Annual Remedial Performance Report for Chromium and Perchlorate

Tronox LLC, Henderson, Nevada
July 2009 – June 2010

Submitted in Accordance with 1986 Chromium Consent Order and
2001 Perchlorate Administrative Order on Consent

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Chromium and Perchlorate
Tronox LLC
Henderson, Nevada

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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.

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1.0 INTRODUCTION

In accordance with the Consent Order for remediation of chromium-impacted groundwater at the Henderson facility, finalized September 9, 1986, and the Administrative Order on Consent (AOC) for remediation of perchlorate-impacted groundwater in the Henderson area, finalized October 8, 2001, Tronox LLC (Tronox) submits this remedial performance report for the Tronox facility located in Henderson, Nevada (the Site) to the Nevada Division of Environmental Protection (NDEP).

This report, covering the period July 2009 through June 2010, summarizes performance data for both the chromium and perchlorate remediation programs. Specifically, this report describes:

- Regional groundwater conditions based on April-June 2010 groundwater levels;
- The hexavalent chromium remediation system (consisting of the on-Site Interceptor well field and the off-Site Athens Road well field) and evaluates its performance in carrying out the chromium remediation program;
- The perchlorate remediation system (consisting of the on-Site Interceptor well field, the off-Site Athens Road well field, the off-Site Seep well field, and the off-site Seep surface-flow capture sump) and evaluates its performance in carrying out the perchlorate remediation program;
- Extent and magnitude of other constituent loading (total dissolved solids, chlorate, nitrate); and
- Planned upcoming work to improve the groundwater extraction and treatment system (GWETS).

Recent annual reports have also included a capture zone evaluation for the GWETS, which is not included in this document. A separate stand-alone capture zone evaluation report will be submitted later this year that incorporates the results of additional field investigations at the Site and a three-dimensional hydrogeologic flow model currently being prepared by Tronox.

Annual groundwater sampling (completed in the second calendar quarter) is a coordinated sampling event with several neighboring companies participating. Data from groundwater samples collected by neighboring companies are incorporated into the Tronox potentiometric, total chromium, and perchlorate maps. Additionally, annually we have mapped the total dissolved solids (TDS), chlorate, and nitrate concentrations combining the available data provided by the other companies. For the 2010 Annual Remedial Performance Report, Tronox received information from American Pacific Corporation (AMPAC), Pioneer/Olin Chlor-

Alkali/Stauffer/Syngenta/Montrose (POSSM), Southern Nevada Water Authority (SNWA), and Titanium Metals Corporation (TIMET); their data were integrated into Tronox's to develop these maps.

This report is provided in both hard copy and electronic forms. Where electronic files are referenced or information is stated as provided on CD, this information is contained on the CD inserted at the front of the hard copy report. Appendix A contains two tables: Table A-1, which has five quarters of analytical data from the Site, and Table A-2, which has April through June 2010 data from AMPAC, POSSM, SNWA, and TIMET used to supplement the Plates in the report. An Access © compatible data file (on the report CD) contains the compliance monitoring analytical results from the period January to June 2010. An Excel spreadsheet (on the report CD) contains an EDD with January to June 2010 water level monitoring data. Appendix B contains the laboratory reports and field sheets from January to June 2010 (on the report CD). Appendix C contains correspondence with NDEP, including responses to comments on previous Tronox reports, and Appendix D contains the data validation summary report.

2.0 AREA GROUNDWATER CONDITIONS

Figure 1, a location map covering the area between the Tronox facility and Las Vegas Wash, shows the components of the remedial systems with an index for accompanying cross sections. The performance of each component will be discussed separately, starting with the on-site Interceptor well field and proceeding to the successively northward components. Plate 1 shows the locations of all monitoring wells in the mapped area

Plate 2, the *Potentiometric Surface Map: Shallow Water-Bearing Zone*, is based on groundwater elevation measurements taken in April-June 2010 by Tronox, AMPAC, POSSM, SNWA, and TIMET, and it shows a generally north-northeast groundwater flow direction, with an average gradient of 0.015 to 0.02 feet per foot south of the Athens Road well field, flattening to 0.007 to 0.010 feet per foot north of the well field. On the plate, wells where the potentiometric surface is located in the shallow Upper Muddy Creek formation (UMCf) are indicated by an orange highlight over the well identifier. Wells where the potentiometric surface is located in the Quaternary alluvium (Qal) overlying the UMCf are not highlighted. On the map's southern end, beneath the Tronox facility, the flow direction is generally north to north-northwesterly, whereas north of the facility the direction changes slightly to the north-northeast. This generally uniform flow pattern may be modified locally by subsurface alluvial channels cut into the underlying UMCf, the on-site bentonite-slurry groundwater barrier wall (barrier wall), on- and off-Site artificial groundwater highs or "mounds" created around the on-Site recharge trenches and City of Henderson Water Reclamation Facility (COH WRF) Rapid Infiltration Basins (RIBs), and by depressions created by the groundwater extraction wells at the three groundwater recovery well fields.

