–	–
MW-10	09/20/2021	09/22/2021		<100	74	-		-		<1.0	<1.0	<1.0	<3.0		8.86	–	–
	08/30/2022	09/02/2022		1,960	240	<190		<17200		254	84	114	63.2		6.45	–	–
MW-11	09/20/2021	09/22/2021		<100	180	-		-		1.3	<1.0	<1.0	<3.0		8.48	–	–
	08/30/2022	09/02/2022		<100	300	200		<17200		7.1	<1.0	<1.0	<3.0		6.24	–	–
MW-12	08/30/2022	09/02/2022		<100	250	260		<17200		<1.0	<1.0	<1.0	<3.0		6.28	–	–
MW-13	08/31/2022	09/02/2022		27,300	22,200	3,200		34,500		###	652	###	2,280		6.96	–	–
MW-14	08/31/2022	09/02/2022		3,710	700	210		<17200		526	114	213	297		7.07	–	–
MW-15	08/31/2022	09/02/2022		6,020	578,000	#####		25,900		222	187	748	750		6.72	–	–
MW-16	08/31/2022	09/02/2022		6,430	110,000	2,900		<17200		719	198	523	645		7.67	–	–
MW-17	08/30/2022	09/02/2022		<100	180	<190		<17200		<1.0	<1.0	<1.0	<3.0		5.15	–	–
MW-18	08/30/2022	09/02/2022		<100	190	<190		<17200		<1.0	<1.0	<1.0	<3.0		6.26	–	–
MW-19	08/30/2022	09/02/2022		<100	130	<200		<17200		<1.0	<1.0	<1.0	<3.0		8.00	–	–

TPH-GRO Groundwater Occurrence

Week 1 — HRSC
Week 3 — Monitoring Well Installation
Week 4 — Groundwater Monitoring
Weeks 4-12 — Equilibrium Measurements
Week 12-ongoing — Conceptual Site Model Development

