

### Introduction to Response to Comments

Upon review of the Nevada Division of Environmental Protection (NDEP) comments dated September 26, 2024, it appears that several comments relate to items that were outside the scope of the Las Vegas Wash Bioremediation Pilot Study Work Plan Addendum (“Work Plan Addendum”) approved by NDEP on December 11, 2019 and/or are appropriate for consideration during the Nevada Environmental Response Trust (NERT or Trust) Feasibility Study (FS) should the in-situ bioremediation (ISB) technology advance through the FS screening process. As stated in the Las Vegas Wash Bioremediation Pilot Study Results Report (“Results Report”), the overall objective of the Pilot Study was to demonstrate and evaluate the effectiveness and implementability of ISB in a geologically complex area where perchlorate-contaminated groundwater is migrating into the Las Vegas Wash (“Wash”). The Pilot Study was carefully designed not simply to destroy contaminant mass nor to simulate what a full-scale remedy might look like, but rather to assess certain components of an ISB approach not previously evaluated by NERT, which included application of ISB in areas with significant geological heterogeneity, large and deep paleochannels, fault-zone channels, large saturated thicknesses of alluvium, Upper Muddy Creek formation (UMCf), and coarse-grained UMCf (UMCf-cg), and perchlorate and chlorate at concentrations and depths greater than previously evaluated (as described in Section 11.1 of the Results Report). The design of three separate Pilot Study zones (referred to as Zones 1, 2, and 3) was determined based solely on the defined Pilot Study objectives and therefore, differs from the objectives of a full-scale remedial design if ISB was selected as a component of NERT’s final remedy. Likewise, implementation of the ISB technology would be designed to achieve a specific objective(s) at a specific location(s), as opposed to the limited nature of the tailored Pilot Study objectives. As a result, data collected and lessons learned during the Pilot Study are meant to inform the FS and potentially the future remedial design and therefore should not be construed as a final determination of the appropriateness of the ISB technology, its cost to be implemented, and/or its application to the NERT Remedial Investigation (RI) Study Area.

Through the performance of this Pilot Study, sufficient data was collected to meet the overall study objective to demonstrate and evaluate the effectiveness and implementability of ISB in a geologically complex area where perchlorate-contaminated groundwater is migrating into the Las Vegas Wash. Overall, groundwater within the Pilot Study area was amenable to biodegradation of perchlorate, chlorate, and nitrate (an ISB competing electron acceptor). As demonstrated in this Pilot Study, periodic injection of EVO and amendments created biologically active treatment zones in all three lithologies evaluated, which is necessary for effective perchlorate and chlorate biodegradation in the groundwater.

If full-scale ISB is selected as a component of the NERT final remedy, remedial design would use the data collected from this Pilot Study and other ISB treatability/pilot studies completed by NERT to inform important remedial design and operational components such as number/spacing of injection wells, targeted injection intervals, injection protocols, injection well transect design (e.g., number, location and orientation), and injection frequency/quantities of injectate solution to account for site-specific variables (i.e., preferential flow pathways, subsurface heterogeneity, and RAOs).

NERT requests that these points be considered in review of the following responses to the received comments.

NDEP Comment (9/26/24)	Response to Comment	NDEP Comment (1/9/25)	Response to Comment
<p><b>General Comment #1: Data Presentation and Clarity</b></p> <p><i>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.</i></p> <p><i>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.</i></p>	<p>A complete and thorough review of the report confirms that all tables and figures presented in the Table of Contents and referenced in the text were provided as part of the Results Report submittal. Accordingly, it is unclear why NDEP was unable to locate referenced tables and figures.</p> <p>To address the request for enhanced clarity in presentation of the data, the following revisions will be made to the report presentation:</p> <ul style="list-style-type: none"> <li>• Additional overarching references to tables and figures will be added to appropriate sections.</li> <li>• Appendix J – Comprehensive Data Tables will be reorganized to present data by treatment zone, screened lithology, and distance from injection transect to allow the reader to more easily locate corresponding data.</li> <li>• Appendix L – Concentration Trends for Effectiveness Monitoring Wells will be reorganized to present graphs by zone to allow the reader to more easily locate corresponding visuals.</li> </ul> <p>Sections 6.7.1.1, 7.7.1.1, 7.7.1.2, and 8.7.1.1 present a summary of the perchlorate degradation response for each treatment zone. These sections also included corresponding figures that provide depictions of concentrations over time and tables that present concentration reductions following injection events for monitoring wells located at varying distances from the injection well transects (Figures 11a through 18c and Tables 4 through 7, respectively). As described in Essential Correction 9, additional text will be added to describe the calculation process for the concentration reductions presented in the tables.</p>	<p><i>No further changes required.</i></p>	<p>Not Applicable.</p>

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<p><b>General Comment #2: Percentage Decreases</b></p> <p><i>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).</i></p>	<p>Although concentration decreases over time can be attributed to several factors other than bioremediation processes (e.g., natural attenuation processes, dilution, and/or seasonal groundwater potentiometric fluctuations), the majority of these monitoring wells were installed for purposes of the pilot study and only sampled one time prior to injections to establish baseline concentrations. As a result, and due to the limited duration of the study, one pre-injection data point does not allow for comparisons of pilot study data to natural groundwater concentration fluctuations over time. Because of this, the Results Report generally focuses on concentration reductions in groundwater inside of the treatment areas that could be directly correlated to bioremediation processes, such as simultaneous decreases in chlorate/nitrate concentrations combined with increases in total organic carbon concentrations. However, data collected from upgradient monitoring wells and extraction wells located outside of the Pilot Study area provide some data indicating that contaminant concentrations generally remained relatively stable during the Pilot Study timeframe.</p> <p>Sections 6.7, 7.7, and 8.7 of the Results Report present a summary of the analytical results, with each section including a discussion of notable concentration reductions in groundwater samples collected from monitoring wells located both within and outside of the treatment area (i.e., upgradient and/or cross-gradient monitoring wells). Additionally, Appendix L – Concentration Trends for Effectiveness Monitoring Wells presents graphical depictions of concentration fluctuations during the Pilot Study timeframe in groundwater samples collected from all Pilot Study monitoring wells, including upgradient and cross-gradient monitoring wells (e.g., LVWPS-U3-MW01B), as well as five extraction wells.</p> <p>Text will be added to Sections 6.7, 7.7, and 8.7 of the Results Report to provide additional clarity on the potential for natural fluctuations compared to bioremediation processes where applicable, including references to concentration trend graphs for both upgradient monitoring wells and extraction wells. Tables 5, 6, and 7 will also be updated to include upgradient concentration changes during the same time period as the Pilot Study. As described in response to General Comment #1, Appendix L – Concentration Trends for Effectiveness Monitoring Wells will also be reorganized to present concentration trend graphs by individual zones to allow the reader to more easily locate corresponding visuals. Lastly, Section 9.0 – Long-Term Water Level Monitoring of the Pilot Study Area will be revised to also include a new section that discusses concentration trends in areas outside of the influence of the Pilot Study.</p>	<p><i>No further changes required.</i></p>	<p>Not Applicable.</p>

