APPENDIX A

FY10 and FY14 Concentration Plots
Upgradient Performance Wells

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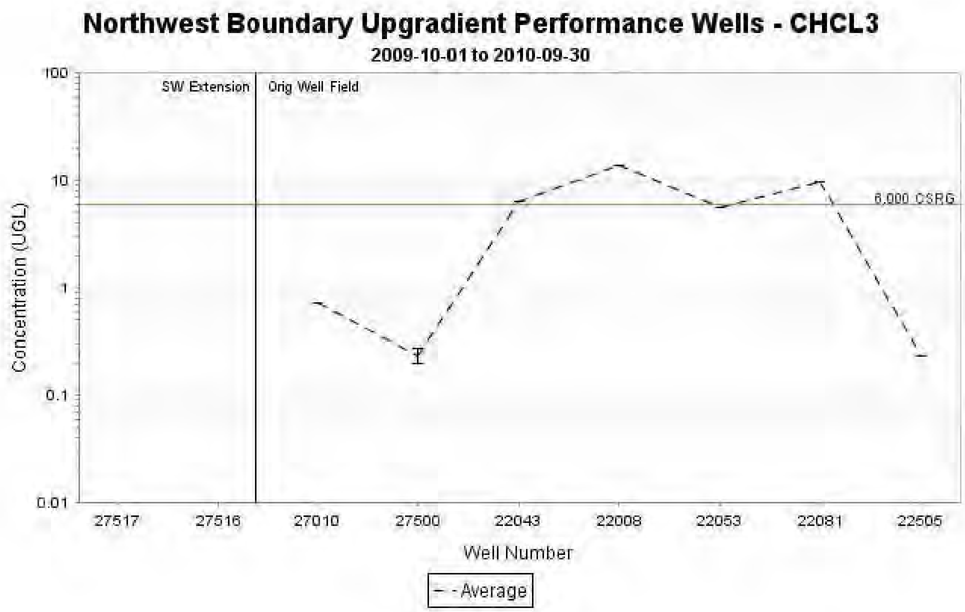
Figure A-1. NWBCS Upgradient Performance Wells – Chloroform, FY10 and FY14



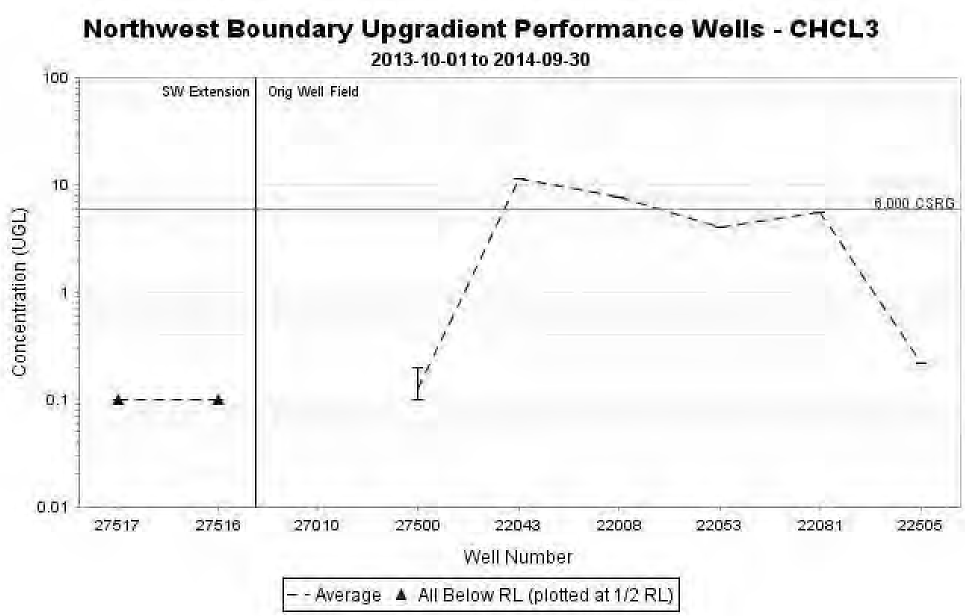
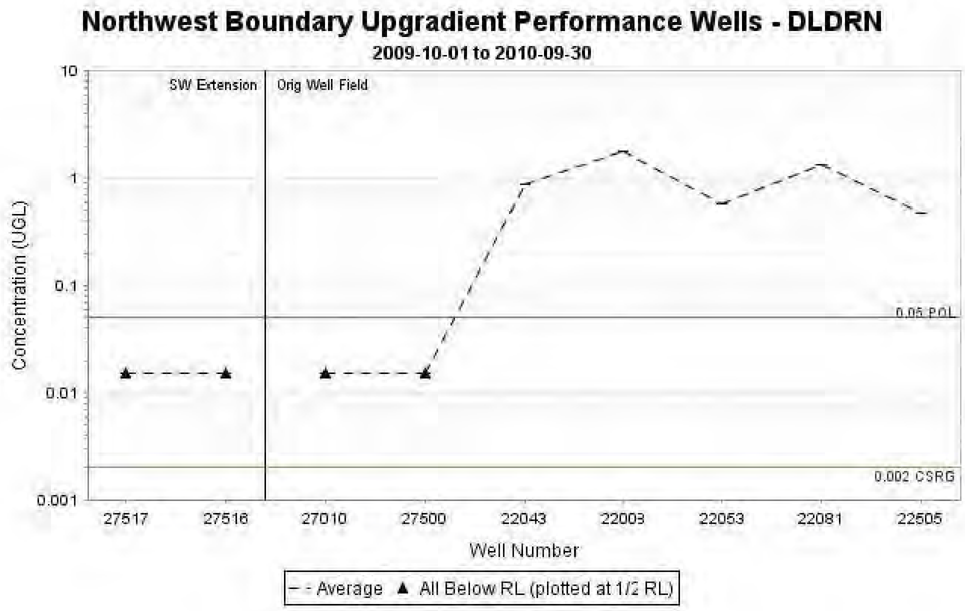


Figure A-2. NWBCS Upgradient Performance Wells – Dieldrin, FY10 and FY14



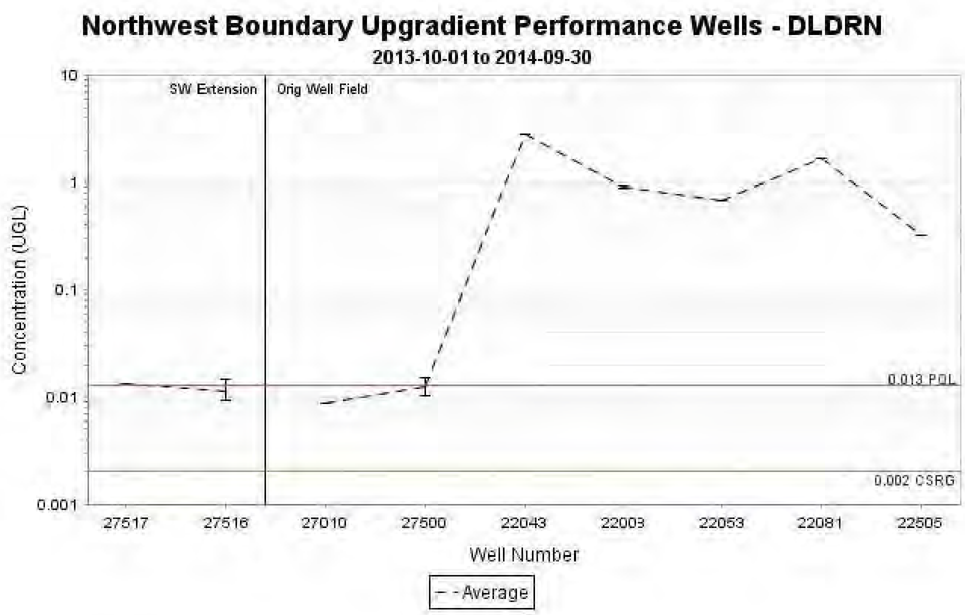
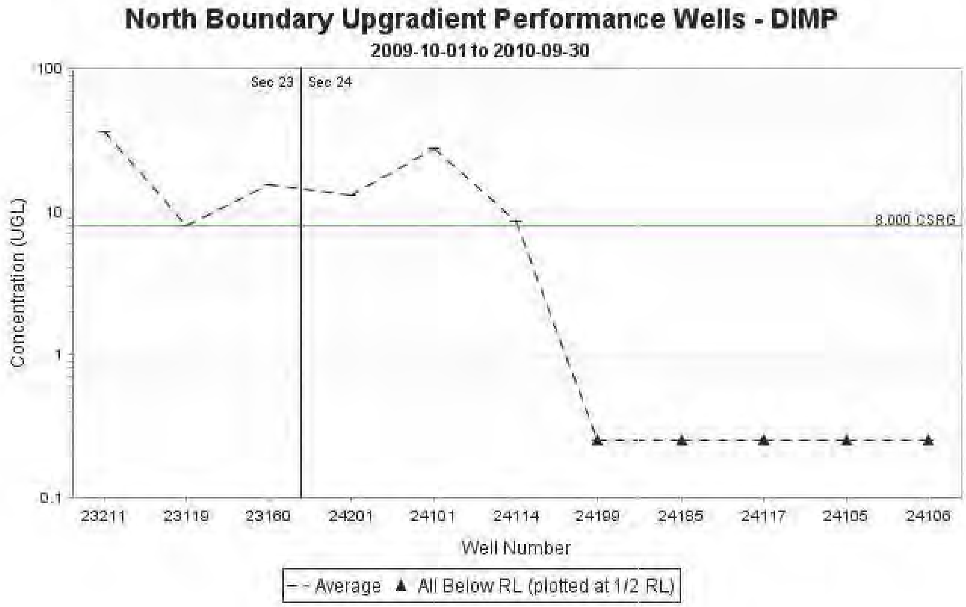


Figure A-3. NBCS Upgradient Performance Wells – DIMP, FY10 and FY14



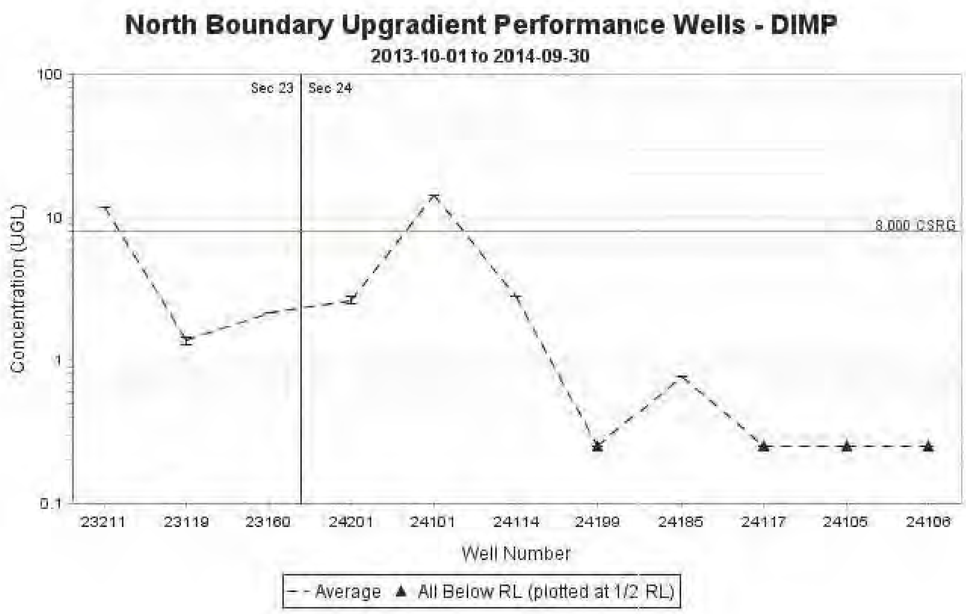
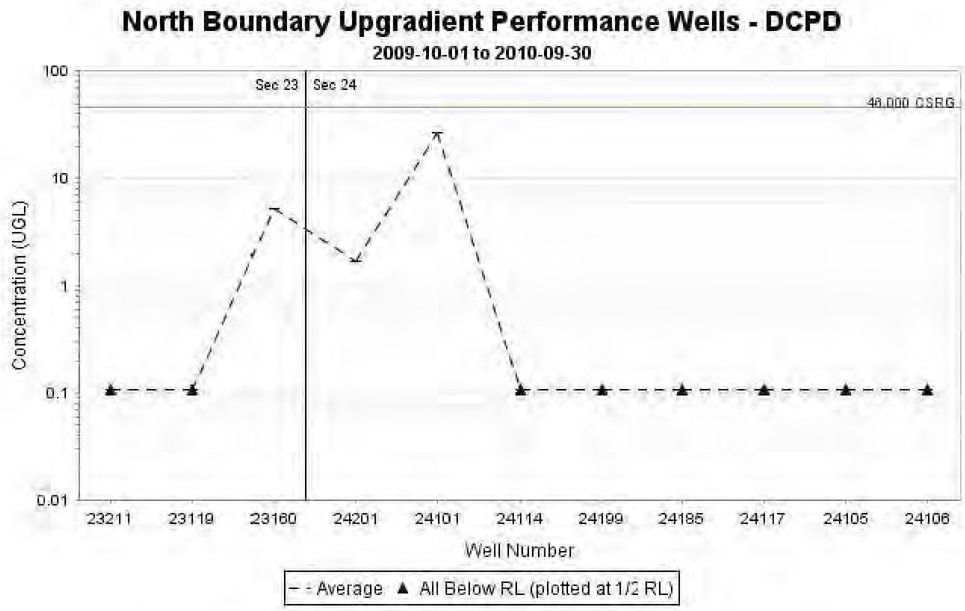


Figure A-4. NBCS Upgradient Performance Wells – DCPD, FY10 and FY14



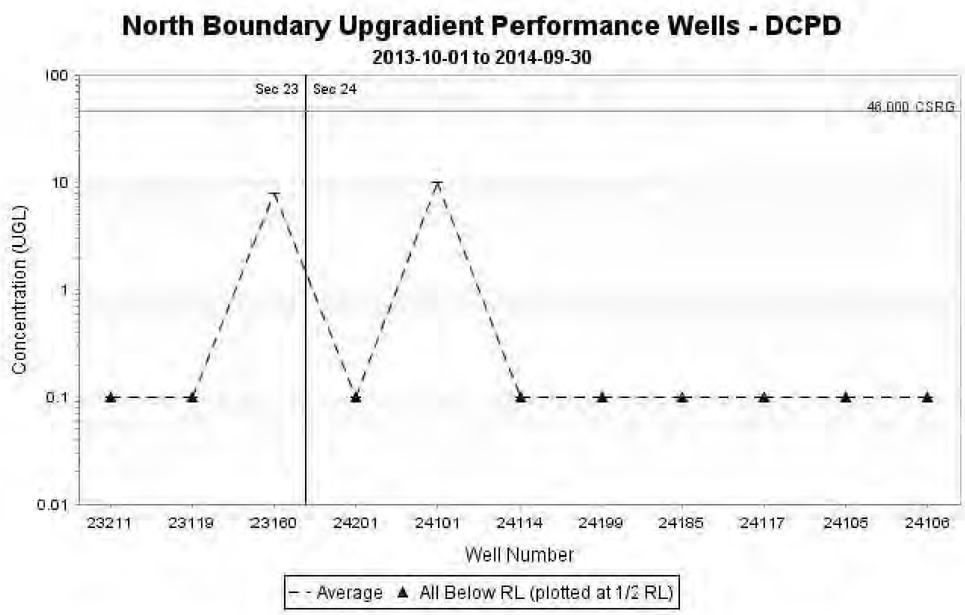
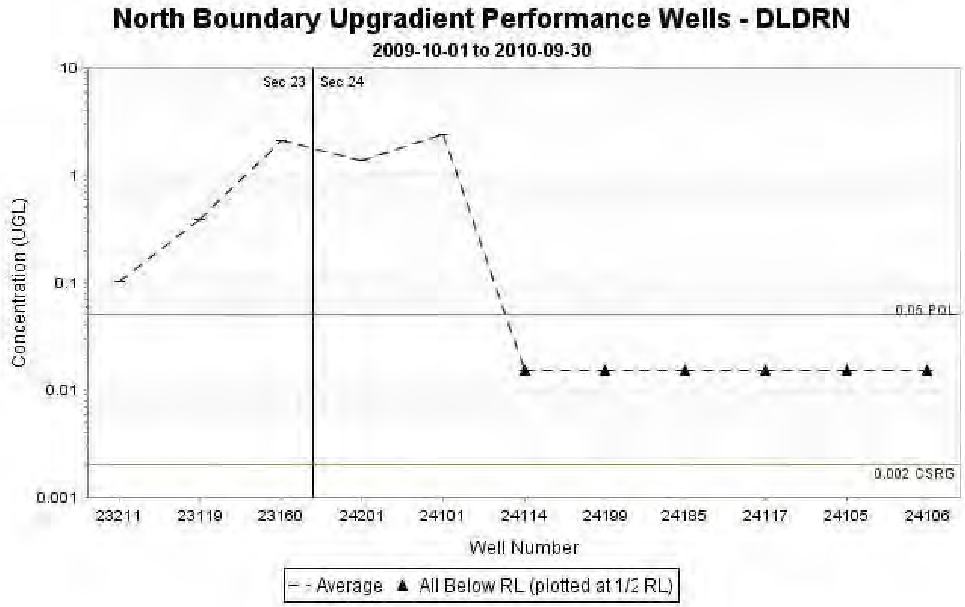


Figure A-5. NBCS Upgradient Performance Wells – Dieldrin, FY10 and FY14



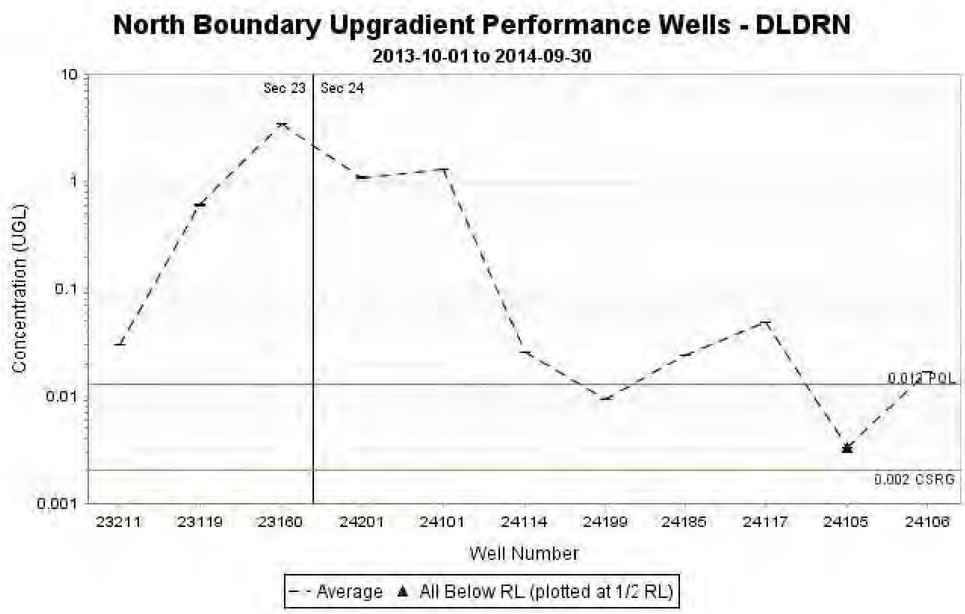
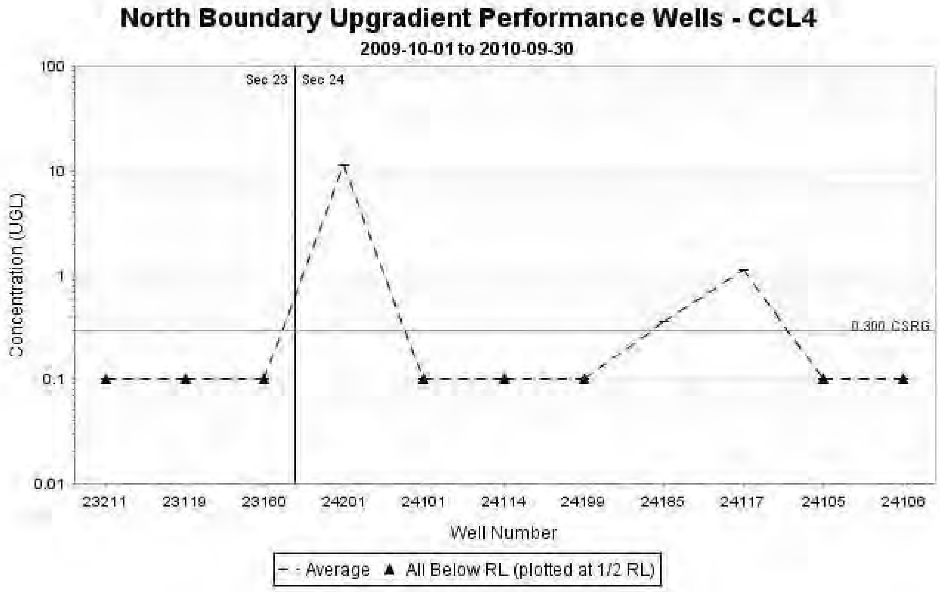


Figure A-6. NBCS Upgradient Performance Wells – Carbon Tetrachloride, FY10 and FY14



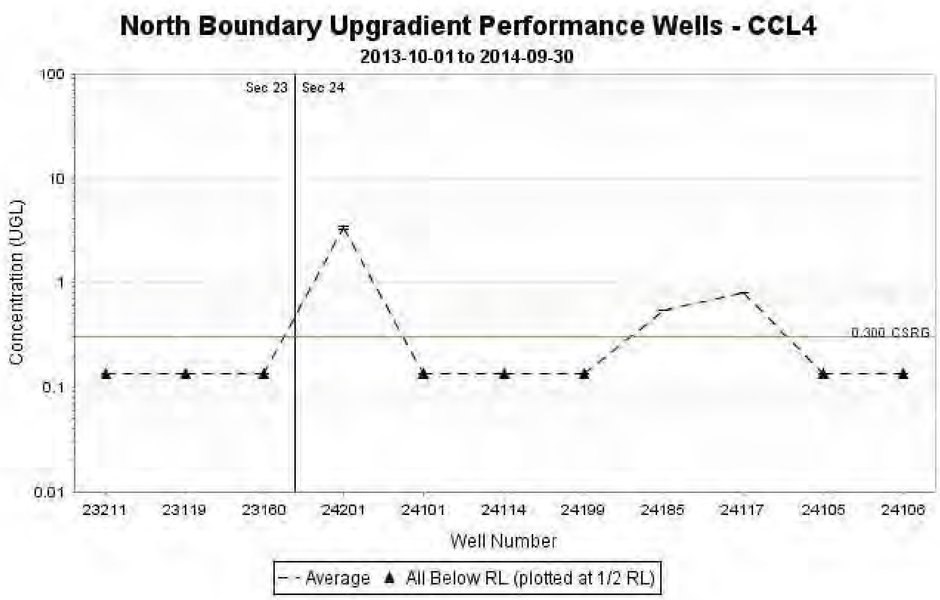
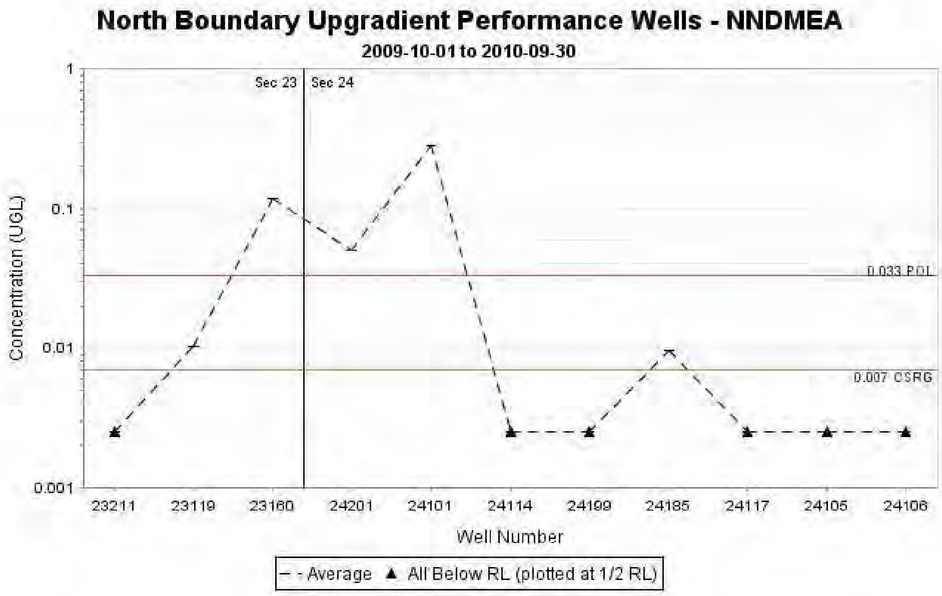


Figure A-7. NBCS Upgradient Performance Wells – N-Nitrosodimethylamine, FY10 and FY14



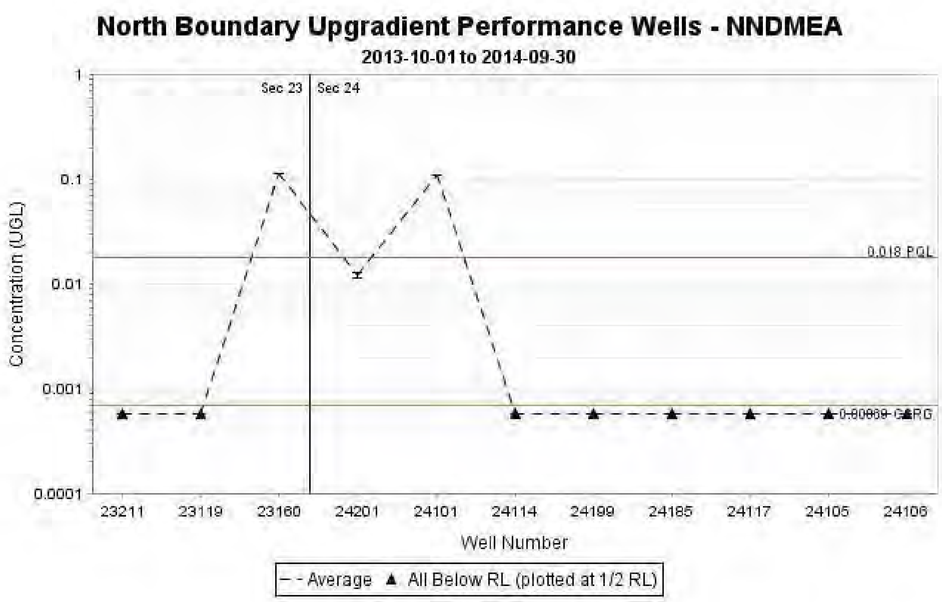
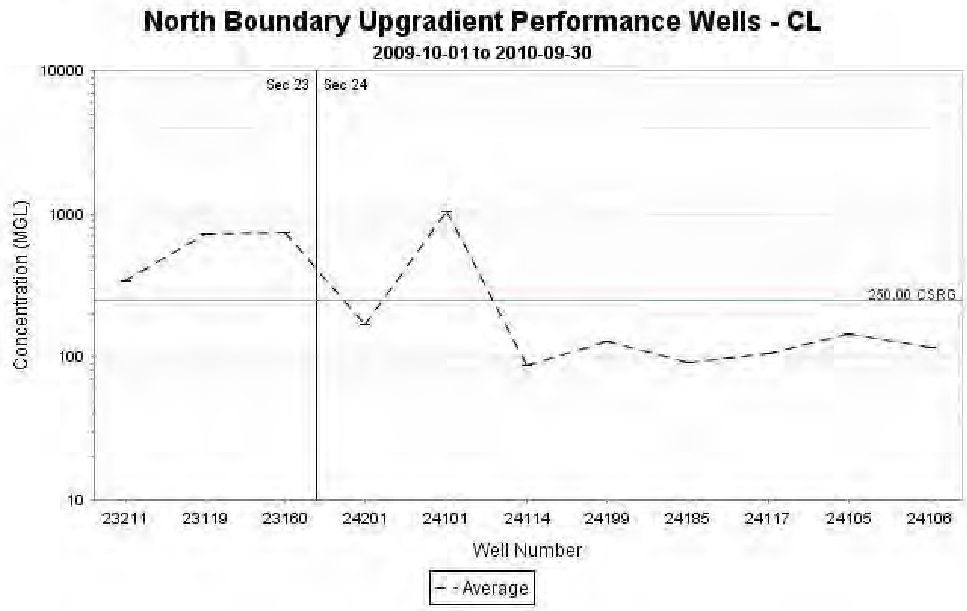


Figure A-8. NBCS Upgradient Performance Wells – Chloride, FY10 and FY14



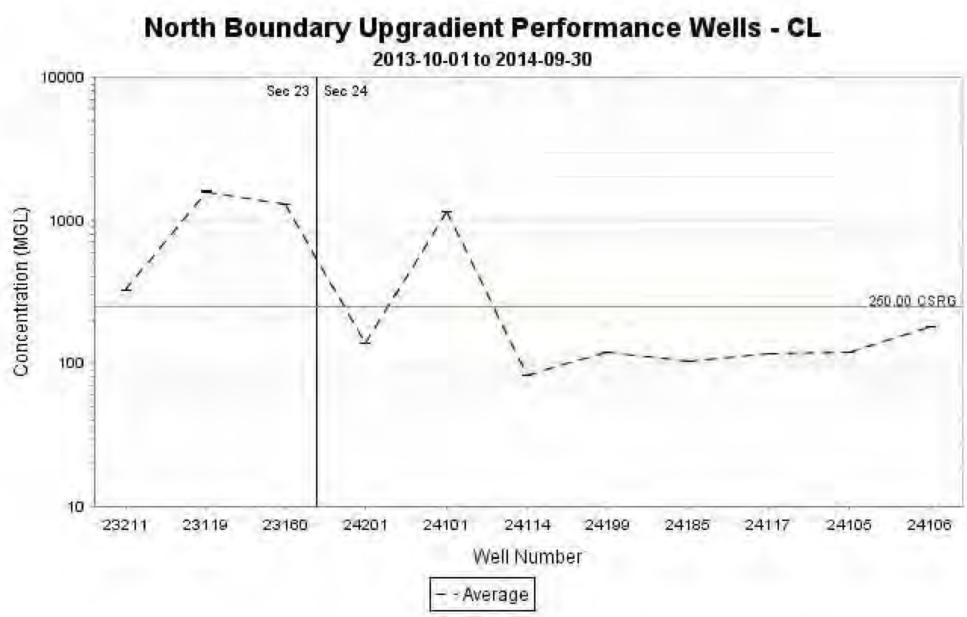
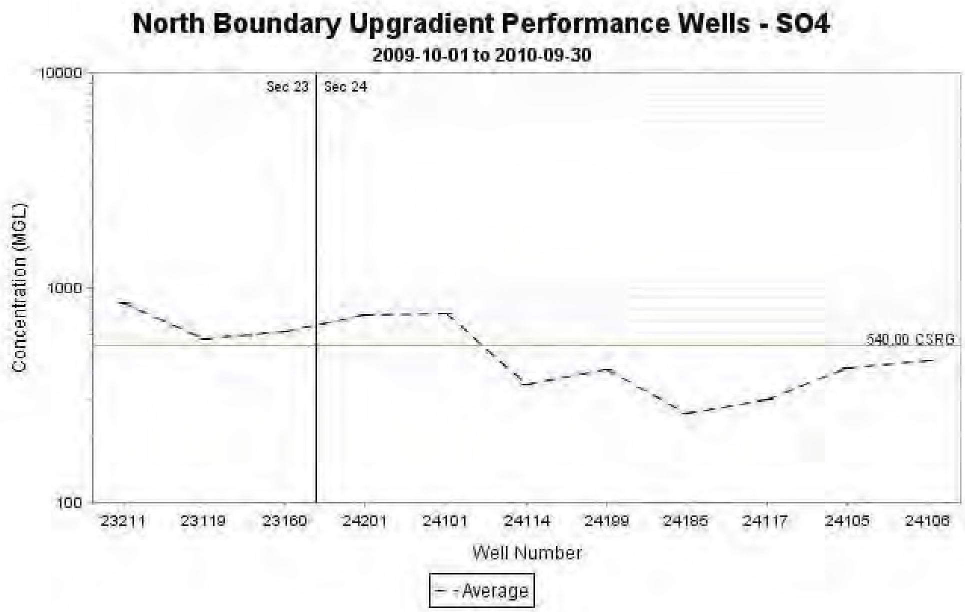


Figure A-9. NBCS Upgradient Performance Wells – Sulfate, FY10 and FY14



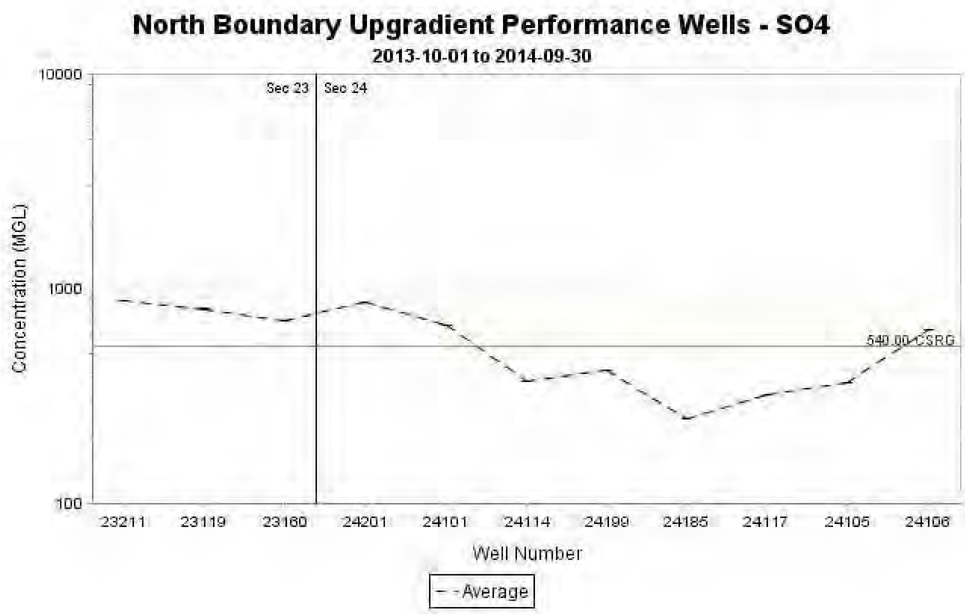
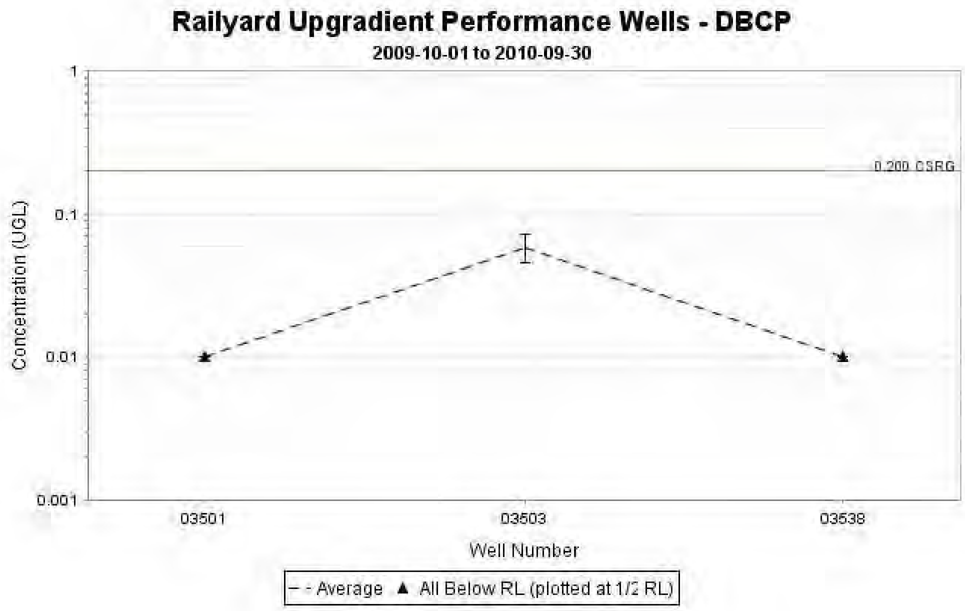


Figure A-10. RYCS Upgradient Performance Wells – DBCP, FY10 and FY14



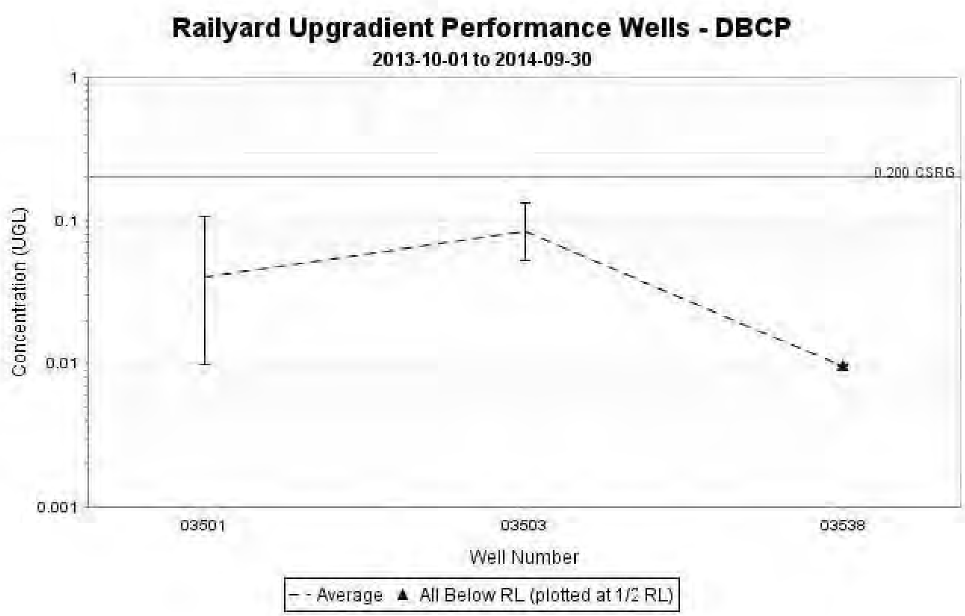
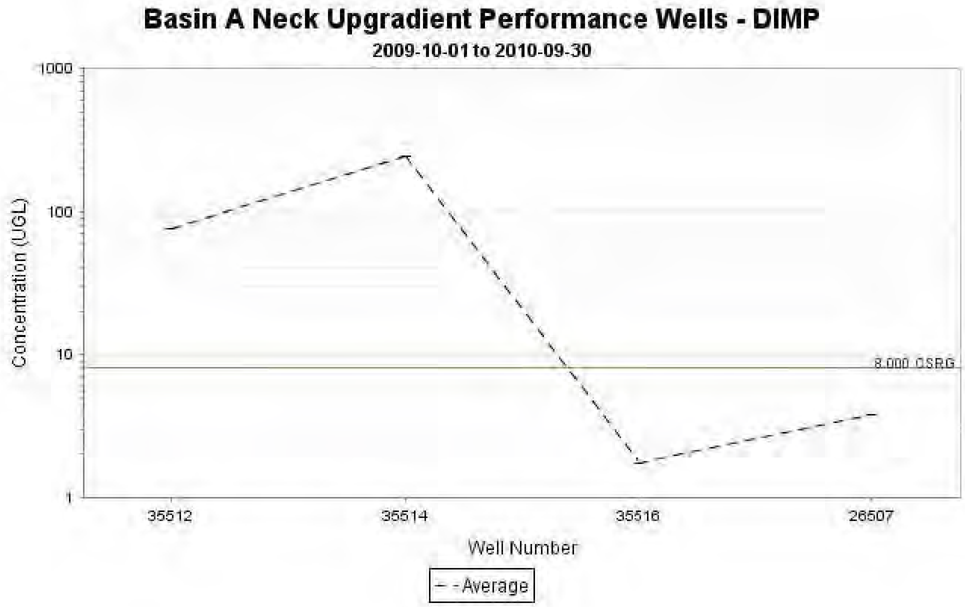


Figure A-11. BANS Upgradient Performance Wells – DIMP, FY10 and FY14



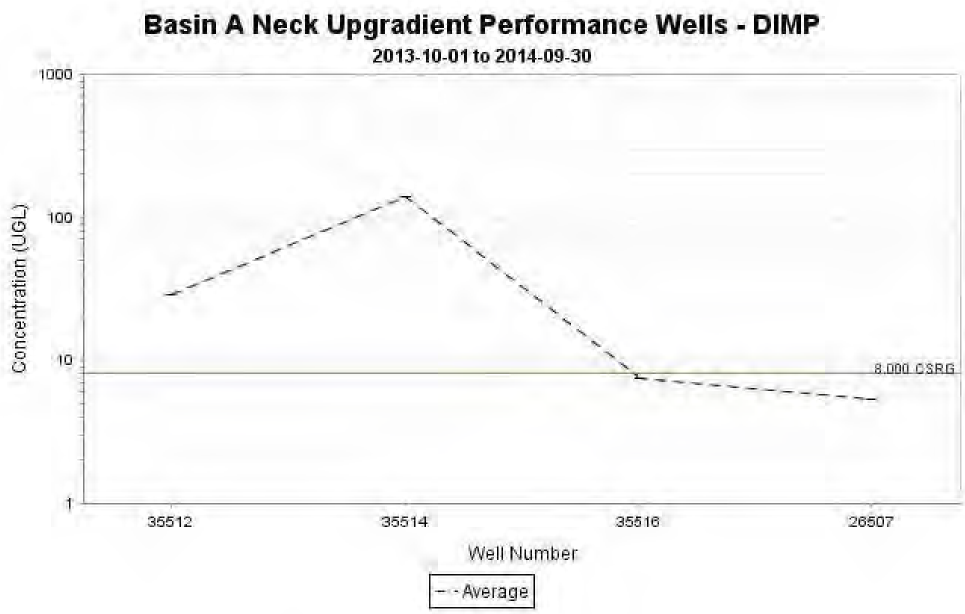
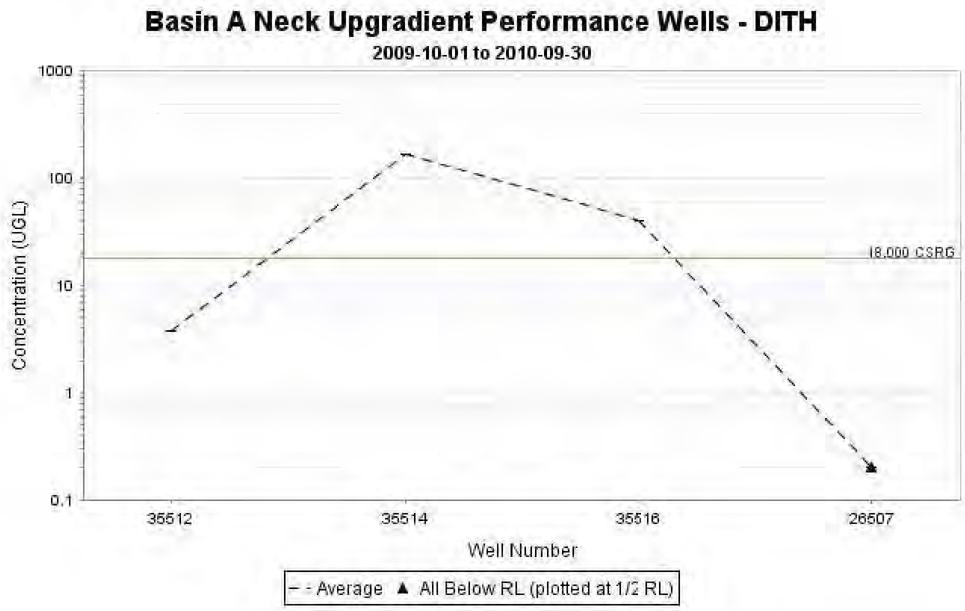


Figure A-12. BANS Upgradient Performance Wells – Dithiane, FY10 and FY14



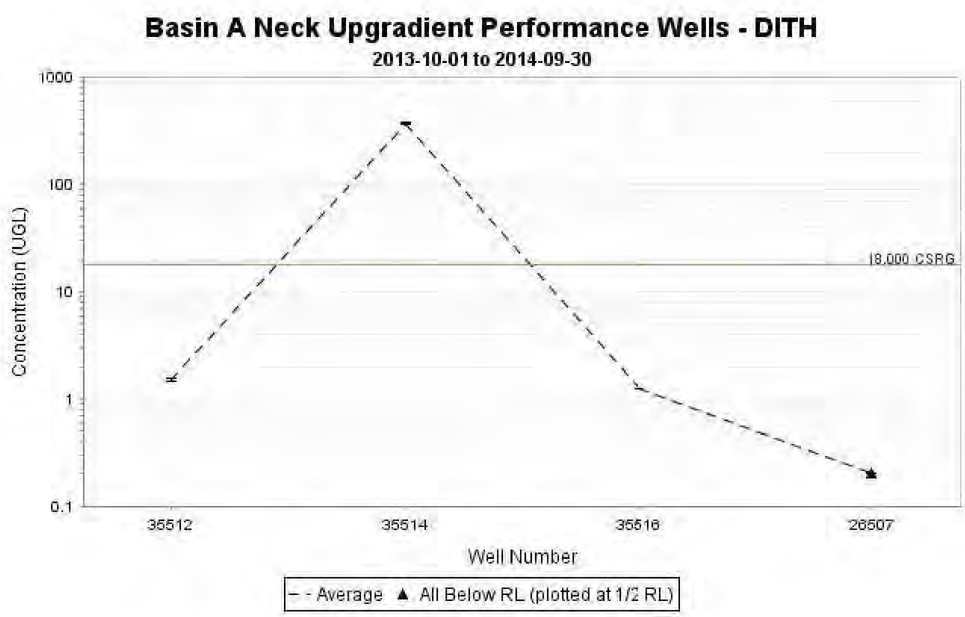
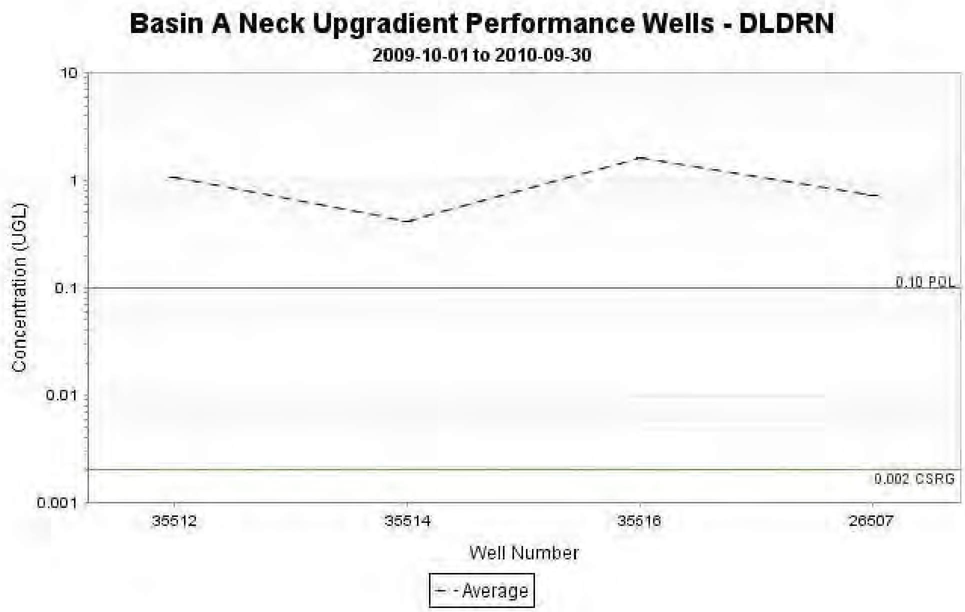


Figure A-13. BANS Upgradient Performance Wells – Dieldrin, FY10 and FY14



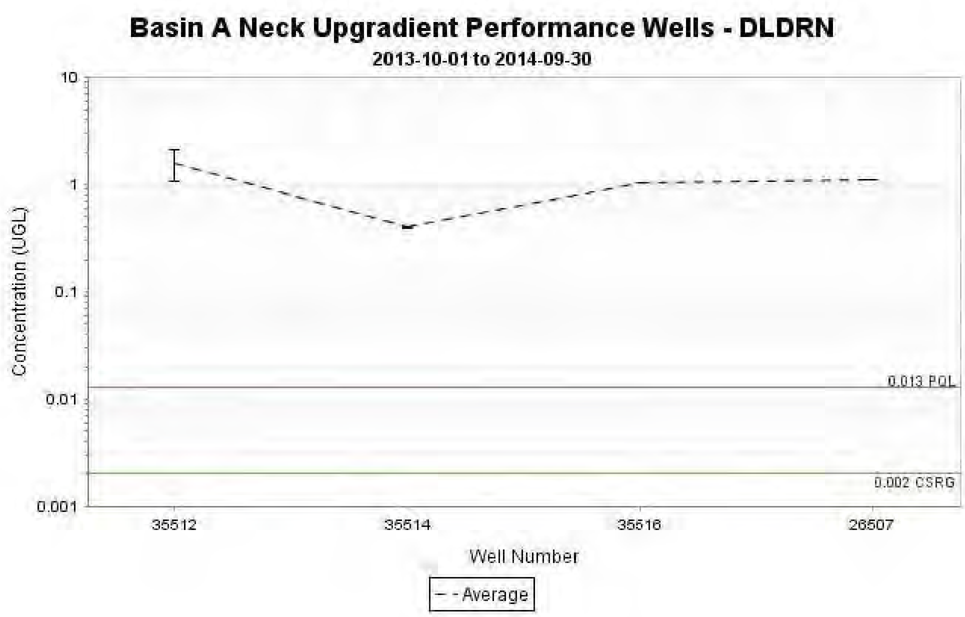
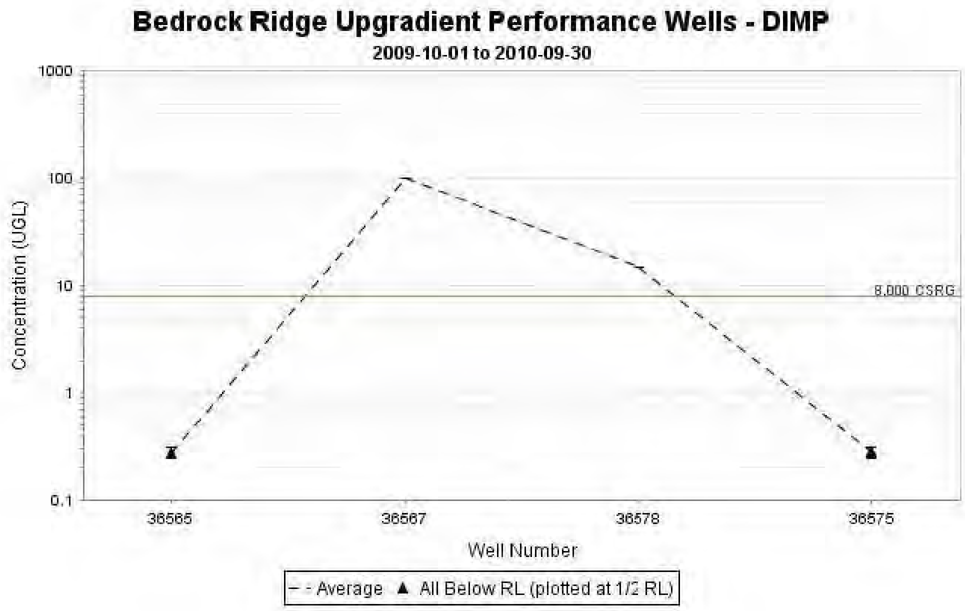


Figure A-14. BRES Upgradient Performance Wells – DIMP, FY10 and FY14



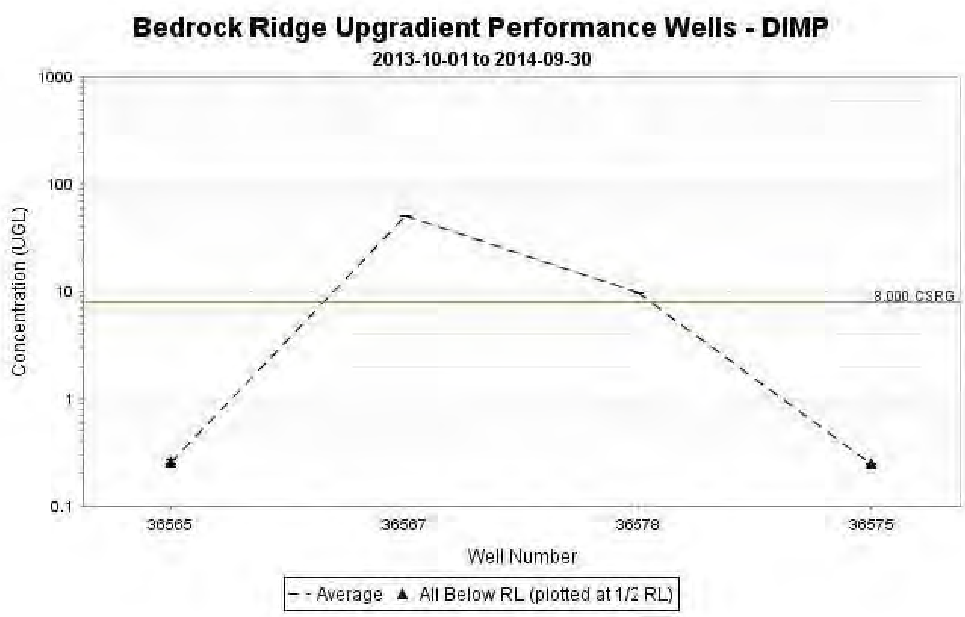
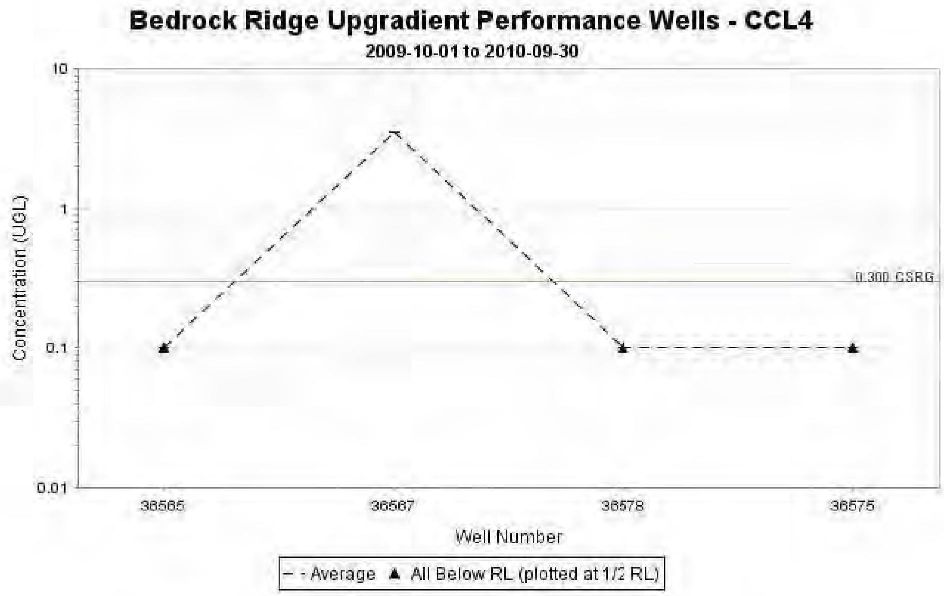


Figure A-15. BRES Upgradient Performance Wells – Carbon Tetrachloride, FY10 and FY14



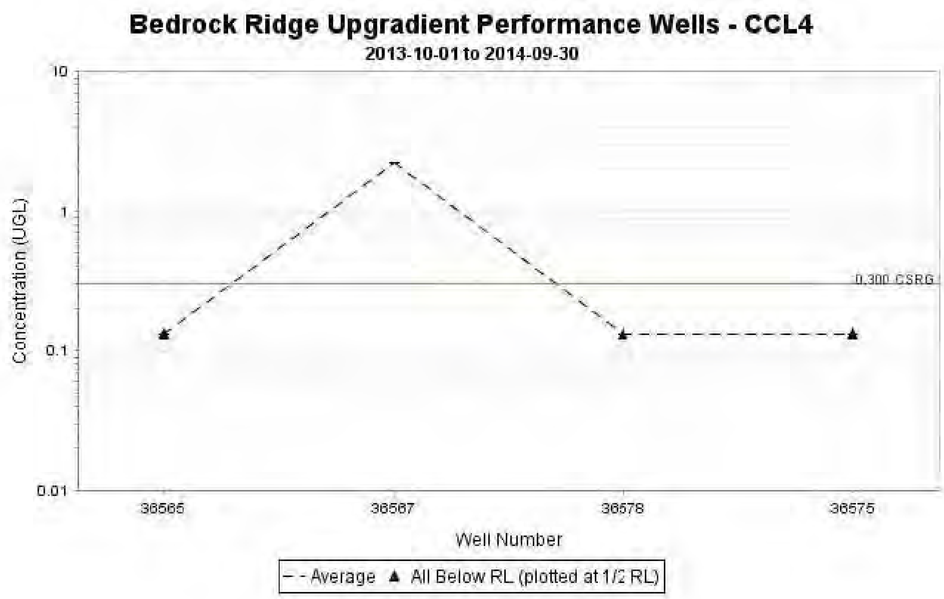
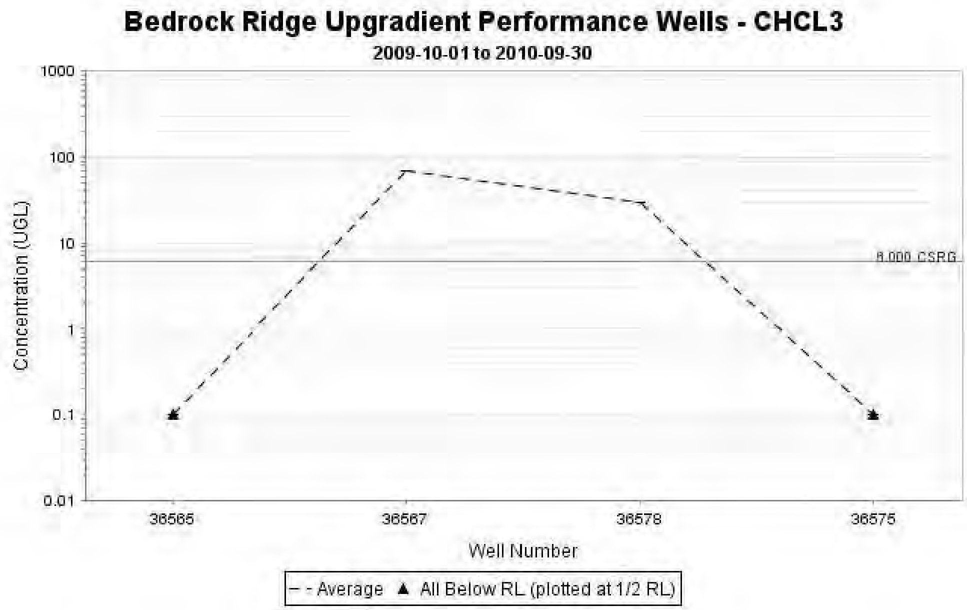


Figure A-16. BRES Upgradient Performance Wells – Chloroform, FY10 and FY14



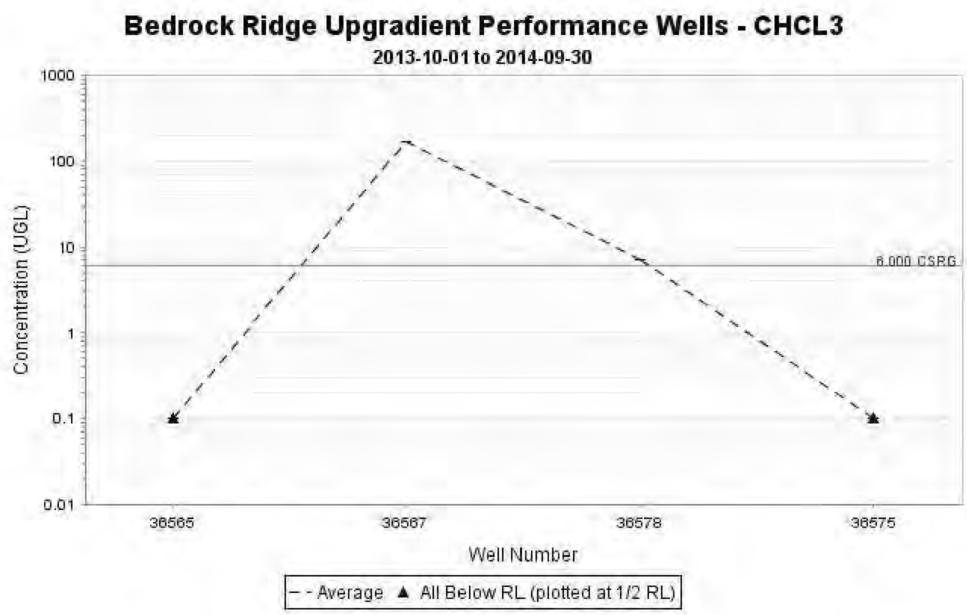
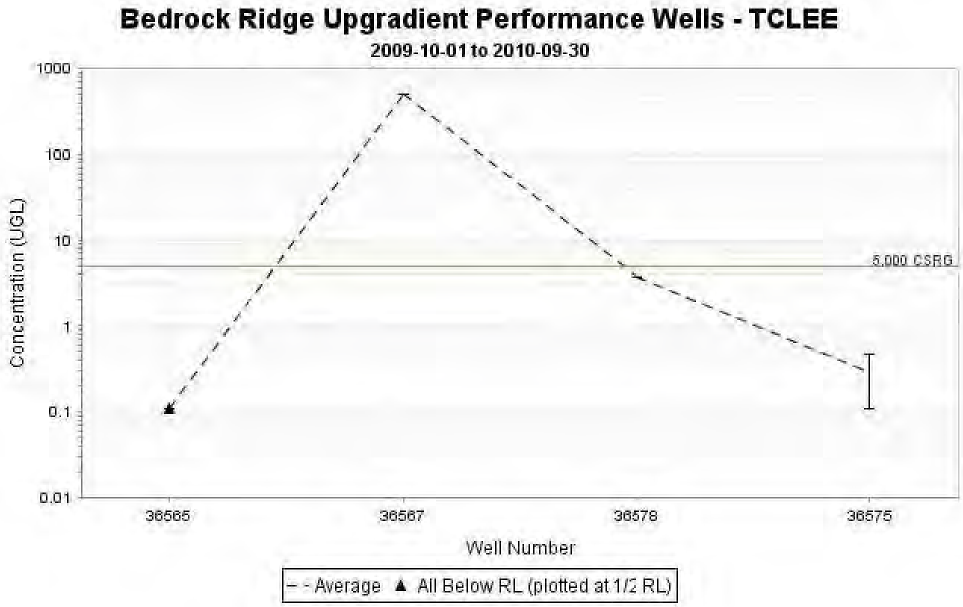


Figure A-17. BRES Upgradient Performance Wells – Tetrachloroethylene, FY10 and FY14



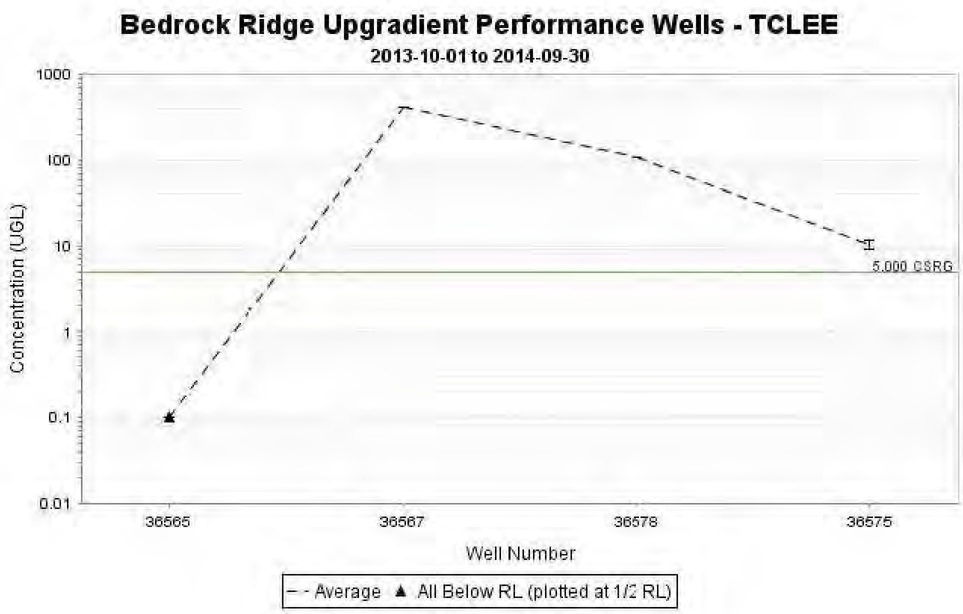


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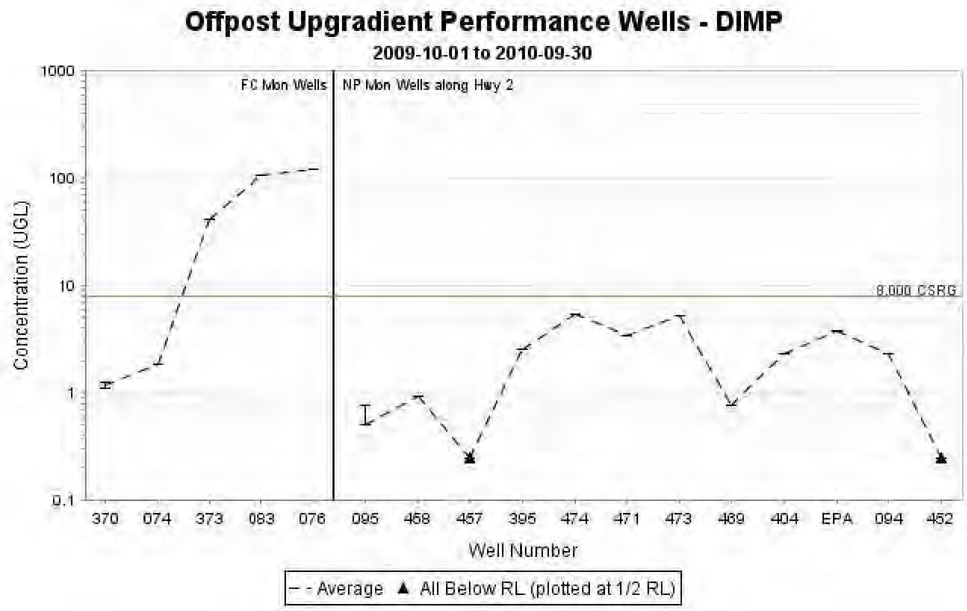
Figure A-18. OGITS Upgradient Performance Wells – DIMP, FY10 and FY14



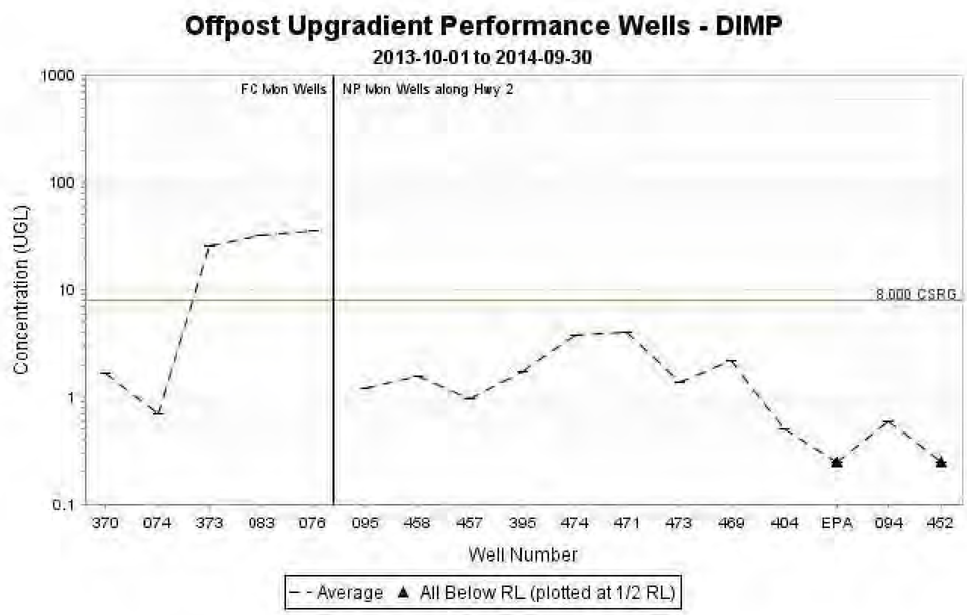
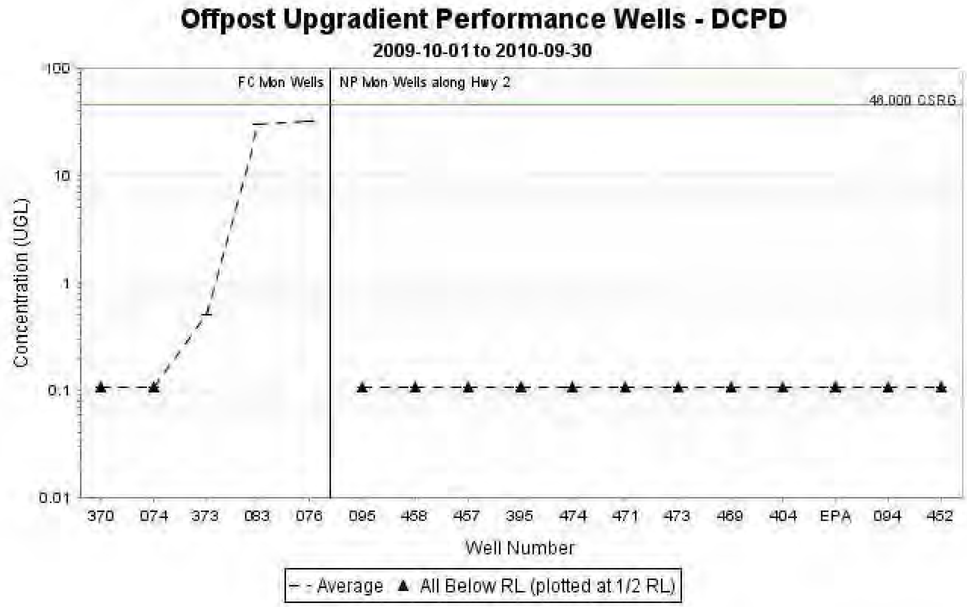


Figure A-19. OGITS Upgradient Performance Wells – DCPD, FY10 and FY14



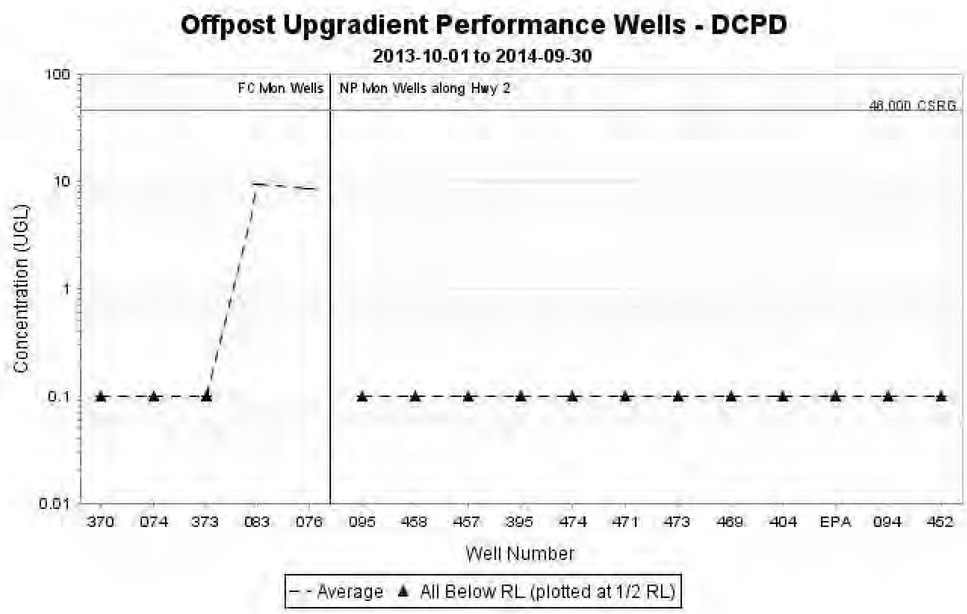
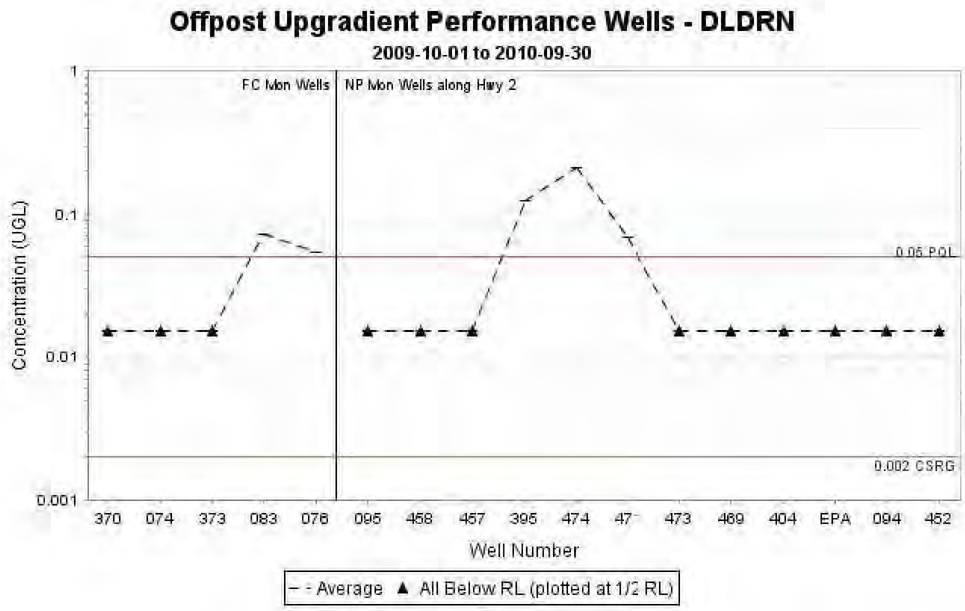


Figure A-20. OGITS Upgradient Performance Wells – Dieldrin, FY10 and FY14



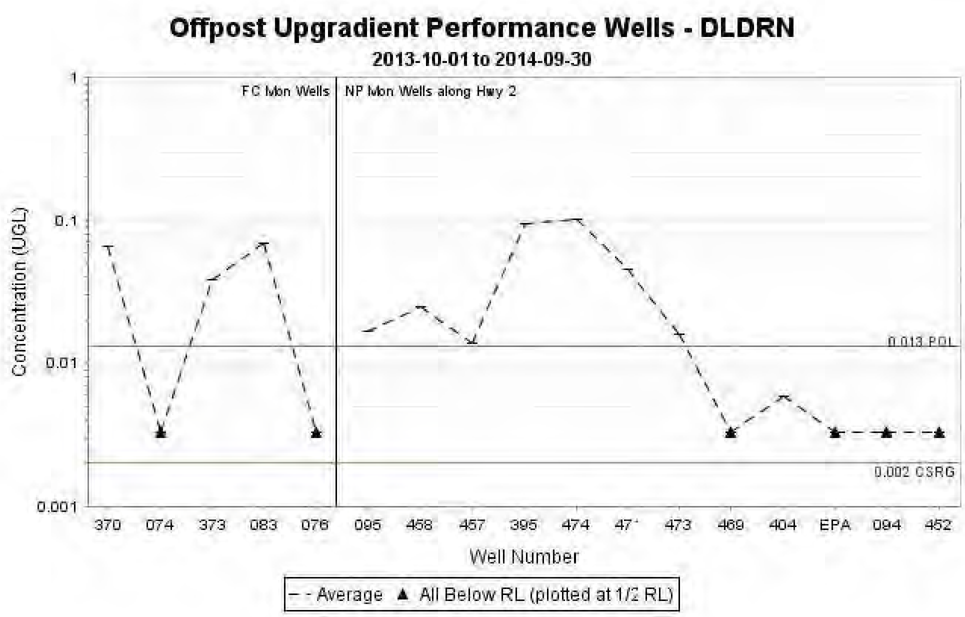
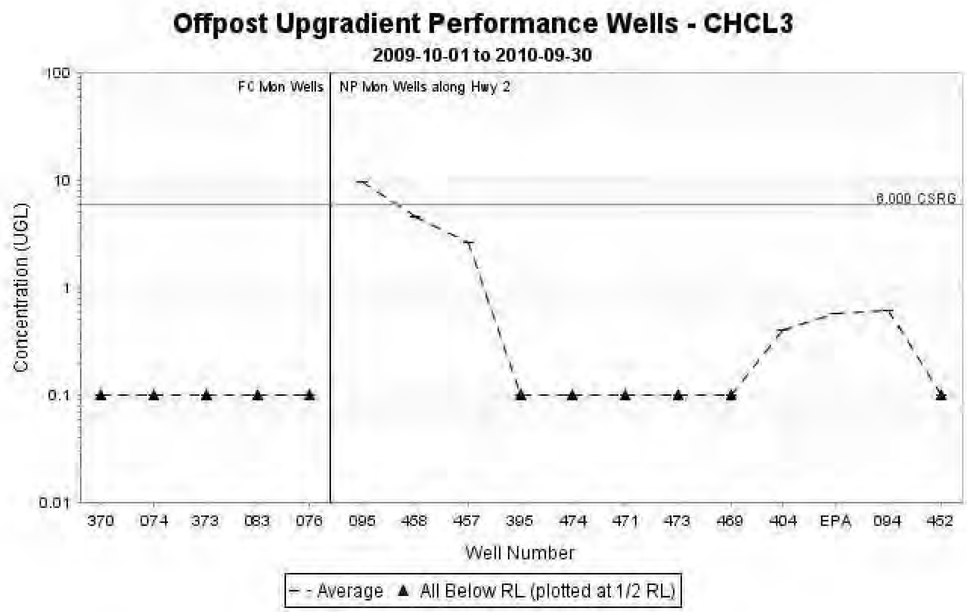
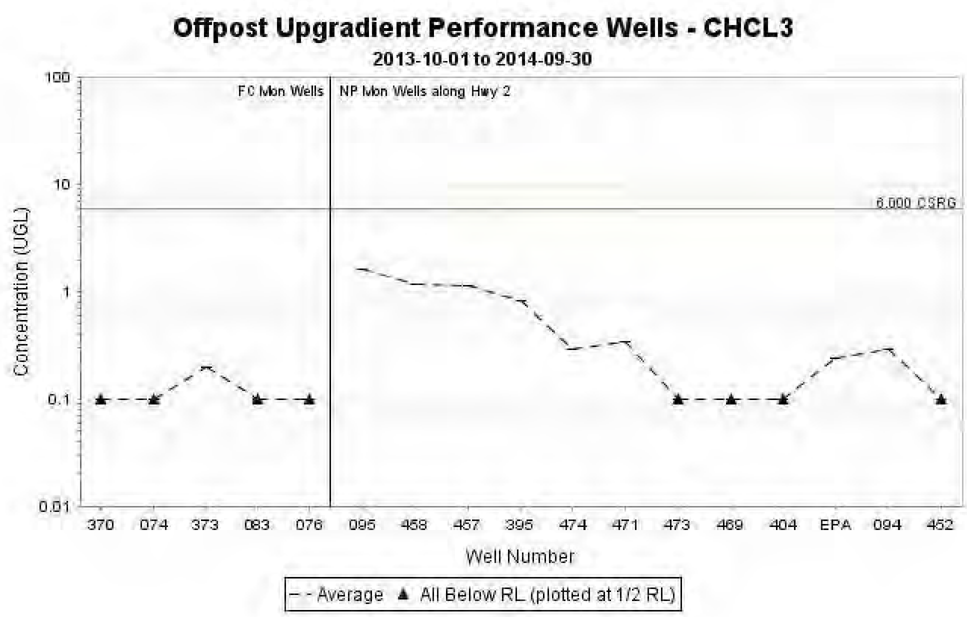


Figure A-21. OGITS Upgradient Performance Wells – Chloroform, FY10 and FY14





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APPENDIX B

North Boundary System Evaluation

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FYSR Appendix B

North Boundary Containment System
Comparison of Former Conformance Well and Performance Well Hydrogeology and Water Quality Data

Introduction

The 2010 Long Term Monitoring Plan (LTMP) established criteria for assessing the North Boundary Containment System (NBCS) performance, which include primary criteria of maintaining a reverse hydraulic gradient along the slurry wall, and plume edge capture at the ends of the slurry wall. If the primary criteria cannot be met, secondary criteria are used to assess the system performance. The secondary criteria are to demonstrate that the concentrations of Containment System Remediation Goal (CSRG) analytes in the downgradient performance wells either are below CSRGs/Practical Quantitation Limits (PQLs) or are decreasing over a period of at least five years. The downgradient performance well network in the 2010 LTMP included a different group of wells than the conformance wells in the 1999 LTMP.

