OFFICE OF THE NEVADA ENVIRONMENTAL RESPONSE TRUST TRUSTEE

Le Petomane XXVII, Inc., Not Individually, But Solely as the Nevada Environmental Response Trust Trustee
35 East Wacker Drive - Suite 690
Chicago, Illinois 60601
Tel: (702) 960-4309

August 17, 2022

Dr. Weiquan Dong, P.E.
Bureau of Industrial Site Cleanup
Nevada Division of Environmental Protection
375 E. Warm Springs Road, Suite 200
Las Vegas, Nevada 89119

RE: Seep Well Field Area Bioremediation Treatability Study
2021 Annual Progress Report
Nevada Environmental Response Trust
Henderson, Nevada

Dear Dr. Dong:

The Nevada Environmental Response Trust (NERT) is pleased to present the 2021 Annual Progress Report for the ongoing Seep Well Field Area Bioremediation Treatability Study for Nevada Division of Environmental Protection (NDEP) review. In addition, an annotated response-to-comments is provided addressing NDEP's comments dated November 17, 2021 on the 2020 Annual Progress Report.

If you have any questions or concerns regarding this matter, feel to contact me at (702) 960-4309 or at steve.clough@nert-trust.com.

Office of the Nevada Environmental Response Trust

Stephen R. Clough

Stephen R. Clough, P.G., CEM
Remediation Director
CEM Certification Number: 2399, exp. 3/24/23

Cc (via NERT Sharefile Distribution):

Jeff Kinder, NDEP, Deputy Administrator
Frederick Perdomo, NDEP, Deputy Administrator
James Dotchin, NDEP, Chief, Bureau of Industrial Site Cleanup
Carlton Parker, NDEP, Bureau of Industrial Site Cleanup
Alan Pineda, NDEP, Bureau of Industrial Site Cleanup
Danielle D. Ward, NDEP, Bureau of Industrial Site Cleanup
William Frier, U.S. Environmental Protection Agency, Region 9
Mark Duffy, U.S. Environmental Protection Agency, Region 9
Jay Steinberg, as President of the Nevada Environmental Response Trust Trustee and not individually
Andrew Steinberg, as Vice President of the Nevada Environmental Response Trust Trustee and not individually
Brian Loffman, Le Petomane, Inc.
Tanya C. O'Neill, Foley and Lardner, LLP
Dan Peterson, Ramboll

Chris Stubbs, Ramboll
Kim Kuwabara, Ramboll
David Bohmann, Tetra Tech
Dana Grady, Tetra Tech

Cc (via NERT Stakeholder Sharefile Distribution):

Betty Kuo, Metropolitan Water District of Southern California
Carol Nagai, Metropolitan Water District of Southern California
Christene Klimek, City of Henderson
Christine Nobles, Central Arizona Project
Daniel Chan, LV Valley Water District
Dave Johnson, LV Valley Water District
Deena Hannoun, Southern Nevada Water Authority
Eric Fordham, Geopentech
Jill Teraoka, Metropolitan Water District of Southern California
Katherine Callaway, Central Arizona Project
Laura Dye, Colorado River Commission
Marcia Scully, Metropolitan Water District of Southern California
Maria Lopez, Metropolitan Water District of Southern California
Mauricio Santos, Metropolitan Water District of Southern California
Mickey Chaudhuri, Metropolitan Water District of Southern California
Orestes Morfin, Central Arizona Project
Steven Anderson, LV Valley Water District
Todd Tietjen, Southern Nevada Water Authority

Cc (via NERT BMI Companies Sharefile Distribution):

