DEPARTMENT OF THE AIR FORCE
AIR FORCE CIVIL ENGINEER CENTER

19 May 2016

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Subject: Response to Need for Continued Extraction for Containment
Site ST012 - Former Williams Air Force Base (AFB), Mesa, Arizona

On May 3, 2016, US Environmental Protection Agency (EPA) and Arizona Department of Environmental Quality (ADEQ) (the Agencies) provided a letter requesting continued groundwater extraction and additional site characterization at Williams AFB Site ST012. The basis of the Agencies' requests was concern over remaining mobile non-aqueous phase liquid (NAPL) at the site, elevated site temperatures, potential loss of contaminant containment during Steam Enhanced Extraction (SEE) operations, and potential higher mobility of contaminants in the Cobble Zone. The Agencies requested continued extraction until identified concerns were addressed and indicated that consideration of methods for drawdown and NAPL recovery to replace the current system would be welcomed. The EPA/ADEQ letter included a figure depicting areas for additional characterization and an emphasis on characterization as a priority to quantify baseline conditions. Most, if not all, of the concerns raised in the Agencies' letter have been communicated in prior comments or discussed in our monthly BRAC Cleanup Team (BCT) meetings. The Air Force (AF) has endeavored to be responsive to all of the Agencies' previous and current concerns, including in our March 29, 2016 response to the EPA/ADEQ joint letter dated March 7, 2016. A general response to the Agencies' May 3, 2016 letter is provided below and specific responses to itemized comments from the letter are provided in Attachment 1. Attachment 2 provides responses to the EPA email sent on April 29, 2016 addressing similar issues.

The AF agrees site characterization is a priority and has presented plans to implement post-steam site characterization. Drilling of post-steam characterization wells was initiated May 3, 2016 concurrent with the Agencies' letter. The post-steam characterization plan is phased in order to optimize data collection steps and implementation of the enhanced

bioremediation (EBR) remedy component. The phased plan presented in the April BCT meeting is designed to address the areas identified by the Agencies for additional characterization. The planning and implementation of activities in support of post-steam characterization do not represent reluctance to address regulatory agency concerns as indicated in the Agencies' letter. The AF acknowledges the comments received from the Agencies and believes we are taking appropriate steps to address the concerns. However, we would encourage the regulatory agencies to support the AF in implementing the remedy in accordance with the Remedial Design/Remedial Action Work Plan, and to consider information collected on post-steam site conditions before making assumptions or drawing conclusions about remedy effectiveness.

Significant efforts and resources are being focused on cleanup of ST012. Implementation of the Operable Unit-2 (OU-2) Record of Decision Amendment (RODA) remedy continues to represent a more aggressive approach to achieve cleanup objectives than previously conceived throughout the period from 2004 through 2010 when the site remedy was in informal or formal dispute. There have been combined efforts by all parties to optimize remedy implementation and there have been significant cleanup results in the past eighteen months (removal of over 2.6 million pounds of contaminants). The AF remains committed to achieving the OU-2 RODA cleanup objectives and estimated remedial timeframe. Towards this end, the AF continues to collect and evaluate data on ST012 site conditions and remedy effectiveness. The Agencies' contributions to remedy evaluation are important and valued by the AF. We will continue to assimilate new site information and regulatory input while implementing the remedy to achieve the cleanup objectives.

The AF suggests that we evaluate data collected during post-steam monitoring and site characterization in order to determine current site conditions and optimal implementation of the EBR phase of the remedy. Groundwater monitoring results over the last decade have not indicated a trend of benzene plume migration away from the historic ST012 plume area and this observation is not anticipated to change during the relatively brief period for SEE/EBR transition, even considering the rise of groundwater into the Cobble Zone. The data to be collected from post-steam site characterization and initial EBR implementation will better inform all of us on what additional steps are necessary to achieve the OU-2 RODA cleanup objectives and remedial timeframe. In the meantime, we will continue perimeter monitoring, NAPL removal, soil vapor extraction (SVE), reconnection of the deep SVE well intervals, and overall optimization of remedy implementation. Updates on site data collection and implementation of the remedy will continue to be provided on a weekly basis and via our monthly BCT meetings in order to take advantage of all of our efforts to ultimately achieve the cleanup objectives.

