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1 July 2019

Ms. Carolyn d'Almeida
U.S. EPA Region IX
75 Hawthorne Street
San Francisco, CA 94105

Subject: Submission of AF responses to EPA comments for " ST012 Remedial Action Field Variance Memorandum 6 – Pilot Study Supplemental Data and Evaluation Metrics and ST012 Remedial Action Field Variance Memorandum 7 – Pilot Study Implementation – Injection-Extraction Modifications" (19-R09-001)

The Air Force is pleased to submit the attached responses to EPA comments for "ST012 Remedial Action Field Variance Memorandum 6 – Pilot Study Supplemental Data and Evaluation Metrics and ST012 Remedial Action Field Variance Memorandum 7 – Pilot Study Implementation – Injection-Extraction Modifications" in a letter dated 12 December 2018.

Please contact me at (315) 356-0810 or catherine.jerrard@us.af.mil if you have any questions regarding the responses.

Sincerely,

CATHERINE JERRARD, PE
BRAC Environmental Coordinator

Attachment:

AF response to EPA comments for " ST012 Remedial Action Field Variance Memorandum 6 – Pilot Study Supplemental Data and Evaluation Metrics and ST012 Remedial Action Field Variance Memorandum 7 – Pilot Study Implementation – Injection-Extraction Modifications" (19-R09-001)

c:

Addressee (1 and 1 CD)
ADEQ - Wayne Miller (2 and 2 CD)
Administrative Record – AFCEC/CIBP-BRAC AR (1 and 1 CD)
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File

AF Response to: EPA Comment Letter (12-12-2018) on Field Variance Memorandum 6 and 7; ST012 EBR Pilot Study Implementation Work Plan; Injection-Extraction Modifications

EPA has reviewed ST012 Remedial Action Field Variance Memorandum 6 (FV6) – Pilot Study Supplemental Data and Evaluation Metrics and ST012 Remedial Action Field Variance Memorandum 7 (FV7) – Pilot Study Implementation – Injection-Extraction Modifications. The purpose of these field variances is to address comments received from Arizona Dept of Environmental Quality (ADEQ) and identify modifications to the planned sulfate injection and extraction locations, respectively. We note continuing deficiencies as previously identified in the Addendum #2 and the Pilot Scale Work Plans. In addition to these documents, the ST012 Field Parameter Summary Table and the October 16, 2018 BCT meeting slides were also reviewed. Please note the comments below as on-going outstanding concerns with the Pilot Study:

AF Response: Prior to the informal dispute, there were unresolved comments and differences of technical interpretation regarding the effectiveness of EBR. Resolution of the dispute was to conduct a Pilot Study using the same methods and means identified in the previous EBR Work Plan. The implementation of the Pilot Study including adjustments based on field data will provide valuable information on the effectiveness of EBR. It is likely that additional phases of EBR will be required for certain areas of the site.

General Comments

1. FV6, Attachment 1, Response to 19 June 2018 ADEQ Request for Supplemental Data and Evaluation Metrics, comment #6, states, "The decision matrix identifies benzene trends and estimated half-lives as the primary measurement of trends that will support acceptable progress." The most likely source for the data to track benzene concentrations over time appears to be the listing in Table 5-1 of FV6 that states that 20 extraction wells will be sampled quarterly for VOCs. However, EPA has repeatedly made the comment on the enhanced bioremediation (EBR) Work Plan that monitoring wells are needed in between the injection and extraction wells for tracking benzene concentrations over time as data from the extraction wells is not adequate for this purpose. The extraction wells will be pulling in water from a larger area than is impacted by the sulfate, and samples from these wells will not represent what is occurring in the sulfate distribution zone.

   AF Response: AF response to this comment has previously been provided. Additional well installations between injection and extraction wells are not required to evaluate effectiveness. Locations of additional wells at other areas of the site are being discussed by the AF, EPA, and ADEQ.

   According to Figures 3-2, 3-3, and 3-4 of FV7, throughout the three vertical zones where benzene concentrations in groundwater exceeds the maximum contaminant level (MCL), the Air Force is planning on 15 primary target areas of sulfate distribution by injection-extraction. Only one of the injection – extraction well pairs has a potentially properly-located monitoring well identified within the anticipated area of sulfate distribution (injection – extraction pair LSZ08 – LSZ51, where LSZ27 is located with the area of expected sulfate distribution and is identified as a groundwater monitoring well). Existing wells UWBZ17 and LSZ35 are located such that they could be useful

for monitoring the effects of sulfate injection at wells UWBZ10 and UWBZ28, and LSZ48, respectively, however, they are not identified on Figures 3-3 and 3-4 as monitoring wells. Data from monitoring wells located between the injection and extraction wells can also be compromised by displacement of benzene-contaminated groundwater during the injection/extraction process, but it will be more representative of the conditions within the sulfate distribution area than data from the extraction wells.

