

**Minutes of Restoration Advisory Board Meeting
Former Atlas “D” Missile Site 4, Belvoir Ranch, Laramie County,
Wyoming**

November 5, 2020 9:00–11:00 a.m.

Location: Adobe Connect online meeting

1. Purpose

The Restoration Advisory Board (RAB) for the Former Atlas “D” Missile Site 4 (Site 4) met for the 22nd time on November 5, 2020. The RAB is organized under guidance and authority established under the Formerly Used Defense Sites (FUDS) Program for the hazardous, toxic, and radioactive waste (HTRW) project at Site 4 (Project Number B08WY046702), located one mile south of Granite, Wyoming. The primary topics discussed during the meeting included the following:

- Remedial Investigation Update: Completion of RI report and RI conclusions
- Status of Long-Term Monitoring (LTM) Program: Spring/Fall 2020 LTM Update
- Data Gaps Investigation Update: 2020 monitoring well installation and planned 2021 monitoring wells
- Pilot testing update

Principal meeting participants included representatives of the U.S. Army Corps of Engineers (USACE), Wyoming Department of Environmental Quality (WDEQ), Cheyenne Board of Public Utilities, Wyoming State Engineer’s Office (WSEO), URS Group (URS), Na Ali’i Consulting and Sales, LLC (Na Ali’i), and Galen Driscoll. A summary of the meeting discussions follows. The meeting agenda, attendance list, and the meeting presentation are included in Attachment A.

2. Meeting Participants

RAB Members

WDEQ:

Troy Sanders, Project Geologist

WSEO:

Jeremy Manley, Natural Res. Program Principal

USACE:

Doug Simpleman, RAB Co-Chair

Community Members:

Dr. Kathleen Quinn, RAB Co-Chair

Judd Eifeldt

Other Community Attendees:

Cheyenne Board of Public Utilities: Clint Bassett

Office of U.S. Senator John Barrasso: Jamie Gronski

Private Citizens:

Russ Dahlgren, Dahlgren Consulting

Joan Barron, Cheyenne Tribune

Robert Kelley

Jean Chytil, Former USACE Project Geologist

RAB Support:

USACE-Omaha District: Jeff Gill, Project Manager; Danielle Bieber, Project Chemist; Dave Becker; Rachel Carson, Project Geologist; Delma Stoner, Project Engineer; Molly Maxwell, FUDS Program Manager

URS: Bob Mallisee, Project Manager; Ryan Mowan, Project Engineer; Dawn Stock, Project Geologist

Redox Tech: Chris Lacko

Galen Driscoll: Leigh-Ann Fabianke, Meeting Facilitator

WDEQ: Lily Barkau, Groundwater Section Manager; John Passehl

Na Ali’i: David Groy, Project Manager; Kelly Hranac, Hydrogeologist; Joe Mastromarchi, Hydrogeologist

HGS: Kent Alexander

Dyno Nobel: Scott Horgen

University of Wyoming: Dr. Michael Urynowicz

3. Opening of Meeting

Mr. Jeff Gill, USACE Project Manager, opened the meeting at 9:05 a.m. Dr. Kathleen Quinn, the RAB Co-Chair, called the meeting to order and stated that there was a not quorum of RAB members to allow voting; however, Troy Sanders and Jeremy Manley later joined the meeting.

Dr. Quinn acknowledged the representative of U.S. Senator John Barrasso as the only elected official present.

Mr. Doug Simpleman recognized Ms. Jean Chytil, Project Geologist, for her excellent long-term work on the project and stated that Ms. Chytil has recently retired. Dr. Quinn stated that the RAB has really appreciated Jean's willingness to help them understand the complexities of the site. Mr. Gill said he also appreciated Jean's work on the project and introduced Ms. Rachel Carson, the new Project Geologist for the site.

Dr. Quinn asked the RAB members if there were any questions or changes regarding the minutes from the last meeting. There were no questions or changes to the meeting minutes, and they were approved by consent.

Ms. Leigh-Ann Fabinake, Meeting Facilitator, then introduced Mr. David Groy to discuss the Remedial Investigation (RI).

4. Remedial Investigation Update

Mr. Groy stated that the area-wide RI report was finalized in the fall and the final report has been posted to the website. Below is a brief summary (Slide 3):

- Installed 135 individual groundwater monitoring wells (45 nested monitoring well locations) within the study area.
- Collected soil samples during drilling and water samples of the new and existing wells during the LTM events.
- Conducted aquifer tests or slug tests of selected wells to estimate aquifer parameters.
- Performed two high-resolution reflection and refraction seismic surveys.
- Flew approximately 384 line-miles of airborne electromagnetic survey (AEM). These data were used to strategically position new monitoring wells.
- Completed human health and ecological risk assessments to evaluate potential risks.

Mr. Groy then introduced Mr. Joe Mastromarchi who discussed the geophysical program that was conducted. He described the surface reflective seismic survey that was conducted, followed by the AEM survey. The surface seismic survey measured the response of the formations to various types of energy, while the AEM survey measured the electromagnetic field in the formations. The most important information gained from the surveys was the location of the top of the White River Formation (WRF). The drilling logs prepared for the monitoring wells, as well as the downhole geophysics, confirmed the geology/hydrogeology interpreted from the geophysics and AEM.

Mr. Groy continued summarizing the RI activities (Slide 5). The LTM program now includes more than 200 samples collected in the spring and fall sampling events. Tech memos summarizing the LTM events are prepared after each event. The key point is that the extent and leading edge of the

plume have been identified. The primary sources of contamination are LSBs 1 and 2 (slides 8 and 9). The plume extends from the source area to the Western Transition Area in the WRF and then migrates to the Ogallala Formation. The contamination in the Eastern Transition Area and Area B is almost exclusively in the Ogallala. Mr. Mastromarchi then showed a cross section (Slide 7) that showed how the contamination moves into the Ogallala as the groundwater flows downgradient and increases in flow velocity moving from west (Source Area) to east (Transition Area and Area B).

(Slide 6) Mr. Groy stated that the human health risk assessment indicates that trichloroethylene (TCE) is the primary contaminant of concern and poses some risk to current and future residents and current and future commercial/industrial workers in the source area. The ecological risk assessment did not identify any risks.

On the next slide (Slide 8), Mr. Groy pointed out that TCE is volatilizing from the high contaminant concentration in groundwater into the vadose zone, as demonstrated by the long-term SVE testing previously conducted.

(Slide 10) Mr. Bob Mallisee then discussed the LTM events conducted in spring and fall 2020. Two hundred and sixty wells and four surface water/sediment locations were sampled in each event; with 25 vapor ports sampled in the fall 2020 LTM event. The results of the LTM, compiled in a tech memo for each event, are used to assess the long-term TCE trends across the site. Samples of 13 residential wells are also collected annually to ensure residents are not being exposed to TCE. A letter with the results of the analyses is sent to each residential well owner. Mr. Mallisee stated there is no current plan to change the number of samples collected.

The LTM results indicate the TCE concentration is remaining stable within the plume. TCE was not detected in the three wells (MW 99, 102, and 103) located just outside the plume downgradient edge. Wells mid-plume remained consistent with concentrations ranging from 20 to 70 µg/L. Although the plume currently appears fairly stable, the TCE concentrations may vary over time.

Mr. Mallisee introduced Ms. Dawn Stock, who discussed data gap wells to be installed in the 2021 field season.

Question from Mr. Clint Bassett: Can we get well logs for the wells that were installed this summer?
Mr. Mallisee stated they will be in the interim report describing this 2020 season's field work. Mr. Gill will let you know when it is available.

(Slide 12) Ms. Stock said four monitoring wells were installed this summer to fill identified data gaps: MW84B, MW104, MW106, and MW92B. All of these wells are to be sampled in fall 2020 outside of the LTM program (Slide 14). Three additional data gap wells will be installed in summer 2021: MW105, MW54B, and MW107.

(Slide 16) Mr. Ryan Mowan then discussed the pilot tests that were begun this summer. Two pilot tests were implemented in the source area in 2020: one to test potassium permanganate (KMnO₄) injected into the WRF and one to test zero-valent iron (ZVI) injected into the WRF. A third pilot test will be installed in 2021 to test a groundwater pump, treat, and reject scenario in the Transition Area.

(Slide 21) ZVI was hydraulically and pneumatically injected into the WRF at LSB 2; however, the application by hydraulic method was not as effective as pneumatic injection. Based on the initial

deployment methodologies, pneumatic injection was selected for all subsequent pilot test borings. The initial assumption was that some zones would not accept the ZVI by either method, but they find most zones did readily take the ZVI.