Please contact me at (315) 356-0810, ext. 204 or catherine.jerrard@us.af.mil if you have any questions regarding this letter.

Sincerely,

CATHERINE JERRARD
BRAC Environmental Coordinator

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Attachments:

1 – Responses to EPA/ADEQ May 3, 2016 Joint Letter – Need for Continued Extraction for Containment at ST-12 Fuels Spill Site, Former Williams AFB, Mesa, AZ
2 – Responses to EPA April 29, 2016 email questions

c:
CNTS – Geoff Watkin
AMEC – Don Smallbeck
Administrative Record – Terie Glaspey
File

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Attachment 1
Responses to EPA/ADEQ Joint Letter – Need for Continued Extraction for Containment at ST-12 Fuels Spill Site, Former Williams AFB, Mesa, AZ

The AF's response to the requests for continued extraction and additional characterization, as well as responses to the Agencies' supplemental and supportive observations are provided below.

Request for Continued Extraction. "The Agencies request the Air Force continue to extract and contain the contaminants until the concerns identified above have been satisfactorily addressed. The agencies are deeply concerned that failure to contain the plume and prevent contaminant migration now could create a more serious and costly problem for Air Force to address in the future.

The agencies would also welcome a timely consideration of more applicable and cost effective methods for drawdown and LNAPL recovery to replace the current extraction system designed for use during steam injection."

Response: The transition period from SEE to EBR as presented in the RD/RAWP and RD/RAWP Addendum 2 does not include continuous extraction based on site hydraulic groundwater conditions. Groundwater velocity estimates under natural gradients have been presented in previous documents and are summarized below.

- *Lower Saturated Zone (LSZ)*
  - *TEE Pilot Test Report, Appendix A – Groundwater velocity was estimated to be 0.1885 feet (ft)/day (68.8 ft/year or 22.9 ft/4-months)*
  - *Focused Feasibility Study (FFS) – Groundwater velocity was estimated to range from 110-290 ft/year based on the range of measured hydraulic conductivities. For an average hydraulic conductivity of 28 ft/day, groundwater velocity was estimated to be 225 ft/year (75 ft/4-months). Lower values for hydraulic conductivity (up to 12 ft/day) were used in the groundwater flow model appendix based on the TEE pilot test report and model calibration. Using this conductivity and the same gradient and porosity used for the other calculated velocities gives a groundwater velocity of 32.1 ft/year (10.7 ft/4-months)*
- *Upper Water Bearing Zone (UWBZ)*
  - *TEE Pilot Test Report, Appendix A – Groundwater velocity estimated to be 0.0635 ft/day (23.2 ft/year or 7.7 ft/4-months)*
  - *FFS – For an average hydraulic conductivity of 15 ft/day, groundwater velocity was estimated as 120 ft/year (40 ft/4-months). Lower values for hydraulic conductivity (up to 10 ft/day) were used in the groundwater flow model appendix based on the TEE pilot test report and model calibration. Using this conductivity and the same gradient and porosity used for the other calculated velocities gives a groundwater velocity of 80 ft/year (26.7 ft/4-months)*
- *Cobble Zone (CZ)*
  - *RD/RAWP – Although testing of hydraulic conductivity in the CZ is not available, a value of 70 ft/day was established in the RD/RAWP modeling. The selection of this*

conductivity was based on literature review as well as model calibration to transient water level rise and gradients observed in the CZ. Using this hydraulic conductivity along with same gradient and porosity used for the other zones give a groundwater velocity of 560 ft/year (187 ft/4-months)

At elevated temperatures viscosity is reduced which can increase hydraulic conductivity; however, the effect on travel times is dampened because the flux of groundwater into and through ST012 is largely controlled by transport in non-heated areas. Based on the calculated travel distances during the 4-month transition period, groundwater extraction and application of amendments for groundwater treatment associated with EBR would address groundwater in downgradient areas (see RD/RAWP Addendum 2, Appendix E figures), thus, continuous liquid extraction is not required. Contingency plans for early extraction will be evaluated during collection of information on post-steam site conditions. Vapor extraction and monitoring of groundwater conditions will continue during the transition period. The following bulleted list represents the planned course of action during transition to the EBR technology.

