ROCKY MOUNTAIN ARSENAL

Fiscal Year 2023
Annual Summary Report for
Groundwater and Surface Water

October 1, 2022 – September 30, 2023

Revision 0
August 13, 2024

Prepared for:
U.S. Department of the Army
Shell Oil Company

Prepared by:

NAVARRO

Navarro Research and Engineering, Inc.

00061456 24597-3

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SUPPORTING DOCUMENTATION
LIST OF ELECTRONIC FILES

Folder	Files
Stand-alone file	FY23 ASR Text-Tables Revision 0.pdf
FY23 ASR Appendices A–K	Individual files provided for each appendix
Data and QA Review	See list in Appendix I
FY23 NWBCS Electronic Files	FY23 NWBCS Cont Removal Rpt.pdf
	FY23 NWBCS Water Mgmt Rpt.pdf
FY23 NBCS Electronic Files	FY23 NBCS Cont Removal Rpt.pdf
	FY23 NBCS Water Mgmt Rpt.pdf
	FY23 NBCS Vertical Gradient Data Rev0.xlsx
FY23 BANS Electronic Files	FY23 BANS Cont Removal Rpt.pdf
	FY23 BANS Water Mgmt Rpt.pdf
	FY23 Lime Basins Water Mgmt Rpt.pdf
	FY23 BANS Mass Removal Rev0.xlsx
	FY3 Lime Basins DNAPL Removal.pdf
FY23 FCTS Electronic Files	FY23 FCTS Cont Removal Rpt.pdf
	FY23 FCTS Water Mgmt Rpt.pdf
	FY23 FCTS Mass Removal Rev0.xlsx
FY23 NPTS Electronic Files	FY23 NPTS Cont Removal Rpt.pdf
	FY23 NPTS Water Mgmt Rpt.pdf
	FY23 NPTS Mass Removal Rev0.xlsx
FY23 Treatment Plant Effluent Reports	Effluent Report_FY23_QTR1_Rev 0.pdf
	Effluent Report_FY23_QTR2_Rev 0.pdf
	Effluent Report_FY23_QTR3_Rev 1.pdf
	Effluent Report_FY23_QTR4_Rev 1.pdf

GENERAL ACRONYMS

ACHD	Adams County Health Department
amsl	above mean sea level
Army	U.S. Department of the Army
ARAR	Applicable or Relevant and Appropriate Requirements
ASR	Annual Summary Report for Groundwater and Surface Water
BANS	Basin A Neck System
BRES	Bedrock Ridge Extraction System
CADT	Complex Army Disposal Trenches
CBSG	Colorado Basic Standard for Groundwater
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFS	Confined Flow System
CSRG	Containment System Remediation Goal
DNAPL	dense non-aqueous phase liquid
DoD	U.S. Department of Defense
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
FCTS	First Creek Treatment System
FY	Fiscal Year (see note at end of list)
FY23	Fiscal Year 2023
FYSR	Five-Year Summary Report
gpm	gallons per minute
ICS	Irondale Containment System
IQR	interquartile range
LCS	laboratory control spikes
Lime Basins DAR	*Lime Basins Dense Non-Aqueous Phase Liquid Remediation Project Design Analysis Report*
LNAPL	light non-aqueous phase liquid
LRSAP	*North Plants Pilot Light Non-Aqueous Phase Liquid Removal System Action Plan*
LT	Less Than (boolean for nondetect values from chemical analysis)

GENERAL ACRONYMS

LTMP	*Long-Term Monitoring Plan for Groundwater and Surface Water*
MCL	Maximum Contaminant Level
MOA	Memorandum of Agreement
MPS	Motor Pool System
MRL	method reporting limit
MS	matrix spike
Navarro	Navarro Research and Engineering, Inc.
NBCS	North Boundary Containment System
NEE	Northeast Extension
NPTS	Northern Pathway Treatment System
NWBCS	Northwest Boundary Containment System
OCN	Operational Change Notice
OGITS	Off-Post Groundwater Intercept and Treatment System
OU	Operable Unit
O&M	operations and maintenance
PE	Performance Evaluation
PFAS	Perfluoroalkyl and Polyfluoroalkyl Substances
PFC	Perfluorinated compound
PQL	practical quantitation limit
QC	quality control
RAO	Remedial Action Objective
RI/FS	Remedial Investigation/Feasibility Study
RMA	Rocky Mountain Arsenal
RMAED	Rocky Mountain Arsenal Environmental Database
ROD	Record of Decision
RPD	relative percent difference
RSL	Regional Screening Level
RVO	Remediation Venture Office
RYCS	Railyard Containment System
SAP	Sampling and Analysis Plan

GENERAL ACRONYMS

Shell	Shell Oil Company
SQAPP	*Sampling Quality Assurance Project Plan*
SWE	Southwest Extension
UFS	Unconfined Flow System
µg/L	micrograms per liter
UV	ultraviolet
VOC	volatile organic compound

Notes:

Numeric fiscal years are identified by the prefix "FY" followed by the last two digits of the four-digit year (e.g., Fiscal Year 2023 is indicated as FY23).

CHEMICAL ACRONYMS

111TCE	1,1,1-Trichloroethane
11DCE	1,1-Dichloroethylene
11DCLE	1,1-Dichloroethane
12DCE	1,2-Dichloroethylene
12DCLB	1,2-Dichlorobenzene
12DCLE	1,2-Dichloroethane
12DCLP	1,2-Dichloropropane
13DCLB	1,3-Dichlorobenzene
14DCLB	1,4-Dichlorobenzene
14DIOX	1,4-Dioxane
ACLDAN	alpha-Chlordane
ALDRN	Aldrin
AS	Arsenic
ATZ	Atrazine
C6H6	Benzene
CCL4	Carbon tetrachloride
CH2CL2	Methylene chloride
CHCL3	Chloroform
CL	Chloride
CL6CP	Hexachlorocyclopentadiene
CLC6H5	Chlorobenzene
CPMS	p-Chlorophenylmethyl sulfide
CPMSO	p-Chlorophenylmethyl sulfoxide
CPMSO2	p-Chlorophenylmethyl sulfone
DBCP	Dibromochloropropane
DCPD	Dicyclopentadiene
DIMP	Diisopropylmethyl phosphonate
DITH	Dithiane
DLDRN	Dieldrin
ENDRN	Endrin

CHEMICAL ACRONYMS

ETC6H5	Ethylbenzene
F	Fluoride
GCLDAN	gamma-Chlordane
HFPODA	Hexafluoropropylene oxide dimer acid
HG	Mercury
ISODR	Isodrin
MEC6H5	Toluene
MLTHN	Malathion
NNDMEA or NDMA	n-Nitrosodimethylamine
NNDNPA or NDPA	n-Nitrosodi-n-propylamine
OXAT	1,4-Oxathiane
PFAS	Perfluoroalkyl and polyfluoroalkyl substances
PFBS	Perfluorobutanesulfonic acid
PFHxS	Perfluorohexane sulfonic acid
PFNA	Perfluorononanoic acid
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulfonic acid
PPDDE	Dichlorodiphenyldichloroethene
PPDDT	Dichlorodiphenyltrichloroethane
SO4	Sulfate
TCLEA	1,1,2,2-Tetrachloroethane
TCLEE	Tetrachloroethylene
TRCLE	Trichloroethylene
XYLEN	Xylenes

Note:

Chemical acronyms listed are those that may be referenced in the text, tables, and other components of the ASR. A full list of chemical acronyms utilized within the Rocky Mountain Arsenal Environmental Database is provided in Appendix I2.

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EXECUTIVE SUMMARY

This Fiscal Year 2023 (FY23) Annual Summary Report for Groundwater and Surface Water (ASR) includes an evaluation of the data collected and an evaluation of the compliance and performance criteria required for the operating groundwater treatment systems; system-specific and site-wide groundwater and surface water hydrology; other monitoring conducted during FY23; as well as any Consultative Process notifications. The regulatory agencies are required to be notified of performance issues in accordance with the consultation triggers presented in the Consultative Process tables presented in Sections 4, 5 and 6 of the *Long-Term Monitoring Plan for Groundwater and Surface Water* (LTMP) (Navarro 2021). The ASR has been prepared to document and evaluate monitoring data collected on behalf of the U.S Department of the Army (Army) at Rocky Mountain Arsenal (RMA) for the period October 2022 through September 2023 for the systems and programs below and as noted in Figure ES-1:

- Northwest Boundary Containment System (NWBCS)
- North Boundary Containment System (NBCS)
- Basin A Neck System (BANS)
- Bedrock Ridge Extraction System (BRES)
- Complex Army Disposal Trenches (CADT)
- Shell Oil Company (Shell) Disposal Trenches
- Lime Basins Slurry Wall Dewatering System and Dense Non-Aqueous Phase Liquid (DNAPL) Remediation Project
- North Plants Light Non-Aqueous Phase Liquid (LNAPL) Pilot Removal Action
- First Creek Treatment System (FCTS)
- Northern Pathway Treatment System (NPTS)
- Treatment System Post-Shut-Off Monitoring
  - Railyard Containment System (RYCS)
  - Motor Pool System (MPS)/Irondale Containment System (ICS)
- LTMP Off-Post Surface Water Monitoring

The current system-related and site-wide monitoring categories, as shown in the LTMP and reported in the FY23 ASR, include the following:

System-Related Monitoring
- Effluent Compliance Monitoring
- Performance Monitoring
- Pre-Shut-Off Monitoring
- Shut-Off Monitoring
- Post-Shut-Off Monitoring
- Operational Monitoring

Site-Wide Monitoring
- Water Level Tracking
- Water Quality Tracking
- Confined Flow System (CFS) Monitoring
- Exceedance Monitoring
- Off-Post Water Level Monitoring
- Surface Water Monitoring

The data used for this ASR were collected pursuant to the 2021 revision of LTMP (Navarro 2021), the Sampling and Analysis Plans (SAP) issued as part of the Operations and Maintenance Plans for the respective extraction and treatment systems, SAPs issued as part of the Post-Closure Plans, and the *Rocky Mountain Arsenal Sampling Quality Assurance Project Plan* (Navarro 2019a).

The long-term groundwater monitoring program described in the LTMP satisfies the requirements of the On-Post and Off-Post Records of Decision (ROD) (Foster Wheeler 1996; HLA 1995). The main objectives, as stated in the RODs, are to evaluate the effectiveness of the remedies, to verify the effectiveness of existing on-post and off-post groundwater treatment systems, to satisfy Comprehensive Environmental Response, Compensation, and Liability Act of 1980 requirements for waste left in place, and to provide data for five-year reviews. The main component of the remedy related to groundwater is continued operation of the groundwater extraction and treatment systems.

Summarized below are the results and conclusions for system-specific operational compliance monitoring and performance monitoring relative to the criteria presented in Table ES-1.

ES.1 ON-POST EXTRACTION AND TREATMENT SYSTEMS

All of the groundwater containment and mass removal systems met the compliance monitoring criteria presented in the LTMP (Navarro 2021) in FY23. In addition, the groundwater containment and mass removal systems predominantly met the performance criteria presented in the LTMP (Navarro 2021), and the objectives identified in the On-Post ROD (Foster Wheeler 1996) and Off-Post ROD (HLA 1995).

In FY23, some specific performance criteria were not met in some portions of the NWBCS, BRES, and Lime Basins systems. Table ES-1 presents a summary of the compliance criteria and the system- and project-specific performance criteria and whether these criteria were met in FY23. In instances where performance criteria were not met, or data suggest that performance criteria are at risk of not being met, proposed or current actions are indicated and will be followed up in FY24, and documented in the FY24 ASR.

Summarized below are the results and conclusions for system-specific operational compliance monitoring and performance monitoring relative to the performance criteria and goals as stated in the LTMP.

Northwest Boundary Containment System

- In FY23, the NWBCS operated at an average flow rate of 820 gallons per minute (gpm), pumping a total volume of 431,089,815 gallons and removing a total of 1.8 pounds of contaminant mass.
- The NWBCS met the compliance and the primary performance criteria for the Original System and objectives established in the LTMP. The NWBCS had no Containment System Remediation Goal (CSRG)/Practical Quantitation Limit (PQL) analyte exceedances for quarterly samples or the four-quarter moving averages in the treatment

system effluent in FY23, with the exception of dieldrin in the second quarter. A reverse hydraulic gradient was maintained within the system and plume capture was evident based on visual observation of the potentiometric surface within the original system as well as within the Northeast Extension (NEE) and Southwest Extension (SWE). Thus, the NWBCS was functioning as intended.

- Dieldrin and n-nitrosodi-n-propylamine (NDPA) were detected above the PQL/CSRG in Original System and NEE downgradient performance wells during the reporting period:
  - Original System downgradient wells 37331, 37332, 37333, and 37600 contained dieldrin above the PQL in FY23. However, the secondary performance criterion was met during the reporting period because the long-term trend was not increasing in these downgradient performance wells.
  - NEE downgradient well 22512 contained dieldrin and NDPA above the PQL or CSRG and well 22015 contained dieldrin above the PQL in FY23. The secondary performance criterion was not met for dieldrin and NDPA in well 22512 because concentrations of dieldrin and NDPA demonstrate increasing trends in this downgradient performance well.
- Dieldrin and NDPA above their respective PQLs/CSRGs in downgradient performance wells may be attributed to a variety of factors including contamination due to mobilization of residual contamination or possible system bypass around the north end of the NEE slurry wall. An investigation of potential bypass of the NEE slurry wall was conducted in FY21 and a supplemental semiannual water quality monitoring program was completed in February 2023. The evaluation of the supplemental monitoring program resulted in recommended actions focusing on aquifer slug tests and pumping tests to take place in FY24. Results of the aquifer testing will support the feasibility and design for improved containment with supplemental extraction and recharge in the vicinity of the NEE.

North Boundary Containment System

- In FY23, the NBCS operated at an average flow rate of 222 gpm and pumped a total volume of 115,130,496 gallons and removed a total of 11.3 pounds of contaminant mass.
- 1,4-Dioxane exceeded the CSRG in the plant effluent during all four quarters. As an emerging contaminant, 1,4-dioxane treatment was not part of the design for the NBCS and therefore is not treated by the system. n-Nitrosodimethylamine (NDMA) exceeded the CSRG/PQL in the plant effluent during the second, third, and fourth quarters of FY23, and the moving average exceeded the PQL during the third and fourth quarters. Formal notification of the NDMA exceedances was made to the regulatory agencies on June 13, 2023.
- A reverse hydraulic gradient was maintained within the system during all four quarters of FY23. Plume capture is evident as indicated by the potentiometric surface map and the evaluation of downgradient water quality data. Relative to the primary performance criterion, the NBCS functioned as intended in FY23.

- Dieldrin occurred at concentrations above the CSRG/PQL in downgradient performance wells but shows indiscernible, stable, or decreasing trends in wells. 1,4-Dioxane and NDMA were detected at concentrations exceeding CSRGs/PQLs in downgradient wells and indicate an increasing trend in wells 24429 and 24006, respectively. Concentrations of anions chloride, fluoride, and sulfate also exceeded CSRGs. Chloride and sulfate are expected to naturally attenuate to background levels. Based on the FY23 information, the contaminant plumes continue to be captured by the NBCS system.

Basin A Neck System

- In FY23, the BANS operated at an average flow rate of 16.4 gpm and pumped a total volume of 8,628,067 gallons during FY23, removing a total of 55.9 pounds of contaminant mass. The BANS had no CSRG/PQL analyte exceedances for quarterly samples or the four-quarter moving averages in the treatment system effluent in FY23.
- The revised 90 percent mass removal criterion was met in FY23, with mass removal estimated at 99.9 percent. Concentrations of analytes that remain above CSRGs/PQLs indicate stable or decreasing trends. Thus, the BANS was functioning as intended.
- The BANS demonstrated treatment system effectiveness, specifically related to dieldrin, p-chlorophenylmethyl sulfone (CPMSO2), and dichlorodiphenyltrichloroethane (PPDDT). Each contaminant showed concentrations exceeding CSRGs/PQLs in upgradient groundwater and treatment plant influent, while concentrations in the treatment plant effluent were less than CSRGs/PQLs. Although these analytes occurred at concentrations greater than CSRGs/PQLs in downgradient performance wells, decreasing, indiscernible, or stable trends are indicated.

Bedrock Ridge Extraction System

- In FY23, the BRES did not meet the plume capture performance criteria and objectives established in the LTMP. Trichloroethylene in downgradient well 36566 shows an increasing concentration trend. Although the plume appears captured at both edges of the system, bypass may be occurring within the west-central portion of the extraction system.
- Evaluation of supplemental monitoring data collected from 2019 through 2021 resulted in a recommendation to include installation of one additional extraction well and one downgradient monitoring well as part of the future optimization of the system.

ES.2 OTHER ON-POST SYSTEMS

Complex Army Disposal Trenches

- In FY23, the CADT system met the performance criteria and objectives established in the LTMP. The inward gradient was maintained across the slurry wall and hydraulic control was maintained in the vicinity of performance wells 36216 and 36217.

Shell Disposal Trenches

- In FY23, the Shell Disposal Trenches met the performance criteria and objectives established in the LTMP. All groundwater elevations were below the bottom of the trenches at all of the borehole performance goal locations.

Lime Basins Slurry Wall Dewatering System

- The first performance criterion requires that a positive inward hydraulic gradient be maintained across the slurry wall. In FY23, an inward gradient was present in all well pairs on the southern side while an outward gradient was still present for all the well pairs on the northern side, consistent with results obtained since FY14. Groundwater elevations inside of the slurry wall have been steadily decreasing; however, progress toward meeting the goal is dependent on water level fluctuations outside the slurry wall.
- The second performance criterion requires that water levels inside the slurry wall are below the elevation of the bottom of the waste (5242 feet above mean sea level [amsl]). During all four quarters of FY23, the water elevation in each well inside the slurry wall was below the bottom of waste elevation. Therefore, this dewatering performance criterion was met during FY23.

Lime Basins DNAPL Remediation Monitoring

- The water level data and DNAPL measurements for FY23 indicated that DNAPL was detected in well 36235 outside and/or adjacent to the slurry wall. DNAPL was detected within the slurry wall in extraction wells 36315, 36319, and 36320 and monitoring wells 36231, 36235, and 36248. The data indicate that the slurry wall has not been adversely impacted by historical DNAPL contamination. Consistent head differentials across the slurry wall have been maintained for all the well pairs showing that the DNAPL remediation system is functioning as intended.
- The observed presence of DNAPL has been consistent since FY13. No additional areas of DNAPL were identified in the vicinity of the Lime Basins slurry wall in FY23. As required, a total of 7 gallons of DNAPL was removed from wells 36248, 36319, and 36320 in FY23 where the thickness was greater than 1 foot (TtEC and URS 2012). Current data indicate that no additional DNAPL sources zones appear to exist within the Lime Basins slurry wall and that the extent of DNAPL is decreasing. Removal of recoverable DNAPL will next take place in FY24.

North Plants LNAPL Pilot Removal Action

- In May and November 2022, LNAPL thickness was measured in well 25301 at 0.74 feet and 1.4 feet, respectively, and a bail down test was performed as required by the *North Plants Pilot Light Non-Aqueous Phase Liquid Removal System Action Plan*. Bail-down testing was completed on March 28, 2023, and 3 gallons of LNAPL were recovered from well 25301. Afterwards, there was no significant recovery of LNAPL in well 25301 for the next six months.
- Based on the pending *North Plants Pilot Light Non-Aqueous Phase Liquid Removal System Completion Report* (currently under Regulatory review), LNAPL monitoring should continue to occur quarterly in the two recovery wells and seven piezometers. If

more than 6 inches of LNAPL is present in a recovery well, the well will be bailed down to remove the LNAPL for appropriate disposal.

ES.3 OFF-POST EXTRACTION AND TREATMENT SYSTEMS

First Creek Treatment System

- The FCTS operated at an average flow rate of 55.7 gpm, pumping a volume of 29,018,947 gallons, and removing a total of 2.5 pounds of contaminant mass.
- There were no individual exceedances of CSRGs/PQLs in treatment plant effluent, including four-quarter moving averages, in FY23.
- Mass removal at the FCTS was 59.1 percent, which did not meet the performance goal of 75 percent removal in FY23. FY23 marks the first time that the mass removal performance goal was not met, the required notification to the agencies will accompany the transmittal of this report.
- No organic analytes, including dieldrin and diisopropyl methylphosphonate (DIMP), were detected at concentrations exceeding CSRGs/PQLs in FY23 in downgradient performance wells. Inorganic analytes including chloride and fluoride were detected above the CSRGs in FCTS downgradient performance wells and will continue to be monitored to determine whether continuous operations of the system results in decreasing concentrations downgradient of the system.

Northern Pathway Treatment System

- The NPTS operated at an average flow rate of 160 gpm, pumping a volume of 84,492,278 gallons, and removing a total of 0.07 pounds of contaminant mass.
- There were no CSRG-analyte exceedances of the four-quarter moving averages in the NPTS effluent in FY23.
- The mass removal at the NPTS was 83.3 percent, meeting the performance goal of 75 percent removal in FY23.
- Chloride, dieldrin, and NDPA were the only contaminants detected above the CSRGs/PQLs in FY23 in downgradient performance wells. Chloride, fluoride, and sulfate were detected above CSRGs in FY23 in cross-gradient performance well 37027. Anions are not treated at NPTS, and the lack of organic contaminants detected at levels less than CSRGs/PQLs indicate the system is effective.
- The NPTS met the performance criteria and objectives established in the LTMP. Thus, the NPTS was functioning as intended.

ES.4 SITE-WIDE ON-POST MONITORING

Water Level Tracking

- Overall, groundwater flow directions and associated migration of contaminant plumes have not changed significantly during the FY23 reporting period.

Water Quality Tracking

- The Water Quality Tracking network is sampled twice every five years, and last sampled in FY22. The next site-wide Water Quality Tracking monitoring event is scheduled for FY24.
- Wells 04535 and 33081, located in the vicinity of the former MPS/ICS, are sampled annually. Well 04535, located downgradient of the MPS, was sampled for trichloroethylene. Trichloroethylene was detected in well 04535 at a concentration of 0.604 µg/L, below the CSRG of 5 µg/L. Well 33081, located between the RYCS and former ICS, was sampled for DBCP and not detected.

Confined Flow System Monitoring

- The CFS network was not sampled in FY23 in accordance with the LTMP sampling schedule. CFS water quality sampling was last conducted in FY22 as part of the twice-in-five-years monitoring program. The next sampling event is scheduled for FY24.

ES.5 SITE-WIDE OFF-POST MONITORING

Off-Post Exceedance Monitoring

- The Off-Post Exceedance Monitoring network was not sampled in FY23 in accordance with the LTMP sampling schedule. Off-Post Exceedance monitoring was last conducted in FY22 as part of the twice-in-five-years monitoring program. The next Off-Post Exceedance monitoring event is scheduled for FY24.

Off-Post Surface Water

- Off-post surface water sampling was not conducted in FY23 because First Creek did not exhibit low-flow or base-flow conditions during the third and fourth quarters of the year when sampling is required. Higher-than-normal precipitation occurred within the vicinity of RMA where there was substantial flooding along First Creek extending from the northern boundary of the site and throughout the footprint of the FCTS. The next off-post surface water sampling event is scheduled for FY24.

Adams County Health Department Off-Post Groundwater Monitoring

- Eleven private wells—including five alluvial wells and six wells providing drinking water from the Arapahoe Formation—were sampled for DIMP, dieldrin, and 1,4-dioxane in FY23. Well 359D had a DIMP detection of 11.9 micrograms per liter (µg/L), which exceeded the Colorado Basic Standard for Groundwater (CBSG) of 8 µg/L. No other analyte concentrations exceeded CSRGs/PQLs in off-post private wells in FY23.
- Well 359D was installed in November 2016, and is screened in two separate zones in the Lower Arapahoe aquifer, similar to the well it replaced (359A). In July 2021, a field investigation took place to evaluate the integrity of the well and whether DIMP in groundwater could be isolated to a specific zone within the Arapahoe aquifer. The result of the field investigation was a recommendation that a small-scale "point of entry" carbon filtration system be installed at the wellhead in order to provide uncontaminated water to the residents on the property. To date, the homeowner has refused to allow the

Army to install the point of entry treatment system at the residence. Bottled water is currently being provided to the residents.

ES.6 PERFLUOROALKYL AND POLYFLUOROALKYL SUBSTANCES

- Influent and effluent samples were collected quarterly in FY23 and analyzed for six perfluoroalkyl and polyfluoroalkyl substances (PFAS).
- PFAS—including perfluorobutanesulfonic acid (PFBS), perfluorohexane sulfonic acid (PFHxS), perfluorooctanoic acid (PFOA), and perfluorooctane sulfonic acid (PFOS)—were detected in the influent samples collected at the NWBCS, BANS, FCTS, and NPTS treatment plants with concentrations exceeding the respective Regional Screening Levels (RSL) for PFOA and PFOS. PFBS and PFHxS were detected in the influent at the NBCS at concentrations below RSLs.
- PFAS—including PFBS, PFHxS, and PFOA—were detected in the effluent samples collected at the NWBCS, FCTS, and NPTS treatment plants. PFBS was detected in NWBCS, FCTS, and NPTS plant effluent during FY23 and concentrations were less than the RSL (0.6 µg/L). PFHxS was detected in the NPTS effluent during the fourth quarter of FY23 below the RSL (0.039 µg/L). PFOA was only detected in NPTS plant effluent during the first quarter of FY23, and the concentration exceeded the RSL (0.0000027 µg/L). However, the concentration was below the Maximum Contaminant Level that was finalized in 2024.
- PFAS monitoring was included for the boundary treatment system downgradient performance wells to provide additional information related to groundwater quality. Concentrations of PFOA and PFOS exceeded the RSLs in wells downgradient of the NBCS and in well 27522 downgradient of the NWBCS Southwest Extension.
- PFAS monitoring is included in the Water Quality Tracking network for wells 01525, 36181, 36210, 36627, and 36631 and occurs once every five years. While sampling did not take place in FY23, these wells will be sampled in FY27 in accordance with the LTMP.

Table ES-1. Summary of FY23 Compliance and Performance Criteria and Goals Achievement

LTMP Performance Criterion or Primary Goal [1]	Criterion or Goal Achievement
Northwest Boundary Containment System – Treatment System	
Compliance Criterion	
Demonstrate system compliance through effluent water quality monitoring to confirm that CSRGs are met. Compliance is based on running averages for the last four quarters, or one annual sample for those analytes that are not sampled quarterly.	Yes
Primary Performance Criteria [2] – Original System	
Demonstrate containment through reverse hydraulic gradient by visual evaluation of potentiometric maps and visual comparison of paired well water levels. If visual inspection is unclear, statistical or other evaluation criteria will be considered.	Yes
Demonstrate containment through plume-edge capture by visual evaluation of flow directions on potentiometric maps and evaluation of water quality data from performance and operational monitoring wells. If visual inspection is unclear, statistical or other evaluation criteria will be considered.	Yes
Secondary Performance Criterion [2] – Original System	
If unable to maintain reverse hydraulic gradient due to factors beyond Army control, the performance evaluation will be based on demonstrating that concentrations in downgradient water quality performance wells are at or below CSRGs/PQLs or show decreasing concentration trends, based on annual evaluations, over the previous period of at least 5 years. If visual inspection is unclear, statistical or other evaluation criteria will be considered.	Secondary performance criterion is not applicable since primary performance criteria were achieved. Continued monitoring will be conducted to evaluate performance wells where CSRG/PQL exceedances occurred.
Northwest Boundary Containment System – Northeast Extension	
Demonstrate plume capture through visual evaluation of flow directions on potentiometric maps and evaluation of water quality data from performance and operational monitoring wells. If visual inspection is unclear, statistical and other evaluation criteria will be considered.	No. Dieldrin and NDPA were detected above CSRGs/PQLs in downgradient performance wells 22015 and 22512. The long-term trends for dieldrin are not increasing in downgradient performance wells, however, NDPA indicates an increasing trend. Aquifer testing is scheduled for FY24 to evaluate the feasibility and design for improved containment with supplemental extraction and recharge in the vicinity of the NEE.
Demonstrate decreasing concentration trends or that concentrations are at or below CSRGs/PQLs in downgradient performance wells.	No. NDPA was detected in well 22512 in FY23 at concentrations exceeding the PQL. Concentrations indicate an increasing trend through FY23.

Table ES-1. Summary of FY23 Compliance and Performance Criteria and Goals Achievement

LTMP Performance Criterion or Primary Goal [1]	Criterion or Goal Achievement
Northwest Boundary Containment System – Southwest Extension	
Demonstrate plume capture through visual evaluation of flow directions on potentiometric maps and evaluation of water quality data from performance and operational monitoring wells. If visual inspection is unclear, statistical or other evaluation criteria will be considered.	Yes
Demonstrate decreasing concentration trends or that concentrations are at or below the CSRGs/PQLs in downgradient performance wells.	Yes
North Boundary Containment System	
Compliance Criterion	
Demonstrate system compliance through effluent water quality monitoring to confirm that CSRGs are met. Compliance is based on running averages for the last four quarters, or one annual sample for those analytes that are not sampled quarterly.	No. 1,4-dioxane concentrations exceeded the CSRG/PQL in plant effluent during all four quarters of FY23, with moving average exceeding the CSRG/PQL. NDMA exceeded CSRG/PQL in the plant effluent—during the second, third, and fourth quarters of FY23—and the moving average exceeded the standard during the third and fourth quarters. Further evaluation of NDMA and related treatment at the NBCS is planned for FY24.
Primary Performance Criteria [2]	
Demonstrate containment through reverse hydraulic gradient by visual evaluation of potentiometric maps and visual comparison of paired well water levels. If visual inspection is unclear, statistical or other evaluation criteria will be considered.	Yes.
Demonstrate containment through plume-edge capture by visual evaluation of flow directions on potentiometric maps, and evaluation of water quality data from performance water quality wells. If visual inspection is unclear, statistical or other evaluation criteria will be considered.	Yes. The potentiometric surface map and the evaluation of water quality data indicate plume edge capture at both ends of the system.
Secondary Performance Criterion [2]	
If unable to maintain reverse hydraulic gradient due to factors beyond Army control, the performance evaluation will be based on demonstrating that concentrations in downgradient water quality performance wells are at or below CSRGs/PQLs or show decreasing concentration trends over the previous period of at least 5 years. If visual inspection is unclear, statistical or other evaluation criteria will be considered.	Secondary performance criterion is not applicable since primary performance criteria were achieved. Continued monitoring will be conducted to evaluate reverse gradient across the system.

Table ES-1. Summary of FY23 Compliance and Performance Criteria and Goals Achievement

LTMP Performance Criterion or Primary Goal [1]	Criterion or Goal Achievement
Basin A Neck System	
Compliance Criterion	
Demonstrate system compliance through effluent water quality monitoring to confirm that CSRGs are met. Compliance is based on running averages for the last four quarters, or one annual sample for those analytes that are not sampled quarterly.	Yes
Performance Criteria	
Demonstrate effective mass removal through comparison of total calculated mass removed by the system for each of the CSRG analytes and mass flux approaching the system estimated by combined well capture and transect methods for the BANS (OCN-LTMP-2023-005).	Yes
Demonstrate that concentrations in downgradient performance wells are stable or decreasing.	Yes
Bedrock Ridge Extraction System Performance Criteria	
Demonstrate plume capture through visual evaluation of flow directions on potentiometric maps and evaluation of water quality data from performance and operational monitoring wells. If visual inspection is unclear, statistical and other evaluation criteria will be considered.	Yes
Demonstrate decreasing or stable concentration trends or that concentrations are at or below CSRGs in downgradient performance wells.	No. Concentrations of trichloroethylene are above the CSRG in well 36566 and exhibit an increasing trend. Evaluation of supplemental monitoring data resulted in a recommendation to include installation of one additional extraction well and one downgradient well as part of the future optimization of the system.
Complex Army Disposal Trenches Performance Criteria	
Demonstrate groundwater elevations in performance monitoring wells 36216 and 36217 are below the target elevations of 5226 and 5227 feet, respectively, or Demonstrate hydraulic gradient from the performance monitoring wells locations is toward the extraction trench.	Yes. The CADT system met the performance criteria and objectives established in the LTMP. Although the water levels remained above the trench-bottom elevation in well 36217, hydraulic control was maintained at both performance well locations.

Table ES-1. Summary of FY23 Compliance and Performance Criteria and Goals Achievement

LTMP Performance Criterion or Primary Goal [1]	Criterion or Goal Achievement
Maintain positive gradient from the outside to the inside of the barrier wall (for as long as active dewatering is occurring).	Yes
Shell Disposal Trenches Performance Criterion	
Demonstrate groundwater elevations are below the disposal trench bottom elevations within the slurry wall enclosure listed in the 2021 LTMP, Table 5.2-2.	Yes. Groundwater elevation is below the bottom of trenches at all borehole locations.
Lime Basins Slurry Wall Dewatering System Performance Criteria	
Maintain a positive gradient from the outside to the inside of the barrier wall (for as long as the surrounding local groundwater table is in the alluvium).	No. Outward gradient is present in wells on the north side of the slurry wall.
Maintain a groundwater level below the elevation of the Lime Basins waste (5242 feet) inside the barrier wall (for as long as the surrounding local groundwater table is in the alluvium).	Yes
Lime Basins DNAPL Remediation Monitoring Performance Criteria	
Primary Goals [3]	
To determine if additional DNAPL source zones exist in the Lime Basins area in addition to those previously identified.	Yes. No additional DNAPL source zones were identified based on measured DNAPL in wells.
To determine if the extent and nature of any discovered DNAPL source zones have the potential to adversely impact the slurry wall.	Yes. No adverse impacts to the slurry wall due to the presence of DNAPL have been observed.
To characterize DNAPL, if present, for the purpose of correlation with groundwater characterization data as a tool in the identification of DNAPL source zones and for the purpose of waste disposal.	Yes. DNAPL continues to be characterized.
First Creek Treatment System	
Compliance Criteria	
Demonstrate system compliance through effluent water quality monitoring to confirm that CSRGs are met. Compliance is based on running averages for the last four quarters, or one annual sample for those analytes that are not sampled quarterly.	Yes

Table ES-1. Summary of FY23 Compliance and Performance Criteria and Goals Achievement

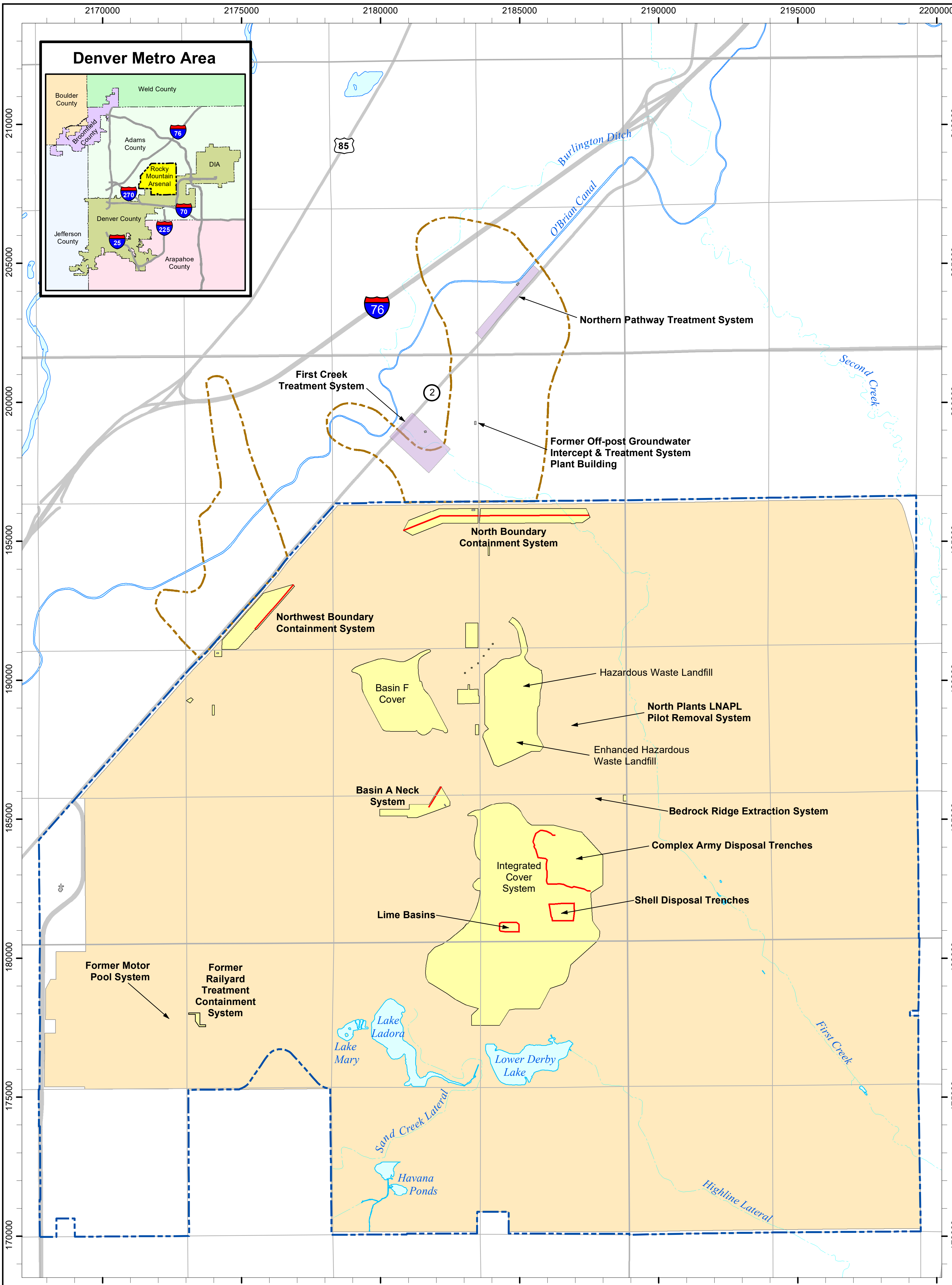
LTMP Performance Criterion or Primary Goal [1]	Criterion or Goal Achievement
Performance Criteria	
Demonstrate effective mass removal through comparison of total calculated mass removed by the system for each of the CSRG analytes and mass flux approaching the system estimated by combined well capture and transect methods for the FCTS (OCN-LTMP-2023-004).	No. Further evaluation will take place supporting the current configuration to determine whether operations and monitoring can be optimized in order to provide more effective capture of contaminants within system area.
Demonstrate that concentrations in downgradient performance wells are stable or decreasing.	Yes
Northern Pathway Treatment System	
Compliance Criteria	
Demonstrate system compliance through effluent water quality monitoring to confirm that CSRGs are met. Compliance is based on running averages for the last four quarters, or one annual sample for those analytes that are not sampled quarterly.	Yes
Performance Criteria	
Demonstrate effective mass removal through comparison of total calculated mass removed by the system for each of the CSRG analytes and mass flux approaching the system estimated by combined well capture and transect methods for the NPTS (OCN-LTMP-2023-004).	Yes
Demonstrate that concentrations in downgradient performance wells are stable or decreasing.	Yes

Notes:

[1] Criteria and goals are listed as presented in the LTMP and reflect any changes in accordance with OCNs as indicated. Primary criteria are provided unless otherwise noted. For systems without primary/secondary criteria, all criteria must be met.

[2] Only the NWBCS and NBCS are bound to secondary performance criteria, and only if primary performance criteria are not met.

[3] There are no performance criteria for the Lime Basins DNAPL Remediation Monitoring program, but goals are specified in the LTMP.



Legend

- RMA On-Post Operable Unit
- Off-Post Operable Unit
- U.S. Army Jurisdiction
- RMA National Wildlife Refuge
- Current Lakes & Ponds
- Slurry Walls
- Intermittent Streams
- Ditches, Canals
- Township & Range Lines
- Section Lines

N

0 2,000 4,000 6,000
Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

Note: Monitoring wells not shown for clarity. Location of monitoring wells is provided in the Long-Term Monitoring Plan for Groundwater and Surface Water (TtEC & URS 2010)

Program Manager
Rocky Mountain Arsenal

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Figure ES-1

Rocky Mountain Arsenal
Site Locations

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6/25/2024

1.0 INTRODUCTION

1.1 REPORT PURPOSE

This Fiscal Year 2023 (FY23) Annual Summary Report for Groundwater and Surface Water (ASR) includes an evaluation of the data collected and an evaluation of the compliance and performance criteria required for the operating groundwater treatment systems; system-specific and site-wide groundwater and surface water hydrology; and any other supplemental monitoring conducted during the time period October 1, 2022 through September 30, 2023. In addition, the ASR includes data reporting for any site-wide monitoring conducted within FY23, project-specific monitoring, and any Consultative Process notifications (Table 1.1-1). The regulatory agencies are required to be notified of performance issues in accordance with the consultation triggers presented in the Consultative Process tables presented in Sections 4, 5 and 6 of the *Long-Term Monitoring Plan for Groundwater and Surface Water* (LTMP) (Navarro 2021).

This report has been prepared to document and evaluate annual monitoring data collected at the Rocky Mountain Arsenal (RMA) on behalf of the U.S. Department of the Army (Army) during FY23 for the following systems and programs:

- Northwest Boundary Containment System (NWBCS)
- North Boundary Containment System (NBCS)
- Basin A Neck System (BANS)
- Bedrock Ridge Extraction System (BRES)
- Complex Army Disposal Trenches (CADT)
- Shell Oil Company (Shell) Disposal Trenches
- Lime Basins Slurry Wall Dewatering System and Dense Non-Aqueous Phase Liquid (DNAPL) Remediation Project
- North Plants Light Non-Aqueous Phase Liquid (LNAPL) Pilot Removal Action
- First Creek Treatment System (FCTS)
- Northern Pathway Treatment system (NPTS)
- Treatment System Post-Shut-Off Monitoring
- Railyard Containment System (RYCS)
- Motor Pool System (MPS)/Irondale Containment System (ICS)
- LTMP Off-Post Surface Water Monitoring

The system-related monitoring categories, as presented in the LTMP, include the following:

- Compliance Monitoring
- Performance Monitoring
- Shut-Off Monitoring

- Post-Shut-Off Monitoring
- Operational Monitoring

The site-wide monitoring programs included in the ASR, as identified in the LTMP, include the following programs:

- Water Level Tracking
- Water Quality Tracking
- Confined Flow System (CFS) Monitoring
- Off-post Water Level Monitoring
- Exceedance Monitoring
- Surface Water Monitoring

Data summaries for all site-wide long-term monitoring programs are included for years when monitoring is conducted. In FY23, the site-wide programs where monitoring was conducted included water level tracking and Adams County Health Department (ACHD) off-post private well sampling. In accordance with the LTMP, site-wide twice-in-five-year sampling was not conducted for the Water Quality Tracking, CFS, and Exceedance monitoring networks in FY23. This sampling will be conducted in FY24. Long-term off-post surface water monitoring of three locations along First Creek was not conducted in FY23 due to the high flowrate within the FCTS area.

All water level measurements and water quality analyses for FY23 are included as an electronic file accompanying this report. Performance water quality monitoring results are provided as exhibits for each operating system in Appendices A through G.

1.2 MONITORING PROGRAMS OVERVIEW

The purpose of this report is to provide an integrated summary of monitoring for on-post and off-post treatment systems, shut-off and post shut-off sites, and the site-wide programs in FY23. This section presents an overview of each monitoring program.

1.2.1 Treatment Systems Operations and Monitoring Overview

The selected groundwater remedies from the On-Post and Off-Post Record of Decision (ROD) include the continued operation of all groundwater intercept and treatment systems and on-post groundwater Interim Response Action systems until shut-off criteria are met, and an extended monitoring program is completed.

During the FY23 reporting period, the treatment systems were operated to reduce the concentrations of the Containment System Remediation Goal (CSRG) analytes in the effluent below their respective regulatory requirements. Quarterly effluent samples were collected from the treatment plants and analyzed for CSRG analytes and other analytes using Army methods specified in the RMA *Sampling Quality Assurance Project Plan* (SQAPP) (Navarro 2019a). Treatment system compliance is based on moving averages for the last four quarters instead of single samples. Treatment system statistics and operational information are reported in the quarterly RMA *Treatment Plant Effluent Water Quality Data Reports* for the NWBCS, NBCS, BANS, and off-post treatment systems.

Treatment system-specific statistics for FY23 are provided in Sections 3 and 5 for the NWBCS, NBCS, BANS, FCTS, and NPTS including:

- Downtime attributable to equipment failures, maintenance, and power failure
- Average annual flow rate
- Total treated volume of groundwater
- Total mass of contaminants removed with an indication of major contaminants
- Carbon usage
- Annual cost of operation

In FY23, there were no modifications made to any of the treatment systems other than normal operations and maintenance (O&M).

The CSRGs presented in the FY23 ASR are those identified in the On-Post ROD (Foster Wheeler 1996), the Off-Post ROD (HLA 1995), the Remediation Scope and Schedule (HLA 1996), and subsequent modifications. Results of sampling for routine CSRG analytes retained for quarterly monitoring, as described in the LTMP, are presented in this report along with results for those analytes required by the ROD that are monitored annually (Navarro 2021).

The Practical Quantitation Limits (PQL) for data collected in FY23 for most of the CSRG analytes are those readily attainable from a certified commercial laboratory. The PQLs for aldrin, dieldrin, and n-nitrosodimethylamine (NDMA) were developed during a site-specific PQL study, which became effective in April 2012 (TtEC 2012). For NDMA, an interim PQL was used beginning in April 2012 until the final PQL was adopted during the first quarter FY17 (Navarro 2016a; TtEC 2012).

Performance water quality trends are presented and evaluated for the on-post and off-post treatment systems. For each treatment system, Mann-Kendall statistical trend analyses were conducted for CSRG analytes considering a 10-year period for upgradient and downgradient performance monitoring wells. Statistical trend analyses are summarized for each system signifying analyte-specific increasing and decreasing trends and for those analytes for which no trend could be determined. Statistical trend analyses were performed using ChemStat software, version 6.5 (StarPoint Software 2023).

System-specific performance water quality data tables are provided in Appendices A through G and with an indication of CSRG or PQL exceedances where a shaded cell indicates the analyte concentration exceeded the CSRG or PQL in FY23. System-specific data summaries are provided within their respective appendices.

Maps presented in Appendices A, B, C, D, F, and G are followed by graphs depicting concentrations versus time for “select” analytes in wells in the vicinity of the NWBCS, NBCS, BANS, BRES, FCTS, and NPTS, respectively. The analytes selected for these maps were detected at levels exceeding their respective CSRGs/PQLs in upgradient and/or downgradient performance wells during FY23, and graphs depict a 20-year time period to demonstrate visual concentration trends. In a few instances, analytes detected at levels less than CSRGs/PQLs have been presented on these maps as follow-up to recent years where performance goals were not met relative to ROD-based standards.

Select CSRG-analyte concentrations in the treatment plants and in upgradient and downgradient performance monitoring wells are plotted on graphs for all systems in Appendices A, B, C, D, F, and G. The graphs for the treatment plants are arranged so that the influent concentrations are plotted above the effluent concentrations, showing the amount of reduction in contaminant concentrations resulting from the treatment system. The graphs for the performance wells are arranged so that the upgradient well concentrations are plotted above the downgradient well concentrations and show the distribution of analyte concentrations along the line of upgradient and downgradient performance wells for each system.

1.2.2 On-Post Monitoring Overview

The data used to complete the FY23 ASR were collected under the LTMP (Navarro 2021) and SQAPP (Navarro 2019a). The chemical analytes discussed in this report all have analyte-specific method reporting limits (MRL) established through a laboratory certification process described in the SQAPP. The discussion of the monitoring results includes terms such as "not detected" or "nondetection," which mean that the analyte in question was not detected at or above its MRL. Similarly, "detected" or "detection" refer to analyte concentrations detected at or above the MRL.

The long-term groundwater monitoring program described in the LTMP satisfies the requirements of the On-Post and Off-Post RODs (Foster Wheeler 1996; HLA 1995). The primary objectives of the program, as stated in the RODs, are to evaluate the effectiveness of the remedies, are to satisfy Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) requirements for waste left in place, and to provide data for the ASRs. The main component of the remedy that relates to groundwater is continued operation of the groundwater containment and treatment systems.

1.2.2.1 LTMP On-Post Monitoring

The LTMP defined six system-related monitoring categories that were developed to meet the On-Post ROD requirements for long-term groundwater monitoring and to support data evaluation. These categories were applied and are evaluated in this report:

- Compliance Monitoring – Quarterly monitoring of treatment system effluent water to confirm that CSRGs are met by on-post (and off-post) treatment systems. Compliance is based on running averages for the last four quarters.
- Performance Monitoring – Quarterly and annual water level and water quality monitoring performed to measure performance against specific criteria.
- Pre-Shut-Off Monitoring – Project- and system-specific monitoring or operational activities to confirm that shut-off should proceed and that the shut-off monitoring program should be initiated.

- Shut-Off Monitoring – Project- and system-specific water quality monitoring at containment systems that have met shut-off criteria defined by the RODs. Such monitoring is conducted for specified analytes for a period of five years to ensure that Applicable or Relevant and Appropriate Requirements (ARAR) continue to be met. This monitoring is to be conducted in accordance with a revised shut-off approach, where sampling frequencies are reduced from the current quarterly sampling to quarterly sampling for the first and last years of the program and annual sampling within intervening years.
- Post-Shut-Off Monitoring – Project- and system-specific monitoring to track groundwater levels, flow directions, and water quality in the area after successful completion of the shut-off monitoring program and termination of system operation.
- Operational Monitoring – Annual monitoring of mass removal system and containment system extraction wells and monitoring wells located near the systems to optimize system performance and ensure that Remedial Action Objectives (RAO) are met.

The site-wide monitoring program categories are as follows:

- Water Level Tracking – Annual on-post water level monitoring used to track the effects of the soil remedy to groundwater migrating within RMA.
- Water Quality Tracking – On-post water quality monitoring of indicator analytes to track contaminant migration in and downgradient of the source areas within the identified plumes. Sampling is conducted once or twice in five years.
- CFS Monitoring – Monitoring in response to the On-Post ROD requirement to monitor water quality in the confined aquifer in three areas—Basin A, South Plants, and Basin F. Sampling is conducted twice in five years.

Sampling for CFS monitoring program did not take place in FY23, and will next take place in FY24. Post-shut-off monitoring for the RYCS and MPS/ICS is now managed under the site-wide Water Quality Tracking monitoring program with annual monitoring of the MPS/ICS taking place in FY23 and results presented in Section 6.2.

1.2.2.2 On-Post Groundwater Treatment Systems Operational Monitoring

Groundwater Treatment System operational monitoring includes monitoring of system extraction wells, recharge wells, recharge trench piezometers, and/or monitoring wells associated with the system. Data are collected from wells upgradient of, and within the systems, to optimize system performance and ensure that RAOs are met. Most of the wells are used for water level monitoring to ensure proper extraction system operation; selected wells are also used for water quality monitoring of indicator compounds. These monitoring data are used to evaluate and adjust the system to ensure optimal operation for containment, capture, and treatment. Effective system operation depends on water level and water quality data and monitoring frequencies are determined based on operational data needs. Depending on the type of data and operational need, monitoring frequencies may be weekly, monthly, quarterly, semiannually, or annually. As operating conditions change, the operational monitoring program may also change. Accordingly, the operational monitoring program is flexible with respect to monitoring locations, frequencies, and chemical analyses. O&M Plans that address operations and monitoring are in place for each system and are updated as necessary. As necessary, operational monitoring data will continue to be presented in the ASRs to support the evaluation of system effectiveness.

The operational monitoring program for existing groundwater containment and treatment systems at RMA is well established and provides the data necessary to ensure optimal performance for the extraction, treatment, and reinjection systems. The operational monitoring program includes water level data collection to determine the hydraulic gradients produced by the extraction system to achieve contaminant plume capture. In addition, influent and effluent samples are collected at various points in the treatment process to monitor treatment system performance. Water quality is also monitored in extraction wells and monitoring wells associated with the systems to optimize treatment system operation.

1.2.3 Off-Post Monitoring Overview

1.2.3.1 LTMP Off-Post Monitoring

The LTMP (Navarro 2021) identified the following eight monitoring categories that meet the monitoring requirements identified in the Off-Post ROD:

- Compliance Monitoring – Quarterly monitoring of treatment system effluent water to confirm that CSRGs are met by off-post (and on-post) treatment systems. Compliance is based on running averages for the last four quarters.
- Performance Monitoring – Quarterly and annual water level and water quality monitoring performed to measure performance against specific criteria.
- Pre-Shut-Off Monitoring – Project- and system-specific monitoring or operational activities to confirm that shut-off should proceed and that the shut-off monitoring program should be initiated.
- Shut-Off Monitoring – Project- and system-specific water quality monitoring at containment systems that have met shut-off criteria defined by the RODs. Such monitoring is conducted for specified analytes for a period of five years to ensure that ARARs continue to be met. This monitoring is to be conducted in accordance with a revised shut-off approach, where sampling frequencies are reduced from the current quarterly sampling to quarterly sampling for the first and last years of the program and annual sampling within intervening years.
- Post-Shut-Off Monitoring – Project- and system-specific monitoring to track groundwater levels, flow directions, and water quality in the area after successful completion of the shut-off monitoring program and termination of system operation.
- Operational Monitoring – System-specific monitoring of containment system extraction wells, recharge wells, recharge trench piezometers, and monitoring wells located near the systems to optimize system performance and ensure that RAOs are met.
- Off-Post Water Level Monitoring – Annual water level monitoring conducted in support of the exceedance monitoring to assess flow paths and contaminant migration in the

exceedance areas. (Separated from "Water Level Tracking" because it serves a different purpose.)

- Exceedance Monitoring – Long-term water quality monitoring conducted in compliance with the Off-Post ROD, to assess contaminant concentration reduction and remedy performance. These water quality data are also used to create groundwater CSRG exceedance area maps to support well permit institutional controls. The exceedance area maps are provided to the Office of the State Engineer, and to City of Commerce City, city of Brighton, and Adams County officials for their use in issuing notifications to well permit applicants and for controlling inappropriate use of off-post water with contaminant concentrations exceeding CSRGs. Sampling is conducted twice in five years.
- Surface Water Monitoring – Annual off-post surface water monitoring to assess changes in surface water quality related to the RMA remedy.

1.2.3.2 Off-Post Groundwater Treatment System Operational Monitoring

Similar to the on-post systems, operational monitoring conducted for the off-post treatment systems in FY23 consisted of monitoring system extraction wells, recharge wells, recharge trench piezometers, and monitoring wells associated with the FCTS and NPTS. Data are collected from monitoring wells upgradient of, and at the systems, to optimize system performance and ensure that RAOs are met. Most of the wells are used for water level monitoring to ensure proper extraction system operation; selected wells are also used for water quality monitoring of indicator compounds. These monitoring data are used to evaluate and adjust the system to ensure optimal operation for containment, capture, and treatment. Depending on the type of data and operational need, monitoring frequencies may be weekly, monthly, quarterly, semiannually, or annually. As operating conditions change, the operational monitoring program may also change. The operational monitoring program, therefore, is flexible with respect to monitoring locations, frequencies, and chemical analyses. O&M Plans that address operation and monitoring are in place for each system and are updated, as necessary.

1.2.3.3 Private Well Monitoring

In FY23, the Private Well Monitoring Program was administered by ACHD in accordance with a Memorandum of Agreement (MOA) with the Army executed in April 2023, which supersedes the prior MOA when the Tri-County Health Department administered the program from 1997–2022 (Navarro 2024b). Private well sampling is conducted to meet the following objectives:

- Provide data to assess contaminant concentration reduction and remedy performance
- Sample new wells installed in the off-post area as required by the Off-Post ROD (HLA 1995)
- Sample existing wells in response to citizen requests
- Sample a selected group of Arapahoe Formation CFS wells to assess well integrity and potential cross contamination from the overlying unconfined aquifer

The private well monitoring program is modified as new wells are installed and citizen requests are received. In accordance with the Off-Post ROD, owners of domestic wells with groundwater contaminants derived from RMA at concentrations at or above Colorado Basic Standard for Groundwater (CBSG) will be provided with an alternate water supply by the Army. In addition, wells that create a pathway for vertical migration of contaminants from the unconfined flow system (UFS) to the CFS will be closed if RMA-related contaminant concentrations in these wells exceed remediation goals.

1.2.3.4 Off-Post Surface Water Monitoring

In accordance with the Off-Post ROD, off-post surface water monitoring is conducted to evaluate the effect of groundwater treatment on surface water quality. Generally, sampling is conducted under low-flow conditions to provide more representative results. Conducting storm event monitoring at SW37001 was specifically identified in the *Off-Post Remediation Scope and Schedule for the Off-Post Operable Unit* (HLA 1996) to evaluate the effects of runoff and higher flows in First Creek. Since the on-post soil remedy was completed and all soil contamination was placed in landfills, or is in place under soil covers, surface water contamination from runoff is no longer likely and storm event surface water sampling is no longer conducted.

In order to continue to evaluate the effect of groundwater treatment on surface water quality in the Off-post operable unit (OU), surface water quality monitoring continues at SW24004 (First Creek at the north fence line) and off-post site SW37001 (First Creek at Highway 2). An upstream sampling location (SW08003), where First Creek flows onto RMA, was added in FY13 to provide data to compare to the two downstream sites. In accordance with the LTMP, annual surface water quality samples are collected at these sites when there is low flow in First Creek, typically during the spring or summer. The target analyte list was expanded from arsenic and DIMP in FY13 to also include aldrin, chloride, dieldrin, NDMA, and sulfate. The requirements for sampling can be found in the LTMP, Section 6.3.

1.2.4 Site-Wide Monitoring Programs Overview

As presented in Sections 1.2.2 and 1.2.3, the following on-post and off-post site-wide monitoring programs are in place:

- Water Level Tracking
- Water Quality Tracking
- Confined Flow System Monitoring
- Exceedance Monitoring
- Off-Post Water Level Monitoring

Of these site-wide monitoring programs, only water level tracking took place in FY23 in accordance with the LTMP. Water levels were measured in the on-post water level tracking network and the off-post water level monitoring network in order to draw the FY23 site-wide potentiometric surface, also referred to as water level contour map (Figure F-1, Appendix F). Results of the water level tracking program are presented in Section 6.1.

The Annual Well Networks Update Summary is included in the ASR as required by the LTMP (Appendix K). The FY23 Annual Well Networks Update Summary includes information on newly installed wells, closed wells, damaged/repaired network wells, and updates to the Rocky Mountain Arsenal Environmental Database (RMAED).

1.2.5 Emerging Contaminants Monitoring Overview

Perfluoroalkyl and polyfluoroalkyl substances (PFAS), n-nitrosodi-n-propylamine (NDPA), and 1,4-dioxane have been classified as emerging contaminants by the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Defense (DoD). The Emerging Contaminants Monitoring Program included the collection of samples from the treatment plant influent/effluent locations, monitoring wells, and surface water locations (Navarro 2019b). Sampling was conducted in 21 wells from February 2017 through March 2018 for PFAS and NDPA analyses to characterize groundwater within and downgradient of potential source areas. Locations sampled for 1,4-dioxane included up to 228 wells and one surface water site as part of the emerging contaminants sampling network and their respective locations within the LTMP network (Navarro 2021). The results of the Emerging Contaminants Monitoring Program were finalized and presented in the *Emerging Contaminants Data Summary Report* in January 2019 (Navarro 2019b).

Since the completion of the monitoring program in early 2019, the LTMP was revised under three operational change notices (OCN)—OCN-LTMP-2019-001, OCN-LTMP-2019-002, and OCN-LTMP-2020-002—to add 1,4-dioxane and NDPA to select on-post water quality tracking wells and off-post CSRG exceedance network wells to monitor plume concentrations and extent. In addition, the CBSGs for these emerging contaminants were added as CSRGs for the NBCS and NWBCS treatment plant influent and effluent, and water quality performance wells, to ensure that the boundary systems protect groundwater quality off post. The CBSG for NDPA was also added as a CSRG for off-post treatment systems. Monitoring results for 1,4-dioxane and NDPA are provided in the fiscal year ASRs, and quarterly treatment plant effluent water quality data reports. In this report, 1,4-dioxane and NDPA results are presented in Sections 3 through 7 for the relevant systems and monitoring programs.

In accordance with the LTMP, monitoring for PFAS continues once every five years in Water Quality Tracking wells (next scheduled for FY24). Beginning in FY23, treatment plant influent and effluent were sampled quarterly. PFAS monitoring results are provided in the fiscal year ASRs and quarterly treatment plant effluent water quality data reports. Section 8 of this report provides a summary of the results for PFAS monitoring conducted during FY23.

1.3 CONSULTATIVE PROCESS NOTIFICATIONS

Consultative Process notifications to the regulatory agencies are required in accordance with the consultation triggers presented in relative to Sections 4, 5, and 6 of the LTMP if performance issues arise (Navarro 2021). Table 1.1-1 presents a summary of the notifications to the regulatory agencies and operational change notices to the LTMP that took place in FY23.

Three notifications were sent to the regulatory agencies in FY23, with one notification required for a performance issue regarding loss of reverse hydraulic gradient at the NBCS during the fourth quarter of FY22. The two remaining notifications were related to individual effluent samples above CSRGs at the NWBCS and NBCS (Table 1.1-1).

Nine OCNs for the LTMP were issued in FY23, with three of those OCNs being approved during the first quarter of FY24 (Table 1.1-1). A summary of the OCNs submitted to the regulatory agencies is provided below:

- OCN-LTMP-2022-005 – LTMP was revised to replace damaged performance well 37084 with nearby existing well 37116.
- OCN-LTMP-2022-006 – LTMP was revised to reflect the addition of ten wells to monitor the off-post dieldrin plume downgradient of the NWBCS.
- OCN-LTMP-2023-001 – LTMP was revised to reflect the closure of wells 37012 and 37013. LTMP text, tables, and figures were revised to add two new performance wells 37030 and 37101. Both wells were added to the off-post water level network and the off-post CSRG exceedance monitoring network.
- OCN-LTMP-2023-002 – LTMP was revised to reflect CSRG analytes requiring quarterly effluent routine analysis at FCTS and NPTS. All ROD CSRG analytes are included in annual effluent monitoring, so removal from quarterly monitoring does not impact annual sampling requirements.
- OCN-LTMP-2023-003 – LTMP was revised to replace well 37336 with 37181 within the CSRG Exceedance Network after a private property access agreement was completed.
- OCN-LTMP-2023-004 – LTMP text and tables were updated to describe the revised contaminant mass removal evaluation for the FCTS and NPTS. Appendix E of the LTMP was revised to include the Technical Approach for the Evaluation of Contaminant Mass Removal for the Basin A Neck System, First Creek Treatment System, and Northern Pathway Treatment System.
- OCN-LTMP-2023-005 – LTMP text and tables were updated to describe the revised contaminant mass removal evaluation for the BANS. Appendix E of the LTMP was revised to include the Technical Approach for the Evaluation of Contaminant Mass Removal for Basin A Neck System, First Creek Treatment System, and Northern Pathway Treatment System was added to the LTMP.
- OCN-LTMP-2023-006 – LTMP was revised to change the treatment plant influent and effluent monitoring from annual to quarterly to continue to provide operational data for emerging contaminants (i.e., PFAS). In addition, terminology in the LTMP was changed from perfluorinated compounds (PFC) to PFAS to be consistent with existing guidance and conventions. The text in LTMP Section 4.8.5 was also revised to be consistent with routine CSRG analyte revisions incorporated under OCN-LTMP-2023-002.
- OCN-LTMP-2023-007 – LTMP text and tables were revised to remove some CSRG analytes from quarterly effluent routine analysis for the NWBCS and NBCS. All ROD CSRG analytes are included in annual effluent monitoring, so removal from quarterly monitoring does not impact annual sampling requirements.

Additional details on the FY23 OCNs are presented in Table 1.1-1 and related sections of this report.

1.4 REPORT ORGANIZATION

This report serves as an annual assessment for FY23 that summarizes annual site-wide and treatment systems groundwater monitoring, project-specific monitoring, and surface-water monitoring and is organized as summarized below:

- **Introduction.** Section 1 presents the overall purpose of the ASR evaluations, a description of the sources of contamination and overviews of the treatment systems operations and the site-wide monitoring programs, as well as the organization of this report.
- **Data Quality Assurance.** Section 2 includes a summary of data quality assurance review process conducted for data collected during the fiscal year supporting the annual assessment of groundwater and surface water.
- **On-Post Extraction and Treatment Systems.** Section 3 provides an assessment of system performance for the major on-post extraction/treatment systems including the NWBCS, NBCS, BANS, and BRES.
- **Other On-Post Systems.** Section 4 presents an assessment of system performance for other on-post systems including the CADT and Shell Disposal Trenches dewatering systems, the Lime Basins Dewatering System and DNAPL Remediation, and the North Plants LNAPL Removal Action.
- **Off-Post Extraction and Treatment Systems.** Section 5 provides an assessment of off-post system performance for the FCTS and NPTS.
- **Site Wide On-Post Monitoring.** Section 6 presents a discussion of on-post monitoring programs including water level and water quality tracking, and CFS monitoring.
- **Site Wide Off-Post Monitoring.** Section 7 presents the results for off-post monitoring programs including water level tracking, exceedance monitoring, off-post surface water quality, and off-post private well monitoring administered by ACHD.
- **Perfluoroalkyl and Polyfluoroalkyl Substances.** Section 8 provides an overview of the PFAS monitoring program conducted during FY23.
- **Summary and Conclusions.** Section 9 summarizes the results, conclusions, and recommendations relative to meeting the performance criteria and goals identified in the LTMP and other relevant monitoring plans.
- **References.** Section 10 lists the references used in the preparation of this report.

This report was prepared by Ms. Carol Rieger, Ms. Nicole Luke, and Ms. Megan Edwards with Navarro Research and Engineering, Inc. (Navarro). Project management was provided by Mr. Tony LaChance and Mr. Scott Ache of Navarro. Navarro acknowledges the support and assistance of Ms. Shannon Gilbert and Ms. Kelli Schneider, with AECOM Technical Services, Inc.

2.0 DATA QUALITY ASSURANCE

The data evaluated in this report were collected in accordance with the LTMP (Navarro 2021), the SQAPP (Navarro 2019a), and the following SAPs:

- LTMP Surface Water Monitoring SAP
- MPS/ICS Post-Shut-Off Monitoring SAP
- RYCS Post-Shut-Off Monitoring SAP

Data review was limited to the respective CSRGs or LTMP analytes for each system or monitoring category. Monitoring program- and treatment system-specific data summary reports were not prepared as separate deliverables in FY23 but are included as narratives in this ASR.

The purpose of the data review is to evaluate data quality with respect to the established data quality objectives (DQO). Components of the data review process include evaluating the data against the data quality indicators of precision, accuracy/bias, representativeness, sensitivity, completeness, and comparability; review of field and laboratory quality control (QC) results; and evaluating the data for suitability based on the intended use. Data were reviewed according to the procedures specified in the SQAPP. The data review has determined that the data quality meets or exceeds the established DQOs and is of the correct type, quality, and quantity to support the intended use. The data review parameters and results are discussed below.

2.1 PRECISION

Results of laboratory and field duplicates were used to calculate precision. Note that laboratory duplicates are prepared by the laboratory and analyzed for inorganics only. Relative percent difference (RPD) values will be calculated for LTMP analytes. If one or both results are rejected or not analyzed, the RPD will not be calculated. The formula for calculating the RPD is:

$$RPD(\%) = \left(\frac{Difference\ between\ concentrations}{Average\ of\ concentrations}\right) \times 100$$

Where:

$$Difference\ between\ concentrations = Investigative\ value - Duplicate\ value$$

$$Average\ of\ concentrations = \frac{Investigative\ value + Duplicate\ value}{2}$$

The default RPD evaluation limit for analytes without detections above the MRL will be less than or equal to 30 percent. The performance criteria for analytes with detections above the MRL will be calculated from historical RPD values for each program-specific LTMP analyte. The data utilized for the historical RPD value calculations will be limited to data values from historical analytical methods with similar MRLs. The analytical data utilized to calculate limits for individual analytes is included as an electronic file accompanying this report.

For each site ID/LTMP analyte, the 25th and 75th percentile RPD values are calculated. The interquartile range (IQR) for each analyte is calculated by subtracting the 25th percentile value from the 75th percentile value. The acceptance, or upper, RPD limit is determined by adding 1.5 times the IQR to the 75th percentile value. The RPD evaluation limits are included as an electronic file accompanying this report.

The investigative and duplicate results will be considered comparable if any of the following statements are true:

- If both sample results are less than the MRL
- If both sample results are greater than the MRL, but less than or equal to twice the MRL
- If both sample results are greater than twice the MRL and the RPD is less than or equal to the specified upper RPD limit
- If both sample results are greater than the MRL, one result is less than or equal to twice the MRL, one result is greater than twice the MRL, and the RPD is less than or equal to the specified upper limit
- If one sample result is less than the MRL, and one result is greater than the MRL and less than or equal to twice the MRL

The investigative and duplicate results will be considered not comparable if any of the following statements are true:

- If both sample results are greater than twice the MRL and the RPD is greater than the specified upper RPD limit
- If both sample results are greater than the MRL, one result is less than or equal to twice the MRL, one result is greater than twice the MRL, and the RPD is greater than the specified upper limit
- If one sample result is less than the MRL, and one result is greater than twice the MRL

Duplicate samples determined to be not comparable will be subject to data qualification. The non-comparable investigative and duplicate data will be assigned a "Z" data qualifier with the comment "Duplicate and investigative values are not comparable." The data are considered acceptable for their intended use and no additional action in addition to the data qualification is considered necessary.

A total of 648 field and laboratory duplicate analyses were performed. The data review identified two analyses as non-comparable. The non-comparable data were qualified with a "Z" data qualifier with the comment "Duplicate and investigative values are not comparable." Precision data are included in an electronic file accompanying this report.

2.2 ACCURACY/BIAS

Accuracy is the degree of agreement between an observed value (sample result) and an accepted reference value. Bias is the systematic or persistent distortion of a measurement process that causes errors in one direction (high or low). The terms accuracy and bias are used interchangeably. Accuracy/bias is indicated by percent recovery calculated from laboratory spike data using the following formula:

$$Recovery\ Rate\ (\%) = (Measured\ value)/(True\ value) \times 100$$

Where:
Measured value = Value after the spike minus the value before the spike
True value = Value of the spike added

Accuracy/bias will be determined based on the percent recovery results of laboratory control spikes (LCS) and matrix spikes (MS). Laboratory control spikes utilize laboratory grade water with some additions of inorganic constituents to mimic water native to RMA. Matrix spikes utilize water native to RMA to account for matrix-related interferences.

The calculated recovery rates are compared to the lower and upper recovery rate limits specific to each analyte. Evaluation limits are calculated for each LTMP analyte by monitoring program to account for matrix interference differences. A single set of limits is calculated for LCS recoveries as matrix interferences will not be present in LCS samples. The recovery rate limits are determined by calculating the 25th and 75th percentiles for each analyte using historical recovery rates. The IQR is calculated by subtracting the 25th percentile value from the 75th percentile value. The lower and upper recovery limits are determined by subtracting and adding 1.5 times the IQR to the 25th and 75th percentile value, respectively. Data will not be qualified solely on an individual recovery rate outside the calculated recovery limits. If an analysis is outside both the MS and LCS recovery limits, the analysis will be assigned a “Z” data qualifier with the comment “MS and LCS recoveries were outside evaluation limits”. The MS and LCS recovery data, calculations, and evaluation limits are included in the electronic file accompanying this report.

The data utilized for the historical recovery rate calculations were limited to the spike values for the analytical lots of the associated investigative data. Spike recoveries were calculated for all LTMP analytes. Specific monitoring programs were assigned to required site IDs and analytes. Recoveries for LTMP analytes not required for specific locations are also included with the sampling program unspecified. Matrix spike values exceeding four times the spiked amount are excluded from the calculation since the MS could possibly be diluted out due to the high original concentration. Analyses with an “@” flag code (value is estimated) or “B” flag code (analyte found in the method blank or QC blank as well as the sample) were also excluded from recovery rate calculations. The historical spike recoveries used in the calculations are included as an electronic file accompanying this report.

For FY23, the average recovery rate for the 1,163 MS and LCS analyses was 93.5 and 96.9 percent, respectively. Upper and lower recovery rate limits are calculated for each analyte from historical recovery rates. Recovery rates outside the lower or upper limits were observed in 35 MS analyses and 16 LCS analyses. Recovery rates outside the limits for both MS and LCS were observed in two analyses and were qualified with a “Z” data qualifier.

Analyst comments in the data packages note that lot ALSU indicated DCPD spike recoveries exceeded the lab MS and LCS limits, but no DCPD was detected in the associated investigative samples so no further action was necessary. In lot AMBY preliminary analyst comments indicated the opening continuing calibration verification was over 25.5% for malathion. No detections of malathion were reported in the associated samples. No further action is necessary.

The Performance Evaluation (PE) program was conducted as specified in the SQAPP. The PE program is used to evaluate the ability of the laboratory to analyze environmental samples and provide required deliverables accurately and completely. The PE samples were submitted in December of 2022, and January and July of 2023. The PE program evaluated the following methods: DIMP, PFAS, NDMA, NDPA, and organochlorine pesticides. The PE program reports and spreadsheets are included as electronic files accompanying this report in the Performance Evaluation folder. The PE program indicated the data are acceptable for their intended use.

2.3 REPRESENTATIVENESS

Representativeness is a qualitative term achieved by evaluating whether measurements were made, and samples were collected in a manner that the resulting data appropriately reflects the sampling unit. The performance criterion is a positive evaluation of representativeness. A review of field and laboratory documentation determined that samples were collected and analyzed as specified for each system or category. Field instruments utilized to collect field measurements were calibrated according to the respective instrument manual and recorded in the Navarro Groundwater Sampling Calibration Record database. As a result, the data appropriately reflects the operation of the RMA treatment systems. The representativeness criterion was met for FY23.

2.4 COMPLETENESS

Completeness is the measure of the amount of valid data obtained from a measurement system; it is expressed as a percentage of the number of valid measurements compared to the total number of measurements planned in the DQOs. Completeness is calculated using the following formula:

$$Completeness\ (\%) = \frac{Amount\ of\ valid\ data}{Amount\ of\ valid\ data\ expected} \times 100$$

Completeness calculations of greater than or equal to 90 percent are acceptable. Completeness was calculated at 97 percent for FY23, so the completeness criterion was met.

2.5 COMPARABILITY

Comparability is a qualitative term achieved by using standard techniques to collect and analyze representative samples and reporting data in appropriate units. Standard techniques as identified in the SQAPP (Navarro 2019a) were utilized to collect and analyze samples and the data were reported in the appropriate units. The analytical results reported are equivalent to data obtained from similar analyses and the MRLs met the project goals.

2.6 SENSITIVITY

Sensitivity is the ability of the method or instrument to detect the target analytes at the level of interest. The performance criterion for sensitivity is no analyte detections above the MRL in the laboratory method blank. Analytical lots with method blank detections of target analytes exceeding the MRL may be qualified.

Method blank samples are analyzed for each analytical lot. A total of 2,590 method blanks consisting of laboratory water were analyzed for LTMP analytes. There were no detections above the MRL for LTMP analytes. Sensitivity is considered acceptable.

Method blank counts are broken out per system in Appendix I. While the count per system is accurate, a single method blank may be represented multiple times in this appendix leading to a total number higher than the correct total represented in this section. This can be explained by batching done at the lab to ensure efficiency. If the lab receives multiple samples to be run under a single method, they will be batched together (up to 20 samples excluding QC) regardless of what system they belong to on the RMA. Method blank data are included in the electronic file accompanying this report.

2.7 FIELD AND QUALITY CONTROL SAMPLES

Field QC samples collected include field blanks, rinse blanks, and duplicate samples. Duplicate sample results are discussed in Section I1, Appendix I. Laboratory QC samples include lab duplicates and method blanks in addition to the MS and LCS samples previously discussed. The FY23 field blank, rinse blank, and method blank data are included in the electronic file accompanying this report.

QC samples with values exceeding the MRL are evaluated according to the following criteria:

- If the associated investigative sample value is less than the MRL, then no action is required
- If the associated investigative sample value is greater than the blank value, then no action is required
- If the associated investigative sample value is less than the blank value, then validation of the analytical lot is requested

Field blanks are collected to determine if cross-contamination exists from ambient sources, such as engine exhaust or dust. In certain instances, field blanks may also be used as an indicator of contamination in the sample containers, or the deionized water used to decontaminate sample equipment and collect field QC samples. A total of 158 field blank analyses were performed with two analyses above the MRL. The two analyses that recovered above the MRL are discussed in Appendix I and QC sample information is included in the electronic file accompanying this report.

Rinse blanks were collected to determine whether the sampling equipment decontamination procedures were effective, thus preventing cross-contamination of samples and/or wells. A total of 218 rinse blank analyses were performed with two results above the MRL. The two analyses that recovered above the MRL are discussed in Appendix I and QC sample information is included in the electronic file accompanying this report. No qualification of the data is required for the analysis as the rinse blank values are less than the investigative sample values in all seven cases.

2.8 DATA USABILITY EVALUATION

The data usability determination evaluates data quality with respect to the established DQOs. Components of the data review process include 1) evaluating the data against the data quality indicators of precision, accuracy/bias, representativeness, completeness, comparability, and sensitivity; 2) review of field and laboratory QC results; 3) data verification and validation results; and 4) evaluating the data for suitability based on the intended use. Data were evaluated as specified in the SQAPP (Navarro 2019a).

Data verification was performed by the RMA Data Management Contractor, Navarro, as described in the SQAPP. Data verification was performed on all data prior to final submittal to the RMAED. Issues identified by the data verification process are addressed prior to the final submittal of the data into the RMAED. The data verification results are included in the electronic file accompanying this report in the Verification Validation Summary subfolder.

Data validation was performed on selected lots by the Navarro Chemist. Validation was performed as specified in the SQAPP. Issues identified during the data validation process are included in the electronic file accompanying this report in the Data and Quality Assurance folder within the Data Verification subfolder.

The suitability evaluation was conducted for only the CSRG or LTMP analytes specific to the sample location. In addition to the components specified above, the data were evaluated for potential outliers and trends. Data were evaluated using the U.S. Environmental Protection Agency software ProUCL, Version 5.2.0, Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations (EPA 2022b). The SQAPP presents specifications for the data review that include the following:

- Conduct an outlier test to evaluate the data for potential outliers using Dixon’s test (fewer than 25 values) or Rosner’s test (greater than or equal to 25 values). The use of either outlier test assumes that the data are normally or lognormally distributed.
- Conduct the Mann-Kendall test to evaluate the data for trends
- Identify treatment plant effluent compliance sample results that exceed the CSRG/PQL

A data usability evaluation was conducted on 3,027 records. An evaluation was not performed on treatment plant process control samples because these data are closely tracked throughout the fiscal year. The individual data usability spreadsheets by monitoring program are included in the electronic file accompanying this report in the Data Usability subfolder.

The data usability evaluation identified two analyses as statistical outliers. A listing of the results identified as outliers is included in the electronic file accompanying this report in the Data Usability subfolder.

The Mann-Kendall test for trends, covering all LTMP data collected to date, identified 275 decreasing trends and 120 increasing trends for analytes at specific well locations. No data quality issues were found with the identified trends. A listing of the identified trends is included in the electronic file accompanying this report in the Data Usability subfolder.

The data usability evaluation did not positively identify data quality issues; thus, the data are considered to be of acceptable quality and meets or exceeds the established DQOs. The data are of the correct type, quality, and quantity to support the intended use.

3.0 ON-POST EXTRACTION AND TREATMENT SYSTEMS

Performance monitoring is conducted in wells upgradient and downgradient of the containment and mass removal systems to evaluate system performance against established performance criteria and objectives provided in the LTMP (Navarro 2021). The performance criteria are specific to each system and depend on the location of the system and whether it is a containment or mass removal system. Depending on the criteria, performance monitoring includes water quality monitoring for all systems, and in most cases, water level monitoring. In some cases, operational wells are included in the performance monitoring networks as well, thereby serving a dual purpose.

Operational water level and/or water quality monitoring is conducted in extraction, recharge, and monitoring wells located near the containment or mass removal systems. Operational water quality monitoring is also conducted for the system influent and at sampling points within the system. Operational monitoring is conducted to evaluate and optimize system performance and ensure that RAOs are achieved.

3.1 NORTHWEST BOUNDARY CONTAINMENT SYSTEM

The NWBCS treatment facility consists of a groundwater extraction system, monitoring wells, pre-treatment filtration, granular activated carbon adsorption, post-treatment filtration and a groundwater recharge system. A slurry wall constructed of a soil-bentonite mixture was installed as part of the system to help contain contaminant migration. The NWBCS is designed to intercept contaminated groundwater from the upgradient side of the slurry wall, treat it to remove the organic contaminants, and inject the treated water back into the alluvial aquifer on the downgradient side of the barrier. The Original System, installed in 1984, consists of 15 extraction wells, 21 recharge wells, and the slurry wall, which measures approximately 1,425 feet. The recharge wells are located northwest (downgradient) of the extraction wells and slurry wall. The objective of the system is to create hydraulic control to contain the contaminant plumes.

Modifications to the NWBCS include the addition of the Northeast Extension (NEE) constructed in 1990 to intercept flow through a small alluvial channel north of the Original System, and the Southwest Extension (SWE) extraction and recharge system in 1991 to extract groundwater from the dieldrin plume originating in Section 2 on the RMA.

The NEE consists of a 660-ft extension of the Original System slurry wall and two additional extraction wells that were installed to intercept a small northwest-trending alluvial channel. The flow downgradient of the slurry wall is towards the Original System recharge wells. Maintaining a reverse hydraulic gradient, therefore, is not required for this portion of the NWBCS. Dieldrin is the primary contaminant at the NEE.

The SWE was installed in 1991 and consists of four additional extraction wells and four additional recharge wells located southwest of the Original System. No slurry wall was installed in this area. The recharge wells were installed in an uncontaminated zone between the SWE and Original System, cross-gradient of the extraction wells, to prevent the SWE and Original System plumes from shifting away from their respective extraction systems. Consequently, the SWE has a hydraulic capture system design. Historically, dieldrin has been the primary contaminant at the SWE, although dieldrin concentrations in SWE wells did not exceed the PQL in FY23.

FY23 treatment system performance data for the NWBCS are provided in Table 3.1-1. The results of CSRG-analyte sampling in NWBCS performance wells in FY23 are presented in Table 3.1-2. Appendix A provides figures to illustrate the performance of the NWBCS during FY23. Groundwater monitoring and water level data are provided in the electronic file accompanying this report.

3.1.1 NWBCS Operations and Compliance

The NWBCS operated at an average flow rate of 820 gallons per minute (gpm), pumping a total volume of 431,089,815 gallons during FY23 and removing a total of 1.8 pounds of contaminant mass. The major contaminants removed via treatment included chloroform, dieldrin, endrin ketone, and NDPA. The total cost to operate the treatment plant in FY23 was $802,604 (Table 3.1-1).

Figure A-1 in Appendix A shows the NWBCS extraction and recharge wells, slurry walls, and associated monitoring wells.

Compliance for all treatment systems at RMA is based on quarterly effluent water quality monitoring. Each system has a list of compliance analytes for which CSRGs were developed in the On-Post and Off-Post RODs. The current CSRG list, including any revisions since the RODs were developed, is provided in the LTMP. The system effluent for the NWBCS was analyzed quarterly in FY23 using the LTMP routine CSRG analyte list for the NWBCS and annually using the complete CSRG list.

The treatment plant influent and effluent concentrations for analytes with concentrations that exceeded CSRGs in treatment plant influent are shown in Figures A-2 and A-3 (Appendix A). The graphs indicate that treatment plant influent concentrations of dieldrin and NDPA exceeded their respective CSRGs/PQLs.

As presented in Table 1 in each of the quarterly *Treatment Plant Effluent Water Quality Data Reports FY23*, the NWBCS individual effluent concentrations and associated four-quarter moving averages showed no exceedances during FY23 with the exception of dieldrin during the second quarter (Navarro 2023b, 2023c, 2024a, 2024c). Although the dieldrin exceeded the PQL, the four-quarter moving average was less than the PQL, thus the treatment plant operated within compliance requirements.

In FY23, the NWBCS demonstrated system effectiveness for analytes addressed by treatment technologies, showing concentrations in treatment plant effluent are less than CSRGs/PQLs.

3.1.2 NWBCS Performance Evaluation

The performance criteria for the NWBCS are designed to address future monitoring needs and facilitate the system performance evaluation. Performance of the NWBCS is addressed for the Original System and the SWE and NEE Systems separately as presented below.

Original System

Criteria presented in the LTMP address the Original System of the NWBCS. The primary performance criteria for the NWBCS Original System are presented below:

- Demonstrate containment through reverse hydraulic gradient by visual evaluation of potentiometric maps and visual comparison of paired well water levels. If visual inspection is unclear, statistical or other evaluation criteria will be considered.
- Demonstrate containment through plume-edge capture by visual evaluation of flow directions on potentiometric maps and evaluation of water quality data from performance and operational monitoring wells. If visual inspection is unclear, statistical or other evaluation criteria will be considered.

A secondary performance criterion was established to address system performance in the event that a reverse hydraulic gradient could not be maintained, which provides assurance that downgradient water quality is not being adversely impacted:

- If unable to maintain reverse hydraulic gradient due to factors beyond Army control, the performance evaluation will be based on demonstrating that concentrations in downgradient water quality performance wells are at or below CSRGs/PQLs or show decreasing concentration trends, based on annual evaluations, over the previous period of at least five years. If visual inspection is unclear, statistical or other evaluation criteria will be considered.

The Original System maintained a reverse gradient during all four quarters of FY23 as presented in Figures A-4 and A-5 in Appendix A, thus meeting the primary performance criterion. Flow rates in the NWBCS dewatering and recharge wells have maintained plume-edge capture for the Original System as demonstrated by the potentiometric surface and groundwater flow directions presented in Figure A-6.

Although the primary performance criterion was met in FY23, concentrations of the following CSRG analytes exceeded CSRGs/PQLs in the noted wells downgradient of the Original System:

- Dieldrin – Wells 37331, 37332, 37333, and 37600

A summary of the NWBCS performance well concentration trend data is provided in Table 3.1-2 for contaminants detected above the CSRG. Exhibit A-7 provides a summary table of the FY23 NWBCS performance well water quality monitoring.

For dieldrin, concentrations exceeded the PQL in wells located upgradient and downgradient of the Original System (Figure A-10). Table 3.1-2 indicates that Original System downgradient performance wells 37331, 37332, 37333 and 37600 do not demonstrate any increasing trends, with dieldrin concentrations in well 37333 decreasing. 1,4-Dioxane, arsenic, and isodrin were also detected at levels exceeding CSRGs/PQLs in upgradient wells in FY23, but were not detected or detected at concentrations less than CSRGs/PQLs, in downgradient wells (Figures A-8, A-9, and A-11, respectively).

Plume-edge monitoring in cross-gradient well 27010 indicated there were no CSRG/PQL exceedances in FY23, thus supporting that plume-edge capture is occurring within the Original System.

Southwest Extension and Northeast Extension

The NWBCS SWE and NEE were designed to capture groundwater that was not being captured by the Original System. Performance criteria established for each of these two system extensions are presented below and both criteria must be met:

- Demonstrate plume capture through visual evaluation of flow directions on potentiometric maps and evaluation of water quality data from performance and operational monitoring wells. If visual inspection is unclear, statistical and other evaluation criteria will be considered.
- Demonstrate decreasing concentration trends, or that concentrations are at or below CSRGs/PQLs, in downgradient performance wells.

Plume capture at the SWE is demonstrated by the water elevation contours and flow directions indicated on Figure A-6. No analytes exceeded CSRGs/PQLs in performance wells at the SWE in FY23. Dieldrin concentrations have continued to decrease in the upgradient performance well 27517 (Table 3.1-2 and Figure A-13). Dieldrin concentrations in SWE cross-gradient wells 27516 and 28521 were also below the PQL in FY23 with decreasing trends noted.

Plume capture at the NEE is demonstrated by the southwesterly gradients shown on Figure A-6. To support system optimization, downgradient performance well water quality is monitored regularly in wells 22015 and 22512. Concentrations of the following CSRG analytes exceeded CSRGs/PQLs in the noted wells downgradient of the NEE:

- Dieldrin – Wells 22015 and 22512
- NDPA – Well 22512

For the first time, dieldrin and NDPA concentrations show increasing trends in well 22512. The prolonged detection of dieldrin contamination in these wells has prompted an evaluation to identify potential causes.

In accordance with Decision Document DD-36, a supplemental monitoring program took place from August 2019 through February 2023 with sampling conducted on a semiannual basis for organochlorine pesticides in wells 22015, 22044, 22060, 22084, 22085, 22508, 22511, and 22512 within the NEE area. Analyses for NDPA were also included for all wells during the fourth quarter of FY22 and the second quarter of FY23 due to the detection of NDPA at concentrations greater than the PQL of 0.005 µg/L in downgradient performance well 22512 (Navarro 2023a). In addition, data for well 22505 were also included in the monitoring program to provide a comparison to results for well 22508. Well 22508 is located hydraulically downgradient of well 22505 and the slurry wall, and concentrations of analytes have consistently exceeded CSRGs/PQLs in both wells.

The results of the supplemental monitoring program were summarized in the *Northwest Boundary Containment System Northeast Extension Data Evaluation Report* (Navarro 2023a). The report concluded that water quality and hydrogeologic data indicates bypass of the system is occurring and contributing to the elevated concentrations of contaminants, including dieldrin, in downgradient wells. In order to mitigate continuing downgradient groundwater contamination, the following activities were recommended:

- Assess the potential to extract groundwater downgradient of the slurry wall by conducting a pumping test in well 22084 to determine whether continuous pumping is feasible at this location. Groundwater extraction in this area may intercept contaminated groundwater as it migrates towards the recharge well alignment and downgradient performance wells.
- Assess the potential to inject treated groundwater water at the north end of the slurry wall to provide hydraulic control and prevent bypass by conducting a single-well aquifer test in well 22085 to determine whether aquifer recharge via injection of treated groundwater is feasible at this location.
- Determine whether there is communication between wells 22505 and 22508 by conducting an aquifer test in well 22505 and/or 22508, or in extraction well 22317, located adjacent to well 22505 to evaluate whether increases or decreases in water levels on the upgradient side of the slurry wall affects drawdown on the downgradient side.

Although primary performance criteria were met in FY23 for the NWBCS, evaluation of the system is ongoing relative to the secondary performance criterion. In the event that downgradient performance wells show analytes that are above CSRGs/PQLs, concentration trends are evaluated. Concentrations trends are determined by visual inspection of time versus concentration plots and supported using Mann-Kendall statistical analysis as part of the data quality assurance review as options presented in the LTMP.

A summary of the NWBCS performance well concentration trend data is provided in Table 3.1-2 for contaminants detected above the CSRG. For dieldrin, Table 3.1-2 indicates that Original System downgradient performance wells 37331, 37332, 37333 and 37600, and NEE downgradient performance wells 22015 and 22512, were above the PQL. Figure A-13 illustrates the dieldrin concentration trends versus time in NWBCS wells. Dieldrin does not indicate an increasing trend in downgradient of the Original System. NDPA exceeded the PQL in downgradient NEE well 22512, and concentrations indicate an increasing trend in FY23 (Figure A-15).

3.1.3 NWBCS Quality Assurance Summary

The purpose of the data review is to evaluate data quality with respect to the established DQOs. Components of the data review process include: 1) evaluating the data against the data quality indicators precision, bias, representativeness, completeness, sensitivity, and comparability; 2) review of field and laboratory QC results; and 3) evaluating the data for suitability based on the intended use. The data review has determined that the data quality meets or exceeds the established DQOs and is of the correct type, quality, and quantity to support the intended use. Detailed information on the quality assurance evaluation for samples collected to support the NWBCS in FY23 is provided in Appendix I1.1.

3.1.4 NWBCS Summary and Conclusions

In FY23, the NWBCS treatment plant operated such that there were no CSRG-analyte exceedances in either the four-quarter moving averages or in annual ROD water quality samples in the NWBCS treatment system effluent in FY23. During FY23, the average flow rate was 820 gpm, pumping a total of 431,089,815 gallons, and removing a total mass of 1.8 pounds. The contaminants that were above the CSRG in influent samples were dieldrin and NDPA, both of which were successfully treated by the system.

For the Original System, the reverse gradient was maintained throughout the year, which is consistent with results in previous reporting periods. Dieldrin was detected above the PQL in Original System downgradient performance wells 37331, 37332, 37333, and 37600, however, the long-term trend is not increasing in downgradient performance wells.

Plume capture was evident for the SWE and there were no exceedances of CSRGs in wells upgradient, cross-gradient, or downgradient of the system and concentrations are continuing to decrease.

Dieldrin and NDPA were detected in NEE downgradient performance well 22512 exceeding their respective PQLs, and concentration trends are increasing. Dieldrin exceeded the PQL in and NEE downgradient performance well 22015, but there is no discernible trend in concentrations. Analyte concentrations were likely above the PQL in these NWBCS downgradient performance wells during the past few years because: 1) mobilization of residual dieldrin in the aquifer sediments downgradient of the slurry wall; 2) dieldrin concentrations previously have been near or above the current PQL in the NWBCS effluent; and/or 3) possible bypass from the NEE area.

The evaluation of semiannual monitoring of water quality within the NEE resulted in recommended actions focusing on aquifer slug tests and pumping tests to take place in FY24. Results of the aquifer testing will support the feasibility and design for improved containment with supplemental extraction and recharge in the vicinity of the NEE.

3.2 NORTH BOUNDARY CONTAINMENT SYSTEM

The NBCS treatment facility consists of a groundwater extraction system, monitoring wells, pre-filtration, granular activated carbon adsorption, post-filtration, ultraviolet (UV) oxidation, soil-bentonite slurry wall, and a groundwater recharge system. The NBCS was designed to intercept contaminated groundwater from the upgradient side of the slurry wall, treat it to remove the organic contaminants, and inject the treated water back into the alluvial aquifer on the downgradient side of the slurry wall. The treatment facility was originally designed as a pulse bed granular activated carbon adsorption system; however, modifications to the treatment plant in May 1995 converted the plant to a down flow carbon adsorption system.

Additional modifications to the NBCS included the addition of UV oxidation treatment in the fall of 1997 to treat NDMA, and the addition of the South Channel well system in the fall of 2002 to extract groundwater upgradient of the NBCS to optimize NBCS operations.

The treatment system is designed to provide hydraulic control and remove organic contaminants known to be present in the extracted groundwater to levels at or below the CSRGs established in the final ROD for the NBCS.

Treatment system information for the NBCS is provided for FY23 in Table 3.2-1. The results of CSRG-analyte sampling in FY23 are presented in Table 3.2-2, and in figures within Appendix B.

Groundwater monitoring and water level data are included in Excel files accompanying this report.

3.2.1 NBCS Operations and Compliance

The NBCS operated at an average flow rate of 222 gpm and pumped a total volume of 115,130,496 gallons during FY23 and removed a total of 11.3 pounds of contaminant mass. The major contaminants removed via treatment included dicyclopentadiene (DCPD), DIMP, chloroform, carbon tetrachloride, trichloroethylene, tetrachloroethylene, NDPA, dieldrin, 1,2-dichloroethane, and methoxychlor (Table 3.2-1). The total cost to operate the treatment plant in FY23 was $591,725 (Table 3.2-1).

Figure B-1 in Appendix B shows the locations of NBCS monitoring wells, extraction and recharge wells, the slurry wall, and the South Channel extraction wells.

Compliance for all treatment systems at RMA is based on quarterly effluent water quality monitoring. Each system has a list of compliance analytes for which CSRGs were developed in the On-Post and Off-Post RODs. The current CSRG list, including any revisions since the RODs were developed, is provided in the LTMP. The system effluent for the NBCS was analyzed quarterly in FY23 using the LTMP routine CSRG analyte list for the NBCS and annually using the complete CSRG list.

The treatment plant influent and effluent concentrations for the following analytes are shown in Figures B-2 through B-10, respectively (Appendix B):

- 1,2-Dichloroethane
- 1,4-Dioxane
- Carbon tetrachloride
- Chloride
- Dieldrin
- Fluoride
- Isodrin
- NDMA
- NDPA

As presented in Table 2 in each of the quarterly *Treatment Plant Effluent Water Quality Data Reports FY23*, the NBCS individual effluent concentrations and associated four-quarter moving averages for analytes addressed by treatment technologies showed no exceedances during FY23, with the exception of 1,4-dioxane and NDMA (Navarro 2023b, 2023c, 2024a, 2024c). The graphs indicate that 1,2-dichloroethane, carbon tetrachloride, dieldrin, and NDPA exceeded CSRGs/PQLs in treatment plant influent concentrations, while concentrations in plant effluent did not exceed CSRGs/PQLs in FY23.

Emerging contaminant 1,4-dioxane exceeded CSRG/PQL in the plant effluent during all four quarters in FY23 and the four-quarter moving average exceeded the CSRG each quarter. The NBCS does not treat for 1,4-dioxane. Chloride exceeded the CSRG in the second and fourth quarters; however, the NBCS does not treat for chloride and it is expected to attenuate naturally to background levels.

NDMA concentrations in the plant effluent samples exceeded the PQL of 0.009 µg/L during the second, third and fourth quarters of FY23. Consequently, the four-quarter moving average for the third and fourth quarters of FY23 also exceeded the PQL. On June 13, 2023, formal notification of the exceedance was made to the regulatory agencies. Potential causes for the occurrence of NDMA include fluctuation in plant influent concentrations and/or issues with the UV treatment system.

Although the long-term influent trend is decreasing, influent concentrations exhibit a slight increasing trend over the last five years, and operational adjustments were made in FY23 to reduce the effluent NDMA concentrations. The NBCS typically achieves adequate NDMA treatment with four UV lamps in service. Two additional lamps were placed in service in early June 2023 after verification that lamp usage did not exceed the 3,000-hour life recommended by the manufacturer. In addition, the quartz tubes housing the UV lamps were replaced in early July 2023 to ensure transmissivity was not diminished from use. Operational samples in July and August 2023 indicated a slight improvement in the UV system effluent (Navarro 2024a).

In FY23, the NBCS demonstrated system effectiveness for most analytes addressed by treatment technologies, reducing contaminant concentrations below the CSRGs/PQL. Exceedances of the four-quarter moving averages for system effluent in FY23 indicate an issue in the treatment of NDMA at the NBCS. Further evaluation of NDMA and related treatment at the NBCS is planned for FY24.

3.2.2 NBCS Performance Evaluation

The performance criteria for the NBCS are designed to address future monitoring needs and facilitate the system performance evaluation. The primary performance criteria for the NBCS are presented below:

- Demonstrate containment through reverse hydraulic gradient by visual evaluation of potentiometric maps and visual comparison of paired well water levels. If visual inspection is unclear, statistical or other evaluation criteria will be considered.
- Demonstrate containment through plume-edge capture by visual evaluation of flow directions on potentiometric maps and evaluation of water quality data from performance water quality wells. If visual inspection is unclear, statistical or other evaluation criteria will be considered.

A secondary performance criterion was established to address system performance in the event that a reverse hydraulic gradient could not be maintained, which provides assurance that downgradient water quality is not being adversely impacted:

- If unable to maintain reverse hydraulic gradient due to factors beyond Army control, the performance evaluation will be based on demonstrating that concentrations in downgradient water quality performance wells are at or below CSRGs/PQLs or show decreasing concentration trends, based on annual evaluations, over the previous period of at least five years. If visual inspection is unclear, statistical or other evaluation criteria will be considered.

The primary performance requirement for the NBCS is to maintain a reverse hydraulic gradient across the system in the alluvium and to ensure plume-edge capture. Figures B-11 and B-12 in Appendix B show that the reverse hydraulic gradient was maintained across the system during all four quarters of FY23. Plume-edge capture at the NBCS can be verified by inspection of the potentiometric surface map in Figure B-13. Water-table contours indicate that groundwater flow is being captured at the western and eastern edges of the system.

Relative to the secondary performance criterion, an evaluation of performance well water quality was conducted. Although the primary performance criterion was met in FY23, concentrations of the following CSRG analytes exceeded CSRGs/PQLs in the noted wells downgradient of the NBCS:

- 1,4-Dioxane – 23438, 24006, 24415, 24421, and 24429
- Chloride – 23434, 24006, 24415, 24418, 24421, and 24424
- Dieldrin – 23405, 23434, 24415, 24418, 24421, 24424, and 24429
- Fluoride – 23436 and 24418
- NDMA – 24006 and 24415
- Sulfate – 23434, 24415, 24418, and 24421

A summary of the NBCS performance well concentration trend data is provided in Table 3.2-2 for contaminants detected above the CSRGs. In FY23 downgradient performance well 24207 could not be sampled due to insufficient water. Nearby well 24429 was monitored instead, which is reflected in the following evaluation and in relevant maps, charts, and tables in this report. Anions chloride, fluoride, and sulfate were detected above CSRGs/PQLs, but the system does not treat for these constituents. Although not treated by the system, the anion concentrations seem consistent with typical natural conditions; however, evaluation is necessary to assess chloride and sulfate attenuation towards meeting remediation goals. The NBCS does not treat for 1,4-dioxane, but the future consolidated water treatment plant will treat for this contaminant.

Dieldrin concentrations were above the PQL in 8 of the 11 downgradient performance wells showing decreasing, or no discernible trends using visual inspection and statistical trend analyses. The dieldrin concentrations present above the PQL in the downgradient wells are likely due to its lower solubility and affinity for soil in soil-water system. Fluctuations in groundwater levels downgradient of the NBCS slurry wall caused by variations in the recharge trench flow rates and variable recharge from First Creek likely causes desorption of dieldrin from the aquifer sediments. NDMA was detected in five downgradient wells in FY23, with concentrations in wells 24006 and 24415 exceeding the CSRG/PQL, and an increasing concentration trend in wells 23405 and 24006. 1,4-Dioxane was detected at a concentration exceeding the CSRG in downgradient performance wells 23438, 24006, 24415, 24421, and 24429, and an increasing concentration trend in well 24429.

Regarding anions, several wells had concentrations of chloride, fluoride, and/or sulfate greater than CSRGs. Although not treated at the NBCS, sulfate in plant effluent has been consistently below the CSRG and the attenuation goal has been met. Concentrations of chloride and fluoride in groundwater are also expected to eventually meet CSRGs via natural attenuation processes.

Exhibit B-14, Appendix B, provides a summary table of the FY23 NBCS Performance Well Water Quality Monitoring. Figures B-15 through B-27 illustrate the distribution of contaminants in performance wells upgradient and downgradient of the NBCS for 1,2-dichloroethane, 1,4-dioxane, aldrin, carbon tetrachloride, chloride, DIMP, dieldrin, fluoride, isodrin, NDMA, NDPA, sulfate, and trichloroethylene.

In the event that downgradient performance wells show analytes are above CSRGs/PQLs, concentration trends are evaluated by visual inspection of time versus concentration plots and Mann-Kendall statistical analysis. Concentration versus time trend plots in NBCS wells for analytes with concentrations that exceeded CSRGs/PQLs in upgradient and downgradient performance wells are presented in Figures B-28 through B-33. In these figures, 1,4-dioxane, chloride, dieldrin, fluoride, NDMA, and sulfate are present in groundwater at levels greater than CSRGs/PQLs, but are generally not increasing in concentrations downgradient of the system. As discussed in previous ASRs, the downgradient detections of dieldrin are most likely caused by residual contamination and are not representative of system effectiveness. Alternate well 24429 also shows increasing trends for 1,4-dioxane and sulfate. Only chloride in downgradient wells 24006 and 24415 appear to be increasing based on a statistical trend analysis. It is likely that elevated levels of chloride in NBCS downgradient performance wells may be attributed to surface runoff from 96th Avenue that has been impacted by the use of salt to mitigate icy road conditions during the winter and spring.

3.2.3 NBCS Denver Formation Monitoring

3.2.3.1 Denver Formation Hydraulic Gradients

Reverse Gradients

Reverse lateral hydraulic gradients across the slurry wall and upward vertical hydraulic gradients on the upgradient (south) side of the slurry wall are desirable in the Denver unconfined wells but are not required to maintain hydraulic control. Water levels were measured quarterly at seven well pairs screened in the Denver Formation sandstone that extends under the slurry wall in the western half of the NBCS and are adjacent to the NBCS slurry wall. Reverse gradient graphs are shown in Figures B-34 and B-35 in Appendix B. The reverse gradient graphs have been consistent for the last several years.

To evaluate reverse gradients across the slurry wall, water levels for well pairs (listed from west to east) were reviewed: 23536/23537, 23538/23539, 23138/23126, 23540/23541, 23194/23195, 23542/23543, and 23242/23243. A reverse gradient was present in well pairs 23138/23126, 23194/23195 and 23542/23543 during all four quarters of FY23. Water levels show that a flat to reverse hydraulic gradient was not present in well pairs 23536/23537, 23538/23539, and 23542/23543. For well pair 23540/23541, a reverse gradient was only present during the second quarter of FY23. The inability to maintain a constant reverse gradient is due to the semi-confined sands in the Denver Formation, which have become a significant factor in this area as water levels have decreased in the region over the past few years.

Vertical Gradients

Vertical gradients were evaluated on the upgradient (south) and downgradient (north) sides of the slurry wall to determine whether the potential exists for downward migration within the UFS of contaminants from the alluvium into the Denver Formation indicative of underflow across the slurry wall. Vertical gradients were calculated utilizing the electronic data provided in the FY23 North Boundary Containment System folder that accompanies this report.

Vertical gradients on the upgradient/south side of the slurry wall were evaluated for well pairs (listed from west to east): 23208/23537, 23207/23539, 23214/23126, 23533/23541, 23534/23195, 23535/23543, and 23212/23243. An upward vertical hydraulic gradient from the Denver Formation unconfined zone to the overlying alluvium on the upgradient side of the slurry wall indicates hydraulic containment with depth. Based on the average hydraulic head difference, upward gradients were present in well pairs during all measured quarters in five of the seven well clusters on the extraction-well side of the slurry wall. For well pair 23208/23537, the alluvial well 23208 was dry all four quarters. In well pair 23207/23539, alluvial well 23207 was dry for all but the first quarter.

On the downgradient/north side of the slurry wall, vertical gradients were evaluated for the following well pairs (listed from west to east): 23519/23538, 23215/23138, 23510/23194, 23528/23542, and 23217/23242. In FY23, vertical hydraulic gradients were downward in all well pairs, indicating hydraulic control was maintained, which is further substantiated by the presence of a reverse gradient across the slurry wall in this portion of the NBCS.

Summary

The FY23 hydraulic gradients in the Denver unconfined wells are consistent with historical gradients. The lateral hydraulic gradients indicate that underflow of contaminants likely is not occurring as upward vertical gradients in well pairs located on the upgradient side of the slurry wall indicate hydraulic containment are being maintained.

3.2.3.2 Denver Formation Water Quality

As presented in Section 4.4.4 of the LTMP, Denver Formation select UFS and CFS wells are sampled once every five years, with the next sampling event taking place in FY24. Therefore, no water quality data are reported for these wells in FY23.

3.2.4 NBCS Quality Assurance Summary

The purpose of the data review is to evaluate data quality with respect to the established DQOs. Components of the data review process include: 1) evaluating the data against the data quality indicators precision, bias, representativeness, completeness, sensitivity, and comparability; 2) review of field and laboratory QC results; and 3) evaluating the data for suitability based on the intended use. The data review has determined that the data quality meets or exceeds the established DQOs and is of the correct type, quality, and quantity to support the intended use. Detailed information on the quality assurance evaluation for samples collected to support the NBCS in FY23 is provided in Appendix I1.2.

3.2.5 NBCS Summary and Conclusions

The NBCS operated at an average flow rate of 227 gpm and pumped a total volume of 115,130,496 gallons during FY23, removing a total of 11.3 pounds of contaminant mass.

In FY23, the NBCS demonstrated system effectiveness for most analytes addressed by treatment technologies, reducing contaminant concentrations below the CSRGs/PQL. CSRG analyte effluent concentrations and associated four-quarter moving averages showed no exceedances during FY23, with the exception of 1,4-dioxane and NDMA. As an emerging contaminant, 1,4-dioxane treatment was not part of the design for the NBCS and therefore is not treated by the system. NDMA concentrations in the plant effluent samples exceeded the PQL of 0.009 µg/L during FY23, and the four-quarter moving average also exceeded the PQL. Formal notification of the NDMA exceedances was made to the regulatory agencies. Further evaluation of NDMA and related treatment at the NBCS is planned for FY24.

Meeting the primary performance criterion, a reverse hydraulic gradient was maintained within the system during all four quarters of FY23. The concentrations in the downgradient performance wells were less than the CSRGs/PQLs and/or show decreasing trends in most of the wells. Dieldrin concentrations were above the PQL in eight downgradient performance wells, but show stable, decreasing, or no discernible trends in these wells. The downgradient dieldrin concentrations above the PQL likely are caused by residual contamination that is not representative of system performance. 1,4-Dioxane and NDMA were detected at concentrations exceeding CSRGs/PQLs in downgradient wells and indicate an increasing trend in wells 24429 and 24006, respectively.

Based on the FY23 information, the contaminant plumes were captured at NBCS. There was no indication of underflow within the Denver Formation as vertical gradients were generally upward upgradient of the slurry wall, and contaminant levels were significantly higher upgradient of the slurry wall. Although a few analytes are above CSRGs/PQLs in downgradient wells because of residual downgradient contamination, the NBCS is functioning as intended. Continued monitoring will be conducted in downgradient performance wells where PQL exceedances occurred in FY23.

3.3 BASIN A NECK SYSTEM

The BANS was designed and constructed in 1989 to intercept contaminated alluvial groundwater originating from Basin A. Contaminated groundwater is removed from the upgradient side of a slurry wall, treated by means of air stripping and granular activated carbon adsorption to remove the organic contaminants, and injected back into the alluvial aquifer through recharge trenches on the downgradient side of the slurry wall. Since the original plant was constructed, two additional extraction systems were added in 2000, and one additional system was added in 2011.

These systems include the BRES, which extracts contaminated groundwater from an area in the north-central part of Section 36, the CADT dewatering system, which pumps contaminated groundwater from the CADT area in the southeast portion of Section 36, and the Lime Basins, which pumps contaminated groundwater from the southwest corner of Section 36. All three of these extraction systems convey contaminated groundwater to the BANS for treatment. The BANS treatment system is designed to remove organic contaminants and arsenic to levels at or below the CSRGs established in the final On-Post ROD.

The contaminated groundwater from the BRES and CADT systems requires pre-treatment by air stripping for removal of VOCs. To accommodate the increased flows from the additional extraction systems, a shallow tray air-stripping system was installed in 2002 to replace the original packed bed air stripping system. In 2004, the air stripper was relocated to the headworks of the plant in order to process the entire plant flow. The Lime Basins Treatment Relocation Project, which directed groundwater from the Lime Basins extraction wells into the BANS treatment plant, was started in FY10 and was completed in FY11 (RVO 2013).

Treatment system information for the BANS is provided for FY23 in Table 3.3-1. Figure C-1 presents a map of the BANS, including the monitoring well network. The results of water level monitoring in BANS performance wells and CSRG-analyte sampling in FY23 are presented in Exhibit C-14 and Figure C-15, respectively, within Appendix C. Groundwater monitoring and water level data are included in electronic files accompanying this report.

3.3.1 BANS Operations and Compliance

The BANS operated at an average flow rate of 16.4 gpm and pumped a total volume of 8,628,067 gallons during FY23, removing a total of 55.9 pounds of contaminant mass. Carbon usage has remained steady over the past few years (Navarro 2024b). The total cost to operate the treatment plant in FY23 was $464,421 (Table 3.3-1).

Compliance for all treatment systems at RMA is based on quarterly effluent water quality monitoring. Each system has a list of compliance analytes for which CSRGs were developed in the On-Post and Off-Post RODs. The current CSRG list, including any revisions since the RODs were developed, is provided in the LTMP. The system effluent for BANS was analyzed quarterly in FY23 using the complete CSRG list.

The treatment plant influent concentrations for the following 11 analytes exceeded CSRGs/PQLs as shown in Figures C-2 through C-13 (Appendix C).

- 1,2-Dichloroethane
- 1,4-Dioxane
- Chloroform
- p-Chlorophenylmethyl sulfone (CPMSO2)
- DIMP
- Dithiane

- Dieldrin
- NDPA
- PPDDT
- 1,1,2,2-Tetrachloroethane
- Trichloroethylene
- Tetrachloroethylene

As presented in Table 4 in each of the quarterly *Treatment Plant Effluent Water Quality Data Reports FY23,* the BANS individual effluent concentrations and associated four-quarter moving averages showed no exceedances during FY23 (Navarro 2023b, 2023c, 2024a, 2024c). The graphs indicate that while treatment plant influent concentrations exceeded CSRGs/PQLs, concentrations of ROD CSRG analytes in the plant effluent did not exceed CSRGs/PQLs in FY23.

Although not a compliance requirement, reverse hydraulic gradient is monitored at the BANS as an operational consideration. As presented in the quarterly *Treatment Plant Effluent Water Quality Data Reports FY23*, the reverse hydraulic gradient at BANS was similar to its historical trend in previous years. Although a reverse hydraulic gradient was not present on the far western and eastern ends of the system, it was maintained in the central part of the system containing the highest concentrations of contaminants.

3.3.2 BANS Performance Evaluation

The performance criteria for the BANS were designed to address future monitoring needs and facilitate the system performance evaluation and are presented below:

- Demonstrate effective mass removal through comparison of calculated mass removed by the system for each of the CSRG analytes and mass flux approaching the system estimated by combined well capture and transect methods.
- Demonstrate that concentrations in downgradient performance wells are stable or decreasing.

Performance of the BANS in FY23 relative to these two criteria is presented below.

3.3.2.1 BANS Mass Removal

A revised approach to evaluate contaminant mass removal at the BANS was proposed in 2019 consisting of a comparison of the calculated mass removed by the system to contaminant plume mass flux approaching the system. As a result of the evaluation, the mass removal approach for BANS was revised in the LTMP under OCN-LTMP-2023-005. Subsequently, OCN-LTMP-2023-008 LTMP was updated to be consistent with the revised mass removal approach and the BANS mass removal goal was revised to 90 percent. The revised technical approach serves as a revision to the LTMP by focusing on measuring the effectiveness of mass removal at the point of capture (extraction) within each system, and not the mass treated at the treatment plant. The mass removal evaluation presented in this report provides a quantitative measure of extraction system performance and better quantifies contaminated groundwater not captured as an indication of potential system bypass. The potentiometric surface map of the BANS area for FY23 is consistent with previous data and indicate flow towards the system, and water levels in FY23 do not indicate any apparent gaps between either end of the slurry wall and unsaturated alluvium (Figure C-14).

Consistent with the methodology incorporated into the LTMP in 2012 (OCN-LTMP-2012-002), two methods are used in combination to estimate contaminant mass removal:

- Transect method – Used to estimate the mass flux approaching the BANS.
- Well capture method – Used to estimate the mass removal extracted within the BANS capture zone by extraction wells.

The revised mass removal performance criterion specifies removal of at least 90 percent of the contaminant plume mass migrating toward the system. Additional details on the technical approach and methodology for the evaluation of contaminant mass removal are presented in LTMP, OCN-LTMP-2023-005.

The calculations for contaminant mass removal for the BANS are provided in the Excel file accompanying this report (FY23 BANS Mass Removal Rev0.xlsx).

Groundwater flows through the BANS to the west-northwest as presented in Figure C-14. The approximate total contaminant flow rate approaching the BANS was 11.78 gpm as shown in Table 3.3-2. The total flow rate is based on the averaged measured extraction flow rate within the capture zone of 11.40 gpm and the estimated contaminated flow outside the capture zone was approximately 0.37 gpm. Based on these flow rates, approximately 96.8 percent of the overall contaminated flow was extracted and treated.

In FY23, the mass flux outside the capture zone was estimated to be 0.006 pounds per year (pounds/year) for all organic and inorganic CSRG analytes, while the mass flux within the capture zone was 15.42 pounds/year for the extraction wells. Based on these data, the total BANS mass removal is 99.9 percent, which exceeds the LTMP performance criterion of 90 percent (Table 3.3-2). Any apparent discrepancies in the quantities for mass removal can be accounted for in mathematical rounding as shown in the calculations presented in the Excel file accompanying this report.

From FY12 through FY23, mass removal has ranged from 88.5 to 99.9 percent, with an average of 99.3 percent. The lowest percentage of mass removal occurred during periods of high precipitation and an increase in the water table where flow around the northern and southern end of the slurry wall likely occurred, thus decreasing capture.

3.3.2.2 BANS Downgradient Performance Evaluation

The second performance requirement is to demonstrate that concentrations in downgradient performance wells are below CSRGs/PQLs, or stable or decreasing if they are above the CSRGs/PQLs. In FY23 concentrations of the following CSRG analytes exceeded CSRGs/PQLs in the noted wells downgradient of the BANS:

- CPMSO2 – 35525

- Dieldrin – 35505 and 35525
- PPDDT – 35525

Table 3.3-3 presents an overview of the FY23 water quality results and concentration trends for the BANS performance wells, while Exhibit C-15, Appendix C, provides a summary of FY23 performance well analytical data. Figures C-16 through C-20 in Appendix C show the upgradient and downgradient performance well concentrations for the following analytes:

- 1,2-Dichloroethane
- CPMSO2
- Dithiane
- Dieldrin
- PPDDT

Time versus concentration maps on Figures C-21 through C-23 show the concentration trends for analytes with concentrations that exceeded CSRGs/PQLs in upgradient and downgradient wells, including CPMSO2, dieldrin, and PPDDT.

Dieldrin concentrations were above the PQL in two of the four downgradient performance wells (35505 and 35525), and appear to be decreasing in both wells and in well 26505, which previously had dieldrin at concentrations exceeding the PQL. The concentrations of CPMSO2 was greater than the CSRG in downgradient performance well 36525 but is not increasing or decreasing in concentration (Table 3.3-3). PPDDT was detected at a concentration greater than the CSRG upgradient of the BANS in FY23, and the concentration of this analyte exceeded the CSRG in downgradient well 35525 and demonstrates a stable or non-discernible trend (Table 3.3-3). The data do not indicate an increasing trend for any of the contaminants as verified by Mann-Kendall trend analyses (Table 3.3-3).

3.3.3 BANS Quality Assurance Summary

The purpose of the data review is to evaluate data quality with respect to the established DQOs. Components of the data review process include: 1) evaluating the data against the data quality indicators precision, bias, representativeness, completeness, sensitivity, and comparability; 2) reviewing field and laboratory QC results; and 3) evaluating the data for suitability based on the intended use. The data review for BANS includes BRES, CADT, and Lime Basins data. The data review has determined that the data quality meets or exceeds the established DQOs and is of the correct type, quality, and quantity to support the intended use. Detailed information on the quality assurance evaluation for samples collected to support the BANS in FY23 is provided in Appendix I1.3.

3.3.4 BANS Summary and Conclusions

In FY23, the BANS met the treatment plant compliance requirements established in the LTMP. The BANS operated at an average flow rate of 16.4 gpm and pumped a total volume of 8,628,067 gallons during FY23, removing a total of 55.9 pounds of contaminant mass. As presented in Table 4 in each of the quarterly *Treatment Plant Effluent Water Quality Data*

Reports FY23, the BANS individual effluent concentrations and associated four-quarter moving averages showed no exceedances during FY23.

In FY23, the BANS met the performance criteria and objectives established in the LTMP. Utilizing the revised approach to evaluate mass removal, BANS met the revised goal of 90 percent for FY23, with mass removal estimated at 99.9 percent.

The BANS demonstrated treatment system effectiveness, specifically related to dieldrin, CPMSO2, and PPDDT. Each contaminant showed concentrations exceeding CSRGs/PQLs in upgradient groundwater and treatment plant influent, while concentrations in treatment plant effluent were less than CSRGs/PQLs. Although these analytes occurred at concentrations greater than CSRGs/PQLs in some downgradient performance wells, decreasing, indiscernible, or stable trends are indicated.

3.4 BEDROCK RIDGE EXTRACTION SYSTEM

The BRES intercepts groundwater flowing northeast out of Basin A from the CADT area. The monitoring network for the BRES is presented in Figure D-1. The potentiometric surface map (Figure D-2) indicates that the groundwater was flowing north-northwest in the vicinity of the extraction wells.

3.4.1 BRES System Operations

Extraction water from BRES is piped to and treated at BANS. Exhibit D-3, in Appendix D, provides a summary of FY23 performance well analytical data.

3.4.2 BRES Performance Evaluation

The performance criteria for the BRES are designed to evaluate the effectiveness of the extraction system in controlling downgradient contaminant migration. The system performance evaluation criteria are presented below:

- Demonstrate plume capture through visual evaluation of flow directions on potentiometric maps and evaluation of water quality data from performance and operational monitoring wells. If visual inspection is unclear, statistical and other evaluation criteria will be considered.
- Demonstrate decreasing or stable concentration trends or that concentrations are at or below CSRGs in downgradient performance wells.

Relative to the first performance criterion, the potentiometric surface map contours illustrated in Figure D-2 in Appendix D indicate that the plume appeared to be generally captured at the western and eastern edges of the extraction system based on the potentiometric surface. There were no significant changes in the groundwater flow directions in the BRES during FY23 compared to previous years.

The second performance criterion requires that concentrations in downgradient performance wells are below CSRGs/PQLs, or stable or decreasing if they are above the CSRGs/PQLs. In FY23 concentrations of the following CSRG analytes exceeded CSRGs/PQLs in the noted wells downgradient of the BRES:

- 1,2-Dichloroethane – 36566
- Chloroform – 36566
- DIMP – 36566
- Tetrachloroethylene – 36566
- Trichloroethylene – 36566

Exhibit D-3, in Appendix D, provides a summary of FY23 performance well analytical data. Figures D-4 through D-11 show the upgradient and downgradient performance well concentrations for analytes that exceed the CSRG/PQLs in upgradient and/or downgradient performance wells including 1,2-dichloroethylene, 1,2-dichloroethane, carbon tetrachloride, chloroform, DIMP, dieldrin, tetrachloroethylene, and trichloroethylene.

Table 3.4-1 presents an overview of the FY23 water quality results and concentration trends for the BRES performance wells. Time versus concentration maps and charts depicting long-term trends are presented in Figures D-12 through D-16 showing the concentrations for 1,2-dichloroethan, chloroform, DIMP, tetrachloroethylene, and trichloroethylene in upgradient and downgradient performance monitoring wells. These contaminants are present in groundwater at levels greater than CSRGs/PQLs in some wells, primarily upgradient of the extraction wells, but generally do not indicate increasing concentrations downgradient of the system.

No CSRG analytes were detected at concentrations exceeding CSRGs in downgradient performance wells 36555, 36571, and 36572 in FY23. Concentrations of 1,2-dichloroethane, chloroform, DIMP, tetrachloroethylene, and trichloroethylene were above the CSRGs in well 36566.

As a result of the supplemental monitoring program at the BRES conducted August 2019 through August 2021, elevated levels of VOCs were detected within the extraction system and in wells located downgradient of extraction wells 36302 and 36306. Increasing trends of trichloroethylene in downgradient performance well 36566 indicates likely bypass between extraction wells 36302 and 36306. Lower concentrations of VOCs were detected at the far western end of the extraction system and in performance well 36571 downgradient of the eastern end of the BRES supplemental monitoring program area of interest (Navarro 2022a).

Based on the results of the BRES supplemental monitoring program, recommended actions include the following:

- Install one new extraction well between extraction wells 36302 and 36306 to improve groundwater capture.
- Enhance the BRES monitoring program by installing a downgradient monitoring well to evaluate system performance related to the enhanced extraction system.

The location of proposed wells will be determined as part of the design analysis supporting future optimization of the overall system.

3.4.3 BRES Quality Assurance Summary

The purpose of the data review is to evaluate data quality with respect to the established DQOs. Components of the data review process include: 1) evaluating the data against the data quality indicators precision, bias, representativeness, completeness, sensitivity, and comparability; 2) reviewing field and laboratory QC results; and 3) evaluating the data for suitability based on the intended use. The data review has determined that the data quality meets or exceeds the established DQOs and is of the correct type, quality, and quantity to support the intended use. Because water extracted at BRES is treated at the BANS, data review for BRES is included with the data for BANS (Section 3.3.3). Detailed information on the quality assurance evaluation for samples collected to support the BRES in FY23 is provided in Appendix I1.3.

3.4.4 BRES Summary and Conclusions

In FY23, the BRES did not meet the plume capture performance criteria and objectives established in the LTMP as indicated by an increasing trend in one downgradient well for trichloroethylene. The potentiometric surface map indicates that the plume is captured at the edges of the system. In well 36566, trichloroethylene indicated increasing concentration trends through FY23. Well 36566 is located downgradient of the extraction system where the hydraulic gradient is relatively flat compared to the other downgradient performance wells. Therefore, the contamination in well 36566 is expected to decrease at a slower rate compared to other wells.

Evaluation of supplemental monitoring data collected 2019 through 2021 resulted in a recommendation to include installation of one additional extraction well and one downgradient well as part of the future optimization of the system.

4.0 OTHER ON-POST SYSTEMS

4.1 COMPLEX ARMY DISPOSAL TRENCHES DEWATERING SYSTEM

The performance criteria for the CADT dewatering system are based on achieving water elevation goals (i.e., below the bottoms of the disposal trenches), rather than water quality or contaminant mass removal goals. Quarterly water level monitoring is conducted in 11 wells to monitor the hydraulic gradient across the slurry wall, and water levels inside the slurry-wall enclosure, to assess progress toward meeting the dewatering goals. Figure E-1, Appendix E, presents the locations of wells within the CADT area. The groundwater pumped by the CADT dewatering system is treated at the BANS to meet CSRGs and reinjected in the BANS recharge trenches. Consultation trigger events for the CADT were established based on system performance criteria and non-routine operational events that might lead to performance issues. These triggers, along with notification requirements, type of consultation, and follow-up criteria, are presented in the LTMP (Navarro 2021). The table also includes a list of operational trigger events that could potentially result in a performance issue.

4.1.1 CADT System Operations

Groundwater extracted from the CADT dewatering trench is piped to and treated at BANS to meet CSRGs. Extracted groundwater is also sampled and monitored to support BANS operations and treatment.

4.1.2 CADT Performance Evaluation

Evaluation of existing conditions at the CADT indicated that there is hydraulic control due to flow directed towards the extraction trench through active dewatering. Because the hydraulic gradient toward the extraction trench represents containment, the LTMP was revised in 2019 (OCN-LTMP-2019-009) to incorporate demonstration of hydraulic control as an alternate performance goal under the first performance criterion for the CADT as follows:

- Demonstrate groundwater elevations in performance monitoring wells 36216 and 36217 are below the target elevations of 5226 and 5227 feet, respectively, or demonstrate hydraulic gradient from the performance monitoring well locations is toward the extraction trench.
- Maintain positive gradient from the outside to the inside of the barrier wall (for as long as active dewatering is occurring).

Relative to the first criterion, quarterly water levels in well 36216 were below the target elevation of 5226 feet above mean sea level (amsl) for all quarters. The water level in well 36217 remained above the target elevation during the first and second quarters, but was below the target elevation goal during the third quarter for the first time since long-term monitoring began. During the fourth quarter, the water level in well 36217 increased and was 0.23 feet higher than the target elevation goal. Water levels in wells 36216 and 36217 have been generally decreasing since October 2016.

The hydraulic gradient from both performance monitoring wells was toward the two extraction wells (36216 and 36217) as indicated in Figure E-1 (Appendix E), which presents the water levels from March through April 2023.

Relative to the second criterion, as shown in Figure E-2, the inward gradient across the CADT slurry wall was maintained where quarterly water levels were measured in well pairs 36218/36219 and 36220/36221.

In FY23, the CADT system met the performance criteria and objectives established in the LTMP. The inward gradient was maintained across the slurry wall and, although the water levels generally remained above the trench-bottom elevation in well 36217, hydraulic control was maintained at both performance well locations.

4.2 SHELL DISPOSAL TRENCHES DEWATERING SYTEM

The performance criteria for the Shell Trenches are based on achieving water elevations below the bottom of the disposal trenches (RVO 1997). In accordance with the LTMP, quarterly water level monitoring was conducted in 11 wells to monitor the hydraulic gradient across the slurry wall and water levels inside the slurry-wall enclosure to assess progress toward meeting the performance criteria through passive dewatering.

The performance requirement for Shell Disposal Trenches is to demonstrate that groundwater elevations are below the disposal trench-bottom elevations within the slurry-wall enclosure (shown in Figure E-3 in Appendix E and Table 4.2-1). Table 4.2-1 also lists the boreholes drilled through the disposal trenches where the trench-bottom elevations were determined. The elevation of the water table at each bore location was interpolated using the quarterly groundwater elevations from monitoring wells. As shown in Table 4.2-1, the water elevations were below the bottom of the trenches at all borehole performance goal locations each quarter of FY23.

4.3 LIME BASINS DEWATERING SYSTEM AND DNAPL REMEDIATION

Baseline operational data collection and system startup of the Lime Basins Slurry Wall Dewatering System began in March 2009. Initially, groundwater was extracted and treated in a periodic “batch” mode, but it was determined that the extraction wells needed to run more continuously in order to meet dewatering goals. After notification to the regulatory agencies in September 2014, continuous operation of the extraction wells commenced. Extracted groundwater is treated in batch mode at the BANS to meet CSRGs.

4.3.1 Slurry Wall Dewatering System

Dewatering system performance for the Lime Basins must meet the standards established in the Amendment to the ROD (TtEC 2005) and cited in the LTMP. The performance criteria for the Lime Basins dewatering include the following:

- Maintain a positive gradient from the outside to the inside of the slurry wall (for as long as the surrounding local groundwater table is in the alluvium).
- Maintain a groundwater level below the elevation of the Lime Basins waste (5242 feet amsl) inside the slurry wall (for as long as the surrounding local groundwater table is in the alluvium).

Figure E-4 (Appendix E) presents the monitoring well network for the Lime Basins.

The first performance criterion requires that positive inward hydraulic gradient be maintained across the slurry wall. Groundwater elevations inside and outside of the slurry wall have been steadily decreasing since remedy was completed, with a greater change observed in wells located within the southern slurry wall. Figure E-5 shows the reverse gradient plots for the northern and southern wells measured during FY23.

During FY23, an inward gradient was present in the well pairs along the southern slurry wall segment, in contrast to an outward gradient present in the northern well pairs. Progress toward meeting the inward gradient goal is dependent on successful dewatering within the slurry wall and the groundwater trend outside the wall. Although the groundwater elevation continues to decrease inside the wall, regional drought conditions and falling water table outside the wall have resulted in slower progress toward meeting the goal and difficulty in projecting a date for achievement. In accordance with OCN-LTMP-2021-004, September 2024 is the current projected target date to re-evaluate whether the inward gradient goal has been achieved. Monitoring of the Lime Basins water levels will continue, and progress toward meeting the inward gradient goal will continue to be reported in the ASRs.

The second performance criterion requires water levels inside the slurry wall to be below the elevation of the bottom of the waste. Figure E-5 also presents quarterly water levels for wells inside the slurry wall relative to the bottom-of-waste elevation of 5242 feet amsl. Based on observed water levels, groundwater inside the slurry wall was below the bottom of waste during all four quarters of FY23.

4.3.2 DNAPL Remediation

In August 2009, monitoring of the Lime Basins dewatering wells indicated the potential presence of DNAPL. A Remedial Investigation/Feasibility Study (RI/FS) was conducted and three suspected DNAPL source zones were identified in the Lime Basins area as shown in Figure E-6 in Appendix E. According to the RI/FS, DNAPL at the Lime Basins primarily consists of the following five compounds: 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, chlorobenzene, and DCPD. The selected remedy consists of DNAPL source containment, removal of DNAPL to the extent practicable, and DNAPL and groundwater monitoring (TtEC and URS 2011). Extracted groundwater is treated at the BANS to meet CSRGs. In FY12, four well pairs were installed adjacent to the slurry wall, and data collection specified in the *Lime Basins Dense Non-Aqueous Phase Liquid Remediation Project Design Analysis Report* (Lime Basins DAR) (TtEC and URS 2012) began in FY13.

The monitoring goals for Lime Basins DNAPL Remediation include the following:

- Determine if additional DNAPL source zones exist in the Lime Basins area in addition to those previously identified.
- Determine if the extent and nature of any discovered DNAPL source zones have the potential to adversely impact the slurry wall.
- Characterize DNAPL, if present, for the purpose of correlation with groundwater characterization data as a tool in the identification of DNAPL source zones and for the purpose of waste disposal.

Lime Basins DNAPL Remediation Project monitoring consists of measuring DNAPL thickness and water levels, and sampling monitoring and dewatering wells (Figure E-4, Appendix E).

Figure E-6 presents the Lime Basins potentiometric surface map for third quarter FY23. Based on interpolated data, groundwater flows to the north-northwest inside the slurry wall area. The hydraulic gradient inside the slurry wall ranges from 0.009 to 0.021 feet per foot, which is comparable to previous results. The highest water level inside the slurry wall was measured at 5238.93 feet amsl in well 36240 in the southwestern corner of the slurry wall enclosure, with the lowest water elevation, at 5236.83 feet amsl, measured in the northwest corner in well 36232. Water levels inside the slurry wall continue to decrease as dewatering continues. There are no depressions in the water table other than those created by the dewatering wells. Additionally, there is no apparent deviation of water levels in the wells adjacent to the slurry wall that would indicate degradation of the slurry wall.

During FY23, DNAPL was measured in monitoring wells 36231, 36235, and 36248, and extraction wells 36315, 36319, and 36320. A total of 7 gallons of DNAPL was removed from wells 36248, 36319, and 36320 in FY23 where the thickness was greater than 1 foot (TtEC and URS 2012). The water level data and DNAPL measurements for FY23 indicate that the slurry wall has not been adversely impacted by DNAPL according to criteria in the DAR (TtEC and URS 2012). Consistent head differentials across the slurry wall have been maintained for all the well pairs showing that the DNAPL remediation system is functioning as intended. In addition, no DNAPL was detected outside of known source zones as presented in Figure E-7. Removal of recoverable DNAPL will continue as required by the *Lime Basins Dense Non-Aqueous Phase Liquid Remediation Project Design Analysis Report* (TtEC & URS 2012). The data for FY23 Lime Basins water level, DNAPL thickness, and water quality are provided in electronic files accompanying this report.

4.4 NORTH PLANTS LNAPL PILOT REMOVAL ACTION

An LNAPL pilot removal system was implemented in 2008 to evaluate and remove LNAPL due to a historical release of fuel oil in the North Plants and to gather operating data for the potential design of a full-scale LNAPL removal action. The design of the pilot removal action is presented in the North Plants LNAPL Removal System Action Plan (TtEC and URS 2009). A separate evaluation report was issued for the LNAPL Removal Action prior to FY12 (URS 2012). As discussed in the report, over two years of monitoring was conducted in the North Plants LNAPL recovery and monitoring wells without detection of sufficient quantities of LNAPL in these wells to support the removal of LNAPL. Data for the North Plants Pilot LNAPL Removal Program have been presented in ASRs and FYSRs since FY12 (URS 2012). The future of the LNAPL Removal Project was evaluated during the 2015 Five-Year Review, and the monitoring frequency was reduced to an annual frequency in FY15 (Navarro 2016a).

Since installation of recovery wells in 2009 under the *North Plants Pilot Light Non-Aqueous Phase Liquid Removal System Action Plan* (LRSAP), there has been insufficient LNAPL present in the wells to perform LNAPL removal. Between 2009 and 2021 there were only three instances of measurable LNAPL, with thickness measured at 0.01 feet or 0.02 feet. The apparent thickness of LNAPL in the piezometers also decreased after implementation of the pilot study, with no measurable LNAPL from 2013 until 2022.

In May and November 2022, LNAPL thickness was measured in well 25301 at 0.74 feet and 1.4 feet, respectively, and a bail down test was performed as required by the LRSAP. Bail-down testing was completed on March 28, 2023, and 3 gallons of LNAPL were recovered from well 25301. Afterwards, monitoring continued for the next six months with no significant accumulation of LNAPL occurring to warrant removal.

In FY23, groundwater levels rose within the former North Plants area and the LNAPL thickness decreased, which is consistent with previous observations that the thickness of LNAPL in the formation is insufficient to overcome the entry capillary pressure in the recovery wells as the water table rises. In addition, downgradient water quality monitoring indicates that the LNAPL is not migrating away from the identified LNAPL source area.

The *North Plants Pilot Light Non-Aqueous Phase Liquid Removal System Completion Report,* currently under review, presents the results of monitoring over the course of the pilot program and the 2023 baildown testing. In the report, the Army recommended that LNAPL monitoring continue to occur quarterly in the two recovery wells and seven piezometers. In addition, if more than 6 inches of LNAPL is present in a recovery well, the well will be bailed down and the LNAPL will be disposed. Following review of the Completion Report, the LTMP will be revised per OCN to remove references to the LRSAP, incorporate monitoring requirements, and prescribe recovery if more than 6 inches of LNAPL is observed. Figure E-8, Appendix E, presents the North Plants LNAPL long-term monitoring well network.

Petroleum remediation is not regulated as a Comprehensive Environmental Response, Compensation, and Liability Act response action, but for ease of reporting, LNAPL updates will continue to be included in the ASRs and the Five-Year Review Reports.

5.0 OFF-POST EXTRACTION AND TREATMENT SYSTEMS

Off-post groundwater "pump and treat" systems consisting of extraction wells, recharge trenches, and recharge wells are in operation within both the Northern Pathway and First Creek paleochannels, and are referred to as the Northern Pathway Treatment System (NPTS) and the First Creek Treatment System (FCTS), respectively. Prior to FY23, groundwater from both the Northern Pathway and First Creek paleochannels was treated in a single plant—the Off-Post Groundwater Intercept and Treatment System (OGITS). The OGITS was shut down on May 3, 2021 in order to accommodate the construction of the FCTS and NPTS treatment plants.

Beginning in FY21, the First Creek and Northern Pathway systems went through significant changes which resulted in the design and construction of a new treatment plant at each site.

The First Creek modifications included an upgrade of the piping and electrical systems, and removal of extraction well concrete vaults. Recharge trenches RCT-1 and RCT-2 were permanently abandoned. Extraction wells 37803 and 37804 were converted into monitoring wells. Extraction well 37800 (FE-01) was found to be severely corroded and therefore replaced by new extraction well 37830 (FE-01R) located in the same area. The FCTS began operations on October 13, 2021. Figure F-1 (Appendix F) presents the current locations of the three extraction wells and four recharge trenches.

The Northern Pathway modifications included the addition of seven extraction wells, three recharge trenches, one monitoring well, and nine piezometers. These additions to the Northern Pathway well field were designed and constructed to cover the "gap" area in the southern part of the system where contaminated groundwater was not being captured by the OGITS Northern Pathway system. The net result of the Northern Pathway upgrades was a more consolidated footprint of the extraction and recharge well field with no gaps in extraction. Construction of the NPTS treatment plant and additional extraction wells and recharge trenches were completed in early FY22, with system operations starting on January 31, 2022. Figure G-1 (Appendix G) presents the locations of the current locations of the 12 extraction wells and 8 recharge trenches.

5.1 FIRST CREEK TREATMENT SYSTEM

5.1.1 FCTS Operations and Compliance

The FCTS operated at an average flow rate of 55.7 gpm, pumped a total volume of 29,018,947 gallons during FY23, and removed a total of 2.5 pounds of contaminant mass. The major contaminants removed via treatment included DIMP and, to a lesser extent, DCPD (Table 5.1-1). The total cost to operate the treatment plant in FY23 was $260,856 (Table 5.1-1). Figure F-1 in Appendix F shows the locations of FCTS monitoring wells, extraction wells and recharge trenches.

Compliance for all treatment systems at RMA is based on quarterly effluent water quality monitoring. Each system has a list of compliance analytes for which CSRGs were developed in the On-Post and Off-Post RODs. The current CSRG list, including any revisions since the RODs were developed, is provided in the LTMP. The system effluent for the FCTS was analyzed quarterly in FY23 using the LTMP routine CSRG analyte list for the FCTS, and annually using the complete CSRG list.

The treatment plant influent concentrations for DIMP exceeded the CSRG/PQL as shown in Figures F-2 (Appendix F). As presented in Table 4 in each of the quarterly *Treatment Plant Effluent Water Quality Data Reports FY23*, the FCTS individual effluent concentrations and associated four-quarter moving averages showed no exceedances during FY23 (Navarro 2023b, 2023c, 2024a, 2024c). The graph for DIMP indicates that while treatment plant influent concentrations exceeded CSRG/PQL, concentrations in the plant effluent did not exceed CSRGs/PQLs in FY23. During all four quarters of FY23, concentrations of anions—chloride fluoride and sulfate—in influent and effluent samples were less than CSRGs.

In FY23, the FCTS demonstrated system effectiveness for analytes addressed by treatment technologies. All contaminants with concentrations exceeding CSRGs/PQLs in treatment plant influent were reduced to concentrations less than CSRGs/PQLs in the treatment plant effluent.

5.1.2 FCTS Performance Evaluation

The performance criteria for the FCTS were designed to address future monitoring needs and facilitate the system performance evaluation and are presented below:

- Demonstrate effective mass removal through comparison of total calculated mass removed by the FCTS for each of the CSRG analytes and mass flux approaching the system estimated combined well capture and transect methods.
- Demonstrate that concentrations in downgradient performance wells are stable or decreasing.

Evaluation of system effectiveness is presented in Sections 5.1.2.1 and 5.1.2.2 for each of the performance criteria.

5.1.2.1 FCTS Mass Removal

As discussed previously for the BANS, a revised approach to evaluate contaminant mass removal was proposed relative to the LTMP performance criterion by comparing the mass approaching the system to the amount of mass extracted by the system.

Consistent with the methodology incorporated into the LTMP in 2012 (OCN-LTMP-2012-002), the two methods are used in combination to estimate contaminant mass removal:

- Transect method – Used to estimate the mass flux approaching the FCTS.
- Well capture method – Used to estimate the mass removal extracted within the FCTS capture zone by extraction wells.

The mass removal performance criterion specifies removal of at least 75 percent of the contaminant plume mass migrating toward the system. Additional details on the technical approach and methodology for the evaluation of contaminant mass removal are presented in the LTMP revisions under OCN-LTMP-2023-004.

The calculations for contaminant mass removal for the FCTS are provided in the Excel file accompanying this report (FY23 FCTS Mass Removal Rev0.xlsx).

Groundwater flows through the FCTS to the west-northwest as presented in Figure F-3. The FY23 estimated rate of contaminated groundwater flow approaching the FCTS is 74.28 gpm based on the plume transect, which is located 800–1,200 feet upgradient of the extraction system. Along this transect, the estimated flow rate of contaminated groundwater into the capture zone is 67.03 gpm, and the flow outside the capture zone is 7.25 gpm (Table 5.1-2).

In FY23, the mass flux for all CSRG analytes detected in the plume approaching the extraction system was 268,428 pounds/year, with 238,673 pounds and 29,755 pounds flowing within and outside of the capture zone, respectively (see Table 5.1-2). The majority of the plume mass flux is attributed to chloride, sulfate, and fluoride. The mass captured by the extraction system was 158,682 pounds. Based on these data, 59.1 percent of the overall mass approaching the system flows into the capture zone and is extracted, which is less than the performance goal of 75 percent.

As previously noted in the annual reports, the discrepancy between the plume mass flux and captured mass may be attributable to one or more of the following factors: position of plume transect located 800–1,200 feet upgradient of the extraction wells, the effect of recharged groundwater that contains a high percentage of mass attributable to anions that are not treated, the conservative assumptions made to calculate mass flux relative to the homogeneity of groundwater concentrations and flow rates, and/or attenuation processes (i.e., biodegradation, dispersion, adsorption, etc.) that may take place as contaminants migrate towards the extraction wells causing groundwater contaminant concentrations to change *in situ*.

As shown in Table 5.1-3, the total and capture zone plume flows, and the associated plume mass approaching the system, was higher in FY23 compared to FY22, while the mass captured within the extraction wells was lower. The increased plume flow in FY23 is attributed to an increase in water levels across the site, including the mass flux transect, and an increase in the hydraulic gradient. High levels of precipitation occurred across the RMA off-post OU during the spring of 2023, which eventually caused severe flooding within the First Creek system area in June. In addition, extraction well 37830 was not operating for four months in FY23, thus reducing the average flow rate compared to the system design parameters which resulted in a lower mass of captured contaminants.

It is recommended that further evaluation of the First Creek system be conducted to determine whether operations and/or monitoring can be optimized to demonstrate more effective capture of contaminants within the system area.

5.1.2.2 FCTS Downgradient Performance Evaluation

The second performance criterion for FCTS is to demonstrate that concentrations of CSRG analytes are below the CSRGs/PQLs, or are stable or decreasing, in downgradient performance wells. In FY23, concentrations of the following CSRG analytes (both anions) exceeded CSRGs/PQLs in two performance wells located downgradient of the FCTS:

- Chloride – 37110 and 37116
- Fluoride – 37110
- Sulfate – 37110 and 37116

Exhibit F-4, Appendix F, provides a summary of FY23 performance well analytical data. Figures F-5 through F-11 in Appendix F show concentrations of analytes that exceeded CSRGs/PQLs in upgradient and downgradient performance wells.

Table 5.1-4 presents an overview of the FY23 water quality results and concentration trends for the FCTS performance wells. Time versus concentration maps and charts depicting long-term trends are presented in Figures F-12 through F-16 showing the concentrations for chloride, DIMP, dieldrin, fluoride, and sulfate in upgradient and downgradient performance monitoring wells.

Only chloride, fluoride, and sulfate were detected in downgradient performance wells exceeding the CSRGs. While these anions exceeded CSRGs/PQLs in both upgradient and downgradient wells in FY23, no increasing concentration trends are evident. As it appears that the concentrations of chloride, fluoride, and sulfate are not increasing and have remained relatively stable, it is likely that the levels in groundwater are not due to residual contamination, but are naturally occurring.

Future monitoring of FCTS performance wells will aid in evaluating long term system effectiveness as operations continue. While aldrin was not detected in downgradient performance wells, it was detected in upgradient performance well 37083 for the first time since 2009, and the concentration exceeded the PQL.

5.1.3 FCTS Quality Assurance Summary

The purpose of the data review is to evaluate data quality with respect to the established DQOs. Components of the data review process include: 1) evaluating the data against the data quality indicators precision, bias, representativeness, completeness, sensitivity, and comparability; 2) review of field and laboratory QC results; and 3) evaluating the data for suitability based on the intended use. The data review has determined that the data quality meets or exceeds the established DQOs and is of the correct type, quality, and quantity to support the intended use. Detailed information on the quality assurance evaluation for samples collected to support the FCTS in FY23 is provided in Appendix I1.4.

5.1.4 FCTS Summary and Conclusions

In FY23, the FCTS operated at an average flow rate of 55.7 gpm, pumped a total volume of 29,018,947 gallons, and removed a total of 2.5 pounds of contaminant mass. The major contaminants removed via treatment included DIMP and, to a lesser extent, DCPD. There were no CSRG-analyte exceedances of the four-quarter moving averages in the FCTS effluent in FY23. Concentrations of anions were less than CSRGs in plant influent and effluent during FY23. Concentrations of sulfate in plant effluent appear to have attenuated to below the CSRG. The FCTS system met the performance criteria and objectives established in the LTMP. Thus, the FCTS was functioning as intended.

The mass removal at the FCTS was 59.1 percent, which does not meet the performance goal of 75 percent removal. The discrepancy between the plume mass flux and captured mass at the FCTS is likely attributable to one or more of the following factors: the position of plume transect located 800-1,200 feet upgradient of the extraction wells, the effect of recharged groundwater that contains a high percentage of mass attributable to anions not treated, and/or the conservative assumptions made to calculate mass removal relative to the homogeneity of groundwater concentrations and flow rates. In addition, extraction well 37830 was not operating for four months in FY23, thus reducing the average flow rate compared to the system design parameters which resulted in a lower mass of captured contaminants.

Concentrations of anions detected greater than CSRGs in FCTS downgradient performance wells 37110 and 37163 will continue to be monitored to evaluate attenuation.

5.2 NORTHERN PATHWAY TREATMENT SYSTEM

5.2.1 NPTS Operations and Compliance

The NPTS startup began on January 31, 2022, and operated at an average flow rate of 160 gpm. The system pumped a total volume of 84,492,278 gallons during FY23, removing a total of 0.07 pounds of contaminant mass. The major contaminants removed via treatment included dieldrin and tetrachloroethylene (Table 5.2-1). The total cost to operate the treatment plant in FY23 was $339,326 (Table 5.2-1). Figure G-1 in Appendix G shows the locations of NPTS monitoring wells, extraction wells and recharge trenches.

Compliance for all treatment systems at RMA is based on quarterly effluent water quality monitoring. Each system has a list of compliance analytes for which CSRGs were developed in the On-Post and Off-Post RODs. The current CSRG list, including any revisions since the RODs were developed, is provided in the LTMP. The system effluent for the NPTS was analyzed quarterly in FY23 using the LTMP routine CSRG analyte list for the NPTS and annually using the complete CSRG list.

The treatment plant influent concentrations for dieldrin and NDPA exceeded the CSRGs/PQLs as shown in Figures G-2 and G-3 (Appendix G). As presented in Table 5 in each of the quarterly *Treatment Plant Effluent Water Quality Data Reports FY23*, the NPTS individual effluent concentrations and associated four-quarter moving averages showed no exceedances during FY23 (Navarro 2023b, 2023c, 2024a, 2024c). The graphs for dieldrin and NDPA indicate that while treatment plant influent concentrations exceeded CSRGs/PQLs, concentrations in the plant effluent did not exceed CSRGs/PQLs in FY23.

5.2.2 NPTS Performance Evaluation

The performance criteria for the NPTS were designed to address future monitoring needs and facilitate the system performance evaluation and are presented below:

- Demonstrate effective mass removal through comparison of total calculated mass removed by the NPTS for each of the CSRG analytes and mass flux approaching the system estimated combined well capture and transect methods.

- Demonstrate that concentrations in downgradient performance wells are stable or decreasing.

Evaluation of system effectiveness is presented in Sections 5.2.2.1 and 5.2.2.2 for each of the performance criteria.

5.2.2.1 NPTS Mass Removal

As discussed previously for the BANS and FCTS, a revised approach to evaluate contaminant mass removal was proposed relative to the LTMP performance criterion by comparing the mass approaching the system to the amount of mass extracted by the system.

Consistent with the methodology incorporated into the LTMP in 2012 (OCN-LTMP-2012-002), the two methods are used in combination to estimate contaminant mass removal:

- Transect method – Used to estimate the mass flux approaching the NPTS.
- Well capture method – Used to estimate the mass removal extracted along the line of NPTS extraction wells.

The mass removal performance criterion specifies removal of at least 75 percent of the contaminant plume mass migrating toward the system. Additional details on the technical approach and methodology for the evaluation of contaminant mass removal are presented in the LTMP revisions under OCN-LTMP-2023-004.

The calculations for contaminant mass removal for the NPTS are provided in the Excel file accompanying this report (FY23 NPTS Mass Removal Rev0.xlsx).

Groundwater flows through the NPTS to the west-northwest as presented in Figure G-4. The FY23 estimated rate of contaminated groundwater flow approaching the NPTS is 181.08 gpm based on the plume transect, which is located along the alignment of the extraction system. Along this transect, the estimated flow rate of contaminated groundwater into the capture zone is 176.49 gpm, and the flow outside the capture zone is 4.59 gpm (Table 5.2-2).

In FY23, the mass flux for all CSRG analytes detected in the plume approaching the extraction system was 314,675 pounds/year, with 305,088 pounds flowing within the capture zone, and 9,587 pounds outside of the capture zone (Table 5.2-2). The majority of the plume mass flux is attributed to chloride, sulfate, and fluoride. Based on these data, 85.9 percent of the mass approaching the system flows into the capture zone for eventual extraction. Compared to the total mass approaching the system, 262,122 pounds was extracted, equating to an overall mass removal of 83.3 percent (Table 5.2-2).

The discrepancy between the plume mass flux and captured mass may be attributable to one or more of the following factors: the effect of recharged groundwater that contains a high percentage of mass attributable to anions that are not treated, the conservative assumptions made to calculate mass flux relative to the homogeneity of groundwater concentrations and flow rates, and/or attenuation processes (i.e., biodegradation, dispersion, adsorption, etc.) that may take place as contaminants migrate towards the extraction wells causing groundwater contaminant concentrations to change *in situ*.

5.2.2.2 NPTS Downgradient Performance Evaluation

Similar to the FCTS, the second performance criterion for NPTS is to demonstrate that concentrations of CSRG analytes are below the CSRGs/PQLs, or are stable or decreasing, in downgradient performance wells. In FY23 concentrations of the following CSRG analytes exceeded CSRGs/PQLs in several wells downgradient of the NPTS:

- Chloride – 37008 and 37101
- Dieldrin – 37011
- NDPA – 37101

Exhibit G-5, in Appendix G, provides a summary of FY23 performance well analytical data. Figures G-6 through G-11 show concentrations of analytes that exceeded CSRGs/PQLs in upgradient and downgradient performance wells including carbon tetrachloride, chloride, dieldrin, fluoride, NDPA, and sulfate in FY23. Table 5.2-3 presents an overview of the FY23 water quality results and concentration trends for the NPTS performance wells. Time versus concentration maps and charts depicting long-term trends are presented in Figures G-12 through G-16 showing the concentrations for chloride, dieldrin, fluoride, NDPA, and sulfate in upgradient and downgradient performance monitoring wells.

Chloride, dieldrin, and NDPA were the only contaminants detected in downgradient performance wells above CSRGs/PQL in FY23. The concentration of dieldrin in downgradient well 37011 exceeds the PQL for the first time and there is an indication that the trend is increasing (Table 5.2-3). NDPA was detected in downgradient well 37101 at a concentration exceeding the PQL, but not enough data are available to determine whether the trend is increasing or decreasing.

As presented in Exhibit G-5, chloride, fluoride, and sulfate were detected above CSRGs in FY23 in cross-gradient performance well 37027. Table 5.2-3 shows that the concentrations of chloride demonstrating an increasing trend, with concentrations of fluoride and sulfate indicating trends are stable or not discernible. Long-term concentration trends for chloride, fluoride, and sulfate are presented in maps and charts for Figures G-12, G-14, and G-16, respectively.

Although elevated concentrations of chloride and sulfate are present in groundwater within the NPTS, the standards are expected to be met by attenuation consistent with the Off-Post ROD (HLA 1995). Concentrations of sulfate in plant effluent have attenuated to below the CSRG. Future evaluation will take place in order to assess chloride attenuation in groundwater towards meeting remediation goals.

5.2.3 NPTS Quality Assurance Summary

The purpose of the data review is to evaluate data quality with respect to the established DQOs. Components of the data review process include: 1) evaluating the data against the data quality indicators precision, bias, representativeness, completeness, sensitivity, and comparability; 2) review of field and laboratory QC results; and 3) evaluating the data for suitability based on the intended use. The data review has determined that the data quality meets or exceeds the established DQOs and is of the correct type, quality, and quantity to support the intended use.

Detailed information on the quality assurance evaluation for samples collected to support the NPTS in FY23 is provided in Appendix I1.5.

5.2.4 NPTS Summary and Conclusions

The NPTS began operating on January 31, 2022 and met the treatment plant compliance requirements established in the LTMP. The NPTS operated at an average flow rate of 160 gpm, pumping a volume of 84,492,278 gallons, and removing 0.07 pounds of contaminant mass during FY23.

There were no CSRG-analyte exceedances of the four-quarter moving averages in the NPTS effluent in FY23. The NPTS met the compliance and performance criteria and objectives established in the LTMP. Thus, the NPTS was functioning as intended.

The mass removal at the NPTS was 83.3 percent, meeting the performance goal of 75 percent removal in FY23. The discrepancy between the plume mass flux and captured mass at the NPTS is likely attributable to one or more of the following factors: the effect of recharged groundwater that contains a high percentage of mass attributable to anions not treated, and/or the conservative assumptions made to calculate mass removal relative to the homogeneity of groundwater concentrations and flow rates.

In FY23, dieldrin and NDPA were the only organic contaminants detected above the CSRGs/PQLs in downgradient performance wells—wells 37011 and 37101, respectively. Chloride was the only anion detected above the CSRGs in FY23 in downgradient performance wells—wells 37008 and 37101. Chloride, fluoride, and sulfate were detected above CSRGs in FY23 in cross-gradient performance well 37027.

6.0 SITE-WIDE ON-POST MONITORING

The site-wide on-post monitoring evaluation includes data from water level tracking, water quality tracking, and CFS monitoring. Water level monitoring for water level tracking is performed annually and a water level contour map is used to present the potentiometric surface across the on-post and off-post areas. The twice-in-five-years groundwater quality sampling of both UFS and CFS wells was last conducted in FY22, along with the once-in-five-years water quality tracking. The next twice-in-five-years groundwater quality sampling will take place in FY24, with sampling of wells for both frequencies planned for FY27.

Water level and water quality monitoring are conducted in areas upgradient of the containment systems to track changes in groundwater flow and contaminant migration within the UFS. Delineation and characterization of groundwater contaminant plumes were completed during the RI/FS and used to describe baseline conditions at the time of remedy selection. Remedies implemented within designated source areas were assumed to have short-term and long-term effects on water levels and water quality. Through implementation of long-term monitoring, the effects of these remedies will be substantiated by tracking water levels and the resulting groundwater flow paths and associated water quality over time. The objective of long-term monitoring is to detect any changes in groundwater conditions that are indicative of remedy performance after implementation. To meet the primary objective of long-term monitoring, a limited number of wells located proximal and downgradient to source areas, and upgradient of the boundary containment systems, are sampled for indicator analytes that represent constituents of the major plumes on post.

6.1 WATER LEVEL TRACKING

Water level tracking, which includes measuring on-post and off-post water levels and determining groundwater flow directions, is the primary means of tracking the effects of remedy activities. Water levels were measured in both on-post and off-post water-level wells in FY23. Each year, the Army collects water level data to construct a site-wide water level map of the RMA, which is used to determine groundwater flow paths and identify changes in groundwater flow directions within the UFS that could affect contaminant plume migration. The site-wide water-table contour map is provided in Figure H-1 in Appendix H.

As expected, remediation activities—such as the installation of groundwater extraction and recharge systems, engineered caps and covers, and slurry walls—have had an effect on water levels in localized areas across the RMA. Precipitation events also affect water levels and are an important source of recharge to the shallow UFS at RMA. The Army collects precipitation data on-post from two locations in Section 36, one at the Shell Disposal Trenches and one at the Lime Basins.

The annual precipitation at RMA, measured at the rain gauge station at the Lime Basins, was 20.92 inches in FY23, which is 9.79 inches more than what was measured in FY22. Annual precipitation data over the past five years, FY19 through FY23, showed a variable trend ranging from a low of approximately 8.46 inches in FY20 to a high of approximately 20.92 inches in FY23. Precipitation in FY23 accounted for short-term water level increases in areas where rainfall impacted surface water resulting in groundwater recharge—specifically in areas downgradient of the lakes at RMA and off post along First Creek area where localized flooding occurred in June 2023.

6.2 WATER QUALITY TRACKING

The Water Quality Tracking network, presented in Figure H-2, is sampled twice every five years, with the exception of annual sampling required for select wells in the vicinity of the former MPS/ICS. The next site-wide Water Quality Tracking monitoring event is scheduled for FY24.

In FY23, annual sampling took place for MPS/ICS wells 04535 and 33081 as required under the *Motor Pool System/Irondale Containment System Post-Shut-Off Monitoring Sampling and Analysis Plan* (URS 2011). Well 04535 is downgradient of the MPS and was sampled for trichloroethylene. Well 33081 is located between the RYCS and former ICS and was sampled for DBCP. Trichloroethylene was detected in well 04535 at a concentration of 0.604 µg/L, below the CSRG of 5 µg/L (Table 6.2-1). DBCP was not detected in well 33081.

The quality assurance review of data for wells 04535 and 33081 determined that the data quality meets or exceeds the established DQOs and is of the correct type, quality, and quantity to support the intended use. Detailed information on the quality assurance evaluation for samples collected to support the MPS/ICS shut-off monitoring program in FY23 is provided in Appendix I1.6.

6.3 CONFINED FLOW SYSTEM MONITORING

The CFS network was not sampled in FY23 in accordance with the LTMP sampling schedule. CFS water quality sampling was last conducted in FY22 as part of the twice-in-five-years monitoring program. The next CFS sampling event is scheduled for FY24. Figure H-3 presents a map of the CFS monitoring network.

In May 2020, the regulatory agencies were notified about the increased concentration of dieldrin in in three CFS wells located north of Basin F at concentrations triggering notification. Based on the first-time presence of dieldrin in groundwater within CFS wells downgradient of Basin F, monitoring data and well integrity will be evaluated in FY24 to better assess the nature of CFS contamination (Navarro 2024b).

To address the address the elevated levels of chloride in CFS well 35083, an out-of-cycle sample was collected form this well in FY23 in May 2023. Chloride was detected in well 35083 at a concentration of 1,520,000 µg/L in FY23. Although elevated, the concentration of chloride in this well has been relatively stable since 2009.

In addition to the investigation of the presence of dieldrin in CFS wells, a future evaluation of chloride in the CFS is planned to determine the source of elevated chloride levels in well 35083. A recommendation was made in the FY19 ASR/FYSR to consider the collection of data that will support the characterization of water quality in the CFS to determine whether the elevated levels of chloride is consistent with natural background, and not related to degradation of RMA contamination.

7.0 SITE-WIDE OFF-POST MONITORING

7.1 OFF-POST EXCEEDANCE MONITORING

In accordance with the LTMP sampling schedule, no off-post exceedance monitoring was conducted in FY23. Off-post exceedance monitoring was last conducted in FY22 at each location presented in Figure H-4, Appendix H. The results were published in the FY22 Off-Post CSRG Exceedance Map (Army 2023a). Off-post exceedance monitoring will next take place in FY24.

7.2 OFF-POST SURFACE WATER MONITORING

In order to evaluate the effect of groundwater treatment on surface water quality off-post of RMA, sampling must be conducted during low-flow or base-flow conditions when groundwater is most likely to be discharging into First Creek. Surface water quality monitoring takes place at SW24004 (First Creek at the north fence line) and off-post site SW37001 (First Creek at Highway 2). An upstream sampling location (SW08003), where First Creek flows onto RMA, was added in FY13 to provide data for comparison to the two downstream sites. Figure H-5, Appendix H, presents the locations of LTMP off-post surface water sample locations.

Surface water sampling was not conducted in FY23 because First Creek did not exhibit low-flow or base-flow conditions during the third and fourth quarters of the year when sampling is required (LTMP, Navarro 2021). Higher-than-normal precipitation occurred within the vicinity of RMA where there was substantial flooding along First Creek extending from the northern boundary of the site and throughout the footprint of the FCTS. Flooding was extensive enough within the FCTS that Highway 2 was closed at the western end of the treatment system area. An OCN to the LTMP (OCN-LTMP-2024-002) was approved in January 2024 to begin collecting surface water samples even if low flow conditions are not met.

7.3 ADAMS COUNTY HEALTH DEPARTMENT OFF-POST GROUNDWATER MONITORING

In FY23, the Private Well Monitoring Program was administered by ACHD in accordance with a MOA with the Army executed in April 2023 (Army 2023b). Under the program, ACHD samples private wells and surface water sources in the off-post study area. This program is separate and independent from the off-post monitoring program administered and conducted by the Army.

Private well monitoring provides water quality data to address community health concerns and communicate the effectiveness of the remedy to the public related to off-post groundwater contamination. Data from the ACHD private well monitoring program are used to help delineate the CSRG exceedance area. In addition, ACHD may collect samples from newly installed private wells within the CSRG exceedance area and from off-post confined aquifer wells that may function as conduits for contaminants to migrate from the shallower UFS to the confined flow systems within the Denver Formation and deeper aquifers such as the Arapahoe Formation.

Eleven private wells—including five alluvial wells and six wells providing drinking water from the Arapahoe Formation—were sampled for DIMP, dieldrin, and 1,4-dioxane by ACHD in FY23

(ACHD 2023). In FY23, well 359D had a DIMP detection of 11.9 µg/L, which exceeds the CBSG of 8 µg/L. No other analyte concentrations exceeded CSRGs/PQLs in off-post private wells in FY23.

Well 359D was installed by the Army in November of 2016 to replace well 359A. In July 2021, a field investigation took place to evaluate the integrity of the well and determine whether DIMP in groundwater could be isolated to a specific zone within the Arapahoe aquifer. The DIMP concentration within the upper and lower screened zones exceeded the CBSG for DIMP (Navarro 2022e). As a result of the field investigation, it was recommended that a small-scale "point of entry" carbon filtration system be installed at the wellhead in order to provide uncontaminated water to the residents on the property. To date, the homeowner has refused to allow the Army to install the point of entry treatment system at the residence. Bottled water is currently being provided to the residents.

Table 7.3-1 presents a summary of the analytical results for off-post private well sampling. The *Private Well Monitoring Program Annual Summary for Fiscal Year 2023* (ACHD 2023) is presented in Appendix J.

8.0 PERFLUOROALKYL AND POLYFLUOROALKYL SUBSTANCES

Per- and polyfluoroalkyl substances (PFAS) are a group of man-made chemicals that include many compounds. PFAS have been classified as emerging contaminants by the EPA and the DoD. The following PFAS are monitored at RMA:

- Perfluorobutanesulfonic acid (PFBS)
- Perfluorohexane sulfonic acid (PFHxS)
- Perfluorononanoic acid (PFNA)
- Perfluorooctanoic acid (PFOA)
- Perfluorooctanesulfonic acid (PFOS)
- Hexafluoropropylene oxide dimer acid (HFPODA), commonly referred to as GenX chemicals

The Army issued guidance for evaluating restoration sites for potential PFAS contamination in 2016. The Army conducted an investigation from July 2017 to August 2018 to assess the potential for PFAS groundwater contamination at the RMA (Navarro 2017). The results of the investigation indicated detectable levels of PFOA and PFAS in RMA groundwater, although only one location near the South Plants area where PFAS foam was used was above the 2016 EPA health advisory level (0.07 µg/L). The initial investigation concluded that further characterization of PFAS contamination was necessary (Navarro 2019b).

In FY19, PFOA and PFOS were analyzed in samples from a select group of wells and the influent and effluent of the treatment plants to verify the results from 2017 and 2018, and determine the extent of potential releases at RMA. PFOA and/or PFOS were detected above the 2016 health advisory level (0.07 µg/L) in one South Plants well, which is located in the area of the single documented use on site, and in four wells located immediately downgradient of the use area. PFOA and PFOS were not present at concentrations above the 2016 health advisory level in the remaining wells sampled or in the treatment plants influent/effluent (Navarro 2020).

Subsequently, the LTMP was revised to include PFAS for select water quality tracking wells, which are sampled once every five years, within and downgradient of the South Plants source area. PFAS were also added to annual treatment plant influent and effluent sampling to provide continued monitoring of these emerging contaminants (OCN-LTMP-2020-004). Treatment plant monitoring frequency was subsequently revised to quarterly, beginning in the first quarter of FY23 (OCC-LTMP-2023-006).

In 2018, EPA began including Regional Screening Levels (RSL) for PFAS on their default screening level tables for ingestion of drinking water. In June of 2022, EPA published revised lifetime drinking water health advisories for four perfluoroalkyl substances, including updated health advisories for PFOA and PFOS and new final health advisories for PFBS and HFPODA (EPA 2022a). Consistent with DoD guidance, issued in July 2022, RMA expanded its PFAS analytical list to also include PFBS, PFHxS, PFNA, and HFPODA (DoD 2022). For this evaluation, the most recent RSLs, published in May 2024, are used for comparison to monitoring results.

8.1 TREATMENT PLANT SAMPLING

Influent and effluent samples were collected quarterly in FY23 and analyzed for six PFAS. PFAS—including PFBS, PFHxS, PFOA, and PFOS—were detected in the influent samples collected at the NWBCS, BANS, FCTS, and NPTS treatment plants with concentrations exceeding the respective RSLs for PFOA and PFOS. PFBS and PFHxS were detected in the influent at the NBCS at concentrations below RSLs. Analytical results for PFAS treatment plant effluent monitoring results are summarized below:

- PFBS was detected in NWBCS plant effluent during the first and fourth quarters of FY23. The PFBS effluent concentrations were less than the RSL (0.6 µg/L).
- PFBS was detected in the FCTS and NPTS plant effluent during three of the four quarters of FY23. The PFBS effluent concentrations were less than the RSL (0.6 µg/L).
- PFHxS was detected in the NPTS effluent during the fourth quarter of FY23. The PFHxS effluent concentration was less than the RSL (0.039 µg/L).
- PFNA was not detected in any quarterly effluent samples collected from the treatment plants during FY23.
- PFOA and HFPODA were detected in the NPTS plant effluent during the first quarter of FY23. The PFOA effluent concentration of 0.0019 µg/L exceeded the RSL (0.0000027 µg/L). However, the concentration was below the Maximum Contaminant Level (MCL) that was finalized in 2024 (0.004 µg/L).
- PFOS was not detected in any quarterly effluent samples collected from the treatment plants during FY23.

Analytical results for PFAS treatment plant monitoring in FY23 are provided in Table 8.1-1.

8.2 GROUNDWATER MONITORING

PFAS monitoring is included in the Water Quality Tracking network for wells 01525, 36181, 36210, 36627, and 36631 and occurs once every five years. In accordance with LTMP, these wells were not sampled in FY23, and will next be sampled in FY27.

Although there were no groundwater standards applicable to RMA in FY23, NWBCS and NBCS downgradient performance wells were sampled in FY23 to provide additional water quality information. PFAS was not detected in wells downgradient of the NWBCS Original System. well 27522, located downgradient of the NWBCS SWE, had detectable levels of PFBS, PFHxS, PFOA and PFOS. Of the 11 downgradient performance wells at the NBCS, seven had detectable levels of at least one PFAS. Concentrations of PFOA and PFOS in these wells exceeded the RSLs. The LTMP was revised under OCN-LTMP-2024-001 to add PFAS monitoring to the annual treatment system downgradient performance well monitoring network at the NBCS, NWBCS, FCTS and NPTS systems to provide operational data for these emerging contaminants beginning in FY24.

9.0 SUMMARY AND CONCLUSIONS

The ASR includes an evaluation of the data collected to evaluate the compliance and performance criteria related to the operating systems, groundwater and surface water quality and hydrology, as well as other supplemental monitoring in FY23. In addition, the ASR includes data reporting for the FY23 site-wide monitoring programs, project-specific monitoring, and Consultative Process notifications.

Sections 9.1 through 9.4 summarize the results supporting the FY23 ASR reporting period as presented in greater detail within Sections 3 through 8 of this report.

9.1 ON-POST AND OFF-POST TREATMENT SYSTEMS

In general, the groundwater containment and mass removal systems met the treatment plant compliance monitoring criteria, and the performance criteria presented in the LTMP (Navarro 2021), as well as the objectives identified in the On-Post ROD (Foster Wheeler 1996) and Off-Post ROD (HLA 1995).

Performance criteria were not met in some portions of the NWBCS, BRES, and Lime Basins systems. Table 9.1-1 presents a summary of the compliance criteria and the system- and project-specific performance criteria and whether these criteria were met in FY23. In instances where compliance or performance criteria were not met, or data suggest that performance criteria are at risk of not being met, proposed or current actions are indicated and will be followed up in the FY24 ASR.

Summarized below are the results and conclusions for system-specific operational compliance monitoring and performance monitoring relative to the performance criteria and goals as stated in the LTMP.

9.1.1 On-Post Extraction and Treatment Systems

Northwest Boundary Containment System

- In FY23, the NWBCS operated at an average flow rate of 820 gpm, pumping a total volume of 431,089,815 gallons and removing a total of 1.8 pounds of contaminant mass.
- The NWBCS met the compliance and the primary performance criteria for the Original System and objectives established in the LTMP. The NWBCS had no CSRG/PQL analyte exceedances for quarterly samples or the four-quarter moving averages in the treatment system effluent in FY23, with the exception of dieldrin in the second quarter. A reverse hydraulic gradient was maintained within the system and plume capture was evident based on visual observation of the potentiometric surface within the original system as well as within the NEE and SWE. Thus, the NWBCS was functioning as intended.
- Dieldrin and NDPA were detected above the PQL/CSRG in Original System and NEE downgradient performance wells during the reporting period:

  - Original System downgradient wells 37331, 37332, 37333, and 37600 contained dieldrin above the PQL in FY23. However, the secondary performance criterion was met during the reporting period because the long-term trend was not increasing in these downgradient performance wells.
  - NEE downgradient well 22512 contained dieldrin and NDPA above the PQLs/CSRGs or CSRGs, and well 22015 contained dieldrin above the PQL in FY23. The secondary performance criterion was not met for dieldrin and NDPA in well 22512 because concentrations of dieldrin and NDPA demonstrate increasing trends in this downgradient performance well.
- Dieldrin and NDPA above their respective PQLs in downgradient performance wells may be attributed to a variety of factors including contamination due to mobilization of residual contamination or possible system bypass around the north end of the NEE slurry wall. An investigation of potential bypass of the NEE slurry wall was conducted in FY21 and a supplemental semiannual water quality monitoring program was completed in February 2023. The evaluation of the supplemental monitoring program resulted in recommended actions focusing on aquifer slug tests and pumping tests to take place in FY24. Results of the aquifer testing will support the feasibility and design for improved containment with supplemental extraction and recharge in the vicinity of the NEE.

Recommended Additional Action: Based on proposed aquifer testing, evaluate the feasibility of system optimization for improved containment within the NWBCS NEE and develop a plan to mitigate system bypass.

North Boundary Containment System

- In FY23, the NBCS operated at an average flow rate of 222 gpm and pumped a total volume of 115,130,496 gallons and removed a total of 11.3 pounds of contaminant mass.
- 1,4-Dioxane exceeded the CSRG in the plant effluent during all four quarters. As an emerging contaminant, 1,4-dioxane treatment was not part of the design for the NBCS and therefore is not treated by the system. n-Nitrosodimethylamine (NDMA) exceeded CSRG/PQL in the plant effluent during the second, third, and fourth quarters of FY23, and the moving average exceeded the PQL during the third and fourth quarters. Formal notification of the NDMA exceedances was made to the regulatory agencies on June 13, 2023.
- A reverse hydraulic gradient was maintained within the system during all four quarters of FY23. Plume capture is evident as indicated by the potentiometric surface map and the evaluation of downgradient water quality data. Relative to the primary performance criterion, the NBCS functioned as intended in FY23.
- Dieldrin occurred at concentrations above the CSRG/PQL in downgradient performance wells but shows indiscernible, stable, or decreasing trends in wells. 1,4-Dioxane and NDMA were detected at concentrations exceeding CSRGs/PQLs in downgradient wells and indicate an increasing trend in wells 24429 and 24006, respectively. Concentrations of anions chloride, fluoride, and sulfate also exceeded CSRGs. Chloride and sulfate are

expected to naturally attenuate to background levels. Based on the FY23 information, the contaminant plumes continue to be captured by the NBCS system.

Recommended Additional Action: Evaluate the occurrence and source of NDMA exceeding the CSRG/PQL in treatment plant effluent in order to mitigate elevated concentrations in groundwater downgradient of the system.

Basin A Neck System

- In FY23, the BANS operated at an average flow rate of 16.4 gpm and pumped a total volume of 8,628,067 gallons during FY23, removing a total of 55.9 pounds of contaminant mass. The BANS had no CSRG/PQL analyte exceedances for quarterly samples or the four-quarter moving averages in the treatment system effluent in FY23.
- The revised 90 percent mass removal criterion was met in FY23, with mass removal estimated at 99.9 percent. Concentrations of analytes that remain above CSRGs/PQLs indicate stable or decreasing trends. Thus, the BANS was functioning as intended.
- The BANS demonstrated treatment system effectiveness, specifically related to dieldrin, CPMSO2, and PPDDT. Each contaminant showed concentrations exceeding CSRGs/PQLs in upgradient groundwater and treatment plant influent, while concentrations in the treatment plant effluent were less than CSRGs/PQLs. Although these analytes occurred at concentrations greater than CSRGs/PQLs in downgradient performance wells, decreasing, indiscernible, or stable trends are indicated.

Bedrock Ridge Extraction System

- In FY23, the BRES did not meet the plume capture performance criteria and objectives established in the LTMP. Trichloroethylene in downgradient well 36566 shows an increasing concentration trend. Although the plume appears captured at both edges of the system, bypass may be occurring within the west-central portion of the extraction system.
- Evaluation of supplemental monitoring data collected from 2019 through 2021 resulted in a recommendation to include installation of one additional extraction well and one downgradient monitoring well as part of the future optimization of the system.

9.1.2 Other On-Post Systems

Complex Army Disposal Trenches

- In FY23, the CADT system met the performance criteria and objectives established in the LTMP. The inward gradient was maintained across the slurry wall and hydraulic control was maintained in the vicinity of performance wells 36216 and 36217.

Shell Disposal Trenches

- In FY23, the Shell Disposal Trenches met the performance criteria and objectives established in the LTMP. All groundwater elevations were below the bottom of the trenches at all of the borehole performance goal locations.

Lime Basins Slurry Wall Dewatering System

- The first performance criterion requires that a positive inward hydraulic gradient be maintained across the slurry wall. In FY23, an inward gradient was present in all well pairs on the southern side while an outward gradient was still present for all the well pairs on the northern side, consistent with results obtained since FY14. Groundwater elevations inside of the slurry wall have been steadily decreasing; however, progress toward meeting the goal is dependent on water level fluctuations outside the slurry wall.
- The second performance criterion requires that water levels inside the slurry wall are below the elevation of the bottom of the waste (5242 feet amsl). During all four quarters of FY23, the water elevation in each well inside the slurry wall was below the bottom of waste elevation. Therefore, this dewatering performance criterion was met during FY23.

Lime Basins DNAPL Remediation Monitoring

- The water level data and DNAPL measurements for FY23 indicated that DNAPL was detected in well 36235 outside and/or adjacent to the slurry wall. DNAPL was detected within the slurry wall in extraction wells 36315, 36319, and 36320 and monitoring wells 36231, 36235, and 36248. The data indicate that the slurry wall has not been adversely impacted by historical DNAPL contamination. Consistent head differentials across the slurry wall have been maintained for all the well pairs showing that the DNAPL remediation system is functioning as intended.
- The observed presence of DNAPL has been consistent since FY13. No additional areas of DNAPL were identified in the vicinity of the Lime Basins slurry wall in FY23. As required, a total of 7 gallons of DNAPL was removed from wells 36248, 36319, and 36320 in FY23 where the thickness was greater than 1 foot (TtEC and URS 2012). Current data indicate that no additional DNAPL sources zones appear to exist within the Lime Basins slurry wall and that the extent of DNAPL is decreasing. Removal of recoverable DNAPL will next take place in FY24.

North Plants LNAPL Pilot Removal Action

- In May and November 2022, LNAPL thickness was measured in well 25301 at 0.74 feet and 1.4 feet, respectively, and a bail down test was performed as required by the *North Plants Pilot Light Non-Aqueous Phase Liquid Removal System Action Plan*. Bail-down testing was completed on March 28, 2023, and 3 gallons of LNAPL were recovered from well 25301. Afterwards, there was no significant recovery of LNAPL in well 25301 for the next six months.
- Based on the pending *North Plants Pilot Light Non-Aqueous Phase Liquid Removal System Completion Report* (currently under Regulatory review), LNAPL monitoring should continue to occur quarterly in the two recovery wells and seven piezometers. If more than 6 inches of LNAPL is present in a recovery well, the well will be bailed down and the LNAPL will be disposed.

<u>Recommended Additional Action</u>: Revise the LTMP per OCN to remove references to the LRSAP, incorporate quarterly monitoring requirements, and prescribe recovery if more than 6 inches of LNAPL is observed in recovery wells.

9.1.3 Off-Post Extraction and Treatment Systems

First Creek Treatment System

- The FCTS operated at an average flow rate of 55.7 gpm, pumping a volume of 29,018,947 gallons, and removing a total of 2.5 pounds of contaminant mass.
- There were no individual exceedances of CSRGs/PQLs in the treatment plant effluent, including four-quarter moving averages, in FY23.
- Mass removal at the FCTS was 59.1 percent, which did not meet the performance goal of 75 percent removal in FY23. FY23 marks the first time that the mass removal performance goal was not met, the required notification to the agencies will accompany the transmittal of this report.
- No organic analytes, including dieldrin and diisopropyl methylphosphonate (DIMP), were detected at concentrations exceeding CSRGs/PQLs in FY23 in downgradient performance wells. Inorganic analytes including chloride and fluoride were detected above the CSRGs in FCTS downgradient performance wells and will continue to be monitored to determine whether continuous operations of the system results in decreasing concentrations downgradient of the system.

Recommended Additional Action: Maintain the current mass removal performance goal of 75 percent until the further optimization of the FCTS is completed. Mass removal can then be evaluated aligning with recommended system-specific goals based on an optimized monitoring network.

Northern Pathway Treatment System

- The NPTS operated at an average flow rate of 160 gpm, pumping a volume of 84,492,278 gallons, and removing a total of 0.07 pounds of contaminant mass.
- There were no CSRG-analyte exceedances of the four-quarter moving averages in the NPTS effluent in FY23.
- The mass removal at the NPTS was 83.3 percent, meeting the performance goal of 75 percent removal in FY23.
- Chloride, dieldrin, and NDPA were the only contaminants detected above the CSRGs/PQLs in FY23 in downgradient performance wells. Chloride, fluoride, and sulfate were detected above CSRGs in FY23 in cross-gradient performance well 37027. Anions are not treated at NPTS, and the lack of organic contaminants detected at levels less than CSRGs/PQLs indicate the system is effective.
- The NPTS met the performance criteria and objectives established in the LTMP. Thus, the NPTS was functioning as intended.

Recommended Additional Action: Maintain the current performance goal of 75 percent for the NPTS until mass removal can be evaluated aligning with system-specific goals.

9.2 SITE-WIDE MONITORING

A summary of the results of site-wide monitoring for the on-post and off-post programs is presented below for the reporting period. Based on the evaluation of data collected during the reporting period, additional actions have been recommended for some monitoring programs as indicated.

9.2.1 Site-Wide On-Post Monitoring

Water Level Tracking

- Overall, groundwater flow directions and associated migration of contaminant plumes have not changed significantly during the FY23 reporting period.

Water Quality Tracking

- The Water Quality Tracking network is sampled twice every five years, and last sampled in FY22. The next site-wide Water Quality Tracking monitoring event is scheduled for FY24.
- Wells 04535 and 33081, located in the vicinity of the former MPS/ICS, are sampled annually. Well 04535, located downgradient of the MPS, was sampled for trichloroethylene. Trichloroethylene was detected in well 04535 at a concentration of 0.604 µg/L, below the CSRG of 5 µg/L. Well 33081, located between the RYCS and former ICS, was sampled for DBCP and not detected.

Confined Flow System Monitoring

- The CFS network was not sampled in FY23 in accordance with the LTMP sampling schedule. CFS water quality sampling was last conducted in FY22 as part of the twice-in-five-years monitoring program. The next sampling event is scheduled for FY24.

9.2.2 Site-Wide Off-Post Monitoring

Off-Post Exceedance Monitoring

- The Off-Post Exceedance Monitoring network was not sampled in FY23 in accordance with the LTMP sampling schedule. Off-Post Exceedance monitoring was last conducted in FY22 as part of the twice-in-five-years monitoring program. The next Off-Post Exceedance monitoring event is scheduled for FY24.

Off-Post Surface Water

- Off-post surface water sampling was not conducted in FY23 because First Creek did not exhibit low-flow or base-flow conditions during the third and fourth quarters of the year when sampling is required. Higher-than-normal precipitation occurred within the vicinity of RMA where there was substantial flooding along First Creek extending from the northern boundary of the site and throughout the footprint of the FCTS. The next off-post surface water sampling event is scheduled for FY24.

<u>Recommended Additional Action</u>: Revise surface water monitoring requirements in the LTMP to provide for annual First Creek sampling if low flow conditions are not met. (Note: An OCN was issued to make this revision in January 2024.)

Adams County Health Department Off-Post Groundwater Monitoring

- Eleven private wells—including five alluvial wells and six wells providing drinking water from the Arapahoe Formation—were sampled for DIMP, dieldrin, and 1,4-dioxane in FY23. Well 359D had a DIMP detection of 11.9 µg/L, which exceeds the CBSG of 8 µg/L. No other analyte concentrations exceeded CSRGs/PQLs in off-post private wells in FY23.
- Well 359D was installed in November 2016, and is screened in two separate zones in the Lower Arapahoe aquifer, similar to the well it replaced, 359A. In July 2021, a field investigation took place to evaluate the integrity of the well and whether DIMP in groundwater could be isolated to a specific zone within the Arapahoe aquifer. The result of the field investigation was a recommendation that a small-scale "point of entry" carbon filtration system be installed at the wellhead in order to provide uncontaminated water to the residents on the property. To date, the homeowner has refused to allow the Army to install the point of entry treatment system at the residence. Bottled water is currently being provided to the residents.

9.3 PERFLUOROALKYL AND POLYFLUOROALKYL SUBSTANCES

- Influent and effluent samples were collected quarterly in FY23 and analyzed for the six PFAS.
- PFAS were detected in the influent samples—including PFBS, PFHxS, PFOA, and PFOS—collected at the NWBCS, BANS, FCTS, and NPTS treatment plants with concentrations exceeding the respective RSLs for PFOA and PFOS. PFBS and PFHxS were detected in the influent at the NBCS at concentrations below RSLs.
- PFAS were detected in the effluent samples—including PFBS, PFHxS, and PFOA—collected at the NWBCS, FCTS, and NPTS treatment plants. PFBS was detected in NWBCS, FCTS, and NPTS plant effluent during FY23 and concentrations were less than the RSL (0.6 µg/L). PFHxS was detected in the NPTS effluent during the fourth quarter of FY23 below the RSL (0.039 µg/L). PFOA was only detected in NPTS plant effluent during the first quarter of FY23, and the concentration exceeded the RSL (0.0000027 µg/L). However, the concentration was below the drinking water MCL that was finalized in 2024.
- PFAS monitoring was included for the boundary treatment system downgradient performance wells to provide additional information related to groundwater quality. Concentrations of PFOA and PFOS exceeded the RSLs in wells downgradient of the NBCS and in well 27522 downgradient of the NWBCS SWE.
- PFAS monitoring is included in the Water Quality Tracking network for wells 01525, 36181, 36210, 36627, and 36631 and occurs once every five years. While sampling did not take place in FY23, these wells will next be sampled in FY27 in accordance with the LTMP.

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TABLES

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Table 1.1-1. Summary of Agency Notifications and Operational Change Notices

Date	Issue	Description	Corrective Action or Change
FY23 Trigger Events and Agency Notifications			
10/25/2022	NBCS – Loss of primary performance criterion, reverse hydraulic gradient for one quarter	Reverse hydraulic gradient was not maintained across the NBCS slurry wall in well pair 23528/23535 during the fourth quarter FY22.	Operational measurements during the fourth quarter indicated several well pairs with forward gradient across the slurry wall, with gradients ranging from 0.17 feet to 1.95 feet. Adjustments in extraction well and recharge trench flows were made to improve performance and reverse gradient was restored at all well pairs except 23528/23535. At the close of the fourth quarter, the forward gradient at this well pair had reduced to 0.3 feet.
2/14/2023	NWBCS – Individual effluent sample above CSRGs	Quarterly sampling was performed at the NWBCS on 1/4/2023. The dieldrin concentration in the plant effluent sample was 0.014 ug/L, which exceeds the current PQL of 0.013 ug/L. Influent concentration was 0.21 ug/L, consistent with typical influent concentrations. The four-quarter moving average for dieldrin remains in compliance at 0.0079 ug/L.	Normal carbon adsorber rotation was completed in December 2022, after which the plant experienced carbon fines plugging the effluent filters. Two power outages on 12/21/2022 and 1/2/2023, likely caused fines to be discharged from the adsorbers during subsequent system start-up. The presence of excess fines after adsorber rotation and power outages likely caused the elevated effluent concentration. Effluent concentrations had been non-detect or below the PQL since the previous exceedance in July 2015. No operational changes are proposed at the time. The sight glass was replaced on the Adsorber V-102 blow case to provide better visibility in determining removal of carbon fines when washing the fresh carbon. Additional operational samples were collected to verify that effluent from V-102 remained below the PQL.
6/13/2023	NBCS – Individual effluent sample above CSRGs	Quarterly sampling was performed at the NBCS on 1/26/2023. The NDMA concentration in the plant effluent sample was 0.0248 ug/L, which exceeds the current PQL of 0.009 ug/L. While the plant data were being reviewed, subsequent regularly scheduled quarterly sampling was conducted on 4/4/2023, and the concentration was 0.0161 ug/L, which also exceeded the PQL. With the third quarter results, the four-quarter moving average was 0.011 ug/L.	Potential causes for the occurrence of NDMA include fluctuation in plant influent concentrations and/or issues with the ultra-violet (UV) treatment system. Although the long-term influent trend is decreasing, influent concentrations exhibited a slight increasing trend over the last five years, and operational adjustments were made in FY23 to reduce the effluent NNDMEA concentrations. The NBCS typically achieves adequate NNDMEA treatment with four UV lamps in service and two additional lamps were placed in service in early June 2023 after verification that lamp usage did not exceed the 3,000-hour life recommended by the manufacturer. In addition, the quartz tubes housing the UV lamps were replaced in early July 2023 to ensure transmissivity was not diminished from use. Operational samples in July and August 2023 indicated an improvement in the UV system effluent.

Table 1.1-1. Summary of Agency Notifications and Operational Change Notices

Date	Issue	Description	Corrective Action or Change
FY23 Operational Change Notices			
Approved 10/17/2022	Damaged FCTS performance well 37084	FCTS downgradient performance well 37084 was damaged during Commerce City mowing operations along Highway 2. The well could not be repaired.	OCN-LTMP-2022-005 – The LTMP was revised to replace the damaged well with nearby existing well 37116. LTMP text, tables, and figures were revised to reflect the new performance well.
Approved 11/10/2022	Off-post CSRG Exceedance Network	Monitoring of wells downgradient of the NWBCS identified a dieldrin plume with some concentrations exceeding the dieldrin PQL. The existing network of wells was not sufficient for long-term monitoring.	OCN-LTMP-2022-006 – The LTMP was revised to add a network of 10 wells downgradient of the NWBCS to monitor the existing dieldrin plume. Five new wells and five existing wells were added to the off-post CSRG exceedance network.
Approved 3/24/2023	NPTS Performance Monitoring Network Off-post Water Level Network Off-post CSRG Exceedance Network	NPTS performance wells 37012 and 37013 were abandoned after FY22 monitoring due to termination of the Army lease and ongoing construction in the area. Existing wells 37030 and 37101 were evaluated and determined to be suitable replacement wells for the NPTS performance monitoring network.	OCN-LTMP-2023-001 – The LTMP was revised to reflect the closure of wells 37012 and 37013. LTMP text, tables, and figures were revised to add the two new performance wells. In addition, both wells were added to the off-post water level network and the off-post CSRG exceedance monitoring network consistent with the wells they are replacing.
Approved 6/13/2023	FCTS and NPTS quarterly (routine) CSRG analyte evaluation	The LTMP includes routine CSRG evaluations for the First Creek System and the Northern Pathway System plumes that were treated at the OGITS plant and identifies those analytes that require quarterly (routine) analysis. With completion of the new FCTS and NPTS and decommissioning of the OGITS, the previous routine CSRG evaluation, completed in 2010, was out of date. Since the contaminants treated at the two new plants are not the same, a separate routine CSRG evaluation was completed for each of the new systems.	OCN-LTMP-2023-002 – LTMP text and tables were revised to reflect CSRG analytes requiring quarterly effluent (routine) analysis. Note: All ROD CSRG analytes are included in annual effluent monitoring, so removal from quarterly monitoring does not impact annual sampling requirements.

Table 1.1-1. Summary of Agency Notifications and Operational Change Notices

Date	Issue	Description	Corrective Action or Change
Approved 6/19/2023	CSRG Exceedance Network	Decision Document DD-38 required installation of 5 new monitoring wells to address the Five-Year Review issue related to groundwater monitoring downgradient of the NWBCS. In FY22, the LTMP was revised to include a network of wells downgradient of the NWBCS to monitor the existing dieldrin plume. The network includes five existing wells and four newly installed wells (OCN-LTMP-2022-006).	OCN-LTMP-2023-003 – In FY23, the LTMP was revised to replace well 37336 with 37181 after a private property access agreement was completed. Note: In FY22, four of the wells were installed and added to the LTMP networks under OCN-LTMP-2022-006. These wells were added as part of the overall CSRG exceedance monitoring network for the off-post operable unit. Monitoring and will include twice-in-five-year sampling with analysis for dieldrin.
	Off-post Water Level Network	Wells 37361 and 37363 are located far downgradient from the NWBCS and are no longer needed for water level mapping.	The LTMP is being revised to delete these wells from the off-post water level monitoring network.
Approved 9/5/2023	PFAS Treatment Plant Effluent Monitoring	Perfluoroalkyl substances (PFAS) monitoring at the RMA treatment plants has been conducted at RMA since being identified as emerging contaminants in 2015. In 2020, the LTMP was revised to incorporate annual PFAS monitoring at the treatment plants to provide continuing monitoring data. Although there are no current groundwater standards applicable to RMA, the LTMP is being revised to change the treatment plant influent and effluent monitoring from annual to quarterly to continue to provide operational data for these emerging contaminants.	OCN-LTMP-2023-006 – The LTMP was revised to change the treatment plant influent and effluent monitoring from annual to quarterly to continue to provide operational data for these emerging contaminants. In addition, terminology in the LTMP is being changed from "perfluorinated compounds" (PFCs) to PFAS to be consistent with existing guidance and conventions. Also, the text in LTMP Section 4.8.5 was revised to be consistent with routine CSRG analyte revisions incorporated under OCN-LTMP-2023-002.
Approved 9/05/2023	NWBCS and NBCS routine CSRG analyte evaluation	The LTMP includes routine CSRG evaluations for the NWBCS and NBCS and identifies those analytes that require quarterly (routine) analysis. The previous evaluation, completed in 2010, was out of date and needed to be reviewed.	OCN-LTMP-2023-007 – LTMP text and tables were revised to reflect CSRG analytes requiring quarterly effluent (routine) analysis. Note: All ROD CSRG analytes are included in annual effluent monitoring, so removal from quarterly monitoring does not impact annual sampling requirements.

Table 1.1-1. Summary of Agency Notifications and Operational Change Notices

Date	Issue	Description	Corrective Action or Change
Approved 11/30/2023 [1]	FCTS and NPTS Mass Removal Calculations	As a result of completing the FY17 ASR, the approach to estimating contaminant mass removal was assessed relative to the performance of the extraction system. Since FY18, a revised approach has been utilized to evaluate mass removal as presented in draft OCN-LTMP-2019-006 that focuses the evaluation of contaminant mass removal on the performance of the *extraction system*, as part of the overall process, and provides a direct means to determine the effectiveness of the system to capture contaminated groundwater. In the revised approach, the treatment system data (influent and effluent) is not included in the mass removal calculation as that data is used to evaluate the effectiveness of the treatment system in remediating the contamination, not capturing the contamination.	OCN-LTMP-2023-004 – LTMP text and tables were updated to describe the revised contaminant mass removal evaluation. In addition, Appendix E, Technical Approach for the Evaluation of Contaminant Mass Removal Basin A Neck System, First Creek Treatment System, and Northern Pathway Treatment System was added to the LTMP.
Approved 11/30/2023 [1]	BANS Mass Removal Calculation	As a result of completing the FY17 ASR, the approach to estimating contaminant mass removal was assessed relative to the performance of the extraction system. Since FY18, a revised approach has been utilized to evaluate mass removal as presented in draft OCN-LTMP-2019-006. The focus of the revised approach is to evaluate the effectiveness of the extraction system based on *plume capture*. The treatment system data (influent and effluent) is no longer included in the mass removal calculation as that data measures the effectiveness of the treatment system in remediating the contamination, not capturing the contamination.	OCN-LTMP-2023-005 – LTMP text and tables were updated to describe the revised contaminant mass removal evaluation. In addition, Appendix E, Technical Approach for the Evaluation of Contaminant Mass Removal Basin A Neck System, First Creek Treatment System, and Northern Pathway Treatment System was added to the LTMP.

Note:
[1] Operational change notices OCN-LTMP-2023-004 and OCN-LTMP-2023-005 were submitted to the regulatory agencies in FY23, but approvals were provided in early FY24, November 2023. The changes presented in these OCNs were incorporated in the FY23 ASR.

Table 3.1-1. NWBCS Treatment System Statistics for FY23

Dates of operation [1]	10/1/2022 through 10/1/2023
Total downtime	64.5 hours
Downtime attributable to maintenance, equipment failure, or other events	11.5 hours
Downtime attributable to power failure	53 hours
Average flow rate and total volume treated [2]	820 gpm 431,089,815 gallons
Total mass of contaminants removed [3]	1.8 pounds
Contaminants contributing to majority of mass removed (pounds) [4]	Chloroform – 0.79 Dieldrin – 0.79Endrin ketone – 0.07 NDPA – 0.04 Aldrin – 0.03 Methoxychlor – 0.03 alpha-Endosulfan – 0.02
Carbon usage	61,000 pounds
Cost of operations	$802,604

Notes:

[1] Data covers the time period October 1, 2023 through October 1, 2022 based on the timing of weekly treatment plant meter readings covering the entirety of FY23.

[2] Average flow rate and total volume treated are based on metered readings for the three adsorbers within the NWBCS plant. See the file *FY23 NWBCS Water Management Report Rev0.pdf* included in data accompanying the report.

[3] See the file *FY23 NWBCS Contaminant Removal Report Rev0.pdf* included in the electronic file accompanying the report.

[4] Refer to Appendix I2 for listing of contaminant names.

gpm – gallons per minute

Table 3.1-2. NWBCS Performance Well CSRG Analyte Concentration Trends

CSRG Analyte	CSRG/PQL (µg/L)	Upgradient							Cross-gradient			Downgradient							
		SWE	Original System					NEE	SWE		Original	SWE	Original System					NEE	
		27517	22008	22043	22053	22081	27500	22505	27516	28521	27010	27522	37330	37331	37332	37333	37600	22015	22512
1,4-Dioxane	0.35	○	●	●	●	●	●	●	○	○	●	○	●	●	●	●	●	●	●
Arsenic	2.35	NS	●	○	●	▲	●	●	NS	NS	●	○	●	●	●	●	●	●	●
Chloroform	6	○	●	▼	▼	●	●	●	○	○	●	○	●	●	●	●	●	●	●
Dieldrin[1a]	0.002/0.013	▼	▼	▼	●	▼	▲	●	▼	▼	●	▼	●	●	●	▼	●	●	▲
Endrin	2	●	●	▼	●	●	●	●	●	●	○	○	○	○	○	▼	●	●	●
Isodrin	0.06	○	●	●	●	●	○	●	○	○	○	○	○	○	○	▼	▼	●	●
NDMA[1b]	0.00069/0.009	○	●	●	●	●	○	○	NS	NS	○	○	○	○	○	○	○	○	○
NDPA	0.005	○	●	○	●	●	○	●	NS	NS	○	○	○	○	○	○	○	○	▲
Trichloroethylene	3	○	▼	○	●	●	○	○	○	○	○	○	○	○	○	○	○	○	○

Notes:

● – Concentrations demonstrate a stable trend or no discernible trend over the past 10 years.

○ – Analyte was not detected during the past 10-year period to support the trend evaluation.

▼ – Concentrations demonstrate a decreasing trend over the past 10 years.

▲ – Concentrations demonstrate an increasing trend over the past 10 years.

NS – Indicates that the respective well was not sampled for the indicated analyte in FY23.

Refer to Exhibit A-4, Appendix A, for a summary of FY23 performance well water quality data.

Shading indicates that the analyte concentration exceeded the CSRG/PQL in FY23.

Bold indicates analytes in which trend information are graphically presented in maps in Appendix A, Figures A-13 through A-16.

[1] The ROD indicates PQLs for the following analytes:

[a] Dieldrin – Effective April 2012 [b] NDMA – Effective September 2016

Table 3.2-1. NBCS Treatment System Statistics for FY23

Dates of operation [1]	10/1/2022 through 10/1/2023
Total downtime	547.5 hours
Downtime attributable to maintenance, equipment failure, or other events	5 hours
Downtime attributable to power failure	542.5 hours
Average flow rate and total volume treated [2]	222 gpm 115,130,496 gallons
Total mass of contaminants removed [3]	11.3 pounds
Contaminants contributing to majority of mass removed (pounds) [4]	DCPD – 5.5 DIMP – 1.9 Chloroform – 0.62 Carbon tetrachloride – 0.59 Trichloroethylene – 0.55 Tetrachloroethylene – 0.45 NDPA – 0.39 Dieldrin – 0.33 1,2-Dichloroethane – 0.27 Methoxychlor – 0.20
Carbon usage	20,000 pounds
Cost of operations	$591,725

Notes:

[1] Data covers the time period October 1, 2023 through October 1, 2022 based on the timing of weekly treatment plant meter readings covering the entirety of FY23.

[2] Average flow rate and total volume treated are based on metered readings for the primary adsorbers within the NBCS plant. See the file *FY23 NBCS Water Management Report Rev0.pdf* included in data accompanying the report.

[3] See the file *FY23 NBCS Contaminant Removal Report Rev0.pdf* included in data accompanying the report.

[4] Refer to Appendix I2 for listing of contaminant names.

gpm – gallons per minute

Table 3.2-2. NBCS Performance Well CSRG Analyte Concentration Trends

CSRG Analyte	CSRG/PQL (µg/L)	Upgradient Wells											Downgradient Wells											
		23119	23160	23211	24101	24105	24106	24114	24117	24185	24199	24201	23405	23434	23436	23438	24004	24006	24415	24418	24421	24424	24207 [3]	24429 [3]
1,2-Dichloroethane	0.4	▼	●	○	●	○	○	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○	NS	○
1,2-Dichloroethylene [1]	70	○	●	○	▲	○	○	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○	NS	○
1,4-Dioxane	0.35	●	●	○	●	○	○	▼	○	○	○	●	●	●	●	●	●	●	●	●	●	●	NS	▲
1,4-Oxathiane	160	○	●	○	▲	○	○	○	○	○	○	●	NS	NS	NS	NS	NS	○	NS	NS	NS	NS	NS	NS
Aldrin [1a]	0.002/0.014	○	●	●	●	○	○	○	○	○	○	●	●	○	●	○	○	●	●	○	○	○	NS	○
Arsenic	2.35	●	●	●	●	○	○	○	○	○	○	●	○	○	○	○	●	●	○	○	○	○	NS	○
Atrazine	3	○	○	○	○	○	○	○	○	○	○	○	NS	NS	NS	NS	NS	○	NS	NS	NS	NS	NS	NS
Benzene	3	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	NS	○
Carbon tetrachloride	0.3	○	○	○	○	○	○	○	▼	●	○	▼	○	○	○	○	○	○	○	○	○	○	NS	○
Chloride	250,000	▼	▲	●	●	●	▲	●	▲	▲	▲	▲	▼	▼	▼	●	●	▲	▲	●	●	●	NS	●
Chloroform	6	●	●	○	●	○	○	●	●	○	○	●	○	○	○	○	○	○	○	●	●	○	NS	○
CPMS	30	○	○	○	○	○	○	○	○	○	○	○	NS	NS	NS	NS	NS	○	NS	NS	NS	NS	NS	NS
CPMSO	36	●	●	○	●	○	○	○	○	○	○	▲	NS	NS	NS	NS	NS	○	NS	NS	NS	NS	NS	NS
CPMSO2	36	○	●	○	●	○	○	○	○	○	○	●	NS	NS	NS	NS	NS	○	NS	NS	NS	NS	NS	NS
DBCP	0.20	○	○	○	●	○	○	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○	NS	○
DCPD	46	○	●	○	●	○	○	○	○	○	○	▲	○	○	○	○	○	●	○	○	○	○	NS	○
Dieldrin [2a]	0.002/0.013	●	●	●	●	●	●	▼	▼	▼	●	●	●	●	●	●	▼	▼	●	●	●	●	NS	▼
DIMP	8	▼	●	●	●	○	○	▼	○	●	○	▲	▼	▲	●	▼	○	▼	●	▼	▼	●	NS	○
Dithiane	18	○	○	○	▲	○	○	○	○	○	○	●	NS	NS	NS	NS	NS	○	NS	NS	NS	NS	NS	NS
Endrin	2	●	●	▼	▼	○	●	●	▼	●	●	●	▼	●	●	●	●	▼	●	●	▲	●	NS	●
Fluoride	2,000	●	▲	▲	●	●	●	●	●	●	●	▼	●	▼	●	▼	●	●	●	●	▲	●	NS	▼
Isodrin	0.06	●	●	●	●	○	●	●	●	○	○	●	●	●	●	○	○	●	○	●	○	○	NS	○
Malathion	100	○	○	○	○	○	○	○	○	○	○	○	NS	NS	NS	NS	NS	○	NS	NS	NS	NS	NS	NS
Methylene chloride	5	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	NS	○

Table 3.2-2. NBCS Performance Well CSRG Analyte Concentration Trends

CSRG Analyte	CSRG/PQL (µg/L)	Upgradient Wells											Downgradient Wells											
		23119	23160	23211	24101	24105	24106	24114	24117	24185	24199	24201	23405	23434	23436	23438	24004	24006	24415	24418	24421	24424	24207 [3]	24429 [3]
NDMA [2b]	0.00069/0.009	●	●	▲	▲	▲	●	○	●	○	●	▲	▲	○	○	●	○	▲	●	●	○	○	NS	○
NDPA	0.005	●	▼	○	●	○	○	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○	NS	○
Sulfate	540,000	●	●	●	▲	●	▲	▼	▲	▲	●	▲	●	▼	▼	●	●	●	●	●	●	▼	NS	▲
Tetrachloroethylene	5	●	▼	○	●	○	○	●	○	○	○	●	○	○	○	○	○	▼	○	●	○	○	NS	○
Toluene	1,000	○	●	○	○	○	●	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○	NS	○
Trichloroethylene	3	●	●	○	●	○	○	○	○	○	○	▲	○	○	○	○	○	○	○	○	○	○	NS	○
Xylenes	1,000	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	NS	○

Notes:

● – Concentrations demonstrate a stable trend or no discernible trend over the past 10 years.

○ – Analyte was not detected during the past 10-year period to support the trend evaluation.

▼ – Concentrations demonstrate a decreasing trend over the past 10 years.

▲ – Concentrations demonstrate an increasing trend over the past 10 years.

NS – Indicates that the respective well was not sampled for the indicated analyte in FY23.

Refer to Exhibit B-10, Appendix B, for a summary of FY23 performance well water quality data.

Shading indicates that the analyte concentration exceeded the CSRG/PQL in FY23.

Bold indicates analytes in which trend **data** are graphically presented in maps in Appendix B, Figures B-28 through B-33.

[1] 1,2-Dichloroethylene is represented by the sum of results for the two isomers cis-1,2-dichloroethylene (C12DCE) and trans-1,2-dichloroethylene (T12DCE).

[2] The ROD indicates PQLs for the following analytes:

[a] Dieldrin – Effective April 2012 [b] NDMA – Effective September 2016

[3] Well 24429 is an alternate well that is sampled when well 24207 is dry or there is insufficient water to sample. Well 24207 could not be sampled in FY23.

Table 3.3-1. BANS Treatment System Statistics for FY23

Dates of operation [1]	10/1/2022 through 10/1/2023
Total downtime	520.75 hours
Downtime attributable to maintenance, equipment failure, or other events	2.75 hours
Downtime attributable to power failure	518 hours
Average flow rate and total volume treated [2]	16.4 gpm 8,628,067 gallons
Total mass of contaminants removed [3]	55.9 pounds
Contaminants contributing to majority of mass removed (pounds) [4]	Chloroform – 14.5 Trichloroethylene – 12.2 Dithiane – 10.2 DIMP – 7.0 Tetrachloroethylene – 3.6 CPMSO2 – 2.27 1,1,2,2-Tetrachloroethane – 1.5 1,4-Oxathiane – 0.89 Arsenic – 0.76 1,2-Dichloroethane – 0.65 1,2-Dichloropropane – 0.37 DCPD – 0.31
Carbon usage	12,900 pounds
Cost of operations	$464,421

Notes:

[1] Data covers the time period October 1, 2023 through October 1, 2022 based on the timing of weekly treatment plant meter readings covering the entirety of FY23.

[2] Average flow rate and total volume treated are based on metered readings for the effluent tank within the BANS plant. See the file *FY23 BANS Water Management Report Rev0.pdf* included in data accompanying the report.

[3] See the file *FY23 BANS Contaminant Removal Report Rev0.pdf* included in data accompanying the report.

[4] Refer to Appendix I2 for listing of contaminant names.

gpm – gallons per minute

Table 3.3-2. FY23 BANS Estimated Mass Removal

Contaminant Flow Rate [1]	Total – 11.78 gpm Into Capture Zone – 11.40 gpm North of Capture Zone – 0.37 gpm South of Capture Zone – 0.00102 gpm
Plume Mass Flux [1]	Total – 15.43 pounds Into Capture Zone – 15.42 pounds North of Capture Zone – 0.006 pounds South of Capture Zone – 0.00002 pounds
Extracted Mass	15.42 pounds
Percent Mass Removed	**99.9% – Meets performance criterion (90%)**

Notes:

[1] Any apparent discrepancies in the quantities for mass removal can be accounted for in mathematical rounding as shown in the calculations presented in the Excel file *FY23 BANS Mass Removal Rev0.xlsx* accompanying this report.

gpm – gallons per minute

Table 3.3-3. BANS Performance Well CSRG Analyte Concentration Trends

CSRG Analyte	CSRG/PQL (µg/L)	Upgradient				Downgradient			
		26507	35512	35514	35516	26501	26505	35505	35525
1,1,1-Trichloroethane	200	○	○	○	○	○	○	○	○
1,1-Dichloroethylene	7	○	○	○	○	○	○	○	○
1,2-Dichlorobenzene	600	○	○	▲	○	○	○	○	●
1,2-Dichloroethane	0.4	●	○	●	▲	●	●	○	○
1,3-Dichlorobenzene	94	○	○	○	○	○	○	○	○
1,4-Dichlorobenzene	75	○	○	●	○	○	○	○	●
1,4-Oxathiane	160	●	○	●	●	●	●	●	●
Arsenic	50	●	▼	●	▲	●	●	●	●
Atrazine	3	○	●	●	○	○	○	○	○
Benzene	5	○	○	●	○	○	○	○	○
Carbon tetrachloride	0.3	○	○	○	○	○	○	○	○
Chlorobenzene	100	○	○	▲	○	○	●	○	●
Chloroform	6	●	○	●	●	●	▼	●	●
CPMS	30	○	○	●	○	○	○	○	○
CPMSO	36	●	○	●	●	○	○	●	●
CPMSO2	36	●	●	▼	●	○	●	○	●
Dicyclopentadiene	46	○	○	○	○	○	○	○	○
Dieldrin [1a]	0.002/0.013	●	●	●	▲	●	▼	▼	▼
Dithiane	18	○	●	●	●	○	●	○	●
Endrin	2	▲	▼	●	●	●	●	●	●
Hexachlorocyclopentadiene	50	●	▼	●	●	▼	▼	○	▼
Mercury	2	○	○	○	○	○	○	○	○
PPDDT	0.10	●	▼	●	●	▼	●	▼	●
1,1,2,2-Tetrachloroethane	0.18	○	○	○	○	○	○	○	○
Tetrachloroethylene	5	▲	○	●	●	○	●	○	▼
Trichloroethylene	5	●	○	●	●	●	●	○	●

Notes:

● – Concentrations demonstrate a stable trend or no discernible trend over the past 10 years.

○ – Analyte was not detected during the past 10-year period to support the trend evaluation.

▼ – Concentrations demonstrate a decreasing trend over the past 10 years.

▲ – Concentrations demonstrate an increasing trend over the past 10 years.

Refer to Exhibit C-13, Appendix C, for a summary of FY23 performance well water quality data.

Shading indicates that the analyte concentration exceeded the CSRG/PQL in FY23.

Bold indicates analytes in which trend **data** are graphically presented in maps in Appendix C, Figures C-21 through C-23.

[1] The ROD indicates PQLs for the following analytes:

[a] Dieldrin – Effective April 2012 [b] NDMA – Effective September 2016

Table 3.4-1. BRES Performance Well CSRG Analyte Concentration Trends

CSRG Analyte	CSRG/PQL (µg/L)	Upgradient				Downgradient			
		36565	36567	36575	36250	36555	36566	36571	36572
1,1,1-Trichloroethane	200	○	○	○	○	○	○	○	○
1,1-Dichloroethylene	7	○	●	○	●	○	●	●	▼
1,2-Dichlorobenzene	600	○	○	○	○	○	○	○	○
1,2-Dichloroethane	0.4	○	●	○	▼	○	●	●	○
1,3-Dichlorobenzene	94	○	○	○	○	○	○	○	○
1,4-Dichlorobenzene	75	○	○	○	○	○	○	○	○
1,4-Oxathiane	160	○	○	○	○	○	○	○	○
Benzene	5	○	○	○	○	○	○	○	○
Carbon tetrachloride	0.3	○	▲	○	▼	○	●	○	○
Chlorobenzene	100	○	○	○	○	○	○	○	○
Chloroform	6	○	●	○	●	○	●	●	●
CPMS	30	○	○	○	○	○	○	○	○
CPMSO	36	○	○	○	○	○	○	○	○
CPMSO2	36	○	○	○	○	○	○	○	○
Dicyclopentadiene	46	○	○	○	○	○	○	○	○
Dieldrin [1a]	0.002/0.013	●	●	●	▼	▼	●	○	▼
DIMP	8	○	▼	●	●	●	●	●	●
Dithiane	18	○	○	○	○	○	○	○	○
Endrin	2	●	●	●	●	○	●	○	○
Hexachlorocyclopentadiene	50	▼	●	○	○	○	○	○	○
PPDDT	0.10	○	▼	○	○	○	○	○	○
1,1,2,2-Tetrachloroethane	0.18	○	○	○	●	○	○	○	○
Tetrachloroethylene	5	▼	●	▼	●	○	●	●	●
Trichloroethylene	5	○	●	○	●	○	▲	●	●

Notes:

● – Concentrations demonstrate a stable trend or no discernible trend over the past 10 years.

○ – Analyte was not detected during the past 10-year period to support the trend evaluation.

▼ – Concentrations demonstrate a decreasing trend over the past 10 years.

▲ – Concentrations demonstrate an increasing trend over the past 10 years.

Refer to Exhibit D-2, Appendix D, for a summary of FY23 performance well water quality data.

Shading indicates that the analyte concentration exceeded the CSRG/PQL in FY23.

Bold indicates analytes in which trend **data** are graphically presented in maps in Appendix D, Figures D-12 through D-16.

[1] The ROD indicates PQLs for the following analytes:

[a] Dieldrin – Effective April 2012 [b] NDMA – Effective September 2016

Table 4.2-1. Shell Disposal Trenches FY23 Performance Groundwater and Trench Bottom Elevations

Borehole ID	Trench Bottom Elevation (feet amsl)	Groundwater Elevation (feet amsl)			
		Quarter 1 10/13 and 11/23/2022	Quarter 2 3/14/2023	Quarter 3 5/23/2023	Quarter 4 9/7/2023
3178	5242.0	5235.6	5234.8	5236.0	5238.2
3444	5244.1	5236.1	5236.1	5235.9	5236.6
3445	5240.5	5235.3	5234.9	5235.0	5237.0
3446	5240.6	5234.9	5234.6	5234.8	5236.8
3457	5240.8	5235.6	5235.1	5235.7	5237.6
SDT-02	5238.4	5236.0	5236.0	5235.9	5236.9

Note:

Groundwater elevations for each quarter at each bore location are presented quarterly in Treatment Plant Effluent Water Quality Data Reports FY23 (Navarro 2023b, 2023c, 2024a, 2024c). Trench bottom elevations were higher than groundwater elevations for all four quarters of FY23.

Table 5.1-1. FCTS Treatment System Statistics for FY23

Dates of operation [1]	10/1/2022 through 10/1/2023
Total downtime	103 hours
Downtime attributable to maintenance, equipment failure, or other events	97.5 hours
Downtime attributable to power failure	5.5 hours
Average flow rate and total volume treated [2]	55.7 gpm 29,018,947 gallons
Total mass of contaminants removed [3]	2.5 pounds
Contaminants contributing to majority of mass removed (pounds) [4]	DIMP – 2.4 DCPD – 0.02
Carbon usage	10,500 pounds
Cost of operations	$260,856

Notes:

[1] Data covers the time period October 1, 2023 through October 1, 2022 based on the timing of weekly treatment plant meter readings covering the entirety of FY23.

[2] Average flow rate and total volume treated are based on metered readings for the extraction/dewatering wells at the FCTS plant. See the file *FY23 FCTS Water Management Report Rev0.pdf* included in data accompanying the report.

[3] See the file *FY23 FCTS Contaminant Removal Report Rev0.pdf* included in data accompanying the report.

[4] Refer to Appendix I2 for listing of contaminant names.

gpm – gallons per minute

Table 5.1-2. FY23 FCTS Estimated Contaminant Mass Removal

Contaminant Flow Rate [1]	Plume Approaching System – 74.28 gpm Plume Entering Capture Zone – 67.03 gpm Plume Outside Capture Zone – 7.25 gpm Extraction System – 58.80 gpm
Plume Mass Flux [1]	Total – 268,428 pounds Inside Capture Zone – 238,673 pounds Outside Capture Zone – 29,755 pounds
Extracted Mass	158,682 pounds
Percent Mass Removed	**59.1% – Does not meet performance criterion (75%)**

Note:

[1] Any apparent discrepancies in the quantities for mass removal can be accounted for in mathematical rounding as shown in the calculations presented in the Excel file *FY23 FCTS Mass Removal Rev0.xlsx* accompanying this report.

gpm – gallons per minute

Table 5.1-3. Comparison of FY23 and FY22 Contaminant Mass Removal

Calculated Flow Rates and Mass	FY23	FY22 [1]
Flow Rates		
Plume Total Flow	74.28 gpm	63.09 gpm
Plume Capture Zone Flow	67.03 gpm	56.03 gpm
Extraction Well Total Flow	58.80 gpm	59.39 gpm
Contaminant Mass		
Plume Mass – Total	268,428 lbs	225,539 lbs
Plume Mass – Capture Zone Only	238,673 lbs	190,502 lbs
Plume Mass – Outside of Capture Zone	29,755 lbs	35,037 lbs
Extraction System Mass – Total	158,682 lbs	172,812 lbs
Extracted/Captured Mass		
Percent Extracted Mass Compared to Total Plume	59.1%	76.6%
Percent Extracted Mass Compared Plume in Capture Zone	66.5%	90.7%

Notes:

[1] Refer to the Annual Summary Report for Groundwater and Surface Water for Fiscal Year 2022 (Navarro 2024b) for details.

gpm – gallons per minute

lbs – pounds

Table 5.1-4. FCTS Performance Well CSRG Analyte Concentration Trends

CSRG Analyte	CSRG/PQL (µg/L)	Upgradient Wells						Downgradient Wells		
		37074	37075	37076	37083	37370	37373	37110	37116	37163
1,2-Dichloroethane	0.4	○	▼	●	●	○	○	○	○	○
1,3-Dichlorobenzene	6.5	○	○	○	○	○	○	○	○	○
1,4-Oxathiane	160	○	○	○	○	○	○	○	○	○
Aldrin [1a]	0.002/0.014	○	●	●	▲	▼	●	○	○	○
Arsenic	2.35	○	●	○	○	●	○	○	○	●
Atrazine	3	○	○	○	○	○	○	○	○	○
Benzene	3	○	○	○	●	○	○	○	○	○
Carbon tetrachloride	0.3	○	○	○	○	○	○	○	○	○
Chlordane [2]	0.03	●	●	●	●	●	●	○	○	○
Chloride	250,000	●	▼	●	▼	▼	●	●	●	●
Chlorobenzene	25	○	○	○	○	○	○	○	○	○
Chloroform	6	○	●	○	●	○	●	●	○	○
CPMS	30	○	○	○	○	○	○	○	○	○
CPMSO	36	○	○	○	○	○	○	○	○	○
CPMSO2	36	○	○	○	○	○	○	○	○	○
DBCP	0.2	○	○	○	○	○	○	○	○	○
DCPD	46	○	▼	●	●	○	●	○	○	○
Dieldrin [1a]	0.002/0.013	●	●	●	●	●	●	○	●	●
DIMP	8	●	▼	●	●	●	●	▼	●	●
Dithiane	18	○	○	●	○	○	○	○	○	○
Endrin	2	○	●	●	●	●	○	○	○	●
Ethylbenzene	200	○	○	○	○	○	○	○	○	○
Fluoride	2,000	▲	●	●	●	●	●	●	●	●
Hexachlorocyclopentadiene	0.23	○	○	○	○	○	○	○	○	○
Isodrin	0.06	●	●	●	●	●	●	○	○	●
Malathion	100	○	○	○	○	○	○	○	○	○
NDMA [1b]	0.00069/0.009	●	●	●	●	●	●	●	○	○
NDPA	0.005	○	▼	●	●	○	○	○	○	○
PPDDE	0.1	▼	●	●	●	●	●	○	●	○
PPDDT	0.1	●	●	●	●	▼	●	○	●	●
Sulfate	540,000	▼	▼	●	▼	▼	●	●	●	●
Tetrachloroethylene	5	●	▼	●	●	○	●	●	●	○
Toluene	1,000	○	○	○	○	○	○	●	○	○
Trichloroethylene	3	○	●	●	○	○	○	○	○	○

Table 5.1-4. FCTS Performance Well CSRG Analyte Concentration Trends

CSRG Analyte	CSRG/PQL (µg/L)	Upgradient Wells						Downgradient Wells		
		37074	37075	37076	37083	37370	37373	37110	37116	37163
Xylenes	1,000	○	○	○	○	○	○	○	○	○

Notes:

● – Concentrations demonstrate a stable trend or no discernible trend over the past 10 years.

○ – Analyte was not detected during the past 10-year period to support the trend evaluation.

▼ – Concentrations demonstrate a decreasing trend over the past 10 years.

▲ – Concentrations demonstrate an increasing trend over the past 10 years.

Refer to Exhibit F-3, Appendix F, for a summary of FY23 performance well water quality data.

Shading indicates that the analyte concentration exceeded the CSRG/PQL in FY23.

Bold indicates analytes in which trend **data** are graphically presented in maps in Appendix F, Figures F-12 through F-16.

[1] The ROD indicates PQLs for the following analytes:

[a] Dieldrin – Effective April 2012 [b] NDMA – Effective September 2016

[2] Chlordane is represented by the sum of results for the two isomers alpha-chlordane (ACLDAN) and gamma-chlordane (GCLDAN).

Table 5.2-1. NPTS Treatment System Statistics for FY23

Dates of operation [1]	10/1/2022 through 10/1/2023
Total downtime	7.5 hours
Downtime attributable to maintenance, equipment failure, or other events	7.5 hours
Downtime attributable to power failure	0 hours
Average flow rate and total volume treated [2]	160 gpm 84,492,278 gallons
Total mass of contaminants removed [3]	0.07 pounds
Contaminants contributing to majority of mass removed (pounds) [4]	DLDRN – 0.02 Tetrachloroethylene – 0.02
Carbon usage	6,000 pounds
Cost of operations	$339,326

Notes:

[1] Data covers the time period October 1, 2023 through October 1, 2022 based on the timing of weekly treatment plant meter readings covering the entirety of FY23.

[2] Average flow rate and total volume treated are based on metered readings for the three adsorbers at the NPTS plant. See the file *FY23 NPTS Water Management Report Rev0.pdf* included in data accompanying the report.

[3] See the file *FY23 NPTS Contaminant Removal Report Rev0.pdf* included in data accompanying the report.

[4] Refer to Appendix I2 for listing of contaminant names.

gpm – gallons per minute

Table 5.2-2. FY23 NPTS Estimated Contaminant Mass Removal

Contaminant Flow Rate [1]	Plume Approaching System – 181.08 gpm Plume Entering Capture Zone – 176.49 gpm Plume Outside Capture Zone – 4.59 gpm Extraction System – 159.05 gpm
Plume Mass Flux [1]	Total – 314,675 pounds Inside Capture Zone – 305,088 pounds Outside of Capture Zone – 9,587 pounds
Extracted Mass	262,122 pounds
Percent Mass Removed	**83.3% – Meets performance criterion (75%)**

Note:

[1] Any apparent discrepancies in the quantities for mass removal can be accounted for in mathematical rounding as shown in the calculations presented in the Excel file *FY23 NPTS Mass Removal Rev0.xlsx* accompanying this report.

gpm – gallons per minute

Table 5.2-3. NPTS Performance Well CSRG Analyte Concentration Trends

CSRG Analyte	CSRG/PQL (µg/L)	Upgradient Wells						Cross-gradient Wells		Downgradient Wells						
		37080	37157	37158	37159	37160	EPA-4	37027	37452	37008	37009	37010	37011	37030	37039	37101
1,2-Dichloroethane	0.4	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
1,3-Dichlorobenzene	6.5	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
1,4-Oxathiane	160	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Aldrin [1a]	0.002/0.014	NS	○	○	○	○	○	○	○	○	○	○	○	NS	○	NS
Arsenic	2.35	○	●	○	○	○	●	○	●	●	●	○	●	○	○	○
Atrazine	3	NS	○	○	○	○	○	○	○	○	○	○	○	NS	○	NS
Benzene	3	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Carbon tetrachloride	0.3	○	○	●	○	○	▼	○	○	○	○	○	○	○	○	○
Chlordane [2]	0.03	○	○	○	○	○	○	○	○	●	○	○	○	○	○	○
Chloride	250,000	●	●	●	●	●	▲	▲	▲	●	▼	▼	●	●	●	●
Chlorobenzene	25	○	○	○	○	○	○	○	○	○	○	●	●	○	○	○
Chloroform	6	○	●	●	○	●	●	●	○	○	○	●	○	●	○	●
CPMS	30	NS	○	○	○	○	○	○	○	○	○	○	○	NS	○	NS
CPMSO	36	NS	○	○	○	○	○	○	○	○	○	○	○	NS	○	NS
CPMSO2	36	NS	○	○	○	○	○	○	○	○	○	○	○	NS	○	NS
DBCP	0.2	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
DCPD	46	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Dieldrin [1a]	0.002/0.013	●	○	●	●	●	●	●	▼	●	○	●	▲	●	▼	○
DIMP	8	●	○	●	○	●	●	●	○	●	▼	●	○	○	▼	○
Dithiane	18	NS	○	○	○	○	○	○	○	○	○	○	○	NS	○	○
Endrin	2	●	○	●	●	○	●	●	●	●	○	●	●	○	○	○
Ethylbenzene	200	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Fluoride	2,000	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Hexachlorocyclopentadiene	0.23	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Isodrin	0.06	○	○	○	○	○	○	●	○	○	○	●	○	○	○	○

Table 5.2-3. NPTS Performance Well CSRG Analyte Concentration Trends

CSRG Analyte	CSRG/PQL (µg/L)	Upgradient Wells						Cross-gradient Wells		Downgradient Wells						
		37080	37157	37158	37159	37160	EPA-4	37027	37452	37008	37009	37010	37011	37030	37039	37101
Malathion	100	NS	○	○	○	○	○	○	○	○	○	○	○	NS	○	NS
NDMA [1b]	0.00069/0.009	●	○	○	○	○	○	▲	▲	▲	○	▲	▲	○	▲	○
NDPA	0.005	○	○	○	○	●	○	○	○	○	○	○	○	○	○	● (shaded)
PPDDE	0.1	○	○	●	○	○	●	○	○	○	○	○	○	○	○	●
PPDDT	0.1	○	○	●	○	○	●	○	○	○	○	○	○	○	○	○
Sulfate	540,000	▼	●	●	●	●	●	● (shaded)	●	●	▼	▼	●	●	▼	●
Tetrachloroethylene	5	○	○	○	○	●	○	●	○	○	○	○	○	○	○	●
Toluene	1,000	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Trichloroethylene	3	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Xylenes	1,000	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

Notes:

● – Concentrations demonstrate a stable trend or no discernible trend over the past 10 years.

○ – Analyte was not detected during the past 10-year period to support the trend evaluation.

▼ – Concentrations demonstrate a decreasing trend over the past 10 years.

▲ – Concentrations demonstrate an increasing trend over the past 10 years.

Refer to Exhibit G-4, Appendix G, for a summary of FY23 performance well water quality data.

Shading indicates that the analyte concentration exceeded the CSRG/PQL in FY23.

Bold indicates analytes in which trend **data** are graphically presented in maps in Appendix G, Figures G-12 through G-16.

[1] The ROD indicates PQLs for the following analytes:

[a] Dieldrin – Effective April 2012 [b] NDMA – Effective September 2016

[2] Chlordane is represented by the sum of results for the two isomers alpha-chlordane (ACLDAN) and gamma-chlordane (GCLDAN).

Table 6.2-1. Motor Pool System/Irondale Containment System Post-Shut-Off Monitoring Results for FY23

Well and Sample Date [1]	Analyte Concentrations (µg/L)	
	DBCP (CSRG – 0.2 µg/L)	Trichloroethylene (CSRG – 5 µg/L)
Motor Pool System		
04021 [2]	NA	NA
04535 (6/27/2023)	NA	0.604
Irondale Containment System		
33081 (6/27/2023)	LT 0.0194	NA

Notes:

[1] No concentrations of detected analytes exceeded CSRGs in FY23. Annual sampling for wells 04535 and 33081 will next take place in the first quarter of FY24.

[2] Well 04021 is sampled twice every five years. This well will be sampled next in FY24.

NA – Not analyzed

Table 7.3-1. FY23 Water Quality Data for the Off-Post Private Well Network

Private Well ID	Sample Date	Analyte Concentrations (µg/L) [1]		
		DIMP (CBSG – 8 µg/L)	1,4-Dioxane (CBSG – 0.35 µg/L)	Dieldrin (PQL – 0.013 µg/L)
Alluvial Aquifer				
359C	8/29/2023	LT 0.50	NA	NA
541A	9/13/2023	1.29	0.288	NA
634A	9/6/2023	LT 0.50	NA	LT 0.00252
981B	9/12/2023	2.1	LT 0.075	NA
989A	9/7/2023	LT 0.50	NA	0.00943
Arapahoe Aquifer				
1334H	8/29/2023	0.9	NA	NA
359D	8/29/2023	**11.9**	NA	NA
640B	9/12/2023	LT 0.50	NA	NA
896A	9/7/2023	LT 0.50	NA	NA
982A	9/12/2023	LT 0.50	NA	NA
983A	9/6/2023	0.853	NA	NA

Notes:

In addition to the analyses presented in the table, heptachlor epoxide was analyzed in the sample collected from well 634A where it was not detected and reported with a result of LT 0.00321 µg/L.

[1] Concentrations greater than CSRG/PQL are presented in **bold**.

LT – Analyte not detected and reported as a value less than the reporting limit.

NA – Not analyzed

Table 8.1-1. Perfluoroalkyl Substances Results for FY23 Treatment Plant Samples

Treatment Plant	Sample Date	Sample Location	Analyte Concentrations and *Regional Screening Levels* (µg/L)					
			HFPO-DA *0.0015*	PFBS *0.6*	PFHxS *0.039*	PFNA *0.0059*	PFOA *0.0000027*	PFOS *0.0002*
On-Post Systems								
NWBCS	11/2/2022	Influent	LT 0.00589	0.0034	0.0042	LT 0.00147	**0.0018**	**0.002**
		Effluent	LT 0.00608	0.002	LT 0.00152	LT 0.00152	LT 0.00152	LT 0.00152
	1/5/2023	Influent	LT 0.00608	0.0028	0.0042	LT 0.00152	**0.0019**	**0.0017**
		Effluent	LT 0.00627	LT 0.00157	LT 0.00157	LT 0.00157	LT 0.00157	LT 0.00157
	4/4/2023	Influent	LT 0.00717	0.0042	0.0044	LT 0.00179	**0.0024**	**0.0027**
		Effluent	LT 0.00723	LT 0.00181	LT 0.00181	LT 0.00181	LT 0.00181	LT 0.00181
	7/10/2023	Influent	LT 0.00768	0.005	0.0048	LT 0.00192	**0.0024**	**0.003**
		Effluent	LT 0.00768	0.002	LT 0.00192	LT 0.00192	LT 0.00192	LT 0.00192
NBCS	11/2/2022	Influent	LT 0.0064	0.0021	0.0037	LT 0.0016	LT 0.0016	LT 0.0016
		Effluent	LT 0.00614	LT 0.00154	LT 0.00154	LT 0.00154	LT 0.00154	LT 0.00154
	1/5/2023	Influent	LT 0.00634	0.0019	0.003	LT 0.00158	LT 0.00158	LT 0.00158
		Effluent	LT 0.00634	LT 0.00158	LT 0.00158	LT 0.00158	LT 0.00158	LT 0.00158
	4/4/2023	Influent	LT 0.00794	0.00391	0.0035	LT 0.00198	LT 0.00198	LT 0.00198
		Effluent	LT 0.0073	LT 0.00182	LT 0.00182	LT 0.00182	LT 0.00182	LT 0.00182
	7/10/2023	Influent	LT 0.00704	0.00309	0.0048	LT 0.00176	LT 0.00176	LT 0.00176
		Effluent	LT 0.00704	LT 0.00176	LT 0.00176	LT 0.00176	LT 0.00176	LT 0.00176
BANS	11/2/2022	Influent	LT 0.00602	LT 0.0015	0.0056	LT 0.0015	**0.0036**	**0.006**
		Effluent	LT 0.00595	LT 0.00149	LT 0.00149	LT 0.00149	LT 0.00149	LT 0.00149
	1/5/2023	Influent	LT 0.00608	LT 0.00152	0.0053	LT 0.00152	**0.0028**	**0.0055**
		Effluent	LT 0.00595	LT 0.00149	LT 0.00149	LT 0.00149	LT 0.00149	LT 0.00149
	4/4/2023	Influent	LT 0.00723	LT 0.0064	0.0064	LT 0.00181	**0.0035**	**0.0055**
		Effluent	LT 0.00704	LT 0.00176	LT 0.00176	LT 0.00176	LT 0.00176	LT 0.00176

Table 8.1-1. Perfluoroalkyl Substances Results for FY23 Treatment Plant Samples

Treatment Plant	Sample Date	Sample Location	Analyte Concentrations and *Regional Screening Levels* (µg/L)					
			HFPO-DA ***0.0015***	PFBS ***0.6***	PFHxS ***0.039***	PFNA ***0.0059***	PFOA ***0.0000027***	PFOS ***0.0002***
BANS	7/10/2023	Influent	LT 0.00832	LT 0.00208	0.0111	LT 0.00208	**0.0028**	**0.0066**
		Effluent	LT 0.00768	LT 0.00192	LT 0.00192	LT 0.00192	LT 0.00192	LT 0.00192
Off-Post Systems								
FCTS	11/2/2022	Influent	LT 0.00595	0.0059	LT 0.00149	LT 0.00149	**0.0015**	LT 0.00149
		Effluent	LT 0.00589	0.002	LT 0.00147	LT 0.00147	LT 0.00147	LT 0.00147
	1/5/2023	Influent	LT 0.00602	0.0047	LT 0.0015	LT 0.0015	LT 0.0015	LT 0.0015
		Effluent	LT 0.00608	0.0016	LT 0.00152	LT 0.00152	LT 0.00152	LT 0.00152
	4/4/2023	Influent	LT 0.00755	0.00789	LT 0.00189	LT 0.00189	LT 0.00189	LT 0.00189
		Effluent	LT 0.00698	LT 0.00174	LT 0.00174	LT 0.00174	LT 0.00174	LT 0.00174
	7/10/2023	Influent	LT 0.00768	0.0086	0.0028	LT 0.00192	**0.0028**	LT 0.00192
		Effluent	LT 0.00704	0.0036	LT 0.00176	LT 0.00176	LT 0.00176	LT 0.00176
NPTS	11/2/2022	Influent	LT 0.00589	0.0064	0.0032	LT 0.00147	**0.0028**	**0.0021**
		Effluent	LT 0.00614	0.0059	LT 0.00154	LT 0.00154	***0.0019***	LT 0.00154
	1/5/2023	Influent	LT 0.00608	0.0057	0.0029	LT 0.00152	**0.0024**	**0.0019**
		Effluent	LT 0.00602	LT 0.0015	LT 0.0015	LT 0.0015	LT 0.0015	LT 0.0015
	4/4/2023	Influent	LT 0.00723	0.0066	0.00299	LT 0.00181	**0.00181**	**0.00231**
		Effluent	LT 0.00704	0.0057	LT 0.00176	LT 0.00176	LT 0.00176	LT 0.00176
	7/10/2023	Influent	LT 0.00768	0.0091	0.004	LT 0.00192	**0.0024**	**0.0021**
		Effluent	LT 0.00768	0.0082	0.0024	LT 0.00192	LT 0.00192	LT 0.00192

Notes:

Bold values indicate an individual concentration exceeds the EPA RSL for tap water ingestion (May 2024, Target Risk = 1E-06, Target Hazard Quotient = 0.1).
LT – Analyte was not detected and reported as less than the method reporting limit.
NA – Not applicable

Table 9.1-1. Summary of FY23 Compliance and Performance Criteria and Goals Achievement

LTMP Performance Criterion or Primary Goal [1]	Criterion or Goal Achievement
Northwest Boundary Containment System – Treatment System	
Compliance Criterion	
Demonstrate system compliance through effluent water quality monitoring to confirm that CSRGs are met. Compliance is based on running averages for the last four quarters, or one annual sample for those analytes that are not sampled quarterly.	Yes
Primary Performance Criteria [2] – Original System	
Demonstrate containment through reverse hydraulic gradient by visual evaluation of potentiometric maps and visual comparison of paired well water levels. If visual inspection is unclear, statistical or other evaluation criteria will be considered.	Yes
Demonstrate containment through plume-edge capture by visual evaluation of flow directions on potentiometric maps and evaluation of water quality data from performance and operational monitoring wells. If visual inspection is unclear, statistical or other evaluation criteria will be considered.	Yes
Secondary Performance Criterion [2] – Original System	
If unable to maintain reverse hydraulic gradient due to factors beyond Army control, the performance evaluation will be based on demonstrating that concentrations in downgradient water quality performance wells are at or below CSRGs/PQLs or show decreasing concentration trends, based on annual evaluations, over the previous period of at least 5 years. If visual inspection is unclear, statistical or other evaluation criteria will be considered.	Secondary performance criterion is not applicable since primary performance criteria were achieved. Continued monitoring will be conducted to evaluate performance wells where CSRG/PQL exceedances occurred.
Northwest Boundary Containment System – Northeast Extension	
Demonstrate plume capture through visual evaluation of flow directions on potentiometric maps and evaluation of water quality data from performance and operational monitoring wells. If visual inspection is unclear, statistical and other evaluation criteria will be considered.	No. Dieldrin and NDPA were detected above CSRGs/PQLs in downgradient performance wells 22015 and 22512. The long-term trends for dieldrin are not increasing in downgradient performance wells, however, NDPA indicates an increasing trend. Aquifer testing is scheduled for FY24 to evaluate the feasibility and design for improved containment with supplemental extraction and recharge in the vicinity of the NEE.
Demonstrate decreasing concentration trends or that concentrations are at or below CSRGs/PQLs in downgradient performance wells.	No. NDPA was detected in well 22512 in FY23 at concentrations exceeding the PQL. Concentrations indicate an increasing trend through FY23.

