

Lessons Learned from Two Phases of TCH Treatment at a Former MGP Site

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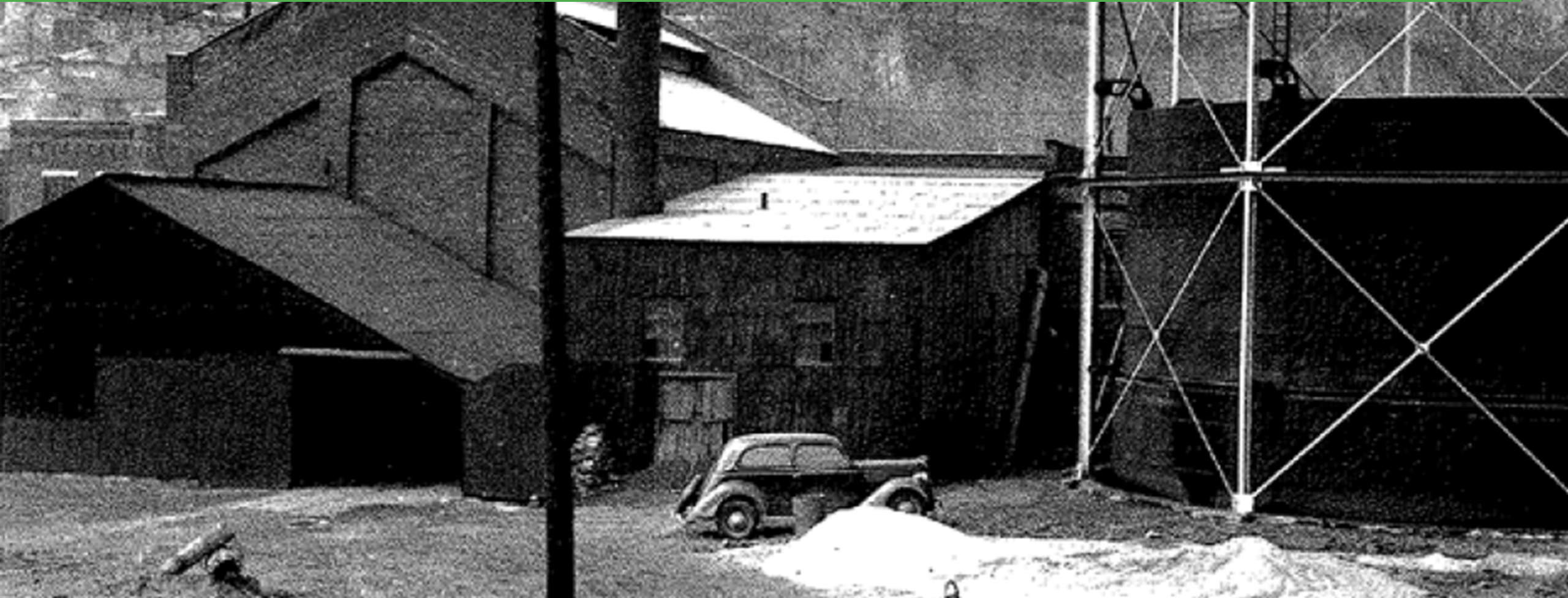


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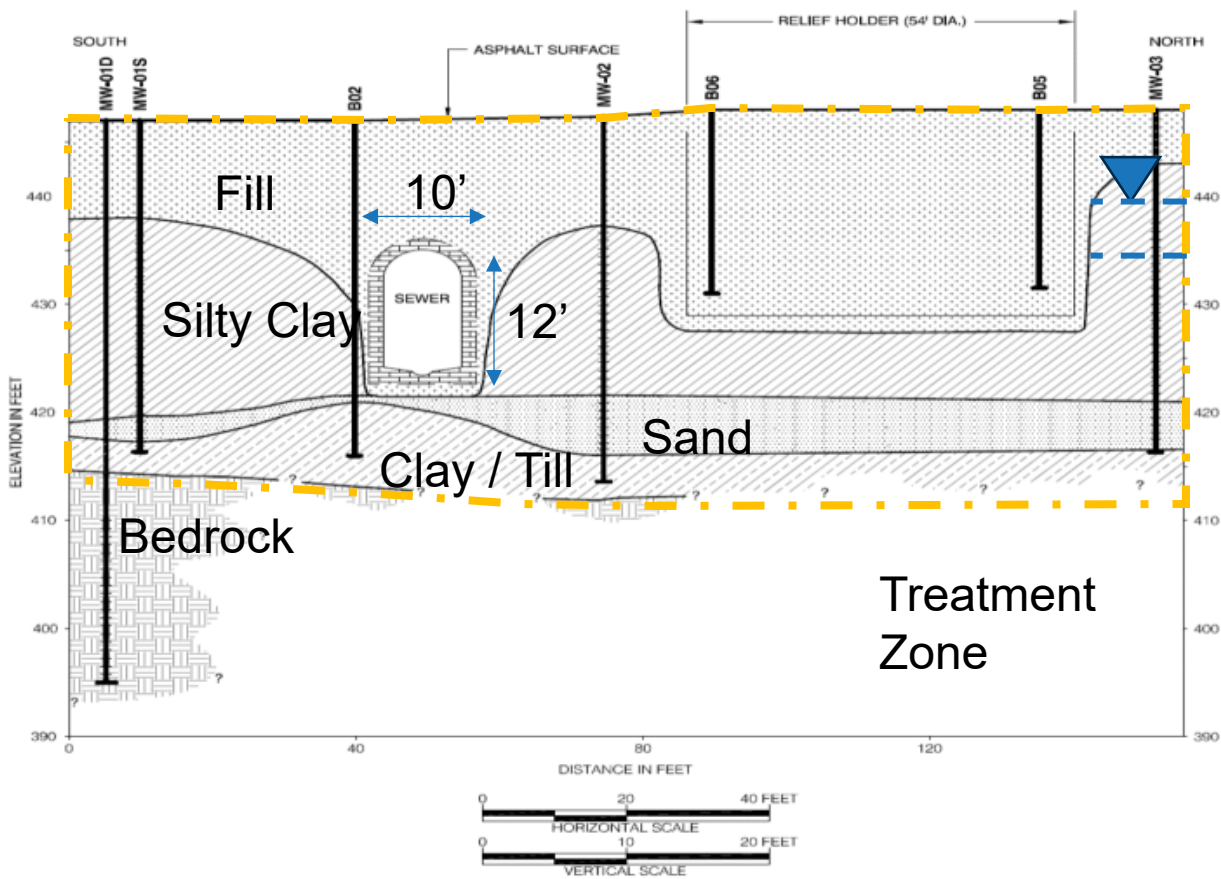


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Source Characterization and Design

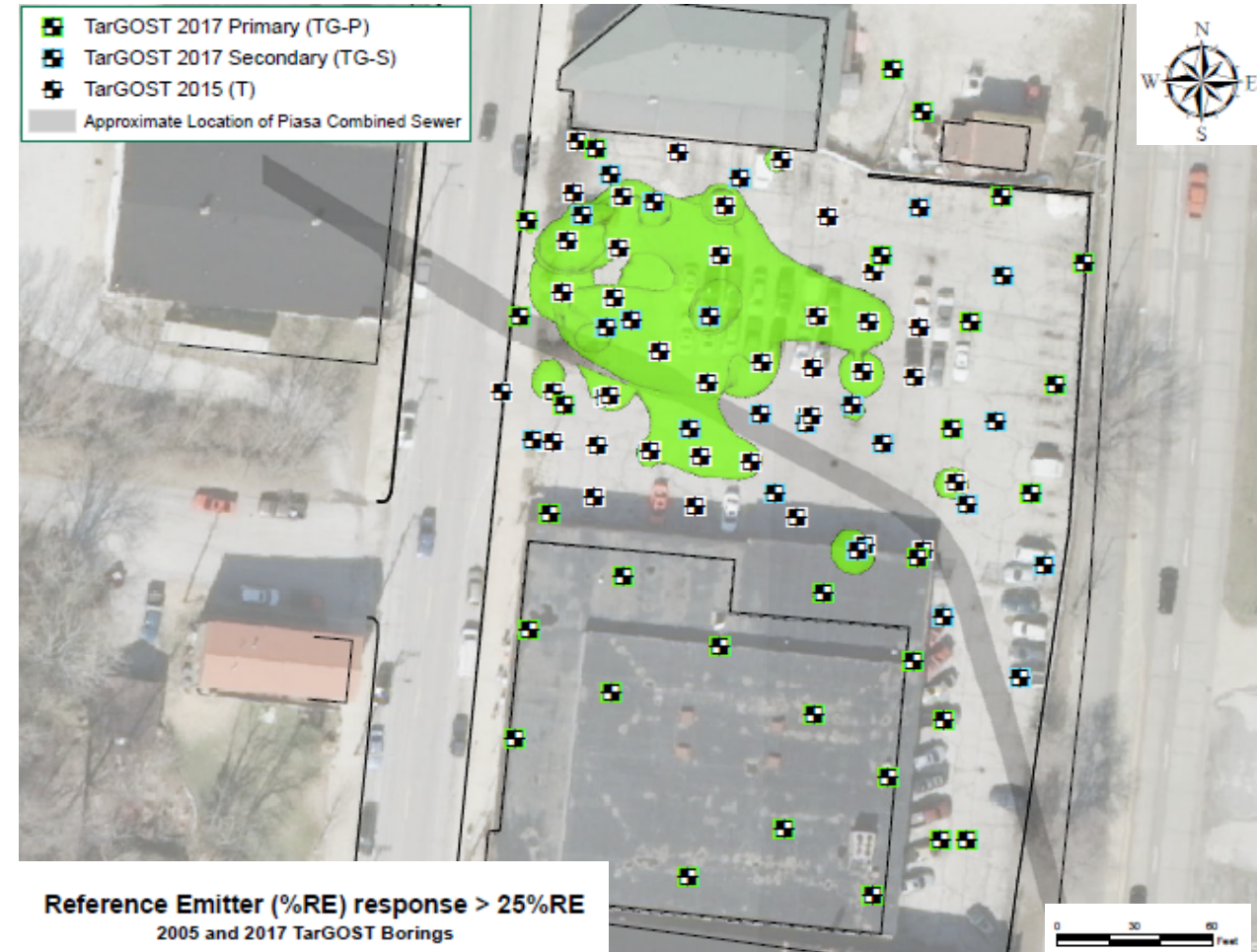
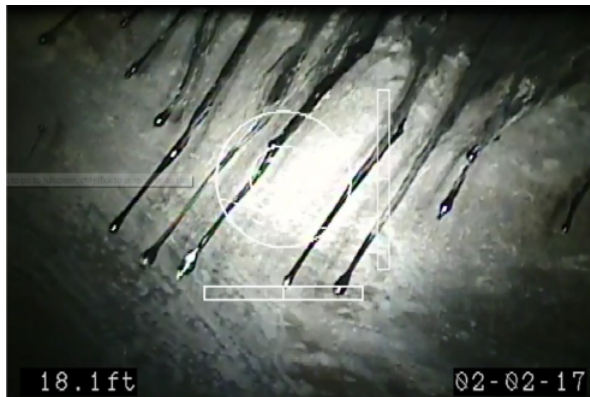


