UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
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January 27, 2015

Catherine Jerrard
Program Manager/BEC
AFCEC/CIBW
706 Hangar Road
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Re: Review of the Draft Addendum #2, Remedial Design and Remedial Action Work Plan for Operable Unit 2, Revised Groundwater Remedy, Site ST012, Former Williams Air Force Base, Mesa, Arizona, November, 2011

Dear Ms. Jerrard:

EPA has reviewed the Draft Addendum #2 to the Remedial Design and Remedial Action Work Plan (RD/RAWP) for Operable Unit 2 for the Revised Groundwater Remedy for Site ST012 at the Former Williams Air Force Base in Mesa, Arizona, dated November 30, 2015. The purpose of this Addendum, according to Section 1.1 of the document, is to update information on site conditions including mass characterization, present the design for enhanced bioremediation (EBR) implementation, and to describe the planned construction, implementation, and monitoring of the EBR phase of the remedial action. According to Section 6.1 of the Addendum, the purpose of EBR is "to achieve conditions . . .. at ST012 such that contaminants will degrade by natural attenuation to achieve the cleanup levels within the projected remedial timeframe (less than 20 years) after completion of EBR." (Please note that the 2012 Record of Decision Amendment (RODA specified RAOs to be complete within 20 years of RODA signature.) While the conditions needed for natural attenuation to be successful in 20 years are not defined in Addendum #2 of the RD/RAWP, Amec has previously stated that benzene concentrations of 100 to 500 μg/L can be degraded by natural attenuation to achieve the RODA Remedial Action Objectives within the specified timeframe.

Conceptually, sulfate reduction (i.e., enhanced sulfate reduction/EBR using injected sulfate as an electron acceptor, and afterwards MNA relying on natural sulfate reduction) seems likely to be useful for degradation of the COCs dissolved in groundwater. However, given the considerable mass of source material (i.e., mobile/residual LNAPL) remaining, the practical efficacy of EBR/MNA towards achieving Site remedial goals in the desired timeframe is highly uncertain. The Draft RAWP Addendum has not demonstrated that the planned EBR can meet the goals of achieving conditions that would allow natural attenuation to reach soil cleanup criteria in the remedial timeframe.

It is EPA's understanding that the initial concept brought to EPA by the Air Force and Amec and

subsequently documented in the 2012 RODA was that Steam Enhanced Extraction (SEE) would be used to treat the light non-aqueous phase (LNAPL) beneath the water table at ST012, and EBR would be used to treat dissolved phase contamination outside of the Thermal Treatment Zone (TTZ) that could not be reached by steam. As wells were installed for the SEE system, soil cores were collected to further characterize the distribution of LNAPL in the subsurface, and LNAPL contamination was found in areas that were expected to be free of LNAPL. This lead to an expansion of the SEE system to the largest extent possible in the lower saturated zone (LSZ), until the system ran up against Sossaman Road and other surrounding land uses that are not compatible with SEE. Although significant LNAPL was found outside of the planned treatment area in the cobble zone (CZ) and upper water bearing zone (UWBZ), above where SEE was to be used in the LSZ, the thermal treatment zone in the CZ and UWBZ were not increased to include these areas. This decision left considerable LNAPL in accessible areas that were not directly addressed by SEE; although operation of the SEE system has and continues to enable the passive recovery of LNAPL in wells 11 and 37 outside of the TTZ.

EBR was never intended to be a primary removal mechanism for LNAPL. ***EPA does not support premature termination of SEE so long as significant mass and mobilized LNAPL is being recovered.*** Furthermore, EPA is concerned that if the mass estimates in the Addendum are correct, AMEC is now proposing to treat a greater amount of LNAPL mass using EBR then was treated using SEE. This is not consistent with the 2012 RODA ST012, and raises serious concerns the ability of the proposed remedies to meet the ROD-stated remedial goals within the remedial timeframe.

Additional comments on the changes to EBR in the Addendum from previously-approved documents, the lack of characterization of the remaining LNAPL mass extent, and the need to provide a complete 100 percent design for EBR are provided in detail below.