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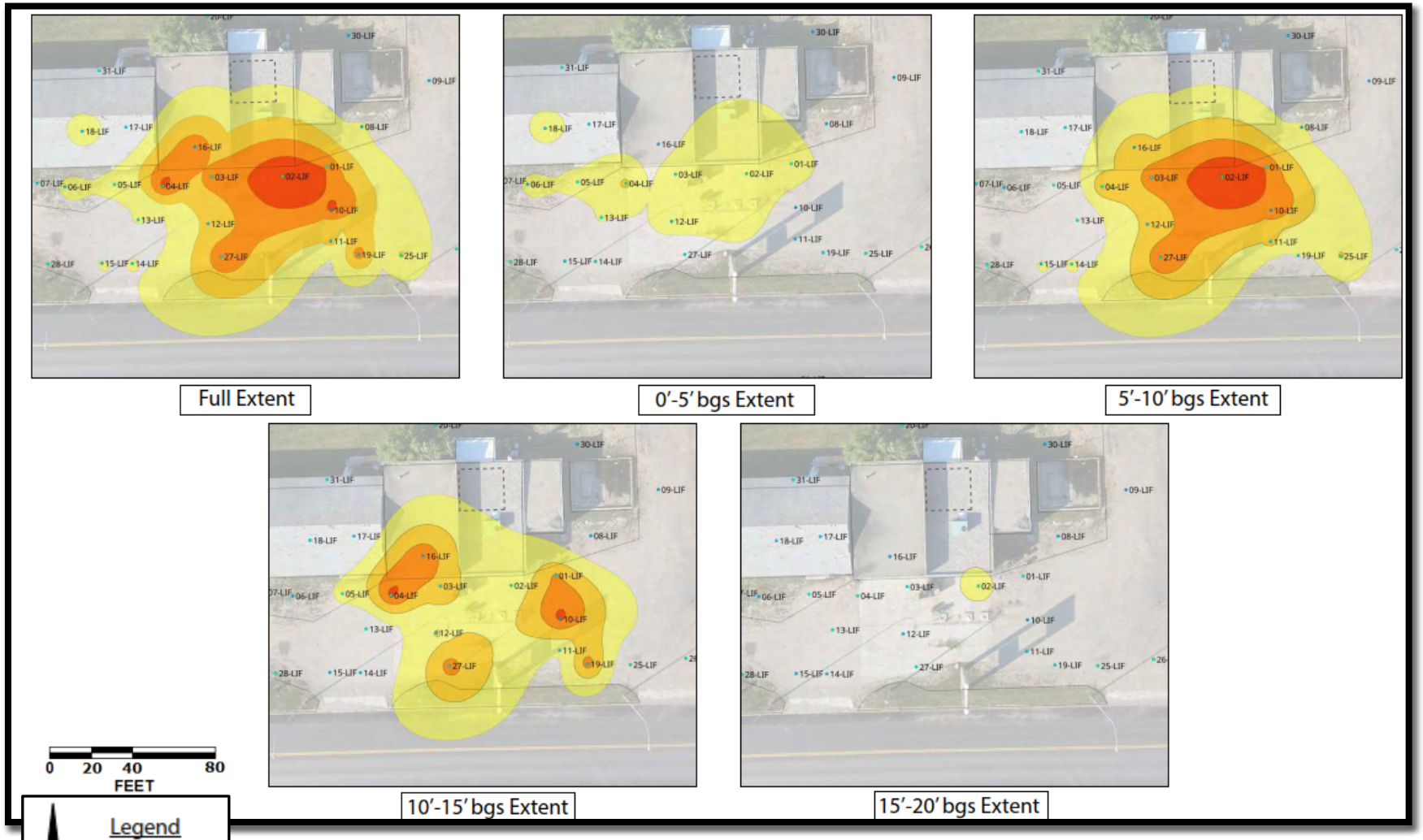
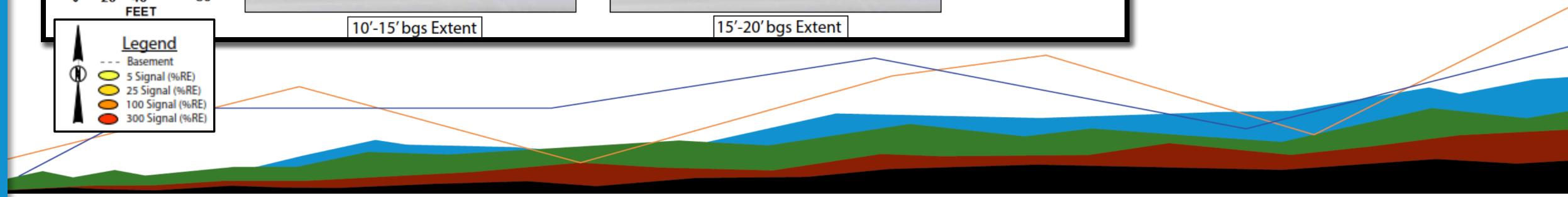


UVOST Signal Response Results



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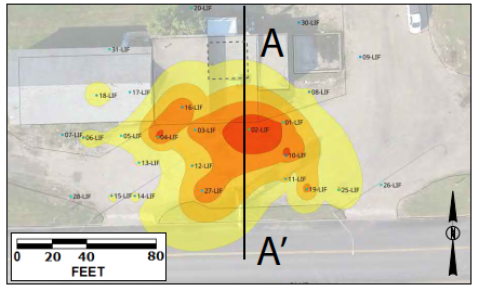
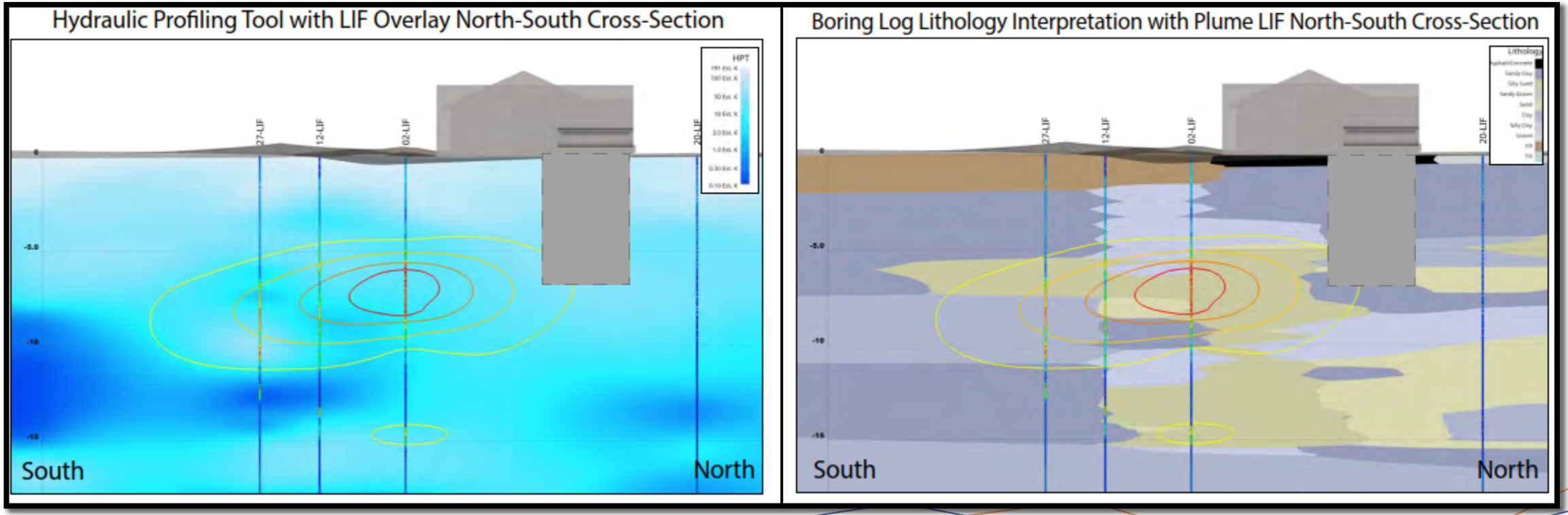
UVOST Results North-South





