NEVADA ENVIRONMENTAL RESPONSE TRUST
CONTINUOUS OPTIMIZATION PROGRAM

2015 ANNUAL SUMMARY REPORT

JANUARY 25, 2016

Continuous Optimization Program Plan

Nevada Environmental Response Trust Site
(Former Tronox LLC Site)
Henderson, Nevada

Responsible Certified Environmental Manager (CEM) for this project

I hereby certify that I am responsible for the services described in this document and for the preparation of this document. The services described in this document have been provided in a manner consistent with the current standards of the profession and, to the best of my knowledge, comply with all applicable federal, state and local statutes, regulations and ordinances.

Stephen R. Clough

January 25, 2016

Stephen R. Clough, PG
Remediation Director

Date

Certified Environmental Manager
CEM Certificate Number: 2399
CEM Expiration Date: March 24, 2017

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1.0 INTRODUCTION

This report has been developed to summarize the work performed in 2015 and work planned in 2016 by the Nevada Environmental Response Trust (NERT of the "Trust") under the Continuous Optimization Program (COP or the "Program"). Implementation of this program is a requirement of the Nevada Division of Environmental Protection (NDEP), was authorized by the Nevada Division of Environmental Protection (NDEP) and the United States Environmental Protection Agency (EPA), in March, 2015, through the approval of the Trust 2015 budget, and is expected to continue through implementation of the NERT final remedy. At the March 26, 2015 Annual Stakeholders Meeting in Las Vegas, NV, the Trust provided a detailed description of the Program along with an initial schedule for the envisioned 2015 tasks to be implemented.

The objective of the COP is to optimize the current groundwater extraction and treatment system (GWETS) to utilize excess treatment capacity available, and at the direction of the NDEP and EPA, increase perchlorate mass removal from the environment. For the 12 month period ending December 31, 2015, the GWETS operated at approximately 30 percent of its total biological loading capacity[1]. Through this Program, NERT is focused on utilizing this available capacity. To measure the success of the Program, NERT will be tracking both biological treatment efficiency and perchlorate mass removal rates of each well field on a monthly basis. The optimization metrics will be measured in terms of FBR Equivalent Load whereas perchlorate mass will be measured using the analytical and flow data routinely captured by NERT. This Program is an integral part of the ongoing Remedial Investigation/Feasibility Study (RI/FS) as the data acquired during the COP will be used to guide the evaluation of potential remedial alternatives.

The COP consists of the following major tasks:

1. Evaluation of Subsurface Conditions
2. Evaluation of the Hydrogeologic Units Impacted by Former Operations
3. Evaluation of Extraction System Infrastructure, Capacity, and Technology
4. Initial and Ongoing Optimization of Groundwater Extraction Systems
5. Evaluation and Implementation of Additional Initiatives to Increase Perchlorate Mass Removal
6. Infrastructure Evaluation and Performance of Modifications Necessary to Support the Program
7. Data Sharing and Program Interface with the Ongoing RI/FS

[1] This percentage assumes operation of all 5 front-stage fluidized bed reactors. Since late 2014, the GWETS has been operated utilizing 3 of the 5 available front-stage fluidized bed reactors as the full capacity has not been required. The remaining 2 reactors are expected to come on-line in 2016 as necessitated by the requirements of the COP and the AP-5 project.

During 2015, NERT completed the first three tasks. The remaining tasks were initiated, are on-going, and to be performed throughout the implementation of the Program.

2.0 COP PROGRESS IN 2015

As indicated previously, NERT completed a number of key activities designed to improve the understanding of the subsurface geology, hydrogeology, migration pathways, and distribution of perchlorate in groundwater. During the development of the COP, NERT realized that the historical work completed by Kerr-McGee and Tronox did not adequately document their findings associated with geologic descriptions of the alluvial material underlying the site, vertical distribution and migration behavior of perchlorate in shallow groundwater, and the current capacity (and limitations) of the existing GWETS. As such, additional investigation work was necessary prior to the development of detailed optimization alternatives and/or plans to increase the overall removal of perchlorate from groundwater. NERT's work performed in 2015 resulted in a variety of accomplishments including:

- Completion of Subsurface and Hydrogeologic Evaluations necessary to improve NERT's understanding of the primary migration pathways and three-dimensional (3D) distribution of perchlorate in groundwater such that additional possible methods of perchlorate removal could be identified.

- Collection of critical aquifer testing data at the Athens Well Field (AWF) to provide NERT an understanding of maximum sustainable extraction rates.

- Implementation of groundwater extraction rate adjustments in September 2015 at the AWF designed as a first step of optimization of the well field. These adjustments have been estimated to increase overall perchlorate mass removal by 38 pounds/day (an approximate 3 percent improvement over the 2014/2015 GWETS daily average mass removal rate of approximately 1,390 pounds/day [as reported in the Annual Remedial Performance Report, October 2015]).

- Initial development of additional groundwater extraction rate adjustments at the AWF focusing on increasing pumping rates at wells with highest perchlorate concentrations (targeting 200 pounds/day of additional perchlorate – 14 percent improvement over 2014/2015 GWETS daily average mass removal rate). Additional monitoring will be required to determine if this perchlorate removal rate can be sustained over time as increased pumping rates will change the dynamics of the groundwater system.

- Completion of a detailed evaluation of the existing GWETS infrastructure to determine existing chokepoints and available capacity to increase flow through the lift stations, pipelines, and treatment systems. Budget has been allocated in 2016 for various infrastructure upgrade and modification projects resulting from this evaluation.

- Identification of two areas where additional perchlorate removal can be accomplished using soil flushing/groundwater extraction or alternate groundwater extraction techniques. Both scenarios target areas of relatively high perchlorate concentrations. Additional evaluation is planned to be conducted in 2016 to determine if project design and implementation are warranted.

- NERT determined that the implementation of soil flushing was necessary to capture additional perchlorate at the Interceptor Well Field (IWF). Long-term groundwater extraction at the IWF has significantly dewatered the alluvium present onsite resulting in reduced pumping rates in this area.

All work described above was completed on or ahead of the schedule described during the March 26, 2015 Stakeholder meeting.

While not direct components of the COP, the following initiatives were started in 2015 and will have a positive impact the performance of the COP and the amount of perchlorate removed from the environment:

- Completion of a conceptual design of an additional soil flushing pilot study at the Central Retention Basin to evaluate the long-term viability of soil flushing in this area. As it relates to the COP, this pilot study will result in the removal of additional perchlorate from the environment. NERT is targeting an increase in mass removal using the IWF of 210 pounds/day, representing a 15 percent improvement over 2014/2015 GWETS daily average mass removal rate. As mentioned previously, additional monitoring will be required to determine if this perchlorate removal rate can be sustained over time as increased pumping rates will change the dynamics of the groundwater system.

- Completion of a conceptual design for the implementation of a biological active zone enhancement (BAZE) Pilot Study adjacent to well PC-94. This pilot study will be critical in evaluating the applicability of groundwater bioremediation as an element of the final remedy addressing perchlorate in shallow groundwater. As it relates to the COP, the success of this program could provide the Trust additional GWETS capacity to target higher concentration up-gradient areas of the plume while efficiently removing additional perchlorate from the environment.

- Completion of the conceptual design for the deployment of an Ion Exchange (IX) Treatment System at Lift Station 1. This system will primarily be utilized by NERT as a tool to control the levels of the GW-11 pond by providing greater flexibility in the selection of treatment technology for groundwater. As it relates to the COP, this deployment will provide the Trust up to an additional 1,100 gallons

per minute (gpm) of overall hydraulic capacity to remove additional perchlorate from the environment.

Throughout 2015, NERT provided monthly updates to NDEP and EPA on Program progress and technical documents including:

- Geologic cross-sections (with and without perchlorate isoconcentration profiles).
- A summary of historic aquifer testing and cross-sectional profiles of the well fields displaying hydraulic conductivity.
- An Infrastructure Evaluation and Data Accessibility Report.
- Various 3D geologic and perchlorate distribution models.
- A presentation outlining the optimization of the AWF and other approaches that collect critical data for the Feasibility Study and remove additional perchlorate from the environment.

The following subsections provide a detailed description of the work performed in 2015 and the key findings of each activity.

2.1 EVALUATION OF SUBSURFACE CONDITIONS

In order to gain a deeper understanding of the migration pathways and 3D distribution of perchlorate in shallow groundwater, NERT completed a detailed evaluation of subsurface conditions. In the past, Kerr-McGee Chemical Company (KMCC) and Tronox LLC (Tronox) had conducted a number of subsurface investigations to gain an understanding of the geology and the distribution of perchlorate and chromium in shallow groundwater at the NERT site (Site) and the area between the Site and Las Vegas Wash. In general, these investigations defined the geology of the area as being comprised of Quaternary alluvium (Qal) underlain by the Upper Muddy Creek Formation (UMCf). In addition, several paleochannels were identified within the Qal that were believed to be preferential migration pathways. The current GWETS was designed and constructed to capture and remove contaminants from these paleochannels at three well fields (IWF, AWF, and Seep Well Field [SWF]). However, detailed geologic evaluations of the Qal were not well documented and the geology of the alluvial materials adjacent to the paleochannels was not adequately characterized. The focus of this evaluation under the COP was to construct a number of detailed geologic cross-sections of subsurface conditions such that NERT could gain a deeper understanding of contaminant migration within and outside the paleochannels and to provide a higher degree of accuracy when optimizing the GWETS and/or targeting the removal of perchlorate from the environment.

Prior to re-examining historical geological data collected by multiple parties, NERT entered available data into a geologic data management software system called gINT. This step facilitated the construction of geologic cross-sections, creation of a 3D

geologic model using Leapfrog Hydro, and creation of a 3D perchlorate distribution model using Environmental Visualization System (EVS). After key historical geologic data obtained from KMCC, Tronox, OSSM, TIMET, and BMI had been uploaded into gINT, NERT constructed a structural contour map of the UMCf, five east-west trending cross-sections, and one north-south trending cross-section. This appears to be the first significant effort to interpret the geology across the BMI complex and north to the Las Vegas Wash. These graphics were constructed to better understand the geology of the Qal, location of the paleochannels, and improve NERT's understanding of groundwater flow and contaminant migration from the Site. Figure 1 displays the location of these cross-sections and Appendix A contains the structural contour map of the UMCf and detailed cross-sections.

Complimentary to and ongoing with this effort, NERT has been preparing a detailed description of the geology underlying the NERT Remedial Investigation (RI) study area. This description will be presented in the upcoming Phase 1 RI Technical Memorandum. This description will include cross-sections that indicate that in general, the paleochannels are filled with predominantly coarse grained materials (i.e., sand and gravel), while the adjacent areas typically consist of finer-grained silty sands. This data supports the concept that the paleochannels serve as preferential groundwater flow and contaminant transport pathways. As part of the RI, NERT also prepared a 3D geologic model to support the ongoing groundwater flow model efforts and support the 3D perchlorate distribution model. It should be noted that to support the COP, the implementation of the above RI activities was accelerated. Figures 2 and 3 display two geologic cross-sectional views using the Leapfrog Hydro geologic model.

In order to gain a better understanding of the 3D distribution of perchlorate in the shallow groundwater, NERT overlaid perchlorate concentrations on each of the cross-sections (Appendix B) and developed a 3D perchlorate distribution model. Figures 4 and 5 present a 3D visualization of perchlorate distribution using EVS. As indicated in these cross-sections and the 3D visualizations, the highest perchlorate concentrations are found in finer grained geologic materials adjacent to paleochannels. As such, NERT determined the existing groundwater capture approach established by KMCC between 2000 and 2004 is somewhat limited in removing perchlorate from shallow groundwater, as the current GWETS is designed to remove groundwater from the paleochannels. Based on this conclusion, NERT also determined that the ultimate groundwater remedy for the site must address removing perchlorate from the finer-grained sediments. This conclusion is significant as it requires NERT to develop a modified remedial approach to address the inadequacies of the current GWETS with regards to the scope of the final remedy. As it relates to the COP, this information provided the Trust new avenues to explore through the Program's implementation.