Residual contamination in the aquifer sediments north of the slurry wall and slow migration of contaminants in fine-grained sediments in the downgradient conformance wells caused a few contaminants to exceed the remediation goals even though a reverse gradient has been maintained and the concentrations have been below the CSRGs in the treatment plant effluent. Only a few of the 29 NBCS CSRG analytes have been detected historically above the remediation goals in the downgradient wells. For example, in FY14, 10 of the 29 NBCS CSRG analytes were detected above the CSRGs/PQLs in one or more upgradient performance wells. The 10 analytes included diisopropylmethyl phosphonate (DIMP), dieldrin, endrin, isodrin, 1,2-dichloroethane, carbon tetrachloride, n-nitrosodimethylamine, chloride, fluoride, and sulfate. In FY14, only five of the 10 analytes (DIMP, dieldrin, chloride, fluoride, and sulfate) were detected above the CSRGs/PQLs in the downgradient performance wells. Since a reverse hydraulic gradient has consistently been maintained, this downgradient contamination most likely has not been caused by underflow or bypass of the system, and thus, has not been considered to be representative of NBCS performance. If bypass or underflow of the NBCS were occurring, more of the 10 CSRG analytes detected above the CSRGs upgradient would be detected downgradient, but they are not. Historically (prior to FY14), more CSRG analytes were detected above the CSRGs/PQLs in upgradient wells, but the same five analytes have been detected downgradient.

Monitoring wells located closer to the NBCS slurry wall and former recharge wells in similar flow paths as the conformance wells were selected as downgradient performance wells in the 2010 LTMP in order to attempt to collect water quality data that are more indicative of system performance. Both sets of wells were sampled contemporaneously several times, including during the current FYR period, and have had similar results. Since the performance wells had similar water quality results as the former conformance wells, with Regulatory Agency approval, annual monitoring of the former conformance wells was discontinued in 2013. Some of the former conformance wells were included in the CSRG exceedance network and will continue to be sampled twice in five years to track contamination downgradient of the NBCS.

Since the former downgradient conformance wells and current downgradient performance wells are: 1) in similar flow paths, 2) they were sampled contemporaneously several times, and 3) had similar water quality results, the same mechanisms for causing the concentrations to exceed the CSRGs/PQLs in the conformance wells appear to be affecting the downgradient performance wells. Some of the downgradient performance wells are former recharge wells, which might cause differences in their water quality results. For example, if the former recharge wells were installed in higher permeability zones than the corresponding conformance wells, their contaminant histories might be affected. Additionally, the recharge wells were used from 1981 until 1988/1990, when they were replaced by recharge trenches, which could have flushed the aquifer of residual and pre-existing contamination and the current concentrations above CSRGs/PQLs might indicate bypass/underflow.

At the Regulatory Agencies' request, this appendix presents an evaluation of the hydrogeology of the area of the former conformance wells and downgradient performance wells, including possible effects on water quality caused by the use of former recharge wells. In response to Regulatory Agency comments, the conformance/performance well historical water quality data were also reviewed to further assess the two groups of wells and help determine whether similar mechanisms are causing contaminant concentrations to be above the remediation goals.

Background Information

In the 2005 FYRR, an analysis using historical chloride concentration trends indicated that the chloride present in downgradient conformance well 37339 between 1985 and 2005 migrated past the future location of the NBCS slurry wall between 1968 and 1973, about 10 years before the NBCS was installed. Since chloride is a conservative contaminant, these timeframes represent approximate groundwater travel times of between 17 and 32 years from the NBCS (well 23001) to well 37339. Using an average travel time of 25 years, the contaminated groundwater that was downgradient of the NBCS when it was completed in 1981 would not reach well 37339 until 2006. Thus, based on these estimates, concentrations of chloride, DIMP, fluoride, and sulfate above the CSRGs in well 37339 during the 2010 FYR period appeared to represent contamination that predated installation of the NBCS. The DIMP concentrations in well 37339 decreased to below the CSRG on a relatively consistent basis beginning in 2004, which strongly agrees with these estimates. This is evidence that contaminant concentrations in conformance well 37339 were not representative of system performance.

In many cases, the contaminant concentrations were high in the groundwater that migrated offpost before the NBCS was installed. The maximum concentrations at or downgradient of the north boundary for selected analytes (chloride [3,400,000 [ug/L]; DIMP [11,900 ug/L]; dieldrin [6.76 [ug/L]; fluoride [10,000 [ug/L]; and sulfate [3,100,000 ug/L]) may have been higher before monitoring began. These high concentrations likely caused substantial residual contamination to be retained in the aquifer sediments that may act as continuing sources of groundwater contamination that impact the downgradient conformance and performance wells. Additionally, groundwater levels were higher prior to 1981 and have been lower since then, which would cause a secondary source of contamination to have remained above the water table. Higher recent water levels may be mobilizing this residual contamination.

The concentrations of a few analytes above CSRGs/PQLs in some of the downgradient wells likely are caused by a combination of desorption of dieldrin from the aquifer sediments downgradient of the NBCS slurry wall; very slow migration of DIMP, chloride, fluoride, and sulfate in finer grained sediments (silts, clays, and claystones) in the alluvium and Denver Formation bedrock particularly in the western part of the system; and natural occurrence of sulfate in the Denver Formation. Gypsum crystals (CaSO4) frequently are observed in Denver well borelogs. In the western portion of the system, the alluvium frequently has been unsaturated and the groundwater flows through the bedrock. This groundwater contamination was already present downgradient of the system when it was installed and it is taking longer to flush out than for other contaminants and longer than in other areas of the system where the aquifer is more permeable.

Regarding flushing of the aquifer near former recharge wells, towards the end of their use, most of the flow was diverted from the recharge wells into the North Bog (located in Section 24 north of the recharge wells between monitoring wells 24162 and 24164) due to carbon fouling of the wells. This may account for incomplete flushing in some areas. Due to a problem with electrical line noise, most of the recorded flow during this time period was shown to be inaccurate (i.e., a high flow would be recorded when the flow was actually shut off).

Methodology

A series of NBCS cross sections were constructed in a 1985 report (WES 1985) that were along the east-west alignments of the following: 1) extraction wells, 2) slurry wall, 3) recharge wells, and 4) monitoring wells along the Rocky Mountain Arsenal north boundary. Several cross sections transverse to the well alignments were also constructed. These cross sections are provided in this appendix and are used to depict the hydrogeology of the alluvial aquifer for the comparison of the conformance wells and downgradient performance wells.

The drawing numbers from the 1985 report are used for reference in this appendix. Plate G-02 is the cross-section location map for cross sections A-A' through K-K'. Cross section A-A' (Plate G-03) and B-B' (Plate G-04) are along the extraction well and slurry wall alignments, respectively. Cross section C-C' (Plate G-05) is along the recharge well alignment and cross section D-D' (Plate G-06) is the north boundary monitoring well alignment. Cross sections E-E' through K-K' (Plates G-07 and G-08) are transverse to the well and slurry wall alignments. In each cross section, the lithology in the alluvium and Denver Formation are shown, along with the Top of Denver Formation and screened interval of the wells.

Contaminant concentration graphs of analytes that are present above CSRGs/PQLs are provided to show the historical concentrations in the former conformance wells and downgradient performance wells, NBCS effluent (PNEFEF) concentrations, and the water elevations in the wells. These graphs are included to compare the corresponding well data and illustrate where there are similarities and differences. Inorganic CSRG analytes chloride, fluoride, and sulfate are less affected by sorption than the organic contaminants and are useful for assessing the downgradient contamination. Recent concentrations (2009 through 2014) of chloride, fluoride, and sulfate in the upgradient performance wells and extraction wells were reviewed for comparison with the downgradient well concentrations. Normally, the upgradient well concentrations would be higher than the downgradient concentrations. Higher downgradient well concentrations of chloride, fluoride, and sulfate would tend to support the hypothesis of pre-existing contamination downgradient of the slurry wall causing CSRG exceedances. Refer to FYSR Figure 5.1.1.2-1 for the NBCS well locations.

Results

In the alluvium, the lithologies range from clay to gravelly sand. The alluvium was deposited by streams in channels eroded into the Denver Formation bedrock surface. The NBCS spans a bedrock channel with the ends of the slurry wall keyed into bedrock highs where the alluvium is unsaturated. The bedrock channel at the NBCS is oriented generally north-south. The deposition of the various alluvial lithologic units ranged from channel fill (sand and gravelly sand) to overbank deposits (silt and clay), which also are oriented generally north-south. The flow paths associated with the conformance wells that were used to select the performance wells also are orientated generally north-south. Consequently, the corresponding conformance and performance wells are typically completed in similar lithologic units.

A detailed discussion of the corresponding conformance and performance wells is provided below. The CSRGs and PQLs also are shown on the graphs, with the two dieldrin PQLs indicated as PQL1 (0.05 ug/L) and PQL2 (0.013 ug/L). The wells are discussed in order from west to east.

- Conformance well 37339 and performance wells 23434 and 23436.

All three wells are screened in alluvial clayey silt to silty clay (ML-CL) and bedrock claystone. Well 37339 is located near and is constructed in similar lithologic units as well 23196 on cross sections D-D’ and E-E’.

DIMP concentrations are variable in well 37339: greater than the CSRG in 2007 and 2011 and less than the CSRG in other years. The DIMP concentrations are less than the CSRG in wells 23434 and 23436 (Figure B-1). Dieldrin concentrations are similar in all three downgradient wells (above and below the new PQL), with a recent increasing trend that may correspond to rising water levels (Figure B-2). Chloride (Figure B-3), fluoride (Figure B-4), and sulfate (Figure B-5) concentrations are similar, above the CSRGs, and above the effluent concentrations, with a recent increasing trend for chloride and sulfate, while the NBCS effluent concentrations have remained below the CSRGs. Increasing chloride and sulfate concentrations in wells 23434 and 23436 correspond with higher water levels, which may be mobilizing additional chloride and sulfate from the aquifer sediments. The chloride and sulfate concentrations in the downgradient wells are significantly higher than in the upgradient wells. The upgradient and downgradient fluoride concentrations are similar.

Wells 23434 and 23436 are located approximately 750 and 1,000 feet closer to the NBCS slurry wall, respectively, than well 37339. Thus, the travel times between the slurry wall and the wells would be less. However, migration in the fine-grained sediments (silt, clay, and claystone) would be very slow, which likely explains why chloride, fluoride, and sulfate concentrations typically are higher than the effluent concentrations and above the CSRGs in the wells. Although slow migration in the fine-grained sediments appears to be affecting the contaminant concentrations in wells 23434 and 23436, they likely are better choices for performance wells than well 37339. The same mechanisms probably explain the chloride, fluoride, sulfate, and dieldrin concentrations above the CSRGs/PQL in all three wells.

- Conformance well 23198 and performance well 23438

Well 23198 is screened in alluvial sand (SP and gravelly sand (SP-GP). Well 23438 is screened in alluvial sand (SP), sandy clay (CL), clayey sand (SC) and bedrock claystone.

DIMP concentrations are variable in well 23198 and below the CSRG in 23438 (Figure B-6). Dieldrin concentrations are above the PQL in well 23198 and below the PQL in well 23438 (Figure B-7). Chloride concentrations (Figure B-8) have been below the CSRG in both wells, but increased above the CSRG in 2014/2015, possibly due to rising water levels. Fluoride concentrations (Figure B-9) have been relatively stable in both wells, with concentrations above the CSRG in well 23198 and near the CSRG in well 23438. Sulfate concentrations (Figure B-10) have been relatively stable below the CSRG in both wells.

The water quality data indicate that there may have been more effective flushing of the aquifer near well 23438 due to its use as a recharge well in the 1980s and its closer proximity to the recharge trenches that began operation in 1988. The higher chloride concentrations in both wells in 2014/2015 suggest that some residual chloride contamination may still be present in the aquifer in this area. The data indicate that well 23438 may be more representative of current system effectiveness than well 23198 with the recent increase in chloride concentrations is an exception.

- Conformance well 23253 and performance well 23405.

Well 23253 is screened in alluvial well-graded sand (SW), fine- to coarse-grained sand and fine gravel based on continuous core. A bore log for well 23405 is not available, so there may be differences in lithology between the two wells.

DIMP (Figure B-11) and dieldrin (Figure B-12) concentrations are higher in well 23405 than in well 23253. Both DIMP and dieldrin show decreasing trends in well 23405. A potable water supply pipeline leak in 2010 caused significantly higher water levels near wells 23253 and 23405 and may have caused the increase in dieldrin concentrations in well 23405 in 2010. Since then, the dieldrin concentrations decreased until 2015, when they increased. The dieldrin trend in well 23405 appears to track the water level trend. The chloride, fluoride, and sulfate concentrations are near or below the CSRGs in both wells. The chloride and sulfate concentrations in well 23253 decreased and the fluoride concentration increased in 2010 likely in response to the potable water line leak. The chloride (Figure B-13), fluoride (Figure B-14), and sulfate (Figure B-15) concentrations in well 23253 track the effluent concentrations, but the fluoride and sulfate concentrations in well 23405 are significantly lower than in well 23253, in the plant effluent, and in the upgradient wells. The chloride concentrations in well 23405 track the effluent concentrations. The vertical hydraulic gradients are downward between the alluvium and the Denver UFS and CFS. Thus, discharge from the Denver to the alluvium is not feasible for causing the lower fluoride and sulfate concentrations in well 23405. The abnormally low fluoride and sulfate concentrations may indicate the presence of a stagnant zone near well 23405, which might explain the higher DIMP and dieldrin concentrations in well 23405 than in well 23253. Consequently, flushing of the aquifer near former recharge well 23405 appears incomplete, and well 23253 may be more representative of system effectiveness than well 23405.

- Conformance and performance well 24006

Well 24006 is both a former conformance well and a current performance well. Well 24006 is screened in alluvial clayey sand to clayey gravelly sand.

DIMP concentrations are below the CSRG (Figure B-16) and the dieldrin concentrations are similar to the former PQL of 0.05 ug/L and higher than the new PQL (Figure B-17). A rise in water levels in 2010 and 2011 corresponded to an increase in dieldrin concentrations in 2011. Since then, the dieldrin concentrations have declined. The chloride (Figure B-18), fluoride (Figure B-19), and sulfate (Figure B-20) concentrations are near or below the CSRGs and track the effluent concentrations. The dieldrin concentrations above the PQL in well 24006 since 2011 likely are caused by residual contamination in the clayey sands near well 24006. A possible more suitable well upgradient of well 24006 is former recharge well 24412. Although no borehole log is available for well 24412, it is likely to be screened in a sand with lower fines content than well 24006 based on the logs for adjacent wells and borings. Other potential alternate wells that have borehole logs (e.g., former recharge well 24413 and monitoring well 23043) are closed. No other wells besides 24412, are suitable for replacing 24006.

- Conformance well 24162 and performance well 24415.

Both wells are screened in alluvial gravelly sand. Well 24415 is also screened in alluvial silty clay.

DIMP concentrations are below the CSRG in both wells (Figure B-21). Dieldrin concentrations are similar and are above or near the former PQL and above the new PQL (Figure B-22). The dieldrin concentrations in both wells generally follow the water level trends. The chloride (Figure B-23), fluoride (Figure B-24), and sulfate (Figure B-25) concentrations are near or below the CSRGs and track the effluent concentrations. The two wells have similar water quality, although the dieldrin concentrations in well 24415 appear slightly more affected by water level fluctuations and the potentially associated mobilization from the aquifer sediments. The two wells are comparable and the same mechanisms probably explain the dieldrin concentrations above the PQL in both wells (e.g., desorption of residual contamination in the aquifer sediments). More flushing of the aquifer near former recharge well 24415 than conformance well 24162 is not indicated.

- Performance well 24418

There is no corresponding conformance well. Well 24418 is screened in alluvial sandy clay and fine sand.

DIMP concentrations are below the CSRG (Figure B-26). Dieldrin concentrations are above the former PQL and above the new PQL (Figure B-27). Well 24418 was not sampled prior to 2010 when water levels were lower. The water levels have been highly variable within a range of about three feet. Consequently, the dieldrin concentrations above the PQLs may be related to the presence of residual dieldrin in the aquifer sediments. The chloride (Figure B-28), fluoride (Figure B-29), and sulfate (Figure B-30) concentrations are near or below the CSRGs and track the effluent concentrations, except in 2012 and 2015 for chloride and sulfate when higher water levels appear to have caused the concentrations to increase above the CSRGs. These data suggest that residual dieldrin, chloride, and sulfate are present in the aquifer sediments and are mobilized by intermittently higher water levels.

Monitoring well 24163 is located father north and was sampled from 1984 to 1999 with no detections of dieldrin, with MRLs as low as 0.04 ug/L (Figure B-31). The lack of contamination above CSRGs/PQLs in this well during and prior to 1999 is why conformance wells were not selected in this part of the system in the 1999 LTMP. Well 24163 is screened in gravelly sand, and the lower fines content may explain why dieldrin was not detected. Water levels were relatively high and similar to or higher than current water levels during this time period, yet the dieldrin concentrations remained below the previous PQL. Based on the historical water quality data and lower fines content, well 24163 may be more representative of system performance than well 24418.

- Performance well 24421

There is no corresponding conformance well. Well 24421 is screened in alluvial silt, sandy clay, silty sand, and bedrock sandstone (hard).

DIMP concentrations are below the CSRG (Figure B-32). Dieldrin concentrations are below the former PQL and at or above the new PQL (Figure B-33). The water levels have been highly variable within a range of about four feet. The dieldrin concentrations above the new PQL may be related to the presence of residual dieldrin in the aquifer sediments. The recent chloride (Figure B-34), fluoride (Figure B-35), and sulfate (Figure B-36) concentrations are near or below the CSRGs and track the effluent concentrations, except in 2015 for chloride and sulfate when higher water levels appear to have caused the concentrations to increase above the CSRGs. These data suggest that residual dieldrin, chloride, and sulfate are present in the aquifer sediments and are mobilized by intermittently higher water levels.

Monitoring well 24164 is located father north and downgradient of well 24421 and was sampled from 1986 to 1999 with no detections of dieldrin, with MRLs as low as 0.024 ug/L (Figure B-37). The lack of contamination above CSRGs/PQLs in this well during and prior to 1999 is why conformance wells were not selected in this part of the system in the 1999 LTMP. Well 24164 is screened in sandy clay and gravelly sand, with the screened interval predominantly in gravelly sand. The lower fines content may explain why dieldrin was not detected in well 24164. Water levels were relatively high and similar to or higher than current water levels during this time period, yet the dieldrin concentrations remained below the previous PQL. Based on the historical water quality data and lower fines content, well 24164 may be more representative of system performance than well 24421.

- Conformance well 37338 and performance well 24424

Both wells are screened in alluvial silty to clayey sand (SM-SC), silty sand to poorly graded sand (SM-SP), and bedrock clayey siltstone. The alluvial sand in well 24424 also contains gravel with cobbles and boulders.

The DIMP concentrations (Figure B-38) are similar in both wells (well below the CSRG and less than the MRL). The dieldrin concentrations (Figure B-39) have decreased to below the former PQL and are similar (below, near or above the new PQL). The dieldrin concentrations in both wells appear to be affected by the fluctuating water levels, which have varied as much as 14 feet historically. The chloride (Figure B-40), fluoride (Figure B-41), and sulfate (Figure B-42) concentrations are near or below the CSRGs and generally have tracked the effluent concentrations, with variations that seem related to the fluctuating groundwater levels and interaction with surface water in First Creek. Since 2010, the concentrations of fluoride and sulfate in well 37338 have been well below the plant effluent concentrations, likely due to surface water interaction from First Creek, which has lower fluoride and sulfate concentrations than the plant effluent. First Creek surface water sampling site SW24004 is located near the NBCS. Well 37338 is closer to First Creek than well 24424, which likely explains the lower fluoride and sulfate concentrations in well 37338. The chloride concentrations have been near or above the plant effluent in both wells, with increases in 2009 and 2014 that appear related to higher groundwater levels. The chloride concentrations in upgradient wells are below the CSRG and the chloride concentrations in First Creek are lower than the plant effluent concentrations, averaging 79 mg/L. Thus, there may be more residual chloride than fluoride and sulfate in the aquifer sediments downgradient of the slurry wall. Dieldrin is not detected in First Creek surface water. The lower dieldrin concentrations in both wells since 2010 may be related to increased recharge from First Creek and dilution of the groundwater.

Since well 24424 is farther from First Creek, it may be less subject to surface water interaction and may be the more representative well. Residual chloride and dieldrin in the aquifer sediments may still be mobilized from higher groundwater levels, and the mechanisms that affected conformance well 37338 would still apply to performance well 24424. The similar dieldrin concentrations in the two wells suggest that flushing of the aquifer by former recharge well 24424 was not more complete than at well 37338.

- Conformance well 24166 and performance well 24004

Well 24166 is screened in alluvial sand with gravel and bedrock claystone. Well 24004 is screened in silty fine sand with occasional pebbles and cobbles, and clayey gravelly sand (SC).

DIMP concentrations are similar in both wells, well below the CSRG, and less than the MRL (Figure B-43). Dieldrin concentrations are similar, near or above the former PQL, and above new PQL (Figure B-44). The chloride (Figure B-45), fluoride (Figure B-46), and sulfate (Figure B-47) concentrations are near or below the CSRGs and generally have tracked the effluent concentrations, with variations that seem related to the fluctuating groundwater levels and interaction with surface water in First Creek. Since 2010, the concentrations of chloride, fluoride, and sulfate in well 24004 have been well below the plant effluent concentrations, likely due to surface water interaction with First Creek, which has lower chloride, fluoride, and sulfate concentrations than the plant effluent. Well 24004 is closer to First Creek than well 24166, which likely explains the lower chloride, fluoride, and sulfate concentrations in well

24004. In 2014, the sulfate concentration in well 24166 was also well below the effluent concentration, suggesting more interaction with First Creek.

Since the wells have very similar dieldrin concentrations, they are comparable and residual dieldrin in the aquifer sediments near both wells likely is causing the concentrations to remain above the PQL. Neither well seems more representative than the other.

- Performance well 37362

There is no corresponding conformance well. Well 37362 is screened in alluvial silty clay, gravelly sand, silty sand, clayey sand, and bedrock siltstone.

DIMP concentrations are below the CSRG and typically below the MRL (Figure B-48). Dieldrin concentrations are usually below the former PQL and at or below the new PQL, except in 2013 (Figure B-49). The 2013 dieldrin concentration was higher than any previous sample, and therefore was suspect. The water levels have been highly variable within a range of about eight feet. The dieldrin concentrations above the new PQL may be related to the presence of residual dieldrin in the aquifer sediments. The recent chloride (Figure B-50) and sulfate (Figure B-51) concentrations are near or below the CSRGs. The fluoride concentrations (Figure B-52) have been at or above the CSRG. These data suggest that residual dieldrin and fluoride are present in the aquifer sediments and are mobilized by intermittently higher water levels.

Former recharge well 24429 is located upgradient of well 37362 and is screened in silty sand, sand, and gravel. It has never been sampled, but based on lower fines content, well 24430 may be more representative of system performance than well 37362. Wells 24430 and 24431 appear unsuitable for potential performance wells because well 23430 contains more clay than 24429, and well 24431 is dry.

Conclusions and Recommendations

1. Similar mechanisms causing concentrations of a few CSRG analytes to be above the CSRGs/PQLs appear to apply both to the former conformance wells and to the current downgradient performance wells. These mechanisms appear unrelated to system effectiveness.

2. The NBCS recharge wells were installed in uniform spacing and distance from the slurry wall to create a reverse hydraulic gradient along the length of the slurry wall. The variation in the lithology across the NBCS indicates that the design of the recharge well array was independent of the hydrogeology. The corresponding conformance and performance wells generally were completed in similar lithologic units. Sometimes the former conformance well is in a more permeable unit and sometimes the current performance well/former recharge well is in a more permeable unit. Therefore, the assumption that the recharge wells were installed in more permeable areas is incorrect.

3. The assumption that flushing of the contaminants occurred in the vicinity of each recharge well also appears incorrect. While the more mobile contaminants such as DIMP may have been flushed from the aquifer sediments, the flushing of the more sorptive compound dieldrin appears

incomplete. The data suggest that flushing of one of the former recharge wells (23438) may have been greater than the corresponding conformance well (23198), but the flushing of the other former recharge wells is not indicated.

4. As stipulated in the 2010 LTMP, when the primary performance criteria are met, the NBCS is functioning as intended. The mechanisms causing the downgradient concentrations of a few analytes to be above the CSRGs/PQLs appear to be unrelated to system performance. Therefore, when the primary criteria are met, the NBCS is functioning as intended, and the downgradient performance well water quality data should be reported, but not be considered in the NBCS performance evaluation. Army/Shell recommends that the LTMP be revised accordingly.

5. Changes to the downgradient performance well network also are recommended based on the evaluation above. Table 1 lists proposed revisions to the downgradient performance well network.

Table 1. Proposed Alternate Performance Wells

2010 LTMP Performance Well	Proposed Alternate Performance Well	Rationale
23405	23253	Stagnant zone near well 23405, no borelog for well 23405
24006	24412	Lower fines content and more permeable aquifer at 24412
24418	24163	Lower fines content and more permeable aquifer at 24163
24421	24164	Lower fines content and more permeable aquifer at 24164
37362	24429	Lower fines content and more permeable aquifer at 24429

Reference

WES 1985 Environmental Laboratory, USAE Waterways Experiment Station, 1985. *1984 North Boundary Containment/Treatment System Performance Report, Rocky Mountain Arsenal, Denver, Colorado.* December.

FIGURES

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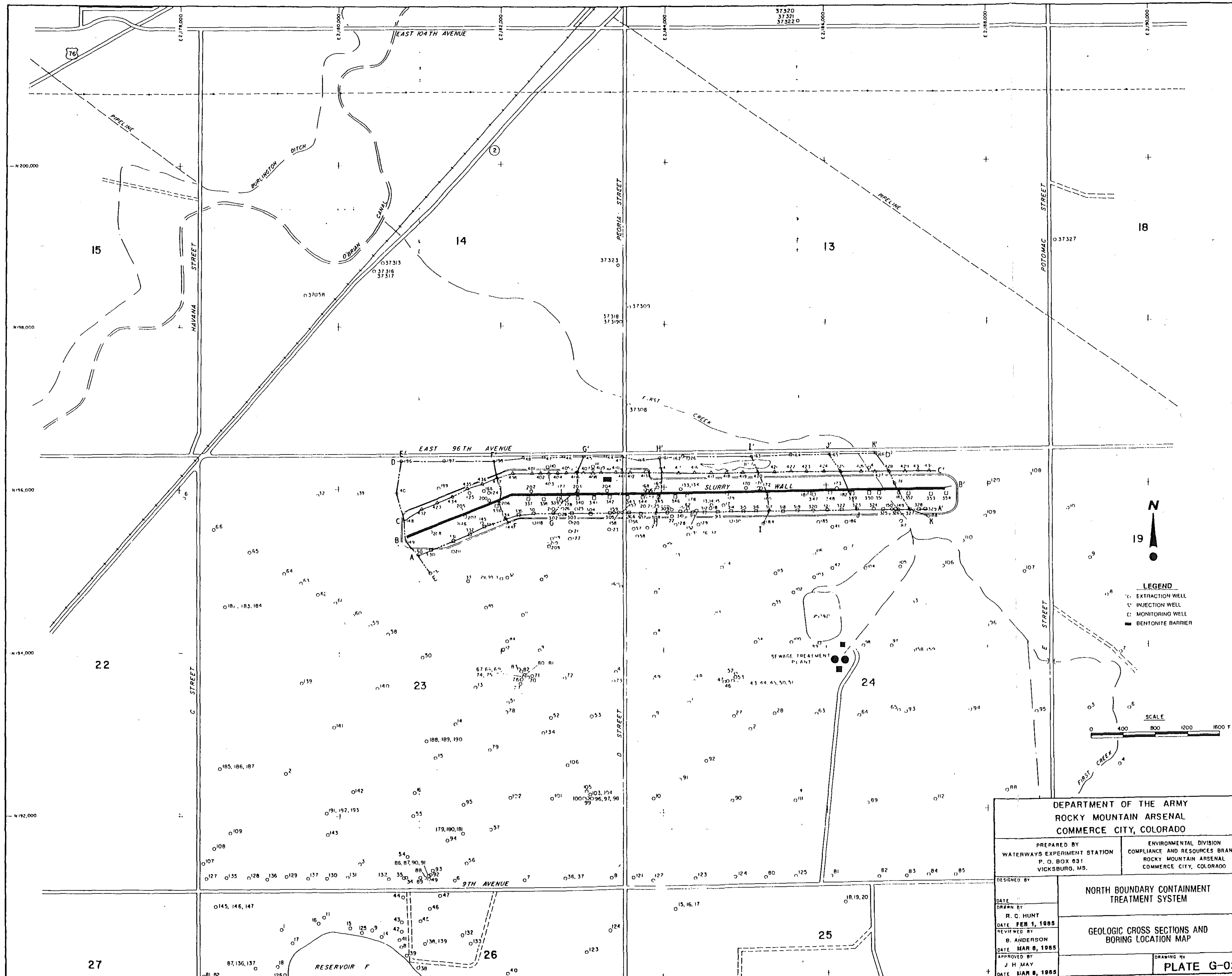
EAST 104TH AVENUE
PIPELINE
BURLINGTON DITCH
O'BRIAN CANAL
HAVANA STREET
PEORIA STREET
POTOMAC STREET
FIRST CREEK
EAST 96TH AVENUE
SLURRY WALL
SEWAGE TREATMENT PLANT
C STREET
D STREET
E STREET
9TH AVENUE
RESERVOIR F
15
14
13
18
22
23
24
19
27
26
25
LEGEND
EXTRACTION WELL
INJECTION WELL
MONITORING WELL
BENTONITE BARRIER
SCALE
0 400 800 1200 1600 FT
DEPARTMENT OF THE ARMY
ROCKY MOUNTAIN ARSENAL
COMMERCE CITY, COLORADO
PREPARED BY
WATERWAYS EXPERIMENT STATION
P. O. BOX 631
VICKSBURG, MS.
ENVIRONMENTAL DIVISION
COMPLIANCE AND RESOURCES BRANCH
ROCKY MOUNTAIN ARSENAL
COMMERCE CITY, COLORADO
DESIGNED BY
DATE
DRAWN BY
R. C. HUNT
DATE FEB 1, 1985
REVIEWED BY
B. ANDERSON
DATE MAR 8, 1985
APPROVED BY
J H MAY
DATE MAR 8, 1985
NORTH BOUNDARY CONTAINMENT TREATMENT SYSTEM
GEOLOGIC CROSS SECTIONS AND BORING LOCATION MAP
DRAWING No
PLATE G-02

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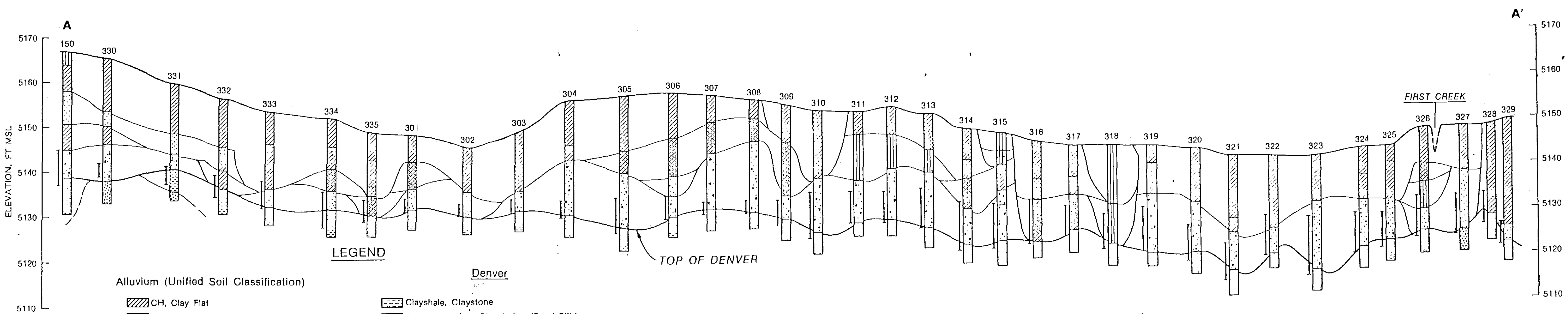

LEGEND

Alluvium (Unified Soil Classification)

- CH, Clay Flat
- CL, Clay, Silty Clay
- ML, Silt
- SC, Clayey Sand
- SM, Silty Sand
- SP, Sand
- SP-GP, Gravelly Sand

Denver

- Clayshale, Claystone
- Sandy Clayshale, Clayshale w/Sand-Silt Lenses
- Silt, Siltstone, Sandy Siltstone
- Sand, Sandstone, Silty Sandstone

SCREENED INTERVAL

SCALE
0 200 400 600 FT

DEPARTMENT OF THE ARMY ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO	
PREPARED BY WATERWAYS EXPERIMENT STATION P. O. BOX 631 VICKSBURG, MS.	ENVIRONMENTAL DIVISION COMPLIANCE AND RESOURCES BRANCH ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO
DESIGNED BY DATE	NORTH BOUNDARY CONTAINMENT TREATMENT SYSTEM
DRAWN BY R. C. HUNT DATE FEB 1, 1985	
REVIEWED BY B. ANDERSON DATE MAR 8, 1985	CROSS SECTION A-A'
APPROVED BY J. H. MAY DATE MAR 8, 1985	DRAWING No PLATE G-03

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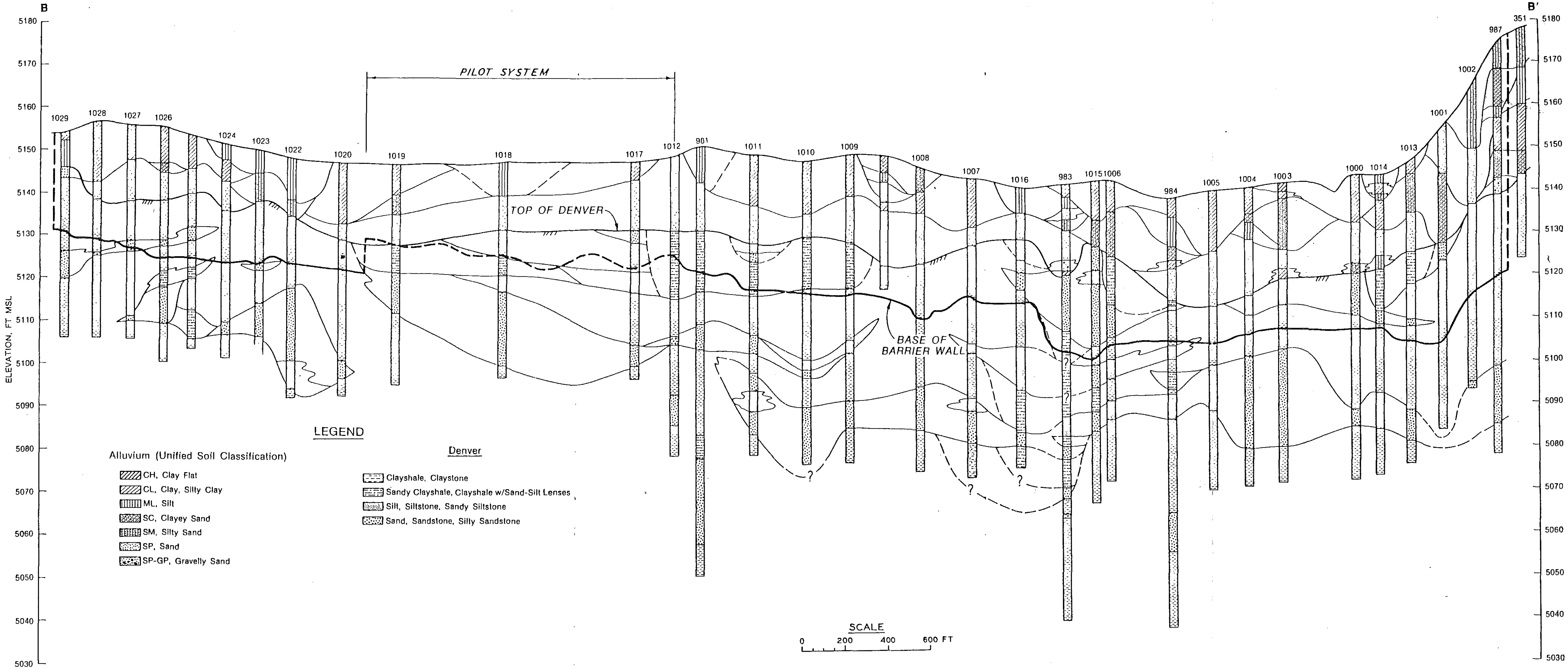

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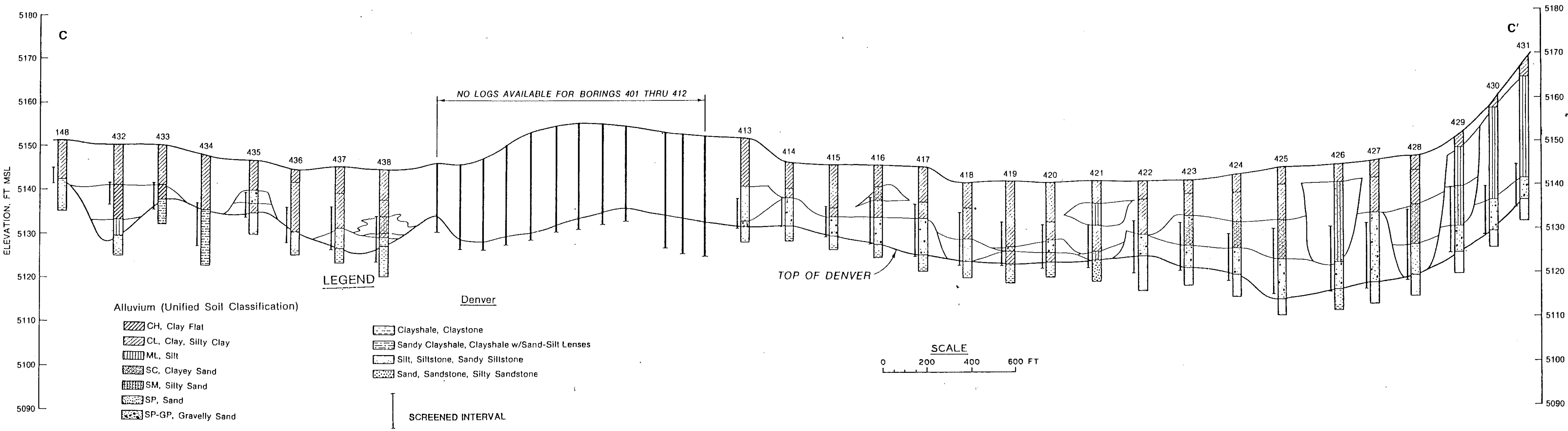
DRAWN BY R. C. HUNT DATE FEB 1, 1985	
REVIEWED BY B. ANDERSON DATE MAR 8, 1985	CROSS SECTION B-B'
APPROVED BY J. H. MAY DATE MAR 8, 1985	DRAWING No PLATE G-04



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DRAWN BY R. C. HUNT DATE FEB 1, 1985	
REVIEWED BY B. ANDERSON DATE MAR 8, 1985	CROSS SECTION C-C′
APPROVED BY J. H. MAY DATE MAR 8, 1985	DRAWING No PLATE G-05

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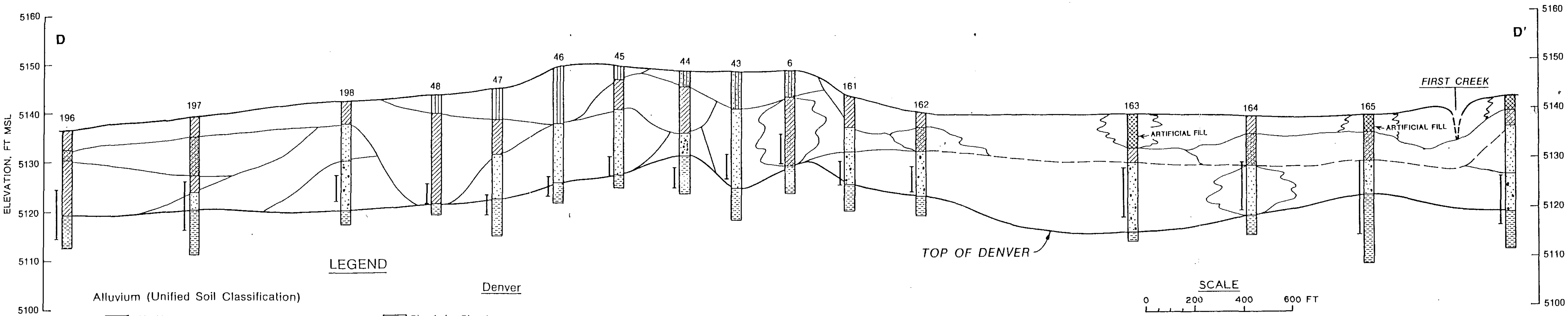

LEGEND

Alluvium (Unified Soil Classification)

- CH, Clay Flat
- CL, Clay, Silty Clay
- ML, Silt
- SC, Clayey Sand
- SM, Silty Sand
- SP, Sand
- SP-GP, Gravelly Sand

Denver

- Clayshale, Claystone
- Sandy Clayshale, Clayshale w/Sand-Silt Lenses
- Silt, Siltstone, Sandy Siltstone
- Sand, Sandstone, Silty Sandstone

SCREENED INTERVAL

DEPARTMENT OF THE ARMY
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COMMERCE CITY, COLORADO

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DRAWN BY R. C. HUNT DATE FEB 1, 1985	CROSS SECTION D-D'
REVIEWED BY B. ANDERSON DATE MAR 8, 1985	
APPROVED BY J. H. MAY DATE MAR 8, 1985	DRAWING No. PLATE G-06

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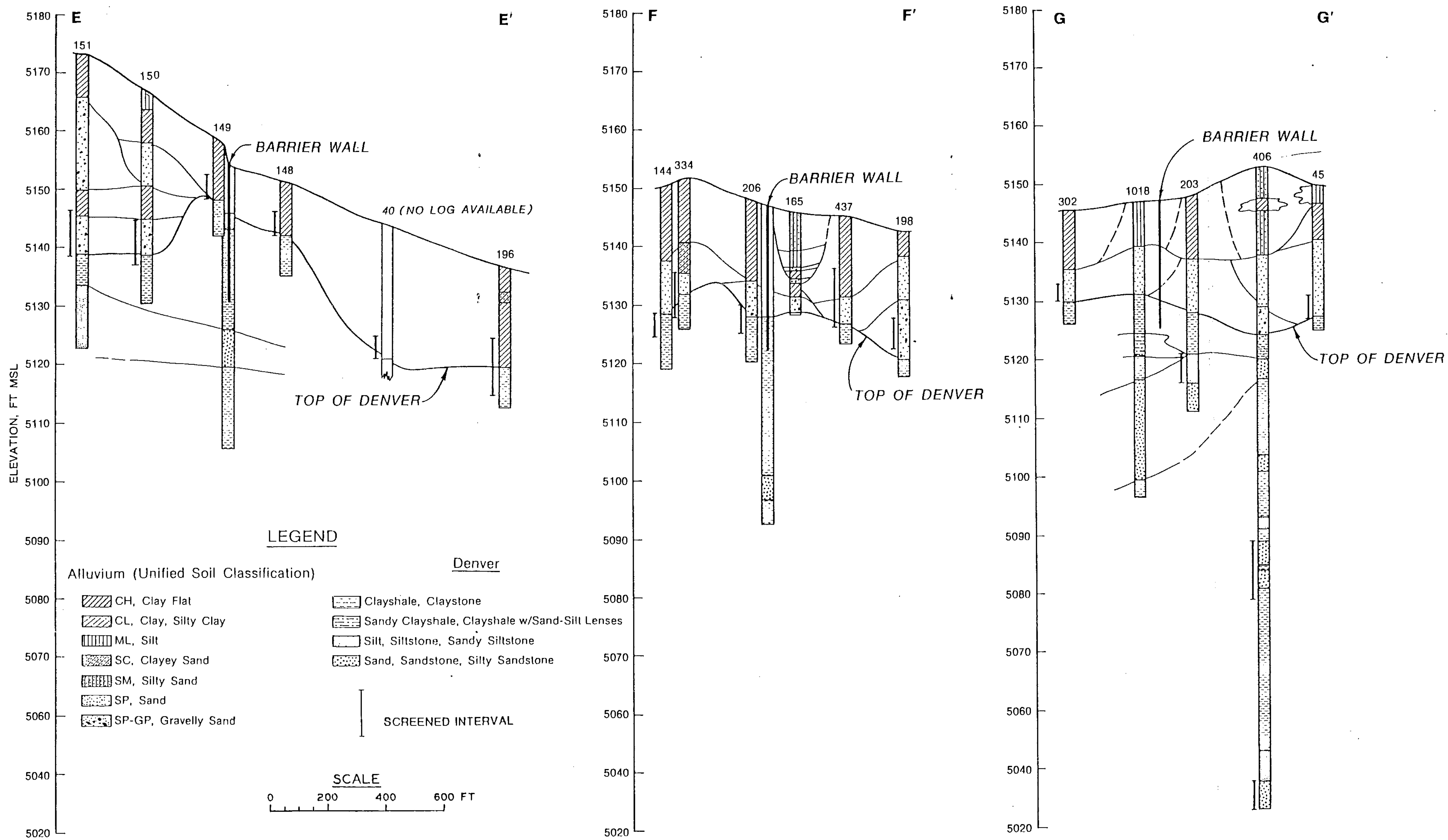

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DESIGNED BY DATE	NORTH BOUNDARY CONTAINMENT TREATMENT SYSTEM
DRAWN BY R. C. HUNT DATE FEB 1, 1985	
REVIEWED BY B. ANDERSON DATE MAR 8, 1985	CROSS SECTIONS E-E', F-F' and G-G'
APPROVED BY J. H. MAY DATE MAR 8, 1985	DRAWING No. **PLATE G-07**

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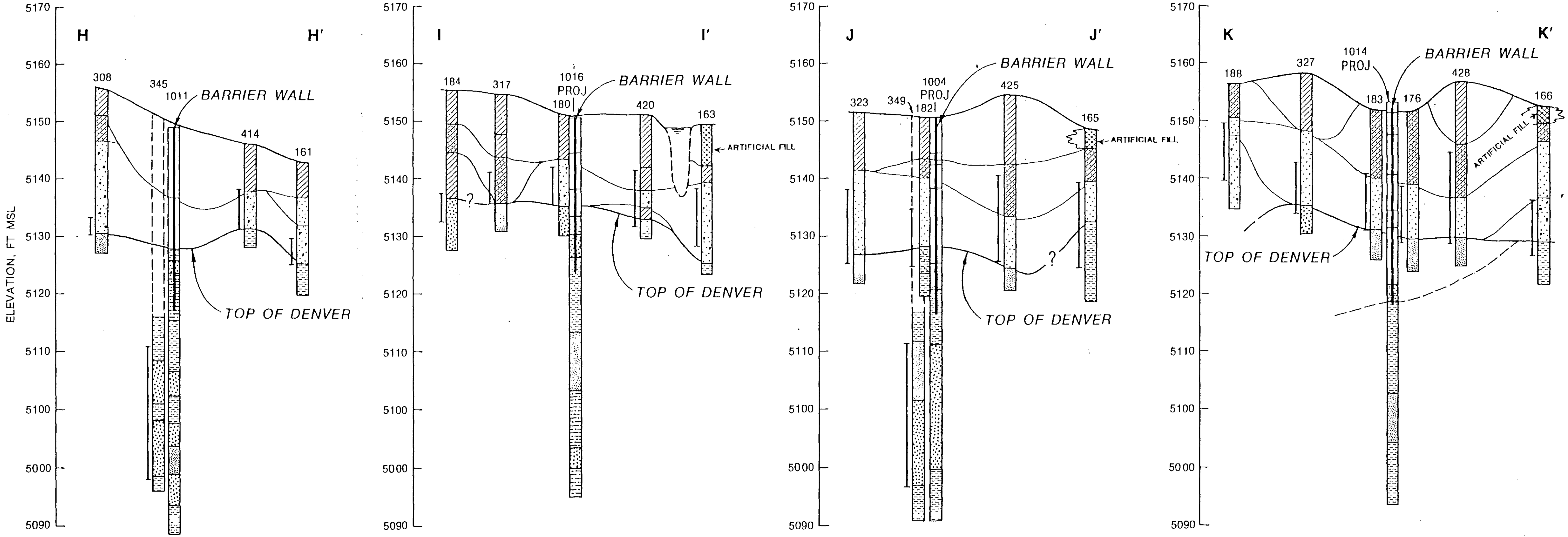

LEGEND

SCALE

0 200 400 600 FT

Alluvium (Unified Soil Classification)

- CH, Clay Flat
- CL, Clay, Silty Clay
- ML, Silt
- SC, Clayey Sand
- SM, Silty Sand
- SP, Sand
- SP-GP, Gravelly Sand

Denver

- Clayshale, Claystone
- Sandy Clayshale, Clayshale w/Sand-Silt Lenses
- Silt, Siltstone, Sandy Siltstone
- Sand, Sandstone, Silty Sandstone

SCREENED INTERVAL

DEPARTMENT OF THE ARMY ROCKY MOUNTAIN ARSENAL COMMERCE CITY, COLORADO	
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DESIGNED BY DATE DRAWN BY R. C. HUNT DATE FEB 1, 1985	NORTH BOUNDARY CONTAINMENT TREATMENT SYSTEM
REVIEWED BY B. ANDERSON DATE MAR 8, 1985	CROSS SECTIONS H-H', I-I', J-J' and K-K'
APPROVED BY J. H. MAY DATE MAR 8, 1985	DRAWING No. PLATE G-08

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North Boundary Containment System

Conformance and Performance Well Graphs

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Figure B-1
DIMP Concentrations and Water Elevations in Wells 37339, 23434, 23436 and PNEFEF DIMP Concentrations

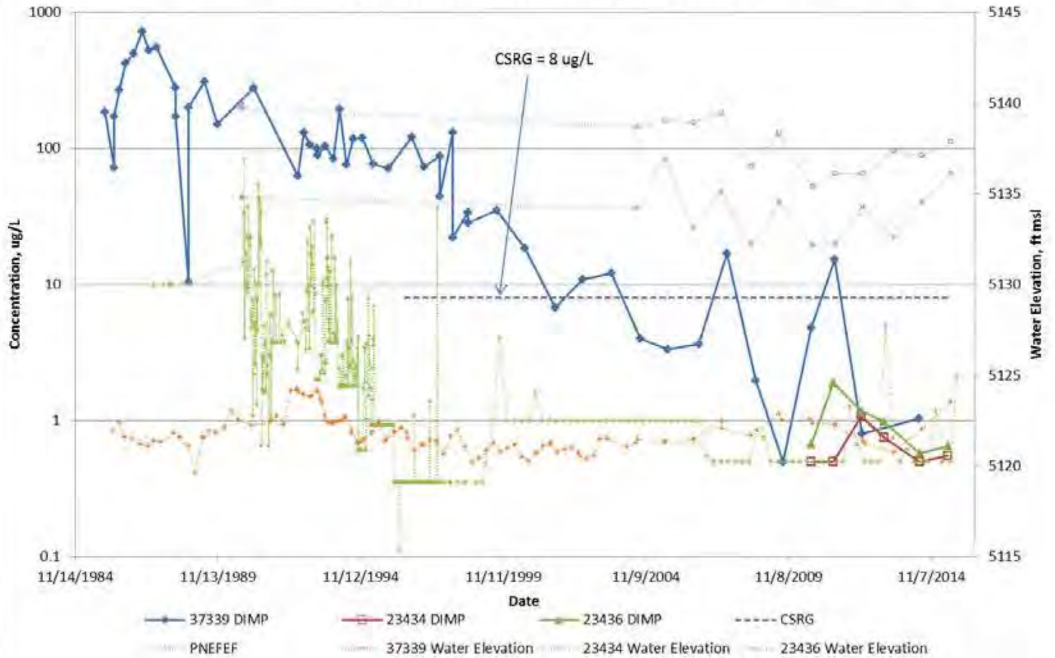
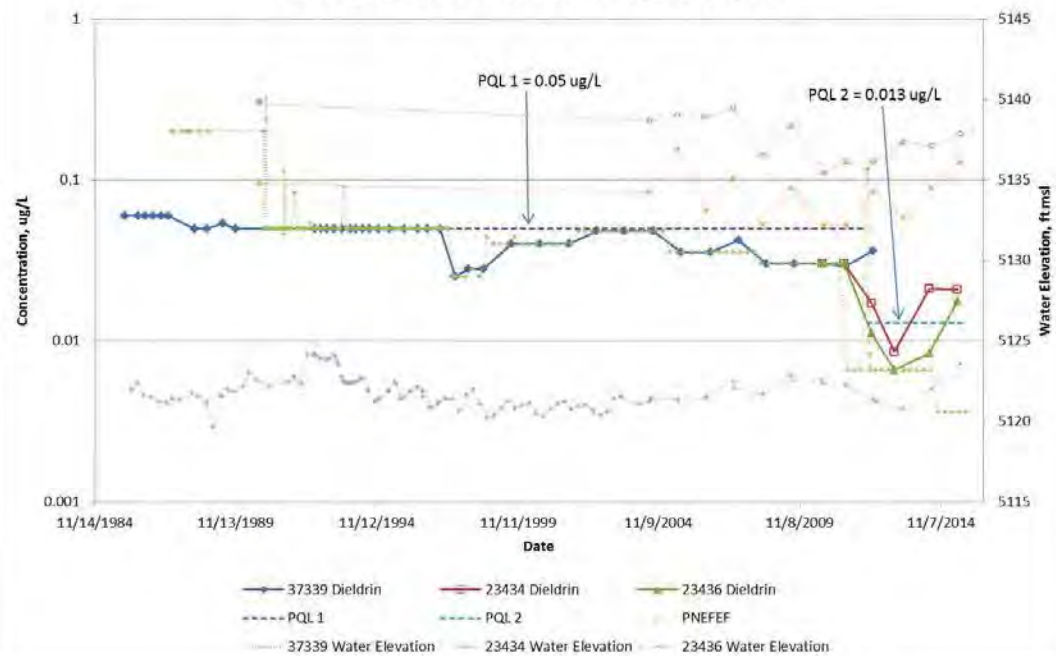


Figure B-2
Dieldrin Concentrations and Water Elevations in Wells 37339, 23434, 23436 and PNEFEF Dieldrin Concentrations



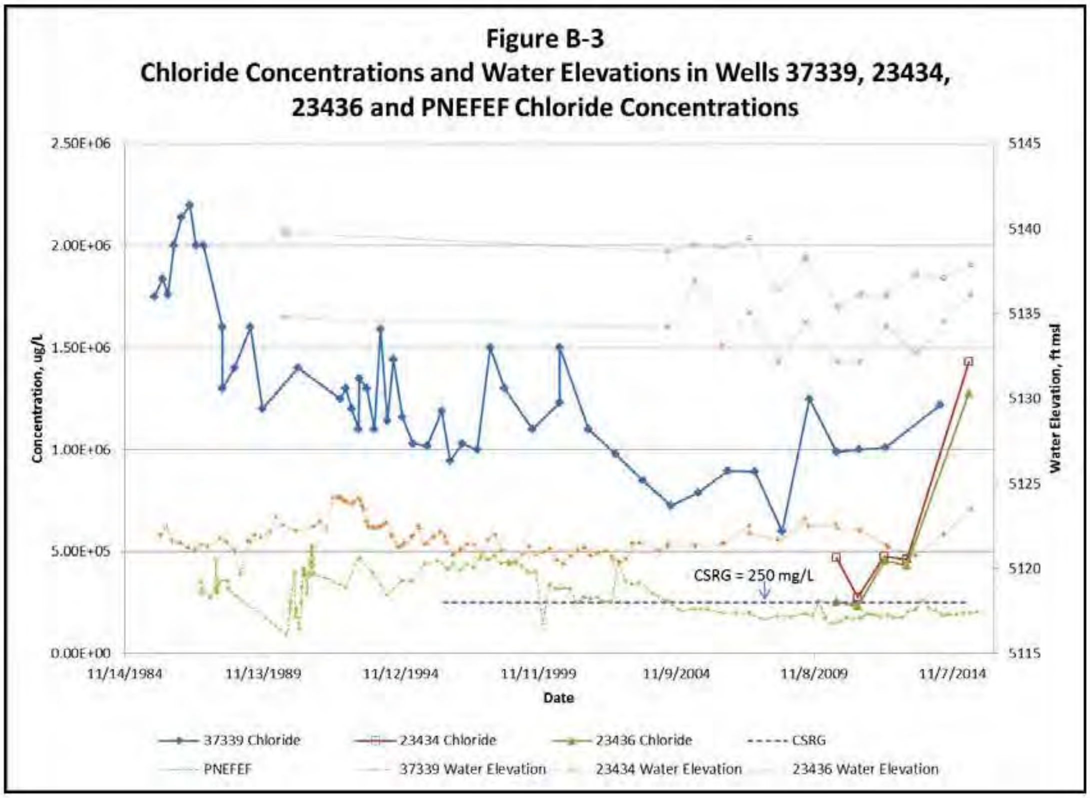


Figure B-3
Chloride Concentrations and Water Elevations in Wells 37339, 23434, 23436 and PNEFEF Chloride Concentrations
2.50E+06
2.00E+06
1.50E+06
1.00E+06
5.00E+05
0.00E+00
Concentration, ug/L
5145
5140
5135
5130
5125
5120
5115
Water Elevation, ft msl
11/14/1984
11/13/1989
11/12/1994
11/11/1999
11/9/2004
11/8/2009
11/7/2014
Date
CSRG = 250 mg/L
37339 Chloride
23434 Chloride
23436 Chloride
CSRG
PNEFEF
37339 Water Elevation
23434 Water Elevation
23436 Water Elevation

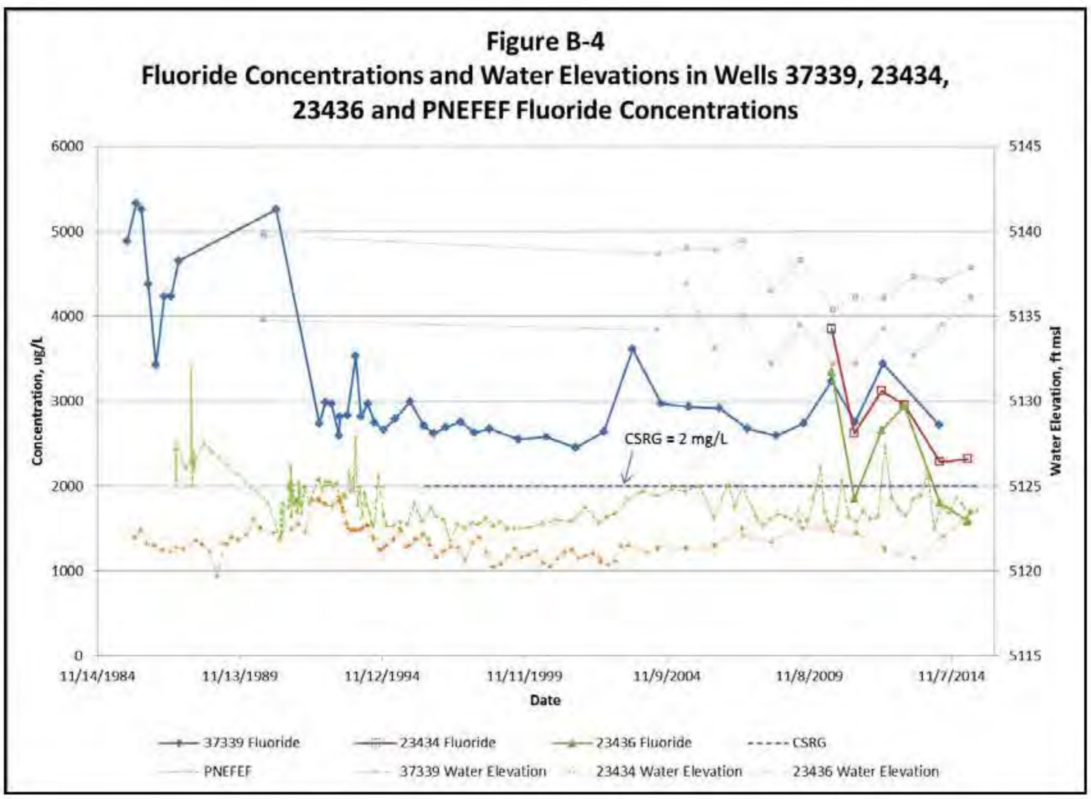


Figure B-4
Fluoride Concentrations and Water Elevations in Wells 37339, 23434, 23436 and PNEFEF Fluoride Concentrations
6000
5000
4000
3000
2000
1000
0
Concentration, ug/L
5145
5140
5135
5130
5125
5120
5115
Water Elevation, ft msl
11/14/1984
11/13/1989
11/12/1994
11/11/1999
11/9/2004
11/8/2009
11/7/2014
Date
CSRG = 2 mg/L
37339 Fluoride
23434 Fluoride
23436 Fluoride
CSRG
PNEFEF
37339 Water Elevation
23434 Water Elevation
23436 Water Elevation

Figure B-5
Sulfate Concentrations and Water Elevations in Wells 37339, 23434, 23436 and PNEFEF Sulfate Concentrations

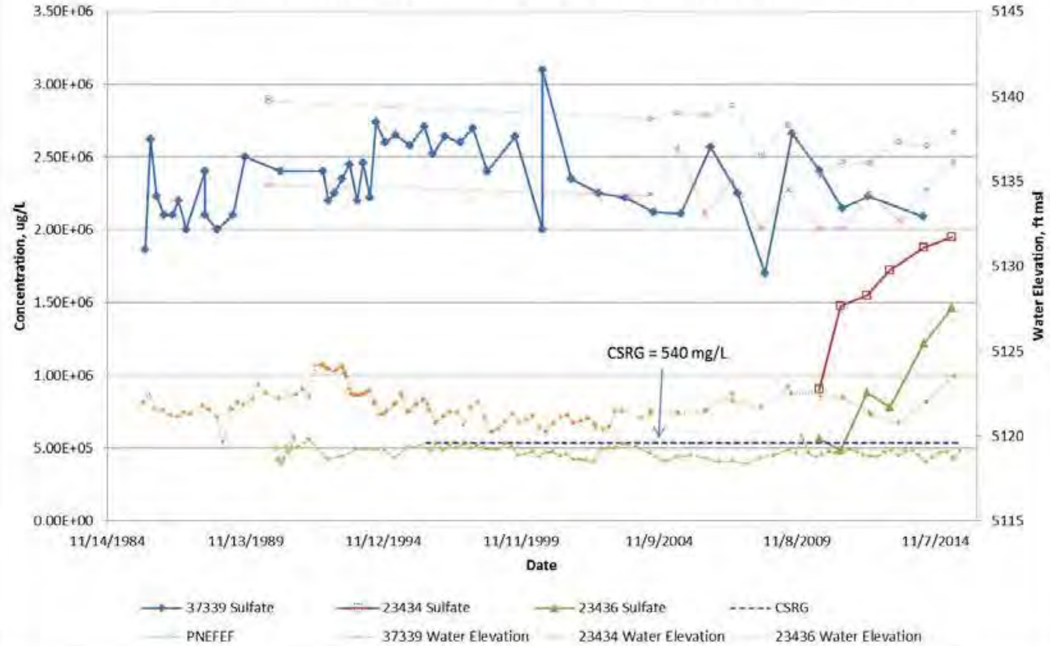
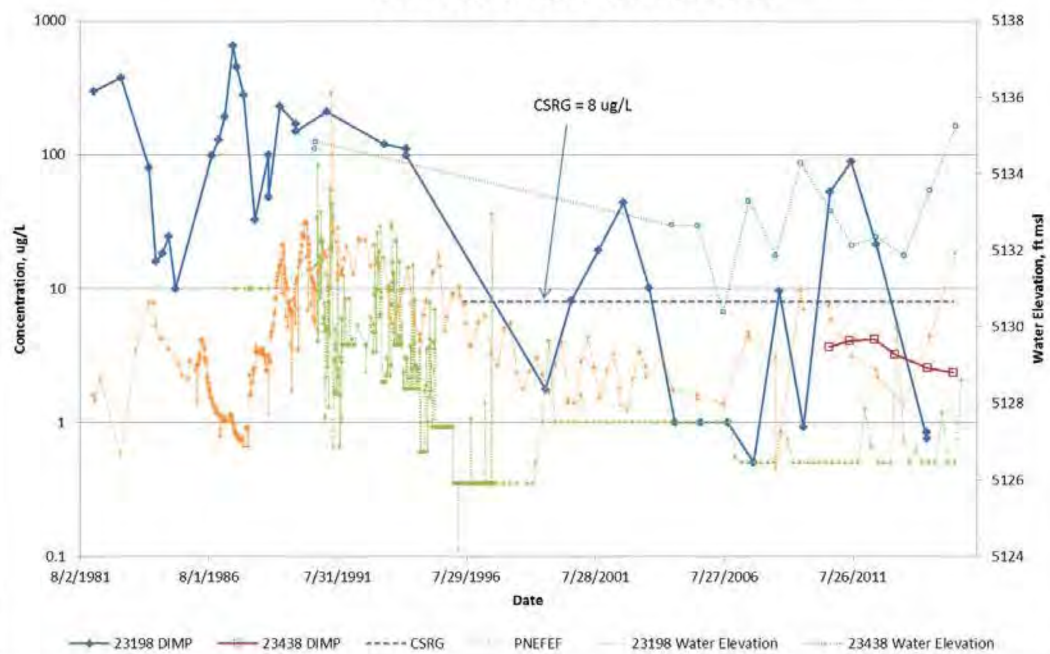


Figure B-6
DIMP Concentrations and Water Elevations in Wells 23198 and 23438, and PNEFEF DIMP Concentrations



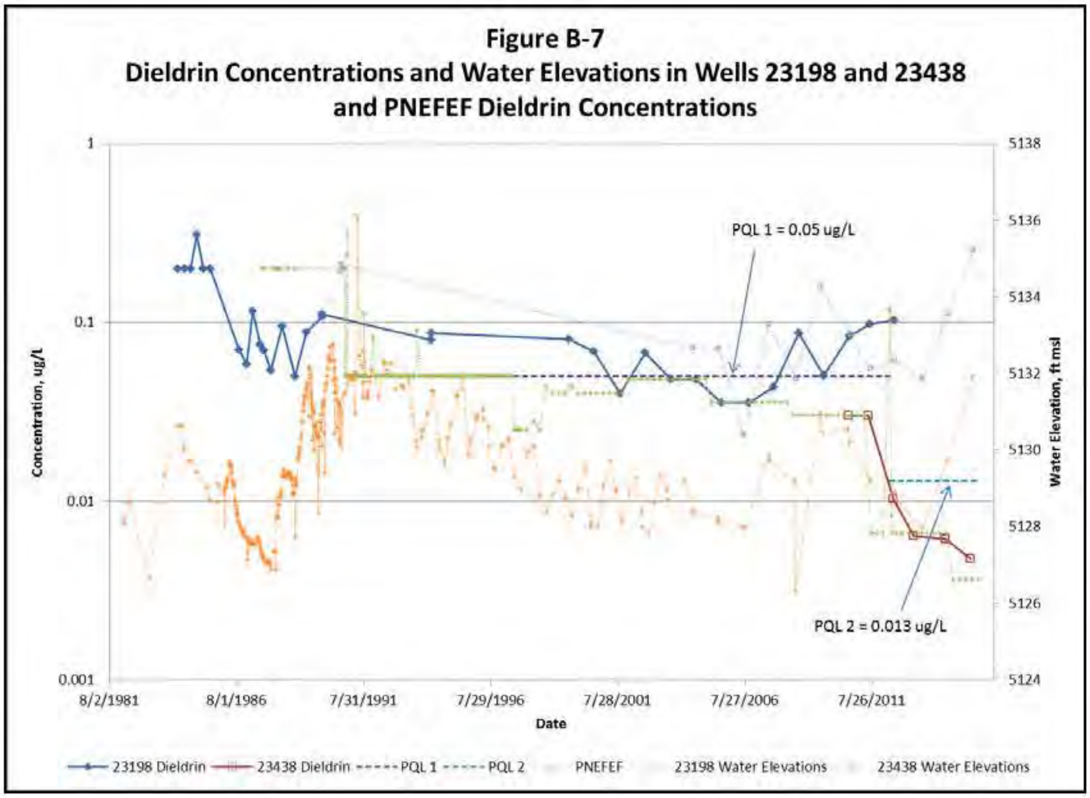


Figure B-7
Dieldrin Concentrations and Water Elevations in Wells 23198 and 23438
and PNEFEF Dieldrin Concentrations
PQL 1 = 0.05 ug/L
PQL 2 = 0.013 ug/L
Concentration, ug/L
Water Elevation, ft msl
Date
8/2/1981
8/1/1986
7/31/1991
7/29/1996
7/28/2001
7/27/2006
7/26/2011
23198 Dieldrin
23438 Dieldrin
PQL 1
PQL 2
PNEFEF
23198 Water Elevations
23438 Water Elevations

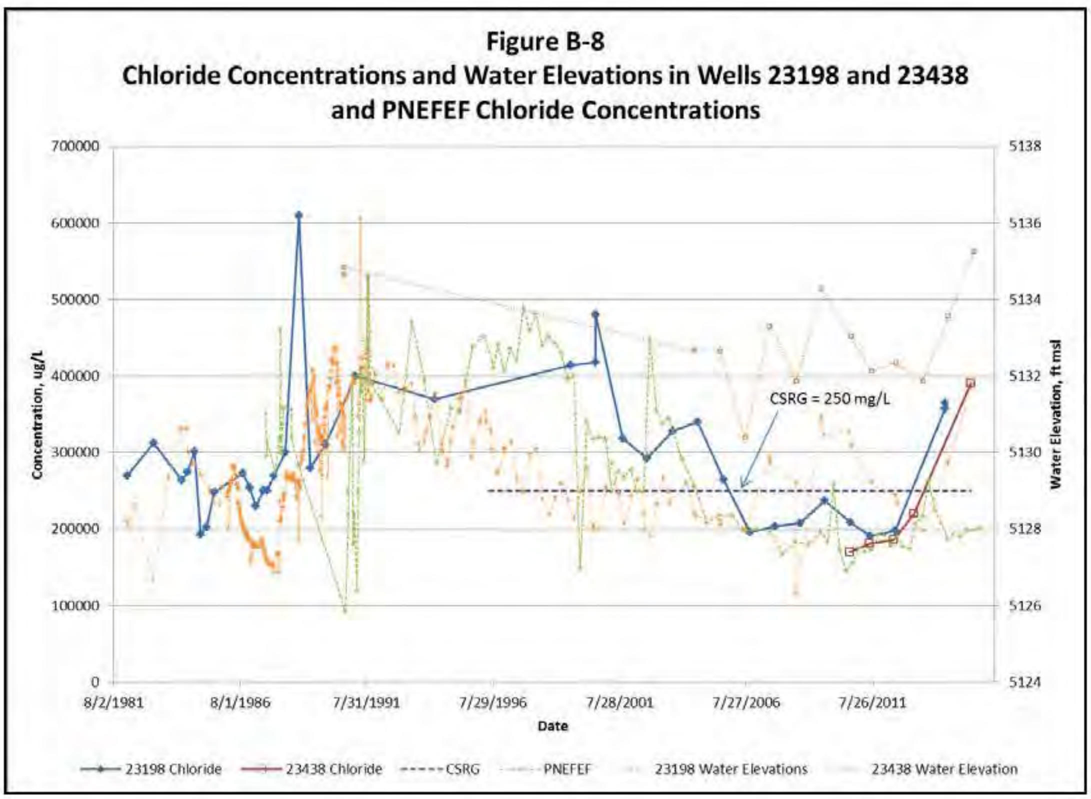


Figure B-8
Chloride Concentrations and Water Elevations in Wells 23198 and 23438
and PNEFEF Chloride Concentrations
CSRG = 250 mg/L
Concentration, ug/L
Water Elevation, ft msl
Date
8/2/1981
8/1/1986
7/31/1991
7/29/1996
7/28/2001
7/27/2006
7/26/2011
23198 Chloride
23438 Chloride
CSRG
PNEFEF
23198 Water Elevations
23438 Water Elevation

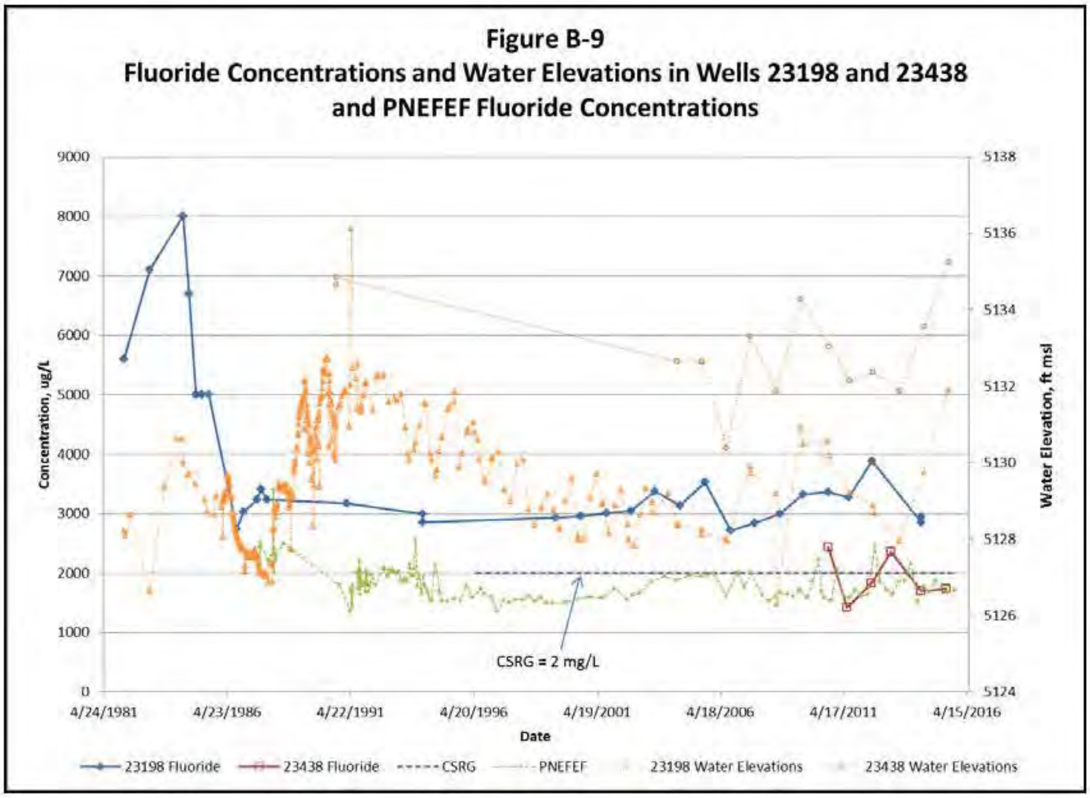


Figure B-9
Fluoride Concentrations and Water Elevations in Wells 23198 and 23438
and PNEFEF Fluoride Concentrations
Concentration, ug/L
Water Elevation, ft msl
CSRG = 2 mg/L
Date
23198 Fluoride
23438 Fluoride
CSRG
PNEFEF
23198 Water Elevations
23438 Water Elevations

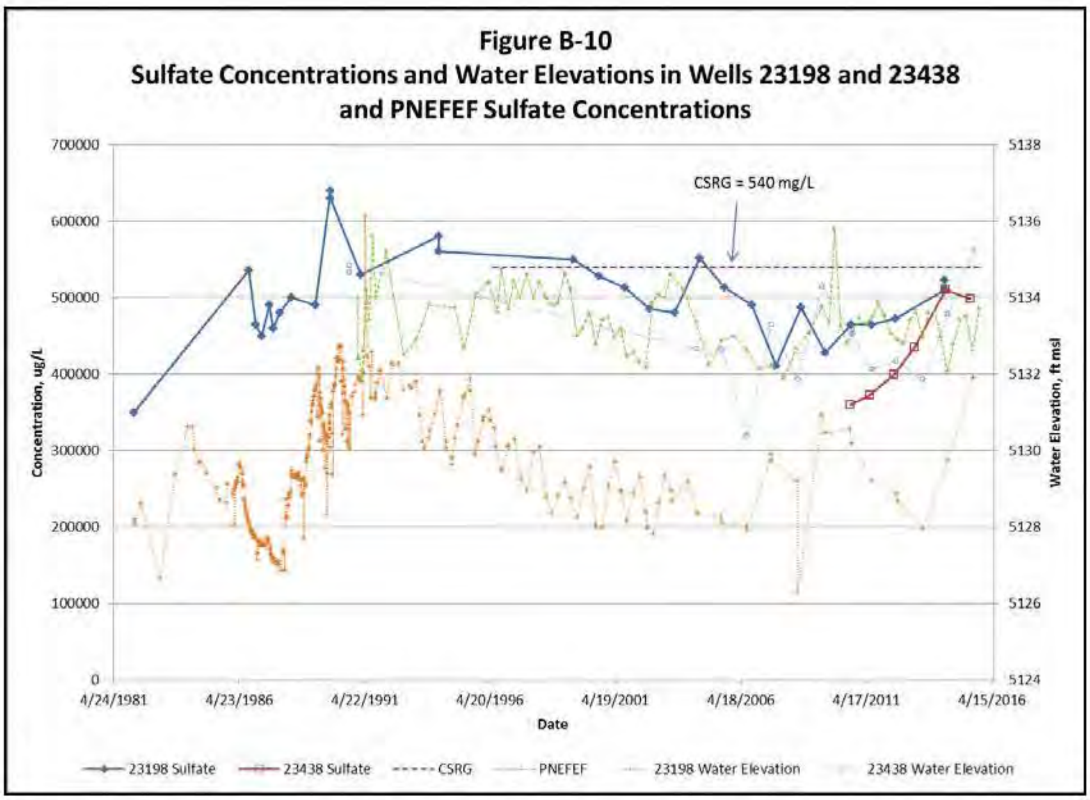


Figure B-10
Sulfate Concentrations and Water Elevations in Wells 23198 and 23438
and PNEFEF Sulfate Concentrations
Concentration, ug/L
Water Elevation, ft msl
CSRG = 540 mg/L
Date
23198 Sulfate
23438 Sulfate
CSRG
PNEFEF
23198 Water Elevation
23438 Water Elevation

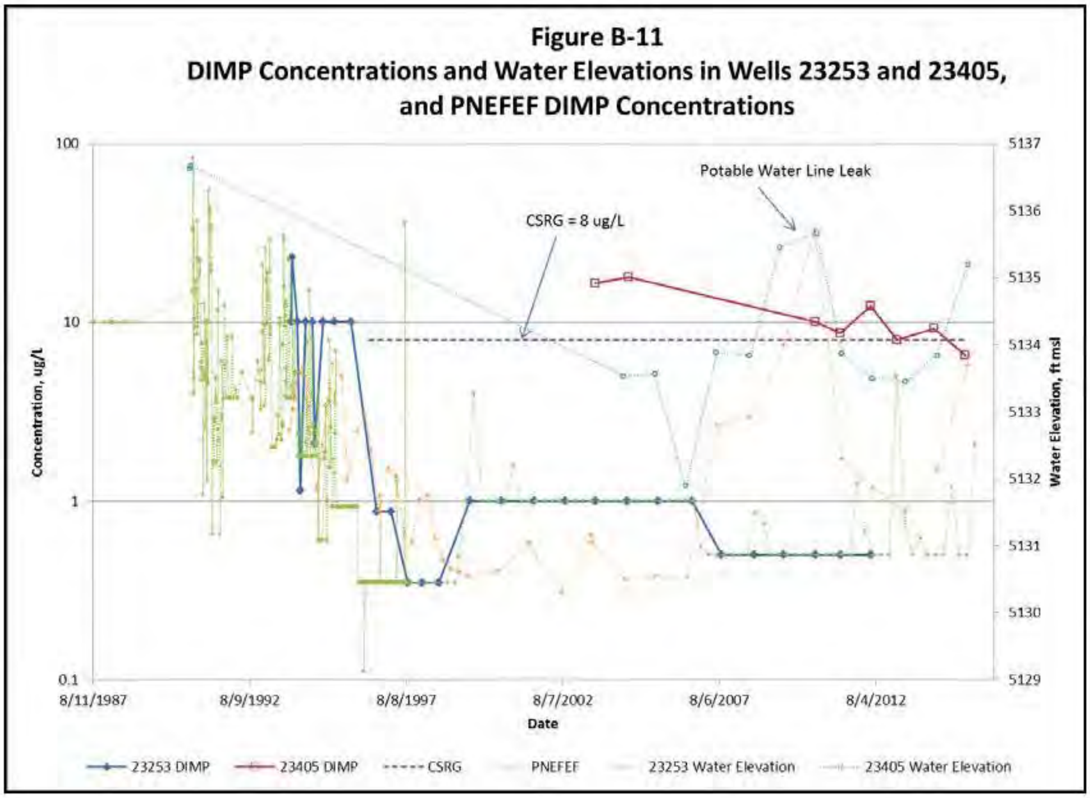


Figure B-11
DIMP Concentrations and Water Elevations in Wells 23253 and 23405, and PNEFEF DIMP Concentrations
Potable Water Line Leak
CSRG = 8 ug/L
Concentration, ug/L
Water Elevation, ft msl
Date
23253 DIMP
23405 DIMP
CSRG
PNEFEF
23253 Water Elevation
23405 Water Elevation

