

Manners Piece: Getting to the Last Bite of Contaminant Mass Through Fracture Emplacement

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June 5, 2024

A brief history...facility operations

- **Manufacturing facility southeast US established in 1952 (~150 acres)**
- **Included use of chlorinated and non-chlorinated chemical compounds**
- **Ceased operations in 2007, decommissioning in 2008, and demolition in 2014**

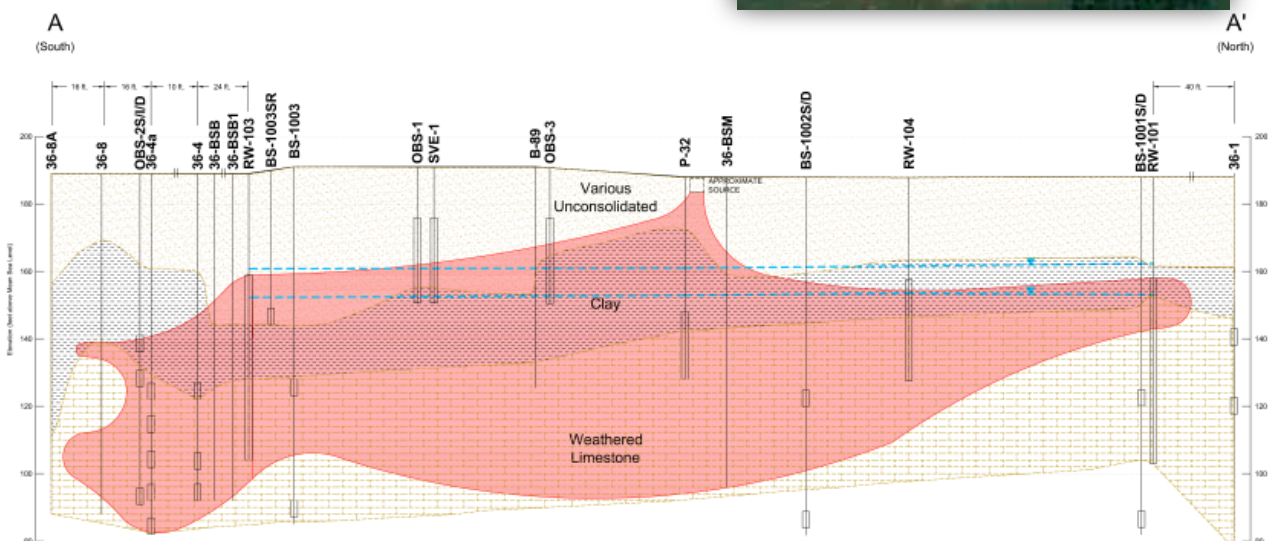
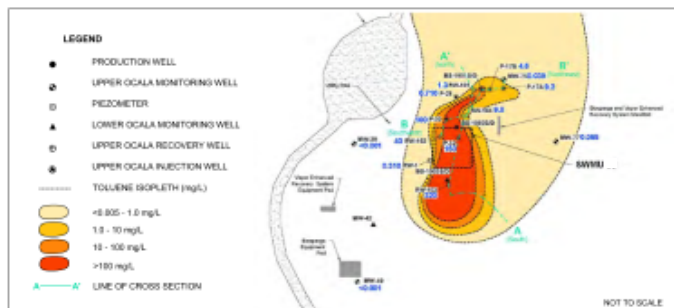


A brief history...a little geology/hydrogeology



- Coastal Plain Province
- Residual soil to ~40 ft bgs; clayey sands/sandy clays w/ thin clay layers
- *Dark brown plastic clay at base of residuum*
- Ocala Limestone: soft, poorly cemented with cavernous zones 60-80 ft thick, more competent with depth (>100 ft bgs)

A brief history...a little geology/hydrogeology



A brief history...a seven-course meal of remediation

- **Hors D'Oeuvre:** DPE (1997 RCRA Facility Investigation/1999 CAP); operated from 2002 – 2007 *Anticipated that primary mass would be removed from the three source areas in 2 to 3 years and then bioremediation
- **Soup:** DPE enhancements (pneumatic fracturing, air injection, and cycling) and groundwater recovery performed from select MWs (2005 – 2007)
- **Appetizer:** Groundwater pumped from on-site production wells during active manufacturing; after decommissioning installed P&T system (2007 – 2011/2012)
- **Salad:** LNAPL recovery – manual, Solar Sippers™ (2009), and VER system (2010) *LNAPL not observed since 2013
- **Main Course:** Biosparge system ('enhanced oxygen'), started with 3 biosparge points in 2011 *Also tested/considered anaerobic bio-oxidation

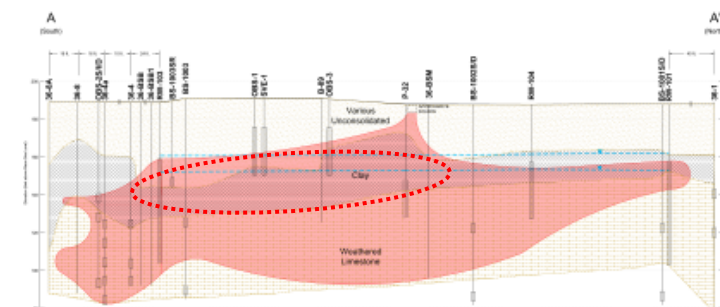
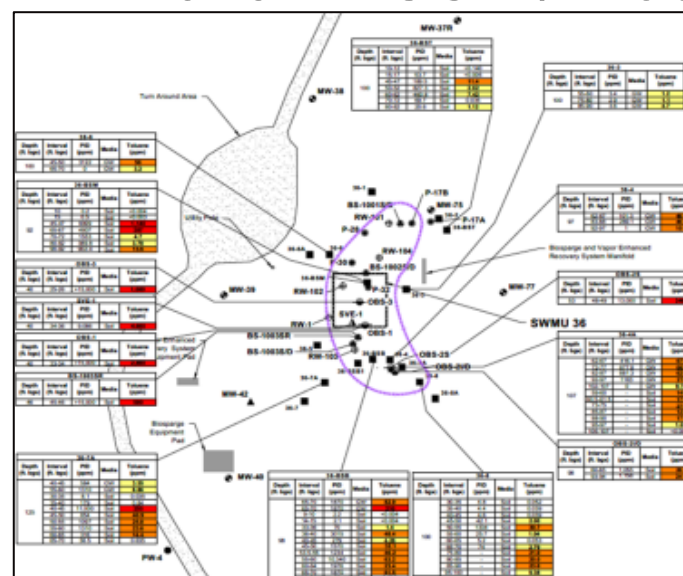


A palate cleanser...