AF Response: UWBZ17 and LSZ35 will be evaluated for addition to the monitoring plan.

2. FV6, Response to 19 June 2018 ADEQ Request for Supplemental Data and Evaluation Metrics, comment #6, states, "The decision matrix identifies benzene trends and estimated half- lives as the primary measurement of trends that will support acceptable progress." Tracking of benzene concentrations over time must also account for the benzene being extracted at each of the extraction wells.

   AF Response: Extraction occurs during injection periods to help distribute sulfate; sulfate and benzene will be measured in extraction wells. Extraction wells will be shut down once sulfate is injected and distributed. The mass of benzene removed during extraction will be tracked but is expected to be a minor contribution compared to the benzene mass removed via EBR.

3. Monitoring wells on Figures 3-2, 3-3, and 3-4 of FV7 (except for well LSZ27) are not located within primary, secondary, or tertiary target areas for sulfate distribution, and thus data from these wells will not indicate what is occurring within the sulfate distribution areas.

   AF Response: AF response to this comment has previously been provided. Additional well installations between injection and extraction wells are not required to evaluate effectiveness. Locations of additional wells at other areas of the site are being discussed by the AF, EPA, and ADEQ. Injections and monitoring will be performed in accordance with Final Pilot Study Work Plan and/or subsequent field variance(s) based on site data obtained during Phase 1 injections.

4. The table included in FV7 states in several places, "Mass injection reduced based on site data and regulator concern with downgradient injections." It was not EPA's intention to limit sulfate injections at the downgradient side of the site where the injections make sense and may aid in enhanced bioremediation of the remaining contaminants. Rather, the intent was to hydraulically contain the injected sulfate as well as the hydrocarbon plume by downgradient extraction and prevent off site migration of contaminants. Downgradient injections may proceed if agreement is reached on a robust plan for active hydraulic containment to prevent off site migration.

   AF Response: Active hydraulic containment is not a component of the pilot study work plan nor was it a component of the approved RD/RA work plan. Downgradient injections will be performed in accordance with Final Pilot Study work plan and/or subsequent field variance(s) based on site data obtained during upgradient Phase 1 injections.

Specific Comments

5. FV6, Attachment 1, response to ADEQ comment #4, states, "Baseline qPCR assessment using BioTraps has been provided including two wells in each zone. As previously discussed in BCT conference calls, sampling of each monitoring well is not necessary." However, only two wells in each zone were sampled, which is a very small portion of the site. Also, the two wells sampled in the CZ were outside of the benzene plume. The sulfate and nitrate data (slides from the October 16, 2018 BCT meeting) show that the geochemical conditions throughout the subsurface are very heterogeneous. Additional microbial data is likely to be very informative.

   AF Response: The work plan includes additional microbial data collected from the same monitoring wells as the baseline sampling. As monitoring data comes in and is assessed, the collection of additional microbial data will be evaluated including evaluation of alternate or additional CZ locations.

6. FV6, response to comment #9, states, "Additional characterization data collected over the past two years demonstrate that the existing well network is adequate to evaluate changes at the site during pilot study implementation." However, the additional characterization borings and well that were installed were at the perimeter of the benzene plume and are not located in between planned injection and extraction wells. It is unclear how AF plans to monitor the effectiveness of sulfate addition for enhancing microbial activity.

   AF Response: AF response to this comment has previously been provided. Additional well installations between injection and extraction wells are not required to evaluate effectiveness. Locations of additional wells at other areas of the site are being discussed by the AF, EPA, and ADEQ. Injections and monitoring will be performed in accordance with Final Pilot Study work plan and/or subsequent field variance(s) based on site data obtained during Phase 1 injections.

7. FV6, Attachment 3, page 4-10 states, "Nutrient limitation will be assessed indirectly as diminished sulfate-reducing activity." This creates a reactionary, rather than proactive, approach to enhancing bioremediation that will likely cause very significant delays in creating the necessary conditions for microbial growth, and thereby, benzene consumption. Also, it will be very difficult to measure "diminished sulfate reducing activity" when such activity varies widely across the site.