Site Features

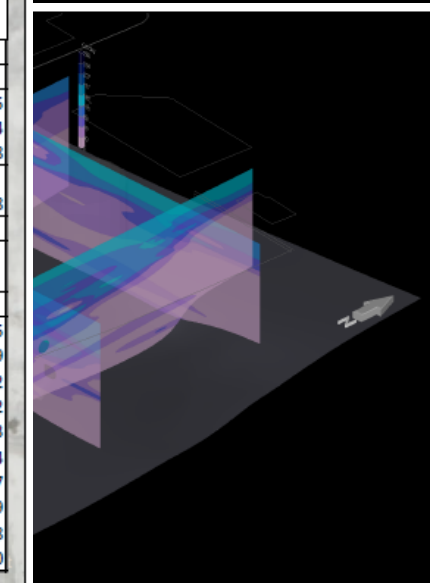
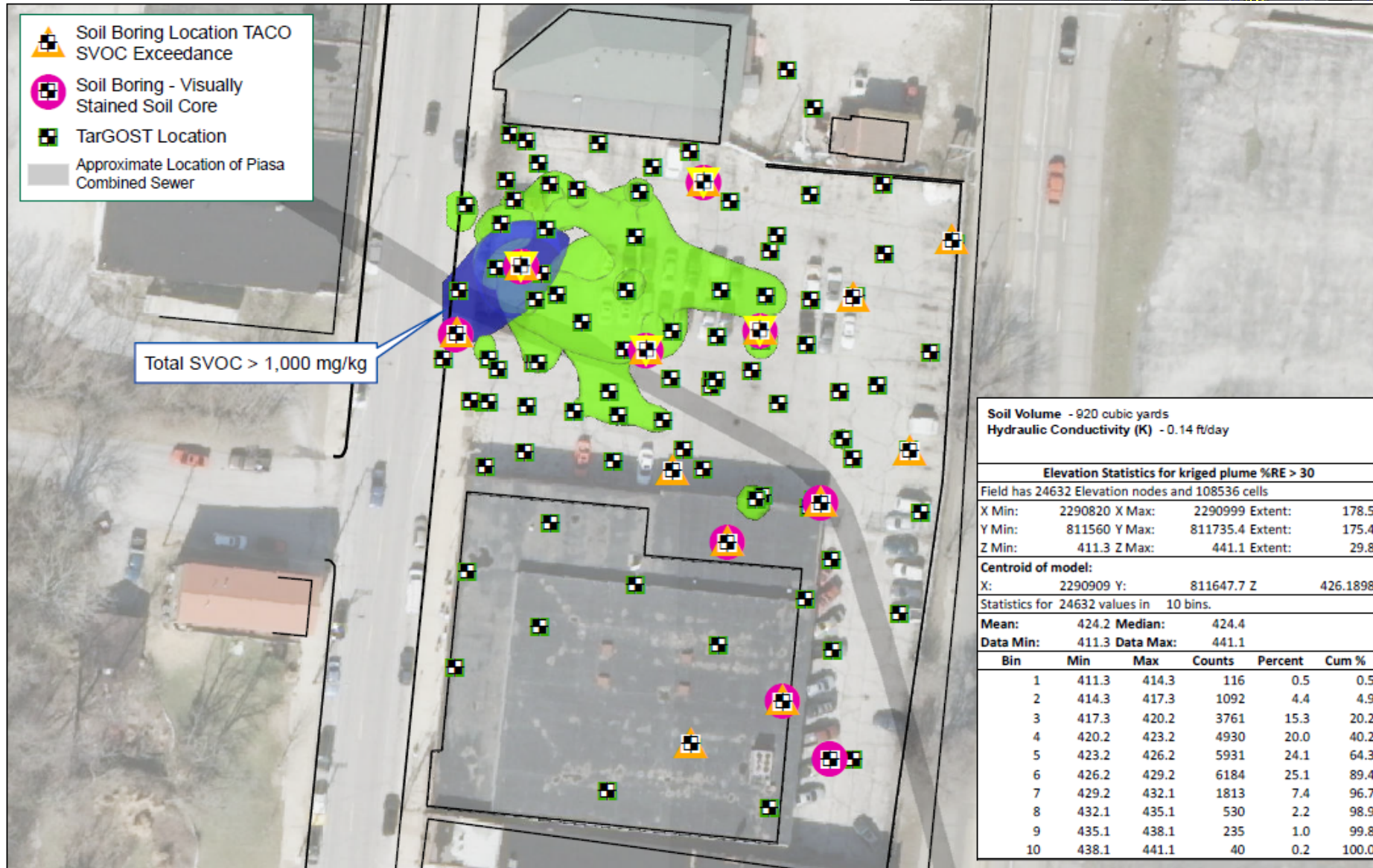


Pre-Design Investigation

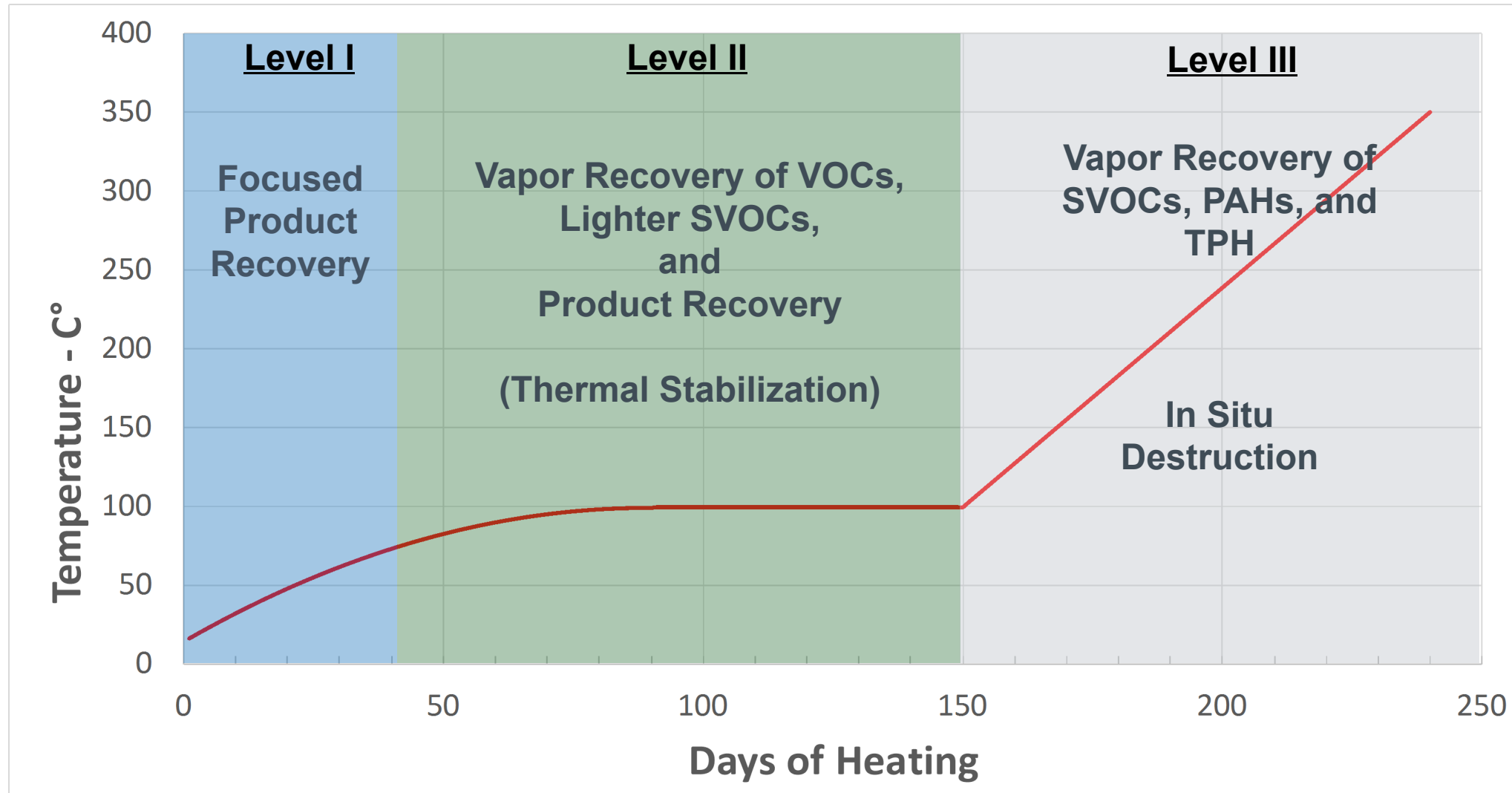
- PDI Objectives
- Methods
 - Surveys
 - TarGOST® grid (52 out of 70)
 - Soil Borings (17)
 - HPT
 - Aquifer Testing



Pre-Design Results



Levels of Treatment at MGP Sites

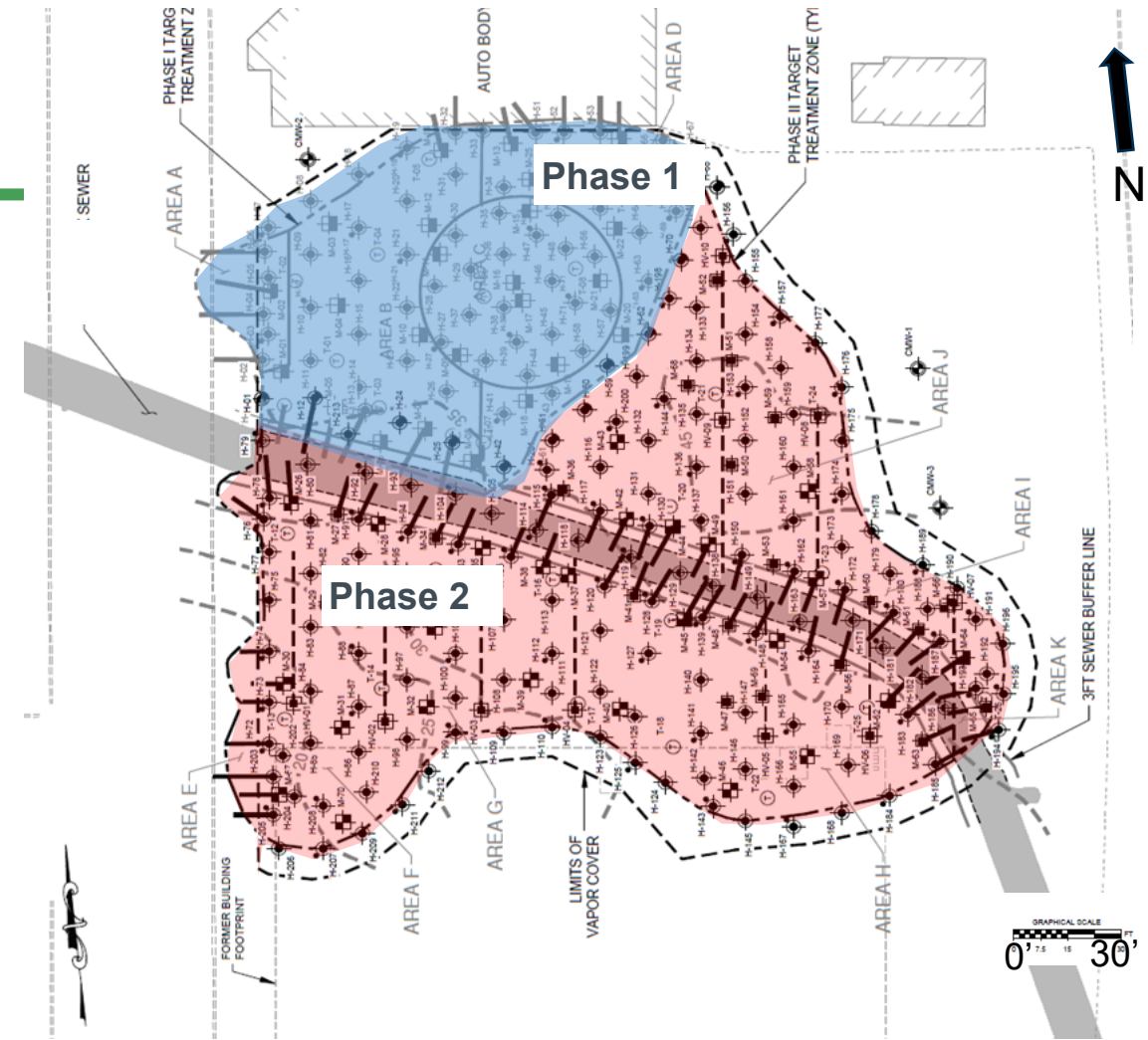


Alton ->

Level I
+
Level II

Treatment Approach

- Treatment Objectives
- Basis for Phasing
 - Uncertainties in baseline mass / mass loading to treatment system
 - Better understand Level of Treatment at 100°C
- Understand Impacts to:
 - Piasa Creek Sewer
 - Neighboring, occupied properties
 - Public roadways
- Incorporate Lessons Learned into Phase 2