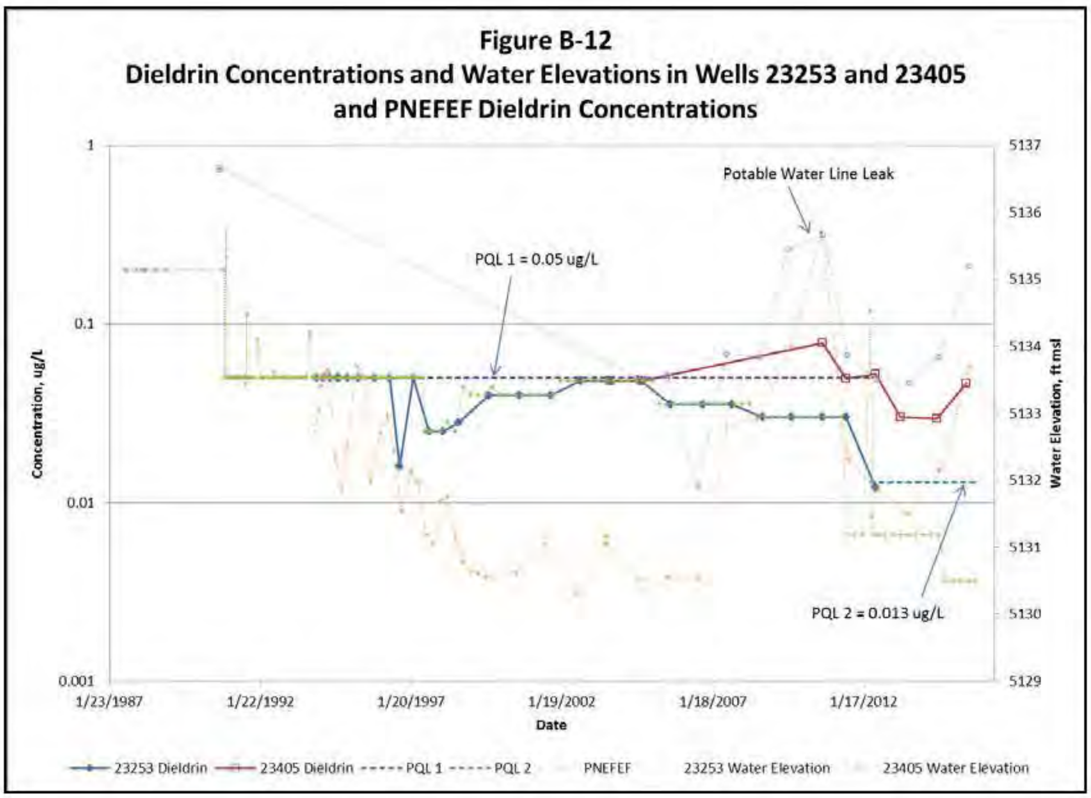


Figure B-12
Dieldrin Concentrations and Water Elevations in Wells 23253 and 23405 and PNEFEF Dieldrin Concentrations
Potable Water Line Leak
PQL 1 = 0.05 ug/L
PQL 2 = 0.013 ug/L
Concentration, ug/L
Water Elevation, ft msl
Date
23253 Dieldrin
23405 Dieldrin
PQL 1
PQL 2
PNEFEF
23253 Water Elevation
23405 Water Elevation

Figure B-13
Chloride Concentrations and Water Elevations in Wells 23253 and 23405 and PNEFEF Chloride Concentrations

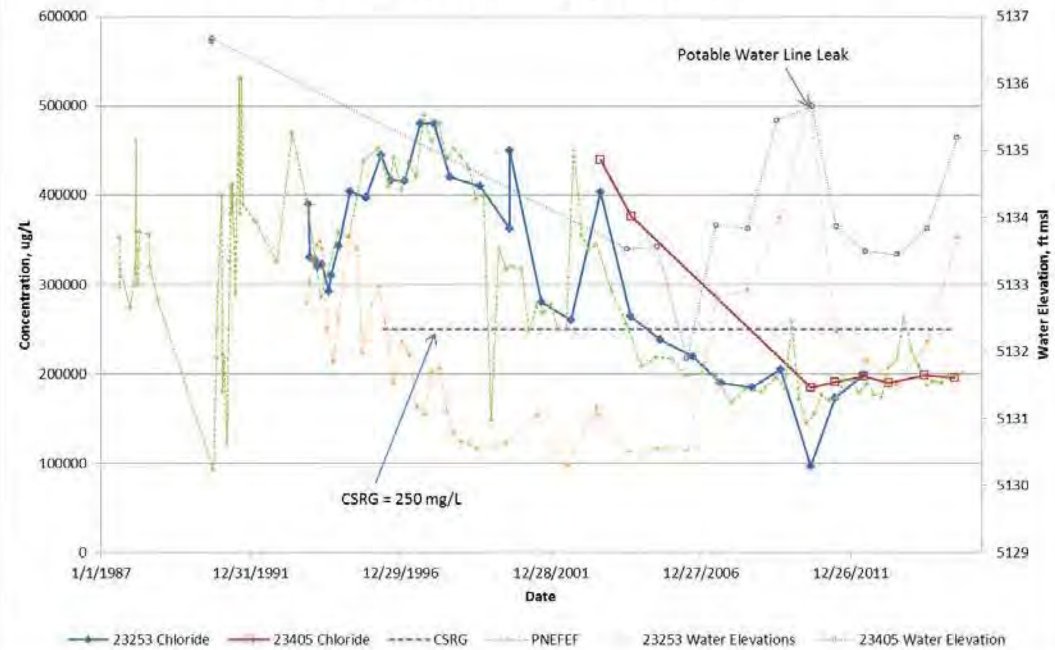
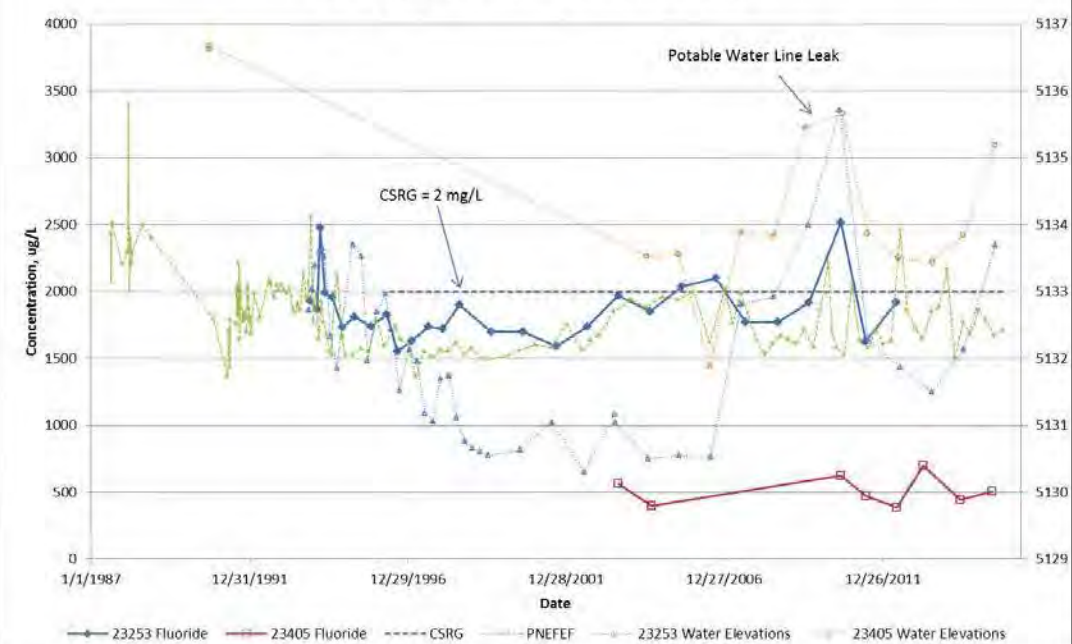


Figure B-14
Fluoride Concentrations and Water Elevations in Wells 23253 and 23405 and PNEFEF Fluoride Concentrations



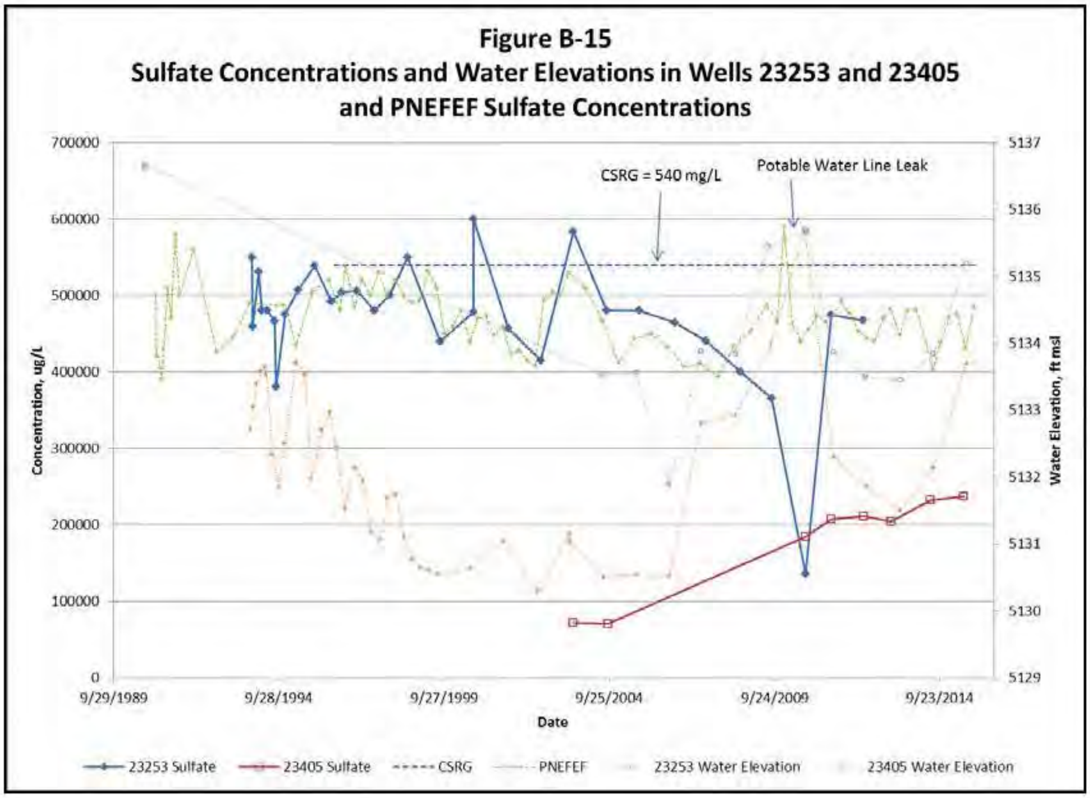


Figure B-15
Sulfate Concentrations and Water Elevations in Wells 23253 and 23405 and PNEFEF Sulfate Concentrations
CSRG = 540 mg/L
Potable Water Line Leak
Concentration, ug/L
Water Elevation, ft msl
Date
23253 Sulfate
23405 Sulfate
CSRG
PNEFEF
23253 Water Elevation
23405 Water Elevation

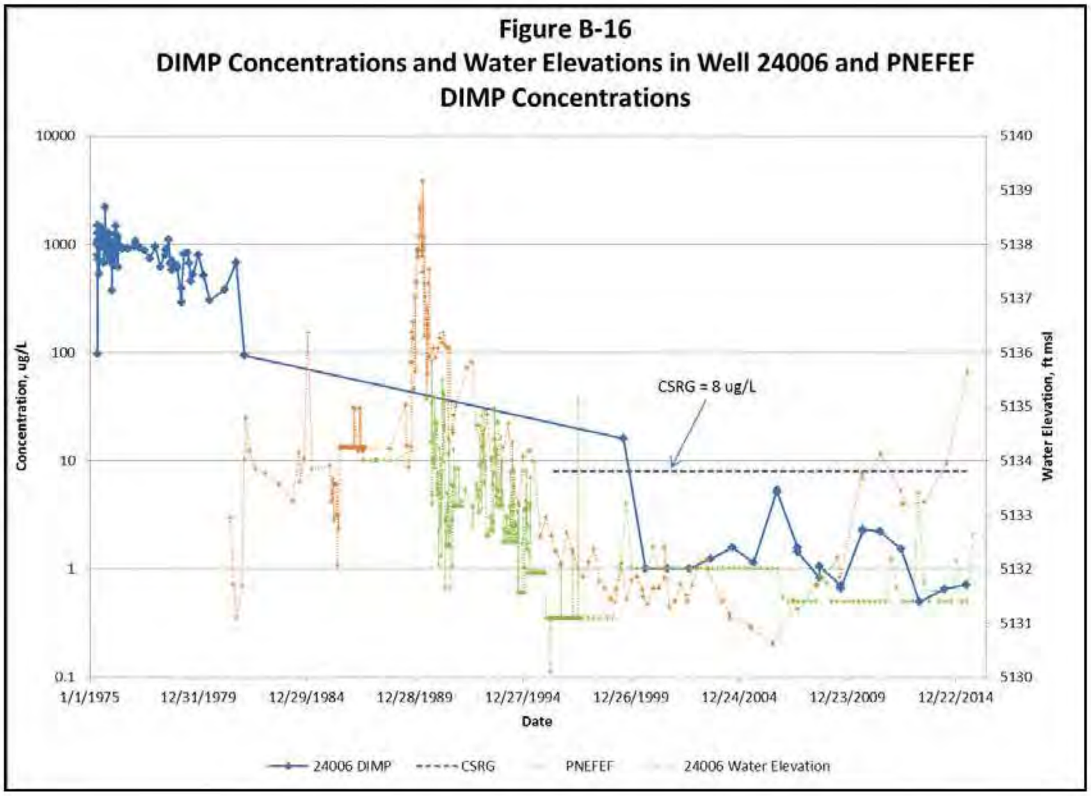


Figure B-16
DIMP Concentrations and Water Elevations in Well 24006 and PNEFEF DIMP Concentrations
CSRG = 8 ug/L
Concentration, ug/L
Water Elevation, ft msl
Date
24006 DIMP
CSRG
PNEFEF
24006 Water Elevation

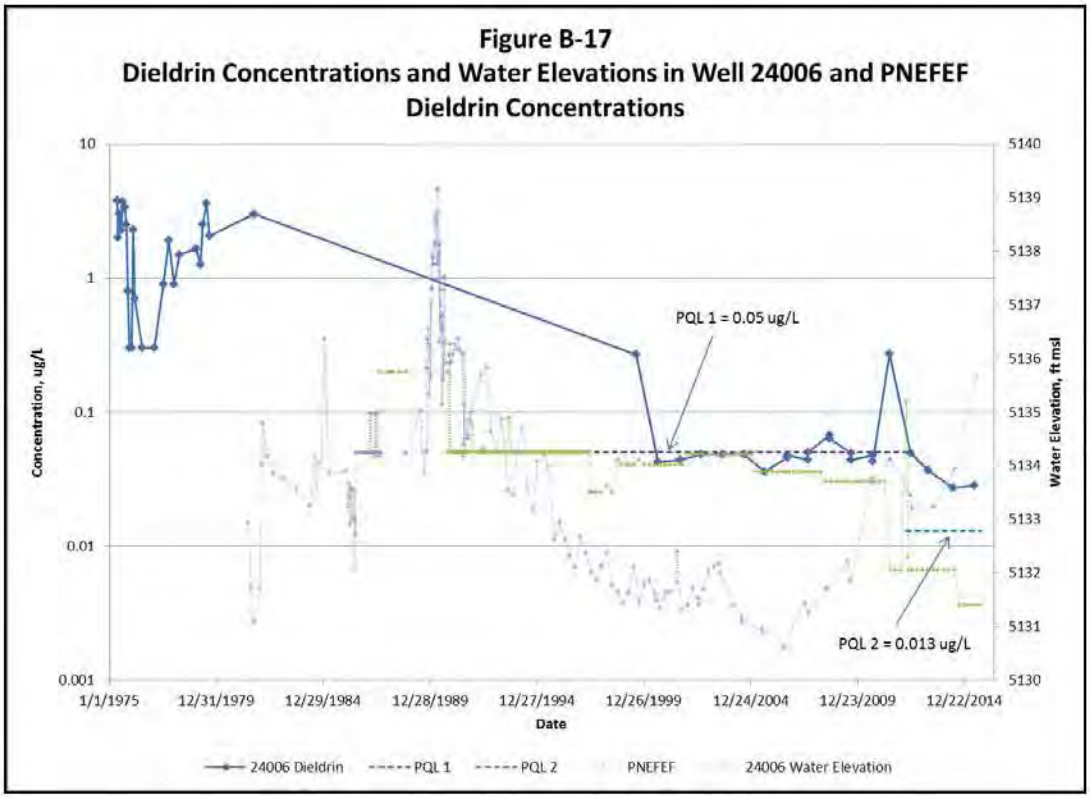


Figure B-17
Dieldrin Concentrations and Water Elevations in Well 24006 and PNEFEF
Dieldrin Concentrations
Concentration, ug/L
Water Elevation, ft msl
PQL 1 = 0.05 ug/L
PQL 2 = 0.013 ug/L
Date
24006 Dieldrin
PQL 1
PQL 2
PNEFEF
24006 Water Elevation

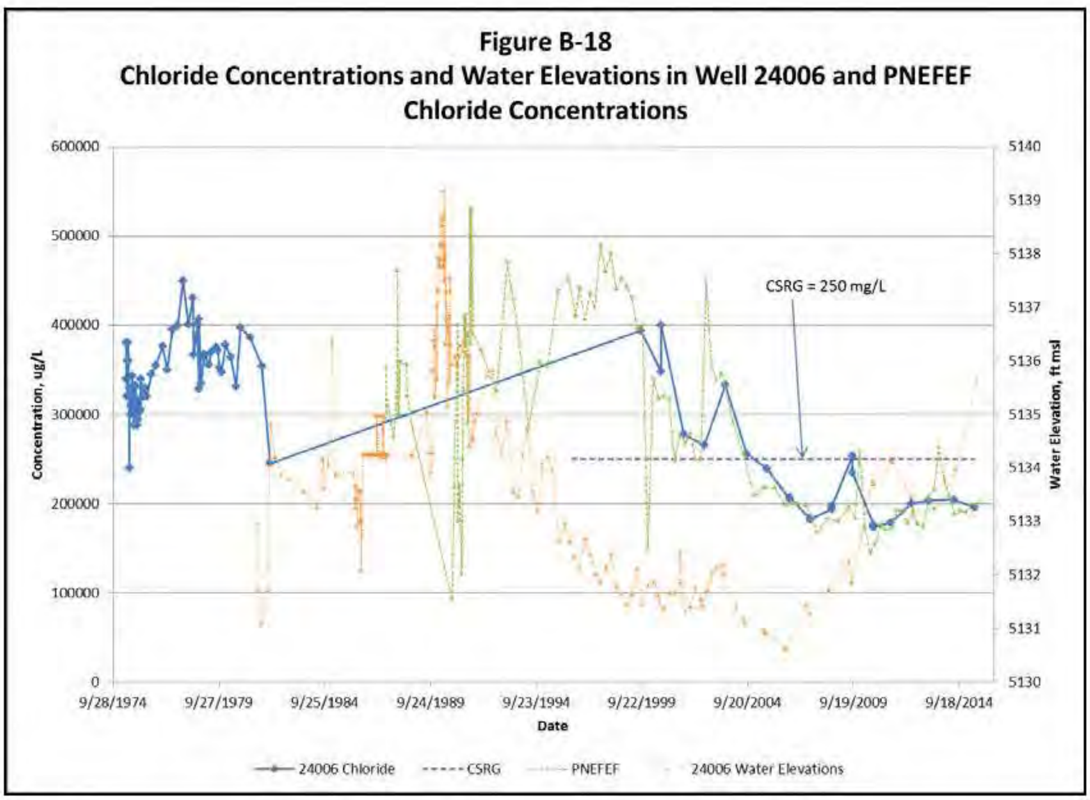


Figure B-18
Chloride Concentrations and Water Elevations in Well 24006 and PNEFEF
Chloride Concentrations
Concentration, ug/L
Water Elevation, ft msl
CSRG = 250 mg/L
Date
24006 Chloride
CSRG
PNEFEF
24006 Water Elevations

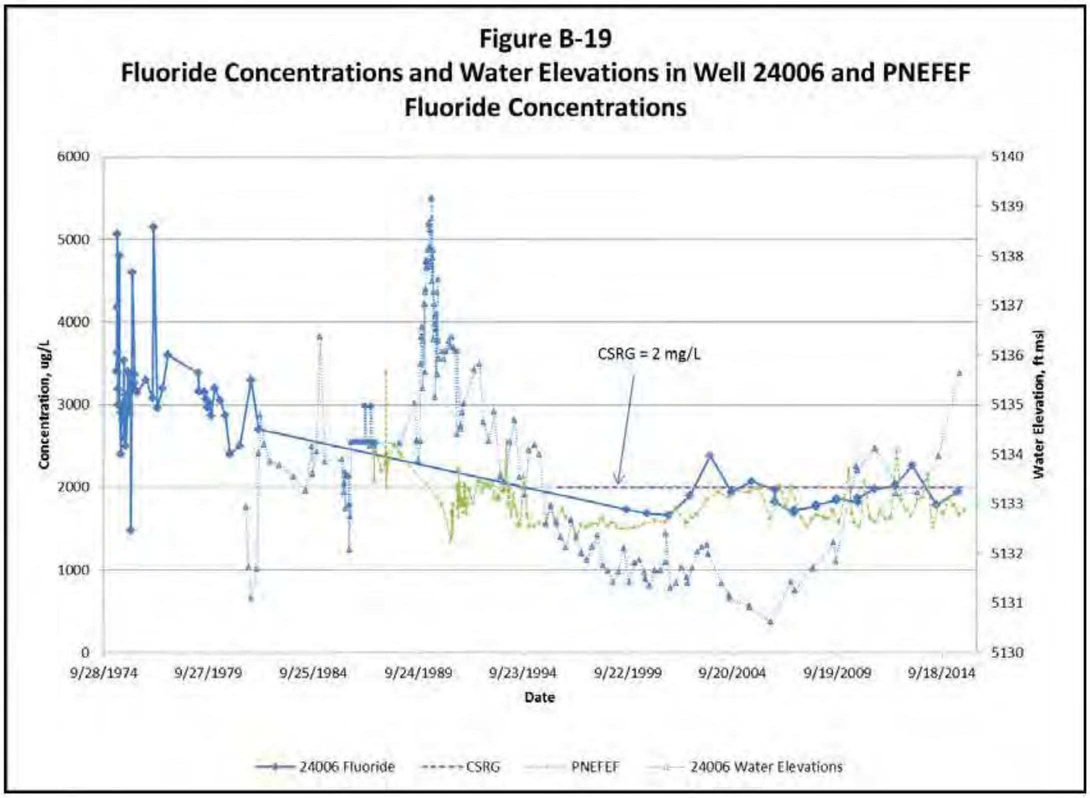


Figure B-19
Fluoride Concentrations and Water Elevations in Well 24006 and PNEFEF
Fluoride Concentrations
Concentration, ug/L
Water Elevation, ft msl
CSRG = 2 mg/L
Date
24006 Fluoride
CSRG
PNEFEF
24006 Water Elevations

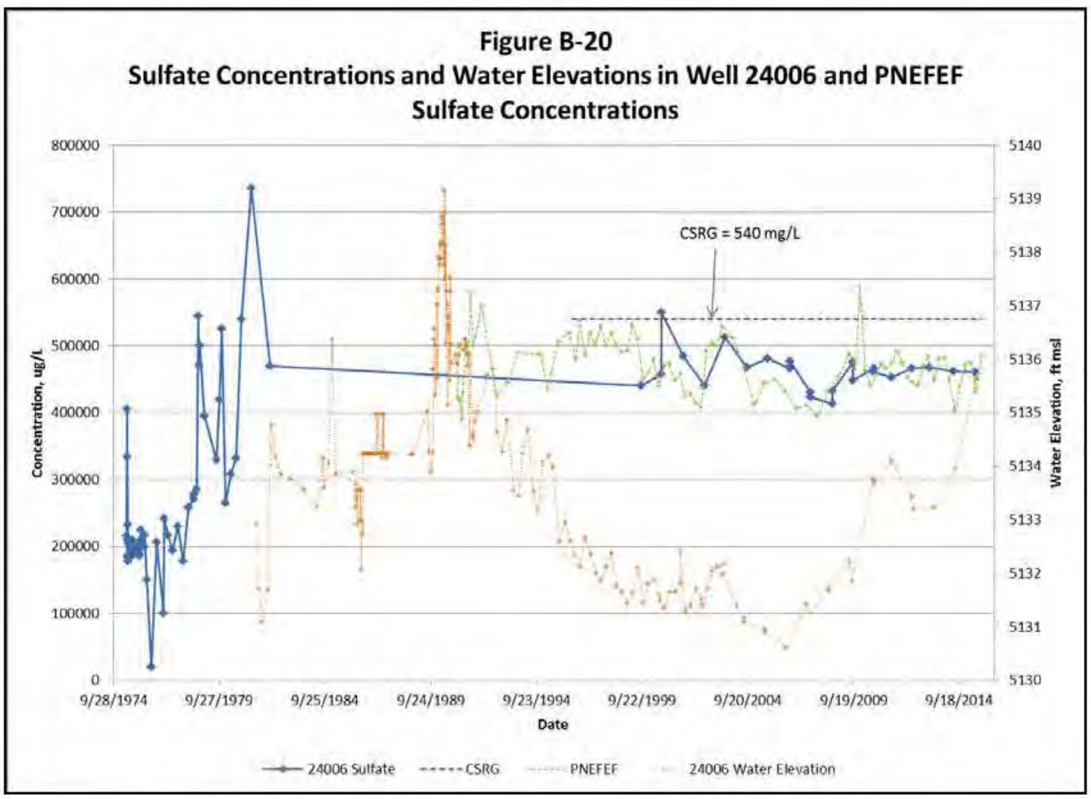


Figure B-20
Sulfate Concentrations and Water Elevations in Well 24006 and PNEFEF
Sulfate Concentrations
Concentration, ug/L
Water Elevation, ft msl
CSRG = 540 mg/L
Date
24006 Sulfate
CSRG
PNEFEF
24006 Water Elevation

Figure B-21
DIMP Concentrations and Water Elevations in Wells 24162 and 24415, and PNEFEF DIMP Concentrations

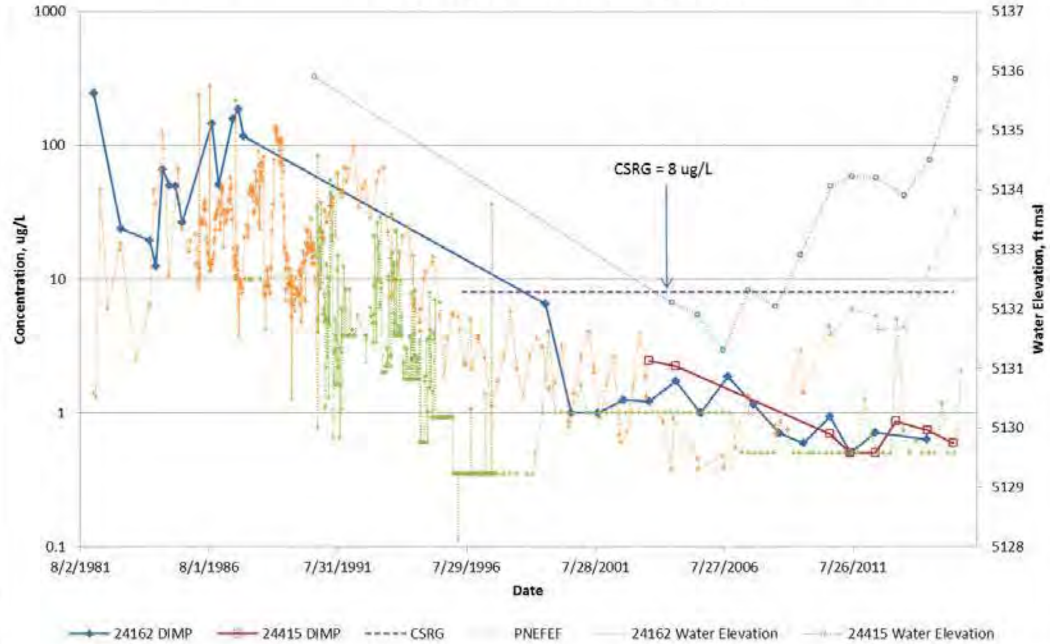
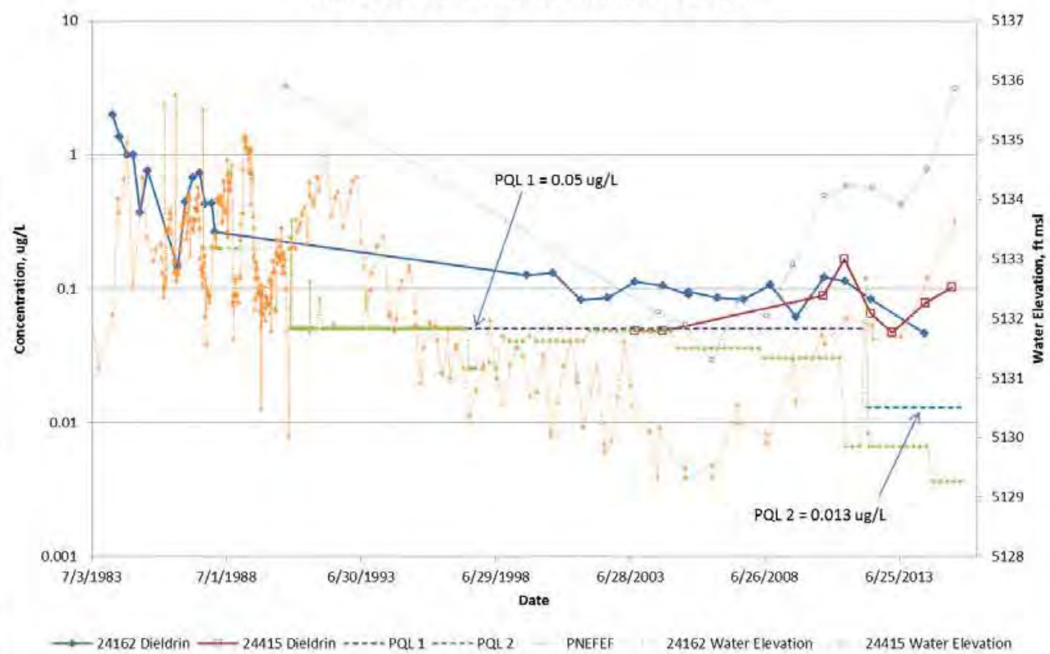


Figure B-22
Dieldrin Concentrations and Water Elevations in Wells 24162 and 24415 and PNEFEF Dieldrin Concentrations



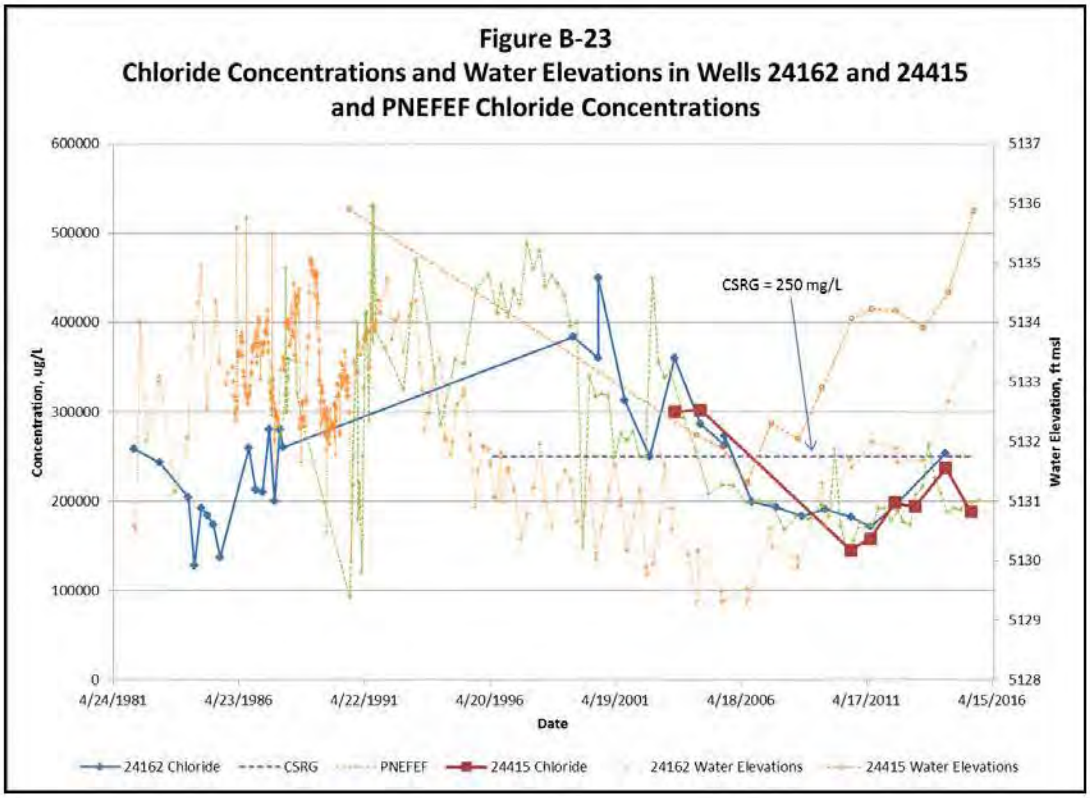


Figure B-23
Chloride Concentrations and Water Elevations in Wells 24162 and 24415 and PNEFEF Chloride Concentrations
600000
500000
400000
300000
200000
100000
0
Concentration, ug/L
5137
5136
5135
5134
5133
5132
5131
5130
5129
5128
Water Elevation, ft msl
CSRG = 250 mg/L
4/24/1981
4/23/1986
4/22/1991
4/20/1996
4/19/2001
4/18/2006
4/17/2011
4/15/2016
Date
24162 Chloride
CSRG
PNEFEF
24415 Chloride
24162 Water Elevations
24415 Water Elevations

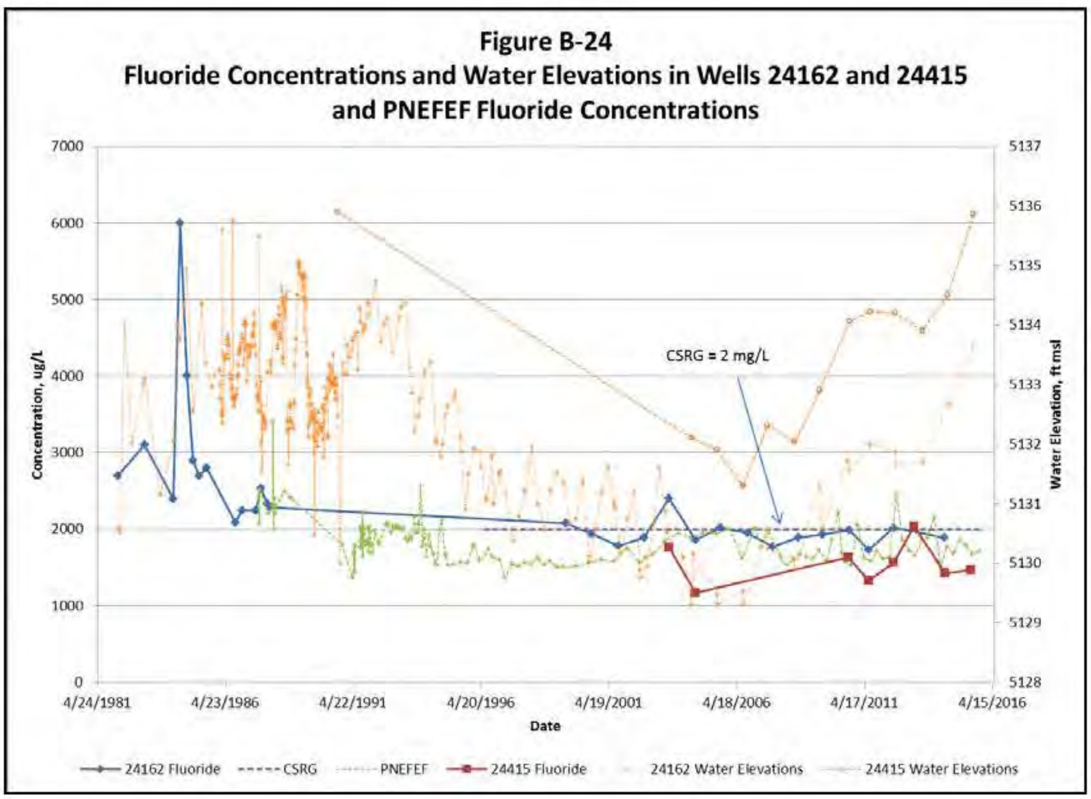


Figure B-24
Fluoride Concentrations and Water Elevations in Wells 24162 and 24415 and PNEFEF Fluoride Concentrations
7000
6000
5000
4000
3000
2000
1000
0
Concentration, ug/L
5137
5136
5135
5134
5133
5132
5131
5130
5129
5128
Water Elevation, ft msl
CSRG = 2 mg/L
4/24/1981
4/23/1986
4/22/1991
4/20/1996
4/19/2001
4/18/2006
4/17/2011
4/15/2016
Date
24162 Fluoride
CSRG
PNEFEF
24415 Fluoride
24162 Water Elevations
24415 Water Elevations

Figure B-25
Sulfate Concentrations and Water Elevations in Wells 24162 and 24415 and PNEFEF Sulfate Concentrations

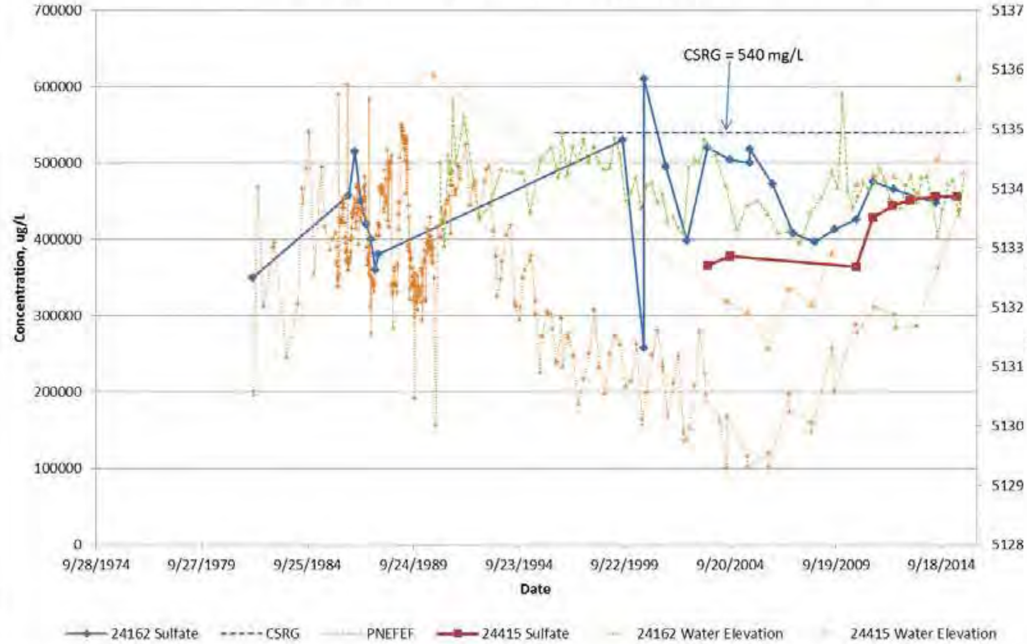
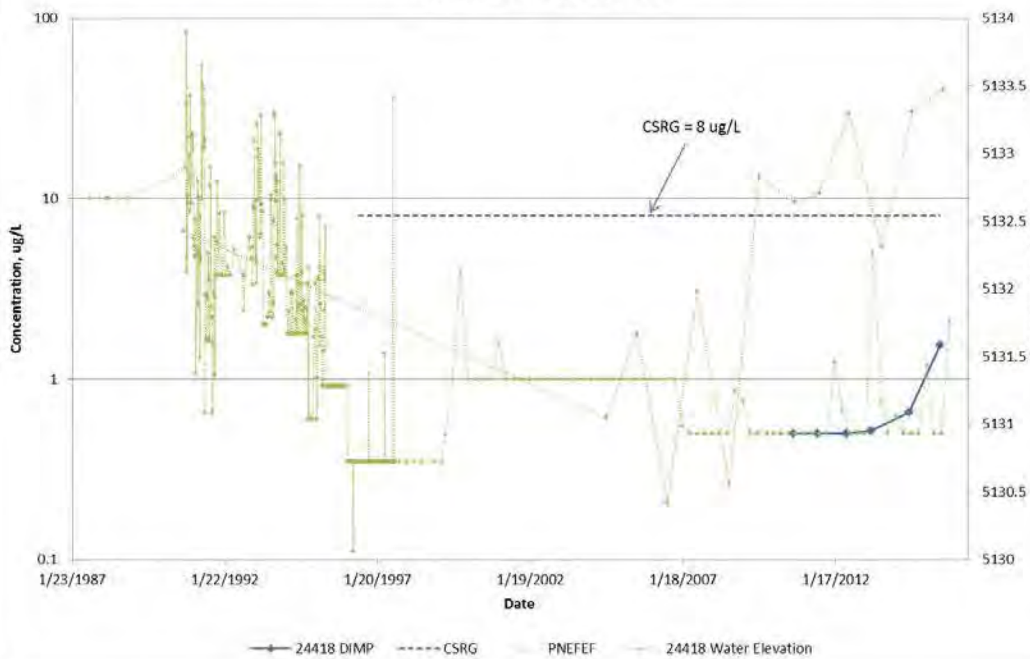


Figure B-26
DIMP Concentrations and Water Elevations in Well 24418 and PNEFEF DIMP Concentrations



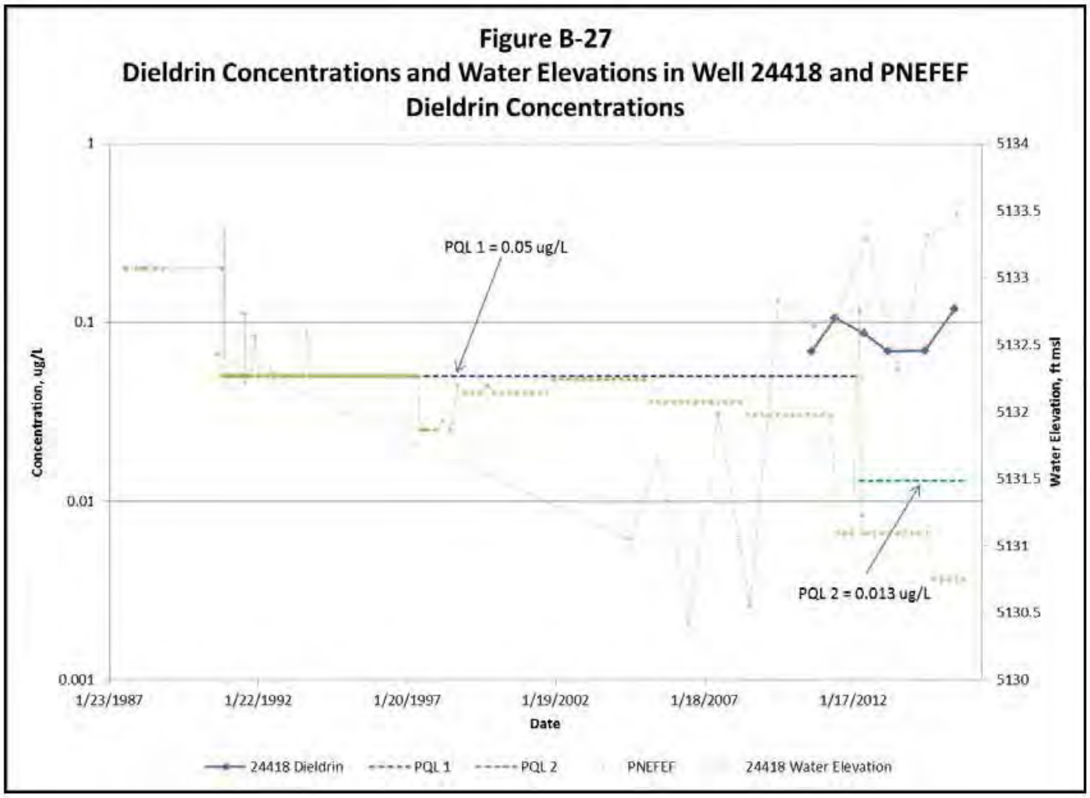


Figure B-27
Dieldrin Concentrations and Water Elevations in Well 24418 and PNEFEF
Dieldrin Concentrations
PQL 1 = 0.05 ug/L
PQL 2 = 0.013 ug/L
Concentration, ug/L
Water Elevation, ft msl
Date
1/23/1987
1/22/1992
1/20/1997
1/19/2002
1/18/2007
1/17/2012
24418 Dieldrin
PQL 1
PQL 2
PNEFEF
24418 Water Elevation

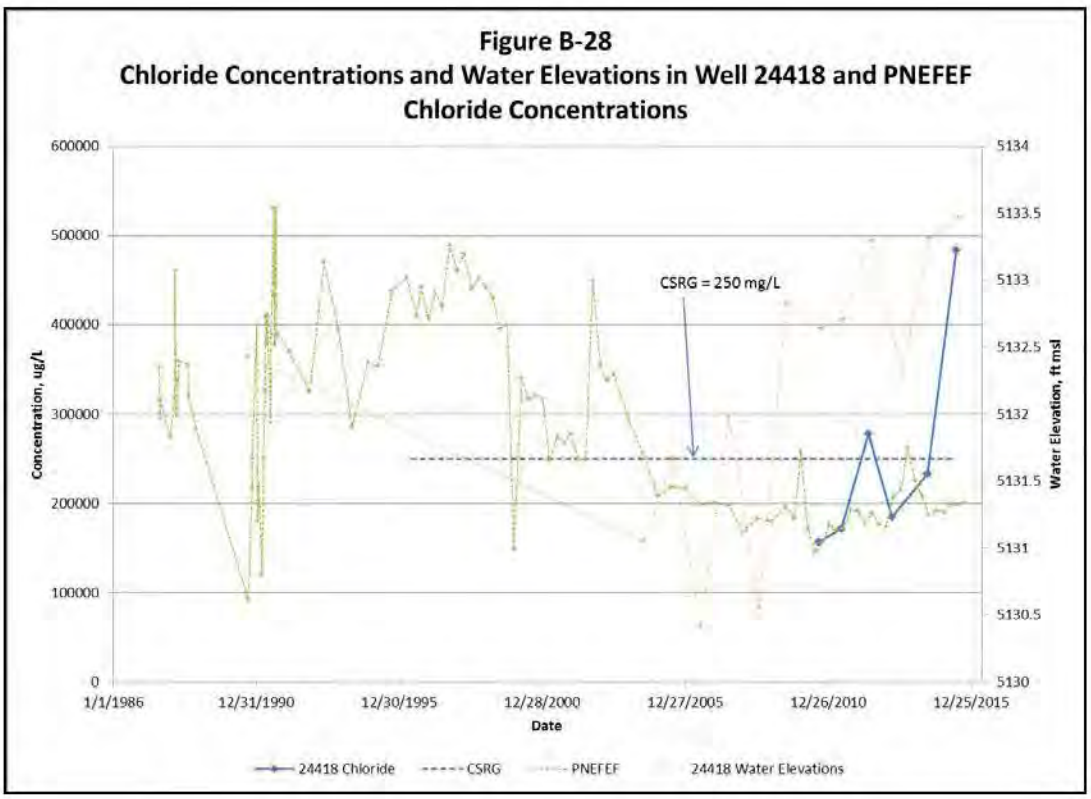


Figure B-28
Chloride Concentrations and Water Elevations in Well 24418 and PNEFEF
Chloride Concentrations
CSRG = 250 mg/L
Concentration, ug/L
Water Elevation, ft msl
Date
1/1/1986
12/31/1990
12/30/1995
12/28/2000
12/27/2005
12/26/2010
12/25/2015
24418 Chloride
CSRG
PNEFEF
24418 Water Elevations

Figure B-29
Fluoride Concentrations and Water Elevations in Well 24418 and PNEFEF Fluoride Concentrations

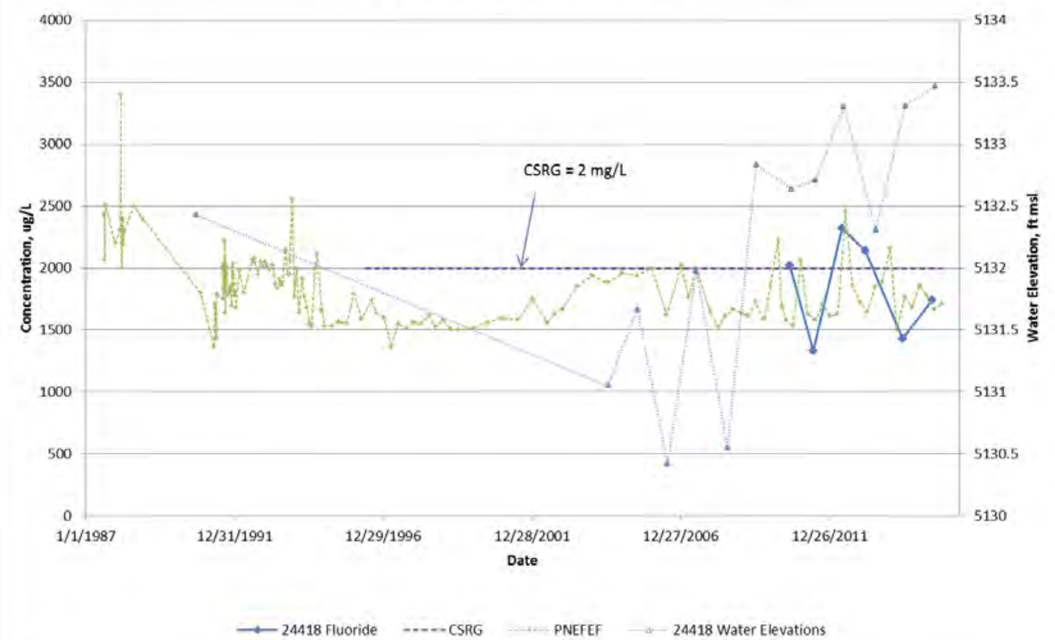
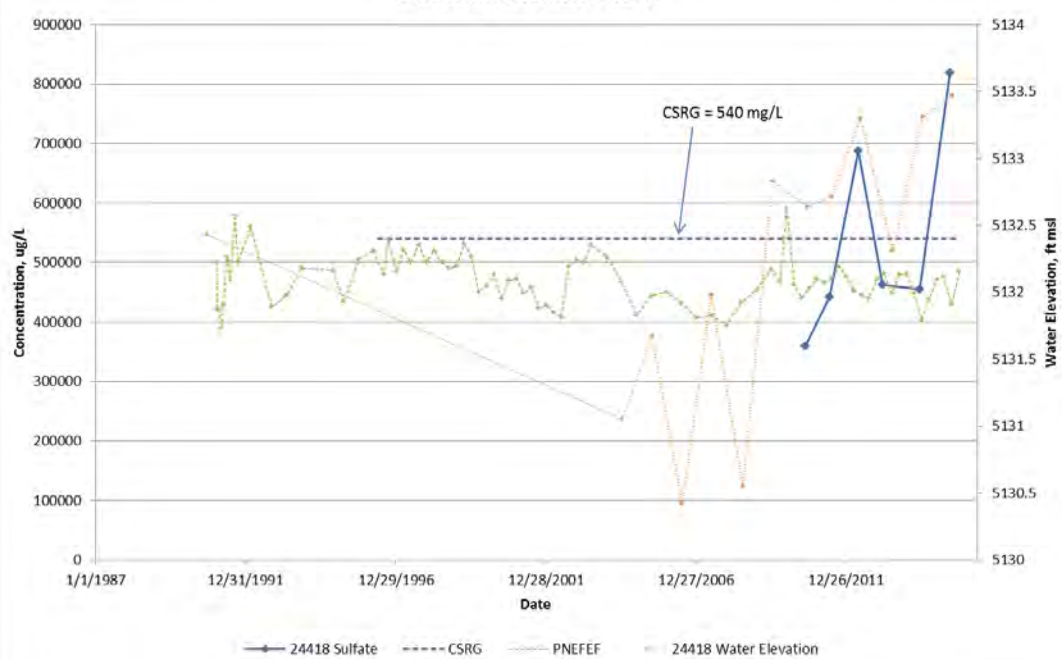


Figure B-30
Sulfate Concentrations and Water Elevations in Well 24418 and PNEFEF Sulfate Concentrations



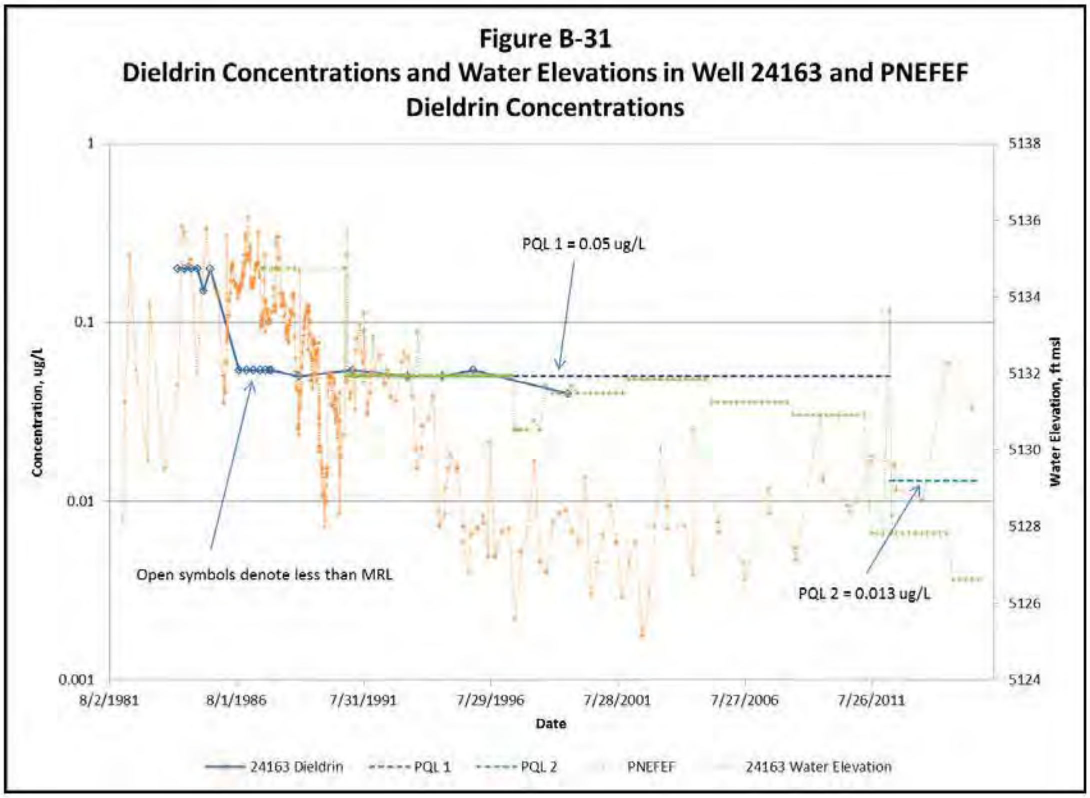


Figure B-31
Dieldrin Concentrations and Water Elevations in Well 24163 and PNEFEF
Dieldrin Concentrations
PQL 1 = 0.05 ug/L
Open symbols denote less than MRL
PQL 2 = 0.013 ug/L
Concentration, ug/L
Water Elevation, ft msl
Date
24163 Dieldrin
PQL 1
PQL 2
PNEFEF
24163 Water Elevation

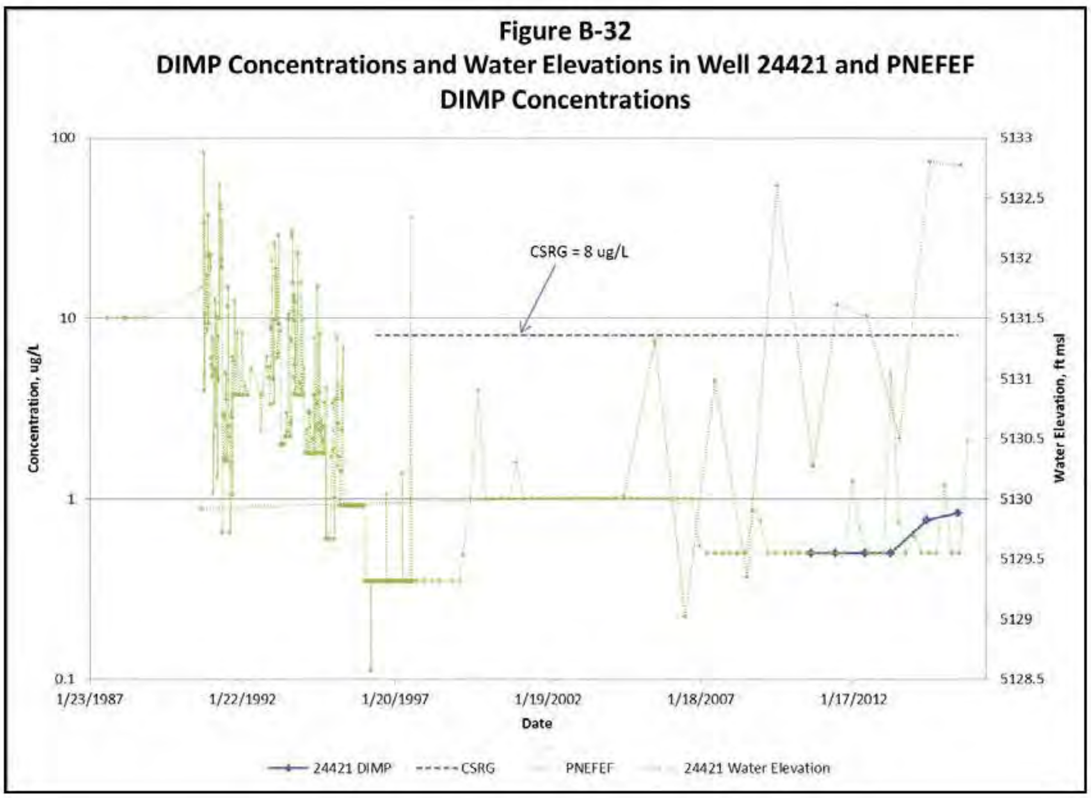


Figure B-32
DIMP Concentrations and Water Elevations in Well 24421 and PNEFEF
DIMP Concentrations
CSRG = 8 ug/L
Concentration, ug/L
Water Elevation, ft msl
Date
24421 DIMP
CSRG
PNEFEF
24421 Water Elevation

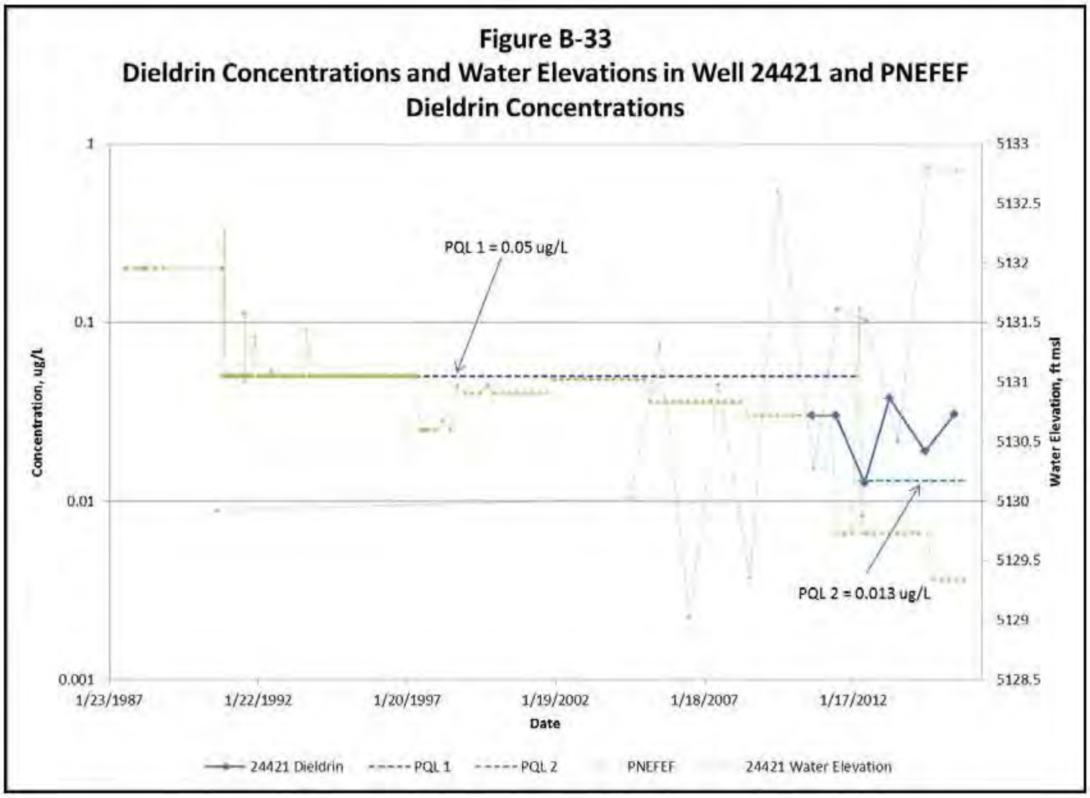


Figure B-33
Dieldrin Concentrations and Water Elevations in Well 24421 and PNEFEF
Dieldrin Concentrations
PQL 1 = 0.05 ug/L
PQL 2 = 0.013 ug/L
Concentration, ug/L
Water Elevation, ft msl
Date
24421 Dieldrin
PQL 1
PQL 2
PNEFEF
24421 Water Elevation

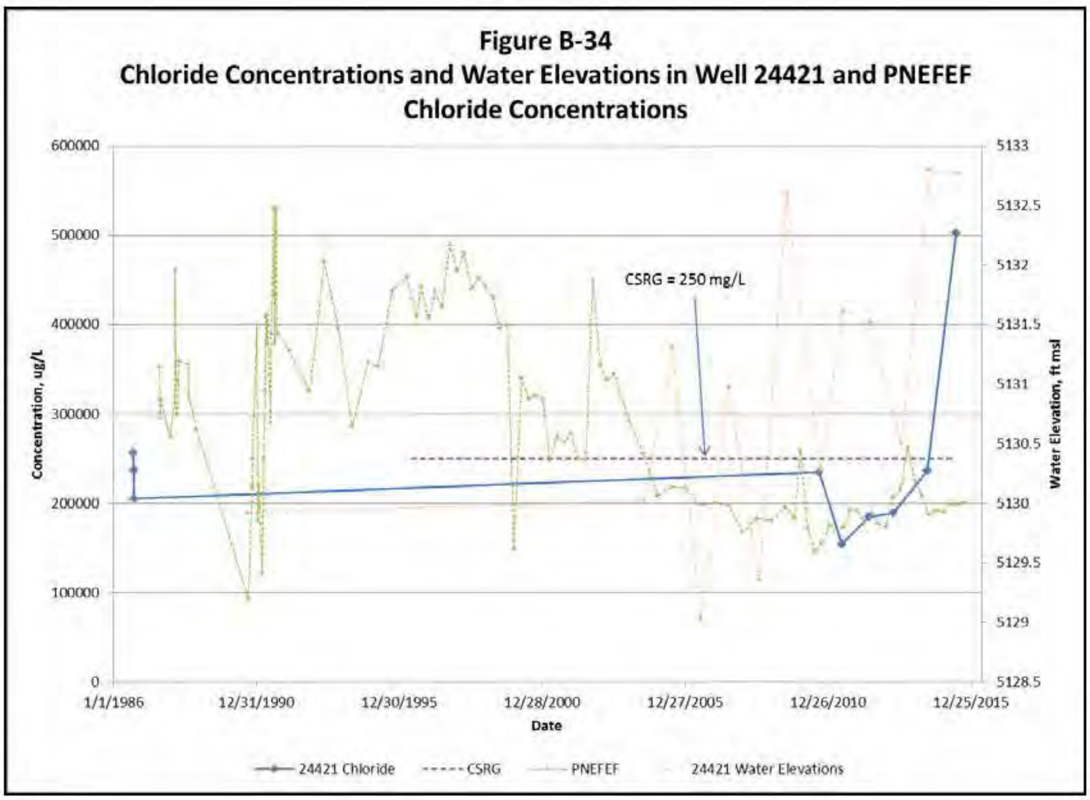


Figure B-34
Chloride Concentrations and Water Elevations in Well 24421 and PNEFEF
Chloride Concentrations
CSRG = 250 mg/L
Concentration, ug/L
Water Elevation, ft msl
Date
24421 Chloride
CSRG
PNEFEF
24421 Water Elevations

Figure B-35
Fluoride Concentrations and Water Elevations in Well 24421 and PNEFEF
Fluoride Concentrations

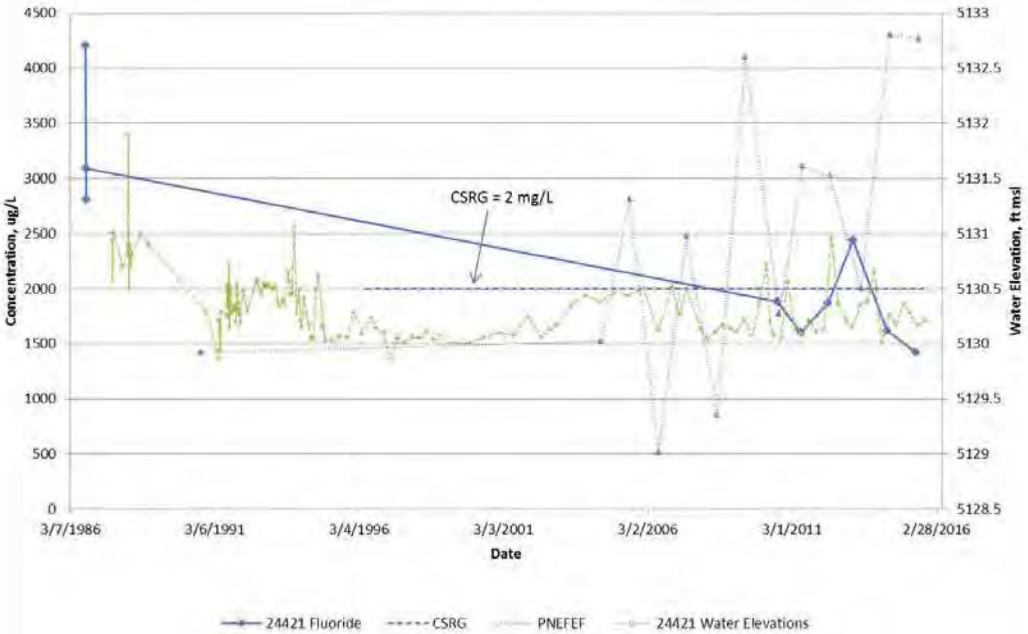
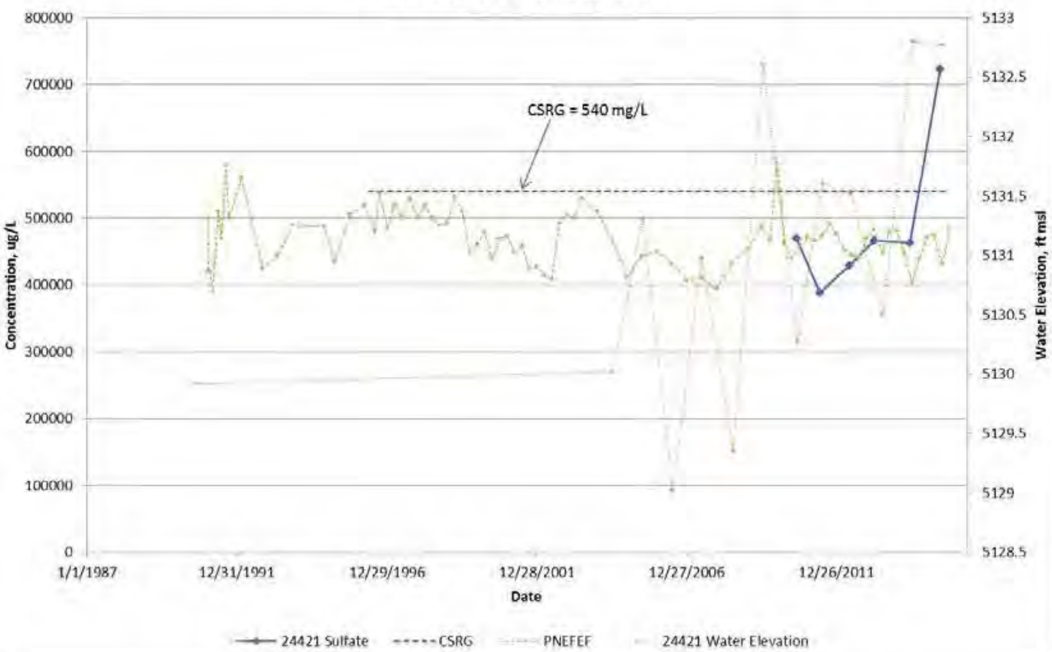


Figure B-36
Sulfate Concentrations and Water Elevations in Well 24421 and PNEFEF
Sulfate Concentrations



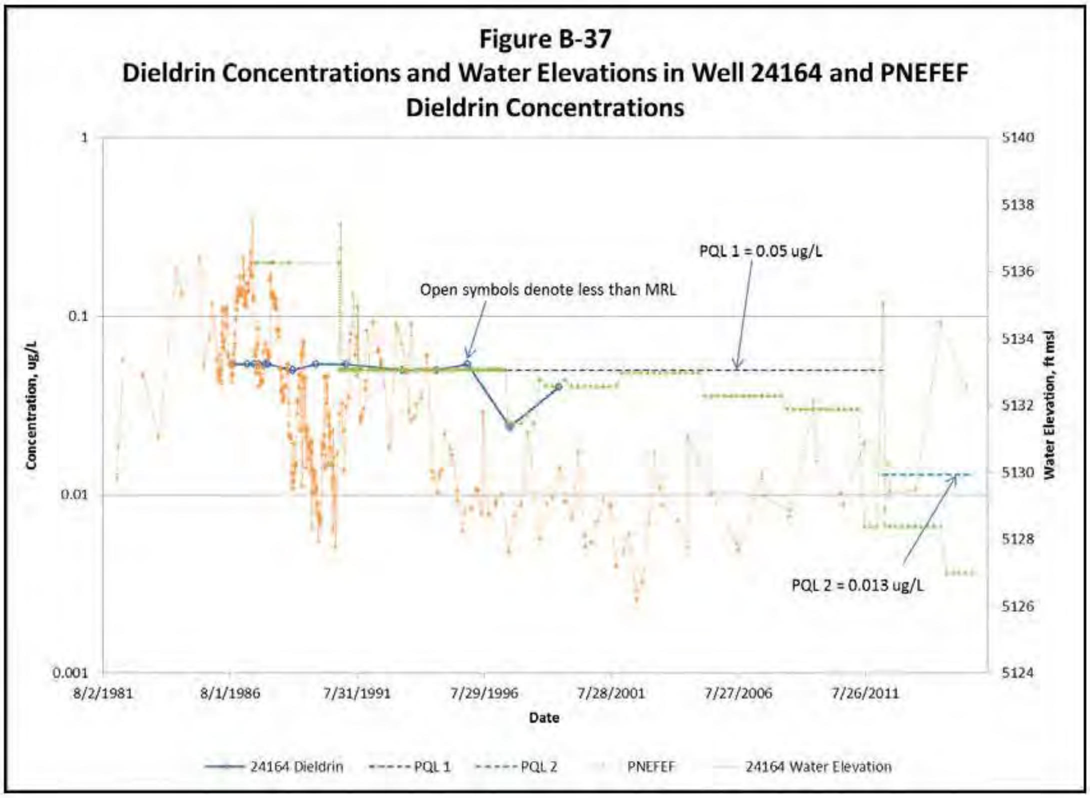


Figure B-37
Dieldrin Concentrations and Water Elevations in Well 24164 and PNEFEF Dieldrin Concentrations
Open symbols denote less than MRL
PQL 1 = 0.05 ug/L
PQL 2 = 0.013 ug/L
Concentration, ug/L
Water Elevation, ft msl
Date
24164 Dieldrin
PQL 1
PQL 2
PNEFEF
24164 Water Elevation

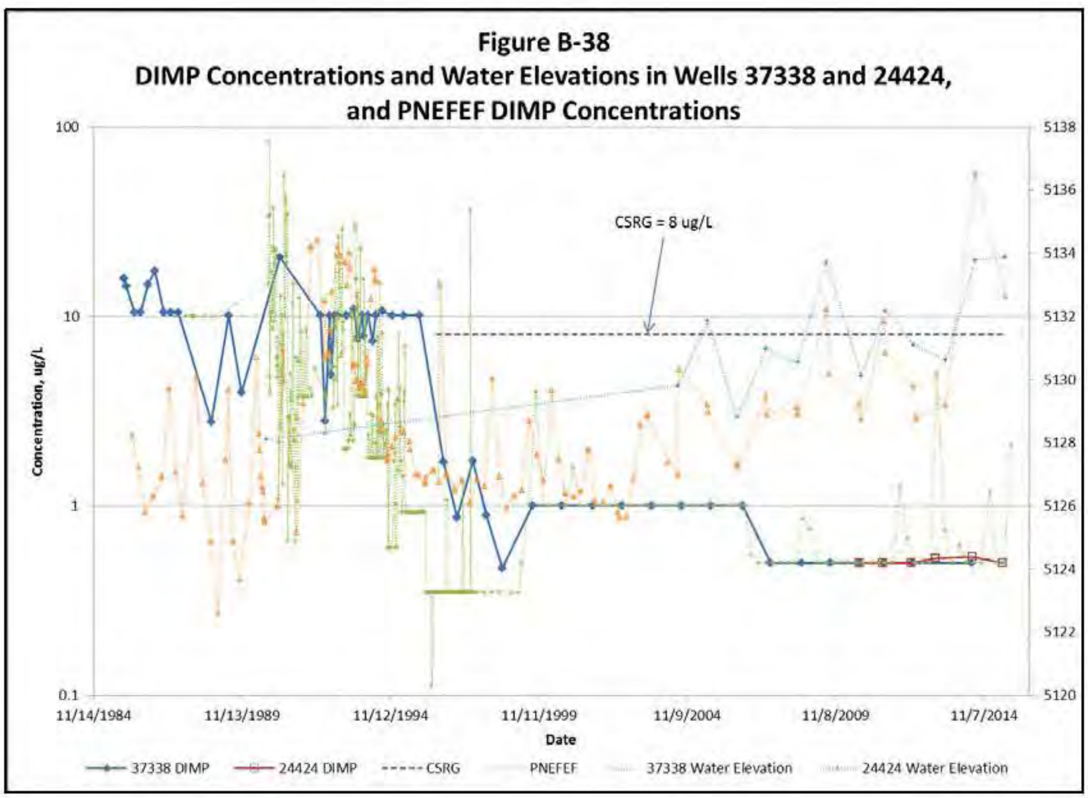


Figure B-38
DIMP Concentrations and Water Elevations in Wells 37338 and 24424, and PNEFEF DIMP Concentrations
CSRG = 8 ug/L
Concentration, ug/L
Date
37338 DIMP
24424 DIMP
CSRG
PNEFEF
37338 Water Elevation
24424 Water Elevation

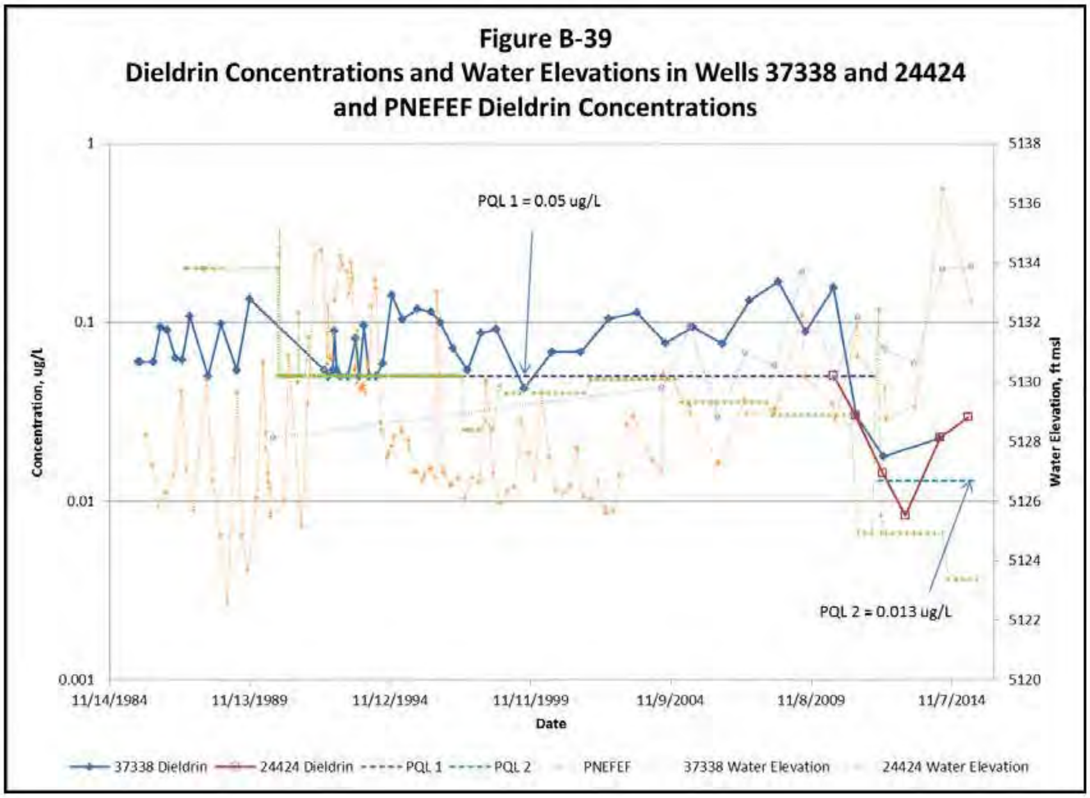


Figure B-39
Dieldrin Concentrations and Water Elevations in Wells 37338 and 24424
and PNEFEF Dieldrin Concentrations
PQL 1 = 0.05 ug/L
PQL 2 = 0.013 ug/L
Concentration, ug/L
Water Elevation, ft msl
Date
37338 Dieldrin
24424 Dieldrin
PQL 1
PQL 2
PNEFEF
37338 Water Elevation
24424 Water Elevation

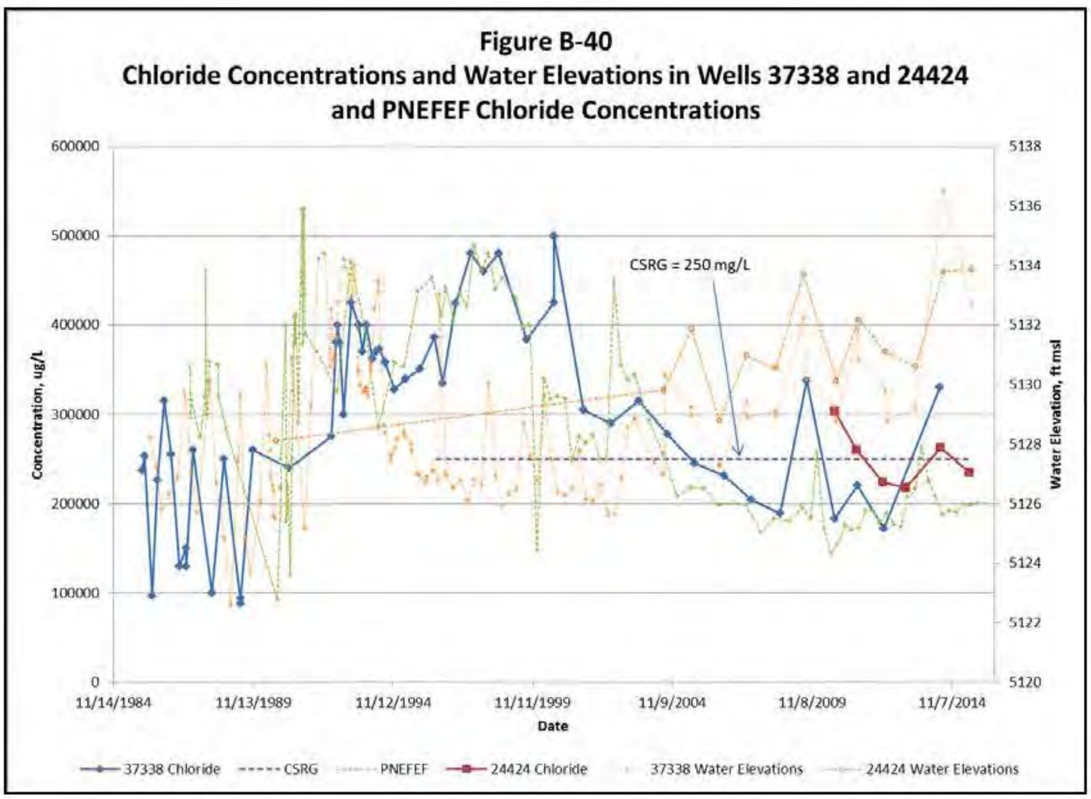


Figure B-40
Chloride Concentrations and Water Elevations in Wells 37338 and 24424
and PNEFEF Chloride Concentrations
CSRG = 250 mg/L
Concentration, ug/L
Water Elevation, ft msl
Date
37338 Chloride
CSRG
PNEFEF
24424 Chloride
37338 Water Elevations
24424 Water Elevations