2.1 Interceptor Well Field Area

The location of the Interceptor well field area is shown on Figure 1 and Plate 2. A bentonite-slurry wall was constructed as a physical barrier across the higher concentration portion of the perchlorate/chromium plume on the Site in 2001. The barrier wall is approximately 1,600 feet in length and 60 feet deep and constructed to tie into approximately 30 feet of UMCf. The Interceptor well field consists of a series of 23 groundwater extraction wells that are situated due south (upgradient) of the barrier wall. In addition, Tronox is currently working on the infrastructure upgrades necessary to connect seven additional extraction wells to the Interceptor well field recovery system (I-W, I-X, I-Y, I-AA, I-AB, I-AC, and I-AD). The monthly average discharge rate for each Interceptor well active during June 2010 is shown on Table 1, along with the discharge rates in June of the five previous years. The combined discharge of the Interceptor well field averaged a record high of 73.8 gallons per minute (gpm) in June 2010. In June 2001, prior to the installation of the barrier wall, the 22 wells comprising the Interceptor well field averaged a combined discharge of 24.7 gpm.

North of the well field and barrier wall, the shallow aquifer is artificially recharged with clean (less than 5 ppb perchlorate) Lake Mead water that is introduced to the subsurface via gravel-filled trenches to balance the loss of groundwater removed from the alluvium and Muddy Creek formations by the Interceptor well field. Recharge rates slowed in 2007 and 2008 to a low of 10.4 gpm in February 2008 as the trenches became clogged with Quagga mussels. Between February 2008 and July 2009, both trenches were cleaned and refurbished and a filtering system was installed to prevent the reintroduction of the mussels. The combined recharge rate of the trenches averaged 67.5 gpm in June 2010.

Plate 3, the *West-East Hydrogeologic Cross Section A-A' – Interceptor Well Field, May 2010,* shows the current water levels in the pumping Interceptor wells, adjacent monitor wells, and the relationships between the pre-pumping and current groundwater level in the vicinity of the well field. The cross section also shows the series of narrow subparallel alluvial channels separated by Muddy Creek ridges, some of which are above the current groundwater level. In general, water elevations in the well field in May 2010 are about one foot higher than in May 2009. Water levels in the pumping wells indicate that the Interceptor well field is dewatering the Qal and the upper portion of the UMCf in the vicinity of the pumping wells. However, the goal of the Interceptor well system is not necessarily to dewater the alluvium at each well, but to capture groundwater in the shallow saturated intervals between the Interceptor wells, and remove contaminant mass.

North (downgradient) of the barrier wall, elevations in wells M-69 through M-74 range between six feet lower to three feet higher than water elevations in wells located south (upgradient) of the barrier wall. Figure 2, *Hydrograph Pairs across the Barrier Wall*, shows water levels as a function of time for pairs of wells located on opposite sides of the wall. The hydrographs for wells M-69 through M-71 in particular show the influence of recharge rates in the infiltration trenches on water levels in the downgradient wells. In contrast, the above-barrier wells, I-Y, and M-55, -56 and -58, show only minor water elevation changes. The hydrograph pairs do not appear to exhibit hydraulic connection or a greater degree of correlation than could be explained by seasonal or regional changes in groundwater levels.

2.2 Athens Road Field Area

Figure 1 and Plate 2 show the location of the Athens Road well field (Athens Road has been renamed Galleria Drive, however the Athens Road designation has been retained for the well field to maintain consistency with past reports), approximately 8,200 feet north (downgradient) of the barrier wall and the Interceptor well field. The Athens Road well field was completed in March 2002, and continuous pumping began in mid-October 2002. In early September 2006, well ART-9 began full-time operation. In addition, Tronox has recently installed ART-7B, located adjacent to existing extraction well pair ART-7/ART-7A, with a screen interval extended down to the Qal/UMCf interface. It is anticipated that the operation of this well will further enhance the capture and treatment of chromium and perchlorate in the eastern subchannel. Currently, the Athens Road well field consists of a series of 14 groundwater extraction wells screened in the Qal at seven paired well locations. The pairs act as “buddy” wells with one well pumping while the adjacent “buddy” well is used to measure water levels adjacent to the well and monitor the effect of pumping on the aquifer. The monthly average discharge rate for each Athens Road pumping well during June 2010 is shown on Table 2, along with the discharge rates in June of the five previous years. The combined discharge rate of the Athens Road well field averaged 267.1 gpm in June 2010, similar to the pumping rates recorded for recent years.

Potentiometric contours for the Athens Road well field area, inferred from groundwater elevations measured in May 2010, are shown on Plate 2, the *Potentiometric Surface Map: Shallow Water-Bearing Zone*. The closed contours shown in Inset A of the Plate, drawn surrounding the east and west portions of the well field, are dashed, as there are insufficient data to prove the interpreted contours. Previous construction activity by the City of Henderson in the vicinity of the well field destroyed some wells and made access to other wells impossible. However, Tronox recently installed several additional wells in the Athens Road area and either restored access or installed replacement wells for others. Lithologic data from these wells has been incorporated into Plate 4 (discussed below), and sampling data will be available starting in the third quarter of 2010.

Plate 4, *West-East Hydrogeologic Cross Section B-B’ – Athens Road Well Field*, shows the current water levels in the pumping wells, adjacent monitor wells, and the relationships between the pre-pumping and current groundwater levels in the vicinity of the well field. As shown on the Plate, the extraction wells in the Athens Road well field target two alluvial subchannels separated by a ridge of UMCf. Recently installed monitoring well M-142 indicates that the deepest part of the western channel may not be as wide as previously thought. Groundwater levels are currently much lower than they were in 2002 before pumping began, and the Qal overlying the UMCf high has been dewatered. In general, the water elevations in the Athens Road well field are similar to or slightly lower than they were one year ago. Historical groundwater level trends for selected wells are shown in Figure 3, *Athens Road Well Field Drawdown*.