Table 9.1-1. Summary of FY23 Compliance and Performance Criteria and Goals Achievement

LTMP Performance Criterion or Primary Goal [1]	Criterion or Goal Achievement
Northwest Boundary Containment System – Southwest Extension	
Demonstrate plume capture through visual evaluation of flow directions on potentiometric maps and evaluation of water quality data from performance and operational monitoring wells. If visual inspection is unclear, statistical or other evaluation criteria will be considered.	Yes
Demonstrate decreasing concentration trends or that concentrations are at or below the CSRGs/PQLs in downgradient performance wells.	Yes
North Boundary Containment System	
Compliance Criterion	
Demonstrate system compliance through effluent water quality monitoring to confirm that CSRGs are met. Compliance is based on running averages for the last four quarters, or one annual sample for those analytes that are not sampled quarterly.	No. 1,4-dioxane concentrations exceeded the CSRG/PQL in plant effluent during all four quarters of FY23, with moving average exceeding the CSRG/PQL. NDMA exceeded CSRG/PQL in the plant effluent—during the second, third, and fourth quarters of FY23—and the moving average exceeded the standard during the third and fourth quarters. Further evaluation of NDMA and related treatment at the NBCS is planned for FY24.
Primary Performance Criteria [2]	
Demonstrate containment through reverse hydraulic gradient by visual evaluation of potentiometric maps and visual comparison of paired well water levels. If visual inspection is unclear, statistical or other evaluation criteria will be considered.	Yes.
Demonstrate containment through plume-edge capture by visual evaluation of flow directions on potentiometric maps, and evaluation of water quality data from performance water quality wells. If visual inspection is unclear, statistical or other evaluation criteria will be considered.	Yes. The potentiometric surface map and the evaluation of water quality data indicate plume edge capture at both ends of the system.
Secondary Performance Criterion [2]	
If unable to maintain reverse hydraulic gradient due to factors beyond Army control, the performance evaluation will be based on demonstrating that concentrations in downgradient water quality performance wells are at or below CSRGs/PQLs or show decreasing concentration trends over the previous period of at least 5 years. If visual inspection is unclear, statistical or other evaluation criteria will be considered.	Secondary performance criterion is not applicable since primary performance criteria were achieved. Continued monitoring will be conducted to evaluate reverse gradient across the system.

Table 9.1-1. Summary of FY23 Compliance and Performance Criteria and Goals Achievement

LTMP Performance Criterion or Primary Goal [1]	Criterion or Goal Achievement
Basin A Neck System	
Compliance Criterion	
Demonstrate system compliance through effluent water quality monitoring to confirm that CSRGs are met. Compliance is based on running averages for the last four quarters, or one annual sample for those analytes that are not sampled quarterly.	Yes
Performance Criteria	
Demonstrate effective mass removal through comparison of total calculated mass removed by the system for each of the CSRG analytes and mass flux approaching the system estimated by combined well capture and transect methods for the BANS (OCN-LTMP-2023-005).	Yes
Demonstrate that concentrations in downgradient performance wells are stable or decreasing.	Yes
Bedrock Ridge Extraction System Performance Criteria	
Demonstrate plume capture through visual evaluation of flow directions on potentiometric maps and evaluation of water quality data from performance and operational monitoring wells. If visual inspection is unclear, statistical and other evaluation criteria will be considered.	Yes
Demonstrate decreasing or stable concentration trends or that concentrations are at or below CSRGs in downgradient performance wells.	No. Concentrations of trichloroethylene is above the CSRG in well 36566 and exhibits an increasing trend. Evaluation of supplemental monitoring data resulted in a recommendation to include installation of one additional extraction well and one downgradient well as part of the future optimization of the system.
Complex Army Disposal Trenches Performance Criteria	
Demonstrate groundwater elevations in performance monitoring wells 36216 and 36217 are below the target elevations of 5226 and 5227 feet, respectively, or Demonstrate hydraulic gradient from the performance monitoring wells locations is toward the extraction trench.	Yes. The CADT system met the performance criteria and objectives established in the LTMP. Although the water levels remained above the trench-bottom elevation in well 36217, hydraulic control was maintained at both performance well locations.
Maintain positive gradient from the outside to the inside of the barrier wall (for as long as active dewatering is occurring).	Yes

Table 9.1-1. Summary of FY23 Compliance and Performance Criteria and Goals Achievement

LTMP Performance Criterion or Primary Goal [1]	Criterion or Goal Achievement
Shell Disposal Trenches Performance Criterion	
Demonstrate groundwater elevations are below the disposal trench bottom elevations within the slurry wall enclosure listed in the 2021 LTMP, Table 5.2-2.	Yes. Groundwater elevation is below the bottom of trenches at all borehole locations.
Lime Basins Slurry Wall Dewatering System Performance Criteria	
Maintain a positive gradient from the outside to the inside of the barrier wall (for as long as the surrounding local groundwater table is in the alluvium).	No. Outward gradient is present in wells on the north side of the slurry wall.
Maintain a groundwater level below the elevation of the Lime Basins waste (5242 feet) inside the barrier wall (for as long as the surrounding local groundwater table is in the alluvium).	Yes
Lime Basins DNAPL Remediation Monitoring Performance Criteria	
Primary Goals [3]	
To determine if additional DNAPL source zones exist in the Lime Basins area in addition to those previously identified.	Yes. No additional DNAPL source zones were identified based on measured DNAPL in wells.
To determine if the extent and nature of any discovered DNAPL source zones have the potential to adversely impact the slurry wall.	Yes. No adverse impacts to the slurry wall due to the presence of DNAPL have been observed.
To characterize DNAPL, if present, for the purpose of correlation with groundwater characterization data as a tool in the identification of DNAPL source zones and for the purpose of waste disposal.	Yes. DNAPL continues to be characterized.
First Creek Treatment System	
Compliance Criteria	
Demonstrate system compliance through effluent water quality monitoring to confirm that CSRGs are met. Compliance is based on running averages for the last four quarters, or one annual sample for those analytes that are not sampled quarterly.	Yes
Performance Criteria	
Demonstrate effective mass removal through comparison of total calculated mass removed by the system for each of the CSRG analytes and mass flux approaching the system estimated by combined well capture and transect methods for the FCTS (OCN-LTMP-2023-004).	No. Further evaluation will take place supporting the current configuration to determine whether operations and monitoring can be optimized in order to provide more effective capture of contaminants within system area.

Table 9.1-1. Summary of FY23 Compliance and Performance Criteria and Goals Achievement

LTMP Performance Criterion or Primary Goal [1]	Criterion or Goal Achievement
Demonstrate that concentrations in downgradient performance wells are stable or decreasing.	Yes
Northern Pathway Treatment System	
Compliance Criteria	
Demonstrate system compliance through effluent water quality monitoring to confirm that CSRGs are met. Compliance is based on running averages for the last four quarters, or one annual sample for those analytes that are not sampled quarterly.	Yes
Performance Criteria	
Demonstrate effective mass removal through comparison of total calculated mass removed by the system for each of the CSRG analytes and mass flux approaching the system estimated by combined well capture and transect methods for the NPTS (OCN-LTMP-2023-004).	Yes
Demonstrate that concentrations in downgradient performance wells are stable or decreasing.	Yes

Notes:

[1] Criteria and goals are listed as presented in the LTMP and reflect any changes in accordance with OCNs as indicated. Primary criteria are provided unless otherwise noted. For systems without primary/secondary criteria, all criteria must be met.

[2] Only the NWBCS and NBCS are bound to secondary performance criteria, and only if primary performance criteria are not met.

[3] There are no performance criteria for the Lime Basins DNAPL Remediation Monitoring program, but goals are specified in the LTMP.

Appendix A

Northwest Boundary Containment System Figures and Documentation

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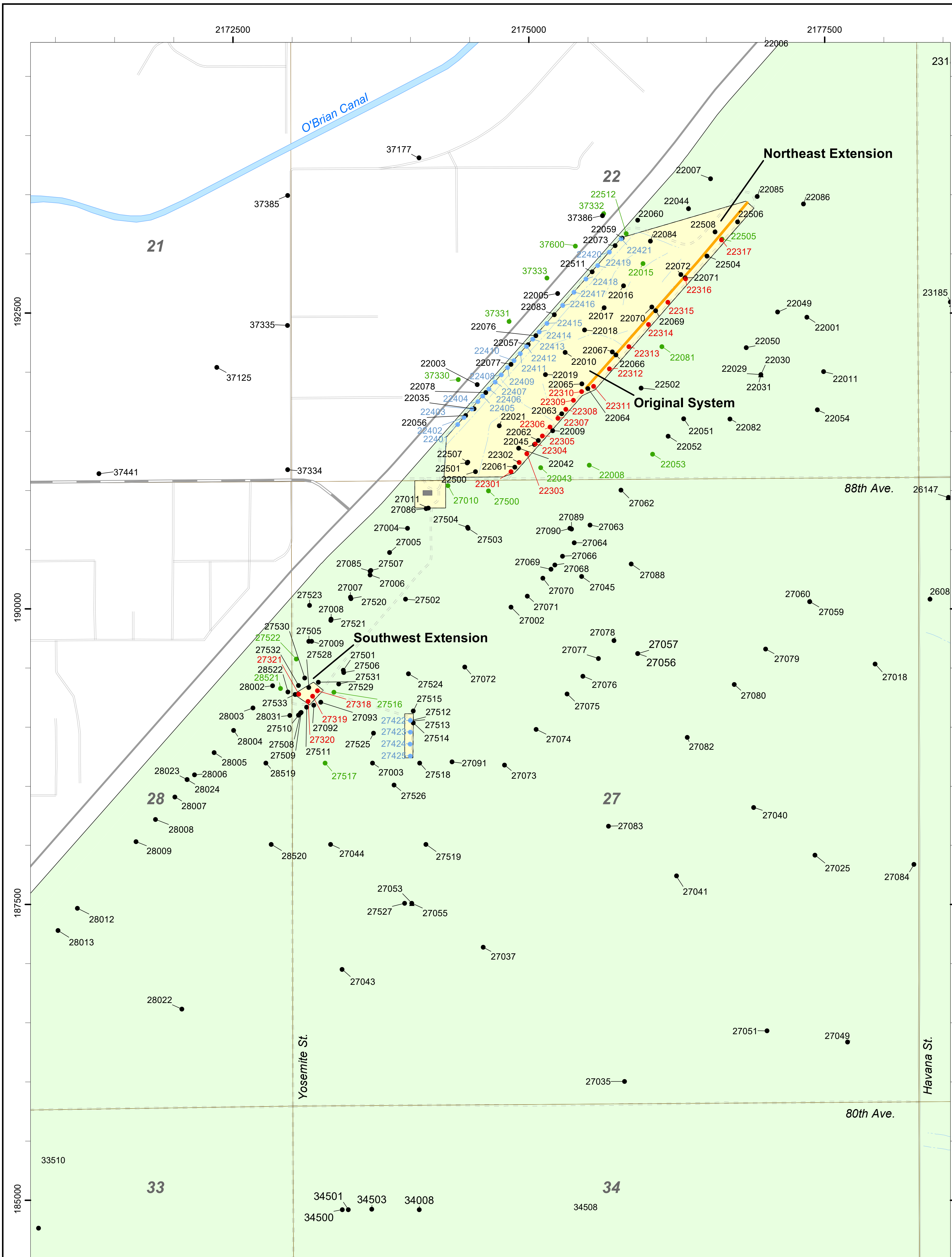

Legend

- Army Maintained Area
- USFWS Managed Area
- Army Maintained Area & USFWS Managed Area Border
- Treatment Building
- Lakes, Ponds, Rivers
- Section Lines
- Light Duty Roads
- Secondary Roads
- Primary Roads
- Unimproved Roads
- Slurry Walls
- Ditches
- Performance Water Quality Wells
- Extraction Wells
- Recharge Wells

Monitoring Wells
- ▲ Confined Flow System
- ● Unconfined Flow System

N

0 315 630 1,260 Feet

State Plane, Colorado North Zone, NAD27, US Survey Feet

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

Program Manager
Rocky Mountain Arsenal

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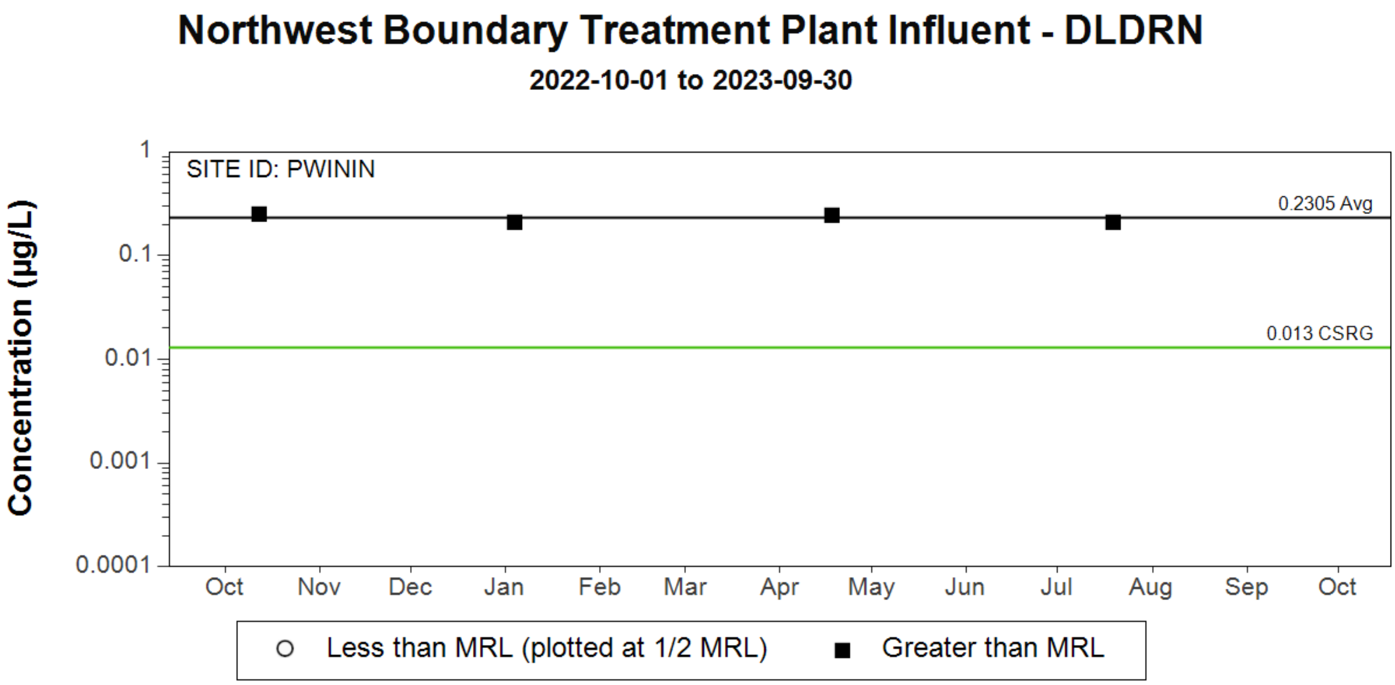
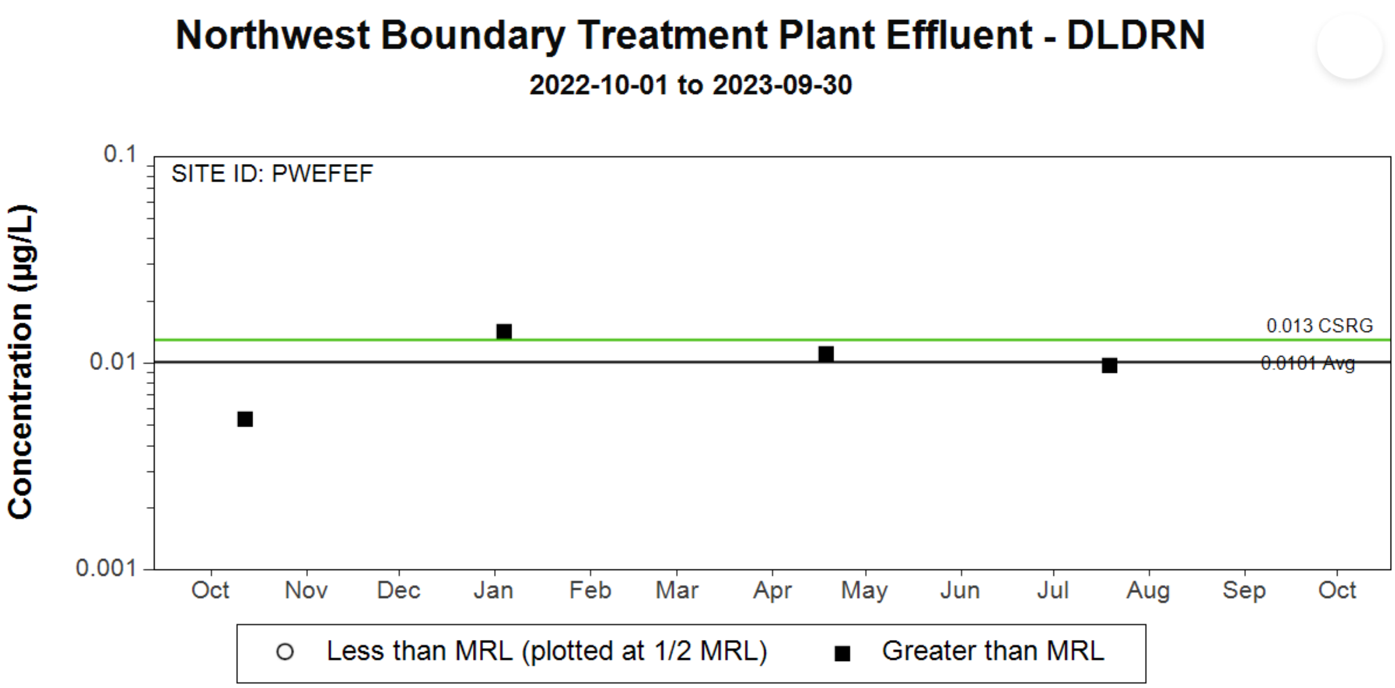
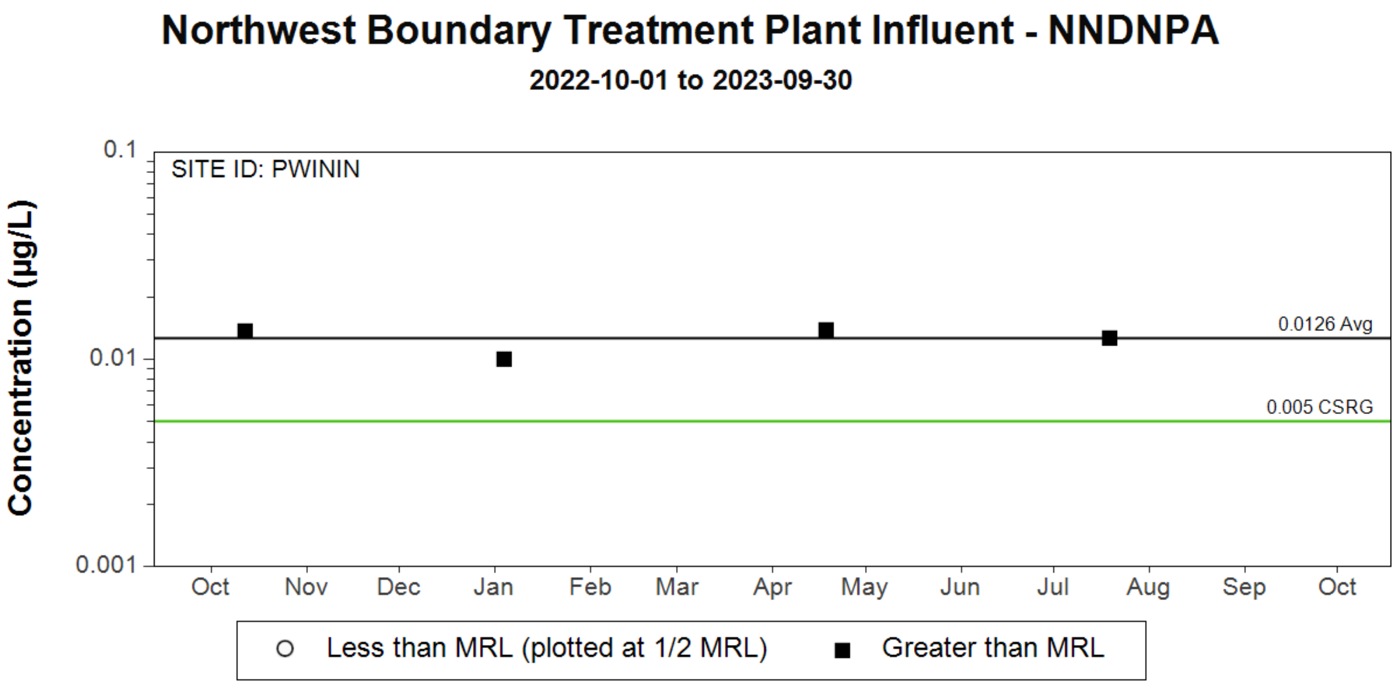
Figure A-1

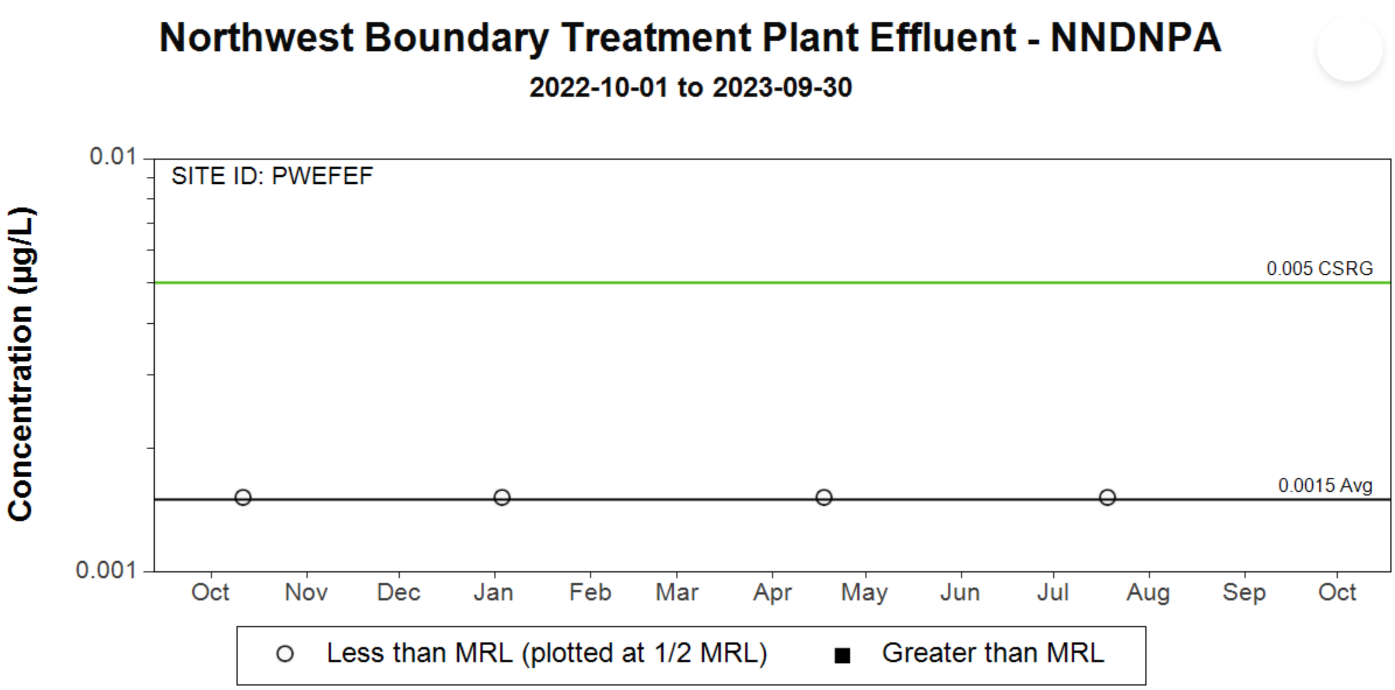
Northwest Boundary
Monitoring Well Network
for the Unconfined Flow System

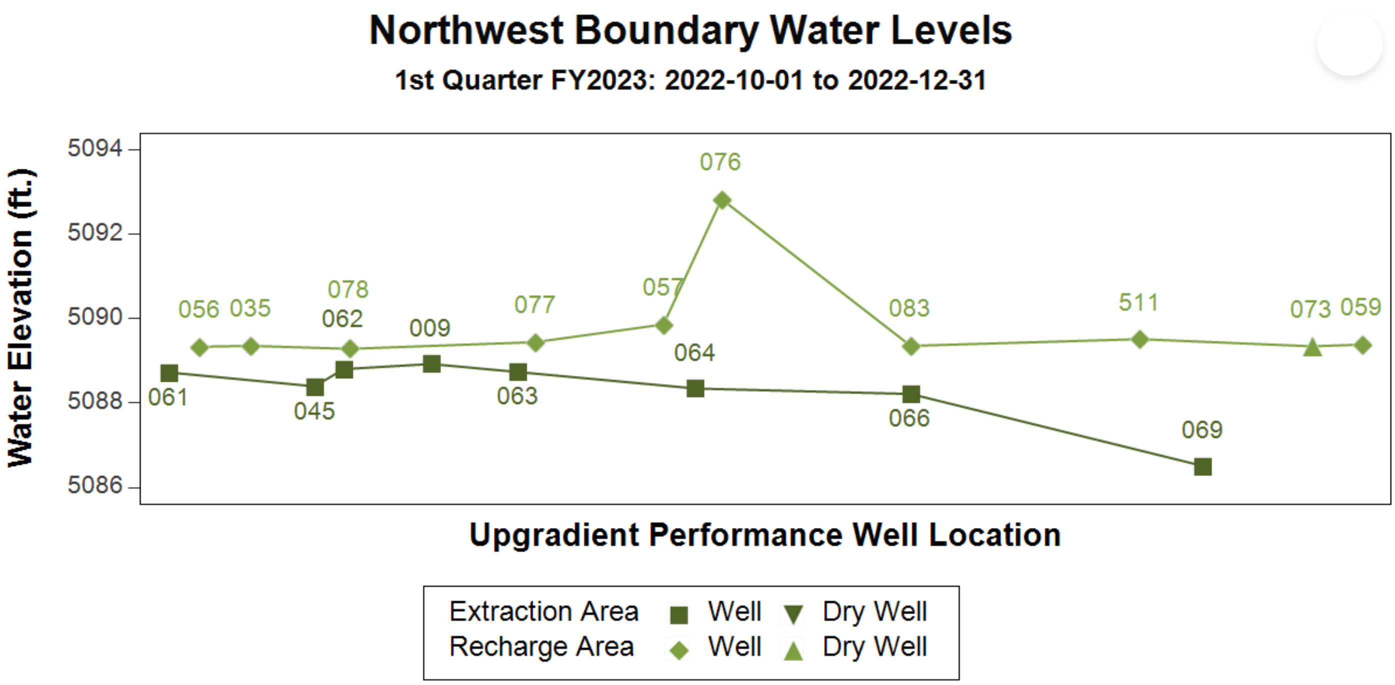
M:\projects\oars\fy23\mxds_nwb23_well_location.mxd
8/10/2024

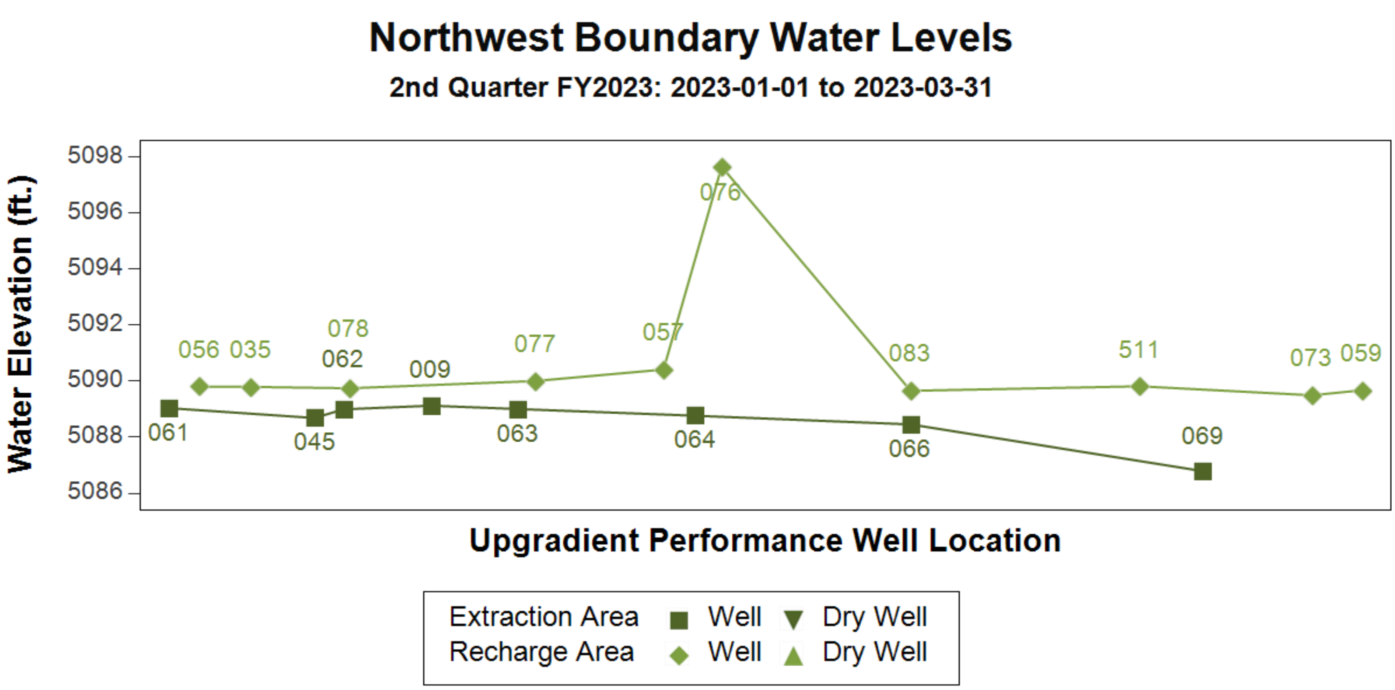

Northwest Boundary Treatment Plant Influent - DLDRN
2022-10-01 to 2023-09-30
SITE ID: PWININ
Concentration (µg/L)
1
0.1
0.01
0.001
0.0001
0.2305 Avg
0.013 CSRG
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Less than MRL (plotted at 1/2 MRL)
Greater than MRL

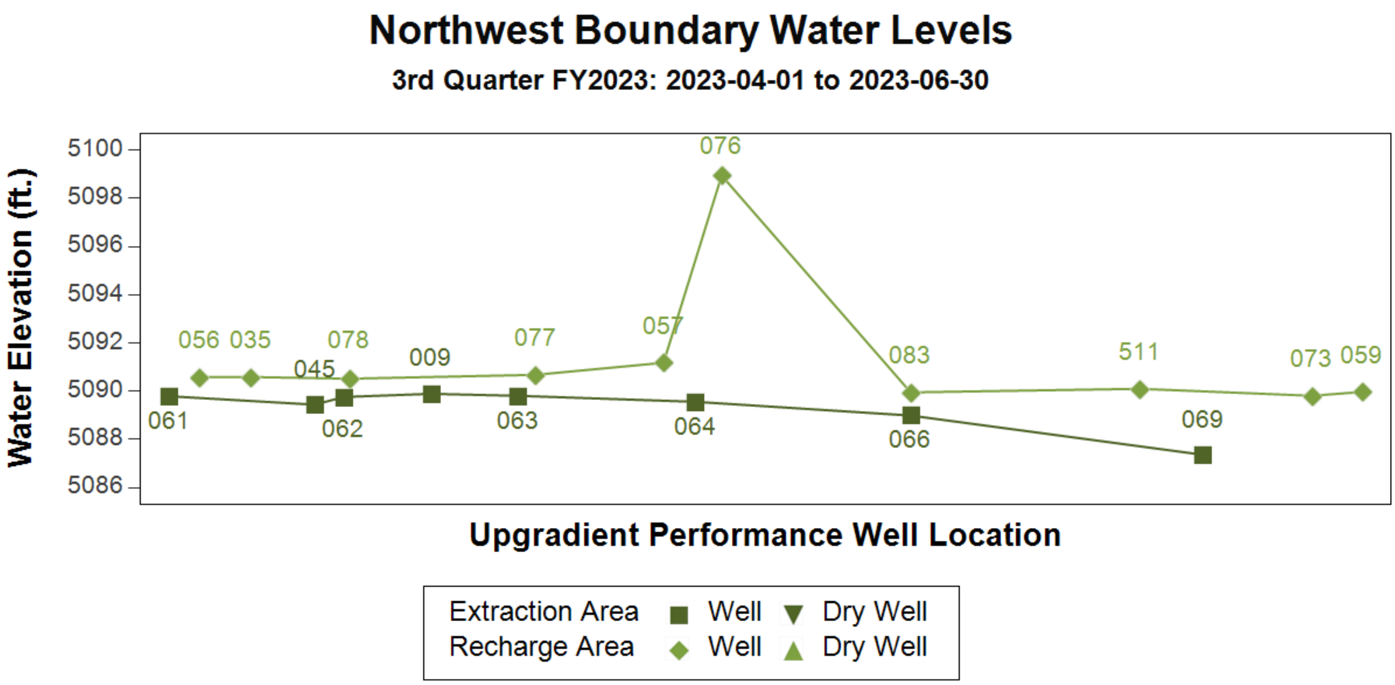

Northwest Boundary Treatment Plant Effluent - DLDRN
2022-10-01 to 2023-09-30
SITE ID: PWEFEF
Concentration (µg/L)
0.1
0.01
0.001
0.013 CSRG
0.0101 Avg
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Less than MRL (plotted at 1/2 MRL)
Greater than MRL

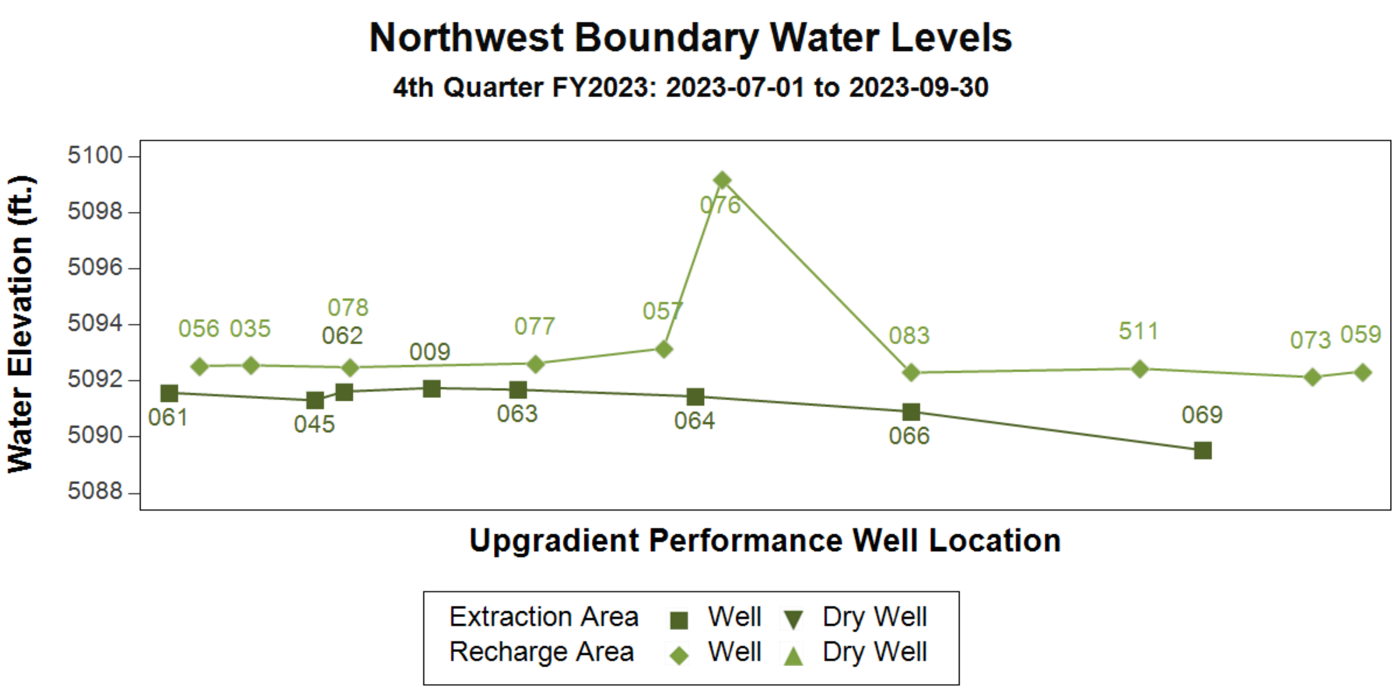

Northwest Boundary Treatment Plant Influent - NNDNPA
2022-10-01 to 2023-09-30
SITE ID: PWININ
Concentration (µg/L)
0.1
0.01
0.001
0.0126 Avg
0.005 CSRG
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Less than MRL (plotted at 1/2 MRL)
Greater than MRL

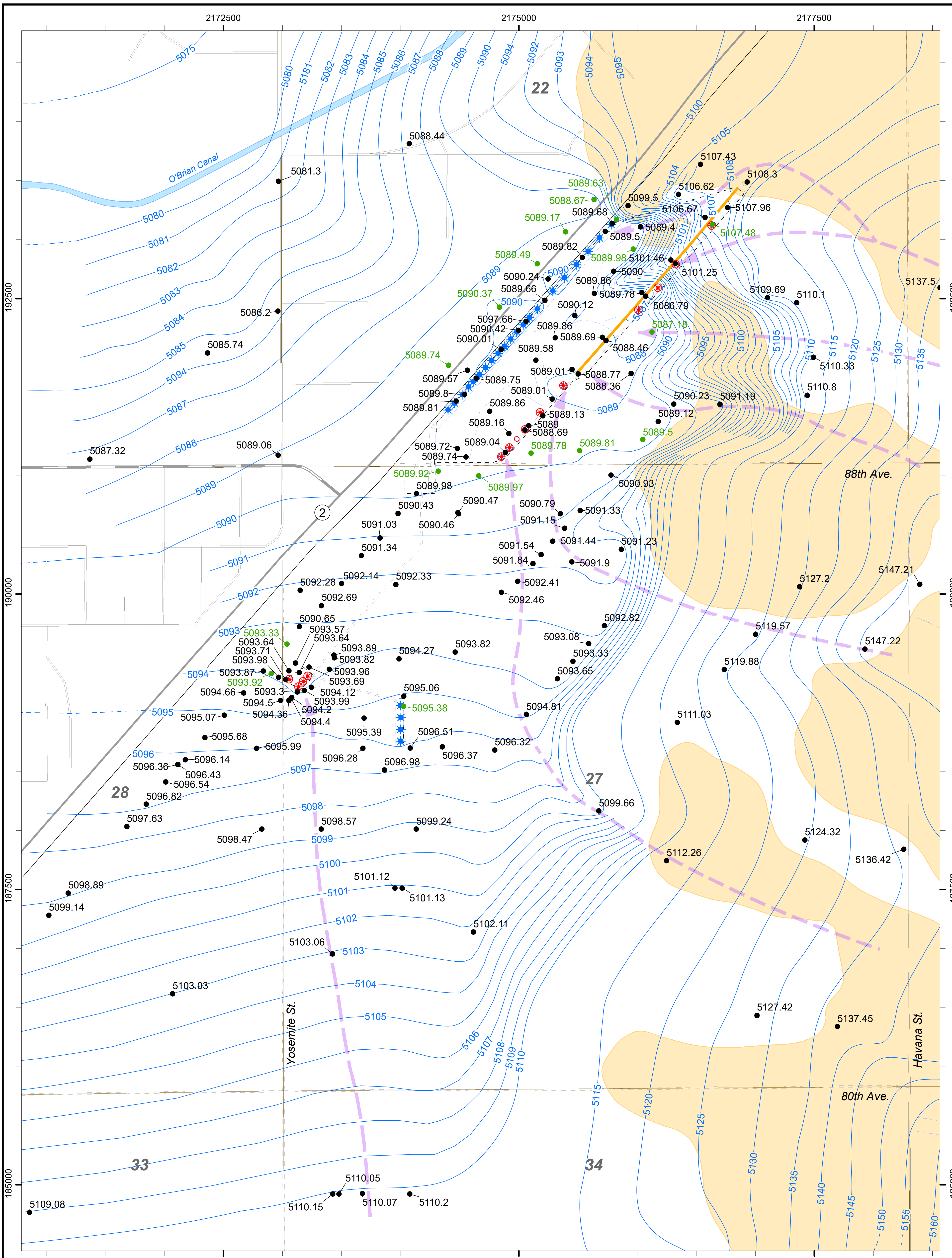

Northwest Boundary Treatment Plant Effluent - NNDNPA
2022-10-01 to 2023-09-30
SITE ID: PWEFEF
Concentration (µg/L)
0.01
0.001
0.005 CSRG
0.0015 Avg
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Less than MRL (plotted at 1/2 MRL)
Greater than MRL


Northwest Boundary Water Levels
1st Quarter FY2023: 2022-10-01 to 2022-12-31
Water Elevation (ft.)
5094
5092
5090
5088
5086
076
056 035
078
062
009
077
057
083
511
073 059
064
061
045
063
066
069
Upgradient Performance Well Location
Extraction Area Well Dry Well
Recharge Area Well Dry Well


Northwest Boundary Water Levels
2nd Quarter FY2023: 2023-01-01 to 2023-03-31
Water Elevation (ft.)
5098
5096
5094
5092
5090
5088
5086
076
056 035
078
062
009
077
057
083
511
073 059
061
045
063
064
066
069
Upgradient Performance Well Location
Extraction Area Well Dry Well
Recharge Area Well Dry Well


Northwest Boundary Water Levels
3rd Quarter FY2023: 2023-04-01 to 2023-06-30
Water Elevation (ft.)
5100
5098
5096
5094
5092
5090
5088
5086
076
056 035
078
009
077
057
083
511
073 059
045
061
062
063
064
066
069
Upgradient Performance Well Location
Extraction Area Well Dry Well
Recharge Area Well Dry Well


Northwest Boundary Water Levels
4th Quarter FY2023: 2023-07-01 to 2023-09-30
Water Elevation (ft.)
5100
5098
5096
5094
5092
5090
5088
076
078
056 035
062
009
077
057
083
511
073 059
061
045
063
064
066
069
Upgradient Performance Well Location
Extraction Area Well Dry Well
Recharge Area Well Dry Well



Legend

Unsaturated Alluvium

Section Lines

Water elevation contour - 1-foot interval

Inferred water elevation contour

Slurry Walls

Lakes, Ponds, Rivers

Local Roads

Secondary Roads

Primary Roads

Measured Wells Used for Contouring with Water Elevations

- Monitoring Wells
- Performance Water Quality Wells

Not Measured or Not Used for Contouring

- Depression in water table due to extraction well. May not match actual areal extent of depression.
- Mound in water table due to recharge well. May not match actual areal extent of mound.
- Monitoring Wells
- Extraction Wells

Note: Water levels were measured in FY23 duriing Quarter 2.

N

0 300 600 1,200 Feet

State Plane, Colorado North Zone, NAD27, US Survey Feet

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

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Figure A-6

FY23 Potentiometric Surface of the Unconfined Flow System, Northwest Boundary Containment System

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8/9/2024

Exhibit A-7. Summary of FY23 NWBCS Performance Water Quality Monitoring

Well ID	Sample Date	Analyte Concentrations with CSRG/PQL noted in italics (ug/L)								
		14DIOX	AS	CHCL3	DLDRN	ENDRN	ISODR	NNDMEA	NNDNPA	TRCLE
		0.35	*2.35*	*6*	*0.013*	*2*	*0.06*	*0.009*	*0.005*	*3*
Upgradient Wells										
22008	2/8/23	**1.14**	**2.57**	4.87	**0.895**	0.189	**0.111**	LT 0.003	**0.323**	LT 0.2
22043	2/8/23	0.172	LT 1	3.26	**1.45**	0.014	LT 0.00619	LT 0.003	LT 0.003	LT 0.2
22053	2/9/23	**0.58**	1.52	1.01	**0.66**	0.0634	**0.104**	—	—	LT 0.2
22081	2/6/23	**1.04**	**2.75**	2.81	**0.742**	0.0475	**0.132**	LT 0.003	**0.352**	LT 0.2
22505	2/6/23	**1.02**	**4.5**	0.205	**0.4**	LT 0.00488	**0.241**	LT 0.003	**0.545**	LT 0.2
27500	11/8/22	—	—	LT 0.2	**0.0351**	LT 0.00488	LT 0.00619	—	—	LT 0.2
	2/8/23	0.169	LT 1	LT 0.2	**0.0281**	LT 0.00488	LT 0.00619	LT 0.003	LT 0.003	LT 0.2
	5/10/23	—	—	LT 0.2	**0.0227**	LT 0.00488	LT 0.00619	—	—	LT 0.2
	7/25/23	—	—	LT 0.2	**0.0233**	LT 0.00488	LT 0.00619	—	—	LT 0.2
27517	2/13/23	—	—	—	0.00665	LT 0.00488	LT 0.00619	—	—	—
Cross-gradient Wells										
27010	11/8/22	—	—	—	0.00785	LT 0.00488	LT 0.00619	—	—	—
	2/8/23	0.166	LT 1	0.863	0.0106	LT 0.00488	LT 0.00619	LT 0.003	LT 0.003	LT 0.2
	5/10/23	—	—	—	0.00618	LT 0.00488	LT 0.00619	—	—	—
	7/25/23	—	—	—	0.00895	LT 0.00488	LT 0.00619	—	—	—
27516	11/8/22	—	—	—	0.00636	LT 0.00488	LT 0.00619	—	—	—
	2/13/23	—	—	—	0.00842	LT 0.00488	LT 0.00619	—	—	—
	5/10/23	—	—	—	0.00692	LT 0.00488	LT 0.00619	—	—	—
	7/26/23	—	—	—	0.0128	LT 0.00488	LT 0.00619	—	—	—
28521	11/8/22	—	—	—	LT 0.00252	LT 0.00488	LT 0.00619	—	—	—
	2/9/23	—	—	—	0.00258	LT 0.00488	LT 0.00619	—	—	—
	5/10/23	—	—	—	LT 0.00252	LT 0.00488	LT 0.00619	—	—	—
	7/26/23	—	—	—	LT 0.00252	LT 0.00488	LT 0.00619	—	—	—

Notes:

Values shaded and in BOLD are concentrations that exceed the CSRG/PQL.

LT – Nondetection reported less than the method reporting limit.

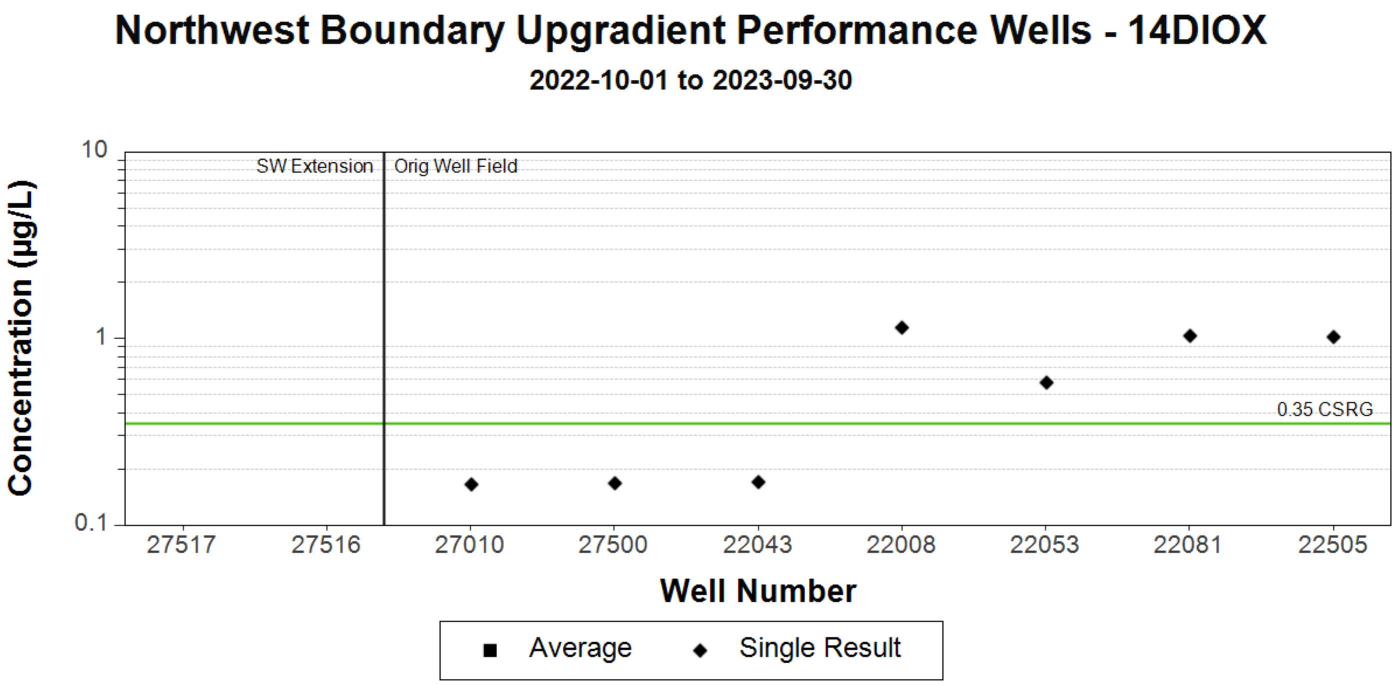
Exhibit A-7. Summary of FY23 NWBCS Performance Water Quality Monitoring

Well ID	Sample Date	Analyte Concentrations with CSRG/PQL noted in italics (ug/L)								
		14DIOX	AS	CHCL3	DLDRN	ENDRN	ISODR	NNDMEA	NNDNPA	TRCLE
		0.35	*2.35*	*6*	*0.013*	*2*	*0.06*	*0.009*	*0.005*	*3*
Downgradient Wells										
22015	2/6/2023	0.163	1.25	1.03	**0.0253**	0.0207	0.0506	LT 0.003	LT 0.003	LT 0.2
	7/27/2023	—	—	—	0.0131	0.0128	0.0114	LT 0.0048	LT 0.003	—
22512	11/7/2022	—	—	—	**0.0666**	0.0105	LT 0.00619	—	—	—
	2/9/2023	0.208	1.1	1.32	**0.0699**	0.0313	0.0169	LT 0.003	**0.0103**	LT 0.2
	5/10/2023	—	—	—	**0.0535**	LT 0.00488	0.00828	—	—	—
	7/25/2023	—	—	—	**0.0295**	LT 0.00488	LT 0.00619	—	—	—
27522	2/13/23	LT 0.075	LT 1	LT 0.2	0.0026	LT 0.00488	LT 0.00619	LT 0.003	LT 0.003	LT 0.2
37330	2/14/23	0.195	LT 1	1.22	0.0102	LT 0.00488	LT 0.00619	LT 0.003	LT 0.003	LT 0.2
37331	2/14/23	0.172	LT 1	1.43	**0.019**	LT 0.00488	LT 0.00619	LT 0.003	LT 0.003	LT 0.2
37332	2/14/23	0.174	LT 1	1.66	**0.0155**	LT 0.00488	LT 0.00619	LT 0.003	LT 0.003	LT 0.2
37333	11/8/22	—	—	—	**0.0187**	0.0141	LT 0.00619	—	—	—
	2/14/23	0.17	LT 1	1.31	0.0233	0.0122	LT 0.00619	LT 0.003	LT 0.003	LT 0.2
	5/10/23	—	—	—	**0.0224**	0.0133	LT 0.00619	—	—	—
	7/25/23	—	—	—	**0.0189**	0.0174	LT 0.00619	—	—	—
37600	2/14/23	0.156	LT 1	1.57	**0.0182**	LT 0.00488	LT 0.00619	LT 0.003	LT 0.003	LT 0.2

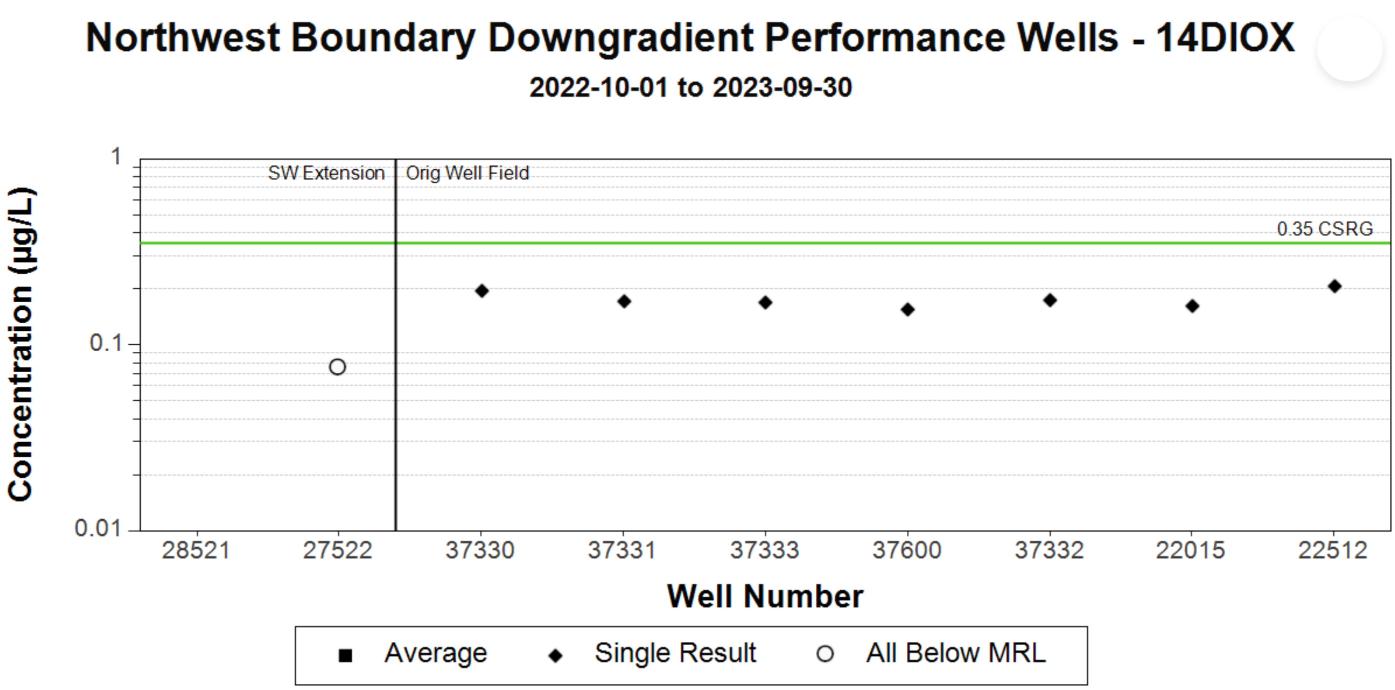
Notes:

Values shaded and in BOLD are concentrations that exceed the CSRG/PQL.

LT – Nondetection reported less than the method reporting limit.



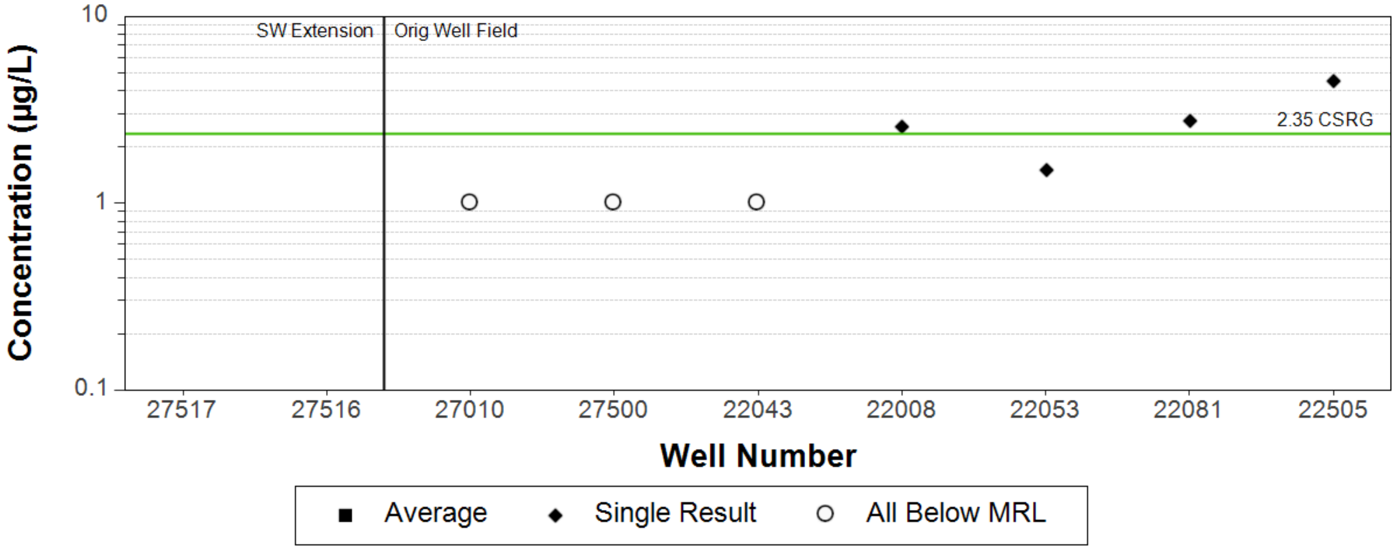
Northwest Boundary Upgradient Performance Wells - 14DIOX
2022-10-01 to 2023-09-30
Concentration (µg/L)
10
1
0.1
SW Extension
Orig Well Field
0.35 CSRG
27517
27516
27010
27500
22043
22008
22053
22081
22505
Well Number
Average
Single Result



Northwest Boundary Downgradient Performance Wells - 14DIOX
2022-10-01 to 2023-09-30
Concentration (µg/L)
1
0.1
0.01
SW Extension
Orig Well Field
0.35 CSRG
28521
27522
37330
37331
37333
37600
37332
22015
22512
Well Number
Average
Single Result
All Below MRL

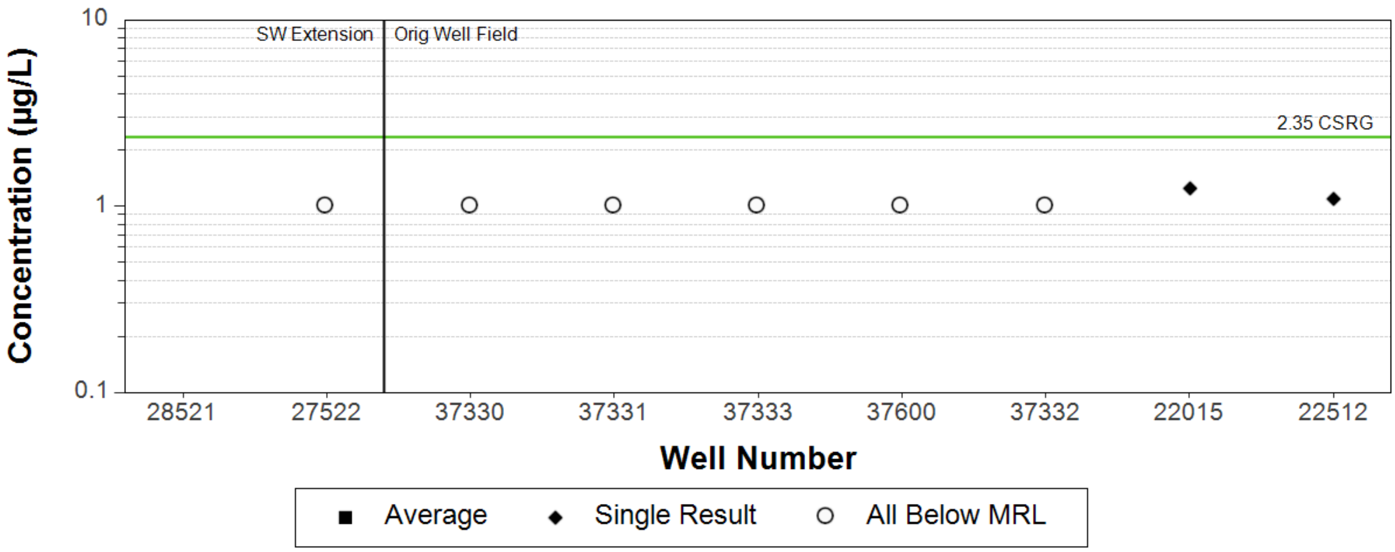
Northwest Boundary Upgradient Performance Wells - AS

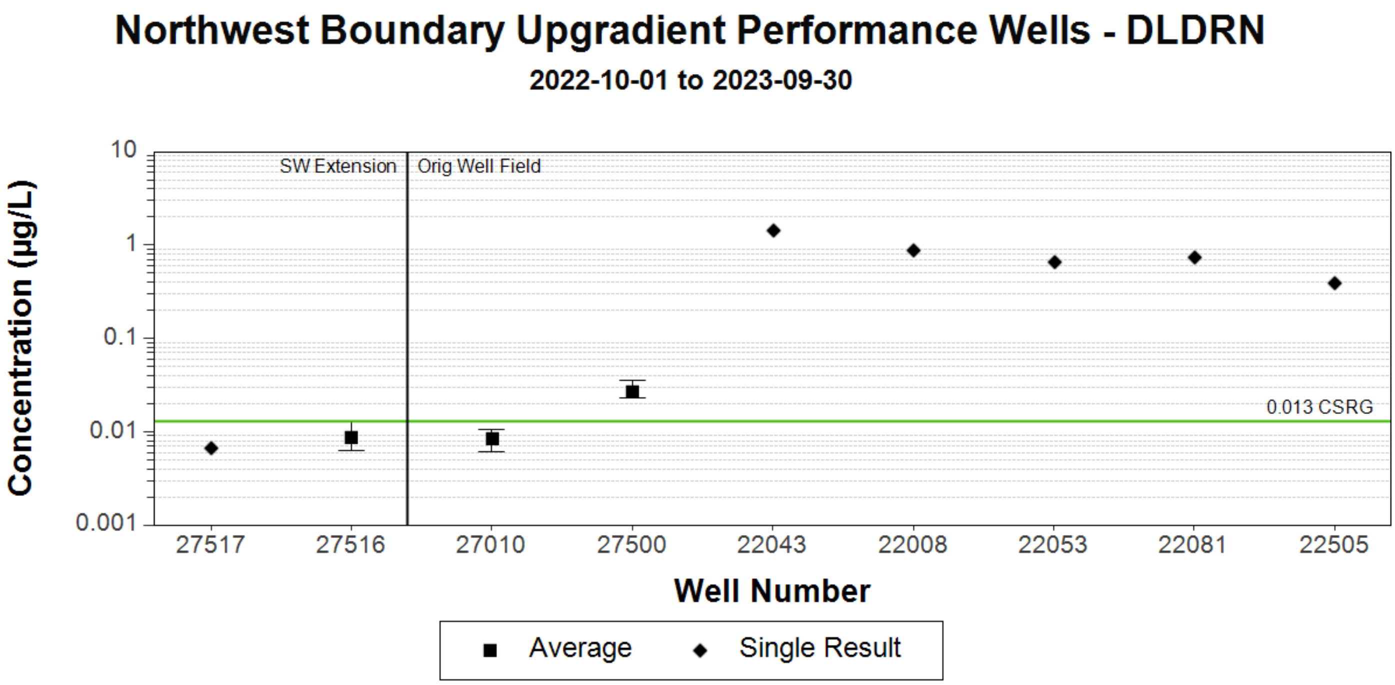
2022-10-01 to 2023-09-30



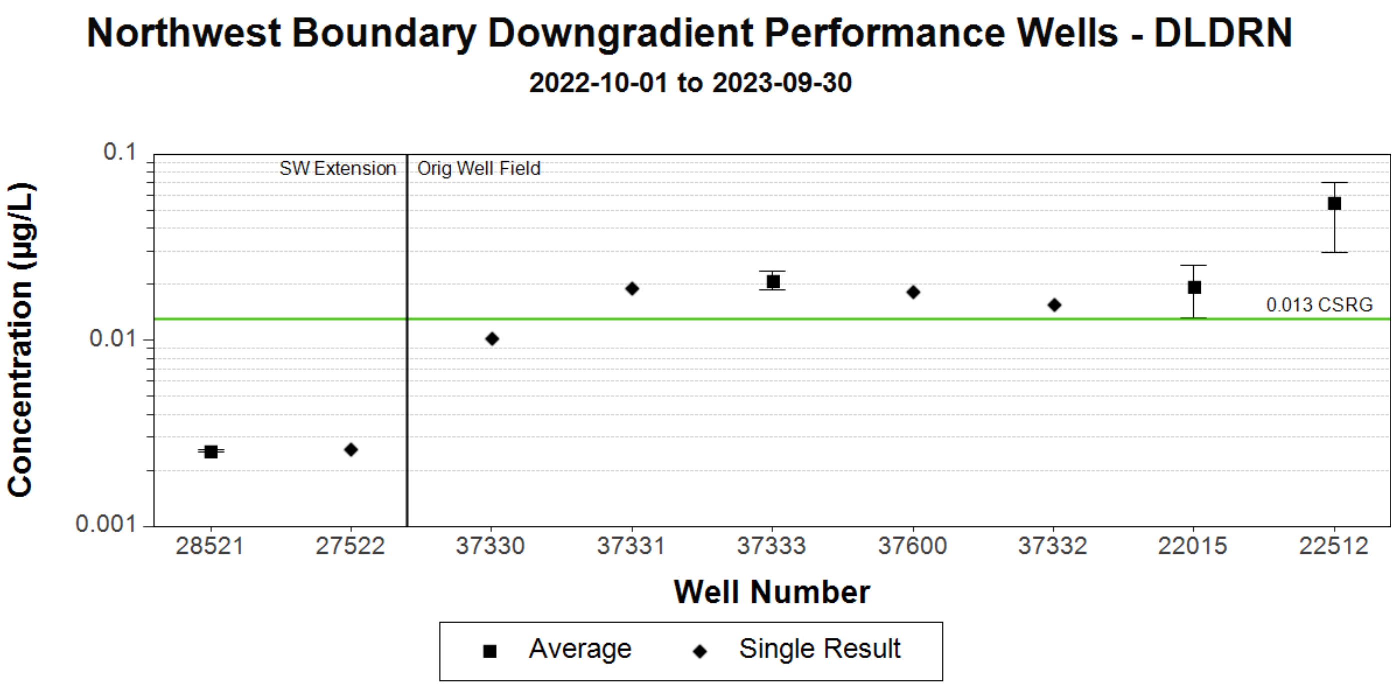
Northwest Boundary Downgradient Performance Wells - AS

2022-10-01 to 2023-09-30

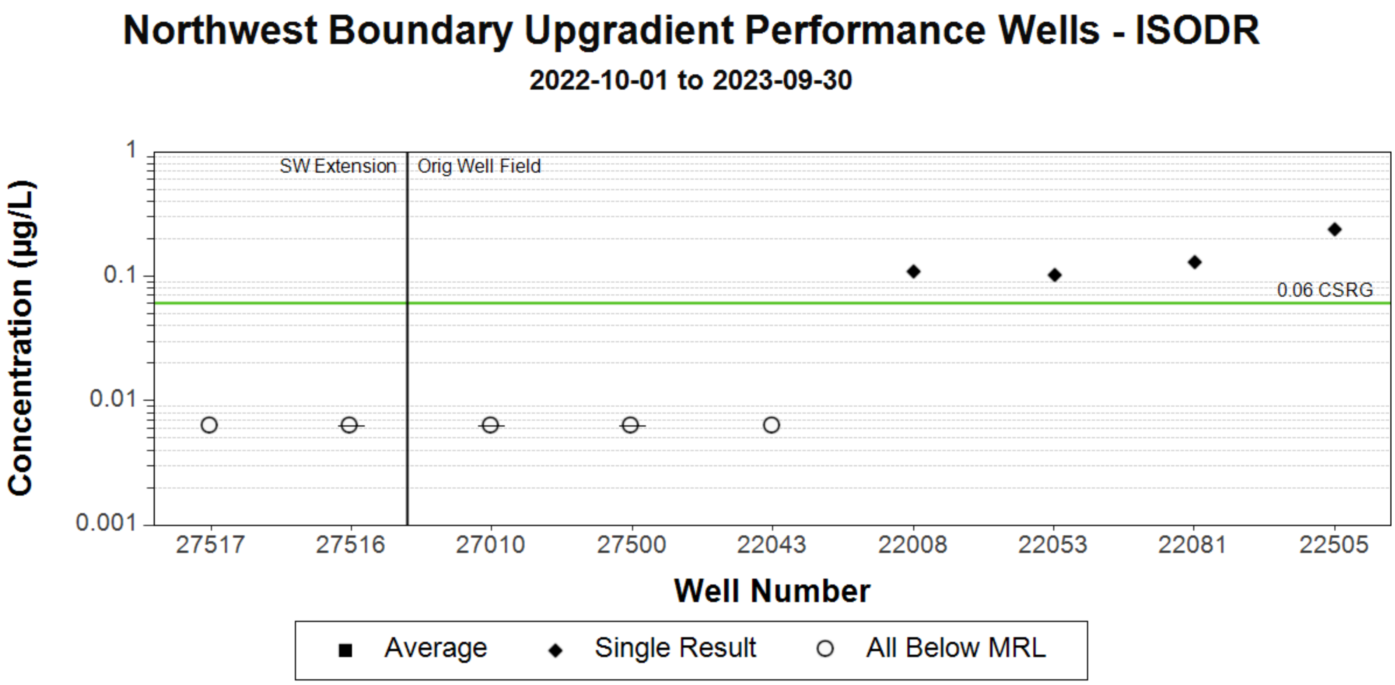




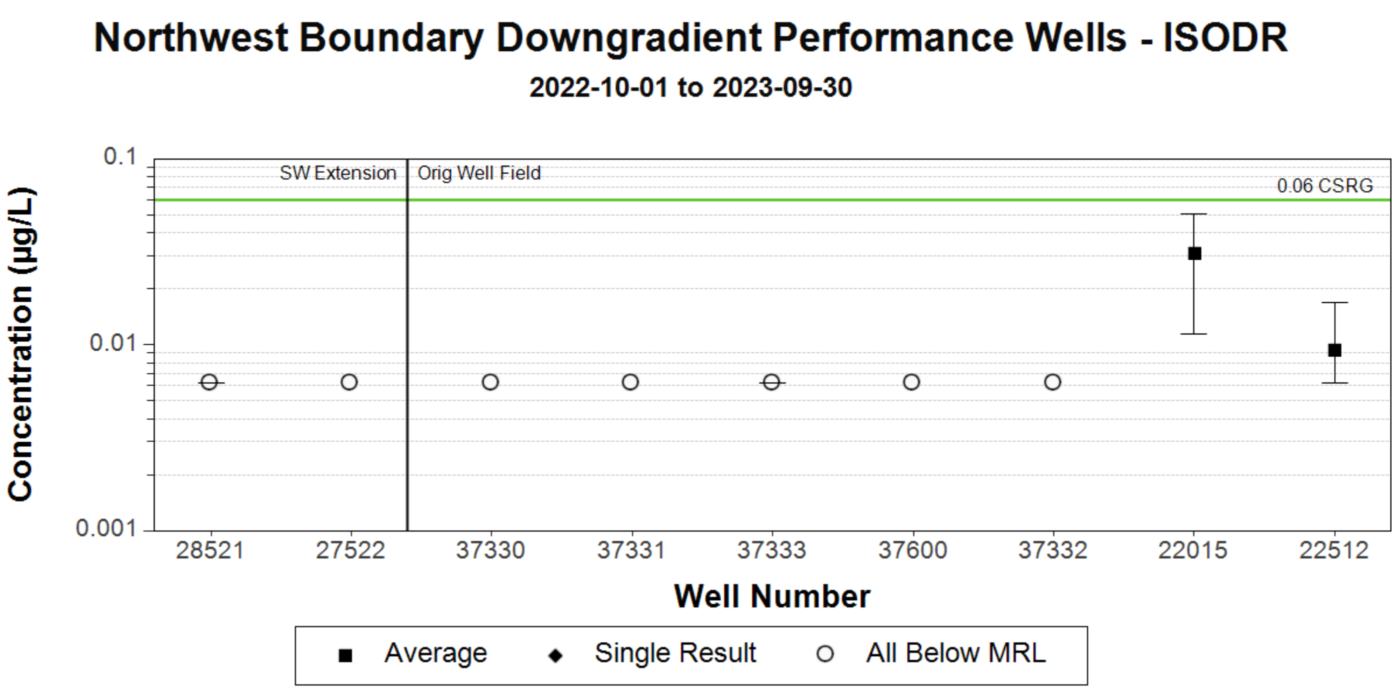
Northwest Boundary Upgradient Performance Wells - DLDRN
2022-10-01 to 2023-09-30
Concentration (µg/L)
10
1
0.1
0.01
0.001
SW Extension
Orig Well Field
0.013 CSRG
27517
27516
27010
27500
22043
22008
22053
22081
22505
Well Number
Average
Single Result



Northwest Boundary Downgradient Performance Wells - DLDRN
2022-10-01 to 2023-09-30
Concentration (µg/L)
0.1
0.01
0.001
SW Extension
Orig Well Field
0.013 CSRG
28521
27522
37330
37331
37333
37600
37332
22015
22512
Well Number
Average
Single Result



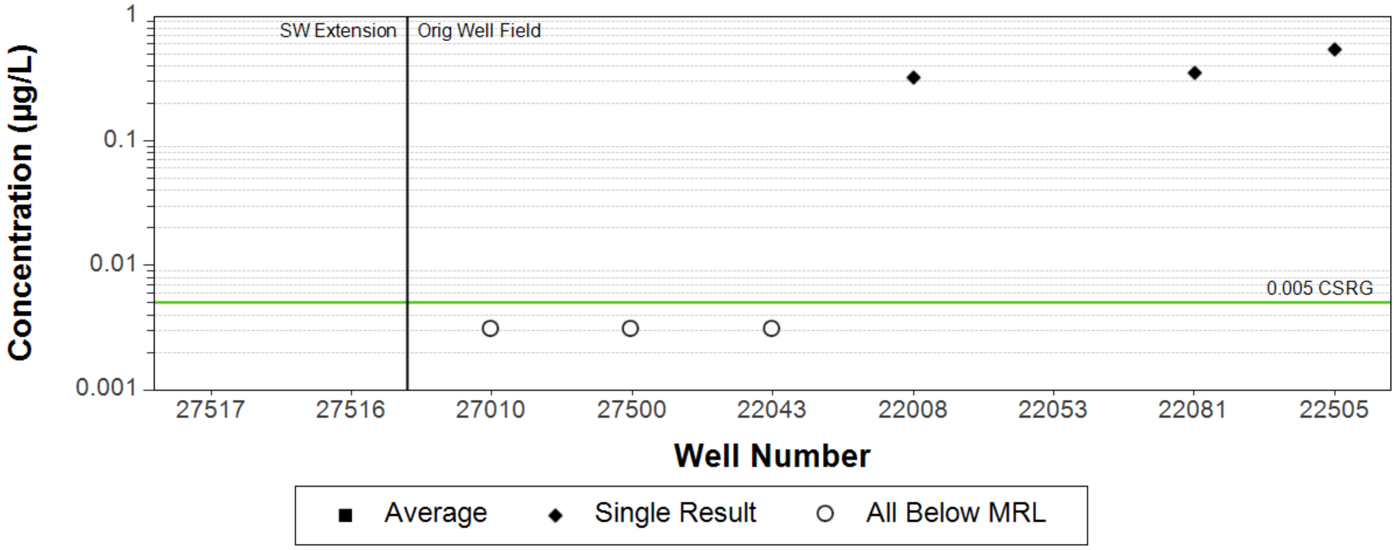
Northwest Boundary Upgradient Performance Wells - ISODR
2022-10-01 to 2023-09-30
Concentration (µg/L)
1
0.1
0.01
0.001
SW Extension
Orig Well Field
0.06 CSRG
27517
27516
27010
27500
22043
22008
22053
22081
22505
Well Number
Average
Single Result
All Below MRL



Northwest Boundary Downgradient Performance Wells - ISODR
2022-10-01 to 2023-09-30
Concentration (µg/L)
0.1
0.01
0.001
SW Extension
Orig Well Field
0.06 CSRG
28521
27522
37330
37331
37333
37600
37332
22015
22512
Well Number
Average
Single Result
All Below MRL

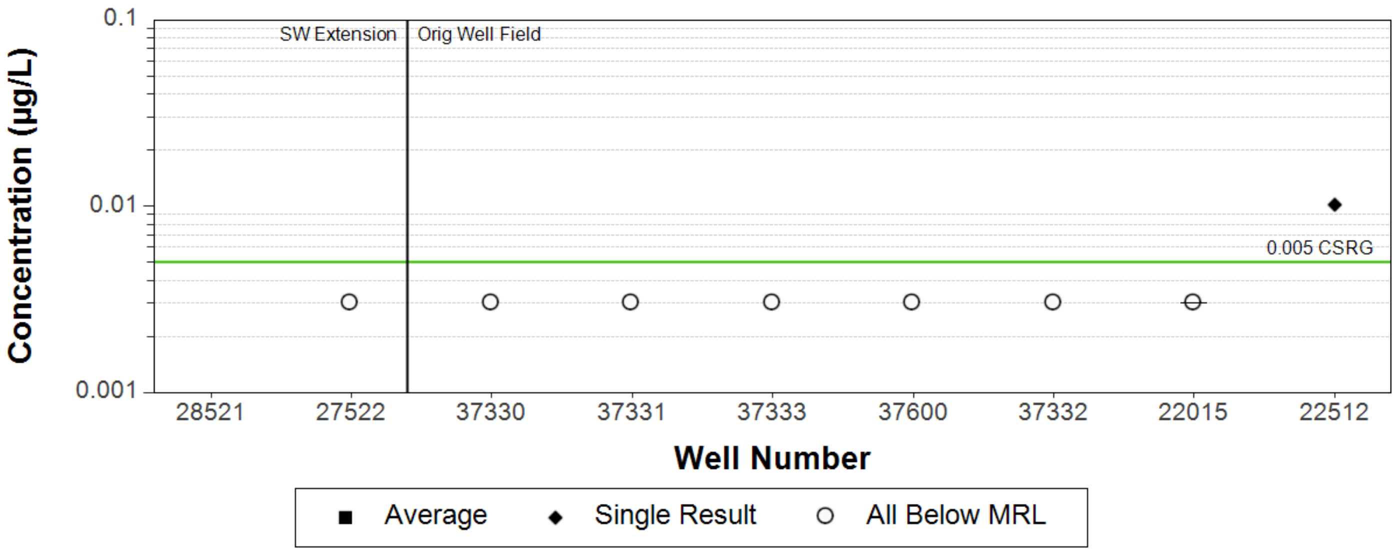
Northwest Boundary Upgradient Performance Wells - NNDNPA

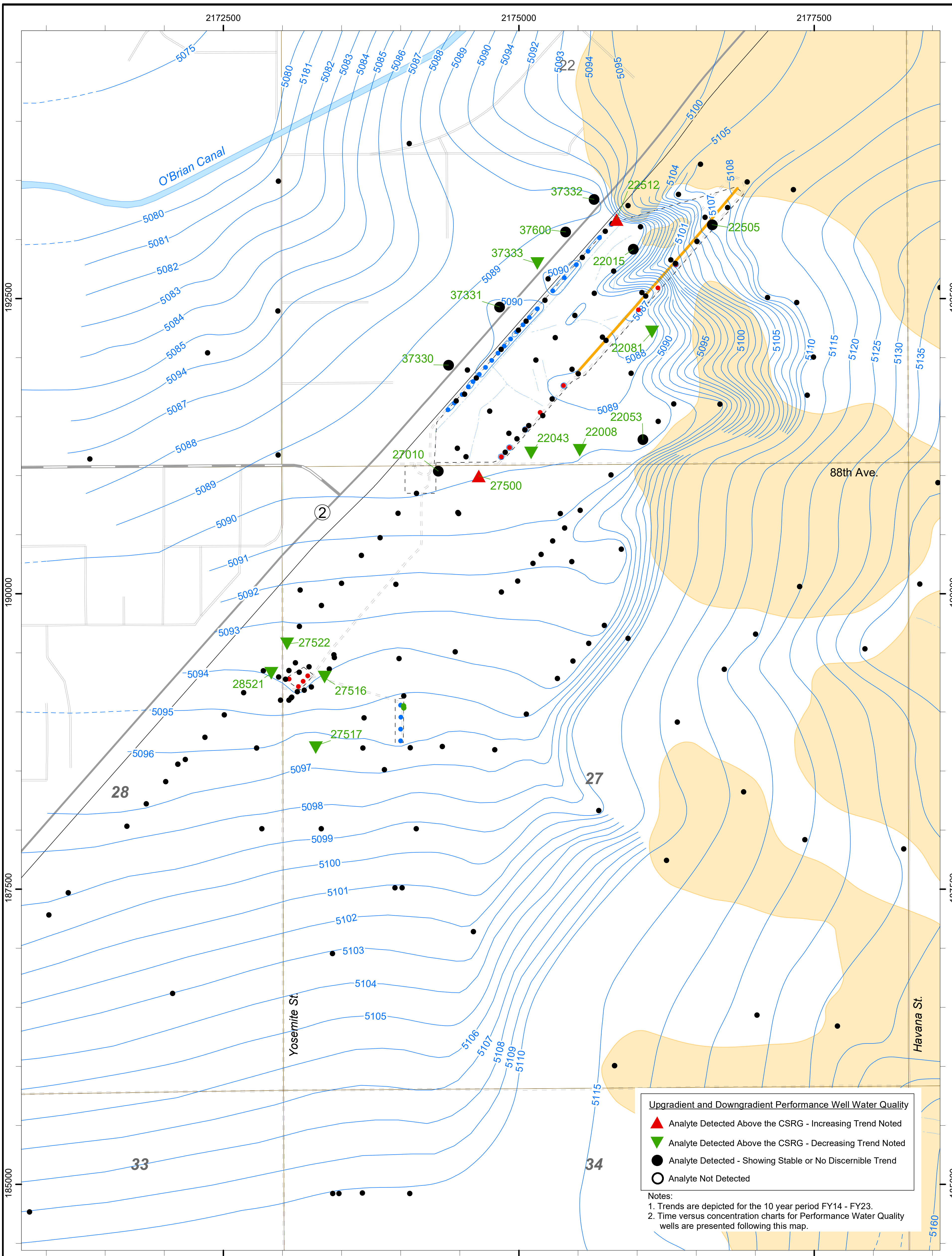
2022-10-01 to 2023-09-30



Northwest Boundary Downgradient Performance Wells - NNDNPA

2022-10-01 to 2023-09-30





Legend

- Unsaturated Alluvium
- Section Lines
- Water elevation contour - 1-foot interval
- Inferred water elevation contour
- Slurry Walls
- Lakes, Ponds, Rivers
- Local Roads
- Secondary Roads
- Primary Roads
- Monitoring Wells
- Performance Water Quality Wells
- Extraction Wells
- Recharge Wells

Note: Water levels were measured in FY23 Quarter 2.

N

0 315 630 1,260 Feet

State Plane, Colorado North Zone, NAD27, US Survey Feet

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

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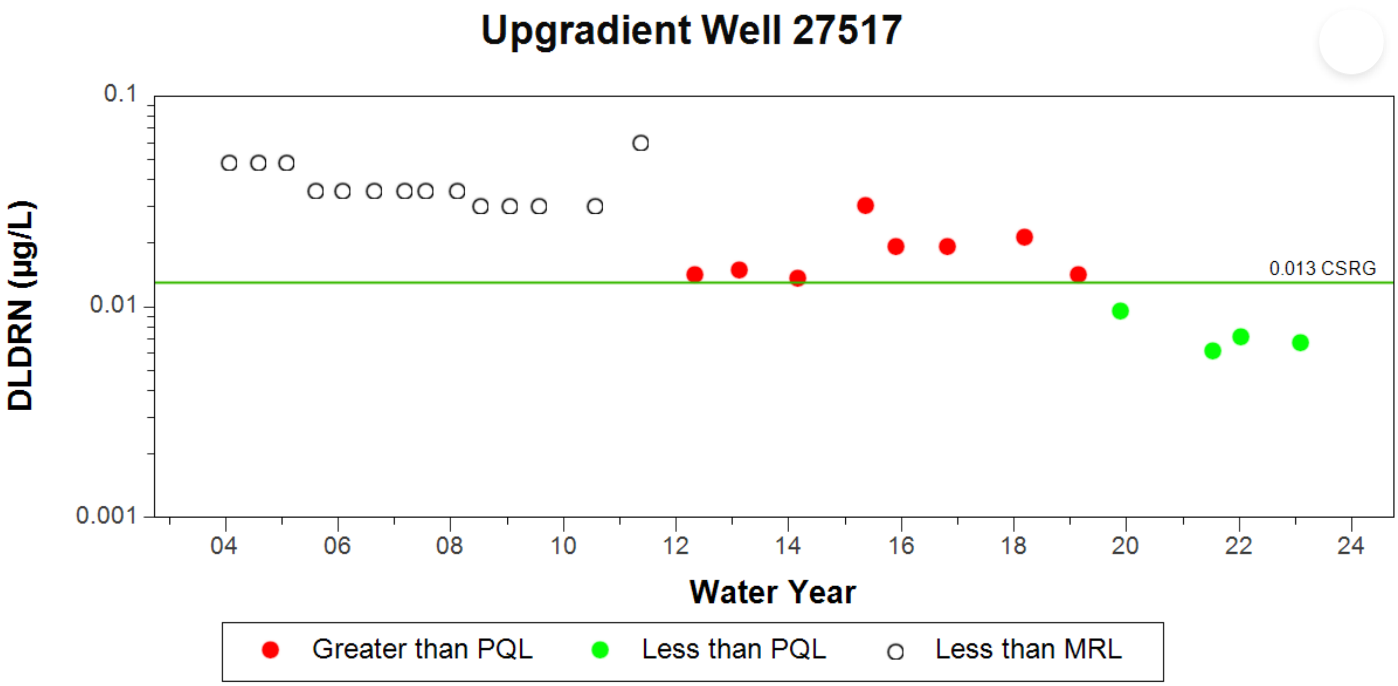
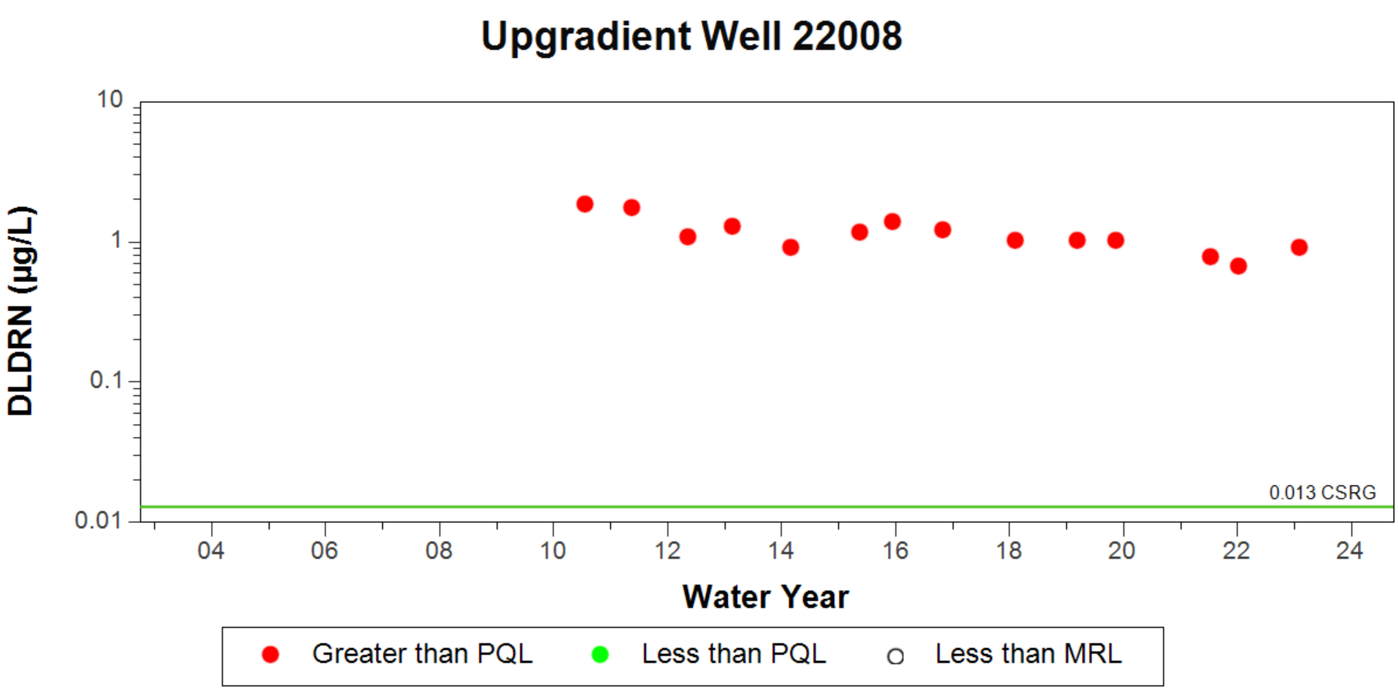
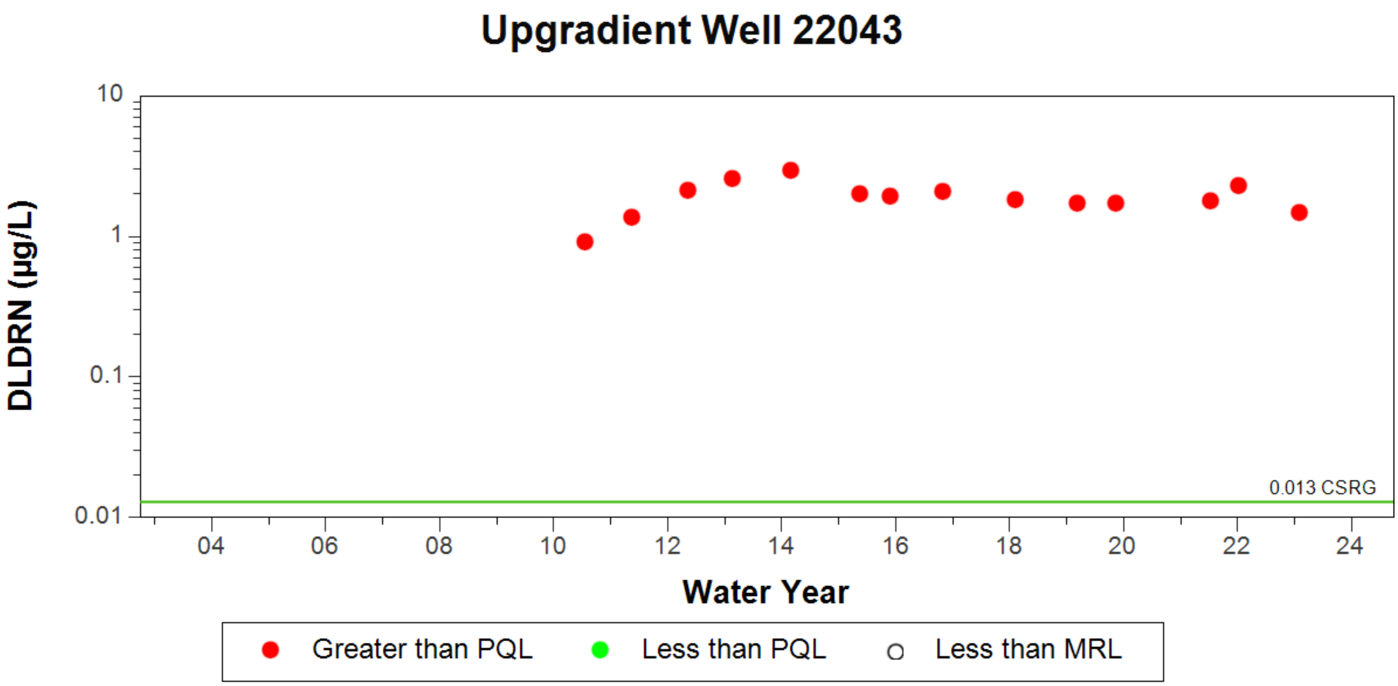
Figure A-13

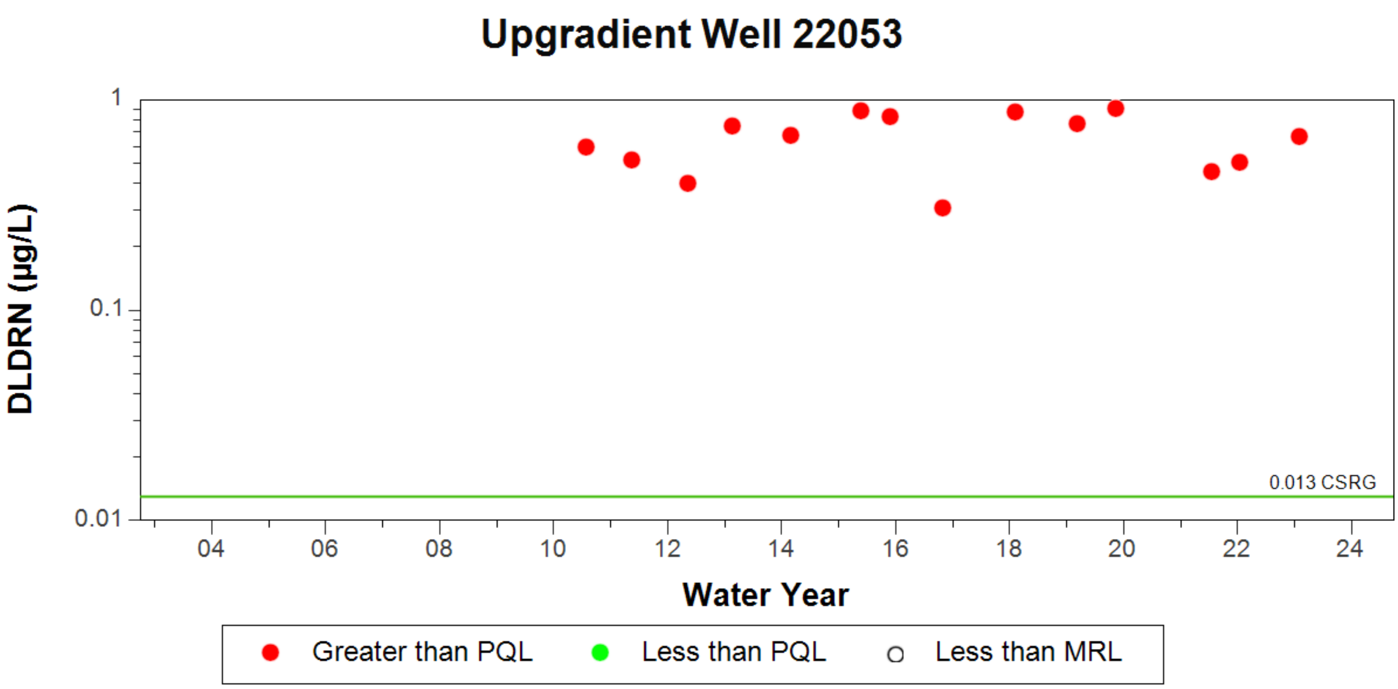
Dieldrin Concentration
Trends in Performance Wells,
Northwest Boundary Containment System

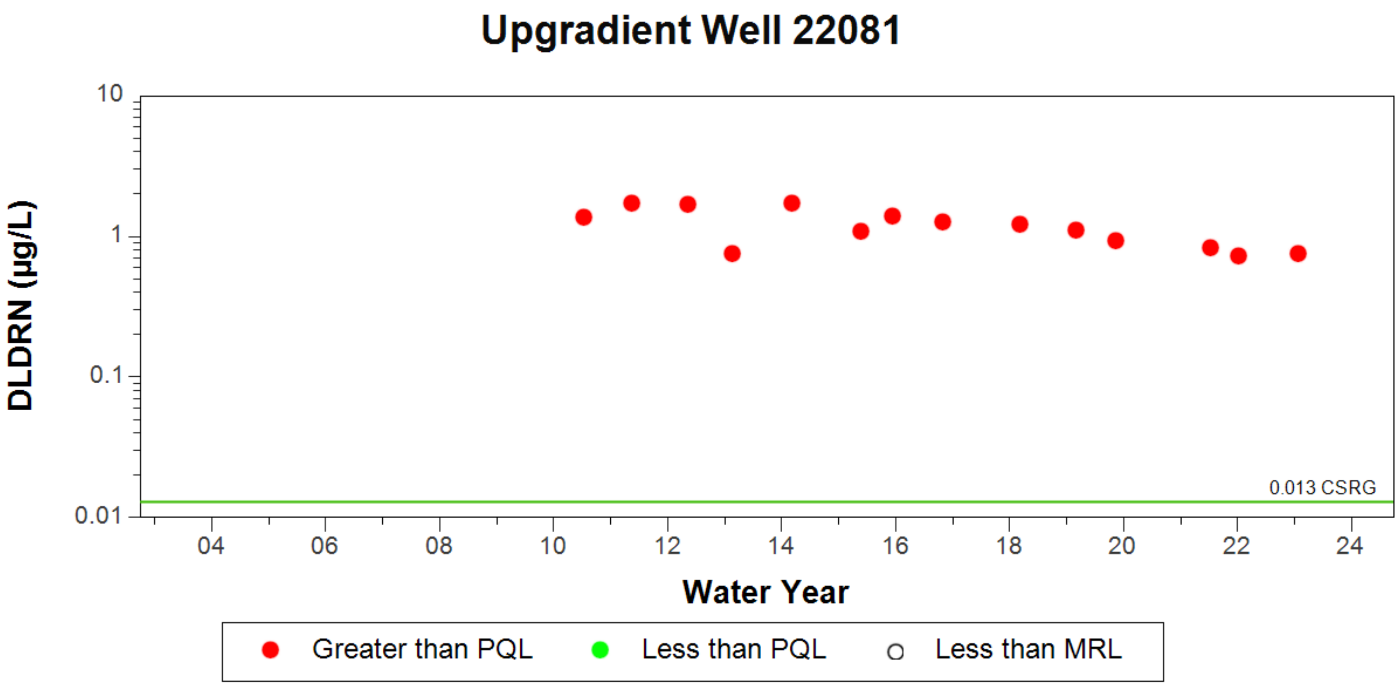
M:\projects\oars\fy23\mxds_NWB_FY23_DLDRN.mxd
8/10/2024


Upgradient Well 27517
DLDRN (µg/L)
0.1
0.01
0.001
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

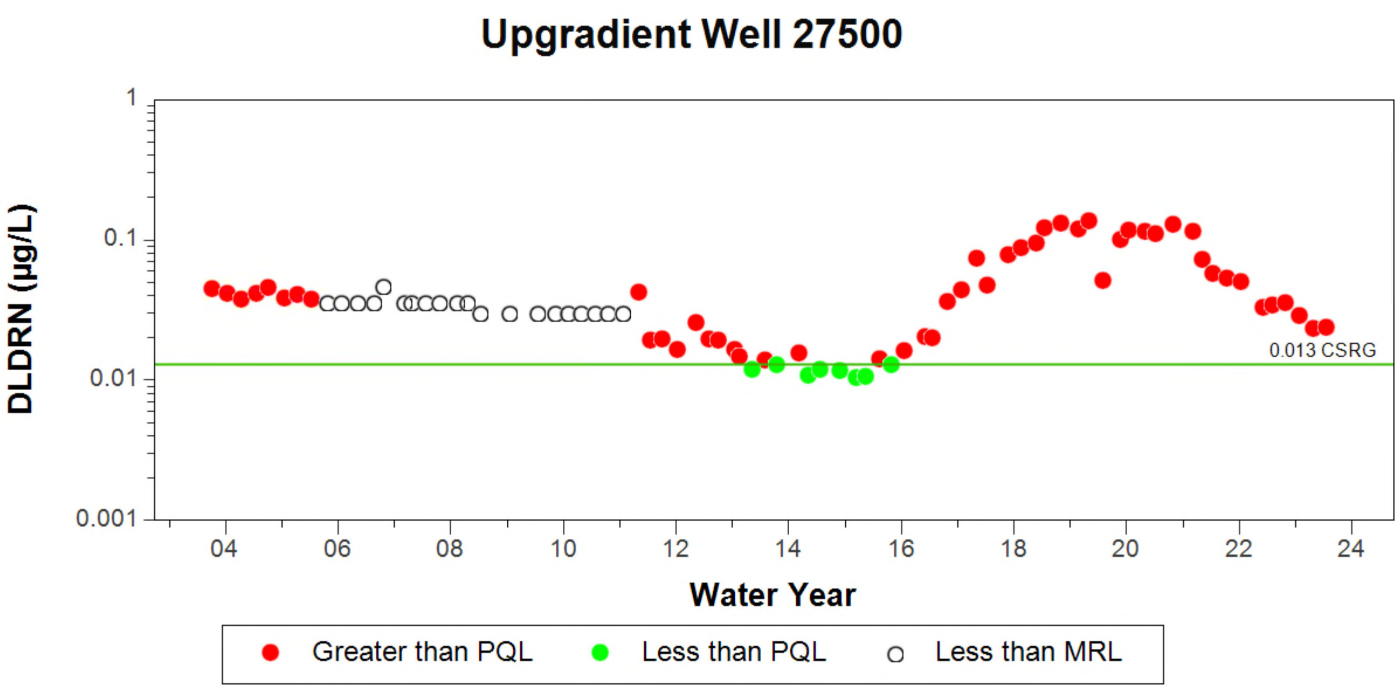

Upgradient Well 22008
DLDRN (µg/L)
10
1
0.1
0.01
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL


Upgradient Well 22043
10
1
0.1
0.01
0.013 CSRG
DLDRN (µg/L)
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

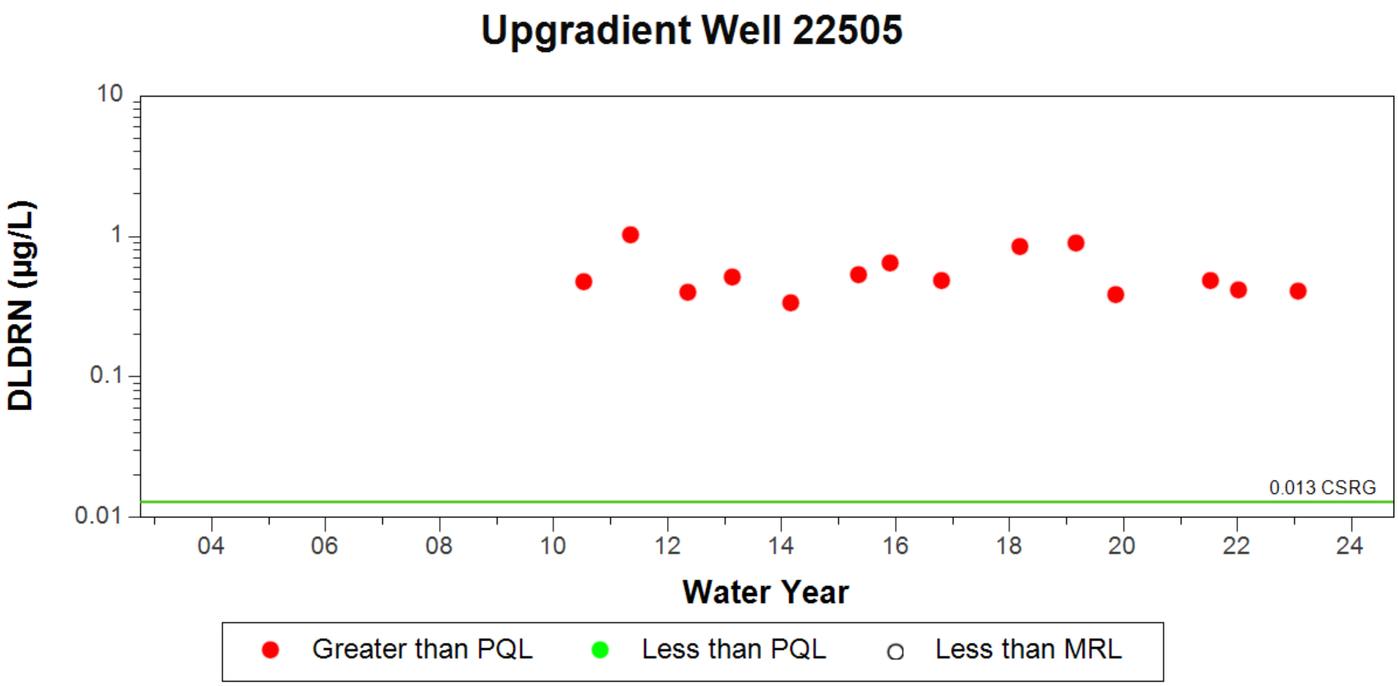

Upgradient Well 22053
1
0.1
0.01
0.013 CSRG
DLDRN (µg/L)
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

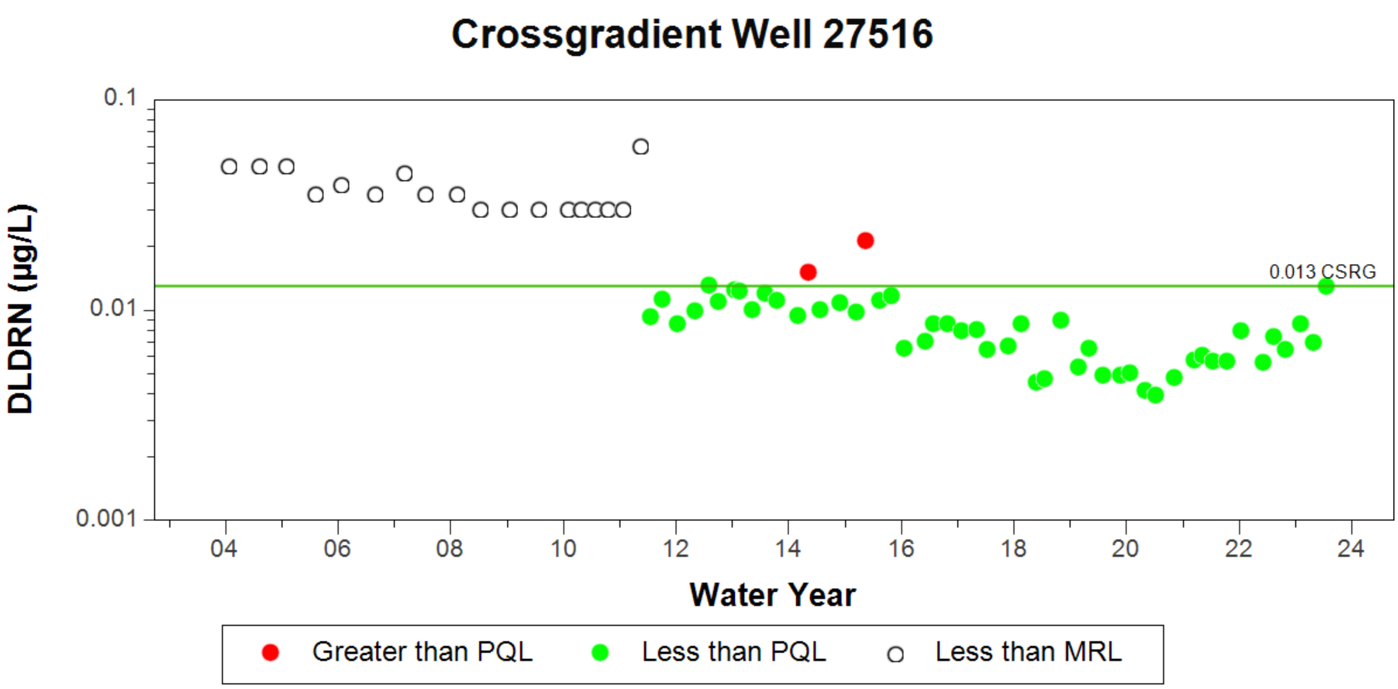


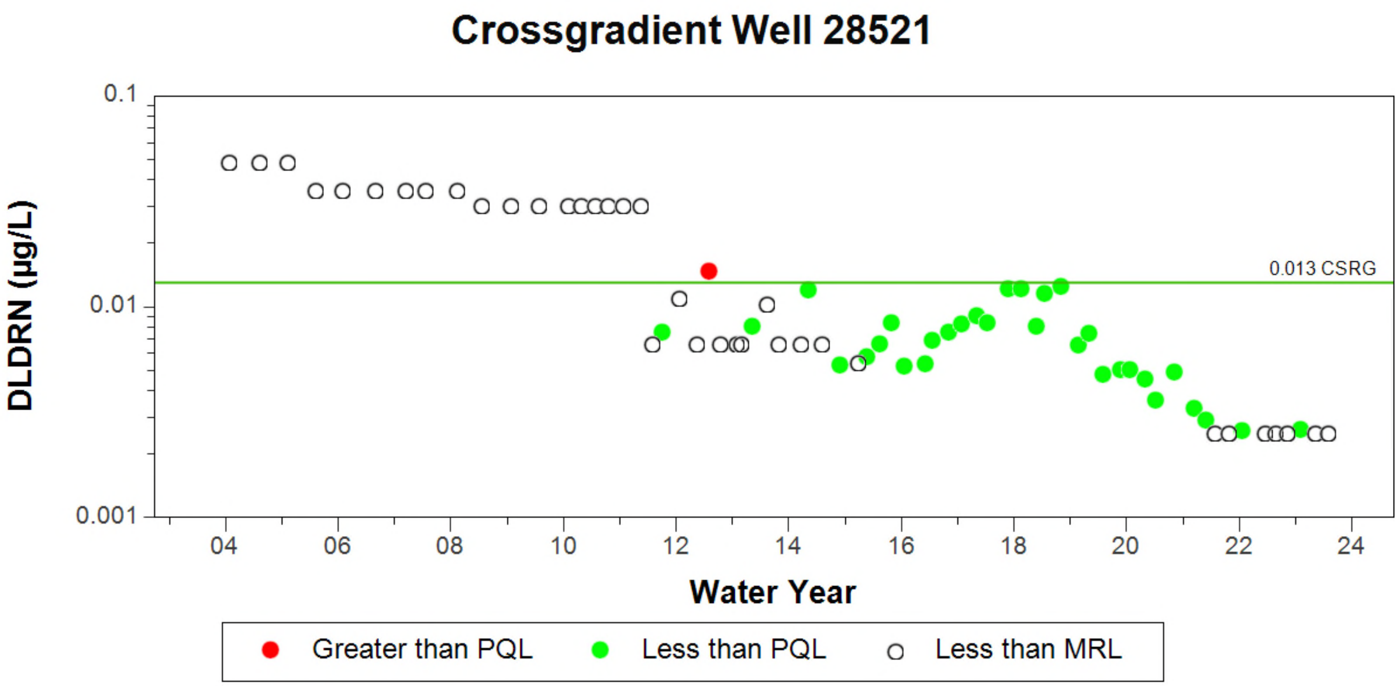
Upgradient Well 22081
DLDRN (µg/L)
10
1
0.1
0.01
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL



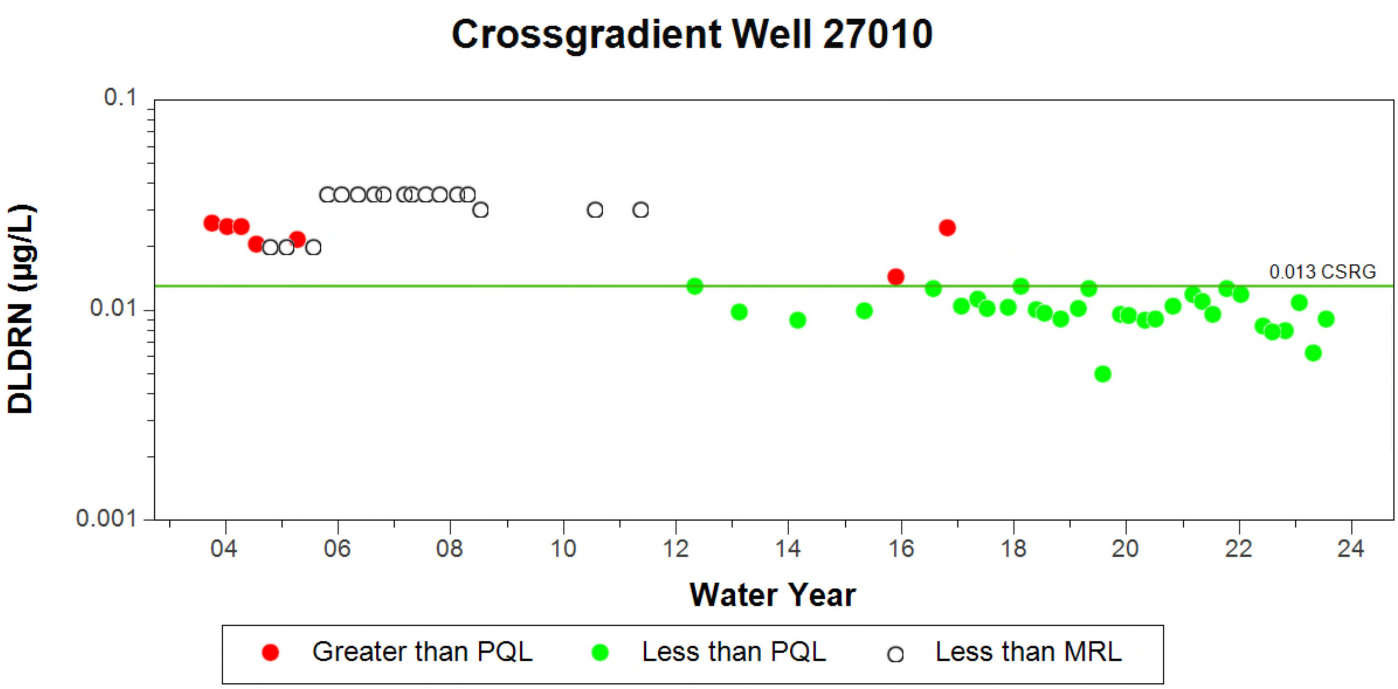
Upgradient Well 27500
DLDRN (µg/L)
1
0.1
0.01
0.001
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL


Upgradient Well 22505
DLDRN (µg/L)
10
1
0.1
0.01
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

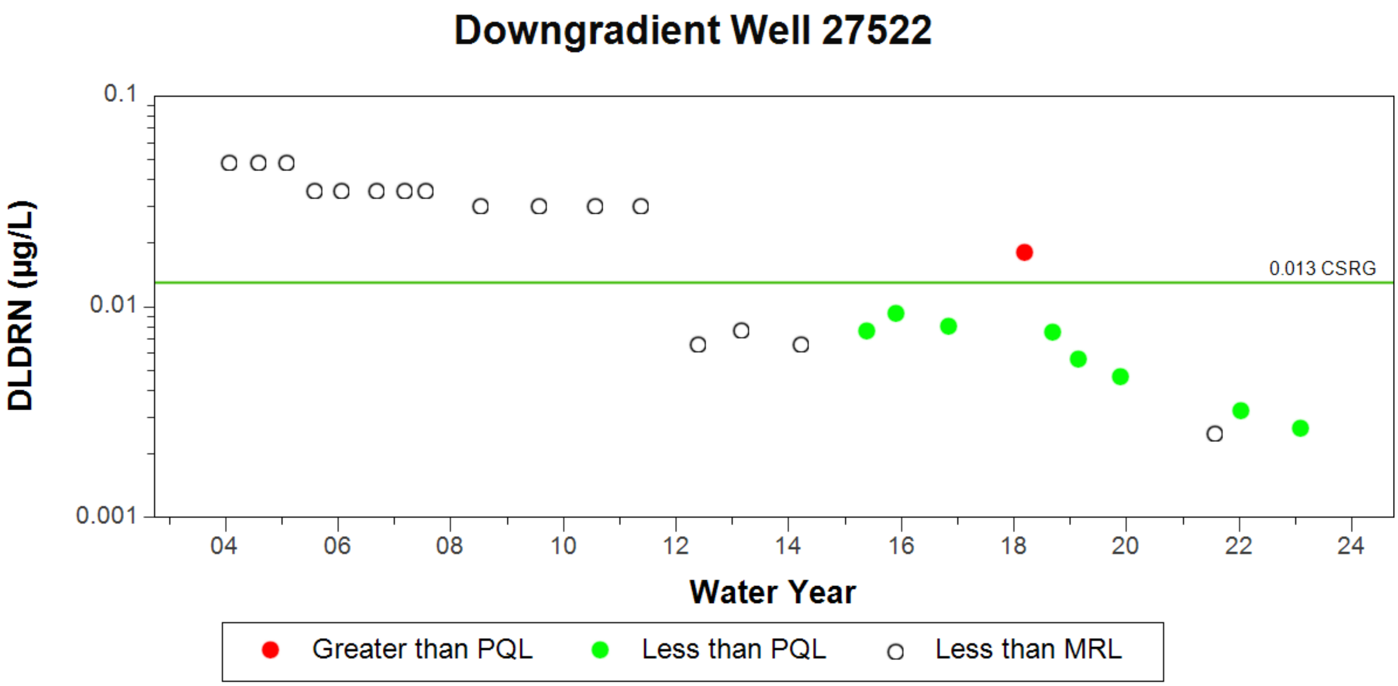

Crossgradient Well 27516
DLDRN (µg/L)
0.1
0.01
0.001
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

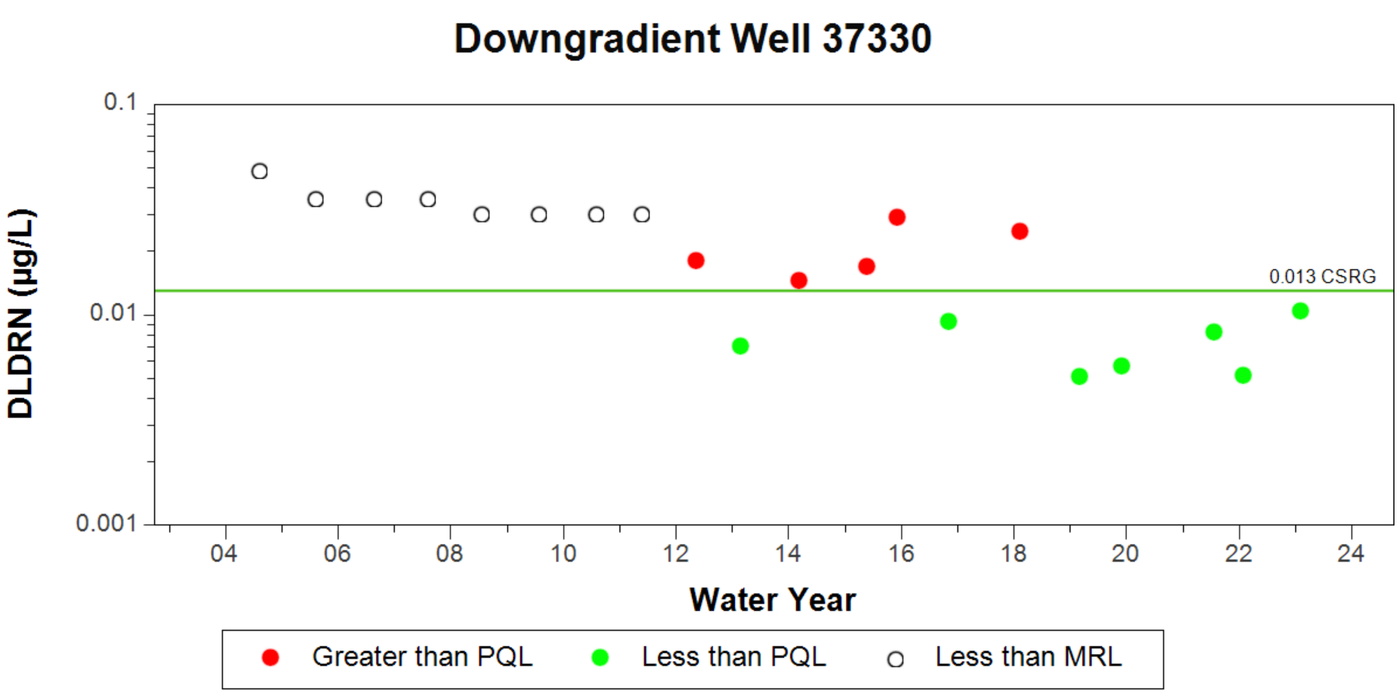


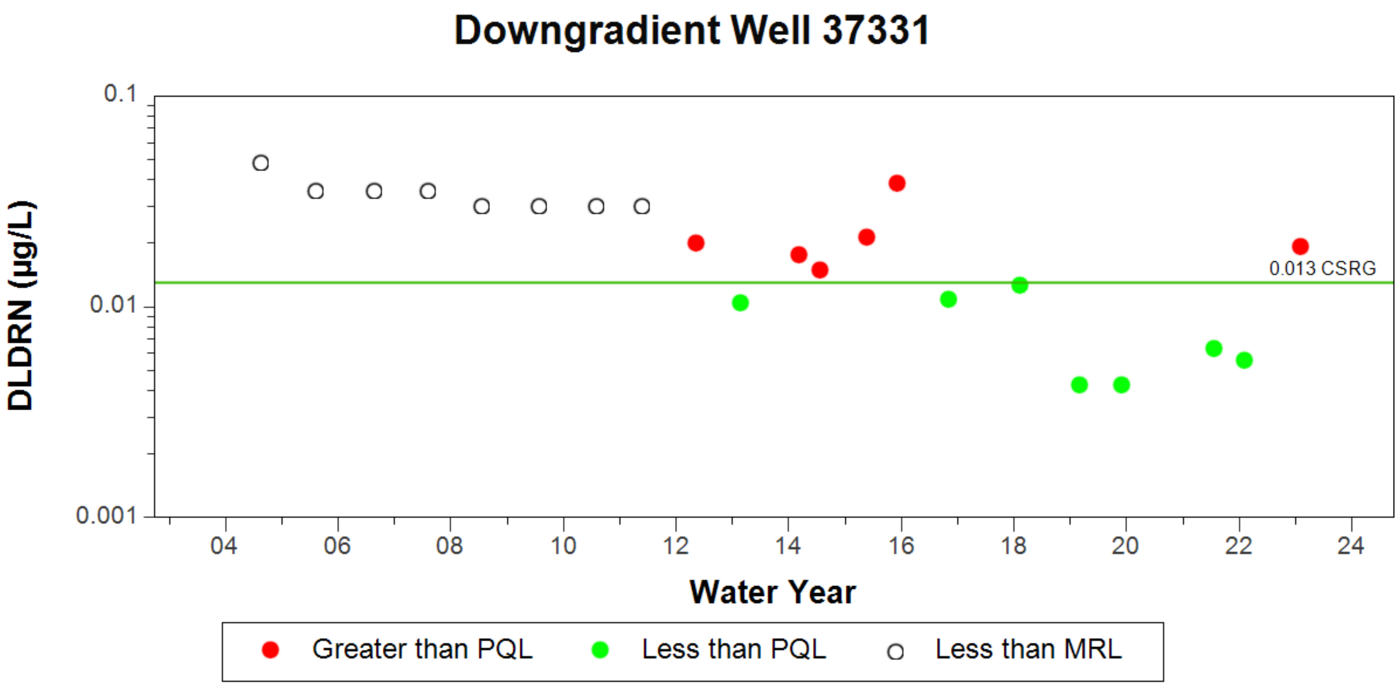
Crossgradient Well 28521
DLDRN (µg/L)
0.1
0.01
0.001
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

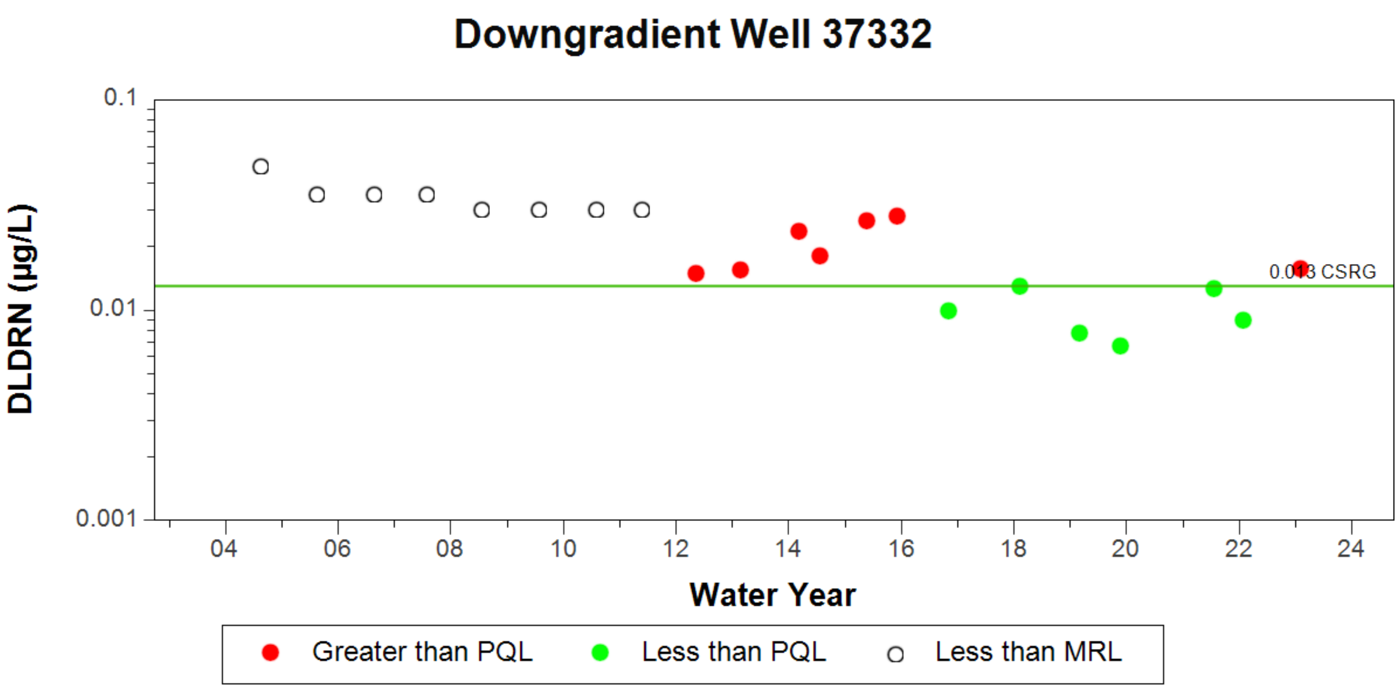


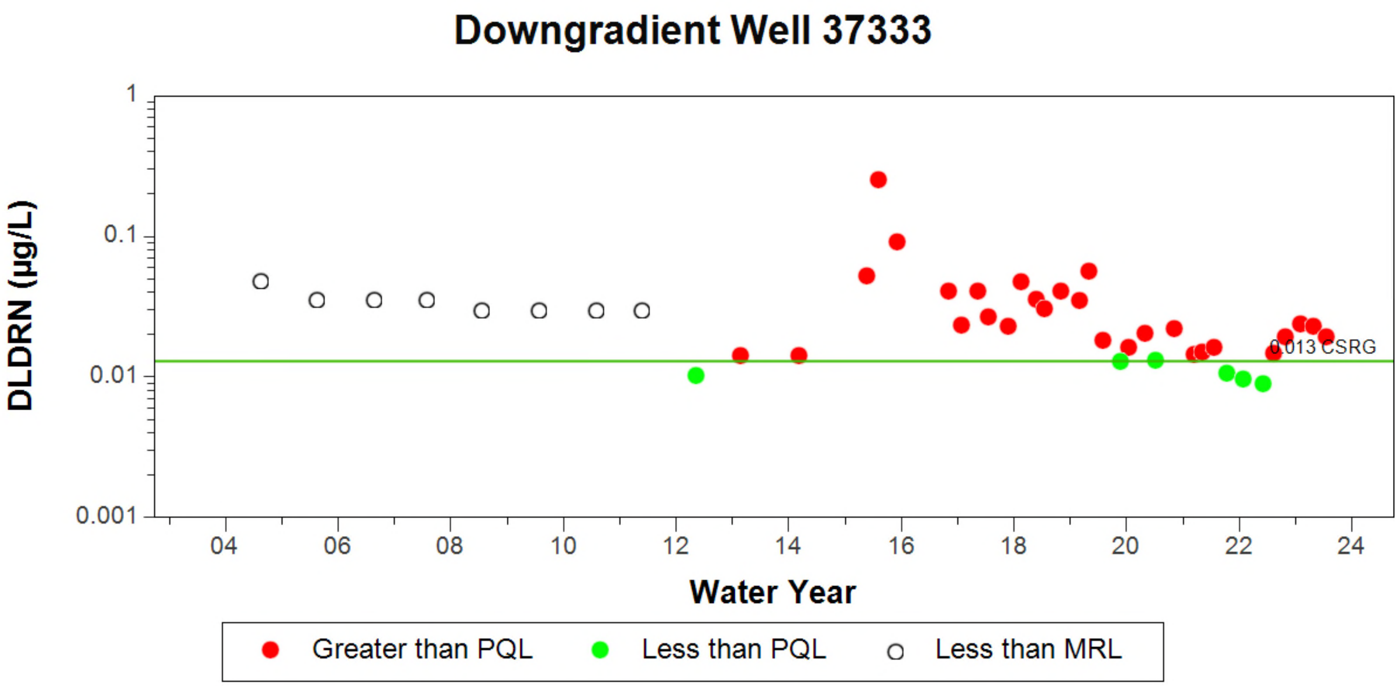
Crossgradient Well 27010
DLDRN (µg/L)
0.1
0.01
0.001
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL


Downgradient Well 27522
DLDRN (µg/L)
0.1
0.01
0.001
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

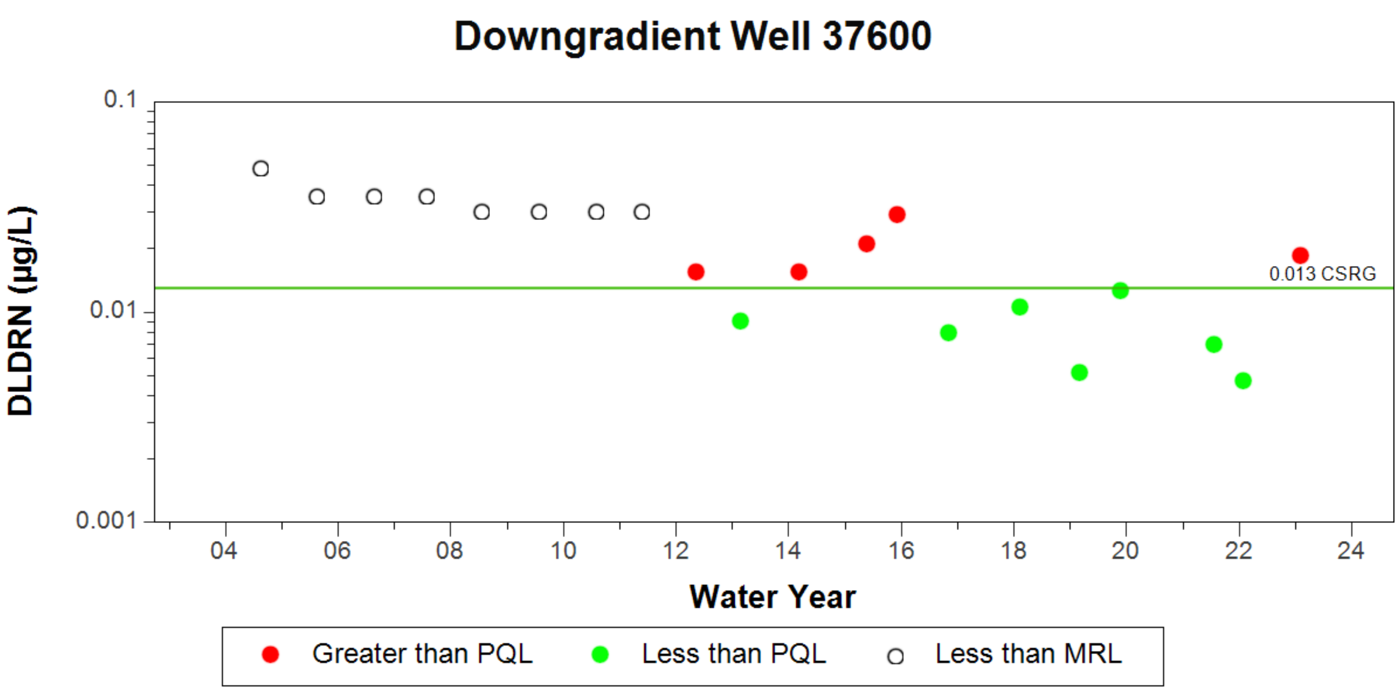

Downgradient Well 37330
DLDRN (µg/L)
0.1
0.01
0.001
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL


Downgradient Well 37331
DLDRN (µg/L)
0.1
0.01
0.001
04
06
08
10
12
14
16
18
20
22
24
Water Year
0.013 CSRG
Greater than PQL
Less than PQL
Less than MRL

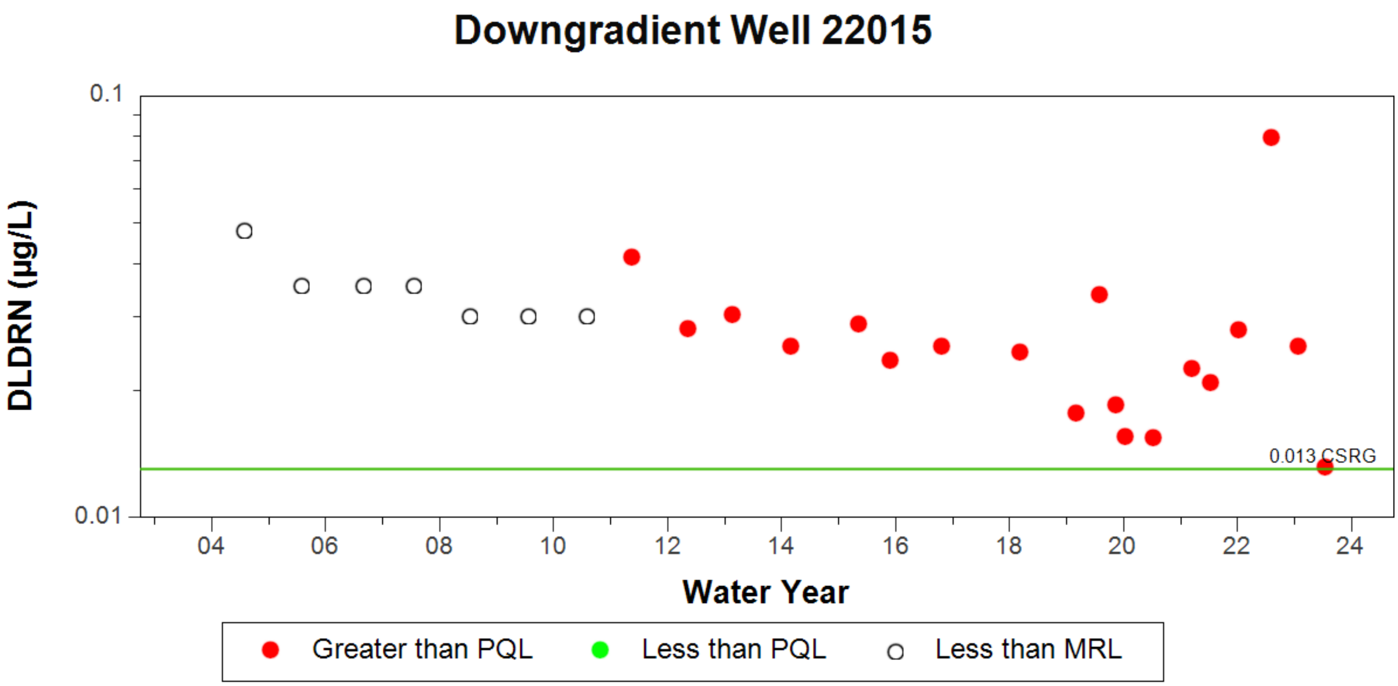

Downgradient Well 37332
DLDRN (µg/L)
0.1
0.01
0.001
04
06
08
10
12
14
16
18
20
22
24
Water Year
0.013 CSRG
Greater than PQL
Less than PQL
Less than MRL



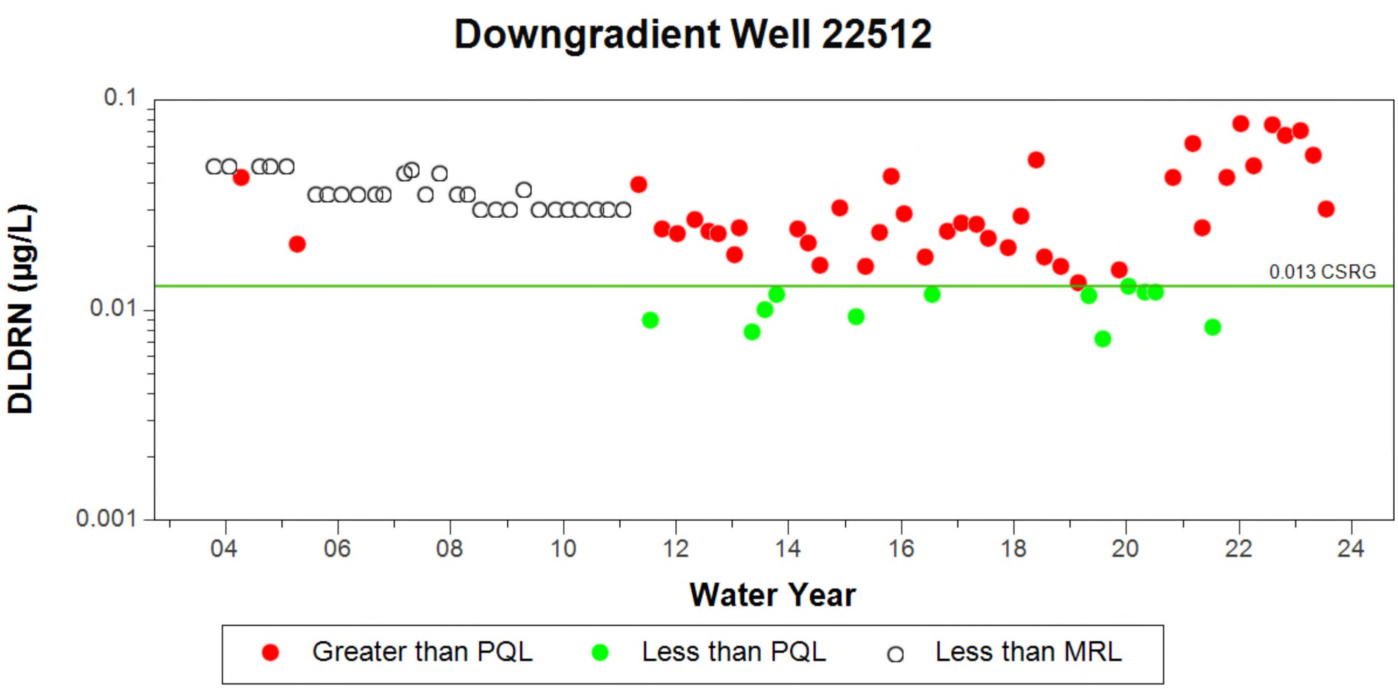
Downgradient Well 37333
DLDRN (µg/L)
1
0.1
0.01
0.001
04
06
08
10
12
14
16
18
20
22
24
Water Year
0.013 CSRG
Greater than PQL
Less than PQL
Less than MRL



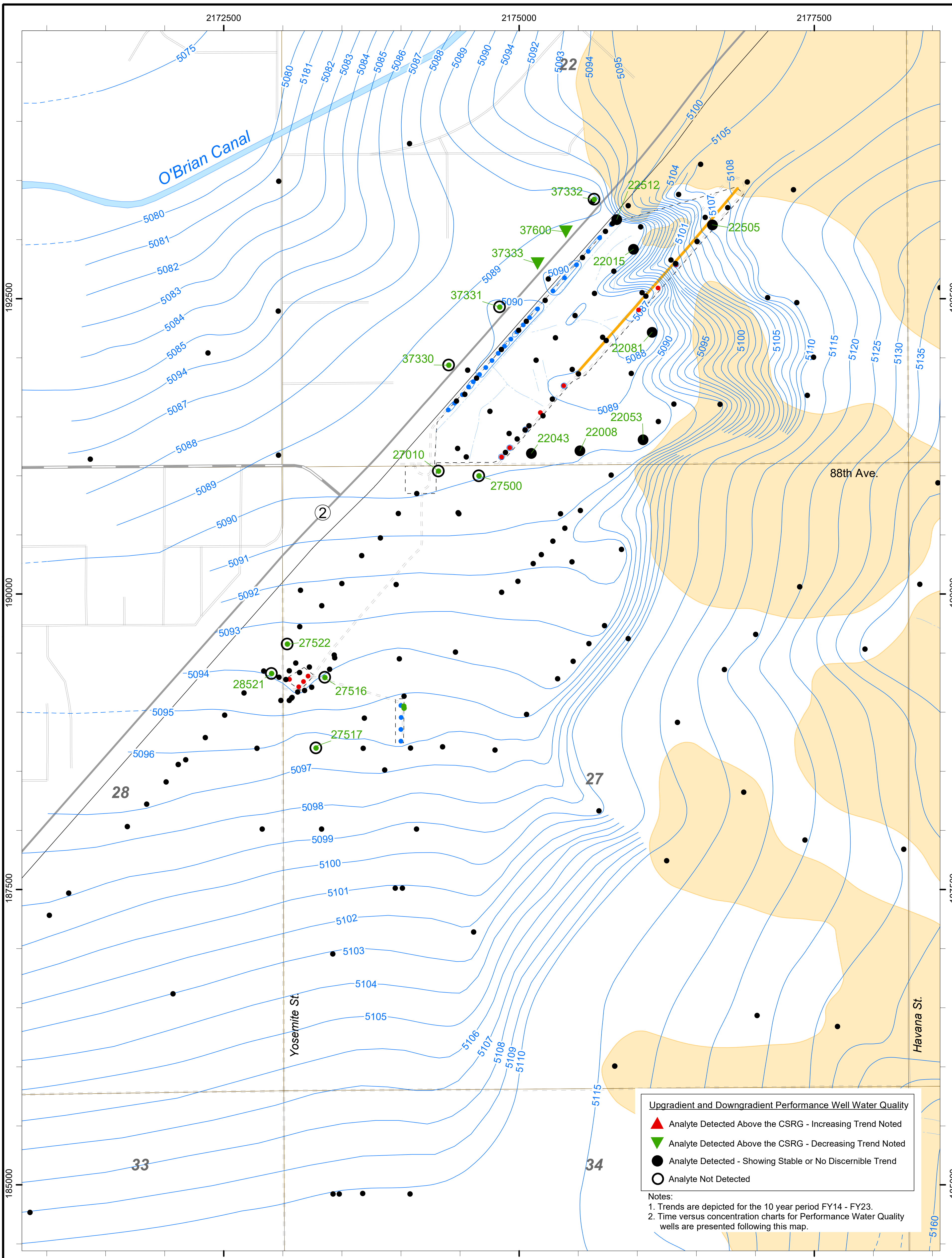
Downgradient Well 37600
DLDRN (µg/L)
0.1
0.01
0.001
04
06
08
10
12
14
16
18
20
22
24
Water Year
0.013 CSRG
Greater than PQL
Less than PQL
Less than MRL



Downgradient Well 22015
DLDRN (µg/L)
0.1
0.01
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL



Downgradient Well 22512
DLDRN (µg/L)
0.1
0.01
0.001
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL



Legend

- Unsaturated Alluvium
- Section Lines
- Water elevation contour - 1-foot interval
- Inferred water elevation contour
- Slurry Walls
- Canal
- Local Roads
- Secondary Roads
- Primary Roads
- Monitoring Wells
- Performance Water Quality Wells
- Extraction Wells
- Recharge Wells

Note: Water levels were measured in FY23 Quarter 2.

N

0 315 630 1,260 Feet

State Plane, Colorado North Zone, NAD27, US Survey Feet

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

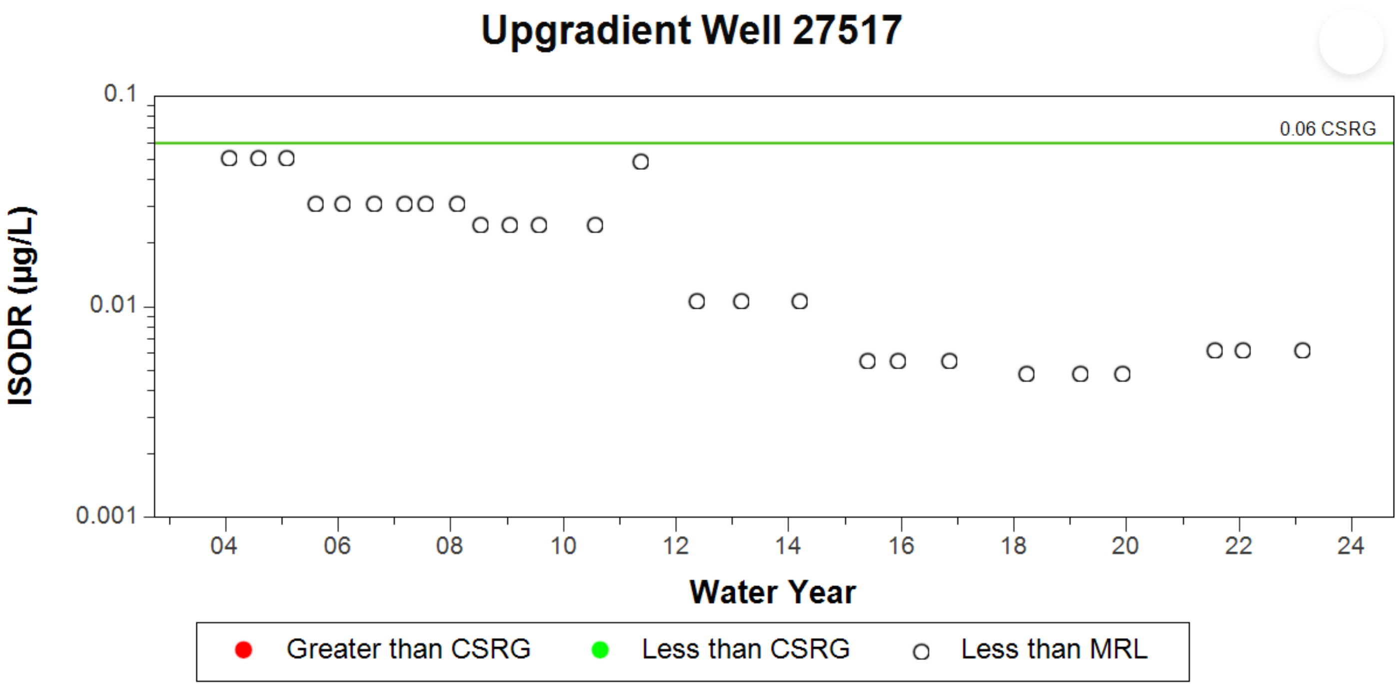
Program Manager
Rocky Mountain Arsenal

U.S. Army • COMMITTED TO PROTECTION OF THE ENVIRONMENT •

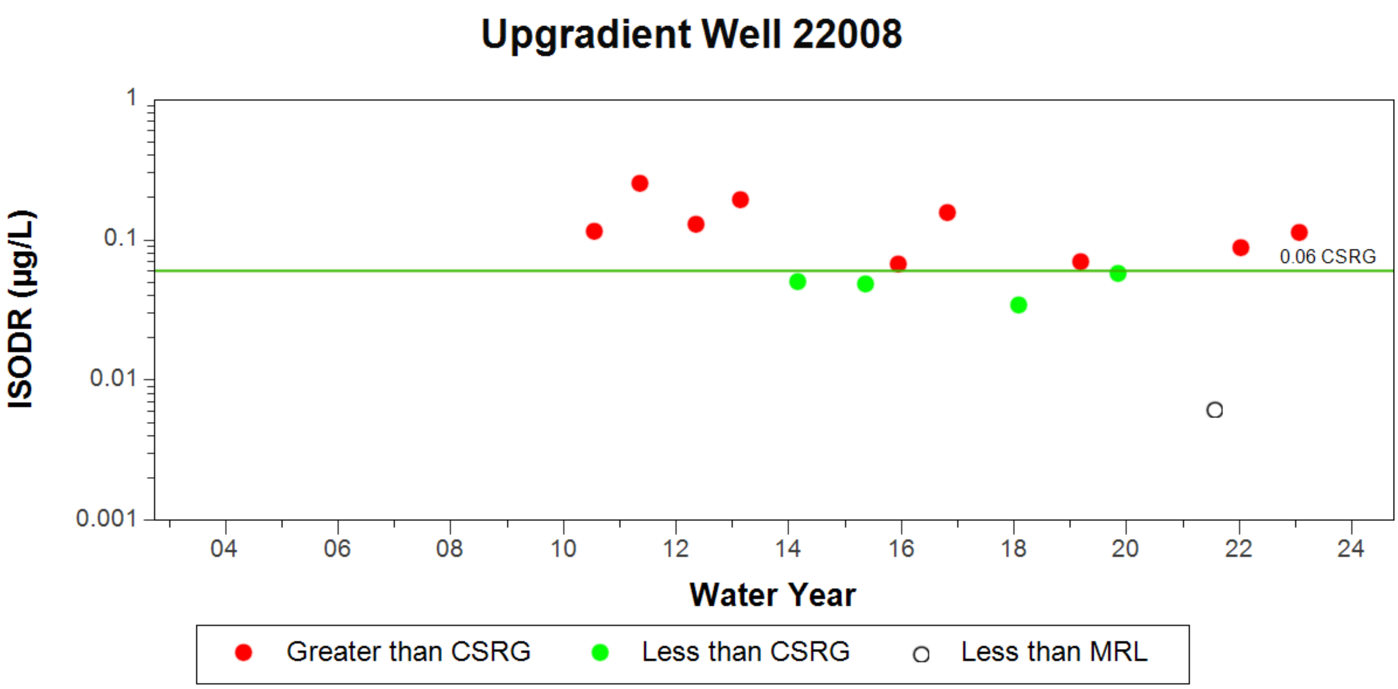
Figure A-14

Isodrin Concentration
Trends in Performance Wells,
Northwest Boundary Containment System

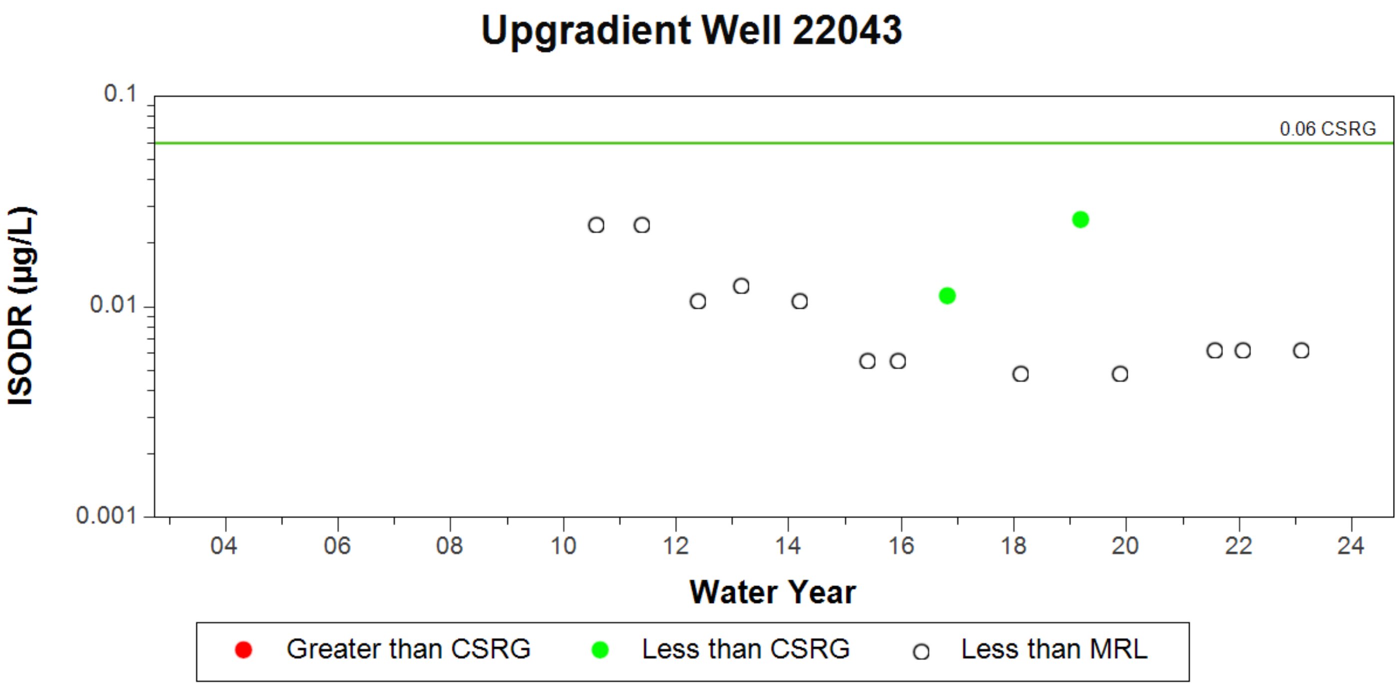
M:\projects\oars\fy23\mxds_NWB_FY23_ISODRN.mxd
8/10/2024



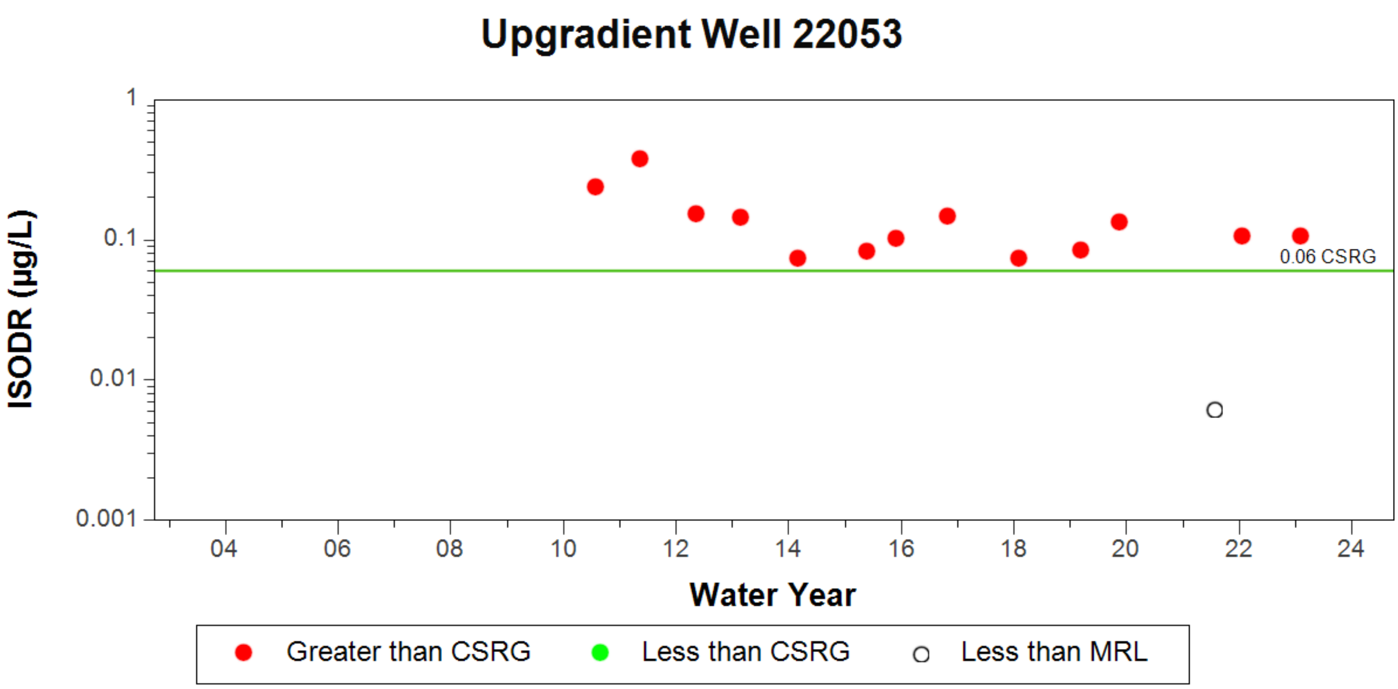
Upgradient Well 27517
ISODR (µg/L)
0.1
0.01
0.001
0.06 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



Upgradient Well 22008
ISODR (µg/L)
1
0.1
0.01
0.001
0.06 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

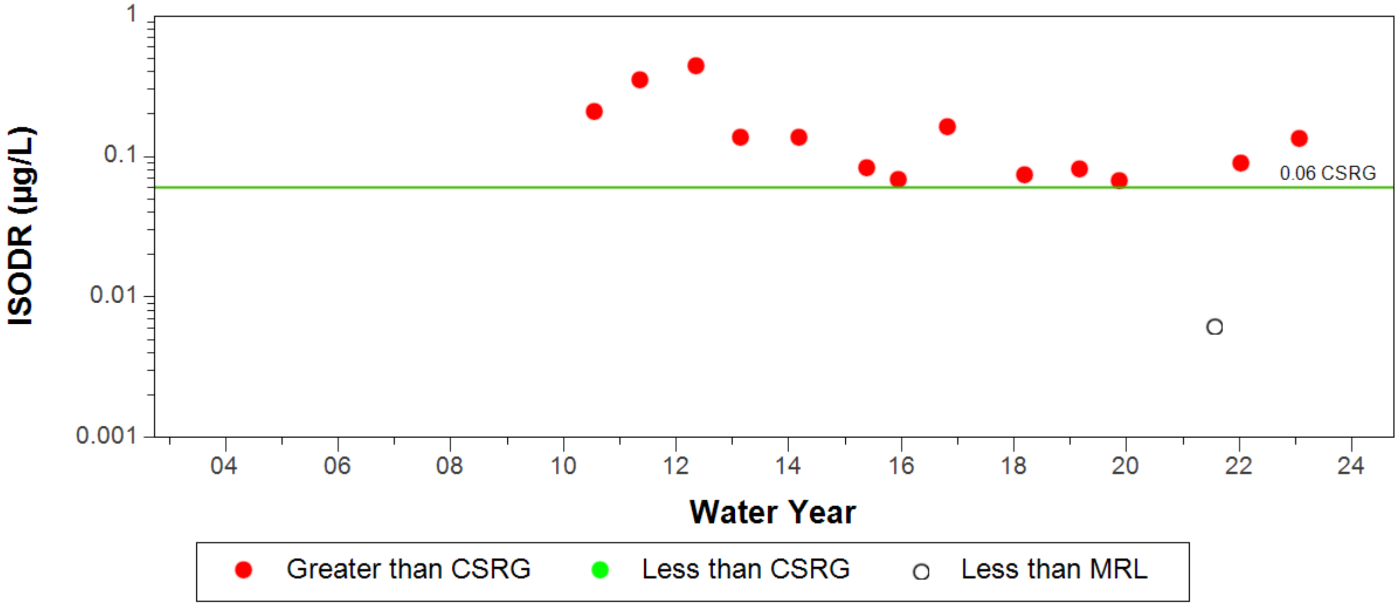


Upgradient Well 22043
0.06 CSRG
ISODR (µg/L)
0.1
0.01
0.001
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

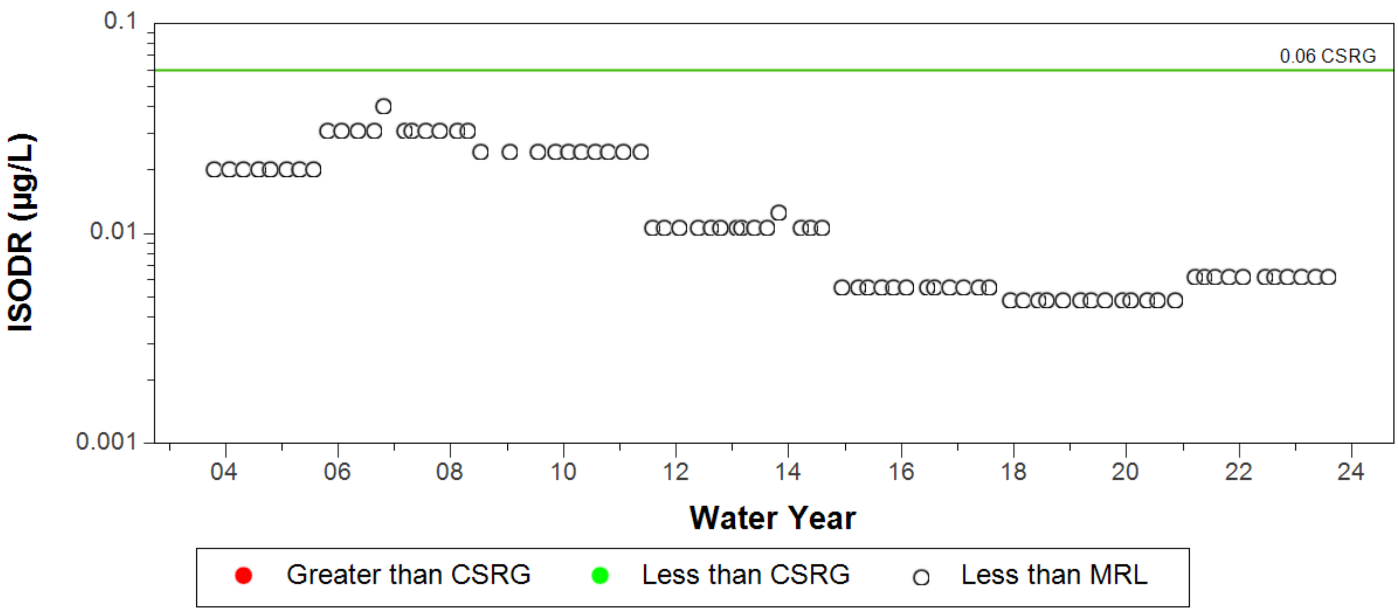


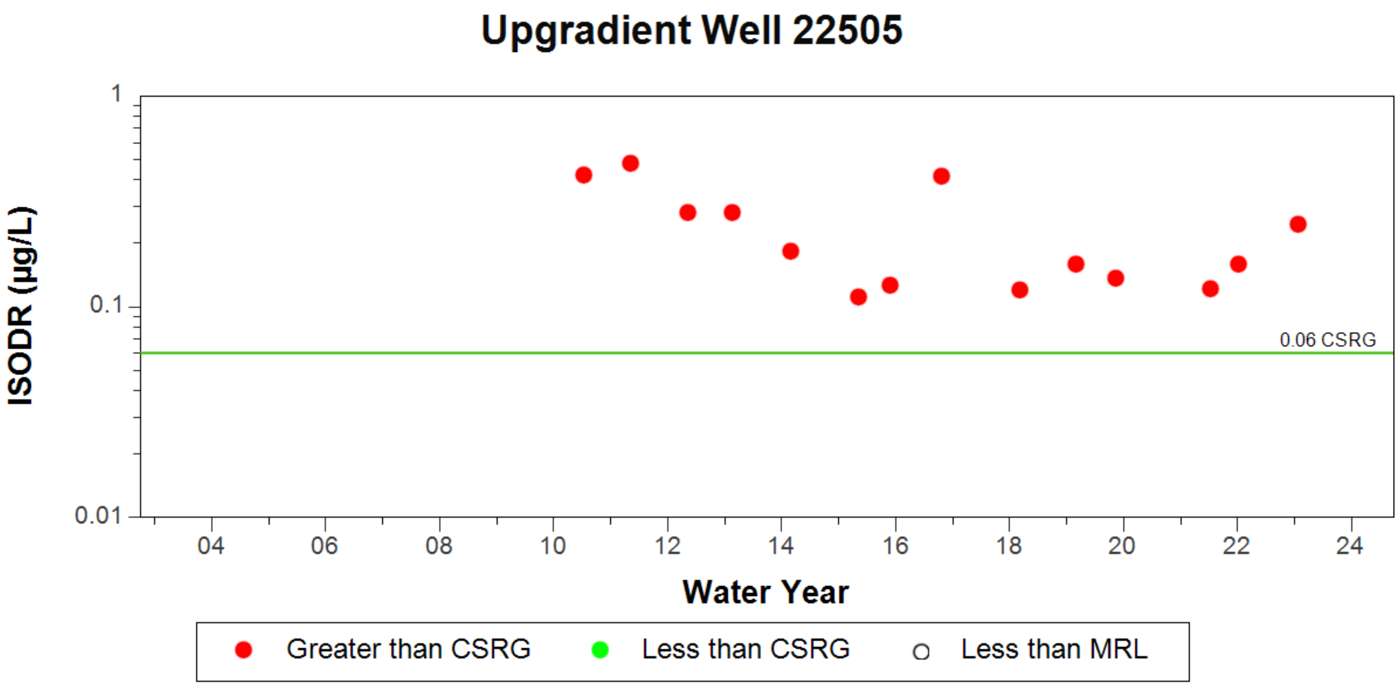
Upgradient Well 22053
0.06 CSRG
ISODR (µg/L)
1
0.1
0.01
0.001
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

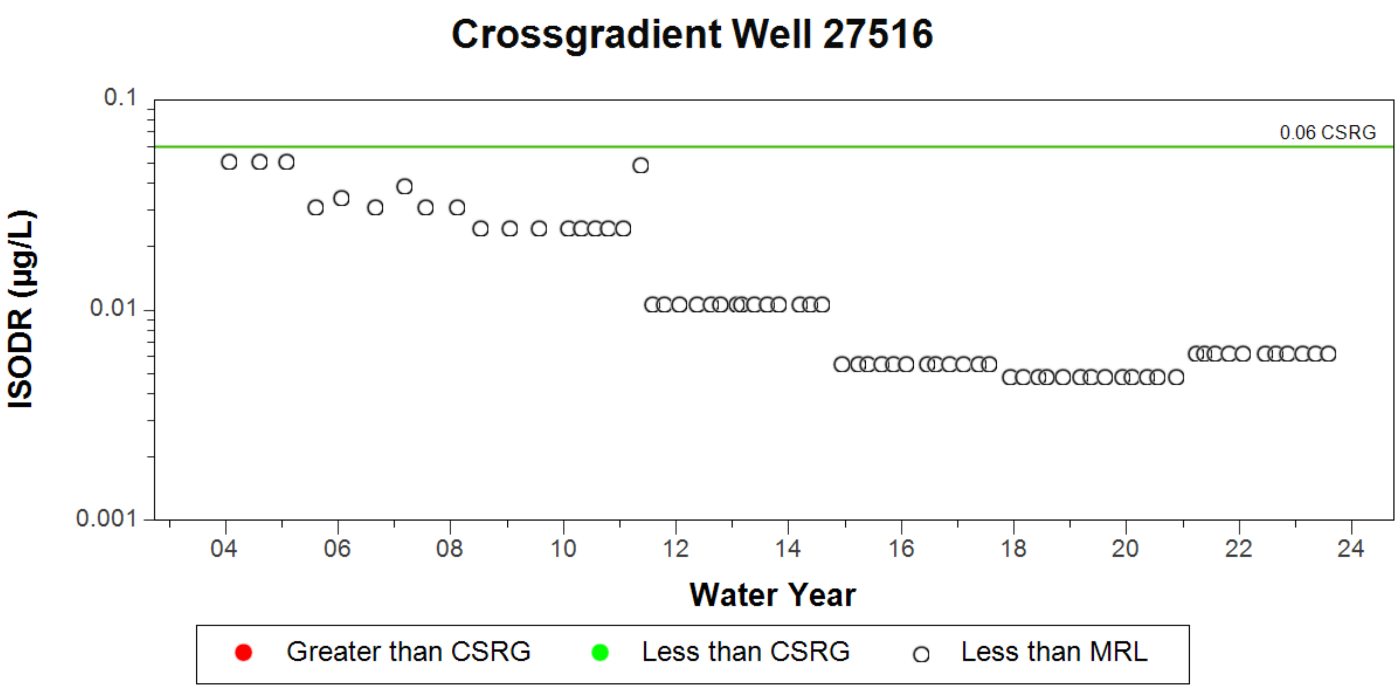
Upgradient Well 22081

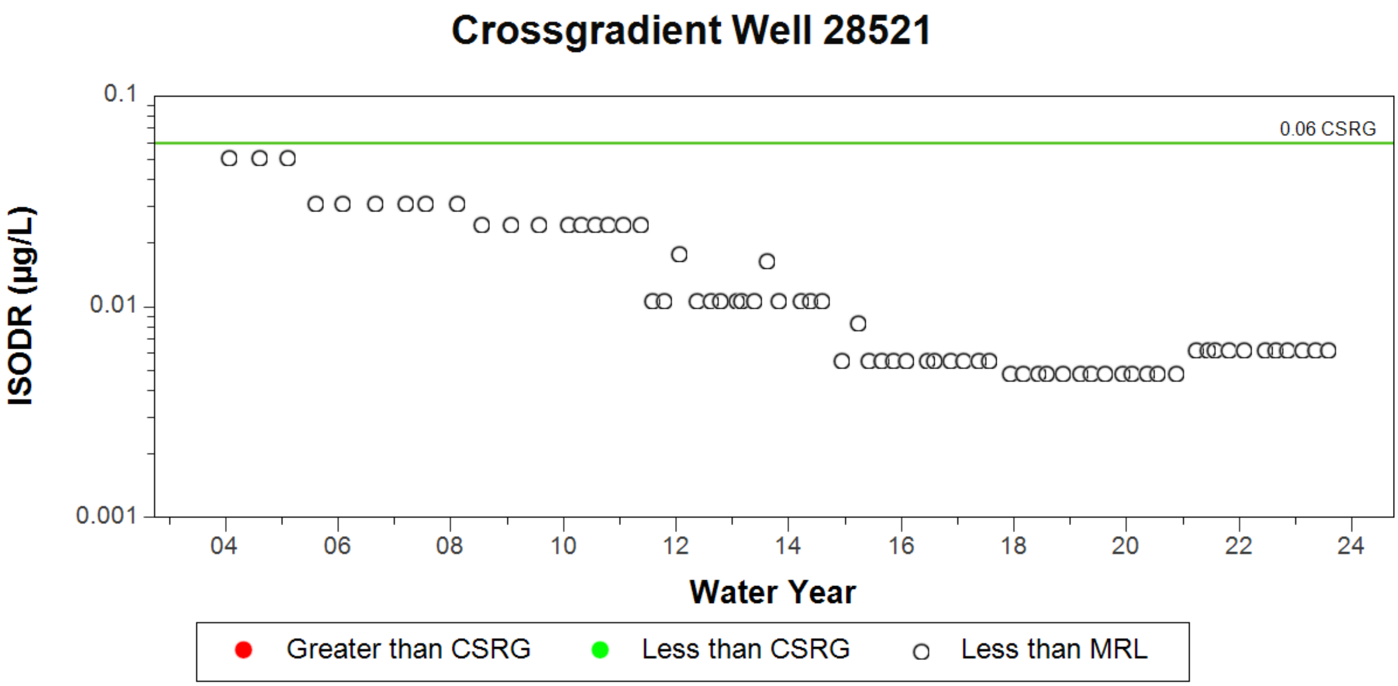


Upgradient Well 27500

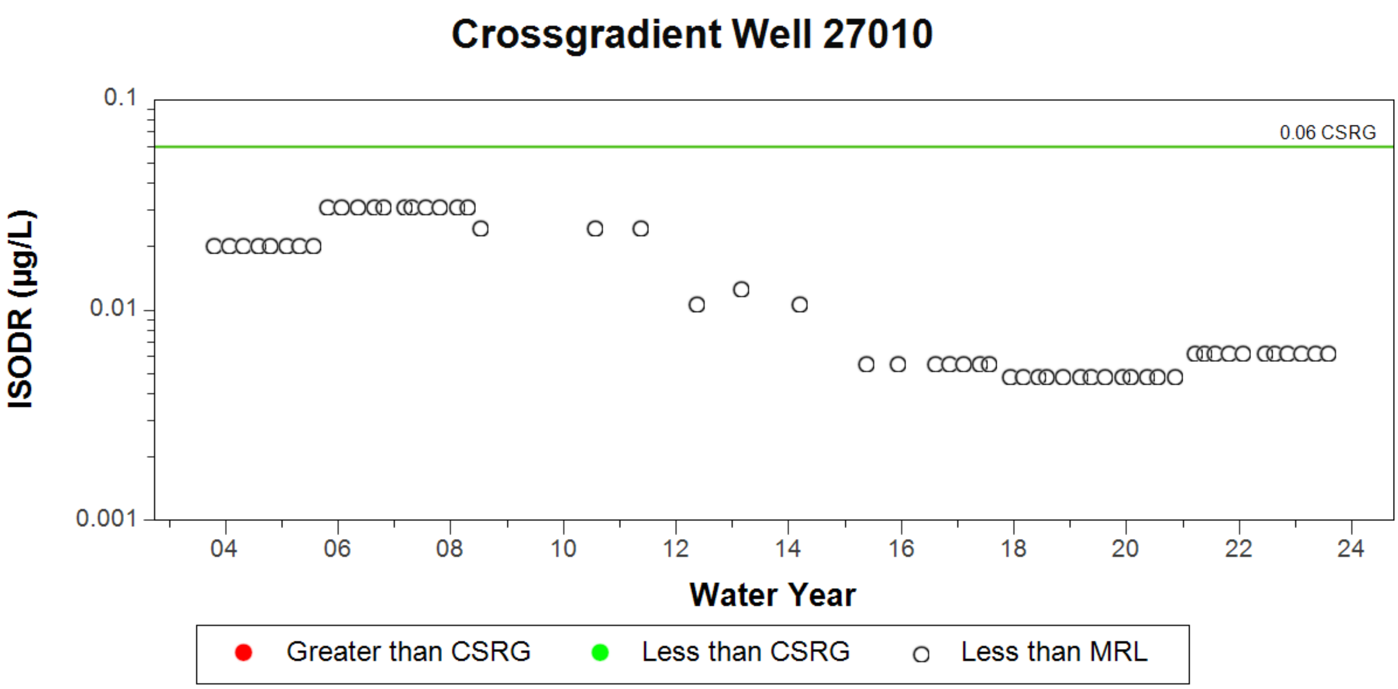



Upgradient Well 22505
ISODR (µg/L)
1
0.1
0.01
0.06 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

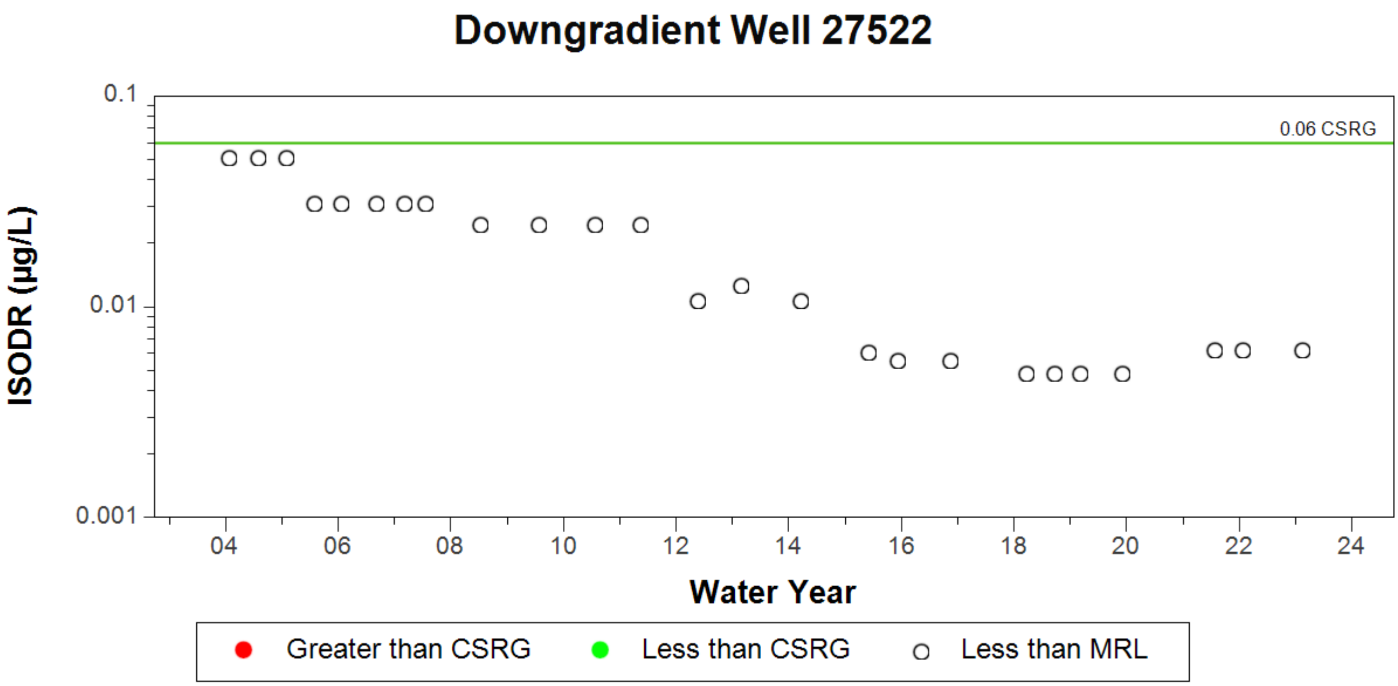

Crossgradient Well 27516
ISODR (µg/L)
0.1
0.01
0.001
0.06 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

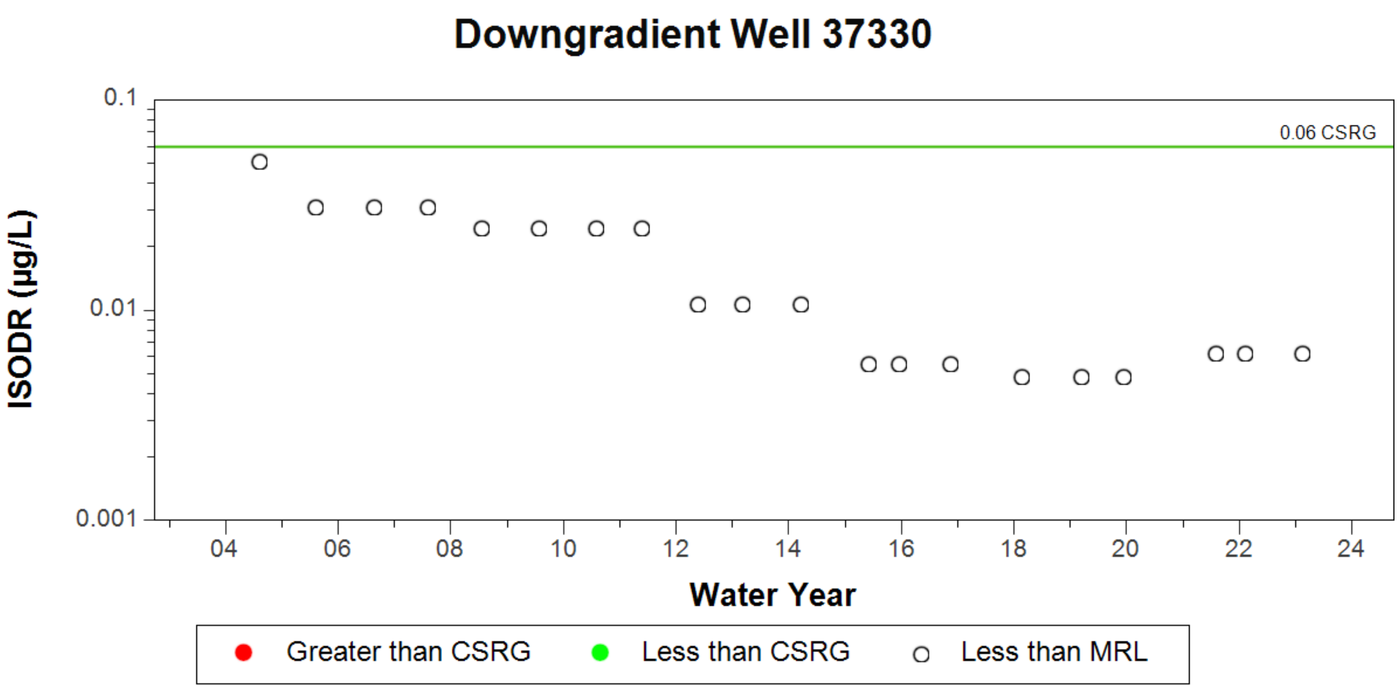


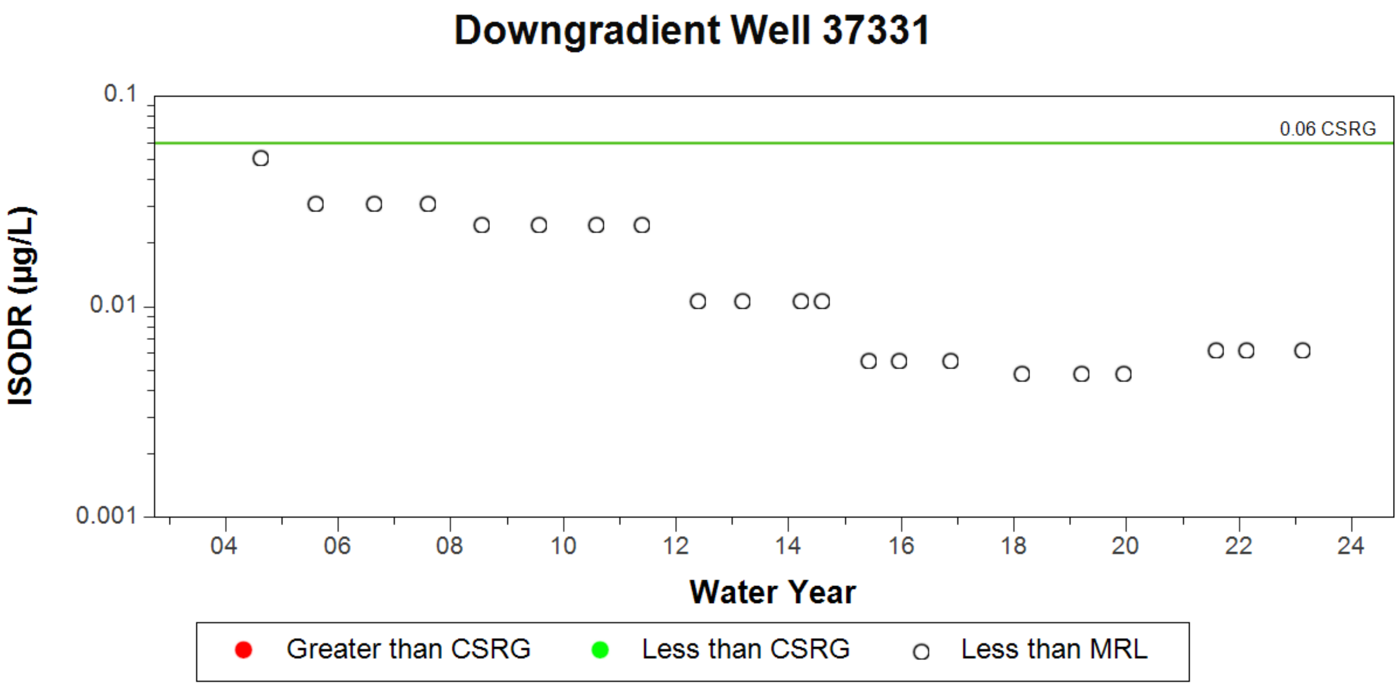
Crossgradient Well 28521
0.1
0.01
0.001
ISODR (µg/L)
0.06 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



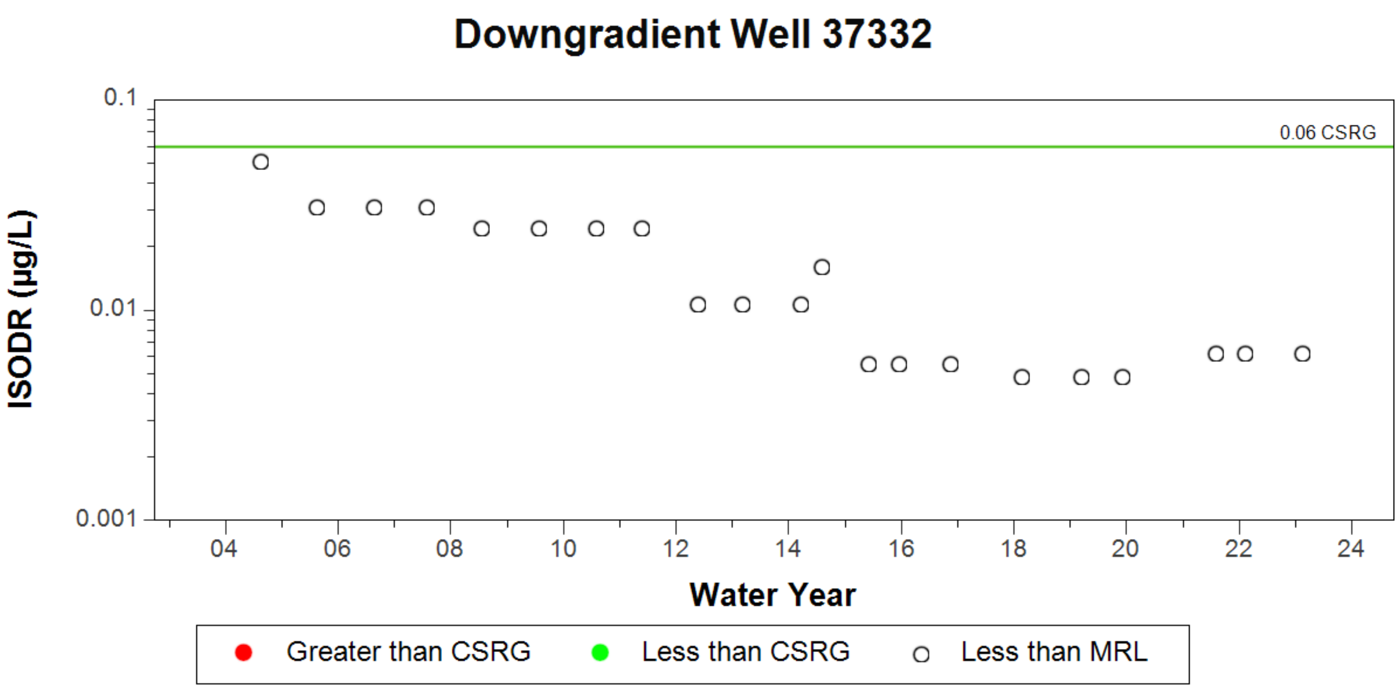
Crossgradient Well 27010
0.1
0.01
0.001
ISODR (µg/L)
0.06 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL


Downgradient Well 27522
0.1
0.01
0.001
0.06 CSRG
ISODR (µg/L)
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

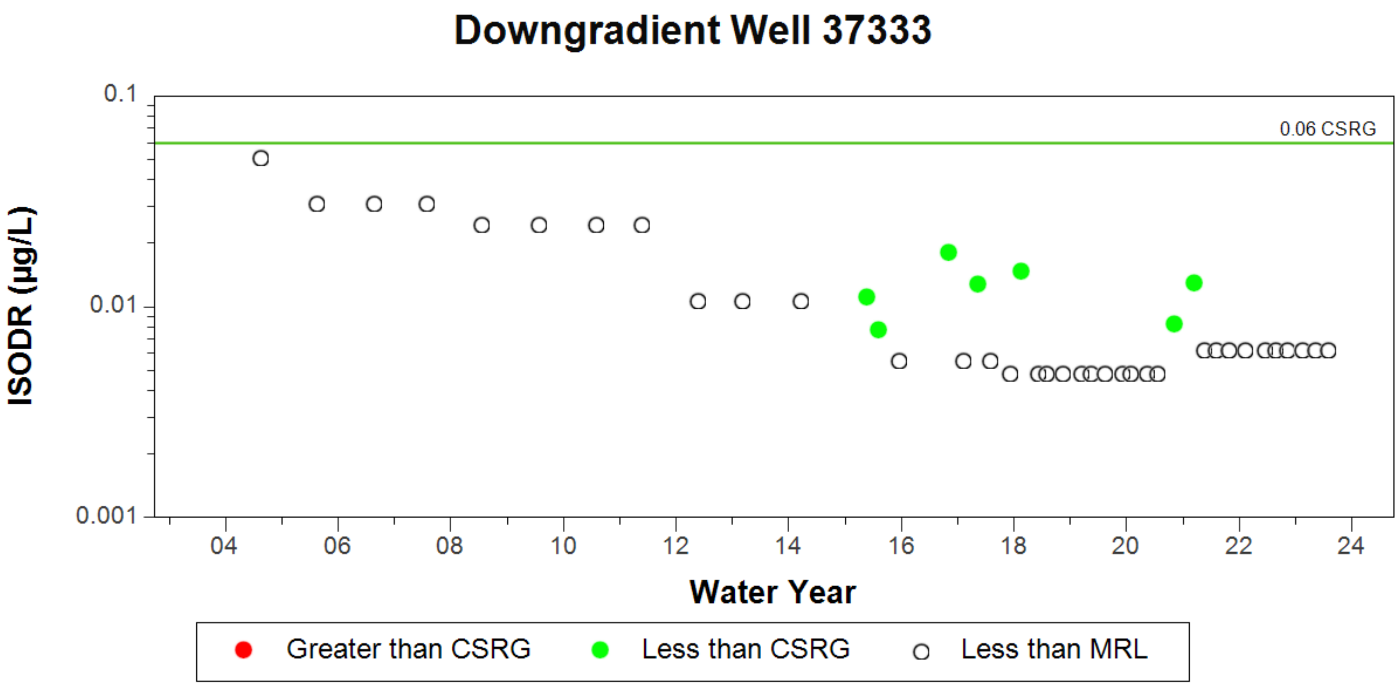

Downgradient Well 37330
0.1
0.01
0.001
0.06 CSRG
ISODR (µg/L)
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



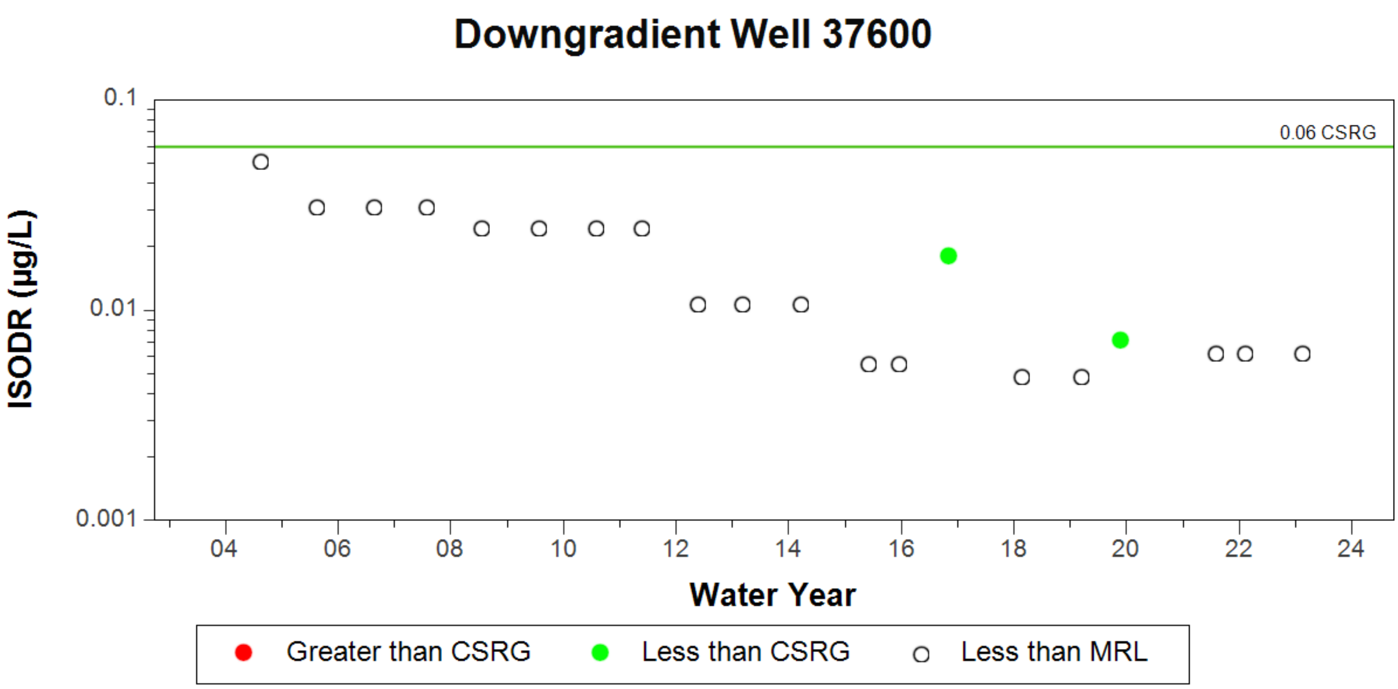
Downgradient Well 37331
ISODR (µg/L)
0.1
0.01
0.001
0.06 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



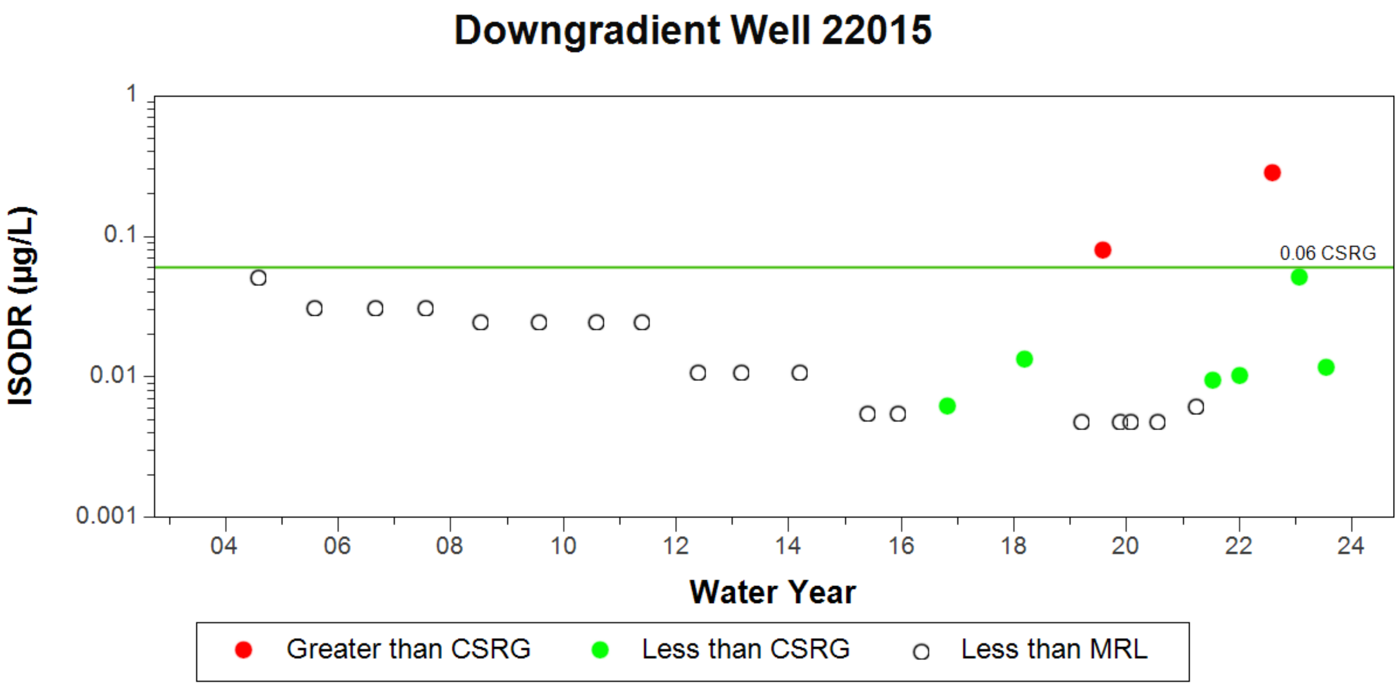
Downgradient Well 37332
ISODR (µg/L)
0.1
0.01
0.001
0.06 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



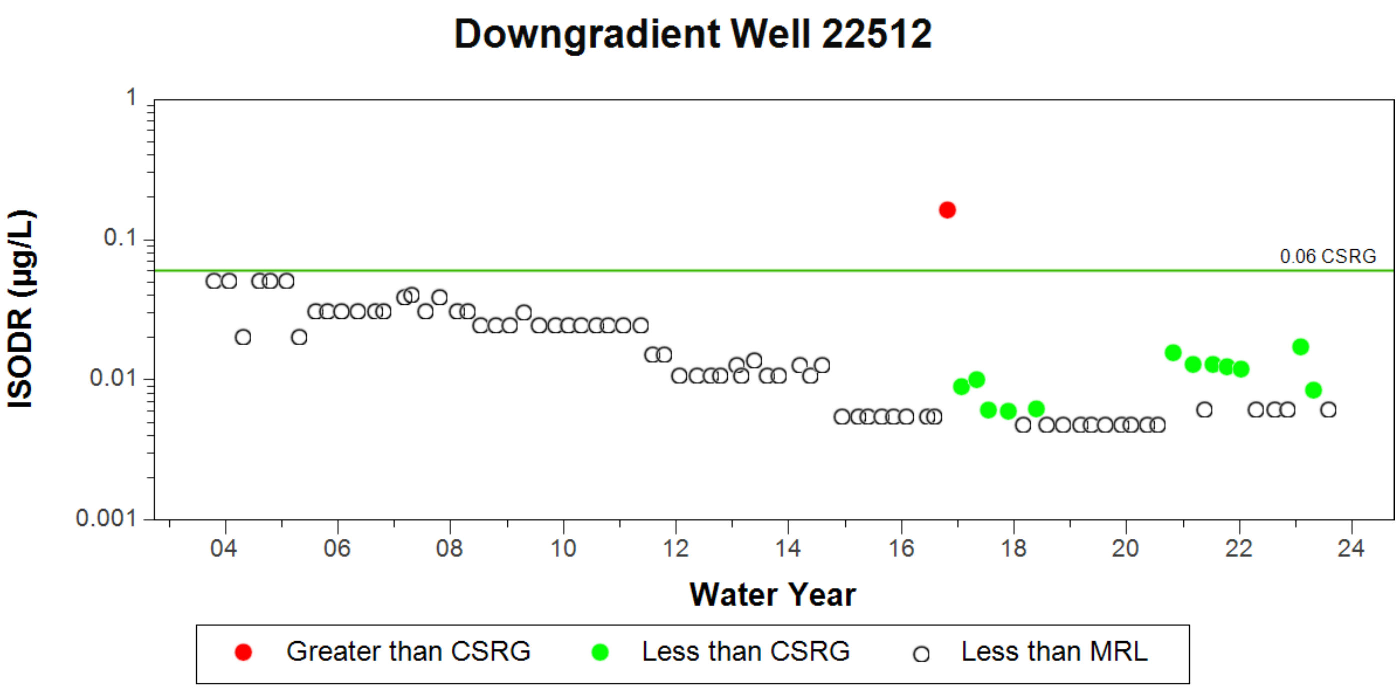
Downgradient Well 37333
0.06 CSRG
ISODR (µg/L)
0.1
0.01
0.001
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



Downgradient Well 37600
0.06 CSRG
ISODR (µg/L)
0.1
0.01
0.001
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



Downgradient Well 22015
ISODR (µg/L)
1
0.1
0.01
0.001
0.06 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



Downgradient Well 22512
ISODR (µg/L)
1
0.1
0.01
0.001
0.06 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

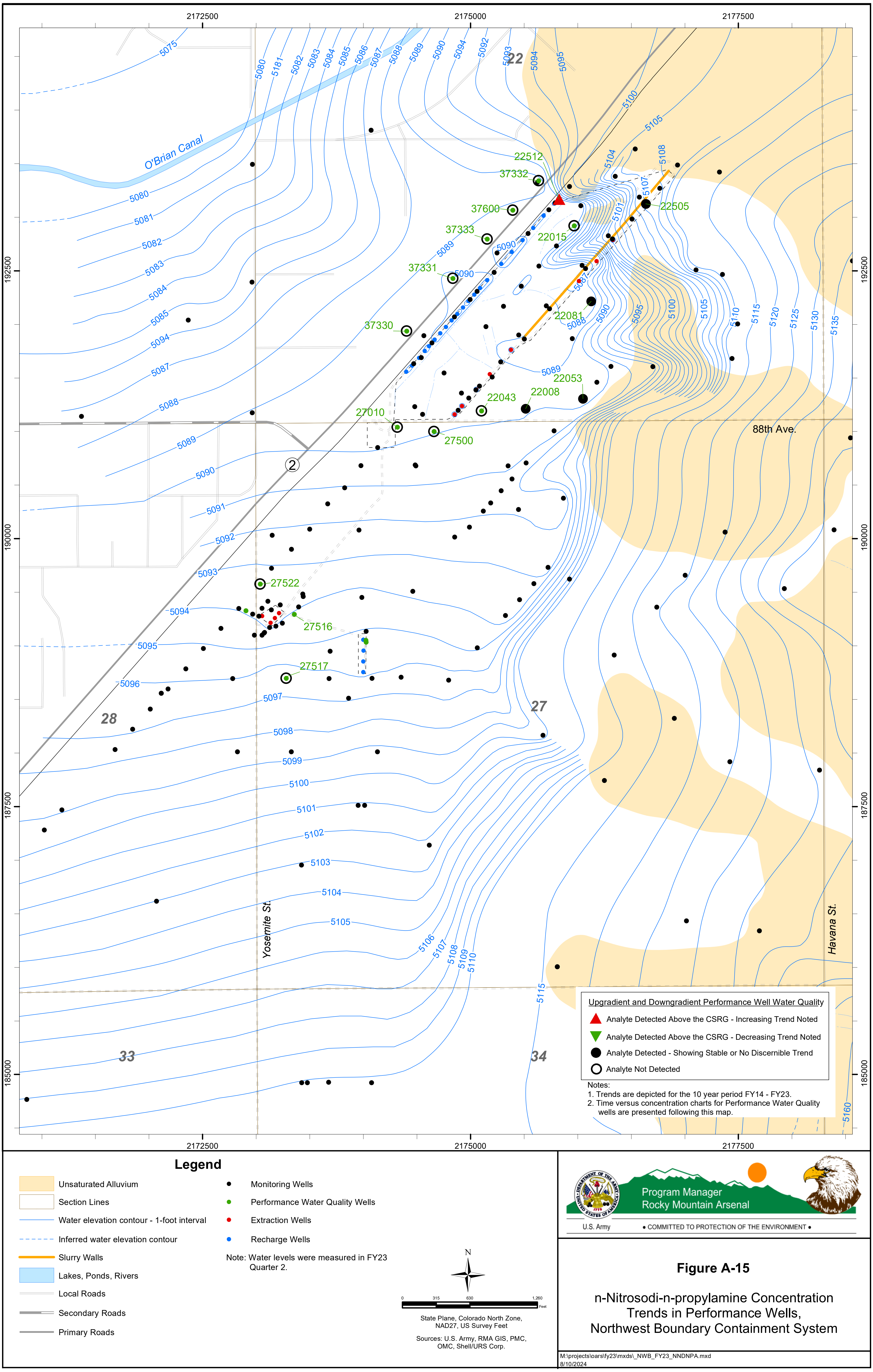
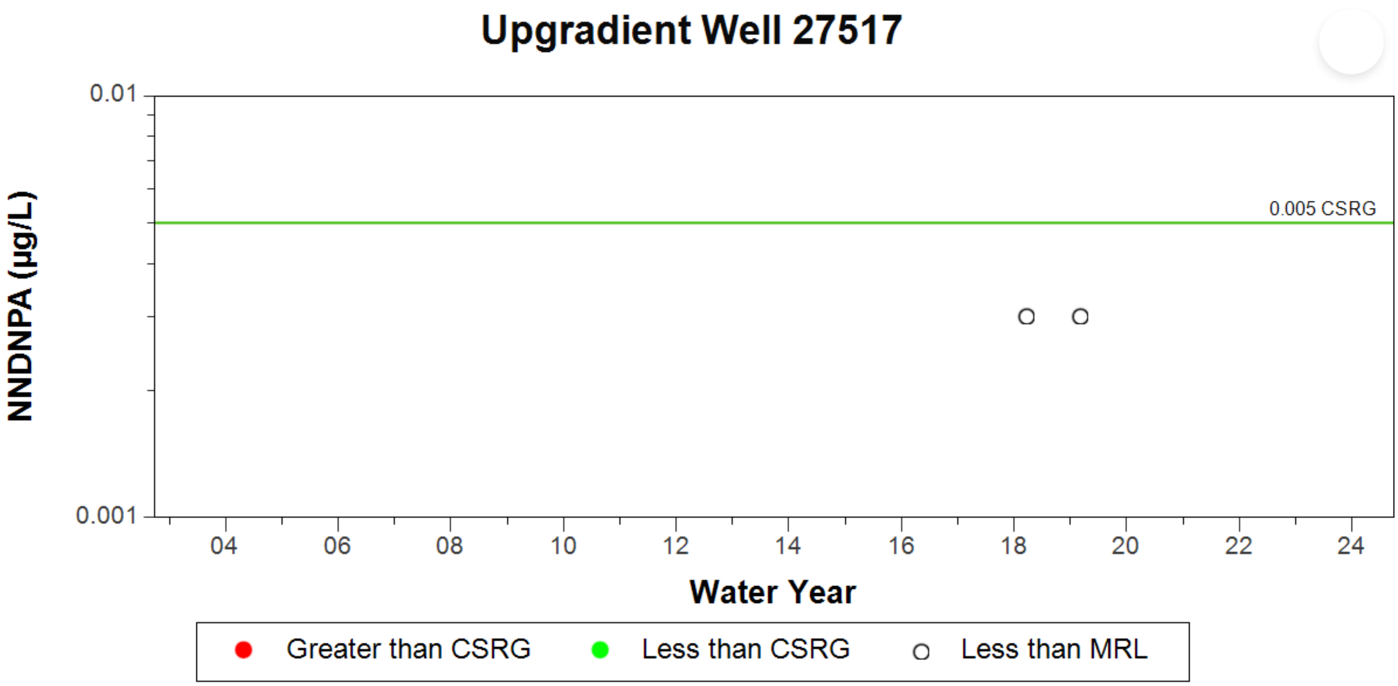


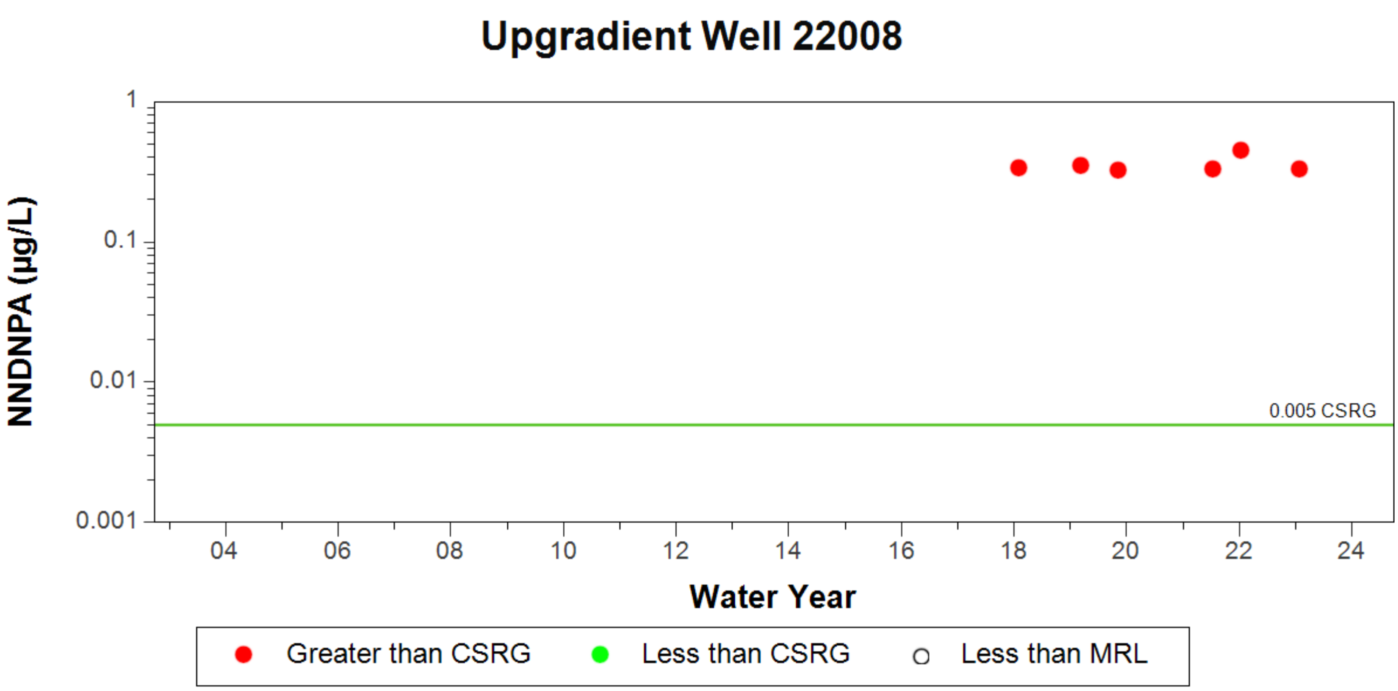
Figure A-15

n-Nitrosodi-n-propylamine Concentration Trends in Performance Wells, Northwest Boundary Containment System

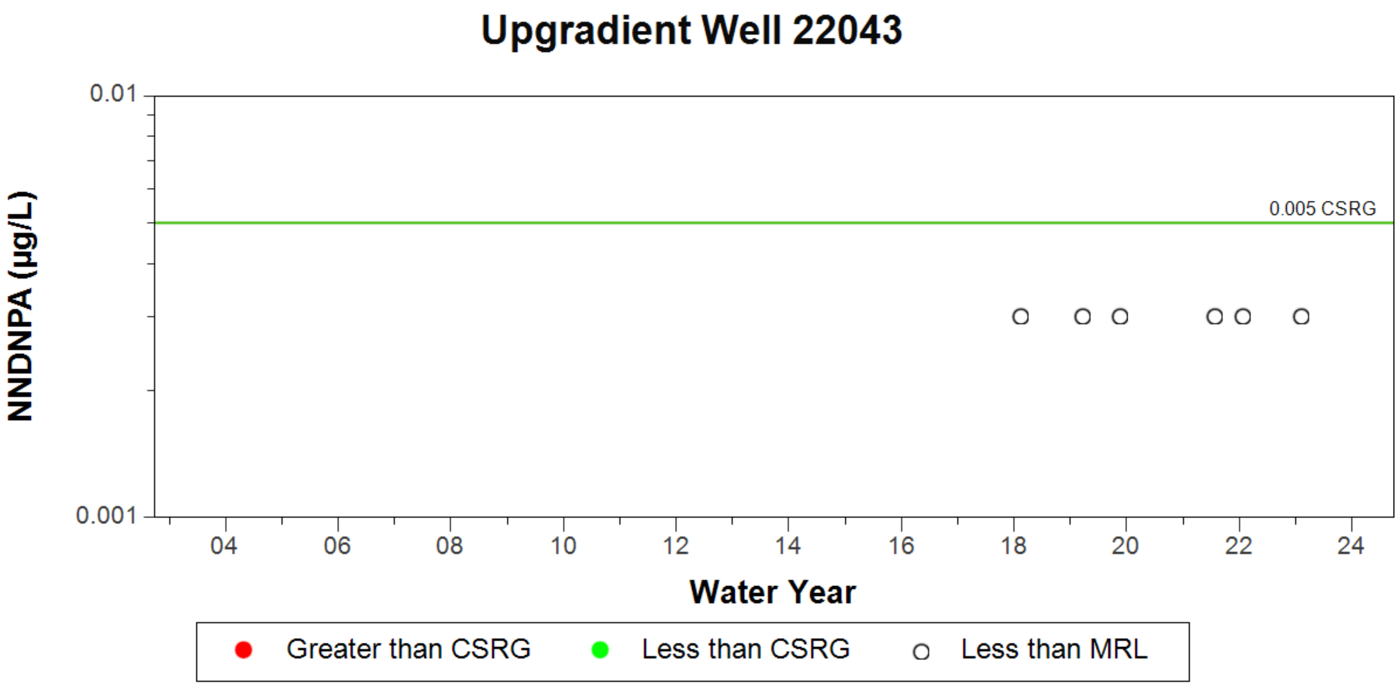
M:\projects\oars\fy23\mxds_NWB_FY23_NNDNPA.mxd
8/10/2024

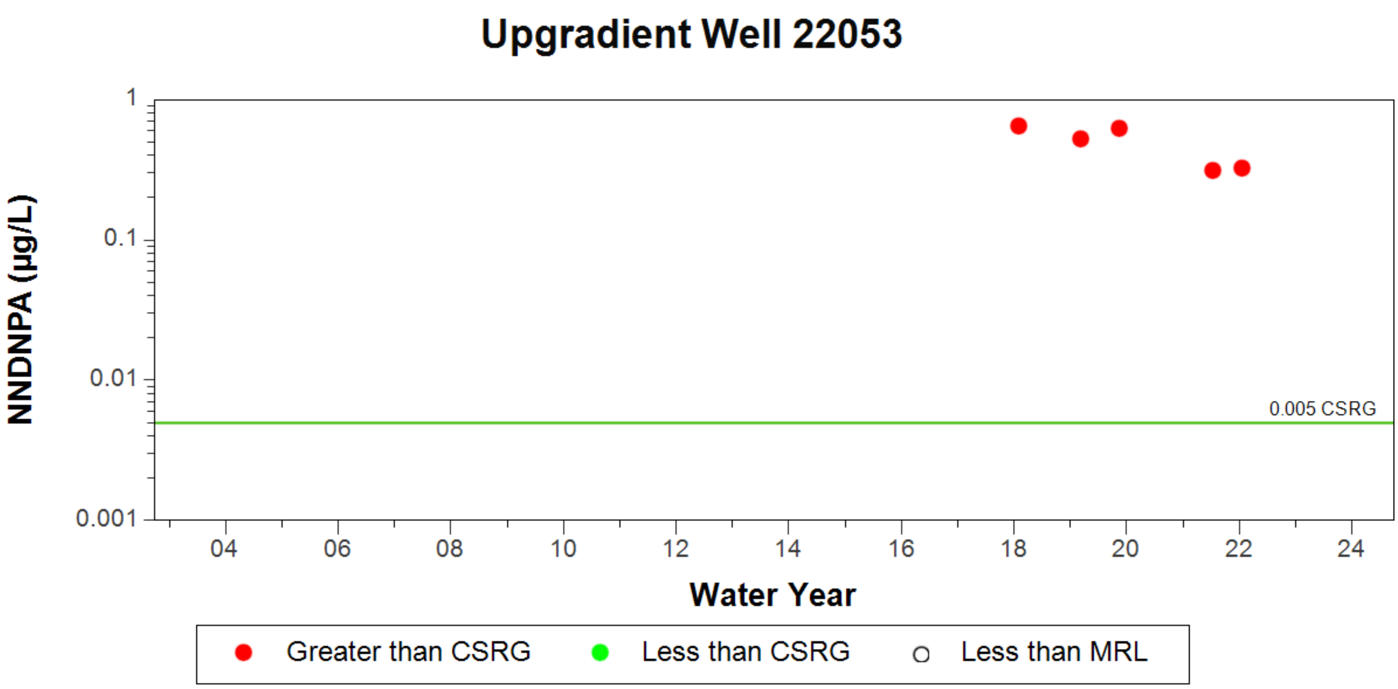


Upgradient Well 27517
NNDNPA (µg/L)
0.01
0.001
0.005 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

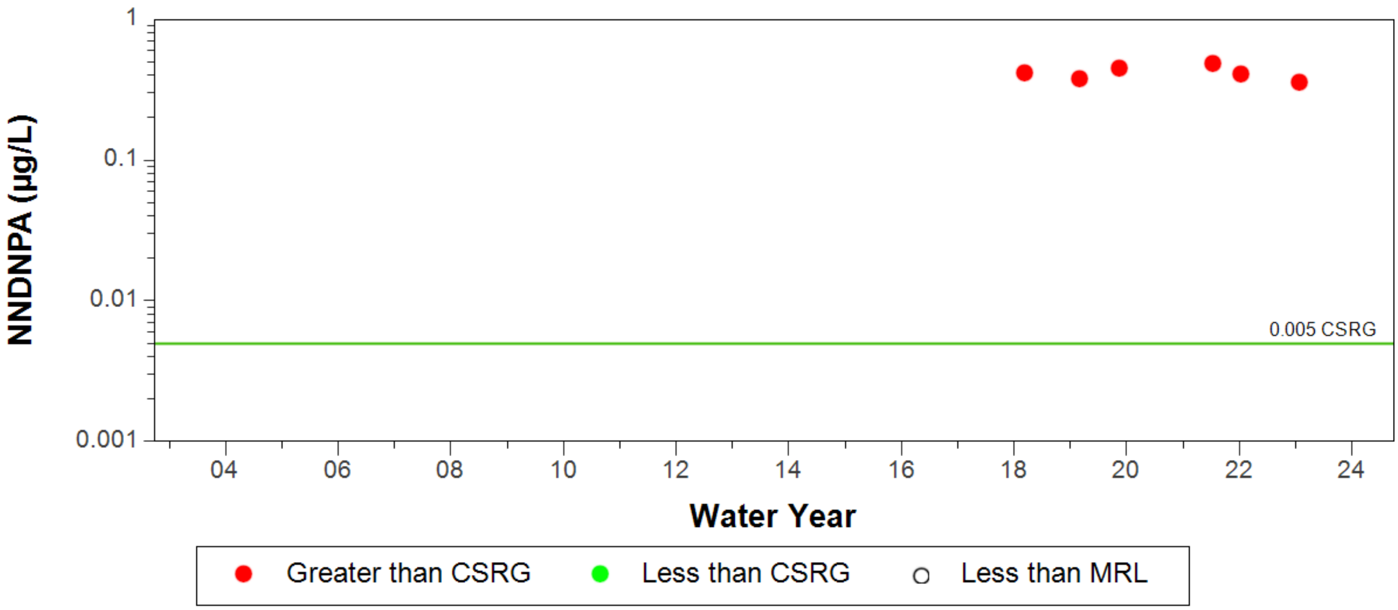


Upgradient Well 22008
NNDNPA (µg/L)
1
0.1
0.01
0.001
0.005 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

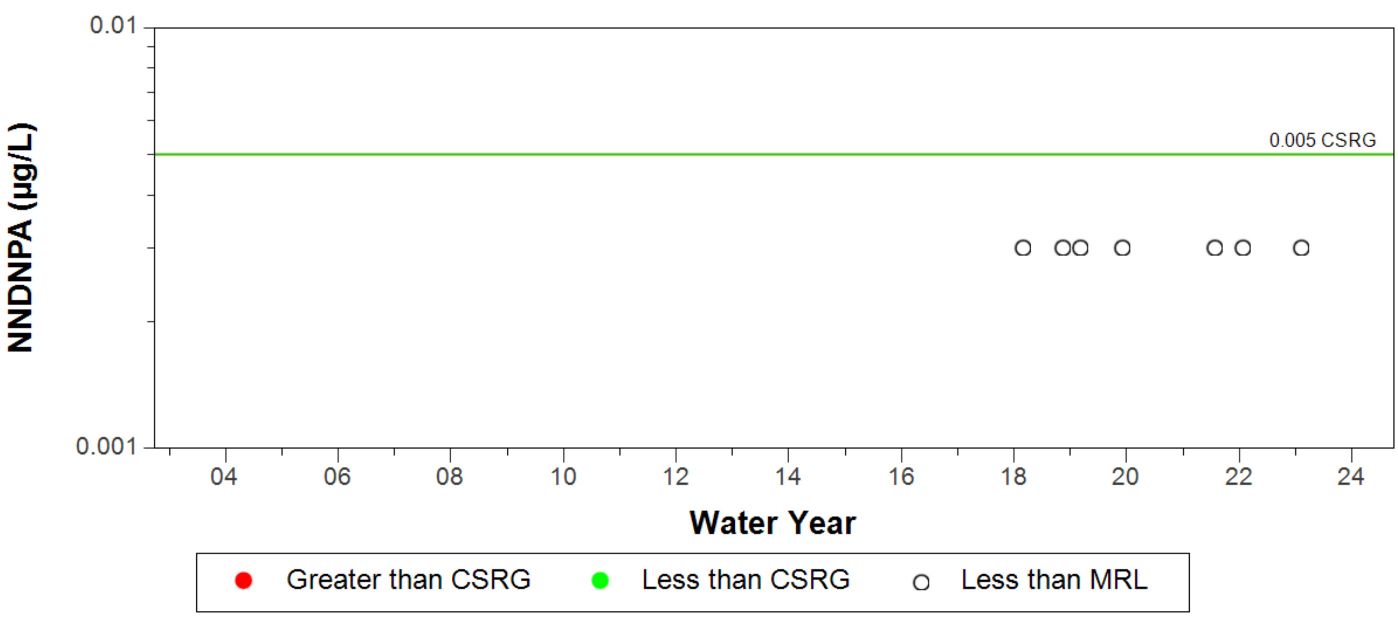

Upgradient Well 22043
NNDNPA (µg/L)
0.01
0.001
0.005 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL


Upgradient Well 22053
NNDNPA (µg/L)
1
0.1
0.01
0.001
0.005 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

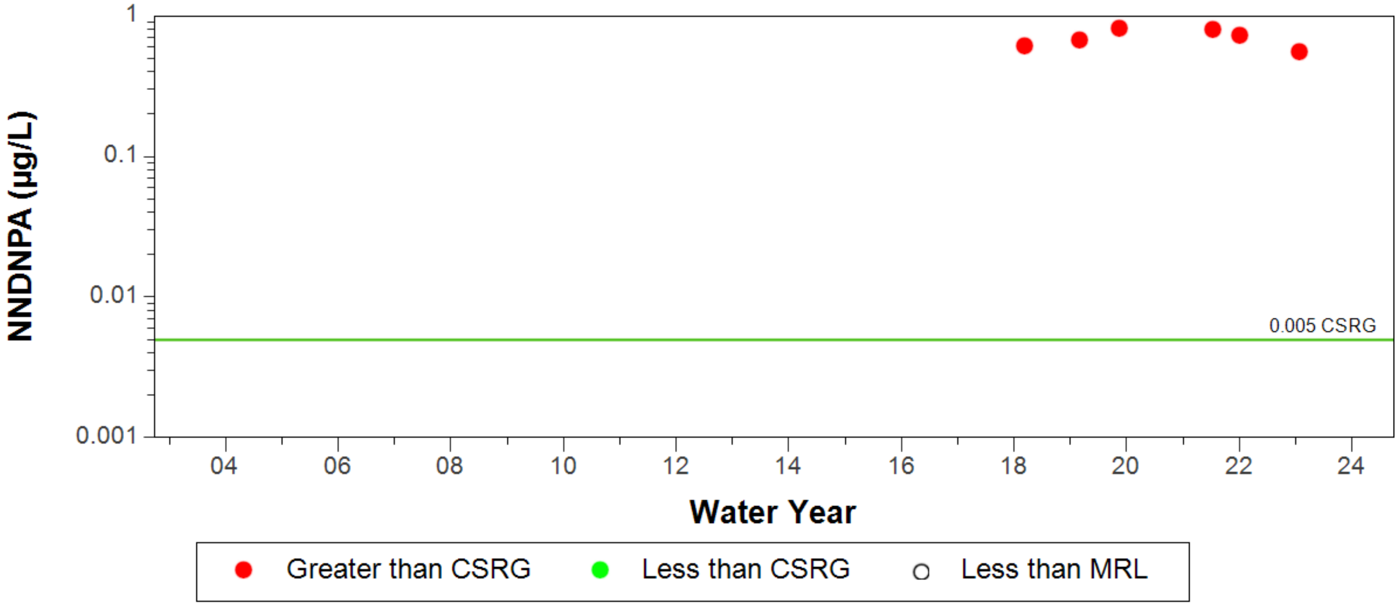
Upgradient Well 22081



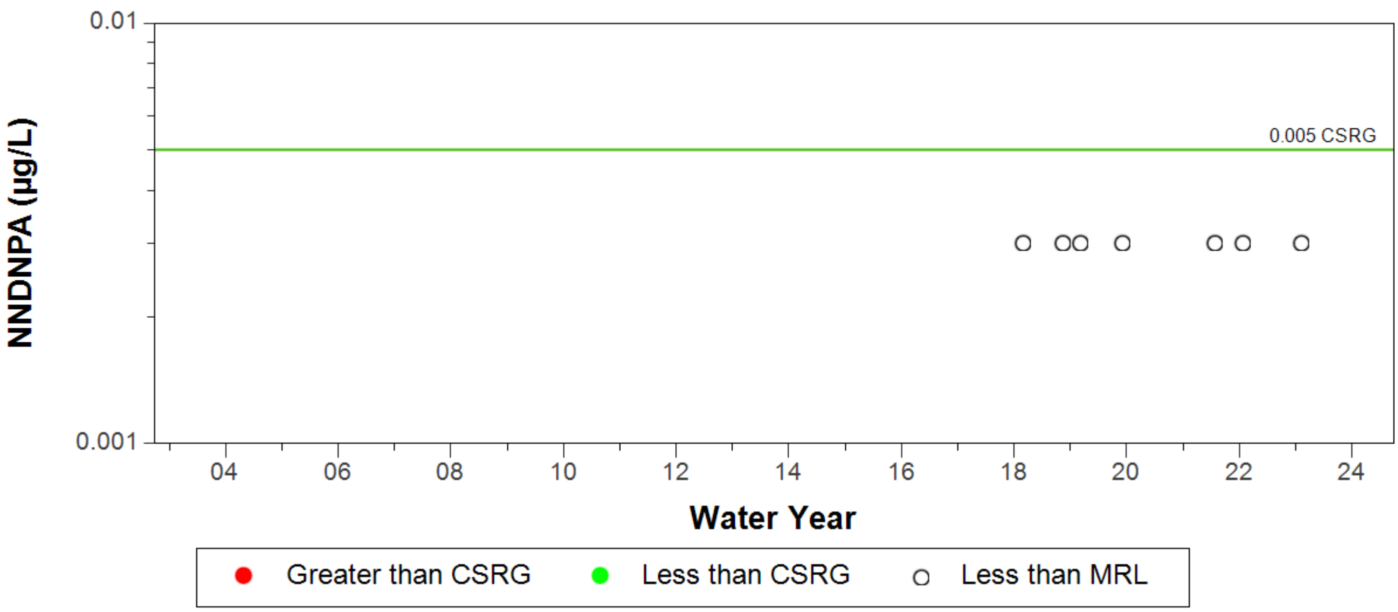
Upgradient Well 27500

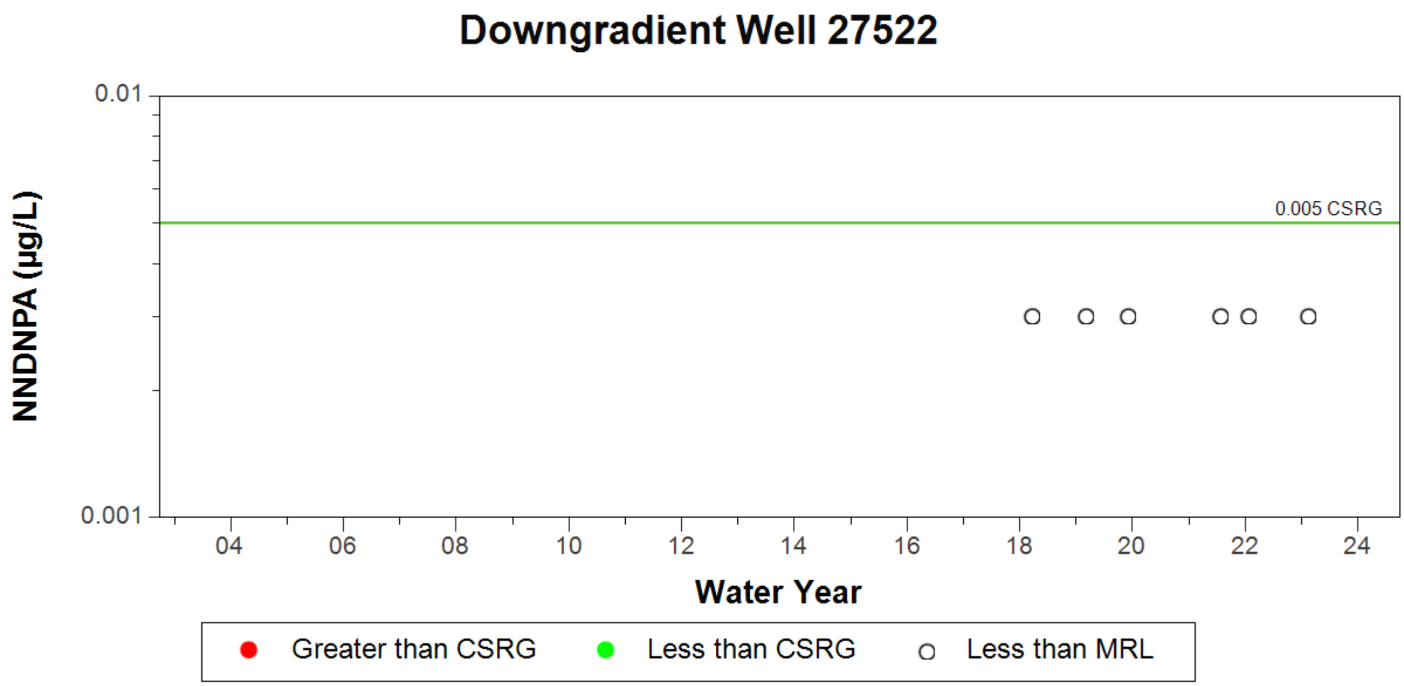


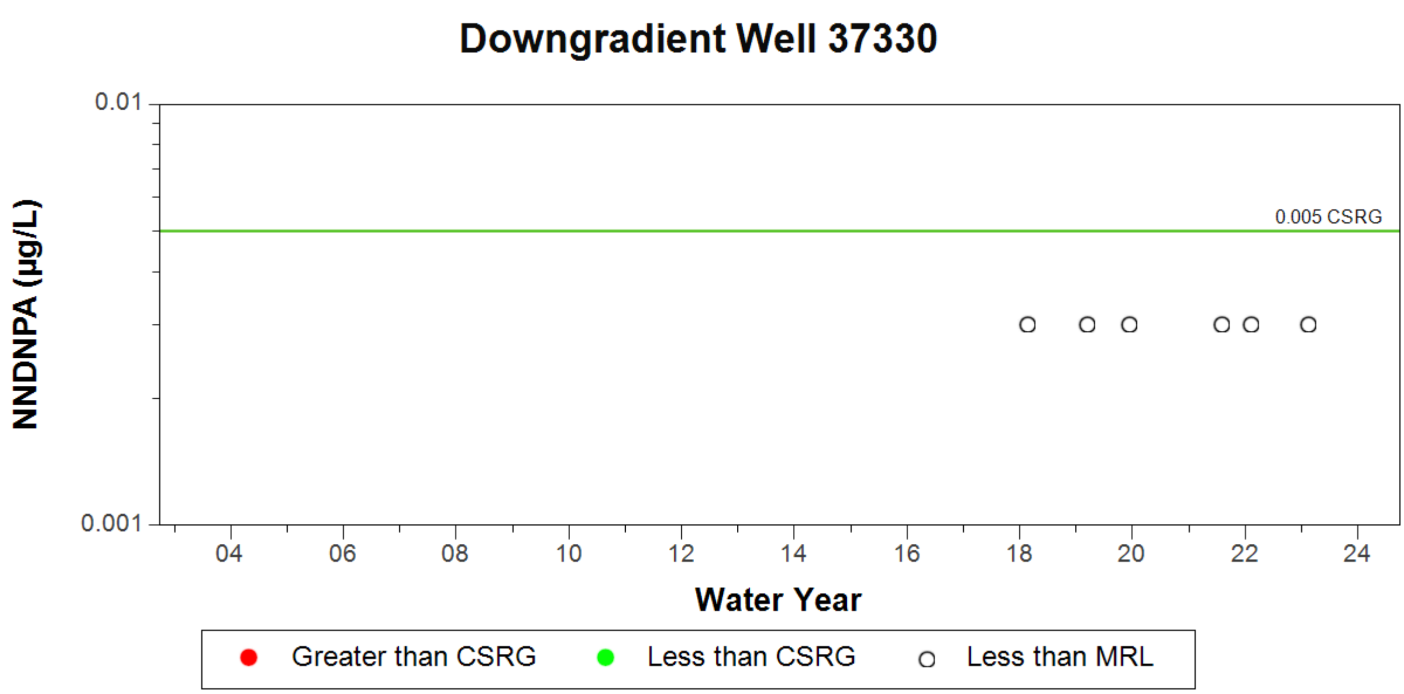
Upgradient Well 22505

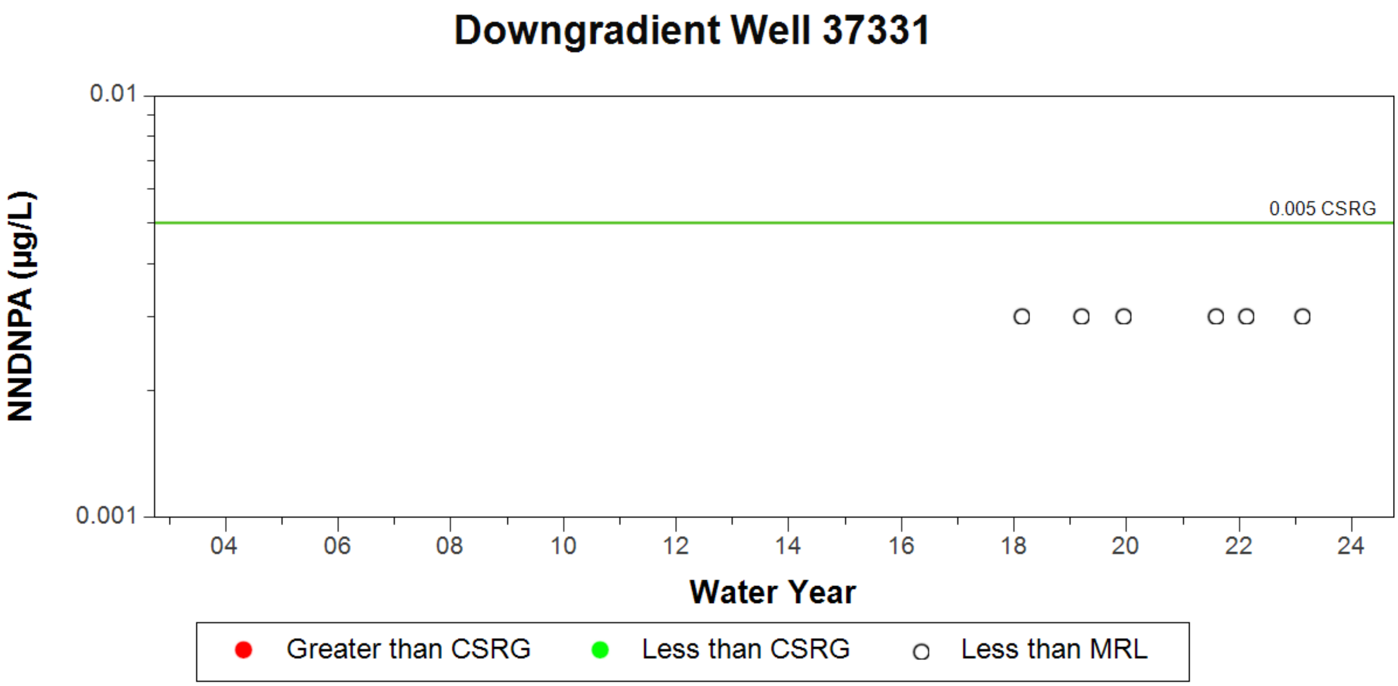


Crossgradient Well 27010

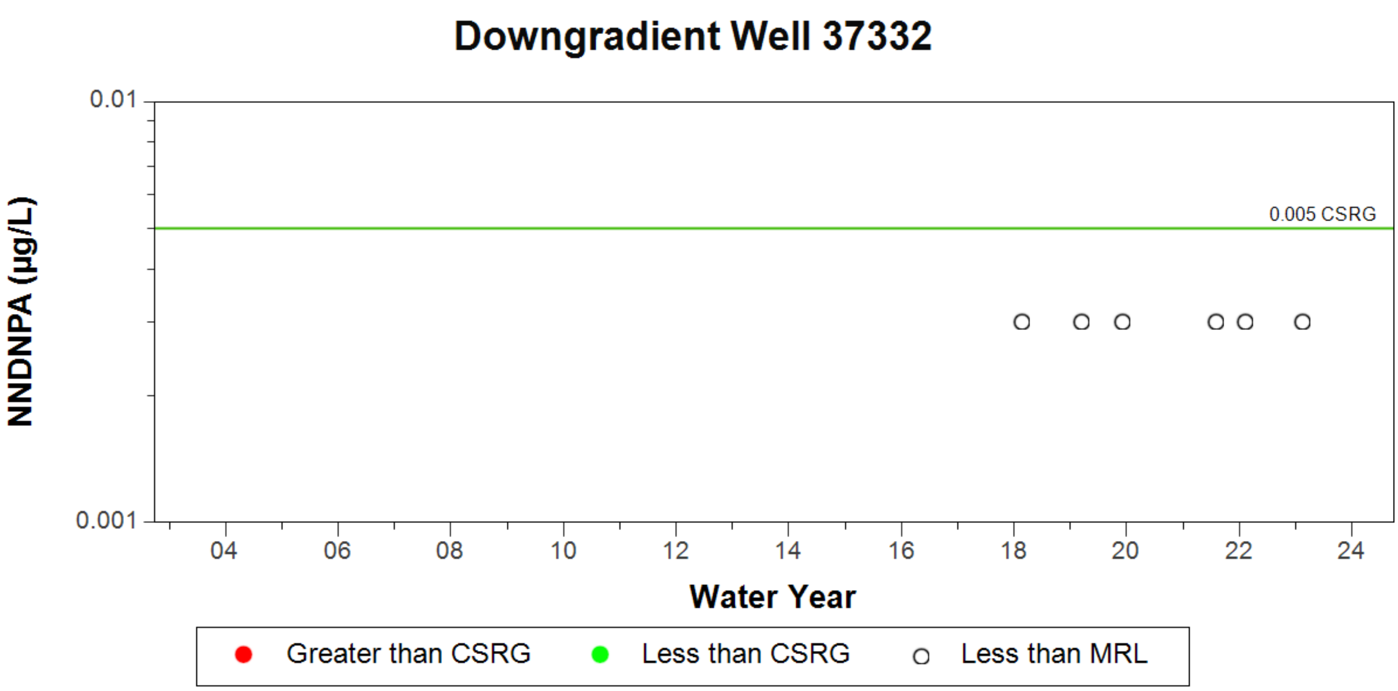



Downgradient Well 27522
0.01
0.005 CSRG
0.001
NNDNPA (µg/L)
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