NDEP Comment (9/26/24)	Response to Comment	NDEP Comment (1/9/25)	Response to Comment
<p><b>General Comment #3: Mass Removal Estimates</b>  <i>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.</i></p>	<p>The software capabilities described by NDEP are correct. The interpretation that the contaminant mass could simply be evaluated to create a mass estimate is also true. However, the intent was not to assess the remaining mass present at a specific time interval compared to a baseline mass estimate, but to estimate the mass treated within a dynamic system over time. The Earth Volumetric Software (EVS) determines the distribution of mass using interpolation and extrapolation routines (i.e., kriging), which not only calculates concentrations between known data points but also outside of known data points. Because of this, the "change matrix" process was implemented to eliminate the effects on mass estimates related to interpolation and extrapolation artifacts associated with potential increases or decreases in concentration beyond the immediate study area. By limiting the model to concentration changes in groundwater at individual well locations, the "change matrix" calculation process provided control for areas outside of the immediate treatment area. This additional step prevented extrapolated concentration decreases beyond the immediate treatment area from appearing as successful treatment and artificially inflating the estimated mass removed. The concept of using the change in mass present within a treatability or pilot study area over time has been used in perchlorate mass removal calculations in previously approved NDEP documents. Therefore, revisions to the mass estimate calculations will not be performed in order to preserve consistency with previous reports.</p> <p>It should also be noted that although quantification of the mass destroyed in this Pilot Study was included in the Results Report, the goal of the Pilot Study was not to destroy mass but to collect data to evaluate effectiveness and implementability of ISB in a geologically complex environment. As such, these calculations are presented as estimates and not critical to the outcome of the Pilot Study or evaluation of an ISB remedy in the forthcoming FS.</p> <p>Section 6.7.1.3 will be updated to provide additional clarity on the mass estimate process. In addition, a new appendix will be added that provides figures illustrating the location of the transects (i.e., vertical slices) of the EVS model and tables presenting the EVS outputs for perchlorate mass flux calculations.</p>	<p><i>No further changes required.</i></p>	<p>Not Applicable.</p>
<p><b>General Comment #4: Migration of Injected Materials</b>  <i>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.</i></p>	<p>This pilot study provided valuable data over an 18-month timeframe to evaluate the longevity of the carbon substrate and potential injection frequencies for a full-scale effort if the ISB technology were selected as a component of the NERT final remedy. As summarized in the Results Report, carbon substrate distribution, longevity, and injection frequency will vary depending on unique location-specific hydrogeologic variables and extent of heterogeneity of the subsurface. The Results Report concludes that the design of a full-scale ISB remedy would be significantly different than the compact pilot study design, and if ISB is selected as a component of the NERT final remedy, the injection well design may potentially include multiple injection well transects and/or varying injection frequencies depending on the groundwater flow rates of the targeted formation to achieve a more uniform biologically active treatment zone that could enhance and maximize perchlorate biodegradation by increasing residence times. While NDEP's comments are correct in that if the configuration of this exact pilot study was implemented as part of final remedy, then frequent injections could be required. However, there is no likelihood that the above scenario would be realized.</p> <p>Data collected in this pilot study as well as other treatability studies performed to-date will be used for evaluation of a full-scale ISB remedy as part of the forthcoming FS. Specifically, Section 1.1 of the Results Report states:</p> <p>"Upon completion of the various OU-3 area treatability and pilot studies and OU-3 RI and risk assessments, it will be the objective of the OU-3 FS to produce an array of potential remedies for OU-3 by incorporating all available study data, nature and extent of COPCs (as identified in the forthcoming OU-3 RI Report) and potential risks to human health and the environment (as identified in the various forthcoming risk assessments relevant to OU-3). This Pilot Study is intended to provide key information needed for the FS to evaluate design, optimization/scale-up, and cost of an ISB approach and its effectiveness to achieve the RAO of mitigating the perchlorate mass flux to the Wash if ISB is selected as part of the final remedy." Based on this explanation, no revisions will be made to the Results Report in response to this comment.</p>	<p><i>No further changes required.</i></p>	<p>Not Applicable.</p>

NDEP Comment (9/26/24)	Response to Comment	NDEP Comment (1/9/25)	Response to Comment
<b>Fatal Flaws</b>			
<p><b>Fatal Flaw #1: Consistency Between Data and Conclusions</b></p> <p><i>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 I IA, 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.</i></p> <p><i>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.</i></p>	<p>The purpose of the injection well transect was to create a continuous biologically active zone in the immediate vicinity of the injection wells for perchlorate concentrations to reduce as groundwater migrates through the biologically active zone. Results from the Pilot Study indicated sustained degradation both within the immediate vicinity and downgradient of injection well transect in select areas.</p> <p>However, areas located farther downgradient of the injection well transects did not indicate the same level of sustained degradation as these areas contained groundwater that migrated into the study areas without passing directly through the biologically active zone, which was expected due to the short injection well transect lengths combined with the limited study duration. These factors, by design, limited the extent of treatment farther downgradient. The Results Report explains that the design of a full-scale remedy utilizing ISB would be significantly different, and if implemented full-scale, the injection well transect would likely extend across the entire width of the targeted groundwater plume and potentially include multiple injection well transects and/or varying injection frequencies to achieve a more uniform biologically active treatment zone that could maximize perchlorate biodegradation.</p> <p>NDEP’s conclusion is correct that ISB, like any remedial technology, has its limitations. As NDEP is aware, the purpose of a pilot study is to understand the limitations of a given technology, inform the FS and, if applicable, the remedial design, to incorporate “lessons learned” through the implementation of a given pilot study. The Results Report did not conclude or state in any way that full-scale injections should proceed, let alone in a configuration such as evaluated in this Pilot Study. The summary sections provided in the Results Report presented key findings based on data collected during the Pilot Study as well as design and operational components that should be considered during evaluation of a full-scale ISB remedial approach in the forthcoming FS or subsequent remedial design. As explained throughout the Results Report, this Pilot Study was intended to provide key information needed for the FS to more accurately develop implementation components and associated costs as well as evaluate design, optimization/scale-up, and effectiveness of an ISB approach to achieve the future design objectives developed during the FS. Based on this explanation, no revisions will be made to the Results Report in response to this comment.</p>	<p><i>As noted below in responses to specific comments, instances where maximum reductions are used should be replaced with ranges and a discussion of the fact that the perchlorate concentrations did not decrease away from the treatment zone over time should be added in order to put the results from the study into better perspective and aid in the ultimate evaluation of this technology as a part of the final remedy.</i></p>	<p>The bulleted summaries provided in the results sections routinely present a range of concentration reductions in groundwater samples collected from a particular well (example below):</p> <p>"Perchlorate concentrations in the Month 1 sample collected from LVWPS-U3-MW02B decreased by 98 percent when compared to baseline, which correlates with the arrival of the injectate as indicated by the slight increase in TOC concentration during this same event (further discussed in Section 8.7.4). Although perchlorate concentrations in samples collected from LVWPS-U3-MW02B continued to be reduced when compared to baseline, the reductions were lower in the Months 2 through 8 sampling events, ranging from 14 percent to 32 percent."</p> <p>All results sections will be reviewed to confirm that similar text presenting ranges of concentration reductions is included in each discussion. In areas where this level of detail is not provided, additional text will be added as required to reference ranges of concentration reductions. Additional text will also be added to explain why only limited treatment farther downgradient was observed.</p>
<b>Essential Corrections</b>			
<p><b>Essential Correction 1. Section 2.2.1 Table 1 Page 5. Previous Bioremediation Applications</b></p> <p><i>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.</i></p>	<p>Table 1 will be updated to include details of the primary reagent injected and general application strategy for each study based on the key differentiators summarized.</p>	<p><i>No further changes required.</i></p>	<p>Not applicable.</p>
<p><b>Essential Correction 2. Section 3.2 Page 9, Paragraph 1. Hydrogeology</b></p> <p><i>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.</i></p>	<p>A reference to Figure 3 will be added to the first sentence in Section 3.2 of the Results Report.</p>	<p><i>No further changes required.</i></p>	<p>Not applicable.</p>