2014: facility demolition...



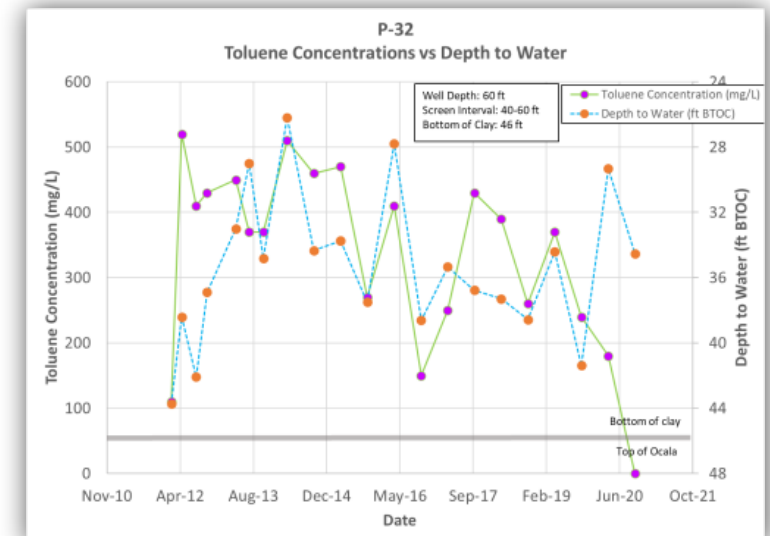
- 2015 HRSC w/ mobile lab



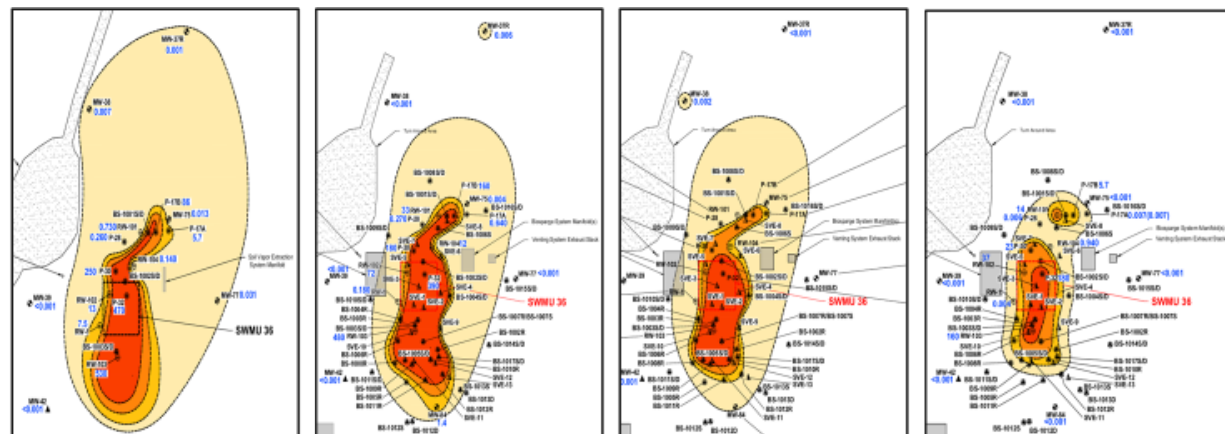
- Considered thermal, ISS, *fracture emplacement*, etc...

A brief history...a seven-course meal of remediation

- **Dessert:** Biosparge expanded in 2016 and 2017; passive venting and SVE system added in 2015/2017 and 2018
- 2020: Expanded biosparge system (41 wells), SVE system (13 wells), and passive venting system resulted in ~1,100 pounds of toluene mass removed and 70-80% reduction in concentrations but...
- Estimated at least ~7 more years of system operation to meet cleanup objectives
 - Clay unit limiting cleanup and increasing concentration fluctuations due to seasonal fluctuations of water levels (back diffusion/smear zone)
 - Flooding events at the site have shown northern reductions and southern area increases (clay influence)



The final course?

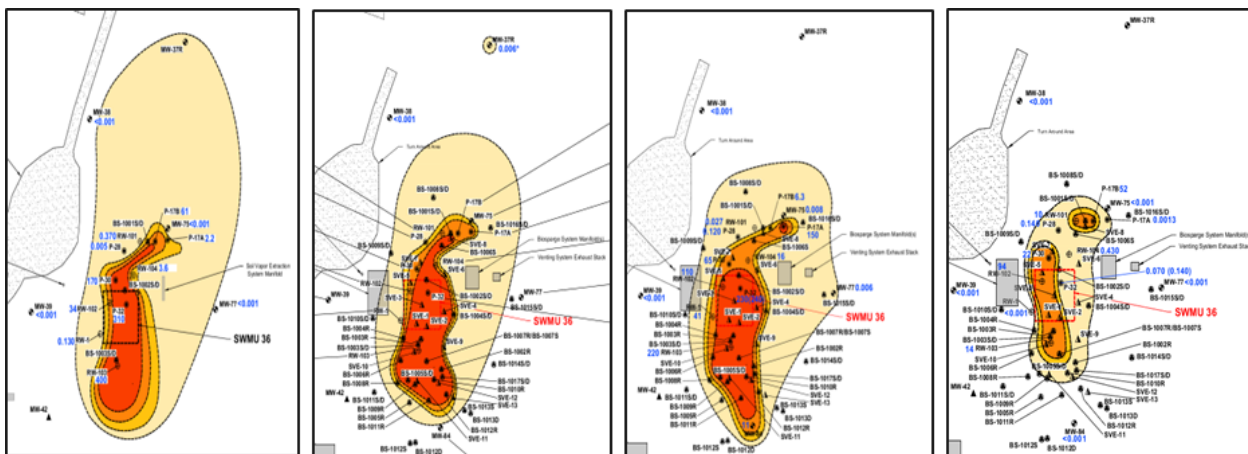


April 2015
(Pre-Biosphere Expansion)

April 2018
(~6 months Post Expansion)

April 2019
(~1.5 yrs Post Expansion)