- *The deep SVE wells that were disconnected during SEE are in the process of being reconnected (anticipated 20 May 2016). This will allow continued extraction of vapor mass from the cobble zone.*
- *The catalyst will be removed from the SVE oxidizer. This will allow the system to handle higher concentration vapors without exceeding temperature limits.*
- *CZ wells will be evaluated for potential connection to the SVE system. The focus will be on CZ wells located in areas not covered by existing deep SVE wells.*
- *SEE wells are in the process of being checked for NAPL accumulation.*
- *Installation of ST012-CZ21 will be prioritized to provide an additional downgradient monitoring location for the CZ.*
- *Baseline sampling, monthly perimeter well sampling, temperature monitoring, and continued LNAPL monitoring/removal will be ongoing.*
- *Weekly LNAPL monitoring/removal will continue at perimeter wells and any SEE wells with LNAPL will be added.*
- *EBR has an extraction component in the remedy that will address a need for containment, if necessary. Contingency measures for accelerated connection of EBR wells for extraction are being evaluated in the event that information collected on post-steam site conditions indicates additional actions are needed.*

Request for Additional Site Characterization. "We believe that characterization of the remaining contamination should be a priority now. Enclosed a figure indicating additional (sic) for characterization that were not included in Amec's proposal to help address the concerns on delineating remaining contamination. It is critical for the success of the Enhanced Bioremediation project to quantify the baseline conditions and initial mass to be addressed for any future modeling effort to determine the effectiveness of the EBR application. We do not understand Amec's reluctance to address these concerns as expressed in the Base Closure Team (BCT) meeting on April 21, 2016."

Response: There is not a reluctance to address the concerns expressed. As presented in monthly BCT meetings/calls since December 2015, additional characterization is an integral part of EBR

Phase 1 implementation. It is also recognized and has been previously indicated that additional characterization will be part of future phases of EBR implementation and will depend on data collected in Phase 1. Sufficient characterization exists to initiate EBR so that progress towards the remedy goals continues. With respect to the suggested characterization locations proposed by the agencies, the Phase 1 data collection will address the following:

- *Northeast of ST012-W36 – This is a down- and side-gradient location. ST012-W36 had elevated benzene concentrations before and during SEE. There has been no indication of LNAPL in W36. For the April perimeter monitoring event, which occurred during the post-steam extraction period when groundwater was being pulled toward the TTZs, the benzene concentration dropped to 4.4 µg/L. This suggests that there is not a source to the north or east of the well. Benzene concentrations at ST012-W36 will continue to be monitored and will be evaluated with data from well installations at ST012-LSZ43 and ST012-LSZ44 to assess further characterization needs north and east of ST012-W36.*
- *Northeast of ST012-W34 and ST012-U02, north of ST012-U38/W38 – This is a down and side-gradient location. Both ST012-W34 and ST012-U02 have had increases in benzene concentrations during SEE and ST012-U02 had positive indications of LNAPL during one event. ST012-W38 had transient concentrations above the MCL during SEE but was below the MCL in the majority of the monthly samples. Concentrations at these wells in April were below the MCL for benzene. Benzene concentrations at ST012-W34, ST012-U02 and ST012-U38/W38 will continue to be monitored and will be evaluated with data from the well installation at ST012-LSZ44 to assess further characterization needs north and east of ST012-W34, ST012-U02 and ST012-W38.*
- *Northeast of ST012-W24– This is a downgradient location. ST012-W24 had transient benzene concentrations above the MCL during SEE but was below the MCL in the majority of the monthly samples. The benzene concentrations in April was below the MCL. Concentrations at ST012-W24 and ST012W38, as well as conditions at new wells ST012-LSZ45 and ST012-LSZ46 near ST012-W37, and new wells ST012-CZ21 and ST012-UWBZ30 at the corner of Ulysses and Sossaman, will be evaluated to assess characterization.*
- *West and South of ST012-W11 – This is an upgradient location. LNAPL accumulated in the well for an extended period during SEE. LNAPL also accumulated in this well historically, especially as the water table was rising into and through the LPZ. However, benzene concentrations prior to SEE were only around 100 µg/L. Conditions at the ST012-LSZ49 boring to the northwest and monitoring of benzene concentrations during EBR will be evaluated to assess further characterization needs west and south of ST012-W11*
- *West and North of ST012-W30 – This is an upgradient location. Benzene concentrations have been detected at this location above the MCL before and during SEE. LNAPL accumulated in the well for a brief period during SEE. Historically, several borings and wells existed in proximity to this well that provide soil core observations and sample data that will be used to interpret the historical extent of LNAPL in this area. Conditions at the ST012-LSZ50 boring to the southeast and monitoring of benzene concentrations during EBR will be evaluated to assess further characterization needs in this area.*
- *North of Ulysses Ave between ST012-UWBZ28/LSZ51 and ST012-LSZ43 – This is a side-gradient location. ST012-UWBZ28/LSZ51 and ST012-LSZ43 will be installed on the*

