OFFICE OF THE NEVADA ENVIRONMENTAL RESPONSE TRUST TRUSTEE

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November 12, 2019

Dr. Weiquan Dong, P.E.
Bureau of Industrial Site Cleanup
Nevada Division of Environmental Protection
2030 E. Flamingo Road, Suite 230
Las Vegas, NV 89119

RE: Las Vegas Wash Bioremediation Pilot Study Work Plan Addendum
Nevada Environmental Response Trust
Henderson, Nevada

Dear Dr. Dong:

As you are aware, the Nevada Environmental Response Trust (NERT or the "Trust") began implementation of the Las Vegas Wash Bioremediation Pilot Study in March 2018, limited to the Phase 1 pre-design activities as specified in the Las Vegas Wash Bioremediation Pilot Study Work Plan dated September 22, 2017 (Work Plan) and subsequently approved by the Nevada Division of Environmental Protection (NDEP) on October 16, 2017. At the conclusion of the initial Phase 1 scope of work in July 2018, the Trust determined that perchlorate in the Upper Muddy Creek formation (UMCf) was deeper and at higher concentrations than anticipated. Additionally, the presence of deeply incised paleochannels in the pilot study area, thought to be a primary transport mechanism of perchlorate, required additional vertical and horizontal delineation. A Treatability/Pilot Study Modification was submitted to NDEP on August 17, 2018 (Modification No. 2) for the purpose of performing additional aquifer testing and further delineate perchlorate impacts to soil and groundwater in the deeper UMCf, as well as confirm details of this complex geologic/hydrogeologic setting with respect to the paleochannels. Modification No. 2 was approved by NDEP on August 23, 2018 and all field activities specified in the Work Plan and Modification No. 2 were completed in January 2019. Based on the results of the Phase 1 efforts, the Trust directed Tetra Tech to prepare documentation to implement a Phase 2 field program of the study to evaluate the effectiveness of implementing in-situ bioremediation to reduce contaminants present in the alluvium and UMCf that are migrating through this area into the Las Vegas Wash in Operable Unit 3 (OU-3). Due to the unique geologic conditions in this area coupled with the notion that the adjacent reach of the Las Vegas Wash exhibits increased amounts of perchlorate flux, the Trust focused considerable efforts working with its consultants on the objectives and scale of this study to ensure availability of the most appropriate and necessary data to inform the Feasibility Study and associated remedy selection process for OU-3. Upon finalization of the Phase 2 project scope, the Trust directed Tetra Tech to prepare a Work Plan Addendum and Phase 2 Cost Estimate and Basis document for final review by Arcadis, the Trust's third-party subject expert. This review involved a detailed evaluation to ensure the following with respect to the proposed Phase 2 scope of work:

1. Implementability;
2. Scope is commensurate with the study's objectives; and,
3. Costs are commensurate with the scope of work.

Arcadis submitted its final Review and Comment memorandum **(Attachment A)** to NERT on September 24, 2019. The attached Work Plan Addendum **(Attachment B)** and Phase 2 Cost Estimate and Basis **(Attachment C)** represent revised documentation to the satisfaction of both Arcadis and the Trust.

Although the final evaluation performed by Arcadis resulted in the comments as detailed in Attachment A, Arcadis concluded that through the collaborative efforts of all parties in 2019 to refine project scope and budget, the study is implementable, the scope is commensurate with the study's objectives, and the costs are commensurate with the scope of work. The attached final comments are principally optimization and performance recommendations with respect to the dye tracer test, which should provide valuable data to inform remedial design. While Attachments B and C address all comments provided by Arcadis and the Trust through the review process, the following table presents the Trust's response to the Arcadis comments provided in Attachment A.

Arcadis Comment	NERT Response
General Comment No. 1: *Arcadis recognizes and appreciates the addition of Section 5.4.4 (Hydraulic Response), which serves to monitor the overall hydraulic influence of simultaneous injection and extraction. The most robust assessment of hydrogeological parameters possible during implementation of the Las Vegas Wash pilot study is strongly endorsed. Strategically positioning transducers and collecting relevant groundwater extraction data simultaneously with relevant injection data opportunistically provides data to inform other technologies to be evaluated in the feasibility study. Understanding how injection and extraction simultaneously influence the aquifer enables an evaluation of engineered hydraulic flushing of aquifer pore space, which can influence the overall lifecycle of an in situ remedial strategy.*	Comment noted and the Trust concurs that utilizing all available data to evaluate other relevant / applicable technologies is crucial to the Feasibility Study and subsequent remedy selection.