2.2 EVALUATION OF THE HYDROGEOLOGIC UNITS IMPACTED BY FORMER OPERATIONS

The purpose of the hydrogeologic evaluation was to consolidate and summarize previous work conducted to characterize aquifer and groundwater flow properties of the two groundwater bearing zones impacted by site-related chemicals, including the Qal and the UMCf. This evaluation included a summary of the results of previously conducted hydraulic aquifer testing in each groundwater bearing zone, an analysis of the variance of hydraulic conductivity values across each of the extraction well fields, and an evaluation of previous capture zone analyses.

Since the early 1980s, numerous hydrogeologic investigations have been conducted in the vicinity of the Site, primarily in support of groundwater cleanup efforts implemented by various BMI Complex parties, including KMCC, Tronox, NERT; Titanium Metals Corporation (TIMET), Olin, Stauffer, Syngenta, and Montrose (OSSM), American Pacific Corporation (AMPAC), and Basic Remediation Company (BRC). For this analysis, available historical reports prepared on behalf of these parties were reviewed in order to compile a comprehensive summary of available aquifer testing data. In addition to these historical reports, documents including various geotechnical investigations prepared for the Southern Nevada Water Authority (SNWA) and correspondence from Ed Krish (former project hydrogeologist for KMCC and Tronox) were reviewed and included in the data compilation.

The locations and screened stratigraphic units of monitoring and extraction wells with available aquifer testing results are presented on Figures C-1a and C-1b in Appendix C. A compilation of all aquifer testing results identified during our review is provided in Table C-1 in Appendix C. The compilation in Table C-1 identifies the aquifer test type, the stratigraphic unit and water-bearing zone screened by the tested well, and the hydraulic properties estimated from each test. The stratigraphic unit was identified from the All Wells Database (December 2014 Update). Depending on the type of hydraulic test applied, values for hydraulic conductivity (K), transmissivity (T), and storativity (S) were reported. The estimated value of K for a given test typically is the more useful value to compare relative hydraulic properties of an aquifer zone or area and therefore was the focus of this evaluation.

A summary of estimated K values by hydrologic unit, area, and test type is presented in Table C-2 in Appendix C. Figure C-2 in Appendix C shows the distribution of estimated hydraulic conductivity values by hydrologic unit. Many of the tested wells are shallow water table wells that are screened across the Qal and UMCf. Estimated values of K for these wells are not solely representative of either the Qal or the UMCf, but rather represent contribution from both units, and therefore are presented separately in Table C-1 and Figure C-2. Estimated values of K for the transitional UMCf (xMCf) were treated as UMCf for the purposes of the statistical summaries.

The variability of estimated K in each of the NERT extraction well fields (IWF, AWF, and SWF) is illustrated in the conceptual cross-sections shown in Figures C-3a, C-3b, C-4, and C-5 in Appendix C. In the cross-sections, the well screens are shaded with different colors to illustrate the estimated K values for extraction wells and monitoring wells in which the tests were performed. The entire well screen is filled in the figures for illustration purposes, even though the screened interval actually tested would be the portion below the water table at the time of the test. The figures also only illustrate lateral variability across the well fields, because the estimated K values from the available aquifer tests do not provide information about vertical variability. The estimated values of K shown are the average of the historical aquifer testing results conducted at a given well, as presented in Table C-1.

In addition to compilation and review of prior aquifer testing data, well field performance was also evaluated in order to inform capture zone analyses and to support well field optimization. Extraction well data sheets are presented in Appendix C, which show groundwater elevations, perchlorate concentrations, chromium concentrations, extraction rates, specific capacity, and estimated mass removal rates over time for each extraction well. Well field summary sheets are also presented in Appendix C, which show the range of perchlorate concentrations and pumping rates observed from fourth quarter 2014 to first quarter 2015, calculated mass removal rates, and available drawdown above the UMCf contact.

As a result of this hydrogeologic evaluation, the hydraulic conductivity distribution within the groundwater model domain was updated as part of the NERT RI Phase III Groundwater Model Refinement, submitted to NDEP on October 30, 2015 as an attachment to 2014-2015 Annual Remedial Performance Report. Specifically, the K values of the paleochannels were revised to be consistent with available aquifer testing estimates, and K values were also adjusted in the vicinity of the AWF and SWF, which resulted in improved reliability and accuracy of capture zone analyses. Additional aquifer testing at the AWF and SWF was also recommended as a result of this evaluation in an effort to reduce uncertainty in the distribution of K throughout the well fields. Additional testing at the AWF has already been conducted through the COP, and the results of these tests supported decisions regarding the AWF optimization, as discussed in Section 2.4.1. As such, this additional analysis resulted in improvements in NERT's understanding of the hydrogeologic properties of the Qal and significant improvements in the Phase III Groundwater Model. Furthermore, based on a review of available boring logs as part of the hydrogeologic and subsurface evaluations, certain well construction details were identified as either missing or incorrect in the All Wells Database. NERT has since begun the process of working with NDEP's consultant to correct this construction information in the All Wells Database.

2.3 EVALUATION OF EXTRACTION SYSTEM INFRASTRUCTURE, CAPACITY, AND TECHNOLOGY

Prior to initiating any modifications to the groundwater extraction well network, NERT determined it was necessary to conduct a detailed evaluation of the GWETS infrastructure and monitoring systems. Given the age of the GWETS (12 to 29 years in age), the number of historical operators, and the desire to move from a static system (operating at the same flow rates and load) to a dynamic system, NERT initiated a detailed audit of the existing infrastructure. The overall objective of the infrastructure and monitoring systems audit was to provide a baseline evaluation of the hydraulic and mass loading capacities of the various elements of the GWETS as they currently exist and to facilitate the development of strategies for implementing the COP. Specifically, evaluations were conducted on the capacity (hydraulic and mass loading) of the various components of the GWETS and identifying infrastructure-related restrictions, potential points of failure, or other factors which limit overall system capacity.

The findings of the infrastructure and monitoring systems audit concluded the following:

- The existing transfer pumps in Lift Station 1, Lift Station 2, Lift Station 3, and the effluent pump station are operating below their hydraulic capacity, and have moderate reserve capacity to allow for variability in discharge rates from the well fields and operational flexibility at the biological treatment plant and the chromium treatment plant (also referred to as the groundwater treatment plant or GWTP). However, the pump at Lift Station 1 may have as little as 12 percent reserve capacity, and could potentially limit increased pumping and mass extraction from the SWF.

- The existing influent pipelines can accommodate large increases in flow.

- The GWTP has sufficient reserve capacity to handle increased flow or increased hexavalent chromium mass loading up to 29 percent greater than current values. If NERT desires to modify the IWF and through doing so, significantly increases flow or hexavalent chromium mass loading to the GWTP, the GWTP will likely require upgrades or replacement.

- The biological treatment plant is currently limited to an effluent flow of approximately 1,000 gallons per minute (gpm) by the National Pollutant Discharge Elimination System (NPDES) and Minor Source issued through the Clark County Division of Air Quality. According to Envirogen Technologies Inc. (ETI), the major subsystems of the biological treatment plant are designed for, and can sustain, flow rates well in excess of 1,000 gpm. However, the internal piping systems may limit hydraulic capacity to somewhat lower values. ETI also noted that at present, the effluent pipeline limits the hydraulic capacity of the biological treatment plant.

- Although the calculated hydraulic capacity (approximately 1,425 gpm) of the effluent pipeline appears to be adequate, a restriction may be present which limits flow to approximately 1,000 gpm.

The findings of the infrastructure audit were initially presented to NDEP and EPA on August 25, 2015. The subsequent Infrastructure Audit and Data Accessibility Report was reviewed and approved by NDEP on November 2, 2015. The recommendations to be implemented by NERT are summarized in Subsection 3.2.

2.4 INITIAL AND ONGOING OPTIMIZATION OF GROUNDWATER EXTRACTION WELLS

A key component of the COP is to routinely implement groundwater extraction rate modifications designed to optimize the GWETS and increase the removal of perchlorate from the environment. NERT initiated modifications to extraction rates in September 2015 and will continue to make adjustments to the GWETS in an effort to achieve Program objectives.

In order to monitor the effectiveness of the COP, NERT routinely reports perchlorate mass removed by well field, monthly mass removal rates by well field, equivalent load changes at the biological treatment plant, and perchlorate mass flux at Northshore Road.

2.4.1 ATHENS WELL FIELD OPTIMIZATION

In September 2015, initial groundwater extraction rate adjustments at the AWF were implemented which improved overall perchlorate mass removal by 38 pounds/day (approximately 3 percent improvement over 2014/2015 GWETS daily average mass removal rate). Following these initial adjustments, a detailed evaluation of AWF extraction rate optimization options was performed. This evaluation was based on a field investigation of the AWF, which included:

- A detailed evaluation of pump specifications and pump positions in all AWF extraction wells.
- The performance of step drawdown tests to determine AWF extraction well capacities (i.e., sustainable groundwater extraction rates) and assist in the identification of AWF extraction rate optimization options. A summary of current AWF pump specifications is provided in Tables 1a and 1b and a summary of current well capacities is provided in Table 2.

Based on the field investigation results, a set of potential pumping scenarios was developed and evaluated in order to determine how best to further optimize the well

field. The scenarios evaluated are shown in Table 3. Each potential scenario was compared against a baseline pumping scenario using pumping rates from second quarter 2015. In addition to the baseline scenario, scenarios involving only existing wells included a scenario with maximum pumping at all wells (Maximum Pumping) and a scenario with pumping shifted to the eastern wells (Shift East). Two scenarios with new wells were developed to address several areas where high concentrations of perchlorate appear to be bound up in finer-grained soil (at the former Parcel A and near Sunset Road).

The various pumping scenarios were evaluated using the following two metrics: perchlorate plume mass captured and instantaneous mass removal rate. The first metric, perchlorate plume mass captured, was developed to represent the potential mass that could be captured over the long term if pumping rates stayed constant. It was calculated by first delineating steady-state capture zones for the AWF wells in a given scenario using the Phase III Groundwater Model. Then, the perchlorate plume mass captured was calculated by estimating the total mass of perchlorate present in groundwater in the alluvium within the capture zone. The distribution of perchlorate mass in the alluvial groundwater shown on Figure 6 was estimated from the perchlorate plume map presented in the 2014-2015 Annual Remedial Performance Report and an estimate of the saturated alluvium thickness.

The second metric, instantaneous mass removal rate, was developed to represent the short-term performance of each pumping scenario. It was calculated using each scenario's pumping rates and the interpolated perchlorate concentrations at each extraction well as shown on the perchlorate plume map presented in the 2014-2015 Annual Remedial Performance Report. Interpolated perchlorate concentrations were used to allow the evaluation of scenarios where extraction wells would be placed in locations where no well currently exists. Because the interpolated concentrations are different than the measured concentrations at current extraction wells, the calculated instantaneous mass removal rate under the baseline pumping scenario differs from the average second quarter 2015 mass removal rate presented in the 2014-2015 Annual Remedial Performance Report. Under the baseline pumping scenario, the instantaneous mass removal rate for the AWF was calculated as 390 pounds per day (pounds/day). The average mass removal rate for second quarter 2015 reported in the 2014-2015 Annual Remedial Performance Report for the AWF was 541 pounds/day. Despite the variation in the instantaneous mass removal rate described above, this approach was applied consistently across all scenarios evaluated and will be utilized by NERT for all subsequent reporting. Therefore, the method is valid for conducting the relative evaluation of scenarios in this analysis.

As shown in Table 4, the two metrics were calculated for each of the AWF pumping scenarios. Figures showing the mass capture are provided in Figures D-1a through D-1f in Appendix D. Based on this evaluation, an optimized pumping scenario was

developed with a total AWF pumping rate increased to approximately 344 gpm as compared to the baseline scenario of 287 gpm and a shift in pumping from the western wells to the eastern wells. Under the optimized scenario, the remaining perchlorate plume mass to be captured by the AWF was calculated at 544,831 pounds. In this optimized scenario the total amount of perchlorate mass captured is slightly smaller than the 2015 capture zone (documented in the 2014-2015 Annual Remedial Performance Report); however, the instantaneous perchlorate removal rate is higher since the extraction wells with the highest perchlorate concentrations are being pump at a higher rate. Compared to the baseline scenario, the total perchlorate plume mass captured by the AWF through this optimized scenario has decreased by only 1.1 percent. However, the the Trust's modeling indicates that the SWF will continue to capture any perchlorate that is outside the new AWF capture zone. The instantaneous mass removal rate for the optimized scenario is estimated to be 580 pounds/day, an increase of approximately 200 pounds/day as compared to the baseline scenario (and approximate 14 percent increase over the 2014/2015 GWETS daily average mass removal rate). The optimization scenario discussed above and related actions to be taken by NERT are further discussed in Subsection 3.1 of this document. As mentioned previously, additional monitoring will be required to determine if this perchlorate removal rate can be sustained over time as increased pumping rates will change the dynamics of the groundwater system.