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<p><b>Essential Correction 3. Section 3.2 Page 9, Paragraph 5. Hydrogeology</b>  <i>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.</i></p>	<p>Section 3.0 of the Results Report will be updated to state that the summaries presented in this section are based on data collected during Phase 1 of the Pilot Study. Additionally, the hydrogeologic properties of the UMCf and UMCf-cg are discussed in more detail in Sections 6, 7, and 8 of the Results Report as well as Appendix F – Borehole Dilution Technical Memorandum.</p> <p>Also described in Section 8.4 of the Results Report, although the coarse-grained facies of the UMCf contains relatively coarser-grained materials compared to the UMCf, the UMCf-cg still contains a significant portion of fines and is commonly interbedded with fine grained UMCf. Therefore, the similar hydrogeologic properties of the two facies of the UMCf are not surprising. Groundwater velocities were similar between the UMCf-cg in Zone 3 (ranging from 0.02 to 0.7 ft/day) and UMCf in Zones 1 and 2 (ranging from 0.04 to 0.6 ft/day).</p> <p>In response to this comment, text will be updated in Section 3.2 of the Results Report to include the following:                      “The similar hydrogeologic properties of the two facies of the UMCf are not surprising as the UMCf-cg still contains a significant portion of fines and is commonly interbedded with fine grained UMCf.”</p>	<p><i>No further changes required.</i></p>	<p>Not applicable.</p>
<p><b>Essential Correction 4. Section 5.2.1 Page 15. Batch Sorption and Column Sorption/Desorption</b>  <i>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?</i></p>	<p>Section 5.5.1 of the Results Report states:                      “A summary of the key factors to consider when determining injectate quantities, the calculation process that was used for preliminary injection quantity estimates, and the results of those estimations were summarized in Appendix I of the Work Plan Addendum.”</p> <p>The NDEP-approved Work Plan Addendum included Appendix I – Injection Well Spacing and Injection Volume Design Summary, which summarized the key considerations and calculation process used for determining the EVO dosage for the Pilot Study. Section 3.2 of Appendix I provided a detailed discussion related to oil sorption rates observed in the bench-scale studies and the selection of the oil retention ratio that was recommended for the injection program associated with this Pilot Study. Specifically, the oil sorption values calculated in the bench-scale study were much higher in comparison to typical oil sorption values provided in protocol documents, including the EVO User’s Guide and Design Tool. A major reason for the marked differences between typical values and site-specific values from batch testing is the tendency for oil flocculation and chemical reactions that could occur due to the large presence of calcium in the saturated soil within the study area of OU-3. Therefore, using the laboratory-determined oil sorption values would not have been practical for calculation of carbon substrate (EVO) quantities. Section 3.2 of Appendix I of the Work Plan Addendum provided a summary of other important considerations for the evaluation and selection of the appropriate oil retention ratio and concluded that based on literature, bench-scale study results, practitioner’s experience with EVO, and vendor consultation, a lower value of 0.002 and 0.0035 grams of oil per gram of soil would be targeted for the alluvium and UMCf, respectively.</p> <p>Additionally, at the request of NDEP, the Trust summarized Appendix I of the Work Plan Addendum, which contained final injectate quantities and calculation process used to derive them, in a presentation made to NDEP prior to the purchase of the carbon substrate on October 29, 2020. Subsequent to the presentation, NDEP provided its approval of injectate quantities.</p>	<p><i>No further changes required.</i></p>	<p>Not applicable.</p>

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<p><b>Essential Correction 5. Section 5.5.1 Page 20 last full Paragraph. Injection Event 1</b>  <i>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.</i></p>	<p>As discussed in Appendix C – Tracer Study Technical Memorandum, effective porosity was estimated following the guidelines presented in <i>Tracer Testing: Recommended Best Practice for Design and Optimization of In Situ Remediation Systems</i> (Suthersan et al., 2014). As NDEP noted, the equation used for the effective porosity calculation assumes uniform radial distribution of injected fluid around the injection well, both horizontally and vertically. However, the actual tracer distribution will be increasingly nonuniform with increasing heterogeneity of the subsurface. As stated in Suthersan et al. (2014), "The degree of deviation from ideal distribution can be evaluated and incorporated into the injection well system design by recording tracer breakthrough at multiple dose response wells." In accordance with this guidance, and as detailed in the Work Plan Addendum, multiple dose response wells were installed and tested within each of the target remedial zones to provide a more robust study of effective porosity and illustrate variability in estimated effective porosity introduced by subsurface heterogeneity.</p> <p>In order to provide additional clarity with respect to heterogeneity of the subsurface as it relates to dose-response monitoring, the following text will be added to Section 5.5.1 of the Results Report and Section 3.2.1 of Appendix C – Tracer Study Technical Memorandum:</p> <p>"It should be noted that the actual tracer distribution will be increasingly nonuniform with increasing heterogeneity of the subsurface. Therefore, and as specified in the Work Plan Addendum, multiple dose response wells were installed and tested within each of the target remedial zones to provide a more robust study of effective porosity and illustrate variability in estimated effective porosity introduced by subsurface heterogeneity."</p>	<p><i>No further changes required.</i></p>	<p>Not applicable.</p>
<p><b>Essential Correction 6. Section 5.6.5 Page 25. Tracer Injection</b>  <i>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.</i></p>	<p>To better understand the effects of emulsified vegetable oil (EVO) and potential interference in charcoal sampler analysis, samples of the EVO product were submitted to the dye analytical laboratory (Ozark Underground Laboratory) in advance of the injections. Laboratory results confirmed that fluorescein and rhodamine concentrations could be accurately measured in samples that contained EVO. Additionally, it should be noted that data obtained from charcoal samplers are intended to only provide qualitative information on the presence or absence of tracer dye and are not intended to provide quantitative information on tracer dye concentration.</p> <p>The following sentence will be added to Section 5.6.5 of the Results Report and Appendix C – Tracer Study Technical Memorandum:</p> <p>"Samples of EVO were also submitted to OUL to confirm that tracer dye could be accurately measured (i.e., the presence of EVO does not inhibit or interfere with the tracer dye analysis) in Pilot Study samples that contained EVO."</p>	<p><i>This comment referred to whether the EVO would become absorbed on the charcoal samplers and block the adsorption of tracer dyes.</i></p>	<p>Although EVO adsorption onto the charcoal samplers could minimize the concentration of tracer dye measured in the charcoal samplers, EVO adsorption did not completely prevent the adsorption of dye onto the charcoal samplers. For example, the highest ratio of EVO to dye would be present in the charcoal samplers collected from the dose response monitoring wells, which are located approximately 7 feet downgradient of the injection well transects. A review of the analytical data indicates that despite very high concentrations of Total Organic Carbon (a proxy for EVO) in groundwater samples collected from the dose response monitoring wells, charcoal samplers collected from dose response monitoring wells still registered positive detections of tracer dye. Following a positive detection of tracer dye on each charcoal sampler, the concurrently collected groundwater sample was analyzed for a tracer dye concentration. As the charcoal sampler results were intended to provide qualitative data only (i.e., presence/absence of tracer dye), there is no change in the interpretations of the tracer dye study as a result of the possible adsorption of EVO onto the charcoal samplers. Additional text will be added Sections 5.6.5, 6.6.4, 7.6.3, and 8.6.4 to provide clarity on the charcoal sampler testing procedure and use of the collected data.</p>