   AF Response: Inorganic geochemical profiles have been developed for the site for essential macronutrients. Selected inorganic nutrients will be tracked (see discussion in Section 4.2.3 of the Pilot Study Work Plan) in addition to sulfate reducing activity and benzene concentrations to assess EBR metabolic activity. The approach outlined in FV6 is proactive and will not cause significant delays in creating the necessary conditions for enhanced microbial growth.

8. Figure 3-2 of FV7 shows that sulfate will be injected into CZ22 and extracted at CZ18. Judging from the benzene contours on this figure, approximately half of the sulfate distribution zone from this injection well will be into groundwater that is not contaminated with benzene. It appears that a better distribution of sulfate into areas that require remediation would be achieved by injecting into CZ18 and extracting at CZ15 or CZ04. With this injection/extraction well pairing, more of the high benzene concentration area within the CZ will receive sulfate.

AF Response: Sulfate injected between CZ22 and CZ18 will continue to migrate downgradient after extraction ceases. Additional injection at CZ18 will be based on monitoring data collected following sulfate injection and extraction. Extraction locations could be modified for future injections based on site observations following completed injections.

9. Figure 3-3 of FV7 shows that the well UWBZ30 had the highest benzene concentrations in the UWBZ during the re-baseline sampling. The existing well configuration is not ideal to address this area. The extent of this high concentration area downgradient (to the east) has not been determined, thus, it is not clear that all of the high concentration area will receive sulfate, based on the currently proposed injection at UWBZ23 with extraction at UWBZ30. Due to the downgradient location of this well, sulfate injected to treat this area should be extracted downgradient of the high benzene concentration area to reduce/eliminate the loss of sulfate and benzene from the treatment area. Additional wells may be needed to improve sulfate distribution.

   AF Response: The potential for additional future phases of sulfate injection and potential additional well installation has been acknowledged in prior correspondence by the AF and discussions are ongoing.

10. Figure 3-3 of FV7 shows that well UWBZ35 is to be used as injection well, paired with extraction at UWBZ27. According to slide 28 from the October 16, 2018 BCT meeting, sulfate concentrations in these wells is already in the optimum range for sulfate reduction. Thus, injecting more sulfate into this area is not likely to enhance benzene degradation.

    AF Response: The optimum range for maximizing the kinetics of sulfate degradation has been previously presented and is provided in the approved RD/RA WP and the Pilot Study Implementation WP. The optimum range is several thousand mg/L of sulfate not 250 to 350 mg/L (which is in the range of site background concentrations).The increased sulfate will enhance sulfate degradation rates and benefit locations downgradient of UWBZ27.

Comments on the ST012 Field Parameter Summary Table

11. A ST012 Field Parameter Summary Table has been made available to the Agencies at the request of Arizona Department of Environmental Quality (ADEQ). This table shows that significant problems have been encountered with the collection of field parameters. The Notes column documents many instances of "DO-ORP disparity" and "DO>Solubility" or "YSI issues with DO". Temperatures in the wells appear to vary randomly. These geochemical parameters are included in the Decision Matrix as part of the critical data for determining if the subsurface conditions are optimal for biological degradation, however, it is not clear that this data is of sufficient quality to determine the geochemical conditions of the subsurface.

    AF Response: In general, DO data quality collected from the subsurface is variable and consistently reliable DO results may be difficult to achieve at the site. DO and temperature data are included in the Decision Matrix, however, the data will be qualitative and will not be used solely in the determination of optimal subsurface conditions. There are a significant number of other geochemical parameters and chemical parameters presented in the Decision Matrix that will be available and considered in the decision making process.

12. If the dissolved oxygen (DO) data within the ST012 Field Parameter Summary Table is accurate, all of the wells within the benzene plume for which field parameter data is provided have significant DO. This includes wells UWBZ34, LSZ29, LSZ44, LSZ49, LSZ50, W11, W36, and W37. Since the re-baseline microbial data did not identify significant aerobic petroleum hydrocarbon degrading populations, significant DO in these wells is perhaps expected. Sulfate injection into these wells is not likely to enhance biodegradation.

    AF Response: See previous response to Comment 11. The DO data is qualitative data and noted as such in the table. Multiple geochemical and chemical parameters will be evaluated and, in this case, DO values are not consistent with observed reductions of nitrate and sulfate from background concentrations in areas of higher benzene concentrations.

Comments on October 16, 2018 BCT Slides

13. Slide 17 is entitled, "Site ST012 Summary of Data Supporting Bioactivity". The first bullet states, "Stability of the benzene plume". However, the benzene plume has been shown to not be stable in the CZ, as was demonstrated by benzene concentrations in well CZ23 in June 2018, which not only exceeded all prior measured concentrations in this well, but also exceeds the MCL for benzene, indicating an increase in the benzene dissolved phase plume. Had extraction not been initiated in 2018, the benzene plume would be continuing to expand in this zone. It is likely that the benzene plume in the UWBZ and LSZ is also migrating, but has not yet reached the perimeter wells, due to the distance between the known extent of the plume and the location of the perimeter wells.