GENERAL COMMENTS

1. This Addendum #2 is an update of Section 3.5 of the Final Remedial Design/Remedial Action Work Plan (RD/RAWP), dated May 2014. Comparing Section 3.5 of the Final RD/RAWP to Addendum #2, it appears that the scope of the workplan for active EBR has been scaled back from the original workplan. The estimate of LNAPL mass in the subsurface has been reduced from a range of 5.8 - 10.4 million pounds, to a range of 4.6 - 10.2 million pounds, but the expected sulfate usage has been reduced from 7,600 tons to 838 tons without justification. The total number of injection and extraction wells has also been reduced from 60 to 50, including reducing the number of injection and extraction wells by 2 and 9 respectively, in the UWBZ, which contains half the remaining mass of contaminants according to the e Addendum. Also, the distribution of terminal electron acceptor (TEA) in the areas outside of the TTZ believed to be contaminated by LNAPL has been significantly reduced (compare Figures 3-4, 3-5, and 3-6 of the Final RD/RAWP to Figures E-1, E-2, and E-3 of Addendum #2). In addition, the operation of a recirculation system, which had been expected to operate for 1.5 to 3 years during EBR, was reduced to 'dosing using batch injections coupled with groundwater extraction . . . will operate until satisfactory TEA distribution is achieved" and recirculation will be employed only "if

necessary". None of these changes from the approved Final RD/RAWP are explained in the Addendum, and these changes have been made before the new wells have been installed to characterize the area. These changes do not appear to be justified based on the small decrease in the modeled area believed to contain LNAPL, and all of them together appear to severely reduce the amount of enhancement to natural biodegradation that is being planned.

2. Addendum #2 presents a confusing array of estimates of LNAPL mass in the subsurface, both pre-SEE (Table 2-1) and post-SEE (Table 2-6 and Table 2-7). According to Section 2.1,pre-SEE LNAPL contours were developed for the site based on Pre-Design Investigation data, historical borings, and where LNAPL had been observed in monitoring wells, which were imported into a three dimensional model which interpolated a surface between the contours. Interpolated contours from a three dimensional model should not be substituted for actual field characterization of the extent of LNAPL in the soil and dissolved in the groundwater. This characterization must be completed before finalizing plans for the EBR, to ensure that all areas of remaining contamination are treated.

3. The design of the EBR system in Addendum #2 is only conceptual in nature. A complete design must include, at a minimum, the following information:

- TEA injection rates, time for injections to occur, injection/extraction ratios, predicted travel time of sulfate to extraction points, criteria to convert to recirculation system if desired TEA distribution is not achieved
- Wier tank to be used, size; design of particle filtration and granular activated carbon systems, controls/interlocks of these systems
- Which injection wells will receive TEA solution via direct pumping, which require portable mixing tanks, size of mixing tank

4. The success of the EBR application at this point relies heavily upon the use of the 3D groundwater model which is barely discussed in the Draft RD/RAWP Addendum. Although calculations are provided in Appendix E, a narrative discussion of model assumptions, input parameters, results, uncertainties and conclusions is warranted.

5. Contaminant concentrations, geochemistry, etc., in the injection and extraction wells can be significantly affected by injection and extraction activity, and data obtained from these wells should be analyzed/interpreted separately from data taken from monitoring wells not used for injection and extraction. Monitoring wells not used for injection and extraction should be used as the primary source of data for determining contaminant degradation, geochemical conditions representative of the aquifer volumes, EBR endpoints, etc.

6. Given that there are relatively few wells set aside for monitoring only, and those wells appear to be concentrated in the interior of the Site, it would be useful to consider installation of monitoring wells that sample the Site in a more representative manner (i.e., laterally and vertically).