April 2020
(~2.5 yrs Post Expansion)



October 2015
(Pre-Biosphere Expansion)

October 2018
(~1 yrs Post Expansion)

October 2019
(~2 yrs Post Expansion)

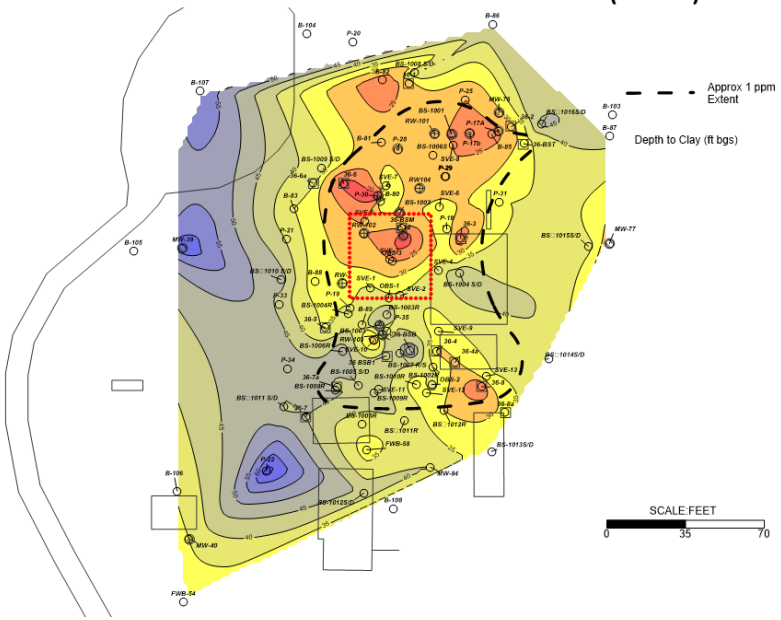
October 2020
(~3 yrs Post Expansion)

- **Mignardise:** Fracture-enhanced biosphere within clay to grab the 'last bite'

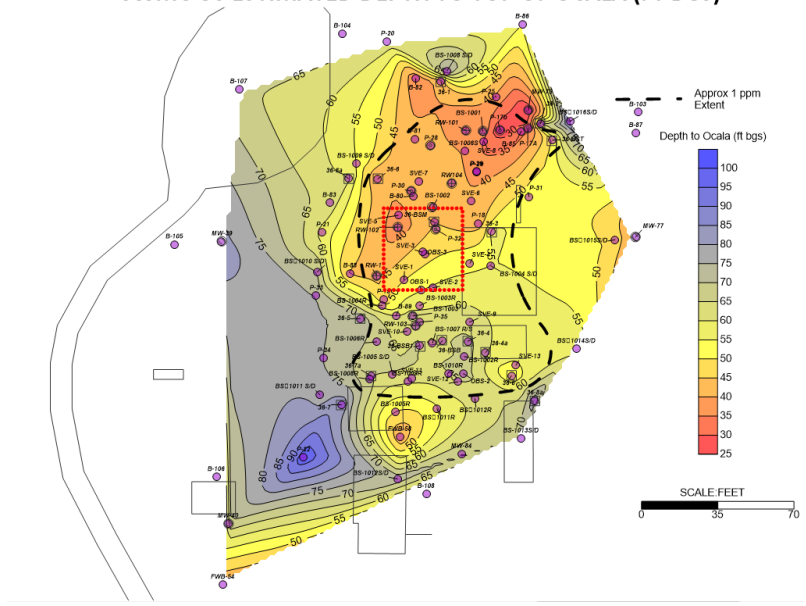


The final course?

SWMU 36 ESTIMATED DEPTH TO TOP OF CLAY (FT BGS)



SWMU 36 ESTIMATED DEPTH TO TOP OF OCALA (FT BGS)

