ENVIRON

November 30, 2011

Shannon Harbour, PE
Special Projects Branch
Bureau of Corrective Actions
NDEP-Carson City Office
901 South Stewart Street
Carson City, NV 89701

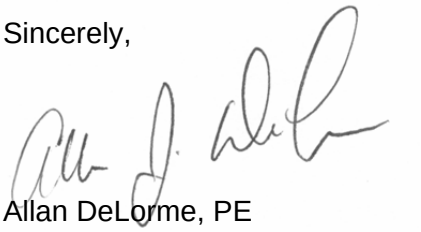
Re: Technical Memorandum on Long-Term Monitoring Optimization; Nevada Environmental Response Trust Site; Henderson, Nevada

Dear Ms. Harbour:

On behalf of the Nevada Environmental Response Trust (NERT), this letter transmits the *Technical Memorandum on Long-Term Monitoring Optimization* for the Nevada Environmental Response Trust Site in Henderson, Nevada.

Please contact either me or Mark Travers with any questions or comments.

Sincerely,



Allan DeLorme, PE
Managing Principal

Attachments

Cc: Greg Lovato, Bureau of Corrective Actions, NDEP
William Knight, Bureau of Corrective Actions, NDEP
Jay Steinberg, Nevada Environmental Response Trust
Tanya O'Neil, Esq., Foley and Lardner
Mark Travers, ENVIRON International Corporation

northgate
environmental management, inc.

LETTER OF TRANSMITTAL

1232.02

November 29, 2011

Allan DeLorme
ENVIRON International Corporation
6001 Shellmound Street
Emeryville, CA 94608

Via Email

The following is attached:

Description	No. of Copies
Technical Memorandum on Long-Term Monitoring Optimization Nevada Environmental Response Trust Site, Henderson, Nevada	1

Allan,

Please find the subject memo attached. Feel free to contact me at contact me at (510) 839-0688, extension 201.

Sincerely,

Deni Chambers
Principal

Technical Memorandum on Long-Term Monitoring Optimization

Nevada Environmental Response Trust Site

Henderson, Nevada

November 29, 2011

Prepared For:

ENVIRON International Corporation
6001 Shellmound Street, Suite 700
Emeryville, California 94608

Prepared By:

Northgate Environmental Management, Inc.
300 Frank H. Ogawa Plaza, Suite 510
Oakland, California 94612

Deni Chambers, C.E.M.
Principal

Josh W. Otis, C.E.M.
Senior Geologist

1232.02

Technical Memorandum on Long-Term Monitoring Optimization
Nevada Environmental Response Trust 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.

Joshua Otis, CEM 2250 Exp.: 3/25/12
Northgate Environmental Management, Inc.

TABLE OF CONTENTS

1.0 INTRODUCTION 1
2.0 REMEDIAL STATUS 2
3.0 EXISTING MONITORING PROGRAM 3
3.1 Monitoring Program Overview 3
3.2 Summary of Long-Term Monitoring Results 4
3.3 Data Gaps 5
4.0 LONG-TERM MONITORING OPTIMIZATION RECOMMENDATIONS 7
4.1 Proposed Long-Term Groundwater Monitoring Plan 8
4.1.1 Objective: Measure Contaminant Removal 8
4.1.2 Objective: Monitor Effectiveness of the Groundwater Intercept Systems 8
4.1.3 Objective: Monitor Changes in Plume Configuration over Time 9
4.2 Additional Recommendations 10
4.2.1 Reporting 10
4.2.2 Data Validation 10
4.3 Periodic Review of Long-Term Monitoring Program 10
5.0 REFERENCES 12

TABLES

1 NERT Site Compliance Monitoring Programs
2 Proposed GWETS Groundwater Monitoring Schedule

FIGURES

1 2010 Monthly Groundwater Monitoring Locations
2 2010 Quarterly and Annual Groundwater Monitoring Locations
3 Groundwater Perchlorate Isoconcentration Maps, 2002-2010
4 Proposed Quarterly Monitoring Locations
5 Proposed Annual/Five Year Monitoring Locations – Perchlorate
6 Proposed Annual/Five Year Monitoring Locations – Chromium

ATTACHMENTS

1 Northshore Road Monitoring Data
2 Spatial Evaluation of the Long-Term Monitoring Program

1.0 INTRODUCTION

Northgate Environmental Management, Inc. (Northgate) has prepared this technical memorandum on long-term monitoring optimization (LTMO) on behalf of the Nevada Environmental Response Trust (NERT) for the Nevada Environmental Response Trust Site in Henderson, Nevada (the Site). Long-term monitoring is defined by the US Environmental Protection Agency (EPA) as "monitoring conducted after some active, passive, or containment remedy has been selected and put in place, and is used to evaluate the degree to which the remedial measure achieves its objectives" (EPA, 2005). The purpose of LTMO is to assure that monitoring achieves its objectives with the appropriate level of effort. As the remedy progresses and additional data are collected about a site, monitored parameters commonly become more predictable and the extent of contamination diminishes. While the primary objective of any long-term monitoring program is to collect adequate data to measure the effectiveness of the remedy, reducing the monitoring frequency, number of locations, and/or parameters where feasible can result in substantial cost savings.

NERT operates a groundwater extraction and treatment system (GWETS) at the Site to remediate an extensive groundwater contaminant plume of perchlorate and hexavalent chromium and conducts a groundwater monitoring program to monitor the effectiveness of the GWETS. The purpose of this memorandum is to define the objectives of a long-term groundwater monitoring program at the Site and provide recommendations for optimizing the current monitoring program.

2.0 REMEDIAL STATUS

The current groundwater remedy at the Site is a GWETS that acts to remove hexavalent chromium and perchlorate from shallow groundwater beneath the Site and at downgradient locations along the existing contaminant plume. The GWETS consists of three extraction well fields: (1) the onsite Interceptor Well Field (IWF) and barrier wall; (2) the Athens Road Well Field (AWF); and (3) the Seep Well Field (SWF). Hexavalent chromium in groundwater from the IWF and AWF is reduced to trivalent chromium through a ferrous sulfate treatment system, while perchlorate in groundwater from all three systems is treated using perchlorate-reducing bacteria in a fluidized bed reactor. Following treatment, the groundwater is discharged to the Las Vegas Wash under a National Pollution Discharge Elimination System (NPDES) permit.

The three extraction well fields and associated treatment facilities were installed in stages between 1986 and 2001 by former Site owner Kerr-McGee Chemical Corporation (KMCC), pursuant to Administrative Orders on Consent (AOCs) issued by the Nevada Division of Environmental Protection (NDEP), and have remained in operation in their current form for approximately ten years.

Northgate conducted a capture zone evaluation (CZE) to evaluate the efficacy of the GWETS in 2010. In conjunction with the CZE, a calibrated groundwater flow model was developed for the Site and several new monitoring wells were installed to address identified data gaps. The remedial performance standard identified in the CZE report was 95% capture at both the IWF and AWF. The CZE report has not yet been finalized and approved by the NDEP; however, the draft report concluded that the IWF met the performance standard, capturing greater than 95% of perchlorate and hexavalent chromium mass flux. Estimated capture at the AWF was less than 95% of mass flux, although the combined capture at the AWF and SWF was estimated at 94% to 97% of the AWF mass flux (Northgate, 2010).

3.0 EXISTING MONITORING PROGRAM

Table 1 lists compliance monitoring and reporting programs being implemented at the Site, grouping them by remediation monitoring and permit monitoring. The historic regulatory basis for each program is noted along with its stated purpose and elements of the program, including the type of data collected, monitoring locations, and frequency of measurements.

The remediation monitoring programs in Table 1 are designed to monitor the effectiveness of the groundwater intercept systems in removing chromium and perchlorate from groundwater, to monitor the effectiveness of the treatment system, estimate the mass of contaminants removed, and track changes in the water levels and contaminant plume configuration upgradient and downgradient of the intercept systems. The permit monitoring programs are in place to meet the applicable Federal/State requirements for waste storage (GW-11 pond) and discharge of treated water (treatment system NPDES monitoring). The following sections address the remediation monitoring programs only.

3.1 Monitoring Program Overview

In 2010, over 1,800 water level measurements and 900 groundwater samples were collected from Site wells as part of the remediation monitoring program. Samples are collected on monthly, quarterly, and annual schedules in accordance with monitoring requirements outlined in the AOCs and through subsequent regulatory correspondence. The current remediation monitoring program can be summarized as follows (numbers referenced are from the 2010 monitoring year):

- On a monthly basis, groundwater samples and water level measurements are collected from most active monitoring wells in the AWF, SWF, and within the plume between these two well fields. Samples are analyzed for perchlorate and total dissolved solids (TDS). Data are used to calculate the mass of perchlorate removed by the well fields and to provide groundwater level and quality data in the northern portion of the plume downgradient of the AWF. Water level measurements are also collected monthly from the IWF extraction wells and approximately 65 monitoring wells located within or adjacent to the NERT facility boundaries to characterize the groundwater levels and flow directions.
- Expanded monitoring events are conducted in the first, third, and fourth quarters and consist of collecting between 90 and 135 groundwater samples and between 134 and 178 water level measurements (inclusive of monthly monitoring activities described above). Groundwater samples are collected from wells screened in the Shallow Water-Bearing Zone (WBZ) located throughout the plume. Samples are analyzed for perchlorate, chromium, TDS, and pH.
- An annual comprehensive monitoring event is conducted in the second quarter, and consists of 238 groundwater samples and 305 water level measurements collected from

wells screened in the Shallow, Middle, and Deep WBZs. In addition to the analytes above, a subset of wells are analyzed for chlorate and nitrate.

Initially, separate quarterly remedial progress reports were submitted for the chromium and perchlorate remediation programs. In 2006, reporting for the two programs was combined, and since then the monitoring reports have been submitted semi-annually. The current semiannual reports consist of text, tables, and figures documenting the status of remediation efforts, with appendices containing laboratory data reports, data validation reports, field documentation, and electronic data deliverables. An annual report submitted following the comprehensive second quarter monitoring event also includes a potentiometric surface map for the plume area and isoconcentration maps for the monitored constituents.

3.2 Summary of Long-Term Monitoring Results

The extensive data record for the Site includes monitoring data collected from over 430 wells installed at the Site and several additional wells installed at neighboring Sites. Over ten years of monitoring data have been collected to evaluate the perchlorate groundwater plume discovered in the late 1990s, and nearly 30 years of monitoring data have been collected to evaluate the chromium plume. A review of these data indicates that shallow groundwater flow from Lake Mead Parkway to the Las Vegas Wash has been very consistent over the past 25 years, with the exception of localized drawdown at groundwater extraction well fields at the Site and adjacent properties. Groundwater flow directions (outside the influence of each of the extraction well fields) were evaluated by comparing shallow groundwater elevation contour maps for years 1985 and 2003-2010. The maps demonstrate that:

- South of the IWF, groundwater flow is to the north with a slight northwest component, varying by less than 10 degrees from north;
- In the mid-Site area, from the recharge trenches on the south to Sunset Road on the north, groundwater flow is to the north-northeast, varying by less than 40 degrees from north over the 25 year period;
- Between Sunset Road on the south and the Las Vegas Wash on the north, groundwater flow is to the north-northeast, varying less than 45 degrees from north;
- Groundwater flow directions vary minimally quarter to quarter; and
- Groundwater levels do not fluctuate significantly over time.

These observations are consistent with the most recent Conceptual Site Model (CSM; Northgate, 2010) which suggests that groundwater flow in the Shallow WBZ, particularly in the uppermost alluvium, is primarily controlled by recharge from the underlying aquifers and the geologic contours of the underlying low-permeability Upper Muddy Creek formation (UMCf), and is not

likely to be significantly influenced by seasonal precipitation. Annual depictions of groundwater elevations are sufficient to understand groundwater movement at the Site.

Contaminant concentration trends were evaluated by comparing groundwater isoconcentration maps of perchlorate and chromium for the years 2002 to 2010. The maps demonstrate that:

- The overall extent of the 1 milligram per liter (mg/L) perchlorate plume contour has remained stable, while concentrations inside the 1 mg/L contour have decreased significantly, particularly upgradient of the barrier wall;
- Between the IWF and AWF the highest concentrations have moved northward in the plume, but have not yet reached the AWF;
- Annual differences in the interpreted perchlorate plume upgradient of the barrier wall and between the AWF and the SWF are relatively small, particularly in recent years; and
- The lateral extent of the 0.02 mg/L chromium plume contour has remained stable between 2005 and 2010, while concentrations inside the 0.02 mg/L contour have decreased.

The extensive data set demonstrates that the plume is generally stable, concentrations are decreasing in the source areas upgradient of the IWF, and the trailing edge of a detached perchlorate plume is slowly migrating northward towards the AWF. The footprint of the plume in the Shallow WBZ, as defined by the 1 mg/L isoconcentration contour, has remained remarkably stable. A series of isoconcentration maps that illustrate the relative stability of the perchlorate plume are presented in Figure 3. It should be noted that, following the removal of the recharge tranches in late 2010 during soil remediation activities at the Site, concentrations downgradient of the IWF and barrier wall are expected to increase in the short term as clean Lake Mead water is no longer recharged to the shallow aquifer. However, the overall footprint of the plume (1 mg/L isoconcentration contour) is not anticipated to be affected by the recharge trench shutdown.

The GWETS perchlorate removal rate presented in the most recent remedial performance report (Northgate, 2011) and perchlorate concentrations measured in the Las Vegas Wash at Northshore Road (Attachment 1) are also stable or with gradually declining trends over the past several years, providing further evidence of plume stability under the current GWETS operating conditions. The data suggest that a reduction in the frequency of measurements may be feasible for a large number of wells and can be implemented without sacrificing monitoring objectives.

3.3 Data Gaps

There are some monitoring areas for which a sufficient data set does not exist to establish meaningful baseline conditions or perform a statistical optimization evaluation. Specific areas

identified are wells installed in the Middle WBZ to investigate the vertical extent of contamination, and recently installed wells in the vicinity of the AWF to further characterize the potentiometric surface and contaminant distribution. Additionally, several new extraction wells were installed in the IWF and AWF, but are not currently operational. As additional wells are brought online and connected to the GWETS, changes to the monitoring program may be required to assess the environmental response to the increased pumping.