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<p><b>Essential Correction 7. Section 6.3.2 Page 33. Injection Details</b>  <i>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.</i></p>	<p>Flushing residual carbon material from the injection well and surrounding filter pack to prevent clogging of the well screen and annular space is only one function of applying follow-up distribution water. When implementing ISB via vertical injection well transects, the generally adopted industry protocol is to maximize the lateral distribution of the EVO and coating of the soil grains within the designed radius of influence of each injection well to make the designed injection well transect as continuous as possible. The primary factors that significantly influence the final oil distribution are: (1) total amount of oil injected, (2) total amount of water injected, and (3) ability of the formation to accept the injectate.</p> <p>Section 6.3.2 of the Results Report explains that the field-determined effective porosity was less than originally estimated and therefore, distribution water volumes were reduced in an effort to minimize extensive downgradient distribution of the carbon substrate. Section 6.8 of the Results Report discussed that the injectate was observed in both upgradient and downgradient monitoring wells that were situated along direct preferential flow paths and less so in other areas. As a result, the injected material distribution movement occurred rather quickly and was likely associated with these preferential pathways combined with the low effective porosities, as well as injection rates and pressures. Section 6.8 of the Results Report also concluded that it was important to maintain relatively low injection rates and pressures to minimize distribution along those preferential paths in order to evenly distribute injectate around the injection well and create a more uniform biologically active zone.</p> <p>NDEP’s comment acknowledges that distribution water is an important component to understand for potential full-scale design and implementation of ISB (whether in the forthcoming FS or subsequent remedial design). If ISB is selected as part of NERT’s final remedy, distribution water quantities should be considered as an important operational variable. As explained throughout the Results Report, this Pilot Study was intended to provide key information needed for the FS to more accurately develop implementation components and costs as well as evaluate design, optimization/scale-up, and effectiveness of an ISB approach to achieve future design objectives developed during the FS. Based on this explanation, no revisions will be made to the Results Report in response to this comment.</p>	<p><i>No further change required but this comment should be considered if/when full-scale design is performed.</i></p>	<p>Not applicable.</p>
<p><b>Essential Correction 8. Sections 6.7.1.1, 7.7.1.1, and 8.7.1.1. Perchlorate Degradation</b>  <i>These sections need to include reference to specific figures in Appendix L, and tables that include the concentration values in the analysis.</i></p>	<p>References to Appendix J – Comprehensive Data Tables and Appendix L – Concentration Trend Graphs for Effectiveness Monitoring Wells are provided at the beginning of Sections 6.7.1, 7.7.1.1, 7.7.1.2, and 8.7.1 of the Results Report. Due to the number of monitoring wells discussed, individual figure references for every monitoring well referenced in the Results Report would be extremely cumbersome and reduce readability of the text. However, for ease of review, Appendix J – Comprehensive Data Tables and Appendix L – Concentration Trend Graphs for Effectiveness Monitoring Wells will be reorganized to group data and graphs by treatment zone and location within each treatment zone (e.g., upgradient monitoring wells within Zone 1). Additional overarching references will also be added throughout Sections 6.7.1.1, 7.7.1.1, 7.7.1.2, and 8.7.1.1 to reference the revised tables and figures provided in Appendices J and L, respectively, to explicitly direct the reviewer to specific tables and figures.</p>	<p><i>No further changes required.</i></p>	<p>Not applicable.</p>

NDEP Comment (9/26/24)	Response to Comment	NDEP Comment (1/9/25)	Response to Comment
<p><b>Essential Correction 9. Section 6. 7.1.1 Table 4. Page 39. Perchlorate Degradation (Also, Table 5 and Table 7.)</b></p> <p><i>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.</i></p> <p><i>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.</i></p>	<p>This methodology has been consistently used in previously approved NDEP treatability/pilot study result reports. Therefore, no revisions will be made to the data presentation in Tables 4 through 7 of the Results Report. However, in acknowledgment of NDEP’s desire for an alternative presentation, the following notes will be added to Sections 6.7.1.1 (Table 4), 7.7.1.1 (Table 5), 7.7.1.2 (Table 6), and 8.7.1.1 (Table 7) of the Results Report:</p> <ol style="list-style-type: none"> <li>Percentage change in perchlorate concentration is calculated relative to the pre- injection baseline groundwater sampling event in September/October 2020 (labeled as event BL04 in Appendix J, Table J.1). Increases in perchlorate concentrations relative to baseline concentrations are represented as positive percentages, while decreases in perchlorate concentrations relative to baseline concentrations are represented as negative percentages.</li> <li>The calculation for average concentration change accounts for both increases and decreases in concentrations compared to baseline.</li> <li>The maximum change shown is the most significant reduction in concentration compared to baseline concentrations and represented by the most negative percentage calculated.</li> </ol> <p>Additionally, the following sentence will be added to Sections 6.7.1.1, 7.7.1.1, 7.7.1.2, and 8.7.1.1 of the Results Report: “Analytical data used in the calculations for concentration changes during the Pilot Study are presented in Table J.1.”</p>	<p><i>The previous use of this methodology does not mean that it cannot be improved. It is still recommended that minimum values are presented. The reference to the analytical data is appreciated.</i></p>	<p>Additional tables will be provided that include presentation of perchlorate concentration reductions on a well-by-well basis for each sampling event, with a summary of the minimum, maximum, and average perchlorate concentration reductions.</p>
<p><b>Essential Correction 10. Section 6.7.1.1.2 - 3rd bullet on Page 41. Perchlorate Degradation Following Event 1</b></p> <p><i>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.</i></p> <p><i>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.</i></p>	<p>Section 6.7.1.1.2 of the Results Report is titled “Perchlorate Degradation Response Following Injection Event 1”. As such, this section of the Results Report discusses results following the first injection event (i.e., October 2020 through August 2021) and does not include discussion of June 2022 sampling results.</p> <p>With respect to the maximum decrease, NDEP is correct as the following sentences are included in the 3rd bullet referenced in this comment: “Specifically, results indicated a 41 percent reduction in perchlorate concentrations one month after the first injection event in samples collected from LVWPS-U1- MW09B. This reduction was sustained through Month 8, with concentrations reducing by as much as 52 percent during the Month 4 sampling event with a concentration of 3,100 mg/L compared to a baseline concentration of 6,400 mg/L. Perchlorate concentrations reduced from a baseline concentration of 4,600 mg/L to a low of 2,900 mg/L in groundwater samples collected from LVWPS-U1-MW10B following the first injection event (representing a 37 percent reduction in concentrations).” The use of “as much as” is not thought to be misleading because it is not representing a long-term trend or range, rather a snapshot of results immediately following the first injection event.</p> <p>Lastly, NDEP is correct in that decreased perchlorate concentrations in farther downgradient areas may not be related to biodegradation. Increases in total organic carbon and strong reducing conditions associated with the biologically active zone are not expected to be observed 100 to 150 feet downgradient of the injection well transect in areas such as monitoring wells LVWPS-U1-MW09B and LVWPS-U1- MW10B. This is because the objective of the carbon substrate injections is to create a biologically active zone in the immediate vicinity of the injection well transect, thereby reducing perchlorate concentrations as groundwater migrates through the transect area. As a result, it is possible that downgradient concentration decreases may be observed without simultaneous increases in organic carbon concentrations. This is a likely scenario for the decreasing concentration trends observed in groundwater samples collected from LVWPS-U1-MW09B, where in addition to perchlorate concentration reductions, chlorate concentrations reduced by up to 61 percent, sulfate concentrations reduced by up to 21 percent, and dissolved oxygen concentrations decreased from 1.8 mg/L to 0.74 mg/L immediately following the first injection event and generally remained less than 1.0 mg/L for the six months following the first injection event. With respect to perchlorate concentration decreases observed in groundwater samples collected from LVWPS-U1-MW10B, the lack of a similar geochemical response as observed in the vicinity of LVWPS-U1-MW09B may indicate that the moderate reductions in perchlorate concentrations in groundwater samples collected from monitoring well LVWPS-U1-MW10B are in part due to natural fluctuations.</p> <p>In acknowledgement of the above discussion, the following sentence will be added to Section 6.7.1.1.2 of the Results Report regarding LVWPS-U1-MW10B: “However, geochemical data in groundwater collected from LVWPS-U1- MW10B suggest that these reductions could be attributed to natural fluctuations, which can be expected due to this monitoring well being located approximately 150 feet downgradient of the injection well transect.”</p>	<p><i>The proposed added language addresses the comment on the possibility that all changes are not due to biodegradation but does not address the misleading use of maximum decreases rather than ranges. It is still recommended that ranges are used.</i></p>	<p>As discussed in earlier responses, all results sections will be reviewed to confirm that text presenting ranges of concentrations is included in each discussion. In areas where this level of detail is not provided, additional text will be added as required. Additionally, new tables will be provided that include presentation of perchlorate concentration reductions on a well-by-well basis for each sampling event, with a summary of the minimum, maximum, and average concentration reductions.</p>