(Slides 23, 24, 25) At LSB 1, where the highest concentrations of TCE are observed, the KMnO_4 was placed by pneumatic injection. Due to the depth of the flame pit, size of the drilling equipment, and to ensure safe working conditions, several injection points were repositioned, and angle drilled to reach the correct injection location. The solution was initially 25 percent KMnO_4 but was diluted to 15 to 20 percent when the flush water used to clean the injection line was added.

Question from Mr. Groy: What was the radius of influence? Mr. Mowan responded that the radius of influence was 25 to 30 feet at both LSBs.

(Slide 28) Minimal borehole collapse was observed from drilling, but it increased if the borehole was left open overnight. The size of drilling equipment and narrow flame pits affected accessible drill locations; this required using angled drilling to reach target locations. When drilling near injection locations, KMnO_4 was observed in some cuttings (Slide 30). Observations from the injections include: 1. there is a correlation between previously identified permeable flow paths and 2. more intervals were receptive to injection than anticipated.

The injection sites will be monitored for three months and then semi-annually in 2021 and 2022. When pumping MW61-107 for sampling, ZVI was observed in the purge water.

Comment by Mr. Gill: We are seeing if the technology can be implemented and if it will work.

Comment by Mr. Mowan: Yes, we are interested to see if we can get the fluids installed and if they provide the results we want to see.

Comment by Dr. Quinn: We appreciate that you have found a way to make this work. Very creative.

Mr. Mowan continued with a discussion of the pilot study in the Transition Area, which included extracting contaminated groundwater, treating it with GAC, and reinjecting the treated groundwater. Slide 37 is a diagram of the treatment system.

In summary:

1. The LTM continues semiannually.
2. Additional data gap wells will be installed in 2021.
3. The pump, treat, reinject pilot study will be installed in spring 2021 and operated throughout the field season with operation continuing in spring 2022 after shutdown for winter.
4. Performance monitoring of the injection pilot studies in the source area will continue through 2021.
5. The Feasibility Study Report will be available in 2024; it will include RI information, the results of the pilot studies, and LTM data.

There were no questions after the presentation.

Comment by Mr. Gill: Thanks to all of the subcontractors for work in the time of COVID.

Comment by Dr. Quinn: The teams worked through COVID and in crazy weather; we are very appreciative of the scientists making progress this summer.

Comment by Ms. Chytil: This was my favorite project and developing professional relationships through it.

Comment by Ms. Fabianke: Please add your name in the chat box if you want to be added to the distribution list.

Comment by Mr. Simpleman: When should the next RAB meeting be, May 2021?

Comment by Mr. Mallisee: We should have three months groundwater results data form the source area pilot study injection data by May 2021 to share.

The group decided the next RAB meeting would be May 6, 2021; details will be sent out.

The meeting was adjourned at approximately 11:00.

Attachment

Former Atlas 'D' Missile Site 4 Laramie County, Wyoming

Restoration Advisory Board Meeting

Presented on behalf of:

Mr. Jeff Gill

USACE-Omaha District,
Project Manager, Environmental
Remediation Branch

05 November 2020



US Army Corps of Engineers
BUILDING STRONG®



Activities Update

- ▶ Remedial Investigation (RI) Program Finalization (David Groy)
- ▶ Long-Term Monitoring (LTM) Program Update (Bob Mallisee)
- ▶ Additional Data Gap Investigation Activities (Dawn Stock)
- ▶ Pilot Study Activities (Ryan Mowan)



Remedial Investigation

► Remedial Investigation Activities

- A total of 135 individual groundwater monitoring wells (45 nested monitoring well locations) were installed within the study area during the area-wide RI
- Two high resolution reflection and refraction seismic surveys
- Approximately 384 line-miles of Airborne Electromagnetic Survey
- Completed human health and ecological risk assessments to evaluate potential risks



Remedial Investigation

- ▶ Remedial Investigation Activities (cont.)
 - Establishment of a consistent LTM program
 - Delineated the trichloroethene (TCE) groundwater plume and identified the leading edge of the plume.
 - Prepared periodic technical memoranda, and an Area-Wide RI Report to summarize investigation activities and document investigation findings



Remedial Investigation

► Remedial Investigation Report Conclusions

- The contaminant source area consists primarily of L&SBs 1 and 2, where TCE occurs predominantly in the low-permeability silty clays of the White River Formation (WRF)
- As the plume extends across the Transition Area, contamination begins to migrate from the WRF into the saturated Ogallala. The contaminant plume exists almost entirely in the saturated Ogallala in the East Transition Area and Area B
- The leading edge of the groundwater plume has been identified, based on the aerial electromagnetic (AEM) and definitive data from wells installed in the Expanded Study Area.



Remedial Investigation

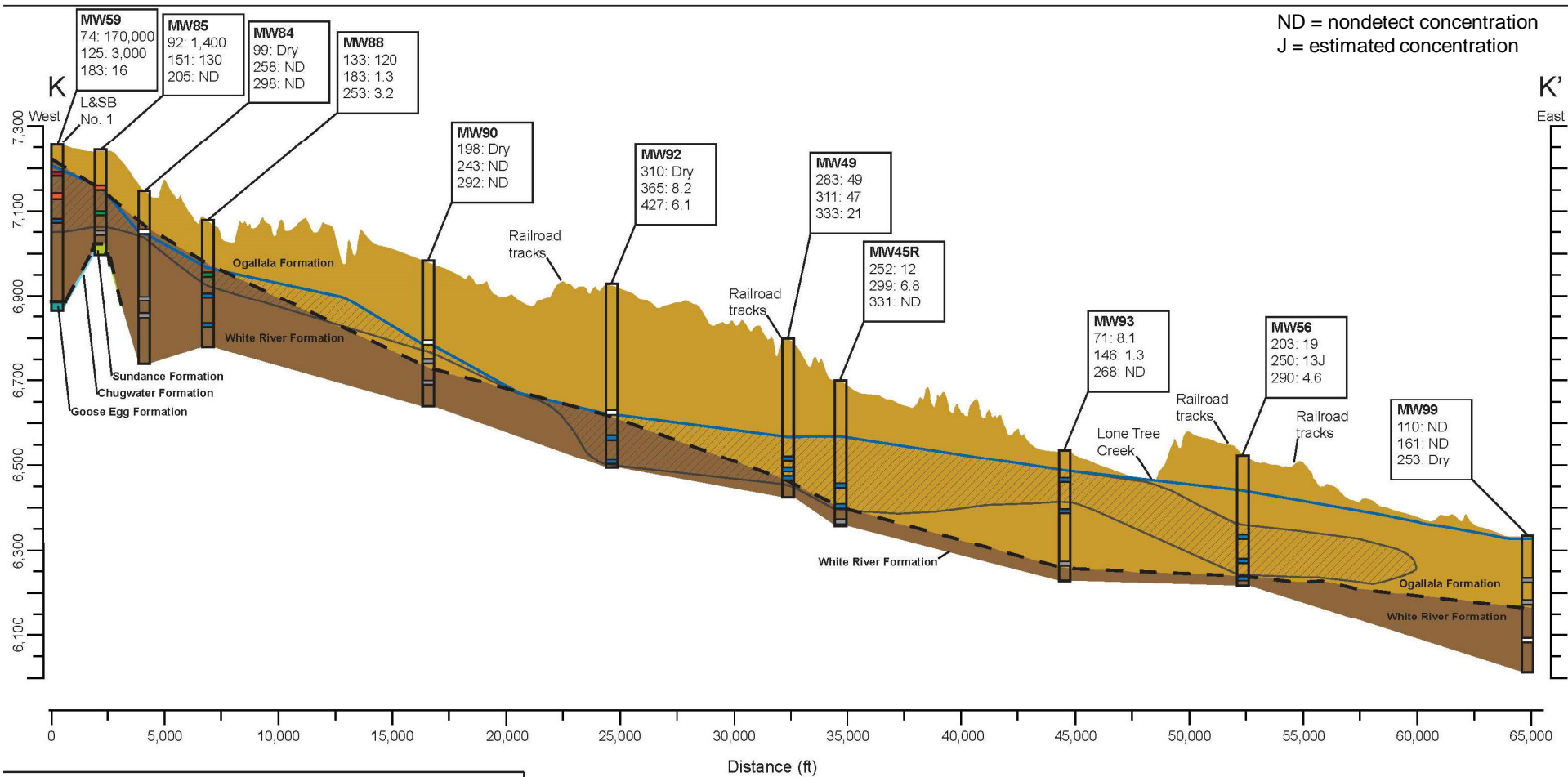
► Remedial Investigation Report Conclusions

- The human health risk assessment indicates that TCE is the primary COC, and there is exposure risk for current and future residents and current and future commercial/industrial workers, including ranch hands. The ecological risk assessment indicates that there is no ecological risk related to surface and subsurface soil, sediment, and soil gas in the source area.
- Interpretation of soil vapor and shallow groundwater data in the source area indicate that TCE is volatilizing from the dissolved phase in groundwater into vadose zone soil; confirming previous soil vapor extraction pilot study findings.