north side of Ulysses during Phase 1 of the EBR. Results from those locations will be evaluated to assess characterization.

Potential needs for additional characterization will be evaluated as information is collected from the initial well installations described above as well as from performance monitoring of the Phase 1 EBR implementation. Additional characterization efforts, if required, may be implemented prior to or concurrent with the Phase 1 EBR implementation.

AF Responses to Supplemental and Supportive Observations.

1. "Vapor and liquid extraction should be continued because:

    a. The total mass removal rate was hovering around 3,000 pounds per day with or without steam injection through the end of March. This rate has increased during April despite diminished LNAPL recovery as illustrated in Weekly Progress Report Figures 3 and 4. In recent meetings TerraTherm continued to assert the majority of mass being treated in the thermal accelerators was coming from the air strippers; ADEQ has continually challenged that by stating the dissolved hydrocarbon mass in extracted water entering the air stripper, under the best conditions, was only about 270 pounds per day and therefore the other 2,000+ pounds per day of extracted mass (not including recovered LNAPL) must be extracted as a vapor from the existing/former steam zone, whether this zone is inside the original, arbitrary, TTZ or outside it. In addition, Figure 2 of the Weekly Progress Report shows the concentration entering the air strippers declining. ADEQ stated during the SEE Pressurization Data Review Teleconference on 2-Mar-16, the Quarterly BCT Meeting on 15-Mar-16 and the Monthly BCT Meeting on 21-Apr-16 that continued extraction was necessary to redeem the benefits of this larger steam zone."

Response: Extraction for vapor mass recovery will continue. The deep SVE wells are in the process of being reconnected (anticipated 20 May 2016) and connection of select CZ wells to the SVE system is being evaluated for locations not directly covered by existing deep SVE wells.

