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Homestake Mining Company of California

Rebound Evaluation Summary Report

Grants Reclamation Project
Grants, New Mexico

December 2012

ARCADIS

Rebound Evaluation Summary Report

Grants Reclamation Project
Grants, New Mexico

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1. Executive Summary

On behalf of Homestake Mining Company of California (HMC), ARCADIS has prepared this Summary Report for the Rebound Evaluation that was conducted from December 2010 to May 2012 at the Grants Reclamation Project (site). The Rebound Evaluation was conducted to evaluate the potential for increases in concentration ("rebound") of constituents of concern (COCs) in the Large Tailings Pile (LTP) when the source control program ends.

The source control program began at the site in 2000 and was designed to promote decreases in the concentration of uranium and other COCs in LTP pore water. The program involves the flushing of the LTP with slightly impacted groundwater to hydraulically force contaminated tailings pore water to toe drains and extraction wells to expedite natural draindown of the LTP.

As part of the Rebound Evaluation, a tracer test was performed to determine pore water transport direction and velocity and the degree of diffusive mass transfer between pore water residing in coarser- and finer-grained tailings material (sands and slimes, respectively). The tracer test indicated that diffusive mass transfer rates into and out of the lower permeability zones are low and therefore post-flushing rebound caused by back diffusion is expected to be minimal. Over a 6-acre area of the LTP where flushing was shut down, nine wells were used to collect data for the key water quality parameters, including uranium, molybdenum, selenium, calcium, alkalinity, pH, sulfate, and total dissolved solids (TDS). Water levels were also monitored in this area and a decrease of up to 16 feet was observed.

An evaluation of concentrations over time demonstrates that widespread rebound of key water quality parameters did not occur in the post-flushing regime established by the Rebound Evaluation shutdown. These data indicate that significant rebound of the COCs should not be expected after the source control program ends for the LTP. Consequently, COC reductions achieved during flushing are likely to be sustained for the long-term.

2. Introduction

HMC owns and operates the site, which is a former uranium mill located in Cibola County, New Mexico. Currently, the primary activity at the site is the containment and treatment of contaminated groundwater through a groundwater restoration program.

The objective of this program is to restore concentrations of the COCs to levels that meet site standards established for each of the aquifers present at the site.

The updated Corrective Action Program (CAP) describes the current site restoration strategy and was submitted to the regulatory agencies and to stakeholders in March 2012 (HMC 2012). This CAP update includes detailed information about current site conditions, recent modifications to the groundwater restoration program, and key aspects of the proposed future implementation of the CAP. The CAP should be consulted for detailed information about the site.

ARCADIS has assisted HMC with source evaluation and control activities since 2010. These activities were specifically designed to address issues raised in the Army Corps of Engineers (ACOE) Remedial System Evaluation (RSE) that was finalized on December 23, 2010 for the Environmental Protection Agency (EPA). In the RSE (ACOE 2010), the ACOE identified the long-term leaching behavior of the COCs under post-flushing conditions in the LTP as a data gap.

The Rebound Evaluation was designed to simulate post-flushing conditions in the LTP and produce data to directly respond to the ACOE's comments. The Rebound Evaluation included a dissolved gas tracer test to evaluate the hydraulics of the rebound evaluation well network, a year of post-flushing monitoring, and a laboratory testing program to evaluate forms of uranium in the LTP.

ARCADIS conducted these activities with the support of HMC staff and Hydro-Engineering, LLC (Hydro-Engineering).

3. Rebound Evaluation

The primary objective of the Rebound Evaluation was to provide further analysis of the source control program and to predict future leaching and hydraulic behavior of uranium in the LTP after completion of the flushing in the LTP. The three phases and associated objectives of the Rebound Evaluation are:

- *Phase 1 – Tracer Testing:* Collect site-specific data about local hydraulic and solute transport properties of the LTP by implementing a tracer test.

- *Phase 2 – Rebound Monitoring:* Evaluate trends in pore water chemistry once flushing of the LTP is discontinued.

- *Phase 3 – Bench Testing*: Evaluate the leaching behavior of uranium, molybdenum, and selenium from the tailings solids.

The field activities for the Rebound Evaluation were conducted in the west-central part of the LTP (**Figure 1**). The primary criterion for selecting this area was the performance of the source control program, which successfully reduced the concentration of uranium and other COC's in the area. Therefore, discontinuing active flushing in the area mimicked the LTP draindown at the end of the source control program.

The tracer system was installed in December 2010 and tracer injections occurred in January 2011 and from March to May 2011. Tracer injections and flushing in the Rebound Area ended on May 9, 2011 and monthly tracer and aqueous monitoring was conducted until October 2011. The monitoring frequency was reduced to bimonthly after October 2011 and continued through May 2012.

3.1 Tracer Test

The objectives of the tracer test were to evaluate the hydraulic connectivity of the Rebound Evaluation well network and to characterize the flow regime and transport velocities of the LTP in the area. For this test, a dissolved gas was used as the applied tracer. The advantage of using dissolved gas as a tracer (instead of isotopes, salts, or dyes) is that it can be injected continuously for an extended period of time with little field oversight; consequently, a much larger volume of water can be dosed. Additionally, dissolved gas tracers have very low detection limits and are therefore measureable in groundwater at low concentrations. The dissolved gas tracer used in the Rebound Evaluation test was sulfur hexafluoride (SF_6), a non-toxic, inert gas and has been used for more than 20 years in applied studies (e.g., Wilson and Mackay 1993).

The well network for the tracer test and subsequent rebound monitoring is depicted in **Figure 1**. Four extraction wells (WE9, WF2, WF9, and WF11) were converted to the primary monitoring wells by pulling pumps and associated tubing and equipment in December 2010. This conversion allowed these wells to serve as representative monitoring wells for the LTP during rebound evaluation activities. Wells WL1, WL2, WM1, WM2, WM3, and WT14 were used for active injections of water and tracer. Well construction details for all wells in the network are included in **Table 1**.

Dissolved Gas Tracer Delivery

The tracer SF_6 was introduced into the six injection wells at a target flow rate of 0.9 standard cubic feet of air per hour (SCFH-air). The gas was conveyed through copper tubing from compressed gas cylinders to approximately five feet from the bottom of each injection well. At the end of the piping, a microporous (6 micron pore size) diffusion stone maximized transfer of SF_6 from the gas to the aqueous (dissolved) phase. Pictures of the dissolved gas tracer diffusion stone are included in **Figure 2**.

The target gas pressure (at the header) was approximately 18 pounds per square inch (psi) for each injection well to overcome hydrostatic pressure on the diffusion stone and any head losses in the conveyance piping. For injection wells where the water column was near the top of the well casing, bubbles at the surface confirmed the gas flow rate was sufficient to overcome hydrostatic pressure and that the aqueous phase transfer rate was not limited by the gas flow rate.

A total of seven 115-pound cylinders of SF_6 were used from January 21 to 31 and from March 24 to May 9, 2011. Due to operational challenges with the injection system during the January injection period, the system was temporarily shut down and modifications were made in February and March to improve system delivery efficiency; injections resumed on March 24.

Evaluation of the dissolved gas tracer injections focuses on the second injection period from March 24 to May 9, 2011. Based on totalizer readings from the active injection wells approximately 854,000 gallons of water were dosed with SF_6, tracer during both injection periods.

Dissolved Gas Tracer Monitoring

The monitoring wells were used to evaluate the distribution and transport of SF_6 in the Rebound Evaluation area. Passive diffusion (PD) samplers (Divine and McCray 2004) were employed to collect representative samples from monitoring wells (a photograph of a PD sampler being deployed down a monitoring well is included in **Figure 2)**.

Three PD samplers were deployed at different depths in the monitoring wells for a minimum of one week; SF_6 diffused through the membrane into the PD sampler to achieve equilibrium. The PD samplers were sent to DHL Analytical (Round Rock, TX) for analysis of SF_6 concentration in air, which was converted to the equilibrium dissolved concentration in water using the ideal gas law and the dimensionless Henry's

Law constant, which is 122 at 10°C for SF_6 (Wilson and Mackay 1993). The dissolved concentration in water is reported as parts per billion on a volumetric basis (ppbV), such that 1 ppbV is one volume of SF_6 in one billion volumes of water.

During the period of active injections (January through May 2011), the PD samplers were collected weekly for analysis; after collection, new PD samplers were deployed for the next monitoring event. After SF_6 injections were discontinued on May 9, 2011, the PD samplers were collected for analysis approximately every other week until August 16, 2011. Additional monitoring events were conducted from November 17, 2011 to May 9, 2012 in a limited number of wells to characterize long-term tracer washout. Throughout the tracer test, the maximum concentration of SF_6 recorded among the three PD samplers deployed in each well was used in the data evaluation. The SF_6 analytical data are included in the Rebound Evaluation At-A-Glance (AAG) charts (**Appendix A**).

3.2 Post-Flushing Monitoring

On May 9, 2011, all active flushing in the Rebound Evaluation area (**Figure 1**) was discontinued. Based on the results of the dissolved gas tracer monitoring (showing an extended area of influence of injected water across the area selected for rebound monitoring), additional injection wells to the southwest of the Rebound Evaluation area (**Figure 3**) were also shut down on May 19, 2011 to increase the extent of the Rebound Evaluation area and produce conditions more representative of post-flushing conditions.

Additionally, five wells to the northeast of the injection wells (WF10, WF12, WT6, WU3, and WU6) were included in continued SF_6 monitoring and the post-flushing rebound monitoring program (**Table 1**). This area remained shut down since May 19, 2011 for the duration of the Rebound Evaluation.

In total, the Rebound Evaluation area is approximately 6 acres, or 3% of the total LTP acreage (215 acres). The injection wells that were shut down had contributed approximately 20 gallons per minute (gpm) to the flushing program, or approximately 7% of the total LTP flushing rate (270 gpm in 2011).

The post-flushing (rebound) water quality monitoring phase of the Rebound Evaluation lasted one year, from May 2011 to May 2012. The rebound monitoring network consisted of nine monitoring wells, as depicted on **Figure 1**. The wells were sampled using a submersible pump and purged for 30 minutes prior to collecting a sample; samples are submitted to Energy Laboratories in Casper, Wyoming for analysis.

In addition to collecting samples for water quality analysis, water levels in the monitoring wells were measured prior to purging at each monitoring event. This hydraulic monitoring tracked decreasing water levels in the local area of the LTP, indicating local draindown.

The monitoring wells were sampled in December 2010 and in January, February, and April 2011 to provide baseline concentrations representative of flushing conditions. Monitoring wells were sampled monthly from May 2011 (after flushing was discontinued on May 9) to October 2011 and were sampled bimonthly from December 2011 to May 2012. All rebound monitoring data is included in the AAG charts in **Appendix A**. Results of the post-flushing monitoring, and an evaluation of this data, are discussed in **Section 4**.

4. Laboratory Testing

Laboratory testing was designed to provide additional technical support to the Rebound Evaluation. The laboratory test program included pore water and solid-phase uranium analyses to determine the form of uranium present in the LTP.

During cone penetrating testing (CPT) conducted in March 2012, two intact cores were collected from borehole EP19 within the Rebound Evaluation area of the LTP. The cores were collected from the saturated zone of the LTP, starting approximately 5 feet below the local potentiometric surface. Coring was targeted for a zone with relatively low permeability based on CPT results from an adjacent boring.

Cores were collected in 21-inch long plastic core sleeves, then were brought to the surface, capped, and shipped on ice to Chemac Environmental Services (Chemac, Centennial, Colorado) for analysis. The two cores were obtained from the same borehole, one directly beneath the other.

4.1 Testing Methods

Pore water from the cores was analyzed for a subset of dissolved water quality parameters relevant to the Rebound Evaluation. Pore water was extruded from the core material through a Whatman-1 filter paper using a filter press. The pore water was then filtered through a 0.45-micron (µm) filter for determination of dissolved metals concentrations.

Tailing solids from the cores were also analyzed for grain size and solid phase parameters relevant to the Rebound Evaluation. After filtering the pore water from the cores, the remaining tailing solids were then dried and homogenized. A comparison of saturated and dry weights of the solids was used to determine the porosity of the sample. The dried and homogenized tailings solids underwent selective extraction testing to determine the relative abundance of different chemical forms of uranium present in the LTP.

Specifically, the following extractions in the selective extraction testing targeted specific forms of uranium:

- *Extraction 1 – NaCl Solution:* The first extraction used a 0.1 molar (M) sodium chloride (NaCl) solution with a solid to solution ratio of 20 grams (g) solids to 160 milliliters (mL) of solution. The target uranium form removed during Extraction 1 was uranium dissolved in pore water and uranium that was weakly adsorbed to solids.

- *Extraction 2 – Carbonate/Bicarbonate Solution:* The second extraction used a 20 millimolar (mM) sodium carbonate/bicarbonate solution with a solid to solution ratio of 20 g solids to 400 mL solution. The solution was at a pH of 9.5. The target uranium form removed during Extraction 2 was all adsorbed uranium.

- *Extraction 3 – EPA Method 3050B:* The third extraction followed EPA Method 3050B (nitric acid total digestion). The target uranium form removed during Extraction 3 was uranium associated (adsorbed and co-precipitated) with all crystalline solids except for silicate minerals.

- *Extraction 4 – EPA Method 3052:* The fourth and final extraction followed EPA Method 2052 (microwave-assisted hydrofluoric acid total digestion). The target uranium form removed during Extraction 4 was uranium contained in all solid phase material (including silicate minerals).

To minimize sample losses, extractions and digestions were not performed sequentially on the same sample of material. Instead, separate solid subsamples from each core were collected after homogenization for each analysis.

The analyses above are listed in order of their ability to extract uranium that is progressively more strongly associated with the solids. Accordingly, each numbered extraction is capable of dissolving the uranium released by preceding extractions. An effective sequential selective extraction can therefore be obtained by subtraction (e.g., Extraction 2 uranium minus Extraction 1 uranium is the strongly adsorbed fraction of uranium).

4.2 Laboratory Analysis Results

The porosity of the tailings solids in the cores was calculated by comparing the saturated and dried masses of the material. The calculated total porosity is approximately 0.43 to 0.46. The drainable fraction of the total porosity was determined to be relatively low based on the small volume of pore water that was extruded from the material by the filter press: approximately 3.5 mL was collected from Core #1 and no pore water was collected from Core #2. This assessment is consistent with the grain size analysis that was performed on the samples, which revealed that 67% of the solids had a grain size less than 180 µm (**Table 2**). The high proportion of fine-grained particles results in relatively low drainable porosity.

The limited amount of pore water extruded from Core #1 was analyzed for dissolved uranium, molybdenum, selenium, vanadium, calcium, and iron (**Table 3**), which are some of the key parameters of the Rebound Evaluation and other LTP evaluations.

The dried and homogenized tailings solids were analyzed for the same solid phase parameters as the pore water, with the addition of total manganese. This parameter list was also used throughout the sequential extraction testing (**Table 4**).

The results from the pore water analysis were compared to the solid phase analysis using a mass of solids basis using a solid to solution ratio of 3.4 kilograms per liter (kg/L), which was calculated from the saturated and dried masses of the solids. Comparing these mass basis pore water concentrations with the results of the first extraction step (NaCl solution) indicates that most of the uranium, selenium, and vanadium that were extracted by this solution were originally in the adsorbed, rather than aqueous, phase before sample drying. In contrast, approximately 70% of the molybdenum present in the adsorbed and nitric acid extractable fractions is present in the pore water (**Table 4**), indicating a much lower sorption affinity for molybdenum.

The extractable uranium uniquely associated with each extraction step was calculated by subtraction, as described in **Section 3.1**. These results, depicted in **Figure 4**, mimic the concentrations that would be observed if the extractions were performed sequentially on the same solids sample. Small differences between Cores #1 and #2 in the relative abundances of different uranium forms are indicative of heterogeneities on a relatively small scale in the LTP.

The results of the sequential extraction tests on Core #1 indicate that a very small fraction of the uranium in the LTP exists in the aqueous phase. Because no pore water could be extruded from Core #2, the aqueous fraction could not be determined. Although the uranium dissolved in pore water from Core #1 represents only 1.5% of the total uranium present in the sample, it represents approximately 7% of the available uranium (assuming that only the uranium dissolved in pore water and adsorbed uranium forms are leachable from the tailings solids).

The selective extraction tests on Core #1 (**Table 4**, **Figure 4**) also indicate that a significant proportion of the metals, including uranium, are extractable by hydrofluoric acid (Extraction 4), but not nitric acid (Extraction 3). These results indicate that this fraction may be associated with silicate minerals, clays, and amorphous silica. However, this phenomenon was not observed in Core #2 (**Table 4**, **Figure 4**). This discrepancy may be attributable to differences between the samples. While the distribution of uranium in the LTP may exhibit significant variability with location, depth, and grain size and should not be assumed to be consistent, the majority of uranium in the LTP is not geochemically available and will not leach from solids under ambient conditions.

5. Results

The sampling results for the Rebound Evaluation are presented in charts in **Appendix A**. These charts include the following information: well network maps; graphs of SF_6 concentrations and depths to water; concentrations of dissolved uranium, molybdenum, selenium, and calcium; and pH, sulfate, TDS, and alkalinity data.

<u>Tracer Monitoring</u>

The four primary monitoring wells in the Rebound Evaluation were WE9, WF2, WF9, and WF11 (**Figure 1**). Tracer was rapidly detected at very high concentrations (generally within an order of magnitude of the average injection concentrations) in all four of these wells. After SF_6 injections ended on May 9, 2011, rapid washout of the tracer was observed in wells WE9, WF2, and WF11. Tracer concentrations remained elevated in well WF9, the well furthest east in the monitoring network. Based on the observed washout and review of water level data, the local direction of groundwater flow was estimated to be to the northeast. Therefore, the monitoring network was expanded to include five additional wells to the northeast of the original network: WT6, WF12, WU6, WU3, and WF10. High concentrations of SF_6 (up to 1,100,000 ppbV), have been observed in well WU3, which is the most distal well in the monitoring network, indicating that this well is in a primary path of pore water flow and that water appears to be moving towards the perimeter sand dikes and central sand dike during the “shutdown” conditions. SF_6 breakthrough curves for the four primary monitoring wells are depicted in **Figure 5** and curves for the five secondary monitoring wells are depicted in **Figure 6**.

The results of the dissolved gas tracer test indicate that flow is focused in zones of coarser material with higher permeability. Based on analysis of the tracer breakthrough data under injection conditions, the flow velocity in this area of the LTP ranges from approximately 3 to 5 feet per day (ft/day). Based on the average bulk permeability of the LTP materials and hydraulic gradient, the mobile porosity (the volume where the majority of advective flow occurs) is estimated to be less than 3%. Additionally, the high peak tracer concentrations and rapid and nearly complete washout observed indicates that that diffusive mass transfer between the higher permeability sands and lower permeability slimes material is relatively slow.

Potentiometric Surface

While the monitoring of the Rebound Evaluation focuses primarily on the changes in geochemical conditions, water level measurements are an indication of the hydraulic effects of shutdown. Since the shutdown, decreases in water levels at monitoring wells in the Rebound Area have ranged from 3.45 to 16.25 feet from approximately March 2011 (during flushing) to May 2012 (the final post-flushing monitoring event). The significant area-wide decrease in water levels confirms that the shutdown has a significant hydraulic footprint. More importantly, this decrease demonstrates that local draindown is occurring and that the rebound monitoring data provide useful insight and a representative model of LTP-wide draindown after the source control program ends.

Water levels in the nine primary and secondary monitoring wells and in other wells in the Rebound Evaluation area were used to generate contours of the local potentiometric surface to monitor changes in the flow direction and hydraulic gradient of local pore water. The local potentiometric surface for June 2011, January 2012, and May 2012 is depicted in **Figures 7**, **8**, and **9**, respectively. These figures demonstrate that the northeasterly pore water flow direction was consistent over time, but the hydraulic gradient decreased.

Water Quality Monitoring

The complete results of the water quality monitoring are included in **Appendix A**. The uranium, selenium, and molybdenum trends in the primary monitoring wells are depicted in **Figures 10**, **11**, and **12**, respectively.

Molybdenum concentrations (**Figure 12**) are relatively variable compared to the uranium and selenium concentrations (**Figures 10** and **11**, respectively). The results of the selective extraction tests (**Section 3.2**) indicated that the tailings solids exhibit a much lower sorption affinity for molybdenum than other metals. Unlike the other metals, most of the molybdenum in the LTP is dissolved in water, rather than adsorbed to or associated with solids. This lower sorption affinity and the variability in post-flushing molybdenum concentrations suggest that molybdenum is significantly more labile in the LTP than other COCs.

Data collected at all nine wells for uranium, molybdenum, selenium, calcium, alkalinity, pH, sulfate, and total dissolved solids (TDS), which are summarized in **Attachment A**, demonstrate that widespread rebound of key water quality parameters did not occur in the post-flushing regime established by the Rebound Evaluation shutdown. These data indicate that significant rebound of the COCs should not be expected after the source control program ends for the LTP.

6. Conclusions and Recommendations

Overall, the Rebound Evaluation confirmed that flushing most effectively addresses the higher-permeability preferential flow paths in the LTP, as demonstrated by the very high tracer transport rates. Lower permeability materials in the LTP are flushed much more slowly (if at all), and therefore treatment efficiency and effectiveness is lower for these zones. However, the tracer test results also demonstrate that diffusive mass transfer rates into and out of the low permeability zones are low and therefore post-flushing rebound caused by back diffusion is expected to be low. Consequently, COC reductions achieved during flushing are likely to be sustained for the long-term.

The objectives of the source control program can be considered achieved once the higher permeability flow paths are flushed and the average concentrations of the wells that monitor permeable zones reach target concentrations. Therefore, it is recommended that the operation of the flushing program be optimized and focused exclusively on injection wells with high uranium concentrations that accept relatively high flow rates (i.e., greater than about 1 gpm), as these wells are connected to more permeable materials. Active flushing should be terminated and post-flushing monitoring should be initiated in areas where injection wells have achieved the target uranium concentration of 2 mg/L and/or have low (<1 gpm) injection rates.