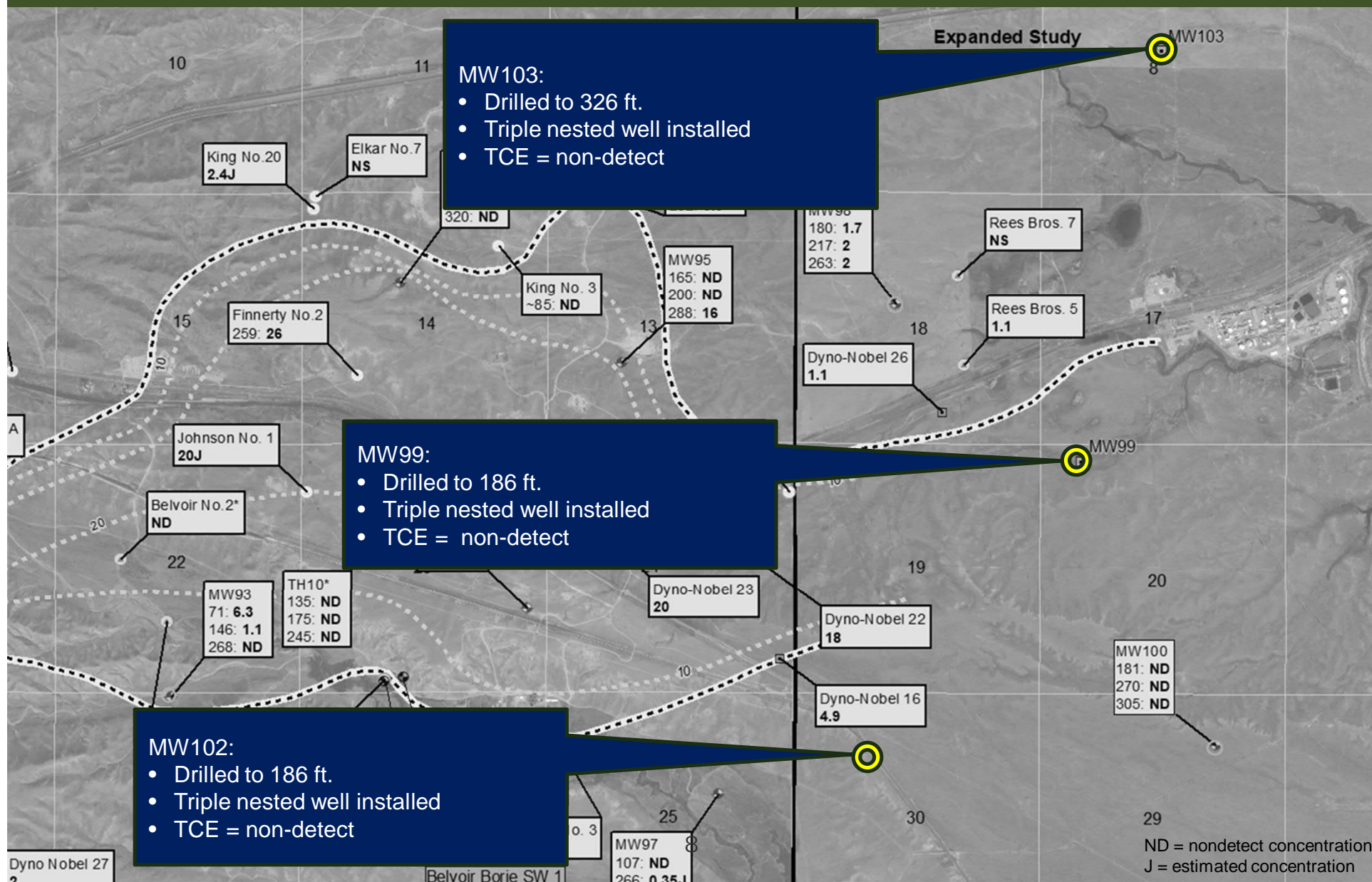


BUILDING STRONG®

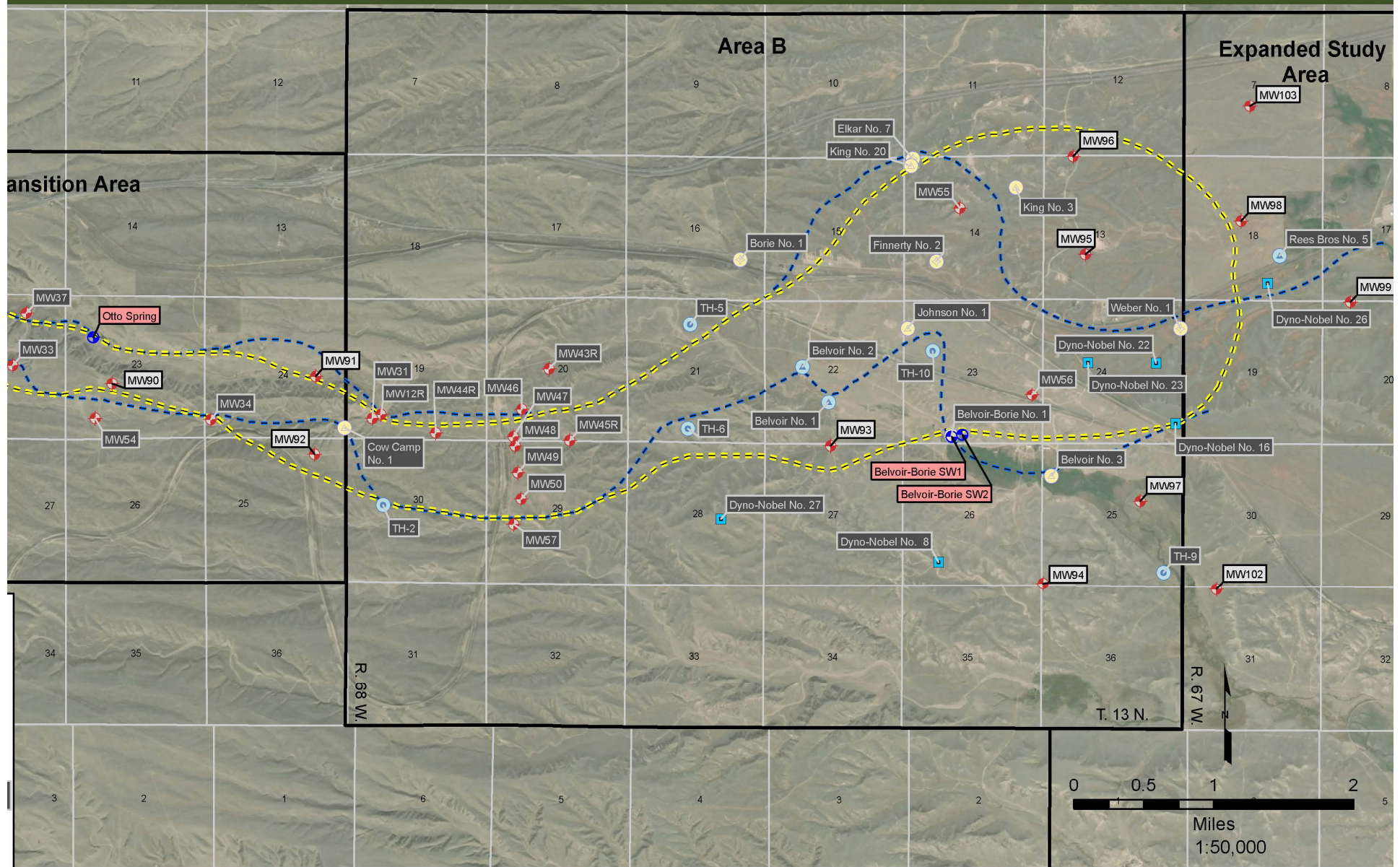
Remedial Investigation



Remedial Investigation



Remedial Investigation



Long-Term Monitoring

- ▶ LTM Sampling Update:
 - Comprehensive Spring and Fall 2020 LTM events
 - Sampling 260 wells and 4 surface water/sediments locations semiannually
 - Sampling residential wells and 25 vapor ports annually
 - These samples are collected to verify the information collected during the RI and assess long-term trends