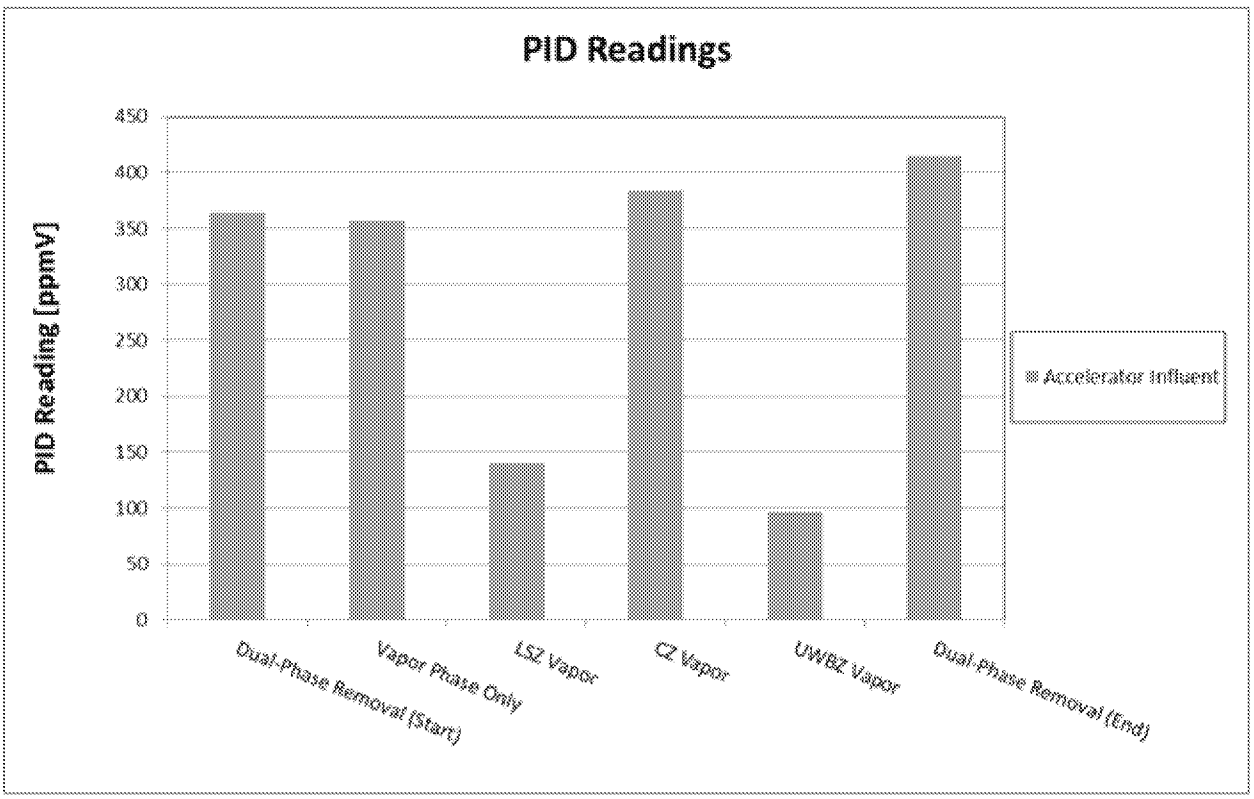
    b. "The contaminant sources for the recent vapor mass recovery (dissolved phase and volatilized contaminants in extracted steam or air) are likely masses of residual LNAPL remaining in the TTZ (and other soil volumes previously heated to steam temperature)."

Response: In the last week of post-steam extraction, a study was conducted to evaluate where the vapor mass was originating. The extraction system was sequentially operated through a sequence to isolate each zone and take PID and flow rate measurements. Time was provided (approximately 45 to 60 mins) to allow flushing of the vapor system. The sequence of tests was as follows:

- *Wellfield vapor and liquid phase. Normal operations.*

- *Wellfield vapor phase only. All eductor skids were shut off, but the air strippers remained running such that they feed "clean" air into the combined accelerator influent to avoid having to adjust dilution air.*
- *Wellfield LSZ vapor phase only. UWBZ and CZ vapor extraction were shut off at the wellheads.*
- *Wellfield CZ vapor phase only. CZ vapor extraction opened at the wellheads. LSZ vapor extraction closed at the wellheads.*
- *Wellfield UWBZ vapor phase only. UWBZ vapor extraction opened at the wellheads. CZ vapor extraction closed at the wellheads.*
- *Wellfield vapor and liquid phase. Normal operations (same as initial conditions). CZ and LSZ vapor extraction opened at the wellheads. Eductors were restarted.*

A graph presenting the PID readings at the thermal accelerator influent is provided below.