7. References

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Table 1 **Well Network and Construction**

	Well ID	Total Depth (*ft BTOC*)	Screened Interval (*ft BTOC*)	Diffusion Stone Deployment Depth (*ft BTOC*)	Passive Diffusion Sampler Depths (*ft BTOC*)
Primary Monitoring Wells	WF2	110	28 - 108	N/A	45, 60, 70
	WF9	116	36 - 116	N/A	45, 60, 70
	WF11	116	36 - 116	N/A	45, 60, 70
	WE9	116	36 - 116	N/A	45, 60, 70
Additional Monitoring Wells	WF10	116	36 - 116	N/A	45, 60, 70
	WF12	116	36 - 116	N/A	45, 60, 70
	WT6	90	40 - 90	N/A	45, 60, 70
	WU3	90	40 - 90	N/A	45, 60, 70
	WU6	90	40 - 90	N/A	45, 60, 70
Injection Wells	WL1	62	N/A	57	N/A
	WL2	43	N/A	38	N/A
	WM1	85	N/A	80	N/A
	WM2	80	N/A	75	N/A
	WM3	85	N/A	80	N/A
	WT14	91	N/A	86	N/A

Key
ft BTOC = feet below top of casing
N/A = Not Applicable

Table 2 LTP Core – Grain Size Analysis

Sieve Size	Percent Passing
18 mesh (1000 µm)	95.3
35 mesh (500 µm)	93.1
80 mesh (180 µm)	67.3
200 mesh (74 µm)	30.7

Key

µm = micron

Table 3 LTP Core – Pore Water Results

Parameter	Result (mg/L)
Calcium	11.11
Iron	0.28
Molybdenum	57.22
Selenium	0.28
Uranium	12.35
Vanadium	1.65

Table 4 **LTP Core – Solid Phase Extraction Results**

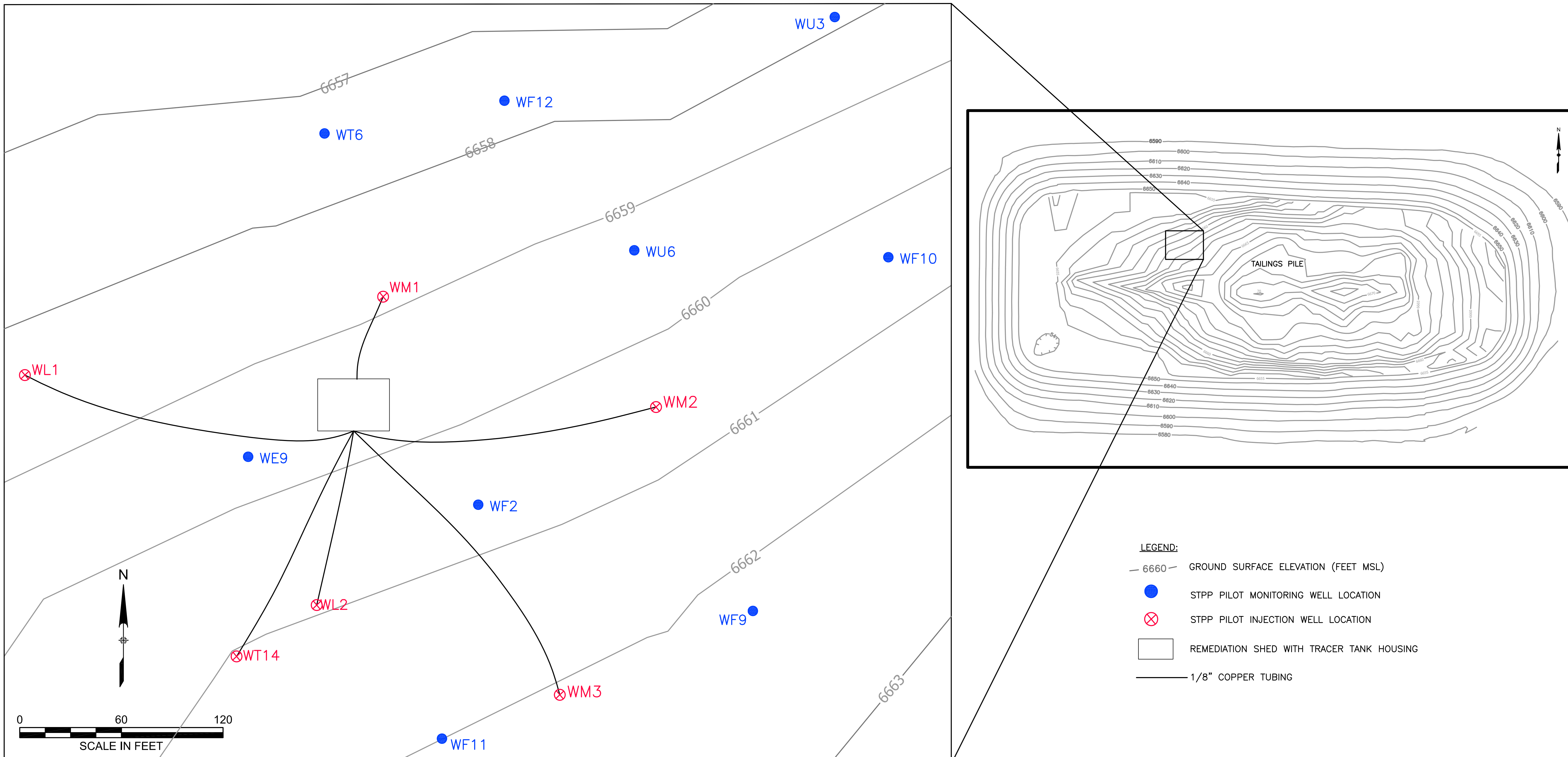
Parameter	Pore Water*	Extraction 1	Extraction 2	Extraction 3	Extraction 4
Core #1					
pH (s.u.)	N/A	9.76	9.47	N/A	N/A
Calcium (mg/kg)	3.27	23.2	24	32,600	75,000
Iron (mg/kg)	0.08	< 0.16	4	10,000	26,900
Manganese (mg/kg)	N/A	N/A	N/A	350	860
Molybdenum (mg/kg)	16.83	23.6	24.2	23	50
Selenium (mg/kg)	0.08	50	48.8	96	<300
Uranium (mg/kg)	3.63	40.96	50.8	160	235
Vanadium (mg/kg)	0.49	15.2	17.62	446	1210
Core #2					
pH (s.u.)	N/A	9.97	9.46	N/A	N/A
Calcium (mg/kg)	N/A	20	30	35,200	40,000
Iron (mg/kg)	N/A	< 0.16	1.8	14,100	16,000
Manganese (mg/kg)	N/A	N/A	N/A	352	410
Molybdenum (mg/kg)	N/A	29.6	28	29	60
Selenium (mg/kg)	N/A	62.32	55.2	116	<300
Uranium (mg/kg)	N/A	71.52	81.4	192	200
Vanadium (mg/kg)	N/A	15.68	16.78	596	730

Key

mg/kg = milligrams per kilogram
N/A = not analyzed

s.u. = standard units

* Pore water analyses were converted to a solids mass basis
using a solid:solution ratio of 3.4 kg/L, based on saturated vs. air dried masses.



REBOUND EVALUATION WELL NETWORK

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REBOUND EVALUATION WELL NETWORK

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FIGURE
1

PHOTO A

PHOTO B

PHOTO A: SULFUR HEXAFLUORIDE (SF_6) GAS BUBBLING FROM DIFFUSION STONE PRIOR TO DEPLOYMENT DOWN A TRACER INJECTION WELL.

PHOTO B: REEL SYSTEM FOR DEPLOYMENT OF PASSIVE DIFFUSION SAMPLERS DOWN A TRACER MONITORING WELL.

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DISSOLVED GAS TRACER TEST PHOTOGRAPHS

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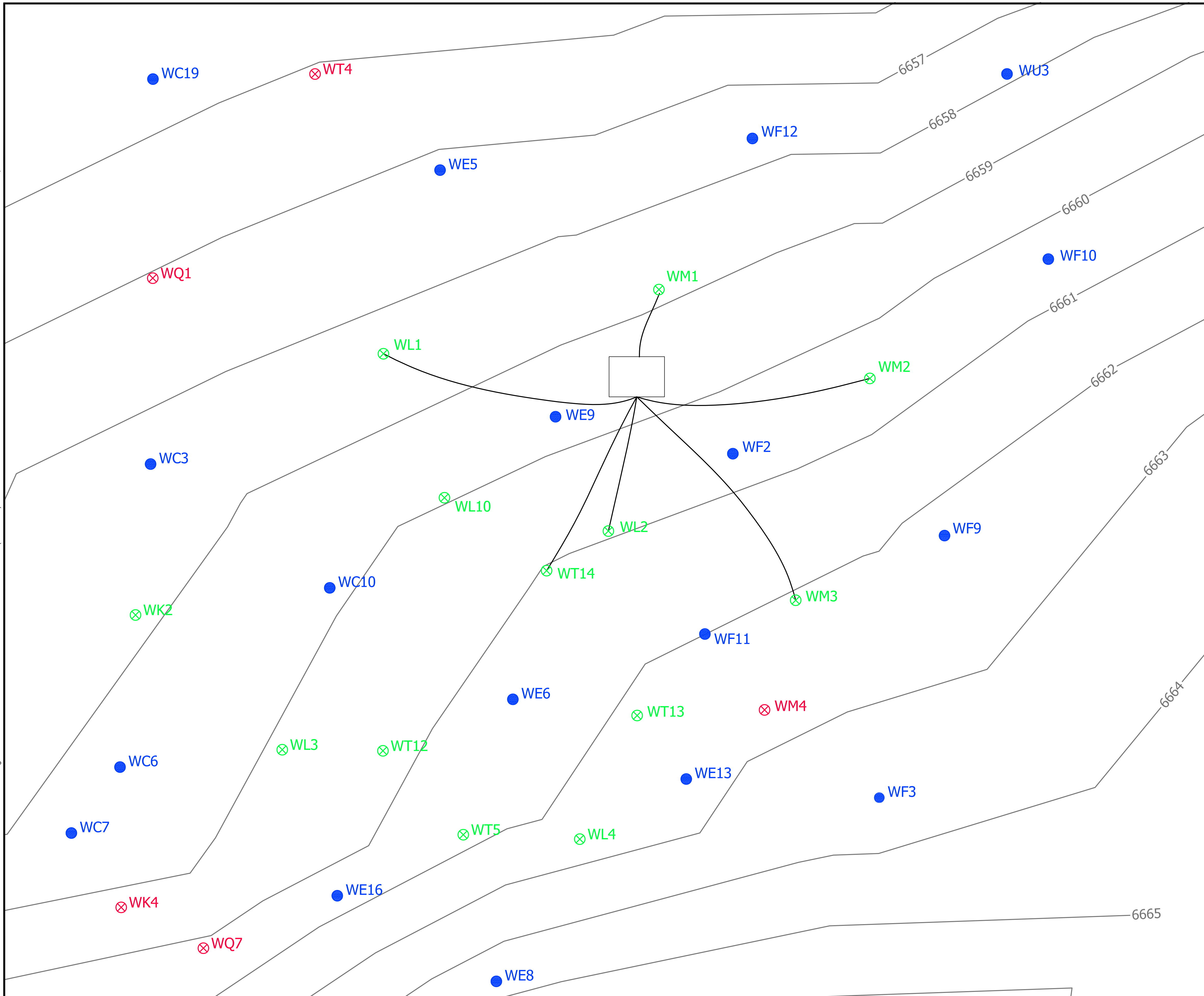
FIGURE
2



LEGEND:

6661 — GROUND SURFACE ELEVATION (FEET MSL)

MONITORING WELL LOCATION

INJECTION WELL LOCATION

INJECTION WELLS SHUT DOWN IN SUPPORT OF REBOUND EVALUATION

REMEDIATION SHED WITH TRACER TANK HOUSING

1/8" COPPER TUBING

N

0 50 100

SCALE IN FEET

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EXTENDED SHUTDOWN AREA

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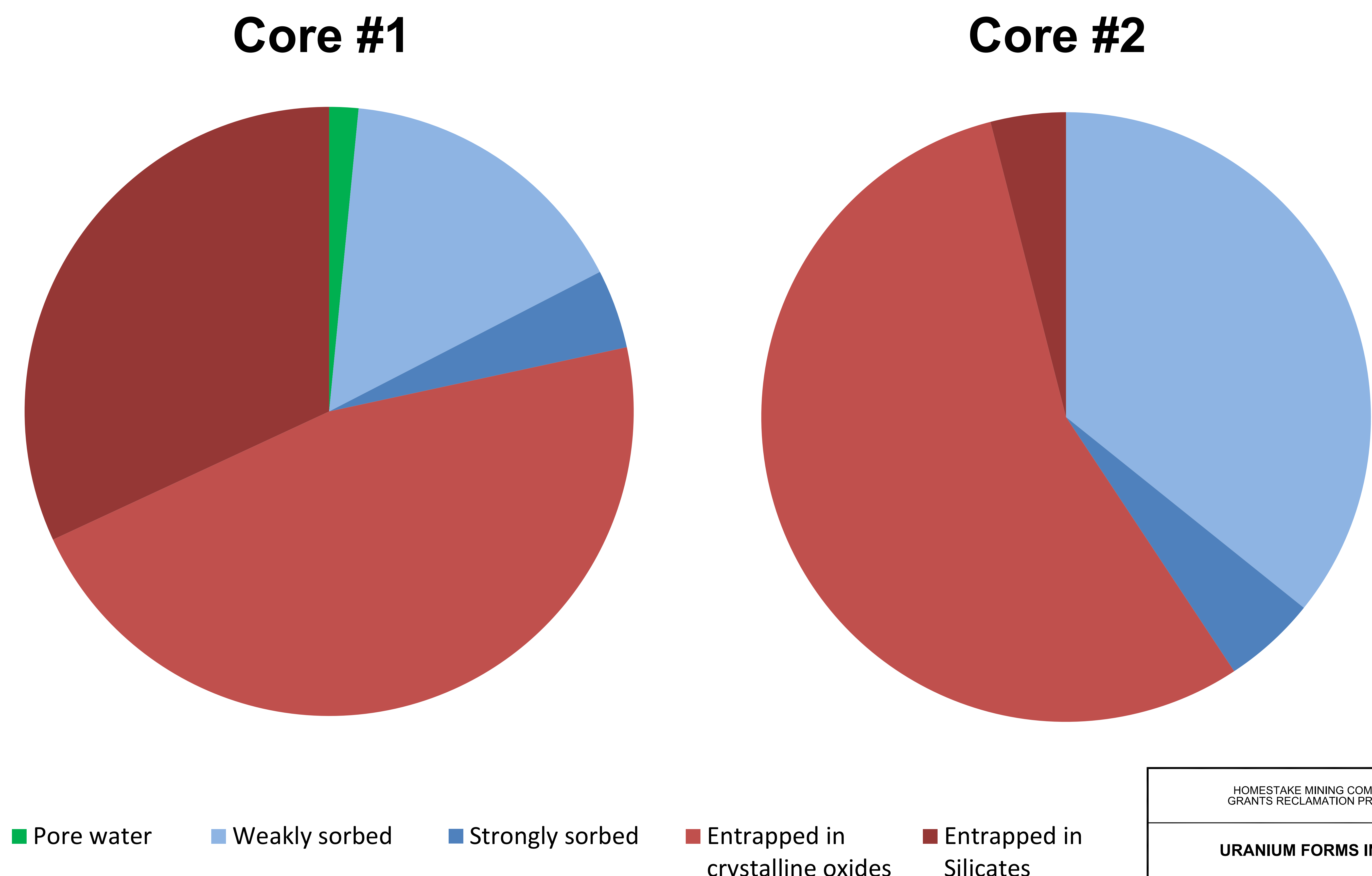
FIGURE 3



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URANIUM FORMS IN LTP

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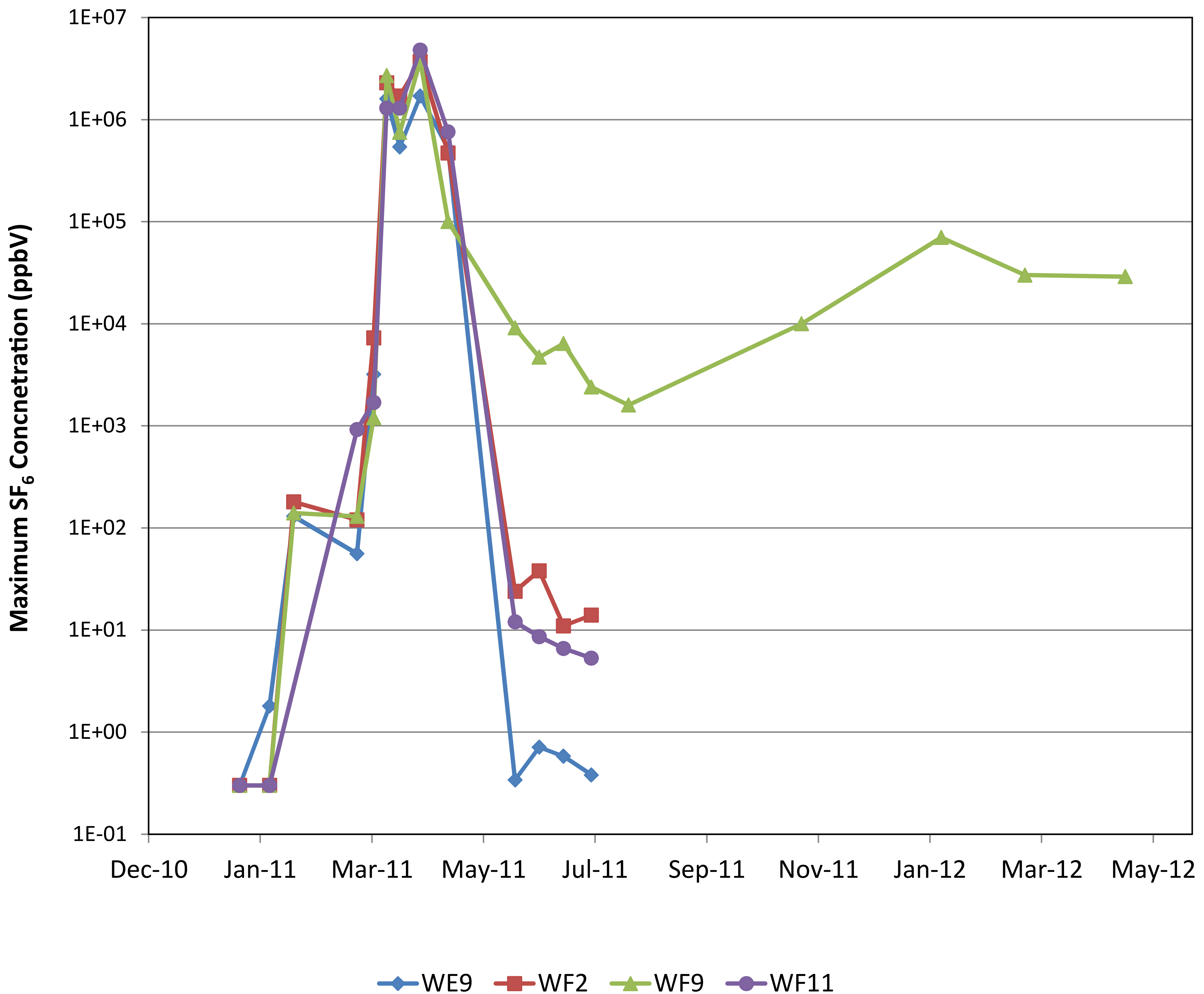
FIGURE
4

K:\AO000120-Grants\Illustrators\2012 Figure Renumber\Figure 4 Uranium Forms in LTP.ai @ 12/11/2012 PREPARED BY: JC



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SF_6 BREAKTHROUGH CURVES
PRIMARY MONITORING WELLS

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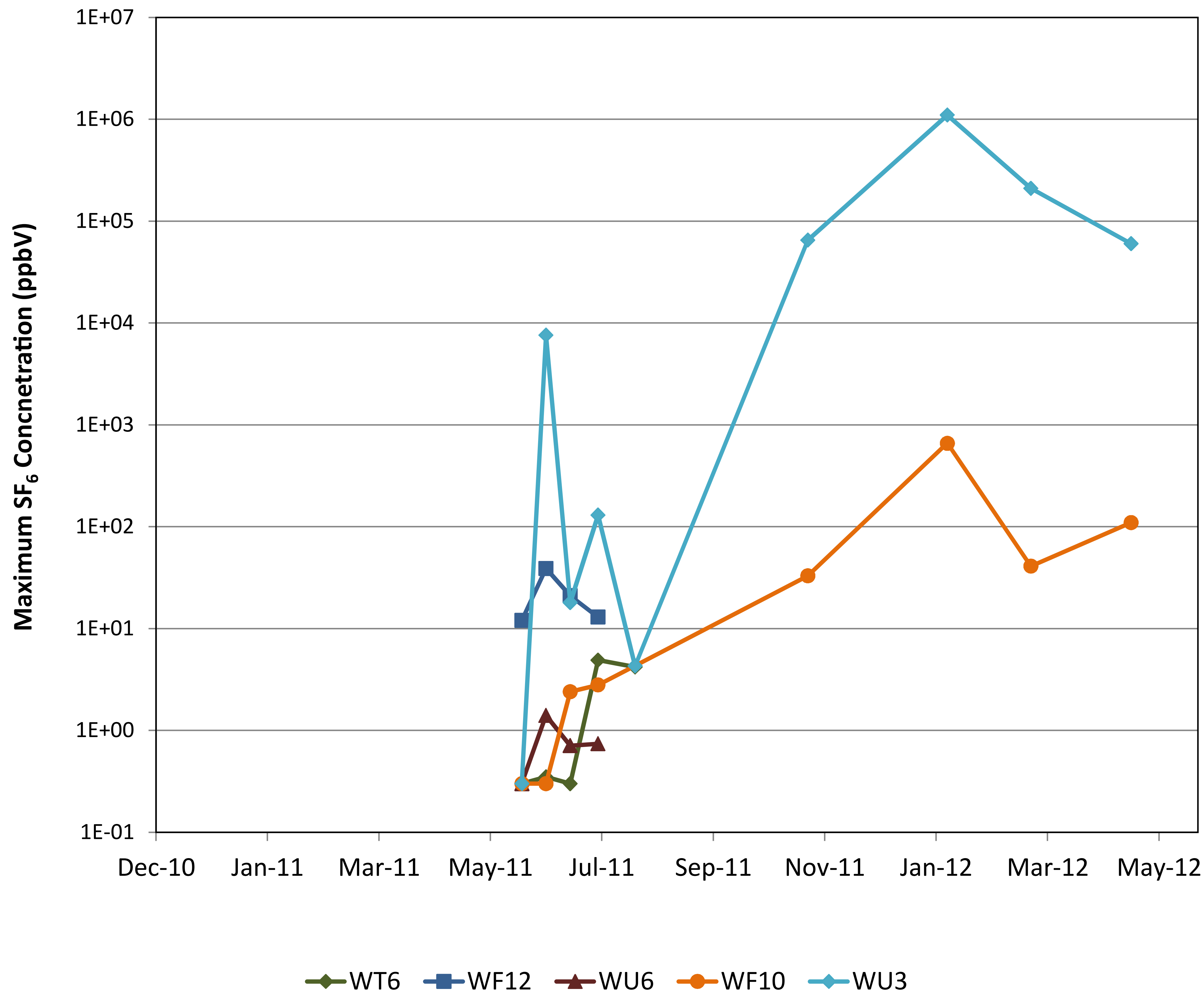
FIGURE
5

K:\AO000120-Grants\Illustrators\2012 Figure Renumber\Figure 5 SF6 Breakthrough Curves – Primary Monitoring Wells.ai @ 12/11/2012 PREPARED BY: JC



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SF_6 BREAKTHROUGH CURVES
SECONDARY MONITORING WELLS

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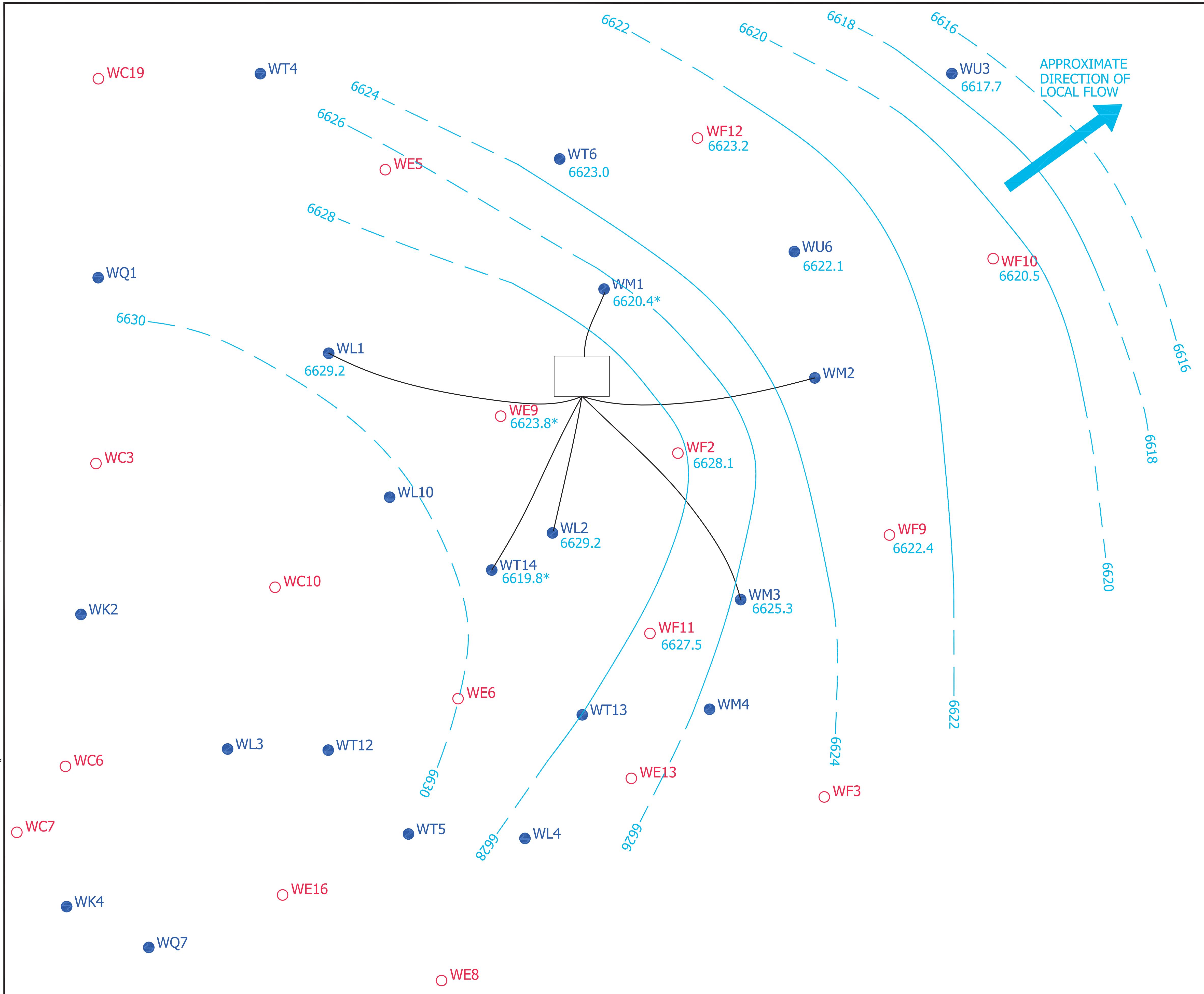
FIGURE
6