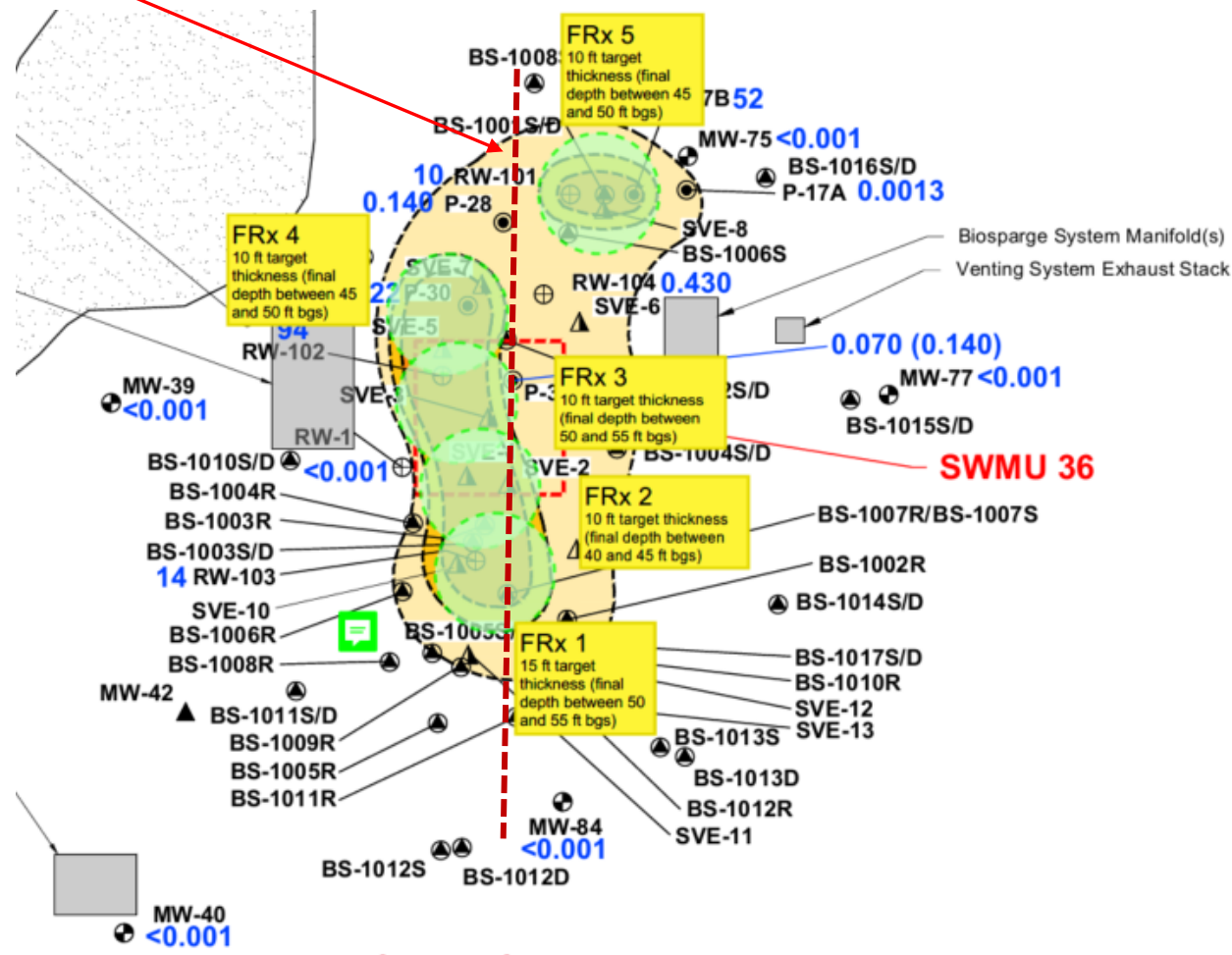
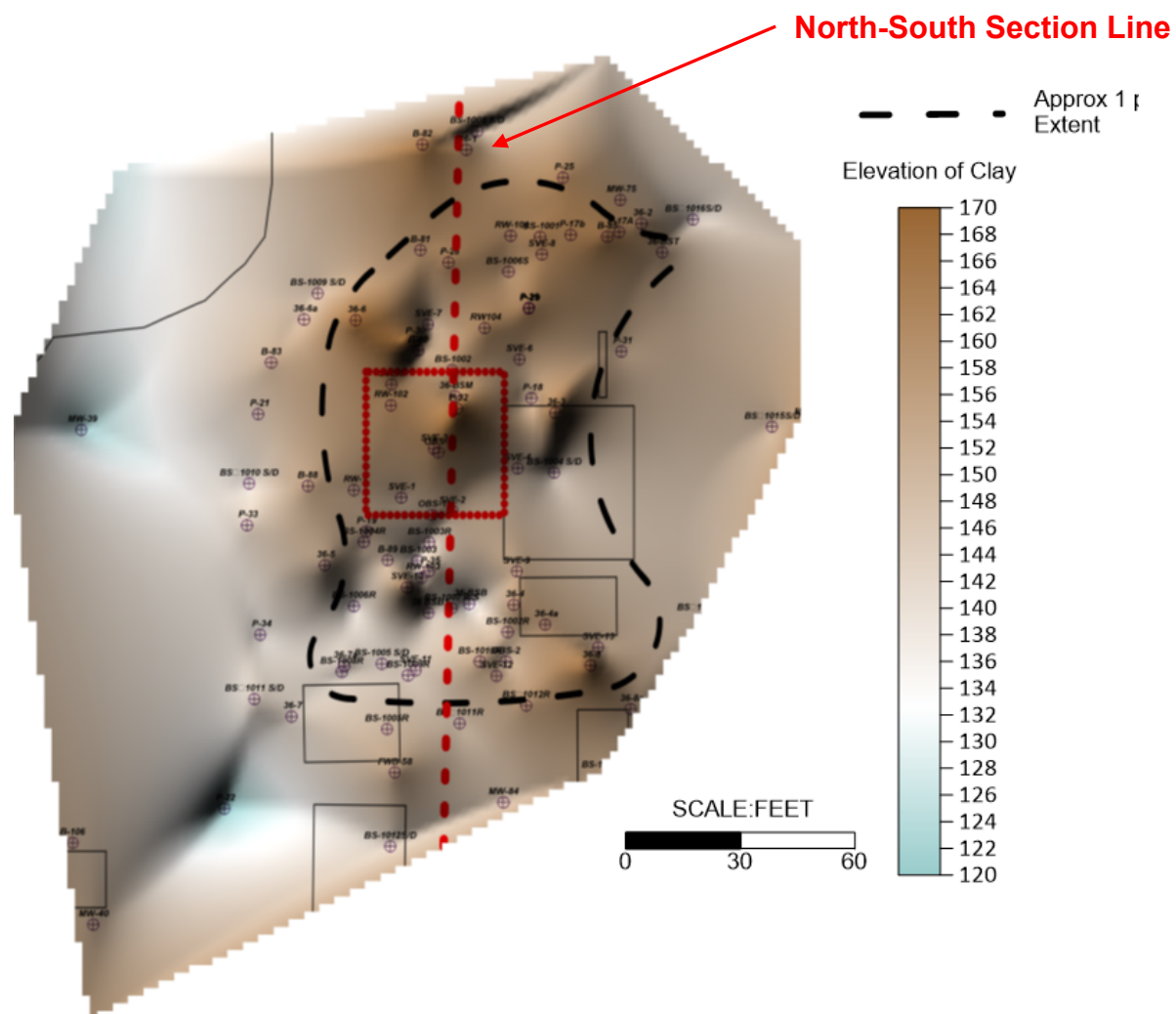


SWMU 36 ESTIMATED THICKNESS OF CLAY (FT)