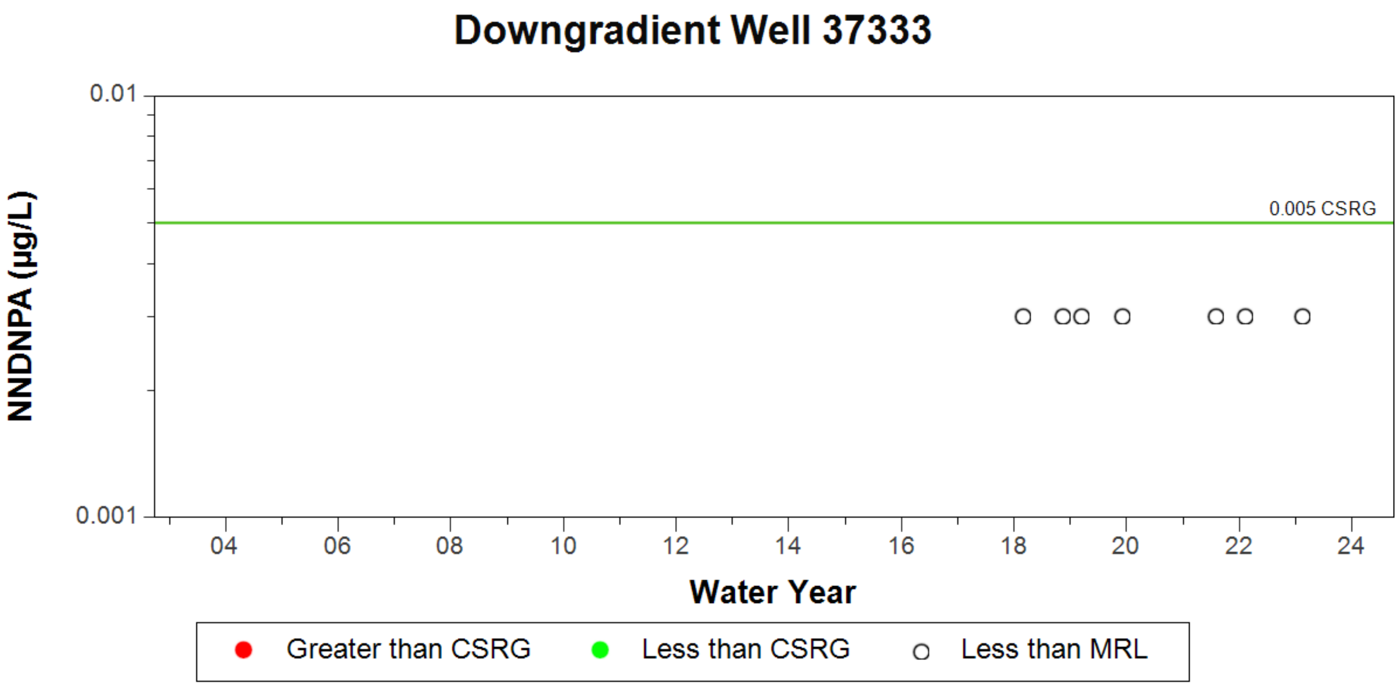

Downgradient Well 37330
0.01
0.005 CSRG
0.001
NNDNPA (µg/L)
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

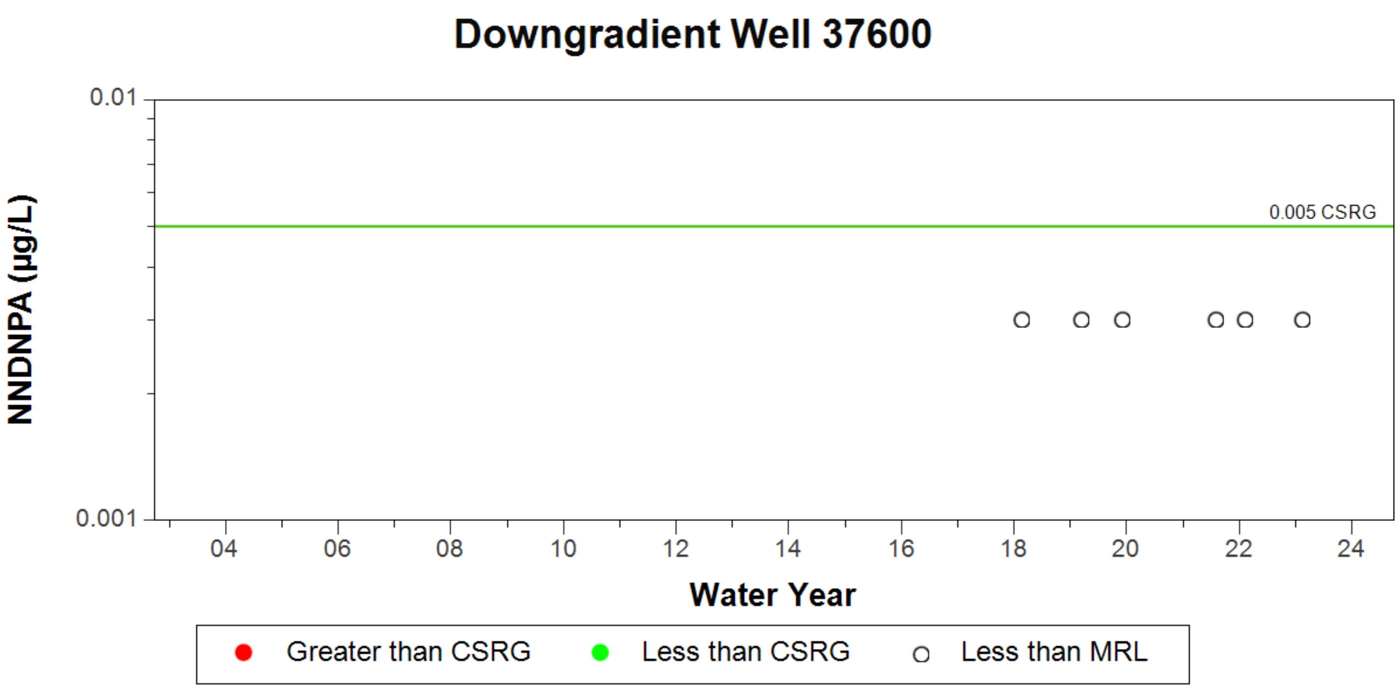


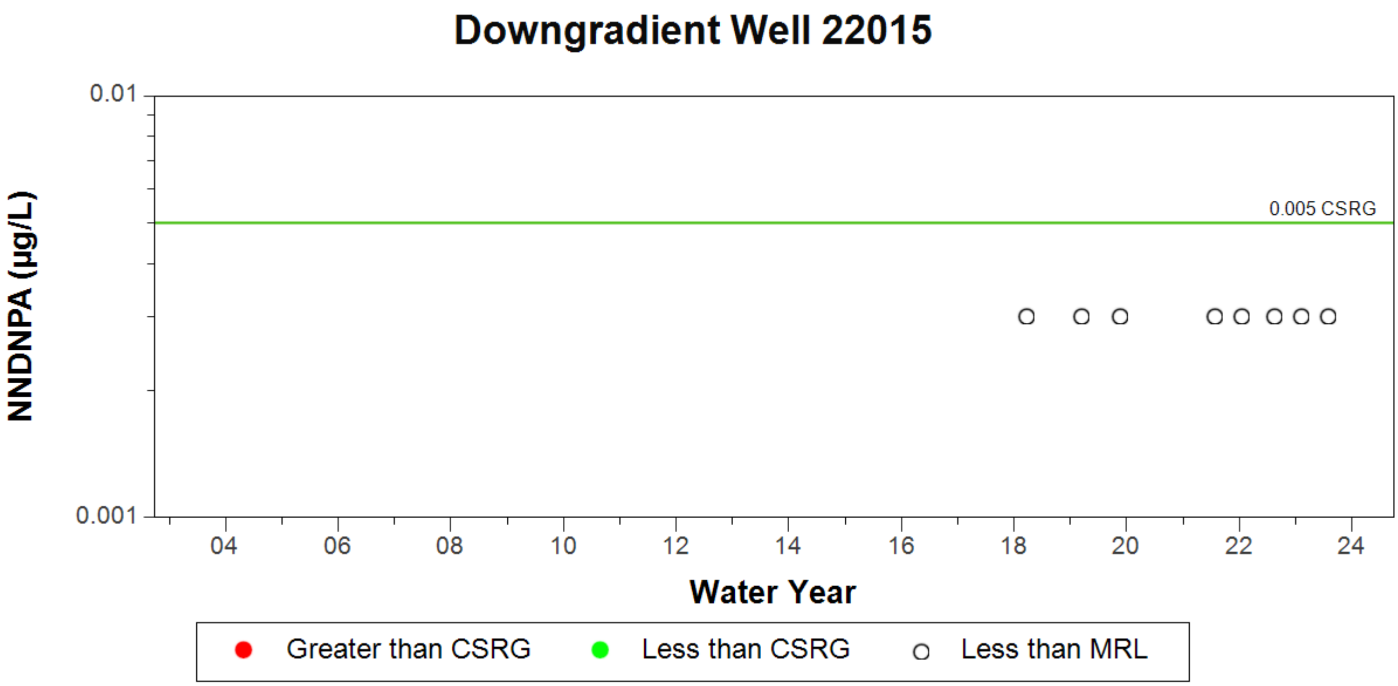
Downgradient Well 37331
NNDNPA (µg/L)
0.01
0.001
0.005 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

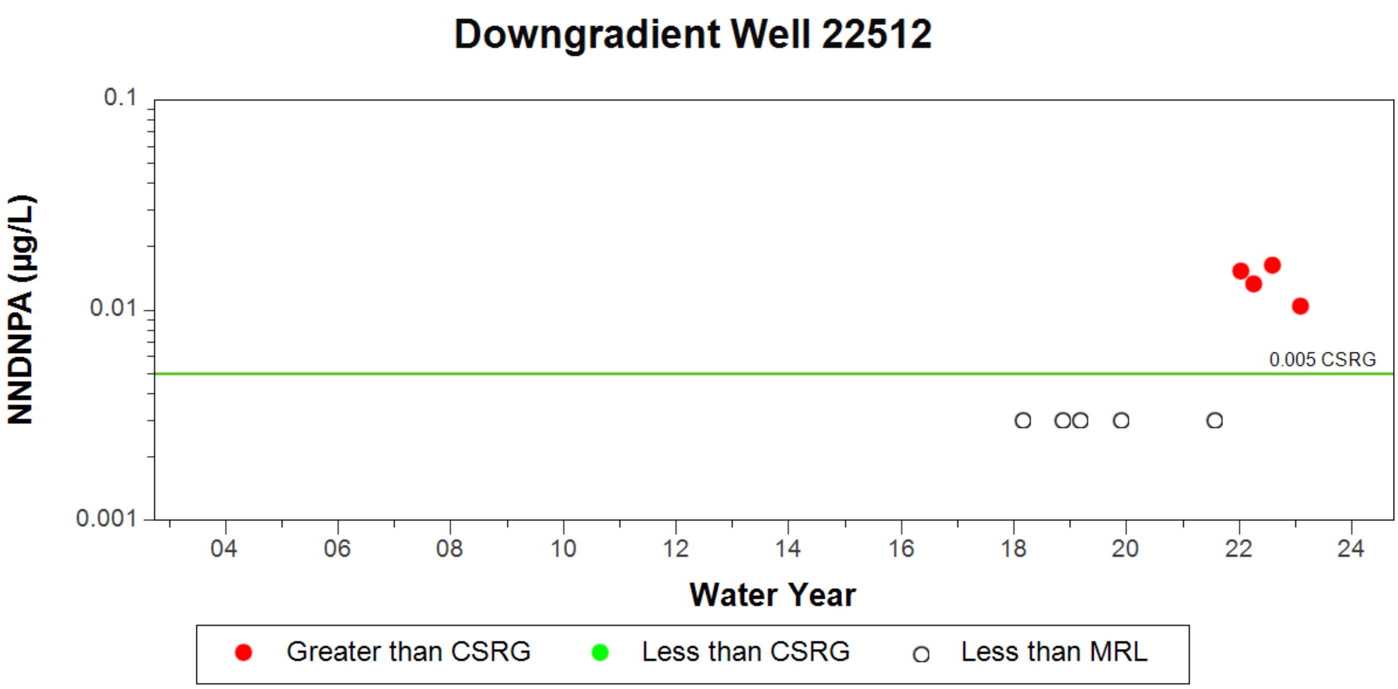


Downgradient Well 37332
NNDNPA (µg/L)
0.01
0.001
0.005 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL


Downgradient Well 37333
NNDNPA (µg/L)
0.01
0.001
0.005 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

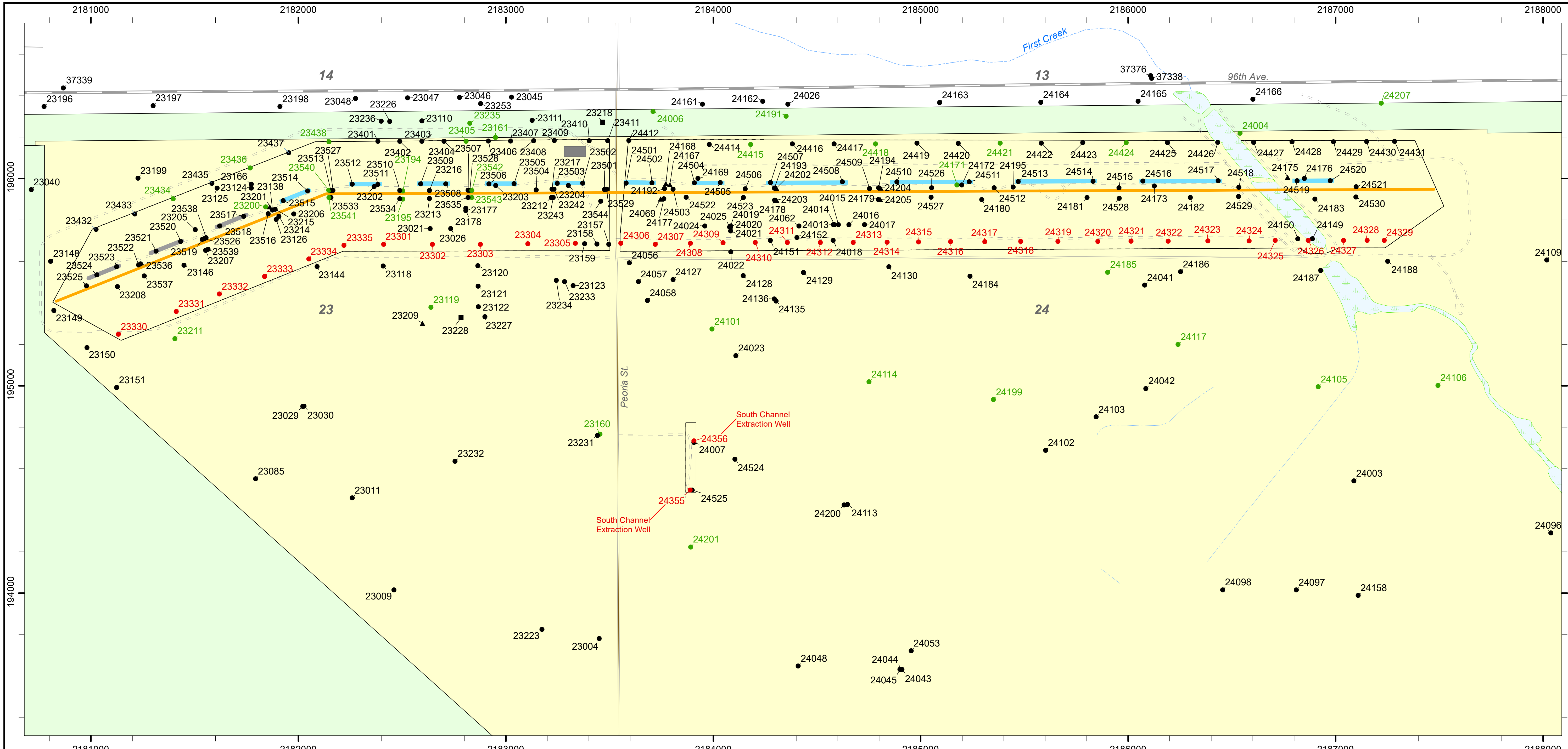

Downgradient Well 37600
NNDNPA (µg/L)
0.01
0.001
0.005 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL


Downgradient Well 22015
NNDNPA (µg/L)
0.01
0.001
0.005 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL


Downgradient Well 22512
NNDNPA (µg/L)
0.1
0.01
0.001
0.005 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

Appendix B

North Boundary Containment System Figures and Documentation



Legend

- Army Maintained Area
- USFWS Managed Area
- Army Maintained Area & USFWS Managed Area Border
- Treatment Building
- Wetlands
- Lakes and Ponds
- Section Lines
- Intermittent Streams
- Ditches
- Slurry Walls
- Recharge Trenches
- Inactive Recharge Trenches
- Local Roads
- Secondary Roads
- Primary Roads
- Unimproved Roads
- Performance Water Quality Wells
- Extraction Wells

Monitoring Wells

- Confined Flow System
- Unconfined Flow System
- Questionable Unconfined Flow System

N

0 250 500 Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

Program Manager
Rocky Mountain Arsenal

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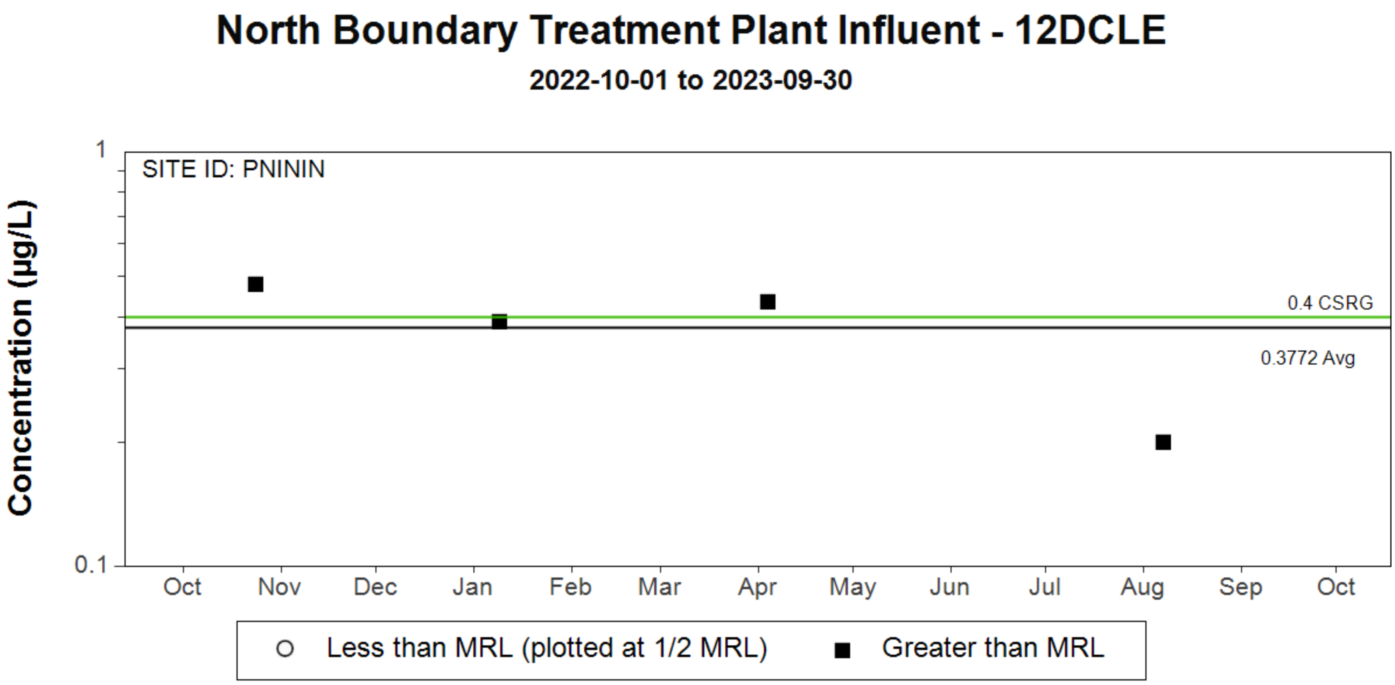
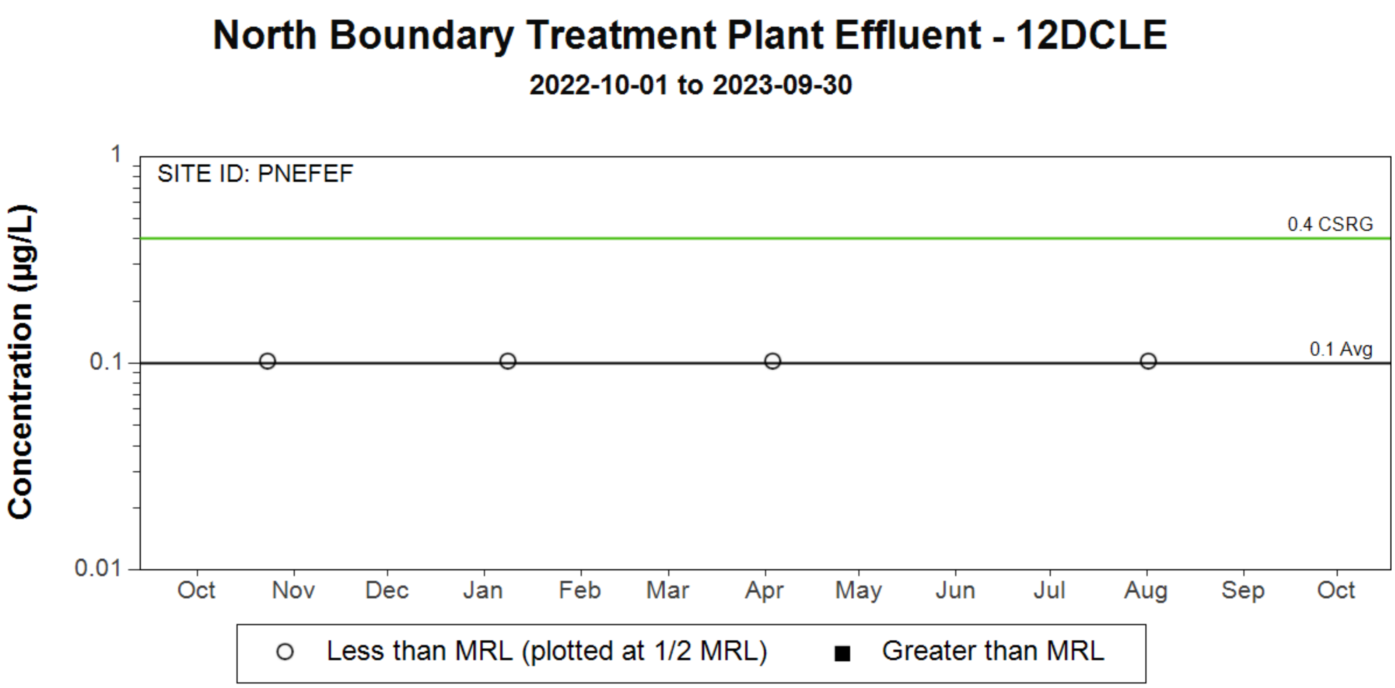
Figure B-1

North Boundary Monitoring Well
Network for the Unconfined Flow System

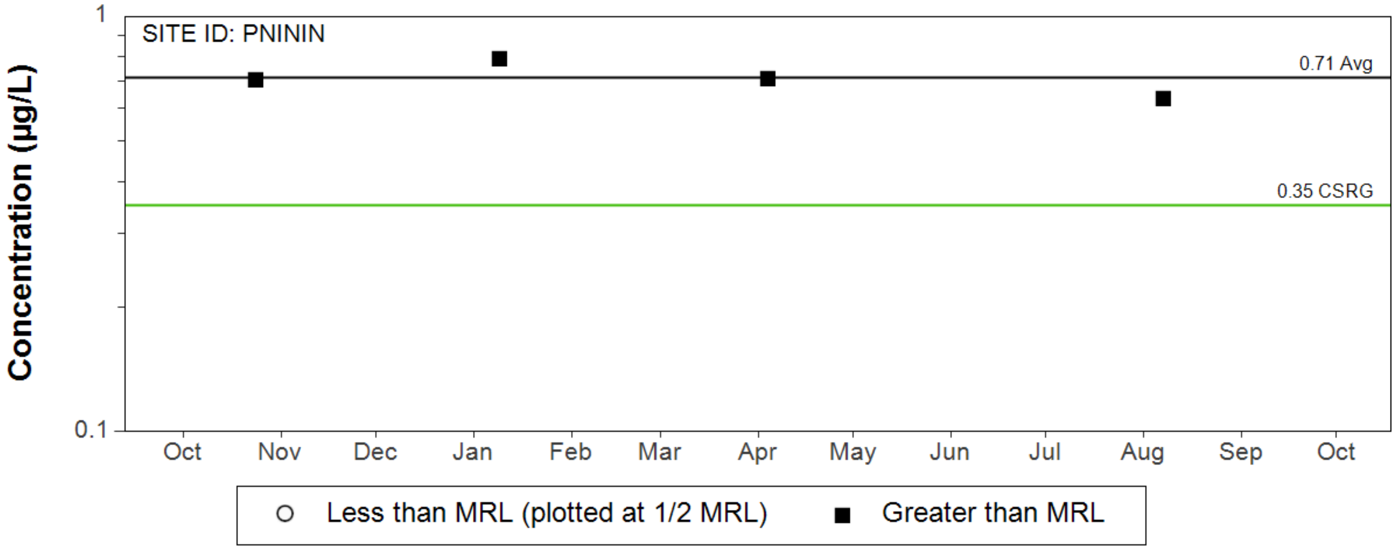
M:\projects\oars\fy23\mxds_nb23_well_location.mxd
8/7/2024


North Boundary Treatment Plant Influent - 12DCLE
2022-10-01 to 2023-09-30
SITE ID: PNININ
Concentration (µg/L)
1
0.1
0.4 CSRG
0.3772 Avg
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Less than MRL (plotted at 1/2 MRL)
Greater than MRL


North Boundary Treatment Plant Effluent - 12DCLE
2022-10-01 to 2023-09-30
SITE ID: PNEFEF
Concentration (µg/L)
1
0.1
0.01
0.4 CSRG
0.1 Avg
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Less than MRL (plotted at 1/2 MRL)
Greater than MRL

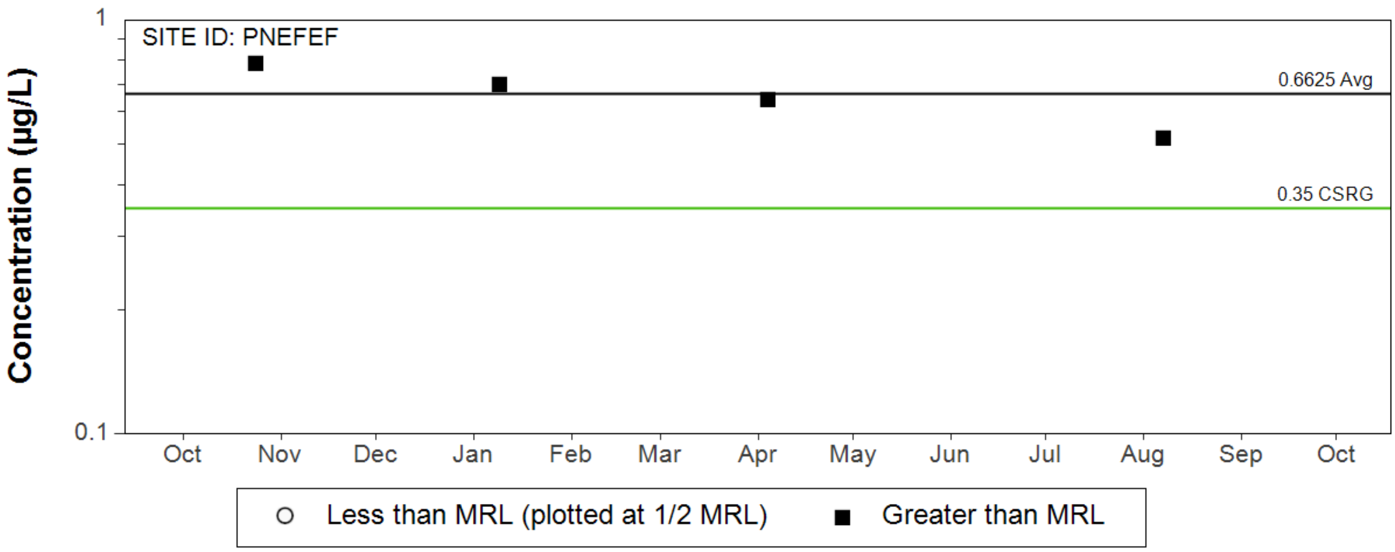
North Boundary Treatment Plant Influent - 14DIOX

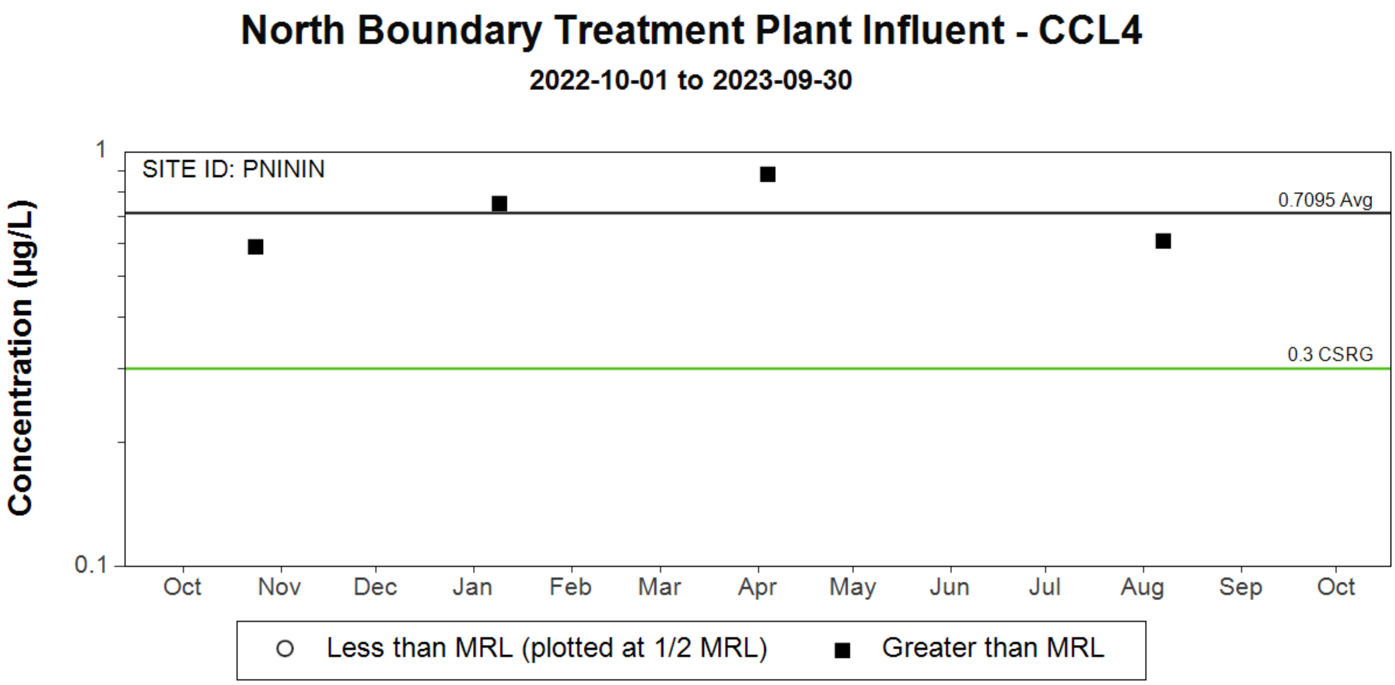
2022-10-01 to 2023-09-30



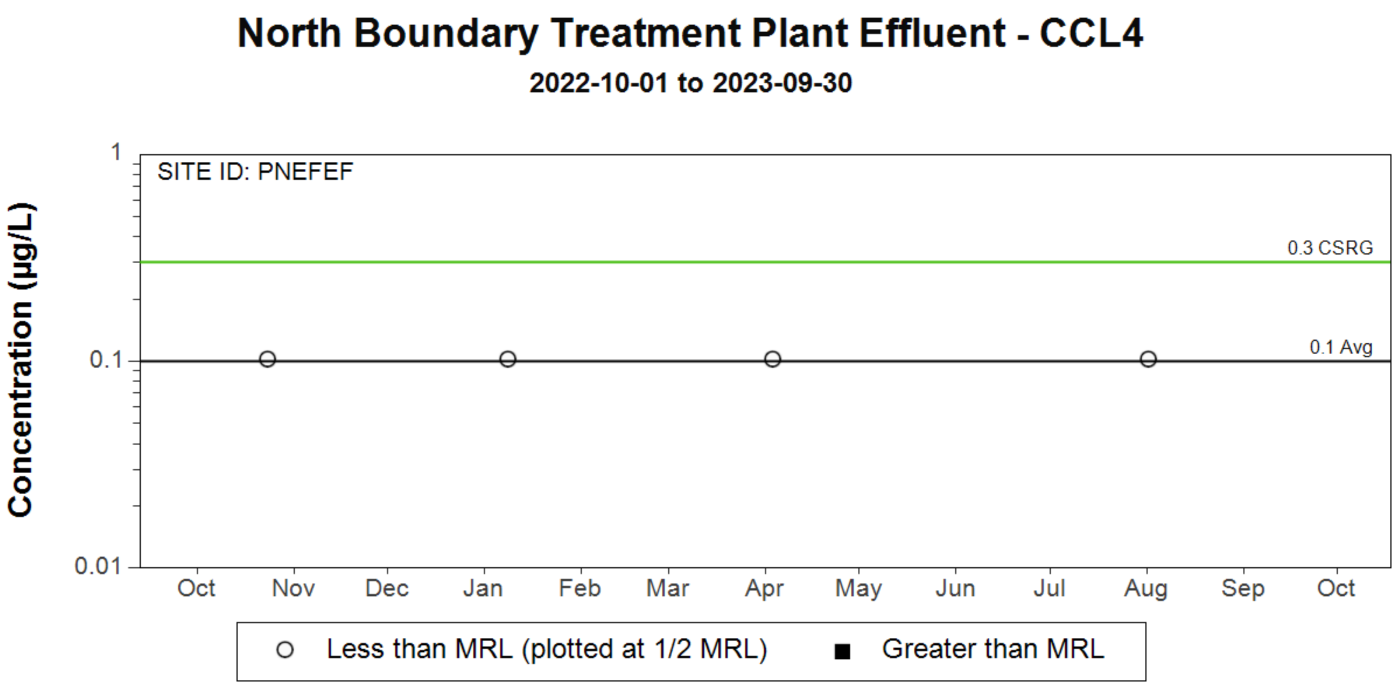
North Boundary Treatment Plant Effluent - 14DIOX

2022-10-01 to 2023-09-30





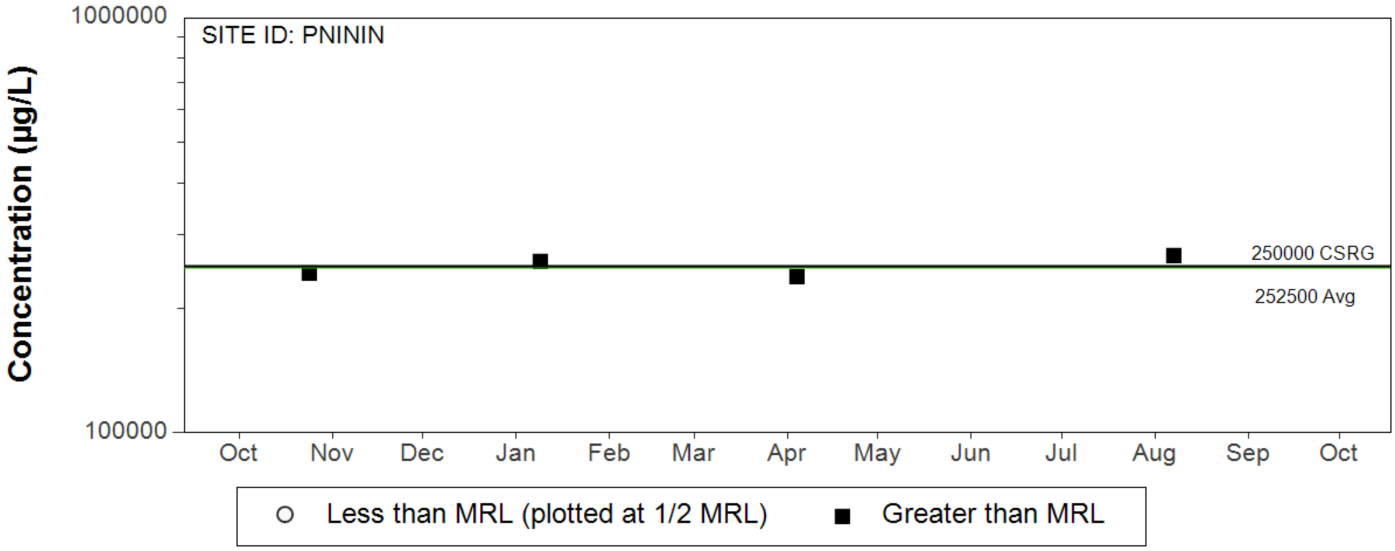
North Boundary Treatment Plant Influent - CCL4
2022-10-01 to 2023-09-30
SITE ID: PNININ
0.7095 Avg
0.3 CSRG
Concentration (µg/L)
1
0.1
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Less than MRL (plotted at 1/2 MRL)
Greater than MRL



North Boundary Treatment Plant Effluent - CCL4
2022-10-01 to 2023-09-30
SITE ID: PNEFEF
0.3 CSRG
0.1 Avg
Concentration (µg/L)
1
0.1
0.01
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Less than MRL (plotted at 1/2 MRL)
Greater than MRL

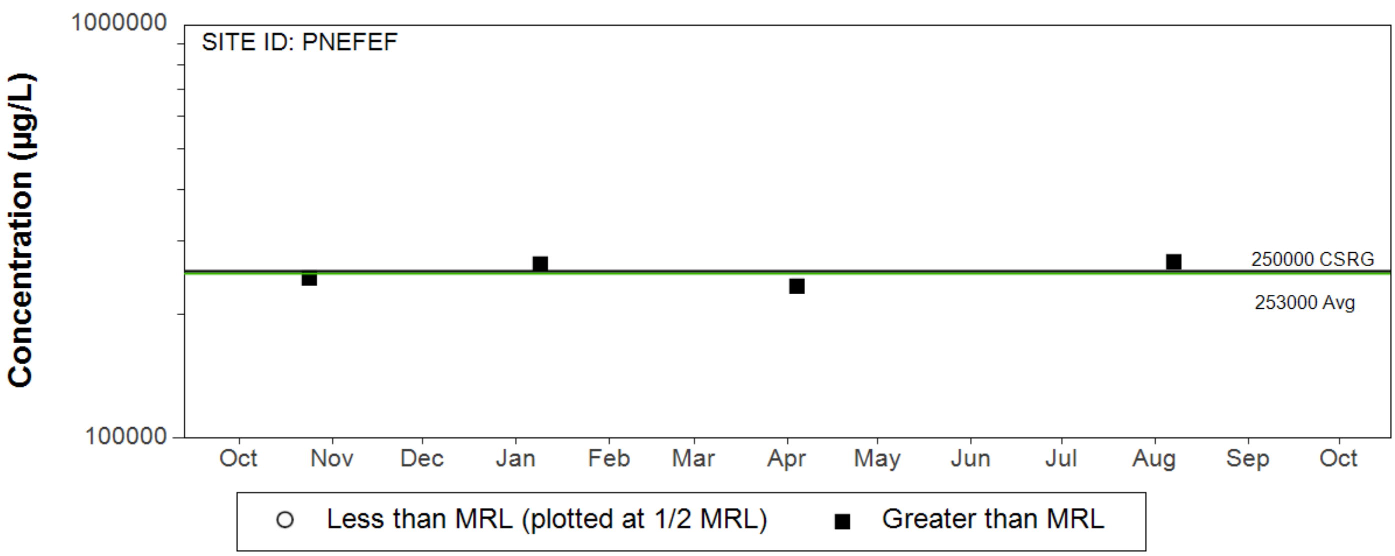
North Boundary Treatment Plant Influent - CL

2022-10-01 to 2023-09-30



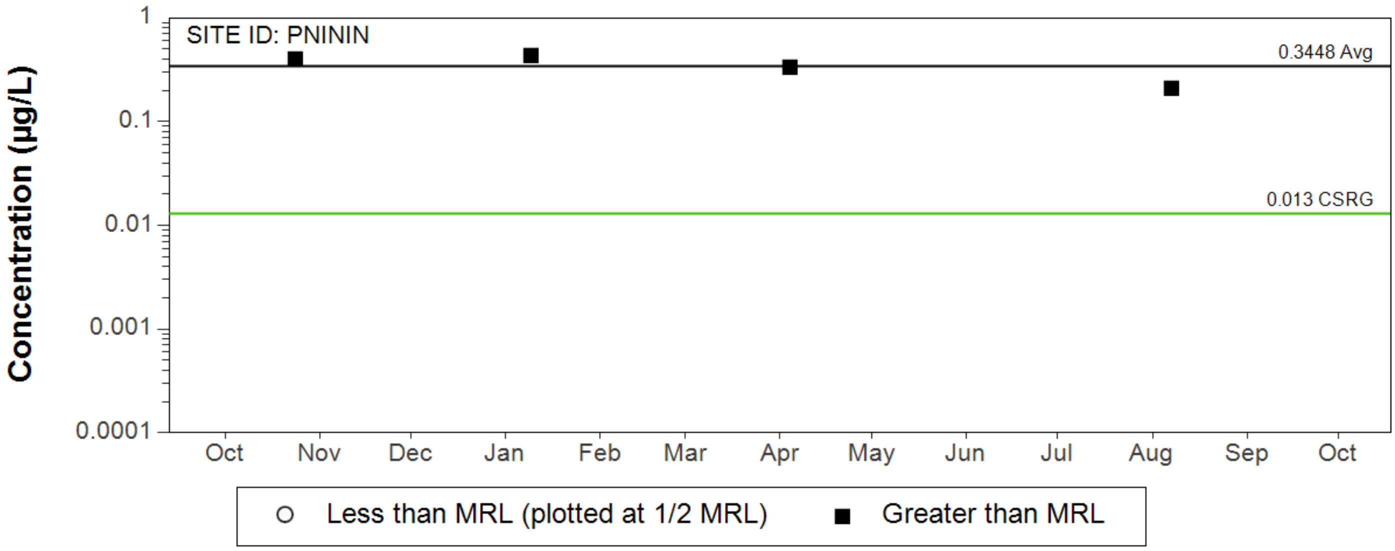
North Boundary Treatment Plant Effluent - CL

2022-10-01 to 2023-09-30



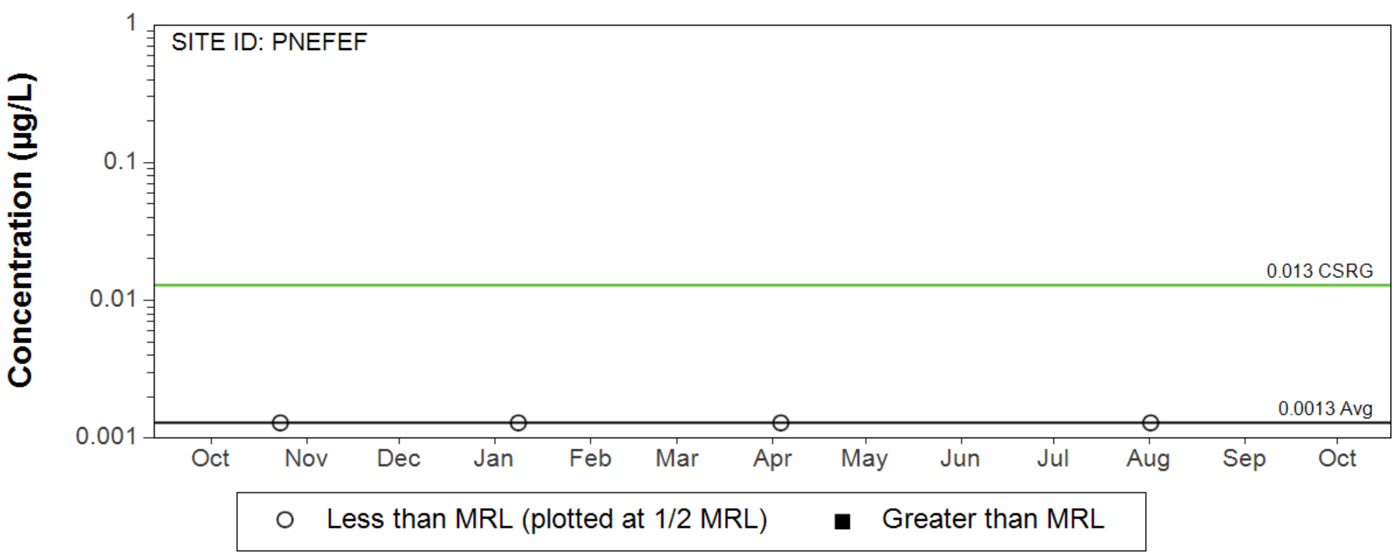
North Boundary Treatment Plant Influent - DLDRN

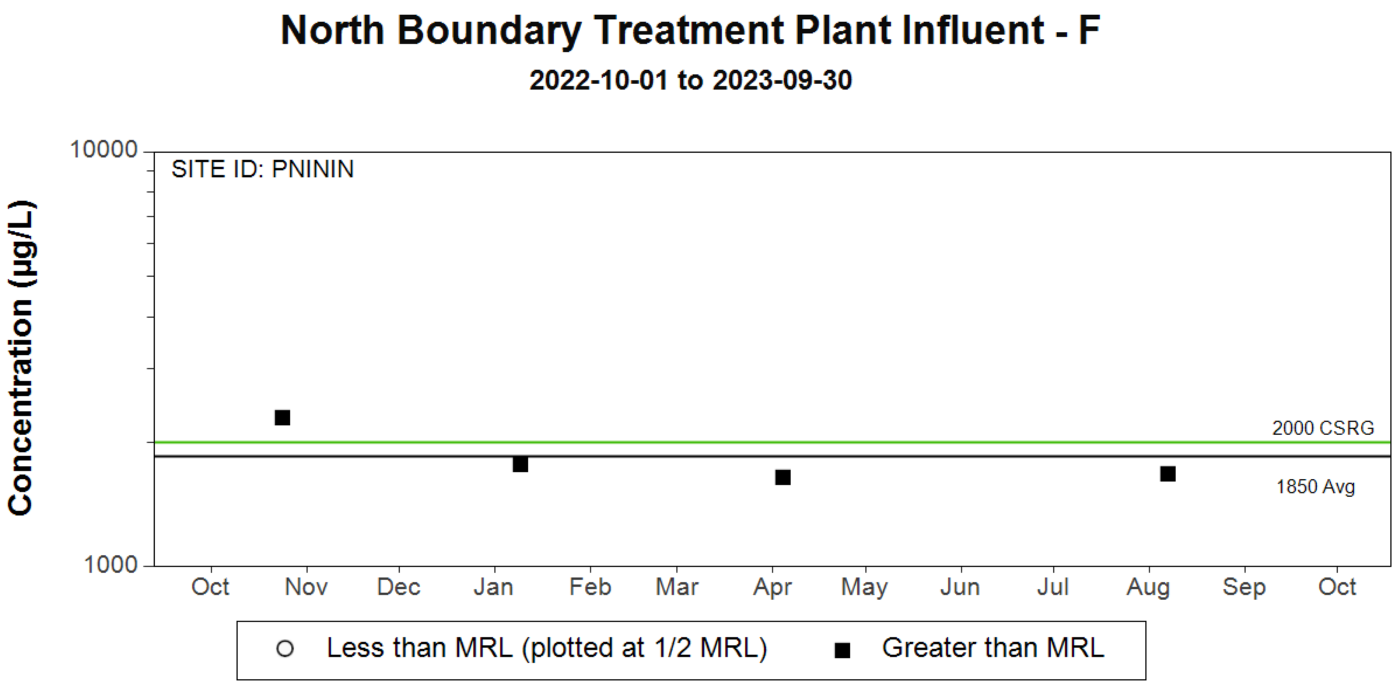
2022-10-01 to 2023-09-30

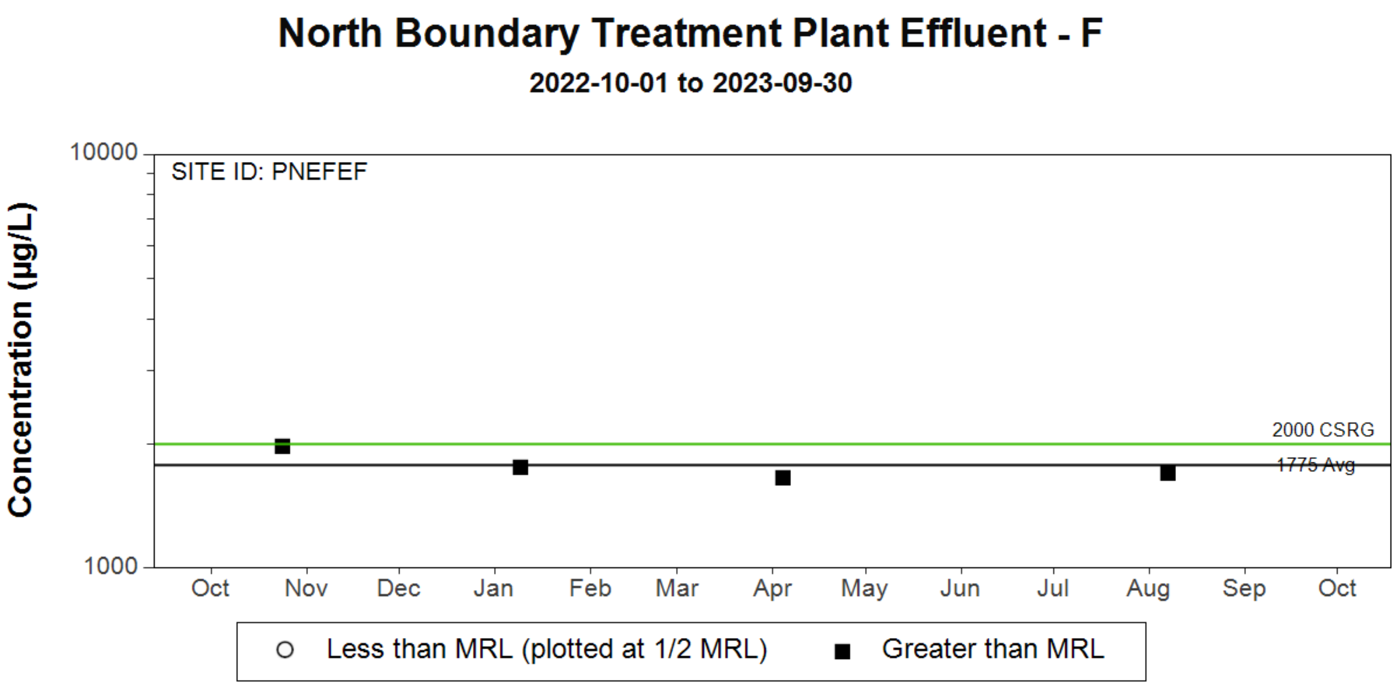


North Boundary Treatment Plant Effluent - DLDRN

2022-10-01 to 2023-09-30

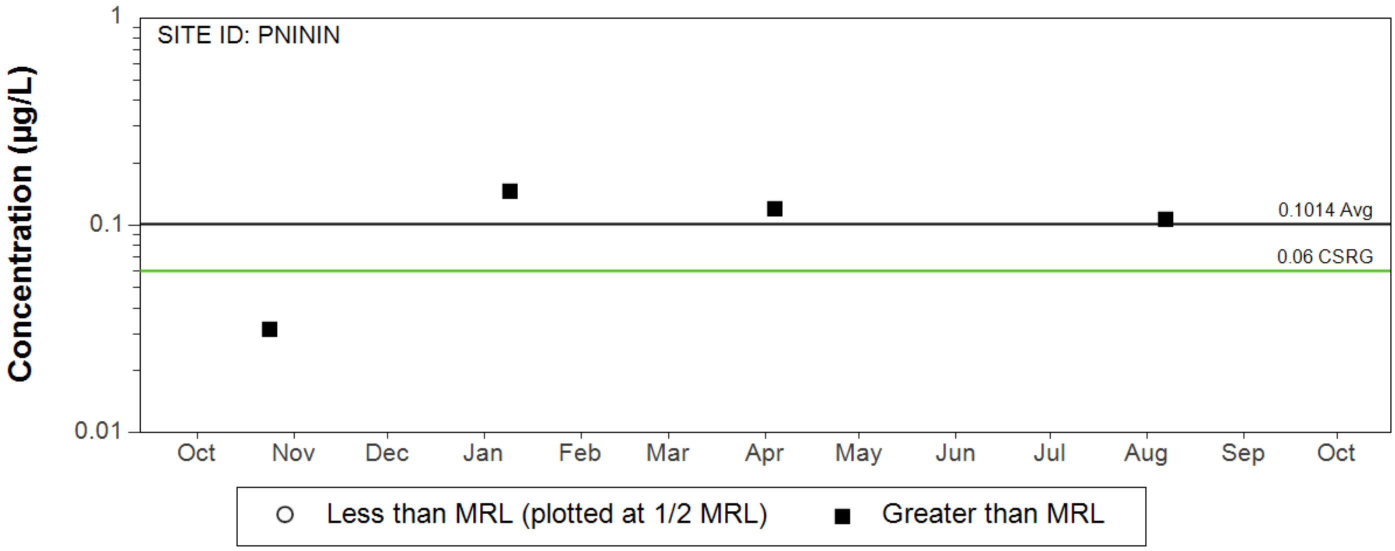



North Boundary Treatment Plant Influent - F
2022-10-01 to 2023-09-30
Concentration (µg/L)
SITE ID: PNININ
10000
1000
2000 CSRG
1850 Avg
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Less than MRL (plotted at 1/2 MRL)
Greater than MRL


North Boundary Treatment Plant Effluent - F
2022-10-01 to 2023-09-30
Concentration (µg/L)
SITE ID: PNEFEF
10000
1000
2000 CSRG
1775 Avg
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Less than MRL (plotted at 1/2 MRL)
Greater than MRL

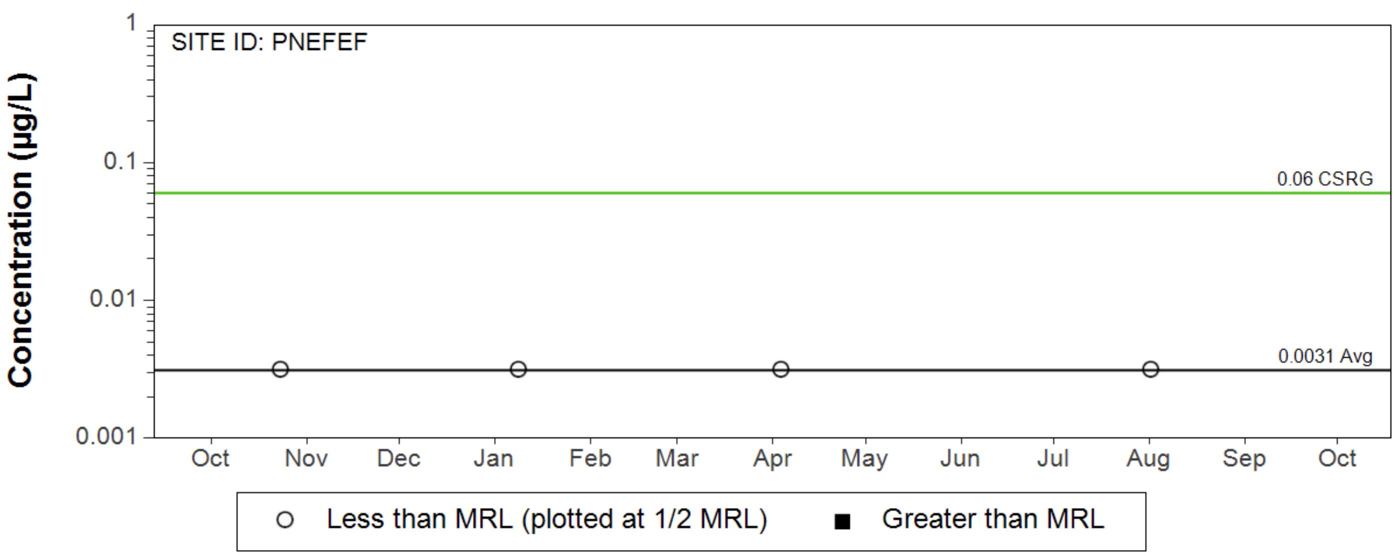
North Boundary Treatment Plant Influent - ISODR

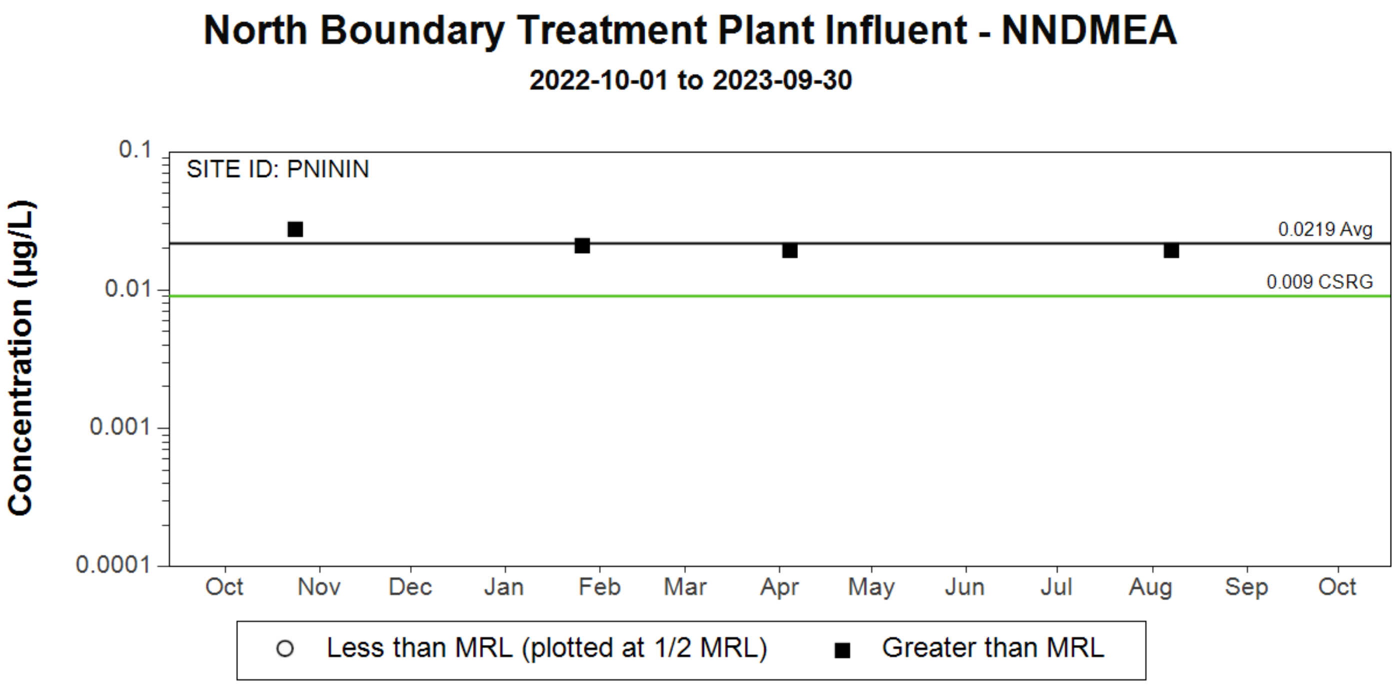
2022-10-01 to 2023-09-30



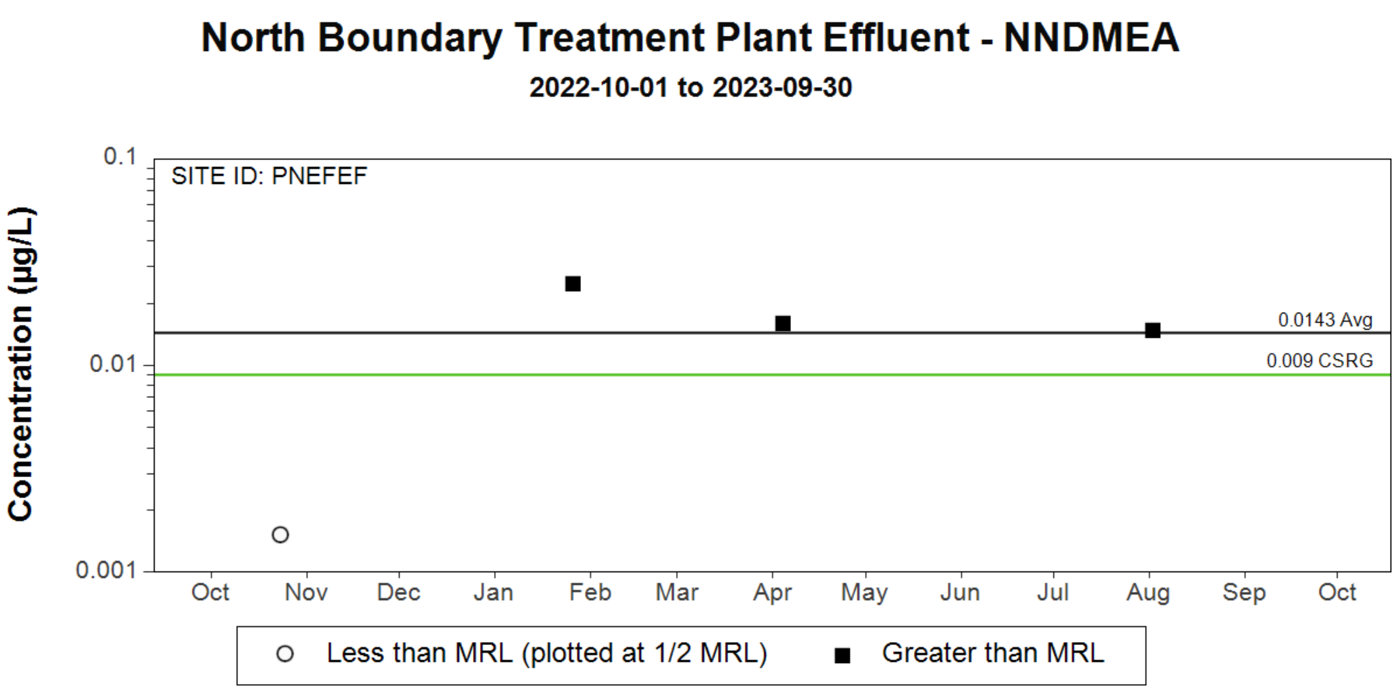
North Boundary Treatment Plant Effluent - ISODR

2022-10-01 to 2023-09-30





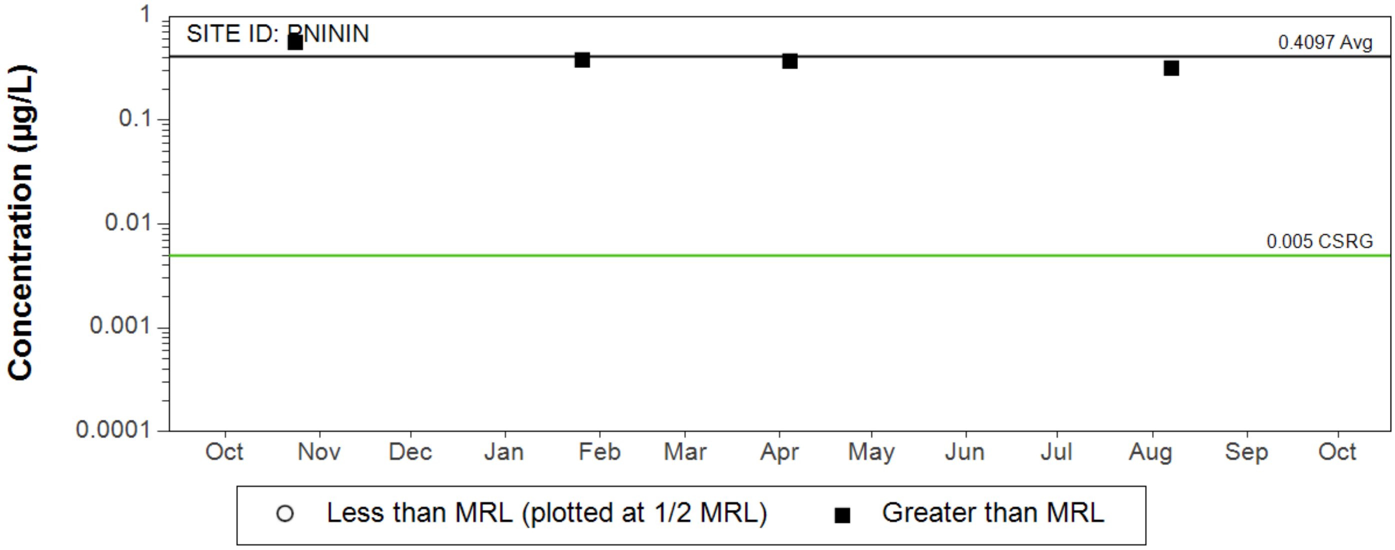
North Boundary Treatment Plant Influent - NNDMEA
2022-10-01 to 2023-09-30
Concentration (µg/L)
SITE ID: PNININ
0.0219 Avg
0.009 CSRG
0.1
0.01
0.001
0.0001
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Less than MRL (plotted at 1/2 MRL)
Greater than MRL



North Boundary Treatment Plant Effluent - NNDMEA
2022-10-01 to 2023-09-30
Concentration (µg/L)
SITE ID: PNEFEF
0.0143 Avg
0.009 CSRG
0.1
0.01
0.001
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Less than MRL (plotted at 1/2 MRL)
Greater than MRL

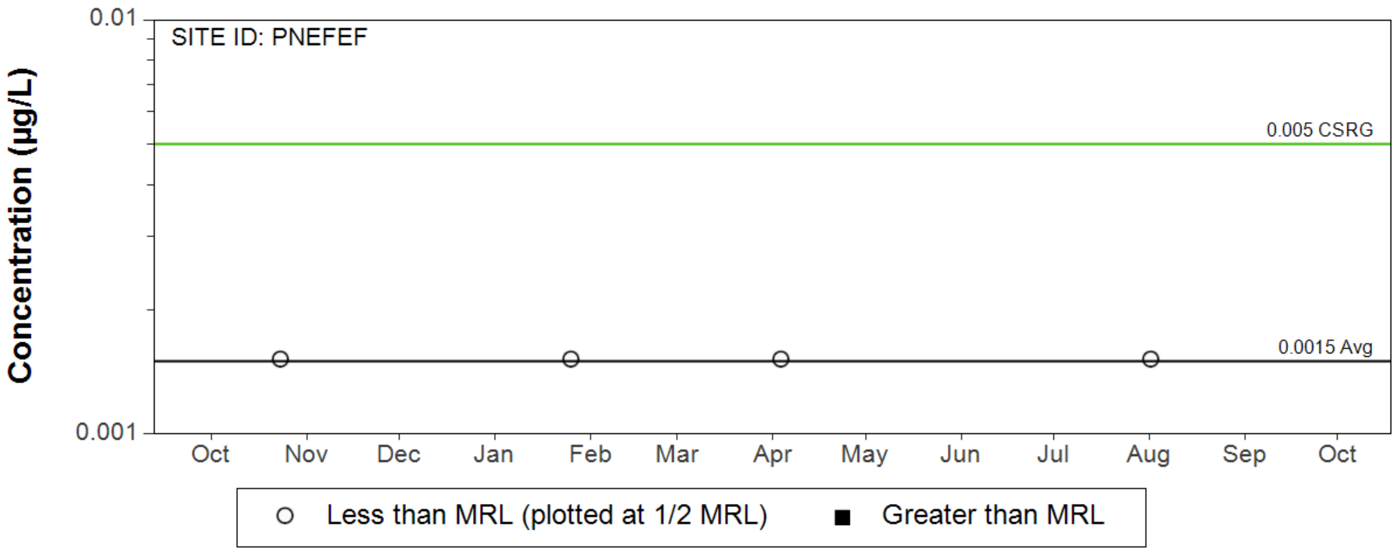
North Boundary Treatment Plant Influent - NNDNPA

2022-10-01 to 2023-09-30



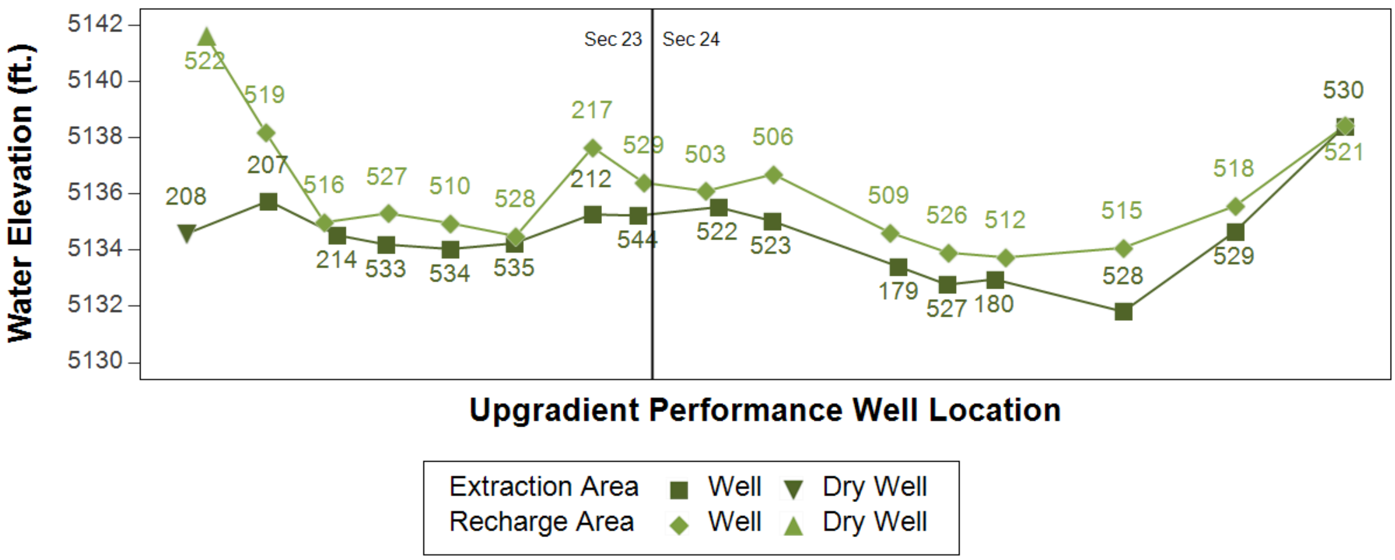
North Boundary Treatment Plant Effluent - NNDNPA

2022-10-01 to 2023-09-30



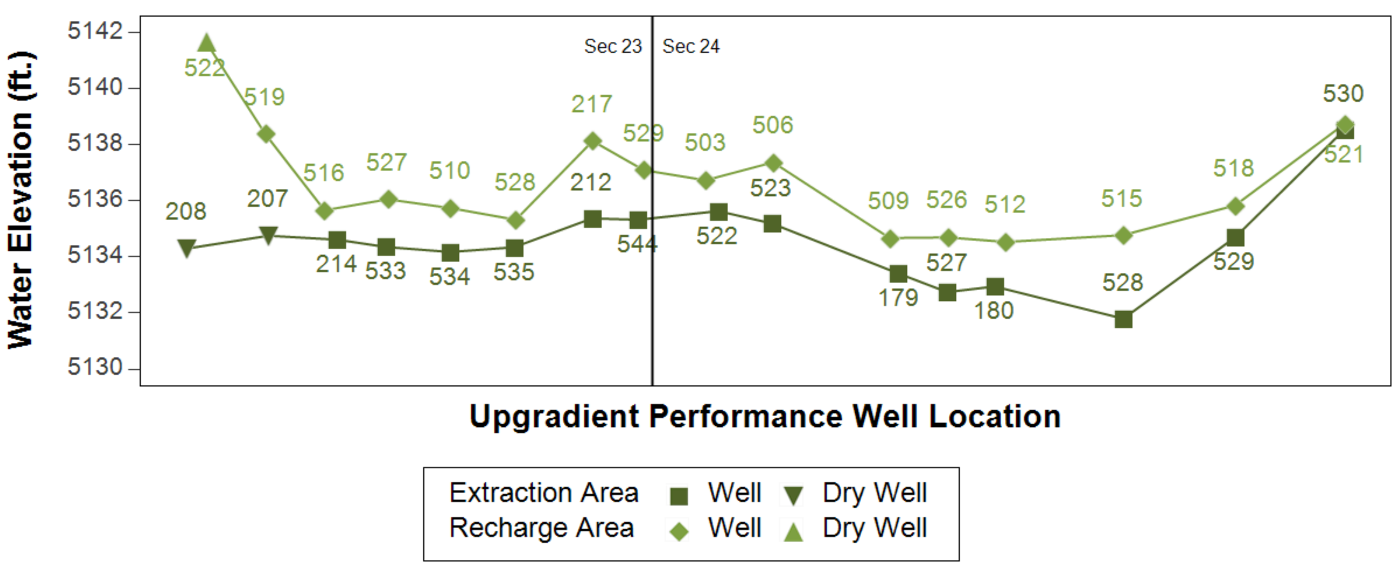
North Boundary Water Levels (Alluvial)

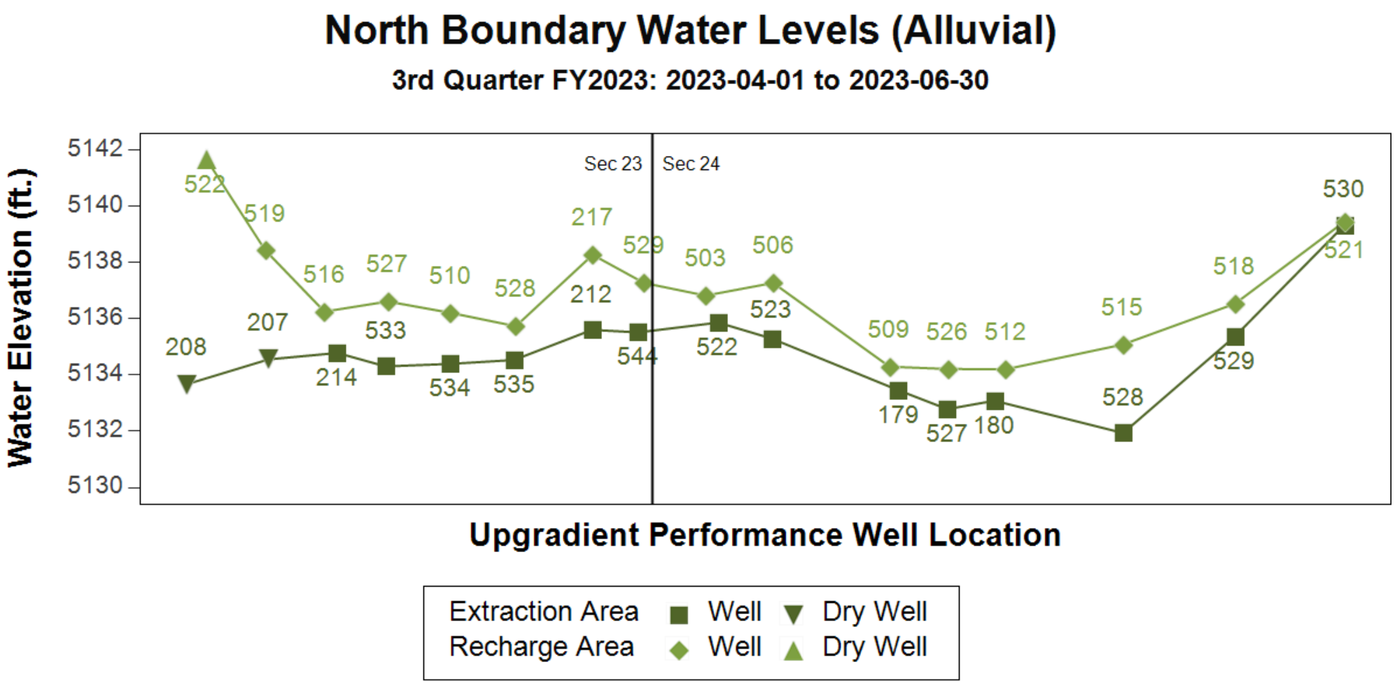
1st Quarter FY2023: 2022-10-01 to 2022-12-31

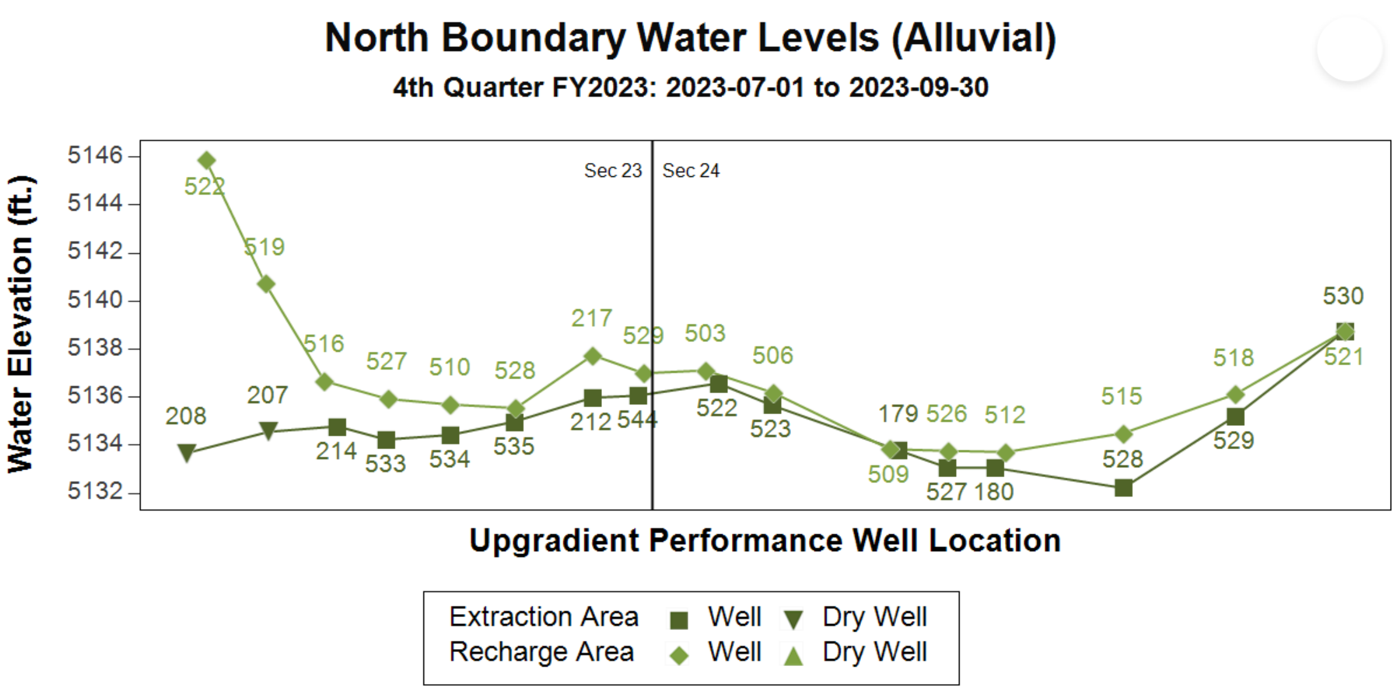


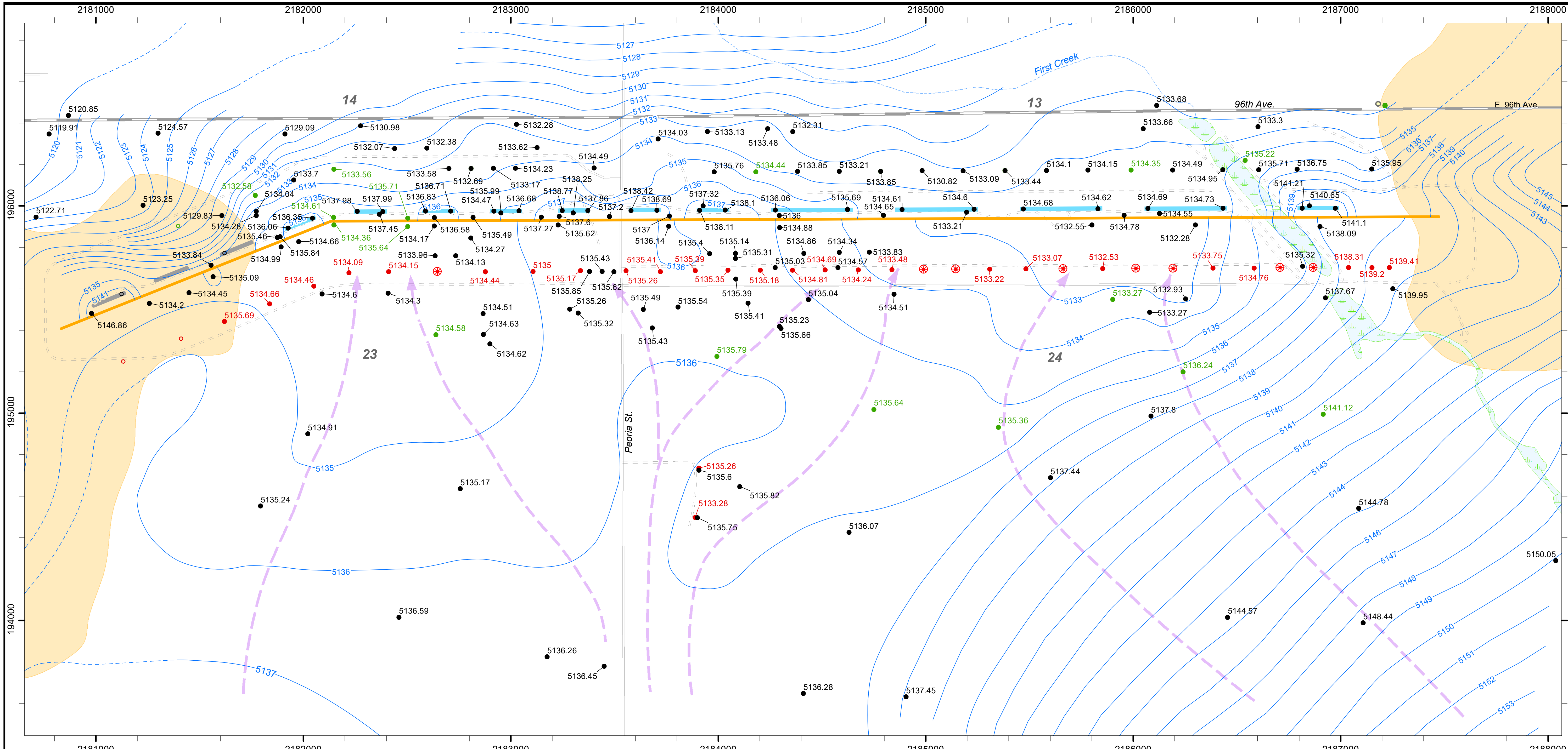
North Boundary Water Levels (Alluvial)

2nd Quarter FY2023: 2023-01-01 to 2023-03-31




North Boundary Water Levels (Alluvial)
3rd Quarter FY2023: 2023-04-01 to 2023-06-30
Water Elevation (ft.)
5142
5140
5138
5136
5134
5132
5130
Sec 23
Sec 24
522
519
516
527
510
528
217
529
503
506
509
526
512
515
518
530
521
208
207
214
533
534
535
212
544
522
523
179
527
180
528
529
Upgradient Performance Well Location
Extraction Area
Well
Dry Well
Recharge Area
Well
Dry Well


North Boundary Water Levels (Alluvial)
4th Quarter FY2023: 2023-07-01 to 2023-09-30
Water Elevation (ft.)
5146
5144
5142
5140
5138
5136
5134
5132
Sec 23
Sec 24
522
519
516
527
510
528
217
529
503
506
179
526
512
515
518
530
521
208
207
214
533
534
535
212
544
522
523
509
527
180
528
529
Upgradient Performance Well Location
Extraction Area
Well
Dry Well
Recharge Area
Well
Dry Well



Legend

Unsaturated Alluvium

Section Lines

Water elevation contour - 1-foot interval

Inferred water elevation contour

Wetlands

Intermittent Streams

Ditches

Groundwater Flow Direction

Slurry Walls

Recharge Trenches

Inactive Recharge Trenches

Unimproved Roads

Local Roads

Secondary Roads

Primary Roads

Measured Wells Used for Contouring with Water Elevations

- Monitoring Wells
- Performance Water Quality Wells
- Extraction Wells

Wells Not Sampled or Not Used for Contouring

- Depression in water table due to extraction well. May not match actual areal extent of depression.
- Extraction Wells
- Monitoring Wells
- Performance Water Quality Wells

Notes: Water levels were measured in FY23 Quarter 2.

N

0 250 500 Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

Program Manager Rocky Mountain Arsenal

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Figure B-13

FY23 Potentiometric Surface of the Unconfined Flow System, North Boundary Containment System

M:\projects\oars\fy23\mxds_NB_FY23.mxd
8/7/2024

Exhibit B-14. Summary of FY23 NBCS Performance Water Quality Monitoring

Well	Sample Date	Analyte Concentration (ug/L, CSRG/PQL shown in italics)																
		12DCLE	14DIOX	ALDRN	AS	ATZ	C6H6	CCL4	CH2CL2	CHCL3	CL	CL6CP	CPMS	CPMSO	CPMSO2	DBCP	DCPD	DIMP
		0.4	*0.35*	*0.014*	*2.35*	*3*	*5*	*0.3*	*5*	*6*	*250,000*	*50*	*30*	*36*	*36*	*0.2*	*46*	*8*
Upgradient Wells																		
23119	8/16/23	LT 0.2	**0.453**	LT 0.00605	LT 1	LT 0.2	LT 0.2	LT 0.2	LT 3	0.231	**1200000**	LT 0.00983	LT 1.2	LT 1.6	LT 1.2	LT 0.0194	LT 0.2	LT 0.5
23160	8/15/23	**1.49**	**0.701**	**0.239**	LT 1	LT 0.2	LT 0.2	LT 0.2	LT 3	0.188	**1700000**	LT 0.00983	LT 1.2	LT 1.6	LT 1.2	LT 0.0194	5.21	3.34
23211	8/16/23	LT 0.2	LT 0.075	LT 0.00605	LT 1	LT 0.2	LT 0.2	LT 0.2	LT 3	LT 0.2	**363000**	LT 0.00983	LT 1.2	LT 1.6	LT 1.2	LT 0.0196	LT 0.2	**11.3**
24101	8/16/23	**2.34**	**1.11**	LT 0.00605	LT 1	LT 0.2	LT 0.2	LT 0.2	LT 3	0.274	**885000**	LT 0.00983	LT 1.2	5.35	3.63	LT 0.0194	35.3	**22.9**
24105	8/21/23	LT 0.2	LT 0.075	LT 0.00605	LT 1	LT 0.2	LT 0.2	LT 0.2	LT 3	LT 0.2	217000	LT 0.00983	LT 1.2	LT 1.6	LT 1.2	LT 0.0196	LT 0.2	LT 0.5
24106	8/21/23	LT 0.2	LT 0.075	LT 0.00605	LT 1	LT 0.2	LT 0.2	LT 0.2	LT 3	LT 0.2	208000	LT 0.00983	LT 1.2	LT 1.6	LT 1.2	LT 0.0192	LT 0.2	LT 0.5
24114	8/17/23	LT 0.2	LT 0.075	LT 0.00605	LT 1	LT 0.2	LT 0.2	LT 0.2	LT 3	0.974	47500	LT 0.00983	LT 1.2	LT 1.6	LT 1.2	LT 0.0194	LT 0.2	LT 0.5
24117	8/21/23	LT 0.2	LT 0.075	LT 0.00605	LT 1	LT 0.2	LT 0.2	LT 0.2	LT 3	LT 0.2	213000	LT 0.00983	LT 1.2	LT 1.6	LT 1.2	LT 0.0194	LT 0.2	LT 0.5
24185	8/17/23	LT 0.2	LT 0.075	LT 0.00605	LT 1	LT 0.2	LT 0.2	**0.543**	LT 3	LT 0.2	146000	LT 0.00983	LT 1.2	LT 1.6	LT 1.2	LT 0.0198	LT 0.2	LT 0.5
24199	8/17/23	LT 0.2	LT 0.075	LT 0.00605	LT 1	LT 0.2	LT 0.2	LT 0.2	LT 3	LT 0.2	130000	LT 0.00983	LT 1.2	LT 1.6	LT 1.2	LT 0.0198	LT 0.2	LT 0.5
24201	8/16/23	LT 0.2	**0.778**	LT 0.00605	LT 1	LT 0.2	LT 0.2	**2.08**	LT 3	**11.4**	203000	LT 0.00983	LT 1.2	LT 1.6	LT 1.2	0.0635	0.309	2.85
Downgradient Wells																		
23405	8/9/23	LT 0.2	0.11	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	LT 3	LT 0.2	162000	LT 0.00983	—	—	—	LT 0.0194	LT 0.2	4.08
23434	8/9/23	LT 0.2	LT 0.075	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	LT 3	LT 0.2	**685000**	LT 0.00983	—	—	—	LT 0.0194	LT 0.2	1.53
23436	8/9/23	LT 0.2	0.27	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	LT 3	LT 0.2	250000	LT 0.00983	—	—	—	LT 0.0196	LT 0.2	0.853
23438	8/9/23	LT 0.2	**0.371**	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	LT 3	LT 0.2	237000	LT 0.00983	—	—	—	LT 0.0192	LT 0.2	1.43
24004	8/14/23	LT 0.2	LT 0.075	LT 0.00605	1.13	—	LT 0.2	LT 0.2	LT 3	LT 0.2	151000	LT 0.00983	—	—	—	LT 0.0198	LT 0.2	LT 0.5
24006	8/14/23	LT 0.2	**0.621**	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	LT 3	LT 0.2	**270000**	LT 0.00983	—	—	—	LT 0.0194	LT 0.2	LT 0.5
24415	8/10/23	LT 0.2	**0.371**	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	LT 3	LT 0.2	**313000**	LT 0.00983	—	—	—	LT 0.0196	LT 0.2	2.04
24418	8/10/23	LT 0.2	0.174	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	LT 3	LT 0.2	**368000**	LT 0.00983	—	—	—	LT 0.0196	LT 0.2	LT 0.5
24421	8/10/23	LT 0.2	**0.379**	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	LT 3	LT 0.2	**473000**	LT 0.00983	—	—	—	LT 0.0192	LT 0.2	LT 0.5
24424	8/14/23	LT 0.2	0.212	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	LT 3	LT 0.2	**298000**	LT 0.00983	—	—	—	LT 0.0196	LT 0.2	LT 0.5
24429	8/14/23	LT 0.2	**0.632**	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	LT 3	LT 0.2	250000	LT 0.00983	—	—	—	LT 0.0196	LT 0.2	LT 0.5

Notes:

Values shaded and in BOLD are concentrations that exceed the CSRG/PQL.

[1] The value for 1,2-dichloroethylene (12DCE) is the sum of its two isomers, cis-1,2-dichloroethylene (C12DCE) and trans-1,2-dichloroethylene (T12DCE).

[2] Well 24429 is sampled as an alternate well to when downgradient performance well 24207 is dry or there is not enough water to sample.

LT – Nondetection reported less than the method reporting limit

Exhibit B-14. Summary of FY23 NBCS Performance Water Quality Monitoring

Well	Sample Date	Analyte Concentration (ug/L, CSRG/PQL shown in italics)																
		DITH	DLDRN	ENDRN	F	ISODR	MEC6H5	MLTHN	NNDMEA	NNDNPA	OXAT	SO4	TCLEE	TRCLE	XYLEN	12DCE [1]	C12DCE	T12DCE
		18	*0.013*	*2*	*2000*	*0.06*	*1000*	*100*	*0.009*	*0.005*	*160*	*540,000*	*5*	*3*	*1000*	*70*	—	—
Upgradient Wells																		
23119	8/16/23	LT 0.4	**0.579**	0.52	**2760**	**0.199**	LT 0.2	LT 0.2	**0.0349**	**0.789**	LT 0.8	**675000**	0.34	0.45	LT 0.4	ND	LT 0.2	LT 0.2
23160	8/15/23	LT 0.4	**1.12**	0.599	**2480**	0.0501	LT 0.2	LT 0.2	**0.216**	**1.75**	LT 0.8	**715000**	0.396	1.05	LT 0.4	ND	LT 0.2	LT 0.2
23211	8/16/23	LT 0.4	**0.0394**	LT 0.00488	**2440**	LT 0.00619	LT 0.2	LT 0.2	**0.00969**	LT 0.003	LT 0.8	**910000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.2	LT 0.2
24101	8/16/23	1.71	**1.28**	LT 0.00488	**2560**	**0.154**	LT 0.2	LT 0.2	**0.195**	**3.59**	3.01	**670000**	3.34	**4.69**	LT 0.4	1.25	1.25	LT 0.2
24105	8/21/23	LT 0.4	0.00632	LT 0.00488	**2060**	LT 0.00619	LT 0.2	LT 0.2	**0.0101**	LT 0.003	LT 0.8	533000	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.2	LT 0.2
24106	8/21/23	LT 0.4	**0.0192**	LT 0.00488	1990	LT 0.00619	LT 0.2	LT 0.2	0.00746	LT 0.003	LT 0.8	**770000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.2	LT 0.2
24114	8/17/23	LT 0.4	0.0116	LT 0.00488	1690	LT 0.00619	LT 0.2	LT 0.2	LT 0.0048	LT 0.003	LT 0.8	207000	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.2	LT 0.2
24117	8/21/23	LT 0.4	**0.0175**	0.00776	1260	LT 0.00619	LT 0.2	LT 0.2	LT 0.0048	LT 0.003	LT 0.8	538000	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.2	LT 0.2
24185	8/17/23	LT 0.4	**0.0202**	LT 0.00488	1130	LT 0.00619	LT 0.2	LT 0.2	LT 0.0048	LT 0.003	LT 0.8	345000	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.2	LT 0.2
24199	8/17/23	LT 0.4	0.0117	LT 0.00488	1020	LT 0.00619	LT 0.2	LT 0.2	LT 0.0048	LT 0.003	LT 0.8	304000	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.2	LT 0.2
24201	8/16/23	LT 0.4	**0.839**	0.554	**2560**	0.019	LT 0.2	LT 0.2	**0.0307**	**0.549**	LT 0.8	**830000**	2.2	0.775	LT 0.4	ND	LT 0.2	LT 0.2
Downgradient Wells																		
23405	8/9/23	—	**0.0407**	LT 0.00488	478	LT 0.00619	LT 0.2	—	0.00862	LT 0.003	—	438000	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.2	LT 0.2
23434	8/9/23	—	**0.0157**	0.00659	1510	0.00973	LT 0.2	—	LT 0.0048	LT 0.003	—	**1450000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.2	LT 0.2
23436	8/9/23	—	0.0129	LT 0.00488	**2340**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	453000	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.2	LT 0.2
23438	8/9/23	—	0.00727	LT 0.00488	1370	LT 0.00619	LT 0.2	—	0.00839	LT 0.003	—	434000	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.2	LT 0.2
24004	8/14/23	—	0.0108	LT 0.00488	1150	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	181000	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.2	LT 0.2
24006	8/14/23	—	0.0107	0.00546	1800	LT 0.00619	LT 0.2	—	**0.0107**	LT 0.003	—	513000	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.2	LT 0.2
24415	8/10/23	—	**0.0934**	0.0484	1520	LT 0.00619	LT 0.2	—	**0.0112**	LT 0.003	—	**670000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.2	LT 0.2
24418	8/10/23	—	**0.089**	0.0454	**2080**	LT 0.00619	LT 0.2	—	0.00894	LT 0.003	—	**743000**	0.226	LT 0.2	LT 0.4	ND	LT 0.2	LT 0.2
24421	8/10/23	—	**0.0364**	0.02	1990	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	**880000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.2	LT 0.2
24424	8/14/23	—	**0.0147**	LT 0.00488	1570	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	449000	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.2	LT 0.2
24429	8/14/23	—	**0.0245**	0.0174	1570	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	485000	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.2	LT 0.2

Notes:

Values shaded and in BOLD are concentrations that exceed the CSRG/PQL.

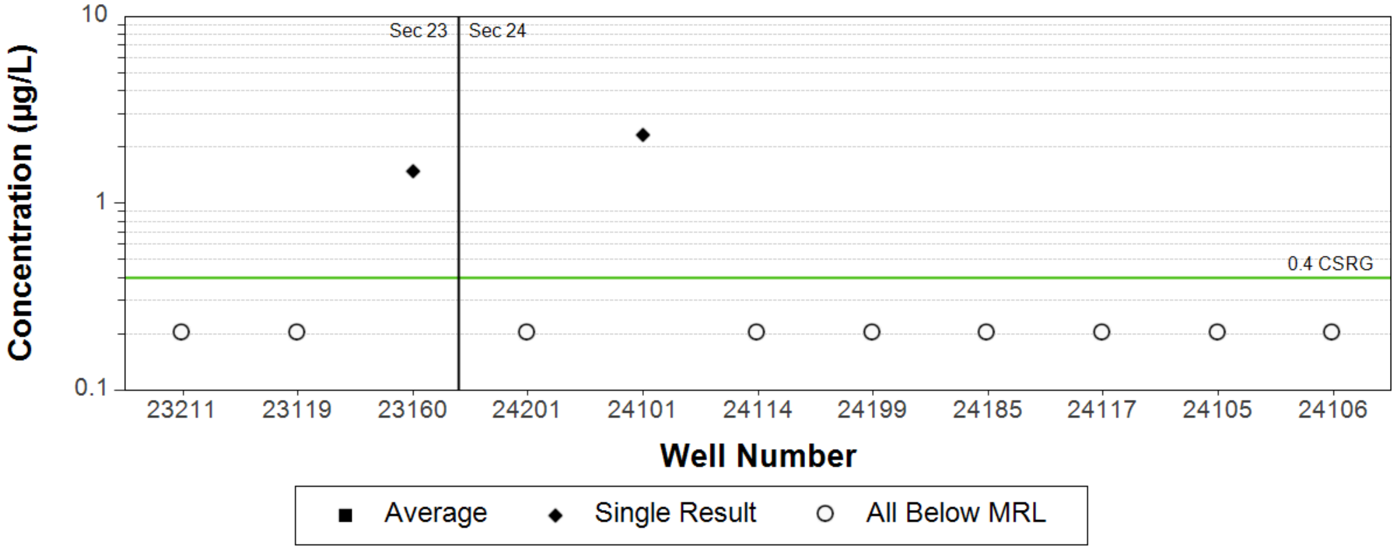
[1] The value for 1,2-dichloroethylene (12DCE) is the sum of its two isomers, cis-1,2-dichloroethylene (C12DCE) and trans-1,2-dichloroethylene (T12DCE).

[2] Well 24429 is sampled as an alternate well to when downgradient performance well 24207 is dry or there is not enough water to sample.

LT – Nondetection reported less than the method reporting limit

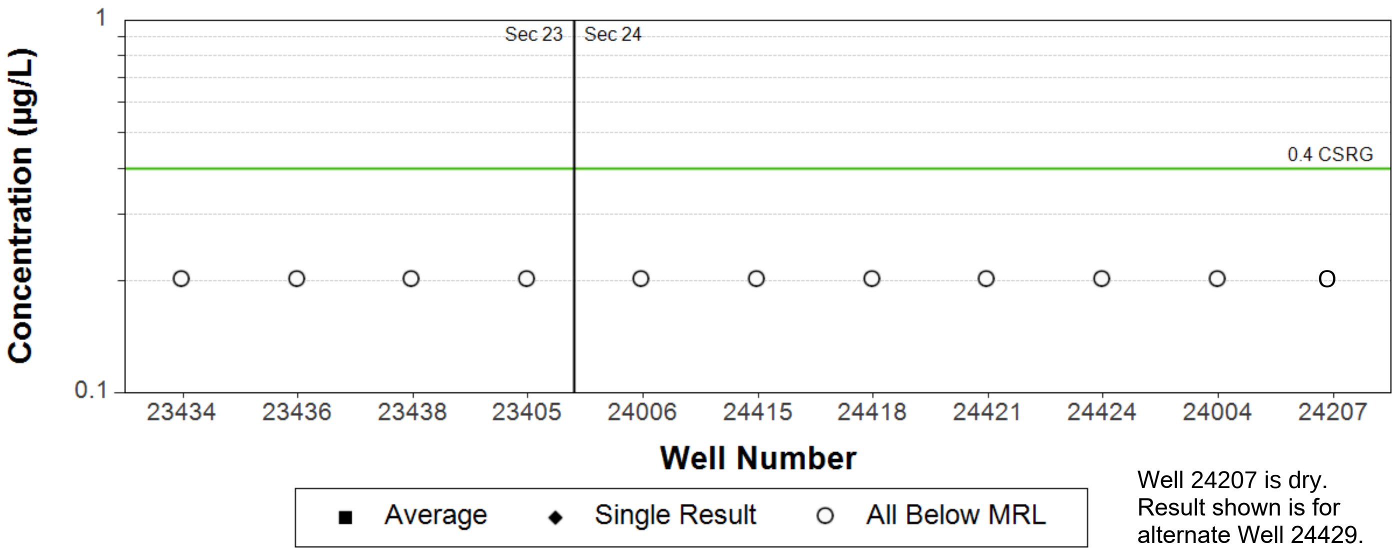
North Boundary Upgradient Performance Wells - 12DCLE

2022-10-01 to 2023-09-30

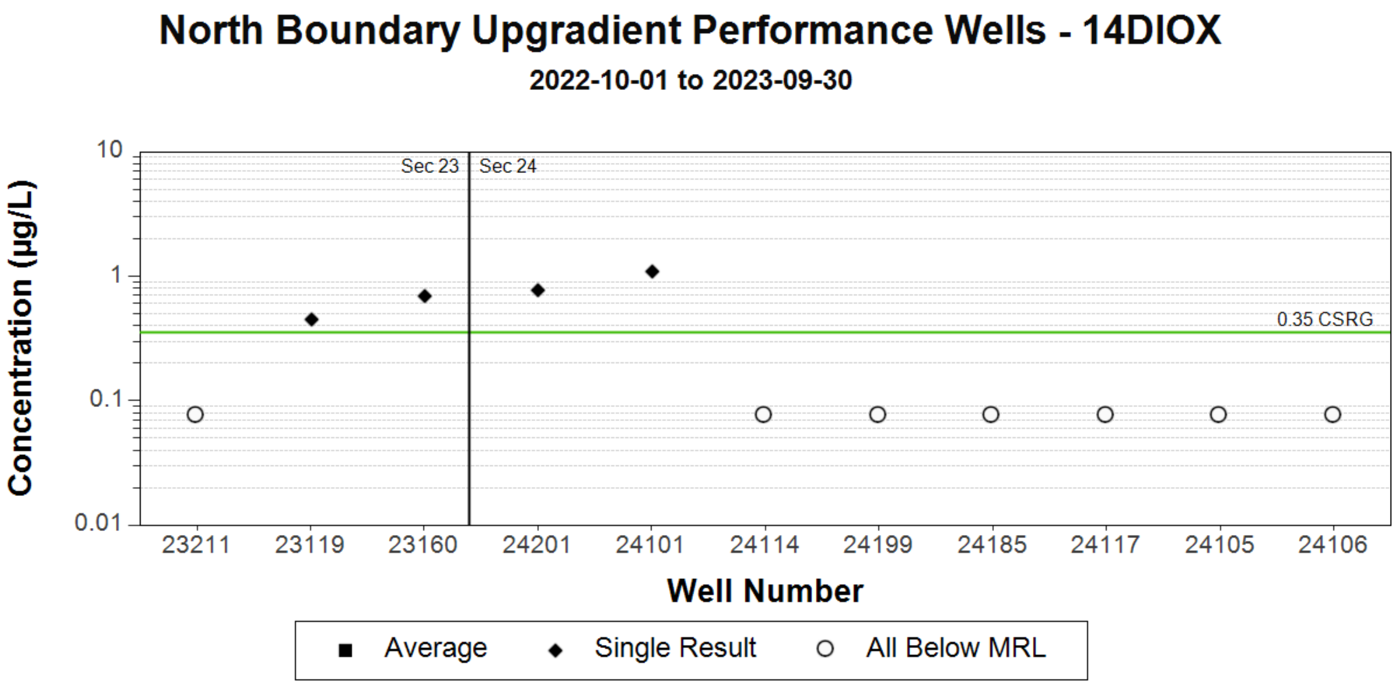


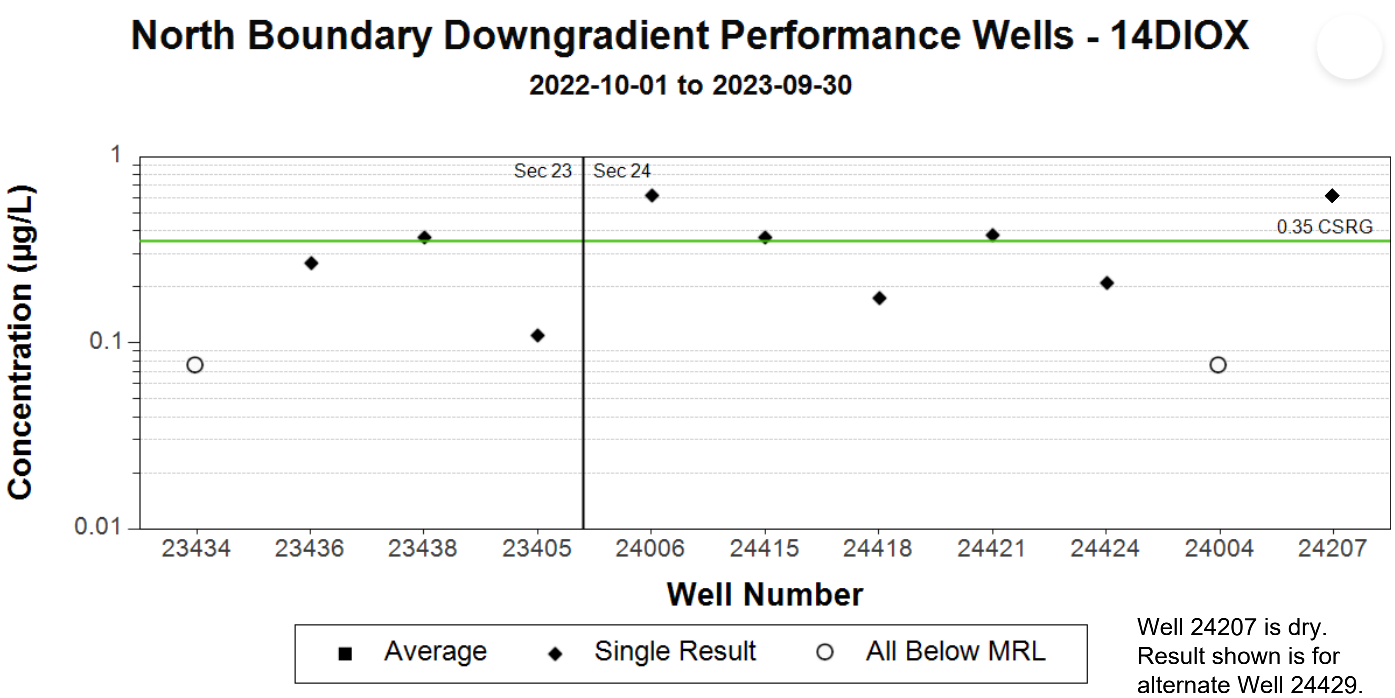
North Boundary Downgradient Performance Wells - 12DCLE

2022-10-01 to 2023-09-30

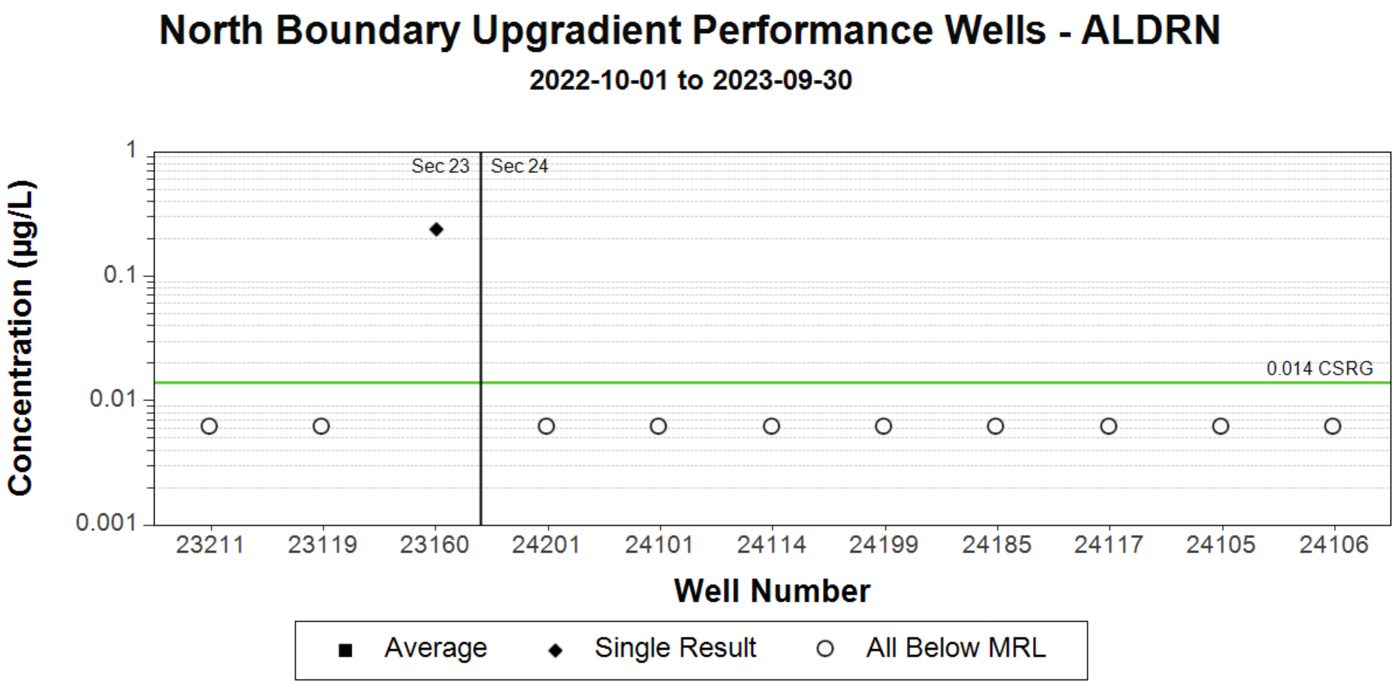


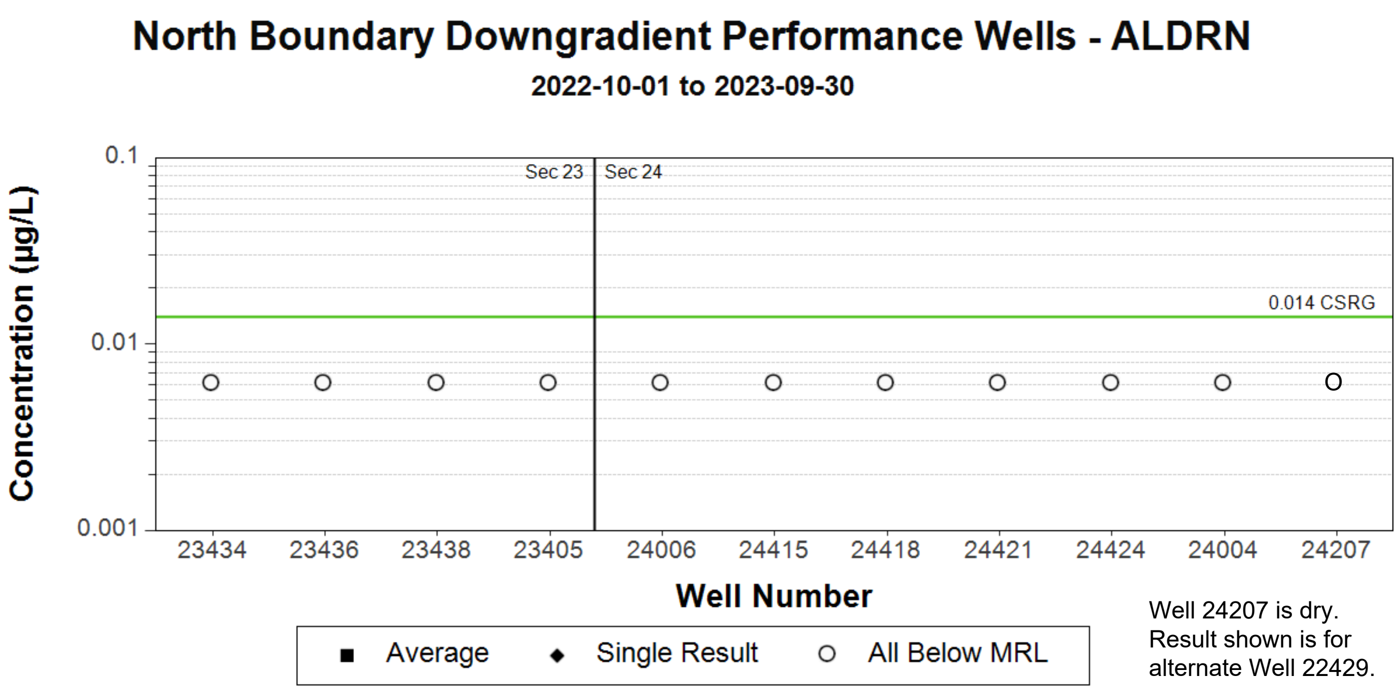
Well 24207 is dry. Result shown is for alternate Well 24429.

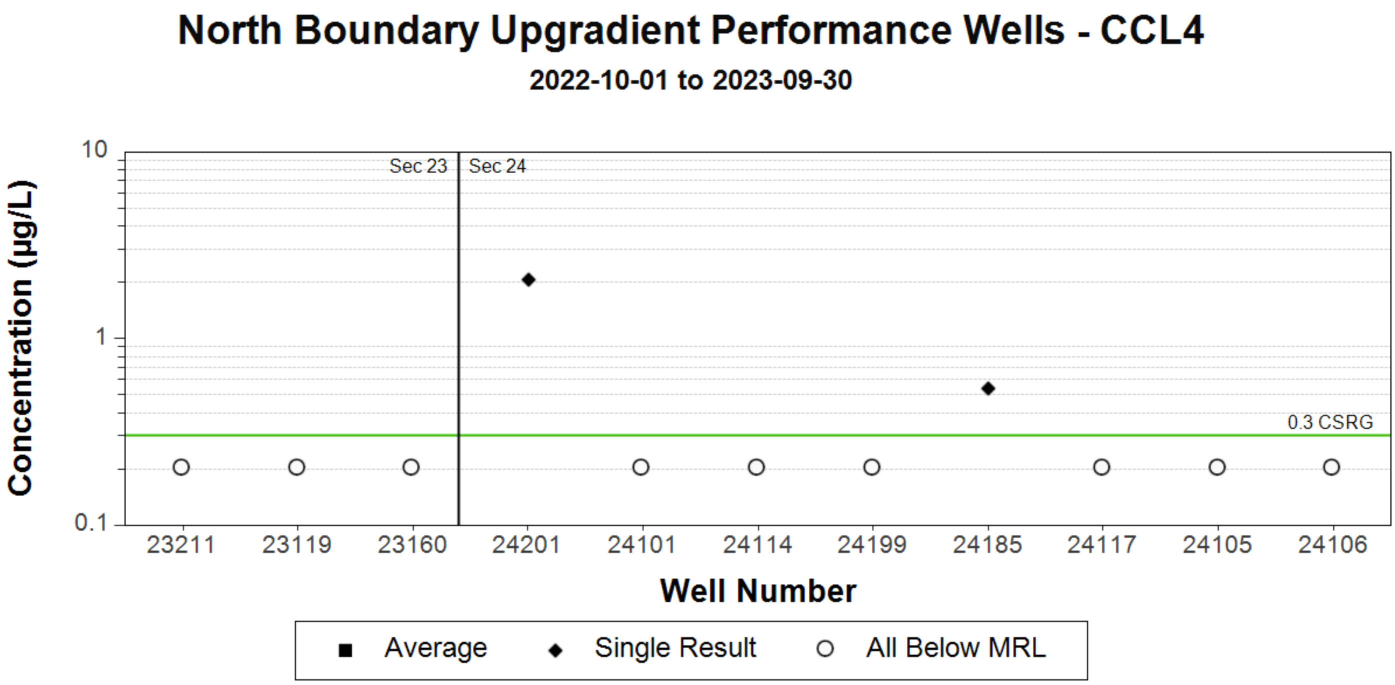


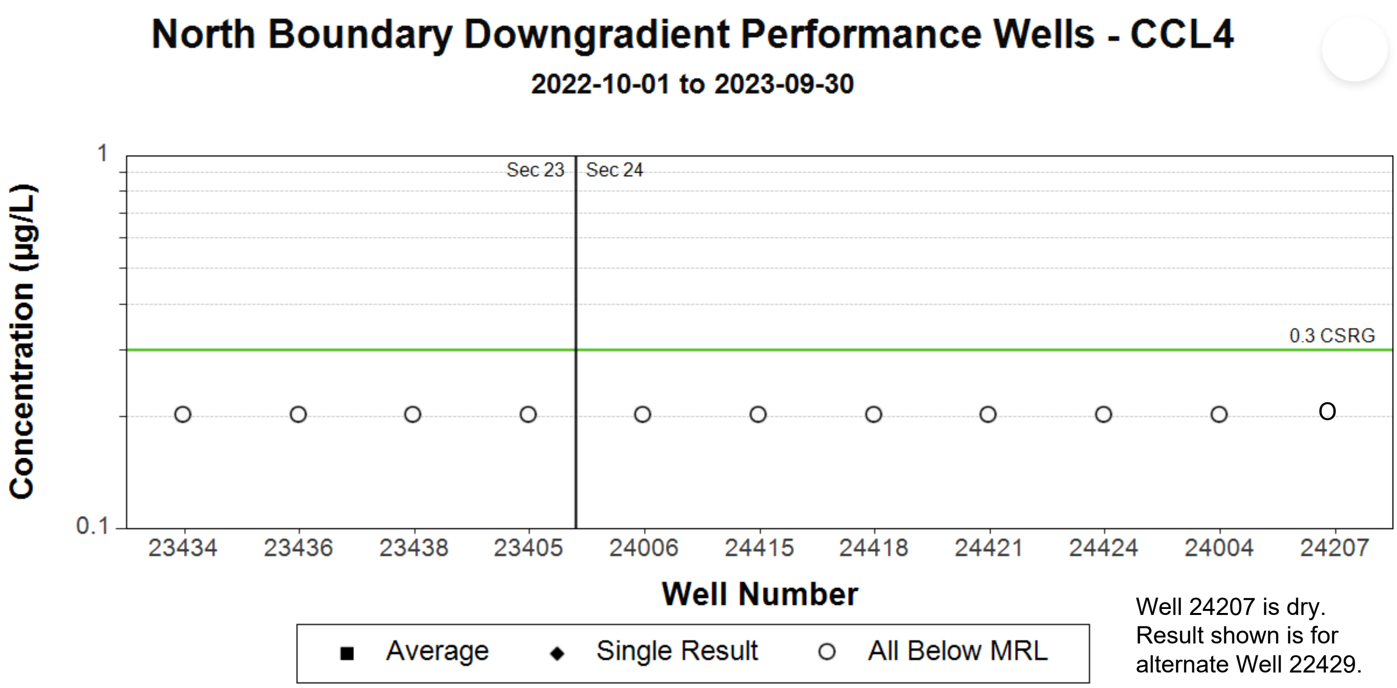


Well 24207 is dry. Result shown is for alternate Well 24429.

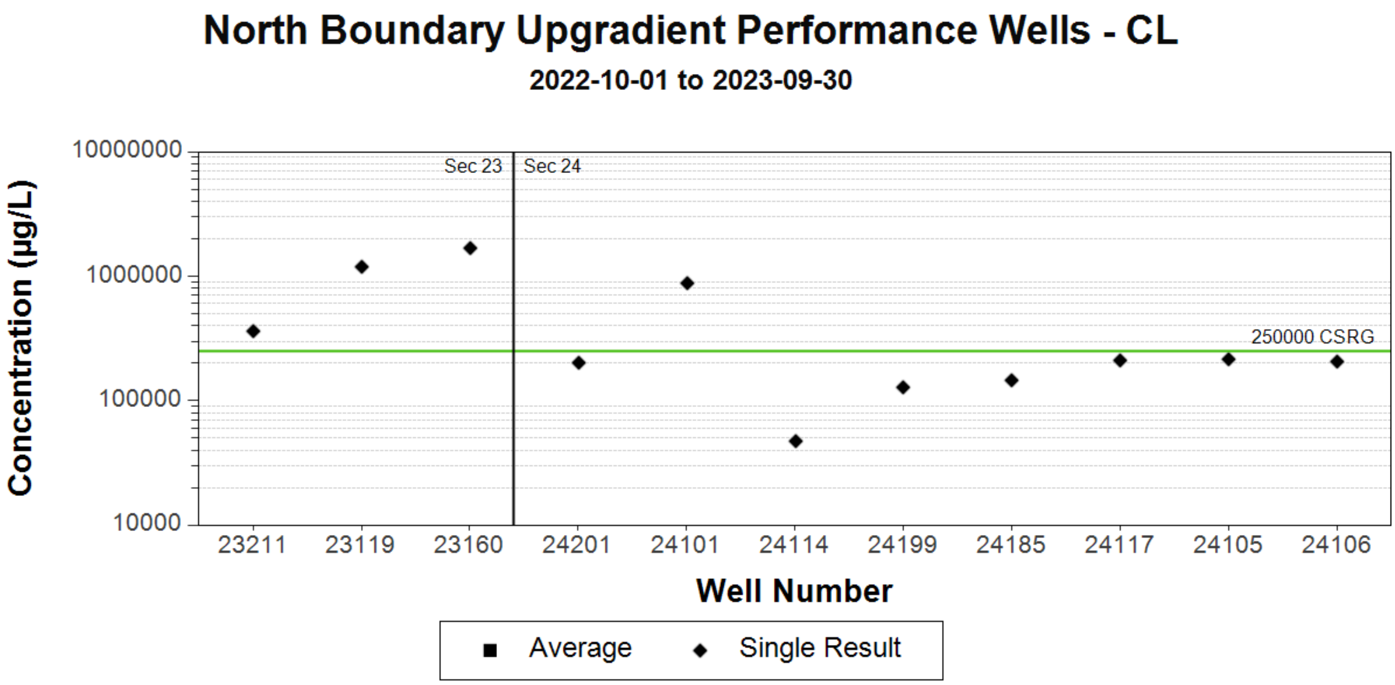

North Boundary Upgradient Performance Wells - ALDRN
2022-10-01 to 2023-09-30
Concentration (µg/L)
1
0.1
0.01
0.001
Sec 23
Sec 24
0.014 CSRG
23211
23119
23160
24201
24101
24114
24199
24185
24117
24105
24106
Well Number
Average
Single Result
All Below MRL


North Boundary Downgradient Performance Wells - ALDRN
2022-10-01 to 2023-09-30
Concentration (µg/L)
0.1
0.01
0.001
Sec 23
Sec 24
0.014 CSRG
23434
23436
23438
23405
24006
24415
24418
24421
24424
24004
24207
Well Number
Average
Single Result
All Below MRL
Well 24207 is dry.
Result shown is for
alternate Well 22429.

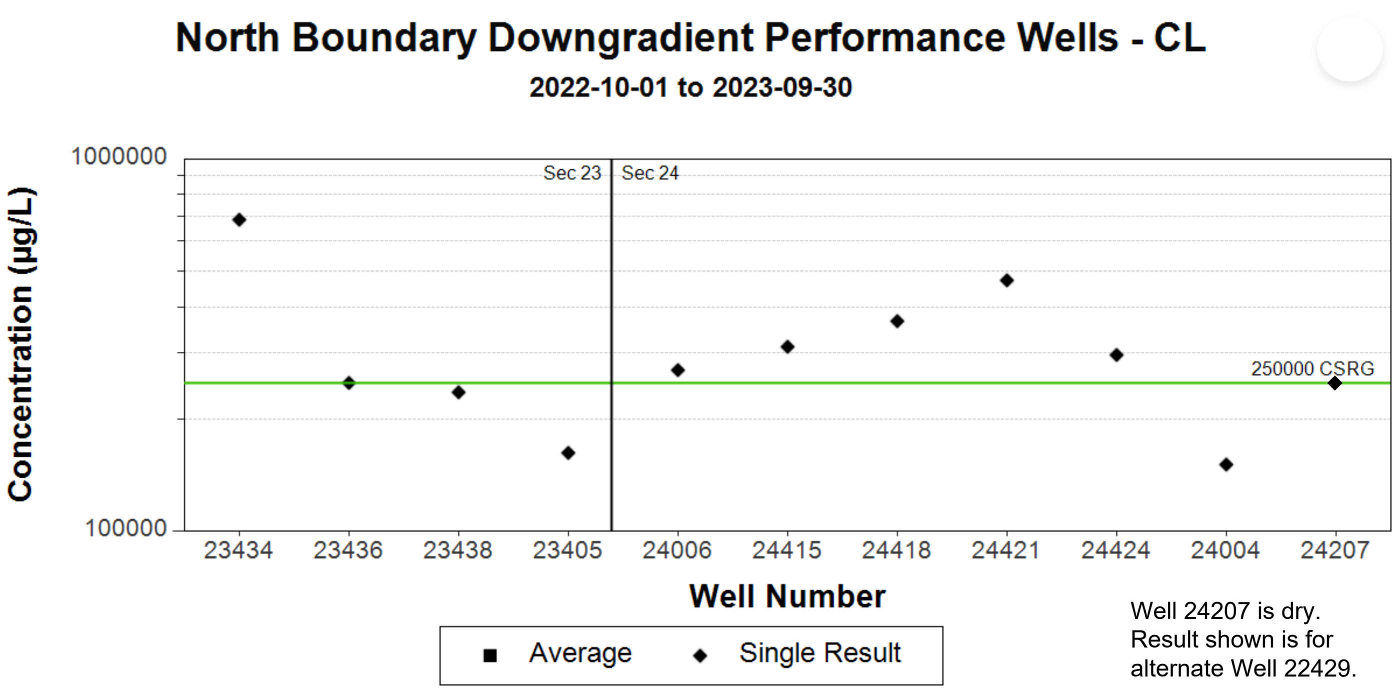




Well 24207 is dry.
Result shown is for
alternate Well 22429.



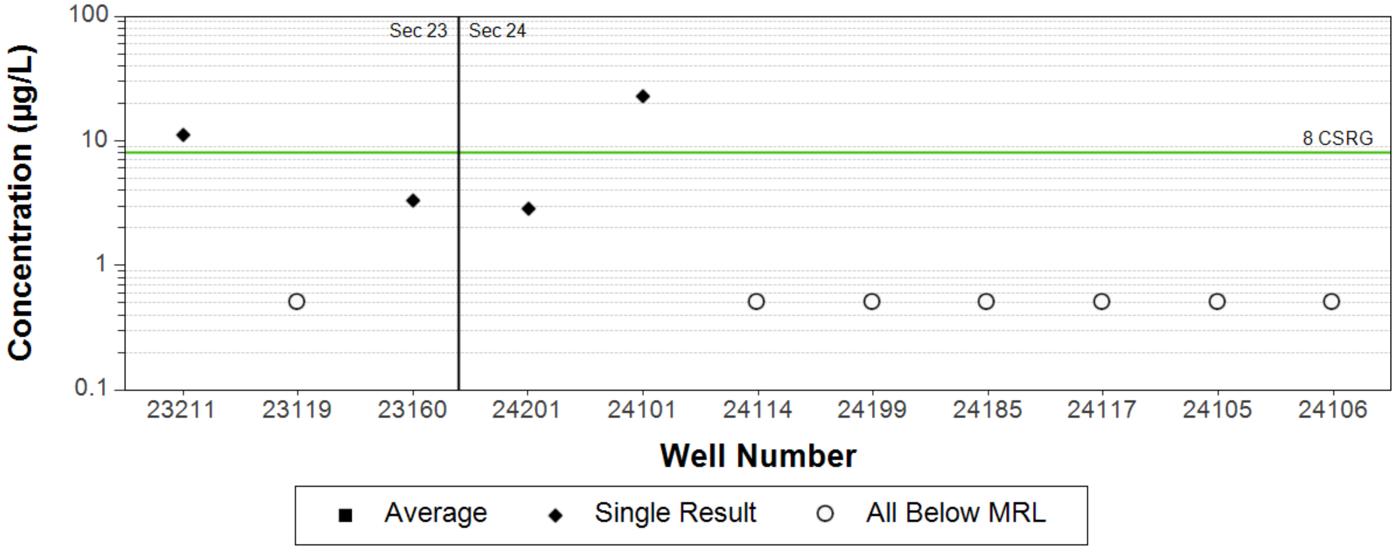
North Boundary Upgradient Performance Wells - CL
2022-10-01 to 2023-09-30
Concentration (µg/L)
10000000
1000000
100000
10000
Sec 23
Sec 24
250000 CSRG
23211
23119
23160
24201
24101
24114
24199
24185
24117
24105
24106
Well Number
Average
Single Result



North Boundary Downgradient Performance Wells - CL
2022-10-01 to 2023-09-30
Concentration (µg/L)
1000000
100000
Sec 23
Sec 24
250000 CSRG
23434
23436
23438
23405
24006
24415
24418
24421
24424
24004
24207
Well Number
Average
Single Result
Well 24207 is dry.
Result shown is for
alternate Well 22429.

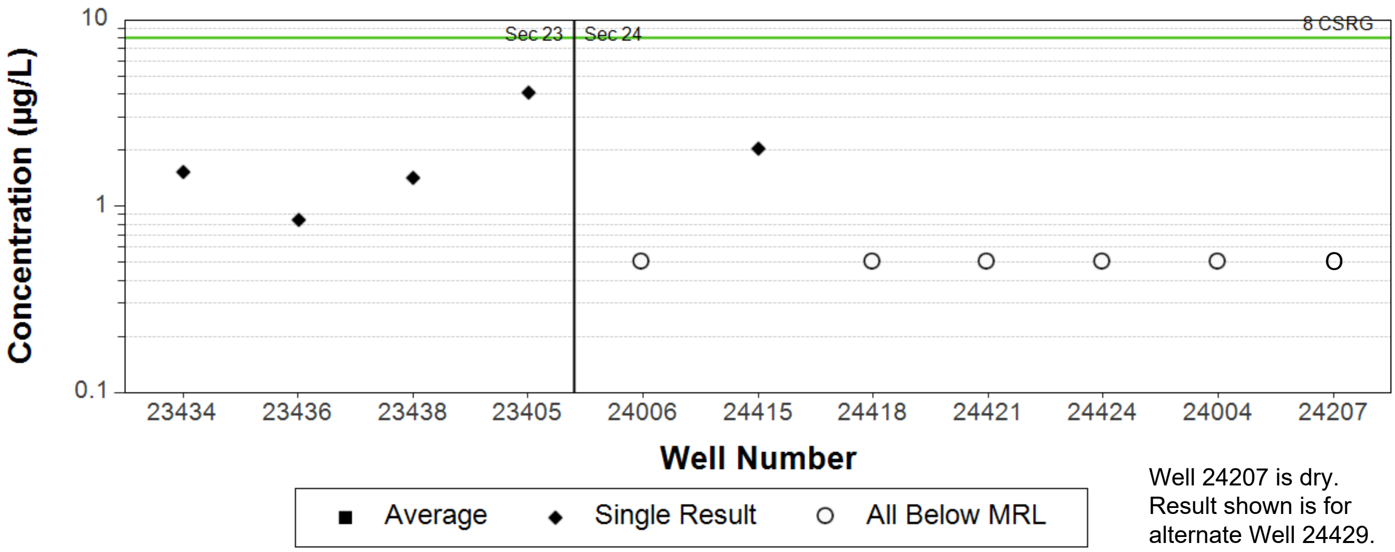
North Boundary Upgradient Performance Wells - DIMP

2022-10-01 to 2023-09-30

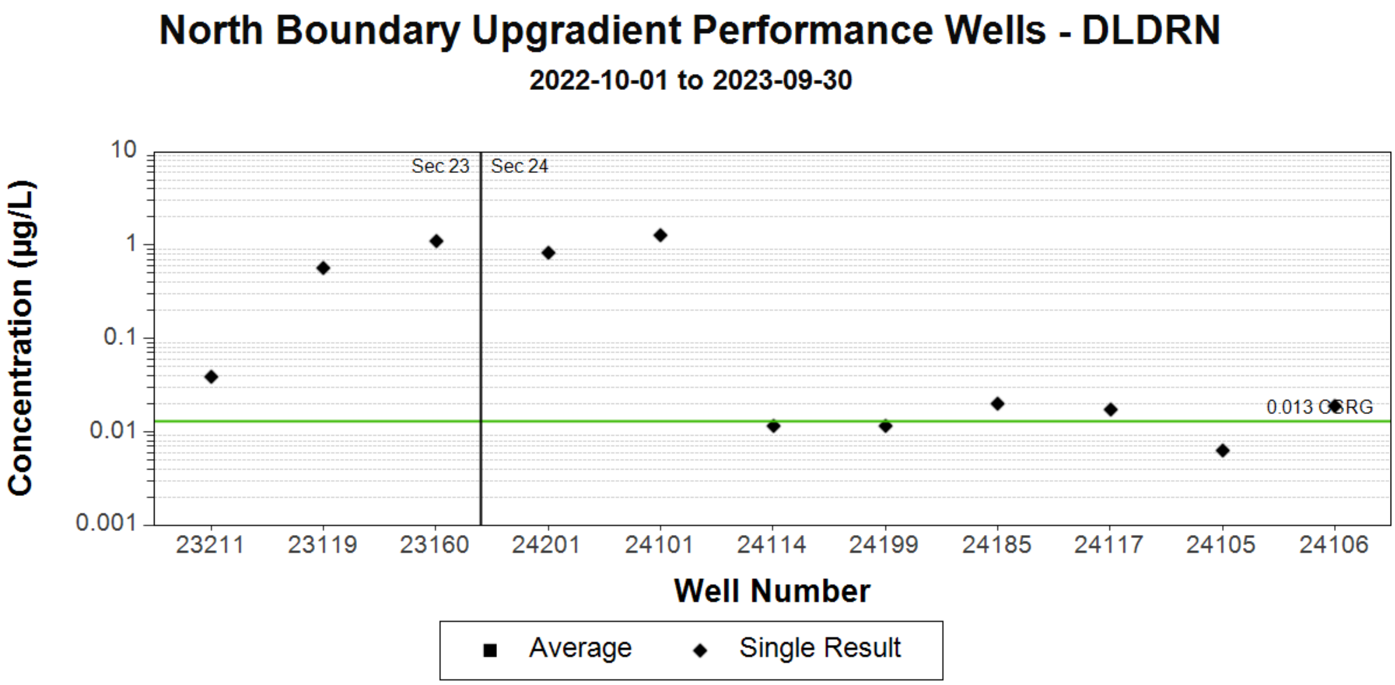


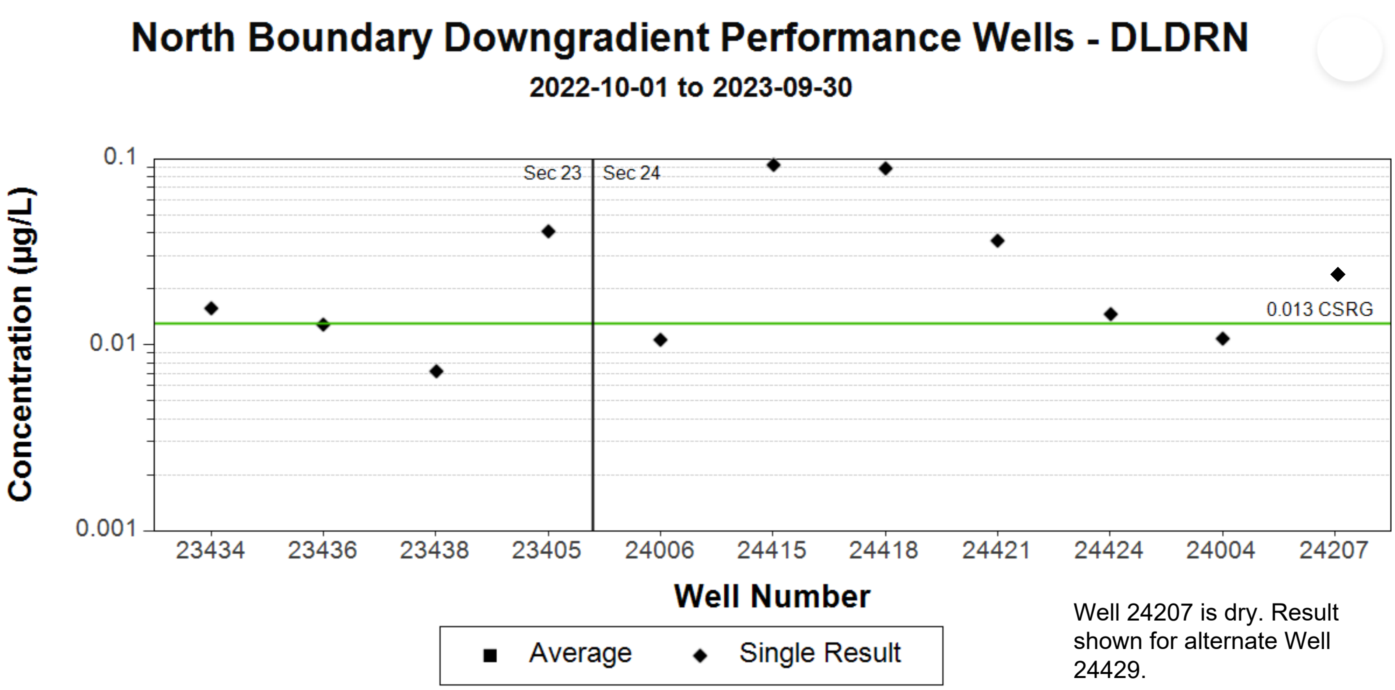
North Boundary Downgradient Performance Wells - DIMP

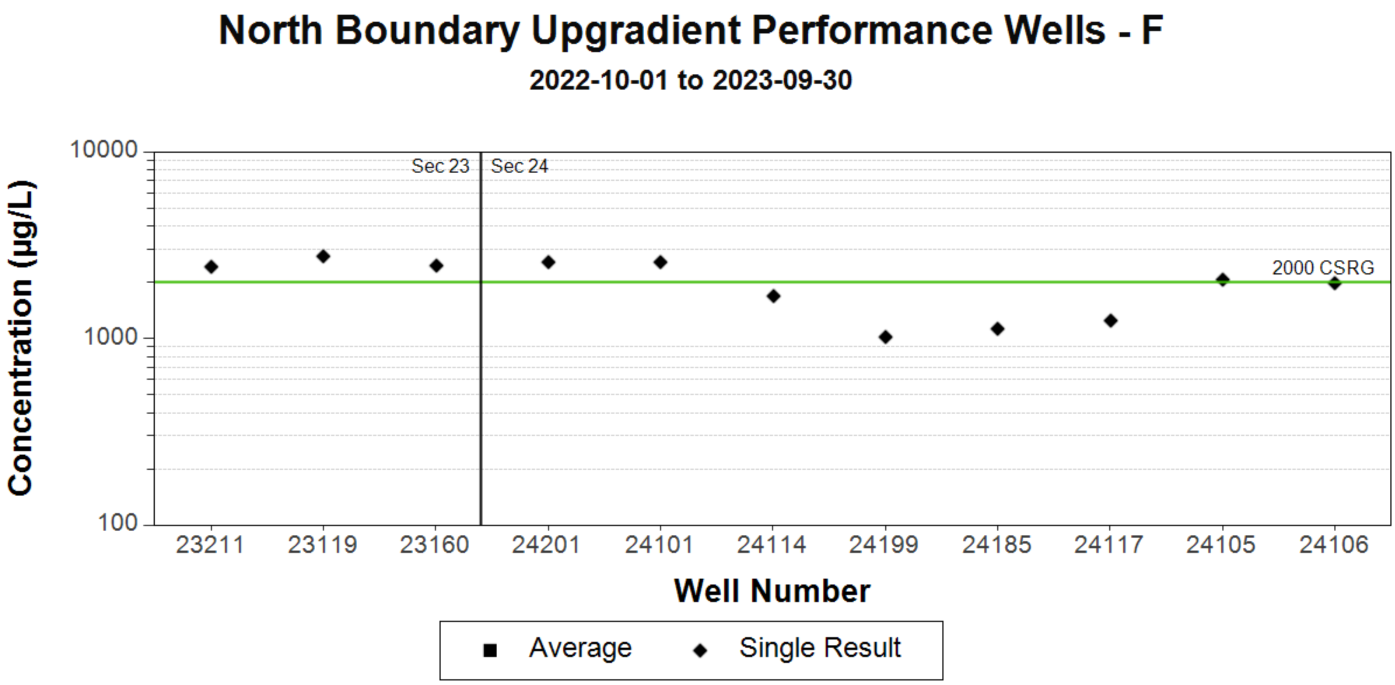
2022-10-01 to 2023-09-30

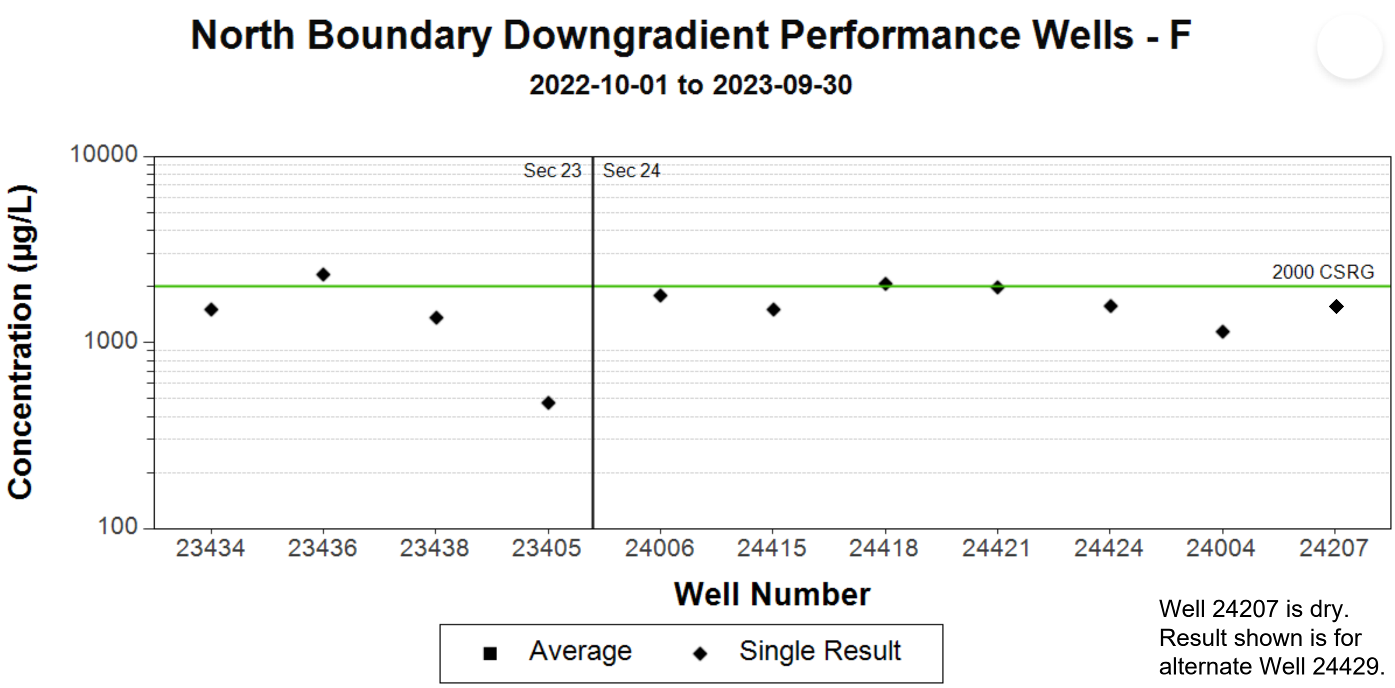


Well 24207 is dry.
Result shown is for
alternate Well 24429.

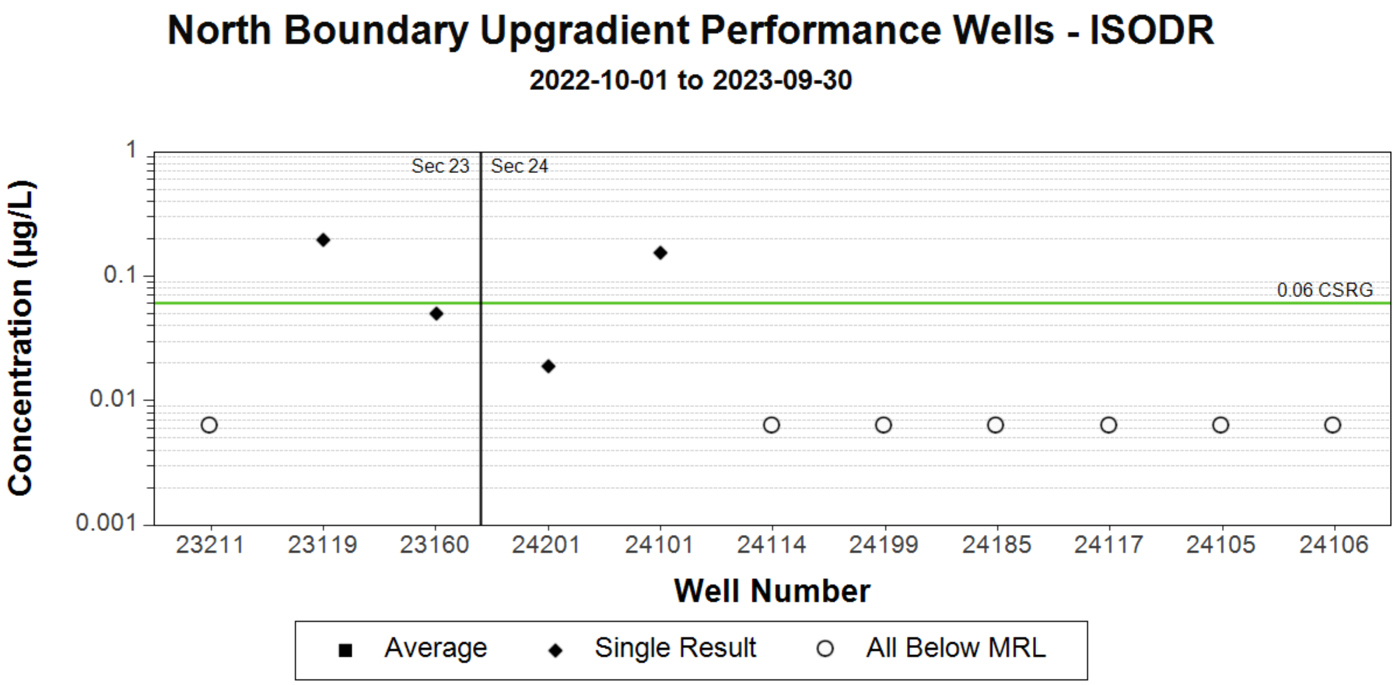

North Boundary Upgradient Performance Wells - DLDRN
2022-10-01 to 2023-09-30
Concentration (µg/L)
10
1
0.1
0.01
0.001
Sec 23
Sec 24
0.013 CSRG
23211
23119
23160
24201
24101
24114
24199
24185
24117
24105
24106
Well Number
Average
Single Result

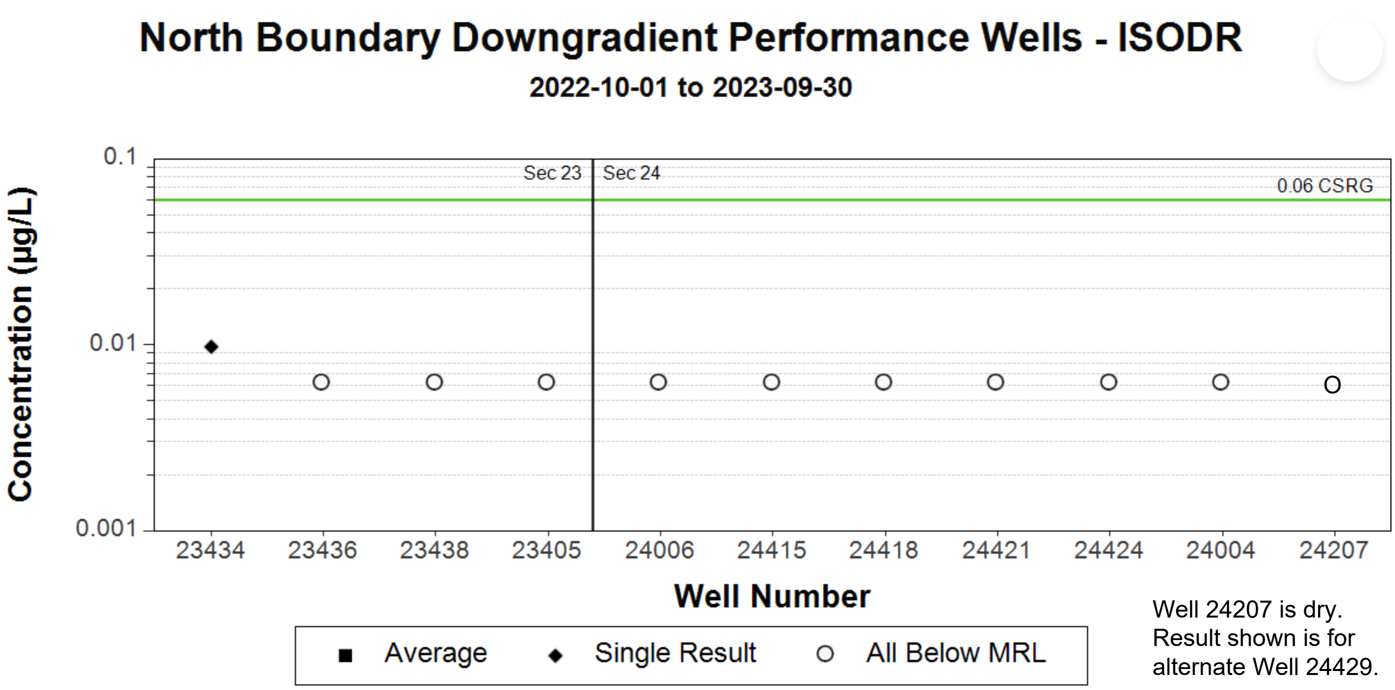

North Boundary Downgradient Performance Wells - DLDRN
2022-10-01 to 2023-09-30
Concentration (µg/L)
0.1
0.01
0.001
Sec 23
Sec 24
0.013 CSRG
23434
23436
23438
23405
24006
24415
24418
24421
24424
24004
24207
Well Number
Average
Single Result
Well 24207 is dry. Result shown for alternate Well 24429.



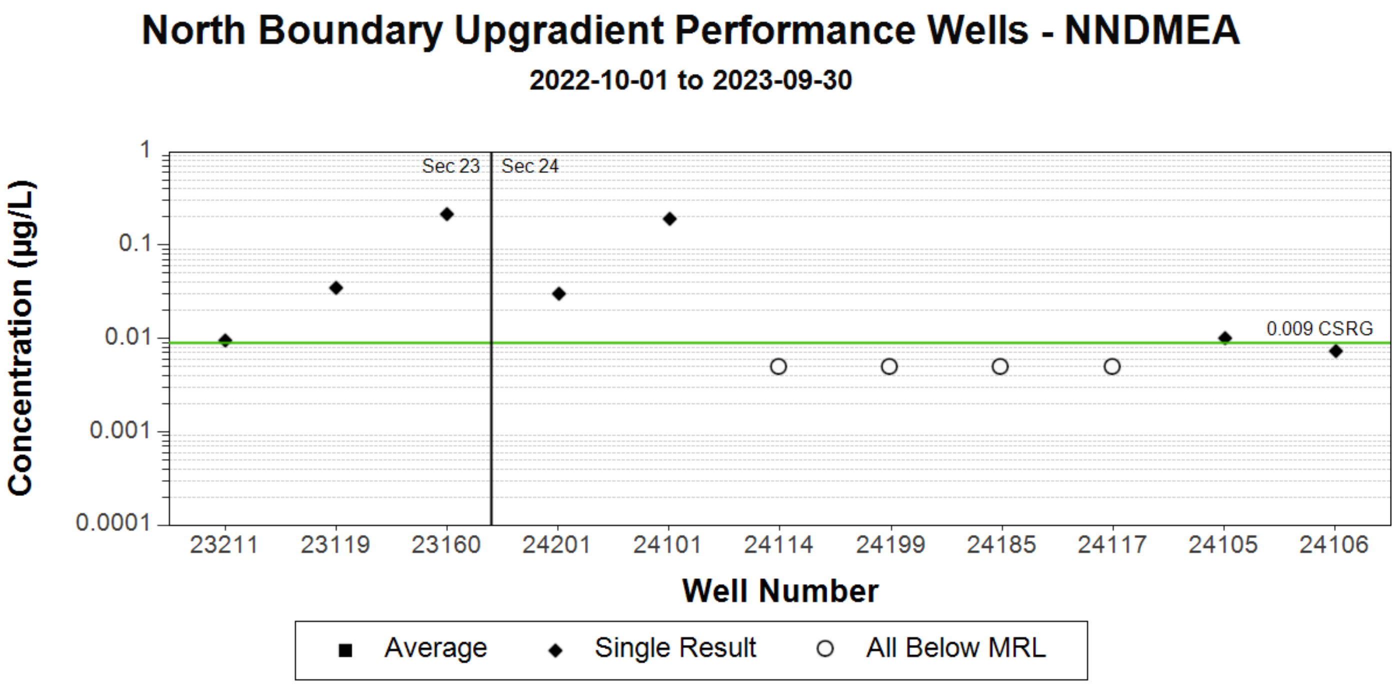


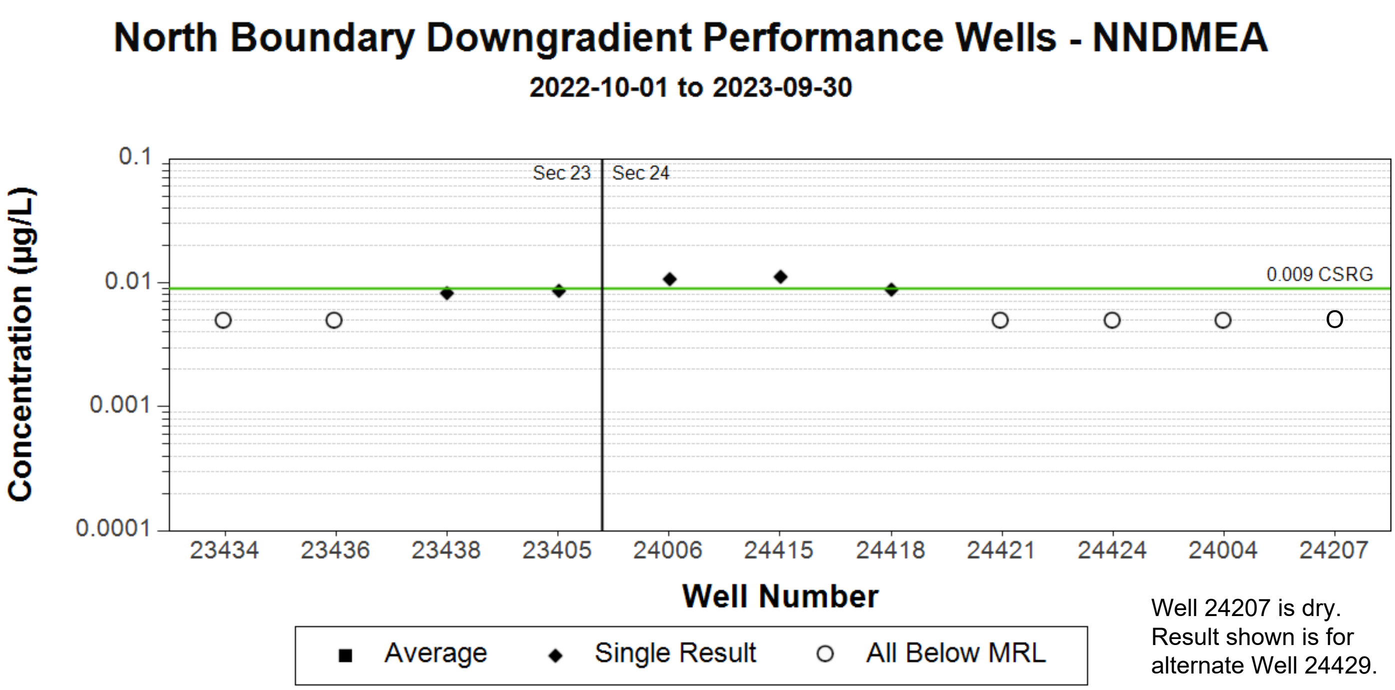
Well 24207 is dry. Result shown is for alternate Well 24429.

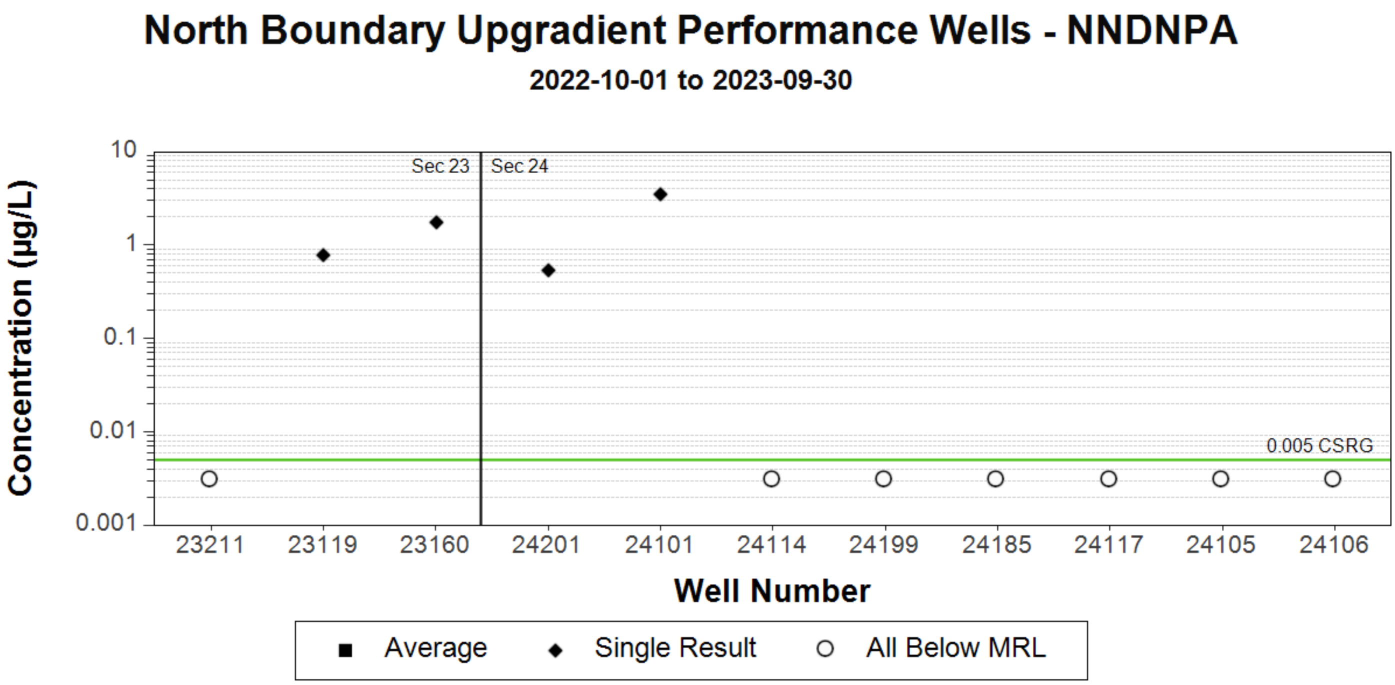


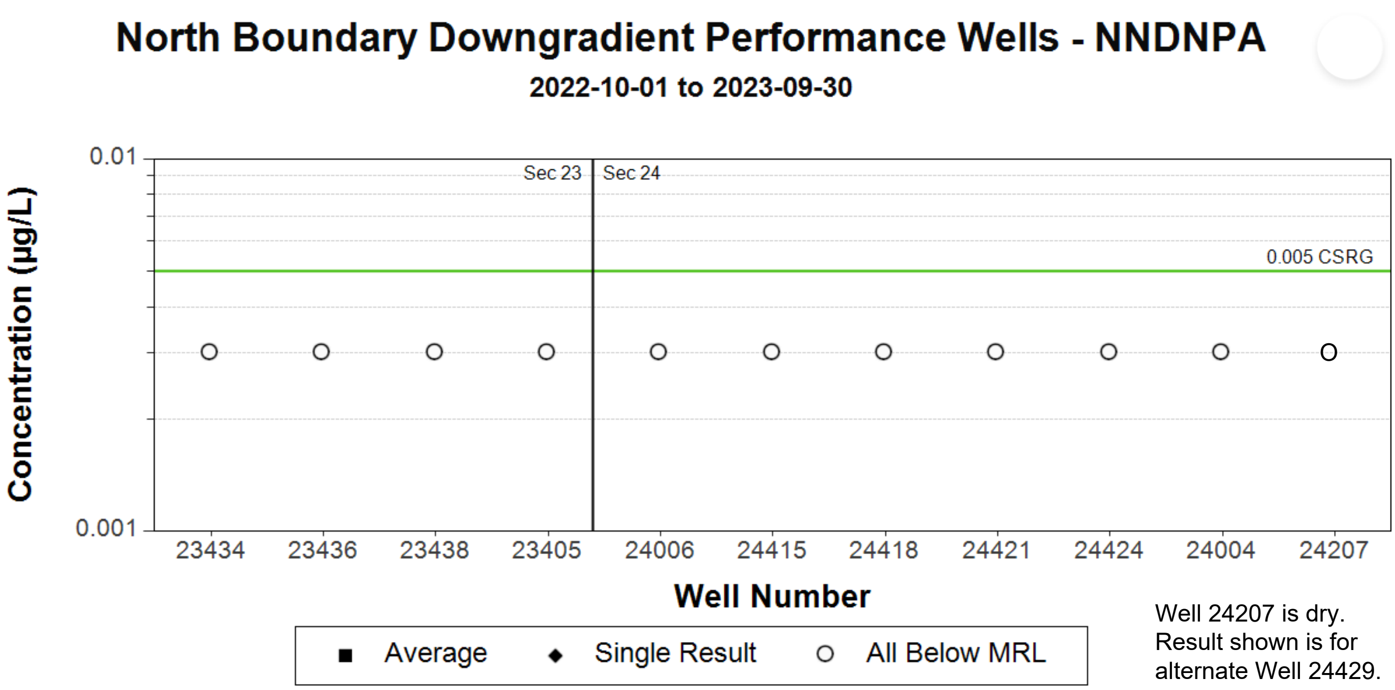


Well 24207 is dry.
Result shown is for
alternate Well 24429.

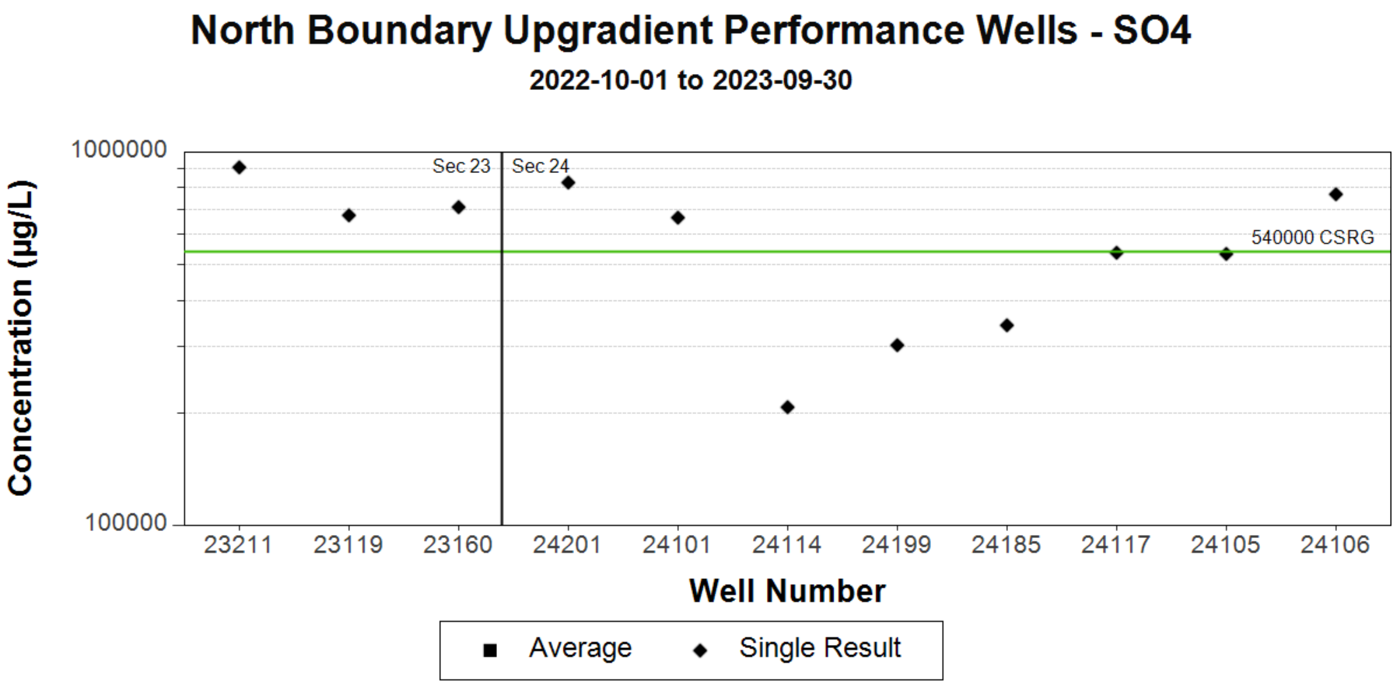

North Boundary Upgradient Performance Wells - NNDMEA
2022-10-01 to 2023-09-30
Concentration (µg/L)
1
0.1
0.01
0.001
0.0001
Sec 23
Sec 24
0.009 CSRG
23211
23119
23160
24201
24101
24114
24199
24185
24117
24105
24106
Well Number
Average
Single Result
All Below MRL

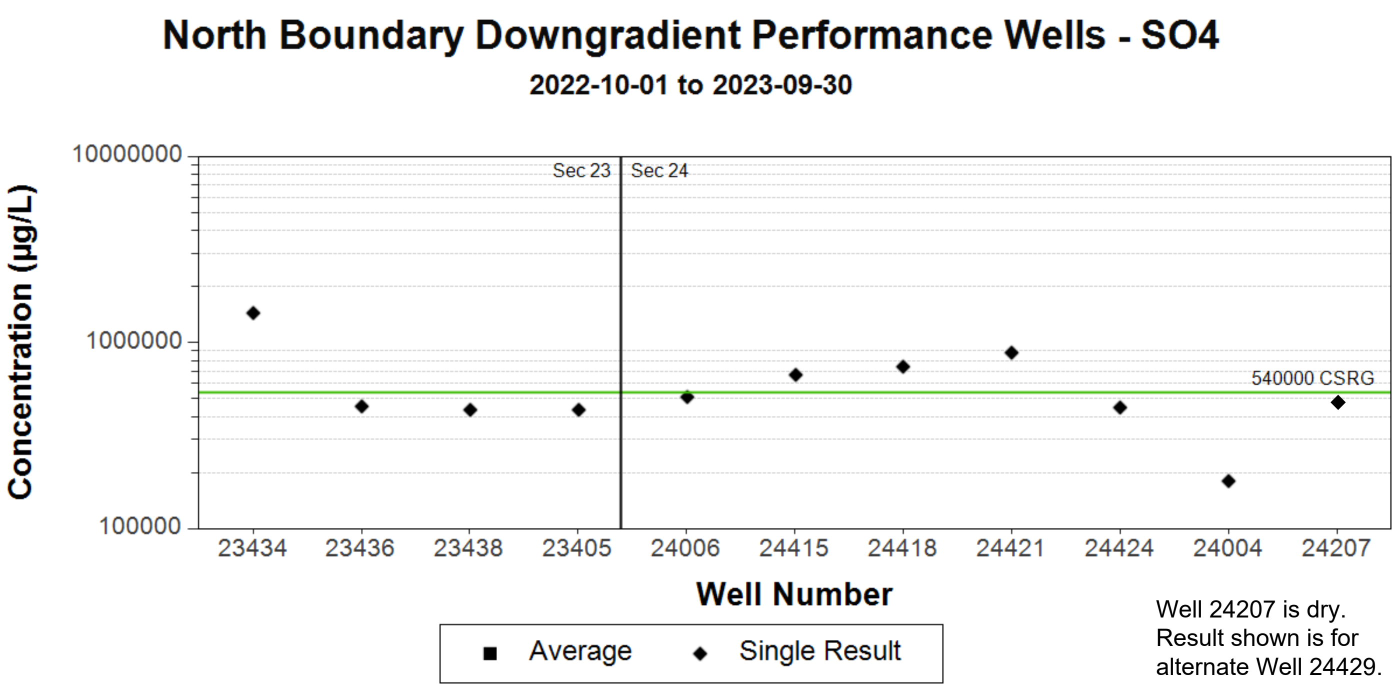

North Boundary Downgradient Performance Wells - NNDMEA
2022-10-01 to 2023-09-30
Concentration (µg/L)
0.1
0.01
0.001
0.0001
Sec 23
Sec 24
0.009 CSRG
23434
23436
23438
23405
24006
24415
24418
24421
24424
24004
24207
Well Number
Average
Single Result
All Below MRL
Well 24207 is dry.
Result shown is for
alternate Well 24429.



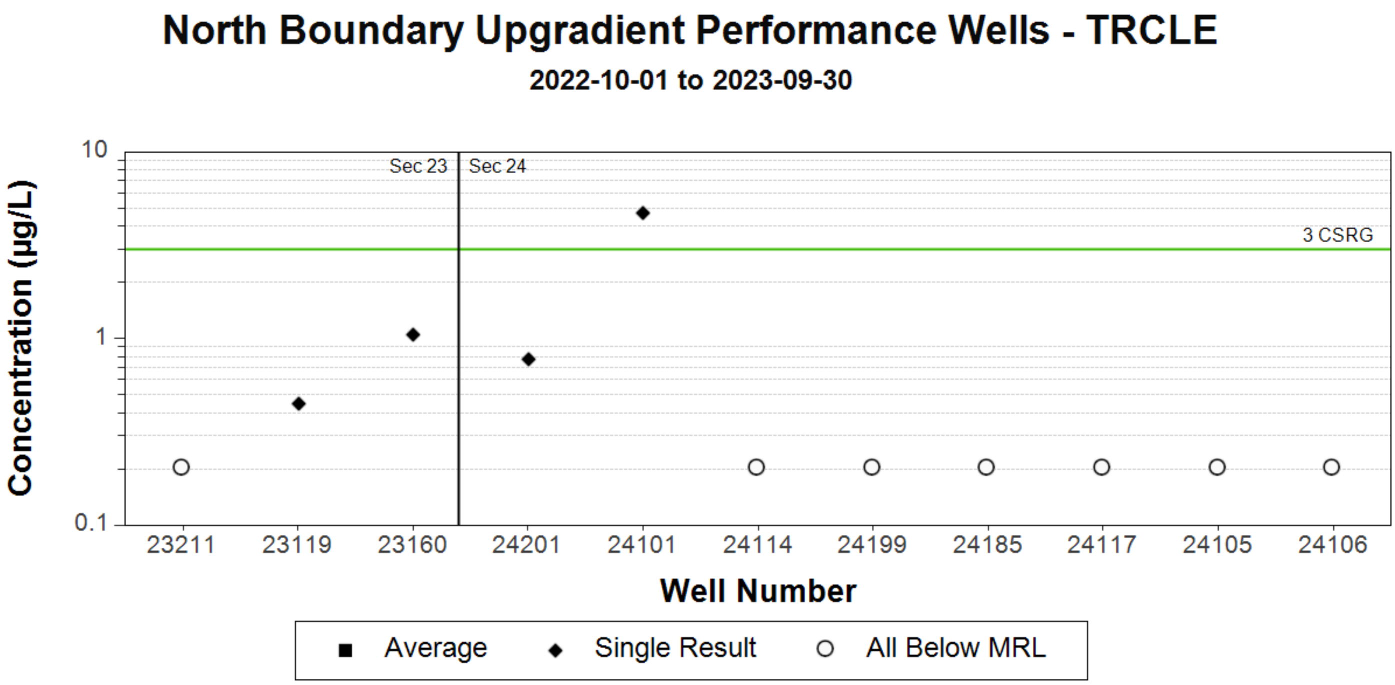


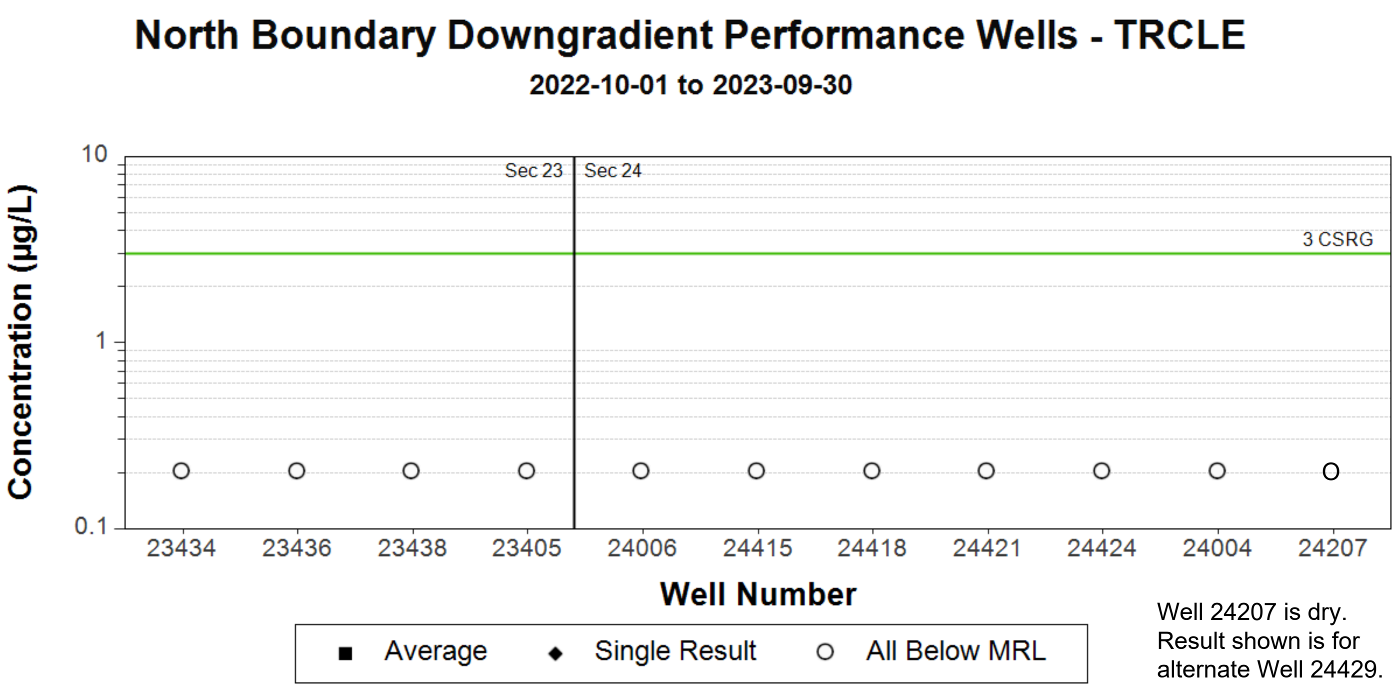
Well 24207 is dry.
Result shown is for alternate Well 24429.



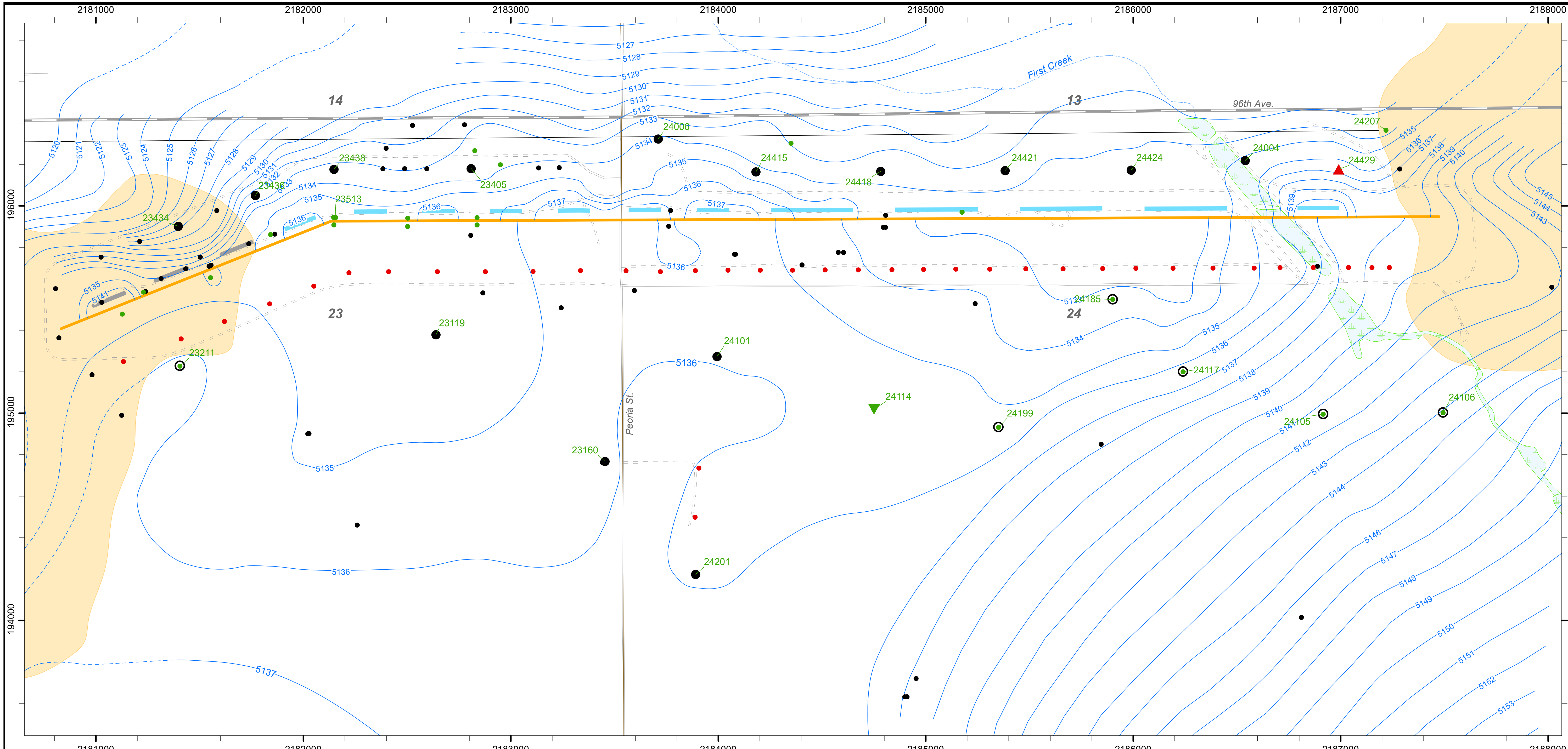


Well 24207 is dry.
Result shown is for
alternate Well 24429.





Well 24207 is dry.
Result shown is for
alternate Well 24429.



Legend

- Unsaturated Alluvium
- Section Lines
- Water elevation contour - 1-foot interval
- Inferred water elevation contour
- Wetlands
- Intermittent Streams
- Ditches
- Slurry Walls
- Recharge Trenches
- Inactive Recharge Trenches
- Unimproved Roads
- Local Roads
- Secondary Roads
- Primary Roads
- Monitoring Wells
- Performance Water Quality Wells
- Extraction Wells

Notes: Water levels were measured in FY23 Quarter 2.

Upgradient and Downgradient Performance Well Water Quality

- Analyte Detected Above the CSRG - Increasing Trend Noted
- Analyte Detected Above the CSRG - Decreasing Trend Noted
- Analyte Detected - Showing Stable or No Discernible Trend
- Analyte Not Detected

Notes:
1. Trends are depicted for the 10 year period FY14 - FY23.
2. Time versus concentration charts for Performance Water Quality wells are presented following this map.

N

0 250 500 Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

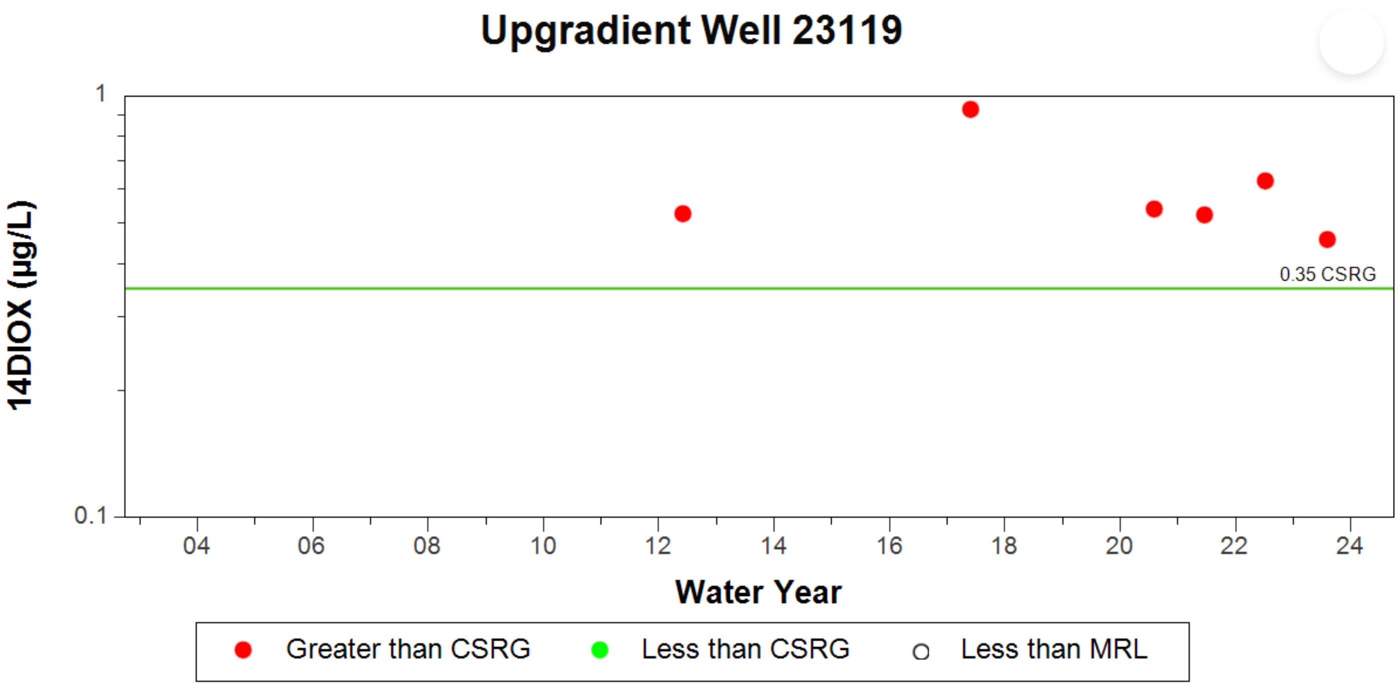
Program Manager
Rocky Mountain Arsenal

U.S. Army • COMMITTED TO PROTECTION OF THE ENVIRONMENT •

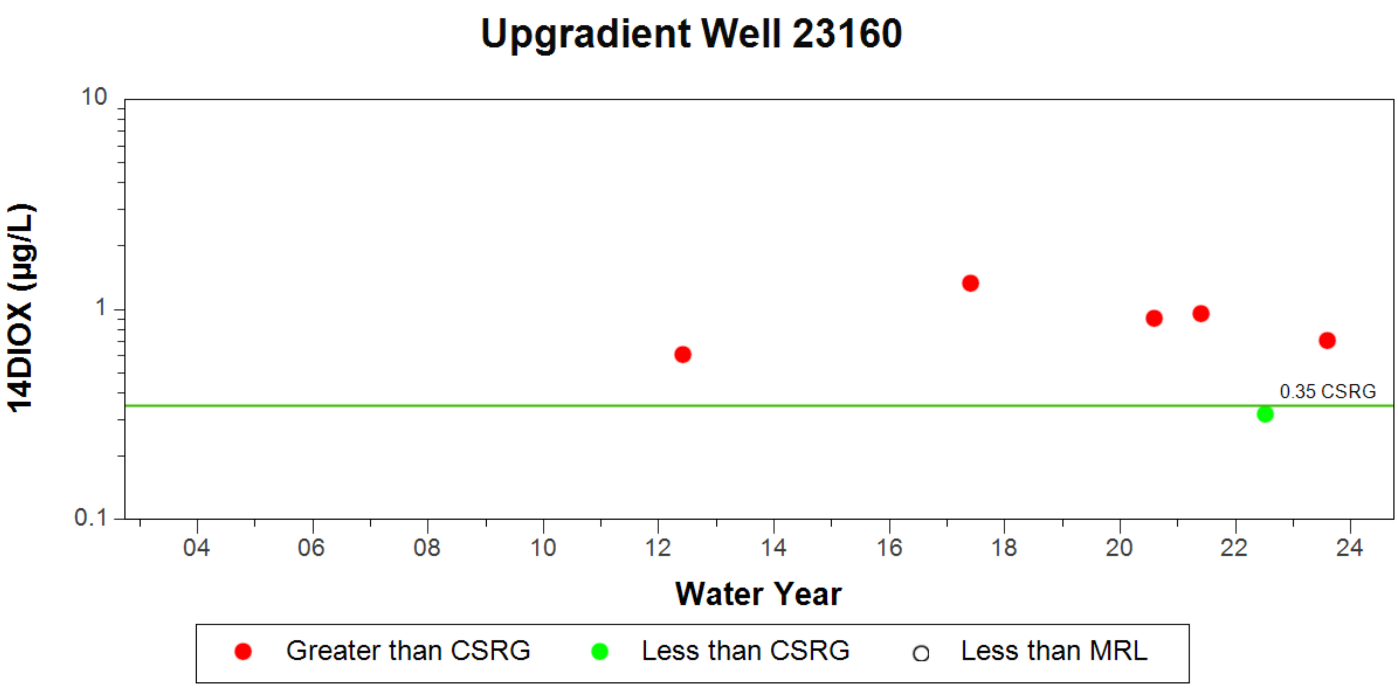
Figure B-28

1,4-Dioxane Concentration Trends in Performance Wells, North Boundary Containment System

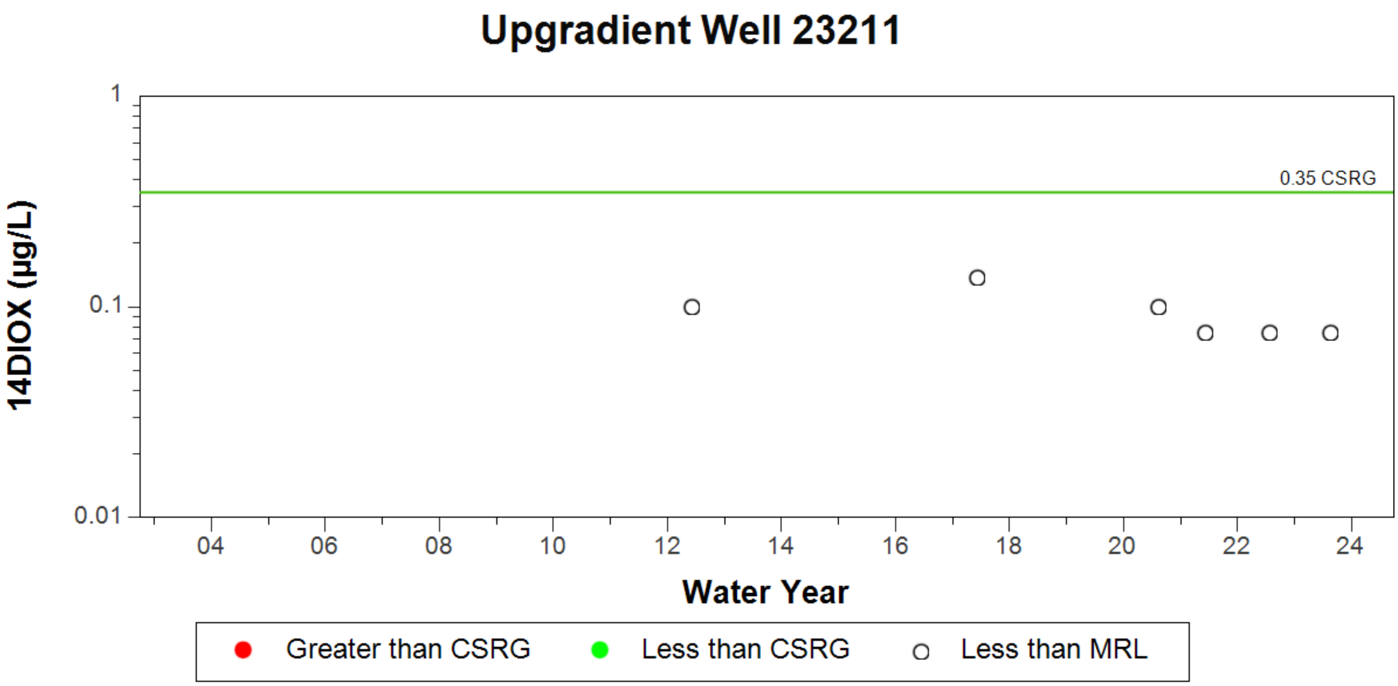
M:\projects\oars\fy23\mxds_NB_FY23_DIOX.mxd
8/7/2024

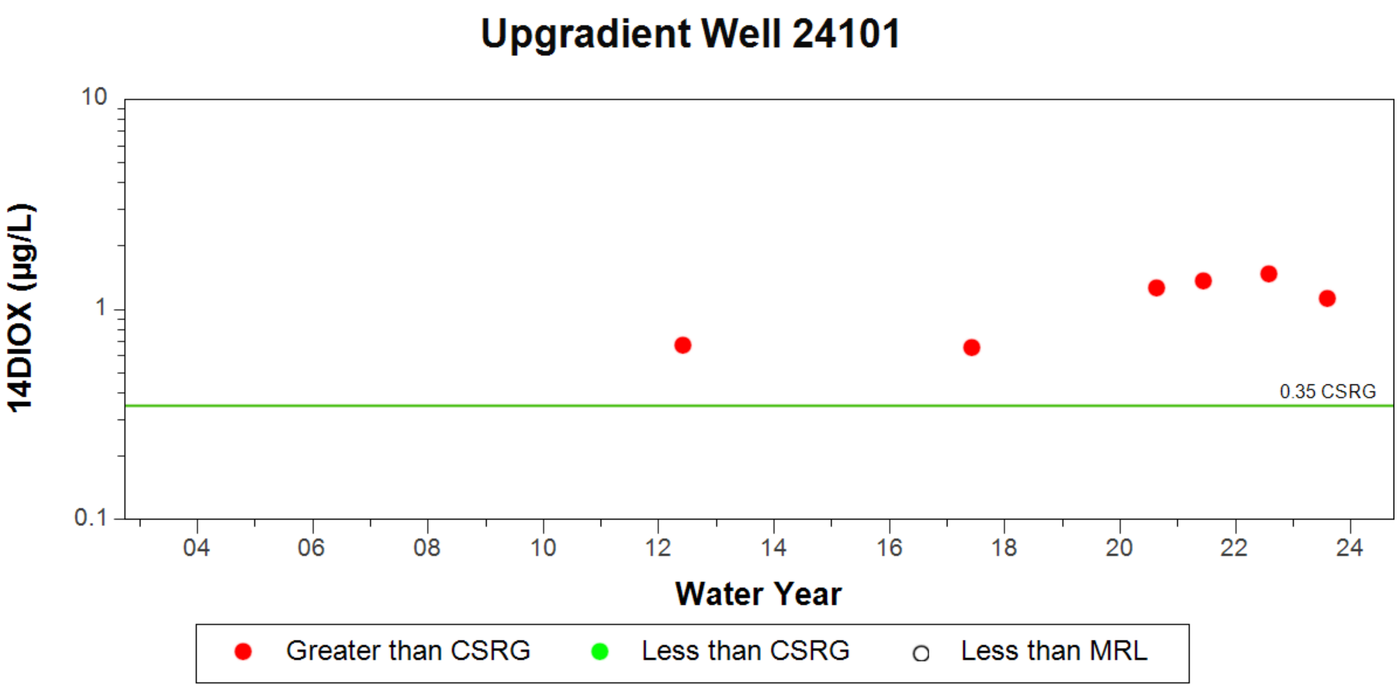


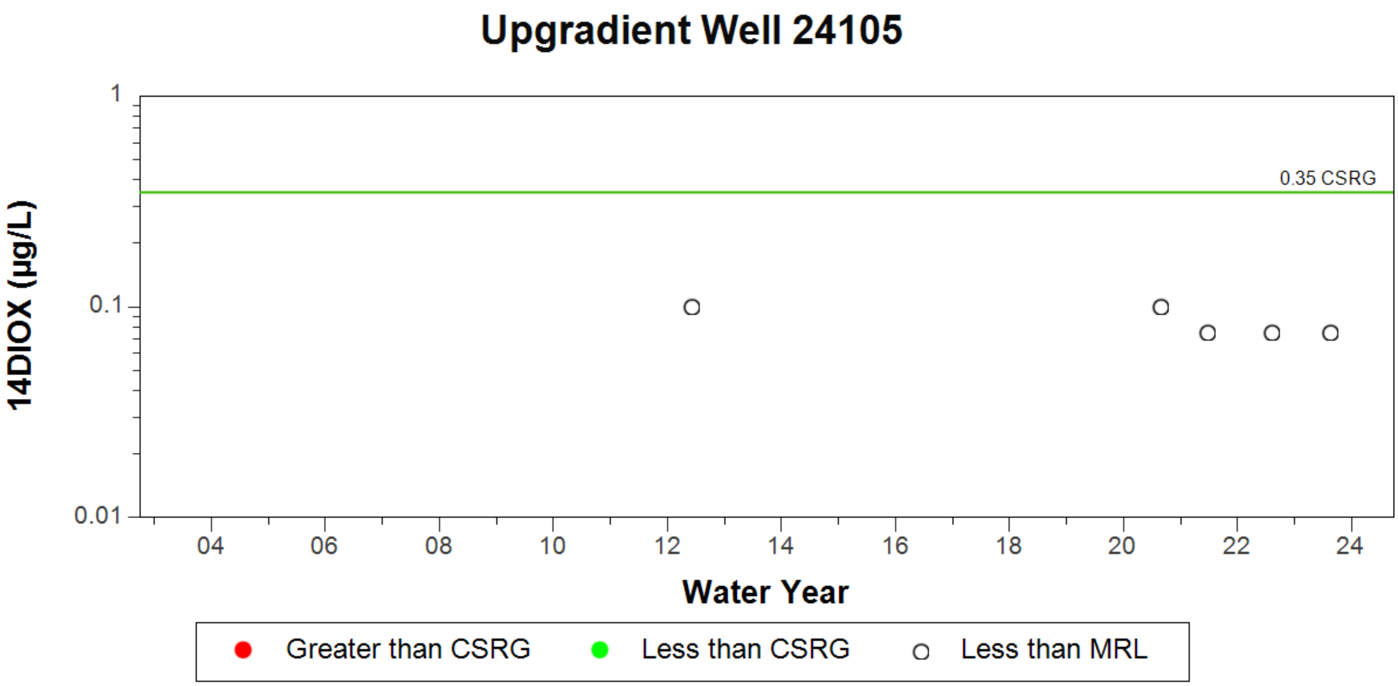
Upgradient Well 23119
14DIOX (µg/L)
1
0.1
0.35 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

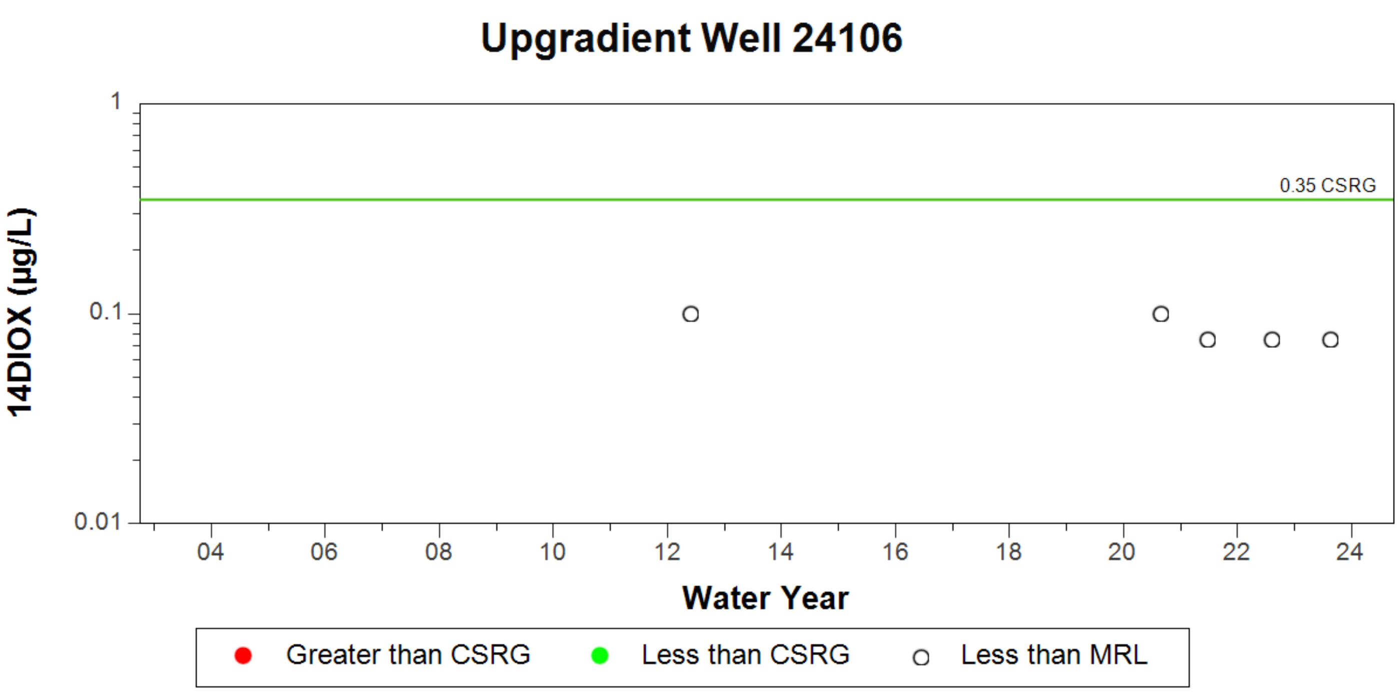


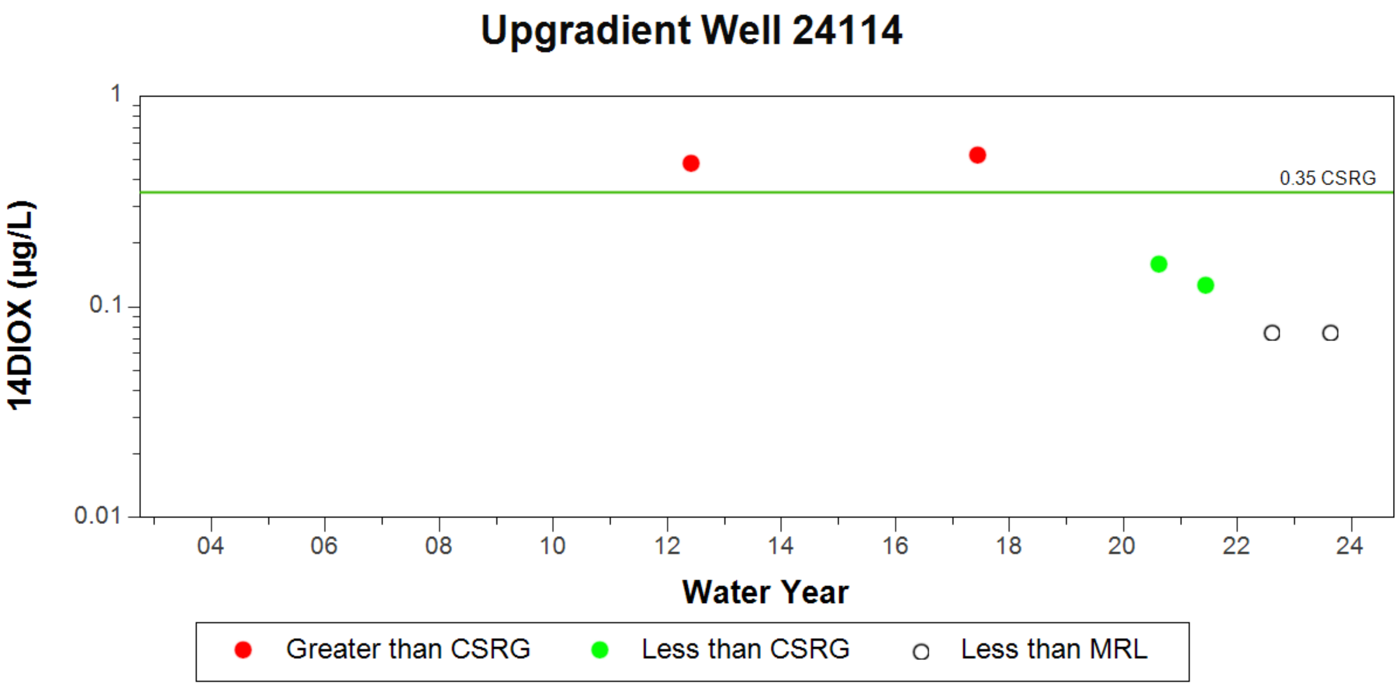
Upgradient Well 23160
14DIOX (µg/L)
10
1
0.1
0.35 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

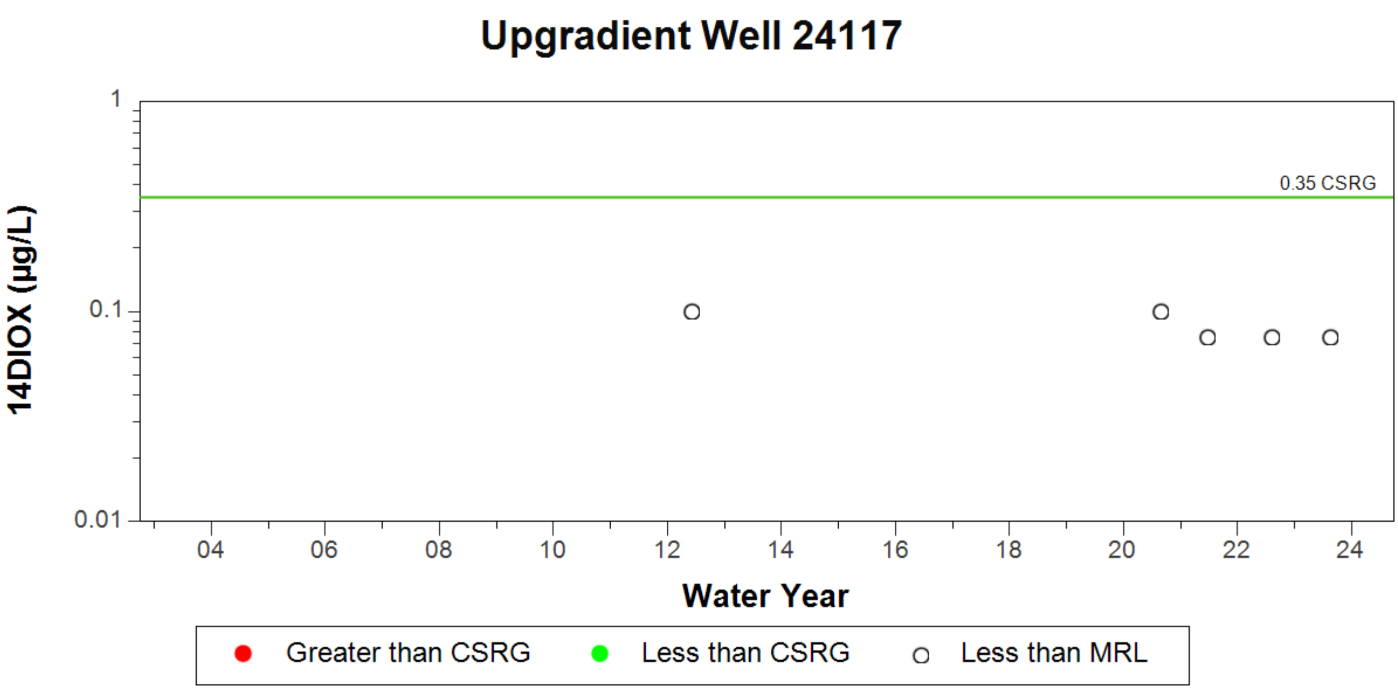

Upgradient Well 23211
14DIOX (µg/L)
1
0.1
0.01
0.35 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

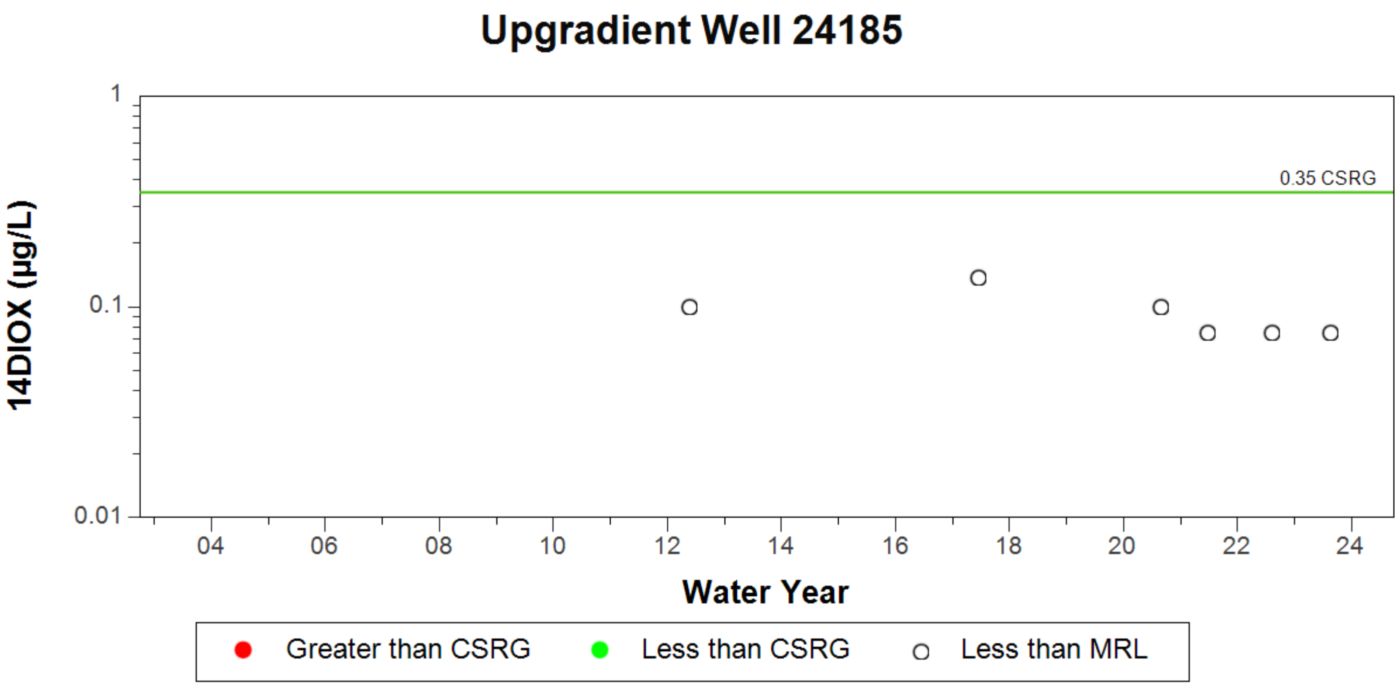

Upgradient Well 24101
14DIOX (µg/L)
10
1
0.1
0.35 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

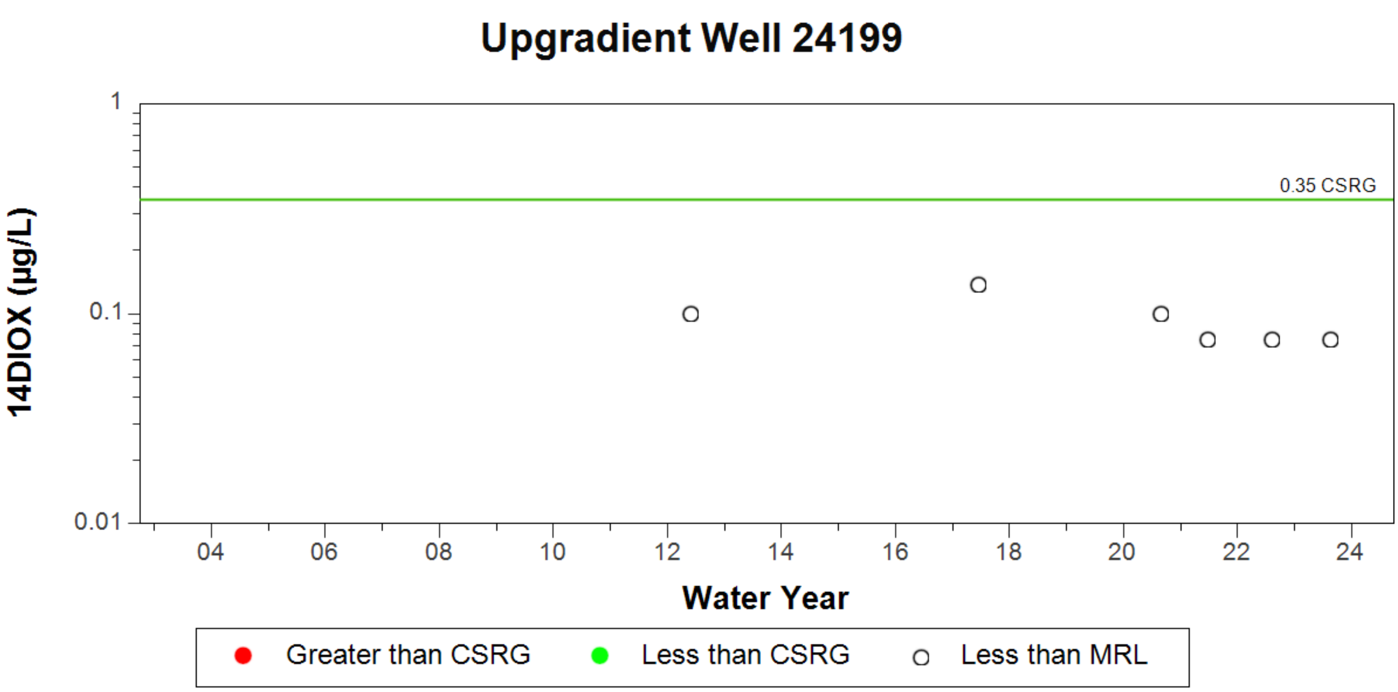

Upgradient Well 24105
14DIOX (µg/L)
1
0.1
0.01
0.35 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

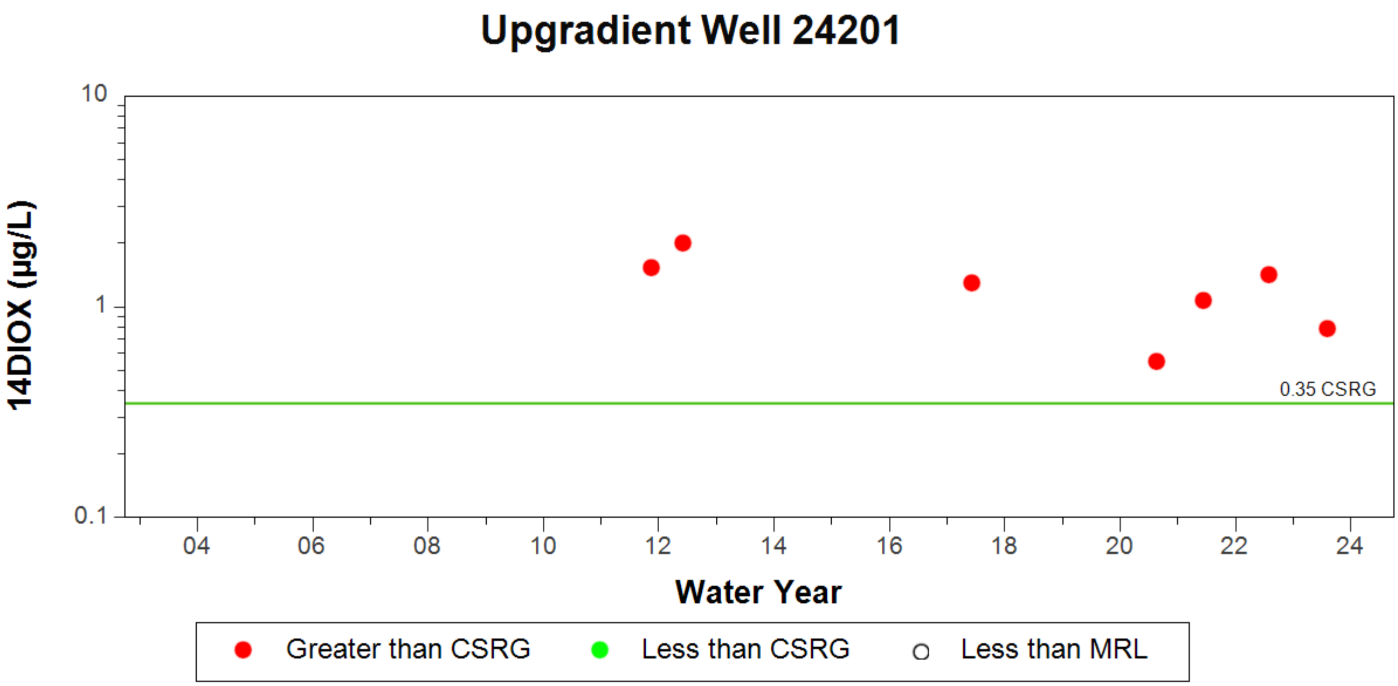

Upgradient Well 24106
14DIOX (µg/L)
1
0.1
0.01
0.35 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL


Upgradient Well 24114
1
0.1
0.01
14DIOX (µg/L)
0.35 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL


Upgradient Well 24117
1
0.1
0.01
14DIOX (µg/L)
0.35 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

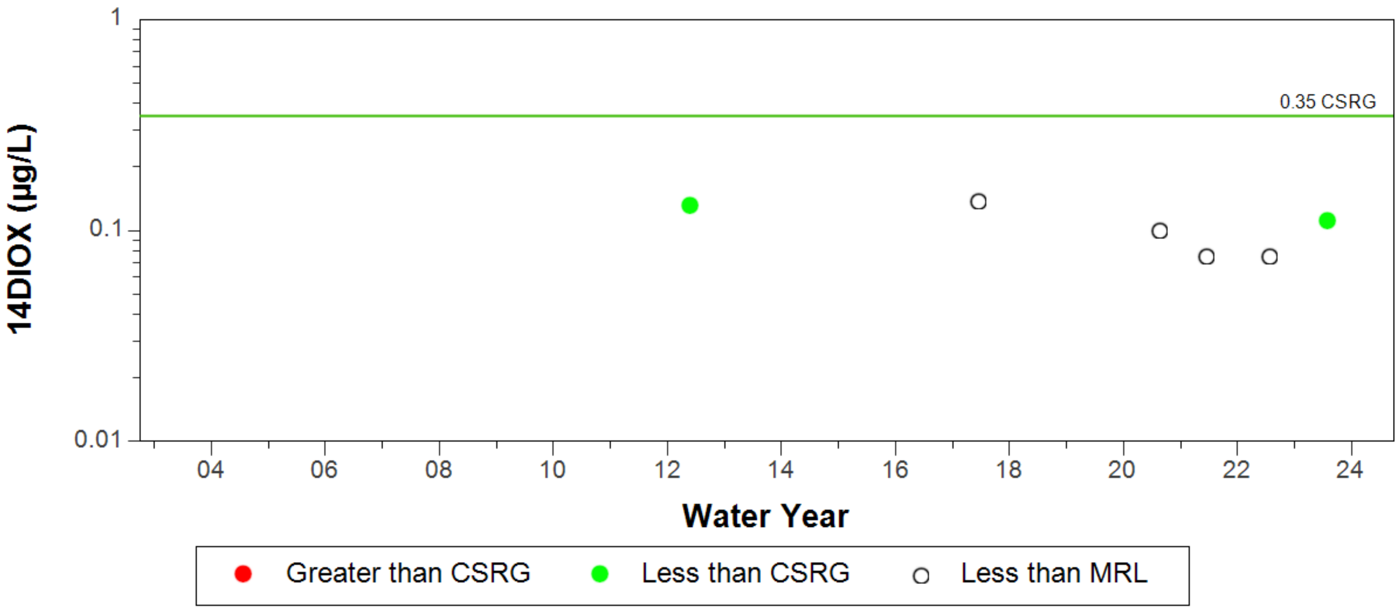

Upgradient Well 24185
14DIOX (µg/L)
1
0.1
0.01
0.35 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL


Upgradient Well 24199
14DIOX (µg/L)
1
0.1
0.01
0.35 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

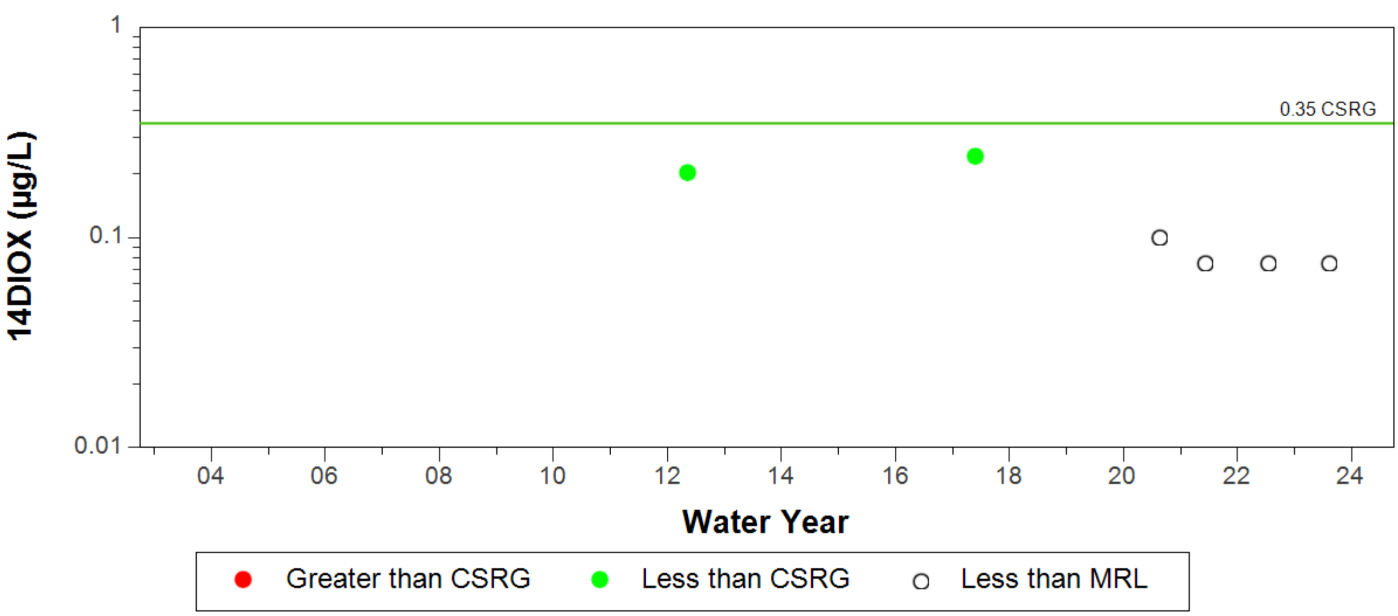


Upgradient Well 24201
10
1
0.1
14DIOX (µg/L)
0.35 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

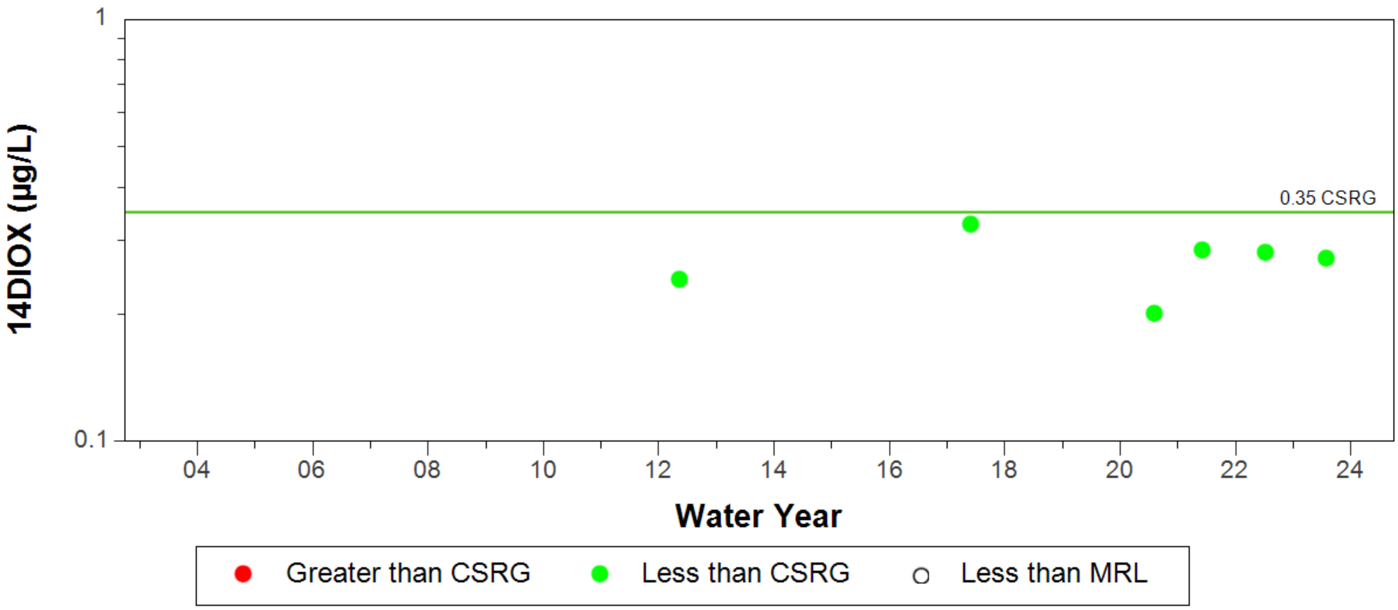
Downgradient Well 23405



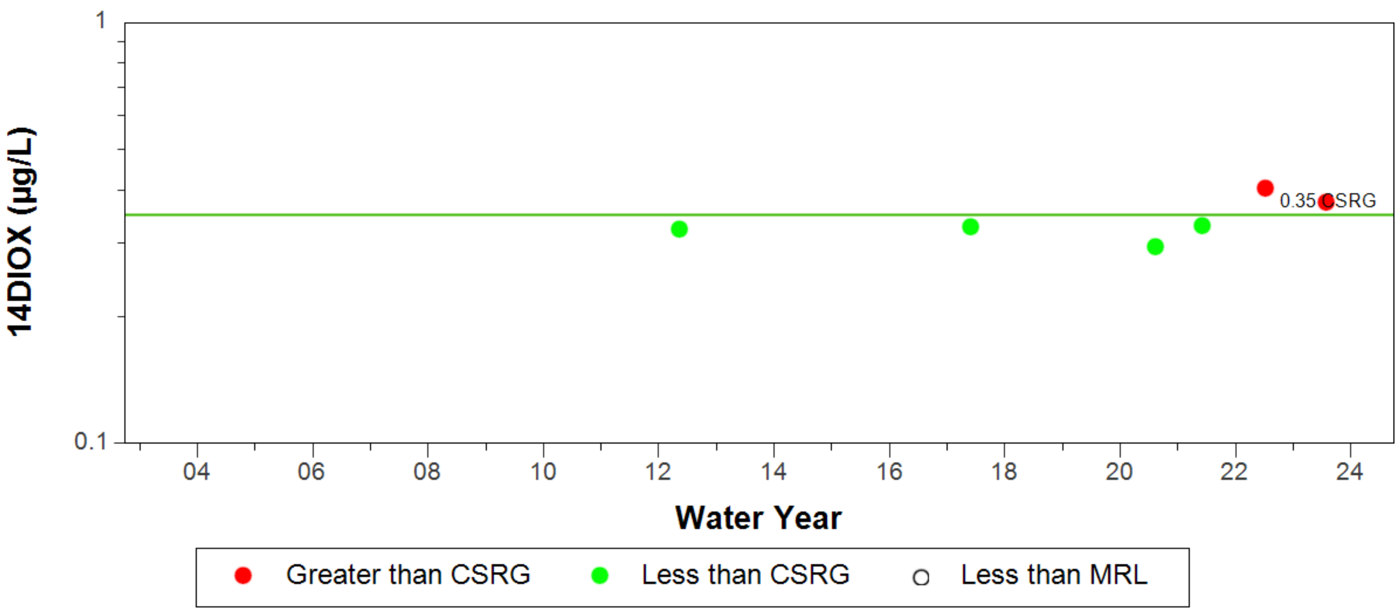
Downgradient Well 23434

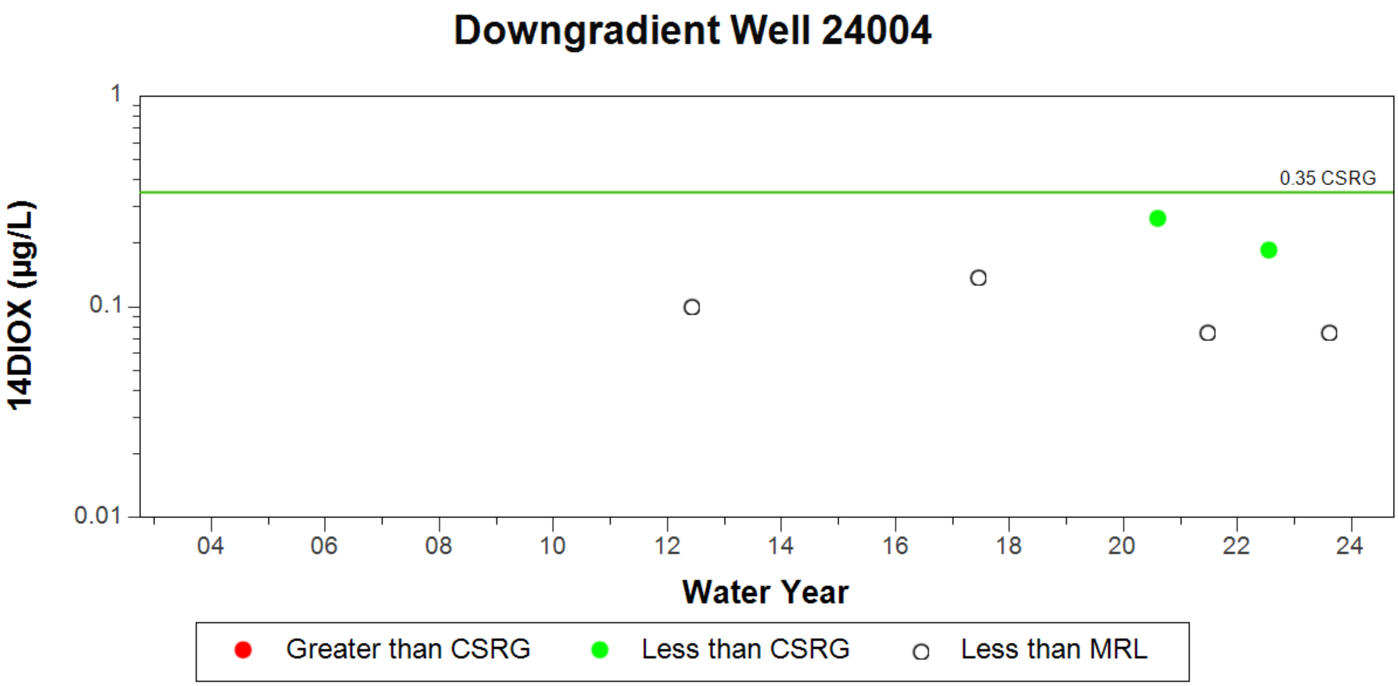


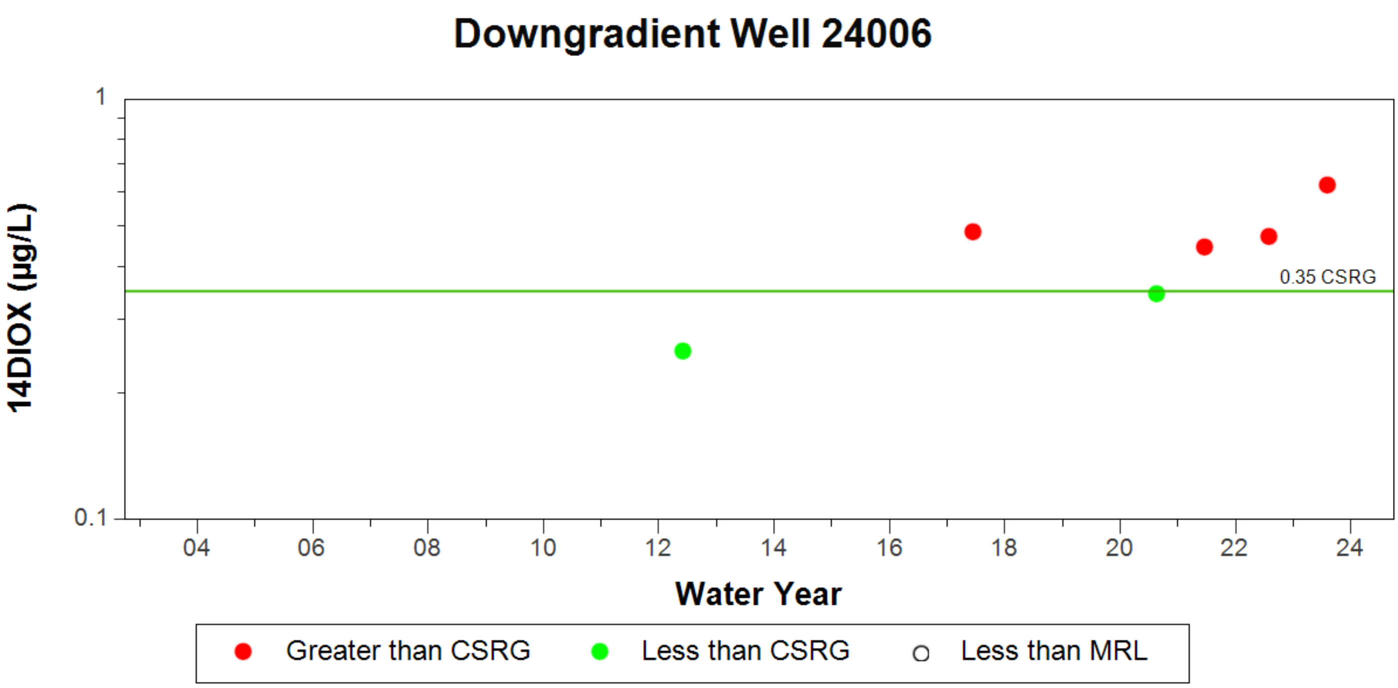
Downgradient Well 23436



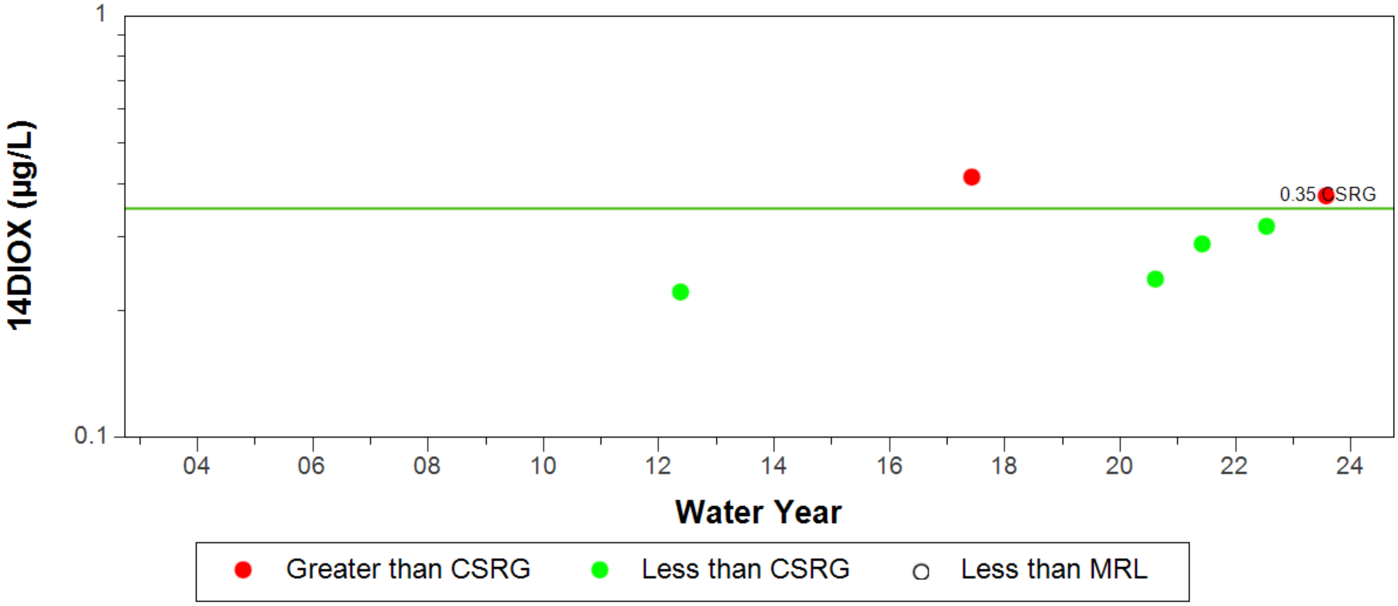
Downgradient Well 23438



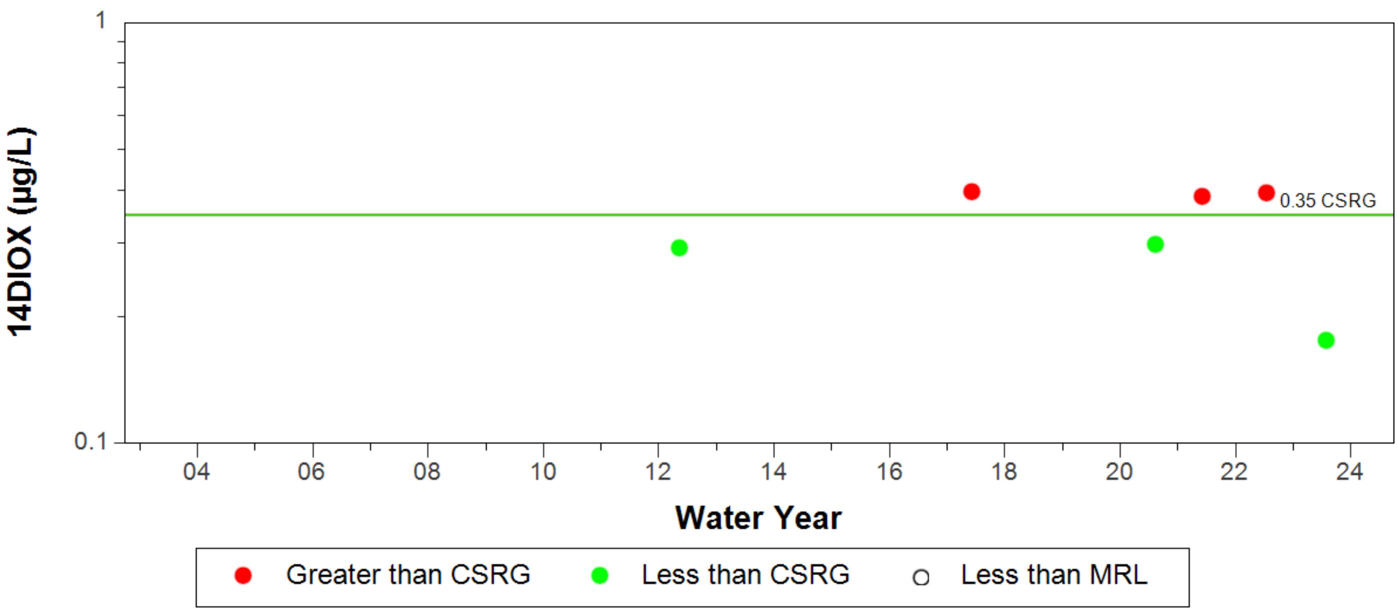

Downgradient Well 24004
14DIOX (µg/L)
1
0.1
0.01
0.35 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

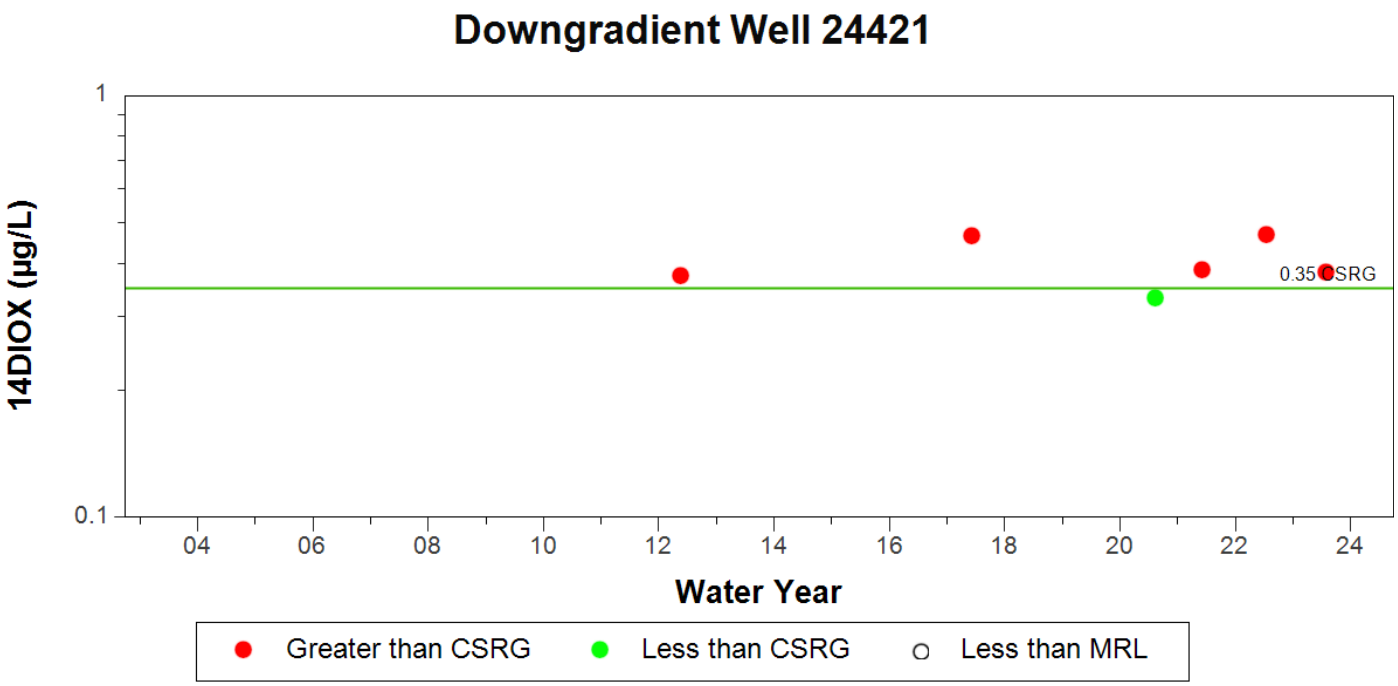

Downgradient Well 24006
14DIOX (µg/L)
1
0.1
0.35 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

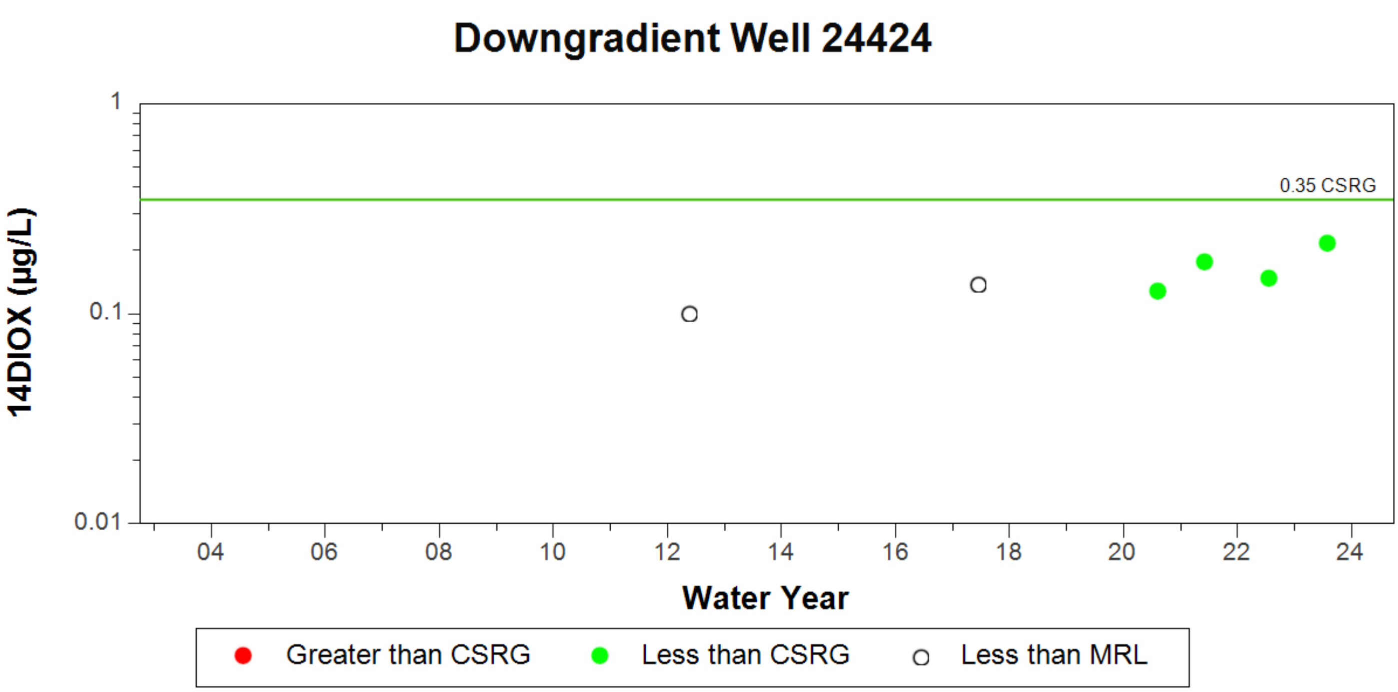
Downgradient Well 24415

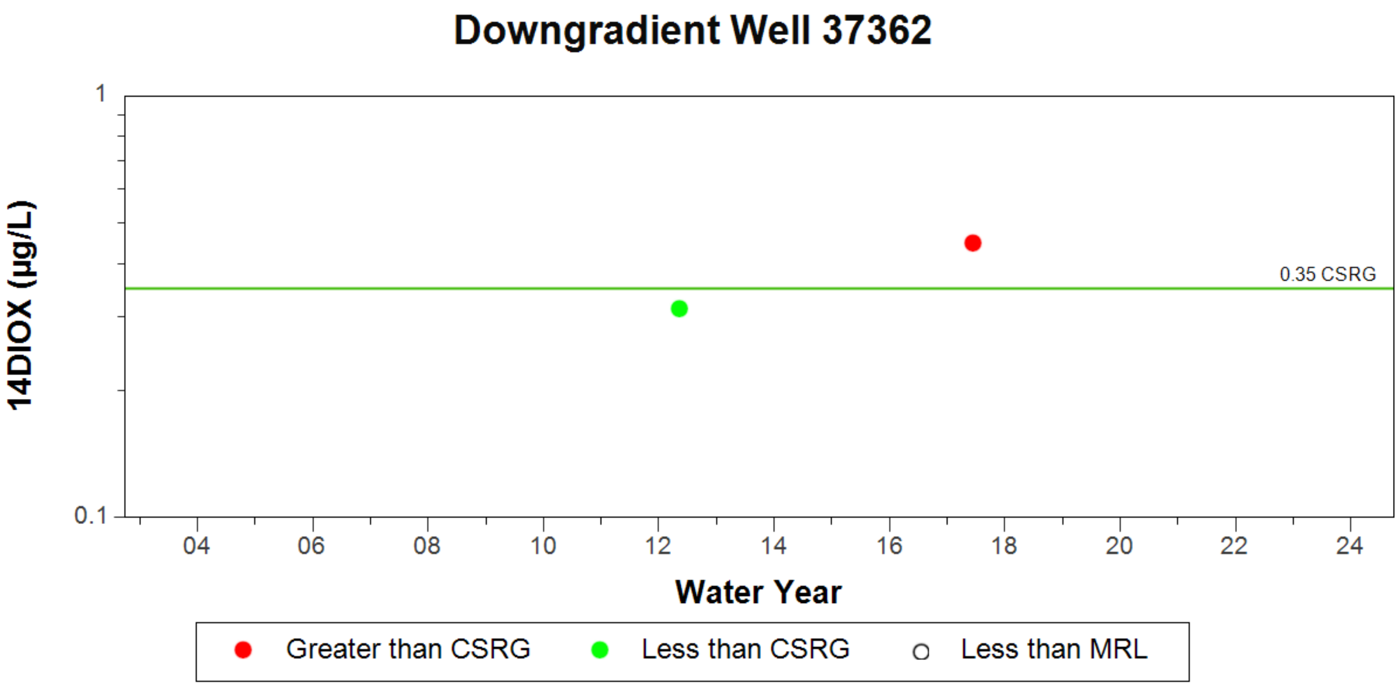


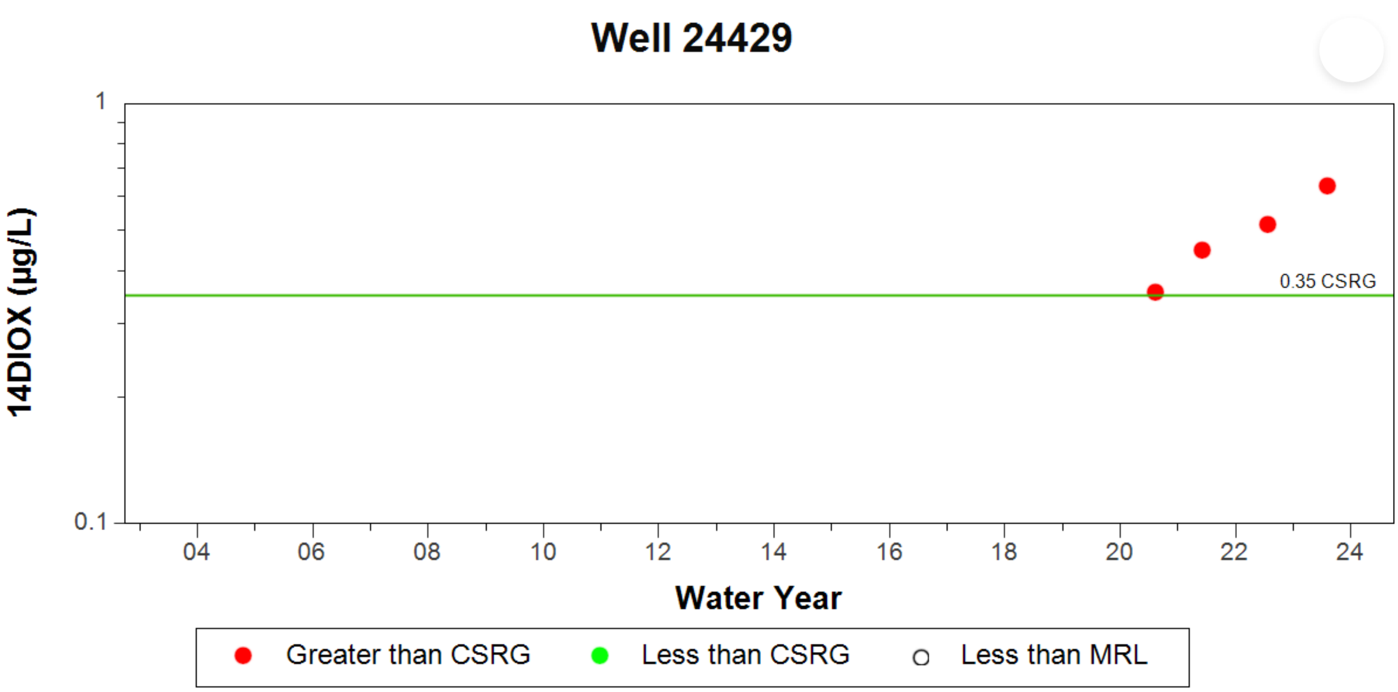
Downgradient Well 24418



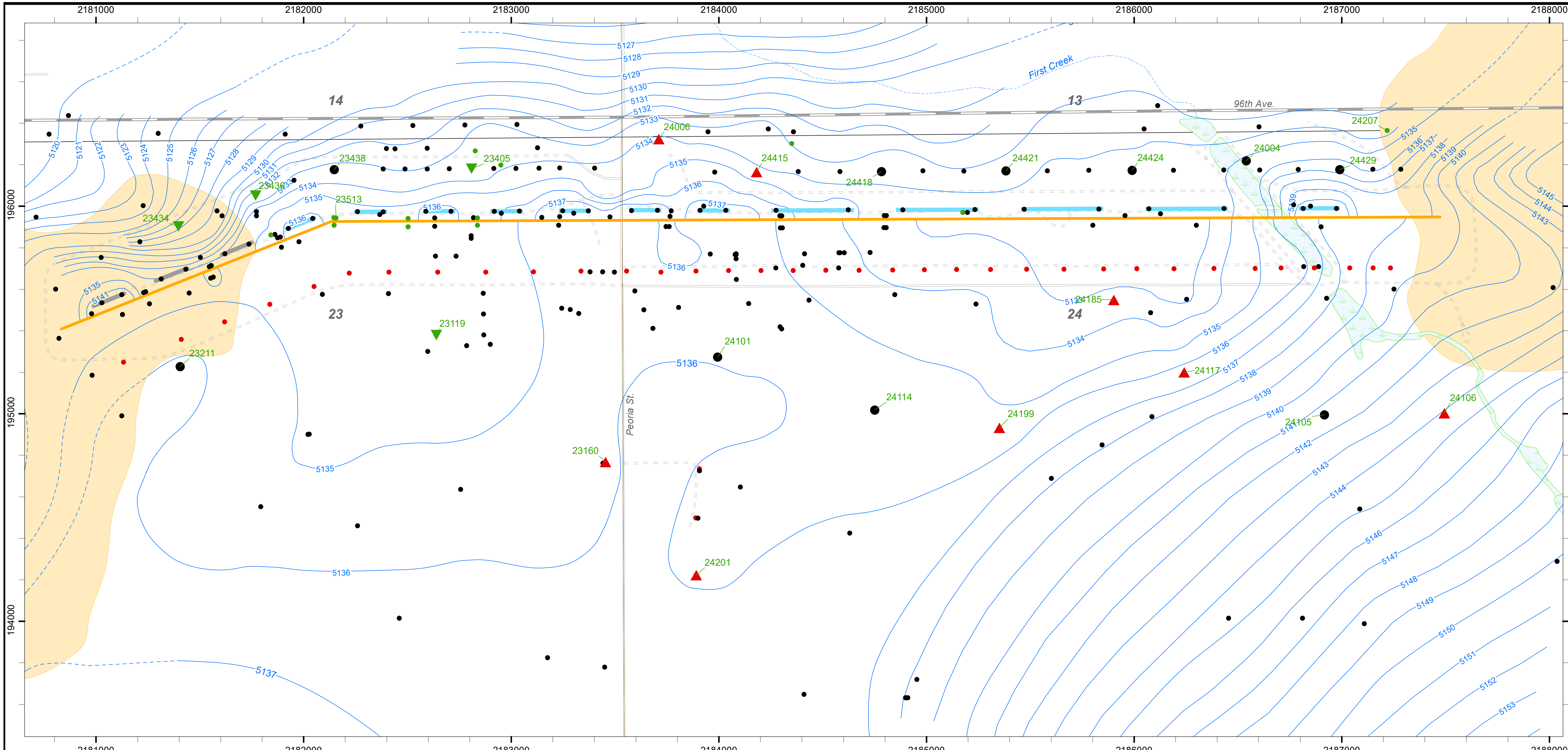

Downgradient Well 24421
14DIOX (µg/L)
1
0.1
0.35 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL


Downgradient Well 24424
14DIOX (µg/L)
1
0.1
0.01
0.35 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL





Downgradient performance Well 24207 replaced Well 37362, but it could not be sampled due to insufficient water. Nearby alternate Well 24429 was monitored instead.