LEGEND:

6629.2 GROUNDWATER ELEVATION (FEET AMSL) JUNE 2011

* EXCLUDED FROM CONTOUR CONSTRUCTION

GROUNDWATER ELEVATION CONTOUR DASHED WHERE INFERRED

INJECTION WELL LOCATION

MONITORING WELL LOCATION

REMEDIATION SHED WITH TRACER TANK HOUSING

1/8" COPPER TUBING

N

0 50 100

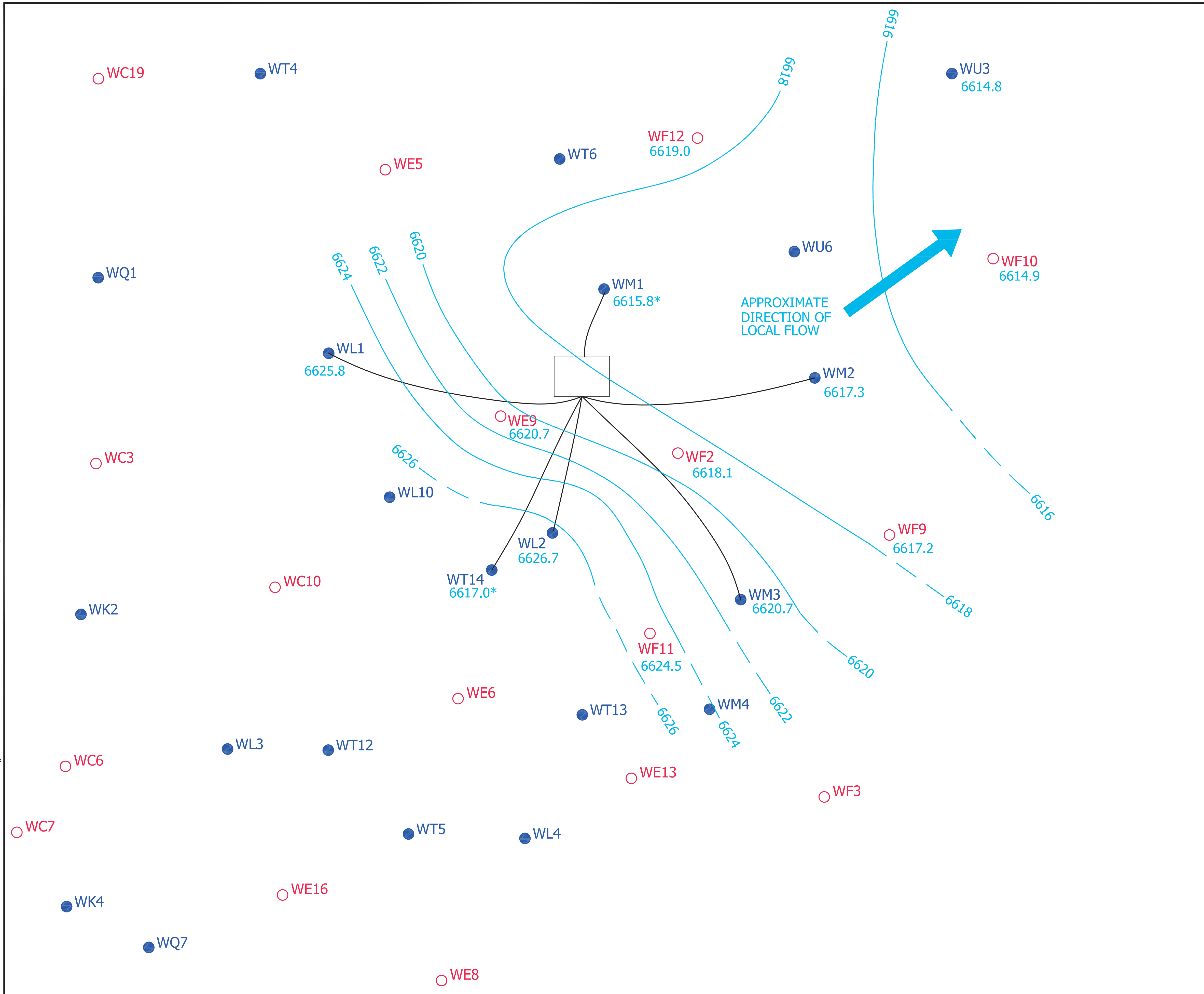
SCALE IN FEET

HOMESTAKE MINING COMPANY
GRANTS SUPERFUND SITE, NEW MEXICO

LOCAL POTENTIOMETRIC CONTOURS (JUNE 2011)

ARCADIS

FIGURE 7



LEGEND:

6624.5 GROUNDWATER ELEVATION (FEET AMSL) JANUARY 2012

* EXCLUDED FROM CONTOUR CONSTRUCTION

GROUNDWATER ELEVATION CONTOUR DASHED WHERE INFERRED

INJECTION WELL LOCATION

MONITORING WELL LOCATION

REMEDIATION SHED WITH TRACER TANK HOUSING

1/8" COPPER TUBING

N

0 50 100

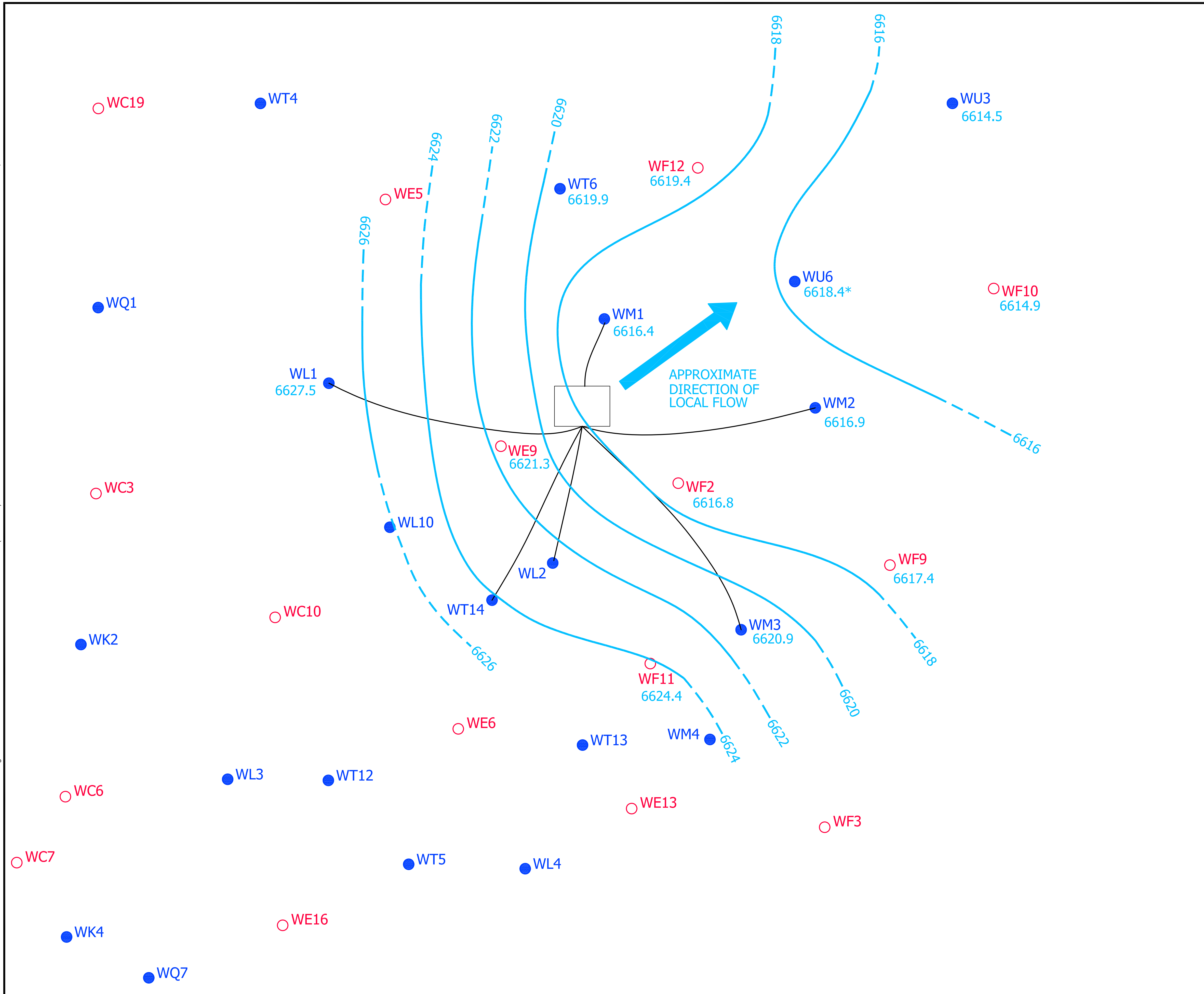
SCALE IN FEET

HOMESTAKE MINING COMPANY
GRANTS SUPERFUND SITE, NEW MEXICO

LOCAL POTENTIOMETRIC CONTOURS (JANUARY 2012)

ARCADIS

FIGURE 8



LEGEND:

- 6614.5 GROUNDWATER ELEVATION (FEET AMSL) JANUARY 2012
- * EXCLUDED FROM CONTOUR CONSTRUCTION
- GROUNDWATER ELEVATION CONTOUR DASHED WHERE INFERRED
- INJECTION WELL LOCATION
- MONITORING WELL LOCATION
- REMEDIATION SHED WITH TRACER TANK HOUSING
- 1/8" COPPER TUBING

N

0 50 100

SCALE IN FEET

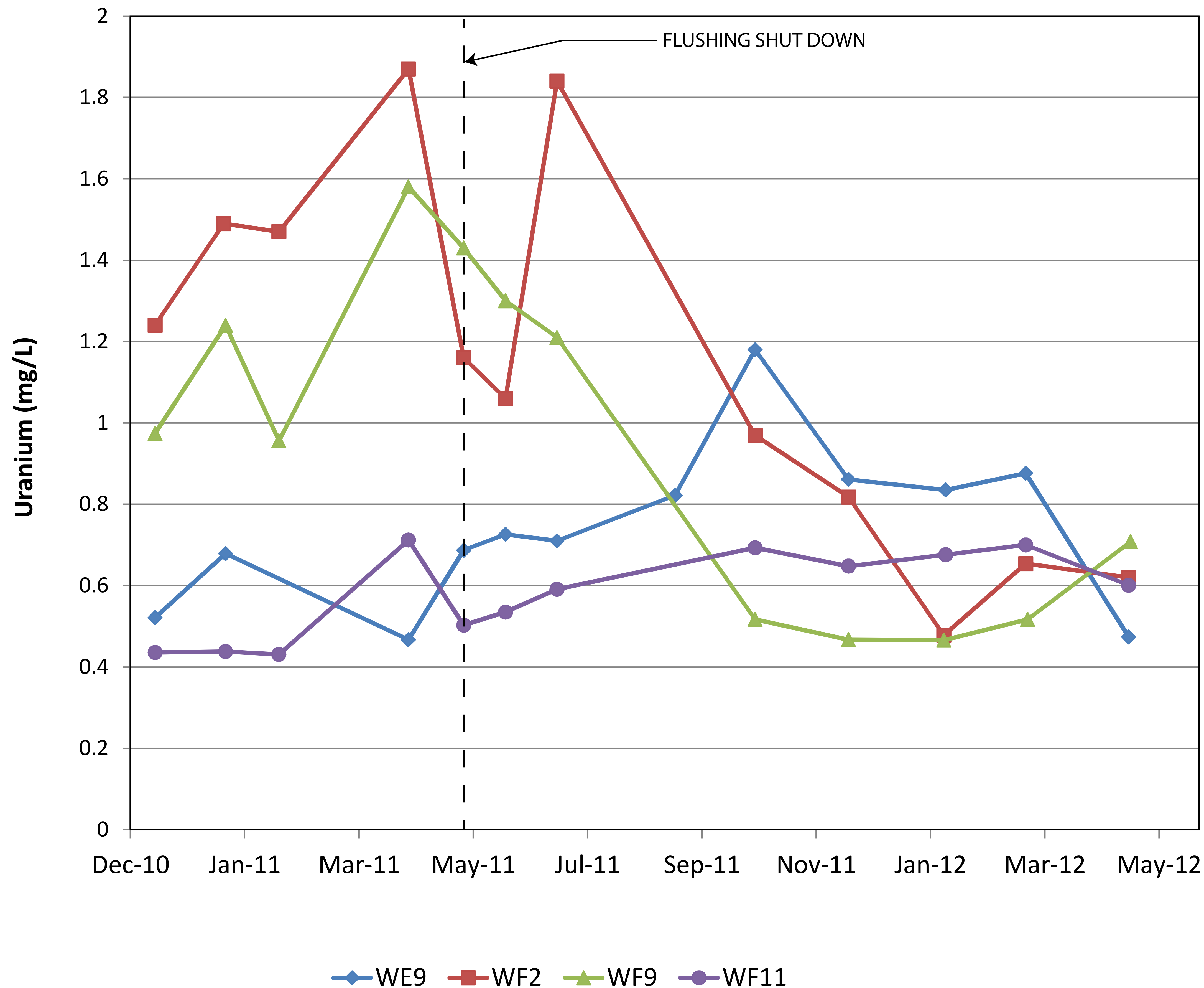
HOMESTAKE MINING COMPANY
GRANTS RECLAMATION PROJECT

LOCAL POTENTIOMETRIC CONTOURS (MAY 2012)

ARCADIS

FIGURE

9



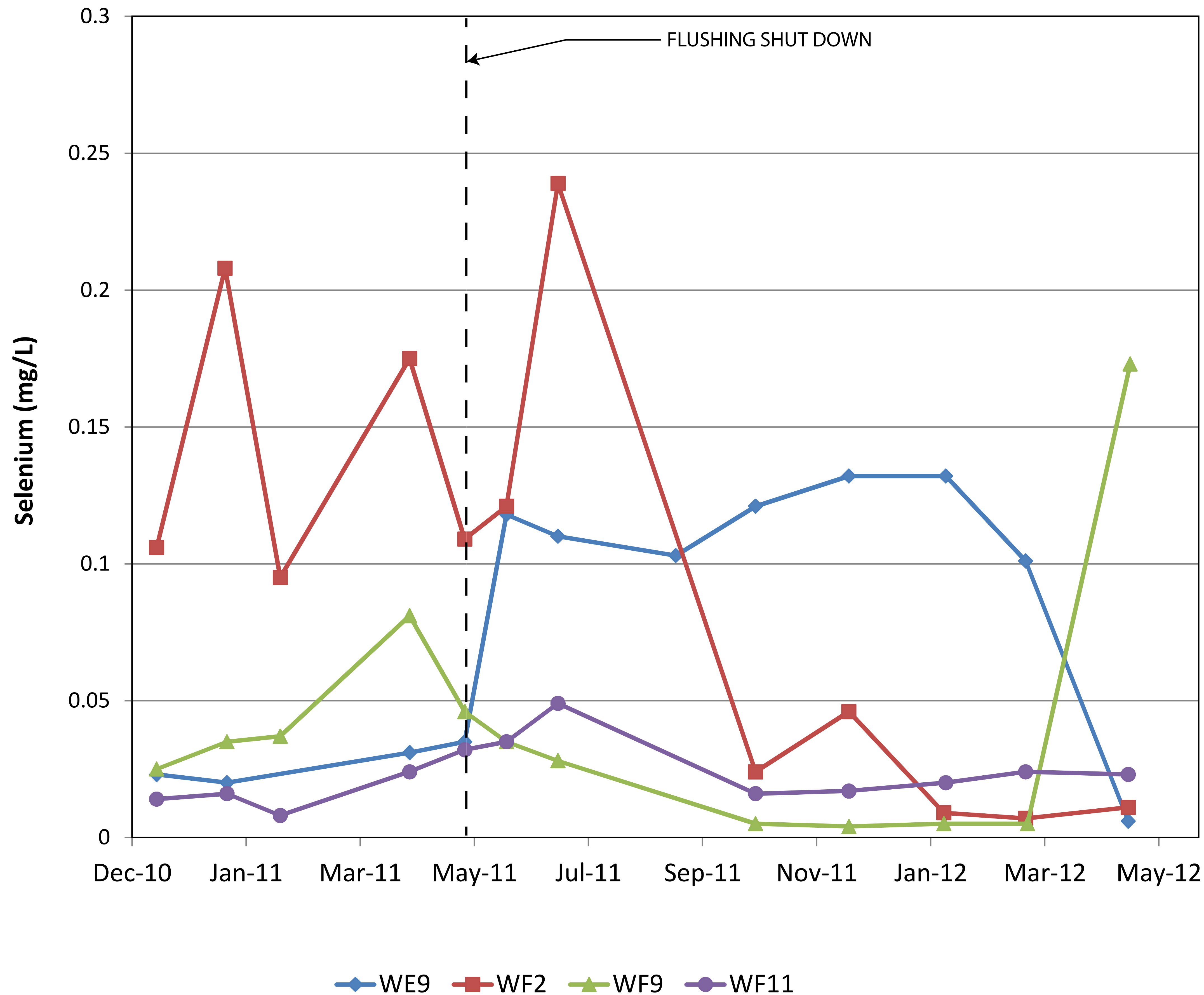
HOMESTAKE MINING COMPANY
GRANTS RECLAMATION PROJECT

URANIUM CONCENTRATION TRENDS
PRIMARY MONITORING WELLS

ARCADIS

FIGURE
10

K:\AO000120-Grants\Illustrators\2012 Figure Renumber\Figure 10 Uranium Concentration Trends – Primary Monitoring Wells.ai @ 12/11/2012 PREPARED BY: JC

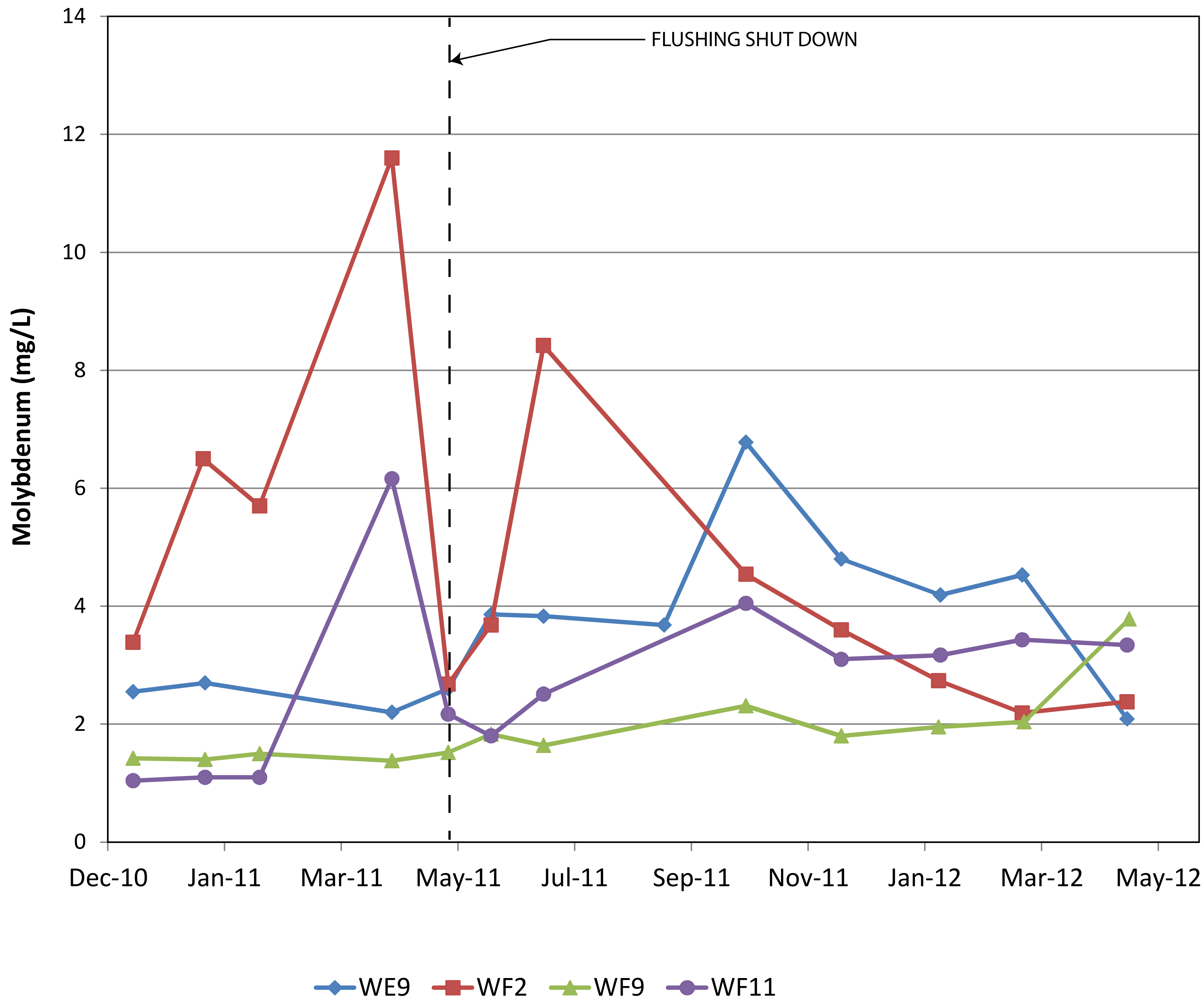


HOMESTAKE MINING COMPANY
GRANTS RECLAMATION PROJECT

SELENIUM CONCENTRATION TRENDS
PRIMARY MONITORING WELLS

ARCADIS

FIGURE
11



HOMESTAKE MINING COMPANY
GRANTS RECLAMATION PROJECT

MOLYBDENUM CONCENTRATION TRENDS PRIMARY MONITORING WELLS

ARCADIS

FIGURE
12

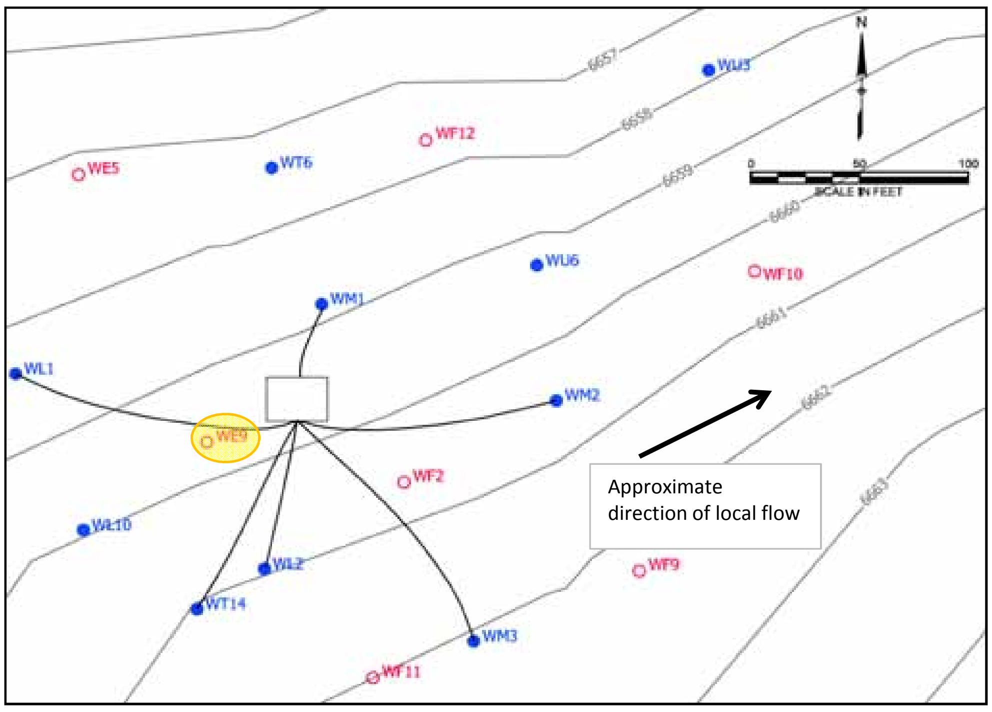
Attachment A

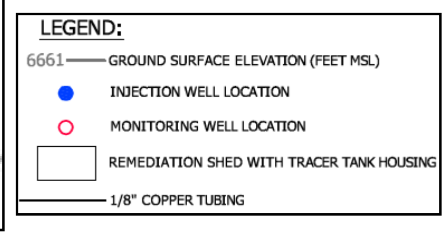
Rebound Evaluation Results

Rebound Evaluation At-A-Glance Charts
Well ID: WE9

Updated May 30, 2012
Most recent data: May 8, 2012

Well Location:



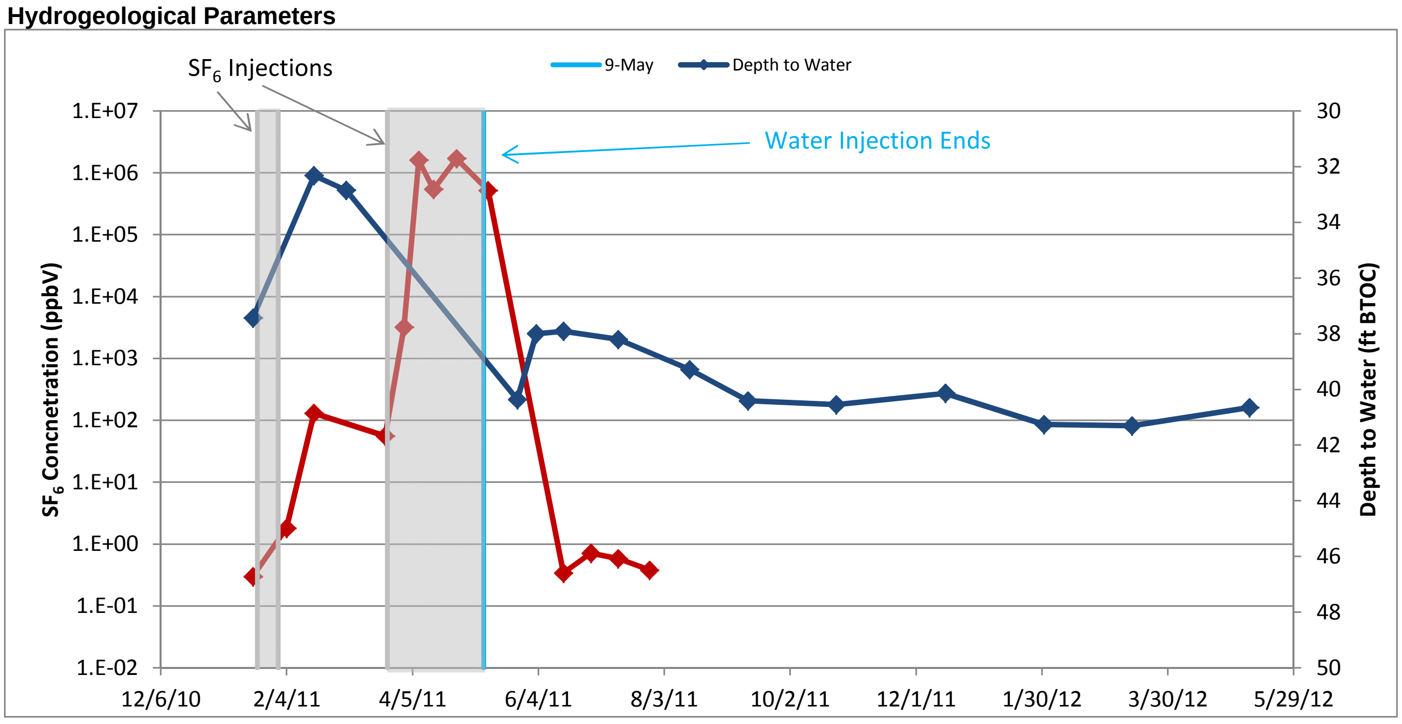


Well Construction Details:

Depth	Screened Interval	Diameter	TOC Elevation	TOC Stickup
116 ft	36 - 116 ft	5 in	6661.96 ft MSL	2.96 ft

Notes:
PD Sampler Deployment at 40, 60, and 80 ft BTOC

Hydrogeological Parameters

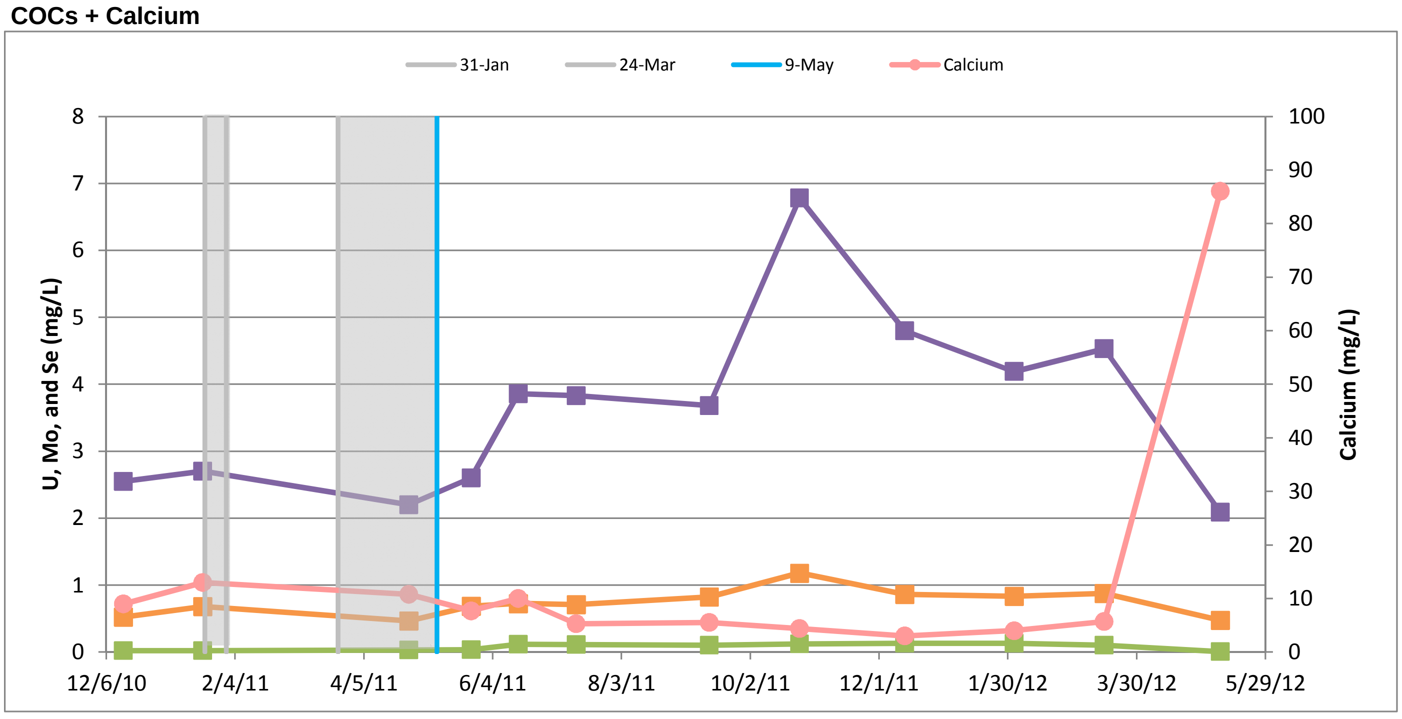


Historic Data

Date	DTW (ft BTOC)
7/7/09	47.15
9/2/09	41.59
10/21/09	42.1
1/7/10	36.75
2/5/10	36.68
6/11/10	45.59
8/9/10	42.82
3/4/11	32.85

No background concentration of SF_6.

COCs + Calcium

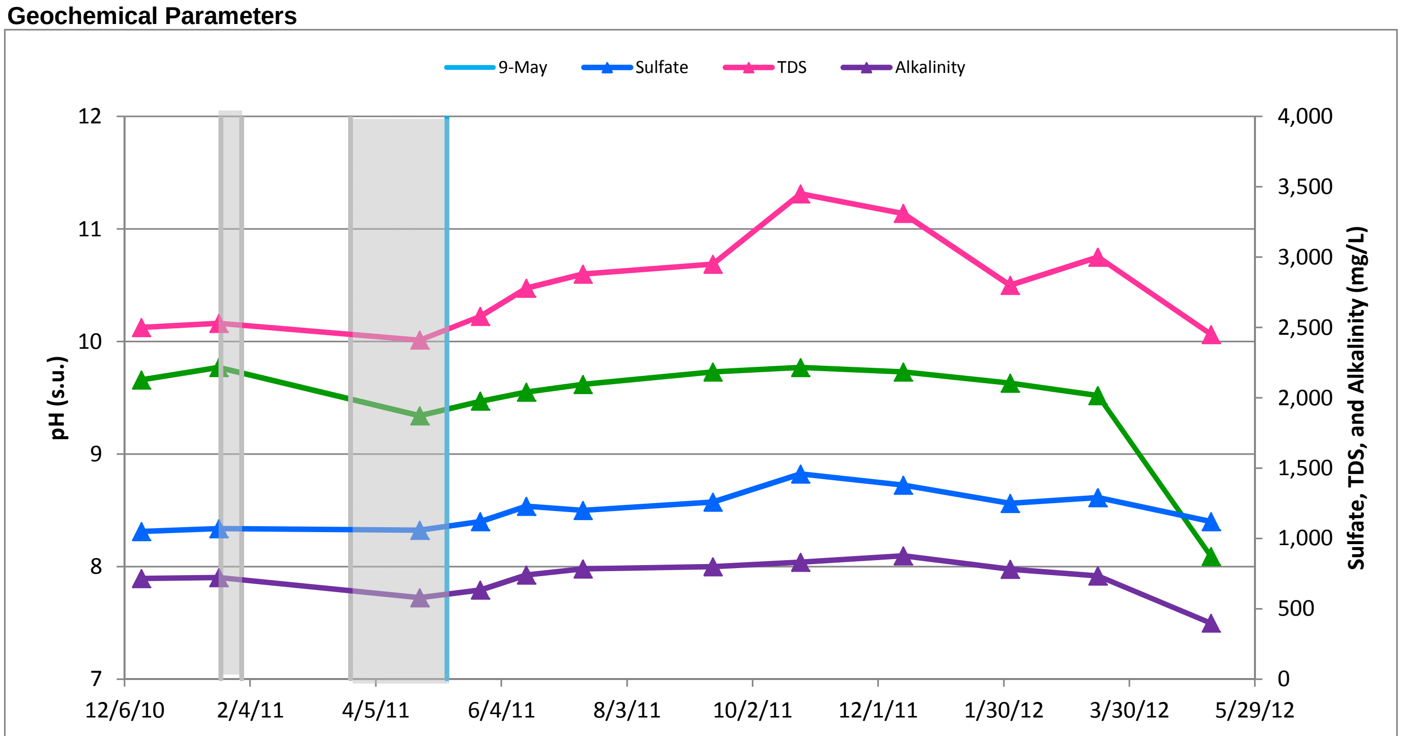


Historic Data

Date	U (mg/L)	Mo (mg/L)	Se (mg/L)
9/13/09	2.49	9.89	0.101
3/31/10	3.1	10.7	0.15
12/14/10	0.521	2.55	0.023
1/20/11	0.679	2.7	0.02
4/26/11	0.467	2.2	0.031

Date	Calcium (mg/L)
12/14/10	9
1/20/11	13
4/26/11	10.8

Geochemical Parameters



Historic Data

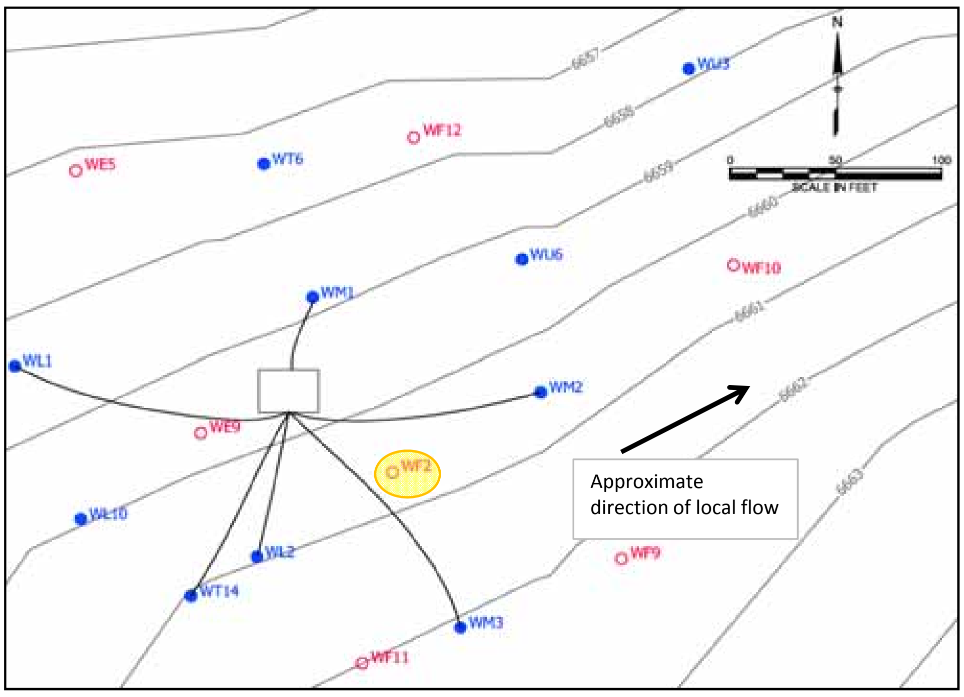
Date	pH (s.u.)	Alkalinity (mg/L)
12/14/10	9.66	715
1/20/11	9.77	723
4/26/11	9.34	580

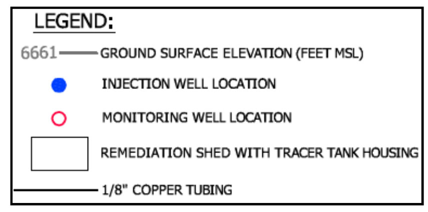
Date	Sulfate (mg/L)	TDS (mg/L)
9/13/09	1780	4570
3/31/10	1570	4310
12/14/10	1050	2500
1/20/11	1070	2530
4/26/11	1060	2410

Rebound Evaluation At-A-Glance Charts
Well ID: WF2

Updated May 30, 2012
Most recent data: May 8, 2012

Well Location:



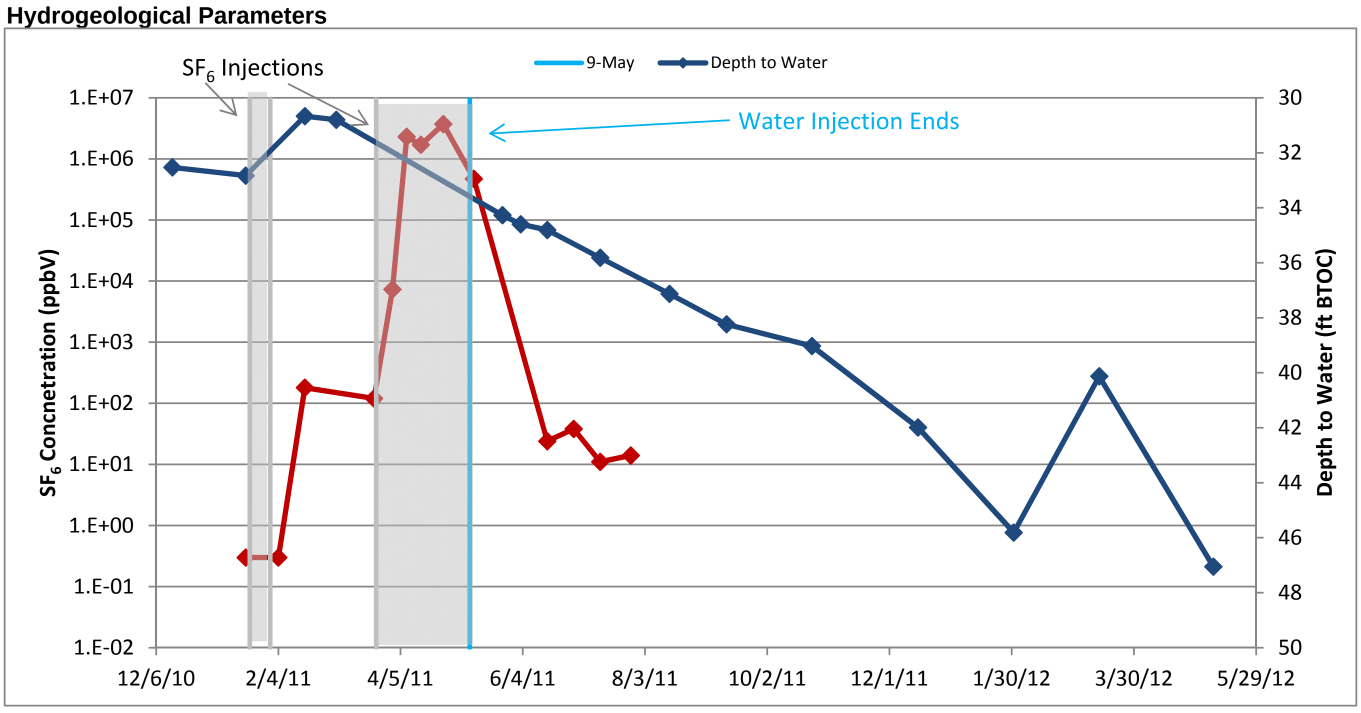


Well Construction Details:

Depth	Screened Interval	Diameter	TOC Elevation	TOC Stickup
111.8 ft	28 - 108 ft	5 in	6660.82 ft MSL	3.7 ft

Notes:
PD Sampler Deployment at 40, 60, and 80 ft BTOC

Hydrogeological Parameters

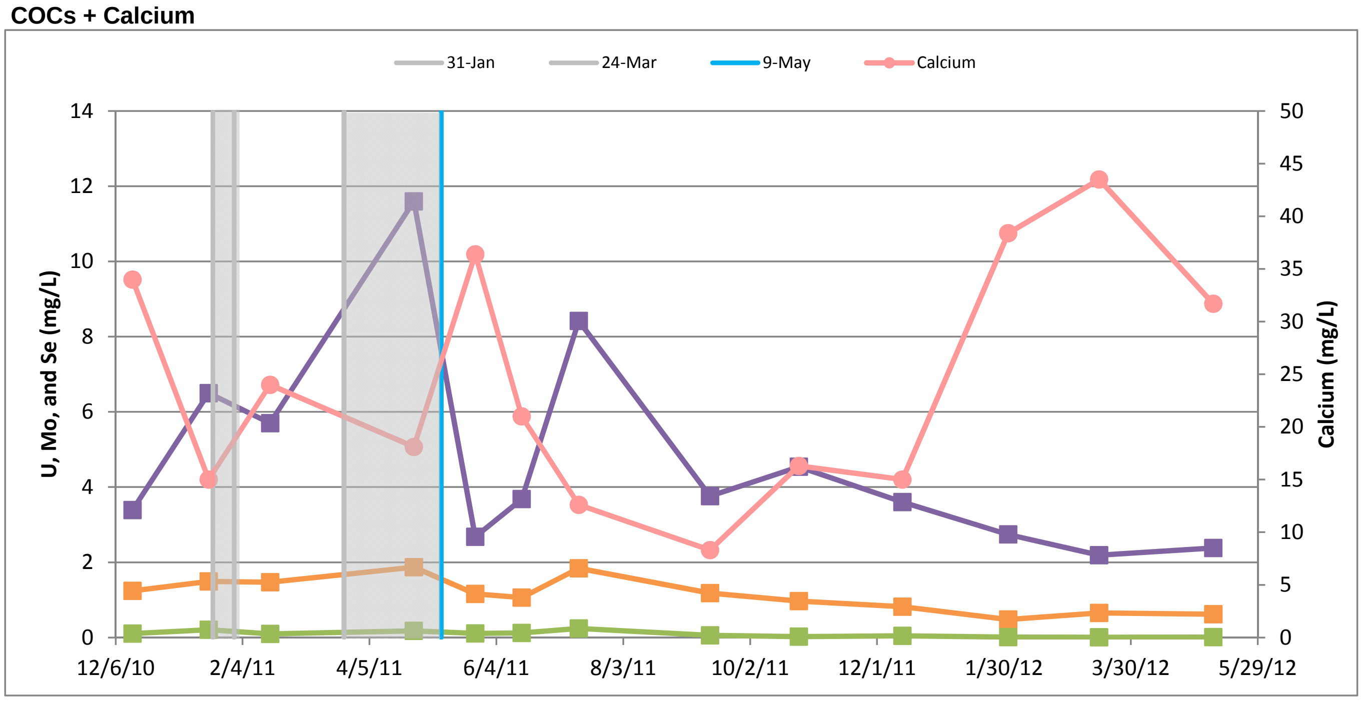


Historic Data

Date	DTW (ft BTOC)
7/16/08	35.3
2/22/09	35.8
7/8/09	32.06
8/6/09	32.64
10/21/09	34.96
1/7/10	30.15
2/5/10	35.25
6/11/10	34.86
8/9/10	31.95
3/4/11	30.8

No background concentration of SF_6.