    AF Response: The plume was stable for a period of over two years following SEE during which no EBR activity could be implemented as planned. Pumping was initiated at CZ07 when the exceedance was noted and is continuing. Concentrations at CZ23 are being closely monitored. Additional actions will be taken if the extraction at CZ07 is not sufficient. Additionally, site monitoring provides evidence that the magnitude of benzene upgradient of the area is diminishing. Finally, long-term benzene observations in the UWBZ and LSZ suggest the plume expansion is limited. Slide 19 showing the benzene plume over many years illustrates that the amount of expansion, if occurring, is not extensive.

    The second bullet states, "Depletion of TEAs and generation of byproducts". However, it is noted that significant TEA remains in the benzene plume, including sulfate, and, if the field parameter data is correct, DO.

    AF Response: The point of the slide is not that TEA is present, but that if TEA is present, including sulfate, TEAs are lower in areas of higher benzene and higher in areas of lower benzene indicating that higher benzene concentration areas are utilizing the TEA in the process of degrading the benzene. See slides 23-32.

    The third bullet states, "Inverse correlations between nitrate-benzene and sulfate-benzene concentrations". However, the figures on slide 33 do not show a strong correlation between benzene concentrations and either nitrate or sulfate concentrations. The low R_2 values (0.2087 and 0.1723, respectively) indicate little to no correlation in the data.

AF Response: R^2 is not a measure of correlation. R^2 is a measure of how reliable the trendline is at predicting actual results. A low R^2 indicates that an individual result can deviate from the trendline. P value is used for correlation which evaluates if there is an overall relationship between the two variables (i.e., one variable influences the other). P values evaluate the likelihood that an apparent relationship between the two variables could happen randomly. A P value of 0.05 indicates there is a 5% chance that the observed relationship could happen randomly and a 95% chance that the two variables are truly correlated. The P values listed on slide 33 are much lower indicating it is exceedingly unlikely that the apparent relationship between the variables (nitrate-benzene or sulfate-benzene) could happen randomly.

The fourth bullet states, "TEA flux at the site". It is not clear what this statement means.

AF Response: It means the flux of TEA mass migrating into the contaminated zone of the site from upgradient. See slides 34-36.

The fifth bullet states, "Demonstration of enhancement during EBR push-pull test". However, no enhancement of sulfate degradation was demonstrated by the 2014 push-pull test. The data obtained was at best, conflicting. The only thing the test clearly demonstrated was biofouling of the wells.

AF Response: During the push-pull text SRB populations increased 1-2 orders of magnitude and sulfate utilization rates were favorable– see slide 37.

14. Slide 18, second bullet, states, "Groundwater velocities suggest a much larger downgradient plume if attenuation including biological mechanisms was not occurring". I agree that this is likely true. However, there is no data to show that benzene degradation within the plume is occurring via sulfate reduction. Under sulfate degrading conditions, toluene, ethylbenzene, and xylenes are known to degrade more readily than benzene. Thus, where sulfate has been depleted, it may be due to degradation of these compounds that are also present within the plume. Downgradient degradation of benzene may be aerobic rather than anaerobic.

    AF Response: The intent of this slide is to establish the benzene plume is generally stable without significant indication of downgradient migration. This is a finding that supports proceeding with the pilot study due to the apparent site limiting factors that are controlling migration regardless of the type of biological mechanism. At downgradient locations outside of the active pilot study area, aerobic biodegradation may be occurring and, if so, would continue to occur during the pilot study.

15. As shown on slide 31, the June 2018 re-baseline data showed a sulfate concentration of 990 mg/l at LSZ10. This concentration is approximately three times the background sulfate concentration. One possible explanation for this significantly higher result is that this is part of a slug of sulfate that was injected in well W-11 as part of the EBR Field Test in July 2014. If this is the case, then this would indicate that significant sulfate reduction has not occurred in this portion of the site in the past four years. This is consistent with the fact that the re-baseline microbial data found that the total sulfate-reducing bacterial population in this well was below the detection limit of $2.5 \times 10_2$ cells per bead.

AF Response: Four years includes SEE operation when LSZ10 was a steam injection well. TPH and benzene concentration data are low at LSZ10 which is the likely cause for high sulfate and low SRB populations.