NDEP Comment (9/26/24)	Response to Comment	NDEP Comment (1/9/25)	Response to Comment
<p><b>Essential Correction 11. Sections 6.7.1.2, 7.7.1.2, and 8.7.1.2 - Estimation of Perchlorate Distribution</b></p> <p><i>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.</i></p> <p><i>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.</i></p> <p><i>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.</i></p>	<p>As described in the response to Fatal Flaw #1, the purpose of the injection well transect was to create a continuous biologically active treatment zone in the immediate vicinity of the injection wells for perchlorate concentrations to reduce as groundwater migrates through the biologically active zone. Results from the Pilot Study indicated sustained degradation both within the immediate vicinity and downgradient of the injection well transects, the extent to which is primarily dependent on the subsurface lithology and hydrogeologic controls. Due to the short injection well transect lengths installed in targeted lithologies combined with a limited study duration, areas located farther downgradient of the injection well transects contained groundwater that has migrated into the study areas without passing directly through the biologically active zone. As such, this limits the extent of farther downgradient treatment that can be observed as part of this small-scale Pilot Study.</p> <p>The comment suggests that injection activities may have reduced the porosity of the aquifer and upgradient groundwater flows around the injection area instead of through it. In acknowledgement of the importance of the potential reduced aquifer porosity following multiple ISB injections, the Seep Well Field (SWF) Area Bioremediation Treatability Study evaluated this component to provide operational data for review during technology evaluation of an ISB remedy during the forthcoming FS. With specific regard to this Pilot Study, an extensive evaluation of potential changes to aquifer permeability was performed as part of this pilot study, with results summarized in Sections 6.3, 6.6, 7.3, 7.6, 8.3, and 8.6 of the Results Report, as well as Appendix G – Slug Testing Technical Memorandum. As part of this evaluation, three post-injection slug testing events were performed on 26 monitoring wells in June/July 2021, January 2022, and June/July 2022 to evaluate potential changes to hydraulic conductivity resulting from carbon substrate injections. The mean hydraulic conductivities observed during post-injection testing were the same order of magnitude as the baseline for 25 of the 26 monitoring wells. Additionally, groundwater levels were gauged on a quarterly basis during the Pilot Study, and these subsequent synoptic groundwater level gauging events performed during the effectiveness monitoring period indicated groundwater flow direction generally remained consistent over time with the baseline October 2020 conditions. Lastly, the alluvium, UMCf, and UMCf-cg continued to accept multiple substrate injections with relatively minor increases in injection pressures indicating that the subsurface continued to be amenable to periodic injections of EVO. The SWF Area Bioremediation Treatability Study also evaluated periodic injection well maintenance techniques to maintain long-term injectability during implementation of ISB. Therefore, while NDEP’s concern is valid, a real-world scenario where upgradient groundwater flows around the injection area instead of through it due to reduced porosity is unlikely given the data collected to date through multiple treatability and pilot studies that would be used to properly design a full-scale ISB remedy if selected as part of NERT’s final remedy.</p> <p>With respect to NDEP’s comment regarding whether or not biodegradation in the downgradient study area is critical, text in Sections 6.7.1.2, 7.7.1.2, and 8.7.1.2 of the Results Report explains the likely reasons for the lack of significant active biodegradation in groundwater samples collected from farther downgradient monitoring wells and why the data collected is sufficient to meet the Pilot Study objectives. For example, Section 6.7.1.2 states: “Some areas within the treatment zone had less reduction in perchlorate concentrations, which is likely due to the heterogeneous nature of the subsurface, localized preferential flow paths due to laterally discontinuous sand beds and secondary porosity generated by faulting, and groundwater that did not flow through the relatively short injection well transect migrating into farther downgradient portions of the Zone 1 study area. While acknowledging that the design of the Pilot Study was compact and specific to meet the study objectives, the design of a full- scale remedy -would be significantly different, and if implemented full-scale, the injection well transect would likely extend across a much larger distance and potentially include multiple injection well transects to achieve a more uniform biologically active treatment zone.”</p> <p>The following text will be added to Sections 6.7.1, 7.7.1, and 8.7.1 to clarify that robust, active reductive biodegradation in farther downgradient wells was not critical to the evaluation of this Pilot Study:</p> <p>“This monitoring program included monitoring wells located at significant distances downgradient of the injection well transect, where concentration reductions may be minimal due to the limited study duration and short injection well transect length that likely results in migration of groundwater into the study area that did not pass directly through the biologically active zone. As such, this limits the extent of farther downgradient treatment that can be observed as part of this small-scale Pilot Study.”</p>	<p><i>It is acknowledged that potential changes to aquifer permeability were examined in this study and the proposed added text will be a helpful addition to the report. Further analysis using the information about permeability and groundwater flow to explain why perchlorate concentrations did not decrease away from the treatment zone as would be expected would be an additional useful addition to the study.</i></p>	<p>In addition to overarching text describing expected ISB effectiveness at farther downgradient locations as discussed in other responses, Sections 6.7.1.2, 7.7.1.3, and 8.7.1.2 will also be updated to include additional information related to the zone-specific hydrogeologic data and how that data supports the resulting perchlorate distribution depictions.</p>