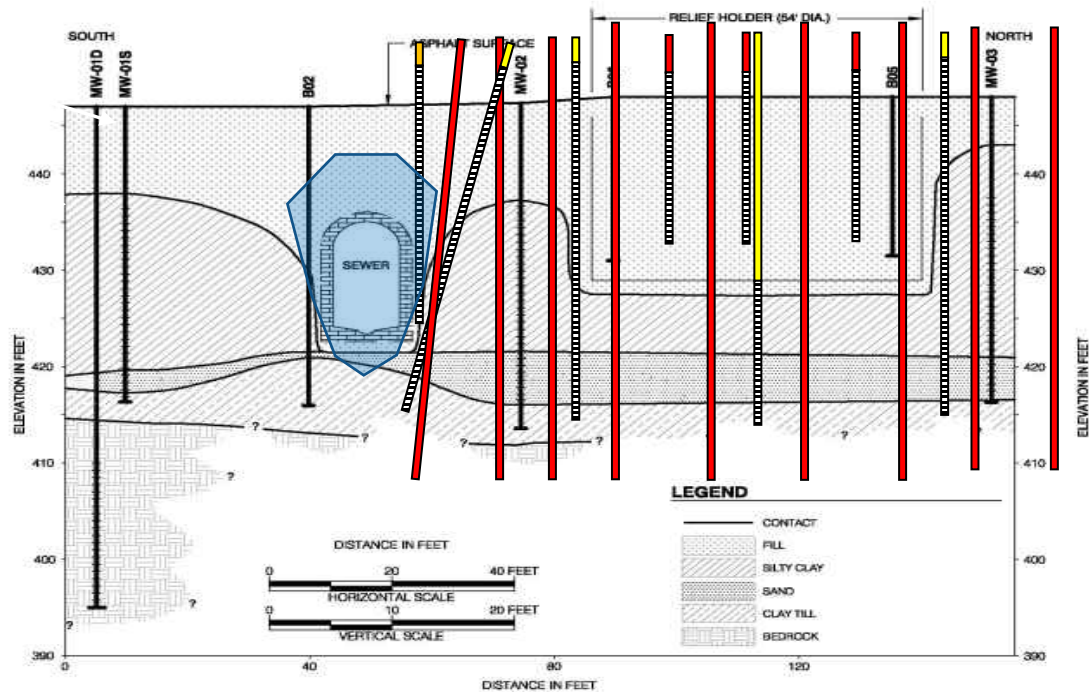
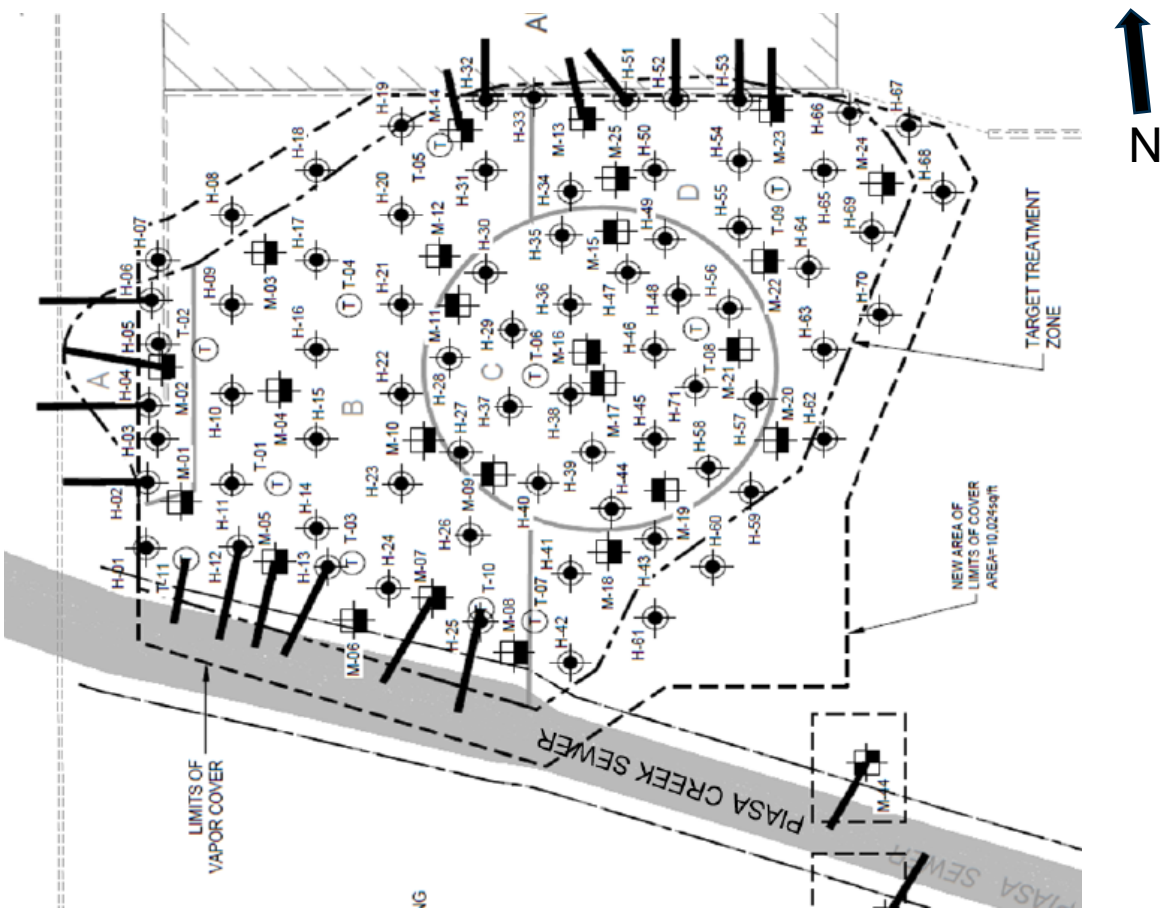


	Phase 1	Phase 2	Unit
Area	7,918	18,005	ft ²
Volume	10,789	24,676	cy
Upper Extent of Treatment	0	0	ft bgs
Lower Extent of Treatment (bedrock)	30 to 45	30 to 45	ft bgs

Phase I



Phase I - Approach



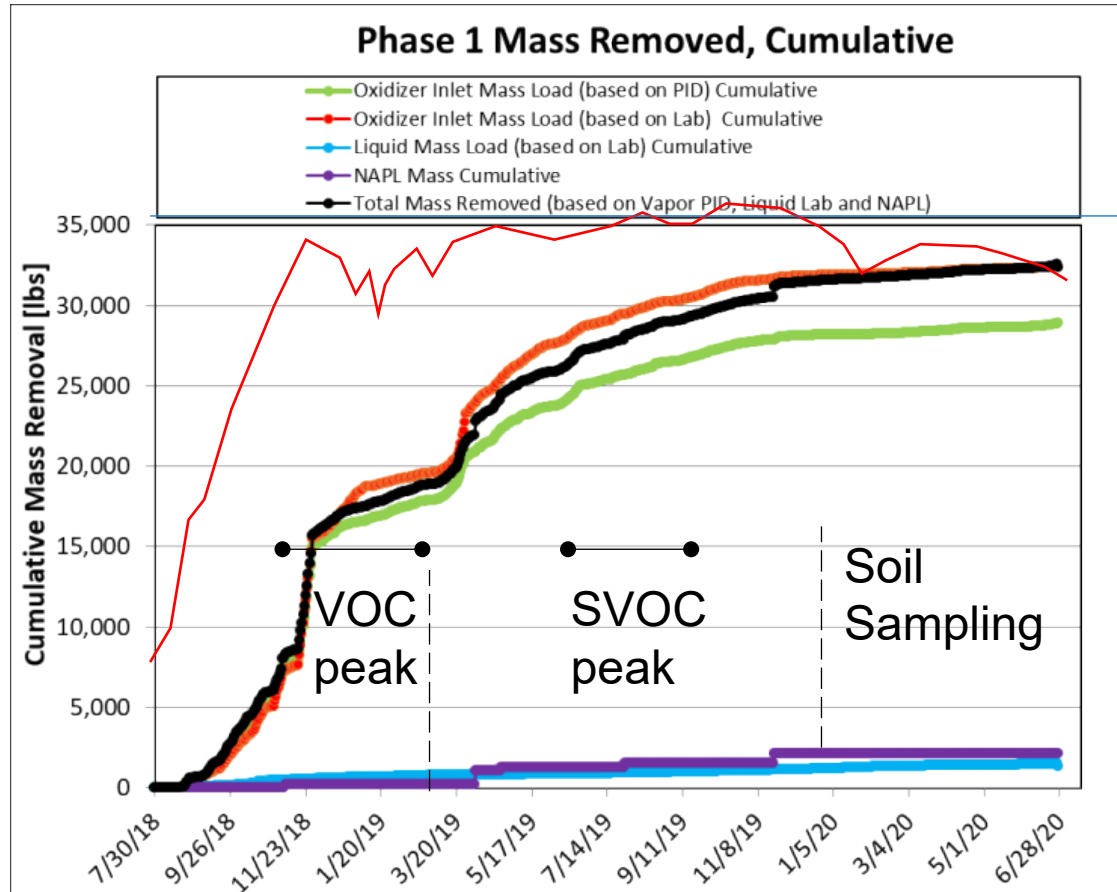
	Heaters	Multiphase Extraction Wells	Temperature Monitoring Points
Vertical	62	19	9
Angled	9	10	2