4.0 LONG-TERM MONITORING OPTIMIZATION RECOMMENDATIONS

EPA guidance suggests that LTMO be considered "for most Sites where long-term monitoring programs are based on monitoring points and/or sampling frequencies that were established during site characterization, or for sites where more than about 20 samples are collected and analyzed on an annual basis", and when site conditions are relatively stable with "no major changes in remediation approaches … occurring or anticipated in the next year or two" (EPA, 2005). The NERT Site meets these criteria. The current groundwater monitoring program, outlined in the Groundwater Sampling Plan (Tronox LLC, 2008) and approved by NDEP, is an amalgamation and update of monitoring requirements originally set forth in the historic AOCs between NDEP and KMCC that governed the implementation of the current interim remedial action. The monitoring programs were designed to collect data needed to characterize the extent and migration of contaminants at the Site as well as the effectiveness of the remedial actions being implemented. Over time, the need for Site characterization has diminished with the accumulation of an extensive collection of monitoring data. The accumulated data have been used to inform detailed CSMs (ENSR, 2005; Northgate, 2010) and develop a calibrated groundwater flow model. Several lines of evidence indicate that under the current Site conditions, the contaminant plumes are relatively stable with only minor changes between monitoring events. Optimizing the monitoring program has the potential to significantly decrease long-term monitoring efforts and associated costs.

An effective monitoring program relies on clearly defined objectives to inform the selection of sampling locations, frequency, and analytical suites. The current monitoring program is based on objectives defined during multiple phases of Site characterization and interim remedial actions performed at the Site, some of which are no longer relevant or necessary. It is, therefore, appropriate to refine or redefine the monitoring objectives in the course of optimizing the existing monitoring program to provide the basis for a revised long-term monitoring plan that is responsive to the current needs of the Site. With the exception of specific data gaps described in Section 3.3 above, the source areas, occurrence, and migration of the target contaminants as described in the CSMs are considered to be well characterized. The collection of additional characterization data as it relates to the current remedy is therefore not considered to be a monitoring objective. The following monitoring objectives were used to define the long-term monitoring optimization recommendations that follow:

- Measure the contaminant mass (perchlorate and hexavalent chromium) removed by the GWETS;
- Monitor the effectiveness of the groundwater intercept system (i.e., the extraction well fields); and

- Monitor changes in plume configuration over time in response to the groundwater remedy.

4.1 Proposed Long-Term Groundwater Monitoring Plan

The following sections describe the proposed optimized long-term groundwater monitoring plan designed to fulfill the identified monitoring objectives. The schedule and analytes for each individual monitoring well are presented in Table 2. Generally, the proposed monitoring plan consists of monthly sampling of individual extraction wells to measure contaminant mass removed by the GWETS, quarterly sampling and water level measurements collected to monitor the effectiveness of the groundwater intercept systems operating at each individual well field, and an annual sampling event to monitor changes in groundwater contaminant plume configurations over time. The monitoring plan as presented does not include process sampling conducted by Veolia during operation of the chromium and perchlorate treatment systems or sampling conducted to meet NPDES permit requirements governing the discharge of treated groundwater to the Las Vegas Wash.

The proposed monitoring plan results in an approximate 60% reduction in perchlorate and chromium analyses and an approximate 85% reduction in TDS analyses compared to the current groundwater monitoring program, resulting in significant savings of labor, laboratory costs, and data validation and management costs. In addition to optimizing the monitoring schedule, we recommend measuring monitoring parameters such as pH and electrical conductivity (EC) using calibrated field monitoring equipment rather than submitting samples for laboratory analysis, as it will be more accurate and cost-effective. This recommendation is reflected in Table 2.

4.1.1 Objective: Measure Contaminant Removal

Calculating the mass of chromium and perchlorate removed from the environment by the GWETS requires discharge rates and concentration data from wells and pipelines that feed the treatment systems. Well and pipeline discharge rates are monitored continuously via flow totalizers with average flow rates calculated daily. No well sampling is required for measurement of chromium removal, which is calculated from weekly influent and effluent samples collected at the on-Site chromium treatment process and the fluidized bed reactors (FBRs). Perchlorate mass removal at the IWF is also measured using concentration data collected from two combined well feeds and FBR effluent samples. Continued monthly sampling of extraction wells operating at the AWF and SWF is proposed to measure perchlorate removal by those well fields.

4.1.2 Objective: Monitor Effectiveness of the Groundwater Intercept Systems

Additional sampling during quarterly groundwater monitoring events is focused on collecting data to evaluate extraction well field performance. Water level data from extraction and/or

observation wells in the vicinity of each well field will be used to evaluate hydraulic capture at these locations and identify changed conditions that may impact GWETS performance. Extraction wells and "sentinel" wells located downgradient from and adjacent to the capture zone of each well field will be analyzed for chromium and perchlorate. Data from these wells will be used to monitor concentration trends over time and identify areas of the well field where contaminants may be evading capture due to changes in Site conditions or declining well performance. Figure 4 shows the proposed monitoring locations at each extraction well field. Sentinel well locations were selected from the network of available monitoring wells based on the groundwater flow analysis and particle-tracking evaluation contained in the recent CZE (Northgate, 2010). A subset of IWF extraction wells were selected for quarterly sampling to be representative of historic contaminant distribution and as paired monitoring points located across the barrier wall from downgradient sentinel wells.

4.1.3 Objective: Monitor Changes in Plume Configuration over Time

Figures 5 and 6 show proposed monitoring locations for an optimized annual monitoring event to be conducted during the second quarter of each year. The purpose of the annual monitoring event is to provide data sufficient to monitor changes in contaminant plumes at the Site (perchlorate, chromium, TDS, chlorate, and nitrate) in response to remedial efforts. Using data from the recent 2011 monitoring event, a spatial evaluation was conducted to optimize the annual monitoring event by eliminating wells that are not needed to characterize the groundwater contaminant plumes. A description of the methods and results of the spatial evaluation is presented in Attachment 2.

In addition to the proposed annual groundwater samples, we recommend collecting water level measurements from all active unsampled wells in the monitoring network during the annual monitoring event. The data collected will be used to construct a detailed potentiometric surface map. In addition, this provides for an annual inspection of each well to confirm access and identify any necessary maintenance.

An expanded monitoring event is proposed for every fifth year, as shown on Table 2 and on Figures 5 and 6. This expanded sampling event will provide more detailed plume characterization and is intended to coincide with periodic review of the status of the groundwater remedy and the overall monitoring program.

4.2 Additional Recommendations

We have the following general recommendations for the compliance monitoring program.

4.2.1 Reporting

In conjunction with the recommended monitoring schedule outlined above, we recommend streamlining the compliance reporting process. The semi-annual reporting schedule consists of a substantial narrative report with monitoring data presented in a series of tables and figures, and appendices containing laboratory and data validation reports, field documentation, and electronic data deliverables (EDDs). The annual report additionally contains a series of plates displaying isoconcentration maps for the primary constituents monitored.

We recommend adopting an annual reporting schedule with a reduced narrative component summarizing significant findings or changes in Site conditions and any recommended changes in the monitoring program. The semiannual report should be replaced with a streamlined data transmittal consisting of data tables and figures documenting contaminant removal and the results of the quarterly monitoring at each extraction well field. An expanded monitoring report, submitted at five-year intervals in conjunction with the expanded annual monitoring event, would describe Site conditions and evaluate the implementation and effectiveness of the remedy, including an updated CZE.

4.2.2 Data Validation

Currently nearly all analytical data collected from the Site are validated, with approximately 90% of samples validated to Stage 2B and approximately 10% of samples validated to Stage 4. Depending on the type of analysis and the level of data validation performed, this process increases the cost of each analysis by approximately 10% to 50%. Due to the extensive data record at the Site and large number of samples collected, it may be worth evaluating whether data quality objectives can reasonably be met with a reduced level of data validation.

4.3 Periodic Review of Long-Term Monitoring Program

As Site conditions can be expected to change over time, a periodic re-evaluation of monitoring objectives and data requirements to meet those objectives is necessary during the course of the remedial effort. The purpose of the review is to ensure that the monitoring plan reflects current conditions and remains capable of meeting the monitoring objectives for the Site, and may further reduce costs over time as conditions at the Site are addressed and monitoring needs decrease. The LTMO therefore becomes an iterative process that is responsive to changing conditions and data requirements. This periodic review should be included in the expanded five-year report discussed above in Section 4.2.1.

In addition, annual monitoring reports should include a brief evaluation of the efficacy of the data collected, including a statement of whether the data is sufficient to satisfy monitoring objectives. This assessment should include recommendations for additional data collection during the subsequent monitoring period if needed to satisfy monitoring objectives or due to a change in Site conditions.

5.0 REFERENCES

ENSR International, Inc, 2005. Conceptual Site Model, Kerr-McGee Facility. Henderson, Nevada. August 2005.

ENVIRON International Corporation, 2011. Annual Removal Performance Report for Chromium and Perchlorate, Nevada Environmental Response Trust Site; Henderson, Nevada, July 2010 – June 2011. August 26, 2011.

Northgate Environmental Management, Inc., 2010. Capture Zone Evaluation Report, Tronox LLC. Henderson, Nevada. December 10, 2010.

Northgate, 2011. Semi-Annual Remedial Performance Report for Chromium and Perchlorate, July 2010 – December 2010, Nevada Environmental Response Trust Site. Henderson, Nevada. March 16, 2011.

Tronox LLC, 2008. Groundwater Sampling Plan, Tronox LLC. Henderson, Nevada. March 28, 2008.

US Environmental Protection Agency (EPA), 2005. Office of Superfund Remediation and Technology Innovation. Road Map to Long-Term Monitoring Optimization. May 2005.

TABLES

TABLE 1
NERT Site Compliance Monitoring Programs

No.	Program	Regulatory Basis	Purpose	Element	Data Collected	Monitoring Locations	Frequency	Notes
1	**Chromium Removal Program**	9/9/1986 AOC between Department and Kerr-McGee: corrective action program for the treatment of chromum contaminants	* Monitor the effectiveness of the intercept system	a) Chemical Monitoring Program: to measure changes in chemistry upgradient and downgradient of the recharge & intercept systems	Groundwater samples analyzed for: specific conductance pH chromium	* All the interceptor wells (in IWF) * approximately 13 upgradient and downgradient monitoring wells associated with the interceptor and recharge systems	quarterly	appendix D-1 notes that KMCC reserves the right to change the frequency and number of wells monitored if data indicate the system can be adequately monitored after the reduction
		- Appendix D Groundwater Monitoring		b) Chemical Monitoring Program: to track the progress of clean-up and note changes to plume configuration	Groundwater samples analyzed for: specific conductance pH chromium	* All Kerr-McGee M-Series wells * selected Stauffer wells (on Kerr-McGee property)	annually	
				c) Water Level Monitoring Program: to measure the configuration of the groundwater surface and ensure full capture of the chromium plume	water levels within the area of the trough of depression created by operating the IWF	* 27 new wells installed within the interceptor well area * all the inteceptor well (in IWF) * all the water quality wells in item 1a	monthly	Capture Zone Evaluation completed and submitted to NDEP on 12/3/10 demonstrates capture
				d) Water Level Monitoring Program: to ensure proper well field management to produce the desired drawdown within the intercept system	water levels throughout the facility to monitor the groundwater elevation surface	* All Kerr-McGee M-Series wells * all the inteceptor wells (in IWF) * all the monitoring wells associated with item 1c	semi-annual	reporting includes: areal groundwater level map
		- Appendix J Monitoring Wells for Disposal System		e) Water Level Monitoring Program: to record changes in gw elevation due to operation of the disposal system (or recharge trenches)	water levels within the area of the disposal system	* upgradient wells M-11, M-31, M-25, M-36, and M-39 * wells downgradient of the disposal system: M-47, M-23, and M-49 * wells in the vicinity of the trenches: M-80, M-81, M-82, M-84, M-86, and M-88 * downgradient wells M-47, M-23, M-49	monthly	originally contoured and presented as monthly water level maps for the trench and interceptor well field area now the data is presented on hydrographs for wells upgradient and down gradient of the barrier wall, rather than upgradient and downgradient of the trench disposal system
2	**Perchlorate Removal Program**	10/8/2001 AOC between NDEP and Kerr-McGee: for perchlorate removal action designed to reduce the amount of perchlorate in ground and surface water reaching the Las Vegas Wash	* Monitor the effectiveness of the groundwater capture and treatment system installed to carry out the perchlorate removal program	a) IWF Component: to demonstrate understanding of gw and contaminant movement in the area of the IWF	* pumping rates of IWF wells * perchlorate concentrations in wells in the area * water levels in wells in the area	see reports: change in response to NDEP comments regarding the submittals, including the GW Capture Zone Workplan and previous versions of the GW Capture Zone Report	now collect data on varying schedules and report semiannually	reports include calculations of perchlorate mass removal per well field, time concentration plots of perchlorate; lines of evidence showing that groundwater and contaminant movement is controlled and understood
			- describe operations of the perchlorate removal system	b) other elements not specified in the Order	Groundwater samples analyzed for: perchlorate and TDS monthly perchlorate, TDS, pH quarterly perchlorate, TDS, pH annually	see Appendix F and March 28, 2008 SAP- 53 wells sampled monthly 144 wells sampled quarterly 227 wells sampled annually		Capture Zone Evaluation completed and submitted to NDEP on 12/3/10 demonstrates capture
			- provide amount of perchlorate removed					Well lists have been modified over time since the 2008 SAP with addition of new wells and abandonment of some wells
			- provide groundwater and surface water monitoring data					