NDEP Comment (9/26/24)	Response to Comment	NDEP Comment (1/9/25)	Response to Comment
<p><b>Essential Correction 12. Sections 6.7.1.3, 7.7.1.3 and 8.7.1.3- Estimation of Mass Removal</b>  <i>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.</i></p> <p><i>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.</i></p> <p><i>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.</i></p>	<p>As explained in response to General Comment 3, a new appendix will be added that provides figures illustrating the location of the transects (i.e., vertical slices) of the EVS model and tables presenting the EVS outputs for perchlorate mass flux calculations.</p> <p>It is agreed that a large initial mass of perchlorate was destroyed immediately following the first injection event, which is consistent with other ISB treatability studies conducted by NERT. However, injection of EVO creates a biologically active zone as the injected EVO coats the soil grains within the injection well transect that continues to support biodegradation of perchlorate migrating into the treatment zone over time. The mass removal rate of 0.13 pounds per day presented in Section 6.7.1.3 of the Results Report was a simple approximation calculated by taking the estimated total perchlorate mass removed during the pilot study and dividing by the time duration of the pilot study of 18 months and not intended to be representative of an average or maximum location-specific first order biodegradation rate attainable during the Pilot Study. As such, the generalized rates for mass destroyed will be removed from the text in Sections 6.7.1.3, 7.7.1.4, and 8.7.1.3 of the Results Report for clarity.</p> <p>The figures provided in Appendix C – Tracer Dye Technical Memorandum represent both qualitative and quantitative detections of tracer dye and therefore, are not intended to be viewed as isoconcentration maps of tracer dye. Depicting detections in both charcoal samplers and groundwater samples provides a more complete representation of dye migration throughout the study areas as tracer dye detections were commonly observed in charcoal samplers but measured below the sample detection limit in the concurrently collected groundwater sample. Because results from the charcoal samplers provide qualitative data related to the presence or absence of tracer dye, quantitative measurements that are associated with detections are not always available. As a result, isoconcentration maps of tracer dye would not present the most complete representation of dye distribution in the subsurface. To provide additional clarity, the following note will be added to the figures in Appendix C of the Results Report:</p> <p>“Idealized plume depicts both qualitative and quantitative data and therefore, is not representative of actual dye concentrations.”</p>	<p><i>No further changes required.</i></p>	<p>Not applicable.</p>
<p><b>Essential Correction 13. Section 6.7.6.2 Page 52. Oxidation Reduction Potential</b>  <i>ORP readings of 24 m V do not seem to be consistent with aerobic conditions as stated in this section. An ORP of 24 mV is fairly anaerobic.</i></p>	<p>As explained in Section 6.7.6.2 of the Results Report, oxidation reduction potential (ORP) readings can be valuable in evaluating the redox conditions in groundwater and ascertain reducing conditions. However, in aquifers with several electron acceptors and redox pairs, such as iron pairs, nitrogen pairs, perchlorate/chlorate/chloride and sulfur pairs, redox measurements may not always be accurate, and inferences from these data should be made cautiously. The combination of slightly positive ORP readings averaging 24 millivolts (mV) combined with dissolved oxygen (DO) readings averaging approximately 2.04 milligrams per liter (mg/L) indicate that aerobic conditions were generally present within the Zone 1 study area prior to injections. The text in Section 6.7.6.2 of the Results Report will be modified as follows:</p> <p>“During the baseline sampling event in October 2020, ORP measurements collected from groundwater in the UMCf averaged 24 millivolts (mV). However, results of samples collected from select monitoring wells during the baseline sampling event indicated aerobic conditions based on DO concentrations, but anaerobic conditions based on ORP measurements (for example, a DO concentration of 3.1 mg/L and ORP measurement of -172.1 mV in the sample collected from LVWPS-U1-MW08B).”</p>	<p><i>No further changes required.</i></p>	<p>Not applicable.</p>

NDEP Comment (9/26/24)	Response to Comment	NDEP Comment (1/9/25)	Response to Comment
<p><b>Essential Correction 14. Section 6.7.6.5 Page 55. Other Parameters</b>  <i>A calculation of whether total N is equal to nitrate as 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.</i></p>	<p>As discussed in Sections 6.7.6.5, 7.7.6.5, and 8.7.6.5 of the Results Report, total nitrogen concentrations in groundwater generally decreased during the Pilot Study when compared to baseline concentrations. Baseline groundwater sampling indicated that on average total nitrogen was primarily comprised of approximately 89% nitrate and 11% total Kjeldahl nitrogen (TKN). As denitrification occurred during the Pilot Study, TKN became the primary component contributing to total nitrogen.</p> <p>An evaluation of whether all losses of nitrogen were due to denitrification would be theoretical given that this is a complex, dynamic system, where nitrogen is only measured in groundwater (not in soil) combined with the conversion of nitrate into nitrogen gases, which was also not measured in this Pilot Study. While NDEP is correct in that the success of ISB could be affected if the system was nutrient limited, through the efforts of four bench-scale studies and three field treatability/pilot studies implemented by NERT at other areas within the RI study area, there is a high level of confidence that due to the high nitrate concentrations in area groundwater, nitrogen should not be a limiting nutrient for bioremediation. Although additional calculations will not be performed based on this explanation, Sections 6.7.6.5, 7.7.6.5, and 8.7.6.5 of the Results Report will be modified to include the following:</p> <p>“Despite the reductions of total nitrogen, high nitrate concentrations in area groundwater combined with the efforts of four bench-scale studies and three field treatability/pilot studies indicate that there is sufficient nitrogen present in the groundwater and therefore, should not be a limiting nutrient for bioremediation.”</p>	<p><i>No further changes required.</i></p>	<p>Not applicable.</p>
<p><b>Essential Correction 15. Section 6.7.6.5 Page 55. Other Parameters</b>  <i>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.</i></p>	<p>Based on the low groundwater flow rates within the UMCf, it is unlikely that phosphorus was washed downgradient. Furthermore, elevated concentrations of phosphorus were not observed in the overlying alluvium. Lastly, phosphorus data collected during the Pilot Study indicated transient increases following both injection events, with the highest phosphorus concentrations observed following the second injection event.</p> <p>Because phosphorus is a key nutrient that could be limiting in the aquifer and gets easily bound (organically and inorganically), particularly due to the presence of high concentrations of calcium, it is helpful to add small doses of phosphorus to the groundwater in order to prevent this nutrient from limiting microbial growth. The patented EOS® PRO EVO product contains minor quantities of phosphorus. However, in order to support initial development of the biologically active zone and acclimation of the microbial community, a phosphate solution was added during the first injection event. As discussed in Sections 5.5.2 and 5.5.3 of the Results Report, the phosphate solution was not added during the second and third injection events because the Phase 1 soil sampling and analyses from the Pilot Study area indicated the presence of bound phosphorus in the subsurface (phosphorus concentrations ranging from 470 milligrams per kilogram [mg/kg] to 1,300 mg/kg). Therefore, while it was deemed necessary to initially add dissolved phosphorus in the first injection event for this macronutrient to not be limiting during the rapid microbial growth expected with EVO addition, it was not required for subsequent injections. This approach also provided effectiveness monitoring data associated with and without injection of a phosphate source. Based on this explanation, no revisions will be made to the Results Report in response to this comment.</p>	<p><i>No further changes required.</i></p>	<p>Not applicable.</p>
<p><b>Essential Correction 16. Section 6.7.7.2 Page 57-58. Analysis of Microbial Results</b>  <i>The MI Reports in Appendix M state that these results are &lt;math&gt;2.5 \times 10^2&lt;/math&gt; cells per bead - in other words ND.</i></p>	<p>The statement in Section 6.7.7.2 of the Results Report will be revised as follows:</p> <p>“Although perchlorate reductase was present at a population of less than <math>2.5 \times 10^2</math> cells per bead, the overall biomass populations during baseline were greater than <math>2.42 \times 10^5</math> cells per bead in both the shallow and deep UMCf.”</p> <p>Additionally, Table J.2 will be revised for clarity.</p>	<p><i>No further changes required.</i></p>	<p>Not applicable.</p>
<p><b>Essential Correction 17. Section 6.7.7.2 Page 57-58. Analysis of Microbial Results</b>  <i>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).</i></p>	<p>As NDEP noted, the perchlorate concentrations had already decreased in groundwater in the vicinity of monitoring wells LVWPS-U1-MW08A and LVWPS-U1-MW08B by the time the post-injection Bio-Traps® were placed in these downgradient monitoring wells. As a result, the microbial sampling likely did not coincide with the proliferation of perchlorate biodegradation. The following text will be added to Section 6.7.7.2 of the Results Report:</p> <p>“Although it did not appear that there was a change in the perchlorate-degrading capability of microorganisms in the aquifer, this is likely because the timing of the microbial sampling did not coincide with the proliferation of perchlorate biodegradation.”</p>	<p><i>No further changes required.</i></p>	<p>Not applicable.</p>

