NEVADA DIVISION OF
ENVIRONMENTAL
PROTECTION

STATE OF NEVADA
Department of Conservation & Natural Resources
Joe Lombardo, Governor
James A. Settelmeyer, Director
Jennifer Carr, Administrator

September 26, 2024

Jay A. Steinberg
Nevada Environmental Response Trust
35 East Wacker Drive, Suite 690
Chicago, IL 60601

Re: **Tronox LLC (TRX) Facility**
Nevada Environmental Response Trust (Trust) Property
NDEP Facility ID #H-000539
Nevada Division of Environmental Protection (NDEP) Response to: *Las Vegas Wash Bioremediation Pilot Study Results Report*

Dated: June 28, 2024

Dear Mr. Steinberg,

The NDEP has received and reviewed the above-identified Deliverable and provides comments in Attachment A. A revised Deliverable should be submitted by **11/25/2024** based on the comments found in Attachment A. Additionally provide an annotated response-to-comments letter as part of the revised Deliverable.

Please contact the undersigned with any questions at cschoop@ndep.nv.gov or 702-668-3926.

Sincerely,

Chad Schoop

Chad Schoop, P.E.
Bureau of Industrial Site Cleanup
NDEP-Las Vegas Office

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Attachment A

General Comments

General Comment #1: Data Presentation and Clarity

In general, the data collection effort was impressive in scope and the data set appear adequate to achieve the project goals. However, the data presentation is lacking, especially the performance monitoring chemistry data, which are the key to the understanding of the potential usefulness of the remedy being tested. The discussion of the results in the text is cumbersome and does not include adequate references to the figures and/or tables required to illustrate the points being made in the text. In many cases, the figure and tables do not exist, but in some cases, the figures and tables exist, but are not referenced in the appropriate sections of the text to allow the reader to easily locate the corresponding tables/visuals. Please revise to enhance the clarity of the discussion.

The concentration trend graphs in Appendix L are good to have, however, portions of the text discuss mass removal values or mass along transects, and the calculations/results are not shown. Concentrations and mass removal calculations in tables with accompanying figures showing transect locations are required to properly evaluate the pilot study results.

General Comment #2: Percentage Decreases

Multiple sections include a discussion of percentage change in concentrations for the treatment zones. Percentage decreases are attributed entirely to treatment without discussing natural fluctuations in groundwater concentrations. A review of changes of concentrations in wells outside the treatment area (upgradient/cross gradient) or increases in concentrations in wells after injection (e.g. at LVWPS-U3-MW01B) should also be evaluated and presented graphically or in table form including the data used to calculate the values. There are other reasons for concentration decreases over time other than biodegradation (e.g., dilution, natural fluctuations).

General Comment #3: Mass Removal Estimates

The benefits of the multi-step EVS calculations are unclear and the usefulness of a "change matrix" is questionable. The EVS volumetrics module is already designed to calculate the mass of contaminants in the model domain (or any sub-volume of the model domain). The model could be sliced at any location to provide a mass estimate along a specific transect with a specified thickness. Mass values can then be easily compared between transects and within transects over time. This would be simpler to calculate in EVS, simpler to explain in the text, and much easier to understand if the results are provided in tabular form. The data are not presented in a way to allow the reader to follow the process of the evaluation and understand the results. Please revise to enhance clarity.

General Comment #4: Migration of Injected Materials

The results of the pilot study show that the injected materials are washed downgradient within a short period of time. For a full-scale system implemented under the same conditions as the pilot studies, injections may need to be repeated every six months or less. The evaluation of remedial options for this area should consider whether this option is sustainable in the long term and what the possible effects of a continuous input of organic carbon would be on downgradient receptors.

Fatal Flaws

Fatal Flaw #1: Consistency Between Data and Conclusions

The data show that it is possible for some stimulation of perchlorate degradation to occur, but the data also show that there are significant limitations to the effectiveness of this approach as demonstrated by the pilot study. Some of the summary text appears to be misleading, as the text implies that the treatment was very successful, whereas the figures in the main text (e.g. Figures 11A, B, C) and in

Appendix L appear to indicate that there was an initial, strong decrease in concentrations in nearby wells following injections, but no or limited additional treatment occurred over the course of the monitoring program or in wells downgradient. This observation is not clearly reflected in the text, or if this is not the case, then the figures are misleading and should be improved to better reflect the data. Overall, the text suggests that the injections were very effective in remediating perchlorate and that full-scale injections should proceed. The current data presentation does not support that conclusion. Additional tables and figures, as indicated in the other comments, are required to support the evaluation. It would be a fatal flaw to present a report that did not accurately present the limitations of this technology.