7. It appears that the endpoints for EBR ("100 to 500 μg/L", "EBR will be implemented to achieve conditions…", as quoted above in the Introduction section of this review) are vague and

somewhat arbitrary, in that:

a) the endpoint contaminant concentrations indicated for EBR ("100 to 500 μg/L") encompass a wide range,

b) no particular sampling locations are specified (e.g., sampling locations providing data representative, in a statistically valid and defensible way, of the various subsurface zones throughout the Site) for providing the concentration data to be used for determining the endpoint,

c) no approach is specified for determining that the endpoint concentration has been met (e.g., a statistically valid, non-arbitrary procedure for analyzing the data), and

d) part of the EBR endpoint determination appears to involve use of mathematical models of Site processes (e.g., groundwater flow, biodegradation/reactive transport) to estimate when EBR has achieved "conditions (residual COC/COPC groundwater concentrations) at ST012 such that contaminants will degrade by natural attenuation to achieve the cleanup levels within the projected remedial timeframe (i.e., about 20 years) after completion of EBR." (Lines 1104-1107, Work Plan). Given the high uncertainty connected with input data and parameters used in such models, it is to be expected that estimates of contaminant attenuation rates in different volumes of the Site subsurface over long periods of time under varying groundwater flow, geochemistry, and microbiological conditions, are subject to high uncertainty.

8. Note that all modeling and statistical approaches should be clearly shown to meet USEPA data quality objectives, and should incorporate uncertainty analyses (USEPA 2009), including sensitivity analyses, confidence limits on predicted values, etc. The uncertainty analyses should clearly indicate the variability of Site data, and how that variability influences assessment (i.e., understanding of current Site conditions, including hydrogeology, contamination, geochemistry, and microbiology) and predictions of contamination nature, contaminant extent (3D location) and contaminant degree (concentration/mass, including attenuation rates), and of future changes in Site conditions (hydrology, geochemistry, microbiology, etc.). Data analyses, and predictions of contaminant and geochemistry values, extent, and changes, should be presented in narrative, tabular, and graphical form to enhance communication of the current and expected conditions, and the associated uncertainty of measurements and predictions. Generally the data analyses and predictions should be updated at least annually for the life of the remedy, to generate updated attenuation rate constants, time-frame predictions, etc., using the latest data.

9. Milestones (e.g., contaminant concentrations achieved at specified locations on specified dates) should be determined, for both EBR and MNA, so that it can be determined in a reasonably substantive way (i.e., not arbitrary, but in a determinate fashion) whether the Site remedial approaches are continuing to progress in such a way as to meet remedial goals in the specified timeframe. USEPA 1999 indicates that "the progress of MNA toward a site's remediation objectives should be carefully monitored and compared with expectations." (USEPA 1999, p2) Procedures should be provided so that if it is determined that milestones are not being

met, either:

a) specific plans can be implemented to enhance the existing remedial approach (e.g., for EBR, more reagent injections, more injection points, better injection/extraction approaches to distribute reagents, change in reagents, etc.), or

b) pre-planned contingency remedy(ies) can be implemented. Note that USEPA policy guidance for MNA (USEPA 1999, p24) indicates that contingency remedies should be prepared for implementation in case MNA is not meeting Site remedial goals. Also, USEPA expects that MNA remedies based on predictive analyses (i.e., modeling) should have contingency remedies prepared for implementation.

i) For contingency remedies, USEPA 1999 indicates that: "Where MNA's ability to meet these [remedial] expectations is uncertain and based predominantly on predictive analyses, decision makers should incorporate contingency measures into the remedy." (USEPA 1999, p2)

ii) Also, USEPA 1999 indicates that: "EPA believes that contingency remedies should generally be included as part of a MNA remedy which has been selected based primarily on predictive analyses rather than documented trends of decreasing contaminant concentrations." (USEPA 1999, p25)

10.) The presumed future efficacy of MNA at the Site must be regarded as based on predictive analyses. Therefore contingency measures should be included in remedial plans so as to be ready for implementation if performance monitoring of MNA indicates that MNA is not achieving Site remedial objectives in a timely fashion, as indicated in the discussion above.

SPECIFIC COMMENTS – Comparison to Final RD/RAWP (May 2014)

11. The Final RD/RAWP, dated May 2014, on page 3-12, states that single well injection-withdraw tests will be conducted in each hydrostratigraphic zone to assess TEA selection and delivery. However, the Addendum states that only wells in the LSZ were used for pilot testing of sulfate injection and determination of utilization rates. BEM (BEM, 2011, Final Phase 1 Thermal Enhanced Extraction (TEE) Pilot Test Performance Evaluation Report, prepared for Air Force Center for Engineering and the Environment, Lackland AFB, Texas, March 2011) in Appendix M states that biodegradation rates are higher in the LSZ than in the UWBZ. Thus, the utilization rate found in the LSZ during the pilot scale may overestimate biodegradation rates in the UWBZ.