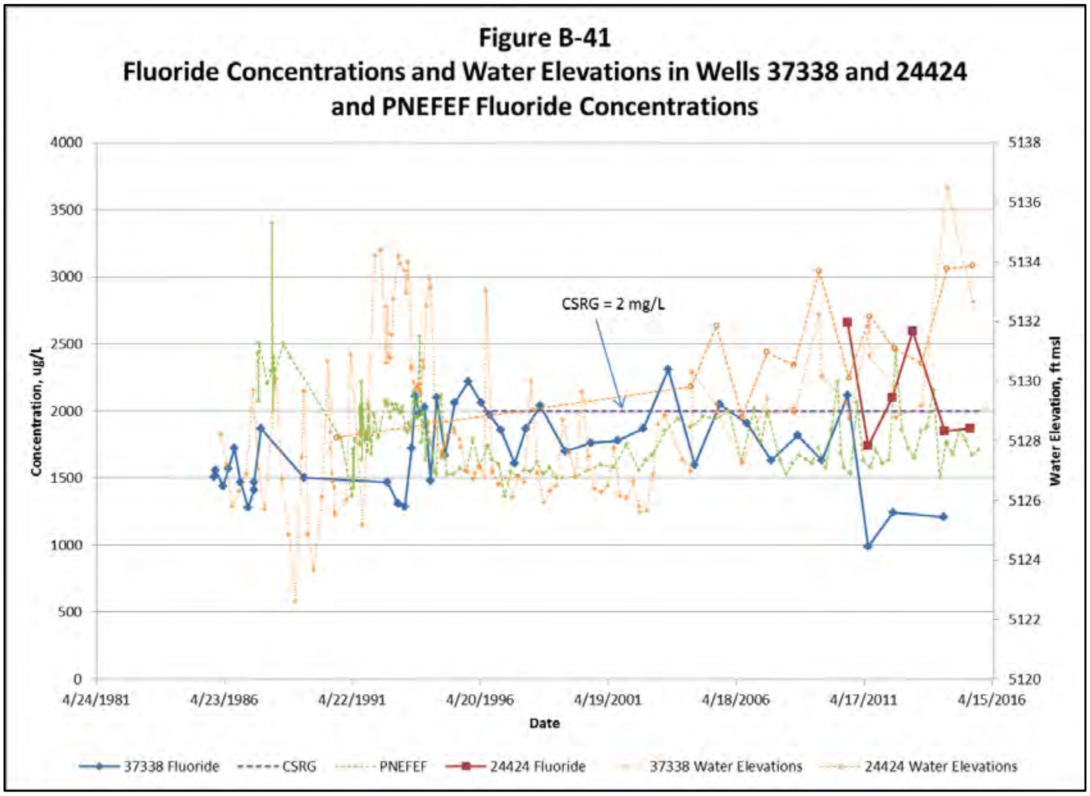


Figure B-41
Fluoride Concentrations and Water Elevations in Wells 37338 and 24424
and PNEFEF Fluoride Concentrations
CSRG = 2 mg/L
Concentration, ug/L
Water Elevation, ft msl
Date
4/24/1981
4/23/1986
4/22/1991
4/20/1996
4/19/2001
4/18/2006
4/17/2011
4/15/2016
37338 Fluoride
CSRG
PNEFEF
24424 Fluoride
37338 Water Elevations
24424 Water Elevations

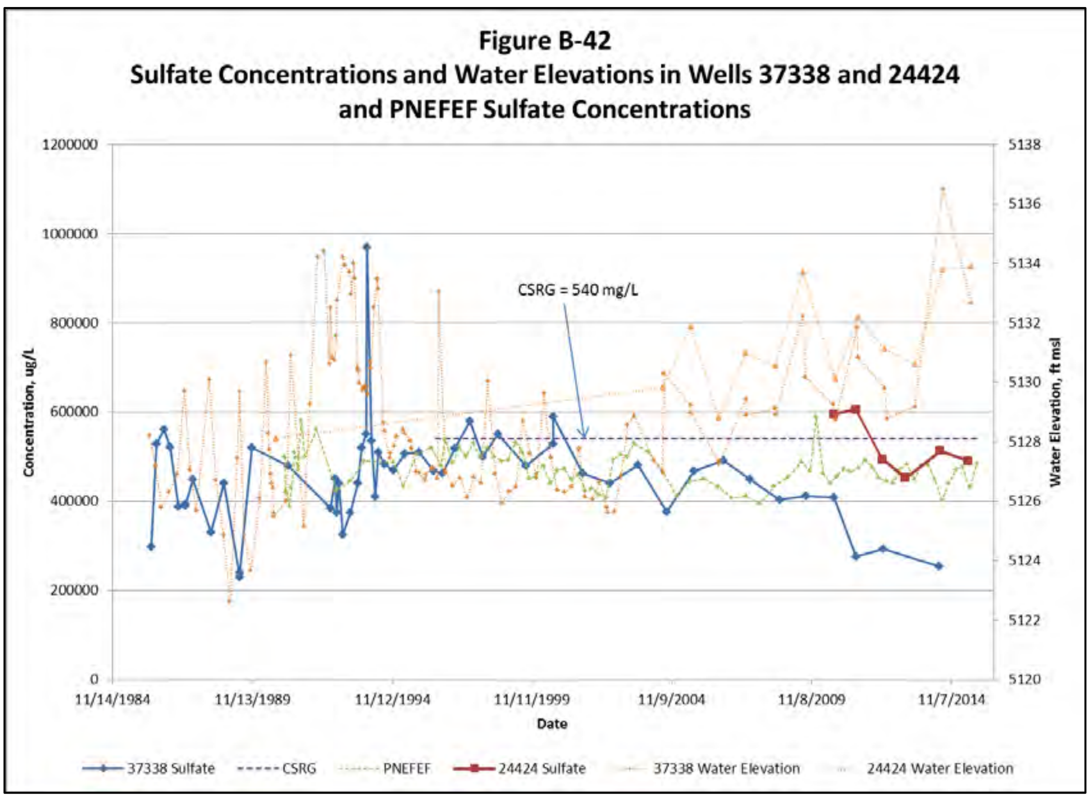


Figure B-42
Sulfate Concentrations and Water Elevations in Wells 37338 and 24424
and PNEFEF Sulfate Concentrations
CSRG = 540 mg/L
Concentration, ug/L
Water Elevation, ft msl
Date
11/14/1984
11/13/1989
11/12/1994
11/11/1999
11/9/2004
11/8/2009
11/7/2014
37338 Sulfate
CSRG
PNEFEF
24424 Sulfate
37338 Water Elevation
24424 Water Elevation

Figure B-43
DIMP Concentrations and Water Elevations in Wells 24166 and 24004, and PNEFEF DIMP Concentrations

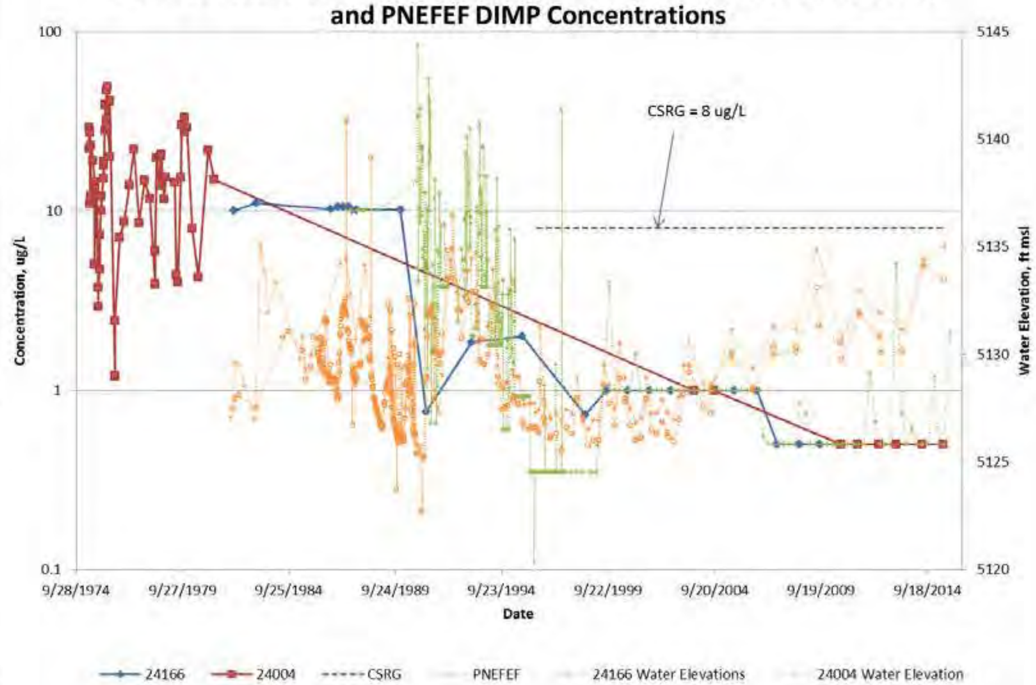


Figure B-44
Dieldrin Concentrations and Water Elevations in Wells 24166 and 24004 and PNEFEF Dieldrin Concentrations

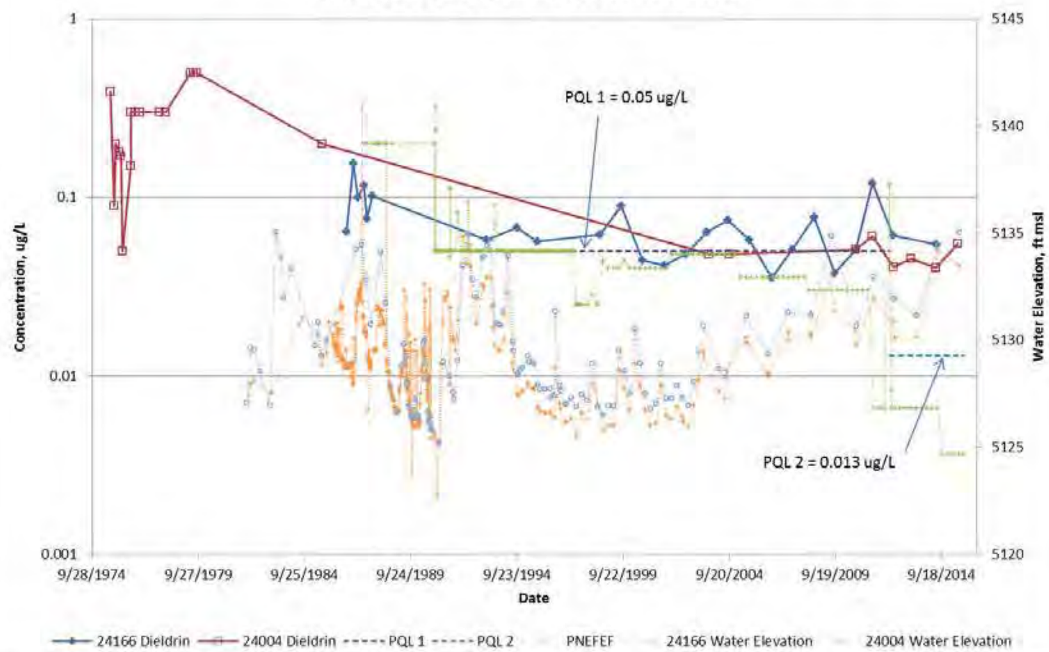


Figure B-45
Chloride Concentrations and Water Elevations in Wells 24166 and 24004 and PNEFEF Chloride Concentrations

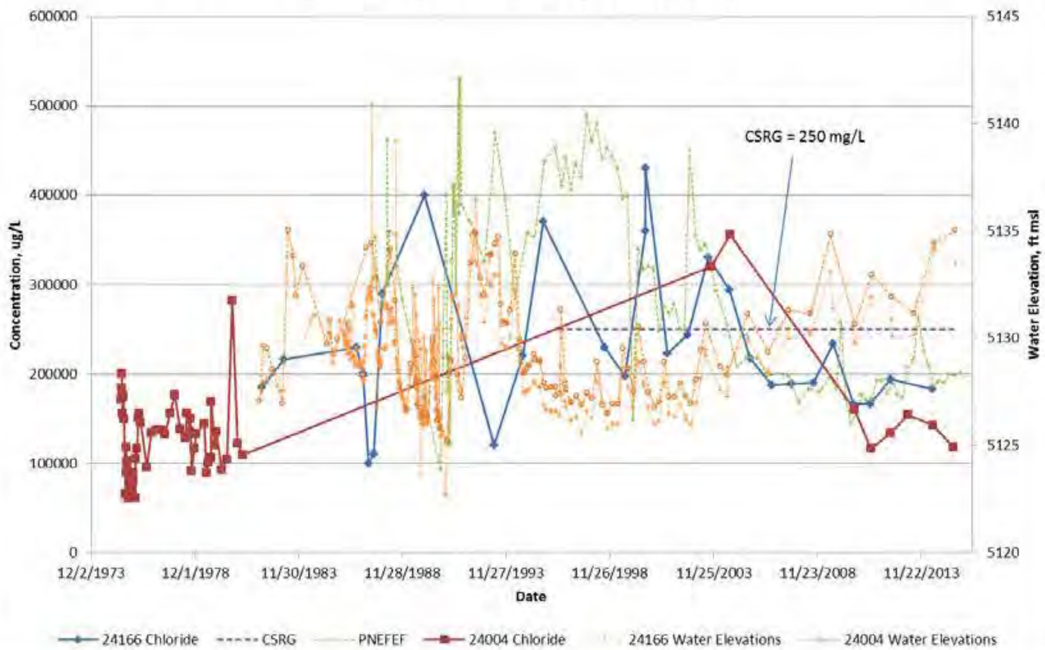
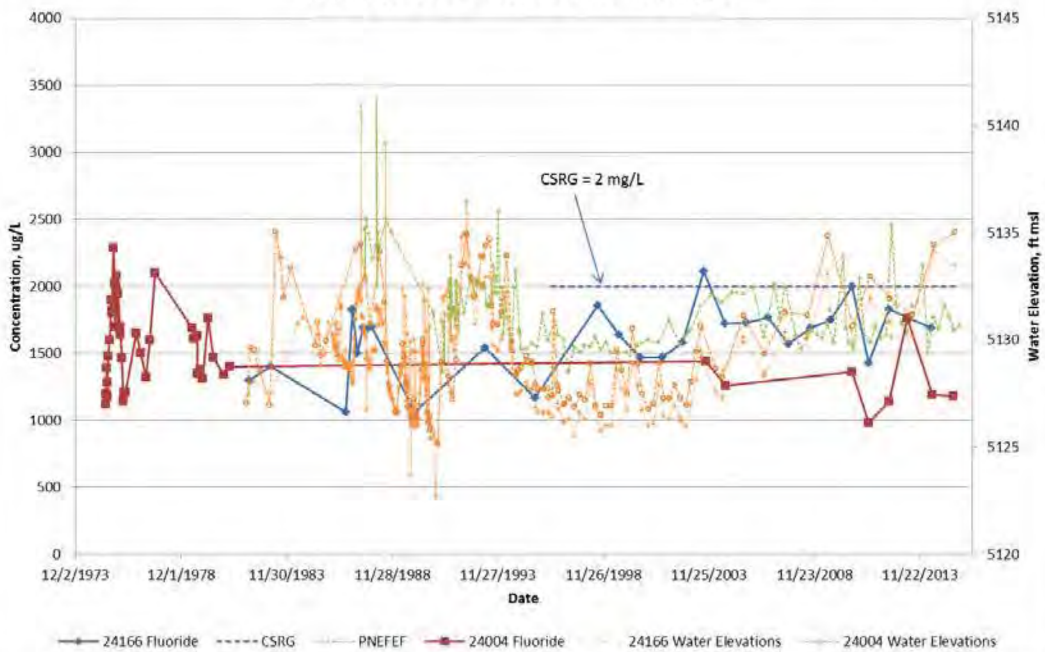


Figure B-46
Fluoride Concentrations and Water Elevations in Wells 24166 and 24004 and PNEFEF Fluoride Concentrations



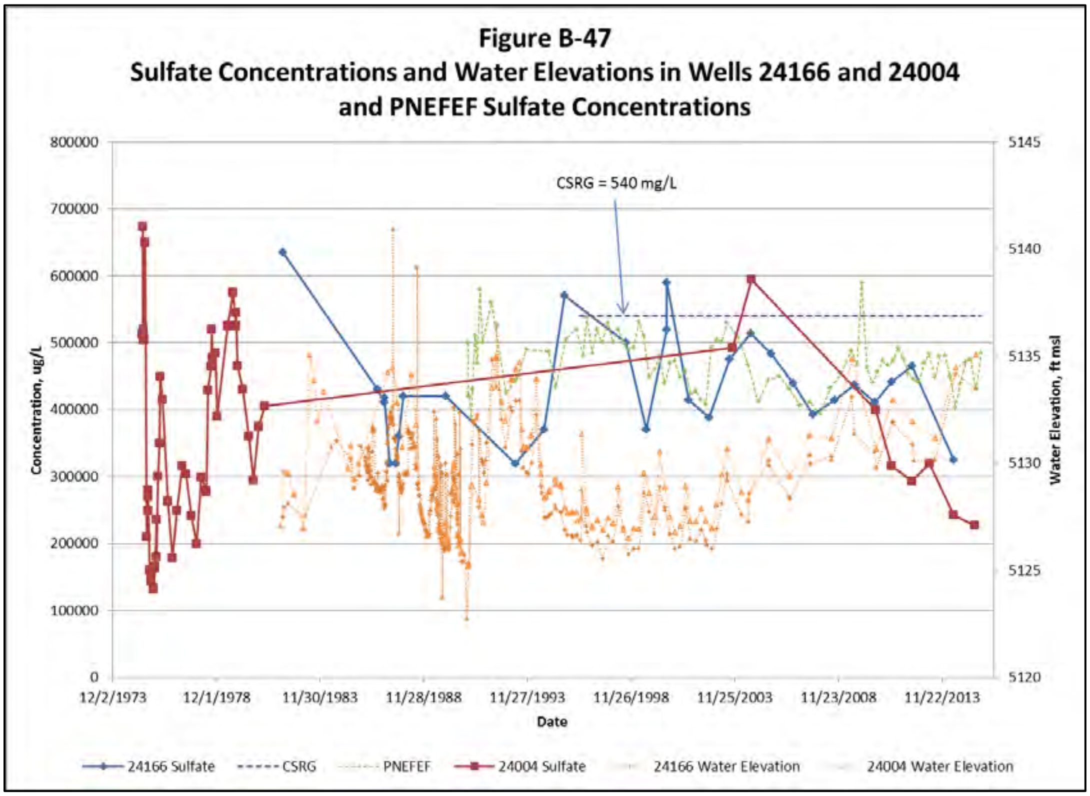


Figure B-47
Sulfate Concentrations and Water Elevations in Wells 24166 and 24004 and PNEFEF Sulfate Concentrations
CSRG = 540 mg/L
Concentration, ug/L
Water Elevation, ft msl
Date
0
100000
200000
300000
400000
500000
600000
700000
800000
5120
5125
5130
5135
5140
5145
12/2/1973
12/1/1978
11/30/1983
11/28/1988
11/27/1993
11/26/1998
11/25/2003
11/23/2008
11/22/2013
24166 Sulfate
CSRG
PNEFEF
24004 Sulfate
24166 Water Elevation
24004 Water Elevation

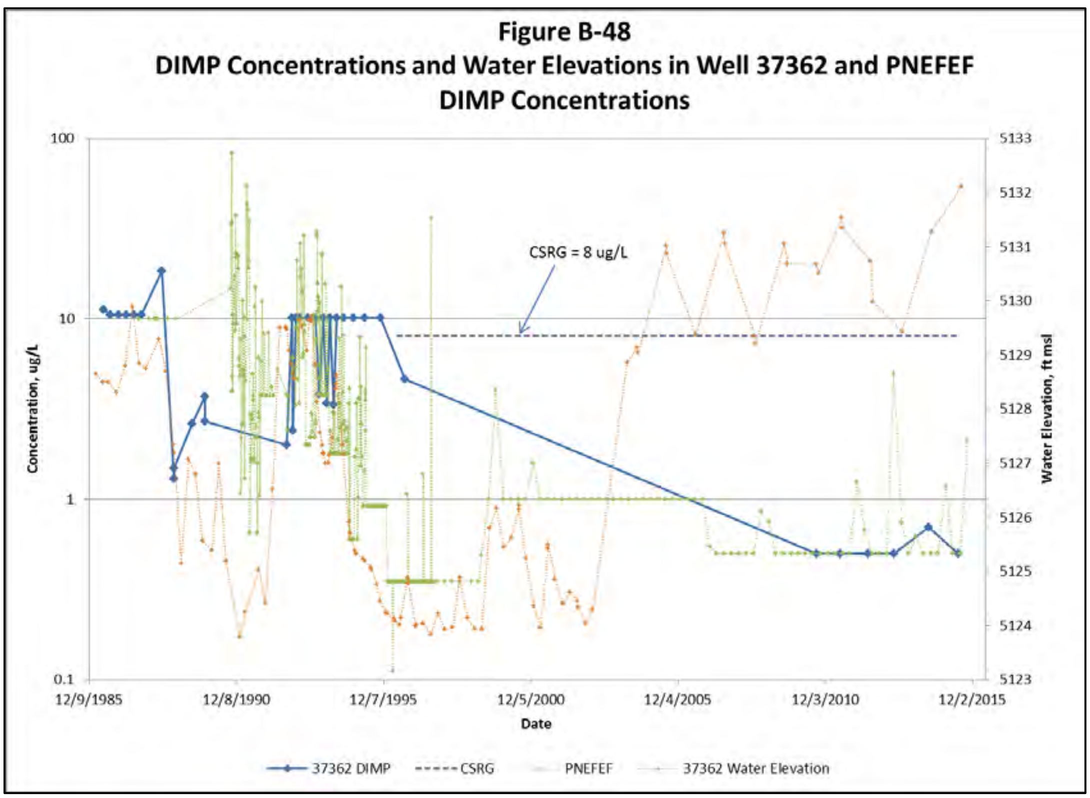


Figure B-48
DIMP Concentrations and Water Elevations in Well 37362 and PNEFEF DIMP Concentrations
CSRG = 8 ug/L
Concentration, ug/L
Water Elevation, ft msl
Date
0.1
1
10
100
5123
5124
5125
5126
5127
5128
5129
5130
5131
5132
5133
12/9/1985
12/8/1990
12/7/1995
12/5/2000
12/4/2005
12/3/2010
12/2/2015
37362 DIMP
CSRG
PNEFEF
37362 Water Elevation

Figure B-49
Dieldrin Concentrations and Water Elevations in Well 37362 and PNEFEF
Dieldrin Concentrations

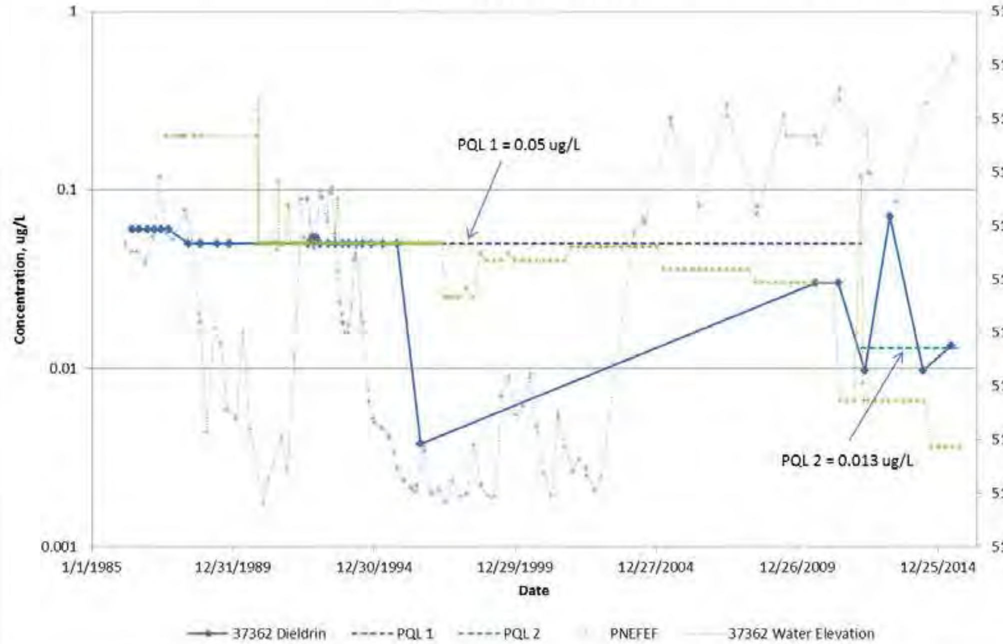
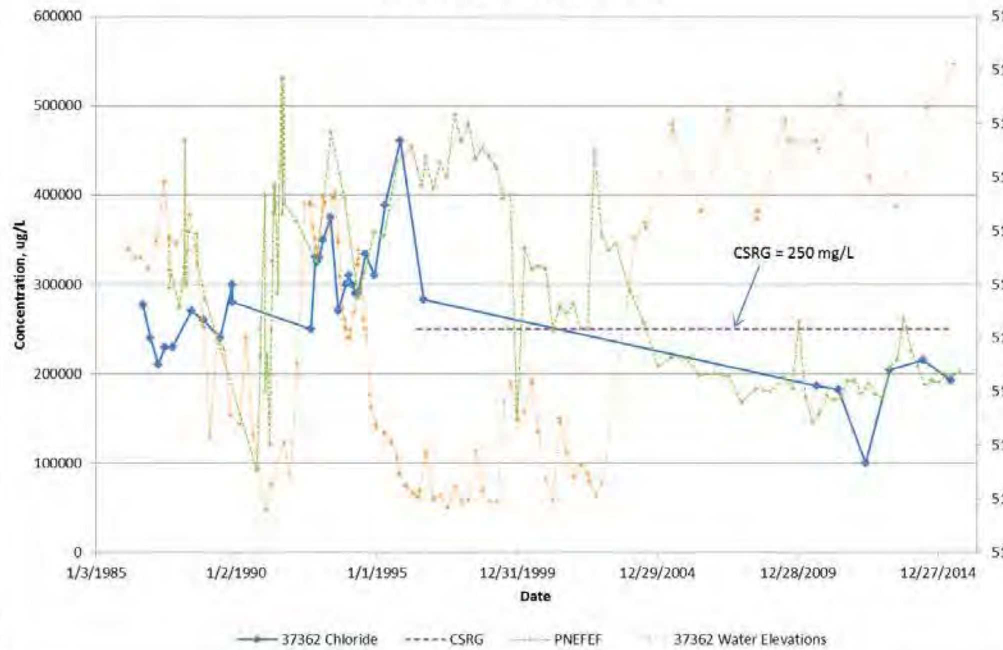


Figure B-50
Chloride Concentrations and Water Elevations in Well 37362 and PNEFEF
Chloride Concentrations



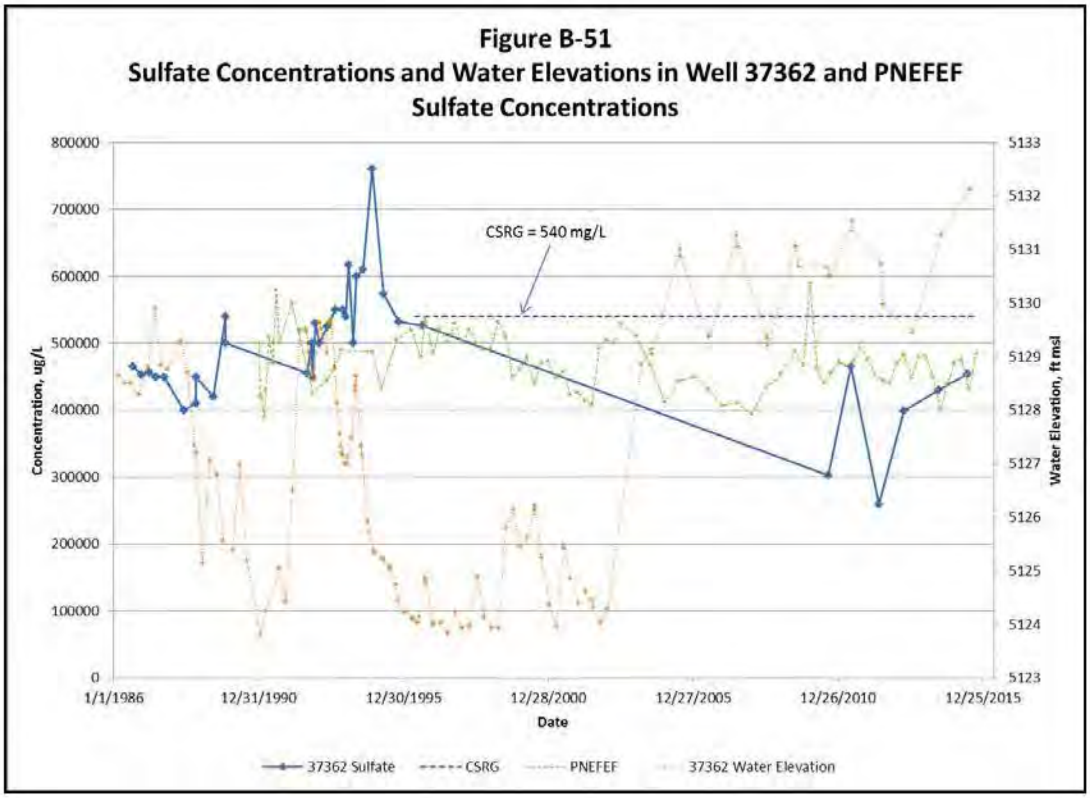


Figure B-51
Sulfate Concentrations and Water Elevations in Well 37362 and PNEFEF
Sulfate Concentrations
CSRG = 540 mg/L
Concentration, ug/L
Water Elevation, ft msl
Date
0
100000
200000
300000
400000
500000
600000
700000
800000
5123
5124
5125
5126
5127
5128
5129
5130
5131
5132
5133
1/1/1986
12/31/1990
12/30/1995
12/28/2000
12/27/2005
12/26/2010
12/25/2015
37362 Sulfate
CSRG
PNEFEF
37362 Water Elevation

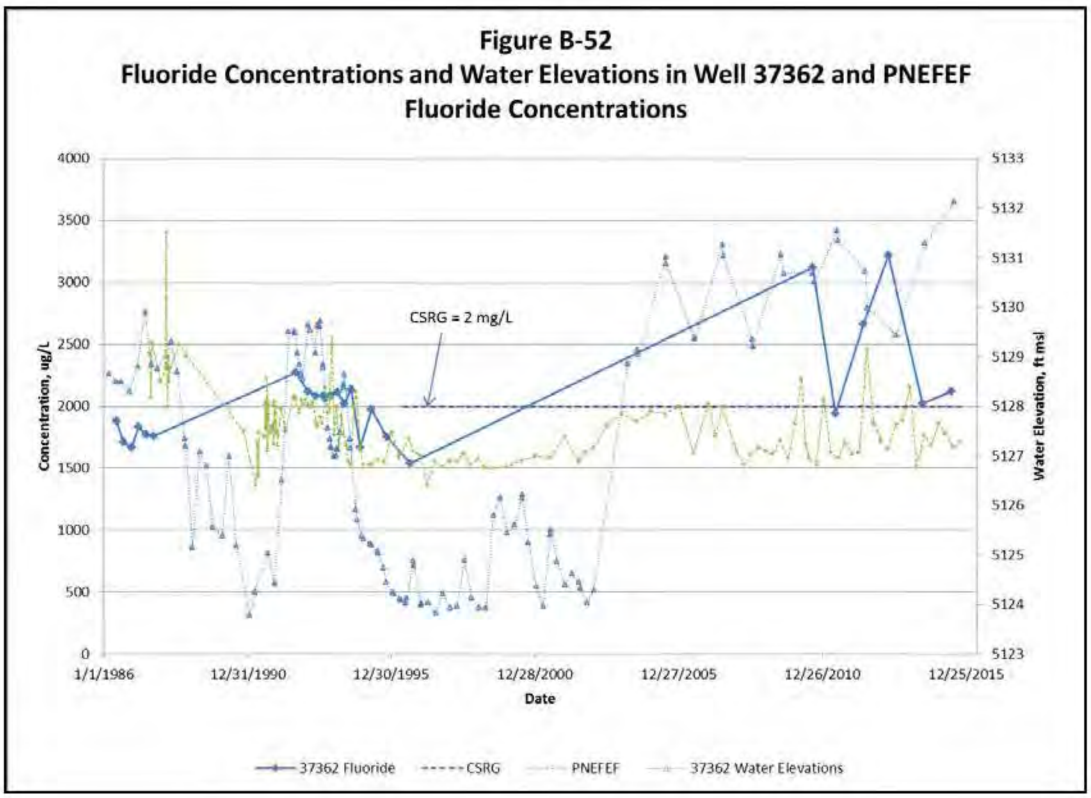


Figure B-52
Fluoride Concentrations and Water Elevations in Well 37362 and PNEFEF
Fluoride Concentrations
CSRG = 2 mg/L
Concentration, ug/L
Water Elevation, ft msl
Date
0
500
1000
1500
2000
2500
3000
3500
4000
5123
5124
5125
5126
5127
5128
5129
5130
5131
5132
5133
1/1/1986
12/31/1990
12/30/1995
12/28/2000
12/27/2005
12/26/2010
12/25/2015
37362 Fluoride
CSRG
PNEFEF
37362 Water Elevations

APPENDIX C

Bedrock Ridge Extraction System Evaluation

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FYSR Appendix C

Bedrock Ridge Extraction System Evaluation

Introduction

According to the 2010 Long-Term Monitoring Plan for Groundwater and Surface Water (LTMP) performance criteria for Bedrock Ridge Extraction System (BRES), the downgradient performance well concentrations should be below the Basin A Neck System (BANS) Containment System Remediation Goals (CSRGs)/Practical Quantitation Limits (PQLs) or have decreasing trends if the concentrations are above the CSRGs/PQLs, for the BRES to be functioning as intended.

BRES plume capture is indicated by quarterly water table maps and water quality data in cross-gradient wells. This is another LTMP criterion for demonstrating that the system is performing as expected. As discussed in the Five-Year Summary Review (FYSR) Section 5.1.1.5, the contaminant concentrations in one of the four downgradient performance wells show opposing trends, with concentrations of three analytes increasing and concentrations of three other analytes decreasing, which makes the performance evaluation of the system equivocal based on this well. The concentrations of three contaminants (1,2-dichloroethane [12DCLE], tetrachloroethylene [TCLEE], and trichloroethylene [TRCLE]) are increasing in downgradient performance well 36566 and the concentrations of three other contaminants (carbon tetrachloride, chloroform, and diisopropylmethyl phosphonate [DIMP]) are decreasing. The other three downgradient performance wells meet the performance criteria.

Due to limited downgradient well data and low permeability of the Denver Formation sandstones, it was uncertain in the LTMP whether the downgradient well water quality data would be representative of system effectiveness. Consequently, five years of water quality data were to be collected in the downgradient performance wells after the LTMP was issued in 2010 before drawing conclusions about the system performance, and determining whether the LTMP criteria should apply. The BRES performance wells are sampled annually. This five-year period ended in FY14, such that conclusions about the performance could be drawn in the FY14 Annual Summary Report (ASR) and 2015 FYSR.

Army and Shell's conclusion in the FY14 ASR and FYSR was that well 36566 is located in an area downgradient of one of the extraction wells where the hydraulic gradient is very flat, and the concentration trends in well 36566 may not be indicative of system performance. Thus, five years of data may not be a sufficient time period for determining system performance based on the concentration trends in this well. At the Regulatory Agencies' request, Army and Shell agreed to perform additional evaluation of the BRES in the FYSR to help resolve questions about the performance of the BRES. This appendix provides the additional evaluation of the BRES.

Background Information

The designers of the BRES chose not to include downgradient water quality monitoring of the BRES to evaluate system performance because the low permeability of the Denver sandstone aquifer might cause the wells to clean up very slowly downgradient of the extraction wells when plume capture is achieved, giving the erroneous impression that the system is not operating effectively. In revising the LTMP in 2010, additional performance criteria were included for the BRES so that all the groundwater systems would have similar performance criteria. Thus, downgradient performance well monitoring and performance criteria were included for the BRES in the 2010 LTMP. The five-year data collection period for the downgradient wells was included as a prerequisite for making performance conclusions to help address the concerns raised by the designers.

Methodology

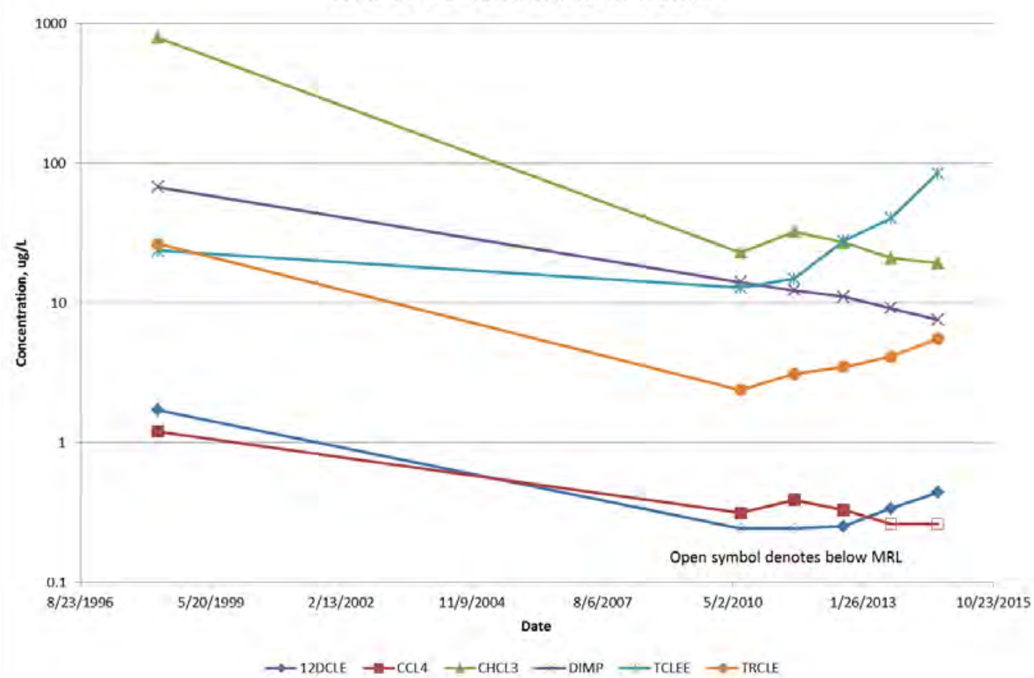
Quarterly BRES water table maps are included in the ASRs and are used in the annual performance evaluations. The fourth quarter FY14 water table map from the FY14 ASR is provided in this appendix**.** The configuration of the water table contours is very consistent over time and has indicated that the contaminated flow paths upgradient of the system appear to be captured. Treatment of the BRES groundwater occurs at the BANS treatment plant.

The analytical data were reviewed to determine if a more complete analysis might provide useful information.

Results

Figure C-1 below shows the concentration trends for the six contaminants discussed previously for well 36566. Except for TCLEE, the FY14 concentrations are lower than the 1998 baseline concentrations.

Figure C-1
Well 36566 Concentration Trends



NAVARRO

The BRES well location map is FYSR Figure 5.1.1.5-1. The fourth quarter FY14 water table map from the FY14 ASR is provided in this appendix as Figure C-22. The configuration of the contours is similar to previous maps. The hydraulic gradient near downgradient well 36566 is extremely flat for a low-permeability aquifer (FY09 to FY14 average is 0.0018 ft/ft between wells 36569 and 36566), which might cause the increasing concentration trends of a few analytes to misrepresent system performance. In Army and Shell's opinion, this map indicates that plume capture appears to be achieved, and the increasing trends of three analytes in well 36566 are not representative of system performance.

In FY14, seven BANS CSRG analytes, plus DIMP, were present upgradient of the BRES at concentrations above the CSRGs/PQLs/Colorado Basic Standards for Groundwater (CBSGs) and only four of these analytes were above the CSRGs/PQLs/CBSGs in one of the four downgradient performance wells (36566). Of these four analytes, the concentrations of one (chloroform) are decreasing. The concentrations of three of the analytes are increasing, but two (12DCLE at 0.44 ug/L and TRCLE at 5.53 ug/L) are just above the CSRGs of 0.4 and 5 ug/L, respectively.

In FY14, a total of 22 organic contaminants were detected in the BRES upgradient performance wells. Of these 22 analytes, 19 either were not detected, below the CSRGs/PQLs/CBSGs, or the concentrations are decreasing in the downgradient performance wells. There were no CSRG/PQL/CBSG exceedances in three of the four downgradient performance wells. Again, only three analytes (12DCLE, TCLEE, and TRCLE) were above the CSRGs and not decreasing in only one of the four downgradient wells. It is uncertain whether the increasing trends for these three analytes are meaningful for system performance when the majority of a large group of contaminants show the system is effectively reducing the downgradient concentrations and the water table maps shows no indication of bypass.

Conclusions and Recommendations

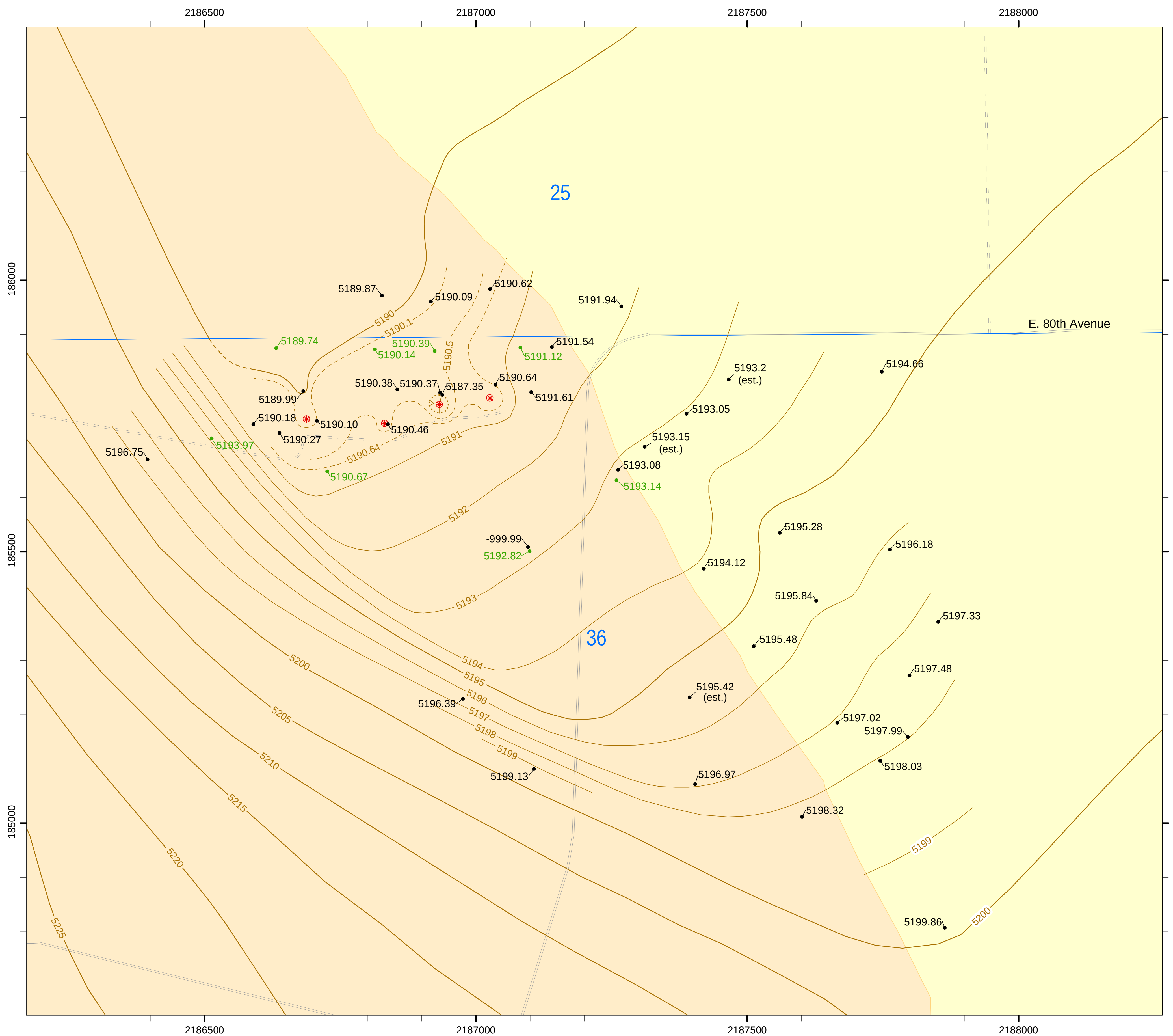
Based on the available data, it is premature to conclude that the BRES is not functioning as intended. The majority of the water level and water quality data indicate that the BRES is intercepting the plumes and effectively reducing the downgradient concentrations. For the three analytes that are present above the CSRGs and the concentrations are increasing, it is not possible to determine whether the increasing trends are due to bypass of the system or represent contamination that was present downgradient of the extraction wells when the system commenced operation and is slower to clean up than the other analytes.

Currently, the downgradient performance wells are sampled annually. Collecting additional water quality data may help resolve the performance question. Increased sampling frequency is listed as an option in LTMP Table 4.7-1 when the downgradient concentrations are increasing. Therefore, Army and Shell propose sampling wells 36569 and 36566 quarterly for one year to assess the contaminant concentration trends. Well 36569 is not currently in the downgradient performance well network and has not been sampled previously, but is included to provide additional data in the area immediately downgradient of extraction well 36302 and upgradient of well 36566. In addition, extraction well 36302 will be sampled semiannually to provide data for comparison to the concentration trends in the downgradient wells. If this proposal is acceptable to the Regulatory Agencies, an Operations and Maintenance Change Notice (OCN) will be issued to temporarily amend the LTMP. The one-year sampling period will commence after the OCN is approved.

The supplemental data will be evaluated in conjunction with the quarterly water level and annual water quality data collected according to the BRES monitoring schedule during the one-year period. A draft interpretation report will be issued within 90 days of the last quarter's water quality data being finalized. The report will evaluate system performance and determine whether the one-year supplemental monitoring period is sufficient or should be extended for one or both wells. The report will also identify any additional follow-up actions, if necessary. The analytical data review/QA and a summary of the results will be provided in the corresponding ASR.

FIGURE

FY14 4th Quarter Groundwater Elevation Contours of the Unconfined Aquifer Bedrock Ridge System



Legend

- Saturated Alluvium
- Unsaturated Alluvium (Developed using summer 2014 data)
- Section Lines
- Ditches
- Paved Roads
- Unimproved Roads
- Water elevation contour - 1 foot interval. Hachures indicate depression. Water elevations collected July 2014.
- Approximate water elevation contour
- Supplemental water elevation contour
- Approximate supplemental water elevation contour

Measured Wells Used for Contouring with Water Elevations (-999.99 indicates dry well - see remarks in water elevation listings included on CD)

- 5109.86 Monitoring Wells
- 5109.86 Performance Water Quality Wells

Wells Not Measured or Not Used for Contouring

- Depression in water table due to extraction well. May not match actual areal extent of depression.

N

0 100 200 Feet

NAD27-NGVD29 Datum, US Survey Feet, Colorado North Zone

Sources: U.S. Army, RMA GIS, PMC, OMC, Shell/URS Corp.

Figure C-22

Army/Shell GIS

8/26/2015 RMITS

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APPENDIX D

Time Concentration Plots for Water Quality Tracking Wells

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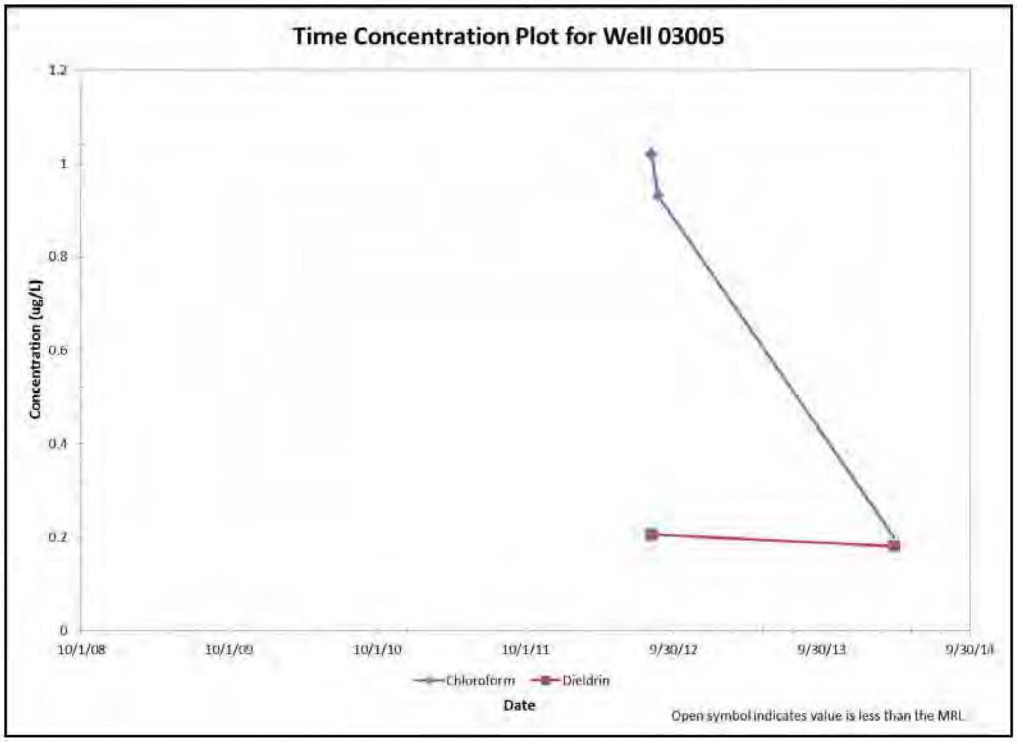
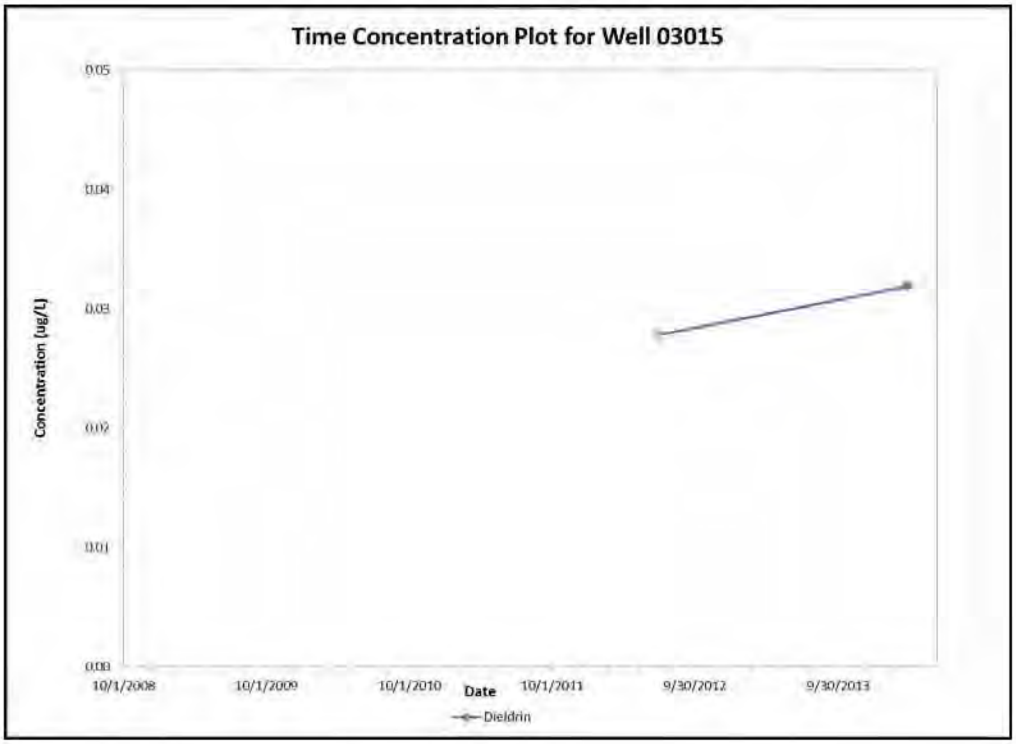
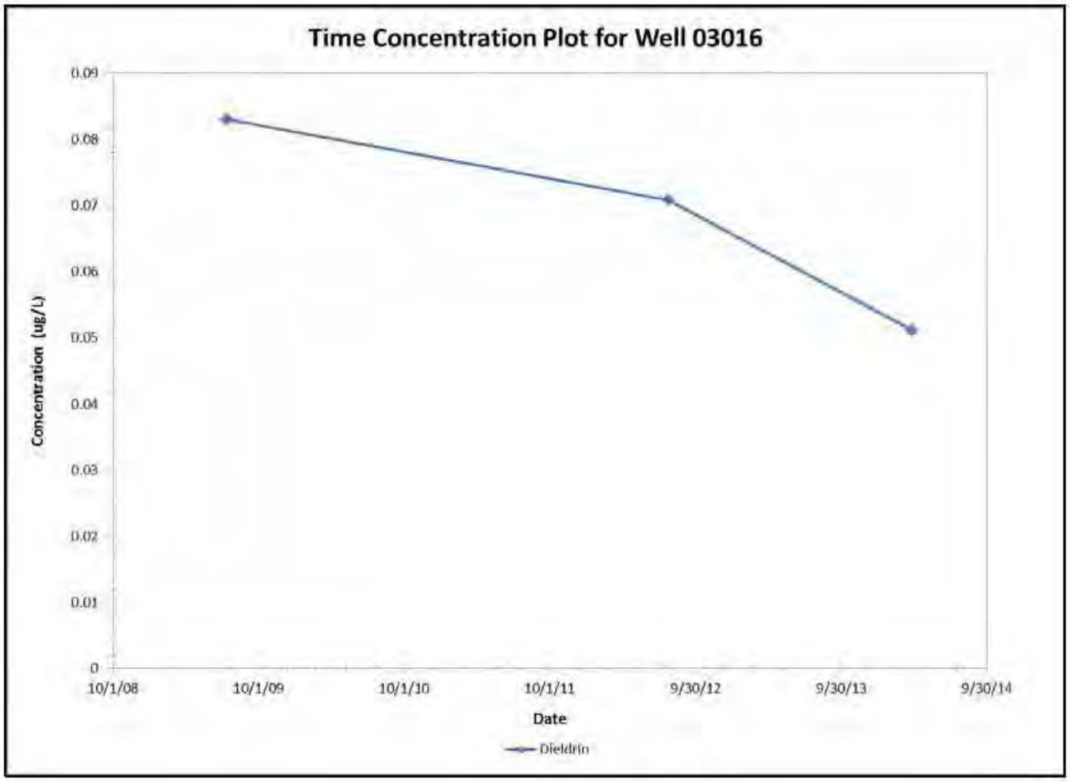
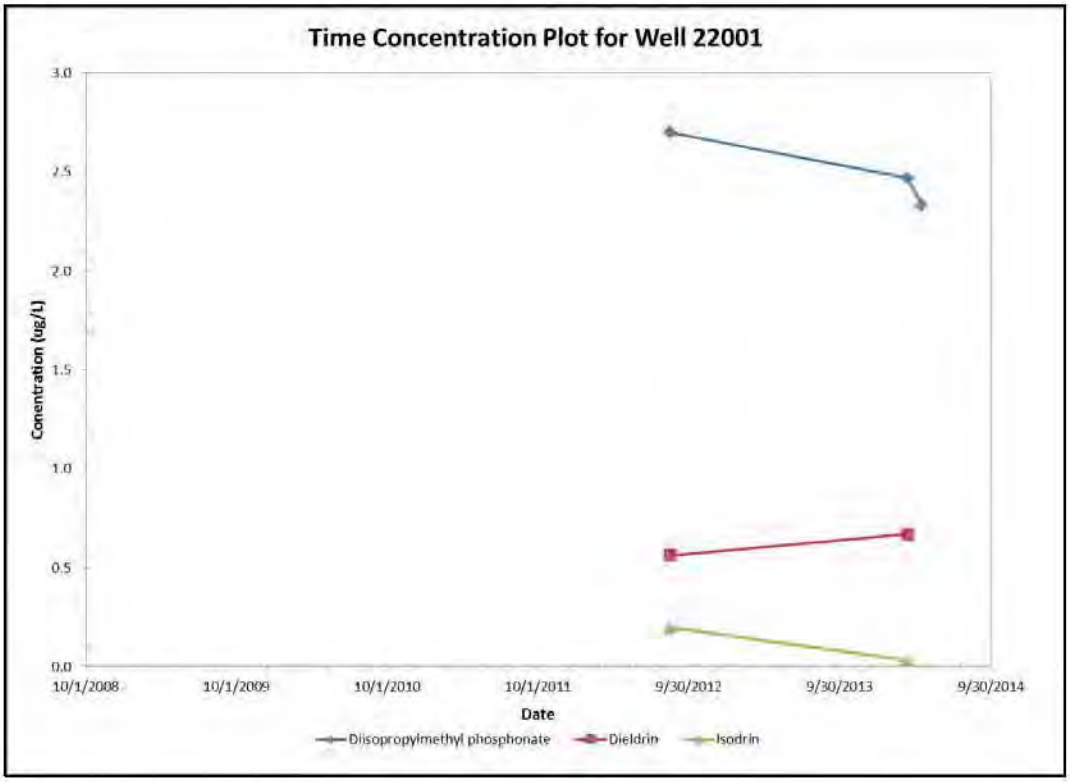
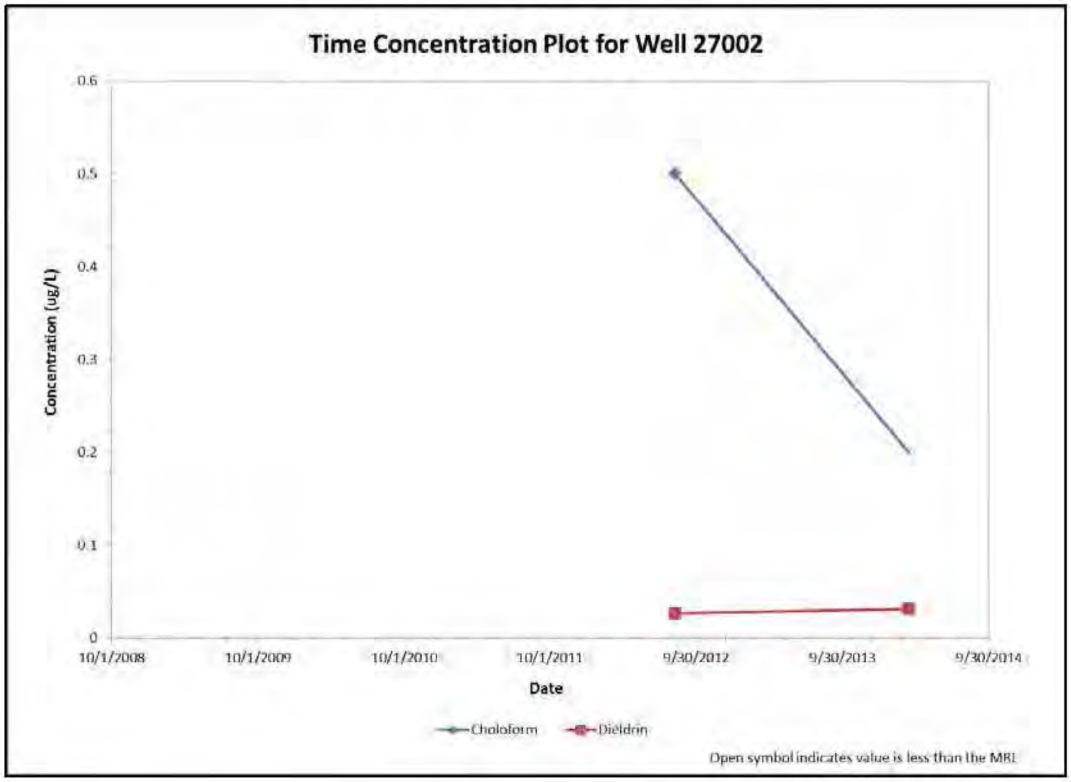
Upgradient of the Northwest Boundary Containment System

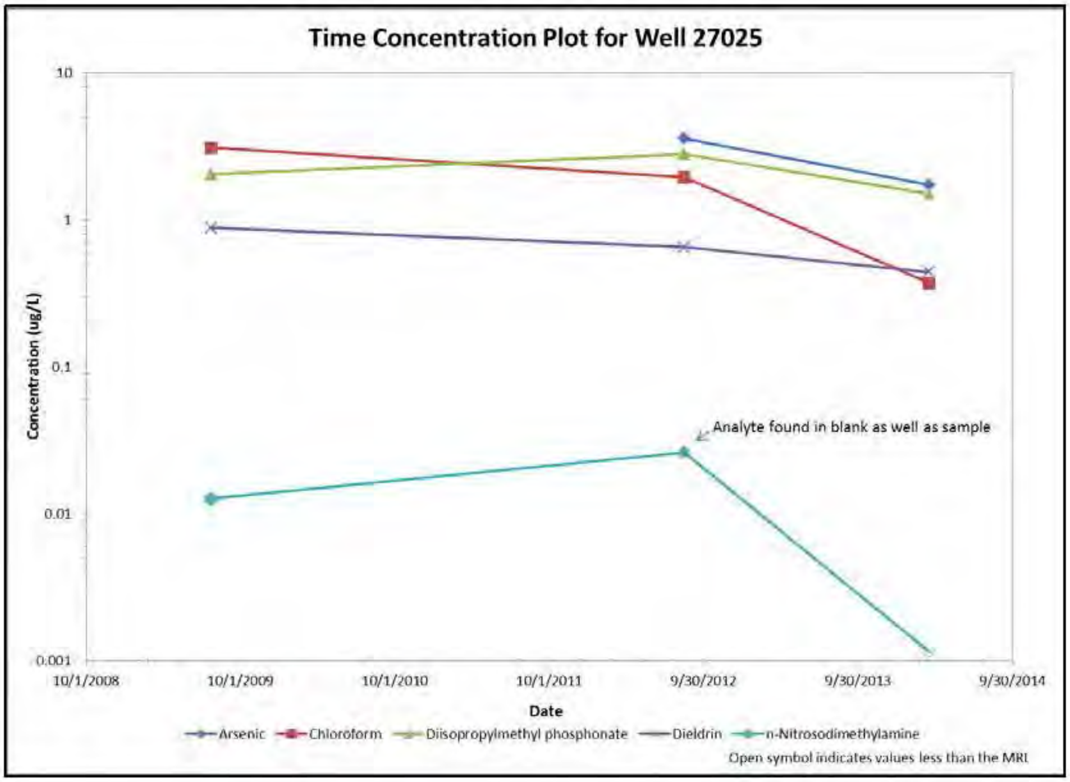


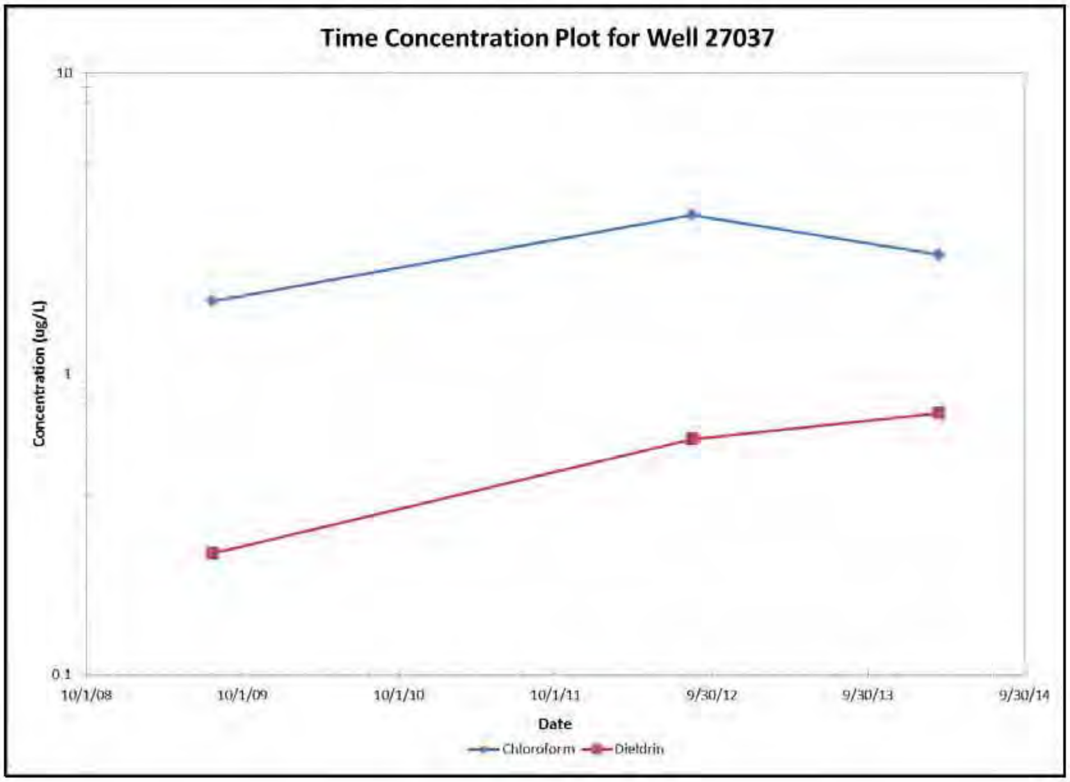


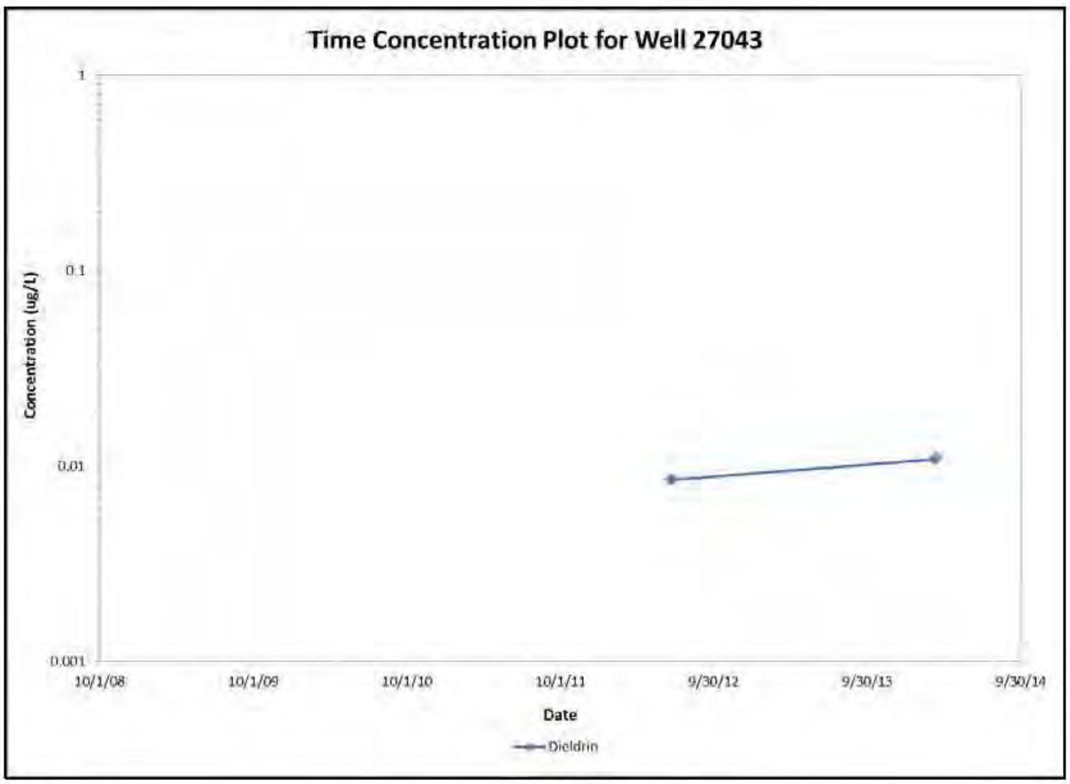

Time Concentration Plot for Well 03016
Concentration (ug/L)
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
10/1/08
10/1/09
10/1/10
10/1/11
9/30/12
9/30/13
9/30/14
Date
Dieldrin

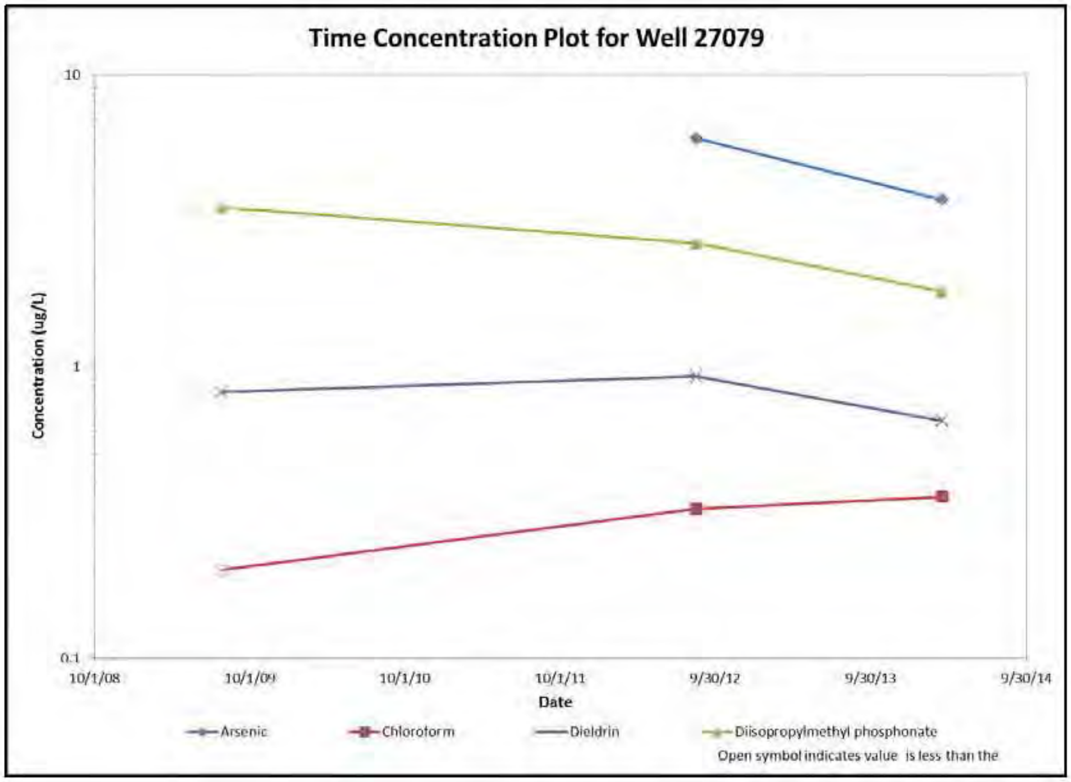

Time Concentration Plot for Well 22001
Conentration (ug/L)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
10/1/2008
10/1/2009
10/1/2010
10/1/2011
9/30/2012
9/30/2013
9/30/2014
Date
Diisopropylmethyl phosphonate
Dieldrin
Isodrin

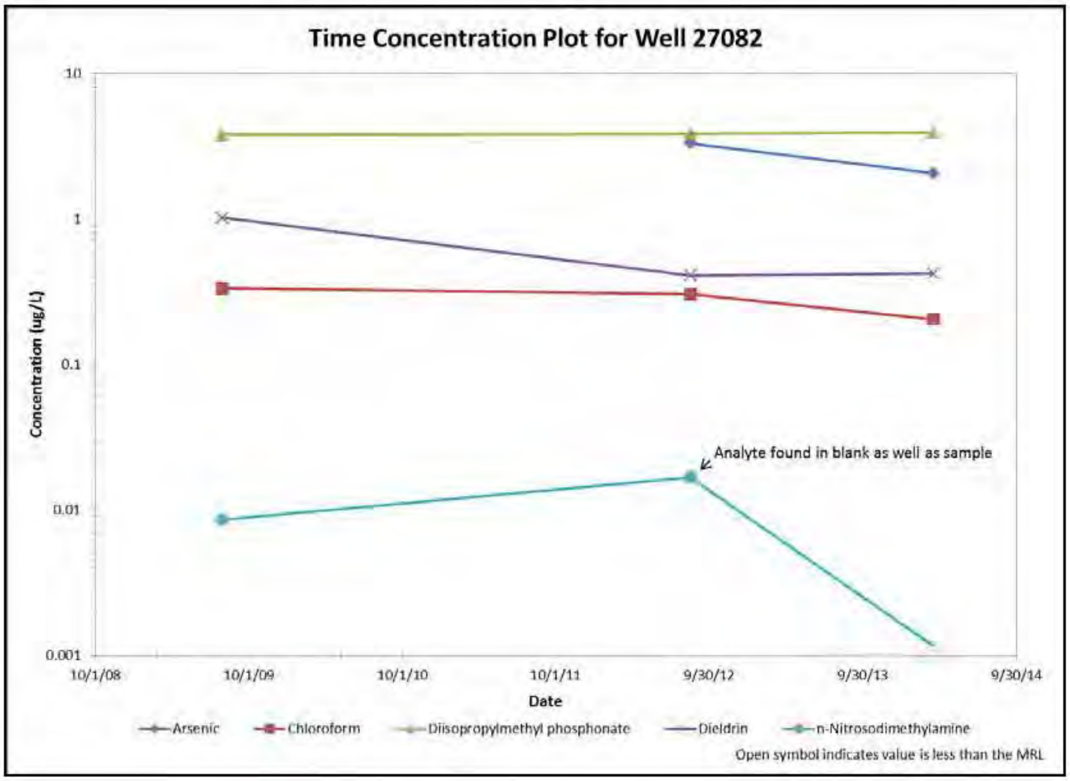

Time Concentration Plot for Well 27002
Concentration (ug/L)
0.6
0.5
0.4
0.3
0.2
0.1
0
10/1/2008
10/1/2009
10/1/2010
10/1/2011
9/30/2012
9/30/2013
9/30/2014
Date
Choloform
Dieldrin
Open symbol indicates value is less than the MRL

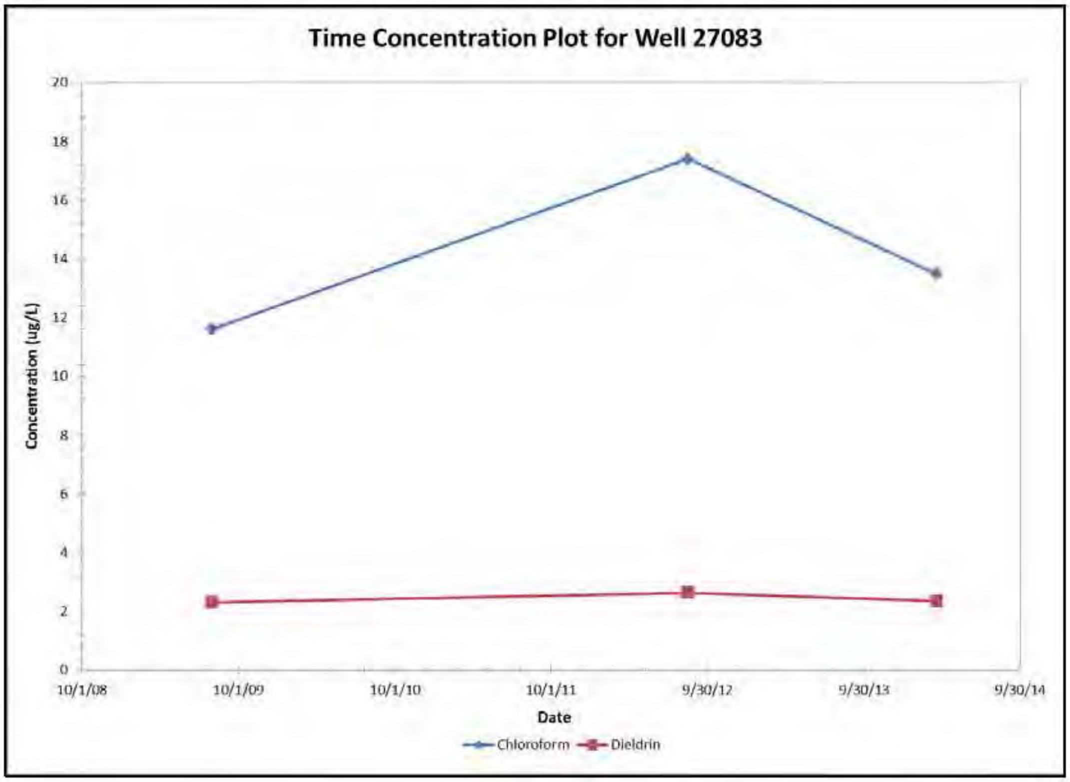

Time Concentration Plot for Well 27025
Concentration (ug/L)
10
1
0.1
0.01
0.001
Analyte found in blank as well as sample
10/1/2008
10/1/2009
10/1/2010
10/1/2011
9/30/2012
9/30/2013
9/30/2014
Date
Arsenic
Chloroform
Diisopropylmethyl phosphonate
Dieldrin
n-Nitrosodimethylamine
Open symbol indicates values less than the MRL

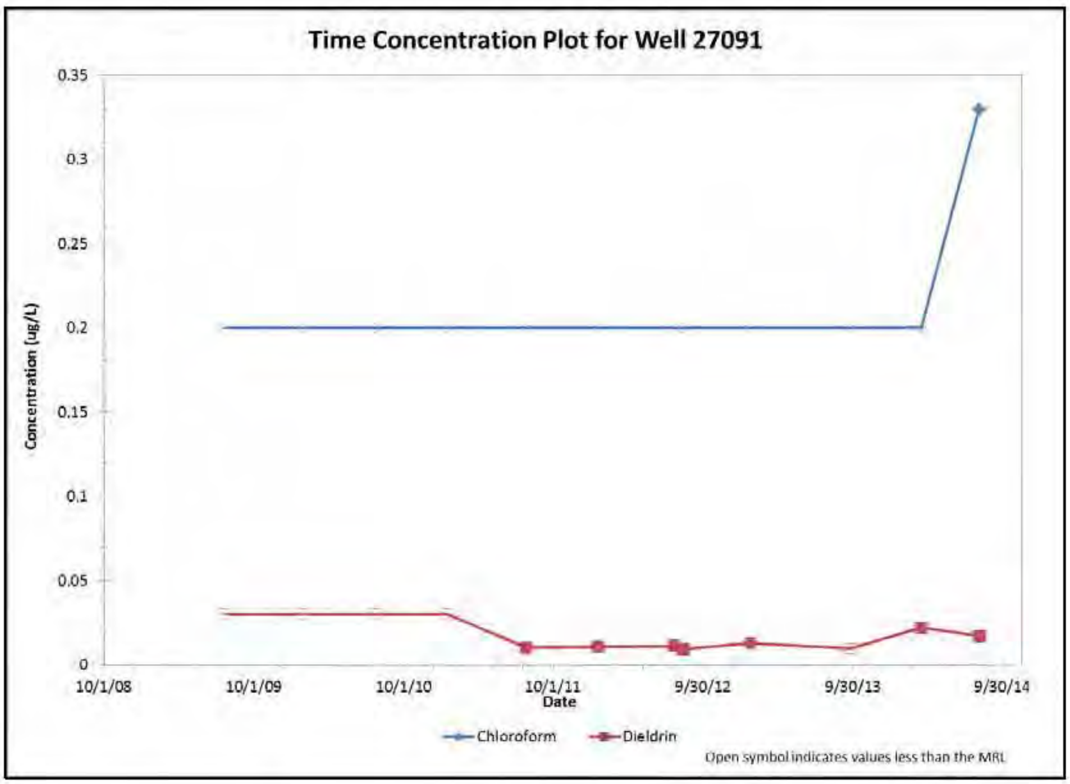

Time Concentration Plot for Well 27037
Concentration (ug/L)
10
1
0.1
10/1/08
10/1/09
10/1/10
10/1/11
9/30/12
9/30/13
9/30/14
Date
Chloroform
Dieldrin