Long-Term Monitoring



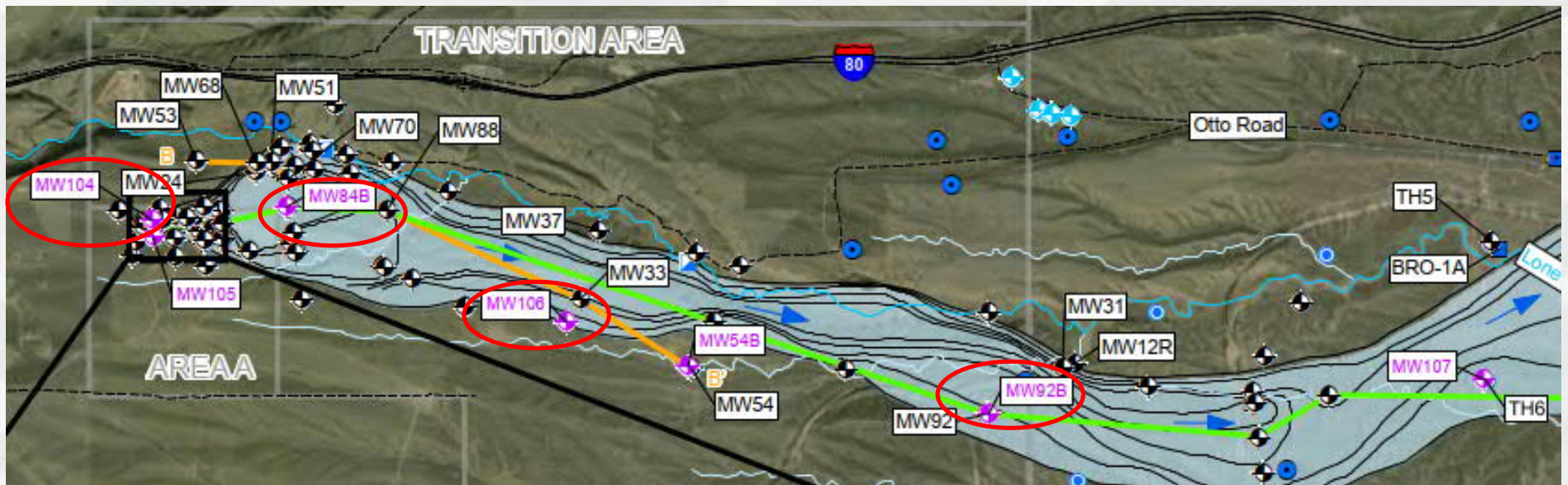
BUILDING STRONG®

Additional Data Gaps Investigation

- ▶ 2020 Additional Monitoring Wells:
 - MW84B - Define extent above 1,000 micrograms per liter ($\mu\text{g/L}$) in upgradient Transition Area for mass evaluation and define vertical extent of TCE and vertical gradients in lower WRF.
 - MW104 - Confirm north extent of TCE concentrations above 1,000 $\mu\text{g/L}$ in Area A for mass evaluation.
 - MW106 - Refine plume core and WRF/Ogallala contact through Transition Area.
 - MW92B - Install screen to replace shallow (dry) screen and determine source of TCE detected in grab sample at 93 $\mu\text{g/L}$ in temporary well.



Additional Data Gaps Investigation - 2020



Additional Data Gaps Investigation

- ▶ 2021 Additional Monitoring Wells:
 - MW105 - Confirm south extent of TCE concentrations above 1,000 µg/L in Area A for mass evaluation.
 - MW54B - Define TCE in groundwater in the 130 feet of saturated thickness above the shallowest screen.
 - MW107 - Refine plume core in Area B near TH6



Additional Data Gaps Investigation - 2021

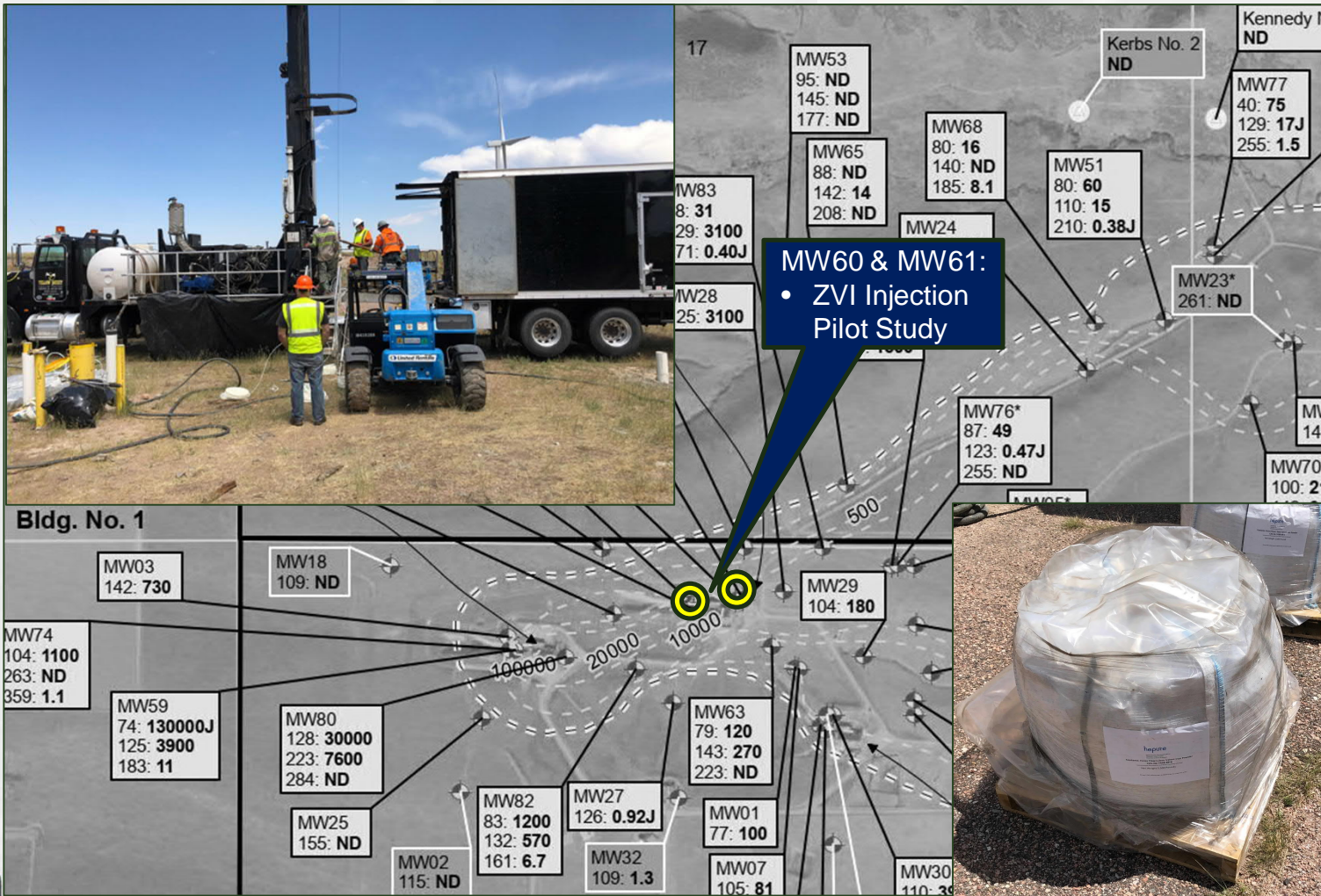


Activities Update—Pilot Testing

- ▶ Implement Three Pilot Studies
 - Two in Source Area – Installed in 2020
 - Potassium Permanganate (KMnO_4) Injection
 - Zero-Valent Iron (ZVI) Injection
 - One along Transect – To be installed in 2021
 - Groundwater Pump, Treat, and Re-Inject



Activities Update—Pilot Testing in Source Area



Activities Update—Pilot Testing in Source Area (ZVI)



Activities Update—Pilot Testing in Source Area (ZVI)

- ▶ Injection Area 2A:
 - Completed 3 injection points
 - Used pneumatic emplacement
 - Injected into 25 of 27 attempted intervals (85-130 feet bgs)
 - 32,400 lbs of ZVI injected
- ▶ Injection Area 2B:
 - Completed 3 injection points
 - Used hydraulic injection (1 point) and pneumatic emplacement (3 points)
 - Injected into 37 of 42 attempted intervals (80-170 feet bgs)
 - 37,600 lbs of ZVI injected



Activities Update—Pilot Testing in Source Area (ZVI)

