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July 3, 2018

Ms. Dana Cannon
West of 4th Project Coordinator
Aspect Consulting
401 2nd Ave S, Suite 201
Seattle, WA 98104

Re: **West of 4th Site,**
Agreed Order #DE 10402
Site Unit 1, In Situ Metals Immobilization Pilot Study Field Investigation Work Plan

Dear Ms. Cannon:

On June 15, 2018, the Washington State Department of Ecology (Ecology) received an Emailed copy of the draft Site Unit 1 *In Situ Metals Immobilization Pilot Study Field Investigation Work Plan.* The draft Field Investigation Work Plan (FIWP) was submitted by the West of 4th PLPs in accordance with Agreed Order (AO) 10402, amended on November 21, 2017.

Thank you for submitting the document by its due date. Ecology agrees with many of the proposals contained in the draft FIWP. However, we have enclosed a number of comments that should be addressed prior to document approval.

Please submit a revised FIWP that satisfactorily addresses today's comments within 30 (thirty) days. If you have any questions, or would like to schedule a meeting or conference call to discuss Ecology's comments, please contact me at (425) 649-4449 or ejon461@ecy.wa.gov.

Sincerely,

EJones

Ed Jones
Environmental Engineer
Hazardous Waste and Toxics Reduction Program

Enclosure: Ecology's Comments Site Unit 1, Draft In Situ Metals Immobilization Pilot Study Field Investigation Work Plan

By certified mail: 9171 9690 0935 0169 7337 30

cc: William Joyce, SJZ
William Carroll, PCE
Janet Knox, PGG
Jeff Kaspar/Peter Jewett, Farallon
Ronald Taylor, CI
Donald Verfurth, G&R
Marlys Palumbo, VNF
William Beck, Stericycle/PSC
Central Files
PLPs' W4 repository

ecc: Tong Li, GWS
Peter Hapke, ALG
Nels Johnson, AAG
Patty Foley/Sherell Ehlers, GTCC

Site Unit 1
Draft In Situ Metals Immobilization Pilot Study Field Investigation Work Plan
Ecology Comments

GENERAL COMMENTS

As discussed in several comments below, the draft Field Investigation Work Plan (FIWP) does not contain a Sampling and Analysis Plan (SAP) or Quality Assurance Project Plan (QAPP). Nor does it contain Standard Operating Procedures (SOPs) for the injection and monitoring fieldwork it proposes. As such, the draft document could not be approved – even conditionally – by Ecology.

SPECIFIC COMMENTS

1. Page 2, Appendix D, and Appendix H. At the bottom of page 2 the FIWP states that appendices include a SAP/QAPP and example operational logs. These appendices were not included in Ecology's copy of the draft FIWP; it is unclear why.

2. Page 11, Section 4.1.3.3, and Table 9. In the second bullet, the soil density should be specified as a (wet or dry) bulk density and the units should be corrected (to kg/l or g/ml). Also, it appears that the value of 2,875 µL was used to derive the required reagent volume of 69 ml. The text and Table 9 should explain how this value was calculated.

3. Page 11, Section 4.1.3.3. The last sentence of this section concludes by proposing a 12% by volume target "reagent application." Later (on page 13), however, the PLPs propose 15% by volume. It is not clear why 12% is described as "targeted" in Section 4.1.3.3 if 15% is the desired volumetric percentage of reagent (to groundwater) in the treatment zone. Please also see Comment #7 below.

4. Page 12, Section 4.2. In this section of the FIWP the PLPs describe the pilot study objectives used to prepare the Design and monitoring proposals in Section 5. Ecology agrees with these objectives, but additional clarity would improve Objectives 2 and 4. Both of these Objectives refer to achieving delivery and distribution of reagent, using reagent "breakthrough" and pH measurements (compared to target pH values) to evaluate delivery/distribution within the expected treatment zone (ROI). However, in this section, or later in Section 5, the FIWP should additionally describe <u>*how*</u> the study results will be used to define the effective treatment radius. For example, will the treatment zone be defined as the WT zone area where a groundwater pH > X is maintained over Y days? Or will the PLPs use other measurements (e.g., alkalinity, HCO_3-, Na+, and/or certain %-reductions in nickel levels over a given timeframe) to approximate the likely *effective* treatment zone?

