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Chapter 6

REMEDICATION OF A HEXAVALENT CHROMIUM RELEASE TO GROUNDWATER USING ION-SPECIFIC RESINS

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ABSTRACT

In March 1986, during installation of a monitoring well at an industrial electroplating facility a chrome rinse line was pierced by an auger. A six-inch recovery well was installed in the borehole at the release point and the recovered groundwater was pumped directly into the facility's wastewater treatment plant. In 1998, a site assessment identified elevated hexavalent chromium concentrations in groundwater in this area of the site. The assessment included the installation of monitoring wells which were sampled over several years. The data indicated that the concentrations in this area of the site were increasing. Additional investigations, conducted upgradient of the process line release, identified another source of hexavalent chromium – one of the platers inside the building.

A remediation system was designed to remediate the hexavalent chromium release which included the installation of five recovery wells and associated piping. In Fall 2006, step tests were conducted to determine the approximate pumping rate for the recovery wells. Based on the results of the test, pumping rates of up to four gallons per minute were included in the design.

A pilot test was subsequently conducted to confirm that the proposed treatment process, utilizing ion-specific exchange filters, was appropriate for the removal of hexavalent chromium and nickel. In addition, the data from the pilot test was used to determine the anticipated frequency of greensand filter backwash and change-out frequency for the resin containing hexavalent chromium.

The system was installed during Spring-Summer 2008 and includes three hexavalent chromium-specific resins and two nickel-specific resins in a remediation building at the site. The majority of the treated effluent is recharged upgradient of the system into a recharge pit to enhance flushing of the aquifer. The remainder of the treated effluent is discharged to the municipal sewerage system under an Industrial Pretreatment Permit.

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1. BACKGROUND

On March 11, 1986, during installation of a monitoring well between an industrial plating facility and a wastewater treatment plant, a chrome rinse line was pierced by a hollow stem auger at a depth of approximately 4.5 feet below grade. The rinse stream was turned off and the area was excavated to repair the line. It was determined that the rinse line, at the time of the release, had an average flow rate of five gallons per minute (gpm) with a concentration of 9.0 milligrams per liter (mg/l) of hexavalent chromium. Based on this rate, a maximum of 540 gallons of rinsewater was estimated to have been released during the incident.

The material surrounding the borehole was reportedly damp. However, the overburden soils surrounding the remainder of the rinsewater pipeline were dry upon excavation, indicating that the release did not migrate laterally along the pipe. Based on this observation, a six-inch recovery well was installed in the borehole at the release point and the recovered groundwater was pumped directly into the adjacent wastewater treatment plant. No additional assessment was conducted at that time.

On August 5, 1998, a monitoring well (MW-19-4SR) was installed immediately downgradient of the 1986 release area, adjacent to the wastewater treatment plant to determine whether hexavalent chromium concentrations continued to be present in groundwater in this area of the site. Numerous attempts were made to install the well as close to the release point as possible. However, due to the presence of numerous utilities, including high voltage electric, process lines, storm drains, sanitary sewer, and water lines, the only location available for boring installation was selected for the location of well MW-19-4SR. A groundwater sample was collected from well MW-19-4SR on August 17, 1998 and hexavalent chromium was detected at a concentration of 3.7 mg/l. The state standard applicable to the site was 0.3 mg/l.

On October 26, 1998, a second monitoring well (MW-19-5S) was installed approximately 120 feet downgradient of well MW-19-4SR. Both monitoring wells were sampled on November 3, 1998. Hexavalent chromium was identified at a concentration of 9.1 mg/l in well MW-19-4SR and 0.15 mg/l in well MW-19-5S. The laboratory analytical results are included in Table 1.

Based on the results of the 1998 assessment, a Class C Response Action Outcome - Partial (RAO-C) was submitted to the Massachusetts DEP indicating that the extent of the release had been delineated, but that a permanent solution as defined in the Massachusetts Contingency Plan (MCP – the Massachusetts Hazardous Waste regulations) had not been achieved. In accordance with the RAO-

C, groundwater samples were collected on an annual basis and submitted for laboratory analysis of hexavalent chromium. The results of the annual sampling of the two monitoring wells are presented in Table 1.