NDEP Comment (9/26/24)	Response to Comment	NDEP Comment (1/9/25)	Response to Comment
<p><b>Essential Correction 18. 7.7.6.2 Page 96. Oxidation Reduction Potential</b>  <i>What is the difference in groundwater chemistry between Zone 1 and Zone 2 (both Alluvium 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?</i></p>	<p>There is very little, if any difference in groundwater chemistry between Zone 1 and Zone 2 (both alluvium and UMCf) known to be controlling ORP changes. The primary difference with respect to more widespread distribution of these anaerobic conditions (i.e., ORP decreases) relates to the differences in the hydrogeologic controls on groundwater flow that resulted in more pronounced preferential flow pathways through the faulted UMCf and into the overlying alluvium downgradient in Zone 1 compared to Zone 2. Sections 6.4, 6.5, 6.6, 6.7, and 6.8 of the Results Report discuss the presence of preferential pathways in Zone 1 that supports this conclusion.</p> <p>As discussed in the response to Essential Correction 17, the perchlorate concentrations had already decreased in groundwater in the vicinity of monitoring wells LVWPS-U1-MW08A and LVWPS-U1-MW08B by the time the post-injection Bio-Traps® were placed in these downgradient monitoring wells. As a result, the microbial sampling likely did not coincide with the proliferation of perchlorate biodegradation. Based on this explanation, no revisions will be made to the Results Report in response to this comment.</p>	<p><i>No further changes required.</i></p>	<p>Not applicable.</p>
<p><b>Essential Correction 19. Section 7.7.7.1 Page 101. Analysis of Microbial Results</b>  <i>The MI Reports in Appendix M state that the baseline results are &lt;2.5 x 10<sup>2</sup> cells per bead - in other words ND.</i></p>	<p>The statement in Section 7.7.7.1 of the Results Report will be revised as follows:</p> <p>“Although perchlorate reductase was present at a population of less than 2.5x10<sup>2</sup> cells per bead in the shallow and deep alluvium and UMCf, the overall biomass populations during baseline ranged from 6.2x10<sup>4</sup> cells per bead to 1.13x10<sup>5</sup> cells per bead.”</p> <p>Additionally, Table J.2 of the Results Report will be revised for clarity.</p>	<p><i>No further changes required.</i></p>	<p>Not applicable.</p>
<p><b>Essential Correction 20. Section 7.7.7.1 Page 101. Analysis of Microbial Results</b>  <i>Text is misleading. For Zone 2 wells, 3 out of 6 wells monitored remained at ND levels for perchlorate reductase.</i></p>	<p>Text in Section 7.7.7.1 of the Results Report only discusses the three downgradient monitoring wells and increases to perchlorate reductase because the other three results relate to upgradient monitoring wells where no notable increases in perchlorate reductase were expected or observed during the Pilot Study. The following statements will be added to the second and fourth paragraphs in Section 7.7.7.1 of the Results Report for clarity:</p> <p>“As expected, perchlorate reductase generally remained below 2.5x10<sup>2</sup> cells per bead in samples collected from upgradient monitoring wells LVWPS-A2-MW01A and LVWPS-A2-MW01B during the Pilot Study.”</p> <p>“As expected, perchlorate reductase remained below 2.5x10<sup>2</sup> cells per bead in samples collected from upgradient monitoring well LVWPS-U2-MW01 during the Pilot Study.”</p>	<p><i>No further changes required.</i></p>	<p>Not applicable.</p>
<p><b>Essential Correction 21. Section 8.7.1.1 Page 117. Table 7. Perchlorate Degradation</b>  <i>How is it possible for the max reduction to be 99% when the average is 2% and there are only 5 wells.</i></p>	<p>As described in response to Essential Correction 9, notes will be added to Table 7 to explain the calculation process.</p> <p>Additionally, the number of monitoring wells within this category in Table 7 will be corrected to indicate a total of nine monitoring wells, which includes the four monitoring wells located approximately 50 feet downgradient of the injection well transect (LVWPS-U3-MW02A, LVWPS-U3-MW02B, LVWPS-U3-MW06A, and LVWPS-U3-MW06B) and five monitoring wells located approximately 100 feet downgradient of the injection well transect (LVWPS-U3-MW10A, LVWPS-U3-MW10B, LVWPS-U3-MW11A, LVWPS-U3-MW11B, and LVWPS-U3-MW11C). When using the data from all nine monitoring wells, the average reduction is 2%.</p>	<p><i>No further changes required.</i></p>	<p>Not applicable.</p>
<p><b>Essential Correction 22. Section 8.7.4 Page 124 Bullet 1. Total Organic Carbon</b>  <i>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?</i></p>	<p>Section 8.7.4 of the Results Report presents a summary of the increases in total organic carbon (TOC) concentrations to provide information related to where the carbon substrate was distributed in the subsurface during the Pilot Study. Discussion of the other three monitoring wells located 25 feet downgradient of the injection well transect was not included because significant increases in TOC concentrations were not observed in samples collected from these wells. In response to this comment, the following additional text will be added to Section 8.7.4 of the Results Report:</p> <p>“No notable TOC concentration increases were reported in samples collected from the remaining three downgradient monitoring wells located approximately 25 feet downgradient (i.e., LVWPS-U3-MW03A, LVWPS-U3-MW03C, and LVWPS-U3-MW13A). These results illustrate that the carbon substrate solution traveled farther downgradient within the coarser, higher hydraulic conductivity subsurface materials of the deeper UMCf-cg.”</p>	<p><i>No further changes required.</i></p>	<p>Not applicable.</p>