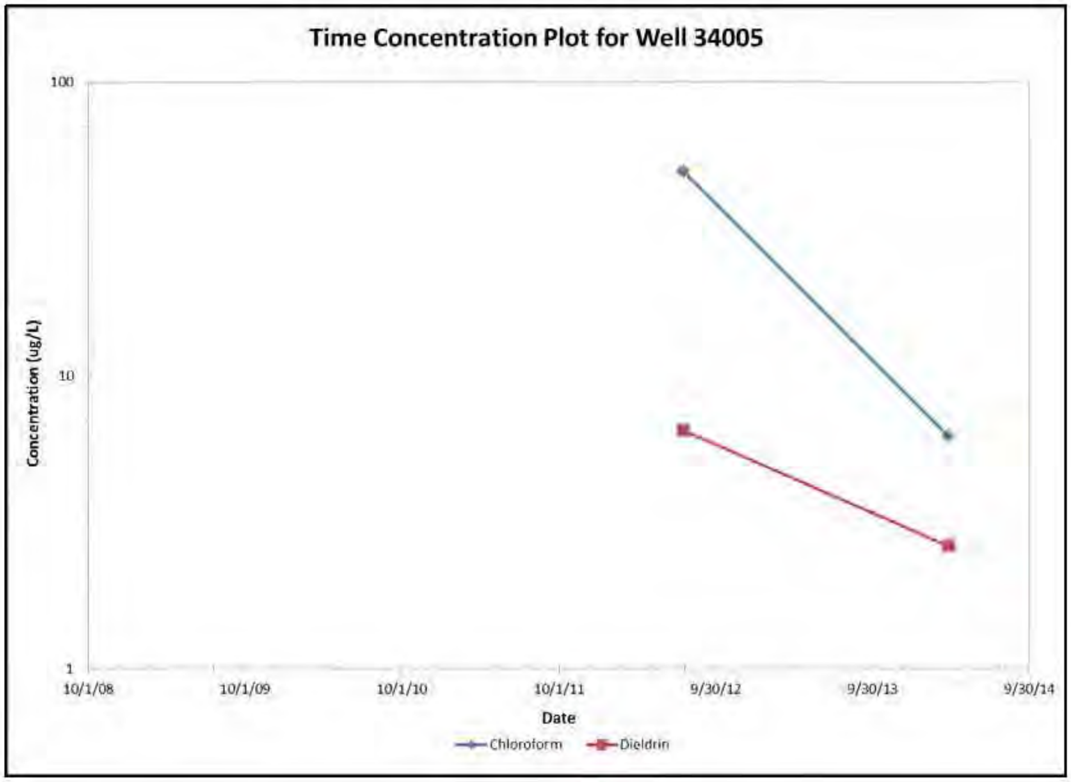

Time Concentration Plot for Well 27043
Concentration (ug/L)
1
0.1
0.01
0.001
10/1/08
10/1/09
10/1/10
10/1/11
9/30/12
9/30/13
9/30/14
Date
Dieldrin

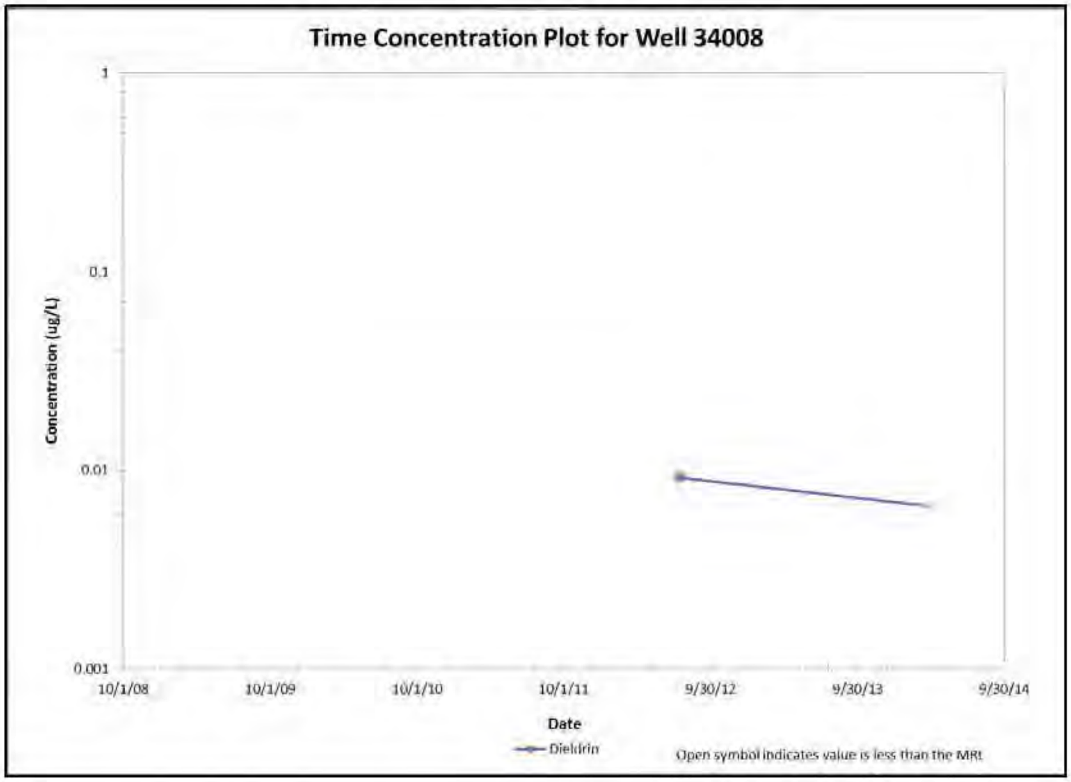

Time Concentration Plot for Well 27079
Concentration (ug/L)
10
1
0.1
10/1/08
10/1/09
10/1/10
10/1/11
9/30/12
9/30/13
9/30/14
Date
Arsenic
Chloroform
Dieldrin
Diisopropylmethyl phosphonate
Open symbol indicates value is less than the

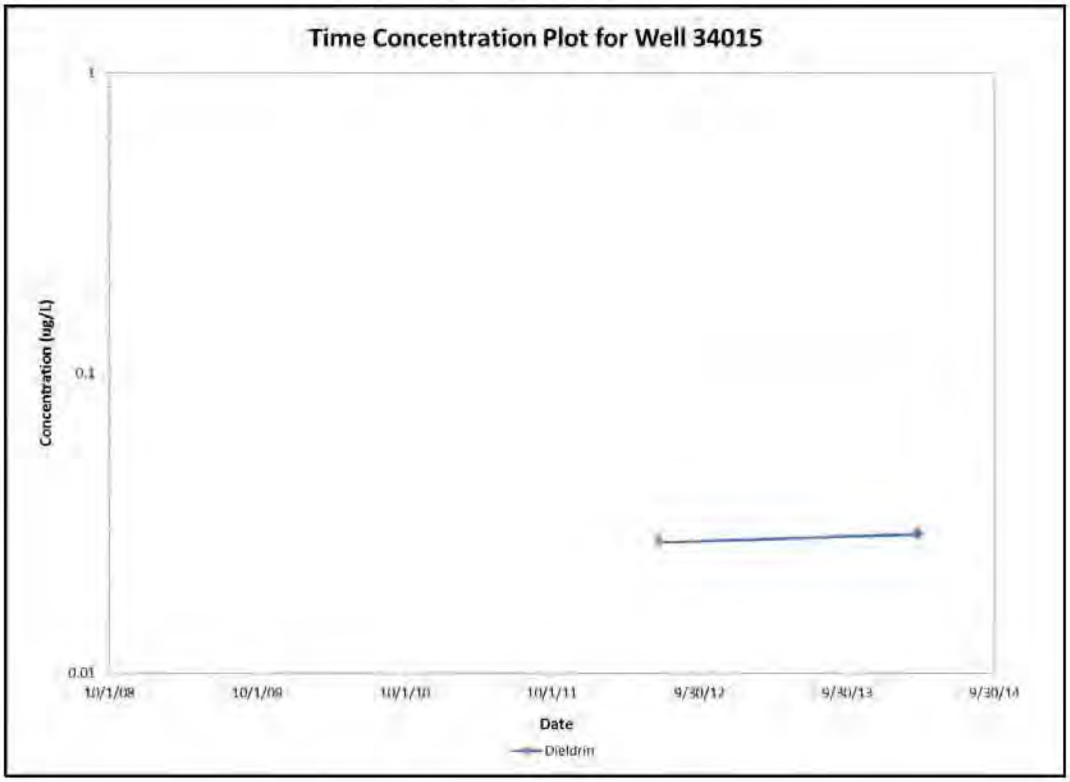

Time Concentration Plot for Well 27082
Concentration (ug/L)
10
1
0.1
0.01
0.001
Analyte found in blank as well as sample
10/1/08
10/1/09
10/1/10
10/1/11
9/30/12
9/30/13
9/30/14
Date
Arsenic
Chloroform
Diisopropylmethyl phosphonate
Dieldrin
n-Nitrosodimethylamine
Open symbol indicates value is less than the MRL

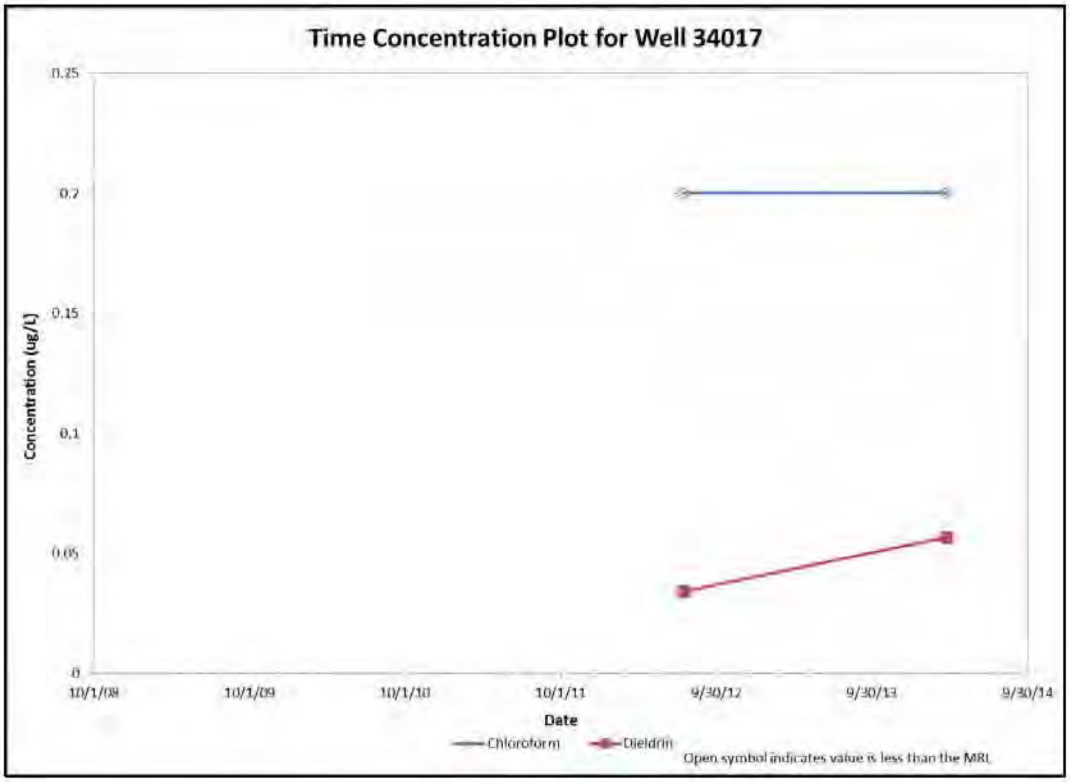

Time Concentration Plot for Well 27083
Concentration (ug/L)
20
18
16
14
12
10
8
6
4
2
0
10/1/08
10/1/09
10/1/10
10/1/11
9/30/12
9/30/13
9/30/14
Date
Chloroform
Dieldrin

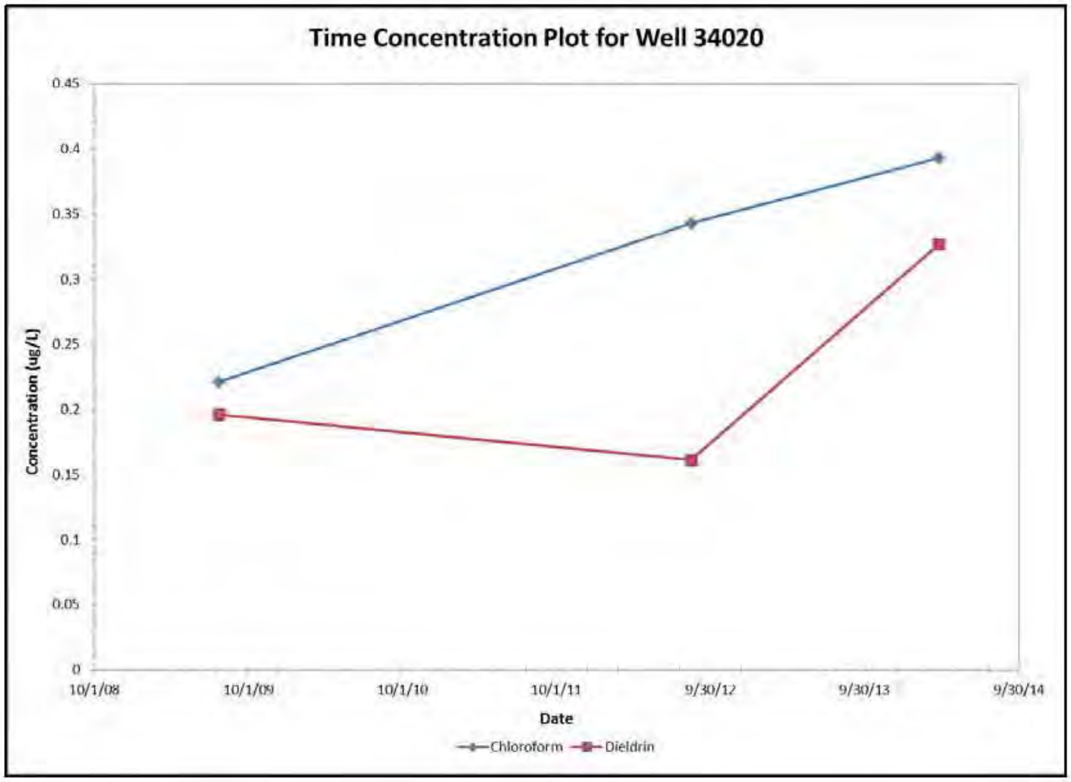

Time Concentration Plot for Well 27091
Concentration (ug/L)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
10/1/08
10/1/09
10/1/10
10/1/11
9/30/12
9/30/13
9/30/14
Date
Chloroform
Dieldrin
Open symbol indicates values less than the MRL

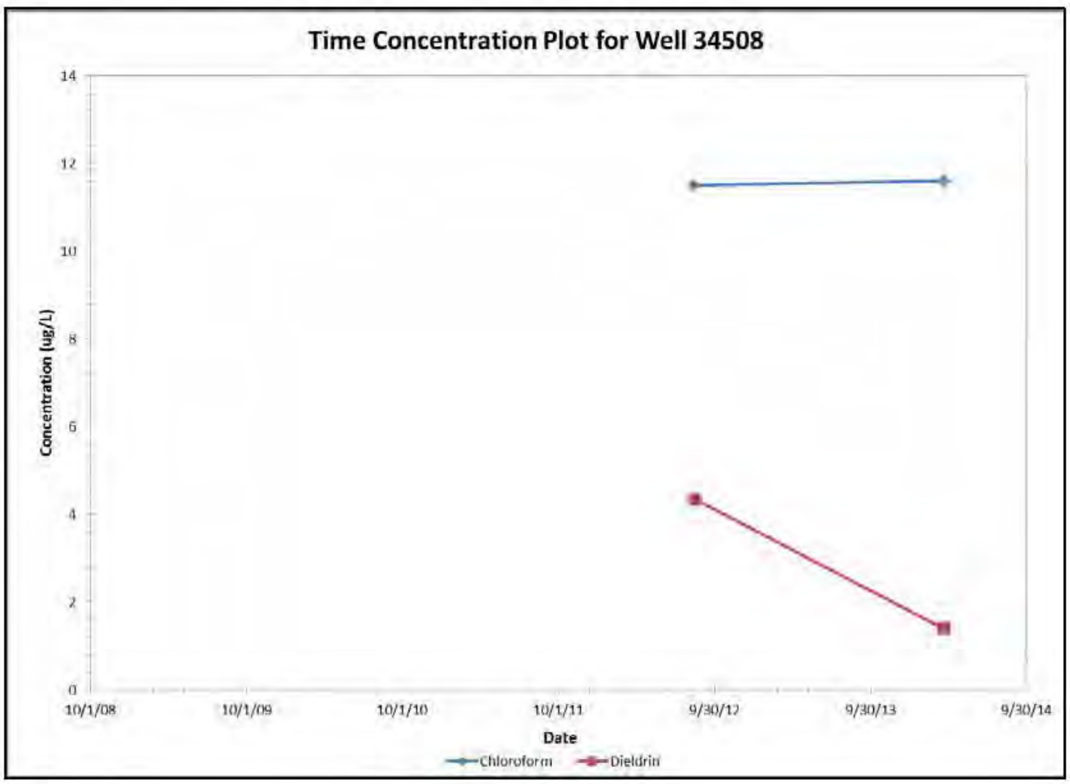

Time Concentration Plot for Well 34005
Concentration (ug/L)
100
10
1
10/1/08
10/1/09
10/1/10
10/1/11
9/30/12
9/30/13
9/30/14
Date
Chloroform
Dieldrin

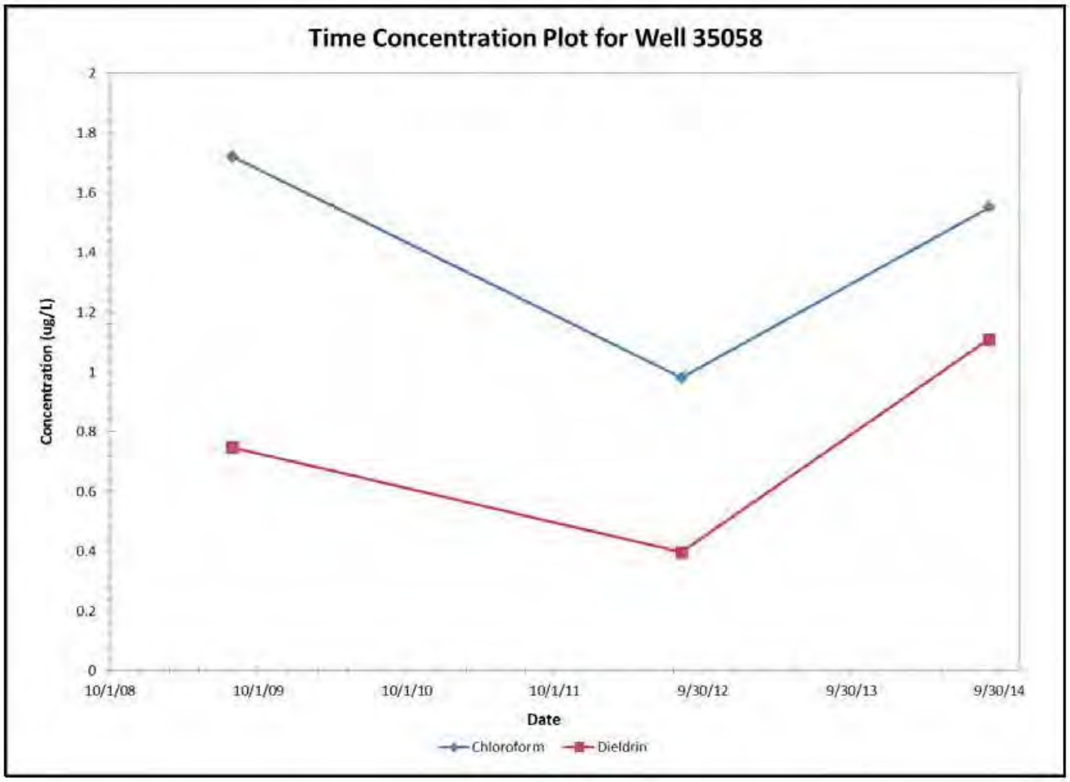

Time Concentration Plot for Well 34008
Concentration (ug/L)
1
0.1
0.01
0.001
10/1/08
10/1/09
10/1/10
10/1/11
9/30/12
9/30/13
9/30/14
Date
Dieldrin
Open symbol indicates value is less than the MRL


Time Concentration Plot for Well 34015
Concentration (ug/L)
1
0.1
0.01
10/1/08
10/1/09
10/1/10
10/1/11
9/30/12
9/30/13
9/30/14
Date
Dieldrin

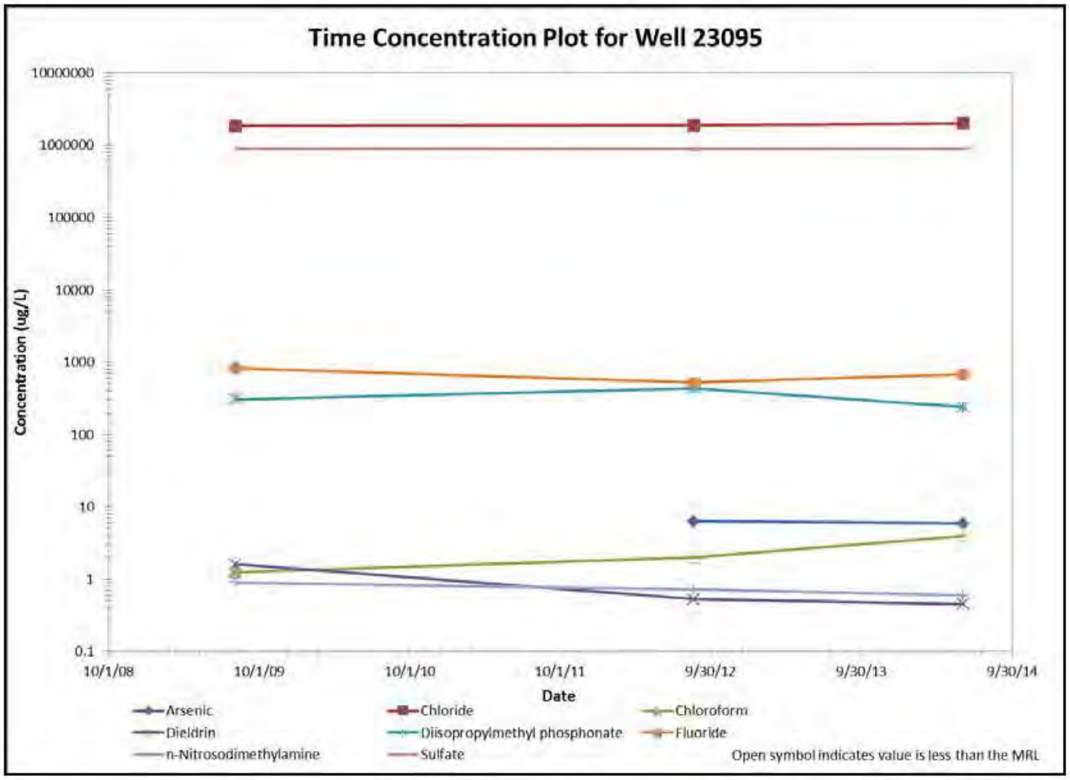

Time Concentration Plot for Well 34017
Concentration (ug/L)
0.25
0.2
0.15
0.1
0.05
0
10/1/08
10/1/09
10/1/10
10/1/11
9/30/12
9/30/13
9/30/14
Date
Chloroform
Dieldrin
Open symbol indicates value is less than the MRL

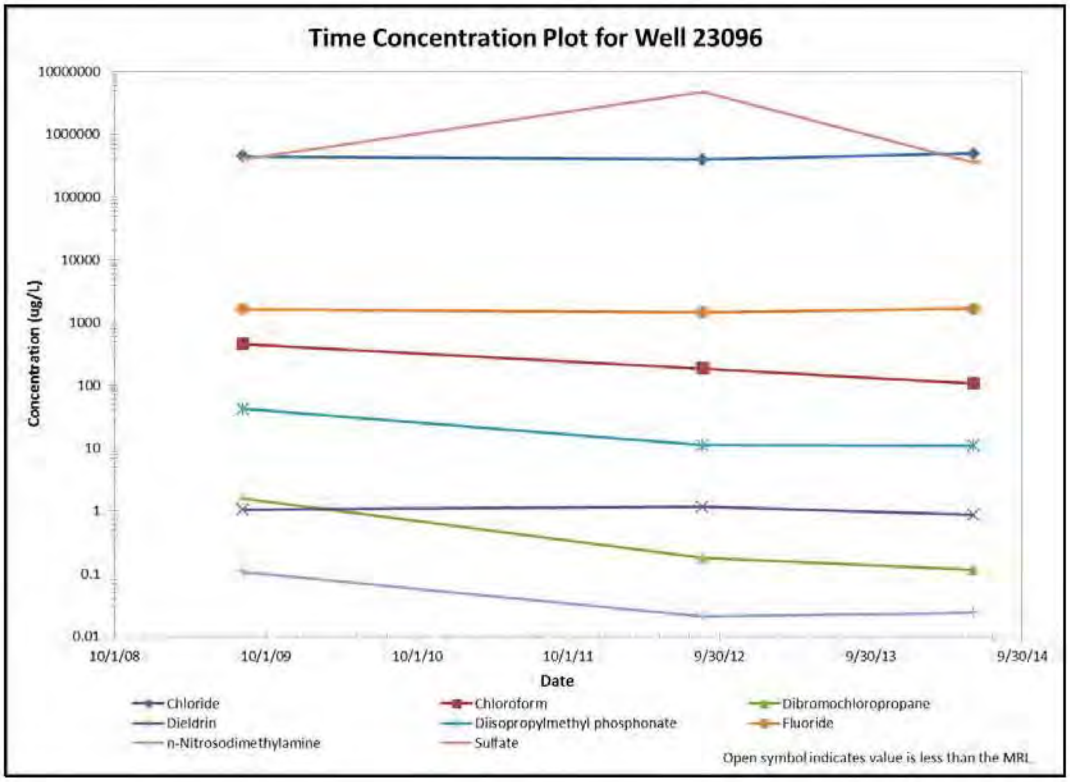

Time Concentration Plot for Well 34020
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Concentration (ug/L)
10/1/08
10/1/09
10/1/10
10/1/11
9/30/12
9/30/13
9/30/14
Date
Chloroform
Dieldrin

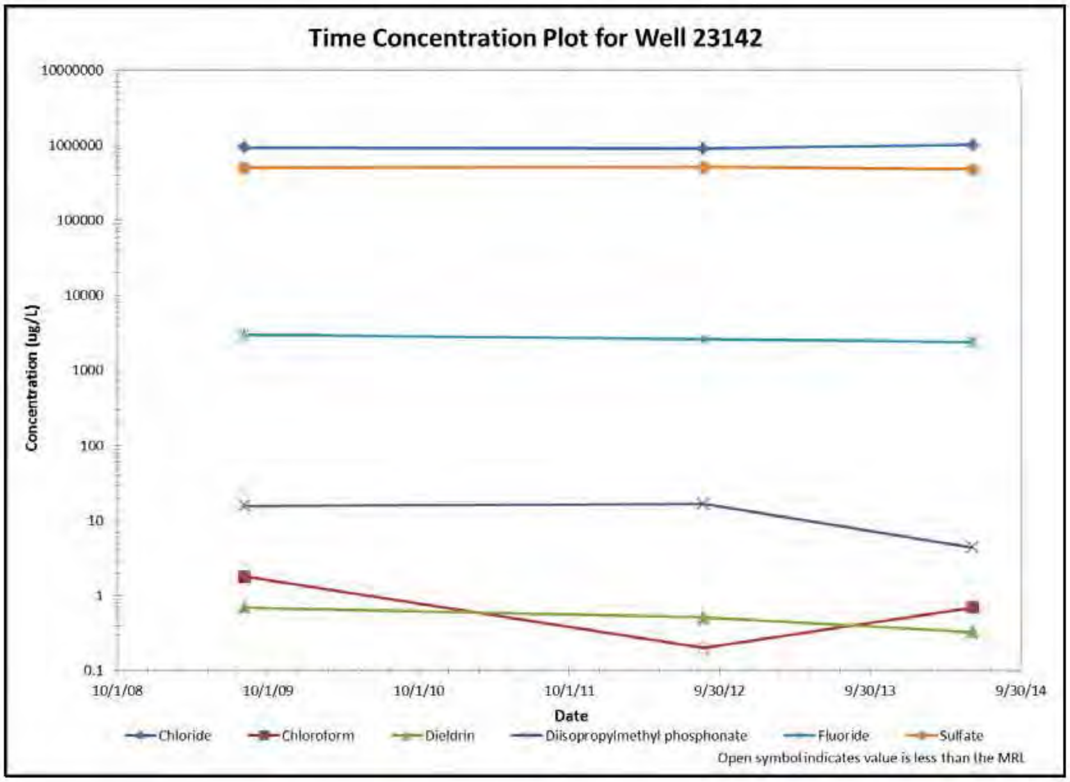

Time Concentration Plot for Well 34508
14
12
10
8
6
4
2
0
Concentration (ug/L)
10/1/08
10/1/09
10/1/10
10/1/11
9/30/12
9/30/13
9/30/14
Date
Chloroform
Dieldrin

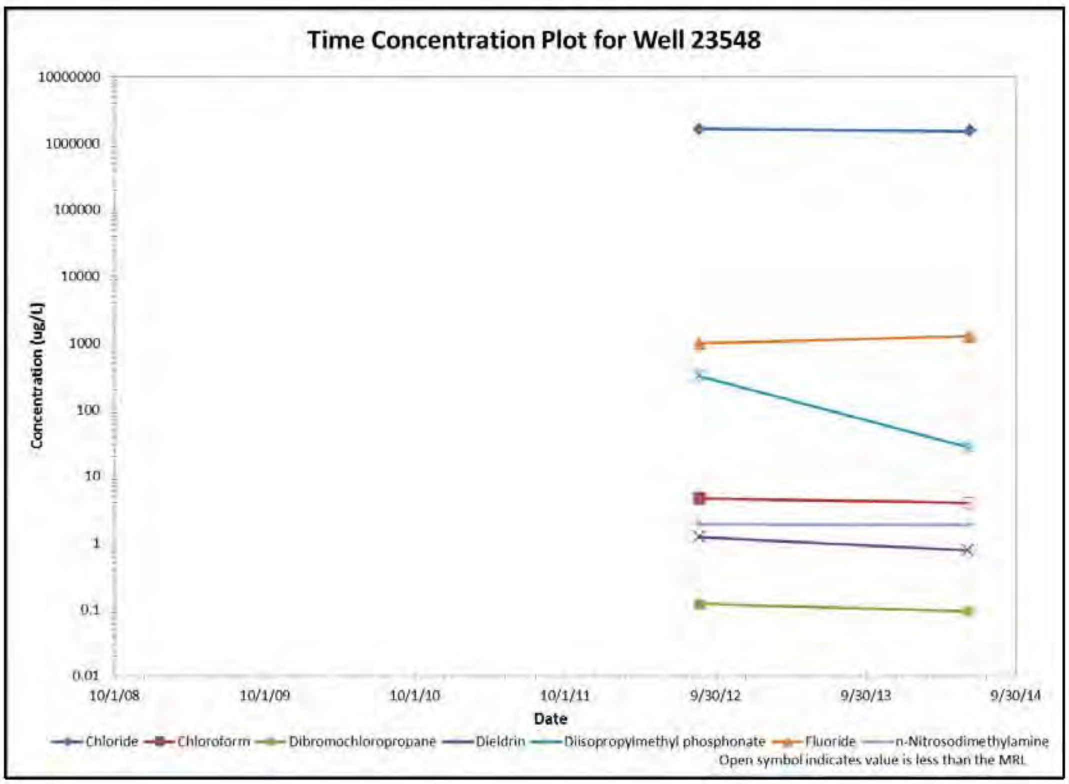

Time Concentration Plot for Well 35058
Concentration (ug/L)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
10/1/08
10/1/09
10/1/10
10/1/11
9/30/12
9/30/13
9/30/14
Date
Chloroform
Dieldrin

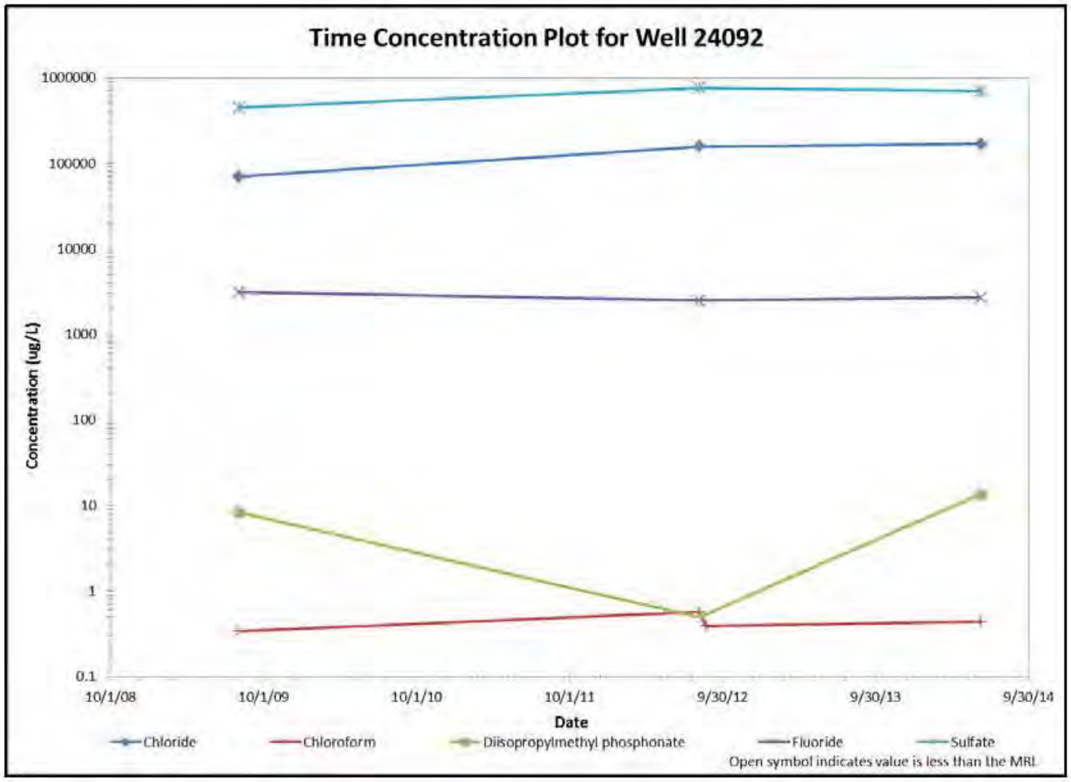
Upgradient of North Boundary Containment System

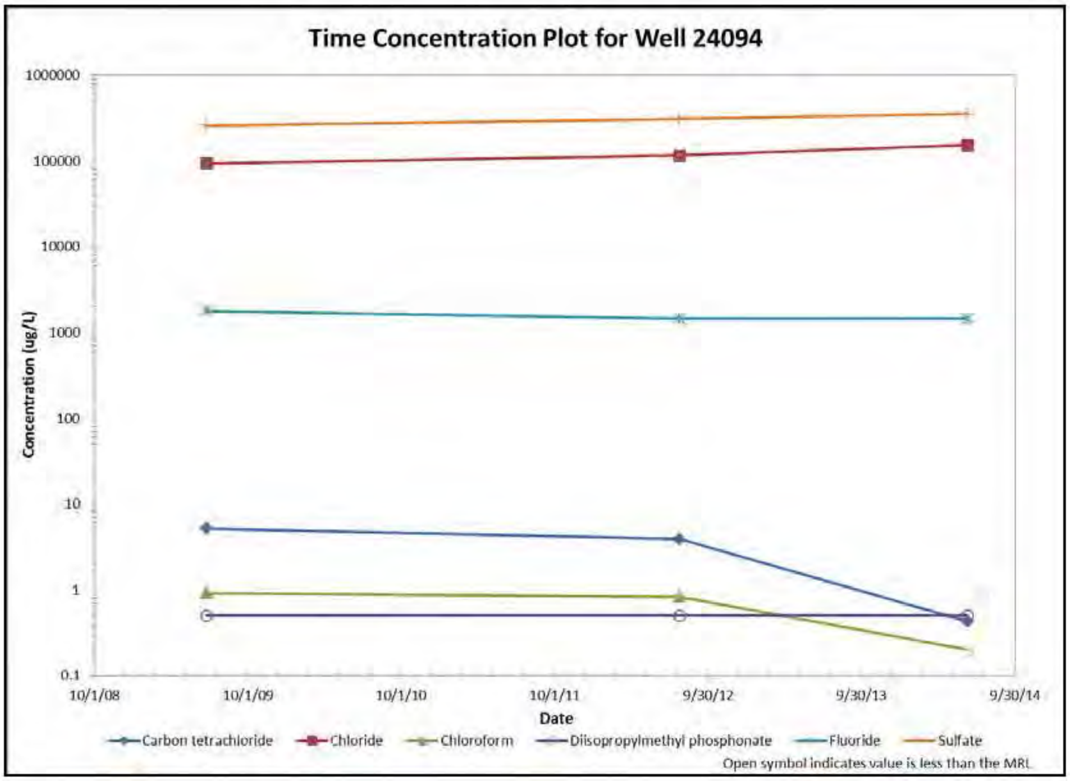




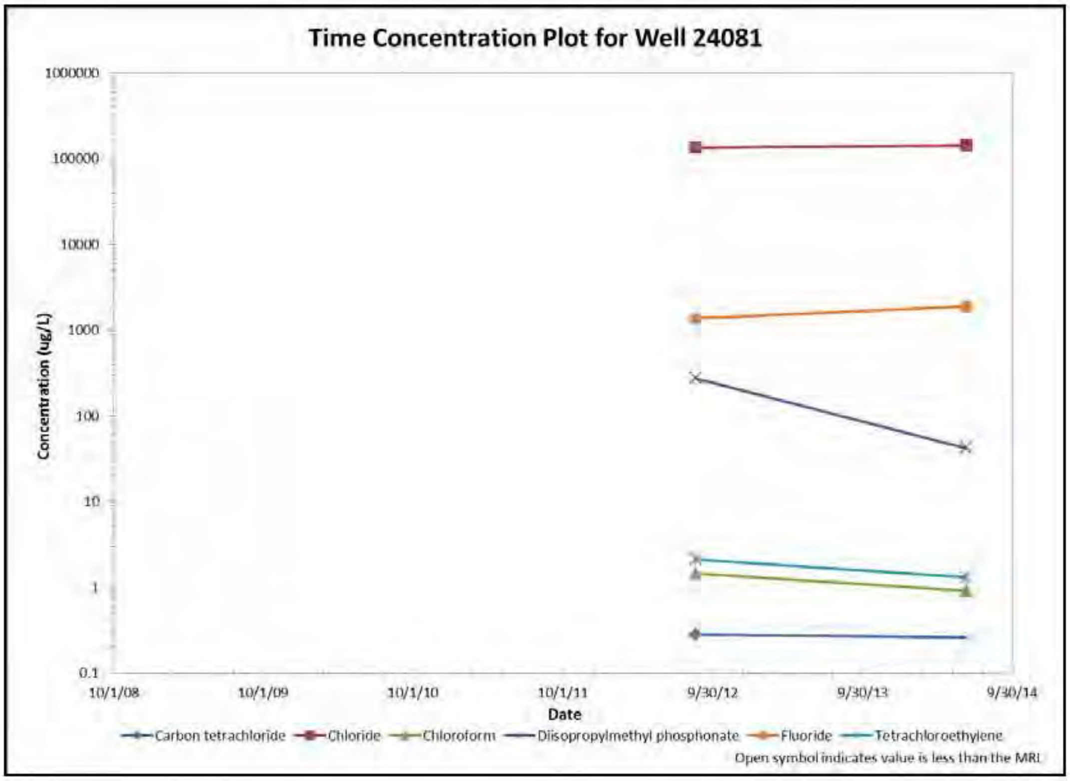

Time Concentration Plot for Well 23142
Concentration (ug/L)
10000000
1000000
100000
10000
1000
100
10
1
0.1
10/1/08
10/1/09
10/1/10
10/1/11
9/30/12
9/30/13
9/30/14
Date
Chloride
Chloroform
Dieldrin
Diisopropylmethyl phosphonate
Fluoride
Sulfate
Open symbol indicates value is less than the MRL

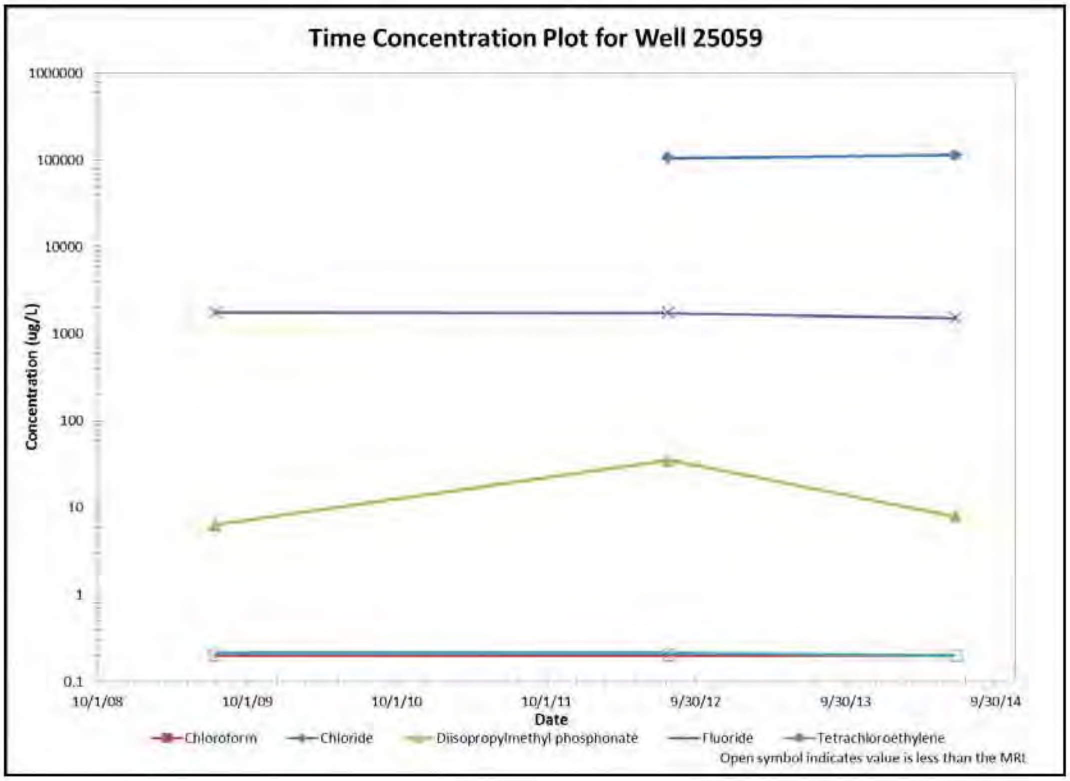

Time Concentration Plot for Well 23548
Concentration (ug/L)
10000000
1000000
100000
10000
1000
100
10
1
0.1
0.01
10/1/08
10/1/09
10/1/10
10/1/11
9/30/12
9/30/13
9/30/14
Date
Chloride
Chloroform
Dibromochloropropane
Dieldrin
Diisopropylmethyl phosphonate
Fluoride
n-Nitrosodimethylamine
Open symbol indicates value is less than the MRL


Time Concentration Plot for Well 24092
Concentration (ug/L)
1000000
100000
10000
1000
100
10
1
0.1
10/1/08
10/1/09
10/1/10
10/1/11
9/30/12
9/30/13
9/30/14
Date
Chloride
Chloroform
Diisopropylmethyl phosphonate
Fluoride
Sulfate
Open symbol indicates value is less than the MRL

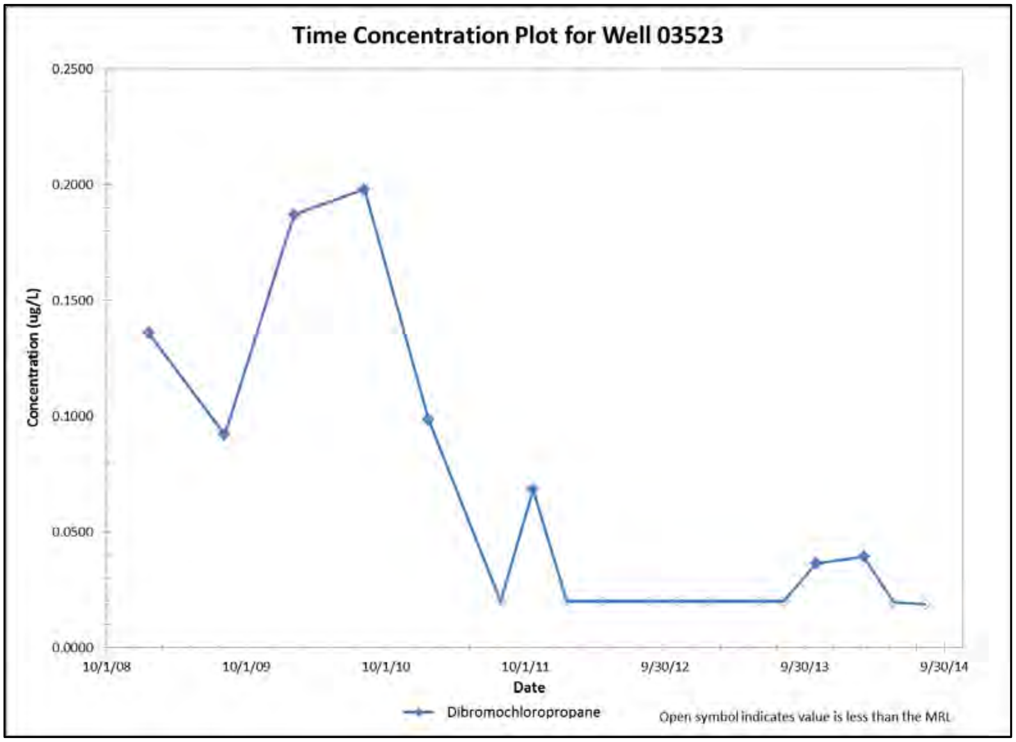

Time Concentration Plot for Well 24094
Concentration (ug/L)
1000000
100000
10000
1000
100
10
1
0.1
10/1/08
10/1/09
10/1/10
10/1/11
9/30/12
9/30/13
9/30/14
Date
Carbon tetrachloride
Chloride
Chloroform
Diisopropylmethyl phosphonate
Fluoride
Sulfate
Open symbol indicates value is less than the MRL

North Plants

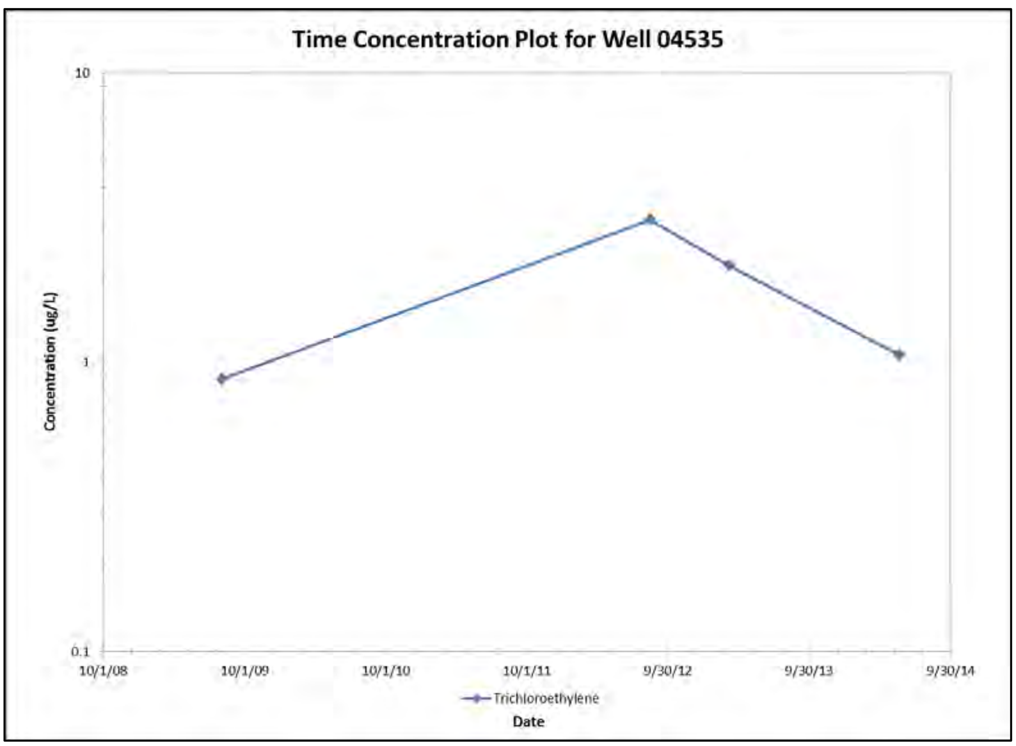




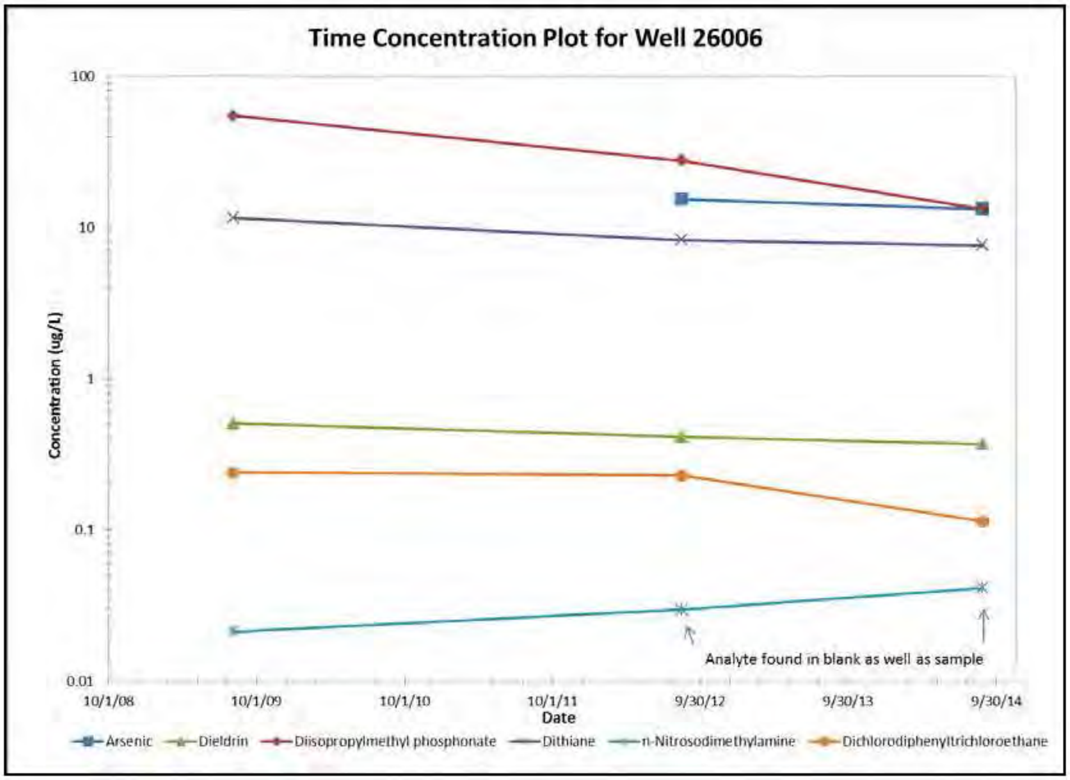
Railyard

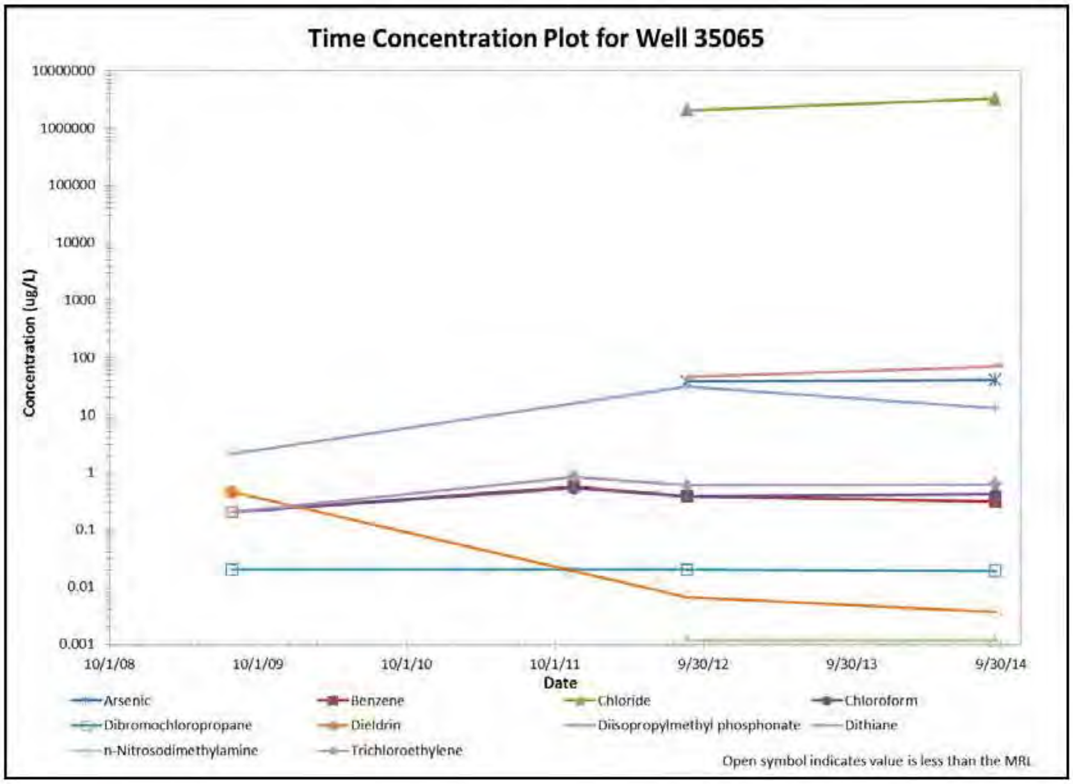


Motor Pool

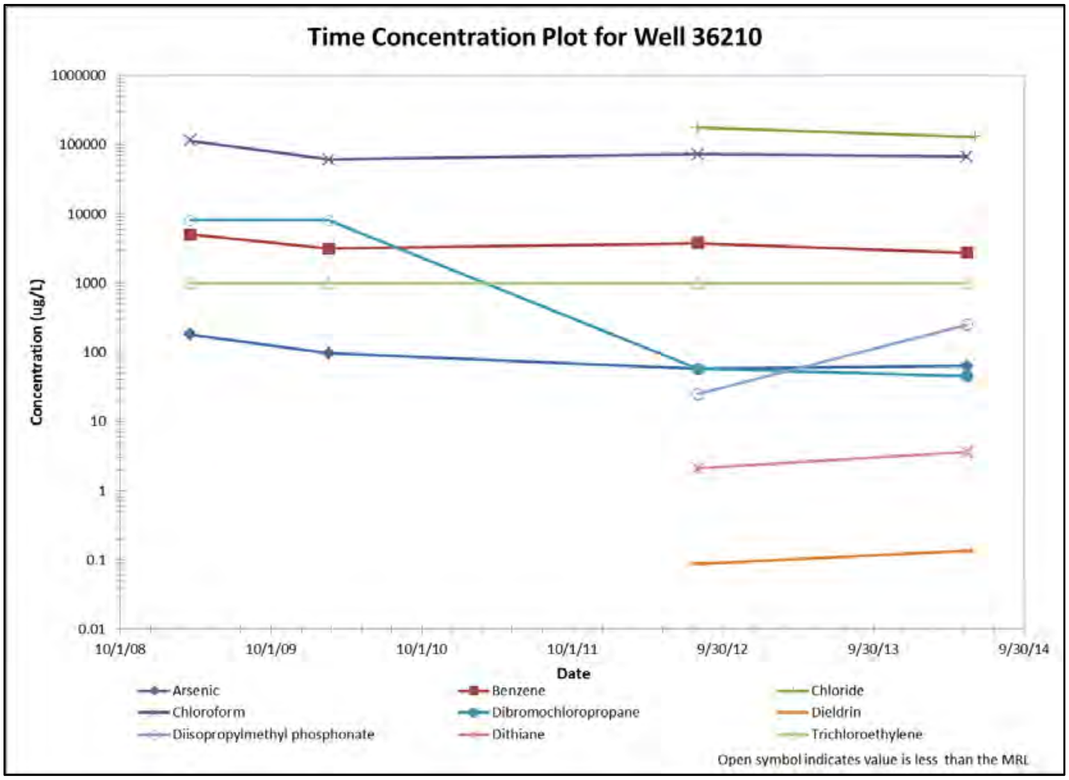


Basin A Neck

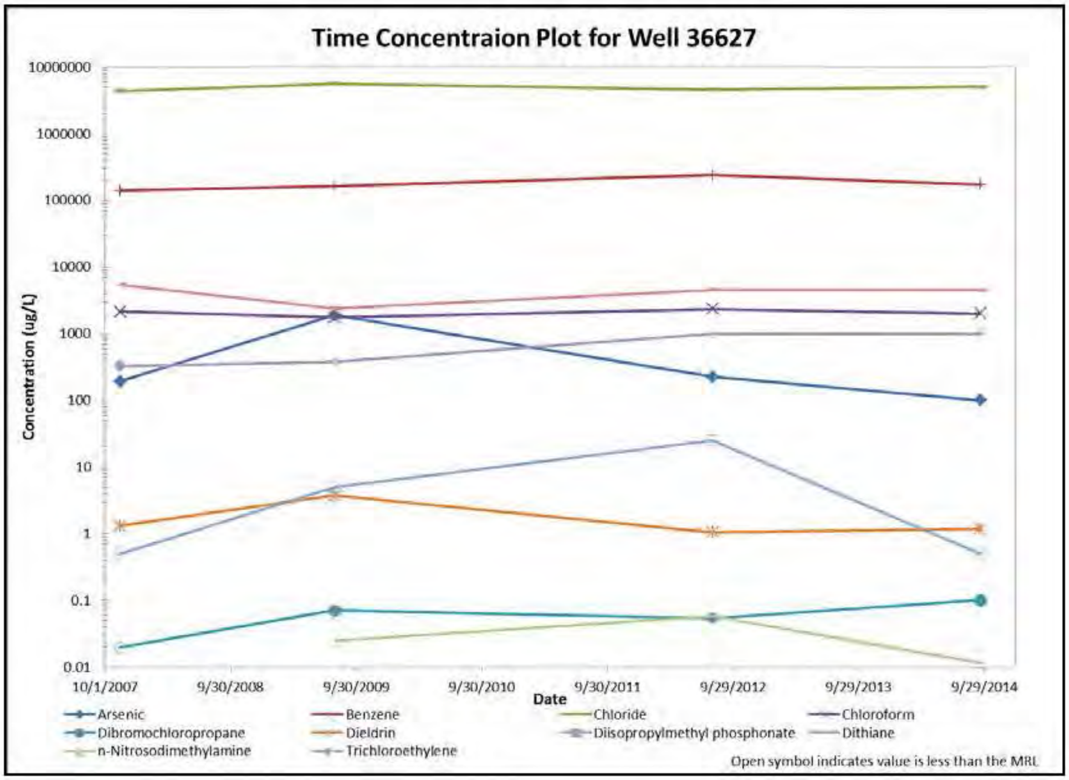

Time Concentration Plot for Well 26006
Concentration (ug/L)
100
10
1
0.1
0.01
10/1/08
10/1/09
10/1/10
10/1/11
9/30/12
9/30/13
9/30/14
Date
Analyte found in blank as well as sample
Arsenic
Dieldrin
Diisopropylmethyl phosphonate
Dithiane
n-Nitrosodimethylamine
Dichlorodiphenyltrichloroethane

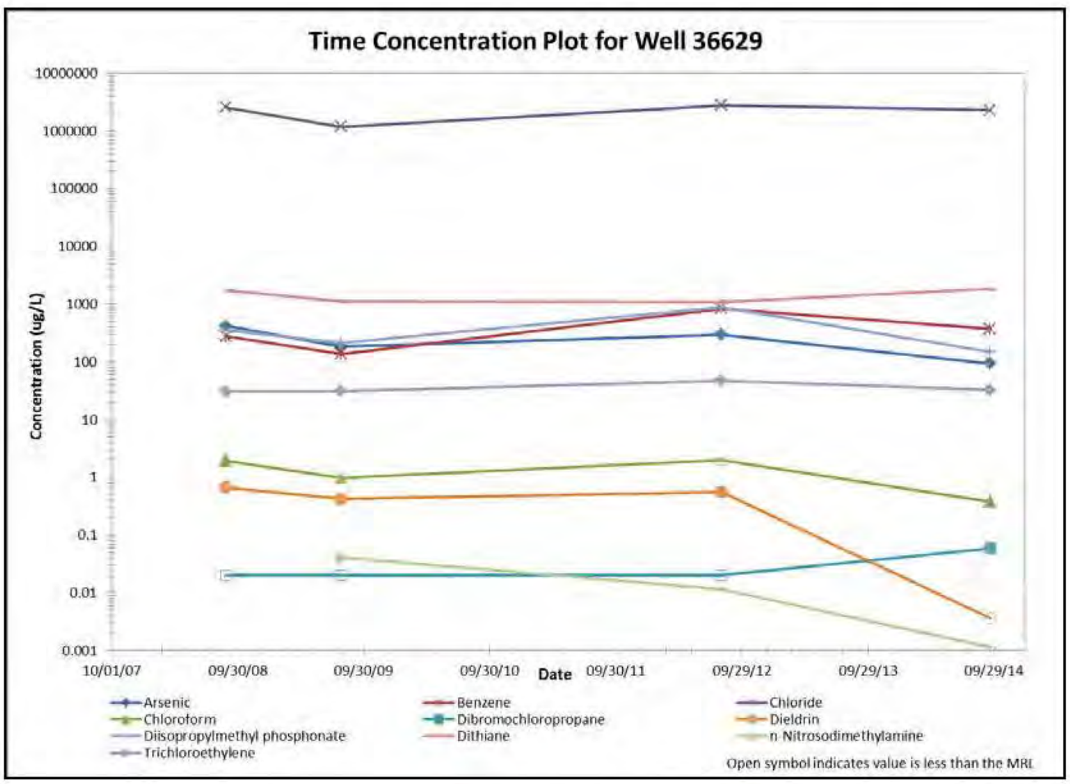

Time Concentration Plot for Well 35065
Concentration (ug/L)
10000000
1000000
100000
10000
1000
100
10
1
0.1
0.01
0.001
10/1/08
10/1/09
10/1/10
10/1/11
9/30/12
9/30/13
9/30/14
Date
Arsenic
Benzene
Chloride
Chloroform
Dibromochloropropane
Dieldrin
Diisopropylmethyl phosphonate
Dithiane
n-Nitrosodimethylamine
Trichloroethylene
Open symbol indicates value is less than the MRL

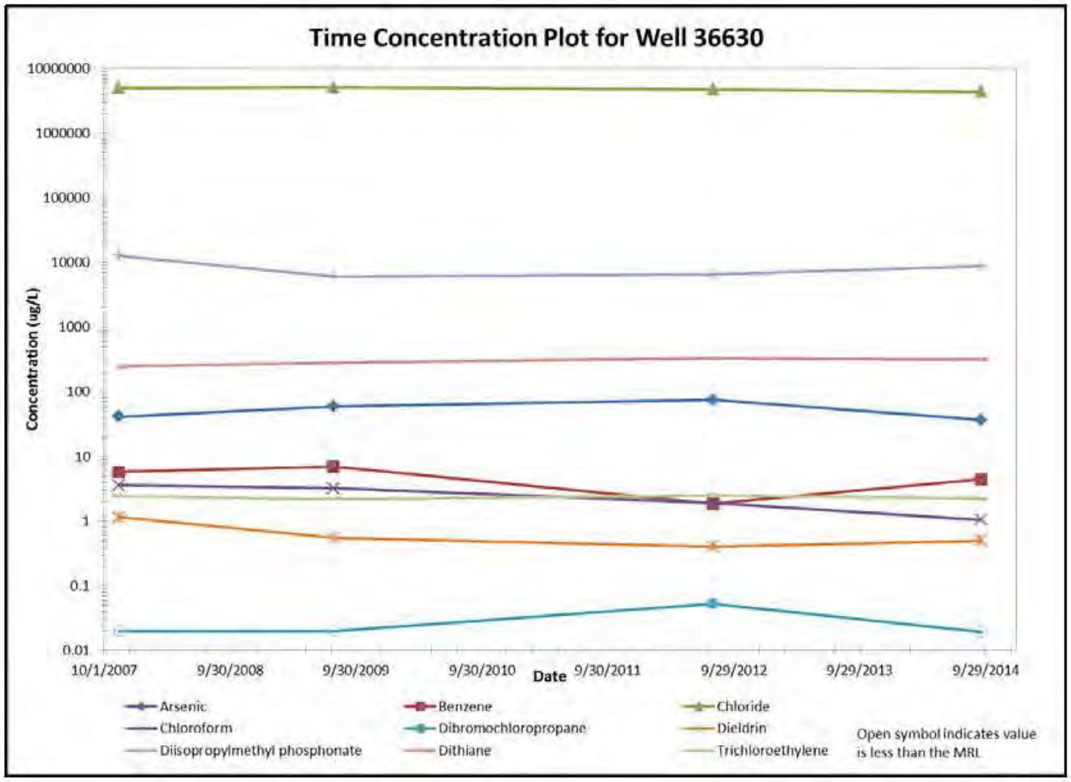
Lime Basins/Basin A

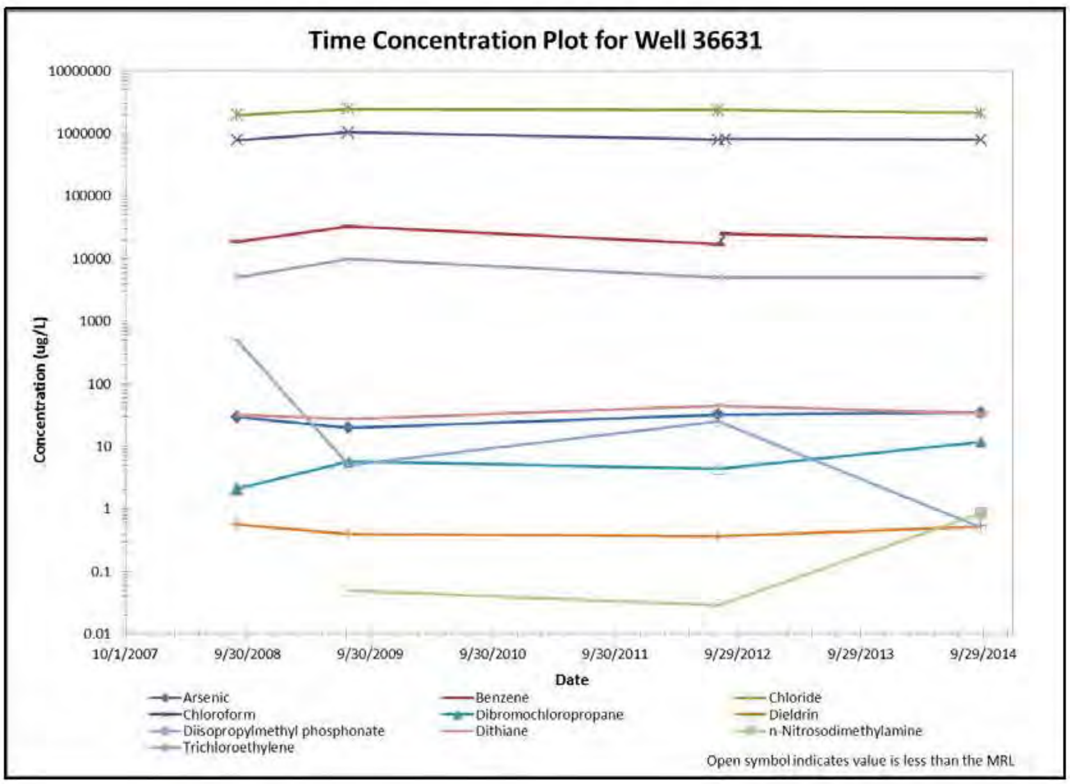


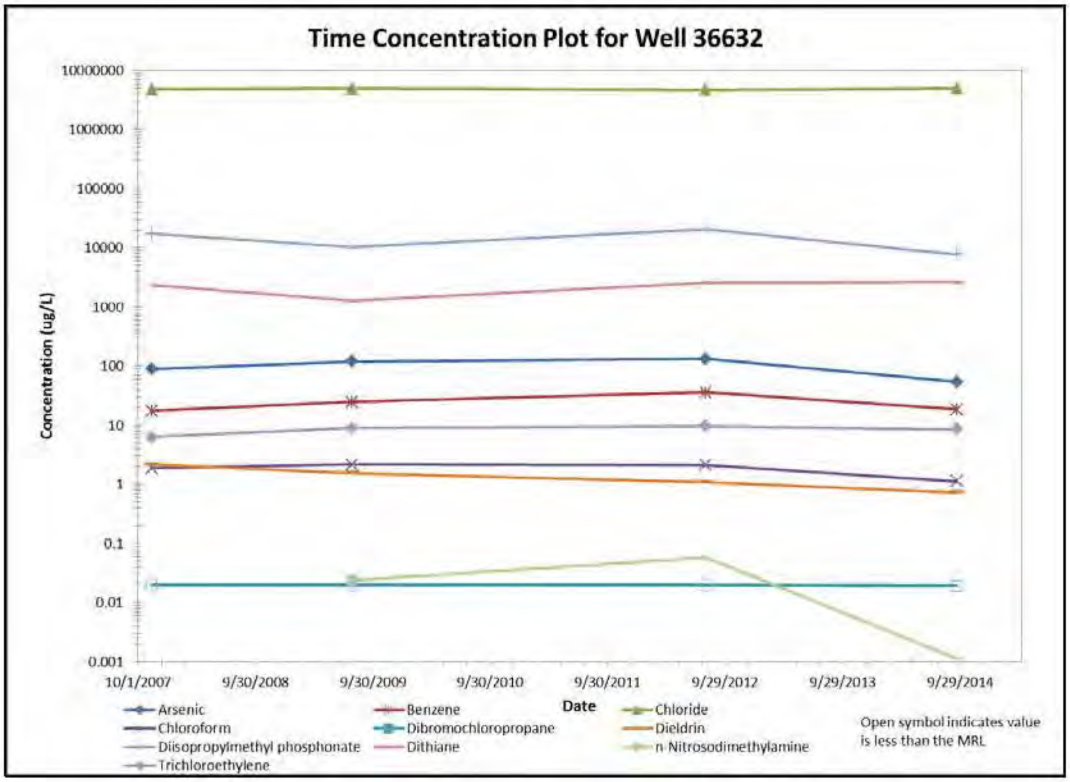
Basin A Source

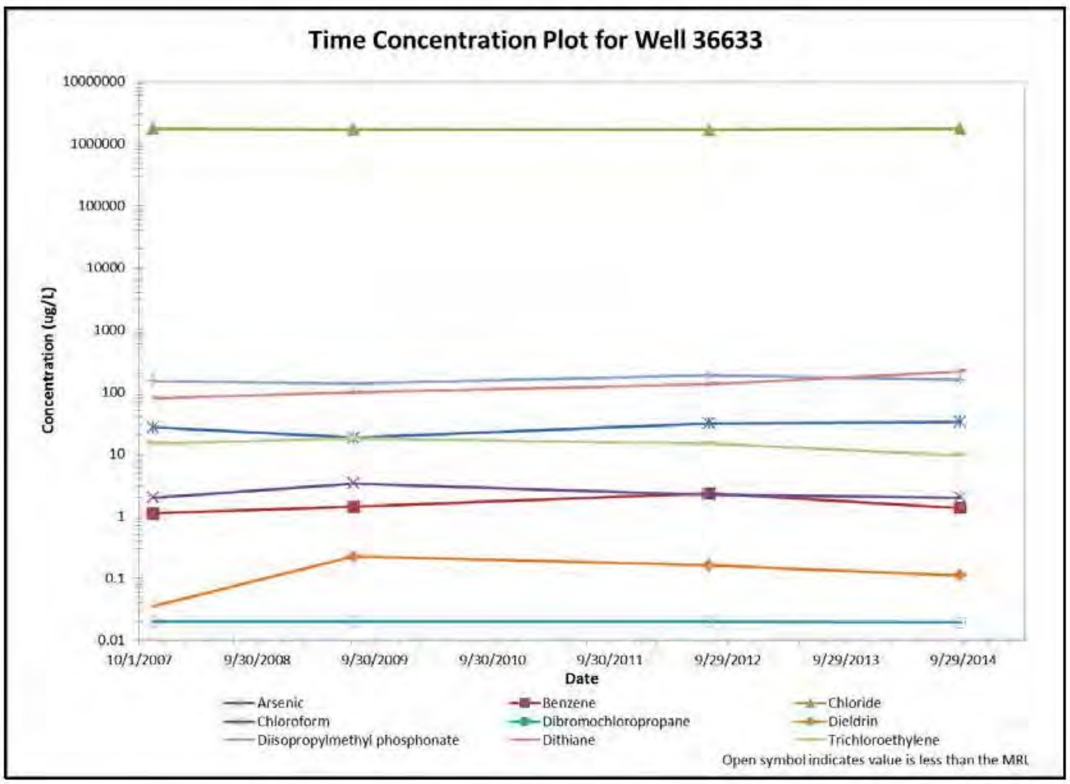




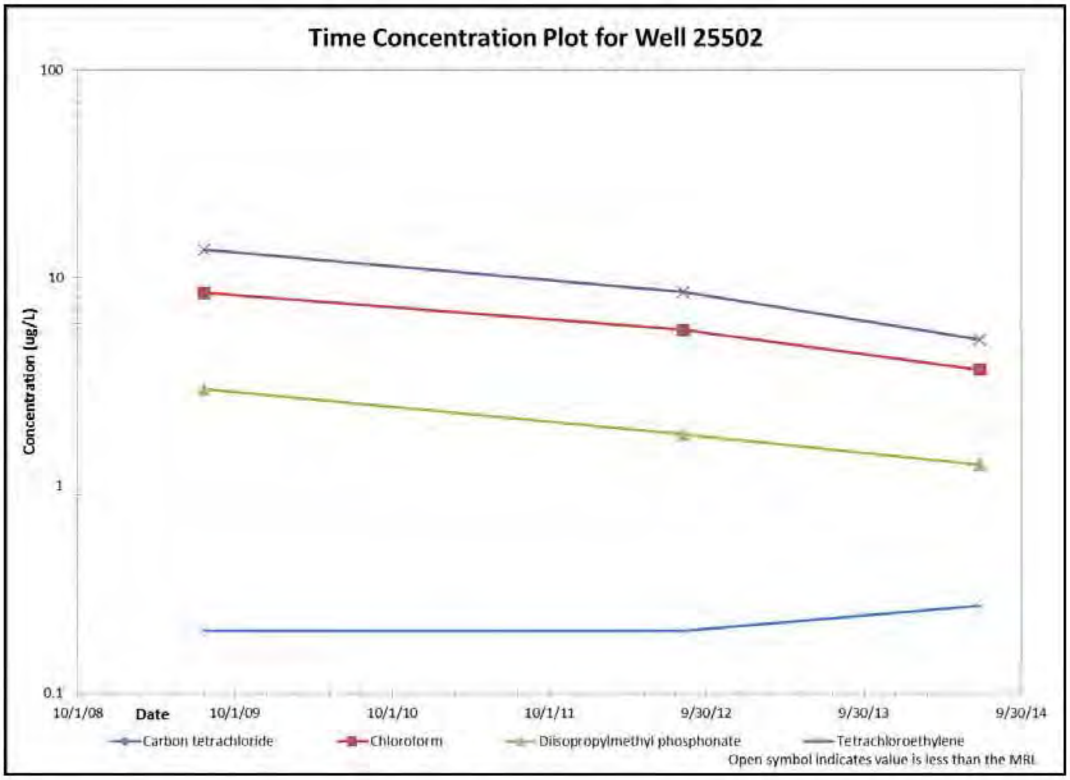

Time Concentration Plot for Well 36630
Concentration (ug/L)
Date
10000000
1000000
100000
10000
1000
100
10
1
0.1
0.01
10/1/2007
9/30/2008
9/30/2009
9/30/2010
9/30/2011
9/29/2012
9/29/2013
9/29/2014
Arsenic
Benzene
Chloride
Chloroform
Dibromochloropropane
Dieldrin
Diisopropylmethyl phosphonate
Dithiane
Trichloroethylene
Open symbol indicates value is less than the MRL

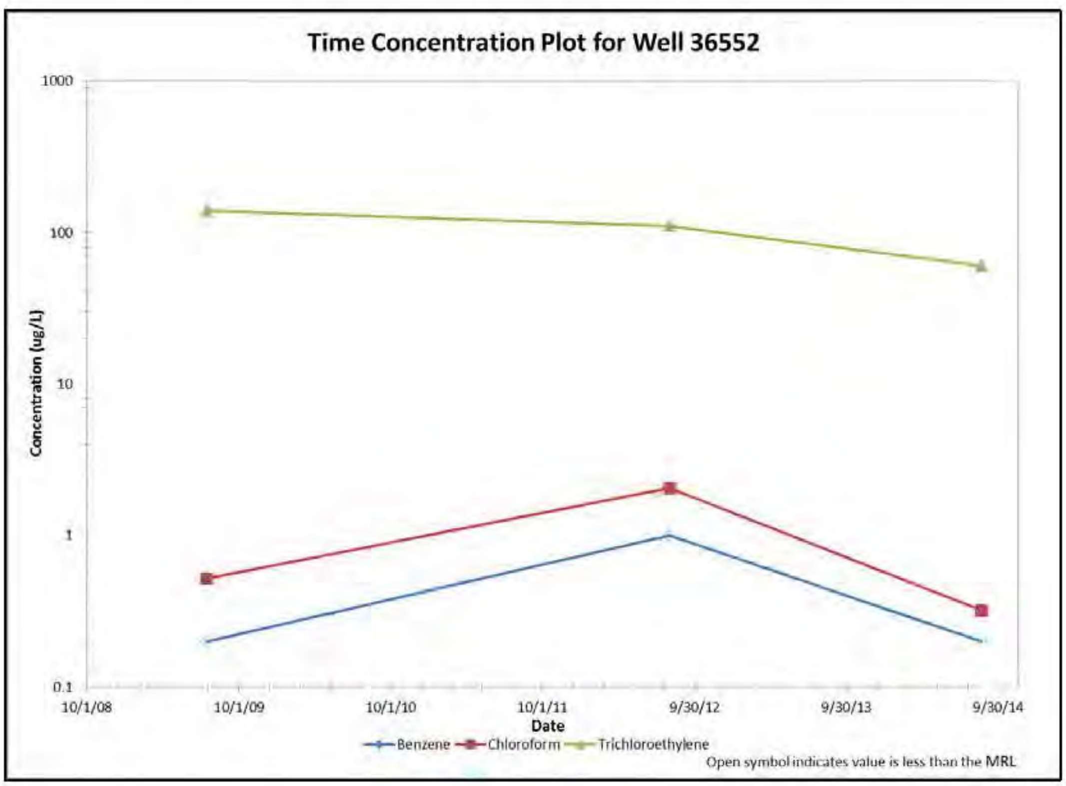

Time Concentration Plot for Well 36631
Concentration (ug/L)
Date
10000000
1000000
100000
10000
1000
100
10
1
0.1
0.01
10/1/2007
9/30/2008
9/30/2009
9/30/2010
9/30/2011
9/29/2012
9/29/2013
9/29/2014
Arsenic
Benzene
Chloride
Chloroform
Dibromochloropropane
Dieldrin
Diisopropylmethyl phosphonate
Dithiane
n-Nitrosodimethylamine
Trichloroethylene
Open symbol indicates value is less than the MRL

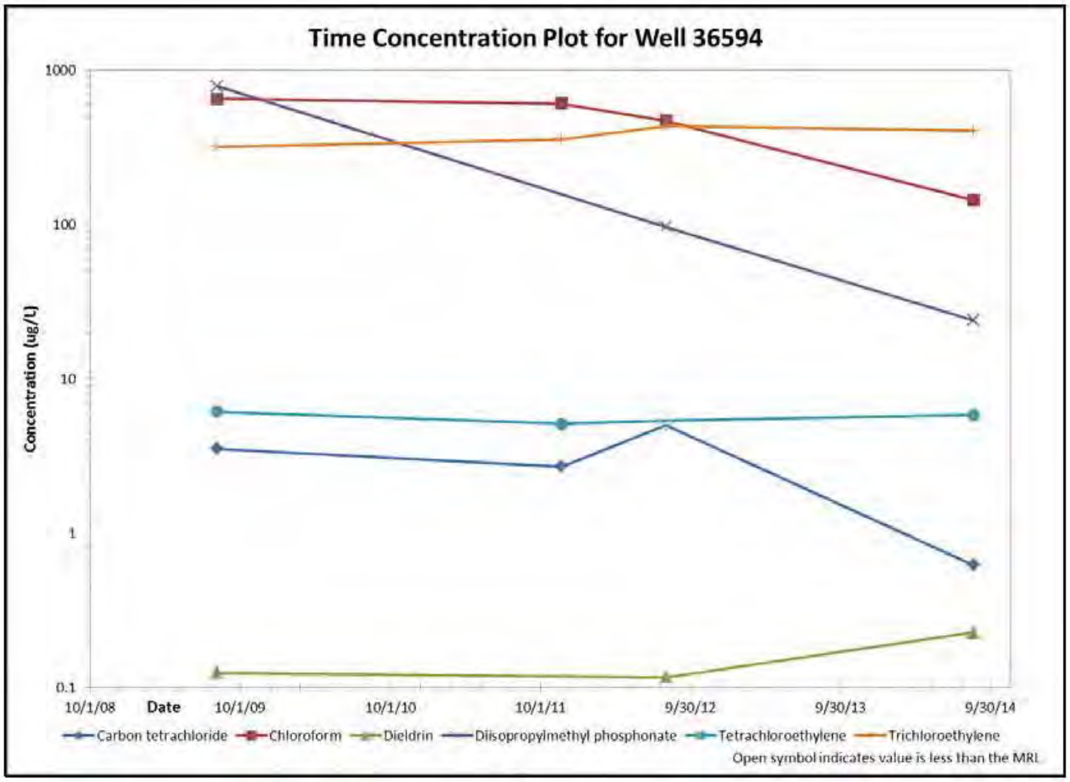

Time Concentration Plot for Well 36632
Concentration (ug/L)
10000000
1000000
100000
10000
1000
100
10
1
0.1
0.01
0.001
10/1/2007
9/30/2008
9/30/2009
9/30/2010
9/30/2011
9/29/2012
9/29/2013
9/29/2014
Date
Arsenic
Benzene
Chloride
Chloroform
Dibromochloropropane
Dieldrin
Diisopropylmethyl phosphonate
Dithiane
n-Nitrosodimethylamine
Trichloroethylene
Open symbol indicates value is less than the MRL