Tronox has conducted systematic surveys of several wells in the Athens Road well field since before pumping began in 2002, in order to monitor subsidence due to dewatering of the aquifer. Tronox currently surveys the well elevations approximately every two years. Figure 4 shows the measured elevations of selected wells across the Athens Road well field in March 2002 compared to the most recent survey in April 2010. As shown on Figure 4, there has been no significant subsidence in the well field.

2.3 Seep Well Field Area

The Seep well field and the Seep stream pumping station, located approximately 4,500 feet north (downgradient) of the Athens Road Well Field near the Las Vegas Wash, are shown on Figure 1 and Plate 2. When pumping began in July 2002, the Seep well field consisted of three recovery wells situated over the deepest part of the subsurface alluvial channel in the UMCf and a surface-capture pump for an intermittent surface stream. In February 2003, five additional wells (PC-117 to PC-121) and in December 2004 one additional well (PC-133) were completed in the Seep well field area. The wells comprising the Seep Well Field are completed in the Qal across the deepest portion of a buried paleochannel. The monthly average discharge rate for each pumping well during June 2010 at the Seep well field is shown on Table 3, along with the discharge rates in June of the five previous years. The combined discharge rate of the Seep well field averaged 530.3 gpm in June 2010. The surface stream has not flowed since April 2007.

Plate 2 shows that north of the Athens Road well field the gradient of the north-northeast sloping potentiometric surface decreases to about 0.007 feet per foot due to constant water infiltration from the COH Birding Ponds, periodic mounding events from the COH WRF, and underflow from Las Vegas Wash. Recent depth to water measurements north of the COH WRF show that water elevations are up to 17 feet lower now than they were in May 2008, particularly to the south-southeast of the Seep well field (wells HM-2, HSW-1). This water elevation decrease is thought to be due to cessation of the discharge of treated effluent to the Pabco Road RIBs since the completion of the COH WRF in 2008.

Plate 5, the *West-East Hydrogeologic Cross Section C-C' – Seep Well Field*, shows that the alluvial channel is much less incised into the underlying UMCf than at Athens Road, and that the configuration of the alluvial channel is a broad shallow feature about 800 feet wide and averaging about 45 feet thick. In May 2001, before pumping began, the groundwater level in the area was very shallow and would daylight every winter. Based on water level measurements collected in May 2010, water levels in the Seep well field are currently six to eight feet lower than pre-pumping levels.

3.0 CHROMIUM MITIGATION PROGRAM

Figure 1 shows the four components of the chromium mitigation program, consisting of the on-site Interceptor well field, groundwater barrier wall and groundwater recharge trenches, and the off-site Athens Road well field. For the last 12 months – July 2009 to June 2010 – a total of about 4,065 pounds of chromium was captured, while hexavalent chromium reduced to trivalent chromium and removed, and residual solids disposed of in a permitted landfill. For the discussion below, total chromium is conservatively considered to be entirely hexavalent chromium. A diagram of the groundwater treatment system is presented on Figure 5, *Tronox Henderson Groundwater Treatment Flow Diagram*. This block diagram is a life cycle presentation of how groundwater impacted with chromium and/or perchlorate is extracted from the four primary groundwater collection areas, moves through the various treatment stages, and is discharged as clean effluent to Las Vegas Wash.

3.1 Chromium Plume Configuration

Plate 6, *Total Chromium in Groundwater Map: Shallow Water-Bearing Zone*, presents an isoconcentration map of the chromium plume from its on-Site source northward to the point where the plume reaches non-detect levels south of Las Vegas Wash. The main portion of the chromium plume and highest concentrations remain south of the barrier wall and are cut off by the Interceptor well field. South of the Interceptor well field, the highest total chromium concentration occurred in M-50 (39 mg/L). North of the recharge trenches the highest total chromium concentration found was 2.9 mg/L in well M-87, located south of Warm Springs Road. Concentrations in well M-12A (25 mg/L in May 2002), located on the trailing edge of the main plume, continue to decline and have been below 10 mg/L since the November 2009 monitoring event. Total chromium concentrations downgradient of the barrier wall and recharge trenches also continue to decline, indicating that the groundwater recovery / barrier system is functioning as an effective barrier to migration of the main portion of the chromium plume. Appendix A contains total chromium data for the last five quarters along with groundwater elevations for these wells.

3.1.1 On-Site Interceptor Well Field Area

The Interceptor well field captures the highest concentrations and the main portion of the groundwater plume located downgradient of the on-Site source area. Plate 3, *West-East Hydrogeologic Cross Section A – A' Interceptor Well Field*, shows the current total chromium concentration in each well; Figure 6, *Interceptor Well Field Total Chromium Section Graph*, shows the concentrations of total chromium in the 22 well field pumping wells over the last five quarters.