COCs + Calcium

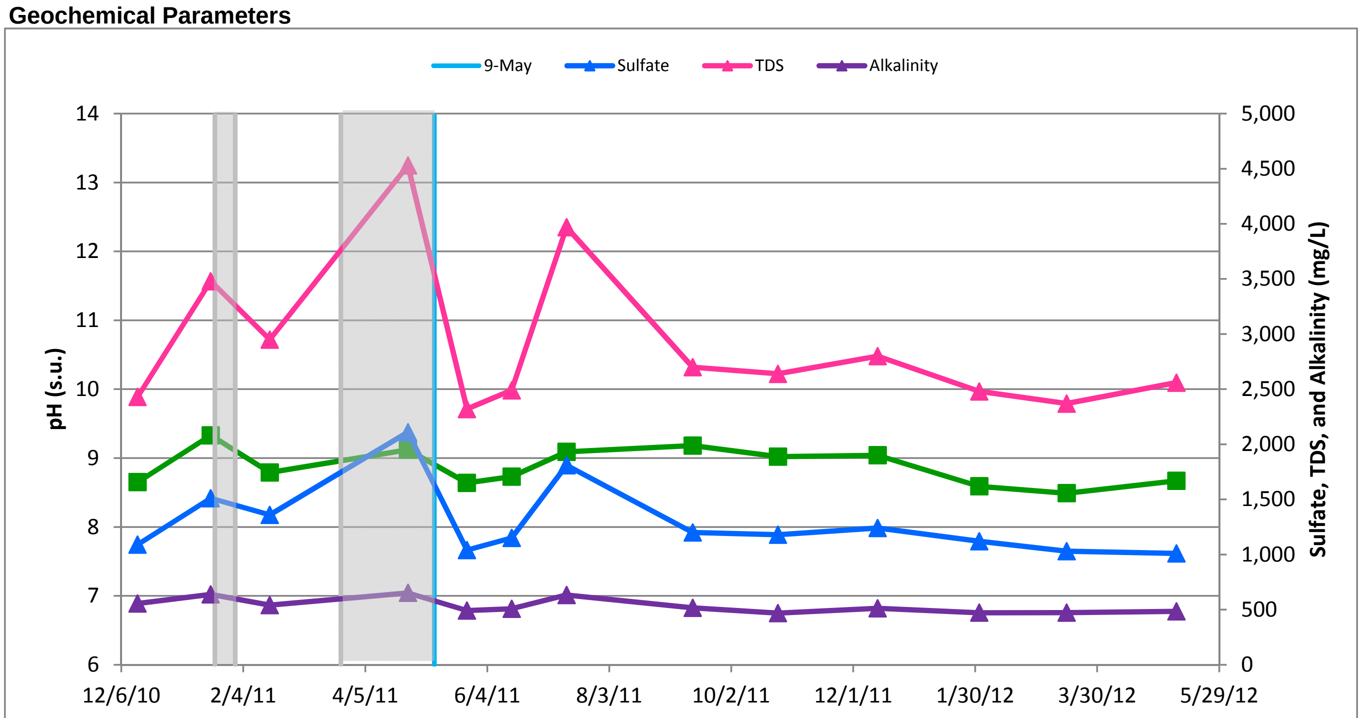


Historic Data

Date	U (mg/L)	Mo (mg/L)	Se (mg/L)
9/28/08	3.7	15.8	1.72
5/13/09	2.81	10.3	0.636
8/13/09	2.71	9.98	0.582
3/31/10	1.5	4.8	0.18
5/4/10	1.32	4.86	0.111
12/14/10	1.24	3.39	0.106
1/19/11	1.49	6.5	0.208
2/17/11	1.47	5.7	0.095
4/26/11	1.87	11.6	0.175

Date	Calcium (mg/L)
9/28/08	8
12/14/10	34
1/19/11	15
2/17/11	24
4/26/11	18.1

Geochemical Parameters



Historic Data

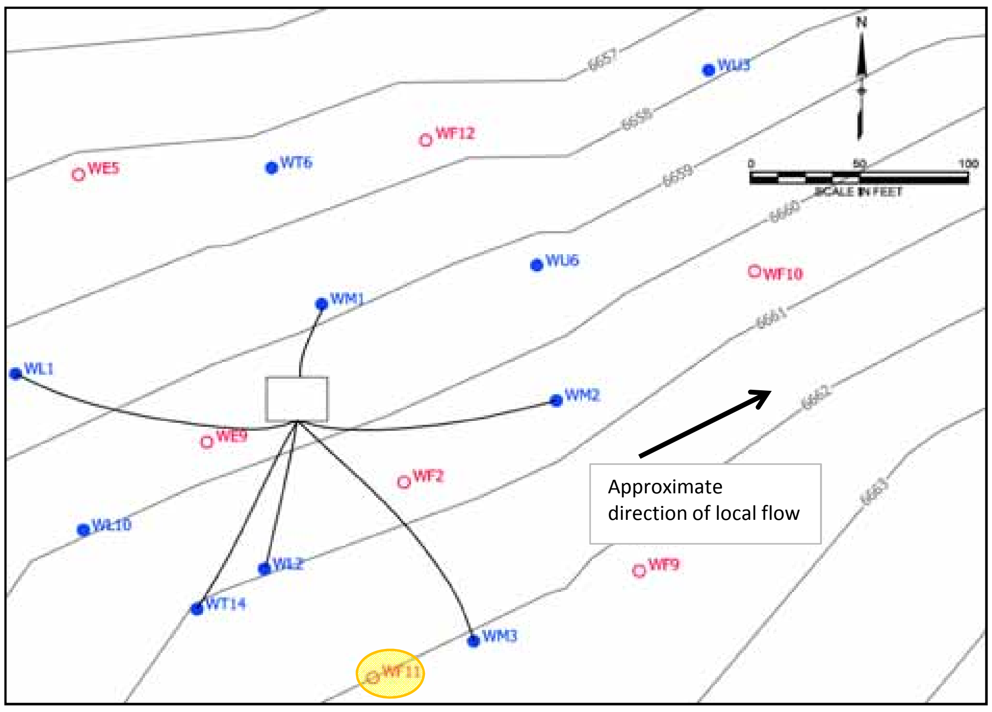
Date	pH (s.u.)	Alkalinity (mg/L)
9/28/08	9.04	719
12/14/10	8.65	555
1/19/11	9.33	638
2/17/11	8.79	541
4/26/11	9.12	652

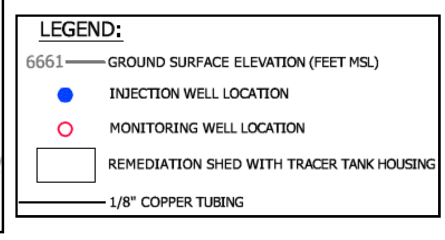
Date	Sulfate (mg/L)	TDS (mg/L)
9/28/08	2260	4950
5/13/09	1820	4000
8/13/09	1730	3730
3/31/10	1220	2940
5/4/10	1180	2780
12/14/10	1090	2430
1/19/11	1510	3480
2/17/11	1360	2950
4/26/11	2110	4530

Rebound Evaluation At-A-Glance Charts
Well ID: WF11

Updated May 30, 2012
Most recent data: May 8, 2012

Well Location:



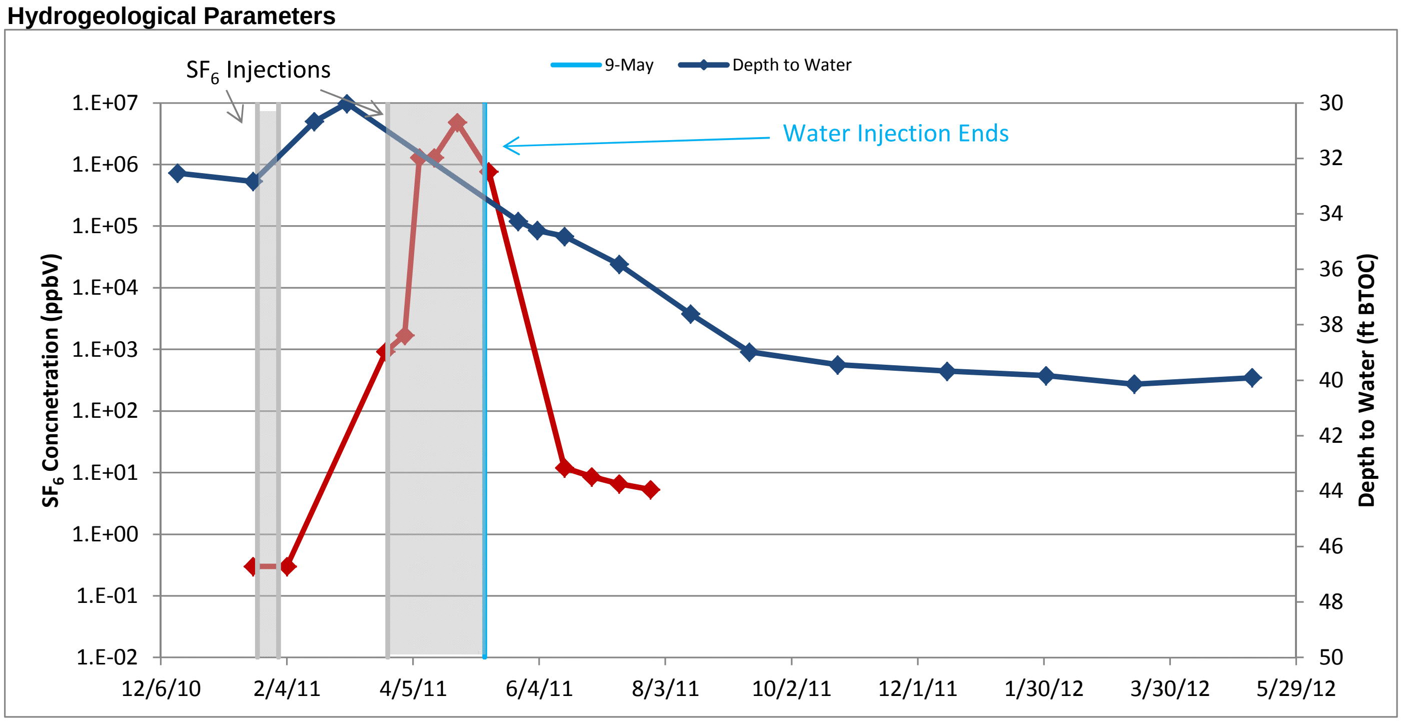


Well Construction Details:

Depth	Screened Interval	Diameter	TOC Elevation	TOC Stickup
116 ft	36 - 116 ft	5 in	6664.84 ft MSL	2.93 ft

Notes:
PD Sampler Deployment at 40, 60, and 80 ft BTOC

Hydrogeological Parameters

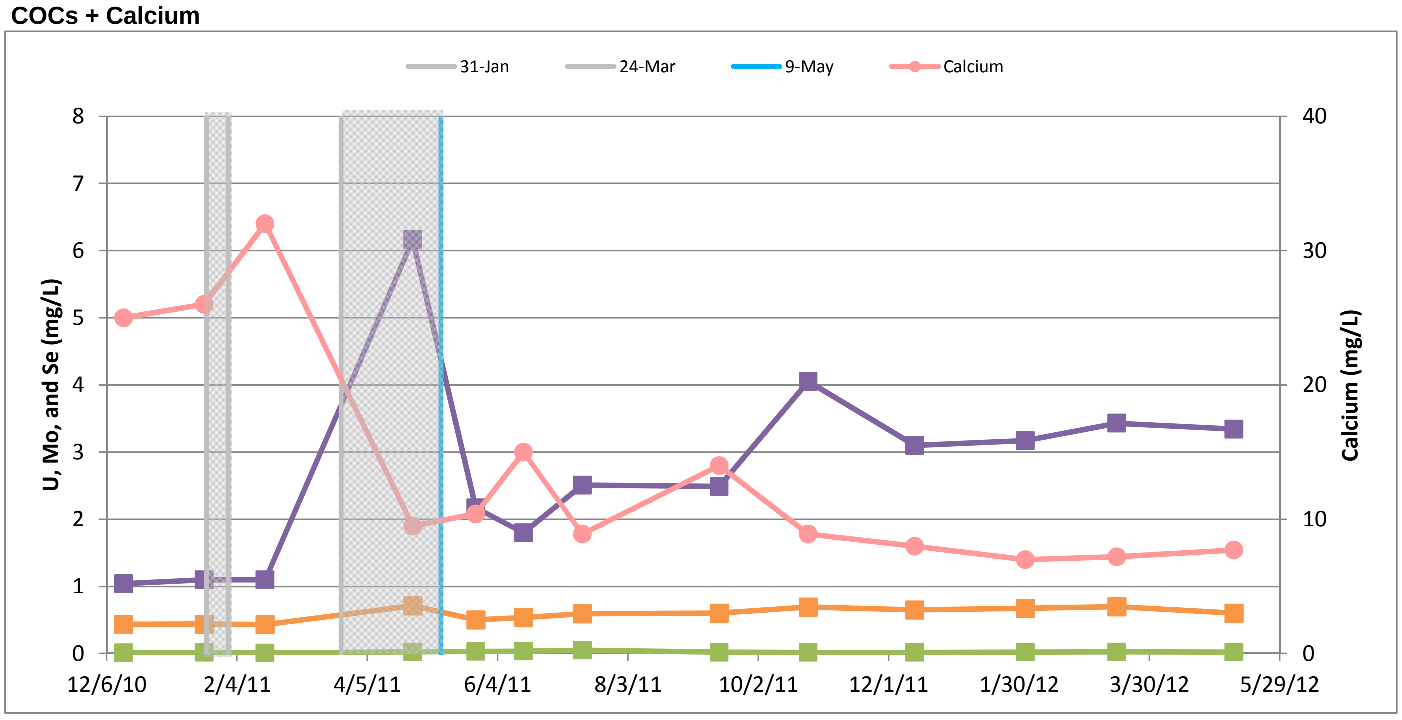


Historic Data

Date	DTW (ft BTOC)
7/16/08	37.5
5/13/09	29.42
7/8/09	56.33
6/11/10	34.19
8/9/10	31.25
3/4/11	30.02

No background concentration of SF_6.

COCs + Calcium

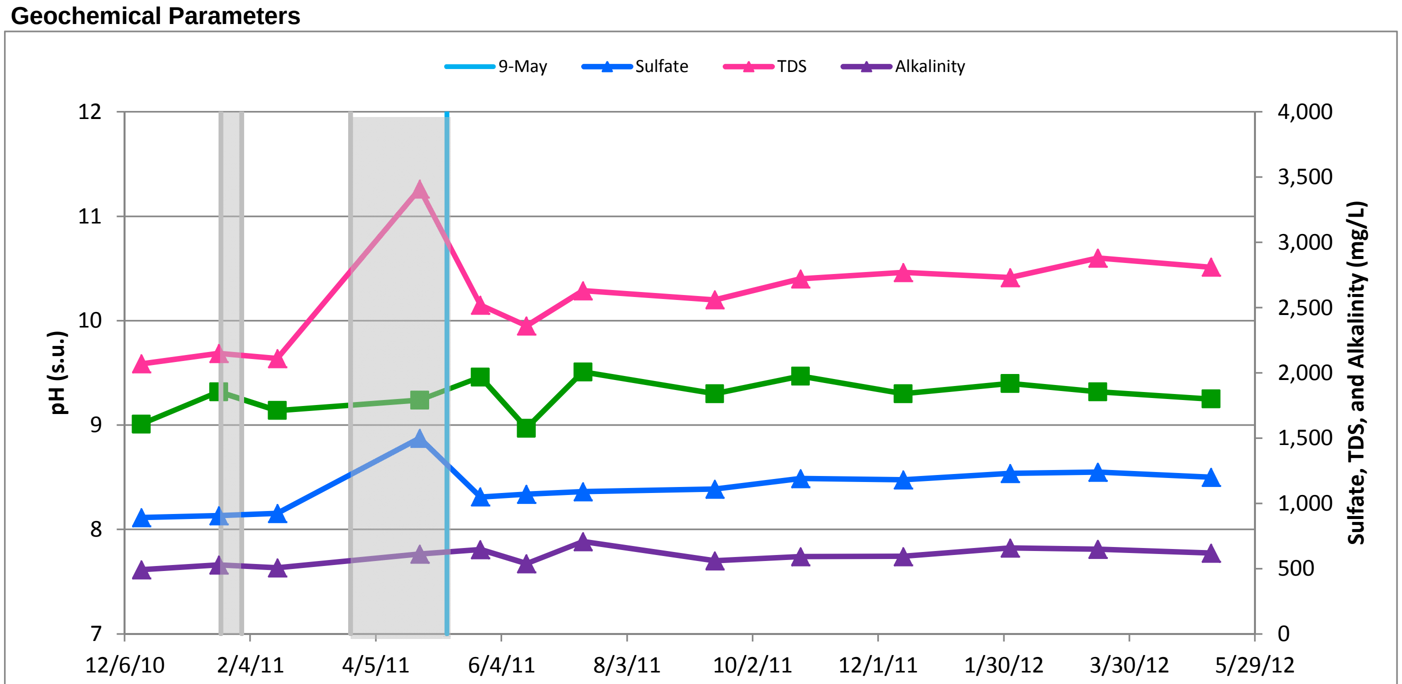


Historic Data

Date	U (mg/L)	Mo (mg/L)	Se (mg/L)
2/22/09	0.676	1.33	0.009
5/13/09	0.64	2.42	0.065
5/5/10	0.706	2.97	0.142
12/14/10	0.436	1.04	0.014
1/20/11	0.438	1.1	0.016
2/17/11	0.431	1.1	0.008
4/27/11	0.712	6.16	0.024

Date	Calcium (mg/L)
12/14/10	25
1/20/11	26
2/17/11	32
4/27/11	9.5

Geochemical Parameters



Historic Data

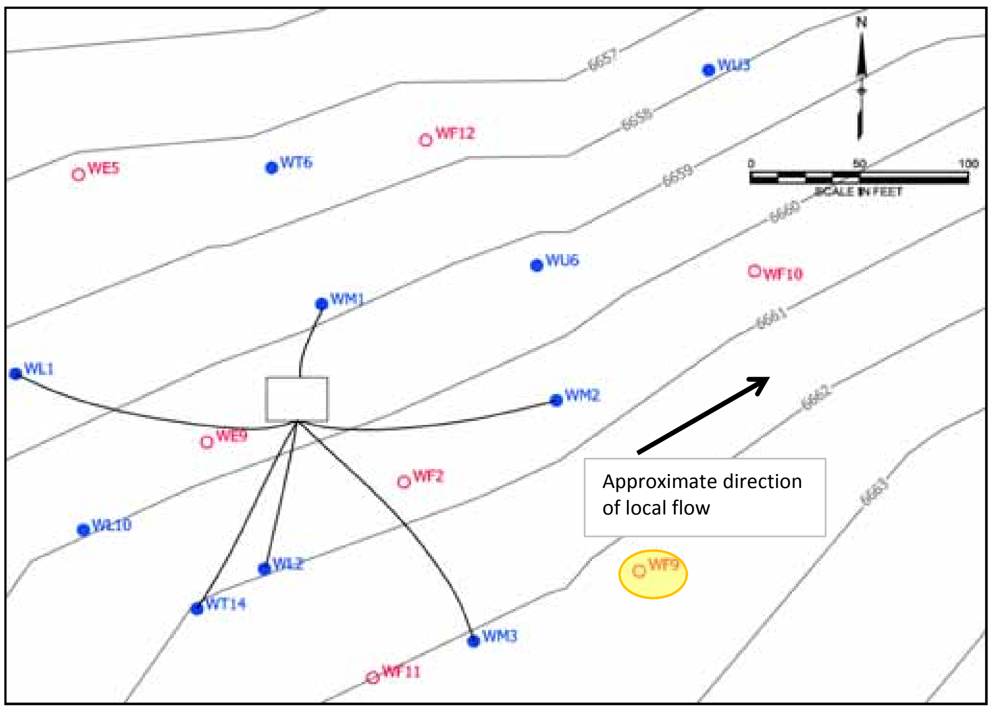
Date	pH (s.u.)	Alkalinity (mg/L)
12/14/10	9.01	493
1/20/11	9.32	528
2/17/11	9.14	506
4/27/11	9.24	613

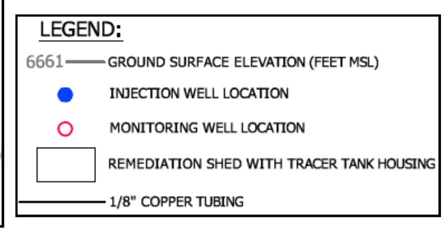
Date	Sulfate (mg/L)	TDS (mg/L)
2/22/09	893	2110
5/13/09	976	2460
5/5/10	987	2440
12/14/10	893	2070
1/20/11	907	2150
2/17/11	924	2110
4/27/11	1500	3410

Rebound Evaluation At-A-Glance Charts
Well ID: WF9

Updated May 30, 2012
Most recent data: May 9, 2012

Well Location:



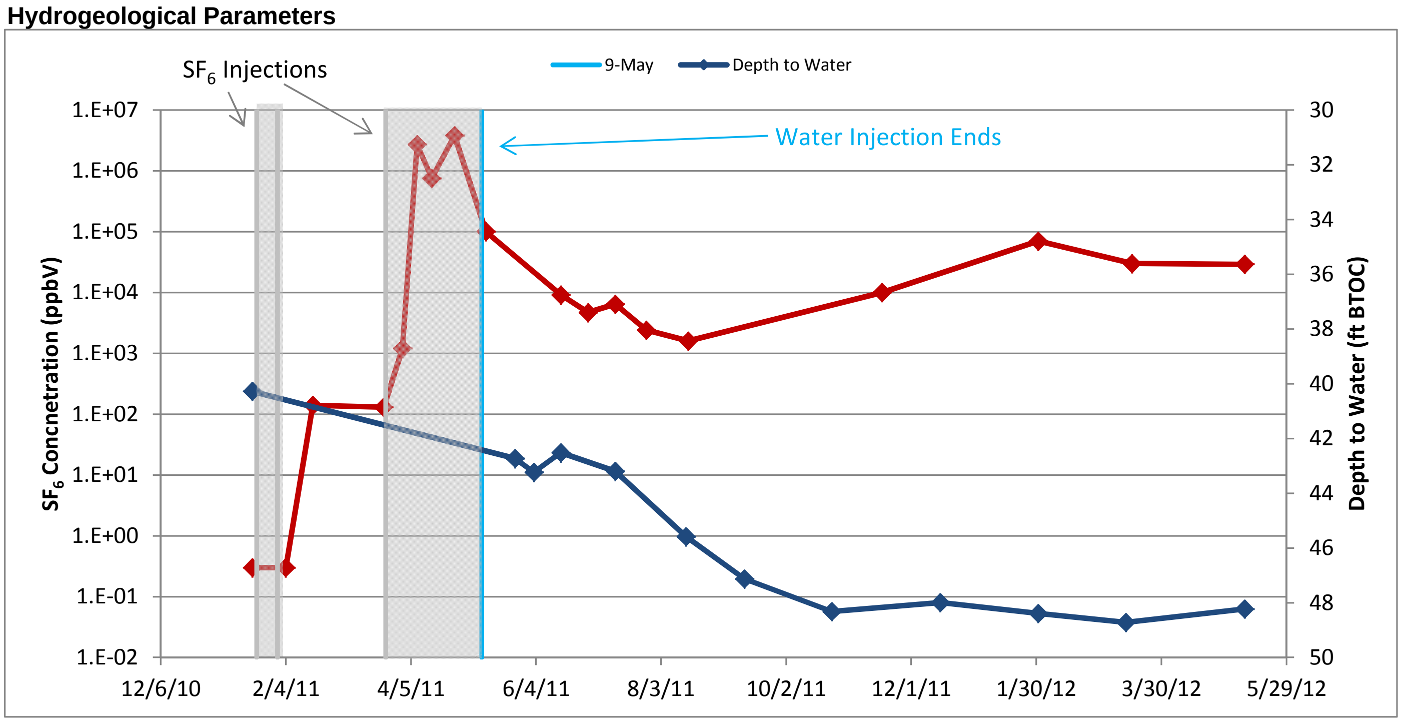


Well Construction Details:

Depth	Screened Interval	Diameter	TOC Elevation	TOC Stickup
116 ft	36 - 116 ft	5 in	6665.7 ft MSL	3.17 ft

Notes:
PD Sampler Deployment at 40, 60, and 80 ft BTOC

Hydrogeological Parameters

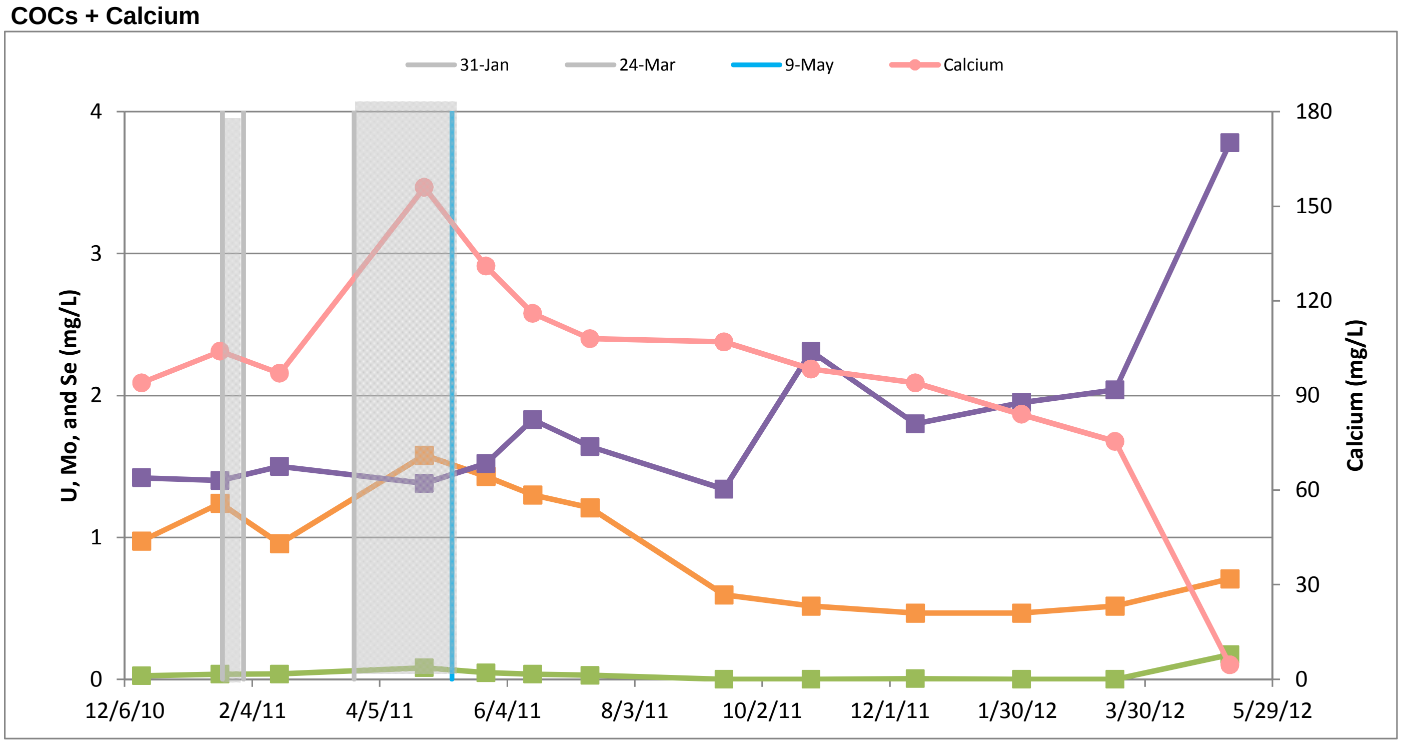


Historic Data

Date	DTW (ft BTOC)
10/21/09	41.24
6/11/10	41.45
8/9/10	40.41

No background concentration of SF_6.