Essential Corrections

Essential Correction 1. Section 2.2.1 Table 1 Page 5. Previous Bioremediation Applications
This table is very useful in understanding the studies that have been performed and that are in progress in the area. It would be helpful to state what treatment was applied in each study (reagent injected and application strategy) and whether there are any differences in the treatment(s) tested in response to the differing conditions in the different studies.

Essential Correction 2. Section 3.2 Page 9, Paragraph 1. Hydrogeology
The text states that "*...groundwater flow appears to be converging toward the fault zone and paleochannels.*" This may be the case, but the data (figure?) used to make this conclusion should be referenced to make it clear to the reader. This is an example of a small addition that will make the text more helpful.

Essential Correction 3. Section 3.2 Page 9, Paragraph 5. Hydrogeology
The text indicates that the groundwater flow velocity in the finer grained and coarser grained portions of the UMCf are identical. This is counter-intuitive because groundwater flow is often greater in the coarser grained material. Please provide the analysis used to make this conclusion.

Essential Correction 4. Section 5.2.1 Page 15. Batch Sorption and Column Sorption/Desorption
The bench scale studies showed that oil sorption by the soils was 0.015 to 0.093 grams of oil/gram of soil for the alluvium and 0.054 to 0.1 grams of oil/gram of soil for the UMCf. The soil to oil ratio actually used for the injections into the three zones was an order of magnitude lower than this. How were the data from the bench scale study used to calculate the EVO dose?

Essential Correction 5. Section 5.5.1 Page 20 last full Paragraph. Injection Event 1
The text states that: "*Calculations of effective porosity based on dose-response monitoring assumed that when the concentration of the injected tracer peaks in the samples collected from the dose-response monitoring wells, the injectate has evenly filled the cylinder of soil between the injection well and that dose-response monitoring well.*"
While this is a helpful assumption for calculations, it is almost certainly false, given the heterogeneity of the subsurface. The uncertainty that using this assumption causes should be discussed in the text.

Essential Correction 6. Section 5.6.5 Page 25. Tracer Injection
Please discuss whether the presence of EVO could impact the effectiveness of the charcoal samplers and whether the data from the tracer study could be affected

Essential Correction 7. Section 6.3.2 Page 33. Injection Details
The volumes used for the first and second injection events were calculated to be approximately one pore volume at each injection well. Based on the monitoring data the injected material dispersed well

and moved downgradient very quickly. For a barrier application horizontal dispersion is required, however it is also preferred that the injected material remain in the barrier area in order to continue to intercept and treat groundwater as it moves downgradient. Should the addition of less distribution water be considered because flushing the injected material downgradient is not the target of this injection? Sufficient chase water to flush residual EVO out of the wells is all that is required after an injection.

Essential Correction 8. Sections 6.7.1.1, 7.7.1.1, and 8.7.1.1. Perchlorate Degradation
These sections need to include reference to specific figures in Appendix L, and tables that include the concentration values in the analysis.

Essential Correction 9. Section 6.7.1.1 Table 4. Page 39. Perchlorate Degradation

(Also, Table 5 and Table 7.)

Giving the Maximum without the Minimum may be misleading. Some Maximum values are much greater than the average values leading to the assumption that this maximum value is not representative of the overall response therefore the minimum value should also be presented to give an idea of the range.

Tables 4, 5 and 7 should be accompanied by tables in appendix showing the data that were used in the calculations of overall removal. The current presentation does not provide sufficient information on how these numbers were derived.

Essential Correction 10. Section 6.7.1.1.2 - 3rd bullet on Page 41. Perchlorate Degradation Following Event 1
The text indicates that concentrations at: "*the LVWPS-U1-MW09B and LVWPS-U1-MW10B indicated perchlorate concentration reductions ranging from 15 percent to 52 percent when compared to baseline concentrations*" The concentration of perchlorate in MW10B decreased from 4,600 ppb (October 2020) to 4,300 ppb (June 2022), which is 7 percent, not 15. The maximum decrease appears to have been used in these calculations rather than the range of decreases or the decrease over the entire course of the program, which can be misleading, and should be clarified. Furthermore, the decreases in both wells were not accompanied by an increase in DOC not a sharp decrease in nitrate, ORP or DO, which may indicate that the decrease was not necessarily related to biodegradation.
This comment is a continuation of the comment regarding tables 4, 5 and 7. The concentration decreases should be presented in tabular form with the data used to calculate the values, for transparency and clarity.