Chromium concentration data from the five Consent Order Appendix J wells (M-11, -23, -36, -72, and -86) are presented in graph form in Figure 7, *Consent Order Appendix J Wells Total Chromium Concentration Trend Graph*. Concentrations have remained relatively stable over the last five years in monitoring well M-11, immediately downgradient from the former primary source area (Units 4 and 5). Concentrations in monitoring wells M-23, downgradient of the Interceptor well field near Warm Springs Road, and M-72, in the "dead zone" between the barrier wall and downgradient infiltration trenches, display an overall slow but steady decline over the same period of time; the trend is slight and masked by low overall concentrations in the wells. Concentrations in well M-36, upgradient of the Interceptor well field and barrier wall in the center of the main plume, also continue to decline, with a historical low of 30 mg/L recorded from the May 2010 monitoring event. M-86, located just downgradient of the infiltration trenches at the Interceptor well field, exhibited an increasing trend in total chromium concentrations from late-2005 to mid-2008, attributed to the fouling of the recharge trenches and concomitant dispersion of "dead zone" groundwater. M-86 was damaged or destroyed during the recharge trench refurbishment activities and is located in an area of planned soil excavation during upcoming remedial activities at the Site. Tronox intends to install a replacement well in the vicinity of M-86 after the completion of remedial activities.

3.1.2 Athens Road / Seep Well Fields Area

The groundwater recovery system at Athens Road has a positive effect on the total chromium concentrations north of the well field, intercepting a residual groundwater plume containing greater than 1 mg/L total chromium. In this area, groundwater flows around both sides of a Muddy Creek formation basement ridge. As shown on Inset A of Plate 6, the 1 mg/L chromium isoconcentration contour stops at the well field. Downgradient of the well field, the highest measured concentration of total chromium during the second quarter 2010 sampling event is 0.16 mg/L in well ARP-6B.

Plate 4, *West-East Hydrogeologic Cross Section B - B' Athens Road Well Field*, shows the current total chromium concentration in each well. Figure 8, the *Athens Road Well Field Total Chromium Concentration Section Graph* shows the concentrations of total chromium across in the eight pumping wells in addition to monitoring wells PC-18, -55, and -122 over the last five quarters. As shown in the figure, chromium concentrations in the western subchannel over the last year have been low relative to those in the eastern subchannel. Another recovery well, ART-9, was installed in this area in 2006 to capture a narrow channel of high chromium-impacted groundwater that was moving through the recovery well field. Consequently, a dramatic decline in chromium concentration occurred in well PC-122 that went from 1.5 to 0.10 mg/L between November 2006 and February 2007 and contained 0.1 mg/L in May 2010. Total chromium present in groundwater collected in this area continues to be treated at Lift Station #3 with metered ferrous sulfate additions to reduce the hexavalent chromium to insoluble trivalent chromium before the water is sent to the on-site perchlorate treatment system.

Further north, no total chromium section graph was prepared for the Seep well field, as wells in this well field closest to Las Vegas Wash continue to contain < 0.01 mg/L total chromium. East of the well field, concentrations of total chromium concentrations in nested monitoring well pair PC-93/ PC-94 were measured at 0.061 and 0.065 mg/L, respectively, in the second quarter of 2009. In May 2010, total chromium was measured at a concentration of 0.054 mg/L in PC-94. PC-93 could not be located and appears to have been plugged and abandoned by an unknown party. As mapped on Plate 6, chromium-impacted groundwater appears to be flowing from the Upper BMI Ponds east of Pabco Road and finally reached these wells in 2009. As discussed under area groundwater conditions, water elevations in this area dropped between three and 17 feet between 2008 and 2009 due to cessation of discharge of treated effluent in the Pabco Road RIBs. It may be possible that past infiltration acted to dilute a previously existing chromium plume, and without this dilution, it is finally being observed. Tronox will continue to monitor the situation.

3.2 On-Site Chromium Treatment System

The operation and maintenance of the total chromium reduction process was contracted to Veolia Water North America (formerly US Filter Operating Services) on June 9, 2003. Tronox retains responsibility for compliance with the terms of the 1986 Consent Order and the subsequent Underground Injection Control (UIC) Permit NEV94218. Table 4 contains the July 2009 to June 2010 process treatment data from the on-site Groundwater Treatment Plant (GWTP). The treated groundwater from the GWTP, which includes about 25 gpm from GW-11, was pumped to two 150,000 gallon tanks (BT-40 and BT-45 in series), then to the equalization tanks where it combined with water from the off-site recovery systems. From the equalization tanks, most of the blended water flows through activated carbon beds before being filtered and pumped to the Fluidized Bed Reactors (FBRs) for treatment to destroy perchlorate, chlorate, and nitrate. A small portion of the blended GWTP flow (1-3 gpm) is not pumped to the FBRs but instead is returned to the GW-11 pond in order to avoid running the underflow pump dry.

As shown in Table 4, since July 2009 the total chromium inflow concentration from the Interceptor wells to the GWTP is holding fairly steady in the range of 12 to 13 mg/L, although the inflow concentration in June 2010 was only 10.6 mg/L. The reduction of hexavalent chromium during the reporting period has been consistently effective. Total chromium outflow concentrations for the last 12 months ranged from 0.005 to 0.357 mg/L – well below the required level of 1.7 mg/L established in the 1986 Consent Order. The hexavalent chromium outflow concentration during the reporting period ranged from 0.000 to 0.024 mg/L – well below the required level of 0.05 mg/L, established in the 1986 Consent Order. For the period between July 2009 and June 2010, about 3,850 pounds of chromium were removed from the groundwater by the GWTP.

Results of total chromium analysis from weekly FBR influent and effluent samples are presented in Table 5. These data, between July 2009 and June 2010, show that the FBR’s influent total chromium concentrations varied from 0.05 to 0.14 mg/L. Based on an average concentration of about 0.073 mg/L total chromium with an average flow rate of 932 gpm, the FBRs were receiving about 0.82 pounds of chromium per day from the equalization tanks.