Treatment System

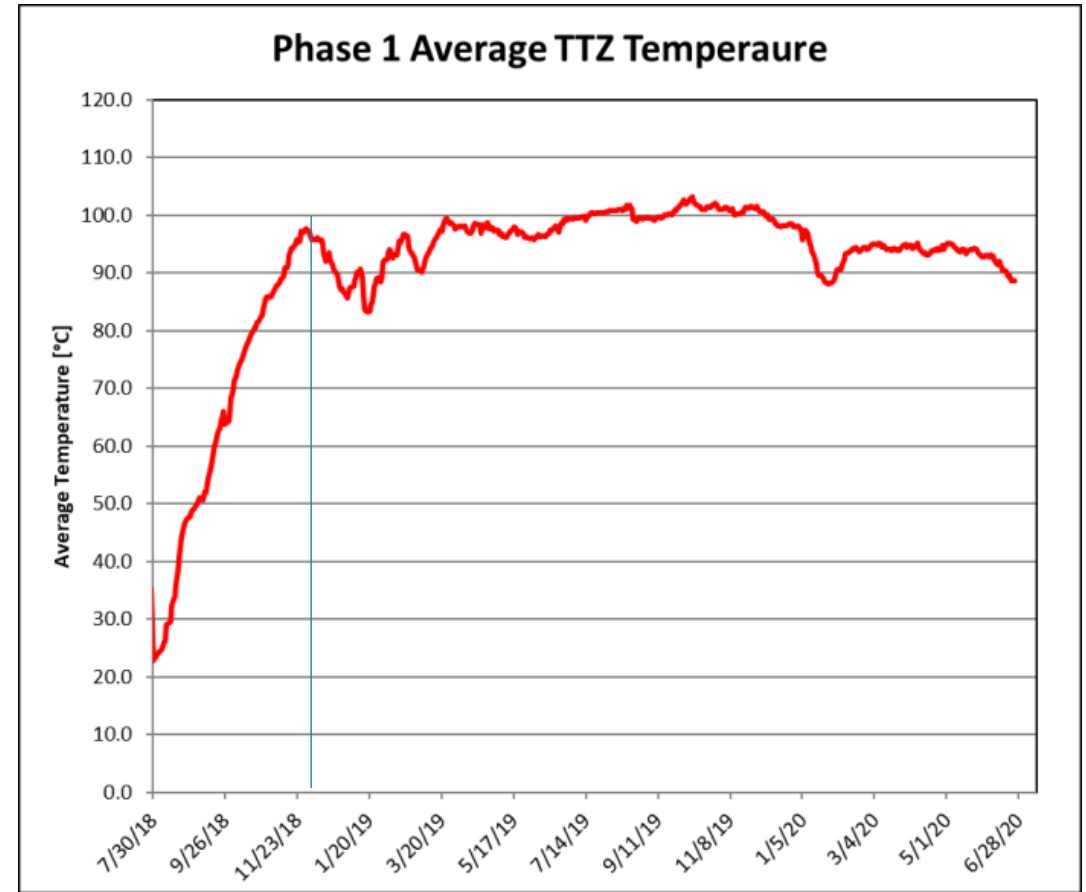
- Vapor
 - Moisture separators / Heat Exchanger (HX)
 - Insertion + duct heaters
 - Blowers
 - Thermal accelerators
- Liquid:
 - Separation tanks + Oil Water Separator / HX
 - Filtration / Organoclay
 - LGAC
 - Treated water discharged to Piasa sewer
- Cooling: Chiller System



Phase I - Operation



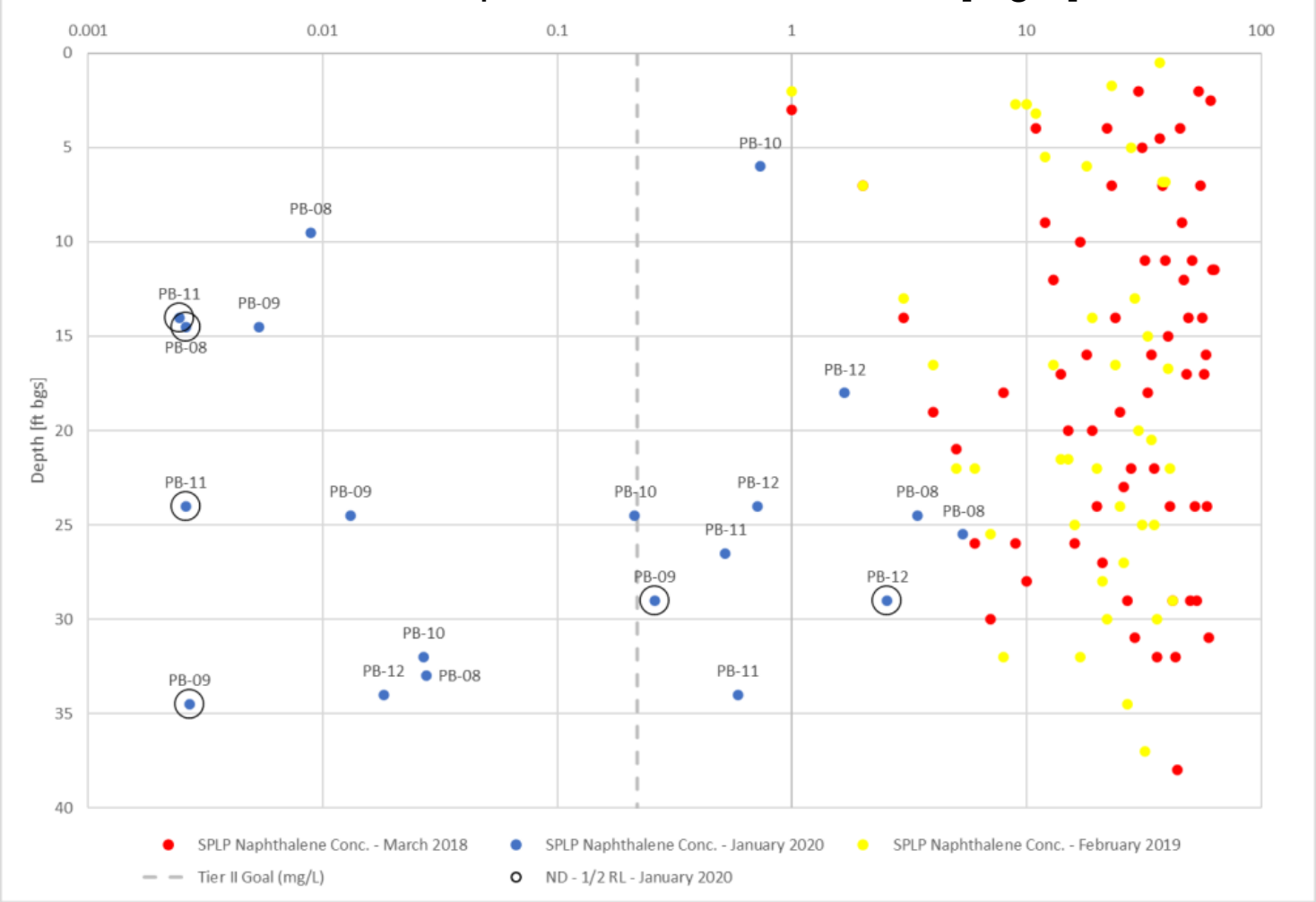
Design: ~20,000 lbs
Actual: ~32,400 lbs
Removed



Design: 225 days
Actual: 690 days

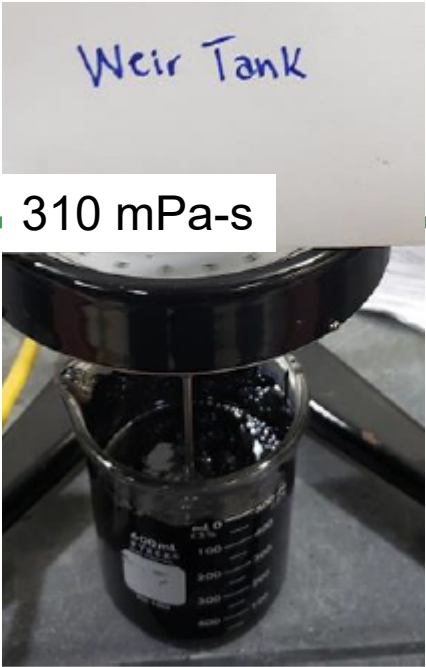
Phase I - Results

SPLP – Naphthalene Concentration [mg/L]

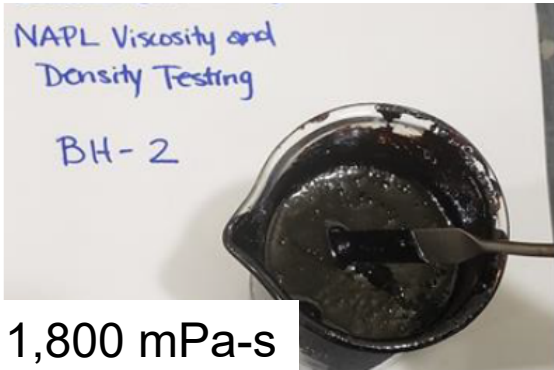


Leachability reduced

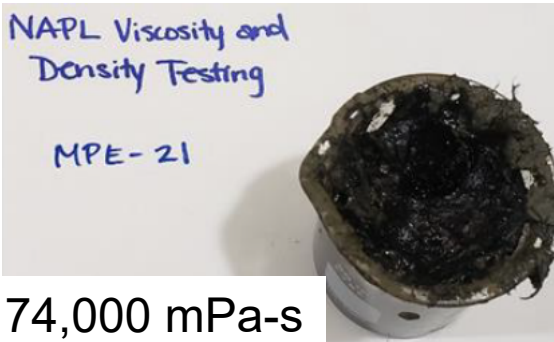
Recovered
in Treatment
System



Outside TTZ



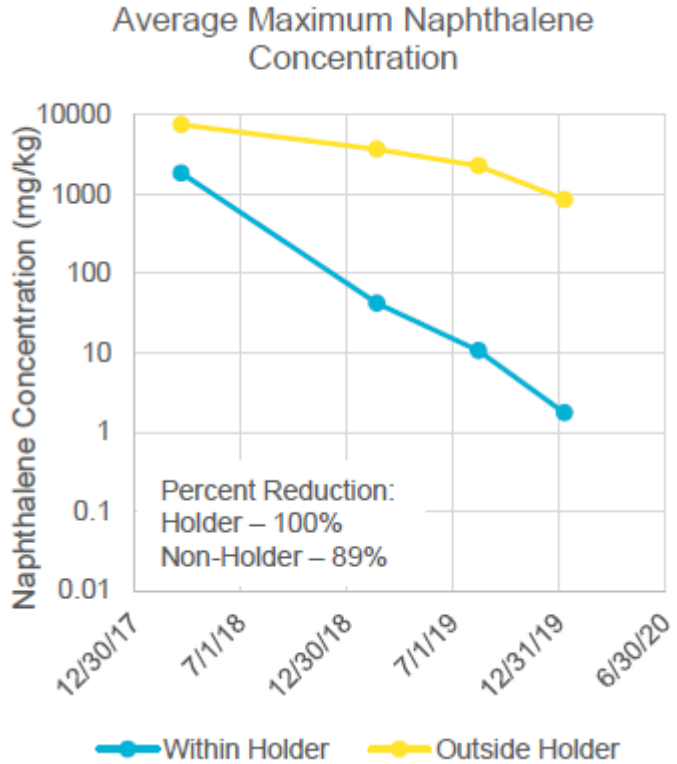
Inside TTZ



Phase I - Results

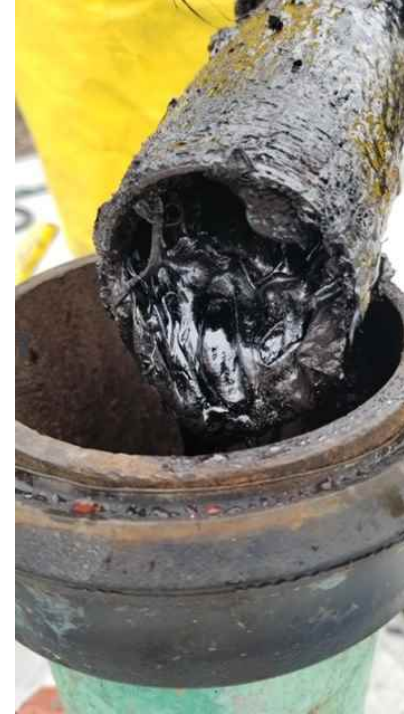
- Consistent with Level 2 Treatment:
 - Remove mobile NAPL
 - Recover VOCs and light end SVOCs
 - Reduce leachability
 - Reductions in soil evident, but did not reach stringent goals
 - Measured Temps inside sewer: 90°F (32°C), 100°F (38°C) outside
- within safe range and consistent with model