TABLE 1
NERT Site Compliance Monitoring Programs

No.	Program	Regulatory Basis	Purpose	Element	Data Collected	Monitoring Locations	Frequency	Notes
Permit Monitoring Programs								
3	**G-11 Permitted Pond Monitoring**	Discharge Permit NEV2001515 Zero Discharge Pond GW-11	Ensure that there are no direct discharge of holding pond contents to waters of the State	a) monitor the flow into the pond (influent)	volume of extracted groundwater and other water pumped to the pond		continuous (monthly cumulative)	the data is reported in a table and used in monthly water balance calculation
				b) monitor the outflow from the pond to the fixed bed units (treatment system)	volume of extracted groundwater and other water pumped from the pond to the treatment system		continuous (bi-monthly cumulative)	the data is reported in a table and used in monthly water balance calculation
				c) monitor the pond level (feet) and calculate the storage volume (gals) and the water balance using the flow into the pond	water level (feet of water)	G-11 pond water level measure point	twice/month	the data is used to calculate the volume of water in the pond on the 1st and 15th of the month and used in the monthly water balance calculation and to report that the storage volume is below the pond capacity of 70MGal
				d) inspect leak detection system (underdrain sumps)	remove, sample and record the volume of liquid collected in the pond sumps	four sumps: SE corner, SW corner, NE corner, NW corner	twice/month	
4	**Treatment System NPDES Permit Monitoring**	Authorization to Discharge Permit #NV0023060	Sets effluent limitations and monitoring requirements and conditions for discharging treated water to a specified discharge point	a) monitor the flow from the treatment system (EFF) to ensure they fall within the daily maximum and the 30-day average permitted flow volume	totalizer readings from flow meter	designated as EFF- after treatment and before confluence with receiving water	continuous (daily cumulative)	reported on NPDES forms (one form per month)
		NV equivalent NPDES permit per the Clean Water Act and NV Revised Statutes		b) monitor the quality of the treatment system influent (INF) and effluent (EFF) to ensure the EFF meets discharge limits listed in the permit	Sample parameters: BOD, perchlorate, pH, Cr+6, Cr, TSS, Fe, Mn, P, ammonia as N, Attachment A list, color, total inorganic N, TDS, S, O&G,, B, DO, Nitate as N, Kejdahl N, Cl, Ra 226 and 228, Gross Alpha, chlorate, acute WET	INF, EFF, or Both	weekly to quarterly based on parameter	reported on NPDES forms (one form per month)
				c) monitor water quality at sampling points in Las Vegas Wash and at well M-10 to ensure samples meet discharge limits as listed in the permit	Sample Parameters: TDS, total inorganic N, color, gross alpha, Fe, Mn, Cr, B, Cl, Attachment A list	upstream of Las Vegas Wash, LW6.05, upgradient well M-10	twice/month, quarterly, or annually	reported in tables with laboratory analytical reports as attachements

TABLE 2
Proposed GWETS Groundwater Monitoring Schedule

Well ID	Northing	Easting	TOC Elevation	Monitoring Analyses																				Notes
				Monthly			Quarterly			Annual							Five Year (Expanded Annual)								
				Perchlorate	Total Chromium	TDS	Perchlorate	Total Chromium	Water Level Only	Perchlorate	Total Chromium	Hexavalent Chromium	TDS	Chlorate	Nitrate	Water Level Only	Perchlorate	Total Chromium	Hexavalent Chromium	TDS	Chlorate	Nitrate	Water LevelOnly	
AA-01	830921.1210	26720238.4730	1757.13							X			X				X			X				Plume Delineation (Annual)
AA-11	830672.6610	26725458.7830	1660.05							X			X				X			X				Plume Delineation (Annual)
AA-MW-16	826447.6390	26719904.4140	1754.81							X	X		X				X	X		X				Plume Delineation (Annual)
ARP-1	828593.1640	26728365.5140	1613.32				X	X	X	X	X		X				X	X		X				AWF Sentinel Well
ARP-2A	828856.2000	26728402.8600	1614.18				X	X	X	X	X		X				X	X		X				AWF Sentinel Well
ARP-3A	828722.8023	26728404.3366	1614.67				X	X		X	X		X				X	X		X				AWF Sentinel Well
ARP-4A	829167.8860	26728411.8080	1615.47				X	X		X	X		X				X	X		X				AWF Sentinel Well
ARP-5A	829375.0050	26728458.4270	1616.10				X	X		X	X		X				X	X		X				AWF Sentinel Well
ARP-6B	829520.5160	26728499.9170	1615.56				X	X		X	X		X				X	X		X				AWF Sentinel Well
ARP-7	829668.2160	26728501.0800	1613.20				X	X		X	X		X				X	X		X				AWF Sentinel Well
ART-1*	828543.9610	26728122.7070	1614.47	X						X	X		X				X	X		X				AWF Extraction Well (as of July, 2011)
ART-1A	828536.7809	26728122.2122	1614.40						X	X	X		X				X	X		X				Buddy Well to ART-1
ART-2*	828625.0250	26728084.7120	1617.10	X						X	X		X				X	X		X				AWF Extraction Well (as of July, 2011)
ART-2A	828618.8241	26728085.5575	1616.81						X	X	X		X				X	X		X				Buddy Well to ART-2
ART-3	828775.4220	26728085.1700	1617.94						X	X	X		X				X	X		X				Buddy Well to ART-3A
ART-3A*	828768.7036	26728084.6971	1617.60	X						X	X		X				X	X		X				AWF Extraction Well (as of July, 2011)
ART-4	828850.6930	26728085.2580	1617.46						X	X	X		X				X	X		X				Buddy Well to ART-4A
ART-4A*	828844.4866	26728084.5809	1617.46	X						X	X		X				X	X		X				AWF Extraction Well (as of July, 2011)
ART-5	829369.9760	26728128.7910	1614.06				X	X		X	X		X				X	X		X				AWF Sentinel Well
ART-6	829472.9050	26728140.5990	1615.31						X	X	X		X				X	X		X				Buddy Well to ART-9
ART-7	829576.5210	26728145.7060	1615.38						X							X							X	Buddy Well to ART-7A
ART-7A*	829582.7947	26728143.1944	1614.78	X						X	X		X				X	X		X				AWF Extraction Well (as of July, 2011)
ART-7B	829576.2526	26728151.9357	1619.62						X	X	X		X				X	X		X				Buddy Well to ART-7A
ART-8*	828697.7200	26728084.0960	1617.69	X						X	X		X				X	X		X				AWF Extraction Well (as of July, 2011)
ART-8A	828691.8865	26728083.3080	1617.10						X	X	X		X				X	X		X				Buddy Well to ART-8
ART-9*	829525.5680	26728143.3240	1615.06	X						X	X		X				X	X		X				AWF Extraction Well (as of July, 2011)
CDL1-R	828993.7209	26720138.2355	1745.19							X	X		X				X	X		X				Plume Delineation (Annual)
H-11	826574.1800	26714839.9400	1868.47							X			X				X			X				Plume Delineation (Annual)
H-28A	825864.6720	26721023.5950	1731.75													X	X	X		X				Plume Delineation (Five Year)
H-48	825658.2699	26723952.9535	1684.29							X	X		X				X	X		X				Plume Delineation (Annual)
H-58A	825642.5500	26723331.8800	1693.43													X	X	X		X				Plume Delineation (Five Year)
HM-2	832199.2000	26731069.8000	1588.00													X	X			X				Plume Delineation (Five Year)
HMW-13	827711.4941	26731740.3493	1595.51													X	X			X				Plume Delineation (Five Year)
HMW-15	827608.0000	26729901.0000	1611.97													X	X			X				Plume Delineation (Five Year)
I-AA	827174.4000	26719770.8500	1753.93						X							X	X	X		X				Plume Delineation (Five Year)
I-AB	827225.0390	26719790.4000	1754.03				X	X		X	X		X				X	X		X				IWF Sentinel Well
I-AC	828792.6142	26719889.6589	1752.76						X	X	X		X				X	X		X				Plume Delineation (Annual)
I-AD	828806.6759	26719794.8159	1755.39						X	X	X		X				X	X		X				Plume Delineation (Annual)
I-A-R	827414.3500	26719429.5200	1758.35							X	X	X	X	X	X		X	X	X	X	X	X		IWF Extraction Well
I-B	827282.8900	26719808.0900	1752.70				X	X		X	X		X				X	X		X				IWF Extraction Well (paired with sentinel well)
I-C	827486.4720	26719791.8980	1752.80													X	X	X		X				IWF Extraction Well
I-D	827582.2070	26719805.2100	1752.70				X	X		X	X		X				X	X		X				IWF Extraction Well (paired with sentinel well)
I-E	827733.3690	26719825.3930	1752.40													X	X	X		X				IWF Extraction Well
I-F	827879.6990	26719845.5790	1749.70				X	X		X	X		X				X	X		X				IWF Extraction Well (paired with sentinel well)

TABLE 2
Proposed GWETS Groundwater Monitoring Schedule

Well ID	Northing	Easting	TOC Elevation	Monitoring Analyses																				Notes
				Monthly			Quarterly			Annual							Five Year (Expanded Annual)								
				Perchlorate	Total Chromium	TDS	Perchlorate	Total Chromium	Water Level Only	Perchlorate	Total Chromium	Hexavalent Chromium	TDS	Chlorate	Nitrate	Water Level Only	Perchlorate	Total Chromium	Hexavalent Chromium	TDS	Chlorate	Nitrate	Water LevelOnly	
I-G	828030.7020	26719866.3340	1752.50													X	X	X		X				IWF Extraction Well
I-H	828177.5460	26719887.1250	1753.20				X	X		X	X		X				X	X		X				IWF Extraction Well (paired with sentinel well)
I-I	828375.0360	26719914.4040	1745.50													X	X	X		X				IWF Extraction Well
I-J	828573.9350	26719940.3320	1750.10													X	X	X		X				IWF Extraction Well
I-K	828738.0890	26719962.8670	1746.00				X	X		X	X		X				X	X		X				IWF Extraction Well (paired with sentinel well)
I-L	827352.8550	26719803.2290	1751.70													X	X	X		X				IWF Extraction Well
I-M	827669.8340	26719817.4160	1752.90													X	X	X		X				IWF Extraction Well
I-N	827802.2510	26719837.8460	1751.40													X	X	X		X				IWF Extraction Well
I-O	828263.1300	26719897.9970	1752.80													X	X	X		X				IWF Extraction Well
I-P	828221.6580	26719892.0840	1751.70													X	X	X		X				IWF Extraction Well
I-Q	827952.1490	26719855.1740	1753.10													X	X	X		X				IWF Extraction Well
I-R	827316.0550	26719801.8480	1751.35				X	X		X	X		X				X	X		X				IWF Extraction Well (paired with sentinel well)
I-S	827404.2040	26719799.8740	1750.03													X	X	X		X				IWF Extraction Well
I-T	828073.4950	26719873.6560	1751.66													X	X	X		X				IWF Extraction Well
I-U	828118.5990	26719879.6700	1752.17													X	X	X		X				IWF Extraction Well
I-V	828326.2750	26719894.9660	1752.13													X	X	X		X				IWF Extraction Well
I-W	828245.8705	26719895.8730	1751.50													X							X	IWF Extraction Well (not in service)
I-X	827840.2280	26719843.0790	1748.60													X							X	IWF Extraction Well (not in service)
I-Y	827334.6865	26719800.7790	1751.40													X							X	IWF Extraction Well (not in service)
I-Z	828467.9210	26719923.3740	1743.78				X	X		X	X		X				X	X		X				IWF Extraction Well (paired with sentinel well)
M-10	828536.1750	26716636.6330	1836.21							X	X	X	X	X	X		X	X	X	X	X	X		Plume Delineation (Annual)
M-100	827659.9860	26720820.2640	1730.93							X	X		X				X	X		X				*dry under current conditions
M-101	828060.8260	26720786.7420	1730.81							X	X		X				X	X		X				*dry under current conditions
M-103	828728.3400	26715622.4800	1866.91													X							X	
M-11	828617.0270	26717608.5590	1815.53							X	X	X	X	X	X		X	X	X	X	X	X		Plume Delineation (Annual)
M-110	827431.4190	26719319.3240	1762.48													X	X	X		X				Plume Delineation (5 year)
M-115	827243.6476	26718612.9018	1783.44							X	X		X				X	X		X				Plume Delineation (Annual)
M-117	828917.0571	26715198.2889	1880.31													X	X	X		X				Plume Delineation (5 year; Middle WBZ)
M-118	828036.3974	26715068.0119	1876.91													X	X	X		X				Plume Delineation (5 year; Middle WBZ)
M-120	828387.7921	26715162.9003	1878.58							X	X		X			X	X	X		X				Plume Delineation (Annual)
M-121	827694.5712	26715011.2369	1875.63							X	X		X				X	X		X				Plume Delineation (Annual)
M-123	826516.4041	26718416.9163	1785.13													X	X	X		X				Plume Delineation (5 year)
M-124	827092.2251	26718226.1385	1787.66													X	X	X		X				Plume Delineation (5 year)
M-125	826531.8234	26718993.8960	1771.33							X			X				X			X				Plume Delineation (Annual)
M-126	826569.3700	26719505.5690	1759.01													X	X	X		X				Plume Delineation (5 year)
M-128	827171.6302	26718501.6974	1783.80													X							X	
M-129	828806.4260	26720079.6360	1747.26						X							X							X	IWF Potentiometric Surface
M-12A	828178.5210	26717575.2910	1812.76							X	X	X	X	X	X		X	X	X	X	X	X		Plume Delineation (Annual)
M-13	827806.0300	26717477.6550	1814.89							X	X	X	X	X	X		X	X	X	X	X	X		Plume Delineation (Annual)
M-130	828832.0090	26719919.7000	1749.23				X	X		X	X		X				X	X		X				IWF Sentinel Well
M-131	827158.0770	26719770.5660	1754.13						X	X	X		X				X	X		X				Plume Delineation (Annual)
M-132	828714.6090	26720048.4910	1744.27							X	X		X				X	X		X				Plume Delineation (Annual; Middle WBZ)
M-133	828698.6080	26720067.2920	1743.62							X	X		X				X	X		X				Plume Delineation (Annual; Middle WBZ)
M-134	827144.3530	26719889.1380	1752.14							X	X		X				X	X		X				Plume Delineation (Annual; Middle WBZ)
M-135	827154.4820	26719890.1730	1751.85				X	X		X	X		X				X	X		X				IWF Sentinel Well