1.1 Additional Investigation

In September 2005, six additional soil borings (MW-1-05 through MW-6-05) were advanced at the site. The locations of the soil borings are depicted on Figure 1. Each of the borings was advanced to depths of between 22 and 25 feet below grade and completed as two-inch PVC monitoring wells. In general, the stratigraphy encountered in the soil borings was a sand underlain by a clay or silt.

No olfactory or visual evidence of contamination was identified during boring advancement. Consequently, one soil sample from each boring collected immediately above or at the observed water table was submitted for analysis of hexavalent chromium, trivalent chromium, and total chromium.

No exceedances of the applicable Method 1 Cleanup Standards were identified in any of the soil samples submitted for laboratory analysis. Total chromium was detected at a concentration above the most stringent standard, but both speciated concentrations were below their applicable soil standards indicating that neither of the applicable speciated standards were exceeded.

On October 6, 2005, the six newly installed monitoring wells and two existing wells (MW-19-4SR and MW-19-5S) were gauged and sampled. The groundwater samples were submitted for laboratory analysis of hexavalent chromium, trivalent chromium, and total chromium. Exceedances of the applicable Method 1 standards (GW-3) continued to be identified in wells MW-19-4SR and MW-19-5S. In addition, hexavalent and total chromium were detected above the Method 1 Cleanup Standards, in place at that time, in well MW-4-05, located downgradient of well MW-19-5S. In December 2007, the state cleanup standard changed and based on these “new” standards no exceedances were detected downgradient of well MW-19-5S during the October 2005 sampling event.

Based on the data collected at the site and the physical attributes of the subsurface environment the conclusions of the 2005 investigation indicated that it was unlikely that the elevated hexavalent chromium concentrations were attributable to the 1986 release. This conclusion was based on the theoretical hydraulic conductivity determined from the overburden materials observed during boring installation and the increasing concentrations identified at the site. The report also concluded that additional comprehensive response actions were required including the installation of additional wells to delineate the horizontal extent of the release beyond existing well MW-4-05 and soil borings inside the Plant #4 facility. The plant had recently been closed and the machinery had been

Table 1. Initial Groundwater Analytical Results

Well ID Date Sampled	MCP Standards		MW-19-4SR						
	GW-3	UCLs	08/17/98	11/03/98	11/22/99	01/13/00	11/20/00	11/06/01	11/27/02
Metals (mg/L)									
Hexavalent chromium	0.3	3	3.7	9.1	10	5	9.5	36	24.5
Trivalent chromium	0.6	10	NA	NA	NA	NA	NA	NA	NA
Total chromium	0.3	3	NA	NA	NA	NA	NA	NA	NA
Total nickel	0.2	2	NA	NA	NA	NA	NA	NA	NA

Well ID Date Sampled	MW-19-4SR (cont.)			
	11/26/03	11/23/04	10/06/05	2/1/2006
Metals (mg/L)				
Hexavalent chromium	37.4	21	16	2.7
Trivalent chromium	NA	NA	<5	NA
Total chromium	NA	NA	15	2.9
Total nickel	NA	NA	NA	NA

Well ID Date Sampled	MCP Standards		MW-19-5S						
	GW-3	UCLs	11/03/98	11/22/99	01/13/00	11/20/00	11/06/01	11/27/02	11/26/03
Metals (mg/L)									
Hexavalent chromium	0.3	3	0.15	0.74	0.62	0.1	2.3	3.06	5.52
Trivalent chromium	0.6	10	NA						
Total chromium	0.3	3	NA						
Total nickel	0.2	2	NA						

Well ID Date Sampled	MW-19-5S (cont.)			
	11/23/04	10/06/05	02/01/06	04/23/08
Metals (mg/L)				
Hexavalent chromium	11	13	11	0.6
Trivalent chromium	NA	<5	NA	NA
Total chromium	NA	11	12	0.59
Total nickel	NA	NA	NA	0.12