COC	Soil Limit [mg/kg]	Baseline Ave. [mg/kg]	Phase I Ave. [mg/kg]	% Reduction
Benzene	6.7	309.3	1.1	98.7% - 99.7%
Ethylbenzene	350	210.2	2.2	98.9% - 99.0%
Toluene	580	334.5	2.2	98.8% - 99.4%
Total Xylenes	280	348.9	8.6	97.5% - 98.4%
Naphthalene	270	2.5	0.2	90.1% - 93.4%

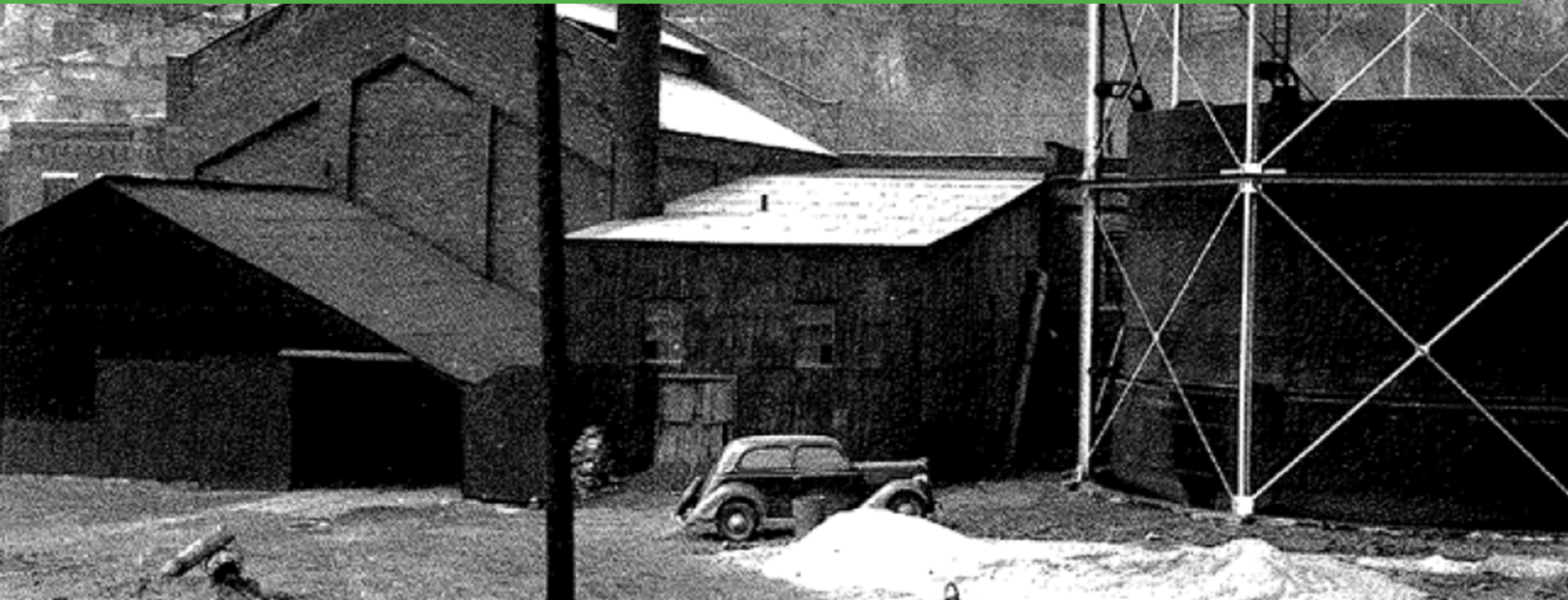


Phase I - Lessons Learned / Design Updates

- Increase Subsurface Vapor Extraction:
 - Added Horizontal VEWs
 - Added Co-located extraction to heaters
- Improve NAPL Recovery:
 - Blackhawk vs. Standard high temp pneumatic
 - Added slurping system
 - “Idle” heating for 5-6 wks ~60°C
- Reduce Heater / Liner failure:
 - Thicker Heater Cans (Sch 40 -> 80)
- Insulated Vapor Cover Design
- Backup duct and insertion heaters, good insulation is key



Phase 2





PHASE II

Phase II Approach

	Heaters	HVEWs	MPEs	TMPs
Vertical	135*	10	28	15
Angled	30**		19	2

*33% w/ extraction

****80% w/ extraction**

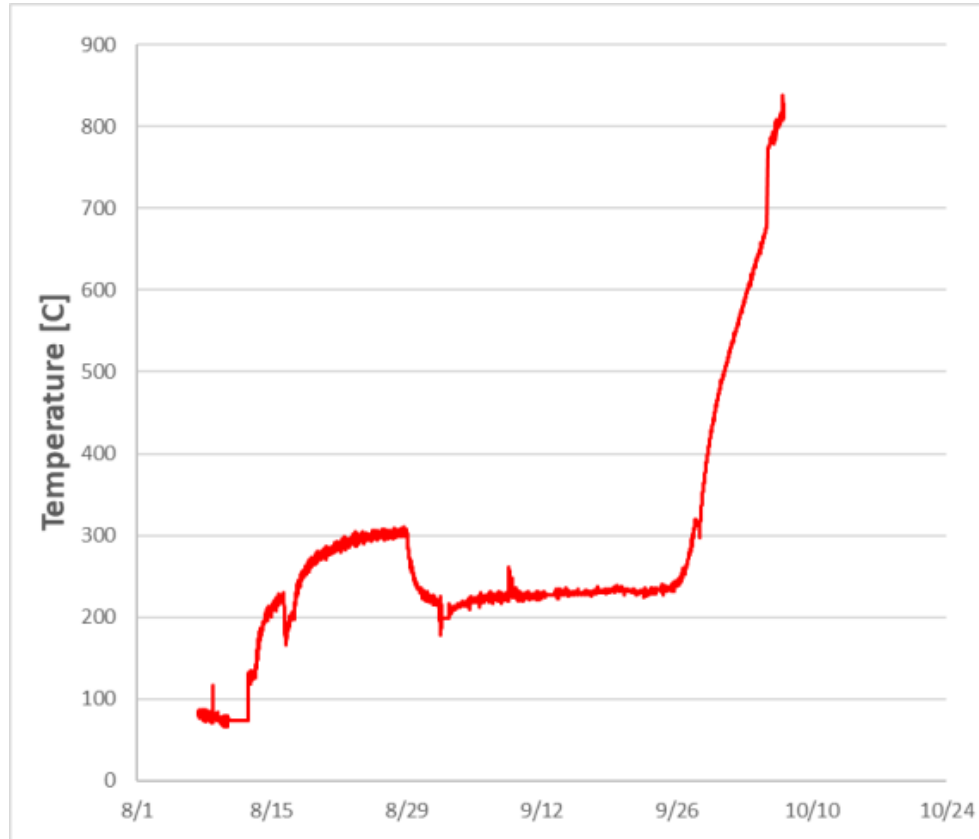
AND...

18 Dousing Points

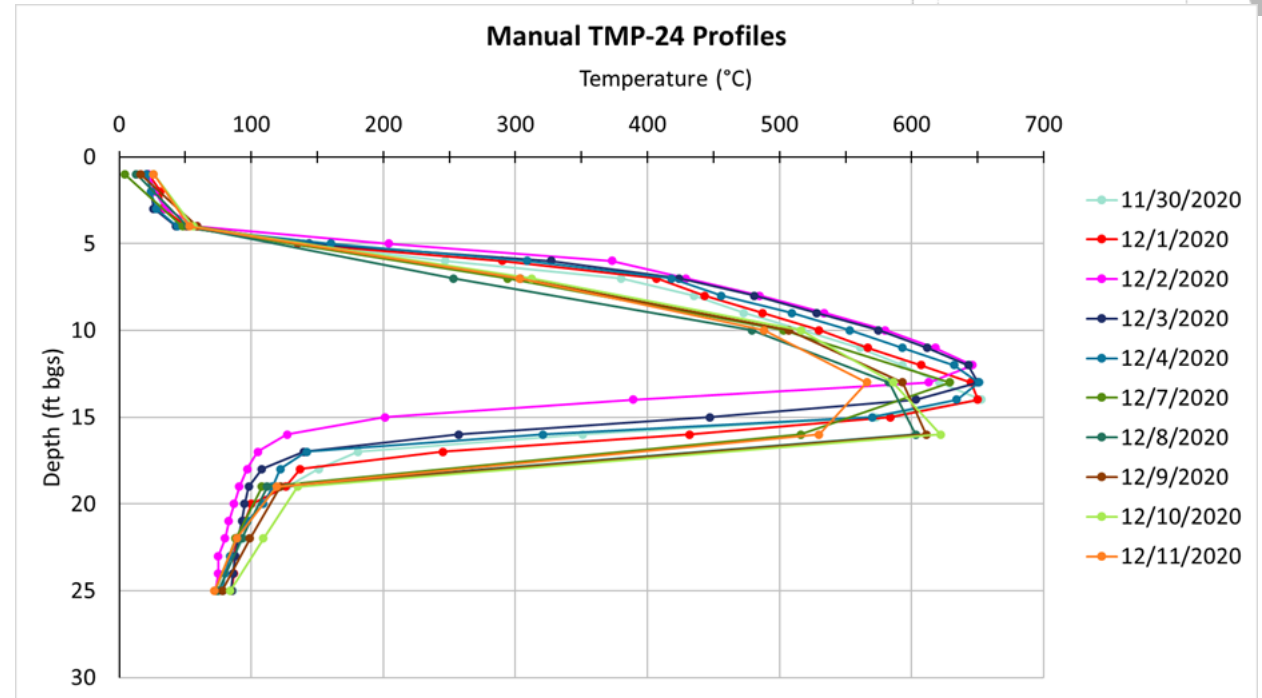
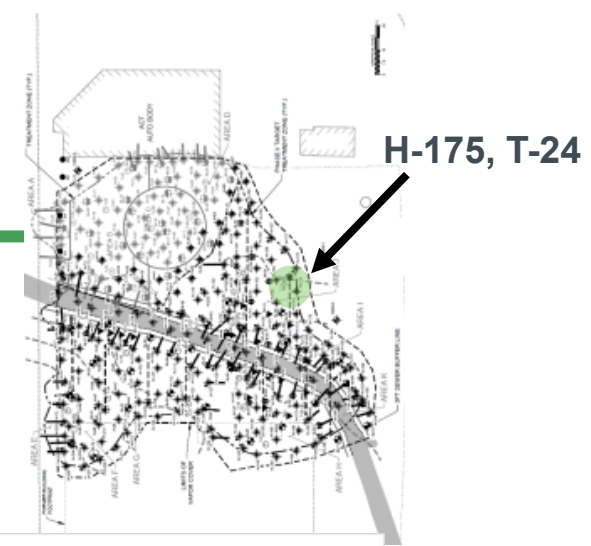


Phase II – Operation

Heater Temperature (H-175)



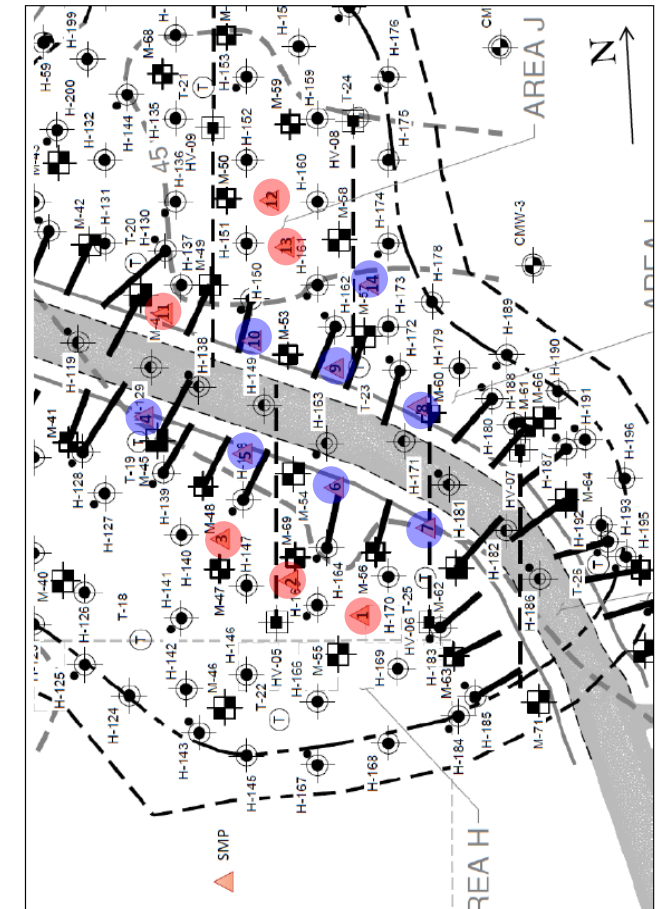
~ 90 days after system startup...