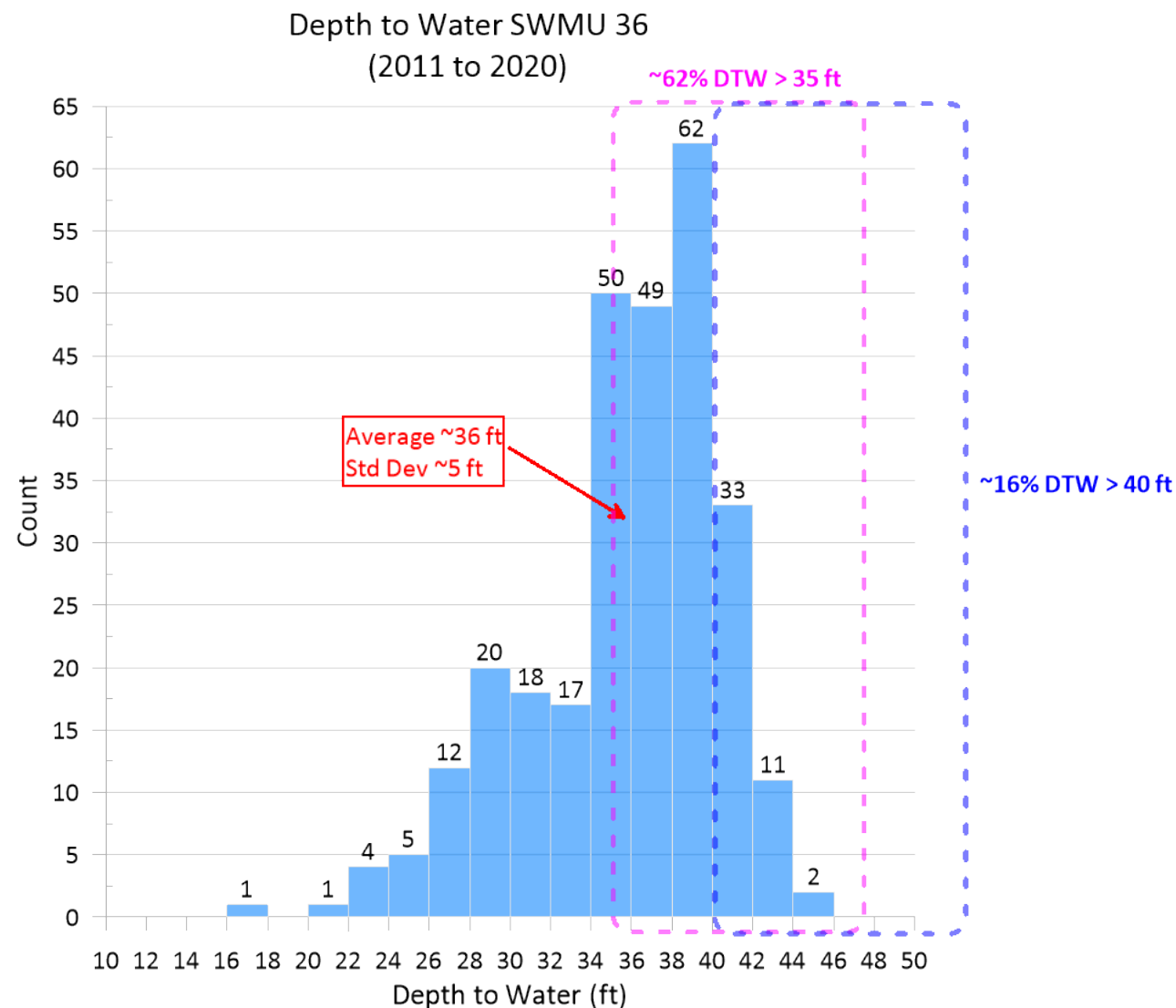




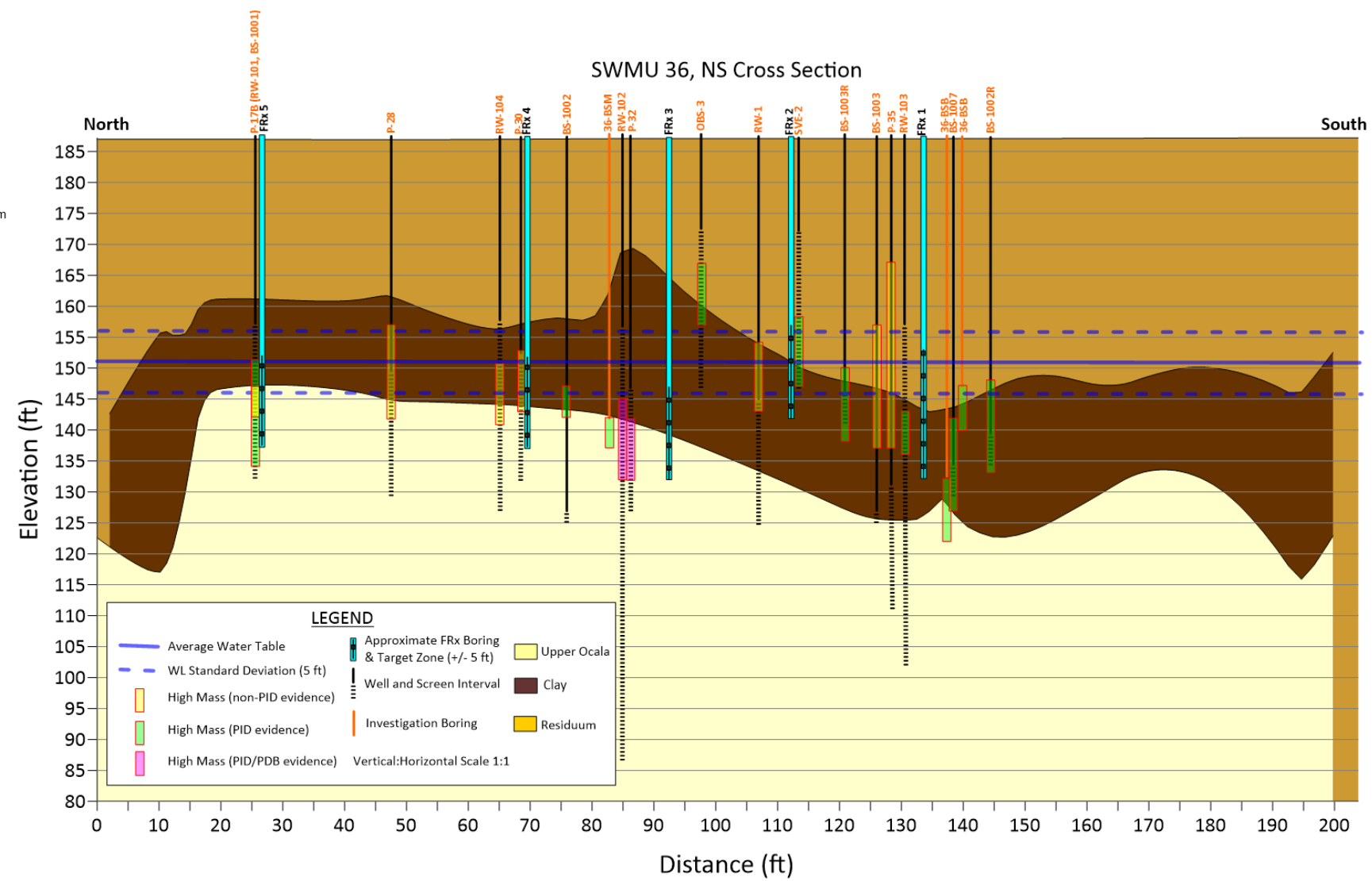
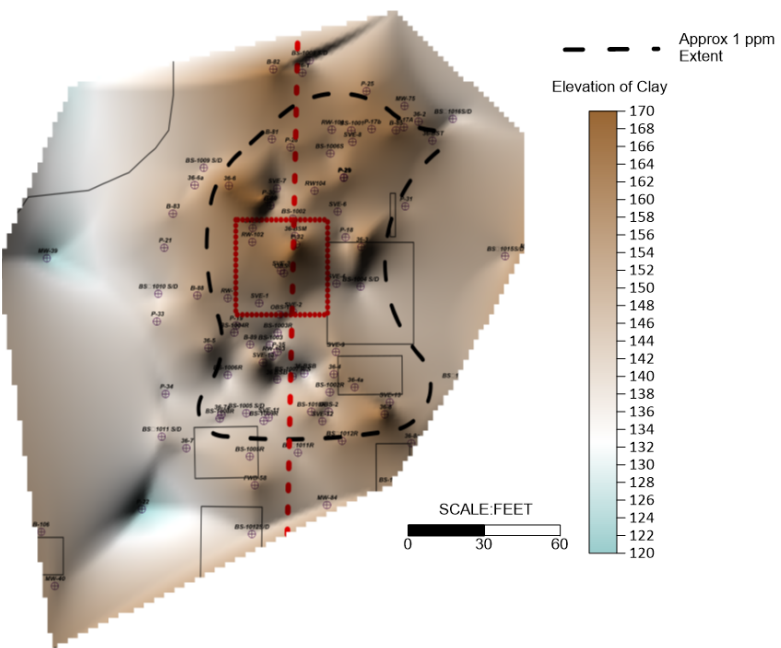
The final course?