Arcadis Comment	NERT Response
General Comment No. 2: *Arcadis recognizes and appreciates the addition of Appendix I (Injection Well Spacing and Injection Volume Design Summary), which summarizes the calculations and hydraulic modeling used to estimate injection volumes. Effective porosity is a key parameter used to estimate injection volumes and is currently approximated by nuclear magnetic resonance data and experience. The only tool available to directly measure the dual-domain nature of porous media (i.e., the relationship of mobile to immobile pore space) is a tracer study. Developing a rationale to support the injection volumes (e.g., Appendix I) is a necessary first step; however, those injection volumes are then field verified (using a tracer) during the pilot study. The field verification is based on an observed tracer response at strategically placed dose response monitoring wells located at a targeted radius of influence from the injection well. The data quality objectives of the tracer study are carefully designed to ensure the test is implemented until the objectives have been accomplished. Tracer studies significantly optimize injection volumes by empirically verifying those injection volumes previously approximated through multiple lines of hydrogeological data.*	The Trust and Tetra Tech understand the potential benefits as well as the potential risks of inconsistent and/or inconclusive results from tracer testing. Aquifer heterogeneities and the presence of preferential flow pathways can result in the tracer either bypassing a well or entering it only through an isolated interval - as encountered in the tracer studies performed by AECOM as part of the NDEP Downgradient Study Area Investigation. In addition, and because each well will monitor a large saturated thickness, incomplete mixing of the tracer within the well casing could occur, resulting in inconsistent tracer concentrations during sampling. Acknowledging the above, an objective has been added to the dye study for the collection of data associated with effective porosity. To incorporate this into the design, two dose response well clusters have been proposed to be installed within each of the three zones for a total of 18 additional monitoring wells (six well clusters, consisting of three monitoring wells per cluster). These dose response wells will be screened across the same intervals as the injection wells. During the injection process, groundwater from the dose response wells will be monitored using visual observation and commercially available field probes to determine when breakthrough occurs and log the concentrations of dye at specific cumulative injection volumes. Groundwater samples will also be collected for laboratory analysis on a daily basis during active dye injections to confirm the field-measured dye concentrations. Lastly, samples of the injectate solution will be periodically collected and analyzed for dye to confirm the targeted injection dye concentration.

Arcadis Comment	NERT Response
Tracer Study Focused Comment No. 1: *Charcoal dye samplers by design are not sufficiently quantitative. They are only as quantitative as the sampling frequency with which they are collected. During injection, dose response should be analyzed via water samples collected from targeted monitoring wells over carefully specified cumulative injection volumes that are then normalized to a consistent injection concentration. Following injection, arrival times and cumulative mass distributions should be analyzed via water samples collected over carefully specified time increments based upon the anticipated groundwater movement. Charcoal dye samplers can be an effective way to manage unanticipated results, but if they are used to identify meaningful dose response, accurate downgradient arrival times, and other hydrogeological specific objectives they are generally insufficient. It is true that charcoal dye samples will continue to collect dye over time, and this is precisely why they are insufficiently quantitative to determine an injected volume to radial distribution relationship.*	Section 5.4.3 of the Work Plan Addendum specifies the analysis of both charcoal samplers and groundwater samples. Where the presence of dye is detected via analysis of charcoal samplers, the groundwater collected concurrently with the charcoal sampler at that monitoring location will be analyzed to quantitatively evaluate dye concentration. This two-step analysis process not only allows presence/absence analysis at all locations, but also permits quantitative analysis where the dye is found to be present. The reason charcoal samplers are used as the first step is that they concentrate the dye by collecting it over multiple days, allowing a lower detection limit. Therefore, dye can be detected by charcoal sampler at detection limits below what are possible using a traditional groundwater grab sample. Furthermore, due to fast groundwater flow rates, there is a possibility of missing the dye with grab samples (i.e., dye passed through the area either before or after the grab sample was collected). In such cases, the charcoal sampler could identify that the dye was present at a time when no grab samples were collected. With respect to dose response and specified cumulative injection volume sampling, please see response to General Comment 2.
Tracer Study Focused Comment No. 2: *The Work Plan Addendum/Cost Basis document does not list a prescriptive tracer injection concentration. This is a potential pitfall. Throughout the course of the tracer injection, several injection solution samples should be collected to maintain consistency of a prescriptive tracer injection concentration (preferably 20 to 40 milligrams per liter [mg/L]). The importance of this is that tracer response will be normalized to the injection solution and is a critical design component of a successful tracer study.*	The Work Plan Addendum has been revised to present a framework to establish a prescriptive tracer concentration prior to injection of the dye. Following completion of injection and monitoring well installation, aquifer testing, baseline sampling for fluorescence, and tracer selection, a prescriptive tracer concentration will be established, with details provided in the UIC permit application. These cannot be specified at the time of the Work Plan Addendum because selection of tracer concentration will need to account for flow rates, expected dilution of the tracer as it migrates, and existing concentrations of tracer (if any) and natural fluorescence in the downgradient groundwater (analyzed during baseline sampling), to ensure that the tracer is visible and detectable but not excessively noticeable if it enters the Las Vegas Wash during the study.