2.4.2 SEEP WELL FIELD OPTIMIZATION

A similar approach was used to evaluate alternative pumping scenarios at the Seep Well Field. This initial evaluation was designed to evaluate groundwater extraction rate reductions that would limit the amount of water captured by the SWF that originates from the Las Vegas Wash and the City of Henderson Bird Viewing Preserve (BVP). Four scenarios were defined to evaluate the effect of reducing the combined pumping rates at the SWF during second quarter 2015 by a factor of 20%, 40%, 60%, and 80%. This analysis was completed to evaluate how the capture zone might be altered by a reduction in groundwater extraction as NERT is trying to better understand surface water interaction with the SWF. An additional scenario was evaluated that includes a new SWF extraction well, located east of well PC-133 and pumping at approximately 125 gpm. The pumping rates, estimated instantaneous mass removal, and mass captured within the NERT plume for each scenario are provided in Table 5. Figures showing the mass capture are provided in Figures D-2a through D-2f in Appendix D.

Because the SWF is located near two surface water bodies (Las Vegas Wash and the BVP, pumping at the SWF potentially induces surface water flow into the SWF extraction wells. The surface water from both Las Vegas Wash and the BVP is comprised primarily of treated municipal wastewater effluent. For the above mentioned SWF pumping scenarios, the corresponding rate of birding pond water captured by SWF was also estimated. As shown in Table 5, approximately 59% of the groundwater

captured by the SWF is surface water from the BVP. As the SWF pumping is reduced by 20%, 40%, 60%, and 80%, the amount of groundwater captured by the SWF that comes from the BVP is reduced to 52%, 47%, 43%, and 22%, respectively. In 2016, NERT will conduct an in-depth study as part of the ongoing RI to more precisely quantify to the amount of surface water that the SWF captures from the BVP and Las Vegas Wash. Additional capture zone analysis is presented in Subsection 3.1 to justify the planned groundwater extraction rate adjustment.

2.4.3 SOIL FLUSHING AT INTERCEPTOR WELL FIELD

In 2015, additional soil flushing scenarios in the vicinity of the IWF were evaluated as necessary components of the NERT RI. NERT has developed each of these scenarios into Pilot Studies, with budgets currently under review by NDEP and EPA, to be conducted through the RI and detailed plans are discussed further in Subsections 3.3 and 3.6.

As related to the COP, implementation of each Pilot Study will increase perchlorate removed from the environment. Currently, the combined total average pumping rate at the IWF is 66 gpm, with an average perchlorate concentration at the IWF of approximately 938 milligrams per liter (mg/l). This results in approximately 744 pounds pounds/day of perchlorate removal by the IWF wells. The two soil flushing pilot studies evaluated involved removing perchlorate from soil upgradient of the IWF and immediately downgradient of the onsite barrier wall.

Upon implementation of the Long-Term Soil Flushing Pilot Study in the area of the central retention basin upgradient of the IWF, it is assumed that the total extraction rate at the IWF can be increased by 30% over the current pumping. As shown in Table 6, assuming no significant changes in perchlorate concentrations at the IWF, this increase in pumping would result in an estimated perchlorate mass removal from the IWF of about 969 pounds/day, an increase of approximately 225 pounds/day (and 15 percent increase) over the 2014/2015 GWETS daily average mass removal rate. This estimated increase in perchlorate mass removal may be an underestimate because concentrations at the IWF may increase in response to the flushing of additional perchlorate mass from the unsaturated zone as they did during the high rainfall period that occurred in 2012. Additional monitoring will be required to determine if this perchlorate removal rate can be sustained over time as there is a limited mass of perchlorate in the unsaturated zone.

Upon implementation of the Soil Flushing Pilot Study downgradient of the barrier wall, it is assumed that new extraction wells at the northern site boundary would pump a total of 60 gpm. Based on estimated perchlorate concentrations in this area as shown on the perchlorate plume map in the 2014-2015 Annual Remedial Performance Report, soil flushing in this area would result in an additional estimated perchlorate mass removal of

approximately 290 pounds/day (an approximate increase of 20 percent over the 2014/2015 GWETS daily average mass removal rate). As mentioned previously, additional monitoring will be required to determine if this perchlorate removal rate can be sustained over time as there is a limited mass of perchlorate in the unsaturated zone that has not been sufficiently defined in past investigations of this area. This estimated increase in perchlorate mass removal may be an underestimate because concentrations downgradient of the barrier wall may increase in response to the flushing of additional perchlorate mass from the unsaturated zone as they did during the high rainfall period that occurred in 2012.

As shown in Table 6, the estimated perchlorate mass removal from soil flushing in both areas is approximately 1,179 pounds/day (an increase of approximately 30 percent increase over the 2014/2015 GWETS daily average mass removal). However, additional investigative and design work will be required before this pilot study can be implemented. Subsection 3.6 describes the additional work that is planned for 2016 to implement this pilot study.

3.0 PLANNED COP ACTIVITIES FOR 2016

Continuing upon the 2015 efforts summarized above, NERT plans to implement a variety of activities in 2016. While not all of these fall under the COP from a programmatic or budgetary perspective, each effort will have a positive impact on the COP in terms of either optimizing the GWETS and/or increasing the removal of perchlorate from the environment. These activities, in order of priority, are:

1. **Continued Optimization of the AWF** – NERT will install larger capacity pumps in wells ART-8 and ART-9, lower the existing pump in ART-7B to optimize the extraction rate in this well, and adjust the extraction rate throughout the entire well field to increase pumping from wells that yield groundwater containing relatively high concentrations of perchlorate.

2. **GWETS Infrastructure Improvements and Performance Monitoring and Data Accessibility** – NERT will implement a variety of infrastructure improvements and a web-based portal to facilitate the management of the GWETS. GWETS operational data will be bridged to the internet to allow NERT to more effectively monitor the removal and treatment of perchlorate-impacted groundwater.

3. **Implementation of a Long-Term Soil Flushing Pilot Study at the Central Retention Basin** – NERT will implement an additional RI Pilot Study to leverage the results of the ongoing Soil Flushing Pilot Study to evaluate the long-term effectiveness of this technology. Based on the results of the Pilot Study, and if directed to do so by NDEP and EPA, NERT may extend the duration of the program to contribute to the overall effectiveness of the COP and/or the NERT final remedy.

4. **Implementation of a Groundwater Bioremediation Pilot Study East of the SWF** – NERT will implement a RI Pilot Study adjacent to well PC-94 to evaluate biological active zone enhancement technology in the alluvium adjacent to the Las Vegas Wash. Based on the results of the Pilot Study, and if directed to do so by NDEP and EPA, NERT may extend the duration of the program to contribute to the overall effectiveness of the COP and/or the NERT final remedy.

5. **Deployment of IX Treatment** – NERT will deploy an IX Treatment System adjacent to Lift Station 1 and construct a new manifold system to provide the ability to manage the treatment of perchlorate (IX versus biological treatment) on a per well basis for the SWF.

6. **Preliminary Evaluation of Soil Flushing Downgradient of the Barrier Wall** – NERT will collect additional data to evaluate and potentially design an additional soil flushing pilot study intended to target perchlorate mass in the unsaturated zone downgradient of the on-site barrier wall, an ongoing source of perchlorate to shallow groundwater.

7. **Alternate Groundwater Extraction Study** – As discussed throughout Section 2, NERT now has a much greater understanding of the distribution of perchlorate in the subsurface. Through the Program, NERT intends to evaluate additional means of removing perchlorate from shallow groundwater. NERT has identified several areas where relatively high concentrations of perchlorate are bound up in finer-grained sediment. NERT will determine if strategically placed groundwater extraction wells and/or trenches outside of the paleochannels could contribute to the effective long-term removal of perchlorate from the environment. If deemed appropriate, NERT will design pilot programs, which through implementation, additional perchlorate will be removed from the environment.

It should be noted that the implementation of these activities will require NDEP and EPA approval of the 2016 NERT Budget and could require additional funding via budget amendment as project specifics evolve. Additional details regarding each of these planned activities are provided in the following subsections.

3.1 CONTINUED OPTIMIZATION OF THE AWF

Based on the evaluation of AWF and SWF pumping scenarios presented in Section 2.4, a pumping plan for both well fields was developed as shown in Table 7. The capture zones for the recommended pumping plan are shown in Figure 7. The optimized pumping in the AWF will be implemented as soon as feasible in 2016. This would be accomplished by:

- Installing larger pumps in wells ART-8 and ART-9, each with a capacity of approximately 150 gpm.
- Lowering the pump in ART-7B to increase its extraction rate.
- Discontinuing pumping at ART-1 and ART-2.
- Adjusting pumping rates at extraction wells in the AWF to increase pumping from wells with relatively higher perchlorate concentrations (Table 7).

At the same time as the total pumping rate at the AWF is increased, the total pumping rate at the SWF will be temporarily decreased by approximately the same amount to keep the system-wide flow rate approximately the same. NERT will temporarily suspend pumping at well PC-119 located at the western end of the SWF (Table 7). Groundwater extracted from this well contains the lowest concentration of perchlorate of

that recovered by the SWF. NERT estimates that this change in pumping will not result in a measureable increase in perchlorate mass flux to the Las Vegas Wash. Figure 7 displays the capture zone with the planned reduction in groundwater extraction at the SWF. Once the IX Treatment System described in Section 3.4 goes on-line, the SWF flow rate may be returned to its original 2015 level.

In order to monitor the effectiveness of the new AWF and SWF capture zones, NERT will collect groundwater samples from monitoring wells ARP-1, ARP-2A, ARP-3A, ARP-4A, ARP-5A, ARP-6B, ARP-7, MW-K4, PC-155A, PC-155B, PC-156A, PC-156B, PC-157A, and PC-157B on a quarterly basis. In addition, NERT will collect groundwater samples from all the operating groundwater extraction wells on a weekly basis throughout 2016 in order to gain a deeper understanding of perchlorate concentration variations at each of the well fields over time.

3.2 GWETS INFRASTRUCTURE IMPROVEMENTS AND PERFORMANCE MONITORING AND DATA ACCESSIBILITY

Based on the infrastructure audit described in Section 2.3, NERT will complete a variety of infrastructure and monitoring system improvements in 2016, as summarized in the Infrastructure Audit and Data Accessibility Report. During 2016, NERT will implement the following:

- Removal of all pumps from the extraction wells and identification of the pump models and condition, determination of the pump intake elevation, and verification of the total well depth. These data will be used to determine if pump modifications are necessary to increase and/or optimize extraction rates at the IWF, AWF, and SWF.

- Development of a well maintenance program to evaluate the condition of wells for their intended purpose (extraction versus monitoring) and degree of silt accumulation to determine if redevelopment is necessary. This program will be incorporated in the ongoing groundwater monitoring program.

- Replacement of the backup pump at Lift Station 2 to ensure uninterrupted well field extraction of the AWF and SWF should the primary pump require servicing.

- Replacement of both submersible pumps at Lift Station 3 to accommodate pumping rates up to 500 gpm.

- Completion of a study to determine if a restriction is present in the effluent pipeline limiting the discharge rate of treated groundwater. As described as a discrete task in the 2016 Budget, NERT will perform a detailed evaluation of flow conditions in the GWETS effluent pipeline. As stated in the Infrastructure Audit

and Data Accessibility Report, it is believed that the existing pipeline should be able to convey up to 1,425 gpm from the GWETS to the NPDES outfall. This theoretical rate is in contrast to the approximately 1,000 gpm ceiling as reported by ETI. Through a three-day evaluation of pipeline hydraulics, the Trust will determine if additional effluent throughput is possible, without sacrificing the integrity of the pipeline, and if any modifications to the various segments of the pipeline are warranted to do so.