Essential Correction 11. Sections 6.7.1.2, 7.7.1.2, and 8.7.1.2 – Estimation of Perchlorate Distribution
The text in these sections makes it appear as though remediation was robust in many downgradient wells, and that the injections were very effective. However, Figures 11, 12, 13, 15, and 16 indicate that the distribution of perchlorate appears stable over time following the initial change after injections in these zones. The exception is in the Deep Alluvium in Zone 2 (Figure 14). If the injections created a stable treatment zone for groundwater, then the area of lower perchlorate concentrations should expand away from the treatment zone, slowly increasing over time as more groundwater gets treated. This is what appears to be happening in the Deep Alluvium in Zone 2 (see Figures 14A-D). In the other Zones, the initial low concentration area that was established following injection appears to remain relatively

unchanged over time. This may indicate that the injection reduced the porosity of the aquifer and the upgradient groundwater flows around the injection area instead of through it.

It is difficult to determine what the conclusions should be, because the data are not presented in a way that allows or demonstrates the effectiveness of the mass removal, except for the concentration over time plots, which do not universally support the apparently positive conclusions presented in these sections.

For example, in Zone 1 according to the figures in Appendix L, the only downgradient wells that had perchlorate concentrations clearly affected by the injections were U1-MW08A/B. Apparent concentration changes noted at other wells may have been biodegradation but may also have been dilution-related or related to natural fluctuations in concentrations. An increase in DOC and a decrease in nitrate, DO, and ORP should accompany any conclusion of biodegradation. This evidence was not clear in the Zone 1 downgradient wells.

If robust, active reductive biodegradation in the downgradient wells is critical to the evaluation of the pilot study, then the text should be revised to include tables comparing decreases in contaminant mass with decreases in nitrate/DO/ORP in tabular form. If active reductive biodegradation in the downgradient wells is not critical to the evaluation of the pilot study, then the text should be revised to remove the speculation.

Essential Correction 12. Sections 6.7.1.3, 7.7.1.3 and 8.7.1.3 – Estimation of Mass Removal

The discussions in these sections would benefit from some tables and figures to demonstrate the results. Mass flux is discussed across the mentioned transect, which is not shown. The results of the mass flux calculations are not presented in tabular form and the mass flux calculations are not apparently used in the calculation of mass removal. The EVS model output is referenced, but not presented. If this output is important for the conclusions, then it must be presented, and if it is not important, then it should be omitted. The EVS calculation of mass along transect could be greatly simplified by defining transects 1 foot in thickness at specified distances from the injection line. The EVS volumetrics model can calculate the mass along these transects.

In Section 6.7.1.3, the text indicates that there was a decrease of 79 pounds of perchlorate from baseline to the end of monitoring and a rate of 0.13 pounds per day is given. However, it appears that all of the change in concentration happened immediately following injection, (according to Figures 11A-C, and in Appendix L), therefore, the rate per day cannot be supported by the available data and should be removed from the text.

The data from the dye testing (Appendix C) show significant downgradient migration of dye within the first month following injections, but the area of dye detections remained generally consistent over the subsequent sampling events. This should be explained in the text and what this means for the effectiveness of injections. If the figures in Appendix C are being misinterpreted or are misleading, and the dye concentrations changed significantly over time as expected, then the figures should be modified to more accurately reflect the conceptual site model.

Essential Correction 13. Section 6.7.6.2 Page 52. Oxidation Reduction Potential

ORP readings of 24 mV do not seem to be consistent with aerobic conditions as stated in this section. An ORP of 24 mV is fairly anaerobic.

Essential Correction 14. Section 6.7.6.5 Page 55. Other Parameters

A calculation of whether total N is equal to nitrate N and whether all losses of N observed are due to denitrification would be useful in determining whether the system is nutrient limited and would benefit from the addition of ammonia-N.

Essential Correction 15. Section 6.7.6.5 Page 55. Other Parameters
Total P rapidly returned to baseline levels. Was it consumed as indicated in the text or washed downgradient? If it was immediately consumed this indicates that P may have been limiting and should probably have been included in Injection 2.

Essential Correction 16. Section 6.7.7.2 Page 57-58. Analysis of Microbial Results
The MI Reports in Appendix M state that these results are $<2.5 \times 10^2$ cells per bead – in other words ND.