Time Concentration Plot for Well 36633
Concentration (ug/L)
10000000
1000000
100000
10000
1000
100
10
1
0.1
0.01
10/1/2007
9/30/2008
9/30/2009
9/30/2010
9/30/2011
9/29/2012
9/29/2013
9/29/2014
Date
Arsenic
Benzene
Chloride
Chloroform
Dibromochloropropane
Dieldrin
Diisopropylmethyl phosphonate
Dithiane
Trichloroethylene
Open symbol indicates value is less than the MRL

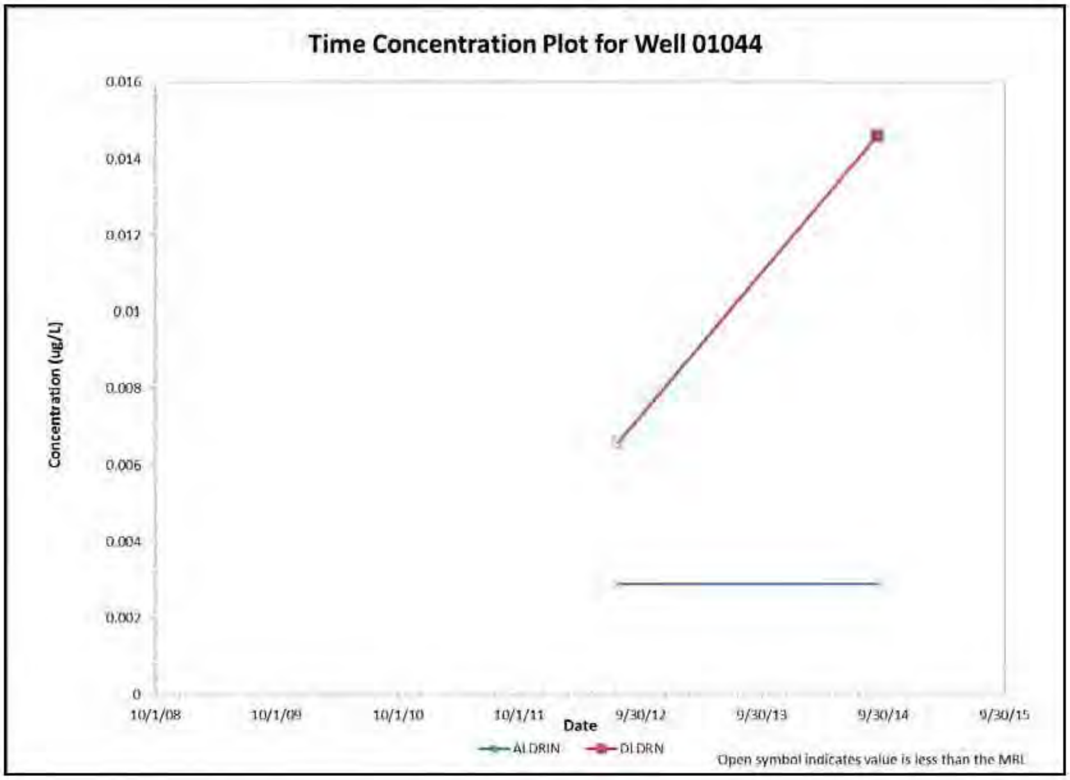
Bedrock Ridge

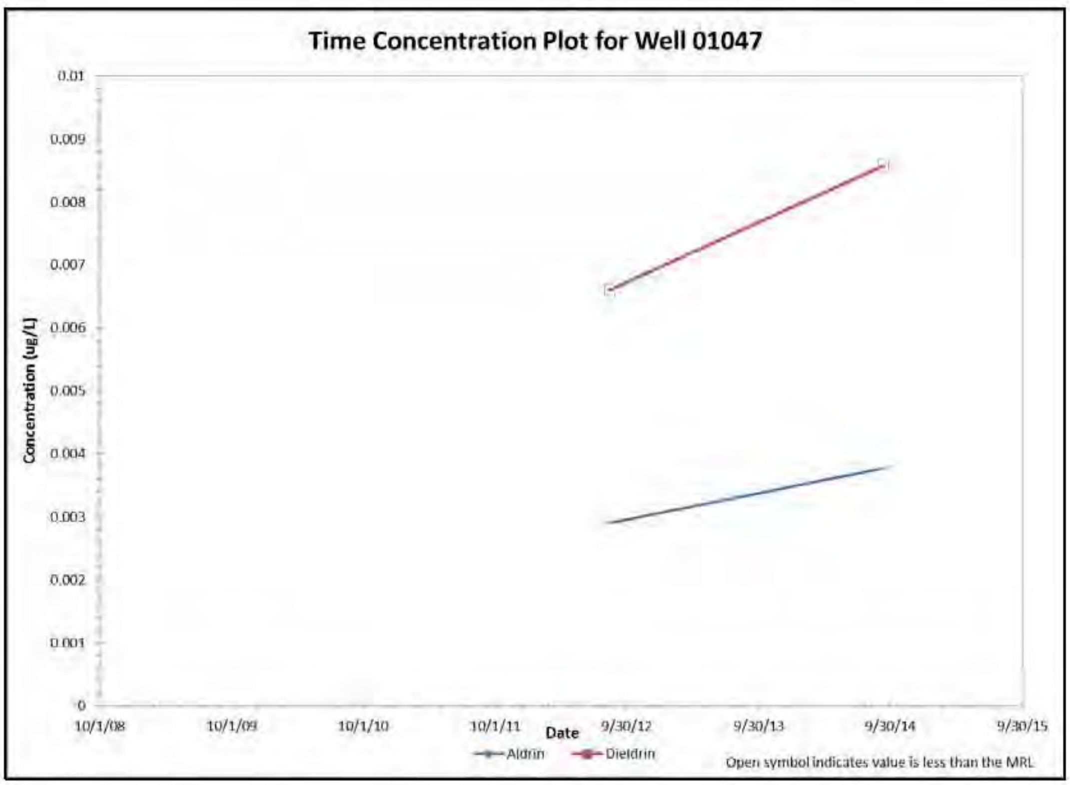


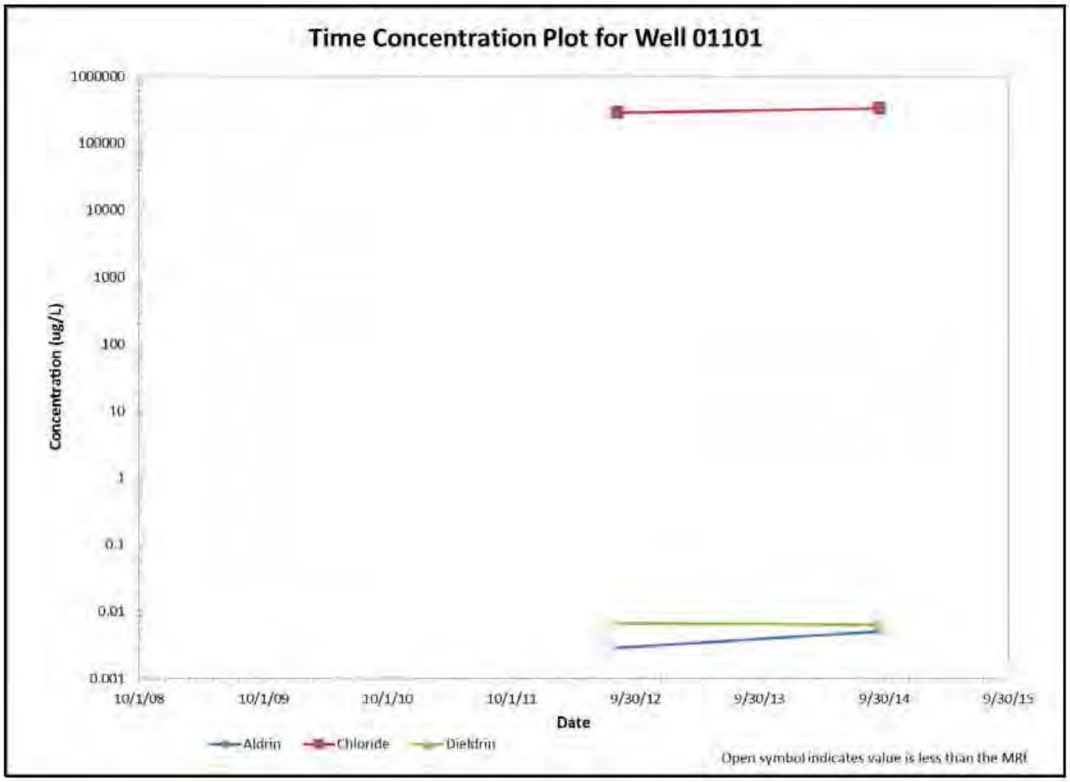


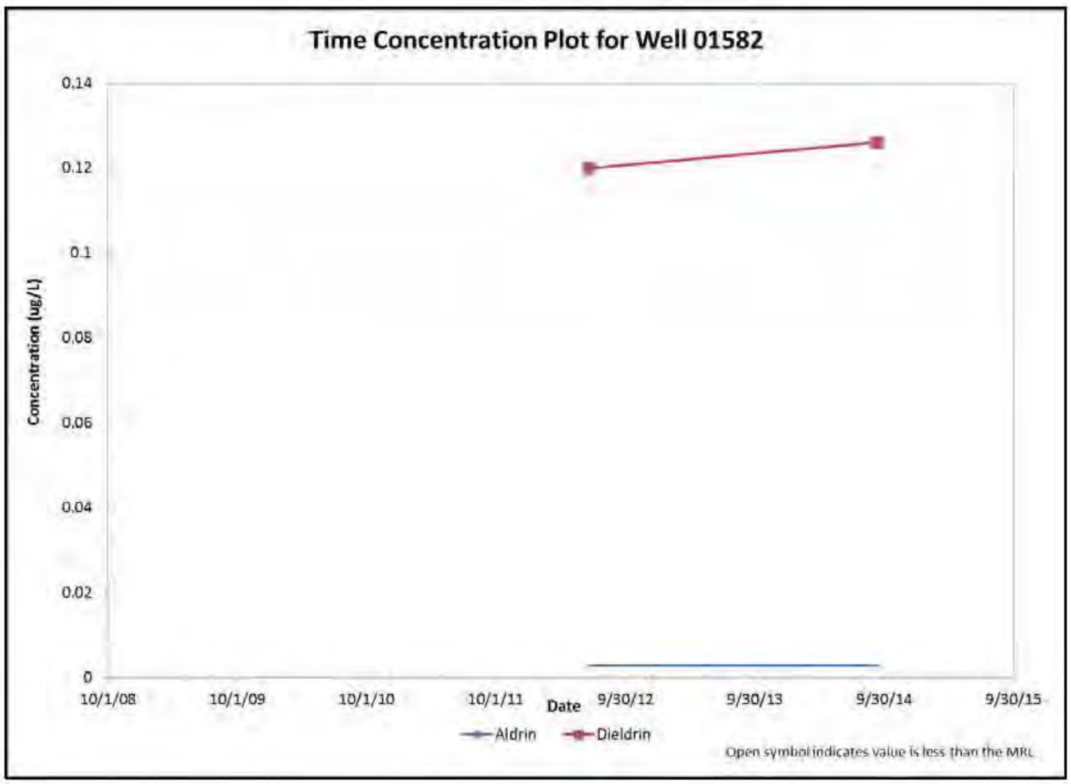

Time Concentration Plot for Well 36594
1000
100
10
1
0.1
Concentration (ug/L)
10/1/08
Date
10/1/09
10/1/10
10/1/11
9/30/12
9/30/13
9/30/14
Carbon tetrachloride
Chloroform
Dieldrin
Diisopropylmethyl phosphonate
Tetrachloroethylene
Trichloroethylene
Open symbol indicates value is less than the MRL

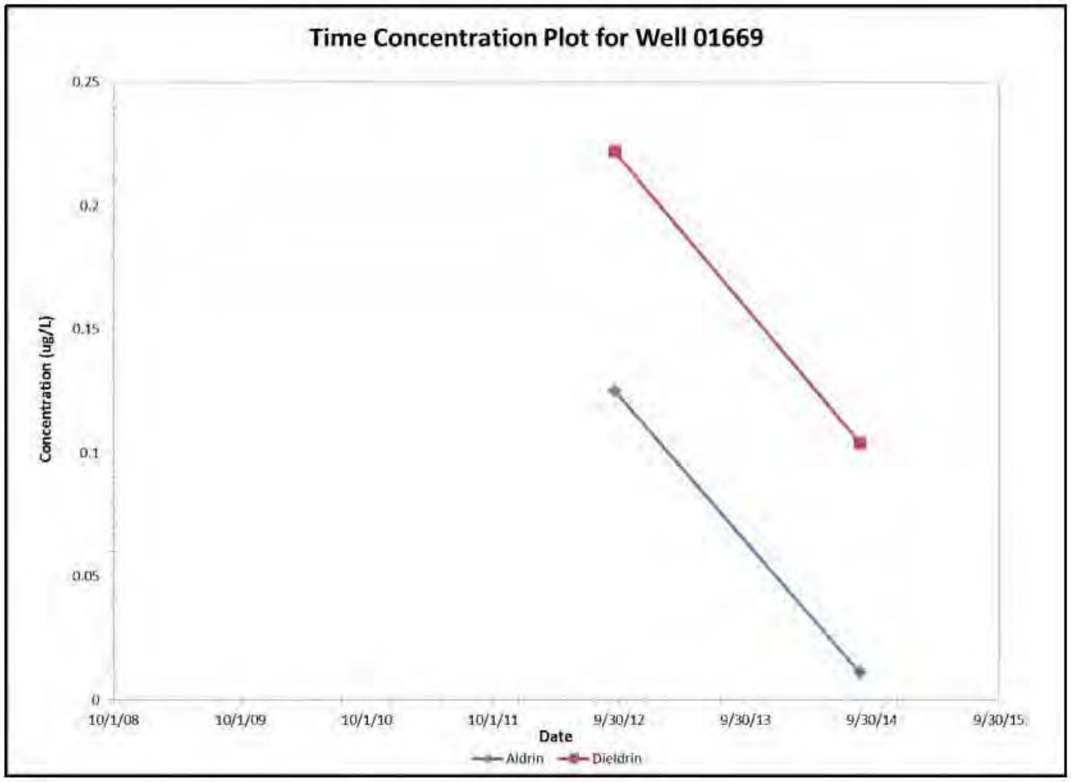
South Plants SPSA-2d Ditch Source

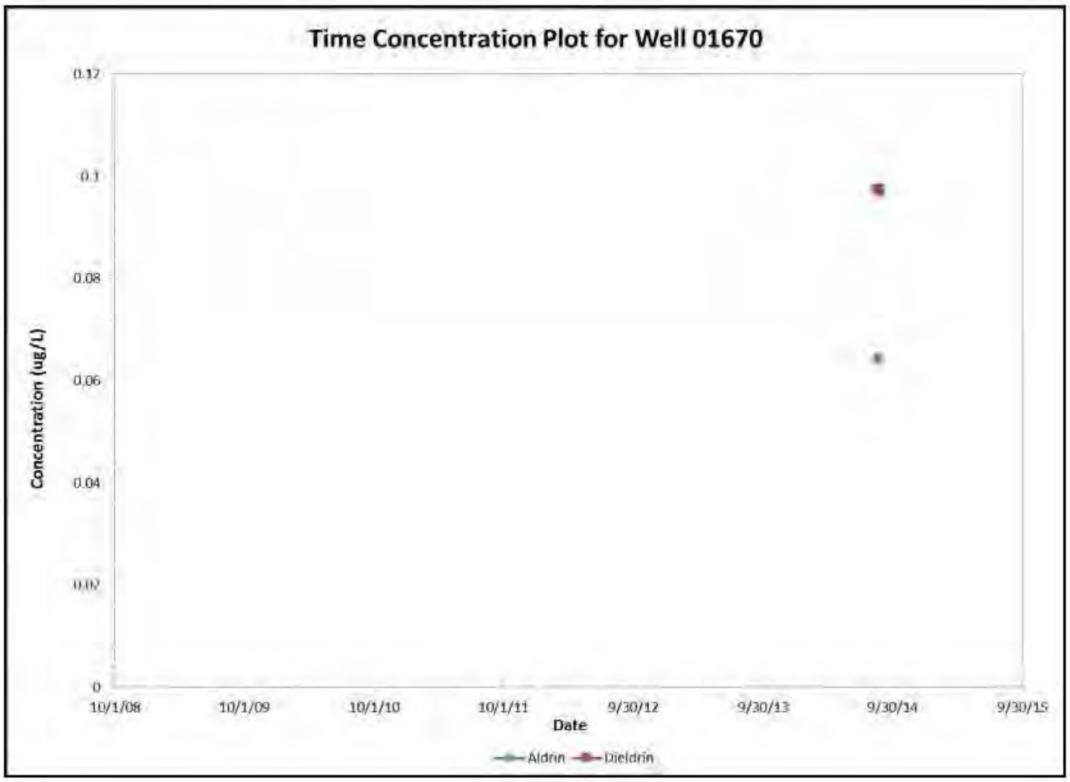





Time Concentration Plot for Well 01101
Concentration (ug/L)
1000000
100000
10000
1000
100
10
1
0.1
0.01
0.001
10/1/08
10/1/09
10/1/10
10/1/11
9/30/12
9/30/13
9/30/14
9/30/15
Date
Aldrin
Chloride
Dieldrin
Open symbol indicates value is less than the MRL

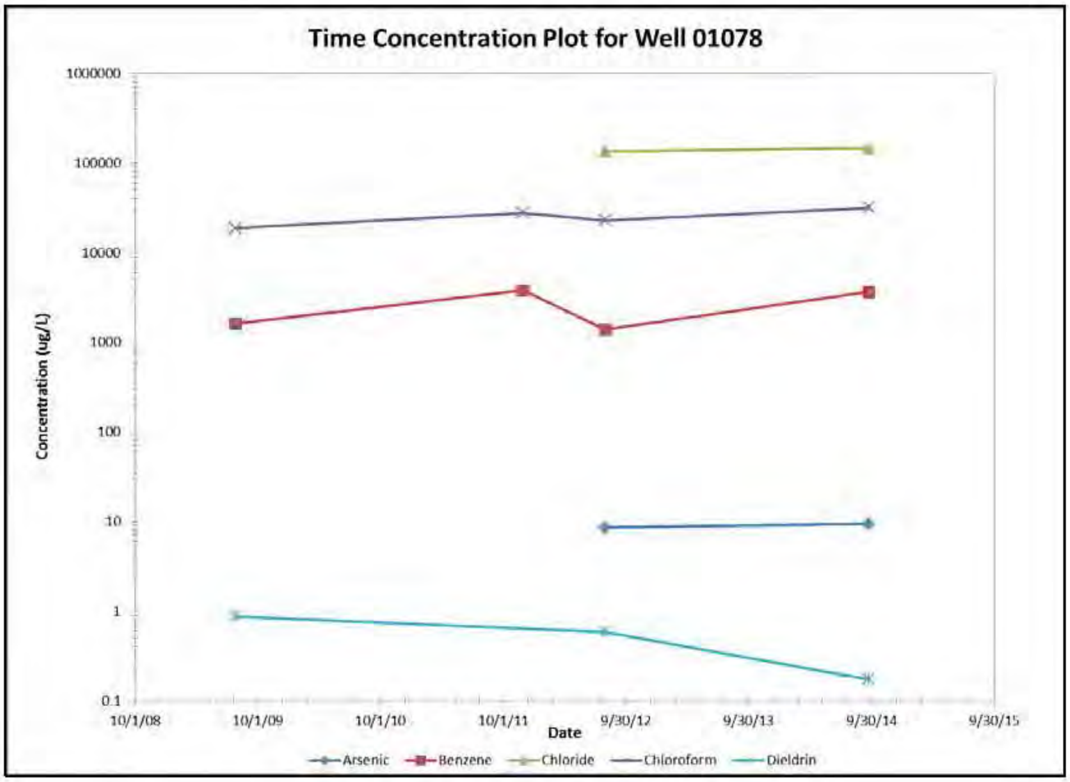

Time Concentration Plot for Well 01582
Concentration (ug/L)
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
10/1/08
10/1/09
10/1/10
10/1/11
9/30/12
9/30/13
9/30/14
9/30/15
Date
Aldrin
Dieldrin
Open symbol indicates value is less than the MRL

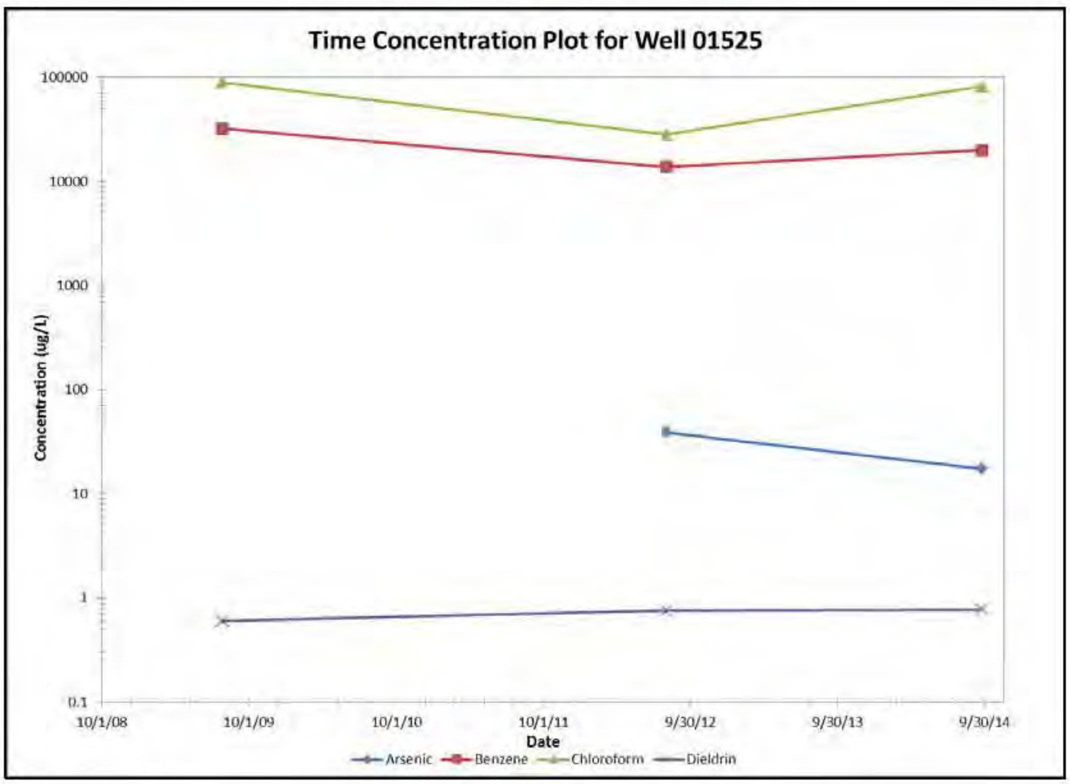




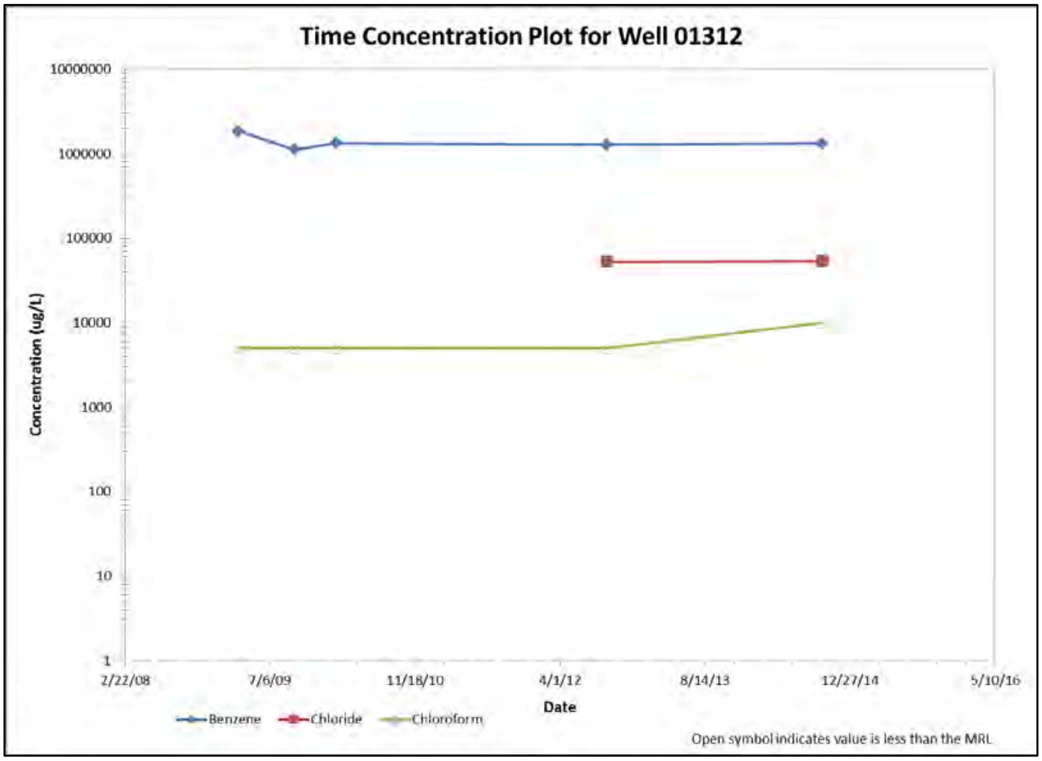
Note: No data collected at Well 01670 in 2012

South Plants Central Processing Area

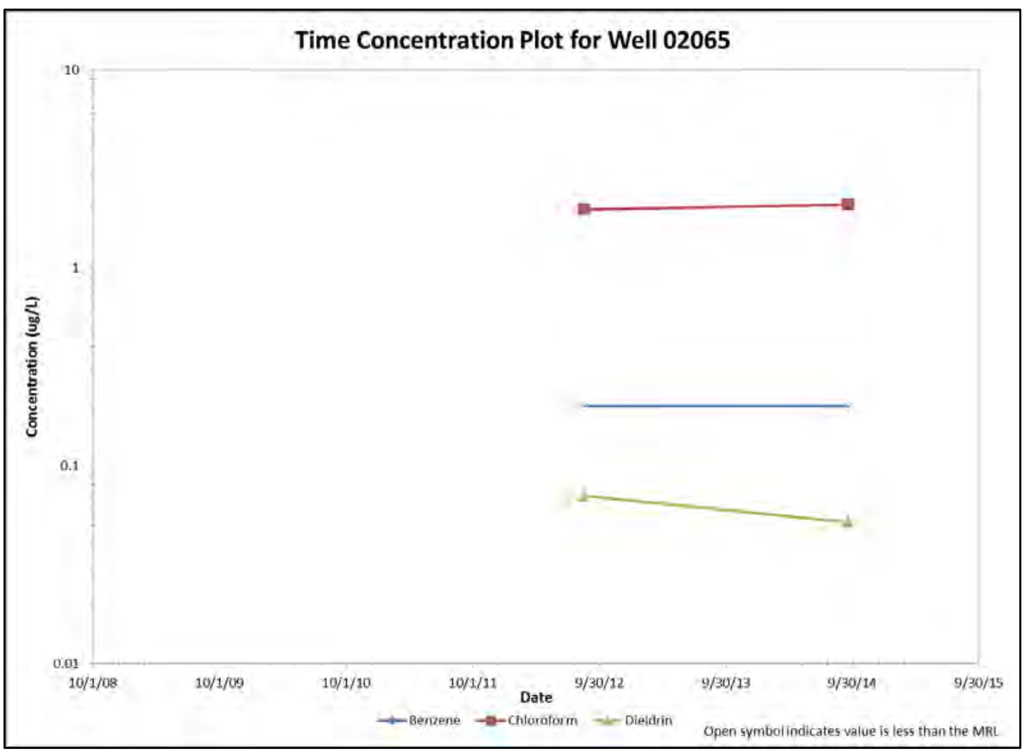


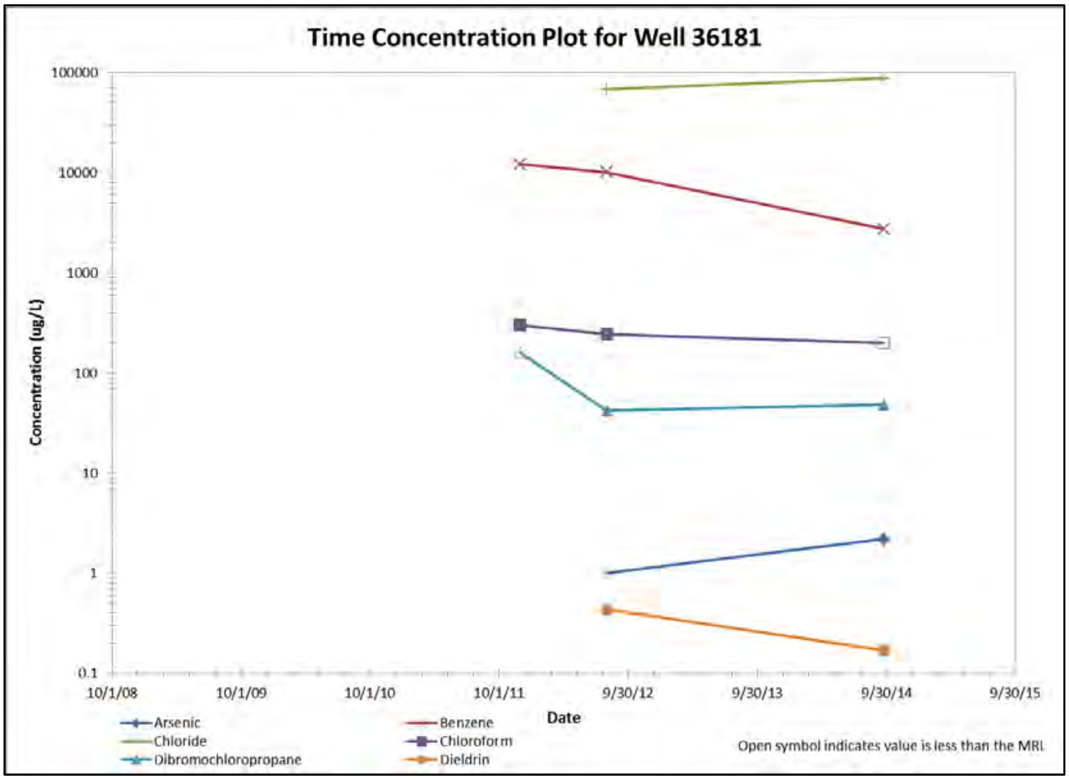


South Tank Farm

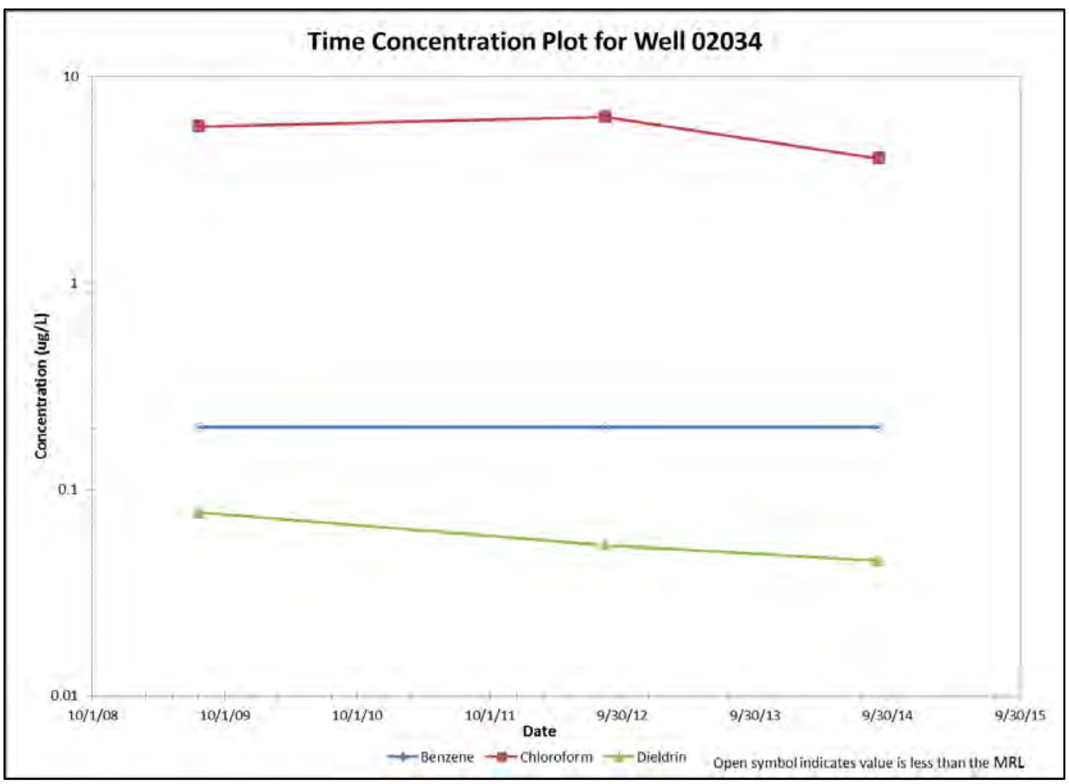


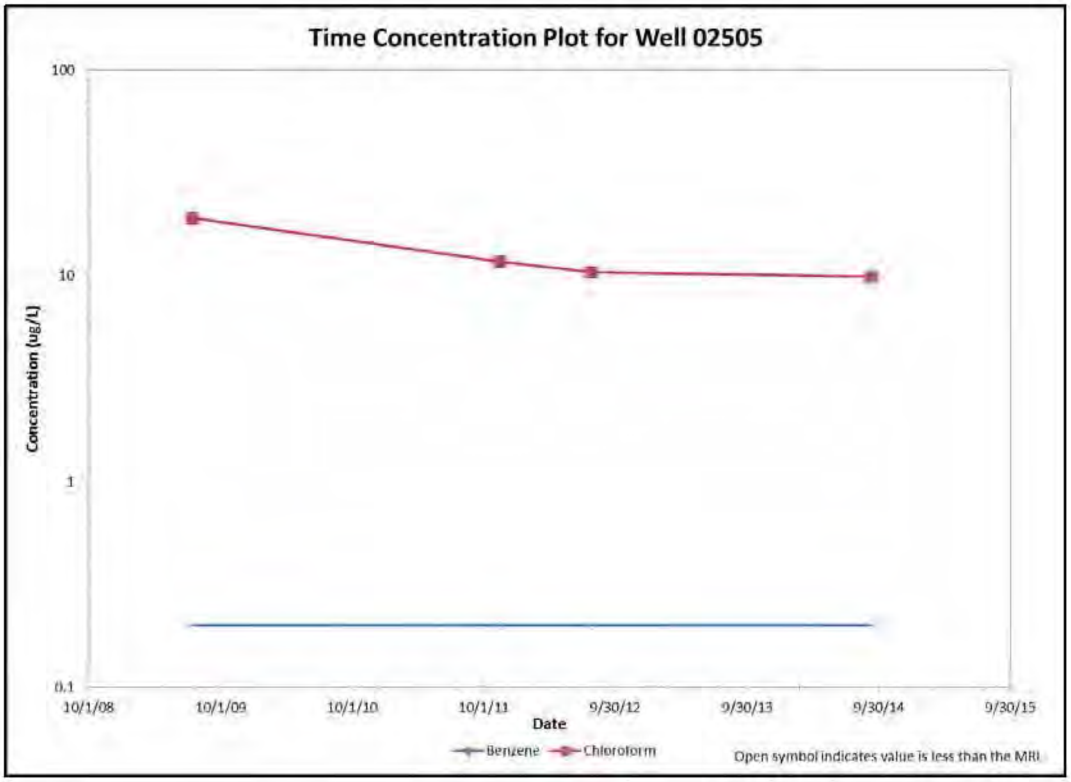
South Plants

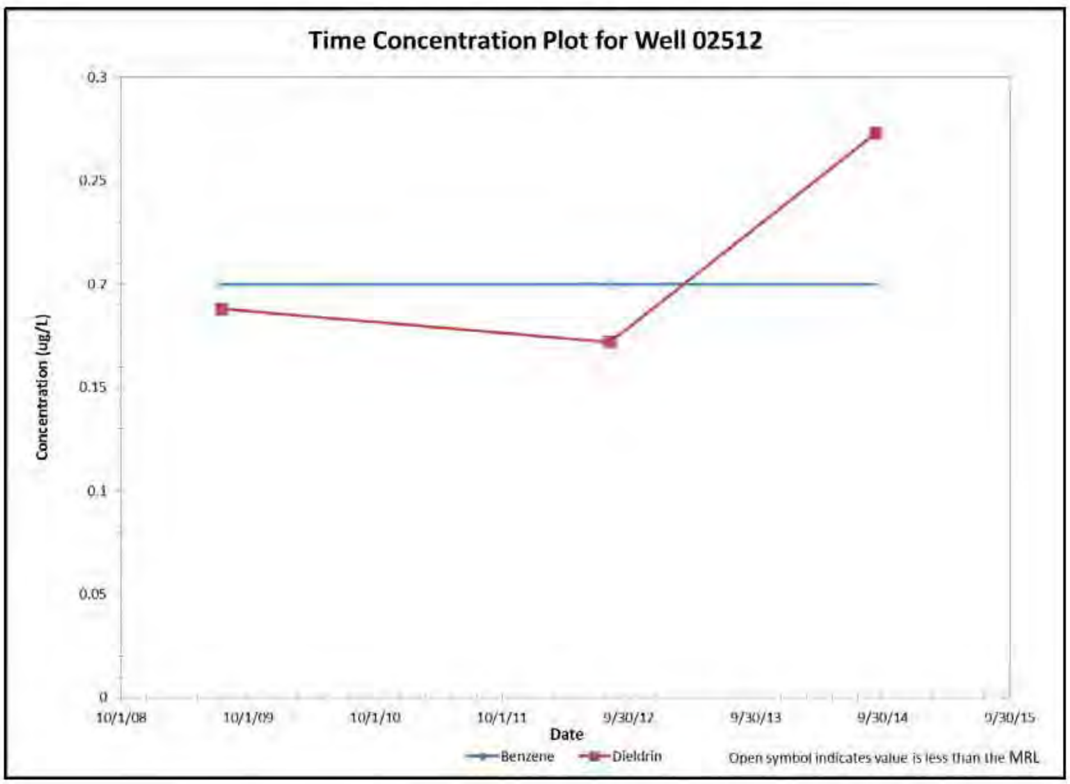


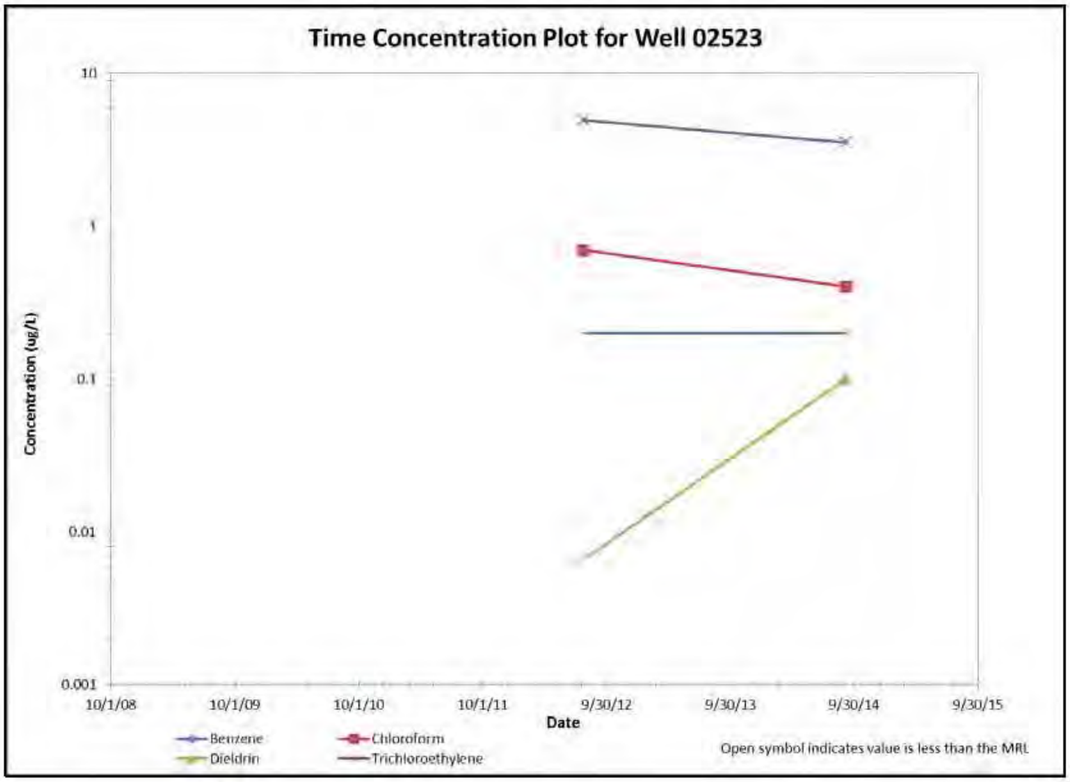

Time Concentration Plot for Well 36181
Concentration (ug/L)
100000
10000
1000
100
10
1
0.1
10/1/08
10/1/09
10/1/10
10/1/11
9/30/12
9/30/13
9/30/14
9/30/15
Date
Arsenic
Chloride
Dibromochloropropane
Benzene
Chloroform
Dieldrin
Open symbol indicates value is less than the MRL

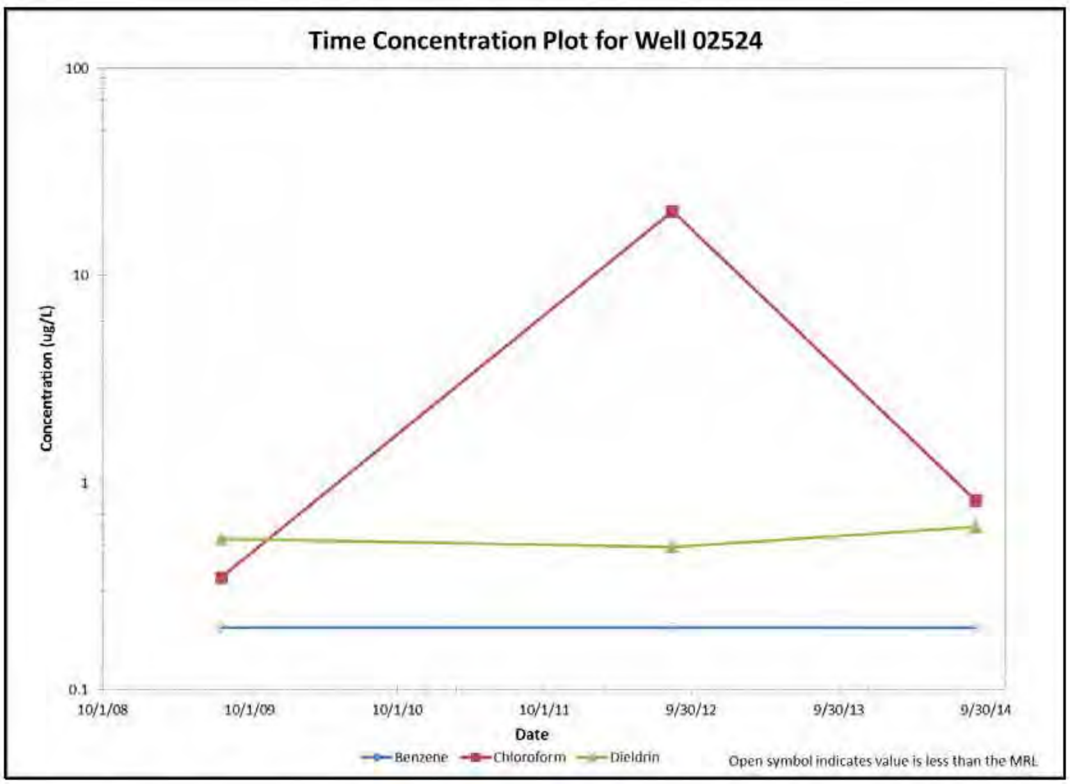
South Lakes

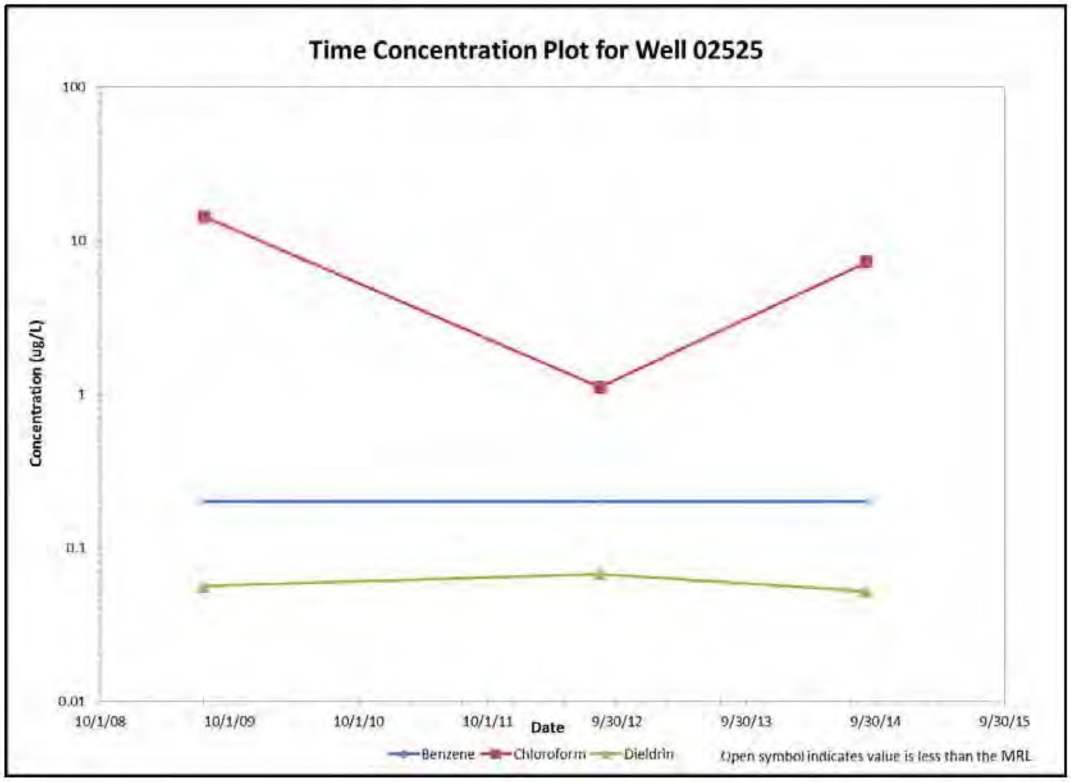

Time Concentration Plot for Well 02034
Concentration (ug/L)
10
1
0.1
0.01
10/1/08
10/1/09
10/1/10
10/1/11
9/30/12
9/30/13
9/30/14
9/30/15
Date
Benzene
Chloroform
Dieldrin
Open symbol indicates value is less than the MRL

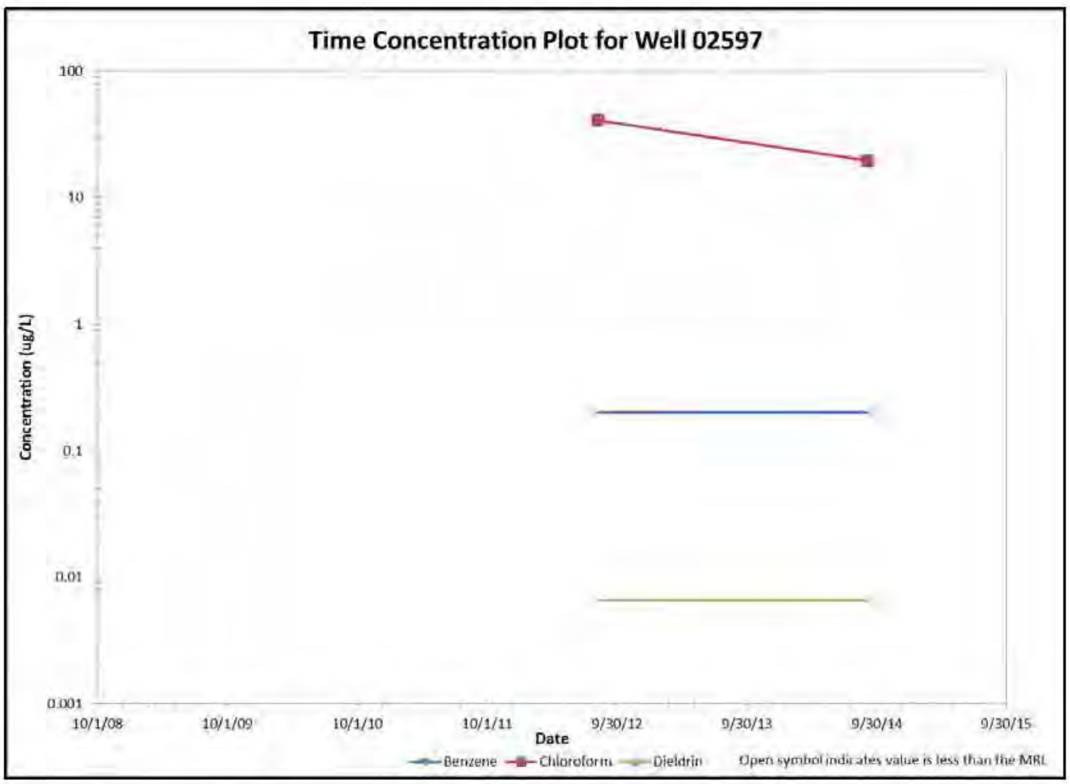

Time Concentration Plot for Well 02505
100
10
1
0.1
Concentration (ug/L)
10/1/08
10/1/09
10/1/10
10/1/11
9/30/12
9/30/13
9/30/14
9/30/15
Date
Benzene
Chloroform
Open symbol indicates value is less than the MRL


Time Concentration Plot for Well 02512
0.3
0.25
0.2
0.15
0.1
0.05
0
Concentration (ug/L)
10/1/08
10/1/09
10/1/10
10/1/11
9/30/12
9/30/13
9/30/14
9/30/15
Date
Benzene
Dieldrin
Open symbol indicates value is less than the MRL

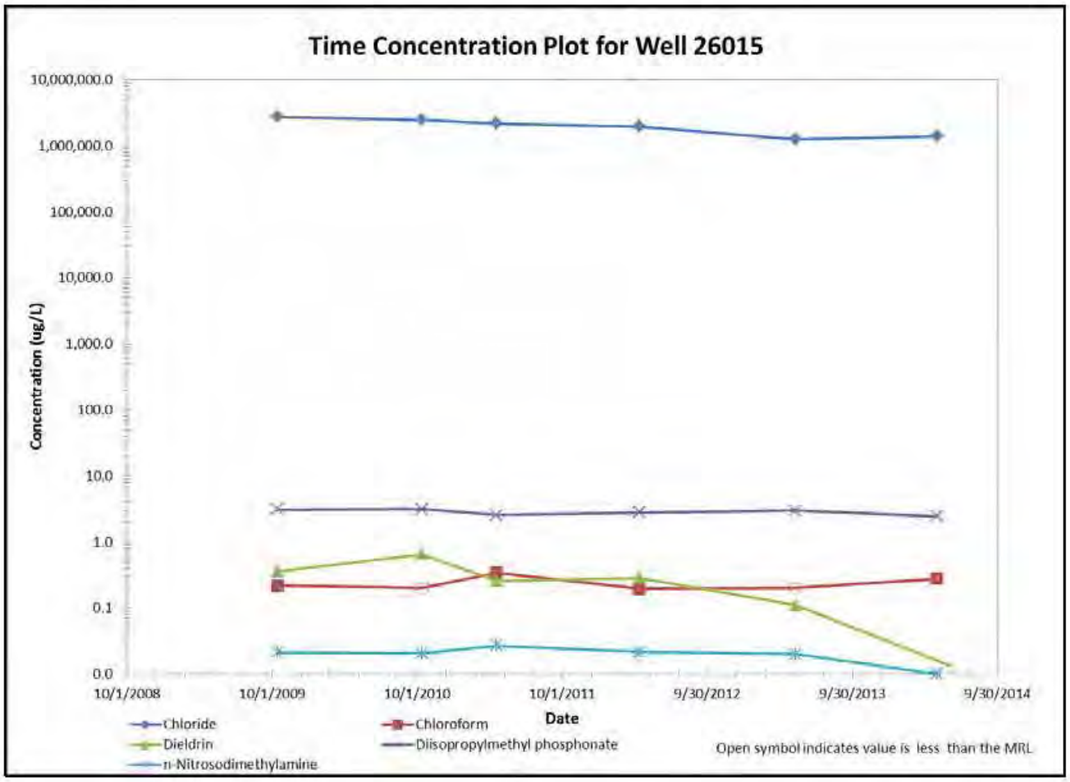

Time Concentration Plot for Well 02523
10
1
0.1
0.01
0.001
Concentration (ug/L)
10/1/08
10/1/09
10/1/10
10/1/11
9/30/12
9/30/13
9/30/14
9/30/15
Date
Benzene
Chloroform
Dieldrin
Trichloroethylene
Open symbol indicates value is less than the MRL

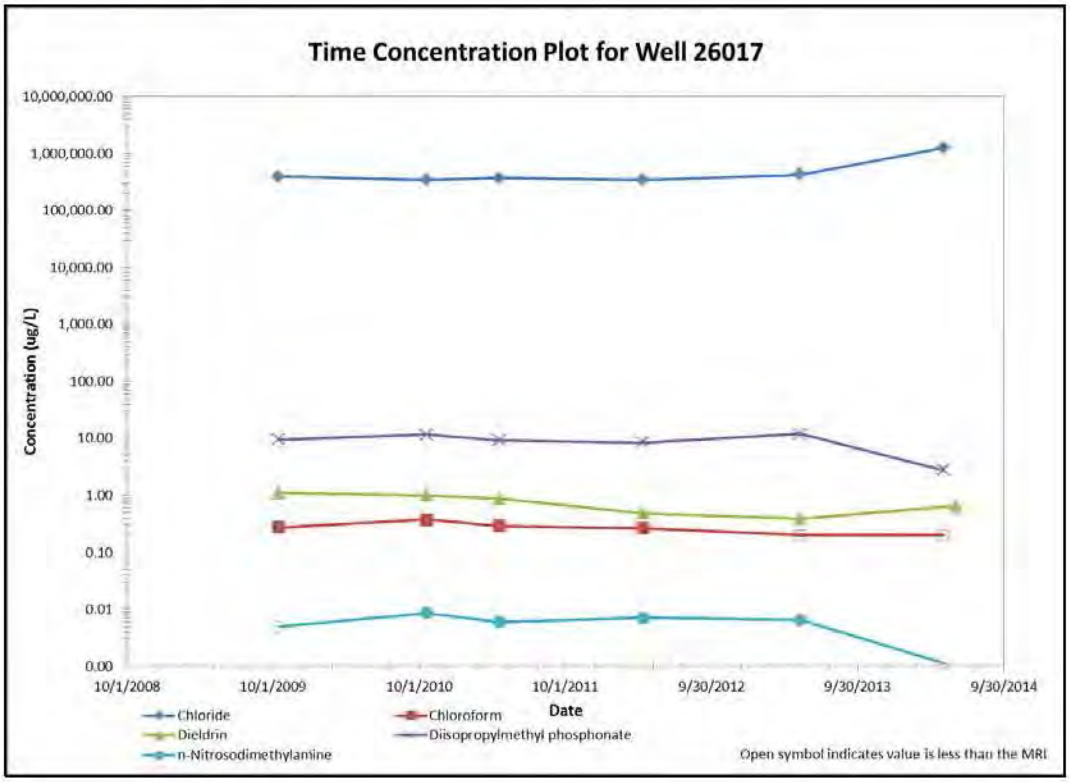

Time Concentration Plot for Well 02524
100
10
1
0.1
Concentration (ug/L)
10/1/08
10/1/09
10/1/10
10/1/11
9/30/12
9/30/13
9/30/14
Date
Benzene
Chloroform
Dieldrin
Open symbol indicates value is less than the MRL

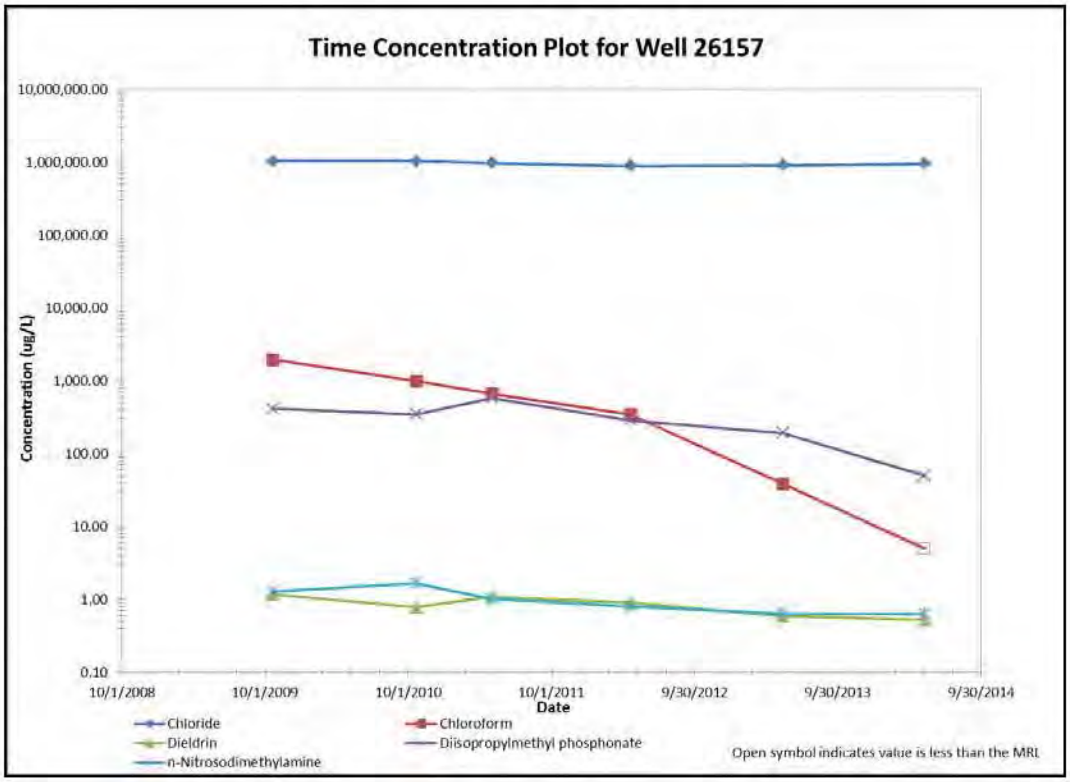

Time Concentration Plot for Well 02525
Concentration (ug/L)
100
10
1
0.1
0.01
10/1/08
10/1/09
10/1/10
10/1/11
9/30/12
9/30/13
9/30/14
9/30/15
Date
Benzene
Chloroform
Dieldrin
Open symbol indicates value is less than the MRL

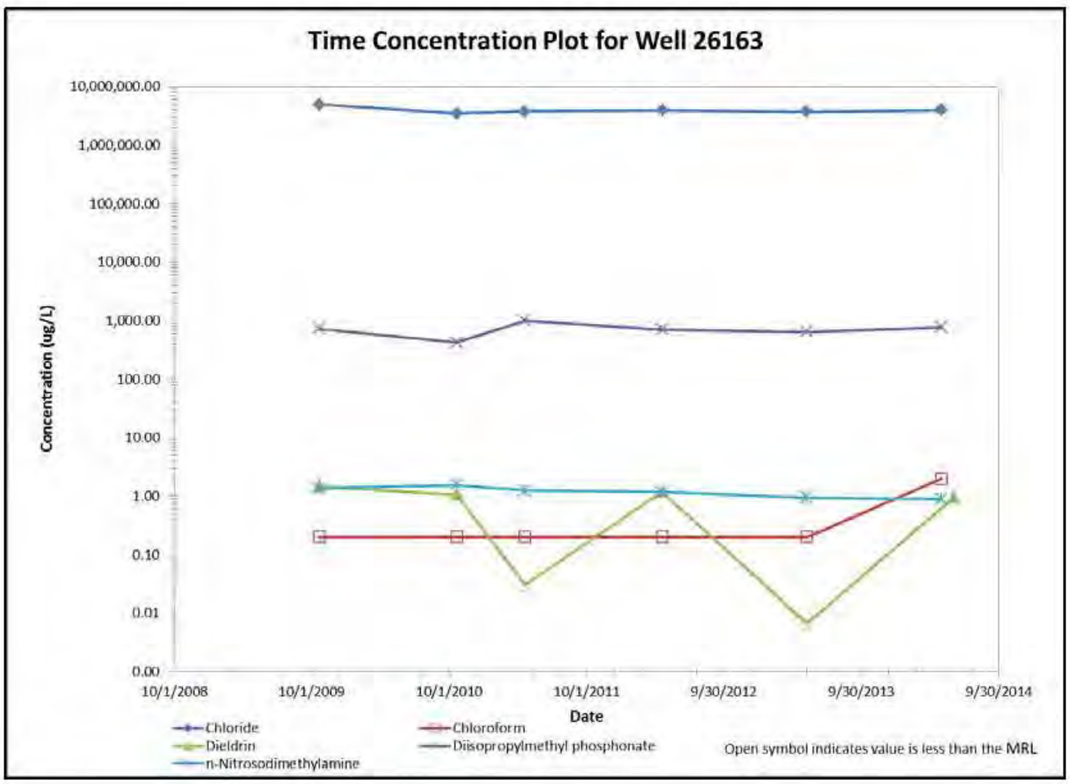

Time Concentration Plot for Well 02597
Concentration (ug/L)
100
10
1
0.1
0.01
0.001
10/1/08
10/1/09
10/1/10
10/1/11
9/30/12
9/30/13
9/30/14
9/30/15
Date
Benzene
Chloroform
Dieldrin
Open symbol indicates value is less than the MRL

Former Basin F






Time Concentration Plot for Well 26157
Concentration (ug/L)
10,000,000.00
1,000,000.00
100,000.00
10,000.00
1,000.00
100.00
10.00
1.00
0.10
10/1/2008
10/1/2009
10/1/2010
10/1/2011
9/30/2012
9/30/2013
9/30/2014
Date
Chloride
Chloroform
Dieldrin
Diisopropylmethyl phosphonate
n-Nitrosodimethylamine
Open symbol indicates value is less than the MRL


Time Concentration Plot for Well 26163
Concentration (ug/L)
10,000,000.00
1,000,000.00
100,000.00
10,000.00
1,000.00
100.00
10.00
1.00
0.10
0.01
0.00
10/1/2008
10/1/2009
10/1/2010
10/1/2011
9/30/2012
9/30/2013
9/30/2014
Date
Chloride
Chloroform
Dieldrin
Diisopropylmethyl phosphonate
n-Nitrosodimethylamine
Open symbol indicates value is less than the MRL

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APPENDIX E

Long Term Trends
in Upgradient and Downgradient Wells
at
HWL, ELF, and Basin F

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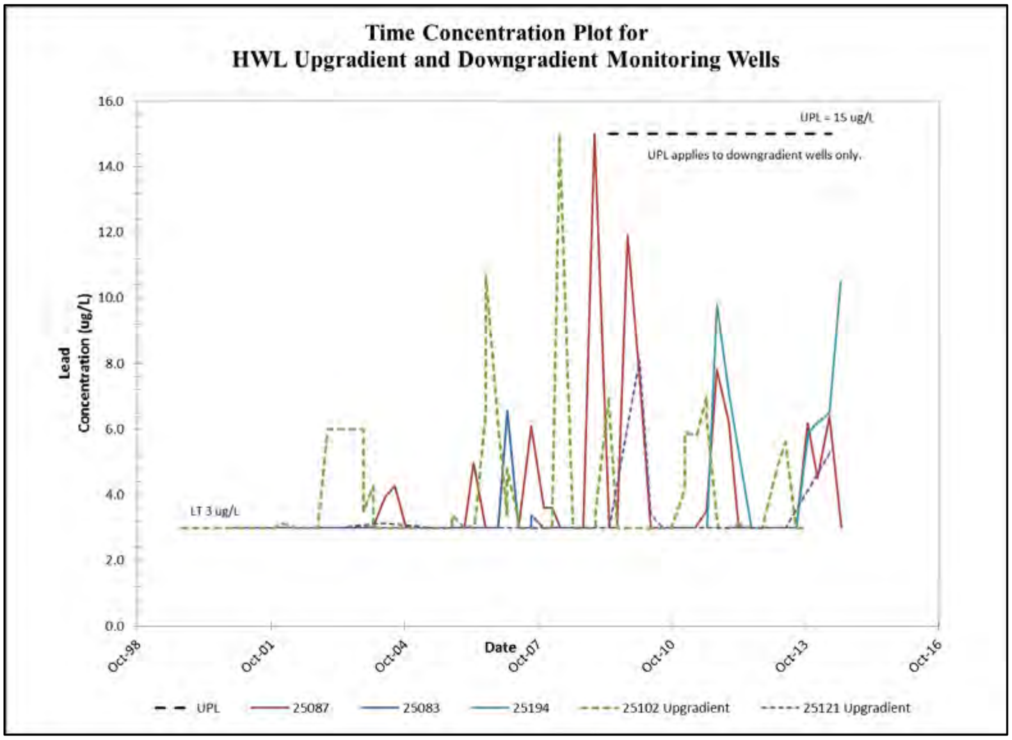
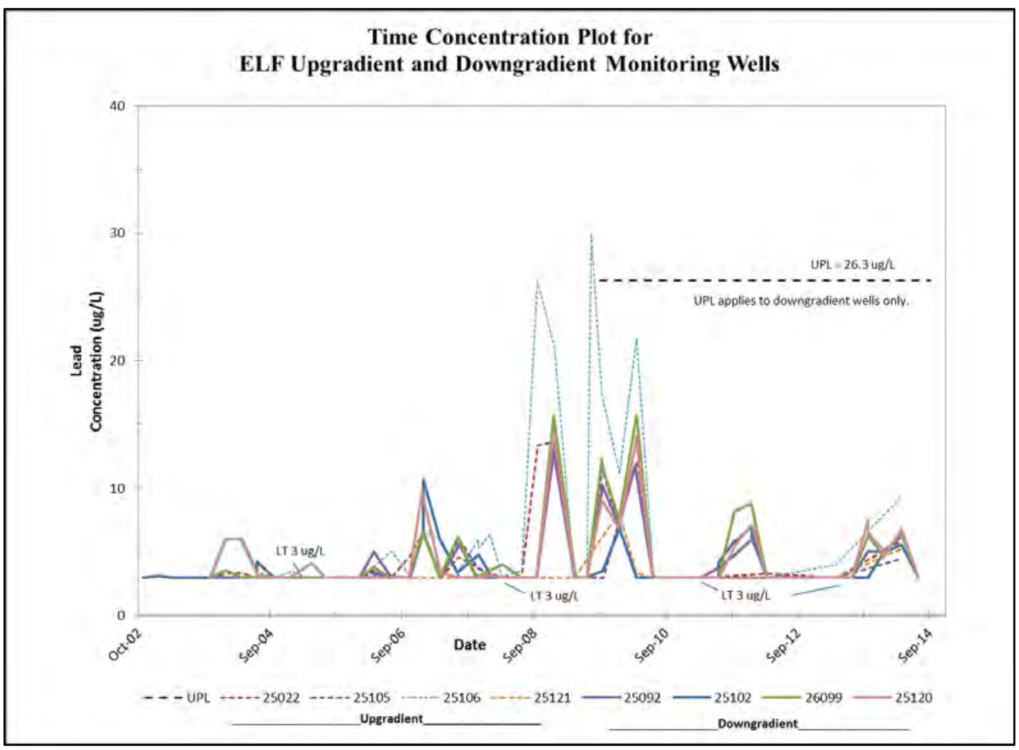
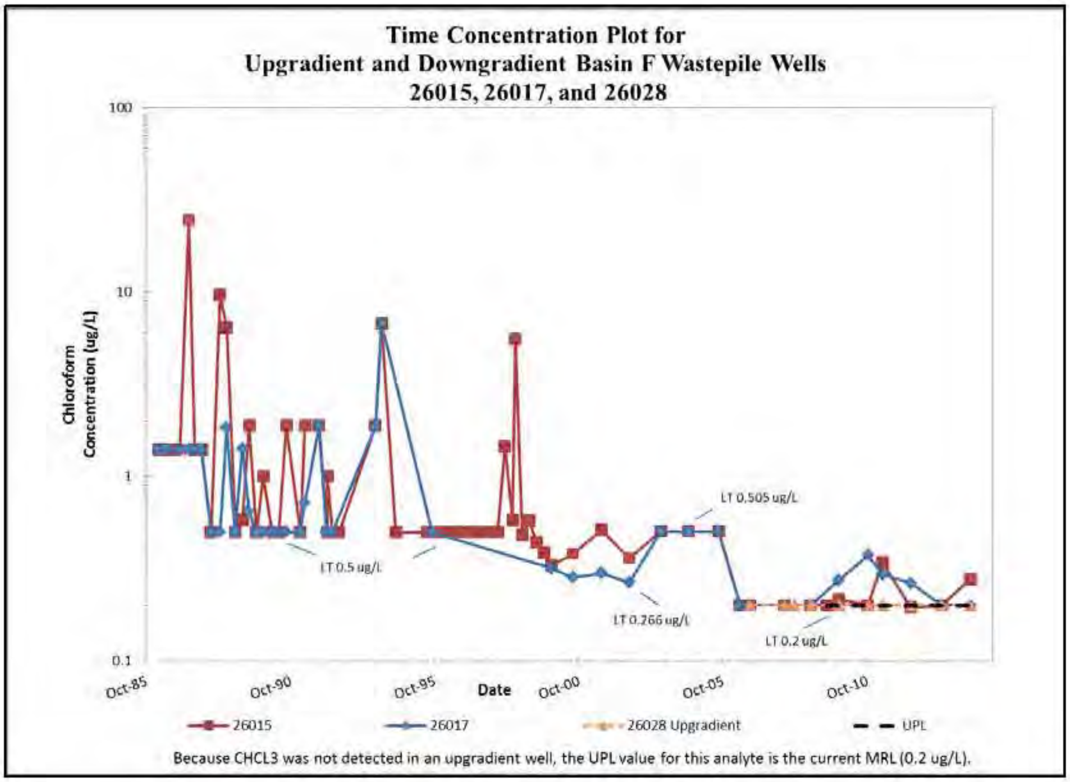
HWL

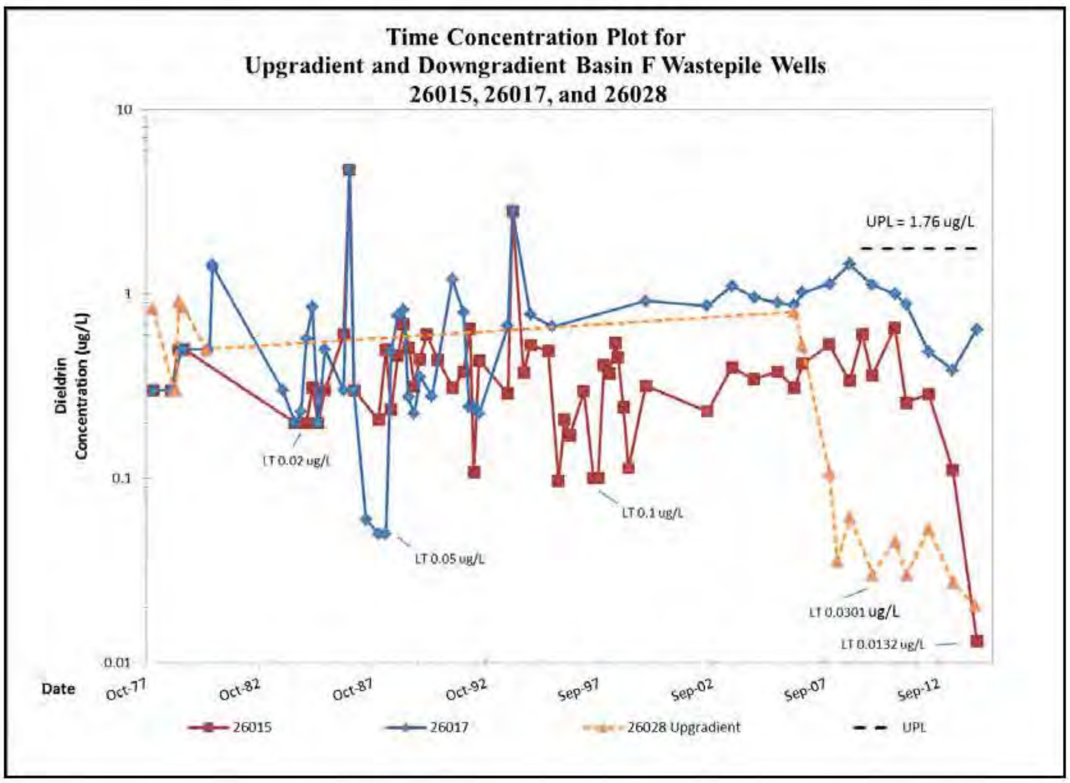

Time Concentration Plot for
HWL Upgradient and Downgradient Monitoring Wells
UPL = 15 ug/L
UPL applies to downgradient wells only.
LT 3 ug/L
Lead
Concentration (ug/L)
Date
UPL
25087
25083
25194
25102 Upgradient
25121 Upgradient

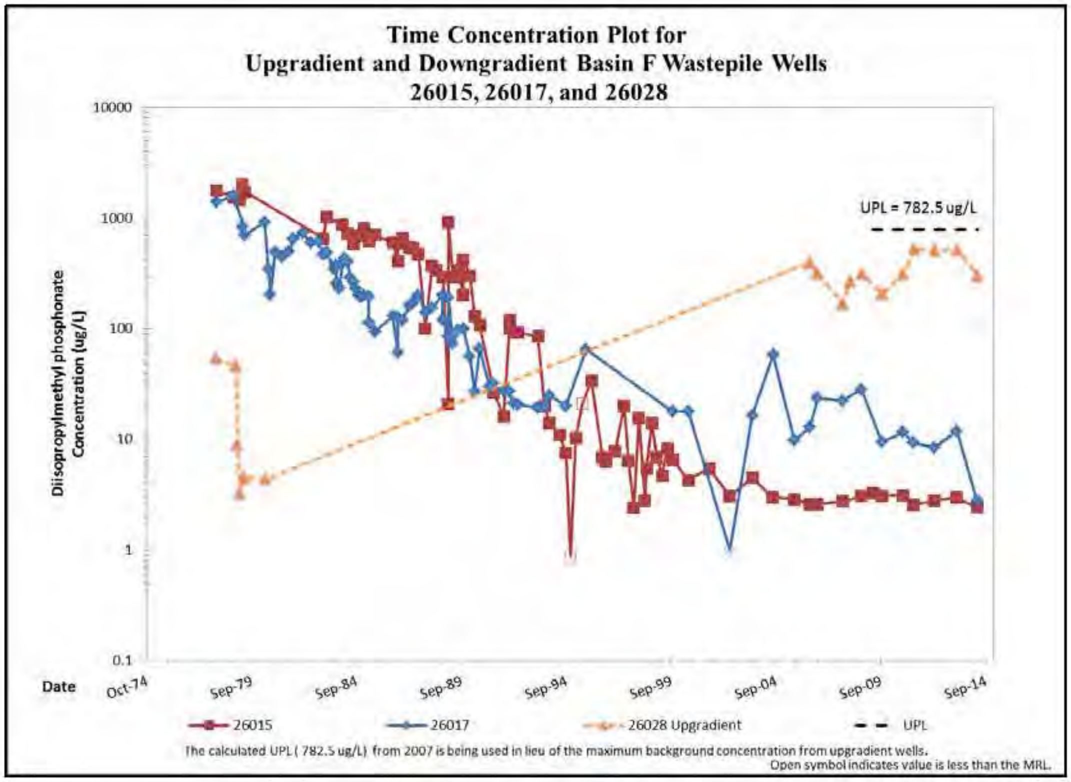
ELF

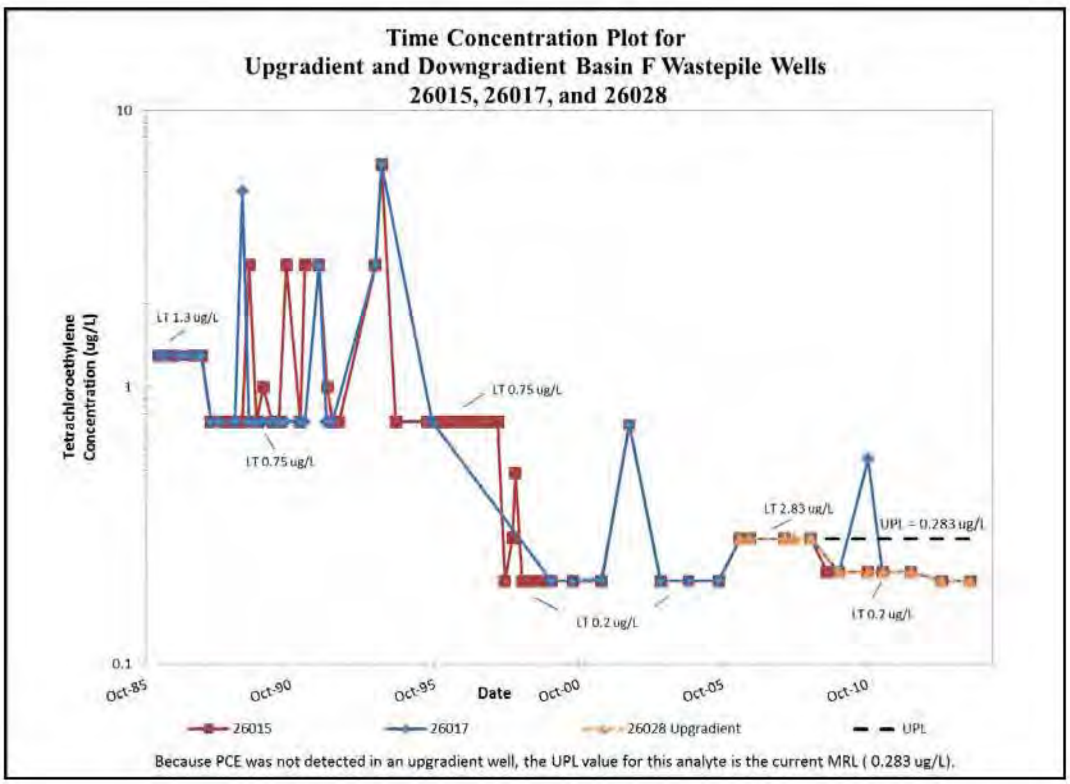

Time Concentration Plot for
ELF Upgradient and Downgradient Monitoring Wells
UPL = 26.3 ug/L
UPL applies to downgradient wells only.
LT 3 ug/L
Lead
Concentration (ug/L)
Date
UPL
25022
25105
25106
25121
25092
25102
26099
25120
Upgradient
Downgradient

Basin F Wastepile Wells

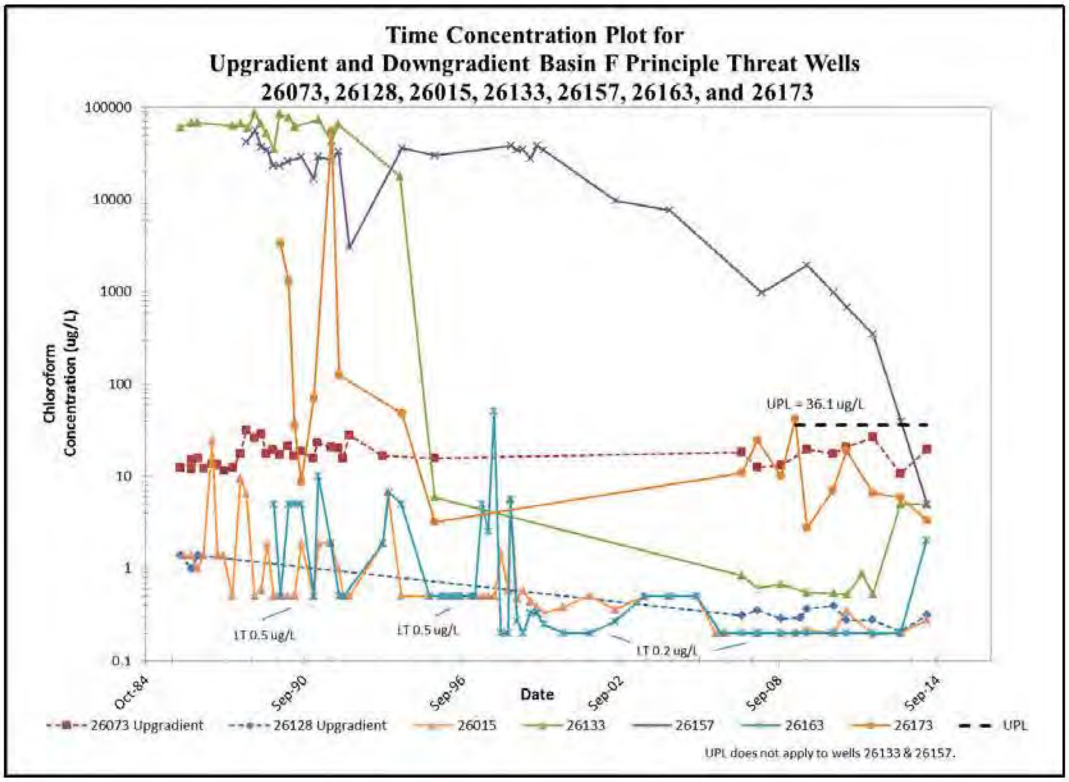


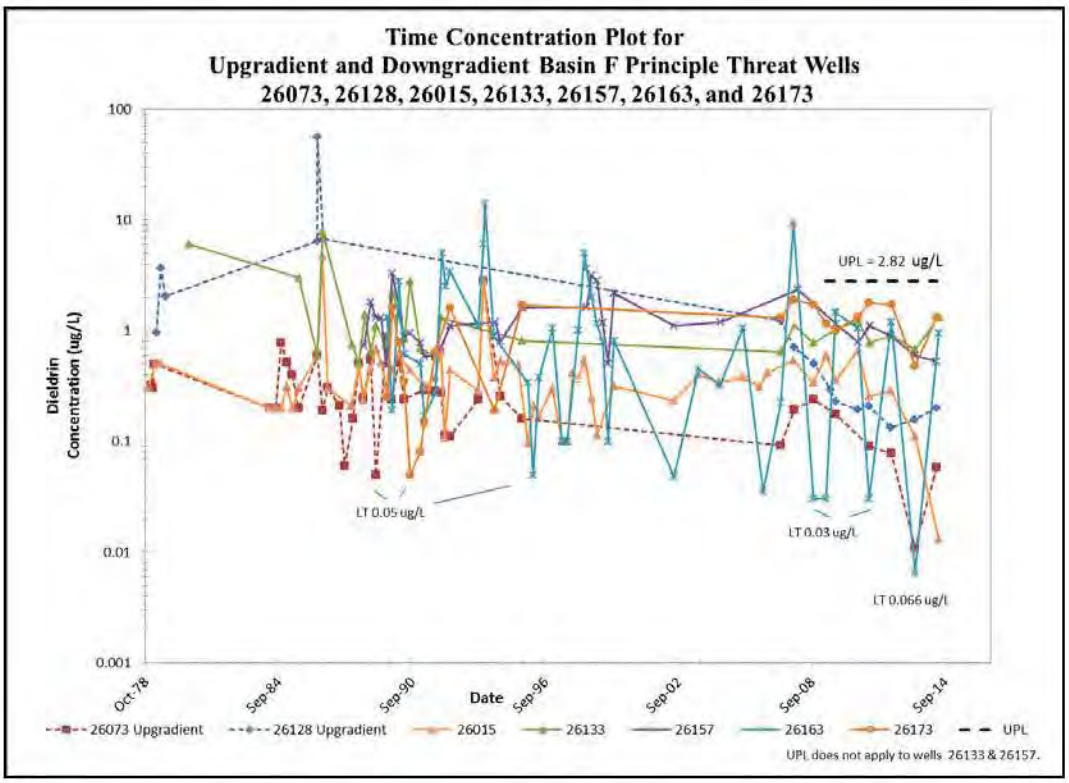


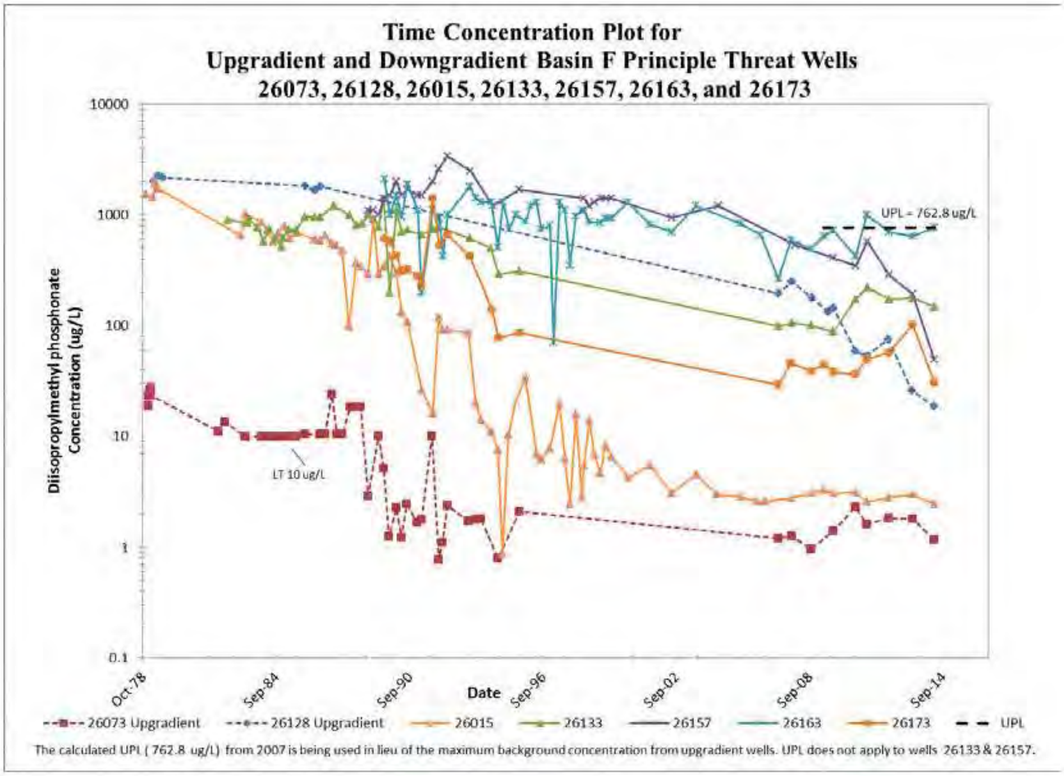

Time Concentration Plot for
Upgradient and Downgradient Basin F Wastepile Wells
26015, 26017, and 26028
Diisopropylmethyl phosphonate Concentration (ug/L)
10000
1000
100
10
1
0.1
UPL = 782.5 ug/L
Date
Oct-74
Sep-79
Sep-84
Sep-89
Sep-94
Sep-99
Sep-04
Sep-09
Sep-14
26015
26017
26028 Upgradient
UPL
The calculated UPL (782.5 ug/L) from 2007 is being used in lieu of the maximum background concentration from upgradient wells.
Open symbol indicates value is less than the MRL.

