Homestake Mining Company of California

HOMESTAKE
Grants Project

Jesse R. Toepfer
Closure Manager

21 August 2014

Mr. David Mayerson
Ground Water Quality Bureau
New Mexico Environment Department
PO Box 5469
Santa Fe, NM 87502-5469

RE: Responses to NMED Comments received 25 June, 2014 regarding the 21 November 2013 submittal entitled, *"Update on treatment activities at Homestake"*

Mr. Mayerson:

On 25 June 2014, Homestake Mining Company of California (HMC) received comments from the New Mexico Environment Department (NMED) pertaining to HMC's *Update on Treatment Activities at Homestake* dated 21 November 2013.

HMC's responses to those comments (RTC) are enclosed. For reference, NMED's letter of 25 June 2014 is enclosed as Attachment 1.

Thank you for your time and attention on this matter. If you or anyone on your staff has any questions, please contact me at the Grants office at 505.287.4456, extension 34, or call me directly on my cell phone at 505.290.3067.

Respectfully,

JRT kφ

Jesse R. Toepfer
Closure Manager
Homestake Mining Company of California
Office: 505.287.4456 x34 | Cell: 505.290.3067

Copy To:

Mr. Jack Parrott, US Nuclear Regulatory Commission – Rockville, Maryland
Mr. Sai Appaji, US Environmental Protection Agency, Region 6 – Dallas, Texas
Mr. Wayne Canon, New Mexico Office of the State Engineer – Albuquerque, New Mexico
Mr. Bill Ferdinand, Barrick Gold – Salt Lake City, Utah
Mr. Patrick Malone, Barrick Gold – Salt Lake City, Utah
Ms. Deborah Barr, US Department of Energy, Office of Legacy Management – Grand Junction, Colorado

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HOMESTAKE MINING COMPANY OF CALIFORNIA

Grants Reclamation Project

Responses to NMED Comments Regarding Homestake's November 2013 "*Update on Treatment Activities*"

Submitted On:
21 August 2014

Submitted To:
New Mexico Environment Department

Submitted By:
Homestake Mining Company of California

Response to Comments (RTC)
Update on treatment activities at Homestake
Prepared 8/5/2014

Comment #	Section(s)	Comment	Response
1	Microfiltration Pilot	The report states that eight weeks of pilot testing indicate that low-pressure membrane technology would accomplish the stated objectives for increasing reverse osmosis efficiency and throughput. However the report does not provide operational details for the pilot testing process, such as the range of water quality parameters that were tested, and the relationship between water quality and expected membrane regeneration periodicity. In addition to the information on water quality and expected regeneration periodicity, please provide additional details about the regeneration cycle, including but not limited to, any chemical used in the regeneration process and the waste stream quantity, quality and disposal mode.	Please see attached Microfiltration Pilot Study Report (Attachment 2) that provides the information requested above.
2, 3	Rebound Evaluation	The HMC RTCs are provided for this activity below under comments for the "Rebound evaluation summary report" (Enclosure 4), with which this activity is associated.	See comments 15-18 below.

Comment #	Section(s)	Comment	Response
4	Tripolyphosphate Pilot Testing	NMED notes that Homestake has stated its expectation to submit a final report on this activity in the near future. The report should address possible reasons why the cited preliminary test results indicate a wide range of effectiveness between the X-area (e.g., 96% reduction of uranium concentrations to below site standard) and the S-Area (e.g., 58% reduction of uranium concentrations, which resulted in uranium concentrations remaining above site standards), and if or how the process might be managed for us in light of this discrepant performance. Additionally, a thorough analysis of long-term process stability under the possible range of site-specific hydrochemical conditions will be critical to possible future acceptance of this technology for full-scale implementation within site-impacted ground water aquifers. Finally Homestake should analyze whether the increased arsenic concentrations that are cited as resulting from this activity, as well as potentially increased chloride concentrations from use of calcium chloride injectate, would still remain within site standards in full-scale implementation.	The difference in uranium treatment observed between the S and X Areas is discussed in **Sections 5.2 and 5.3** of the *TPP Alluvial Pilot Testing Summary Report* (TPP Summary Report; ARCADIS 2014) that was submitted to NMED on July 3, 2014. The distribution of the TPP solution is retarded in the subsurface due to sorption and various precipitation reactions (retardation of TPP in the aquifer is advantageous because it is the means by which an "in situ reactive treatment zone" can be established in the aquifer). In the X Area, the retardation was increased by the presence of finer-grained materials (of lower permeability), resulting in a radius of influence that did not reach the dose response monitoring wells. Thus, the changes in water quality (i.e., reduction in uranium concentration) were much lower relative to the S area where breakthrough of phosphate was observed at dose response monitoring wells. However, the injection well in the X Area showed comparable treatment to the S Area (e.g., peak uranium treatment at 99% after washout of the injection solution), confirming greater treatment within the achieved radius of influence. This difference in retardation and the achievable distribution is an important consideration for continued application of the technology – the design (well spacing and injection volumes) of a

Comment #	Section(s)	Comment	Response
4 *(Continued)*	Tripolyphosphate Pilot Testing		transect of injection points to create a "barrier" will ensure complete lateral distribution between the points. This important design consideration is discussed further in **Section 6** of the report. The uranium-phosphate precipitates that form during TPP injection have very low solubility under ambient aquifer conditions (Wellman et al. 2005). Additionally, the oxidation state of uranium is not changed during the application of the technology, which limits the possibility of uranium re-oxidation and remobilization. Thus, the phosphate precipitates are likely to be highly stable in the alluvial aquifer. One of the primary objectives of the TPP Pilot Testing is to evaluate this long-term stability (**Section 5.3**). In the S Area, dissolved uranium concentrations remained below the site standard six months after injection, with maximum uranium treatment observed at 182 days post-injection at two downgradient locations, while other signatures of the injection solution (e.g., conservative tracers) confirm the washout of injection solution and return of upgradient groundwater. This supports the stability and the residual treatment capacity of the precipitates in the S Area. Additionally, push pull testing was used to assess remobilization of uranium phosphate mineral precipitates that formed as a result of TPP

Comment #	Section(s)	Comment	Response
4 *(Continued)*	Tripolyphosphate Pilot Testing		treatment. Push pull tests utilized low-uranium site groundwater as well as low-uranium site groundwater blended with reverse osmosis-treated water, representing inflow by ambient, uranium-free groundwater and hydraulic-control injectate, respectively. Release of uranium and phosphate from dissolution of emplaced minerals was insignificant during this test (**Section 5.3.2** and **Appendix C** of the TPP Summary Report). Thus, it was concluded that uranium precipitated within the treatment zone is highly stable under a range of representative long-term alluvial geochemical conditions. Secondary geochemistry effects are discussed in **Section 5.4** of the TPP Summary Report (ARCADIS 2014). As expected, arsenic concentrations temporarily increased above baseline values in the dose-response wells due to the displacement of naturally-occurring arsenic by phosphate from mineral surfaces. Despite this increase in arsenic concentration within the radius of influence, the concentration attenuated to at or below the MCL by the next downgradient monitoring points (10 feet further downgradient). Additionally, one month after the injections concluded, arsenic concentrations in the dose-

Comment #	Section(s)	Comment	Response
4 *(Continued)*	Tripolyphosphate Pilot Testing		response wells decreased. These results confirm that any arsenic liberated through the application of this technology would be temporary and limited to the areas immediately proximal to the injection wells. As discussed in **Section 5.2** of the TPP Summary report, increases in chloride and total dissolved solids (TDS) occurred concurrently with other signatures of the injection solution. However, the concentrations of TDS and chloride have returned to near baseline values in all wells at 180 days post injection and, similar to arsenic, attenuate downgradient of the injected radius of influence. In terms of full-scale implementation, chloride and TDS concentration increases can be minimized by less reliance upon added calcium chloride for uranium treatment and more reliance upon the naturally-occurring calcium in the alluvial groundwater. Lower concentrations of calcium chloride, limited use of this reagent, and elimination of this reagent altogether is possible in full-scale implementation and this will be further evaluated in additional pilot testing. At full-scale, and based upon data discussed above, arsenic concentration increases will be short-lived and limited in aerial extent, with increases in concentration confined to within the injection-well network.

Comment #	Section(s)	Comment	Response
5	Sitewide water balance tool	Please provide additional information about the scope of this tool, including but not limited to whether this will provide better quantification of injection and extraction activities into contaminated aquifers throughout the site.	The current version of the Site Water Balance Tool (Tool) consists of inter-connected Excel spreadsheets that allow HMC the ability to summarize the primary water and brine movements throughout the site. The Tool was developed to evaluate water/brine flows throughout the site and to estimate the associated contaminant loading. The Tool may be used to support HMC decision-making by providing a concise graphical output of the overall site. A snapshot of this graphical output was included in the *Corrective Action Program* (HMP 2012) to depict annual average water/brine flows across the site. Additionally, per discussions with NMED that took place on July 8, 2014, HMC will carbon copy NMED on the monthly State Engineer reports, which provide details of HMC's diversionary and consumptive water use throughout the site.
6	Corrective Action Plan	NMED has previously provided comments to the NRC on the 2012 updated Corrective Action Plan.	HMC acknowledges that NMED has provided comments to the NRC on the 2012 updated Corrective Action Program.

Comment #	Section(s)	Comment	Response
7	Decommissioning and Reclamation Plan	NMED has previously provided comments to the NRC on the 2013 Decommissioning and Reclamation Plan.	HMC acknowledges that NMED has provided comments to the NRC on the 2013 Decommissioning and Reclamation Plan.
8	Electric (sic)-coagulation pilot study test and results	Although page numbers are referenced in the Table of Contents, these are not included in the report.	HMC agrees that in the submittal delivered to the agency page numbers are referenced in the Table of Contents, but not included in the report. Upon request from NMED, HMC will provide a standalone version of the report under separate cover with numerically identified pagination.
9	Electric (sic)-coagulation pilot study test and results	The stated purpose of the aeration process step was to ensure "that redox conditions were optimized for uranium and molybdenum removed during EC…>5 mg/L dissolved oxygen;" however no data are presented to evaluate whether the aeration produced the desired optimal redox conditions.	While EC remains a potentially viable treatment technology, it would require several more months and the commitment of other site resources to prove it effective. HMC has no immediate plans to pursue the EC technology further at the current time, but reserves the right to do so under the provisions of the new Draft Discharge Plan, DP-200. Accordingly, HMC agrees with NMED that such information would need to be evaluated if HMC does decide to pursue this technology further.

Comment #	Section(s)	Comment	Response
10	Electric (sic)-coagulation pilot study test and results	Although in the report text Table 1 is stated to show a hydrochemical comparison between "source waters from the treatability study to those for the demonstration," data are shown only for the demonstration influent.	Table 1 in the text is intended to illustrate the performance of the electrocoagulation pilot study with regard to its ability to remove the constituents of concern listed therein. The "treatability study" referred to in the text (as well as in NMED's comment), refers to previous testing that was done prior to the pilot study; Table 1 is not, and was not, intended to compare the water quality results of that prior study to those of the subject pilot study. The text in question wherein Table 1 is introduced merely informs the reader that such a first step was taken; the introduction of Table 1 in the text is meant to point the reader to the influent water quality data for the pilot study, not the treatability study. The purpose of comparing the water quality of the influent water used during the pilot study to that of the prior treatability study was to ensure the proper operational parameters (e.g., pH, residence time, resin selection, etc.) were considered prior to running the subject pilot study. Water quality data is provided annually to NMED as required by the applicable provisions of Discharge Plan DP-200.

Comment #	Section(s)	Comment	Response
11	Electric (sic)-coagulation pilot study test and results	Both the text and Figure 6 include references to "M9" influent water; however this term is not defined in the report.	"M9" water refers to water that was piped in from Well M9, which is located just west of the southwestern corner of the large tailings pile. Well M9 is one of the collection wells for the RO Plant. This water was used for the electrocoagulation pilot study as it is the same water that reports to the RO Plant.
12	Electric (sic)-coagulation pilot study test and results	The captions for Figures 10 and 11 reference a "…reduction in ***sulfate***…due to the regeneration of vessel #1" (***emphasis added***); however the figures display data for molybdenum and selenium respectively.	The phrase, *"...reduction in sulfate... due to the regeneration of vessel #1"* in the captions of Figures 8, 10, and 11 is a reference to the discussion that was presented in the first paragraph of page 12, which states, "*...The data show each bed was loaded by adsorbed sulfate, uranium, molybdenum and selenium and released chloride (Figures 7, 8, 9, 10 and 11). As the beds became fully loaded, molybdenum was released due to preferential sulfate adsorption. However, uranium continued to be adsorbed due to its higher affinity to the resin than the sulfate.*" These captions were merely meant to further explain the performance trends observed during the running of the pilot study.

Comment #	Section(s)	Comment	Response
13	Electric (sic)-coagulation pilot study test and results	The report states that "the targeted iron dosage from the [electro-coagulation] process…was 35 mg/L" based upon the treatability study, in which the influent water that was tested has a molybdenum concentration of 1.17 mg/l. Although the magnitude of molybdenum concentration removal in the demonstration pilot study, for which the average influent molybdenum concentration was higher than for the treatability study (e.g., 2.20 mg/l), was similar to that achieved in the treatability study, data presented by Homestake in this report indicate that the overall success of the demonstration processes in reducing molybdenum concentrations to target remedial levels was extremely limited. The report also states that "for any given [molybdenum' content, a given [iron] co-precipitate concentration can be determined. Additionally, the report notes that "the cell lifetime was calculated to be 350,000 gallons per cell, lower than cell life averages in other EC applications…the need to generate enough iron to co-precipitate molybdenum decreased the [EC cell] lifetime significantly." Please provide additional information on what, if any, additional testing of iron concentration higher than the target 35 mg/l concentration was or will be performed to reduce molybdenum concentrations in light of the relationship to cell lifetime.	See response to Comment 9.

Comment #	Section(s)	Comment	Response
14	Electric (sic)-coagulation pilot study test and results	Appendix II (resin regeneration procedure) includes an asterisk (*) in the third step which is not defined further.	The asterisk (*) in question refers to the subsequent sentence, which explains that a *"...low flow rate is required to avoid excessive bed expansion."*
15	Rebound Evaluation Summary Report	Page 5 states that "[O]n May 9, 2011, all active flush in the Rebound Evaluation area...was discontinued." On page 4 it is stated that "[E]valuation of the dissolved gas tracer injections focuses on the second injection period from March 24 to May 9, 2011." Please comment on whether flushing activities that were ongoing throughout the second injection period in the Rebound Evaluation area possibly skewed the tracer gas transit times that were determined from the analyses of the passive diffusion samplers deployed in the associated monitoring wells.	It is possible that the pore water velocities within the tracer testing/ rebound evaluation vary during active injection period versus the "shutdown" period. The estimated pore water velocities derived from the tracer testing (3-5 ft/day) are estimated based on tracer arrival during the "shutdown" period which is more representative of advective flow transport rates and not flushing-induced rates which could be assumed to be greater. However, this variability is not anticipated to be significant relative to the variability inherent to the tracer testing and analytical methods nor does it change any of the rebound evaluation conclusions.

Comment #	Section(s)	Comment	Response
16	Rebound Evaluation Summary Report	NMED notes that tracer detection occurred in monitoring well WF11, which is located in an apparent upgradient or cross-gradient position relative to the injection wells, at approximately the same time and concentration as for the primary down-gradient monitoring wells. Please comment on potential reasons for this observation.	The arrival of tracer at all dose-response monitoring wells was strikingly comparable in magnitude and timing (**Figure 5 of *Rebound Evaluation Report*** (ARCADIS 2012)). This is likely due to the active injection overwhelming the advective flow regime resulting in a radial distribution from the injection points resulting in the arrival of tracer at WF11. After tracer injections, the slower washout rate observed at WF9 supports an advective flow direction of northeast based on interpretation of water levels presented on **Figures 7 through 9**. It should also be noted that due to the adaptive operation of the LTP flushing program, pore water flow directions can be variable in the LTP.
17	Rebound Evaluation Summary Report	The charts labeled "COCs + calcium" on the "At-a-glance" charts that comprise Attachment A each include time-series concentration plots for four analytes; however only the calcium line is labeled. Please submit corrected figures with appropriate labeling.	Revised "At-a-glance" are included as an Attachment 3.

Comment #	Section(s)	Comment	Response
18	Rebound Evaluation Summary Report	Please comment on why plots for some analytes in the "At-a-glance" charts for monitoring wells WF12 (one to two analytes), WT6 (one analyte), WF9 (one analyte), WF2 (one analyte) and possibly WE9 (one analyte) appear to have increasing concentration trend after the cessation of water injection. These observations may contradict the conclusion that "widespread rebound of key water quality parameters did not occur in the post-flushing regime established by the Rebound Evaluation shutdown" (page 11).	By way of review, the rebound evaluation was primarily focused on 4 locations: WE9, WF2, WF9, and WF11 due to the fact that these were within an area where ongoing flushing would be least likely to affect constituent concentrations. The evaluation was expanded to an additional 5 locations (WF10, WF12, WT6, WU3, and WU6) to the northeast of the area within which the primary 4 wells were located, however there was less control over the ability to isolate these 5 locations from ongoing flushing. The 4 primary locations, and 5 secondary locations, all showed stability or decreases in uranium concentrations, the key water quality parameter monitored during the evaluation. As noted in the comment, one parameter (molybdenum) did exhibit concentration fluctuations. At WE9, the molybdenum concentration increased from approximately 2.5 mg/L to almost 7 mg/L mid-way through the evaluation, then decreased back down to 2 mg/L. This location is furthest upgradient of the flow of water through the rebound evaluation area and locations WF2 and WF9 are sidegradient/downgradient of this location. Molybdenum is a very soluble oxyanion (as the molybdate anion (MoO_4^{2-})) under oxic conditions and at the elevated pH that is present in the LTP. It is likely than molybdenum desorbed or dissolved

Comment #	Section(s)	Comment	Response
18 *(Continued)*	Rebound Evaluation Summary Report		initially in response to a change in the hydraulic conditions within the monitoring well network (as shown by a temporary rise in concentrations at WE9 and subsequent decrease in concentration). This is the only analyte that exhibited this behavior, and an increase in molybdenum was detected further downgradient at WT6 and WF12 due to molybdenum moving downgradient through the well northern side of the well network after the initial dissolution reaction at WE9). Decreasing molybdenum concentrations were noted in WF11, WF10, WT6, WU3, and WU6 further supporting the conclusion that the increase in molybdenum concentrations at the 5 wells noted in the comment was not an indication of significant rebound.

References:

ARCADIS. 2012. Rebound Evaluation Summary Report. Prepared on behalf of Homestake Mining Company. December 17.

ARCADIS. 2014. TPP Alluvial Pilot Testing Summary Report. Prepared on behalf of Homestake Mining Company. July 3.

Homestake Mining Company. 2012. Grants Reclamation Project Updated Corrective Action Program. March.

Wellman, D.M., J.P. Icenhower, E.M. Pierce, B.K. McNamara, S.D. Burton, K.N. Geiszler, S.R. Baum, and B.C. Butler. 2005. Polyphosphate Amendments for In-Situ Immobilization of Uranium Plume. Proceedings of the Third International Conference on the Remediation of Contaminated Sediments. PNNL-SA-43638.

Attachments:

Attachment 1 NMED Comments regarding the Update on treatment activities at Homestake

Attachment 2 Microfiltration Pilot Study Report

Attachment 3 Rebound Evaluation At-A-Glance Charts

ARCADIS

Attachment 1

NMED Comments regarding the Update on treatment activities at Homestake

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CERTIFIED MAIL—RETURN RECEIPT REQUESTED

June 25, 2014

Jesse Toepfer, Closure Manager
Homestake Mining Company of California
P.O. Box 98
Grants, NM 87020

RE: **Homestake Mining Company of California uranium millsite/DP-200**— Comments from NMED's review of "Update on treatment activities at Homestake" (November 21, 2013)

Dear Mr. Toepfer:

The New Mexico Environment Department (NMED) herein provides comments on reports that Homestake Mining Company of California (Homestake) submitted under the above-referenced letter. As was discussed during our meeting of May 29, 2014, NMED will provide comments on the "300 GPM zeolite-based treatment system pilot test results," which comprises Enclosure 2, following submittal of a final report.

Enclosure 1—Progress summary

1. Microfiltration pilot

The report states that eight weeks of pilot testing indicate that low-pressure membrane technology would accomplish the stated objectives for increasing reverse osmosis efficiency and throughput. However the report does not provide operational details for the pilot testing process, such as the range of water quality parameters that were tested, and the relationship between water quality and expected membrane regeneration periodicity. In addition to the information on water quality and expected regeneration periodicity, please provide additional details about the regeneration cycle, including but not limited to, any chemicals used in the regeneration process and the waste stream quantity, quality and disposal mode.

2. LTP tracer testing

Comments are provided for this activity below under comments for the "Rebound evaluation summary report" (Enclosure 4), with which this activity is associated.

3. Rebound evaluation

Comments for this activity are provided below under comments for the "Rebound evaluation summary report" (Enclosure 4).

4. Tripolyphosphate pilot testing

NMED notes that Homestake has stated its expectation to submit a final report on this activity in the near future. The report should address possible reasons why the cited preliminary test results indicate a wide range of effectiveness between the X-area (*e.g.*, 96% reduction of uranium concentrations to below site standards) and the S-area (*e.g.*, 58% reduction of uranium concentrations, which resulted in uranium concentrations remaining above site standards), and if or how the process might be managed for use in light of this discrepant performance. Additionally, a thorough analysis of long-term process stability under the possible range of site-specific hydrochemical conditions will be critical to possible future acceptance of this technology for full-scale implementation within site-impacted ground water aquifers. Finally Homestake should analyze whether the increased arsenic concentrations that are cited as resulting from this activity, as well as potentially increased chloride concentrations from use of calcium chloride injectate, would still remain within site standards in full-scale implementation.

5. Sitewide water balance tool

Please provide additional information about the scope of this tool, including but not limited to whether this will provide better quantification of injection and extraction activities into contaminated aquifers throughout the site.

6. Corrective Action Program

NMED has previously provided comments to the NRC on the 2012 updated Corrective Action Plan.

7. Decommissioning and Reclamation Plan

NMED has previously provided comments to the NRC on the 2013 Decommissioning and Reclamation Plan.

Enclosure 3—Electric (*sic*)-coagulation pilot study test and results

Although page numbers are referenced in the Table of Contents, these are not included in the report.

The stated purpose of the aeration process step was to ensure "that redox conditions were optimized for uranium and molybdenum removal during EC...>5 mg/L dissolved oxygen;" however no data are presented to evaluate whether the aeration produced the desired optimal redox conditions.

Although in the report text Table 1 is stated to show a hydrochemical comparison between "source waters from the treatability study to those for the demonstration," data are shown only for the demonstration influent.

Both the text and Figure 6 include references to "M9" influent water; however this term is not defined in the report.

The captions for Figures 10 and 11 reference a "...reduction in ***sulfate***...due to the regeneration of vessel #1" (***emphasis added***); however the figures display data for molybdenum and selenium respectively.

The report states that "the targeted iron dosage from the [electro-coagulation] process...was 35 mg/L" based upon the treatability study, in which the influent water that was tested had a molybdenum concentration of 1.17 mg/l. Although the magnitude of molybdenum concentration removal in the demonstration pilot study, for which the average influent molybdenum concentration was higher than for the treatability study (*e.g.*, 2.20 mg/l), was similar to that achieved in the treatability study, data presented by Homestake in this report indicate that the overall success of the demonstration processes in reducing molybdenum concentrations to target remedial levels was extremely limited. The report also states that "for any given [molybdenum] content, a given [iron] co-precipitate concentration can be determined. Additionally, the report notes that "the cell lifetime was calculated to be 350,000 gallons per cell, lower than cell life averages in other EC applications...the need to generate enough iron to co-precipitate molybdenum decreased the [EC cell] lifetime significantly." Please provide additional information on what, if any, additional testing of iron concentrations higher than the target 35 mg/l concentration was or will be performed to reduce molybdenum concentrations in light of the relationship to cell lifetime.

Appendix II (Resin regeneration procedure) includes an asterisk (*) in the third step, which is not defined further.

Enclosure 4—Rebound evaluation summary report

Page 5 states that "[O]n May 9, 2011, all active flushing in the Rebound Evaluation area...was discontinued." On page 4 it is stated that "[E]valuation of the dissolved gas tracer injections focuses on the second injection period from March 24 to May 9, 2011." Please comment on whether flushing activities that were ongoing throughout the second injection period in the Rebound Evaluation area possibly skewed the tracer gas transit times that were determined from the analyses of the passive diffusion samplers deployed in the associated monitoring wells.

NMED notes that tracer detection occurred in monitoring well WF11, which is located in an apparent upgradient or cross-gradient position relative to the injection wells, at approximately the same time and concentration as for the primary down-gradient monitoring wells. Please comment on potential reasons for this observation.

The charts labeled "COCs + calcium" in the "At-a-glance" charts that comprise Attachment A each include time-series concentration plots for four analytes; however only the calcium line is labeled. Please submit corrected figures with appropriate labeling.

Please comment on why plots for some analytes in the "At-a-glance" charts for monitoring wells WF12 (one to two analytes), WT6 (one analyte), WF9 (one analyte), WF2 (one analyte) and possibly WE9 (one analyte) appear to have increasing concentration trends after the cessation of water injection. These observations may contradict the conclusion that "widespread rebound of key water quality parameters did not occur in the post-flushing regime established by the Rebound Evaluation shutdown" (page 11).

Please provide a response to these comments within 60 days of your receipt of this letter. Please contact me at (505) 476-3777 or by email at david.mayerson@state.nm.us if you should have any questions on this letter.

Sincerely

David L. Mayerson
Mining Environmental Compliance Section
Ground Water Quality Bureau
New Mexico Environment Department

ARCADIS

Attachment 2

Microfiltration Pilot Study Report

ARCADIS

Infrastructure · Water · Environment · Buildings

Imagine the result

Homestake Mining Company

Microfiltration Pilot Study Report

13 January 2014

ARCADIS

Microfiltration Pilot Study Report

Prepared for:

Homestake Mining Company

Prepared by:

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Tel 720 344 3500
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Date:

13 January 2014

Tables

Figures

Appendices

Acronyms and Abbreviations

CIP	Clean In Place
COCs	constituents of concern
EFM	Enhanced Flux Maintenance
gfd	gallons per square foot per day
gpm	gallons per minute
HMC	Homestake Mining Company
LTP	Large Tailings Pile
MF	Microfiltration
mg/L	milligrams per liter
mNTU	milli Nephelometric Turbidity Units
NTU	Nephelometric Turbidity Units
pCi/L	pico curies per liter

RO	Reverse Osmosis
RO WTP	Reverse Osmosis Water Treatment Plant
SCC	Solids Contact Clarifier
SDI	Silt Density Index
TMP	Transmembrane Pressure
UF	Ultrafiltration
WCP	West Collection Pond

1. Introduction

ARCADIS was contracted by the Homestake Mining Company (HMC) in June 2013 to conduct pilot testing of a microfiltration (MF) system in support of planned upgrades and expansion of the reverse osmosis water treatment system (RO WTP) at the Grants Mill Site in New Mexico. Improvement and expansion of RO WTP (1,200 gallons per minute (gpm) capacity) is central to the goal of site closure by 2020. Pilot testing was initiated on August 27, 2013 and conducted through November 23, 2013. Pilot testing goals included:

- Proof-of-Concept: confirm that MF is a viable long-term filtration technology option for the RO WTP.
- Full-Scale Design Parameters: establish design criteria for the full-scale equipment that will treat. 1,200 gpm including flux rate and cleaning regimes that promote greater than 30-day run time.
- Challenge Testing: evaluate the performance of MF under challenging operational conditions that included runs of more than 30 days and weekly enhanced flux maintenance (EFM) cleans.
- Blending Evaluation: assess the impact of blending on the characterization of water quality entering the solids contact clarifier (SCC), including large tailings pile (LTP), west collection pond (WCP), and alluvial groundwater.

The following sections present the approach to the pilot testing, results, and conclusions.

2. Approach

This section presents the pilot testing approach and includes a description of the MF equipment, pilot treatment process, and testing plan.

2.1.1 MF Pilot Equipment

ARCADIS worked with HMC to identify three of the top MF vendors for the RO WTP upgrade and expansion: Pall, General Electric/Zenon, and Siemens. Following a preliminary evaluation of the vendor systems, HMC selected the *Pall Aria MF* pilot unit based on pilot availability, flexibility in full-scale equipment arrangement (including skid, container, and trailer systems), and experience.

The characteristics of the Pall Aria MF pilot unit are presented in Table 2-2.

Table 2-1 MF Pilot Specifications

Item	Pall Aria
Type	Pressure MF
Module Model	UNA-620A
Membrane Area (ft^2)	538
Flow Pattern	Outside-In
Nominal Pore Size (microns or µm)	0.1
Membrane Material	Polyvinylidene fluoride (PVDF)
pH Tolerance	1 – 10
Maximum Transmembrane Pressure (pounds per square inch differential or psid)	43.5

2.1.2 Pilot Process Flow Diagram

ARCADIS preformed work at the HMC Project Site on July 24 and 25, 2013 to evaluate and assess how the MF pilot would be integrated into the existing RO WTP and to evaluate feed and discharge locations for all water streams. The feed water for the pilot was the SCC effluent from the full-scale RO WTP to mimic current water treatment conditions. This work resulted in the pilot system process flow diagram shown on Figure 2-1.

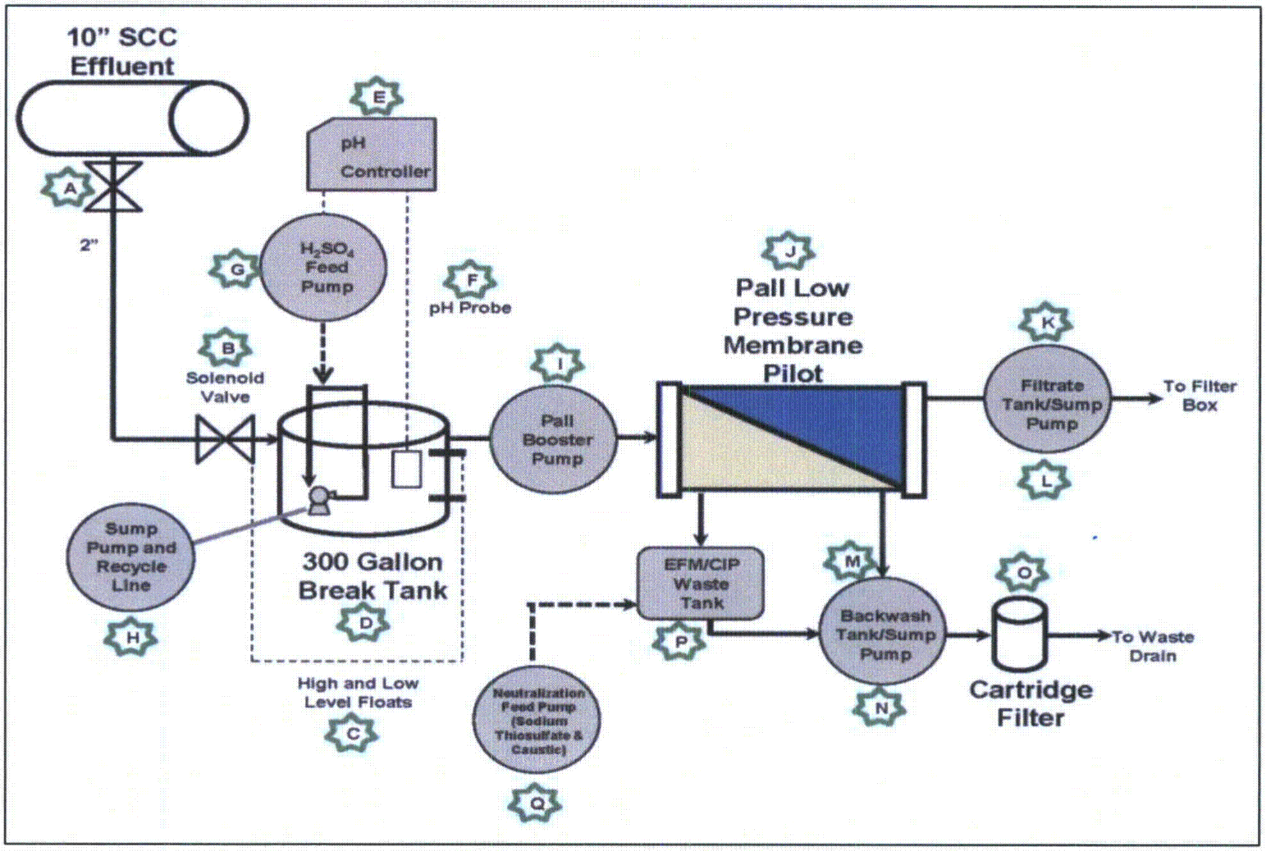

Figure 2-1 Pilot Testing Process Flow Diagram

2.1.3 Pilot Testing Plan

A testing plan was presented to HMC on August 16, 2013, titled "Low Pressure MF Membrane Pilot Testing Plan" (Testing Plan), which provided details on the pilot program. The pilot testing plan is located in Appendix A. The details included the schedule for the program, a water quality sampling and monitoring plan, and a description of the three phases of the pilot program:

1. Commissioning and Proof of Concept
2. Full-scale Design Operation
3. Supplemental/Challenge Testing

The three phases are discussed in detail in the Testing Plan. The schedule included anticipated dates of pilot commissioning/decommissioning, as well as implementation dates for each of the three phases. The

water quality sampling and monitoring plan included specifics on which parameters would be tested and the frequency at which they would be collected/tested.

3. Pilot Testing Results

The following section provides a summary and assessment of the pilot testing results.

3.1.1 Test Run # 1 & 2 Results

Two test runs were conducted during the three months of pilot testing. One of the key operational parameters that was evaluated throughout the MF pilot testing was the optimization of the MF flux. The flux of a MF system is defined as the amount of water transferred through the membrane surface per unit time and area (gallons per square foot per day (gfd)). Initially, based on discussions with Pall and source water quality, it was projected that the flux for testing would be set at 30 gfd. After the MF pilot operating for a brief period of time it was found that the flux was very conservative and the membranes would be able to meet the testing objectives at a much higher flux. A higher flux through the MF pilot allows for an increased flow through the membrane module, which ultimately results in fewer modules being required (reduced CAPEX) for a full-scale installation. A summary of duration and operational parameters for each test run, including flow through the pilot and the membrane flux is shown on Table 3-1.

Table 3-1 Pilot Testing Operational Parameters

Test Run	Duration (days)	Influent Flow (gpm)	Flux (gfd)
1	21	15	40
	15	17	45
2	38	17	45

3.1.1.1 Pilot Feed and Permeate Water Quality Results

Pilot feed and permeate samples were collected during test run # 1 and # 2 and shipped to Energy Laboratories (Casper, WY) for analysis. Analyses included the key constituents of concern (COCs) as well as several other key operational parameters as shown on Table 3-2.

Table 3-2 Feed and Permeate Water Quality

Location	Alkalinity (mg/L as CaCO3)	Calcium (mg/L)	Chloride (mg/L)	Magnesium (mg/L)	Sulfate (mg/L)	TOC (mg/L)	TDS (mg/L)	Iron (mg/L)	Manganese (mg/L)	Molybdenum (mg/L)	Selenium (mg/L)	Silica (mg/L)	Uranium (mg/L)	Vanadium (mg/L)	Combined Radium (pCi/L)
Pall Feed -Test Run # 1	997	–	426	–	3720	2.9	7160	<0.03	0.002	21.7	0.861	19.6	16.3	0.02	1.91
Pall Permeate – Test Run # 1	1090	–	422	–	3580	2.9	7000	<0.03	0.002	21.0	0.840	19.5	16.2	0.02	2.39
Pall Feed -Test Run # 2	715	5	389	67	3230	1.9	6020	<0.03	<0.001	20.0	0.834	11.0	15.7	0.02	–
Pall Permeate – Test Run # 2	1050	3	396	66	2890	1.9	5930	<0.03	<0.001	20.1	0.837	10.5	15.4	0.02	–

As shown on Table 3-2, there is no statistically significant variation between any of the water quality parameters before MF (Pall feed) and after MF (Pall permeate). This is to be expected of the chemical constituents, as the main operational purpose of MF is to provide an absolute-barrier for particulate matter (i.e. turbidity). The results of particulate matter removal can be found in the following section (3.1.1.2).