UCL – Upper Concentration Limits

NA - Not analyzed

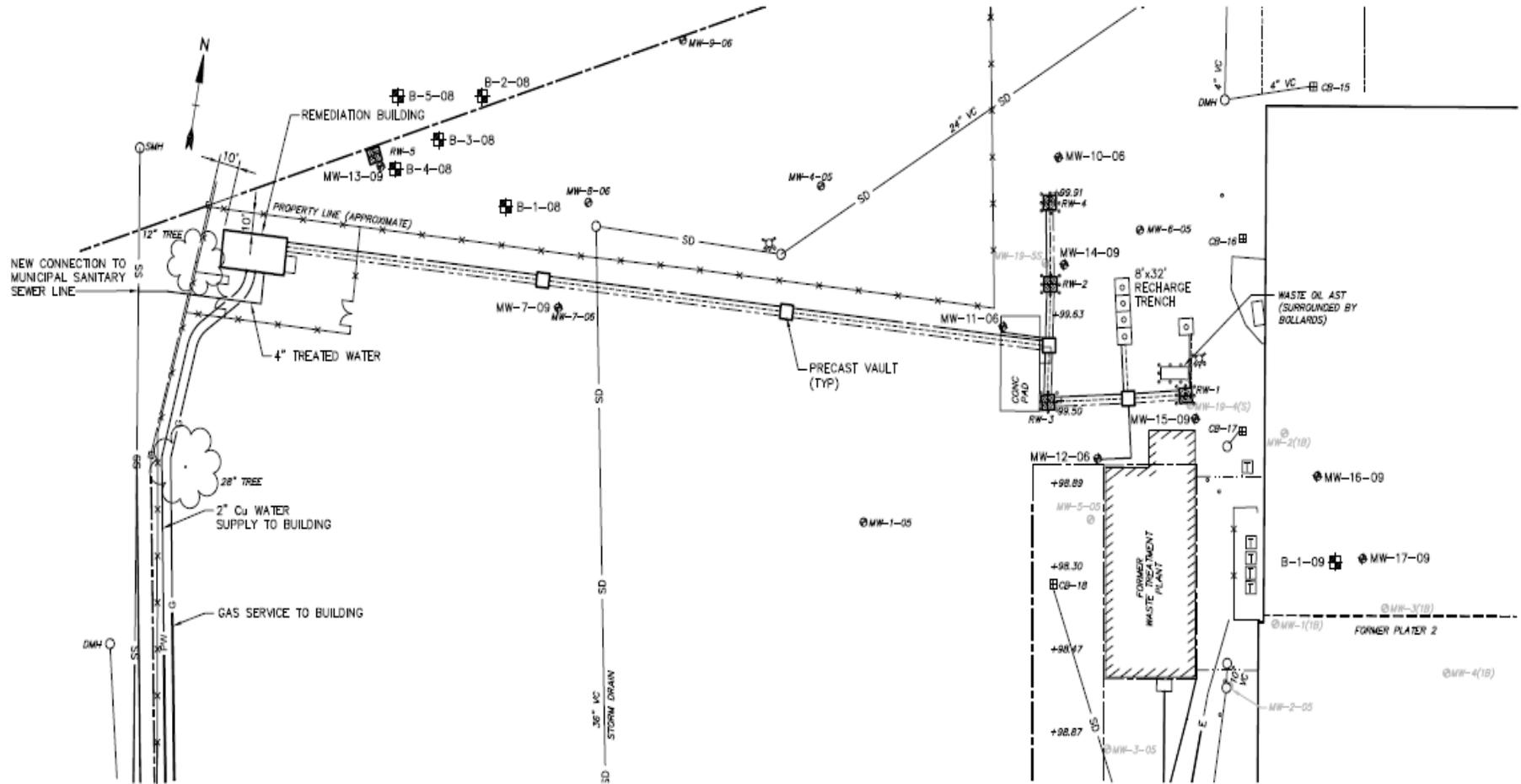


Figure 1. Site Plan

removed as part of the plant decommissioning process. The installation of interior soil borings/monitoring wells was recommended to determine the source of the hexavalent chromium release.

1.1.1 Source Investigation

On December 9, 2005, seven borings were completed inside Plant #4. Four of the borings were completed as monitoring wells, MW-1(IB) through MW-4(IB). The borings were advanced with a truck-mounted Geoprobe direct push rig. Following concrete removal, the borings were installed through the floor of the plant to evaluate soil conditions beneath the slab. Continuous soil samples were collected from the borings. The locations of the wells are included on Figure 1.