Legend

- Unsaturated Alluvium
- Section Lines
- Water elevation contour - 1-foot interval
- Inferred water elevation contour
- Wetlands
- Intermittent Streams
- Ditches
- Slurry Walls
- Recharge Trenches
- Inactive Recharge Trenches
- Unimproved Roads
- Local Roads
- Secondary Roads
- Primary Roads
- Monitoring Wells
- Performance Water Quality Wells
- Extraction Wells

Notes: Water levels were measured in FY23 Quarter 2.

Upgradient and Downgradient Performance Well Water Quality

- Analyte Detected Above the CSRG - Increasing Trend Noted
- Analyte Detected Above the CSRG - Decreasing Trend Noted
- Analyte Detected - Showing Stable or No Discernible Trend
- Analyte Not Detected

Notes:
1. Trends are depicted for the 10 year period FY14 - FY23.
2. Time versus concentration charts for Performance Water Quality wells are presented following this map.

N

0 250 500 Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

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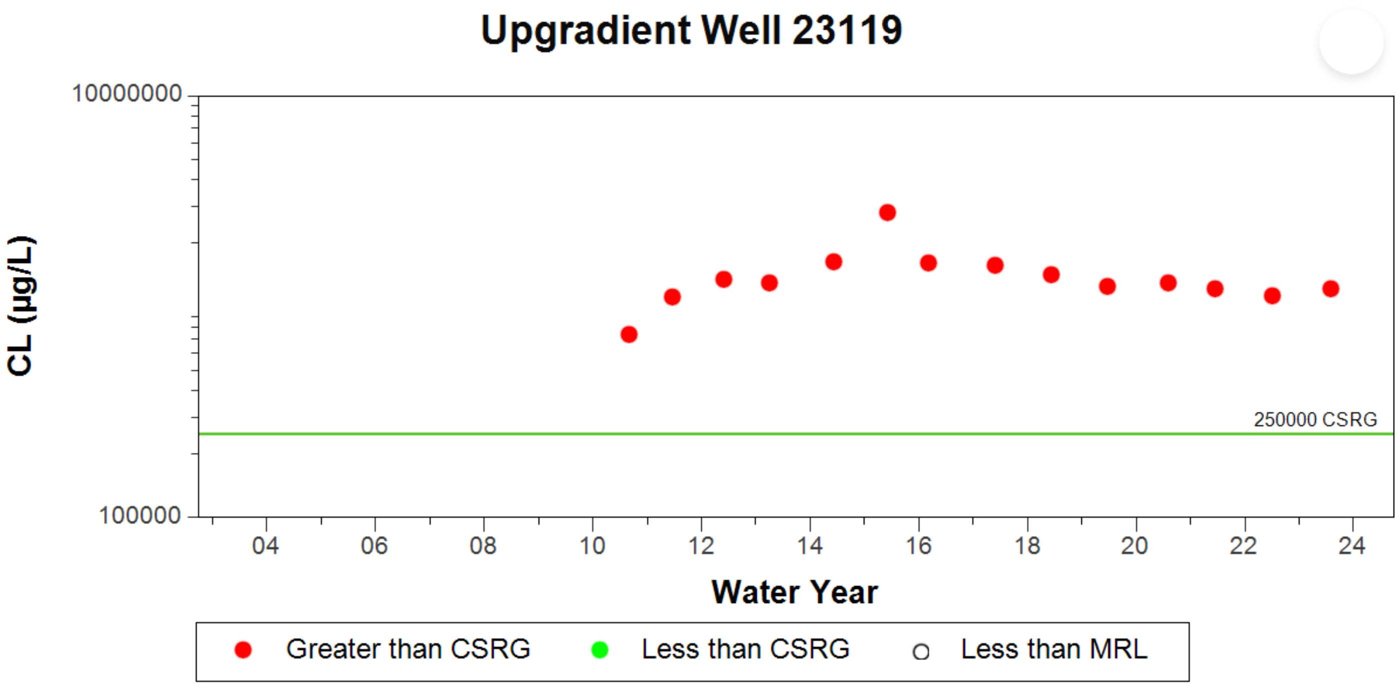
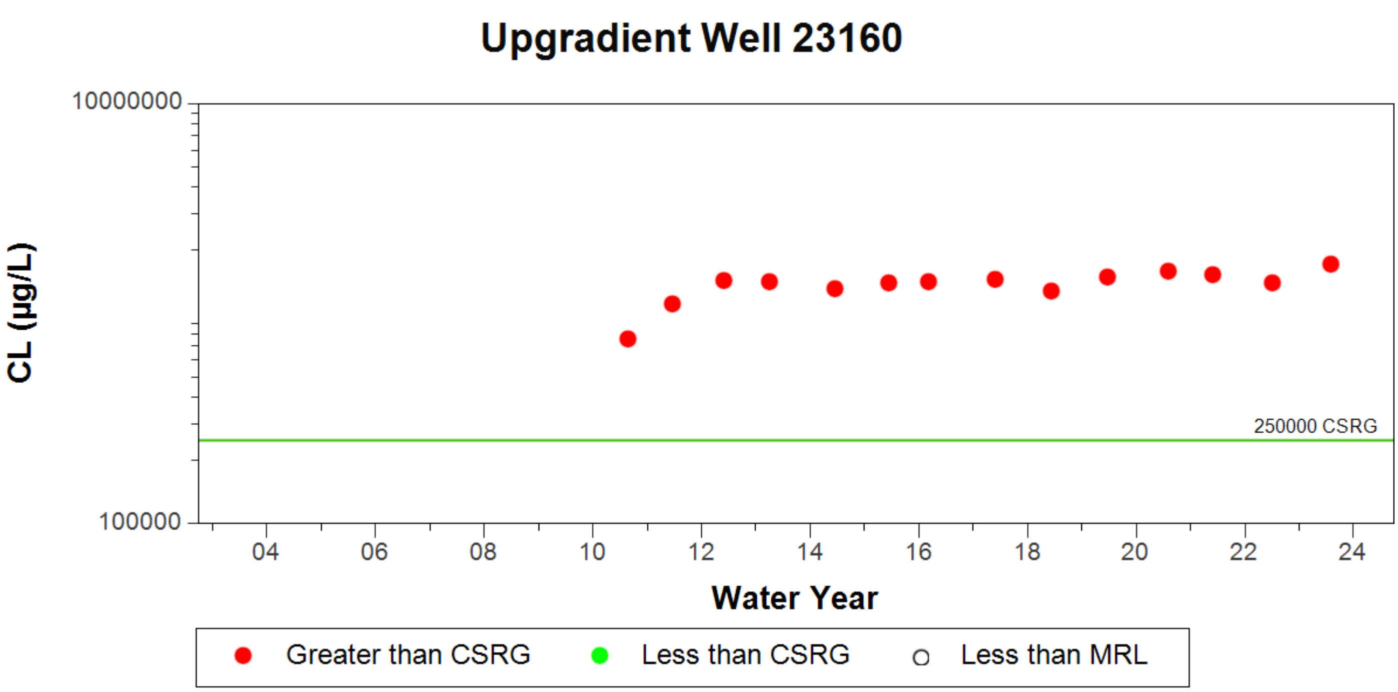
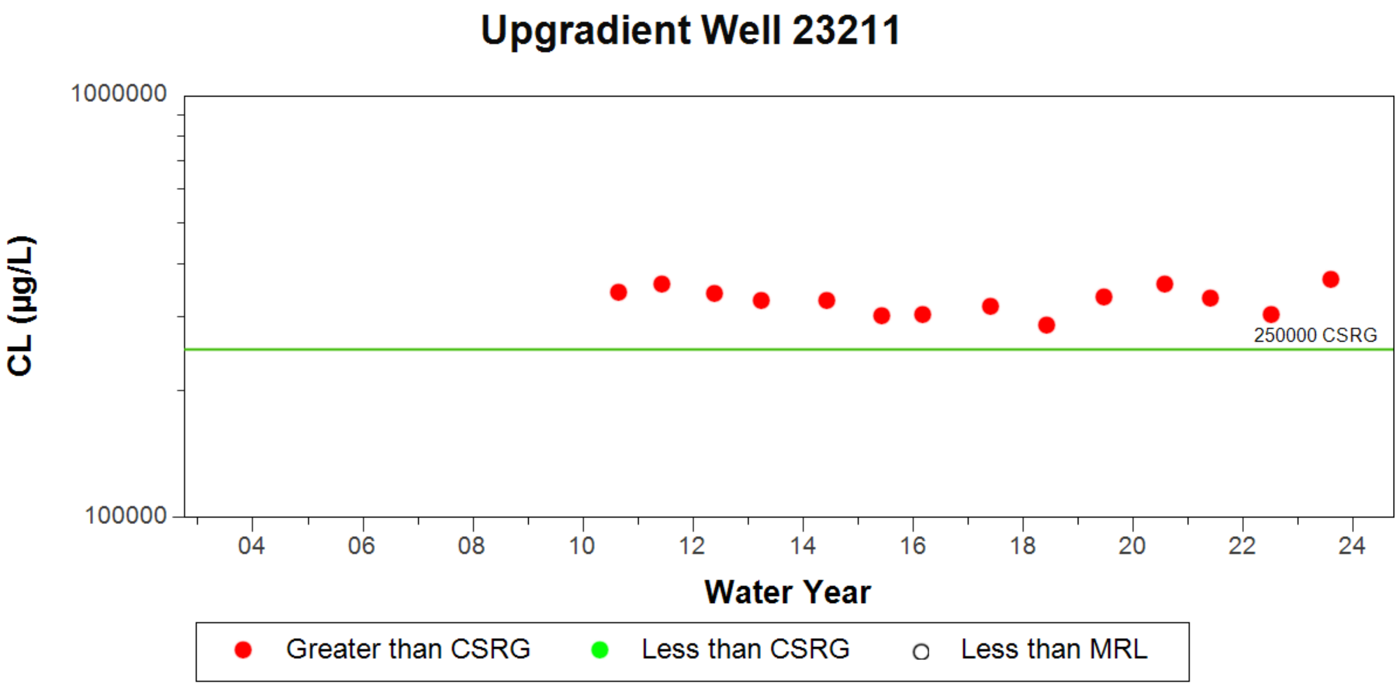
Figure B-29

Chloride Concentration Trends in Performance Wells, North Boundary Containment System

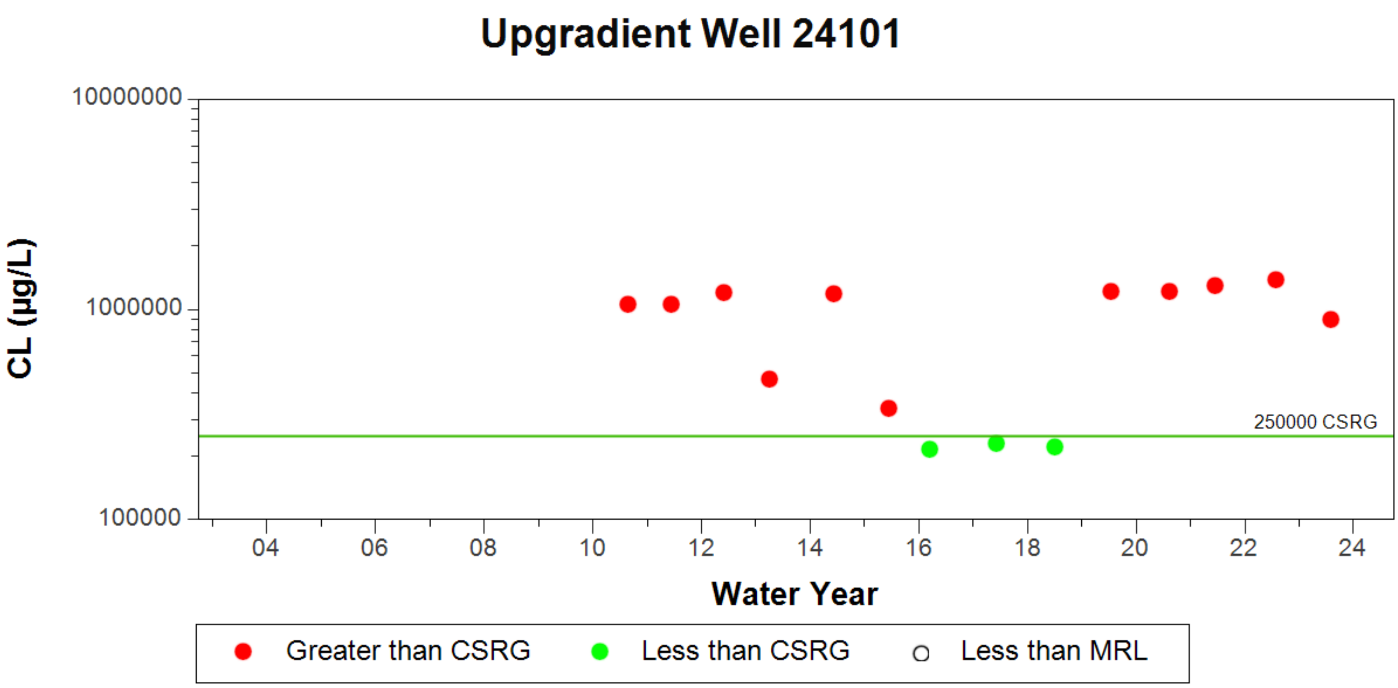
M:\projects\oars\fy23\mxds_NB_FY23_CL.mxd
8/7/2024


Upgradient Well 23119
10000000
100000
CL (µg/L)
250000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL


Upgradient Well 23160
10000000
100000
CL (µg/L)
250000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

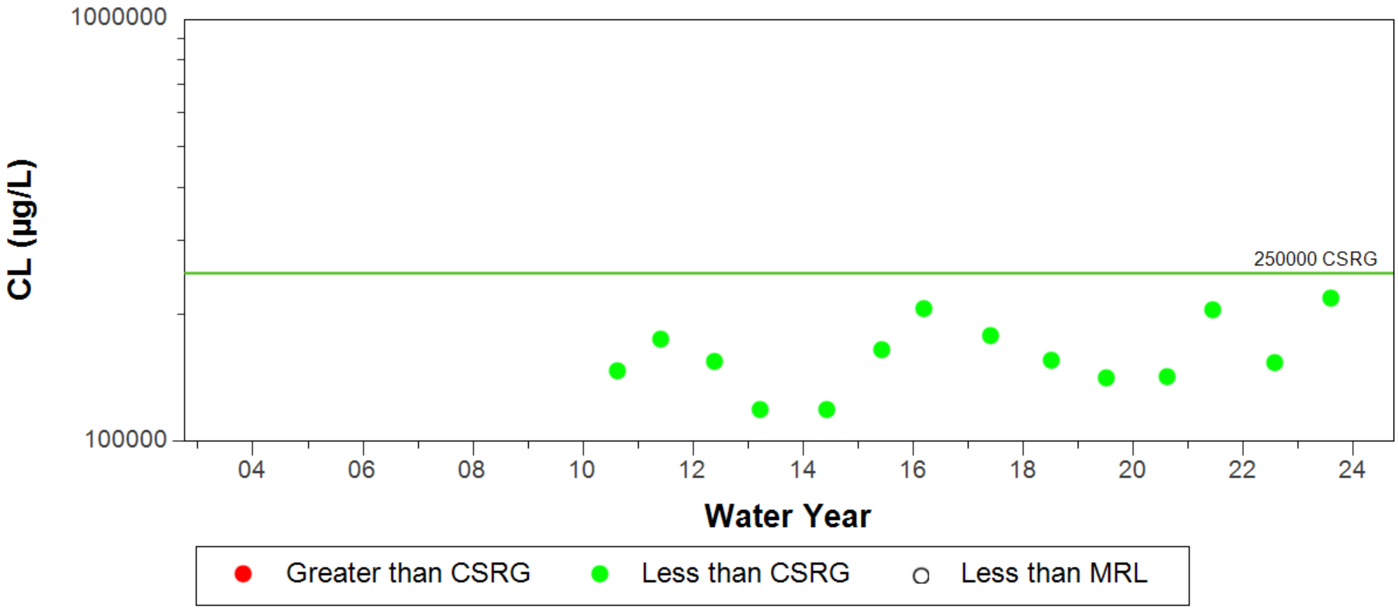


Upgradient Well 23211
CL (µg/L)
1000000
100000
250000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

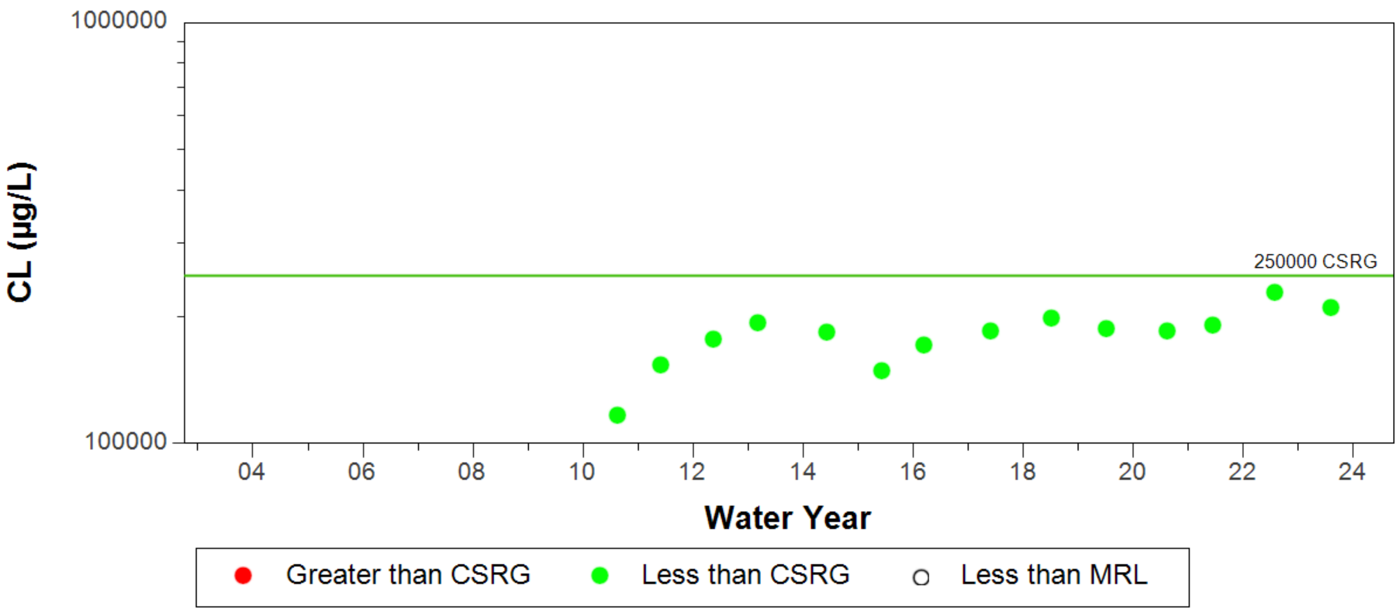


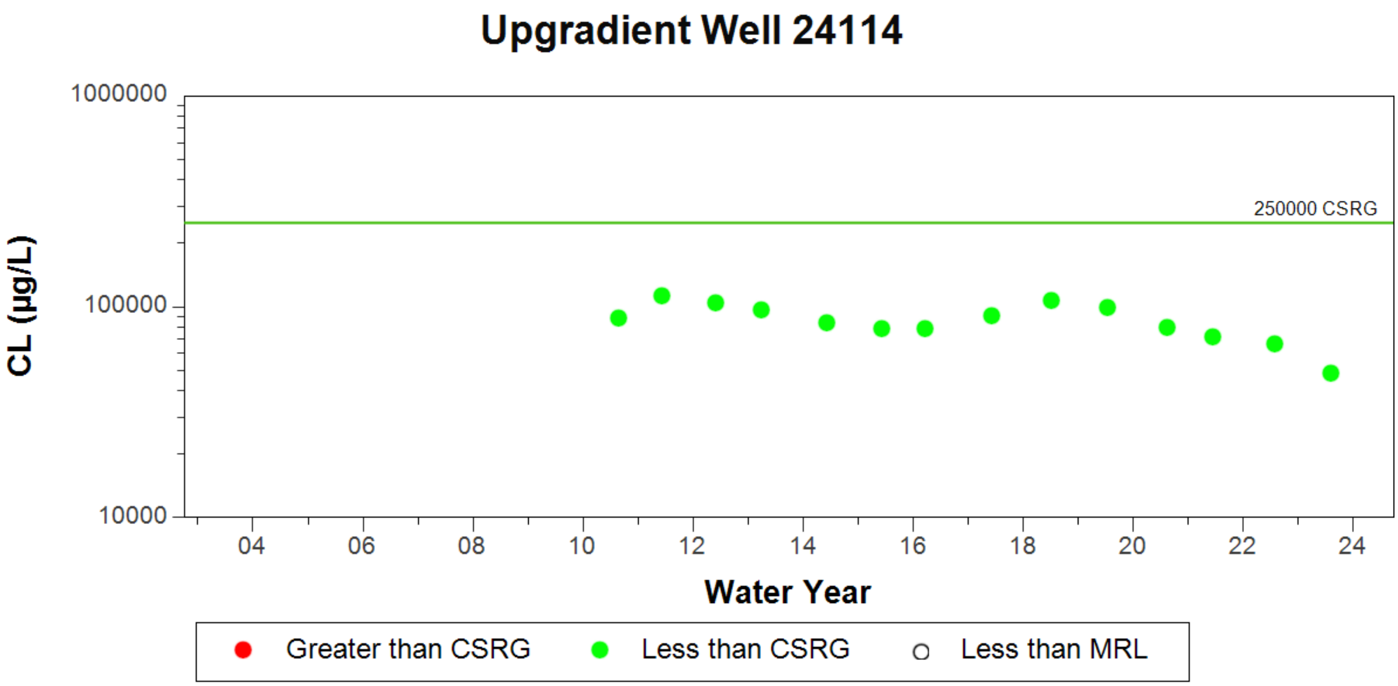
Upgradient Well 24101
CL (µg/L)
10000000
1000000
100000
250000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

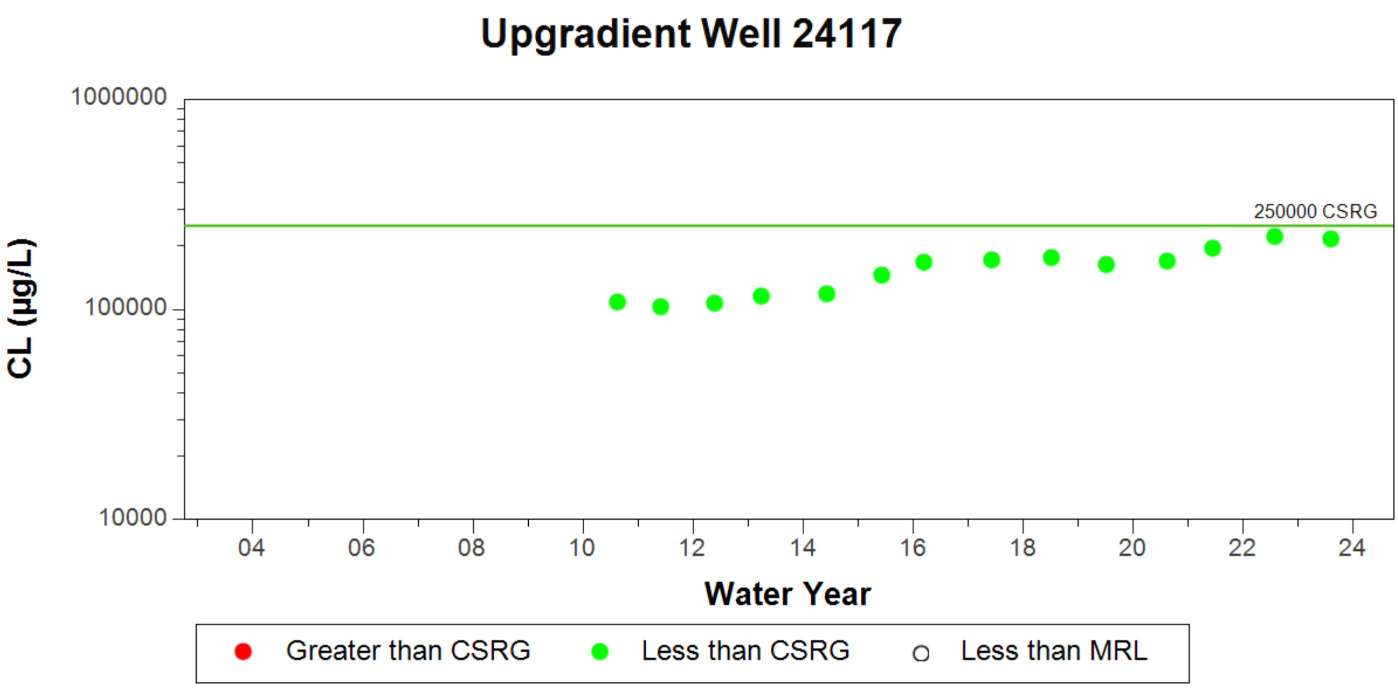
Upgradient Well 24105

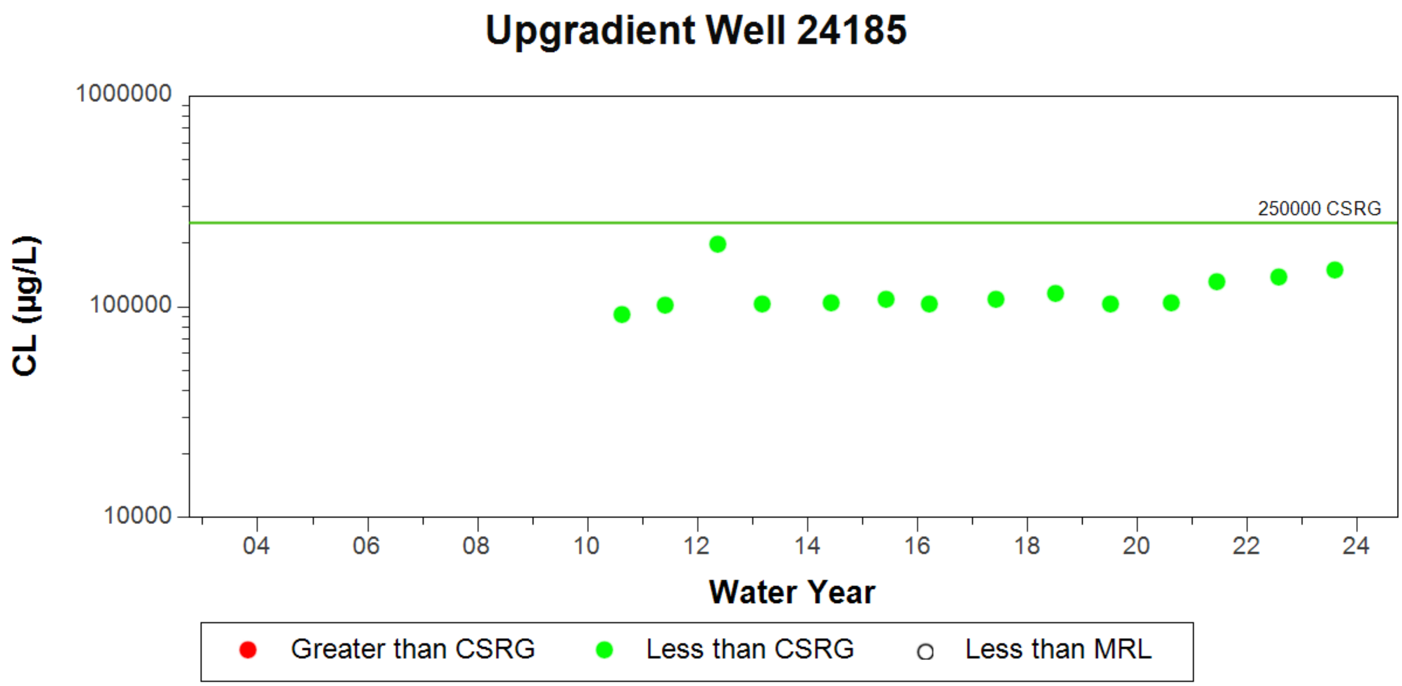


Upgradient Well 24106

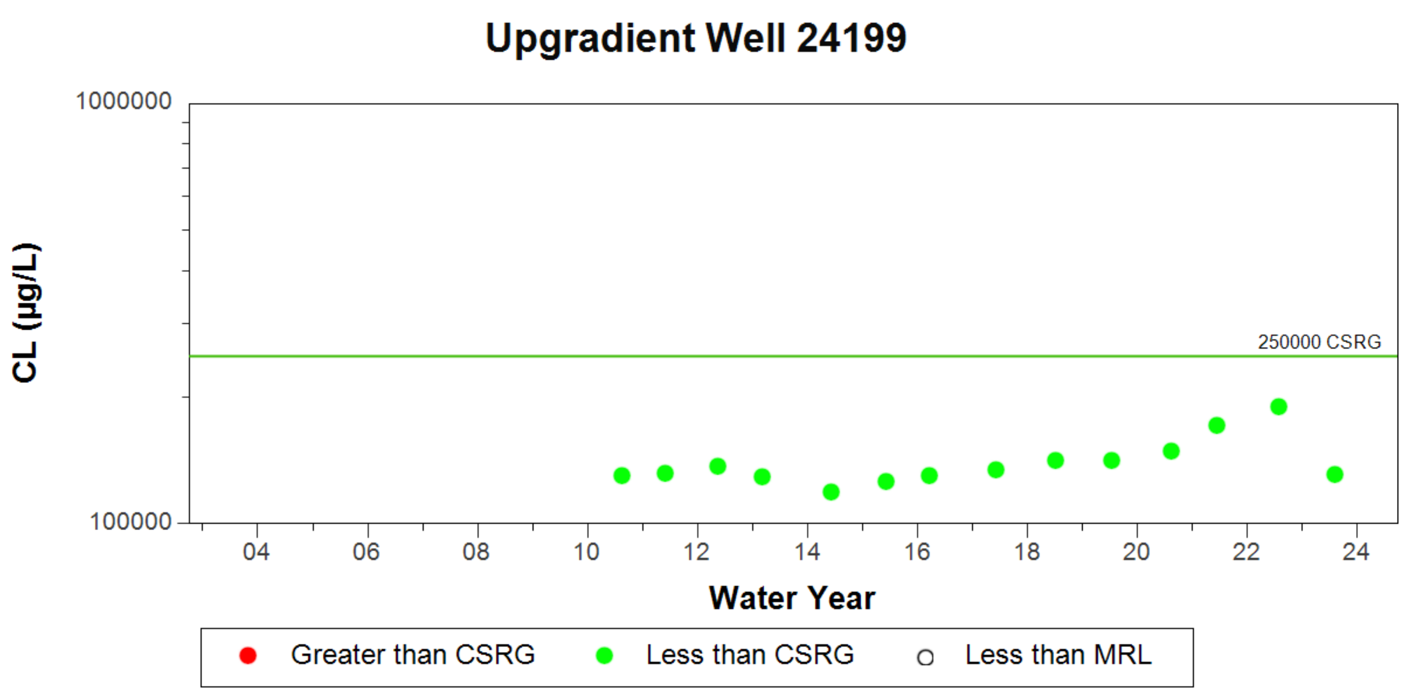



Upgradient Well 24114
1000000
100000
10000
CL (µg/L)
250000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

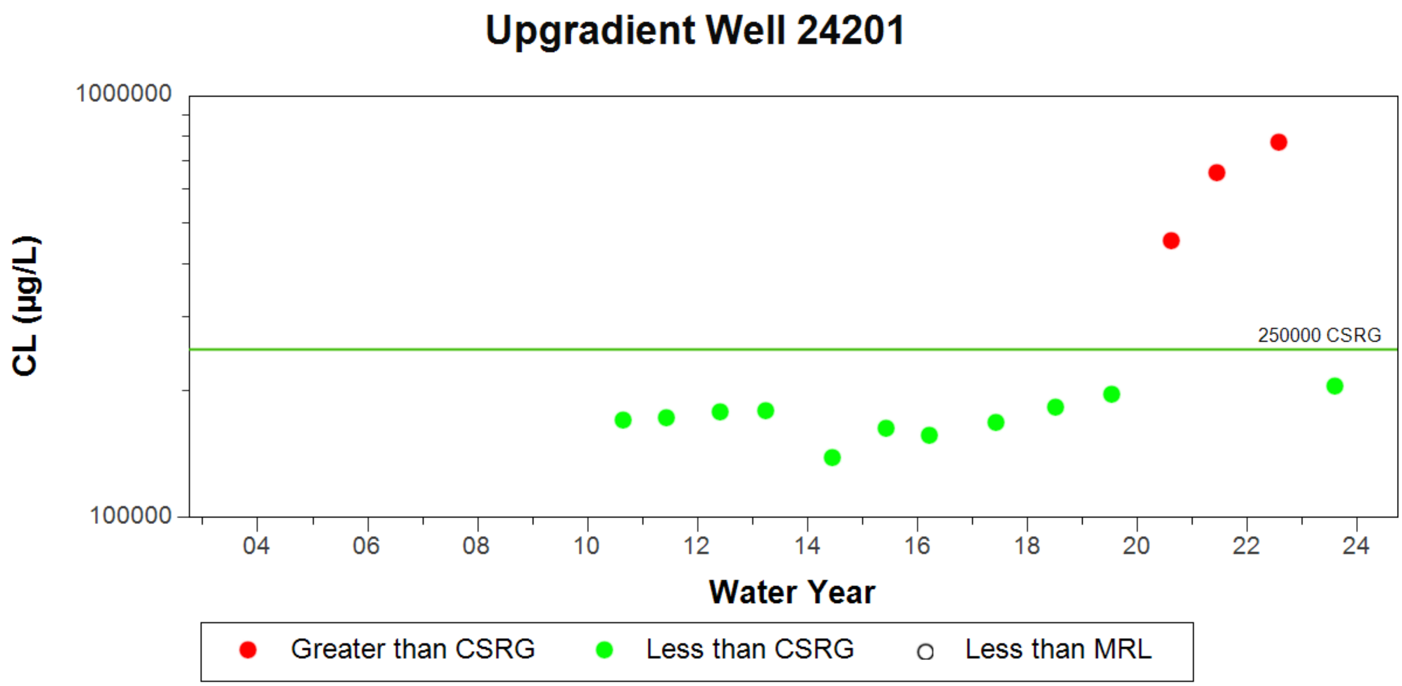

Upgradient Well 24117
1000000
100000
10000
CL (µg/L)
250000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



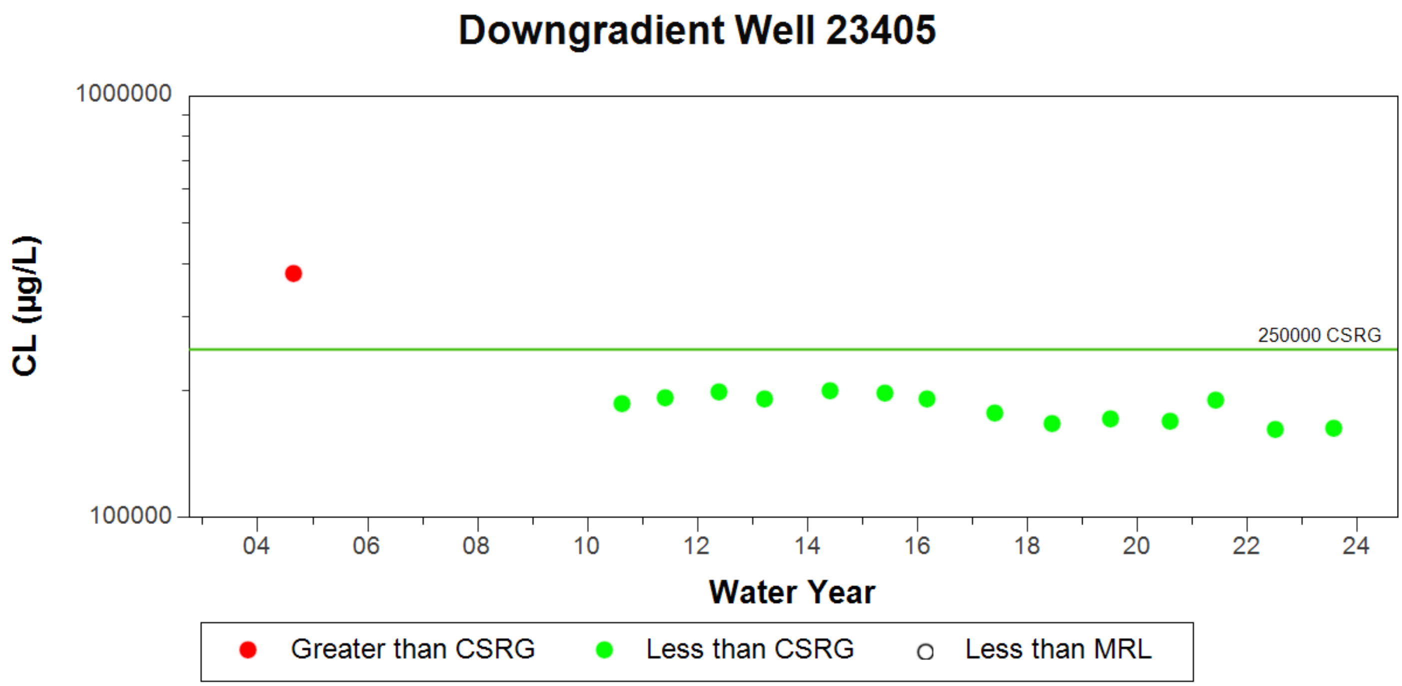
Upgradient Well 24185
1000000
100000
10000
CL (µg/L)
250000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

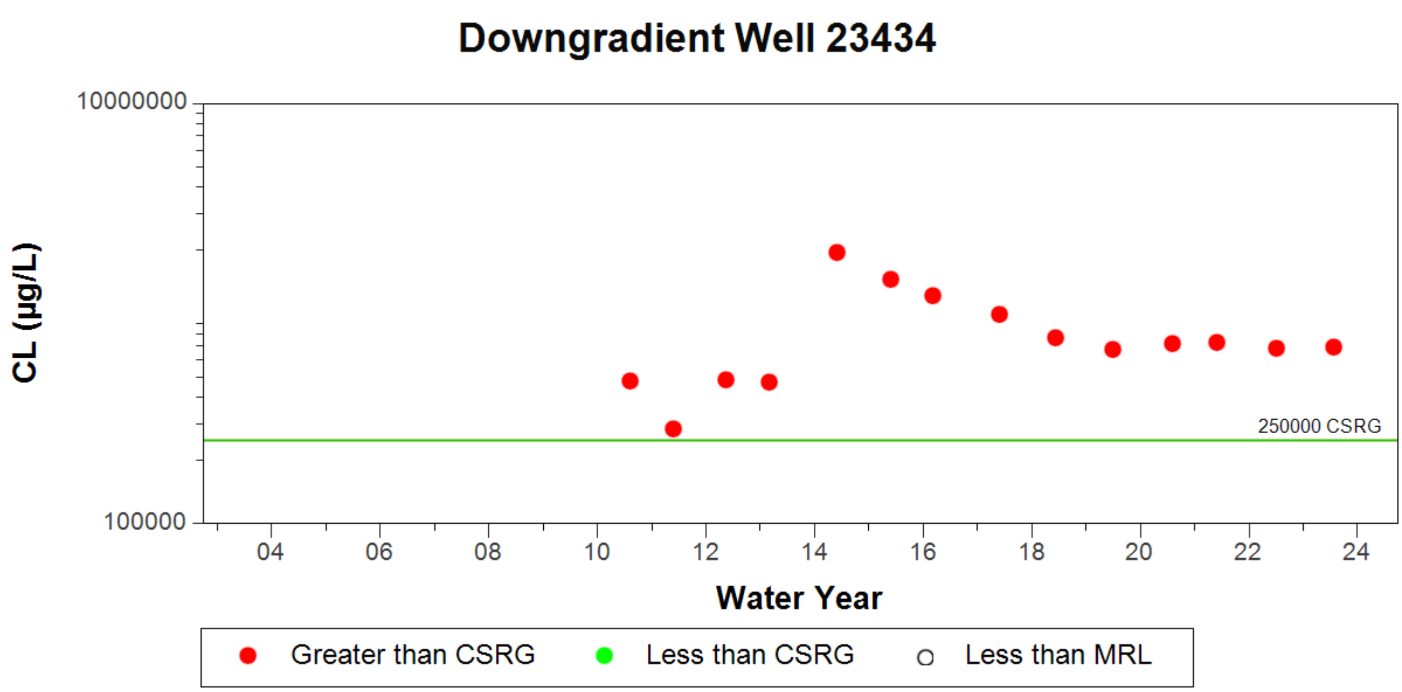


Upgradient Well 24199
1000000
100000
CL (µg/L)
250000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

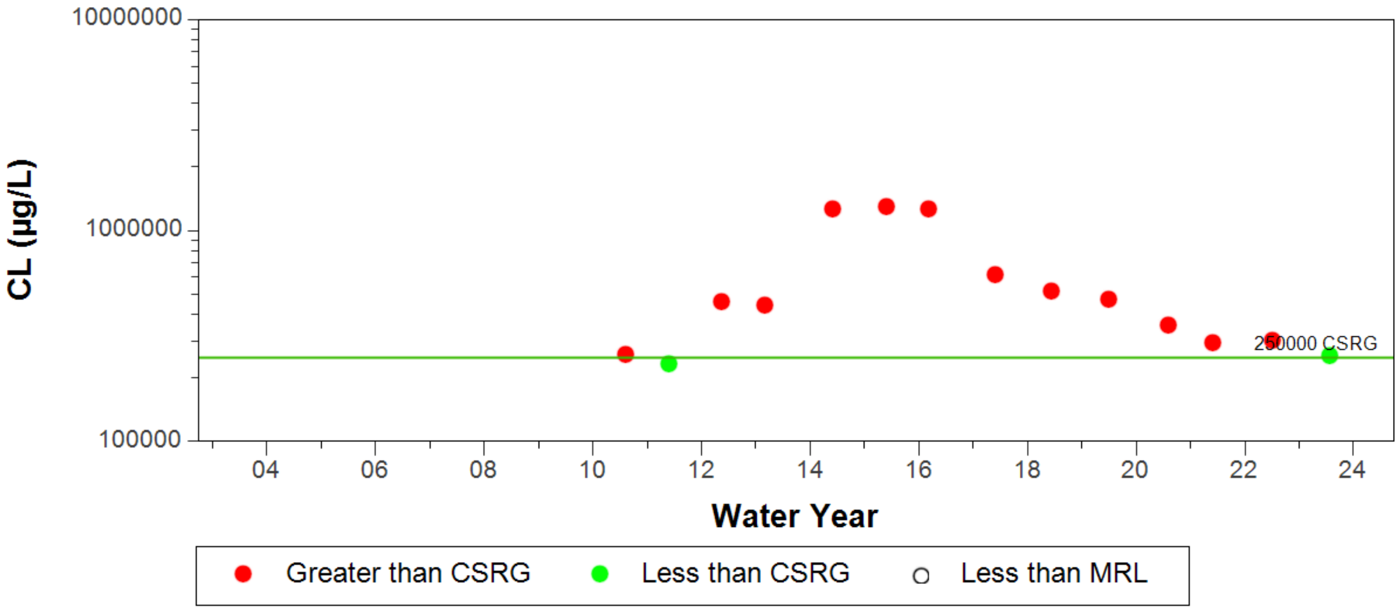


Upgradient Well 24201
1000000
100000
CL (µg/L)
250000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

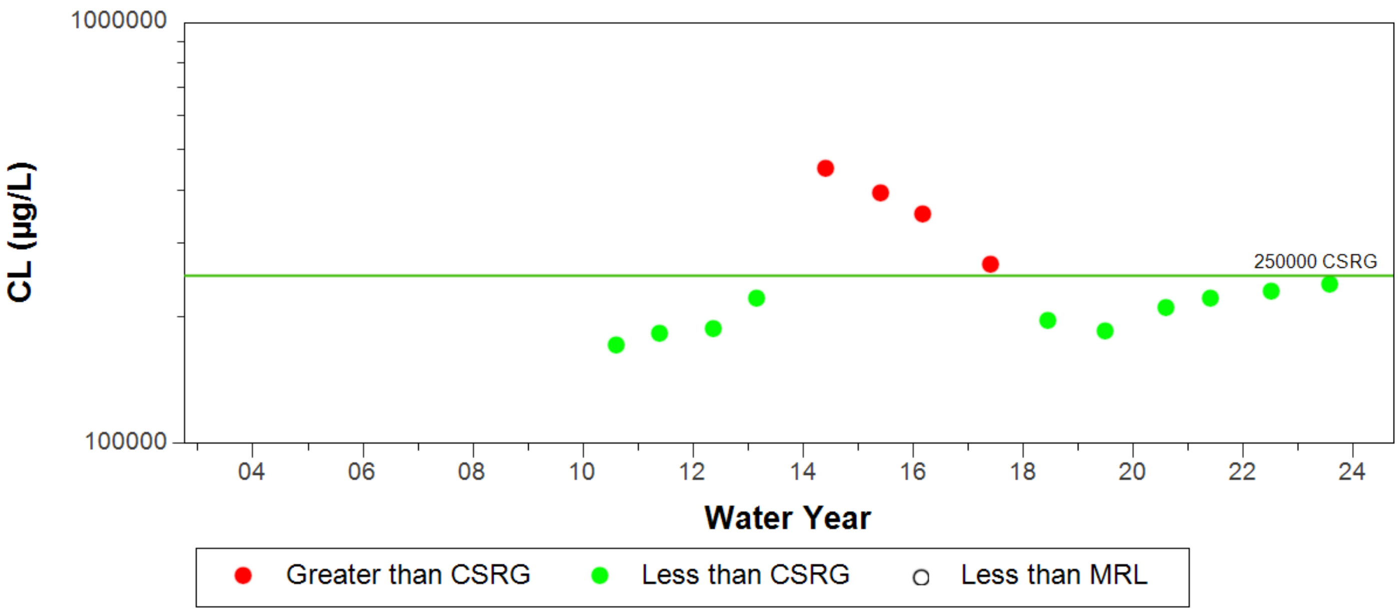

Downgradient Well 23405
1000000
100000
CL (µg/L)
250000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

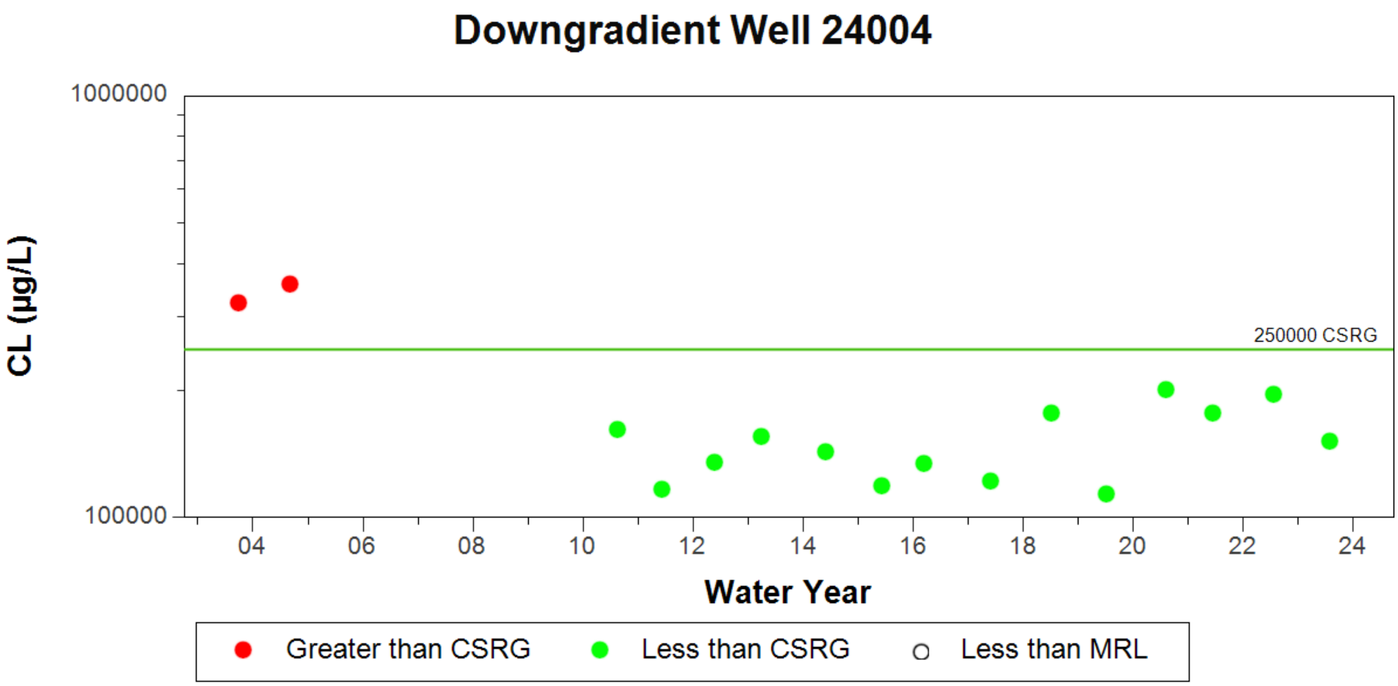

Downgradient Well 23434
10000000
100000
CL (µg/L)
250000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

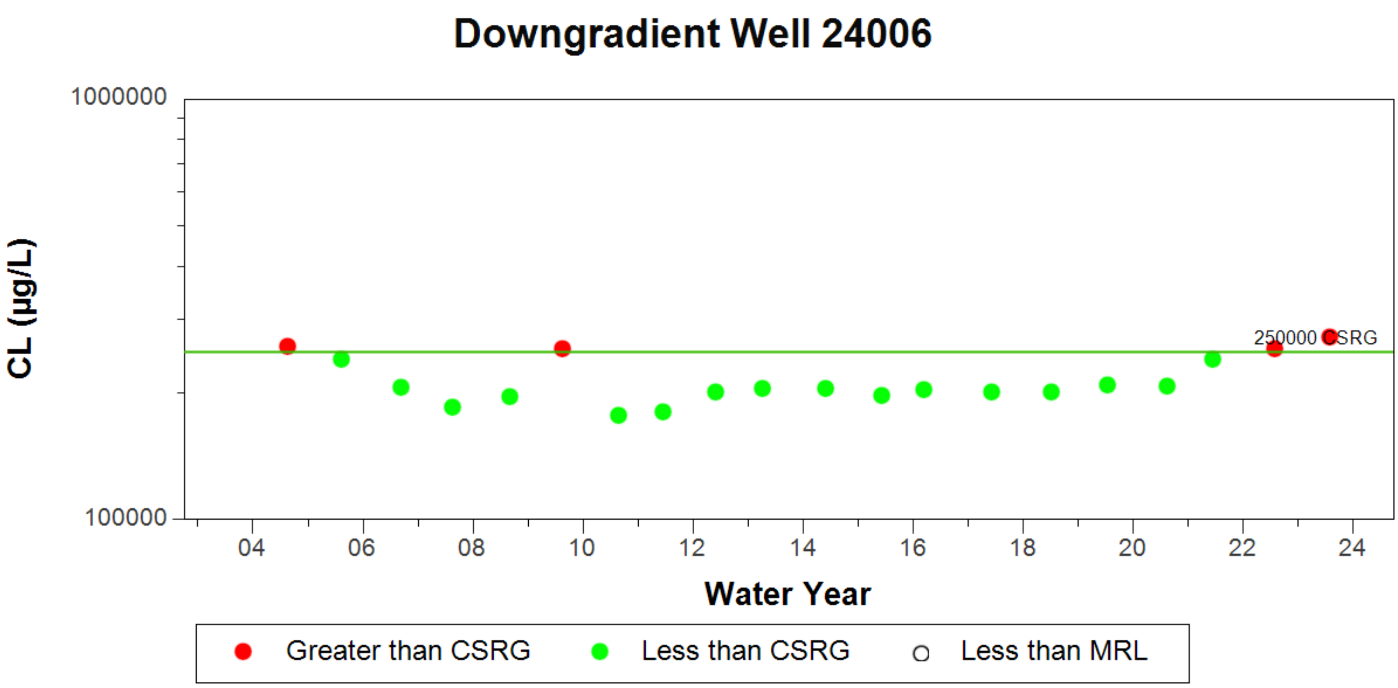
Downgradient Well 23436



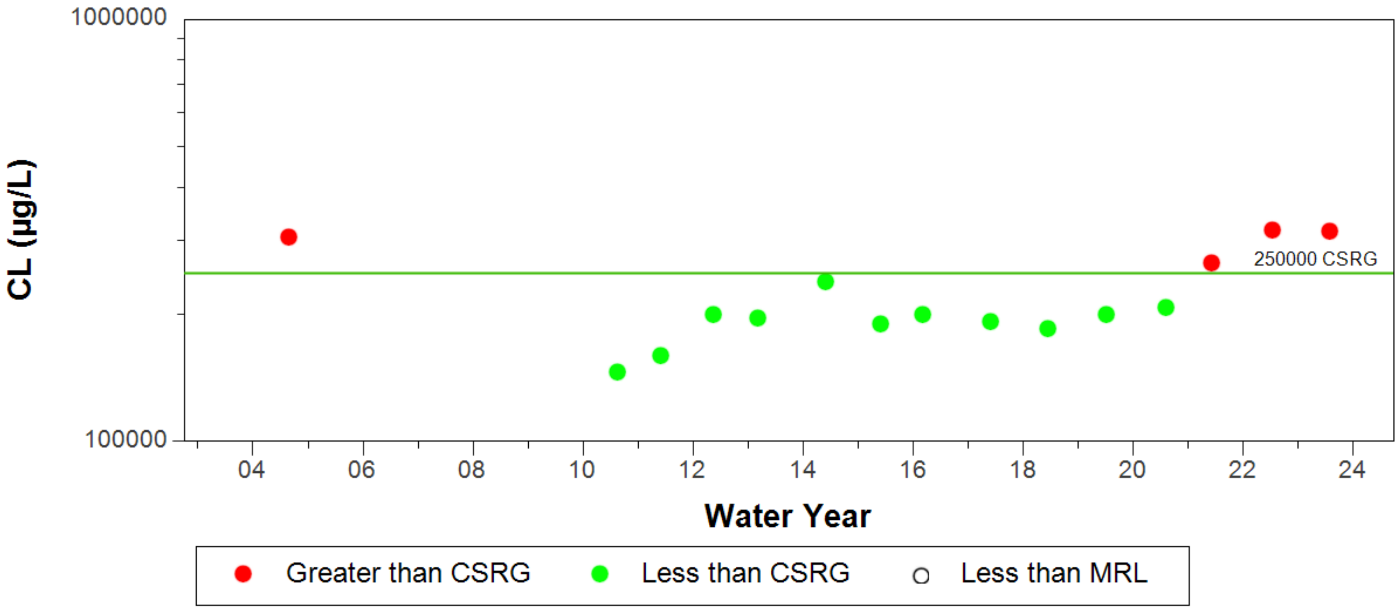
Downgradient Well 23438



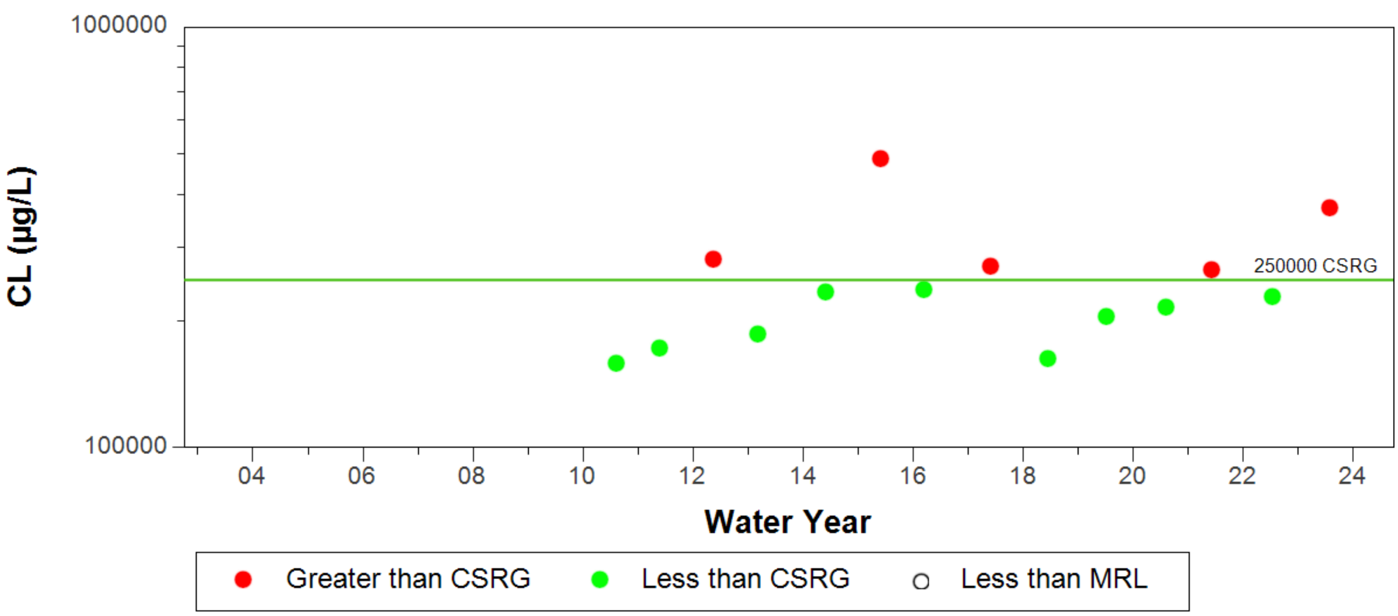

Downgradient Well 24004
1000000
100000
CL (µg/L)
250000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

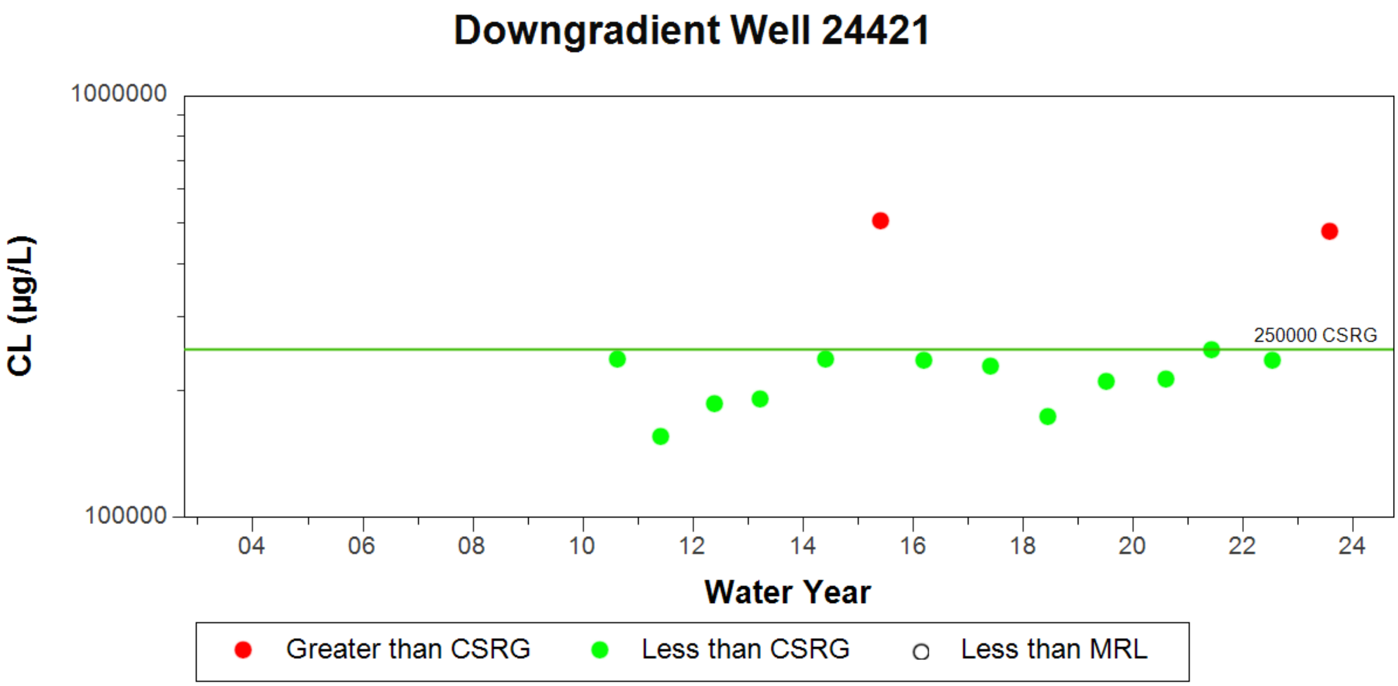

Downgradient Well 24006
1000000
100000
CL (µg/L)
250000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

Downgradient Well 24415

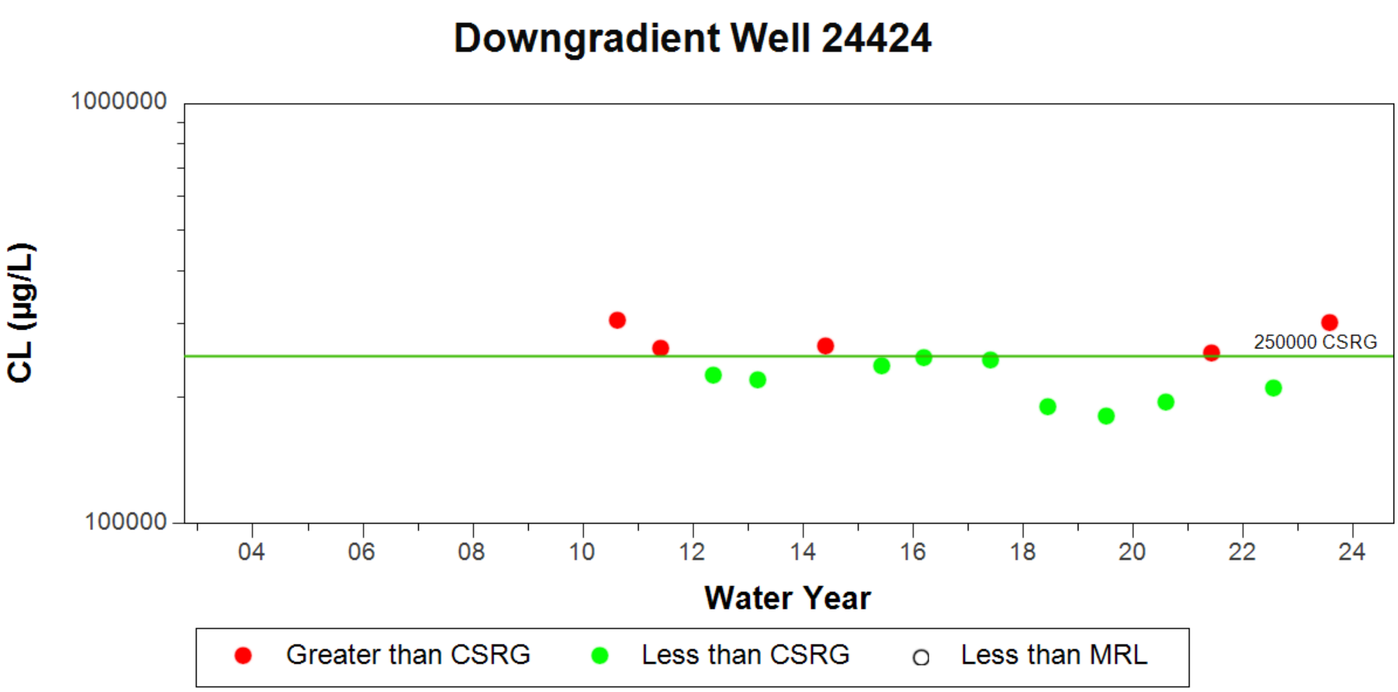


Downgradient Well 24418



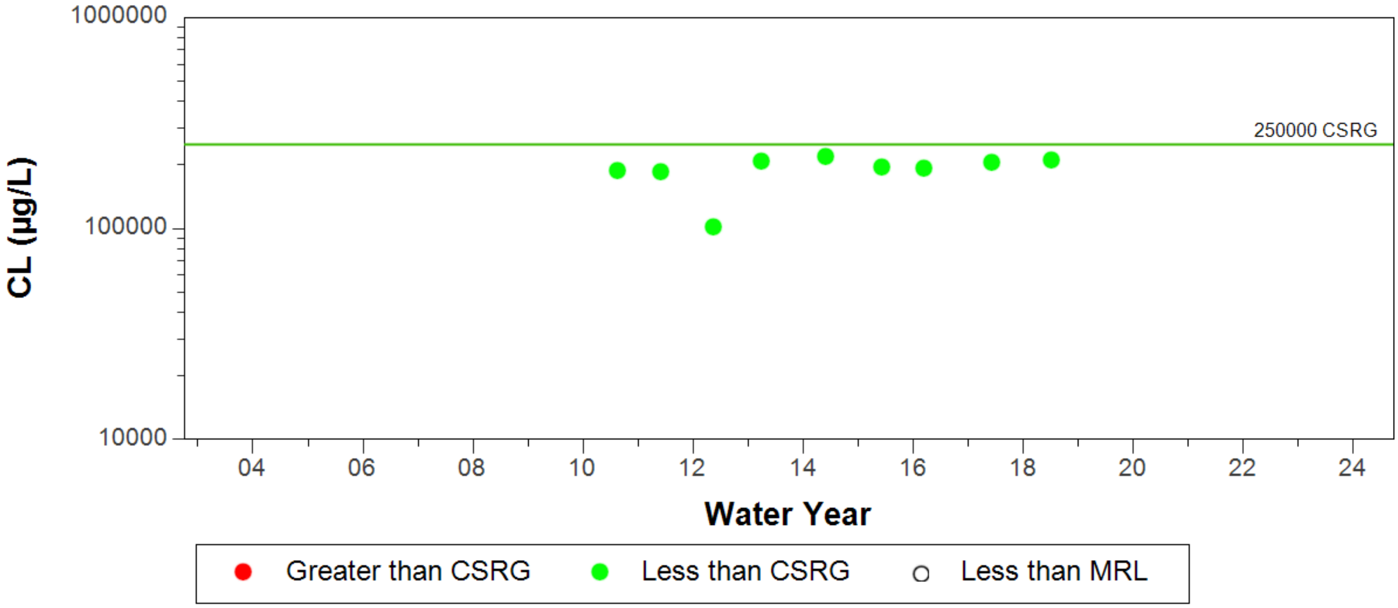


Downgradient Well 24421
1000000
100000
CL (µg/L)
250000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

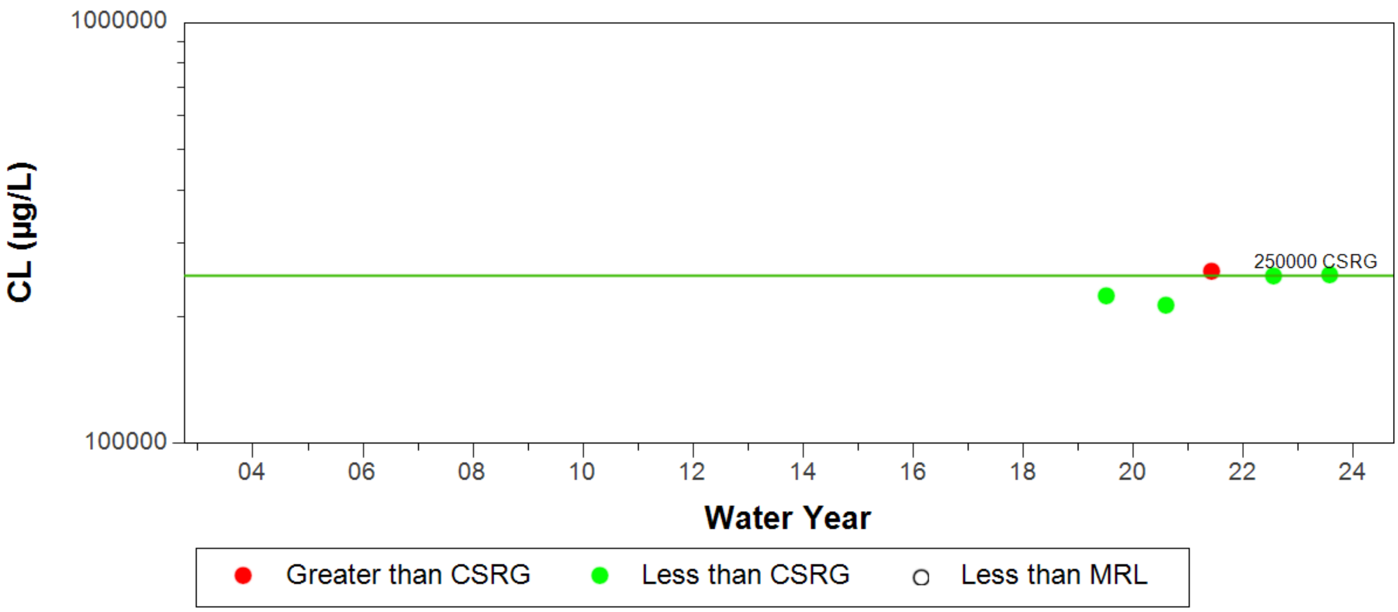


Downgradient Well 24424
1000000
100000
CL (µg/L)
250000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

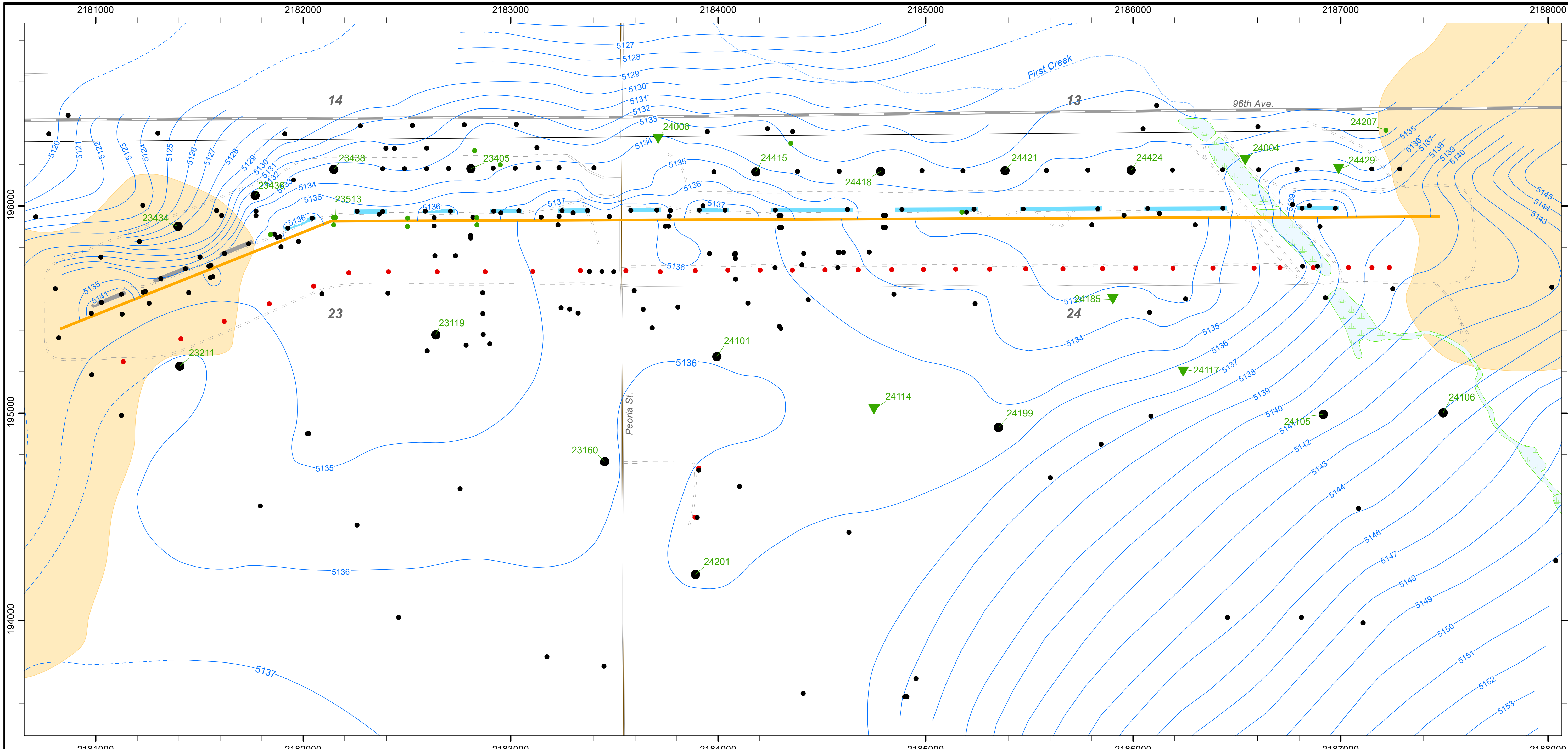
Downgradient Well 37362



Well 24429



Downgradient performance Well 24207 replaced Well 37362, but it could not be sampled due to insufficient water. Nearby alternate Well 24429 was monitored instead.



Legend

- Unsaturated Alluvium
- Section Lines
- Water elevation contour - 1-foot interval
- Inferred water elevation contour
- Wetlands
- Intermittent Streams
- Ditches
- Slurry Walls
- Recharge Trenches
- Inactive Recharge Trenches
- Unimproved Roads
- Local Roads
- Secondary Roads
- Primary Roads
- Monitoring Wells
- Performance Water Quality Wells
- Extraction Wells

Notes: Water levels were measured in FY23 Quarter 2.

Upgradient and Downgradient Performance Well Water Quality

- Analyte Detected Above the CSRG - Increasing Trend Noted
- Analyte Detected Above the CSRG - Decreasing Trend Noted
- Analyte Detected - Showing Stable or No Discernible Trend
- Analyte Not Detected

Notes:
1. Trends are depicted for the 10 year period FY14 - FY23.
2. Time versus concentration charts for Performance Water Quality wells are presented following this map.

N

0 250 500 Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

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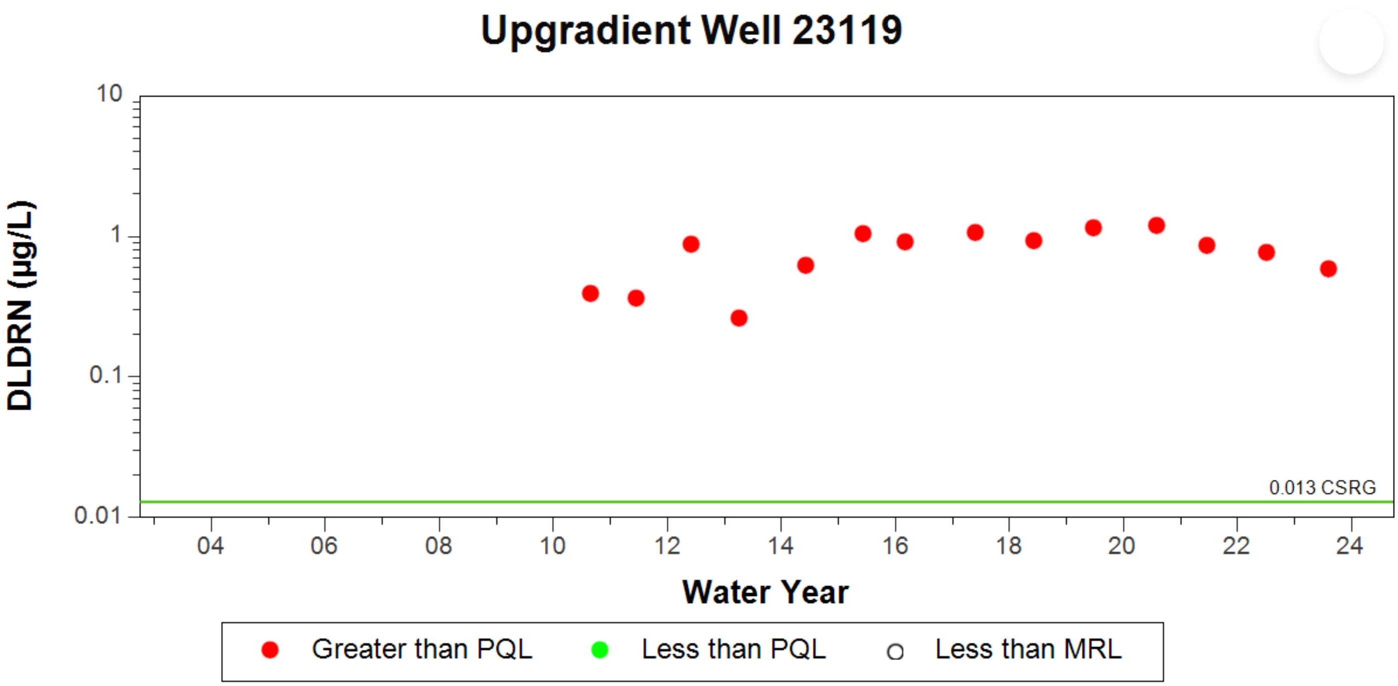
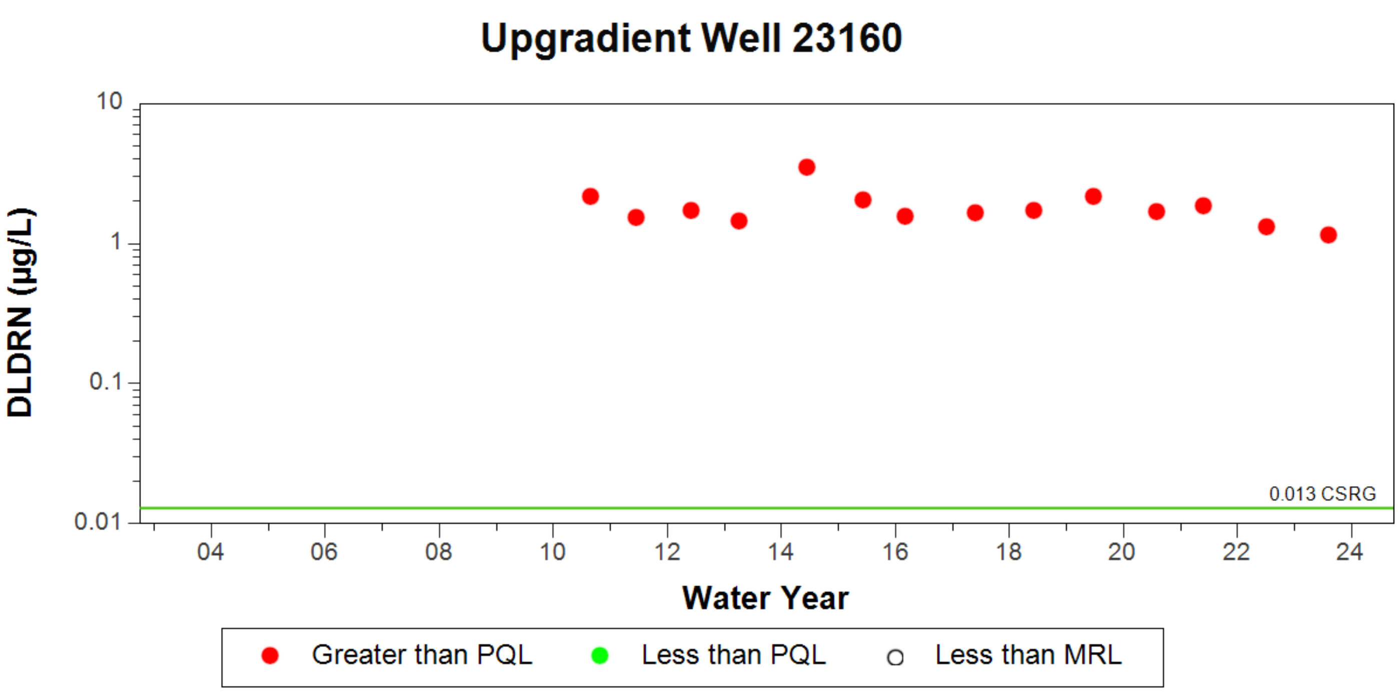
Figure B-30

Dieldrin Concentration Trends in Performance Wells, North Boundary Containment System

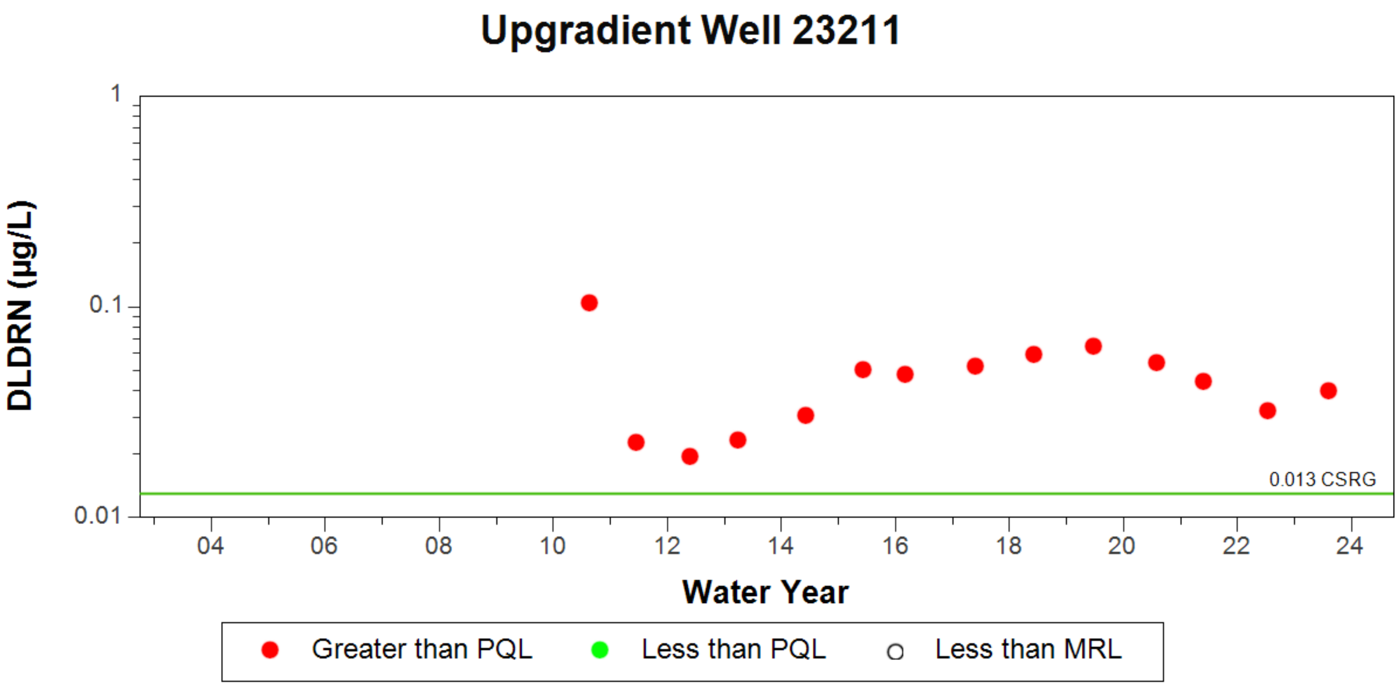
M:\projects\oars\fy23\mxds_NB_FY23_DLDRN.mxd
8/7/2024

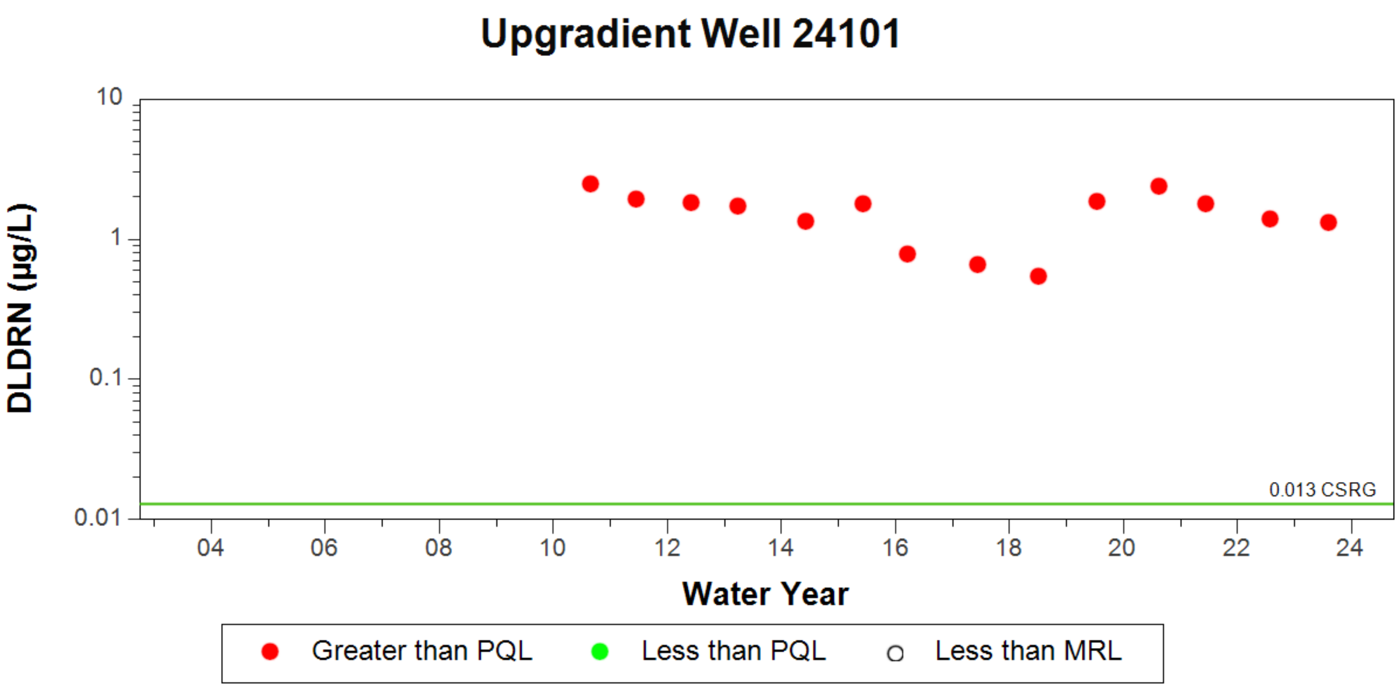


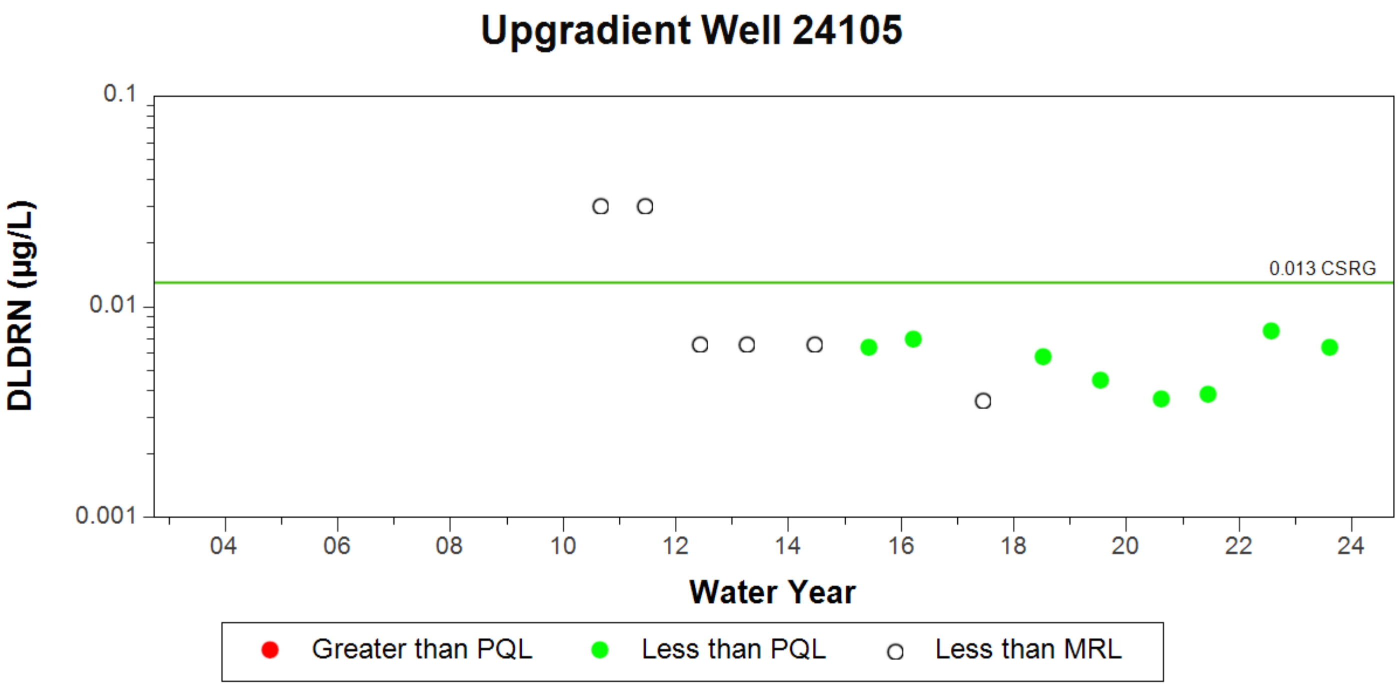
Upgradient Well 23119
DLDRN (µg/L)
10
1
0.1
0.01
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL



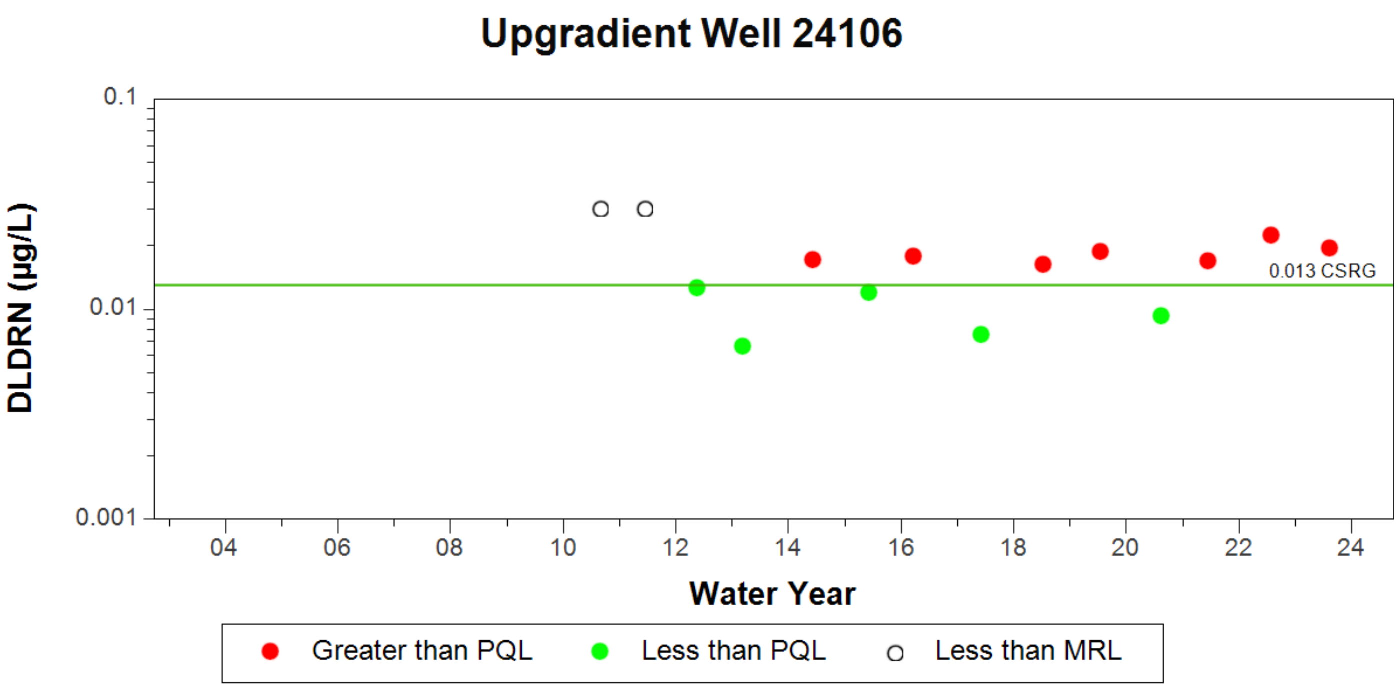
Upgradient Well 23160
DLDRN (µg/L)
10
1
0.1
0.01
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL


Upgradient Well 23211
DLDRN (µg/L)
1
0.1
0.01
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL


Upgradient Well 24101
DLDRN (µg/L)
10
1
0.1
0.01
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

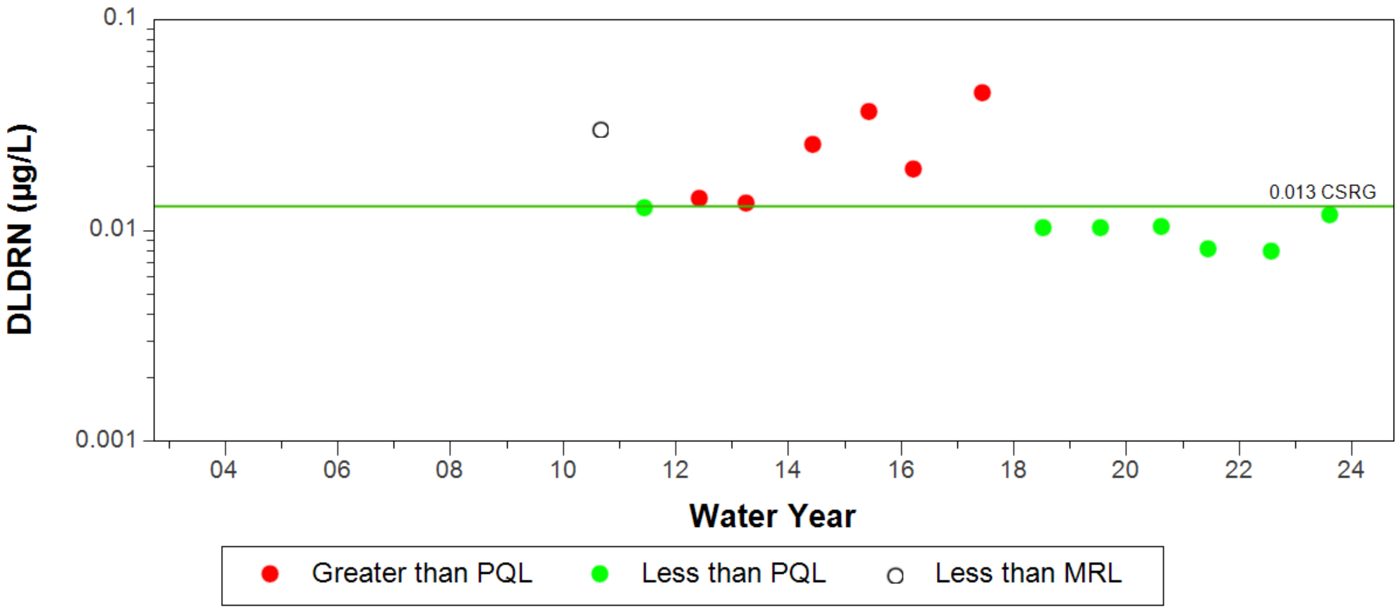


Upgradient Well 24105
DLDRN (µg/L)
0.1
0.01
0.001
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

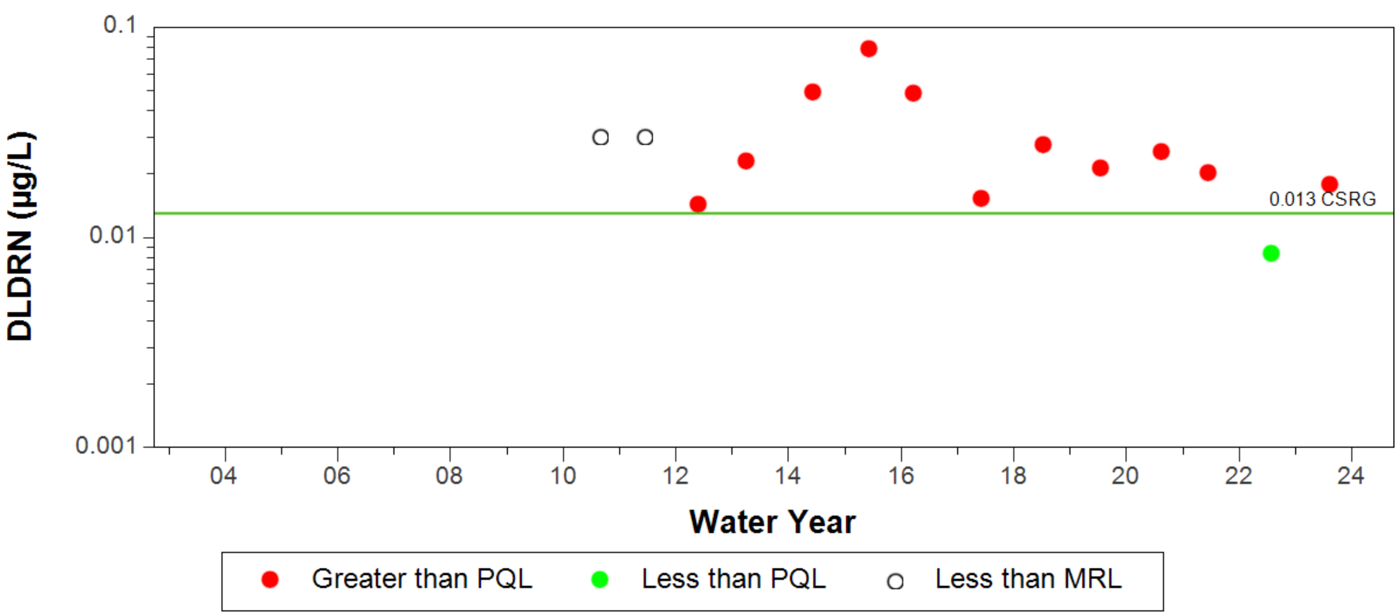


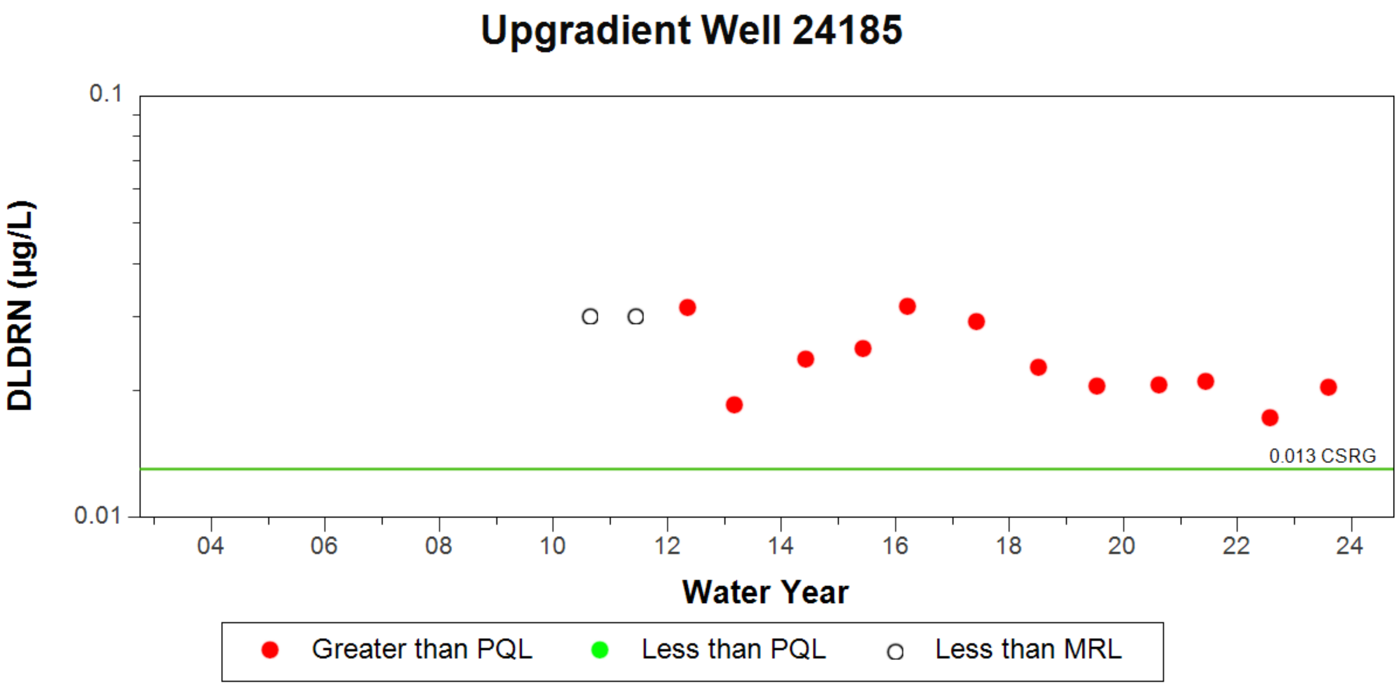
Upgradient Well 24106
DLDRN (µg/L)
0.1
0.01
0.001
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

Upgradient Well 24114

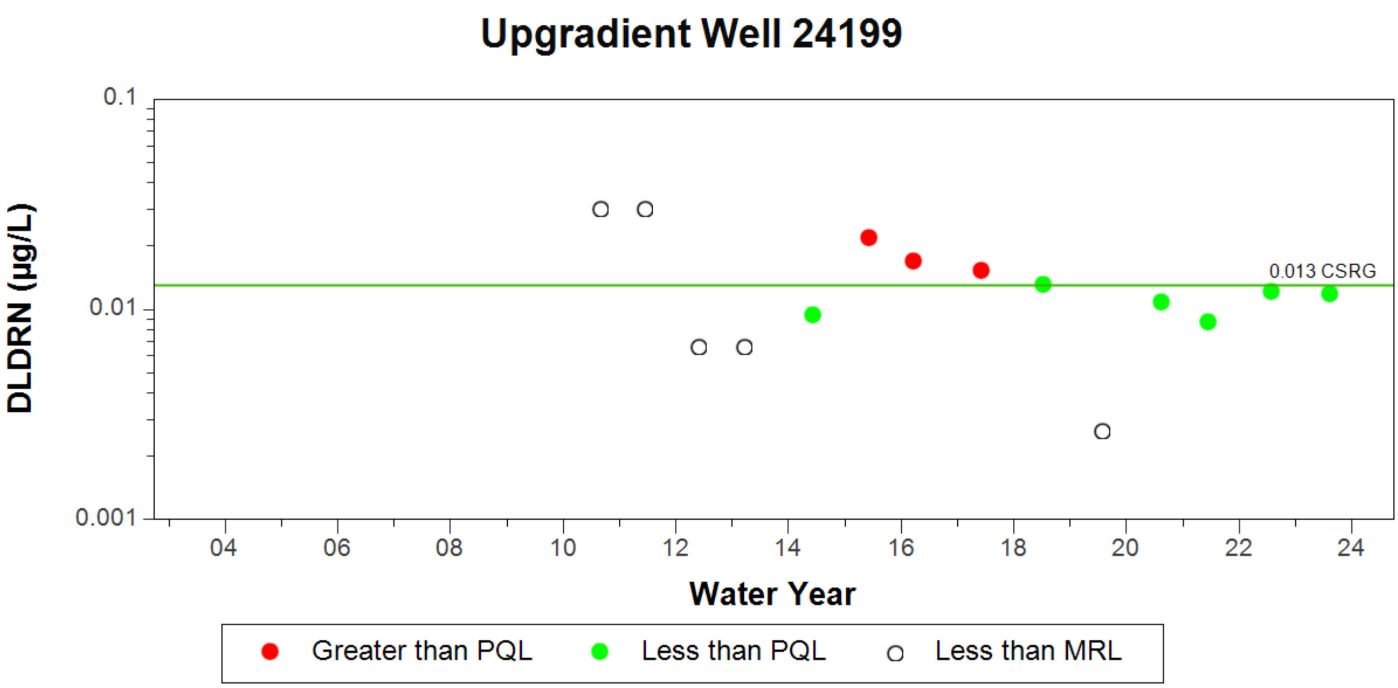


Upgradient Well 24117

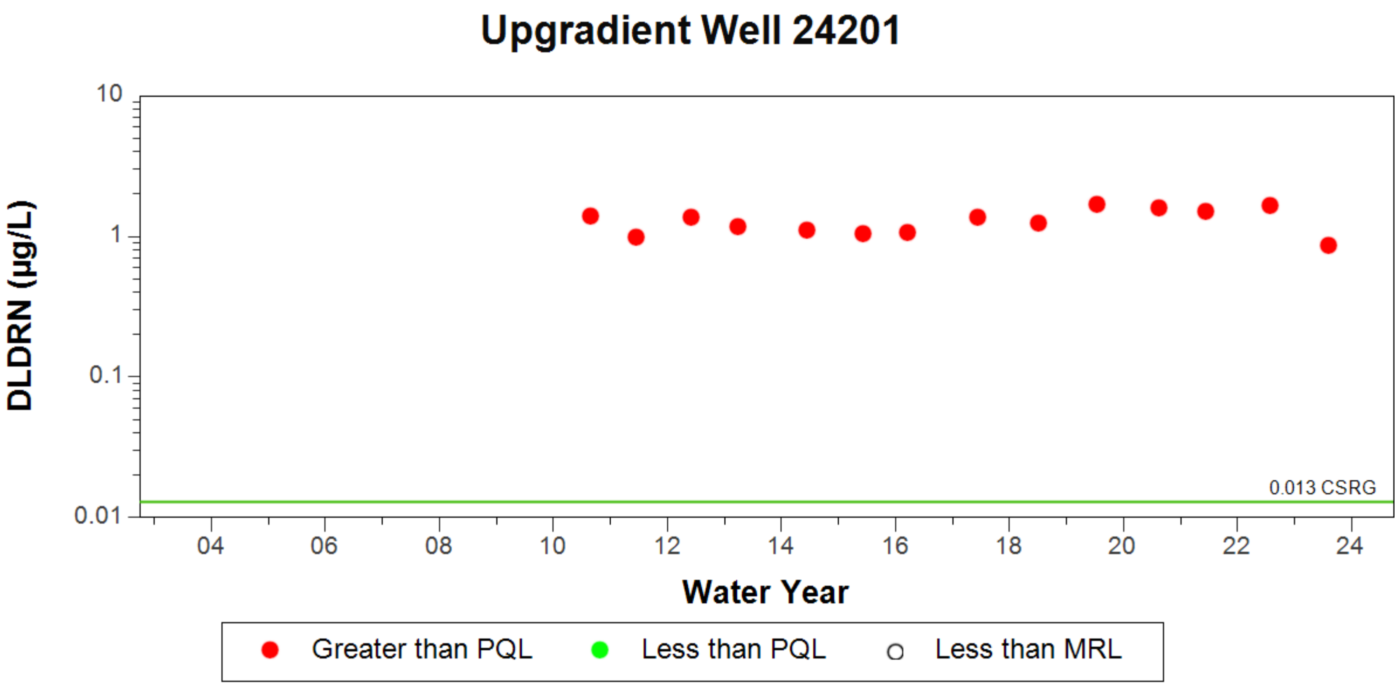




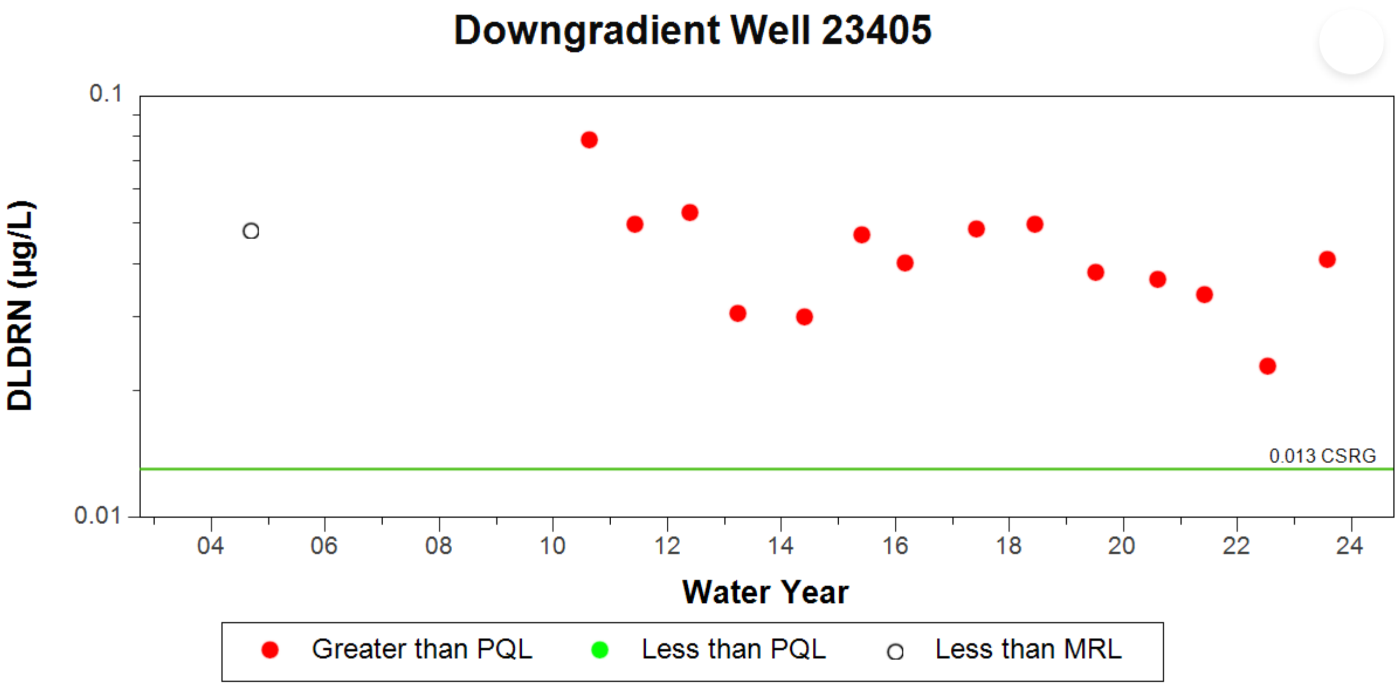
Upgradient Well 24185
DLDRN (µg/L)
0.1
0.01
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

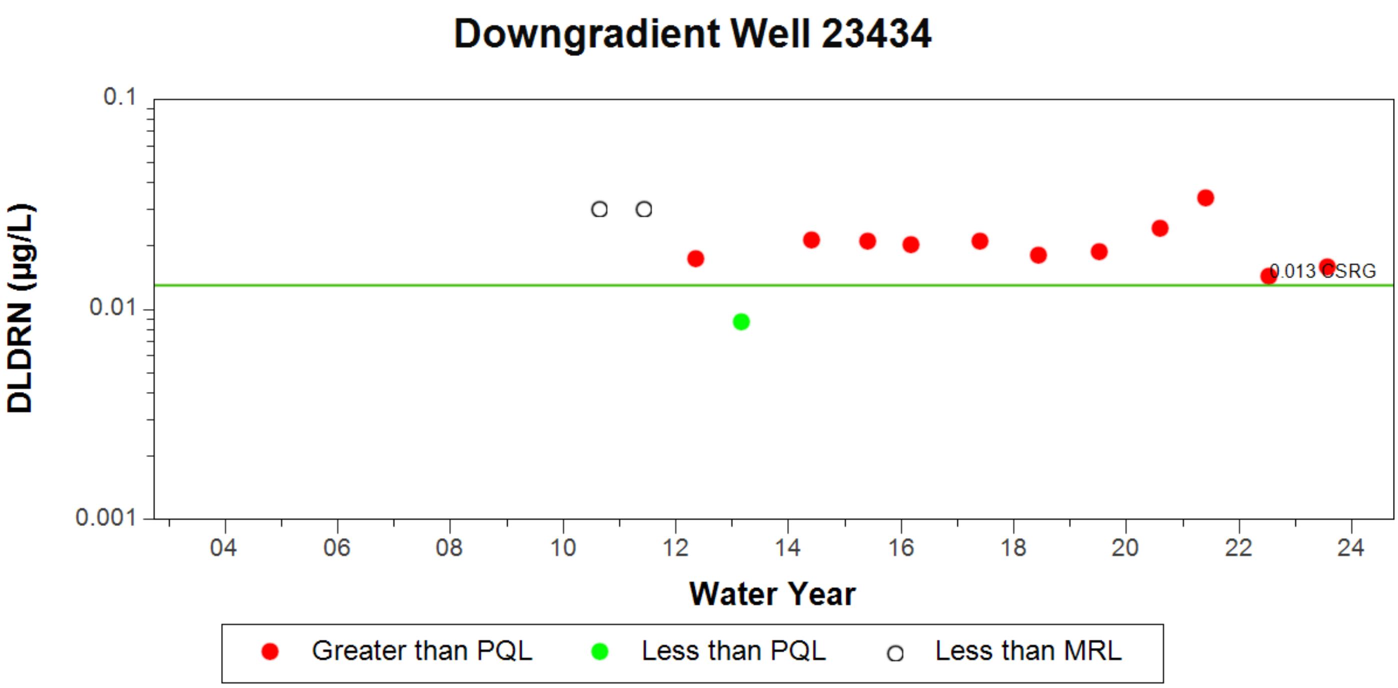


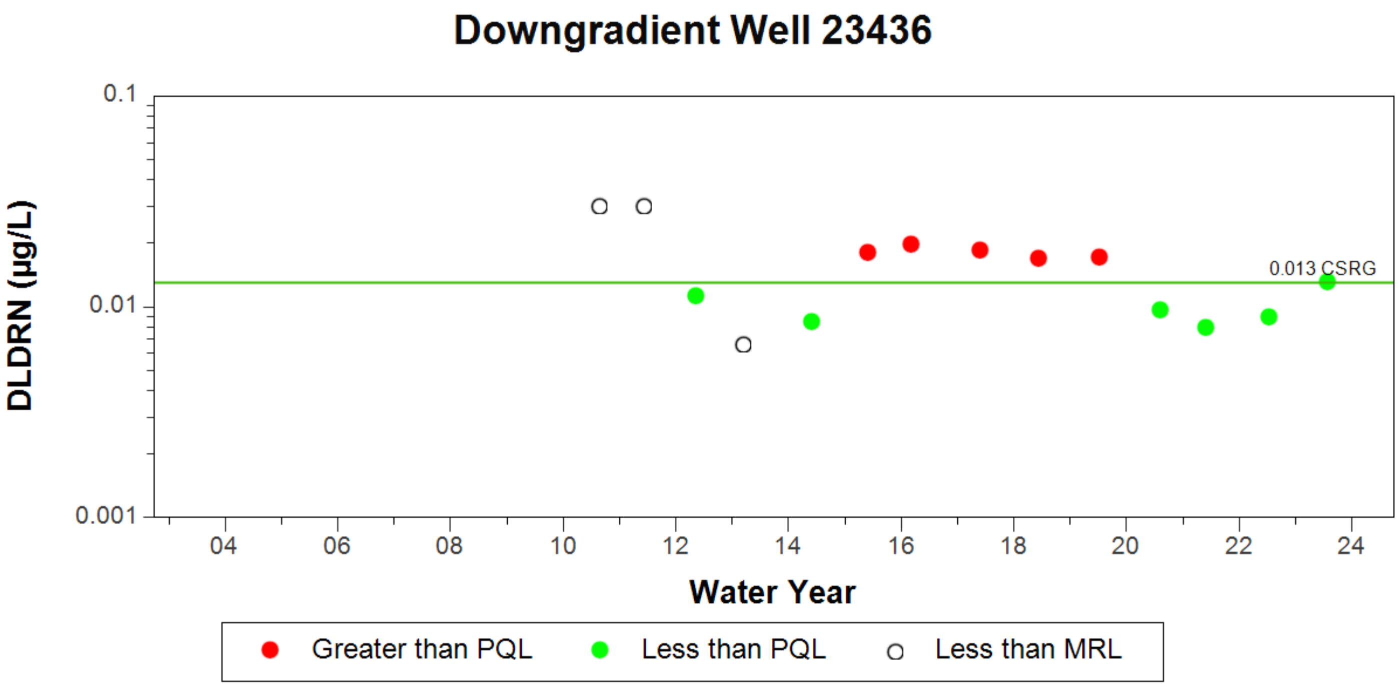
Upgradient Well 24199
DLDRN (µg/L)
0.1
0.01
0.001
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL



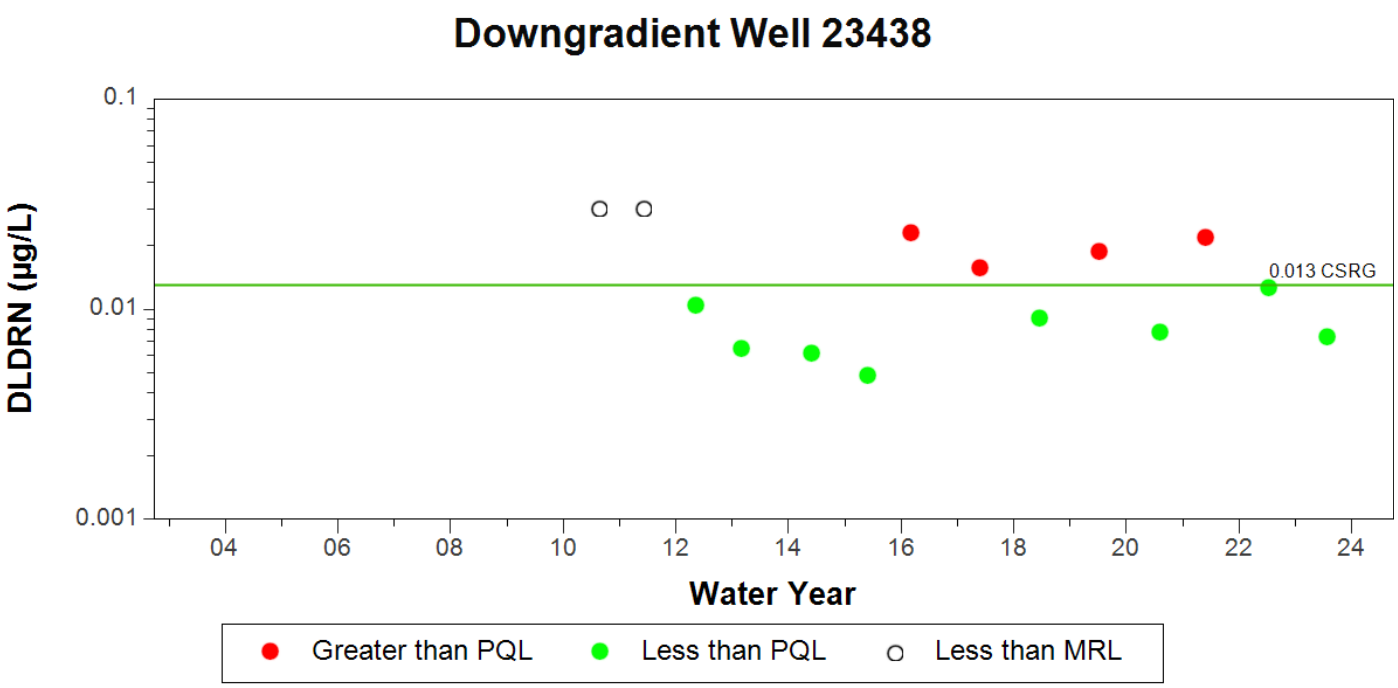
Upgradient Well 24201
DLDRN (µg/L)
10
1
0.1
0.01
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL


Downgradient Well 23405
DLDRN (µg/L)
0.1
0.01
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL


Downgradient Well 23434
DLDRN (µg/L)
0.1
0.01
0.001
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

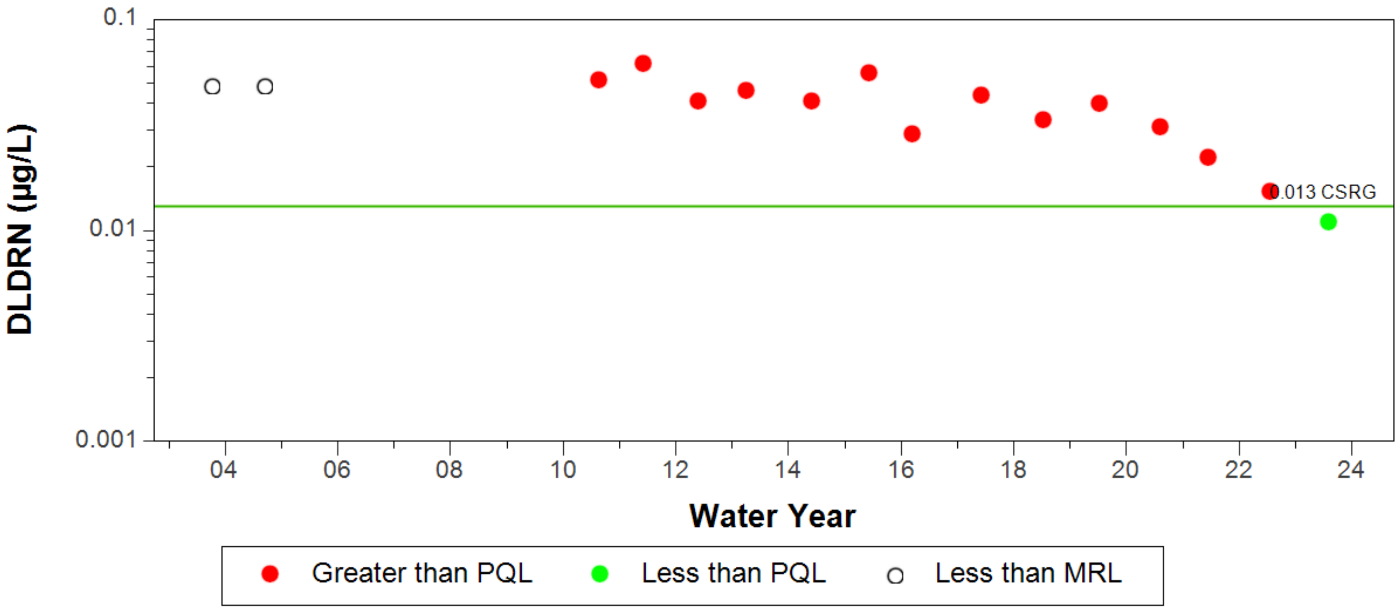


Downgradient Well 23436
DLDRN (µg/L)
0.1
0.01
0.001
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

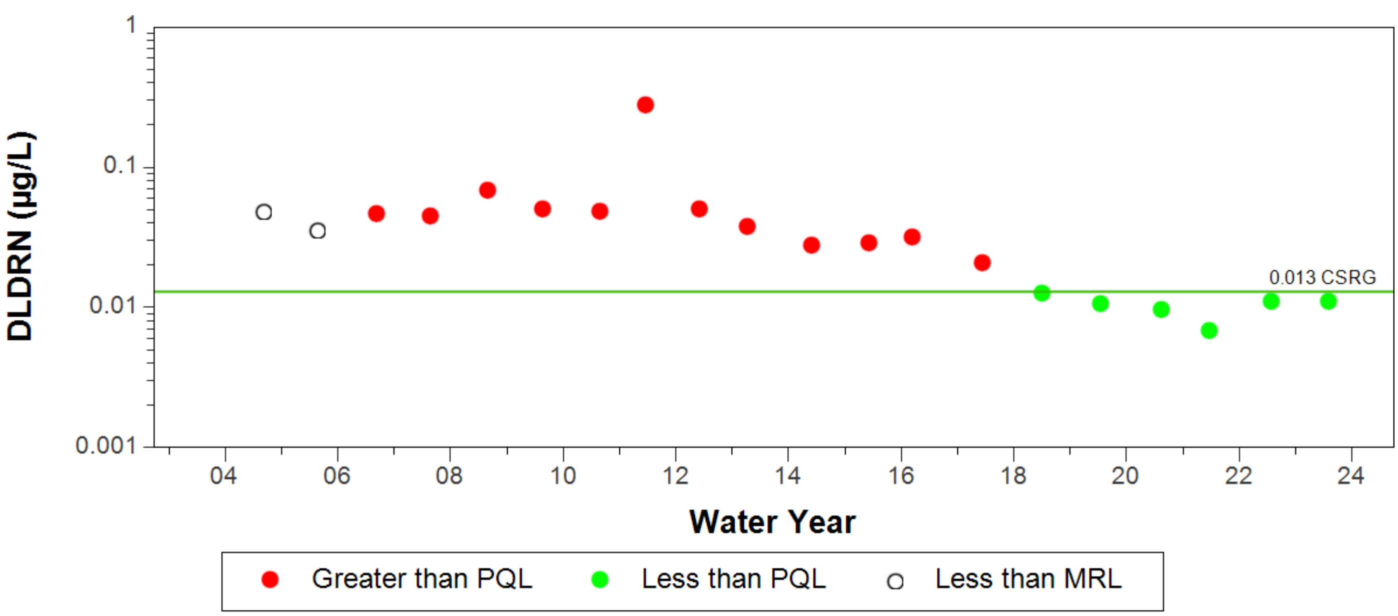


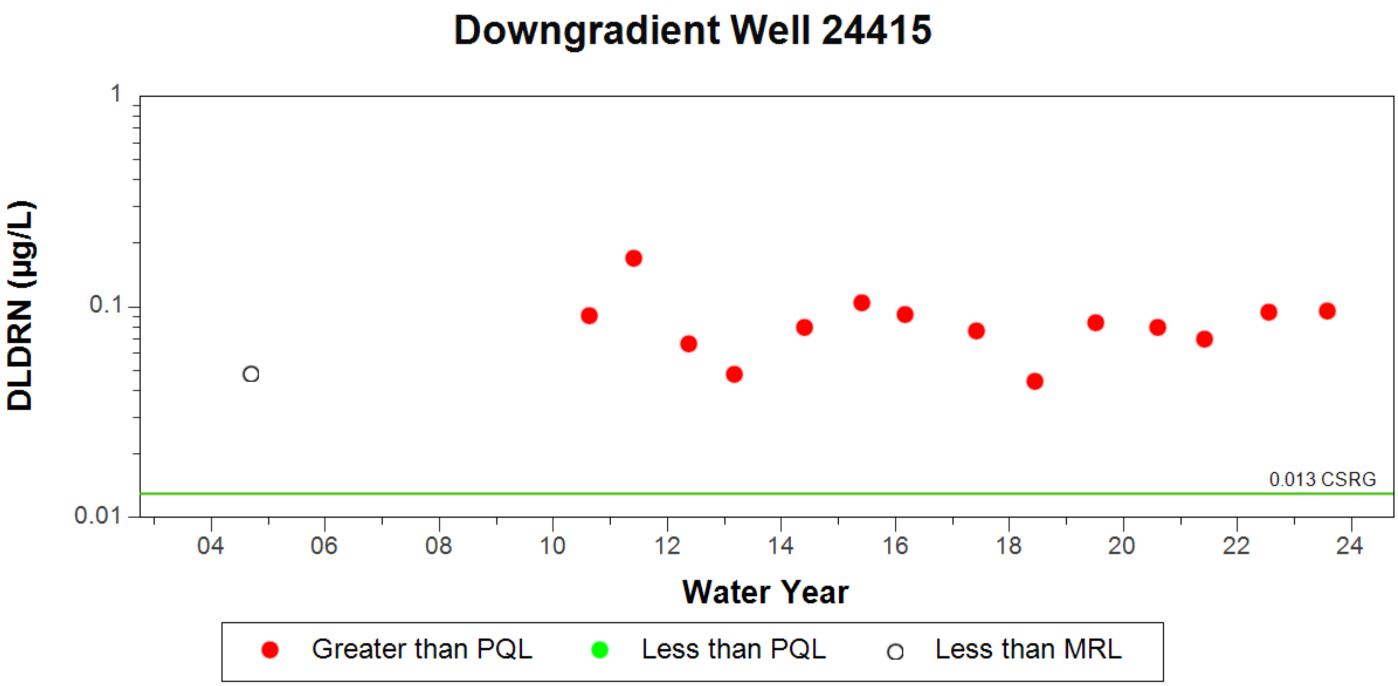
Downgradient Well 23438
DLDRN (µg/L)
0.1
0.01
0.001
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

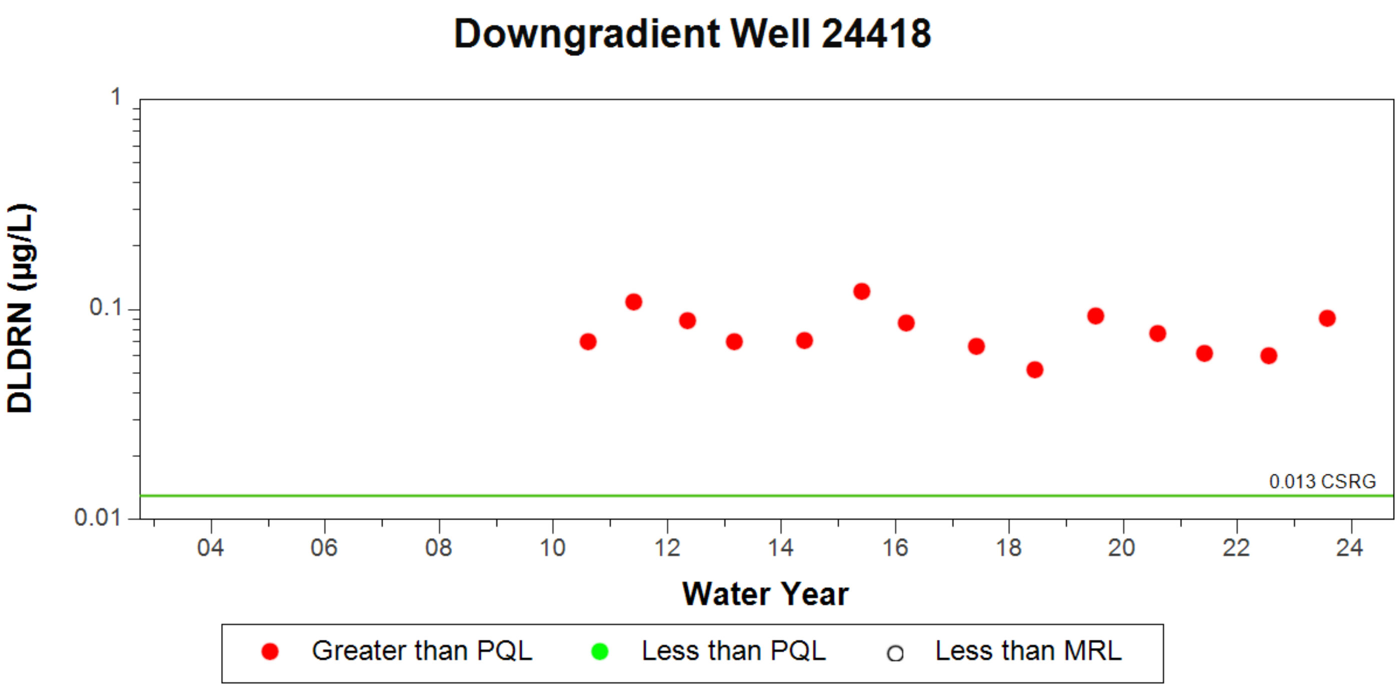
Downgradient Well 24004

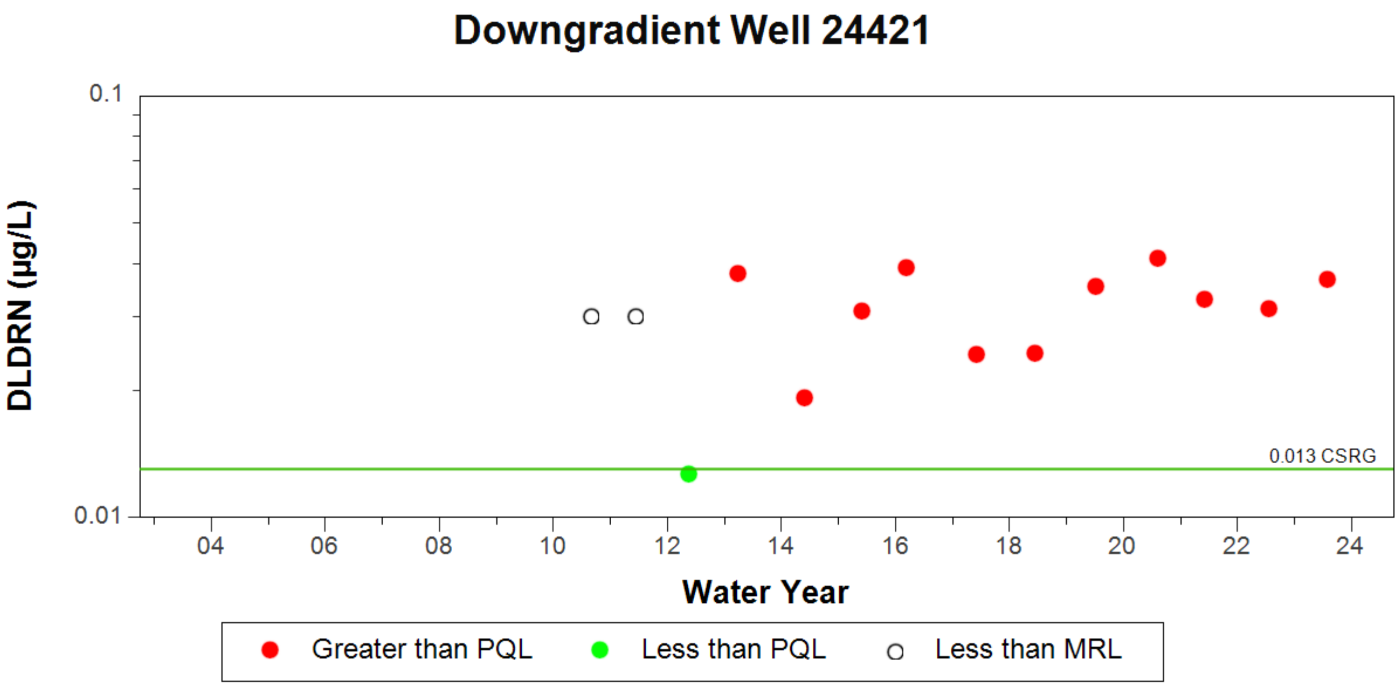


Downgradient Well 24006

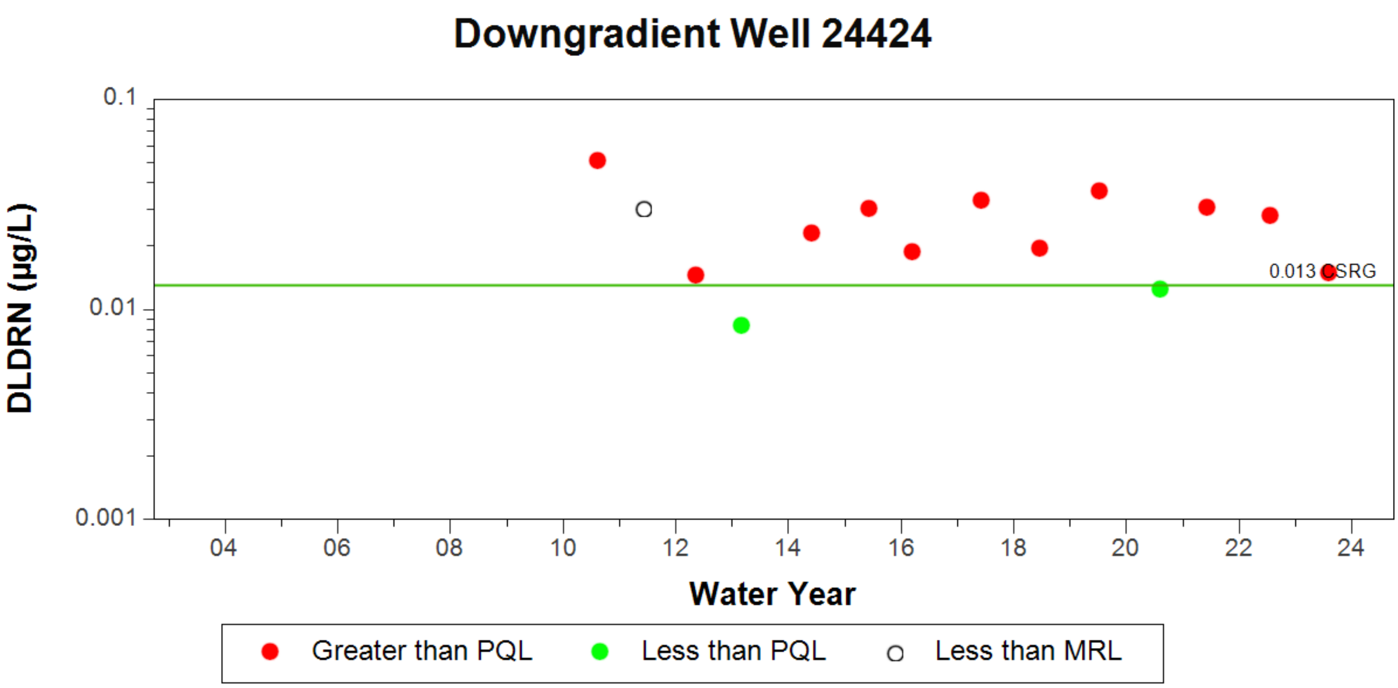



Downgradient Well 24415
DLDRN (µg/L)
1
0.1
0.01
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL


Downgradient Well 24418
DLDRN (µg/L)
1
0.1
0.01
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

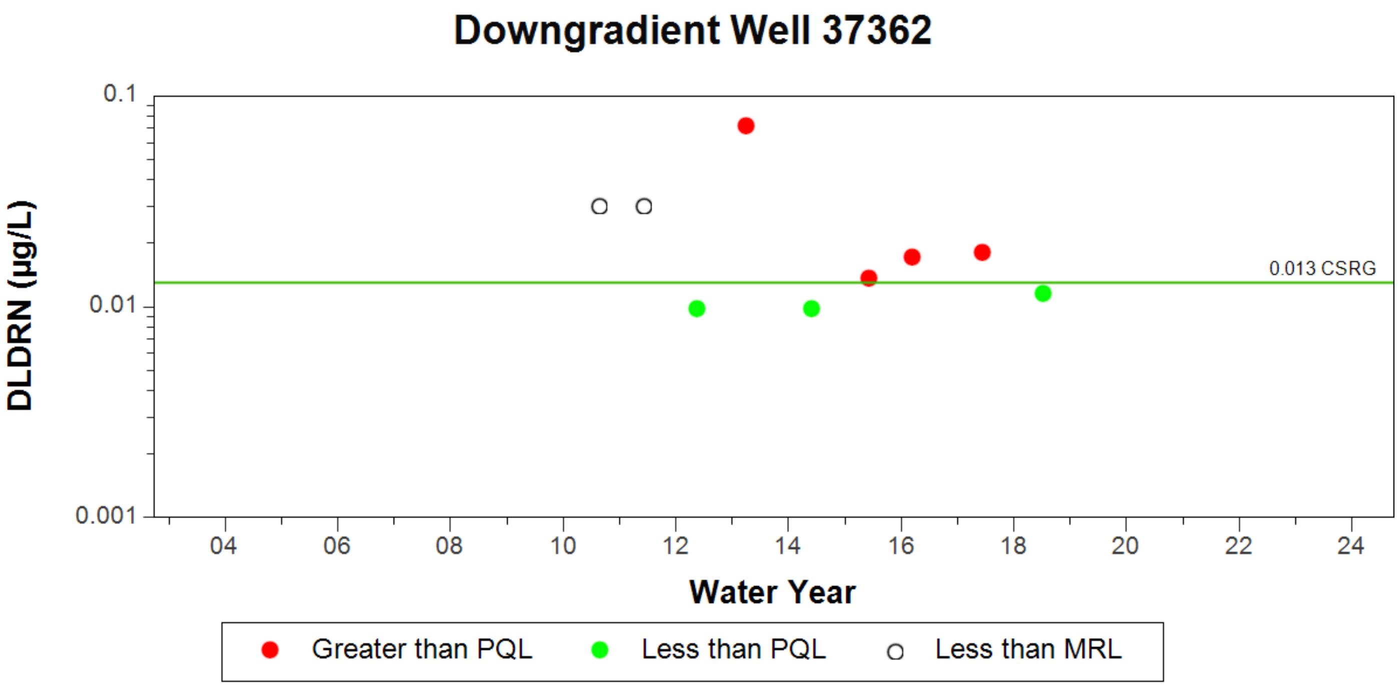


Downgradient Well 24421
0.1
0.01
DLDRN (µg/L)
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

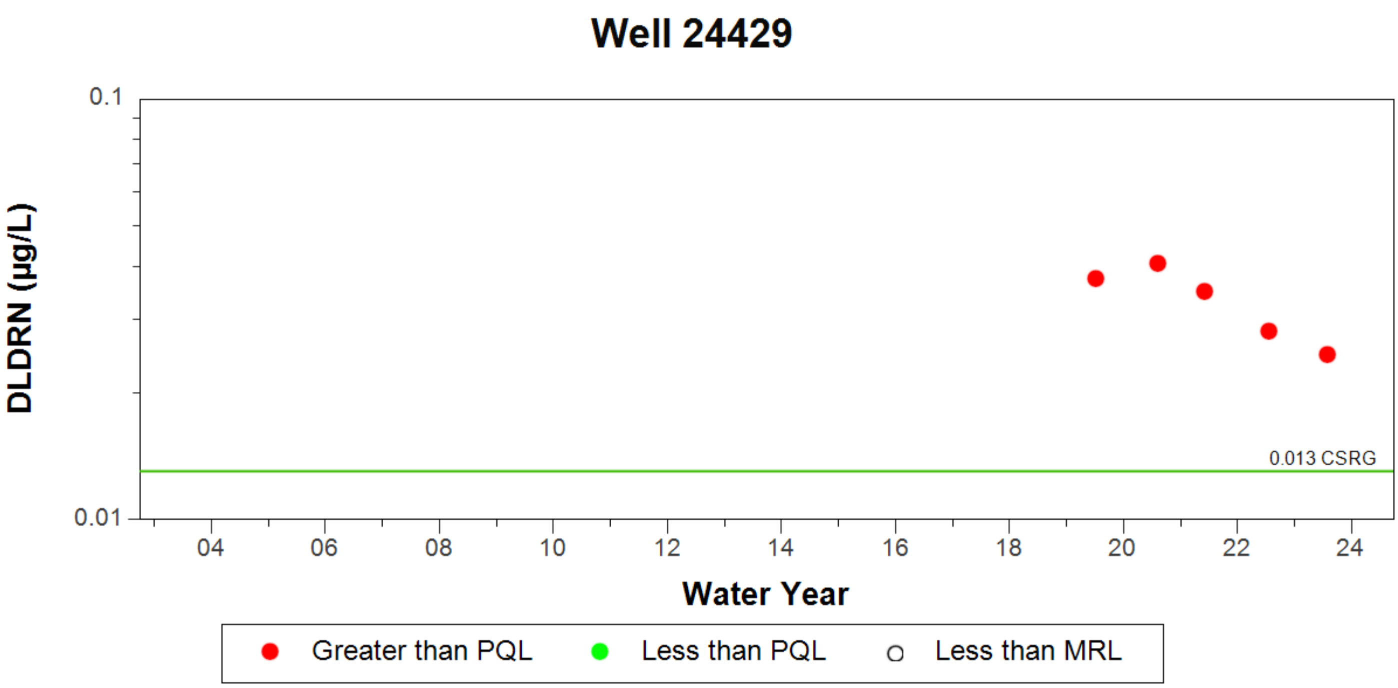


Downgradient Well 24424
0.1
0.01
0.001
DLDRN (µg/L)
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

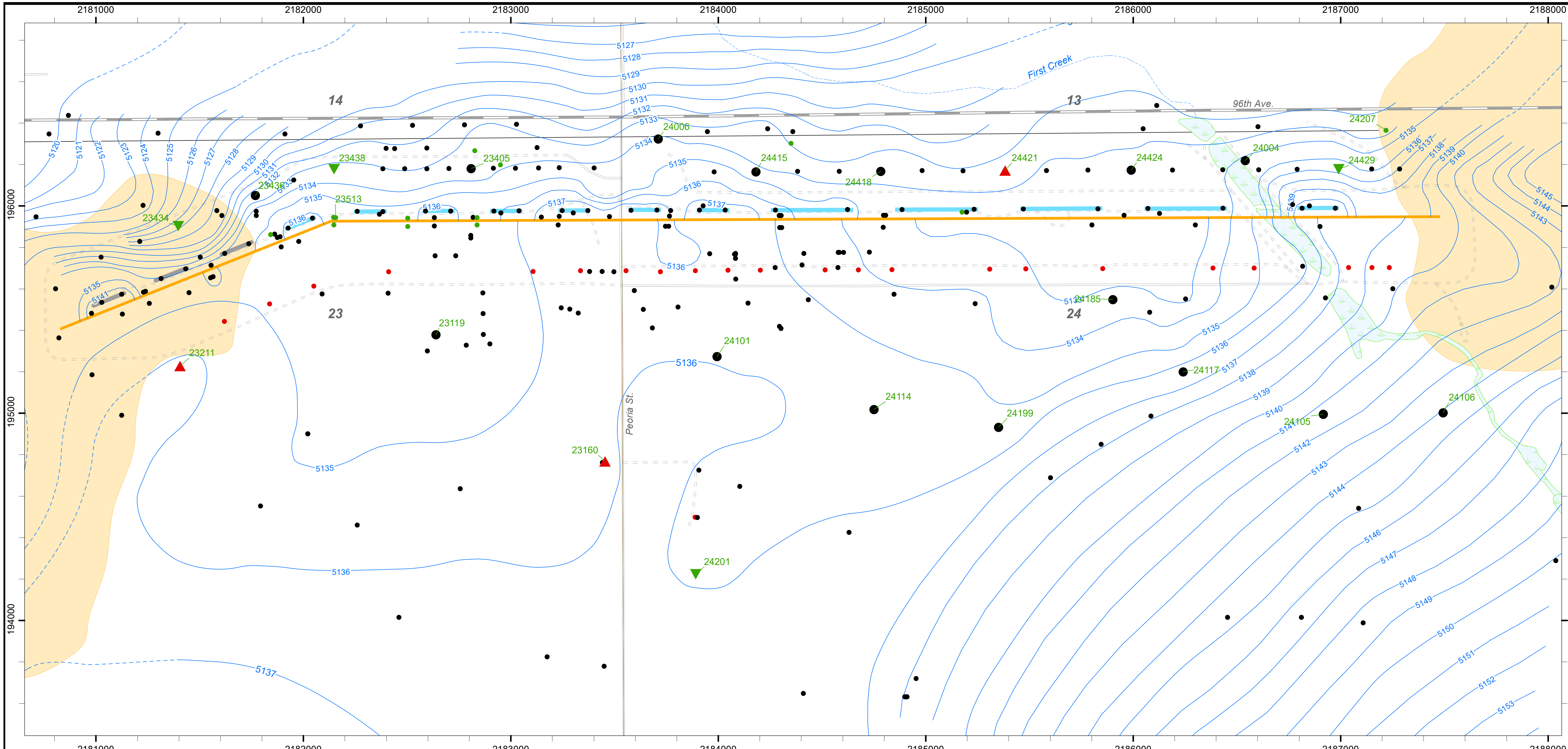
Downgradient Well 37362



Well 24429



Downgradient performance Well 24207 replaced Well 37362, but it could not be sampled due to insufficient water. Nearby alternate Well 24429 was monitored instead.



Legend

- Unsaturated Alluvium
- Section Lines
- Water elevation contour - 1-foot interval
- Inferred water elevation contour
- Wetlands
- Intermittent Streams
- Ditches
- Slurry Walls
- Recharge Trenches
- Inactive Recharge Trenches
- Unimproved Roads
- Local Roads
- Secondary Roads
- Primary Roads
- Monitoring Wells
- Performance Water Quality Wells
- Extraction Wells

Notes: Water levels were measured in FY23 Quartes 2.

Upgradient and Downgradient Performance Well Water Quality

- Analyte Detected Above the CSRG - Increasing Trend Noted
- Analyte Detected Above the CSRG - Decreasing Trend Noted
- Analyte Detected - Showing Stable or No Discernible Trend
- Analyte Not Detected

Notes:
1. Trends are depicted for the 10 year period FY14 - FY23.
2. Time versus concentration charts for Performance Water Quality wells are presented following this map.

N

0 250 500 Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

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Rocky Mountain Arsenal

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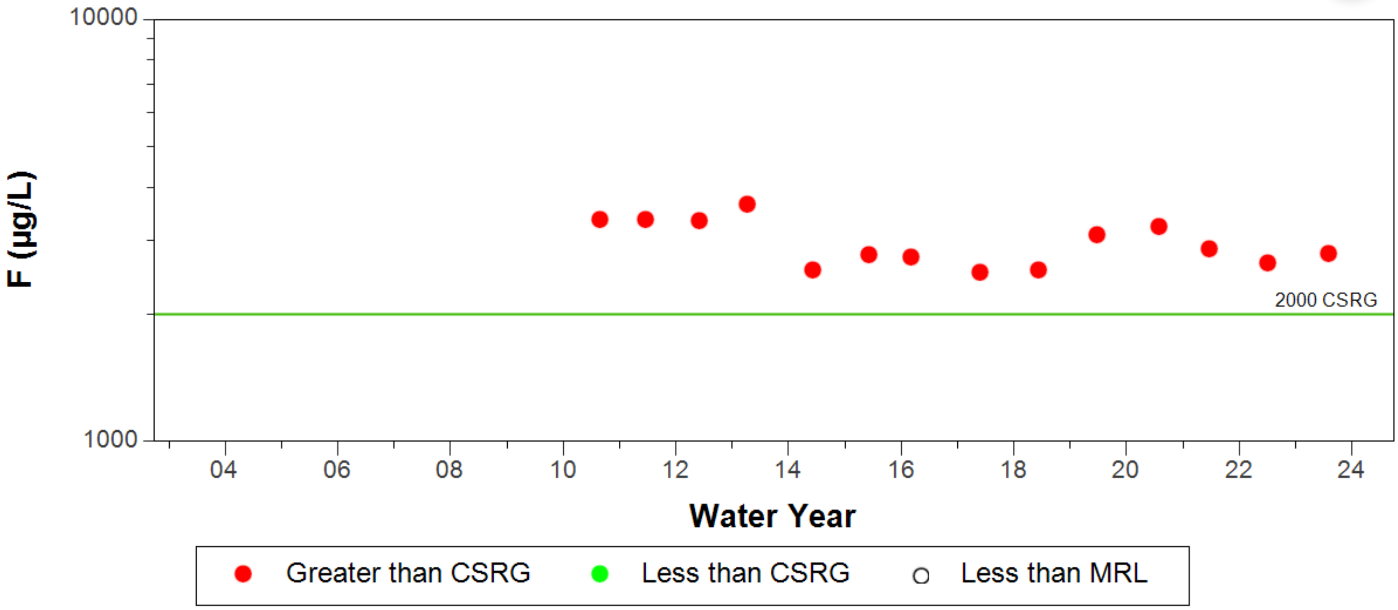
Figure B-31

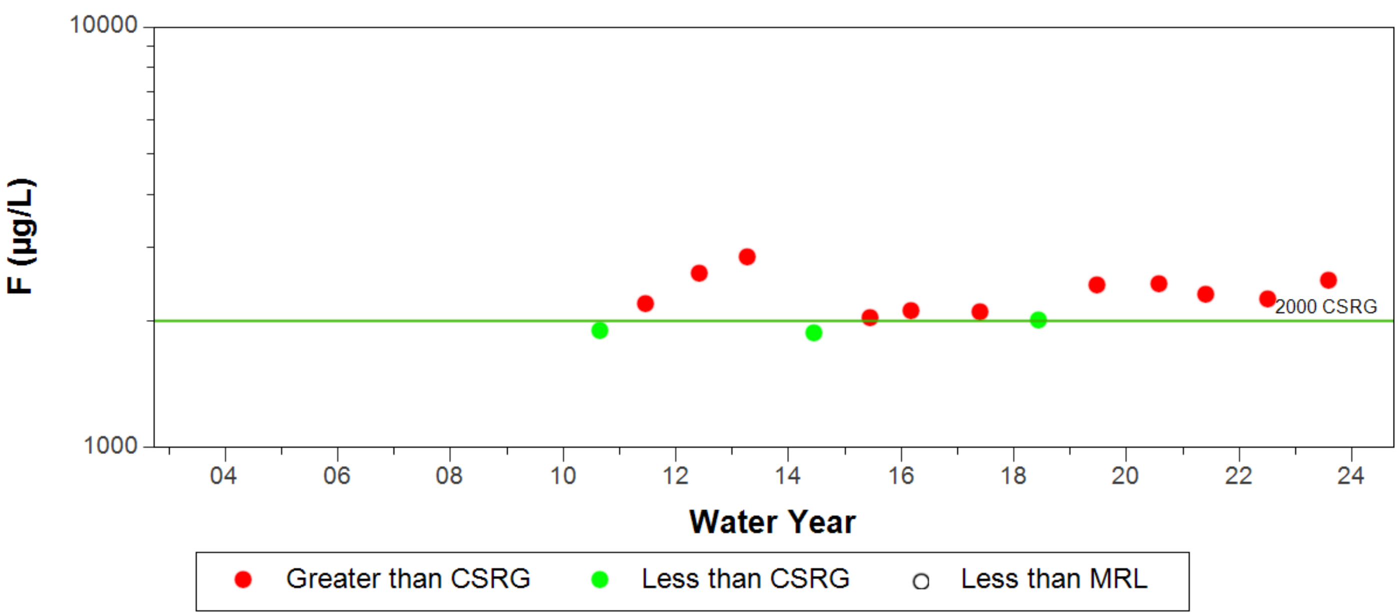
Fluoride Concentration
Trends in Performance Wells,
North Boundary Containment System

M:\projects\oars\fy23\mxds_NB_FY23_F.mxd
8/7/2024

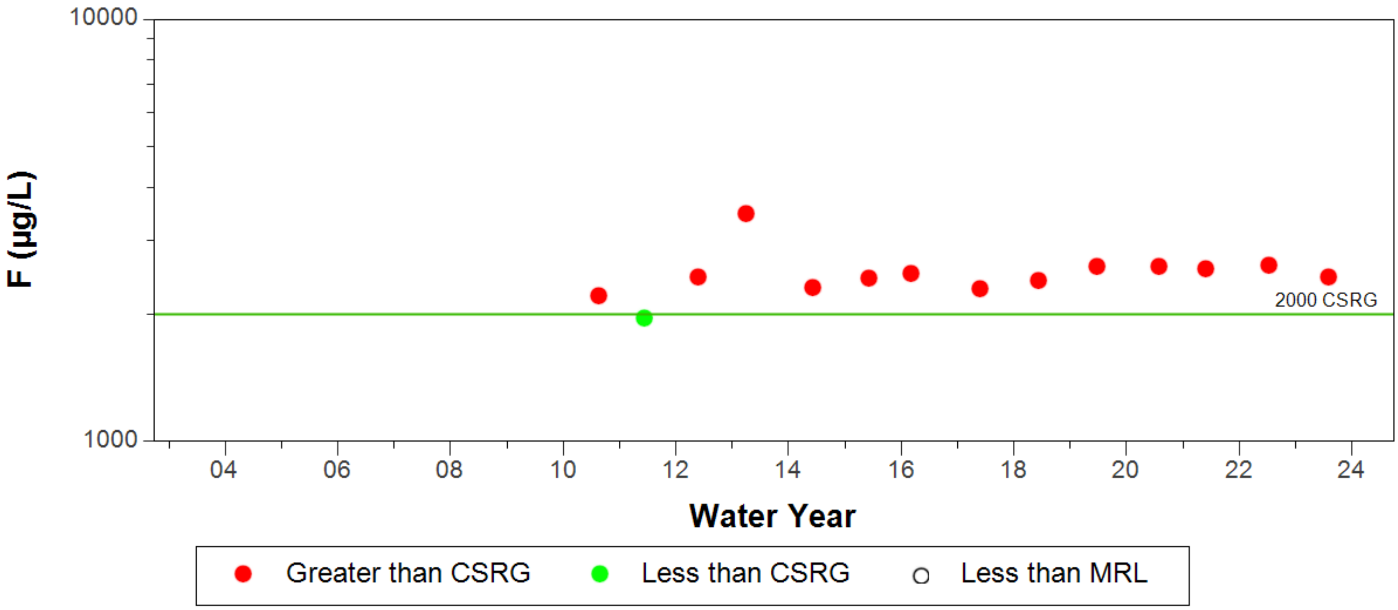
Upgradient Well 23119



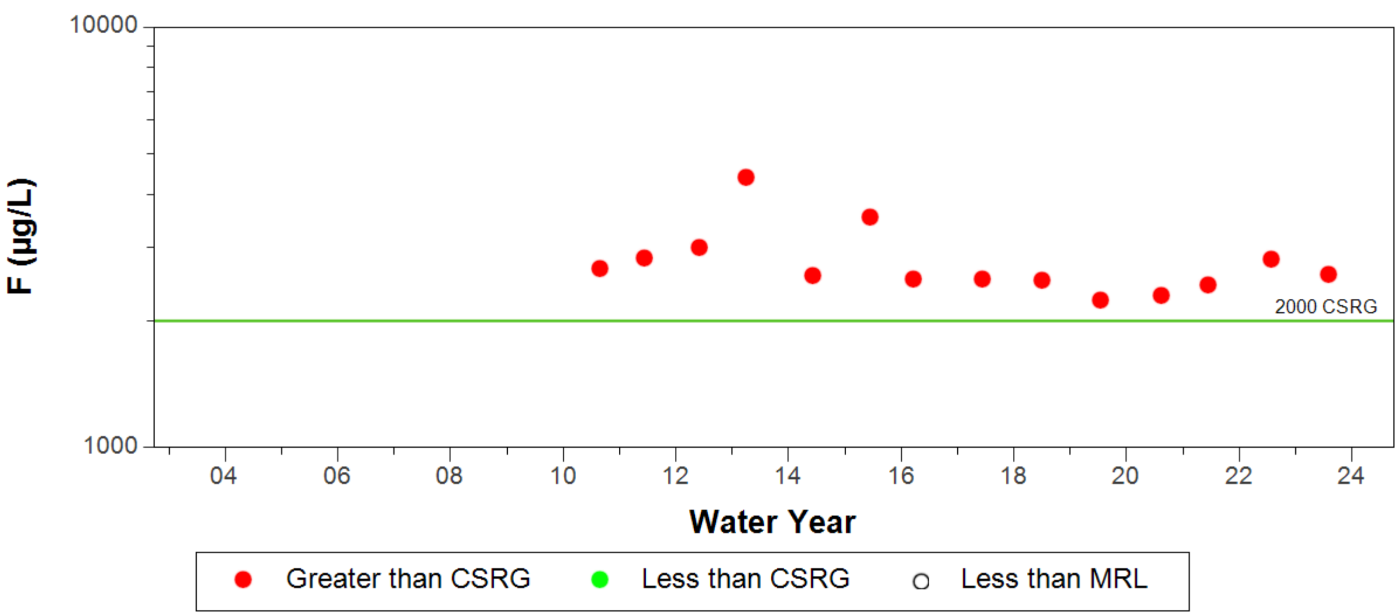
Upgradient Well 23160

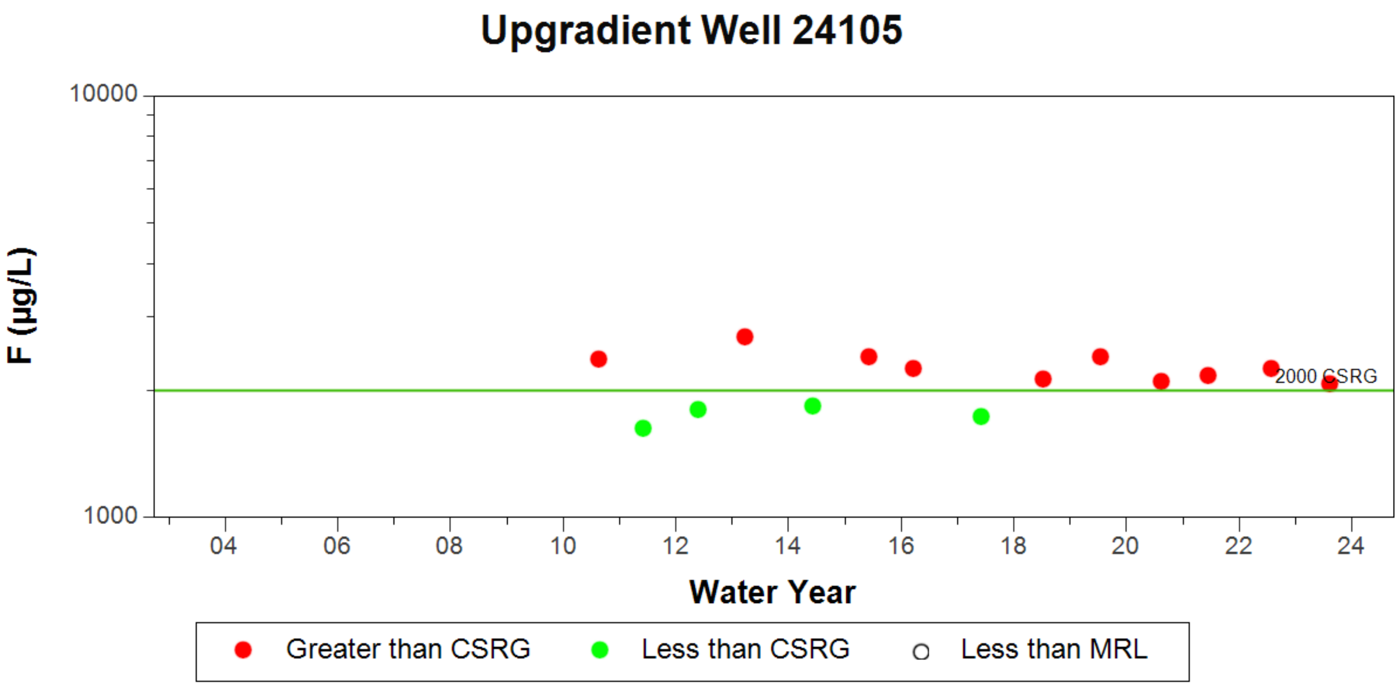


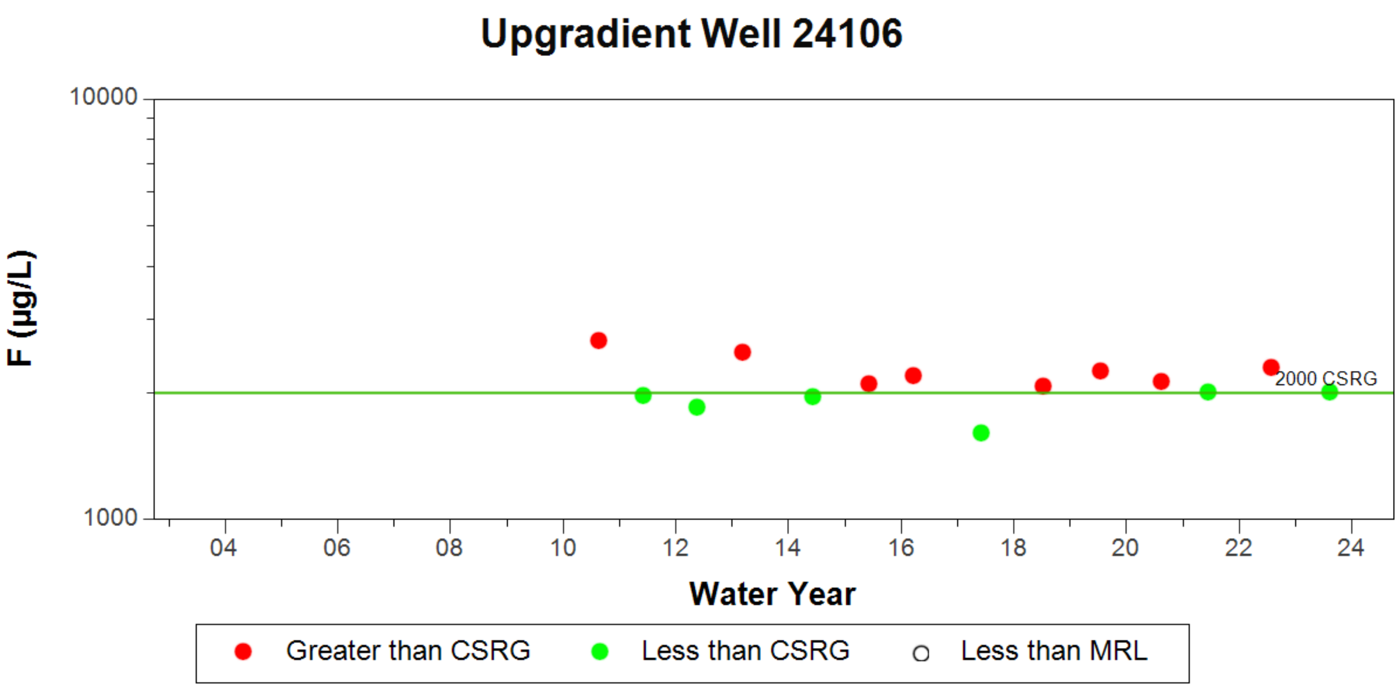
Upgradient Well 23211

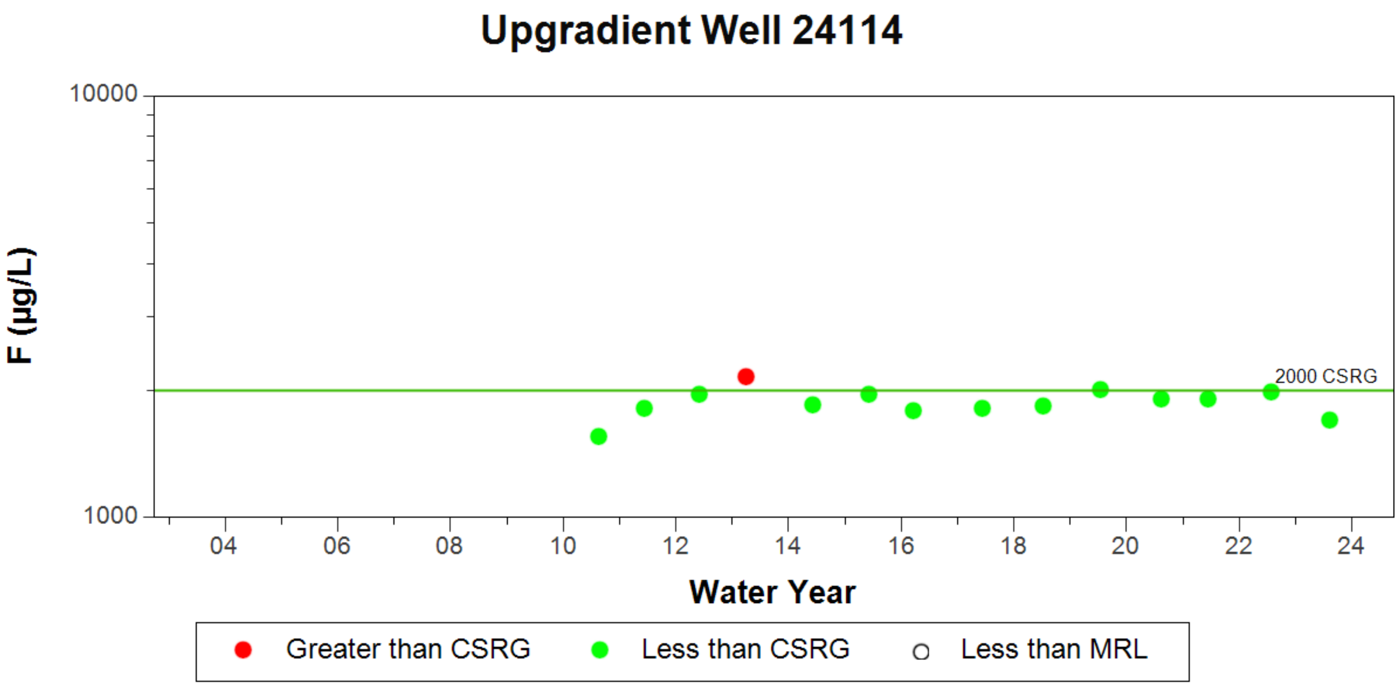


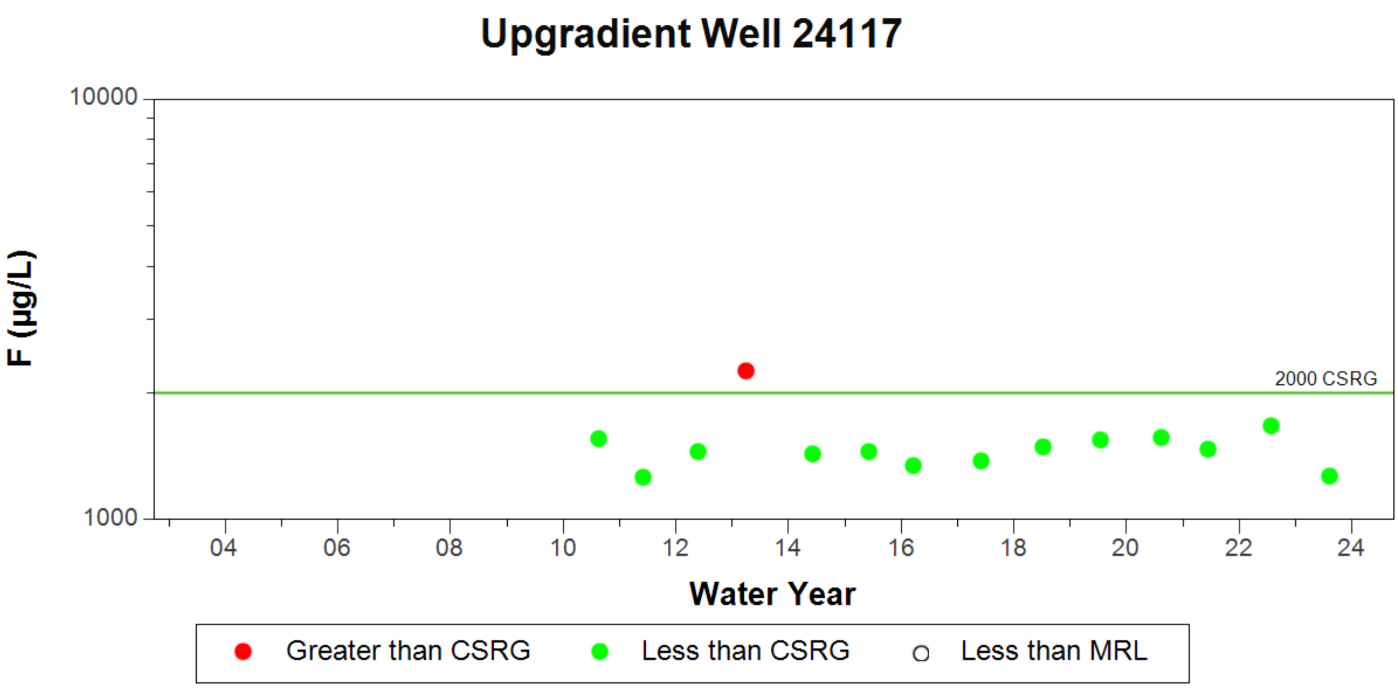
Upgradient Well 24101

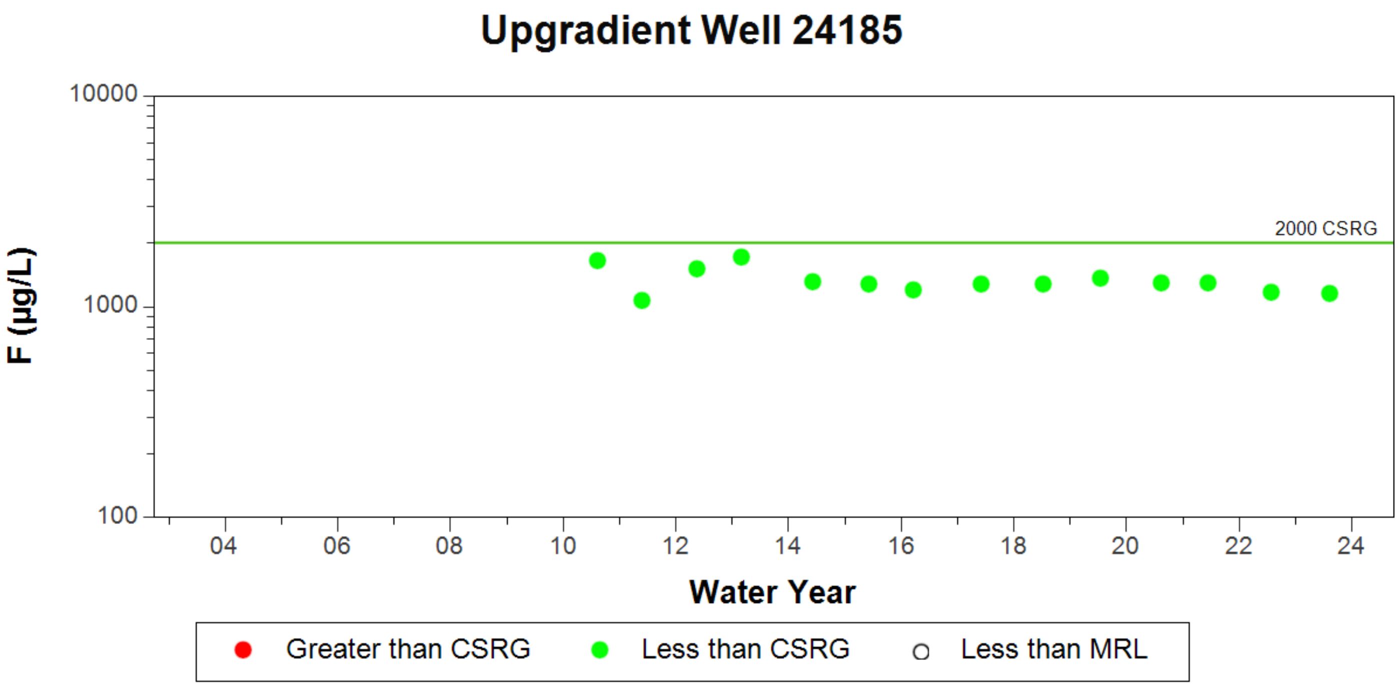



Upgradient Well 24105
10000
1000
F (µg/L)
2000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

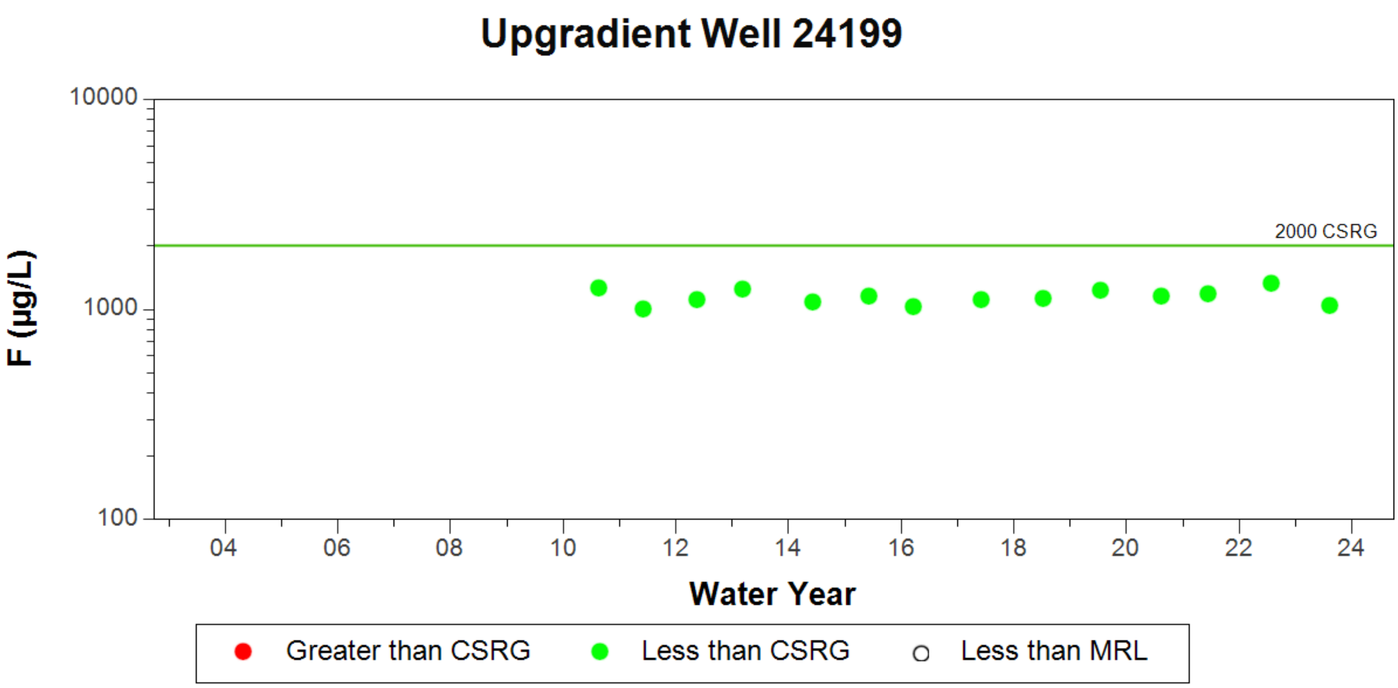

Upgradient Well 24106
10000
1000
F (µg/L)
2000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL


Upgradient Well 24114
F (µg/L)
10000
1000
2000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

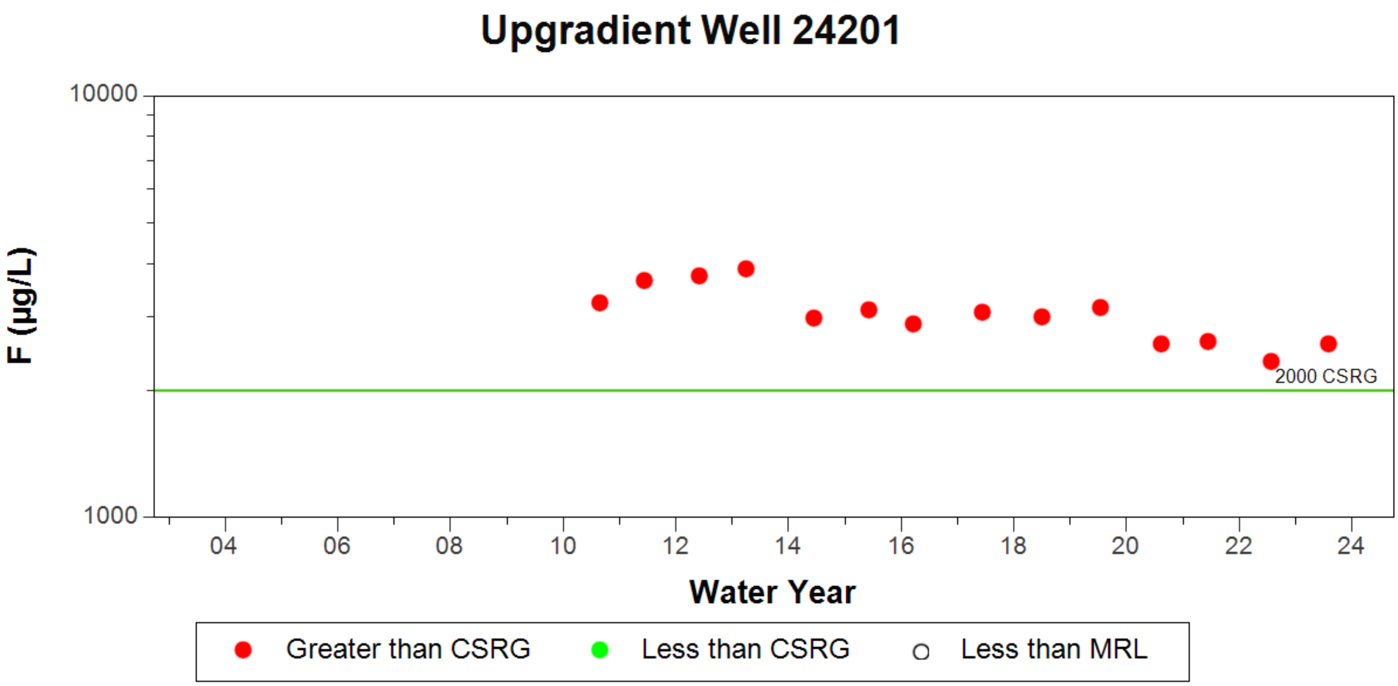

Upgradient Well 24117
F (µg/L)
10000
1000
2000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



Upgradient Well 24185
F (µg/L)
10000
1000
100
2000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

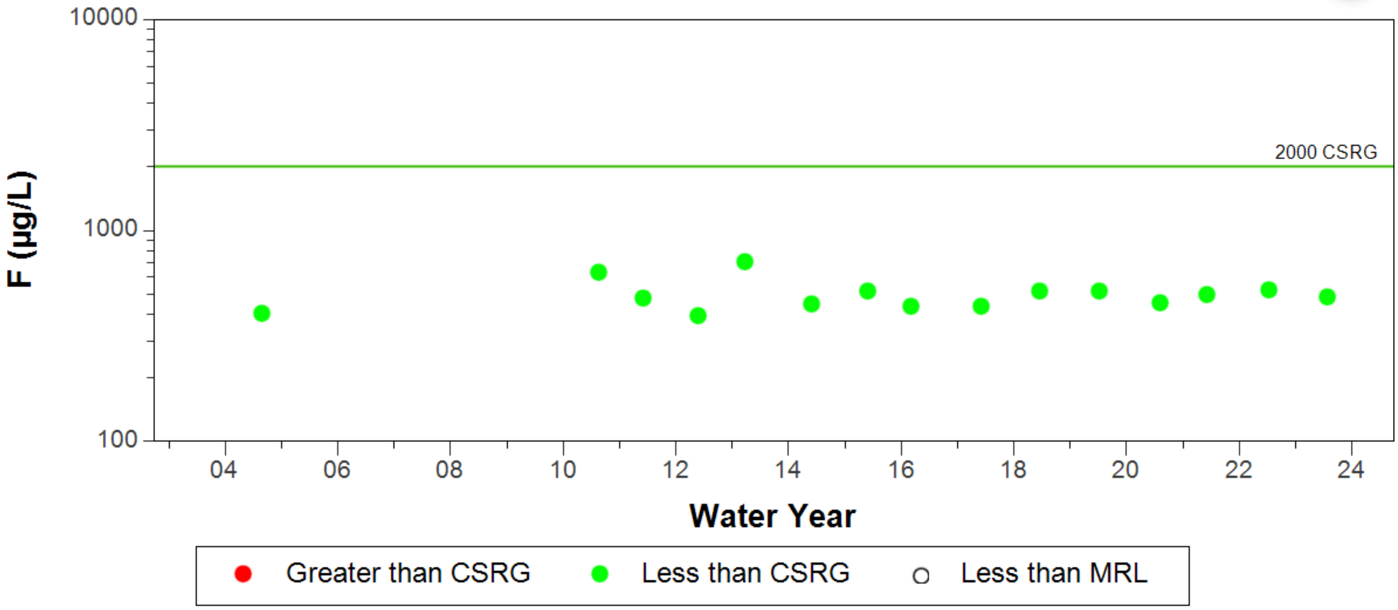


Upgradient Well 24199
F (µg/L)
10000
1000
100
2000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

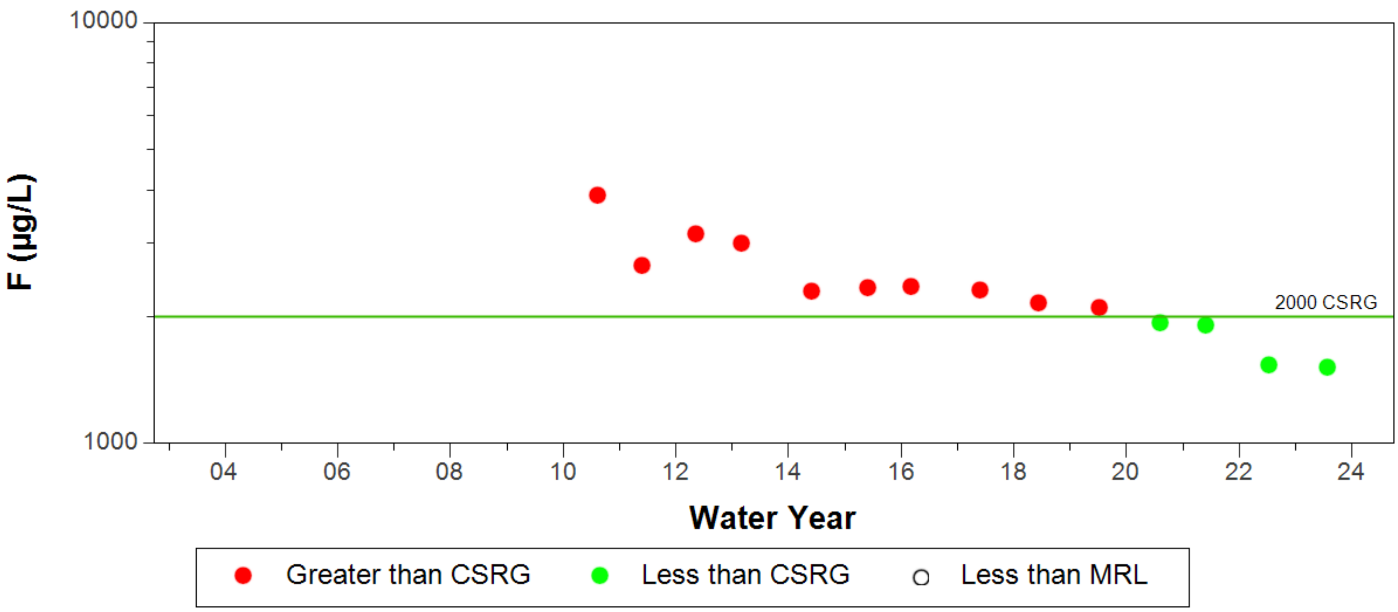


Upgradient Well 24201
10000
1000
F (µg/L)
2000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

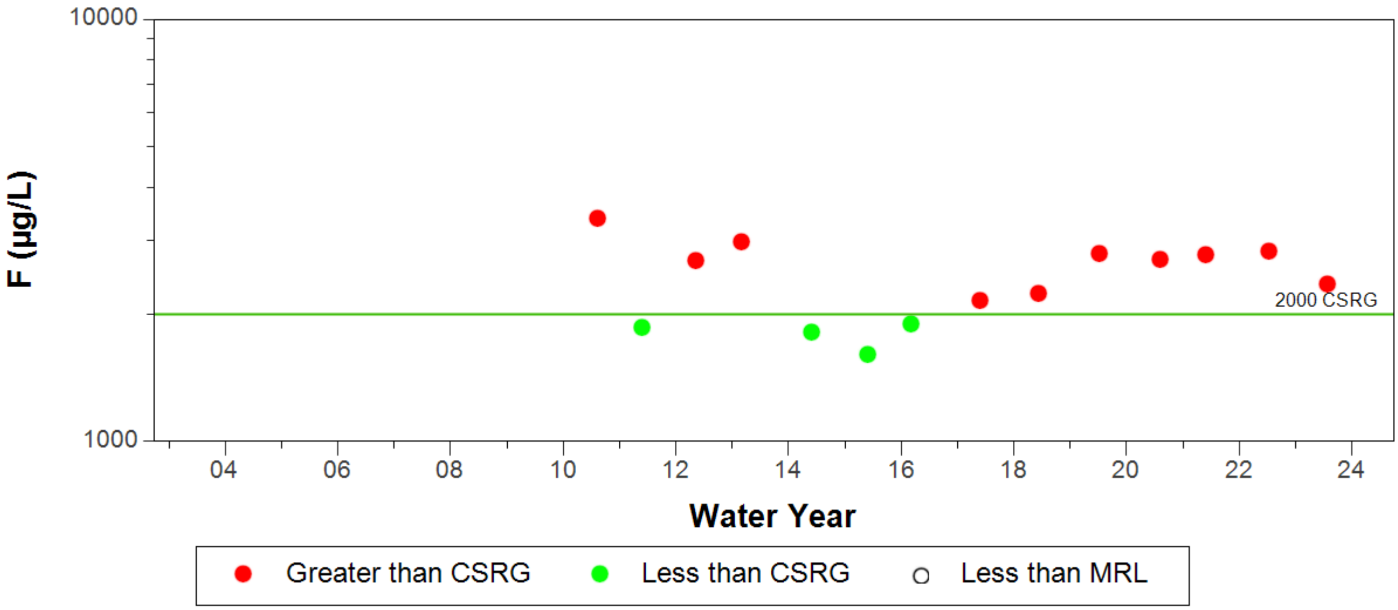
Downgradient Well 23405



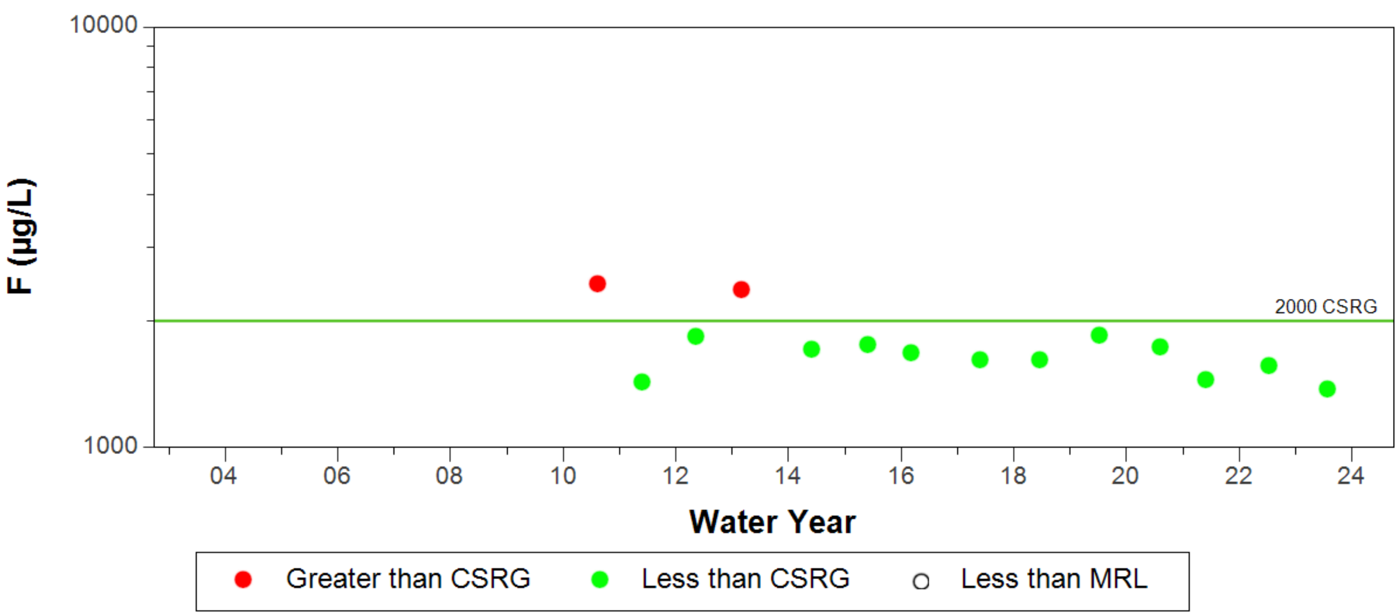
Downgradient Well 23434

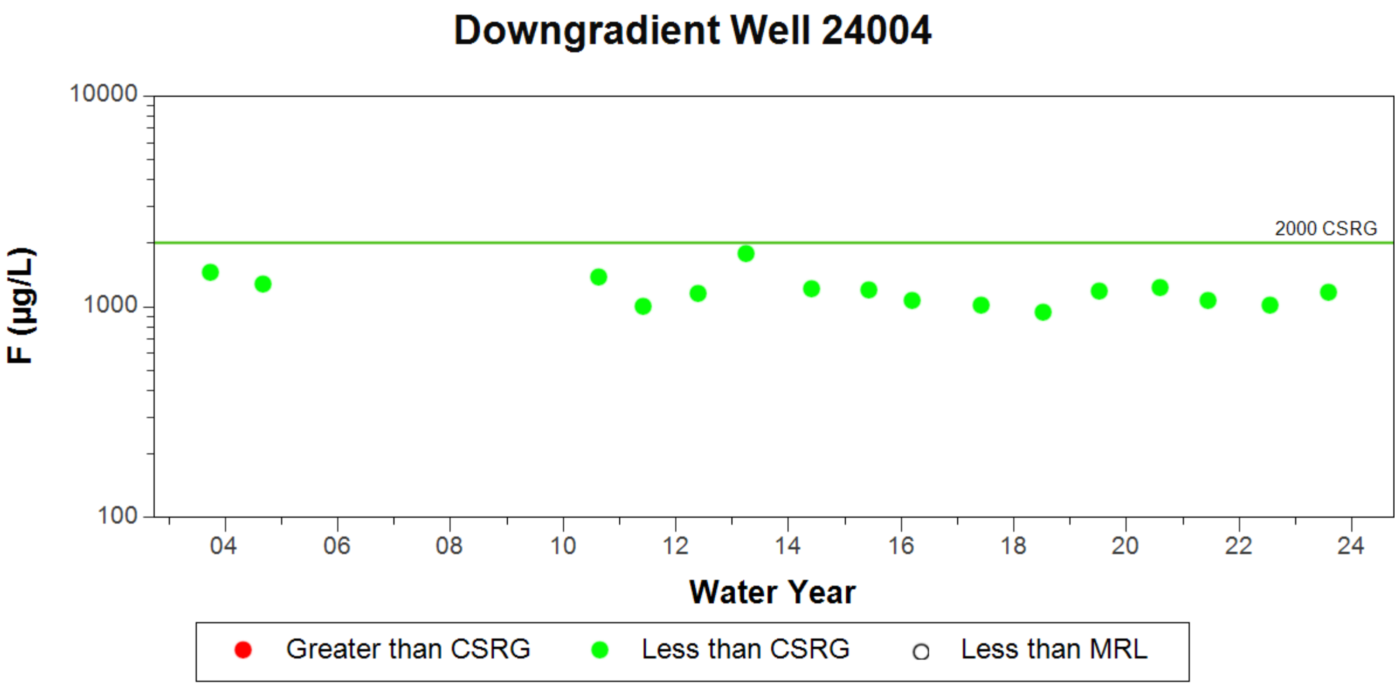


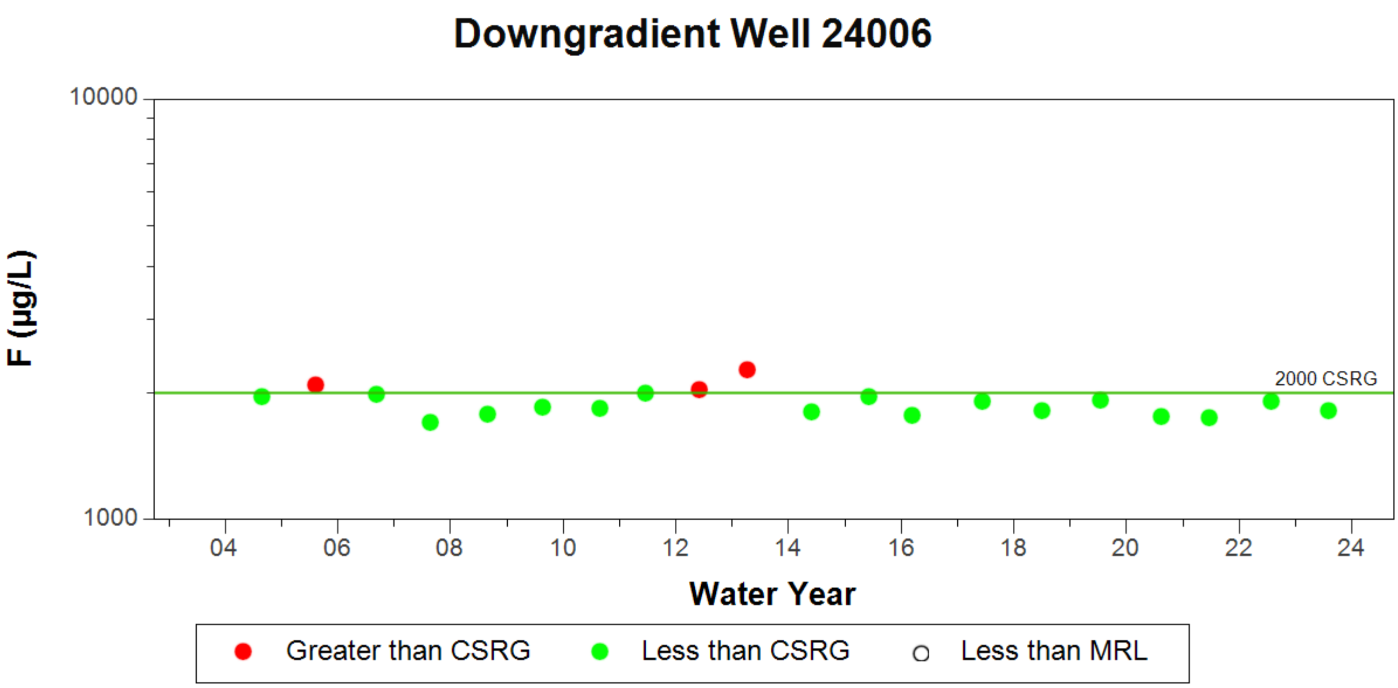
Downgradient Well 23436

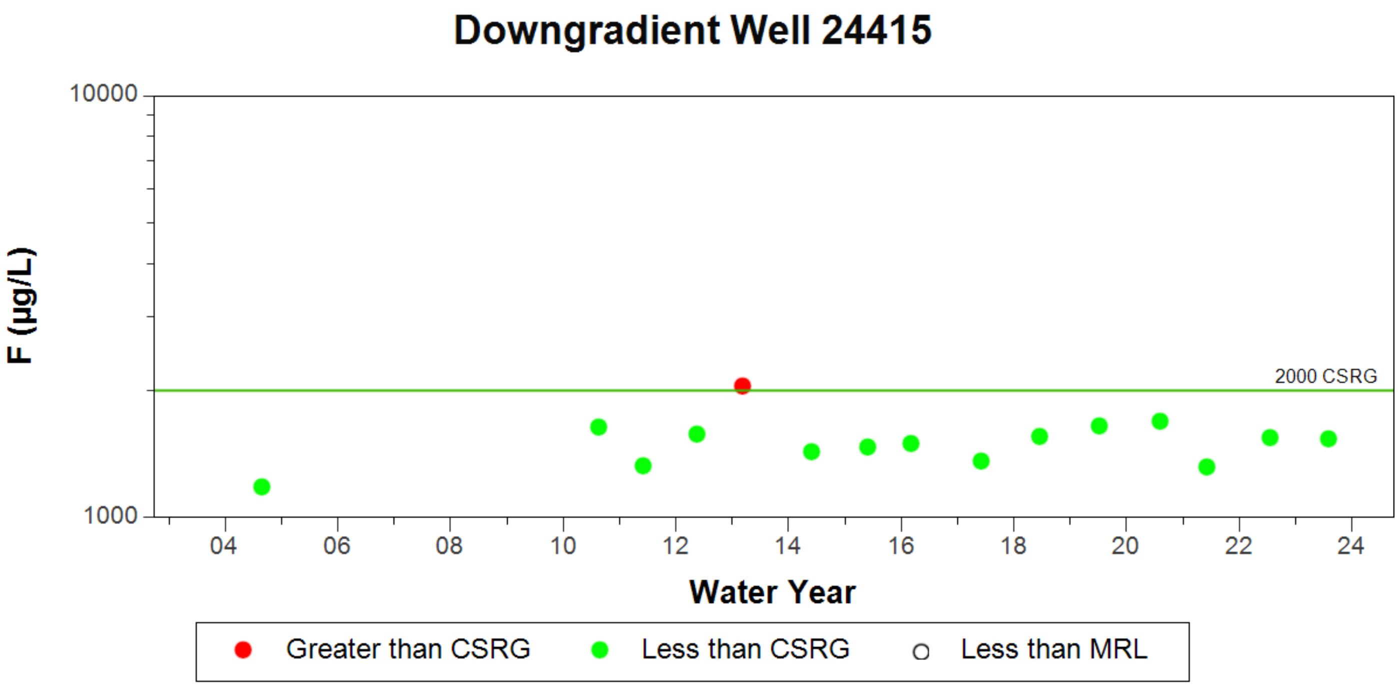


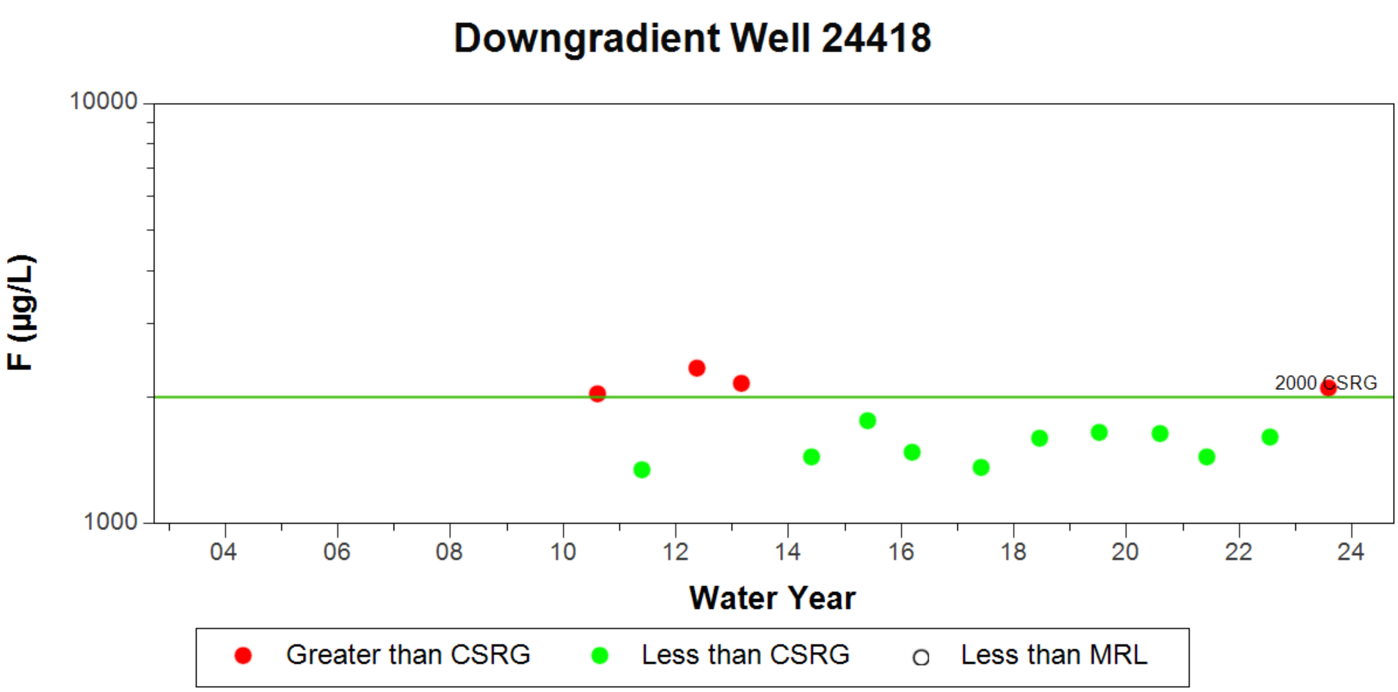
Downgradient Well 23438

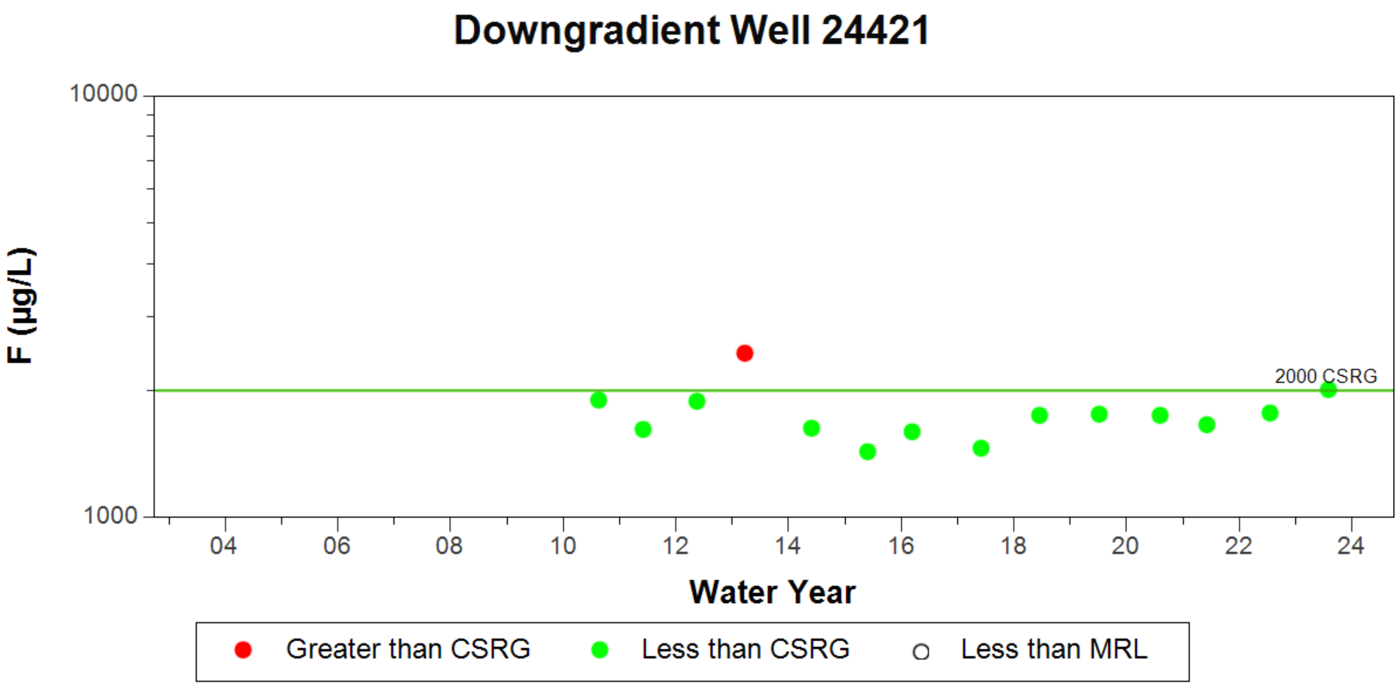


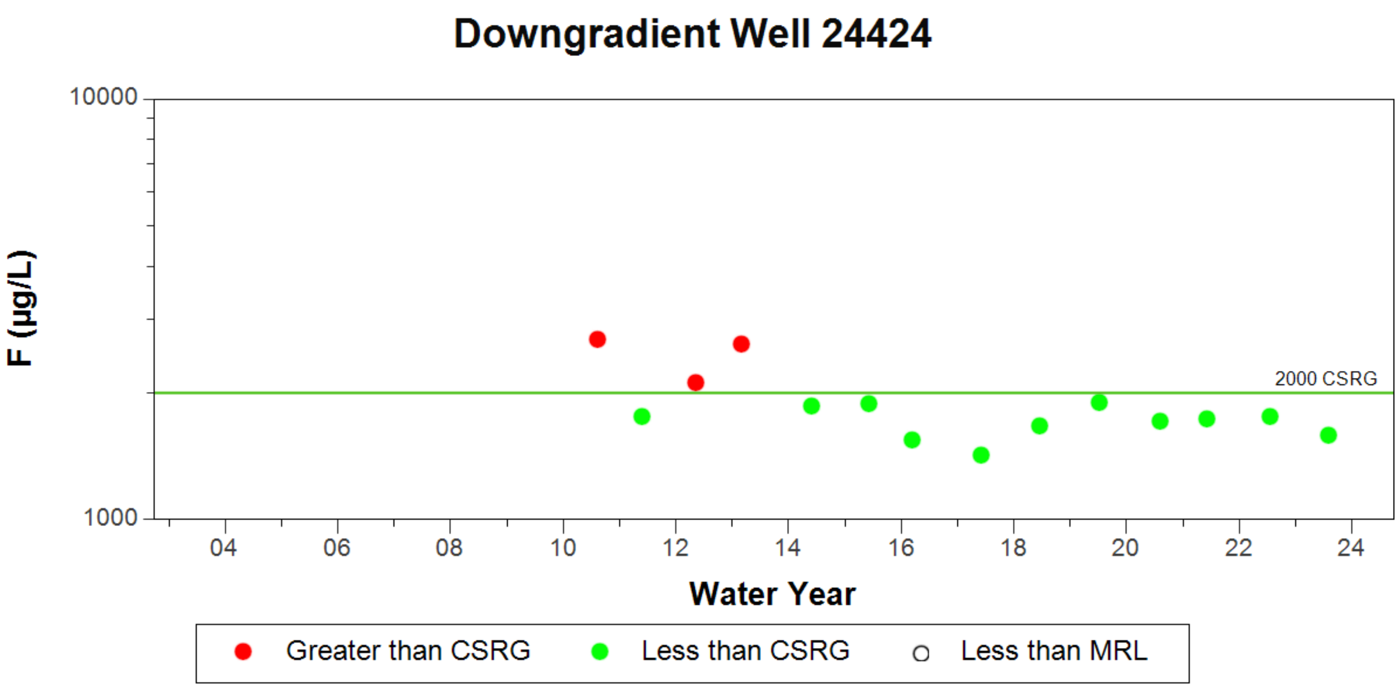

Downgradient Well 24004
10000
1000
100
F (µg/L)
2000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

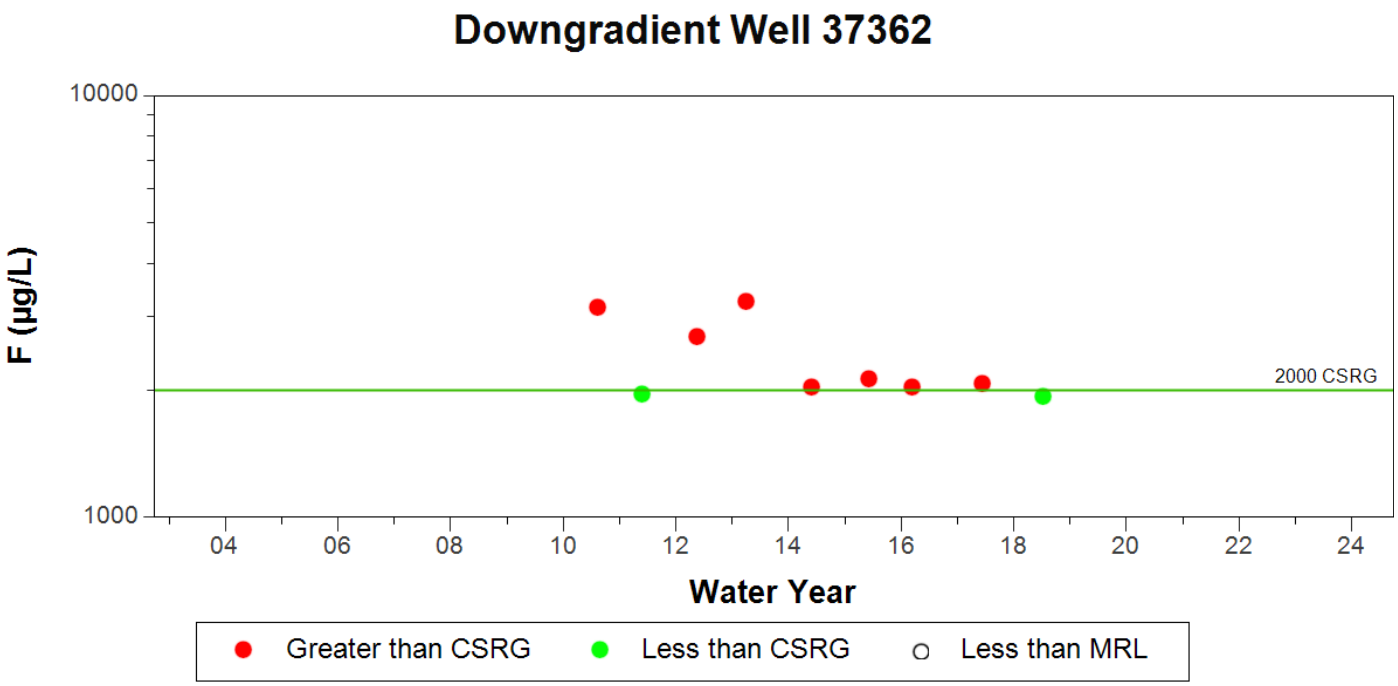

Downgradient Well 24006
10000
1000
F (µg/L)
2000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

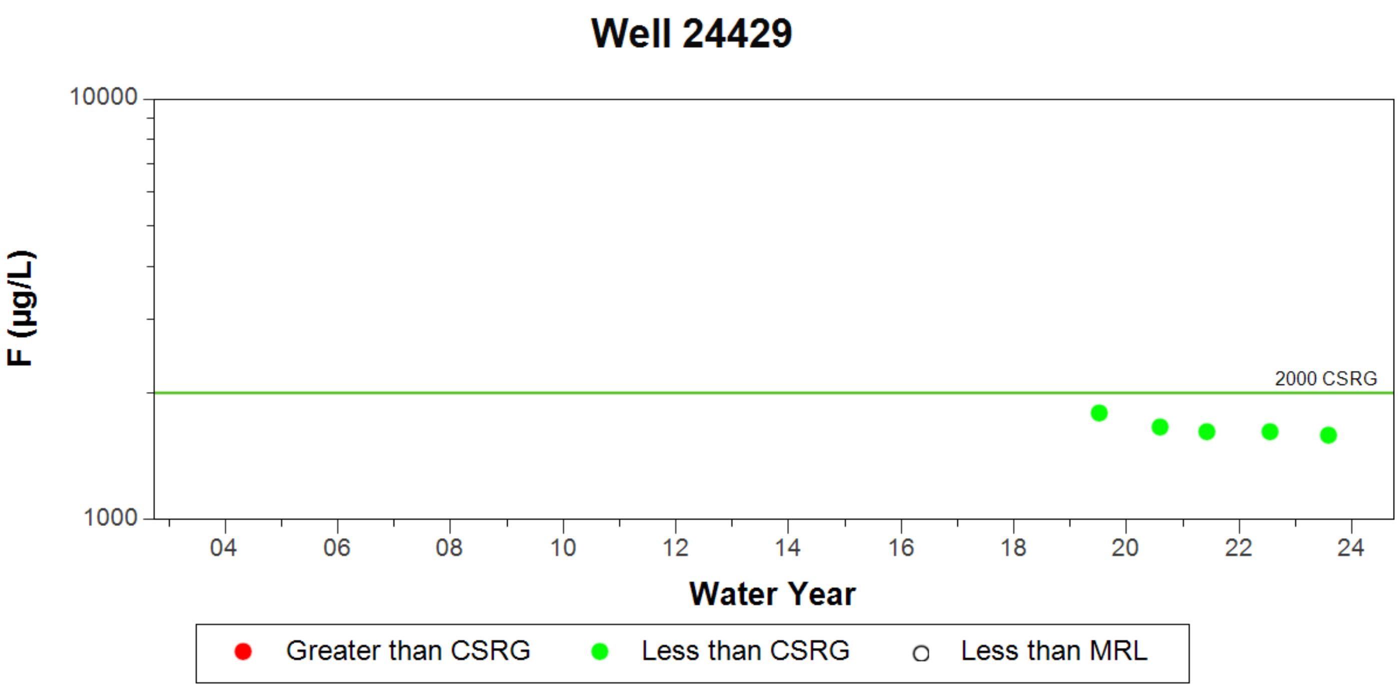

Downgradient Well 24415
F (µg/L)
10000
1000
2000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL


Downgradient Well 24418
F (µg/L)
10000
1000
2000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

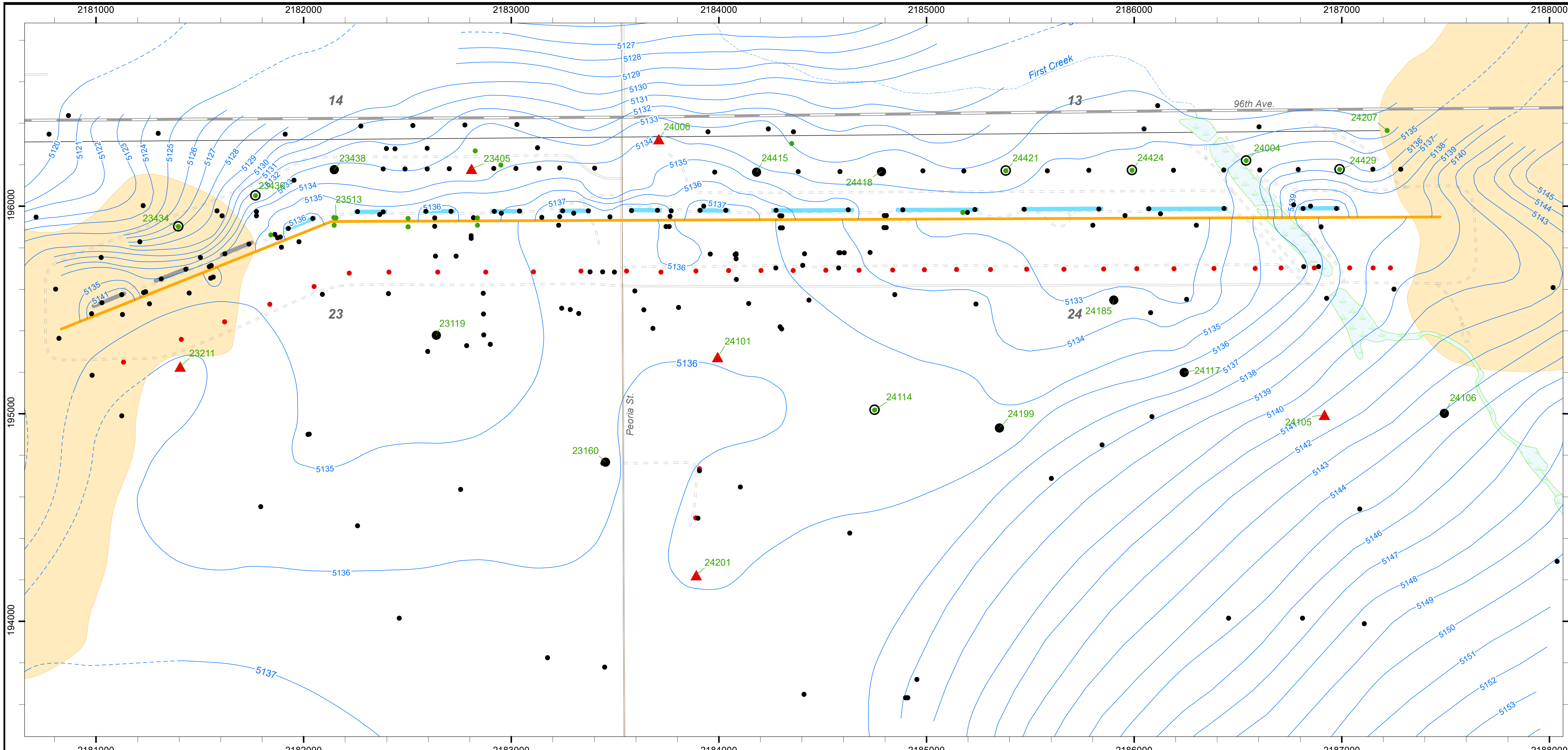

Downgradient Well 24421
F (µg/L)
10000
1000
2000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL


Downgradient Well 24424
F (µg/L)
10000
1000
2000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL





Downgradient performance Well 24207 replaced Well 37362, but it could not be sampled due to insufficient water. Nearby alternate Well 24429 was monitored instead.