COCs + Calcium

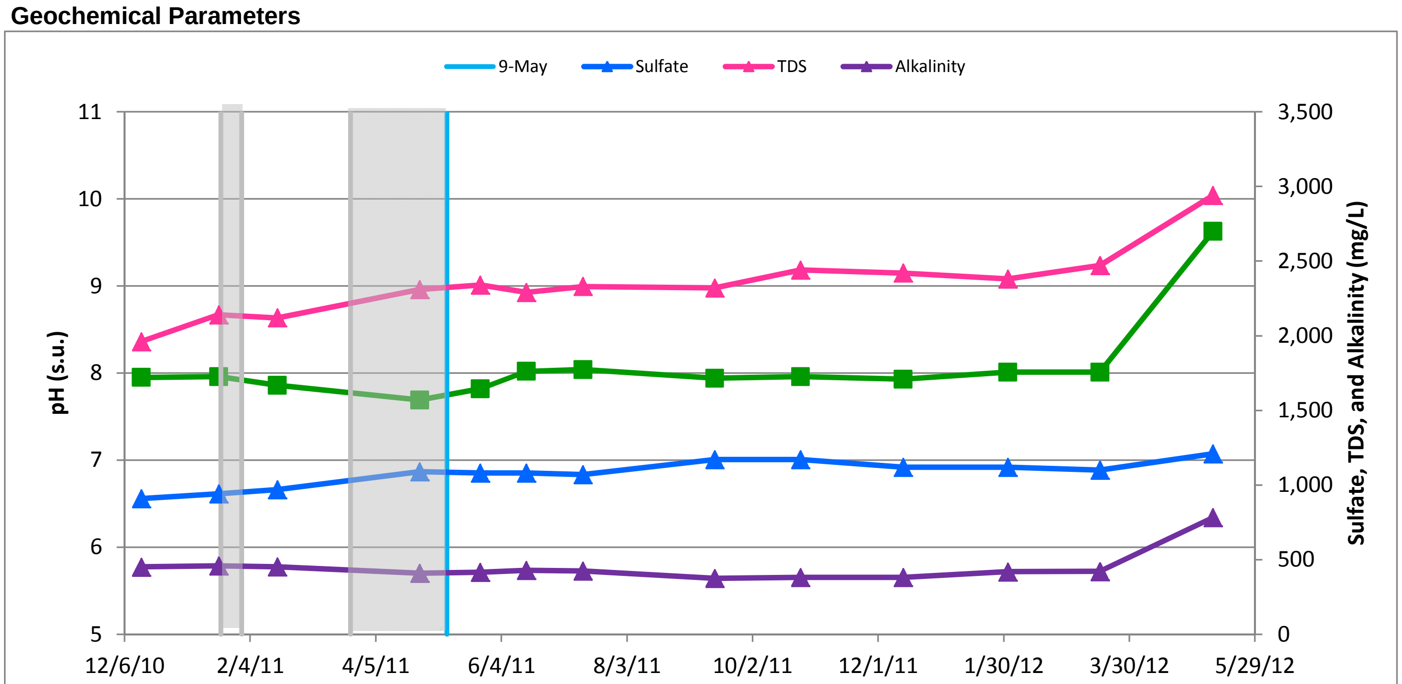


Historic Data

Date	U (mg/L)	Mo (mg/L)	Se (mg/L)
3/31/10	1.3	2.3	0.038
12/14/10	0.974	1.42	0.025
1/20/11	1.24	1.4	0.035
4/26/11	1.58	1.38	0.081

Date	Calcium (mg/L)
12/14/10	94
1/20/11	104
4/26/11	156

Geochemical Parameters



Historic Data

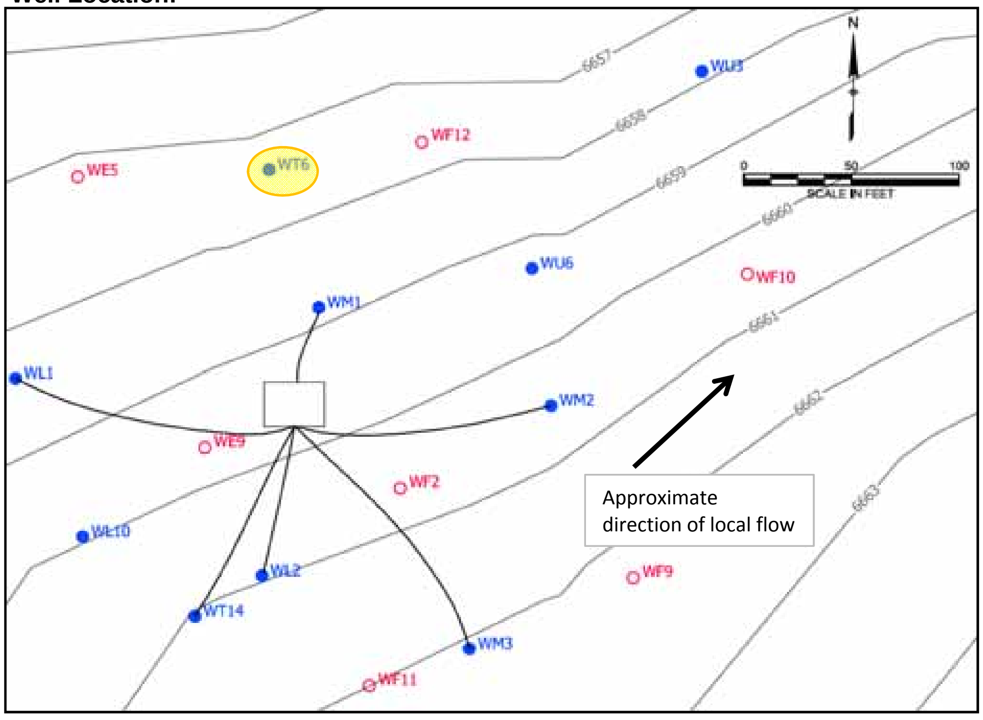
Date	pH (s.u.)	Alkalinity (mg/L)
12/14/10	7.95	451
1/20/11	7.96	459
4/26/11	7.69	410

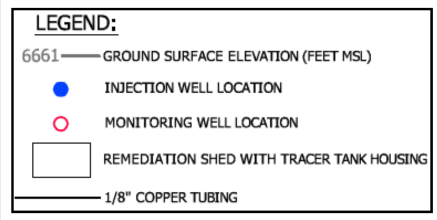
Date	Sulfate (mg/L)	TDS (mg/L)
3/31/10	1020	2270
12/14/10	910	1960
1/20/11	941	2140
4/26/11	1090	2310

Rebound Evaluation At-A-Glance Charts
Well ID: WT6

Updated May 30, 2012
Most recent data: May 8, 2012

Well Location:



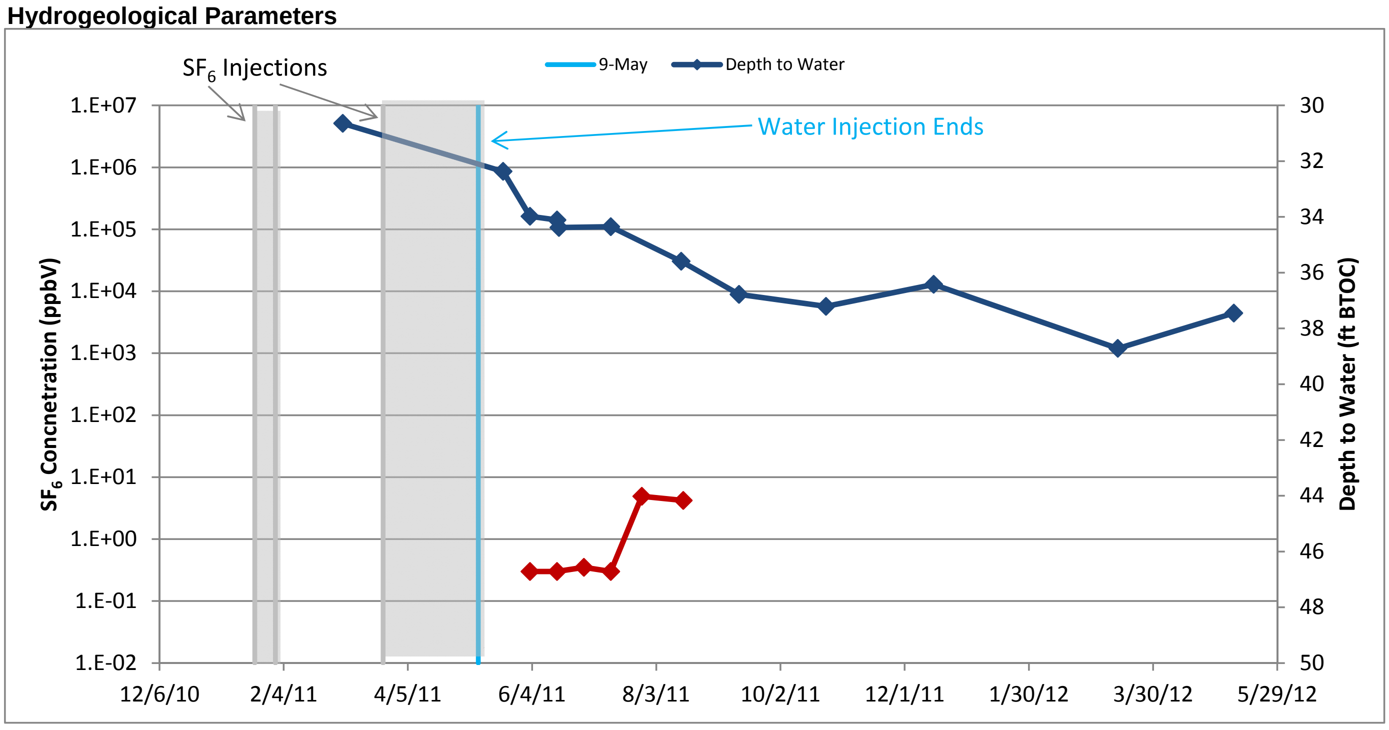


Well Construction Details:

Depth	Screened Interval	Diameter	TOC Elevation	TOC Stickup
90 ft	40 - 90 ft	2 in	6657 ft MSL	2

Notes:
PD Sampler Deployment at 40, 60, and 80 ft BTOC

Hydrogeological Parameters

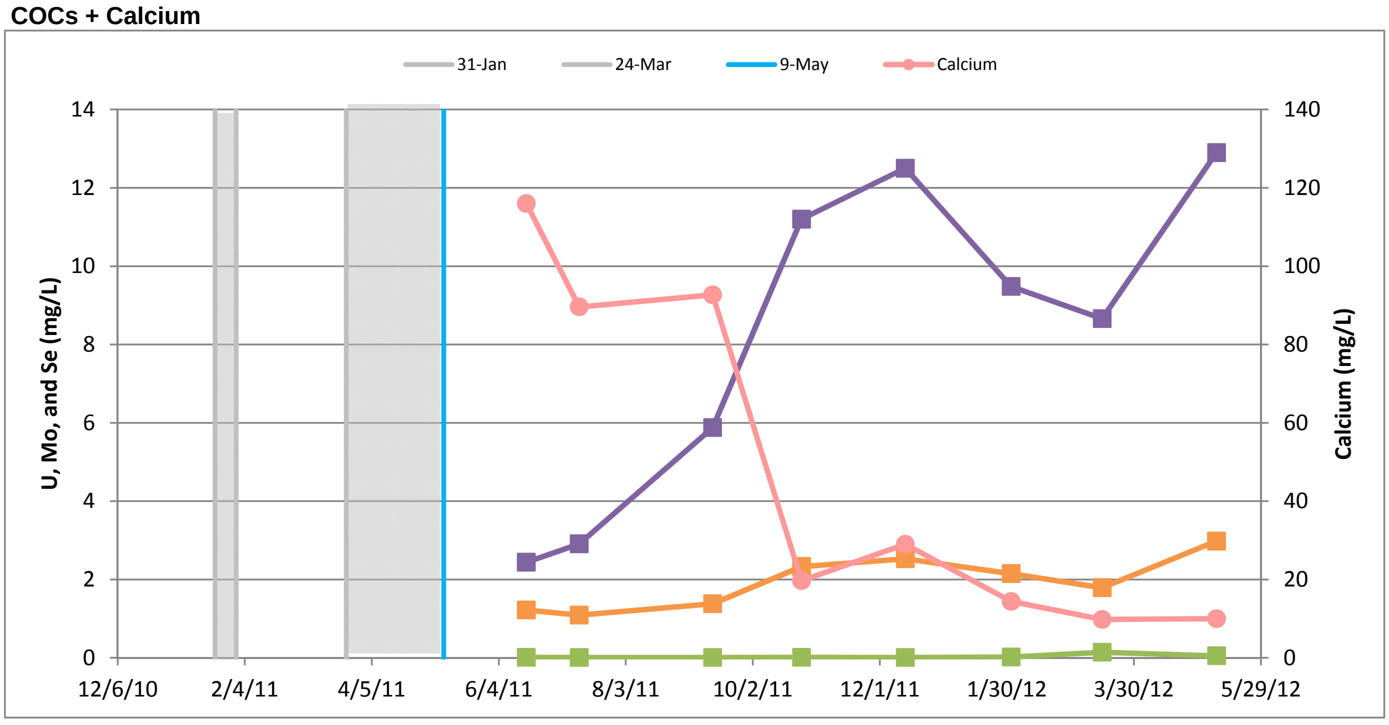


Historic Data

Date	DTW (ft BTOC)
5/16/08	38.55
5/17/08	38.55
2/22/09	32.79
2/22/09	32.79
4/10/10	32.98
10/8/10	35
3/4/11	30.65

No background concentration of SF_6.

COCs + Calcium

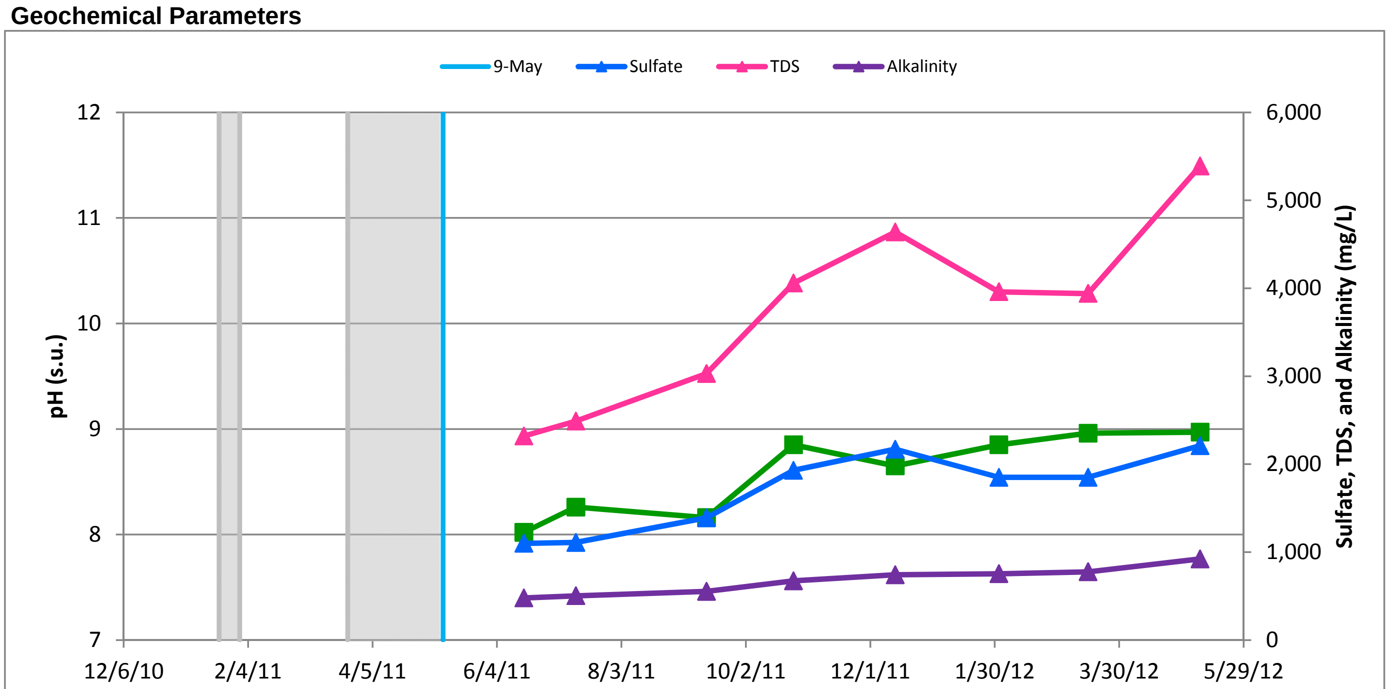


Historic Data

Date	U (mg/L)	Mo (mg/L)	Se (mg/L)
5/17/08	1.37	7.37	0.05
2/22/09	0.795	2.58	0.011
4/10/10	0.903	1.26	<0.005
10/8/10	0.844	0.97	<0.005

Date	Calcium (mg/L)
5/17/08	10.8

Geochemical Parameters



Historic Data

Date	pH (s.u.)	Alkalinity (mg/L)
5/17/08	9.21	623

Date	Sulfate (mg/L)	TDS (mg/L)
5/17/08	1620	3350
2/22/09	1000	2260
4/10/10	884	1890
10/8/10	826	2220

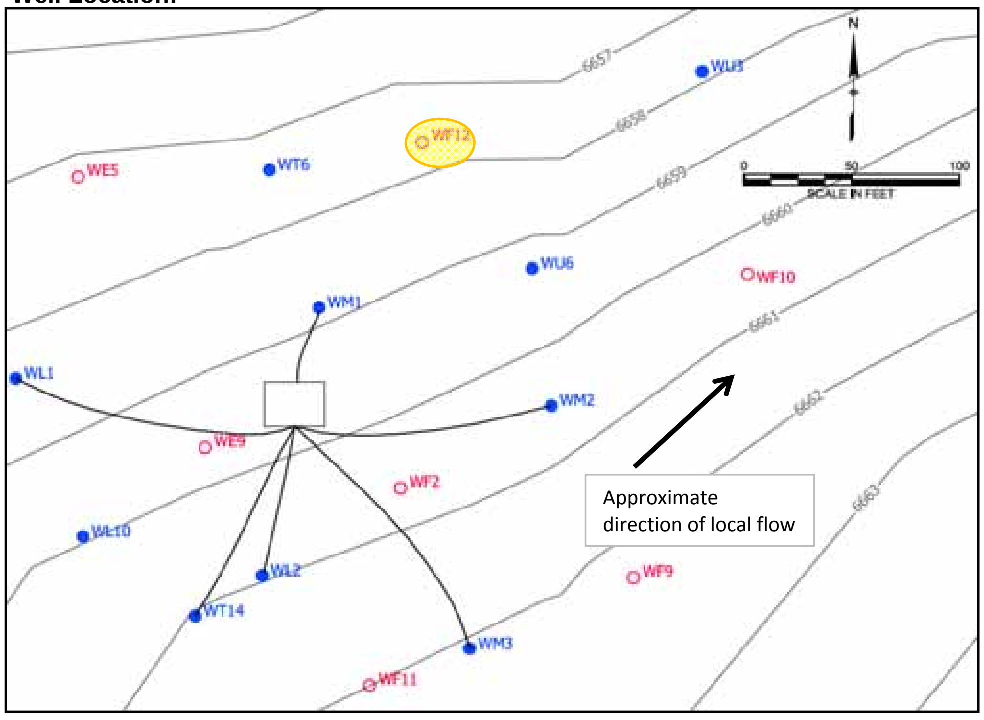
Rebound Evaluation At-A-Glance Charts

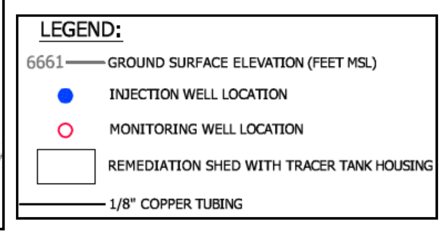
Updated May 30, 2012

Well ID: WF12

Most recent data: May 8, 2012

Well Location:





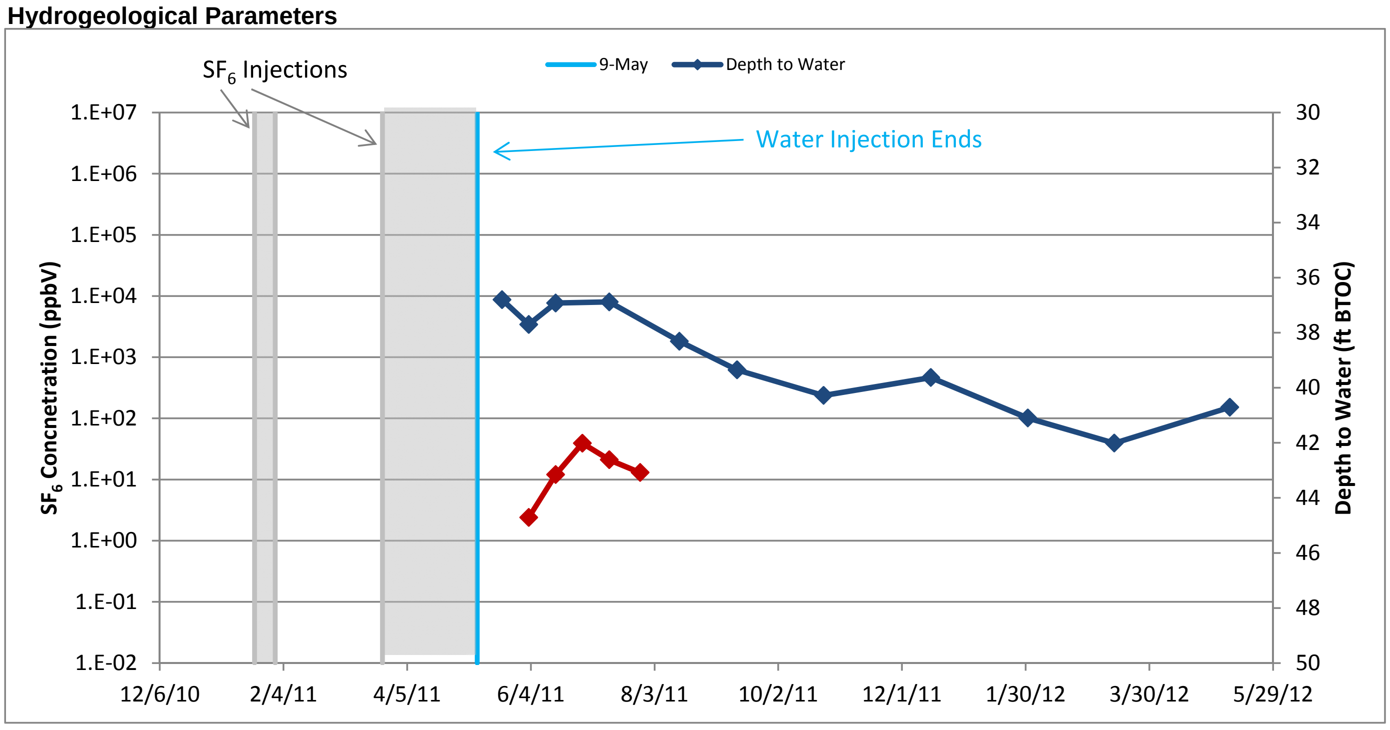
Well Construction Details:

Depth	Screened Interval	Diameter	TOC Elevation	TOC Stickup
116 ft	36 - 116 ft	5 in	6655.65 ft MSL	3.26 ft

Notes:

PD Sampler Deployment at 40, 60, and 80 ft BTOC

Hydrogeological Parameters

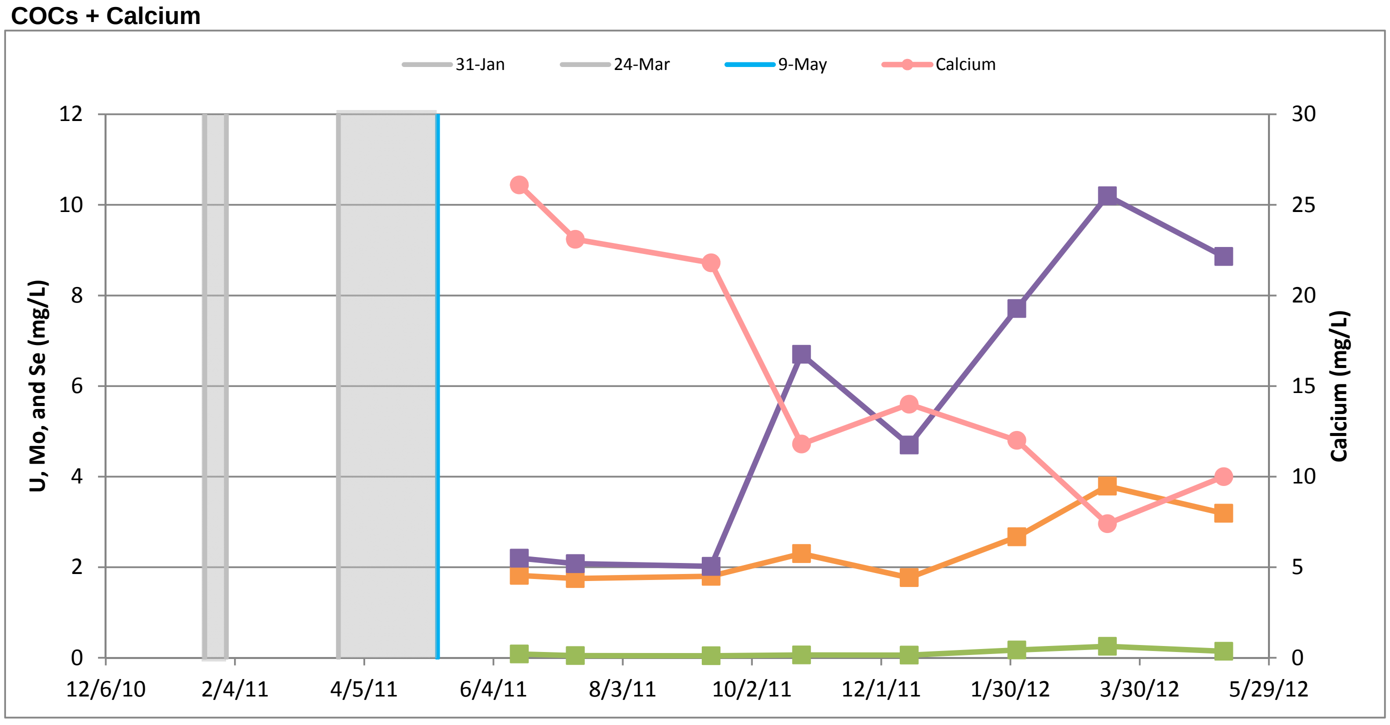


Historic Data

Date	DTW (ft BTOC)
7/16/08	45.4
7/8/09	51.94
8/6/09	42.6
9/2/09	38.23
6/11/10	38.48
8/9/10	37.8

No background concentration of SF_6.

COCs + Calcium

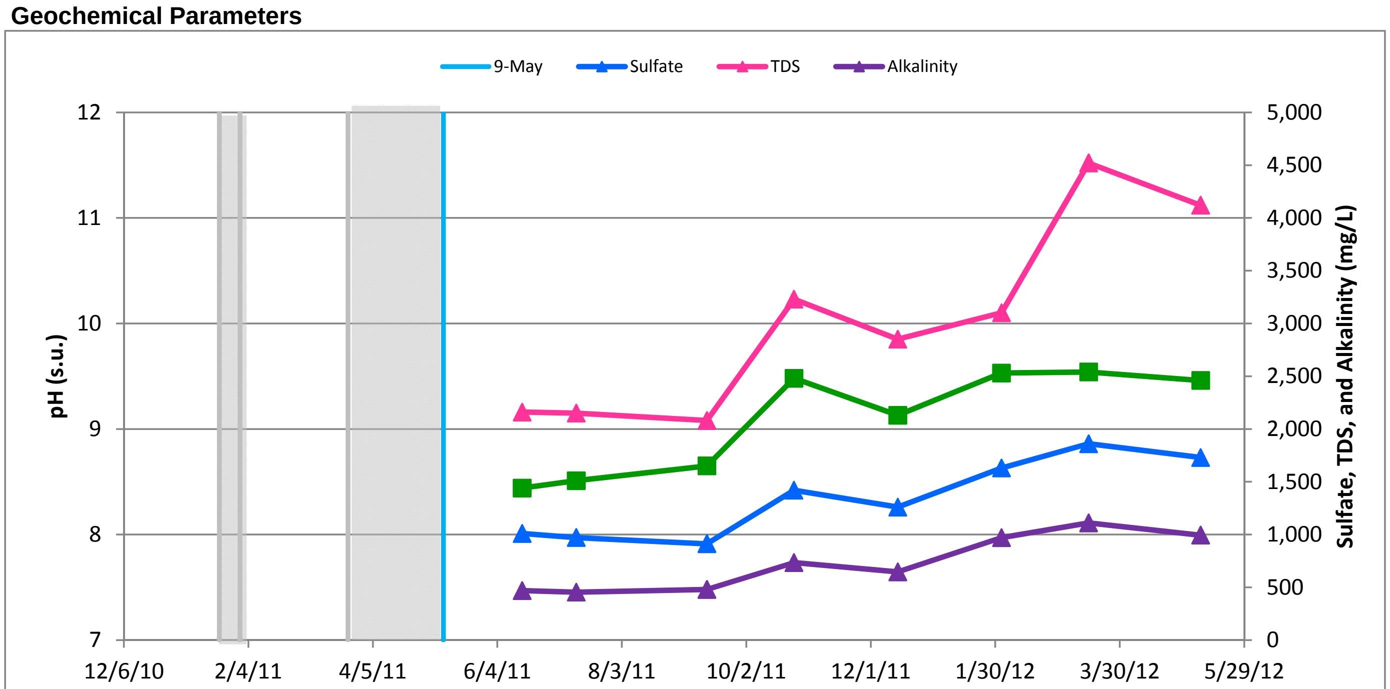


Historic Data

Date	U (mg/L)	Mo (mg/L)	Se (mg/L)
1/14/09	7.37	10.2	0.255
9/13/09	3.41	3.49	0.319
5/4/10	1.56	1.31	0.112

Date	Calcium (mg/L)
1/14/09	19.4

Geochemical Parameters



Historic Data

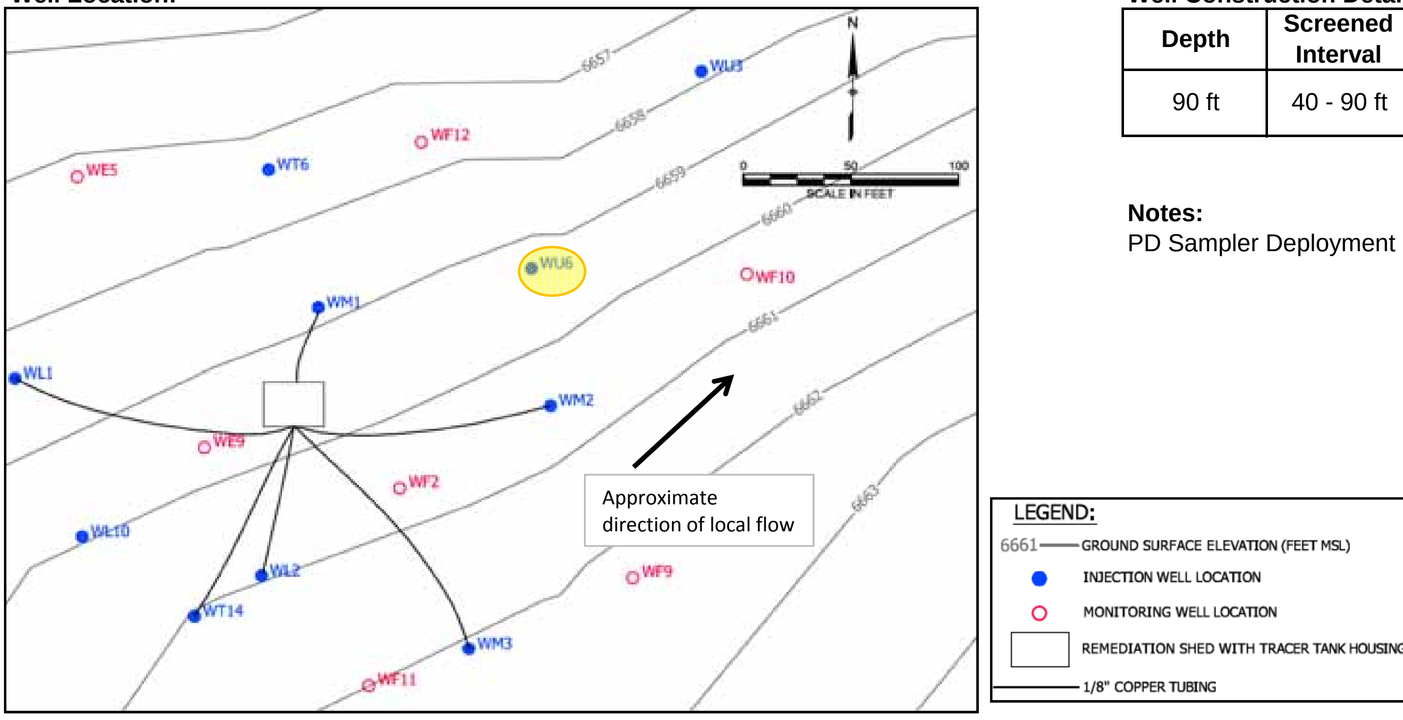
Date	pH (s.u.)	Alkalinity (mg/L)
1/14/09	8.9	681

Date	Sulfate (mg/L)	TDS (mg/L)
1/14/09	1700	3730
9/13/09	1060	2290
5/4/10	862	1910

Rebound Evaluation At-A-Glance Charts
Well ID: WU6

Updated May 30, 2012
Most recent data: May 8, 2012

Well Location:

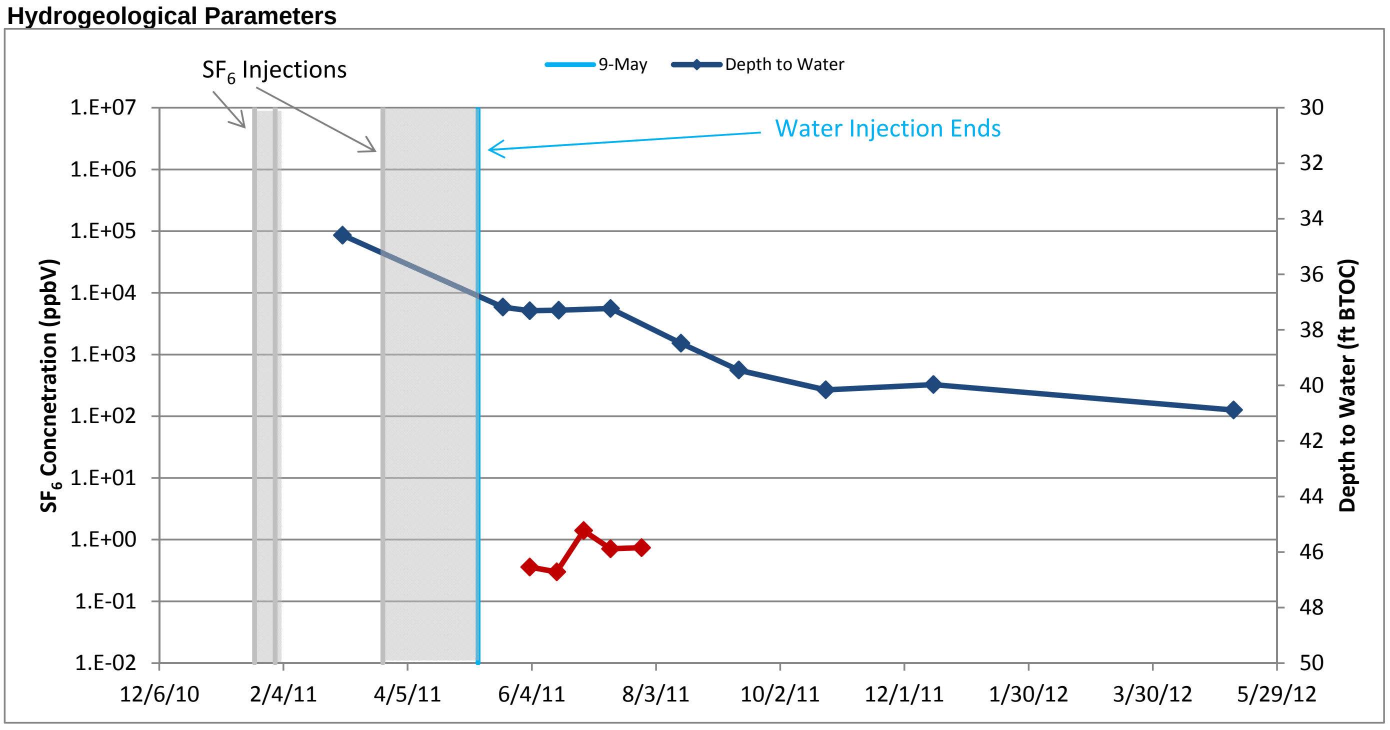


Well Construction Details:

Depth	Screened Interval	Diameter	TOC Elevation	TOC Stickup
90 ft	40 - 90 ft	2 in	6661 ft MSL	2

Notes:
PD Sampler Deployment at 40, 60, and 80 ft BTOC

Hydrogeological Parameters

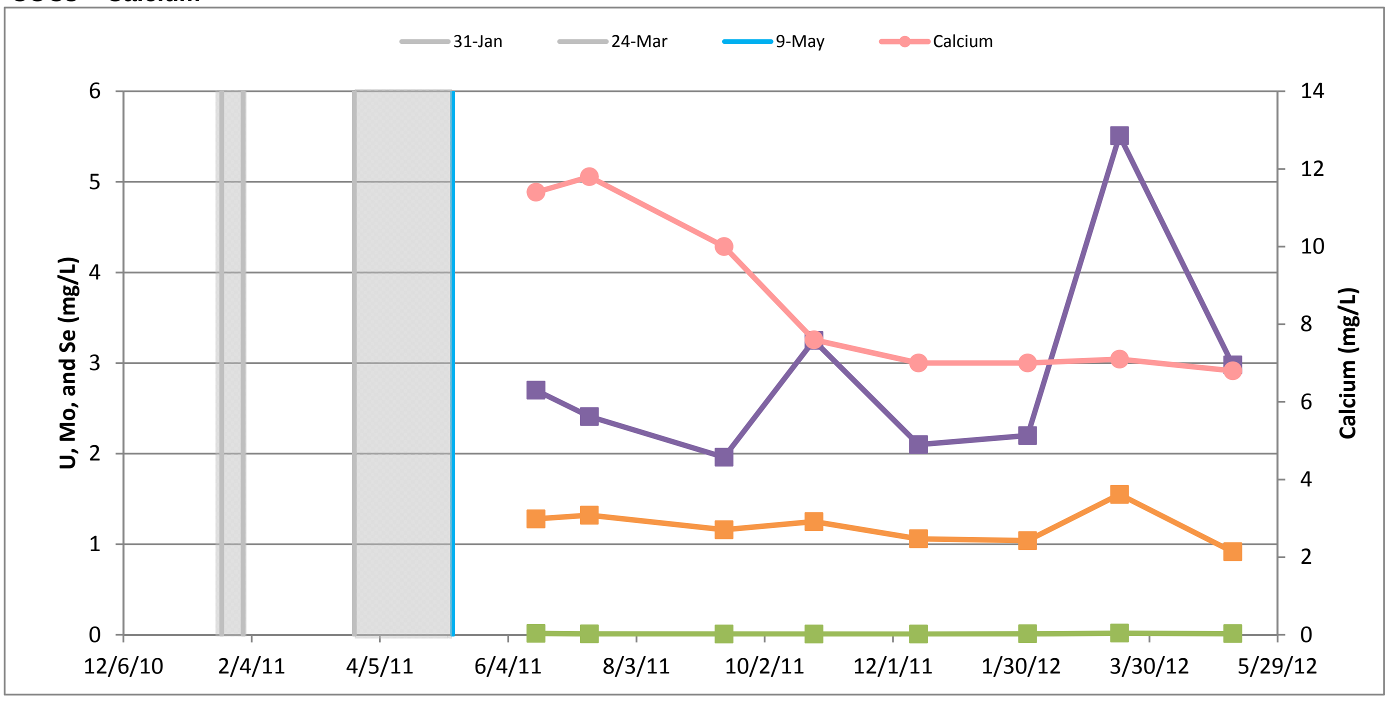


Historic Data

Date	DTW (ft BTOC)
5/16/08	40.8
5/16/08	40.8
2/22/09	37.47
4/10/10	37.33
10/7/10	38.4
3/4/11	34.59

No background concentration of SF_6.

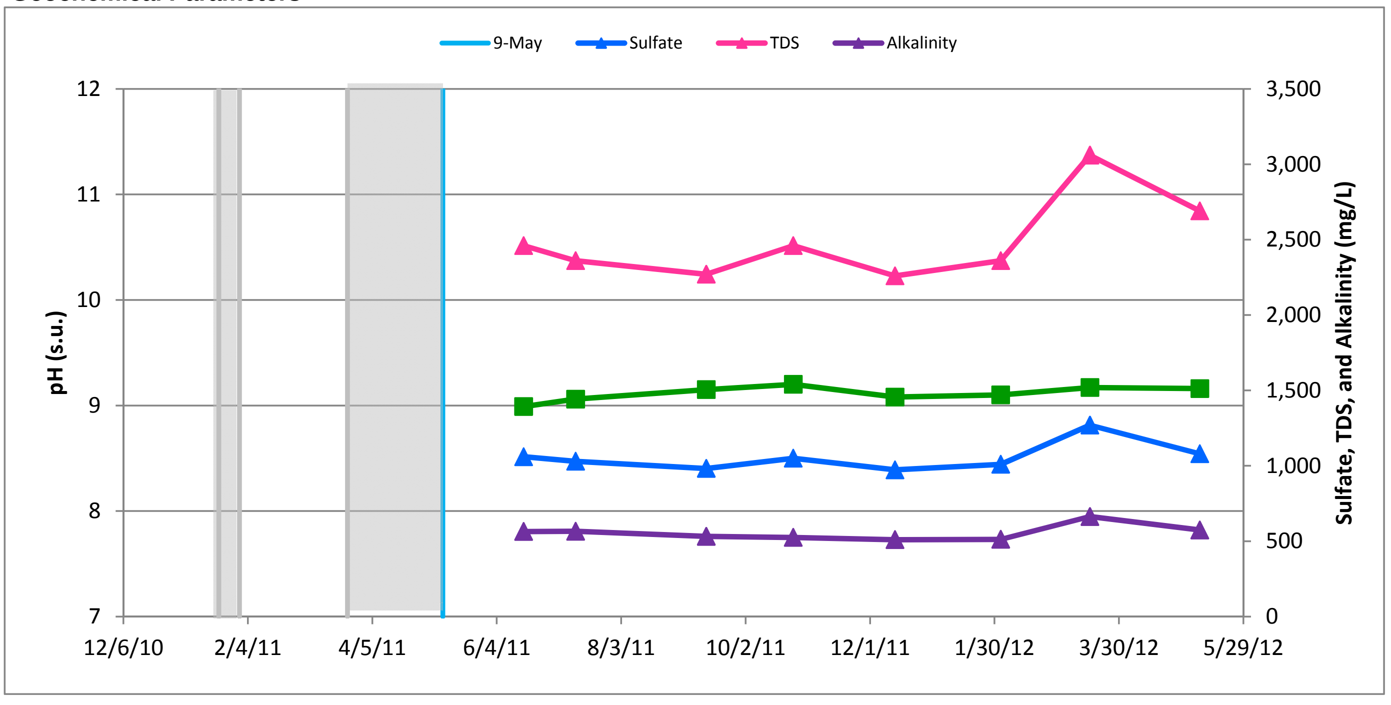
COCs + Calcium



Historic Data

Date	U (mg/L)	Mo (mg/L)	Se (mg/L)
5/16/08	5.63	21.9	0.021
2/22/09	2.01	7.55	<0.005
4/10/10	1.5	5.04	0.007
10/7/10	1.54	3.88	0.009

Geochemical Parameters



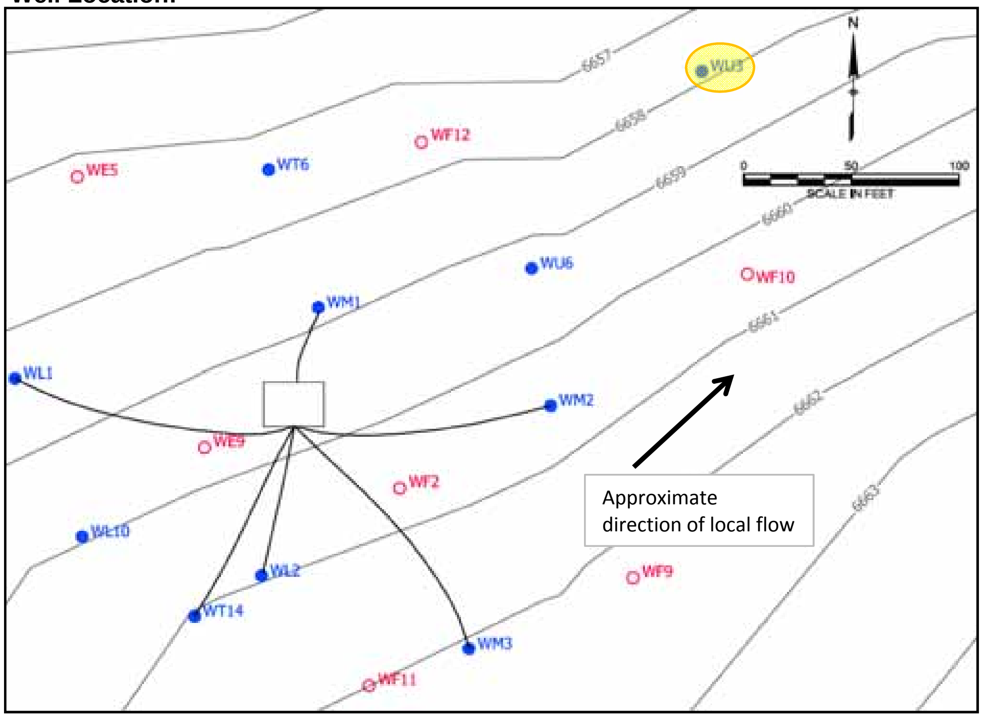
Historic Data

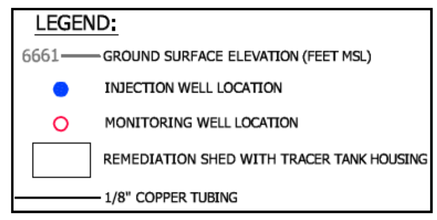
Date	Sulfate (mg/L)	TDS (mg/L)
5/16/08	3110	6260
2/22/09	1600	3560
4/10/10	1210	2810
10/7/10	1070	2570