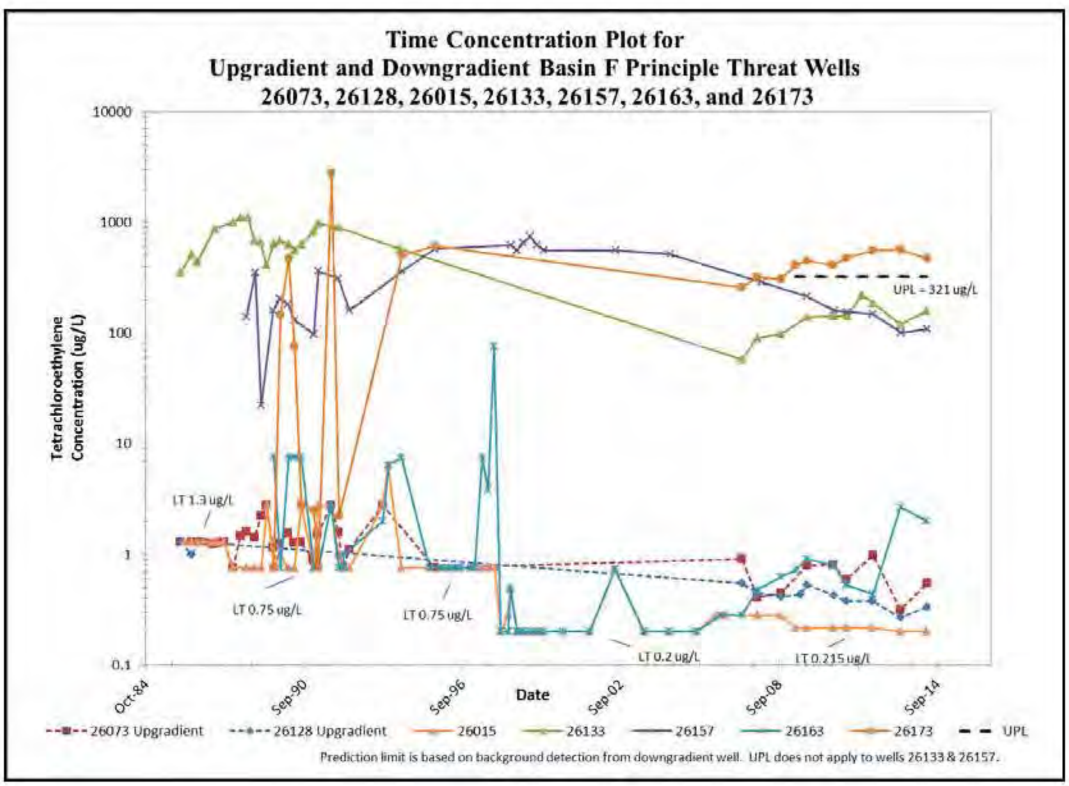

Time Concentration Plot for
Upgradient and Downgradient Basin F Wastepile Wells
26015, 26017, and 26028
Tetrachloroethylene Concentration (ug/L)
10
1
0.1
LT 1.3 ug/L
LT 0.75 ug/L
LT 0.75 ug/L
LT 2.83 ug/L
UPL = 0.283 ug/L
LT 0.2 ug/L
LT 0.2 ug/L
Oct-85
Oct-90
Oct-95
Date
Oct-00
Oct-05
Oct-10
26015
26017
26028 Upgradient
UPL
Because PCE was not detected in an upgradient well, the UPL value for this analyte is the current MRL (0.283 ug/L).

Basin F Principle Threat Wells






Time Concentration Plot for
Upgradient and Downgradient Basin F Principle Threat Wells
26073, 26128, 26015, 26133, 26157, 26163, and 26173
Diisopropylmethyl phosphonate Concentration (ug/L)
10000
1000
100
10
1
0.1
Oct-78
Sep-84
Sep-90
Sep-96
Sep-02
Sep-08
Sep-14
Date
UPL = 762.8 ug/L
LT 10 ug/L
26073 Upgradient
26128 Upgradient
26015
26133
26157
26163
26173
UPL
The calculated UPL (762.8 ug/L) from 2007 is being used in lieu of the maximum background concentration from upgradient wells. UPL does not apply to wells 26133 & 26157.


Time Concentration Plot for
Upgradient and Downgradient Basin F Principle Threat Wells
26073, 26128, 26015, 26133, 26157, 26163, and 26173
Tetrachloroethylene Concentration (ug/L)
10000
1000
100
10
1
0.1
Oct-84
Sep-90
Sep-96
Sep-02
Sep-08
Sep-14
Date
UPL = 321 ug/L
LT 1.3 ug/L
LT 0.75 ug/L
LT 0.75 ug/L
LT 0.2 ug/L
LT 0.215 ug/L
26073 Upgradient
26128 Upgradient
26015
26133
26157
26163
26173
UPL
Prediction limit is based on background detection from downgradient well. UPL does not apply to wells 26133 & 26157.

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APPENDIX F

North Basin A Pathway Evaluation

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FYSR Appendix F

North Basin A Pathway Evaluation

Introduction

The Basin A Neck System (BANS) and Bedrock Ridge Extraction System (BRES) were installed to extract the contaminated groundwater flowing out of former Basin A and treat it to meet remediation goals at the BANS treatment plant. The migration pathways to these systems were the only known outlets for contaminated groundwater migrating from former Basin A. As discussed in Five-Year Summary Report (FYSR) Section 5.1.5.1, a migration pathway at the north end of former Basin A was identified for dieldrin and arsenic in the 2014 on-post plume mapping project.

The dieldrin plume map is FYSR Figure 5.1.5.1-2 and the arsenic map is FYSR Figure 5.1.5.1-11. The alluvium is unsaturated at the north end of former Basin A, and portions of the Basin A dieldrin and arsenic plumes appear to have migrated through the subcropping A Sandstone in the Denver Formation bedrock at the north end of Basin A. This migration pathway is not intercepted by either the BANS or BRES.

This migration pathway explains the dieldrin and arsenic detections in wells south of the Enhanced Hazardous Waste Landfill (ELF) and south and east of former Basins C and F. This appendix provides additional evaluation of the north Basin A migration pathway.

Background Information

- Hydrogeology

Cross sections for large areas of RMA were constructed in two reports that are relevant to the north Basin A pathway: 1) *White Paper*, *Evaluation of the Denver Formation at RMA* (MK 1994); and 2) *Final Landfill Site Feasibility Report for the Feasibility Study Soils Support Program* (HLA 1995). Both reports mapped the extent of the A Sandstone north of Basin A. Plate 2 and Figure 4.29 show the interpreted extent of the A Sandstone from these reports, respectively. Wells 25022 and 25106 are located upgradient of the ELF and have contained dieldrin and arsenic, and are shown on Figure 4.29. Plate 2 also shows the cross section locations from the MK report. Figure 4.17 shows the cross section locations from the HLA report.

The pertinent cross sections in the north Basin A area are provided in this appendix to depict the hydrogeology of the alluvium and Denver Formation bedrock. The cross sections are also used to determine the saturated thickness in the calculations for estimating the contaminated flow and mass flux of dieldrin and arsenic in this migration pathway.

Cross sections I-I' (Figure 4.24) and L-L' (Figure 4.26) from the HLA report show the east-west and north-south extents, respectively, of the A Sandstone present in well 25022. Wells 26500 and 25106 were added to cross-section G-G' from the MK report to better define the extent of the A Sandstone. The A Sandstone is absent near well 25106 and the zone screened in well 25106 is correlative to the zones screened in well 25023 and the upper portion of well 25024 (upper portion of Lignite A) shown on the three cross sections.

- Water Quality Data

Historically, dieldrin has been detected intermittently in wells 25022 and 25106 (Figure 1). Arsenic has been detected intermittently in well 25022 and been detected consistently in well 25106 (Figure 2). Both wells are located upgradient of the ELF. Besides dieldrin, other organochlorine pesticides (OCPs) have also been detected intermittently in well 25106, including chlordane, endrin, heptachlor, isodrin, methoxychlor, DDD, DDE, and DDT. Through the FYR period, the concentrations of the contaminants in both wells are below the BANS Containment System Remediation Goals (CSRGs)/Practical Quantitation Limits (PQLs) and are decreasing. On FYSR Figure 5.1.5.1-2, the dieldrin plume east of the BANS is interpreted to extend north toward former Basin F at concentrations above the PQL based on wells farther north and upgradient of former Basin F.

- FY14 Dieldrin and Arsenic Plumes

North of former Basin A, the dieldrin plume splits, with the majority of the plume migrating to the northwest (FYSR Figure 5.1.5.1-2). The plume intersects the Basins C/F plume and migrates to the North Boundary Containment System (NBCS), where it is treated to meet remediation goals. A small portion of the dieldrin plume migrates to the northeast, but is interpreted to end upgradient of well 25106. This is based on the dieldrin concentration in well 25106 decreasing to below the MRL in FY14 (Figure 1).

North of former Basin A, the arsenic plume migrates to the northeast intersecting well 25106, and is interpreted to end near the ELF (FYSR Figure 5.1.5.1-11). The arsenic concentration in well 25106 has decreased since 2011 and was 6.25 µg/L in 2014, well below the BANS CSRG of 50 µg/L.

Methodology

The contaminated groundwater flow rate and mass flux for dieldrin and arsenic were calculated using available information for the north Basin A pathway. The Darcy's Law equation, Q = KIA (Q = discharge in gpm, K = hydraulic conductivity in ft/day, I = hydraulic gradient in ft/ft, and A = area in ft^2) was used to calculate the flow rate within the 2014 plumes as mapped in the FYSR. The contaminant mass flux, in pounds per year (lbs/yr), was calculated using the average concentration within each concentration interval from the two plume maps, and the corresponding flow rates for the aquifer cross sectional area for each concentration interval.

Results

- Dieldrin

The dieldrin plume east of the BANS is estimated to be about 800 feet wide (FYSR Figure 5.1.5.1-2). The saturated thickness within the plume ranges from 10 to 21.5 feet. The FY14 hydraulic gradient is based on wells screened in the A Sandstone that include 36538, 36112, 26500, 25500, 25004, and 25022. The hydraulic conductivity of 1.134 ft/day for the A Sandstone is from an aquifer test of well 25022 (Tetra Tech and URS, 2010).

Table 1 shows the calculations for the contaminated flow rate and mass flux for dieldrin. Using an average hydraulic conductivity of 1.134 ft/day for the A Sandstone, and a hydraulic gradient of 0.0045 ft/ft, the contaminated flow rate is estimated to be 0.34 gpm. The dieldrin mass flux is estimated to be 0.000059 lb/yr. For comparison, the BANS FY14 total contaminated flow rate was 17 gpm, and the total mass flux of all contaminants was 17.4 lbs/yr. The FY14 BANS dieldrin mass flux was estimated to be 0.038 lb/yr, so the FY14 dieldrin mass flux in the migration pathway at the north end of former Basin A is estimated to be almost three orders of magnitude lower than at BANS.

Table 1. Dieldrin Contaminated Flow Rate and Mass Flux

FY14 Average Concentration, µg/L	Plume Width, ft	Saturated Thickness, ft	Hydraulic Gradient, ft/ft	Hydraulic Conductivity, ft/day	Flow Rate, gpm	Mass Flux, lb/yr
0.0083	174	10	0.0045	1.134	0.046	0.00000167
0.0315	102	12	0.0045	1.134	0.032	0.00000448
0.089	205	16.3	0.0045	1.134	0.089	0.0000345
0.0315	215	20.8	0.0045	1.134	0.119	0.0000164
0.0083	102	21.5	0.0045	1.134	0.058	0.00000211
Total	798				0.34	0.0000592

- Arsenic

A small portion of the Basin A arsenic plume is interpreted to migrate to well 25106 (FYSR Figure 5.1.5.1-11). The A Sandstone is absent at well 25106 and the well is screened in a zone below the A Sandstone stratigraphically. The zone is comprised of siltstone, claystone, and lignite and likely has lower permeability than the A Sandstone. Based on the cross sections, the zone does not appear hydraulically connected to the A Sandstone, but there likely is a connection since both dieldrin and arsenic have been detected in well 25106, and would have migrated from former Basin A. This migration pathway to well 25106 initially would be through the subcropping A Sandstone.

The screened interval for well 25106 includes a lignite zone (Lignite A). According to the U.S. Geological Survey (2006), arsenic can be naturally associated with lignite, and there are examples of elevated arsenic concentrations in wells screened in the same lignite zone as well 25106 (Lignite A) at RMA where no RMA-related arsenic contaminant plume is known to be present. However, because well 25106 also has intermittently contained dieldrin and other OCPs, and an arsenic plume is present in former Basin A, the arsenic is assumed to have migrated to well 25106 from former Basin A.

The arsenic plume exiting the north end of former Basin A is estimated to be about 440 feet wide (Figure 5.1.5.1-11). The saturated thickness in the A Sandstone within the plume ranges from 12.8 to 22 feet. Since the hydraulic connection between the A Sandstone and well 25106 is not apparent, a range in hydraulic gradients was used in the calculations. This range includes the gradients between different pairs of wells screened in the A Sandstone and/or the zone below the A Sandstone that is correlative to the zone screened in well 25106, and includes well pairs 25004/25022, 25004/25106, 36112/25106, and 36113/25106. The wells screened in the correlative zone as well 25106 (i.e., wells 25023, 25024, and 36113) either are not contaminated or are not hydraulically upgradient of well 25106 , hence, the arsenic plume likely migrates from the Basin A alluvium into the subcropping A Sandstone initially and then migrates into the lower zone near well 25106.

Table 2 shows the calculations for the contaminated flow rate and mass flux for arsenic. Using an average hydraulic conductivity of 1.134 ft/day for the A Sandstone, and a hydraulic gradient ranging from of 0.0038 ft/ft to 0.0168 ft/ft to address migration from the A Sandstone to the lower zone screened by well 25106, the contaminated flow rate is estimated to range from 0.19 to 0.85 gpm, and the arsenic mass flux is estimated to range from 0.007 to 0.03 lb/yr. The BANS arsenic mass flux was 1.5 lbs/yr in FY14, and so the FY14 arsenic mass flux in the migration pathway at the north end of former Basin A is estimated to be nearly two to three orders of magnitude lower than at BANS. Additionally, the concentrations in the north Basin A arsenic plume are lower than the CSRG at BANS. The arsenic contaminated flow and mass flux estimates may be conservative because the hydraulic conductively of the zone screened in well 25106 may be lower than the value for the A Sandstone used in the calculations.

Table 2. Arsenic Contaminated Flow Rate and Mass Flux

FY14 Average Concentration, µg/L	Plume Width, ft	Saturated Thickness, ft	Hydraulic Gradient, ft/ft	Hydraulic Conductivity, ft/day	Flow Rate, gpm	Mass Flux, lb/yr
1.7	51	22	0.0038-0.0168	1.134	0.025-0.111	0.00019-0.00083
6.2	61	22	0.0038-0.0168	1.134	0.03-0.133	0.00082-0.0036
18.7	123	21.5	0.0038-0.0168	1.134	0.059-0.261	0.0048-0.0214
6.2	102	21	0.0038-0.0168	1.134	0.048-0.213	0.0013-0.0058
1.7	102	12.8	0.0038-0.0168	1.134	0.029-0.13	0.00022-0.00097
Total	439				0.19-0.85	0.0074-0.033

Conclusions and Recommendations

In developing the remedy for RMA, Basin A was determined to be a natural groundwater containment feature, with the only known outlets for contaminated groundwater flow assumed to be toward BANS and BRES. A third outlet for contaminated groundwater north of former Basin A is interpreted to exist that is not intercepted by BANS and BRES.

Dieldrin has been detected historically upgradient of former Basins C and F and can now be attributed to the north Basin A pathway. The north Basin A dieldrin plume intersects the Basins C /F plume and is intercepted and treated to meet remediation goals at the NBCS.

The north Basin A arsenic plume is interpreted to only migrate a short distance and does not appear to reach the First Creek alluvium east of the ELF. If the arsenic plume would migrate into the First Creek alluvium, it potentially would migrate to the NBCS and be intercepted and treated to meet remediation goals. Additionally, the arsenic concentrations in well 25106 are below the BANS CSRG and are decreasing. Therefore, based on the arsenic treatment criteria at BANS, no further action would be required for the north Basin A arsenic plume.

The presence of dieldrin and arsenic in wells upgradient of the ELF affects the ELF groundwater monitoring program, but is addressed by the upper prediction limit statistical evaluation of the ELF groundwater data, and does not significantly hinder the landfill performance evaluations.

The contaminant mass flux in the north Basin A pathway is estimated to be extremely low and the contaminant migration does not affect remedy protectiveness. Therefore, in the Army and Shell's opinion, additional remedial action for the north Basin A pathway is not warranted.

Future monitoring of this migration pathway is appropriate, however. Monitoring of wells 25022 and 25106 is conducted under the ELF Post-Closure Plan (PCP). Water quality monitoring of wells 25004 and 36112, which are screened in the A Sandstone and located upgradient of wells 25022 and 25106, is proposed and would be conducted under the Long-Term Monitoring Plan for Groundwater and Surface Water (LTMP) Water Quality Tracking category (twice in five-year frequency). Water levels are already monitored for these wells under the LTMP and ELF PCP. Well 25004 is shown on HLA Figures 4.29 and 4.17 and well 36112 is shown on FYSR Figure 5.1.3.2-1. If this proposal is acceptable to the Regulatory Agencies, an Operations and Maintenance Change Notice (OCN) will be issued to amend the LTMP.

References

MK-Environmental Services, 1994. *White Paper, Evaluation of the Denver Formation at Rocky Mountain Arsenal*. April.

Harding Lawson Associates, 1995. *Final Landfill Site Feasibility Report for the Feasibility Study Soils Support Program*. July.

U.S. Geological Survey, 2006. *Arsenic in Coal*. Fact Sheet 2005-3152. February. pubs.usgs.gov/fs/2005/3152/fs2005-3152.pdf

FIGURES

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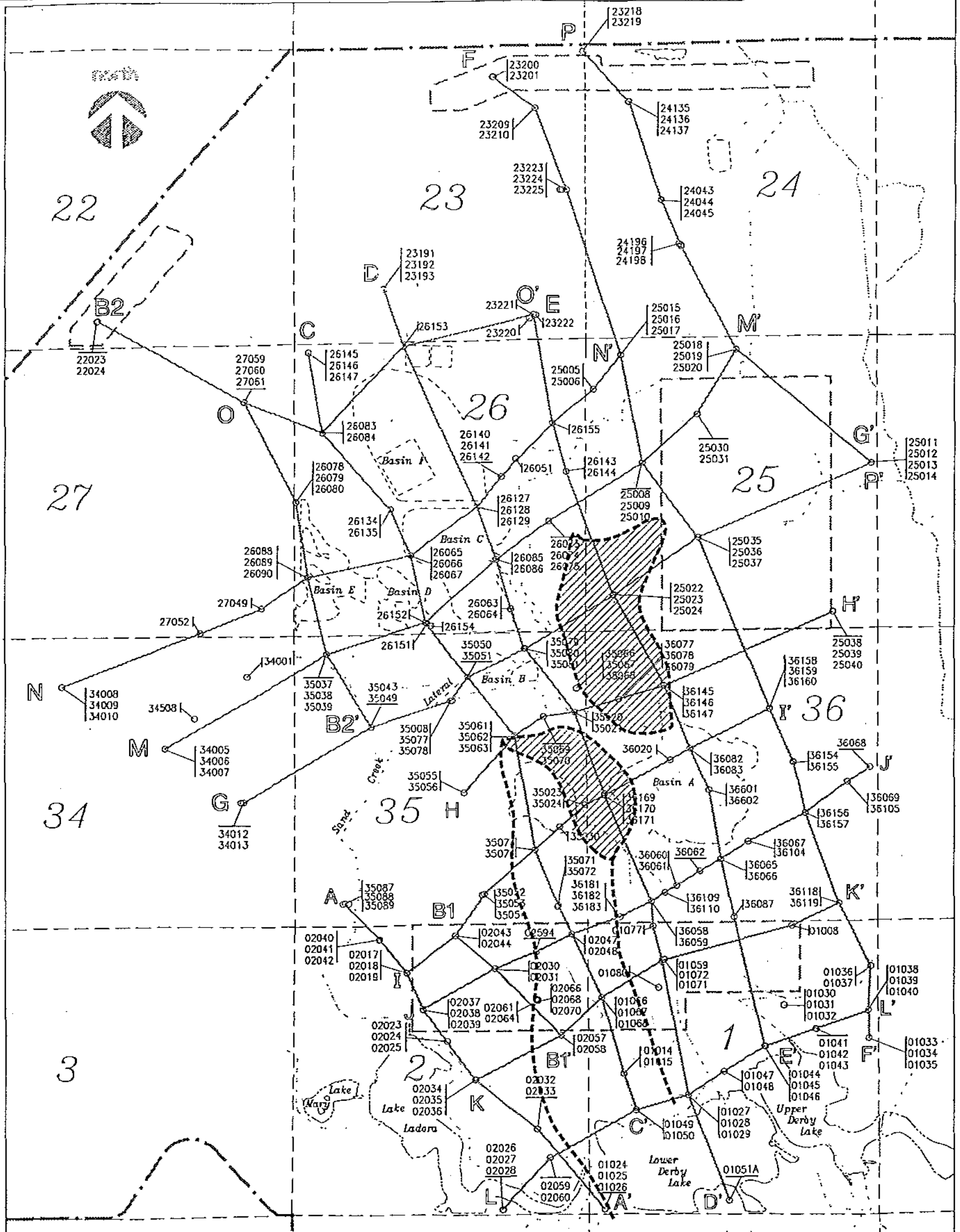

Legend

Inferred Sand Extent

Sand Subcrop

2500 1250 0 2500

Scale in Feet

RR 148778

PLATE 2

Rocky Mountain Arsenal

A Sand Extent and Subcrop

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES DIVISION

<CFN: 0103X040.DWG> <CPD:01/12/94> <AUT: REW>

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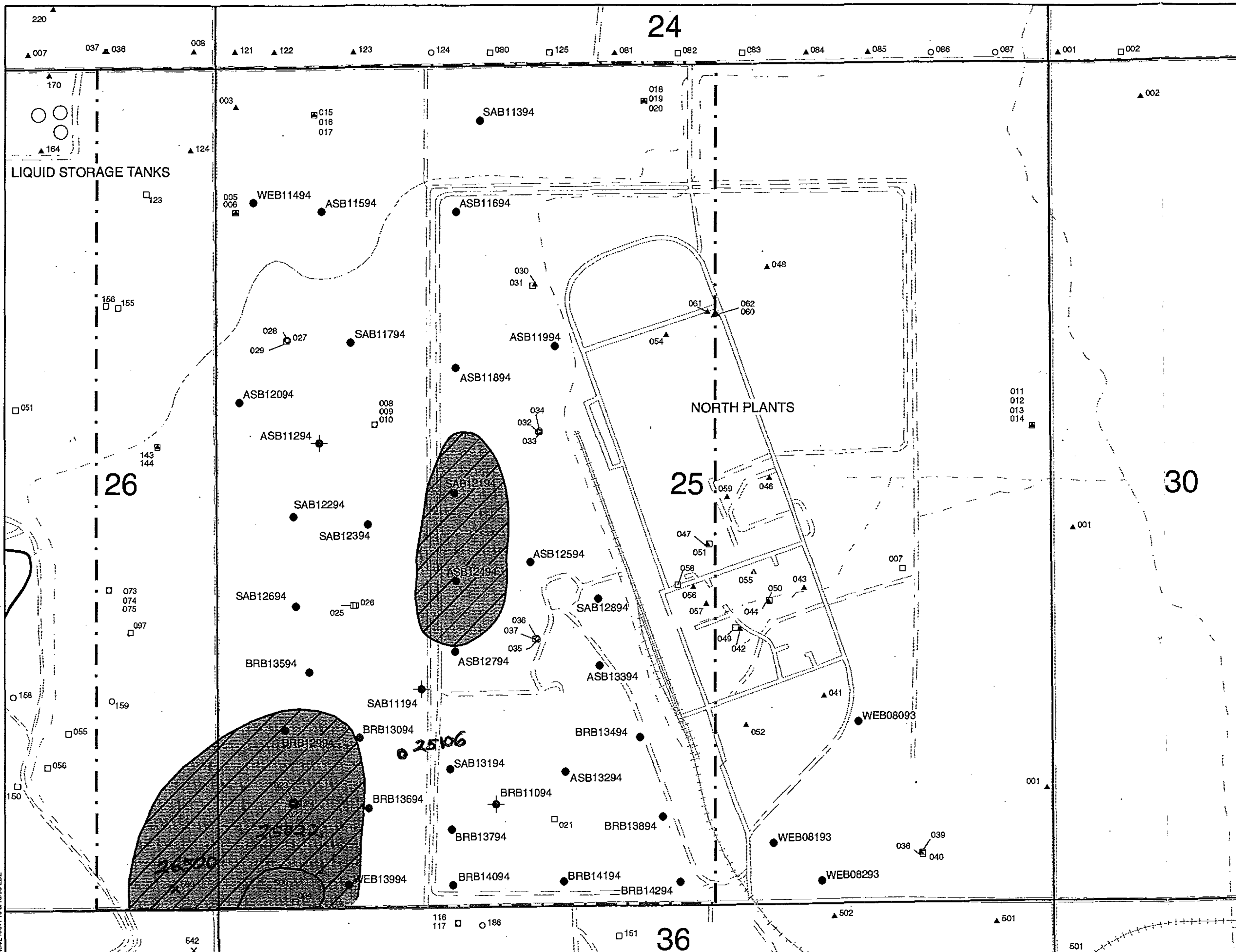

Explanation

- Alluvial well with well number (038)
- Unconfined Denver Formation well with well number (192)
- Confined Denver Formation well with well number (123)
- Shallow Soil Borings (30) (WEB11494)
- Deep Bore Holes (3) (BRB11094)
- Unpaved roadway
- Surface drainage
- Section number (25)
- Thick sequence of A Sand
- Area where A Sand subcrops into the alluvium
- Study area boundary

N

0 600
Scale in feet

Prepared for:
Program Manager for
Rocky Mountain Arsenal
Commerce City, Colorado

Prepared by:
Harding Lawson Associates

Figure 4.29

A Sand Extent and Subcrop Map

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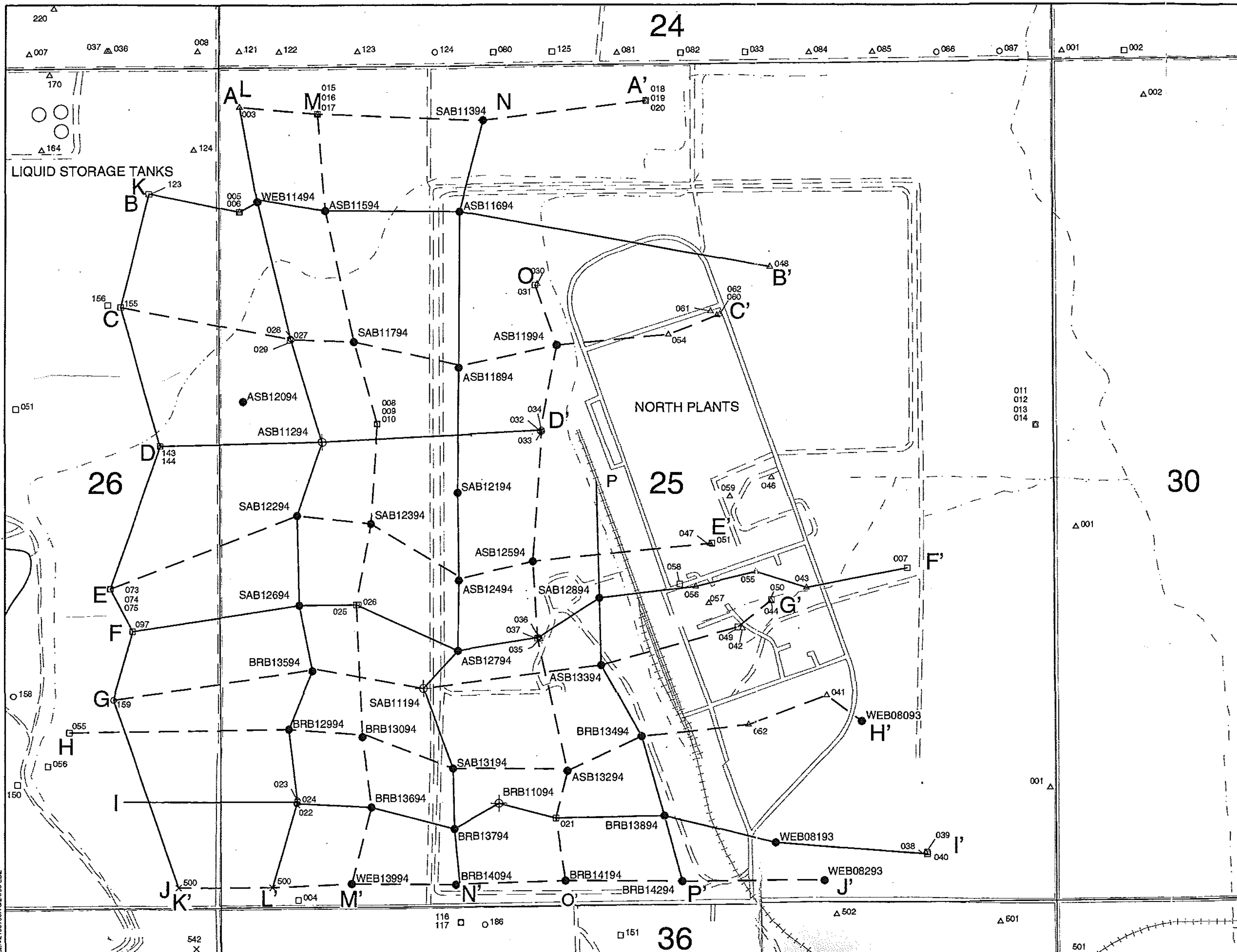

Explanation

△ 038	Alluvial well with well number
○ 192	Unconfined Denver Formation well with well number
□ 123	Confined Denver Formation well with well number
● WEB11494	Shallow Soil Borings (30)
⊕ BRB11094	Deep Bore Holes (3)
	Unpaved roadway
	Surface drainage
25	Section number
B——B'	Cross sections developed for evaluation of geologic data (included in report)
A— —A'	Cross sections developed for evaluation of geologic data (not included in report)

0 600

Scale in feet

Prepared for:

Program Manager for
Rocky Mountain Arsenal
Commerce City, Colorado

Prepared by:

Harding Lawson Associates

Figure 4.17

Boring and Cross-Section Location Map
Section 25

RMA2190750A 3/24/95 LDZ

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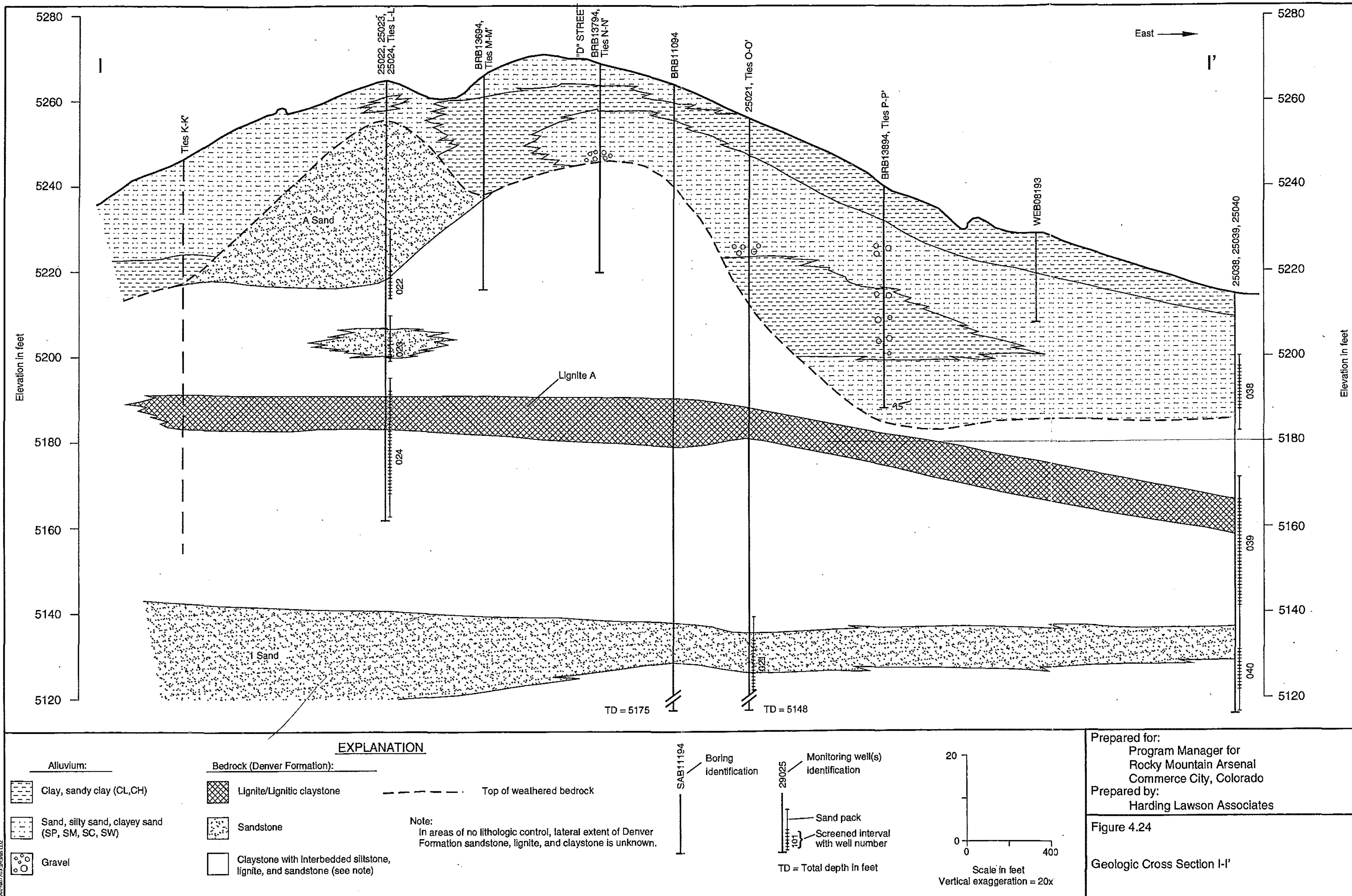

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Program Manager for
Rocky Mountain Arsenal
Commerce City, Colorado
Prepared by:
Harding Lawson Associates

Figure 4.24

Geologic Cross Section I-I'

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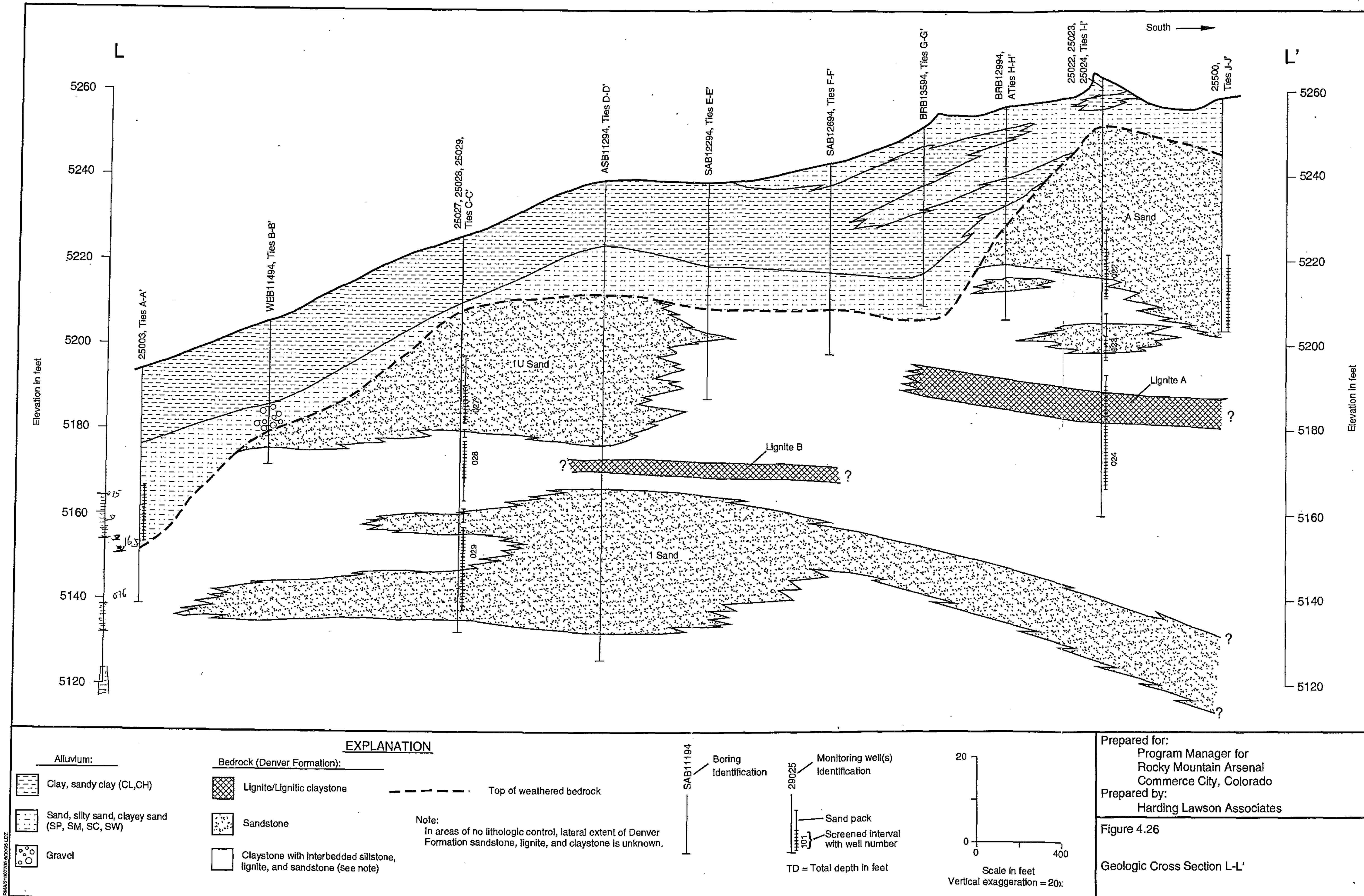

Prepared for:
Program Manager for
Rocky Mountain Arsenal
Commerce City, Colorado
Prepared by:
Harding Lawson Associates

Figure 4.26

Geologic Cross Section L-L'

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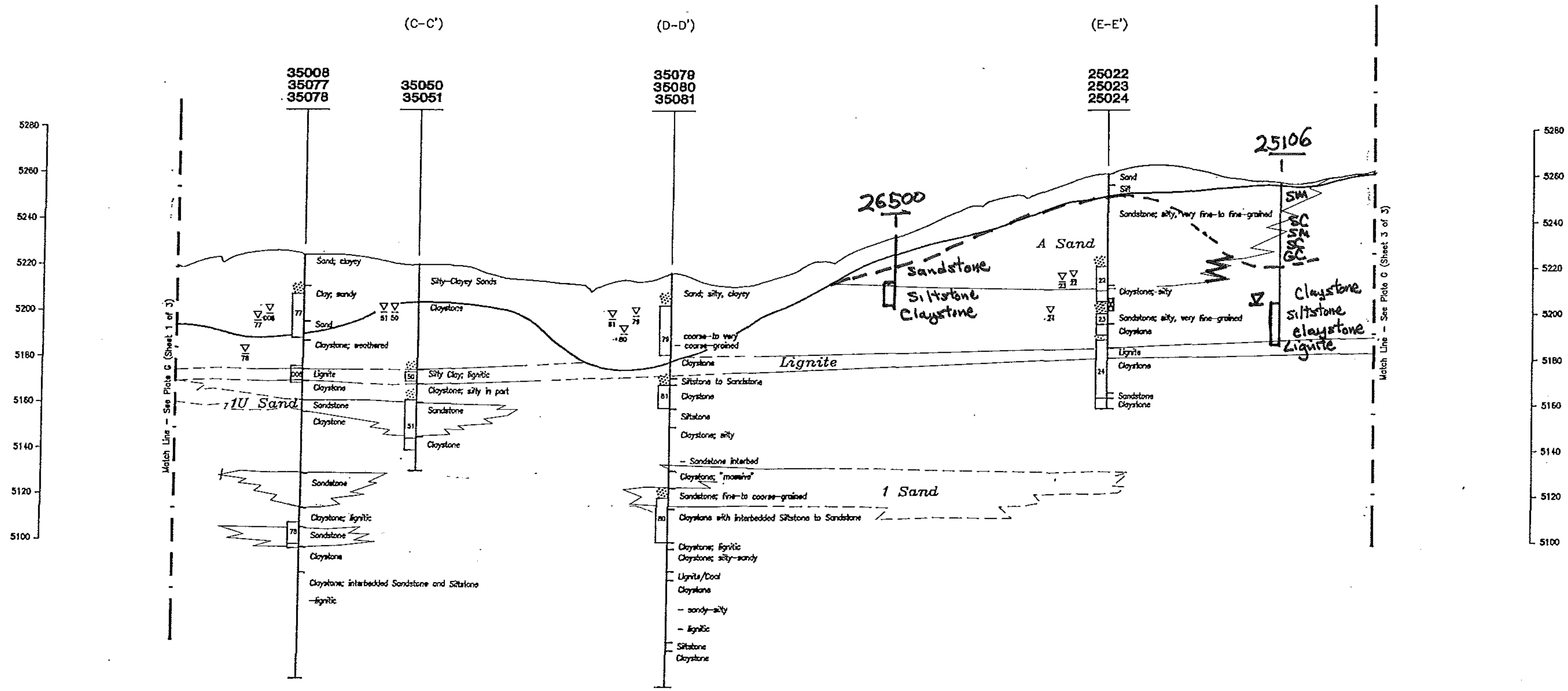

PLATE G
Sheet 2 of 3

500 250 0 500
Horizontal Scale, in Feet
See PLATE 1 for Explanation

RR 148802

Rocky Mountain Arsenal

Geologic Cross-Section G-G'

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES DIVISION

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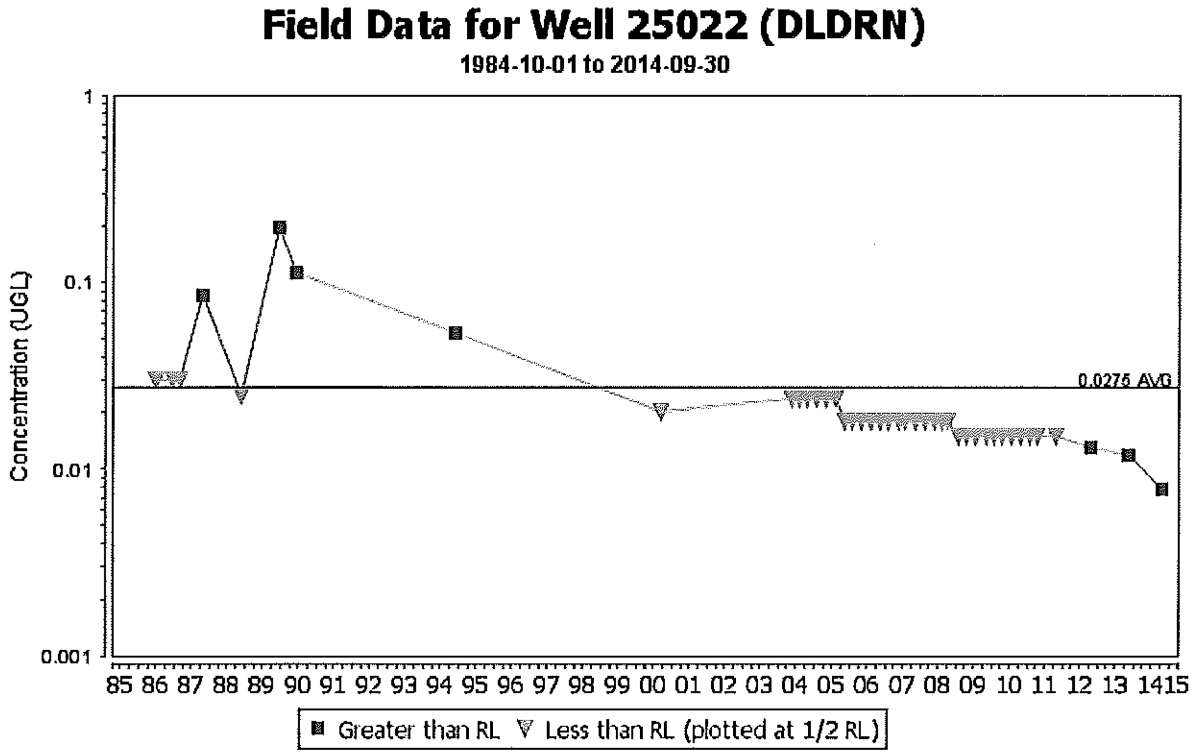
Figure 1


Field Data for Well 25022 (DLDRN)
1984-10-01 to 2014-09-30
Concentration (UGL)
1
0.1
0.01
0.001
0.0275 AVG
85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 1415
Greater than RL
Less than RL (plotted at 1/2 RL)

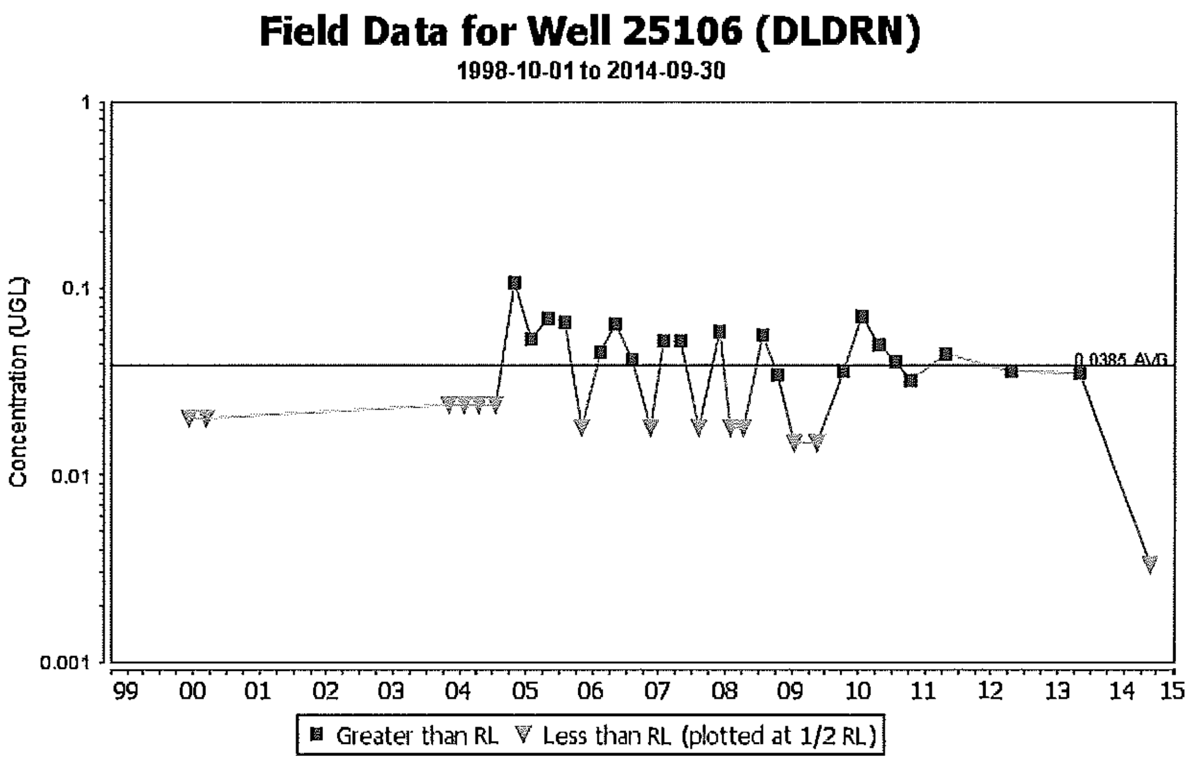
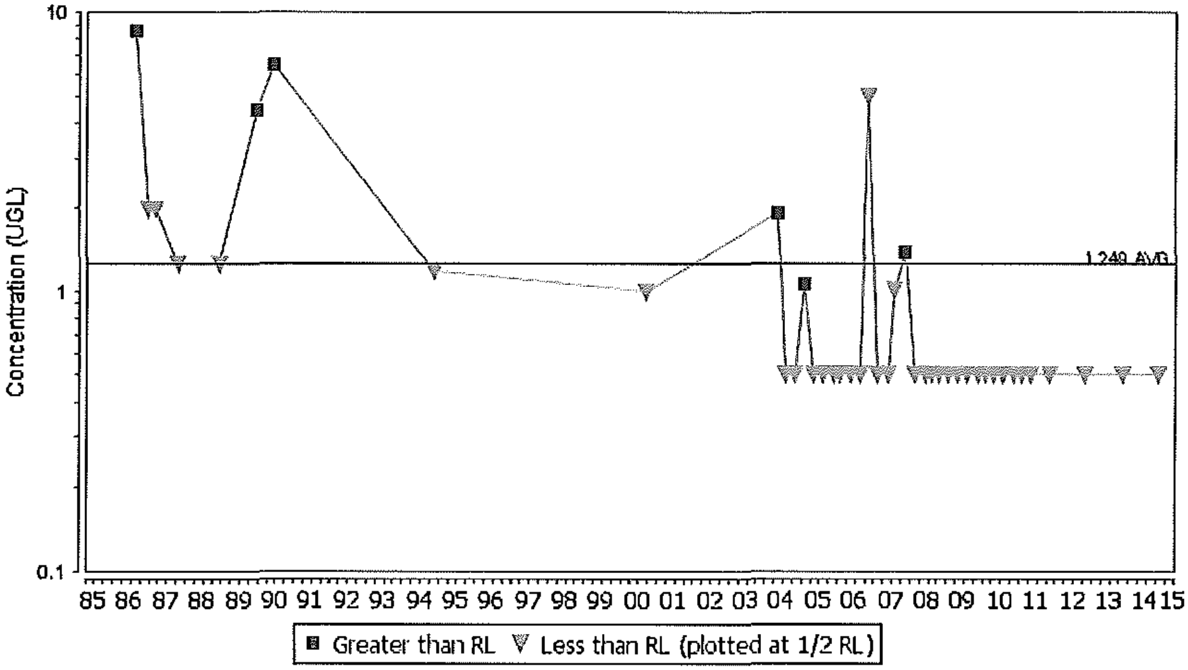

Field Data for Well 25106 (DLDRN)
1998-10-01 to 2014-09-30
Concentration (UGL)
1
0.1
0.01
0.001
0.0385 AVG
99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15
Greater than RL
Less than RL (plotted at 1/2 RL)

Figure 2

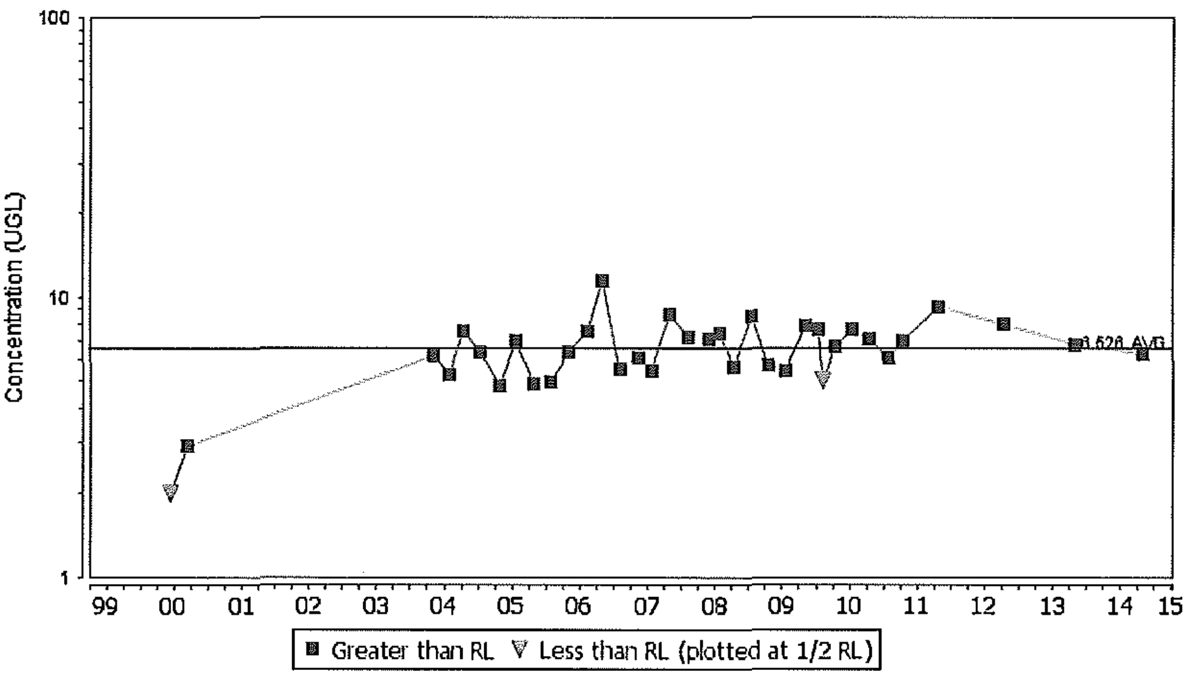
Field Data for Well 25022 (AS)

1984-10-01 to 2014-09-30



Field Data for Well 25106 (AS)

1998-10-01 to 2014-09-30



APPENDIX G

Responses to Regulatory Agency Comments

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**U.S. Army and Shell Oil Company Responses to
U.S. Environmental Protection Agency (EPA) August 6, 2015 Technical Comments on the Rocky Mountain Arsenal 2015 Five-Year Summary Report for Groundwater and Surface Water, Revision B, June 9, 2015
Revision 1**

COMMENTS FOR INCORPORATION

SPECIFIC COMMENTS

Comment 1. **<u>Section 5.1.1.1, Pages 50 through 54</u>.** This section provides a detailed discussion of the performance of the Northwest Boundary Containment System (NWBCS) during the five-year review period. The following are comments on this section:

a. Table 5.1.1.1-2 indicates that the downgradient performance wells consistently show dieldrin concentrations above the Practical Quantitation Limit (PQL). The recommended action is to obtain additional dieldrin data using the lower PQL before reaching any conclusions on whether a problem exists. However, the fact that seven of the eight downgradient performance wells have exceedances of the dieldrin PQL indicates that the NWBCS may not be functioning as intended. The text should be revised to explain that a dieldrin exceedance issue has been identified and that evaluation of these exceedances will be initiated.

b. Based on the *Offpost Estimated Areas Exceeding Containment System Remediation Goals (CSRGs) for Fiscal Year 2014 Map* there are currently no exceedance monitoring wells being monitored downgradient of the NWBCS (Navarro 2015). Section 5.2.2 states that the Army/Shell propose to conduct exceedance monitoring in two wells downgradient of the NWBCS, but no rationale is provided to support selection of these two additional wells. Given the exceedance of the dieldrin PQL in the downgradient performance monitoring wells, an evaluation should be conducted to establish the basis and rationale for conducting monitoring to evaluate the extent of the dieldrin plume off post.

c. This section indicates that additional changes in treatment may be necessary due primarily to dieldrin concentrations near the PQL in the treatment plant effluent. However, there is no additional discussion of what changes are being considered. This section should describe proposed changes in treatment and identify a schedule for development of the design details and implementation.

Response:

a. Issues are identified in the FYRR, and the downgradient performance well exceedances is included as an issue in the FYRR.

b. The rationale and basis for monitoring downgradient of the NWBCS and for the wells selected will be added.

c. The potential changes include pulsing more carbon, using virgin carbon instead of regenerated carbon, and investigating the potential desorption of dieldrin from carbon fines during sample extraction and analysis. This information will be added to the text.

Comment 2. **Section 5.1.1.2, Pages 54 through 68.** This section provides a detailed discussion of the performance of the North Boundary Containment System (NBCS) during the five-year review period. The following are comments on this section:

a. Table 5.1.1.2-2 indicates that the downgradient performance wells are showing dieldrin concentrations above the PQL. The first paragraph on Page 57 references the 2005 and 2010 Five-Year Review Reports and explains that these reports concluded that the downgradient performance wells were not representative of system performance. Reference to these previous documents is no longer relevant because new downgradient performance monitoring wells were identified in the revised *Long-Term Monitoring Plan for Groundwater and Surface Water* (LTMP) in 2010, to provide wells more suitable for evaluating system performance (TTECI-URS 2010). Therefore, reference to conclusions identified in the previous Five-Year Reviews should be removed.

b. This section indicates that residual contamination was present and migrated into these areas before the NBCS and/or slurry wall was installed. However, eight of the downgradient performance wells identified in the 2010 LTMP are former recharge wells which would have been screened in the more coarse-grained portions of the alluvium and where recharge would have flushed residual contamination during years of pumping treated recharge water from these wells. The discussion in this section should be corrected appropriately.

c. The text indicates that the influent concentration for dieldrin increased during the five-year review period which is opposite to other contaminant trends at NBCS. This discrepancy should be identified and addressed in the report.

Based on the issues identified above, it cannot be concluded that the NBCS is performing as intended. The text should be revised to discuss the causes of the dieldrin exceedances based on the new performance monitoring results and indicate that this issue has been identified for further evaluation.

Response:

a. The Army and Shell disagree. The same mechanisms that affected the NBCS former conformance wells appear to be affecting the downgradient performance wells. Contemporaneous water quality data were collected from both sets of wells during this FYR period, and they were found to be comparable. Consequently, with Regulatory Agency approval, sampling of the former conformance wells was discontinued. Therefore, the conclusions that applied to the conformance wells also apply to the performance wells. An evaluation of the hydrogeology in the areas of the NBCS former conformance wells and current performance wells will be added to the FYSR to better compare their water quality data.

b. The Army and Shell disagree. The recharge wells were installed across the full length of the system at uniform spacing in order to attempt to create a reverse hydraulic gradient across the entire system. They were not necessarily installed in more coarse-grained portions of the alluvium. While many of the recharge wells were installed in coarser-grained sediments (silty sand, poorly graded sand, and gravelly sand), several of the recharge wells that were selected as downgradient performance wells were screened in finer grained sediments, including clay, clayshale, silt, and clayey sand. Flushing of the more mobile contaminants by the recharge wells, and later, by the recharge trenches likely has occurred, but flushing of the less mobile and less soluble compound dieldrin is still ongoing. As stated in the response to Comment 2a above, an evaluation of the hydrogeology in the areas of the NBCS former conformance wells and performance wells, some of which are recharge wells, will be added to the FYSR to better compare their hydrogeology and water quality data.

c. The long-term trend in dieldrin concentrations in the NBCS influent is downward, but the short-term trend during the FYR period was slightly upward. Between 2009 and 2014, the groundwater elevations upgradient of the NBCS were two to four feet higher (Figure 5.1.3-7), which may explain the increase in dieldrin concentrations in the influent due to mobilization of additional dieldrin from the previously unsaturated aquifer sediments. Overall, the dieldrin concentrations in the NBCS plant influent have been relatively stable, consistent with the less soluble and less mobile nature of dieldrin compared to the more mobile contaminants that have shown decreases in concentrations in the influent. The above discussion will be added to the report.

The Army and Shell disagree that it cannot be concluded that the NBCS is performing as intended. The NBCS primary performance criteria are being met. According to the Decision Rules in the LTMP, when the primary performance criteria are met, the NBCS is functioning as intended. The secondary performance criterion (downgradient well concentrations are at or below CSRGs/PQLs or show decreasing trends) applies when the primary criteria are not met. Thus, meeting the secondary criterion is not a requirement. Although a few contaminants with concentrations above CSRGs/PQLs are present downgradient, the concentrations are stable or decreasing. Defensible explanations exist for the presence of the downgradient contamination that are unrelated to current performance of the system. These explanations are not new and have been presented in the Annual Summary Reports (ASRs) and 2005, 2010, and 2015 FYSR and/or FYRR reports. Therefore, according to the performance criteria in the LTMP, The Army and Shell believe that the NBCS is functioning as intended.

Comment 3. **<u>Section 5.1.1.4, Pages 71 and 80</u>.** This section provides a detailed discussion of the performance of the Basin A Neck System (BANS) during the five-year review period. Table 5.1.1.4-2 presents the mass removal percentages for 2010 through 2014 for the BANS. The table shows that the system achieved mass removal greater than the preliminary mass removal goal established in the LTMP of 75 percent. However, the last paragraph in this section indicates that the mass removal goal should not be increased above the 75 percent because some analytes are approaching their CSRGs. Review of the LTMP performance criteria indicates that though there is a requirement to use the ROD CSRG analytes (and DIMP) as indicator compounds for determining mass removal, there is no association between the mass removal requirement and CSRGs (TTECI-URS 2010). Therefore it is unclear why achieving the CSRGs affects the mass removal goals. Based on the information included in the report, it appears that the mass removal goal could be increased. This section should be revised appropriately.

Response: The Army and Shell strongly disagree with EPA's statement that there is no association between the mass removal requirement and CSRGs. The On-Post ROD stipulates that the groundwater contaminants will be treated to meet the CSRGs/PQLs. If the upgradient concentrations are below CSRGs, no treatment (and therefore, no mass removal) is required. It is unrealistic to expect or require that mass removal meet a performance criterion when the concentrations already meet the ROD remediation goals. Furthermore, since the BANS treatment plant receives untreated flow from the BRES, Lime Basins, and Complex Trenches dewatering systems, where concentrations are higher for numerous analytes than in the BANS dewatering wells, it's possible, if not likely, that the concentrations in the BANS effluent may meet the CSRGs/PQLs, but be higher than the concentrations in the BANS-specific influent and BANS dewatering wells. Thus, the BANS-specific mass removal would be negative. The LTMP should be revised to clarify this issue. As stated in the FYSR, The Army and Shell will continue to optimize the BANS mass removal, and performance similar to that during the past FYR period is anticipated during the next FYR period.

Comment 4. **<u>Section 5.1.1.5, Pages 80 through 83</u>.** This section provides a detailed discussion of the performance of the Bedrock Ridge Extraction System (BRES) during the five-year review period. The following are comments on this section:

a. Table 5.1.1.5-1 shows that downgradient Performance Well 36566 had numerous concentrations above the CSRGs for carbon tetrachloride, chloroform, tetrachloroethene and periodic exceedance of the CSRGs for 1,2-dichlorothane and trichloroethene. The text indicates that because these analytes do not show the same concentration trends, that bypass is not occurring. However, there are no requirements in the LTMP for all contaminants of concern to behave similarly to identify a problem with the system (TTECI-URS 2010). In addition, the results from Water Quality Tracking Well 25502 are incorporated into the performance discussion to indicate that the system is performing successfully, but this well is not a performance well and may not be in the flow path of Well 36566. Therefore, data from this well is not applicable for evaluating plume capture. Also, Extraction Well 36302 is mentioned but no data from this well is provided to support any conclusions about the contamination in Well 36566. Given the observed contamination in downgradient Performance Well 36566, it cannot be concluded that the system is functioning as intended. A more detailed evaluation should be initiated to determine why contamination is occurring in Well 36566.

b. The conclusion states that Well 36566 may be located in a stagnant zone downgradient of the extraction system, suggesting that system bypass is not occurring. However, this well is located at the west end of the system with few water-level wells nearby to provide data indicating whether or not a stagnant zone exists. Therefore bypass cannot be ruled out and further evaluation is needed. This section should be revised appropriately.

Response:

a. As stated in the 2010 LTMP, the 1999 BRES design document concluded that given the slow migration and low permeability in the Denver Formation, the downgradient wells would be expected to clean up very slowly and not indicate system effectiveness. Thus, no performance criteria were required for the downgradient wells in the design document. In order to attempt to make the BRES performance criteria more similar to the other systems in the 2010 LTMP, four downgradient performance wells were included in the BRES performance network. However, the LTMP stipulated that these wells would be sampled for five years before any performance conclusions would be drawn. Five years of data have now been collected, but this time frame may be too short for evaluating one of the wells (36566). Concentrations in three of the four downgradient performance wells have decreased to below the CSRGs. The fourth well, 36566, is the westernmost well and the hydraulic gradient is much flatter in this area than in the other three performance wells. The contaminant concentrations in well 36566 either are below the CSRG, decreasing, or near the CSRGs, except for tetrachloroethylene (TCLEE). The TCLEE concentration in well 36566 has increased and was 84.6 µg/L in 2014. However, the TCLEE concentrations in well 36566 are much lower than in the upgradient wells in the western portion of the Bedrock Ridge plume (419 µg/l in well 36567 in 2014, and 360 µg/l in extraction well 36302 in 2009). Given the low permeability of the Denver Formation (3.9×10^{-3} cm/second in well 36560 [MK 1999]), low hydraulic gradient (avg. of 0.0018 ft/ft from FY10 to FY14 between wells 36569 and 36566), and equivocal nature of the water quality data in well 36566, additional monitoring is needed to determine whether the well is appropriate as a downgradient performance well and whether the data from the well indicate system performance. Decreasing concentrations in water quality tracking well 25502 indicate the BRES is causing the downgradient concentrations to decrease, but does not necessarily confirm that the BRES plume is being captured. The FYSR will be revised to include more evaluation of the BRES performance and contaminant migration near well 36566.

b. Well 36566 may be located downgradient of the stagnation point (EPA 2008) for extraction well 36302, but the gradient is much flatter at well 36566 than at the other performance wells. Thus, well 36566 would be expected to clean up slower than the other performance wells. The section will be revised accordingly.

Comment 5. **<u>Section 5.1.2.1, Pages 94 through 99</u>.** This section provides a detailed discussion of the performance of the Complex (Army) Trenches (CAT) remedy during the five-year review period. The following are comments on this section:

a. Figure 5.1.2.1-3 shows the water table elevations for the two wells used to determine whether target elevations have been achieved. This table shows that water levels in Well 36217 have never achieved the target elevation during the fourteen year operating life of this remedy. In addition, the September 9, 2014, date established in the LTMP for achieving the dewatering goals at CAT has elapsed without this goal being achieved (TTECI-URS 2010. Therefore it cannot be concluded that the remedy is functioning adequately. This section should be revised appropriately.

b. This section states that there is no adverse impact to the protectiveness of the remedy because the contamination is contained within the slurry wall. However, there is no specifically-identified water quality monitoring criteria established for CAT to validate this statement. This statement should be removed. Based on the five-year review results, improvements to the remedy system for the CAT should be initiated.

Response:

a. On page 99, first sentence, it is stated that, "Based on criteria in the Design Document (RVO 1997), On-Post ROD, and 2010 LTMP, the Complex (Army) Trenches dewatering system is not performing as expected in the Decision Documents." The status of attaining the dewatering goals is discussed at length. Therefore, no revisions seem necessary.

b. The ROD standard is to dewater as necessary to ensure containment. Containment by a slurry wall typically is demonstrated using water level data. At the Complex Trenches, water level monitoring of the performance wells is conducted to demonstrate that an inward hydraulic gradient has been maintained. An inward gradient has been demonstrated since dewatering commenced and the inward gradient ensures containment. The Army and Shell disagree that the statement should be removed. Issues are identified in the FYRR and meeting the dewatering goal in the second compliance well is included as an issue in the FYRR. Subsequent to the FYRR, a cost-benefit evaluation for installing dewatering wells in the Complex Trenches will also be conducted.

Comment 6. **<u>Section 5.1.2.2, Pages 99 through 102</u>.** This section provides a detailed discussion of the performance of the Shell Disposal Trenches (SDT) remedy during the five-year review period. The following are comments on this section:

a. The text indicates that the remedy goal for achieving water levels below the bottoms of the trenches within SDT was not consistently achieved during the five-year review period and has not been consistently achieved since. The LTMP states the performance criteria for SDT is to demonstrate that water level elevations are below the bottom of the disposal trenches (TTECI-URS 2010). Also, the October 2, 2012, target date for compliance has passed (TTECI-URS 2010). The text indicates that there is not a dewatering goal for SDT even though Section 1.4.1.7 references the *Record of Decision for the On-Post Operable Unit* (ROD) statement that the remedy for SDT is "*dewater as necessary to ensure containment*" (FWENC 1996). The wells used for compliance monitoring were configured to monitor water levels within and outside the slurry wall and not to determine whether water levels are below a specific elevation representative of the bottom of the trenches. As a result, interpolation of water levels within the trench areas based on data from the perimeter wells is necessary to estimate whether the remedy goals have been achieved. Given that the remedy goals have not been achieved based on the five-year summary results, improvements to the remedy system for SDT should be initiated. As a first step, piezometers should be installed within the SDT area to provide an improved evaluation of whether water levels below the trench bottom elevations are being achieved.

b. The last paragraph in this section indicates that there are no adverse impacts to the protectiveness of the remedy because the contamination is contained within the slurry wall. However, there is no specifically-identified water quality monitoring established for SDT to validate this statement. This statement should be removed. Based on the five-year review results, improvements to the remedy system for SDT should be initiated.

Response:

a. EPA is incorrect. The text does not state that "there is not a dewatering goal" for the Shell Trenches. The dewatering goals are discussed. The text does state that active dewatering was determined to be unnecessary in the design document, which is a fact. Interpolation of the groundwater elevations at the compliance borehole locations was the methodology agreed upon by the Regulatory Agencies and the Army and Shell to evaluate performance in meeting the dewatering goal in the 2010 LTMP. Attainment of the Shell Trenches dewatering goals is identified as an issue in the FYRR and the monitoring network will be part of the evaluation of the remedy system. Subsequent to the FYRR, a cost-benefit evaluation for installing dewatering wells in the Shell Trenches will also be conducted.

b. The statement will be clarified. Although an inward hydraulic gradient is not required at the Shell Trenches, the presence of two slurry walls undoubtedly provides benefits in containing the groundwater contamination. Water level monitoring is conducted to evaluate performance in meeting the dewatering goals. There are no water quality performance requirements. Additionally, downgradient of the Shell Trenches, the groundwater is extracted by the BRES and BANS, and treated to meet CSRGs. Thus, the remedy contains multiple layers of protectiveness.

Comment 7. **<u>Section 5.1.2.3, Pages 102 through 107</u>.** This section provides a detailed discussion of the performance of the Lime Basins remedy during the five-year review period. The text indicates that during the 2015 five-year review period and as of the target date of September 9, 2014, the dewatering goals were not achieved. However, significant progress has been made during the five-year review period in achieving the dewatering goals. A revised target date for meeting the dewatering goals should be developed and submitted as an Operation Change Notice (OCN) for Regulatory Agency review.

Response: Attainment of the dewatering goals for the Lime Basins Dewatering Project has been identified as an issue in the FYRR and will be evaluated further, including developing revised target dates for meeting the dewatering goals. Steady progress is being made toward meeting the Lime Basins dewatering goals, and revised compliance dates will be developed and documented in the LTMP with an OCN.

Comment 8. **<u>Section 5.1.3.1, South Plants SPSA-2d Ditch, Page 136</u>.** This section discusses results from monitoring the SPSA-2d Ditch, and indicates that dieldrin encountered in the wells is related to a larger dieldrin plume and that monitoring for organochlorine pesticides should be discontinued. However, these wells are identified as source monitoring wells in the LTMP (TTEC-URS 2010), so if source material was not removed in this area it is unclear why monitoring would be discontinued, especially when dieldrin was detected above the PQL in two of the three downgradient monitoring wells. Because of this and the fact that neither the LTMP nor DCN-ICSC-69 provide criteria for termination of monitoring for these wells, monitoring for the organochlorine pesticides should continue. This section should be revised appropriately.

Response: This section will be revised as requested.

Comment 9. **<u>Section 5.1.3.2, Pages 147 and 155</u>.** This section provides a detailed discussion of the Confined Flow System (CFS) Monitoring during the five-year review period. The following are comments on this section:

a. The first paragraph in this section indicates that CFS Well 23193 is damaged and cannot be sampled. This well should be replaced to meet the requirements of the LTMP and the On-Post ROD.

b. The summary indicates that Wells 01067, 02057 and 35067 may have questionable aquitards and may display semi-confined conditions rather than confined conditions. Therefore, these wells may be unsuitable for the CFS monitoring program and should be replaced to meet the requirements of the LTMP and the On-Post ROD.

c. The last paragraph of this section indicates that Well 35083 has a defective well seal which would make it unsuitable for the CFS monitoring program. This well should be replaced to meet the requirements of the LTMP and the On-Post ROD.

Response:

a. Well 23193 was last sampled in 2002. It has not been sampled since then because of an obstruction, but water levels may still be measured. It was already obstructed when the 2010 LTMP was developed, and it was retained for water level monitoring. The other CFS wells selected for monitoring Basin F were considered adequate in the LTMP and replacing well 23193 was unnecessary. Thus, The Army and Shell believe that the requirements of the LTMP and On-Post ROD are being met. Well 23193 was recently inspected with a downhole camera and sampling may be possible. If well 23193 cannot be sampled during the next scheduled sampling event, alternate CFS well 23230 will be sampled instead.

b. Well 01067 has only had a single detection of an indicator analyte near the MRL (11DCLE in FY14). The chloride concentrations in well 01067 are stable and equal to or lower than historical levels. Thus, monitoring of well 01067 should continue.

   Well 02057 may be semi-confined because of a questionable aquitard. The presence of contamination in the well and the questionable aquitard were known when the well was selected for the CFS network. Overall, the well has shown decreasing concentration trends, which are consistent with expectations. Thus, replacing well 02057 or any other action besides continued monitoring is considered unnecessary by the Army and Shell.

   Well 35067 may be semi-confined because of a questionable aquitard. The questionable aquitard and increasing chloride concentration trend were apparent when well 35067 was selected for the CFS network in the 1999 LTMP. Thus, no change in the status of the well is indicated, and no action besides continued monitoring is appropriate. Adjacent CFS well 35068 is screened in the next lower sandstone zone and is in the LTMP CFS monitoring network. Since the deeper zone is monitored by well 35068, and the status of well 35067 has not changed, replacing well 35067 is not considered necessary by the Army and Shell.

c. Although well 35083 does not appear to have a bentonite seal, the grout well seal may be effective. While the chloride concentrations had an increasing trend prior to FY14, possibly due to a combination of lateral and vertical migration, no organic contaminants have been detected. Since the chloride concentrations decreased in FY14, continuing to monitor well 35083, and not closing or replacing it, is suggested. Additionally, adding alternate wells 02047 and 02048 to the LTMP CFS network is proposed. Wells 02047 and 02048 are located upgradient of well 35083 and are completed in the A Sand and 1U Sand, respectively.