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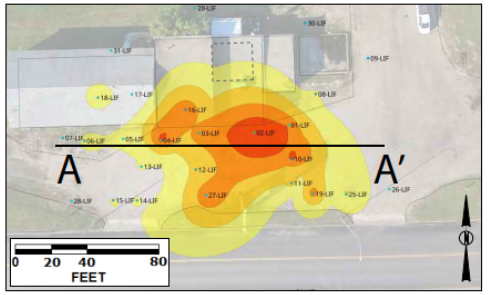
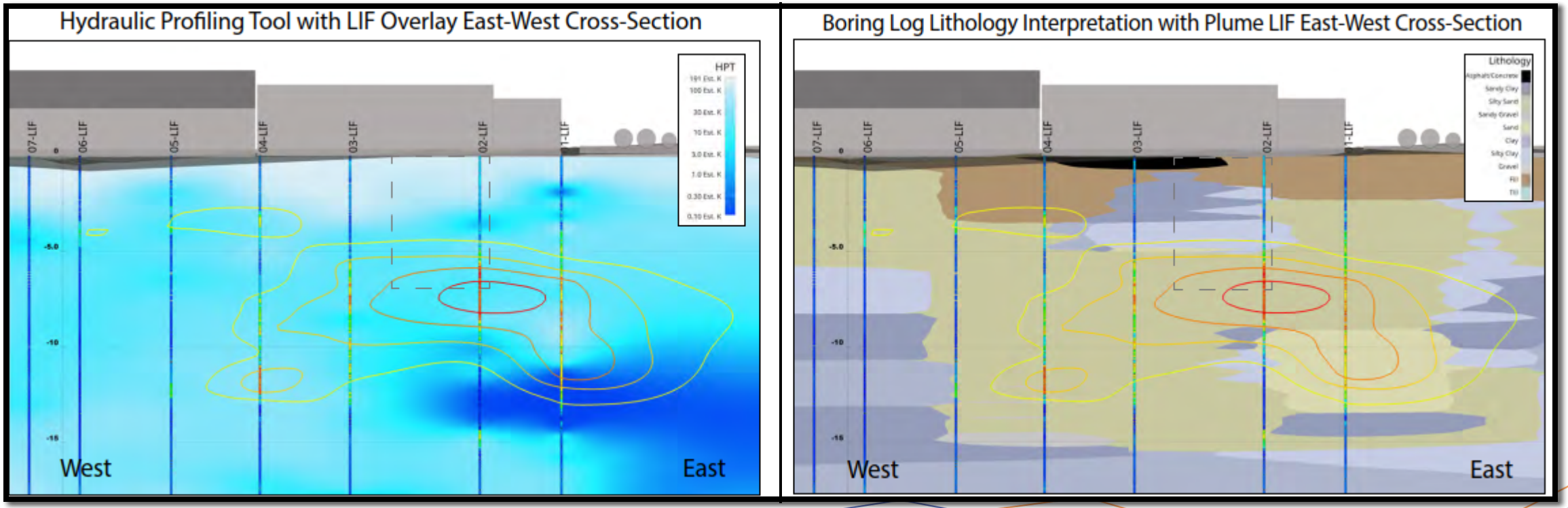
UVOST Results East-West