Rebound Evaluation At-A-Glance Charts
Well ID: WU3

Updated May 30, 2012
Most recent data: May 9, 2012

Well Location:



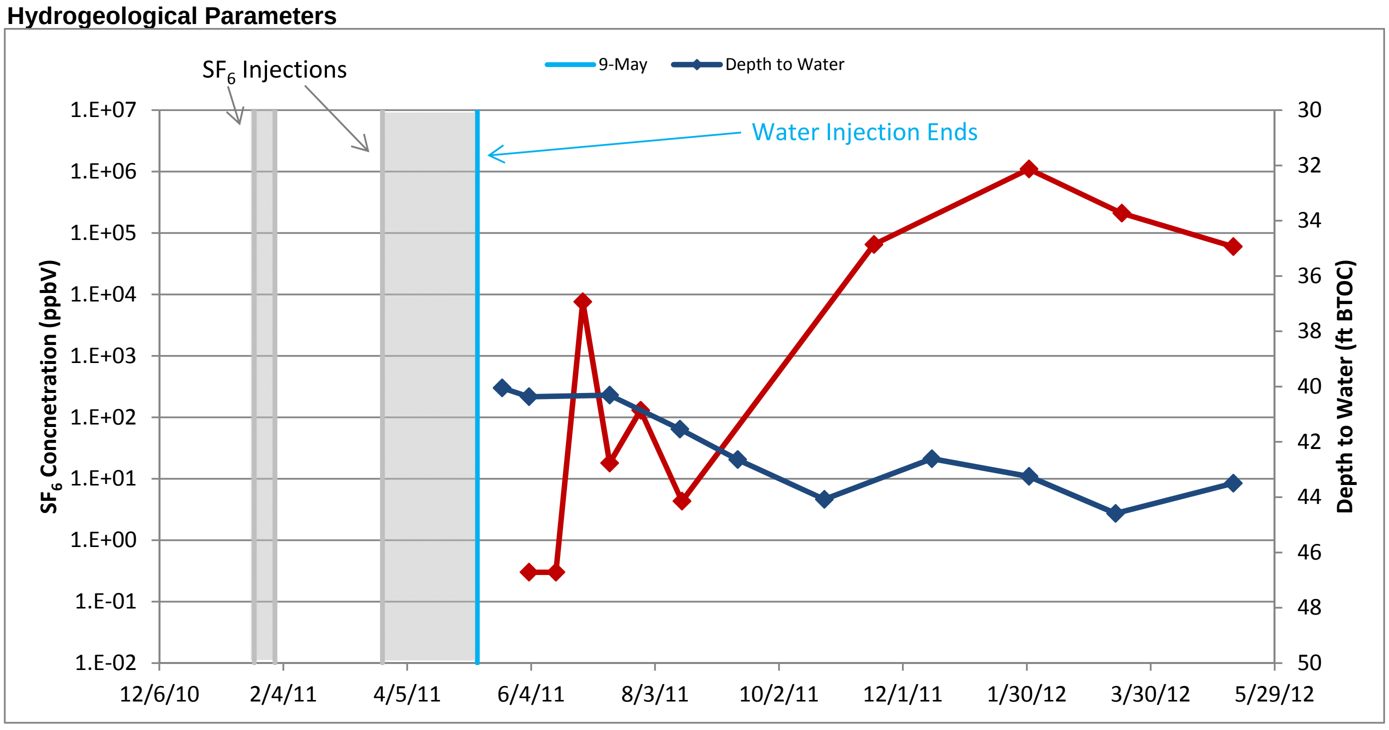


Well Construction Details:

Depth	Screened Interval	Diameter	TOC Elevation	TOC Stickup
90 ft	40 - 90 ft	2 in	6661 ft MSL	(flush)

Notes:
PD Sampler Deployment at 40, 60, and 80 ft BTOC

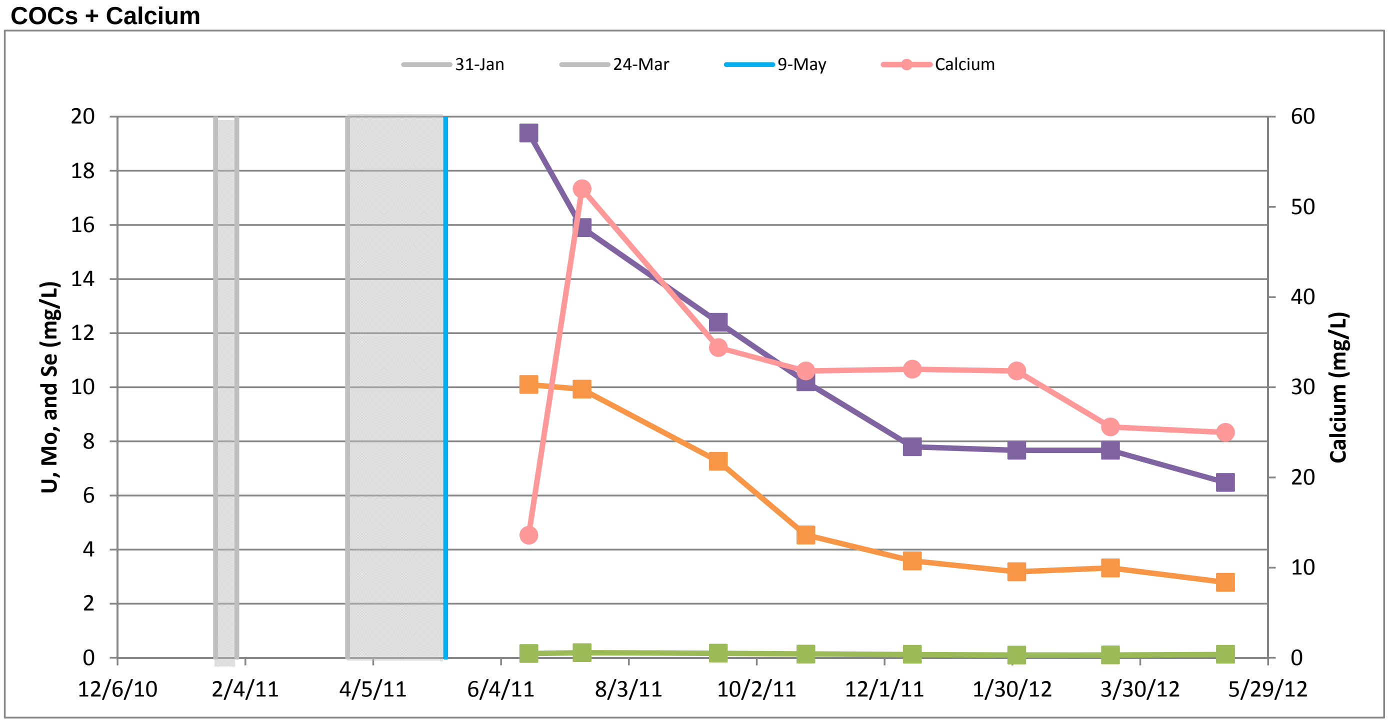
Hydrogeological Parameters



Historic Data - none

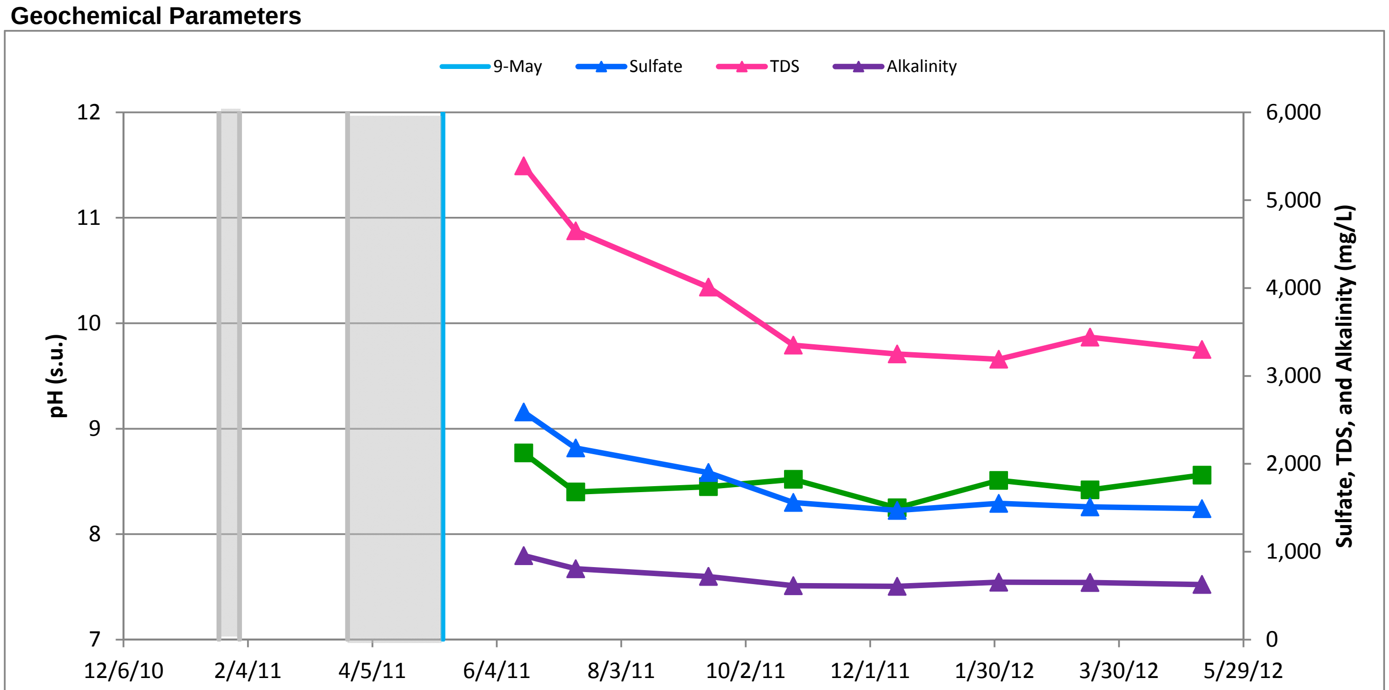
No background concentration of SF_6.

COCs + Calcium



Historic Data - none

Geochemical Parameters

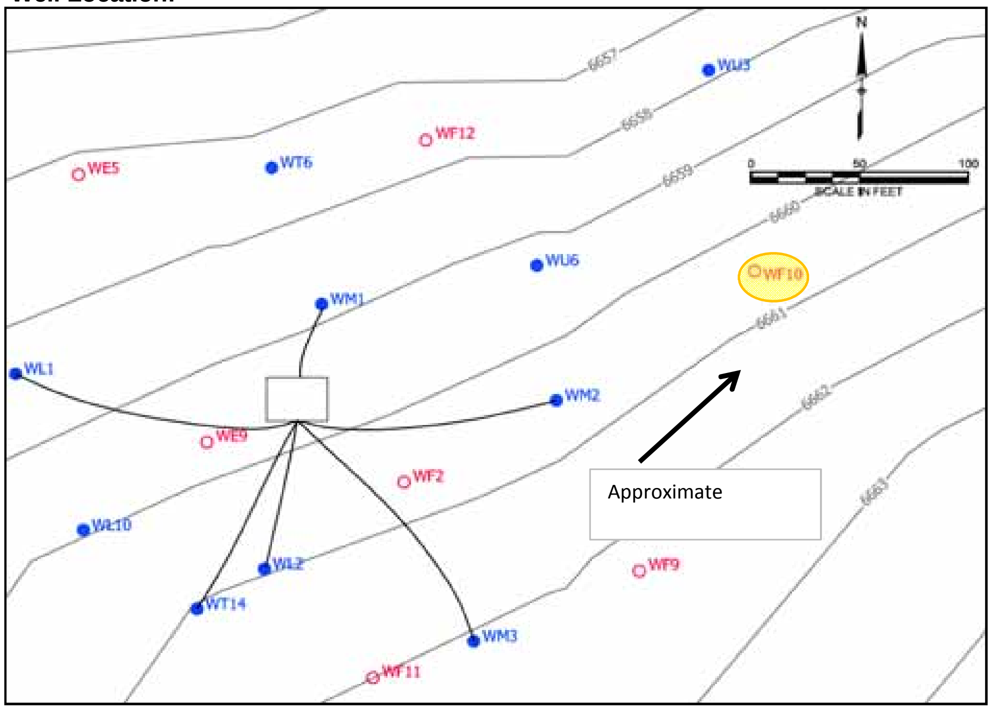


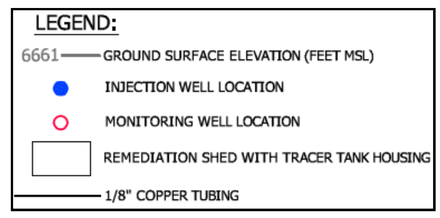
Historic Data - none

Rebound Evaluation At-A-Glance Charts
Well ID: WF10

Updated May 30, 2012
Most recent data: May 9, 2012

Well Location:



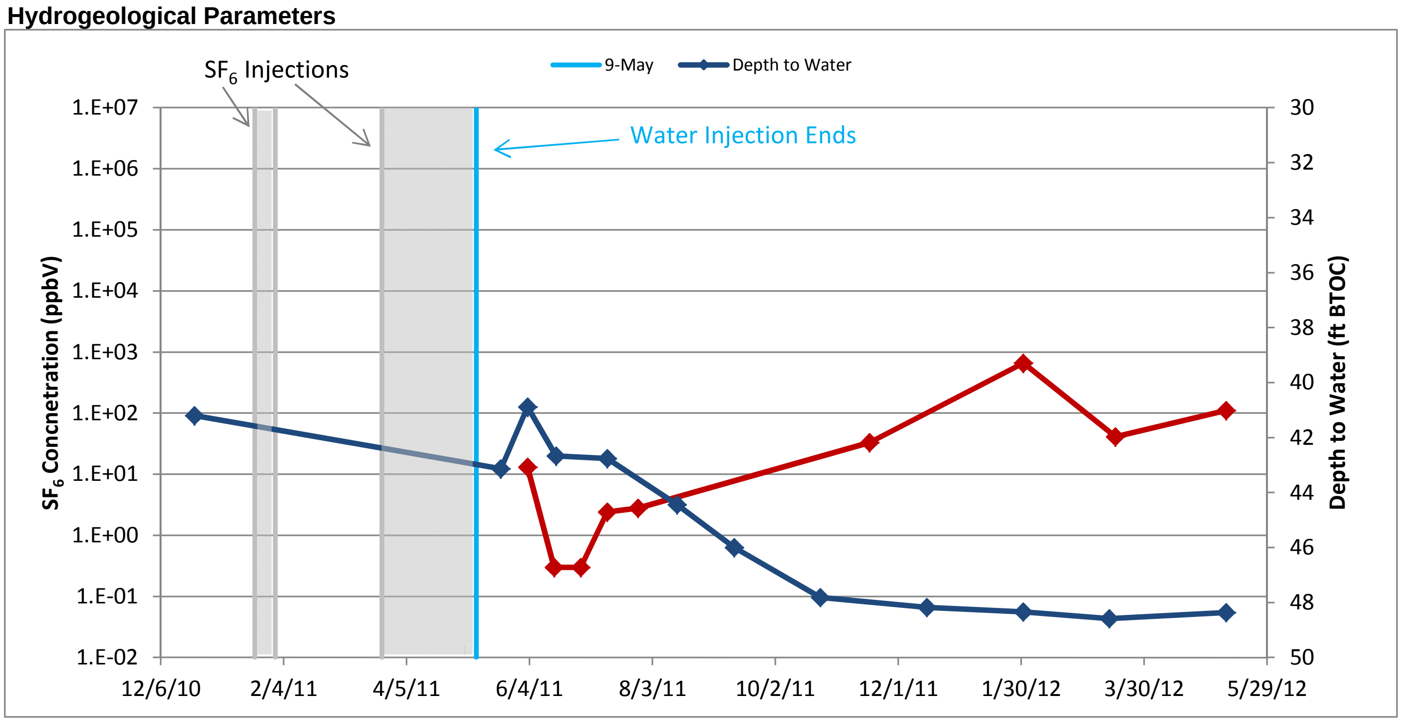


Well Construction Details:

Depth	Screened Interval	Diameter	TOC Elevation	TOC Stickup
116 ft	36 - 116 ft	5 in	6663.39 ft MSL	3.08 ft

Notes:
PD Sampler Deployment at 40, 60, and 80 ft BTOC

Hydrogeological Parameters

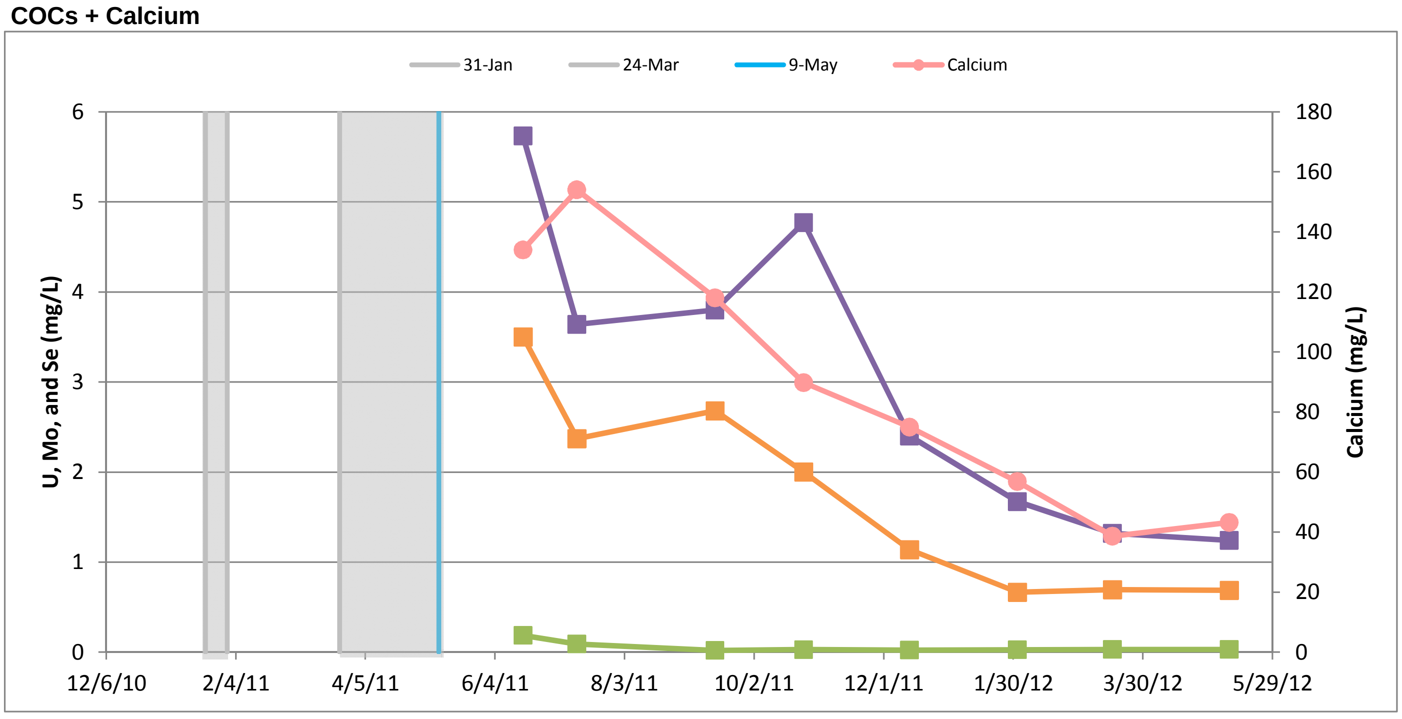


Historic Data

Date	DTW (ft BTOC)
7/16/08	46.7
8/23/08	47.11
2/22/09	44
2/24/09	44.2
7/8/09	50.79
8/6/09	47.46
10/29/09	42.8
4/10/10	43.5
6/11/10	42.4
8/9/10	43.03
12/22/10	41.2

No background concentration of SF_6.

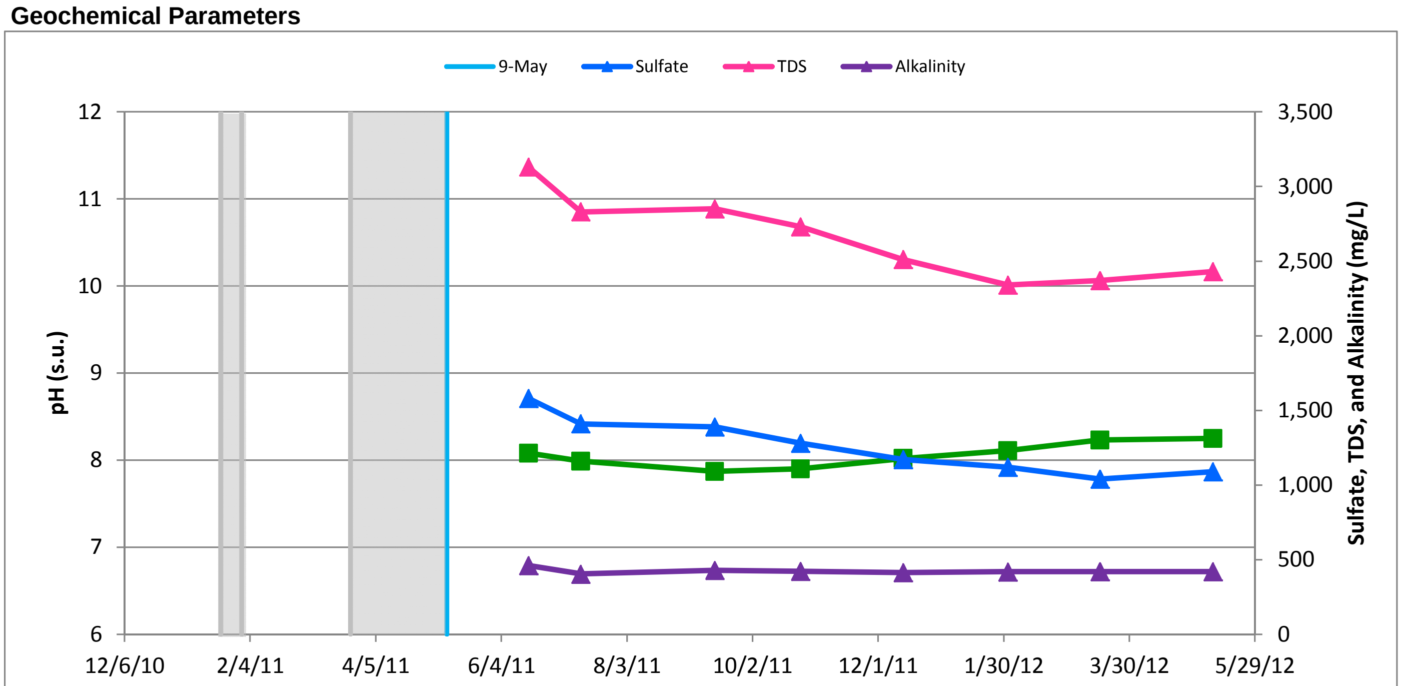
COCs + Calcium



Historic Data

Date	U (mg/L)	Mo (mg/L)	Se (mg/L)
4/21/09	1.94	2.03	0.13
5/13/09	9	9.82	0.564
5/4/10	3.84	7.84	0.438

Geochemical Parameters



Historic Data

Date	Sulfate (mg/L)	TDS (mg/L
4/21/09	1950	4150
5/13/09	1840	4010
5/4/10	1440	3150