Legend

- Unsaturated Alluvium
- Section Lines
- Water elevation contour - 1-foot interval
- Inferred water elevation contour
- Wetlands
- Intermittent Streams
- Ditches
- Slurry Walls
- Recharge Trenches
- Inactive Recharge Trenches
- Unimproved Roads
- Local Roads
- Secondary Roads
- Primary Roads
- Monitoring Wells
- Performance Water Quality Wells
- Extraction Wells

Notes: Water levels were measured in FY23 Quarter 2.

Upgradient and Downgradient Performance Well Water Quality

- Analyte Detected Above the CSRG - Increasing Trend Noted
- Analyte Detected Above the CSRG - Decreasing Trend Noted
- Analyte Detected - Showing Stable or No Discernible Trend
- Analyte Not Detected

Notes:
1. Trends are depicted for the 10 year period FY14 - FY23.
2. Time versus concentration charts for Performance Water Quality wells are presented following this map.

N

0 250 500 Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

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Figure B-32

n-Nitrosodimethylamine Concentration Trends in Performance Wells, North Boundary Containment System

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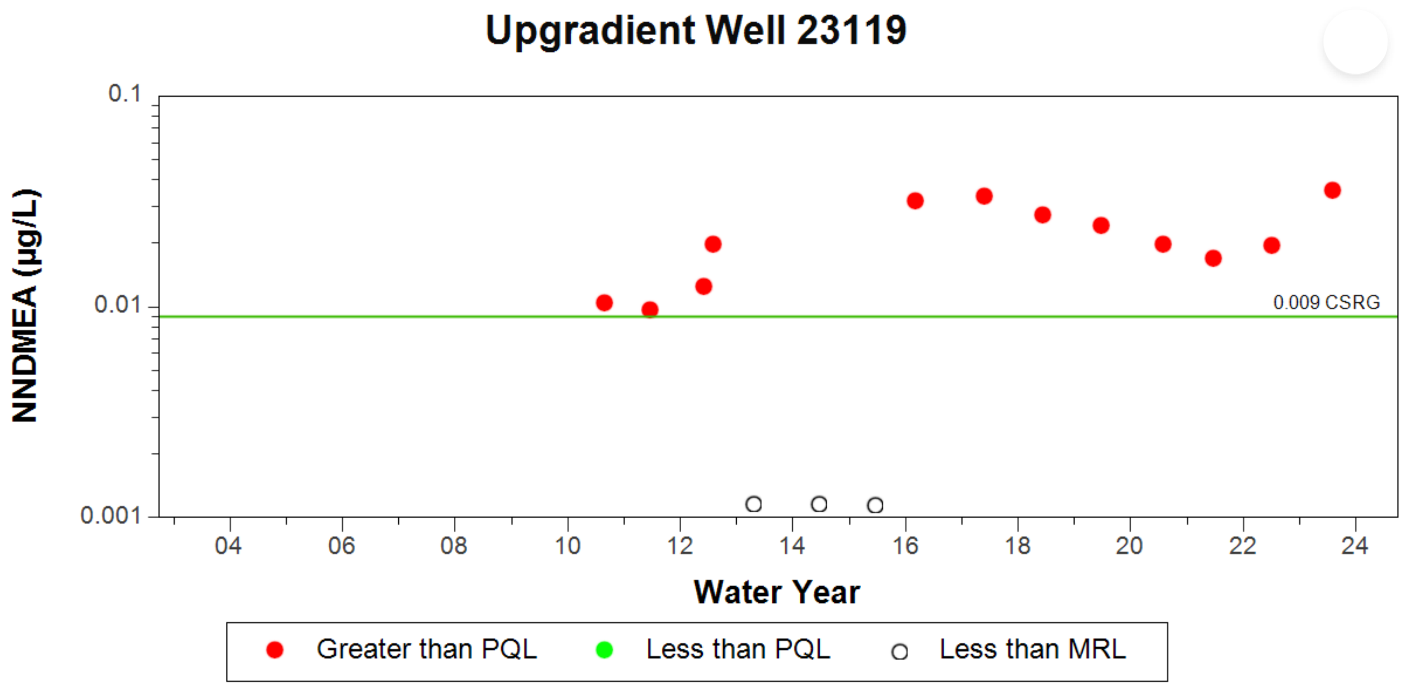
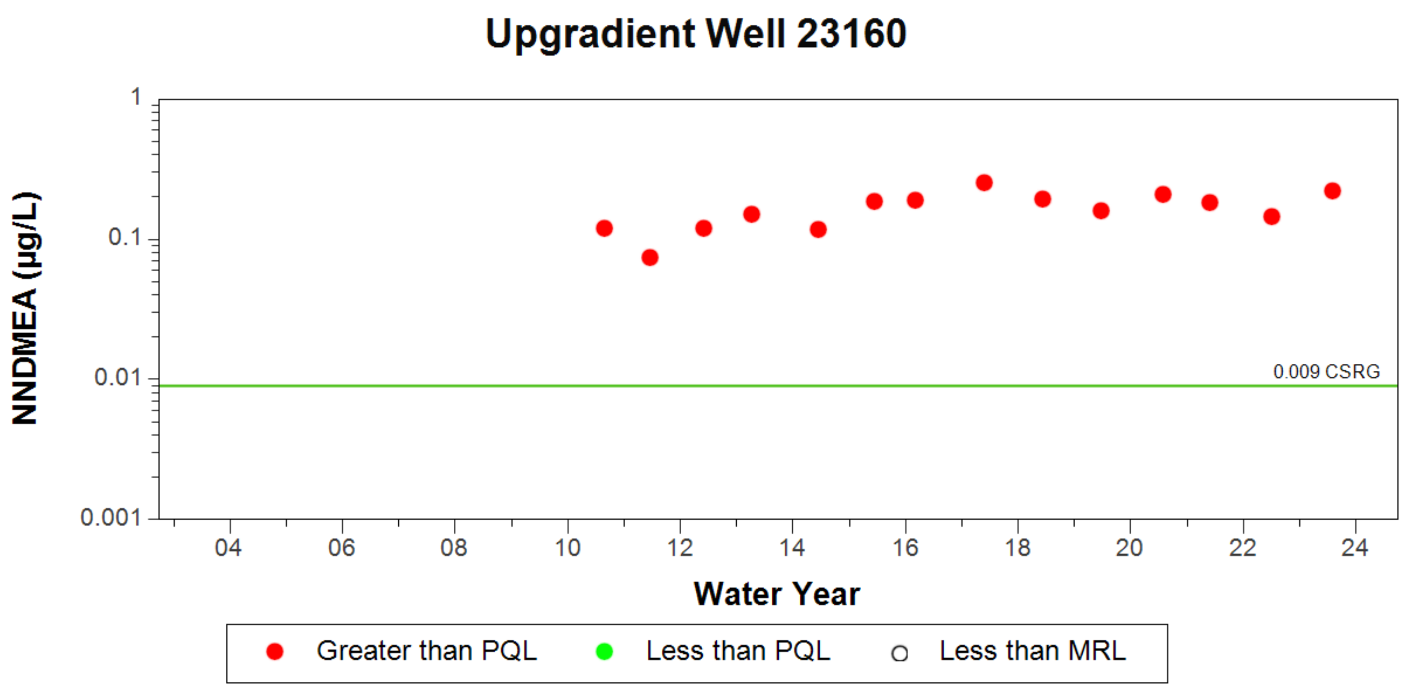
8/7/2024

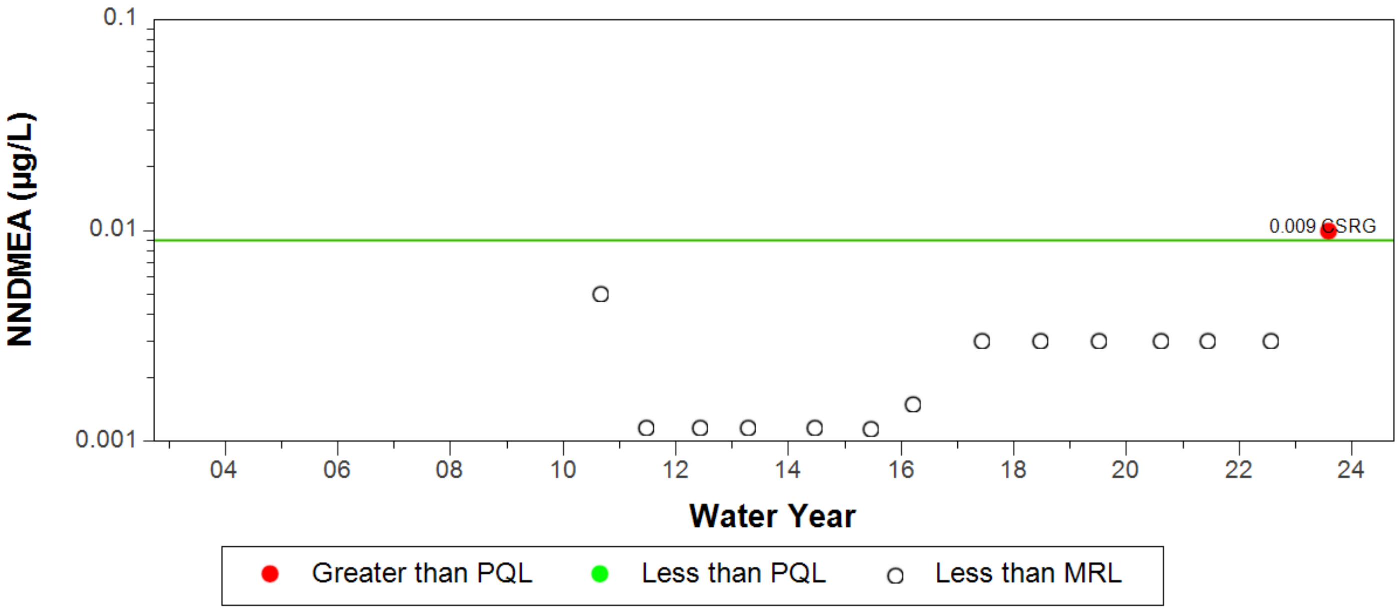


Upgradient Well 23119
NNDMEA (µg/L)
0.1
0.01
0.001
0.009 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

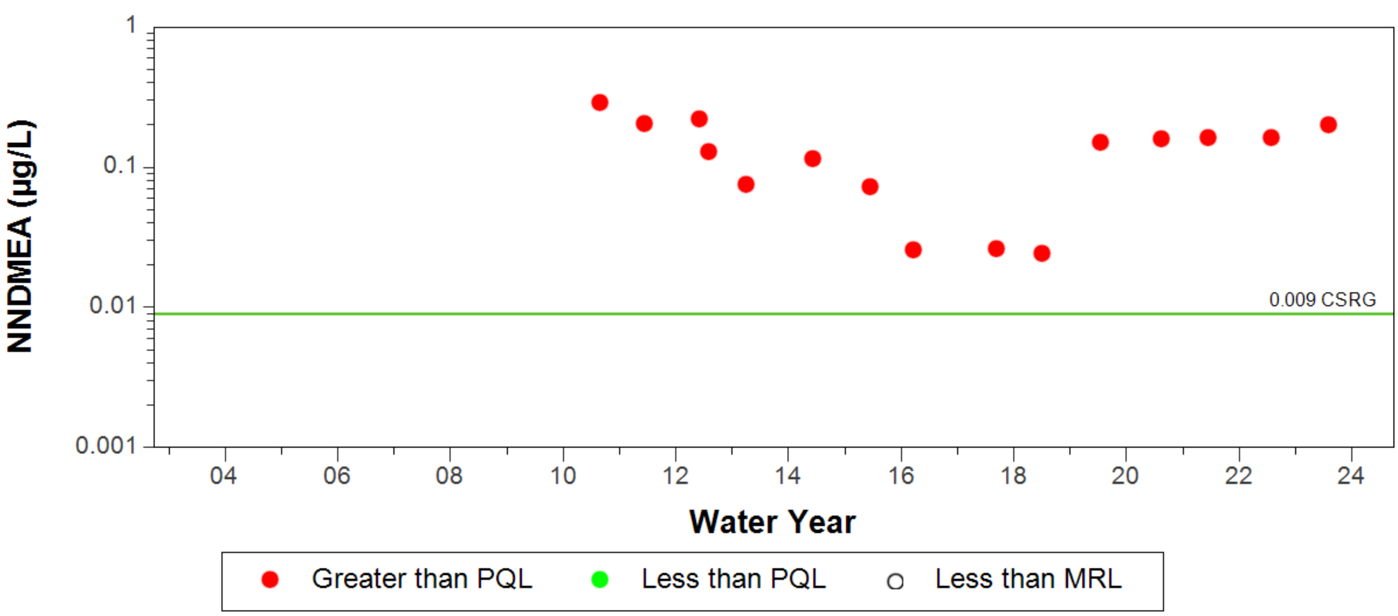


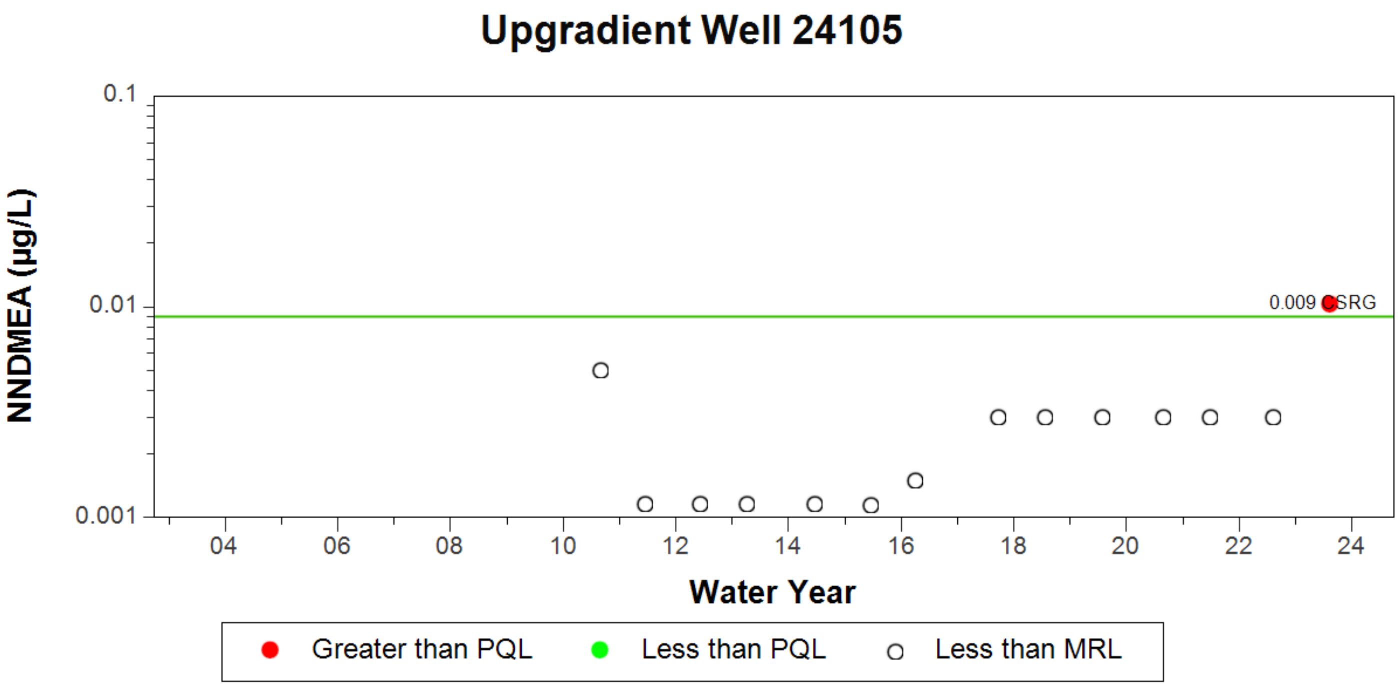
Upgradient Well 23160
NNDMEA (µg/L)
1
0.1
0.01
0.001
0.009 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

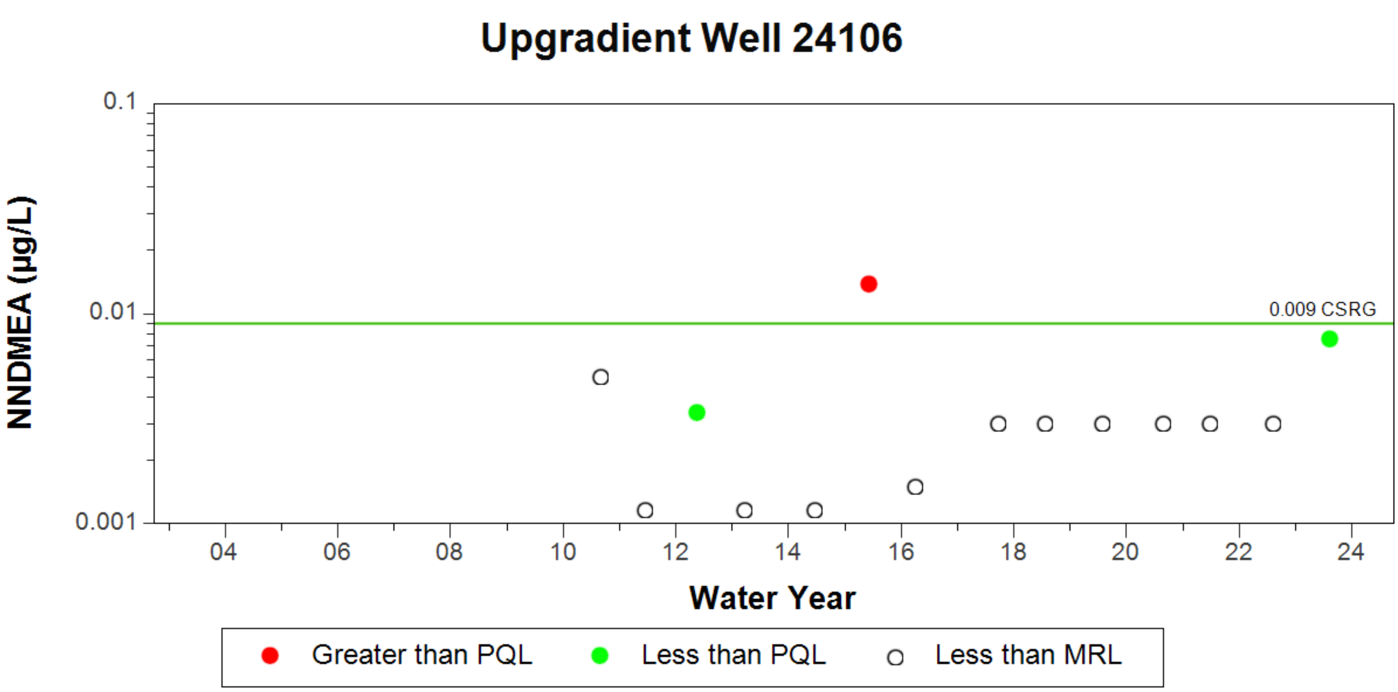
Upgradient Well 23211

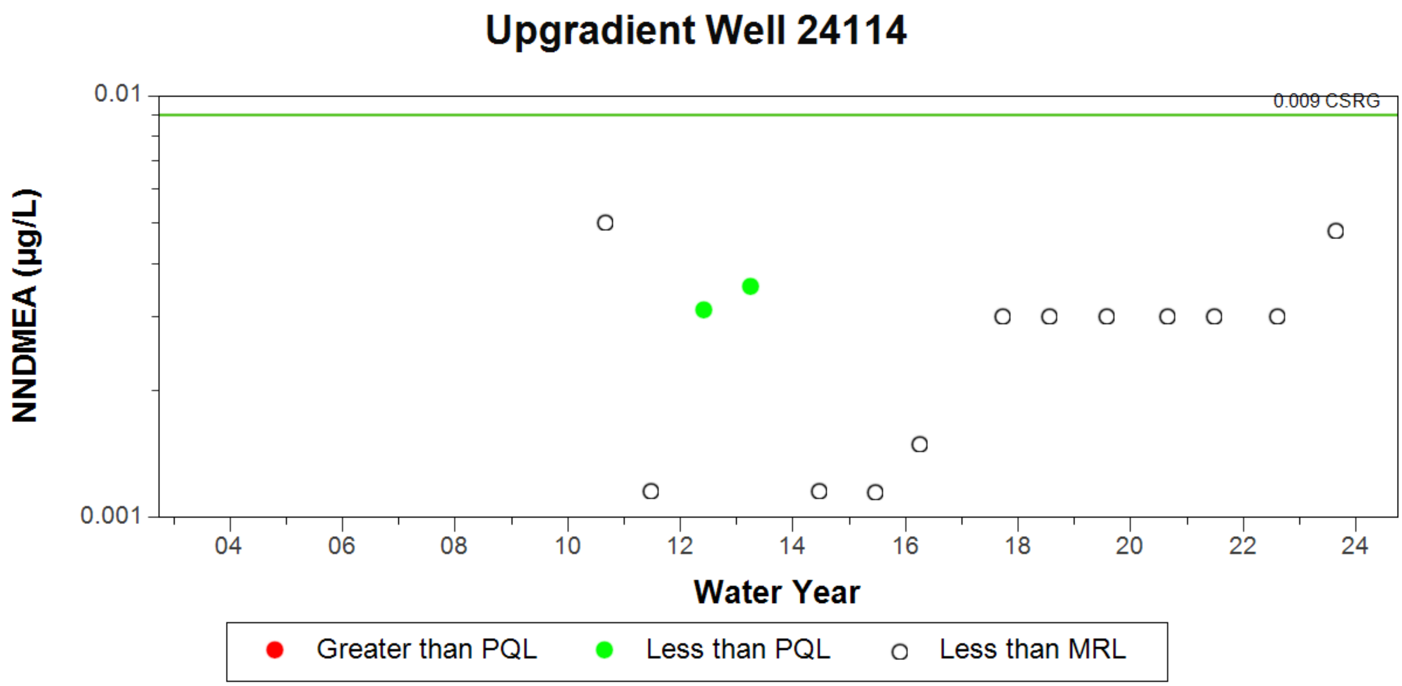


Upgradient Well 24101

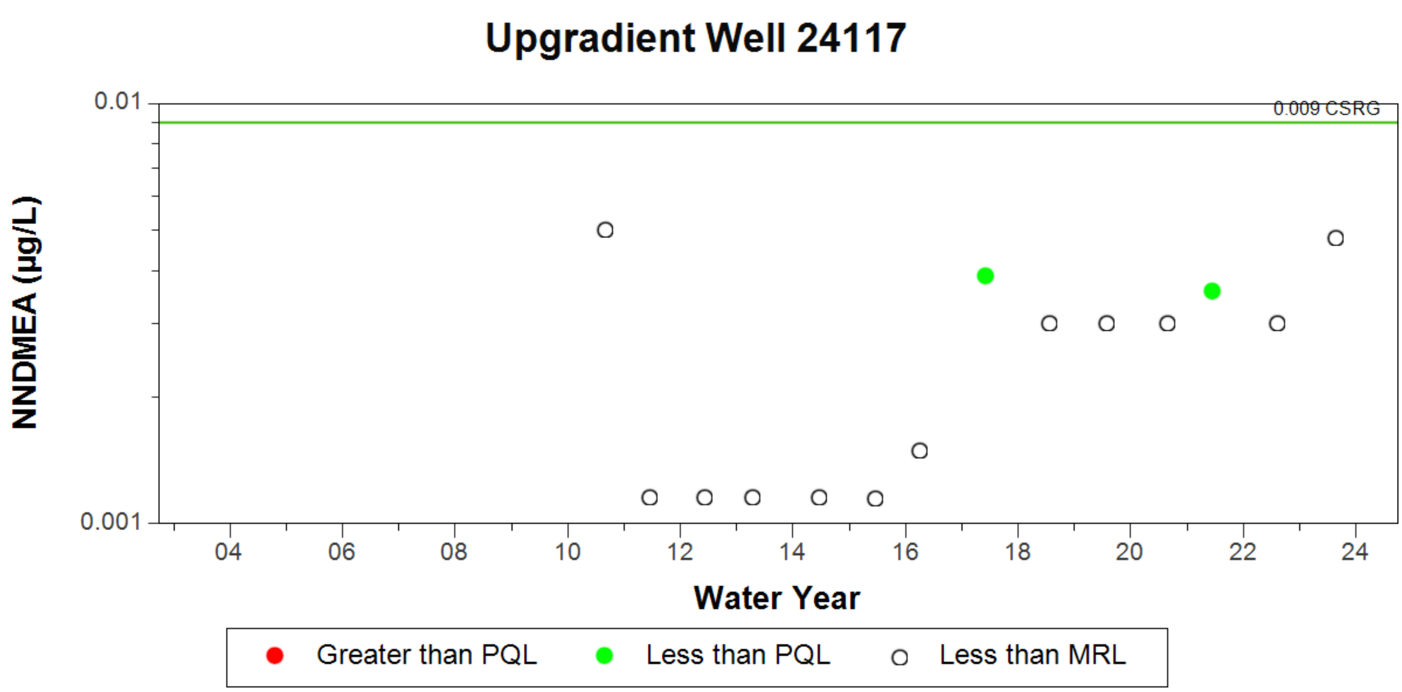



Upgradient Well 24105
NNDMEA (µg/L)
0.1
0.01
0.001
0.009 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

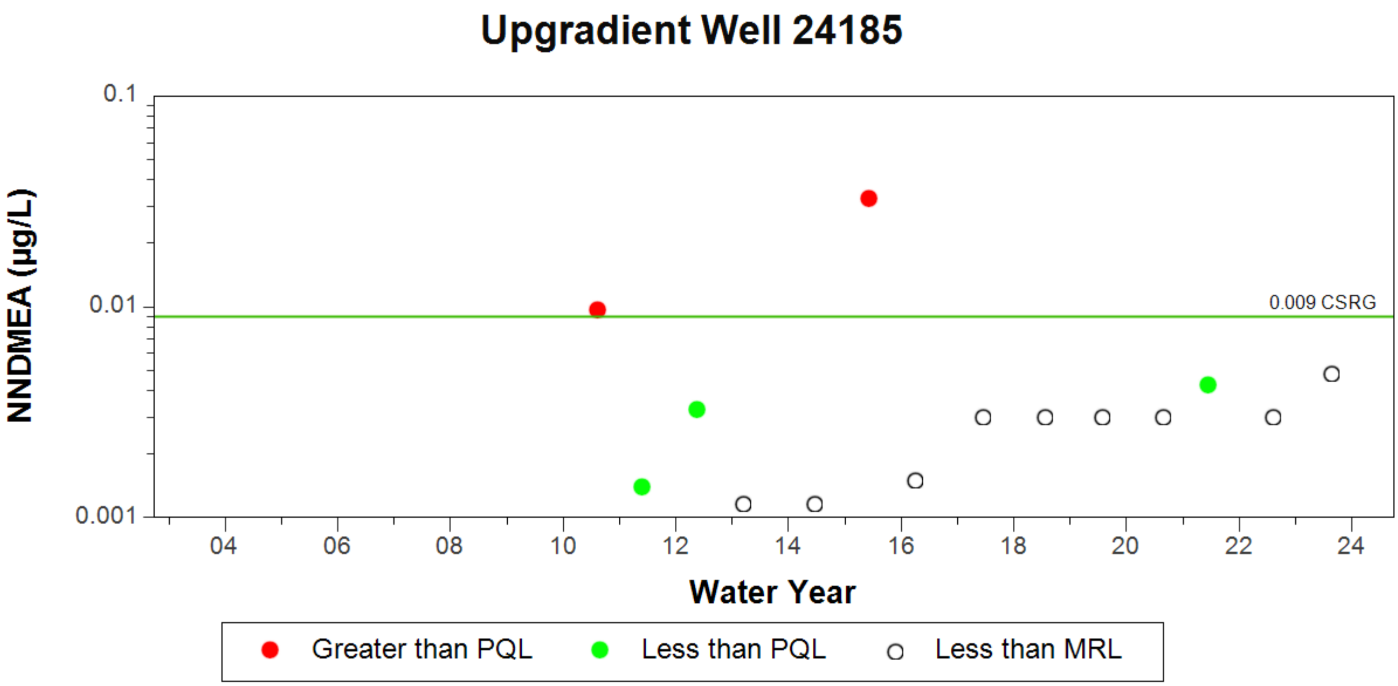

Upgradient Well 24106
NNDMEA (µg/L)
0.1
0.01
0.001
0.009 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL



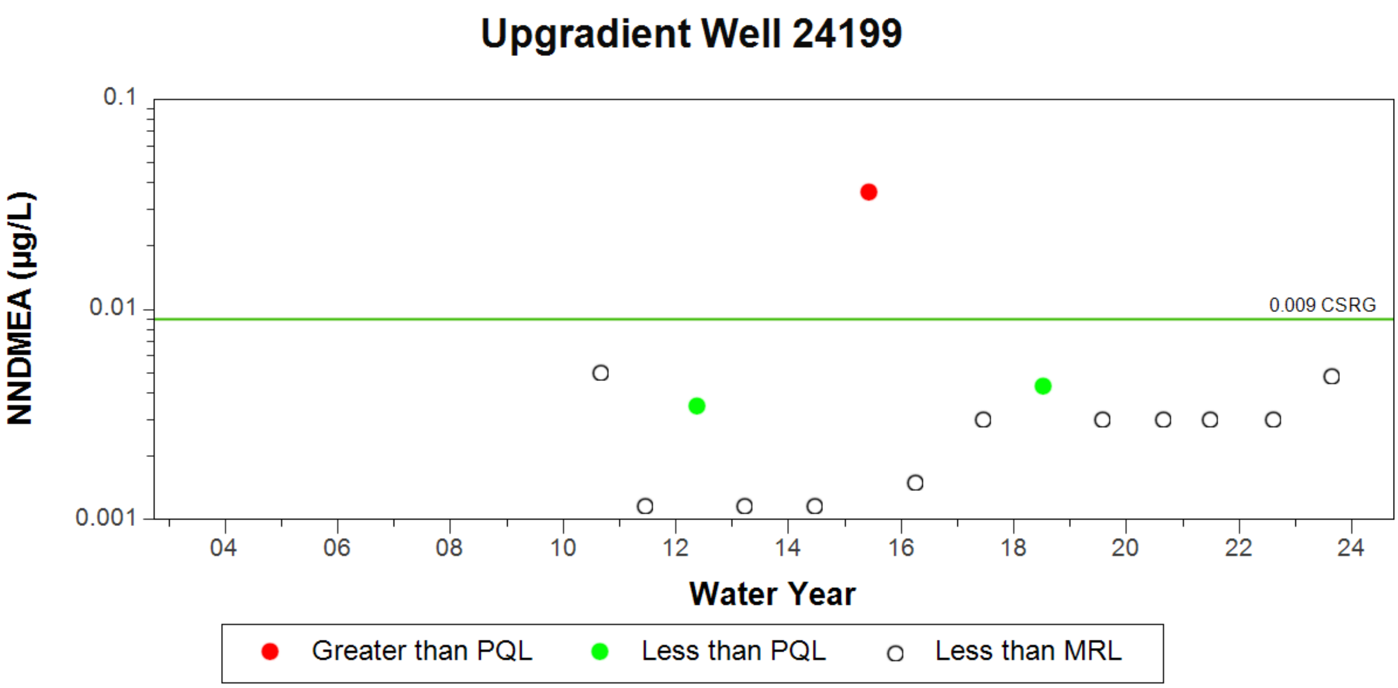
Upgradient Well 24114
0.009 CSRG
0.01
0.001
NNDMEA (µg/L)
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL



Upgradient Well 24117
0.009 CSRG
0.01
0.001
NNDMEA (µg/L)
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

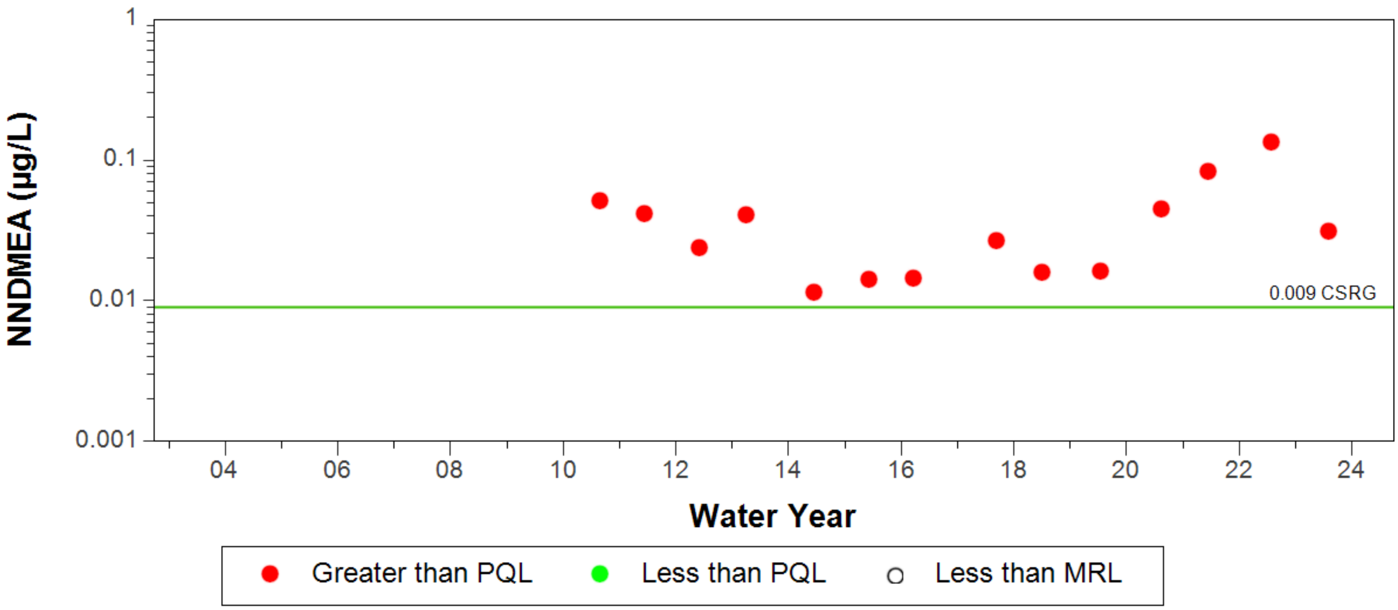


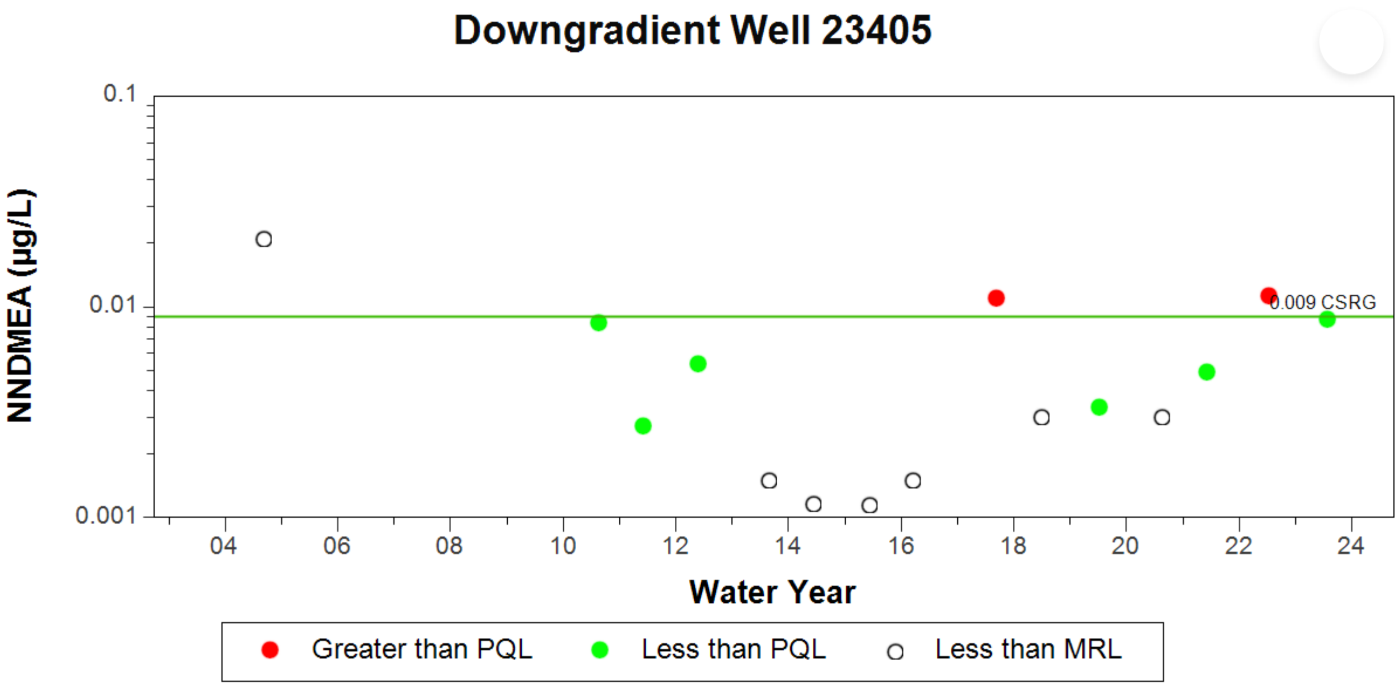
Upgradient Well 24185
NNDMEA (µg/L)
0.1
0.01
0.001
0.009 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL



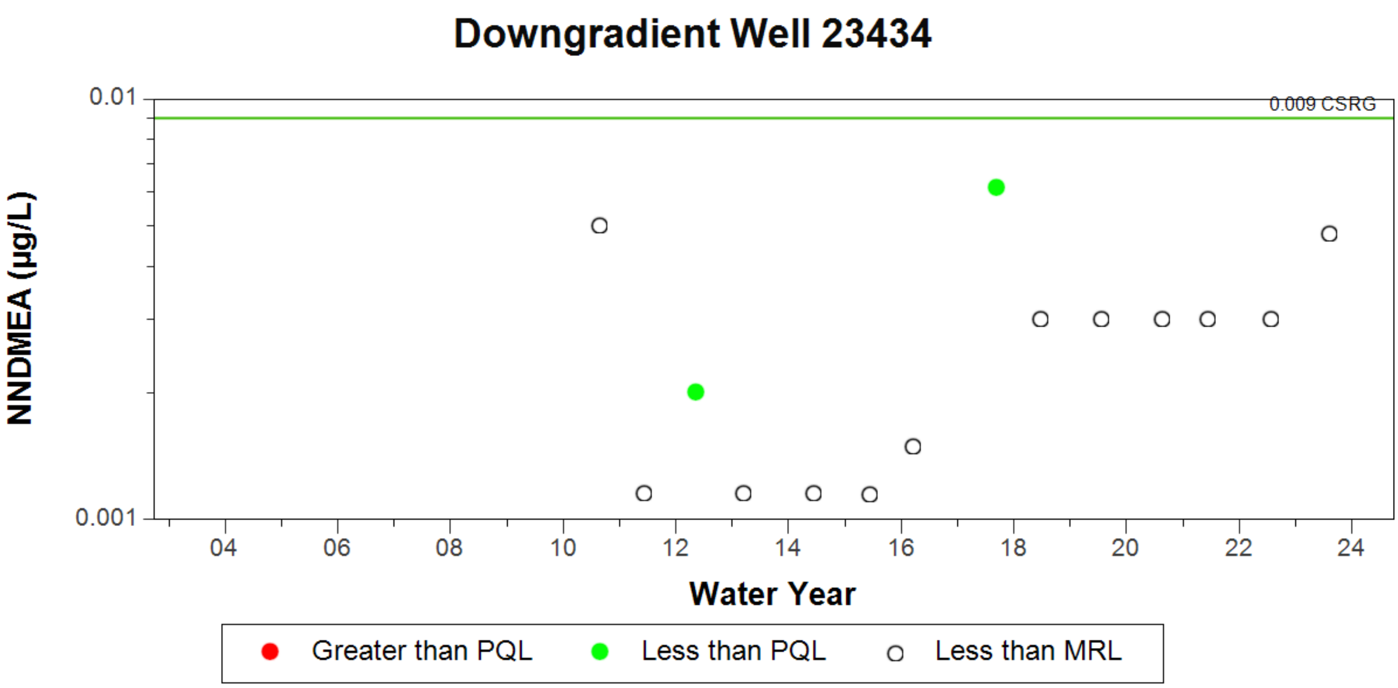
Upgradient Well 24199
NNDMEA (µg/L)
0.1
0.01
0.001
0.009 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

Upgradient Well 24201

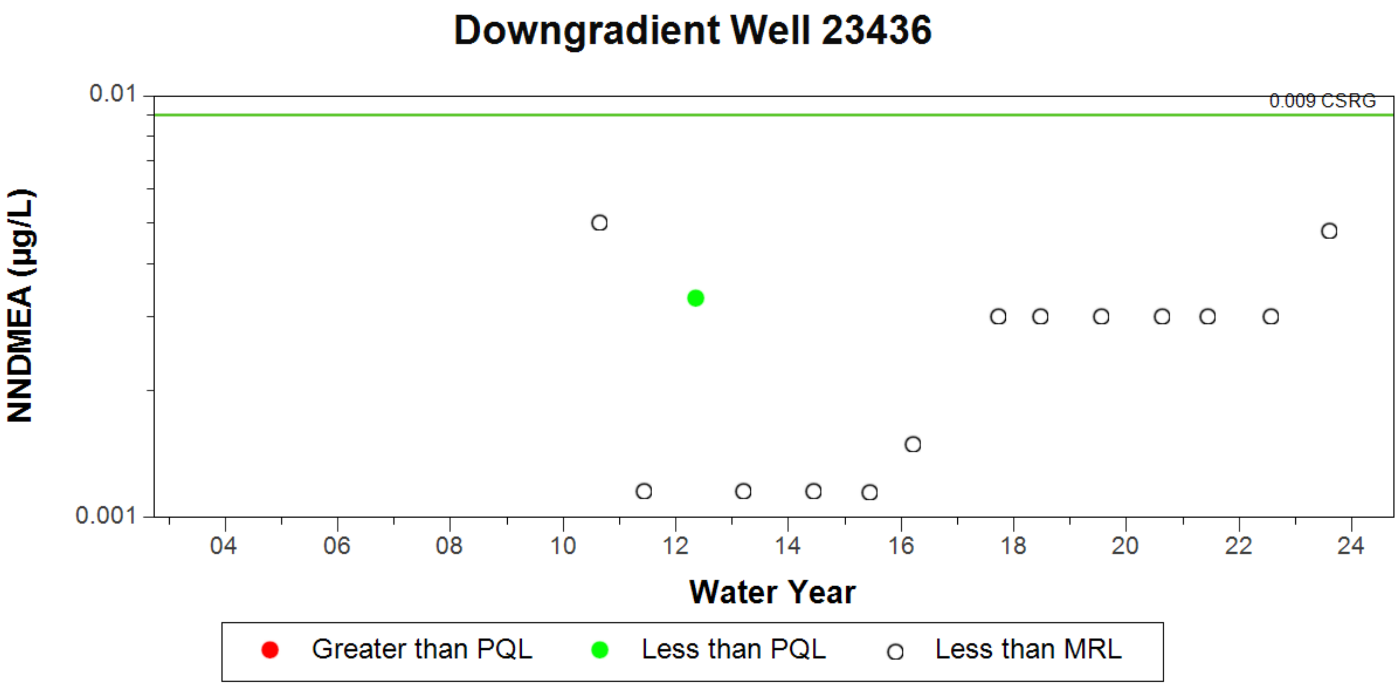


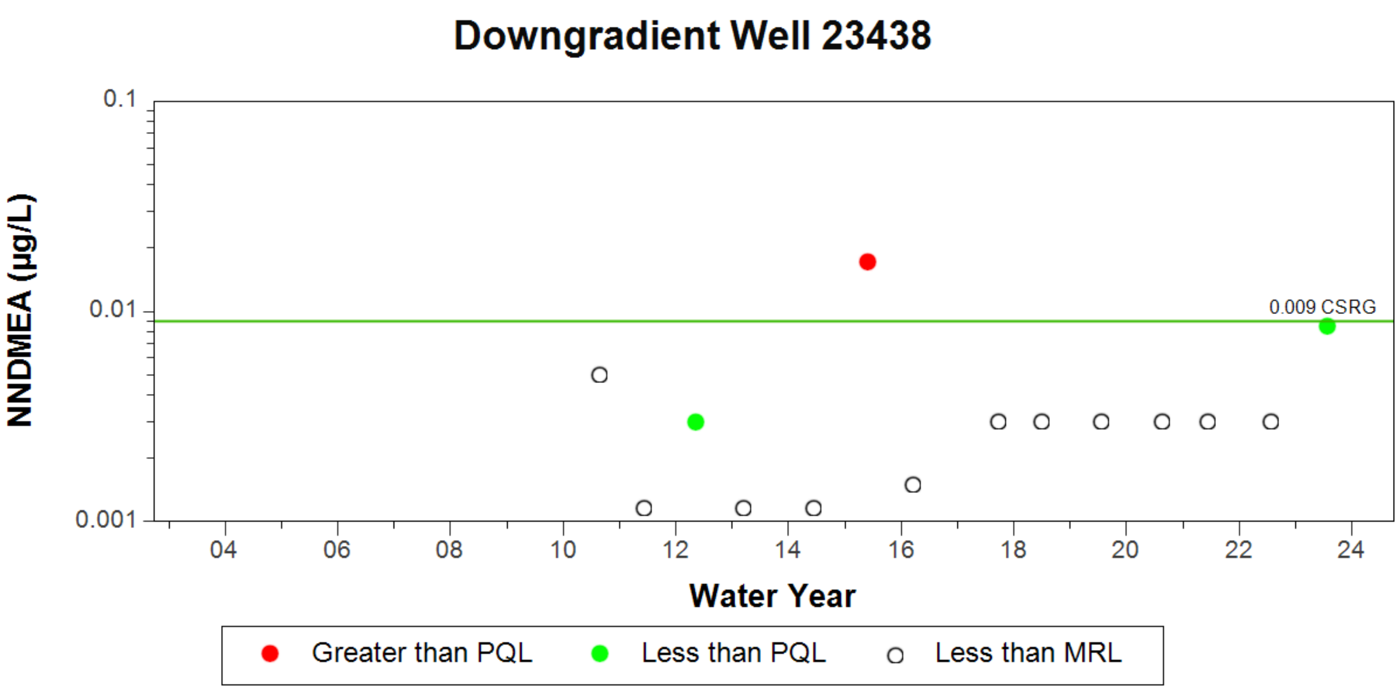


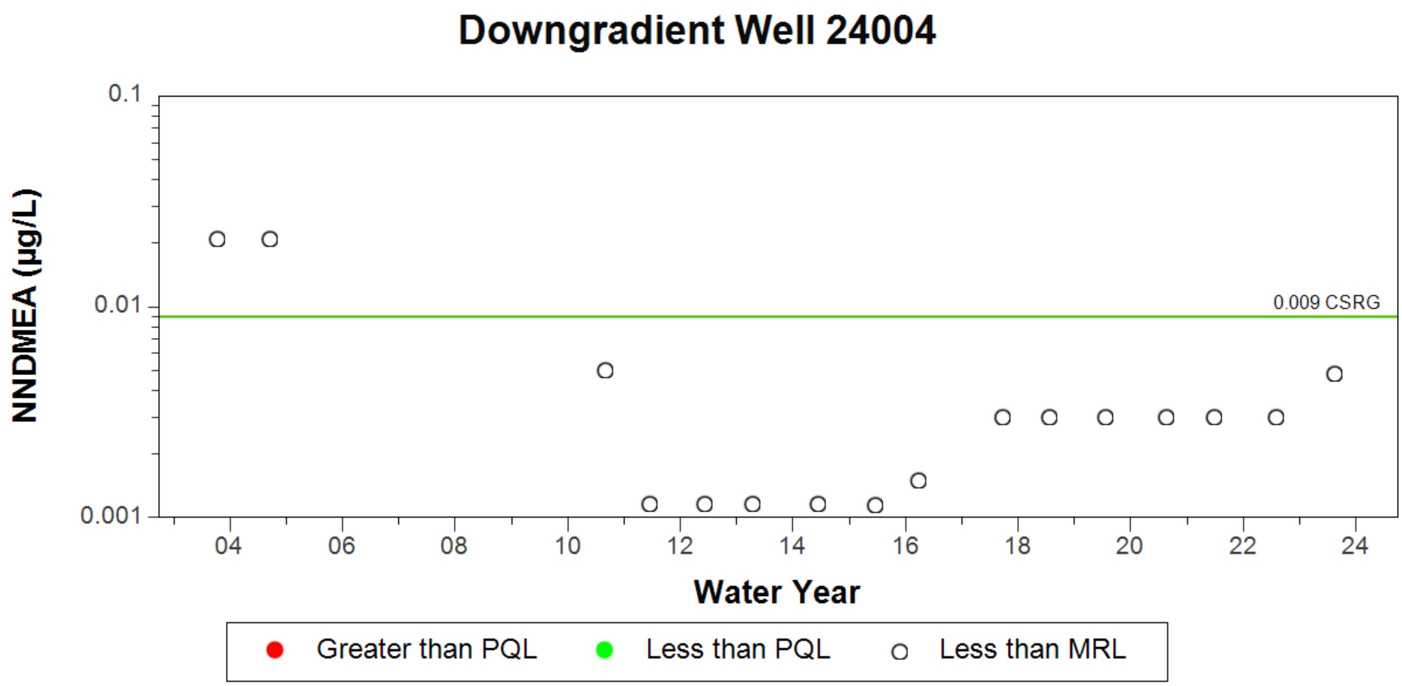
Downgradient Well 23405
NNDMEA (µg/L)
0.1
0.01
0.001
0.009 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

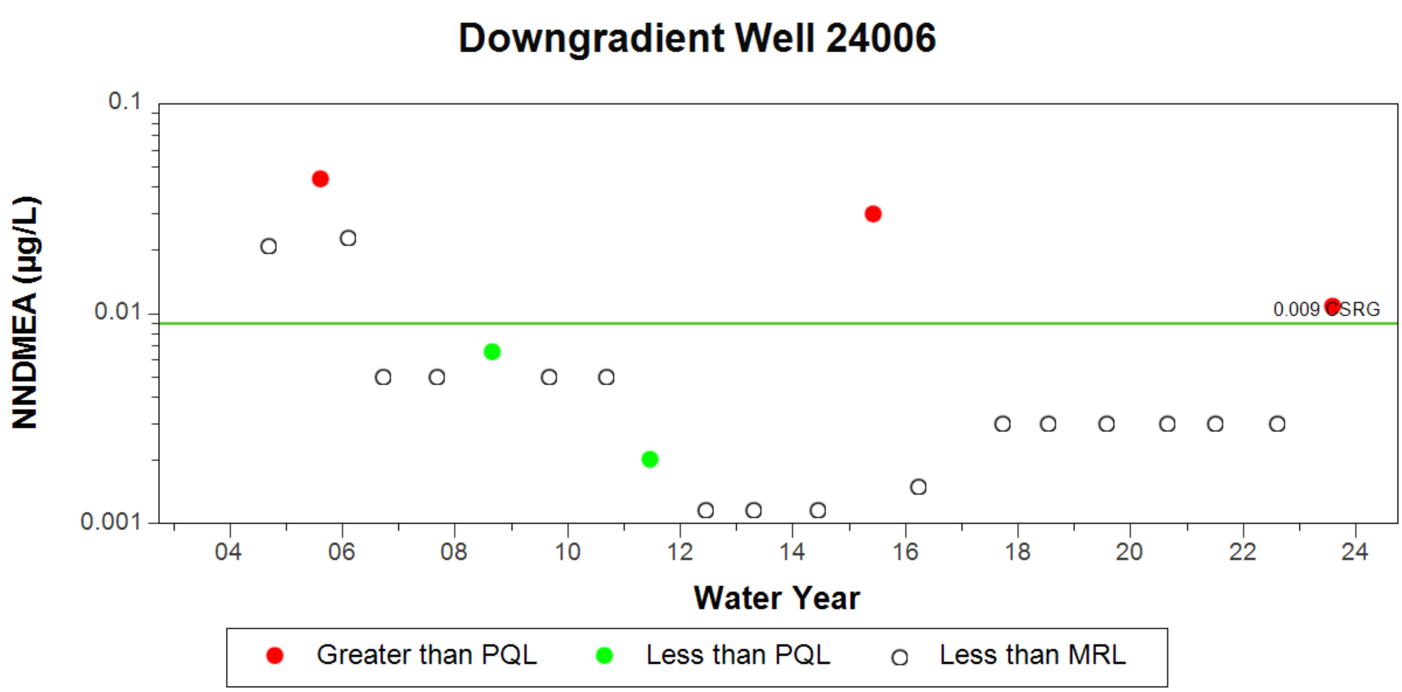


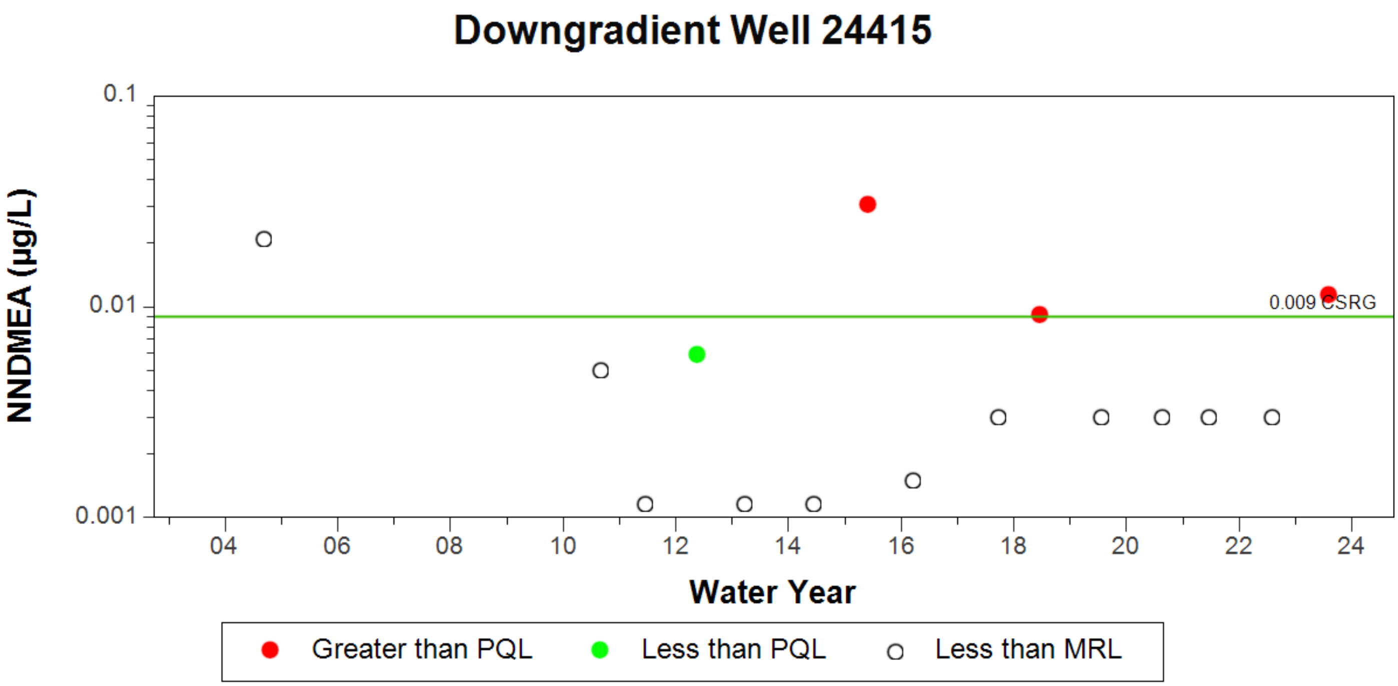
Downgradient Well 23434
NNDMEA (µg/L)
0.01
0.001
0.009 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL


Downgradient Well 23436
NNDMEA (µg/L)
0.01
0.001
0.009 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

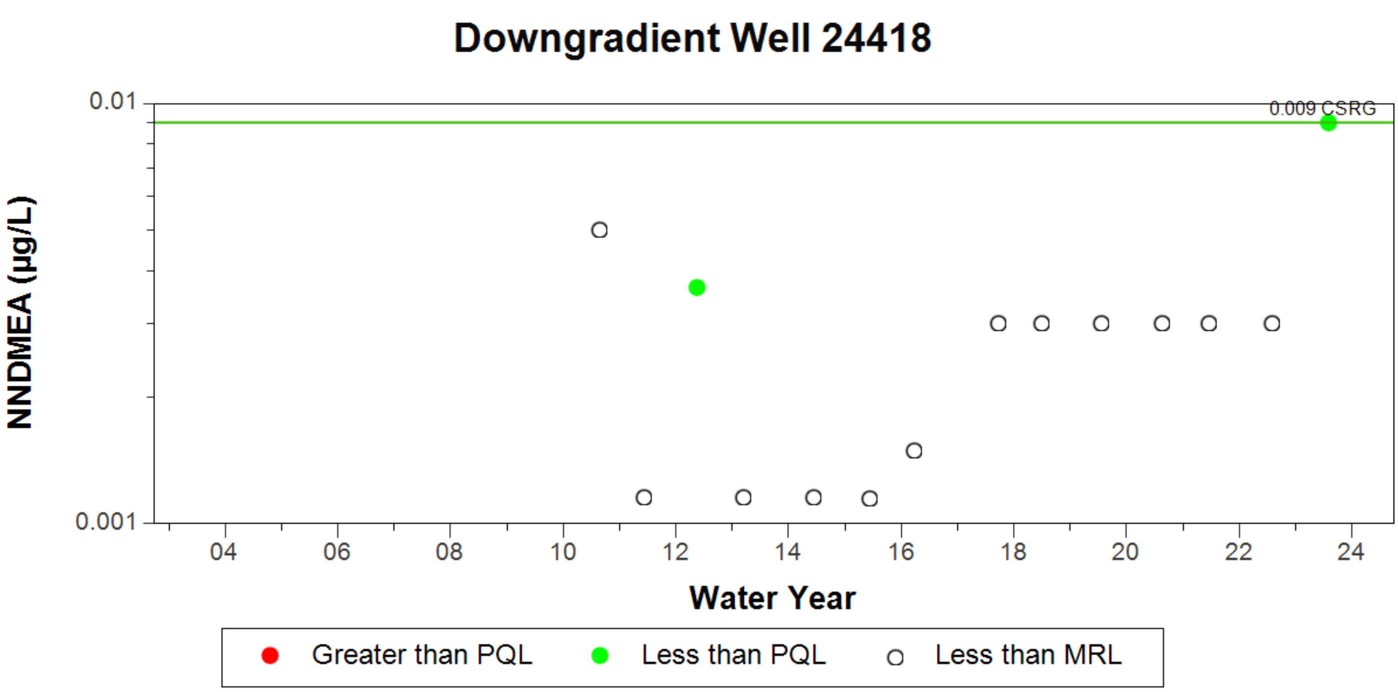

Downgradient Well 23438
NNDMEA (µg/L)
0.1
0.01
0.001
0.009 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL


Downgradient Well 24004
NNDMEA (µg/L)
0.1
0.01
0.001
0.009 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

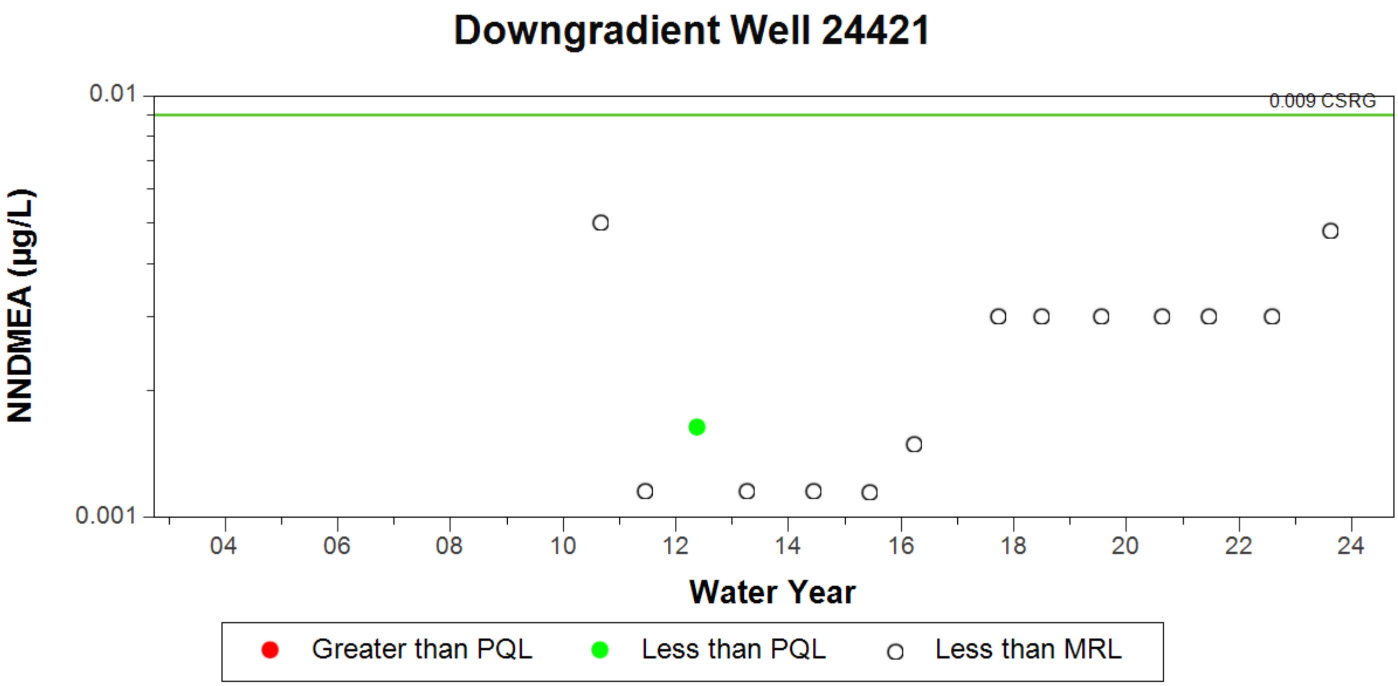

Downgradient Well 24006
NNDMEA (µg/L)
0.1
0.01
0.001
0.009 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

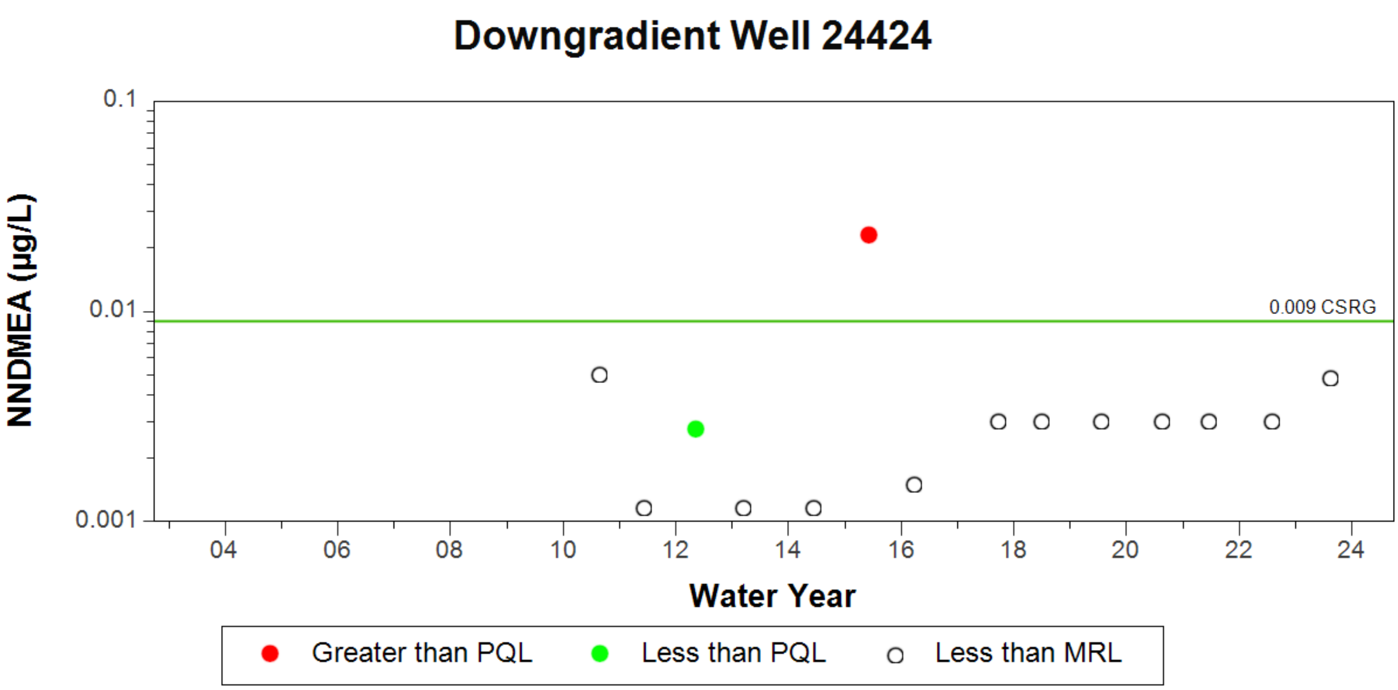


Downgradient Well 24415
NNDMEA (µg/L)
0.1
0.01
0.001
0.009 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

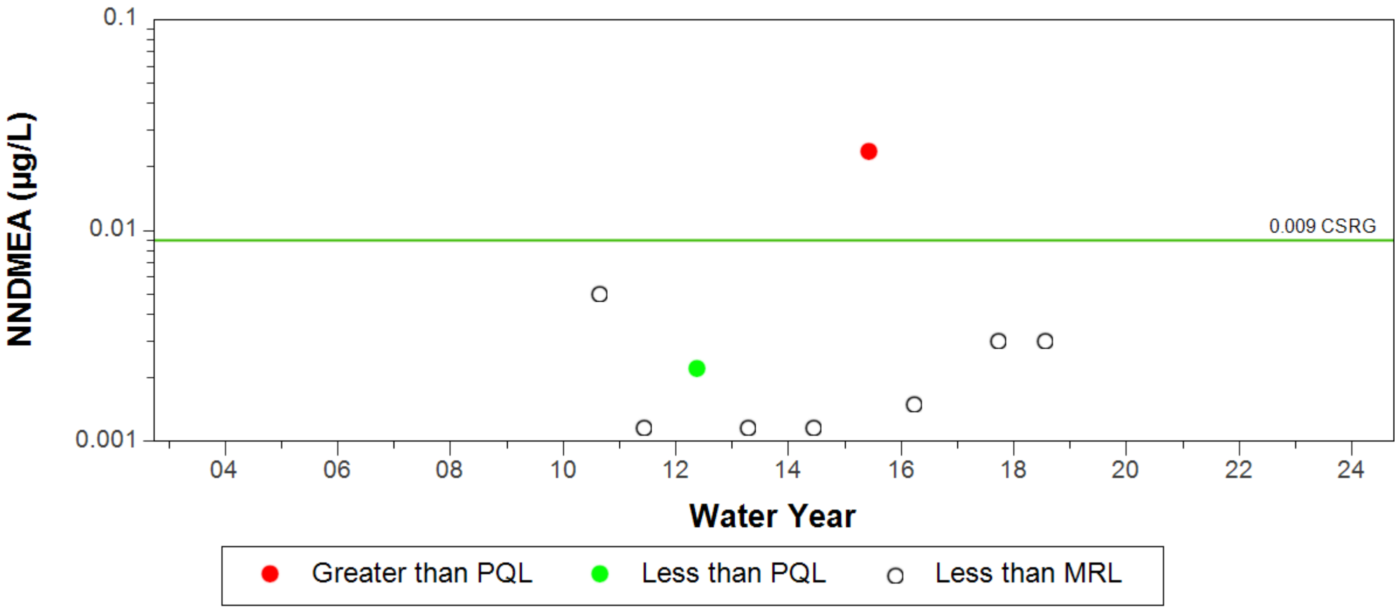


Downgradient Well 24418
NNDMEA (µg/L)
0.01
0.001
0.009 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

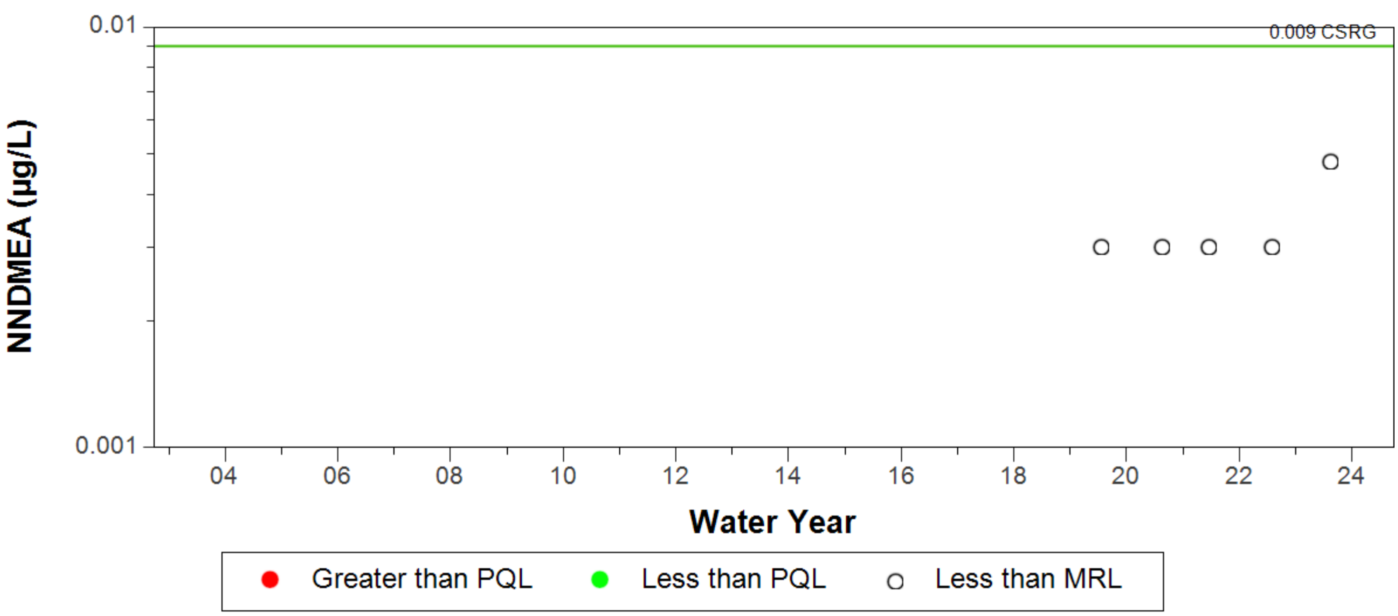

Downgradient Well 24421
NNDMEA (µg/L)
0.01
0.001
0.009 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL


Downgradient Well 24424
NNDMEA (µg/L)
0.1
0.01
0.001
0.009 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

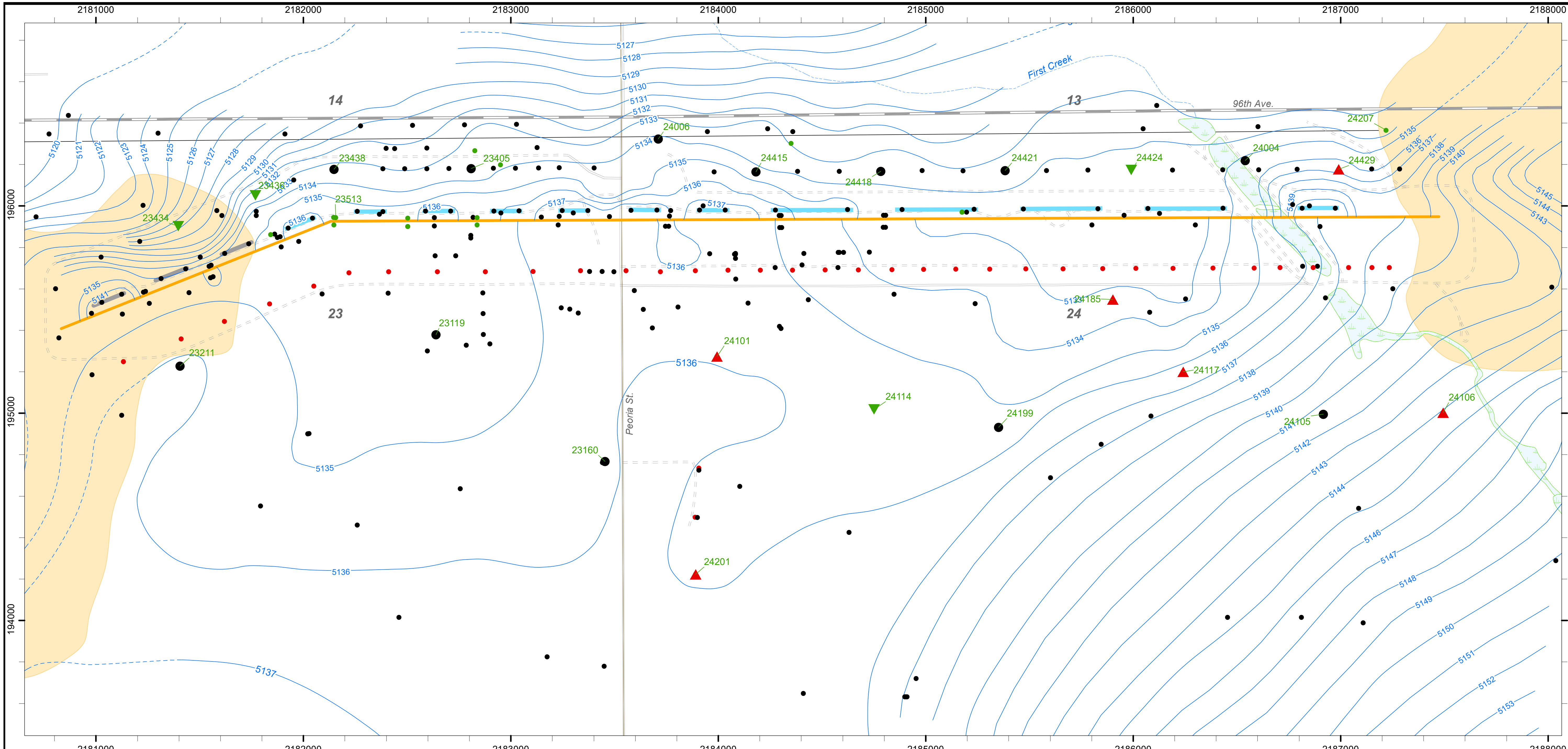
Downgradient Well 37362



Well 24429



Downgradient performance Well 24207 replaced Well 37362, but it could not be sampled due to insufficient water. Nearby alternate Well 24429 was monitored instead.



Legend

- Unsaturated Alluvium
- Section Lines
- Water elevation contour - 1-foot interval
- Inferred water elevation contour
- Wetlands
- Intermittent Streams
- Ditches
- Slurry Walls
- Recharge Trenches
- Inactive Recharge Trenches
- Unimproved Roads
- Local Roads
- Secondary Roads
- Primary Roads
- Monitoring Wells
- Performance Water Quality Wells
- Extraction Wells

Notes: Water levels were measured in FY23 Quarter 2.

Upgradient and Downgradient Performance Well Water Quality

- Analyte Detected Above the CSRG - Increasing Trend Noted
- Analyte Detected Above the CSRG - Decreasing Trend Noted
- Analyte Detected - Showing Stable or No Discernible Trend
- Analyte Not Detected

Notes:
1. Trends are depicted for the 10 year period FY14 - FY23.
2. Time versus concentration charts for Performance Water Quality wells are presented following this map.

N

0 250 500 Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

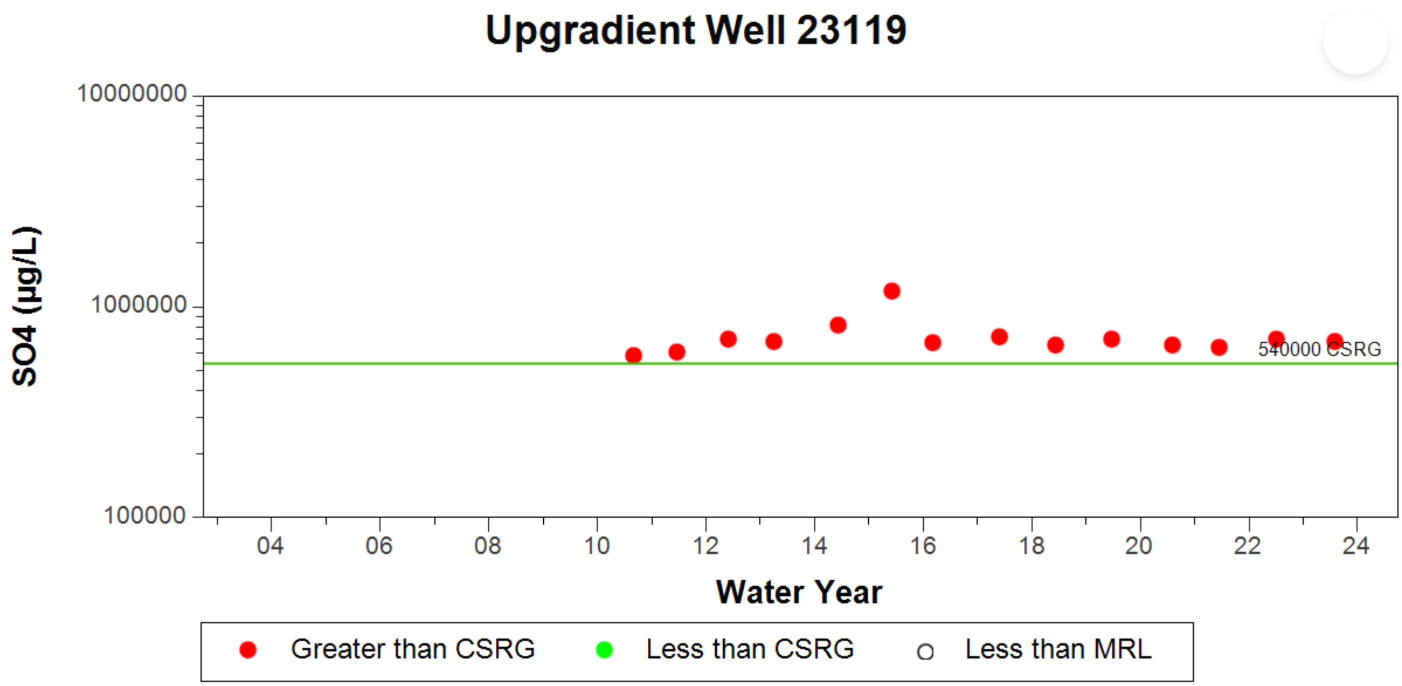
Program Manager
Rocky Mountain Arsenal

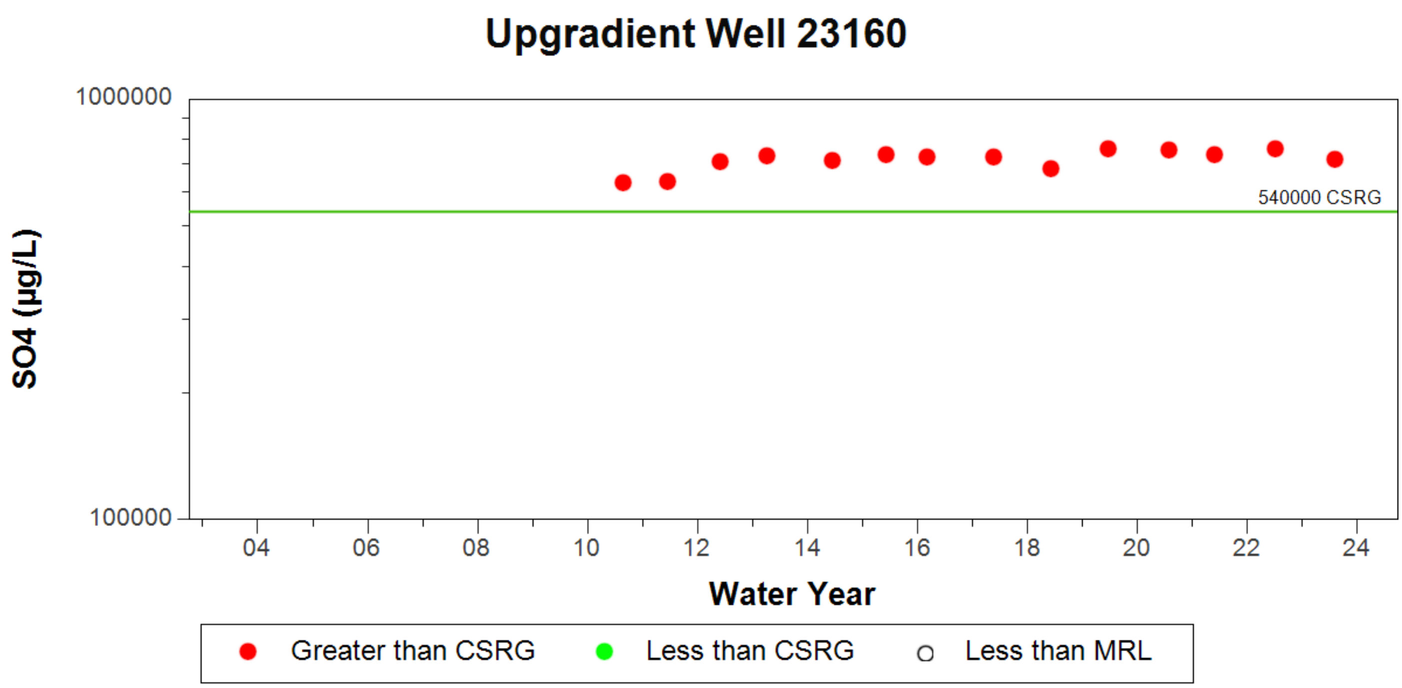
U.S. Army • COMMITTED TO PROTECTION OF THE ENVIRONMENT •

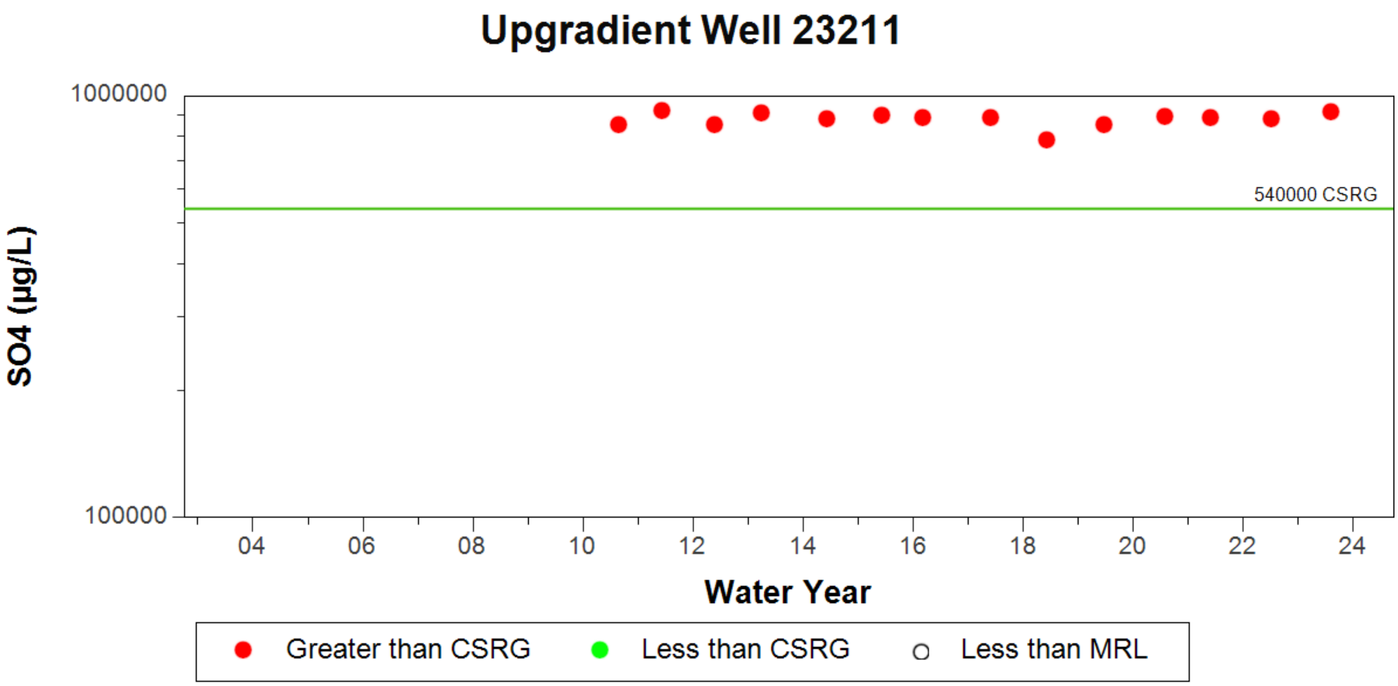
Figure B-33

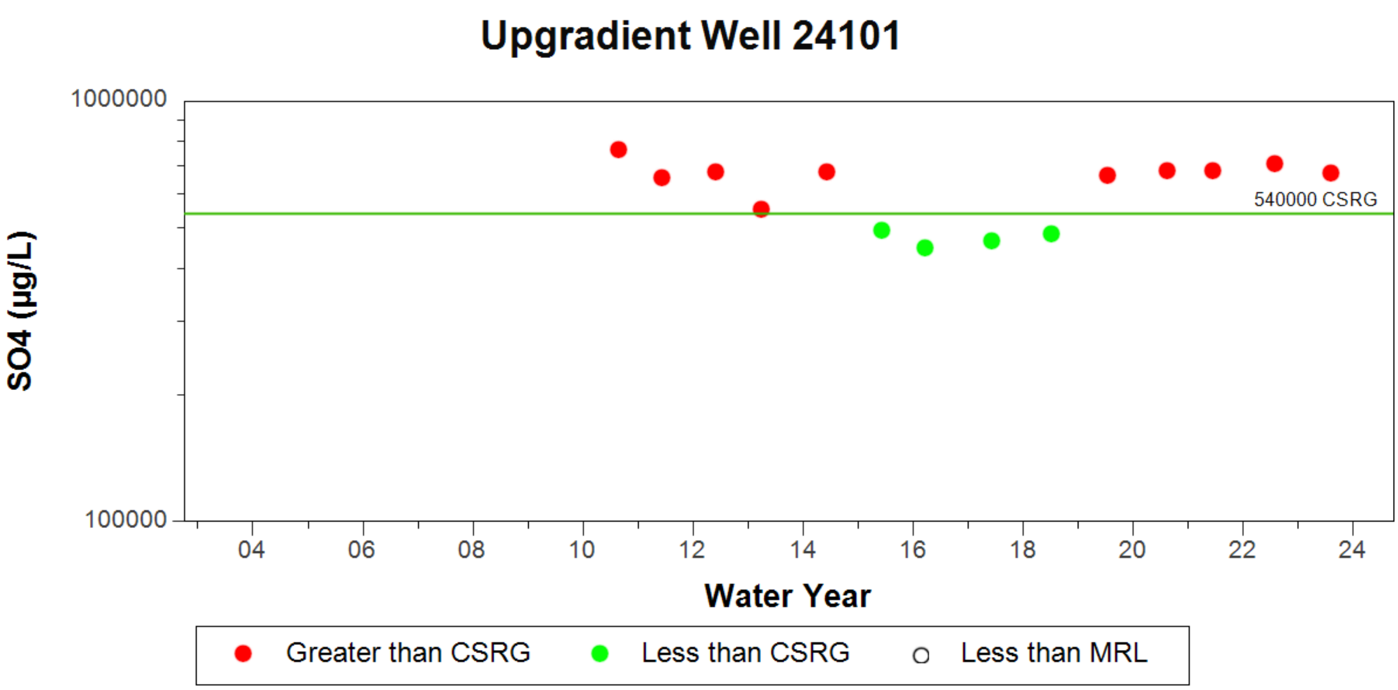
Sulfate Concentration
Trends in Performance Wells,
North Boundary Containment System

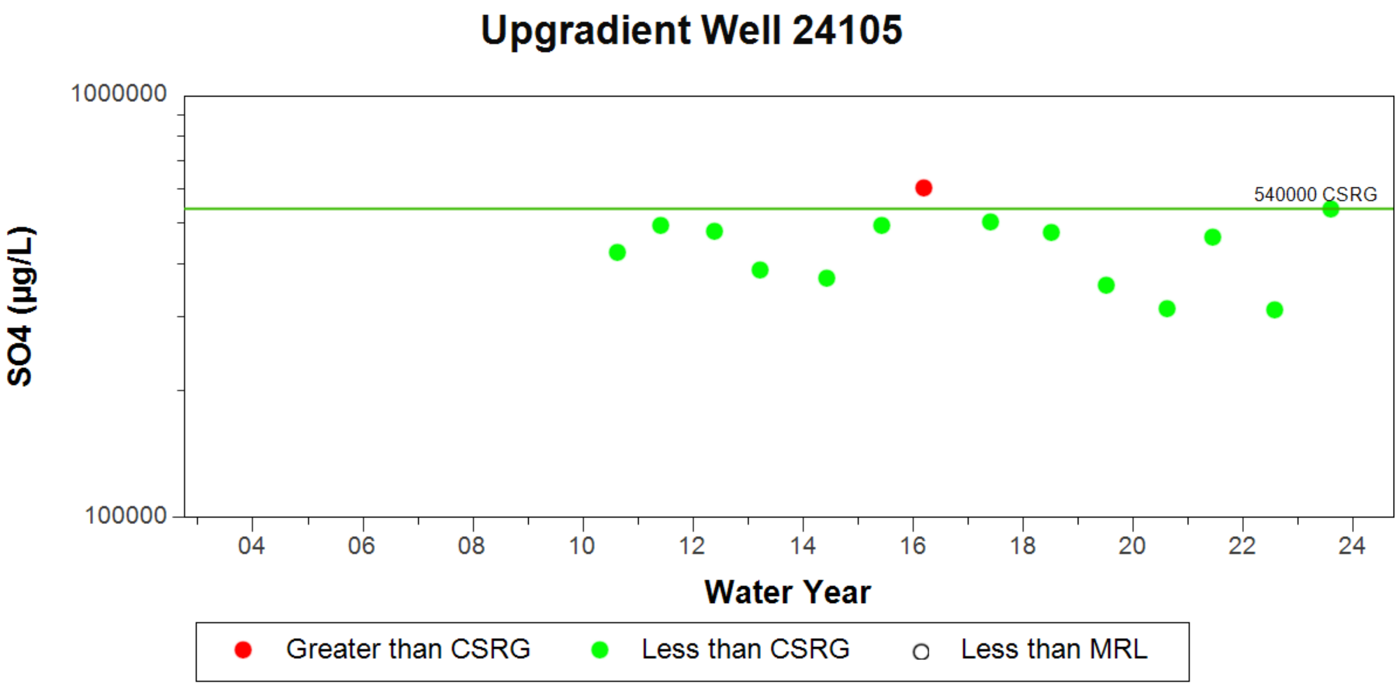
M:\projects\oars\fy23\mxds_NB_FY23_SO4.mxd
8/7/2024


Upgradient Well 23119
SO4 (µg/L)
10000000
1000000
100000
540000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

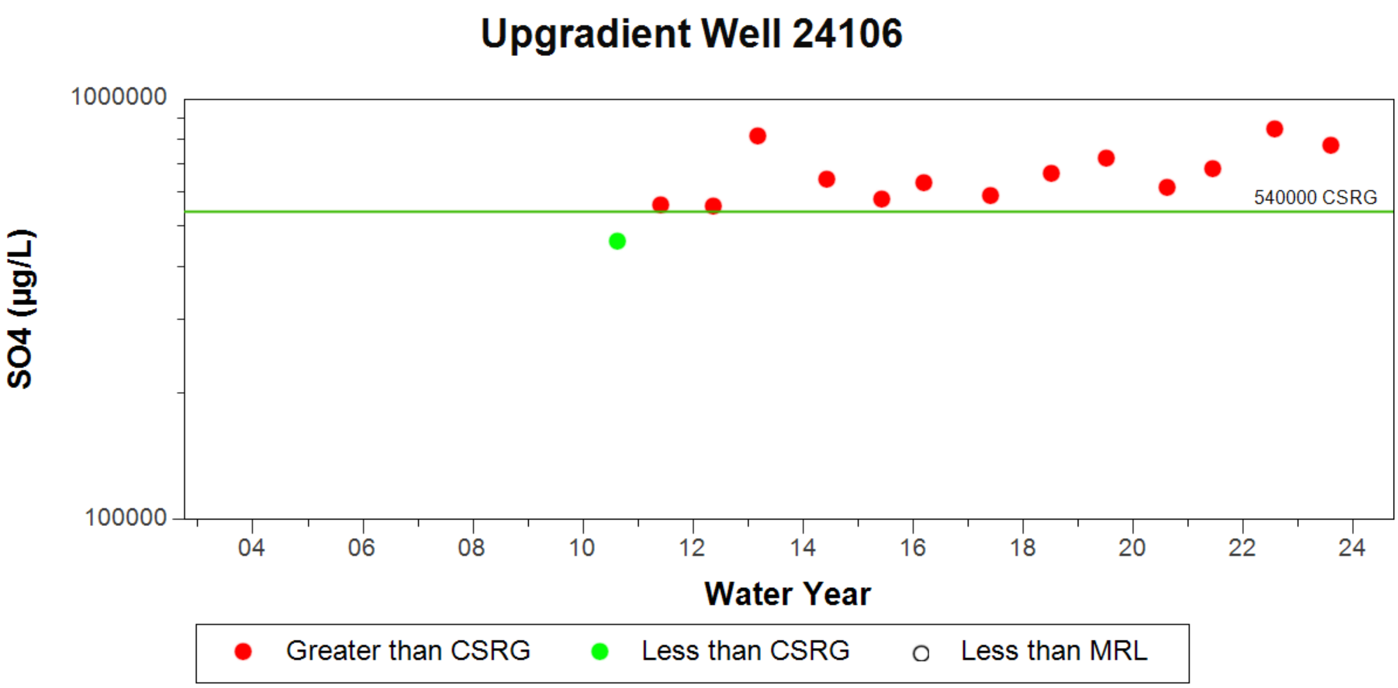

Upgradient Well 23160
SO4 (µg/L)
1000000
100000
540000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL


Upgradient Well 23211
SO4 (µg/L)
1000000
100000
540000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

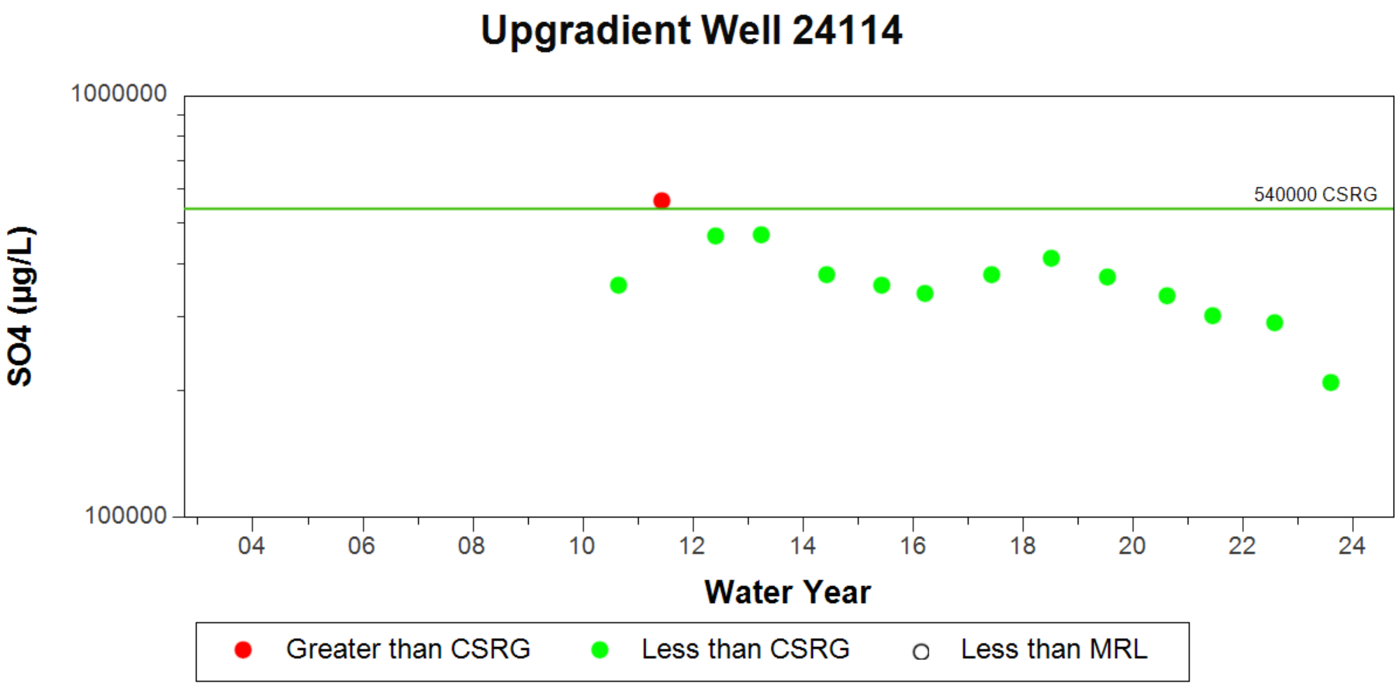

Upgradient Well 24101
SO4 (µg/L)
1000000
100000
540000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

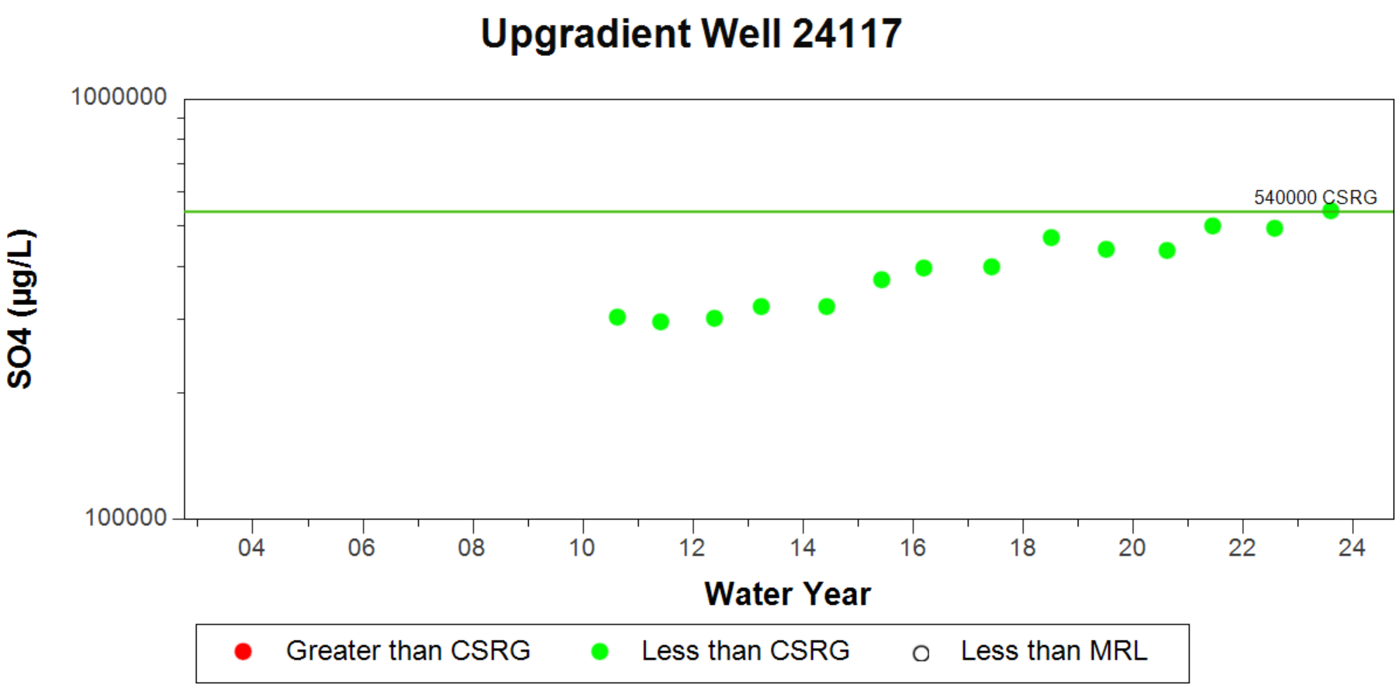


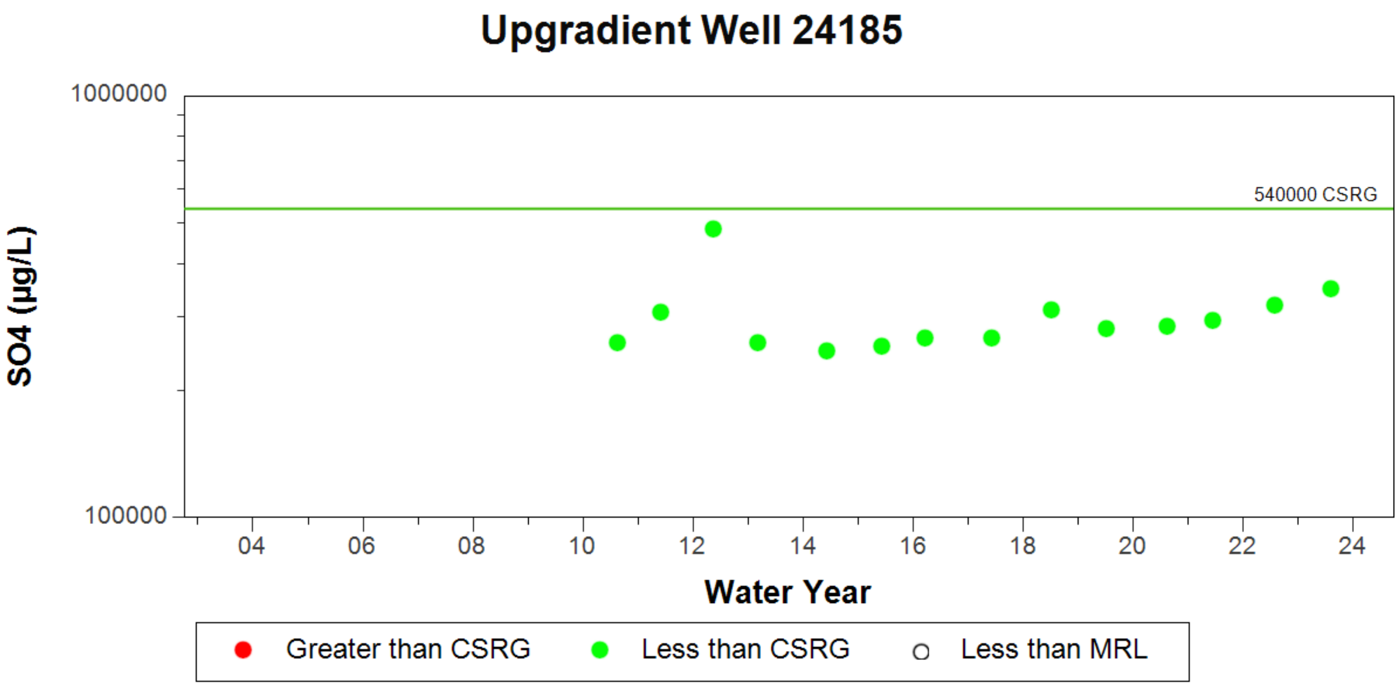
Upgradient Well 24105
1000000
100000
SO4 (µg/L)
540000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

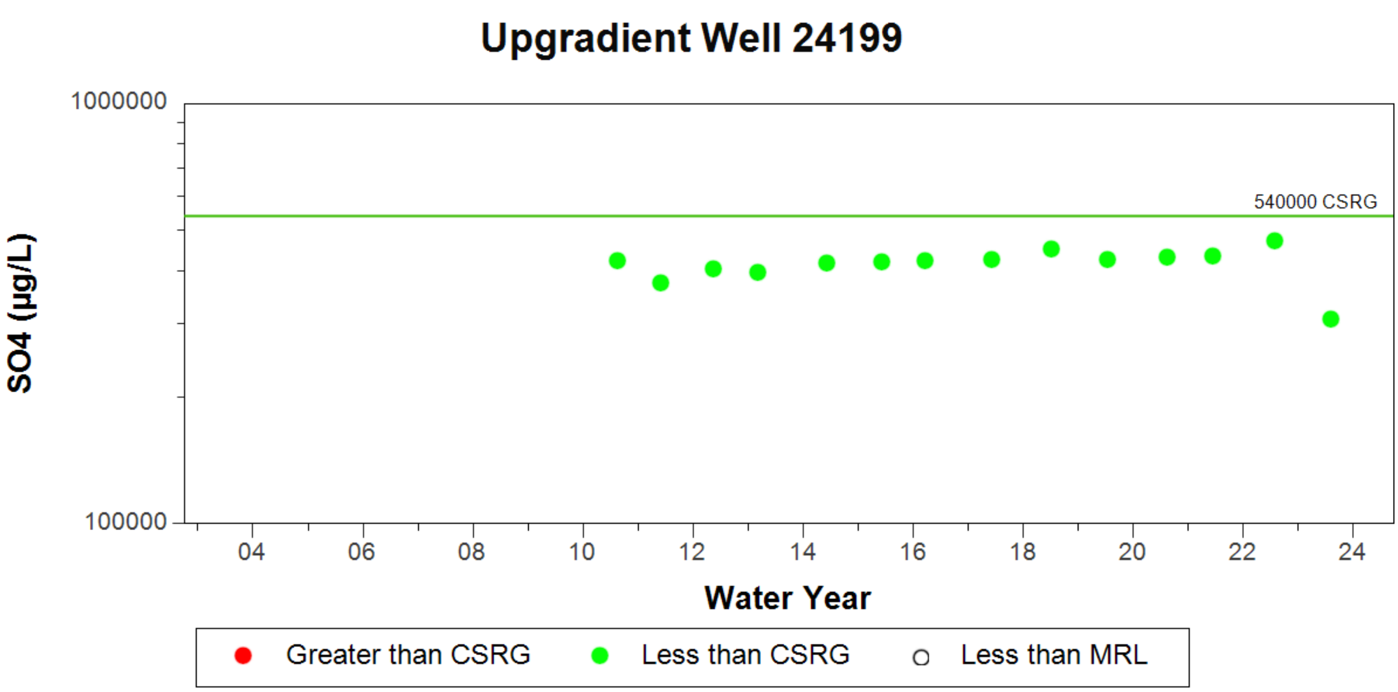


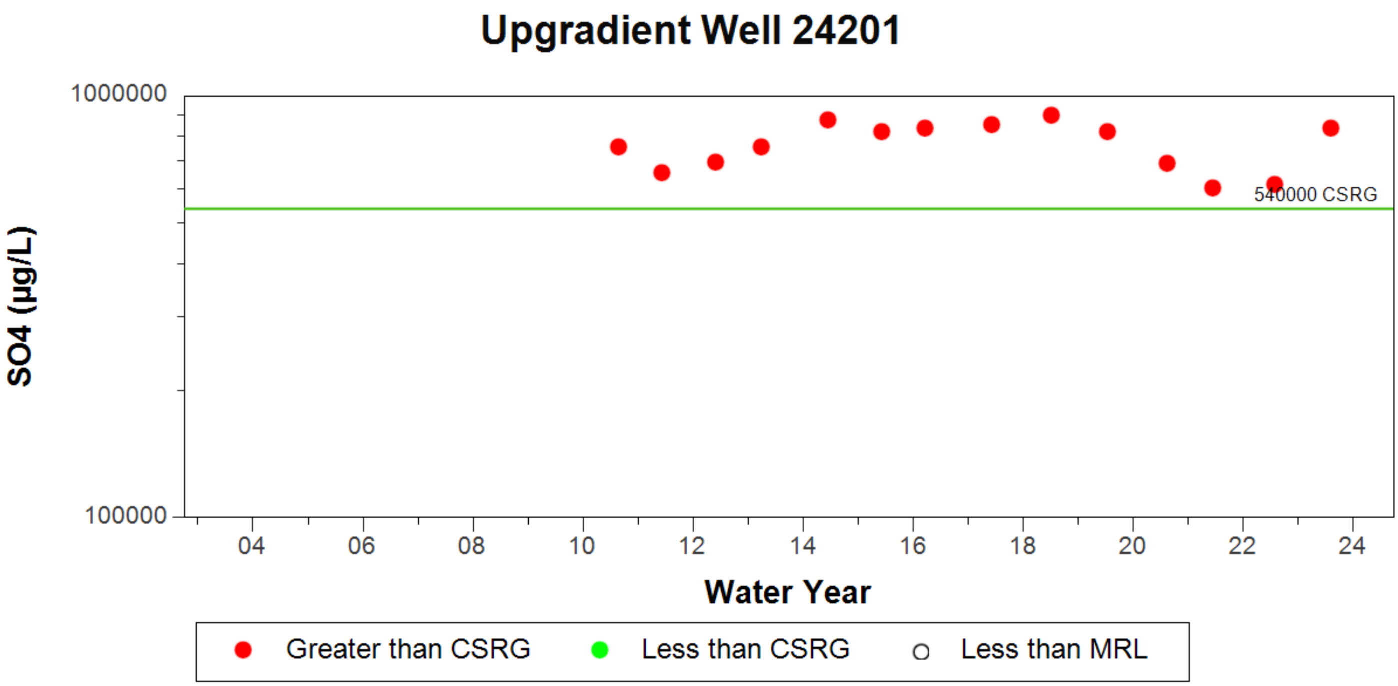
Upgradient Well 24106
1000000
100000
SO4 (µg/L)
540000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL


Upgradient Well 24114
1000000
100000
540000 CSRG
SO4 (µg/L)
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

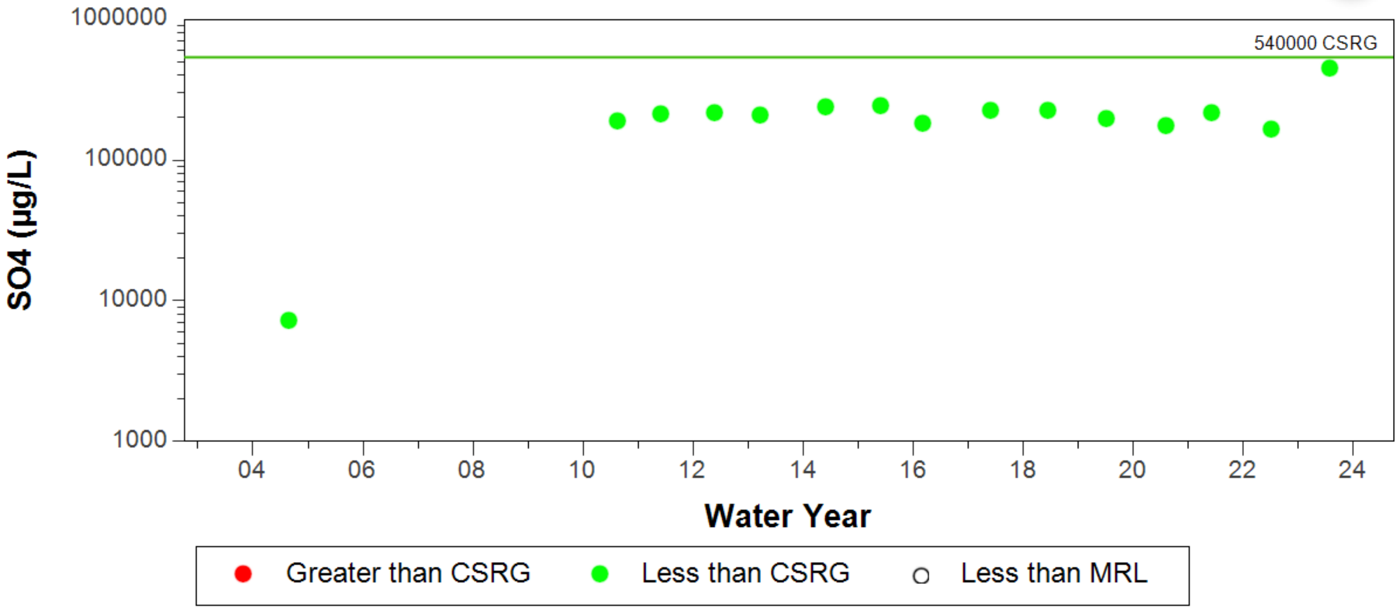

Upgradient Well 24117
1000000
100000
540000 CSRG
SO4 (µg/L)
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL


Upgradient Well 24185
1000000
100000
SO4 (µg/L)
540000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

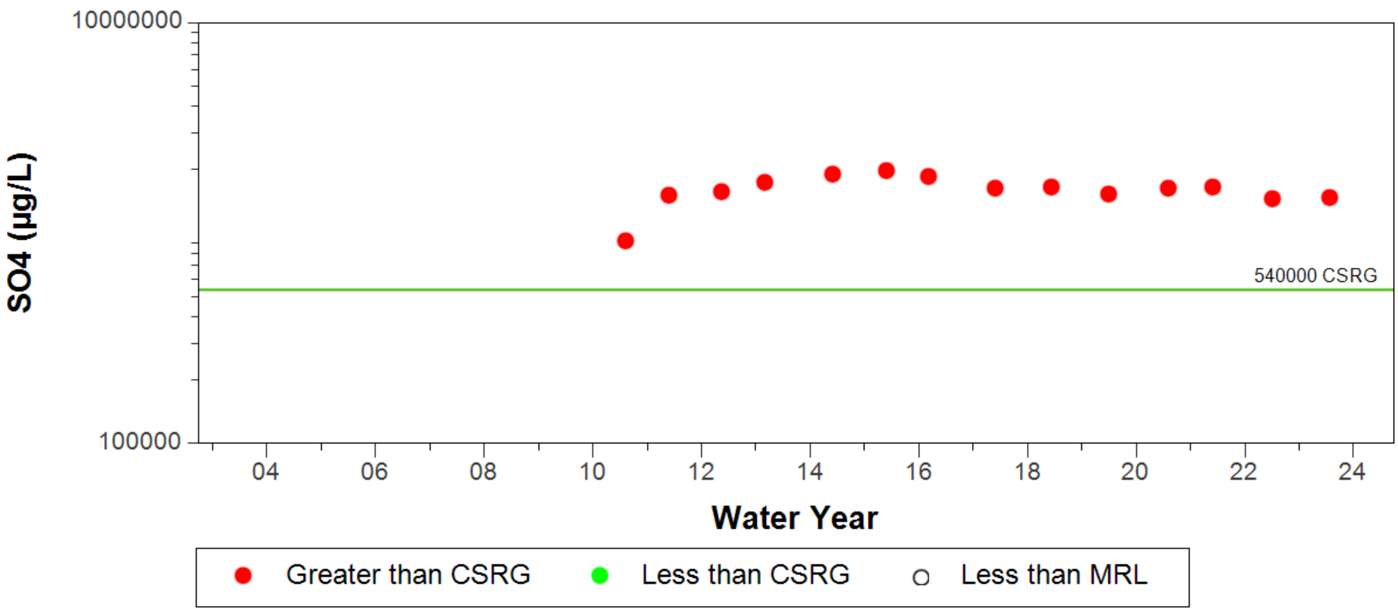

Upgradient Well 24199
1000000
100000
SO4 (µg/L)
540000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

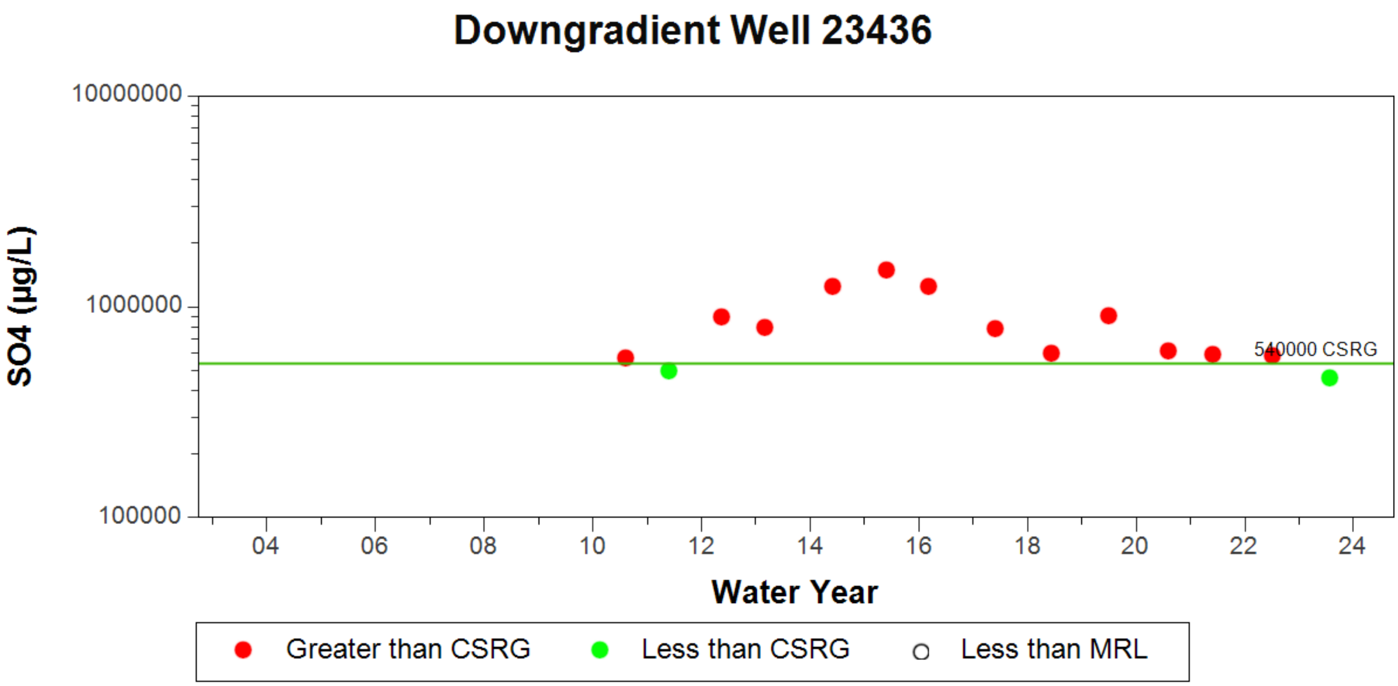

Upgradient Well 24201
1000000
100000
SO4 (µg/L)
540000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

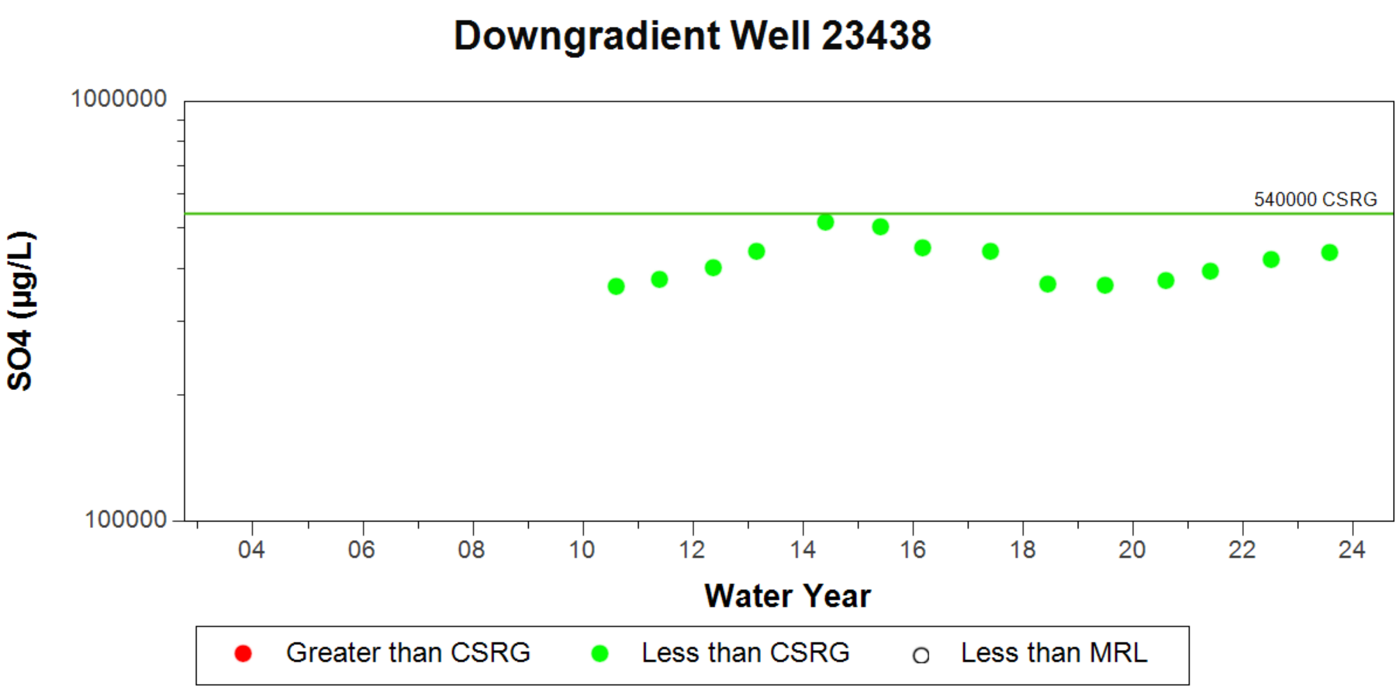
Downgradient Well 23405

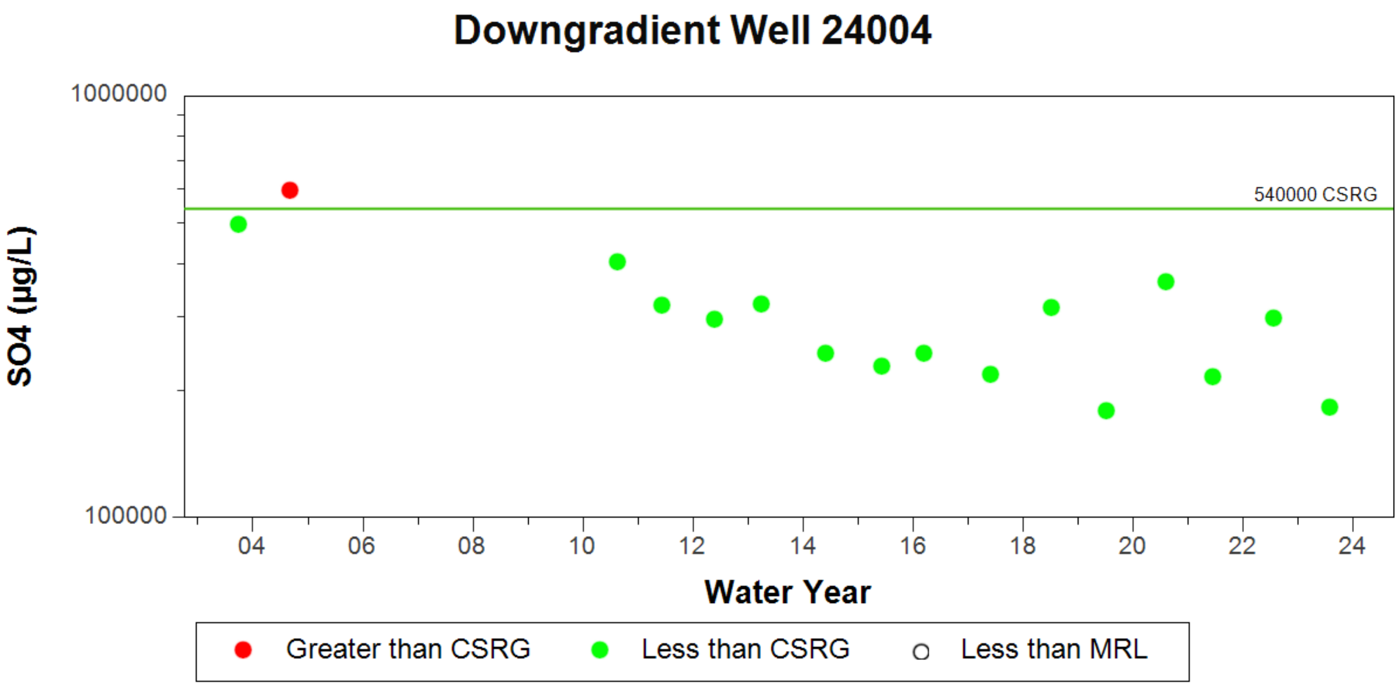


Downgradient Well 23434

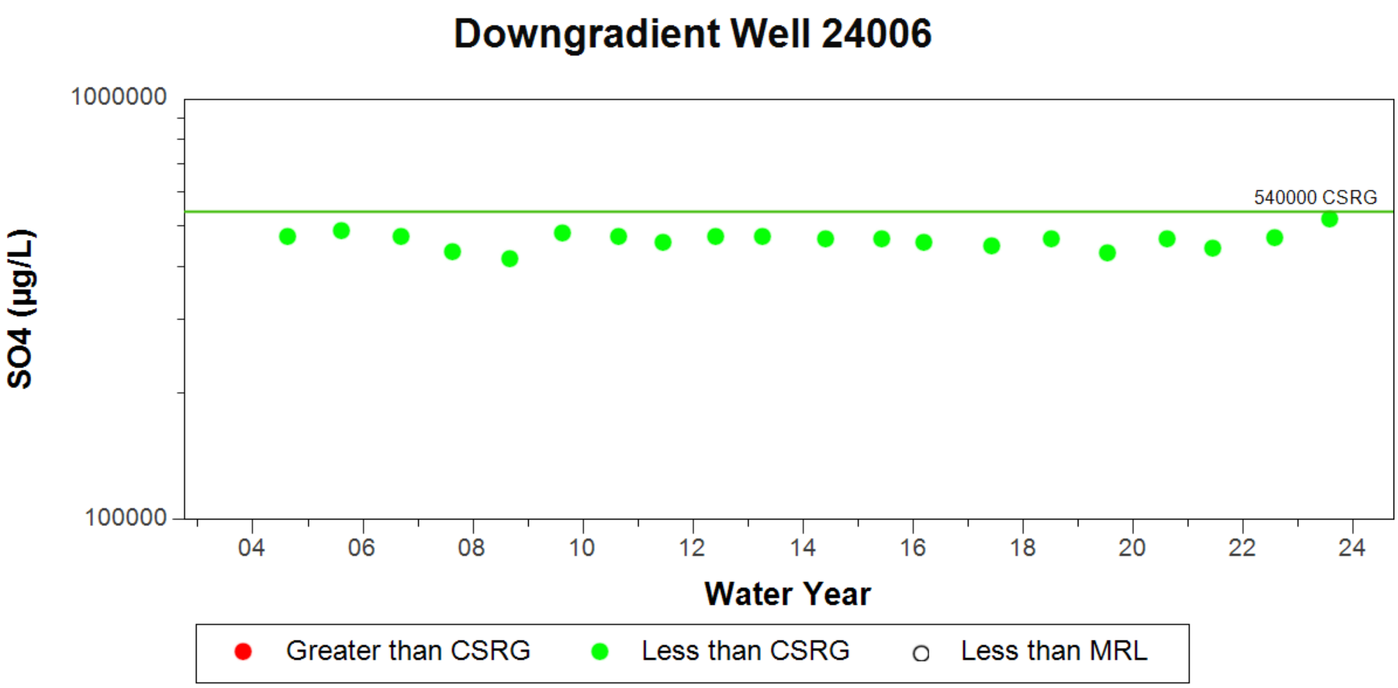



Downgradient Well 23436
10000000
1000000
100000
SO4 (µg/L)
540000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL


Downgradient Well 23438
1000000
100000
SO4 (µg/L)
540000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

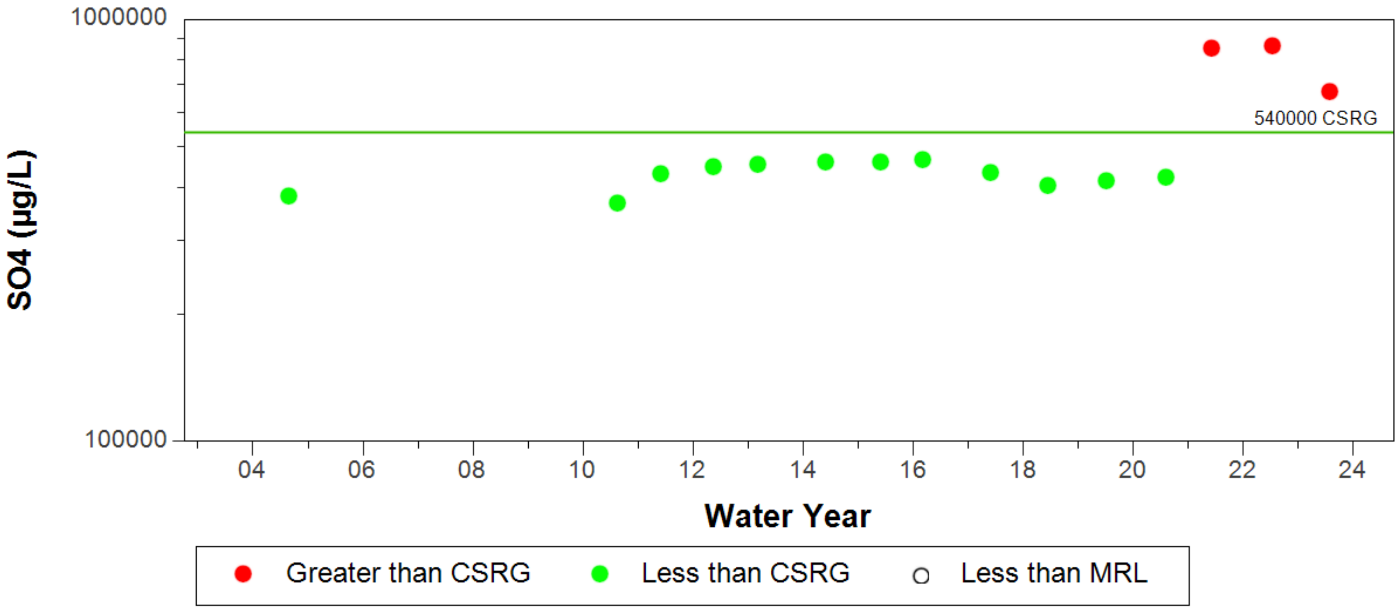


Downgradient Well 24004
1000000
100000
540000 CSRG
SO4 (µg/L)
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

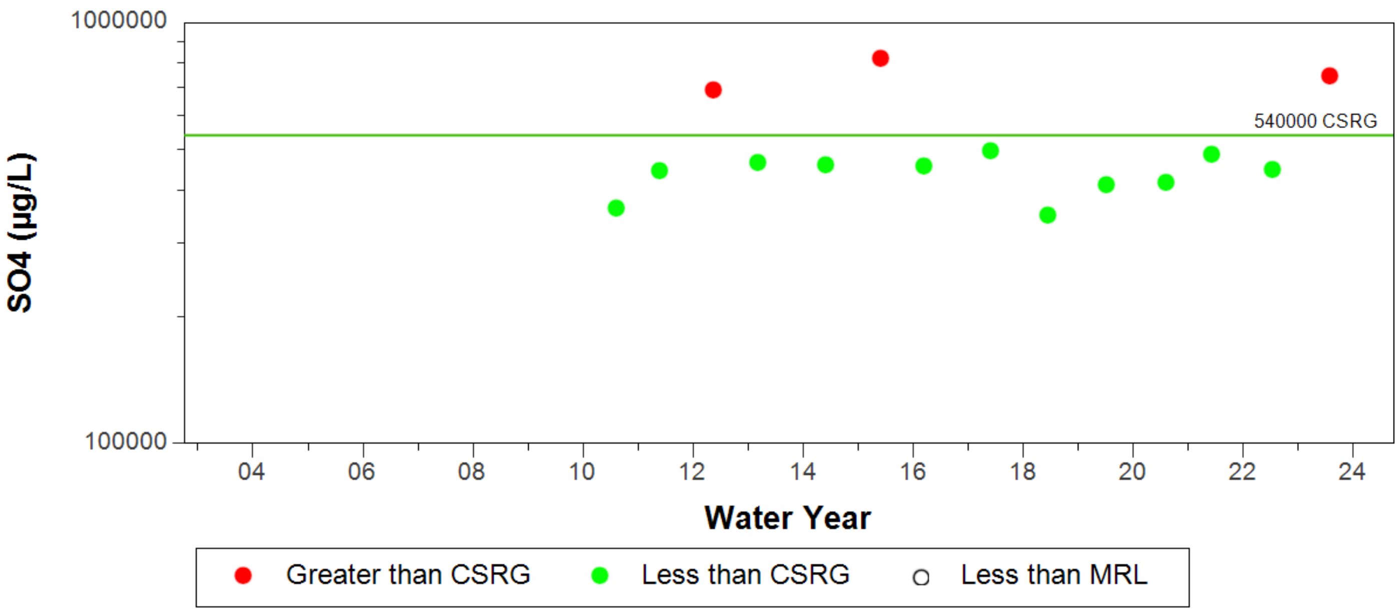


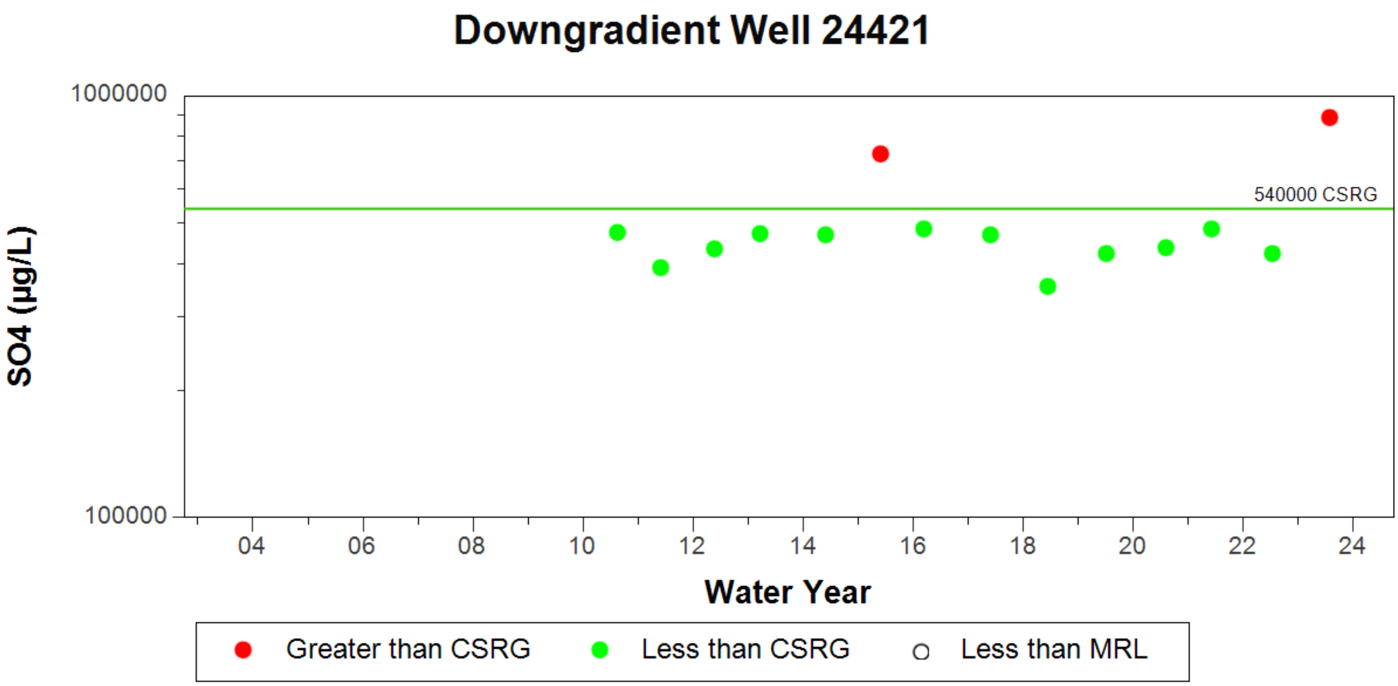
Downgradient Well 24006
1000000
100000
540000 CSRG
SO4 (µg/L)
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

Downgradient Well 24415

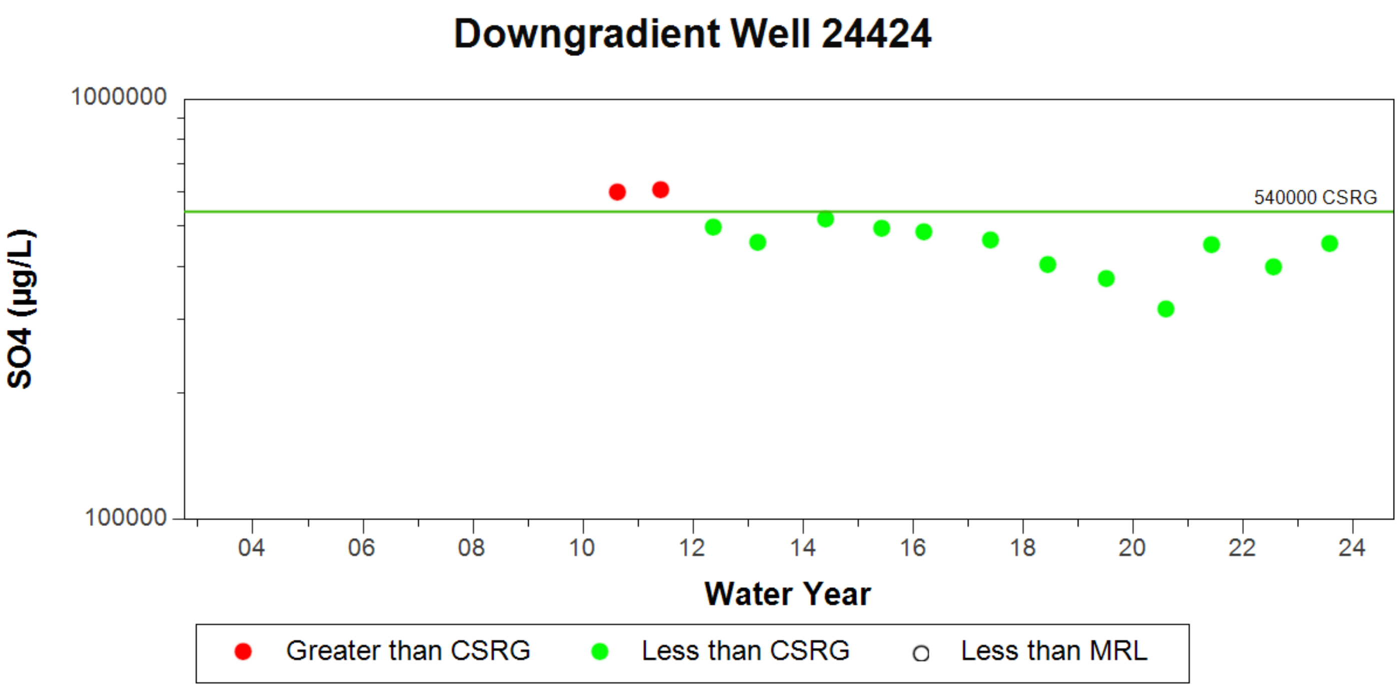


Downgradient Well 24418

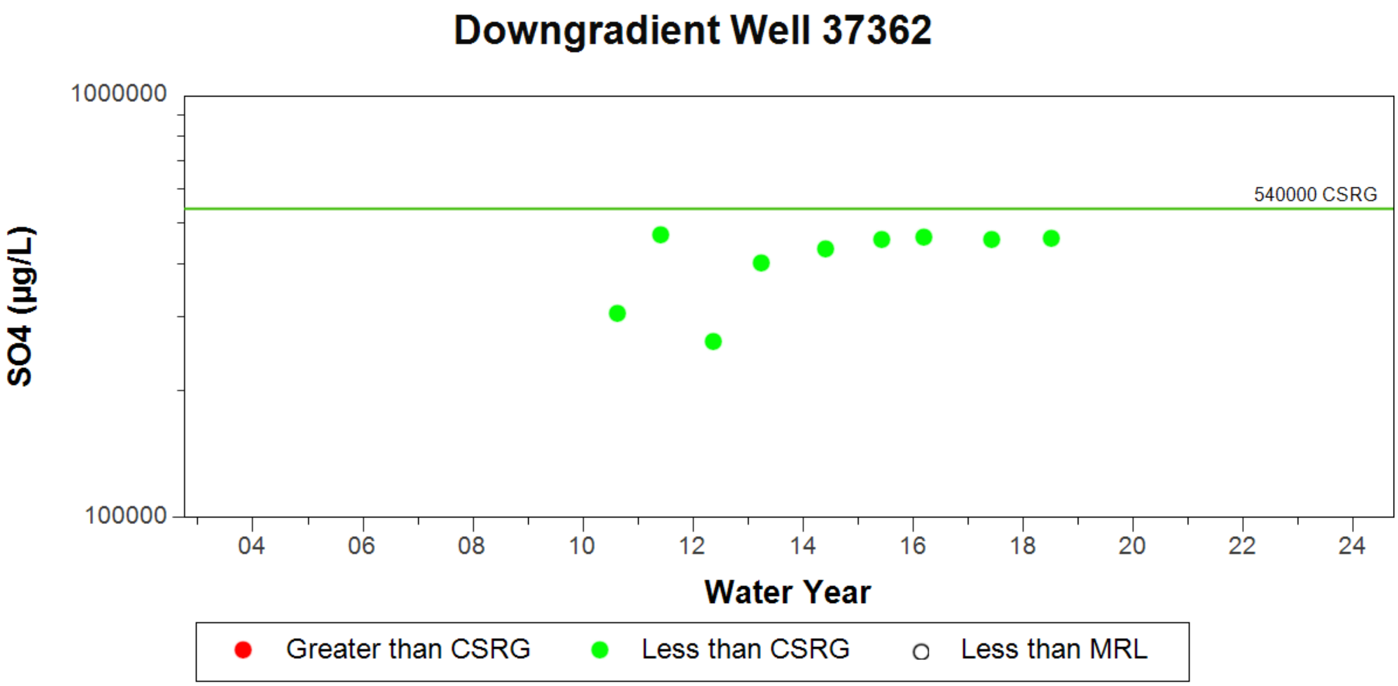


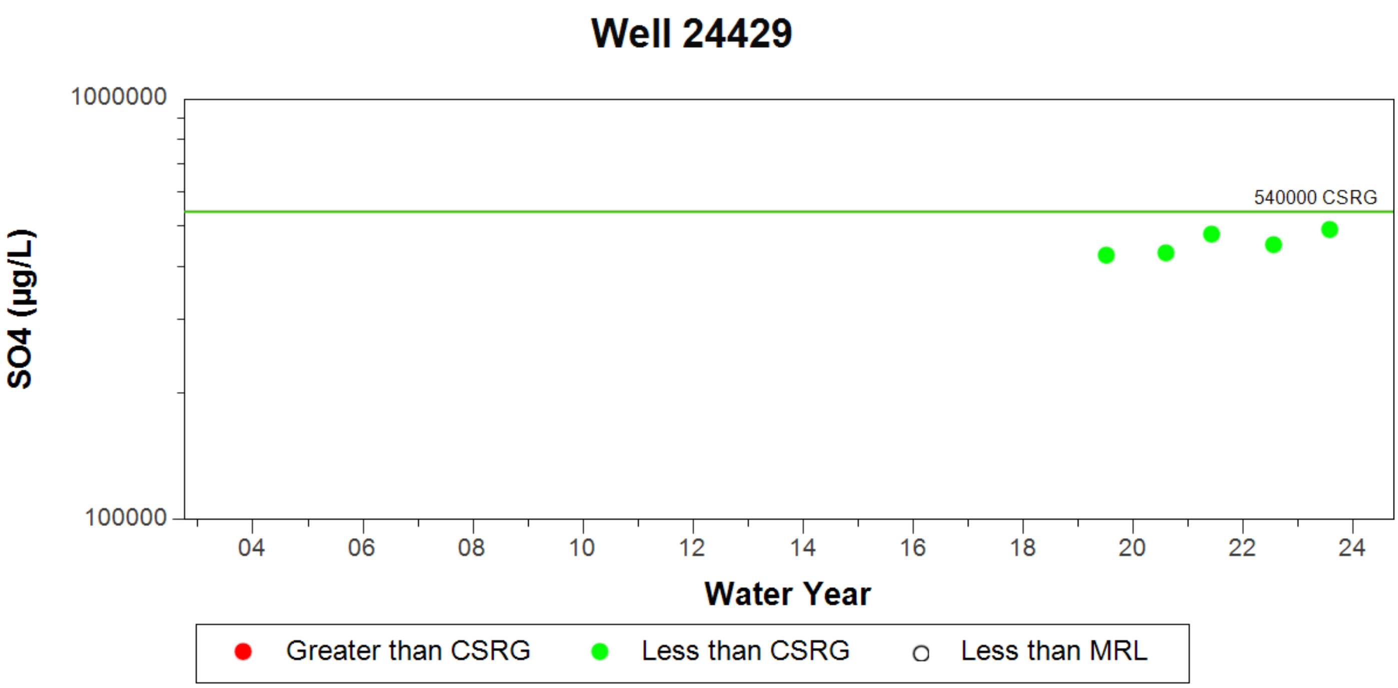


Downgradient Well 24421
1000000
100000
540000 CSRG
SO4 (µg/L)
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



Downgradient Well 24424
1000000
100000
540000 CSRG
SO4 (µg/L)
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

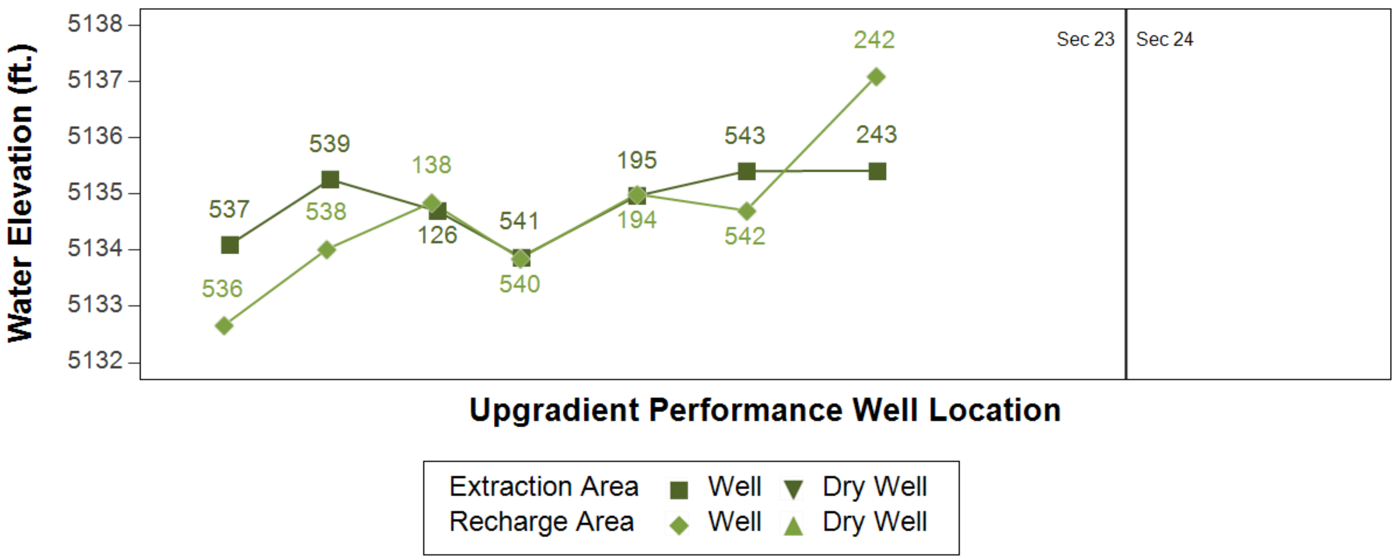




Downgradient performance Well 24207 replaced Well 37362, but it could not be sampled due to insufficient water. Nearby alternate Well 24429 was monitored instead.

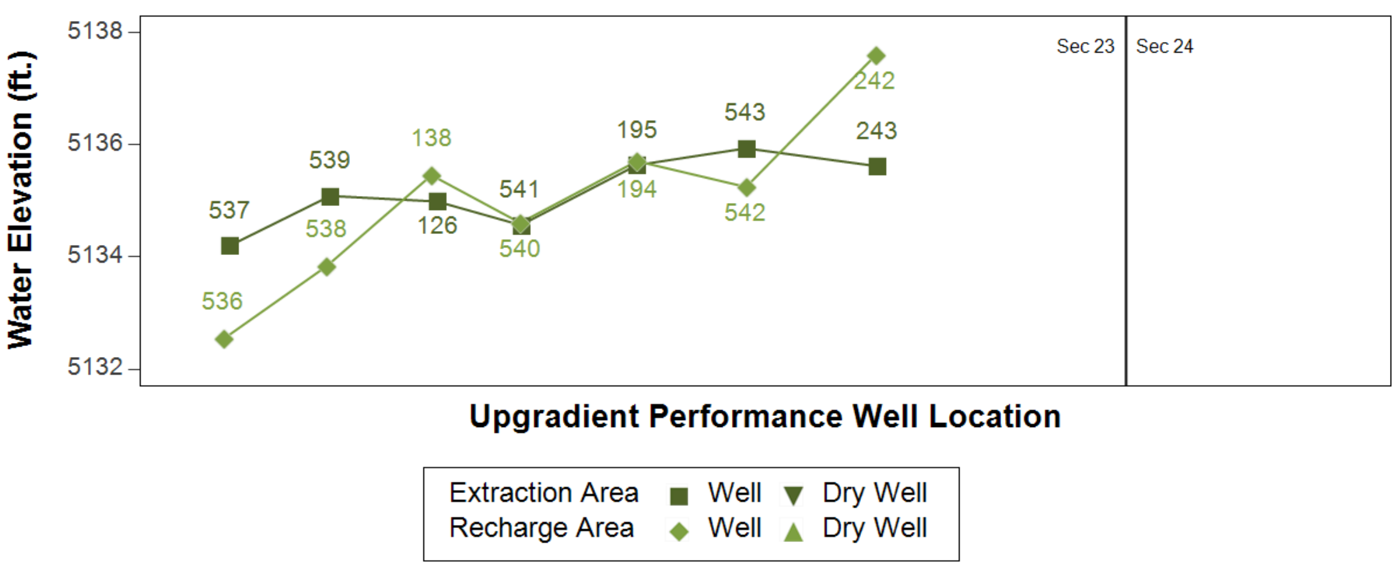
North Boundary Water Levels (Denver)

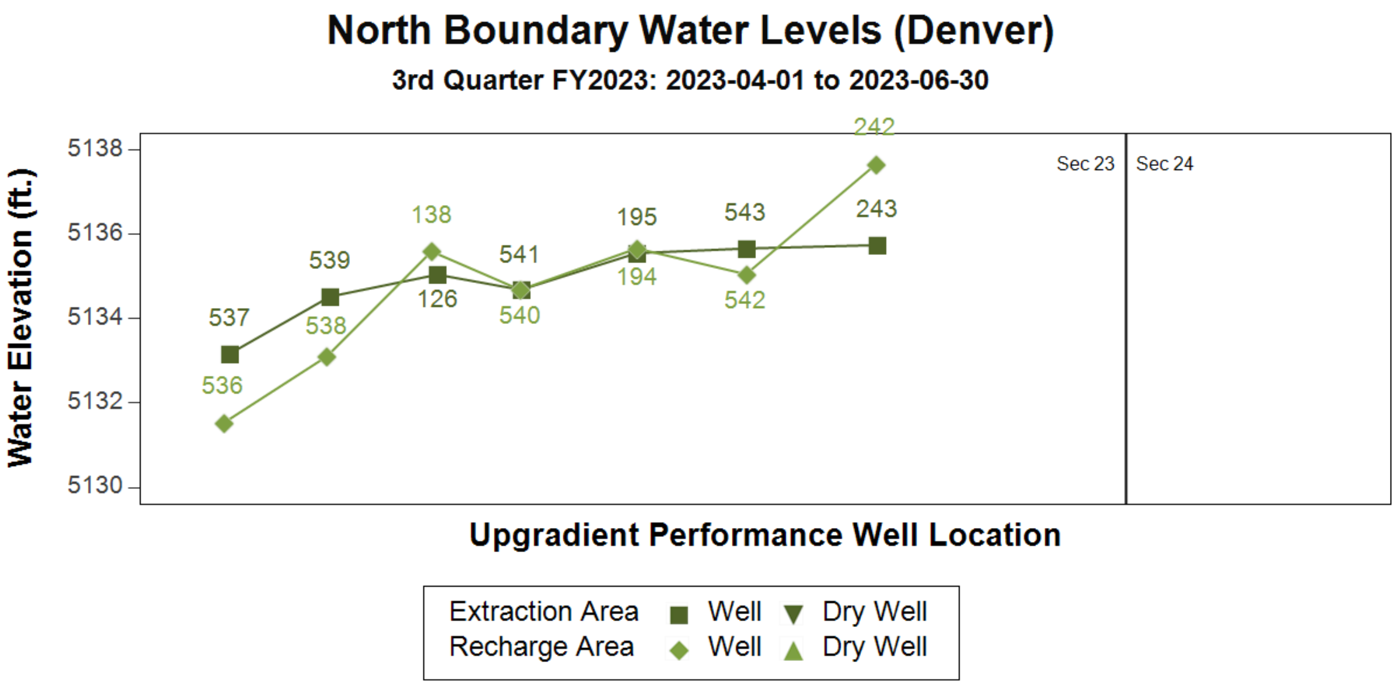
1st Quarter FY2023: 2022-10-01 to 2022-12-31

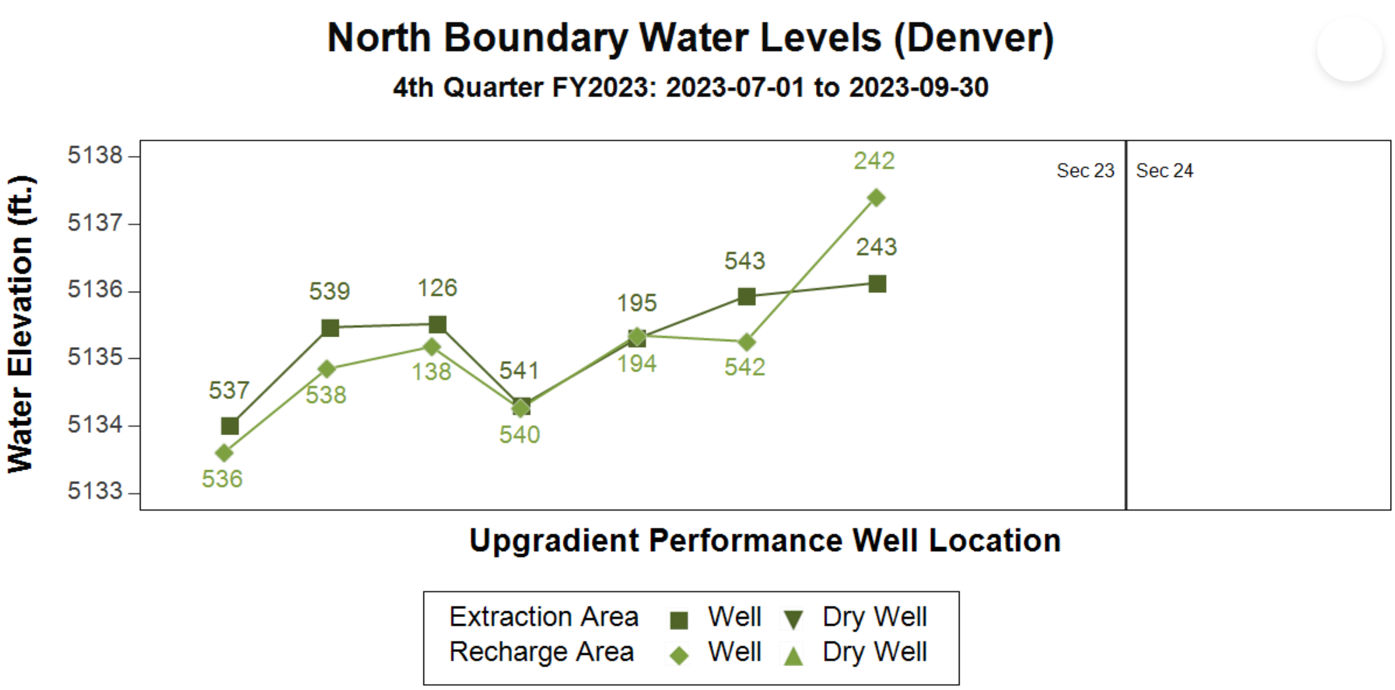


North Boundary Water Levels (Denver)

2nd Quarter FY2023: 2023-01-01 to 2023-03-31




North Boundary Water Levels (Denver)
3rd Quarter FY2023: 2023-04-01 to 2023-06-30
Water Elevation (ft.)
5138
5136
5134
5132
5130
Upgradient Performance Well Location
Sec 23
Sec 24
537
536
539
538
138
126
541
540
195
194
543
542
242
243
Extraction Area
Recharge Area
Well
Dry Well
Well
Dry Well


North Boundary Water Levels (Denver)
4th Quarter FY2023: 2023-07-01 to 2023-09-30
Water Elevation (ft.)
5138
5137
5136
5135
5134
5133
Upgradient Performance Well Location
Sec 23
Sec 24
537
536
539
538
126
138
541
540
195
194
543
542
242
243
Extraction Area
Recharge Area
Well
Dry Well
Well
Dry Well

Appendix C

Basin A Neck System
Figures and Documentation

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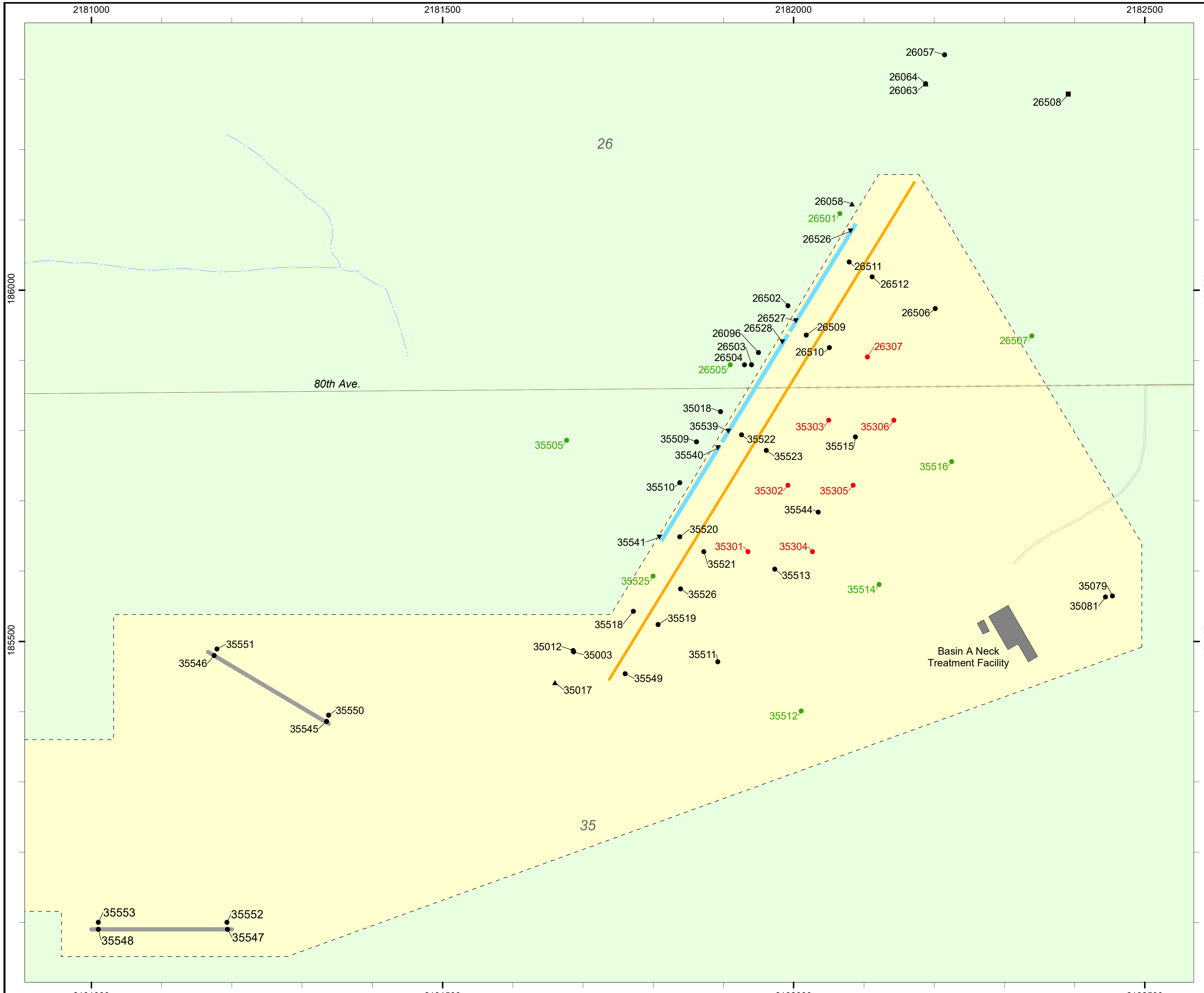


Legend

- USFWS Managed Area
- Army Maintained Area
- Section Lines
- Army Maintained Area & USFWS Managed Area Border
- Treatment Building
- Ditches
- Slurry Wall
- Recharge Trench
- Inactive Recharge Trench
- Paved Roads
- Unimproved Roads
- Performance Water Quality Wells
- Extraction Wells

Monitoring Wells

- Confined Flow System
- Unconfined Flow System
- Flow System Not Confirmed
- Piezometers within Recharge Trenches

N

0 100 200 Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

Program Manager Rocky Mountain Arsenal

U.S. Army • COMMITTED TO PROTECTION OF THE ENVIRONMENT •

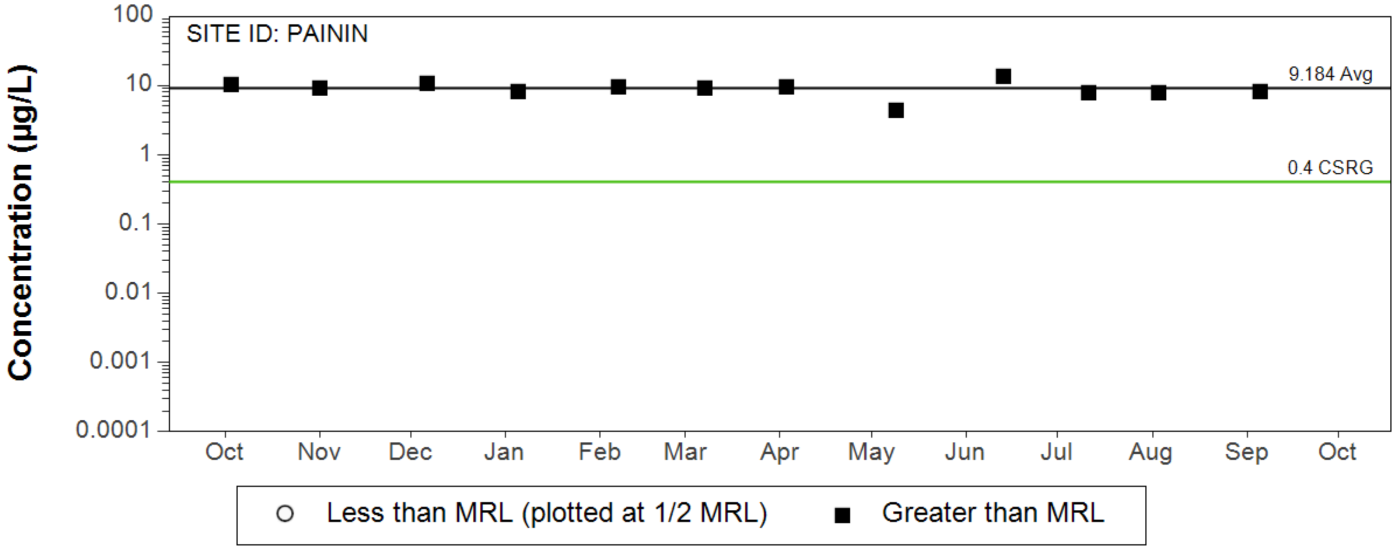
Figure C-1

Basin A Neck System
Monitoring Well Network
for the Unconfined Flow System

M:\projects\oars\fy23\mxds_ban23_well_location.mxd
8/7/2024

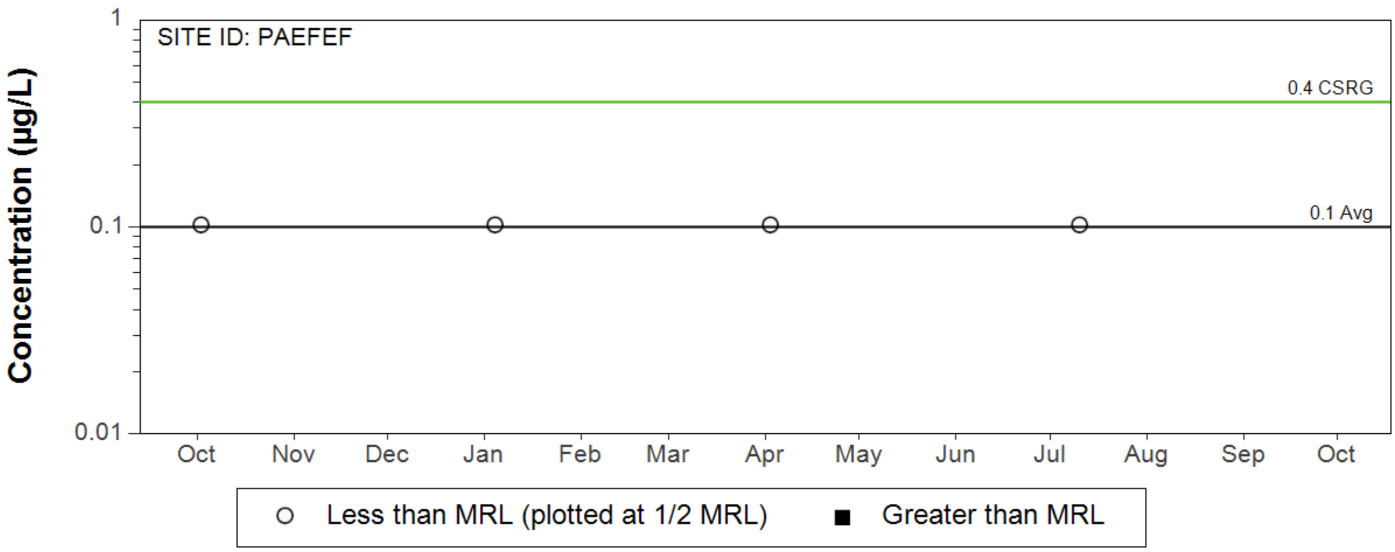
Basin A Neck Treatment Plant Influent - 12DCLE

2022-10-01 to 2023-09-30



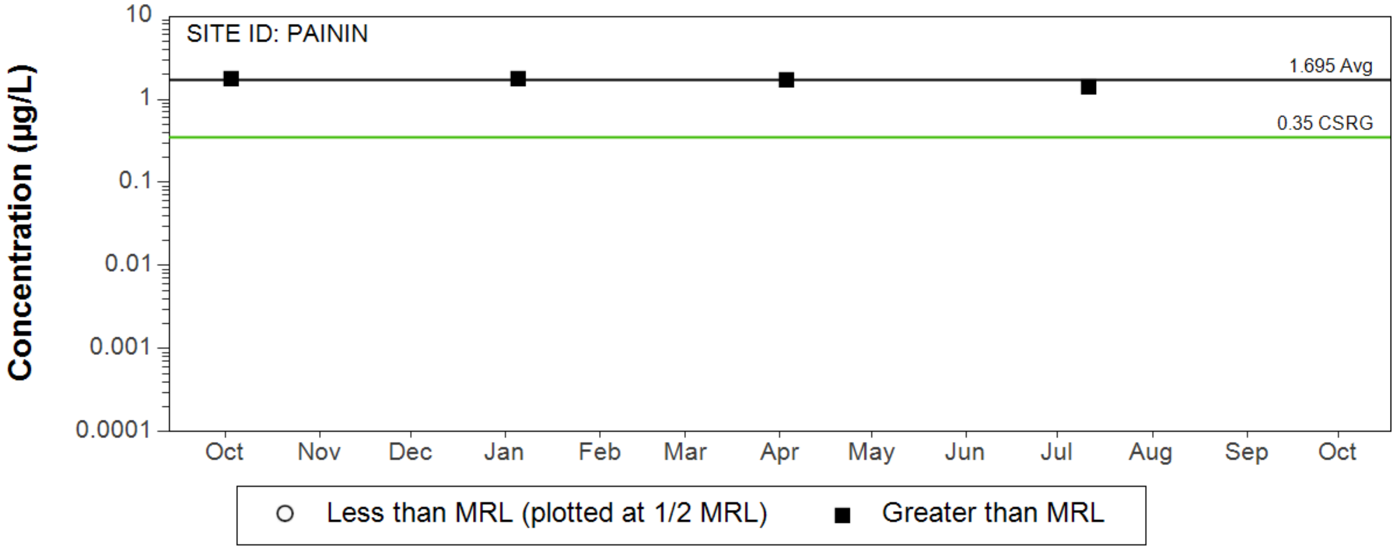
Basin A Neck Treatment Plant Effluent - 12DCLE

2022-10-01 to 2023-09-30



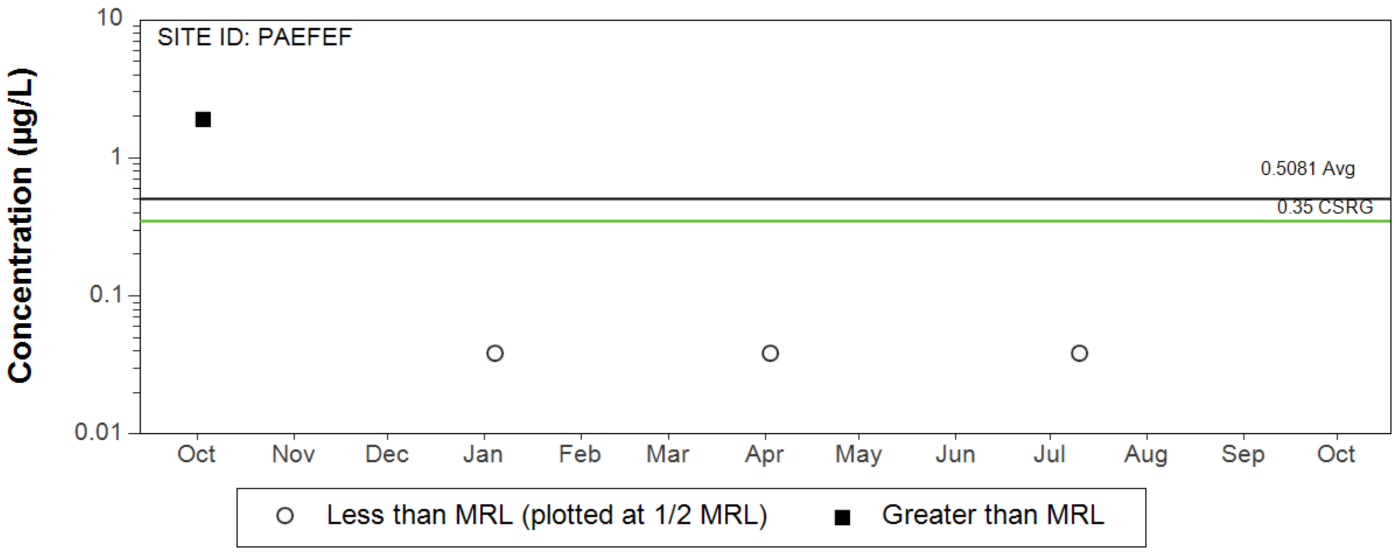
Basin A Neck Treatment Plant Influent - 14DIOX

2022-10-01 to 2023-09-30



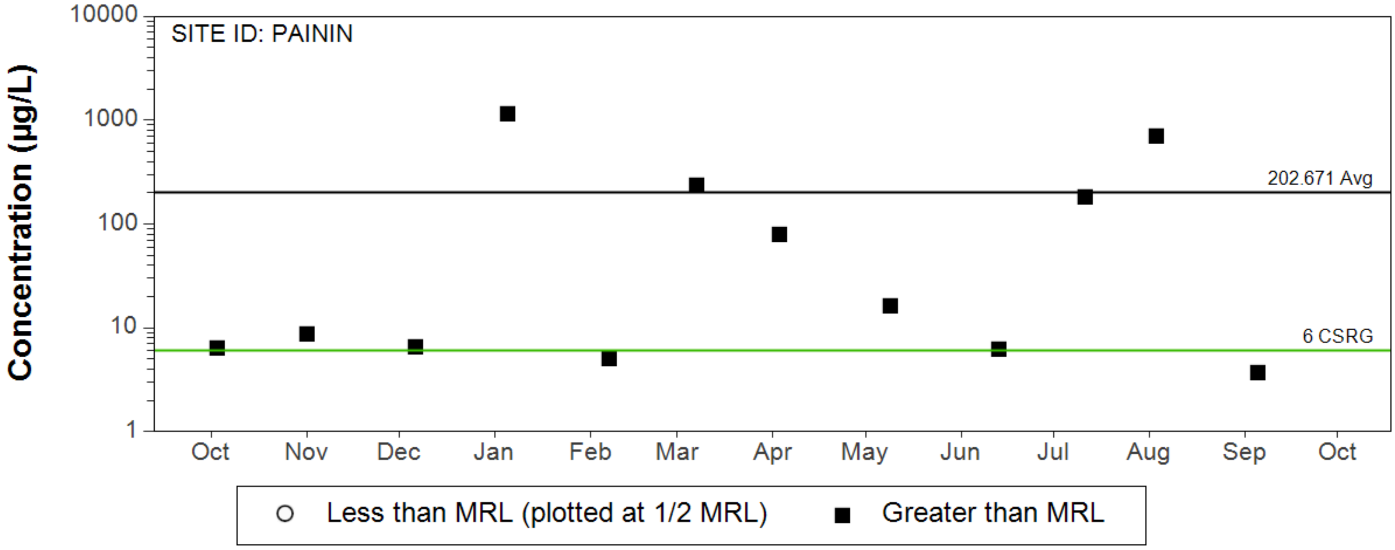
Basin A Neck Treatment Plant Effluent - 14DIOX

2022-10-01 to 2023-09-30



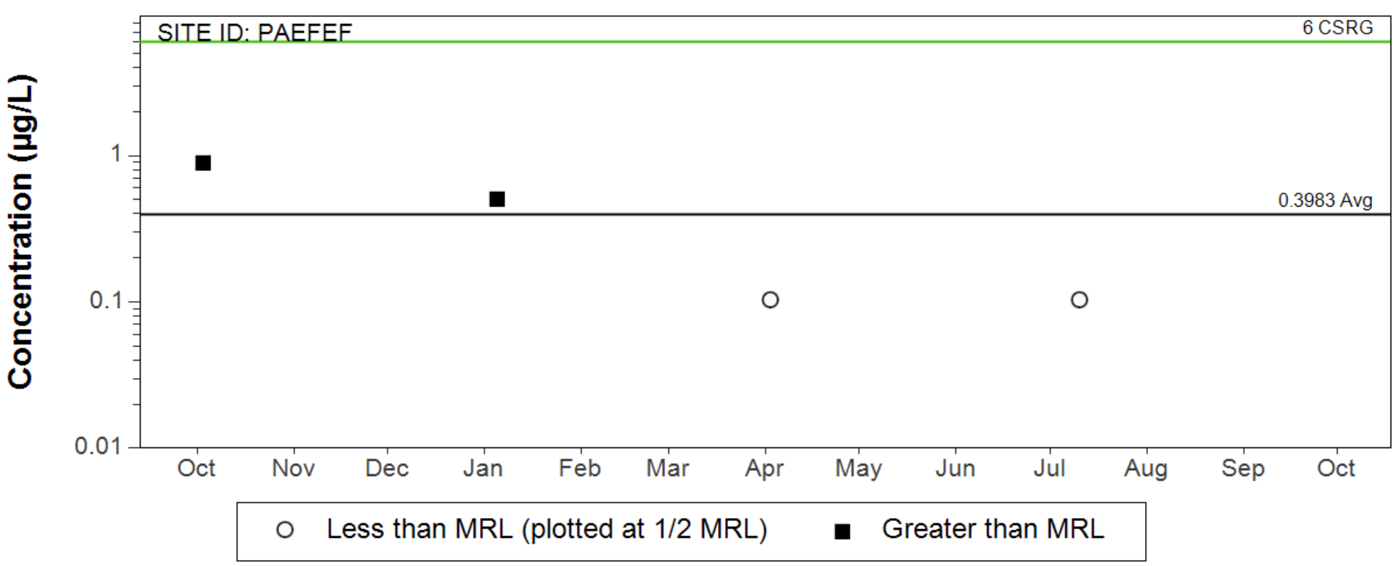
Basin A Neck Treatment Plant Influent - CHCL3

2022-10-01 to 2023-09-30



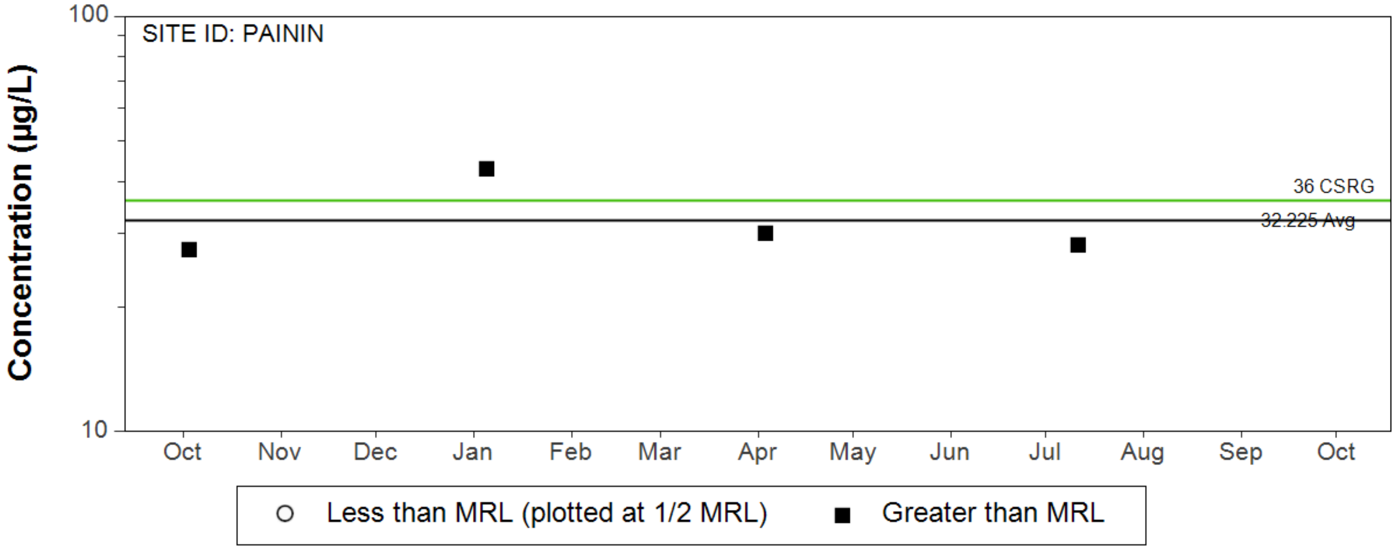
Basin A Neck Treatment Plant Effluent - CHCL3

2022-10-01 to 2023-09-30



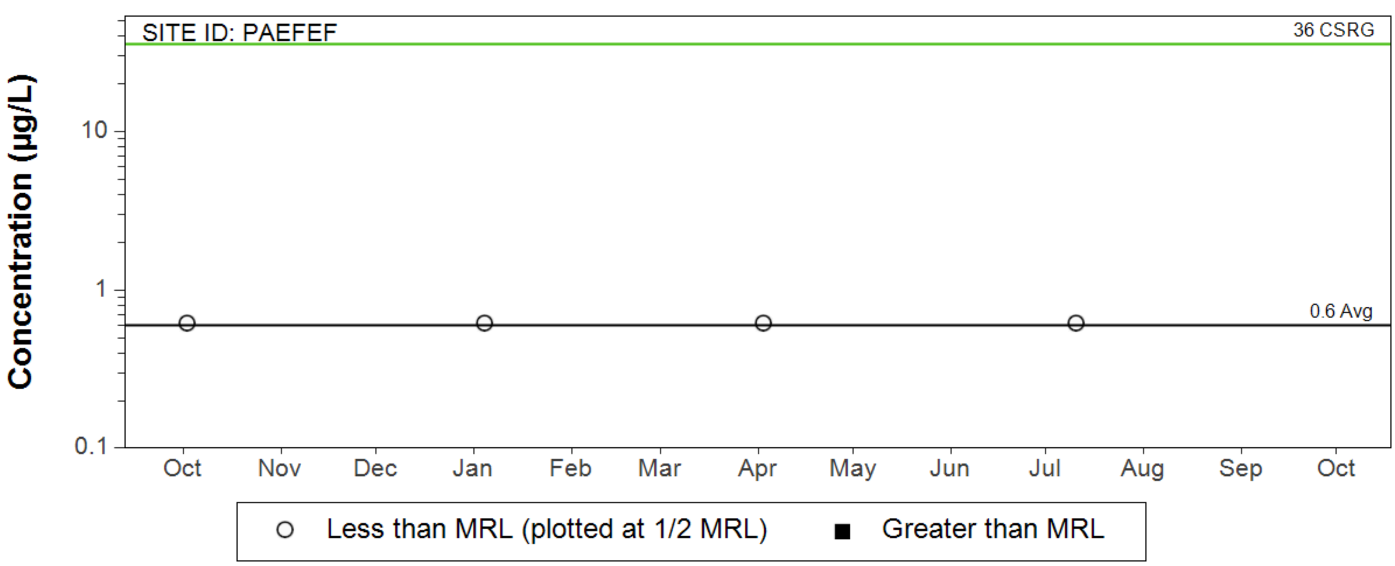
Basin A Neck Treatment Plant Influent - CPMSO2

2022-10-01 to 2023-09-30



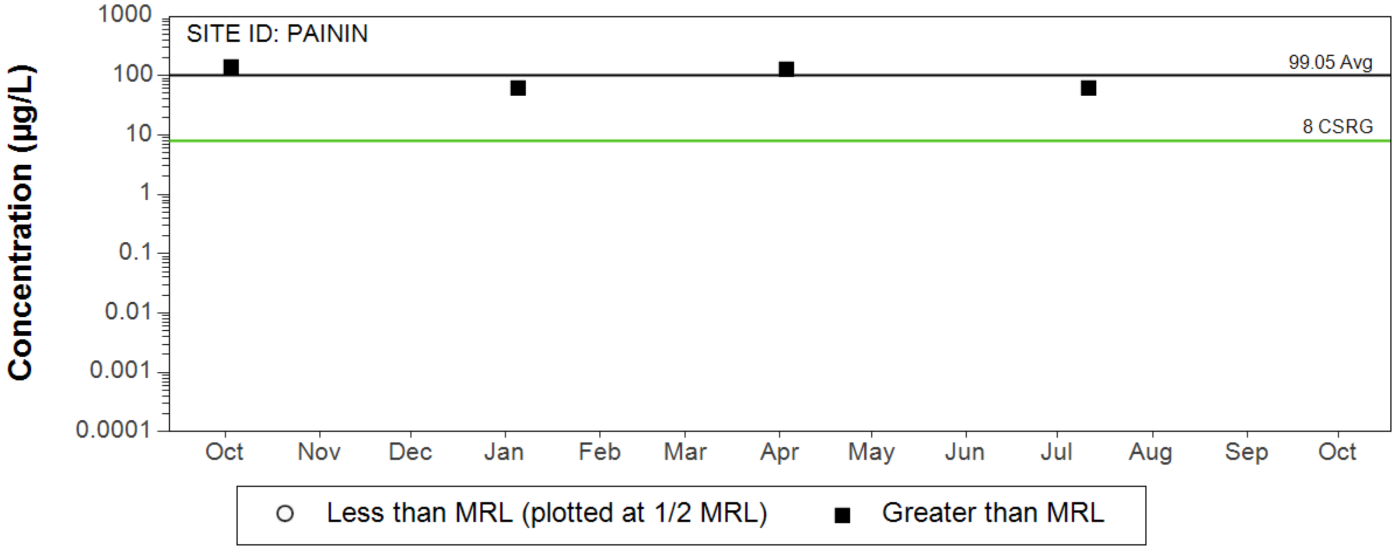
Basin A Neck Treatment Plant Effluent - CPMSO2

2022-10-01 to 2023-09-30



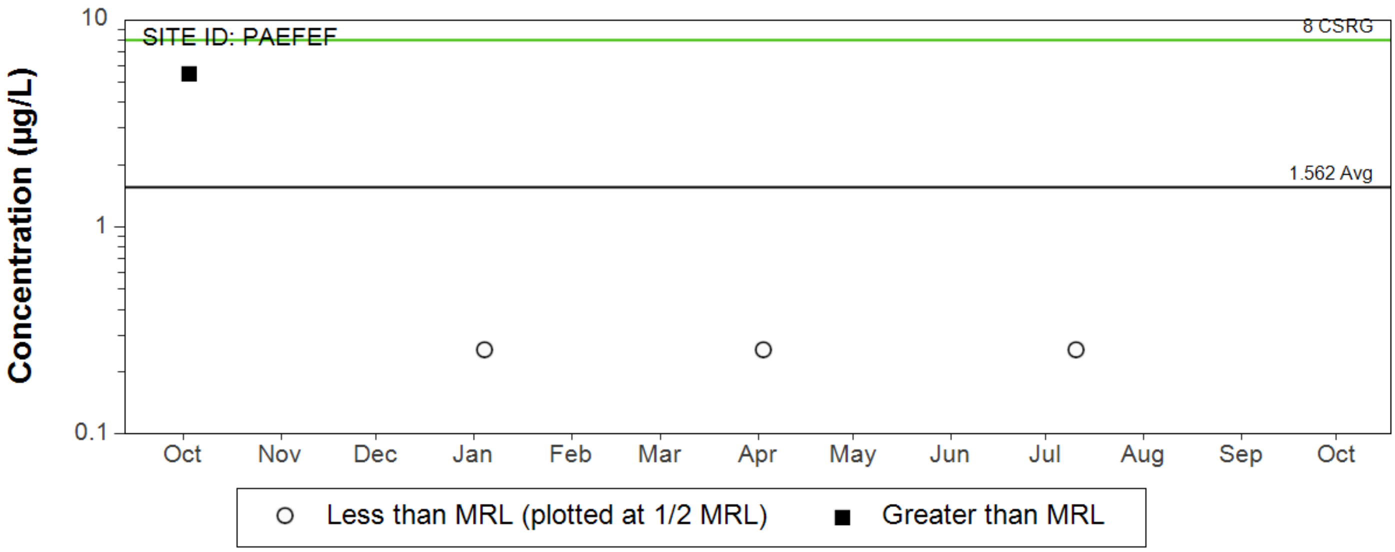
Basin A Neck Treatment Plant Influent - DIMP

2022-10-01 to 2023-09-30



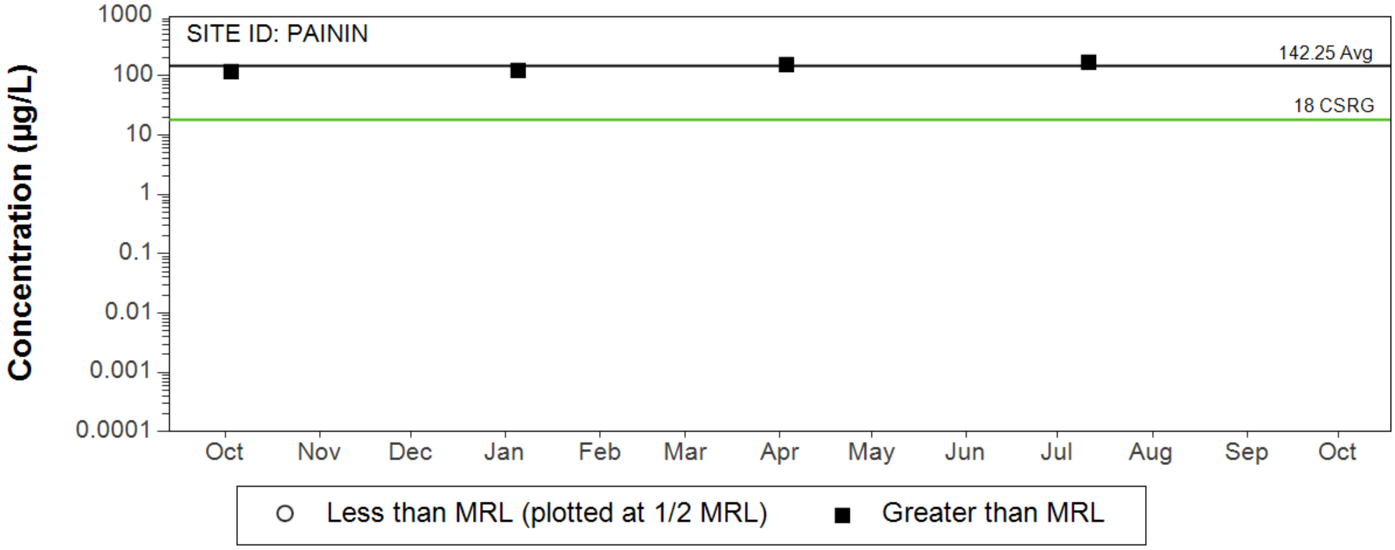
Basin A Neck Treatment Plant Effluent - DIMP

2022-10-01 to 2023-09-30



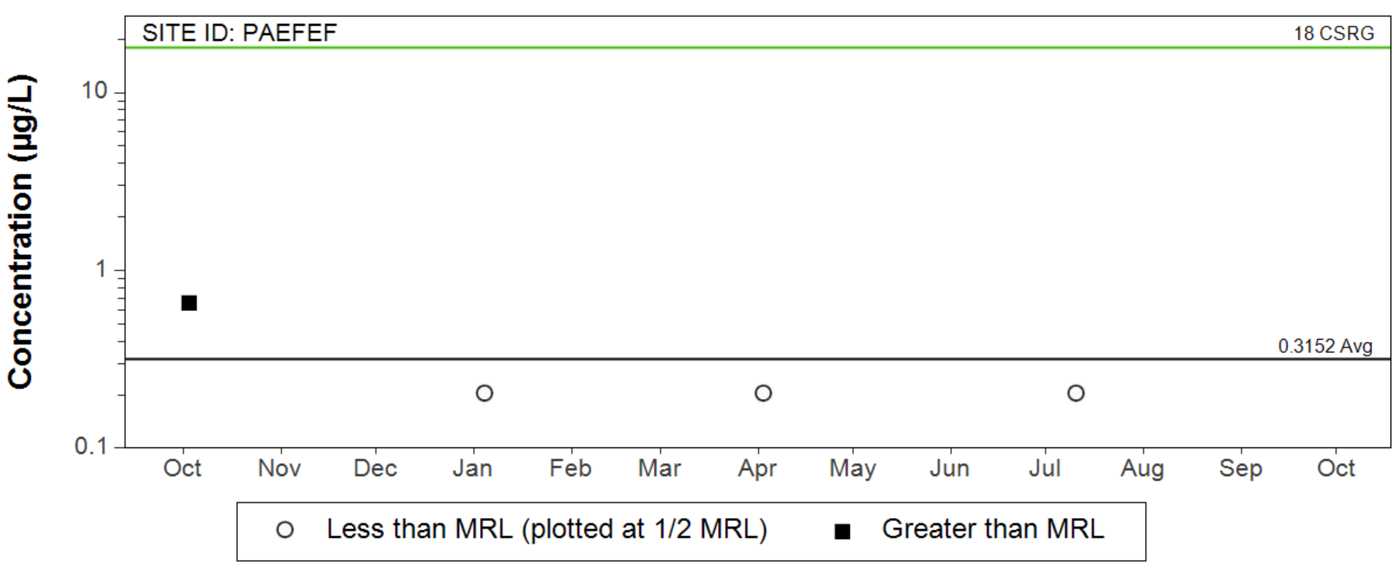
Basin A Neck Treatment Plant Influent - DITH

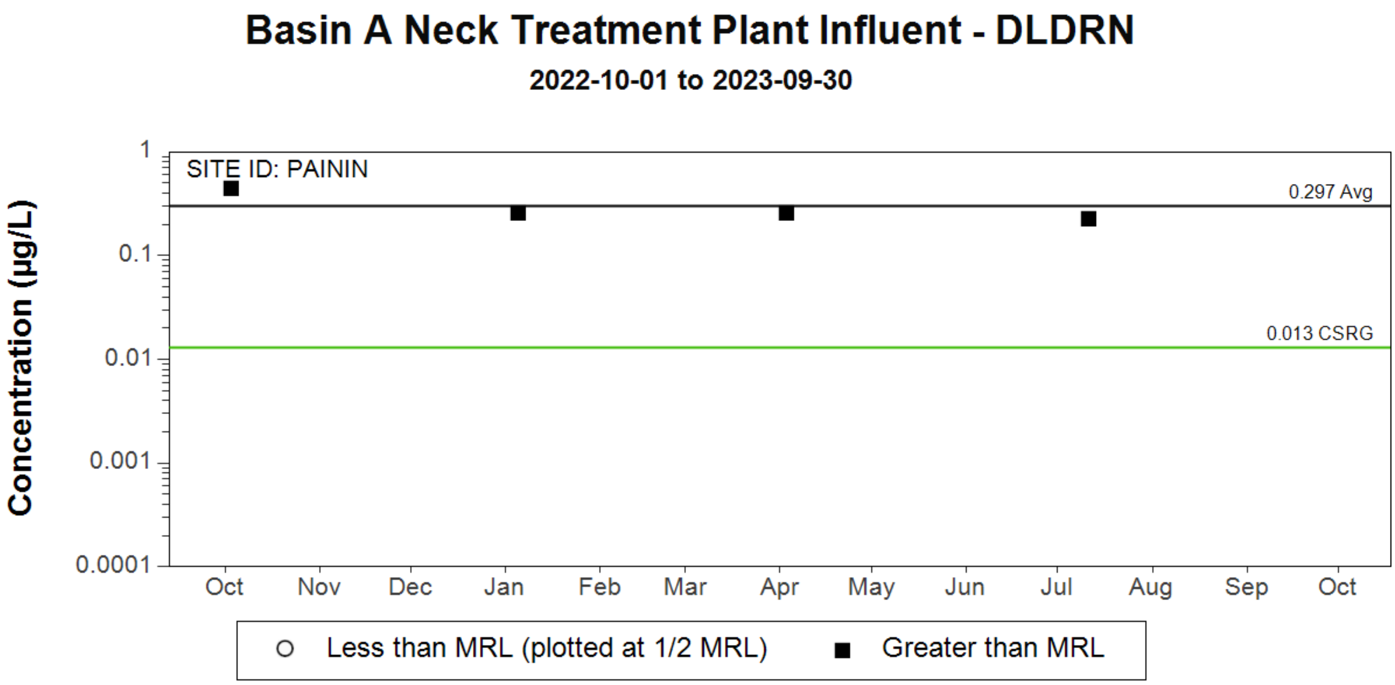
2022-10-01 to 2023-09-30

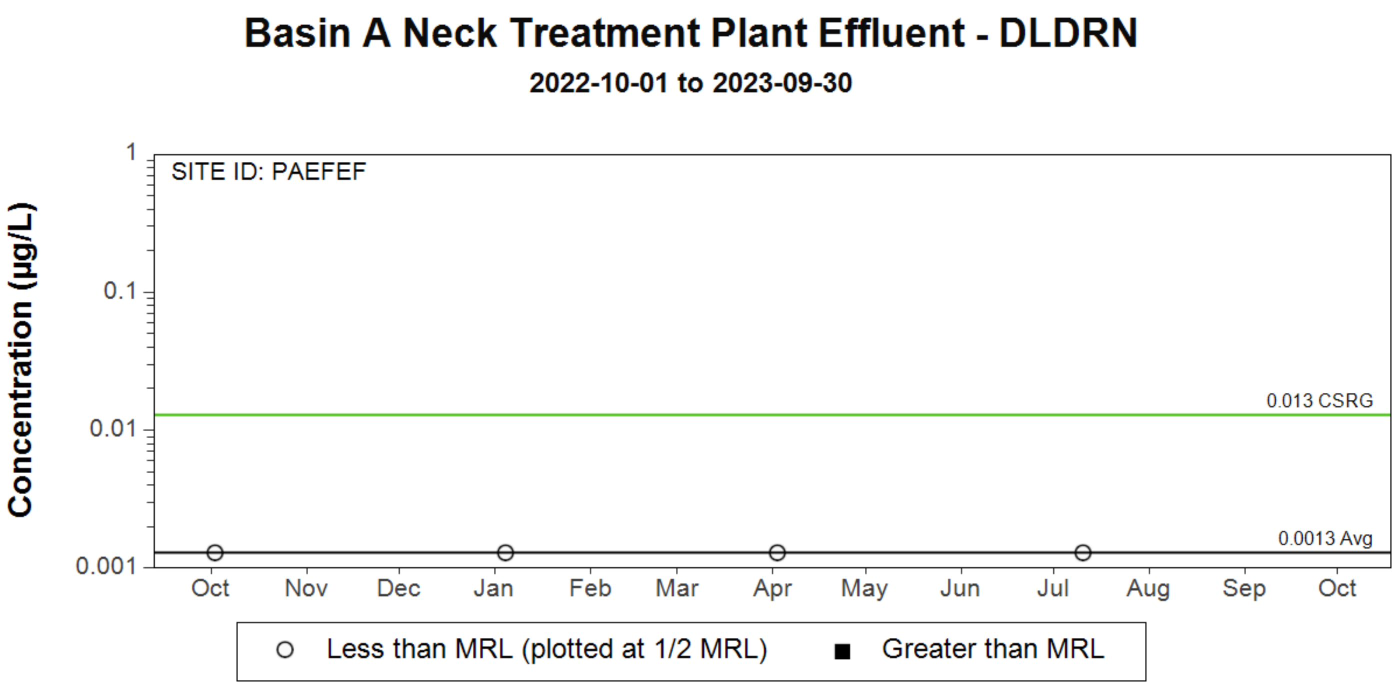


Basin A Neck Treatment Plant Effluent - DITH

2022-10-01 to 2023-09-30

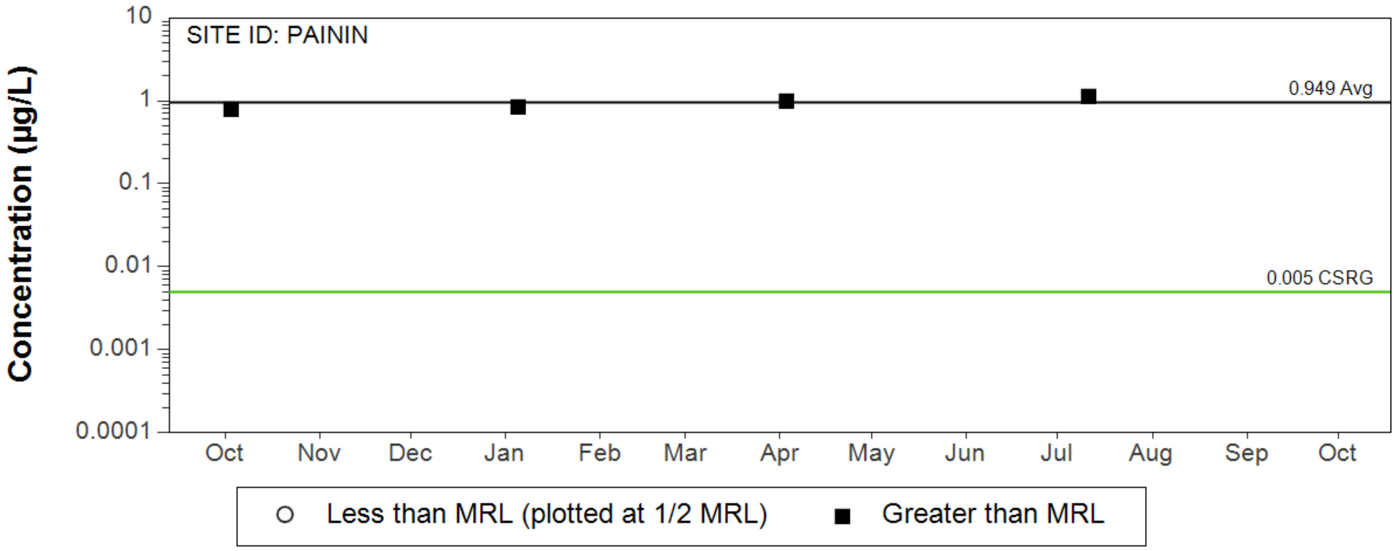



Basin A Neck Treatment Plant Influent - DLDRN
2022-10-01 to 2023-09-30
SITE ID: PAININ
0.297 Avg
0.013 CSRG
Concentration (µg/L)
1
0.1
0.01
0.001
0.0001
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Less than MRL (plotted at 1/2 MRL)
Greater than MRL


Basin A Neck Treatment Plant Effluent - DLDRN
2022-10-01 to 2023-09-30
SITE ID: PAEFEF
0.013 CSRG
0.0013 Avg
Concentration (µg/L)
1
0.1
0.01
0.001
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Less than MRL (plotted at 1/2 MRL)
Greater than MRL

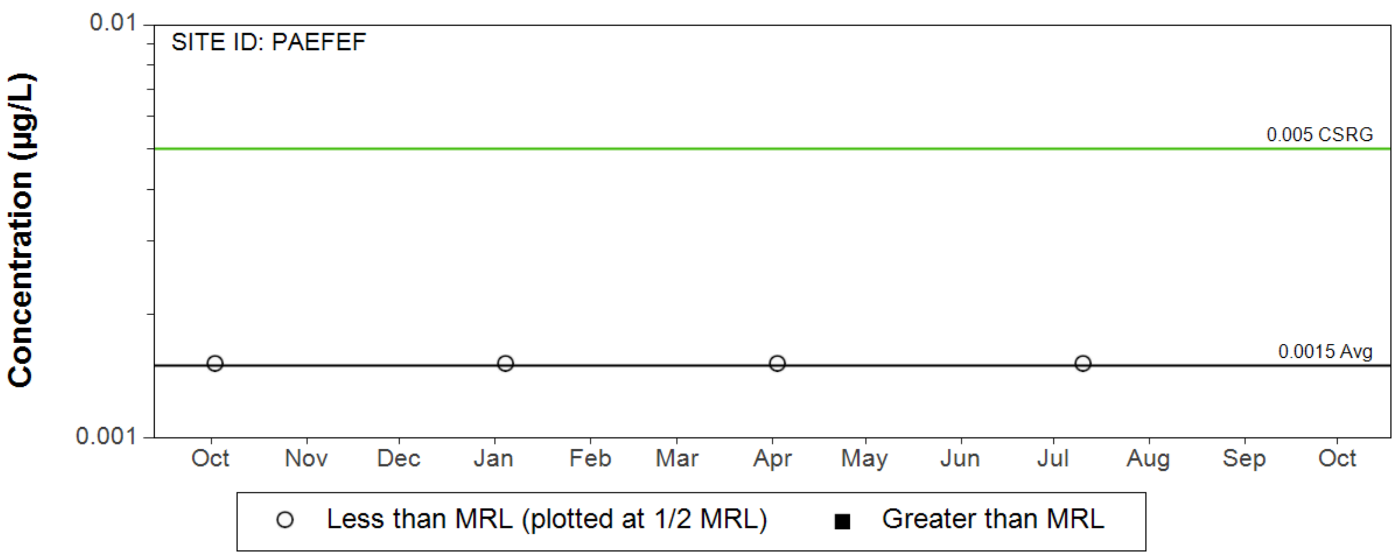
Basin A Neck Treatment Plant Influent - NNDNPA

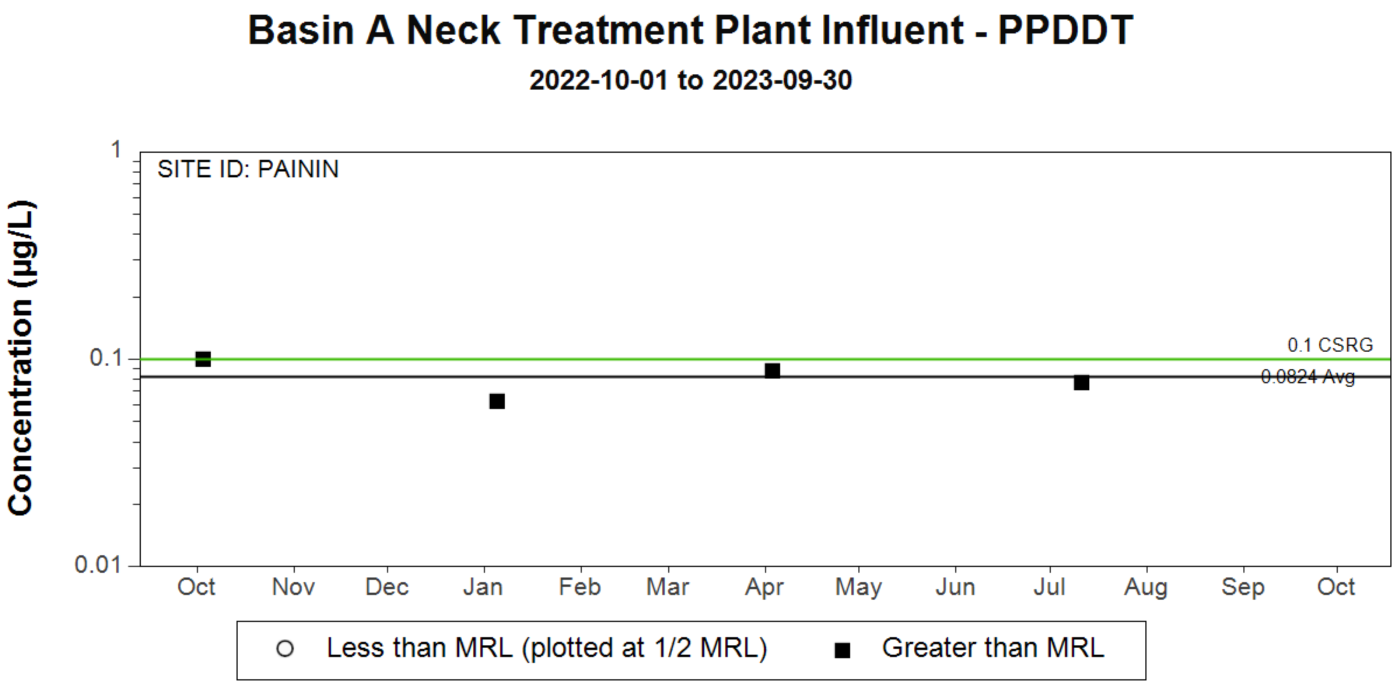
2022-10-01 to 2023-09-30

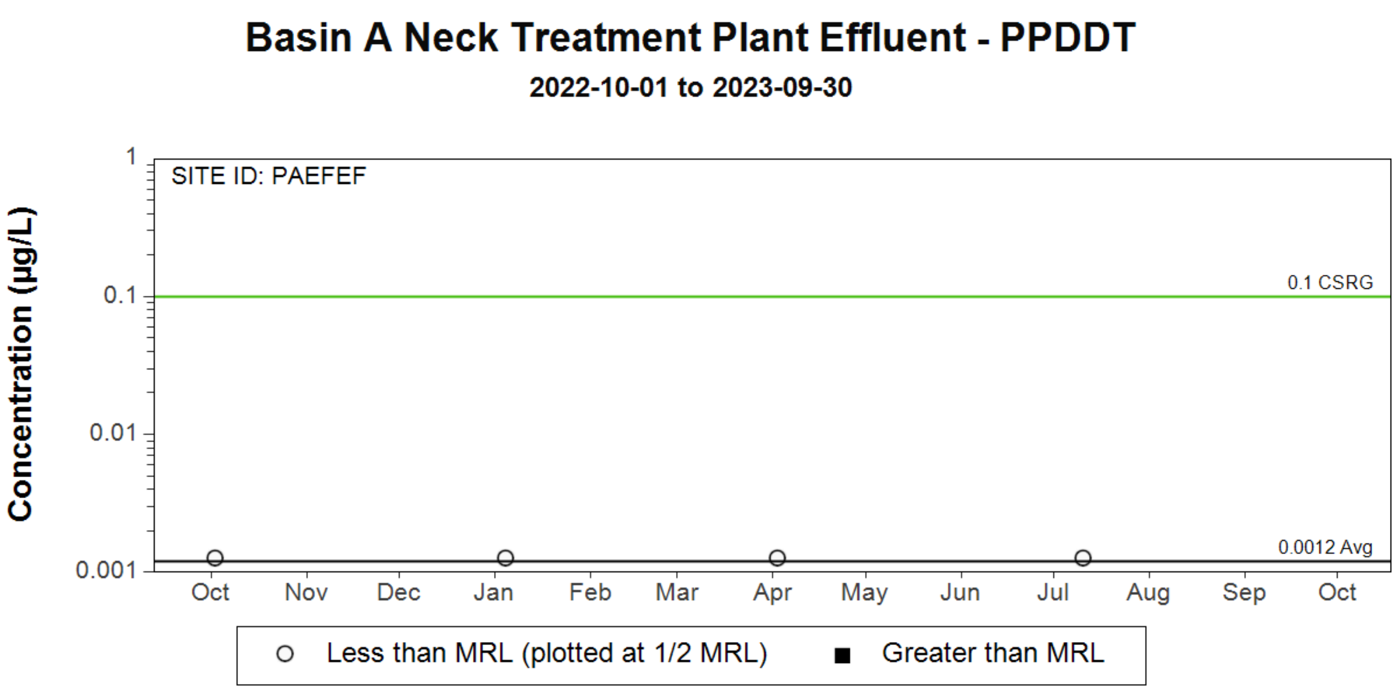


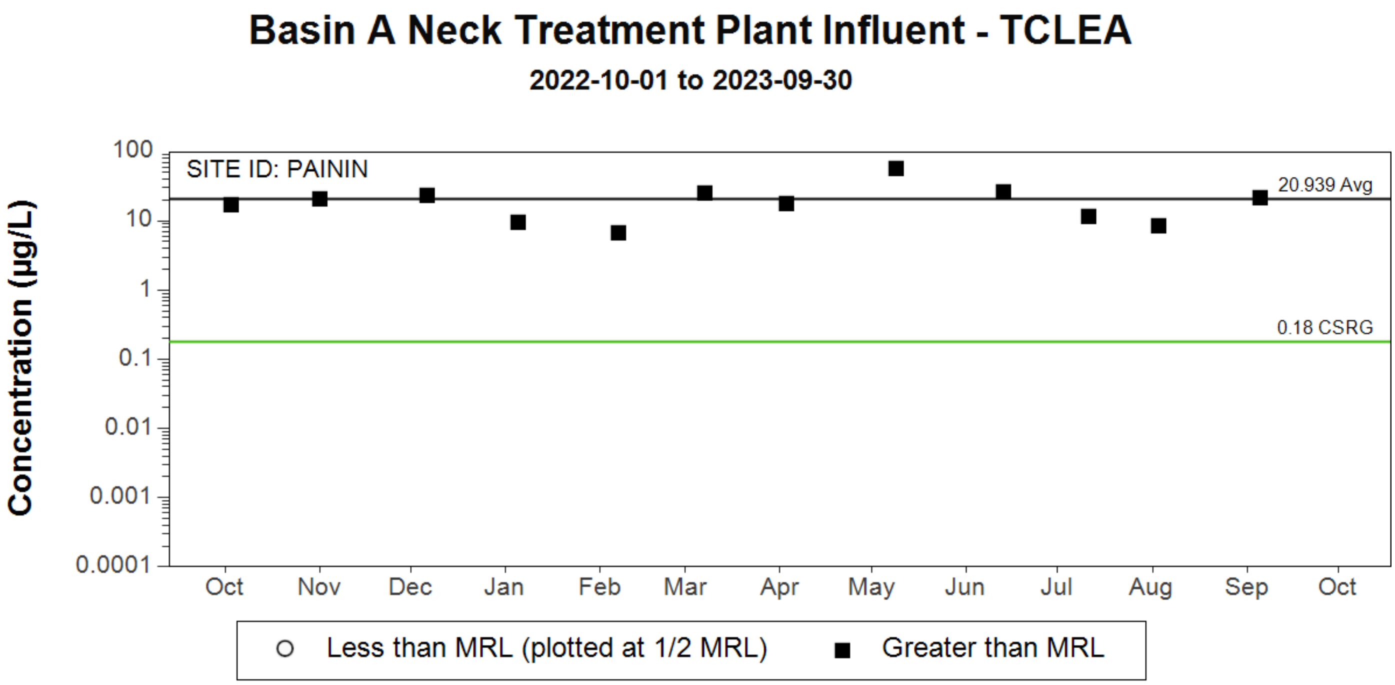
Basin A Neck Treatment Plant Effluent - NNDNPA

2022-10-01 to 2023-09-30

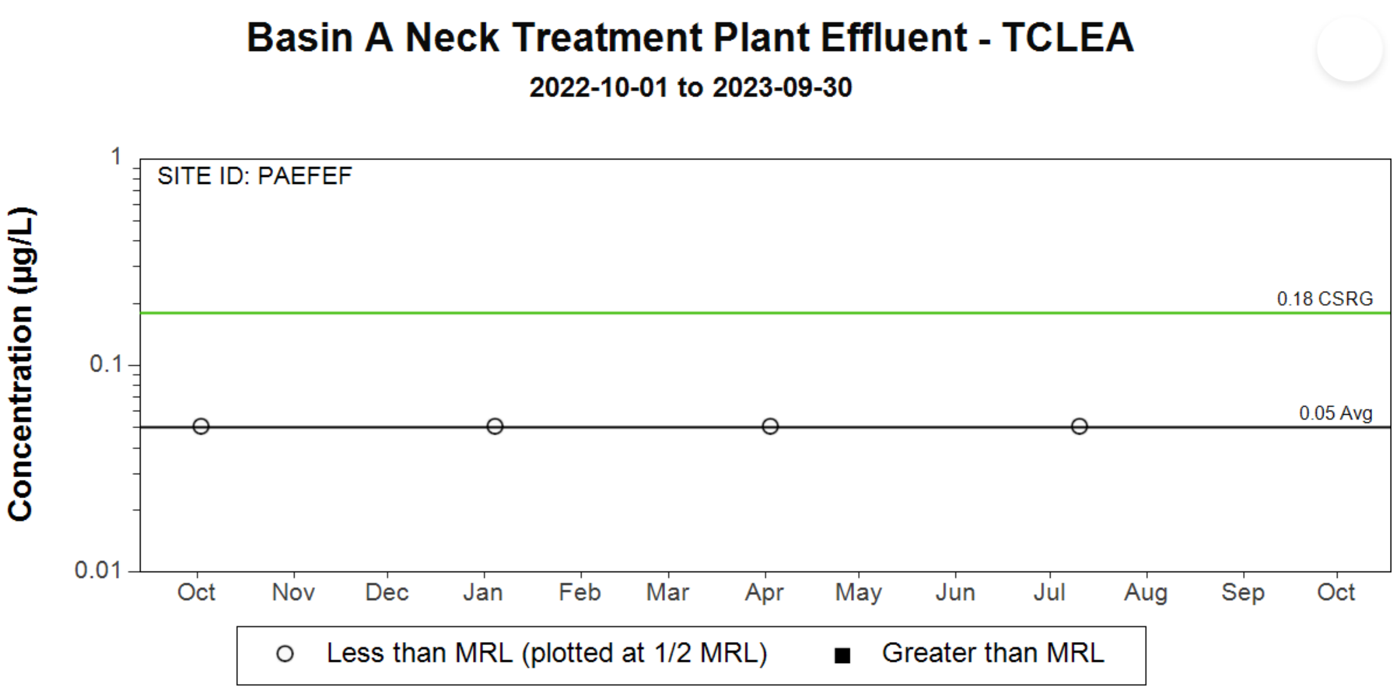



Basin A Neck Treatment Plant Influent - PPDDT
2022-10-01 to 2023-09-30
Concentration (µg/L)
SITE ID: PAININ
1
0.1
0.01
0.1 CSRG
0.0824 Avg
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Less than MRL (plotted at 1/2 MRL)
Greater than MRL

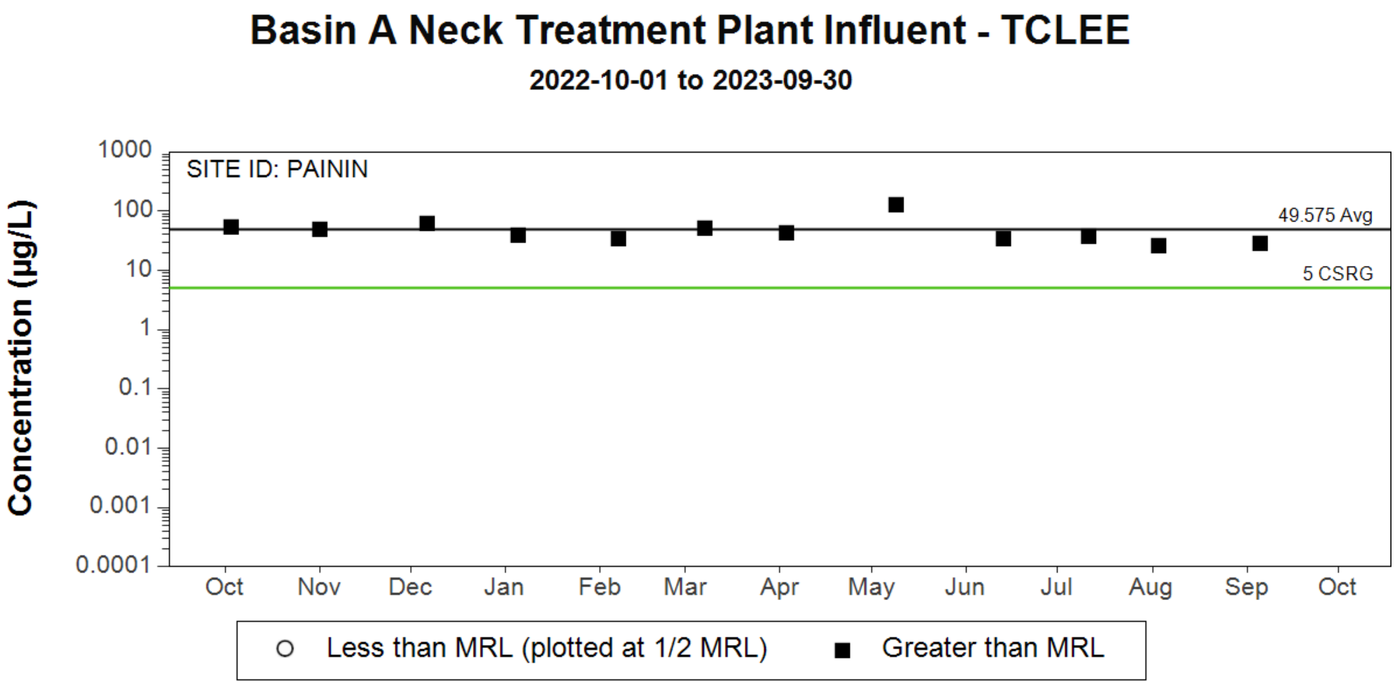

Basin A Neck Treatment Plant Effluent - PPDDT
2022-10-01 to 2023-09-30
Concentration (µg/L)
SITE ID: PAEFEF
1
0.1
0.01
0.001
0.1 CSRG
0.0012 Avg
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Less than MRL (plotted at 1/2 MRL)
Greater than MRL

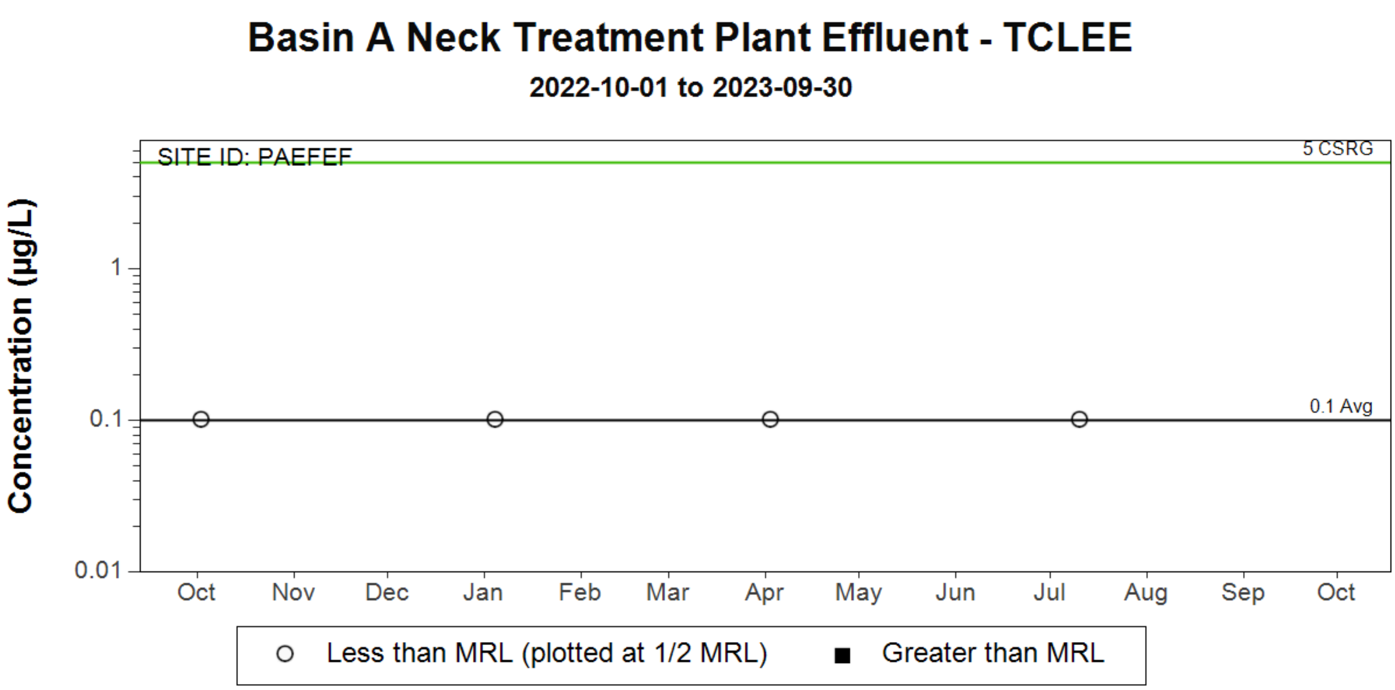


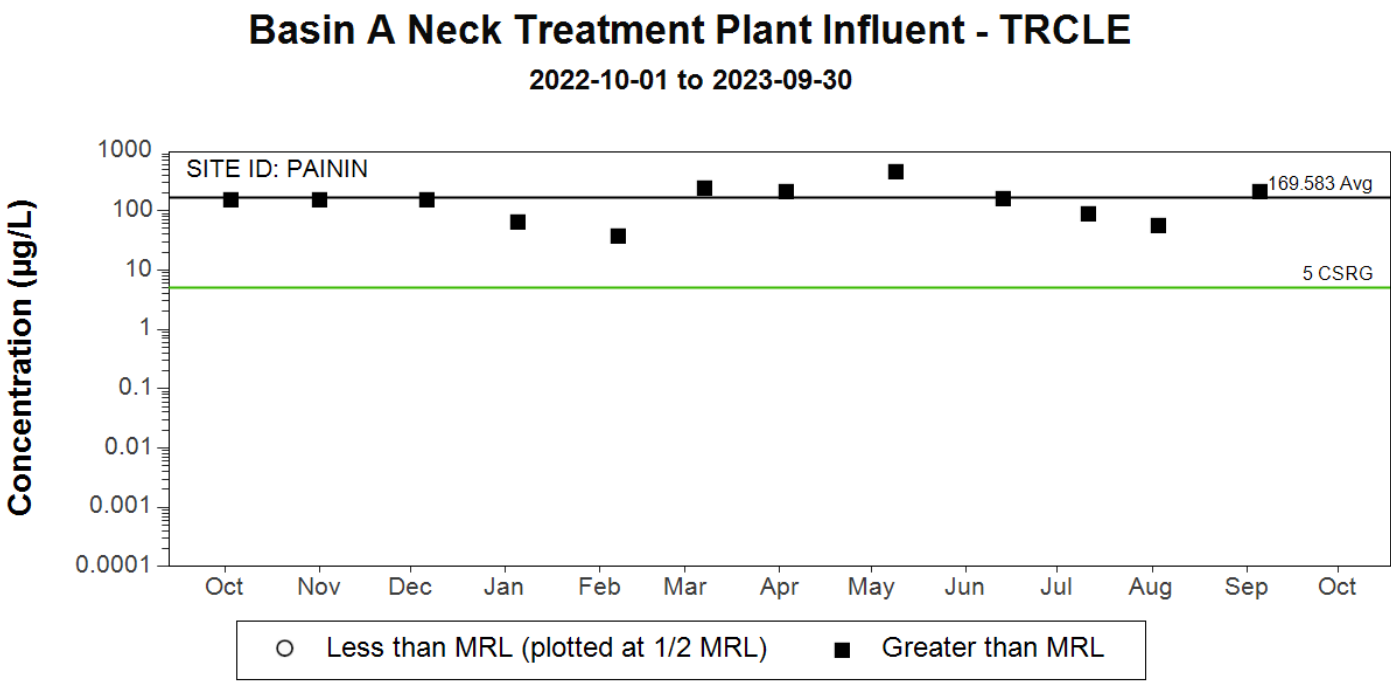
Basin A Neck Treatment Plant Influent - TCLEA
2022-10-01 to 2023-09-30
SITE ID: PAININ
20.939 Avg
0.18 CSRG
Concentration (µg/L)
100
10
1
0.1
0.01
0.001
0.0001
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Less than MRL (plotted at 1/2 MRL)
Greater than MRL

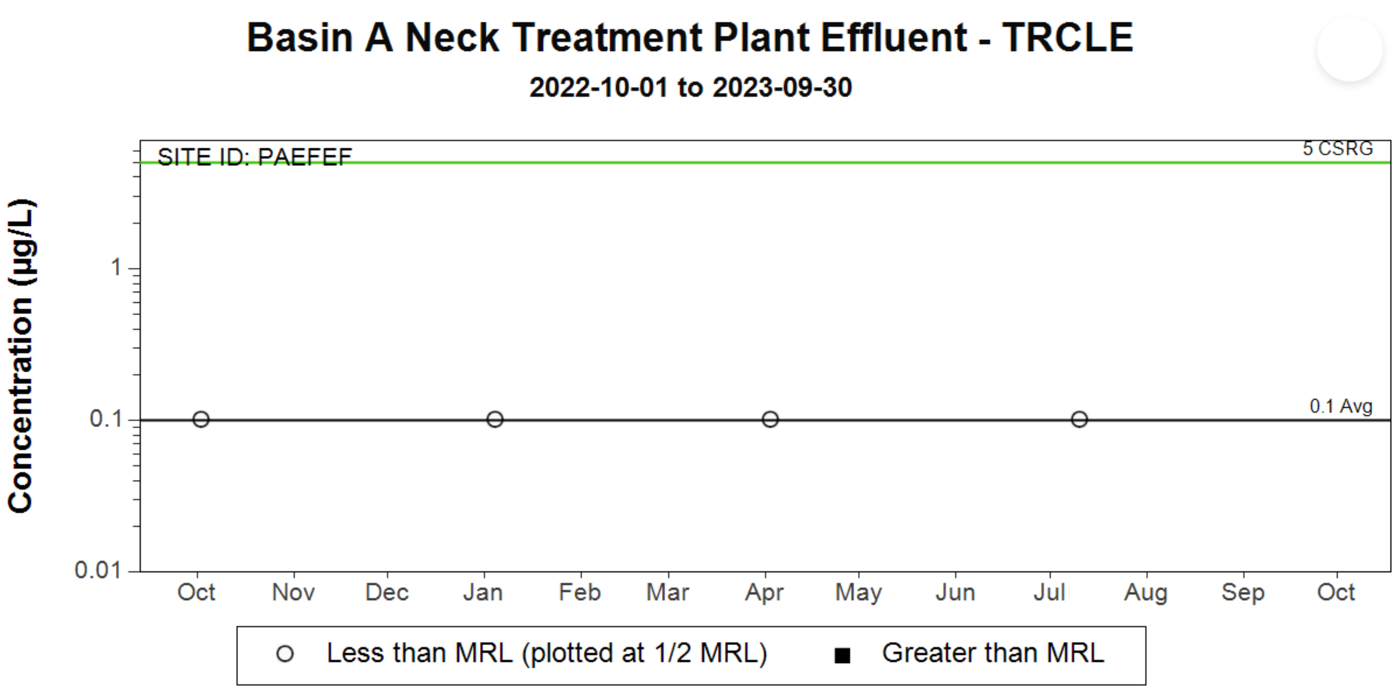


Basin A Neck Treatment Plant Effluent - TCLEA
2022-10-01 to 2023-09-30
SITE ID: PAEFEF
0.18 CSRG
0.05 Avg
Concentration (µg/L)
1
0.1
0.01
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Less than MRL (plotted at 1/2 MRL)
Greater than MRL


Basin A Neck Treatment Plant Influent - TCLEE
2022-10-01 to 2023-09-30
Concentration (µg/L)
SITE ID: PAININ
49.575 Avg
5 CSRG
Less than MRL (plotted at 1/2 MRL)
Greater than MRL


Basin A Neck Treatment Plant Effluent - TCLEE
2022-10-01 to 2023-09-30
Concentration (µg/L)
SITE ID: PAEFEF
5 CSRG
0.1 Avg
Less than MRL (plotted at 1/2 MRL)
Greater than MRL


Basin A Neck Treatment Plant Influent - TRCLE
2022-10-01 to 2023-09-30
Concentration (µg/L)
SITE ID: PAININ
169.583 Avg
5 CSRG
1000
100
10
1
0.1
0.01
0.001
0.0001
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Less than MRL (plotted at 1/2 MRL)
Greater than MRL


Basin A Neck Treatment Plant Effluent - TRCLE
2022-10-01 to 2023-09-30
Concentration (µg/L)
SITE ID: PAEFEF
5 CSRG
0.1 Avg
1
0.1
0.01
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Less than MRL (plotted at 1/2 MRL)
Greater than MRL

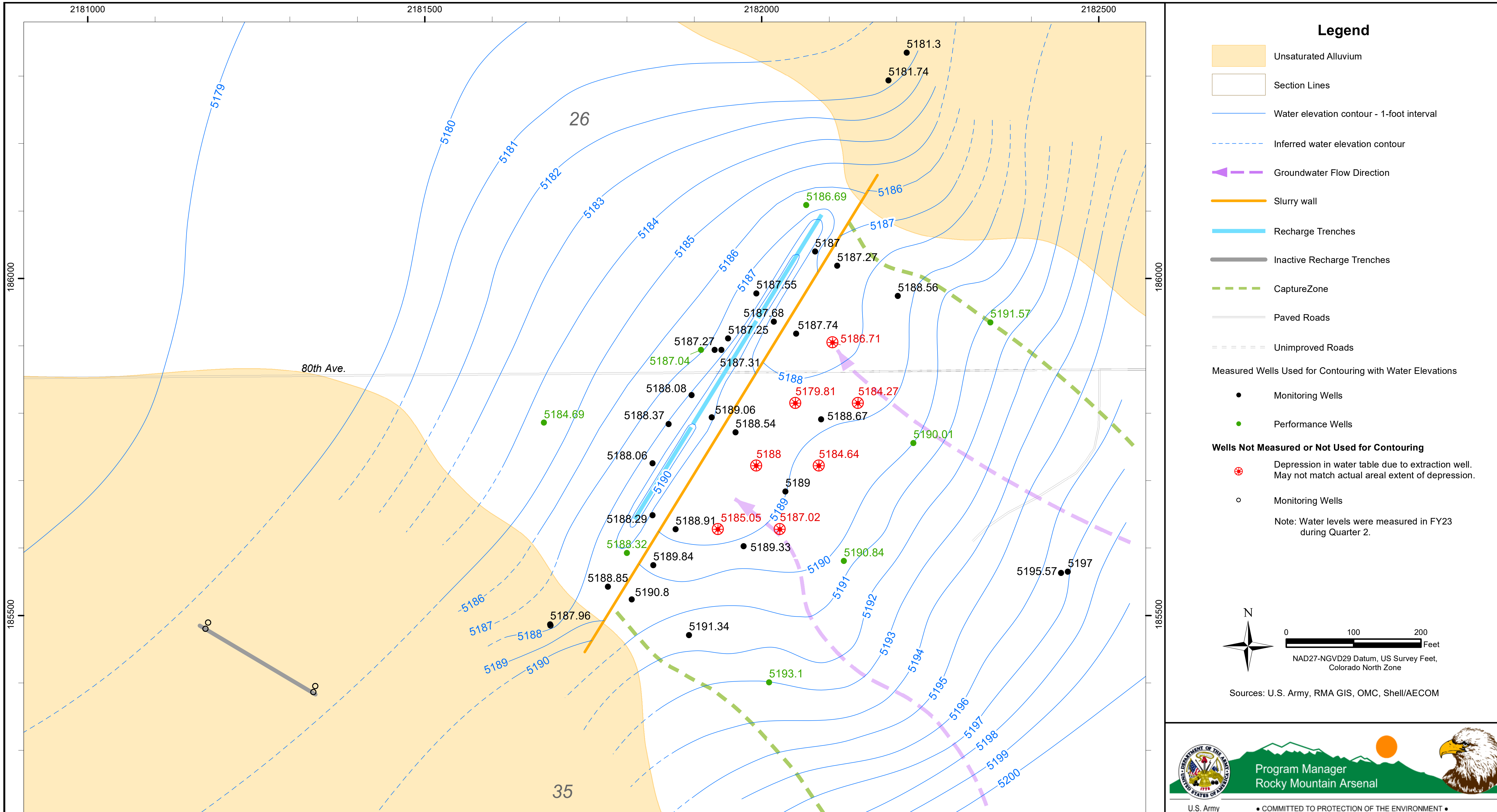


Figure C-14

FY23 Potentiometric Surface of the Unconfined Flow System, Basin A Neck System

M:\projects\oars\fy23\mxds_BAN_FY23.mxd
8/7/2024

Exhibit C-15. Summary of FY23 BANS Performance Water Quality Monitoring

Well ID	Sample Date	Analyte Concentration (ug/L, CSRG/PQL shown in italics)									
		111TCE	11DCE	12DCLB	12DCLE	13DCLB	14DCLB	AS	ATZ	C6H6	CCL4
		200	*7*	*600*	*0.4*	*94*	*75*	*50*	*3*	*5*	*0.3*
Upgradient Wells											
26507	8/22/23	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	2.19	LT 0.2	LT 0.2	LT 0.2
35512	8/22/23	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	1.65	LT 0.2	LT 0.2	LT 0.2
35514	8/22/23	LT 0.2	LT 0.2	0.699	**36.4**	LT 0.2	0.788	16.5	LT 0.2	0.471	LT 0.2
35516	8/22/23	LT 0.2	LT 0.2	LT 0.2	**0.8**	LT 0.2	LT 0.2	10.2	LT 0.2	LT 0.2	LT 0.2
Downgradient Wells											
26501	8/23/23	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	3.77	LT 0.2	LT 0.2	LT 0.2
26505	8/31/23	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	3.8	LT 0.2	LT 0.2	LT 0.2
35505	8/23/23	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	3.28	LT 0.2	LT 0.2	LT 0.2
35525	8/23/23	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	0.632	2.23	LT 0.2	LT 0.2	LT 0.2
Extraction Wells											
26307	8/30/23	LT 0.2	LT 0.2	0.233	**2.42**	LT 0.2	0.218	20.1	LT 0.2	LT 0.2	LT 0.2
35301	8/30/23	LT 0.2	LT 0.2	LT 0.2	0.227	LT 0.2	LT 0.2	2.14	LT 0.2	LT 0.2	LT 0.2
35302	8/30/23	LT 0.2	LT 0.2	0.334	**16.5**	LT 0.2	0.415	17.3	LT 0.2	LT 0.2	LT 0.2
35303	8/30/23	LT 0.2	LT 0.2	0.223	**4.62**	LT 0.2	0.228	19.2	LT 0.2	LT 0.2	LT 0.2
35304	8/30/23	LT 0.2	LT 0.2	0.223	**11.5**	LT 0.2	0.259	11.6	LT 0.2	LT 0.2	LT 0.2
35305	8/30/23	LT 0.2	LT 0.2	0.426	**10.8**	LT 0.2	0.466	19.9	LT 0.2	0.284	LT 0.2
35306	8/30/23	LT 0.2	LT 0.2	LT 0.2	**1.36**	LT 0.2	0.218	16.7	LT 0.2	LT 0.2	LT 0.2

Notes:

Values shaded and in BOLD are concentrations that exceed the CSRG/PQL.