3.1.1.2 Transmembrane Pressure and Turbidity Results

Another key operational parameter tracked throughout the course of the MF pilot testing is the transmembrane pressure (TMP) across the membrane module. TMP is defined as the difference in pressure from the feed side of the membrane module to the filtrate side of the membrane module. Throughout each test run, the TMP pressure across the membrane module will increase due to fouling and eventually will need to undergo a chemical clean-in-place (CIP) to reduce the TMP. Typically a CIP is conducted when the MF system nears the termination TMP of the system (Pall termination TMP is 43.5 psi), and is desired to be at least 30 days between cleans (industry benchmark). A key goal of the MF pilot testing was to determine a flux where a run of at least 30 days could be conducted prior to cleaning. The TMP and pilot flux results for test run # 1, and # 2, respectively are illustrated in Figures 3-1 and 3-2. As can be seen in Figure 3-1, there is a data gap between 9/24 and 10/8 which is a result of a two week shutdown of the RO WTP.

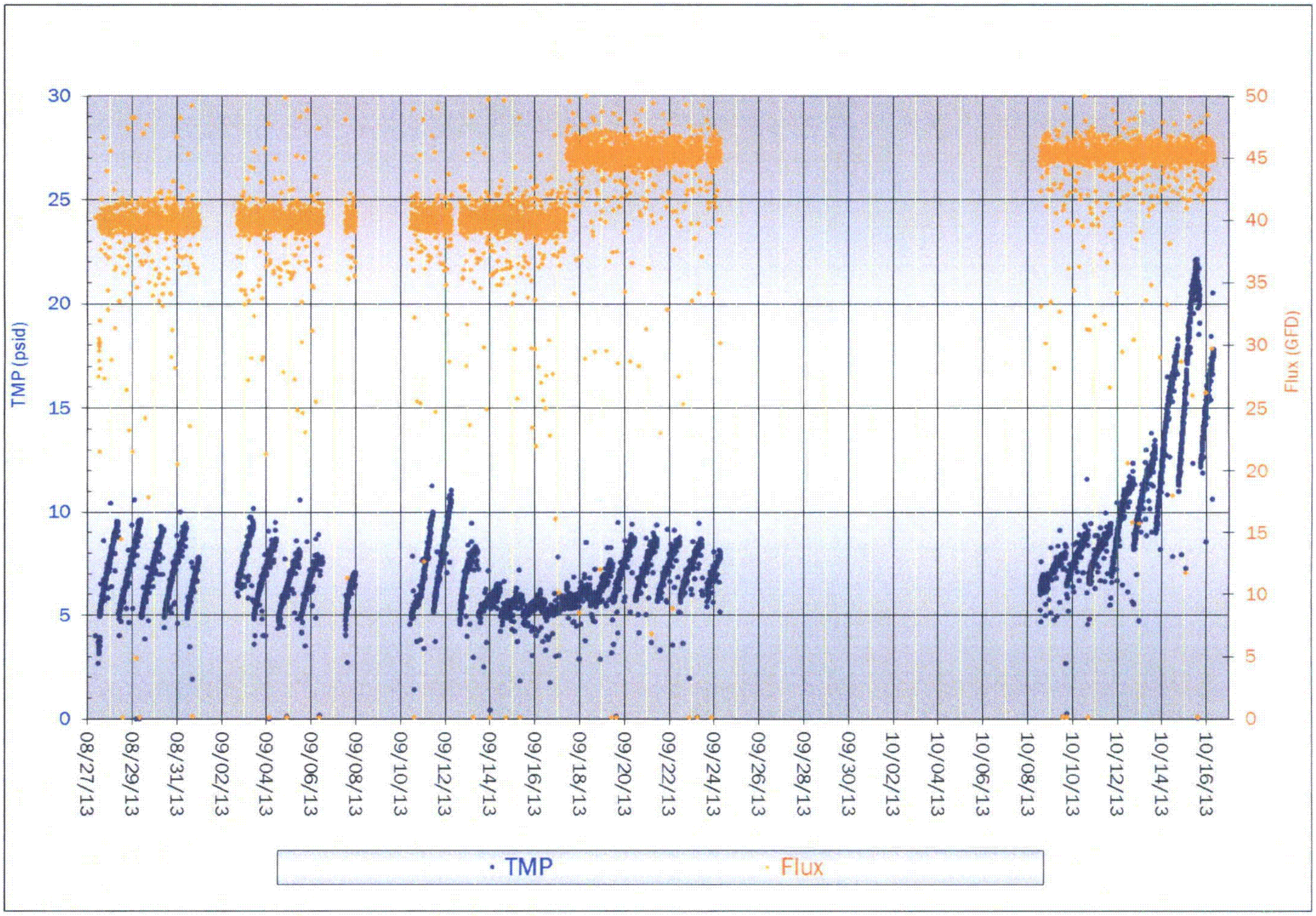

Figure 3-1 Test Run # 1 TMP/Flux Results

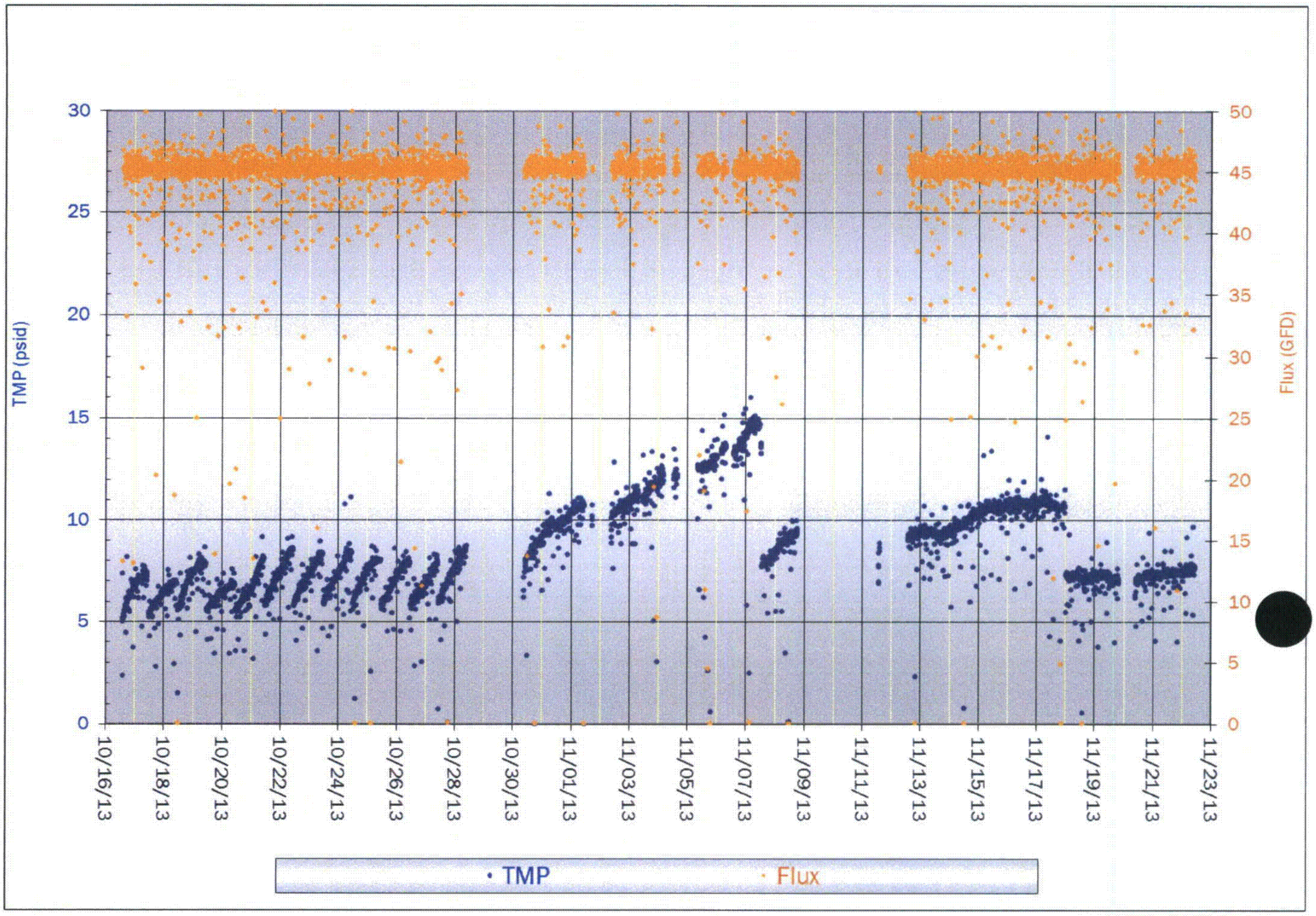

Figure 3-2 Test Run # 2 TMP/Flux

As presented in Table 1-2, the termination TMP for the Pall Aria pilot unit is 43.5 psid. As can be seen in both graphs above, the pilot units were able to successfully operate well below this threshold. This directly correlates to the ability of the MF system to operate at least 30 days, which is the typical design criterion for operation.

Additionally, Figure 3-3 and 3-4 below present the turbidity plots of both test run # 1 and #2, respectively. As can be seen in Figure 3-3, there is a data gap between 9/24 and 10/8 which is a result of a two-week shutdown of the RO WTP.

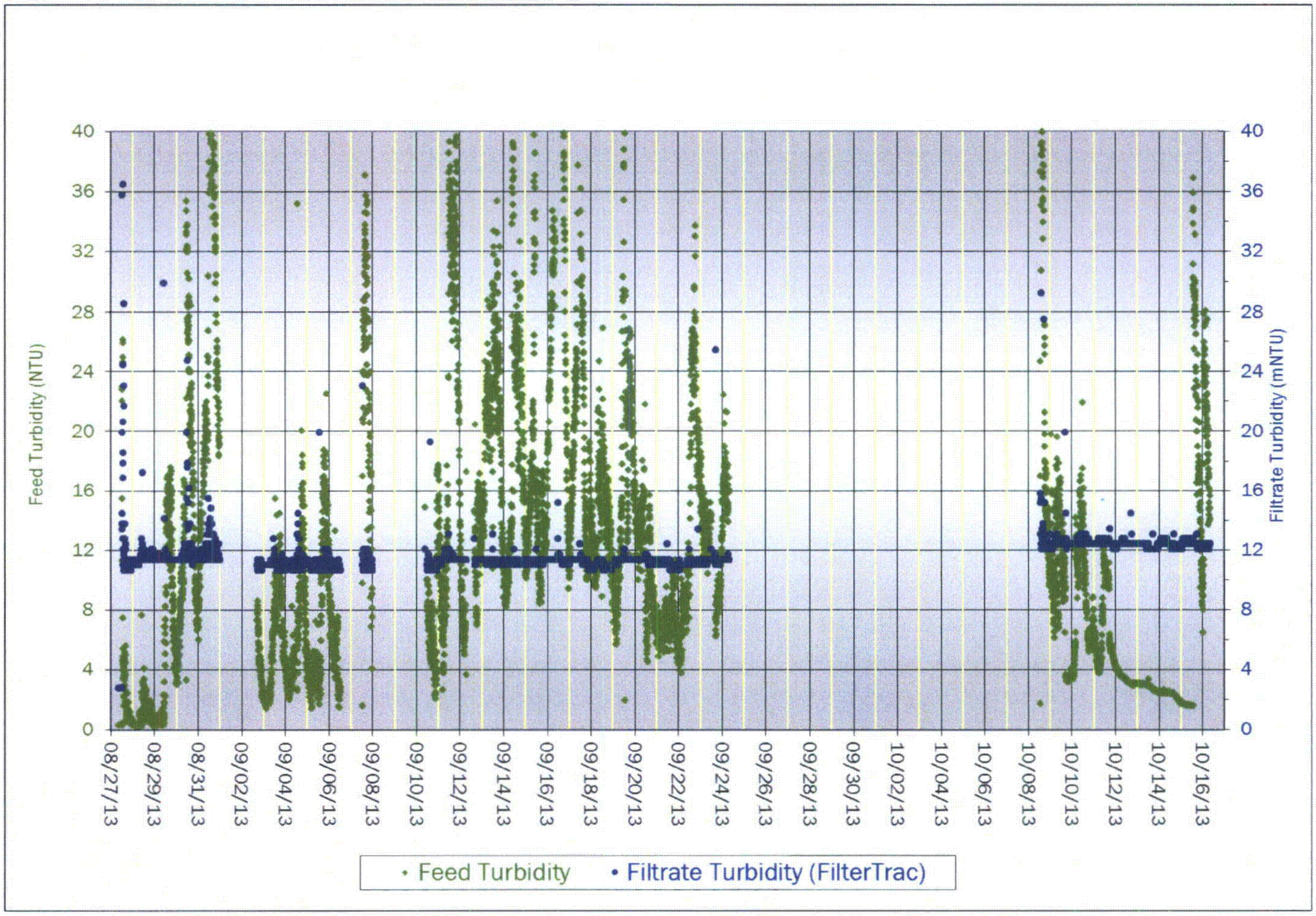

Figure 3-3 Test Run # 1 Turbidity Results

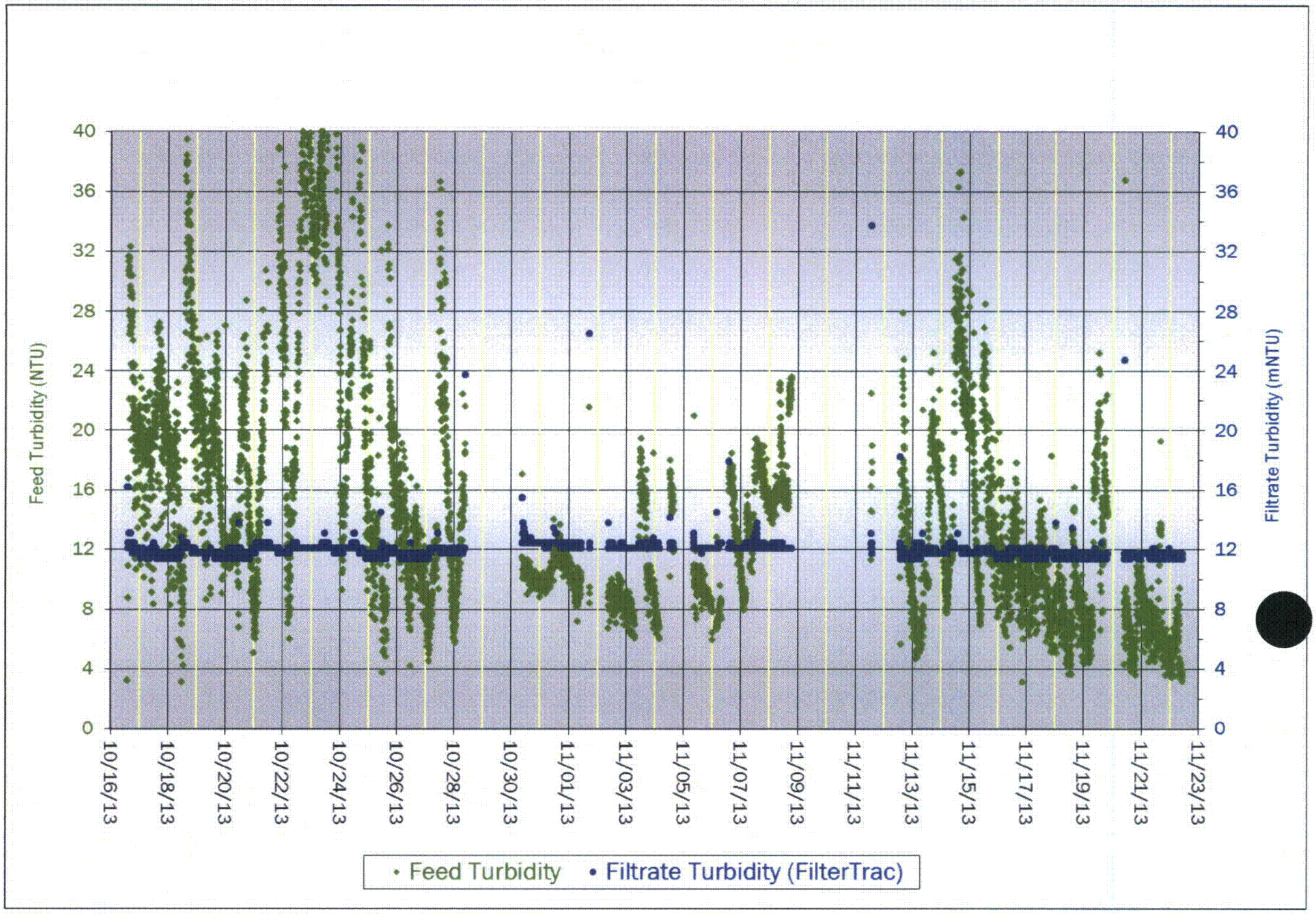

Figure 3-4 Test Run # 2 Turbidity Results

As can be seen above, during both test run # 1 (8/27 to 10/16) and test run # 2 (10/16 to 11/23), there is significant variability in the feed turbidity entering the MF pilot, but the filtrate turbidity is consistently reduced to 12 mNTU. This consistent removal of turbidity aids in delivering very high quality water to the RO membranes downstream.

3.1.2 CIP Performance

A chemical CIP procedure was performed after each test run to clean the MF pilot. Typically a CIP is performed when the MF unit has reached a high TMP and is used to reduce the TMP to the differential at the start of a test run. The cleaning procedure used for the MF pilot system included a two-stage clean with

the first stage using 2 percent citric acid, and the second using a 1 percent caustic/2,000 mg/L hypochlorite clean.

The fraction of initial CIP permeability is a measure of the effectiveness of the cleaning procedure, and is the ratio of the permeability after cleaning compared to a baseline permeability established after the first cleaning. A summary of the permeability following each CIP is presented on Table 3-3.

Table 3-3 CIP Effectiveness

Test Run	Date of CIP	Fraction of Initial CIP Permeability
1	10/16/2013	1.00
2	12/02/13	0.95

These cleaning procedures are intended to restore the permeability of the membranes to close to 100 percent of the original permeability. As can be seen above, the first test run clean achieved a 100 percent recovery of the permeability and the second test run achieved a 95 percent recovery of permeability. After discussions with Pall, it was concluded that the 5 percent reduction of permeability was not statistically relevant, and is within the error measurement of the permeability method, and any value within 5% of the initial permeability confirms an effective CIP clean. Overall, the MF pilot was successful at demonstrating the ability to regenerate the membrane permeability after each CIP.

3.1.3 MF and Sand Filtration Comparison

A key driver for the testing of the MF system is to improve the quality and quantity of water being sent to the downstream RO units. Two of the key water quality parameters affecting the downstream RO units include:

- Turbidity: The effluent turbidity of a filtration process is a measure of the suspended solids present after filtration. It is recommended that the effluent turbidity of a filtration process be less than 1 NTU.
- Silt density index (SDI): SDI is a unitless index characterizing the fouling potential of the RO units feed water. It is recommended that the SDI be less than 3 with a maximum of 5 per typical RO membrane warranty.

A comparison of the effluent turbidities produced during the pilot testing by the existing sand filters and the MF pilot is illustrated on Figure 3-5. It should be noted that the vertical axis is a logarithmic scale.

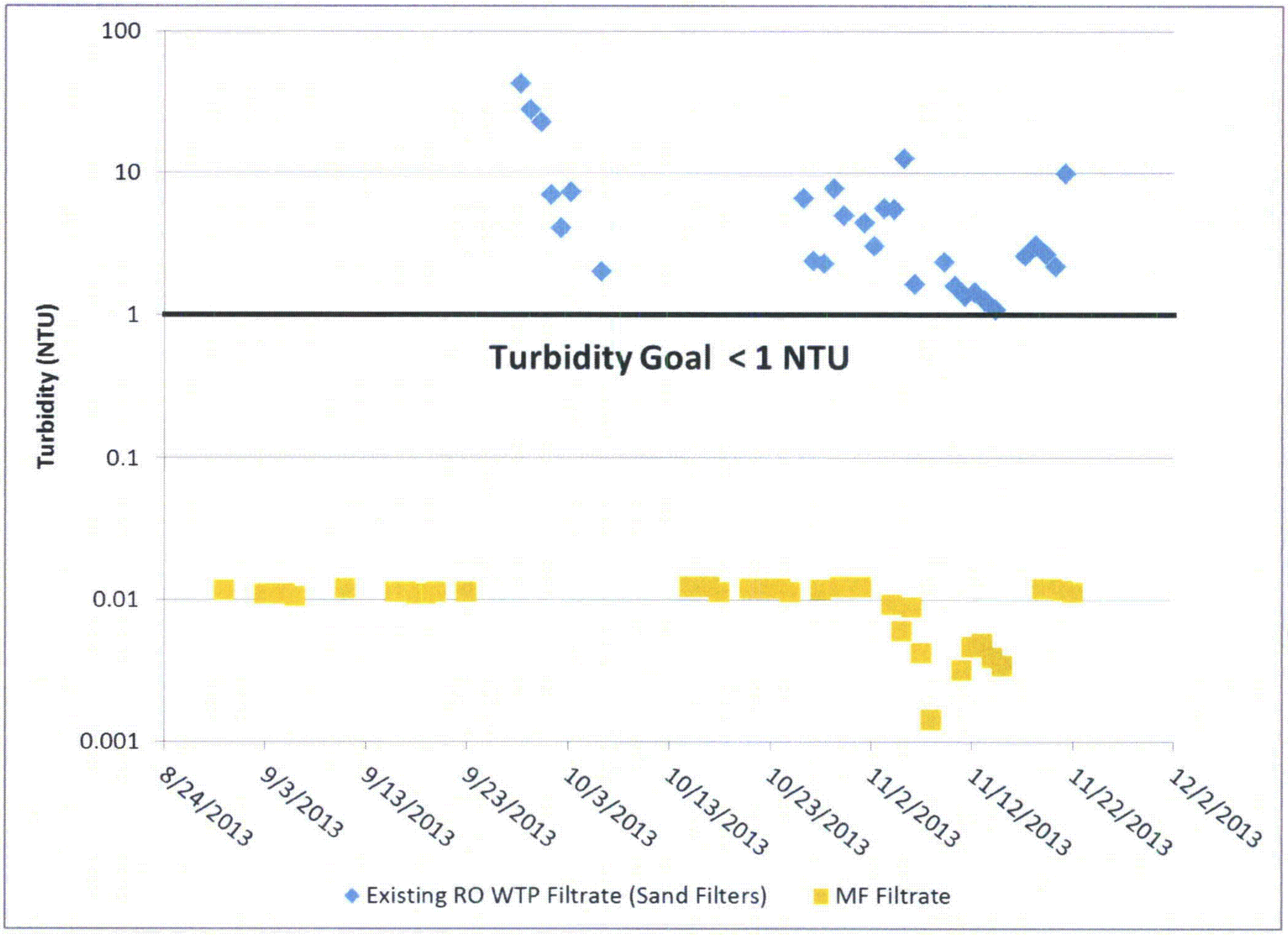

Figure 3-5 Turbidity Comparison

As can be seen above, the MF filtrate is consistently around 0.012 NTU, while the sand filter effluent fluctuates daily and averages approximately 12 NTU (with spikes upwards of 40 NTU). The consistent turbidity removal through the low pressure membranes will greatly increase the quality of feed water to the RO membranes, as compared to the current sand filters.

The results of several SDI tests conducted on both the sand filter effluent as well as the MF pilot are shown on Figure 3-6.

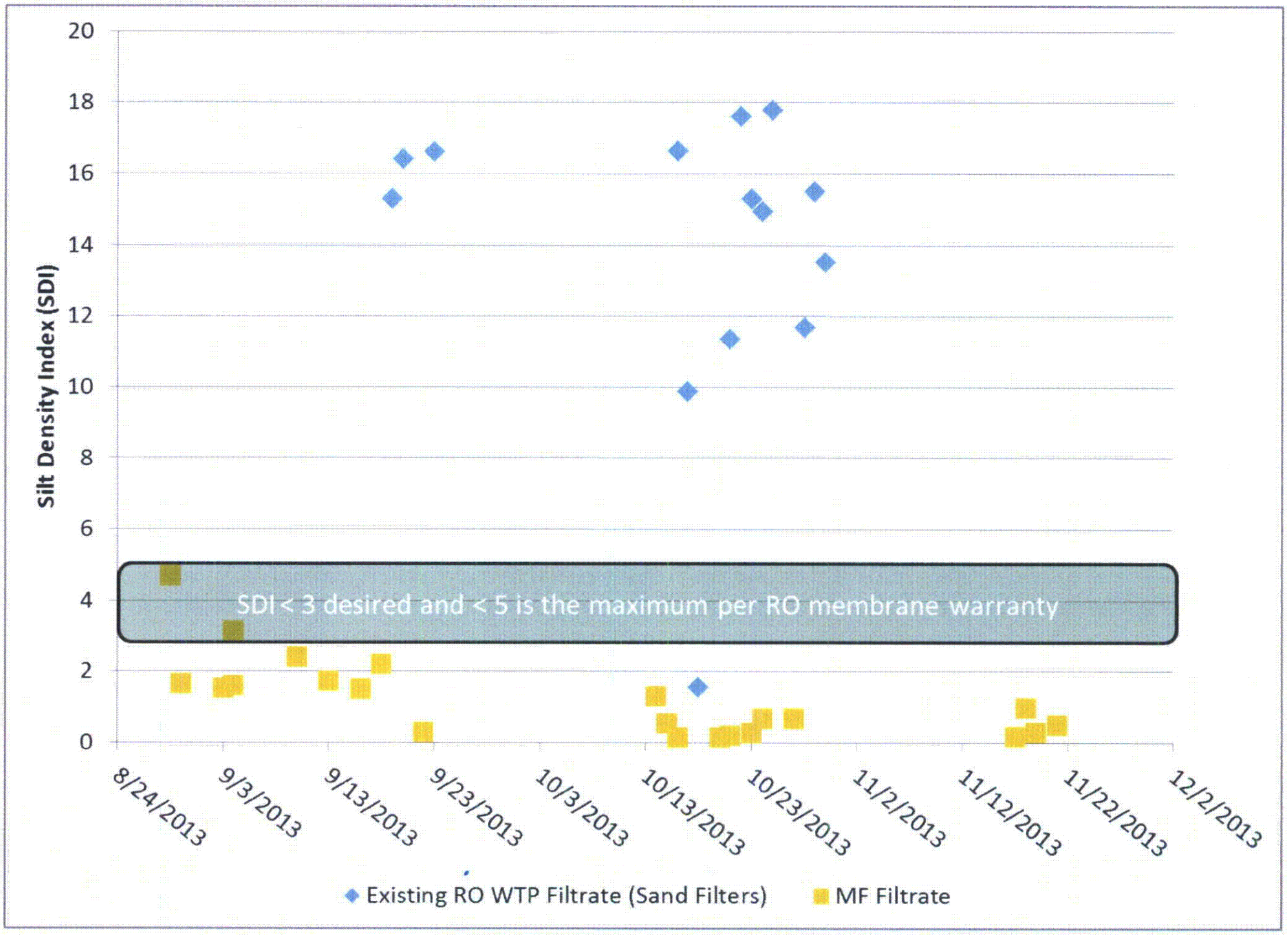

Figure 3-6 SDI Comparison

As can be seen throughout the pilot testing, the SDI of the low pressure membrane permeate is consistently less than 5, and typically less than 2. The sand filter SDI fluctuated day by day and consistently was above 10, with a maximum of 18.

3.1.4 Blending Evaluation

In addition to the MF pilot testing conducted on-site, ARCADIS also evaluated at bench-scale level the potential for blending different water sources for treatment through the RO WTP. A blending evaluation plan was prepared and submitted to HMC on September 25, 2013 (Appendix C). The purpose of this study was to evaluate the potential for blending a broader range of source waters to stabilize the RO WTP feed waters prior to the SCC, using an engineered equalization basin, as well as evaluate the full-scale design

parameters for this alternative. The blending evaluation was conducted during the week of October 7 to 11, 2013. The LTP, WCP and alluvial water used for the on-site blending tests are shown on Table 3-4. The Northeast quadrant of the LTP was used as the LTP source for each of the different blending evaluations based on recommendations from Hydro-Engineering.

Table 3-4 Blending Evaluation Testing Matrix

	0% LTP	10% LTP	20% LTP	30% LTP	40% LTP	100% LTP
Volume of Alluvial (Liters)	18L	16L	14L	12L	10L	0L
Volume of LTP (Liters)	0L	2L	4L	6L	8L	20L
Volume of WCP (Liters)	2L	2L	2L	2L	2L	0L

The results of the blending analysis are shown on Figures 3-7 and 3-8. Key conclusions from this evaluation include:

- Blending of the source waters results in the precipitation of calcium carbonate crystals
- Suspended solids concentration stabilized in 30 to 45 minutes
- Highest concentration of suspended solids was found at 30 and 40percent LTP water blends
- Calcium concentrations stabilized in 30 to 45 minutes
- Calcium concentration decreased over time due to calcite precipitation

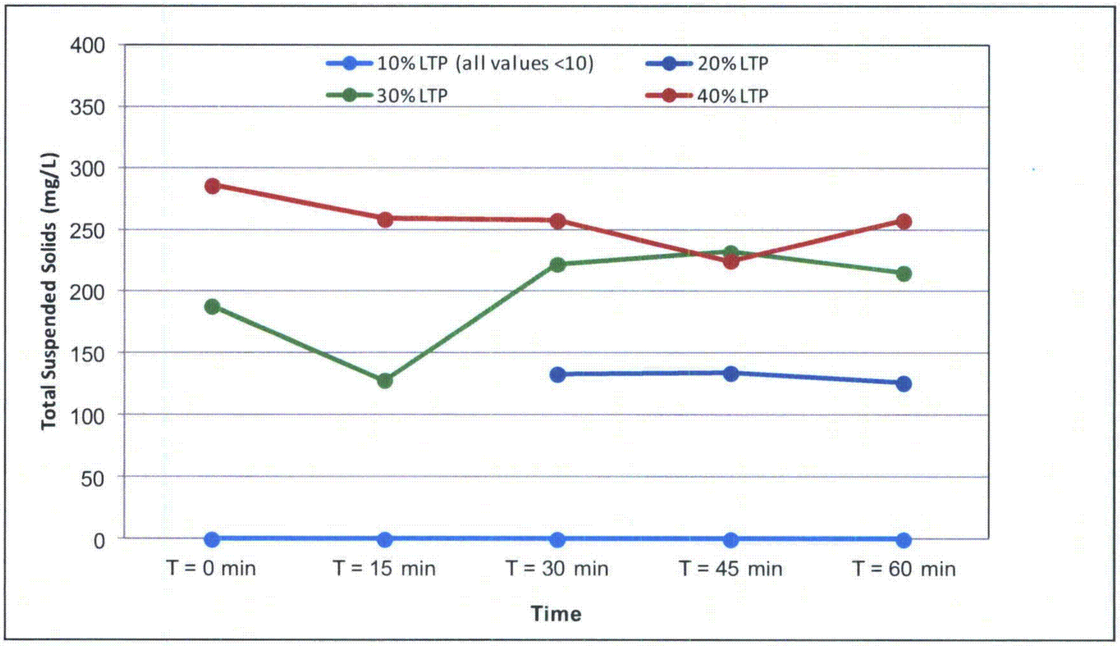

Figure 3-7 Total Suspended Solids Results

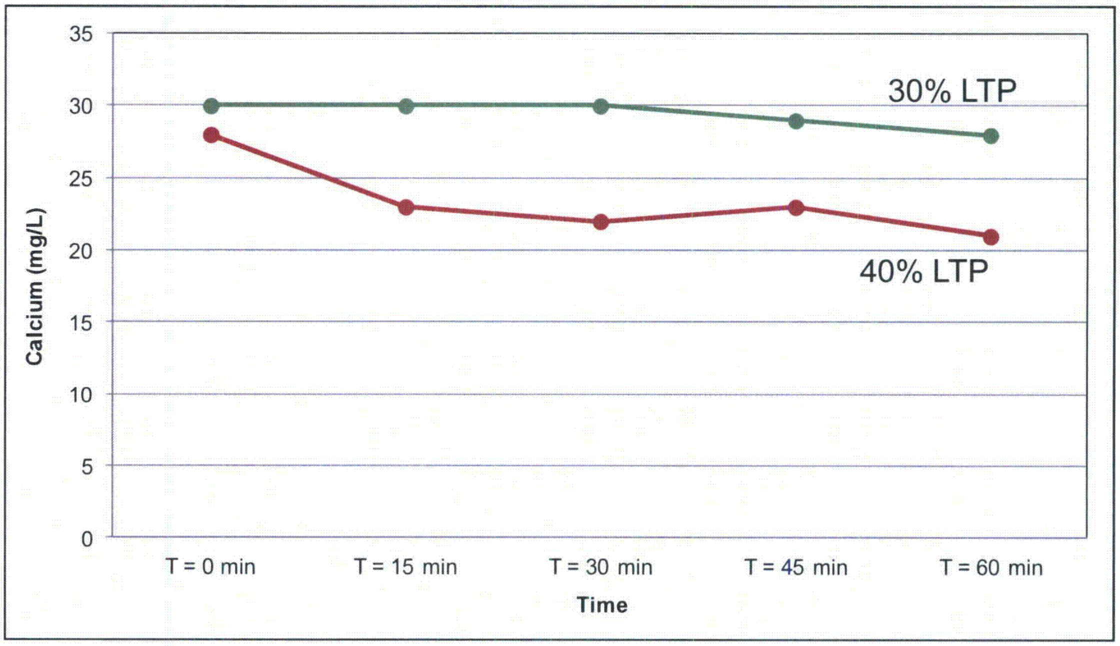

Figure 3-8 Calcium Results

Based on these results, it was concluded that an engineered equalization basin would be beneficial to the stabilization of RO WTP source waters. With a detention time of 30 to 45 minutes, key water quality parameters, including total suspended solids and calcium, were found to stabilize which would result in a more uniform source water quality for the RO WTP. To be conservative, the full-scale operation will have an equalization basin capable of providing 60 minutes of detention time.

4. Conclusions

Overall, the MF treatment process successfully demonstrated the ability to perform reliably and effectively with a wider range of feed water than currently being sent to the sand filter system. Specific MF pilot study conclusions can be summarized as follows:

- The MF pilot was able to stably and consistently treat RO WTP SCC effluent at 45 gfd with a 95.4 percent recovery.
- The MF pilot produced excellent finished water quality, averaging a permeate turbidity of 0.012 NTU.
- The MF pilot confirmed that a CIP interval greater than 30 days could be achieved under design conditions.
- The chemical cleaning processes (EFMs and CIPs) effectively restored membrane permeability, indicating that the specified cleaning regime (chemical types/sequences, duration and frequency) is appropriate for this feed water source.
- Testing demonstrated a higher flux through the MF pilot allowed an increased flow through the membrane module, which ultimately results in fewer modules being required (reduced CAPEX) for a full-scale installation.
- The quality and quality of water currently being sent to the RO units will result on less wear RO membranes.

In addition, the MF pilot testing successfully accomplished the three goals presented in Section 1. Table 4-1 presents a summary of the goals and how each was accomplished.