- Installation of additional flow meters on the effluent pipeline, diversion pipeline to GW-11, and D1 Building sump discharge pipeline. NERT will also evaluate the value of installing a turbidity meter to optimize the backwash procedure and limit the volume of water introduced to the GW-11 pond. The installation of these meters will assist with improving the accuracy of water balance calculations as requested by NDEP in the past.

- Development of a web enabled data portal to facilitate monitoring of the GWETS. This portal will capture data from the on-site monitoring systems and provide remote access to well pump status, rates and groundwater elevations; well field pumping rates; totalizer values; process pressures; data trending; and mass removal information and predictions.

- Construction of a stilling well in the GW-11 equalization pond to obtain accurate and consistent water level measurements regardless of weather conditions. This data will be made available via the web portal to provide accurate real-time pond volume information and trends.

3.3 IMPLEMENTATION OF A LONG-TERM SOIL FLUSHING PILOT STUDY AT THE CENTRAL RETENTION BASIN

As described in the 2016 NERT Budget as the Addendum to the Soil Flushing Treatability Study Work Plan and Permitting, the planned soil flushing pilot study is intended to determine the long-term effectiveness of a full-scale implementation of this technology. This program could use any of several water application methods and either of two readily-available water sources. Based on preliminary results from the soil flushing treatabilitiy study currently in progress at the site, NERT intends to utilize agricultural spray irrigation equipment and a blend of stabilized Lake Mead water and GWETS effluent water, both of which are likely candidates for long-term implementation. Surface application of water by spray irrigation is likely the lowest cost and most readily implementable alternative for water application. Using a blend of stabilized Lake Mead water with relatively lower total dissolved solids (TDS) and GWETS effluent with relatively higher TDS would allow for optimized TDS concentrations in applied water, reduce costs, reduce impacts to water resources, and would provide valuable data for evaluating the potential impacts of TDS on the overall

performance of the GWETS. The results of the ongoing soil flushing pilot study will be used to fine tune the long-term program but some additional testing will be performed following the pilot study to evaluate the use of GWETS effluent in the long-term soil flushing pilot study.

As described as a discrete task in the 2016 NERT Budget, implementation of this pilot study will include preparation of a work plan for NDEP and EPA review. Work plan activities will include the following:

- Reviewing existing lithologic and contaminant distribution data in the vicinity of the proposed pilot test area to better understand site conditions and potential impacts to the GWETS.

- Refining the long-term pilot study objectives and goals.

- Identifying pre-design field activities, including potential tasks such as installation of soil borings/monitoring wells; soil and/or groundwater sampling to better define the nature and extent of contamination and potential impacts to the GWETS; and hydraulic testing, such as slug tests and/or infiltration tests, to provide additional information on the hydraulic characteristics of the central retention basin area.

- Preparing a conceptual test design, including items such as program objectives; soil flushing location(s); preliminary configuration and conceptual layout, including the water application system and monitoring well layout; permitting requirements; and health and safety requirements.

- Developing a conceptual effectiveness monitoring program, including sampling locations, sampling frequency, and a proposed suite of field and laboratory tests.

- Developing a cost estimate and schedule for subsequent implementation of the long-term soil flushing program.

Permitting requirements for this program are anticipated to include obtaining a long-term NDEP Bureau of Water Pollution Control (BWPC) Groundwater Discharge Permit, which is required for applying water directly to the ground surface without distribution piping. In addition, a Dust Control Permit from the Clark County Department of Air Quality (DAQ) is expected to be required for surface disturbance associated with construction. The use of spray irrigation will allow the program to be implemented without constructing berms or infiltration galleries to contain the water applied to the ground surface, which eliminates the need for a grading permit from the Clark County Building Department.

Following approval of the work plan, NERT will implement the long-term soil flushing pilot study and report progress via monthly COP meetings.

It should be noted that the implementation timeline for the preparation of the work plan and implementation of the subsequent program is dependent upon budget and work plan approvals by NDEP and EPA and the various permitting elements highlighted above.

3.4 IMPLEMENTATION OF A GROUNDWATER BIOREMEDIATION PILOT STUDY EAST OF THE SWF

As described as a discrete task in the 2016 NERT Budget, the intent of this pilot study is to examine the effectiveness of a broadly-implemented bioremediation approach (BAZE) at reducing the flux of perchlorate mass to the Las Vegas Wash and potentially aid development of a more cost effective final remedy. This program will initially begin with a pilot study that will leverage the results of the ongoing groundwater bioremediation pilot study and apply this same technology in a different geologic setting. Through this pilot study, perchlorate mass adjacent to well PC-94 and loading to the Las Vegas Wash will be reduced. After successful completion of the pilot study, this remedial technology will be considered for application over a larger geographic area to further reduce perchlorate mass flux at the Las Vegas Wash. If the technology is not effective in removing perchlorate from shallow groundwater, NERT has already presented a conceptual option to NDEP and EPA of expanding the SWF eastward to capture perchlorate impacted groundwater in the vicinity of well PC-94 (as described in Subsection 2.4.2).

The activities identified in the upcoming work plan for the pilot study will build upon on the promising results of the on-going laboratory studies being performed at the University of Nevada, Las Vegas (UNLV) in connection with the groundwater bioremediation pilot test (ongoing near the AWF). This includes utilizing the pilot test laboratory studies to evaluate the viability of groundwater bioremediation using a BAZE approach as a more efficient and cost-effective alternative to: (1) expanding the SWF to further reduce the flux of perchlorate to the Las Vegas Wash; and (2) the continued operation of the SWF altogether. A BAZE approach differs from a permeable reactive barrier or other linear in-situ bioremediation configurations. It consists of a staggered grid configuration of injection points to achieve higher likelihood of obtaining full in-situ treatment of perchlorate.

The following tasks will be completed as part of the work plan process:

- Reviewing existing site information to gain a better understanding of the aquifer properties in the vicinity of the pilot test location (anticipated to be adjacent to well PC-94).

- Developing pilot-test objectives and project goals.

- Performing a data-gap analysis to determine the appropriate pre-design field activities that are required for the final pilot-test design.

- Identifying required pre-design field activities, including potential tasks such as installation of borings/monitoring wells; soil and/or groundwater sampling to better define the nature and extent of the contamination and geochemical make-up of groundwater; and performing aquifer tests such as slug tests, borehole dilution, or pump tests to provide additional information on hydraulic and lithological characteristics.

- Reviewing the results of the existing laboratory studies (completed as part of the ongoing groundwater bioremediation pilot study) in order to develop targeted and efficient supplemental bench-scale studies (batch and/or column tests). This will potentially include:

    - Evaluation and selection of different substrates and associated dosage effects on perchlorate biodegradation on site-specific soil and groundwater.
    - Evaluation of potential substrate combinations.
    - Evaluation of lag time for inducing perchlorate biodegradation.
    - Evaluation of the effects of TDS on perchlorate biodegradation.
    - Evaluation of the effect of other electron acceptors (such as nitrate) on perchlorate biodegradation.
    - Determination of kinetics of perchlorate biodegradation.
    - Assessment of the need for micronutrients (nitrogen and phosphorus).
    - Evaluation of the effects of soil pH on the biodegradation of perchlorate.

- Preparing a conceptual design for the pilot test, including items such as pilot test objectives; final pilot test location; preliminary configuration and conceptual layout; preliminary injection protocols, including carbon source and dosages, nutrients, and potential tracer studies; permitting requirements; access agreement requirements; review of potential ecological requirements; and review of health and safety requirements.

- Developing a conceptual effectiveness monitoring program that includes the proposed suite of laboratory analytical, geochemical, field, and microbial constituents required to evaluate the pilot-test effectiveness, sampling frequency, and sample locations.

- Developing a cost estimate and schedule for the subsequent field implementation.

It should be noted that the implementation timeline for the preparation of the work plan and implementation of the subsequent program is dependent upon budget and work plan approvals by NDEP and EPA and the various permitting elements highlighted above.

3.5 DEPLOYMENT OF IX TREATMENT

As discussed earlier in this document, NERT plans to deploy an IX Treatment System at Lift Station 1 with a primary objective to more effectively manage the volume of the GW-11 pond. Although not specifically part of the COP, implementation of this system will also accommodate future GWETS improvements focused on improving groundwater capture. As presented in the December 21, 2015 meeting, NERT will deploy an IX Treatment System to Lift Station 1 and reconfigure the extraction well manifold system for the SWF such that NERT can control the method of perchlorate treatment, by well, at the SWF. This approach allows NERT to improve the storage capacity condition at GW-11 and provides additional hydraulic capacity necessary to accommodate future groundwater extraction rate increases at the IWF, AWF, and SWF as implemented through the COP. As part of this work, the current lift station motor starters with be replaced with variable frequency drives and connected to the new controls system installed during the Enhanced Metrics project (largely completed in 2015).

The IX Treatment System will be designed to process between 90 and 1,100 gpm. Based on the current operation at Lift Station 1 and the flows from the SWF, the IX Treatment System would be capable of treating all water extracted from the SWF wells in the event that the SWF extracted groundwater could not be treated in the biological treatment plant. The proposed IX unit is also designed to treat a portion of the SWF water (with low level contaminant concentrations) to lessen the hydraulic load on the fluidized bed reactors (FBRs). The IX Treatment System will be capable of consistently removing perchlorate, currently present in concentration less than 20 mg/L in raw water, to concentrations less than 18 micrograms per liter (μg/L), the effluent requirement established in the NPDES permit maintained by the Trust. Since the proposed unit is a single-pass IX Treatment System, the resin will eventually be exhausted and will require change out. The frequency of the change out will depend on which wells are operational and feed the IX Treatment System and at what flow rate they operate. NERT will engage in regular dialogue with NDEP regarding the COP and utilization of the IX Treatment System as its usage will directly correlate to the amount of budget authority NERT will require to facilitate resin change-outs.

The IX Treatment System discharge will be connected into the current 10-inch effluent pipeline that runs through Lift Station 1 and ultimately discharges to the Las Vegas Wash. It is intended that both the IX and FBR plants can operate simultaneously to this single discharge line. Based on current conditions, the current 10-inch effluent pipeline

between the lift station and the Las Vegas Wash should handle a combined discharge flow rate of 1,600 gallons per minute with a 10-psi discharge pressure at Lift Station 1.

Once the IX Treatment System is operational, NERT may resume groundwater extraction at well PC-119 of the SWF to 2015 conditions (approximately 60 gpm), as appropriate.

It should be noted that the implementation timeline for this project is dependent upon budget and work plan approvals by NDEP and EPA and the renewal of the NERT NPDES permit.

3.6 PRELIMINARY EVALUATION OF SOIL FLUSHING DOWNGRADIENT OF THE BARRIER WALL

Similar to the planned long-term soil flushing pilot study at the central retention basin, NERT also plans to evaluate soil flushing downgradient of the on-site barrier wall. The overall objectives of this effort will be to assess the potential long-term effectiveness and feasibility of soil flushing downgradient of the barrier wall and to evaluate the potential impacts to the GWETS and the need for new/upgraded infrastructure.

The specific area to be evaluated is on-site is located north (downgradient) of the barrier wall and south of the Tronox's WC-East and West Ponds. A key difference between soil flushing in this area versus the long-term soil flushing pilot study planned for the central retention basin is that there is currently no on-site extraction system that can capture contaminants mobilized during soil flushing downgradient of the barrier wall. It is anticipated that it will be necessary to capture mobilized contaminants before they migrate off-site; therefore, this preliminary work will include an evaluation of options for additional groundwater extraction at the future northern NERT property boundary. This evaluation will consider not only the potential locations of additional extraction wells, but what means of extraction would be most efficient in these areas.

The results of the ongoing soil flushing pilot study being conducted at the central retention basin will be used in the evaluation of the feasibility of soil flushing downgradient of the barrier wall. However, additional investigation will be necessary to meet the objectives described above. As described as a discrete task in the 2016 NERT Budget, the evaluation and investigation are expected to include the following:

- Reviewing existing lithologic and contaminant distribution data in the area downgradient of the barrier wall to identify data gaps and locations for further investigation, and to perform a first-cut analysis of the feasibility of this approach to significantly enhance long-term mass removal.