5. Pages 13 through 15, Section 5. Preliminary to performing injections, and on the days of injection themselves, the PLPs should notify neighboring property owners and

businesses. This outreach effort does not appear to be discussed in the draft FIWP. The revised document should therefore include:

- a proposed schedule for these notifications,
- identification of the property owners and businesses that will be notified, and
- a summary of the information that will be conveyed and how it will be communicated (flyers, verbally, etc.).

6. Page 13, Section 5.1.1. Since the December 2017 Work Plan proposed a 10' ROI, the FIWP should explain why a 12' ROI is now being targeted. That is, what was learned from baseline sampling and the bench-scale testing that suggests 12' would be the better target ROI? Or, is the 12' ROI simply being used to calculate a conservative injection volume so that the amount of injected reagent is more likely to actually *achieve* a ROI of 10 feet?

7. Page 13, Section 5.1.1. The second paragraph of this section states that 10,200 gallons of reagent will be injected, and that this volume corresponds to "15% of the total aquifer in the ROI, by volume…". 15% has apparently been chosen because this is the value the PLPs assume to be the WT zone's mobile porosity. However, as the text notes, a 12% (by volume) reagent dose was determined earlier in the FIWP, and appears to have been based in part on a total porosity assumption of 0.35. As noted in Comment #3, the FIWP should more clearly describe: how the volume of reagent needed for 200 ml of groundwater (i.e. 69 ml) was calculated from the titration batch test results; what the relationship is between the 12% and 15%-by-volume values; and, why the selected reagent dose should be a volume of 1M sodium bicarbonate solution that corresponds to 15% (the mobile porosity) of the total aquifer volume to be treated.[1]

8. Page 13, Section 5.1.2. If the sodium bicarbonate solution being delivered to the site requires any special handling care – during transportation or during storage on the days of injection – this information should be included in the revised FIWP. Are there, for example, limitations to how much agitation can be applied to the solution once delivered, or capping requirements for the solution's storage tank?

9. Page 13, Section 5.1.3, and Figure 10. Based on the description of the injection system and the PID in Figure 10, it appears that the PLPs do not intend to monitor injection pressures. In addition to recording total flow (with the proposed flow totalizer), Ecology believes that injected reagent pressures and (instantaneous) flowrates should be monitored during both injections. Pressure measurements could be obtained by installing a gauge at the well head below the air release valve, or downstream of the flow meter/totalizer.[2] Please also see Comment #14 below.

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[1]The 12%-by-volume value proposed in Section 4.1.3.3 was seemingly derived from bench-scale titration curve data, and scaling and safety factors with a total porosity assumption of 0.35. Table 9 shows that for 200 ml groundwater, 69 ml of 1M reagent solution is needed for 571 ml of aquifer volume, which results in 12%. The 15%-by-volume value, on the other hand, appears to be simply the ratio of the porewater volume (available for movement) to the total volume of a 10'-long cylindrical section of the aquifer, with a 24' diameter centered on the IW.

[2] We assume the proposed flow totalizer is also capable of serving as a flowmeter.

10. Page 14, Section 5.1.4. The Design of the study's reagent-injection action is premised on radial subsurface distribution. Ecology agrees with this premise, but subsurface conditions such as lithologic heterogeneities and preferential pathways may result in a non-ideal distribution pattern. The revised FIWP should discuss how the PLPs will infer the distribution patterns at IW-1 and IW-2, and explain how the proposed operational and short-term performance monitoring will be capable of quickly alerting the fieldteam to any interception of the reagent by preferential pathways, such as utility lines or the bedding those lines are placed in, and/or surfacing/daylighting of the reagent. Even though the PLPs intend to inject under low pressures, these outcomes are possible. Figure 9 should also be revised to indicate the locations of all known subsurface utility, AS/SVE, and other buried lines in the vicinity of the two injection points.

11. Page 14, Section 5.1.4. The December 2017 pilot study Work Plan discussed the possibility of a second, follow-up injection event. It stated that the conditions triggering a second injection would be identified in the FIWP, and a description of how this second event would be implemented and monitored would also be included. The draft FIWP, however, does not appear to contain this discussion. The revised document should at least describe the conditions (monitoring results) that would clearly trigger the need for a second injection event within the first several months following the initial injections.

