Status as of last Weekly Progress Report 5/4/16 *immediately following termination of Extraction System*

ST12 Steam Enhanced Extraction: Has criteria for termination of Steam Injection Been Met?

I. Criteria for amount of steam to be injected:

Final RD/RAWP (May 2014): Table 4-2: SEE to EBR Transition Criteria

Steam injection (guideline)	319,357,000 lbs	Numerical thermal modeling of TTZs.	A targeted total of 319,357,000 lbs of steam is expected to be injected into the TTZ over the course of operations. This represents an average flushing of the TTZ pore volume of 1.6 pore volumes of steam as water throughout operation. Actual steam required to achieve the other criteria may be more or less than this estimate. Because this parameter does not directly measure remediation performance its primary use will be as a guideline to measure progress compared to the design.

Table 5-2 SEE to EBR Transition Criteria Monitoring

Parameter	Target Criteria	Summary of Monitoring or Sampling and Analysis for Evaluation of Progress Toward Transition Criteria
Steam injection (guideline)	319,357,000 lbs	Steam production will be measured at the boilers.

Weekly progress report as of 5/4/16

Total Steam Injected	302.4	million pounds (lbs)
Projected Total Steam Injection	320	million lbs
Steam Injected Vs Projected	94	%

Analysis: Status remains unchanged since shutdown of the steam injection system in early March. Criteria for amount of steam injection has not been 100% met. The design steam injection rate was based on 1.6 pore volumes of steam injection, which is lower than the commonly used criteria of 2 pore volumes of steam. The projected steam injection should be seen as a minimum amount of steam to be injected. Note actually energy usage was 53% of projection as of 5/4/16:

Estimated Total Energy Usage	11,343,000	kilowatt hours (kWh)
Total Energy Used	6,025,716	kWh
Used Electrical Energy vs. Estimate	53	%

II. Criteria for residual benzene concentrations:

Final RD/RAWP (May 2014): Table 4-2: SEE to EBR Transition Criteria

Benzene concentrations:	100 to 500 µg/L	Concentration range where natural attenuation can complete degradation within the remedy time frame.	Benzene concentrations in extracted groundwater provide an indication of the amount of benzene remaining in the TTZ. These concentrations will be monitored against a target benzene concentration in the 100 to 500 µg/L range within the TTZ. This concentration range is predicted to achieve cleanup levels within the 20-year remedial timeframe based on modeling of groundwater contaminant attenuation outside the TTZs after active EBR (Appendix E). Benzene located around the perimeter of the TTZ and the perimeter/interior extraction wells will be evaluated for benzene concentrations to identify any perimeter influx that may mask benzene removal within the TTZ. It is expected that lower benzene concentrations within this range will be achieved in the interior of the TTZs than at the perimeter.

Table 5-2 SEE to EBR Transition Criteria Monitoring:

Benzene concentrations	100 to 500 µg/L	Benzene concentrations will be monitored in SEE wells during baseline sampling. Samples of extracted water (see Table 5-1) will be used to evaluate benzene concentrations during SEE operation. Sampling locations during operation will be determined in the field with a sampling strategy that starts at influent to the liquid treatment system and then moves progressively out to individual manifolds and, in some cases individual wells to trace the source of benzene contribution. The locations will also be selected to evaluate the relative contribution of contamination from outside vs. inside the TTZs.

Analysis: EPA considers 500 µg/l of benzene in groundwater an appropriate target for a successful remediation, and would not support terminating steam treatment before the stated target (100 – 500 µg/l) is reached

Weekly progress report 5/4/16: LSZ

Progress Report
Steam Enhanced Extraction Remediation at the Former Williams AFB ST012 Site, Mesa, AZ
May 4, 2016