LT – Nondetection reported less than the method reporting limit.

Exhibit C-15. Summary of FY23 BANS Performance Water Quality Monitoring

Well ID	Sample Date	Analyte Concentration (ug/L, CSRG/PQL shown in italics)									
		CHCL3	CL6CP	CLC6H5	CPMS	CPMSO	CPMSO2	DCPD	DITH	DLDRN	ENDRN
		6	*50*	*100*	*30*	*36*	*36*	*46*	*18*	*0.013*	*2*
Upgradient Wells											
26507	8/22/23	0.487	LT 0.00983	LT 0.2	LT 1.2	LT 1.6	LT 1.2	LT 0.2	LT 0.4	**1.57**	1.22
35512	8/22/23	LT 0.2	LT 0.00983	LT 0.2	LT 1.2	LT 1.6	LT 1.2	LT 0.2	0.762	**1.7**	LT 0.00488
35514	8/22/23	0.667	0.0195	3.34	3.51	LT 1.6	**75.4**	LT 0.2	**609**	**0.317**	LT 0.00488
35516	8/22/23	0.205	0.0233	LT 0.2	LT 1.2	LT 1.6	LT 1.2	LT 0.2	1.85	**1.49**	0.554
Downgradient Wells											
26501	8/23/23	0.376	LT 0.00983	LT 0.2	LT 1.2	LT 1.6	LT 1.2	LT 0.2	LT 0.4	0.00694	LT 0.00488
26505	8/31/23	0.291	LT 0.00983	LT 0.2	LT 1.2	LT 1.6	LT 1.2	LT 0.2	LT 0.4	LT 0.00252	LT 0.00488
35505	8/23/23	0.197	LT 0.00983	LT 0.2	LT 1.2	LT 1.6	LT 1.2	LT 0.2	LT 0.4	**0.0928**	0.0393
35525	8/23/23	0.316	LT 0.00983	LT 0.2	LT 1.2	LT 1.6	**40.1**	LT 0.2	6.2	**0.269**	LT 0.00488
Extraction Wells											
26307	8/30/23	0.59	0.2	0.387	LT 1.2	LT 1.6	6.57	LT 0.2	5.86	**0.908**	LT 0.00488
35301	8/30/23	LT 0.2	LT 0.00983	LT 0.2	LT 1.2	LT 1.6	13	LT 0.2	**24.4**	**0.598**	LT 0.00488
35302	8/30/23	0.573	0.0663	1.78	LT 1.2	LT 1.6	**50.6**	LT 0.2	**168**	**0.627**	LT 0.00488
35303	8/30/23	0.419	0.212	0.763	LT 1.2	LT 1.6	**55.3**	LT 0.2	**126**	**0.925**	LT 0.00488
35304	8/30/23	0.265	LT 0.00983	1.01	LT 1.2	LT 1.6	21.1	LT 0.2	**222**	**0.199**	LT 0.00488
35305	8/30/23	0.675	0.0672	1.81	3.62	3.73	**103**	LT 0.2	**372**	**1.31**	LT 0.00488
35306	8/30/23	0.316	0.131	LT 0.2	LT 1.2	LT 1.6	4.49	LT 0.2	6.71	**1.14**	0.53

Notes:

Values shaded and in BOLD are concentrations that exceed the CSRG/PQL.

LT – Nondetection reported less than the method reporting limit.

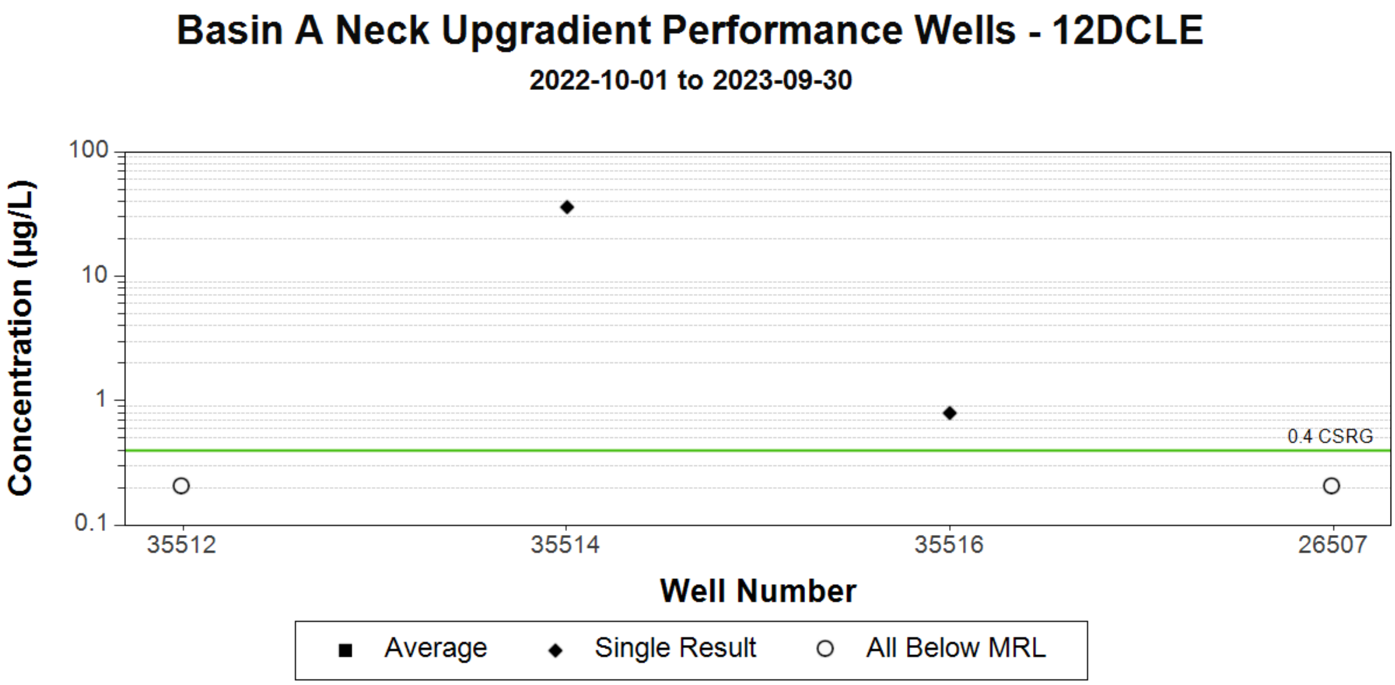
Exhibit C-15. Summary of FY23 BANS Performance Water Quality Monitoring

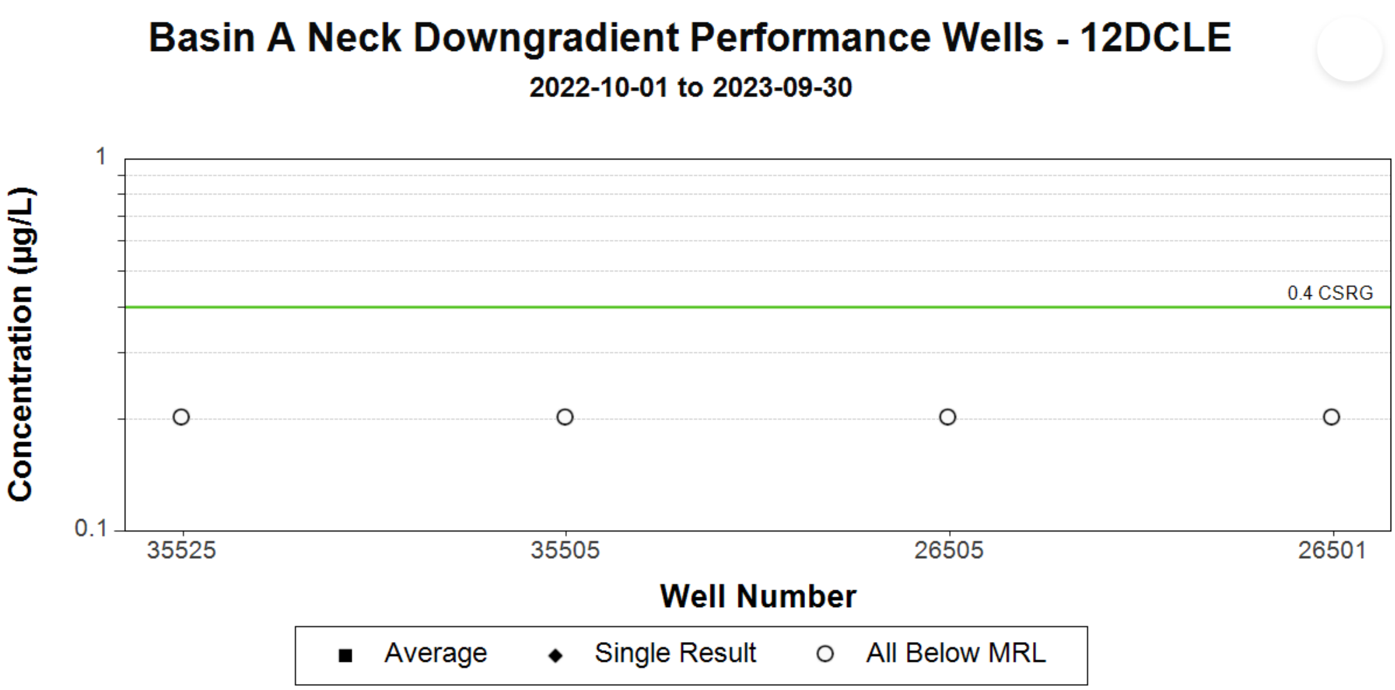
Well ID	Sample Date	Analyte Concentration (ug/L, CSRG/PQL shown in italics)					
		HG	OXAT	PPDDT	TCLEA	TCLEE	TRCLE
		2	*160*	*0.1*	*0.18*	*5*	*5*
Upgradient Wells							
26507	8/22/23	LT 0.2	LT 0.8	LT 0.00247	LT 0.1	0.396	0.477
35512	8/22/23	LT 0.2	LT 0.8	LT 0.00247	LT 0.1	LT 0.2	LT 0.2
35514	8/22/23	LT 0.2	51.6	**0.375**	LT 0.1	1.64	3.44
35516	8/22/23	LT 0.2	3.57	**0.283**	LT 0.1	LT 0.2	0.703
Downgradient Wells							
26501	8/23/23	LT 0.2	LT 0.8	LT 0.00247	LT 0.1	LT 0.2	LT 0.2
26505	8/31/23	LT 0.2	LT 0.8	LT 0.00247	LT 0.1	LT 0.2	LT 0.2
35505	8/23/23	LT 0.2	LT 0.8	0.00357	LT 0.1	LT 0.2	LT 0.2
35525	8/23/23	LT 0.2	2.19	**0.122**	LT 0.1	0.528	0.189
Extraction Wells							
26307	8/30/23	LT 0.2	7.04	**0.111**	LT 0.1	0.764	1.39
35301	8/30/23	LT 0.2	2.82	**0.132**	LT 0.1	LT 0.2	LT 0.2
35302	8/30/23	LT 0.2	34.6	LT 0.00247	LT 0.1	1.86	2.12
35303	8/30/23	LT 0.2	17.1	**0.118**	LT 0.1	1.17	1.28
35304	8/30/23	LT 0.2	20.6	LT 0.00247	LT 0.1	0.632	1.05
35305	8/30/23	LT 0.2	37.2	**0.373**	LT 0.1	2.53	2.95
35306	8/30/23	LT 0.2	8.28	**0.14**	LT 0.1	LT 0.2	1.12

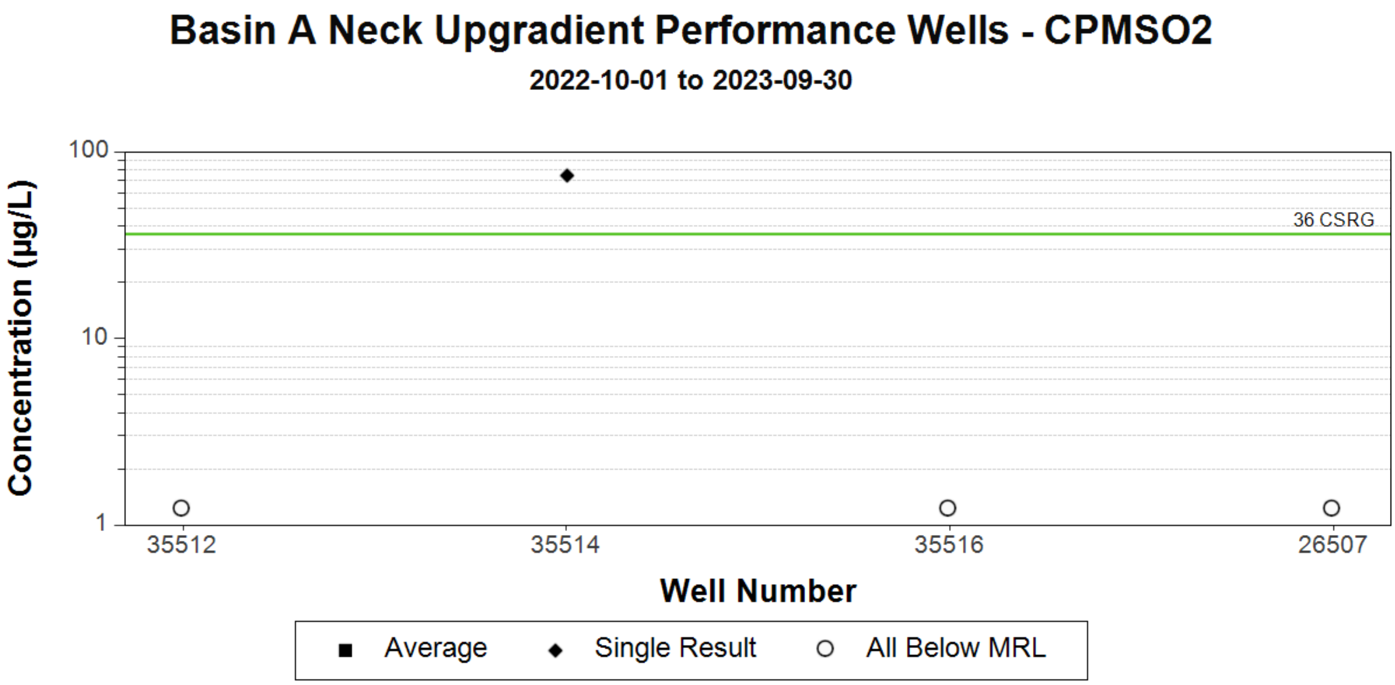
Notes:

Values shaded and in BOLD are concentrations that exceed the CSRG/PQL.

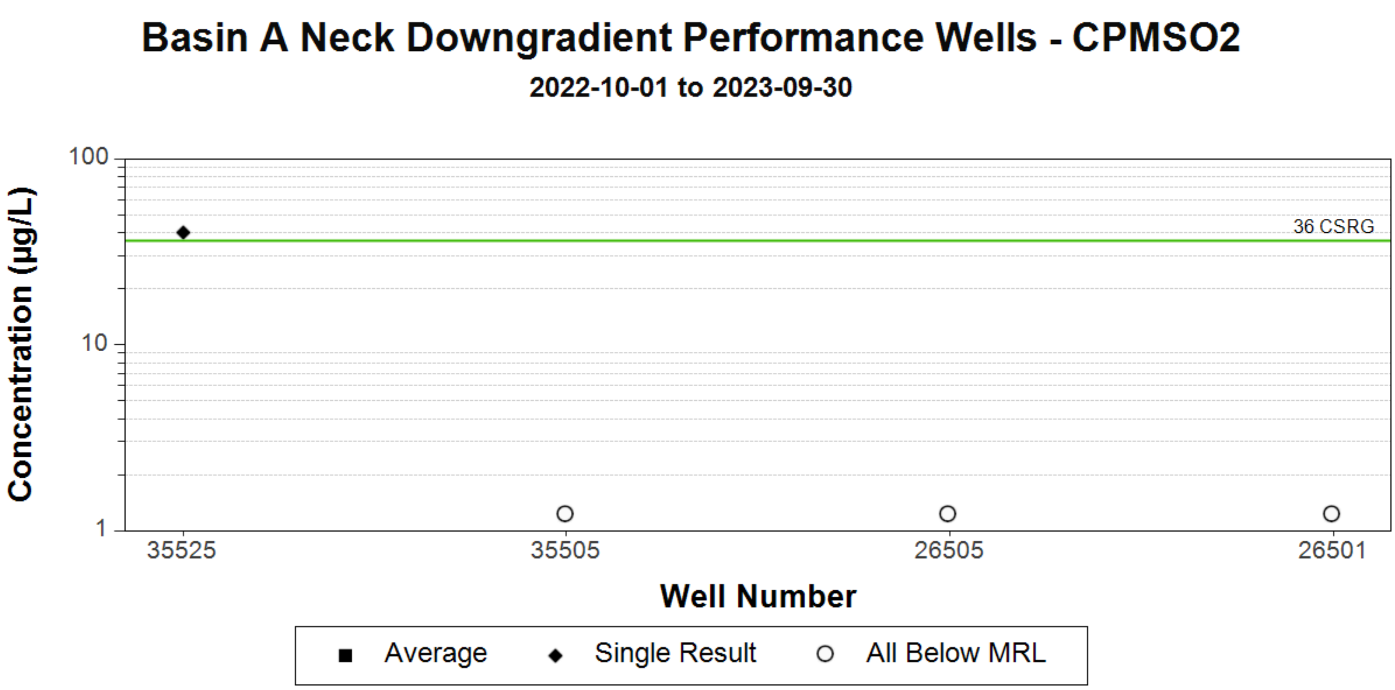
LT – Nondetection reported less than the method reporting limit.


Basin A Neck Upgradient Performance Wells - 12DCLE
2022-10-01 to 2023-09-30
Concentration (µg/L)
100
10
1
0.1
0.4 CSRG
35512
35514
35516
26507
Well Number
Average
Single Result
All Below MRL

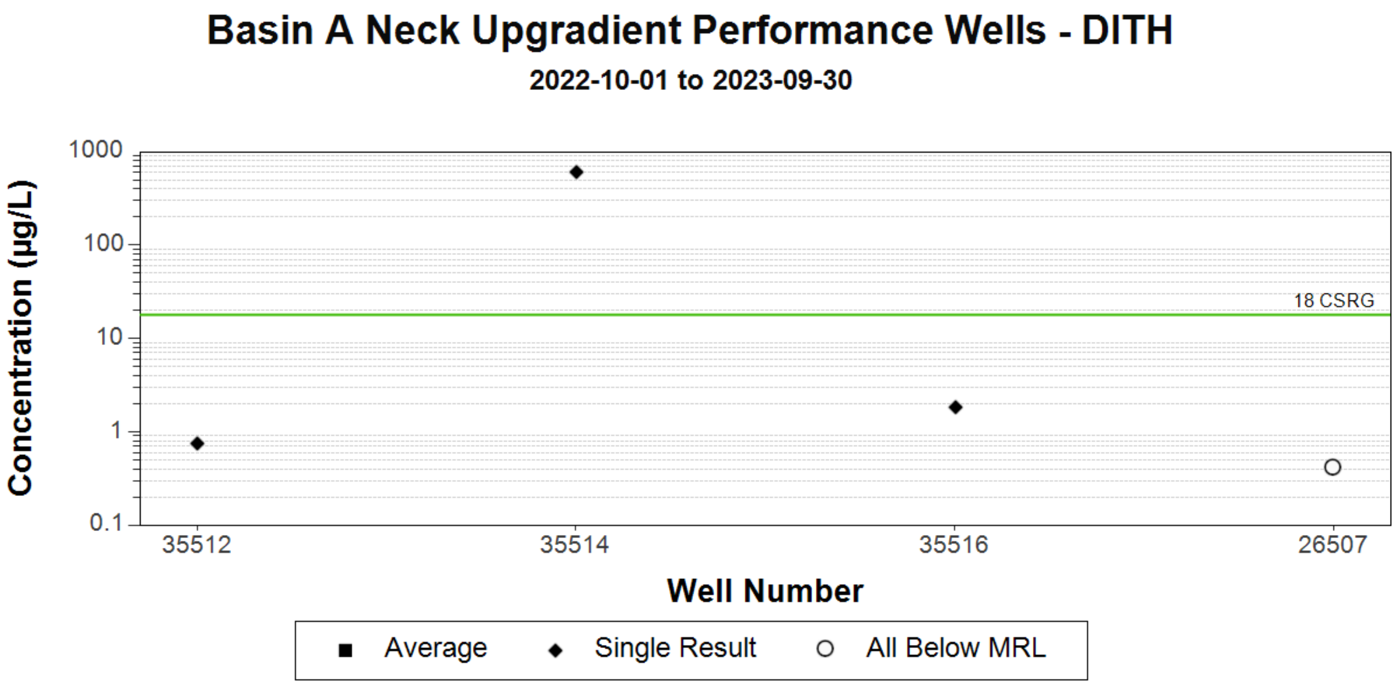

Basin A Neck Downgradient Performance Wells - 12DCLE
2022-10-01 to 2023-09-30
Concentration (µg/L)
1
0.1
0.4 CSRG
35525
35505
26505
26501
Well Number
Average
Single Result
All Below MRL

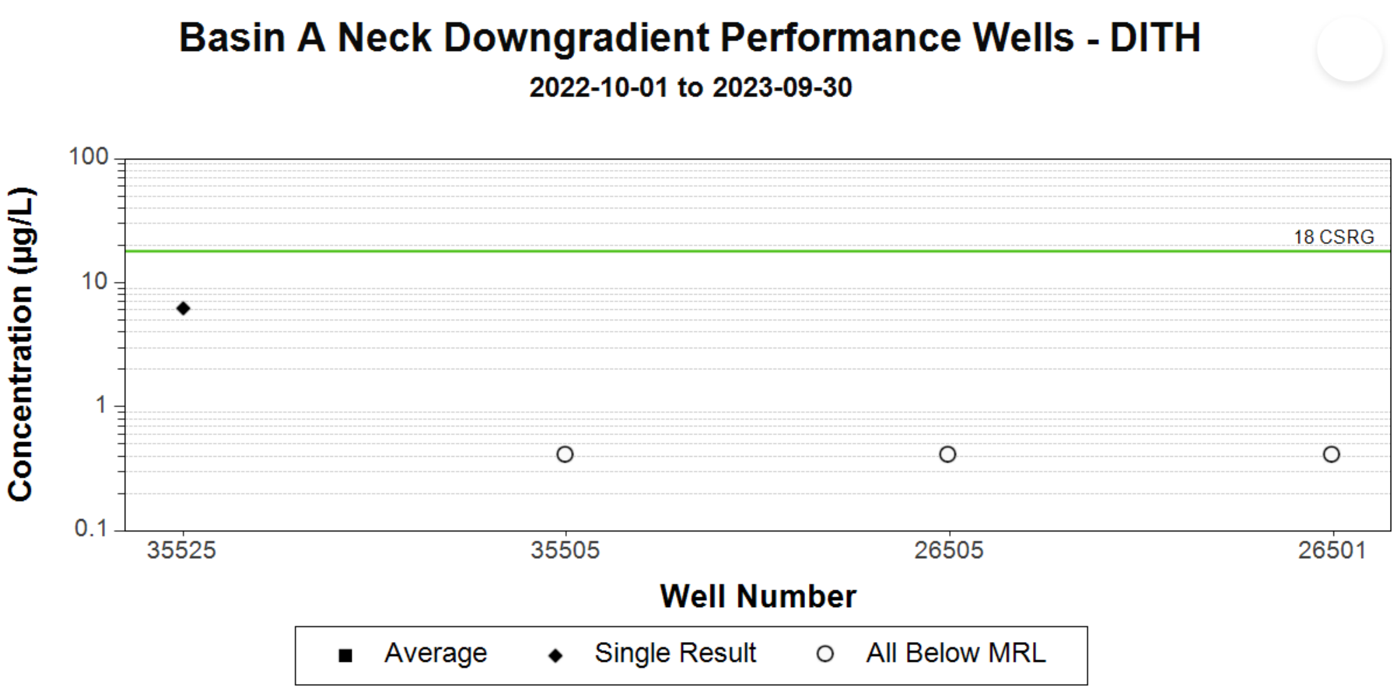


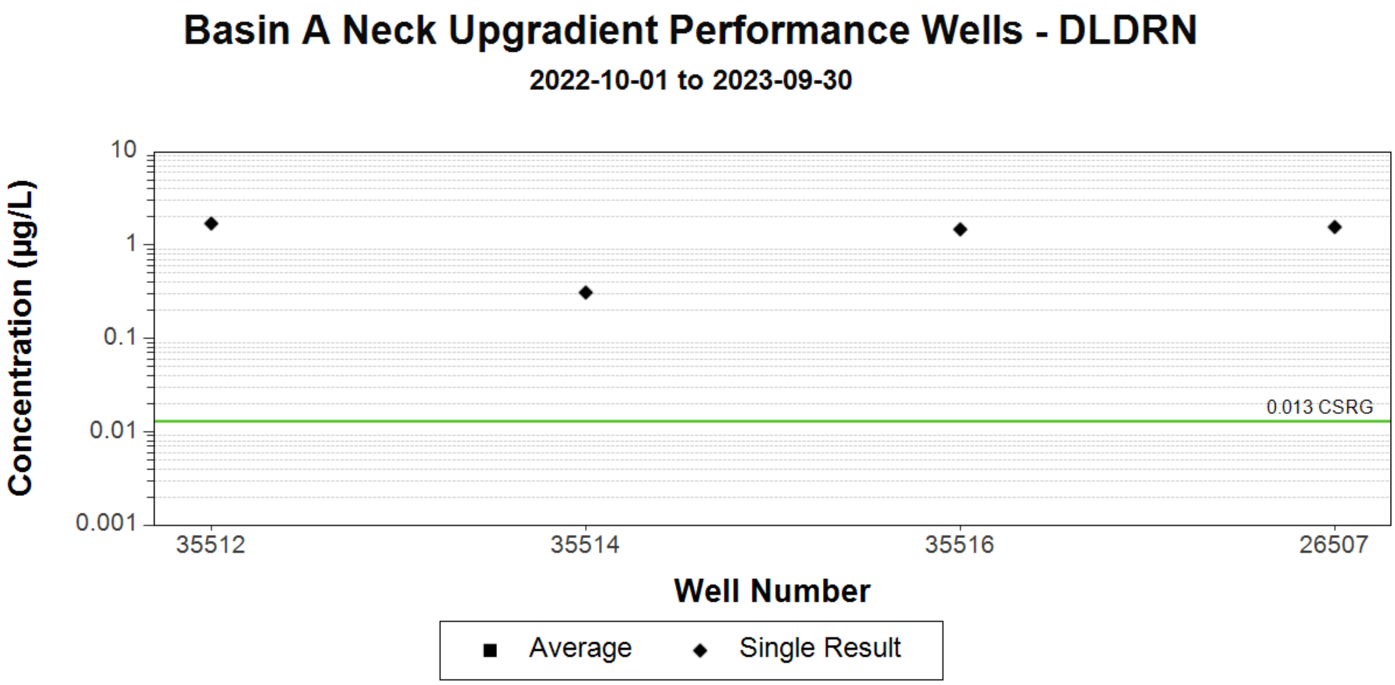
Basin A Neck Upgradient Performance Wells - CPMSO2
2022-10-01 to 2023-09-30
Concentration (µg/L)
100
10
1
36 CSRG
35512
35514
35516
26507
Well Number
Average
Single Result
All Below MRL



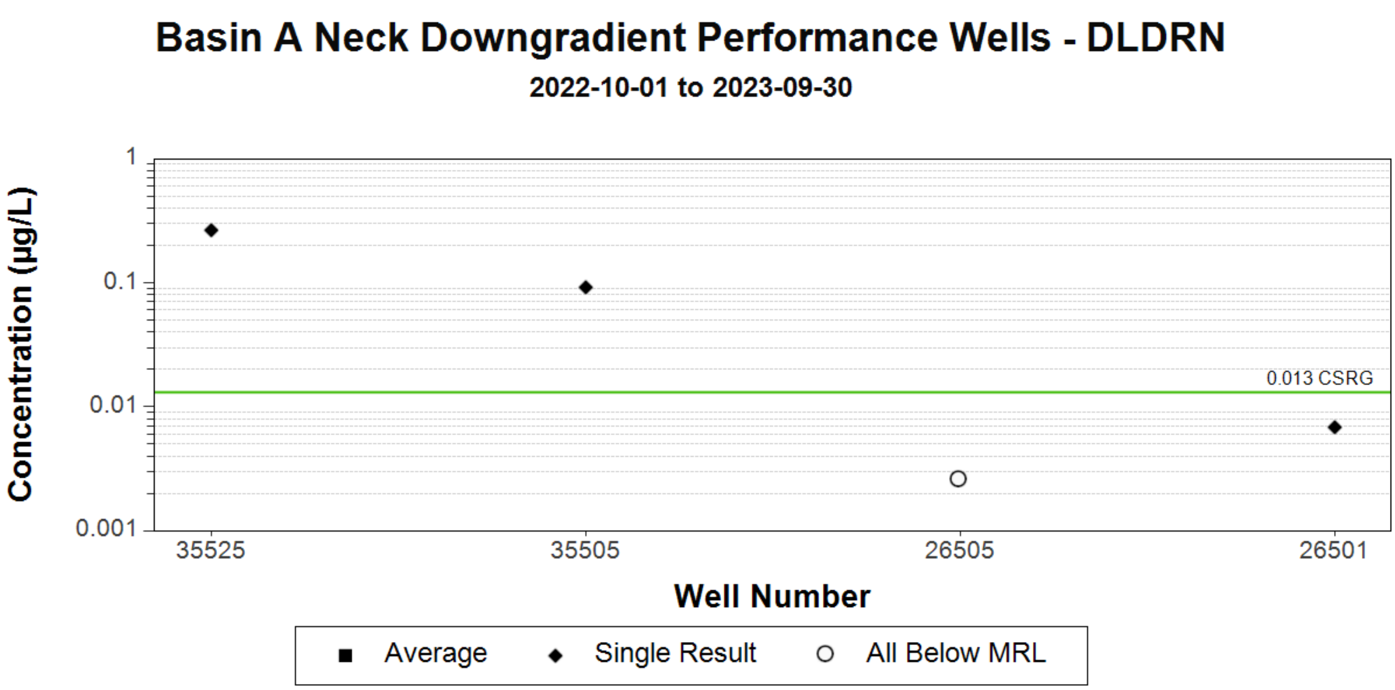
Basin A Neck Downgradient Performance Wells - CPMSO2
2022-10-01 to 2023-09-30
Concentration (µg/L)
100
10
1
36 CSRG
35525
35505
26505
26501
Well Number
Average
Single Result
All Below MRL


Basin A Neck Upgradient Performance Wells - DITH
2022-10-01 to 2023-09-30
Concentration (µg/L)
1000
100
10
1
0.1
18 CSRG
35512
35514
35516
26507
Well Number
Average
Single Result
All Below MRL

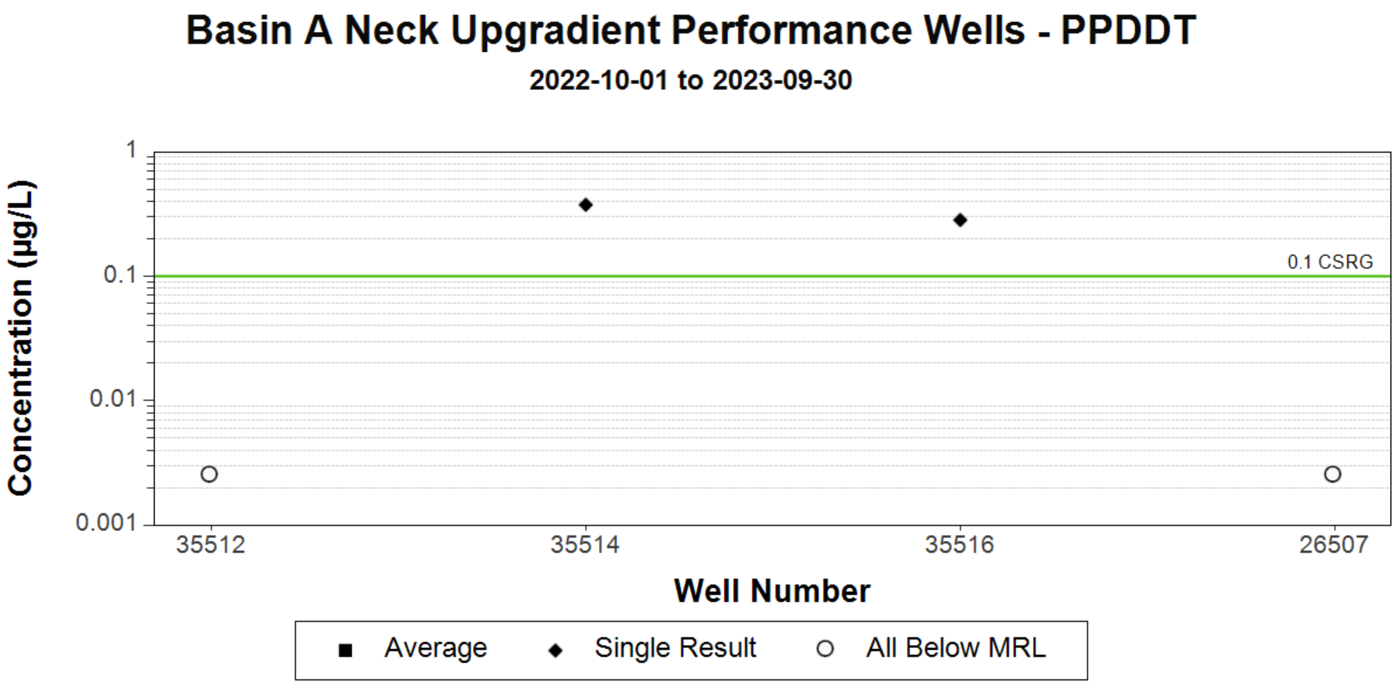

Basin A Neck Downgradient Performance Wells - DITH
2022-10-01 to 2023-09-30
Concentration (µg/L)
100
10
1
0.1
18 CSRG
35525
35505
26505
26501
Well Number
Average
Single Result
All Below MRL

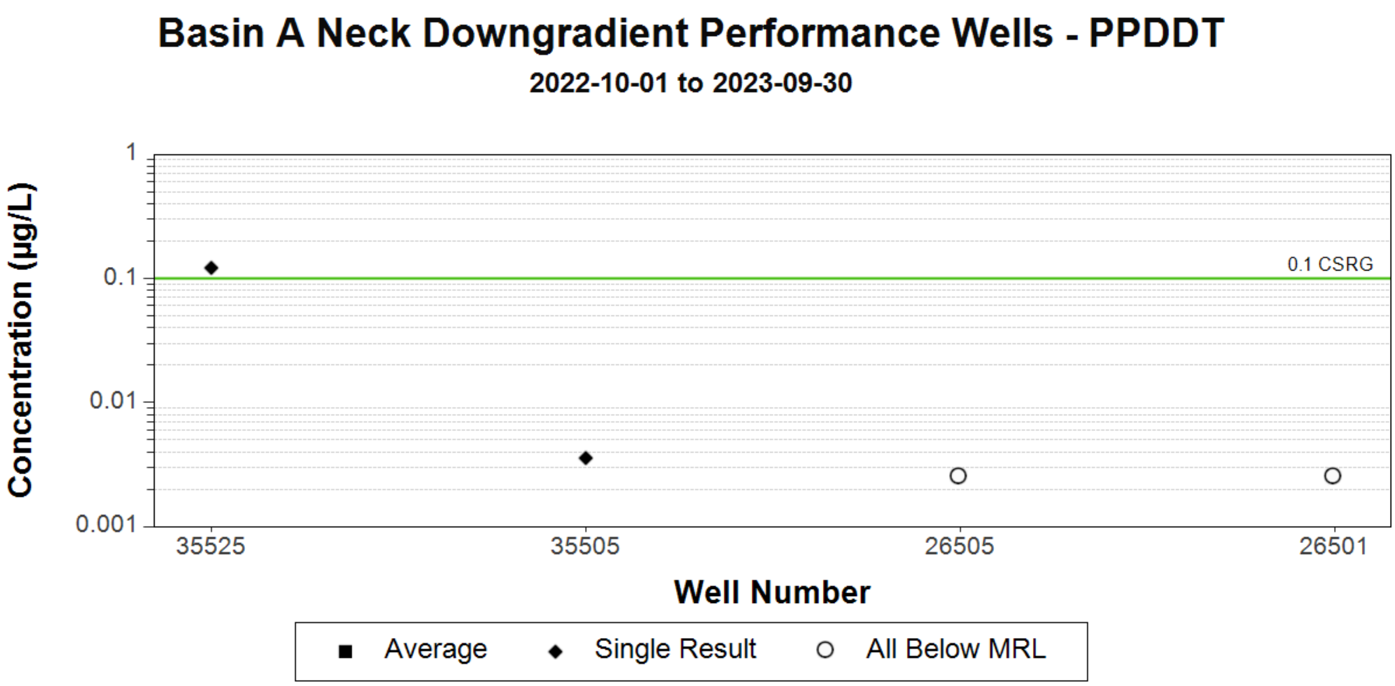


Basin A Neck Upgradient Performance Wells - DLDRN
2022-10-01 to 2023-09-30
Concentration (µg/L)
10
1
0.1
0.01
0.001
0.013 CSRG
35512
35514
35516
26507
Well Number
Average
Single Result



Basin A Neck Downgradient Performance Wells - DLDRN
2022-10-01 to 2023-09-30
Concentration (µg/L)
1
0.1
0.01
0.001
0.013 CSRG
35525
35505
26505
26501
Well Number
Average
Single Result
All Below MRL


Basin A Neck Upgradient Performance Wells - PPDDT
2022-10-01 to 2023-09-30
Concentration (µg/L)
1
0.1
0.01
0.001
0.1 CSRG
35512
35514
35516
26507
Well Number
Average
Single Result
All Below MRL


Basin A Neck Downgradient Performance Wells - PPDDT
2022-10-01 to 2023-09-30
Concentration (µg/L)
1
0.1
0.01
0.001
0.1 CSRG
35525
35505
26505
26501
Well Number
Average
Single Result
All Below MRL

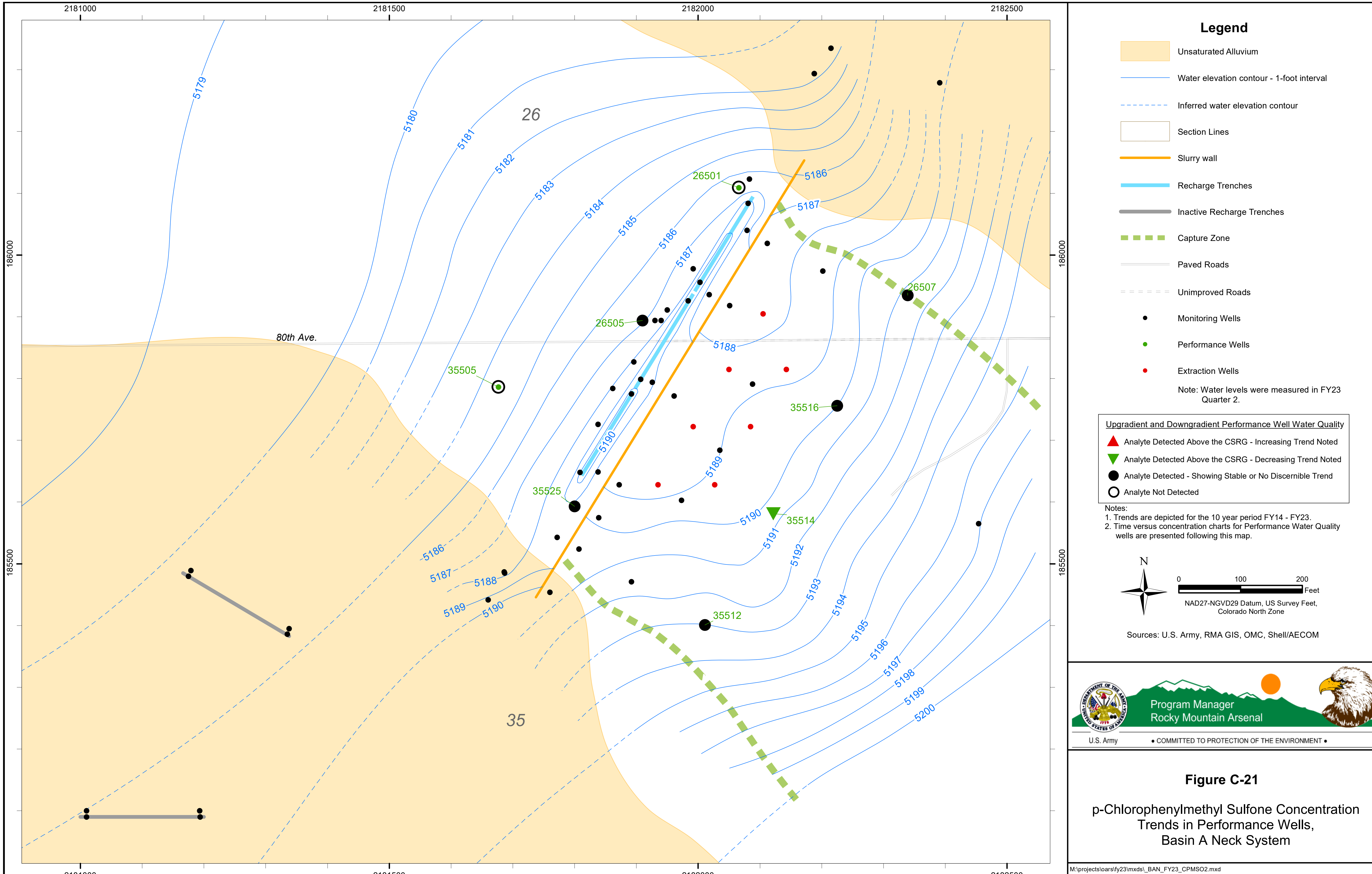
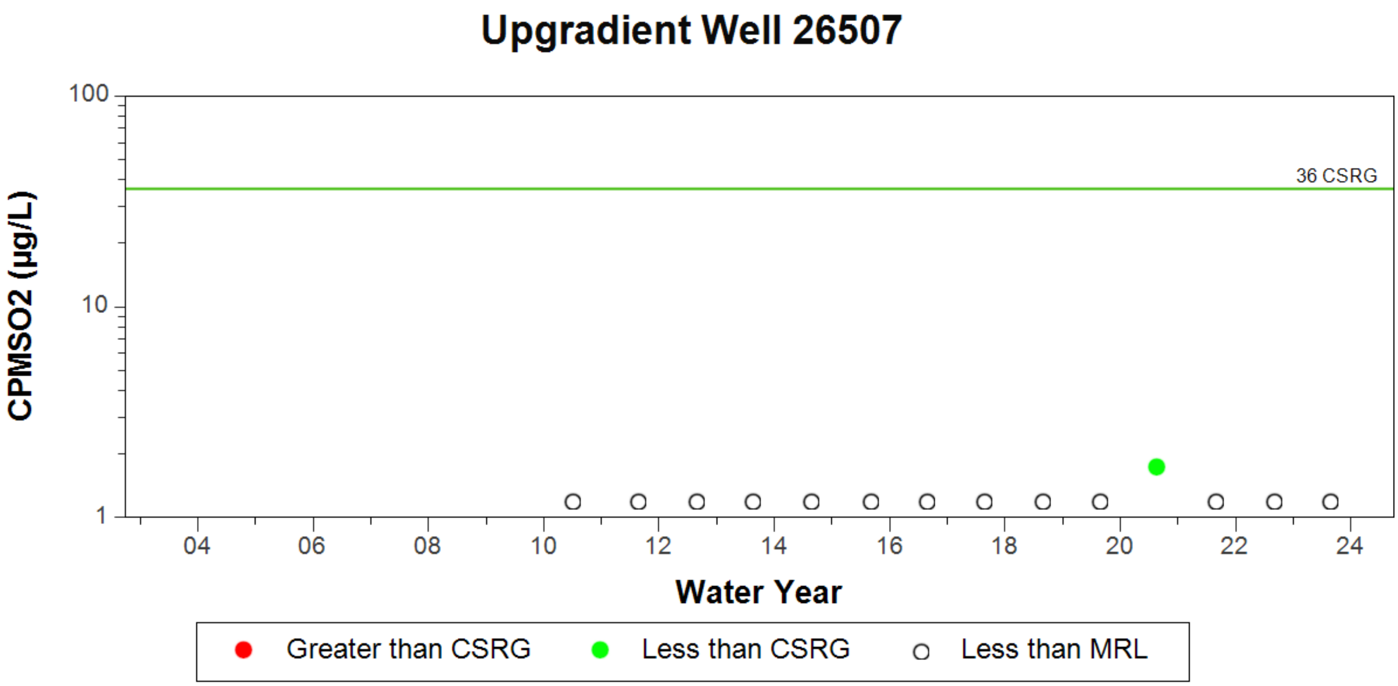
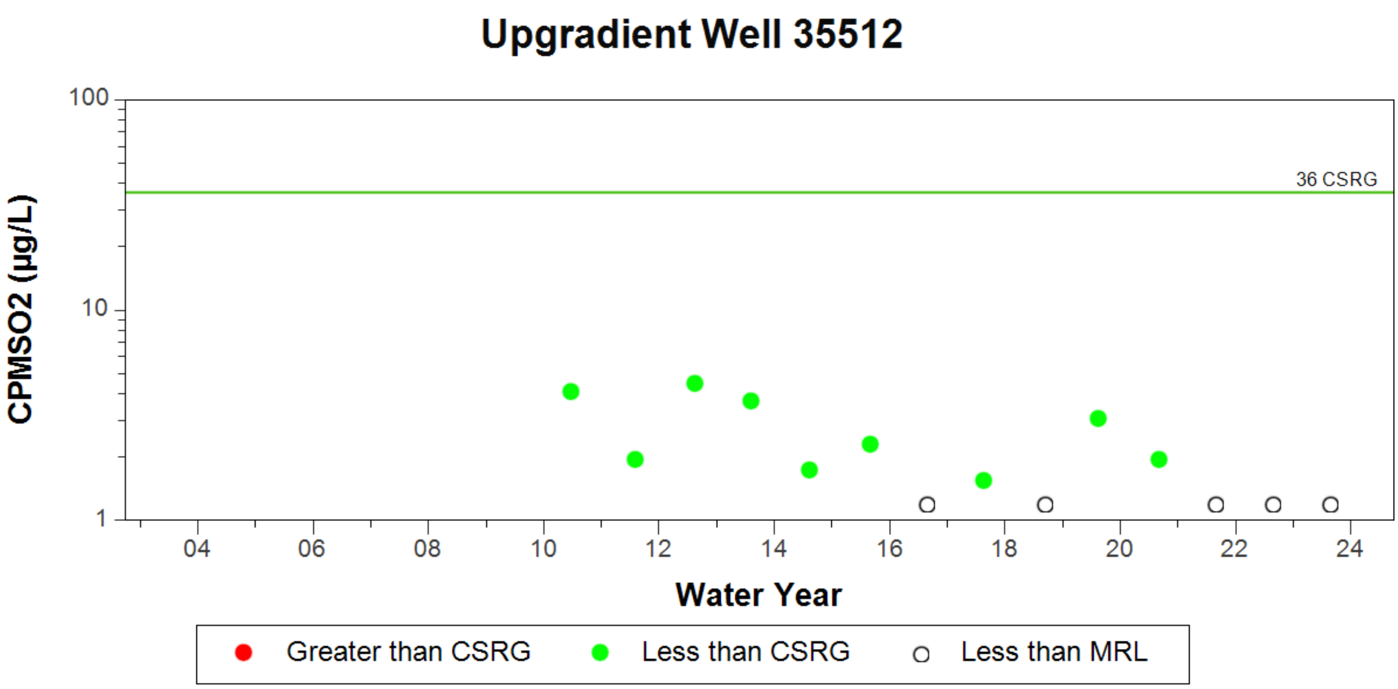


Figure C-21

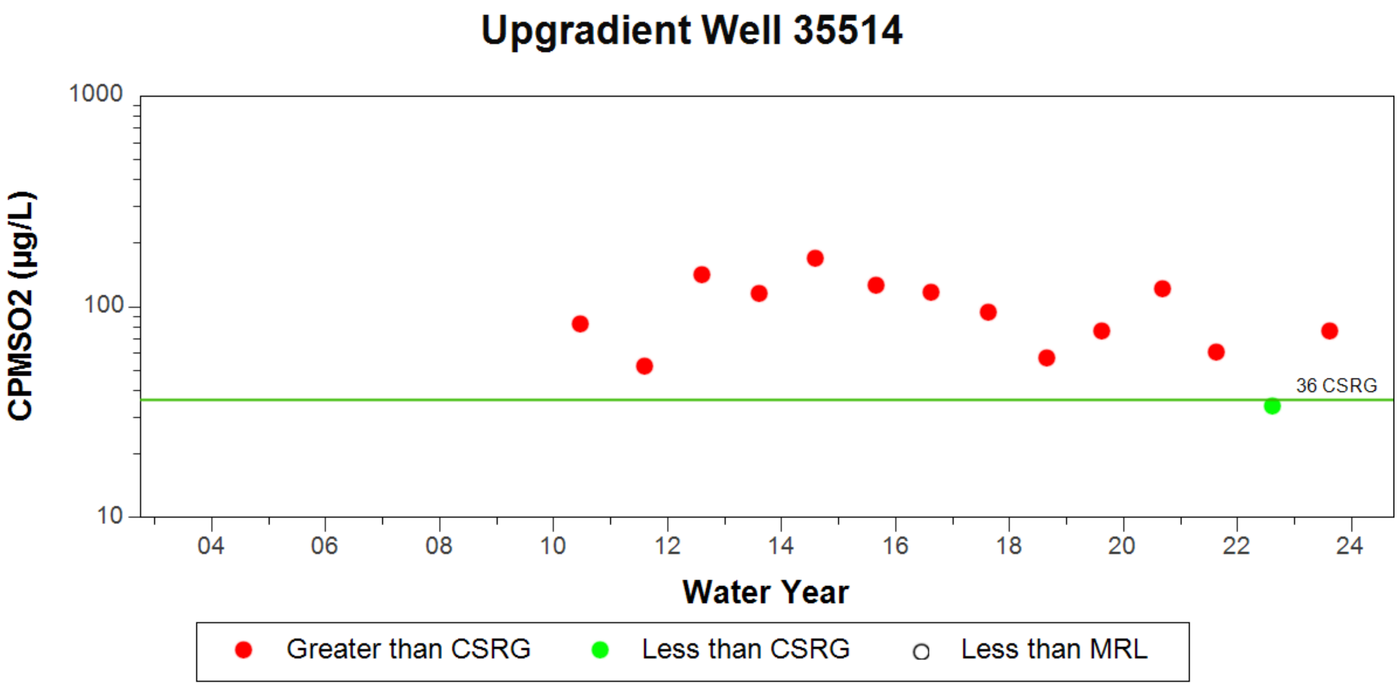
p-Chlorophenylmethyl Sulfone Concentration Trends in Performance Wells, Basin A Neck System



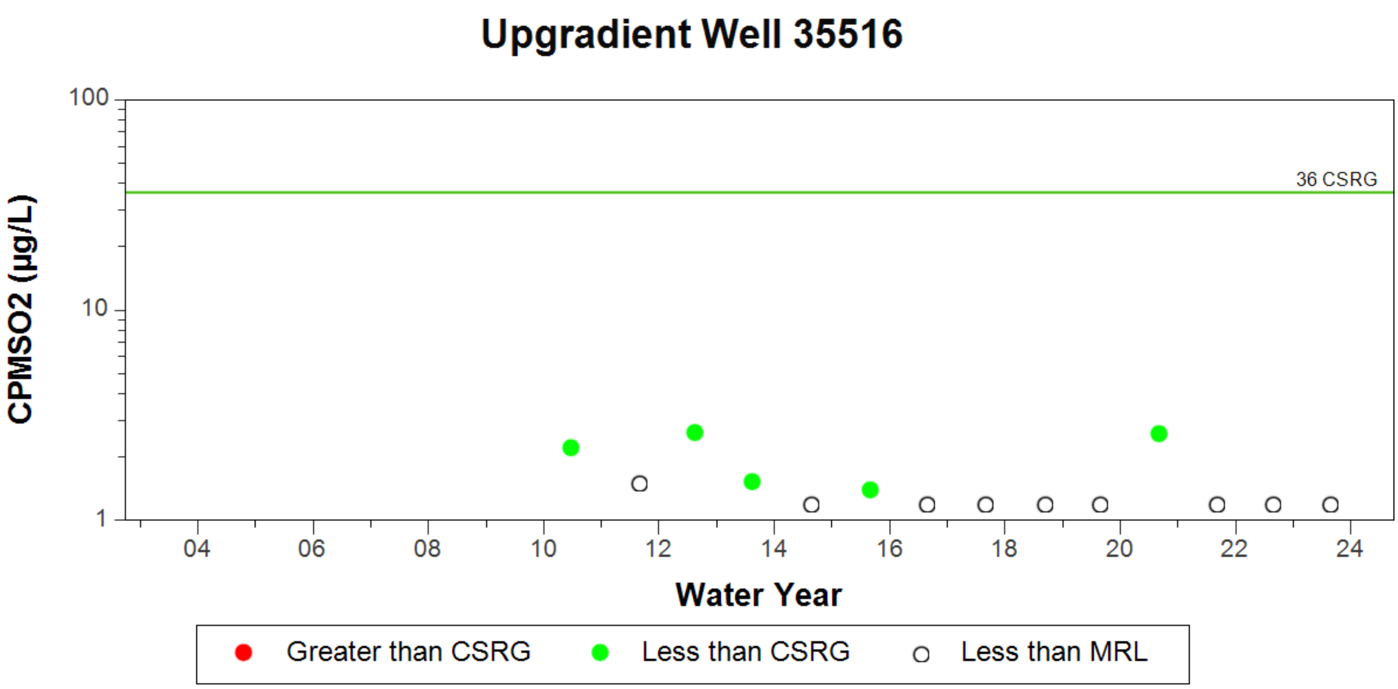
Upgradient Well 26507
100
10
1
36 CSRG
CPMSO2 (µg/L)
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



Upgradient Well 35512
100
10
1
36 CSRG
CPMSO2 (µg/L)
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

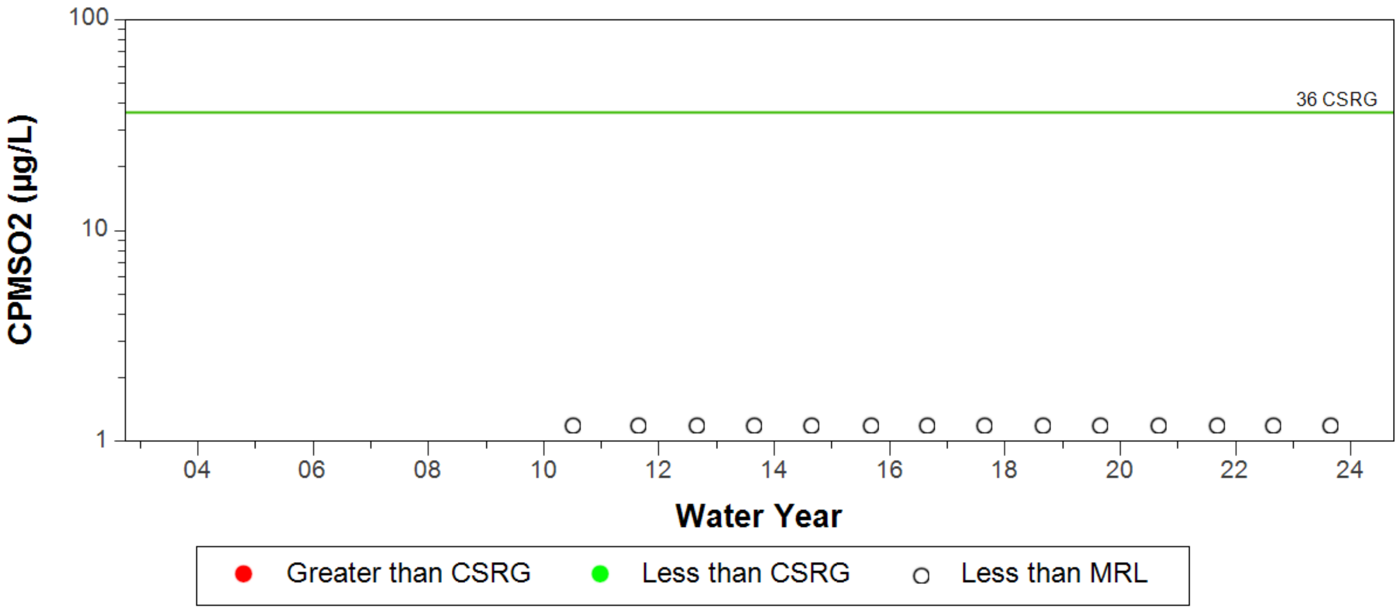


Upgradient Well 35514
CPMSO2 (µg/L)
1000
100
10
36 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

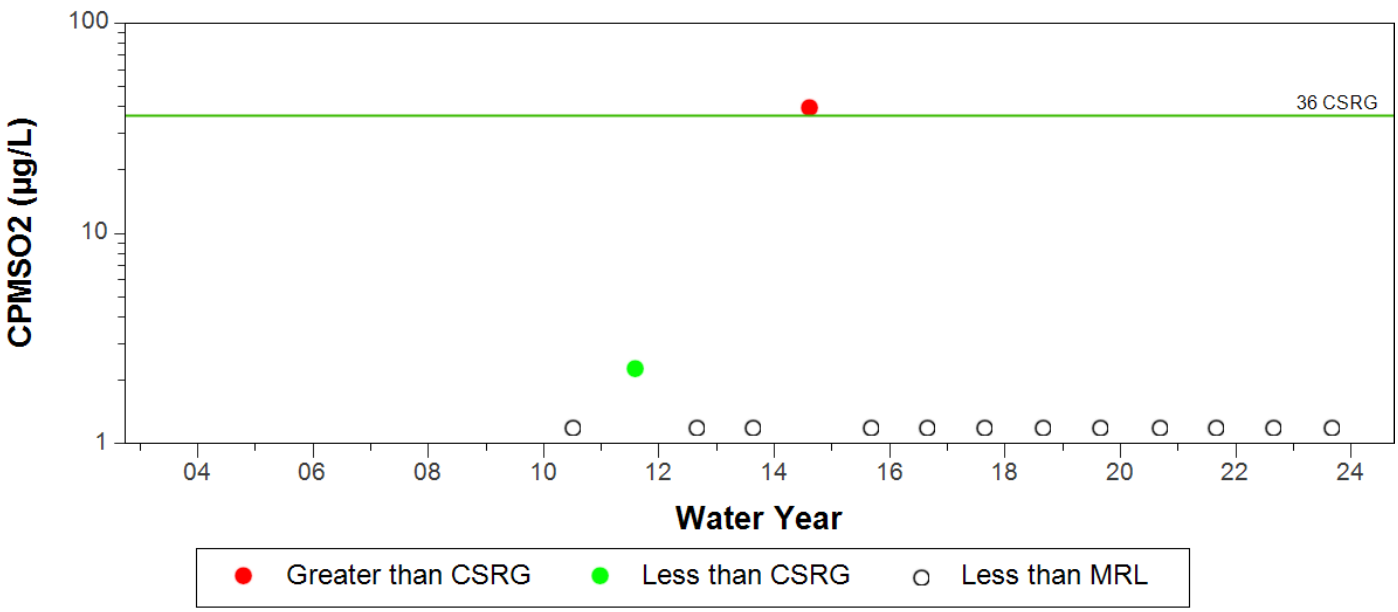


Upgradient Well 35516
CPMSO2 (µg/L)
100
10
1
36 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

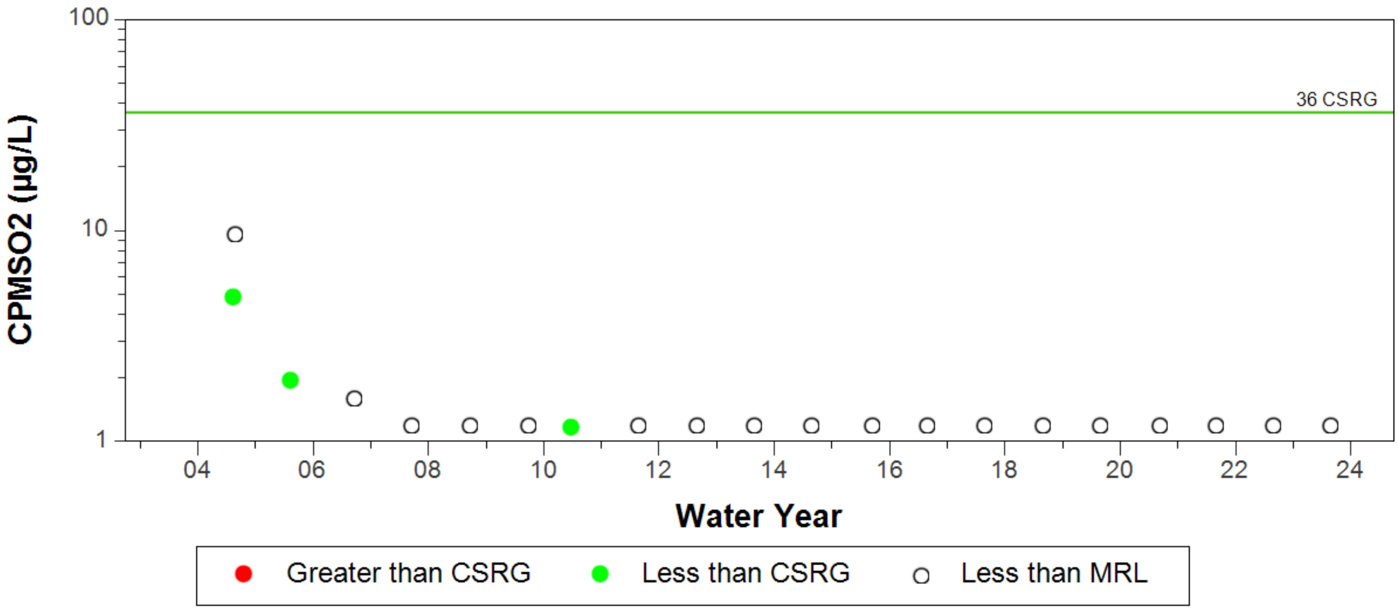
Downgradient Well 26501



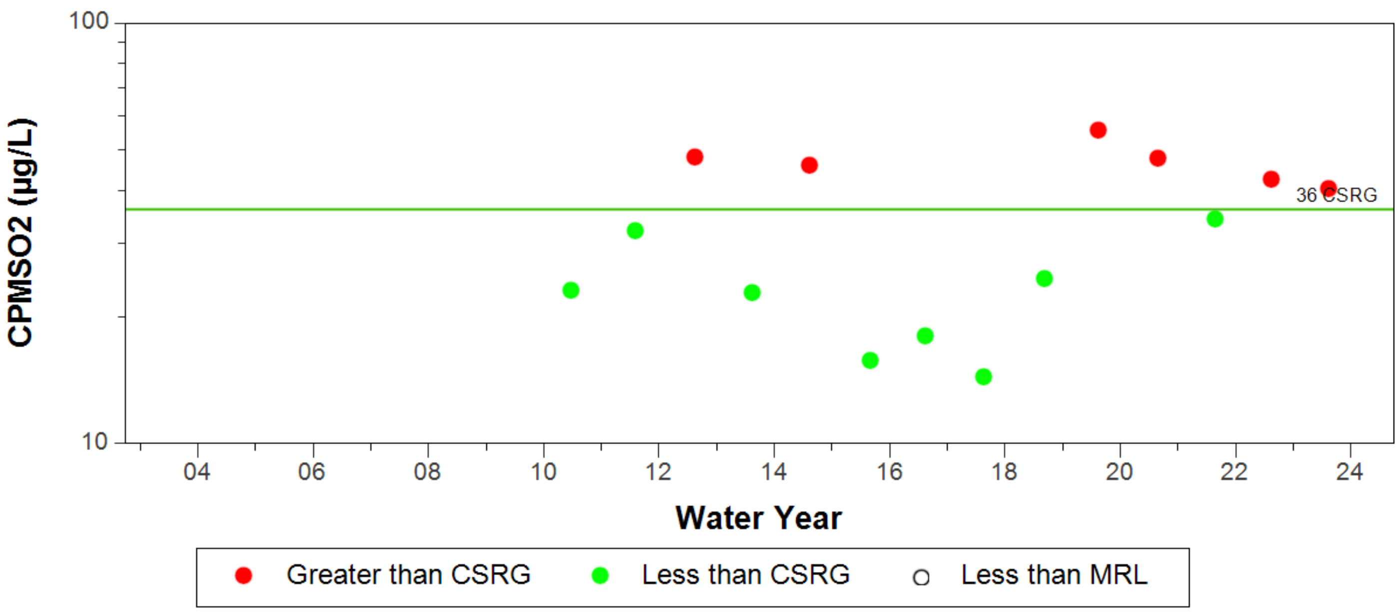
Downgradient Well 26505

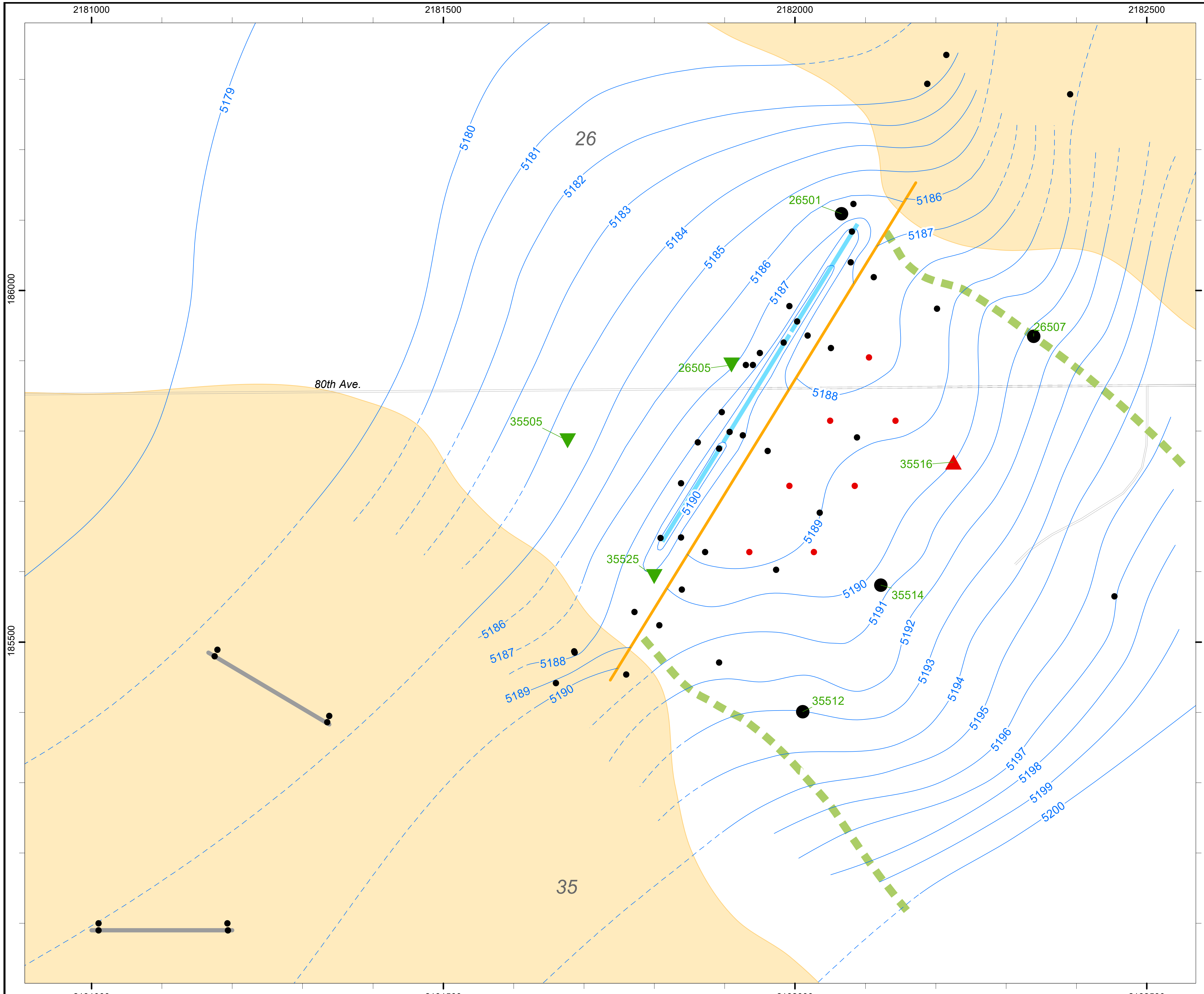


Downgradient Well 35505



Downgradient Well 35525





Legend

- Unsaturated Alluvium
- Water elevation contour - 1-foot interval
- Inferred water elevation contour
- Section Lines
- Slurry wall
- Recharge Trenches
- Inactive Recharge Trenches
- Capture Zone
- Paved Roads
- Unimproved Roads
- Monitoring Wells
- Performance Wells
- Extraction Wells

Note: Water levels were measured in FY23 during Quarter 2.

Upgradient and Downgradient Performance Well Water Quality

- Analyte Detected Above the CSRG - Increasing Trend Noted
- Analyte Detected Above the CSRG - Decreasing Trend Noted
- Analyte Detected - Showing Stable or No Discernible Trend
- Analyte Not Detected

Notes:
1. Trends are depicted for the 10 year period FY14 - FY23.
2. Time versus concentration charts for Performance Water Quality wells are presented following this map.

N

0 100 200 Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

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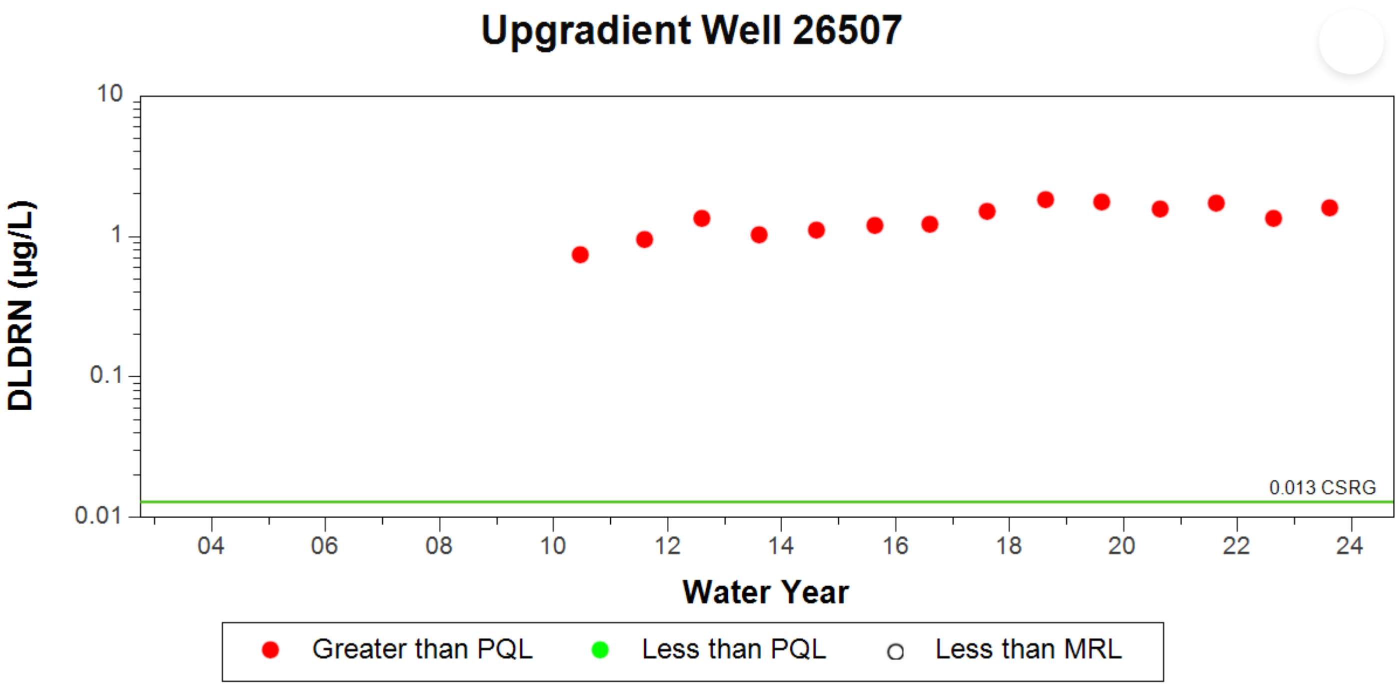
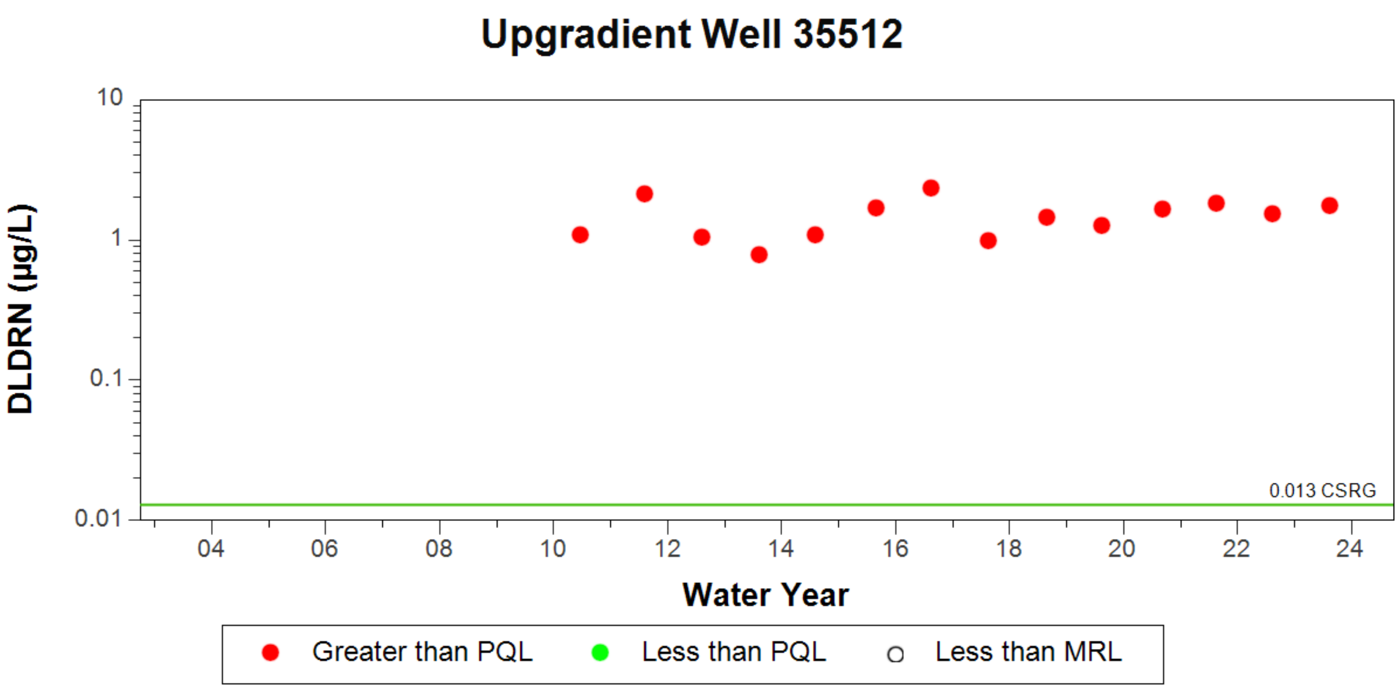
Figure C-22

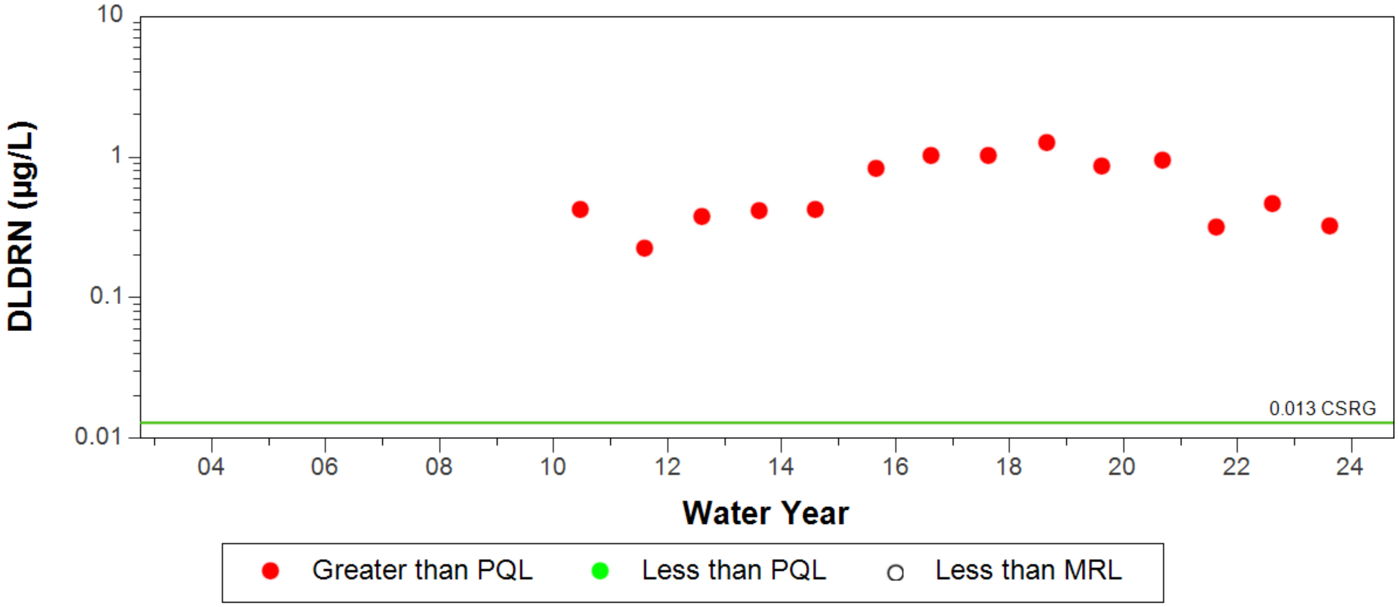
Dieldrin Concentration
Trends in Performance Wells,
Basin A Neck System

M:\projects\oars\fy23\mxds_BAN_FY23_DLDRN.mxd
8/7/2024

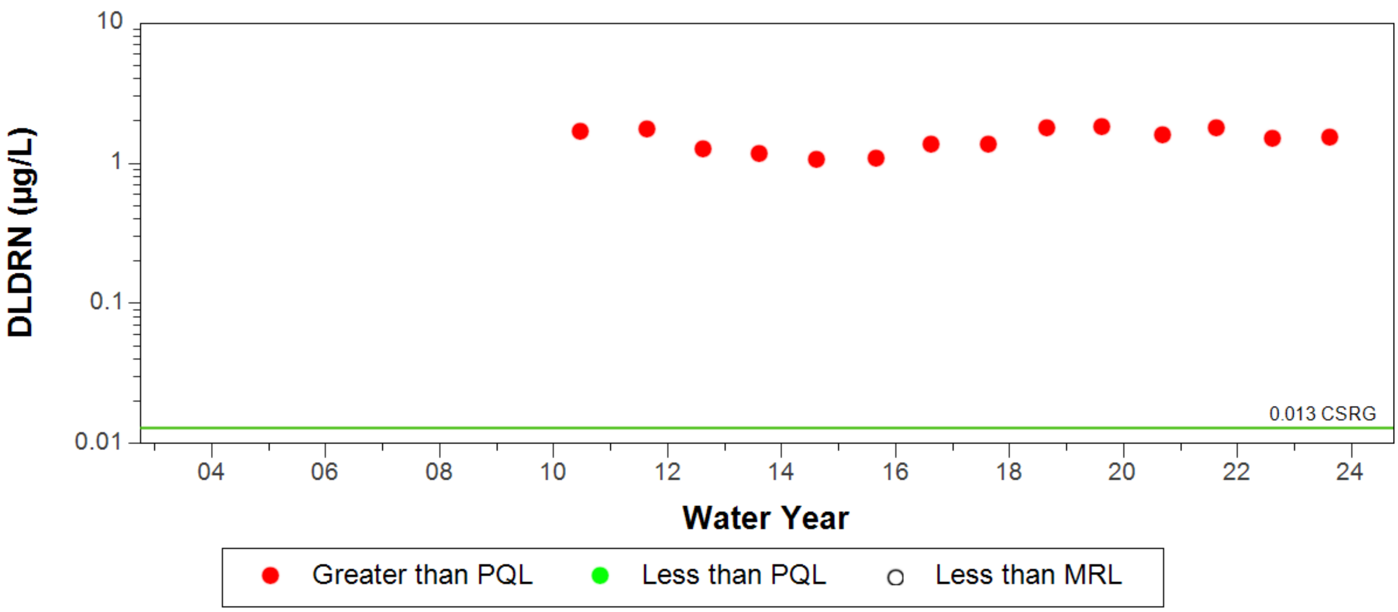

Upgradient Well 26507
DLDRN (µg/L)
10
1
0.1
0.01
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

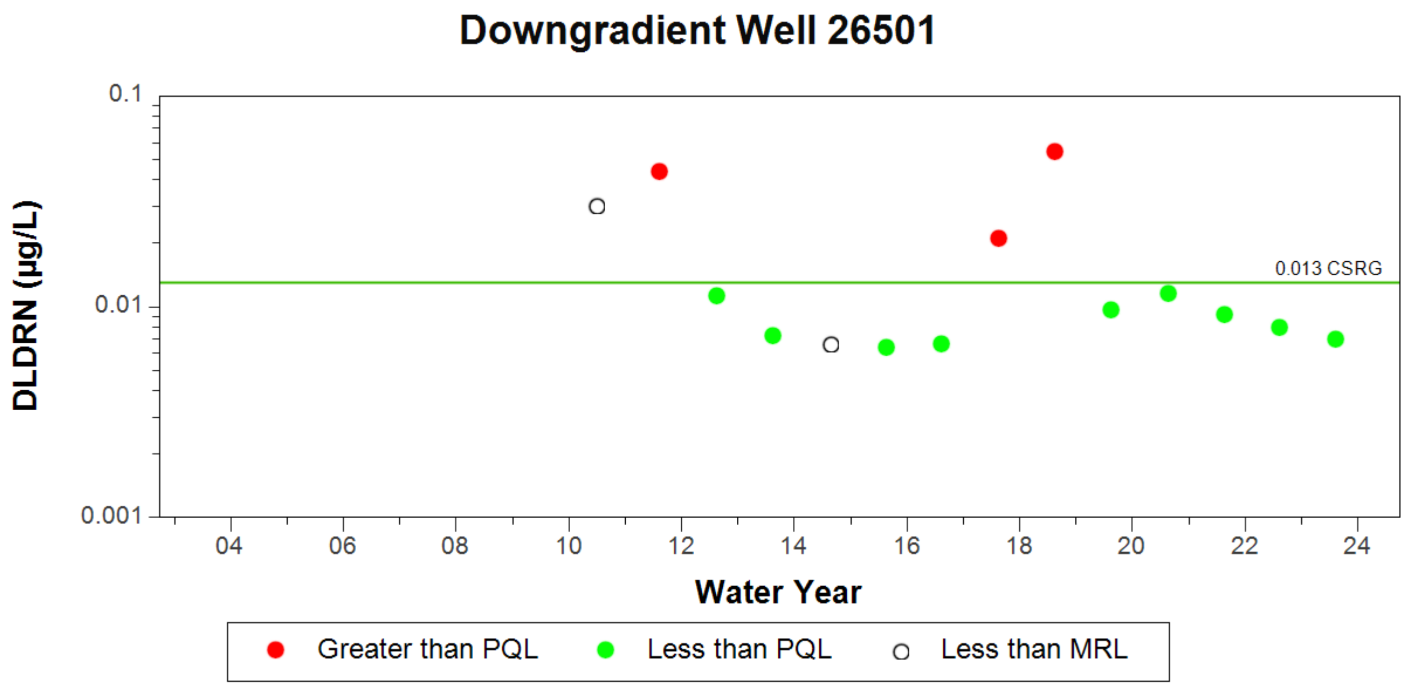

Upgradient Well 35512
DLDRN (µg/L)
10
1
0.1
0.01
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

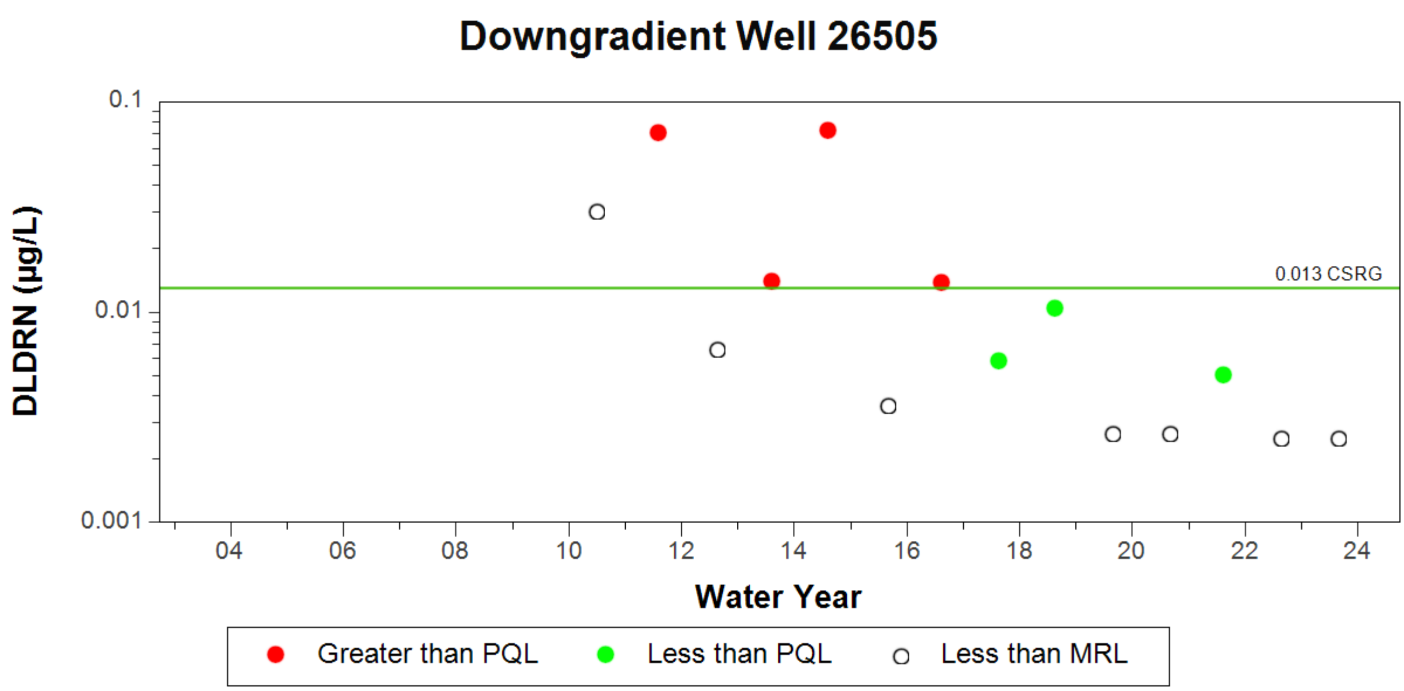
Upgradient Well 35514

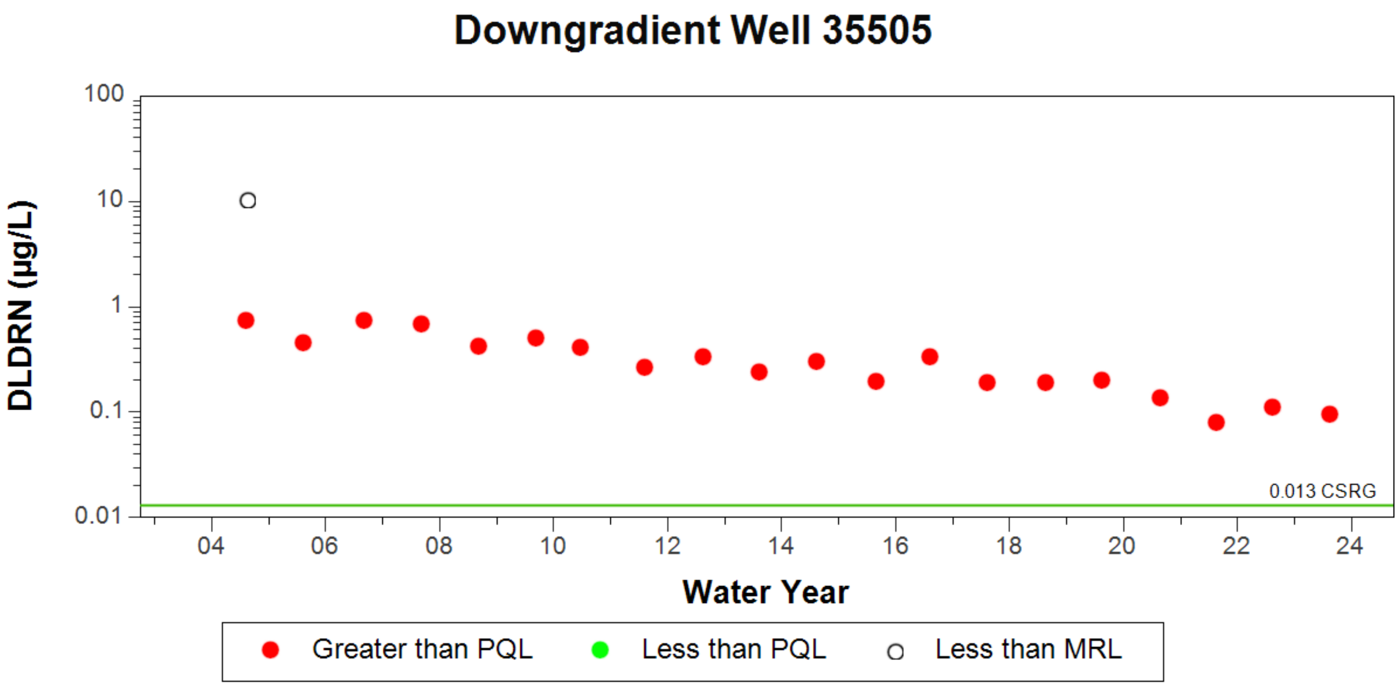


Upgradient Well 35516

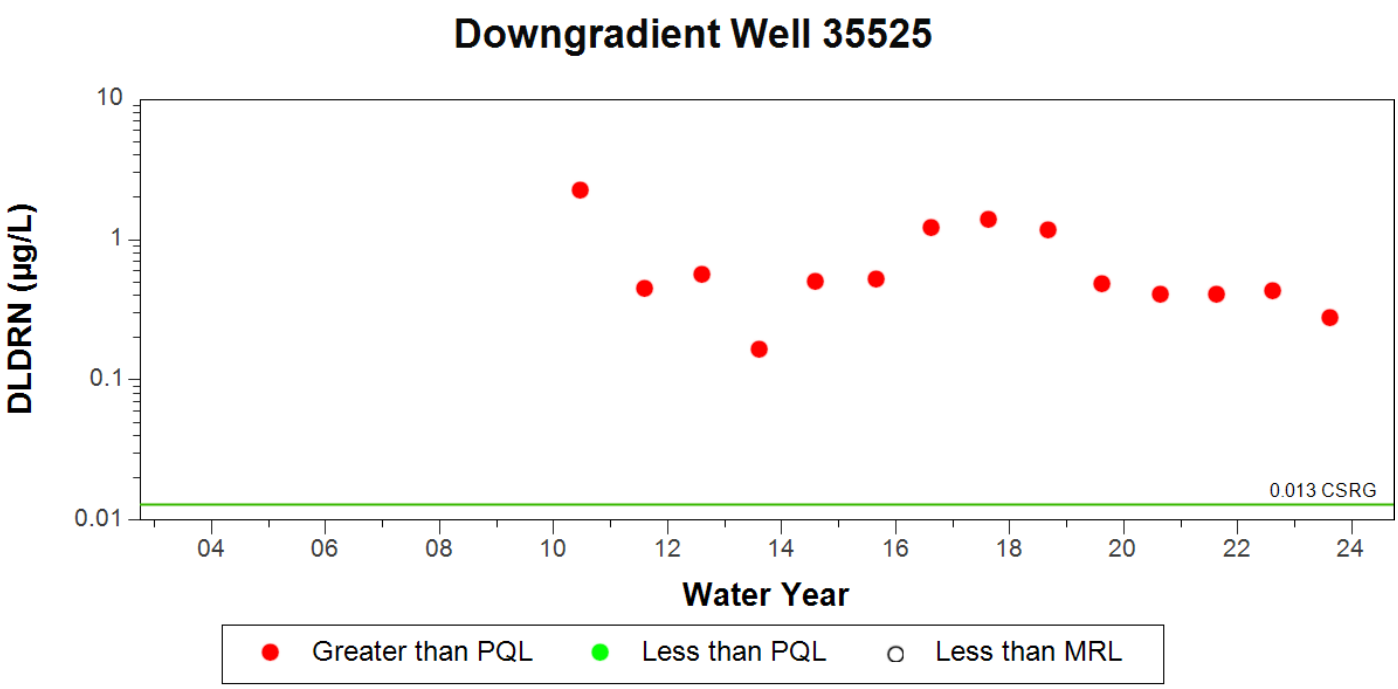



Downgradient Well 26501
DLDRN (µg/L)
0.1
0.01
0.001
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

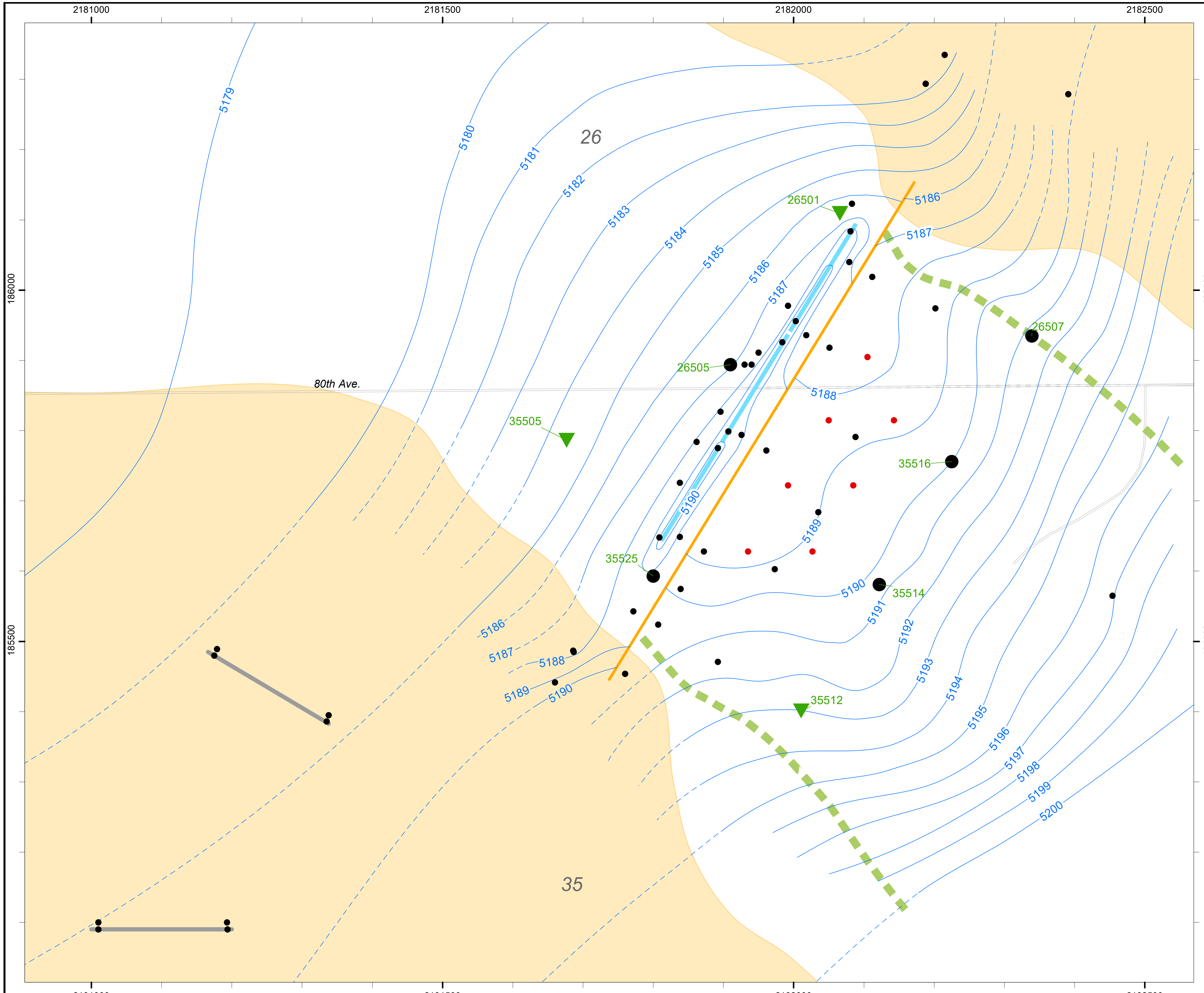

Downgradient Well 26505
DLDRN (µg/L)
0.1
0.01
0.001
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL



Downgradient Well 35505
DLDRN (µg/L)
100
10
1
0.1
0.01
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL



Downgradient Well 35525
DLDRN (µg/L)
10
1
0.1
0.01
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL



Legend

- Unsaturated Alluvium
- Water elevation contour - 1-foot interval
- Inferred water elevation contour
- Section Lines
- Slurry wall
- Recharge Trenches
- Inactive Recharge Trenches
- Capture Zone
- Paved Roads
- Unimproved Roads
- Monitoring Wells
- Performance Wells
- Extraction Wells

Note: Water levels were measured in FY23 during Quarter 2.

Upgradient and Downgradient Performance Well Water Quality

- Analyte Detected Above the CSRG - Increasing Trend Noted
- Analyte Detected Above the CSRG - Decreasing Trend Noted
- Analyte Detected - Showing Stable or No Discernible Trend
- Analyte Not Detected

Notes:
1. Trends are depicted for the 10 year period FY14 - FY23.
2. Time versus concentration charts for Performance Water Quality wells are presented following this map.

N

0 100 200 Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

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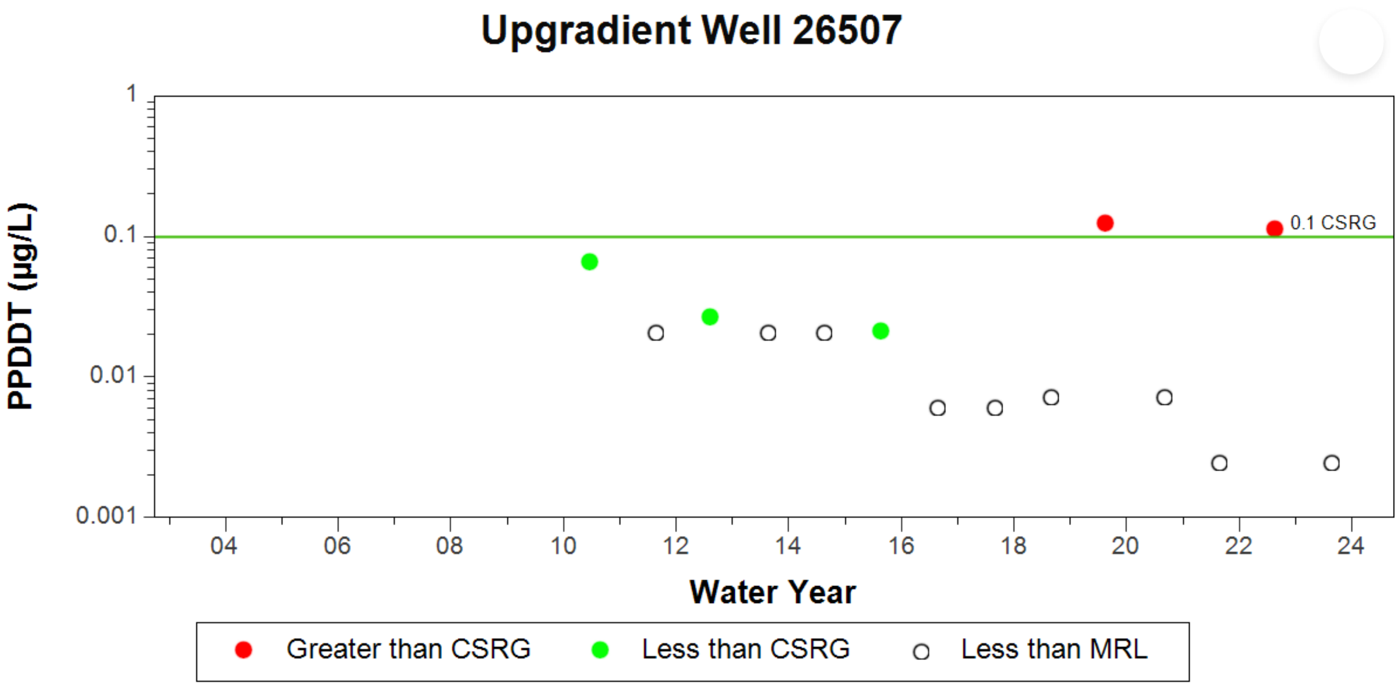
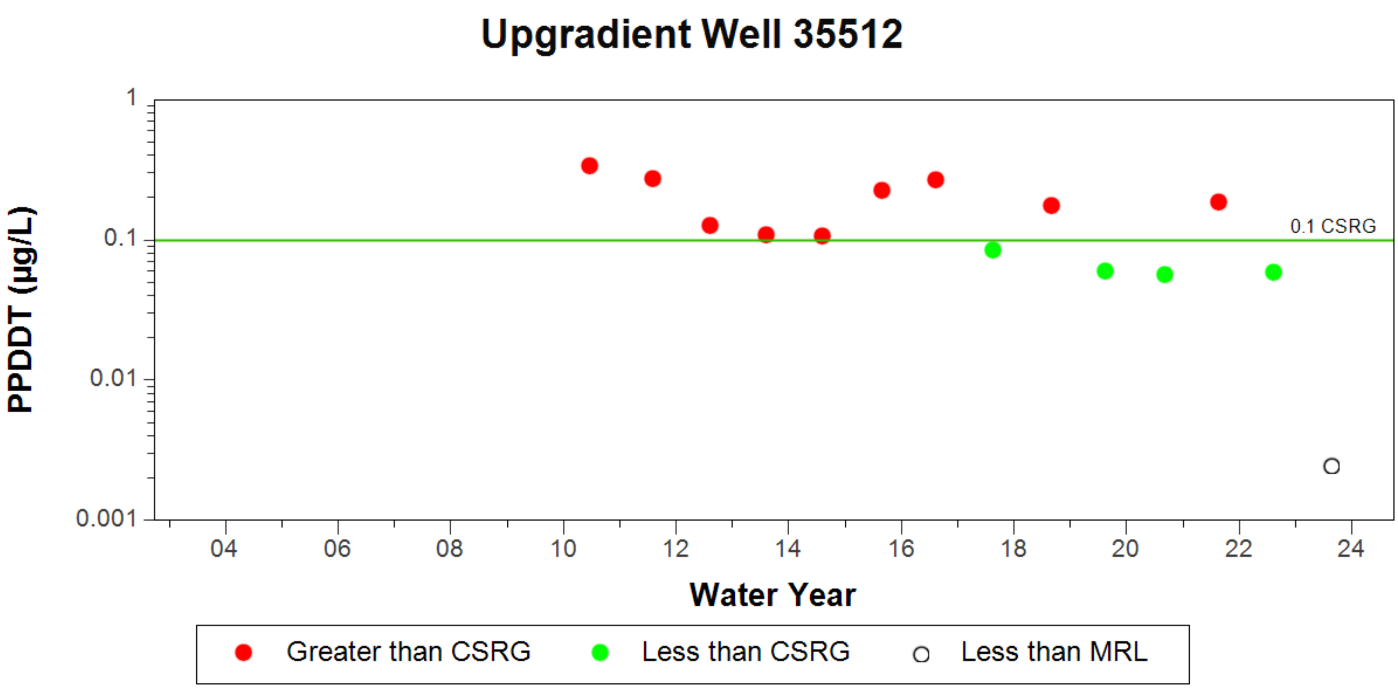
Figure C-23

Dichlorophenyltrichloroethane Concentration Trends in Performance Wells, Basin A Neck System

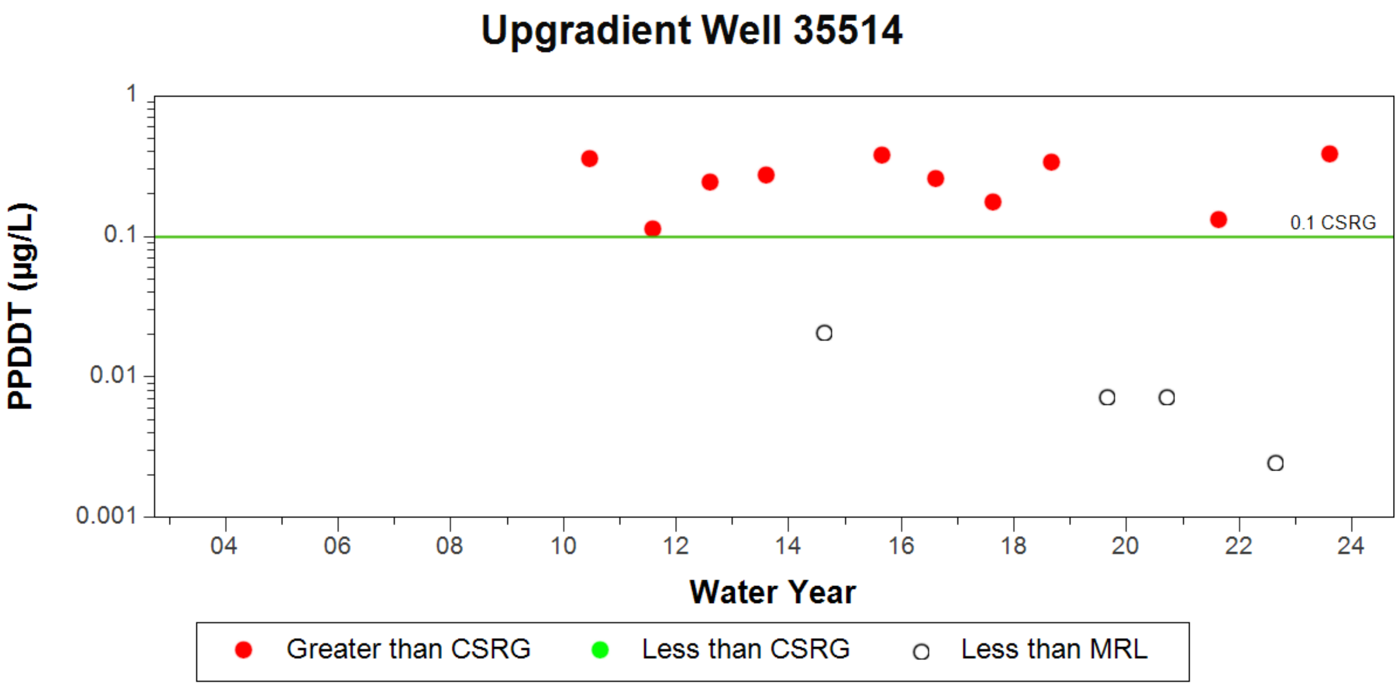
M:\projects\oars\fy23\mxds_BAN_FY23_PPDDT.mxd
8/7/2024

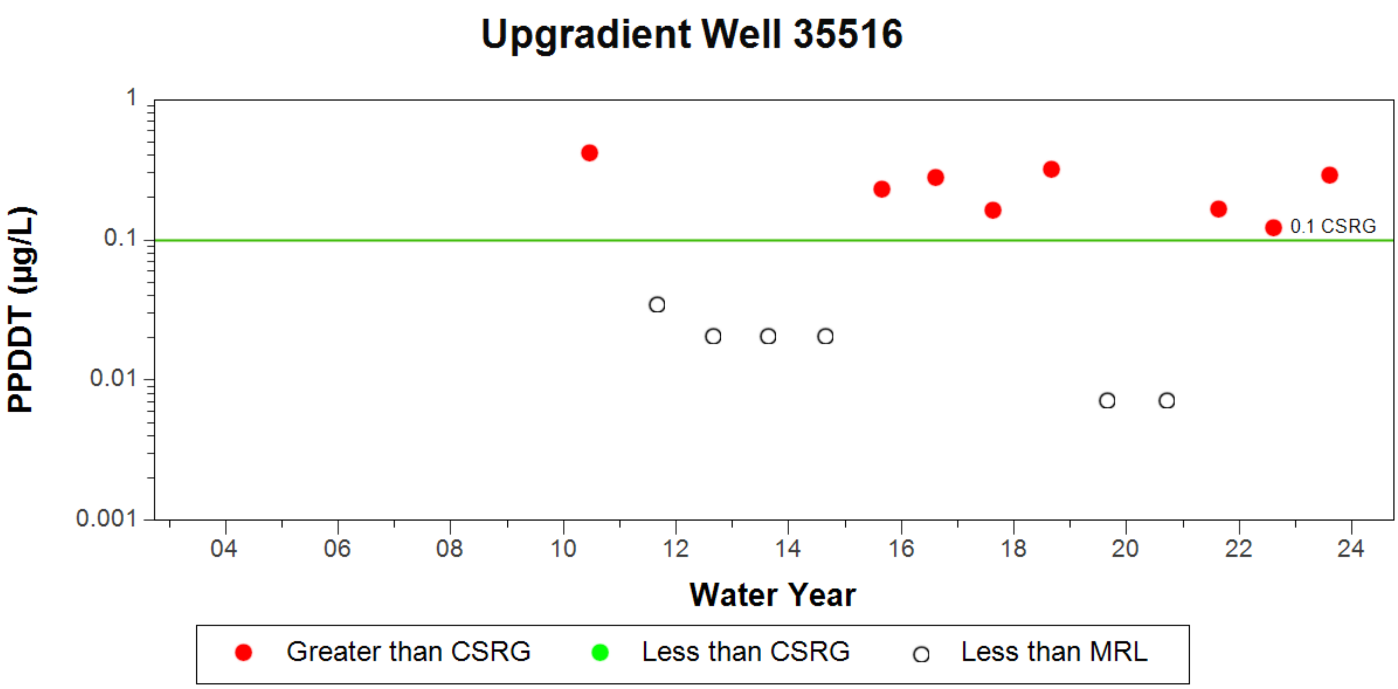


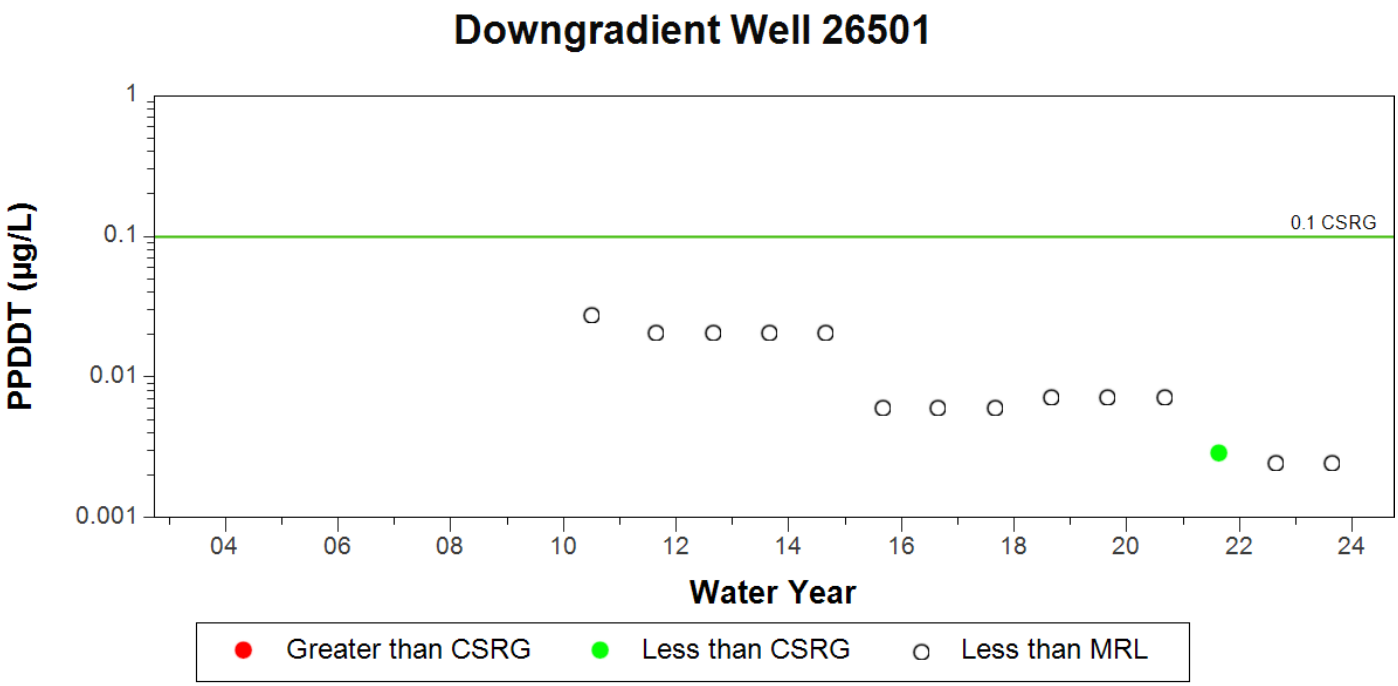
Upgradient Well 26507
PPDDT (µg/L)
1
0.1
0.01
0.001
0.1 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



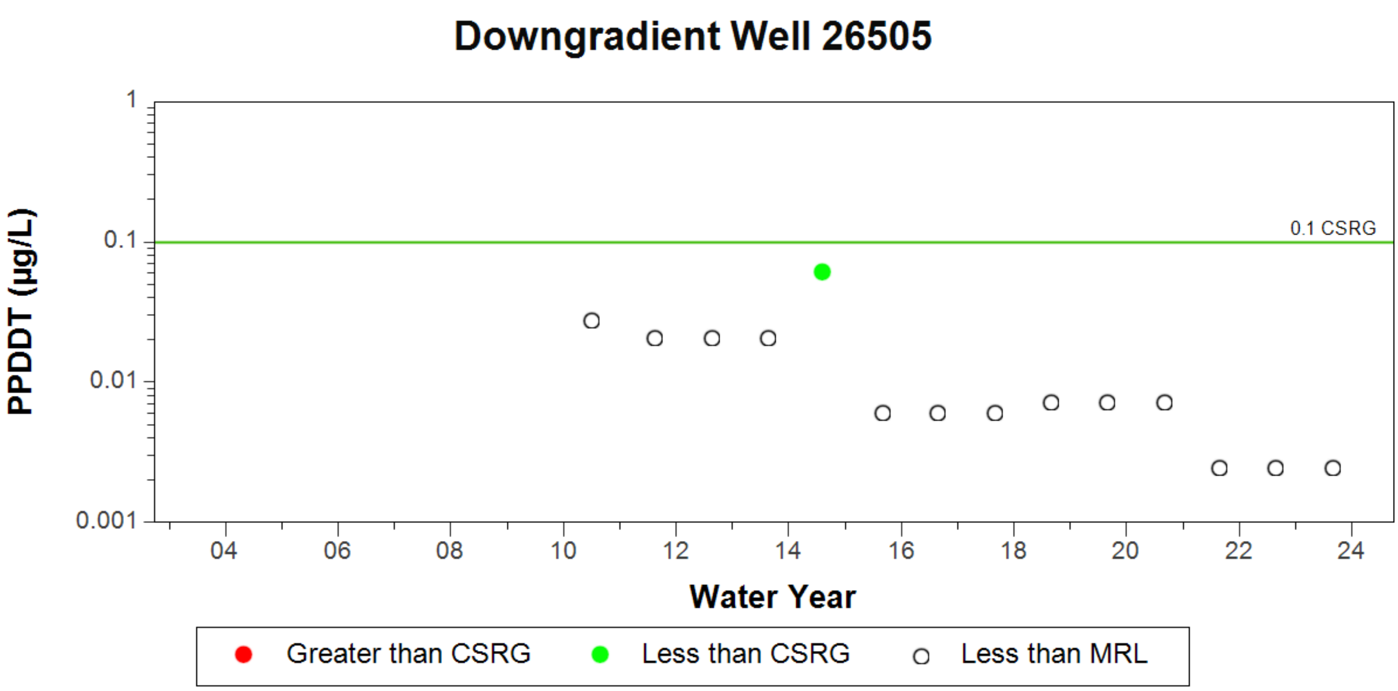
Upgradient Well 35512
PPDDT (µg/L)
1
0.1
0.01
0.001
0.1 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL


Upgradient Well 35514
PPDDT (µg/L)
1
0.1
0.01
0.001
0.1 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

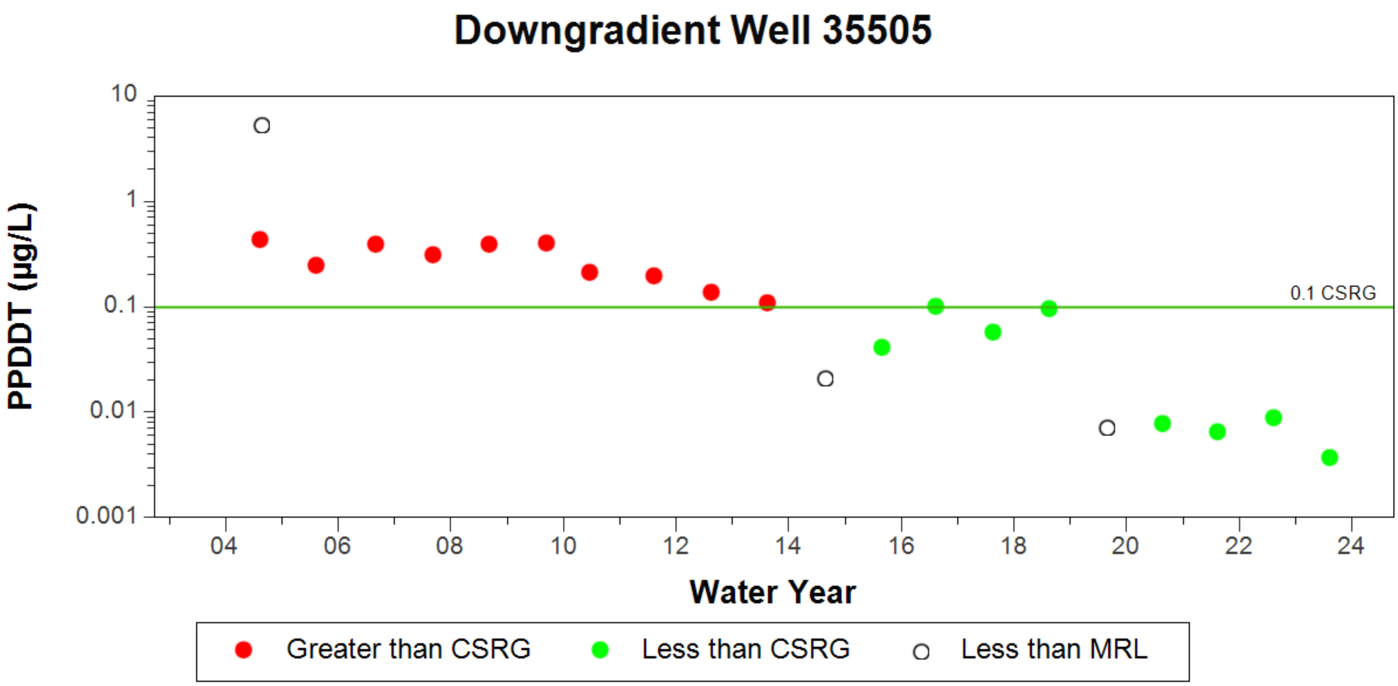

Upgradient Well 35516
PPDDT (µg/L)
1
0.1
0.01
0.001
0.1 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

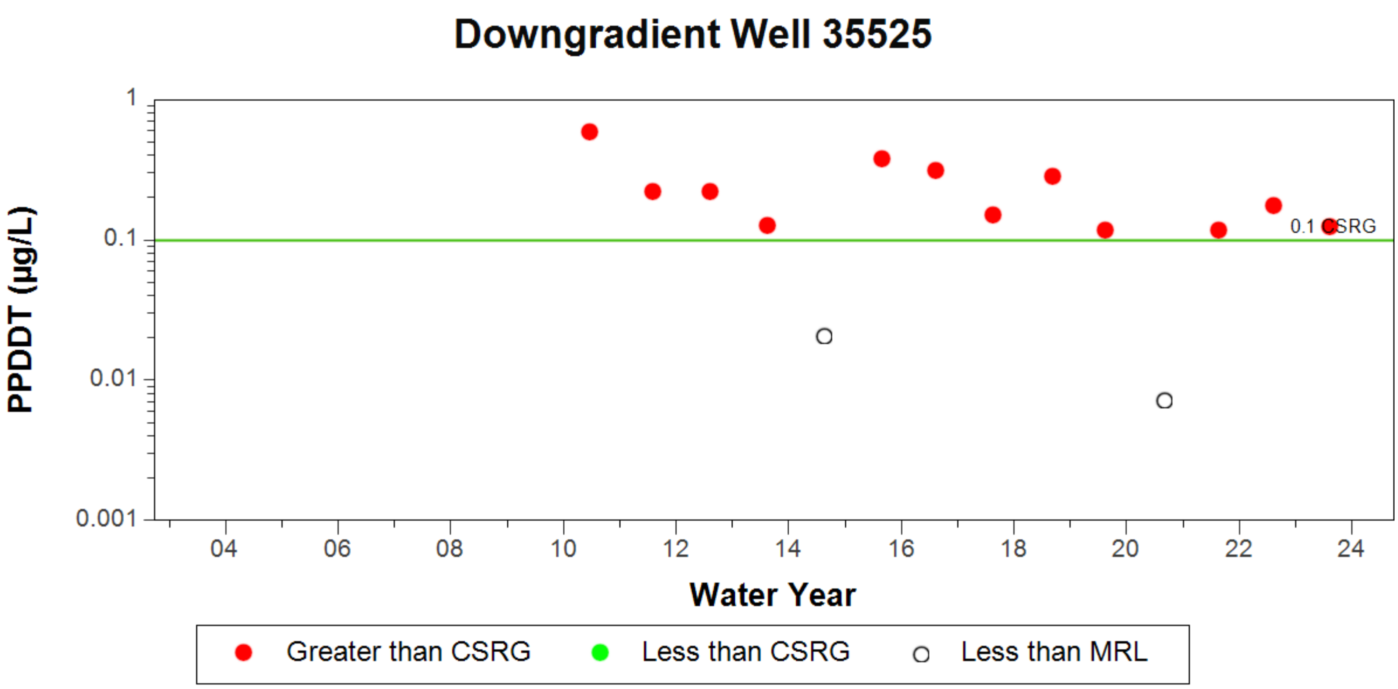


Downgradient Well 26501
PPDDT (µg/L)
1
0.1
0.01
0.001
0.1 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

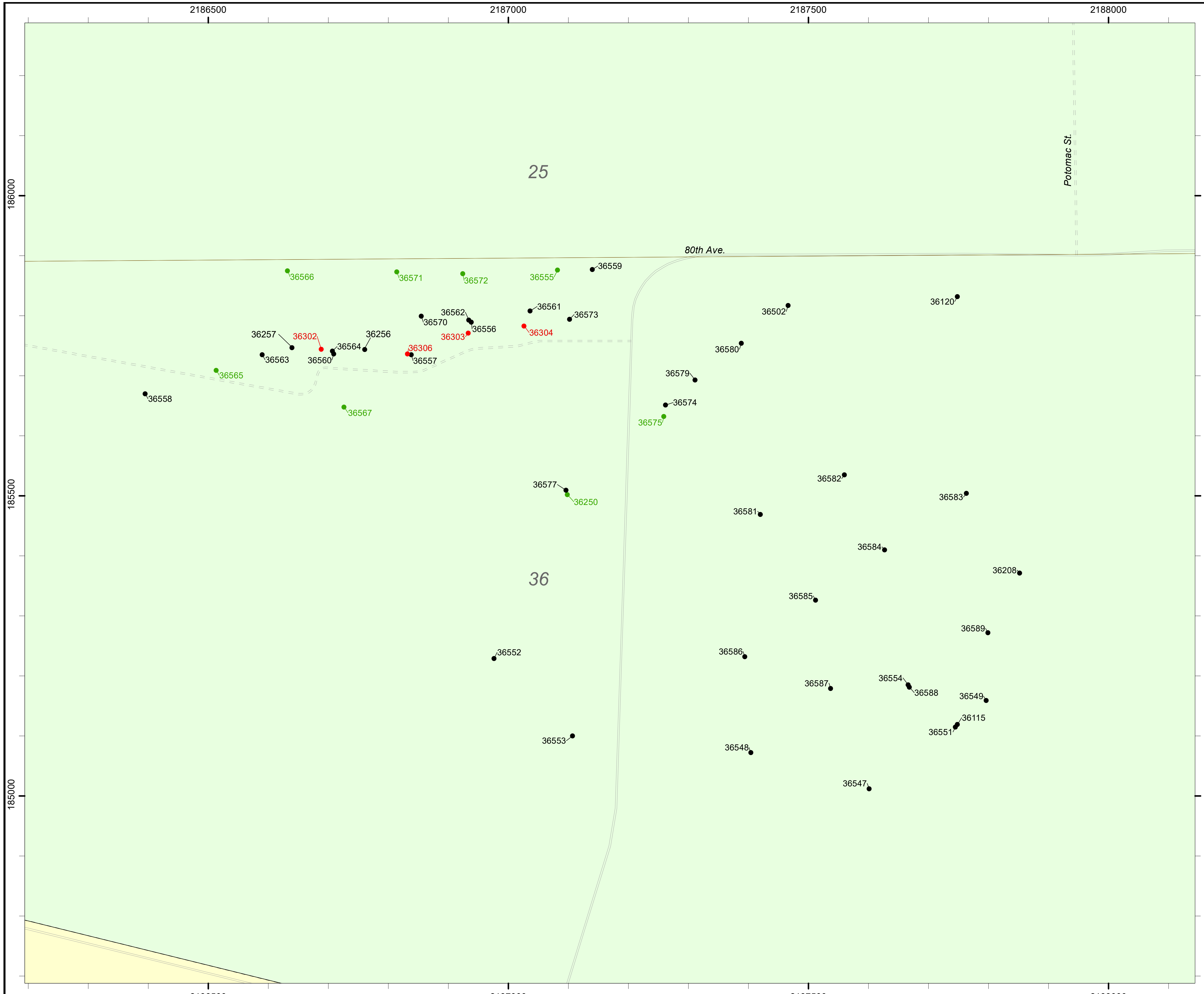


Downgradient Well 26505
PPDDT (µg/L)
1
0.1
0.01
0.001
0.1 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL


Downgradient Well 35505
PPDDT (µg/L)
10
1
0.1
0.01
0.001
0.1 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL


Downgradient Well 35525
PPDDT (µg/L)
1
0.1
0.01
0.001
0.1 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

Appendix D
Bedrock Ridge Extraction System
Figures and Documentation



Legend

- Army Maintained Area
- USFWS Managed Area
- Section Lines
- Paved Roads
- Unimproved Roads
- Performance Water Quality Wells
- Extraction Wells
- Monitoring Well

N

0 100 200 Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

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Figure D-1

Bedrock Ridge Extraction System
Monitoring Well Network
for the Unconfined Flow System

M:\projects\oars\fy23\mxds_brr23_well_location.mxd
6/23/2024

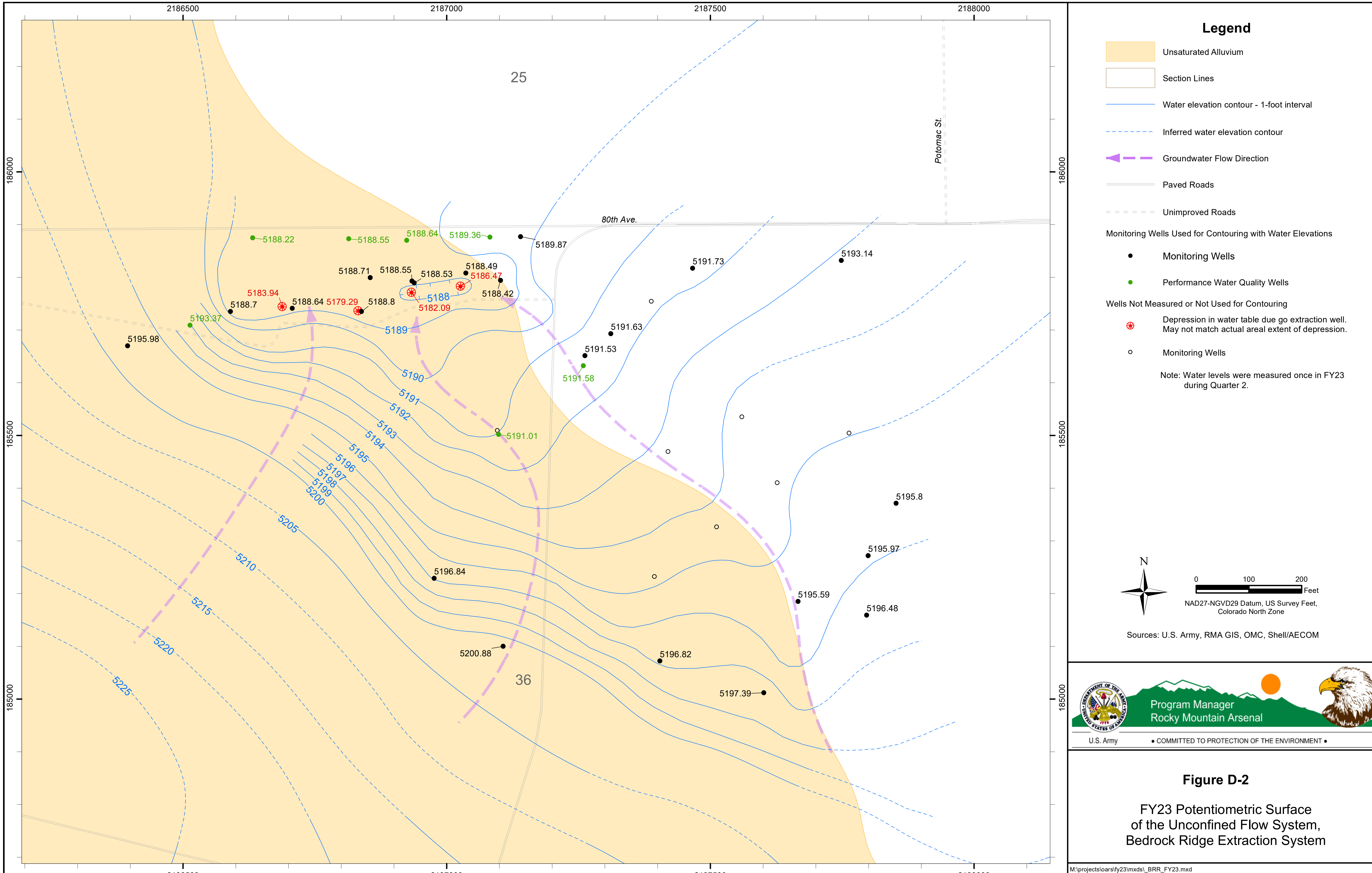


Figure D-2

FY23 Potentiometric Surface of the Unconfined Flow System, Bedrock Ridge Extraction System

Exhibit D-3. Summary of FY23 BRES Performance Water Quality Monitoring

Well ID	Sample Date	Analyte Concentration (ug/L, CSRG/PQL shown in italics)									
		111TCE	11DCE	12DCLB	12DCLE	13DCLB	14DCLB	C6H6	CCL4	CHCL3	CL6CP
		200	*7*	*600*	*0.4*	*94*	*75*	*5*	*0.3*	*6*	*50*
Upgradient Wells											
36250	9/7/23	LT 0.2	0.822	LT 0.2	**0.909**	LT 0.2	LT 0.2	LT 0.2	**0.362**	**15.5**	LT 0.00983
36565	11/3/22	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	—
	9/7/23	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.00983
36567	9/7/23	LT 4	**11.3**	LT 4	LT 4	LT 4	LT 4	LT 4	LT 4	**82.2**	LT 0.00983
36575	9/7/23	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.00983
Downgradient Wells											
36555	9/6/23	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.00983
36566	9/6/23	LT 0.2	1.69	LT 0.2	**0.682**	LT 0.2	LT 0.2	LT 0.2	0.229	**19.2**	LT 0.00983
36571	9/6/23	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.00983
36572	9/6/23	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	LT 0.2	1.39	LT 0.00983

Notes:

Values shaded and in BOLD are concentrations that exceed the CSRG/PQL.

[1] The value for 1,2-dichloroethylene (12DCE) is the sum of its two isomers, cis-1,2-dichloroethylene (C12DCE) and trans-1,2-dichloroethylene (T12DCE).

LT – Nondetection reported less than the method reporting limit

Exhibit D-3. Summary of FY23 BRES Performance Water Quality Monitoring

Well ID	Sample Date	Analyte Concentration (ug/L, CSRG/PQL shown in italics)								
		CLC6H5	CPMS	CPMSO	CPMSO2	DCPD	DIMP	DITH	DLDRN	ENDRN
		100	*30*	*36*	*36*	*46*	*8*	*18*	*0.013*	*2*
Upgradient Wells										
36250	9/7/23	LT 0.2	LT 1.2	LT 1.6	LT 1.2	LT 0.2	**22.3**	LT 0.4	0.00332	LT 0.00488
36565	11/3/22	LT 0.2	—	—	—	LT 0.2	LT 0.5	—	—	—
	9/7/23	LT 0.2	LT 1.2	LT 1.6	LT 1.2	LT 0.2	LT 0.5	LT 0.4	**0.0295**	0.0405
36567	9/7/23	LT 4	LT 1.2	LT 1.6	LT 1.2	LT 4	**36.8**	LT 0.4	**0.0367**	LT 0.00488
36575	9/7/23	LT 0.2	LT 1.2	LT 1.6	LT 1.2	LT 0.2	LT 0.5	LT 0.4	LT 0.00252	LT 0.00488
Downgradient Wells										
36555	9/6/23	LT 0.2	LT 1.2	LT 1.6	LT 1.2	LT 0.2	LT 0.5	LT 0.4	LT 0.00252	LT 0.00488
36566	9/6/23	LT 0.2	LT 1.2	LT 1.6	LT 1.2	LT 0.2	**18.5**	LT 0.4	0.00553	LT 0.00488
36571	9/6/23	LT 0.2	LT 1.2	LT 1.6	LT 1.2	LT 0.2	LT 0.5	LT 0.4	LT 0.00252	LT 0.00488
36572	9/6/23	LT 0.2	LT 1.2	LT 1.6	LT 1.2	LT 0.2	LT 0.5	LT 0.4	LT 0.00252	LT 0.00488

Notes:

Values shaded and in BOLD are concentrations that exceed the CSRG/PQL.

[1] The value for 1,2-dichloroethylene (12DCE) is the sum of its two isomers, cis-1,2-dichloroethylene (C12DCE) and trans-1,2-dichloroethylene (T12DCE).

LT – Nondetection reported less than the method reporting limit

Exhibit D-3. Summary of FY23 BRES Performance Water Quality Monitoring

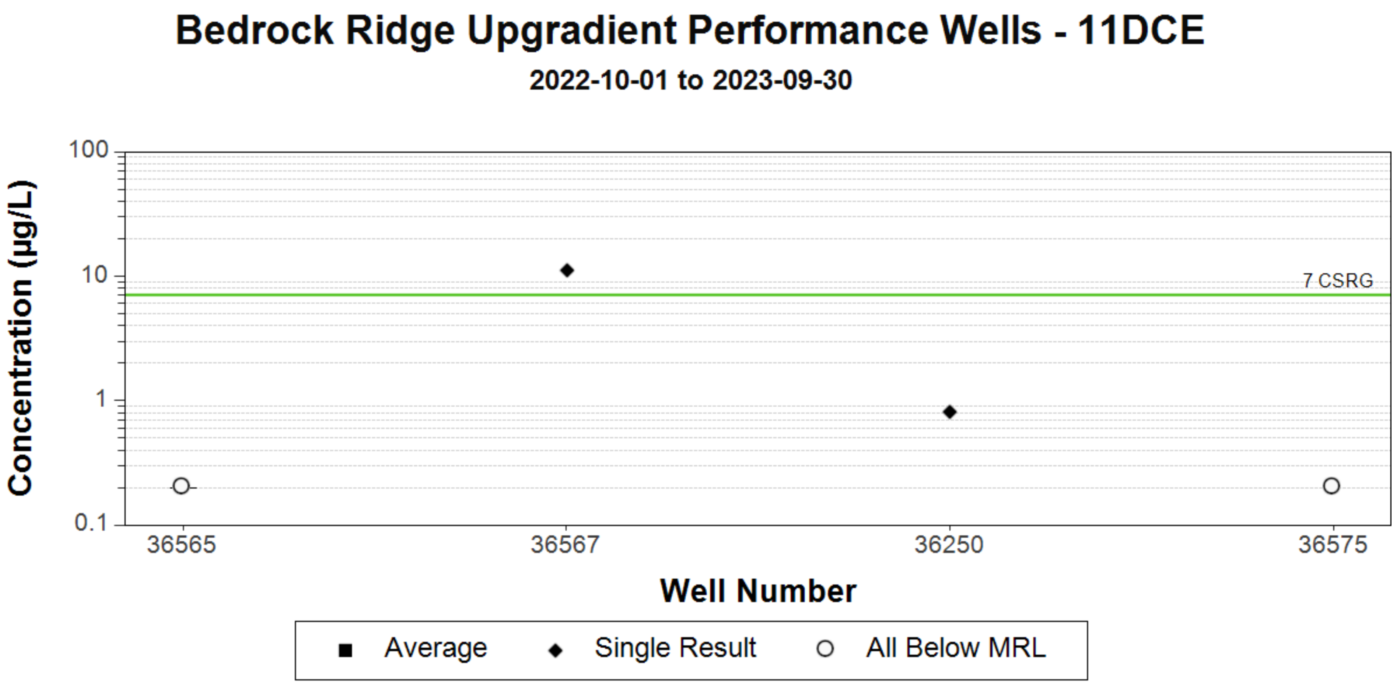
Well ID	Sample Date		Analyte Concentration (ug/L, CSRG/PQL shown in italics)						
		OXAT	PPDDT	TCLEA	TCLEE	TRCLE	12DCE [1]	C12DCE	T12DCE
		160	*0.1*	*0.18*	*5*	*5*	*70*	—	—
Upgradient Wells									
36250	9/7/23	LT 0.8	LT 0.00247	LT 0.1	**344**	**11.5**	ND	0.306	LT 0.2
36565	11/3/22	—	—	LT 0.1	LT 0.2	LT 0.2	ND	LT 0.2	LT 0.2
	9/7/23	LT 0.8	LT 0.00247	LT 0.1	LT 0.2	LT 0.2	ND	LT 0.2	LT 0.2
36567	9/7/23	LT 0.8	LT 0.00247	LT 2	**360**	**130**	ND	LT 4	LT 4
36575	9/7/23	LT 0.8	LT 0.00247	LT 0.1	1.54	LT 0.2	ND	LT 0.2	LT 0.2
Downgradient Wells									
36555	9/6/23	LT 0.8	LT 0.00247	LT 0.1	LT 0.2	LT 0.2	ND	LT 0.2	LT 0.2
36566	9/6/23	LT 0.8	LT 0.00247	LT 0.1	**72.3**	**23**	0.298	0.388	0.208
36571	9/6/23	LT 0.8	LT 0.00247	LT 0.1	0.5	LT 0.2	ND	LT 0.2	LT 0.2
36572	9/6/23	LT 0.8	LT 0.00247	LT 0.1	0.642	LT 0.2	ND	LT 0.2	LT 0.2

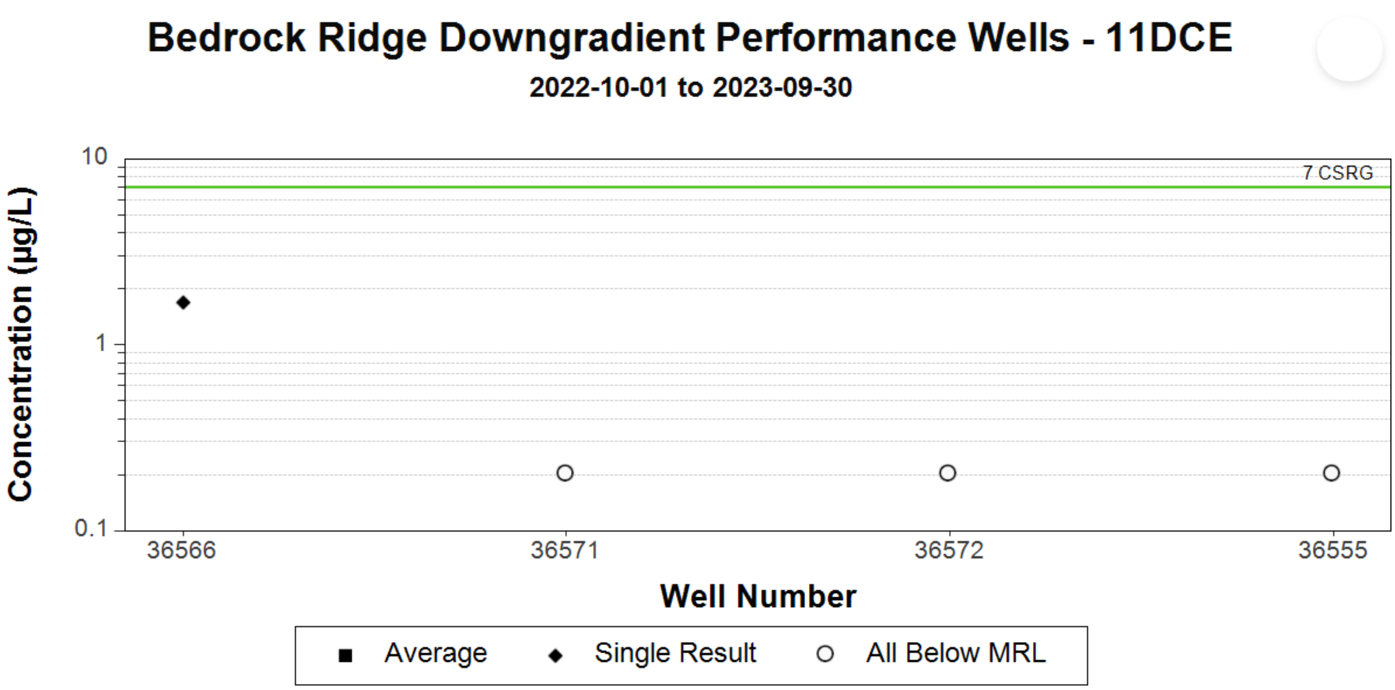
Notes:

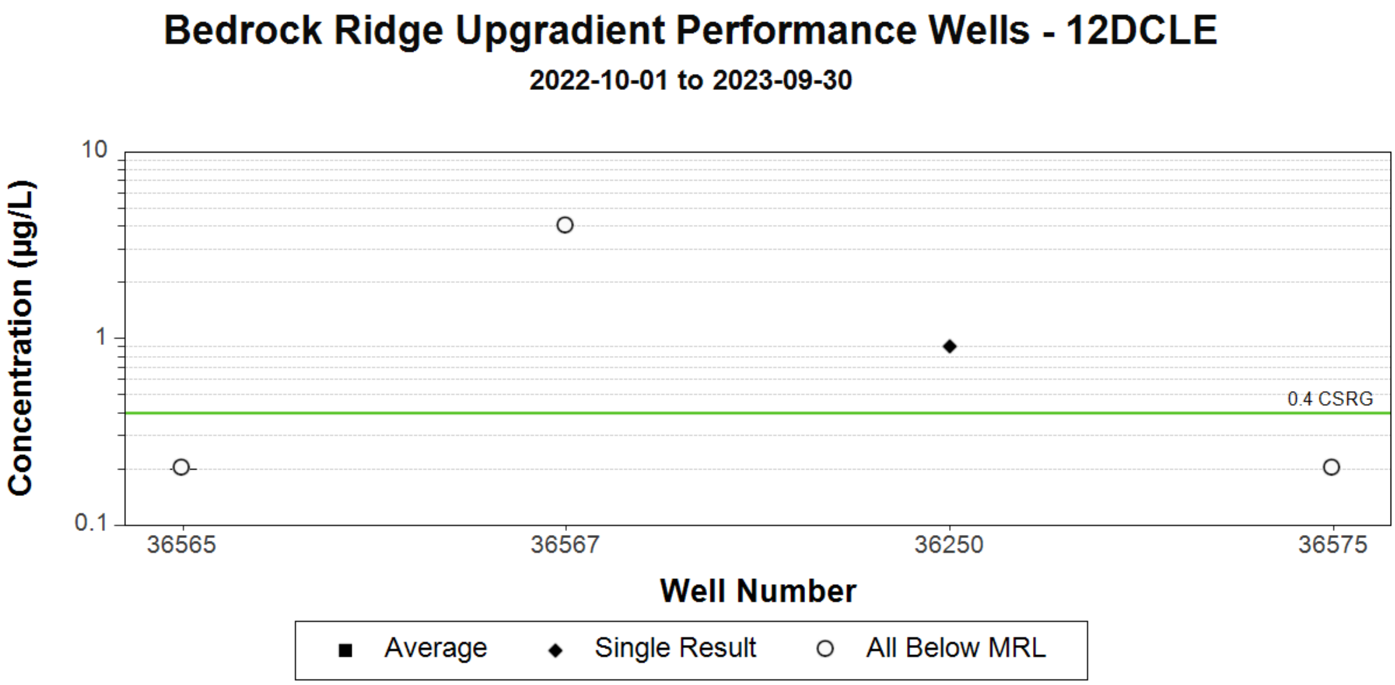
Values shaded and in BOLD are concentrations that exceed the CSRG/PQL.

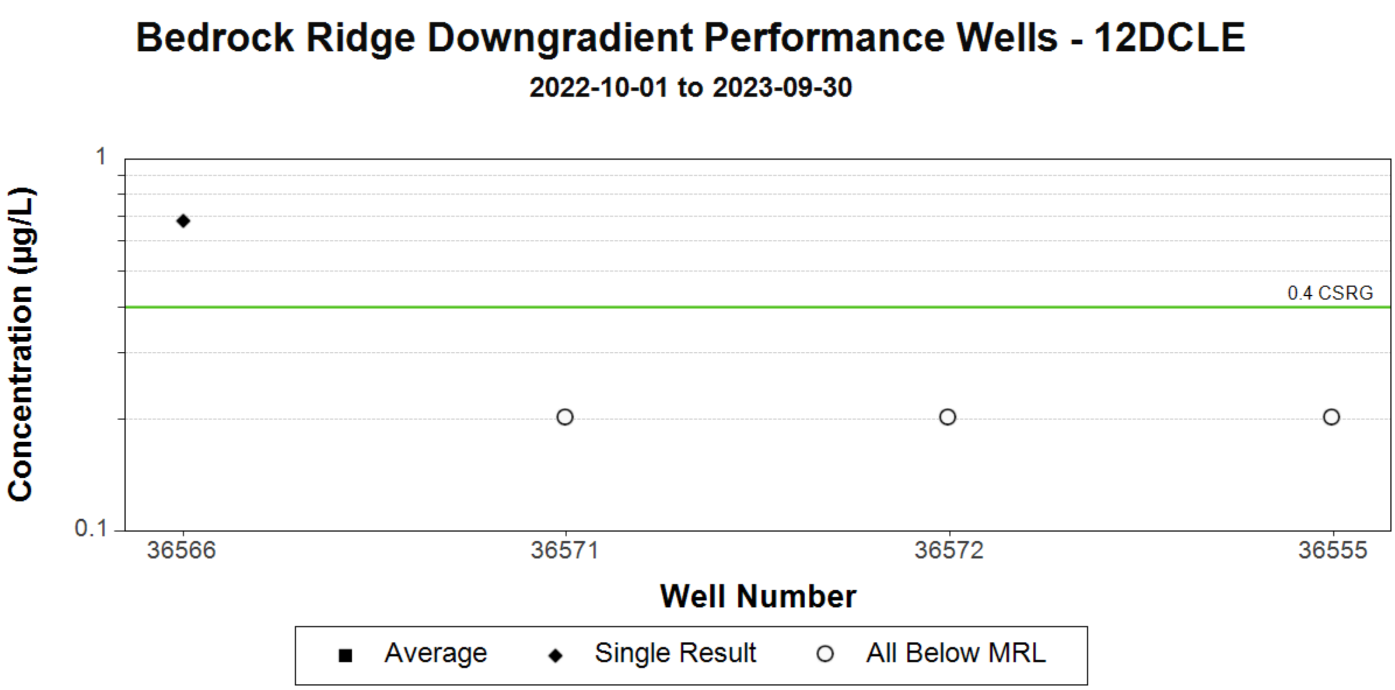
[1] The value for 1,2-dichloroethylene (12DCE) is the sum of its two isomers, cis-1,2-dichloroethylene (C12DCE) and trans-1,2-dichloroethylene (T12DCE).

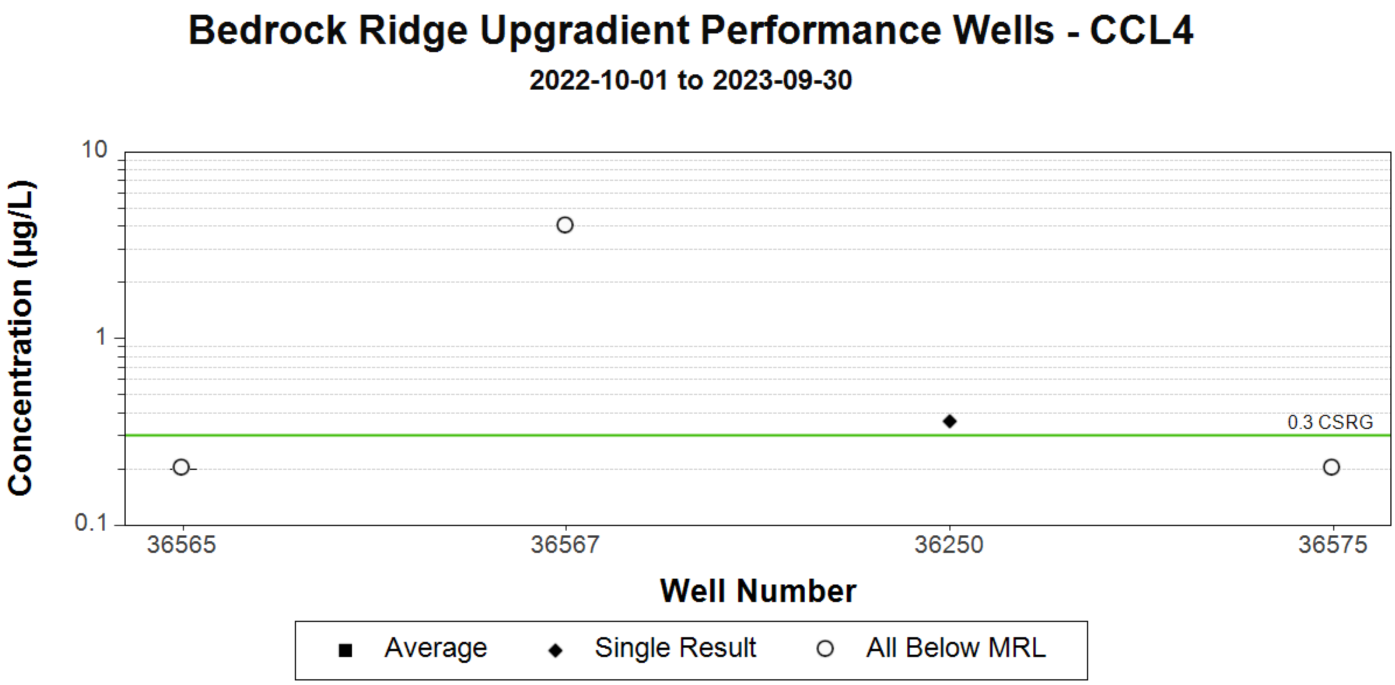
LT – Nondetection reported less than the method reporting limit


Bedrock Ridge Upgradient Performance Wells - 11DCE
2022-10-01 to 2023-09-30
Concentration (µg/L)
100
10
1
0.1
7 CSRG
36565
36567
36250
36575
Well Number
Average
Single Result
All Below MRL

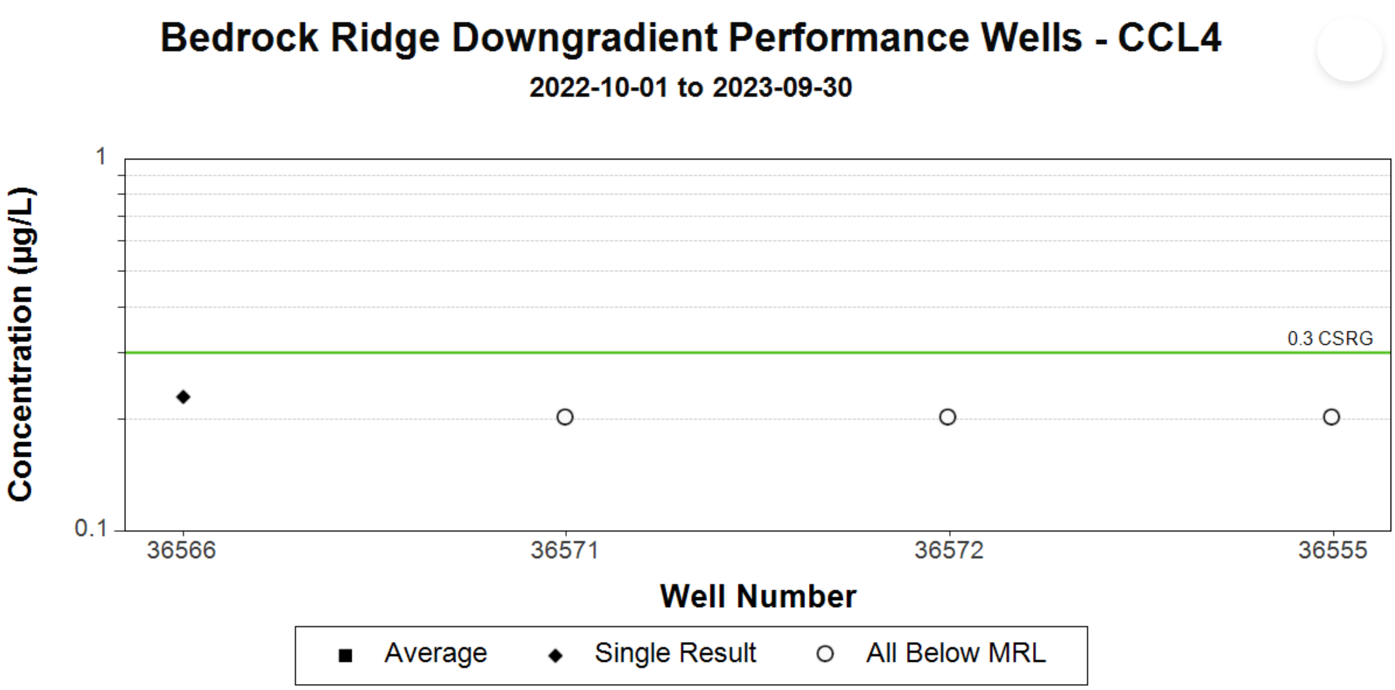

Bedrock Ridge Downgradient Performance Wells - 11DCE
2022-10-01 to 2023-09-30
Concentration (µg/L)
10
1
0.1
7 CSRG
36566
36571
36572
36555
Well Number
Average
Single Result
All Below MRL


Bedrock Ridge Upgradient Performance Wells - 12DCLE
2022-10-01 to 2023-09-30
Concentration (µg/L)
10
1
0.1
0.4 CSRG
36565
36567
36250
36575
Well Number
Average
Single Result
All Below MRL


Bedrock Ridge Downgradient Performance Wells - 12DCLE
2022-10-01 to 2023-09-30
Concentration (µg/L)
1
0.1
0.4 CSRG
36566
36571
36572
36555
Well Number
Average
Single Result
All Below MRL



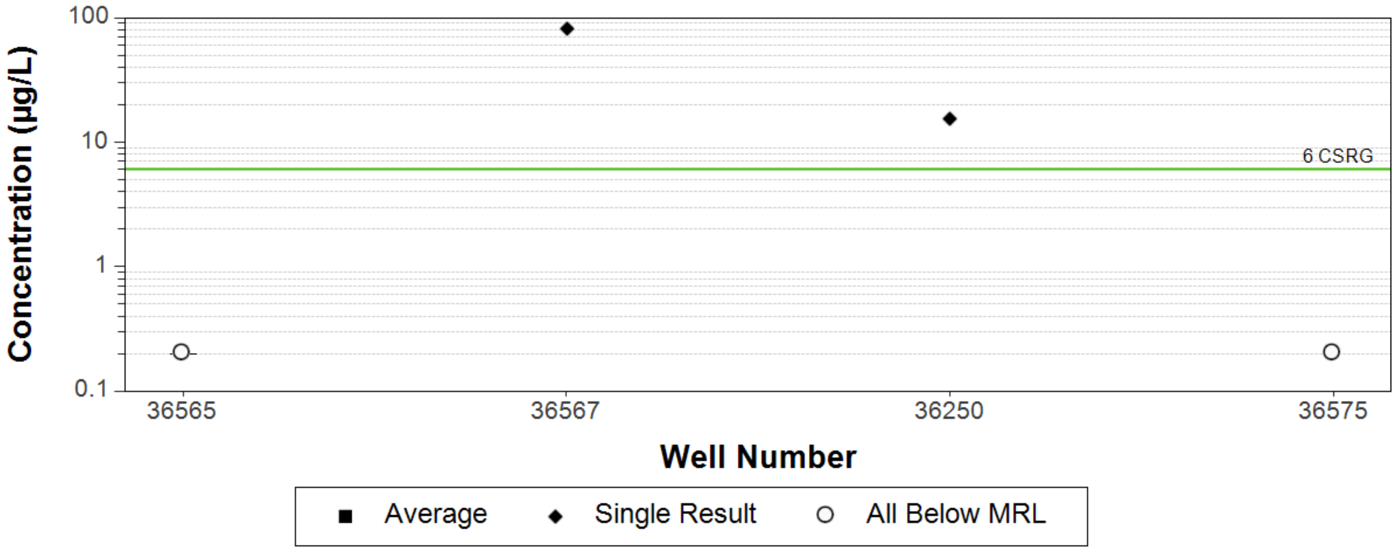
Bedrock Ridge Upgradient Performance Wells - CCL4
2022-10-01 to 2023-09-30
Concentration (µg/L)
10
1
0.1
0.3 CSRG
36565
36567
36250
36575
Well Number
Average
Single Result
All Below MRL



Bedrock Ridge Downgradient Performance Wells - CCL4
2022-10-01 to 2023-09-30
Concentration (µg/L)
1
0.1
0.3 CSRG
36566
36571
36572
36555
Well Number
Average
Single Result
All Below MRL

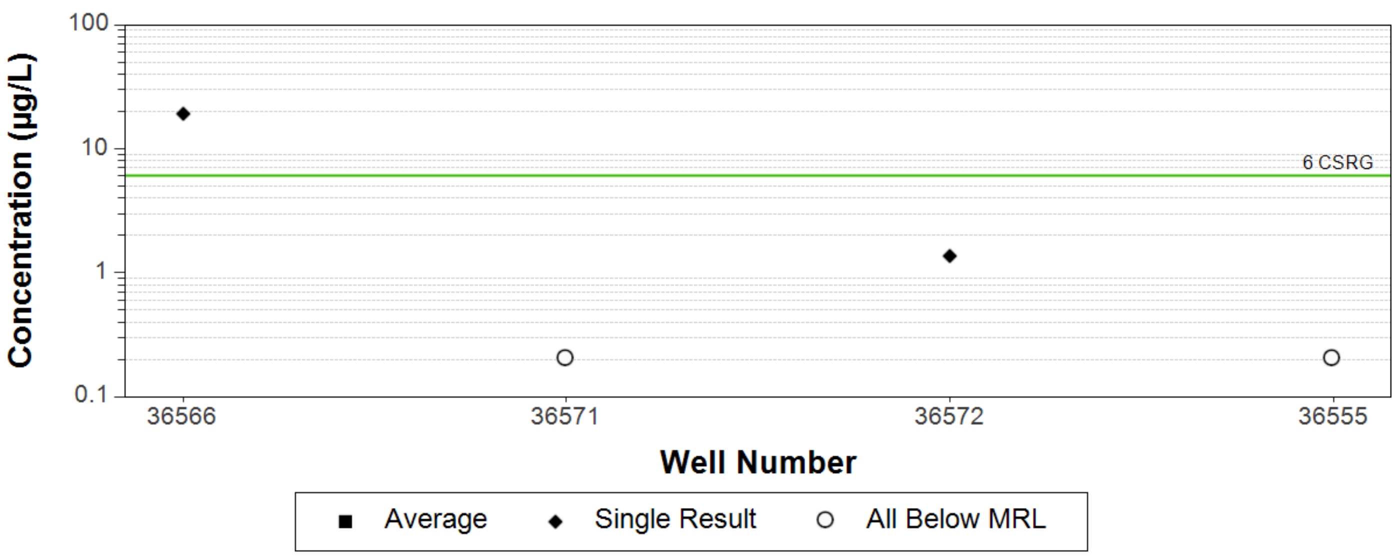
Bedrock Ridge Upgradient Performance Wells - CHCL3

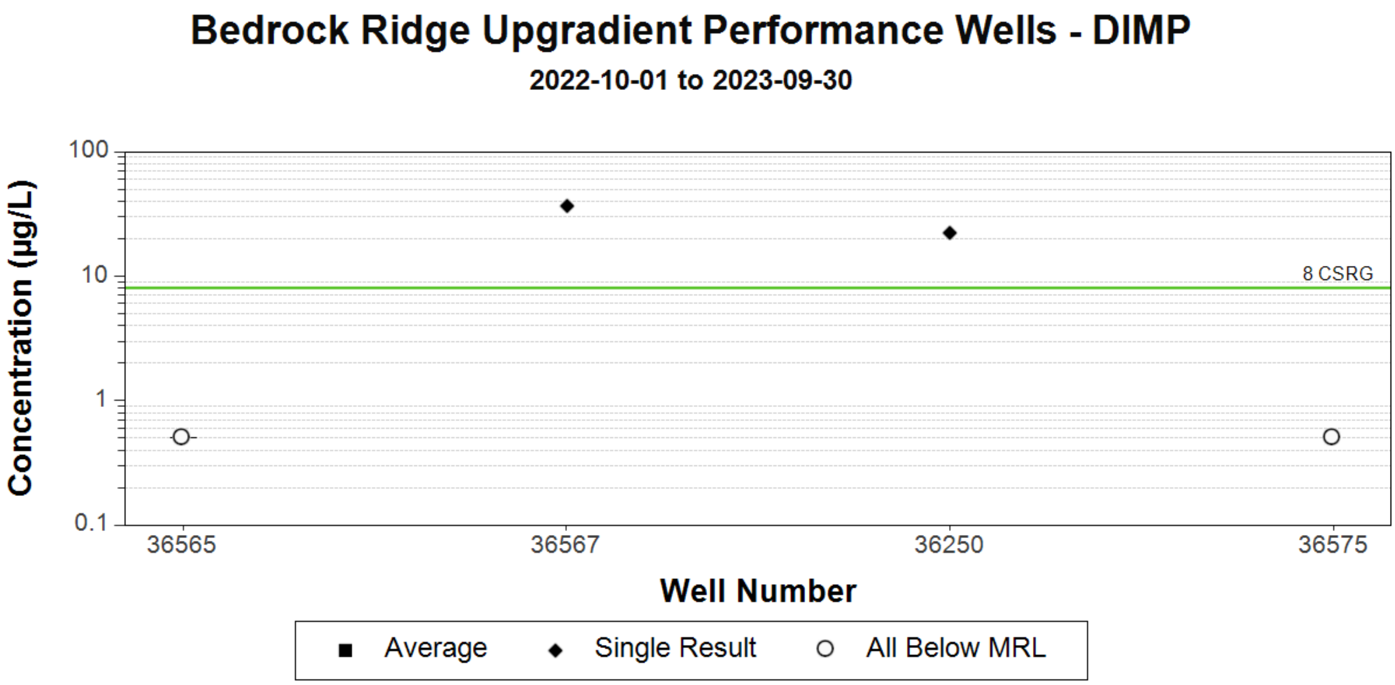
2022-10-01 to 2023-09-30

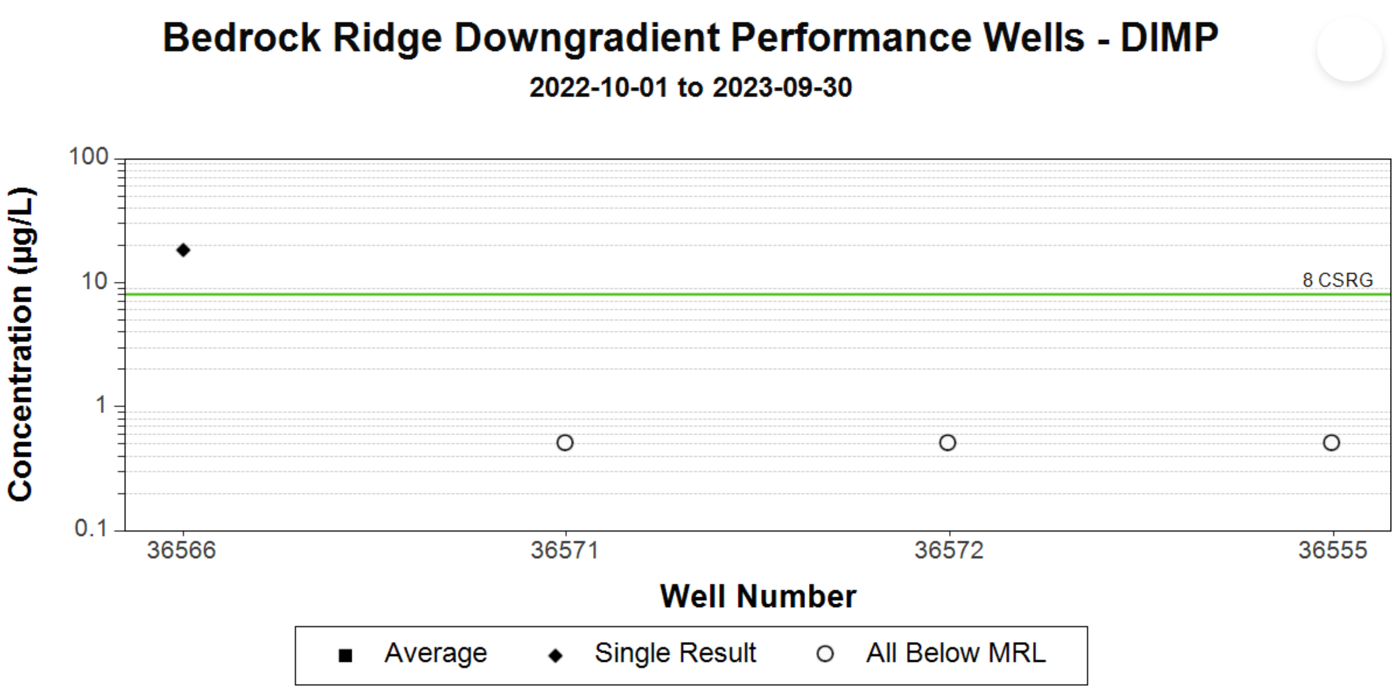


Bedrock Ridge Downgradient Performance Wells - CHCL3

2022-10-01 to 2023-09-30

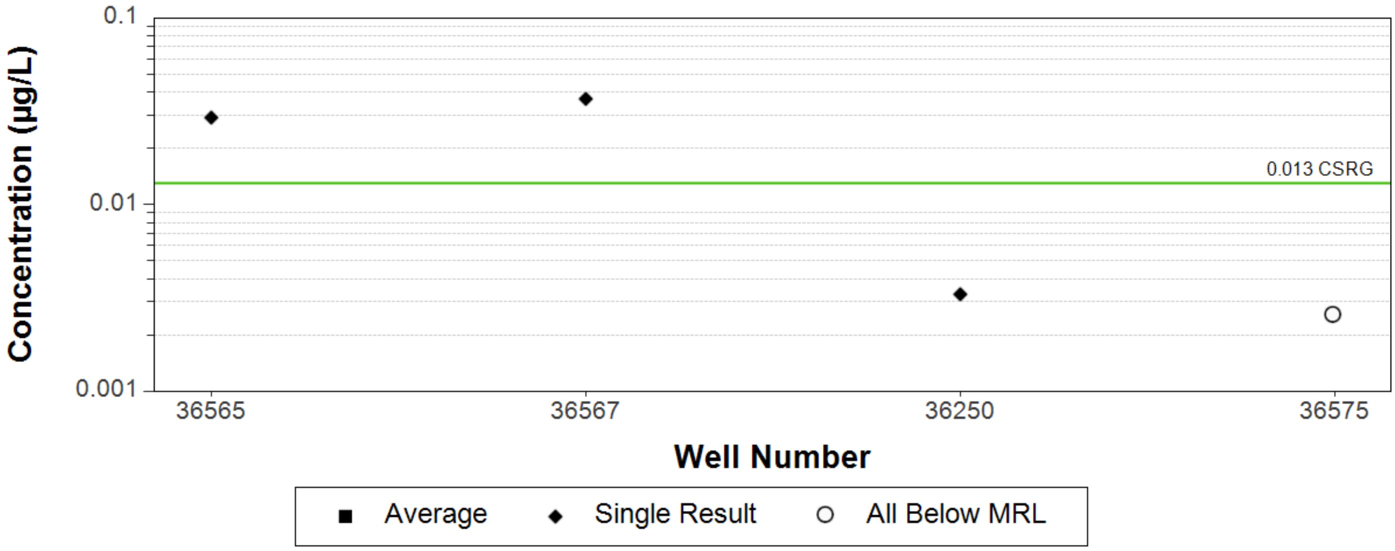



Bedrock Ridge Upgradient Performance Wells - DIMP
2022-10-01 to 2023-09-30
Concentration (µg/L)
100
10
1
0.1
8 CSRG
36565
36567
36250
36575
Well Number
Average
Single Result
All Below MRL


Bedrock Ridge Downgradient Performance Wells - DIMP
2022-10-01 to 2023-09-30
Concentration (µg/L)
100
10
1
0.1
8 CSRG
36566
36571
36572
36555
Well Number
Average
Single Result
All Below MRL

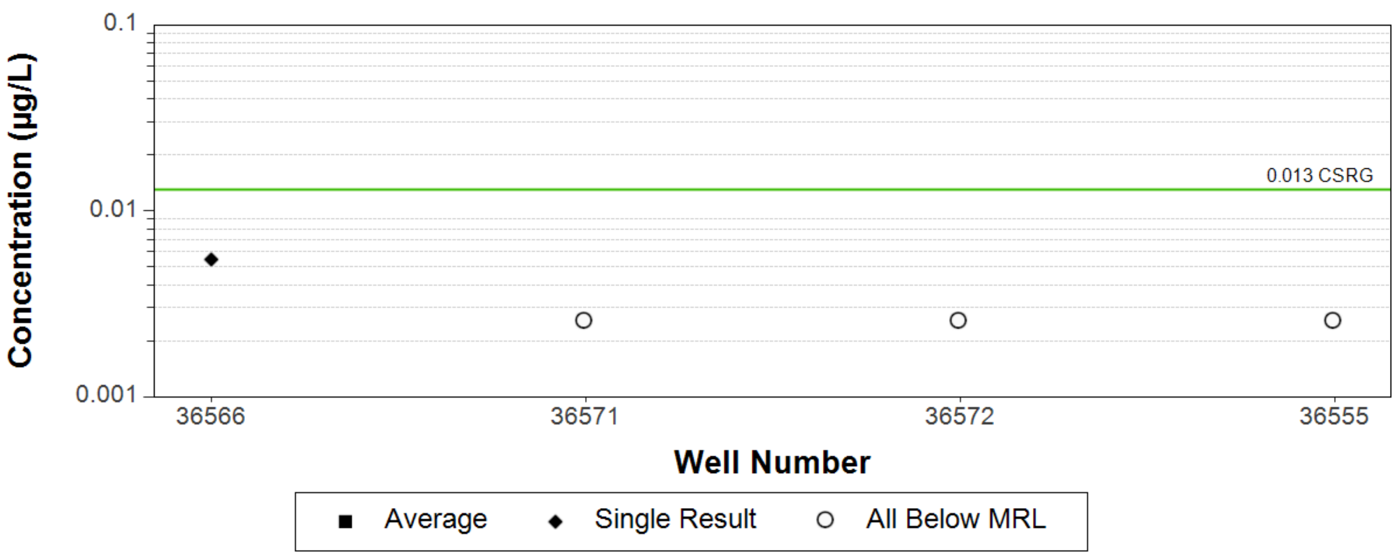
Bedrock Ridge Upgradient Performance Wells - DLDRN

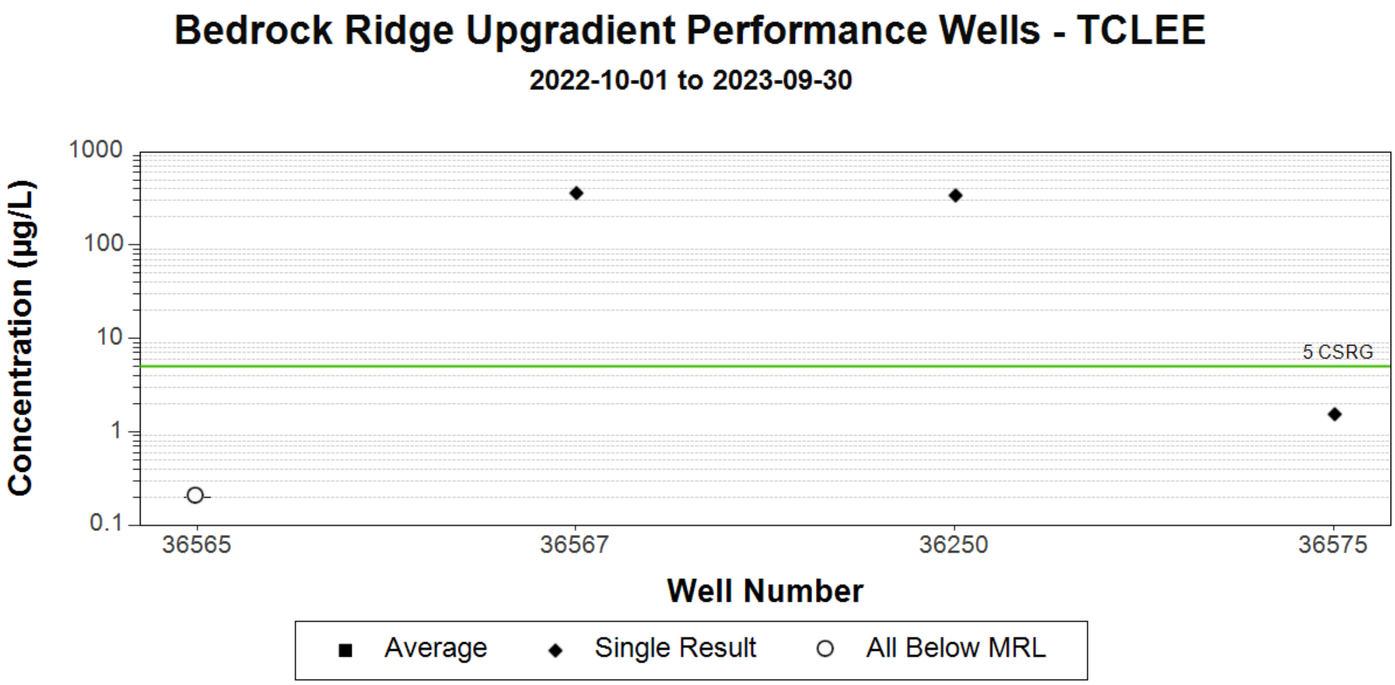
2022-10-01 to 2023-09-30

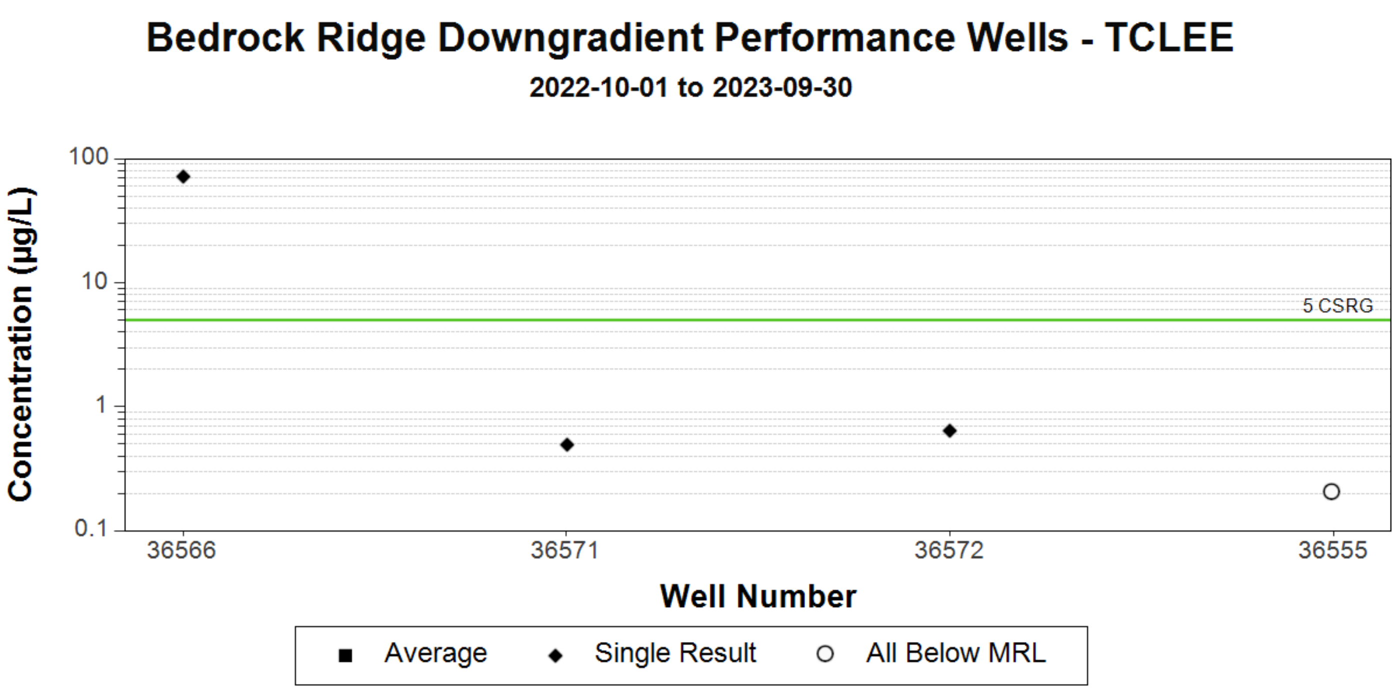


Bedrock Ridge Downgradient Performance Wells - DLDRN

2022-10-01 to 2023-09-30

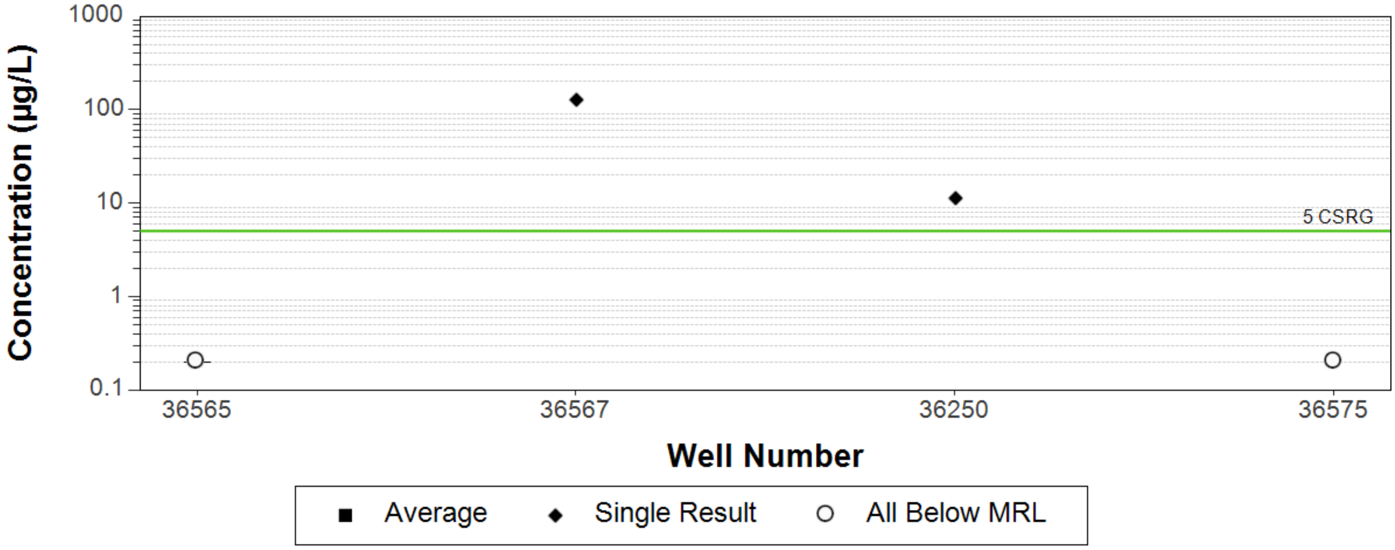



Bedrock Ridge Upgradient Performance Wells - TCLEE
2022-10-01 to 2023-09-30
Concentration (µg/L)
1000
100
10
1
0.1
5 CSRG
36565
36567
36250
36575
Well Number
Average
Single Result
All Below MRL


Bedrock Ridge Downgradient Performance Wells - TCLEE
2022-10-01 to 2023-09-30
Concentration (µg/L)
100
10
1
0.1
5 CSRG
36566
36571
36572
36555
Well Number
Average
Single Result
All Below MRL

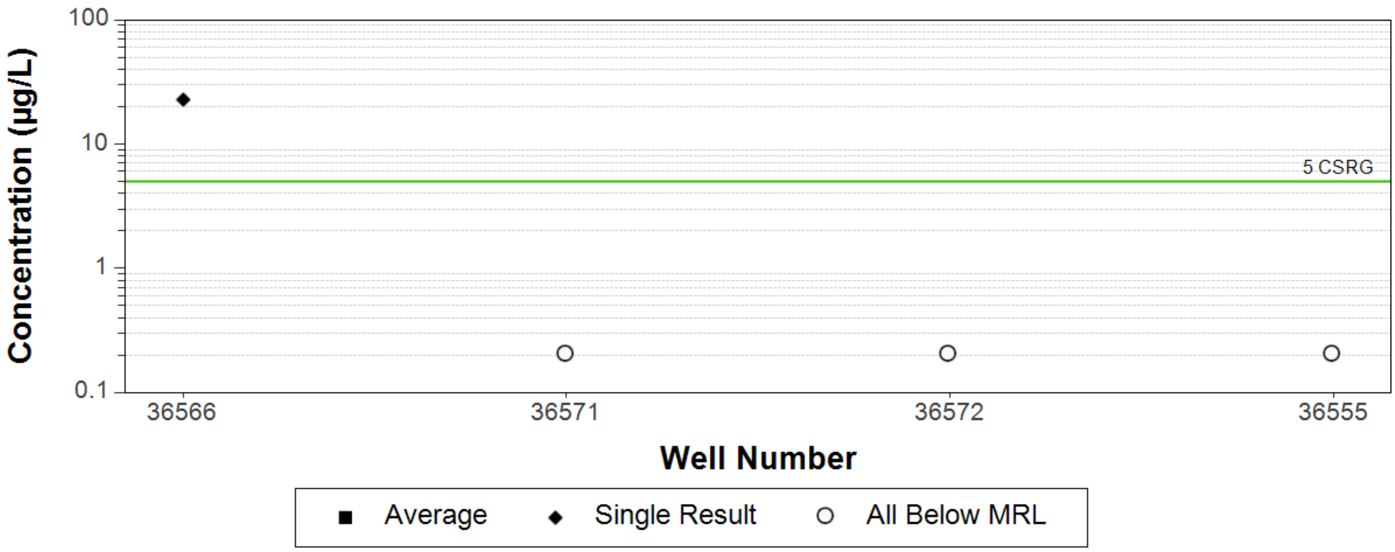
Bedrock Ridge Upgradient Performance Wells - TRCLE

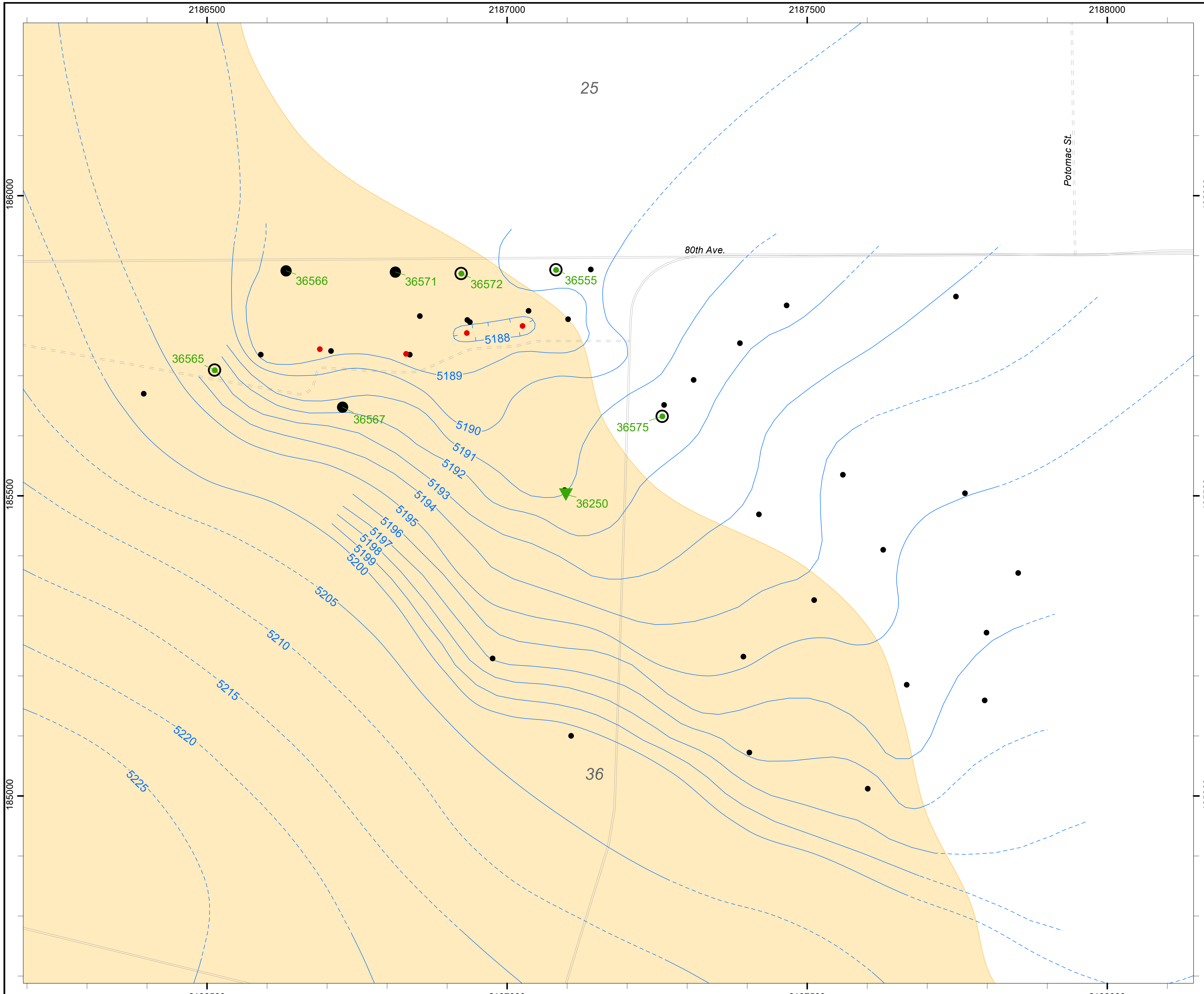
2022-10-01 to 2023-09-30



Bedrock Ridge Downgradient Performance Wells - TRCLE

2022-10-01 to 2023-09-30





Legend

- Unsaturated Alluvium
- Section Lines
- Water elevation contour - 1-foot interval
- Inferred water elevation contour
- Paved Roads
- Unimproved Roads
- Monitoring Wells
- Performance Water Quality Wells
- Extraction Wells

Note: Water levels were measured once in FY23 during Quarter 2.

Upgradient and Downgradient Performance Well Water Quality

- Analyte Detected Above the CSRG - Increasing Trend Noted
- Analyte Detected Above the CSRG - Decreasing Trend Noted
- Analyte Detected - Showing Stable or No Discernible Trend
- Analyte Not Detected

Notes:
1. Trends are depicted for the 10 year period FY14 - FY23.
2. Time versus concentration charts for Performance Water Quality wells are presented following this map.

N

0 100 200 Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

Program Manager Rocky Mountain Arsenal

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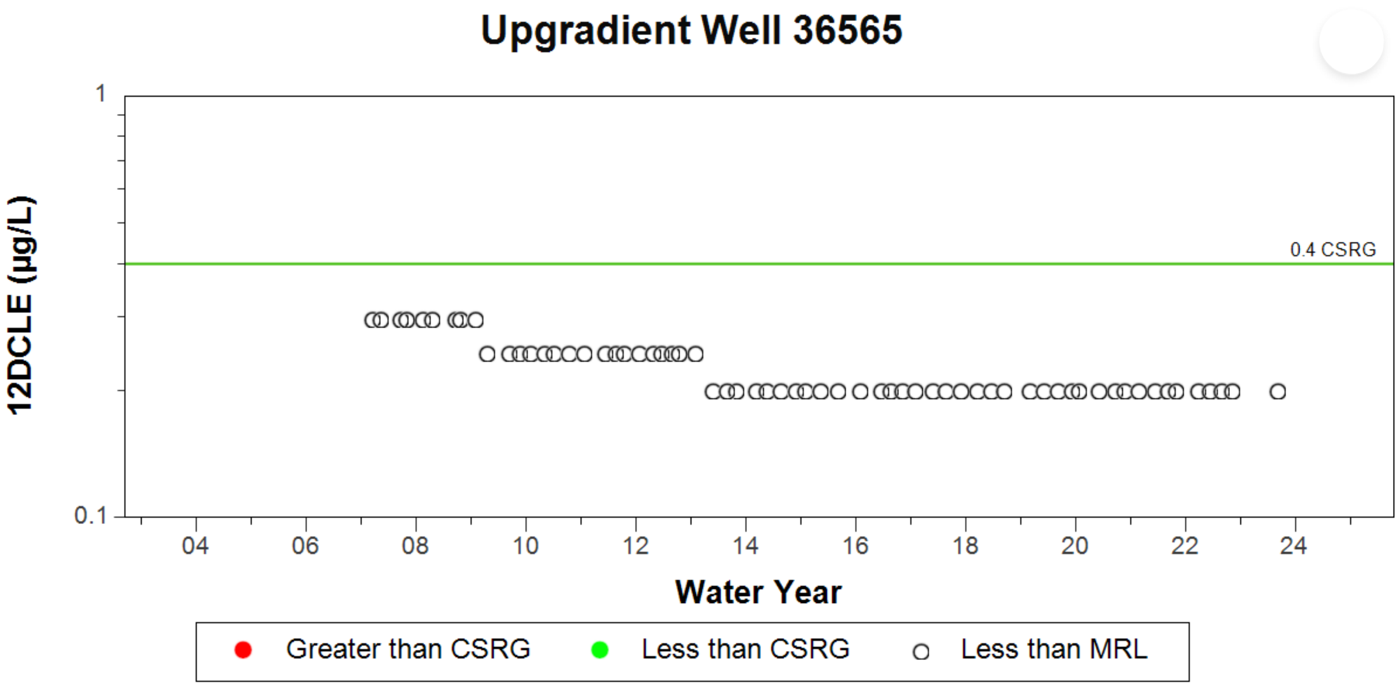
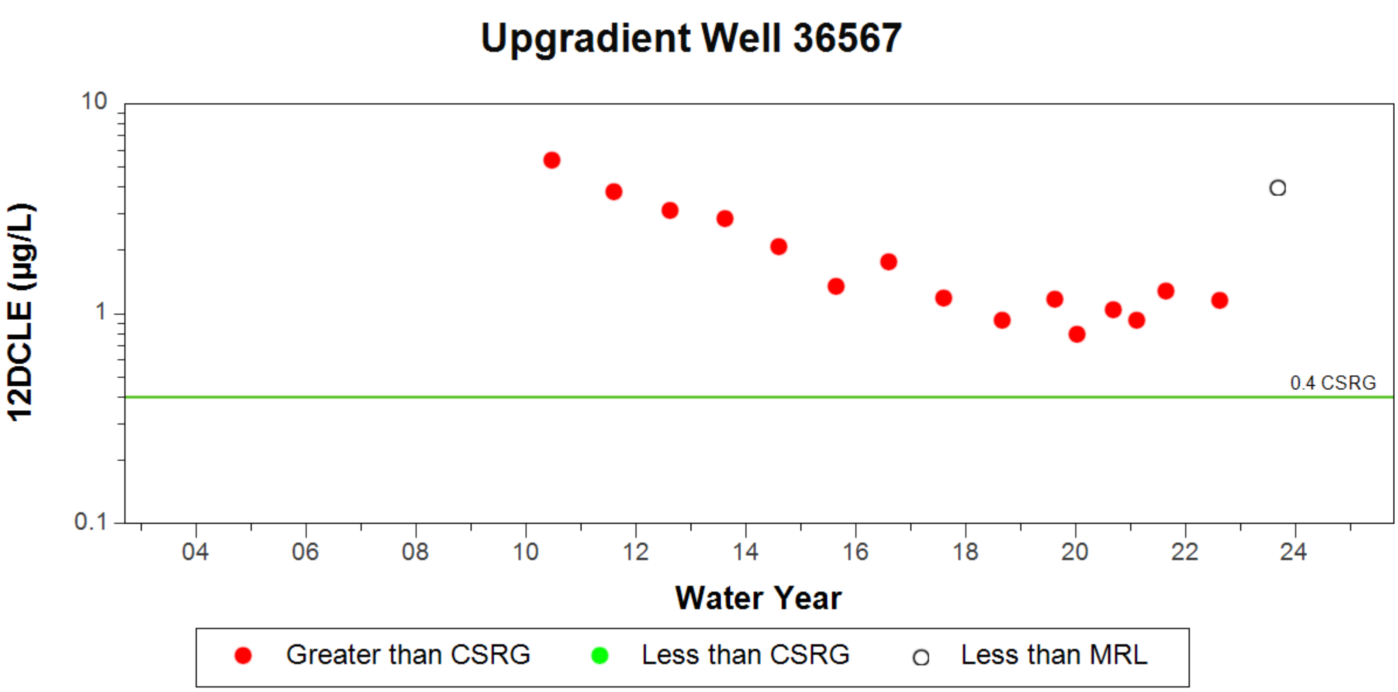
Figure D-12

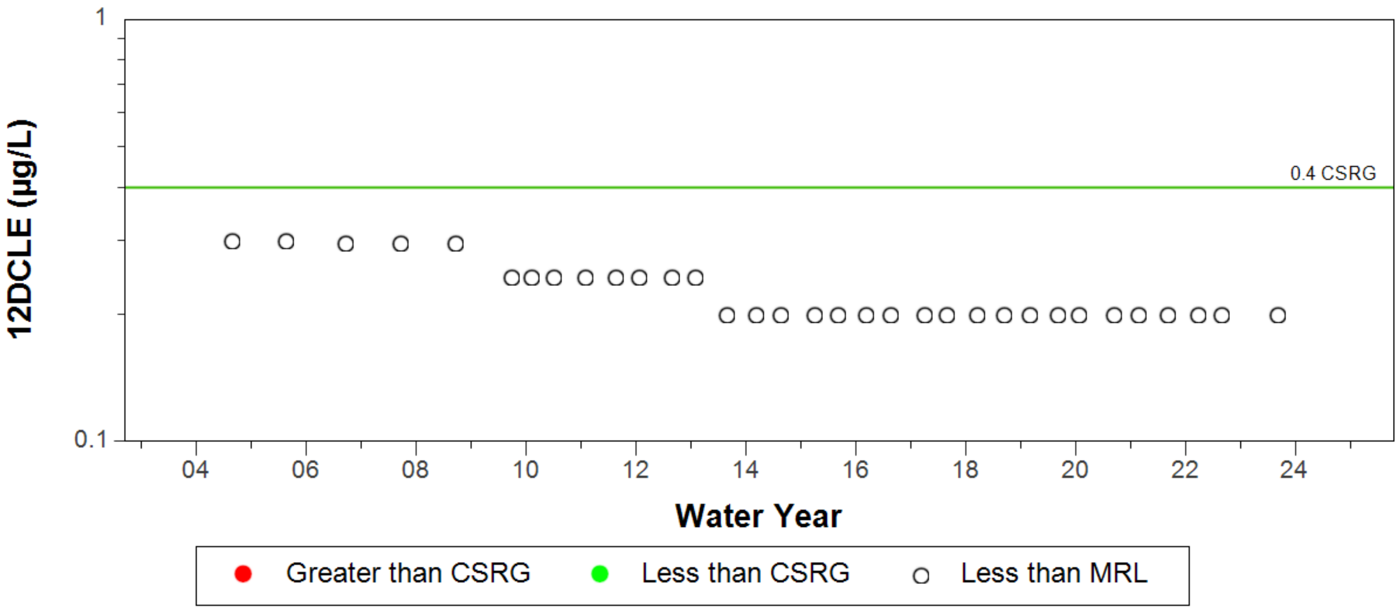
1,2-Dichloroethane Concentration Trends in Performance Wells, Bedrock Ridge Extraction System

M:\projects\oars\fy23\mxds_BRR_FY23_12DCLE.mxd
6/25/2024

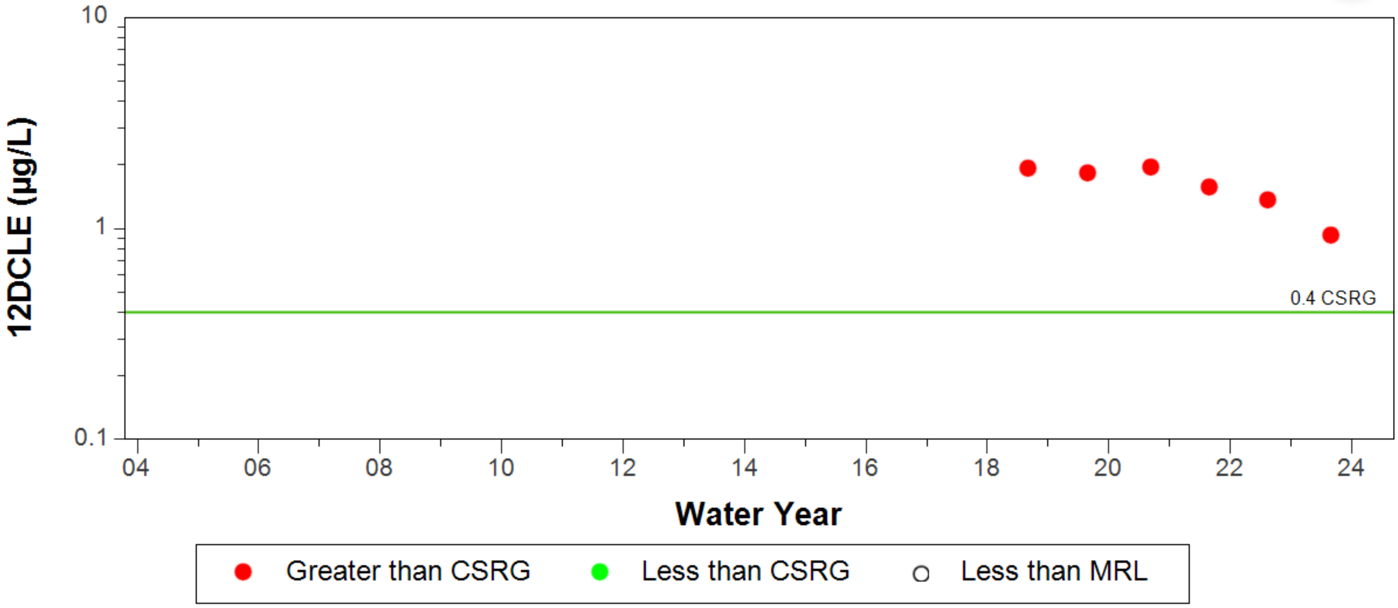

Upgradient Well 36565
12DCLE (µg/L)
1
0.1
0.4 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL


Upgradient Well 36567
12DCLE (µg/L)
10
1
0.1
0.4 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

Upgradient Well 36575

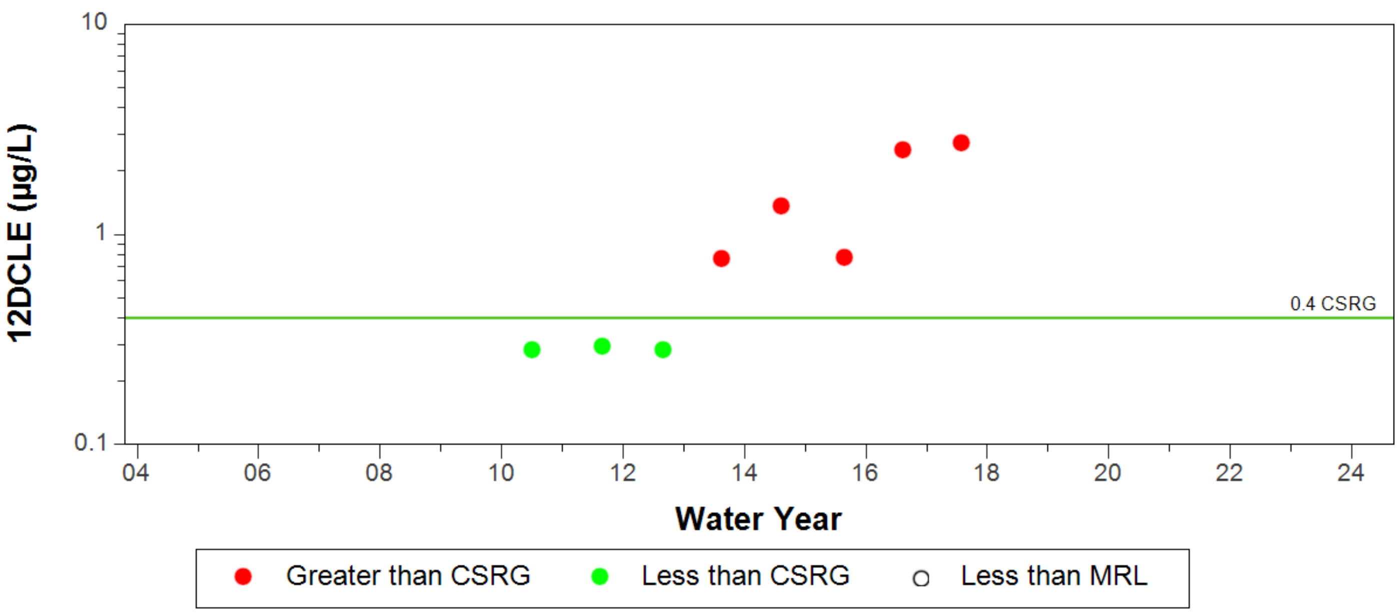


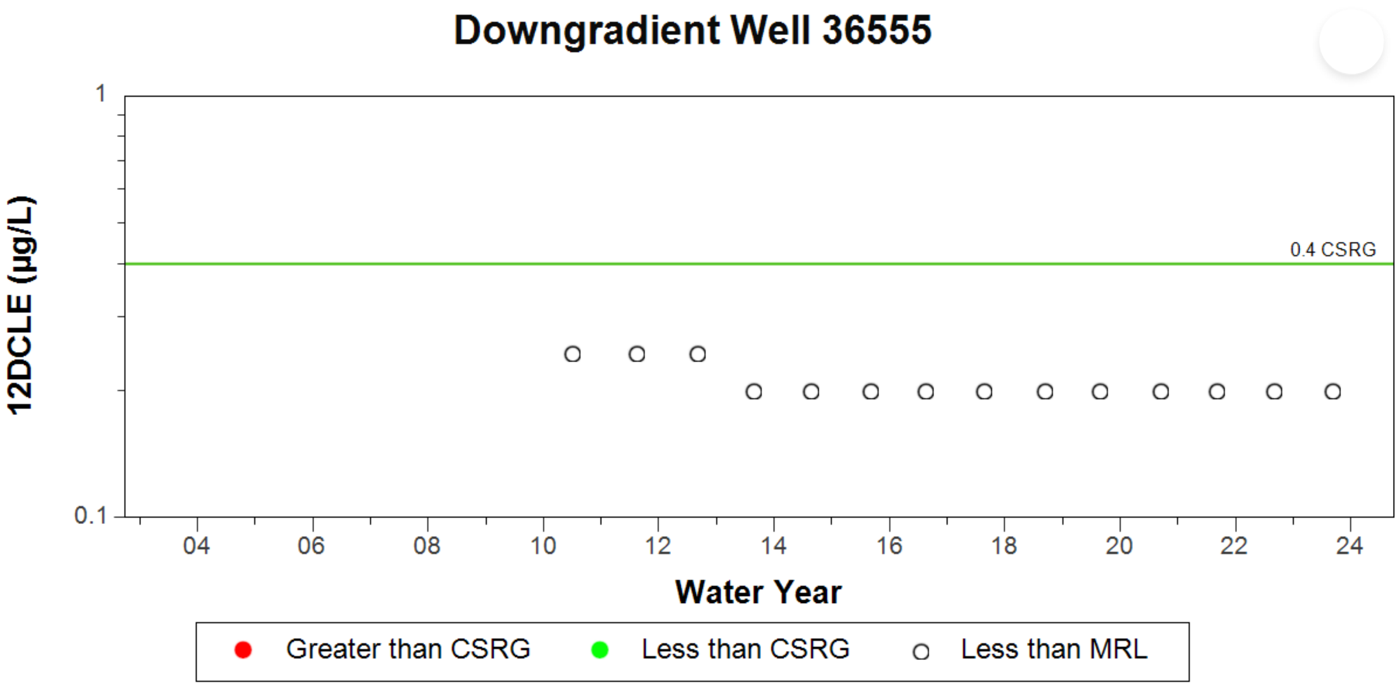
Upgradient Well 36250

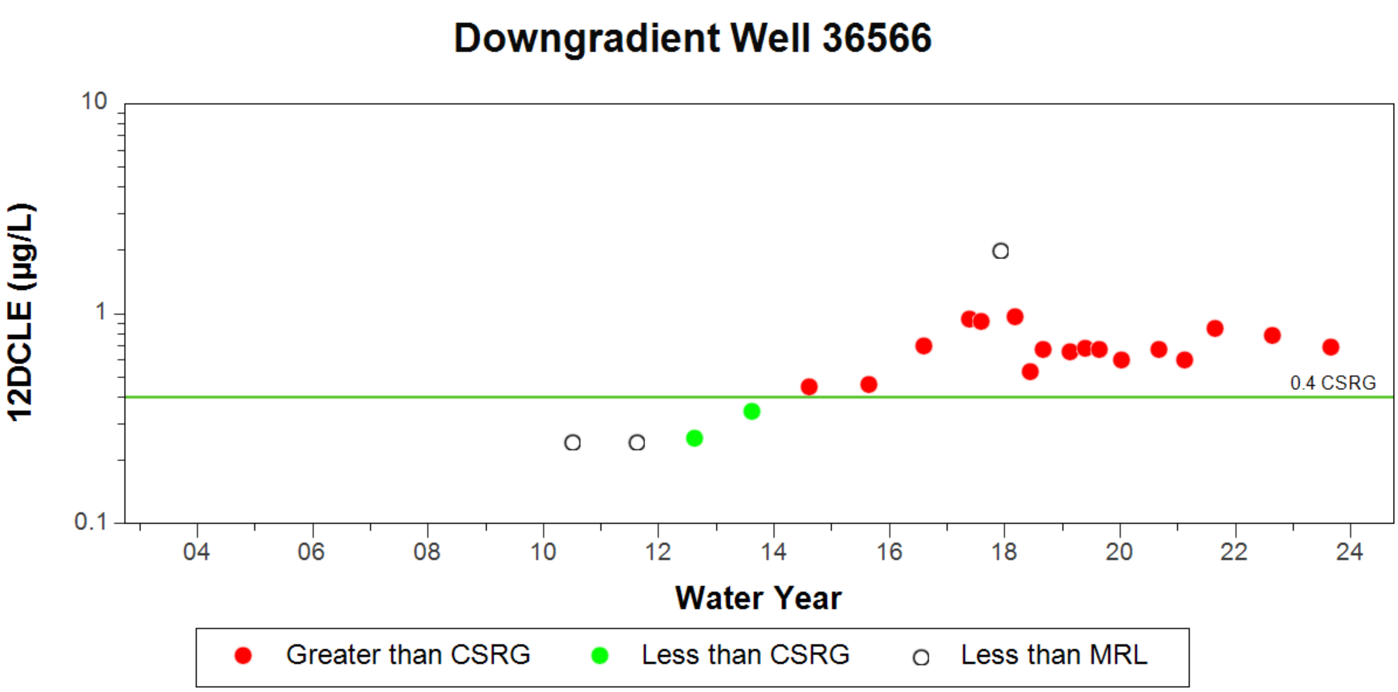


Well 36250 replaced well 36578.

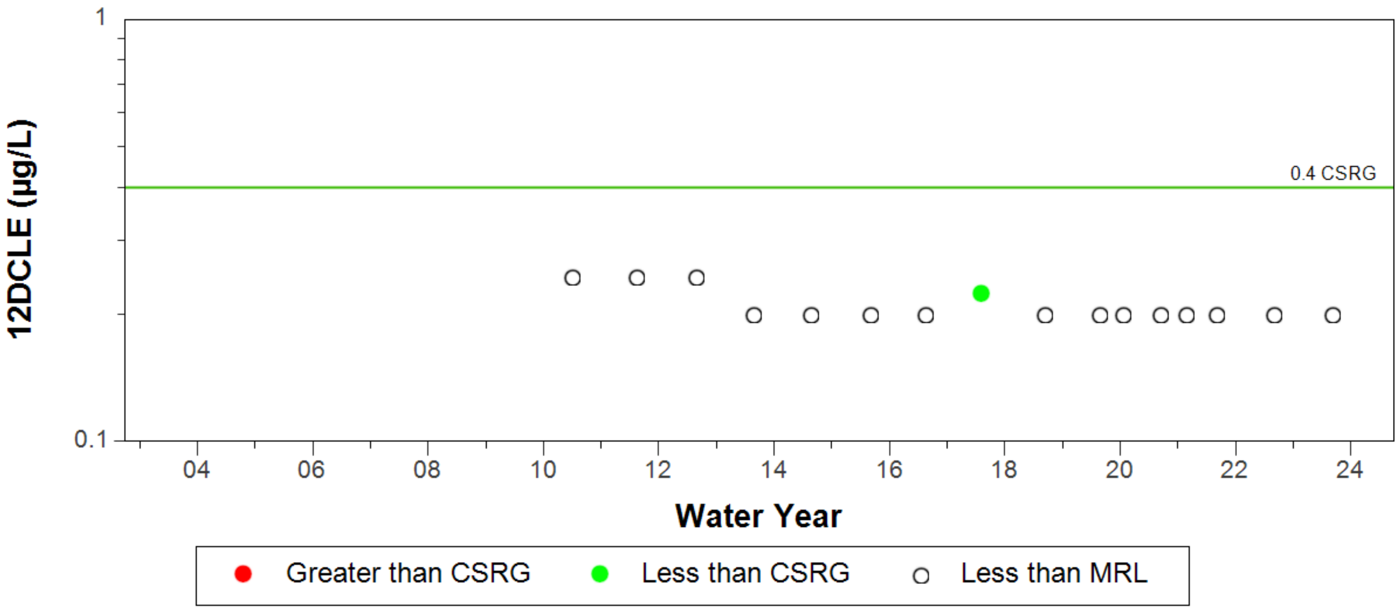
Upgradient Well 36578



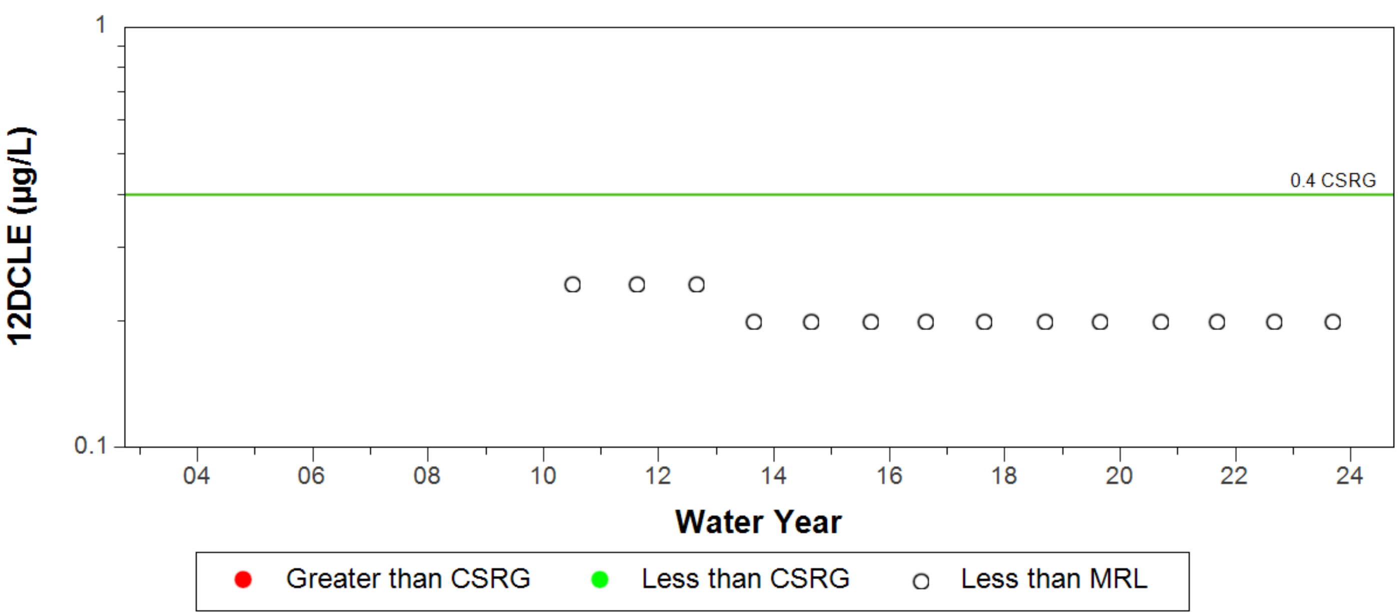

Downgradient Well 36555
12DCLE (µg/L)
1
0.1
0.4 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

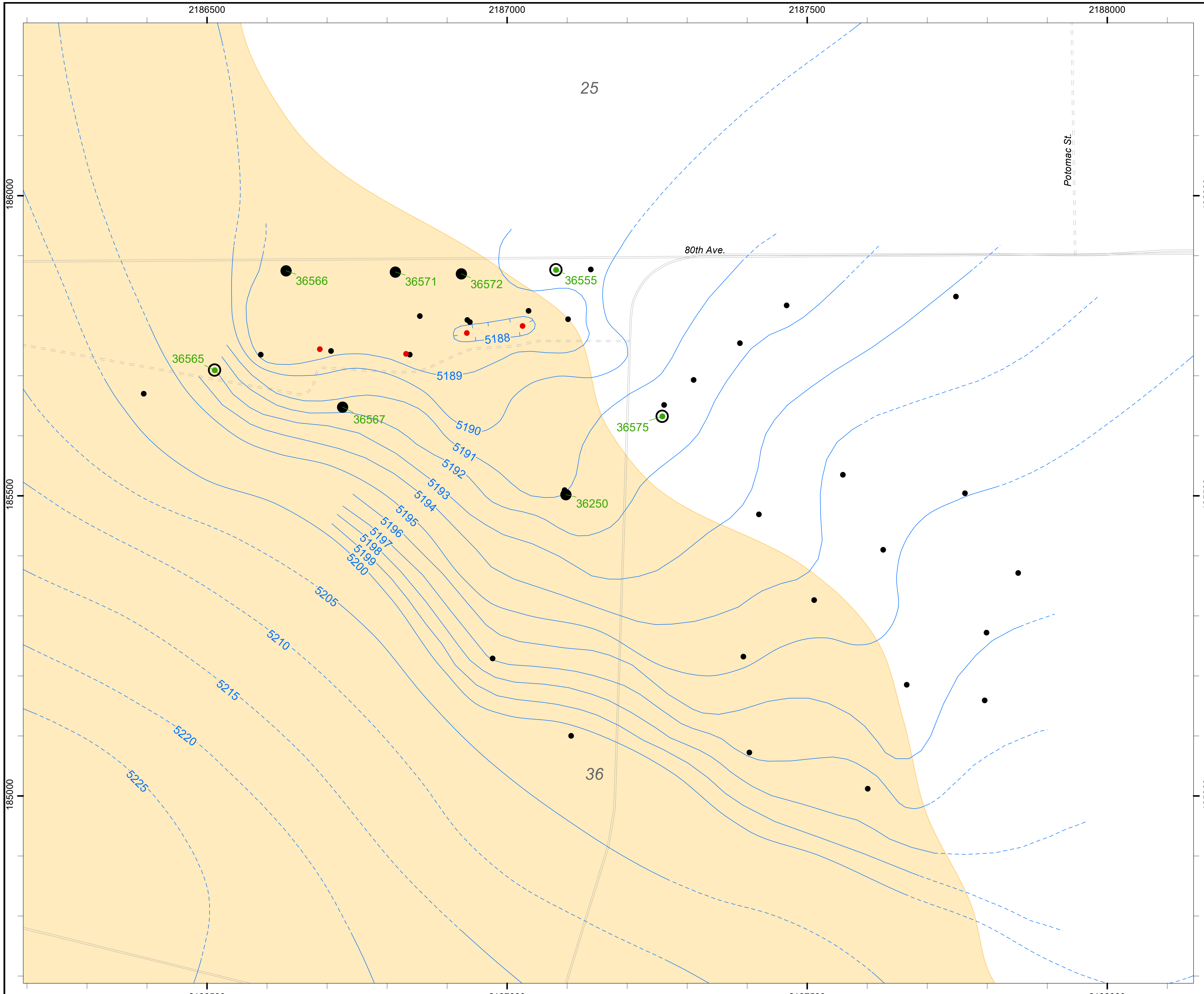

Downgradient Well 36566
12DCLE (µg/L)
10
1
0.1
0.4 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

Downgradient Well 36571



Downgradient Well 36572





Legend

- Unsaturated Alluvium
- Section Lines
- Water elevation contour - 1-foot interval
- Inferred water elevation contour
- Paved Roads
- Unimproved Roads
- Monitoring Wells
- Performance Water Quality Wells
- Extraction Wells

Note: Water levels were measured once in FY23 during Quarter 2.

Upgradient and Downgradient Performance Well Water Quality

- Analyte Detected Above the CSRG - Increasing Trend Noted
- Analyte Detected Above the CSRG - Decreasing Trend Noted
- Analyte Detected - Showing Stable or No Discernible Trend
- Analyte Not Detected

Notes:
1. Trends are depicted for the 10 year period FY14 - FY23.
2. Time versus concentration charts for Performance Water Quality wells are presented following this map.