The final course?

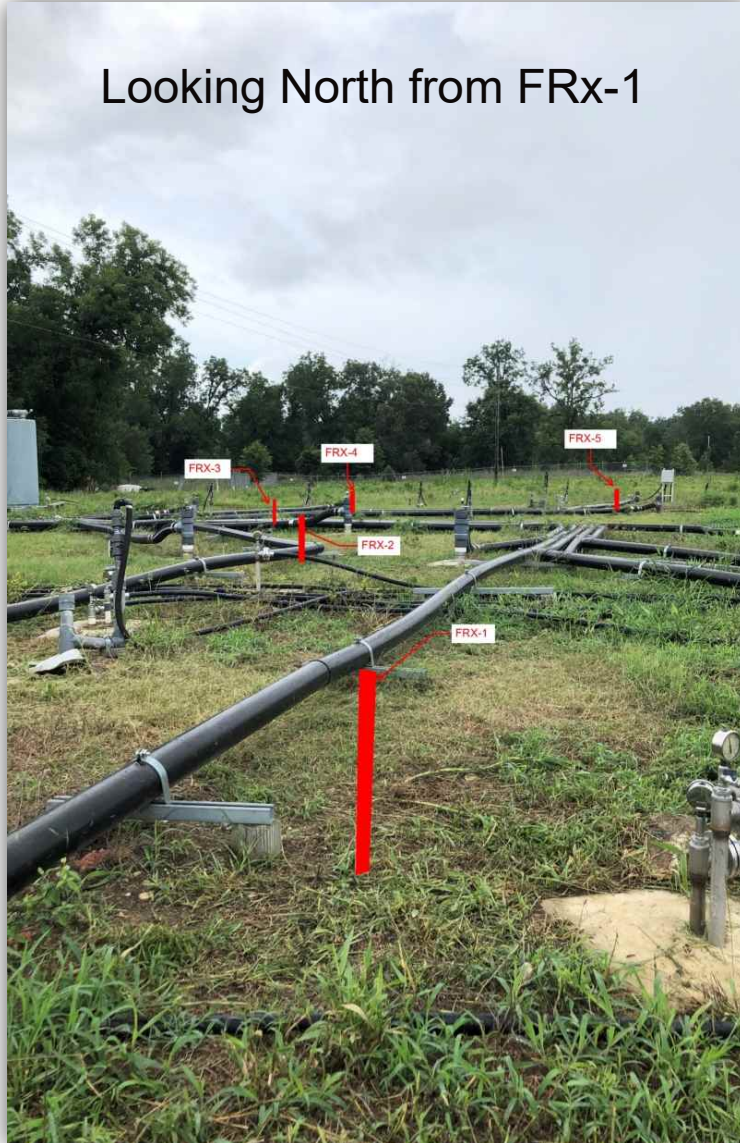


The final course?



The final course?