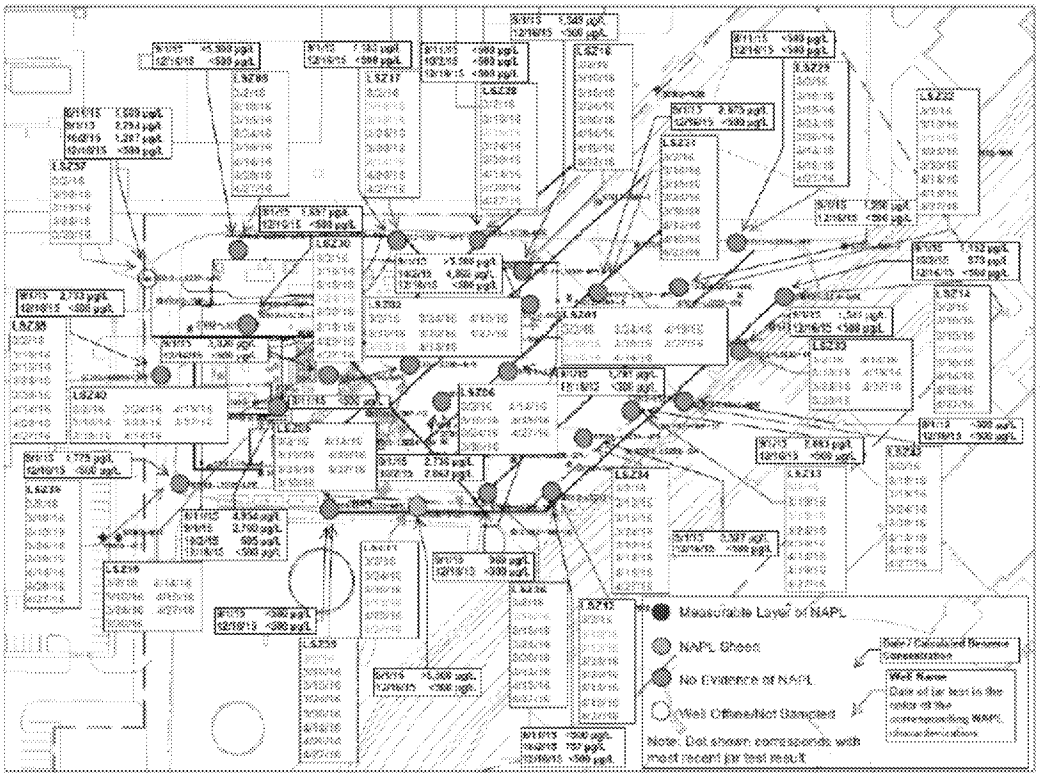

Figure 27. NAPL Screening Results and Calculated Benzene Concentrations – Lower Saturated Zone

LSZ Is looking good, although it appears that LNAPL was continuing to be recovered from outside the southern perimeter; helping to attain long term RAO at the time the extraction system was shut off.

Weekly progress report 5/4/16: UWBZ

Progress Report
Steam Enhanced Extraction Remediation at the Former Williams AFB ST012 Site, Mesa, AZ
May 4, 2016

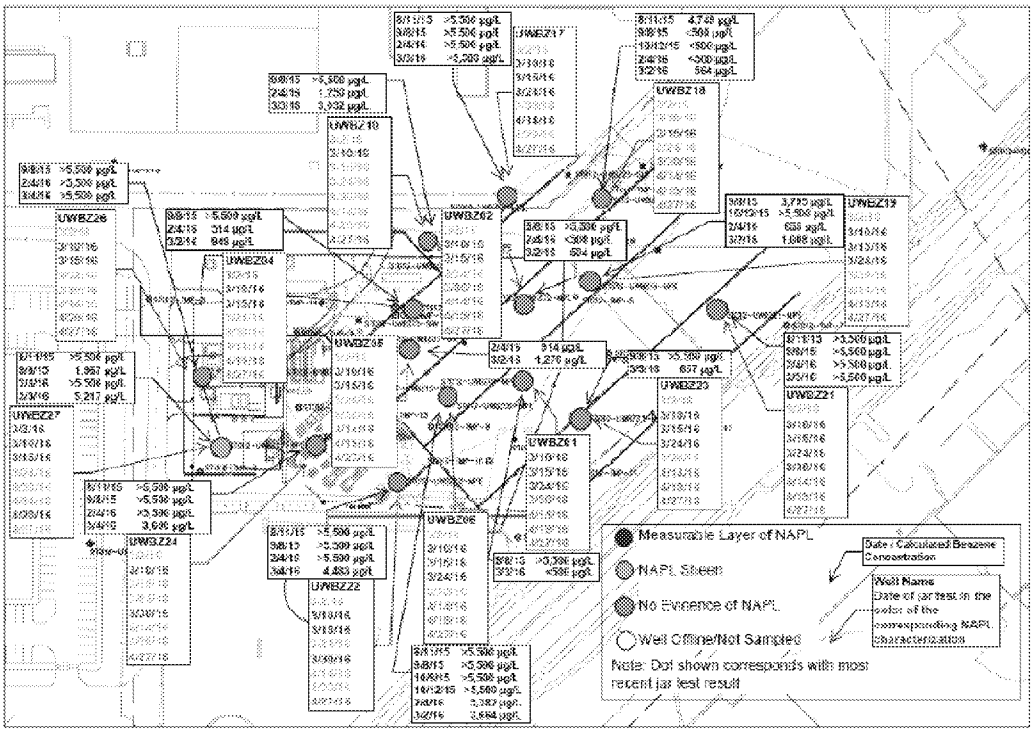

Figure 26. NAPL Screening Results and Calculated Benzene Concentrations – Upper Water Bearing Zone