12. Pages 14 and 15, Section 5.1.5. The FIWP should explain <u>how</u> the PLPs intend to use dissolved Na+ measurements from groundwater samples collected at PSW-8 (and other monitoring wells) to: a) define reagent "breakthrough," b) determine full reagent "washout," and c) estimate groundwater flowrate within the project area. The reference to Figure <u>10</u> in the second-to-last paragraph of 5.1.5 should also be changed to Figure <u>9</u>.

13. Page 15, Section 5.2. As noted above in Comment #1, Appendix H has not been included in the draft FIWP. So no "example operational monitoring logs" are contained in the document.

14. Page 15, Section 5.2.1. As discussed in Comment #9, Ecology prefers that injection pressures be monitored and recorded even if they are minimal. Pressure and flow rate should be constantly monitored, and recorded at least hourly.

15. Page 16, Section 5.2.1. In the third bullet regarding DR monitoring, PSW-8 is not mentioned. This well should be monitored for field TDS/pH measurements during the injection at IW-2. Since it is located farther downgradient than other DR wells, however, it can be monitored less frequently (e.g., every 2 hours, instead of every 50 minutes).

16. Page 16, Section 5.2.1. As noted above in Comment #1, Appendix D has not been included in the draft FIWP. So no SAP and QAPP with detailed "operational monitoring" activities/procedures are contained in the document. The revised FIWP should contain such procedures – including proposals for how the DR wells will be purged prior to field measurements and groundwater sample collection.

17. Pages 17 and 18, Sections 5.2.2 and 6.2, and Tables 11 and 12. As noted above in Comment #1, Appendix D, the SAP and supplemental QAPP with detailed "performance monitoring" activities/procedures and "specific QA/QC elements unique to the pilot study," is not contained in the document. When including these materials in the revised FIWP the PLPs should additionally:

    - Explain why alkalinity will be measured per EPA Method 310.1 instead of SM2320B, and consider whether there is value in quantifying "bicarbonate alkalinity" instead of, or in addition to, (total) "alkalinity."
    - Propose Na+ analyses ("analyte #4") for the groundwater samples collected at MW-1 and MW-8.
    - Consider adding a decision-point into the monitoring schedule at Month 1 or 3. Depending on the first month's monitoring results from measurements taken, or samples collected, at MW-1 and PSW-6, the PLPs should consider adding measurements/sampling at wells MW-5 and -7 during the next round of performance monitoring.

18. Page 18, Section 6.2, and Appendix B. The FIWP states that the traffic control plan in Appendix B will be "revisited and updated." Ecology agrees. If the plan will not be finalized until the FIWP has been approved, it should be submitted to Ecology prior to injection mobilization (per a date identified in the project schedule [Figure 11]).

19. Page 18, Section 6.3. The FIWP states that the Pilot Study Completion Report will contain study conclusions and recommendations regarding full-scale application of a groundwater pH-adjustment cleanup action. The West of 4th AO requires that pilot study Completion Reports contain "project information as established in each study's preceding Final Field Investigation Work Plan." The revised FIWP should therefore outline the proposed content of the metals' study Completion Report in sufficient detail to allow Ecology to understand the full extent of the data and other information to be included, as well as the types of evaluations the PLPs intend to perform on the operational and performance monitoring data they collect.

20. Table 2, Soil Core Inventory. A minor comment, but it is not clear how the "recovery" at IW-2's 11.5-13' core can be 1 foot if the "start depth" was 12.5' and the "end depth" was 13'.

21. Table 8, Treatment Batch Test Analytical Results. The dissolved nickel concentration at MW-3, according to Table 3, was 11,400 µg/l in January. The pH was 4.9. However, the nickel level in the control reactor on Day 1 was only 3,800 µg/l (at a pH = 4.7). It then rose to 6,300 µg/l after 13 more days (and the pH slightly dropped).

    In the absence of "Day 0" data, is it reasonable to assume that on this day the nickel concentrations in bicarb batches 1A, 1B, and 1C were ~3,800 µg/l? The revised FIWP should provide the PLPs' hypothesis for why Day 1 batch concentrations were much lower than concentrations measured at MW-3 in January.