Shallow Temp Monitoring

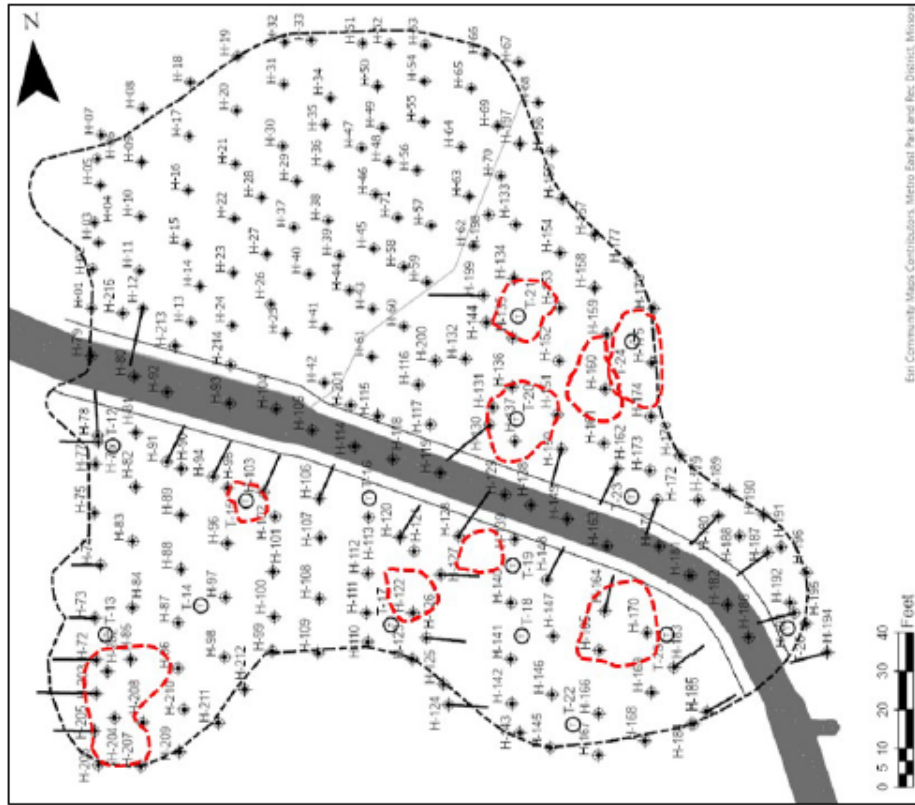
		12/3/2020		12/4/2020		12/7/2020		12/9/2020		12/10/2020		12/11/2020	
Location	Total Depth (ft)	Hot Spot Depth (ft)	Temp (C)	Hot Spot Depth (ft)	Temp (C)	Hot Spot Depth (ft)	Temp (C)	Hot Spot Depth (ft)	Temp (C)	Hot Spot Depth (ft)	Temp (C)	Hot Spot Depth (ft)	Temp (C)
1	15	5	748.6	4	508	4	491	4	487	4	482	4	493
2	6	5	564.9	7	554	8	552	8	548	8	559	8	549
3	14	6	477.3	10	443	5	105	5	109	5	111	5	373
4	14	8	84.7	12	83	12	82	10	425	10	476	10	518
5	14	6	68.7	11	74	16	72	16	72	16	72	16	71
6	14	7	62.9	5	59	3	55	5	55	5	54	5	53
7	10	3	61.6	8	53	8	53	4	63	4	63	4	55
8	14	14	61.8	6	62	16	61	16	62	16	61	16	59
9	14	14	64.2	7	65	6	33	6	39	6	34	6	33
10	14	14	67.2	10	68	11	84	13	78	13	78	13	84
11	14	5	100.3	8	133	8	212	7	251	7	248	7	242
12	12	10	679.5	6	509	5	91	5	110	5	107	5	114
13	13	10	473.5	8	401	5	100	5	100	5	101	5	192
14	13	13	66.3	5	60	5	28	5	27	5	28	5	69

- Initially installed to more closely monitor sewer
- Captured attendant smoldering