Extraction system was still effectively removing LNAPL at time it was shut down. Benzene Concentrations in UWBZ still exceed 500 µg/L; Criteria has not been met for UWBZ

Weekly progress report 5/4/16 CZ

20. NAPL Screening Results and Calculated Benzene Concentrations

Figures 25-27 below present the screening level results for NAPL detected in samples collected from MPE wells across the site. Screening samples are typically collected on a weekly basis. The figures below also include calculated benzene concentrations of groundwater samples collected from MPE wells across the site.

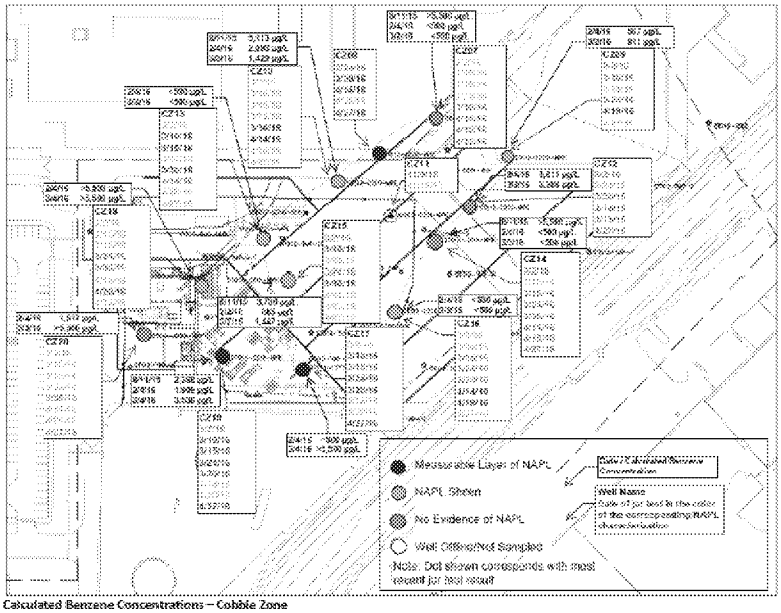

Figure 25. NAPL Screening Results and Calculated Benzene Concentrations – Cobble Zone

SEE was successfully removing LNAPL but benzene concentrations still Exceed 500 $\mu g/L$ in CZ at the time extraction system was terminated, SEE Termination Criteria has not been met for CZ. The Cobble Zone is also more highly transmissive and remaining contaminants will spread as water table rebounds.

III. Criteria for Mass Removal

Final RD/RAWP (May 2014):

Table 5-2 SEE to EBR Transition Criteria Monitoring:

Mass removal	Less than 10 percent of peak removal rate	Mass removal will be determined from a sum of individual mass removal rates such as: • Recovered LNAPL as measured by totalizing flow meter on the inlet to the LNAPL storage tanks • Mass in extracted vapors as measured at vapor collection manifold (vapor flow rate logged in PLC and influent vapor measured by FID/PID) • Mass in extracted water as measured in air stripper off gas and liquid laboratory samples (liquid discharge flow rate logged in the PLC, air stripper blower flow rate logged in the PLC, air stripper off gas measured by FID/PID, water treatment influent and GAC influent)

Final RD/RAWP (May 2014): Table 4-2: SEE to EBR Transition Criteria

Mass removal	Less than 10 percent of peak removal rate	10 percent selected as an indication of significant decline in mass removal by SEE. This target is consistent with removal rate trends observed at other sites and provides some accommodation for the uncertain mass present and the uncertain peak extraction rate. The actual site-specific removal rate curve will be evaluated to confirm or adjust the appropriateness of this value to represent a condition of diminishing returns.	The rate of contaminant mass removal from the subsurface will play a major factor in determining when SEE is complete or sufficient. The mass removal rate will be closely monitored and will be optimized by using pressure cycling events. Toward the end of the operational period, the mass removal rates will be modest when compared to the peak removal rates (typically less than 10 percent of the rate observed at peak operations). Contaminant mass located around the perimeter of the TTZ may contribute a continuing source of mass for removal by the SEE system, which could mask the progress of mass removal within the TTZs, so the contribution of perimeter/interior extraction wells may be evaluated for mass removal towards the end of operations to identify any perimeter influx. Continued operation below the 10 percent of peak removal rate may be implemented depending on the significance of continued mass removal, the status of COC concentrations (e.g., benzene) in extracted fluids, and the need/ability for EBR to achieve further degradation based on data collected during the EBR field test.