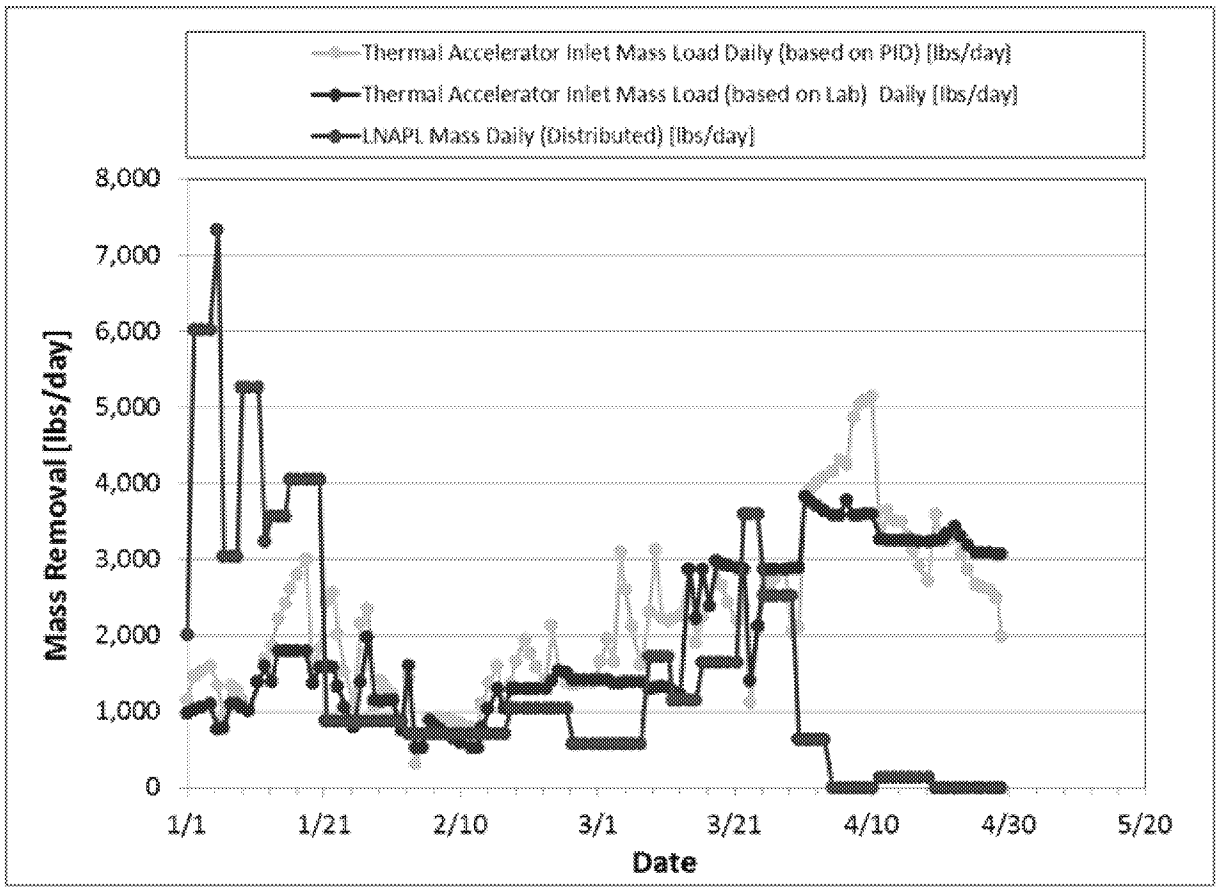


This data indicates that the CZ is contributing most of the mass in the vapor phase since the vapor mass removal rate when only the CZ was open to extraction was close to the mass removal rates during normal operations (vapor and liquid extraction) and vapor only extraction from all three zones. This observation is consistent with previous technical explanations because this zone has more open screen for vapor extraction available and vapors extracted through this zone would, in part, capture mass from the vadose zone (such as the deep vadose zone intervals addressed by the deep SVE well screens). This observation is not consistent with the agencies suggestion that masses of residual LNAPL within the TTZ are the likely primary source of vapor mass recovery. However, as discussed below, SEE wells will be checked and monitored for LNAPL.