- Evaluating potential land-use scenarios for parcels C and D north of GW-11 and the WC Ponds to evaluate whether these areas may be used for future groundwater extraction.

- Reviewing the results of the existing soil flushing studies ongoing at the central retention basin relative to the hydraulic and chemical conditions expected to be encountered downgradient of the barrier wall to evaluate the applicabilty of soil flushing in this application.

- Evaluating potential groundwater extraction alternatives for the identified areas downgradient of the barrier wall in conjuction with the Alternate Groundwater Extraction Study (see section 3.7). For example, much of the Qal downgradient of the barrier wall is unsaturated; therefore, groundwater extraction rates are expected to be low—likely limited by the amount of water that can be added via soil flushing. Efficient extraction may warrant use of alternative methods, e.g., vacuum-enhanced extraction.

- Identifying investigation activities to address data gaps, including potential tasks such as installation of soil borings/monitoring wells; soil and/or groundwater sampling to better define the nature and extent of contamination and potential impacts to the GWETS; and hydraulic testing, such as slug tests, infiltration tests, and/or pilot tests of alternative groundwater extraction methods to provide additional information on the hydraulic characteristics and constraints of the areas identified.

- Completion of the field work necessary to eliminate and data gaps and design a soil flushing program for this area.

If the investigations indicate that soil flushing downgradient of the barrier wall will be feasible and effective in the long term, further steps will be initiated. These would include preparing a conceptual test design, which would include items such as program objectives, soil flushing location(s), preliminary configuration and conceptual layouts (including the water application system and monitoring well layout), permitting requirements, and health and safety requirements.

It should be noted that the implementation timeline for this effort is dependent upon budget and work plan approvals by NDEP and EPA

3.7 ALTERNATE GROUNDWATER EXTRACTION STUDY

Through the implementation of the COP, NERT has a much greater understanding of the distribution of perchlorate in the subsurface. In 2016, NERT intends to evaluate additional means of removing perchlorate from shallow groundwater. NERT has

identified several areas where high concentrations of perchlorate appear to be bound up in finer-grained soil (at the former Parcel A and along Sunset Road). NERT will evaluate if strategically placed groundwater extraction wells and/or other extraction technologies (e.g., trenches, vacuum-enhanced extraction, and horizontal wells) outside of the paleochannels could contribute to the effective long-term removal of perchlorate from the environment. If deemed potentially feasible and appropriate, NERT will evaluate and/or design pilot programs to remove additional perchlorate from the environment, targeting these areas. NERT anticipates presenting the results of this study to NDEP and EPA in October 2016.

4.0 SCHEDULE AND REPORTING

With the exception of the specific projects noted above involving permitting or additional work plan requirements, NERT will begin implementation of 2016 COP tasks upon approval of the NERT 2016 budget. All activities will be reported within the COP Monthly Progress Reports which will be submitted to NDEP and US EPA.

5.0 SUMMARY

As discussed in this report, NERT has accomplished each of the COP objectives identified for completion in 2015. Through this process, NERT dramatically increased its understanding of the subsurface, has obtained a thorough knowledge of the GWETS infrastructure that will be required throughout implementation of the program, has improved the accuracy of the RI Groundwater Model through the collection of additional data, and has determined that a strategic change in the groundwater remedial approach is necessary to efficiently remove perchlorate from the finer grained sediments adjacent to the paleochannels. These milestones could not have been accomplished if NERT hadn't initiated the effort to complete the activities described in the previous sections. As evident by the various tasks outlined in Section 3.0 of this report, NERT intends to implement a variety of groundwater extraction rate modifications, pilot studies, and investigations designed to optimize the GWETS, increase the amount of perchlorate removed from the environment, and provide a wealth of data to the ongoing NERT RI that will be leveraged in both the RI Report and subsequent Feasibility Study.

Each of the planned activities is designed to remove additional perchlorate from the environmental and in total, dramatically increase the loading to the biological treatment plant. Figure 8 displays the total GWETS perchlorate mass removal rate as each planned activity comes online. After implementation of each of these activities the incoming perchlorate load to the biological treatment plant will significantly increase driving the equivalent load towards the plant's maximum capacity. Based on the successful completion of the tasks described in this report, NERT estimates that perchlorate mass removal rate can be ultimately improved by 30 percent over the baseline period (July 2014 through June 2015). However, achieving this degree of success is dependent upon obtaining the required permitting and budget authority from NDEP as well as confirming the results of various studies and modelling exercises currently underway. Using the new equipment installed as part of the 2015 Enhanced Operational Metrics project, NERT will be able to report perchlorate mass removal and treatment rates with much greater accuracy.

Tables

TABLE 1A: AWF PUMP SPECIFICATIONS
Continuous Optimization Program
Nevada Environmental Response Trust Site
Henderson, Nevada

Well ID	Well Status	Nominal Capacity (gpm)	Pump Model	Horsepower (HP)		Current Pump Motor Model	Length (feet)		
				Original	Current		Pump	Motor	Total
ART-1	Primary	40	Grundfos 40S10-3	1	1	Franklin 2345239403	1.1	1.0	2.0
ART-1A	Backup	40	Grundfos 40S10-3	1	1.5	Franklin 2345249403	1.1	1.0	2.0
ART-2	Primary	60	Grundfos 60S30-5	3	1.5	Franklin 2345249403	1.7	1.0	2.7
ART-2A	Backup	60	Grundfos 60S30-5	3	2	Franklin 2343259404	1.7	1.1	2.8
ART-3	Backup	40	Grundfos 40S20-7	2	3	Franklin 2343262604	1.6	1.3	3.0
ART-3A	Primary	40	Grundfos 40S20-7	2	3	Franklin 2343262604	1.6	1.3	3.0
ART-4	Primary	40	Grundfos 40S20-7	2	2	Franklin 2343259404	1.6	1.1	2.8
ART-4A	Backup	40	Grundfos 40S20-7	2	2	Franklin 2343259404	1.6	1.1	2.8
ART-6	Inactive	--	--	--	--	--	--	--	--
ART-6A	Inactive	--	--	--	--	--	--	--	--
ART-7	Inactive	--	--	--	--	--	--	--	--
ART-7A	Backup	40	Grundfos 40S15-5	1.5	1.5	Grundfos MS402	1.3	1.0	2.3
ART-7B	Primary	40	Grundfos 40S50-15	5	1.5	Franklin 2345249403	2.7	1.0	3.7
ART-8	Primary	85	Grundfos 85S50-3[2]	5	5	Franklin 2343278602	1.4	1.9	3.4
ART-8A	Backup	60	Grundfos 60S30-5	3	5	Franklin 2343278602	1.7	1.9	3.6
ART-9	Primary	25	Grundfos 25S07-5	0.75	1.5	Franklin 2345249403	0.9	1.0	1.8
PC-150[1]	Primary	16	Grundfos 16S05-5	0.5	0.5	Grundfos MS402	0.9	0.9	1.8

Notes:
gpm= gallons per minute
[1]Pump information provided by S&B Christ Consulting, LLC.
[2]Pump did not have faceplate. Pump model determined from pump dimensions and characteristics.

TABLE 1B: AWF CURRENT PUMP PLACEMENT
Continuous Optimization Program
Nevada Environmental Response Trust Site
Henderson, Nevada

Well ID	Well Status	Date of Inspection	Length of Boreline (ft)	Depth of Top of Pump (ft bTOC)	Depth of Bottom of Motor (ft bTOC)	Depth of Intake (ft bTOC)	Depth of Bottom of Screen (ft bTOC)	Distance Between Intake and Bottom of Screen (ft)	Distance Between Bottom of Motor and Bottom of Well (ft)
ART-1	Primary	10/14/15	35.5	36.5	38.6	37.6	52.9	15.3	16.3
ART-1A	Backup	10/14/15	52.5	53.5	55.6	54.6	52.6	-2.0	0.0
ART-2	Primary	10/12/15	40	41	43.6	42.5	53.7	11.2	12.1
ART-2A	Backup	10/12/15	45	46	48.8	47.5	54.5	7.0	7.7
ART-3	Backup	10/13/15	41.50	42.5	45.5	44.1	45.3	1.2	0.5
ART-3A	Primary	10/13/15	46.9	47.9	50.9	49.5	51.5	1.9	2.6
ART-4	Primary	10/13/15	37	38	40.9	39.6	43.5	3.9	4.6
ART-4A	Backup	10/13/15	41	42	44.8	43.6	42.6	-1.1	0.0
ART-6	Inactive	--	--	--	--	--	32.9		--
ART-6A	Inactive	--	--	--	--	--	32.5		--
ART-7	Inactive	--	--	--	--	--	36.0		--
ART-7A	Backup	10/13/15	33	34	36.5	35.3	36.4	1.1	2.0
ART-7B	Primary	10/13/15	31	38	41.8	40.7	42.2	1.5	5.7
ART-8	Primary	10/12/15	40	41	44.4	42.4	47.2	4.7	5.3
ART-8A	Backup	10/12/15	49.5	50.5	54.1	52.2	50.6	-1.6	0.0
ART-9	Primary	10/13/15	38.9	39.9	41.8	40.8	39.2	-1.5	0.0

Notes:

ft= feet

bTOC= below top of casing

TABLE 2: AWF STEP TEST RESULTS
Continuous Optimization Program
Nevada Environmental Response Trust Site
Henderson, Nevada

Well ID	Test Date	Pumping Rate (gpm)	Step Duration (min)	Accumulated Drawdown (ft below static water level)	Depth of Pump Intake (ft bTOC)	Depth of Static Water Level (ft bTOC)	Depth of Pump Intake (ft below static water level)	Maximum Flow Rate (gpm)	Maximum Flow Rate With Current Pump (gpm)
ART-1	11/02/15	5.0	43	0.55	37.60	22.26	15.34	37	32
		22.0	69	5.36					
		32.0	203	14.47					
		27.5	46	10.07					
ART-2	10/14/2015	18.0	51	0.29	42.50	25.35	17.15	94	70
		30.0	39	0.50					
		41.0	35	0.73					
		50.0	36	0.86					
		70.0	26	1.23					
ART-3A	10/23/2015	11.0	62	1.94	49.50	26.23	23.27	44	44
		24.0	78	4.92					
		37.0	72	9.57					
		40.0	90	12.69					
		43.0	36	17.30					
ART-4	10/15/2015	1.0	44	0.49	39.60	27.20	12.40	20	20
		10.0	50	5.50					
		19.0	31	11.08					
		20.0	27	11.18					
ART-7B	10/22/2015	13.0	77	2.13	40.70	28.65	12.05	33	33
		19.0	91	3.64					
		23.0	82	4.57					
		28.0	90	5.98					
		33.0	80	10.11					

TABLE 2: AWF STEP TEST RESULTS
Continuous Optimization Program
Nevada Environmental Response Trust Site
Henderson, Nevada

Well ID	Test Date	Pumping Rate (gpm)	Step Duration (min)	Accumulated Drawdown (ft below static water level)	Depth of Pump Intake (ft bTOC)	Depth of Static Water Level (ft bTOC)	Depth of Pump Intake (ft below static water level)	Maximum Flow Rate (gpm)	Maximum Flow Rate With Current Pump (gpm)
ART-8	10/21/2015	19.0	73	0.82	42.40	26.50	15.90	103	74
		33.0	62	1.49					
		44.0	62	2.03					
		63.0	73	3.16					
		74.0	75	4.42					
ART-9	10/20/2015	21.0	75	0.49	40.80	28.76	12.04	178	74
		35.0	68	0.90					
		52.0	65	1.46					
		64.0	70	2.02					
		74.0	69	2.61					