Table 4-1 Pilot Testing Conclusions

Goal	Conclusion
Proof of Concept Testing	Throughout the three months of pilot testing, the MF pilot unit was able to successfully operate for at least 30 days at both 40 gfd and 45 gfd. Additionally, it was determined that the backwashes, EFMs and CIPs were successful at reducing the TMP of the pilot unit.
Development of Full-Scale Design Parameters	Based on the MF pilot testing, the following full-scale design criteria were developed for the 1,200 gpm design: Operating Flux – 45 gfd EFM Cleaning Frequency – 3 to 7 days Recovery – 95 percent CIP Frequency – greater than 30 days Chemical Cleaning Types, Sequences, Duration

Goal	Conclusion
Challenge Testing	The MF pilot testing was able to demonstrate that the low pressure membrane was able to operate for longer than 30 day durations between CIPs (typical practice), as well as decrease from daily EFM cleans to weekly EFM cleans without approaching the termination TMP for the unit of 45 psid.
Blending Evaluation	Results show that the blending of alluvial, LTP, and WCP waters in an equalization basin will stabilize and allow for a more uniform SCC feed with a detention time of 30 to 45 min. At 1,200 gpm, this results in an equalization basin volume of 36,000 to 54,000 gallons.

Based on the successful completion of pilot testing goals, it was demonstrated that MF is a viable pre-treatment alternative to sand filtration for the RO WTP expansion.

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Appendix A

Pilot Testing Plan

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Infrastructure · Water · Environment · Buildings

Imagine the result

Homestake Mining Company of California

Low Pressure MF Membrane Pilot Testing Plan

12 August 2013

ARCADIS

Low Pressure MF Membrane Pilot Testing Plan

Prepared for:

Homestake Mining Company of California

Our Ref.:

Project Number

Date:

12 August 2013

Tables

Figures

Acronyms and Abbreviations

CIP	Clean-in-Place
EFM	Enhanced Flux Maintenance
GFD	Gallons per Square Foot per Day
HMC	Homestake Mining Company
µm	Micron
MF	Microfiltration
PSID	Pounds per Square Inch per Day
PVC	Polyvinyl Chloride
PVDF	Polyvinylidene fluoride
QA	Quality Assurance
QC	Quality Control
RO WTP	Reverse Osmosis Water Treatment Plant
SCC	Solids Contact Clarifier
SOP	Standard Operating Procedures

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1. Background

The Reverse Osmosis Water Treatment Plant (RO WTP) at the Grants Reclamation Project was designed and installed in 1999 to produce 600 gallons per minute (gpm) of treated water in support of groundwater remediation and site closure objectives. Based on a comprehensive evaluation of the RO WTP capacity conducted in 2011-2012, ARCADIS and Homestake Mining Company (HMC) have determined that the RO WTP can only reliably produce approximately 300 gpm of treated water due to treatment process limitations. Specifically, the existing sand filters are 1) unable to achieve 600 gpm due to hydraulic restrictions and 2) have historically produced filtered water of highly variable quality, which adversely impacts system throughput, reduces the life of the RO membrane, and increases the cost per gallon of water needing treatment.

ARCADIS is recommending the evaluation of low pressure membrane filtration to replace the sand filters and increase the RO WTP capacity to 600 gpm. ARCADIS has identified a pilot testing program for evaluation of this alternative filtration technology at the RO WTP. Pilot testing will be initiated in August 2013 and conducted for a period of approximately 4 months (16 weeks) at the RO WTP. Pilot testing goals include:

- Proof-of-Concept: confirm that the low pressure membrane technology is a viable long-term filtration technology for the RO WTP.
- Full-Scale Design Parameters: establish design criteria for the full-scale equipment that will treat 600 gpm.
- Challenge Testing (to be adjusted as time permits): evaluate the performance of low pressure membranes under challenging water quality conditions that will include testing of water from higher conductivity wells, increased recycle from collection ponds, and blends of Large Tailings Pile (LTP) waters. As part of this goal, ARCADIS will also assess the viability and benefits of an equalization basin prior to the Solids Contact Clarifier (SCC).

ARCADIS is responsible for overseeing the design, construction, operation, and reporting for the pilot testing. This will include having a pilot system operator at the RO WTP five days a week during the testing. The subsequent sections of this Pilot Testing Plan provide additional details on the following topics:

- Pilot unit integration into the RO WTP
- Pilot testing equipment
- Low pressure membrane testing conditions and schedule

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- Pilot testing water quality monitoring program
- Data analysis and reporting protocol

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2. Pilot Integration and Summary of Pilot Testing Equipment

ARCADIS made a site visit to Grants, NM on July 24 and 25, 2013, to evaluate and assess how the low pressure membrane pilot will be integrated into the existing RO WTP. A key outcome of this evaluation was to establish a plan that allows the RO WTP to operate in a routine fashion during the evaluation and provide feed water from the SCC as close to actual conditions as possible. In addition, ARCADIS evaluated feed and discharge locations for all water streams. Figure 2-1 below presents the process flow diagram overview of the pilot system.

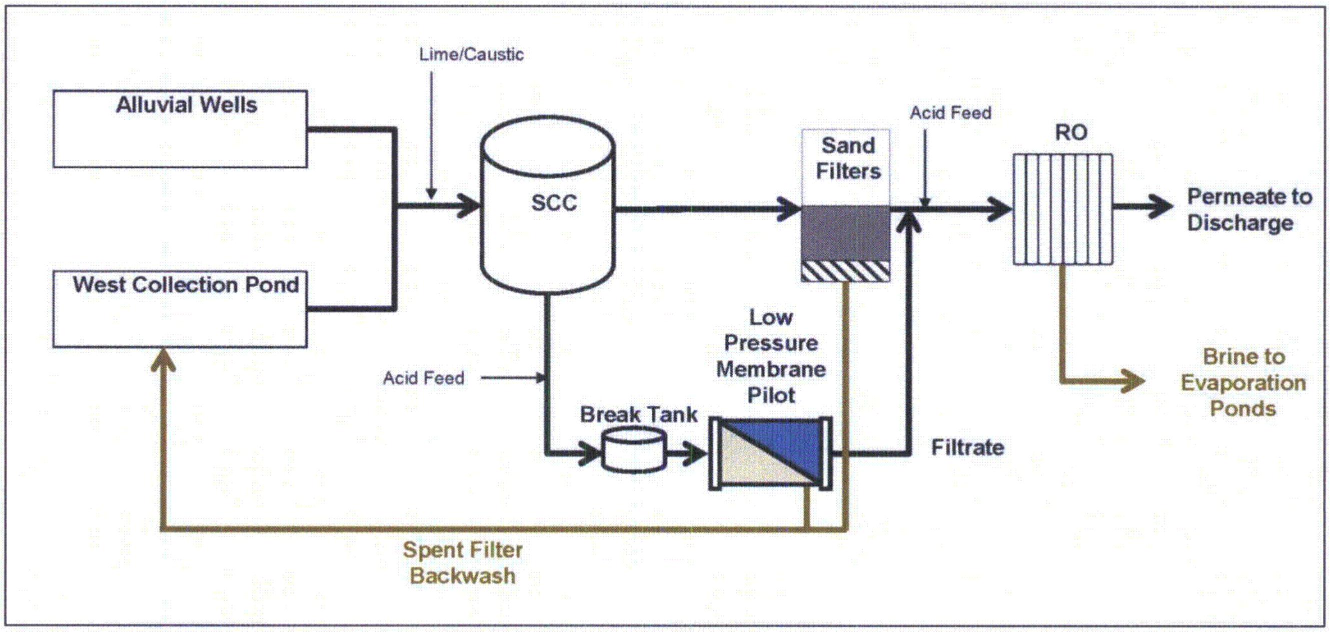

Figure 2-1 Overview of Pilot Setup

The low pressure membrane pilot will be integrated into the current operation of the RO WTP. Additionally, all waste streams will ultimately be sent to the West Collection Pond. The filtrate from the low pressure membranes will be discharged into the filter effluent box to allow for treatment of this stream by the RO membranes. Figure 2-2 below presents a more detailed process flow diagram of the low pressure membrane pilot system.

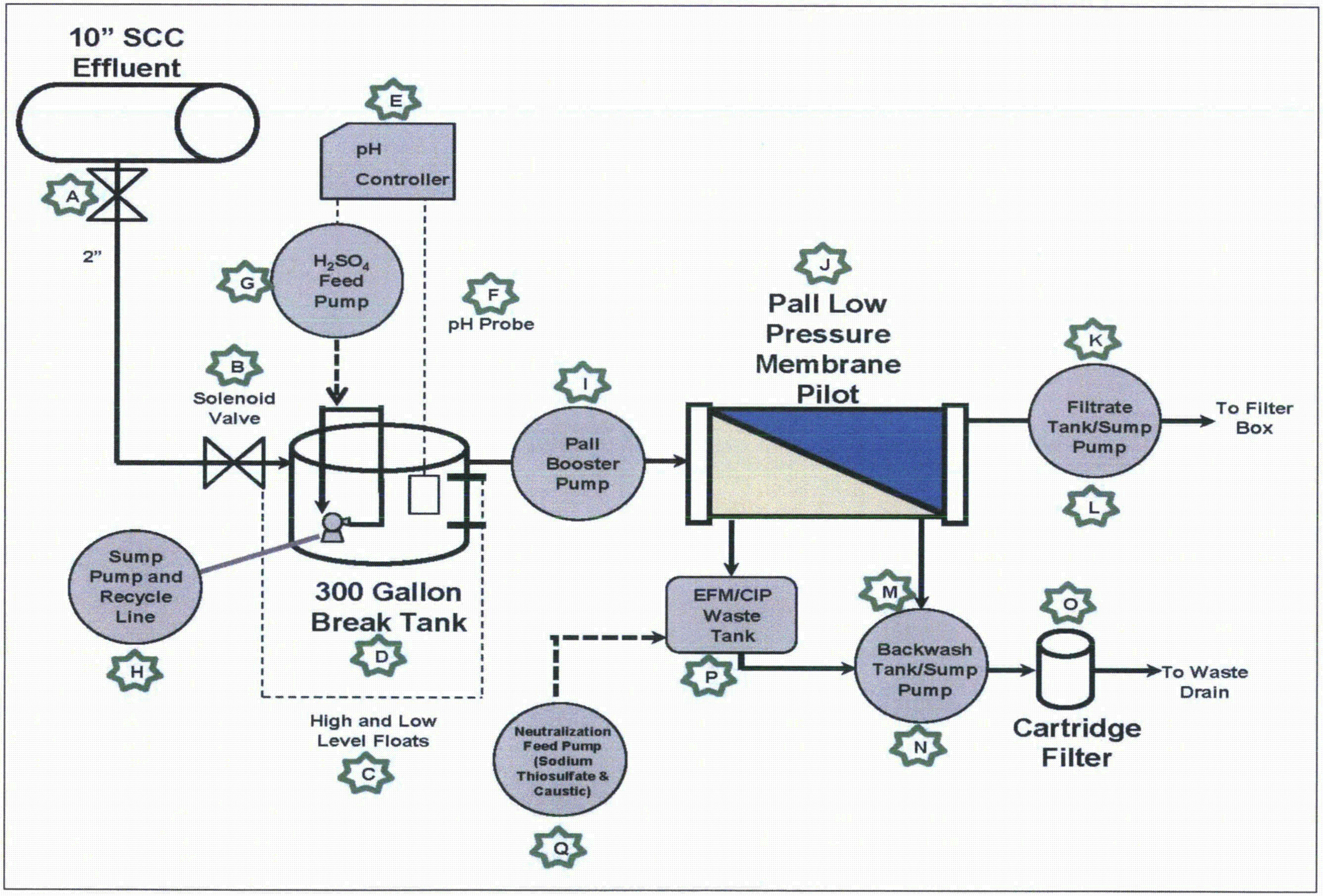

Figure 2-2 Pilot Testing Process Flow Diagram

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Several terms specific to low pressure membranes will be used throughout the remainder of this test plan. Table 2-1 summarizes these terms.

Table 2-1 Low Pressure Membrane Terminology

Term	Definition
Backwash	A cleaning operation that typically involves periodic reverse flow to remove foulants accumulated at the membrane surface; also, a term for the intermittent waste stream from a MF or UF membrane system.
Clean-In-Place (CIP)	The periodic application of a chemical solution (or a series of solutions) to a membrane unit for the intended purpose of removing accumulated foulants and thus restoring permeability and resistance to baseline levels.
Enhanced Flux Maintenance (EFM)	EFM is a short cleaning of membranes to maintain optimal performance. Called by various names, including chemical washes, mini-cleans, and relaxation, the basic process involves circulation of a chemical cleaning solution on the feed side of the membrane at an elevated temperature for 30 minutes before returning the unit back to normal operation.
Filtrate Flux	The amount of water transferred through the membrane surface per unit time and area.
Feed-Water System Recovery	The fraction of feed water recovered as product.
Filtrate Water Quality	The water quality of the water produced by the membrane filtration process.
Membrane Element Recovery	The recovery of filtrate from total recirculation influent water.
Membrane Fouling	Reversible fouling is a reduction in filtrate flux that can be restored by mechanical or chemical means. Irreversible fouling is permanent loss in filtrate flux capacity that cannot be restored.
Permeability	The ability of a membrane barrier to allow the passage or diffusion of a substance.
Specific Flux	Filtrate flux that has been normalized for the transmembrane pressure.
Transmembrane Pressures	The difference in pressure from the feed to the filtrate across a membrane barrier.

Table 2-2 below presents a more detailed description of the different components that will be required for the operation and integration of the low pressure membrane pilot unit.

Table 2-2 Pilot Testing Equipment List and Details

Fig. 2-2 Label	Component	Description
A	2" connection into 10" SCC effluent line and isolation valve	2" wet tap connection and isolation valve into the existing SCC clarifier effluent line to provide sufficient feed water flow for the low pressure membrane pilot test.
B	Solenoid feed water valve	Solenoid valve to control the flow into the break tank by communicating with a high and low float switch in the break tank.
C	Float switches	High and low float switches in the break tank to control the flow into the break tank. If the high float or low float is triggered, both pumps will shut off to prevent overflowing.
D	300 gallon break tank	300 gallon tank to provide mixing and storage time for the membrane feed water.
E	pH controller	HACH sc200 controller to control and output the pH in the break tank, as well as control the chemical feed pump.
F	pH meter	HACH pH meter to measure the pH in the break tank. Output to be monitored via the pH controller.
G	H_2SO_4 chemical feed pump	Automatic LMI pump to communicate with pH controller and dose appropriate sulfuric acid into the membrane feed water.
H	Sump pump and recycle line	Sump pump and recycle line for facilitating the chemical addition and promoting mixing
I	Booster Pump	Booster pump downstream of the break tank to provide feed water to the low pressure membrane.
J	Pall Aria MF Pilot	MF low pressure membrane pilot that can treat approximately 10-15 gpm (see below for more details).
K	Filtrate Tank	50 gallon tank to collect pilot filtrate prior to conveyance to the filter effluent box
L	Filtrate Pump	Filtrate sump pump located in the filtrate tank downstream of the low pressure membrane pilot to convey the filtrate of the pilot unit to the filter effluent box.
M	Backwash Tank	50 gallon tank to collection pilot backwash
N	Backwash Pump	Backwash pump to be used to pump backwash water and EFM/CIP water through the cartridge filter prior to discharging into the waste drain.
O	Cartridge Filter	5 micron cartridge filter to be utilized for backwash waste and

Fig. 2-2 Label	Component	Description
		EFM/CIP waste to remove suspended solids prior to discharging into the waste drain
P	EFM/CIP Waste Tank	150-200 gallon tank to neutralize maintenance cleaning/CIP waste stream. The waste streams will be collected and manually neutralized using sodium thiosulfate and caustic. The treated waste will be pumped to the full-scale RO WTP backwash waste sump.
Q	Neutralization Feed Pump	A chemical feed pump for the neutralization (sodium thiosulfate and caustic) of both the maintenance clean and CIP waste streams.

ARCADIS reviewed and shortlisted low pressure membrane system suppliers based on vendor experience in the mining sector, equipment performance and cost. ARCADIS started with three microfiltration (MF)/ultrafiltration (UF) low pressure membrane vendors (Pall, General Electric/Zenon, and Siemens). Following evaluation of the vendor systems, Pall and General Electric/Zenon were short listed as the top two vendors as Siemens did not respond to repeated emails and phone calls with ARCADIS during the process of obtaining system information. Ultimately, the Pall Aria MF low pressure membrane pilot unit was selected based on pilot availability, vendor evaluation, and containerized full-scale packages.

The characteristics of the Pall Aria MF low pressure membrane pilot unit are presented in Table 2-3.

Table 2-3 Low Pressure Membrane Pilot Details

Item	Pall Aria
Type	Pressure MF
Module Model	UNA-620A
Membrane Area (ft^2)	538
Flow Pattern	Outside-In
Nominal Pore Size (microns or µm)	0.1
Membrane Material	Polyvinylidene fluoride (PVDF)
pH Tolerance	1 – 10
Maximum Transmembrane Pressure (pounds per square inch per day or psid)	43.5

3. Schedule and Overview of LP Membrane Testing Conditions

The following sections present the pilot testing schedule and pilot testing conditions to be conducted throughout the course of the pilot evaluation.

3.1 Pilot Testing Schedule

The total program duration will be conducted for a period of approximately 24 weeks (16 weeks of piloting) beginning with the mobilization of the equipment on August 19, 2013, and ending with the demobilization of the pilot site in December. Figure 3-1 below presents the schedule for the complete pilot testing evaluation.

Pilot Testing Schedule																									
Activity	Description	August				September				October				November				December				January			
		Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15	Week 16	Week 17	Week 18	Week 19	Week 20	Week 21	Week 22	Week 23	Week 24
Pilot Testing	Develop Pilot Testing Plan	■																							
	Develop Health and Safety Plan	■	■																						
	Equipment Arrives on Site			■																					
	Install and Shakedown Pilot			■	■																				
	Test Run # 1 - Optimization/Proof-of-Concept Testing					■	■	■	■																
	Test Run # 2 - Verification/Design Testing									■	■	■	■												
	Develop Pilot Testing Proof of Concept Memo										■	■	■	■	■										
	Test Run # 3 - High Conductivity Wells Testing													■	■	■	■								
	Test Run # 4 - Challenge Testing																	■	■	■	■				
	Develop Challenge Testing Memo																			■	■	■	■	■	■

Figure 3-1 Pilot Testing Schedule

As can be seen above, the pilot testing will consist of five different conditions including:

- Install and Shakedown
- Test Run # 1 – Optimization/Proof-of-Concept Testing
- Test Run # 2 – Verification/Design Testing
- Test Run # 3 – High Conductivity Wells
- Test Run # 4 – Challenge Testing

These four test runs will be defined further in the following sections.

3.2 Pilot Testing Operation and Water Quality Goals

There are several key objectives throughout the duration of the pilot testing. The first key objective of the pilot testing is to operate for 30 days prior to needing to initiate a CIP. However, if the low pressure membrane pilot system requires a CIP prior to 30 days, one will be conducted. If a test run exceeds the 30 day test run objective, ARCADIS, HMC and Pall will discuss if a clean should occur immediately, or if the test run should be extended. Other operational objectives of the pilot testing include the determination of the backwash and maintenance clean frequency and the achievable recovery through the low pressure membrane pilot.

In addition to these operational objectives, there are several water quality goals which will be evaluated throughout the pilot testing for pretreatment and the low pressure membrane. Table 3-1 below summarizes the water quality goals.

Table 3-1 Water Quality Goals

Parameter	Water Quality Goal
Filtrate Turbidity	<0.1 NTU
Filtrate Silt Density Index (SDI_{15})	< 5
Membrane Feed pH range	7 - 8

3.3 Installation and Shakedown

The Pall low pressure membrane pilot unit will be arriving August 19, 2013. Once located on site and connected to the infrastructure added/identified for the pilot, several activities will be initiated:

- Wet testing: the low pressure membrane pilot will be wet tested with RO water permeate to ensure there are no leaks or issues with plumbing
- CIP: a CIP will be conducted to present a baseline cleaning performance for the low pressure membrane pilot

3.4 Test Run #1: Optimization and Proof-of-Concept

After installation and shakedown, a 30-day period of optimization/proof-of-concept testing will start. During this testing stage, several different flux rates will be evaluated to determine the optimum value. Table 3-2 below presents the initial set points for Test Run #1.

Table 3-2 Test Run #1: Operating Parameters

Stage #	Duration	Flux (gfd)	Backwash Frequency	EFM Frequency	Description
1	10 days	30	10 – 40 min	1/day	Per discussions with Pall, a flux of 30 gfd will be initially tested
2	10 days	TBD	TBD	TBD	To be determined through discussions and performance evaluation with HMC and Pall
3	10 days	TBD	TBD	TBD	To be determined through discussions and performance evaluation with HMC and Pall
4 - CIP	1 day	N/A	N/A	N/A	Typical CIP parameters (1000 ppm NaOCl / 1% NaOH, 2% Citric Acid)

ARCADIS, HMC and Pall Corporation will review the data throughout the first stage of testing (30 gfd) and determine what flux should be applied during Stage #2. The same approach will be conducted to determine the flux for Stage #3.

A Clean-in-Place (CIP) will be conducted at the completion of the optimization/proof-of-concept testing to evaluate the amount of reversible and/or irreversible fouling which may have occurred during the test. If irreversible fouling is occurring, steps will be taken to modify the cleaning regimes.

At the completion of Test Run #1, ARCADIS, HMC and Pall Corporation will review the data and determine an acceptable flux and optimized feed pH for Test Run #2. Key data to be reviewed include:

- Transmembrane Pressure (TMP)
- Backwash effectiveness
- Enhanced Flux Maintenance (EFM) effectiveness
- Permeate Turbidity
- Permeate Calcium
- Silt Density Index (SDI)
- Permeate Conductivity

3.5 Test Run #2: Verification and Full-Scale Design Criteria

After the completion of Test Run # 1, Test Run #2 will be conducted for another 30 days. The purpose of this test run includes:

- Confirmation of design criteria for a full-scale low pressure membrane installation including:
    - Feed pH
    - Flux rate
    - EFM cleaning regime
    - CIP cleaning regime
    - Backwash cleaning regime
    - Recovery rate

During Test Run #2, the flux will be held constant at the rate determined at the finish of Test Run #1. Backwash frequencies and EFM frequencies will be held constant as well.

3.6 Test Runs #3 and #4 (Challenge Testing)

After the completion of Test Run #2, Test Runs #3 and #4 will be conducted for another 30 days each. The purpose of these test runs is to evaluate the effectiveness of the low pressure membranes and SCC at treating more challenging blends of water at the site, including the following examples:

- Higher conductivity wells
- Large Tailings Pile (LTP) water

Each test run will conclude with a CIP. The structure of this test run will depend on the results of Test Run #1 and #2, and the blending evaluation to be conducted through Task 6 work in parallel with this pilot study. Therefore, the detailed testing protocol for these runs will be determined prior to Test Run #3 and #4, through discussions with ARCADIS, HMC and Pall Corporation.

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4. Water Quality Monitoring Program

The water quality monitoring plan for the pilot testing effort is presented in Table 4.1.

Table 4-1 Pilot Testing Monitoring Plan

Parameter	Raw Water	SCC Effluent	Pall Feed	Pall Permeate	Pall Backwash	Pall EFM Waste	Pall CIP Waste
pH	Daily	Daily	Daily	Daily	Bi-Weekly	1/test run	1/test run
Temperature	Online	Online	Online	Online	-	-	-
Total Calcium	Daily	Daily	Daily	Daily	Bi-Weekly	1/test run	1/test run
Silt Density Index (SDI)	-	-	Daily	Daily	-	-	-
Turbidity (NTU)	Daily	Daily	Daily	Online	Bi-Weekly	2/study	2/study
Alkalinity	3/test run	3/test run	3/test run	3/test run	Bi-Weekly	2/study	2/study
Hardness	Daily	Daily	Daily	Daily	Bi-Weekly	2/study	2/study
Conductivity	Daily	Daily	Daily	Daily	Bi-Weekly	2/study	2/study
Solids, Total Dissolved	3/test run	3/test run	3/test run	3/test run	-	-	-
Carbon, Total Organic	3/test run	3/test run	3/test run	3/test run	-	-	-
Metals[1], Total	3/test run	3/test run	3/test run	3/test run	-	-	-
Metals[1], Dissolved	3/test run	3/test run	3/test run	3/test run	-	-	-
Anions[2]	3/test run	3/test run	3/test run	3/test run	-	-	-
Radium 226, Dissolved	3/test run	3/test run	3/test run	3/test run	-	-	-
Radium 226, Total	3/test run	3/test run	3/test run	3/test run	-	-	-
Thorium, Total	3/test run	3/test run	3/test run	3/test run	-	-	-
Radium 228, Total	3/test run	3/test run	3/test run	3/test run	-	-	-
Radium 228, Dissolved	3/test run	3/test run	3/test run	3/test run	-	-	-

[1] Metals include: Molybdenum, Selenium, Vanadium, Uranium, and select other trace metals

[2] Anions include: Chloride, Fluoride, Sulfate, Nitrate, and Nitrite

Quality control samples and duplicates will be collected to provide verification of instrument and method accuracy. Duplicate samples will be collected and analyzed for pH, Calcium, Turbidity and SDI at a frequency of 10%. External samples will have QA/QC procedures performed by the external lab. Bench verification of online turbidimeters will be conducted weekly and online turbidimeters will be calibrated between each test.

ARCADIS will conduct additional water quality monitoring not identified in Table 4-1 if pilot operating conditions are significantly changed and/or for QA/QC purposes as discussed above.

The integrity of the water quality monitoring data is crucial to confirming that this pilot project can demonstrate the ability of the MF process to provide high quality water to the RO membranes and meet the water quality goals presented in Table 3-1. All samples will be analyzed using industry approved analytical methods (Table 4-2). All samples collected and measured on-site will be validated in accordance with recommended calibration procedures and frequencies by ARCADIS. On-line equipment will be calibrated prior to each new run. QA/QC procedures will be conducted by all contract laboratories to ensure data integrity is maintained while conducting the testing.

Table 4-2 Sampled Parameters and Standards Analytical Methods

Analyte	Sample Type	Sample Analysis Location	Method	Energy Labs Reporting Limit
pH	Grab/Online	On Site	4599-H+ Electrometric Method	--
Temperature	Online	On Site	Temperature	--
Turbidity	Grab/Online	On Site	A2130 B	--
Calcium	Grab	On Site	Hach 8204	--
SDI	Grab	On Site	TBD	--
Alkalinity	Grab	On Site	A2320 B	--
Hardness	Grab	On Site	A2340 B	--
Conductivity	Grab	On Site	A2520 B	--
Solids, Total Dissolved	Grab	Energy Laboratories	A2540 C	10 mg/L
Fluoride	Grab	Energy Laboratories	A4500-F C	0.1 mg/L
Carbon, Total Organic	Grab	Energy Laboratories	A5310 C	0.5 mg/L
Metals, Total	Grab	Energy Laboratories	E200.7_8	Varies
Molybdenum, Total	Grab	Energy Laboratories	E200.7_8	0.001 mg/L
Selenium, Total	Grab	Energy Laboratories	E200.7_8	0.001 mg/L
Vanadium, Total	Grab	Energy Laboratories	E200.7_8	0.01 mg/L
Uranium, Total	Grab	Energy Laboratories	E200.7_8	0.0003 mg/L
Metals, Dissolved	Grab	Energy Laboratories	E200.7_8	Varies
Molybdenum, Total	Grab	Energy Laboratories	E200.7_8	0.001 mg/L
Selenium, Total	Grab	Energy Laboratories	E200.7_8	0.001 mg/L
Vanadium, Total	Grab	Energy Laboratories	E200.7_8	0.01 mg/L

Analyte	Sample Type	Sample Analysis Location	Method	Energy Labs Reporting Limit
Uranium, Total	Grab	Energy Laboratories	E200.7_8	0.0003 mg/L
Anions	Grab	Energy Laboratories	E300.0	Varies
Chloride	Grab	Energy Laboratories	E300.0	1 mg/L
Fluoride	Grab	Energy Laboratories	E300.0	0.1 mg/L
Nitrate	Grab	Energy Laboratories	E300.0	0.1 mg/L
Nitrite	Grab	Energy Laboratories	E300.0	0.1 mg/L
Sulfate	Grab	Energy Laboratories	E300.0	1 mg/L
Radium 226, Dissolved	Grab	Energy Laboratories	E903.0	0.2 pCi/L
Radium 226, Total	Grab	Energy Laboratories	E903.0	0.2 pCi/L
Thorium, Total	Grab	Energy Laboratories	TBD	TBD
Radium 228, Total	Grab	Energy Laboratories	RA-05	1 pCi/L
Radium 228, Dissolved	Grab	Energy Laboratories	RA-05	1 pCi/L

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5. Data Analysis and Report

This section provides the data processing plan and reporting procedures to be followed throughout the study

5.1 Operational Logs

Operational logs will be maintained during piloting to track the progress of the testing and will include the monitoring parameters listed in Table 4-1. The operational logs will include both hand written and electronic logs depending on the data source. Logs will include data collected during daily pilot monitoring changes to the operational parameters, and notes of significant events and any shutdowns. In addition, failure of any piece of equipment to provide adequate service or to meet expectations will be documented and reported at the time of such failure and in the final report. Significant events will be noted in a weekly pilot summary e-mail to HMC.

5.2 Data Processing

Data collected from the field and laboratory monitoring will be processes and reviewed on a weekly basis. Conference call meetings with technical advisors will be held during each stage of testing to review the data for QA/QC. The data will be summarized in tables and graphs and presented in the final report.

5.3 Pilot Reports

The ARCACDIS team will develop two pilot testing memos throughout the course of the pilot testing to present the results of the testing. These include:

- Test # 1 and # 2 Results Memo – Present the proof-of-concept and basis of design results for the low pressure membrane testing.
- Test # 3 and # 4 Results Memo – Present the results of the high conductivity wells and challenge testing.

The documents will include:

- Introduction and goals
- Methodology
- Summary of Pilot Testing Results
- Recommendations and Next Steps

6. Staffing and Communication Plan

ARCADIS has several key personnel who will be active throughout the pilot testing project to ensure that results are obtained successfully. Table 6-1 below outlines the project leaders and their key responsibilities.

Table 6-1 ARCADIS Pilot Testing Team

Name	Role
Jason Kerstiens	*Project Manager* • Primary point of contact • Responsible for project management processes and achievement of project objectives
Bayard Yang	*Design Lead* • Responsible for leading site preparation and design team throughout project
Laurie Sullivan	*Pilot Testing Technical Lead* • Responsible for leading the technical elements of the pilot testing program
Jeff Jackson	*Field Staff* • Responsible for pilot operation, sampling and data collection/management during the pilot • Leader for health and safety related activities at the pilot system
Steve Diamond, Matt DeMarco, and Jeff Gillow	*Quality Assurance/Quality Control* • Team responsible for the review and quality assurance and quality control of the piloting throughout the entire project
Phil DeDycker	*Principal in Charge* • Responsible for overseeing all work performed by ARCADIS at the Grants Site

The pilot project will be staffed 40 hours per week by the on-site field staff member. The field staff will be in daily communication with the pilot testing lead. This will be the procedure for the duration of the project to ensure results are obtained successfully. Additionally, weekly update calls with the HMC and ARCADIS team will be conducted on Thursdays throughout the project. This will ensure a collaborative approach throughout the course of the pilot testing.

Throughout the course and completion of the pilot testing, there are several deliverables that will be provided to HMC in draft and final versions. Table 6-2 presents each deliverable and an estimated completion dates.

Table 6-2 ARCADIS Pilot Testing Deliverables

Deliverable	Estimated Completion Date
Draft Pilot Test Plan	August 2, 2013
Final Pilot Test Plan	August 19, 2013
Weekly Updates	Every Thursday throughout pilot testing
Test # 1 and # 2 Results Workshop and Memo	After completion of Test # 1 and Test # 2
Test # 3 and # 4 Results Workshop and Memo	After completion of pilot testing

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Appendix B

Pall Pilot Report

Pall Water Processing

Pall Water Processing Technical Report W0664

Homestake Mining Company – Grants, NM

Arcadis – US

Attention:
Jason Kerstiens
Laurie Sullivan
Jeff Jackson
Bayard Yang
Steve Diamond
Rachel Schmidt

Submitted by Scott Toomey, Pall Corporation

December 2013

TABLE OF CONTENTS

FIGURES

TABLES

APPENDICES

PURPOSE

The purpose of this demonstration pilot was to evaluate the performance of the Pall 0.1 µm microfiltration (MF) system filtering a pretreated blend from the various alluvial ground water wells on the Homestake Mines site located in Grants, NM. The existing pretreatment system was utilized which includes lime softening and clarification. Sulfuric acid is injected into the MF feed stream for pH adjustment. This report summarizes the findings of the pilot test. Specific objectives of the pilot test included:

- Demonstration of the design criteria and operating parameters to be used in the full-scale 1200 GPM system
- Demonstration of particulate and microbial removal capability via on-line turbidity
- Confirmation of on-line integrity test procedures
- Evaluation of membrane flux and recovery
- Evaluation of membrane fouling, CIP intervals, and effectiveness

SUMMARY

Pall Corporation began demonstration testing in August 2013 to determine the performance characteristics of the Pall MF system for filtering a pretreated blend from the alluvial ground water source. An initial stage of testing evaluated filtration on the pretreated source. The measured pH of the effluent from the lime softening/clarification process was found to be approximately 10. Sulfuric acid was injected into the MF feed stream to adjust and control the pH in a range of 9.0 – 9.5 for the majority of the study. Cycle 1 operated with relative stability in spite of a few operational interruptions at 40 – 45 GFD, 95.4% recovery, and daily 500 ppm sodium hypochlorite EFMs. Cycle 2 continued to evaluate the MF performance operating at 45 GFD, 95.4% recovery. The EFM process was initially triggered on a daily interval however the EFM interval would be increased to weekly, during the last portion of the test cycle. Membrane performance was stable with the tested parameters during cycle 2. The MF filtrate turbidity produced during the pilot was consistently low, with an average of 0.012 NTU. The average feed water temperature measured during the pilot was 57.6 °F. Throughout the pilot test, the Pall membrane demonstrated regenerative ability using EFM and CIP procedures. Membrane integrity was verified throughout the pilot with weekly pressure hold tests.