It should be noted that some mass removal is observed in the vapor phase for both the UWBZ and the LSZ tests. This mass removal is likely due to the lack of complete isolation of those zones during the tests. If open screen is not available in either the UWBZ or the LSZ, isolation on one of those zones may encourage leakage at other wells that have been shut off but are all connected to the same piping manifolds.

c. "LNAPL columns likely reside in extraction well casings. The bottom of such LNAPL columns may exist above the pump intakes because of limited drawdown and therefore LNAPL does not appear in jar tests. This LNAPL is not recovered by pumping but can supply vapors for extraction. If so, the persistence and increase in vapor mass recovery indicates this LNAPL is being replenished from a "reservoir" of NAPL around such extraction wells. If the bottom of the LNAPL column is below the top of the screen intervals it is hydraulically connected to the formation for replenishment. Recent mass vapor extraction rates exceed the equivalent of 300 gallons/day of LNAPL. Each casing has a capacity on the order of 50 gallons therefore, if this LNAPL is the source of extracted vapors, the formation is replenishing the LNAPL in the casing as fast as it is removed. The drawdown increased with the cessation of steam injection and likely contributes to the increased vapor recovery rate. If the water levels in the extraction wells are allowed to rise, the vapor mass recovery will likely diminish. That reduction will not be the result of LNAPL remediation but rather hydraulically disconnecting residual LNAPL in the formation from vapor extraction."

Response: While LNAPL volumes could exist in well casings, this is a conceptual explanation for the vapor mass recovery that doesn't have any direct measures to verify it. SEE wells are in the process of being opened and checked for the presence of NAPL layers. If NAPL is present, the wells will be included in routine NAPL monitoring/removal activities. The recent testing described above suggests that the CZ is the primary source of vapor mass. Further, the significant increases of vapor mass removal during depressurizations are delayed from the drawdown associated with depressurization (see mass removal graph below, with depressurizations between 28 December to 21 January, 5 February to 18 February, and 4 March to 29 April), which would not be consistent with an LNAPL reservoir in close proximity to the well casing.



2. "AMEC Foster Wheeler has stated the criteria for transitioning from SEE to EBR described in the Work Plan have been met, but the agencies have continually disagreed on two points. First, the mass removal rate has not decayed sufficiently, and secondly, the extracted benzene concentration continues to be elevated. Claims that contaminant mass and elevated benzene are coming from the "outside" are unfounded as described above and extraction should continue."

Response: The status regarding the transition criteria has been extensively presented previously in monthly BCT meetings/calls. Although a reduction to 10% of the maximum mass removal rate was not consistently established, information has been presented to support the contribution of mass from outside the TTZ, including vapor mass contributions from the vadose zone above the TTZ. Continued mass contributions from outside the TTZ was identified in the RD/RAWP as a factor that could affect achieving the 10% criteria. The regulatory explanations presented above suggesting a continuing source within the TTZ are not supported by site operational data. As discussed above, SEE wells will be checked for LNAPL as soon as they can be accessed.

a. "Much of the reported data for determining benzene concentrations was collected during steam injection when dilution was occurring (i.e., clean water in the form of steam condensate was being introduced) and is not representative of subsurface conditions for EBR."

Response: Collection of samples during active steam injection provides the best measure of contaminant concentrations remaining within the TTZ during SEE operations. Baseline and performance monitoring samples will be collected as part of EBR Phase 1 to provide a representative indication of subsurface conditions for EBR.

b. "The agencies continually contend that the peak mass removal rate cited for comparison to determining the reduction in mass removal rate is not valid. The cited peak is based on a PID reading calibrated to analytical data collected a week later. A single PID reading is not valid for regulatory decisions; data for this level of decision should come from a certified laboratory."

Response: The RD/RAWP states that influent vapor as measured by PID would be the basis for evaluation of this criterion. Certified laboratory data collected throughout SEE operations at the frequency specified in the RD/RAWP were consistent with the comparable PID readings. Mass removal rates based on PID readings were adjusted when laboratory results were received. This method of frequent monitoring with a PID supplemented with routine laboratory confirmation data provided the best basis for evaluating mass removal rate trends and was documented in the RD/RAWP. There is no way to know during SEE operations when the maximum PID reading would have occurred such that a simultaneous laboratory sample could also be obtained.