Notes:

gpm=gallons per minute

min= minute

ft = feet

bTOC=below top of casing

TABLE 3: AWF PUMPING SCENARIOS

Continuous Optimization Program

Nevada Environmental Response Trust Site

Henderson, Nevada

Well Name	Pumping Rate (gpm)					
	Baseline (2015Q2)	Maximum Pumping	Shift Pumping East	Sunset Road Wells	Parcel A Wells	AWF Recommended
ART-1	8	32	0	0	0	0
ART-2	62	70	0	0	0	0
ART-3A	44	44	44	44	44	44
ART-4	16	20	16	16	16	20
ART-7B	29	33	37	29	29	35
ART-8	62	74	62	62	62	100
ART-9	61	74	123	61	61	140
PC-150	5	5	5	5	5	5
New Well#1	0	0	0	62	0	0
New Well#2	0	0	0	62	0	0
New Well#3	0	0	0	62	0	0
New Well#4	0	0	0	0	15	0
New Well#5	0	0	0	0	15	0
New Well#6	0	0	0	0	15	0
Total AWF	**287**	**352**	**287**	**217**	**217**	**344**

Notes:

gpm=gallons per minute

TABLE 4: EVALUATION OF AWF PUMPING SCENARIOS

Continuous Optimization Program

Nevada Environmental Response Trust Site

Henderson, Nevada

Scenarios	Combined Pumping (gpm)	Captured Plume Mass (lbs)	Instantaneous Mass Removal Rate (lbs/d)
Baseline (2015Q2)	287	550,683	390
Maximum Pumping	352	557,891	495
Shift Pumping East	287	539,210	509
Sunset Road Wells	403	537,708	1,078
Parcel A Wells	262	462,496	719
AWF Recommended	344	544,831	580

Notes:

gpm=gallons per minute

lbs=pounds

lbs/d=pounds per day

TABLE 5: EVALUATION OF SWF PUMPING SCENARIOS

Continuous Optimization Program

Nevada Environmental Response Trust Site

Henderson, Nevada

Scenarios	Total Pumping (gpm)	Captured Plume Mass (lbs)	% BVP Water Captured at SWF
2015Q2 Rates	539	99,250	59%
20% Reduction from 2015Q2	431	94,496	52%
40% Reduction from 2015Q2	324	89,019	47%
60% Reduction from 2015Q2	216	85,228	43%
80% Reduction from 2015Q2	108	78,751	22%
New Well	598	110,239	46%

Notes:

gpm=gallons per minute

lbs=pounds

BVP= City of Henderson Bird Viewing Preserve

TABLE 6: EVALUATION OF ONSITE SOIL FLUSHING SCENARIOS

Continuous Optimization Program

Nevada Environmental Response Trust Site

Henderson, Nevada

Scenarios	Combined Flow Rate (gpm)	Average Concentration (mg/L)	Instantaneous Mass Removal (lbs/d)
2015Q2	66	938	744
Soil Flushing (South)	86	938	969
Soil Flushing (South and North)	126	938 (South) 290 (North)	1,179

Notes:

gpm=gallons per minute

mg/L=milligrams per liter

TABLE 7: AWF AND SWF OPTIMIZED PUMPING RATES
Continuous Optimization Program
Nevada Environmental Response Trust Site
Henderson, Nevada

		2015Q2		Recommended		
Wells	**Interpolated Perchlorate Concentration (mg/L)**	**Pumping Rate (gpm)**	**Instantaneous Mass Removal Rate (lbs/d)**	**Pumping Rate (gpm)**	**Change From 2015/Q2 (gpm)**	**Instantaneous Mass Removal Rate (lbs/d)**
Athens Road Well Field						
ART-1	14	8	1	0	-8	0
ART-2	32	62	24	0	-62	0
ART-3A	166	44	88	44	0	88
ART-4	205	16	38	20	4	49
ART-7B	155	29	54	35	6	65
ART-8	66	62	49	100	38	79
ART-9	173	61	127	140	79	291
PC-150	137	5	8	5	0	8
Total AWF		**287**	**390**	**344**	**57**	**580**
Seep Well Field						
PC-99R2	17	63	13	64	1	13
PC-115R	11	93	12	93	0	12
PC-116R	14	143	24	143	0	24
PC-117	10	101	13	101	0	13
PC-118	2	77	2	77	0	2
PC-119	0.4	58	0.3	0	-58	0
PC-120	0.2	0	0	0	0	0
PC-121	0.3	0	0	0	0	0
PC-133	9	4	0.5	4	0	0.5
Total SWF		**539**	**64**	**482**	**-57**	**64**

Notes:

mg/L=milligrams per liter

gpm=gallons per minute

lbs/d=pounds per day

The mass removal rates are not the actual rates for 2015Q2 but are based on the interpolated concentrations at each extraction well.

Figures

Inset C

Inset B

Las Vegas Wash

Former AMPAC Re-injection System

Seep Well Field

PABCO ROAD

City of Henderson Bird Viewing Preserve

AMPAC Extraction Systems

GALLERIA ROAD

N. BOULDER HIGHWAY

SUNSET ROAD

Athens Road Well Field

OSSM Extraction Well Field

NERT Barrier Wall and Interceptor Well Field

TIMET Barrier Wall and Extraction Well Field

Legend

- Shallow Well
- Deeper Well
- Inactive
- P&A (Plugged & Abandoned)
- Borings
- D D' Subsurface Cross-Section Location
- NERT Downgradient Plume

SOURCE: BMI All Wells Database Spreadsheet.

Note: Subsurface Cross-Sections A-A', B-B', and C-C' are presented in the Annual Remedial Performance Report for Chromium and Perchlorate, July 2014 - June 2015 dated October 30, 2015.

Grid: State Plane, Nevada East, NAD83, Feet

Path: H:\LePetomane\NERT\GWETS\Continuous Optimization Program\GIS\Plate 1 - COPs Wells by Category_xsecloc.mxd

Figure 1

PROJECT: 21-34800H

COP Area Wells and Borings

Continuous Optimization Program (COP)
Nevada Environmental Response Trust (NERT)
Henderson, Nevada

DESIGNED BY:	REVISIONS			
	NO.	DESCRIPTION:	DATE:	BY:
DRAWN BY: RS	0	GENERATE APPROVED MAP	6/12/2015	RS
CHECKED BY: JD	1	Revision 1	7/15/2015	RS
APPROVED BY: JD				

RAMBOLL ENVIRON

Oblique View Looking North

- Alluvium (Qal)
- Upper Muddy Creek Formation, First Coarse-Grained Facies (UMCF-cg1)
- Upper Muddy Creek Formation, Fine-Grained Facies (UMCF-fg)
- Upper Muddy Creek Formation, Second Coarse-Grained Facies (UMCF-cg2)

Site Geological Model

Nevada Environmental Response Trust (NERT)
Henderson, Nevada

RAMBOLL ENVIRON

FIGURE
2

DRAFTED BY:	DATE: 1/19/2016	PROJECT

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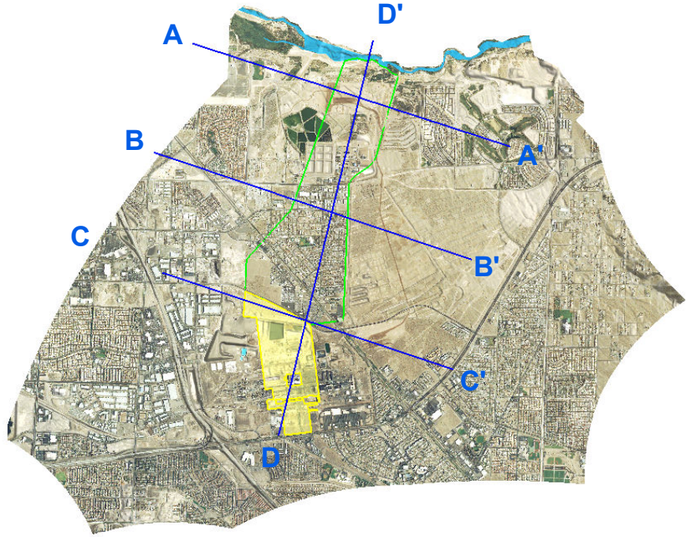
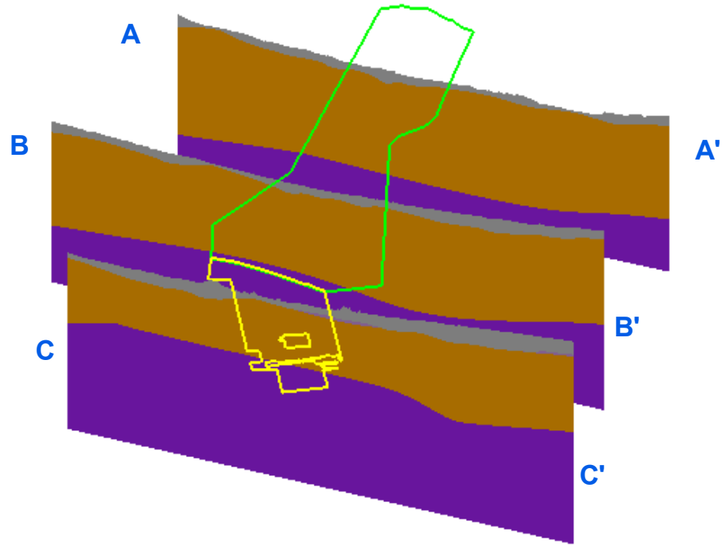
Cross Section Locations

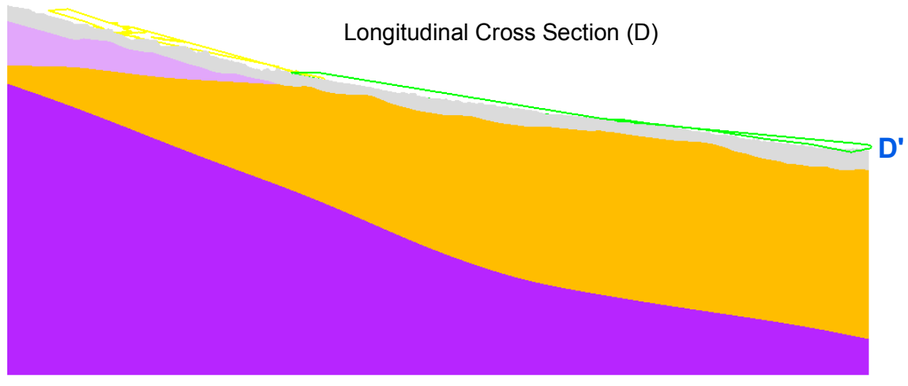


Cross Sections Through Site and Offsite Plume Area (A, B, C)



D

Longitudinal Cross Section (D)



Site Geological Model

Cross-Sections

Nevada Environmental Response Trust (NERT)
Henderson, Nevada

RAMBOLL ENVIRON

FIGURE
3

DRAFTED BY:	DATE: 1/19/2016	PROJECT

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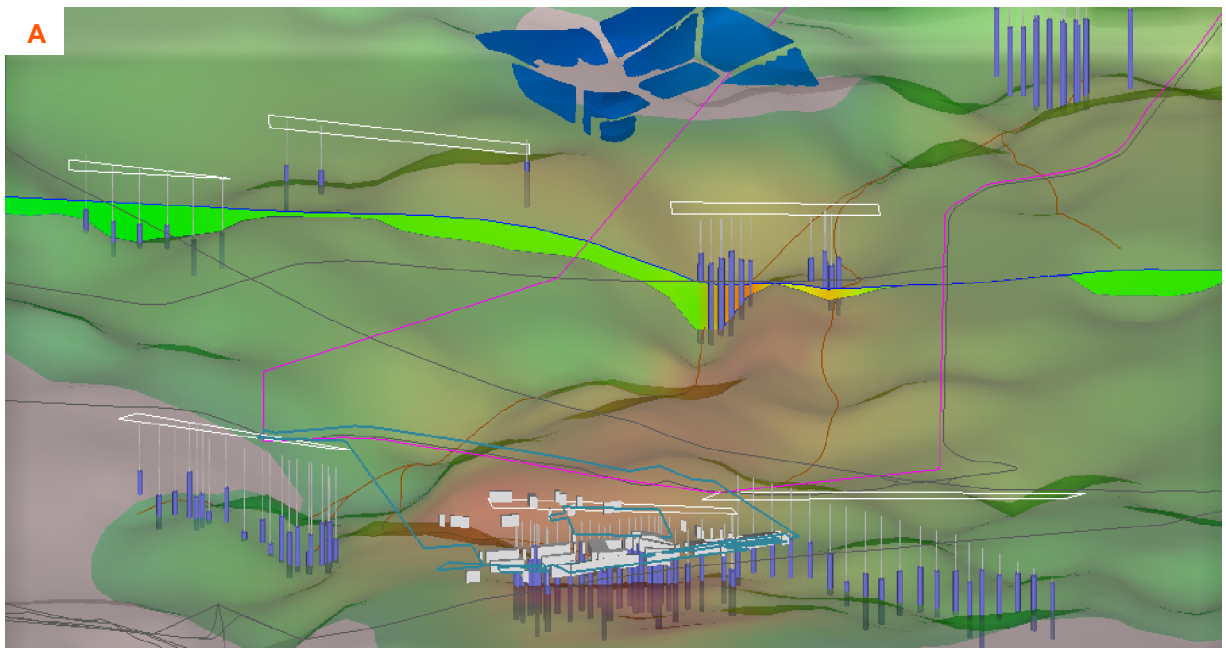