Injection Point ID	Injection Date	Treatment Interval (ft bgs)	Fracture Initiation Pressure (psi)	Fracture Maintenance Pressure (psi)	Injection Pressure (psi)	Injection Flow Rate (gpm)	Water Injected (lbs)	ZVI Injected (lbs)	Guar Injected (lbs)	Slurry Injected (lbs)	Monitoring Pressure (psi) Adjacent Monitoring Well(s)		
											MW75-93	MW61-80	MW61-107
IP07	7/16/2020	125-130	585	545	180	20	1,928	1,200	9	3,137	>0	NA	0
		120-125	350	340	100	42.9	1,928	1,200	9	3,137	>0	NA	0
		115-120	435	400	100	11.5	1,928	1,200	9	3,137	>0	NA	0
	7/17/2020	110-115	430	410	100	20	1,928	1,200	9	3,137	0	NA	0
		105-110	540	460	150	16.7	1,928	1,200	9	3,137	>0	NA	0
		100-105	440	400	180	13.6	1,928	1,200	9	3,137	>0	NA	0
		95-100	515	485	NA	NA	NA	NA	NA	NA	0	NA	0
		90-95	NA	NA	250	21.4	1,928	1,200	9	3,137	0	0	NA
		85-90	NA	NA	NA	NA	NA	NA	NA	NA	NM	NM	NA
IP08	7/14/2020	125-130	400	350	120	16.7	1,928	1,200	9	3,137	>0	NA	0
	7/15/2020	120-125	425	415	130	17.7	1,928	1,200	9	3,137	>0	NA	0
		115-120	455	430	160	21.4	1,928	1,200	9	3,137	>0	NA	0
		110-115	350	340	180	20	1,928	1,200	9	3,137	>0	NA	23
		105-110	360	340	100	21.4	1,928	1,200	9	3,137	0	NA	21
		100-105	400	380	170	20	1,928	1,200	9	3,137	0	NA	5
		95-100	400	390	160	21.4	1,928	1,200	9	3,137	0	NA	14
		90-95	390	370	200	18.8	1,928	1,200	9	3,137	>0	NA	>0
		85-90	265	250	100	11.1	643	400	3	1,046	>0	NM	NA
IP09	7/18/2020	125-130	555	530	200	20	1,928	1,200	9	3,137	>0	0	0
		120-125	435	415	100	16.7	1,928	1,200	9	3,137	>0	0	0
		115-120	435	420	100	16.7	1,928	1,200	9	3,137	>0	0	0
		110-115	490	460	150	15.8	1,928	1,200	9	3,137	>0	0	0
		105-110	495	490	180	23.1	3,855	2,400	18	6,273	>0	0	0
		100-105	505	490	180	18.8	1,928	1,200	9	3,137	>0	0	0
	7/19/2020	95-100	555	530	200	25	3,855	2,400	18	6,273	>0	0	0
		90-95	545	515	300	25	1,928	1,200	9	3,137	>0	0	0
		85-90	520	495	200	26.3	3,213	2,000	15	5,228	>0	5	0
Total Injected							52,054	32,400	243	84,697			



Injection Area 2A Quantities/Parameters



BUILDING STRONG®

Activities Update—Pilot Testing in Source Area (ZVI)

Injection Point ID	Injection Date	Treatment Interval (ft bgs)	Fracture Initiation Pressure (psi)	Fracture Maintenance Pressure (psi)	Maximum Well Head Pressure (psi)	Injection Pressure (psi)	Injection Flow Rate (gpm)	Water Injected (lbs)	ZVI Injected (lbs)	Guar Injected (lbs)	Slurry Injected (lbs)	Monitoring Pressure (psi) Adjacent Monitoring Well(s)		
												MW60-90	MW60-146	MW04
IP04	7/23/2020	170-175	NA	NA	550	300	20	1,452	900	8	2,360	0	>0	>0
		165-170	NA	NA	550	250	20	1,452	900	8	2,360	0	>0	>0
		160-165	NA	NA	550	250	20	1,452	900	8	2,360	0	>0	>0
		155-160	NA	NA	525	175	22	1,452	900	8	2,360	0	>0	>0
	7/24/2020	150-155	NA	NA	475	250	16.9	1,452	900	8	2,360	0	0	0
		145-150	NA	NA	550	300	12.9	1,452	900	8	2,360	0	0	0
		140-145	NA	NA	NA	NA	NA	NA	NA	NA	NA	NM	NM	NM
		135-140	NA	NA	NA	NA	NA	NA	NA	NA	NA	NM	NM	NM
		130-135	NA	NA	NA	NA	NA	NA	NA	NA	NA	NM	NM	NM
		125-130	NA	NA	500	250	20	1,452	900	8	2,360	0	0	0
		120-125	NA	NA	NA	NA	NA	NA	NA	NA	NA	NM	NM	NM
		115-120	NA	NA	500	250	16.9	1,452	900	8	2,360	0	0	0
		110-115	NA	NA	NA	NA	NA	NA	NA	NA	NA	NM	NM	NM
		105-110	NA	NA	500	250	18.3	1,452	900	8	2,360	0	0	0



Injection Area 2B Quantities/Parameters



Activities Update—Pilot Testing in Source Area (ZVI)

Injection Point ID	Injection Date	Treatment Interval (ft bgs)	Fracture Initiation Pressure (psi)	Fracture Maintenance Pressure (psi)	Maximum Well Head Pressure (psi)	Injection Pressure (psi)	Injection Flow Rate (gpm)	Water Injected (lbs)	ZVI Injected (lbs)	Guar Injected (lbs)	Slurry Injected (lbs)	Monitoring Pressure (psi) Adjacent Monitoring Well(s)		
												MW60-90	MW60-146	MW04
IP05	8/4/2020	145-150	580	520	NA	450	22	1,452	900	8	2,360	0	5	NA
		140-145	470	440	NA	350	27.5	1,452	900	8	2,360	0	10	NA
		135-140	540	510	NA	300	36.7	1,452	900	8	2,360	0	5	NA
		130-135	460	435	NA	250	31.4	1,452	900	8	2,360	0	5	NA
		125-130	450	420	NA	250	44	1,452	900	8	2,360	0	5	NA
	8/5/2020	120-125	450	410	NA	300	20	1,452	900	8	2,360	0	>0	NA
		115-120	470	440	NA	350	31.4	1,452	900	8	2,360	0	>0	NA
		110-115	475	440	NA	325	28.6	1,452	700	8	2,160	0	0	NA
		105-110	470	440	NA	300	27.5	1,452	900	8	2,360	0	0	NA
		100-105	475	430	NA	300	27.5	1,452	900	8	2,360	0	0	NA
		95-100	460	430	NA	200	36.7	1,452	900	8	2,360	75+	0	NA
		90-95	480	440	NA	200	31.4	1,452	900	8	2,360	0	0	NA
		85-90	475	425	NA	250	44	1,452	900	8	2,360	0	0	NA
		80-85	465	430	NA	250	22	1,452	900	8	2,360	0	0	NA
IP06	8/1/2020	165-170	702	640	NA	400	20	1,452	900	8	2,360	0	60+	NA
		160-165	670	605	NA	300	24.4	1,452	900	8	2,360	0	60+	NA
		155-160	680	600	NA	200	27.5	1,452	900	8	2,360	0	110	NA
		150-155	460	450	NA	250	27.5	1,452	900	8	2,360	0	0	NA
		145-150	505	480	NA	200	33.8	2,904	1,800	16	4,720	0	0	NA
		140-145	460	450	NA	200	31.4	2,904	1,800	16	4,720	0	0	NA
	8/2/2020	135-140	625	570	NA	250	31.4	1,452	900	8	2,360	0	0	NA
		130-135	550	450	NA	200	44	1,452	900	8	2,360	0	21	NA
		125-130	515	480	NA	200	36.6	1,452	900	8	2,360	0	4	NA
		120-125	495	475	NA	200	44	1,452	900	8	2,360	0	>0	NA
		115-120	510	475	NA	200	31.4	1,452	900	8	2,360	0	>0	NA
		110-115	460	430	NA	150	36.6	2,904	1,800	16	4,720	>0	>0	NA
		105-110	505	465	NA	150	36.6	2,904	1,800	16	4,720	0	0	NA
		100-105	460	430	NA	200	40	2,904	1,800	16	4,720	0	0	NA
Total Injected								60,984	37,600	336	98,920			