3. "Though some efforts have been made to estimate the mass of mobile LNAPL remaining at the site, these estimates are subject to high uncertainty. It appears from contaminant extraction data (i.e., continued removal of NAPL), the NAPL found in numerous wells, and high dissolved contaminant concentrations in many locations, that the remaining NAPL source mass is significant and likely to adversely affect the effectiveness and timeliness of the proposed EBR and MNA remedies. Neither EBR nor MNA are source removal remedies, so they are inadequate to address the remaining NAPL."

Response: It is agreed that there will always be uncertainty with subsurface NAPL estimates for ST012 and it is therefore premature to conclude that any remaining NAPL will interfere with achieving remedial objectives. Over 2.6 million pounds of contamination were removed by SEE and NAPL removal diminished rapidly during the final four weeks of extraction following depressurization. High dissolved contaminant concentrations observed at the site, and even the presence of NAPL, do not necessarily preclude achieving the cleanup objectives and remedial timeframe. Currently, data collection efforts to determine post-steam site conditions are a priority. SEE wells are in the process of being checked for the presence of NAPL and drilling is proceeding in areas of concern. We would encourage the regulatory agencies to support the AF in implementing the remedy in accordance with the Remedial Design/Remedial Action Work Plan and to base further site evaluations on post-steam site conditions. Ultimately, the remedy objectives are directed at achieving the cleanup levels for COCs, primarily benzene, in groundwater. EBR and MNA will be focused on achieving the OU-2 RODA cleanup levels.

4. "The site is still at elevated temperatures from SEE operations, so contaminants are more mobile at this time; continuing the extraction efforts is likely to remove significantly more NAPL source material."

Attachment 2
Responses to EPA April 29, 2016 email questions

"Are you planning to evaluate the extent of off site migration of contaminants to verify the conceptual model?"

Response: *Yes. As detailed in the RD/RAWP Addendum #2, the drilling of the new wells for EBR will include evaluation of contaminant extent. These wells will be drilled using sonic drilling methodology to provide a continuous soil core for evaluation. Soil cores will be screened for signs of potential LNAPL. If potential LNAPL is suspected, dye test kits will be used to evaluate soil from the suspect interval. Positive dye test kits will also be confirmed by off-site laboratory analysis. Newly installed wells will be sampled after development and prior to sulfate injections. All of this information will be used to verify and update the conceptual site model. Additional phases of characterization may occur depending on the results from initial drilling or groundwater sampling.*

"Or do you plan to continue extracting as we did post TEE to keep hot fluids from migrating down gradient?"

Response: *SEE operations included eight weeks of extraction as part of the post-steam extraction period. Extraction was discontinued on April 29 based on sufficient cooling to allow for drilling in support of post-SEE characterization and EBR implementation. The duration of post-steam extraction for the purpose of cooling and contaminant removal was similar to the duration performed for the TEE pilot system (8 weeks for the LSZ and 6 weeks for the UWBZ). Water injection was not used to assist in post-steam cooling as it was during the pilot test since some leakage from the pilot test cell was reported.*

EBR also includes extraction at ST012 as described in RD/RAWP Addendum #2; however, there will be an interim period of about four months to allow for SEE decommissioning and EBR system construction and startup during which no extraction will take place. Hydraulic gradients at ST012 will not result in significant contaminant migration during the brief transition period. During this interim period, the perimeter monitoring wells will be sampled on a monthly basis until EBR extraction commences. The SEE and perimeter wells will be routinely monitored for accumulation of NAPL and the NAPL will be removed if significant volumes are measured (generally 5 feet or greater). The EBR baseline sampling will be conducted in May/early June and the EBR quarterly monitoring will be conducted in June. The EBR quarterly monitoring includes the perimeter monitoring wells that have been routinely monitored during SEE (see details in RD/RAWP Addendum #2).