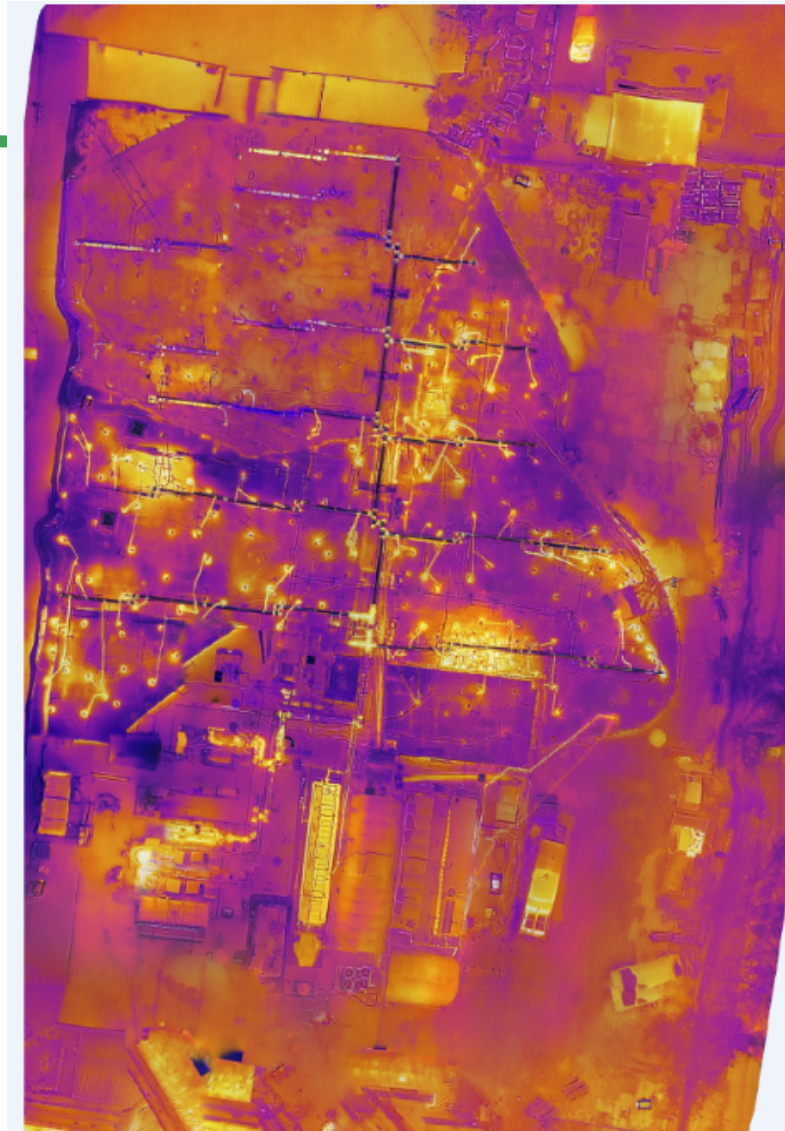


- Smoldering
- Normal Temps

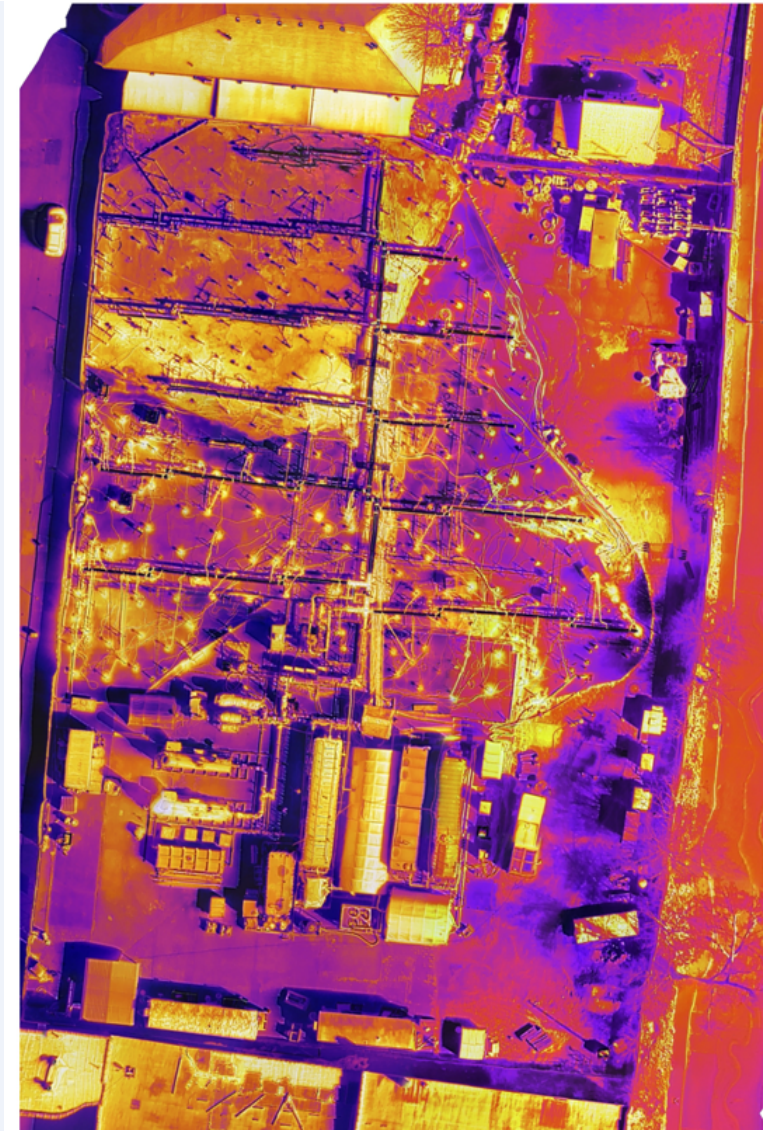
Thermal Imaging



Areas of smoldering

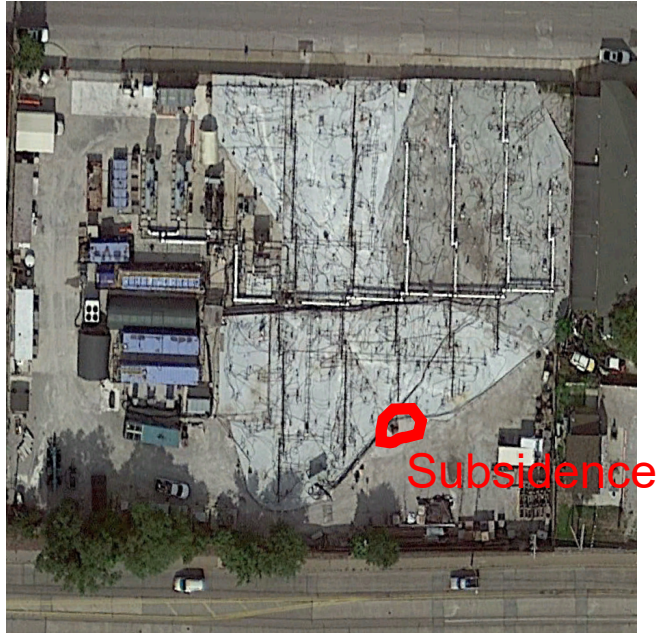


12/13/20



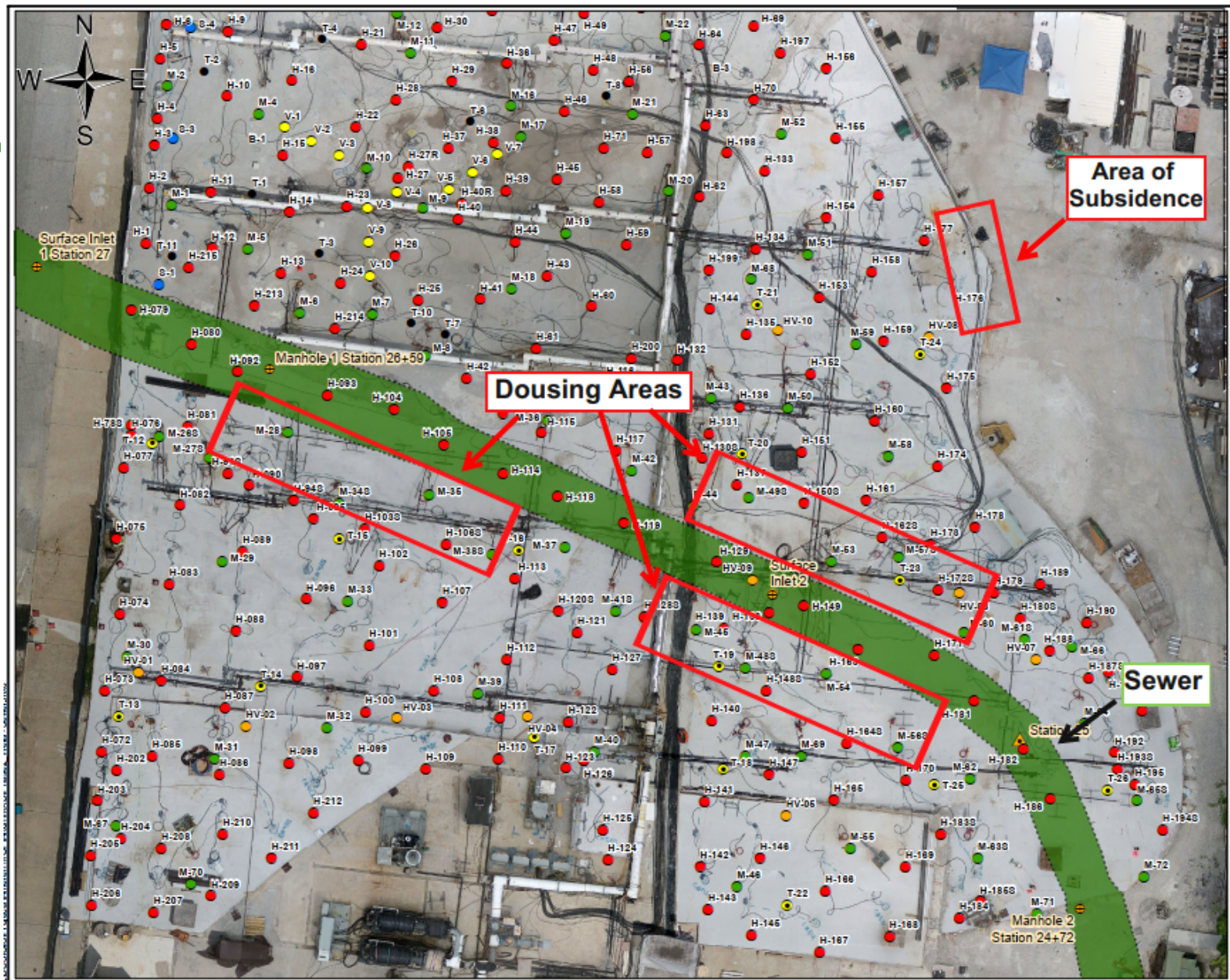
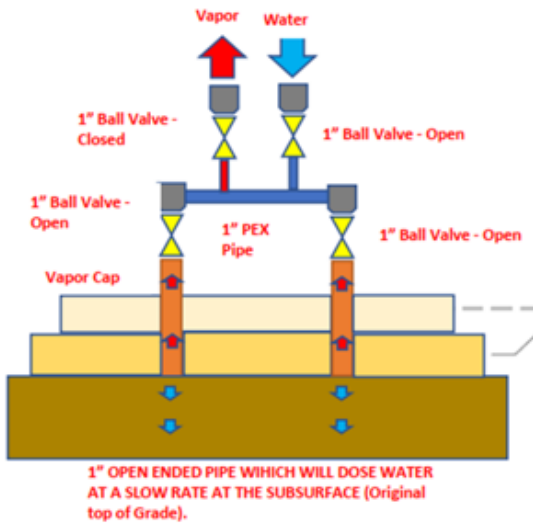
03/27/21