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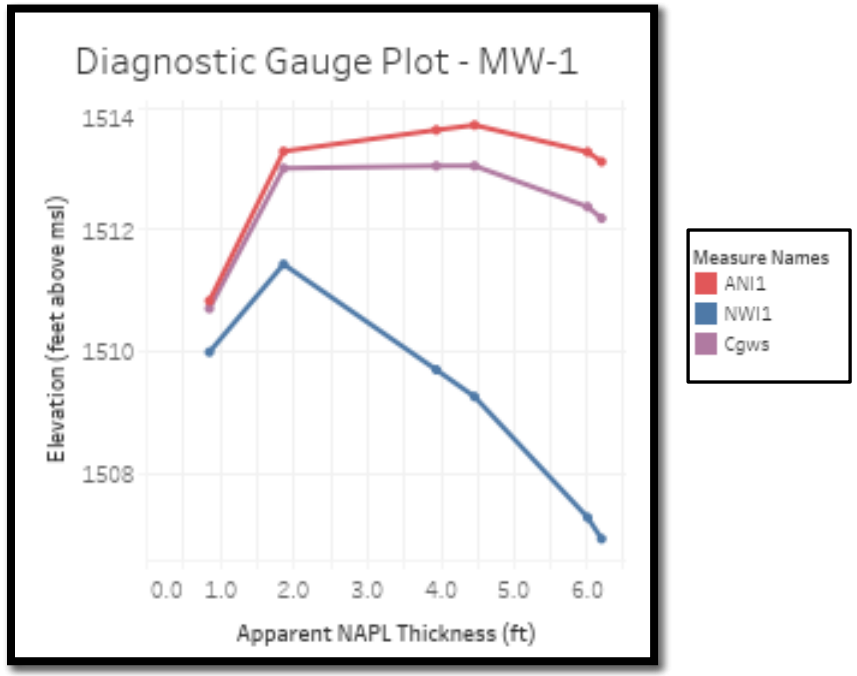
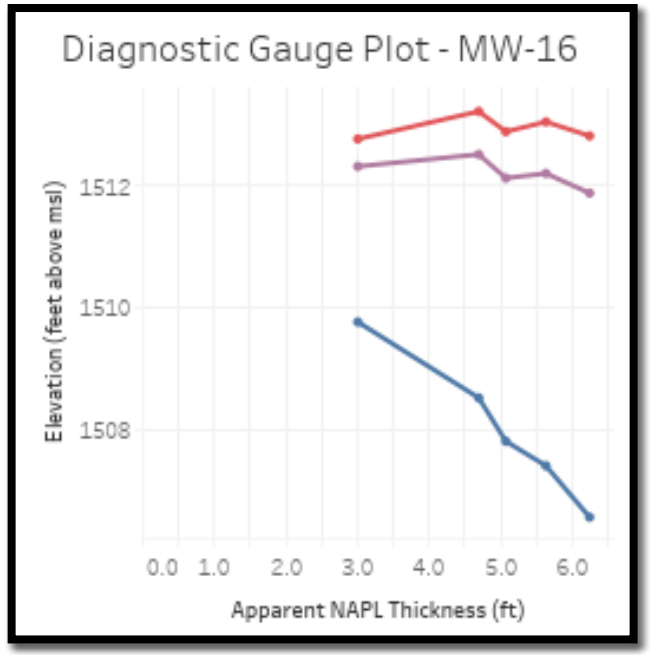
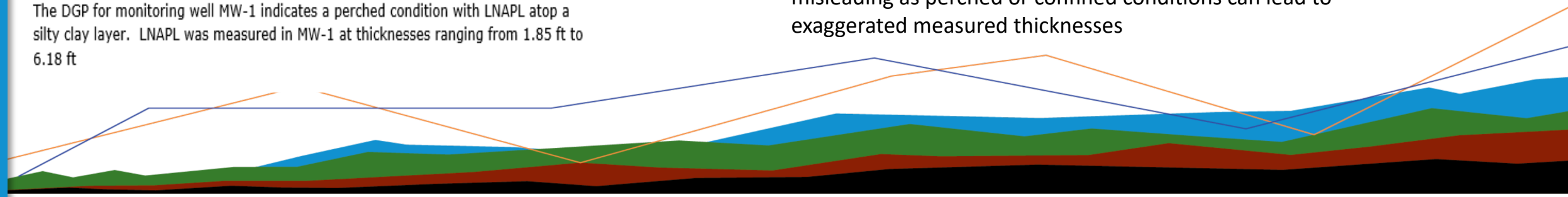
Fluid Level Measurement Results