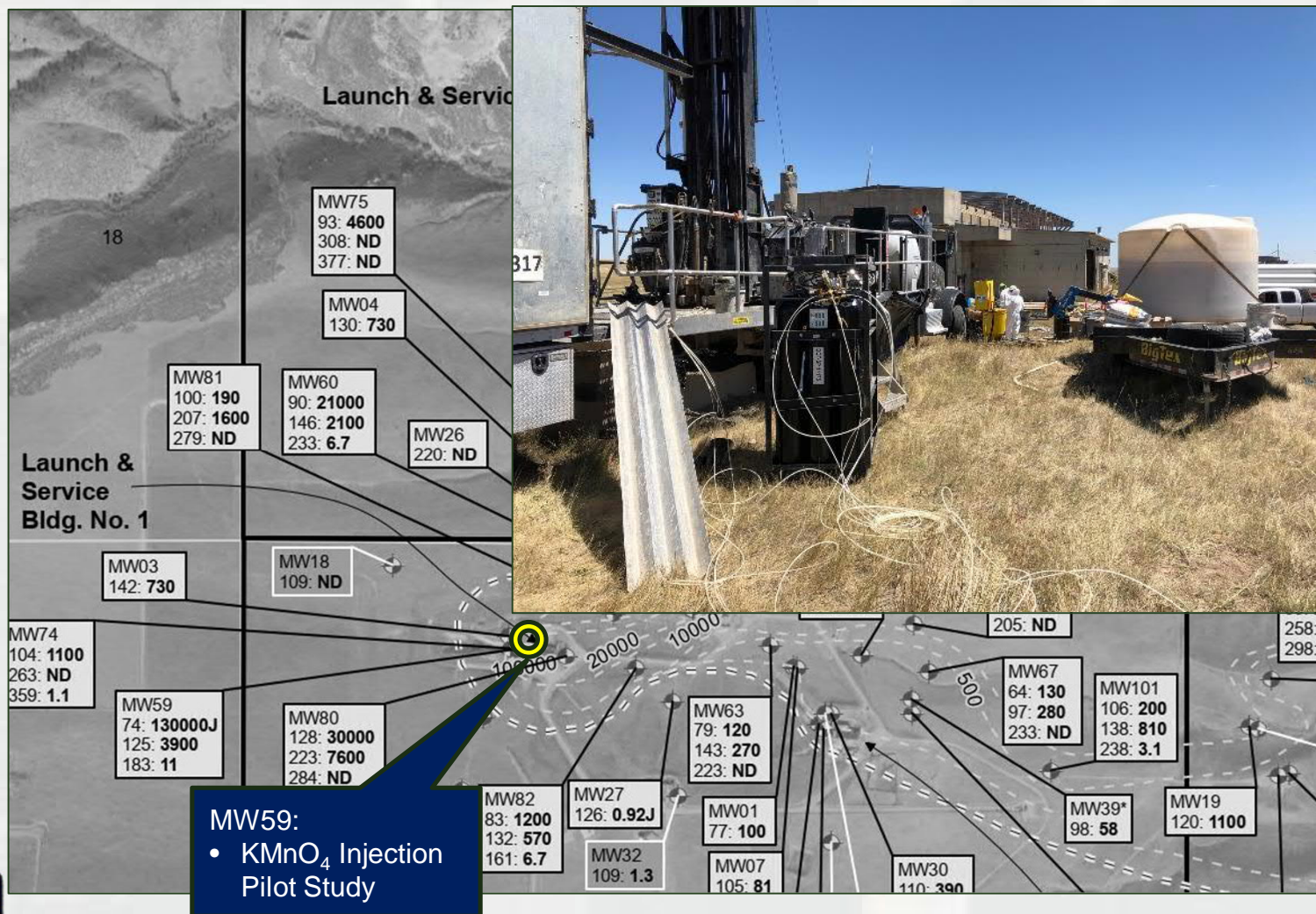


Injection Area 2B Quantities/Parameters



BUILDING STRONG®

Activities Update—Pilot Testing in Source Area



Activities Update—Pilot Testing in Source Area (KMnO_4)



Activities Update—Pilot Testing in Source Area (KMnO₄)

- ▶ Injection Area 1:
 - Completed 4 injection points (added 1 additional injection point)
 - Used pneumatic emplacement
 - Injected into 38 of 45 attempted intervals (70-148 feet bgs)
 - 25,137 lbs of KMnO₄ injected
 - KMnO₄ injected at 25% solution, diluted to 15-20% solution after injection of flush water



Activities Update—Pilot Testing in Source Area (KMnO₄)

Injection Point ID	Injection Date	Treatment Interval (ft bgs)	Fracture Initiation Pressure (psi)	Fracture Maintenance Pressure (psi)	Injection Pressure (psi)	Injection Flow Rate (gpm)	Water Injected (lbs)	KMnO ₄ Injected (lbs)	Slurry Injected (lbs)	Monitoring Pressure (psi) Adjacent Monitoring Well(s)		
										MW59-125	MW59-74	MW74-104
IP01	8/11/2020	142-147	615	580	300	17.5	2,837	400	3,237	75+	>0	>0
		137-142	590	550	200	17.5	2,837	400	3,237	>0	>0	>0
		132-137	610	560	300	23.3	2,837	400	3,237	>0	>0	>0
		127-132	615	570	150	10	1,669	417	2,086	0	>0	>0
		122-127	715	595	350	23.3	1,110	277	1,387	>0	>0	>0
		117-122	650	575	200	13.5	1,878	400	2,278	>0	>0	0
	8/12/2020	112-117	NA	NA	NA	NA	NA	NA	NA	NM	NM	NM
		107-112	NA	NA	NA	NA	NA	NA	NA	NM	NM	NM
		102-107	555	540	200	18.8	4,840	800	5,640	>0	75+	>0
		97-102	520	500	200	17.6	4,840	800	5,640	>0	75+	>0
		92-97	510	480	250	17.8	6,426	1,200	7,626	>0	10	0
IP02	8/19/2020	87-92	540	505	250	24.2	6,175	1,400	7,575	>0	20	0
		125-130	550	500	300	17.5	2,253	400	2,653	3	0	>0
		120-125	585	525	250	19.2	2,003	400	2,403	5	10	10
		115-120	685	670	250	14	2,837	400	3,237	>0	0	5
		110-115	650	610	400	15.9	2,837	400	3,237	>0	0	8
	8/20/2020	105-110	580	560	400	16.7	2,420	400	2,820	0	0	6
		100-105	560	540	200	20	2,420	400	2,820	0	0	5
		95-100	575	530	400	15.8	2,420	400	2,820	0	0	10
		90-95	630	565	250	14.3	1,586	400	1,986	0	0	13
		85-90	630	590	400	10	793	200	993	0	0	8
		80-85	620	550	300	25	2,003	400	2,403	0	75+	2
	8/21/2020				250	11.6	4,006	800	4,806			
		75-80	515	500	200	19.6	3,572	900	4,472	0	100	>0
		70-75	575	530	300	16.3	6,033	1,100	7,133	0	100	>0



Injection Area 1 Quantities/Parameters



Activities Update—Pilot Testing in Source Area (KMnO₄)

Injection Point ID	Injection Date	Treatment Interval (ft bgs)	Fracture Initiation Pressure (psi)	Fracture Maintenance Pressure (psi)	Injection Pressure (psi)	Injection Flow Rate (gpm)	Water Injected (lbs)	KMnO ₄ Injected (lbs)	Slurry Injected (lbs)	Monitoring Pressure (psi) Adjacent Monitoring Well(s)		
										MW59-125	MW59-74	MW74-104
IP03	8/7/2020	143-148	450	400	400	NM	5,282	694	5,976	0	0	4
		138-143	680	600	300	16.7	5,282	694	5,976	0	>0	>0
		133-138	550	480	400	23.4	5,282	694	5,976	0	>0	>0
	8/8/2020	128-133	NA	NA	NA	NA	NA	NA	NA	NM	NM	NM
		123-128	610	580	350	21.4	5,349	972	6,321	0	>0	>0
		118-123	640	600	300	14.7	4,657	902	5,559	0	>0	>0
		113-118	595	525	400	24.3	5,074	902	5,976	0	>0	>0
		108-113	575	530	250	21.8	5,282	694	5,976	0	>0	>0
		103-108	NA	NA	NA	NA	NA	NA	NA	NM	NM	NM
		98-103	NA	NA	NA	NA	NA	NA	NA	NM	NM	NM
		93-98	NA	NA	NA	NA	NA	NA	NA	NM	NM	NM
		88-93	NA	NA	NA	NA	NA	NA	NA	NM	NM	NM
IP10	8/23/2020	120-125	720	690-710	300	20	3,421	600	4,021	5	0	0
		115-120	600	550	200	21	3,421	600	4,021	>0	>0	0
		110-115	640	590	200	18.3	3,421	600	4,021	>0	>0	0
		105-110	580	545	200	23.9	4,214	800	5,014	>0	5	>0
		100-105	610	560	400	20	1,586	400	1,986	>0	3	>0
		95-100	670	605	400	20	5,007	1,000	6,007	0	5	0
		90-95	605	555	300	25.7	5,800	1,200	7,000	0	3	0
		85-90	595	570	250	23.7	7,243	1,291	8,534	0	3	0
	8/24/2020	85-90	595	570	250	23.7	7,243	1,291	8,534	0	3	0
Total Injected							140,953	25,137	166,090			