12. The Final RD/RAWP, dated May 2014, on page 3-13, states that the top of the well screen section for each UWBZ injection well will be set 20 feet below the top of the CZ/UWBZ interface because particle tracking analysis had concluded that when liquids were injected into the entire depth of the UWBZ, a large portion of the liquid traveled rapidly into the CZ due to its high conductivity. The CZ/UWBZ interface is at approximately 161 feet below ground surface,

thus UWBZ injection well screens should be at 181 feet and deeper. However, Table 4-1 shows that UWBZ injection well screens will start at 170 feet bgs.

13. The Final RD/RAWP, dated May 2014, in Table 3-6, shows a total extraction rate of 160 gpm, with a ratio of extraction to injection of 1.4. Addendum #2 states that the extraction rate is expected to be approximately 100 gpm, however, no injection rate is given. What is the reason for the decrease in extraction rate? Will the ratio of extraction to injection be maintained at 1.4?

14. The Final RD/RAWP, dated May 2014, states in Table 3-8 that one of the advantages of sulfate as a terminal electron acceptor is, "The utilization factor for sulfate and JP-4 is estimated at approximately 5 pounds of sulfate per pound of JP-4 degraded. Therefore, based on the estimated volume of LNAPL to be treated outside the TTZ, approximately 7,600 tons of sulfate are required." What is the basis for the utilization factor for sulfate and JP-4 given here? What is the basis for reducing the planned sulfate usage to 838 tons, as given in the Addendum?

15. The Final RD/RAWP, dated May 2014, states in Table 3-8 that one of the disadvantages of sulfate as a terminal electron acceptor is, "sulfate reduction of petroleum hydrocarbons can produce hydrogen sulfide gas. However, the relatively deep vadose zone and site hydrogeology along with careful attention to dosing mass and distribution can limit the potential for hydrogen sulfide gas accumulation at unsafe levels." How will the dosing mass and distribution be monitored and controlled to limit the potential for hydrogen sulfide gas to accumulate at unsafe levels? A proactive attempt should be made to estimate the dosing that would produce unsafe levels of hydrogen sulfide to avoid this scenario; this contingency should also be addressed in the health and safety plan

16. The Final RD/RAWP, dated May 2014, in Table 3-8, states that sulfate is a secondary groundwater contaminant. Figures E-1 and E-3 show that some of the injected sulfate is expected to migrate downgradient from the existing plume. What are the expected downgradient concentrations of sulfate, and do these concentrations exceed the standards for sulfate?

17. The Final RD/RAWP, dated May 2014, on page 3-17, states that the required mass of sulfate could be added to the CZ, UWBZ, and LSZ over a 30-day period of recirculation, utilizing a stock solution at 20 percent of the solubility limit of sulfate. Once the sulfate is added, the "system recirculation would be operated to distribute the sulfate throughout the treatment area. Sulfate distribution in the UWBZ and LSZ would be accomplished by recirculating the system for approximately 1.5 to 3 years." The Addendum #2 states that the sulfate will be injected at a concentration near its solubility limit, but does not discuss the length of time required to inject it.

18. The Final RD/RAWP, dated May 2014, on page 3-18, states that the overall system will be hydraulically designed to capture and maintain the plume geometry. However, the modeled TEA injection pathlines shown in Figure E-1 for the CZ and E-3 for the LSZ do not show that the plume – or the injected sulfate – will be captured by the extraction well system.

19. The Final RD/RAWP, dated May 2014, included recirculation of the injected TEA. Addendum #2 includes recirculation only 'if necessary' (Section 3.2.3). What is the basis for this

change in approach? What performance monitoring data would indicate that a recirculation system is necessary?

20. The Final RD/RAWP, dated May 2014, on page 3-18 states that hydraulic capture will be evaluated during EBR. However, monitoring for hydraulic capture does not appear to be included in the Addendum in Table 5-1.