Looking North from FRx-1



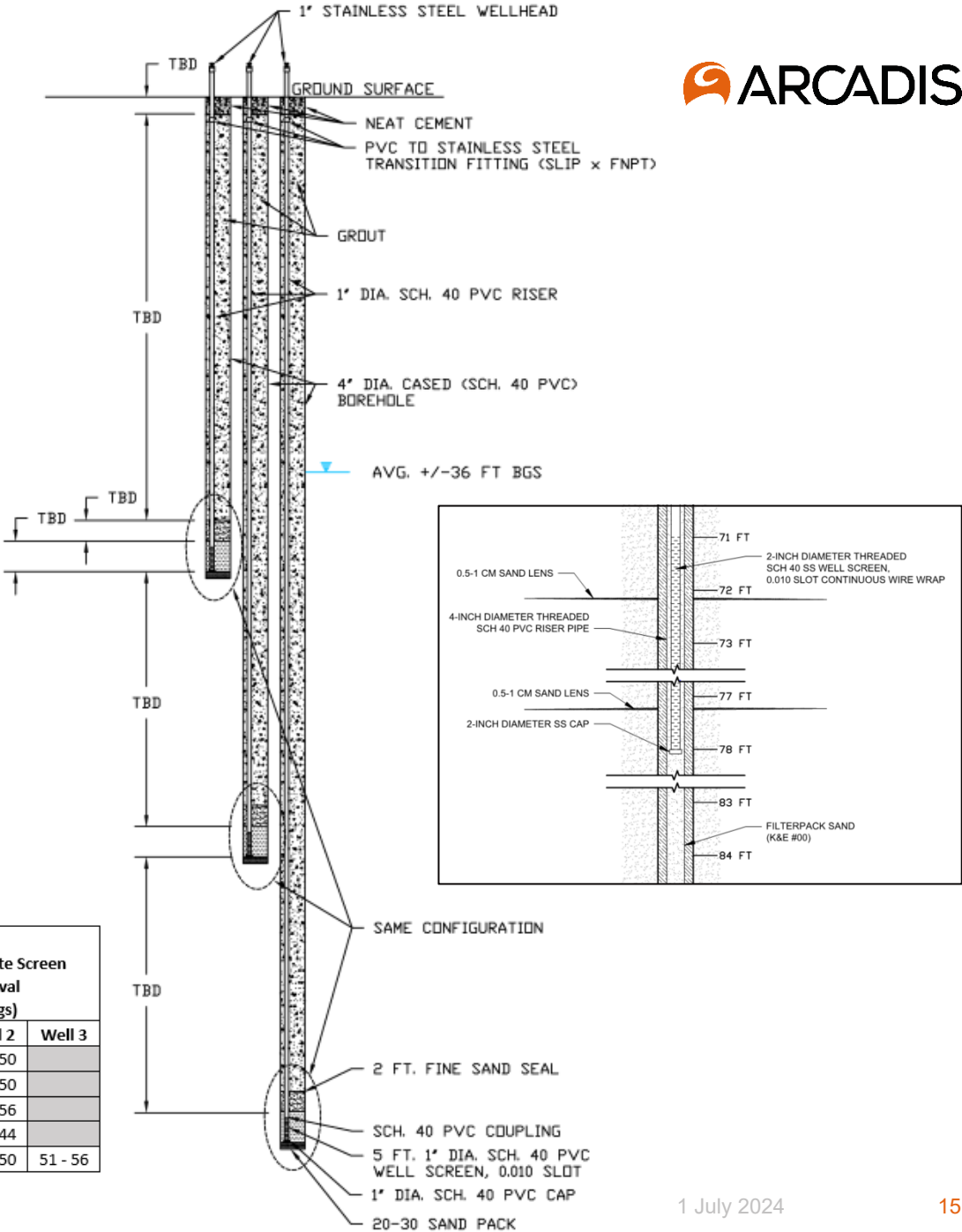
Looking South from FRx-5



The final course?



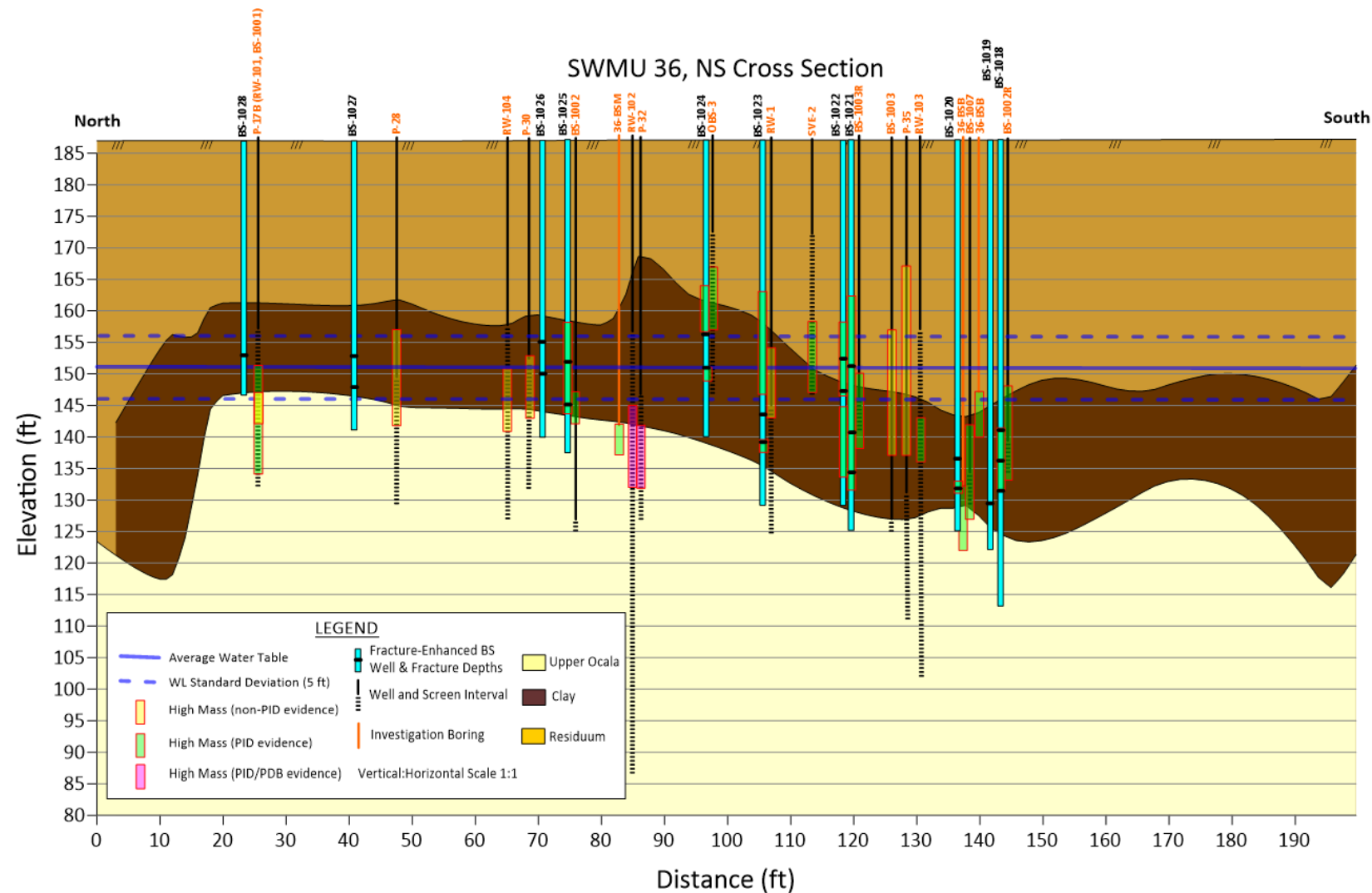
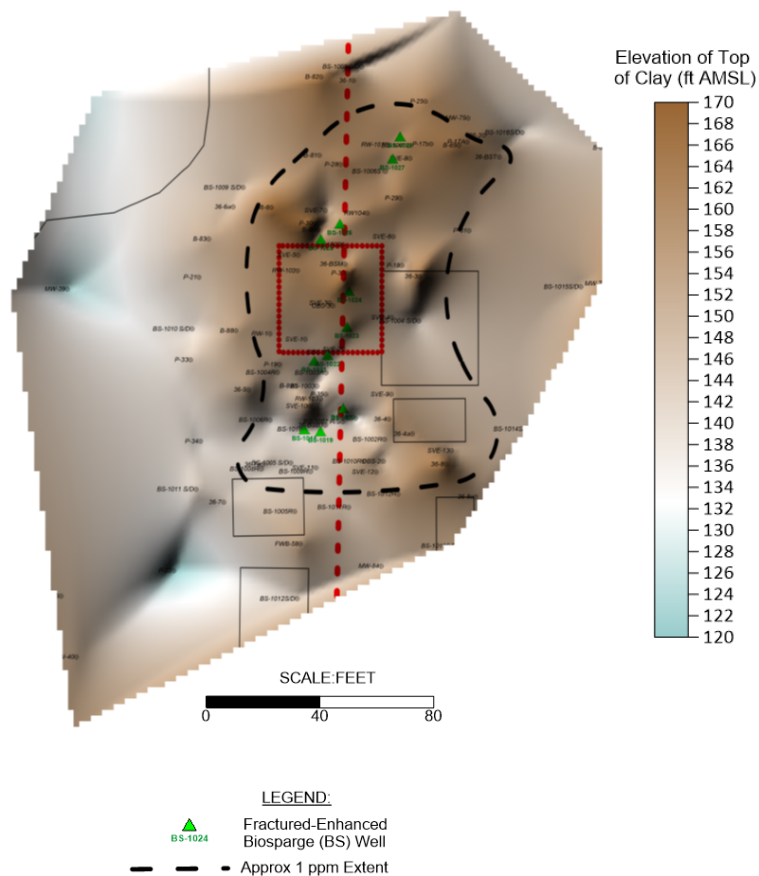
Location	Loc ID	Target Treatment Interval		Target Treatment Thickness (ft)	Number of Fractures per Location	Cased-Hole Well Depths (ft bgs)			Approximate Fracture Depths (ft bgs)			Approximate Screen Interval (ft bgs)		
		Top (ft bgs)	Bottom (ft bgs)			Well 1	Well 2	Well 3	Well 1	Well 2	Well 3	Well 1	Well 2	Well 3
Northernmost	FRx 5	40	50	10	4	52	57		40, 43	46, 49		39 - 44	45 - 50	
	FRx 4	40	50	10	4	52	57		40, 43	46, 49		39 - 44	45 - 50	
Middle	FRx 3	45	55	10	4	57	62		46, 49	52, 55		45 - 50	51 - 56	
	FRx 2	35	45	10	4	47	52		34, 37	40, 43		33 - 38	39 - 44	
Southernmost	FRx 1	40	55	15	6	52	57	62	40, 43	46, 49	52, 55	39 - 44	45 - 50	51 - 56