One sample from each boring was submitted for laboratory analysis of total RCRA 8 metals plus hexavalent chromium. The highest concentration of hexavalent and total chromium in soil were identified in the boring for well MW-3(IB). Total chromium in boring MW-3(IB) was detected at a concentration above the S-1/GW-3 standard, but both of the speciated concentrations were below their applicable soil standards indicating that neither of the applicable speciated standards were exceeded. However, the concentrations detected in boring MW-3(IB) were an order of magnitude higher than any concentration detected in soil at the site to date. Well MW-3(IB) was installed adjacent to one of the former platers inside the site building.

On January 11, 2006, monitoring wells MW-7-06, MW-8-06 and MW-9-06 were installed at the site downgradient of well MW-4-05 where elevated concentrations of hexavalent chromium had been detected in groundwater during a previous sampling event.

On February 1, 2006, monitoring wells MW-7-06, MW-8-06, MW-9-06, MW-1(IB), MW-2(IB), MW-3(IB), MW-4(IB), MW-19-4SR, and MW-19-5S were gauged and sampled using low-flow procedures. Elevated concentrations of hexavalent chromium were identified in wells MW-2(IB), MW-19-4SR, and MW-19-5S.

1.1.2 Building Demolition

On August 3, 2007, monitoring wells MW-1(IB), MW-2(IB), MW-3(IB), and MW-4(IB) inside the building, as well as wells installed adjacent to the wastewater treatment plant were abandoned in accordance with the *Standard Reference for Monitoring Wells* (DEP Publication #WSC-310-91) prior to the demolition of the site buildings. The wells that had been abandoned are identified using a gray notation on Figure 1. The demolition of the plant building was conducted during the summer and early fall of 2007 by the current site owner.

1.1.3 Pilot Test

On September 7, 2006, a six-inch recovery well (RW-1) was installed using hollow stem augers (HSA) adjacent to monitoring well MW-19-4SR. On September 27, 2006, a step test was conducted to determine the approximate pumping rate for the well. The groundwater pumped from the well was pumped into a fractionation tank. Based on the results of the test, the well maintained a steady groundwater elevation at 1.0 gpm.

Due to the low pumping rate, on October 18, 2006, a second six-inch well (RW-2) was installed adjacent to well MW-19-5S. Previous borings advanced in this area of the site indicated that a thicker area of fine sand was present in this area of the site and that this well may be able to maintain a higher pumping rate. Based on a second step test, well RW-2 was able to sustain a pumping rate of 4 gpm.

A pilot test was conducted to confirm that the remedial approach using a specific ion exchange filter was suitable for the site. In addition, the data from the pilot test was used to determine the anticipated frequency of greensand filter backwash and change-out frequency for the resin containing hexavalent chromium. The pilot study was initiated on October 20, 2006 on well RW-2.

The treatment unit utilized for the pilot included: a 10 micron (μ) cartridge filter, a potassium permanganate pretreated greensand filter (vessel size of 1.3 cubic feet (ft^3)), and a hexavalent chromium ion exchange resin (vessel size of 1.2 ft^3). Based on the results of the assessment and pilot test conducted at the site the installation of a pump and treat system using Siemens resins was proposed.

Based on the elevated detections in groundwater, a Release Abatement Measure (RAM) Plan for the remediation of the hexavalent chromium release, based on the results of the pilot test, was submitted to DEP on November 20, 2006. On November 30, 2006, six-inch recovery wells RW-3 and RW-4 were installed with a hollow stem auger drill rig. The locations of the wells are indicated on Figure 1.

1.1.4 Installation of Additional Monitoring Points

Between June 2008 and April 2009, additional monitoring wells were installed to provide site coverage and replace wells that had been destroyed or abandoned during demolition of the site buildings. The locations of the wells are included on Figure 1.