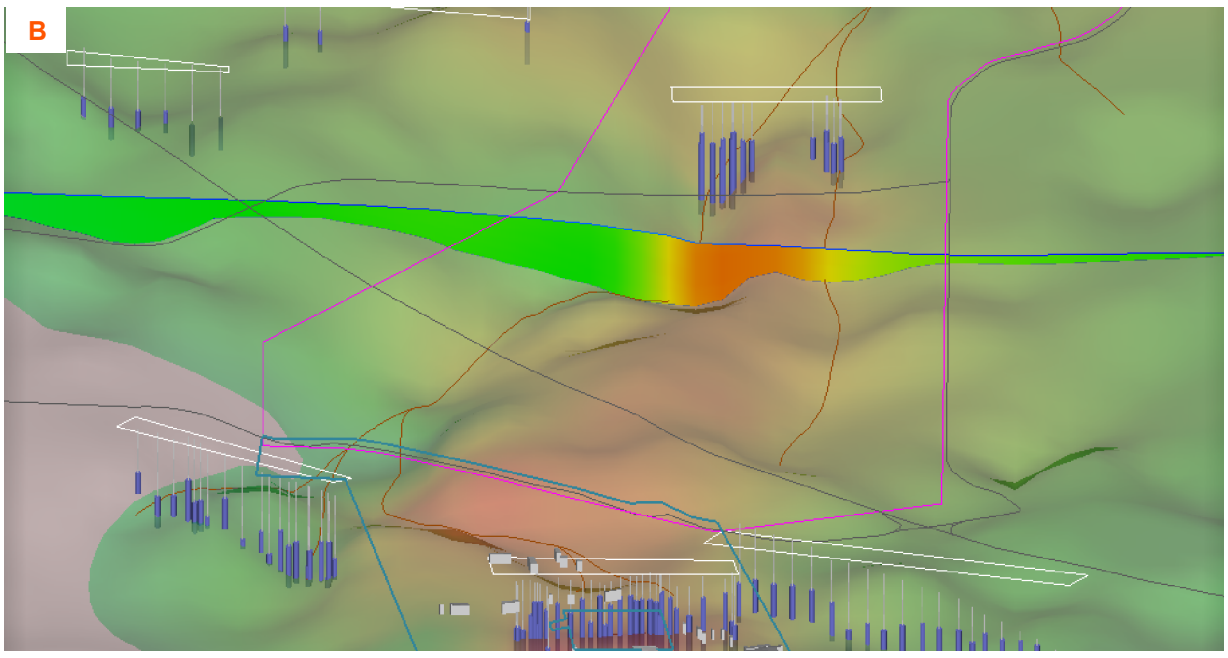

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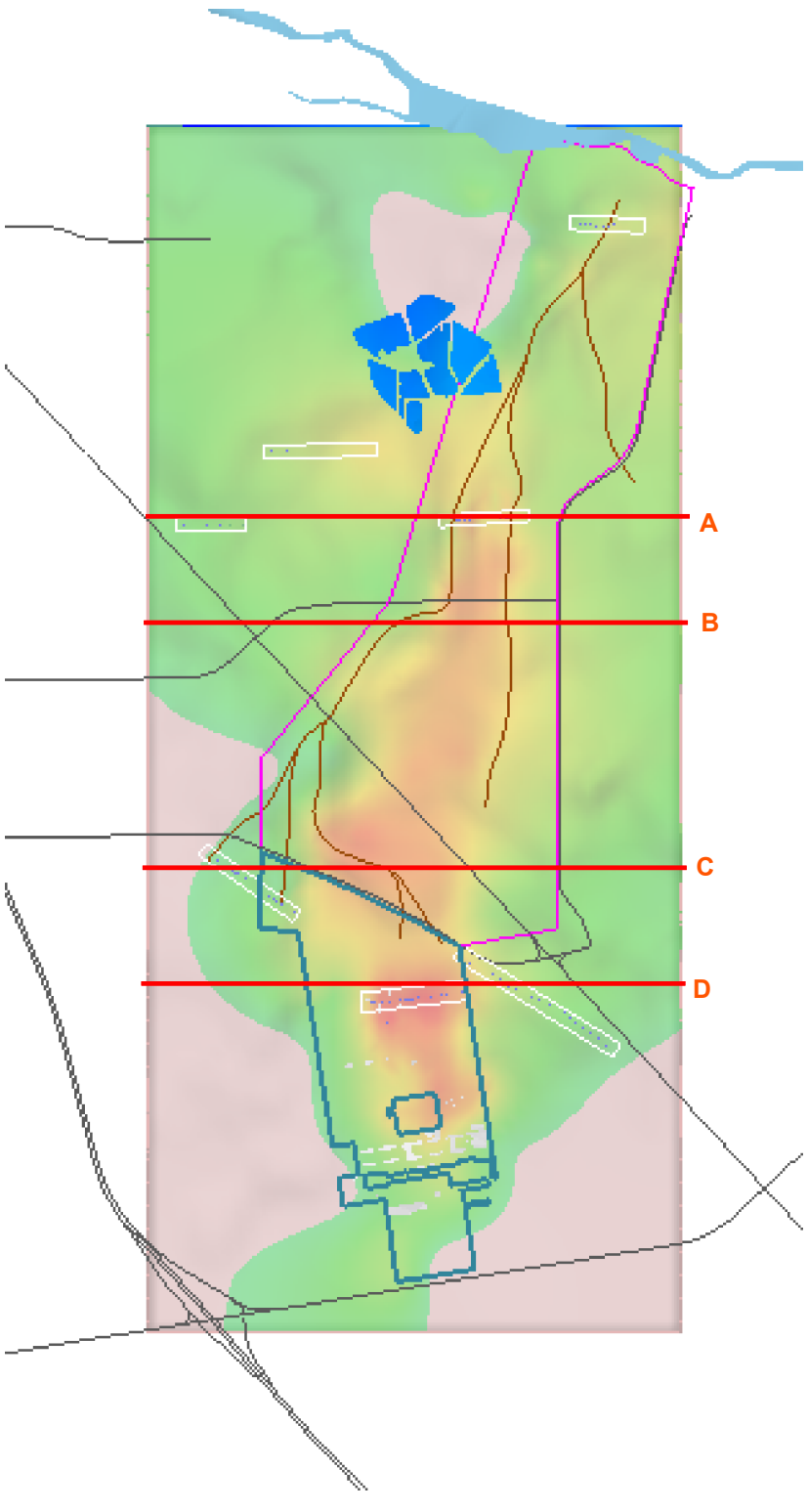

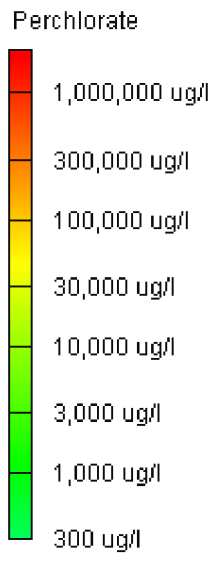

Plume and Paleochannel Visualization: Slice A and B

Nevada Environmental Trust Site (NERT)
Henderson, Nevada

RAMBOLL ENVIRON

FIGURE
4

DRAFTED BY:	DATE: 1/19/2016	PROJECT

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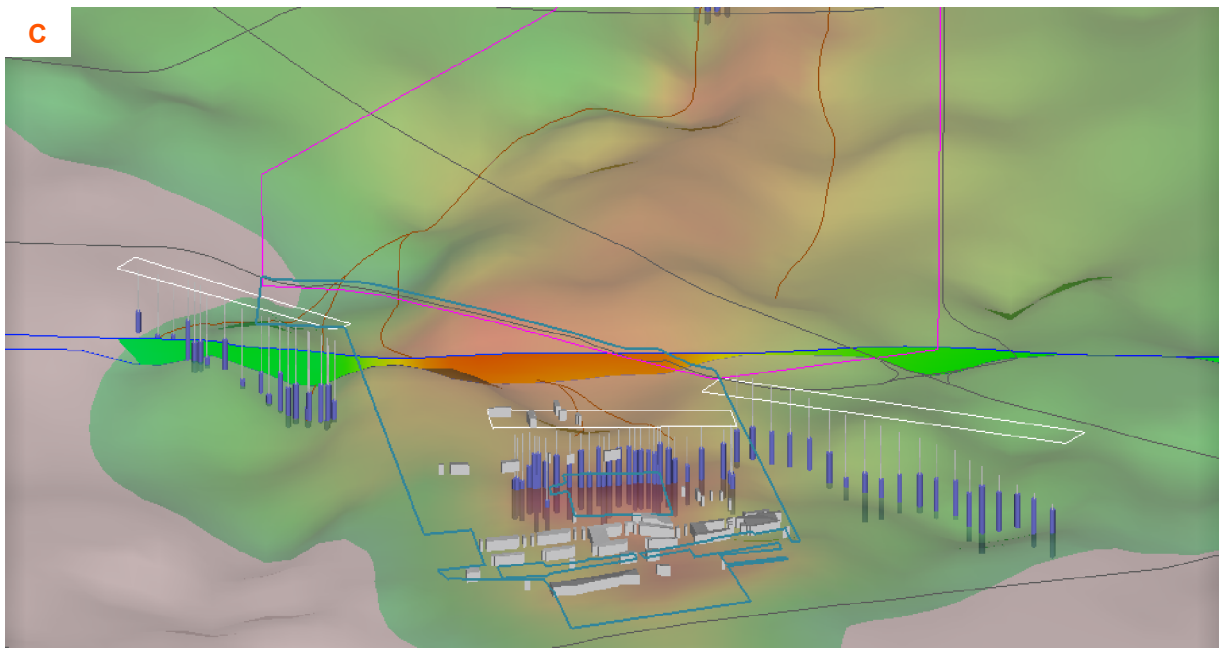