Injection Area 1 Quantities/Parameters



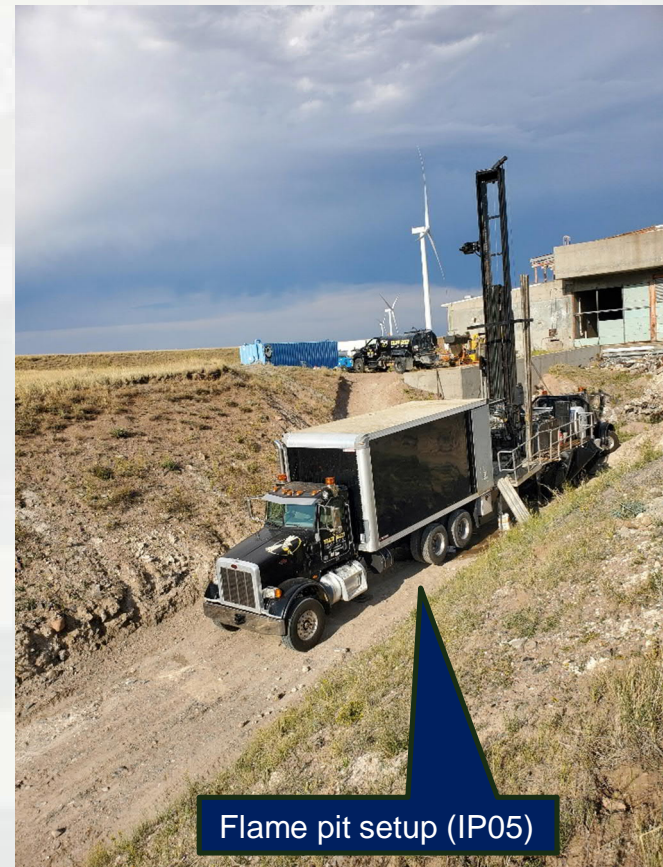
Activities Update—Pilot Testing in Source Area

► Drilling Observations:

- Minimal borehole collapse from drilling observed
 - Removed need for 6-inch temporary surface casing
 - Developed efficient drilling methods to get drilling down to less than 1 day (4x3 system)
- Size of drilling equipment affected accessible drill locations
 - Adjusted drilling locations accordingly
 - Completed angled borings (IP01, IP04, IP06)
- Potential for borehole collapse increased when borehole left open overnight during injection



Activities Update—Pilot Testing in Source Area



Activities Update—Pilot Testing in Source Area



Core Bags (IP02)



Core Bags (IP08)



Activities Update—Pilot Testing in Source Area

- ▶ Injection Observations:
 - Hydraulic injection method saw minimal success (IP04)
 - Pneumatic emplacement method most efficient and effective implementation method
 - Radius of influence observed at greater than 40 feet
 - Correlation exists between previously identified permeable flow paths and receptiveness to injection
 - More intervals receptive to injection than anticipated (decreased loading rate that would affect longevity)



Activities Update—Pilot Testing in Source Area



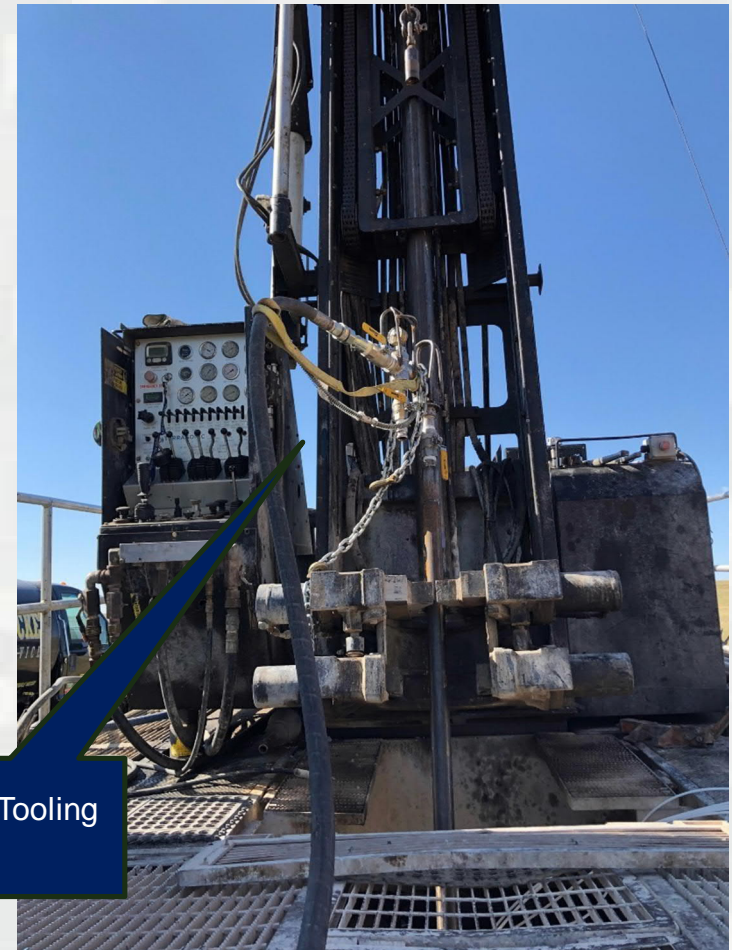
Injection Setup (ZVI)



Activities Update—Pilot Testing in Source Area



Inserting Injection
Tooling



Injection Tooling
Installed



Activities Update—Pilot Testing in Source Area

► Performance Monitoring Schedule

Injection Area	Performance Monitoring Wells	Injection Completion	2 Week Post-Injection Parameter Check	1 Month Post-Injection Sample	2 Months Post-Injection Sample	3 Months Post-Injection Sample	Summer 2021 Post-Injection Sample ¹	Fall 2021 Post-Injection Sample ²	Summer 2022 Post-Injection Sample ³	Fall 2022 Post-Injection Sample ⁴
2A (ZVI)	MW61, MW75 ⁵	19-Jul-20	4-Aug-20	20-Aug-20	18-Sep-20	19-Oct-20	19-Jul-21	19-Oct-21	19-Jul-22	19-Oct-22
2B (ZVI)	MW60 ⁶	5-Aug-20	22-Aug-20	2-Sep-20	7-Oct-20	4-Nov-20	19-Jul-21	19-Oct-21	19-Jul-22	19-Oct-22
1 (Permanganate)	MW59, MW74 ⁷	24-Aug-20	--	24-Sep-20	23-Oct-20	24-Nov-20	19-Jul-21	19-Oct-21	19-Jul-22	19-Oct-22

Notes:

¹ Sampling event will coincide with Summer 2021 LTM sampling event.

² Sampling event will coincide with Fall 2021 LTM sampling event.

³ Sampling event will coincide with Summer 2022 LTM sampling event.

⁴ Sampling event will coincide with Fall 2022 LTM sampling event.

⁵ Sample results from nearby monitoring wells MW28, MW62, and MW63 collected during Summer and Fall LTM sampling events in 2021 and 2022 will be incorporated into evaluation of this injection area.

⁶ Sample results from nearby monitoring well MW04 collected during Summer and Fall LTM sampling events in 2021 and 2022 will be incorporated into evaluation of this injection area.

⁷ Sample results from nearby monitoring wells MW03 and MW80 collected during Summer and Fall LTM sampling events in 2021 and 2022 will be incorporated into evaluation of this injection area.

Initial sample dates determined upon completion of injections and will be modified to suit site conditions accordingly.

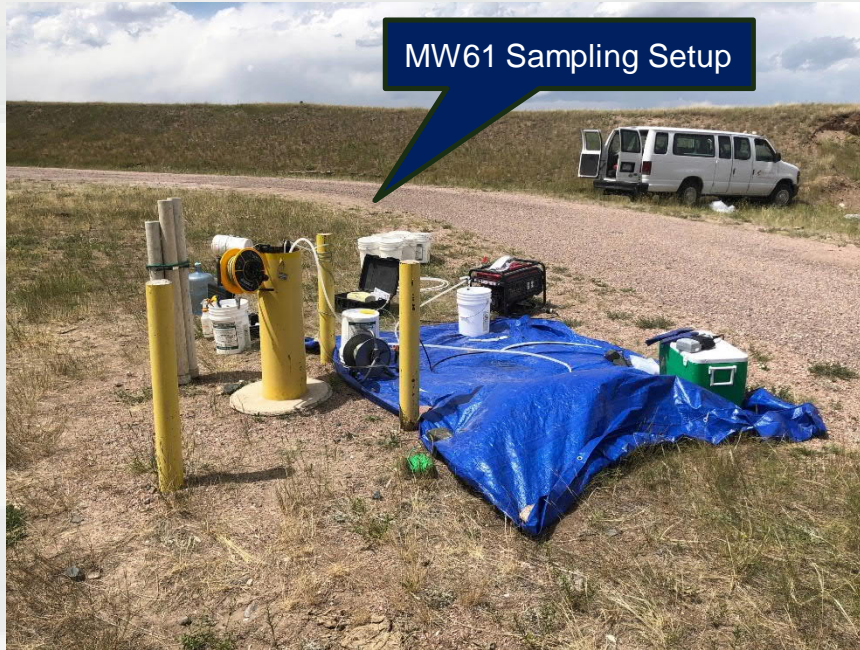
Sampling completed in accordance with Table 7-1 and 7-2 of Final Injection Pilot Study Work Plan.