SPECIFIC COMMENTS – Pertaining to Draft RD/RAWP Addendum #2 (Nov. 2015)

21. Page 2-2 Lines 257- 259 express the expectation and assumption that remaining mobile LNAPL will be much less the residual LNAPL. This statement underscores the necessity to continue to operate SEE to maximize removal of mobile LNAPL. In the 2012 RODA EBR was intended to be a polishing step, not a primary removal mechanism.

22. Addendum #2 on page 2-4 states that the 18,000 to 25,000 pounds of BTEX+N in the LPZ will not be targeted directly with EBR. How will this affect the ability of this remediation to achieve the remedial goals?

23. Section 2.1 of Addendum #2 states, "it is expected that mobile LNAPL will be removed via mechanical extraction from wells during both the remainder of SEE operations and EBR system implementation." NAPL extraction under ambient conditions is not efficient, all mobile NAPL will not generally migrate to extraction wells. Where NAPL extraction has been used as a remedial technology, much closer well spacing is generally used, on the order of 20 feet. It should not be assumed that all mobile NAPL will be mechanically removed by the system described in this Addendum15. Page 2-4, Table 2-2, and Page 2-9 table 2-4 need to be updated with the most current SEE operations data.

24. Section 2.1 states that the PDI LNAPL total residual volume estimates ranged from 5,600,000 to 10,400,000 pounds. Table 2-6 and 2-7 show 1,914,704 to 2,012,020 pounds of LNAPL removed during SEE treatment, with 58,519 to 86,966 pounds of that being benzene, toluene, ethylbenzene, xylene, and naphthalene (BTEX+N). According to Table 2-5, on average 9.85 percent of the LNAPL is BTEX+N, thus the remaining LNAPL, based on the BTEX+N estimates given in these tables, would be 594,101 to 882,904 pounds. This is not in agreement with remaining mass calculations based on the residual estimates given in Section 2.1 based on the PDI, and the removal estimates provided in Tables 2-6 and 2-7, which would lead to a remaining LNAPL mass of 3,588,000 to 8,485,296 pounds. The BTEX+N remaining mass given in Tables 2-6 and 2-7 are also not in agreement with the estimates provided in Section 2.3 of up to 987,000 pounds of BTEX+N.

25. Page 2-10 Line 396 specifies the remedial goal to achieve MNA criteria by 2032, within 16 years from now, not 20 years.

26. Page 2-11 Table 2-5 Why was PIANO analysis was only initiated in January 2015 while steam was already underway? Initial composition of LNAPL needs to be representative of initial conditions of LNAPL at the site to avoid introducing error into assumptions in determining the mass remaining. Determining the mass remaining will be critical in evaluating whether or not the EBR phase will be successful in meeting MNA goals by 2016.

27. Pages 3-1 and 3-2, TEA Evaluation: This section implies that oxygen has a faster degradation rate than sulfate, however, sulfate was selected for EBR applications. Please elaborate on the impact of this decision upon the model and capability to meet MNA goals within 16 years.

28. Page 3-3. Line 650: Please clarify the decision criteria for termination of extraction post steam injection ("at least 4 weeks").

29. Page 3-3 line 655: What factors will determine whether sulfate can be injected "prior to or during post steam extraction phase"? Can sulfate be injected while steam injection is occurring, during post steam extraction phase, or sometime thereafter? We agree that injection of sulfate while the steam bubble is collapsing could be very useful to enhance distribution of sulfate through the system, however the timing must be planned and coordinated to take advantage of this. This is also a reason why steam injection should continue until you are prepared to begin EBR injections. Please revise this section to include specific decision criteria for scheduling the transition to EBR.

30. Section 3.2.2 states that "Additional well locations may be added based on information collected in the field". Please describe what information is to be collected in the field, and what information would lead to adding well locations.

31. Page 3-3 line 663: The 3D groundwater model assumptions include operations of wells that have yet to be constructed, developed and sampled. The model will need to be calibrated once the new wells are in place and data has been collected.

32. Page 3-3 Lines 672: Sentence is confusing: Figure 3-1 is only showing well locations, not 3D Groundwater Model. Also the combined mixed use of past and present tenses suggest the work plan is not ready to implement.