TEST METHODS & EQUIPMENT

Membrane Module

The system was equipped with a new UNA-620A (S/N 073270903) hollow-fiber MF module. The module contains 538 square feet of active membrane surface area and operates in an outside-to-inside filtration mode. The membrane is a polyvinylidene fluoride (PVDF) hollow fiber type with a nominal pore size of 0.1 µm. PVDF fibers has excellent mechanical and chemical resistance. The physical characteristics of the membrane are described below in *Table 1.*

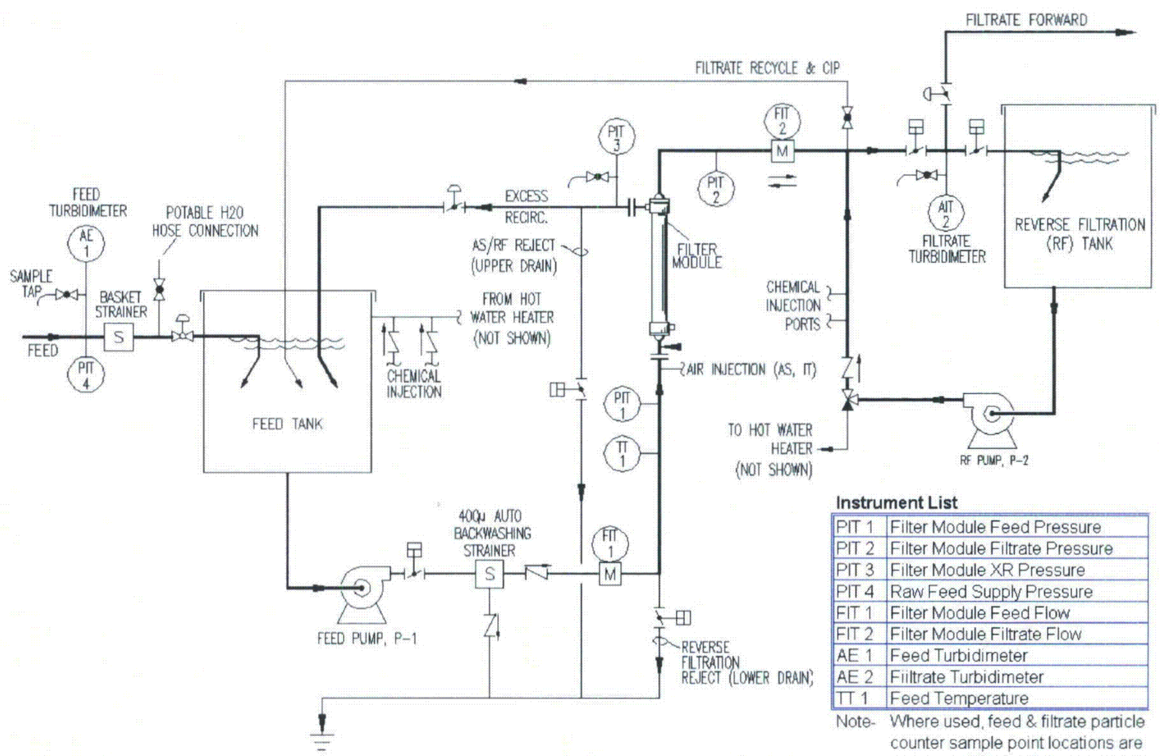
TABLE 1: MEMBRANE CHARACTERISTICS

Module Type	UNA-620A
Membrane Material	PVDF
Housing Material	ABS
Membrane Area (Outer Surface)	538 ft^2/50 m^2
Module Length	2 m
Module Diameter	15.24 cm
Nominal Membrane Pore Diameter	0.1µm
Number of Fibers per Module	6400
Fiber Diameter (ID/OD)	0.7mm/1.3mm
Filtration Mode	Outside-In, Dead End
Maximum Permeation Transmembrane Pressure	43.5 psid
Typical Operating Transmembrane Pressure	5-43.5 psid
Maximum Air Pressure for Integrity Test	>30
Maximum Operating Temperature	40°C
Maximum Cleaning Temperature	40°C
Operating pH Range	1-10
Cleaning pH Range	1-13
Maximum OCl- Exposure (Lifetime Contact Time)	>7,200,000 ppm-hr
Maximum Concentration for OCl- Cleaning	10,000 ppm

Pall MF Pilot System

The Pall MF pilot system is a fully automated membrane system designed with a range of capacity and capability intending to be applied to a wide range of process conditions. An industrial computer and a PLC controlled the operation of the system during this pilot study. The system was also monitored and controlled remotely through a wireless cellular router and remote access software. Critical operational parameters were logged continuously at 10 minute intervals and recorded automatically on the system computer hard drive. A schematic of the Pall MF system is show below in *Figure 1*. The pilot unit also included a hot water heater and chemical pumps for the direct coagulation and EFM processes.

FIGURE 1: PILOT PROCESS FLOW DIAGRAM



Instrument List

PIT 1	Filter Module Feed Pressure
PIT 2	Filter Module Filtrate Pressure
PIT 3	Filter Module XR Pressure
PIT 4	Raw Feed Supply Pressure
FIT 1	Filter Module Feed Flow
FIT 2	Filter Module Filtrate Flow
AE 1	Feed Turbidimeter
AE 2	Filtrate Turbidimeter
TT 1	Feed Temperature

Note- Where used, feed & filtrate particle counter sample point locations are same as AE 1 & AE 2 respectively.

There are five basic modes of operation for the MF membrane unit:

1. Forward Filtration
The feed pump draws water from the feed tank and pumps it into the feed port at the bottom of the module and through the membrane filter. Filtrate comes out of the vertical filtrate port at the top of the module. Excess recirculation (XR) entails circulating a small fraction of the feed water back to the feed tank to retain particulate suspension. This is performed by allowing a fraction of the feed flow to return to the feed tank through the horizontal XR port at the top of the module. The pilot unit is capable of operating with or without excess recirculation.

2. Reverse Filtration (RF)
The RF pump draws filtrate stored in the RF tank and pumps it through the membrane filter in the opposite direction as that during forward filtration. RF is used as a form of hydraulic cleaning for the membrane and is discharged through both the upper and lower discharge ports to drain. Chemicals such as chlorine or acid can be injected in the RF flow if necessary to keep the membrane clean. The frequency and duration of the RF is user defined.

3. Simultaneous Air Scrub/RF (AS)
AS (or sometimes termed SASRF) is another way to clean the membrane hydraulically. During an AS, air is injected into the module on the feed side of the fibers while filtrate is pumped in the reverse direction through the module. All discharge during the AS is sent to drain. The combined water-air flow creates turbulent flow generating a shearing force to dislodge foulant that has deposited on the membrane surface. The frequency and duration of an AS is dependent on feed water quality and is user defined.

4. Feed Flush (FF)
The feed pump is used to pump feed water into the module and out the upper drain/XR port. This process is used following an AS to flush waste out of the module. Flushed waste is directed to drain. The FF frequency and duration is also user defined.

5. Enhanced Flux Maintenance (EFM)
EFM is a short cleaning of membranes to maintain optimal performance. Called by various names, including chemical washes, mini-cleans, and relaxation, the basic process involves circulation of a chemical cleaning solution on the feed side of the membrane at an elevated temperature for 30 minutes before returning the unit back to normal operation.

TEST RESULTS & DISCUSSION

Cycle 1

The demonstration pilot began the test Tuesday, August 27th to evaluate the Pall MF membrane performance on the pretreated blend from the alluvial ground wells. The MF pilot system is fed a stream from the lime softening and clarification system. Sulfuric acid is injected into this raw stream for ph adjustment. At the start of the test, the ph was lowered to the range of 7 -8. On 8/30, the ph adjustment was set up to be controlled in the range of 9.0 – 9.5. *Table 2* provides a summary of operating conditions utilized in Cycle 1.

TABLE 2: CYCLE 1 OPERATING PARAMETERS

Filtrate Flux	40 - 45 GFD
Recovery	95.4 %
SASRF: Frequency Flow Rate Air Flow Rate Duration	 298 gal per 6" module (19.0-21.2) minute interval) 8 GPM 3.0 SCFM 60 seconds
Feed Flush (FL): Frequency Flow Rate Duration	 298 gal per 6" module (19.0-21.2) minute interval) 18 GPM 20 seconds
Feed Water Pretreatment	Lime Softening/ Clarification/ph adjustment
Excess Recirculation (XR)	N/A
EFM Interval	24 hr
EFM Chemical Concentration	500 ppm NaOCl, 30 mins
Cycle Length	~31 days

The MF pilot began filtration at a flux of 40 GFD, a 21.2 minute SASRF interval, 95.4% recovery, and daily 500 ppm NaOCl EFMs. Stable and predictable trends would emerge suggesting appropriate operating parameters with the given water quality. There were two brief interruptions, 8/31 - -9/2 and 9/6 – 9/7 due to data collection errors. The system was operational, but failed to collect the raw data points. This situation was remedied successfully on 9/7. On 9/8 there was a power issue at the plant which shut the MF pilot rig down over the weekend. The MF pilot rig was brought back in service on 9/10.

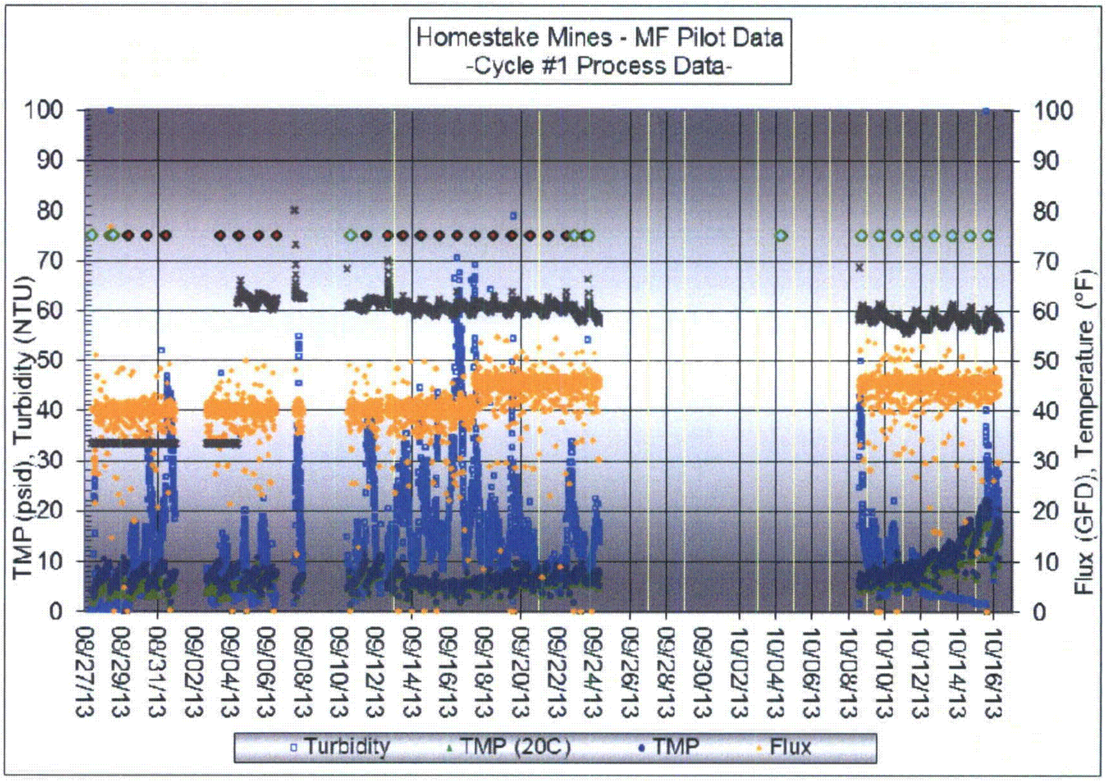
On Tuesday, 9/17 the operating flux was increased to 45 GFD, a 19.0 minute SASRF interval, 95.4% recovery, and daily NaOCl EFMs. On Tuesday, 9/24 there was a failure of the existing plant's clarifier. The MF pilot was down for 14 days before being restarted on Tuesday 10/8.

The period of operation between 10/8 and 10/16 experienced a fairly steep rise in the TMP trend. This process upset was likely caused by a couple of items. During a site visit to perform a scheduled CIP, it was discovered that the chlorine storage tank used for the EFM process had run dry. It is very likely that the prior EFMs during this period injected no chemical into the heated water, limiting the means to regenerate the

membrane permeability. There was also a failure of the pump used to deliver sulfuric acid for ph adjustment. This also likely played a role in the process upset previously noted.

The turbidity of the MF feed in cycle 1 was generally in a range of 3 – 40NTU. The average turbidity of the MF feed was 12.3 NTU. The turbidity of the MF filtrate was 11 – 12 mNTU, indicating that the MF process produced excellent water quality. The average feed water temperature was 54.4°F. A CIP was performed on 10/16 in completion of this test cycle.

FIGURE 2: CYCLE 1 PROCESS DATA



Cycle 2

A CIP was performed 10/16 in preparation for the next test cycle. The CIP process fully restored permeability as expected. Cycle 2 would begin on 10/16. Operating conditions for Cycle 2 are summarized below in *Table 3*.

TABLE 3: CYCLE 2 OPERATING PARAMETERS

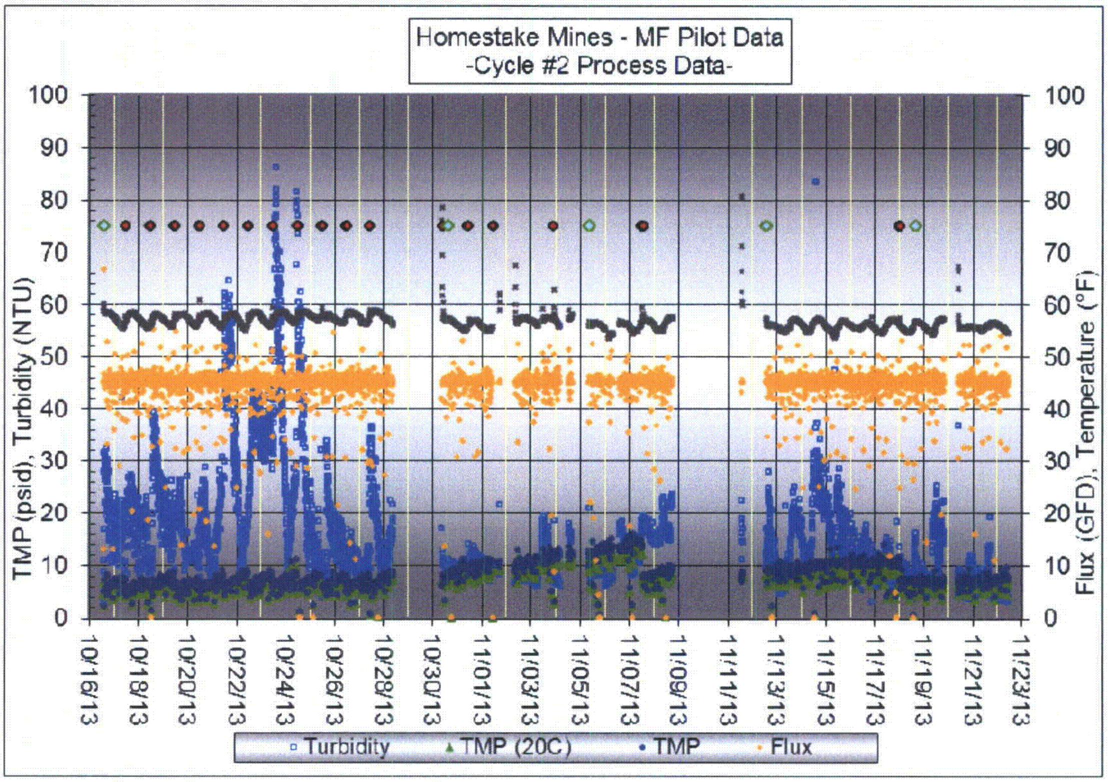
Filtrate Flux	45 GFD
Recovery	95.4 %
SASRF: Frequency Flow Rate Air Flow Rate Duration	 298 gal per 6" module (19 mins) 8 GPM 3.0 SCFM 60 seconds
Feed Flush (FF): Frequency Flow Rate Duration	 298 gal per 6" module (19 mins) 18 GPM 20 seconds
Feed Water Pretreatment	Lime Softening/Clarifiacation
Excess Recirculation (XR)	N/A
EFM Interval	24 hr
EFM Chemical Concentration	500 ppm NaOCl, 30 mins
Cycle Length	~32 days

The MF pilot system continued to be fed a stream from the existing pretreatment system with the ph adjusted to 9.0 – 9.5. The MF pilot system began operations at 45 GFD, a 19.0 minute SASRF interval, 95.4% recovery, and daily NaOCl EFMs. The MF performance was reliably stable and predictable. The EFM process was useful in controlling TMP growth and to restoring membrane permeability. On 10/28, the booster pump failed. A replacement was quickly ordered and replaced. The MF pilot rig was brought back into service on 10/30. This was followed by a failure of FIT1, the feed flow transmitter. During the period of operation between 10/30 and 11/7, the EFM process did not function properly. This was due to the fact that the EFM process flow is controlled FIT1 and when an EFM was triggered no flow was detected. "High Pressure" alarms shut down the MF pilot rig. On 11/7 a Pall Field Tech replaced the faulty flow transmitter, bringing the system back into full service. At this point the EFM trigger was changed from daily to weekly intervals. The MF performance remained stable.

The average temperature of the MF feed water is 58.1 °F. The MF feed turbidity recorded an average of 22.4 NTU. The filtrate turbidity recorded an average of 12.8 mNTU. The average TMP was 8.4 PSI.

PALL Water Processing

FIGURE 3: CYCLE 2 PROCESS DATA



TURBIDITY

The average raw water, MF feed water, and MF filtrate turbidity for the pilot is shown below in *Table 4*. Graphed turbidity data is shown in Appendix C.

TABLE 4: TURBIDITY SUMMARY

	Average MF Feed Turbidity (NTU)	Average Filtrate Turbidity (mNTU)
Cycle 1	12.3	12.5
Cycle 2	22.4	12.8
All Data	17.35	12.64

CIP EFFECTIVENESS

A chemical CIP procedure was performed after each cycle during the pilot study using the protocol outlined in Appendix A. A typical measure of CIP effectiveness is the specific flux or permeability, reported in GFD/psid. The fraction of initial CIP permeability is a measure of the effectiveness of the cleaning procedure, and is a ratio of the permeability after cleaning compared to a baseline permeability established after the first cleaning. Appendix C contains graphs displaying the specific flux during pilot. Additionally, *Table 5* provides a summary of permeability following each CIP.

TABLE 5: CIP EFFECTIVENESS

Cycle	Cycle Length (Days)	Date of CIP	Fraction of Initial CIP Permeability
Initial	-	-	1.15
1	43.1	10/16/13	1.00
2	28.6	12/02/13	0.95

The pilot was successful at demonstrating the ability to regenerate the membrane's permeability after each CIP. The cleaning parameters highlighted in Appendix A have proven to be appropriate and effective in restoring membrane permeability. The cleaning parameters were used after the completion of each cycle, were consistent with Appendix A.

INTEGRITY TESTING

In order for a membrane treatment system to be an effective barrier against pathogens and particulate matter it must be free of breaches. The presence or breaches, or membrane integrity, can be demonstrated on an ongoing basis during system operation using pressure based tests. A pressure hold test was performed at the start of the pilot, daily during the pilot, and after each CIP. The procedure is outlined in Appendix B, and consists of pressurizing the wetted filtrate side of the membrane while exposing the feed side to atmosphere. The pressure decay rate is then monitored and compared to a standard to ensure breaches are not present. Each integrity test performed during piloting passed with an average pressure decay rate of 0.1 psi/min. Complete IT data is provided in Appendix C, and also is summarized in Table 6.

The upper control limit (UCL) of the PDR for a Pall pilot system is 0.2 psi/min or 1 psi per 5 minute direct integrity test (DIT). This UCL is based on empirical data from previous Pall fiber cuts and integrity tests. Experience has dictated that minor air leaks are inevitable in pilot systems, and this actuality needs to be considered when determining the PDR UCL. Transportation of piloting equipment can often contribute to air breaches in piping and instrument connections. Air leaks are less likely with a full scale plant that does not move once installed. Additionally, full scale plants have larger air hold up volumes than pilot units. The PDR of a larger volume of air has substantially less sensitivity from a single air leak, thus full scale systems are less sensitive to each individual air breach. The PDR of 0.2 psi/min is conservative enough to account for air leaks, but is still capable of verifying membrane integrity (based on previous Pall testing).

Under the Long-Term Stage 2 Enhanced Surface Water Treatment Rule (LT2ESWTR), a direct integrity test must meet a resolution criterion (for the purpose of granting removal credit for *Cryptosporidium* from regulatory agencies). A direct integrity test is required to have sufficient resolution to detect an integrity breach of 3 μm or less. The resolution computation below shows that a minimum test pressure of 17.5 psi is required to meet this criterion. The pressure-hold procedure used by Pall for full scale systems typically applies testing pressures as high as 25 to 30 psi. All IT's performed during the pilot trial exceeded 25 psi. This high testing pressure not only ensures the resolution criterion specified in LT2ESWTR can be met, but also considerably increases the sensitivity of the test.

The minimum testing pressure required in order to achieve a resolution of 3μm (P_{test}) with the Pall pilot is calculated below using equation 4.1 from the US EPA's Membrane Filtration Guidance Manual (MFGM).

$$P_{test} = (0.193 \bullet \kappa \bullet \sigma \bullet \cos\theta) + BP_{\max} \quad \text{(MFGM Equation 4.1)}$$

κ	=	pore shape correction factor ($\kappa = 1$)
σ	=	surface tension at the air-liquid interface ($\sigma = 74.9$ dynes/cm @5°C)
θ	=	liquid-membrane contact angle ($\theta = 0°$)
BP_{max}	=	the sum of back pressure and static head ($BP_{max} = 3.0$ psid[11])

[1] BPmax is calculated by adding the back pressure (0 psi during an IT) and the static head pressure (module height is 2 meter resulting in 3 psi of hydrostatic head).

Therefore, $P_{test} = 14.5 + 3 = 17.5$ psi

The pilot's integrity test data is summarized in Table 6 below. All integrity tests performed during the pilot had pressure decays less than 0.2 psi/min, implying the absence of membrane breaches and ensuring membrane integrity.

TABLE 6: INTEGRITY TEST DATA SUMMARY

	Minimum Value	Maximum Value	Average Value
Beginning Pressure, P_{test} (psi)	22.9	26.9	23.5
Ending Pressure (psi)	22.7	26.1	23.3
Change in Pressure (psi)	0.037	0.806	0.195
Change in Pressure (psi/min)	0.01	0.16	0.04

Conclusions & Recommendations

The conclusions of this pilot study proved to be valid under raw water quality conditions tested and within the range of the pretreatment conditions and parameters utilized. The results of the pilot study indicated the following:

- The Pall MF system can be stably and consistently operated on pretreated water (Lime Softening/Clarification) at 45 GFD with a 95.4% recovery, and daily 500 ppm NaOCl EFM procedures.
- The Pall membrane system produced excellent finished water quality, averaging 12.2 mNTU.
- The pilot confirmed that a CIP interval greater than 30 days could be achieved under design conditions.
- The chemical cleaning processes (EFM & CIP) effectively restored membrane permeability, indicating that the specified cleaning regime (chemical, duration, and frequency) is appropriate for this feed water source.
- Membrane integrity was successfully verified on a weekly basis during the pilot study using a pressure-hold test.

Pall Corporation's *Water Processing Division* appreciates the opportunity to work with the Arcadis team and the Homestake Mines staff on this project. We will be happy to assist in the future implementation of the Pall MF technology.

Scott Toomey
Pilot Project Manager
Water Processing
Pall Corporation

REFERENCES

Membrane Filtration Guidance Manual, USEPA, Office of Water, EPA-815-R-06-009, November, 2005.

Sethi et al., (2004); Assessment and Development of Low-Pressure Membrane Integrity Testing Tools. AwwaRF Report 91032, Denver, CO. AwwaRF

APPENDIX A: MF STANDARD CIP PROTOCOL

System Preparation:

1.0 Initiate appropriate AS/RF sequence.
1.1 Close Feed valve to unit after ensuring that all secondary feed pumps to system is shut off.
1.2 Close valves to turbidimeters, particle counters and other instruments, as required.
1.3 Drain feed tank: Wipe sides and bottom of feed tank, floater valve, inside of cover, etc. Rinse and drain feed tank so it is clean.
1.4 Drain module and any prefilters.

2. Softened (Potable) Water Flushing:

2.0 Fill feed and filtrate tanks with softened water to 15 gal level
2.1 Recirculate feed through XR valve at 8 gpm for 5-10 minutes
2.2 Flush the feed to drain
2.3 Perform a RF with filtrate at 15 gpm for one minute
2.4 Drain feed and filtrate tanks.

3. 2% Citric Acid Cleaning

3.0 Switch filtrate valve to tank (recirculation mode)
3.1 Fill feed and filtrate tanks with softened heated (90-100°F) water to 12 gal
3.2 Add 50% citric acid (1464 ml in 12 gal)
3.3 Recirculate with 3-4 gpm forward flow for 1 hrs
3.4 Stop the system and AS the chemical solution to drain
3.5 Perform a RF with filtrate at 15 gpm for one minute
3.6 Drain feed and filtrate tanks.

4. Softened (Potable) Water Flushing: see section 3 above

4.0 Fill feed and filtrate tanks with softened water to 15 gal level
4.1 Recirculate feed through XR valve at 8 gpm for 5-10 minutes
4.2 Flush the feed to drain
4.3 Perform a RF with filtrate at 15 gpm for one minute
4.4 Drain feed and filtrate tanks.

5. 1% Caustic/2000 (ppm) Chlorine Cleaning:

5.0 Switch filtrate valve to tank (recirculation mode)
5.1 Fill feed and filtrate tanks with softened heated (90-100°F) water to 12 gal
5.2 Add 50% NaOH (593 ml in 12gal) and 8% NaOCl (1001 ml in 12gal)
5.3 Recirculate with 3-4 gpm forward flow for 2 hrs
5.4 Stop the system and AS the chemical solution to drain
5.5 Perform a RF with filtrate at 15 gpm for one minute
5.6 Drain feed and filtrate tanks.

6. Softened (Potable) Water Flushing: see section 4 above

Appendix B: Integrity Test Protocol

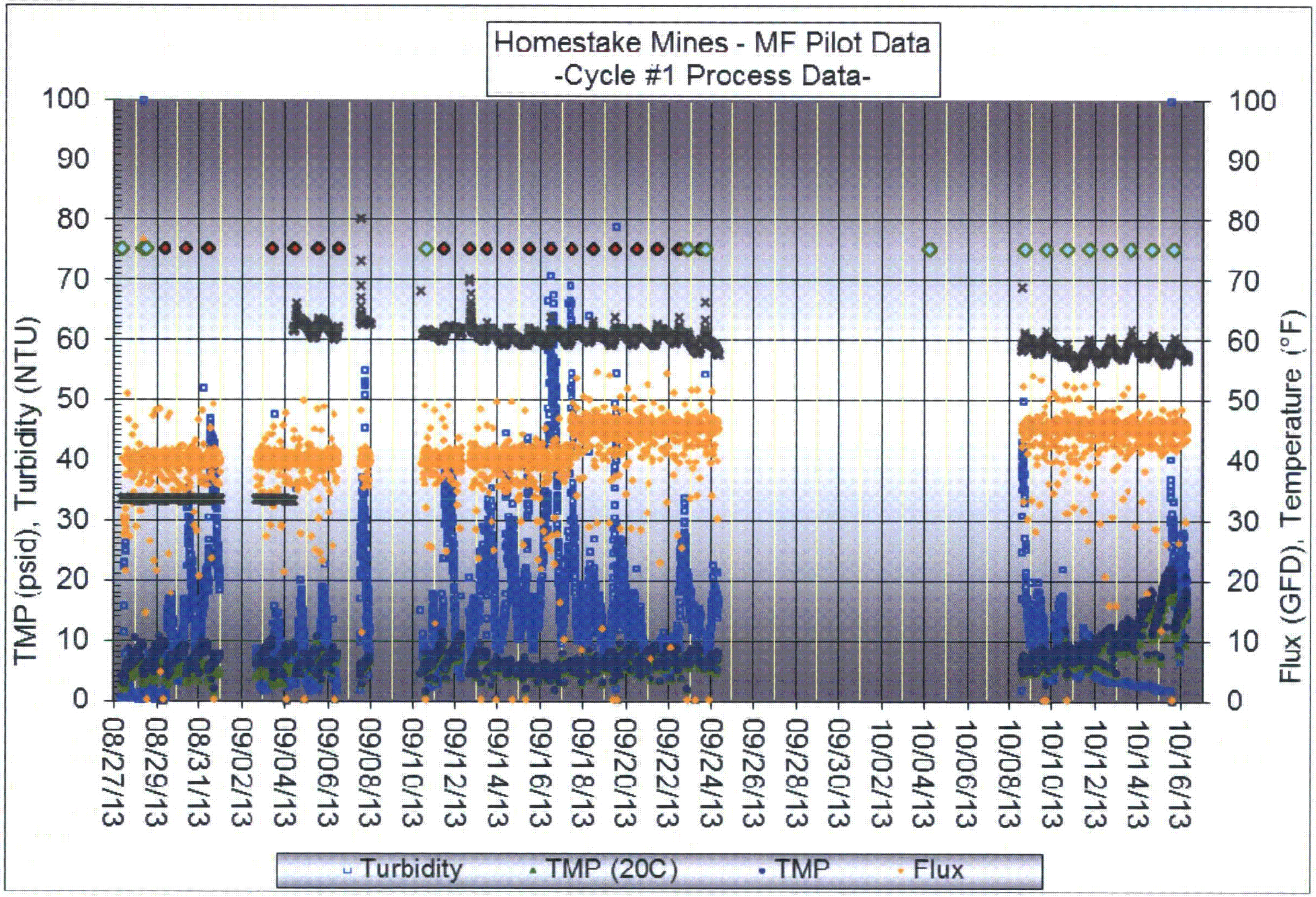
1. **In Automatic Mode**
   - 1.1 Open the *Mode* view in the HMI
   - 1.2 Select *Integrity Test* tab from the view. The integrity test sequence is automatically executed and the test data is logged into data file. If the pressure decay rate exceeds the set point (typically 0.2 psid/min.), an alarm is activated. If the system passes the integrity test, the system will return to the normal operation after integrity test.

2. **In Manual Mode**
   - 2.1 Open the *Process* view in the HMI
   - 2.2 Set the system in *Manua*l mode by clicking *Auto/Manual* button
   - 2.3 Close valves on feed and excess recirc line and open the valve on the filtrate line by clicking valves on process flow diagram. The color Red indicates "Close" and Green indicates, "Open"
   - 2.4 Open the air valve to pressurize the module to the set point (typically 25 – 30 psi).
   - 2.5 Wait until pressure stabilizes and record the pressure reading on the feed pressure transmitter tag as initial pressure; close the air valve start the timer.
   - 2.6 Record pressure reading every 30 seconds for 5 minutes.
   - 2.7 If the pressure reading at the end of 5 minutes exceeds the set point (typically 1.0 psi), the module fails the test. Check for leaks from piping and valves and look at the clear plastic coupling at the top of the module for air bubbles. If a continuous stream of air bubbles is visible, then the module failure is positively confirmed.
   - 2.8 If the pressure loss at the end of 5 minutes is within or less than the set point (typically 1.0 psi), the module passes the test. Proceed to the next step.

APPENDIX C: PILOT DATA CHARTS AND FIGURES

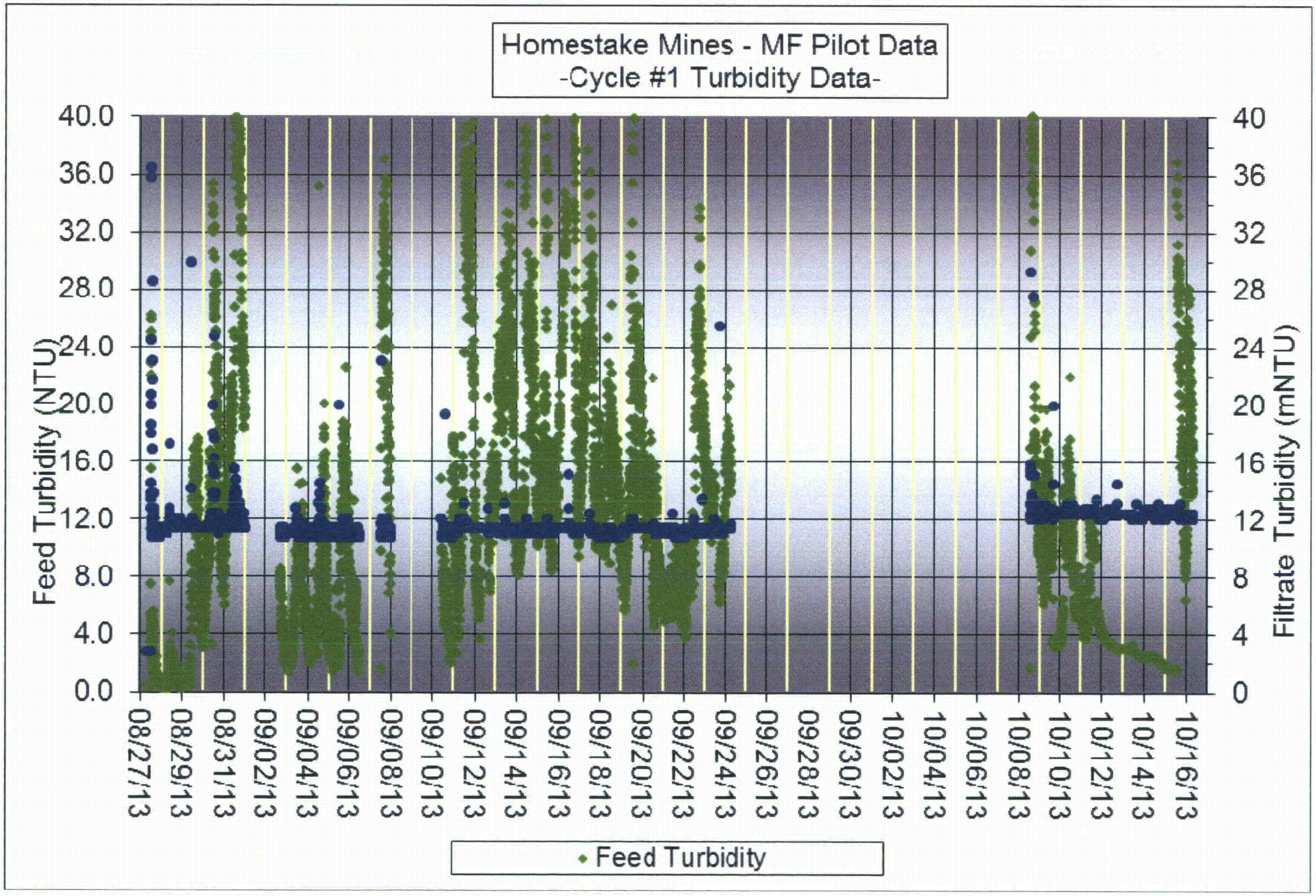
Appendix C Table of Contents

PALL Water Processing



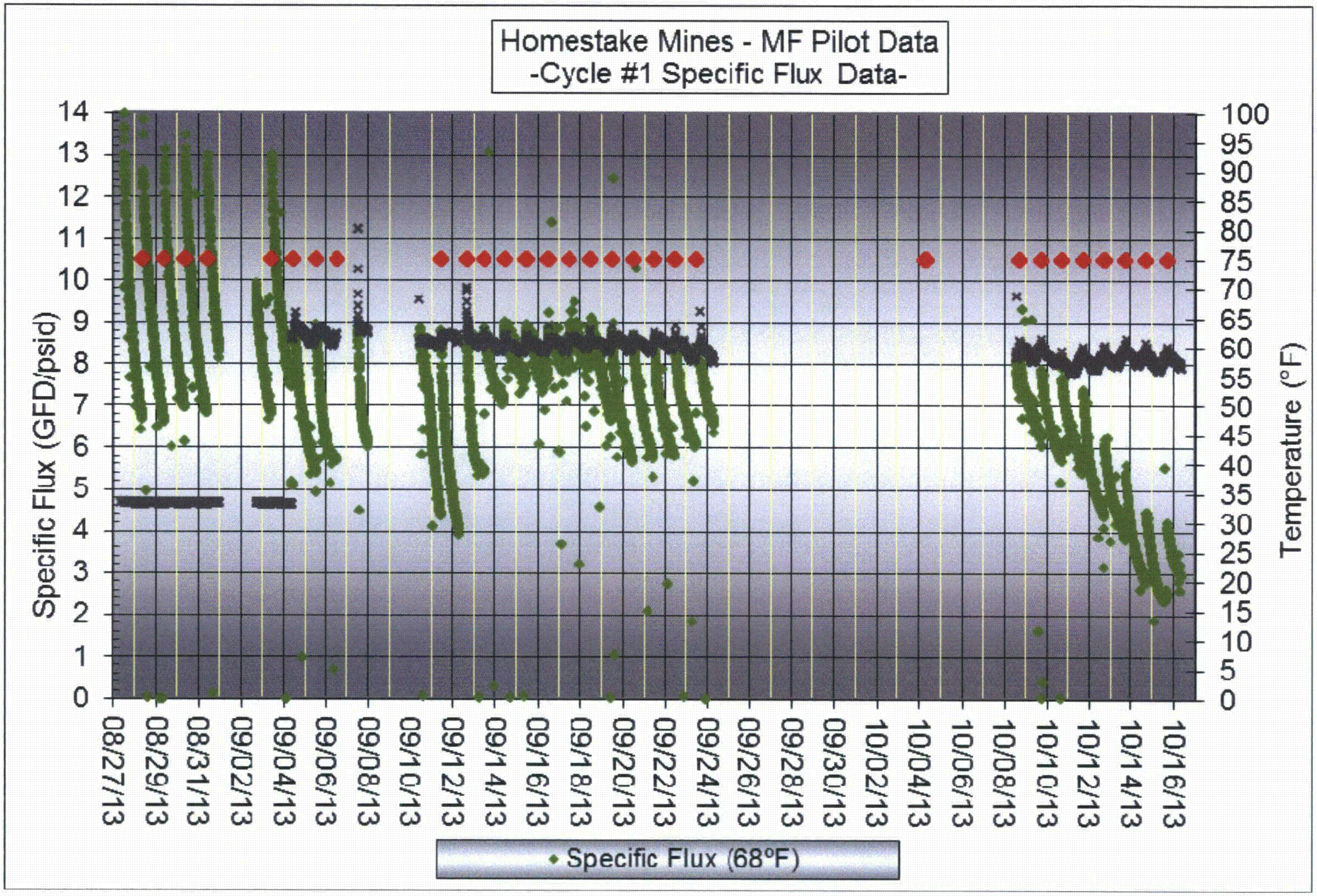
APPENDIX C

(PALL) Water Processing



APPENDIX C

PALL Water Processing



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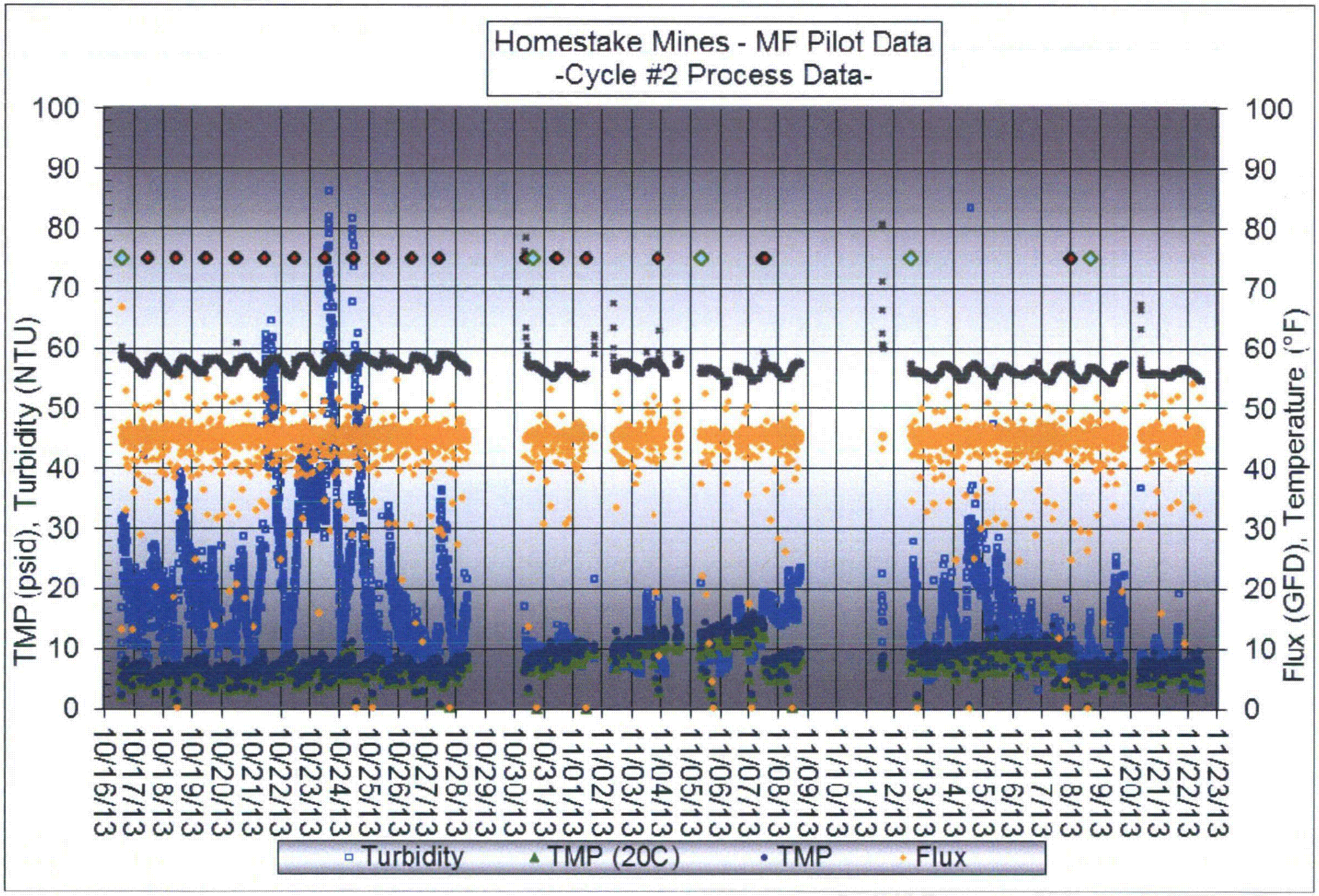