LTM = long-term monitoring

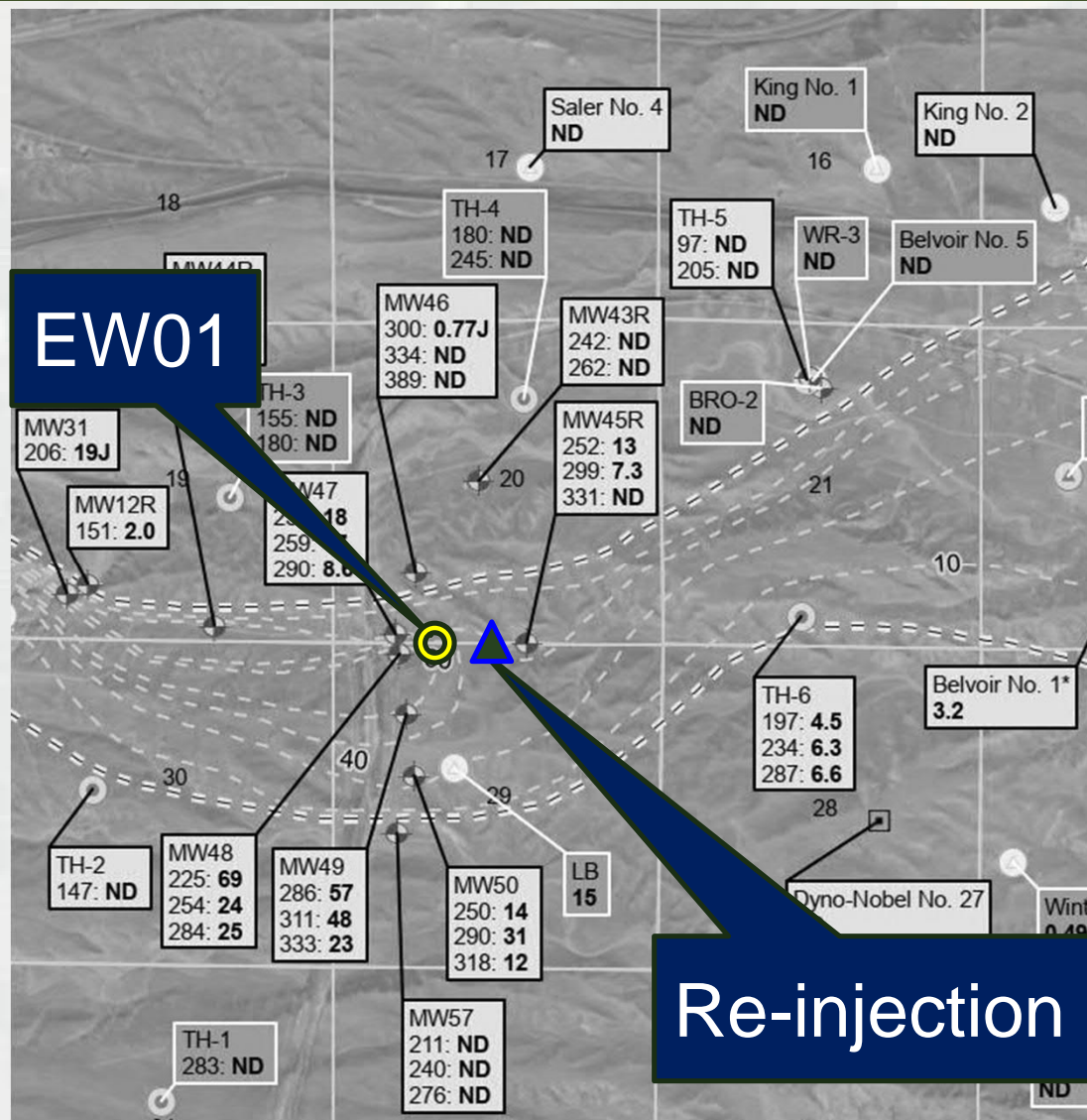
ZVI = zero-valent iron



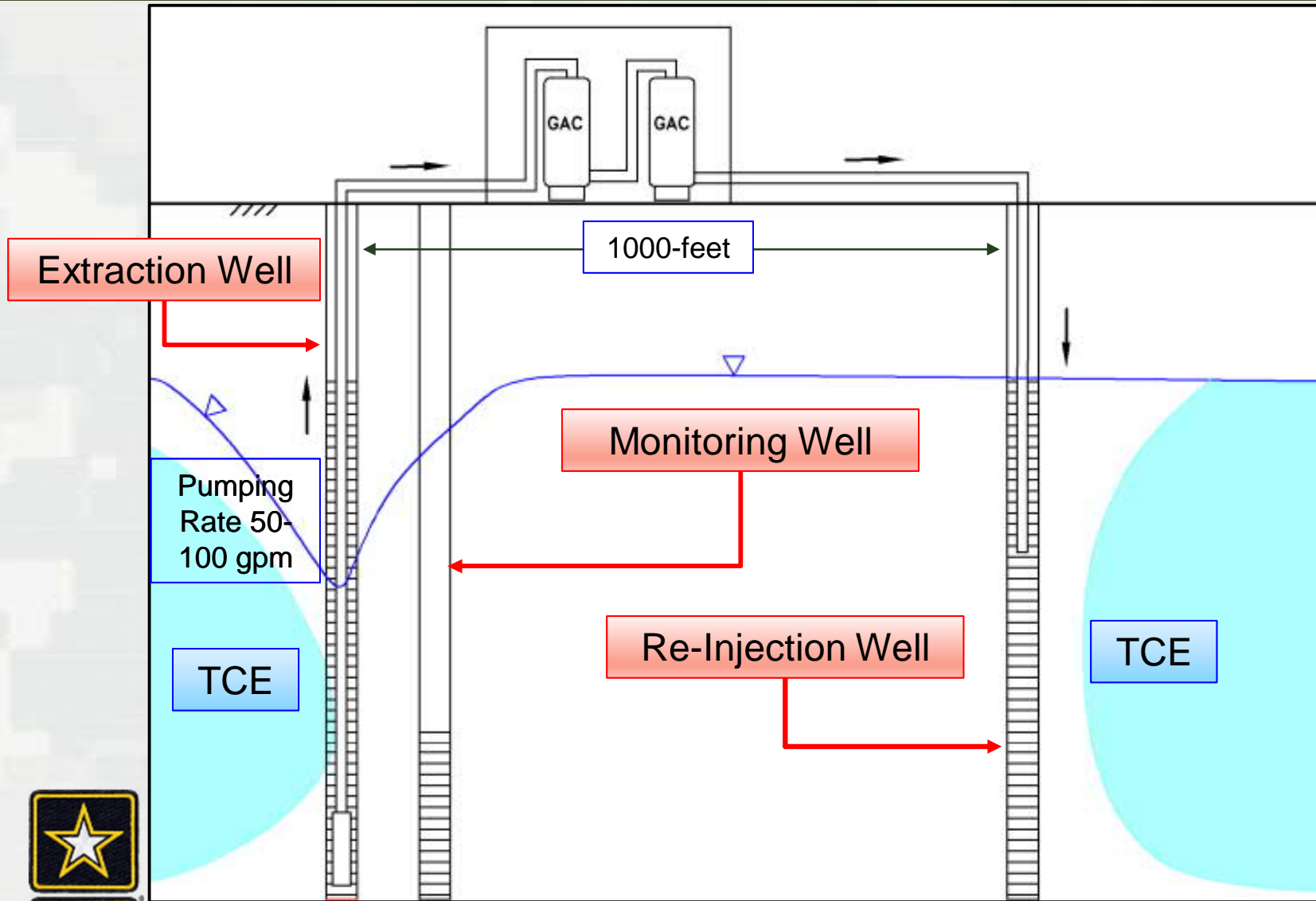
Activities Update—Pilot Testing in Source Area



Activities Update—Pilot Testing along Transect



Activities Update—Pilot Testing along Transect



Activities Summary —LTM Program, Additional Data Gap Investigation, Pilot Studies and FS

- ▶ LTM program continues semiannually
- ▶ Additional monitoring well installations to complete a few data gaps
- ▶ Pilot studies in the source and mid-point areas
- ▶ Feasibility Study Report (2024):
 - FS will include analysis of existing RI information, pilot studies, and LTM data



Atlas Site 4

November 2020 RAB Wrap-Up

► Questions.....