N

0 100 200 Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

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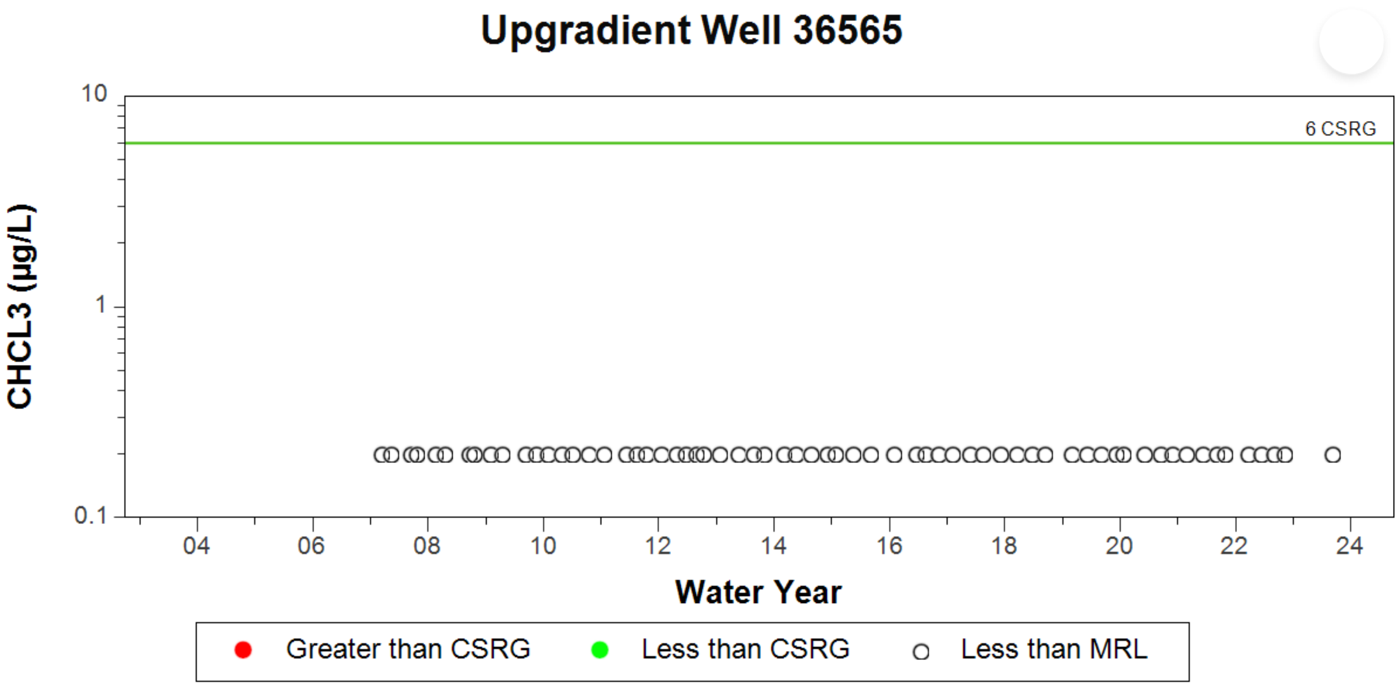
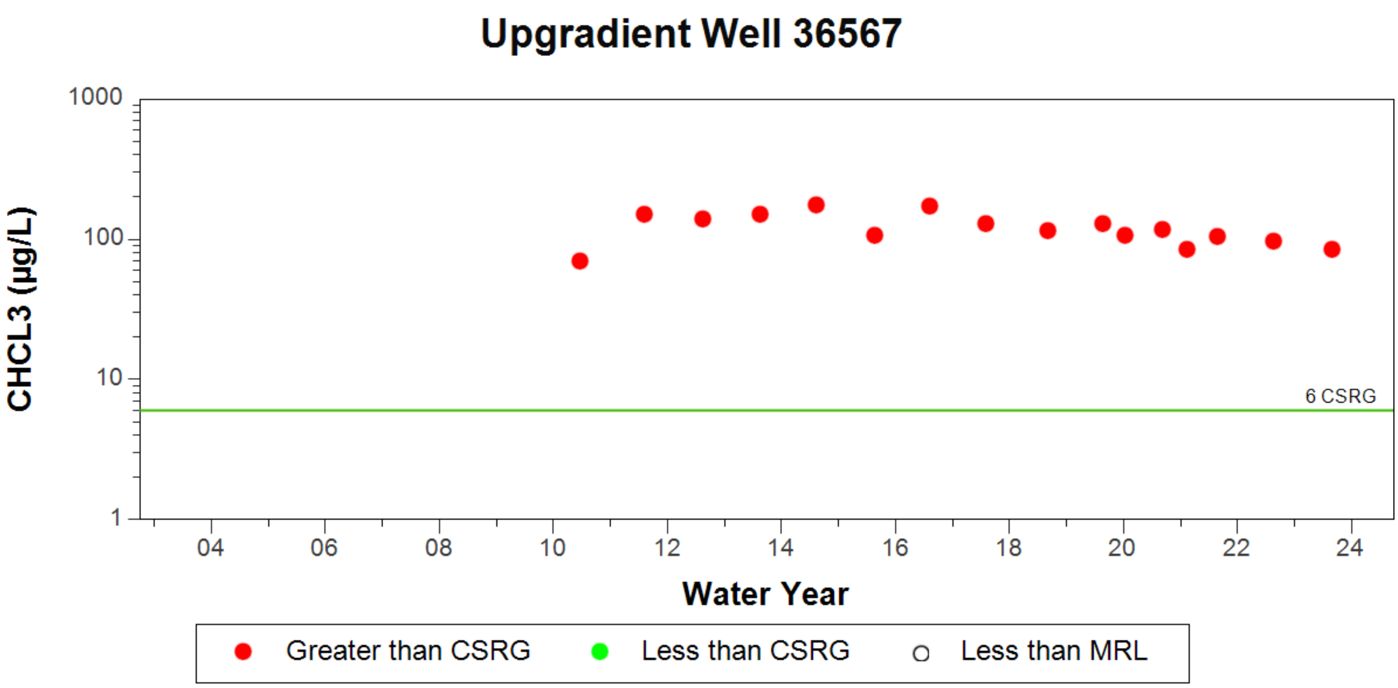
Figure D-13

Chloroform Concentration Trends in Performance Wells, Bedrock Ridge Extraction System

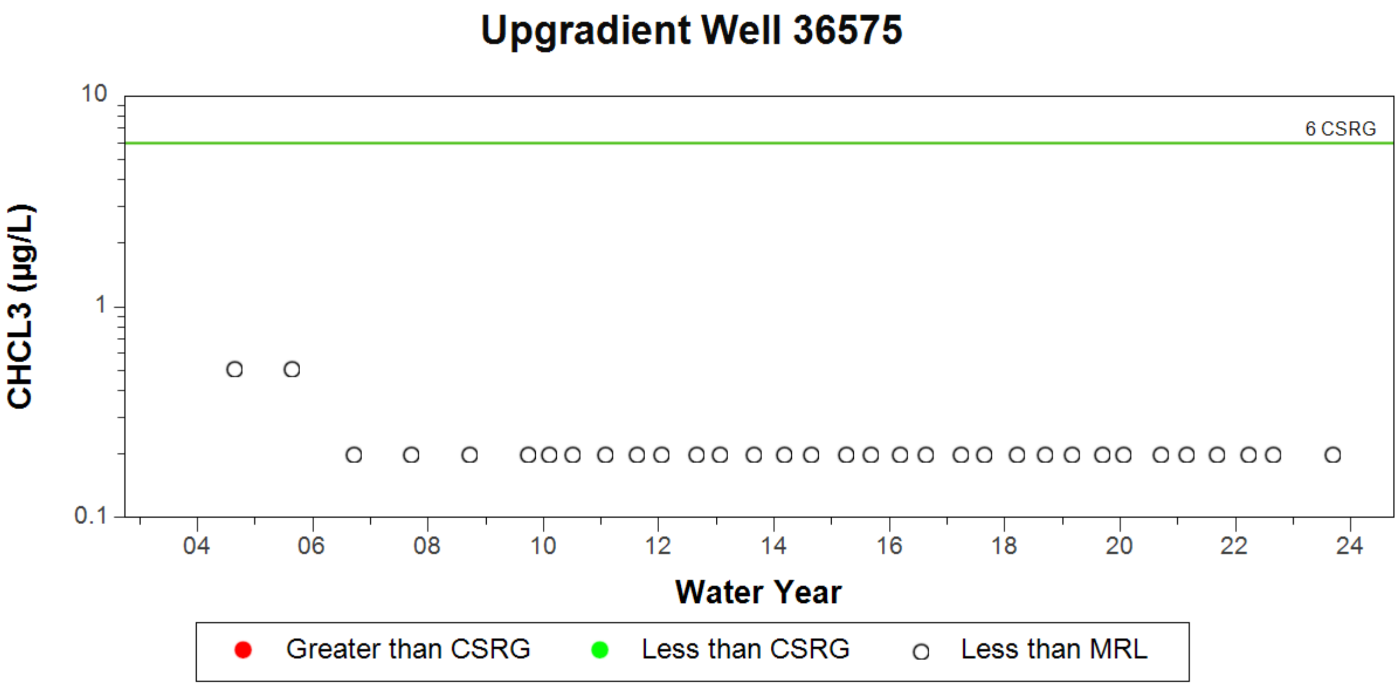
M:\projects\oars\fy23\mxds_BRR_FY23_CHCL3.mxd
6/25/2024



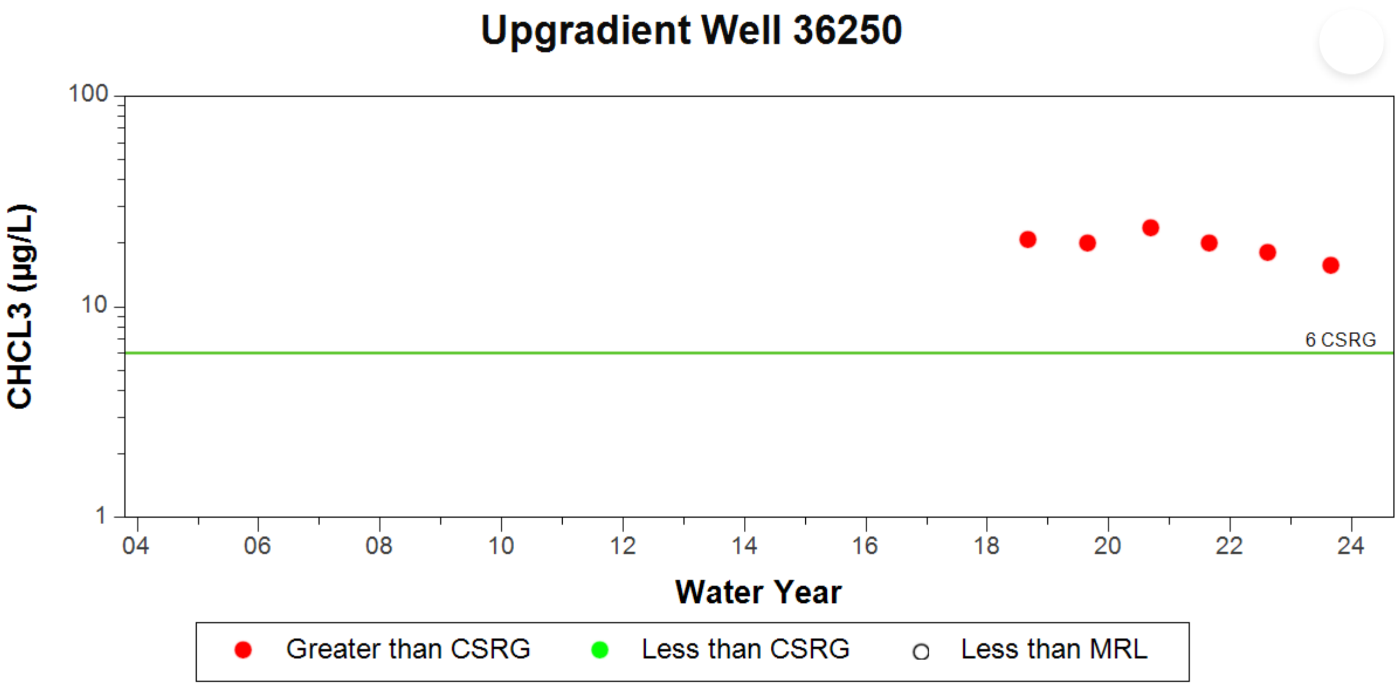
Upgradient Well 36565
CHCL3 (µg/L)
6 CSRG
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



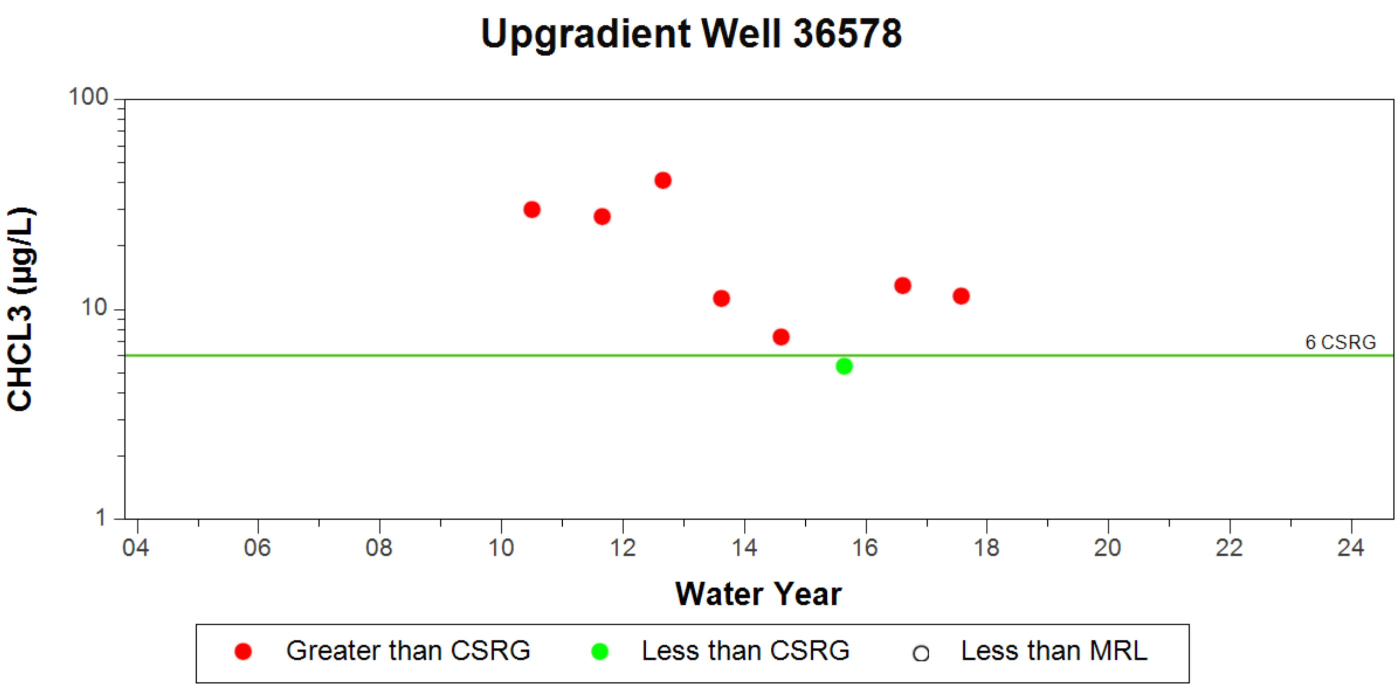
Upgradient Well 36567
CHCL3 (µg/L)
6 CSRG
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



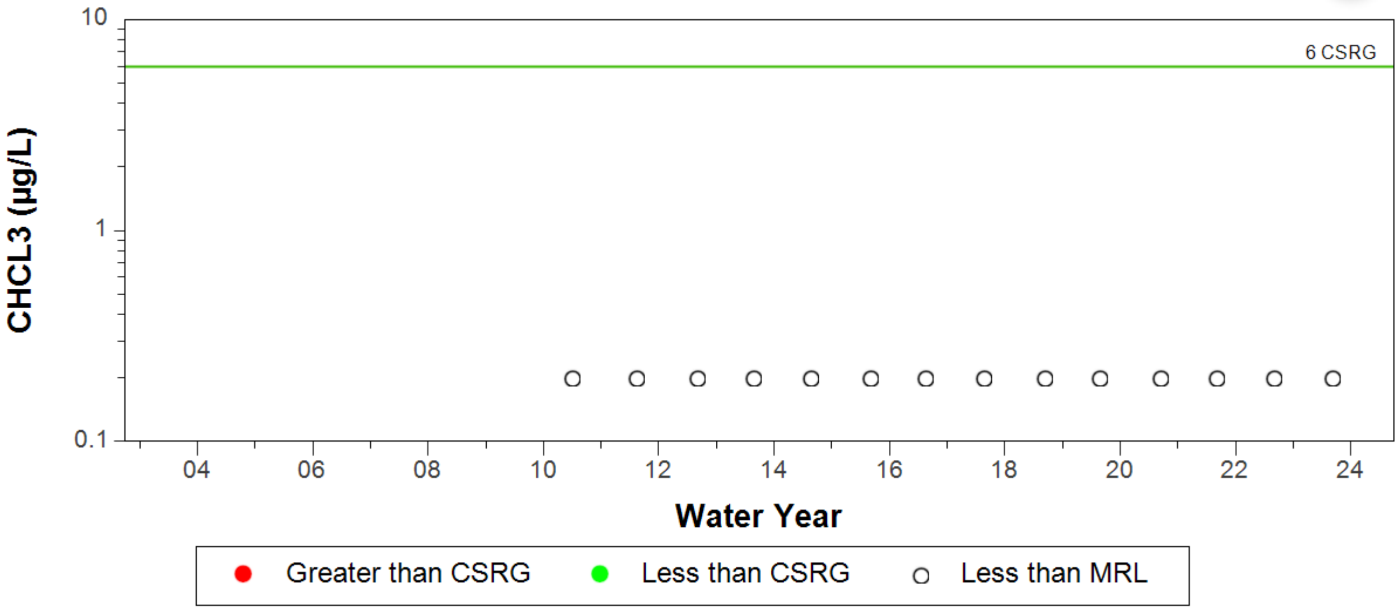
Upgradient Well 36575
CHCL3 (µg/L)
10
1
0.1
6 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



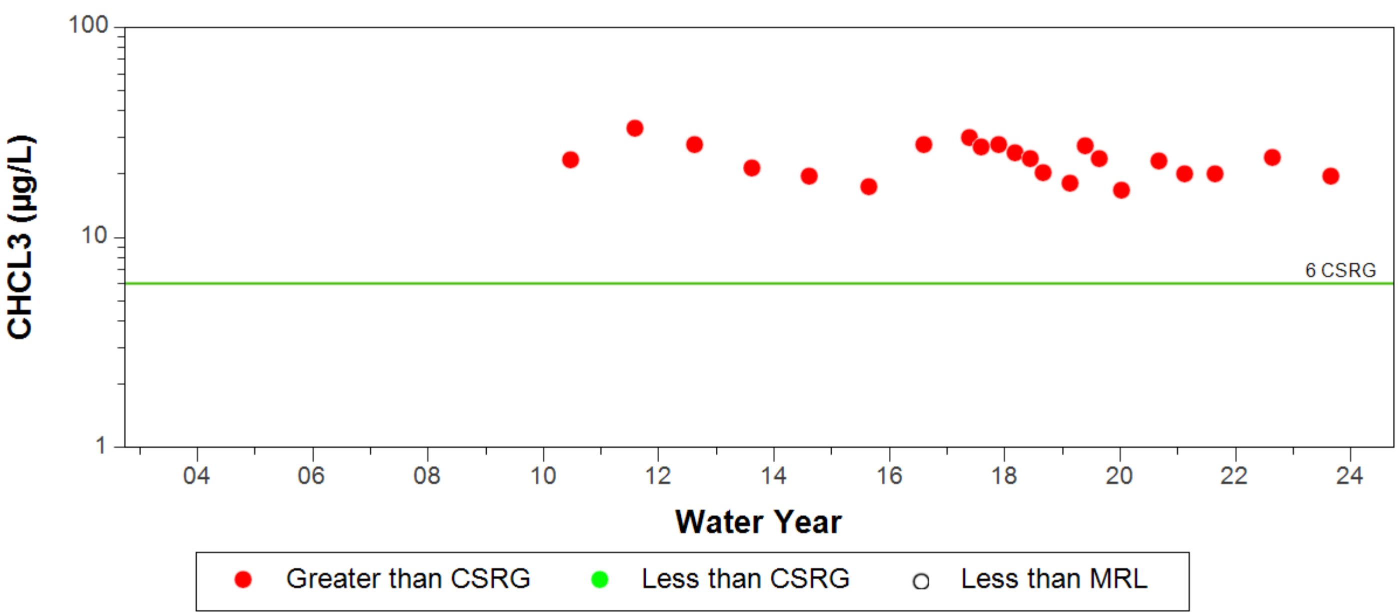
Well 36250 replaced well 36578.



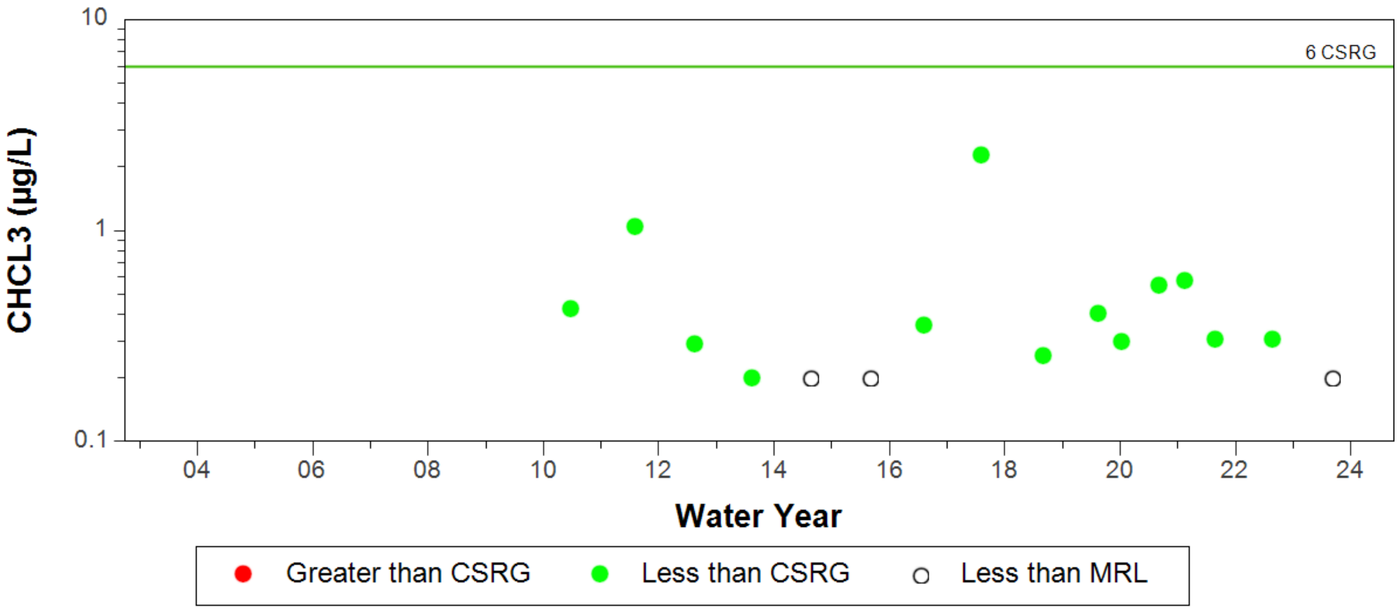
Downgradient Well 36555



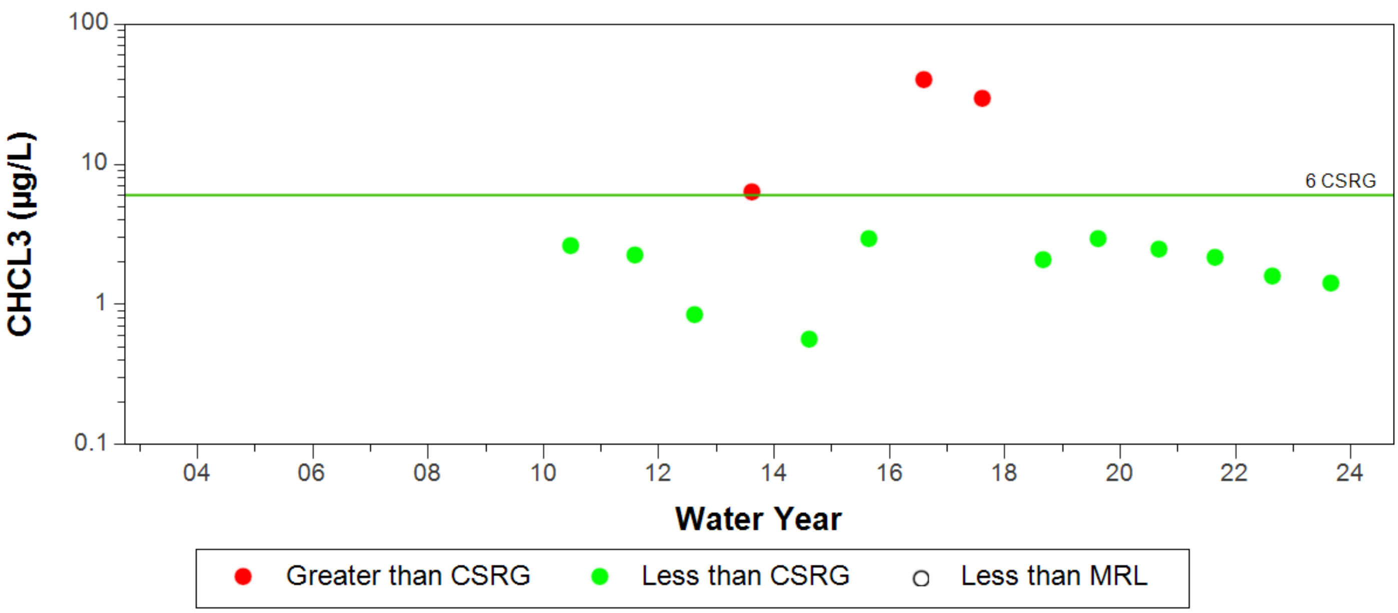
Downgradient Well 36566



Downgradient Well 36571



Downgradient Well 36572



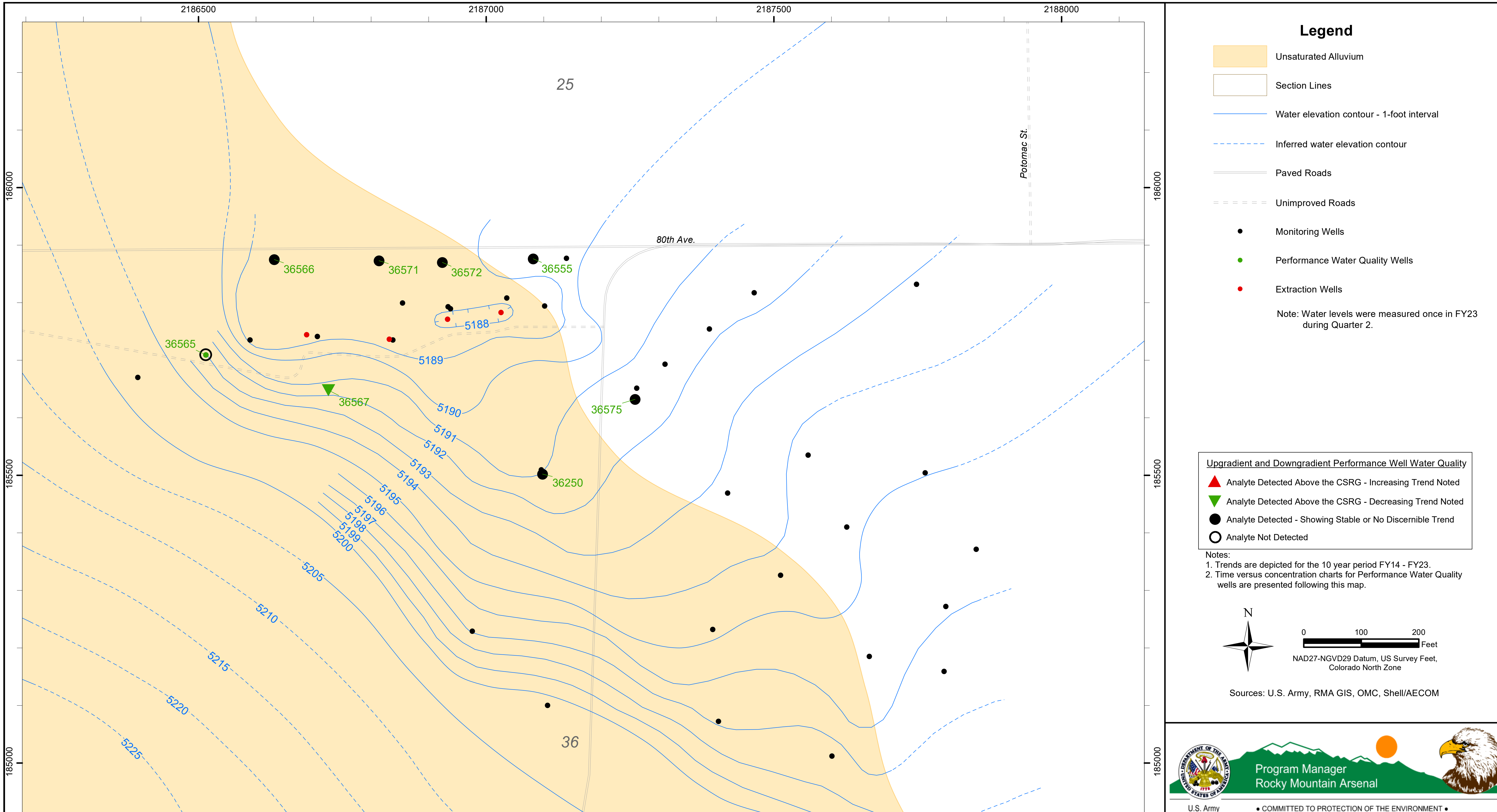
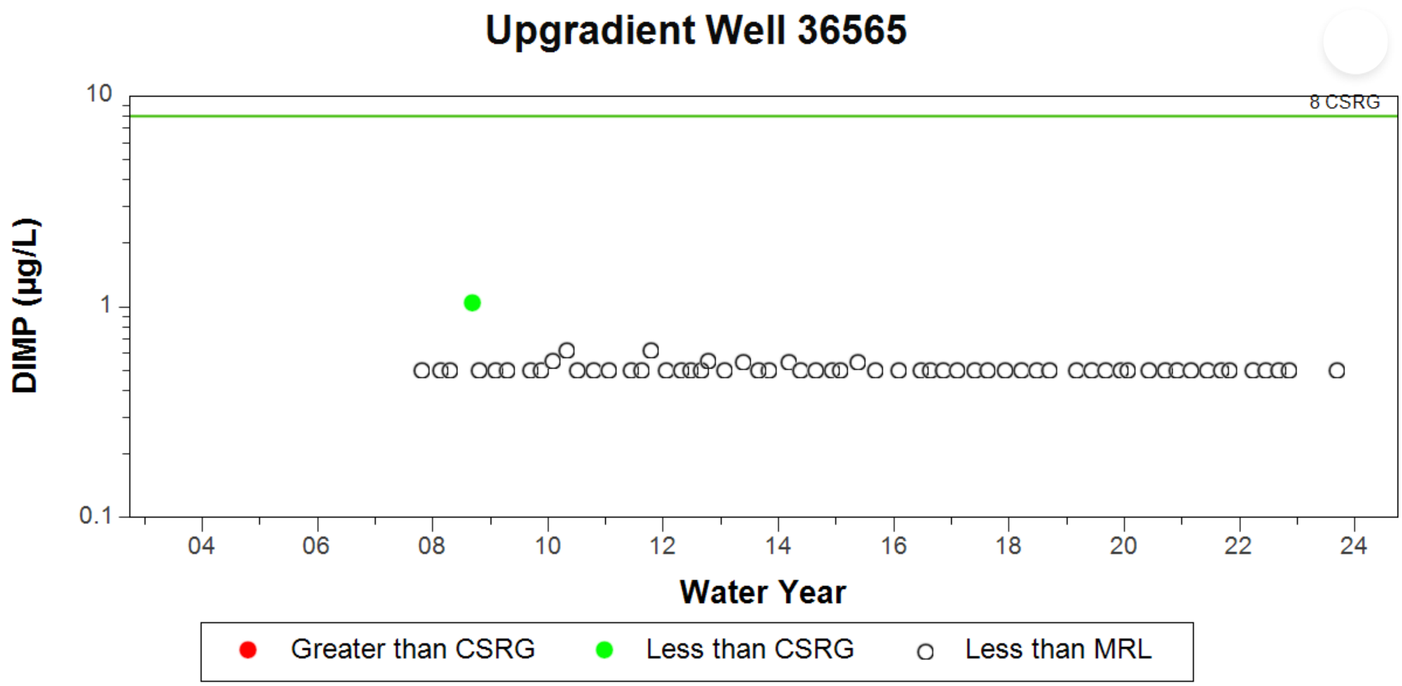


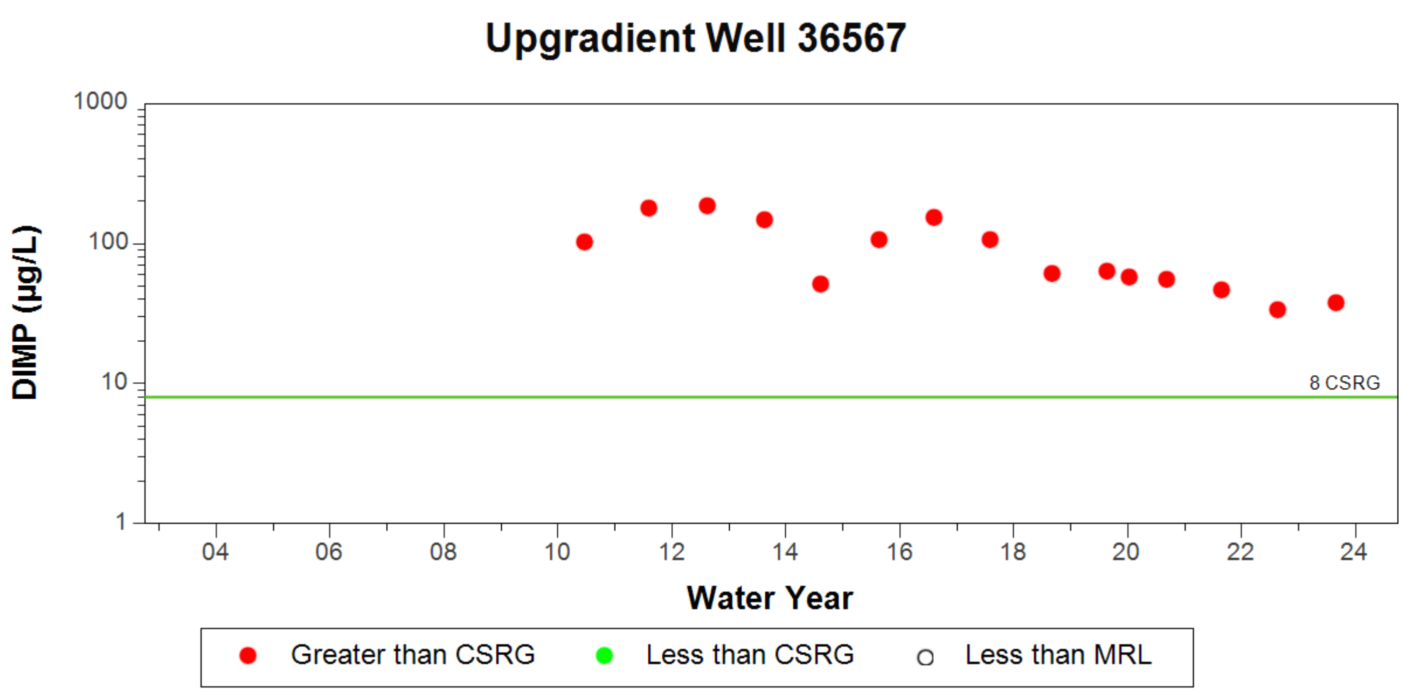
Figure D-14

Diisopropylmethyl Phosphonate Concentration Trends in Performance Wells, Bedrock Ridge Extraction System

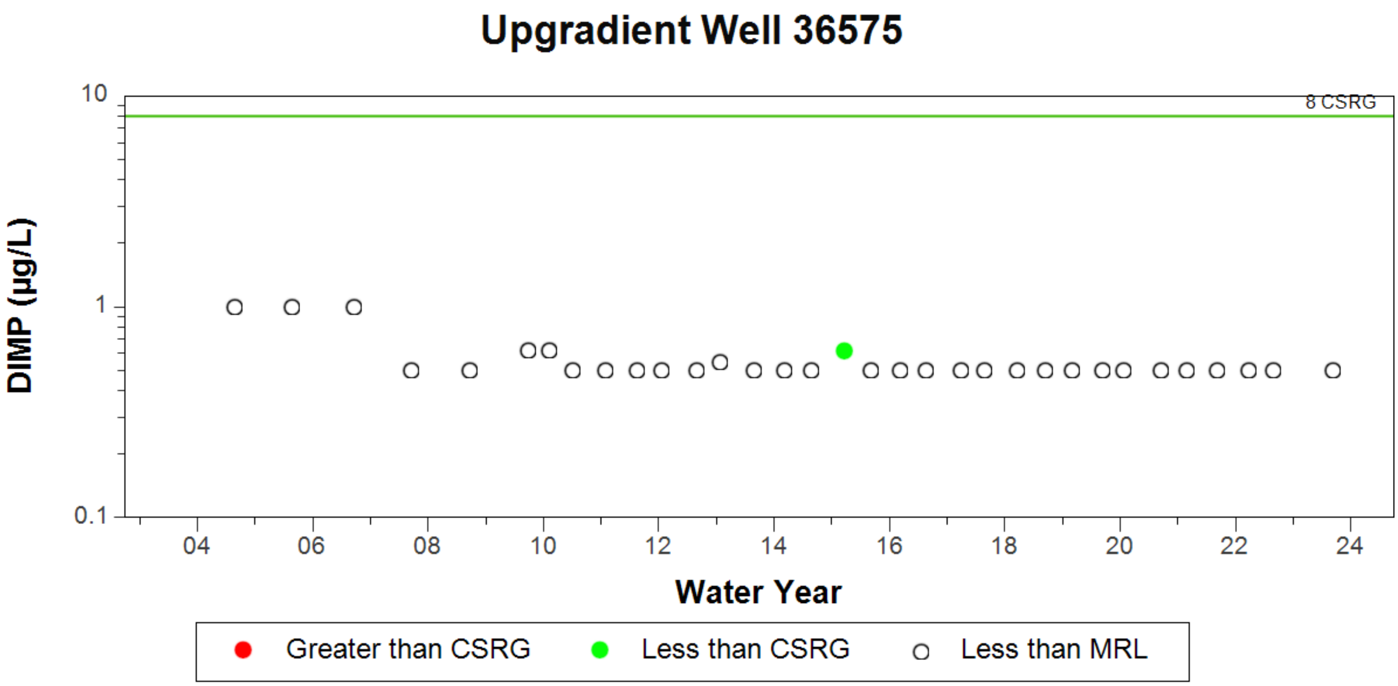
M:\projects\oars\fy23\mxds_BRR_FY23_DIMP.mxd
6/25/2024



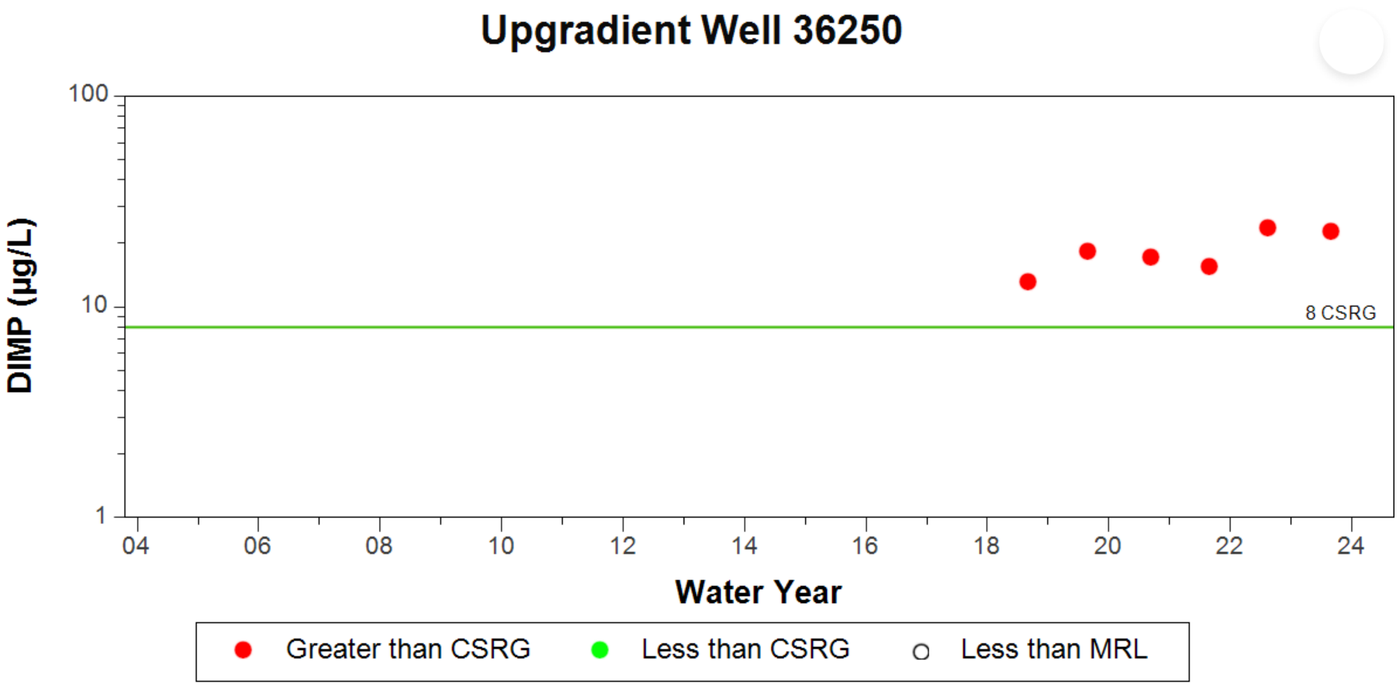
Upgradient Well 36565
DIMP (µg/L)
10
1
0.1
8 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



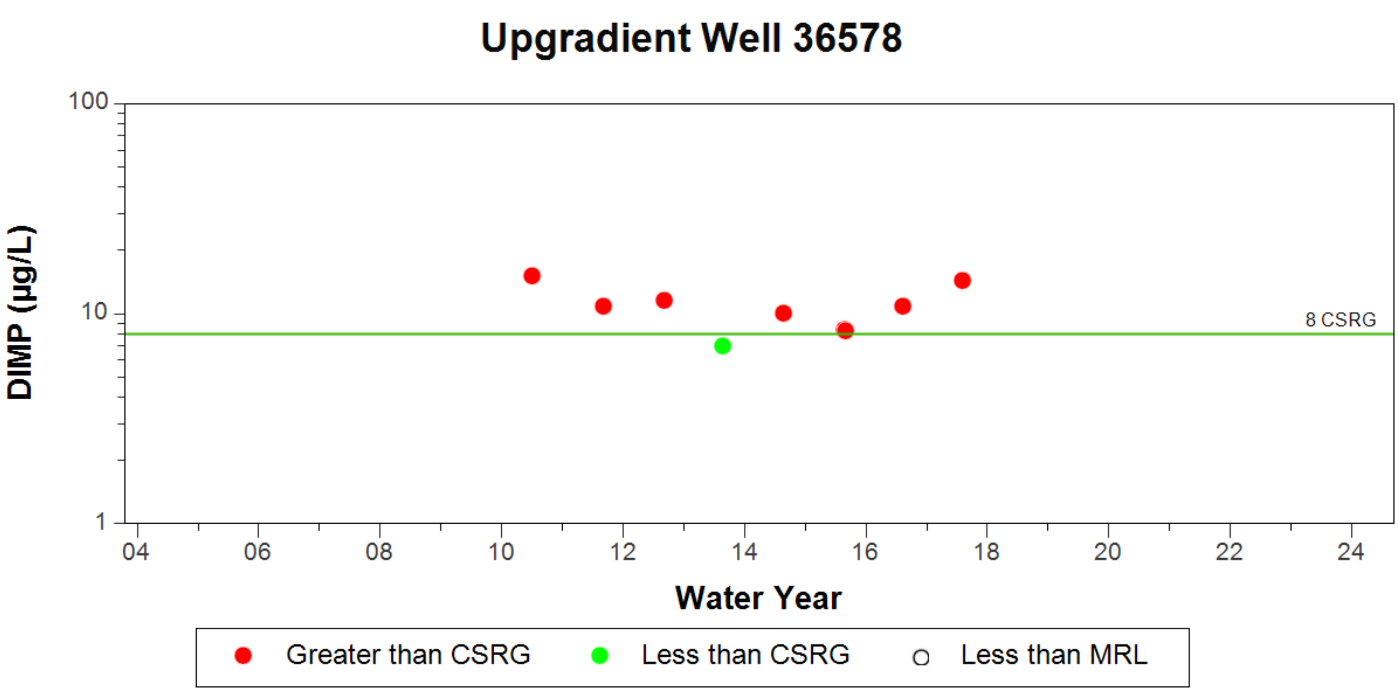
Upgradient Well 36567
DIMP (µg/L)
1000
100
10
1
8 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



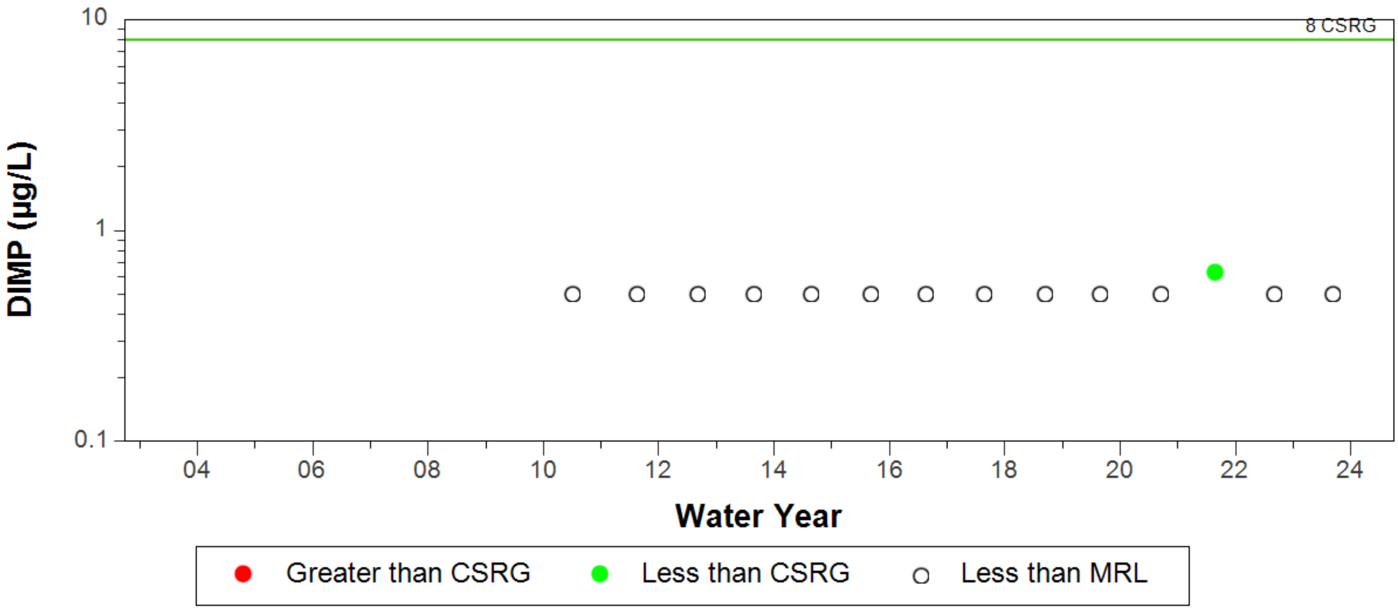
Upgradient Well 36575
DIMP (µg/L)
10
1
0.1
8 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



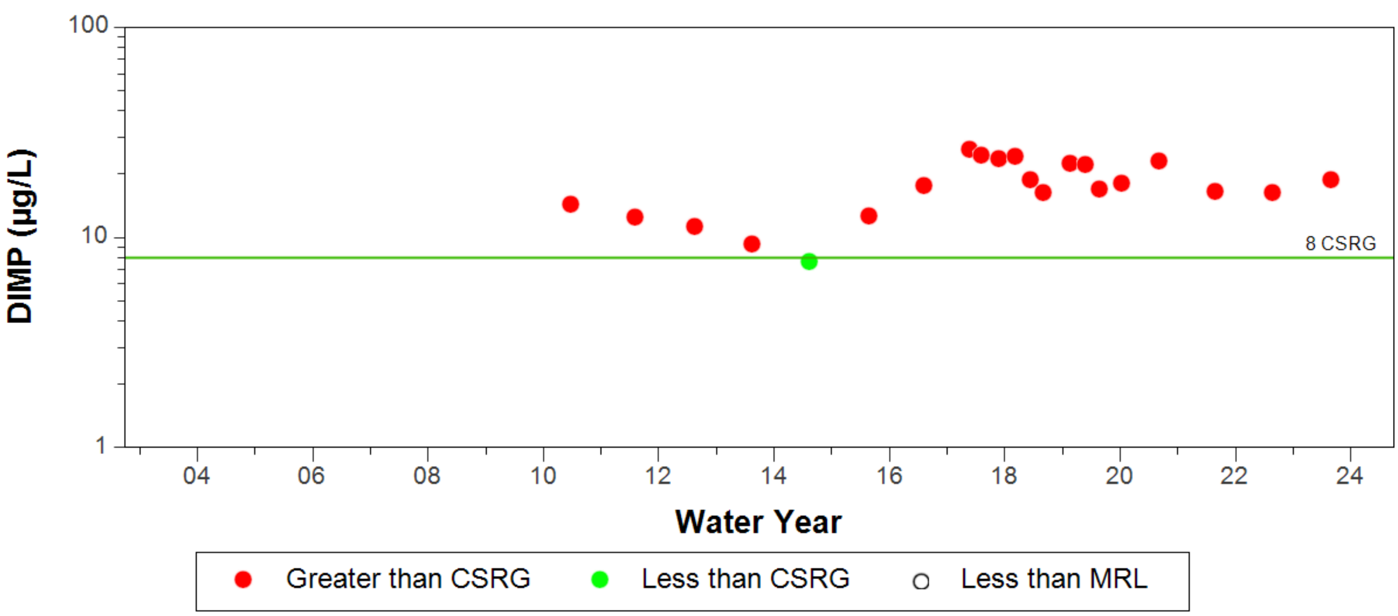
Well 36250 replaced well 36578.

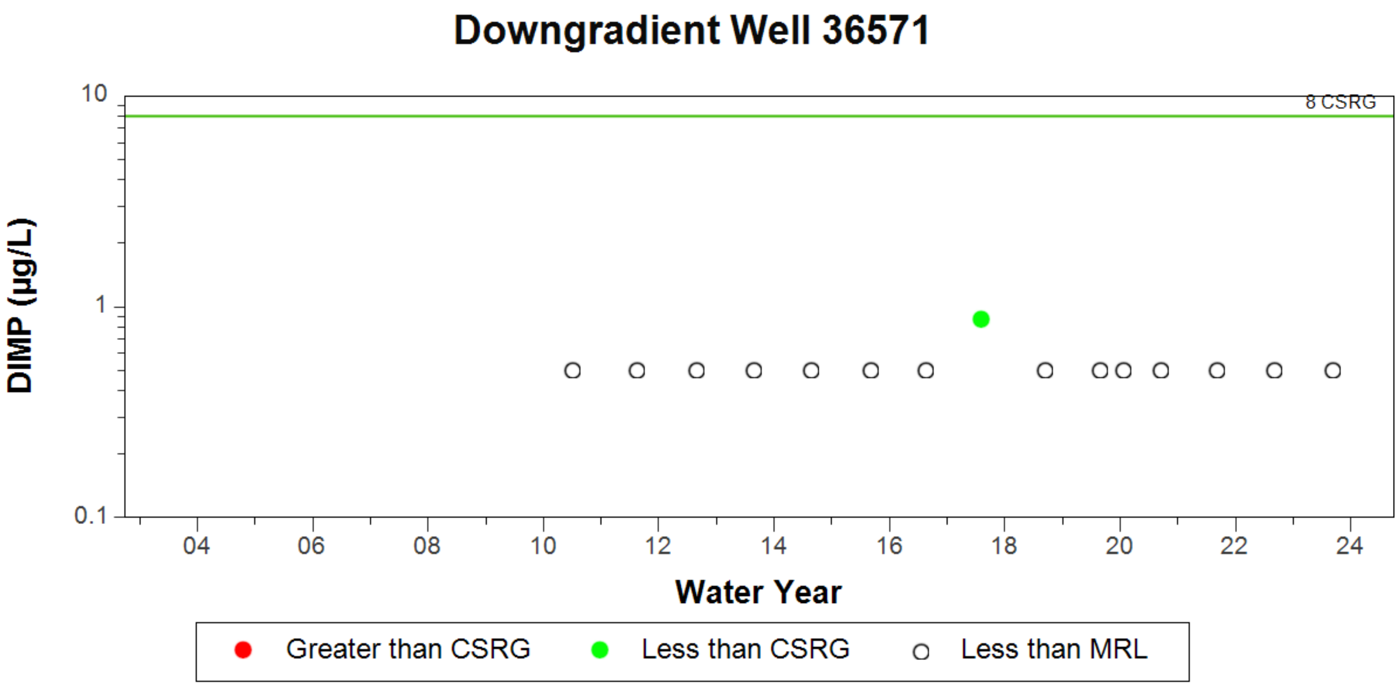


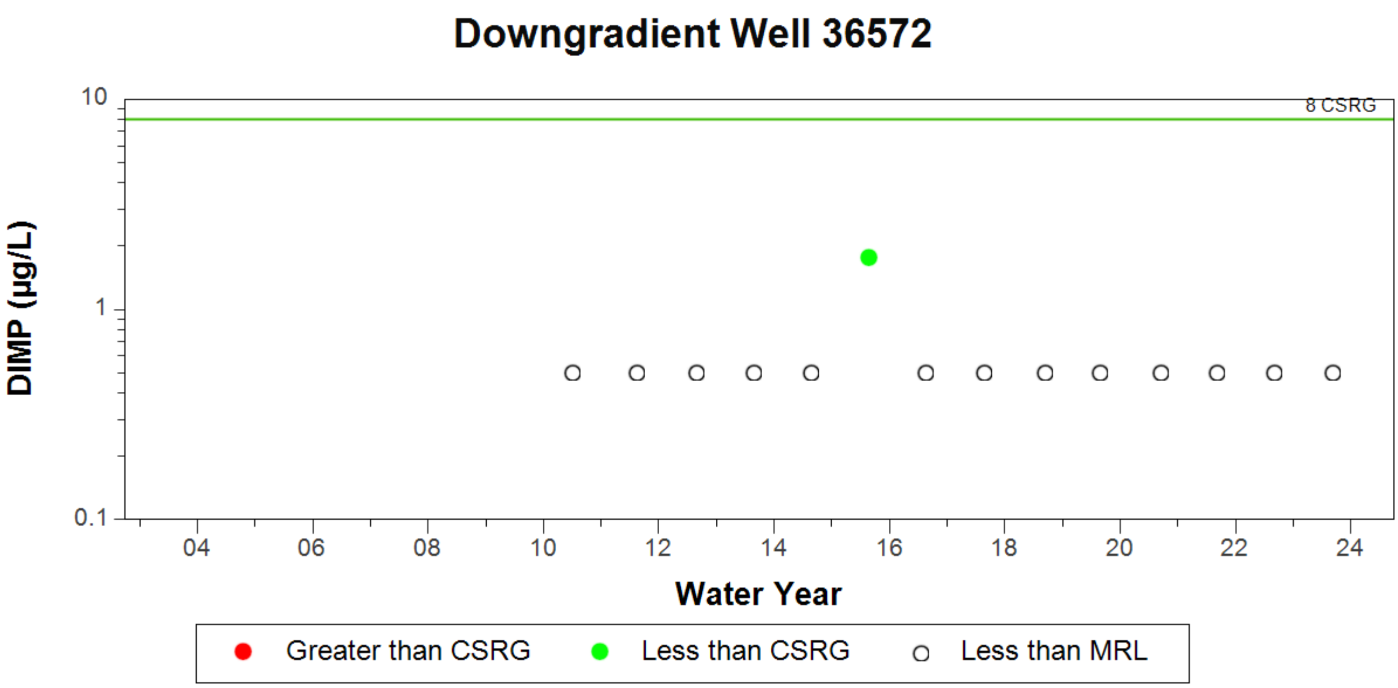
Downgradient Well 36555

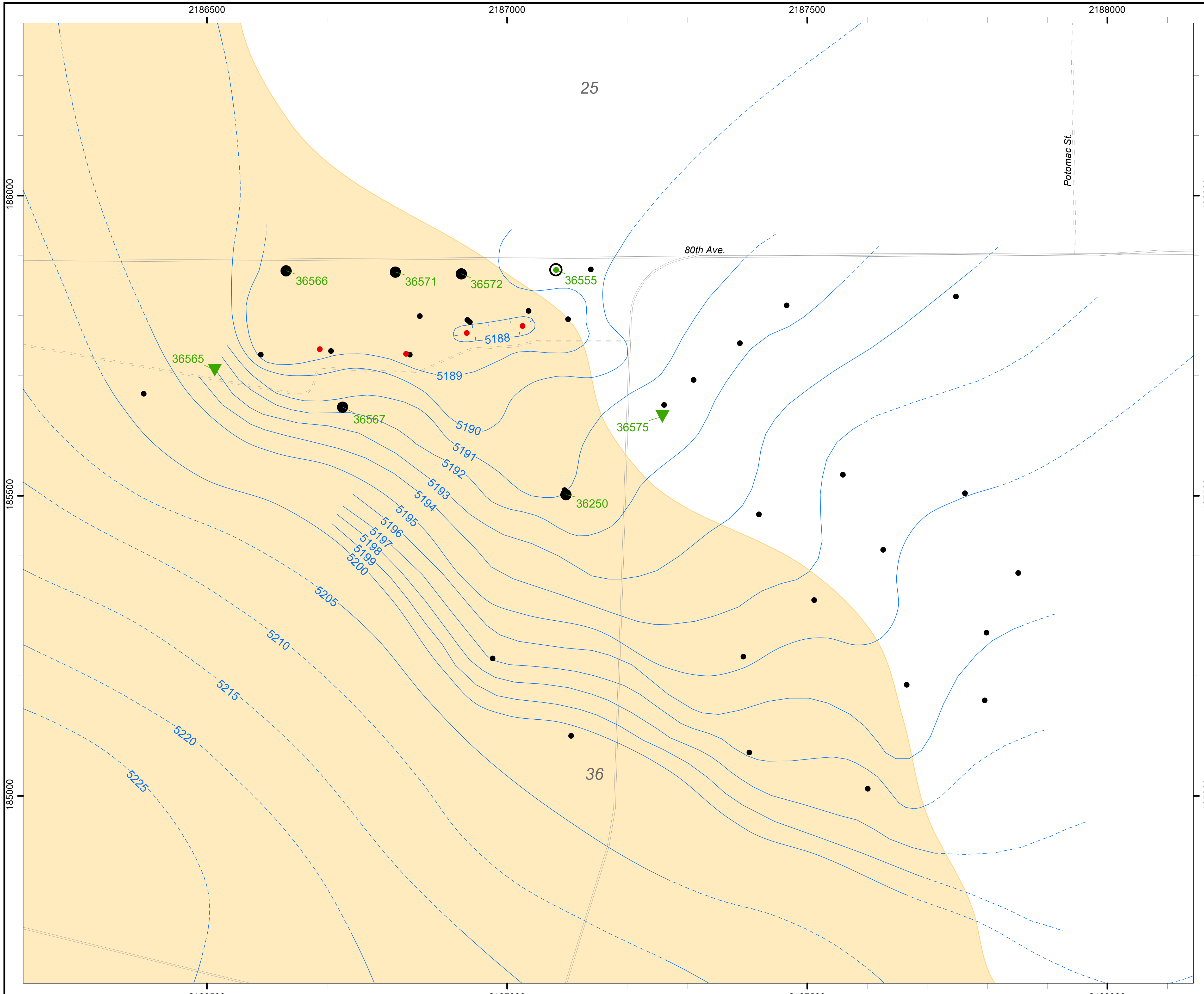


Downgradient Well 36566




Downgradient Well 36571
10
1
0.1
8 CSRG
DIMP (µg/L)
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL


Downgradient Well 36572
10
1
0.1
8 CSRG
DIMP (µg/L)
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



Legend

- Unsaturated Alluvium
- Section Lines
- Water elevation contour - 1-foot interval
- Inferred water elevation contour
- Paved Roads
- Unimproved Roads
- Monitoring Wells
- Performance Water Quality Wells
- Extraction Wells

Note: Water levels were measured once in FY23 during Quarter 2.

Upgradient and Downgradient Performance Well Water Quality

- Analyte Detected Above the CSRG - Increasing Trend Noted
- Analyte Detected Above the CSRG - Decreasing Trend Noted
- Analyte Detected - Showing Stable or No Discernible Trend
- Analyte Not Detected

Notes:
1. Trends are depicted for the 10 year period FY14 - FY23.
2. Time versus concentration charts for Performance Water Quality wells are presented following this map.

N

0 100 200 Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

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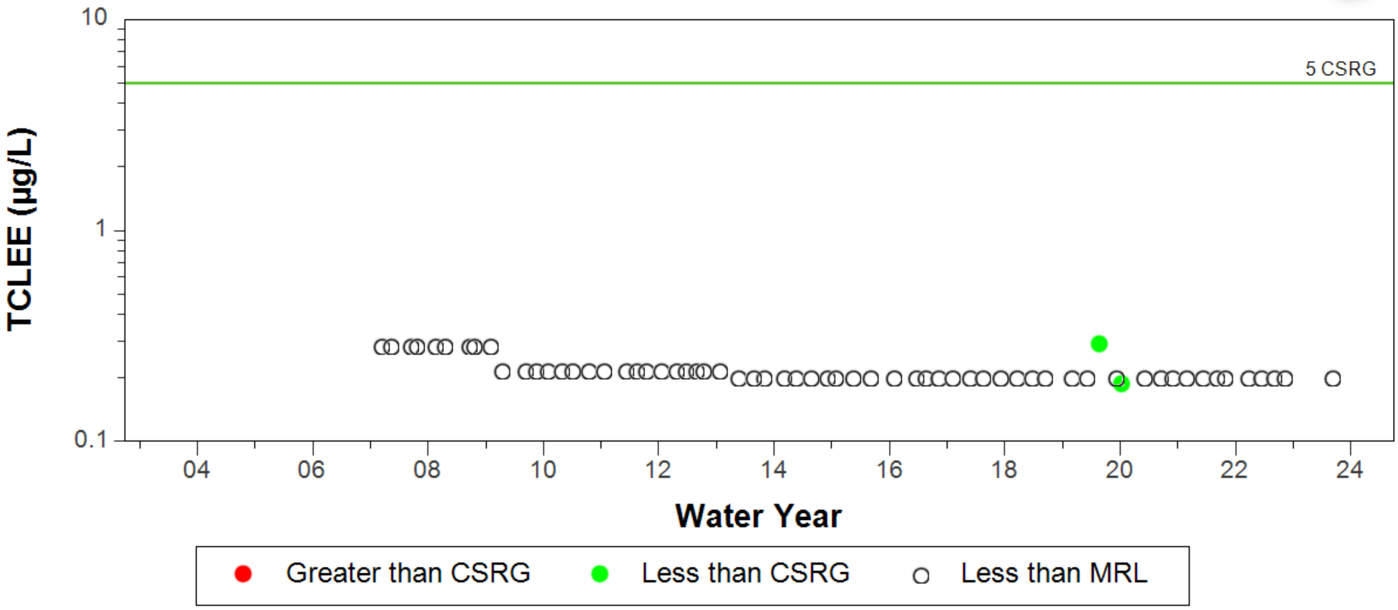
Figure D-15

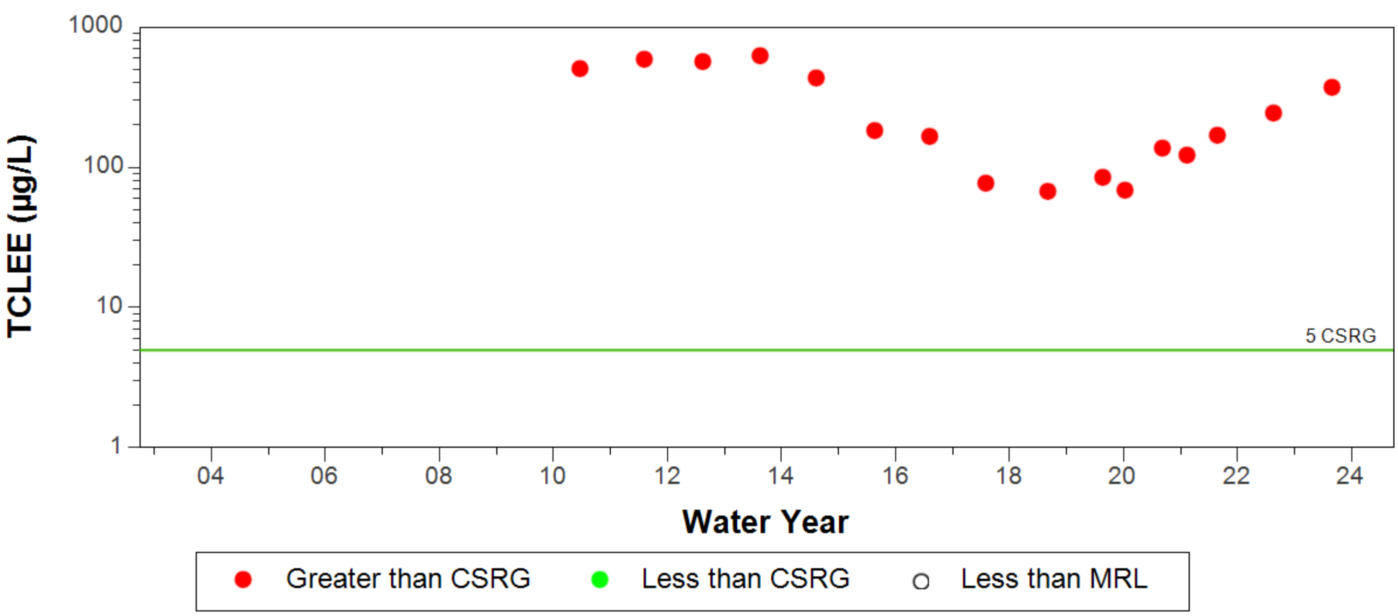
Tetrachloroethylene Concentration Trends in Performance Wells, Bedrock Ridge Extraction System

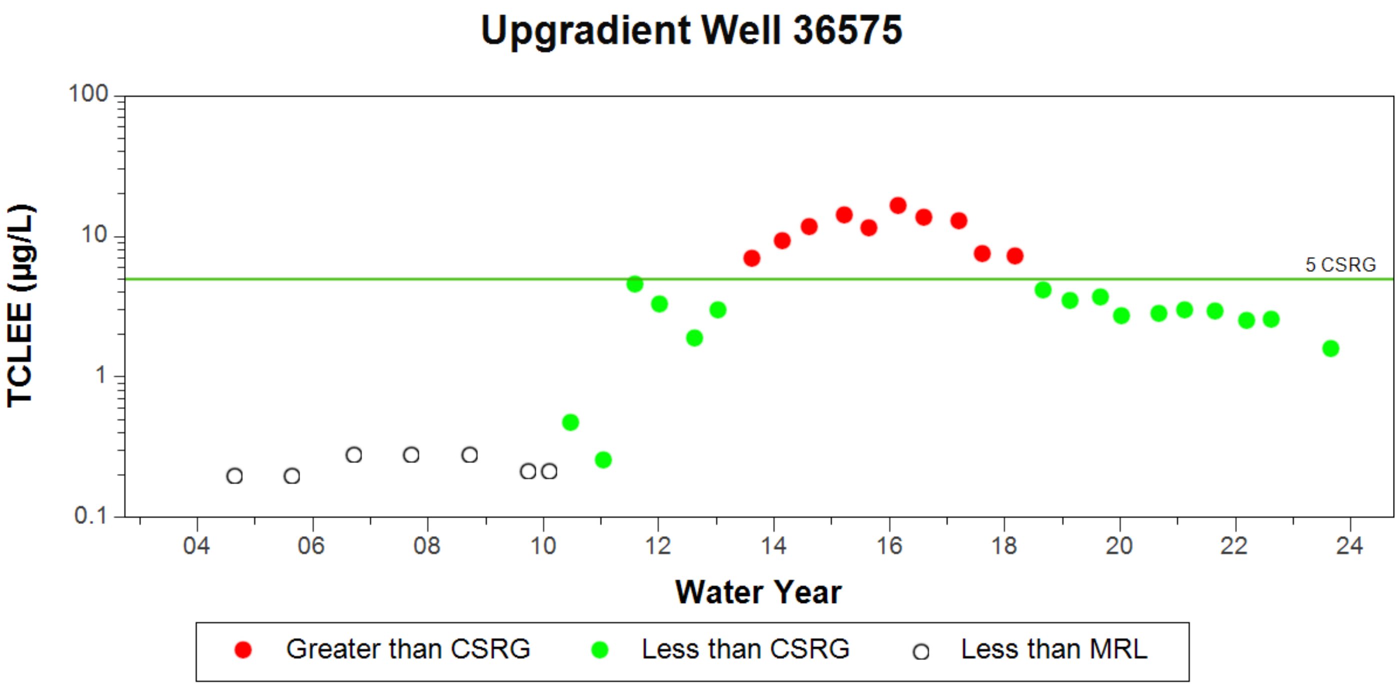
M:\projects\oars\fy23\mxds_BRR_FY23_TCLEE.mxd
6/25/2024

Upgradient Well 36565

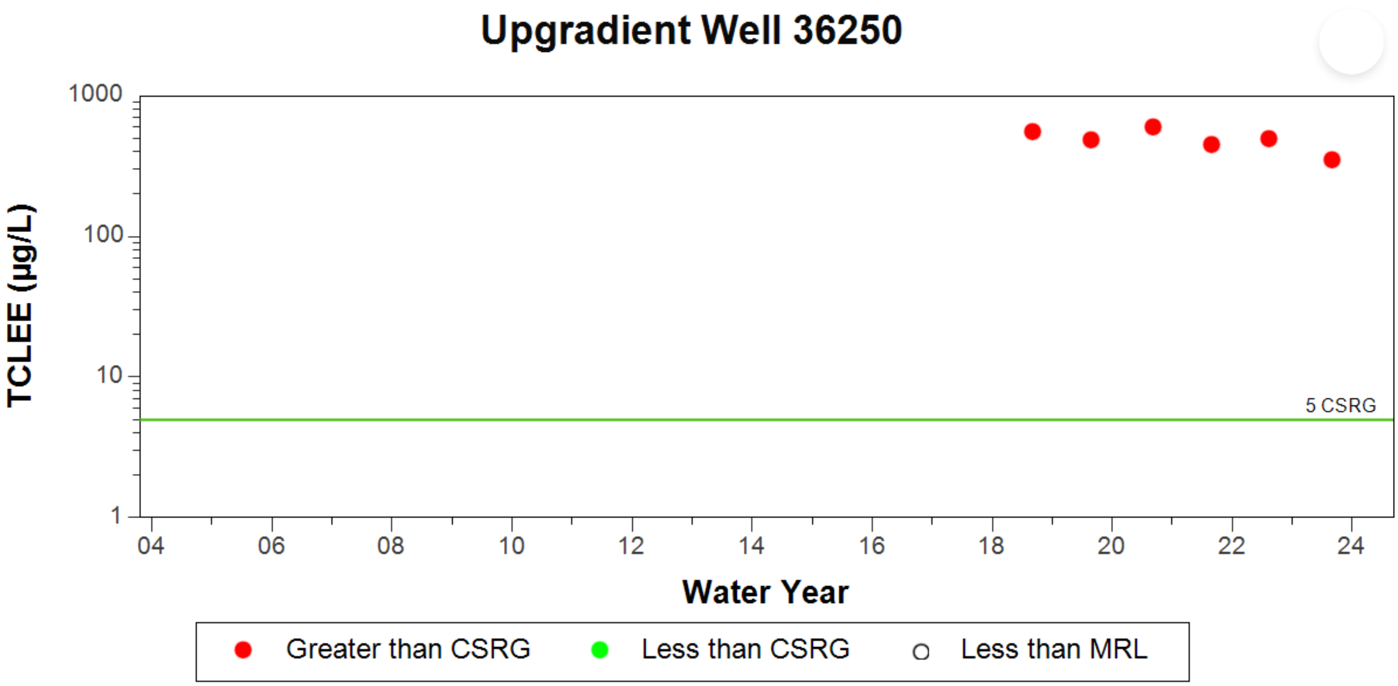


Upgradient Well 36567

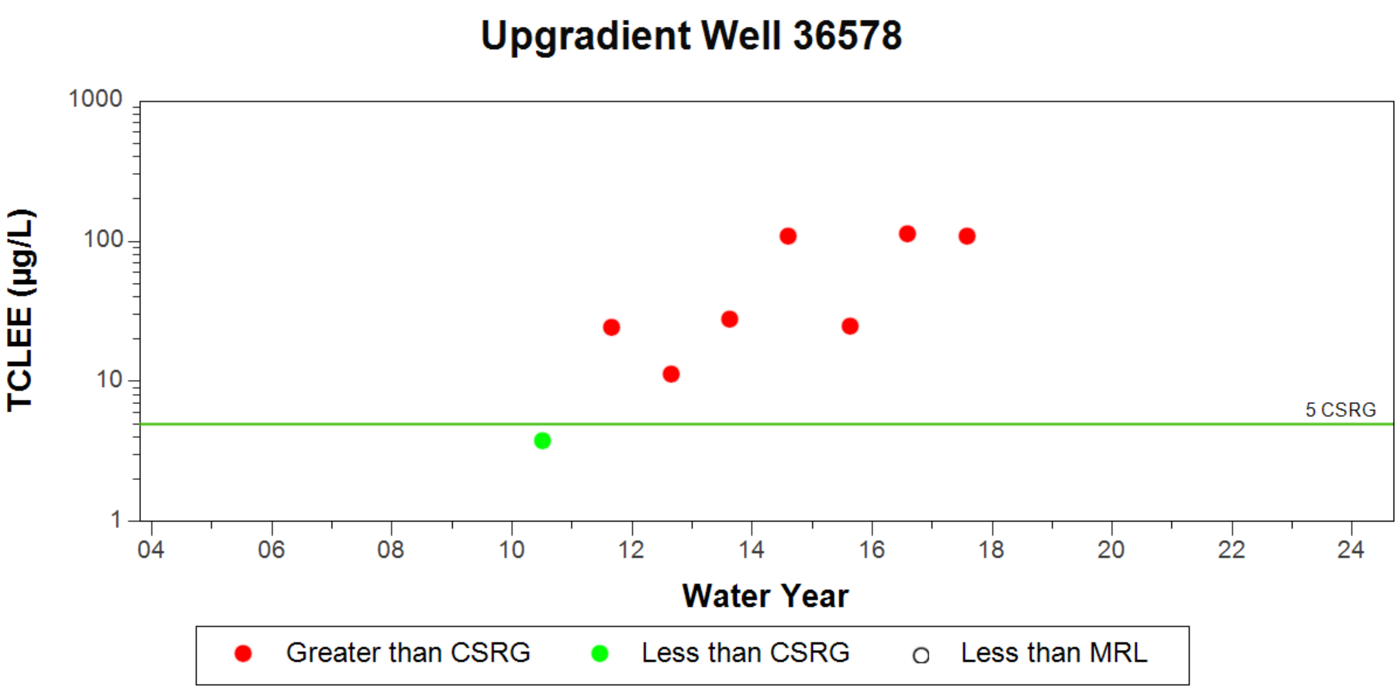




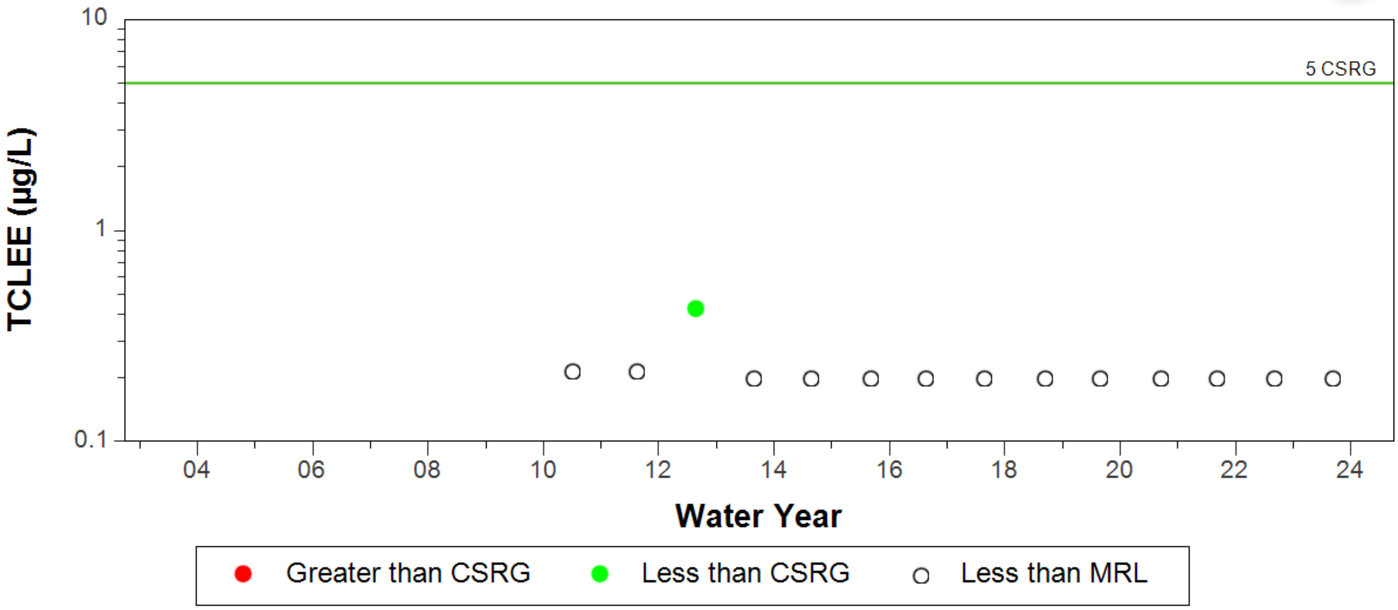
Upgradient Well 36575
100
10
1
0.1
TCLEE (µg/L)
5 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



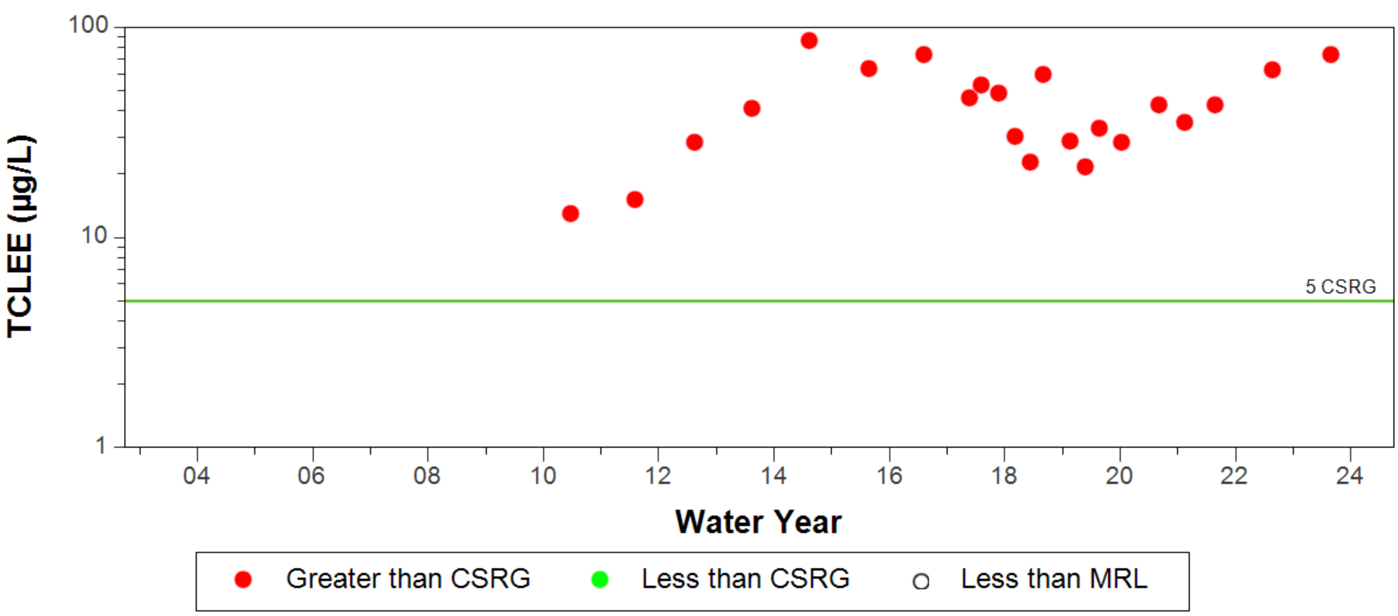
Well 36250 replaced well 36578.

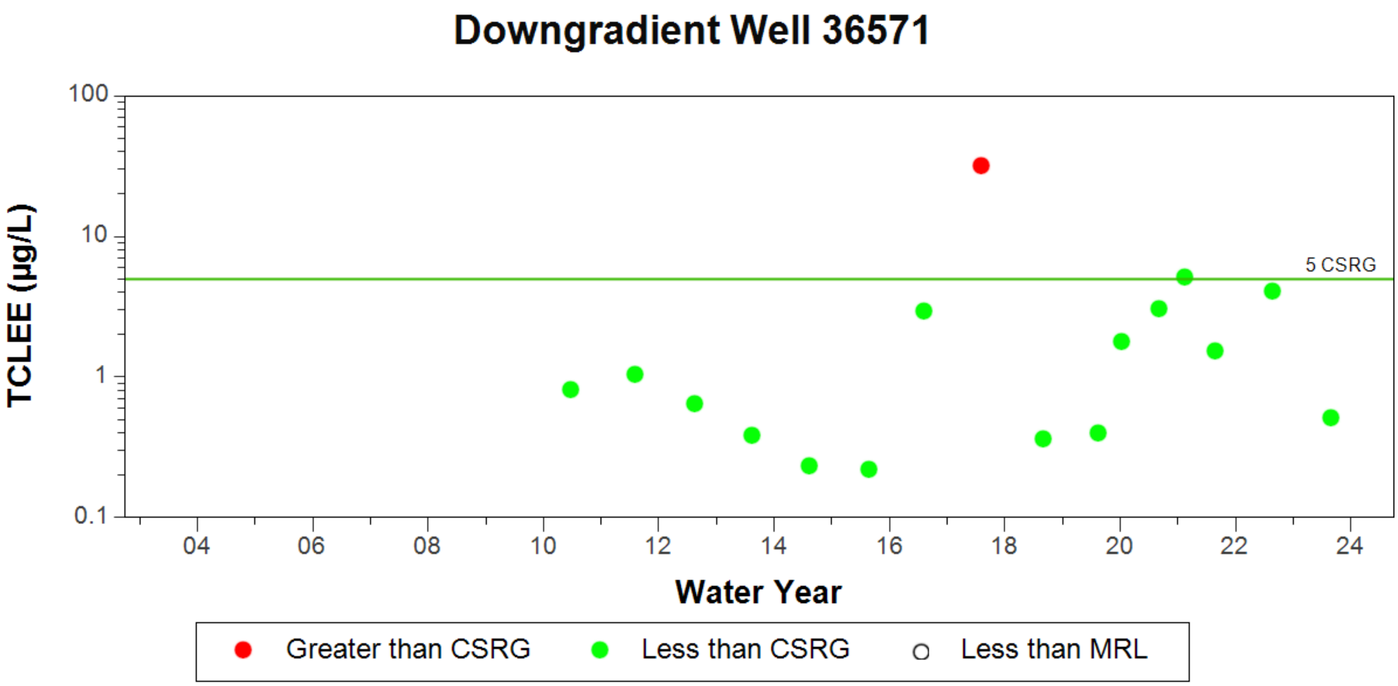


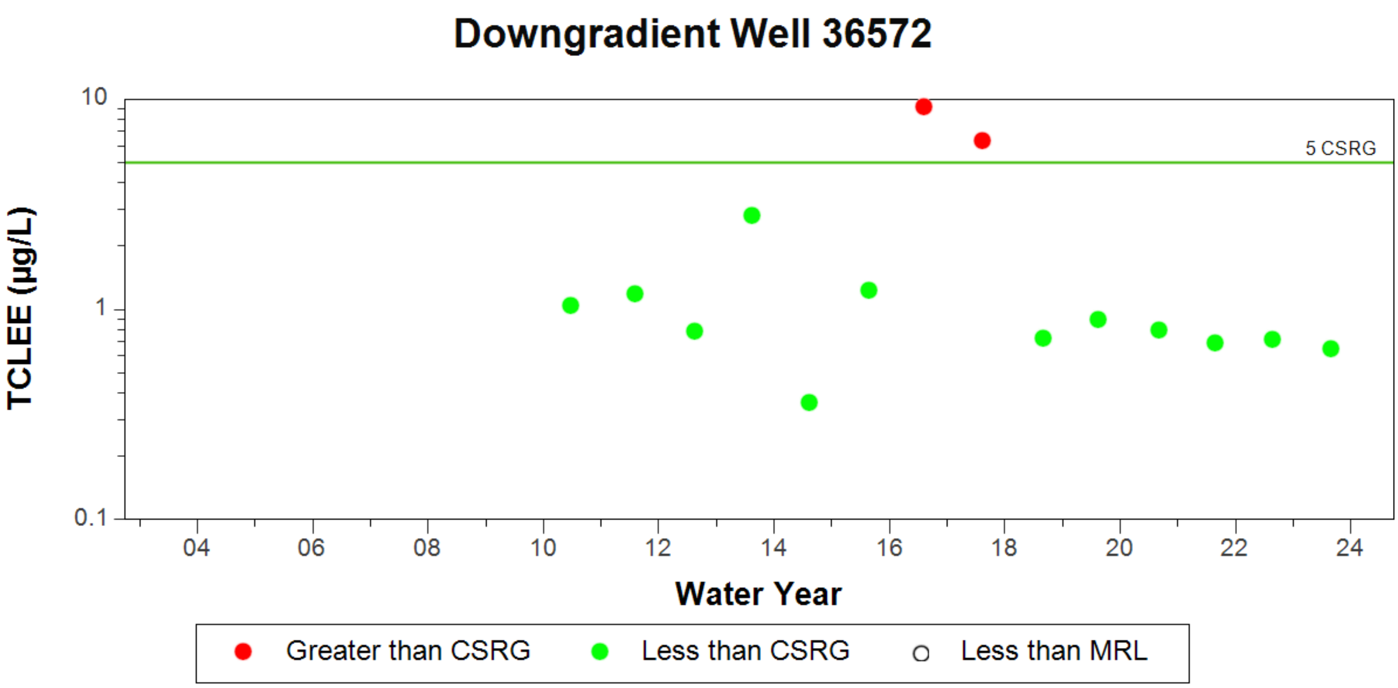
Downgradient Well 36555

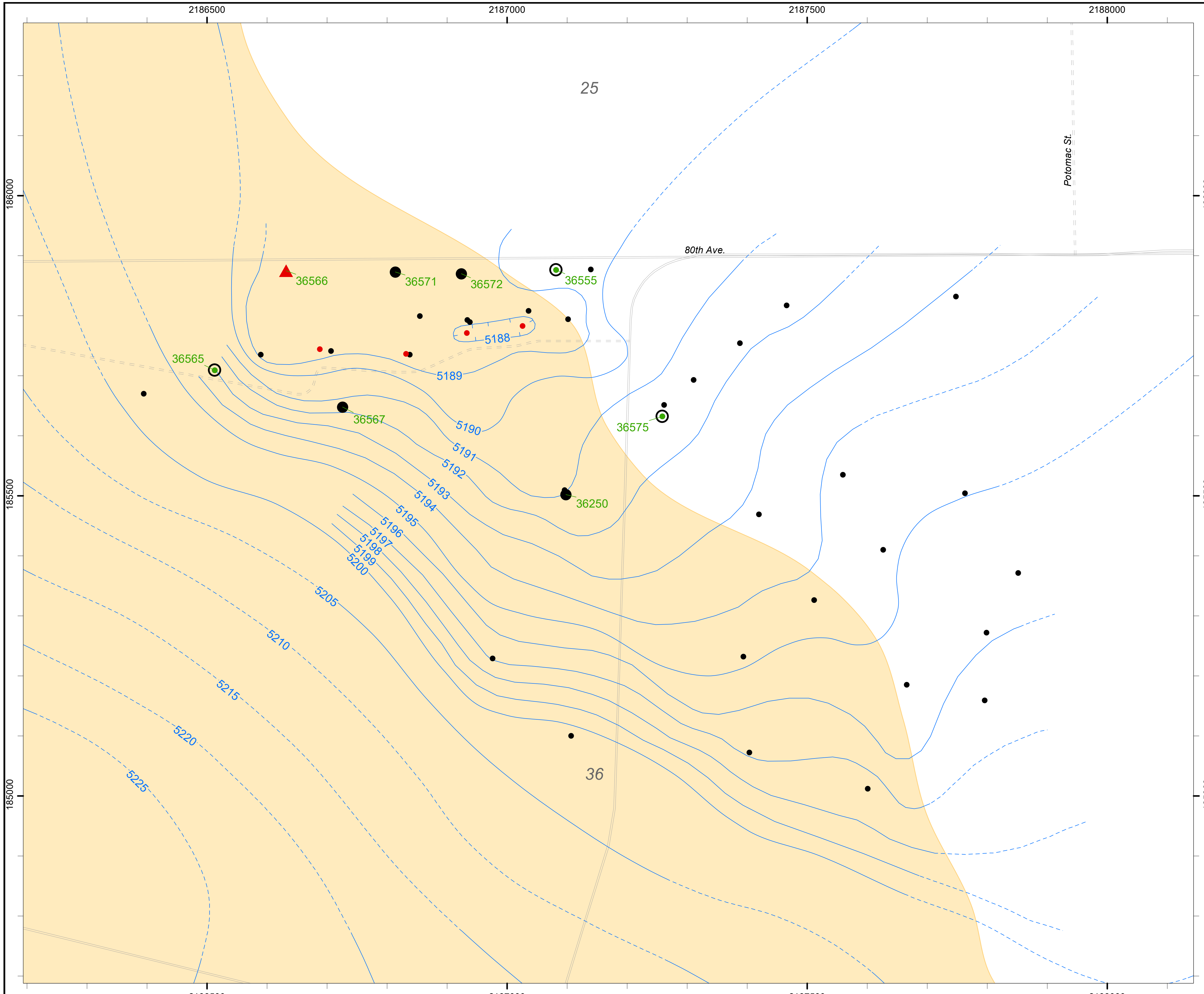


Downgradient Well 36566




Downgradient Well 36571
100
10
1
0.1
TCLEE (µg/L)
5 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL


Downgradient Well 36572
10
1
0.1
TCLEE (µg/L)
5 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



Legend

- Unsaturated Alluvium
- Section Lines
- Water elevation contour - 1-foot interval
- Inferred water elevation contour
- Paved Roads
- Unimproved Roads
- Monitoring Wells
- Performance Water Quality Wells
- Extraction Wells

Note: Water levels were measured once in FY23 during Quarter 2.

Upgradient and Downgradient Performance Well Water Quality

- Analyte Detected Above the CSRG - Increasing Trend Noted
- Analyte Detected Above the CSRG - Decreasing Trend Noted
- Analyte Detected - Showing Stable or No Discernible Trend
- Analyte Not Detected

Notes:
1. Trends are depicted for the 10 year period FY14 - FY23.
2. Time versus concentration charts for Performance Water Quality wells are presented following this map.

N

0 100 200 Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

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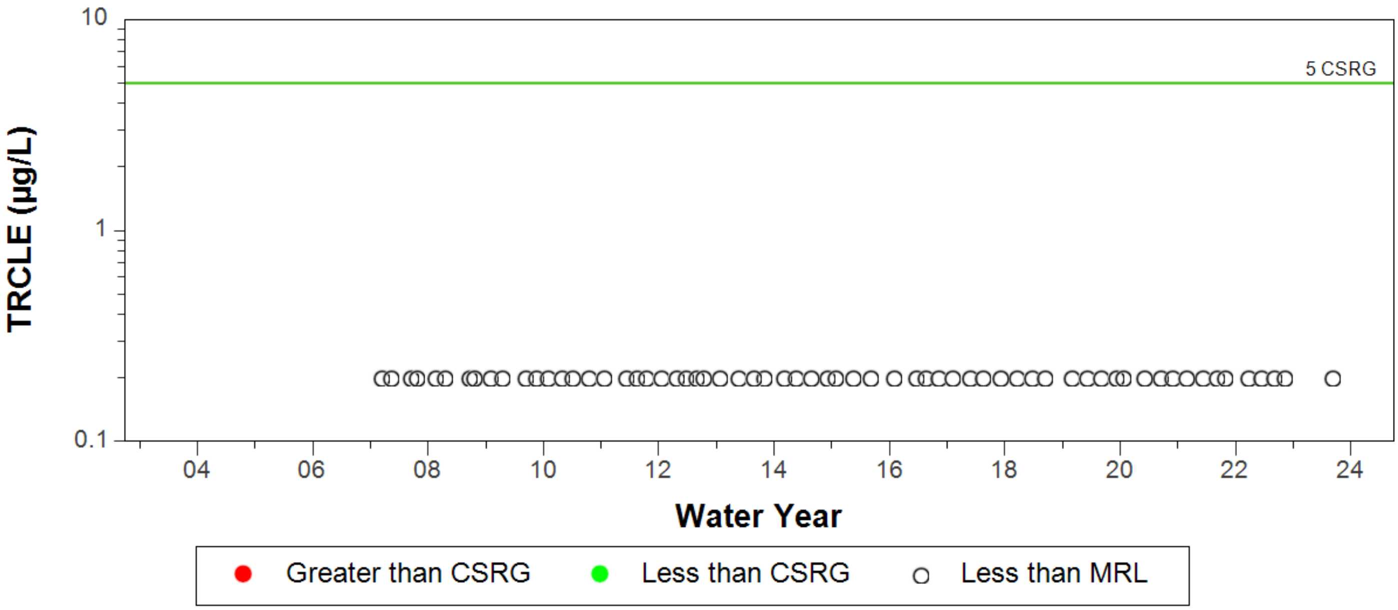
Figure D-16

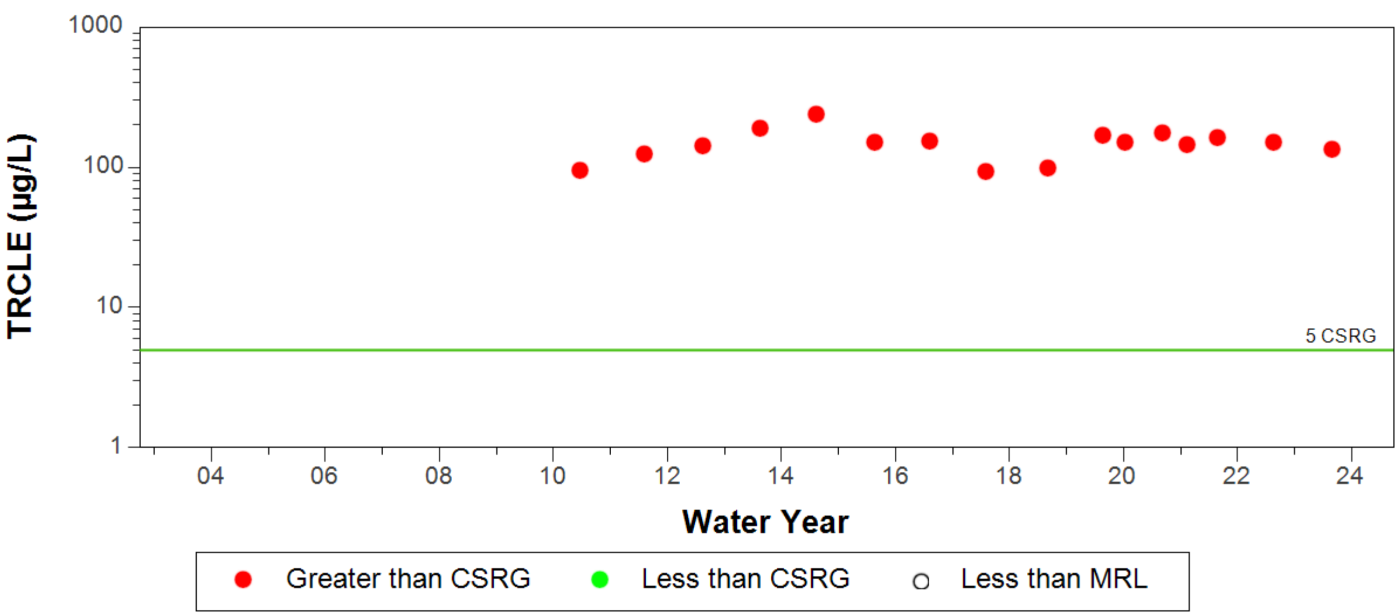
Trichloroethylene Concentration Trends in Performance Wells, Bedrock Ridge Extraction System

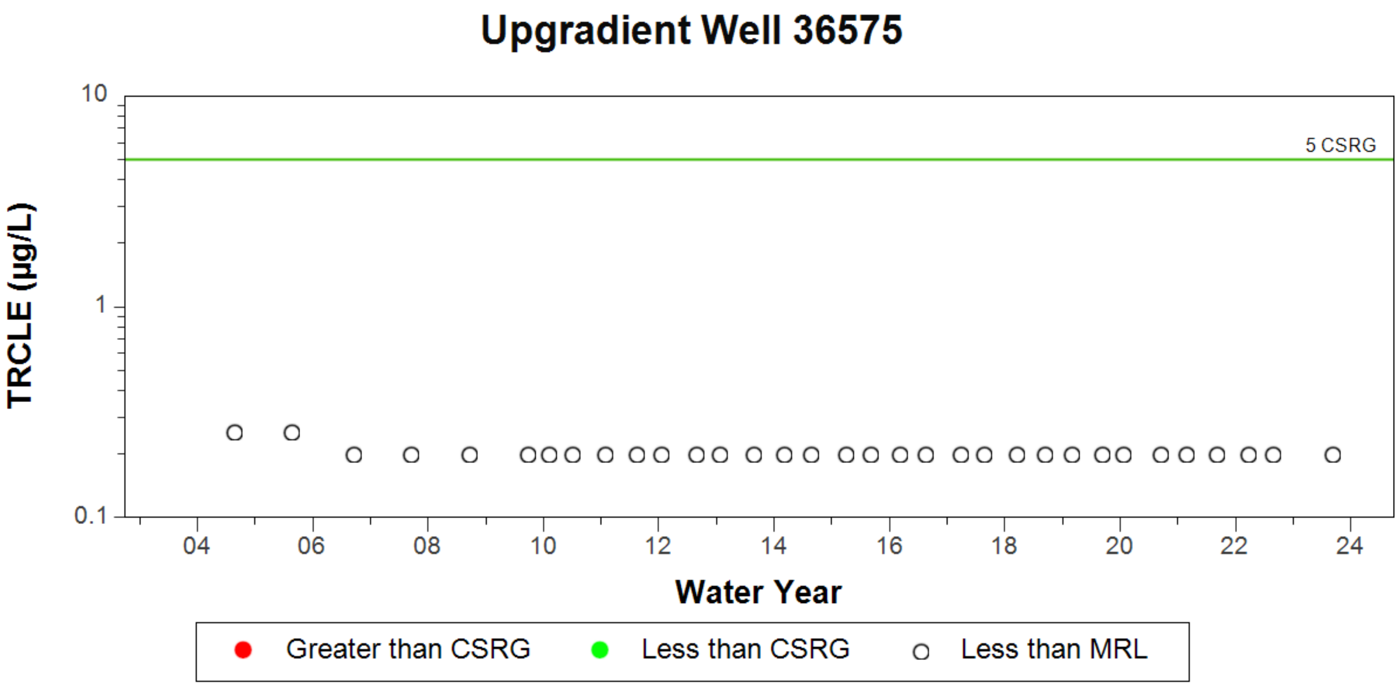
M:\projects\oars\fy23\mxds_BRR_FY23_TRCLE.mxd
6/25/2024

Upgradient Well 36565

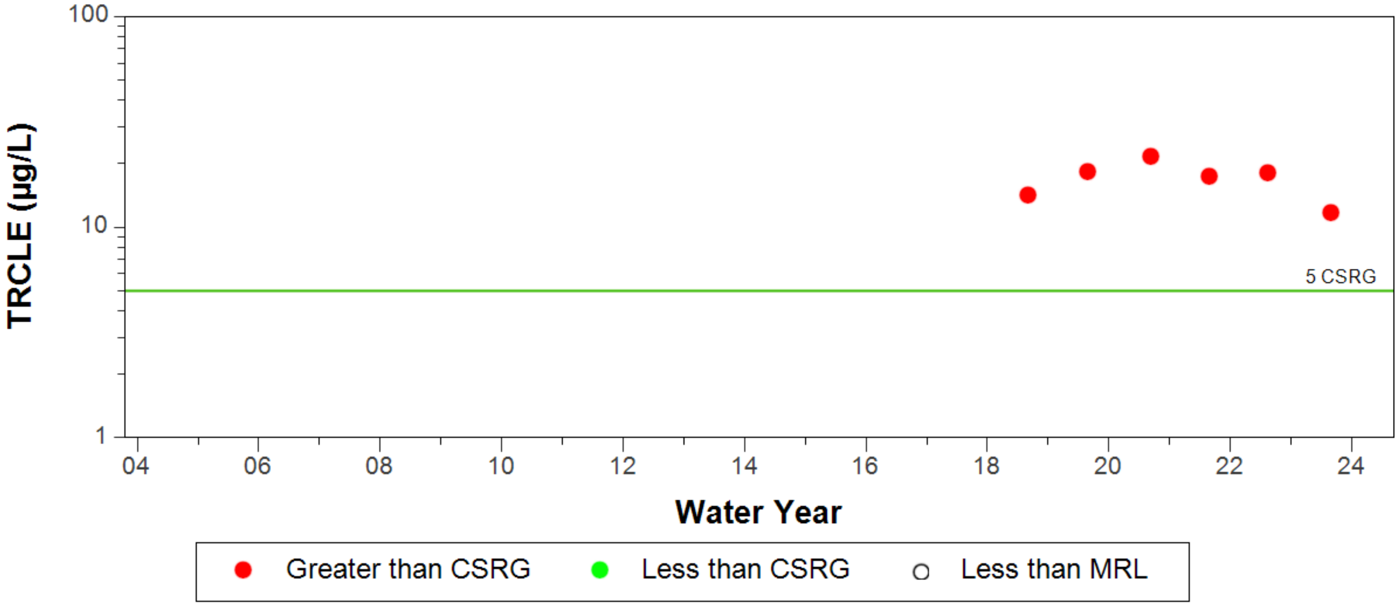


Upgradient Well 36567



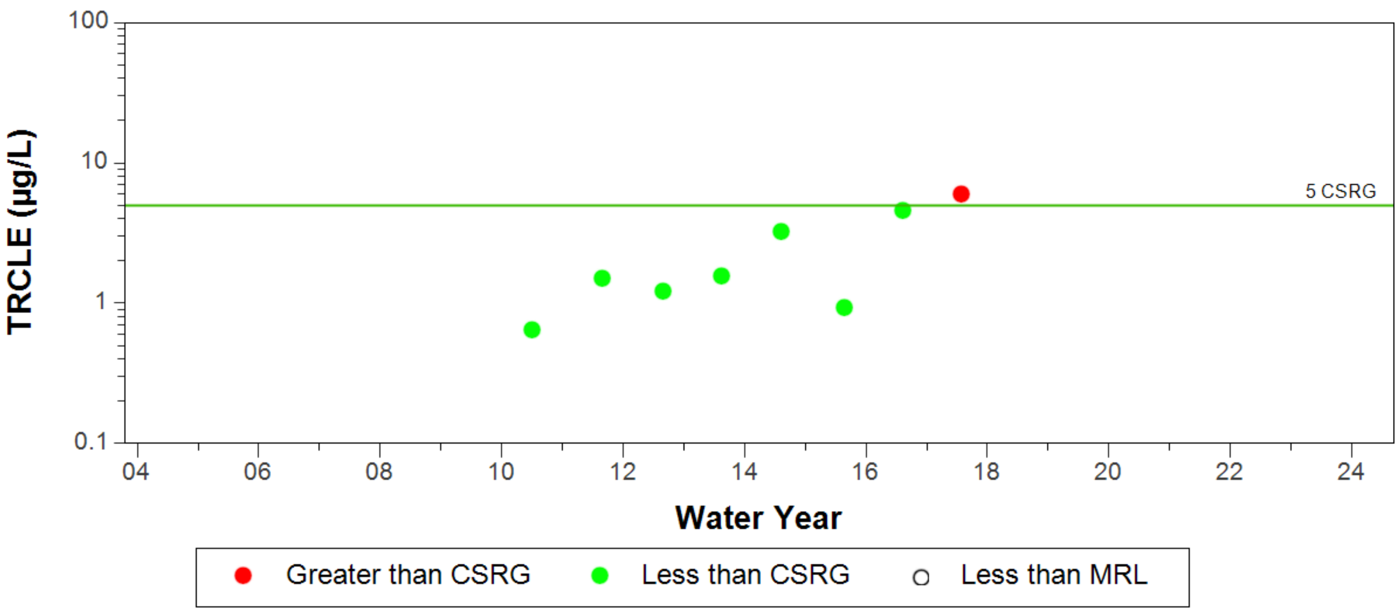

Upgradient Well 36575
TRCLE (µg/L)
10
1
0.1
5 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

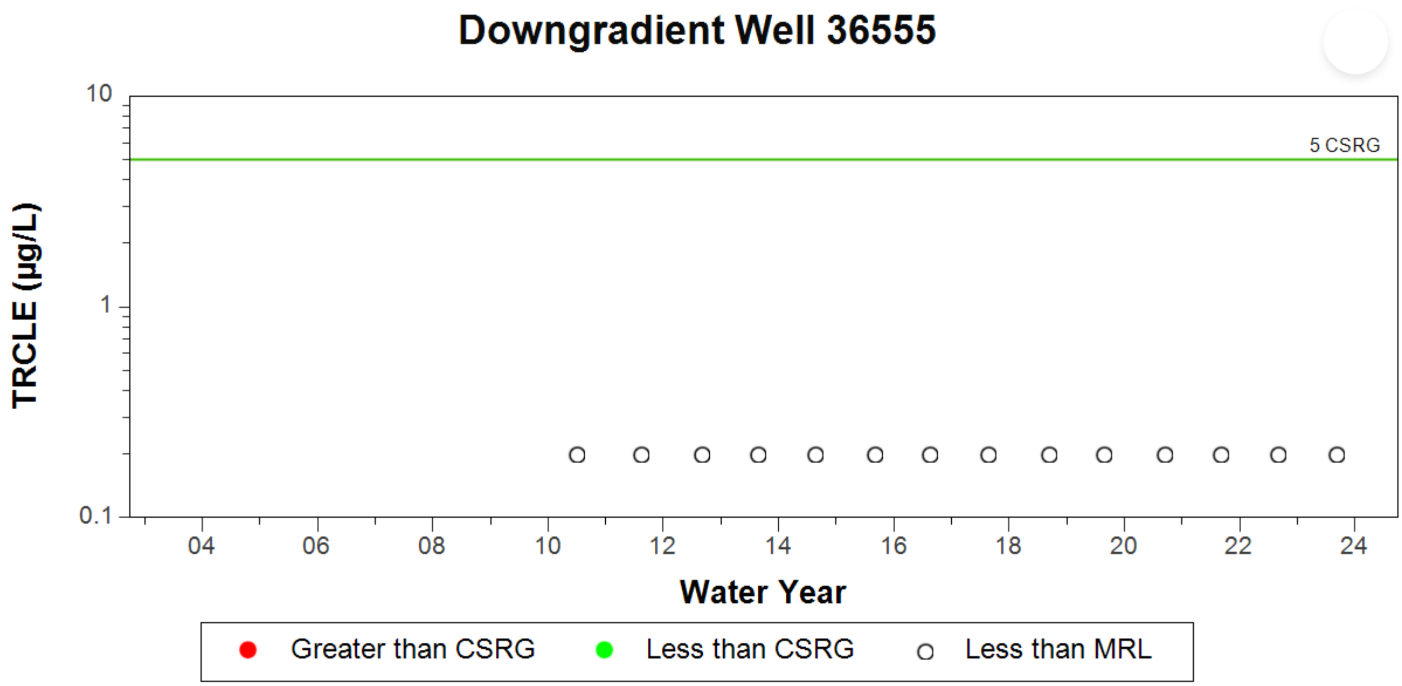
Upgradient Well 36250



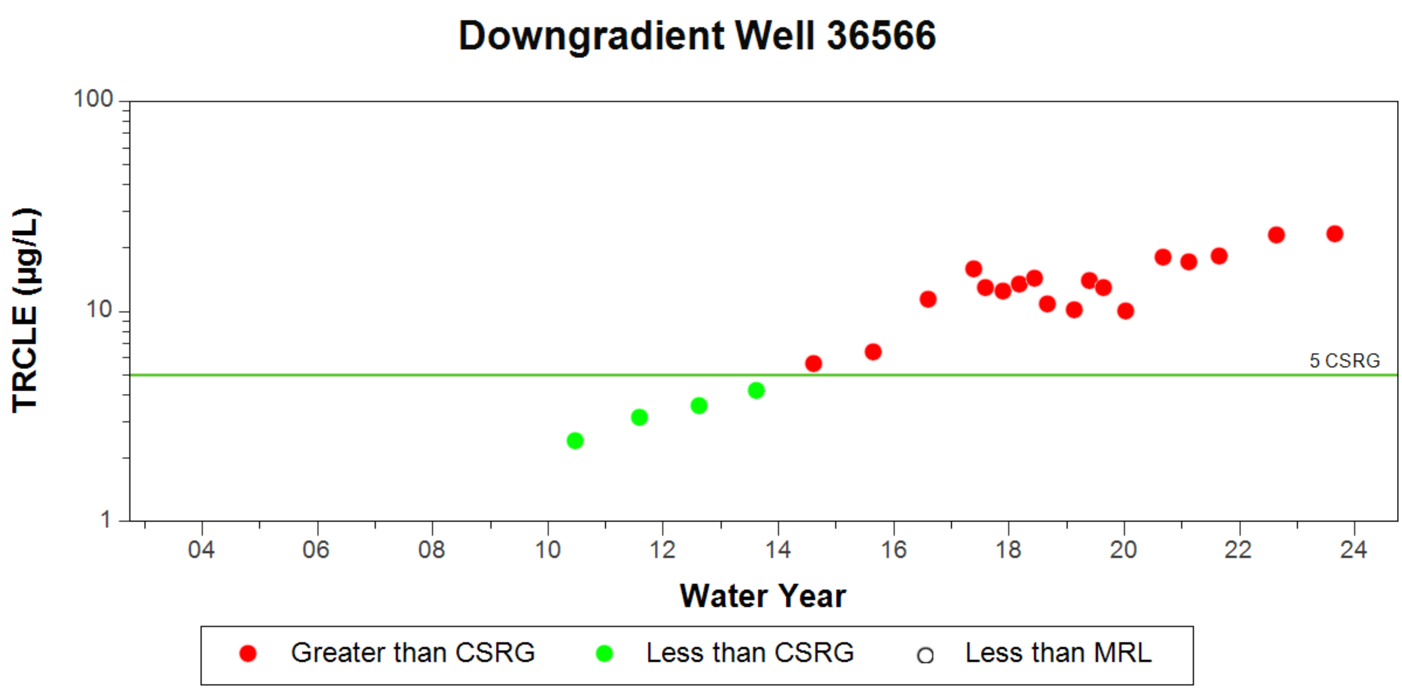
Well 36250 replaced well 36578.

Upgradient Well 36578



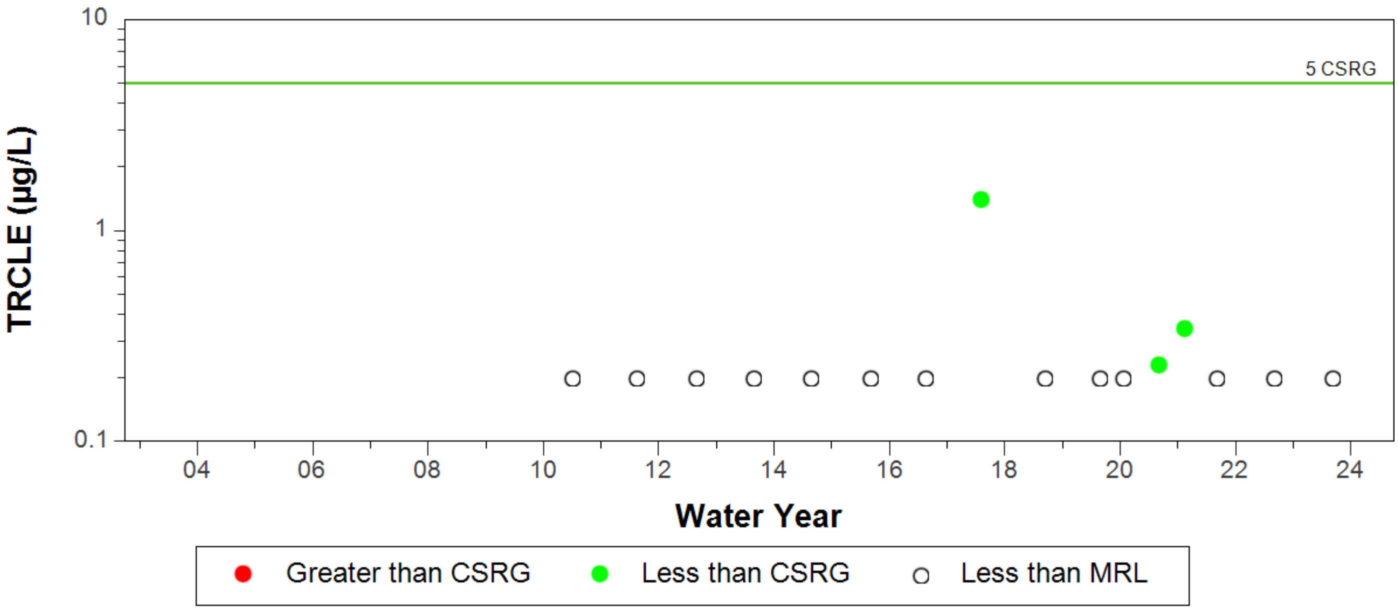


Downgradient Well 36555
10
1
0.1
5 CSRG
TRCLE (µg/L)
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

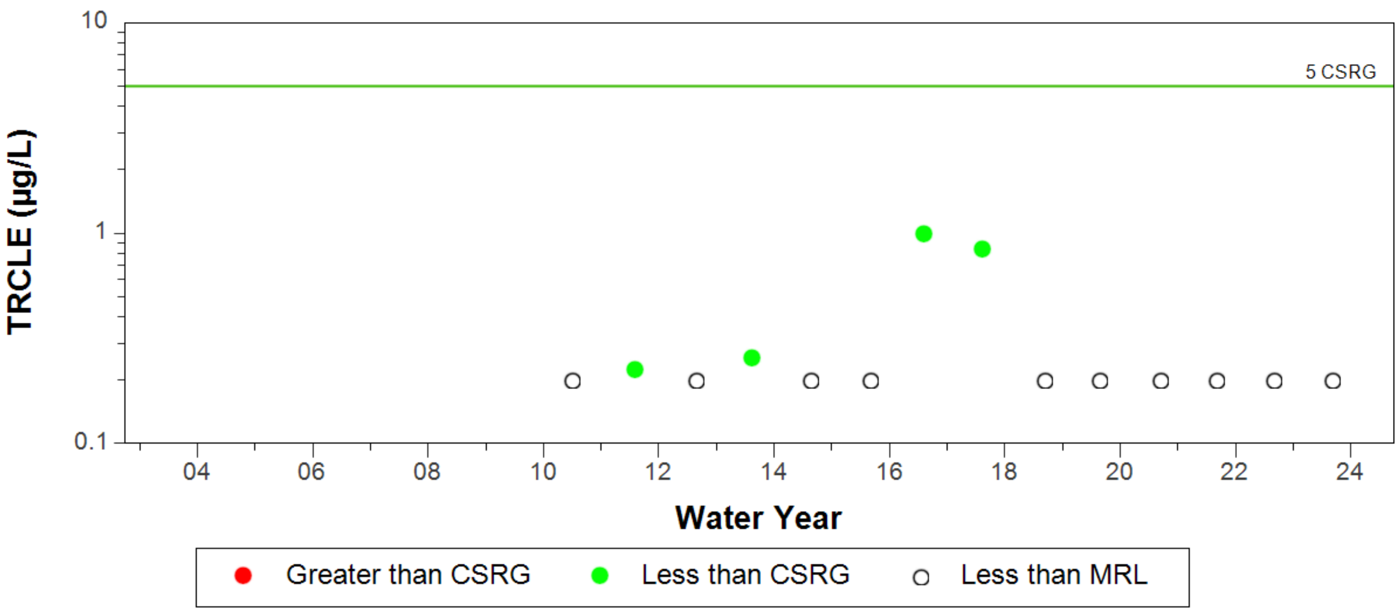


Downgradient Well 36566
100
10
1
5 CSRG
TRCLE (µg/L)
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

Downgradient Well 36571



Downgradient Well 36572



Appendix E

Complex Army Disposal Trenches, Shell Disposal Trenches, Lime Basins, and North Plants Figures and Documentation

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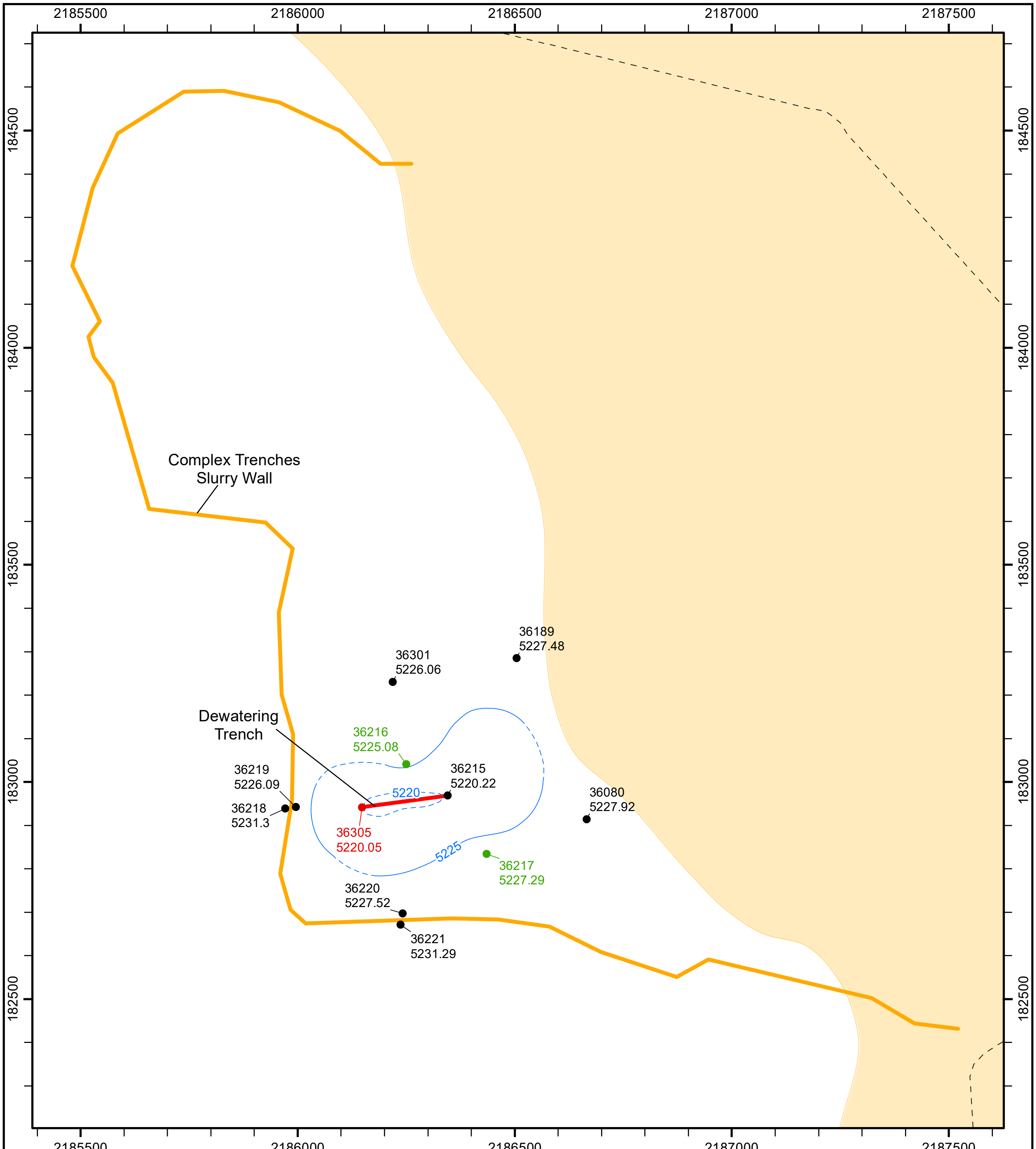

Legend

Army Maintained Area & USFWS Managed Area Border (shown under the Unsaturated Alluvium layer)
Unsaturated Alluvium
Water elevation contour - 5-foot interval
Inferred water elevation contour
Dewatering Trench
Complex Trenches Slurry Wall
Monitoring Wells
Performance Wells
Dewatering Well

Note: Water levels were measured in FY23 Quarter 2.

N
0 165 330
Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

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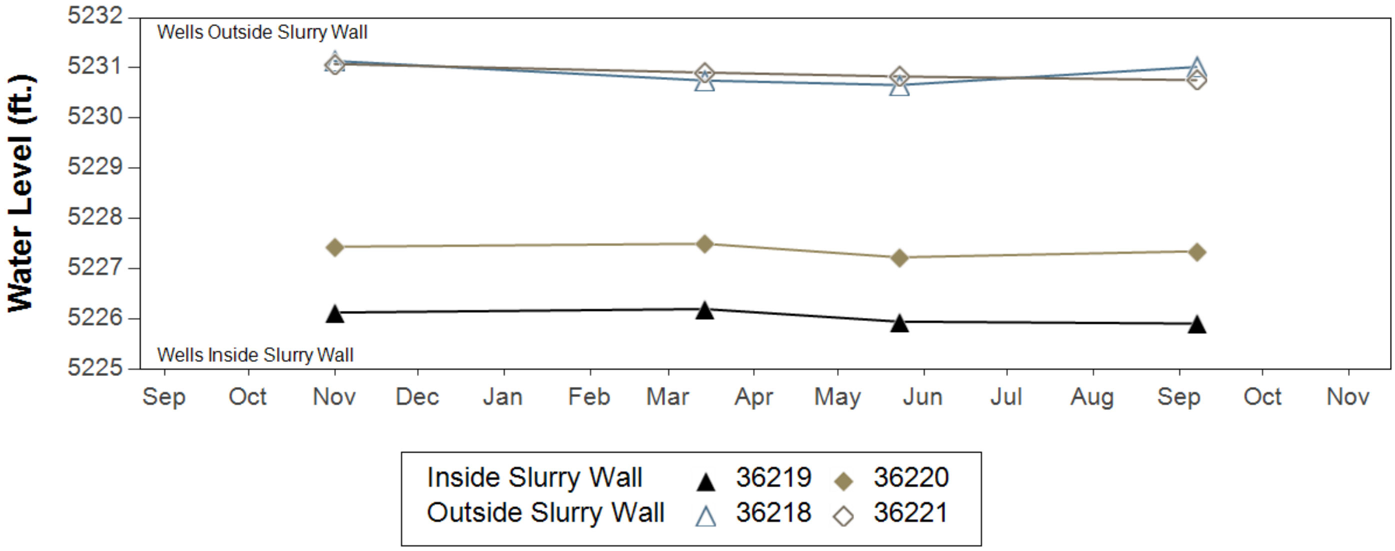
Figure E-1

Complex Army Disposal Trenches Monitoring Well Network and FY23 Potentiometric Surface

M:\projects\oars\fy23\mxds_complex_trenches23_well_location.mxd
5/14/2024

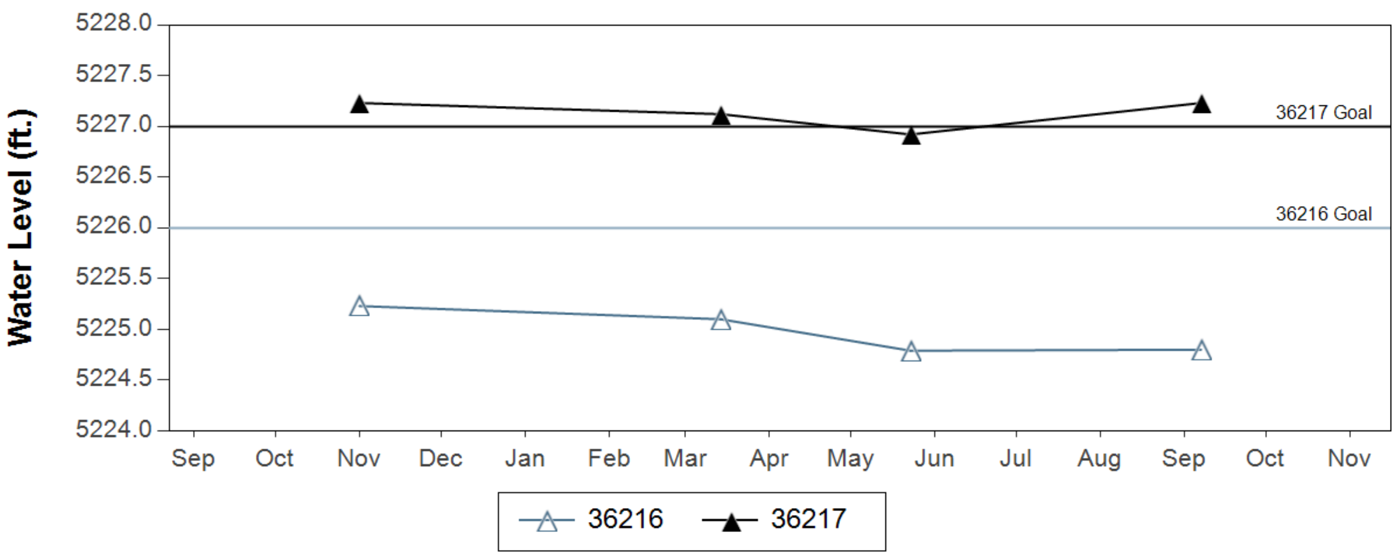
Complex Army Disposal Trenches Paired Wells

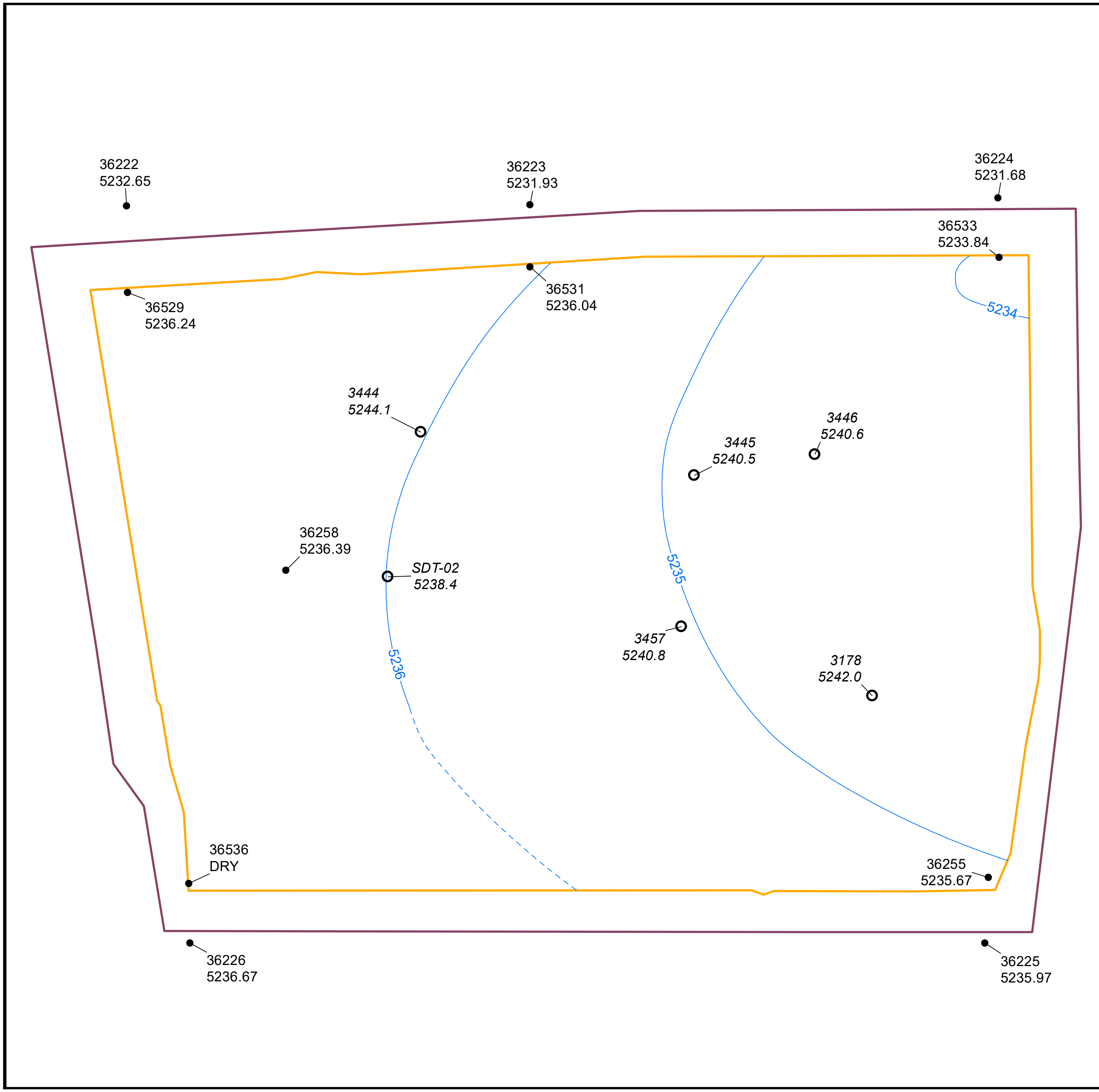
FY2023: 2022-10-01 to 2023-09-30



Complex Army Disposal Trenches Compliance Wells

FY2023: 2022-10-01 to 2023-09-30





Legend

- Water elevation contours - 1-foot interval
- Inferred water elevation contour
- ROD Slurry Wall
- IRA Slurry Wall
- Boreholes with Site ID and Trench Bottom Elevation in Feet (Italics)
- Monitoring Wells with Site ID and Water Elevation in Feet

Note: Water levels were measured in FY23 Quarter 2. See Table 4.2-1 for interpolated water levels at borehole locations for each quarter.

N

0 50 100 150

Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

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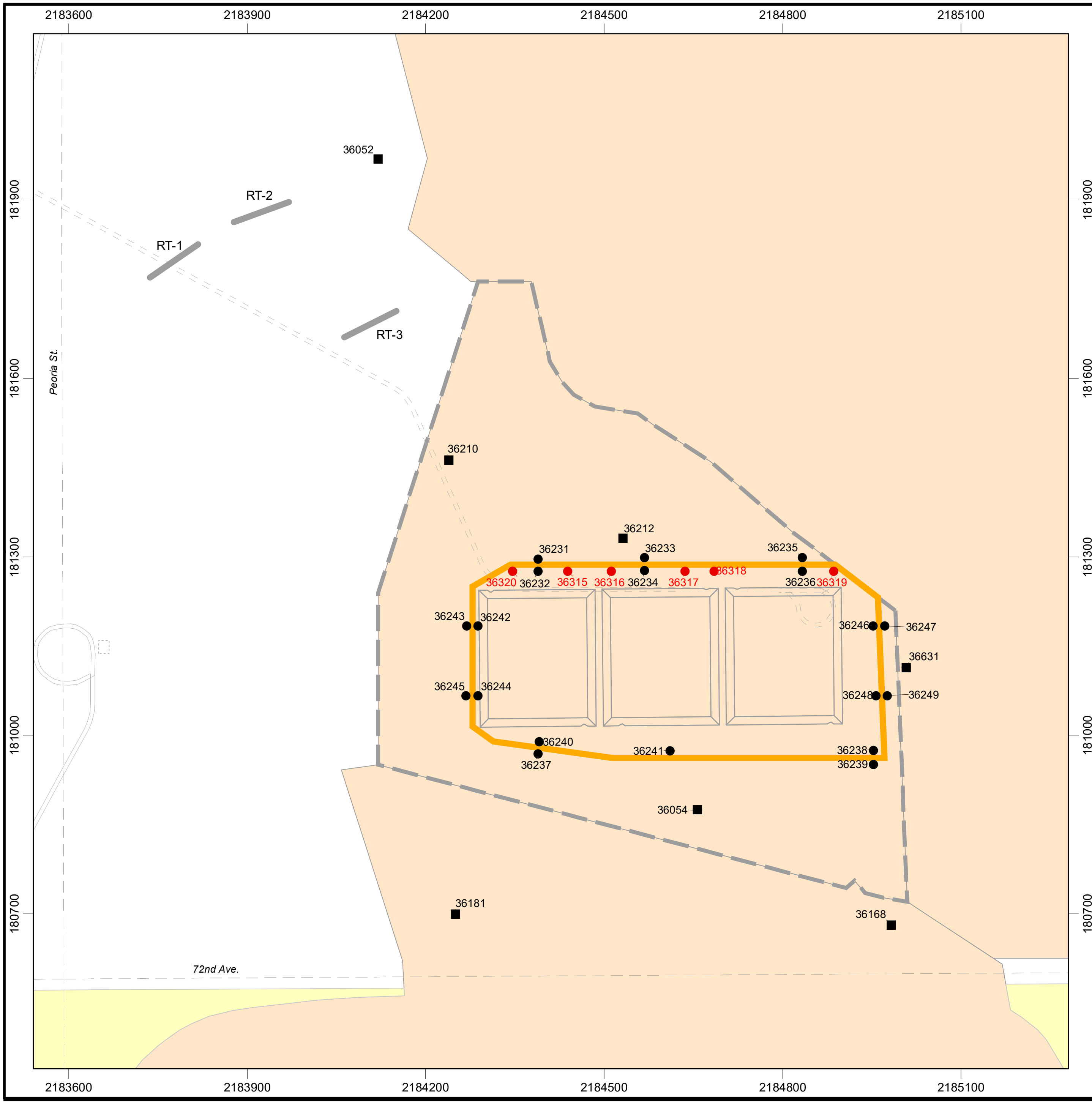
Figure E-3

Shell Disposal Trenches
Well Monitoring Network and
FY23 Groundwater Elevations

M:\projects\oars\fy23\mxds_shelltr23q3.mxd
8/9/2024



Legend

Slurry Wall Dewatering System
- Extraction Wells
- Monitoring Wells
- Other Monitoring Wells
- Inactive Recharge Trenches
- Slurry Wall
- Lime Settling Basins
- Paved Road
- Unpaved Road
- Section Line
- Lime Basins Project Boundary
- RCRA-Equivalent Cover
- 3-foot Soil Cover

N

0 120 240
Feet

NAD27-NGVD29 Datum, US Survey Feet,
Colorado North Zone
Sources: U.S. Army, GIS, OMC, Shell/AECOM

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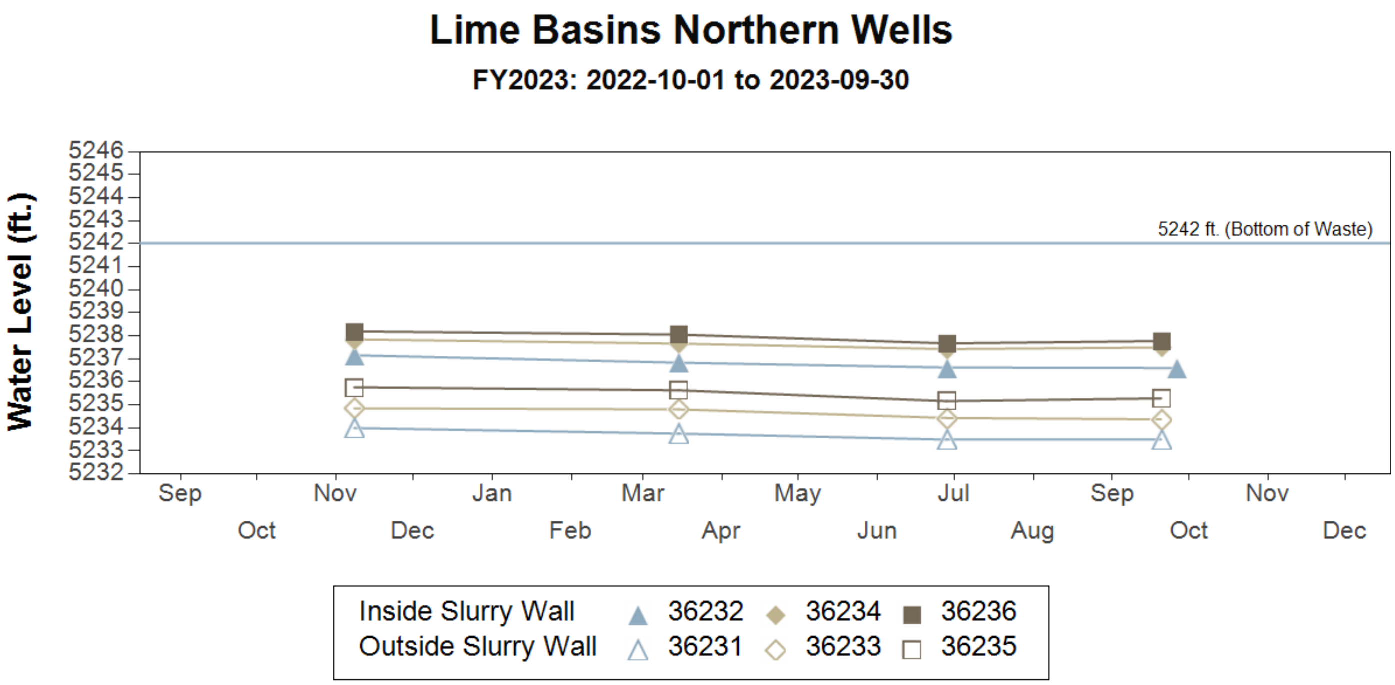
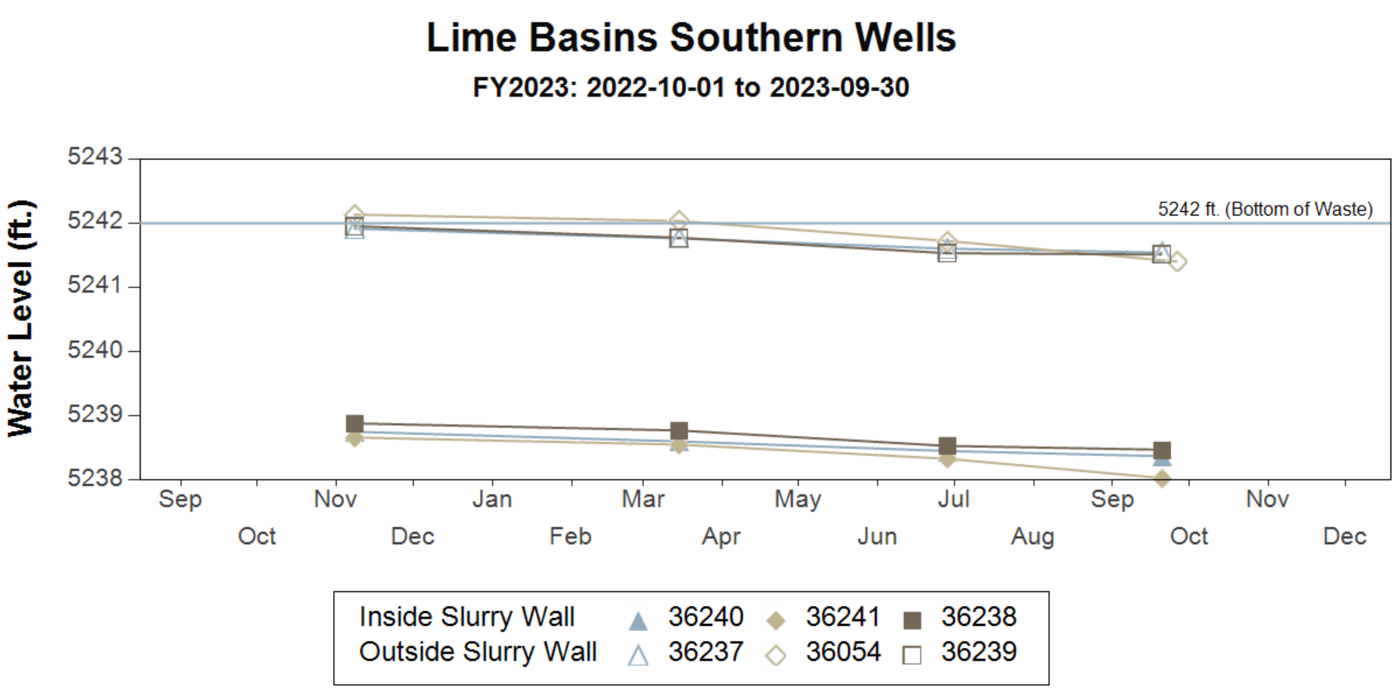
Figure E-4

Lime Basins
Monitoring Well Network

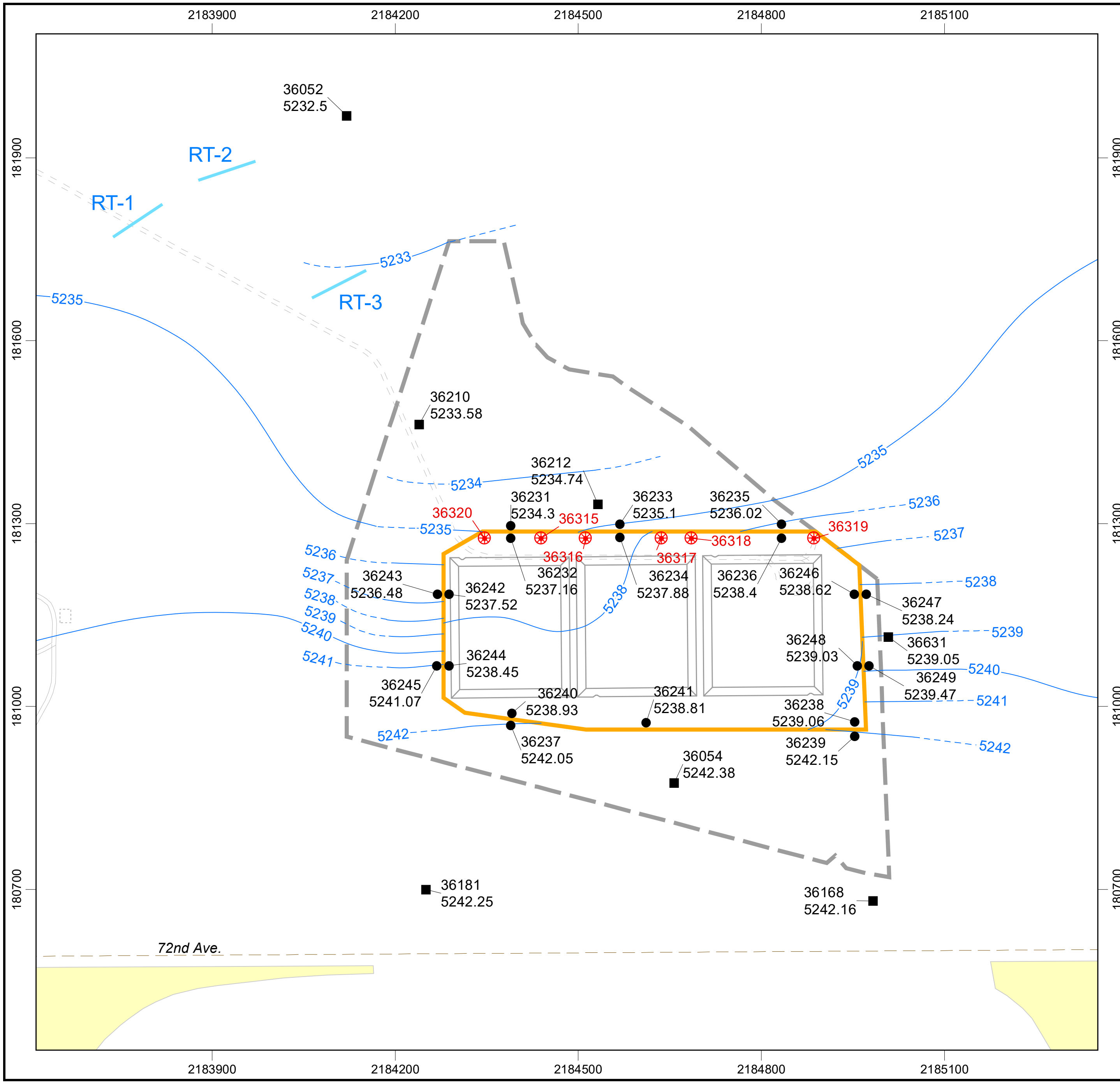
M:\projects\oars\fy23\mxds_limebasins23_well_location.mxd
8/9/2024



Lime Basins Northern Wells
FY2023: 2022-10-01 to 2023-09-30
Water Level (ft.)
5246
5245
5244
5243
5242
5241
5240
5239
5238
5237
5236
5235
5234
5233
5232
5242 ft. (Bottom of Waste)
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Inside Slurry Wall 36232 36234 36236
Outside Slurry Wall 36231 36233 36235



Lime Basins Southern Wells
FY2023: 2022-10-01 to 2023-09-30
Water Level (ft.)
5243
5242
5241
5240
5239
5238
5242 ft. (Bottom of Waste)
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Inside Slurry Wall 36240 36241 36238
Outside Slurry Wall 36237 36054 36239



Legend

Slurry Wall Dewatering System
- Extraction Wells
- Monitoring Wells

LTMP Wells
- Monitoring Wells
- Recharge Trenches (Not Operational)
- Slurry Wall
- Lime Settling Basins
- Paved Road
- Unpaved Road
- Section Line
- Section 36 Lime Basins Project Boundary
- 3-foot Soil Cover
- Water elevation contour - 1-foot interval
- Inferred water elevation contour

Note: Water levels were measured in FY23 Quarter 2.

N

0 120 240
Feet

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

Sources: U.S. Army, GIS, OMC, Shell/AECOM

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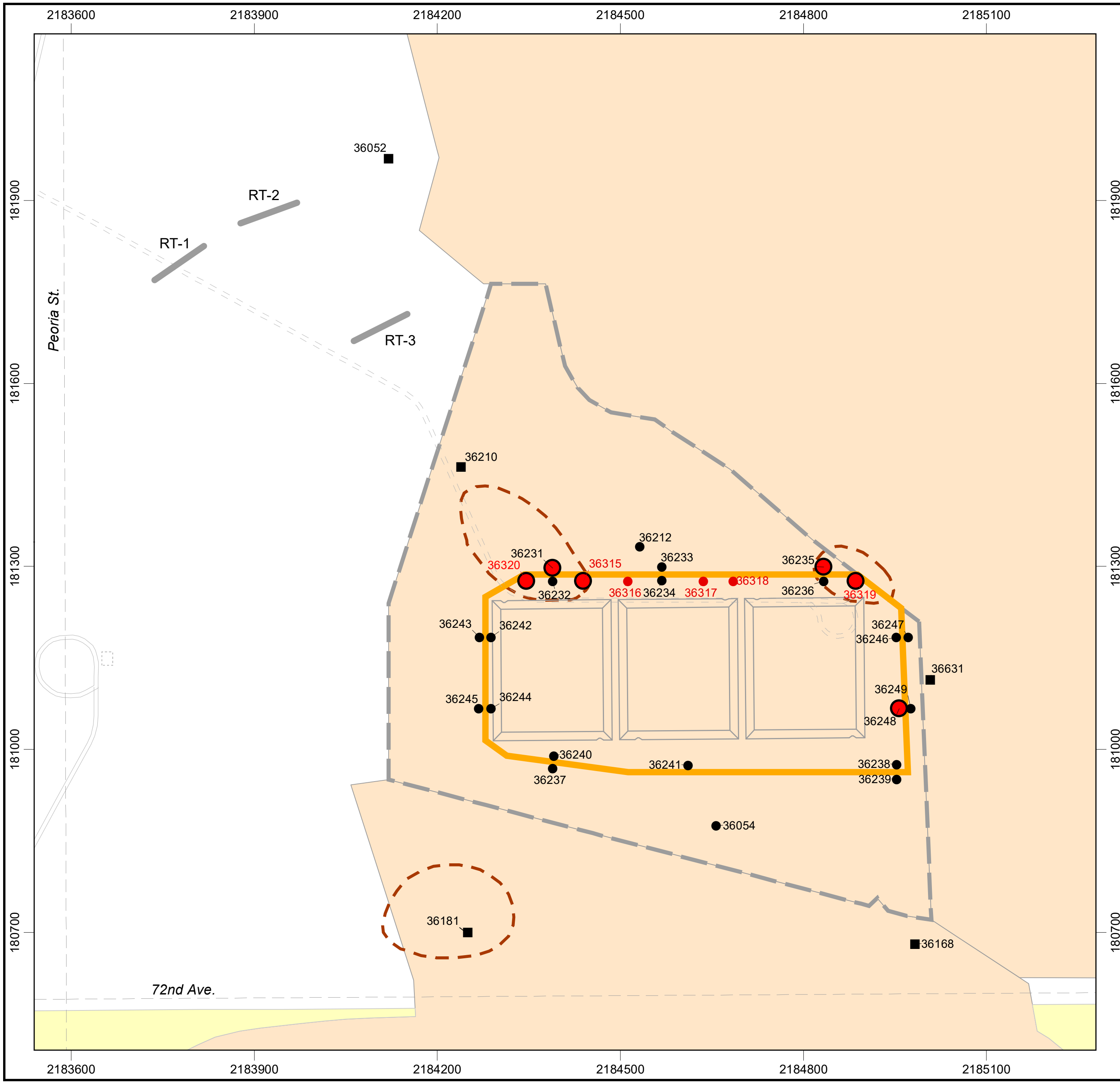
Figure E-6

Lime Basins Groundwater System FY23 Potentiometric Surface

M:\projects\oars\fy23\mxds_limebasins23q3.mxd
6/25/2024



Legend

- Extraction Wells
- LTMP Lime Basins Performance Wells
- Other Monitoring Wells
- Well with measurable DNAPL in FY23
- Inactive Recharge Trenches
- Slurry Wall
- Lime Settling Basins
- Paved Road
- Unpaved Road
- Section Line
- Section 36 Lime Basins Project Boundary
- RCRA-Equivalent Cover
- 3-foot Soil Cover
- Structure Location
- DNAPL RI/FS Data

Note: All wells are measured for DNAPL except LTMP wells 36210, 36631, 36168 and 36181.

N

0 120 240
Feet

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

Sources: U.S. Army, GIS, OMC, Shell/AECOM

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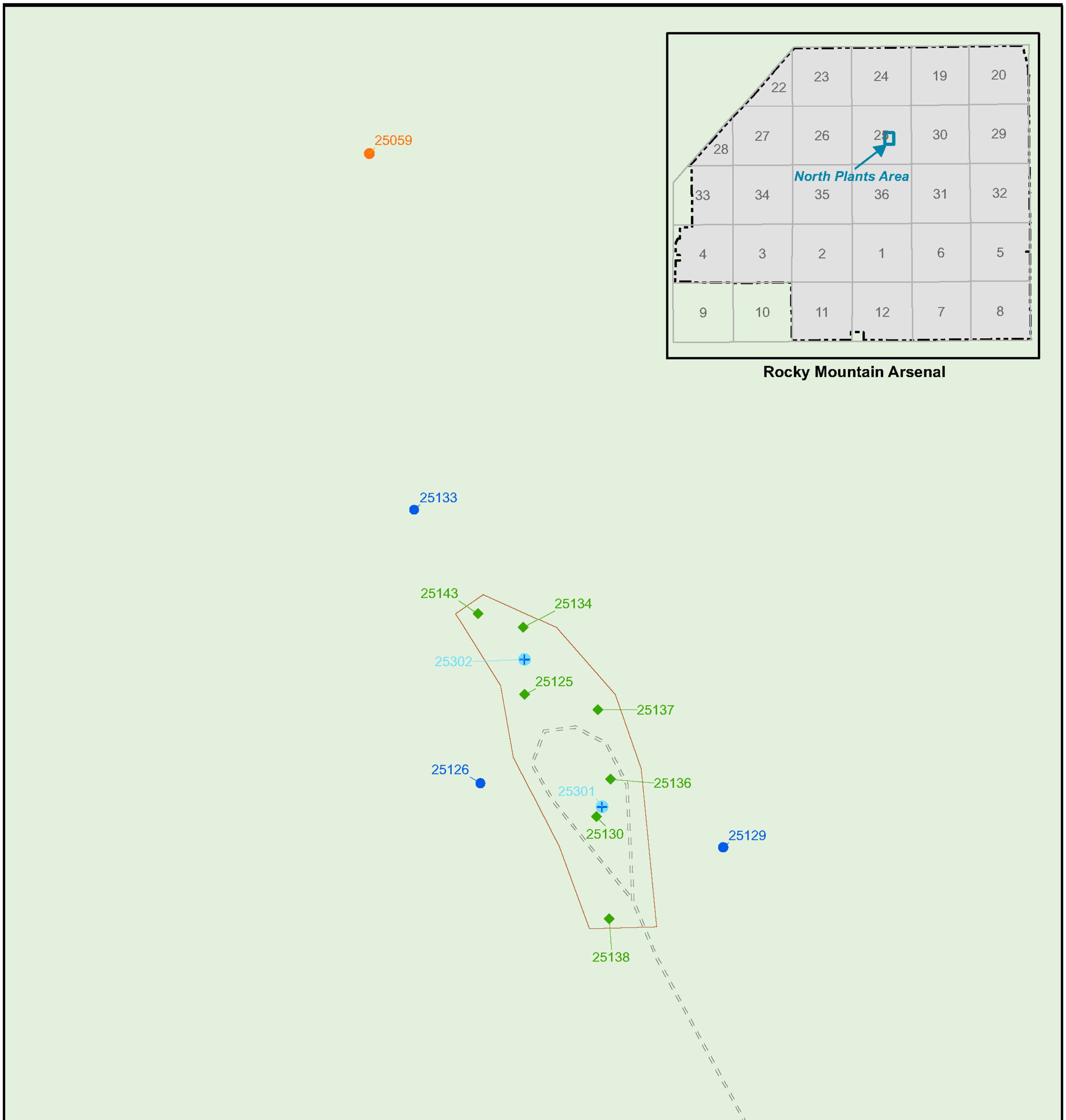
Figure E-7

FY23 Lime Basins
Delineation of Suspected
DNAPL Source Zones

M:\projects\oars\fy23\mxds_limebasins23_dnapl.mxd
8/9/2024



Legend

	RMA Boundary		Piezometer
25	Sections		Recovery Well
	Proposed Bison Fence		LTMP Water Quality Tracking Well
	Access Road		LTMP Water Level Tracking Wells

N

0 25 50 100 Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

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Figure E-8

North Plants LNAPL Long-Term Monitoring Well Network

P:\projects\remedy\np_chem\mxds\LongTermNPlantsLNAPLMonWell.mxd
8/31/2023

Appendix F
First Creek Treatment System
Figures and Documentation

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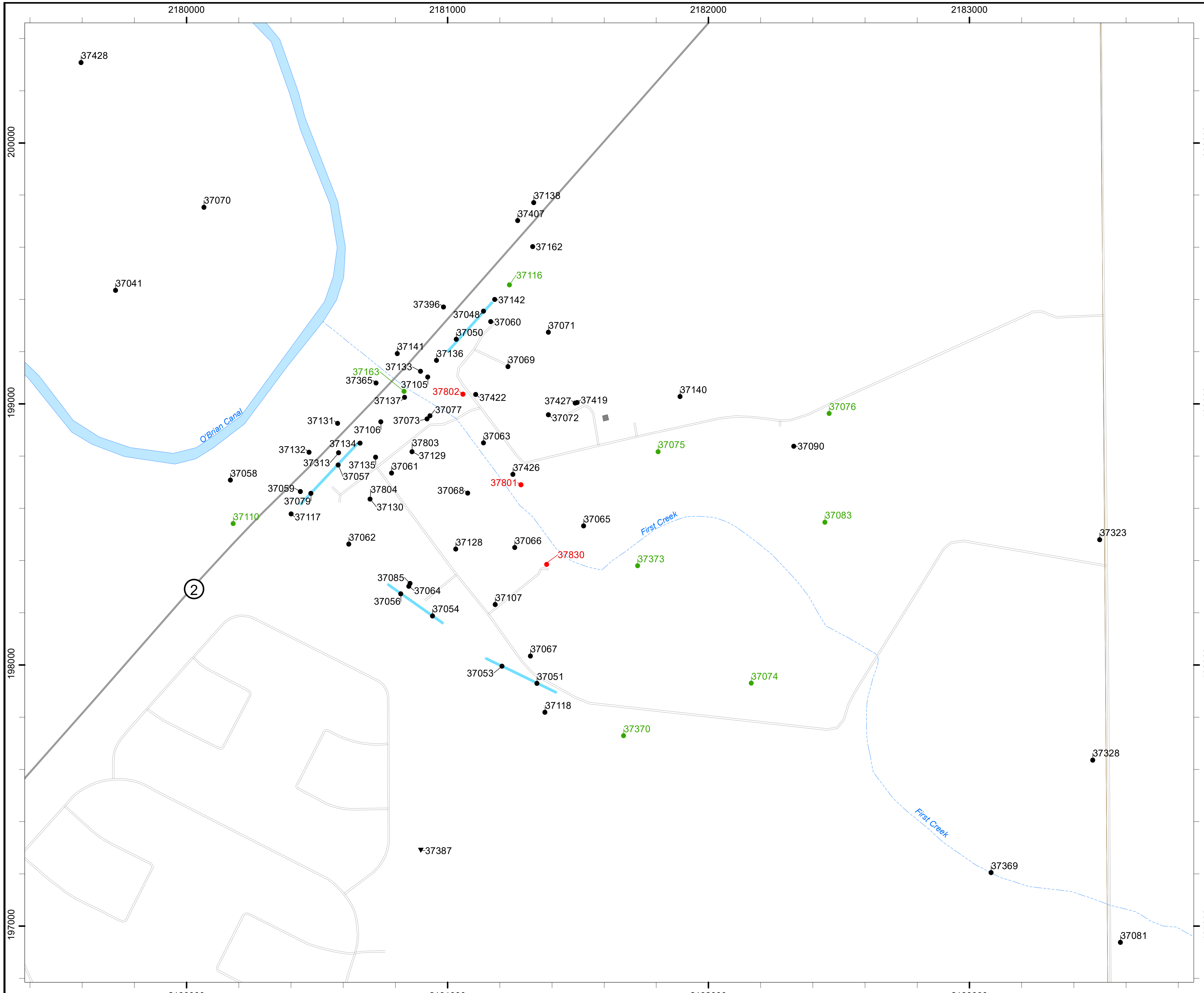

Legend

- Section Lines
- Treatment Building
- Lakes, Ponds, and Rivers
- Intermittent Streams
- Ditches
- Recharge Trenches
- Local Roads
- Secondary Roads
- Primary Roads
- Unimproved Roads
- Performance Water Quality Wells
- Extraction Wells

Monitoring Wells

- Questionable Flow System
- Unconfined Flow System

N

0 300 600 Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

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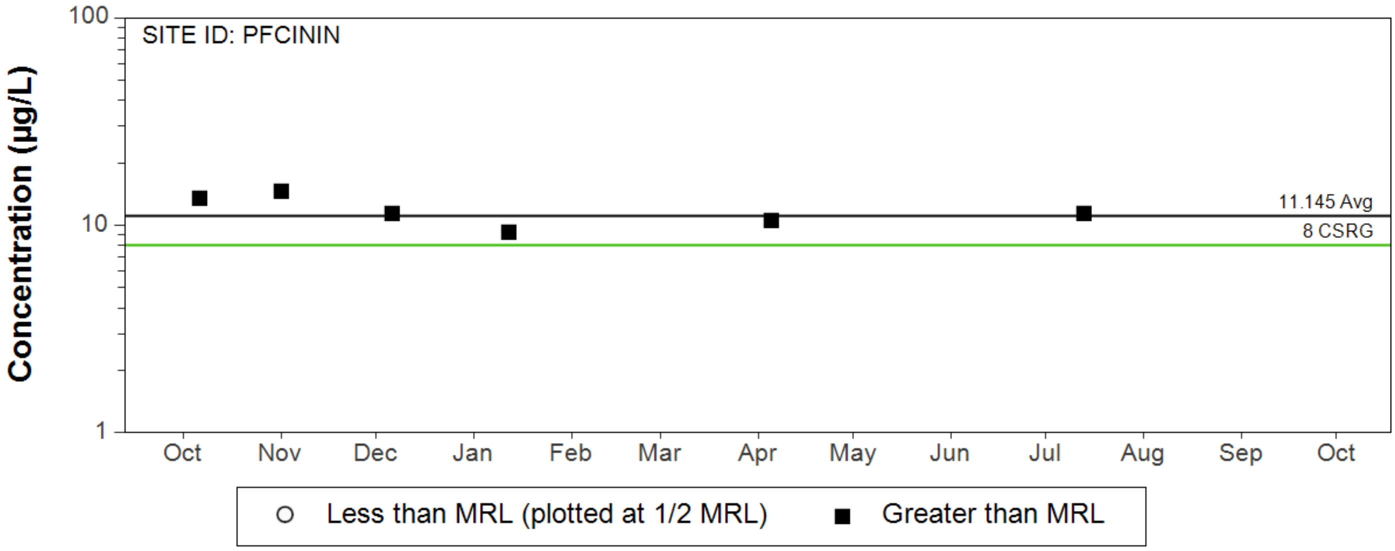
Figure F-1

First Creek Treatment System
Monitoring Well Network
for the Unconfined Flow System

M:\projects\oars\fy23\mxds_fc23_well_location.mxd
6/25/2024

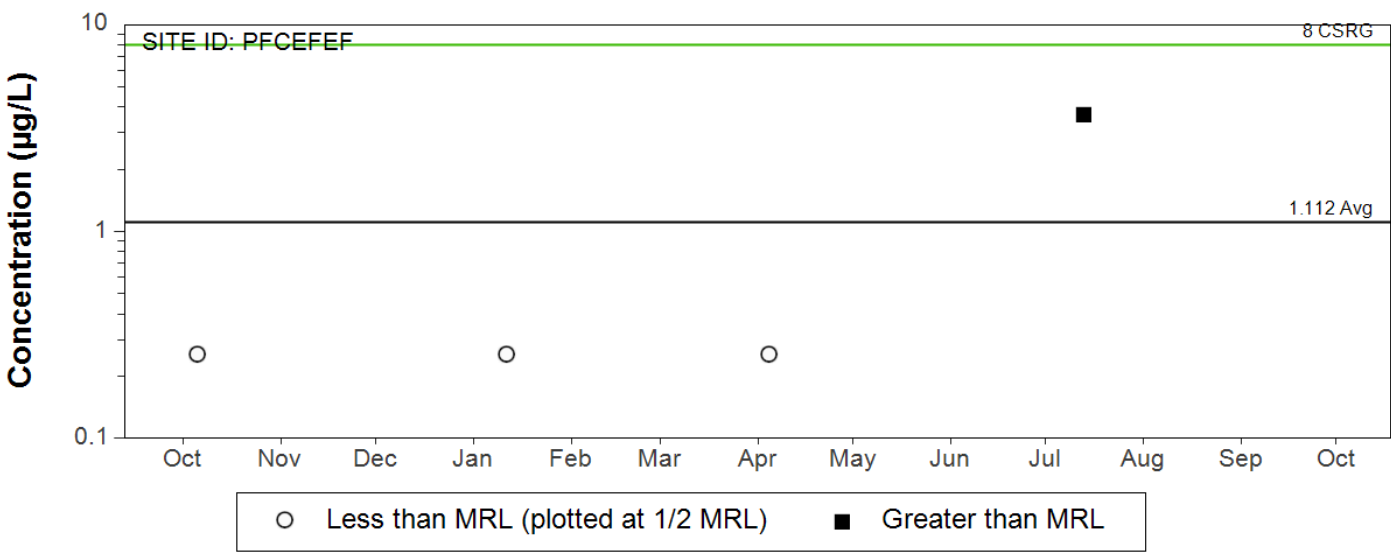
First Creek Treatment Plant Influent - DIMP

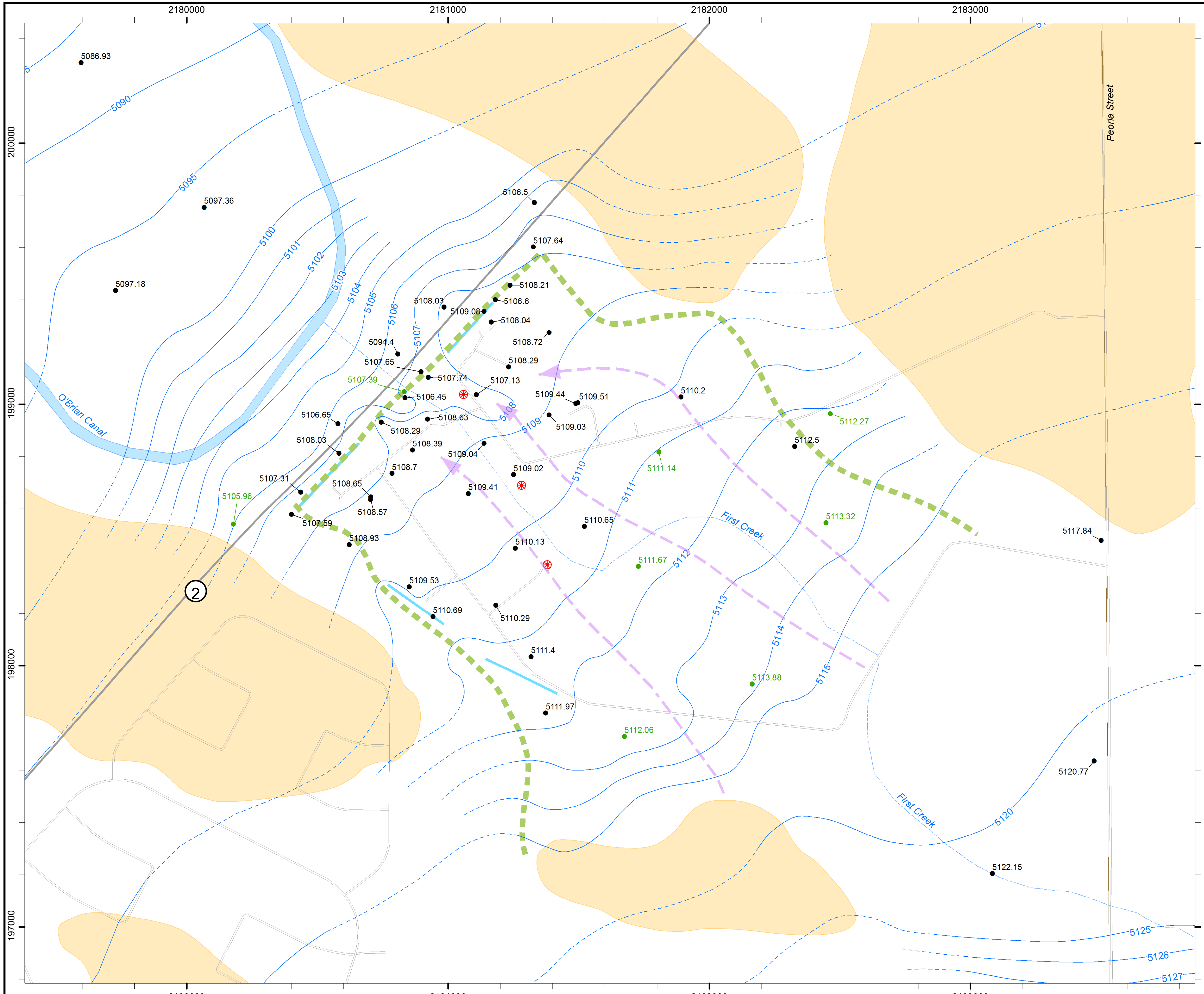
2022-10-01 to 2023-09-30



First Creek Treatment Plant Effluent - DIMP

2022-10-01 to 2023-09-30





Legend

- Unsaturated Alluvium
- Section Lines
- Water elevation contour - 1-foot interval
- Inferred water elevation contour
- Recharge Trenches
- Capture Zone
- Groundwater Flow Direction
- Lakes, Ponds, Rivers
- Intermittent Streams
- Ditches
- Local Roads
- Secondary Roads
- Primary Roads

Measured Wells Used for Contouring with Water Elevations

- Monioring Wells
- 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.

Note: Water levels were measured in FY23 Quarter 2.

N

0 200 400 Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

Program Manager
Rocky Mountain Arsenal

U.S. Army • COMMITTED TO PROTECTION OF THE ENVIRONMENT •

Figure F-3

FY23 Potentiometric Surface
of the Unconfined Flow System,
First Creek Treatment System

M:\projects\oars\fy23\mxds_FC_FY23.mxd
6/25/2024

Exhibit F-4. Summary of FY23 FCTS Performance Water Quality Monitoring

Well ID	Sample Date	Analyte Concentration (ug/L, CSRG/PQL shown in italics)									
		12DCLE	13DCLB	ALDRN	AS	ATZ	C6H6	CCL4	CHCL3	CL	CL6CP
		0.4	*6.5*	*0.014*	*2.35*	*3*	*5*	*0.3*	*6*	*250,000*	*0.23*
Upgradient Wells											
37074	6/15/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	LT 0.2	**200,000**	LT 0.00983
37075	6/14/23	LT 0.2	LT 0.2	LT 0.00605	**1.14**	—	LT 0.2	LT 0.2	LT 0.2	**210,000**	LT 0.00983
37076	6/14/23	**0.673**	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	LT 0.2	**320,000**	LT 0.00983
37083	9/20/23	**0.318**	LT 0.2	**0.0337**	LT 1	—	LT 0.2	LT 0.2	LT 0.2	**293,000**	LT 0.00983
37370	6/15/23	LT 0.2	LT 0.2	LT 0.00605	**1.3**	—	LT 0.2	LT 0.2	LT 0.2	**380,000**	LT 0.00983
37373	9/20/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	LT 0.2	**335,000**	LT 0.00983
Downgradient Wells											
37110	6/14/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	0.316	**1,300,000**	LT 0.00983
37116	9/21/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	LT 0.2	**423,000**	LT 0.00983
37163	9/19/23	LT 0.2	LT 0.2	LT 0.00605	**1.83**	—	LT 0.2	LT 0.2	LT 0.2	**157,000**	LT 0.00983
Extraction Wells											
37801	5/23/23	LT 0.2	LT 0.2	LT 0.00605	**1.42**	—	LT 0.2	LT 0.2	LT 0.2	**205,000**	LT 0.00983
37802	5/23/23	LT 0.2	LT 0.2	LT 0.00605	**1.28**	—	LT 0.2	LT 0.2	LT 0.2	**213,000**	LT 0.00983
37830	5/23/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	LT 0.2	**210,000**	LT 0.00983

Notes:

Values shaded and in BOLD are concentrations that exceed the CSRG/PQL.

[1] The value for chlordane (CLDAN) is the sum of its two isomers, alpha-chordane (ACLDAN) and gamma-chlordane (GCLDAN).

LT – Nondetection reported less than the method reporting limit

Exhibit F-4. Summary of FY23 FCTS Performance Water Quality Monitoring

Well ID	Sample Date	Analyte Concentration (ug/L, CSRG/PQL shown in italics)										
		CLC6H5	CPMS	CPMSO	CPMSO2	DBCP	DCPD	DIMP	DITH	DLDRN	ENDRN	ETC6H5
		25	*30*	*36*	*36*	*0.2*	*46*	*8*	*18*	*0.013*	*2*	*1000*
Upgradient Wells												
37074	6/15/23	LT 0.2	—	—	—	LT 0.0194	LT 0.2	LT 0.5	—	**0.0219**	LT 0.00488	LT 0.2
37075	6/14/23	LT 0.2	—	—	—	LT 0.0196	**0.711**	**5.49**	—	**0.00826**	LT 0.00488	LT 0.2
37076	6/14/23	LT 0.2	—	—	—	LT 0.0192	**17**	**133**	—	**0.0545**	LT 0.00488	LT 0.2
37083	9/20/23	LT 0.2	—	—	—	LT 0.0194	**8.27**	**75.7**	—	**0.0157**	LT 0.00488	LT 0.2
37370	6/15/23	LT 0.2	—	—	—	LT 0.0194	LT 0.2	**1.4**	—	**0.0461**	LT 0.00488	LT 0.2
37373	9/20/23	LT 0.2	—	—	—	LT 0.0194	**0.701**	**33.5**	—	**0.00684**	LT 0.00488	LT 0.2
Downgradient Wells												
37110	6/14/23	LT 0.2	—	—	—	LT 0.0192	LT 0.2	LT 0.5	—	LT 0.00252	LT 0.00488	LT 0.2
37116	9/21/23	LT 0.2	—	—	—	LT 0.0194	LT 0.2	**4.74**	—	**0.00642**	LT 0.00488	LT 0.2
37163	9/19/23	LT 0.2	—	—	—	LT 0.0194	LT 0.2	**1.36**	—	**0.01**	**0.0126**	LT 0.2
Extraction Wells												
37801	5/23/23	LT 0.2	—	—	—	LT 0.0196	**0.34**	**19.3**	—	**0.00275**	LT 0.00488	LT 0.2
37802	5/23/23	LT 0.2	—	—	—	LT 0.0194	LT 0.2	**6.72**	—	**0.00245**	LT 0.00488	LT 0.2
37830	5/23/23	LT 0.2	—	—	—	LT 0.0194	LT 0.2	**21.9**	—	LT 0.00252	LT 0.00488	LT 0.2

Notes:

Values shaded and in BOLD are concentrations that exceed the CSRG/PQL.

[1] The value for chlordane (CLDAN) is the sum of its two isomers, alpha-chordane (ACLDAN) and gamma-chlordane (GCLDAN).

LT – Nondetection reported less than the method reporting limit

Exhibit F-4. Summary of FY23 FCTS Performance Water Quality Monitoring

Well ID	Sample Date	Analyte Concentration (ug/L, CSRG/PQL shown in italics)								
		F	ISODR	MEC6H5	MLTHN	NNDMEA	NNDNPA	OXAT	PPDDE	PPDDT
		2000	*0.06*	*1000*	*100*	*0.009*	*0.005*	*160*	*0.1*	*0.1*
Upgradient Wells										
37074	6/15/23	**2320**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	**0.0237**
37075	6/14/23	**1860**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247
37076	6/14/23	**1990**	LT 0.00619	LT 0.2	—	LT 0.0048	**0.0251**	—	LT 0.00403	LT 0.00247
37083	9/20/23	**1970**	**0.022**	LT 0.2	—	LT 0.0048	**0.00996**	—	LT 0.00403	**0.0342**
37370	6/15/23	**2080**	**0.026**	LT 0.2	—	LT 0.0048	LT 0.003	—	**0.0241**	LT 0.00247
37373	9/20/23	**1440**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	**0.0266**
Downgradient Wells										
37110	6/14/23	**3700**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247
37116	9/21/23	**1070**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	**0.00649**	**0.0292**
37163	9/19/23	**1330**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	**0.0102**
Extraction Wells										
37801	5/23/23	**1410**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247
37802	5/23/23	**1100**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247
37830	5/23/23	**2160**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	**0.00495**	**0.0168**

Notes:

Values shaded and in BOLD are concentrations that exceed the CSRG/PQL.

[1] The value for chlordane (CLDAN) is the sum of its two isomers, alpha-chordane (ACLDAN) and gamma-chlordane (GCLDAN).

LT – Nondetection reported less than the method reporting limit

Exhibit F-4. Summary of FY23 FCTS Performance Water Quality Monitoring

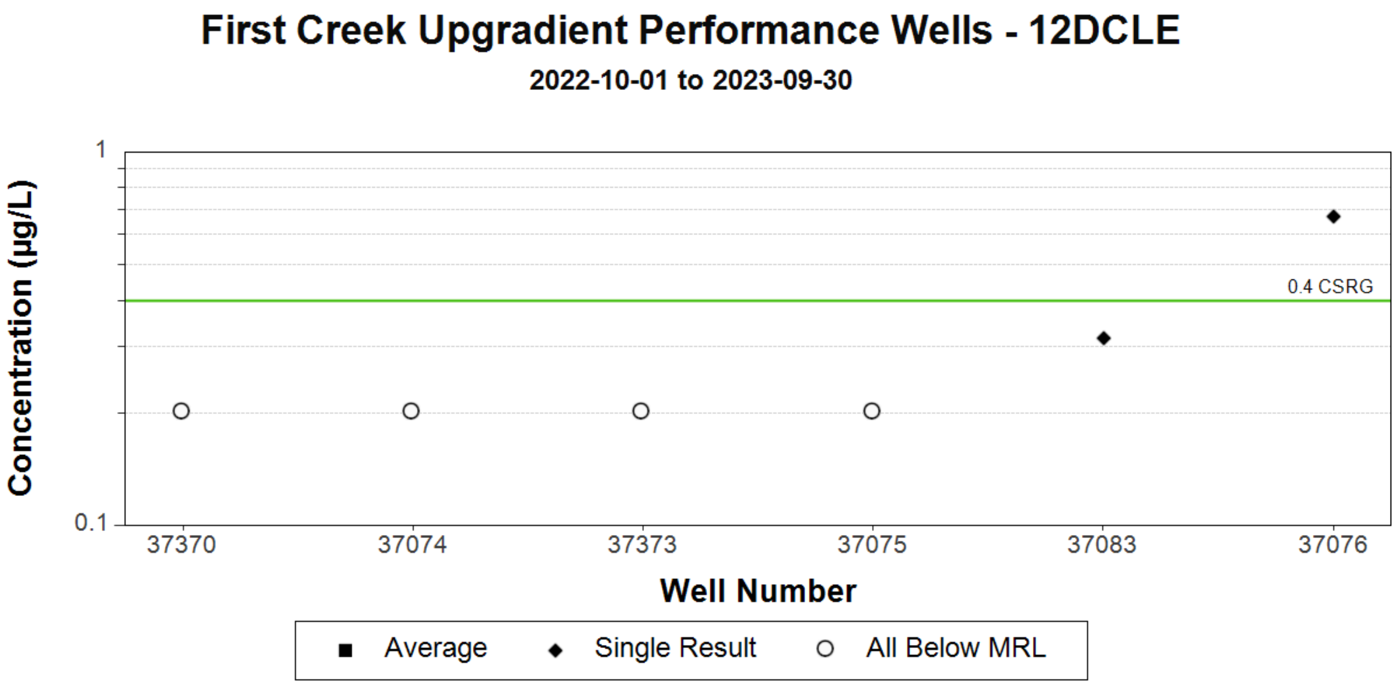
Well ID	Sample Date	Analyte Concentration (ug/L, CSRG/PQL shown in italics)						
		SO4	TCLEE	TRCLE	XYLEN	CLDAN [1]	ACLDAN	GCLDAN
		540,000	*5*	*3*	*1000*	*0.03*	—	—
Upgradient Wells								
37074	6/15/23	**366,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37075	6/14/23	**453,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37076	6/14/23	**678,000**	**1.48**	**0.18**	LT 0.4	ND	LT 0.00405	LT 0.00426
37083	9/20/23	**605,000**	**0.755**	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37370	6/15/23	**738,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37373	9/20/23	**928,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
Downgradient Wells								
37110	6/14/23	**1,400,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37116	9/21/23	**1,090,000**	**0.189**	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37163	9/19/23	**210,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
Extraction Wells								
37801	5/23/23	**414,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37802	5/23/23	**464,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37830	5/23/23	**424,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426

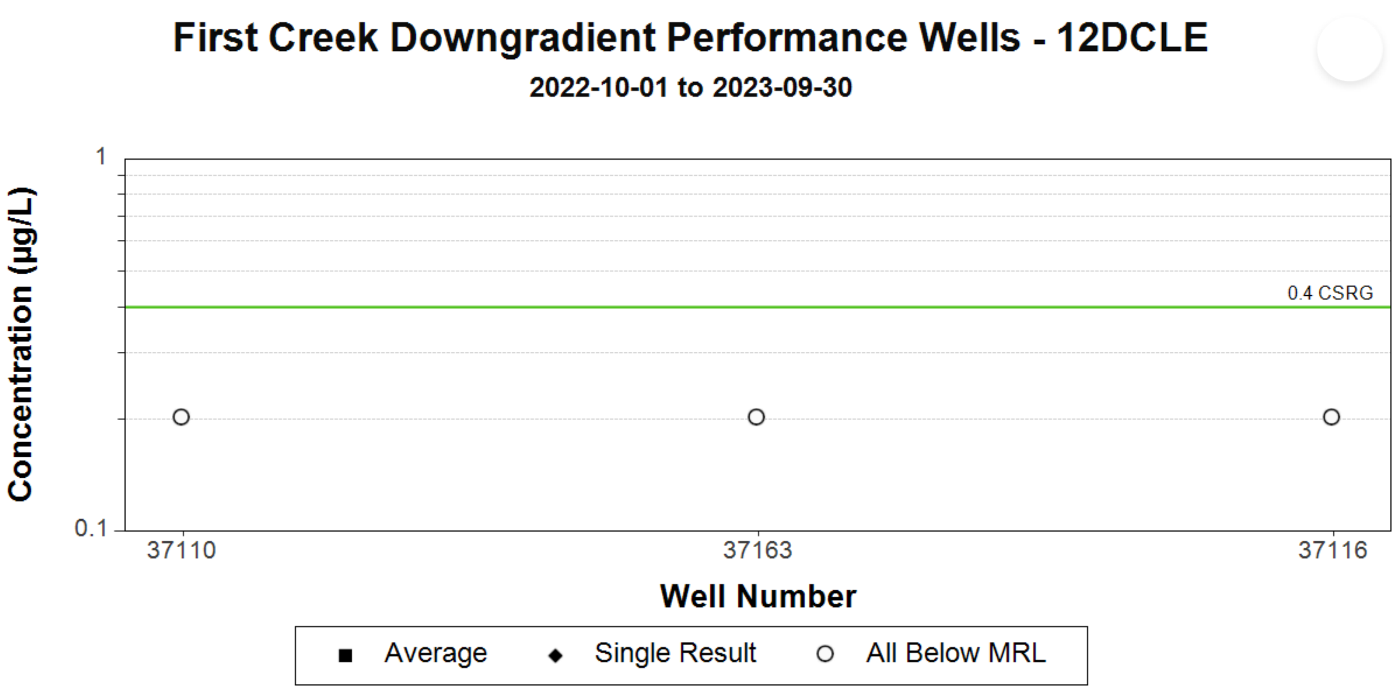
Notes:

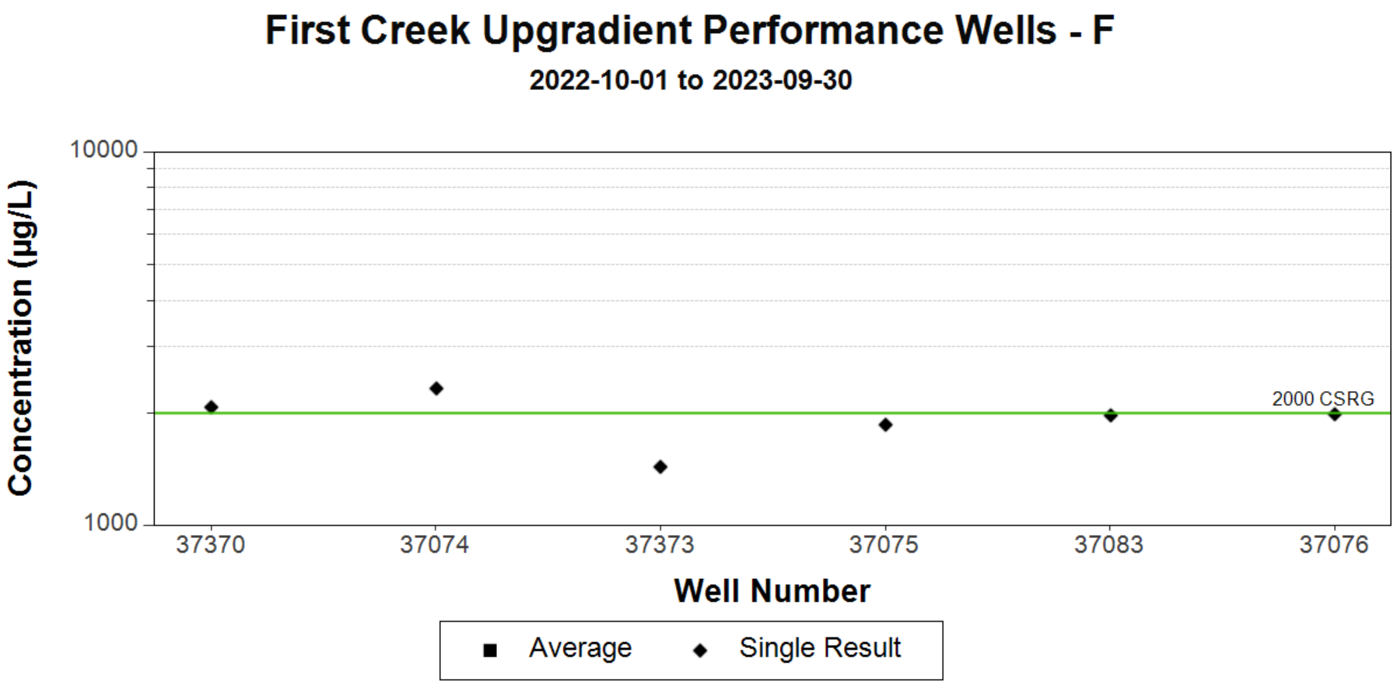
Values shaded and in BOLD are concentrations that exceed the CSRG/PQL.

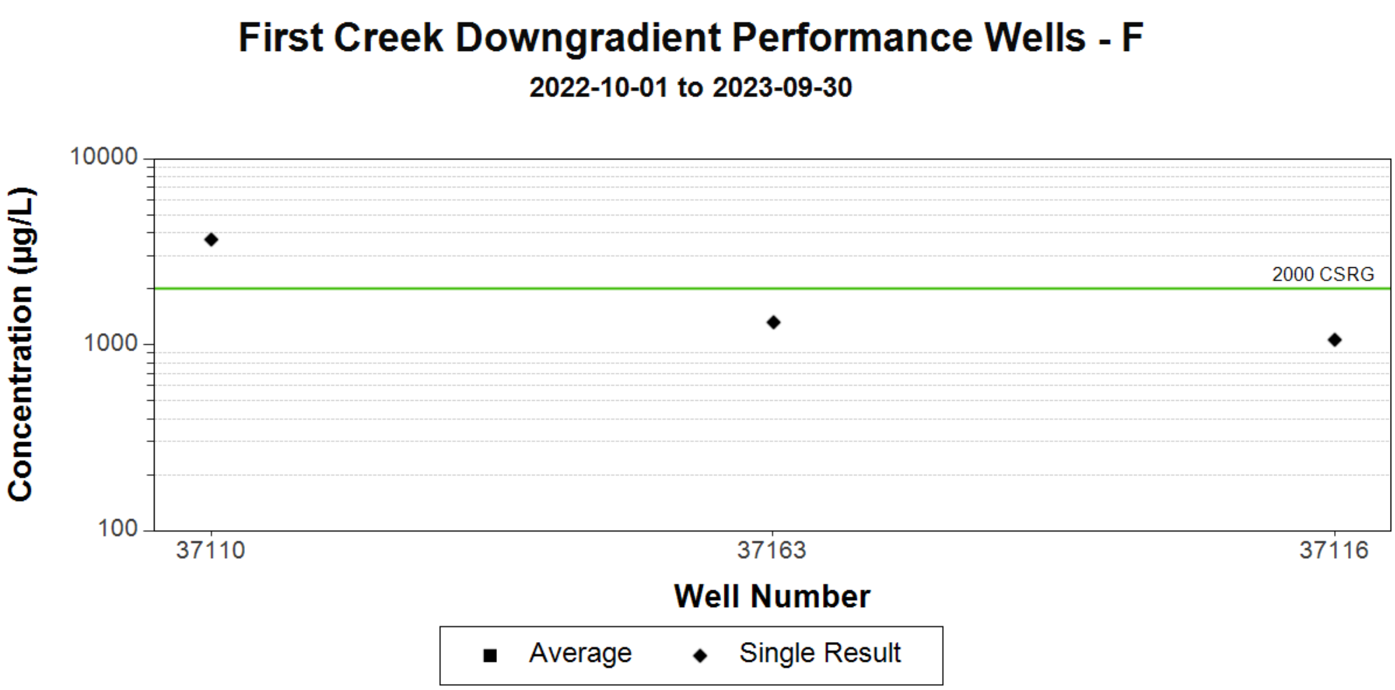
* The value for chlordane (CLDAN) is the sum of its two isomers, alpha-chordane (ACLDAN) and gamma-chlordane (GCLDAN).

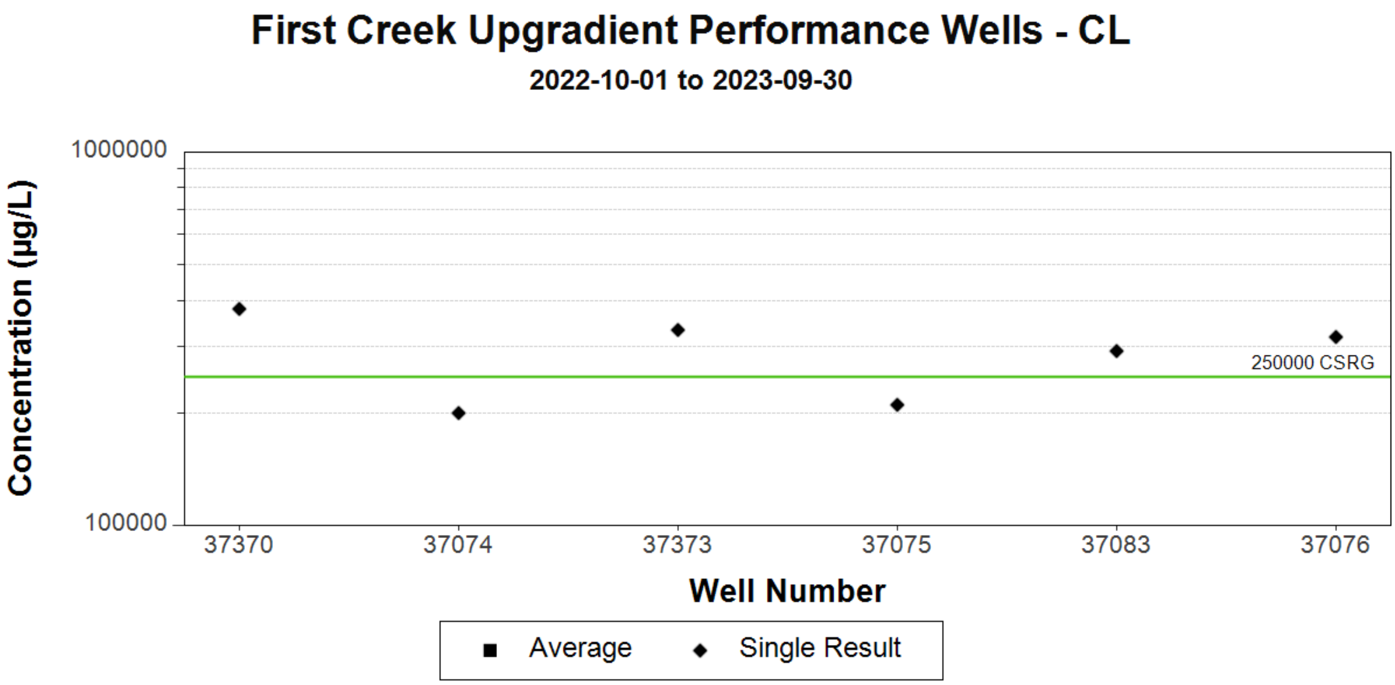
LT – Nondetection reported less than the method reporting limit

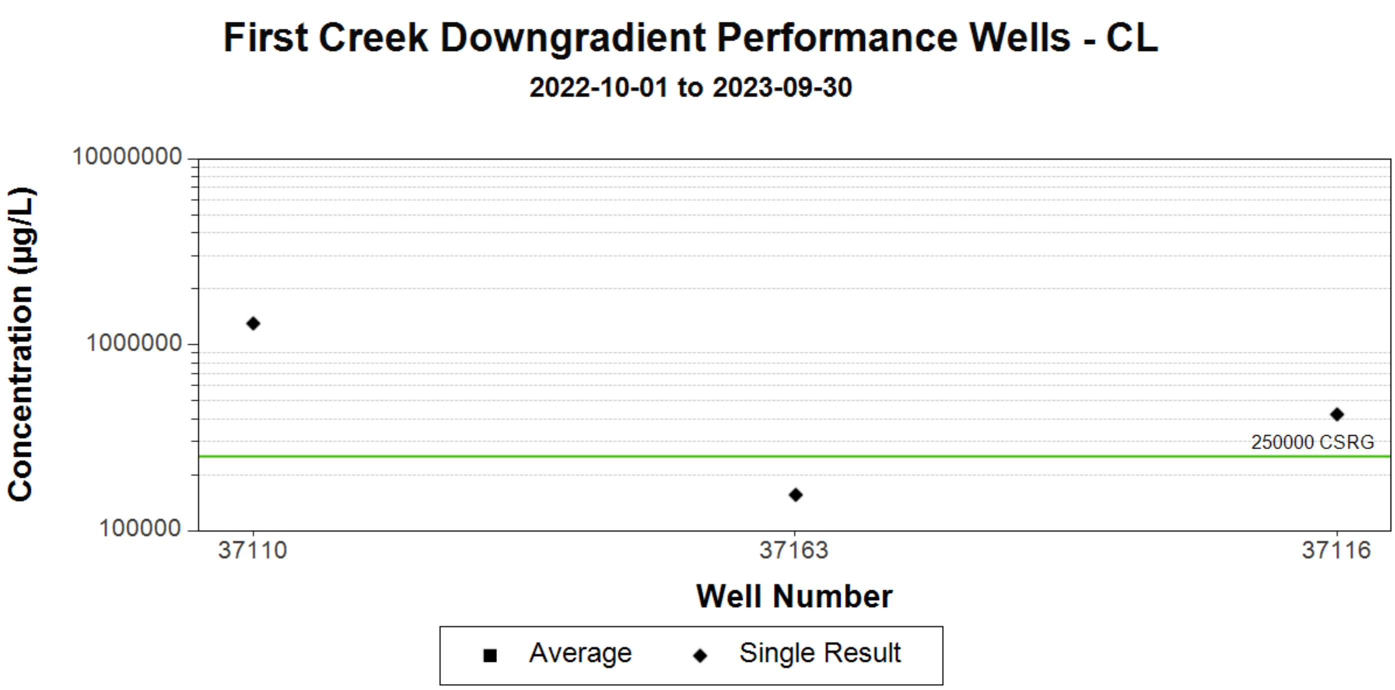

First Creek Upgradient Performance Wells - 12DCLE
2022-10-01 to 2023-09-30
Concentration (µg/L)
1
0.1
0.4 CSRG
37370
37074
37373
37075
37083
37076
Well Number
Average
Single Result
All Below MRL

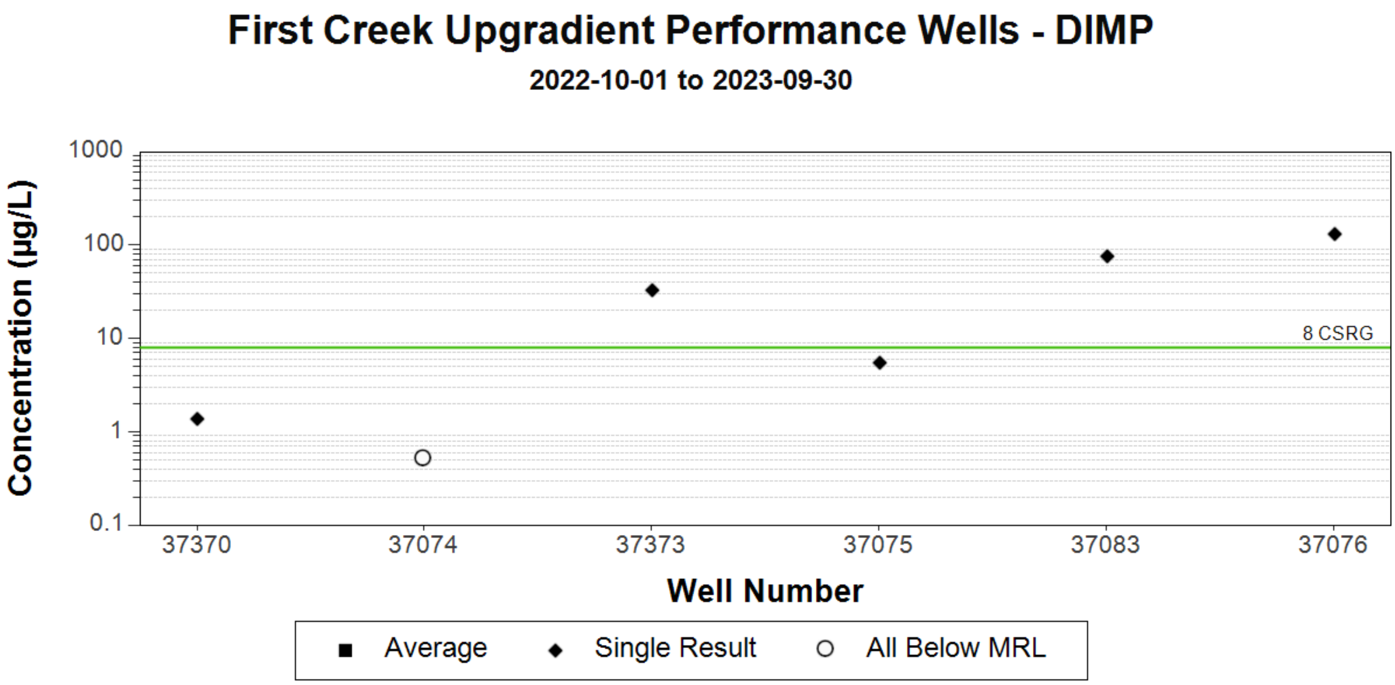

First Creek Downgradient Performance Wells - 12DCLE
2022-10-01 to 2023-09-30
Concentration (µg/L)
1
0.1
0.4 CSRG
37110
37163
37116
Well Number
Average
Single Result
All Below MRL


First Creek Upgradient Performance Wells - F
2022-10-01 to 2023-09-30
10000
1000
Concentration (µg/L)
2000 CSRG
37370
37074
37373
37075
37083
37076
Well Number
Average
Single Result

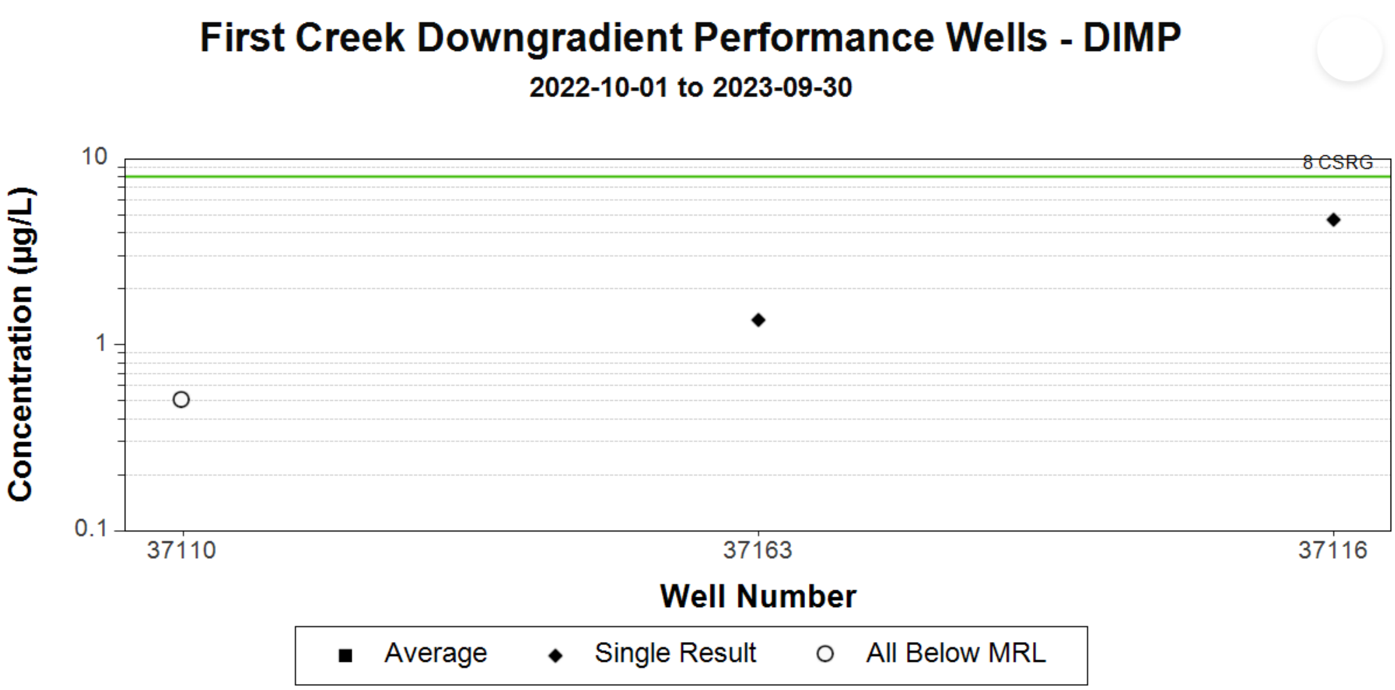

First Creek Downgradient Performance Wells - F
2022-10-01 to 2023-09-30
10000
1000
100
Concentration (µg/L)
2000 CSRG
37110
37163
37116
Well Number
Average
Single Result


First Creek Upgradient Performance Wells - CL
2022-10-01 to 2023-09-30
Concentration (µg/L)
1000000
100000
250000 CSRG
37370
37074
37373
37075
37083
37076
Well Number
Average
Single Result

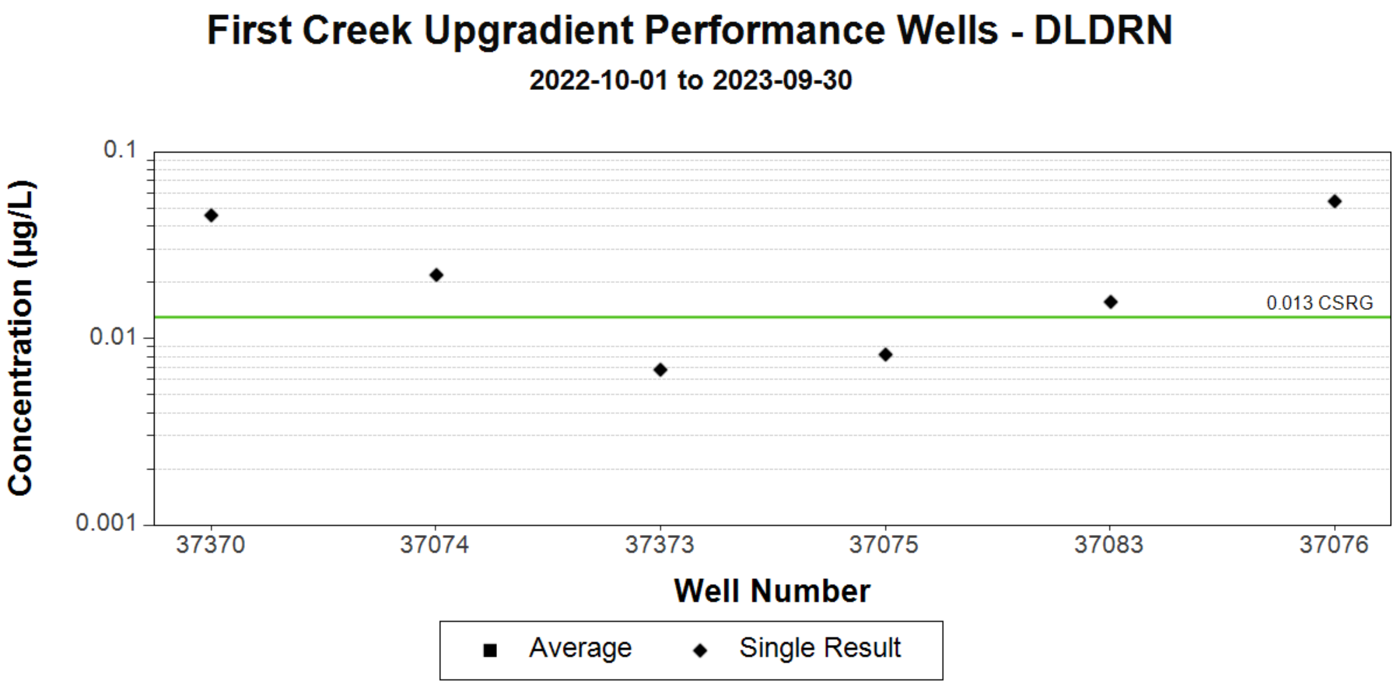

First Creek Downgradient Performance Wells - CL
2022-10-01 to 2023-09-30
Concentration (µg/L)
10000000
1000000
100000
250000 CSRG
37110
37163
37116
Well Number
Average
Single Result

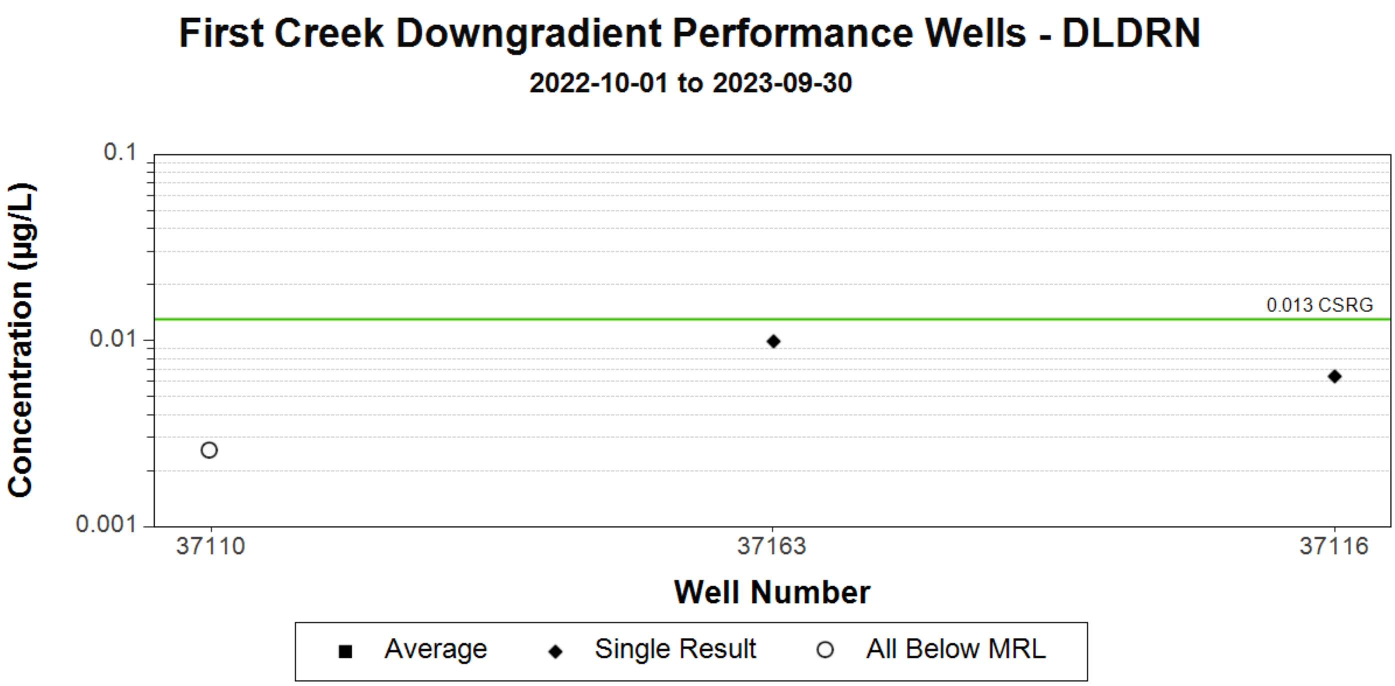


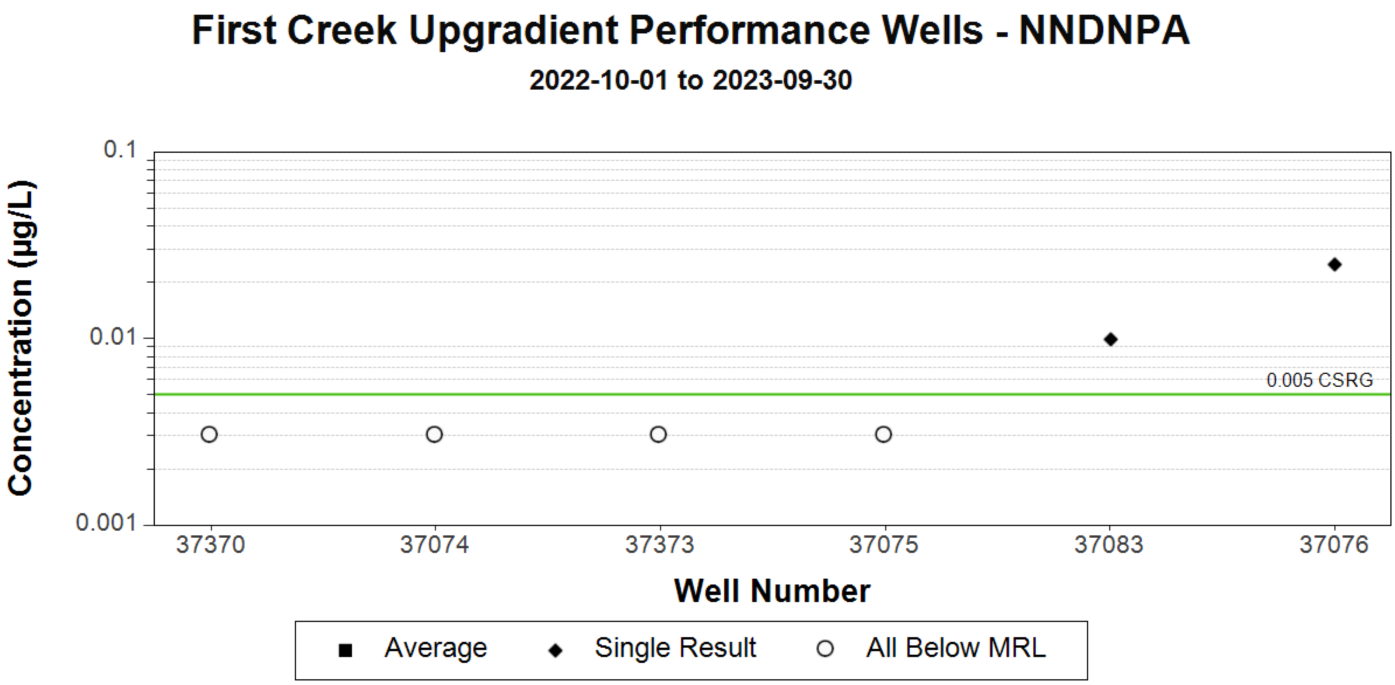
First Creek Upgradient Performance Wells - DIMP
2022-10-01 to 2023-09-30
Concentration (µg/L)
1000
100
10
1
0.1
8 CSRG
37370
37074
37373
37075
37083
37076
Well Number
Average
Single Result
All Below MRL



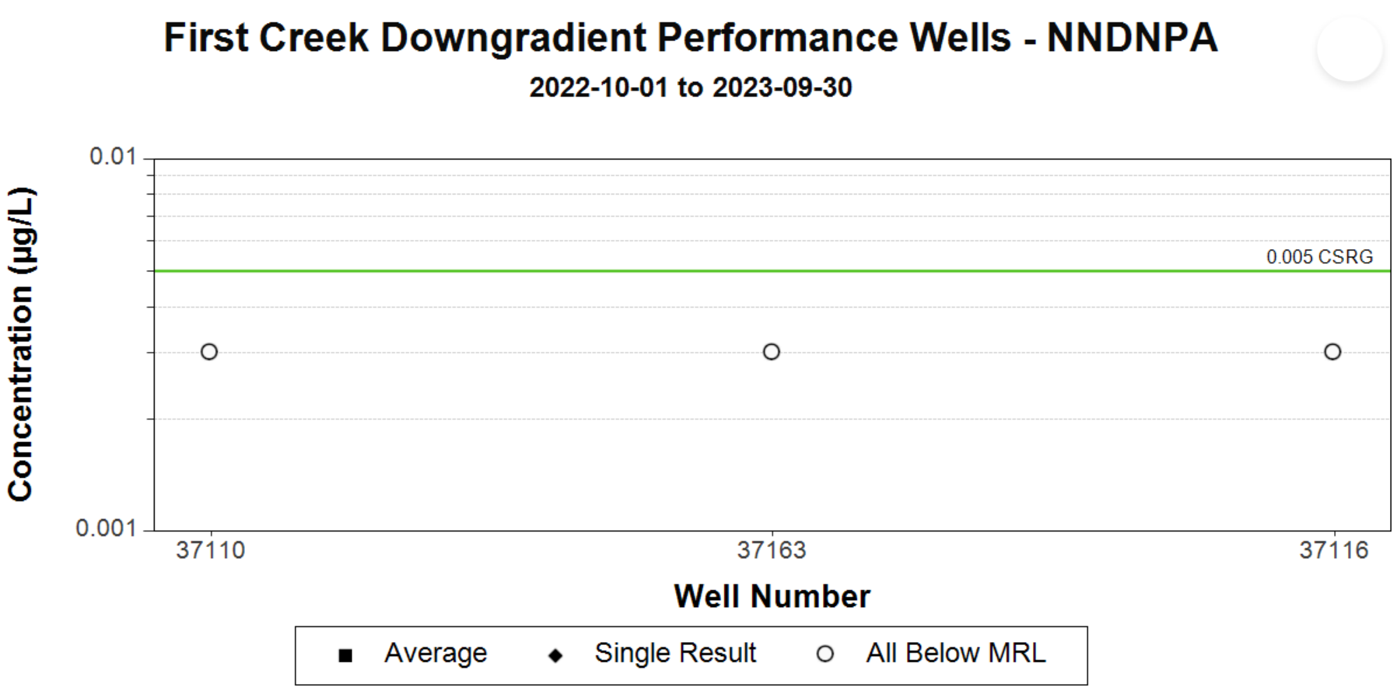
First Creek Downgradient Performance Wells - DIMP
2022-10-01 to 2023-09-30
Concentration (µg/L)
10
1
0.1
8 CSRG
37110
37163
37116
Well Number
Average
Single Result
All Below MRL


First Creek Upgradient Performance Wells - DLDRN
2022-10-01 to 2023-09-30
Concentration (µg/L)
0.1
0.01
0.001
0.013 CSRG
37370
37074
37373
37075
37083
37076
Well Number
Average
Single Result

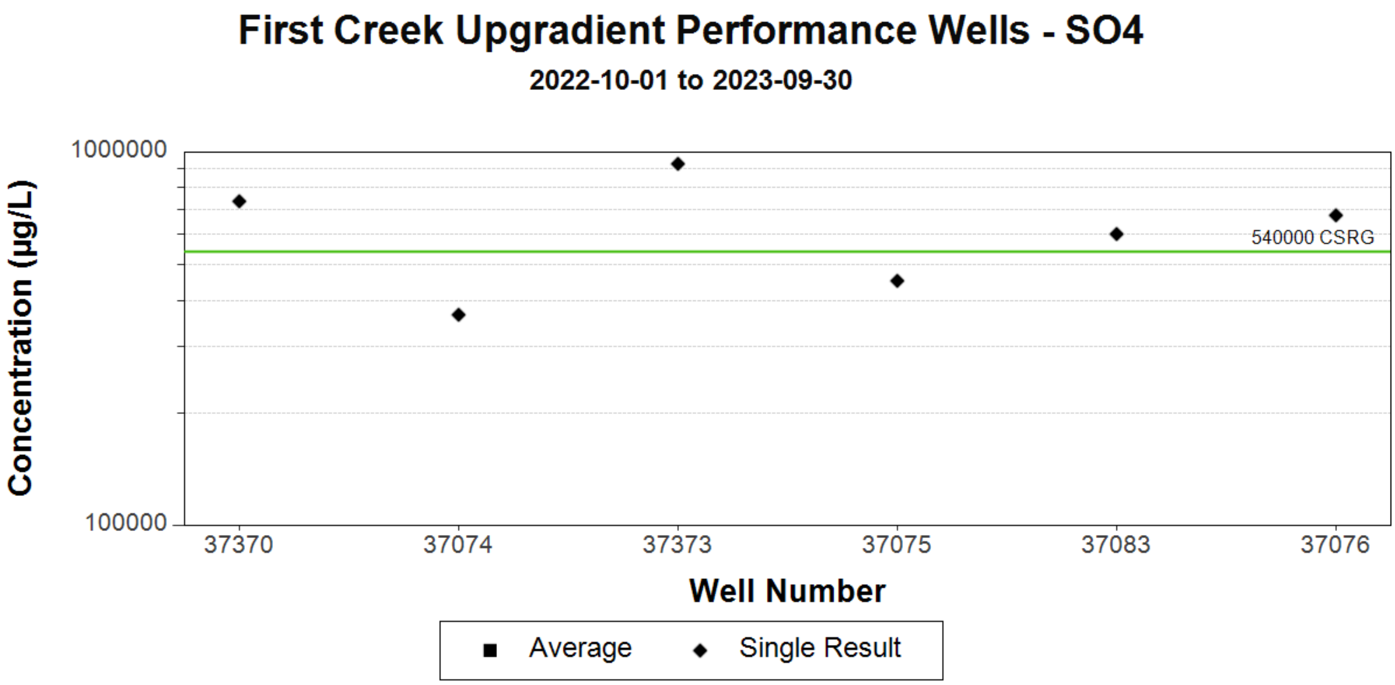

First Creek Downgradient Performance Wells - DLDRN
2022-10-01 to 2023-09-30
Concentration (µg/L)
0.1
0.01
0.001
0.013 CSRG
37110
37163
37116
Well Number
Average
Single Result
All Below MRL

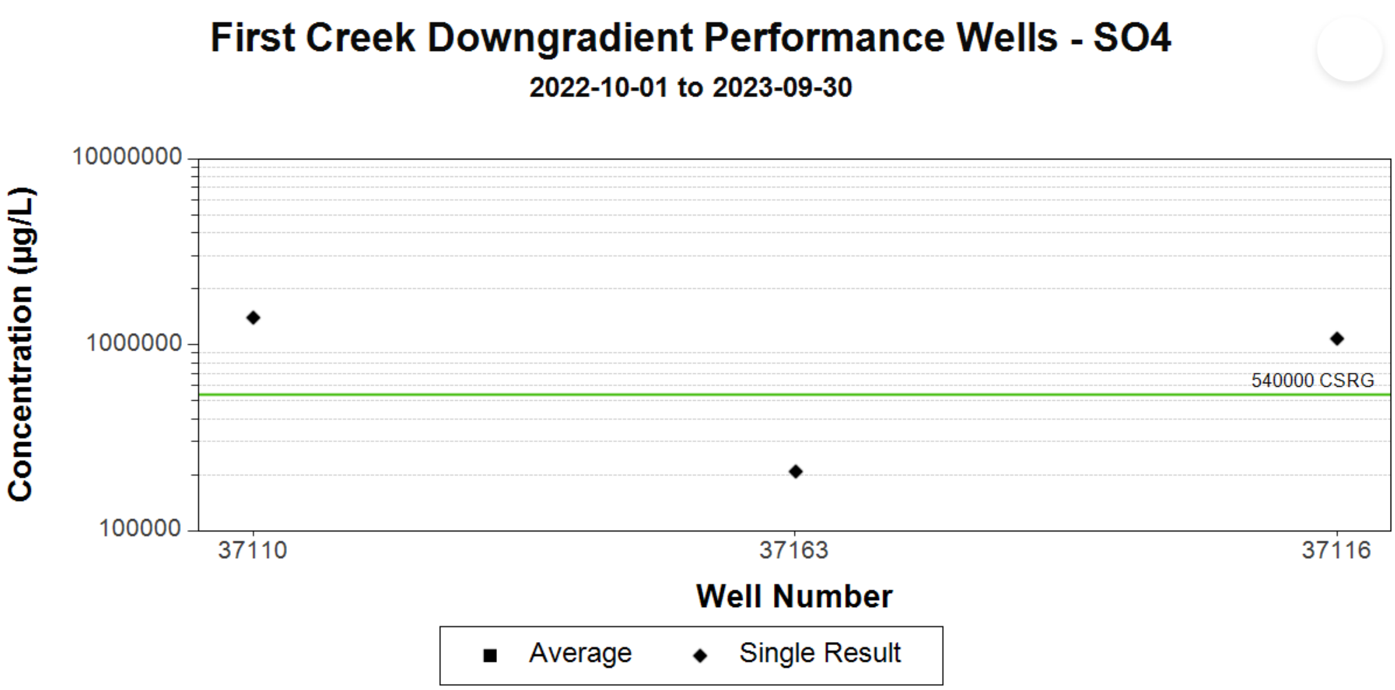


First Creek Upgradient Performance Wells - NNDNPA
2022-10-01 to 2023-09-30
0.1
0.01
0.001
Concentration (µg/L)
0.005 CSRG
37370
37074
37373
37075
37083
37076
Well Number
Average
Single Result
All Below MRL



First Creek Downgradient Performance Wells - NNDNPA
2022-10-01 to 2023-09-30
0.01
0.001
Concentration (µg/L)
0.005 CSRG
37110
37163
37116
Well Number
Average
Single Result
All Below MRL


First Creek Upgradient Performance Wells - SO4
2022-10-01 to 2023-09-30
Concentration (µg/L)
1000000
100000
540000 CSRG
37370
37074
37373
37075
37083
37076
Well Number
Average
Single Result


First Creek Downgradient Performance Wells - SO4
2022-10-01 to 2023-09-30
Concentration (µg/L)
10000000
1000000
100000
540000 CSRG
37110
37163
37116
Well Number
Average
Single Result

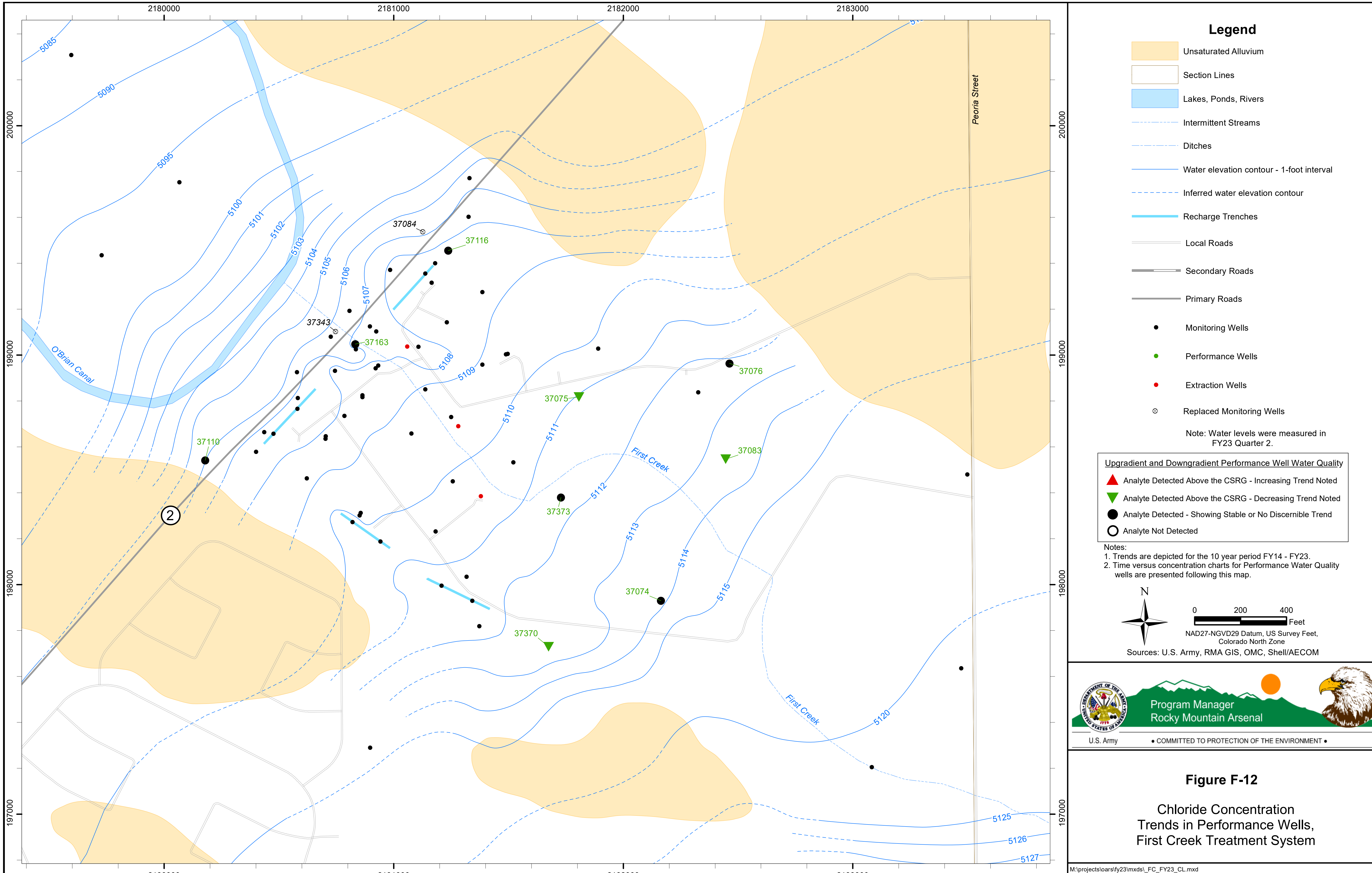
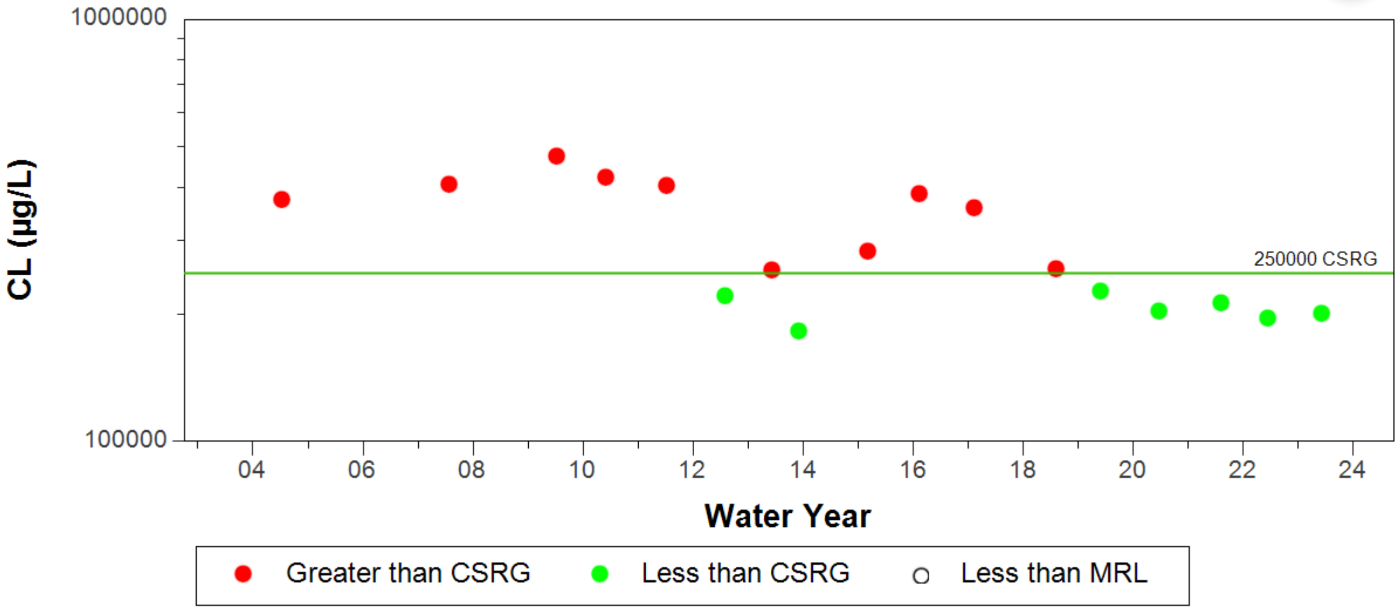


Figure F-12

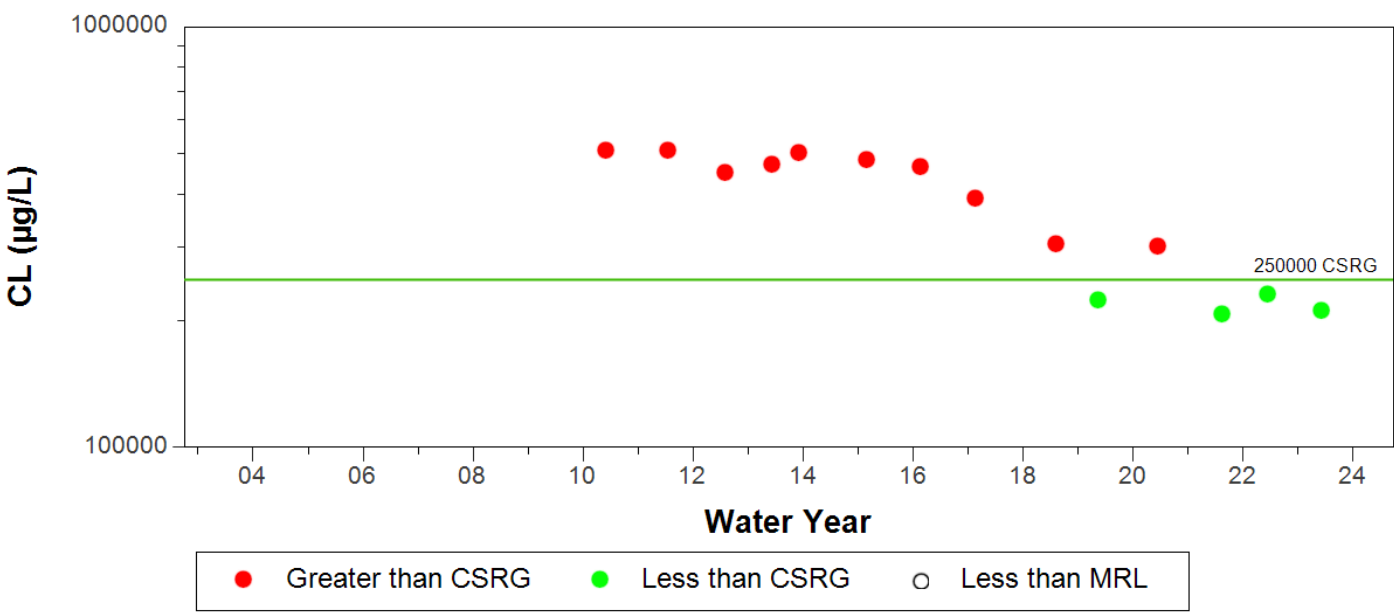
Chloride Concentration Trends in Performance Wells, First Creek Treatment System

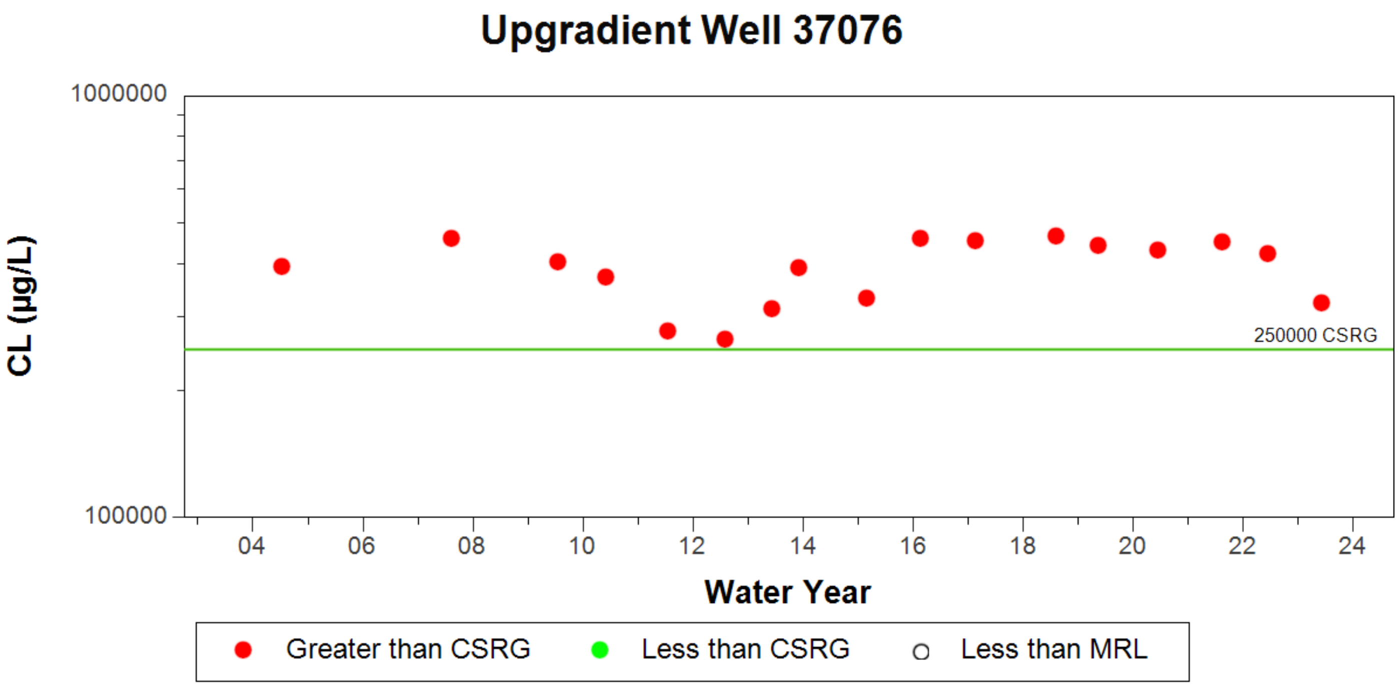
M:\projects\oars\fy23\mxds_FC_FY23_CL.mxd
8/7/2024

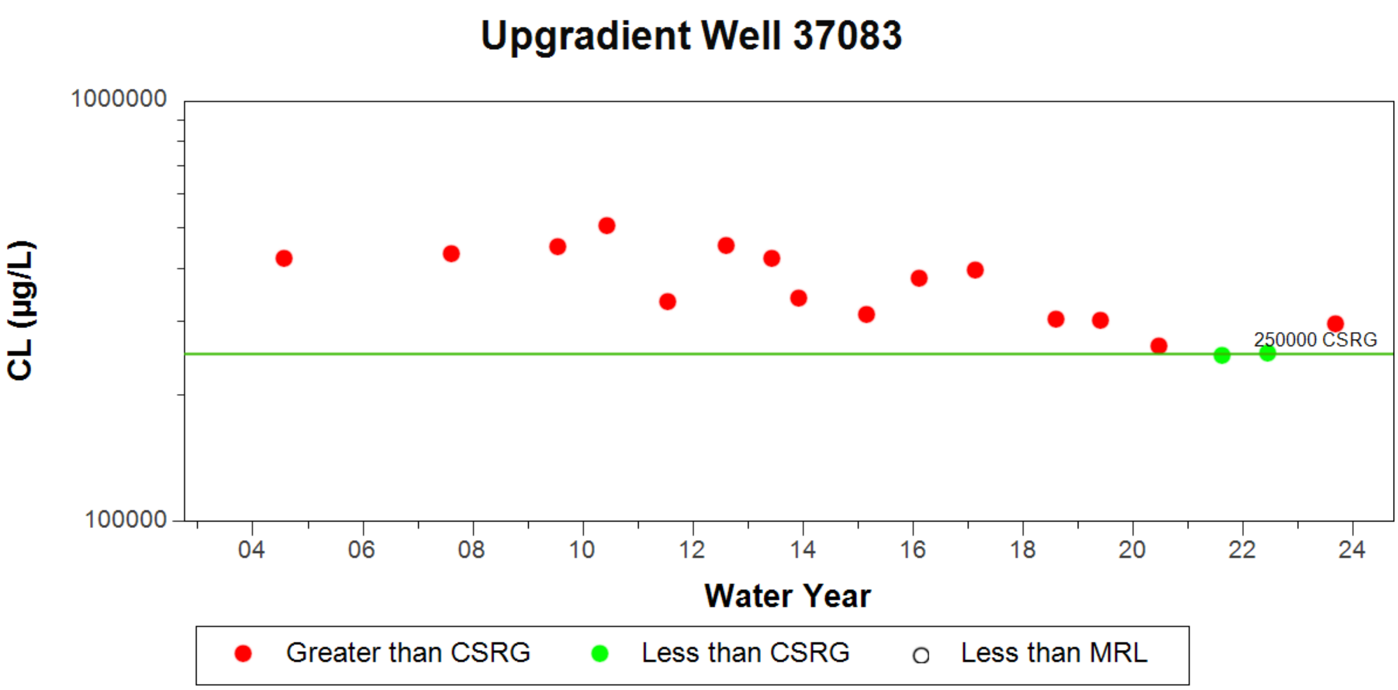
Upgradient Well 37074

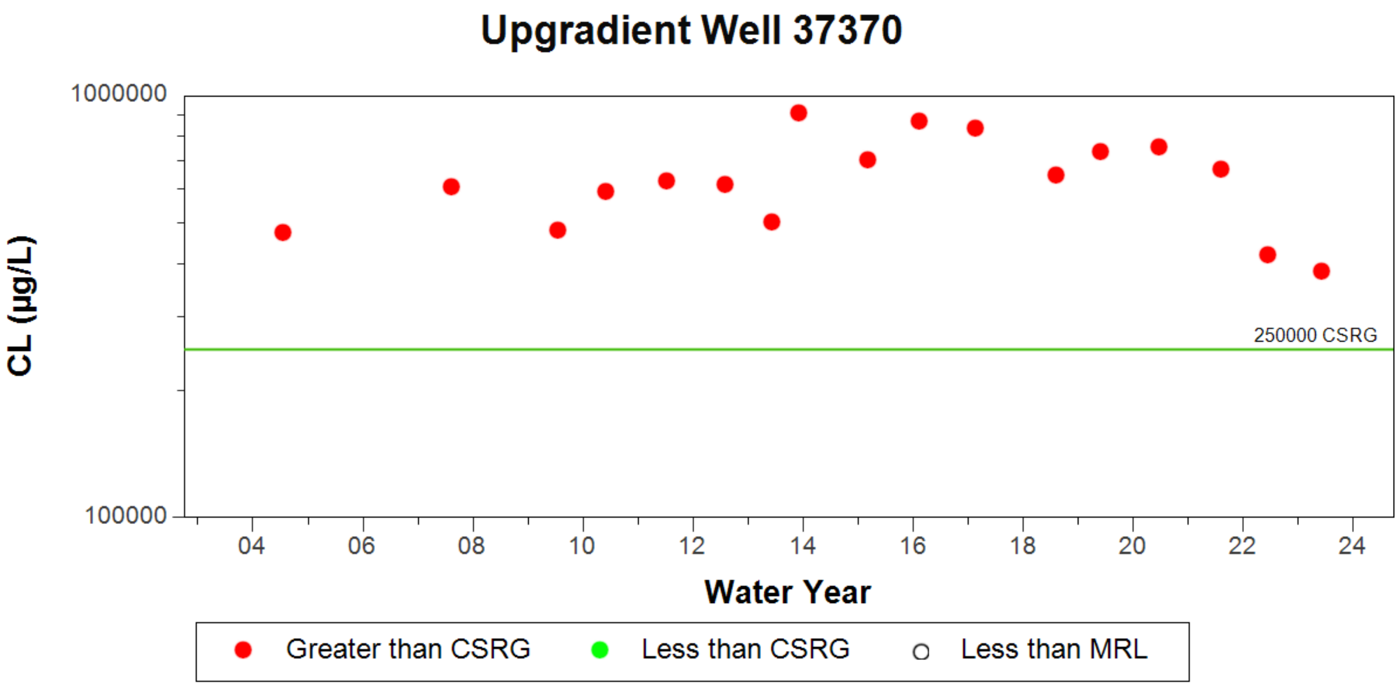


Upgradient Well 37075

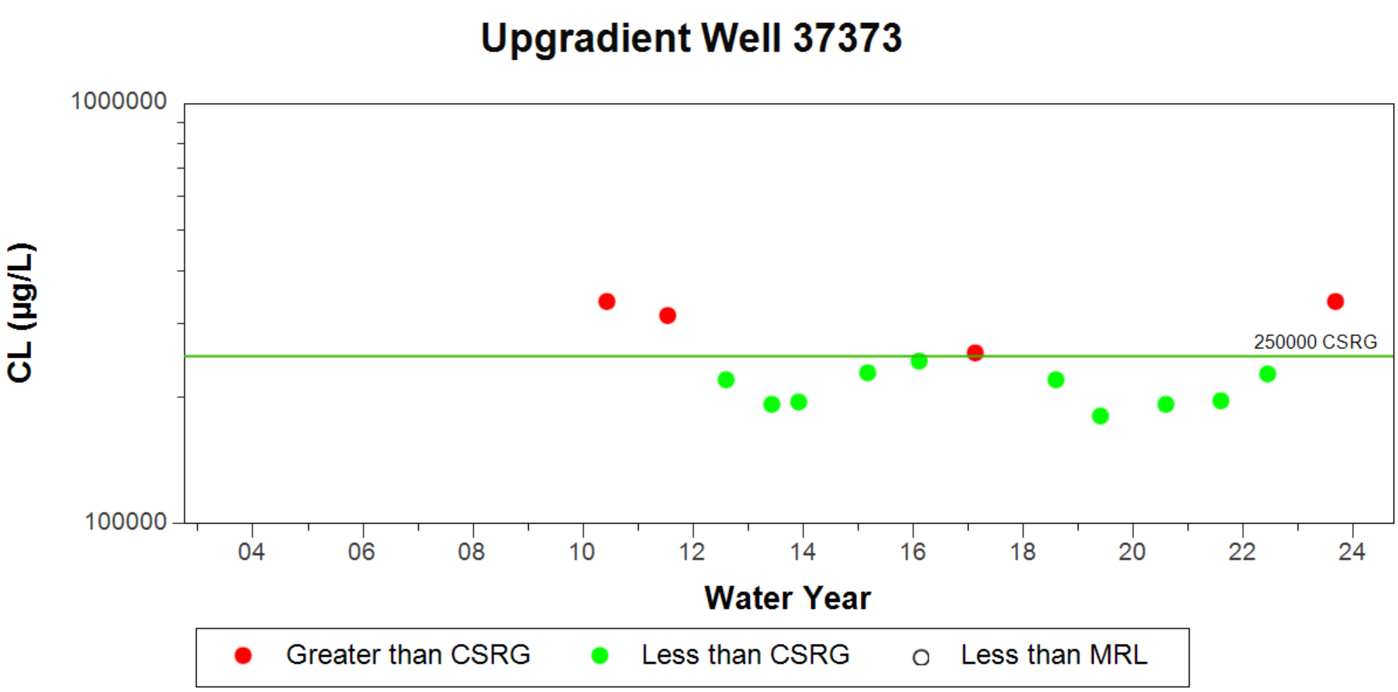



Upgradient Well 37076
1000000
100000
CL (µg/L)
250000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

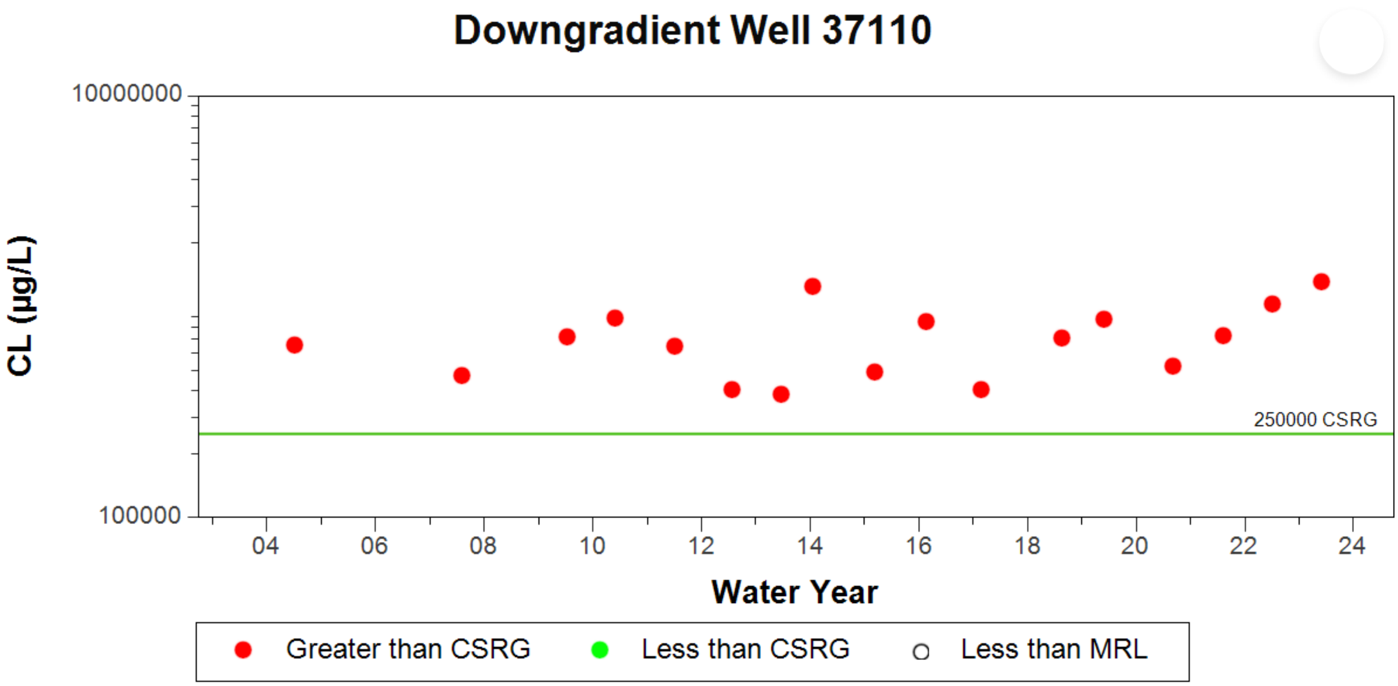

Upgradient Well 37083
1000000
100000
CL (µg/L)
250000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



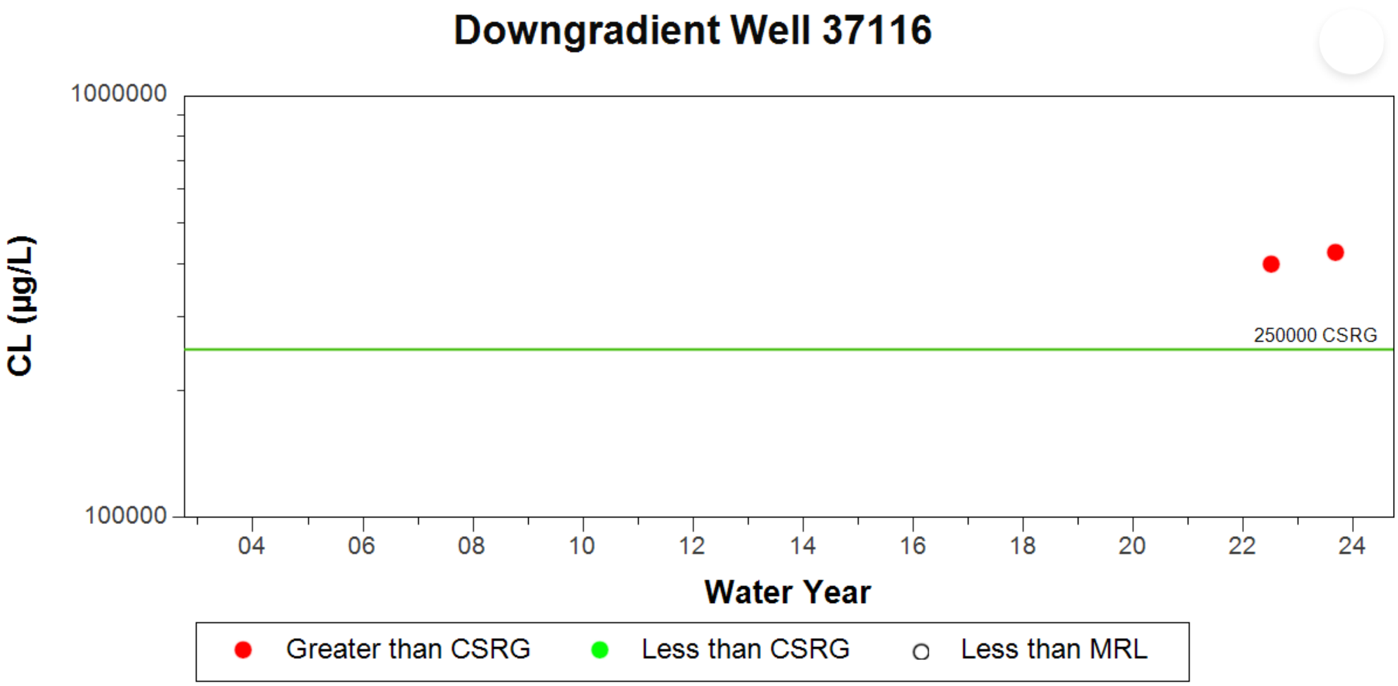
Upgradient Well 37370
1000000
100000
CL (µg/L)
250000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



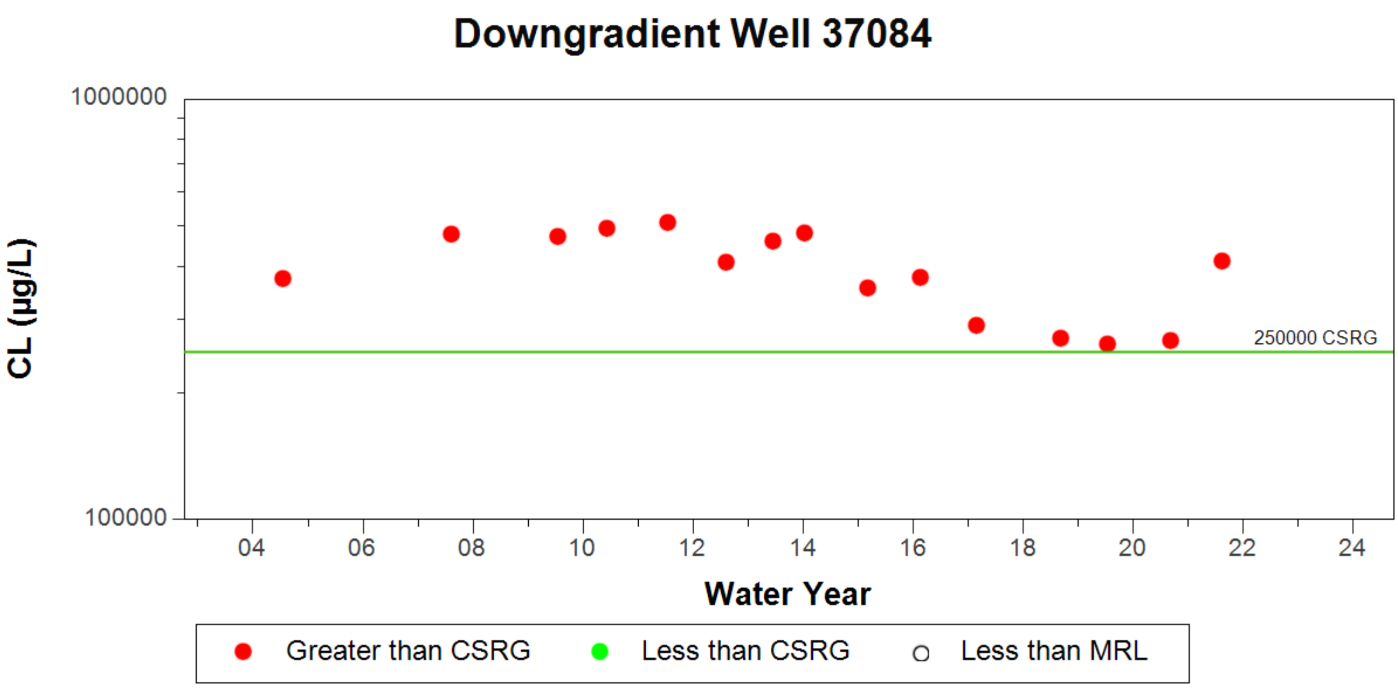
Upgradient Well 37373
1000000
100000
CL (µg/L)
250000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

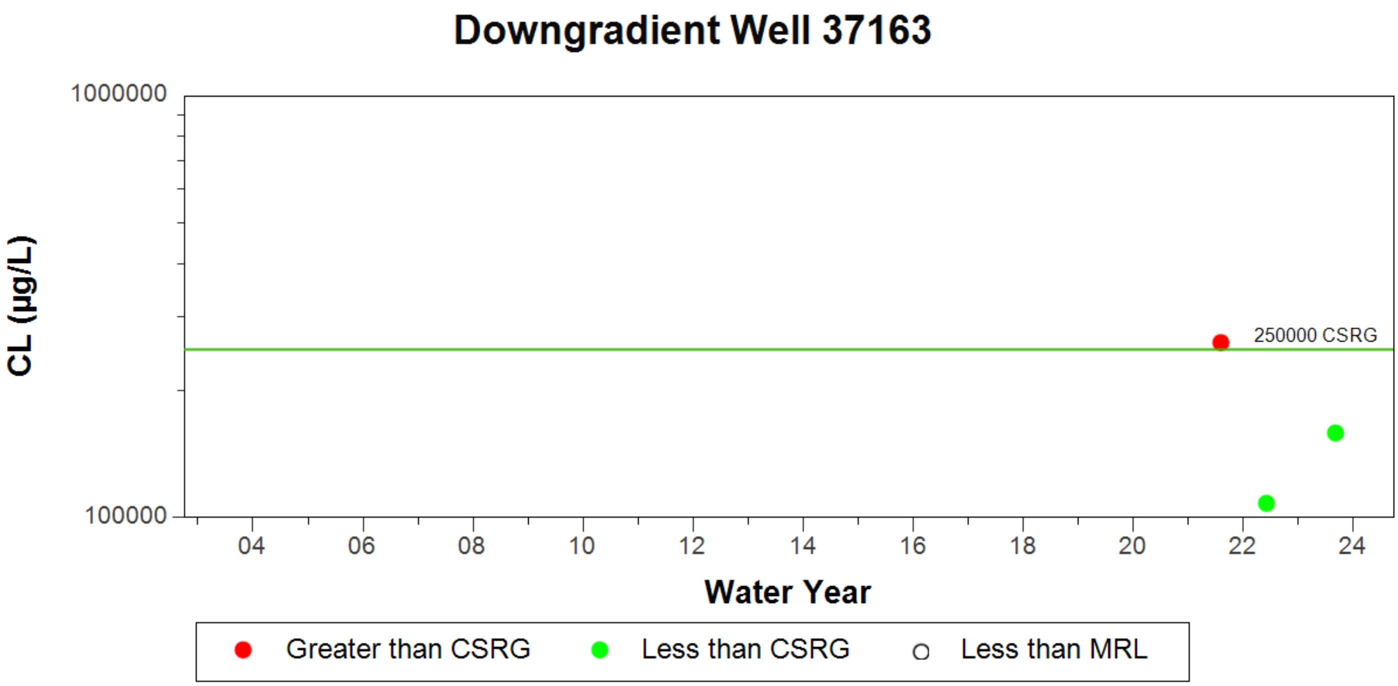


Downgradient Well 37110
10000000
100000
CL (µg/L)
250000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

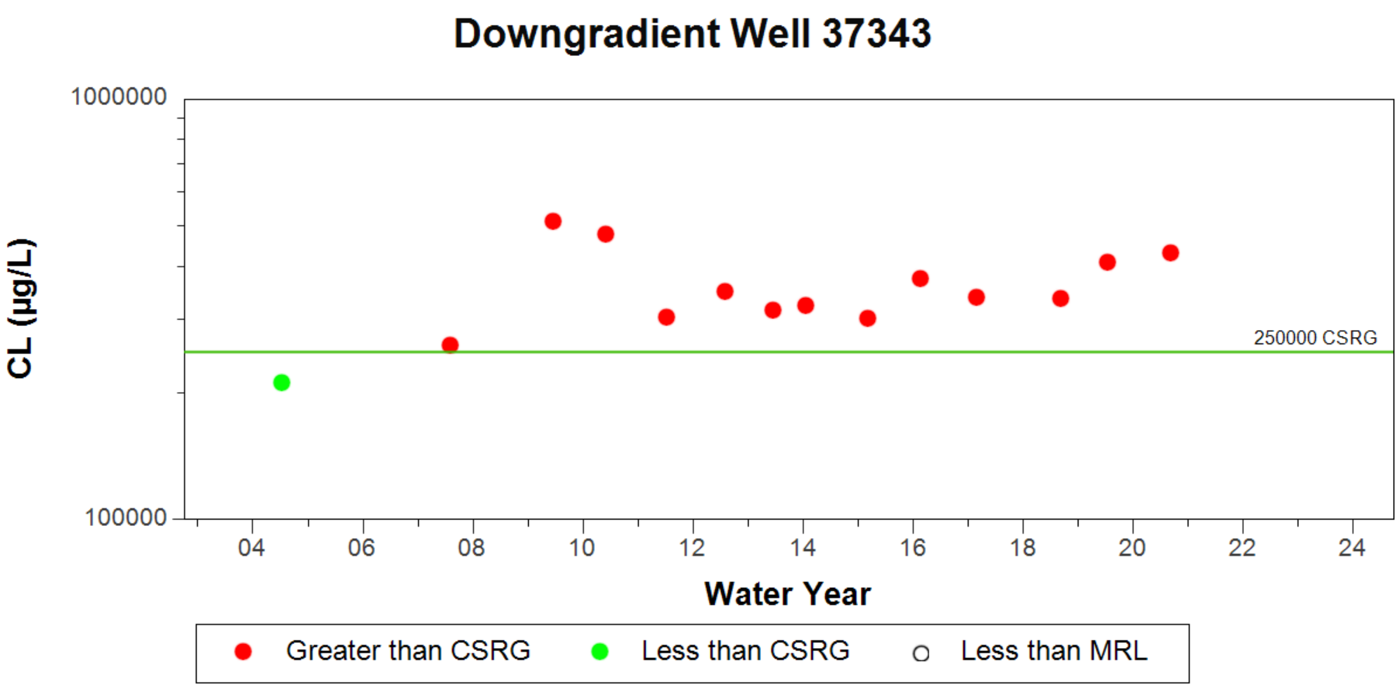


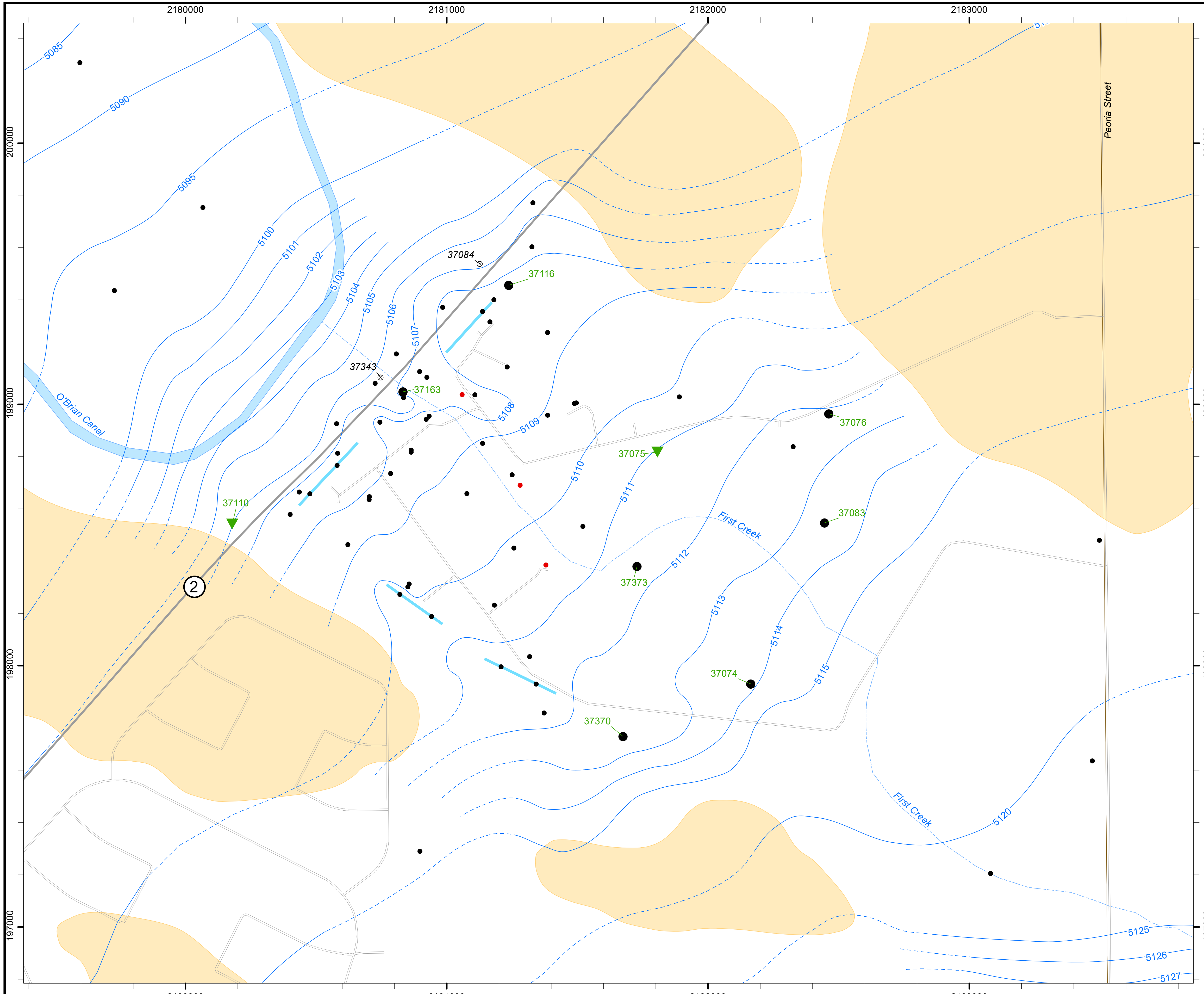
In FY22, well 37084 was replaced by well 37116.
Prior to FY22, chloride in well 37084 did not show an increasing trend.