Comment 10. **Section 5.1.5.1, Pages 169 through 174.** This section provides a detailed discussion of the 2014 On-Post Plume Mapping Project. The following are comments on this section:

a. Results of the 2014 Plume Mapping Project are represented in Figures 5.1.5.1-1 through 5.1.5.1-12 which show the extent of the plumes for each analyte that was evaluated on the project. However, these maps are too small and do not list the well numbers or the actual contaminant concentrations. Larger figures (similar to Figure 5.1.5.3-1) should be provided which contain the necessary information for evaluating the plume mapping results.

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b. The text provides a discussion for each analyte where changes in concentrations were identified in wells that were sampled both in 1994 and 2014. Although the comparison in analyte concentration between individual wells is useful, comparing site-wide average concentrations is less useful because the project was not designed to provide the spatial integrity necessary to estimate site-wide concentration changes. Also, the conclusions may tend to mask areas where higher concentrations have been encountered such as near Lime Basins and in the South Plants benzene plume for which a small number of wells were included in the plume mapping. The site-wide average calculations should be removed.

c. The text also includes a quantitation of the change in plume area above the CSRG/PQLs for each analyte. However, the plume area calculations are not comparable because more wells were used in the 1994 plume mapping than were used in the 2014 plume mapping, providing less confidence in the mapped areas presented. Therefore, the plume area changes should be discussed in a more qualitative manner than currently presented.

d. The subsection titled "Dieldrin" indicates that a previously unidentified contaminant pathway exists in the sub-cropping Denver Formation north of Basin A. However, there is no information provided as to what wells were used to make this conclusion. Discovery of a new contaminant pathway out of Basin A constitutes new information which may have implications for remedy assessment. Therefore, consultation should be initiated with the Regulatory Agencies and a plan presented for evaluating this pathway.

e. Based on information provided in this section, it is clear that new information about contaminant plume extent was gained as a result of the Plume Mapping Project, but no recommendations have been made for changes to the LTMP monitoring programs. Given that this updated plume information was not available at the time of the 2010 LTMP revision, an evaluation should be performed to determine if revisions to the LTMP are warranted.

Response:

a. Since comparison of the 2014 plume maps to the 1994 plume maps was an objective, the 2014 plume maps were made to be similar to the 1994 maps (e.g., same scale, well locations plotted, contour intervals, etc.). Please refer to the 2014 Plume Mapping DSR for the associated data.

b. Calculating the average concentrations is just one of several methods for evaluating the data. The Regulatory Agencies were interested in qualitative and quantitative comparisons of the 1994 and 2014 plumes. Selecting wells sampled in 1994 was one of the criteria for selecting wells for the 2014 network. Since the averages only pertain to the subset of wells sampled in both monitoring events, the data seem useful. More discussion of the factors discussed by EPA will be added to the text.

c. Calculating the plume areas is just one of several methods for evaluating the data. The Regulatory Agencies were interested in qualitative and quantitative comparisons of the 1994 and 2014 plumes. As discussed in the text, considerable effort was placed in re-examining the 1994 data and using historical and current data to augment the 2014 plume interpretations. In 1994, numerous isolated detections were plotted instead of drawing plumes in known migration pathways. Thus, although the 2014 plume interpretations were based on fewer wells than in 1994, the 2014 plumes reflect a more realistic depiction and likely is more conservative than the 1994 depiction. Thus, the decreases in the plume extents likely are greater than indicated.

d. Well 25022 is located in the area where some of the groundwater contaminants migrated through subcropping Denver sandstones at the north end of Basin A, south of the ELF, and east of former Basins C and F. Dieldrin was first detected in well 25022 in 1987, and it was also detected in 1994. Thus, the presence of dieldrin in this area is not new. A description/explanation of the migration in this area adds to the understanding of the plume distributions, but does not materially affect the remedy assessment because the contamination has been present historically. Other wells where dieldrin has been detected in this area include 25106, 36112, and 36538. Additional evaluation of this migration pathway will be added to the FYSR.

e. Revision of the 2010 LTMP is being considered. An evaluation of the LTMP well networks will be conducted at that time.

Comment 11. **<u>Section 5.1.5.3, Pages 192 through 200</u>.** This section provides a detailed discussion of the On-Post 1,4-dioxane characterization performed during the five-year review period. The following are comments on this section:

a. The last paragraph on page 194 suggests that compared to other soluble Rocky Mountain Arsenal (RMA) compounds, the maximum groundwater concentrations for 1,4-dioxane are quite low (266-324 micrograms per liter (µg/L)). However, it is the toxicity of a contaminant not the maximum concentration of a contaminant that should be of concern. Given that the CBSG for 1,4-dioxane, which is a risk based value, is 0.35 µg/L, a value of 200-300 µg/L is substantial and should not be dismissed. In addition, this paragraph speculates that the 1,4-dioxane is in a "depleted state" but also indicates that there is insufficient data to make this conclusion. Because there is no technical validity for the statements in this paragraph it should be deleted.

b. The subsection titled "Conclusions and Recommendations" proposes additional monitoring for 1,4-dioxane and identifies monitoring frequency and monitoring locations. Though some of these proposed activities have merit, a decision needs to be reached on whether 1,4-dioxane should be added as a CSRG for RMA before a monitoring design can be approved. The 1,4-dioxane project was initiated as an outgrowth of an issue in the 2010 Five-Year Review requesting that the presence of 1,4-dioxane be determined. Now that the presence and extent of 1,4-dioxane at RMA has been established, the 2015 Five-Year Review should be the decision document for future investigation and monitoring. This comment also applies to Section 5.3 which discusses Off-Post 1,4-dioxane characterization.

Response:

a. The Army and Shell are not dismissing the 1,4-dioxane detections; however, comparison of relative concentrations to other soluble compounds is provided as part of the evaluation. The maximum concentrations of 1,4-dioxane are three orders of magnitude above the CBSG. For other soluble groundwater contaminants such as benzene and chloroform, the maximum concentrations are six orders of magnitude above the CSRG/CBSG. Hence, the comparison of 1,4-dioxane concentrations to other contaminants is useful, and an observation that 1,4-dioxane sources may be in a depleted state should be retained. The above supporting information will be added to the text.

b. Evaluation of the 1,4-dioxane standard, effect on remedy protectiveness, and recommendation on whether to adopt the standard will be made in the FYRR.

Comment 12. **<u>Section 5.2.1, Pages 201 through 210</u>.** This section provides a detailed evaluation of the Off-Post Groundwater Intercept and Treatment System (OGITS) performance during the five-year review period. The conclusion section indicates that the 75 percent mass removal goal was not attained in FY2010 and FY2012 for the First Creek component of OGITS, and that the combined First Creek and Northern Pathway Systems did not meet the goal in FY2012. However, the last paragraph in this section indicates that changes to the method for calculating mass removal using the upgradient performance wells should be implemented because some analytes are approaching their CSRGs. Review the LTMP performance criteria indicates that though there is a requirement to use the ROD CSRG analytes as indicator compounds for determining mass removal, there is no association between the mass removal requirement and CSRGs. Therefore it is unclear why the CSRGs are being used to change the mass removal goals. The methodology for mass removal calculation at OGITS should not be changed based on the CSRGs.

Response: Please see the response to Comment 3, which is a similar comment about BANS.

Comment 13. **Section 5.2.2, Pages 210 through 215.** This section discusses the Off-Post Exceedance and Water Level Monitoring. The last paragraph in this section proposes changes to the Exceedance Monitoring well network. However, there is no rationale provided to justify the proposed changes. An explanation of the proposed monitoring changes should be presented to the Regulatory Agencies to validate that the recommendations are sufficient for achieving the exceedance monitoring objectives.

Response: Rationale for the proposed changes will be added to the text.

Comment 14. **Figure 5.1.5.1-9.** This figure is a map of the carbon tetrachloride plume. The first gradation in the legend for carbon tetrachloride concentration shows a range from 0.263 to <5.0 µg/L. However, the CSRG for carbon tetrachloride is 0.3 µg/L. It is unclear why the gradation range was not established to be below the CSRG, as was done for all other plume maps. The gradation should be changed to show where carbon tetrachloride is above and/or below the CSRG.

Response: The MRL (0.263 µg/L) and CSRG (0.3 µg/L) are essentially the same number. It was not feasible to show a distinction between the two concentrations in a site-wide scale map.

Reference:

EPA 2008. *A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems.* U.S. EPA Ground Water and Ecosystems Restoration Division. National Risk Management Research Laboratory. EPA/600/R-08/003. January 2008. www.epa.gov/ord

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U.S. Army and Shell Oil Company Responses to
Colorado Department of Public Health and Environment (CDPHE) Comments on the
Rocky Mountain Arsenal Five-Year Summary Report for Groundwater and Surface Water
June 9, 2015
Revision 1

General Comments

Comment 1. The Five-Year Summary Report for Groundwater and Surface Water (FYSR) includes a proposal to retain the 75 percent mass removal goals for the Basin A Neck System (BANS) and Off-Post Groundwater Intercept and Treatment System (OGITS). It is the Divisions understanding that a higher performance goal was considered but not recommended due to potential difficulties in attainment if upgradient concentrations decrease in the future. CDPHE has the following comments regarding this recommendation:

a. The application of a five-year timeframe for evaluation of mass removal rates, as outlined in the 2010 Long-Term Monitoring Plan for Groundwater and Surface Water (LTMP), was anticipated to provide enough time to evaluate operational changes and mass flux/removal calculations to further refine achievable performance goals to demonstrate the RMA Record of Decision (ROD) requirements. Since there has been 5 years of operational experience, including fluctuating contaminant concentrations, a more methodical approach to determine new performance goals should be used in developing mass removal goals. Any approach should also identify the most consistent and accurate mass removal calculation procedures (extraction wells vs. influent) to provide comparable and consistent results in the future.

b. As discussed briefly in the document, Army/Shell has proposed a clarification to the mass removal quantification by limiting the contaminant removal calculations to contaminants with upgradient concentrations above their respective Containment System Remediation Goals (CSRGs). If this approach is to be examined more completely during this 2015 Five Year Review Report (FYR), more detail should be provided in this FYSR regarding how this change would affect remedy effectiveness. This added detail should include how it will be determined that: a) an analyte is below CSRGs upgradient of the system (performance wells, extraction wells, water quality tracking wells, etc.), and b) upgradient concentrations are below the most conservative, site-wide CSRG (e.g., Arsenic at BANS). Also, contaminants with Practical Quantitation Limits (PQLs) should not be treated in the same manner since these represent a temporary, analytical limiting factor yet treatment beyond this concentration is still desirable.

Response: a) A revision to the 2010 LTMP is being considered. For the reasons provided in the FYSR, retaining a 75 percent mass removal goal is still recommended. The more accurate and consistent of the methods (extraction wells vs. influent) will be determined at that time. In the meantime, both methods (based on extraction wells and influent) will be used.

b) The requested details will be provided during the LTMP revision process. In the meantime, both calculation methods (based on concentrations above and below CSRGs) will be used. Adding wells to the off-post exceedance network has been proposed in the FYSR which will affect the Northern Pathway System mass removal evaluation.

Comment 2. Not provided.

Comment 3. The Division believes that the 1,4-dioxane studies conducted in 2011 and 2012, as documented in the 2014 Data Summary Report, provide substantial evidence for the addition of 1,4-dioxane as a Contaminant of Concern (COC) for RMA. Because the Off-post ROD identifies Colorado Basic Standards for Groundwater (CBSG) as the basis for RMA CSRGs, combined with the presence of RMA related groundwater above the promulgated standard, evaluation for inclusion as a COC should occur as part of this FYR period (2010-2015), not during the next FYR. While the Division understands that modifications to the current systems may take time, immediate adjustments must be made to quarterly influent/effluent monitoring requirements, as well all applicable ground and surface water monitoring programs.

Response: Evaluation of the 1,4-dioxane standard, effect on remedy protectiveness, and recommendation on whether to adopt the standard will be made in the FYRR.

Comment 4. Evaluations of the performance and protectiveness of the North West Boundary Containment System (NWBCS) indicate that further monitoring of the dieldrin downgradient of the system could be warranted. Furthermore, treatment system changes may be required. At present, there is not sufficient evidence to suggest attainment of secondary performance goals, because all downgradient wells contain concentrations of dieldrin above the current PQL. Furthermore, introduction of the lower dieldrin standard has made compliance with the effluent standard provisional, at best. Since both of these factors are linked to the assessment of treatment system performance, details related to potential system improvements need to be part of this FYSR. Without sufficient detail, the Division is unable to assess, and therefore ultimately concur with the conclusions provided in this report.

Response: Dieldrin treatment and downgradient performance well exceedances of the PQL at the NWBCS have been identified as issues in the FYRR. Additional information about treatment options (more frequent pulsing, using virgin carbon instead of regenerated carbon, and evaluation of desorption of dieldrin from carbon fines during sample extraction and analysis) will be added to the text.

Comment 5. The CSRG for chloroform (6 µg/L) has not changed since the implementation of the ROD, however, the current applicable standard for chloroform, per the CBSG tables, is 3.5 µg/L. Please address/justify this apparent standard change in the FYSR and include an evaluation of the current groundwater and treatment plant influent/effluent concentrations relative to support for a lower standard.

Response: This issue has been discussed in previous Five-Year Review Reports. The 2005 FYRR identified the change in the chloroform standard; however, the assessment concluded that attainment or waiver of the revised standard was not necessary for protection of human health and the environment since the revised standard did not result in risk outside the acceptable risk range. The 2010 FYRR confirmed this evaluation.

Comment 6. A more complete evaluation is required in the FYSR regarding dewatering containment remedies at RMA. To determine a need for potential, additional remedial action or refinement, estimated target dates must be established as a benchmark for future comparisons/decisions. Establishing these target dates would need to address both waste elevation and slurry wall gradient goals, where applicable. Each system should be evaluated individually, using all relevant data; and results be presented to the regulatory agencies as soon as possible.

Response: Attainment of dewatering goals for the dewatering remedies has been identified as an issue in the FYRR, with a recommendation to review the dewatering system, monitoring network, and estimate for revised compliance dates. Subsequent to the FYRR, cost-benefit evaluations for installing dewatering wells in the Shell Trenches and Complex Trenches will also be conducted. Steady progress is being made toward meeting the Lime Basins dewatering goals, and revised compliance dates will be developed and documented as a revision to the LTMP.

Comment 7. Per the 2008 North Plants Petroleum Release Evaluation and Action Plan, if the Light Non-Aqueous Phase Liquid (LNAPL) Pilot system is found to be ineffective or unsatisfactory, other removal alternatives will be evaluated. The Action Plan also states that if the pilot program indicates further removal of LNAPL to be impractical, long-term monitoring to demonstrate biodegradability of the plume over time will be considered. The Division highly suggests that the RMA Water Team be convened to discuss alternative removal actions or the development of a long-term monitored attenuation program. Annual monitoring, as is currently proposed, may not be sufficient to fulfill these actions.

Response: Discussion at Water Team resulted in agreement to accept the annual monitoring schedule, provided the commitment/requirement for additional actions if LNAPL accumulates in sufficient quantities is maintained.

Comment 8. The Division notes that the FYSR now includes summary sections on the post-closure groundwater monitoring programs for the Hazardous Waste Landfill (HWL), the Enhanced Hazardous Waste Landfill (ELF), and Basin F. While the Division understands and appreciates the need for these sections in the FYSR and FYR Report, technical comments on each specific program will be provided in conjunction with our review of the annual post-closure groundwater monitoring reports.

Response: Comment noted.

Specific Comments

Comment 9. Section ES, page ES-2, 1st bullet - According to the second paragraph, if the primary performance criteria are met, the secondary criteria do not normally apply. The Division does not agree with this statement. Per Table 4.3-1 of the LTMP, loss of secondary performance criterion at NWBCS (e.g., downgradient concentrations trends increasing) while primary criteria are met initiates Agency notification and the consultative process. Please delete this sentence in the referenced bullet.

Response: There is a discrepancy between the Performance Criteria and Decision Rules for the NWBCS and Table 4.3-1. The Army and Shell believe the Performance Criteria and Decision Rules take priority over the table regarding the performance evaluation. Table 4.3-1 addresses trigger events and notifications. The LTMP should be revised to correct this discrepancy.

Comment 10. Section ES, page ES-3 – According to this section, annual monitoring is proposed to continue to demonstrate that no further actions are required for the Light Non-Aqueous Phase Liquid (LNAPL) Pilot System. It is the Division's understanding that the accumulation of LNAPL in the wells is directly related to groundwater levels in the area. Therefore, in the future, if water levels fall for an extended period LNAPL may, once again accumulate in the wells, requiring additional actions. Please indicate this on-going commitment/requirement.

Response: The data suggest that accumulation of LNAPL may no longer be directly related to groundwater level changes. The on-going commitment/requirement for additional actions if LNAPL accumulates in sufficient quantities will be added, however.

Comment 11. Section ES, page ES-5, 3rd paragraph- According to the last sentence of this paragraph the Army/Shell suspect that elevated chloride concentrations in a confined flow system (CFS) monitoring well may be due to a bad well seal, thereby allowing vertical contaminant migration. If contaminant movement within the well is a realistic concern, this well should be properly closed to prevent further cross-contamination. Furthermore, CDPHE does not agree to abandon this well without the installation of a suitable replacement well.

Response: Although the well (35083) does not appear to have a bentonite seal, the grout well seal may be effective. While the chloride concentrations had an increasing trend prior to FY14, possibly due to a combination of lateral and vertical migration, no organic contaminants have been detected. Since the chloride concentrations decreased in FY14, continuing to monitor well 35083, and not closing it or replacing it, is suggested.

Comment 12. Section ES, page ES-7, 2nd paragraph- According to this section, 1,4-dioxane contamination is limited to the uppermost water-bearing zone. For clarification, please indicate the number of CFS wells that were sampled to make this determination.

Response: The number of CFS wells sampled will be added.

Comment 13. Section ES, pages ES-8 and ES-9 – The off-post private well monitoring program, conducted by the Tri-County Health Department (TCHD), was not designed to refine the CSRG Exceedance Map or determine if CFS wells are acting as conduits for contaminant transport. It is understood that the Army/Shell may interpret data from this program for numerous purposes; but the text should be revised to clearly state the purpose of the TCHD program.

Response: The text will be revised as requested.

Comment 14. Section 2.1, page 30, 1st bullet – Operational monitoring is to be performed on mass removal systems as well as the containment systems. Please revise this paragraph to include both types of systems, and review the FYSR for consistency.

Response: The text will be revised as requested.

Comment 15. Section 2.3.3, page 36, first paragraph – It should be noted that on-post plume extent mapping is being used to evaluate the long-term progress of the remedy in regards to the extent and concentrations of the selected indicator compounds (ICs). Any impact on non-ICs can only be inferred, but not substantiated with this program. Please clarify this statement.

Response: The text will be revised as requested.

Comment 16. Section 3.3, page 42 - While the use of private well data may be helpful for further defining the plume maps, the sampling data is not collected in a manner that supports such a task. It is important to note that the primary objective of the private well sampling program is for citizen protection rather than to provide data for refining CSRG exceedances. Please revise the text, as applicable.

Response: The text will be revised as requested.

Comment 17. Section 3.5, page 43 – According to this section, the Army/Shell are proposing to terminate surface water monitoring of storm events because the soil remedy is complete and because diisopropyl methylphosphonate (DIMP) detections are solely due to occasional discharges of alluvial groundwater into First Creek. Since the On-Post Short-Term Surface Water Sampling program has identified some potential storm water related impacts, the Division does not agree to terminate storm event monitoring, at this time.

Response: The text will be revised to indicate that storm-related monitoring will continue under the On-Post Short-Term Surface Water Monitoring Program.

Comment 18. Section 4.3, page 48, second paragraph– Establishment of site-specific PQLs, including reconsideration of the current safety factor for the n-Nitrosodimethylamine (NDMA) PQL, should be performed within this FYSR. This assessment should consider the associated data assessments for each system and the data quality evaluations performed as part of each Annual Summary Report (ASR).

Response: As stated in the FYSR, a recommendation for removal of the interim PQL for NDMA will be made in the 2015 FYRR.

Comment 19. Section 4.4, page 48, general – This section should be revised to clearly state that the inclusion of 1,4-dioxane to the RMA list of applicable or relevant and appropriate requirements (ARARs) will be done in this 2015 FYR.

Response: This section will be revised to state that the decision whether to include 1,4-dioxane in the RMA list of applicable or relevant and appropriate requirements (ARARs) will be done in the 2015 FYRR.

Comment 20. Section 5.1.1.1– CDPHE has the following comments on this section:

a) Page 52, first paragraph - Please identify the two wells with chloroform concentrations above the CSRG on page 52 in order to facilitate review.

b) Page 54, NWBCS Evaluation Conclusions – As stated in the general comments, more detail is required regarding potential treatment changes.

Response: a) The chloroform concentrations were above the CSRG in upgradient performance wells 22008 and 22043 in FY14.

b) The requested details will be added to the text.

Comment 21. Not provided.

Comment 22. Not provided.

Comment 23. Section 5.1.1.2– CDPHE has the following comments on this section:

a) Page 57, first paragraph - When evaluating downgradient performance wells that are not considered representative of system performance, a more specific statistical trend analysis should be provided. While multiple factors could be influencing the contaminants found in these wells, continued successful operation of NBCS should eventually show decreasing concentrations in all downgradient wells. Please provide individual, downgradient well evaluations to statistically support the statement that contamination trends are "decreasing or stable" or, in cases where more data is necessary for statistical evaluations, provide the initial contaminant trends.

b) Page 68, NBCS Evaluation Conclusions – This paragraph indicates that "concentrations were below CSRGs/PQLs in the treatment plant effluent", neglecting the Third Quarter FY12 aldrin and dieldrin effluent exceedances. Please revise this paragraph accordingly.

Response: a) The downgradient performance well data and trends are evaluated in the ASRs and summarized in the FYSR. Please refer to the ASRs for the details.

b) The paragraph will be revised to indicate that the four-quarter moving averages were below the CSRGs/PQLs in the treatment plant effluent.

Comment 24. Section 5.1.1.4 – CDPHE has the following comments on this section:

a) Page, 76, Figure 5.1.1.4-2 – Please include the current dieldrin PQL on this graph for reference.

b) Page 79, BANS Evaluation Conclusions – Please provide additional detail to explain what impact the BANS mass removal has on the performance of the boundary systems. This information is required to more thoroughly evaluate the ROD requirement.

c) Page 80, first full paragraph – The proposed mass removal goal of 75% is not supported by the removal rates calculated during this FYR timeframe. As stated in the general comment, the FYSR should provide a methodical approach to developing an attainable mass removal goal designed to optimize the system to better achieve ROD requirements. Also, using an average of the extraction well and influent concentration calculation methods for compliance does not appear appropriate.

Response: a) The former and current PQLs will be added to the graph.

b) The additional details will be added to the text.

c) Retaining the 75 percent mass removal goal is proposed for the reasons discussed in the FYSR. Furthermore, since the BANS treatment plant receives untreated flow from the BRES, Lime Basins, and Complex Trenches dewatering systems, where concentrations are higher for numerous analytes than in the BANS dewatering wells, it’s possible, if not likely, that the concentrations in the BANS effluent may meet the CSRGs/PQLs, but be higher than concentrations in the BANS-specific influent and BANS dewatering wells. Thus, the BANS-specific mass removal would be negative. The LTMP should be revised to clarify this issue. As stated in the FYSR, the Army and Shell will continue to optimize the BANS mass removal, and performance similar to that during the past FYR period is anticipated during the next FYR period.

A revision to the 2010 LTMP is being considered. For the reasons provided in the FYSR, retaining a 75 percent mass removal goal is still recommended. The more accurate and consistent of the methods (extraction wells vs. influent) will be determined at that time.

Comment 25. Section 5.1.1.5 – CDPHE has the following comments on this section:

a) Page 80, second paragraph – The statement made in the last sentence is misleading. The LTMP did not list any performance criteria for downgradient wells prior to reaching five sampling events because it was not certain how system effectiveness would be assessed. However, the LTMP did establish trigger criteria and decision rules pertaining to increasing trends in downgradient monitoring wells once five sampling events had occurred. Please revise this paragraph to accurately reflect the LTMP requirements. (Also see page 83)

b) Page 81, 4th and 5th paragraphs – According to this section, an evaluation of the contaminant trends in well 36566 suggests that this well is in a “stagnant zone” downgradient of the system and therefore doesn’t indicate potential bypass of the system. The observations used to support this hypothesis (that only some of the contaminants are increasing, the extraction rates are consistent, etc.) are not sufficient to fully support this conclusion. Also, as indicated in CDPHE comments regarding the FY14 Annual Summary Report (ASR), the increasing trends in this well represent a consultation trigger event.

c) Page 83, second paragraph – Please revise the last sentence of this paragraph. Though wells 36578 and 36575 do appear to be within the capture zone according to water-table contours, downgradient wells 36566 and 25502 do not support or refute, plume capture.

Response: a) As stated in the 2010 LTMP, the 1999 BRES design document concluded that given the slow migration and low permeability in the Denver Formation, the downgradient wells would be expected to clean up very slowly and not indicate system effectiveness. Thus, no performance criteria were required for the downgradient wells in the design document. In order to attempt to make the BRES performance criteria more similar to the other systems in the 2010 LTMP, four downgradient performance wells were included in the BRES performance network. However, the LTMP stipulated that these wells would be sampled for five years before any performance conclusions would be drawn. Five years of data have now been collected, but this time frame may be too short for evaluating one of the wells (36566). The FYSR will be revised to include more evaluation of the BRES performance and contaminant migration near well 36566.

b) Concentrations in three of the four downgradient performance wells have decreased to below the CSRGs. The fourth well, 36566, is the westernmost well and the hydraulic gradient is much flatter in this area than in the other three performance wells. The contaminant concentrations in well 36566 either are below the CSRG, decreasing, or near the CSRGs, except for tetrachloroethylene (TCLEE). The TCLEE concentration in well 36566 has increased and was 84.6 µg/L in 2014. However, the TCLEE concentrations in well 36566 are much lower than in the upgradient wells in the western portion of the Bedrock Ridge plume (419 µg/l in well 36567 in 2014, and 360 µg/l in extraction well 36302 in 2009). Given the low permeability of the Denver Formation (3.9×10^{-3} cm/second in well 36560 [MK 1999]), low hydraulic gradient (avg. of 0.0018 ft/ft from FY10 to FY14 between wells 36569 and 36566), and equivocal nature of the water quality data in well 36566, additional monitoring is needed to determine whether the well is appropriate as a downgradient performance well and whether the data from the well indicate system performance.

c) The reference to the downgradient wells will be removed.

Comment 26. Section 5.1.1.8, page 94 – According to this section, the Army's proposed plan for the North Plants LNAPL removal project is continued annual monitoring during the next FYR period with a reassessment in the 2020 FYR Report. Per the 2008 North Plants Petroleum Release Evaluation and Action Plan, if the pilot system is found to be ineffective or unsatisfactory, other removal alternatives are to be evaluated. Alternatively, the Action Plan also states that if the pilot program indicates further removal of LNAPL is impractical, Army/Shell will consider long-term monitoring to demonstrate biodegradability of the plume over time. The Division asks that the RMA Water Team be convened to discuss alternative removal actions or the development of a long-term attenuation program be developed. The existing annual monitoring program may not be sufficient to fulfill these actions.

Response: Discussion at Water Team resulted in agreement to accept the annual monitoring schedule, provided the commitment/requirement for additional actions if LNAPL accumulates in sufficient quantities is maintained.

Comment 27. Section 5.1.2.1– CDPHE has the following comments on this section:

a) There is no discussion in the text of this section to explain the short-term rise in water levels during FY11 depicted in Figure 5.1.2.1-5. While it is assumed, by reviewing Figure 5.1.2.1-4, that a temporary shut-down of the dewatering trench was the cause for this jump, a description clarifying this event should be added to the text body.

b) Page 99, second paragraph – As previously stated in our general comments and in our FY14 ASR comments, any discussion regarding the continued monitoring and expected attainment of dewatering goals at Complex Trenches should include an evaluation of the potential need and criteria for further action. This discussion should include, at a minimum, an estimated target date in order to provide a benchmark for future comparisons and decisions.

Response: a) A notation of a temporary shutdown of the dewatering trench in FY11 will be added.

b) Attainment of the dewatering goals has been identified as an issue in the 2015 FYRR. This issue has been identified for further technical review by the RMA Water Team. Subsequent to the FYRR, a cost-benefit evaluation for installing dewatering wells in the Complex Trenches will also be conducted.

Comment 28. Section 5.1.2.2 – CDPHE has the following comments on this section:

a) Page 100, second paragraph – The statement made that "dewatering is not required" for Shell trenches is misleading. While the final design stated that dewatering was unwarranted given the groundwater levels at the time, it was never stated that the option to dewater would not be available or necessary in the future. Please revise this statement.

b) Page 102 – As previously stated in our general comments and in our FY14 ASR comments, discussion regarding the continued monitoring and expected re-attainment of dewatering goals at Shell Trenches should include an evaluation of the potential need and criteria for further action. This discussion should include, at a minimum, an estimated target date for attainment of design dewatering goals in order to provide a benchmark for future comparisons and decisions.

Response: a) The paragraph will be revised as requested.

b) Attainment of the dewatering goals has been identified as an issue in the 2015 FYRR. This issue has been identified for further technical review by the RMA Water Team Subsequent to the FYRR, a cost-benefit evaluation for installing dewatering wells in the Shell Trenches will also be conducted.

Comment 29. Section 5.1.2.3 - CDPHE has the following comments on this section:

a) The April/May 2010 discovery of Lime Basins piping deterioration and the chemical in-compatibility of the materials should be discussed in this section, including the corrective actions taken.

b) Discussion regarding the continued monitoring and expected attainment of dewatering goals at Lime Basins should include an evaluation of the potential need for further action and the associated decision criteria. This discussion should include, at a minimum, an estimated target date for attainment of design dewatering goals in order to provide a benchmark for future comparisons and decisions.

c) Page 104, 4th paragraph – Included with the list of potential factors preventing attainment of the dewatering goals, is the statement that the dewatering system was operated in a batch mode rather than continuously. While this may represent a sub-optimal operation of the system, this was an operational choice, uninfluenced by outside factors, and should be presented as such.

Response: a) The section will be revised as requested.

b) Attainment of the dewatering goals has been identified as an issue in the 2015 FYRR. This issue has been identified for further technical review by the RMA Water Team. Steady progress is being made toward meeting the Lime Basins dewatering goals, and revised compliance dates will be developed and documented as a revision to the LTMP.

c) The initial operation was dictated by the need to demonstrate that the treatment requirements could be met before the water was recharged. The intermittent operation occurred because of the turnaround time needed for the analytical data to be obtained.

Comment 30. Section 5.1.3.1 - CDPHE has the following comments on this section:

a) Page 120, 1st paragraph – The last half of this paragraph describes the reinterpretation of the water level contours on the west side of the Hazardous Waste Landfill (HWL) at well 25194. While it is important to highlight the reasons behind the corresponding contour changes in Figure 5.1.3-7, please remove the following statement: "rising groundwater levels…has changed the hydrology of the west side of the HWL such that reclassification of one of the downgradient HWL monitoring wells as upgradient has been proposed".

b) Page 136, Second Full paragraph – This section includes a proposal to discontinue sampling for Organochlorine Pesticides (OCPs) in the SPSA-2d ditch area. Given that these wells are only sampled once in five years (per LTMP), more data is required before SPSA-2d ditch can be discounted as an OCP source area.

Response: a) The statement will be removed.

b) As discussed in the FYSR, these wells were sampled twice because of the 2014 Plume Mapping task. While these data were considered sufficient to show that the SPSA-2d ditch is not a source, the recommendation to discontinue monitoring the wells for OCPs will be removed.

Comment 31. Section 5.1.4.1 - CDPHE has the following comments on this section:

a) Page 159 – The discussion found on this page relates to Post-Closure Groundwater Monitoring. General discussion regarding groundwater monitoring approaches and results is sufficient here to inform the 2010-2015 FYR process. However, events may be overtaking the discussion regarding the reclassification of well 25194. CDPHE will not approve reclassifying the well as a solution to this issue so the proposal should be removed in this document. CDPHE suggests revising this section to include a simple narrative of each year's Post-Closure Groundwater Monitoring Reports, as appropriate to support a protectiveness determination for this 5YR cycle. (Also see page 162)

b) Page 166 – Since the Basin F Post-Closure Groundwater Monitoring program utilizes an atypical monitoring approach, please further indicate how trend analysis is used to assess cover performance at Basin F.

Response: a) The discussion related to reclassifying well 25194 will be removed.

b) Water quality data and concentration trend analysis is not used to assess Basin F cover performance. Cover performance is based on lysimeter data and meeting the percolation goals.

Comment 32. Section 5.1.5.3

a) Page 198, first full paragraph – The proposed sampling frequency of once in 5 years for 1,4-dioxane is not sufficient. Sampling frequency for all proposed wells should be equivalent to all other analytes for each specific well/network (e.g., annually for performance, twice in five years for exceedance, etc.).

b) Page 198, final paragraph - Given detections of 1,4-dioxane downgradient of the eastern side of NBCS, CDPHE does not agree with the recommendation to not sample in this area. All NBCS performance and water quality tracking wells should be included in future sampling events.

c) Page 199, third full paragraph - There is reasonable evidence to conclude that RMA is a source of 1,4-dioxane in the South Plants area and, as a result, the contaminant is present in the groundwater both on and off-post (to the north, not the west). Given this evidence, 1,4-dioxane compliance issues related to groundwater monitoring and treatment need to be fully discussed in the FYSR. This includes assurances that all current, applicable monitoring well networks are adequate to capture the full width and extent of the 1,4-dioxane plumes as well as a discussion regarding the inclusion of 1,4-dioxane in LTMP trigger events and mass removal calculations.

Response: a) Evaluation of the 1,4-dioxane standard, effect on remedy protectiveness, and recommendation on whether to adopt the standard will be made in the FYRR. Adding 1,4-dioxane to the LTMP analyte lists for the various monitoring categories has not been proposed. Rationale was provided for the once in five-year frequency.

b) Only the upgradient wells on the east side of the NBCS where 1,4-dioxane was not detected would be deleted.

c) Evaluation of the 1,4-dioxane standard, effect on remedy protectiveness, and recommendation on whether to adopt the standard will be made in the FYRR. Adding 1,4-dioxane to the LTMP analyte lists for the various monitoring categories has not been proposed.

Comment 33. Section 5.2.2, page 215 – Please provide a figure indicating the wells subject to these proposed changes. In addition, more comprehensive dieldrin monitoring should be proposed downgradient of NWBCS due to recent sampling and effluent concentrations.

Response: The requested figure will be added. The rationale for the recommended changes in the network will be added. If available, additional wells will be considered for inclusion.

Comment 34. Section 5.2.3, Table 5.2.3-1 – Please review the DIMP concentration for the 6/26/14 sampling of well 359A.

Response: The reported DIMP value is incorrect and will be revised to 7.32 µg/L.

U.S. Army and Shell Oil Company Responses to
Colorado Department of Public Health and Environment (CDPHE)
Comments on the Rocky Mountain Arsenal
Five-Year Summary Report for Groundwater and Surface Water
Revision C, March 31, 2016

SPECIFIC COMMENTS

Comment 1. **New Figure 5.2.2-4** (as listed in the Table of Contents) – this figure is listed to depict the locations of proposed changes to the exceedance monitoring network, but it is not available in the current transmittal. The text in Section 5.2.2 states that these proposed wells are shown on Figure 5.2.2-1. Please correct.

Response: The Table of Contents has been corrected. The proposed wells are included on Figure 5.2.2-1, as indicated in the text.

Comment 2. **Executive Summary, ES-10, third bullet** – The statements made in this bullet raise some doubts about the validity of the analytical data. However, there have never been any flagged or rejected data associated with these NWBCS effluent samples. Please clarify.

Response: As stated in the text, the dieldrin recoveries have not met desired rates. Additionally, the recoveries have not met criteria for flagging or rejection. Consequently, more data are needed to perform statistical tests to further validate the data.

Comment 3. **Section 5.1.1.4, page 80, BANS Evaluation Conclusions** – Please define what is meant by the "BANS-specific contaminant mass removal" in this paragraph. Does this signify the mass removal of contaminants inclusive to those on the BANS CSRG-list?

Response: The BANS mass removal is described in detail in Section 5.1.1.4. As stated in the text, BANS treats water from the BANS dewatering wells, Complex Trenches, BRES, and Lime Basins. The BANS-specific mass removal is based on the BANS-specific mass flux.

Comment 4. **Section 5.1.3.1, page 139, SPSA-2d Ditch** – Please clarify in the text which monitoring wells will continue to be sampled for OCPs.

Response: Based on previous comments, changes in the OCP monitoring for the SPSA-2d Ditch no longer are proposed. Thus, all six wells listed will continue to be monitored for OCPs, and no changes in the text are needed.

Comment 5. **<u>Section 5.1.5.3, page 201, 4th full paragraph (CDPHE Comment 32a)</u> –**

<u>Original Comment:</u> The proposed sampling frequency of once in 5 years for 1,4-dioxane is not sufficient. Sampling frequency for all proposed wells should be equivalent to all other analytes for each specific well/network (e.g., annually for performance, twice in five years for exceedance, etc.)

<u>Army/Shell Response</u>: Evaluation of the 1,4-dioxane standard, effect on remedy protectiveness, and recommendation on whether to adopt the standard will be made in the FYRR. Adding 1,4-dioxane to the LTMP analyte lists for the various monitoring categories has not been proposed. Rationale was provided for the once in five-year frequency.

<u>CDPHE Response</u>: CDPHE recommends that future monitoring proposals and discussions regarding contaminant behavior be deferred to the 1,4-dioxane assessment that will be conducted in accordance with the FYRR resolution.

Response: Assessment of the 1,4-dioxane plume and recommendations for additional monitoring are provided in the FYSR based on the available data. The Army and Shell recognize that the data evaluation has not been completed and will coordinate with the Regulatory Agencies to finalize the evaluation and determine future monitoring requirements. The recommendations provided in the FYSR represent one option for collecting additional data in 2017.

<u>Appendix B</u>

Comment 1. **<u>General</u> –** CDPHE believes that the evaluation provided in this appendix is helpful in comparing the lithology and contaminant trends in former conformance wells and current performance wells downgradient of the NBCS. Specific changes to the monitoring network will be made with subsequent OCNs and/or a revision to the LTMP. Note, though, CDPHE does not necessarily agree with the proposed alternate wells. Regardless of lithology and the presence of new or residual contamination, the continued successful operation of the system should eventually show decreasing trends in all downgradient wells and continuity within the network will be important in developing these trends.

Response: Comment noted.

Comment 2. **<u>Introduction, page B-2, Second paragraph</u> –** The final sentence of this paragraph makes the statement that “Historically, more CSRG analytes were detected above the CSRGs/PQLs in upgradient wells, but the same five analytes have been detected downgradient.” Is this sentence trying to convey that the contaminant composition in downgradient wells has remained unchanged while the contaminant composition approaching the system has diminished? Please clarify this analysis.

Response: The sentence is intended to convey that historically (prior to FY14), more CSRG analytes were detected at concentrations above the CSRGs/PQLs upgradient of the NBCS, but the same five analytes have been detected above the CSRGs/PQLs downgradient. The sentence will be clarified.

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**U.S. Army and Shell Oil Company Responses to
Tri-County Health Department (TCHD) July 21, 2105 Comments on the
Rocky Mountain Arsenal Five-Year Summary Report for Groundwater and
Surface Water, Revision B, June 8, 2015
Revision 1**

General Comments

Comment 1. The overall report is very well written and extensive. The report also addresses numerous problems/non-compliances that are present and gives the impression that the problems will resolve with more monitoring and more time. While this might be true with some issues, it will not be true with others. The completion of the 2014 On-Post plume mapping effort, the ongoing 1,4-dioxane requirement, combined with lower contaminant concentration in the extraction wells suggests that this may be an opportune time for significant evaluation and decision making. Numerous alternatives come to mind that would require extensive study, analysis and decision making, if sufficient resources were available to cover all the issues in a timely manner.

Comment 2. The accumulation of missed deadlines brings into question the adequacy of some remedy designs. It is hoped that the specific comments will identify some of the issues that seem to be developing as the contaminant levels drop and the infrastructure (including the slurry walls) ages.

Comment 3. The Executive Summary represents an excessively favorable view of the compliance issues during this 5-year review. An overview of the report identifies several problem areas that TCHD believes should be highlighted and acted upon by the Army in concert with the agencies. The entire infrastructure is aging, and many inefficiencies seem to be coming to the forefront. The solutions currently in place seem to present the potential for increased inefficiency as contaminant concentrations decline. The operational philosophy seems to be to stay the course with respect to the ROD/2010 LTMP, yet it seems increasingly difficult. The suggestion is made on page ES-3 that the 75-per cent mass removal goal may have to be reduced in the future as contaminant concentrations continue to decline. This may be true, but this report represents the clearest evidence that pumping may be dictated for two reasons other than mass removal- reverse gradient and/or dilution.

Comment 4. Since weather is variable, two compliance criteria may present continuing problems: down gradient dieldrin concentrations, maintenance of water levels below waste in some projects, and mass removal goals. There is also the suggestion in the report that some down gradient performance wells are not representative of system performance. While not proven, standards should be established that can be met and not explained away.

Comment 5. The 1,4-dioxane issue should be resolved more expeditiously than is stated in the report.

Response: General comments noted. Individual responses are provided for the Specific Comments.

Specific Comments

Comment 1. Numerous questions arise from the Executive Summary:

a. ES-1, next to last line: FYR per page xii is a Five-Year Site Review. This acronym is confusing. All other acronyms that end in "R" refer to reports-not reviews. Please examine the potential confusion between this and FYR being assumed to be Fiscal Year Report.

Response: The "FYR" notation has been used in the previous five-year review reports and will be retained.

b. ES-2, NWBCS, 1st paragraph: There is lack of clarity over additional steps that may be needed to reduce effluent concentrations. This creates an impression of uncertainty on the part of the contractor/Army. Steps to improve the operation should be taken immediately, if they are of an operational nature.

Response: The operational steps will be described in the text and have already been implemented.

c. ES-2, NWBCS, 2nd paragraph: If remobilization of dieldrin is a proven fact, then performance is not consistent or controllable and modifications should be considered. Should compliance be based on more controllable factors such as GAC removal efficiency, retention time, contaminant concentration, and dilution? None of these more controllable factors are analyzed or discussed. Also, the end of the 2nd paragraph suggests five more years of data is required before it can be decided if the secondary performance criteria are being met. This decision should not have to be based on five more years of data, but if valid, the criteria is inadequate for prompt decision-making, and should be reevaluated.

Response: The NWBCS treatment and downgradient performance well exceedances are identified as issues in the FYRR. This issue has been identified for further technical review by the RMA Water Team. The five years for determining the downgradient well concentration trends is a requirement in the LTMP. The dieldrin PQL and MRL were lowered in 2012. Prior to that, the dieldrin concentrations in the downgradient wells were below the MRL. Consequently, five years of well data are needed after the dieldrin PQL and MRL were lowered in 2012. Thus, only one more year (FY16) of data are needed to assess the trends.

d. ES-2, NBCS: If some wells are not representative of system performance, why call them Performance Wells? Should efforts be made to find performance criteria that are more definable?

Response: When the primary performance criteria are met, as is the case at the NBCS, the system is functioning as intended. Since some of the downgradient performance wells exceed CSRGs/PQLs, the secondary criteria also are discussed for completeness. Residual contamination (primarily dieldrin) present in the aquifer north of the NBCS slurry wall is causing the dieldrin concentrations to be above the PQL in the downgradient performance wells. The concentrations of the other 25 NBCS organic CSRG analytes treated by the NBCS have been below the CSRGs/PQLs, and thus, the performance wells are representative of system performance for the majority of the CSRG analytes.

e. ES-2, RYCS: This summary is brief and unclear as to future actions. Since the shut-off of a system is a major event, can an estimated time frame be provided so that prompt action is shown?

Response: The Draft RYCS Shut-Off Monitoring SAP was issued for Regulatory Agency review in November 2015.

f. ES-2, BANS: If the described down-gradient exceedance was caused by the lack of a non-required reverse gradient, has this situation occurred in the past, and should a reverse gradient be considered as a performance criterion in a revised LTMP? Also, please consider using this language in other parts of the report when referring to the 500- to 1,000-year storm event unless the terminology can be supported with On-Post rain gauge data.

Response: The 2014 increase in concentrations in two of the four downgradient performance wells, which likely was caused by the reduced extent of the reverse gradient, is a first-time occurrence. Establishing some reverse gradient performance criteria in the LTMP will be considered when the LTMP is revised. Please note that the BANS was not designed to create a reverse gradient along the entire length of the slurry wall. The link below is a NOAA report concerning the September 2013 storm and is the basis for the 500- to 1000-year storm classification at RMA. The report mapped the storm probabilities for worst case 24-hour, 48-hour, and 7-day rainfall.

http://www.nws.noaa.gov/oh/hdsc/aep_storm_analysis/8_Colorado_2013

g. ES-3, 1st complete paragraph on page: The text, with respect to the 75% mass removal goal, is significant. Two alternatives are available that relate to this question: Lower the mass removal standard with the potential for increased inefficiencies, or increase the extraction well contaminant level by evaluating the potential reduction of dilution or higher contaminant extraction wells up-gradient that may now be better defined due to the recent On-Post plume mapping. This type of study would allow for an improved understanding of the optimization/efficiency of this system.

Response: As upgradient concentrations decrease to below the CSRGs, treatment (and mass removal) no longer will be required. Shut-off criteria were developed to address when a system may be shut down. Shutting down all or a portion of a system that meets CSRGs addresses the optimization/efficiency of the system while meeting the ROD requirements for treatment to meet CSRGs. Installing additional extraction wells in areas where concentrations are above the CSRGs would also be an option, if necessary. However, as concentrations approach the CSRGs, the additional cost may not provide justifiable benefits.

h. ES-3, BRES: Again, the adequacy of the 2010 LTMP standard is being brought into question. If the standards are not indicative of system effectiveness, then continued monitoring does not appear to be effective in obtaining clarity. Again, can more representative/ controllable standards be developed?

Response: The LTMP attempted to develop consistent performance criteria for all of the systems. At BRES, the Denver Formation sandstone has lower permeability than the aquifers at other systems. Consequently, the original BRES design did not include downgradient monitoring to indicate whether the system is functioning as intended. One of the four downgradient wells shows conflicting concentration trends that may be resolved by continued monitoring. Additional evaluation of the BRES will be added to the FYSR.

i. ES-3, GWMR: It is not clear how this paragraph is relevant to the report.

Response: The GWMR project was in operation during a portion of the FYR period and should be included for completeness.

j. ES-3, LNAPL: Is it necessary to gather five more years of data before a decision can be reached? Why not evaluate the data each year and make a recommendation? Does the suggestion of five years of data-gathering before evaluation represent a staff shortage?

Response: In the past, the North Plants LNAPL thickness in a well was related to fluctuating groundwater levels. It appears that LNAPL will no longer enter the wells in sufficient quantities to initiate removal. Continued monitoring is proposed to continue to confirm that sufficient quantities for removal no longer are present. However, if the LNAPL thickness increases such that removal may be conducted, LNAPL removal will commence.

k. ES-3, top line: Please document or remove the 500- to 1000-year storm event language. Boulder rainfall amounts might justify that classification, but publically available data from around the RMA is much less than the Boulder amounts. Any design should accommodate a safety factor but the quantification of a storm event should be done on the basis of specific data such a RMA measured rainfall amounts. Please evaluate and modify as appropriate.

Response: The precipitation recorded at the RMA rain gauges was variable. The annual precipitation data from the Shell Trenches rain gauge was provided in the FYSR. The Lime Basins gauge may have been more representative than the Shell Trenches gauge. The Lime Basins and DIA/Stapleton precipitation data will be added to the FYSR. The 500- to 1000- year storm event designation for the September 2013 storm for RMA was based on mapping by NOAA (see the response to comment 1f).

l. ES-4, Shell Trenches, 1st complete paragraph: Again, please see previous comment about storm event classification. Also, the loss of compliance may be a one- time event or it may be a recurring event. If recurring, it may be the result of an overoptimistic assumption at the time of 100% design (Sec. 1.4.1.7, 2 bulleted items on page 19). Also, protectiveness may be adequate but timeliness is lagging.

Response: Attainment of dewatering goals has been identified for further technical review by the RMA Water Team and as an issue in the FYRR. Subsequent to the FYRR, a cost-benefit evaluation for installing dewatering wells will be conducted.

m. ES-4, Lime Basin, 2nd paragraph: Since the LB dewatering goal was also not met (but with an active system in place), it is unclear if the dewatering system is under-designed or if the lack of implementation of a more continuous de-watering operation might be a problem. Delaying the compliance of this remedy project for five more years seems excessive. Please consider a schedule which would achieve compliance in a more timely manner.

Response: Attainment of dewatering goals has been identified for further technical review by the RMA Water Team and as an issue in the FYRR. Steady progress is being made toward meeting the Lime Basins dewatering goals, and revised compliance dates will be developed.

n. ES-5, 1st paragraph on page: Shouldn't some of this paragraph be deleted here, but included in On-Post plume extent mapping on page ES-6? Also (last line of first paragraph), reading page 189, 2014 On-Post Plume Mapping Summary, there were little or no "...observations about the longer term progress of the remedy." The failure to not have more periodic data limits the ability to allocate plume concentration reductions to: the reduction of source areas; natural attenuation; dilution; or the pump and treat systems. Can consideration be given to remapping the On-Post plumes every five years as a more reliable guide for operating with lower contaminant heads in the future?

Response: Site-wide water level and water quality tracking are conducted for different purposes than on-post plume mapping. The purpose of water quality tracking is to monitor concentration trends in source areas and between source areas and the boundary systems. The 20-year frequency for on-post plume mapping was agreed upon by the Regulatory Agencies, the Army, and Shell to address longer term changes in the plumes.

o. ES-6, 1st paragraph on page: Can this activity be clarified by identified bench marks, timelines, and putting them on a schedule which should include an update in each ASR, and a summary and recommendation in the next 5-Year Summary Report for Groundwater and Surface Water?

Response: Section 5.1.3.3 includes the schedule for surface water sampling in 2015, which will be reported in the FY15 ASR. Additional monitoring of Basin E Pond (SW26002) is planned for FY16 and will be reported in the FY16 ASR.

p. ES-6, On-Post Plume Extent Mapping: See comment above from page ES-5. This would also seem to be a place to discuss/evaluate natural attenuation. In addition to the 9 analytes, were analyses obtained for chloride, sulfate, and fluoride? Is it time to start considering natural attenuation?

Response: The changes in plume areas and concentrations and the resulting effects on treatment plant influent concentrations are discussed in detail in Section 5.1.5.1. These details address the long term progress of the remedy. For example, reducing the extent and concentrations of the contaminant plumes upgradient of the boundary systems meets the RAO for on-post groundwater. Natural attenuation of benzene and chloroform in Basin A and benzene in the South Tank Farm are discussed. Chloride, fluoride, and sulfate were not included in the indicator analyte list for on-post plume mapping. Adding a monitored natural attenuation component to the remedy for groundwater contaminants other than chloride and sulfate would require a ROD change, but it is not apparent to the Army and Shell that it would be appropriate at this time.

q. ES-7, H and V extent of 1,4-dioxane, last part of 2nd paragraph of this section: This was identified as an issue in the 2010 FYRR with the recommendation to prepare a technical memorandum to document evaluation and decision (page 46). On page 48 of this report it is stated that a "...technical memorandum will be prepared during the next five- year review period to document this evaluation and the resulting decision." This text does not appear timely nor responsive. Can this task be put on a schedule with milestones and deadlines?

Response: Evaluation of the 1,4-dioxane standard, effect on remedy protectiveness, and recommendation on whether to adopt the standard will be made in the FYRR.

r. ES-7, Off-Post OU Monitoring Programs: The first bullet should be removed.

Response: Agreed.

s. ES-7, OGITS: Based on the missed compliance deadlines described in this report, should some other language be developed other than "...consistent with the On-Post Remedy for chloride and sulfate"?

Response: The chloride and sulfate compliance deadlines have not been missed. In fact, they were met far ahead of schedule at the NBCS and likely will be met soon at OGITS, instead of 2026 and 2021 for chloride and sulfate, respectively.

t. ES-8, first 3 paragraphs: Many issues revolve around the 75% mass removal goals. These issues seemingly should be discussed and revised as necessary. The theory of decreasing concentration leading to increasing efficiency should be examined with the potential goal of reducing dilution, increasing concentration, and increasing efficiency.

Response: Shutting off systems or portions of systems when they meet shut-off criteria is the ultimate goal. Shut-off criteria have not been developed for the mass removal systems, but as concentrations decrease to below CSRGs, treatment (and mass removal) no longer are required. Portions of the systems may then be shut off, reducing dilution, increasing concentrations in the operating system, and increasing efficiency.

u. ES-8, CSRG Exceedance Monitoring, 1st paragraph: The fourth line down is misleading. The FY12 map had 15 plumes. For FY14, one additional contaminant was added, but six were deleted. The Draft CSRG map was also unclear if the deleted six contaminants were also sampled in FY14. Can this summary be clarified?

Response: The summary will be clarified as requested.

v. ES-9, Groundwater and Surface Water Events: What does evaluating the validity of the dieldrin analytical data and the new PQL mean? Please clarify.

Response: The dieldrin recoveries vary greatly and do not meet the desired rates. This calls the data validity into question. More data are needed to statistically evaluate the validity of the data.

Comment 2. Page 9, Introduction, 3 bullets in 2nd paragraph: This is an appropriate statement of objectives. The Executive Summary seems to achieve the 1st bullet, but not the other two bullets. Can the other two bullets be summarized somewhere in the text and discussed in the Executive Summary?

Response: Discussions about the NWBCS Northeast and Southwest Extensions will be added.

Comment 3. Page 1, Section 1.1, 1st paragraph: Isn't the Wildlife Refuge larger than the 5.6 square miles mentioned? Please see Figure 1.1-1.

Response: This description of the On-Post OU is outdated. The On-Post OU currently occupies approximately 1.7 square miles, none of which has been transferred to the USFWS for refuge use. The text will be revised to reflect the current status of the OU.

Comment 4. Page 3, Section 1.1, 3rd paragraph: A very relevant figure for this report would be one that shows where groundwater has been deleted, and where it has not. This would be particularly significant for the new On-Post plume mapping effort. Please consider.

Response: A figure showing where groundwater has been deleted will be added.

Comment 5. Page 6, Section 1.4, 3rd paragraph on page: The last sentence of this paragraph is significant since it related to the criteria for shut-off of a well (Basin F IRA extraction well) in 2000. These criteria also seem applicable to the RYCS and other systems. Please review and provide consistent language here, and throughout the document.

Response: The On-post ROD was unclear about shut-off criteria details. Consequently, shut-off criteria and monitoring details were developed in the 2010 LTMP for systems or discrete portions of systems. An operational shut-off procedure for individual extraction wells was developed separately.

Comment 6. Page 7, Section 1.4, 1st complete paragraph on page: The first sentence needs review. Based on the previous comment, decreased system efficiency and reduced influent concentrations were a reason for shutting down the Basin F IRA extraction well in 2000. The current sentence states the reverse. The soil remedies are designed to reduce contaminant mobility and this in return should reduce the contaminant concentration flowing to the extraction systems, but this reduced concentration is most likely to reduce, rather than enhance, the effectiveness of the groundwater extraction system.

Response: This section restates the remedial actions specified in the On-Post and Off-Post RODs. The paragraph is consistent with the initial ROD objectives and does not need revision.

Comment 7. Page 7, last paragraph on page, 1st and 2nd bullets: The shutoff criteria for OGITS were changed in the 2010 LTMP, and a review of the current criteria seems appropriate. The report suggests the future possibility of reducing the 75% mass flux removal criteria. The Army and the agencies should try to find simplified criteria to the apparent problem of increased inefficiency of OGITS within the current design or operational guidelines. The 2nd bullet has largely maintained the same language for many years. While continuing to be unclear as to meaning, there is no specific analysis for the potential of achieving this, or for the effect of natural attenuation on CSRG contaminants up-gradient. Both of these steps seem possible with the development of the 2014 On-Post plume map.

Response: The bullets are from the Off-Post ROD. An evaluation of chloride and sulfate attenuation (MK and Foster Wheeler 1996), which included setting the remediation goals and the time frames for meeting the CSRGs at the NBCS (2026 for chloride and 2021 for sulfate), were developed for the On-Post ROD.

Comment 8. Page 9, Section 1.4.1.1, NWBCS, last bullet: It is unclear to TCHD why the SWE was not shut down between 2004 and 2012 when the PQL for dieldrin was 0.05 ug/I. One explanation could be that the clean water was being used to blend the extraction wells from the other portion of the system to help insure compliance. It is also possible this water was used to insure reverse gradient. Even with the new PQL, this area appears to be capable of shutting down and potentially raising the contaminant concentrations and the effectiveness of removal by increasing contact time. Please discuss.

Response: The Regulatory Agencies requested that the Army and Shell defer shutdown of the SWE until a PQL study for dieldrin could be conducted. The current dieldrin concentrations at the SWE are at or slightly above the new PQL and might meet the shut-off criteria based on the PQL in the near future. However, the Regulatory Agencies have stated that they will not allow shutdown of a system when the concentrations are above the CBSG even though they are below the PQL.

Comment 9. Page 11, NBCS:

a. Quote in 3rd paragraph: See previous comment with respect to quote about attenuation of chloride and sulfate.

b. Next to last paragraph on page: Interesting comment about providing water to help with the reverse gradient. Could this also apply to the SW Extension of the NWBCS?

c. Last paragraph on page: The words "...reduce the contaminant load on the system ..." imply a favorable system outcome, and perhaps not a contributing factor to increased system inefficiency which is being raised in this report as a possibility.

Response: The information in this section is background information for the NBCS.

Comment 10. Page 12, last paragraph: The updating or evaluating of conclusions derived in 1996 which estimated the natural attenuation time frame for chloride to be 30 years {2026) and for sulfate to be 25 years (2021} should be looked at and updated during the next 5-year review period if possible. The status of fluoride should also be addressed.

Response: The information in this section is background information for the NBCS. The status of chloride and sulfate attenuation and meeting the CSRGs at NBCS and OGITS are addressed in this FYSR and will be evaluated in the 2020 FYSR. Both the chloride and sulfate CSRGS have been met at the NBCS since FY05, and were met for the first time in FY14 at OGITS.

Comment 11. Page 15, Section 1.4.1.3, last line of continuing paragraph at top of page: First EPA CCR sign-off noted. This is in compliance of the 3rd bullet on page 3. Please consider summarizing this and other EPA CCR approvals to more clearly show and draw attention to this objective.

Response: It is not clear how the Motor Pool CCR pertains to the 3rd bullet on page 3 (Off-post Monitoring Programs).

Comment 12. Page 16, Section 1.4.1.4, On-Post ROD quote at top of page: This quote seems to support accelerating upgradient high grade contaminant mass removal, but without the concept that lowering the contaminant concentrations to the boundary systems might negatively affect system performance without system modifications.

Response: The information in this section is background information for the BANS, which was installed in 1990. The On-Post ROD quote is related to the objectives for the BANS.

Comment 13. Page 16, 2"d bullet on page: The second bulleted item seems questionable at this time, as previously discussed. It is not understood if a Final Response Action was performed unless this was the On-Post ROD. It is not clear why these bullets are included from the 1989 IRA Decision Document when there may have been a Final Response Action (ROD?) which would have updated or incorporated these elements.

Response: The information in this section is background information for the BANS. The On-Post ROD quote on page 15 indicates that the Basin A Neck system (IRA) was incorporated into the selected remedy.

Comment 14. Page 19, Section 1.4.1.6, Complex (Army) Trenches, last paragraph in section: No mention is made of the design flow rate. Is it possible that the lack of attainment was caused by an under- design or failure to maximize pumping?

Response: The information in this section is background information for the Complex Trenches. Please see Section 5.1.2.1 for the data evaluation.

Comment 15. Page 19, Section 1.4.1.7, two bullets: Possibly an overly optimistic assumption in the 1997 100% design document. Also the six-inch slurry wall appears to have been under-designed in 1991.

Response: The information in this section is background information for the Shell Trenches.

Comment 16. Page 21, Section 1.4.1.9, last part of last paragraph in section: Can this sentence be reviewed? How can a report (DOA 2015) be presented to the RAs on November 20, 2013? Is there any update possible?

Response: The FY13 monitoring results were presented to the Regulatory Agencies in a meeting in November 2013 and then formalized in a report in 2015. The FY14 results were reported in the FY14 ASR.

Comment 17. Page 21, Section 1.4.1.10, end of 1st paragraph: Is this another EPA CCR that could be summarized and highlighted? Also, are completed but unapproved CCRs being referenced in this document?

Response: The information in this section is background information for the GWMR project. Please refer to Section 5.1.1.6 for the discussion of the results.

Comment 18. Page 22, Section 1.4.1.11, last paragraph in section: Can a date be provided for the completion of the pilot study final report?

Response: The evaluation report for the 2010 and 2011 data was issued in February 2012. Since then, the data have been reported in the ASRs.

Comment 19. Page 22, Section 1.4.2, OGITS, two bulleted items: See previous comment about shut-off criteria, which the report is currently maintaining at 75%, but speculates about the need to lower.

Response: The information in this section is background information for the OGITS.

Comment 20. Page 27, Section 1.4.3.1, 3rd paragraph: Please cite the Annual Covers Report, if that is where the annual reporting is done (as was done for Basin F).

Response: The Annual Covers Report for the RCRA Caps will be cited.

Comment 21. Page 27, Section 1.4.3.1, 4th paragraph: Shouldn't the RAs be notified of any result above the prediction limit?

Response: Yes, the Regulatory Agencies will be notified of any result that exceeds the respective prediction limit. The PCGMPs define concentrations of water quality analytes that exceed their respective prediction interval upper concentration limits as statistically significant increases.

Comment 22. Page 31, Section 2.2: Some operational monitoring data that was previously reported has been eliminated. Better understanding into current issues in this report would be enhanced by inclusion of extraction well sampling and flow data for all systems.

Response: The 2010 LTMP eliminated operational extraction well sampling and added sampling of upgradient monitoring wells under the performance category for the containment systems. The extraction wells for the mass removal systems are also sampled to provide data for the mass removal performance calculations. The average system flowrates are provided in Sections 1.4 and 5.1.1.

Comment 23. Page 36, Section 2.3.2, 2nd paragraph on page: Is there any information on a CCR that should be included here?

Response: The LWTS CCR will be added.

Comment 24. Page 37, Section 2.3.3, bottom of last paragraph on page: Is it possible to estimate a date for the Data Summary Report?

Response: The date for the DSR will be added.

Comment 25. Page 46, Table 4.0-1: The issue of potential inclusion of 1,4-dioxane in RMA's ARARS carried a recommendation that a technical memorandum be prepared to document evaluation and decision. No date was stated, but another five years seems unreasonably long.

Response: Evaluation of the 1,4-dioxane standard, effect on remedy protectiveness, and recommendation on whether to adopt the standard will be made in the FYRR.

Comment 26. Page 47, Section 4.3: A standardized procedure is alluded to in the text, but no frequency of reevaluation is noted. Has a frequency of review been established?

Response: A frequency of review has not been established. Experience with data and the perceived reliability of data under the current PQLs provides information on their status and applicability. The Army laboratories are re-certified every three years, which provides feedback on the status of MRLs, which could indicate when conducting a PQL study might be appropriate. Currently, only three analytes (aldrin, dieldrin, and NDMA) have PQLs.

Comment 27. Page 48, Section 4.4, last paragraph: It is unclear what further data is needed beyond Figure 5.1.5.3-1 to accept 1,4-dioxane as an ARAR on the basis that it is an On-Post contaminant that has migrated off-post. Are there ramifications that dictate it being treated differently from chloride, sulfate, and fluoride? While no treatment exists, it appears as though treatment and natural attenuation are effective. Please explain why another five years of evaluation is being recommended.

Response: Evaluation of the 1,4-dioxane standard, effect on remedy protectiveness, and recommendation on whether to adopt the standard will be made in the FYRR. EPA guidance provides criteria for adopting post-ROD changes in ARARs that relate to remedy protectiveness and acceptable risk ranges.

Comment 28. Page 51, 1st paragraph on page: From Figure A-14 in the ASR, down-gradient Performance Well 22508 seems to have the same or higher dieldrin concentration than the very close up-gradient Performance Well 22505. From these graphs, the last sentence seems hard to justify. Figures A-1 land A-2 in the ASR also do not show the presence of a reverse gradient in that area. Can any elaboration be made in this report? Also, in the 3rd paragraph, the reference to additional plant changes is made. Can the scope of these potential changes be elaborated?

Response: Well 22508 is an operational well, not a downgradient performance well, which is why it is not listed in Table 5.1.1.1-2. There is a small forward gradient across the slurry wall between wells 22508 and 22505. The flow in this area on the northwest side of the slurry wall is to the southwest, parallel to the slurry wall, toward extraction well 22309. Treatment changes have included pulsing more carbon, using virgin carbon instead of regenerated carbon, and evaluating the effects of desorption of dieldrin from carbon fines during sample extraction and analysis.

Comment 29. Page 52, Table 5.1.1.1-2: This table would indicate that dieldrin is a major problem. A general appraisal of the extraction efficiency of this and other extraction systems seems justified - particularly if done in conjunction with the 2014 On-Post plume mapping effort.

Response: The Regulatory Agencies were informed about the dieldrin exceedances of the PQL in the downgradient performance wells after the PQL changed in 2012. Changes in treatment and recharge well flow rates have been made in response to these detections. The dieldrin detections in the downgradient wells have been identified as an issue in the FYRR.

Comment 30. Page 57, 58, and 59: This discussion as to why clean-up is not occurring as expected over the past several years may be absolutely true and valid. If true, then the remedy as envisioned years ago in the ROD, may not be achievable. This leaves the question as to a different clean-up approach that might lead to a ROD Amendment. Is it time to start looking for different solutions to some of these issues?

Response: The OGITS was installed in 1993/1994 to intercept and treat groundwater contamination that had migrated off post. OGITS also intercepts and treats the majority of contamination present north of the NBCS because of the factors discussed in the report. Therefore, the remedy is functioning as it was envisioned.

Comment 31. Page 61 and 62, text on DIMP concentrations: The text on the bottom of page 61 highlights a potential operational conflict between the maintenance of a reverse gradient and the maximizing of pumping from the extraction wells with the highest concentrations. Pumping clean or low contamination water for the purpose of maintaining a reverse gradient may potentially reduce the effectiveness of the extraction system based on less contact time.

Response: Maintaining the reverse gradient is the primary performance criterion. Contact time typically refers to treatment. Assuming TCHD is referring to treatment effectiveness, the NBCS uses downflow carbon adsorption treatment which is highly efficient even at low influent concentrations. Consequently, meeting CSRGs/PQLs in the plant effluent has not been, and is not anticipated to be, a problem. At some point when the upgradient concentrations are below CSRGs/PQLs in the eastern portion of the system, shutting off a portion of the NBCS and breaching the slurry wall may become feasible.

Comment 32. Page 68, NBCS Evaluation Conclusions: The text indicated that some performance wells are not representative of system effectiveness. Is it possible that the criteria are unable to account for natural variability in the system?

Response: It is unclear what TCHD is referring to regarding natural variability in the system. The water quality of some of the downgradient performance wells does not represent system effectiveness because of the presence of pre-existing and residual contamination downgradient of the slurry wall. Natural variability in the contaminant concentrations in these wells is observed. Variability in system operation is not a factor because the NBCS is operated in a very consistent manner, with few shutdown periods of short duration.

Comment 33. Page 68, Table 5.1.1.3-1: The table shows 0.026 lbs. of DBCP removed during the 5-year period at a cost of $865,856. This calculates out to $26,379,076 per pound. Does safety factor in the pre-shutdown process seem excessive in this case? Could shutdown have been achieved after fewer years without any loss of safety/protectiveness? Are existing shutdown criteria too rigid?

Response: The RYCS shutdown process was delayed because of several factors. Historically, fluctuating regional water levels have affected DBCP concentrations in Railyard wells due to mobilization of residual DBCP in aquifer sediments near the water table in the DBCP source area. Re-grading of the land and development near and south of the new Visitor's Center had the potential to increase infiltration of precipitation and affect groundwater levels in the Railyard. The September 2013 storm event caused groundwater levels in the Railyard to rise to historic highs, which have remained so since then. The Army and Shell opted to continue operation and monitoring of the RYCS during these events in order to avoid shutting the system down prematurely. In hindsight, the RYCS could have been shut down sooner, but the Army and Shell chose to use a conservative approach because of the above factors.

Comment 34. Page 70, 1st paragraph: A presentation of the variability of the sample from the operating extraction well versus the shutdown well would be very interesting in evaluating the amount of dilution. Also, please consider previous comments regarding the 500- to 1000-year terminology.

Response: During the Railyard IRA investigation in 1989/1990, the Railyard DBCP plume was found to occur in the upper part of the alluvial aquifer, which is about 40 feet thick. Since the extraction wells pump from the entire saturated thickness, dilution occurs in and near the operating extraction wells. Hence, the extraction system was turned off temporarily during pre-shut-off monitoring to obtain more representative samples. Please refer to the Pre-Shut-Off Monitoring Report (Navarro 2015c) for more details. The 500- to 1000- year storm event designation for RMA was based on mapping by NOAA and will be retained.

Comment 35. Page 71to 74, Section 5.1.1.4: The text in the 2nd paragraph would suggest that the note under FY2010 in the table should also be in the FY2011 table. Please check. BANS is the most cost effective system. Yet it also seems to be treating the most easily removed contaminants. Table 5.1.1.4-3 shows that dieldrin, which has the greatest number of detections above the detection level, does not show up on the major contaminant list for any year in Table 5.1.1.4-1. On page 73, the text mentions that effective mass removal of each CSRG analyte is to be demonstrated, yet this does not appear to have been done. Please explain. Also, since a reverse gradient is not required by the ROD, and it is suggested that the absence of reverse gradient caused down- gradient increases, should a reverse gradient be evaluated for incorporation into an LTMP revision? On Figure 5.1.1.4-1, extraction wells do not seem to have been plotted, and yet are indicated in the legend.

Response: Treatment of the Lime Basins flow began at BANS in FY11. Thus, the table is correct. Only the major contaminants removed (about 1 pound or greater) are shown on the table. The mass removal calculations included dieldrin (0.02 pounds removed in FY14) and other organic contaminants not shown on the table. Since the reduced extent of the reverse gradient in 2014 likely caused an increase in some of the downgradient well concentrations, adding reverse gradient performance criteria will be considered in an LTMP revision. The BANS extraction wells are indicated as performance extraction wells on Figure 5.1.1-4. The red extraction well symbols will be removed.

Comment 36. Page 78, 1st paragraph: Should either DIMP become a CSRG analyte, or should the mass removal of DIMP be omitted? Can the LTMP be updated for this issue?

Response: DIMP is included in the BANS contaminant removal (BANS, CDT, BRES, and LB) and mass removal (BANS) calculations because it represents a significant portion of the contaminant mass at most of the systems and of the mass flux at BANS. Adding DIMP to the BANS CSRG list will be considered in an LTMP revision.

Comment 37. Page 78 to 79, BANS Evaluation Conclusions: Dieldrin does not appear as a major extracted contaminant on Table 5.1.1.4-1. Is this due to the low flow at BANS, compared to the boundary systems? Also, the text states that the BANS mass removal improves the performance of the boundary systems. The opposite has been suggested in this report, and seems possible. Would it be more correct to say that the mass extraction increases the overall mass removal?

Response: Less dieldrin is removed than some of the other BANS contaminants because the dieldrin concentrations are lower. BANS mass removal improves the performance of the boundary systems by eliminating the majority of the groundwater contaminant mass flux migrating from former Basin A and the Bedrock Ridge area toward the NWBCS and NBCS, respectively. A total of 850 pounds of contaminants were removed by BANS during this FYR period. Most of the mass removed was from the Lime Basins and Complex Trenches, which are contained by slurry walls, but the BANS-specific mass removal averaged 16-18 pounds per year (85 pounds in 5 years). If the BANS did not exist, this contaminant mass would migrate to the NWBCS.

Comment 38. Page 80, 1st complete paragraph: Again, the statement that lower contamination levels may cause treatment plant efficiencies to decline. This is just opposite of what was stated in the 4th line under BANS Evaluation Conclusions on page 79. Please check.

Response: In this context, reduced contaminant loading on a boundary system because of upgradient interception and treatment (mass removal) at BANS is viewed as improving the performance of the boundary system by reducing the potential for contaminant bypass of the boundary system and by potentially reducing the treatment requirements. The resulting lower concentrations at the boundary system may cause the treatment efficiency to decrease, however.

Comment 39. Page 90, Section 5.1.17, 2nd paragraph: Is any reference to a CCR appropriate?

Response: The CCR will be referenced.

Comment 40. Page 96, last paragraph: Please consider previous comments about "...500- to 1000-year storm event...."

Response: The 500- to 1000- year storm event designation for RMA was based on mapping by NOAA. The reference to the 500- to 1000-year storm event will be retained.

Comment 41. Page 99, 2nd paragraph on page: Another five years does not seem justified based on Figures 5.1.2.1-3 and -4, and the relatively wet spring in 2015. It can be speculated that the dewatering design is insufficient for guaranteeing long term compliance. Should an active system be considered?

Response: Attainment of dewatering goals for the dewatering remedies has been identified as an issue in the FYRR, with a recommendation to review the dewatering system, monitoring network, and estimate for revised compliance dates.

Comment 42. Page 100, 3rd complete paragraph: The prospect of in-and-out of compliance seems untenable, and should be evaluated considering other factors in the FYRR. Please consider previous comments on the 500- to 1000-year language.

Response: Attainment of dewatering goals for the dewatering remedies has been identified as an issue in the FYRR, with a recommendation to review the dewatering system, monitoring network, and estimate for revised compliance dates. The 500- to 1000- year storm event designation for RMA was based on mapping by NOAA. The reference to the 500- to 1000-year storm event will be retained.

Comment 43. Page 101, last paragraph: Good statement about the 2-foot-thick slurry wall, but it could be speculated that slurry wall problems could be developing at the aging boundary slurry walls.

Response: No evidence suggests that the integrity of the boundary system slurry walls has declined. Additionally, maintaining a flat to reverse hydraulic gradient ensures containment.

Comment 44. Page 104, last two paragraphs: A variety of reasons are given for non-attainment, but they seem to suggest a lack of contingency planning in the design process.

Response: Installing a dewatering trench instead of dewatering wells would have been preferred in the design to achieve higher flow rates in the low permeability aquifer, but was not feasible because of health and safety concerns. Even with the low flow rate, the first dewatering goal likely will be met in FY16 and significant progress toward meeting the second dewatering goal is being made.

Comment 45. Page 107, only paragraph on page: It seems that protectiveness is not in jeopardy, but appears that lack of timeliness will extend remedy completion and increase costs. Progress should be assessed by the Water Team continuously, with decision for actions taking place as indicated by the data. More flexibility of action and decision-making seems to be indicated.

Response: Attainment of dewatering goals for the dewatering remedies has been identified as an issue in the FYRR, with a recommendation to review the dewatering system, monitoring network, and estimate for revised compliance dates.

Comment 46. Page 144, Railyard/Motor Pool: Shouldn't mention be made of the completion of Pre-Shutoff Monitoring?

Response: This section concerns water quality tracking and evaluates concentration trends in the source areas and between sources and boundary systems. RYCS operation and status are not pertinent to this section.

Comment 47. Page 162, Statistical Evaluation of 2013 and 2014 water quality data relating to HWL: The text states a recommendation to reclassify Well 25194. Since two years have gone by without action on the OCN, can the status of this issue be more explicitly described?

Response: The recommendation for reclassification of well 25194 will be removed.

Comment 48. Page 169, Table 5.1.4.3-4 and text below: Can PCE in the table and text be changed to tetrachloroethene, which was used in previous tables?

Response: The requested changes will be made.

Comment 49. Page 189, 2014 On-Post Plume Map Summary: The plume mapping in 2014 is a help but does the necessary interpretation from the 1994 data make the comparison of limited value in operational planning? Can consideration be given to 5-year updates so that more viable estimates can be made between natural attenuation, dilution, and extraction?

Response: The 2014 plume mapping task and results have little impact on operational planning. Although aquifer restoration is a desirable outcome of remedy implementation, it is not a remedy objective or requirement. The 20-year frequency for on-post plume mapping was agreed upon by the Regulatory Agencies, the Army, and Shell to address longer term changes in the plumes. Site-wide water level and water quality tracking are conducted more frequently to evaluate shorter term trends and remedy effectiveness.

Comment 50. Page 190, Section 5.1.5.2, end of 2nd paragraph under GWMR Project: Based on the Railyard Containment System result, is it possible that current data from the GWMR Project Post Shut- off Monitoring might be judged in a less rigid, but still protective manner?

Response: Assuming the data continue to show that the benzene plume is stable and not impacting the lakes, the GWMR post-shut-off monitoring may end in 2016.

Comment 51. Page 193, Horizontal Extent, 2nd paragraph: Discussion of blending with respect to 1,4-dioxane is good, since blending also occurs with all of the contaminants in all of the treatment systems. Can the overall roll of blending on the extraction systems be evaluated?

Response: As stated in the comment, blending occurs with all of the contaminants in all of the treatment systems. Most of the systems intercept multiple plumes of varying widths and varying concentrations. Thus, the blended concentration in the treatment plant influent typically is lower than the concentrations in the discrete upgradient plumes. In some cases, the influent concentrations are lower than the CSRG when the upgradient discrete plume concentrations may exceed the CSRG. Adding a section to the FYSR to evaluate the roll of blending seems unnecessary.

Comment 52. Page 197, 2nd paragraph under treatment systems: Please see comment #51 above.

Response: The discussion of blending in the paragraph seems sufficient.

Comment 53. Page 198, Conclusions and Recommendations: From the 2010 FYRR recommendation for 1,4-dioxane in Table 4.0-1 on page 46, it was implied that the technical memorandum was expected by the 2015 FYRR. Based on this write-up,"...additional monitoring is warranted..." but additional monitoring was performed. Why is more monitoring required? Also, the SAP and DSR do not seem to be referenced in Section 8.

Response: Evaluation of the 1,4-dioxane standard, effect on remedy protectiveness, and recommendation on whether to adopt the standard will be made in the FYRR. The 1,4-dioxane characterization SAP and DSR will be referenced. Additional monitoring is identified in the SAP to determine temporal changes in the horizontal extent and concentration trends, with the next sampling event in 2017.

Comment 54. Page 200, 4th paragraph: The lack of an assessment and pushing the reevaluation of the monitoring to the 2020 review does not sound responsive to the 2010 issue. Please evaluate a more responsive time table.

Response: Evaluation of the 1,4-dioxane standard, effect on remedy protectiveness, and recommendation on whether to adopt the standard will be made in the 2015 FYRR.

Comment 55. Page 204, OGITS Mass Removal: As previously noted, the word "each" is included here, but it is not apparent that "each" organic CSRG analyte meets the 75% removal criteria. Please clarify.

Response: The mass flux and mass removal for each CSRG analyte is evaluated separately based on the concentrations of that analyte and the dewatering well and system flow rates. The mass removal is calculated in spreadsheets that are provided in the ASRs. The individual analyte mass flux, mass extracted, and mass removed for each analyte is summed, such that the total mass removal is reported. When a question exists about whether the mass removal for an individual analyte meets the 75 percent mass removal goal (e.g. dieldrin at the NPS), it is reported separately.

Comment 56. Page 214, bottom of page, 2nd bullet: Shouldn't the bullet be removed?

Response: Yes.

Comment 57. Page 216, Table 5.2.3-1: The DIMP value for Well 359A on 6/26/2014 is a typo. The correct value is 7.32. Please check. Also, this well was resampled on February 9, 2015, with a result of 6.13 from an initial grab sample, and a result of 8.14 after purging. Could this data be included in Table 5.2.3-1 and a note made that the resident was provided with bottled water.

Response: The table will be corrected. The 2015 data are past the cut-off date for inclusion in the FYSR for this reporting period; however, the data have been included per Regulatory Agency request.

Comment 58. Page 227, Section 7.1, 2nd paragraph: Shouldn't CSRG in the 3rd line be changed to PQL?

Response: Yes. Thank you for catching the error.

Comment 59. Page 228, 3rd paragraph: Please check the word selection in the last line.

Response: The unfortunate error will be corrected.

Comment 60. Page 228, 5th paragraph: Wasn't the plume extent for dieldrin expanded due to the PQL change?

Response: Yes, the dieldrin plume was larger in 2014 with the lower PQL, but the plume extent was less in 2014 when the same concentration intervals were compared.

Comment 61. Figure 5.l.l.4-1, BANS Monitoring Network: Contrary to the legend, there are no extraction wells shown on the figure.

Response: The BANS extraction wells were shown as Performance Extraction Wells. The red extraction well symbol will be removed from the Legend.