TABLE 2
Proposed GWETS Groundwater Monitoring Schedule

Well ID	Northing	Easting	TOC Elevation	Monitoring Analyses																			Notes
				Monthly			Quarterly			Annual							Five Year (Expanded Annual)							
				Perchlorate	Total Chromium	TDS	Perchlorate	Total Chromium	Water Level Only	Perchlorate	Total Chromium	Hexavalent Chromium	TDS	Chlorate	Nitrate	Water Level Only	Perchlorate	Total Chromium	Hexavalent Chromium	TDS	Chlorate	Nitrate	Water LevelOnly	
M-136	827165.3420	26719889.7740	1751.87							X	X		X				X	X		X				Plume Delineation (Annual; Middle WBZ)
M-137	827666.0090	26716034.1400	1847.54													X	X	X		X				Plume Delineation (5 year)
M-138	827665.8420	26716058.3900	1846.35													X							X	
M-139	827816.1800	26717213.1300	1813.19													X							X	
M-140	827428.8396	26719889.5142	1748.21						X							X	X	X		X				Plume Delineation (5 year)
M-141	829044.4460	26718195.3400	1797.16													X							X	
M-142	827191.7525	26718713.0897	1773.55													X							X	
M-144	827413.8810	26717026.0000	1813.31													X							X	
M-145	829205.2660	26717451.1531	1812.18							X	X		X				X	X		X				Plume Delineation (Annual)
M-146	829203.2890	26716991.9900	1812.48							X	X		X				X	X		X				Plume Delineation (Annual)
M-147	827775.0510	26718857.9000	1781.21							X	X		X				X	X		X				Plume Delineation (Annual)
M-148A	829030.3464	26718357.1402	1800.04							X	X		X				X	X		X				Plume Delineation (Annual)
M-149	828373.0930	26718285.8200	1796.81							X	X		X				X	X		X				Plume Delineation (Annual; Middle WBZ)
M-14A	827045.3612	26719382.6659	1760.93							X	X		X				X	X		X				Plume Delineation (Annual)
M-150	828058.9550	26719569.8400	1758.86							X	X		X				X	X		X				Plume Delineation (Annual; Middle WBZ)
M-151	827642.7970	26720826.9300	1730.64							X	X		X				X	X		X				Plume Delineation (Annual; Middle WBZ)
M-152	826973.4860	26722690.6300	1698.50							X	X		X				X	X		X				Plume Delineation (Annual; Middle WBZ)
M-153	828385.6280	26718288.0800	1796.69							X	X		X				X	X		X				Plume Delineation (5 year; Deep WBZ)
M-154	828047.6290	26719568.4600	1758.78							X	X		X				X	X		X				Plume Delineation (5 year; Deep WBZ)
M-155	827635.8370	26720827.5100	1730.69							X	X		X				X	X		X				Plume Delineation (5 year; Deep WBZ)
M-156	826964.2240	26722690.7400	1698.38							X	X		X				X	X		X				Plume Delineation (5 year; Deep WBZ)
M-159	826758.0015	26719824.0631	1754.88							X	X		X				X	X		X				Plume Delineation (Annual; Middle WBZ)
M-160	826769.0537	26719826.2166	1754.73							X	X		X				X	X		X				Plume Delineation (Annual)
M-161	827134.1285	26719889.8470	1752.40							X	X		X				X	X		X				Plume Delineation (Annual; Middle WBZ)
M-162	827877.8112	26719946.0229	1747.82							X	X		X				X	X		X				Plume Delineation (Annual; Middle WBZ)
M-163	827873.4219	26719939.0420	1747.95							X	X		X				X	X		X				Plume Delineation (Annual; Middle WBZ)
M-164	827870.1687	26719949.6092	1747.61							X	X		X				X	X		X				Plume Delineation (Annual; Middle WBZ)
M-165	828701.3725	26720053.2414	1743.84							X	X		X				X	X		X				Plume Delineation (Annual; Middle WBZ)
M-166	827230.0462	26719779.4088	1751.09						X							X							X	
M-167	827337.7164	26719787.6900	1749.95						X							X							X	
M-168	827408.0804	26719788.4968	1748.46						X							X							X	
M-169	827469.3011	26719786.6271	1750.22						X							X							X	
M-170	827577.5466	26719796.3755	1750.66						X							X							X	
M-171	827718.1500	26719905.8527	1749.48						X							X	X	X		X				Plume Delineation (5 year)
M-172	827894.8730	26719835.8342	1750.58						X							X							X	
M-173	828181.8237	26719875.6000	1749.88						X							X							X	
M-174	828378.9996	26719902.9669	1742.29						X							X							X	
M-175	828471.2233	26719911.1376	1742.74						X							X							X	
M-176	828586.4177	26719948.0737	1745.35						X							X							X	
M-177	828724.8315	26719965.7919	1743.23						X							X							X	
M-178	828012.6354	26719955.9613	1749.65						X							X	X	X		X				Plume Delineation (5 year)
M-179	828317.1910	26720002.9522	1749.98						X							X	X	X		X				Plume Delineation (5 year)
M-181	828816.2999	26719579.7224	1761.76							X	X		X				X	X		X				Plume Delineation (Annual; Middle WBZ)
M-182	828815.4997	26719588.7313	1761.83							X	X		X				X	X		X				Plume Delineation (Annual; Middle WBZ)
M-186	829022.5497	26718356.1892	1800.60							X	X		X				X	X		X				Plume Delineation (Annual; Middle WBZ)

TABLE 2
Proposed GWETS Groundwater Monitoring Schedule

Well ID	Northing	Easting	TOC Elevation	Monitoring Analyses																			Notes
				Monthly			Quarterly			Annual							Five Year (Expanded Annual)							
				Perchlorate	Total Chromium	TDS	Perchlorate	Total Chromium	Water Level Only	Perchlorate	Total Chromium	Hexavalent Chromium	TDS	Chlorate	Nitrate	Water Level Only	Perchlorate	Total Chromium	Hexavalent Chromium	TDS	Chlorate	Nitrate	Water LevelOnly	
M-19	828846.1870	26719350.0260	1766.77							X	X		X				X	X		X				Plume Delineation (Annual)
M-21	827792.8590	26718359.3040	1792.07													X	X	X		X				Plume Delineation (5 year)
M-22A	828270.1090	26719531.6270	1759.46													X	X	X		X				Plume Delineation (5 year)
M-23	827373.9620	26721391.2460	1720.35													X	X	X		X	X	X		Plume Delineation (5 year)
M-25	827677.8040	26719503.5690	1759.93							X	X		X	X	X		X	X		X	X	X		Plume Delineation (Annual)
M-29	828999.0000	26717598.0000	1806.60													X							X	
M-2A	827984.7460	26718769.5640	1781.16							X	X		X				X	X		X				Plume Delineation (Annual)
M-31A	828368.3710	26718289.5780	1796.87							X	X		X				X	X		X				Plume Delineation (Annual)
M-32	828592.6330	26718354.0690	1799.86													X	X	X		X				Plume Delineation (5 year)
M-33	828784.1220	26718382.7260	1800.29													X	X	X		X				Plume Delineation (5 year)
M-35	828509.3710	26718840.1250	1775.95							X	X		X				X	X		X				Plume Delineation (Annual)
M-36	828069.0920	26719556.6280	1759.82							X	X	X	X	X	X		X	X	X	X	X	X		Plume Delineation (Annual)
M-37	827414.2230	26719422.0120	1761.06													X							X	
M-38	827877.6550	26719523.2730	1759.73													X	X	X		X				
M-39	828548.8210	26719525.3410	1761.13							X	X		X	X	X		X	X		X	X	X		Plume Delineation (Annual)
M-44	827005.6097	26722699.1535	1698.31							X	X	X	X				X	X	X	X				Plume Delineation (Annual)
M-48A	828294.3839	26721339.0665	1718.36							X	X	X	X				X	X	X	X				Plume Delineation (Annual)
M-52	828394.4770	26717985.3850	1801.92							X	X		X				X	X		X				Plume Delineation (Annual)
M-55	827683.0370	26719819.3580	1750.88						X							X							X	
M-56	827980.3620	26719859.5150	1750.83						X							X							X	
M-57A	826993.3068	26719716.7386	1753.44						X	X	X		X				X	X		X				Plume Delineation (Annual)
M-58	828276.6190	26719900.5510	1751.25						X							X							X	
M-5A	826179.2850	26719961.1180	1751.80							X	X		X				X	X		X				Plume Delineation (Annual)
M-60	828079.1100	26719872.4750	1750.94						X							X							X	
M-64	827601.3000	26719748.4000	1749.76						X							X							X	
M-65	827899.7160	26719746.3610	1753.91						X							X							X	
M-66	828183.6420	26719787.4660	1754.24						X							X							X	
M-67	828508.5180	26719829.7170	1745.91						X							X							X	
M-68	828751.0010	26719864.4720	1750.23						X							X							X	
M-69	827265.7330	26719885.2760	1749.75				X	X		X	X		X				X	X		X				IWF Sentinel Well
M-6A	825984.5360	26721013.6870	1733.19							X	X		X				X	X		X				Plume Delineation (Annual)
M-70	827567.3520	26719904.6910	1748.25				X	X		X	X		X				X	X		X				IWF Sentinel Well
M-71	827859.7090	26719943.6260	1747.04				X	X		X	X		X				X	X		X				IWF Sentinel Well
M-72	828172.1260	26719977.1350	1746.49				X	X		X	X		X				X	X		X				IWF Sentinel Well
M-73	828427.8230	26720018.4660	1741.14				X	X		X	X		X				X	X		X				IWF Sentinel Well
M-74	828713.6510	26720062.1790	1744.38				X	X		X	X		X				X	X		X				IWF Sentinel Well
M-75	827718.8170	26718702.6410	1784.21													X	X	X		X				Plume Delineation (5 year)
M-76	827550.7340	26718659.9230	1785.22							X	X		X				X	X		X				Plume Delineation (Annual)
M-77	828932.3200	26718045.9950	1799.61							X	X		X	X	X		X	X		X	X	X		Plume Delineation (Annual)
M-78	827777.4530	26719838.1700	1751.50						X							X							X	
M-79	827382.0990	26720048.9170	1742.53						X	X	X		X				X	X		X				Plume Delineation (Annual)
M-7B	826106.4970	26720979.6610	1732.83													X	X	X		X				Plume Delineation (5 year)
M-80	827759.7860	26720112.8740	1746.04						X	X			X				X			X				Plume Delineation (Annual)
M-81A	828139.6710	26720176.8520	1744.16						X	X			X				X			X				Plume Delineation (Annual)
M-83	827584.7030	26720159.9180	1742.77						X	X	X		X				X	X		X				Plume Delineation (Annual)

TABLE 2
Proposed GWETS Groundwater Monitoring Schedule

Well ID	Northing	Easting	TOC Elevation	Monitoring Analyses																			Notes
				Monthly			Quarterly			Annual							Five Year (Expanded Annual)							
				Perchlorate	Total Chromium	TDS	Perchlorate	Total Chromium	Water Level Only	Perchlorate	Total Chromium	Hexavalent Chromium	TDS	Chlorate	Nitrate	Water Level Only	Perchlorate	Total Chromium	Hexavalent Chromium	TDS	Chlorate	Nitrate	Water LevelOnly	
M-92	827138.0920	26717531.9410	1800.76							X	X		X				X	X		X				Plume Delineation (Annual)
M-93	827143.4410	26717685.9180	1797.54													X	X	X		X				Plume Delineation (5 year)
M-94	827222.8460	26722695.8140	1695.07													X	X	X		X				Plume Delineation (5 year)
M-95	827426.7380	26722701.6920	1694.09													X	X	X		X				Plume Delineation (5 year)
M-96	827626.0780	26722700.2980	1693.52							X	X	X	X				X	X	X	X				Plume Delineation (Annual)
M-97	827492.4670	26717795.1820	1800.85							X	X		X				X	X		X				Plume Delineation (Annual)
M-98	826873.4500	26720914.1400	1731.90							X	X		X				X	X		X				Plume Delineation (Annual)
M-99	827309.6880	26720851.7180	1730.74							X	X		X	X	X		X	X		X				Plume Delineation (Annual)
MC-29	825566.3853	26721514.5606	1723.40							X	X		X				X	X		X				Plume Delineation (Annual)
MC-3	825209.4960	26721410.0106	1725.73							X	X		X				X	X		X				Plume Delineation (Annual)
MC-45	825400.4199	26722230.3512	1710.98													X	X	X		X				Plume Delineation (5 year)
MC-50	825534.8678	26722076.1544	1713.32													X							X	
MC-51	825647.6745	26721900.0521	1715.88													X	X	X		X				Plume Delineation (5 year)
MC-53	825942.2363	26721920.0067	1715.27													X							X	
MC-6	825207.9228	26722160.2238	1712.17													X							X	
MC-65	826119.2700	26722421.1521	1705.43													X	X	X		X				Plume Delineation (5 year)
MC-69	825235.6279	26721806.9208	1718.66													X	X			X				Plume Delineation (5 year)
MC-7	824933.2030	26721865.4347	1718.66							X	X		X				X	X		X				Plume Delineation (Annual)
MC-93	825948.7754	26721673.1526	1719.26							X			X				X			X				Plume Delineation (Annual)
MC-97	825838.3525	26721425.6633	1723.95													X							X	
MW-K4	828994.0000	26728410.0000	1615.70				X	X		X	X		X				X	X		X				AWF Sentinel Well
MW-K5	829617.0000	26730252.0000	1589.30													X							X	
PC-1	830925.1130	26730308.6461	1599.13													X	X	X		X				Plume Delineation (5 year)
PC-101R	828711.7180	26728107.7410	1618.12						X							X							X	
PC-103	829110.8690	26730205.7345	1599.49							X	X		X				X	X		X				Plume Delineation (Annual)
PC-106	827110.0560	26730247.5055	1601.85													X							X	
PC-107	827136.4995	26729287.5790	1616.94													X							X	
PC-108	828526.9585	26731913.0470	1584.81													X	X			X				Plume Delineation (5 year)
PC-110	826778.3060	26731928.1095	1594.47													X							X	
PC-111	826540.1470	26732782.1250	1585.36													X							X	
PC-115R	831148.6350	26733131.3250	1554.71	X						X	X		X				X	X		X				SWF Extraction Well
PC-116R	831348.4260	26733203.1530	1552.10	X						X	X		X				X	X		X				SWF Extraction Well
PC-117	831422.3709	26733275.9447	1552.26	X						X	X		X				X	X		X				SWF Extraction Well
PC-118	831051.9853	26733167.3922	1554.53	X						X	X		X				X	X		X				SWF Extraction Well
PC-119	830951.2901	26733188.5008	1554.66	X						X	X		X	X	X		X	X		X	X	X		SWF Extraction Well
PC-120	830851.4727	26733185.7661	1554.64	X						X	X		X				X	X		X				SWF Extraction Well
PC-121	830751.3147	26733180.3901	1554.10	X						X	X		X				X	X		X				SWF Extraction Well
PC-122	829675.1730	26728145.1710	1617.39				X	X		X	X		X				X	X		X				AWF Sentinel Well
PC-123	829485.0410	26727358.4400	1626.44													X	X	X		X				Plume Delineation (5 year)
PC-124	830132.9530	26726741.5830	1635.73							X	X		X	X	X		X	X		X	X	X		Plume Delineation (Annual)
PC-125	829925.9450	26726739.8170	1635.06							X	X		X				X	X		X				Plume Delineation (Annual)
PC-126	829724.7220	26726737.8370	1634.33							X	X		X				X	X		X	X	X		Plume Delineation (Annual)
PC-127	829316.6470	26726735.6210	1632.42							X	X		X				X	X		X				Plume Delineation (Annual)
PC-128	828953.9740	26726732.3910	1633.36							X	X		X	X	X		X	X		X	X	X		Plume Delineation (Annual)
PC-129	828747.2840	26726730.8120	1633.99													X	X	X		X				Plume Delineation (5 year)