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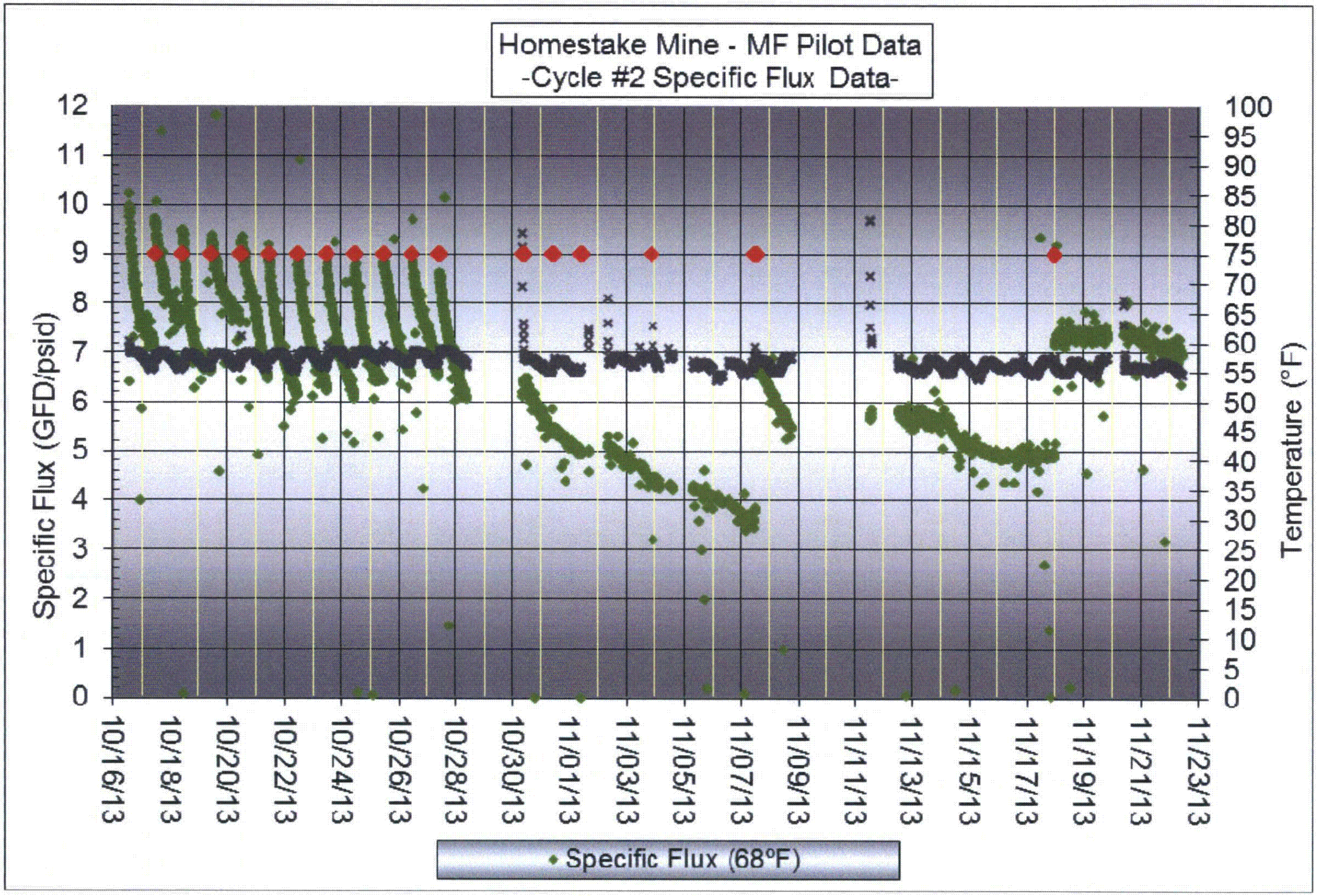

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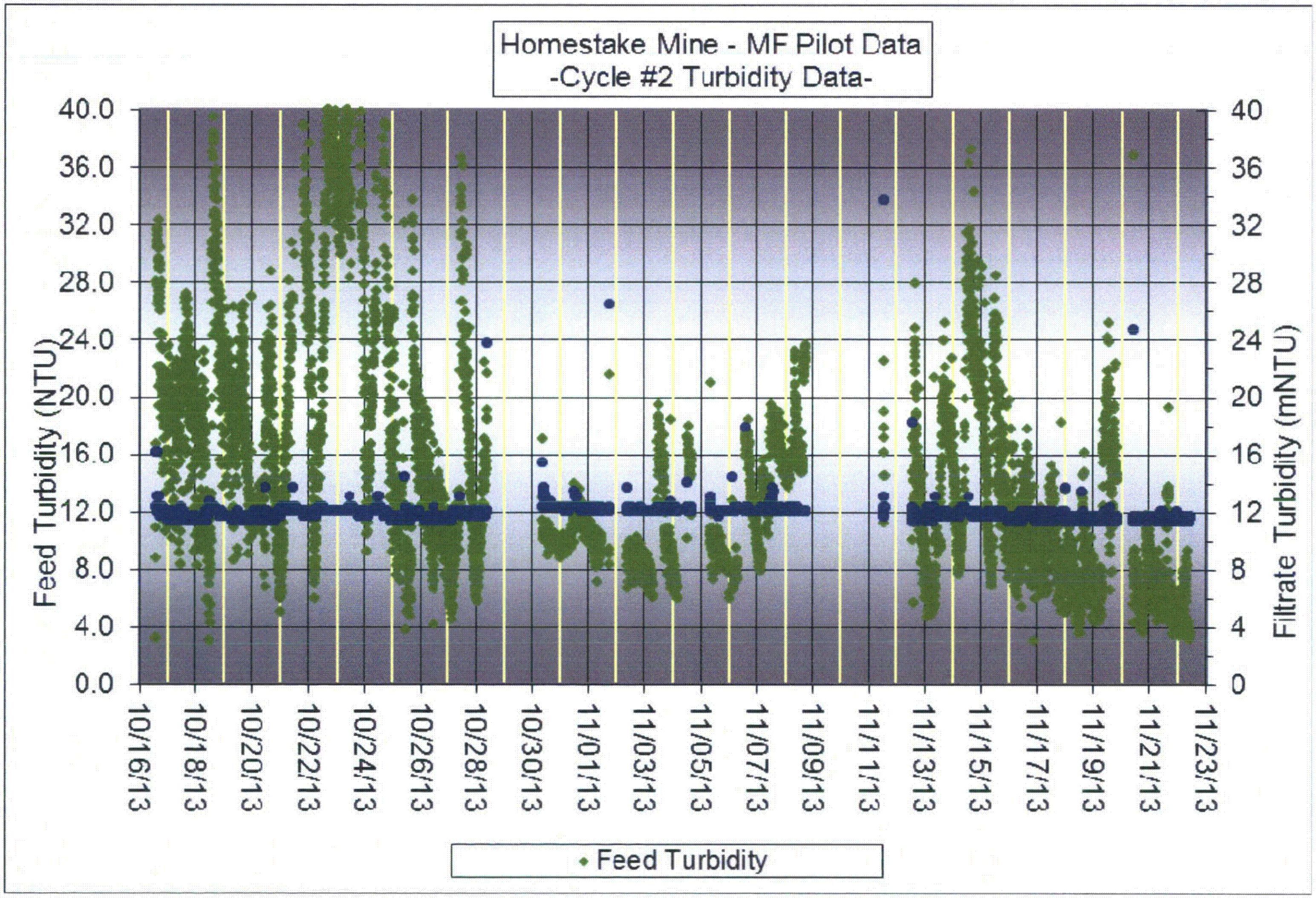

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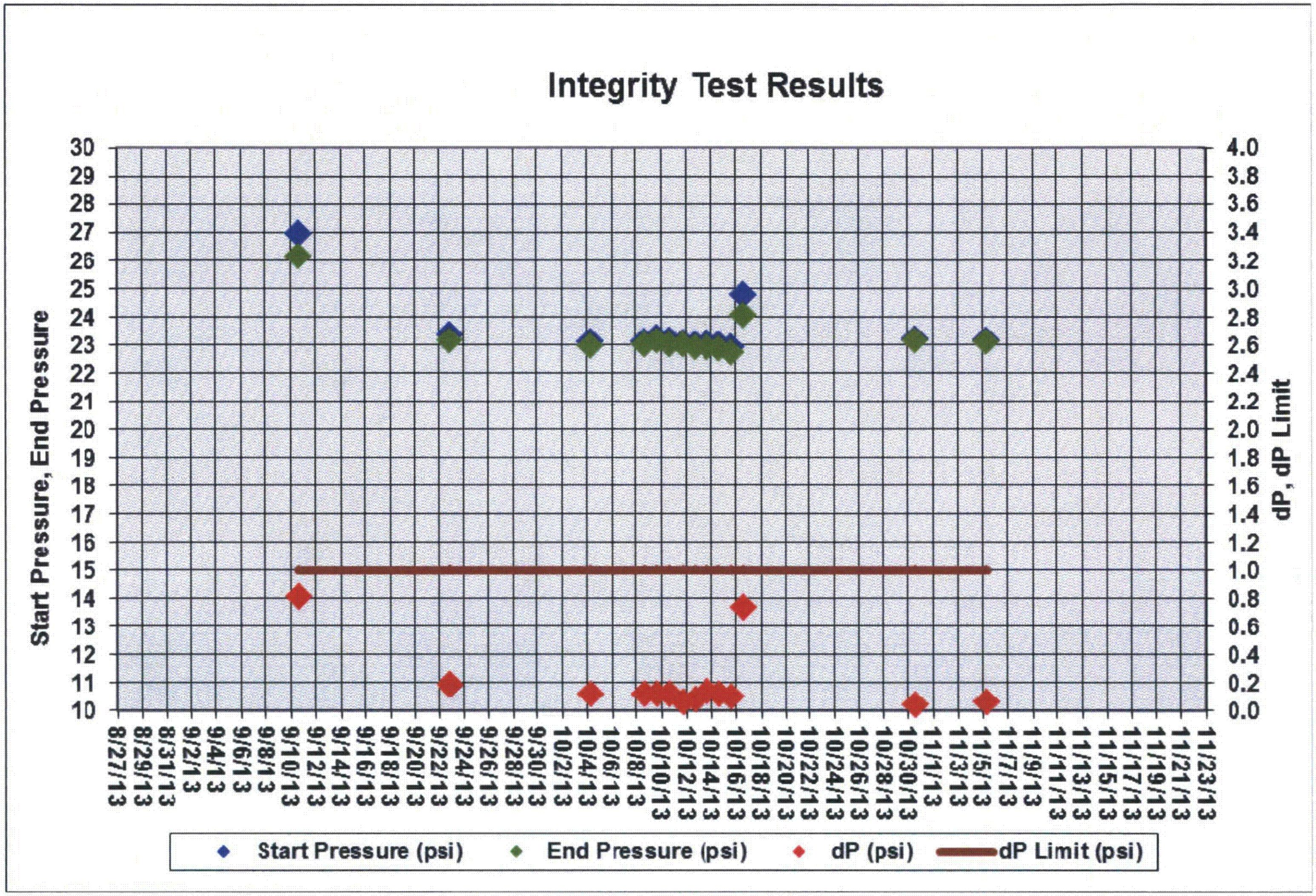
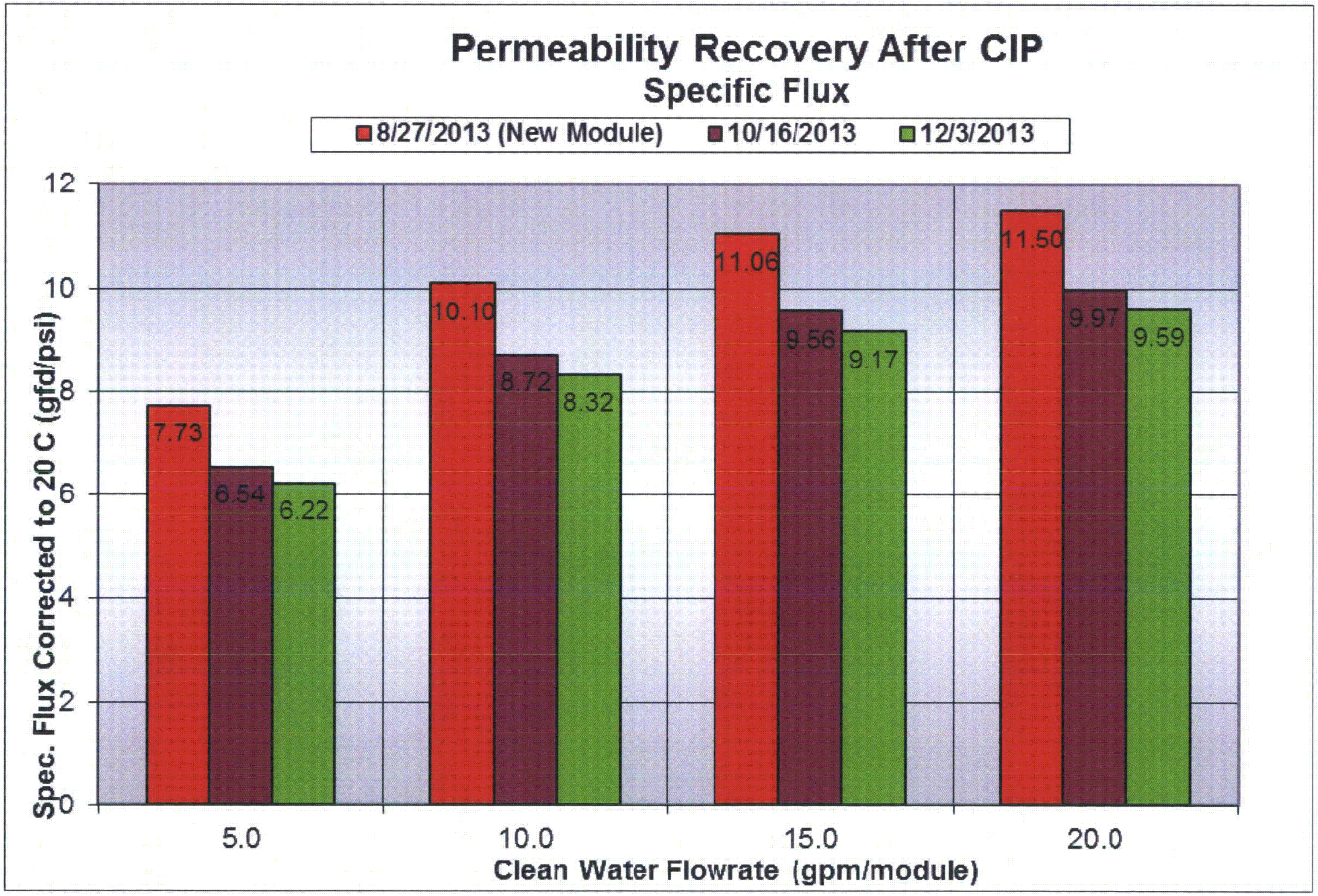


PALL Water Processing



PALL Water Processing

ARCADIS

Appendix C

Blending Evaluation Plan

Grants Bench-Scale RO WTP Blending Evaluation Plan

Bench-Scale Blending Evaluation Objectives:

ARCADIS is organizing and facilitating the bench-scale evaluation of Large Tailings Pile (LTP) and alluvial water blending at the reverse osmosis (RO) water treatment plant (WTP). The objectives and benefits of the testing include:

- Assess the impact of blending on the characterization of water quality entering the solids contact clarifier (SCC)
- Evaluate the impact on the Grants Site closure date if LTP water can be treated at the RO WTP
- Establish design criteria and a mobilization plan for full-scale equalization basin improvements

Approach:

These tests will be conducted to visually and chemically characterize changes occurring in blended alluvial and LTP water samples. Water quality sampling will be conducted at several different detention intervals to evaluate the kinetics of the reactions which will provide insights on which blends are most suitable for the RO WTP. During the testing, ARCADIS will evaluate the data relative to the RO WTP performance targets that are summarized in Table 1 for the SCC and combined filter effluent (CFE).

Table 1. SCC and CFE Performance Targets

Parameter	Location	Target
Turbidity	SCC	10 to 30 NTU
Calcium	SCC	< 15 mg/L
pH	SCC	9.8 to 10.5 s.u.
Sludge Depth	SCC	2 to 5 feet
Solids Concentration, Mixing Zone (SCC Sample Tap #1)	SCC	5 to 15%
Solids Concentration, Solids Recycle	SCC	25 to 35%
Total Iron	SCC,CFE	<0.10 mg/L to ND*
Turbidity	CFE	<1.0 NTU
SDI_{15}	CFE	< 5

*If kept anoxic and under strict pH control, higher concentrations such as 1 mg/l is tolerable.

Materials:

Table 2 presents a summary of the materials and equipment required for the blending evaluation and jar testing.

Table 2. Blending Evaluation Materials

Item	Quantity	Description	Notes
20 L clear plastic container	4	Container to be used for blending evaluations	ARCADIS
6 L clear plastic container	3	Container to be used for blending evaluations	ARCADIS
Jar testing setup	1	Jar testing unit for SCC evaluation	ARCADIS
Sample Collection Bottles	TBD	Collection bottles from Energy Labs	Energy Labs
Lime	TBD	Jar testing evaluation	Homestake
Nitrile gloves	1 box	Health and safety	ARCADIS

Testing Schedule:

Testing will be completed in September and October 2013. Table 3 presents a summary of the testing schedule, and Figure 1 presents a detailed Gantt chart schedule.

Table 3. Schedule of Activities

#	Date	Description of Activities
1	October 7-10, 2013	• ARCADIS conduct bench-testing setup and blending evaluation • ARCADIS send samples to laboratory
2	October 25, 2013	• Laboratory send results to ARCADIS
3	October 28 – November 4, 2013	• ARCADIS review data and prepare and submit draft technical memorandum to HMC
4	November 5 and 6, 2013	• ARCADIS present draft results to HMC in Denver
5	November 7 – 21, 2013	• HMC review draft technical memorandum
6	November 22 – December 3, 2013	• ARCADIS prepare and submit final technical memorandum

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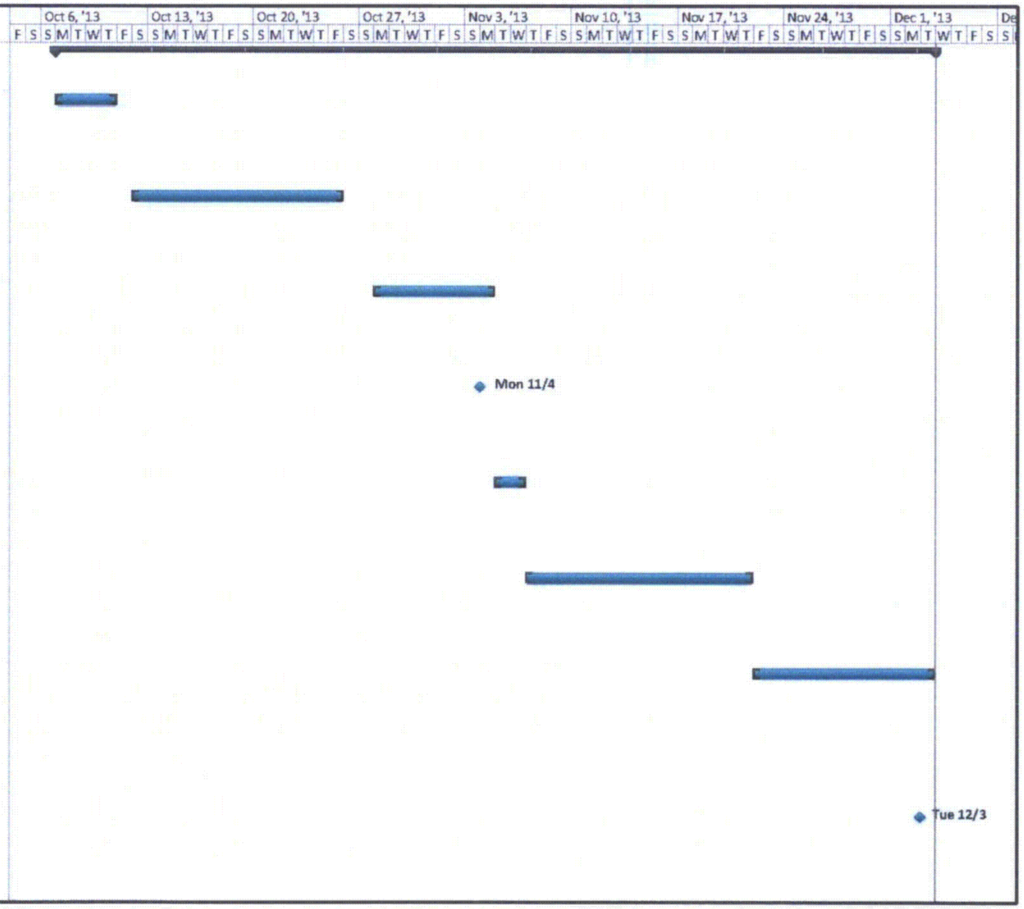
Figure 1. Gantt Chart Schedule

ID	Task Name	Duration	Start	Finish
1	**Bench Scale Blending Evaluation**	**42 days**	**Mon 10/7/13**	**Tue 12/3/13**
2	Bench Scale Blending Evaluation on Site	4 days	Mon 10/7/13	Thu 10/10/13
3	Data back from Energy Labs	11 days	Sat 10/12/13	Fri 10/25/13
4	Blending Evaulation Report Development	6 days	Mon 10/28/13	Mon 11/4/13
5	ARCADIS Submit Draft Technical Memorandum to HMC	0 days	Mon 11/4/13	Mon 11/4/13
6	Review Results at Pre-Design Workshop	2 days	Tue 11/5/13	Wed 11/6/13
7	HMC Review Draft Technical Memorandum	11 days	Thu 11/7/13	Thu 11/21/13
8	ARCADIS Review HMC Comments and Prepare Final Technical Memorandum	8 days	Fri 11/22/13	Tue 12/3/13
9	ARCADIS Submit Final Technical Memorandum to HMC	0 days	Tue 12/3/13	Tue 12/3/13



Blending Evaluation:

The blending evaluation will assess six different blends of alluvial, WCP and LTP water as presented in Table 4. The Northeast quadrant of the LTP will be used as the source for each of the different blending evaluations based on recommendation from Hydro-Engineering

Table 4. Blending Evaluation Testing Matrix

	0% LTP	10% LTP	20% LTP	30% LTP	40% LTP	100% LTP
Volume of Alluvial (Liters)	18L	16L	14L	12L	10L	0L
Volume of LTP (Liters)	0L	2L	4L	6L	8L	20L
Volume of WCP (Liters)	2L	2L	2L	2L	2L	0L

The following summarizes the steps that ARCADIS will perform as part of the blending evaluation.

- Step 1: Add prescribed volume of alluvial water and LTP water to 20L container (refer to Table 4)
- Step 2: Collect a time = 0 minutes sample for characterization purposes
- Step 3: Visually characterize and collect samples every 15 minutes for water quality equalization characterization
- Step 4: Collect a time = 60 minutes sample for characterization purposes
- Step 5: At time = 60 minutes add lime to reach pH = 10.8

Samples collected during the blending evaluation will be analyzed either in the field or sent to Energy Laboratories. Table 5 presents the analytes that will be screened and identifies the sample analysis location.

Table 5(a). Analyte List (t=15 minutes, t=30 minutes and t=45 minutes)

Parameter	Sample Analysis Location
pH	On-Site
Conductivity	On-Site
Temperature	On-Site
Turbidity	On-Site
Hardness	On-Site
Calcium	On-Site
Alkalinity, Total (filtered sample)	Energy Laboratories
Alkalinity, Bicarbonate (filtered)	Energy Laboratories
Solids, Total Dissolved	Energy Laboratories
Solids, Total Suspended	Energy Laboratories
Metals, Dissolved Iron Silica	Energy Laboratories
Anions, Dissolved	Energy Laboratories

Parameter	Sample Analysis Location
Chloride Fluoride Sulfate	
Cations, Dissolved Calcium Sodium Magnesium Potassium	Energy Laboratories

Table 5(b). Analyte list (t=0 and t=60 minutes)

Parameter	Sample Analysis Location
pH	On-Site
Conductivity	On-Site
Temperature	On-Site
Turbidity	On-Site
Hardness	On-Site
Calcium	On-Site
Alkalinity, Total (filtered sample)	Energy Laboratories
Alkalinity, Bicarbonate (filtered)	Energy Laboratories
Solids, Total Dissolved	Energy Laboratories
Solids, Total Suspended	Energy Laboratories
Carbon, Total Organic	Energy Laboratories
Metals, Dissolved Molybdenum Selenium Vanadium Uranium Iron Manganese Silica	Energy Laboratories
Anions, Total and Dissolved Chloride Fluoride Sulfate	Energy Laboratories
Cations, Total and Dissolved Calcium Sodium Magnesium Potassium	Energy Laboratories
Radium 226, Dissolved	Energy Laboratories
Radium 228, Dissolved	Energy Laboratories
Thorium, Dissolved	Energy Laboratories

All samples will be analyzed using industry approved analytical methods. All samples collected and measured on-site will be validated at a frequency of 10% or in accordance with standard procedures, whichever is most conservative. QA/QC procedures will be conducted by all contract laboratories to ensure data integrity is maintained while conducting the testing.

Table 6 presents the draft budget for the analytical sampling to be conducted.

Table 6. DRAFT Budget for Analytical Sampling

Time	Alluvial Only	10%	20%	30%	40%	LTP Only*	Total Cost
t = 0	$ 465.00	$ 465.00	$ 465.00	$ 465.00	$ 465.00	$ 465.00 - $1,860.00	$ 2,790.00 - $4,185.00
t = 15	$ -	$ 150.00	$ 150.00	$ 150.00	$ 150.00	$ -	$ 600.00
t = 30	$ -	$ 150.00	$ 150.00	$ 150.00	$ 150.00	$ -	$ 600.00
t = 45	$ -	$ 150.00	$ 150.00	$ 150.00	$ 150.00	$ -	$ 600.00
t = 60	$ -	$ 465.00	$ 465.00	$ 465.00	$ 465.00	$ -	$ 1,860.00
						Total	$ 6,450.00 - $7,845.00

* Note: $465.00 represents the cost of sampling one LTP quadrant

ARCADIS

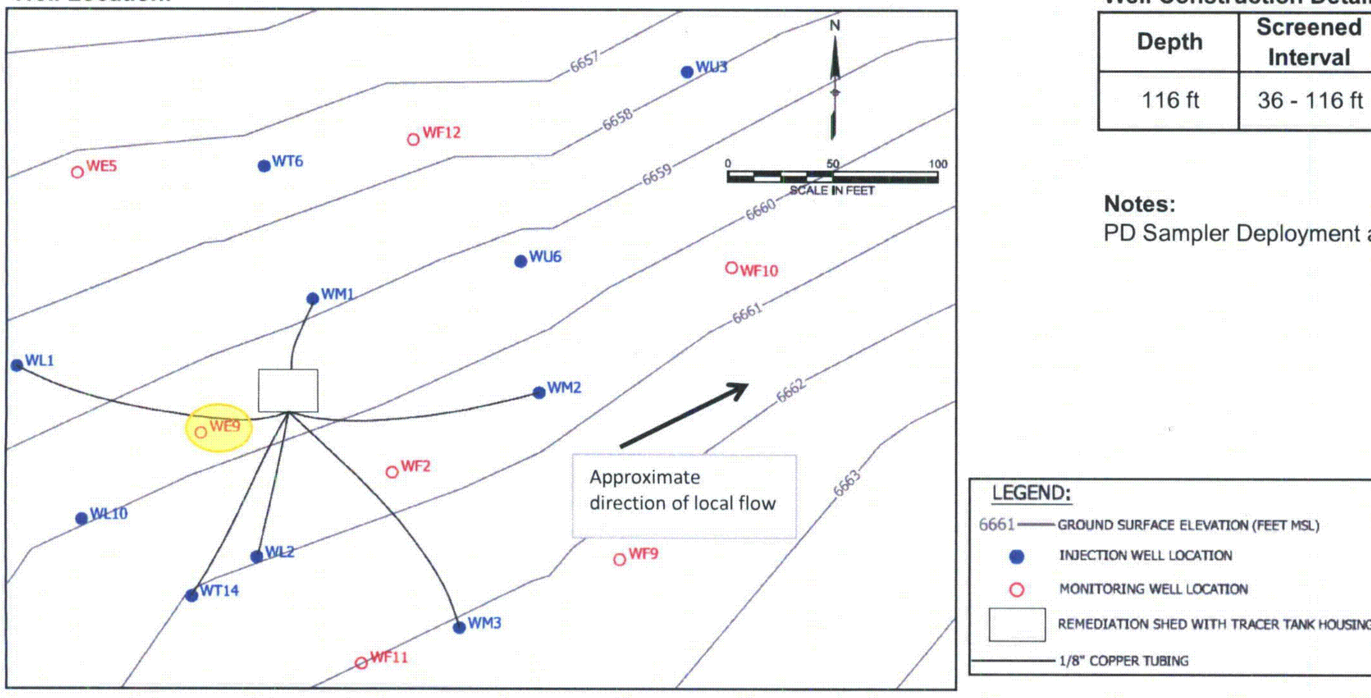
Attachment 3

Rebound Evaluation: At-A-Glance Charts

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

Updated: July 21, 2014
Most recent data: May 8, 2012

Well Location:

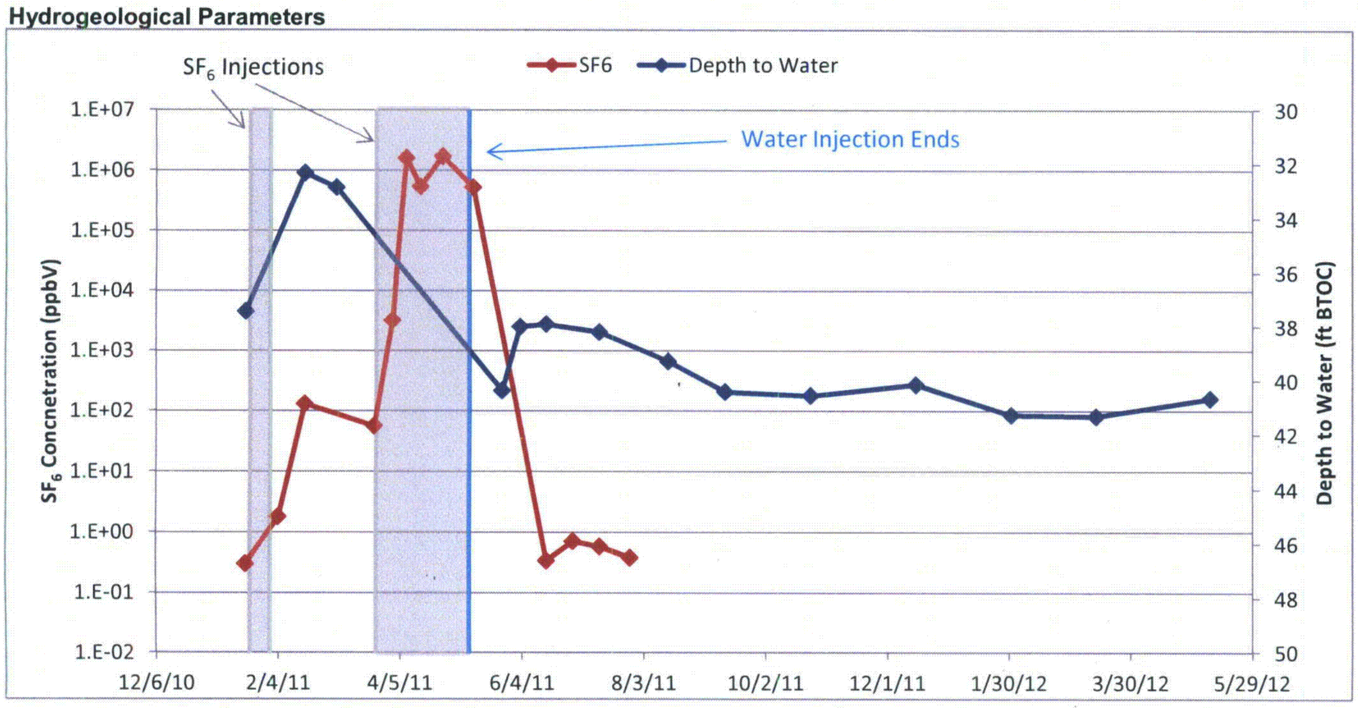


Well Construction Details:

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

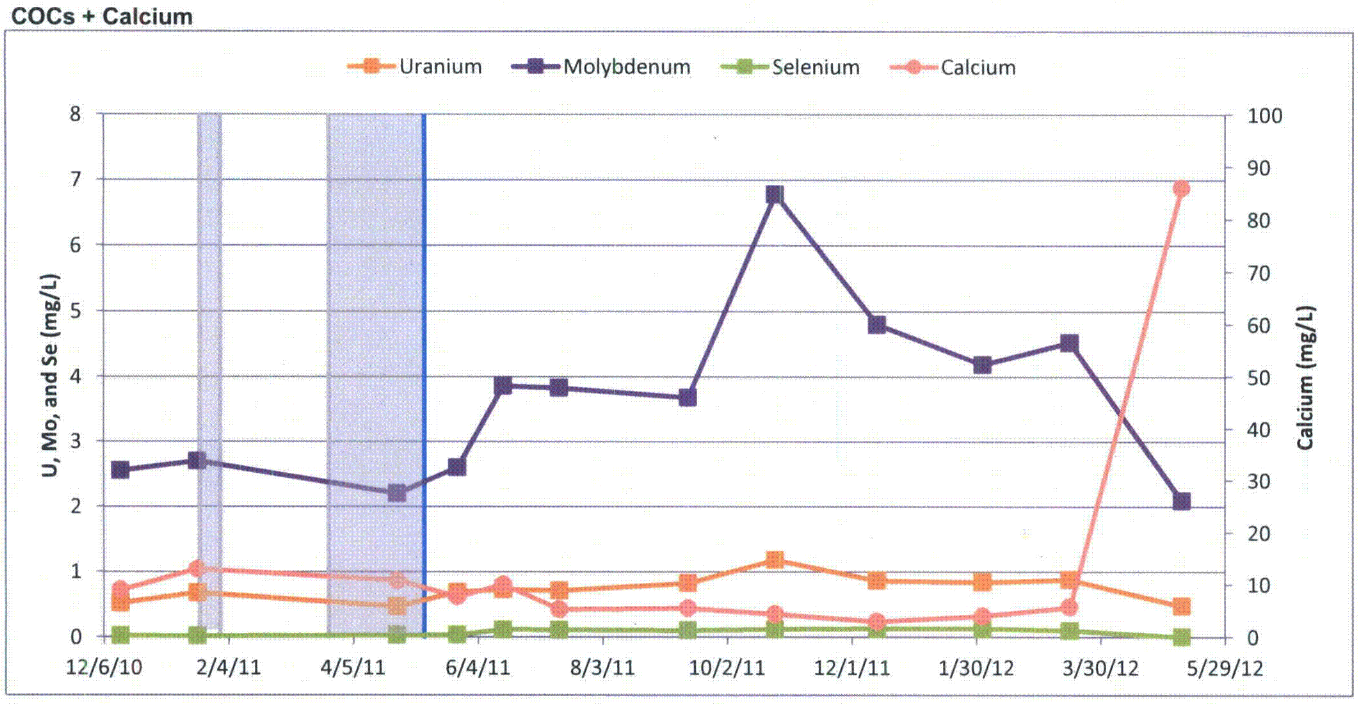


Historic Data

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

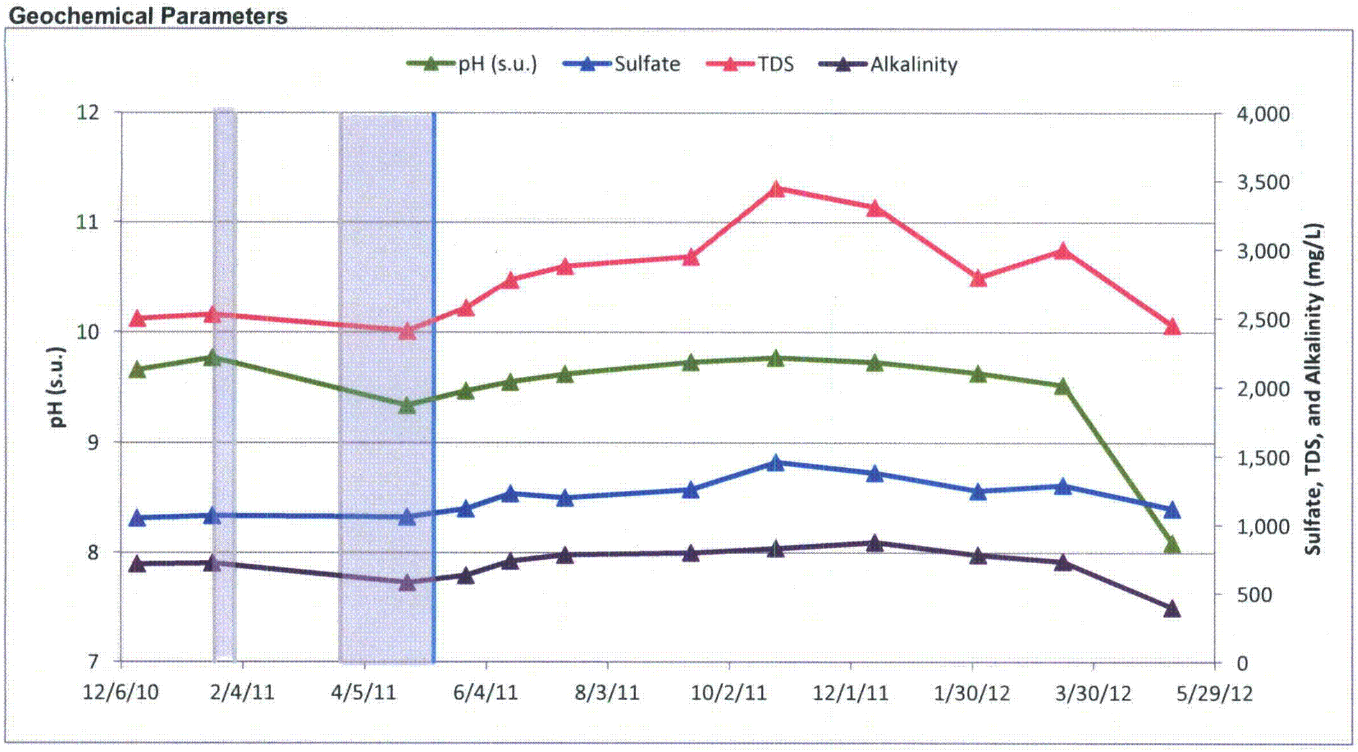


Historic Data

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

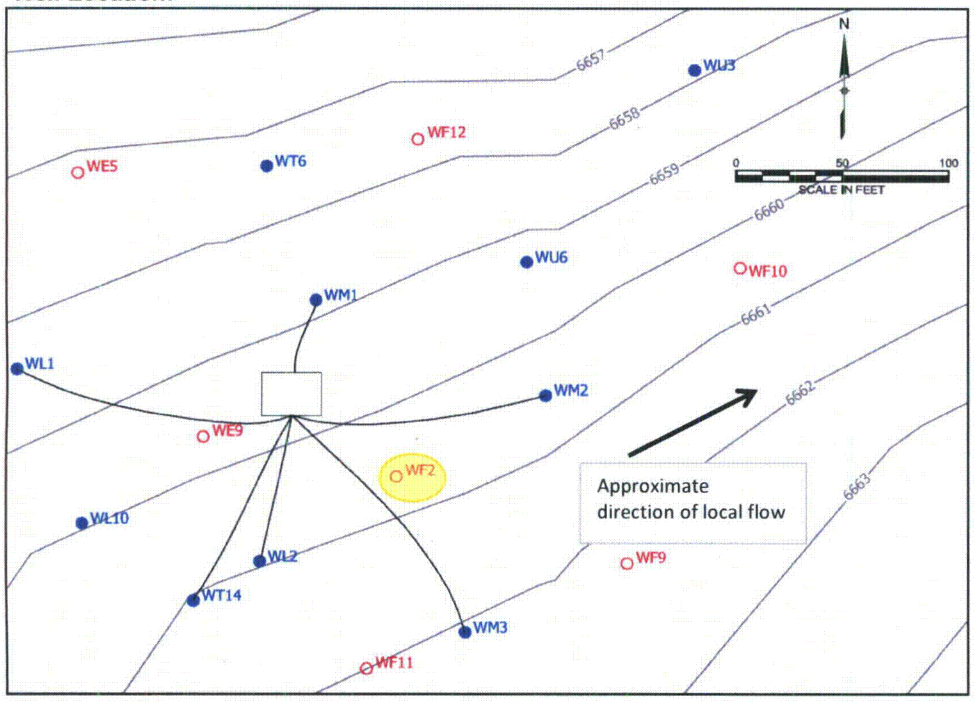


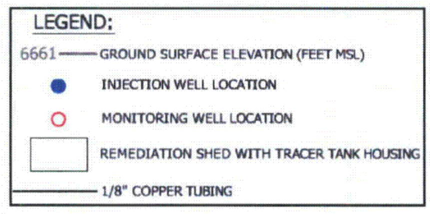
Historic Data

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

Well Location:



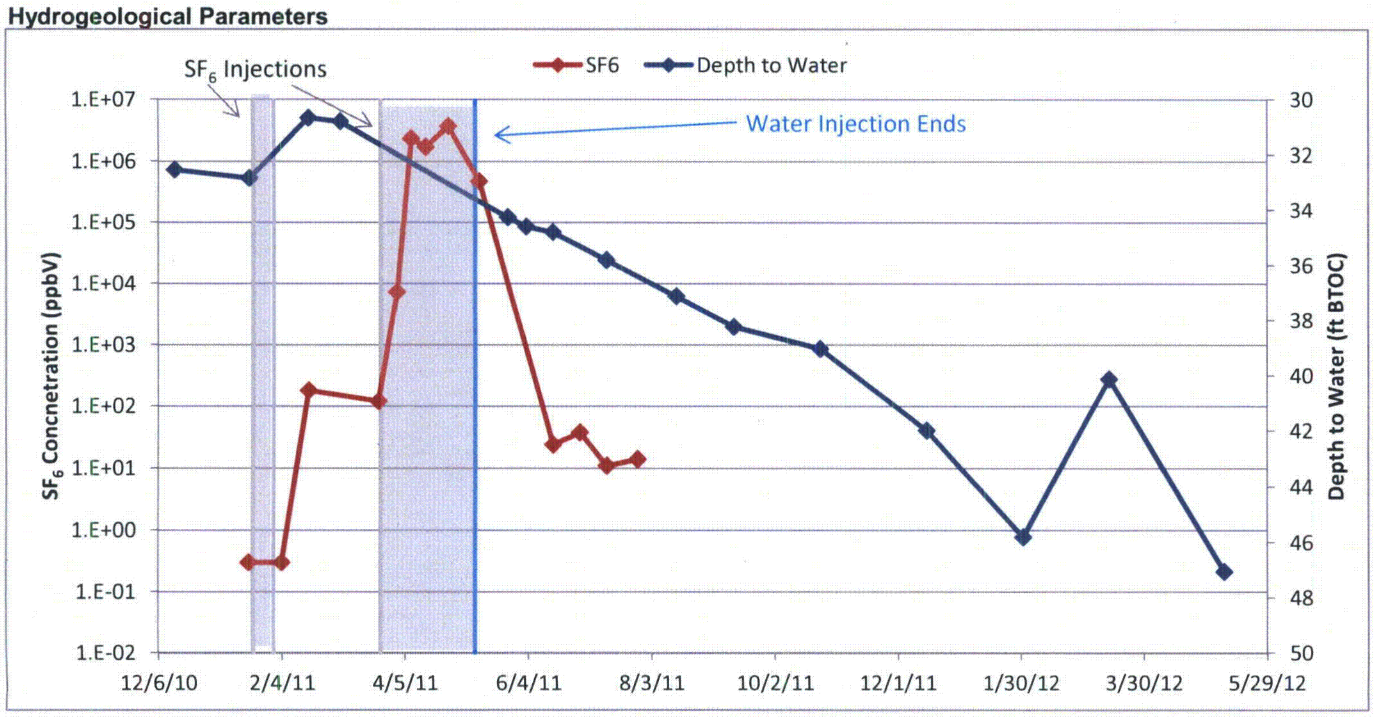


Well Construction Details:

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

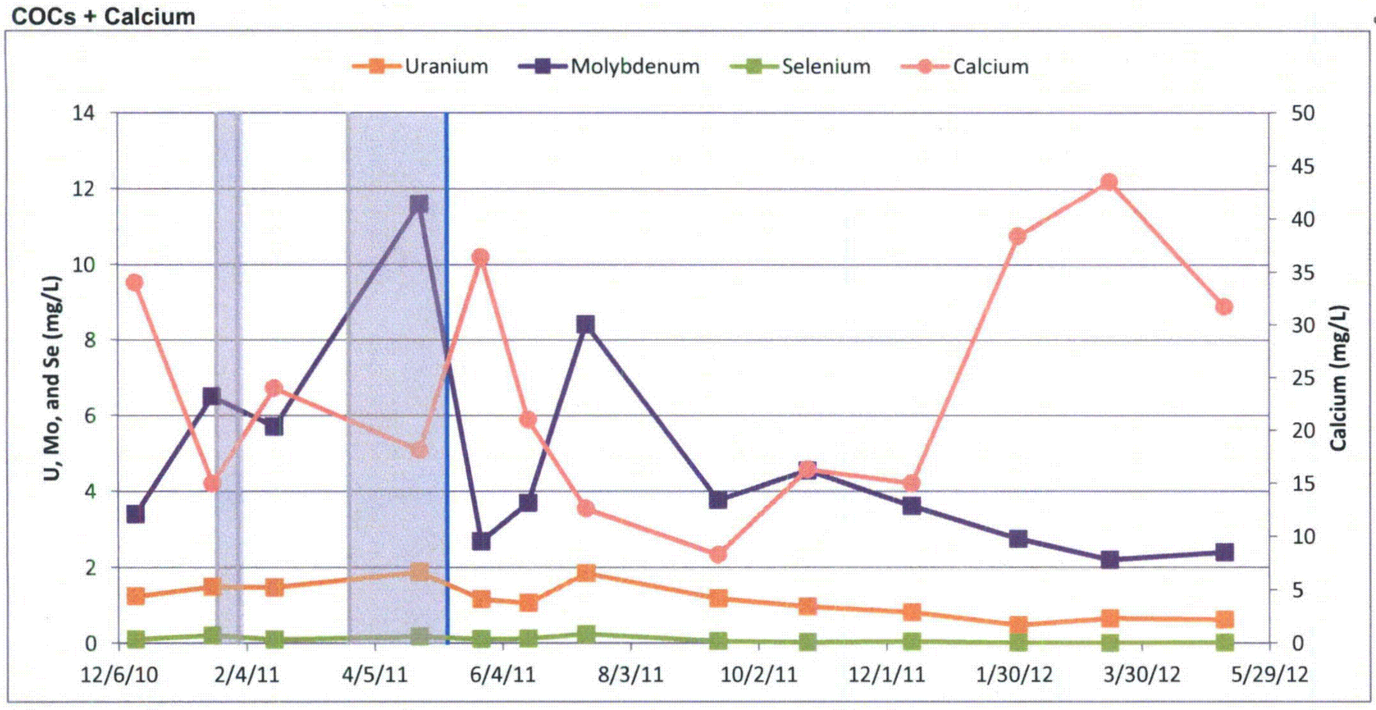


Historic Data

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

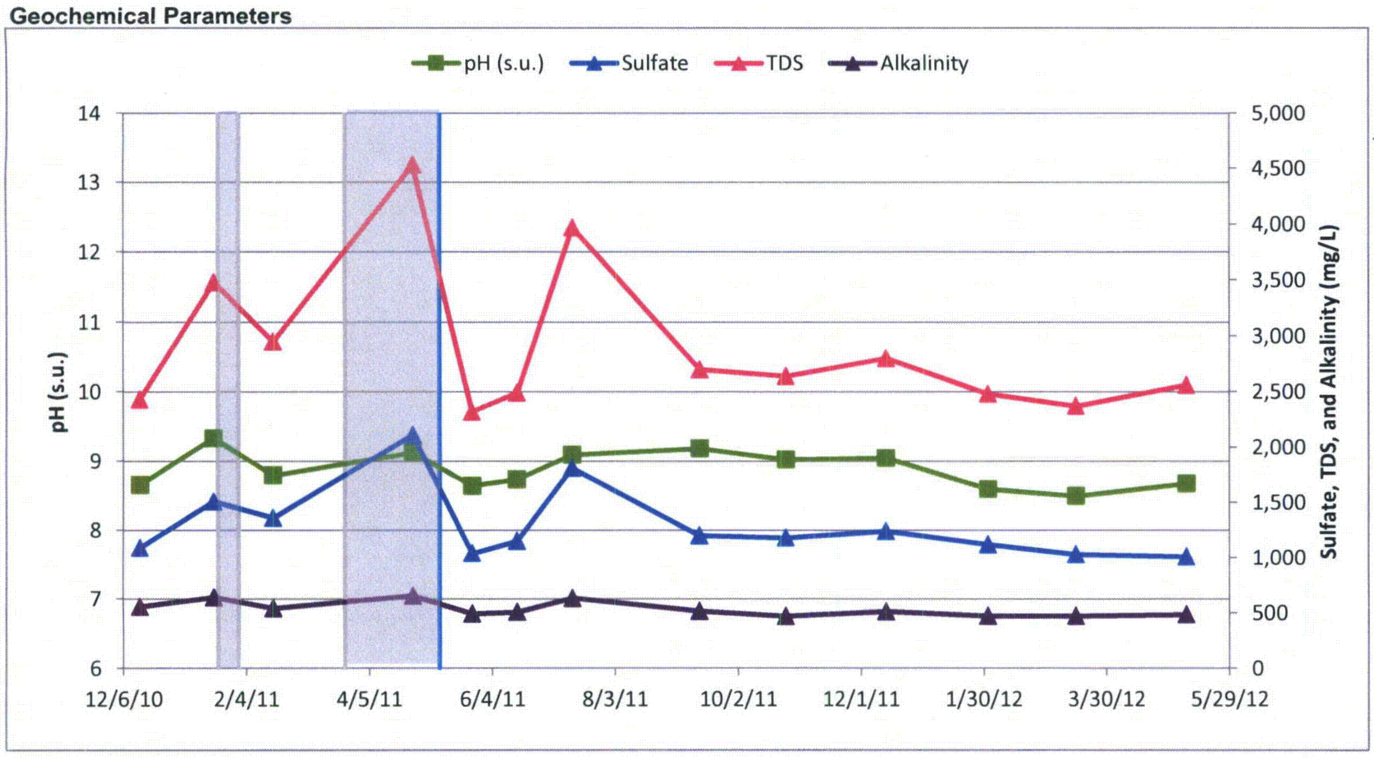


Historic Data

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

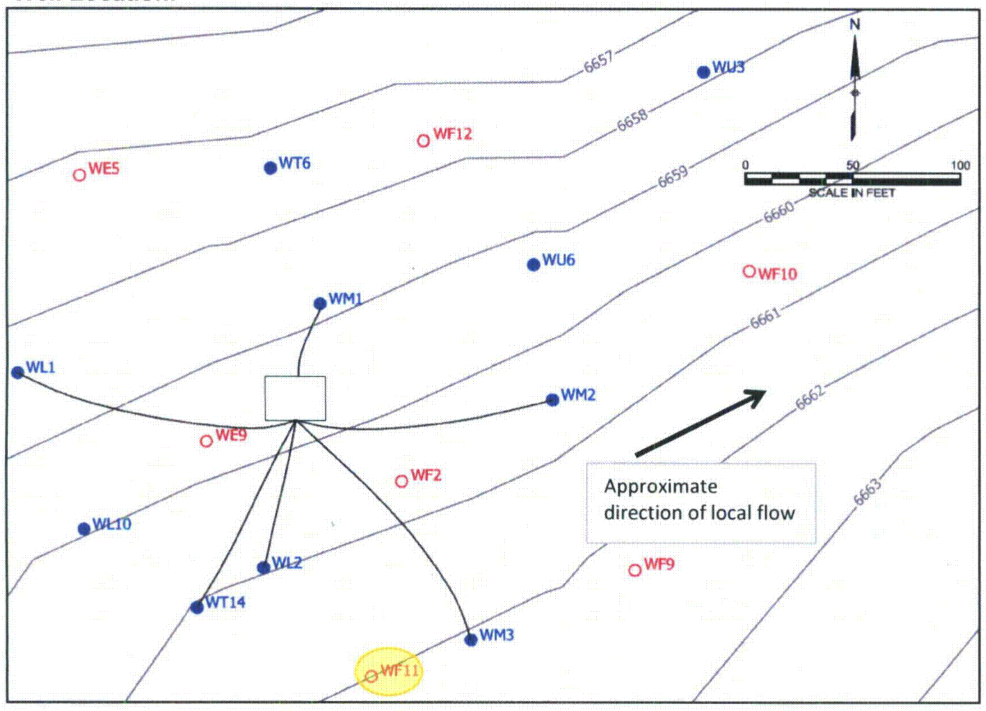
Date	pH (s.u.)	Alkalinity (mg/L)
9/28/08	9.04	719
12/14/10	8.65	555
1/19/11	9.33	638
2/17/11	8.79	541
4/26/11	9.12	652

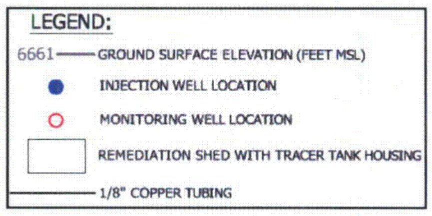
Date	Sulfate (mg/L)	TDS (mg/L)
9/28/08	2260	4950
5/13/09	1820	4000
8/13/09	1730	3730
3/31/10	1220	2940
5/4/10	1180	2780
12/14/10	1090	2430
1/19/11	1510	3480
2/17/11	1360	2950
4/26/11	2110	4530

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

Updated: July 21, 2014
Most recent data: May 8, 2012

Well Location:



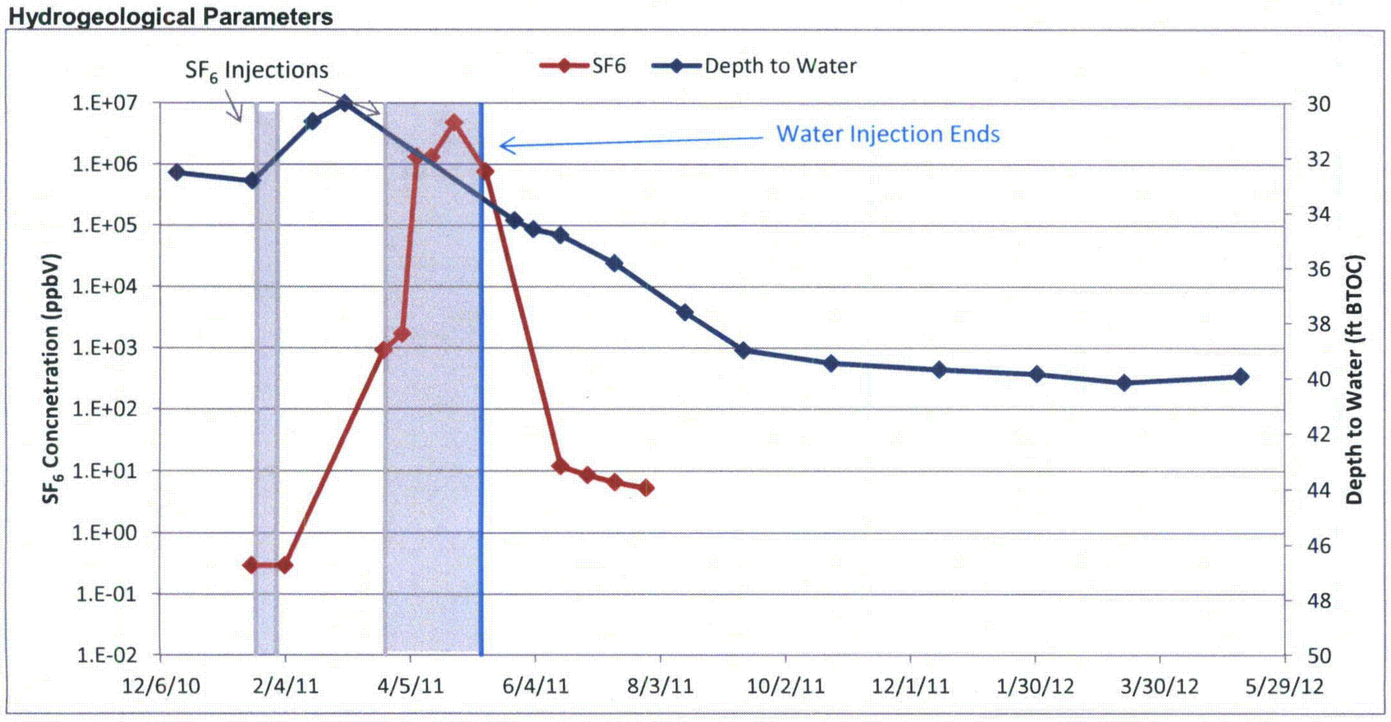


Well Construction Details:

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

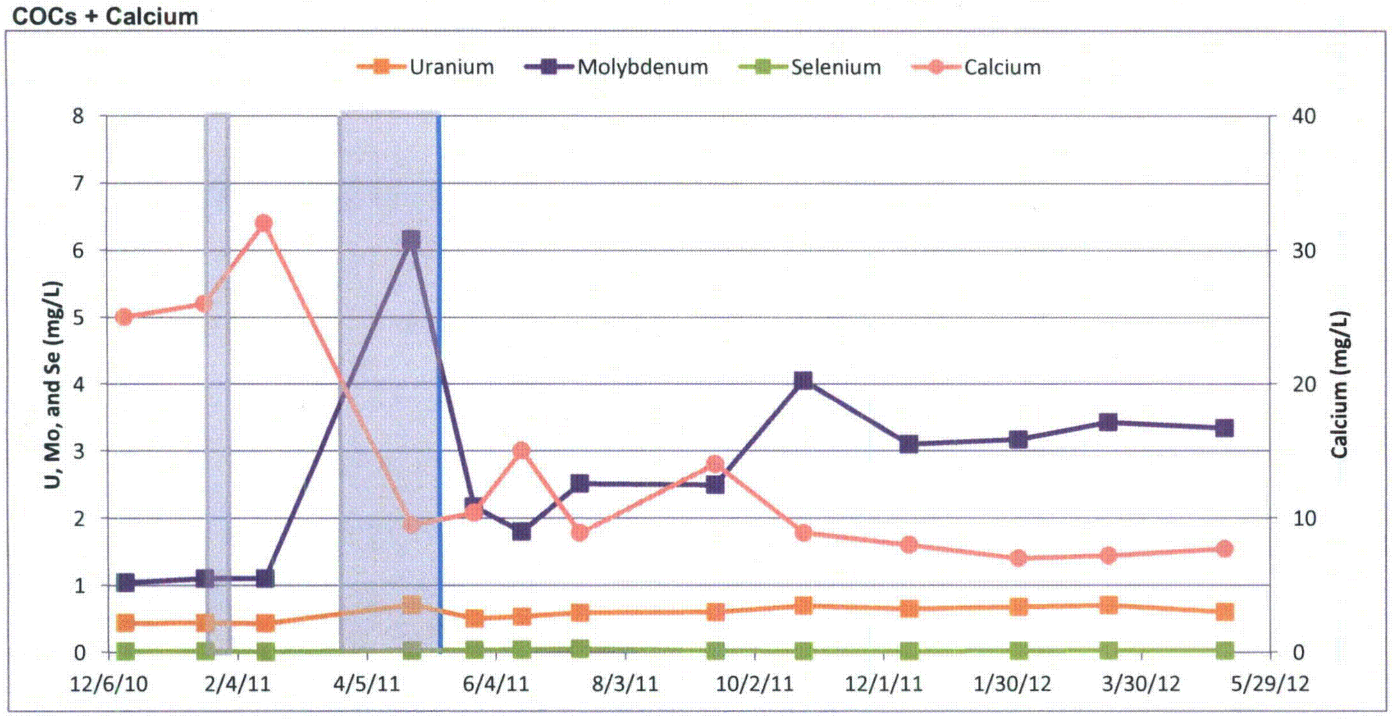


Historic Data

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

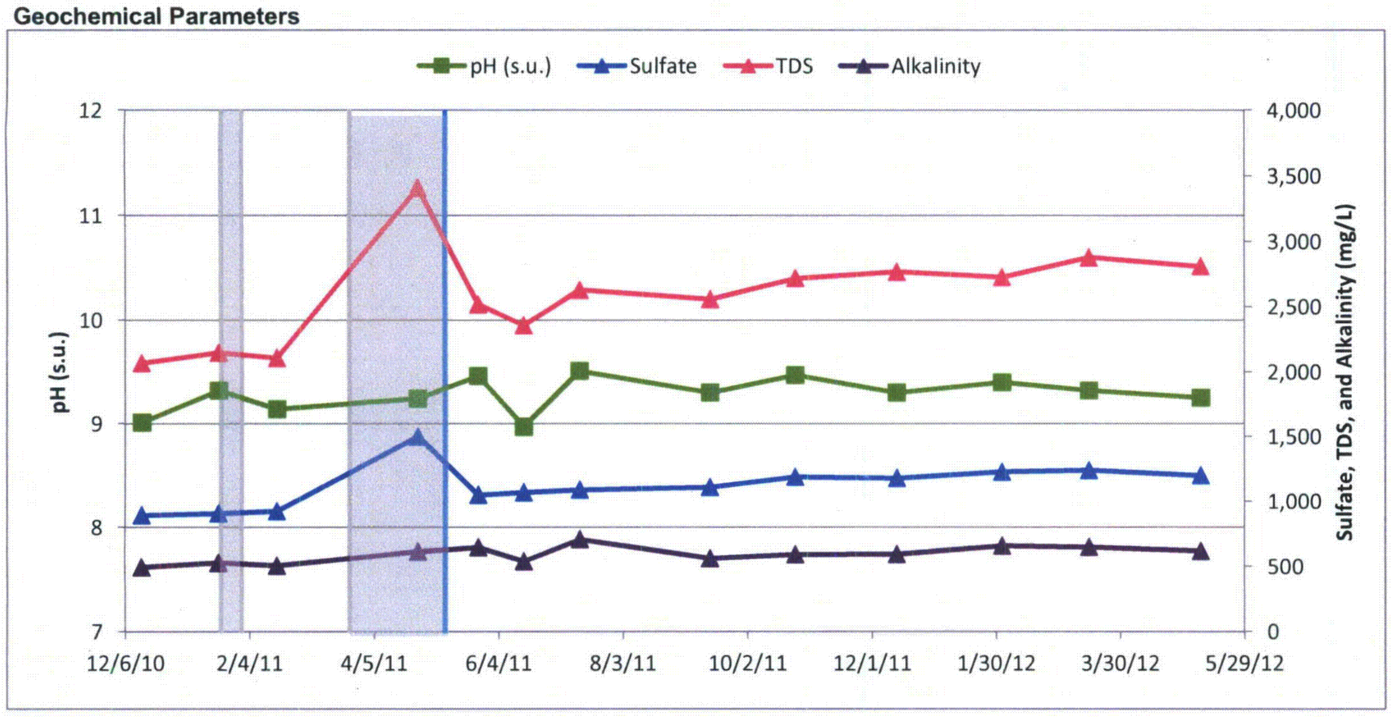


Historic Data

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

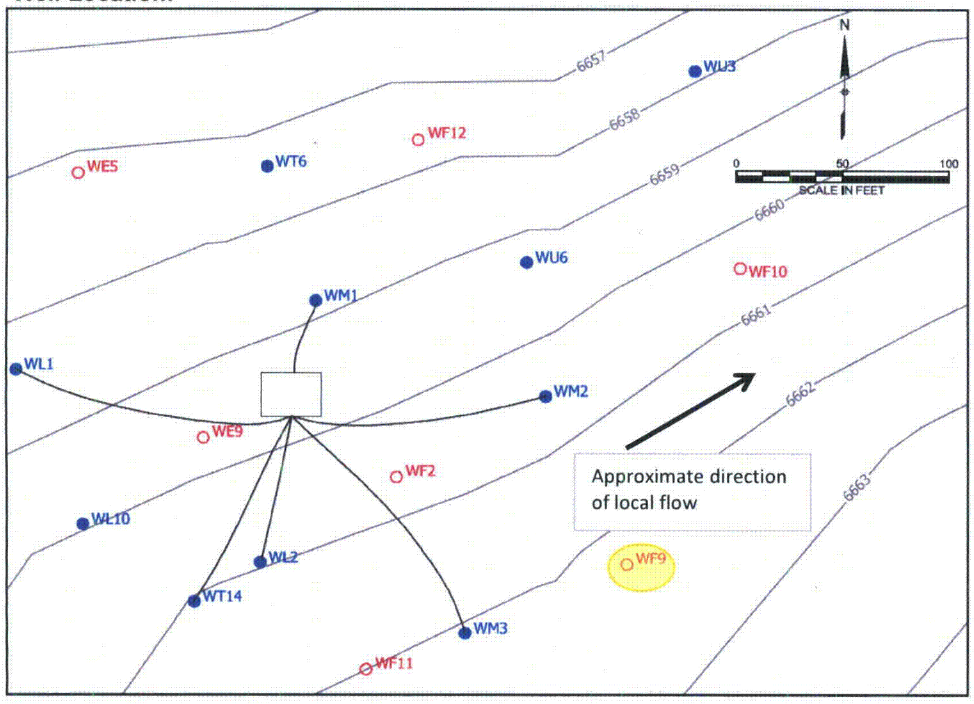


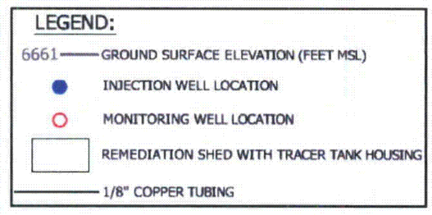
Historic Data

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

Well Location:



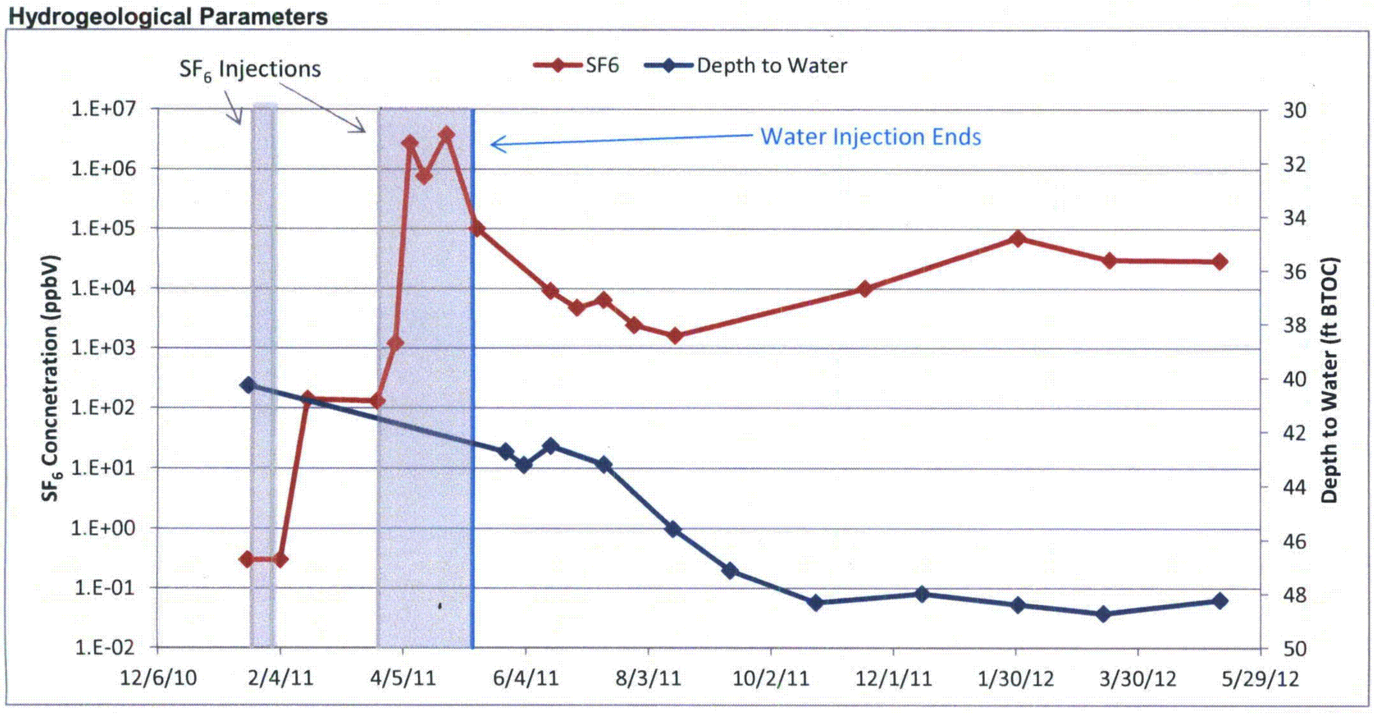


Well Construction Details:

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

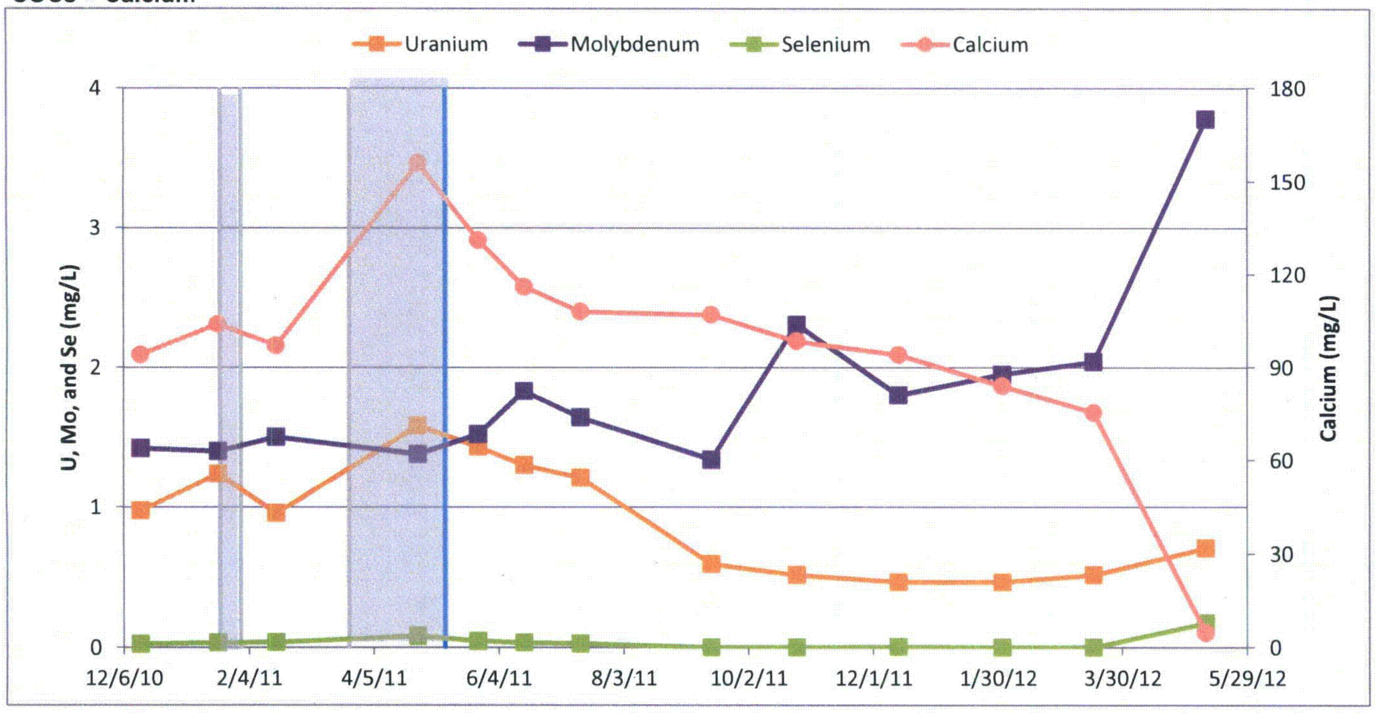


Historic Data

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

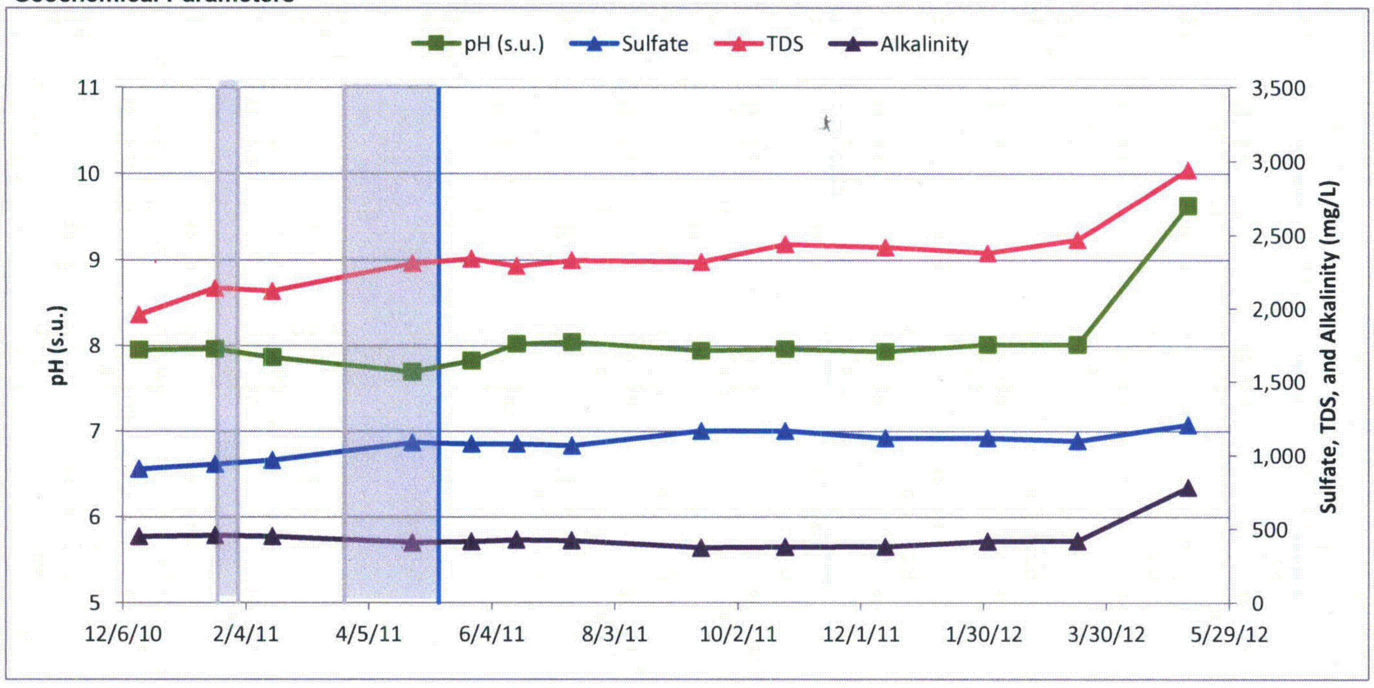


Historic Data

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

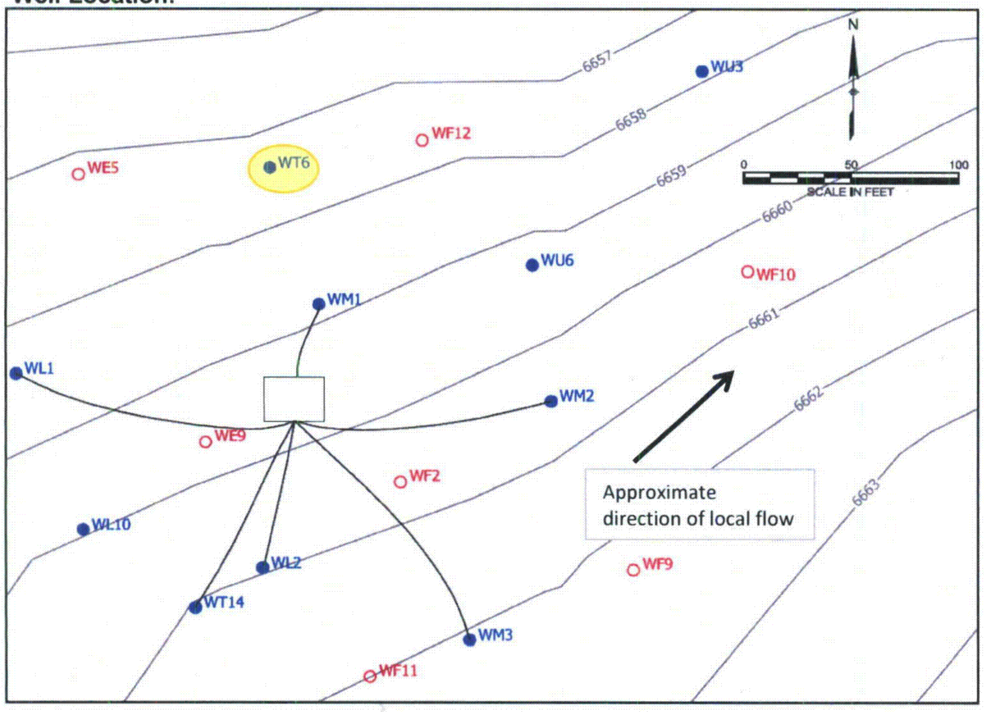
Date	pH (s.u.)	Alkalinity (mg/L)
12/14/10	7.95	451
1/20/11	7.96	459
4/26/11	7.69	410

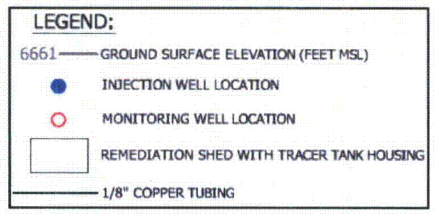
Date	Sulfate (mg/L)	TDS (mg/L)
3/31/10	1020	2270
12/14/10	910	1960
1/20/11	941	2140
4/26/11	1090	2310

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

Updated July 21, 2014
Most recent data: May 8, 2012

Well Location:



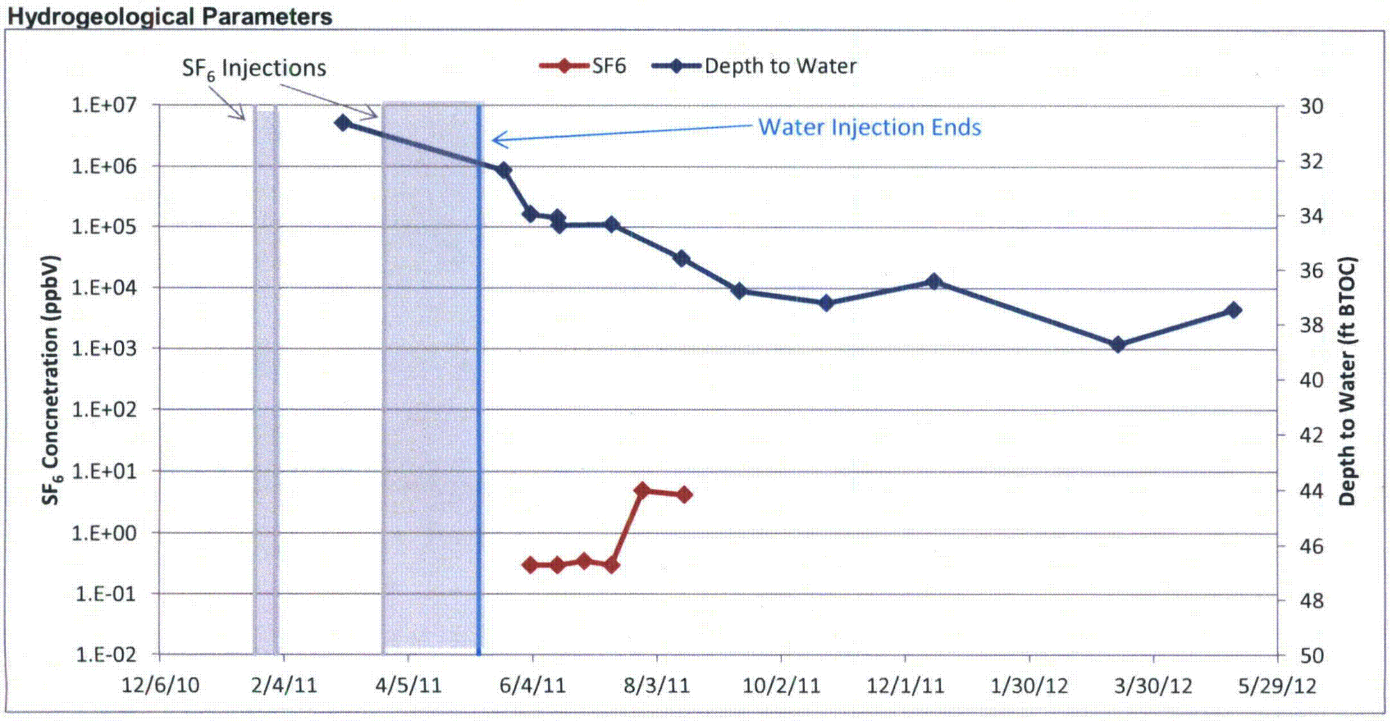


Well Construction Details:

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

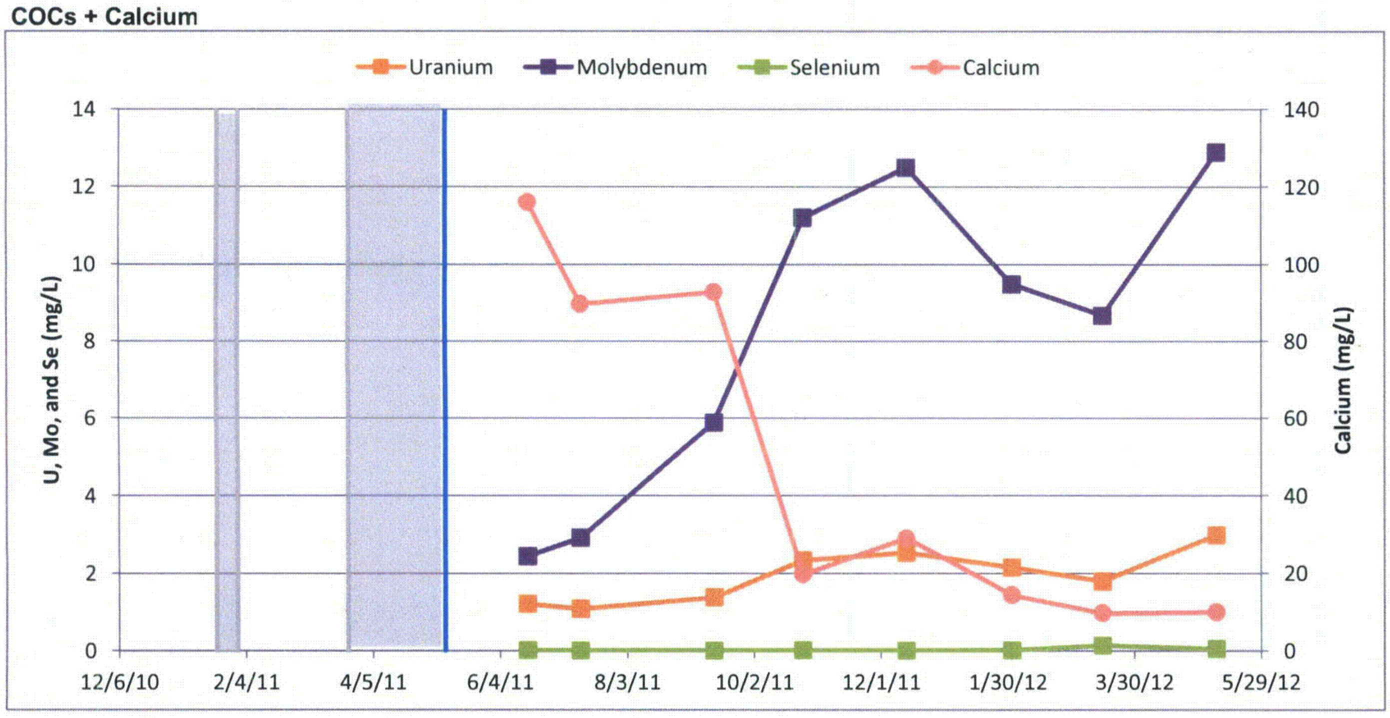


Historic Data

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

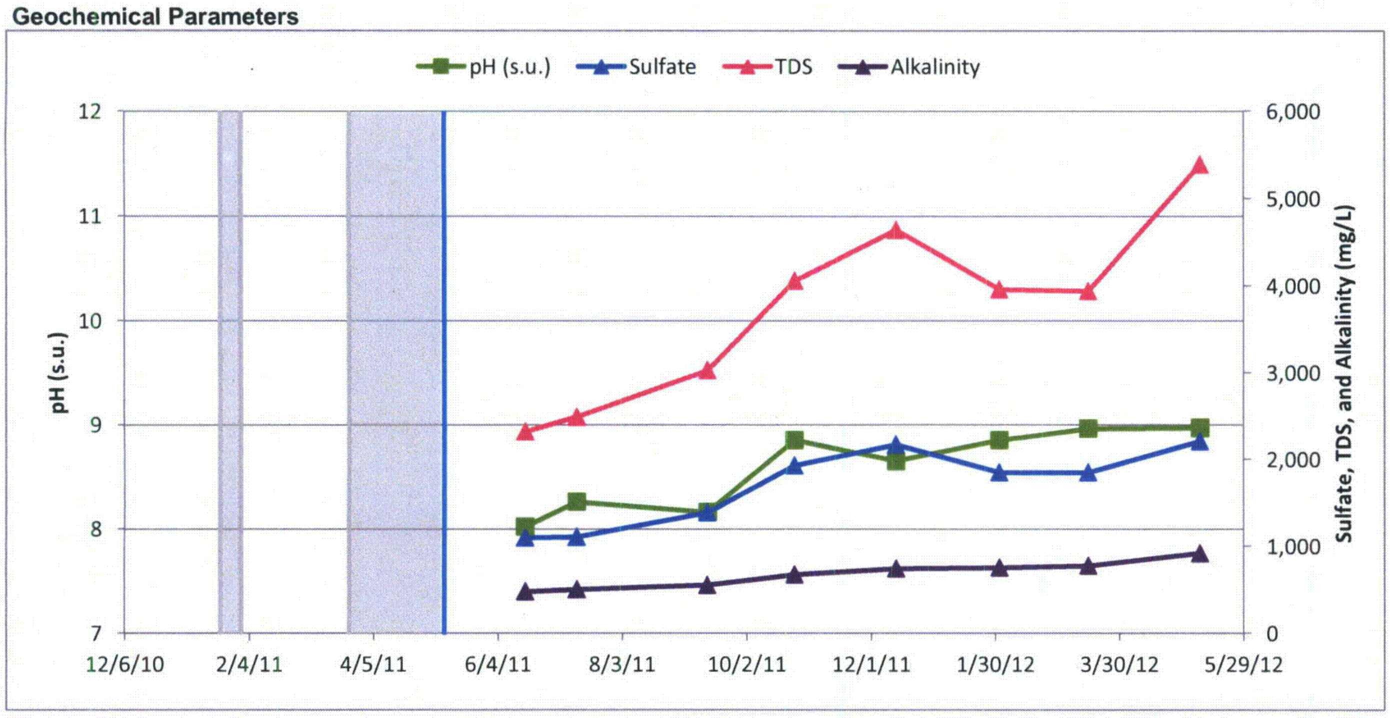


Historic Data

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

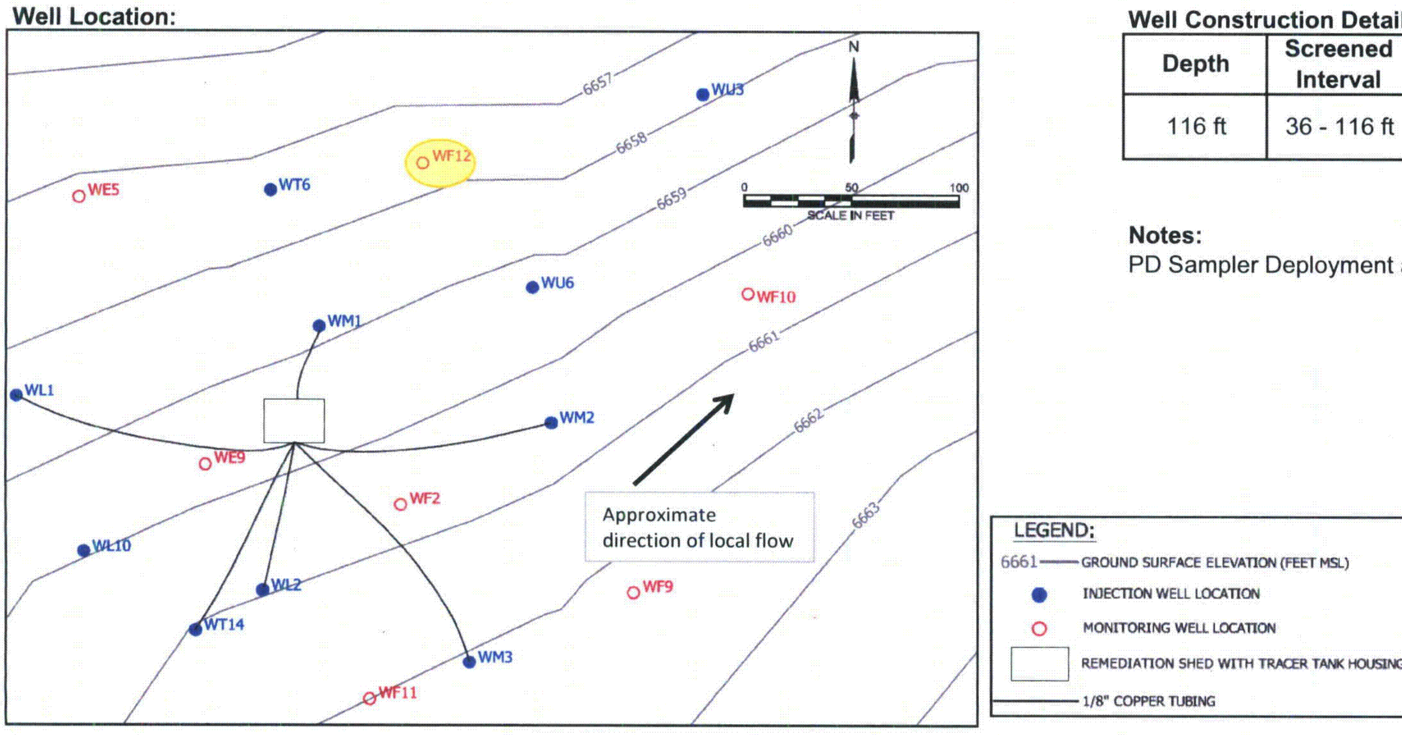
Date	pH (s.u.)	Alkalinity (mg/L)
5/17/08	9.21	623

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
Well ID: WF12

Updated: July 21, 2014
Most recent data: May 8, 2012

Well Location:

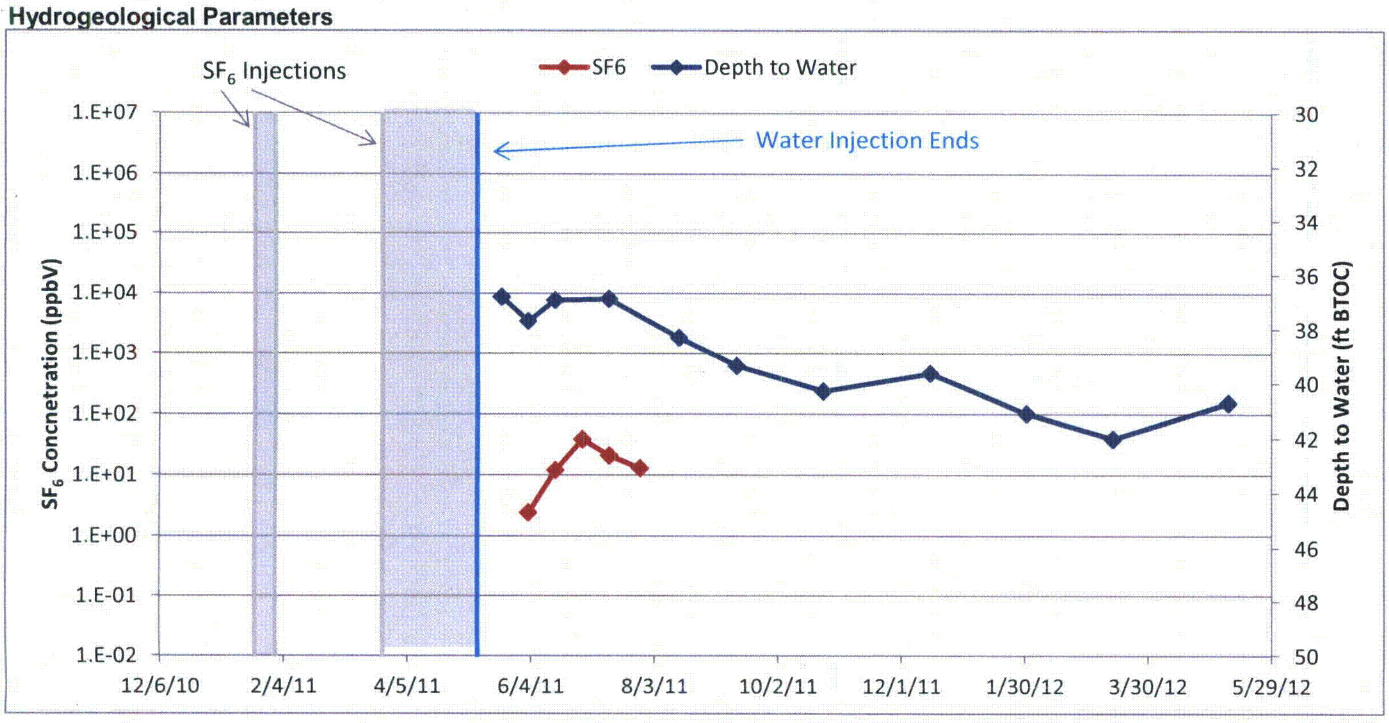


Well Construction Details:

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

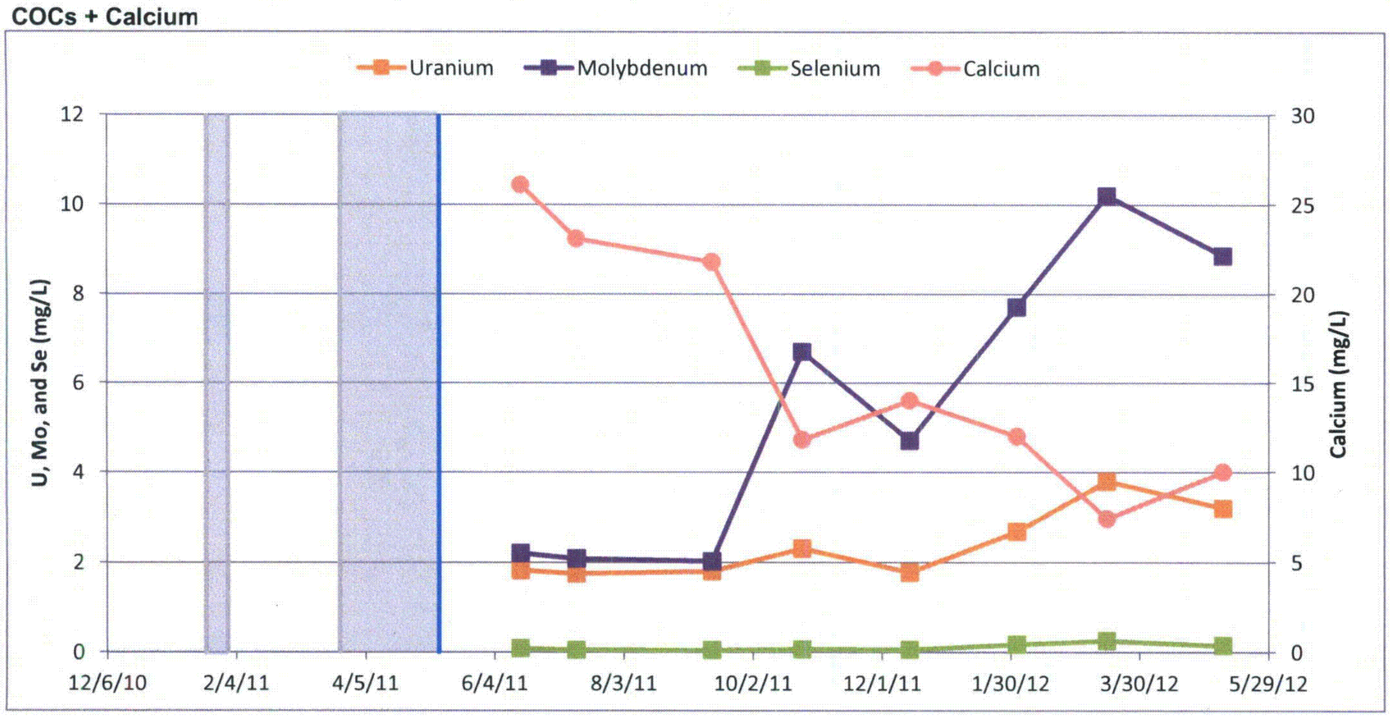


Historic Data

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

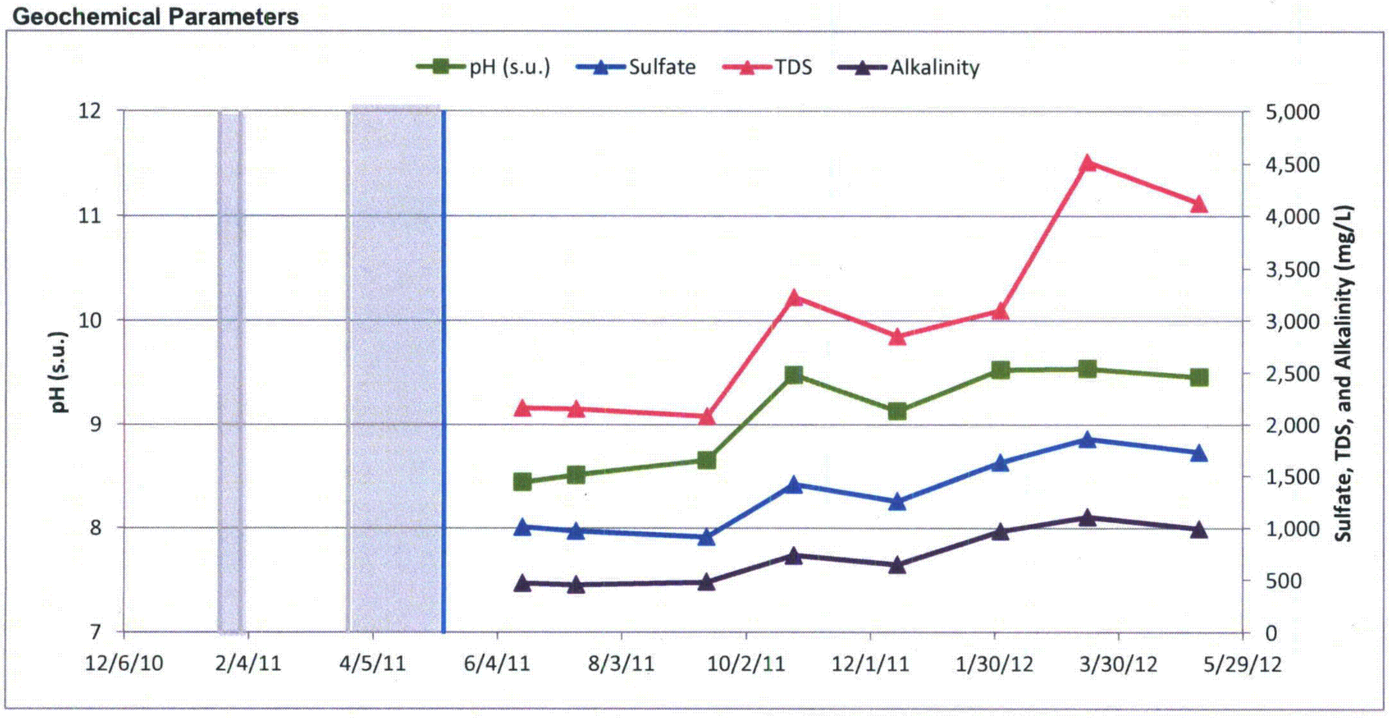


Historic Data

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

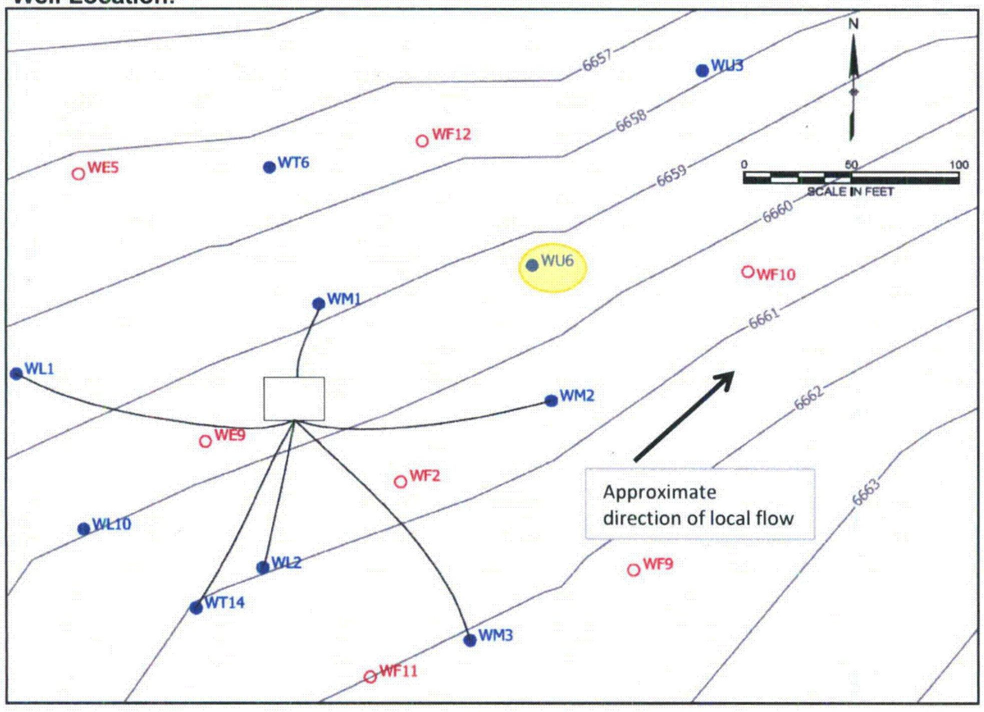


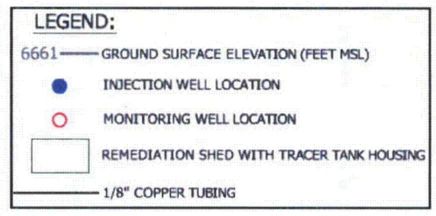
Historic Data

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

Well Location:



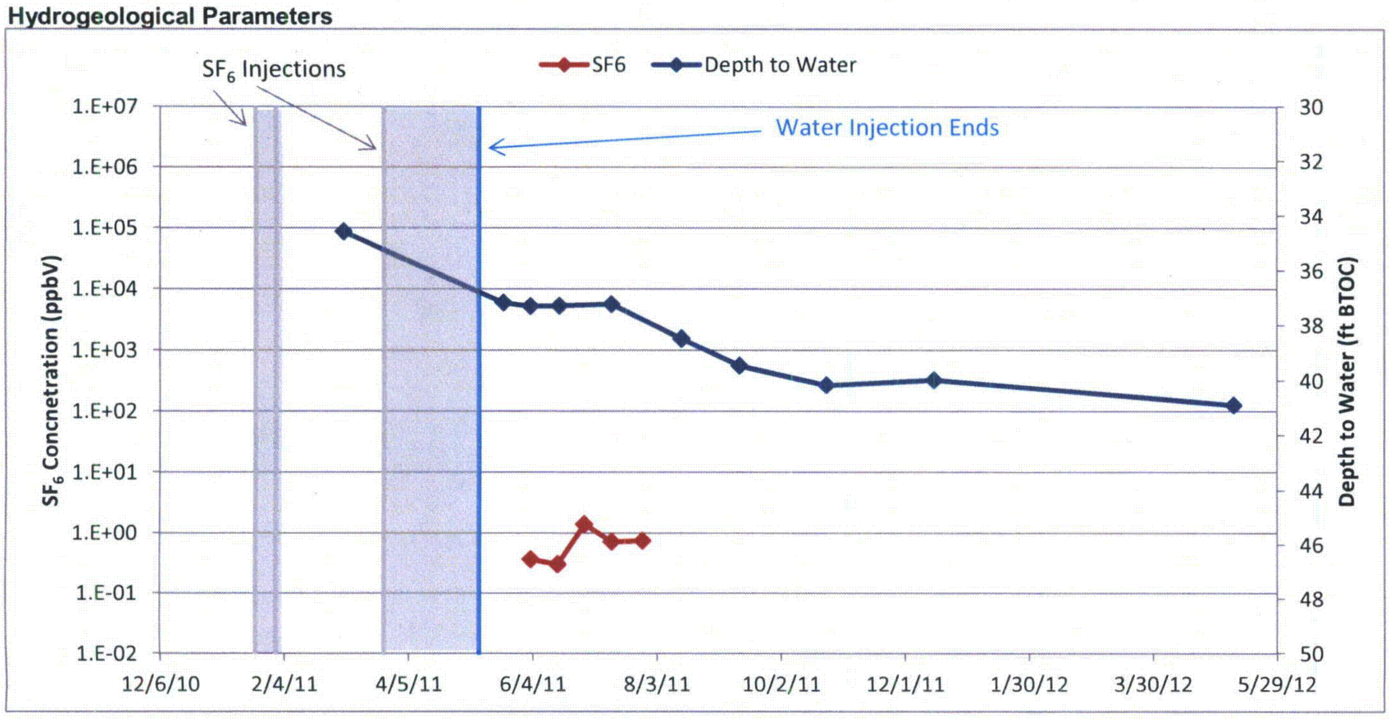


Well Construction Details:

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

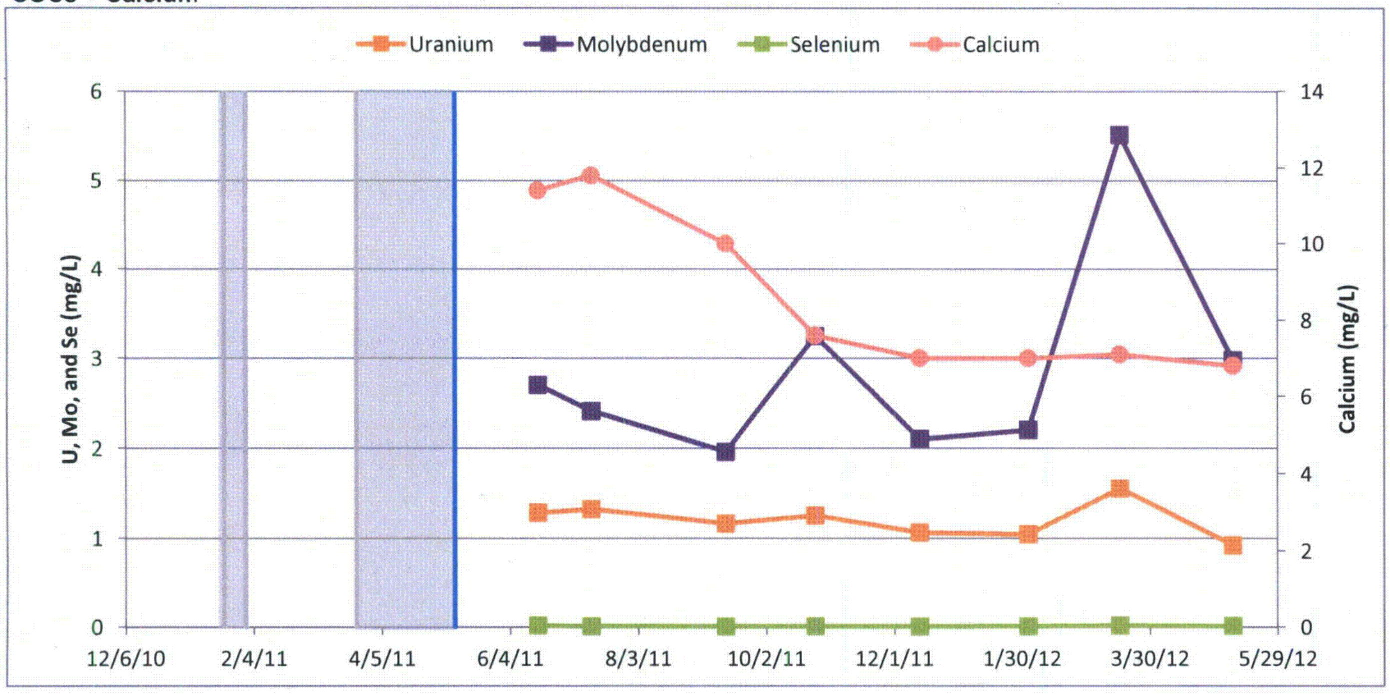


Historic Data

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.

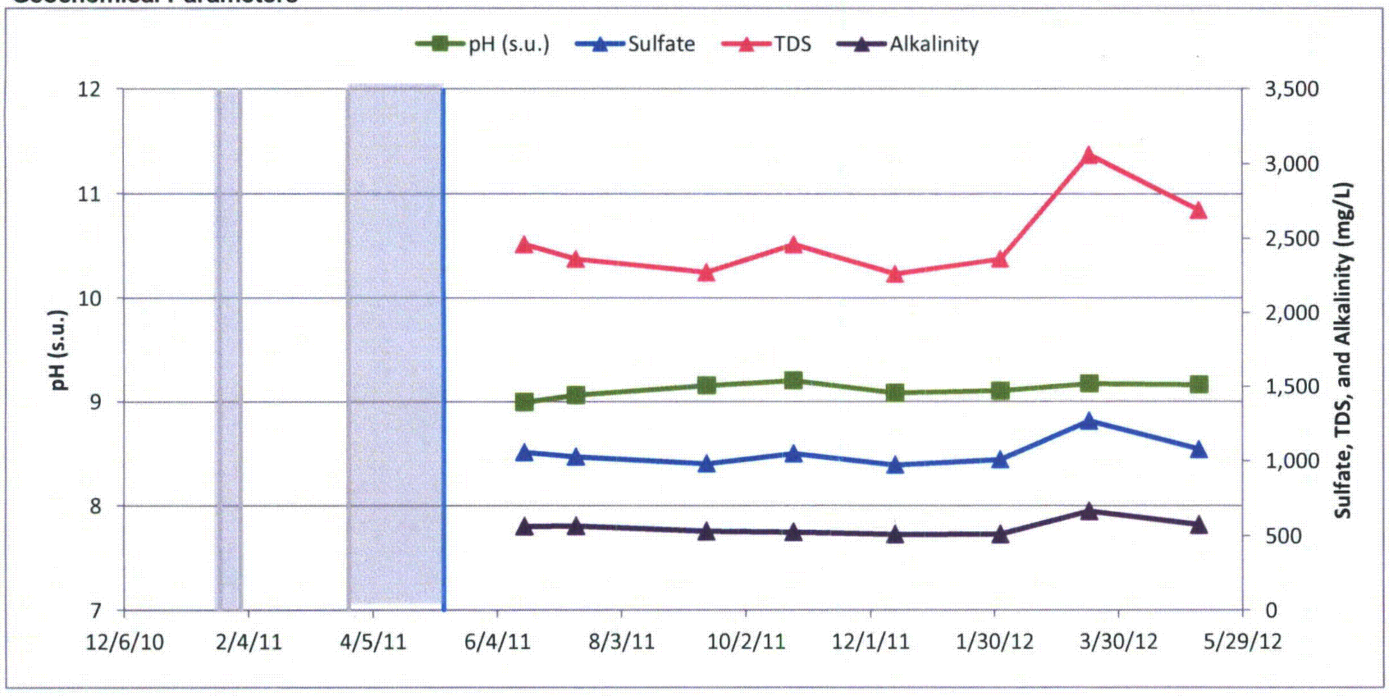
COCs + Calcium



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



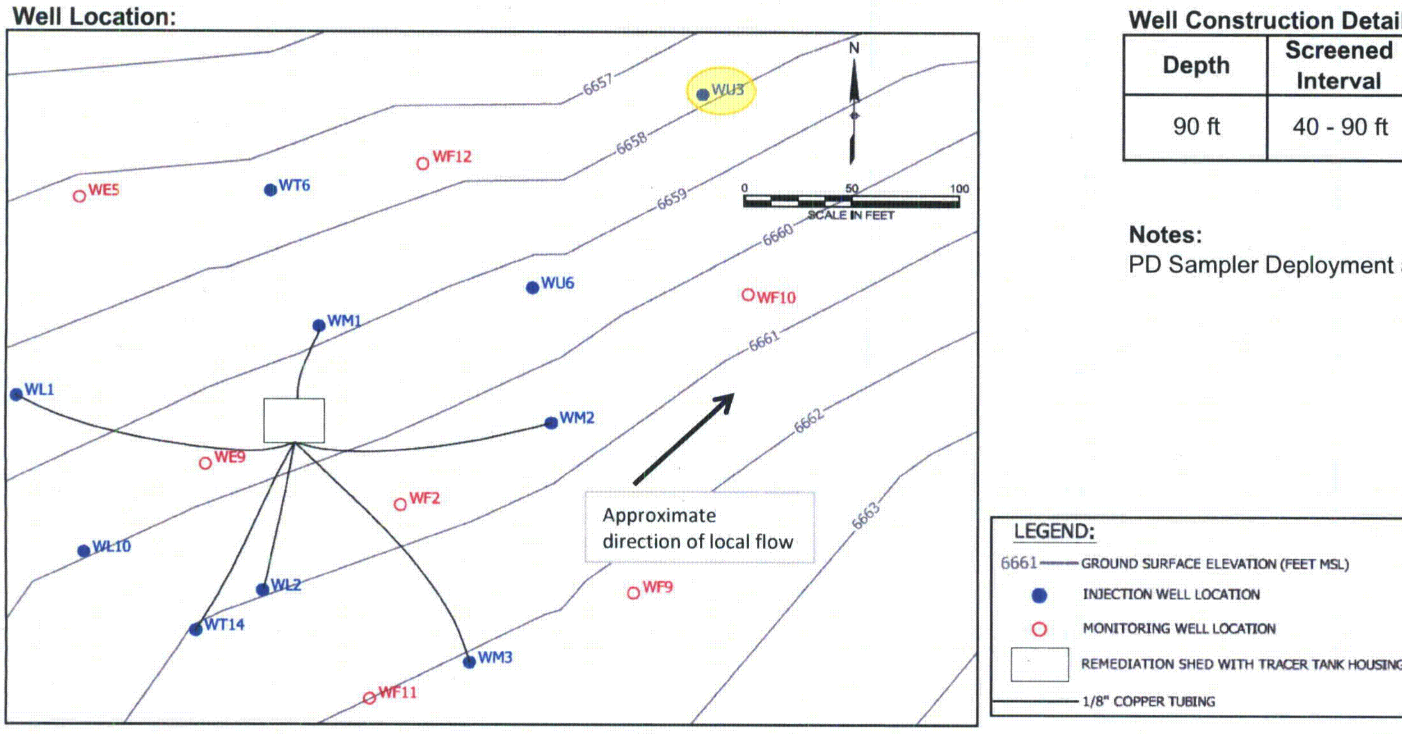
Historic Data

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 July 21, 2014
Most recent data: May 9, 2012

Well Location:

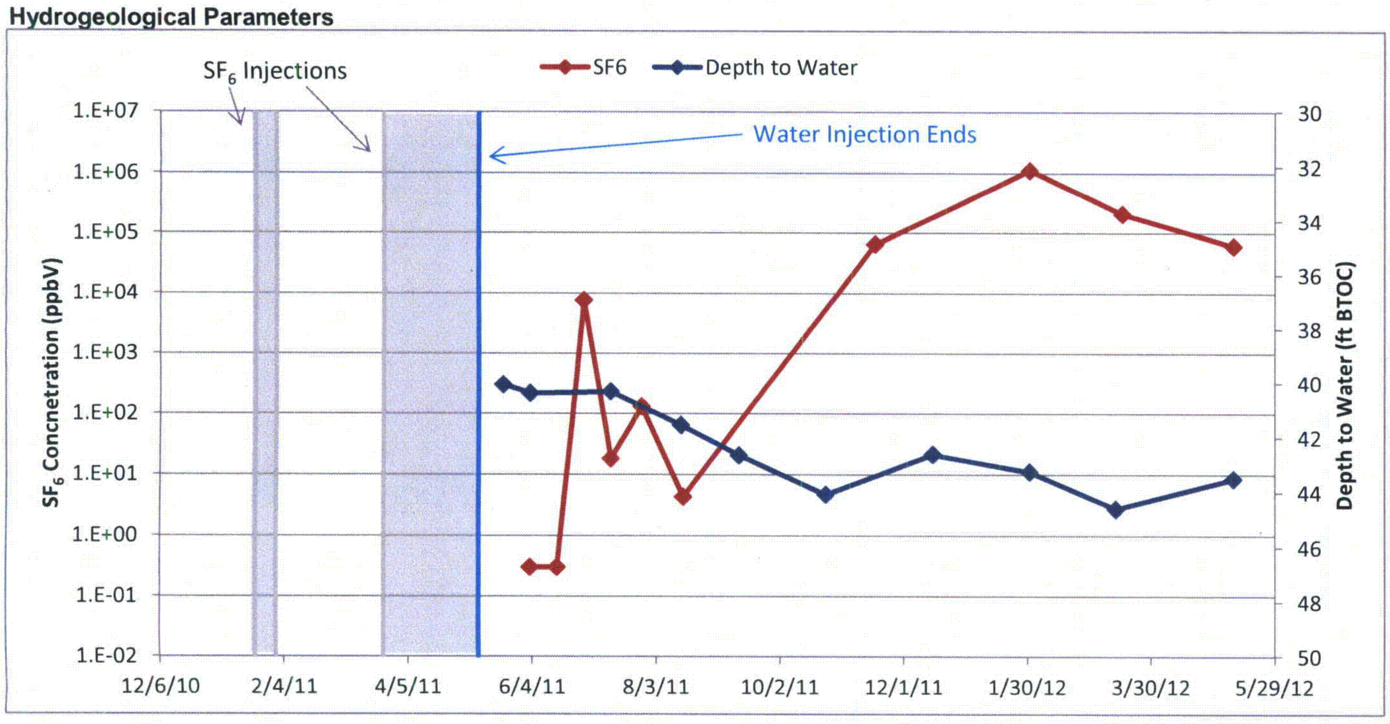


Well Construction Details:

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

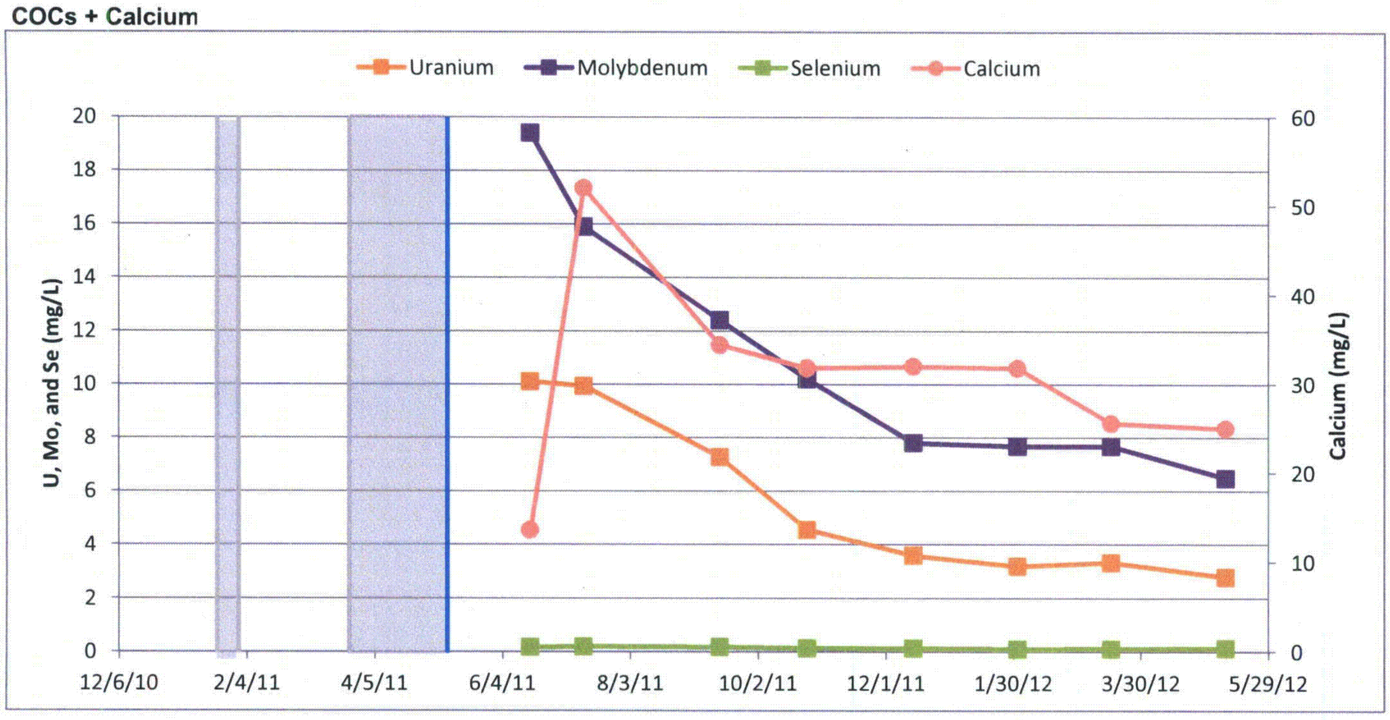
Hydrogeological Parameters



Historic Data - none

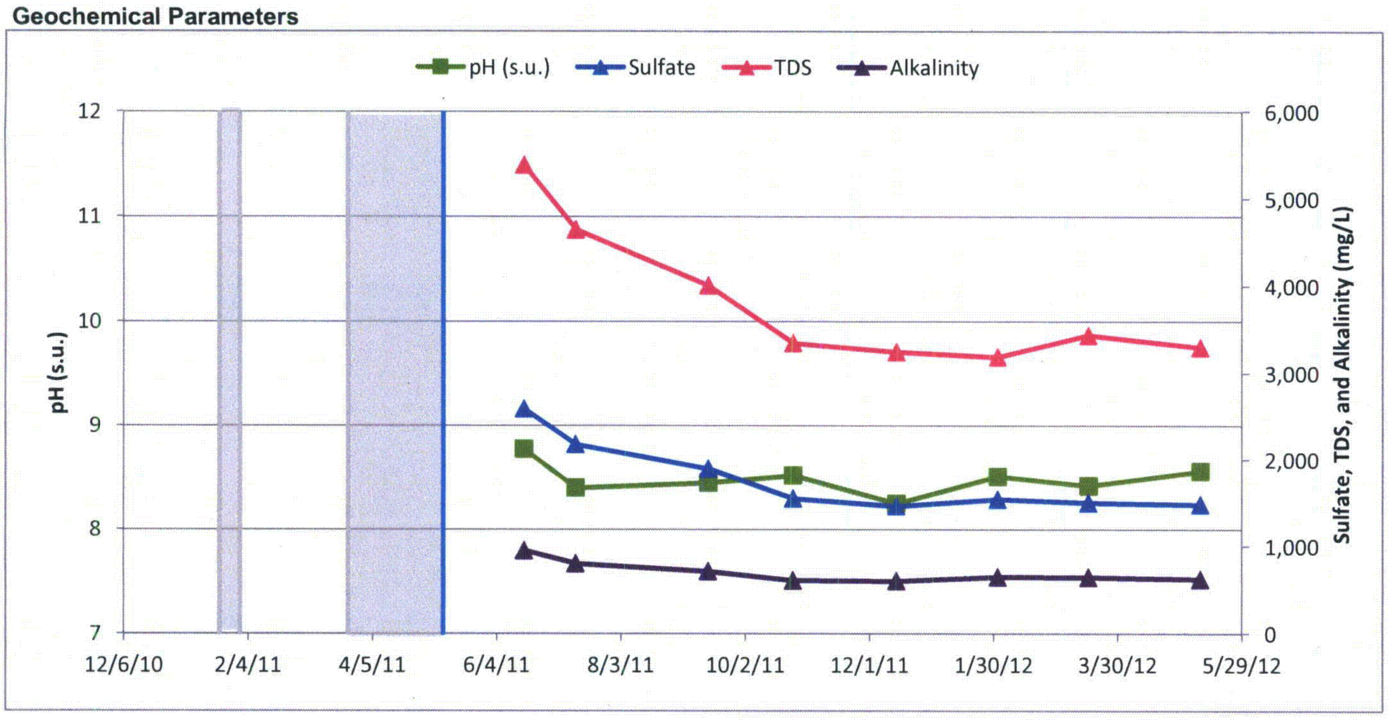
No background concentration of SF_6.

COCs + Calcium



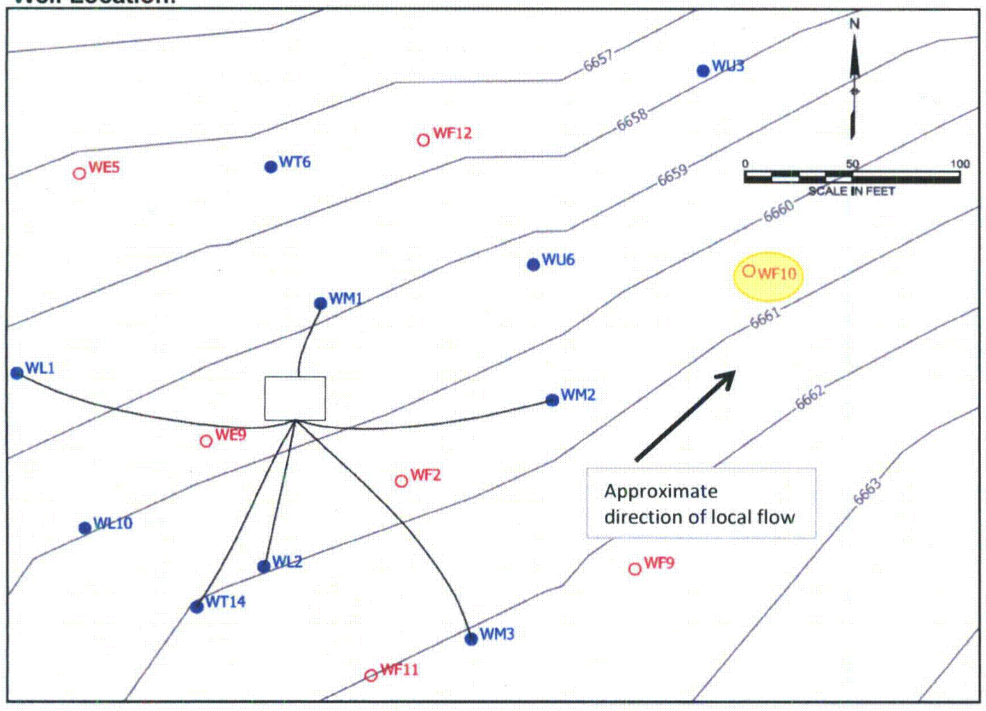
Historic Data - none

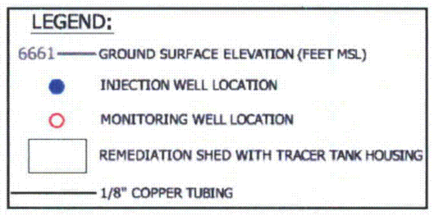
Geochemical Parameters



Historic Data - none

Well Location:



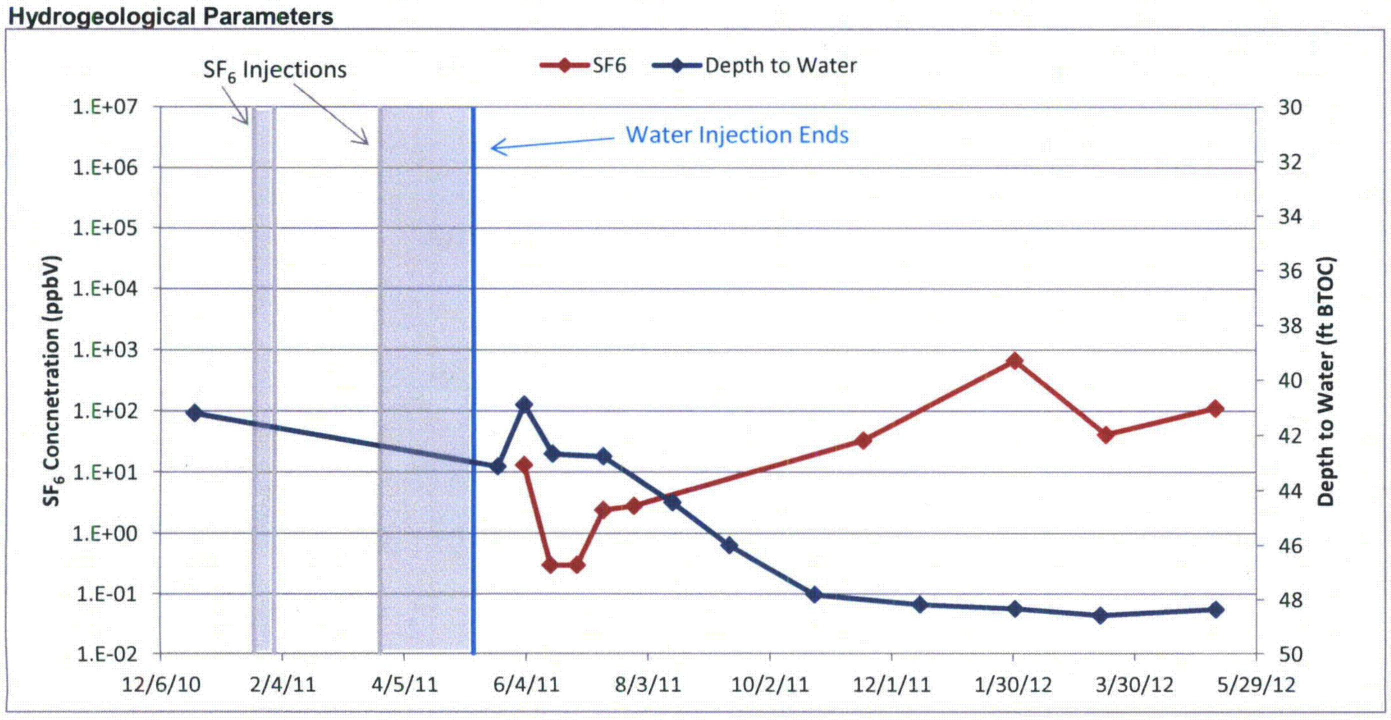


Well Construction Details:

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

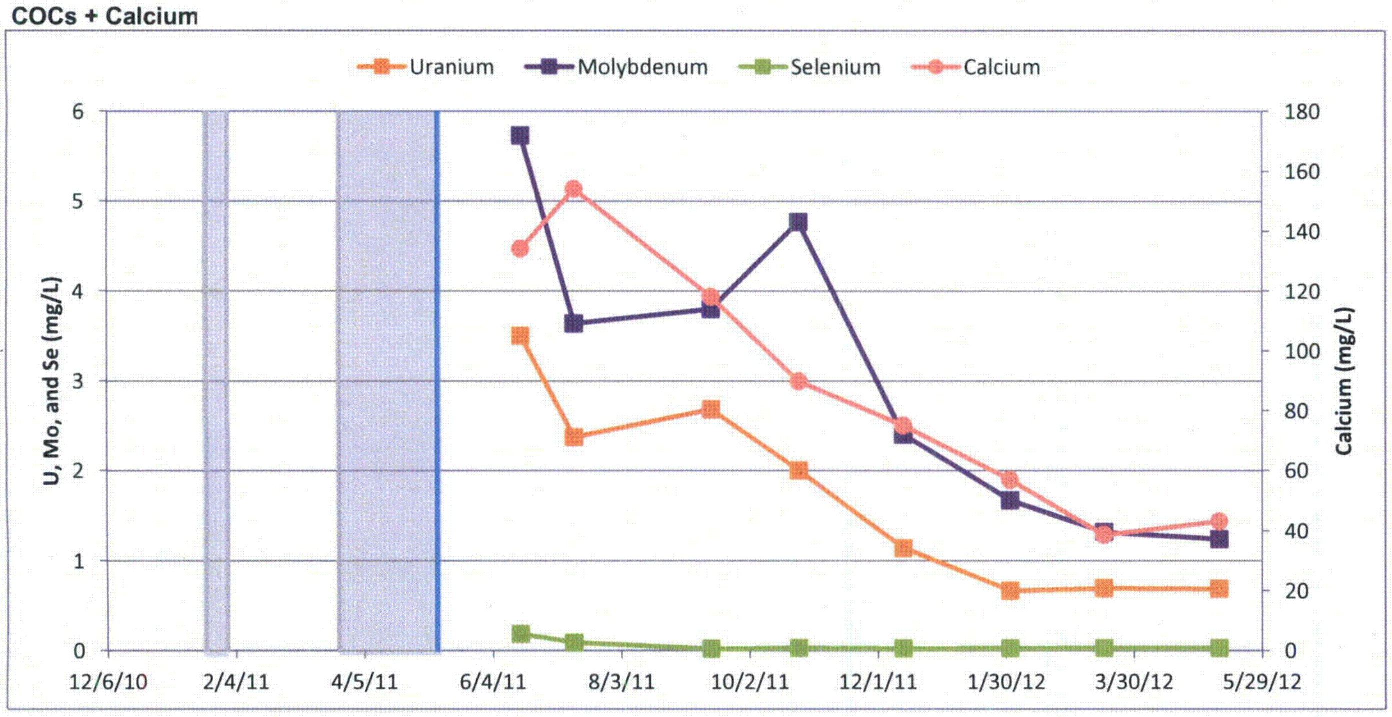


Historic Data

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.

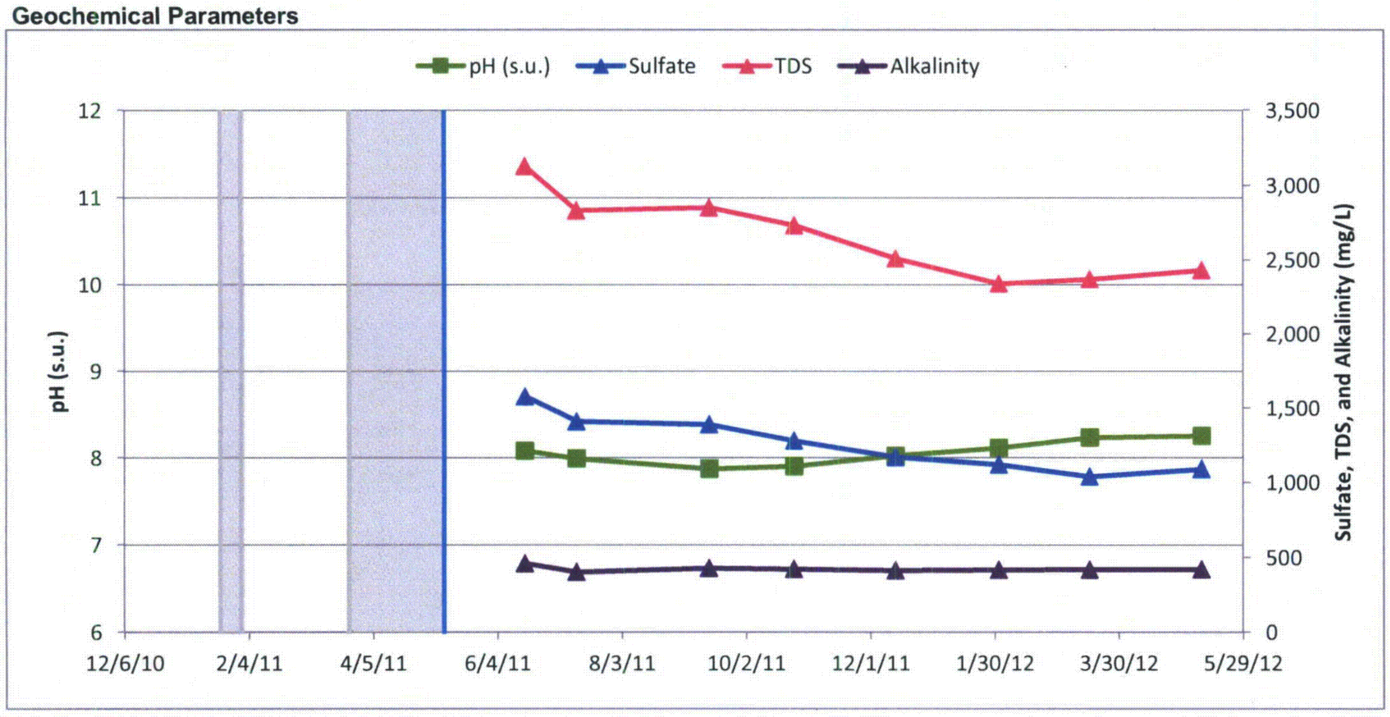
COCs + Calcium



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