33. Addendum #2 on page 3-5 states that. "The calculations for the distribution of TEA amongst injection wells used the lower bound of the estimated remaining mass at ST012". What is the planned dosage of sulfate per pound of JP-4 to be degraded? Does this approach, of using the lower bound of the mass estimate to calculate the dosage when there is so much uncertainty in the amount of mass present, set this process up for failure?

34. Page 3-6. a) Please clarify why the sodium sulfate amendment proposed to be applied contains arsenic, and discuss other options for finding sodium sulfate that does not contain arsenic. b) What is the plan for mitigation if arsenic in groundwater exceeds 10 μg/l? c) The presence of arsenic in the amendment has the potential to limit the amount of sulfate that can

ultimately be injected. This is another reason to remove as much mass as possible via the SEE system if the amount of sulfate that can be injected could be limited. d) If the presence of arsenic in the amendment has the potential to exacerbate groundwater conditions the geochemical fate and transport should be modeled.

35. Page 5-5 Line 987: Can installation of EBR wells outside of TTZ be completed, developed and sampled while steam injection continues? Samples need to be collected to verify mass estimates, calibrate the 3D GW model for the final RAWP.

36. Section 5.0 states that process monitoring will include microbial activity. However, microbial activity sampling is not included in Table 5-1.

37. Table 5-1 of the Addendum lists wells C02, U02, W12, U37, RB-3A, W24, U38, W38, U12 as monitoring wells for monitoring the performance of EBR. The locations of these wells are not shown on Figure 3-1. The monitoring wells that are shown in Figure 3-1 are not consistent with Table 5-1. To evaluate the adequacy of the proposed monitoring well network, a figure should be provided showing the extent of contamination in each of the three zones, the injection and extraction wells, the modeled TEA injection pathlines, and the proposed monitoring wells. Monitoring wells should be within and/or just downgradient of the LNAPL areas that are to be treated using EBR. Table 5-1 and this figure must be consistent.

38. Page 6-1 Line 1111: section 4.3.3 is missing from the text. Please clarify the decision criteria for transitioning from active EBR to monitoring phase.

39. According to Section 6.1 of the Addendum, the purpose of EBR is "to achieve conditions . . .. at ST012 such that contaminants will degrade by natural attenuation to achieve the cleanup levels within the projected remedial timeframe (i.e., about 20 years) after completion of EBR." However the Addendum #2 has not demonstrated that the planned approach to implementing EBR it is capable of achieving this goal. This is critical to avoid potential remedy failure.

40. Figure 7: The project schedule incorporates dates already in the past and needs to be updated, incorporating the timing of interdependent critical decision elements. (See comments 29 and 35)

Specific Comments on Addendum #2 Appendices:

41. Appendix C EBR Field Test; page 1-1 line 152 specifies the purpose of EBR is to address dissolved phase contaminants inside the TTZ; which implies that LNAPL within the TTZ will be removed via SEE. This underscores the need to operate SEE to completion, until 500 ppb criteria for EBR transition has been met.

42. Appendix C EBR Field Test page 1-1 lines 157 -158: Please describe in detail the "significant assumptions" referenced in regards to anaerobic approach to EBR and address how any uncertainties will be managed.

43. Figures E-1, E-2, and E-3 of Appendix E show the modeled TEA injection pathlines in the CZ, UWBZ, and LSZ, respectively. The projected pathlines appear to show that the entire LNAPL extent (outside of the thermal treatment zone) in each of these zones will not receive TEA. It is not clear how the proposed distribution of injection and extraction wells can be considered adequate based on the modeled LNAPL extents.

REFERENCES

USEPA. 1999. Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites. OSWER Directive 9200.4-17P. April 21, 1999. Office of Solid Waste and Emergency Response.

USEPA. 2009. EPA Quality System.
http://www.epa.gov/quality/qa_docs.html

If you have any questions regarding these comments, please contact me at (415) 972-3150.

Sincerely,

Carolyn d'Almeida

Carolyn d'Almeida
Remedial Project Manager

cc: Terie Glaspey, AFCEC/CIBW
Wayne Miller, ADEQ

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