Arcadis Comment	NERT Response
Tracer Study Focused Comment No. 3: *As written, the Work Plan Addendum/Cost Basis assumes 6 months of monitoring for the tracer study. This can be a potential pitfall. Rather than specify a timeframe associated with observing tracer response downgradient, it is advisable to specify a total number of samples to be collected adaptively based on arrival/field observation. There is infinitely more value in a longer tracer study that yields meaningful results than a tracer study arbitrarily stopped too soon.*	The six-month time period of the tracer study was specified in the Work Plan Addendum to minimize costs while providing an amount of time that is anticipated to be sufficient to evaluate downgradient response/distribution data following injections. If additional monitoring is warranted based on review of the dye tracer results during the first 6 months of the pilot study, the timeframe of the tracer study will be extended through a Treatability/Pilot Study Modification.
Tracer Study Focused Comment No. 4: *Setting the expectation that tracer may be observed in surface water is ill-advised (4th objective of Section 5.4.3). Monitoring for tracer arrival in surface water would be an ideal application of the charcoal filters, but the concentrations may be so low due to dilution that any response at all may be significantly muted. Given the distance of the injection well transects from the Las Vegas Wash, it should be explicitly stated that visual or analytically quantified dye arrival in the surface water may be unrealistic due to dilution (it is not recommended to be one of the objectives of the tracer study)*	The text of Section 5.4.3 has been slightly revised to describe that the surface water sampling for the dye will be performed as a secondary component to the study as opposed to a primary objective. As described in Section 5.4.3 and Section 6.2, charcoal samplers will be used during dye sampling in surface water, as they collect dye over time concentrating the dye within the sampler, which improves the likelihood of detection of the dye in the Wash. This method of sampling was selected to optimize the likelihood of detection given the recognized challenges (distance of the injection well transects, concentration dilution).
Comment No. 7: *Ozark Underground Laboratory can analyze for multiple dyes in a single sample. It is recommended to report as many dyes as can be reported for a single fluorescent spectroscopic analysis given historical tracer use. If eosine and fluorescein are selected, please be aware that their spectroscopic peaks are similar and concentration differences may be required to further distinguish these dyes.*	The text of Section 6.1.3 has been revised to specify the analysis of multiple dyes.

Acknowledging successful completion of the third-party review process, it is the desire of the Trust to initiate the Phase 2 efforts as detailed in Attachment B as soon possible. The Trust currently estimates field mobilization can begin within 60 days of receipt of NDEP comments and/or approval of the attachments contained herein. Project updates on all facets of this study will continue to be provided through submittal of monthly progress reports.

If you have any questions or concerns regarding this matter, feel to contact me at (702) 960-4301 or at brian.loffman@lepetomaneinc.com.

Office of the Nevada Environmental Response Trust

Brian K. Loffman, CEM
Senior Program Manager
CEM Certification Number: 2265, exp. 9/21/20

Attachments:

Attachment A: Arcadis Review and Comment Memo on the Las Vegas Wash Bioremediation Pilot Study
Attachment B: Las Vegas Wash Bioremediation Pilot Study Work Plan Addendum
Attachment C: Las Vegas Wash Bioremediation Pilot Study Phase 2 Cost Estimate and Basis

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