5/4/16 Weekly Progress Report

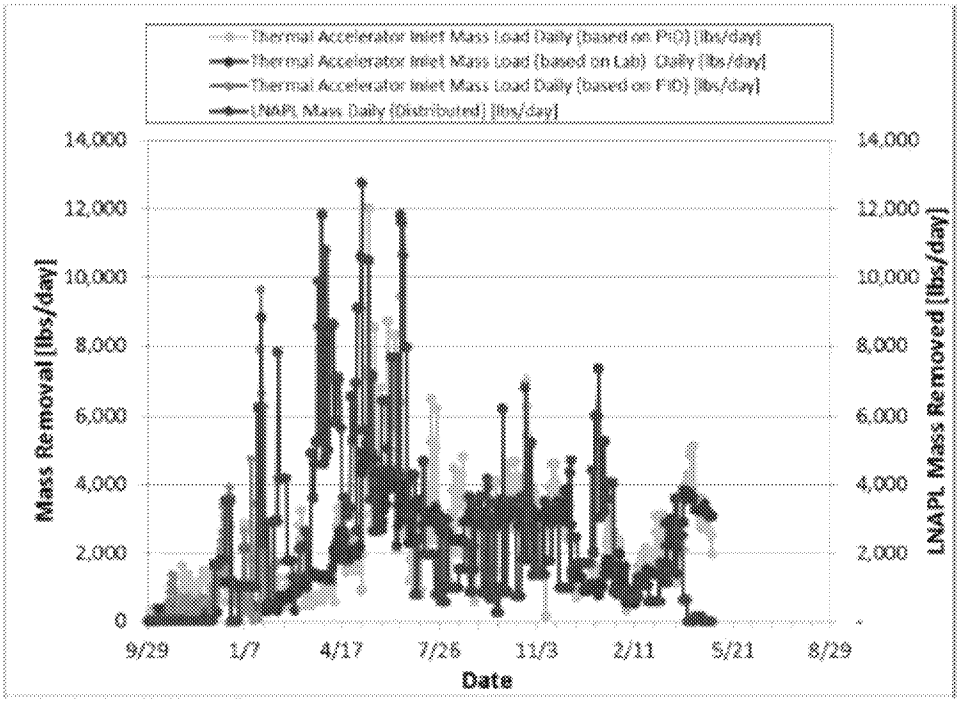

Figure 4. Daily Mass Removed

Analysis: Vapor recovery alone was at more than 3000 lbs per day, up to 25% of peak removal rate; Criteria for termination of steam injection has not been met. Figure indicates

daily LNAPL recovery rate has dropped off only due to termination of steam injection, However the tally in the weekly reports show that 35,254 gallons of LNAPL were recovered between the week the steam injection system was shut down and the extraction system terminated, and there was still LNAPL being recovered at the time the extraction system was shut down.

The 5/4/16 weekly report summarizes total mass recovery from SEE system at the time of shutdown and dismantling, showing LNAPL mass recovery was slightly more than 50% of total liquid and vapor removal

Steam Injected vs Projected	54	%
Total Mass Removed in Vapor Based on Photoionization Detector (PID) Readings	1,257,290*	lbs
Total Mass Removed as NAPL	1,391,026	lbs
Average Daily NAPL Mass Removal Last Week	0	lbs/day
Total Vapor and Liquid Mass Removal (based on PID readings)	2,648,316	lbs

IV. Criteria for completion of pressure cycling:

Pressure cycling had terminated with the termination of the steam injection system in early March.