TABLE 2
Proposed GWETS Groundwater Monitoring Schedule

Well ID	Northing	Easting	TOC Elevation	Monitoring Analyses																				Notes
				Monthly			Quarterly			Annual							Five Year (Expanded Annual)								
				Perchlorate	Total Chromium	TDS	Perchlorate	Total Chromium	Water Level Only	Perchlorate	Total Chromium	Hexavalent Chromium	TDS	Chlorate	Nitrate	Water Level Only	Perchlorate	Total Chromium	Hexavalent Chromium	TDS	Chlorate	Nitrate	Water LevelOnly	
PC-130	828538.1890	26726729.3090	1633.21							X	X		X	X	X		X	X		X	X	X		Plume Delineation (Annual)
PC-131	828123.2780	26726725.4140	1633.58													X	X	X		X				Plume Delineation (5 year)
PC-132	827913.9440	26726723.1020	1634.84							X	X		X	X	X		X	X		X	X	X		Plume Delineation (Annual)
PC-133	831758.0000	26733209.0000	1553.00	X						X	X		X				X	X		X				SWF Extraction Well
PC-134A	828775.8007	26728143.1512	1618.57							X	X		X				X	X		X				Plume Delineation (Annual; Middle WBZ)
PC-135A	828767.4916	26728143.0273	1618.58						X	X	X		X				X	X		X				Plume Delineation (Annual)
PC-136	829517.8880	26728191.3740	1618.04						X	X	X		X				X	X		X				Plume Delineation (Annual)
PC-137	829517.5680	26728198.9760	1618.45							X	X		X				X	X		X				Plume Delineation (Annual; Middle WBZ)
PC-141	828446.3080	26728106.6347	1619.53				X	X		X			X				X			X				AWF Sentinel Well
PC-142	828436.0440	26728106.7576	1619.64							X			X				X			X				AWF Sentinel Well
PC-143	828698.7055	26728238.6396	1619.20						X							X	X	X		X				Plume Delineation (5 year)
PC-144	828903.7495	26728223.8609	1618.63						X							X	X	X		X				Plume Delineation (5 year)
PC-145	829536.0691	26728324.9691	1617.76						X							X	X	X		X				Plume Delineation (5 year)
PC-146	829812.5369	26728152.1941	1617.67				X	X		X	X		X				X	X		X				AWF Sentinel Well
PC-147	829767.4319	26728153.1735	1617.51				X	X		X	X		X				X	X		X				AWF Sentinel Well
PC-148	829249.3269	26728124.4200	1617.96						X	X	X		X				X	X		X				Plume Delineation (Annual)
PC-149	829117.9675	26728122.8964	1618.93						X	X	X		X				X	X		X				Plume Delineation (Annual)
PC-150	828915.2875	26728104.1820	1619.09				X	X		X	X		X				X	X		X				AWF Sentinel Well
PC-18	828636.2460	26728079.9730	1618.50													X	X	X		X				Plume Delineation (5 year)
PC-2	830443.4539	26730209.5846	1597.07							X	X		X	X	X		X	X		X	X	X		Plume Delineation (Annual)
PC-21A	829269.5290	26721332.7192	1724.52							X	X		X	X	X		X	X		X	X	X		Plume Delineation (Annual)
PC-24	829524.1840	26726729.8213	1633.48													X	X	X		X				Plume Delineation (5 year)
PC-28	828530.6493	26725375.6671	1650.85							X	X		X				X	X		X				Plume Delineation (Annual)
PC-31	826781.6534	26725195.8315	1657.86							X	X		X				X	X		X				Plume Delineation (Annual)
PC-37	826612.0967	26722172.2385	1707.72													X	X	X		X				Plume Delineation (5 year)
PC-4	831171.8021	26730353.4164	1600.42							X	X		X	X	X		X	X		X	X	X		Plume Delineation (Annual)
PC-40	826476.7787	26723971.0440	1679.23													X	X	X		X				Plume Delineation (5 year)
PC-50	828326.9423	26726722.2950	1633.46							X	X		X				X	X		X				Plume Delineation (Annual)
PC-53	829941.5848	26730225.2900	1595.03							X	X		X				X	X		X				Plume Delineation (Annual)
PC-54	828296.3387	26722067.7866	1704.43													X	X	X		X				Plume Delineation (5 year)
PC-55	828530.4930	26728056.6590	1618.46						X							X	X	X		X				Plume Delineation (5 year)
PC-56	830645.2874	26732289.4296	1568.25							X	X		X				X	X		X				Plume Delineation (Annual)
PC-58	831123.7750	26732118.1990	1568.01													X	X	X		X				Plume Delineation (5 year)
PC-59	830150.3016	26732452.6937	1567.92							X	X		X				X	X		X				Plume Delineation (Annual)
PC-60	830405.1436	26732358.7536	1568.38													X	X	X		X				Plume Delineation (5 year)
PC-62	829764.2754	26732733.5232	1567.83													X	X	X		X				Plume Delineation (5 year)
PC-64	827916.5199	26723702.4389	1675.29							X	X		X				X	X		X				Plume Delineation (Annual)
PC-65	828386.9029	26723682.7375	1675.21							X	X		X				X	X		X				Plume Delineation (Annual)
PC-66	828779.3988	26723966.9528	1673.53							X	X		X				X	X		X				Plume Delineation (Annual)
PC-67	829207.8002	26723846.8710	1673.82							X	X		X				X	X		X				Plume Delineation (Annual)
PC-68	829616.9594	26732906.8201	1566.97							X	X		X				X	X		X				Plume Delineation (Annual)
PC-71	826805.8970	26722687.7220	1698.73													X	X	X		X				Plume Delineation (5 year)
PC-72	826604.7210	26722688.8150	1699.43							X	X		X				X	X		X				Plume Delineation (Annual)
PC-73	826404.9030	26722694.9320	1699.50													X	X	X		X				Plume Delineation (5 year)
PC-74	829203.5200	26734003.5200	1565.34													X	X			X				Plume Delineation (5 year)

TABLE 2
Proposed GWETS Groundwater Monitoring Schedule

				Monitoring Analyses																				
				Monthly			Quarterly			Annual								Five Year (Expanded Annual)							
Well ID	Northing	Easting	TOC Elevation	Perchlorate	Total Chromium	TDS	Perchlorate	Total Chromium	Water Level Only	Perchlorate	Total Chromium	Hexavalent Chromium	TDS	Chlorate	Nitrate	Water Level Only	Perchlorate	Total Chromium	Hexavalent Chromium	TDS	Chlorate	Nitrate	Water LevelOnly	Notes
PC-76	829183.7900	26734006.7400	1565.10													X							X	
PC-77	829031.6300	26733568.0700	1566.90													X	X			X				Plume Delineation (5 year)
PC-78	829033.2500	26733560.3200	1566.72													X							X	
PC-79	829815.1530	26733246.6970	1564.06				X			X	X		X				X	X		X				SWF Sentinel Well
PC-80	829823.8180	26733250.4620	1564.18													X							X	
PC-81	829833.4010	26733254.7690	1563.96													X							X	
PC-82	830316.9270	26733194.9630	1559.15				X			X			X	X	X		X			X	X	X		SWF Sentinel Well
PC-83	830325.4290	26733201.3740	1559.22													X							X	
PC-85	830816.0500	26733185.5600	1553.65						X							X							X	
PC-86	830826.9900	26733185.7600	1553.85						X							X	X	X		X				Plume Delineation (5 year)
PC-87	830837.8200	26733185.3700	1554.00						X							X							X	
PC-88	831259.4100	26733178.4200	1551.01						X							X							X	
PC-90	831271.9200	26733192.6300	1550.46						X							X	X	X		X				Plume Delineation (5 year)
PC-91	831729.9900	26733110.8500	1552.33						X	X	X		X	X	X		X	X		X	X	X		SWF Sentinel Well
PC-92	831749.3000	26733109.8500	1552.05						X	X	X		X				X	X		X				Plume Delineation (Annual)
PC-94	832189.0500	26733122.4800	1548.95				X	X		X	X		X				X	X		X				SWF Sentinel Well
PC-96	830896.5600	26733450.8300	1552.57				X			X			X				X			X				SWF Sentinel Well
PC-97	831565.6900	26733441.5400	1548.53				X	X		X	X		X				X	X		X				SWF Sentinel Well
PC-98R	829522.5790	26730260.5325	1593.35							X	X		X	X	X		X	X		X	X	X		Plume Delineation (Annual)
PC99R2/R3	831258.7260	26733155.4170	1552.55	X						X	X		X	X	X		X	X		X	X	X		SWF Extraction Well
TR-1	826168.0400	26719957.9100	1752.18													X	X	X		X				Plume Delineation (5 year; Deep WBZ)
TR-10	827562.5300	26715739.7700	1854.06													X	X	X		X				Plume Delineation (5 year; Middle WBZ)
TR-11	825422.5700	26721918.2900	1717.12													X	X	X		X				Plume Delineation (5 year; Deep WBZ)
TR-12	825286.3700	26723271.8200	1695.84													X	X	X		X				Plume Delineation (5 year; Deep WBZ)
TR-2	826156.8500	26719954.5700	1751.79													X	X	X		X				Plume Delineation (5 year; Middle WBZ)
TR-3	826342.8900	26718941.6100	1772.84													X	X	X		X				Plume Delineation (5 year; Deep WBZ)
TR-4	826342.5300	26718951.5800	1772.55													X	X	X		X				Plume Delineation (5 year; Middle WBZ)
TR-5	826595.8600	26717592.1300	1800.27													X	X	X		X				Plume Delineation (5 year; Deep WBZ)
TR-6	826594.3400	26717608.3800	1800.36													X	X	X		X				Plume Delineation (5 year; Middle WBZ)
TR-7	826724.9900	26716525.4700	1829.03													X	X	X		X				Plume Delineation (5 year; Deep WBZ)
TR-8	826722.8100	26716512.1500	1829.08													X	X	X		X				Plume Delineation (5 year; Middle WBZ)
TR-9	827560.2200	26715752.7100	1854.29													X	X	X		X				Plume Delineation (5 year; Deep WBZ)
Totals:				**16**	**0**	**0**	**35**	**32**	**61**	**163**	**154**	**9**	**163**	**22**	**22**	**136**	**245**	**229**	**9**	**245**	**23**	**23**	**53**	

Notes

pH, Conductivity, and Temperature to be recorded at all sample locations using calibrated field instrument(s).

FIGURES

M:\01_Projects\1232_Environ\1232.02_NERT_GW\Optimization_Memo\P1232_02_T10_F1_Monthly_MonWells_20110826.mxd 8/26/2011

INSET A

INSET B

INSET C

RECHARGE TRENCHES

BARRIER WALL

SEEP WF

ATHENS ROAD WF

INTERCEPTOR WF

Las Vegas Wash

Las Vegas Valley Lateral

Pittman Lateral

PITTMAN LATERAL

SUNSET ROAD

INTERSTATE 515

PABCO ROAD

BOULDER HIGHWAY

LAKE MEAD PARKWAY

FORMER PEPCON PLANT

R 62 E

R 63 E

Legend

- Monthly Water Level Measurement Location
- Monthly Groundwater Sample Location
- Perchlorate Groundwater Isoconcentation Contours – May 2010 (mg/L) (Dashed where approximate)
- Seep Pumping Station
- Unsaturated Alluvium
- Site Outline

Grid: State Plane, Nevada East, NAD83, Feet

N

1:12,000
1 inch = 1,000 feet

1,000 500 0 1,000 Feet

SHEET NUMBER: 1

PLATE NUMBER: 1

2010 MONTHLY GROUNDWATER MONITORING LOCATIONS

Technical Memorandum on Long-Term Monitoring Optimization
Nevada Environmental Response Trust Site
Henderson, Nevada

SCALE:	DATE:	PROJECT NUMBER:
1:12,000	08/26/11	1232.02 T10

DESIGNED BY:	REVISIONS			
J. OTIS	NO.:	DESCRIPTION:	DATE:	BY:
DRAWN BY:				
O. SLIVNYAK				
CHECKED BY:				
NGEM				
APPROVED BY:				
NGEM				

northgate environmental management, inc.
ngem.com

M:\01_Projects\1232_Environ\1232.02_NERT_GW\Optimization_Memo\P1232_02_T10_F2_Quarterly_MonWells_20110826.mxd 8/26/2011

INSET A

INSET B

INSET C

RECHARGE TRENCHES

BARRIER WALL

Las Vegas Wash

Las Vegas Valley Lateral

SEEP WF

ATHENS ROAD WF

Pittman Lateral

PITTMAN LATERAL

SUNSET ROAD

INTERCEPTOR WF

INTERSTATE 515

PABCO ROAD

BOULDER HIGHWAY

LAKE MEAD PARKWAY

FORMER PEPCON PLANT

R 62 E

R 63 E

Legend

- Quarterly Monitoring Measurement Location
- Additional Annual Monitoring Measurement Location
- Perchlorate Groundwater Isoconcentation Contours – May 2010 (mg/L) (Dashed where approximate)
- Seep Pumping Station
- Unsaturated Alluvium
- Site Outline

Grid: State Plane, Nevada East, NAD83, Feet

N

1:12,000
1 inch = 1,000 feet

1,000 500 0 1,000 Feet

PLATE NUMBER: 2

SHEET NUMBER: 1

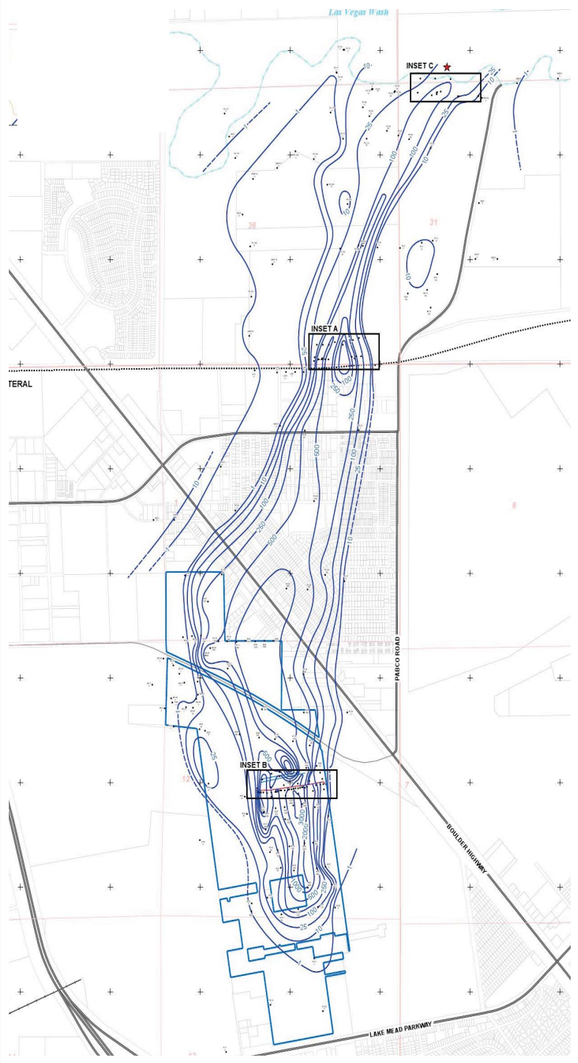
2010 QUARTERLY AND ANNUAL GROUNDWATER MONITORING LOCATIONS

Technical Memorandum on Long-Term Monitoring Optimization
Nevada Environmental Response Trust Site
Henderson, Nevada