    In addition, the discussions in the revised FIWP should answer the following questions:

a) Day 1 nickel levels for bicarb batches 1A, 1B, and 1C were 947, 621, and 215 µg/l, respectively. Between Day 1 and Day 14 the concentrations in 1A and 1C fell by 4 and 2 times, respectively. These are not very large decreases, and the decrease at 1A was not accompanied by any increase in pH. Do the PLPs assume that: (1) levels in 1A and C were much higher on Day 0, and (2) between Day 0 and Day 1 a ~4X decrease at 1A, and a much bigger drop (like 20X) at 1C, occurred?

b) Between Day 1 and Day 7 the nickel concentrations in Batch 1B (where more soil was added to the reactor) dropped by about a third, but by Day 14 had bounced up to a value about 40% higher than the Day 1 level. Over these 13 days the pH fell from 6.4 to 5.6. Why was no more than 250 µL of bicarbonate added to this batch – i.e., to maintain a pH $\geq$ 6, if possible?

c) The 1st bullet under Section 4.1.3.3 states that during the bench-scale study the quantity of bicarbonate needed to raise pH to 8 was between 1,050 and 3,800 µL. These values are based on Anchor's titration curves. In Table 9 it appears that Aspect has taken this range and chosen a value of 2,875 µL to base their scale-up proposal on. In Comment #2 above Ecology has asked the PLPs to explain this choice.

Following the reagent injections, upgradient groundwater will continue to flow through the test area. The pH of this water is expected to be low, and the aquifer contains a much higher ratio of soil to groundwater than the Batch 1B (or other batches) slurry tested. Since neutralization of the acid capacity of the saturated soil matrix is anticipated to require a significant reagent dose, the revised FIWP should explain: (1) why the high-end value of 3,800 µL was not used to estimate the quantity of bicarbonate needed in the field; and, b) how much rebound (over certain timeframes) we should anticipate in groundwater pH and plating-metal concentrations if the proposed dosing volumes of 1M sodium bicarbonate are selected.

22. Table 9, pH Adjustment Calculations. Please see Comment #2 above.

23. Table 10, and page 13. Please see Comment #7 above.

24. Monitoring program Tables 11 and 12. Please see Comment #17 above.

25. Figure 10 (titled "Appendix 10" in the submitted FIWP). Please see Comment #9 above.

26. Figure 11, pilot study implementation schedule. The schedule should explicitly include a "pre-final inspection," to be conducted just prior to the injection events. Ecology plans to visit the project site at this time.

27. Appendix F, Bench-scale Pilot Test Laboratory Report. Appendix F appears to contain a "redlined" version of a (draft) Anchor QEA Report to Aspect Consulting. It is unclear why the FIWP submitted to Ecology would include such a draft/redlined report.

In addition,

- Table 1 shows "total reagent volume added." Ecology assumes that for batches other than the control, reagent volumes were added at Day 0, and then added as needed between Days 1 and 14 (in an effort to maintain each batch's target pH). It would therefore be helpful if the Appendix noted not only the total reagent added, but also the: a) amount added initially (Day 0), and b) amounts added, if any, later. Any amounts added later should be accompanied by the corresponding Day those later amounts were added; and,
- the report in the Appendix, or text within the FIWP itself, should note that no sampling/analysis of Ni concentrations was performed after Day 14 (or, for that matter, on Days 1, 3, or 7) on the solids fractions of treatment batches 1A, 1B, 1C, or Control-1. No mass balance on nickel was therefore possible.

28. Appendix G. According to the technical specifications sheet from the bicarbonate vendor, the $NaHCO_3$ solution that is proposed for the study will be comprised of industrial-grade powder. The quality of this product may be suitable for injecting into site groundwater, but no information has been included about the possible impurities contained in the product. Before concluding that "Industrial #3"-grade $NaHCO_3$ is appropriate for the pilot study, the PLPs should contact the vendor and discuss the issue of possible product impurities. If the vendor has no information regarding impurities, or the possible impurities include substances we would not want to introduce into the subsurface, the PLPs should either select a higher-grade powder or sample/analyze the powder well before the scheduled injection events.