FBRs discharge treated water to the Las Vegas Wash just upgradient of the Pabco Road erosion control structure under authority of NPDES Permit NV0023060. Analyses of this water performed between July 2009 and June 2010 appear in Table 5. The table shows that all hexavalent chromium analyses have been non-detect at <0.0001 mg/L and that 14 of 52 total chromium analyses have been non-detect at <0.01 mg/L, with the 38 detections ranging from 0.011 to 0.038 mg/L and at an average concentration of 0.021 mg/L. At an influent concentration of approximately 0.82 pounds per day the FBR system removed an additional 215 pounds of chromium over the 12 month period. The sum of the chromium removed from the groundwater between July 2009 and June 2010 by the chromium recovery and treatment system and by the FBRs totals 4,065 pounds.

4.0 PERCHLORATE RECOVERY PROGRAM

The four components of the perchlorate recovery system, consisting of the on-site Interceptor well field and barrier wall, the off-site Athens Road well field, the off-site Seep well field, and the off-site Seep surface-flow capture sump, are shown on Figure 1. In the last 12 months, since July 2009, a total of about 590,525 pounds of perchlorate (1,618 pounds per day) have been captured, removed, and destroyed in the biological treatment system. Of this total, about 333,228 pounds (913 pounds per day) came from the on-site Interceptor well field, about 239,549 pounds (656 pounds per day) came from the Athens Road well field, about 17,748 pounds (49 pounds per day) came from the Seep well field and zero pounds came from the Seep surface-flow capture sump. Figure 9 shows the July 2009 – June 2010 monthly perchlorate recovery totals and the relative significance of each of the four components, whereas Table 6 shows the average pounds of perchlorate per day removed by each component. Note also on Table 6 that the June 2010 recovery is an estimate that will be recalculated next month.

4.1 Perchlorate Plume Configuration

Plate 7, *Groundwater Perchlorate Map: Shallow Water-Bearing Zone – Second Quarter 2010*, shows the contoured perchlorate plume from the Tronox plant site to Las Vegas Wash based on data collected in May and June 2010. Based on this sampling, the highest perchlorate concentration south of the Interceptor well field occurred in well I-A-R (2400 mg/L) whereas north of the recharge trenches the highest perchlorate concentration found was 630 mg/L in well M-44 along the north boundary of the Tronox property. Appendix A contains the results of the last five quarters of sampling.

Comparing Plate 7 with Plate 7A, *Groundwater Perchlorate Map: Shallow Water-Bearing Zone – Second Quarter 2002*, it is obvious that significant changes in the perchlorate plume have occurred over eight years. In 2002, the highest perchlorate concentration (M-37, adjacent to I-A-R) contained 5300 mg/L, whereas in 2010 the same well contains only 1690 mg/L. As shown on Plate 7A, a large area downgradient of the barrier wall contained perchlorate in excess of 1,000 mg/L, including M-23 and M-44 with measured concentrations of 1,430 mg/L and 1,400 mg/L, and concentrations at the downgradient edge of the plume in 2002 were as high as 160 mg/L (PC-115R, -116R, -99R2/R3) where it intersects the Las Vegas Wash. In the most recent sampling event, M-23 and M-44 were measured at 370 mg/L and 630 mg/L, respectively, and the highest concentration measured in the Seep well field is 13 mg/L in well PC-99R2/R3.

4.1.1 Interceptor Well Field Area

The three components of this well field area, the recovery well line, the barrier wall and the groundwater recharge trenches, target the highest concentrations of perchlorate at the Site and significantly reduce the amount of perchlorate in the downgradient groundwater.

Plate 3, *West-East Hydrogeologic Cross Section A – A' Interceptor Well Field*, shows the current perchlorate concentration in each well; Figure 10, *Interceptor Well Field Perchlorate Concentration Section Graph*, shows the perchlorate concentrations for the 22 pumping wells in May 2002 compared to the last four quarters. The most recent data from May 2010 show that the perchlorate concentrations in many of the Interceptor wells are significantly lower than in May 2002 and many wells are at or near their historic lows. The section graph and Figures 11 and 11A, *Interceptor Well Field Perchlorate Concentration Trend Graphs*, show that there are two sub-lobes impacting the well field – a western sub-lobe centered on wells I-R and I-L, and a wider eastern sub-lobe located east of well I-E – and the overall perchlorate loading is declining over time. Since high perchlorate concentrations are often associated with high TDS concentrations, a TDS section graph was constructed across the well field. A comparison of Figures 10 and 12, the *Interceptor Well Field Total Dissolved Solids Section Graph*, shows that the broad zone of high TDS in the central part of the well field continues in the most recent sampling, concomitant with the eastern perchlorate sub-lobe. It is noteworthy that the high perchlorate plume on the west side of the well field is not associated with high TDS. It is thought that the western sub-lobe of perchlorate, with no other salts present, is due to past piping leaks and represents a separate perchlorate source from the eastern sub-lobe.

The monthly average perchlorate concentration collected at the well field generally decreased, with short-lived minor reversals, from a high of about 1,900 mg/L in 2002 to about 1,001 mg/L in June 2008 (see Figure 13, *Interceptor Well Field Average Perchlorate Concentration and Mass Removed*). Over the past two years the average perchlorate concentration has remained relatively steady, and increasing pumping rates over this period of time have led to an increase in the monthly average mass of perchlorate removed from the groundwater by the Interceptor well field. Approximately 28,938 pounds of perchlorate were removed from the environment by the Interceptor well field in June 2010.