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Kirk Stowers, Broadbent Inc.
Kristen Lockhart, Neptune Inc.
Kurt Fehling, The Fehling Group
Patti Meeks, Neptune Inc.
Paul Black, Neptune Inc.
Chinny Esakkiperumal, Olin Corporation
Chuck Elmendorf, Stauffer
Curt Richards, Olin Corporation
Dave Share, Olin Corporation
Ebrahim Juma, Clark County Water Quality
Ed Modiano, de maximus
Jeff Gibson, Endeavour LLC
Joe Kelly, Montrose Chemical
Joe Leedy, Clark County Water Quality
John Solvie, Clark County Water Quality
Kevin Lombardozzi, Valhi
Lee C. Farris, Landwell
Mark Paris, Landwell
Nick Pogoncheff, PES Environmental, Inc.
Ranajit Sahu, BRC
Richard Pfarrer, TIMET
Roy Thun, GHD
Keenan Sanders, EMD
Sonnia Lewandowski, EMD

NDEP Comment	Response to Comment
1. NDEP suggest an adjustment of the frequency of monitoring of these parameters as suggested in Section 5 .3 of the report because minimal changes in concentrations of sulfide, ferrous iron and metals have been observed during the study.	We concur. In accordance with Section 5.3 of the Seep Well Field Area Bioremediation Treatability Study 2020 Annual Progress Report, the monitoring frequency for sulfide and ferrous iron was reduced from quarterly to semi-annual, and the monitoring frequency for metals was reduced from semi-annual to annual during the 2021 and 2022 reporting periods.
2. Section 2.1.3: Injection Well Performance Page 5. This section states that different injection effectiveness was observed at wells SWFTS-IW12 and SWFTS-IW15 between the injection of EOS Pro solution and the injection of distribution water likely due to the viscosity of the EOS Pro solution. Currently a fairly concentrated solution of EOS Pro (4 parts water to 1 part EOS) is injected. This is more concentrated than the typical 9 parts water to 1 part EOS commonly injected. NERT may consider injecting a more dilute EOS solution and keeping the total amount of water injected the same or even reduced.	A variable ratio of emulsified vegetable oil (EVO):water will be considered in the design of potential future injection applications in connection with NERT's final remedy since this treatability study will be ceased at the end of 2022. Injectate solution for all eight SWFTS injection events performed to date has been mixed at a ratio of 1:4 parts of EOS® Pro:extracted groundwater. There are advantages and practical limitations of varying the ratio of EVO:water. The critical aspect for treatment is to inject a pre-designated targeted total quantity of injected fluids to maximize the radius of influence of the injection well. Research studies performed on EOS® distribution have indicated that increasing the injection flow rate or diluting the oil with more water will have little effect on final oil distribution in the aquifer (Borden, Effective Distribution of Emulsified Edible Oil for Enhanced Anaerobic Bioremediation," *Elsevier Journal of Contaminant Hydrology 94, 2007*, www.sciencedirect.com). As a result, the only factors that significantly influence the final oil distribution are: (1) the total amount of oil injected and (2) the total amount of water injected. Secondly, from a practical/logistical point of view, it is prudent to first complete injection of all the carbon substrate (EVO) solution at the lowest ratio that is practical of 1:4 parts of EOS® Pro: extracted groundwater (which has worked quite successfully thus far) followed by the injection of distribution water. This is particularly true given the large quantities of EVO required for the hydrogeologic setting of this study (i.e., high permeability sediments with high groundwater flow rates associated with a paleochannel). Lastly, as noted in Section 2.1.3, injection well maintenance was performed for the first-time on injection well SWFTS-IW15 in February 2021, which significantly improved injections rates. Specifically, the average injection rate during the seventh injection event performed in February/March 2021 was 11 gallons per minute (gpm) compared to the previous sixth injection event in May/June 2020 that had an average injection rate of 6.9 gpm.