V. Criteria for Boiling Temperatures

Table 5-2 SEE to EBR Transition Criteria Monitoring:

Subsurface Temperature	Varies by Depth (higher boiling temperatures with depth – see Figure 5.3, in Appendix D of the RD/RAWP)	17 individual TMPs will be equipped with 15-24 vertical temperature measurement locations per TMP. In addition, each SIW and MPE well will be equipped with the infrastructure for a co-located TMP to be installed for temperature measurements to be collected. Co-located TMPs will be permanently installed for the 18 deep SIWs in the LSZ and will monitor the temperature at the top, middle and bottom of these wells. Two mobile temperature arrays in the CZ and two mobile temperature arrays in the UWBZ will be used to monitor temperatures in the remaining MPEs and SIWs (top, middle and bottom depths). Temperature monitoring of the SIW/MPE wells, along with extracted fluid and vapor temperatures, will supplement the 17 individual TMPs to monitor temperature distribution at the site.
Completion of	Completion of	Because the pressure cycling process results in the volatilization

Final RD/RAWP (May 2014): Table 4-2: SEE to EBR Transition Criteria:

Table 4-2 SEE to EBR Transition Criteria

Parameter	Target Criteria	Basis for Target Criteria	Description
Subsurface Temperature	Varies by Depth (higher boiling temperatures with depth – see Figure 5.3, in Appendix D of the RD/RAWP	Numerical thermal modeling of TTZs supported by depth-specific boiling points.	Efforts will be made during operations to inject steam throughout the TTZ to target achievement of boiling point temperatures for groundwater throughout the TTZ. A steam zone will be generated and maintained where possible with the goal of pushing steam across the TTZ to form a steam zone between injection and extraction wells, with breakthrough of steam demonstrated at extraction wells. It is anticipated that a steam zone will not be able to be created and maintained in the LPZ. Other areas of low permeability may also be discovered during operation that limit achievement of target temperatures. Operational adjustments will be made where possible to increase temperatures in such zones that are slower to reach target temperatures. The energy balance will be used to support evaluation of achieving the temperature goal. Shut-down of steam will only be considered after achieving boiling point temperatures throughout the TTZ with the exception of the LPZ and other potential areas of low permeability and provided that operational adjustments are made to attempt to achieve the temperature goal in areas that are resistant.

Soil temperatures starting to decline a time extraction system was shut off and no longer a mechanism to cool the site down, the concern now is that hot mobile contaminants will spread if not contained.

5/4/16 Weekly Progress Report:

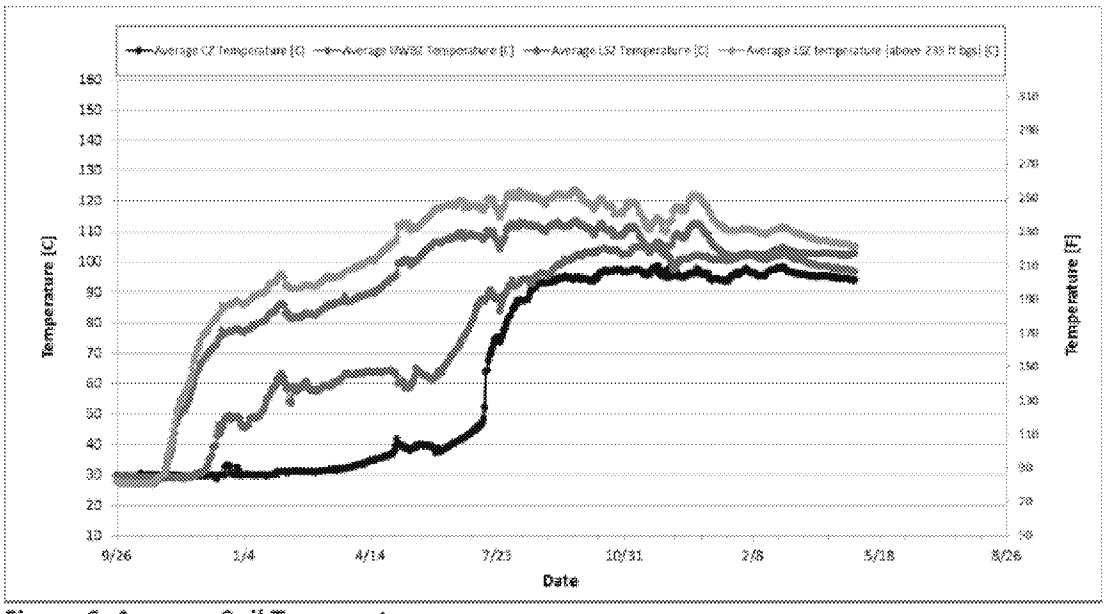

Figure 6. Average Soil Temperatures