On April 13, 2009, soil samples were collected from just above the clay layer in wells MW-16-09 and MW-17-09 and boring B-1-09 (installed adjacent to well MW-17-09) and submitted for laboratory analysis of hexavalent chromium, total

chromium, and total nickel to determine whether high concentrations of chromium and/or nickel are present below the former platers, but above the underlying clay layer, and contributing to the groundwater impacts present at the site. The chromium concentrations were well below the applicable Method 1 standards. The concentration of nickel ranged between 21 and 42 mg/kg which exceeds the applicable Method 1 standard of 20 mg/kg. However, these concentrations are similar to those detected in soils previously identified throughout the footprint of the Former Plant #4 and consequently do not appear to represent an ongoing source to groundwater.

On June 20, 2008, five temporary monitoring points (B-1-08 through B-5-08) were installed with a Geoprobe direct push rig downgradient of well MW-8-06 to delineate the extent of the groundwater plume. Following installation of the wells, groundwater samples were collected via low flow methodology, from each of the temporary well points for analysis of hexavalent and total chromium. The locations of the points are included on Figure 1. Based on the elevated concentrations of hexavalent chromium in well points B-1-08, B-3-08, B-4-08 and B-5-08 DEP was notified of an Immediate Response Action (IRA) condition on July 9, 2008.

1.1.5 Immediate Response Action (IRA)

As previously discussed a pump and treat remediation system is currently operating at the site under a RAM for the remediation of hexavalent chromium-impacted groundwater. Following the detection of elevated hexavalent chromium in groundwater downgradient of the existing recovery wells in June 2008, DEP approved the installation of an additional recovery well (RW-5) that was piped to the remediation system under an IRA.

On October 16, 2008, recovery well RW-5 was installed in the approximate location of B-4-08 using a hollow stem auger drill rig. The location of the recovery well is included on Figure 1.

1.1.5.1 Sediment and Surface Water Sample Collection

As part of the IRA, semiannual sediment and surface water samples are collected from the Connecticut River at three locations (upstream, crossgradient, and downstream of the site) to confirm that the release is not impacting the river. The sampling was initiated in May 2008 and to date no detections of contaminants attributable to the release have been identified in the river.

2. SYSTEM DESIGN

The remediation design was based on a pump and treat system with recharge. The groundwater from five recovery wells (RW-1 through RW-5) is pumped through a two-inch high-density polyethylene (HDPE) pipe to a remediation building. The recovered groundwater flow goes through bag and cartridge filters for the removal of suspended solids. After these filters, the groundwater flows through a series of Siemens ion exchange resins for the removal of hexavalent chromium and nickel. The treated effluent from the ion exchange resins is stored in a tank, from which the majority of the water is pumped to the recharge pit and the remainder is discharged to the municipal sanitary sewer. The resins are transported off-site intact for regeneration and eventual re-use.

Conventional off-the-shelf treatment units were purchased for the removal of particulates, iron, hexavalent chromium and nickel from the recovered groundwater. The majority (approximately 80%) of the treated effluent is recharged upgradient of the recovery wells to expedite aquifer flushing through an underground pit and trench (Figure 1). The remainder of the treated effluent is discharged to the municipal sewerage system under a municipal Industrial Pretreatment Permit. System monitoring, including groundwater recharge elevations, is available within the treatment building and remotely via Supervisory Control and Data Acquisition (SCADA) systems.

3. OPERATION OF REMEDIAL SYSTEM

On a monthly schedule, samples from each of the recovery wells, system influent and effluent are screened with a Hach kit for total nickel and hexavalent chromium. Select samples may also be submitted for laboratory analysis to confirm the screening results. The data are used to determine if breakthrough is occurring from any of the resins. Based on the analytical data, the first resin cylinder was removed from the site on October 22, 2008 by Siemens for recycling and the remaining resins were moved up in line. A new resin cylinder was replaced at the end of the treatment. A second resin change-out was conducted in mid-February 2009.

The recovery well Hach results for nickel and hexavalent chromium, respectively, from each of the recovery wells are presented in Figures 2 and 3.