Data shown on Figure 14, *Well M-100 Perchlorate vs. Water Elevation Trend Graph*, from monitoring well M-100 located 700 feet north of the recharge trenches, show how the recharge trenches began to lose effectiveness around May 2007 as Quagga mussels reduced the rate of infiltration and caused water levels in M-100 to drop. Since the refurbishment of the trenches and installation of a bag filter in July 2009, the groundwater elevation began to rise once more, demonstrating the groundwater mounding effect from the trenches.

4.1.2 Athens Road Well Field Area

Plate 4, *West-East Hydrogeologic Cross Section B - B' Athens Road Well Field*, shows the current total perchlorate concentration in each well; Figure 15, *Athens Road Well Field Perchlorate Concentration Section Graph*, shows perchlorate concentrations in the eight pumping wells in addition to monitoring wells PC-18, -55, and -122 in May 2002 compared to the last four quarters. The data show that over the last four quarters concentration changes have occurred in a narrow range – with the exception of ART-6 – and that most of the present concentrations are below those from May 2002. Note that the perchlorate concentrations on the western side of the well field (PC-55 and ART-1) and the eastern side of the well field (PC-122) continue to remain very low.

The perchlorate concentrations of the ART-series wells are shown in Figures 16 and 16A, *Athens Road Well Field Perchlorate Concentration Trend Graphs*. Figure 16 shows that overall since 2002 perchlorate concentrations in the well field have generally been stable or declined slightly. Figure 16A, an expanded view of the last five quarters of Figure 16, indicates that more recently concentrations in the ART-series wells have remained stable, with the exception of ART-6, which continues to fluctuate between approximately 75 mg/L and 350 mg/L (380 mg/L in May 2010). The perchlorate concentration measured in ART-8 in May 2010, as shown on Figure 17, *Athens Road Well Field Average Perchlorate Concentration in ART-8 and Mass Removed*, was 260 mg/L – in the middle of its range. Also shown on this graph is the monthly average perchlorate mass removed from the well field which was estimated to be 21,992 pounds in June 2010.

Starting in August 2006, TDS data have been collected from the well field. A section graph, Figure 18, *Athens Road Well Field Total Dissolved Solids Section Graph*, shows that two zones of higher TDS exist at the well field, centered on PC-18 on the west (9,700 mg/L) and highest at PC-122 on the east (9,900 mg/L). The trough in the TDS concentrations corresponds with the peak of the perchlorate section graph in Figure 15. As shown on Plate 8, the TDS peaks on the east and west of the ART section graph are from high-TDS plumes originating from the Timet and POSSM sites, respectively.

About 250 feet north of the Athens Road well field, seven ARP-series wells and one MW-K-series well make up the Athens Road piezometer well line. A section graph of perchlorate in the Athens Road piezometer well line is presented in Figure 19, and perchlorate concentrations of these wells over time are shown on Figures 20 and 20A, the *Athens Road Piezometer Wells Perchlorate Concentration Trend Graphs*. The western well (ARP-1) and the eastern well (ARP-7) continue to contain perchlorate concentrations below 5.6 mg/L. In December 2007 ARP-4A, -5A and -6B replaced ARP-4, -5 and -6A, which were plugged and abandoned to make way for COH area development and drainage ditch construction. No data have been available from wells ARP-2 and -3 since June 2008 because these wells were buried during City of Henderson construction activities. Replacement wells ARP-2A and ARP-3A were installed during the second quarter of 2010 but will not be sampled until the third quarter sampling event. Figure 20A shows an expanded view of the last five quarters. Perchlorate concentrations in wells ARP-1, -4A, -5A, -6B and -7 appear to be holding steady, while well MW-K4 (240 mg/L in May 2009) remains high, following a rapid increase from 77.8 mg/L in December 2008 to 300 mg/L in January 2010. No changes in the pumping history of the ART wells (see Table 2) or the groundwater elevations at the well field (see Figure 3) have occurred in the last five years that would seem to account for this trend. Tronox expects that additional wells installed at the Athens Road well field during the second quarter of 2010 will provide insight to the source of the higher perchlorate concentrations in MW-K4 and a means to mitigate them.

Intermediate between the Athens Road area and the Seep area are the COH WRF and the Lower Ponds monitor well lines. Figures 21, 22, and 22A present perchlorate concentrations in the COH WRF well lines on section and trend graphs. As shown in the figures, current perchlorate concentrations are well below levels measured in the same wells in May 2002. Concentrations measured in May 2010 are consistent with or slightly higher than monitoring results for the previous four quarters. Figure 23, *PC-98R Perchlorate vs. Water Elevation Trend Graph*, shows that since February 2003 the groundwater level has continued to generally decline, but significant groundwater “mounding events” due to increased COH WRF surface water infiltration continue to occur sporadically.

The Lower Ponds well line is 2,200 feet north of the COH WRF well line. Figures 24, 25, and 25A, the perchlorate section and trend graphs for the Lower Ponds Well Line, show that perchlorate concentrations have not shown much variation since about February 2004. As shown on the figures, the generally low concentrations present in the Lower Ponds Well Line are remaining steady or slightly declining, with well PC-58 containing the highest perchlorate concentration (9.5 mg/L) along the well line.

4.1.3 Seep Well Field Area

The original three recovery wells in the Seep well field went on-line in August 2002. In February 2003, five additional wells (PC117 to PC121), and in December 2004, one additional well (PC133), were completed in the Seep well field (see Plate 1). At present, the Seep well field consists of ten extraction wells – two of which (PC-99R2 and -99R3) are connected and operate as one – positioned over the deepest part of the alluvium channel that contains the highest concentrations of perchlorate. The well field is located about 600 feet upgradient of the seep surface-flow capture sump. Tronox has proposed to install three additional monitoring wells at the well field if and when an access agreement is obtained. However, it is not anticipated that any additional wells will be installed in the Seep well field in 2010 due to access issues.

Plate 5, the *West-East Hydrogeologic Cross Section C - C' Seep Well Field*, shows the perchlorate concentrations in the wells as of May 2010; Figures 26, Figure 27, and 27A present the perchlorate section and trend graphs for the Seep well field. As shown on Figure 27A, perchlorate concentrations in the Seep wells have slightly increased over the last five quarters. However, as shown in Figure 27, the perchlorate concentrations in Seep wells are still dramatically lower than they were in July 2002 when pumping began. TDS concentrations for the last five quarters are plotted on Figure 28, the *Seep Well Field Total Dissolved Solids Section Graph*. This figure shows that the highest TDS concentration (5000 mg/L) is currently measured in well PC-99R2/R3, which also contains the highest perchlorate concentration for the well field (13 mg/L in May 2010).

The monthly perchlorate concentration, as shown on Figure 29, *Seep Area Average Perchlorate Concentration and Mass Removed*, currently averages about 4.9 mg/L. Also shown on this graph is the monthly average perchlorate mass removed, which was estimated to be 1,602 pounds in June 2010.

The May 2010 SNWA sampling of four vegetation irrigation wells (plotted on Plate 7) completed in the Las Vegas Wash show that these wells all contain less than 1.3 mg/L perchlorate. Well WMW-6.15S, which contained 45.6 mg/L in June 2002, contained only 1.3 mg/L in May 2010, a 97% decrease. These results provide evidence that the in-place recovery systems are functioning well to reduce concentrations of perchlorate in the Las Vegas Wash. As plotted on Plate 7, the 1 mg/L groundwater perchlorate contour is only about 700 feet downgradient of the Pabco structure.

4.2 On-Site Perchlorate Groundwater Treatment System and Remediation

Throughout the reporting period, groundwater was collected and treated in both the Groundwater Treatment Plant (GWTP, for on-site water containing hexavalent chromium) and the biological treatment plant (FBRs, for on-Site, Athens Road, and Seep Area collection systems, to remove nitrate, chlorate and perchlorate). Effluent from the biological treatment process was discharged into Las Vegas Wash and, with few exceptions, stayed within the limits specified in the NPDES NV0023060 discharge permit. As shown on Table 7, since July 2009 the perchlorate influent to the FBRs has ranged from 170 mg/L to 447 mg/L; whereas the effluent discharged to Las Vegas Wash was mostly non-detect at <0.005 or < 0.010 mg/L perchlorate. Four out of 53 effluent samples contained perchlorate above the laboratory method reporting limit at concentrations ranging from 0.01 mg/L to 0.108 mg/L. Routine maintenance is completed as needed at the GWTP and FBRs.

5.0 OTHER MAPPED ANALYTES

5.1 Total Dissolved Solids

Plate 8, the *Total Dissolved Solids (TDS) in Groundwater Map: Shallow Water-Bearing Zone*, shows the contoured TDS configuration from the Tronox plant site area to Las Vegas Wash based on data collected in April through June 2010 by Tronox, AMPAC, POSSM, SNWA, and TIMET. Prior mapping shows that the Tronox facility is sandwiched between two high TDS zones originating from off-site sources. High TDS on the Tronox site occurs up to 19,000 mg/L in well M-50, upgradient of the barrier wall. Figures 12, 18, and 28 show, in section graph format, the distribution of TDS across the Interceptor, Athens Road and Seep well fields, respectively.

5.2 Chlorate

Plate 9, the *Chlorate in Groundwater Map: Shallow Water-Bearing Zone,* shows the contoured chlorate configuration from the Tronox plant site to Las Vegas Wash based on data collected in April through June 2010 by Tronox, AMPAC, POSSM, SNWA, and TIMET. The map shows that upgradient of the barrier wall, well M-25 contained the highest measured chlorate concentration at 3,000 mg/L. Between the barrier wall and the Wash, the maximum chlorate concentration is 750 mg/L (PC-50) along Sunset Road. Concentrations continue to decrease northward toward the Wash. North of the City of Henderson, WRF PC-4 contains 94 mg/L chlorate, suggesting a separate source in the BMI Upper Ponds. The biological treatment plant also destroys the chlorate in water treated for perchlorate removal.

5.3 Nitrate

Plate 10, the *Nitrate in Groundwater Map: Shallow Water-Bearing Zone*, shows the contoured nitrate configuration from the Tronox plant site to Las Vegas Wash, based on data collected in April through June 2010 by Tronox, AMPAC, POSSM, SNWA, and TIMET. The map shows that upgradient of the barrier wall, well M-37 contains the highest nitrate concentration at 170 mg/L. Between the barrier wall and the Athens Road well field, well M-99, PC-64, and PC-28 contain 310 mg/L, 220 mg/L, and 160 mg/L, respectively. Concentrations continue to decline closer to the Las Vegas Wash, with the highest concentration in the Seep well field measured at 8.2 mg/L in PC-90. The biological treatment plant also destroys the nitrate in water treated for perchlorate removal.