NDEP Comment	Response to Comment
3. Section 2.3: Evaluation of Injection Frequency Page 6. Please provide the criteria used to determine when an additional injection is required. Note that increasing the dose of EOS Pro may result in a decreased need for injections. EOS Pro can last up to 2 years in the subsurface.	Consistent with the NDEP-approved Treatability / Pilot Study Modification No. 6, timeframes between injection events are being evaluated as part of this extended treatability study. Although the major trigger for determining the injection frequency during this study is the overall increase in perchlorate concentrations, groundwater concentrations of chlorate and nitrate as well as geochemical indicator parameters (such as dissolved oxygen and oxidation reduction potential) are also regularly evaluated to determine the need for additional injections. In addition, contamination concentration plume maps have been regularly generated to compare plume changes over time. Because this is a treatability study and not a full-scale remedy, groundwater monitoring data will continue to be evaluated in 2022 to establish a relationship between contaminant concentrations and the requirement for EVO injections, which will provide valuable data for NERT's future evaluations of the ISB technology. With regards to dosing of EOS® Pro, as discussed in responses to previous reports for this study, adding larger quantities of substrate as suggested could potentially be problematic at this site. Bench-scale column studies performed by UNLV using site-specific soil and groundwater indicated that higher quantities of carbon substrate did not result in greater longevity under these high groundwater flow conditions. Furthermore, given the high concentrations of sulfate in this aquifer, increasing substrate quantities could also result in unwanted secondary impacts such as increased sulfate reduction, excessive biomass growth, and precipitation.
4. Section 3.2: Injection Well Maintenance Activities Page 9. The products Aqua Clear MGA and Aqua Clear AE were used to clean the wells that showed decreased injection rates. Aqua Clear MGA contains acids for scale removal and Aqua Clear AE is formulated to break down bacterial slime contamination from iron related and sulfate reducing bacteria. Neither of these products is optimal for the breakdown of calcium oleate which is the material thought to be clogging the wells. Some success has been shown in using ethyl lactate to dissolve oleate clogging wells. NERT may consider the use of an organic material such as ethyl lactate to dissolve the organic material clogging the well in the future.	To date, a variety of well cleanup and rehabilitation procedures have been successfully employed at NERT. Thus far, the preference from both a technical and cost effectiveness standpoint is to employ physical mechanisms and, if needed, typical industry-available chemical reagents, generally acids to dissolve precipitated materials. Aqua Clear MGA and Aqua Clear AE have both been successful in restoring injection well performance. The option of using ethyl lactate for injection wells that accumulate excessive calcium oleate could be considered in future applications when other traditionally accepted techniques for well rehabilitation are not effective. Ultimately, the most cost effective well maintenance activity that has been proven to resolve the encountered issues will be implemented.