The final course?



The final course?



The final course?

Injection Well ID	Injection Depth (ft)	Date	Pump Start Time	Pump End Time	Sand Quantity (lbs)	Guar Gel Volume (gal)	Chase Volume (gal)	Notes
BS-1020	55'	7/18/2023	7:35	7:54	1,500	200	35	
BS-1020	50'	7/18/2023	9:10	9:23	1,500	150	30	
BS-1019	58'	7/18/2023	10:51	11:06	1,500	150	30	Fracture connected to BS-1020 during injection; mechanical packer sealed after water reached top of well.
BS-1018	56'	7/18/2023	12:38	12:53	1,500	160	35	Fracture connected to BS-1019 during injection; mechanical packer sealed after water reached top of well.
BS-1018	51'	7/18/2023	13:20	13:28	1,500	130	30	
BS-1018	46'	7/18/2023	14:00	14:13	1,500	150	30	
BS-1023	50'	7/18/2023	15:10	15:26	1,500	170	35	
BS-1023	45'	7/18/2023	15:36	15:50	1,500	150	35	
BS-1022	41'	7/19/2023	7:54	8:20	1,500	210	35	Fracture connected to existing air sparge well during injection; mechanical packer placed/sealed in air sparge well after connection was identified.
BS-1022	35'	7/19/2023	8:43	8:54	1,500	130	30	
BS-1021	53'	7/19/2023	9:31	9:44	1,500	150	30	
BS-1021	46'	7/19/2023	10:13	10:24	1,500	120	30	
BS-1021	36'	7/19/2023	10:52	11:05	1,500	120	35	Fracture connected to BS-1022 during injection; mechanical packer sealed after water reached top of well.
BS-1024	37'	7/19/2023	13:58	14:09	1,500	140	35	
BS-1024	32'	7/19/2023	14:40	14:53	1,500	130	36	
BS-1026	38'	7/19/2023	15:42	15:56	1,500	150	35	
BS-1026	33'	7/20/2023	7:49	8:02	1,500	139	34	
BS-1025	42'	7/20/2023	9:11	9:24	1,500	140	35	Fracture connected to BS-1026 during injection; mechanical packer sealed after water reached top of well.
BS-1025	35'	7/20/2023	10:08	10:20	1,500	130	35	
BS-1027	41'	7/20/2023	12:15	12:28	1,500	130	30	
BS-1027	35'	7/20/2023	13:22	13:40	1,500	120	35	
BS-1028	34'	7/20/2023	14:12	14:26	1,500	130	30	Fracture connected to BS-1027 during injection; mechanical packer sealed after water reached top of well.
Totals					33,000	3,199	725	

Who wants the last piece?

- Completed system connections end of August 2023
- Not able to start system until December
 - Equipment issues
 - Only ~4-5 months of operation
 - High water table conditions last 3 months
- Operate at significantly higher flow rates and lower pressures (e.g., 10 scfm at 10-25 psi vs. 1.5 scfm at >40 psi)
- Only one round of sampling post fracture-emplaced BS wells (only 3 locations currently above closure criteria)



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Thank you