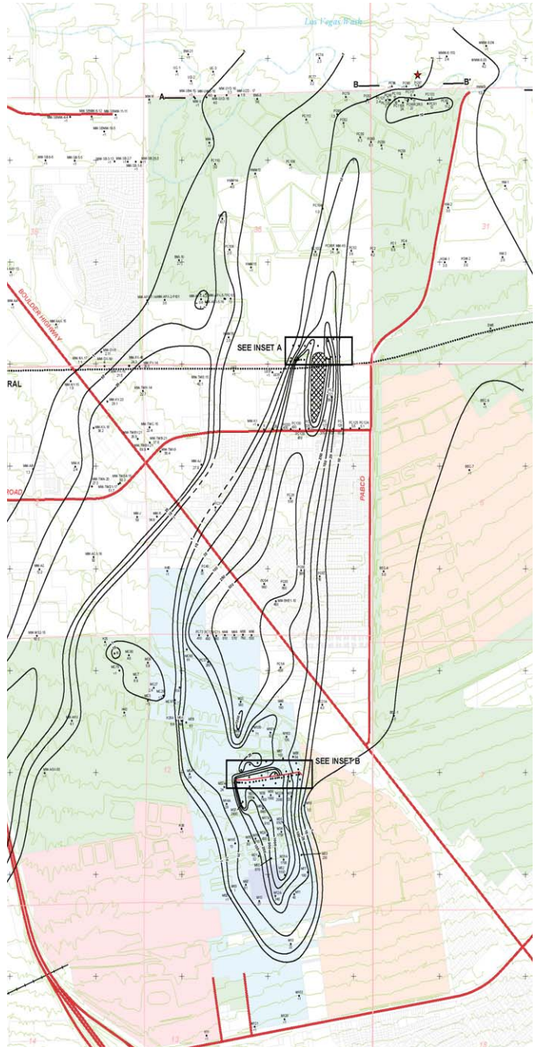
SCALE:	DATE:	PROJECT NUMBER:
1:12,000	08/26/11	1232.02 T10

DESIGNED BY:	REVISIONS			
J. OTIS	NO.:	DESCRIPTION:	DATE:	BY:
DRAWN BY:				
O. SLIVNYAK				
CHECKED BY:				
NGEM				
APPROVED BY:				
NGEM				

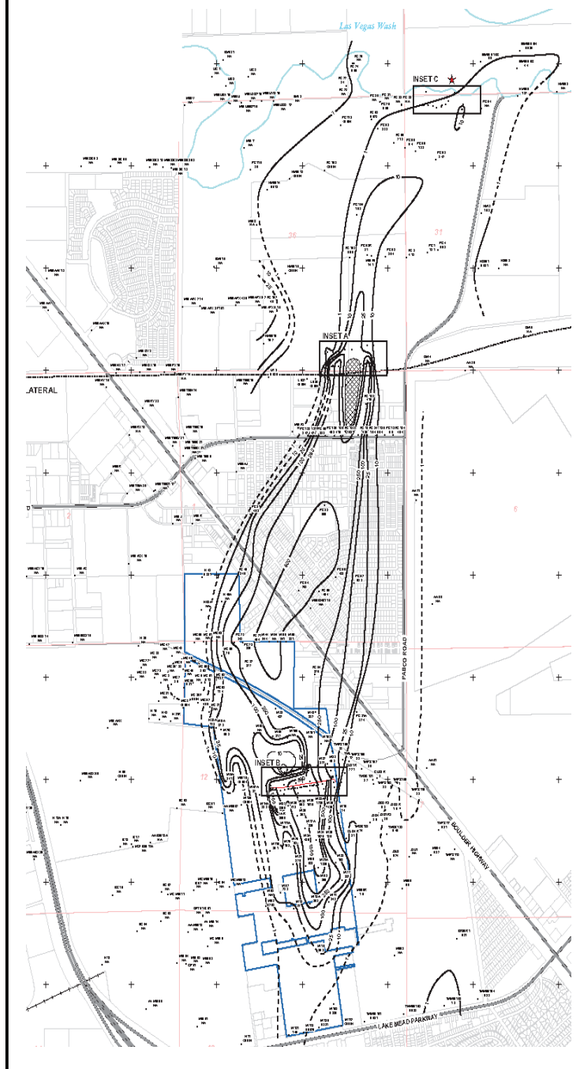
northgate environmental management, inc.
ngem.com



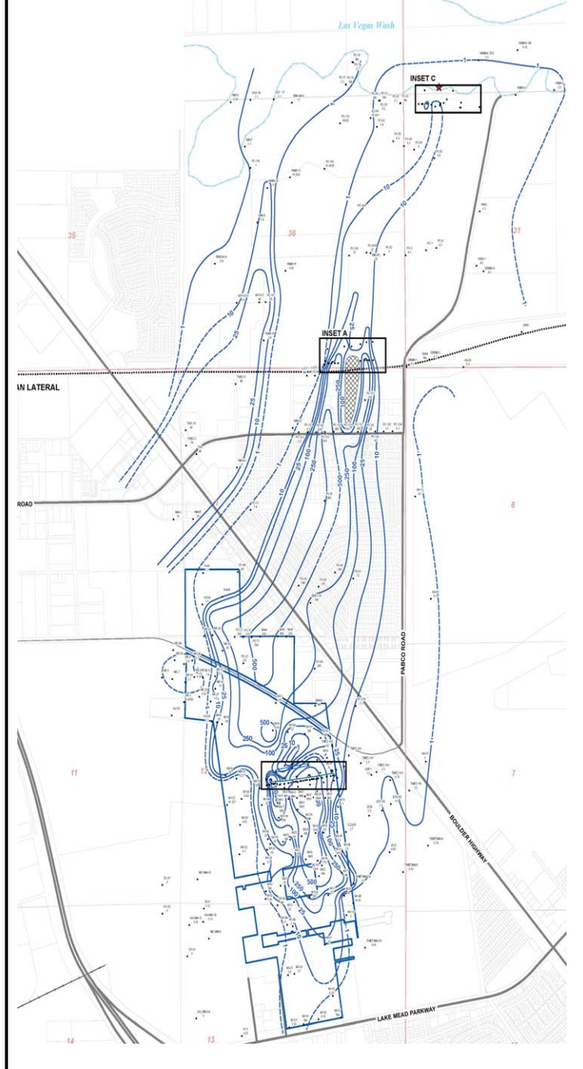
2002



2006



2008

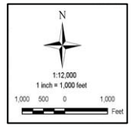


2010

Figure 3

Groundwater Perchlorate Isoconcentration Maps, 2002-2010
Technical Memorandum on Long-Term Monitoring Optimization
Nevada Environmental Response Trust Site, Henderson, Nevada

northgate environmental management, inc.



Interceptor Well Field

0 100 200 400

Feet

Former Recharge Trenches

Barrier Wall

M-83, M-81A, M-80, M-79, M-74, M-133, M-165, M-132, M-129, M-73, M-72, M-179, M-71, M-164, M-162, M-163, M-178, M-176, M-177, I-K, M-130, M-135, M-161, M-136, M-134, M-69, M-140, M-70, M-171, I-Z, M-175, I-H, I-O, I-I, M-174, I-P, M-58, I-V, I-J, I-AC, M-68, I-F, I-Q, I-G, I-T, I-U, M-60, M-173, M-56, I-B, I-R, I-AB, I-L, I-S, I-C, I-D, I-M, I-E, I-N, I-X, M-55, M-78, M-172, M-67, I-AD, M-131, I-AA, M-166, I-Y, M-167, M-168, M-169, M-170, M-64, M-65, M-66

Athens Road Well Field

0 100 200 400

Feet

ARP-1, ARP-3A, ARP-2A, MW-K4, ARP-4A, ARP-5A, ARP-6B, ARP-7, PC-145, 36, PC-143, PC-144, PC-137, PC-136, PC-149, PC-148, ART-5, ART-6, ART-7B, PC-122, PC-147, PC-146, ART-7A, ART-7, ART-9, ART-1, ART-2, PC-135A, PC-134A, PC-141, ART-4A, PC-150, PC-101R, ART-8A, ART-3, ART-1A, ART-2A, ART-4, ART-3A, PC-55, PC-18, ART-8

Seep Well Field

0 150 300 600

Feet

25, 30, PC-96, PC-97, PC-81, PC-79, PC-83, PC-82, PC-120, PC-117, PC-133, PC-86, PC-119, PC-90, PC-116R, PC-121, PC-85, PC-87, PC-88, PC-99R2/99R3, PC-115R, PC-91, PC-92, PC-94, PC-118, 36, 31, PC-68

LEGEND

- Sentinel well
- Water level measurement only
- Monitoring/extraction well

Grid: State Plane, Nevada East, NAD83, Feet

Path: C:\Users\Mike\Documents\ArcGIS\Packages\2011Q2 - P07 - Perchlorate\v10\SentinelWells.mxd

Plate 4

PROJECT: XX-XXXXXXX

Proposed Quarterly Monitoring Locations

Technical Memorandum on Long-Term Monitoring Optimization
Nevada Environmental Response Trust (NERT)
Henderson, Nevada

northgate environmental management, inc.

Inset B

Inset A

Former Recharge Trenches

Barrier Wall

Inset C

Las Vegas Wash

E RUSSELL RD

BOULDER HWY

E SUNSET RD

N US 95

N BOULDER HWY

W LAKE MEAD DR

PABCO

Inset C

Inset B

Inset A

LEGEND

- Wells to be sampled during annual monitoring event
- Wells to be additionally sampled during expanded five-year monitoring event
- Location Not Sampled
- May 2011 Perchlorate Iso-concentration Line (mg/L) (Dashed where approximate)
- Nevada Environmental Response Trust Property Boundary
- Unsaturated Alluvium

Grid: State Plane, Nevada East, NAD83, Feet

1 : 12,000
1 inch = 1,000 ft

Feet

Path: C:\Users\Mike\Documents\ArcGIS\Packages\2011Q2 - P07 - Perchlorate\v10\PerchlorateSamplingMap.mxd

Plate
5

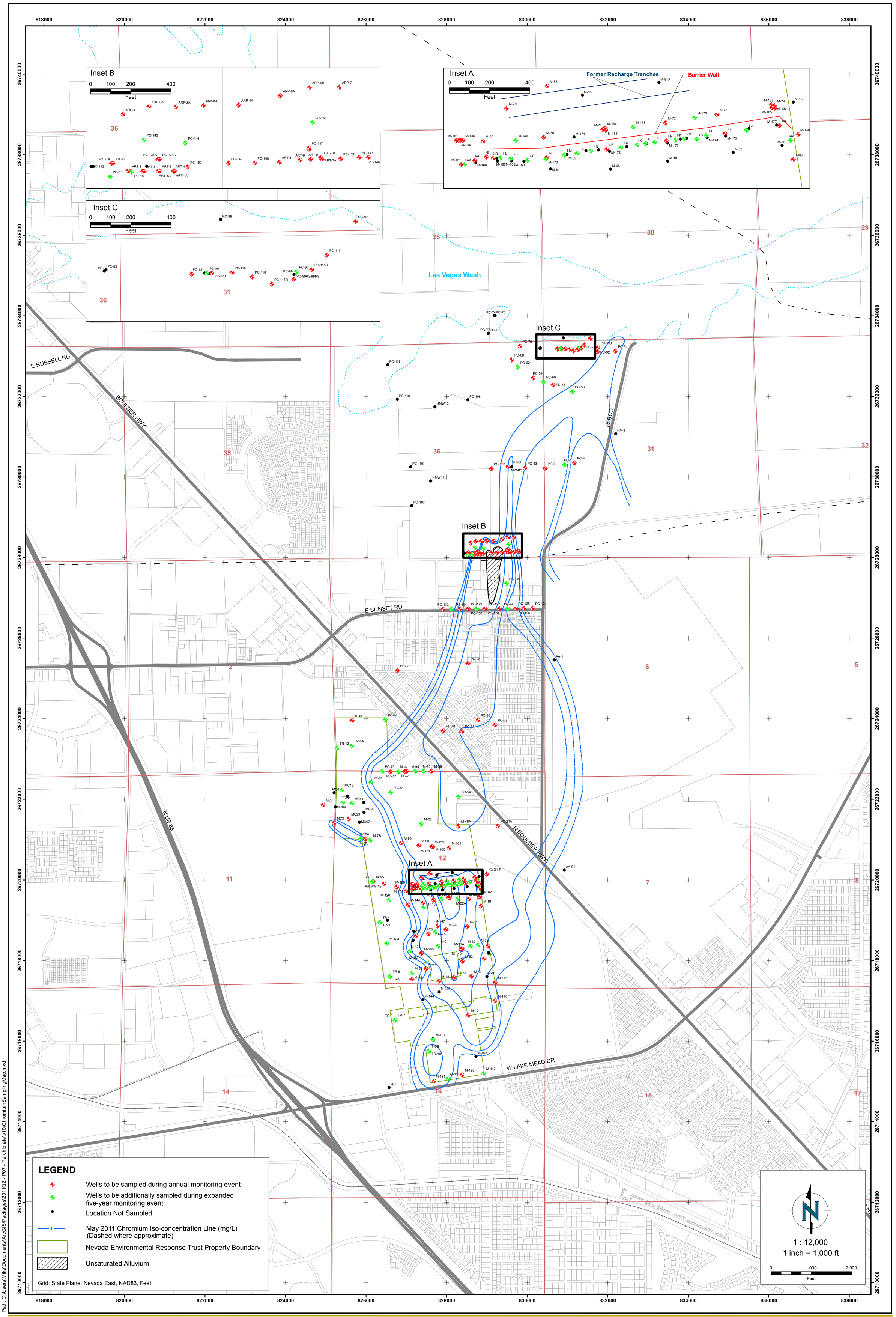
PROJECT: XX-XXXXXXX

Proposed Annual/Five Year Monitoring Locations – Perchlorate

Technical Memorandum on Long-Term Monitoring Optimization
Nevada Environmental Response Trust (NERT)
Henderson, Nevada

	REVISIONS			
DESIGNED BY:	NO.	DESCRIPTION:	DATE:	BY:
DRAWN BY:				
CHECKED BY:				
APPROVED BY:				

northgate
environmental management, inc.