NDEP Comment	Response to Comment
5. Section 4.2.1.1: Perchlorate Degradation Response Page 14. Well SWFTS-MW12 inadvertently received a large amount of EOS raising the total organic carbon in this well to greater than 600 mg/L in 2019 which resulted in perchlorate, chlorate and nitrate all being reduced to non-detect levels. This reduction is greater than that observed in the wells targeted by the treatment which received a much smaller dose of EOS and demonstrates the effectiveness of a larger dose of EOS. Similarly, at well SWFTS-MW14 high TOC values were observed in 2018 and 2019 and perchlorate and nitrate were at non-detect levels. Concentrations started to rebound once TOC concentration dropped below 5 mg/L in 2020. NERT may consider a larger EOS dose in future.	The arrival of injectate solution at SWFTS-MW12, as indicated by increased TOC concentrations, resulted from a combination of extraction from SWFTS-MW12 and an increase in injection rates and pressures during the fifth injection event encouraging upgradient flow along a preferential pathway beyond the expected radial upgradient flow, as described in Section 4.2.1.1. Therefore, injection of higher doses of EOS® Pro will not necessarily increase TOC concentrations at nearby monitoring wells in the same way. Additionally, TOC concentrations at levels this high are typical of groundwater samples collected directly from an injection well and are not representative of concentrations that would be targeted for nearby and downgradient monitoring wells. As discussed in previous responses, increasing substrate concentrations could also result in unwanted secondary impacts such as overconsumption of carbon substrate, increased sulfate reduction, excessive biomass growth, and precipitation. Groundwater samples collected from SWFTS-MW12 indicate that when TOC concentrations were elevated in 2019, sulfate reduction was observed as concentrations reduced from 2,800 mg/L to 2.6 mg/L.
6. Section 4.2.1.1: Perchlorate Degradation Response Page 14. This section discusses the delayed and modest response of well SWFTS-MW15 to the injections and the reasons for this response. It should be noted that no increase in TOC is observed at this well until July 2020 at which point the concentrations of perchlorate and chlorate start to decrease.	As discussed in responses to previous reports associated with this study, the option to install an additional injection well to promote a better response of perchlorate degradation in groundwater in the vicinity of SWFTS-MW15 was considered in 2018. However, because this is a treatability study, and not final remedy, this modification was deemed not necessary as the study has demonstrated that perchlorate concentrations in groundwater can be reduced to below laboratory detection limits via the injection of a carbon substrate into injection wells and the study is being continued to primarily focus on long-term operation and maintenance. If the technology were implemented in full-scale, additional injection wells would definitely be one option to "fill in the biological" gaps if a similar phenomenon is observed. Following the third injection event, groundwater samples collected from SWFTS-MW15 in 2018/2019 indicated perchlorate concentration reductions similar to those observed in August 2020. However, during the 2018/2019 sampling events, TOC concentrations were not elevated and typically ranged from 1.8 to 3.5 mg/L. Therefore, TOC concentrations in groundwater samples collected from downgradient monitoring wells may not necessarily correlate with perchlorate concentration reductions at these locations. For transect-type biobarriers, it is more important to retain the substrate/TOC in the vicinity of the injection wells rather than transport the carbon downgradient with groundwater flow. In this manner, perchlorate concentrations in groundwater are reduced within the transect vicinity as groundwater flows past the injection well transect(s).

NDEP Comment	Response to Comment
7. Section 4.2.5.1.2 pH. Please explain the mechanism by which the natural gypsum in the aquifer buffers the reduction in pH in groundwater that can be caused by biological activity in next annual report.	The natural gypsum in the subsurface contains calcium, which generally results in a more alkaline groundwater system. Discussion of the buffering capacity will be included in the 2022 Annual Progress Report.
8. Section 5.3: Future Activities Page 31. The use of less distribution water is discussed in this section. NDEP concurs with this plan, but also suggests that this is coupled with the injection of a more dilute solution of EOS Pro.	The seventh and eighth injection events performed in February and November 2021 (discussed in the 2021 Annual Progress Report) included the same quantity of injectate and distribution water as previous events. A reduced distribution of water and/or a more dilute solution of EVO:water will be considered in the design of potential future injection applications in connection with NERT's final remedy.
9. Section 5.3: Future Activities Page 31. The elimination of phosphate from the injection solution is discussed, however dissolved phosphorus concentrations in groundwater were generally below the sample detection limit throughout the reporting period. Phosphate may, therefore, become limiting to biodegradation and it is recommended that the addition of phosphate is continued.	As discussed in Section 4.2.5.3, dissolved phosphorus concentrations in groundwater were generally below the sample detection limit throughout the reporting period, which indicates that the augmented phosphorus was likely used as a nutrient, adsorbed to the soil, or combined with cations such as calcium, rather than increasing its concentration in groundwater. Because EOS® PRO is already formulated with macronutrients, namely phosphorus, only a nominal quantity of additional phosphate was added to the injectate solution. As the focus of the extended study is to evaluate long-term operations and maintenance requirements, examination of the aquifer response following an injection event without the inclusion of phosphorus was not integral to Treatability / Pilot Study Modification No. 6 but could be an additional data point for evaluation of potential future injection applications in connection with NERT's final remedy. As a result, other ISB pilot studies performed at NERT have included injections both with and without phosphorus, which has provided sufficient data to evaluate the necessity of phosphate in the injectate solution for potential future ISB applications at NERT.