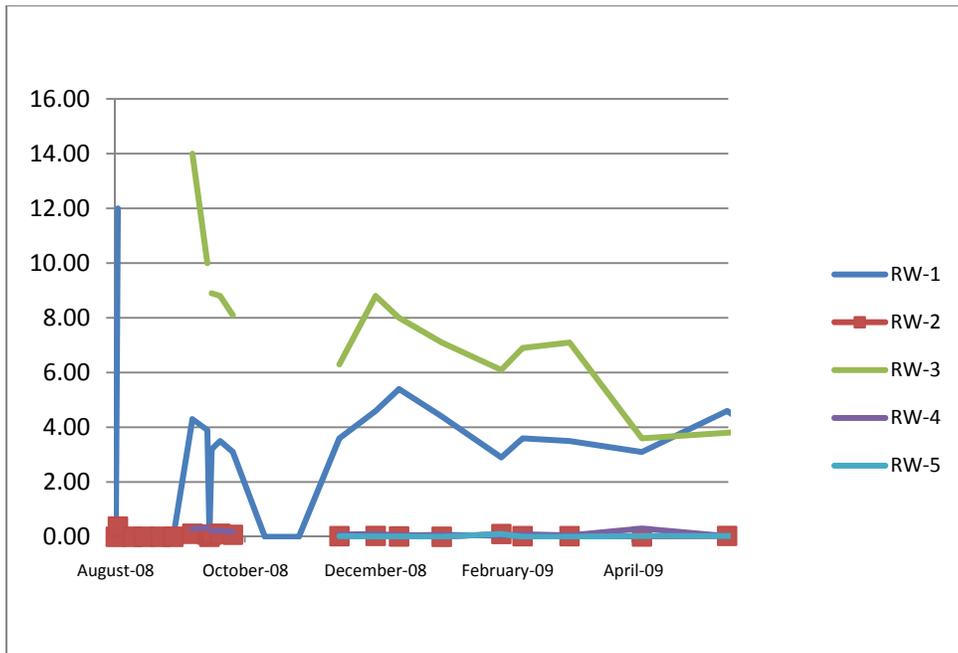


Figure 2. Graph of nickel concentrations between August 2008 and August 2009 in mg/l.

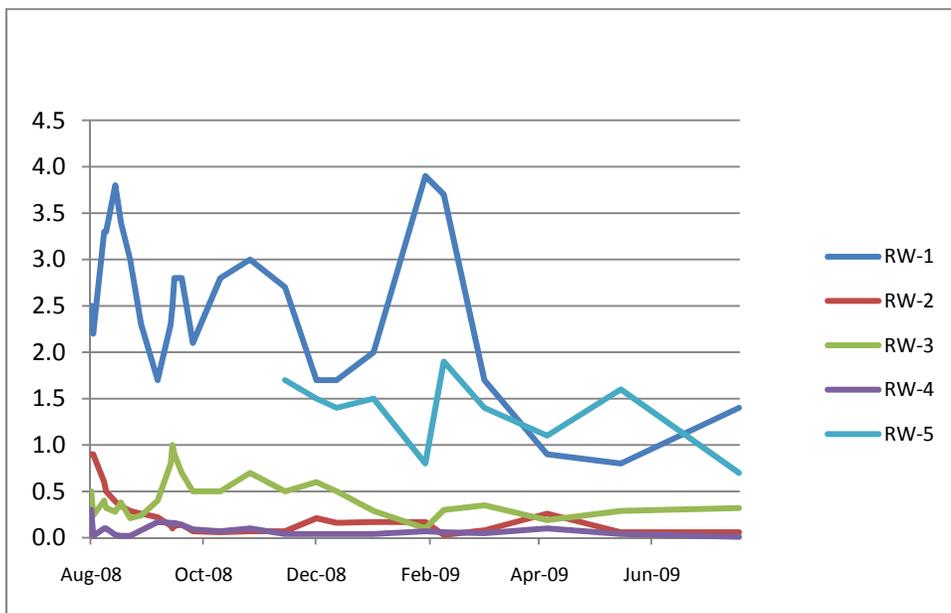


Figure 3. Graph of hexavalent chromium concentrations between August 2008 and August 2009 in mg/l.

4. CONCLUSION

Following demolition of the former industrial buildings and installation of the remediation system the site has been undergoing redevelopment. Two medical office buildings are currently being constructed on the site and a portion of the property is used as a parking lot for a nearby construction project. The remediation system layout was designed to maximize the developable portion of the site while still achieving the objectives of the cleanup.

5. REFERENCES

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