Path: C:\Users\Mike\Documents\ArcGIS\Packages\2011Q2 - P07 - Perchlorate\v10\ChromiumSamplingMap.mxd

Plate
6

PROJECT: XX-XXXXXXX

Proposed Annual/Five Year Monitoring Locations – Chromium

Technical Memorandum on Long-Term Monitoring Optimization
Nevada Environmental Response Trust (NERT)
Henderson, Nevada

	REVISIONS			
DESIGNED BY:	NO.	DESCRIPTION:	DATE:	BY:
DRAWN BY:				
CHECKED BY:				
APPROVED BY:				

northgate
environmental management, inc.

ATTACHMENT 1
Northshore Road Monitoring Data

Attachment 1 - North Shore Road Data

NDEP Sampling Data Northshore Road Sampling Point Las Vegas Wash downstream of Lake Las Vegas at or near Northshore Road Real-Time Flow Values						**Note:** Number and position of gage have changed over time. The position of the gage has remained within approximately one-half mile of Northshore Bridge.
USGS Gage Notes	**Sample Date/Time**	**Real Time Flow Rate (cfs)**	**Perchlorate Concentration (ug/L)**	**Perchlorate Loading (lbs/day)**	**12 Month Rolling Average of Perchlorate Loading (lbs/day)**	**Present Location:** 36°07' 20" N by 114°54' 15" W
Gage # 09419790	1/30/98 8:30	230	818	1,013		Del Mar Laboratory
	2/14/98 10:35	215	815	947		
	3/30/98 14:31	275	667	989		
	4/27/98 10:02	186	989	995		
	5/26/98 13:58	234	459	579		
	6/19/98 9:49	140	873	658		
	7/20/98 10:05	639	68	236		
	8/31/98 9:30	268	447	647		
	9/25/98 13:50	253	672	916		
	10/23/98 10:37	194	1,200	1,256		
	11/6/98 12:10	206	645	715		
	12/30/98 13:30	228	684	840	**816**	
	1/29/99 11:50	215	670	779	796	
	2/25/99 11:12	223	680	820	786	
	3/26/99 13:30	232	670	837	773	
	4/30/99 13:10	642	180	624	742	
	5/27/99 13:24	215	950	1,104	786	
	6/25/99 11:15	305	700	1,151	827	
	7/22/99 9:12	300	710	1,149	903	
	8/26/99 9:10	528	710	2,024	1,018	
	9/21/99 9:01	146	820	646	995	Laboratory Change to NEL Laboratory
	10/29/99 9:10	175	760	719	951	
	11/29/99 9:29	240	520	673	947	
	12/27/99 13:00	253	560	763	**941**	
	1/27/00 9:45	215	569	661	931	
	2/28/00 9:10	238	720	923	940	
	3/29/00 10:00	190	870	892	944	
	4/27/00 14:30	248	750	1,005	976	
	5/29/00 12:00	213	740	851	955	
	6/28/00 13:00	184	410	408	893	
	7/27/00 11:00	188	650	660	852	
	8/28/00 9:15	184	510	508	726	
	9/27/00 8:00	183	430	424	707	
No discharge data for 9:30. Used data collected at 8:15.	10/26/00 9:30	244	340	448	684	
No discharge data for 8:20. Used data collected at 7:00.	11/29/00 8:20	221	370	442	665	
	12/26/00 12:45	205	320	355	**631**	
No discharge data for 7:45. Used data collected at 7:00.	1/25/01 7:45	192	280	290	600	
	2/27/01 14:00	207	350	391	556	
	3/26/01 8:50	217	480	562	529	
	4/26/01 14:10	319	320	550	491	
	5/29/01 14:50	183	240	236	439	
	6/27/01 10:20	198	400	426	441	
	7/25/01 9:25	161	550	478	426	
	8/27/01 9:50	198	420	448	421	
	9/27/01 8:20	213	460	529	430	
	10/29/01 9:15	211	420	479	432	
No discharge data for 11/27/01 9:00. Used 11/29/01 10:30.	11/27/01 9:00	281	810	1,229	498	
	12/20/01 8:55	229	440	544	**514**	
	1/29/02 9:15	231	510	637	543	
	2/26/02 12:00	232	470	589	559	
	3/26/02 9:15	173	430	403	546	
	4/25/02 9:30	223	360	434	536	
	5/29/02 12:30	179	610	589	565	
	6/29/02 8:45	138	630	468	569	
	7/26/02 9:30	314	430	729	590	
	8/27/02 9:00	108	520	302	578	
	9/26/02 11:30	190	450	461	572	
	10/28/02 9:30	213	630	725	592	
	11/26/02 9:30	177	480	459	528	
	12/26/02 9:20	215	530	615	**534**	Laboratory Change to Alpha Analytica
	1/28/03 9:30	197	590	627	533	
Gage # 09419800 No discharge data available for 11:30. 4:00 AM data used.	2/28/03 11:30	326	390	686	541	Change in USGS gage location and gage number

Attachment 1 - North Shore Road Data

NDEP Sampling Data Northshore Road Sampling Point Las Vegas Wash downstream of Lake Las Vegas at or near Northshore Road Real-Time Flow Values						**Note:** Number and position of gage have changed over time. The position of the gage has remained within approximately one-half mile of Northshore Bridge.
USGS Gage Notes	**Sample Date/Time**	**Real Time Flow Rate (cfs)**	**Perchlorate Concentration (ug/L)**	**Perchlorate Loading (lbs/day)**	**12 Month Rolling Average of Perchlorate Loading (lbs/day)**	**Present Location:** 36°07' 20" N by 114°54' 15" W
	3/28/03 9:15	115	460	285	532	
No discharge data available on or near sampling time. **See note on right.**	4/28/03 9:30	150	500	405	529	**Note:** Pabco Rd gage (USGS Gage #09419700) was used for discharge data for 4/28/03 sampling event. A one-hour travel time was assumed from Pabco Road gage to Northshore Road gage; therefore, the discharge value for 8:30 am is listed.
	5/28/03 9:30	228	400	492	521	
	6/27/03 9:15	214	230	266	504	
	7/28/03 9:30	274	220	325	471	
	8/26/03 9:15	200	270	291	470	
	9/30/03 9:15	209	270	304	457	
	10/28/03 9:30	192	260	269	419	
	11/25/03 14:45	280	170	257	402	
	12/30/03 9:00	256	200	276	374	
	1/27/04 9:00	171	220	203	338	
	2/24/04 8:45	359	190	368	312	**Note:** Frequent rain events for the Las Vegas Wash drainage basin have been occurring for the last three days.
	3/30/04 9:30	183	210	207	305	
	4/27/04 9:15	214	160	185	287	
	5/25/04 8:45	175	140	132	257	
	6/29/04 8:00	209	140	158	248	
	7/27/04 9:15	167	140	126	231	
	8/31/04 9:00	175	140	132	218	
	9/28/04 8:30	159	140	120	203	
	10/26/04 9:15	196	130	137	192	**Note:** Rain events in Las Vegas Valley 10/19/04 through 10/21/04
	11/30/04 10:15	195	160	168	184	**Note:** Rain events in the Las Vegas Valley 11/20/04 through 11/22/04
	12/28/04 10:45	164	120	106	170	**Note:** Rain events in Las Vegas Valley 12/28/04 through 12/29/04
	1/25/05 10:30	169	140	128	164	
	2/22/05 8:00	1670	28	252	154	**Note:** Heavy to Moderate rain events in the Las Vegas Valley on 02/18, 19, 21, & 22
	3/29/05 9:00	229	140	173	152	
	4/26/05 8:30	143	130	100	144	
	5/31/05 9:00	147	130	103	142	
	6/28/05 9:00	186	150	151	141	
	7/26/05 9:00	229	130	161	144	
	8/30/05 9:00	169	130	119	143	
	9/27/05 9:30	164	134	119	143	
	10/25/05 9:15	196	139	147	144	
	11/29/05 9:15	159	144	124	140	
	12/27/05 9:45	191	129	133	142	
	1/31/06 9:15	251	121	164	145	**Note:** At time of sampling, water level was noticably decreasing. The following 15 min increment flow measurement was 53 cfs. As on 02/21/06, no correction by the USBS to the flow data has been made.
	3/1/06 9:00	201	111	120	134	**Note:** Sample collection did not occur on the last Tuesday of the month. The sample was collected the following Wednesday due to scheduling confilcts
	3/28/06 15:00	360	73.9	144	132	**Note:** Sampling was conducted in the afternoon due to scheduling confilcts
	4/25/06 9:45	196	119	126	134	
	5/29/06 11:00	196	143	151	138	
	6/27/06 9:45	206	103	114	135	
	7/25/06 8:15	210	88.2	100	130	
	8/28/06 8:30	215	98.7	115	130	
	9/26/06 11:45	230	114	141	132	
	10/26/06 10:00	210	129	146	132	
	11/27/06 11:15	256	126	174	136	
	12/29/06 10:30	215	107	124	135	
	1/30/07 12:30	288	100	155	134	**Note:** Sample collected during group visit to sampling location. Location ID listed as LVW 0.55. Tronox to conduct future sampling.
	2/19/07 7:30	235	67	85	131	
	3/19/07 9:00	201	84	91	127	
	4/16/07 9:00	191	82	85	124	
	5/21/07 8:00	201	80	87	118	
	6/19/07 7:15	210	59	67	114	
	7/16/07 7:30	206	77	86	113	Chuck Savard (USGS) 564-4543 provided July 16th provision flow data as of 9-4-07
	8/20/07 7:45	196	51	54	108	
	9/17/07 0:00	225	59	72	102	
	10/15/07 8:30	235	59	75	96	
	11/19/07 9:45	210	59	67	87	
	12/17/07 8:15	168	60	54	81	
	1/14/08 9:30	201	66	72	74	Chuck Savard (USGS) 564-4543 provided January 14th provision flow data as of 2-26-08
	2/20/08 9:45	196	73	77	74	
	3/17/08 8:15	220	68	81	73	
	4/21/08 8:45	155	67	56	71	Chuck Savard (USGS) 564-4543 provided April 21 provisional flow data as of 5-5-08
	5/19/08 6:45	225	61	74	69	Suzanne Crowley (USGS - by e-mail) provided May 19th provisional flow as of 5-19-08

Attachment 1 - North Shore Road Data

NDEP Sampling Data Northshore Road Sampling Point Las Vegas Wash downstream of Lake Las Vegas at or near Northshore Road Real-Time Flow Values						**Note:** Number and position of gage have changed over time. The position of the gage has remained within approximately one-half mile of Northshore Bridge.
USGS Gage Notes	**Sample Date/Time**	**Real Time Flow Rate (cfs)**	**Perchlorate Concentration (ug/L)**	**Perchlorate Loading (lbs/day)**	**12 Month Rolling Average of Perchlorate Loading (lbs/day)**	**Present Location:** 36°07' 20" N by 114°54' 15" W
	6/16/08 8:45	177	61	58	69	Suzanne Crowley (USGS - by e-mail) provided June 16th provisional flow as of 6-30-08
	9/15/08 10:45	210	78	88	70	Suzanne Crowley (USGS - by e-mail) provided Sept 15th provisional flow as of 11-17-08
	12/15/08 7:15	251	46	62	69	Flow from the USGS site - retrieved 12-23-08
	4/6/09 8:00	210	54	61	68	Flow from the USGS site - retrieved 4-23-09
	7/6/09 9:00	182	56	55	68	Flow from the USGS site - retrieved 7-21-09
	10/5/09 9:15	168	65	59	67	Flow from the USGS site - retrieved 11-5-09
	1/4/10 8:00	235	50	63	66	Flow from the USGS site - retrieved 4-26-10
	2/1/10 8:00	215	61	71	65	Flow from the USGS site - retrieved 4-26-10
	4/5/10 7:45	215	58	67	66	Flow from the USGS site - retrieved 4-26-10
	7/5/10 7:15	220	56	66	65	Flow from the USGS site - retrieved 10-26-10
	10/18/10 7:30	288	44	68	66	Flow from the USGS site - retrieved 11-22-10

ATTACHMENT 2
Spatial Evaluation of the Long-Term Monitoring Program

ATTACHMENT 2

Spatial Evaluation of the Long-Term Monitoring Well Program

The NERT Site monitoring network was evaluated to identify potential opportunities to streamline monitoring activities while still maintaining an effective monitoring program. Comparison of the annual perchlorate and chromium plumes from the past five years indicates that the plumes are remaining stable. Localized changes are observed near the well fields, but the overall footprint of the plume has remained nearly the same. The stable plumes and the large network of monitoring wells at the NERT Site suggest that a number of monitoring wells may not be needed. This attachment presents the results of the spatial statistical analysis and the qualitative spatial evaluation performed to assess the potential of reducing the number of monitoring wells sampled annually for perchlorate and chromium.

Statistical Evaluation

Spatial statistical techniques were used to optimize the well monitoring program at the Site and to select potential wells for removal from the sampling program. A total of 250 monitoring and extraction wells with perchlorate concentrations from the shallow water-bearing zone were used to contour the perchlorate data in the *Annual Removal Performance Report for Chromium and Perchlorate* (ENVIRON, 2011). These wells were evaluated in the statistical analysis. Of the 250 wells, 48 of them were sampled by the neighboring companies. While the neighbor wells were included in the analysis, none of them were considered for removal. Only the wells that were sampled for perchlorate were used in the statistical analysis. The wells sampled for chromium are a subset of the perchlorate wells and were evaluated after the statistical analysis was completed.

The Geostatistical Analyst toolbox in ArcGIS 10.1 was used to perform the statistical spatial evaluation. The perchlorate concentrations from the 250 wells identified from the 2011 Annual Report were inputted into ArcGIS to generate two-dimensional contours of the perchlorate plume using ordinary kriging. Three semivariogram models were used to perform the kriging that resulted in three realizations of the perchlorate contours. Different realizations were used to assess whether the wells selected for removal were sensitive to differences in the plume. The concentration data was log transformed prior to estimating the parameters to the semivariogram model. Anisotropy was also accounted for to adjust for the directional influence of groundwater flow to the north-northeast. The parameters of the three semivariogram models are summarized in Table 2-1.The perchlorate plume contours generated using kriging and the hand-drawn perchlorate contour map in the 2011 Annual Report were qualitatively compared and observed to be generally similar.