NDEP Comment (9/26/24)	Response to Comment	NDEP Comment (1/9/25)	Response to Comment
<p><b>Essential Correction 23. Section 8.7.7.2 Page 131. Analysis of Microbial Results</b>  <i>The MI Reports in Appendix M state that the baseline results are &lt;math&gt;2.5 \times 10^2&lt;/math&gt; cells per bead - in other words ND.</i></p>	<p>There is not a Section 8.7.7.2 in the Results Report. Based on previous comments herein, it is likely NDEP was referring to Section 8.7.7.1. The statement in Section 8.7.7.1 of the Results Report will be revised as follows:            “Although perchlorate reductase was present at a population of less than <math>2.5 \times 10^2</math> cells per bead, the overall biomass populations during baseline were greater than <math>8.16 \times 10^4</math> cells per bead in both the shallow and deep UMCf-cg.”            Additionally, Table J.2 of the Results Report will be revised for clarity.</p>	<p><i>No further changes required.</i></p>	<p>Not applicable.</p>
<p><b>Essential Correction 24. Section 8.7.7.2 Page 131. Analysis of Microbial Results</b>  <i>It is not stated that for 2 out of 4 wells perchlorate reductase results remained at ND levels.</i></p>	<p>There is not a Section 8.7.7.2 in the Results Report. Based on previous comments herein, it is likely that NDEP was referring to Section 8.7.7.1. Results from the samples collected from three of the four monitoring wells indicated increases in perchlorate reductase, which is described in Section 8.7.7.1. Minor text revisions to Section 8.7.7.1 of the Results Report will be made to improve clarity as follows:            “Following injections and approximately a year after the initial injection event, perchlorate reductase increased by one order of magnitude (increase from <math>10^2</math> to <math>10^3</math>) in the sample collected from monitoring well LVWPS-U3-MW08B. Additionally, perchlorate reductase increased by two orders of magnitude (increase from <math>10^2</math> to <math>10^4</math>) in the sample collected from LVWPS-U3-MW13B and three orders of magnitude (increase from <math>10^2</math> to <math>10^5</math>) in the sample collected from LVWPS-U3-MW08A. No increases were observed in perchlorate reductase in samples collected from monitoring well LVWPS-U3-MW13A.”</p>	<p><i>No further changes required.</i></p>	<p>Not applicable.</p>
<p><b>Essential Correction 25. Section 10.0 pages 137-138. Surface Water Monitoring</b>  <i>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).</i></p>	<p>As discussed in Section 10.0 of the Results Report, low concentrations of tracer dye (visually imperceptible) were observed in samples collected from downgradient alluvial monitoring wells and the Las Vegas Wash due to upflux of groundwater from underlying UMCf in Zone 1. Although isolated low concentrations of tracer dye were detected, TOC concentrations in surface water samples remained at baseline levels throughout the Pilot Study timeframe with one notable exception. Text in Section 10.0 of the Results Report explains the following:            “Lastly, TOC was monitored throughout the Pilot Study to monitor for potential TOC increases in the Wash following injections. TOC concentrations were measured during baseline at concentrations less than 5.0 mg/L and remained at these levels following injections. One notable exception was the significant increases in TOC concentrations during the July 2021 sampling event, with concentrations ranging from 13 mg/L to 33 mg/L in all samples collected from LVW4.2-1 through LVW5.3-1, which includes areas both upstream and downstream of the Pilot Study area. During this sampling event, perchlorate concentrations were also unusually high at multiple locations within the Wash. Per the 2021 Semi-Annual Performance Memorandum (Ramboll, 2022), it was concluded that these increases were potentially associated with Fourth of July fireworks and a low-intensity rain event throughout the Las Vegas Valley from July 12 to July 13, 2021.”            NDEP is correct in that the injection of large amounts of TOC in an area immediately upgradient of the Las Vegas Wash has the potential to migrate into surface water and therefore, this was considered in the design of the Pilot Study and discussed during the underground injection control (UIC) permitting process with NDEP – Bureau of Water Pollution Control. This will be an important design consideration during remedy design if ISB is selected as a component to the NERT final remedy. Based on this explanation, no revisions will be made to the Results Report in response to this comment.</p>	<p><i>No further changes required.</i></p>	<p>Not applicable.</p>
<p><b>Essential Correction 26. Section 10.0 pages 137-138. Surface Water Monitoring</b>  <i>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?</i></p>	<p>The small-scale pilot study was not designed to treat the NERT downgradient plume impacting mass loading to the Las Vegas Wash. Evaluating perchlorate loading in the Las Vegas Wash and effectiveness of a theoretical full-scale ISB system is outside the scope and objectives of this Pilot Study. As explained throughout the Results Report and in the introduction to this Response to Comments matrix, this Pilot Study was designed to meet a well-defined set of objectives intended to provide key information needed for the FS to more accurately evaluate an ISB remedial approach to achieve future design objectives developed during the FS. Based on this explanation, no revisions will be made to the Results Report in response to this comment.</p>	<p><i>No further changes required.</i></p>	<p>Not applicable.</p>
<p><b>Essential Correction 27. Appendix J Table J.2.</b>  <i>Table needs to be corrected to indicate that the <math>2.5 \times 10^2</math> values are ND.</i></p>	<p>Table J.2 of the Results Report will be updated for all entries of <math>2.5 \times 10^2</math> to less than <math>2.5 \times 10^2</math>.</p>	<p><i>No further changes required.</i></p>	<p>Not applicable.</p>

NDEP Comment (9/26/24)	Response to Comment	NDEP Comment (1/9/25)	Response to Comment
<p><b>Essential Correction 28. Appendix L</b>  <i>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.</i></p>	<p>For ease of review, Appendix L – Concentration Trends for Effectiveness Monitoring Wells will be reorganized to be grouped by treatment zone and location within each treatment zone (e.g., upgradient monitoring wells within Zone 1).</p>	<p><i>No further changes required.</i></p>	<p>Not applicable.</p>
<b>Minor Corrections</b>			
<p><b>Minor Correction 1. Section 3.2 Page 9, Paragraph-5. Hydrogeology</b>  <i>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?</i></p>	<p>No, the text is correct. The unconsolidated UMCf in the western portion of the study area is being compared to the unconsolidated UMCf-cg near the fault zone in the eastern portion of the study area discussed in the next sentence. The text will be revised slightly for clarity as follows:           “In the western portion of the Pilot Study area, the unconsolidated UMCf had an average hydraulic conductivity of approximately 1 ft/day. In the eastern portion of the Pilot Study area below the alluvium near the fault zone adjacent to the bedrock outcrop, the UMCf-cg had an average hydraulic conductivity of 6 ft/day.”</p>	<p><i>No further changes required.</i></p>	<p>Not applicable.</p>
<p><b>Minor Correction 2. Section 5.6.3 Page 24 Paragraph 1. Slug Tests</b>  <i>Falling-head tests cannot be performed by the "insertion or removal" of a slug, just the insertion.</i></p>	<p>Text will be revised to remove “or removal”.</p>	<p><i>No further changes required.</i></p>	<p>Not applicable.</p>
<p><b>Minor Correction 3. Section 6.2.1. Injection Wells</b>  <i>This section mentions 8 injection wells in Zone 1. Correct to state that this is 8 nested injection well pairs - to avoid confusion.</i></p>	<p>Text in Section 6.2.1 of the Results Report will be revised as follows:           “As presented in the Work Plan Addendum, the injection well transect within the Zone 1 study area was designed to be approximately 200-foot long, consist of nested injection wells at eight locations spaced approximately 25 feet apart and screened within the UMCf, and oriented perpendicular to groundwater flow.”</p>	<p><i>No further changes required.</i></p>	<p>Not applicable.</p>
<p><b>Minor Correction 4. Section 6. 7.1.1 Table 4. Page 39. Perchlorate Degradation</b>  <i>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.</i></p>	<p>While NDEP’s perspective on this matter is understood, the presentation of concentration reductions as negative percentages is consistent with previous NDEP-approved treatability study reports. As such, no changes to the negative signs in the tables will be made in response to this comment. However, the introductory text in Section 6.7.1.1 of the Results Report will be updated to include the following:           “Increases in perchlorate concentrations relative to baseline concentrations are represented as positive percentages, while decreases in perchlorate concentrations relative to baseline concentrations are represented as negative percentages.”           The same text will be added to Sections 7.7.1.1, 7.7.1.2, and 8.7.1.1 of the Results Report.</p>	<p><i>No further changes required.</i></p>	<p>Not applicable.</p>
<p><b>Minor Correction 5. Section 7.7.6.5 Page 100. Other Parameters</b>  <i>(Also Page 129) "Groundwater is undergoing biodegradation" change to "Biodegradation is occurring in the groundwater".</i></p>	<p>Text in Section 7.7.6.5 of the Results Report will be revised as follows:           “These increases in groundwater alkalinity of more than twice the baseline concentrations indicated that biodegradation is occurring in groundwater.”</p>	<p><i>No further changes required.</i></p>	<p>Not applicable.</p>
<p><b>Minor Correction 6. Section 7.7.7.2 Page 101. Analysis of Microbial Results</b>  <i>States that concentration of 5.3x10<sup>3</sup> cells per bead in samples collected from deep alluvial monitoring well LVWPS-A2-MW14B. Number from MI report is 3.2 x 10<sup>3</sup></i></p>	<p>As shown in Table J.2, the concentration of perchlorate reductase in samples collected from monitoring well LVWPS-A2-MW14B increased from less than 2.5 X 10<sup>2</sup> cells per bead in November 2020 (prior to injections) to 3.2 x 10<sup>3</sup> cells per bead in October 2021 after injections. However, the perchlorate reductase concentration in the sample collected in April 2022 from monitoring well LVWPS-A2-MW14B further increased to 5.3x10<sup>3</sup> cells per bead. Based on this explanation, no revisions will be made to the Results Report in response to this comment.</p>	<p><i>No further changes required.</i></p>	<p>Not applicable.</p>