The DGP for monitoring well MW-1 indicates a perched condition with LNAPL atop a silty clay layer. LNAPL was measured in MW-1 at thicknesses ranging from 1.85 ft to 6.18 ft



The point: Measured LNAPL thicknesses in monitoring wells can be misleading as perched or confined conditions can lead to exaggerated measured thicknesses



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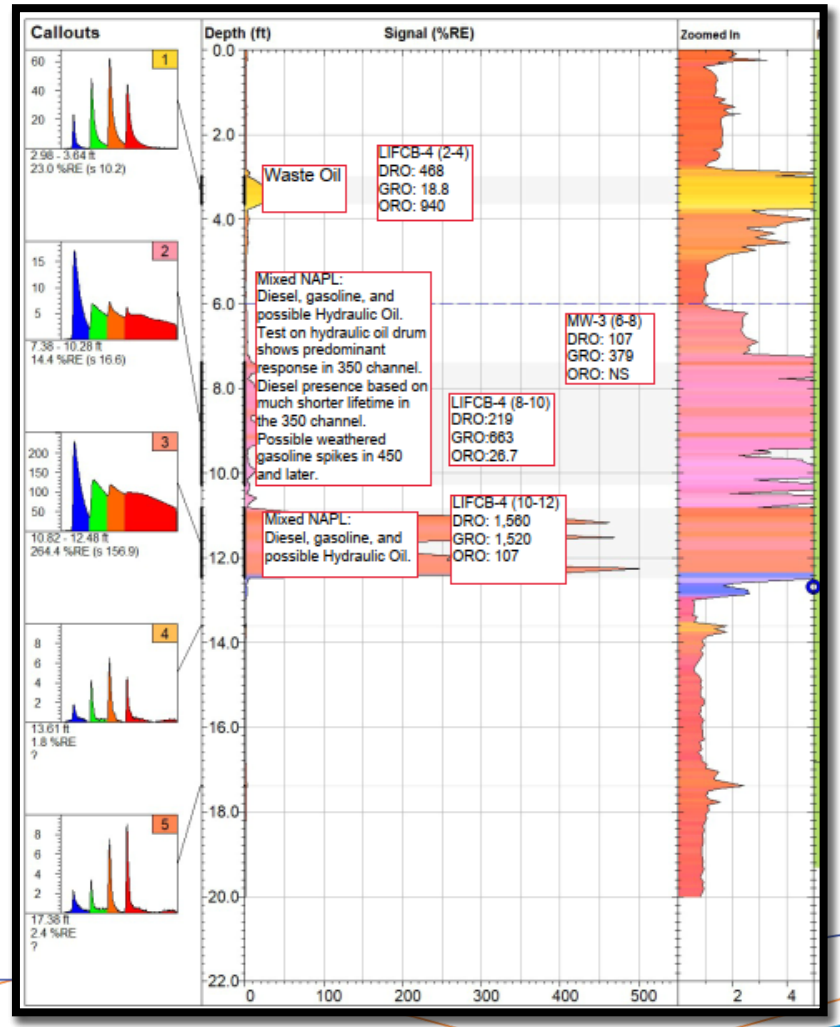
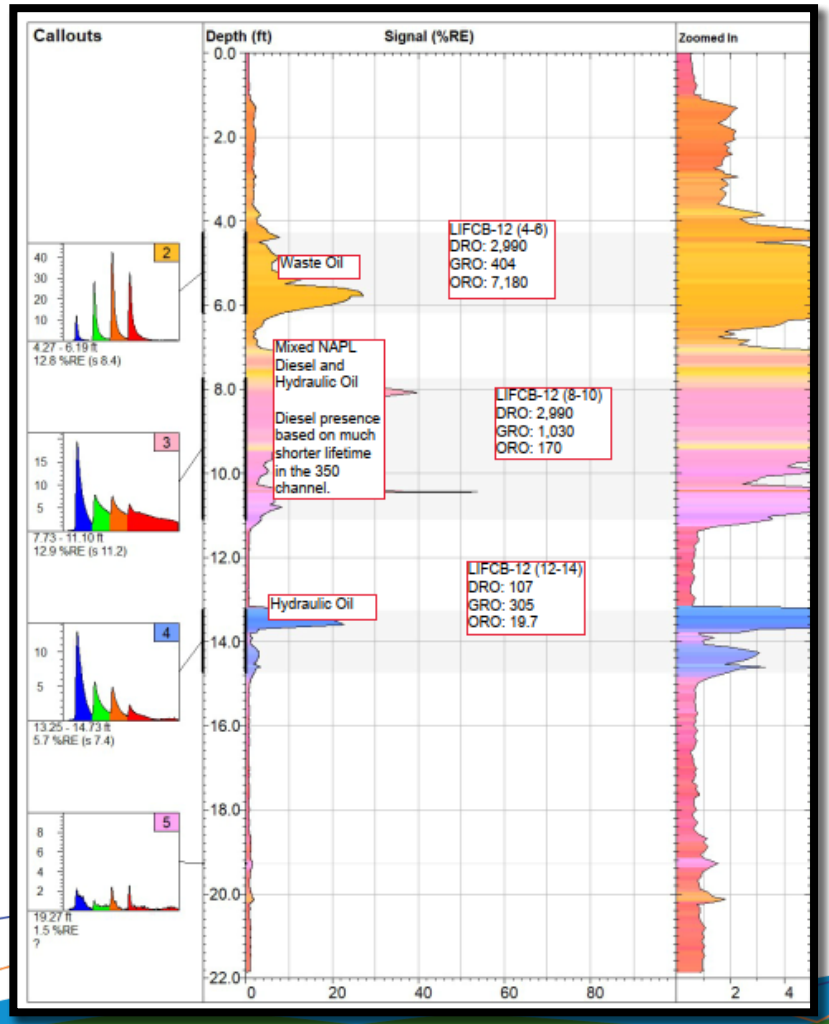
Waveforms and LNAPL Types