The kriged contour maps were subsequently used in the Densify Sampling Network tool within Geostatistical Analyst to evaluate which wells could be considered candidates for removal. The prediction standard error for each well location is calculated using this tool, which quantifies the uncertainty of the prediction. Well locations with lower prediction standard errors are candidates for removal while ones with higher values should be retained. The prediction standard error for each well location was calculated for all three realizations of the plume. Prediction standard errors for the three plume realizations ranged from less than 0.0002 to 835. Using a prediction standard error of less than 20 as the threshold criteria, 140 – 151 wells (depending on the realization) were identified for potential removal. Wells that had an error less than 20 in at least two out of three of the realizations and were not neighboring wells were considered candidates for removal, resulting in 109 monitoring wells as potential candidates. These wells were qualitatively assessed for their significance to the monitoring program, and over half of the potential candidates were retained because they are extraction wells, near a significant boundary or contour line, or were designated as sentinel wells. Both the chromium and perchlorate plumes were considered when selecting the wells that were retained or removed. This evaluation resulted in 42 wells selected for removal from the annual monitoring program (Table 2-2).

Qualitative Evaluation

A qualitative assessment was also performed to identify additional wells located upgradient of the barrier wall and between the Interceptor Well Field and the Athens Road Well Field for potential removal from the annual monitoring program. These wells were not identified as candidates for removal based on the statistical analysis, but a qualitative assessment indicated that several wells provide spatially redundant information with neighboring wells that are completed in same water-bearing zone. An additional 38 wells were selected for potential removal based on this qualitative evaluation (Table 2-2), bringing the total number of wells identified for removal from the annual sampling event to 80.

Comparison of Contours

To determine how the removal of the 80 wells affected the concentration contours, the 2011 perchlorate and chromium concentration data were contoured using Geostatistical Analyst in ArcGIS 10.1 with all the wells currently sampled and with the 80 wells removed. Ordinary kriging was used to produce the two-dimensional perchlorate and chromium contours. The Gaussian semivariogram model was used to perform the kriging. The model parameters summarized in Table 2-3 were kept the same when contouring was performed with all the wells and with the selected wells removed. The perchlorate and chromium contours are shown in Figures 2-1 and 2-2, respectively. While minor differences in the contours are observed, the contours are overall very similar, indicating that the removal of the 80 selected wells from the annual event does not significantly alter the interpreted plume contours.

TABLES

Table 2-1 Summary of Kriging Model Parameters Used to Contour Concentration Data for the Statistical Evaluation

Table 2-2 Summary of Wells Removed from Sampling Program Based on the Statistical Evaluation and the Quantitative Evaluation

Table 2-3 Summary of Kriging Model Parameters Used to Contour Concentration Data from All the Wells and a Subset of the Wells

FIGURES

Figure 2-1 Comparison of Perchlorate Concentration Contours, Shallow WBZ

Figure 2-2 Comparison of Chromium Concentration Contours, Shallow WBZ

TABLE 2-1
Summary of Kriging Model Parameters Used to Contour Concentration Data for the Statistical Evaluation

	MODEL		
Parameter	**Gaussian**	**Spherical**	**Stable**
Sill	12.7	12.5	12.4
Nugget	1.4	0	1.2
Anisotropy	yes	yes	yes
Range (feet)	5200	5200	5200
Minor Range (feet)	2400	2500	2700
Direction (degrees)	0.9	1.2	2.3
Lag size (feet)	430	430	430

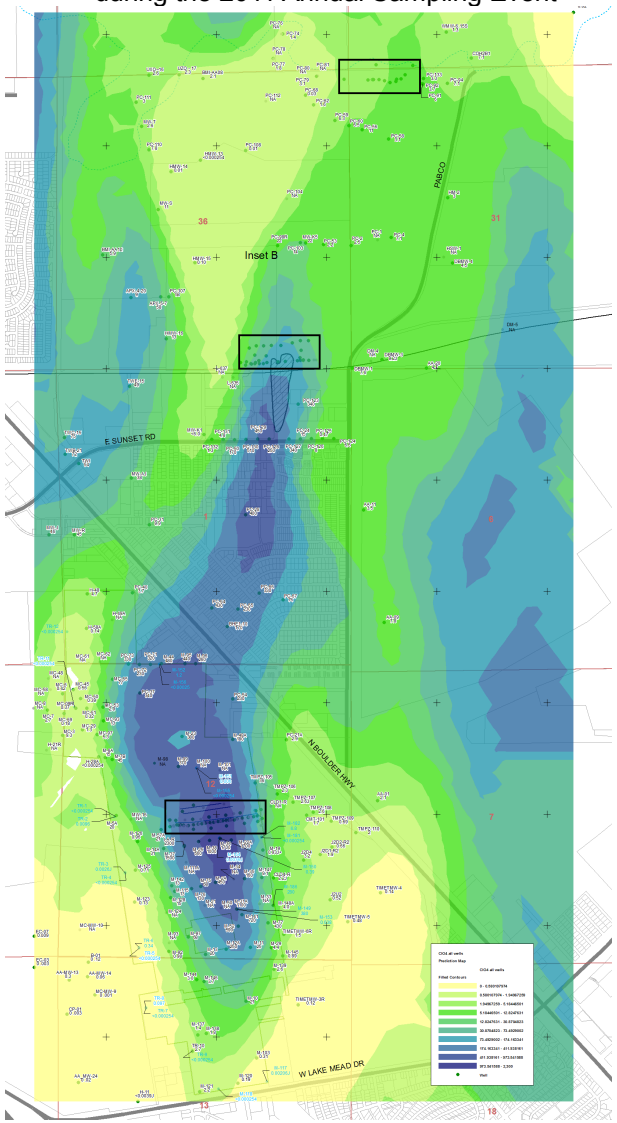
TABLE 2-2
Summary of Wells Removed from Sampling Program Based on the Statistical Evaluation and the Quantitative Evaluation

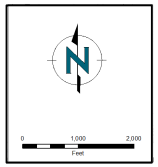
Wells removed based on statiscal evaluation	Wells removed based on qualitative evaluation
ART-7	I-C
H-28A	I-E
H-58A	I-G
HM-2	I-I
HMW-13	I-J
HMW-15	I-L
M-103	I-M
M-123	I-N
M-126	I-O
M-128	I-P
M-137	I-Q
M-138	I-S
M-139	I-T
M-142	I-U
M-144	I-V
M-29	M-129
M-7B	M-141
MC-45	M-22A
MC-50	M-23
MC-51	M-37
MC-53	M-38
MC-6	M-64
MC-69	M-65
MC-97	M-66
MW-K5	M-67
PC-101R	M-68
PC-108	M-75
PC-110	M-95
PC-111	MC-65
PC-131	PC-107
PC-143	PC-123
PC-145	PC-129
PC-18	PC-144
PC-40	PC-24
PC-55	PC-37
PC-58	PC-54
PC-60	PC-71
PC-62	PC-73
PC-74	
PC-77	
PC-86	
PC-90	

TABLE 2-3
Summary of Kriging Model Parameters Used to Contour Concentration Data from All the Wells and a Subset of the Wells

	Gaussian Model	
Parameter	**Perchlorate**	**Chromium**
Sill	12.7	8.9
Nugget	1.4	1.8
Anisotropy	yes	yes
Range (feet)	5200	6200
Minor Range (feet)	2400	2100
Direction (degrees)	0.9	3.5
Lag size (feet)	430	518

Perchlorate contours with data from wells sampled during the 2011 Annual Sampling Event





Perchlorate contours with data from 80 selected wells removed

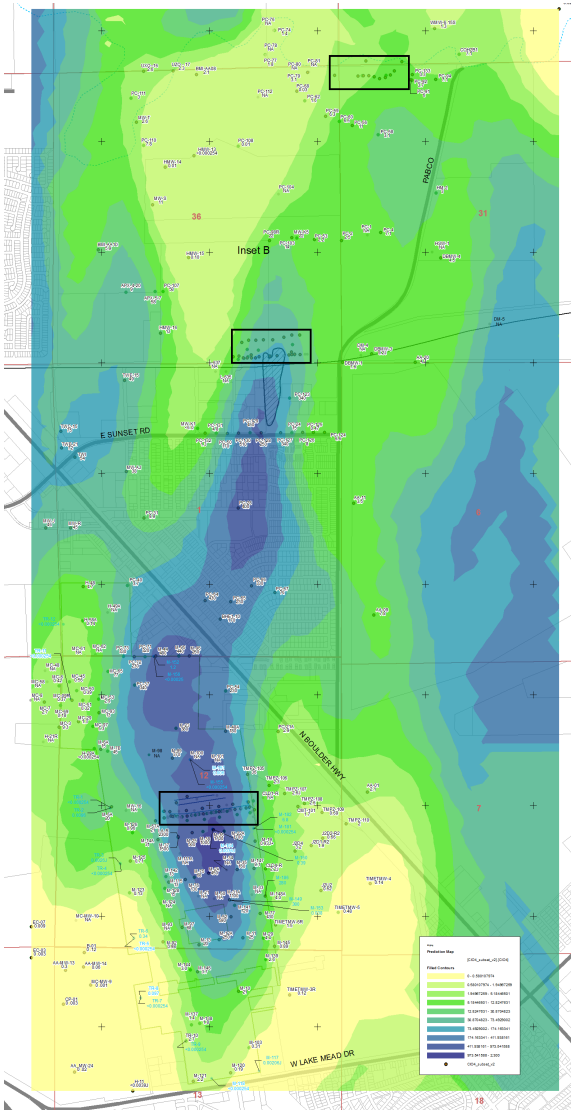
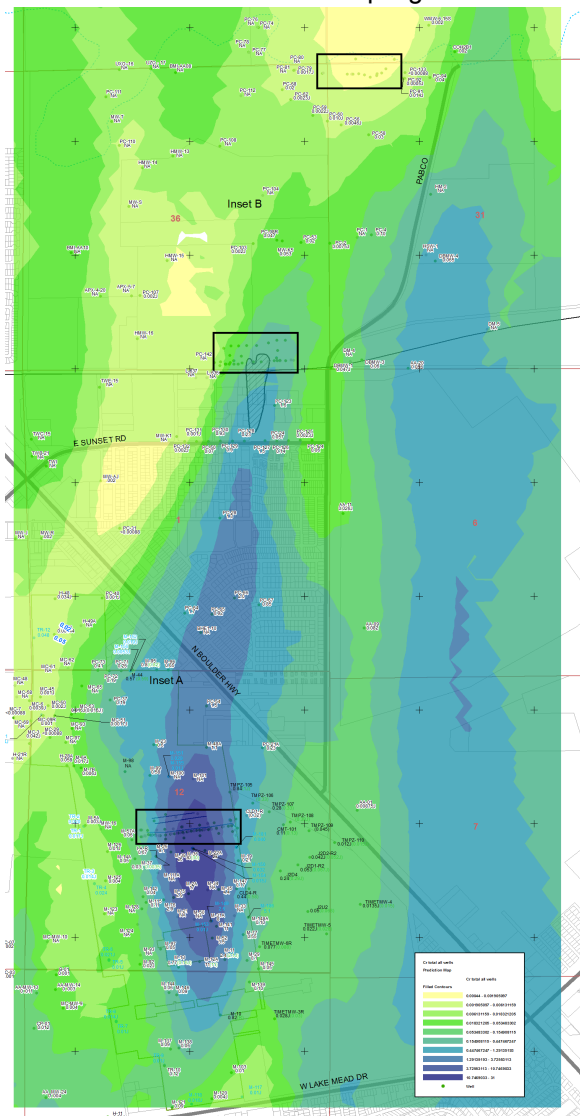


Figure 2-1

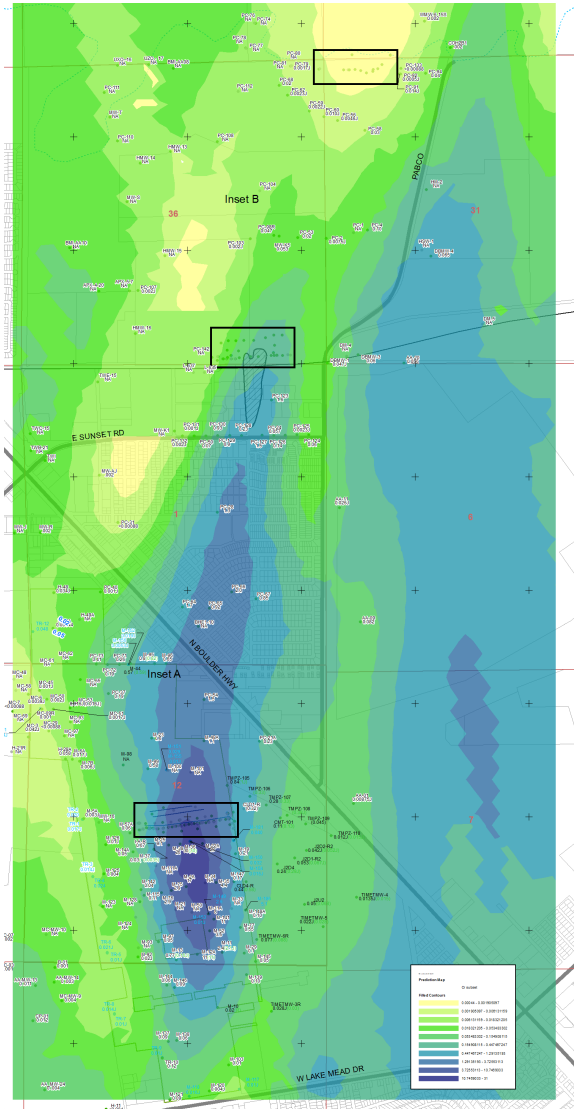
Comparison of Perchlorate Concentration Contours, Shallow WBZ
Attachment 2, Spatial Evaluation of the Long-Term Monitoring Program
Nevada Environmental Response Trust Site, Henderson, Nevada

northgate
environmental management, inc.

Chromium contours with data from wells sampled during the 2011 Annual Sampling Event



Chromium contours with data from 80 selected wells removed



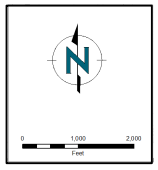


Figure 2-2

Comparison of Chromium Concentration Contours, Shallow WBZ
Attachment 2, Spatial Evaluation of the Long-Term Monitoring Program
Nevada Environmental Response Trust Site, Henderson, Nevada

northgate
environmental management, inc.