Subsidence

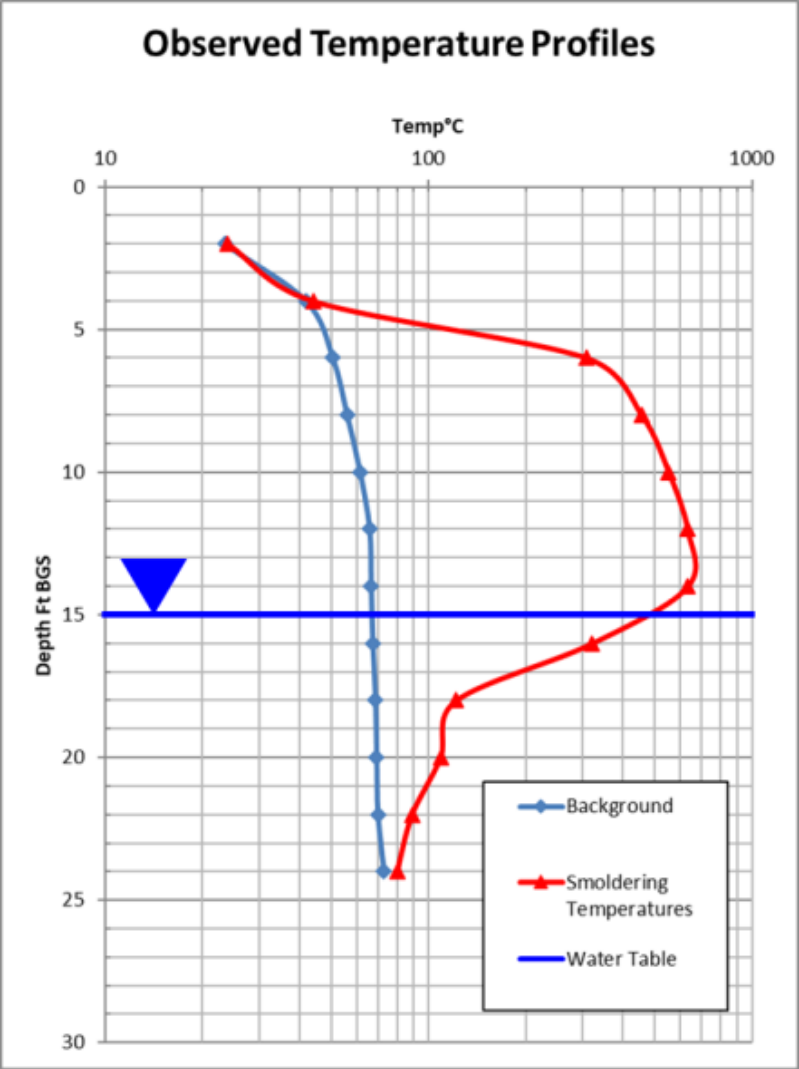


Dousing Areas

Sewer Ultimately Protected



Estimating Mass Destroyed In Situ

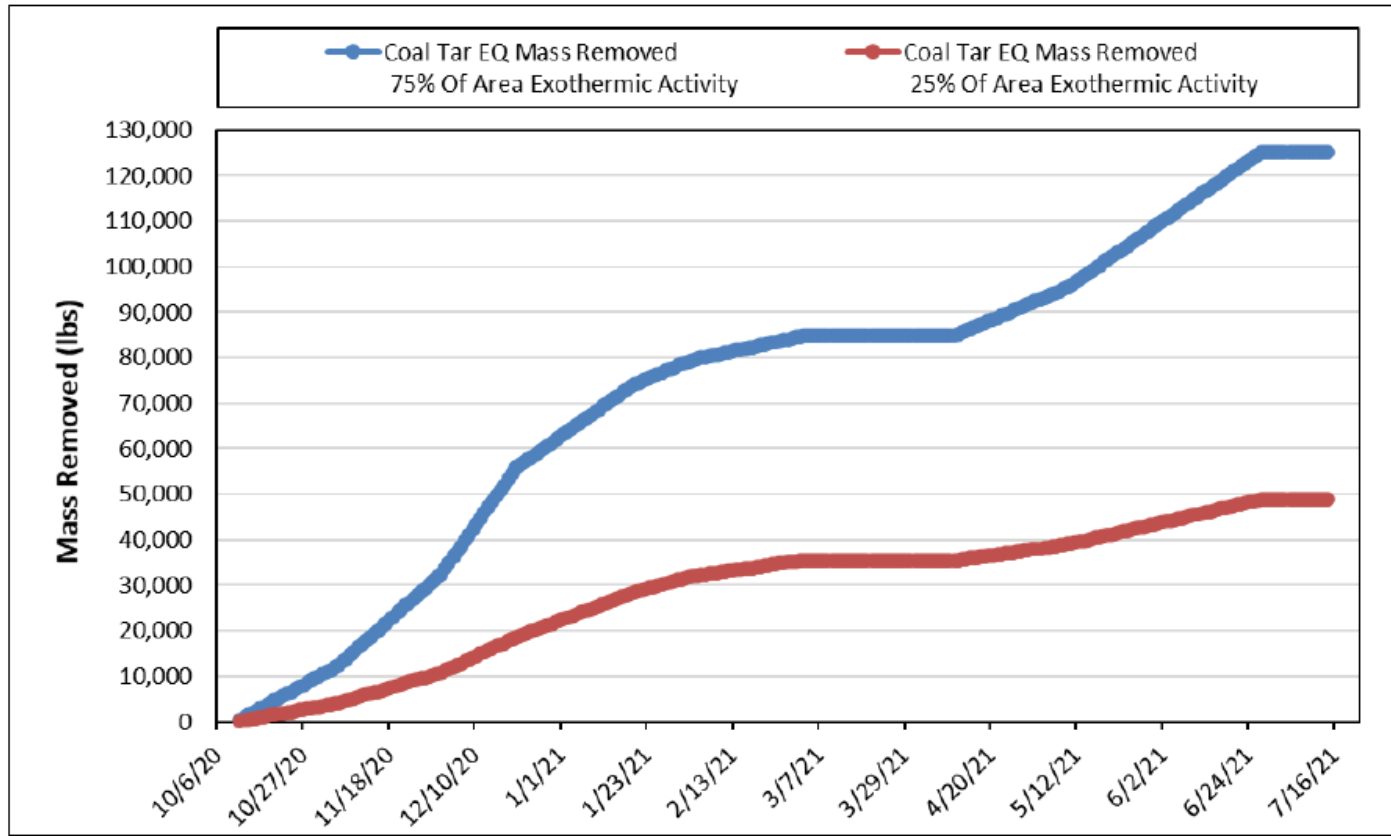


Start with ΔT and Estimate Net Energy Change and Smoldering Rate

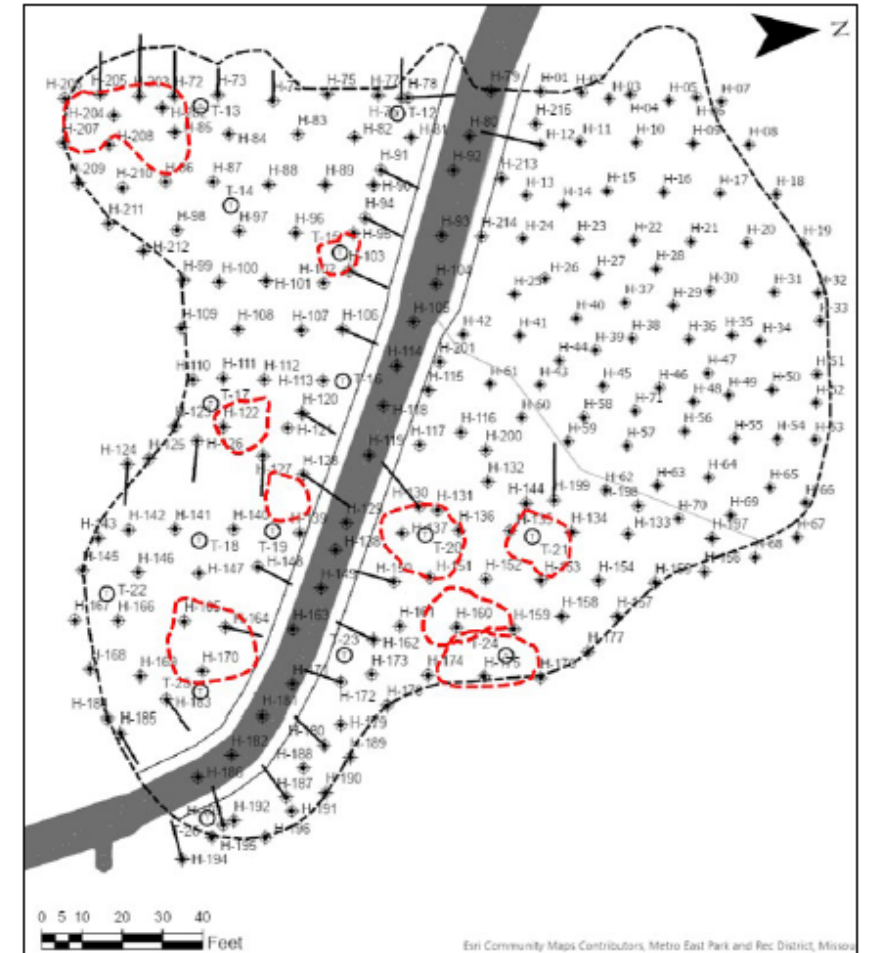
	Model Layer Midpoint Depth Ft	Interpolated Background Layer Temp C	Interpolated Fuel Layer Temp C	Diff. Fuel Zone and Background C	Energy Input Rate KJ/day	Model Predicted Difference due to Smoldering C	Variance Model and Obs
Layer 1	1	16.75	17.00	0.25	-175,000	55.53	55.28
Layer 2	3	32.70	34.00	1.30	-175,000	126.61	125.31
Layer 3	5	46.30	176.50	130.20	-100,000	223.25	93.05
Layer 4	7	53.40	382.50	329.10	0	334.49	5.39
Layer 5	9	58.80	504.50	445.70	190,000	445.72	0.02
Layer 6	11	63.65	592.50	528.85	320,000	529.22	0.37
Layer 7	13	66.18	633.00	566.83	1,510,000	564.62	-2.20
Layer 8	15	66.93	477.50	410.58	0	399.92	-10.65
Layer 9	17	67.95	221.50	153.55	0	244.11	90.56
Layer 10	19	68.90	115.50	46.60	0	119.44	72.84

Energy input rates for model to match smoldering temperature data

Phase II – In Situ Destruction

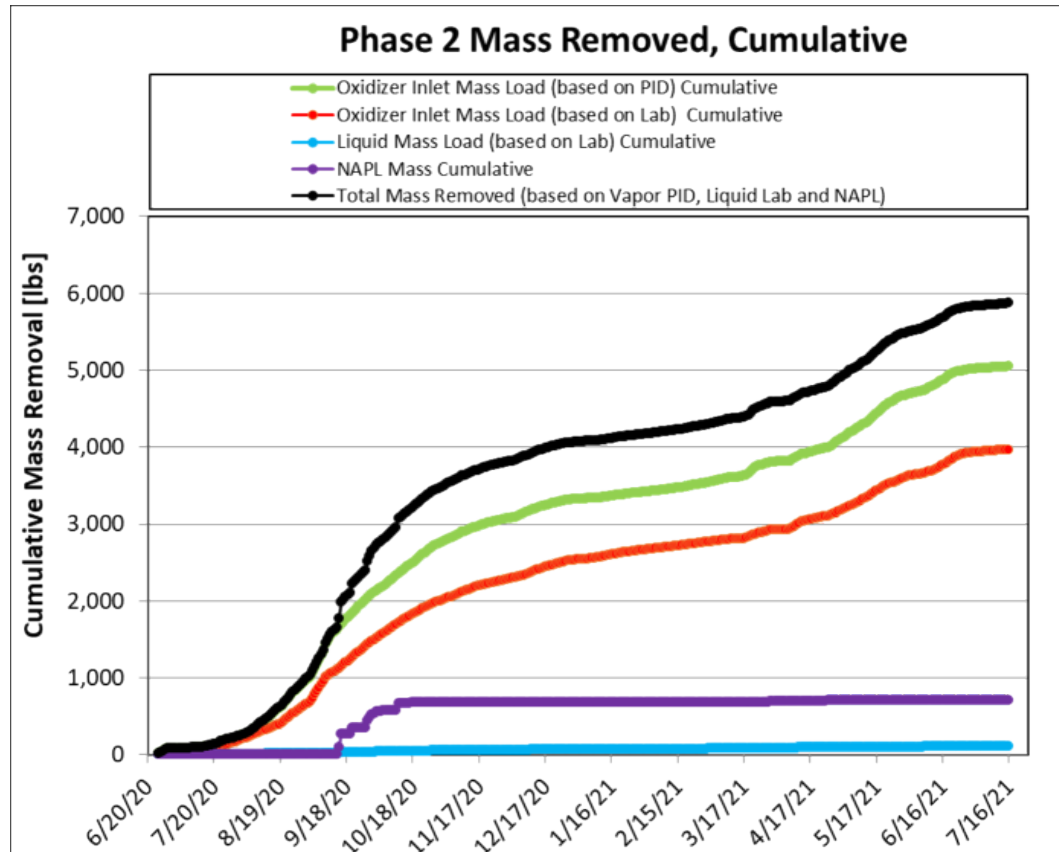


Estimated ~50,000 to 125,000 lbs removed due to smoldering



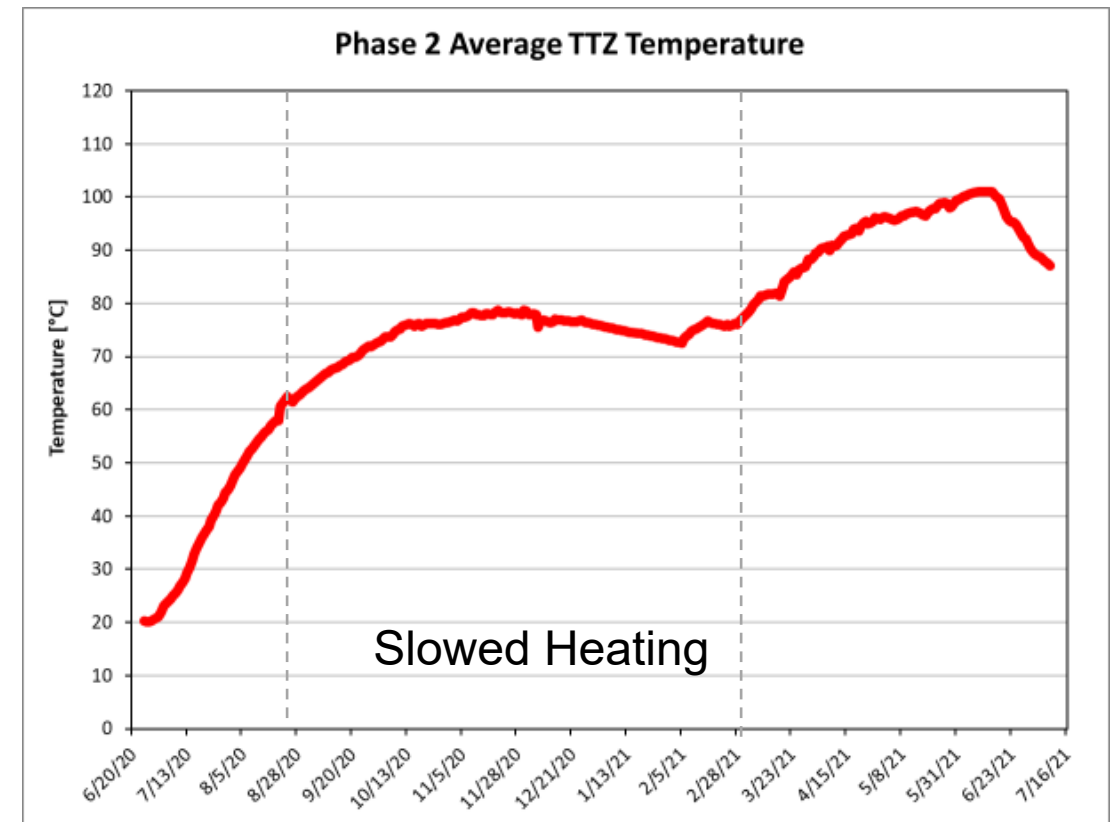
Map of Elevated Temps Observed

Phase II - Operation



Design: ~30,000 lbs

Actual: ~5,900 lbs + (50,000 – 125,000 lbs in situ)



Actual: 386 days

(Slowed for NAPL recovery, manage smoldering)

Conclusions

- Overall Treatment Results Consistent with “Level 2” Approach
- Managing uncertainties collaboratively, upfront, and through a phased approach improved Project Execution and Change Management
- NAPL Recovery:
 - Slowed heating
 - Switched to “oil field” pumps
- More Subsurface Extraction + Improved Vapor Cover
- Heated and insulated manifolds critical to manage naphthalene
- Smoldering:
 - Temperature Monitoring alerted team
 - Prompt action needed to address subsidence
 - Installed dousing system to protect ~180 yr-old sewer
 - Significant portion of mass destroyed in situ with less energy



Acknowledgements

- TerraTherm: Project Teams for both Phases (so many!)
- AECOM
- Confidential Client

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