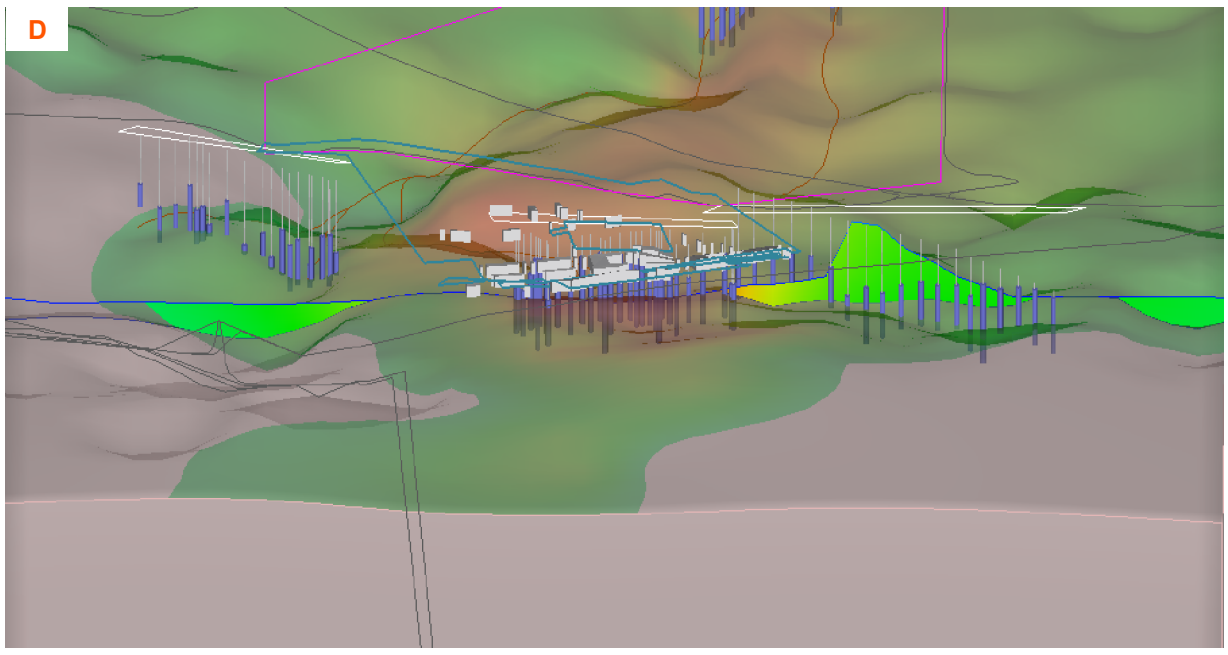

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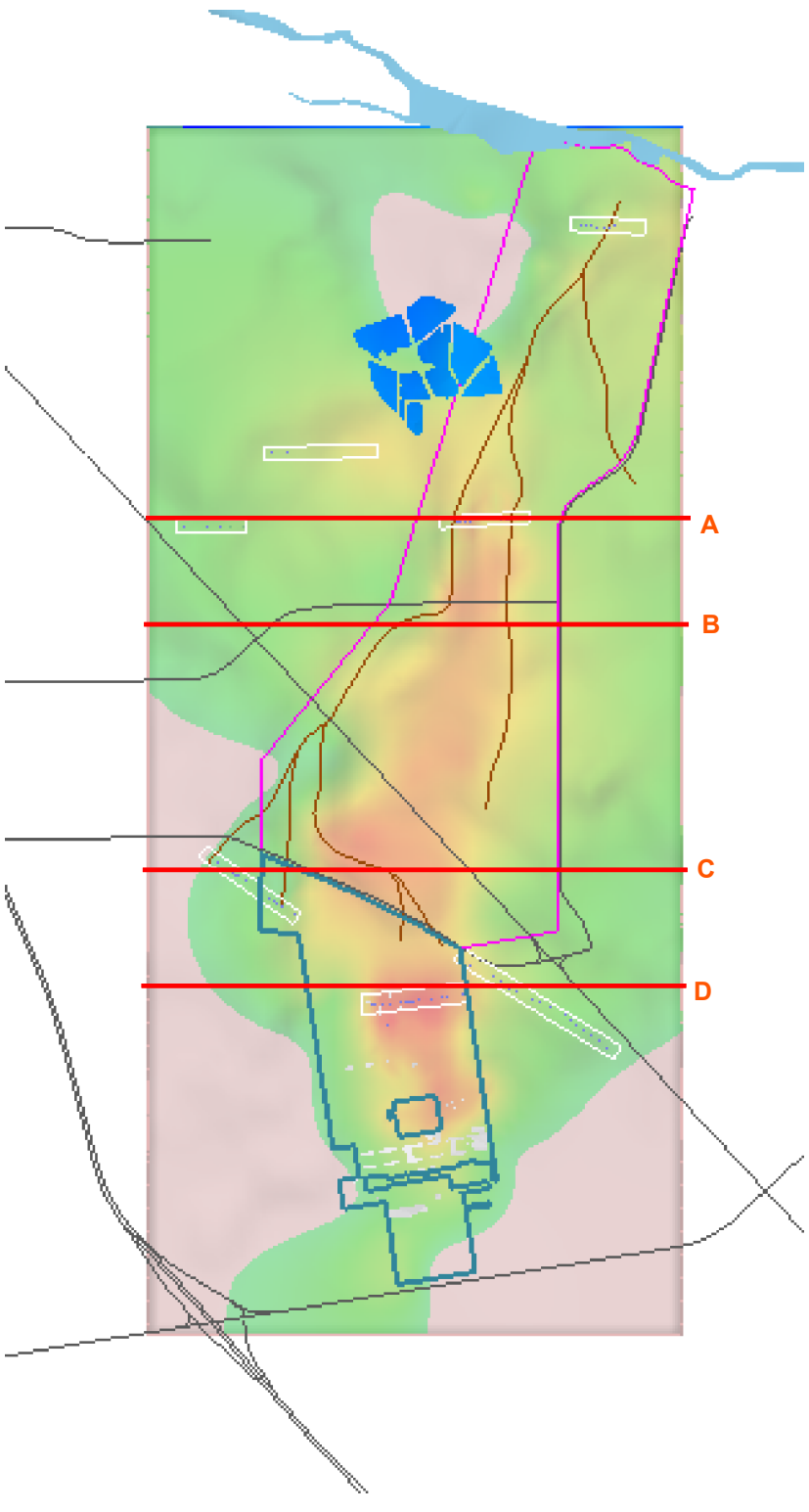

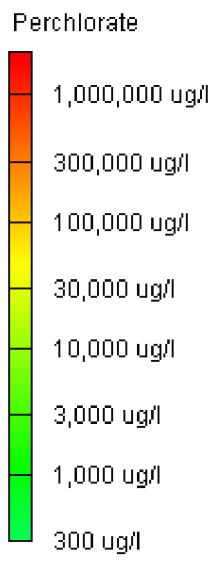

Plume and Paleochannel Visualization: Slice C and D

Nevada Environmental Trust Site (NERT)
Henderson, Nevada

RAMBOLL ENVIRON

FIGURE
5

DRAFTED BY:	DATE: 1/19/2016	PROJECT

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Las Vegas Wash

SEEP WELL FIELD

COH Birding Pond

AMPAC ATHENS PEN EXTRACTION WELLS

AMPAC ATHENS ROAD EXTRACTION WELLS

ATHENS ROAD WELL FIELD

OSSM WELL FIELD

INTERCEPTOR WELL FIELD

TIMET WELL FIELD

AMPAC AUTO MALL EXTRACTION WELLS

EXPLANATION

- Extraction Wells
- Paleochannels
- Downgradient Plume
- Site Boundary

Perchlorate Plume Mass (lbs)

- 0 - 20
- 20 - 62
- 62 - 138
- 138 - 256
- 256 - 416
- 416 - 747
- 747 - 1,368
- 1,368 - 2,395
- 2,396 - 4,792

N
W E
S

0 0.4 0.8 Miles

RAMBOLL ENVIRON

PERCHLORATE MASS DISTRIBUTION
Nevada Environmental Response Trust Site
Henderson, Nevada

Date: 1/22/2016	Contract Number: 21-38800B		Figure 6
Drafter: AS	Approved:	Revised:	

Path: H:\LePetomane\NERT\GWETS\Continuous Optimization Program\2015 Year-End TM\Figures\Fig 6 - Perchlorate Mass Distribution.mxd

SEEP WELL FIELD

COH Birding Pond

AMPAC ATHENS PEN EXTRACTION WELLS

ATHENS ROAD WELL FIELD

AMPAC ATHENS ROAD EXTRACTION WELLS

OSSM WELL FIELD

EXPLANATION

- Extraction Wells
- Transect - Seep Well Field
- Transect - Athens Road Well Field
- Paleochannels
- Downgradient Plume
- Site Boundary

Capture Zone

- Athens Road Well Field
- Seep Well Field

Plume Mass (lbs)

- 0 - 20
- 20 - 62
- 62 - 138
- 138 - 256
- 256 - 416
- 416 - 747
- 747 - 1,368
- 1,368 - 2,395
- 2,396 - 4,792

N
W E
S

0 0.25 0.5 Miles

RAMBOLL ENVIRON

PLANNED OPTIMIZATION
Nevada Environmental Response Trust Site
Henderson, Nevada

Date: 1/22/2016	Contract Number: 21-38800B		Figure 7
Drafter: AS	Approved:	Revised:	

Path: H:\LePetomane\NERT\GWETS\Continuous Optimization Program\2015 Year-End TM\Figures\Fig 7- Recommended_Scenario.mxd

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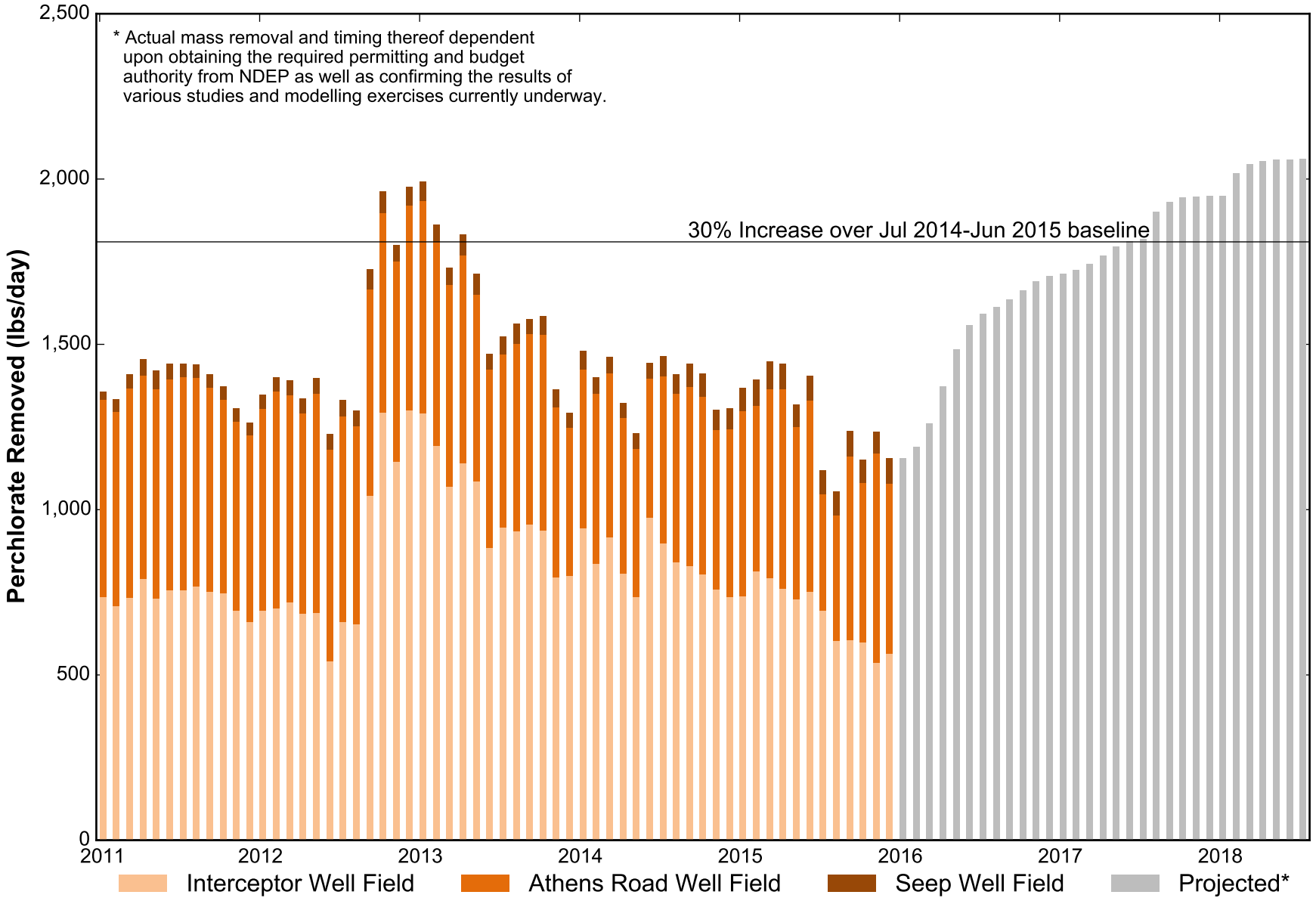

RAMBOLL ENVIRON

Perchlorate Removed from the Environment
Nevada Environmental Response Trust Site
Henderson, Nevada

Figure
8

Drafter: JH	Date: 01/25/16	Contract Number:	Approved:	Revised: