TRONOX

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May 30, 2007

Mr. Brian Rakvica, P.E.
Nevada Division of Environmental Protection
2030 E. Flamingo Road, Suite 230
Las Vegas, Nevada 89119-0818

Subject: **Response to NDEP Comments on the Tronox Semi-annual Performance Report dated February 28, 2007 and the Required Work Plan to Evaluate Effective Groundwater Capture at Tronox Extraction Systems, Henderson, Nevada**

Dear Mr. Rakvica:

In response to NDEP comments on the Tronox February 28, 2007 *Semi-annual Performance Report*, Tronox has developed a full Response to Comments (RTC). The RTC is included in Appendix D to the quarterly perchlorate monitoring report being submitted under separate cover. As required in the comments, Tronox has also developed the attached Work Plan to evaluate the effectiveness of its groundwater capture systems: "*Work Plan to Evaluate Effective Groundwater Capture at Tronox Extraction Systems, Henderson, NV*".

Please contact me at (405) 775-6526 if you have any comments or questions concerning this correspondence. Susan Crowley had successful back surgery this morning and will not be in the office for a few weeks. I will try to keep things moving in her absence. Please continue to copy her on all communications.

Sincerely,

Keith Bailey
Director, Waste Minimization

E-mail and Overnight Mail

Attachment

CC: See attached Distribution List

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Updated: 2-Apr-07

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WORK PLAN TO EVALUATE EFFECTIVE GROUNDWATER CAPTURE AT TRONOX EXTRACTION SYSTEMS, HENDERSON, NV

I. INTRODUCTION

In commenting on the Tronox LLC (Tronox) Semi-annual Performance Report (February 28, 2007), the Nevada Division of Environmental Protection (NDEP) requested that Tronox evaluate the effectiveness of its groundwater capture systems by utilizing at least three of six USEPA "lines of evidence".[1] Tronox has included a discussion of the existing lines of evidence for capture at each of its collection/recovery systems in this Work Plan. This plan identifies areas where additional data is needed to further support and strengthen the current lines of evidence that demonstrate hydraulic capture at each of the extraction systems. Enhancements to the monitoring well field and extraction program are recommended, along with other methods to evaluate the hydraulic data in support of the development of converging lines of evidence that capture is occurring at each location.

Operational History

Tronox operates three primary groundwater containment and extraction systems associated with its Henderson Facility:

- On-Site Cutoff Wall and Interceptor Well Field – The subsurface cutoff trench or slurry wall, extends 1600 feet in length, is about 60 feet deep, and is combined with an upgradient series of 23 extraction wells. The upgradient well field pumps about 70 gallons per minute (gpm) of impacted water, effectively dewatering the alluvial aquifer in the vicinity of the barrier.

- Athens Road Well Field – Located approximately 8,200 feet north of the On-Site Collection System, the Athens Road (now Galleria Drive) Well Field includes a series of 14 extraction wells at 6 paired and 2 single well locations. The wells span a roughly 1,000-foot wide alluvial paleochannel and pump at a combined rate of about 270 gpm.

- Seep Area Collection System – Located near Las Vegas Wash, approximately 4,500 feet north of the Athens Road Well Field, the system includes a surface capture pump for the intermittent surface stream flow and 10 wells in the Seep well field to capture subsurface flow. The Seep Area Collection System pumps at a combined rate of about 620 gpm.

All groundwater from the hydraulic containment systems is routed for treatment to the Tronox facility and is discharged under an NPDES permit.

[1] NDEP comments dated March 29, 2007 referring to *Elements for Effective Management of Operating Pump and Treat Systems, EPA 542-R-02-009, December 2002.*

NDEP Comments to Tronox Quarterly Reports

NDEP requires verification that the Tronox systems are effectively removing contaminants passing through the capture zone [1]. The evaluation of the containment must consider a three-dimensional capture including flow contributions from both the alluvium in the paleochannels and the upper portion of the Muddy Creek Formation.

At least three of the six possible lines of evidence are required by the EPA[2] to demonstrate adequate capture. The possible lines of evidence include the following:

1. Capture zone estimated through calculations of flow-budget or analytical modeling.
2. Demonstration of overlapping cones of depression via flow nets both in plan view and vertical cross section.
3. Demonstration of inward flow from a compliance boundary using groundwater elevations at two or more locations perpendicular to the boundary.
4. Concentration trends over time at sentinel wells located down-gradient of the containment.
5. Particle tracking using a calibrated numerical model.
6. Tracer testing.

II. PROPOSED APPROACH FOR FURTHER CAPTURE ZONE EVALUATION

On-Site Cutoff Wall and Extraction Wells

Performance Evaluation

As presented in the accompanying Quarterly Performance Report, the current lines of evidence for effective groundwater capture include:

- Capture Zone: The 1,600-foot width of barrier wall was designed to provide a physical barrier to groundwater migration across the width of the identified perchlorate plume. According to the lines of evidence discussed below, the barrier wall has effectively impeded downgradient groundwater migration along its length, and has allowed the effective capture of impacted water as evidenced by the dewatering of the alluvial aquifer upgradient of the barrier wall

- Flow Budget: The barrier wall, installed in 2001, has dramatically improved groundwater capture. Current capture rates (70 gpm) are double those before the wall was installed. Water level data indicate the alluvial aquifer has been mined and is effectively dewatered behind the physical barrier. The wall is keyed at least 30 feet into the Muddy Creek Formation, and since there is an upward vertical gradient from the Muddy Creek to the alluvium, it is unlikely that contaminated water is flowing under the wall. This upward flow of groundwater is further enhanced by the pumping upgradient to and behind the barrier.

[2] *Elements for Effective Management of Operating Pump and Treat Systems, EPA 542-R-02-009, December 2002.*

Groundwater pumping behind the barrier produces about 70 gpm. A generalized flow budget suggests that the majority of groundwater produced comes from alluvium and areas where the Muddy Creek daylights to the alluvium. Based on assumptions of hydraulic conductivity and saturated thickness, contributions from the Muddy Creek are expected to be significantly less than from the alluvial aquifer.

The volume of water potentially moving around the west end of the wall is limited since the alluvium is not saturated in this area; as such, groundwater bypassing the barrier wall would have to migrate through the low permeability sediments of the Muddy Creek Formation. Based on the limited saturated thickness, and low permeability of the Muddy Creek Formation, the volume of groundwater migrating around the western end of the barrier is estimated to be less than 1 gpm.

At the east end of the wall, the alluvium has been similarly dewatered, also limiting the migration path through the low permeability Muddy Creek Formation. In addition, concentrations of perchlorate are dropping in samples from monitor wells in this area. Additional sampling of adjacent Timet wells conducted as part of the annual sampling event in May 2007 will also provide additional data in support of this trend analysis. Similar to estimates of bypass on the west end of the wall, an estimate of the volume of water migrating around the eastern end of the barrier is less than 1 gpm.

Using the assumptions of flow to the barrier, and what might possibly be bypassing the barrier on the east and west end, capture efficiency, based on the flow budget, is then calculated at approximately 70 gallons captured/72 gallons flow (70 gpm/72 gpm = 97% capture efficiency).

- Downgradient Concentration Declines over Time: Perchlorate itself is an effective tracer, since it migrates advectively and is not readily adsorbed to soils. Plume maps[3] indicate expansion of a zone containing less than 100 ppm perchlorate downgradient of the recharge trenches where stabilized lake water is added to offset extracted groundwater and maintain groundwater flow. Since the recharge water flow is slightly smaller than the water volume being extracted upgradient of the slurry wall, the rapidly expanding area containing less than 100 ppm perchlorate indicates perchlorate capture. Comparison of the current plume map with previous maps shows a continuing trend moving the 100 ppm perchlorate contour lines eastward. Tronox expects that the trend will continue. Since the average perchlorate concentration in water captured upgradient of the slurry wall during the first quarter of 2007 is about 1,075 ppm, the expanding plume area containing less than 100 ppm indicates at least 90 percent capture [(1,075-100)/1,075=0.907]. Similar arguments can be made regarding expansion of the plume area containing less than 25 ppm of perchlorate, which while not

[3] Plate 6, Semi-Annual Performance Report for Chromium and Perchlorate, Tronox LLC, Henderson Nevada, July-December 2006, February 26, 2007.

advancing as rapidly as the <100 ppm area, would equate to over 97 percent capture [(1,075-25)/1,075=0.977].

Proposed Additional Evaluation

The physical barrier wall on the Tronox Site simplifies evaluation of capture and is additive to the criteria established by USEPA. To strengthen the lines of evidence for capture, Tronox proposes to:

- Demonstrate effectiveness of the slurry wall by pumping wells on the downgradient side of the wall (Well M-72 or Well M-71) and monitoring the perchlorate concentrations over time. Concentrations of perchlorate are expected to decrease, indicating that the slurry wall is functioning as designed.

- Confirm that underflow below the slurry wall is not carrying perchlorate or hexavalent chromium by installing two, 2-inch piezometers screened at depths of 60-70 and 80-90 feet. Compare water levels to determine the head differential from the Muddy Creek to the alluvium in the vicinity of the barrier.

- Confirm the characteristics of horizontal and vertical flow around the barrier's west end by installation of at least one multi-level piezometer. The results of this monitoring will support decisions regarding the need for added extraction points and monitor the suspected contaminant flow in this area.

- Consider installation of an additional extraction well to capture suspected flow moving around the western end of the slurry wall. The pumping rate from well I-A-R has already been increased to enhance recovery in this area.

- Conduct short-term shutdowns of up to 4 interceptor wells with low pumping rates in areas lacking monitoring coverage within the well field in order to obtain water elevation data to aid in contouring cones of depression and inward flow.

Athens Road Extraction Gallery

Performance Evaluation

- Capture Zone: The Athens Road Extraction Gallery was designed to provide a hydraulic barrier spanning the approximately 1,200-foot width of the identified perchlorate plume in this area. According to the lines of evidence discussed below, the extraction gallery wells have significantly impeded downgradient groundwater migration along its width and have allowed the capture of impacted groundwater.

- Flow Budget: The Athens Road wells are extracting over 270 gallons of groundwater per minute and perchlorate at a rate of approximately 730 pounds per day. This volume of groundwater and perchlorate removal compares favorably with the flow budget and mass flux calculated from pre-pumping

conditions at this location (i.e., calculations using 1998, pre-pumping conditions at Athens Road estimated approximately 310 gpm of groundwater and up to 755 pounds per day of perchlorate; and 2007 flow budget calculations at Sunset Road, 1,375 feet upgradient of the well field, estimated groundwater flows of from 195 gpm up to 401 gpm of groundwater, and perchlorate loading of from 573 up to 774 pounds per day), and serves to provide a line of evidence that the anticipated capture rate is being achieved (i.e., if an average of the maximum rates of the estimated perchlorate loading is compared to the current perchlorate removal rates, the estimated current capture rate exceeds 95% [730 lbs-day / (774+755)/2 lbs-day = 95.4%]).

- Overlapping Cones of Depression: Overlapping cones of depression are evident from data collected from adjacent piezometers and monitoring wells, indicating that the well field has developed a capture zone sufficient to encompass the width of the plume in this area In fact, the entire 1,200 feet length of the target capture zone is within an area of overlapping cones of depression and significant drawdown (of as much as 11.1 feet in ART-3[4])

- Inward Flow: Inward flow is clearly demonstrated by pieziometric surface maps created with groundwater level data from piezometers and monitoring wells in the area.

- Numerical Modeling: Numerical modeling used to design the program indicated capture using particle tracking across the width of the plume.

- Downgradient Concentration Declines over Time: Downgradient wells have shown consistent decreasing trends of perchlorate concentrations with time.

Proposed Additional Evaluation

To further evaluate the capture zone at Athens Road, the following measures are proposed:

- Additional numerical modeling will be conducted, updating the existing model to current conditions and using an expanded number of particles along the width of the perchlorate plume. The results of the modeling will be used to identify potential gaps in the water level monitoring program. Additional monitoring or the installation of piezometers may be considered as a result of the additional numerical analysis.

- Additional water levels will be collected from all available and accessible monitor wells along the width of Athens Road to verify inward movement of water along the line of extraction wells. From these data plan-view and cross-sectional view,

[4] Semi-Annual Performance Report for Chromium and Perchlorate, Tronox LLC, Henderson Nevada, July-December 2006, February 26, 2007.

flow nets will be constructed to demonstrate the inward flow of groundwater and to calculate capture zone width.

Seep Area Collection System

Performance Evaluation

- Capture Zone: The Seep Area Collection System was designed to provide a hydraulic barrier spanning the approximately 800-foot width of the identified perchlorate plume in this area. According to the lines of evidence discussed below, the collection system wells have impeded downgradient groundwater migration along its width and have allowed the capture of impacted groundwater.

- Flow Budget: The Seep Area Collection System which was installed beginning in 2001 is currently extracting over 600 gallons of groundwater that would otherwise discharge into the adjacent Las Vegas Wash.

  Perchlorate concentrations encountered at the Seep Area have steadily declined since system startup in 2002. Similarly, the perchlorate removal rate has declined from an estimated 495 pounds per day at system startup, to the current removal rate of just over 120 pounds per day.

- Overlapping Cones of Depression: Overlapping cones of depression are suggested from water level data collected from the adjacent piezometers. In fact, the target capture zone is within an area of overlapping cones of depression and significant drawdown (of as much as 14.7 feet in PC-116R[5]).

- Inward Flow: Inward flow is demonstrated by groundwater surface maps created with groundwater level data from piezometers and monitoring wells in the area.

- Downgradient Concentration Declines over Time: Perchlorate loading in the Las Vegas Wash downstream of the Seep Area Collection System shows significant decreasing trends.

Proposed Additional Evaluation

To further evaluate the capture zone at the Seep Area Collection System, the following measures are proposed:

- Up to five additional piezometers will be proposed for installation to support the delineation of capture zones. These wells are proposed to be installed as multilevel monitoring wells to evaluate the horizontal and vertical movement of groundwater, and to evaluate the drawdown in the extraction wells and their efficiency.

[6] Semi-Annual Performance Report for Chromium and Perchlorate, Tronox LLC, Henderson Nevada, July-December 2006, February 26, 2007.

- Water level data from the new wells and the current well field will be used to construct plan-view and cross-sectional view flow nets from which to demonstrate the inward flow of groundwater and to calculate capture zone width.

- Following installation of the new monitor wells, wells or collections of wells will be proposed for temporary shut down and restart to determine respective well influence and efficiency. Well efficiency data will be used to establish a pumping water level for the extraction well such that data from the extraction wells can be used in the contouring.