Essential Correction 17. Section 6.7.7.2 Page 57-58. Analysis of Microbial Results
The lack of increase in numbers of perchlorate reductase genes is difficult to explain. The increased biodegradation of perchlorate suggests that microbial numbers and degradation of perchlorate did increase. Why didn't the gene numbers increase? Had perchlorate concentrations already decreased by the time the post injection BioTraps were placed in the wells? (10 months and 16 months after the first injection event).

Essential Correction 18. 7.7.6.2 Page 96. Oxidation Reduction Potential
What is the difference in groundwater chemistry between Zone 1 and Zone 2 (both Aluvium and UMCf) that made ORP decrease in Zone 2 but not in Zone 1, and also made prcA numbers increase in Zone 2 but not in Zone 1?

Essential Correction 19. Section 7.7.7.1 Page 101. Analysis of Microbial Results
The MI Reports in Appendix M state that the baseline results are $<2.5 \times 10^2$ cells per bead – in other words ND.

Essential Correction 20. Section 7.7.7.1 Page 101. Analysis of Microbial Results
Text is misleading. For Zone 2 wells, 3 out of 6 wells monitored remained at ND levels for perchlorate reductase.

Essential Correction 21. Section 8.7.1.1 Page 117. Table 7. Perchlorate Degradation
How is it possible for the max reduction to be 99% when the average is 2% and there are only 5 wells.

Essential Correction 22. Section 8.7.4 Page 124 Bullet 1. Total Organic Carbon
This Section discussed the increase in TOC in groundwater samples collected from three of the six monitoring wells located approximately 25 feet downgradient of the injection well transect. The other 3 wells are not discussed. What is happening in the other 3 wells and why?

Essential Correction 23. Section 8.7.7.2 Page 131. Analysis of Microbial Results
The MI Reports in Appendix M state that the baseline results are $<2.5 \times 10^2$ cells per bead – in other words ND.

Essential Correction 24. Section 8.7.7.2 Page 131. Analysis of Microbial Results
It is not stated that for 2 out of 4 wells perchlorate reductase results remained at ND levels

Essential Correction 25. Section 10.0 pages 137-138. Surface Water Monitoring
Fluorescein results indicate that the LV Wash surface water was affected by the pilot studies and some elevated TOC concentrations were observed in the surface water. If full scale treatment was performed with longer injection transects and injections ~every 6 months as the data seems to indicate would be

required, what is the potential effect on the LV Wash surface water and would high TOC in this water have any negative effects (water quality).

Essential Correction 26. Section 10.0 pages 137-138. Surface Water Monitoring
The Pilot Study results indicated that approximately 1,810 pounds of perchlorate were destroyed during the 18-month Pilot Study time frame. From Ramboll per perchlorate loading to the LV Wash is 50.3 lbs/day = 27,500 lbs in 18 months, therefore 6.5% was destroyed. Can we extrapolate from this how much perchlorate would be expected to be destroyed by the full-scale system?

Essential Correction 27. Appendix J Table J.2.
Table needs to be corrected to indicate that the 2.5×10^2 values are ND.

Essential Correction 28. Appendix L
These figures should be better grouped by treatment zone and aquifer, the current presentation has some Zone 2 figures first, then some Zone 1 and Zone 3 figures, then various additional Zone 2,1, and 3 figures. This makes it unnecessarily difficult to find wells discussed in the text.

Minor Corrections

Minor Correction 1. Section 3.2 Page 9, Paragraph 5. Hydrogeology
The text refers to the western portion of the pilot study area near the fault zone, should this be the eastern portion of the area?

Minor Correction 2. Section 5.6.3 Page 24 Paragraph 1. Slug Tests

Falling-head tests cannot be performed by the "*insertion or removal*" of a slug, just the insertion.

Minor Correction 3. Section 6.2.1. Injection Wells

This section mentions 8 injection wells in Zone 1. Correct to state that this is 8 nested injection well pairs - to avoid confusion

Minor Correction 4. Section 6.7.1.1 Table 4. Page 39. Perchlorate Degradation
The use of negative signs is confusing. The description of the tables states that these are percent reductions when compared to baseline. A negative percent reduction is typically an increase in concentration. Same for Table 5 and Table 7.

Minor Correction 5. Section 7.7.6.5 Page 100. Other Parameters
(Also Page 129) "Groundwater is undergoing biodegradation" change to "Biodegradation is occurring in the groundwater".

Minor Correction 6. Section 7.7.7.2 Page 101. Analysis of Microbial Results
States that concentration of 5.3×10^3 cells per bead in samples collected from deep alluvial monitoring well LVWPS-A2-MW14B. Number from MI report is 3.2×10^3.