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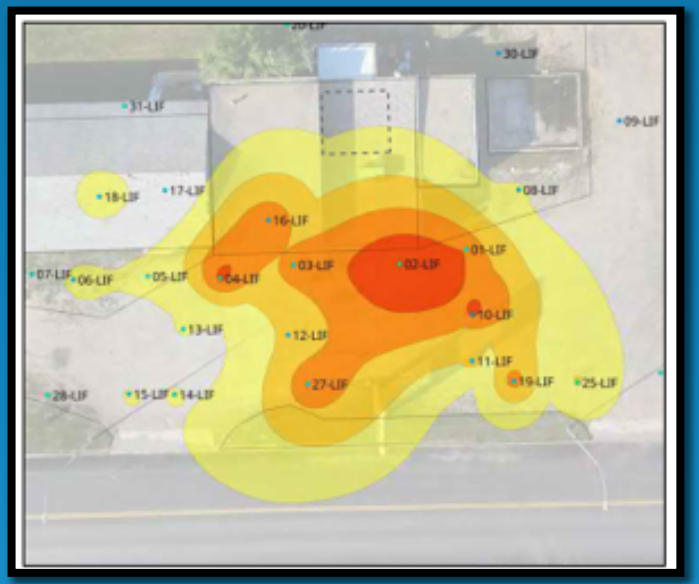
What We Know Now



The Issues

Multiple Sources

Multiple Fuel Types

Large (+4.5’) LNAPL In-Well Thicknesses

Confirmed Indoor Air Vapor Intrusion

Lack of COC definition in multiple media

Our Understanding

Multiple Sources and Fuel Types Confirmed

Better Correlation of Fuel Type

Perched LNAPL Conditions

Basement Flooding/COC Water Intrusion due to Source Location

COC Defined with Volumetric Understanding

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Summary

Where We're At Now

- **Funding**
- **Incorporation of RBCA Process**
- **Remedial Alternatives Evaluation**
  - **LNAPL Tn Testing and Fingerprinting**
  - **Indoor Air Evaluation**
  - **Considering Excavation or MPE**

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Summary

Key Takeaways

- **Defined Site:** TPH and LNAPL release extents defined
- **Accelerated Schedule:** Implementation of Triad Approach rapidly reduced project uncertainty
- **CSM:** Post-HRSC data collection and analysis has led to a well documented understanding of the site

"Everyday bite off more than you can chew and chew it!"

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Thank you!

Contacts

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