6.0 CONCLUSIONS

Chromium and perchlorate concentrations in monitoring wells immediately downgradient of the on-site groundwater barrier wall show a marked decline in concentration due to a combination of groundwater capture in the Interceptor well field and dilution by Lake Mead water in the recharge trenches. The infiltration trenches downgradient of the barrier wall were fully returned to service in July 2009 and recharged an average of 67.5 gpm in June 2010. For the 12-month period ending in June 2010, the chromium recovery and treatment system captured and removed approximately 3,850 pounds of chromium. Adding the 215 pounds of chromium removed by the FBRs for the 12 month period, a total of 4,065 pounds of chromium were removed from the groundwater between July 2009 and June 2010. The FBRs also removed a total of approximately 295 tons of perchlorate from the groundwater through the Interceptor, Athens Road, and Seep well fields. Ongoing assessment and monitoring will continue during 2010 to monitor capture of the chromium- and perchlorate-impacted groundwater upgradient of the groundwater barrier.

Concentrations of total chromium in Seep well field wells continue to be below the laboratory method reporting limit. Chromium capture at the Athens Road well field may be further improved with the expected initiation of pumping in recovery well ART-7B extending through the Qal to the UMCf interface.

Perchlorate continues to be captured by the four components of the remediation program. The on-site Interceptor well field, coupled with the groundwater barrier wall, provides capture of the highest plume concentrations in this on-Site area. Since October 2002 the Athens Road area well field has been in continuous operation and is maturing into an efficient interception line. Additional wells installed during the second quarter of 2010 will provide Tronox the opportunity and information to assess the efficacy of the Interceptor and Athens Road well fields and further refine perchlorate capture efforts. The Seep well field and the seep surface capture make up the remaining portions of the perchlorate recovery system. The Seep well field is advantageously located over the main part of the alluvium channel and is in close proximity to Las Vegas Wash, and capture in this area makes the most immediate impact on Wash perchlorate concentrations.

As the ultimate measure of the effectiveness of the combined systems over the last 10 years, one needs look no further than the decrease in perchlorate loading in Las Vegas Wash since 1999. In May 1999 the perchlorate loading in the wash was 1,104 pounds per day compared to 67 pounds per day in April 2010, a 93.9 percent drop.

7.0 PROPOSED FUTURE ACTIVITIES

Tronox is currently conducting additional field investigations at the Site and building a hydrogeologic flow model that encompasses the three extraction well fields at the Site. These efforts are designed to support a standalone capture zone evaluation report for the groundwater remediation system, which Tronox expects to submit to NDEP in December 2010. In addition, Tronox is actively working to upgrade the treatment system infrastructure, particularly at the Interceptor well field, to support the addition of new recovery wells at the Site.

The NPDES permit under which Tronox discharges treated groundwater into the Las Vegas Wash expires in November of this year. Tronox has filed a renewal application with NDEP to renew the permit and does not anticipate any interruptions in the groundwater extraction and treatment work at the Site due to the NPDES renewal process.

Tronox will continue to record water levels in the Consent Order and AOC areas. Potentiometric surface maps will be developed as well as chromium and perchlorate in groundwater maps. The effect of changing the pumping rates of the recovery wells will be monitored, and responses (i.e. pump rate adjustments) will be made to ensure optimal drawdown and plume interception at the well fields. Pumping wells will be rehabilitated as necessary. The monitoring plan in current use will be modified, as necessary, to facilitate collection of pertinent data to track the progress of chromium and perchlorate capture at the well fields and the seep.

A significant and wide-ranging effort to remediate source soils at the Site, including some that may be contributing to the groundwater contamination plumes is being undertaken at the Site. Tronox expects to excavate and dispose of several hundred thousand cubic yards of soil in 2010. In addition, Tronox is evaluating alternative strategies to remediate potential source soils and/or residual groundwater contamination at the Site in order to support the existing groundwater extraction and treatment system. A bench-scale test is underway to evaluate soil flushing as a mechanism to attack deep or dilute, or perchlorate source soils that are not amenable to remediation by excavation. Tronox has also proposed a pilot test to study in-situ technology along the COH WRF well transect, using an edible oil substrate injected below the water table to form a permeable reactive barrier. Perchlorate entering the barrier would be destroyed biologically, similar to the process used in the biological treatment plant.

Finally, other contaminants present in groundwater that have been identified as potential concerns based on the 2009 Phase B groundwater sampling and recent soil leaching evaluation are also being considered. The source(s), distribution, and expected fate-and-transport of these lesser groundwater constituents are being evaluated and results will be presented in a Phase B

Groundwater Assessment report to be submitted to NDEP later this year. The results of this assessment will be used to determine the likely effects of these constituents on the long-term remediation of groundwater, and to develop alternative remedial strategies for addressing these constituents, if appropriate.

FIGURES

TABLES

PLATES

APPENDIX A
GROUNDWATER ELEVATION AND ANALYTICAL DATA

APPENDIX B
GROUNDWATER ANALYTICAL DATA AND FIELD SHEETS

APPENDIX C
CORRESPONDENCE WITH NDEP AND
TRONOX'S RESPONSE TO COMMENTS

APPENDIX D
ANALYTICAL DATA REVIEW MEMORANDUM