In FY22, well 37343 was replaced by well 37163.
Prior to FY22, chloride in well 37343 did not show an increasing trend.





Legend

- Unsaturated Alluvium
- Section Lines
- Lakes, Ponds, Rivers
- Intermittent Streams
- Ditches
- Water elevation contour - 1-foot interval
- Inferred water elevation contour
- Recharge Trenches
- Local Roads
- Secondary Roads
- Primary Roads
- Monitoring Wells
- Performance Wells
- Extraction Wells
- Replaced Monitoring Wells

Note: Water levels were measured in FY23 Quarter 2.

Upgradient and Downgradient Performance Well Water Quality
- Analyte Detected Above the CSRG - Increasing Trend Noted
- Analyte Detected Above the CSRG - Decreasing Trend Noted
- Analyte Detected - Showing Stable or No Discernible Trend
- Analyte Not Detected

Notes:
1. Trends are depicted for the 10 year period FY14 - FY23.
2. Time versus concentration charts for Performance Water Quality wells are presented following this map.

N

0 200 400 Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

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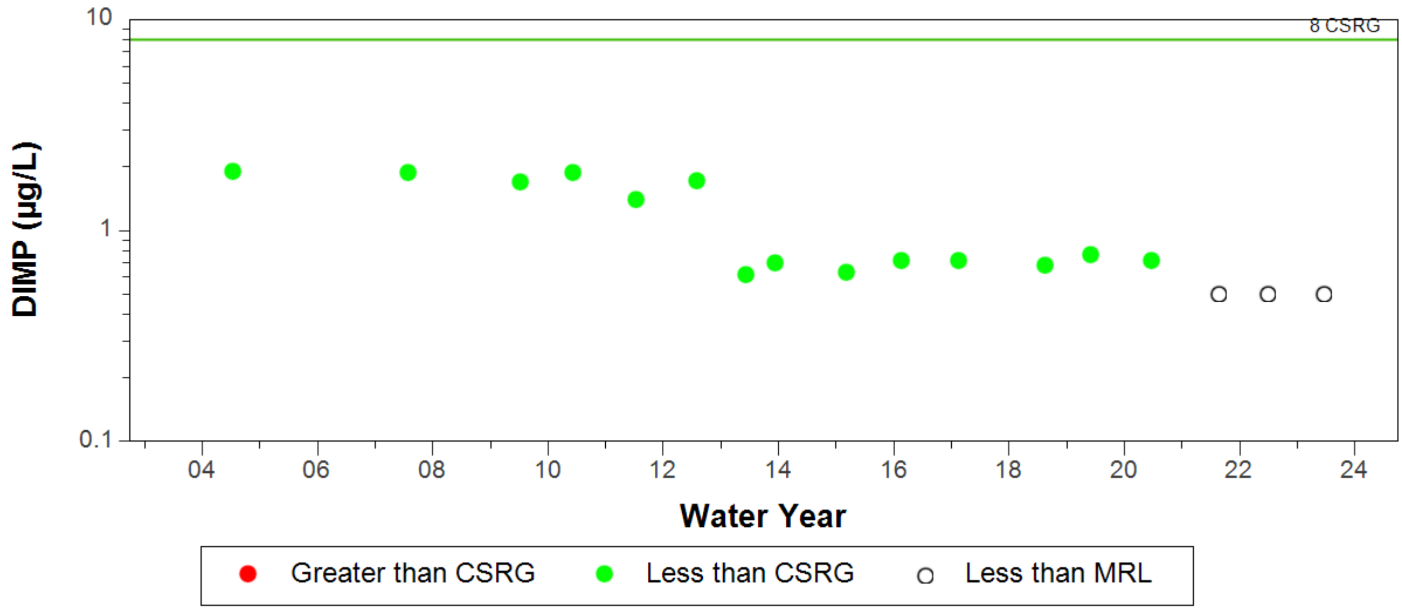
Figure F-13

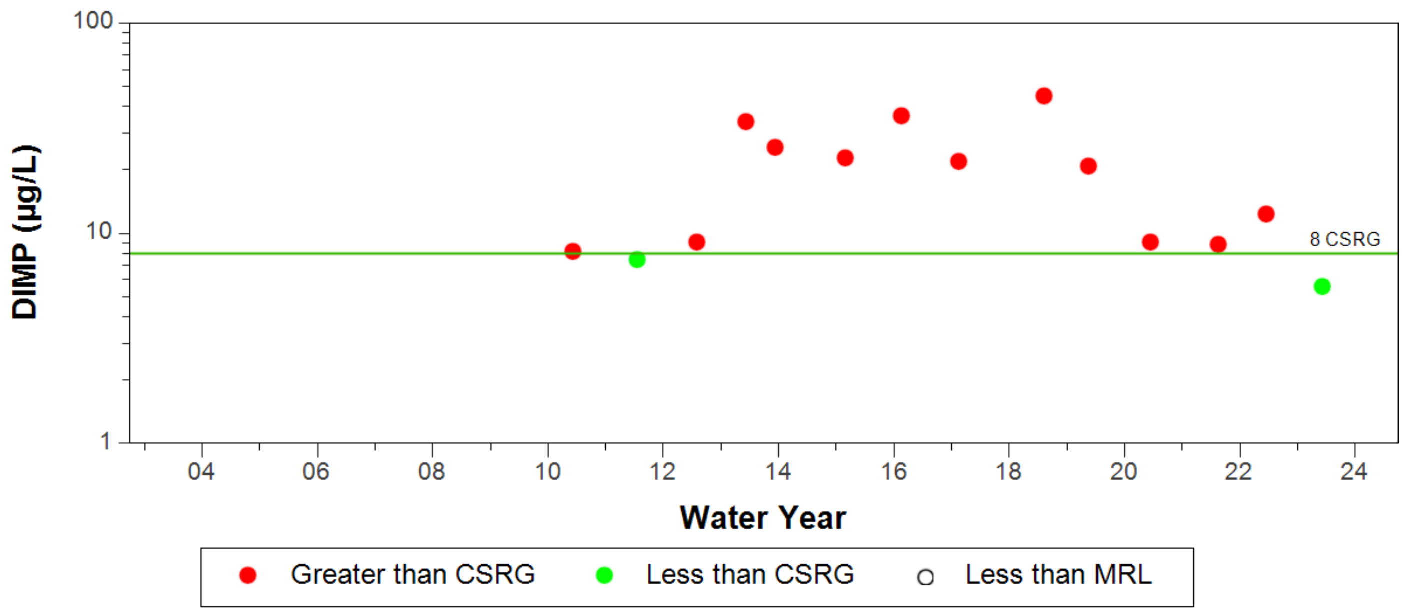
Diisopropylmethyl Phosphonate Concentration Trends in Performance Wells, First Creek Treatment System

M:\projects\oars\fy23\mxds_FC_FY23_DIMP.mxd
8/7/2024

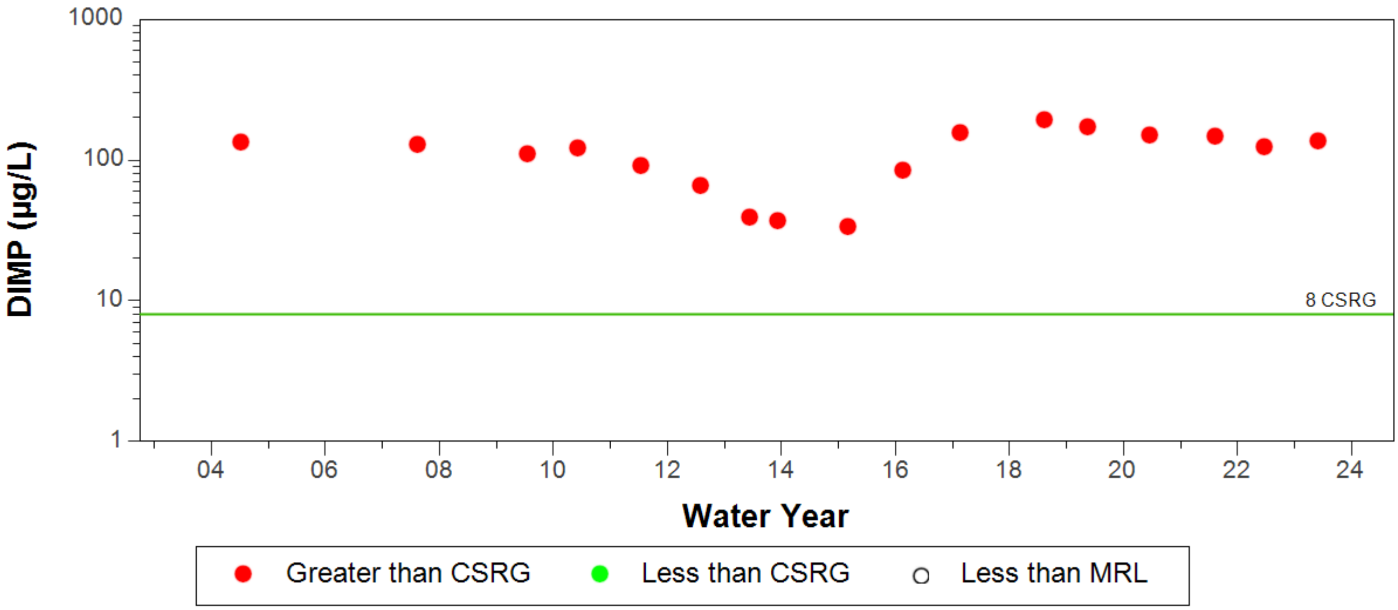
Upgradient Well 37074



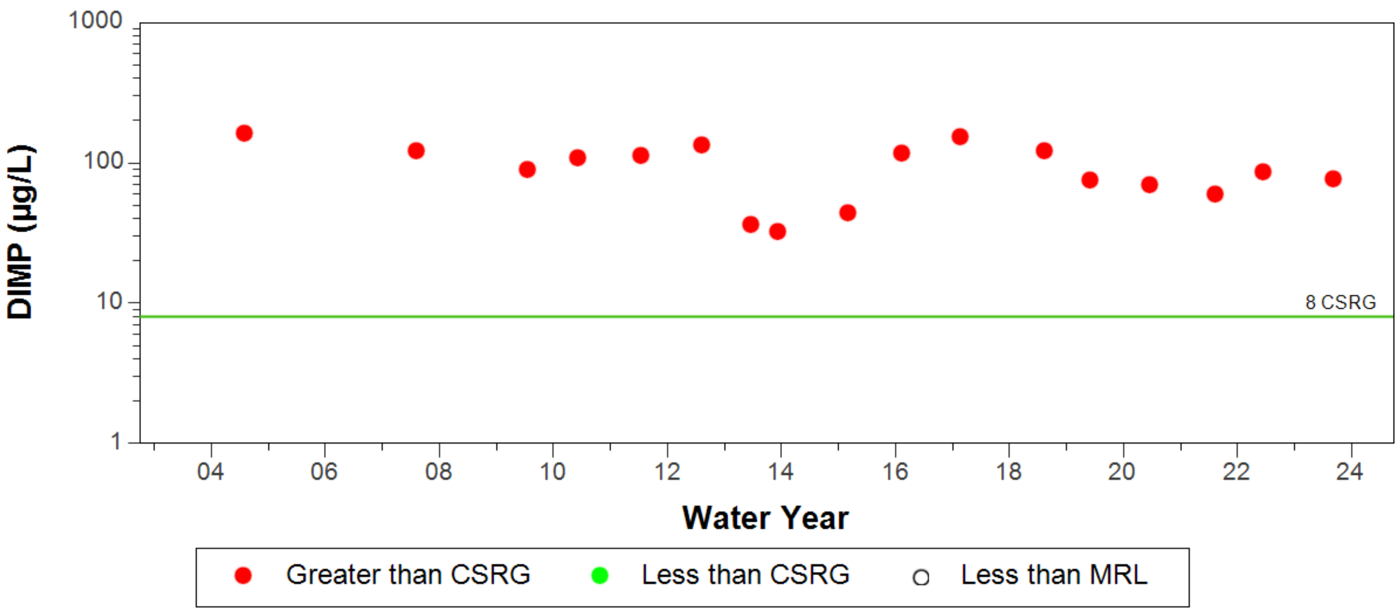
Upgradient Well 37075

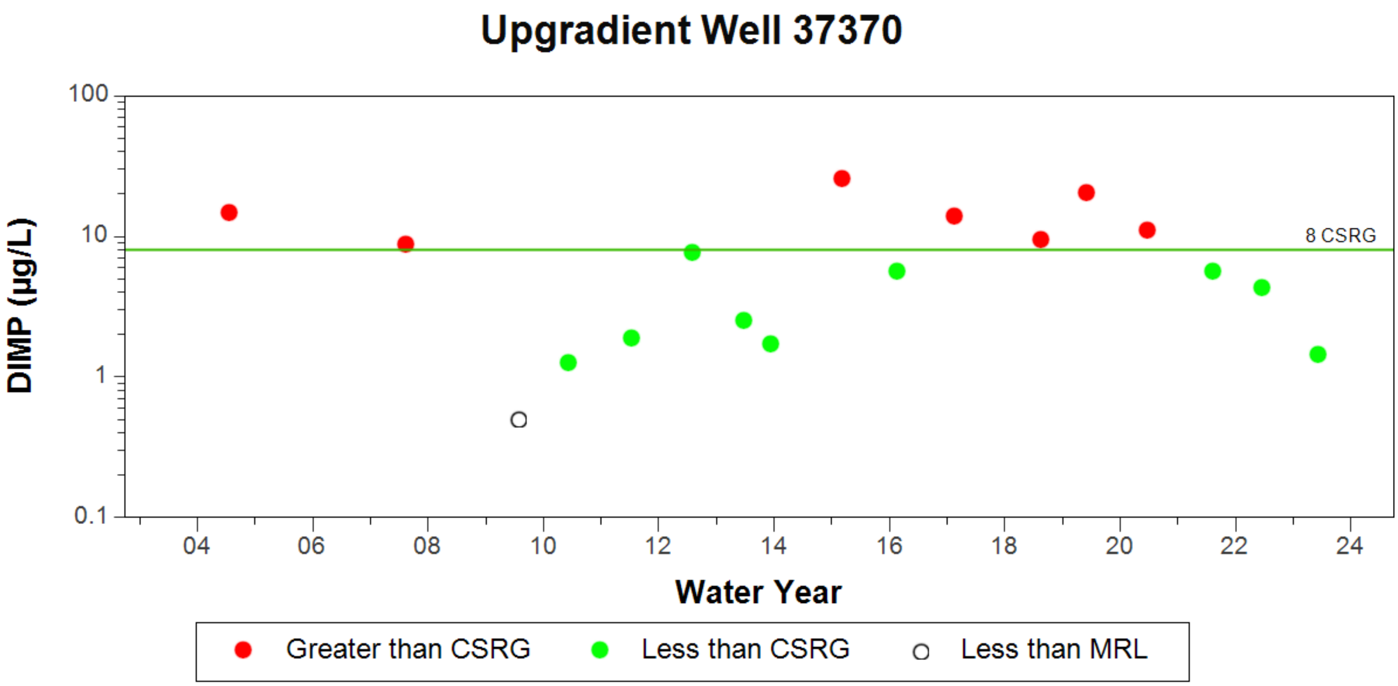


Upgradient Well 37076

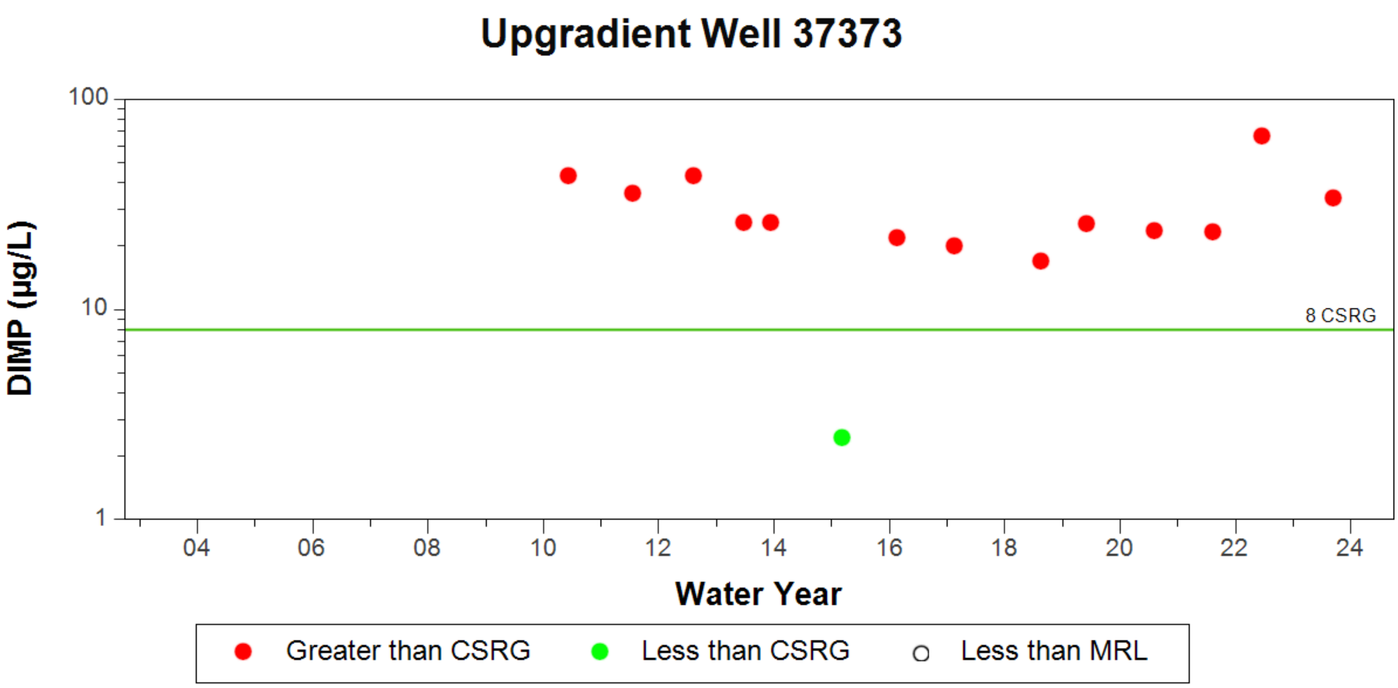


Upgradient Well 37083

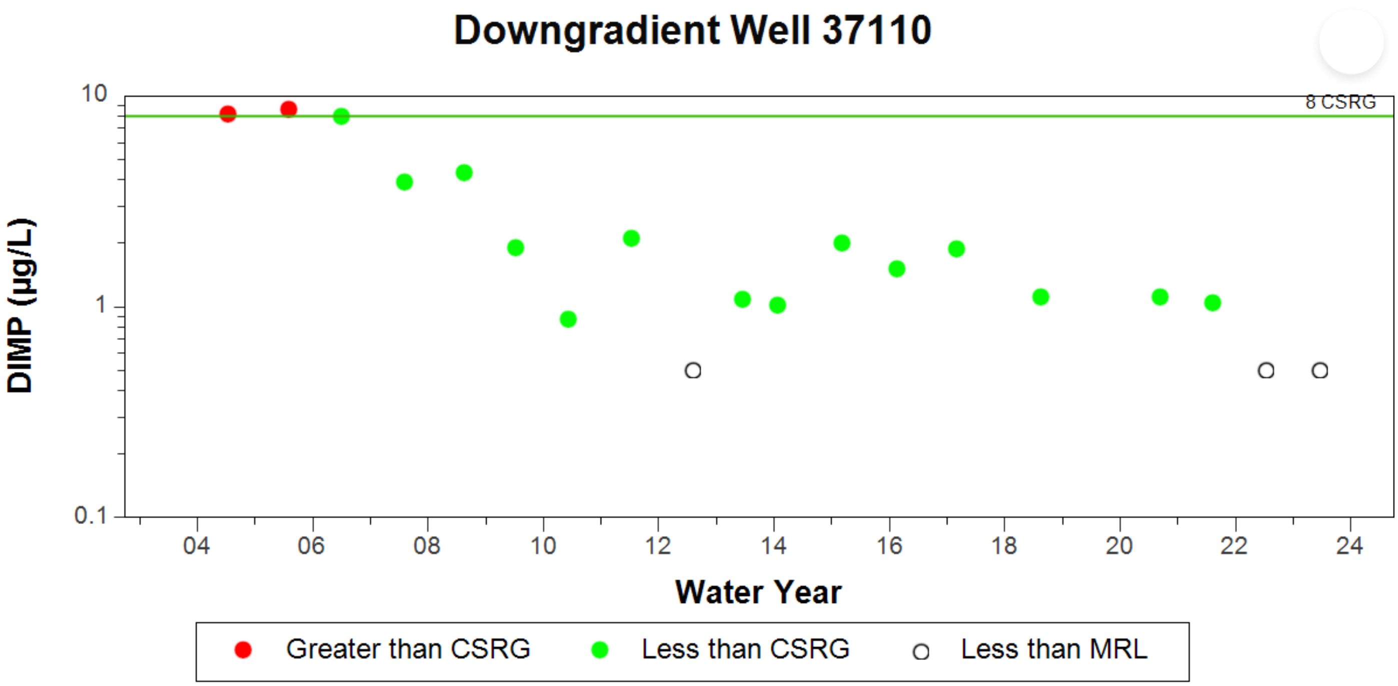




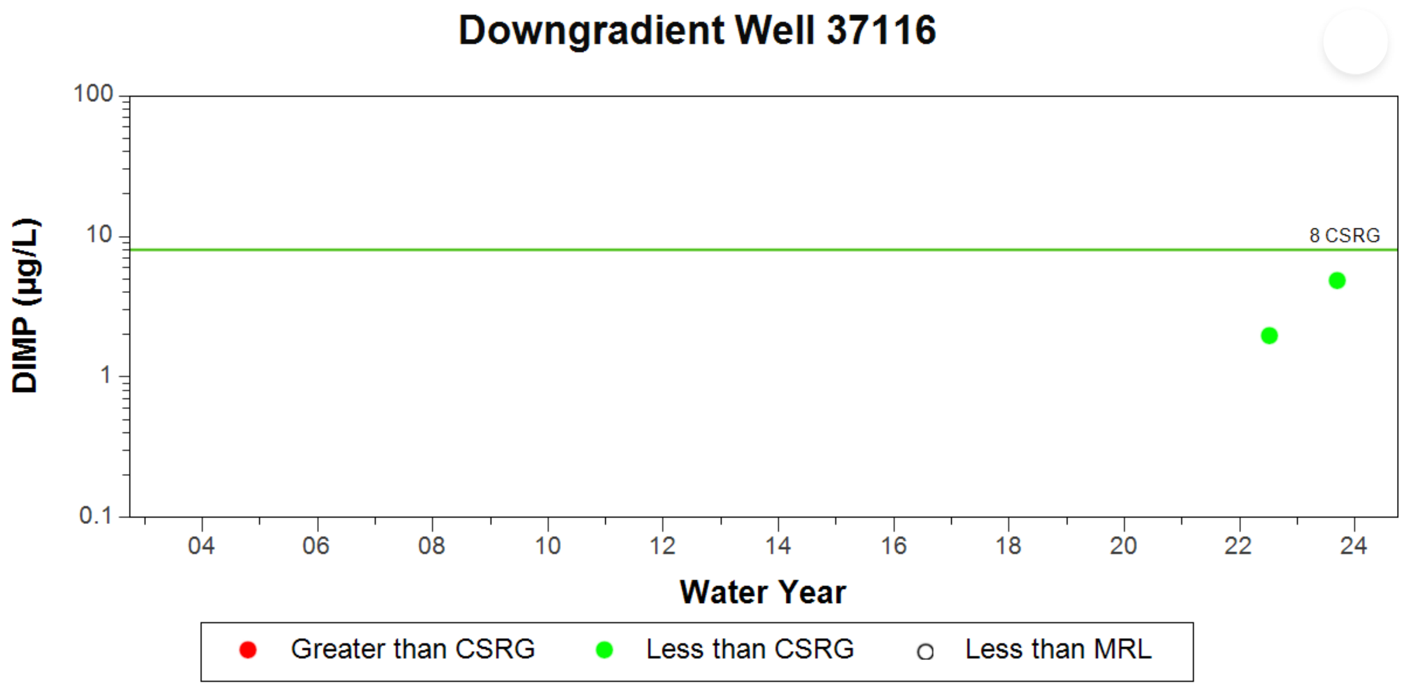
Upgradient Well 37370
DIMP (µg/L)
100
10
1
0.1
8 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



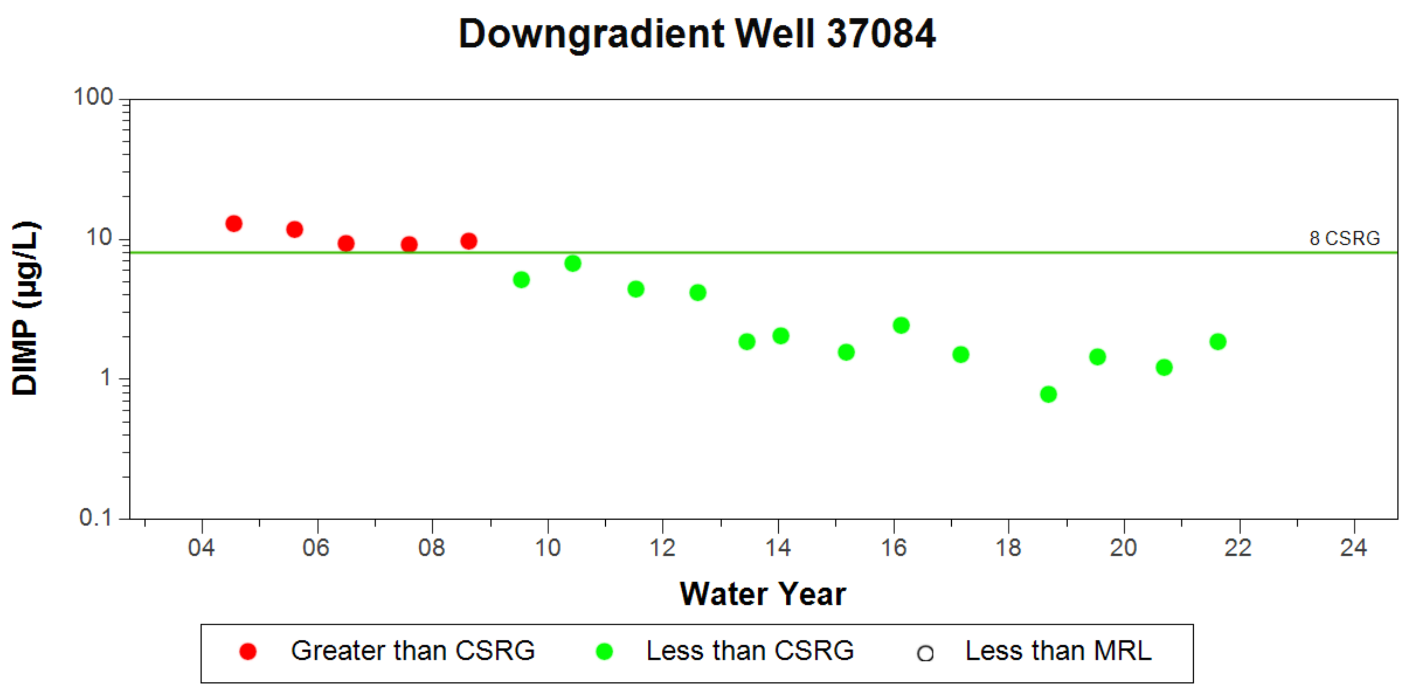
Upgradient Well 37373
DIMP (µg/L)
100
10
1
8 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



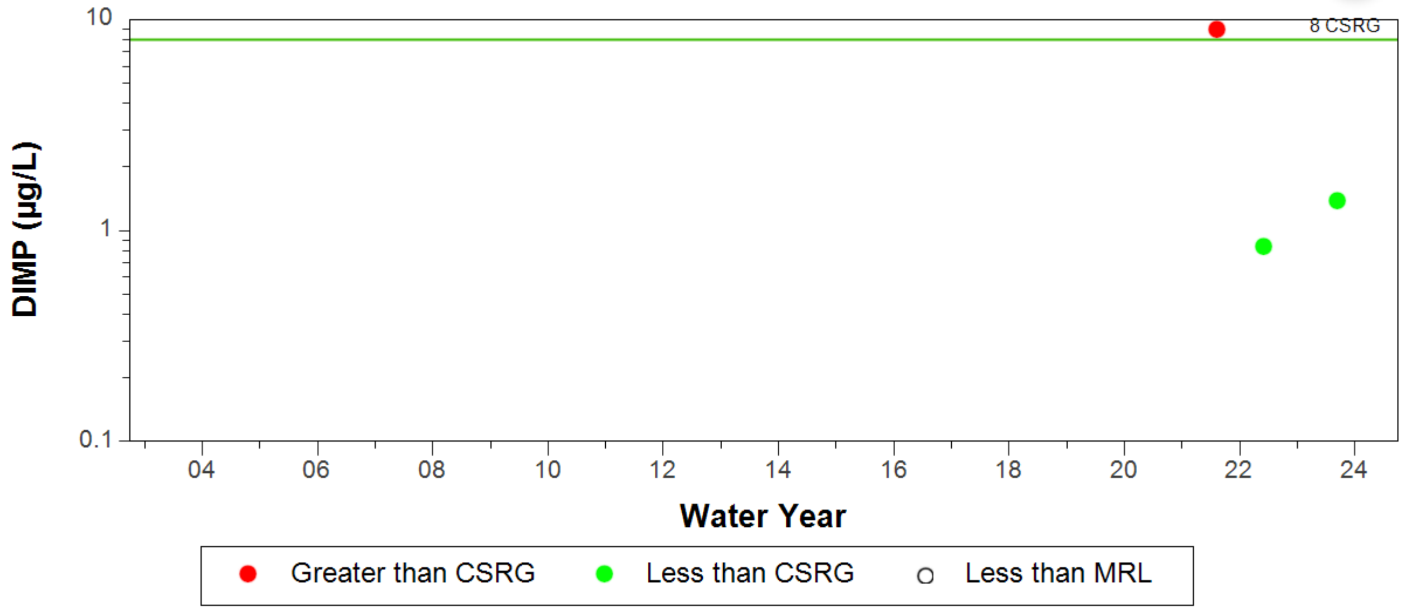
Downgradient Well 37110
DIMP (µg/L)
10
1
0.1
8 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



In FY22, well 37084 was replaced by well 37116.
Prior to FY22, DIMP in well 37084 did not show an increasing trend.

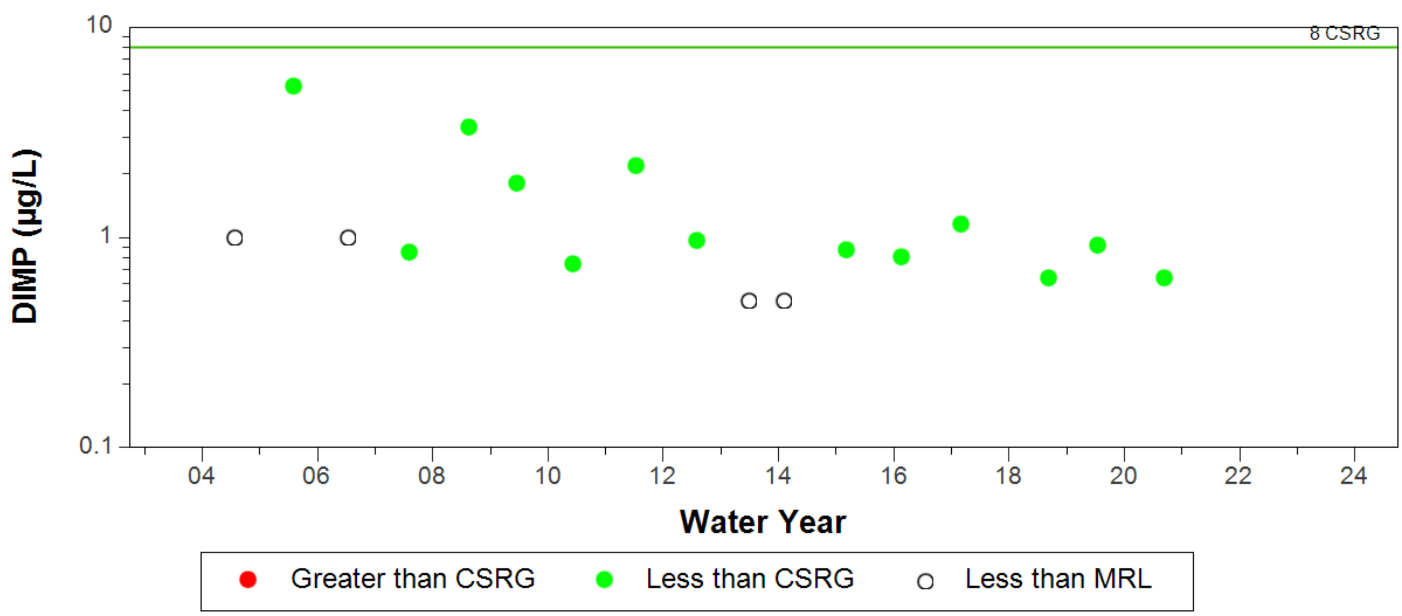


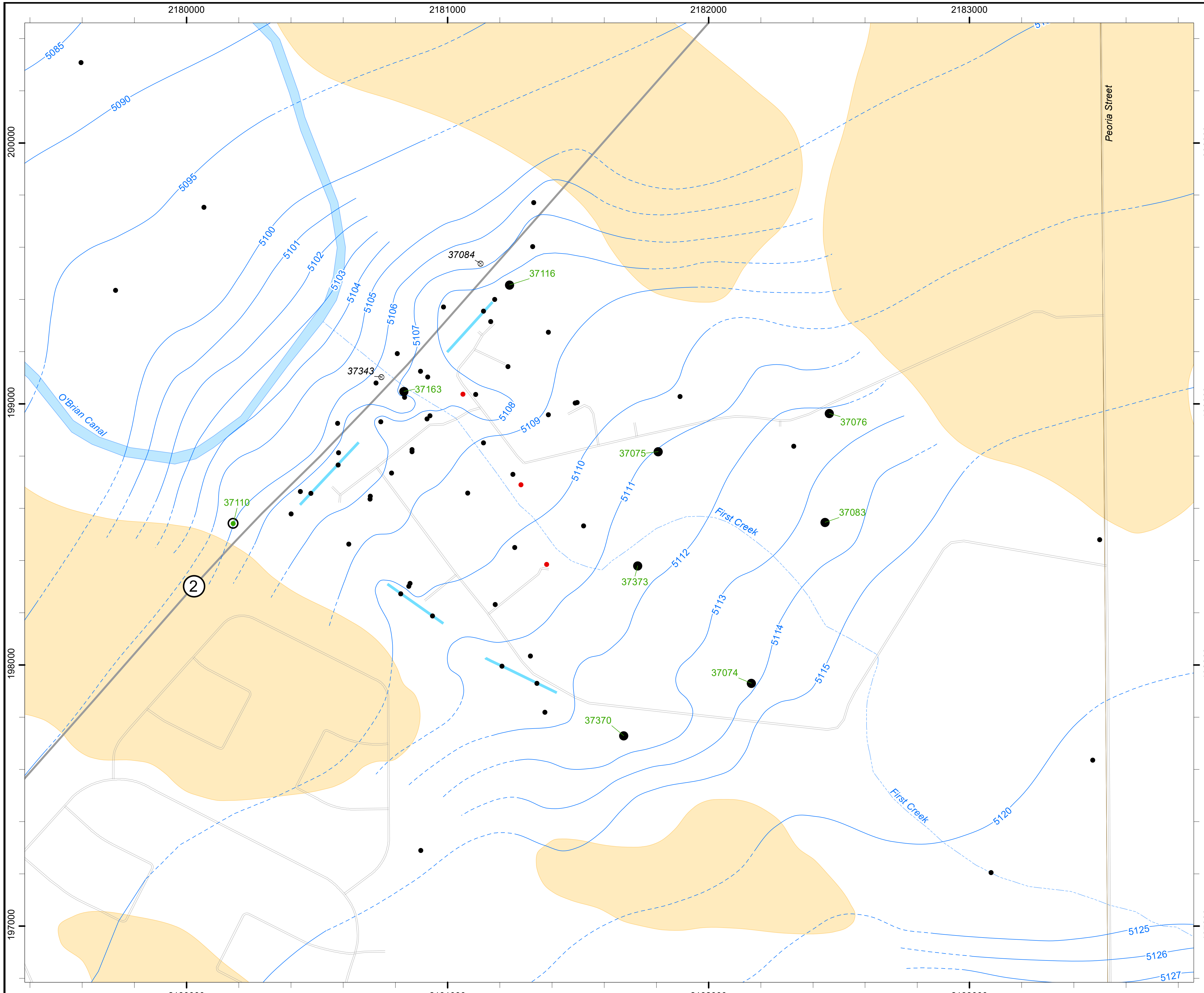
Downgradient Well 37163



In FY22, well 37343 was replaced by well 37163.
Prior to FY22, DIMP in well 37343 did not show an increasing trend.

Downgradient Well 37343





Legend

- Unsaturated Alluvium
- Section Lines
- Lakes, Ponds, Rivers
- Intermittent Streams
- Ditches
- Water elevation contour - 1-foot interval
- Inferred water elevation contour
- Recharge Trenches
- Local Roads
- Secondary Roads
- Primary Roads
- Monitoring Wells
- Performance Wells
- Extraction Wells
- Replaced Monitoring Wells

Note: Water levels were measured in FY23 Quarter 2.

Upgradient and Downgradient Performance Well Water Quality

- Analyte Detected Above the CSRG - Increasing Trend Noted
- Analyte Detected Above the CSRG - Decreasing Trend Noted
- Analyte Detected - Showing Stable or No Discernible Trend
- Analyte Not Detected

Notes:
1. Trends are depicted for the 10 year period FY14 - FY23.
2. Time versus concentration charts for Performance Water Quality wells are presented following this map.

N

0 200 400 Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

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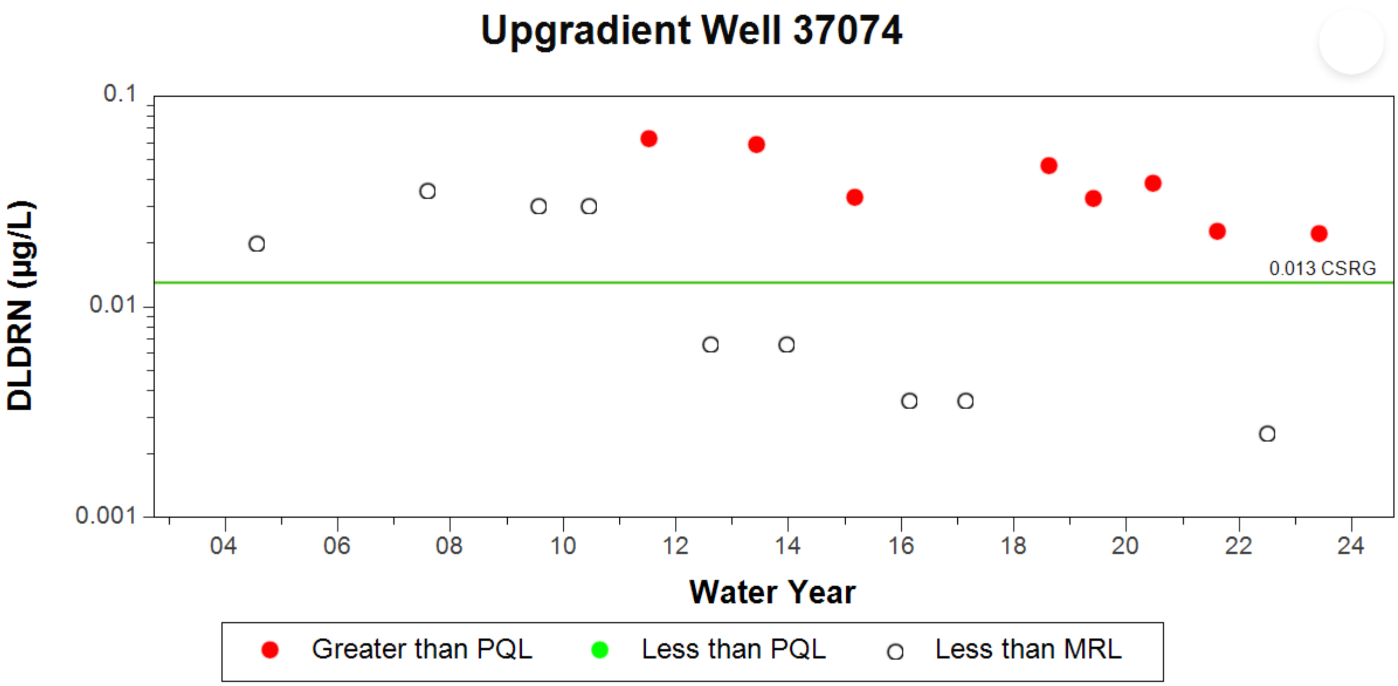
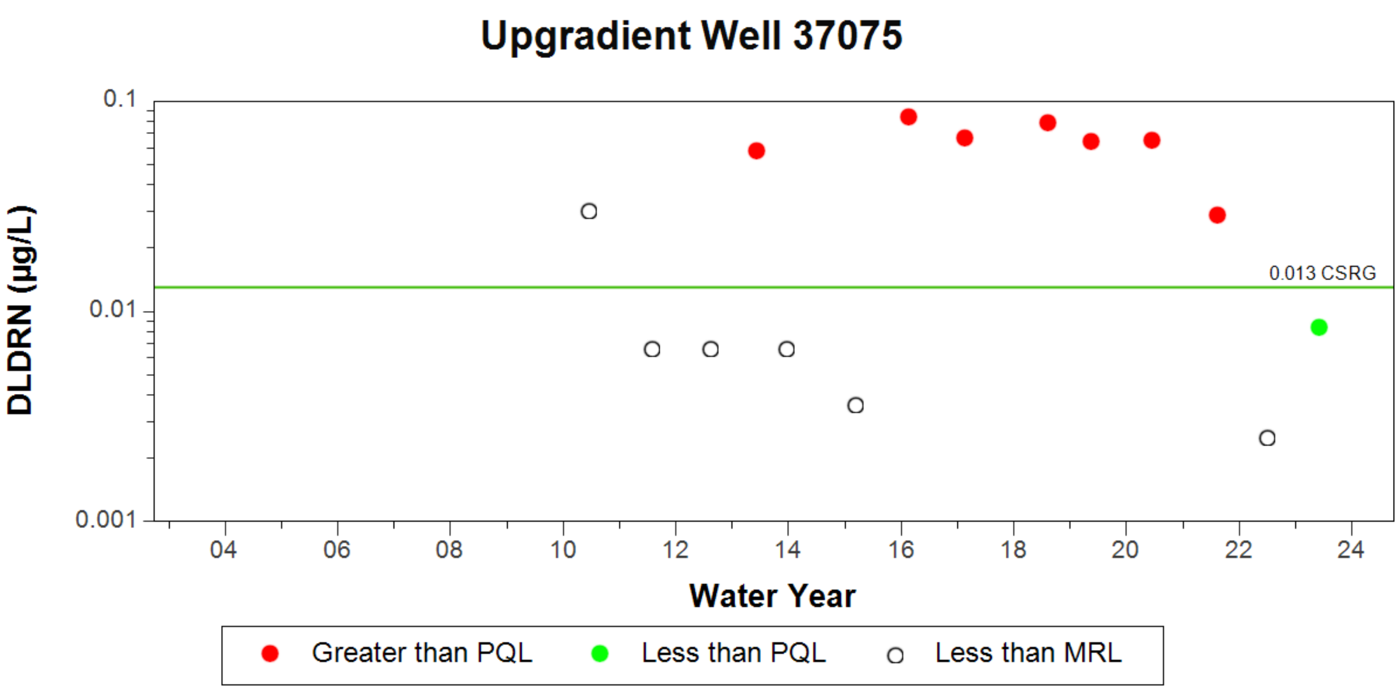
Figure F-14

Dieldrin Concentration
Trends in Performance Wells,
First Creek Treatment System

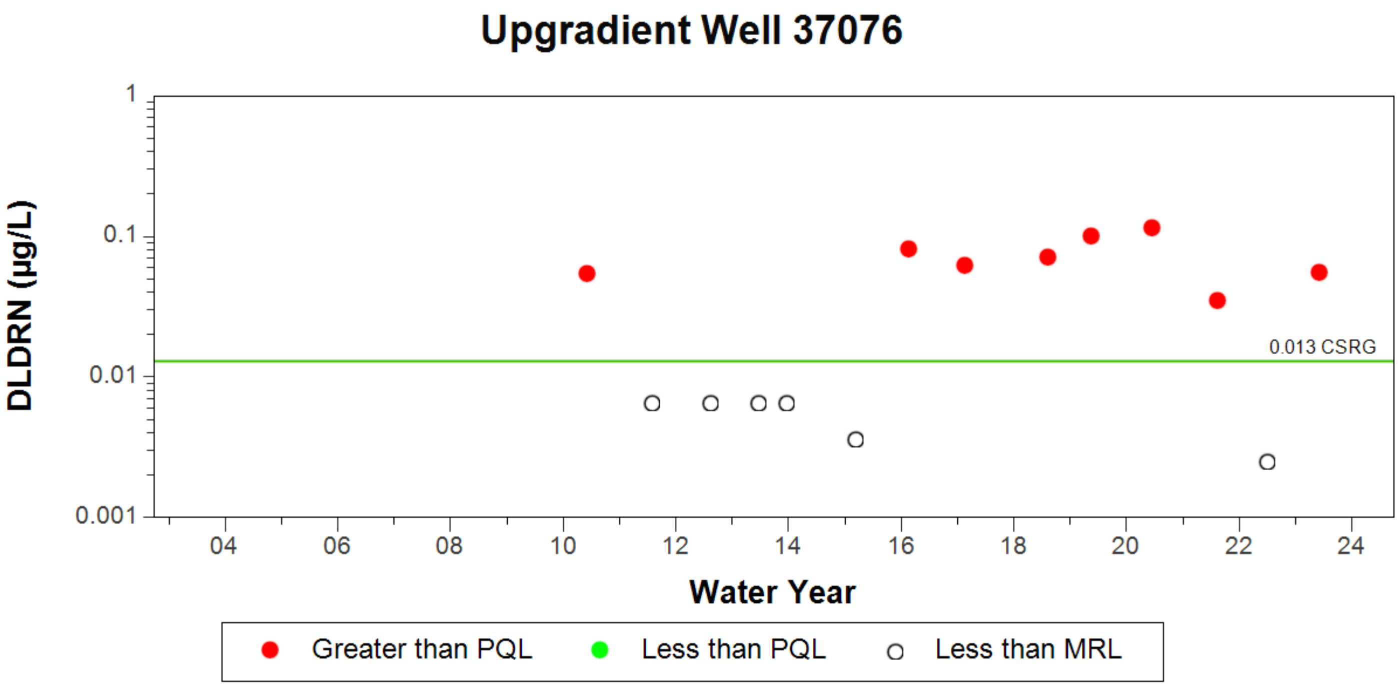
M:\projects\oars\fy23\mxds_FC_FY23_DLDRN.mxd
8/7/2024

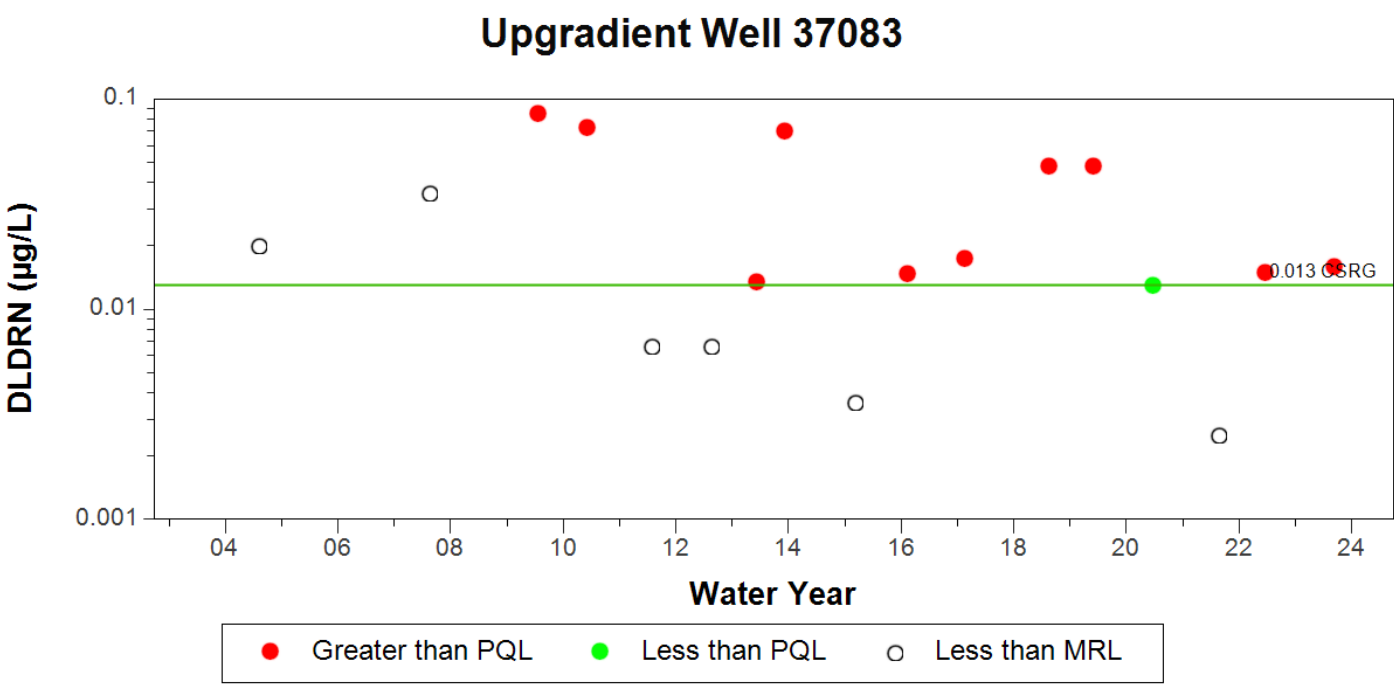


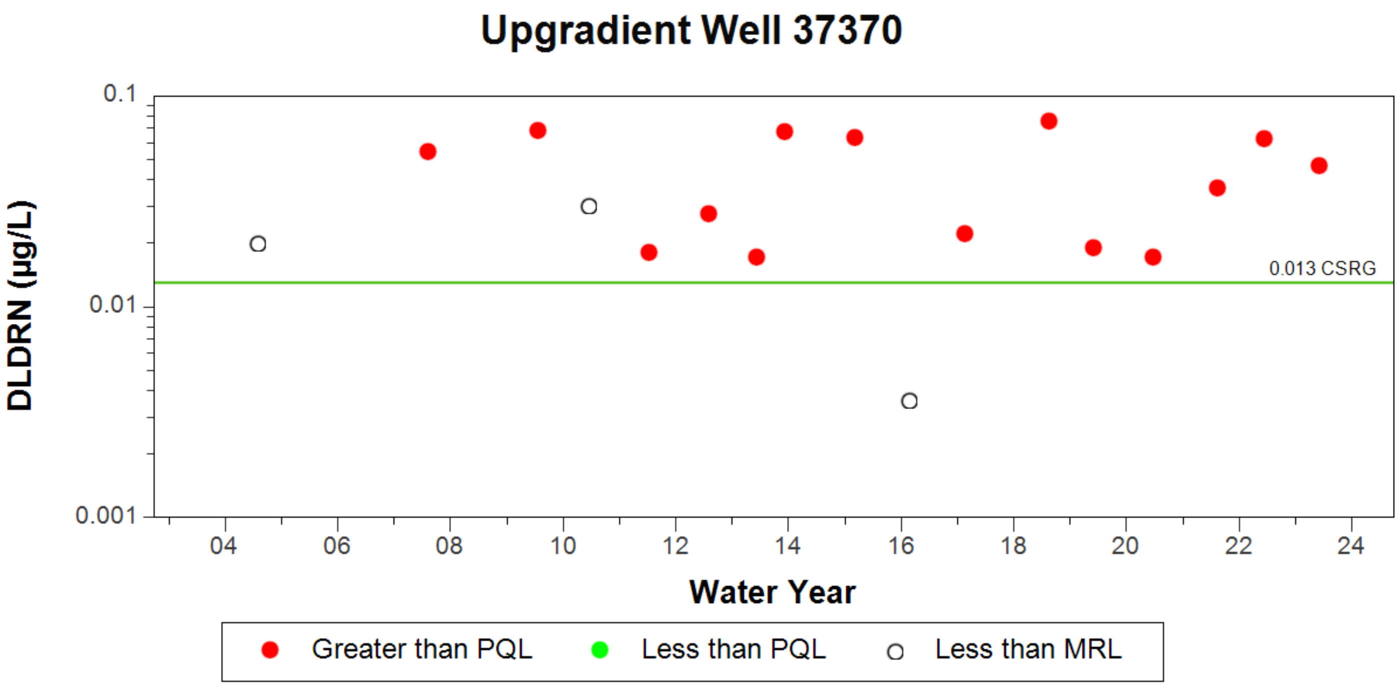
Upgradient Well 37074
DLDRN (µg/L)
0.1
0.01
0.001
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

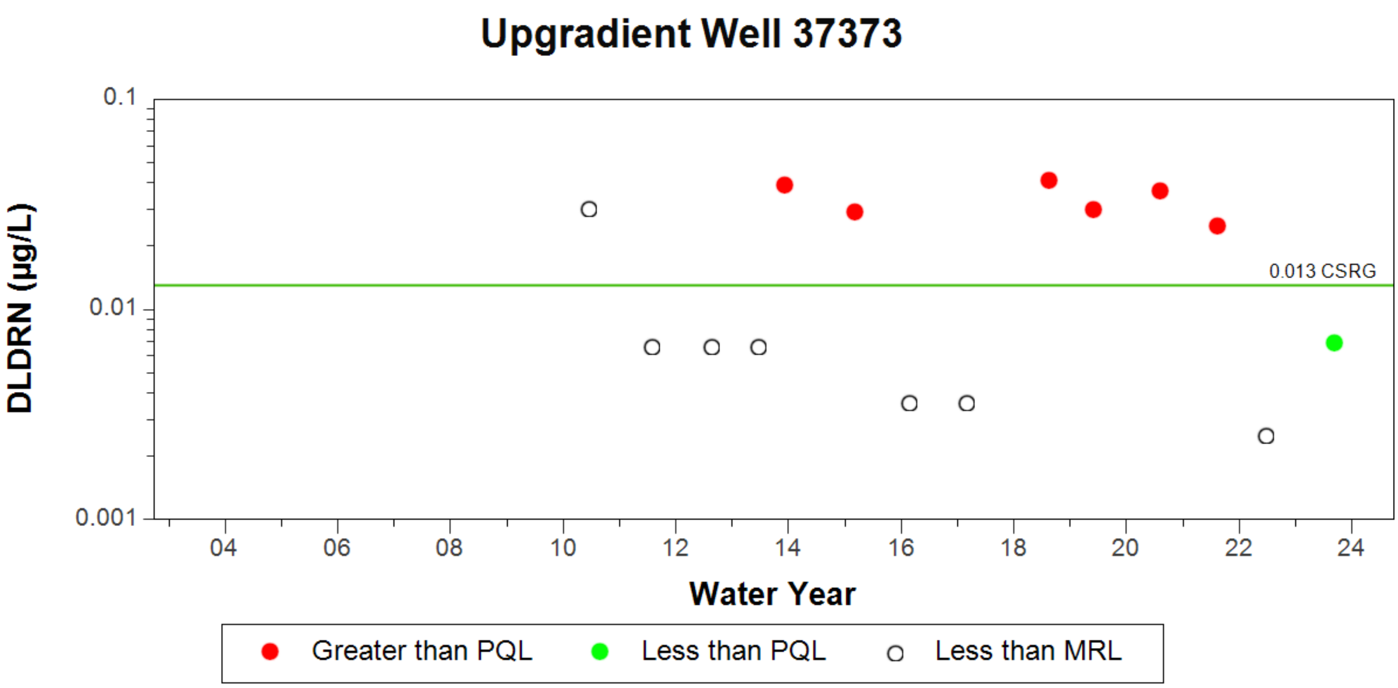


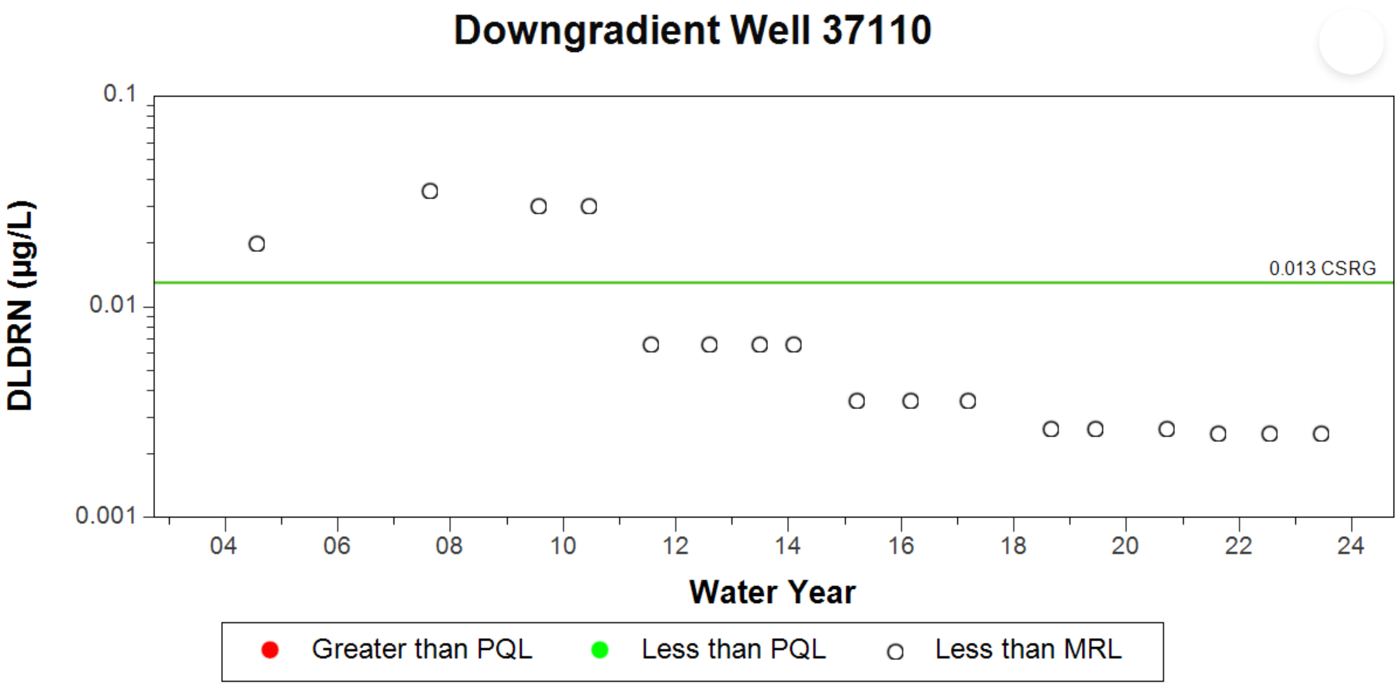
Upgradient Well 37075
DLDRN (µg/L)
0.1
0.01
0.001
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

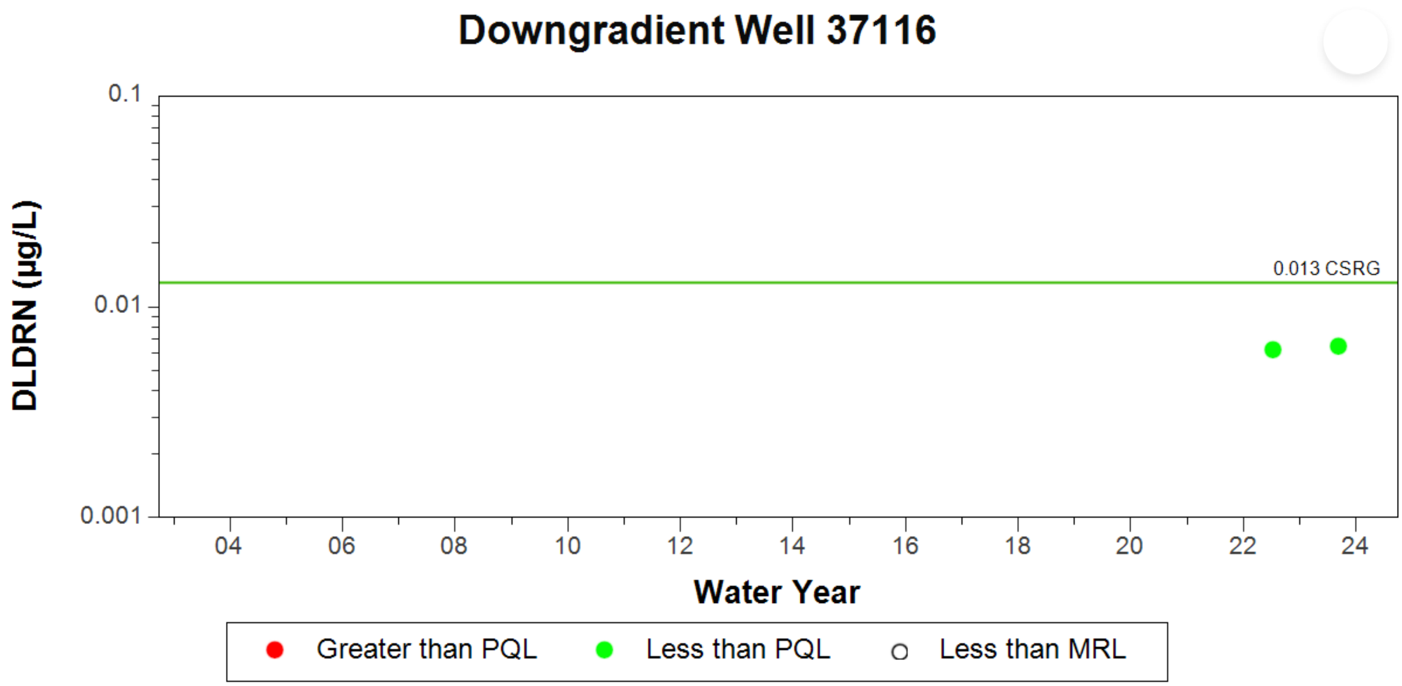

Upgradient Well 37076
DLDRN (µg/L)
1
0.1
0.01
0.001
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL


Upgradient Well 37083
DLDRN (µg/L)
0.1
0.01
0.001
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

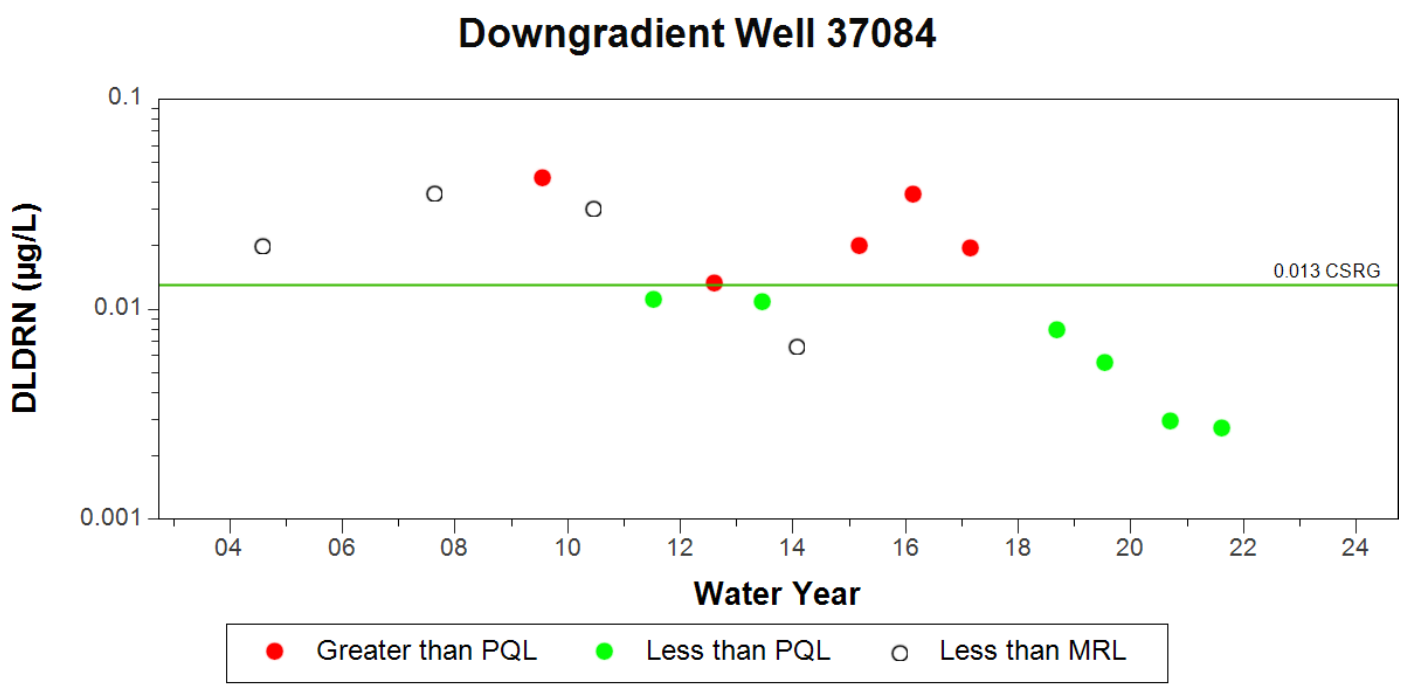

Upgradient Well 37370
DLDRN (µg/L)
0.1
0.01
0.001
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

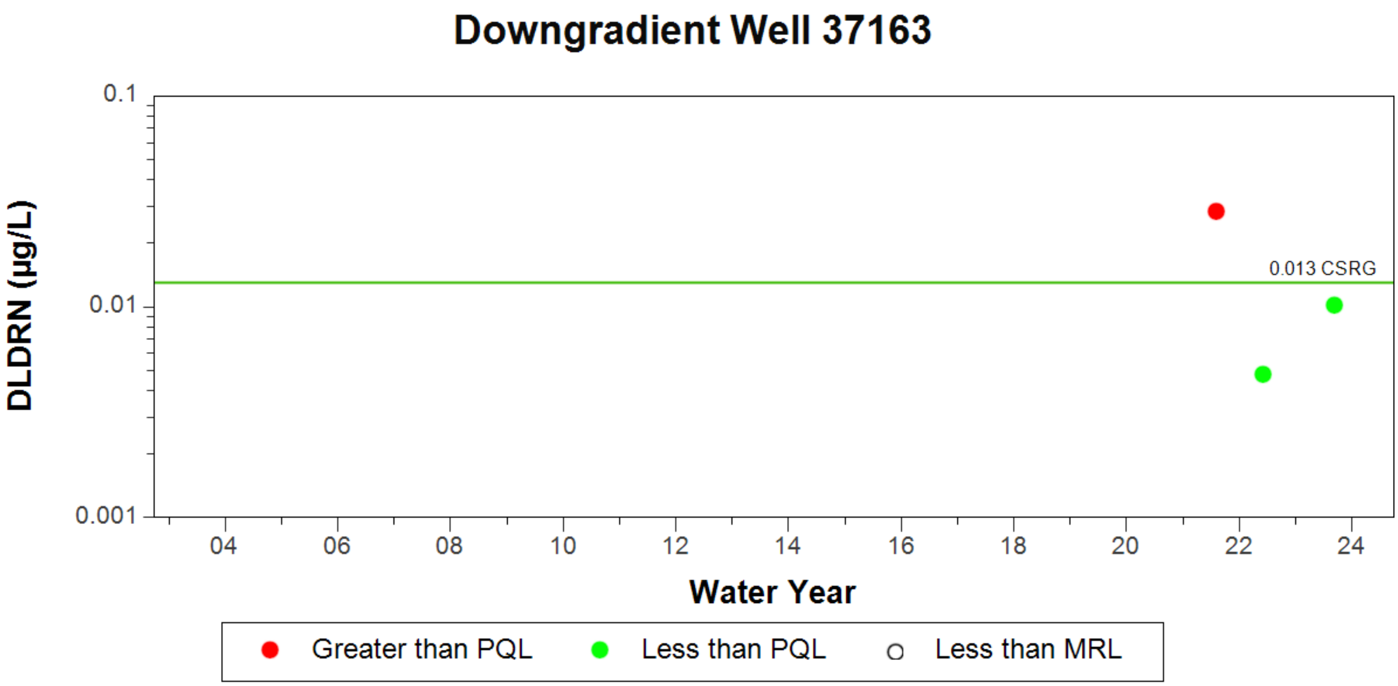

Upgradient Well 37373
DLDRN (µg/L)
0.1
0.01
0.001
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL


Downgradient Well 37110
DLDRN (µg/L)
0.1
0.01
0.001
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

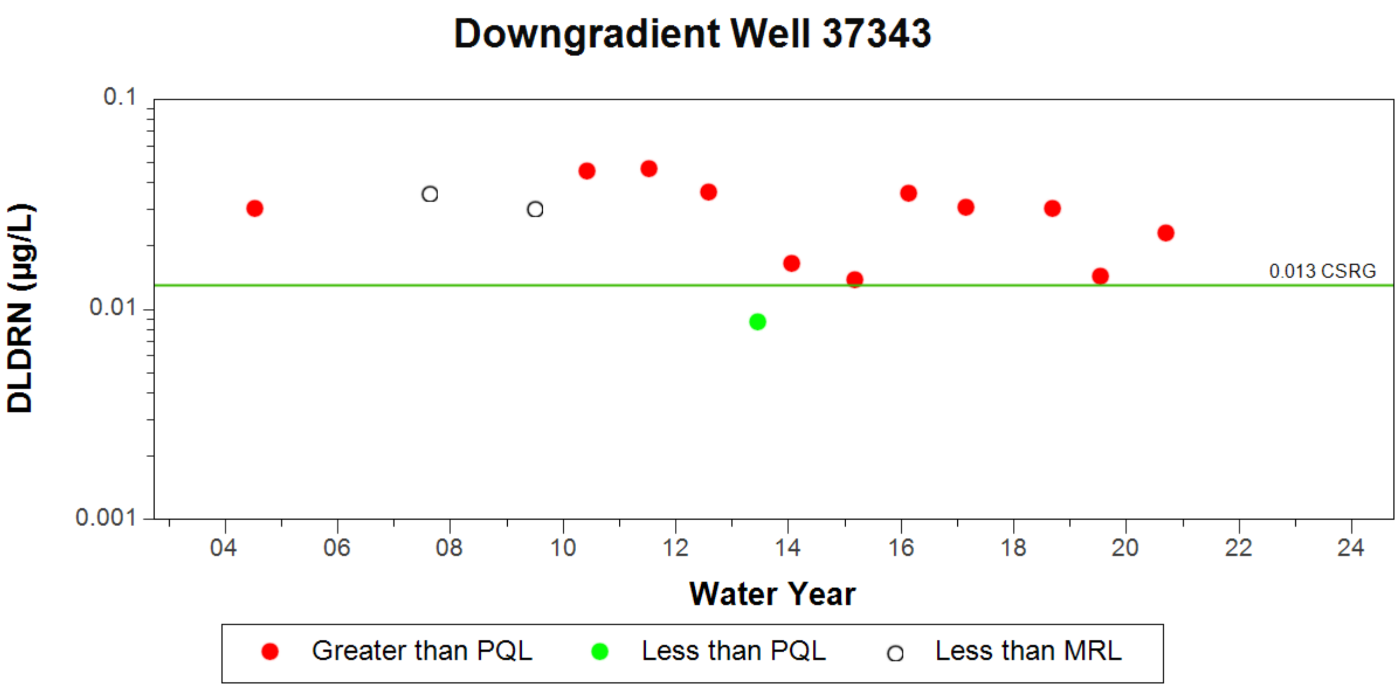


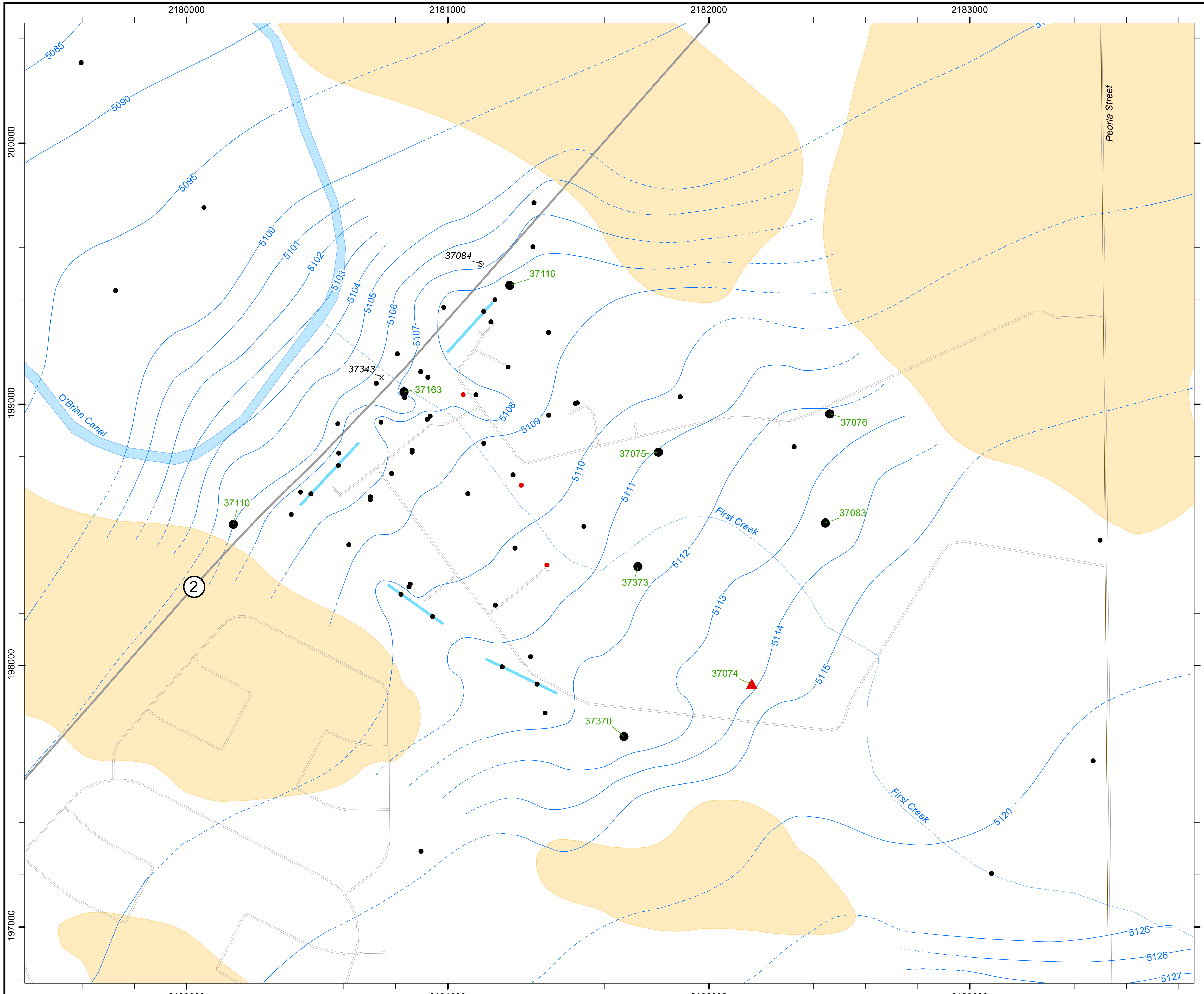
In FY22, well 37084 was replaced by well 37116.
Prior to FY22, dieldrin in well 37084 did not show an increasing trend.





In FY22, well 37343 was replaced by well 37163.
Prior to FY22, dieldrin in well 37343 did not show an increasing trend.





Legend

- Unsaturated Alluvium
- Section Lines
- Lakes, Ponds, Rivers
- Intermittent Streams
- Ditches
- Water elevation contour - 1-foot interval
- Inferred water elevation contour
- Recharge Trenches
- Local Roads
- Secondary Roads
- Primary Roads
- Monitoring Wells
- Performance Wells
- Extraction Wells
- Replaced Monitoring Wells

Note: Water levels were measured in FY23 Quarter 2.

Upgradient and Downgradient Performance Well Water Quality

- Analyte Detected Above the CSRG - Increasing Trend Noted
- Analyte Detected Above the CSRG - Decreasing Trend Noted
- Analyte Detected - Showing Stable or No Discernible Trend
- Analyte Not Detected

Notes:
1. Trends are depicted for the 10 year period FY14 - FY23.
2. Time versus concentration charts for Performance Water Quality wells are presented following this map.

N

0 200 400 Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

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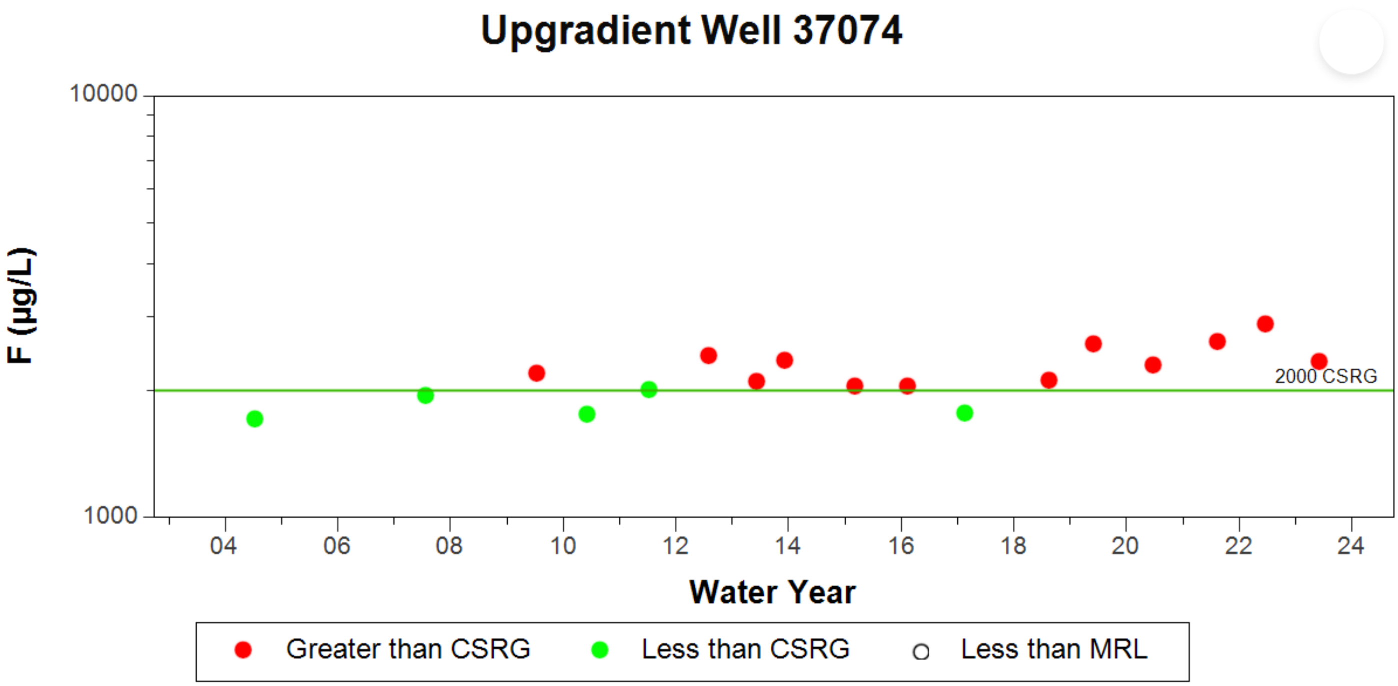
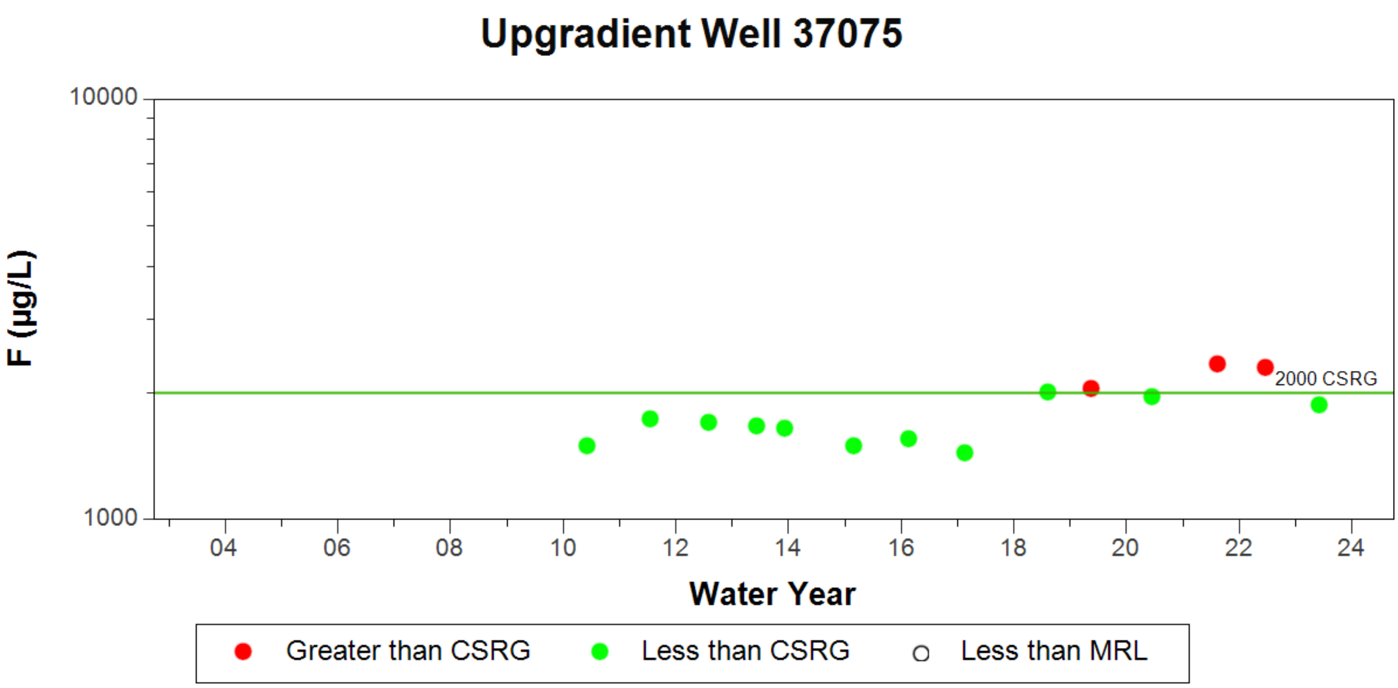
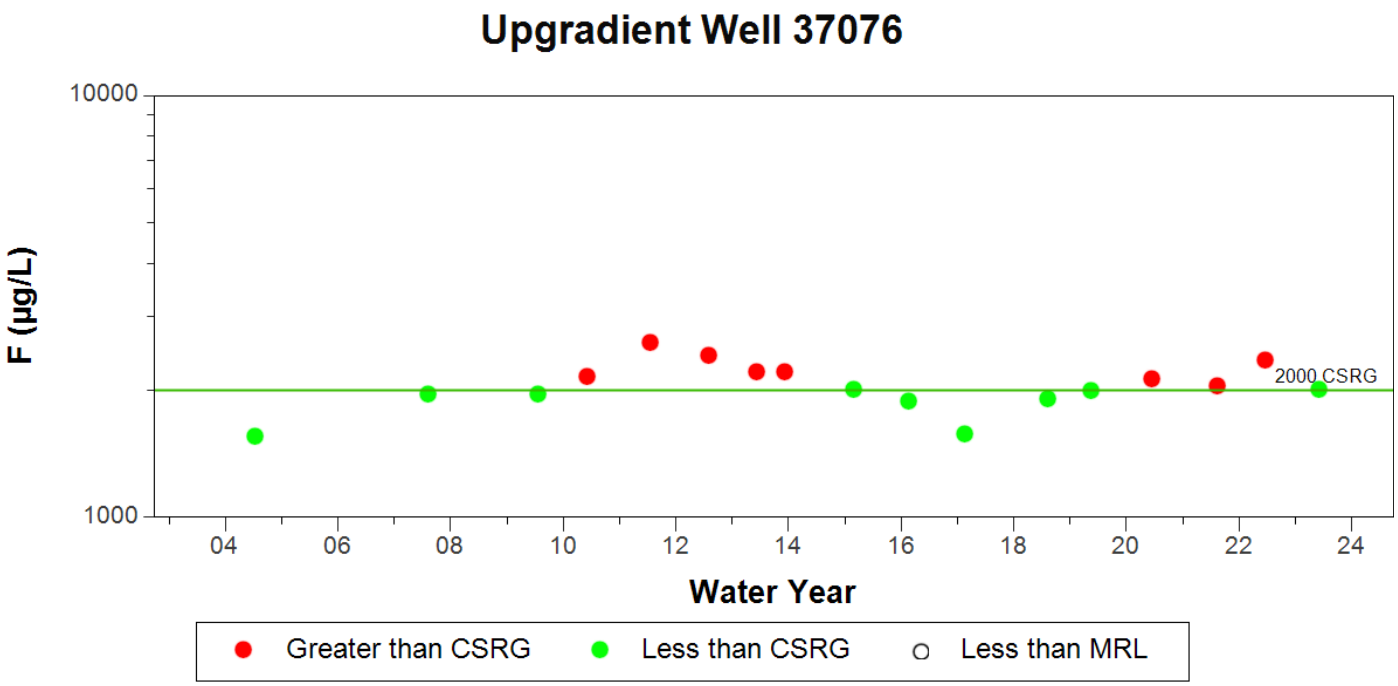
Figure F-15

Fluoride Concentration
Trends in Performance Wells,
First Creek Treatment System

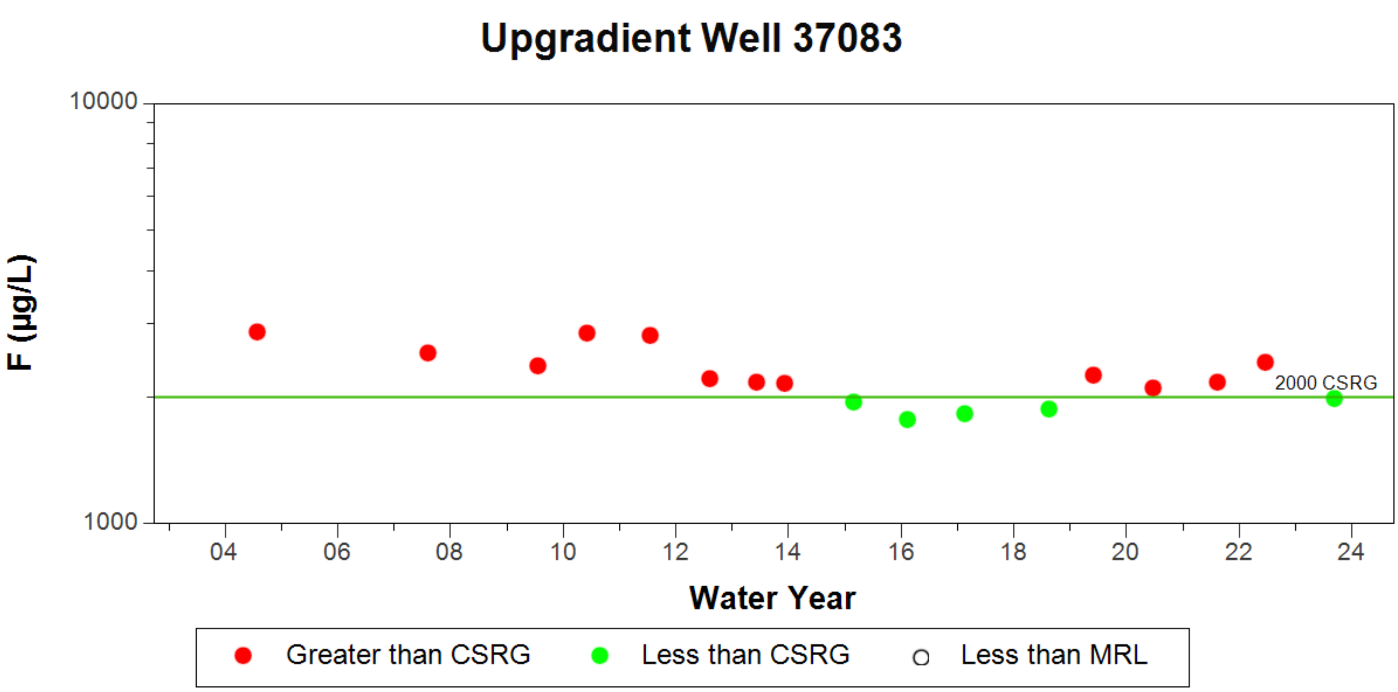
M:\projects\oars\fy23\mxds_FC_FY23_F.mxd
8/7/2024


Upgradient Well 37074
10000
1000
F (µg/L)
2000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

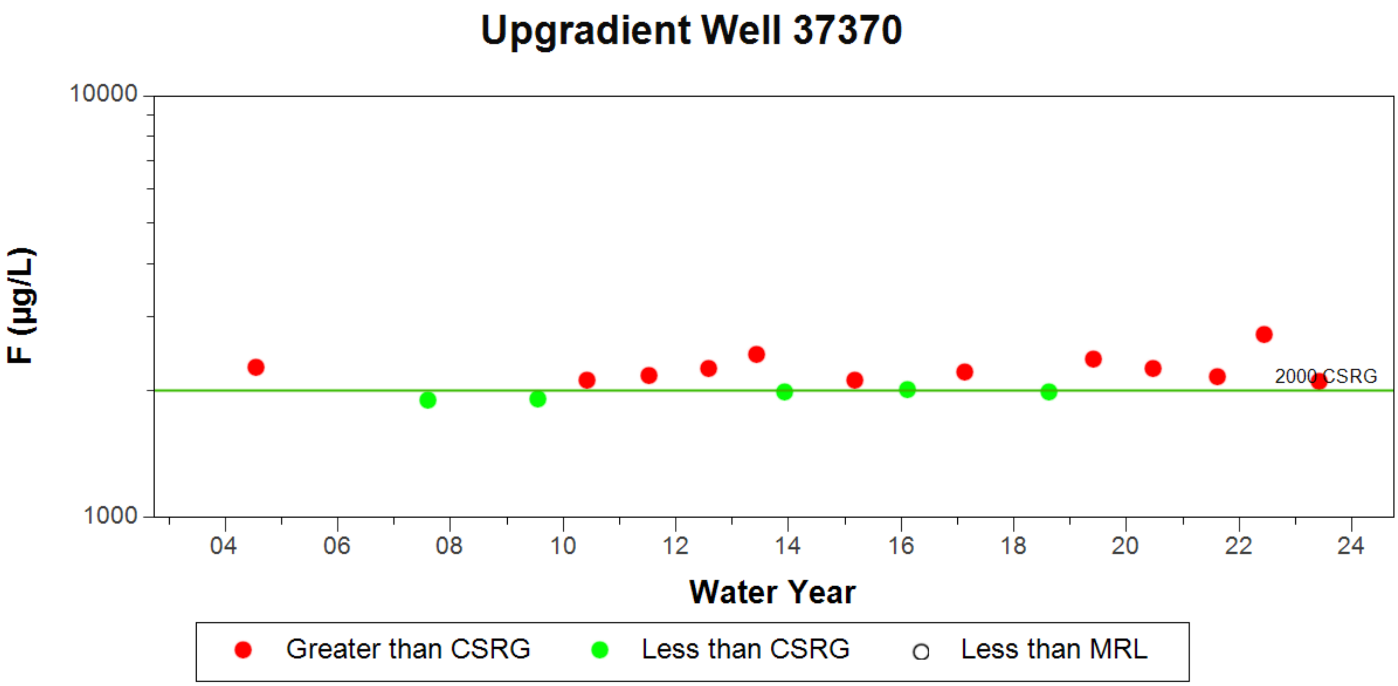

Upgradient Well 37075
10000
1000
F (µg/L)
2000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

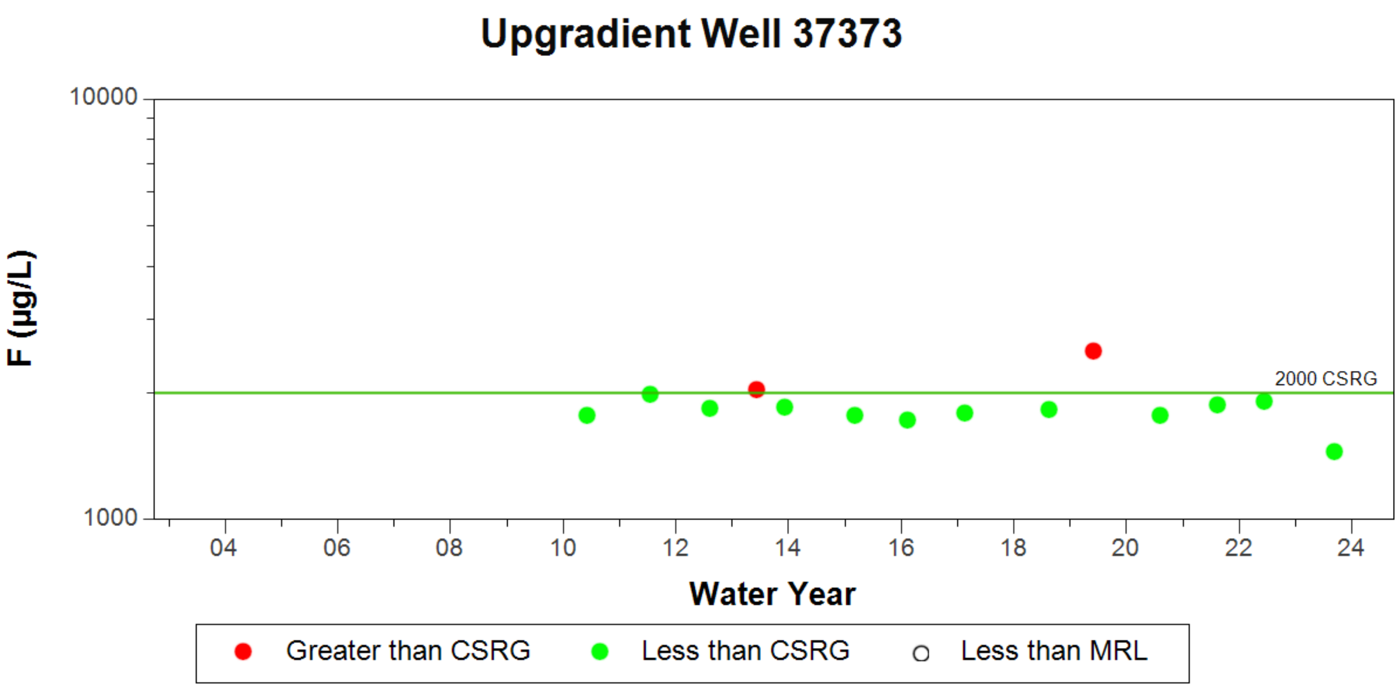


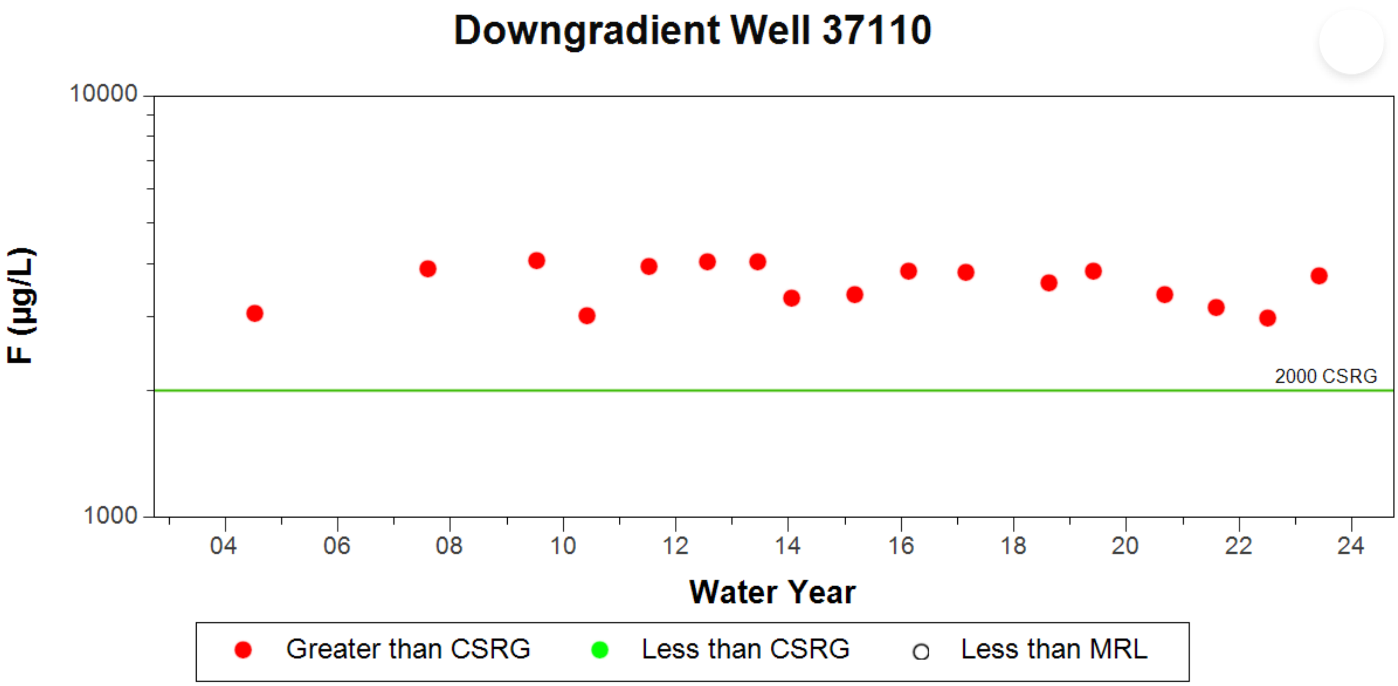
Upgradient Well 37076
10000
1000
F (µg/L)
2000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



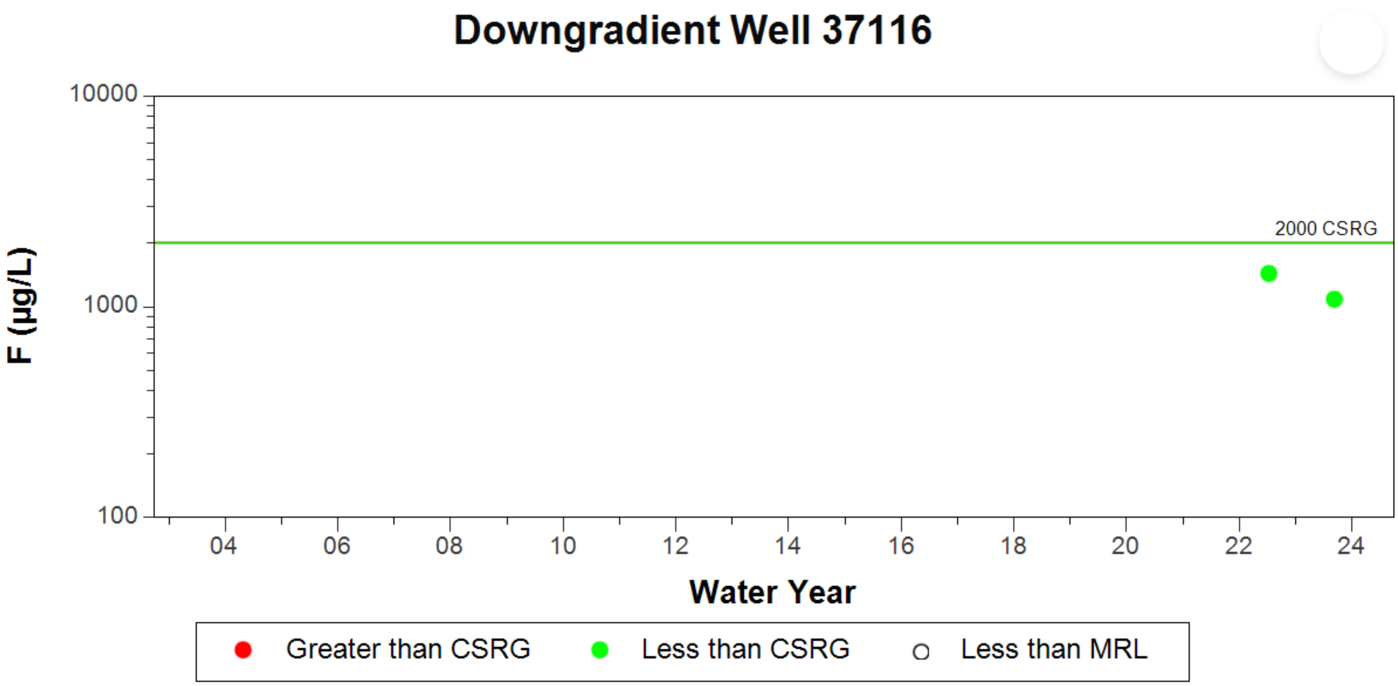
Upgradient Well 37083
10000
1000
F (µg/L)
2000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL


Upgradient Well 37370
F (µg/L)
10000
1000
2000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

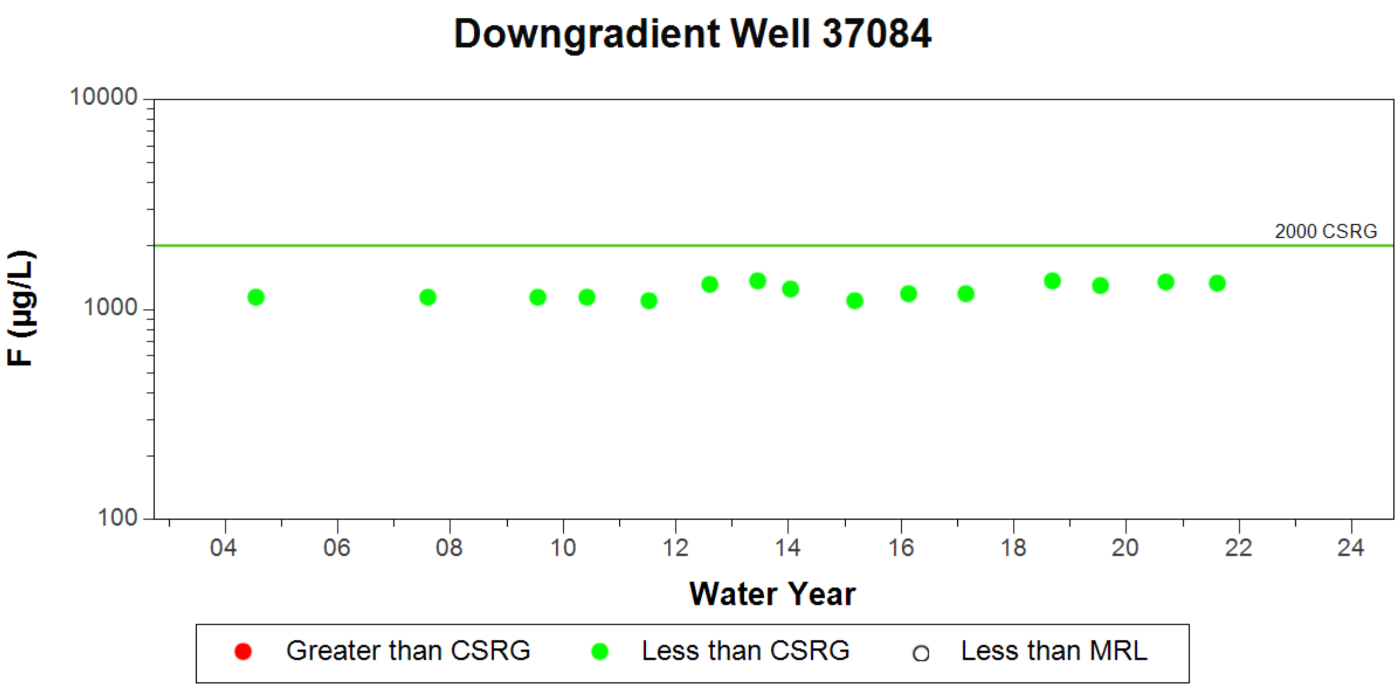

Upgradient Well 37373
F (µg/L)
10000
1000
2000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

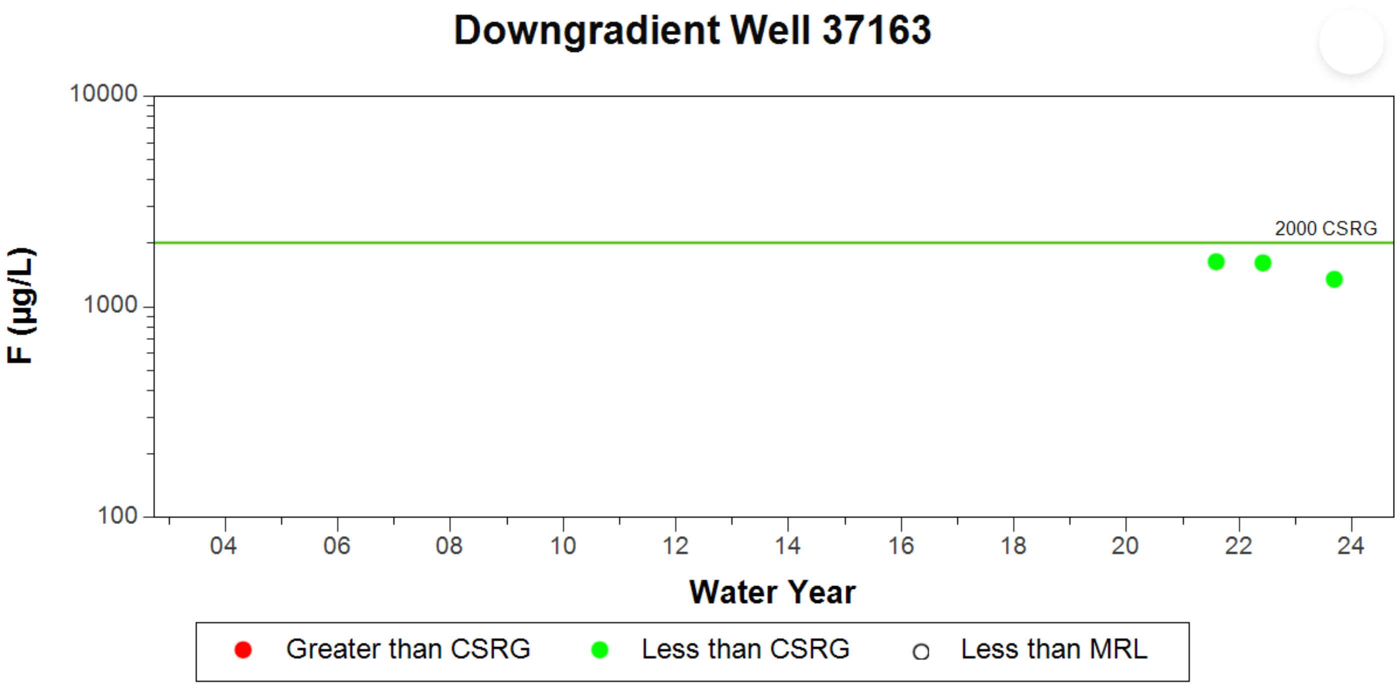


Downgradient Well 37110
10000
1000
F (µg/L)
2000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

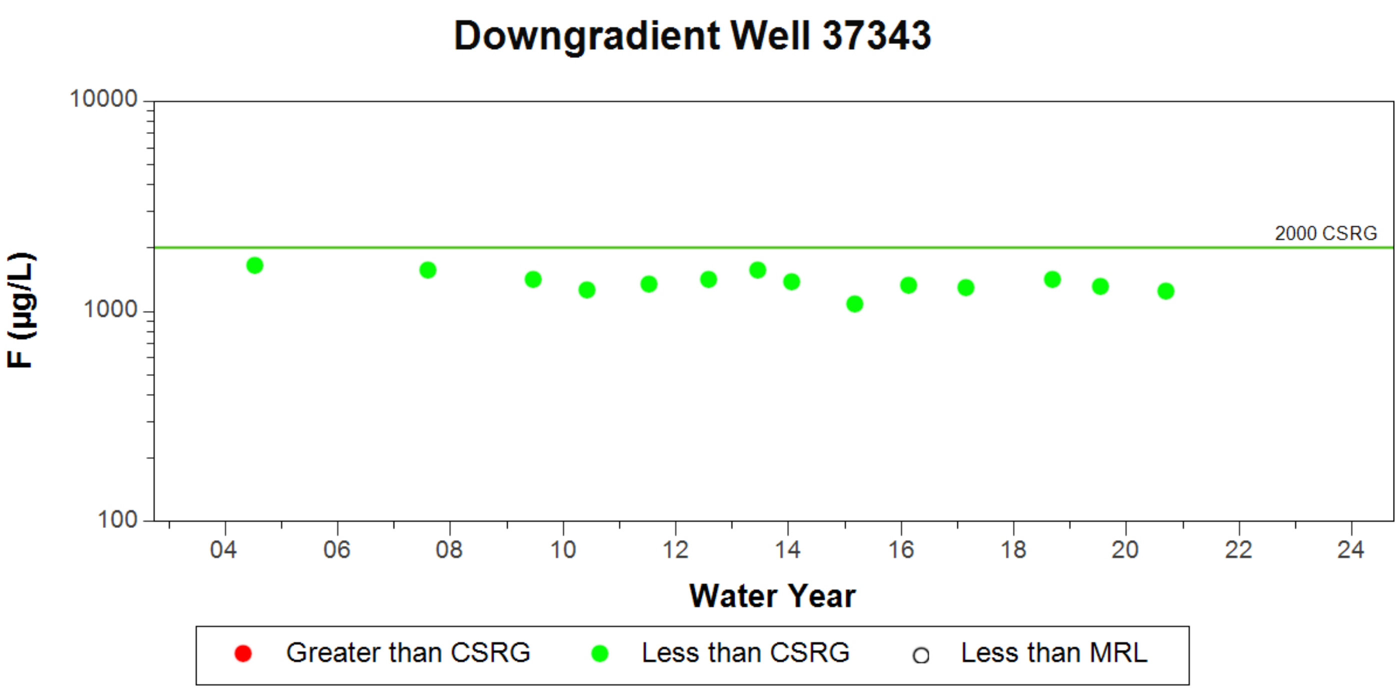


In FY22, well 37084 was replaced by well 37116.
Prior to FY22, fluoride in well 37084 did not show an increasing trend.





In FY22, well 37343 was replaced by well 37163.
Prior to FY22, fluoride in well 37343 did not show an increasing trend.



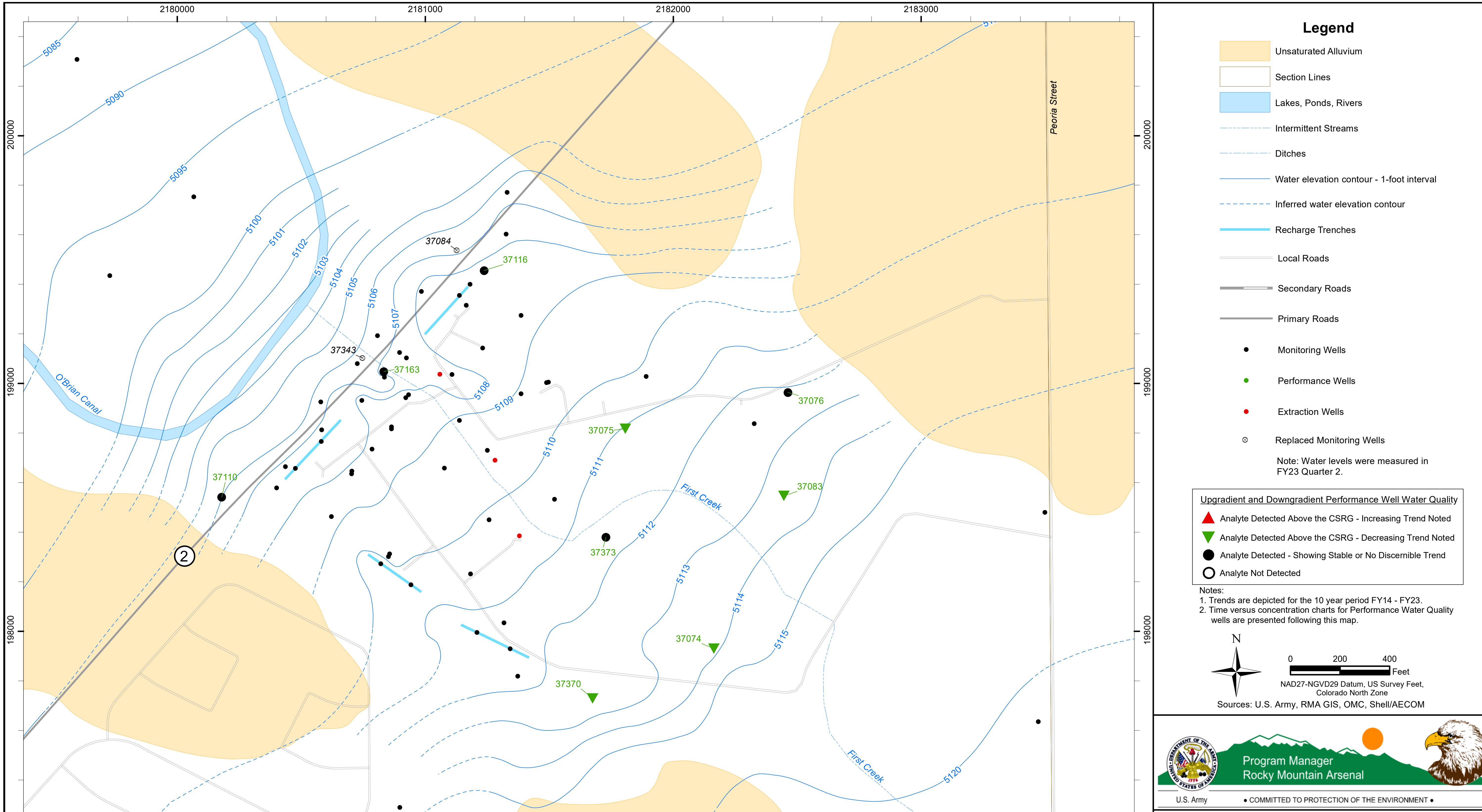
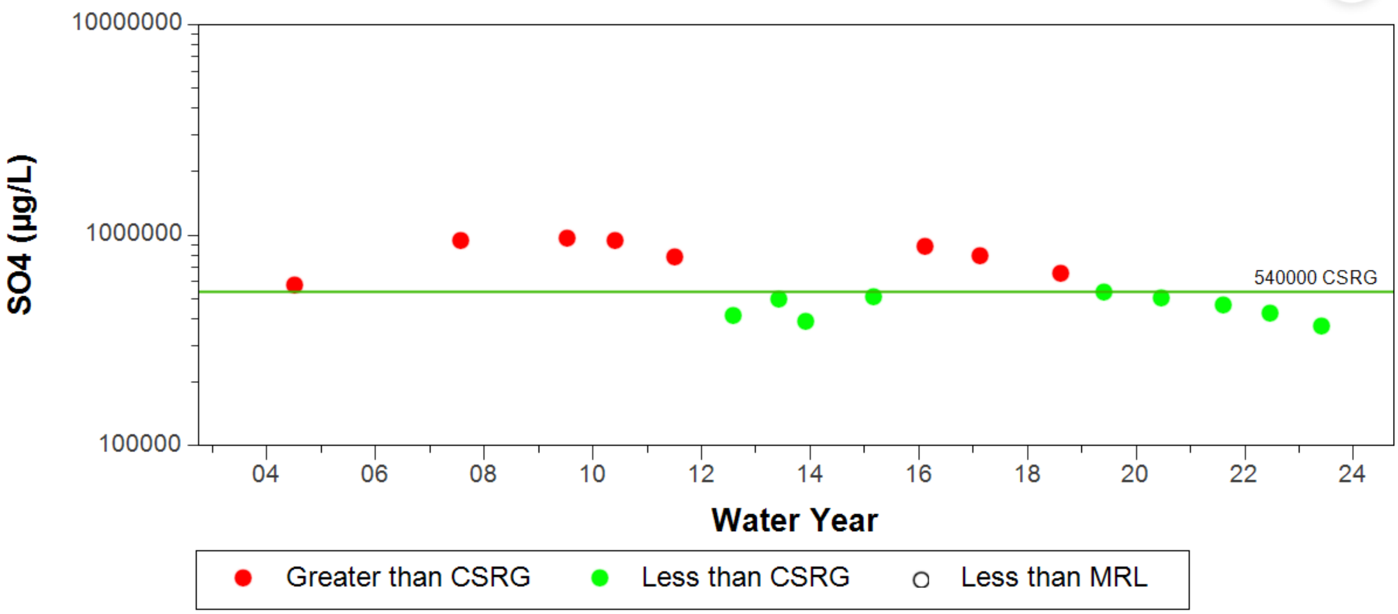


Figure F-16

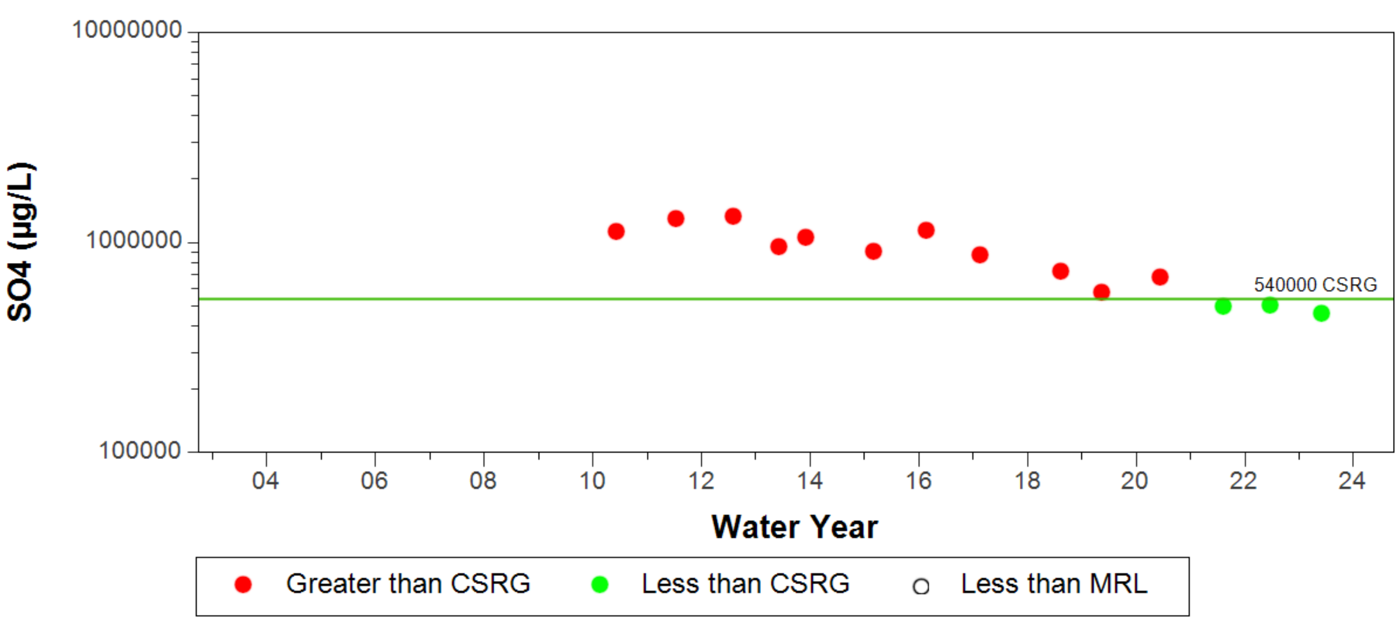
Sulfate Concentration
Trends in Performance Wells,
First Creek Treatment System

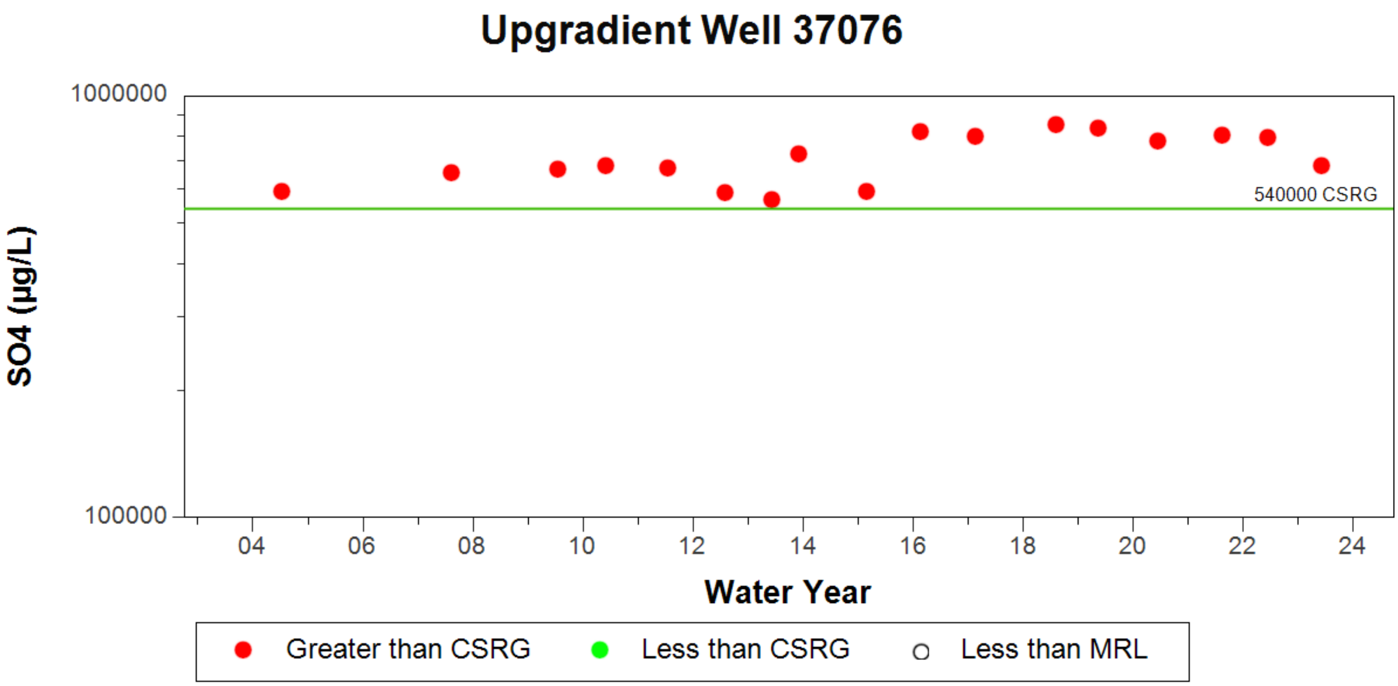
M:\projects\oars\fy23\mxds_FC_FY23_SO4.mxd
8/7/2024

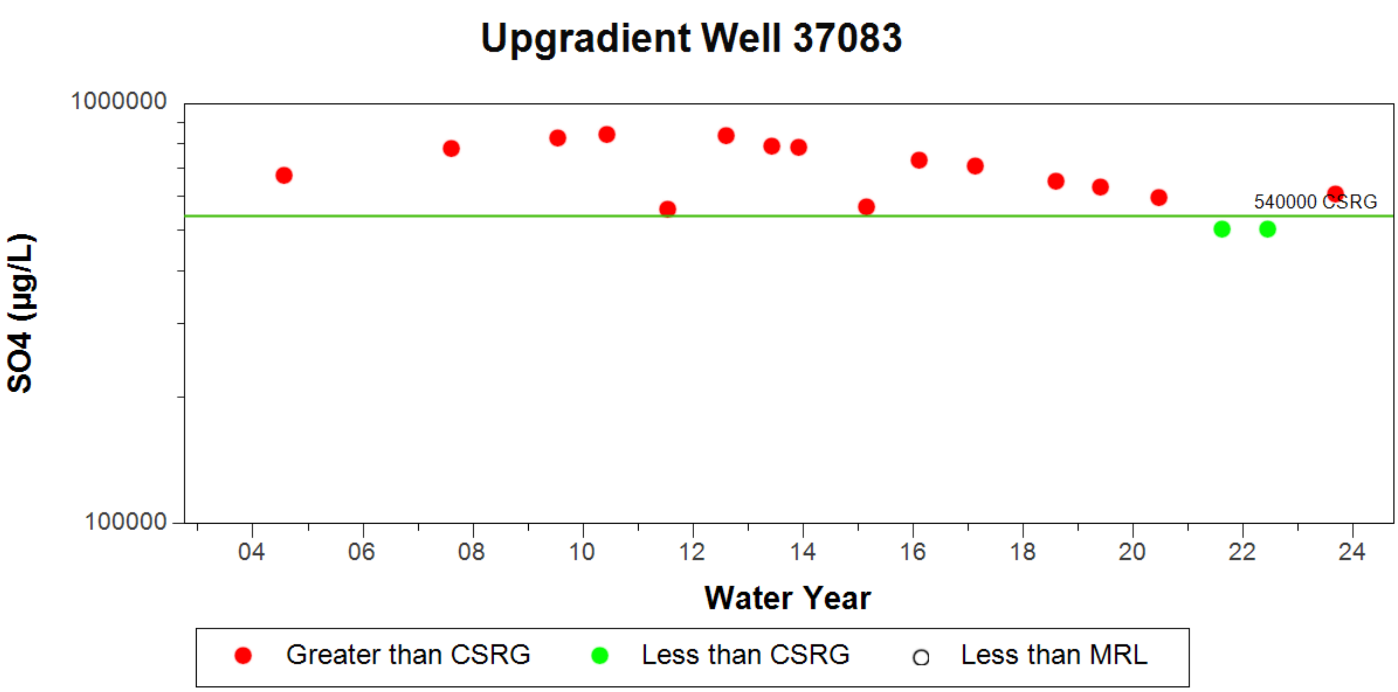
Upgradient Well 37074



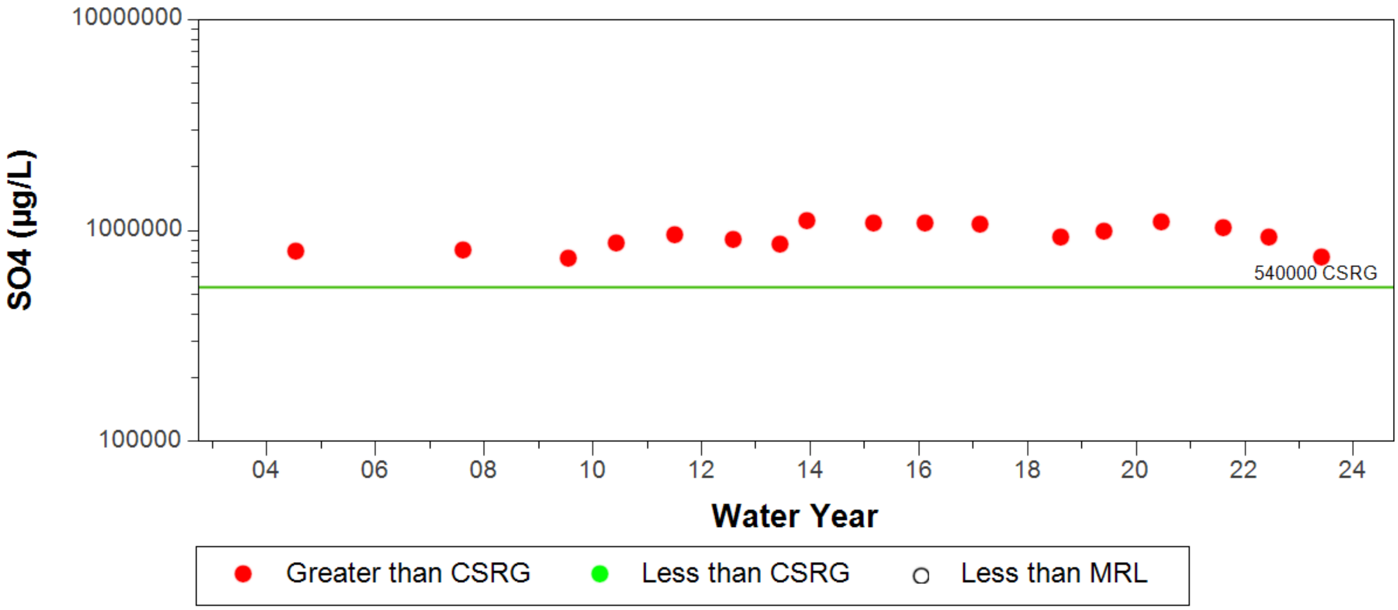
Upgradient Well 37075



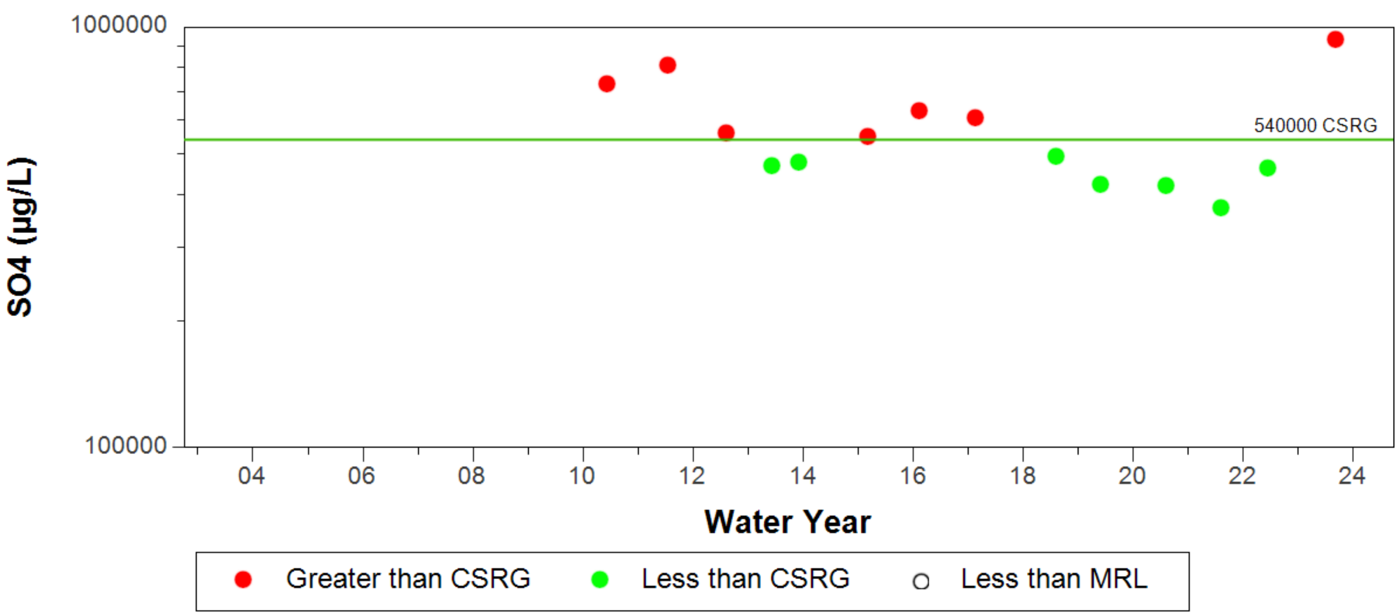

Upgradient Well 37076
1000000
100000
SO4 (µg/L)
540000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

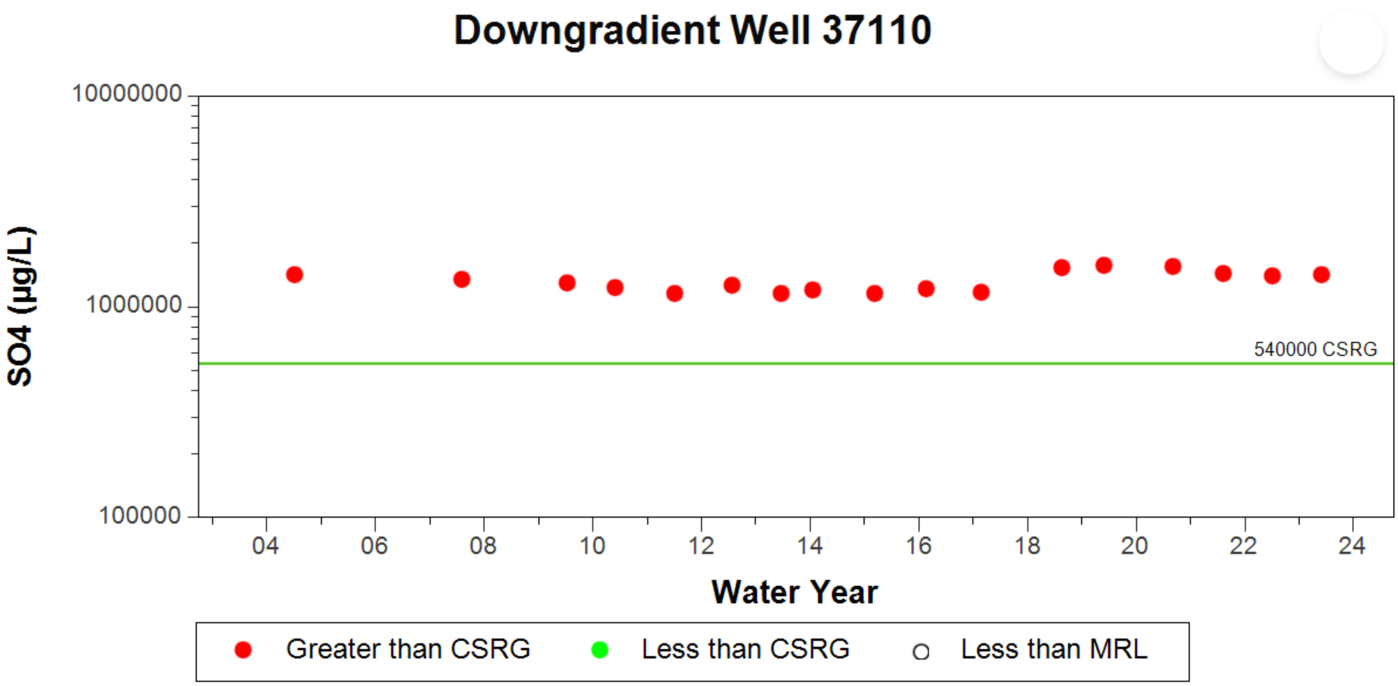

Upgradient Well 37083
1000000
100000
SO4 (µg/L)
540000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

Upgradient Well 37370

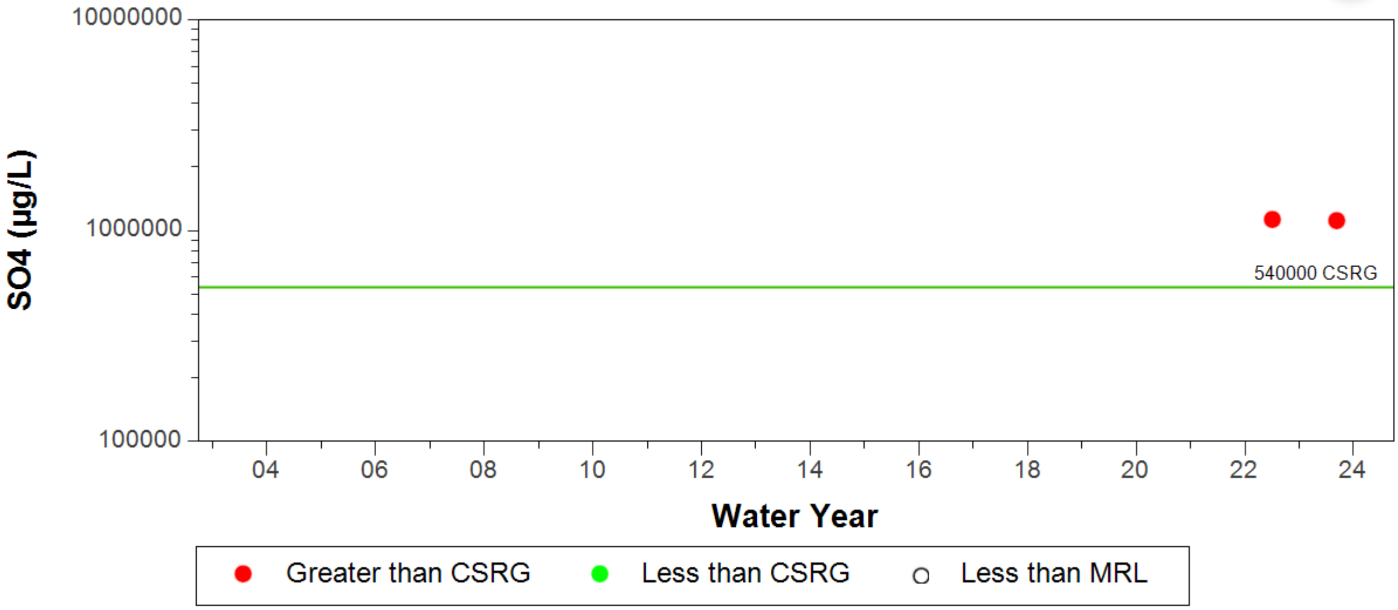


Upgradient Well 37373



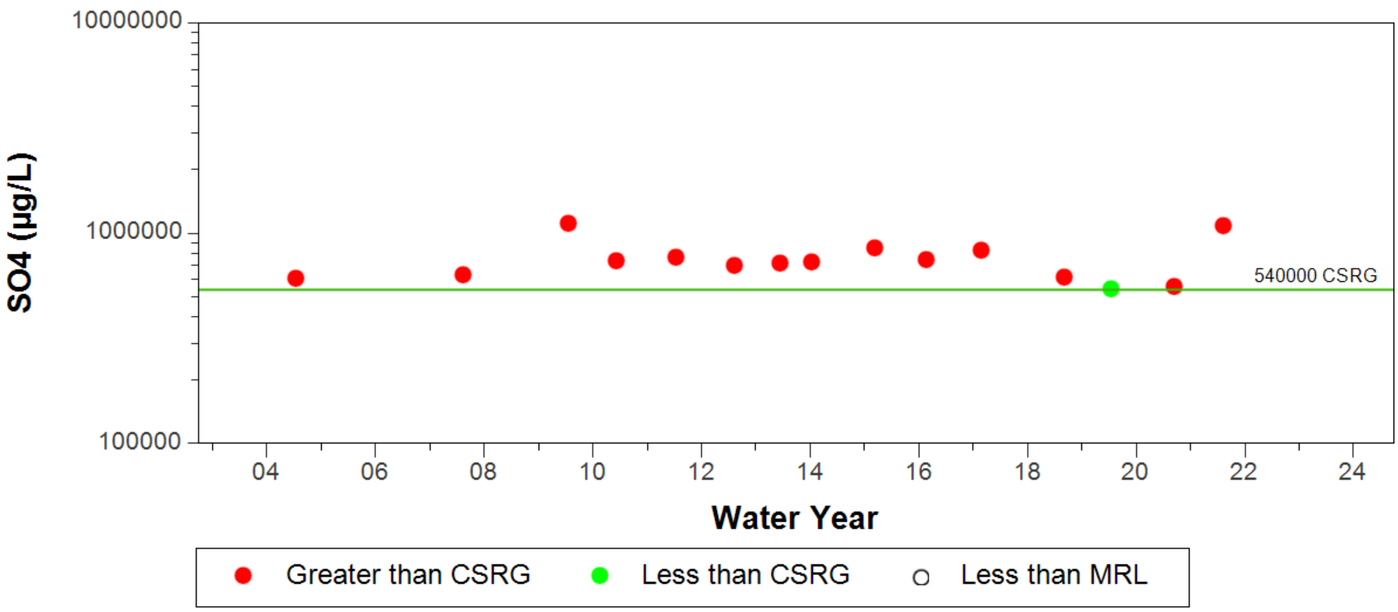

Downgradient Well 37110
SO4 (µg/L)
10000000
1000000
100000
540000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

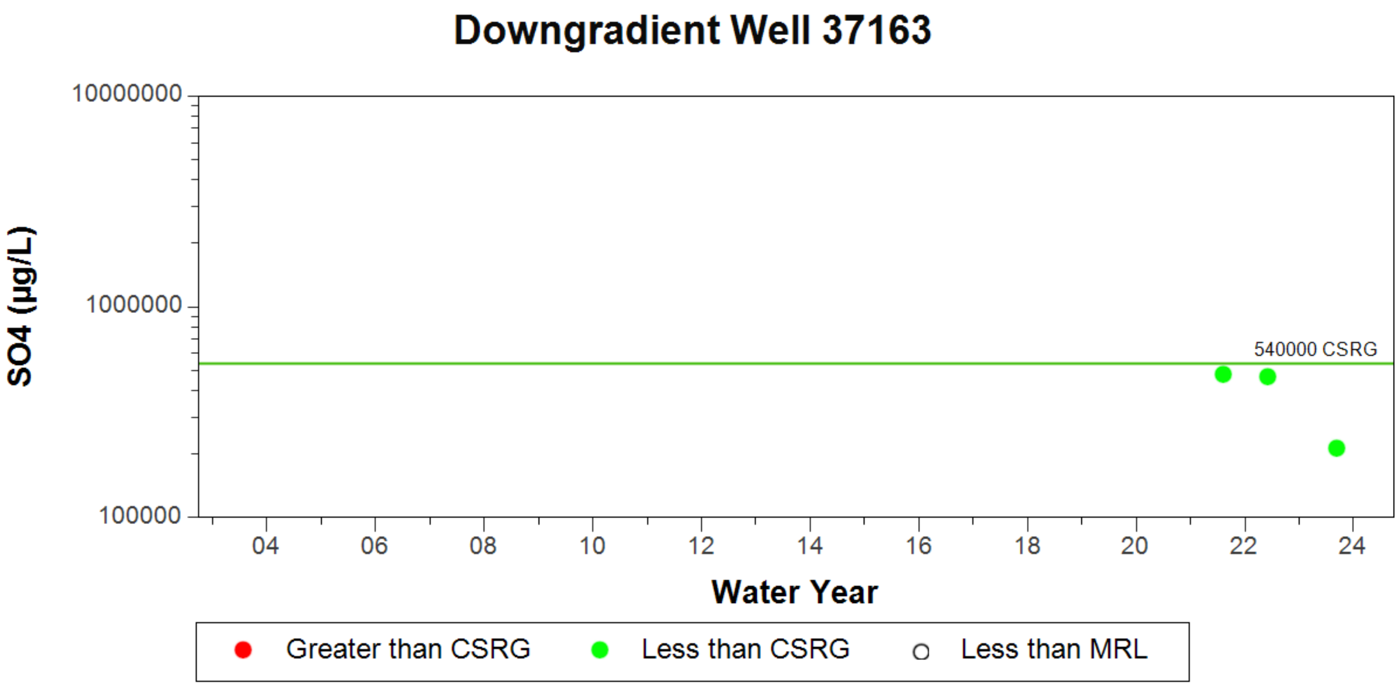
Downgradient Well 37116



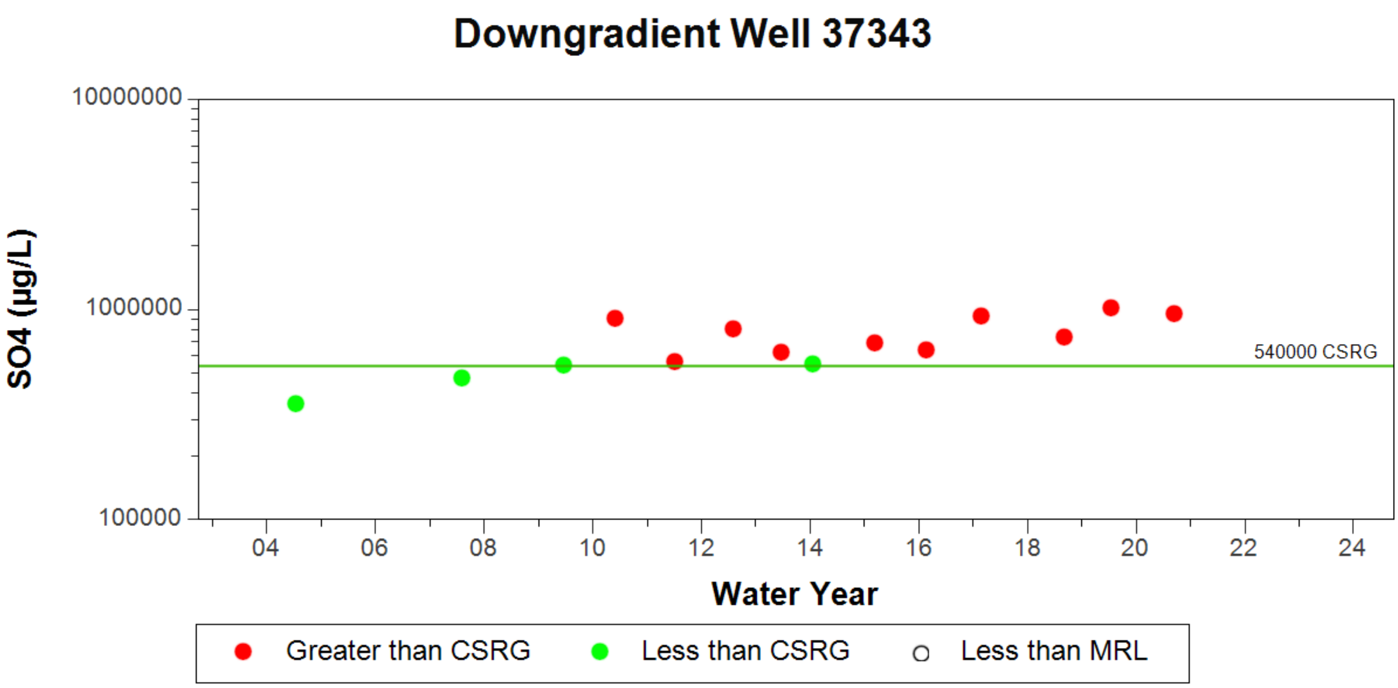
In FY22, well 37084 was replaced by well 37116.
Prior to FY22, sulfate in well 37084 did not show an increasing trend.

Downgradient Well 37084





In FY22, well 37343 was replaced by well 37163.
Prior to FY22, sulfate in well 37343 did not show an increasing trend.



Appendix G

Northern Pathway Treatment System

Figures and Documentation

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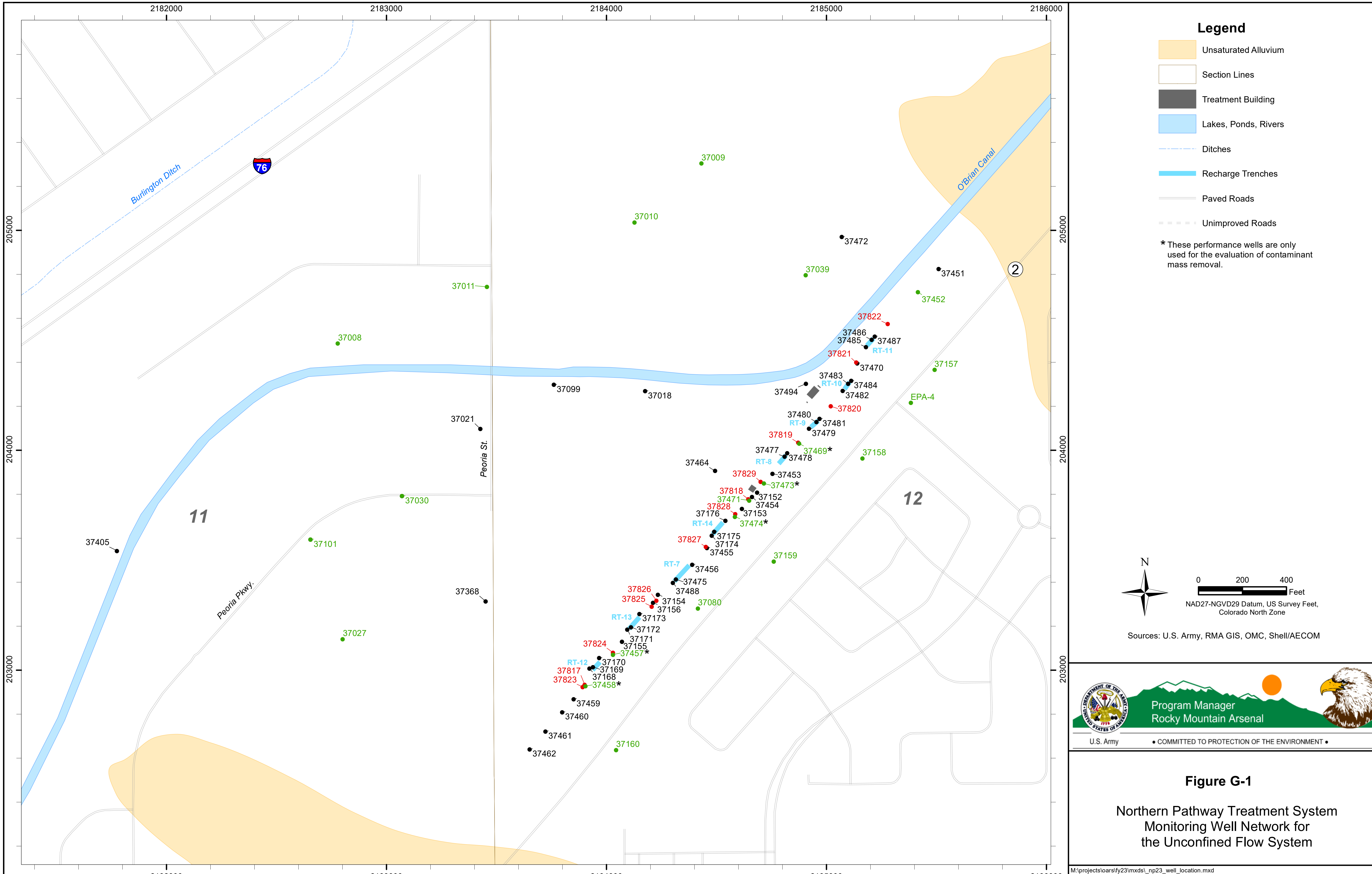


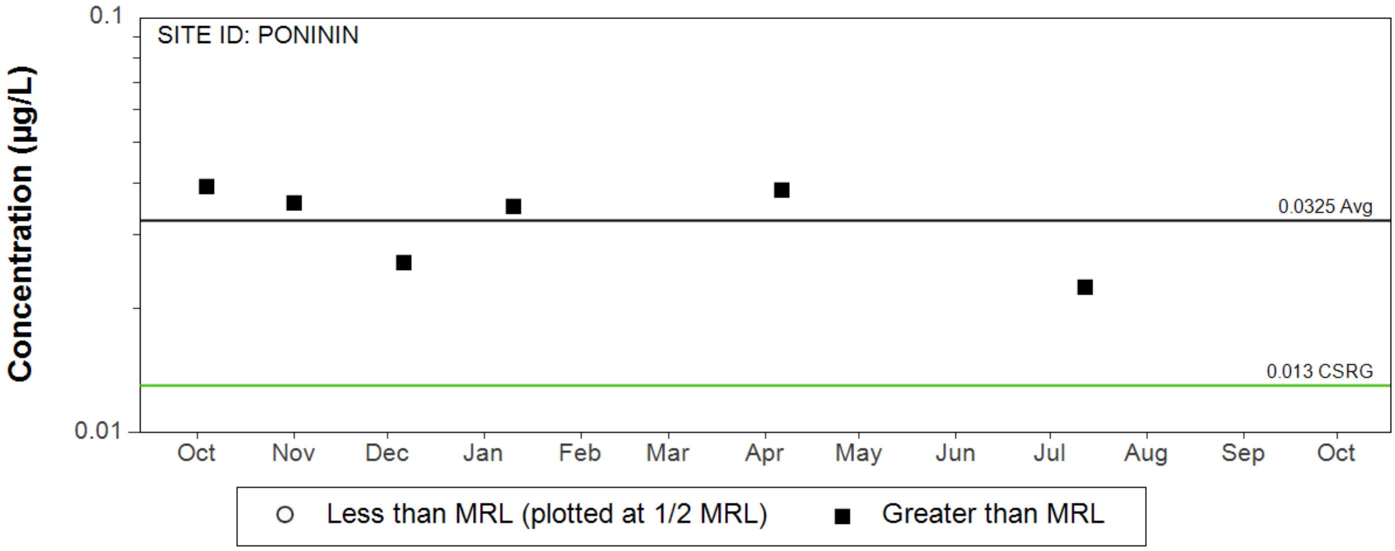
Figure G-1

Northern Pathway Treatment System
Monitoring Well Network for
the Unconfined Flow System

M:\projects\oars\fy23\mxds_np23_well_location.mxd
6/24/2024

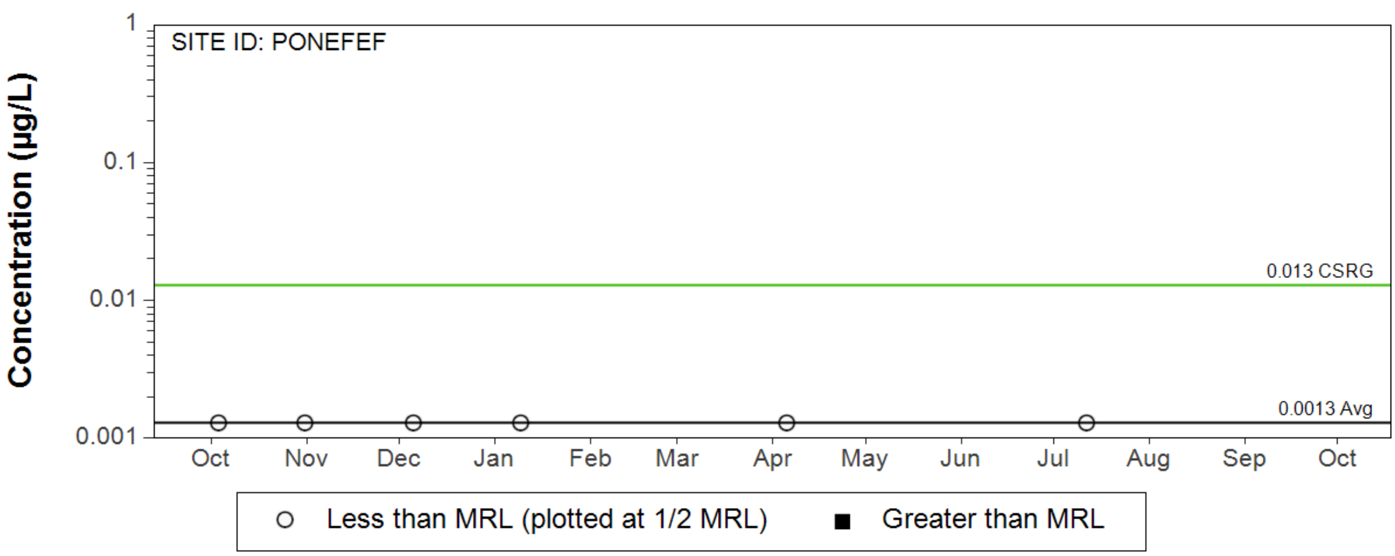
Northern Pathway Treatment Plant Influent - DLDRN

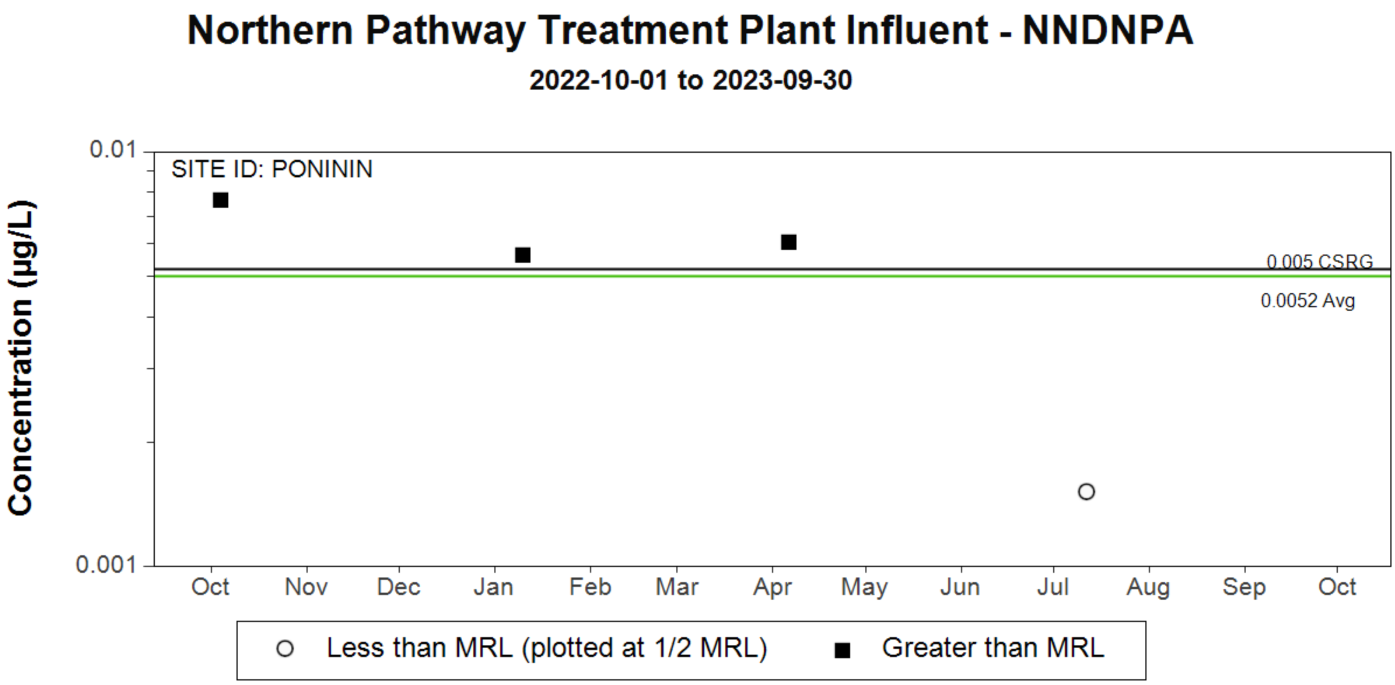
2022-10-01 to 2023-09-30



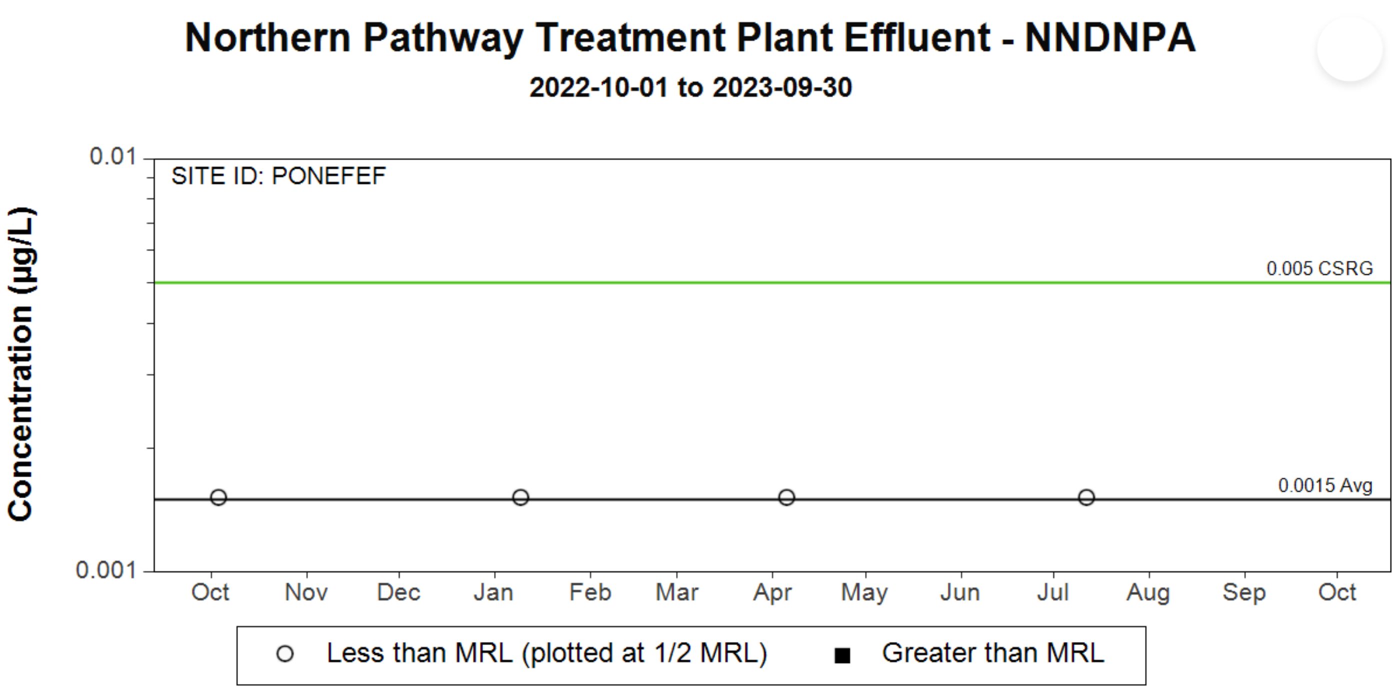
Northern Pathway Treatment Plant Effluent - DLDRN

2022-10-01 to 2023-09-30





Northern Pathway Treatment Plant Influent - NNDNPA
2022-10-01 to 2023-09-30
Concentration (µg/L)
0.01
0.001
SITE ID: PONININ
0.005 CSRG
0.0052 Avg
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Less than MRL (plotted at 1/2 MRL)
Greater than MRL



Northern Pathway Treatment Plant Effluent - NNDNPA
2022-10-01 to 2023-09-30
Concentration (µg/L)
0.01
0.001
SITE ID: PONEFEF
0.005 CSRG
0.0015 Avg
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Less than MRL (plotted at 1/2 MRL)
Greater than MRL

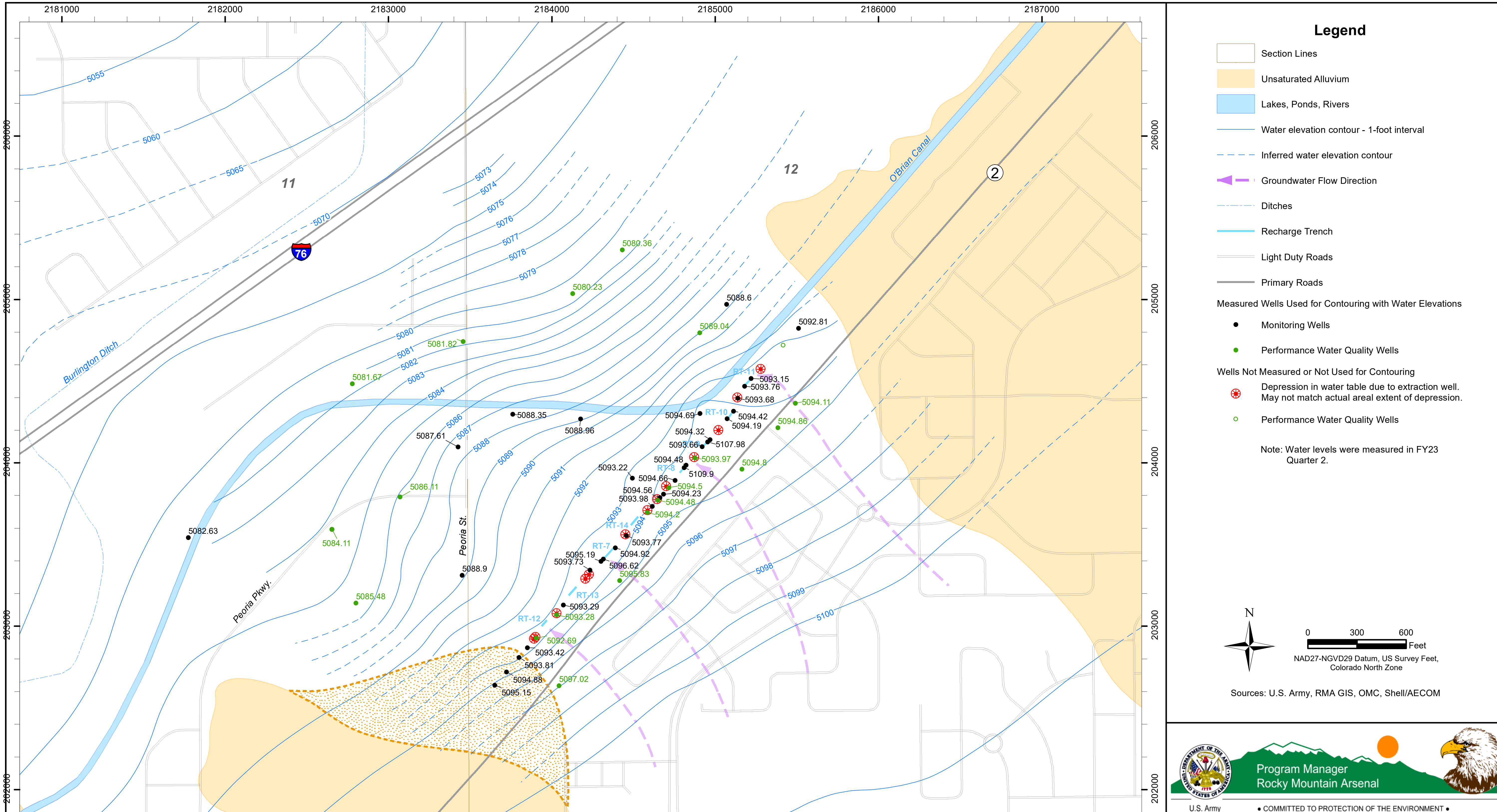


Figure G-4

FY23 Potentiometric Surface
of the Unconfined Flow System,
Northern Pathway Treatment System

M:\projects\oars\fy23\mxds_NP_FY23.mxd
6/25/2024

Exhibit G-5. Summary of FY23 NPTS Performance Water Quality Monitoring

Well ID	Sample Date	Analyte Concentration (ug/L, CSRG/PQL shown in italics)																		
		12DCLE	13DCLB	ALDRN	AS	ATZ	C6H6	CCL4	CHCL3	CL	CL6CP	CLC6H5	CPMS	CPMSO	CPMSO2	DBCP	DCPD	DIMP	DITH	DLDRN
		0.4	*6.5*	*0.014*	*2.35*	*3*	*5*	*0.3*	*6*	*250,000*	*0.23*	*25*	*30*	*36*	*36*	*0.2*	*46*	*8*	*18*	*0.013*
Upgradient Wells																				
37080	5/31/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	LT 0.2	**178,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.0194	LT 0.2	LT 0.5	—	**0.0398**
37157	9/19/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	LT 0.2	**258,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.0196	LT 0.2	LT 0.5	—	LT 0.00252
37158	6/6/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	**0.41**	**0.325**	**164,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.0194	LT 0.2	**1.05**	—	LT 0.00252
37159	6/6/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	LT 0.2	**162,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.0192	LT 0.2	LT 0.5	—	**0.0736**
37160	6/6/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	LT 0.2	**74,700**	LT 0.00983	LT 0.2	—	—	—	LT 0.0192	LT 0.2	LT 0.5	—	LT 0.00252
EPA-4	6/6/23	LT 0.2	LT 0.2	LT 0.00605	**1.22**	—	LT 0.2	**0.19**	**0.274**	**177,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.019	LT 0.2	LT 0.5	—	LT 0.00252
Cross-gradient Wells																				
37027	5/30/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	LT 0.2	**440,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.0196	LT 0.2	LT 0.5	—	**0.00337**
37452	6/1/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	LT 0.2	**215,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.019	LT 0.2	LT 0.5	—	LT 0.00252
Downgradient Wells																				
37008	5/24/23	LT 0.2	LT 0.2	LT 0.00605	**2.06**	—	LT 0.2	LT 0.2	LT 0.2	**260,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.0192	LT 0.2	LT 0.5	—	**0.00892**
37009	5/24/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	LT 0.2	**197,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.0196	LT 0.2	LT 0.5	—	LT 0.00252
37010	5/24/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	LT 0.2	**210,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.0192	LT 0.2	**1.79**	—	**0.00488**
37011	9/19/23	LT 0.2	LT 0.2	LT 0.00605	**2.33**	—	LT 0.2	LT 0.2	LT 0.2	**142,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.0194	LT 0.2	LT 0.5	—	**0.0147**
37030	5/30/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	**0.256**	**246,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.0194	LT 0.2	LT 0.5	—	**0.00361**
37039	5/24/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	LT 0.2	**227,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.0192	LT 0.2	LT 0.5	—	**0.00266**
37101	5/30/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	**0.538**	**280,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.0194	LT 0.2	LT 0.5	—	LT 0.00252
Extraction/Recharge Alignment																				
37153	6/27/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	**0.179**	**187,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.019	LT 0.2	LT 0.5	—	**0.0255**
37155	5/30/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	**0.496**	**232,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.0192	LT 0.2	**0.666**	—	**0.00391**
37457	5/31/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	**0.291**	**216,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.0192	LT 0.2	LT 0.5	—	LT 0.00252
37458	5/31/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	**0.581**	**390,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.0196	LT 0.2	**0.958**	—	**0.00519**
37469	6/1/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	**0.564**	**191,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.019	LT 0.2	LT 0.5	—	LT 0.00252
37471	6/1/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	**0.205**	**197,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.0192	LT 0.2	**1.06**	—	**0.0486**
37473	6/1/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	**0.248**	**188,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.0194	LT 0.2	LT 0.5	—	**0.0261**
37474	5/31/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	LT 0.2	**158,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.0196	LT 0.2	LT 0.5	—	**0.0883**
37817	6/27/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	**0.342**	**260,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.0196	LT 0.2	**0.806**	—	**0.0107**
37818	5/17/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	**0.368**	**184,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.0194	LT 0.2	**1.54**	—	**0.0493**
37819	5/17/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	**0.333**	**181,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.0194	LT 0.2	**1.8**	—	**0.0055**
	5/23/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	**0.265**	**193,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.0194	LT 0.2	**2.21**	—	**0.00492**
37820	5/17/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	**1.07**	**0.538**	**228,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.0194	LT 0.2	**2.5**	—	LT 0.00252
37821	5/17/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	**0.21**	**0.239**	**190,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.0192	LT 0.2	LT 0.5	—	LT 0.00252
37822	5/17/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	LT 0.2	**183,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.0194	LT 0.2	LT 0.5	—	LT 0.00252
37823	5/18/23	LT 0.2	LT 0.2	**0.00845**	LT 1	—	LT 0.2	LT 0.2	**0.41**	**270,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.0194	LT 0.2	**0.783**	—	**0.00807**
37824	5/18/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	**0.556**	**255,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.0194	LT 0.2	**1**	—	**0.00606**
37825	5/22/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	LT 0.2	**178,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.0196	LT 0.2	**0.678**	—	**0.00745**
37826	5/22/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	LT 0.2	**176,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.0192	LT 0.2	LT 0.5	—	**0.0198**
37827	5/22/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	LT 0.2	**168,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.0194	LT 0.2	LT 0.5	—	**0.063**
37828	5/22/23	LT 0.2	LT 0.2	LT 0.00605	LT 1	—	LT 0.2	LT 0.2	LT 0.2	**173,000**	LT 0.00983	LT 0.2	—	—	—	LT 0.0192	LT 0.2	**0.794**	—	**0.0585**

Notes:

Values shaded and in BOLD are concentrations that exceed the CSRG/PQL.

[1] The value for chlordane (CLDAN) is the sum of its two isomers, alpha-chordane (ACLDAN) and gamma-chlordane (GCLDAN).

LT – Nondetection reported less than the method reporting limit

Well ID	Sample Date	Analyte Concentration (ug/L, CSRG/PQL shown in italics)																	
		ENDRN	ETC6H5	F	ISODR	MEC6H5	MLTHN	NNDMEA	NNDNPA	OXAT	PPDDE	PPDDT	SO4	TCLEE	TRCLE	XYLEN	CLDAN [1]	ACLDAN	GCLDAN
		2	*1000*	*2000*	*0.06*	*1000*	*100*	*0.009*	*0.005*	*160*	*0.1*	*0.1*	*540,000*	*5*	*3*	*1000*	*0.03*	*—*	*—*
Upgradient Wells																			
37080	5/31/23	**0.0172**	LT 0.2	**1300**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247	**376,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37157	9/19/23	LT 0.00488	LT 0.2	**258**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247	**267,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37158	6/6/23	LT 0.00488	LT 0.2	**780**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247	**179,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37159	6/6/23	**0.0273**	LT 0.2	**928**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247	**416,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37160	6/6/23	LT 0.00488	LT 0.2	**3820**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247	**180,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
EPA-4	6/6/23	LT 0.00488	LT 0.2	**688**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247	**178,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
Cross-gradient Wells																			
37027	5/30/23	**0.00493**	LT 0.2	**3380**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247	**625,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37452	6/1/23	LT 0.00488	LT 0.2	**868**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247	**149,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
Downgradient Wells																			
37008	5/24/23	LT 0.00488	LT 0.2	**644**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247	**187,000**	LT 0.2	LT 0.2	LT 0.4	**0.0101**	LT 0.00405	**0.0101**
37009	5/24/23	LT 0.00488	LT 0.2	**852**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247	**255,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37010	5/24/23	LT 0.00488	LT 0.2	**1120**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247	**401,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37011	9/19/23	**0.00644**	LT 0.2	**796**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247	**171,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37030	5/30/23	LT 0.00488	LT 0.2	**1340**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247	**493,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37039	5/24/23	LT 0.00488	LT 0.2	**698**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247	**315,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37101	5/30/23	LT 0.00488	LT 0.2	**1150**	LT 0.00619	LT 0.2	—	LT 0.0048	**0.0109**	—	**0.00653**	LT 0.00247	**484,000**	**0.623**	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
Extraction/Recharge Alignment																			
37153	6/27/23	**0.00892**	LT 0.2	**848**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247	**346,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37155	5/30/23	**0.00531**	LT 0.2	**1520**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247	**497,000**	**0.189**	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37457	5/31/23	LT 0.00488	LT 0.2	**1390**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247	**330,000**	**0.236**	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37458	5/31/23	LT 0.00488	LT 0.2	**1670**	LT 0.00619	LT 0.2	—	LT 0.0048	**0.0805**	—	**0.0138**	LT 0.00247	**648,000**	**2.02**	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37469	6/1/23	LT 0.00488	LT 0.2	**956**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247	**294,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37471	6/1/23	**0.0201**	LT 0.2	**850**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247	**435,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37473	6/1/23	**0.013**	LT 0.2	**1040**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247	**285,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37474	5/31/23	**0.0309**	LT 0.2	**922**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247	**365,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37817	6/27/23	LT 0.00488	LT 0.2	**1690**	LT 0.00619	LT 0.2	—	LT 0.0048	**0.0438**	—	**0.00938**	LT 0.00247	**508,000**	**1.27**	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37818	5/17/23	**0.0183**	LT 0.2	**864**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247	**387,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37819	5/17/23	LT 0.00488	LT 0.2	**978**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247	**318,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
	5/23/23	LT 0.00488	LT 0.2	**1020**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247	**333,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37820	5/17/23	LT 0.00488	LT 0.2	**916**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247	**248,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37821	5/17/23	LT 0.00488	LT 0.2	**820**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247	**182,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37822	5/17/23	LT 0.00488	LT 0.2	**682**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247	**184,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37823	5/18/23	LT 0.00488	LT 0.2	**1730**	**0.0102**	LT 0.2	—	LT 0.0048	**0.0467**	—	LT 0.00403	LT 0.00247	**440,000**	**0.877**	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37824	5/18/23	LT 0.00488	LT 0.2	**1320**	LT 0.00619	LT 0.2	—	LT 0.0048	**0.0106**	—	LT 0.00403	LT 0.00247	**460,000**	**0.434**	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37825	5/22/23	LT 0.00488	LT 0.2	**1300**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247	**449,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37826	5/22/23	**0.00849**	LT 0.2	**1140**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247	**375,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37827	5/22/23	**0.0204**	LT 0.2	**1010**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247	**339,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426
37828	5/22/23	**0.0204**	LT 0.2	**816**	LT 0.00619	LT 0.2	—	LT 0.0048	LT 0.003	—	LT 0.00403	LT 0.00247	**379,000**	LT 0.2	LT 0.2	LT 0.4	ND	LT 0.00405	LT 0.00426

Notes:

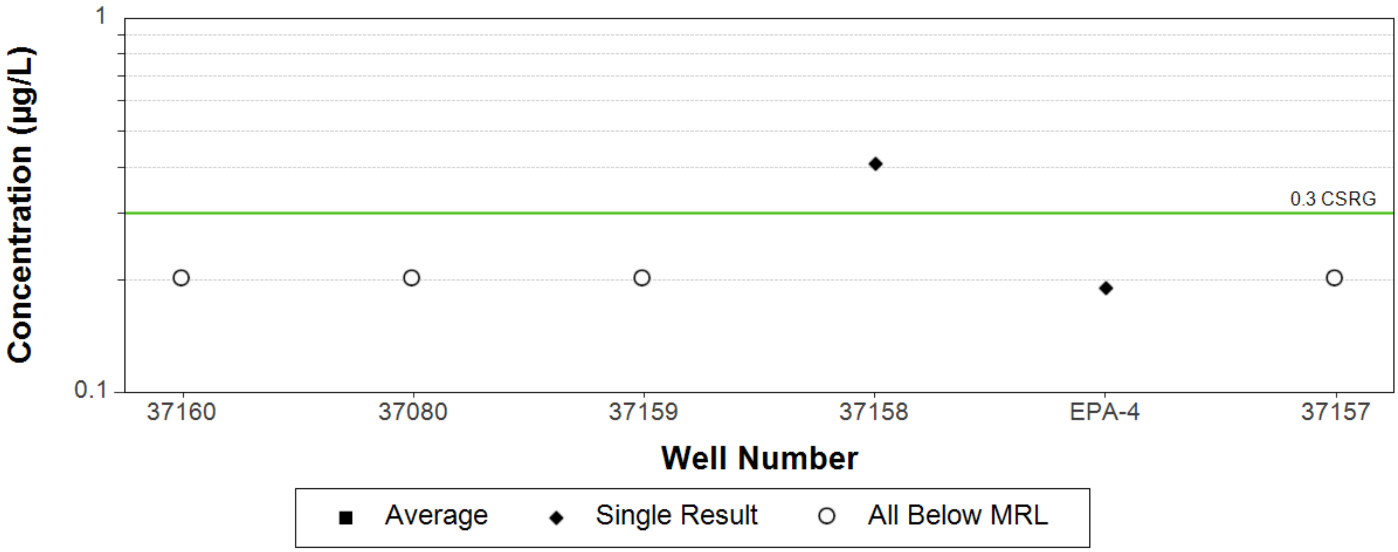
Values shaded and in BOLD are concentrations that exceed the CSRG/PQL.

[1] The value for chlordane (CLDAN) is the sum of its two isomers, alpha-chordane (ACLDAN) and gamma-chlordane (GCLDAN).

LT – Nondetection reported less than the method reporting limit

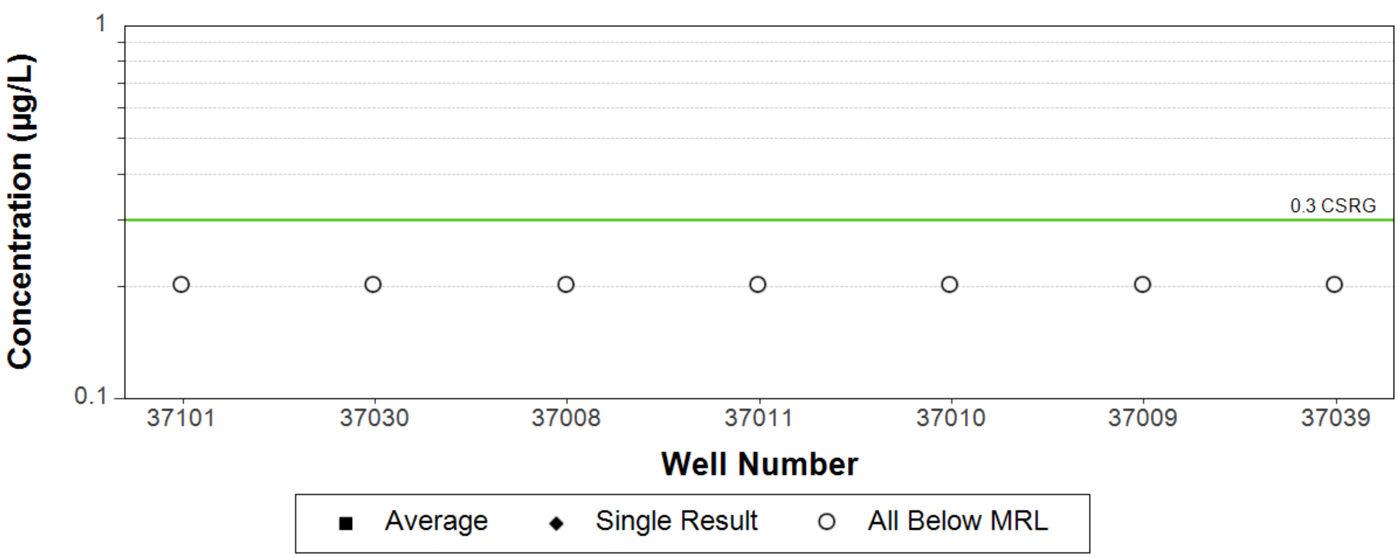
Northern Pathway Upgradient Performance Wells - CCL4

2022-10-01 to 2023-09-30



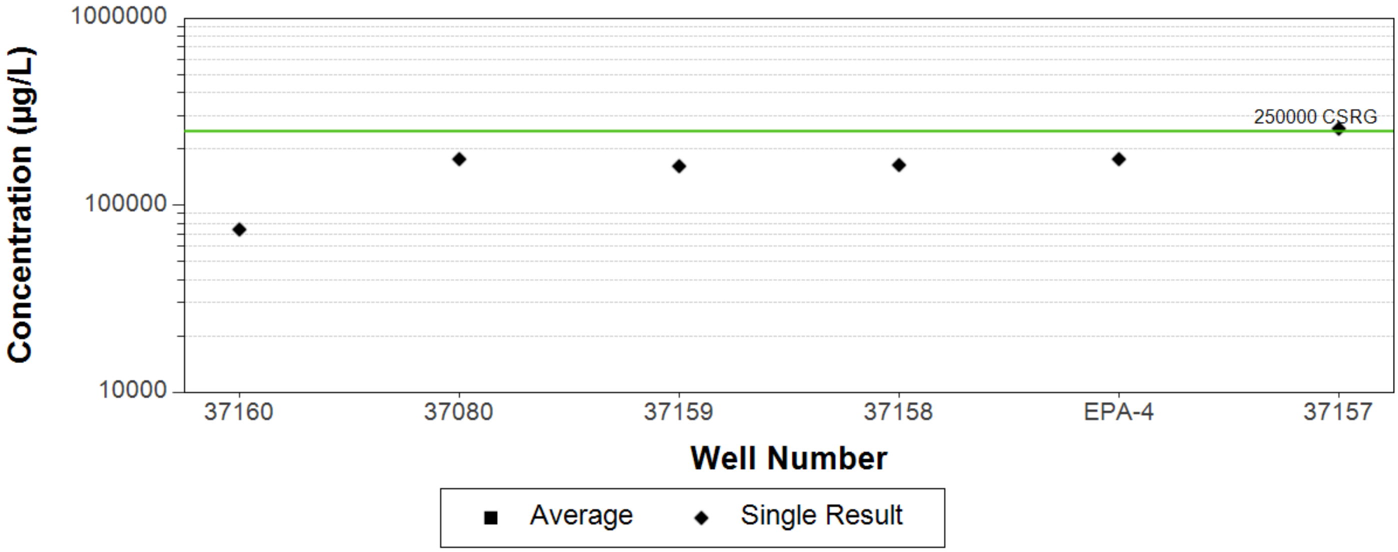
Northern Pathway Downgradient Performance Wells - CCL4

2022-10-01 to 2023-09-30



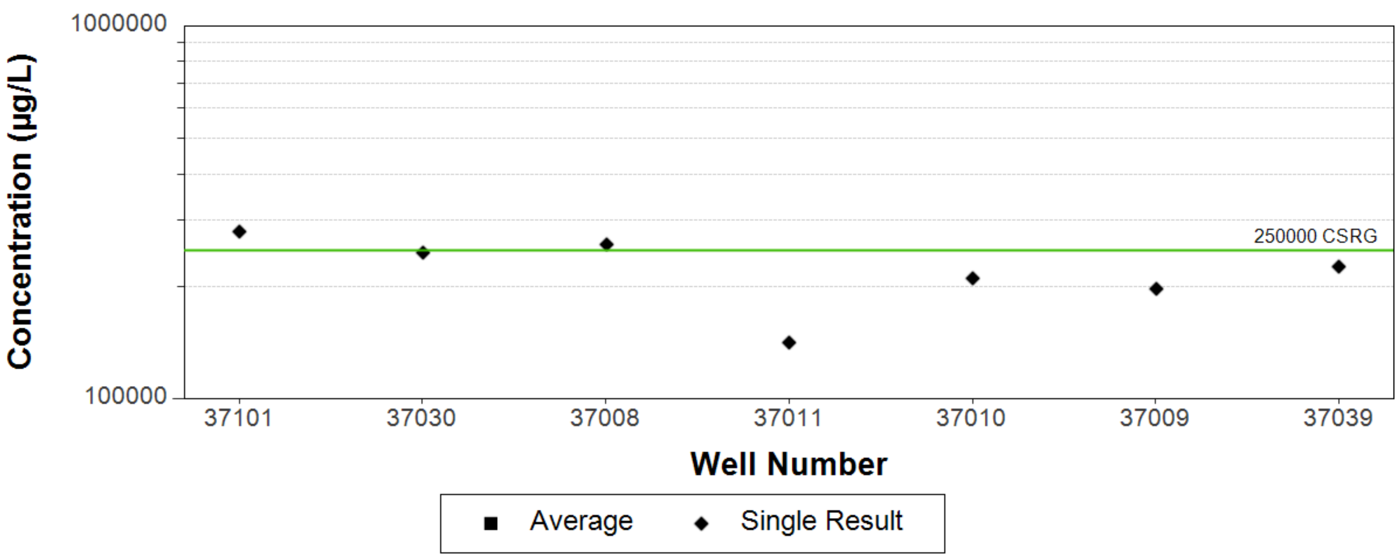
Northern Pathway Upgradient Performance Wells - CL

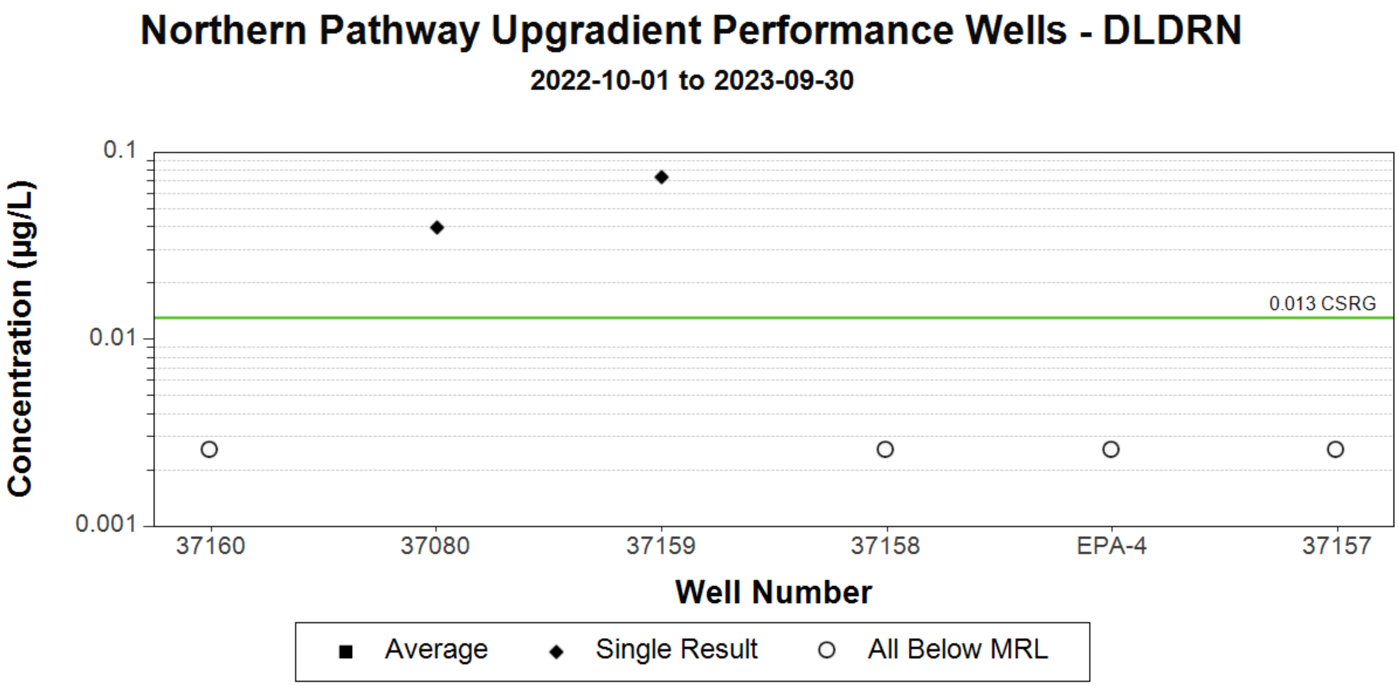
2022-10-01 to 2023-09-30

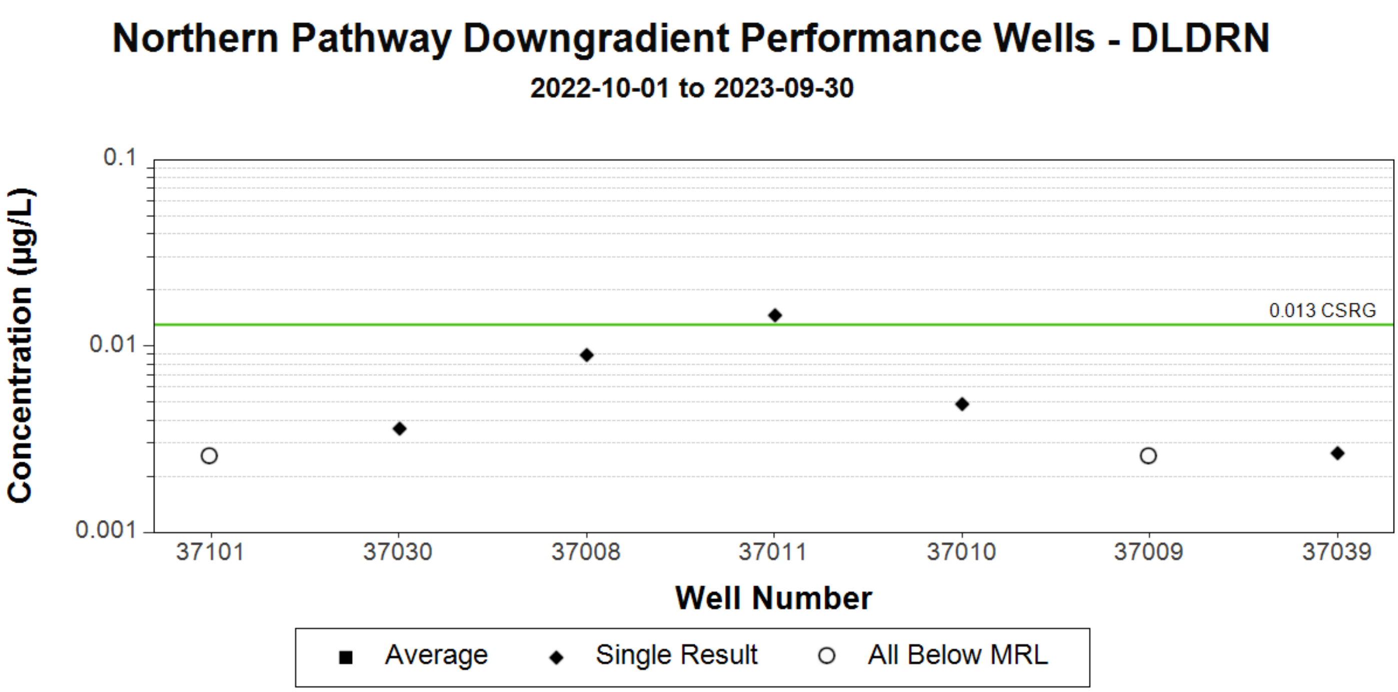


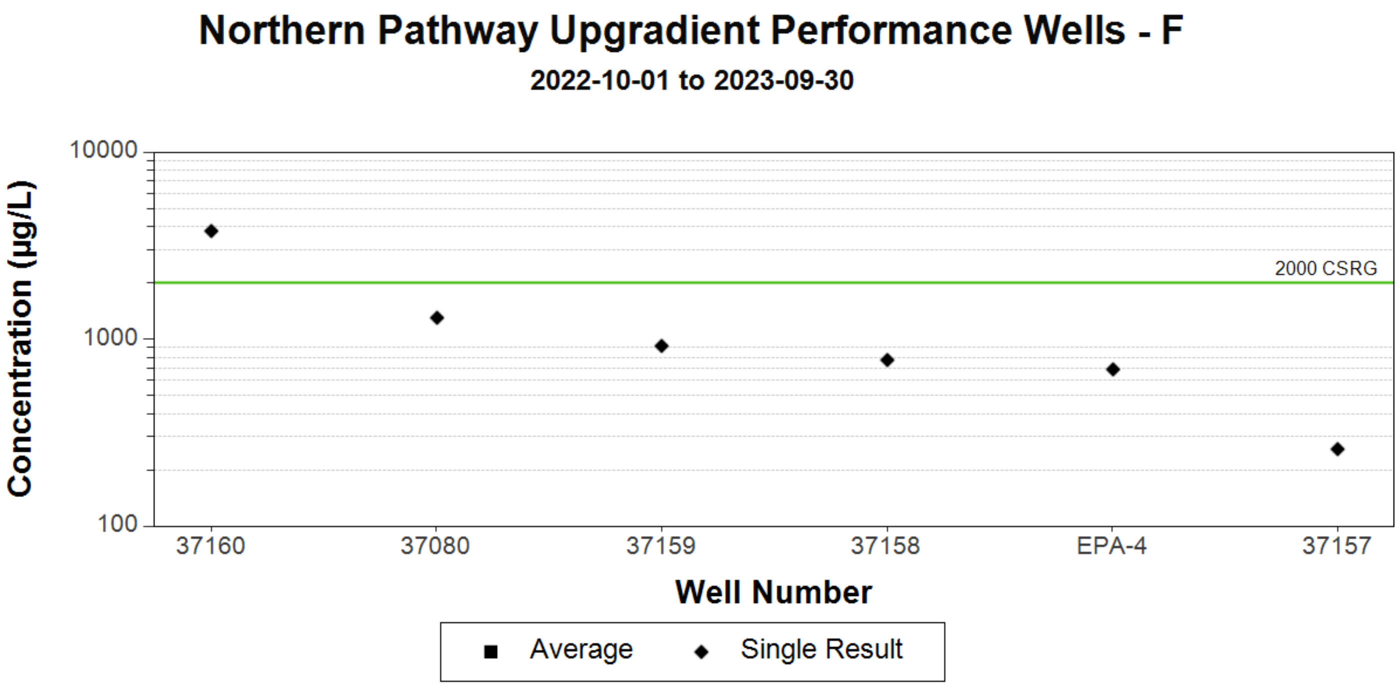
Northern Pathway Downgradient Performance Wells - CL

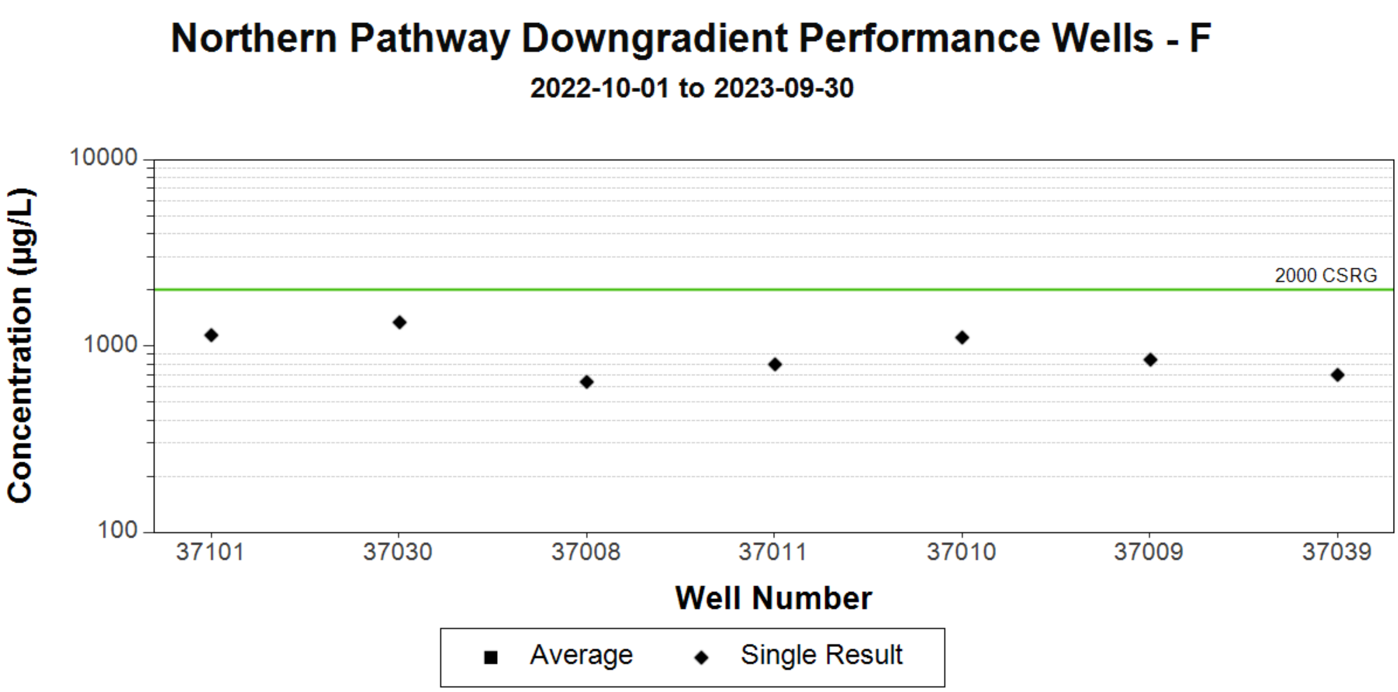
2022-10-01 to 2023-09-30

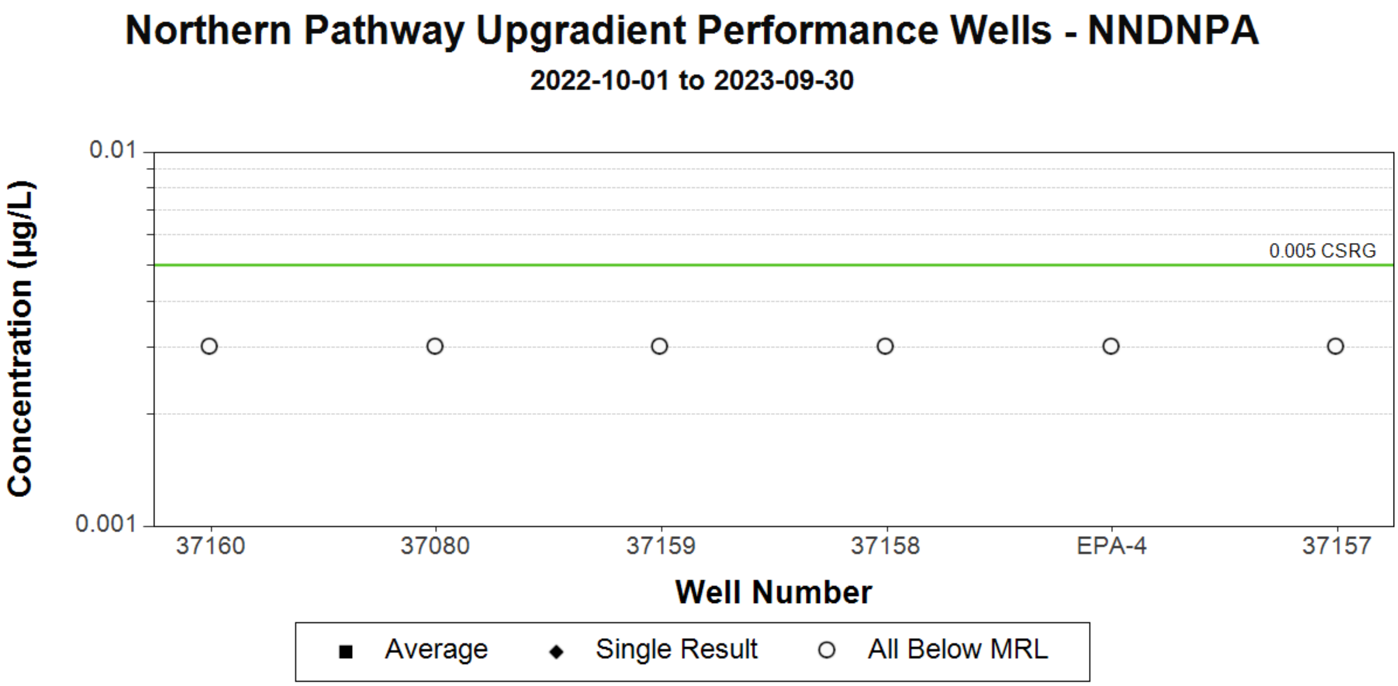



Northern Pathway Upgradient Performance Wells - DLDRN
2022-10-01 to 2023-09-30
Concentration (µg/L)
0.1
0.01
0.001
0.013 CSRG
37160
37080
37159
37158
EPA-4
37157
Well Number
Average
Single Result
All Below MRL

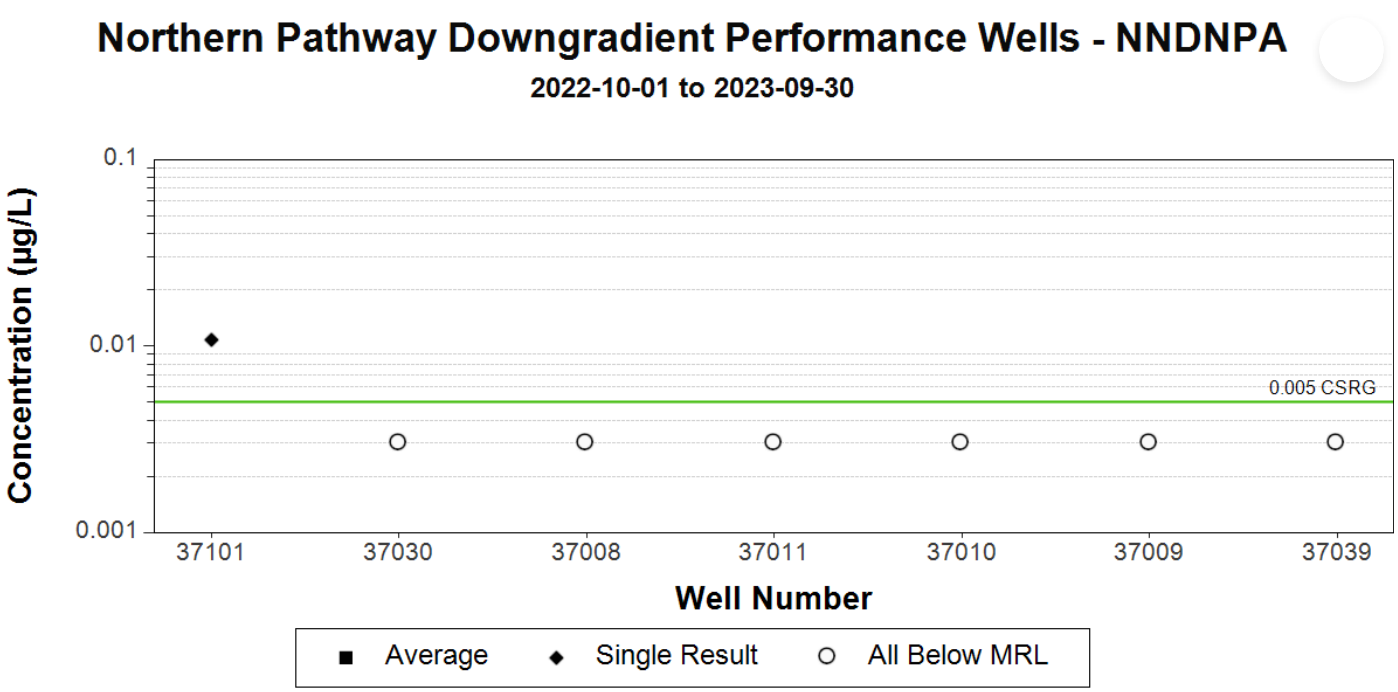

Northern Pathway Downgradient Performance Wells - DLDRN
2022-10-01 to 2023-09-30
Concentration (µg/L)
0.1
0.01
0.001
0.013 CSRG
37101
37030
37008
37011
37010
37009
37039
Well Number
Average
Single Result
All Below MRL


Northern Pathway Upgradient Performance Wells - F
2022-10-01 to 2023-09-30
Concentration (µg/L)
10000
1000
100
2000 CSRG
37160
37080
37159
37158
EPA-4
37157
Well Number
Average
Single Result

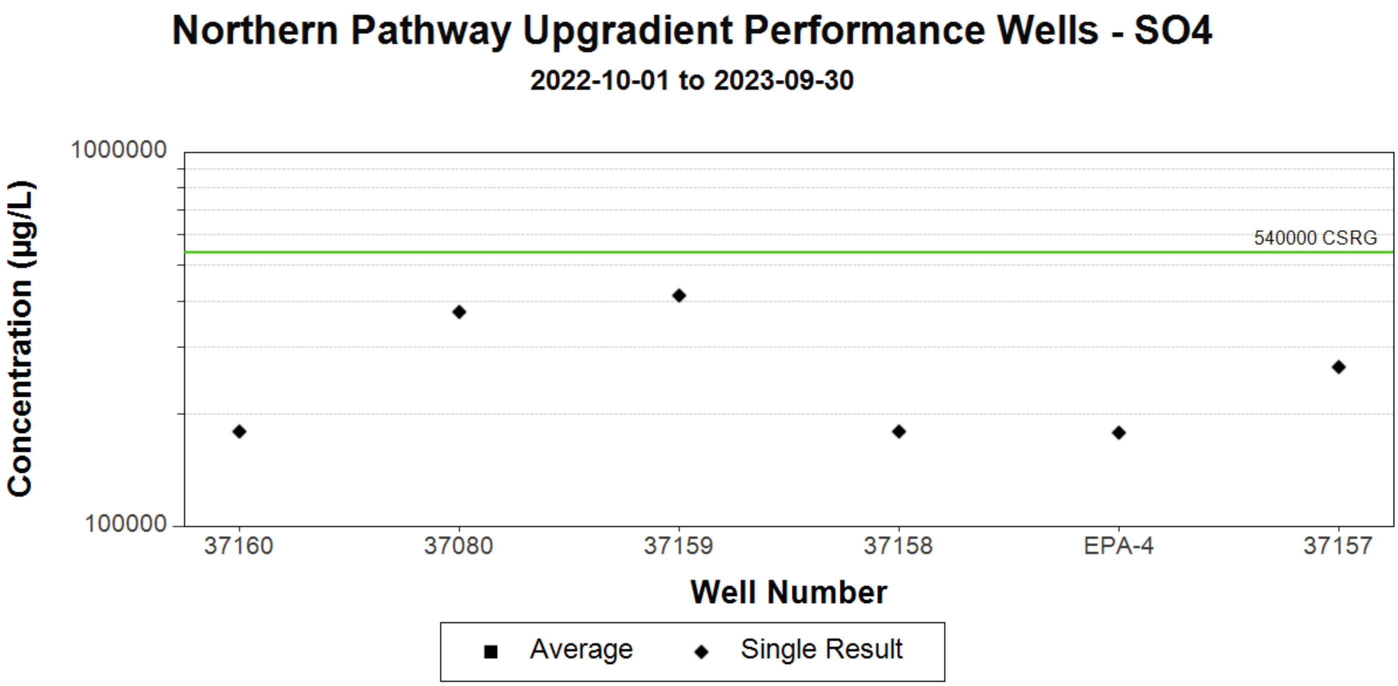

Northern Pathway Downgradient Performance Wells - F
2022-10-01 to 2023-09-30
Concentration (µg/L)
10000
1000
100
2000 CSRG
37101
37030
37008
37011
37010
37009
37039
Well Number
Average
Single Result



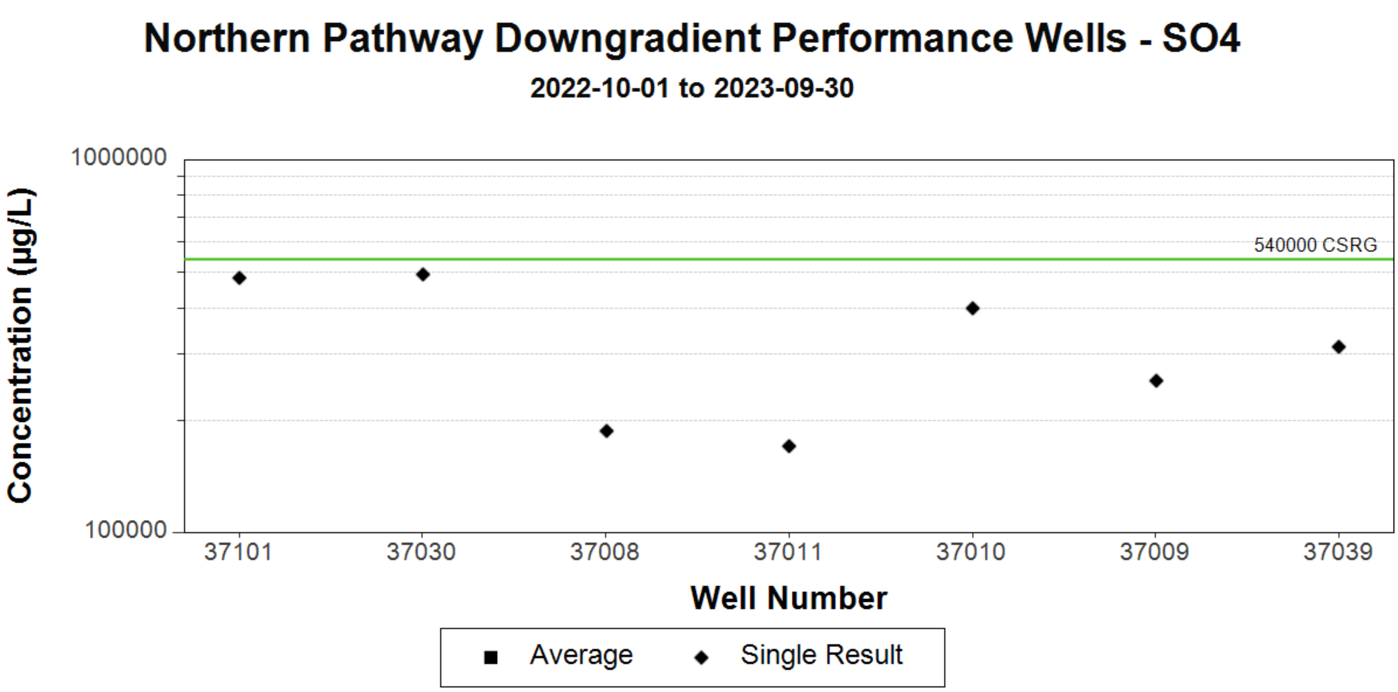
Northern Pathway Upgradient Performance Wells - NNDNPA
2022-10-01 to 2023-09-30
0.01
0.001
0.005 CSRG
Concentration (µg/L)
37160
37080
37159
37158
EPA-4
37157
Well Number
Average
Single Result
All Below MRL



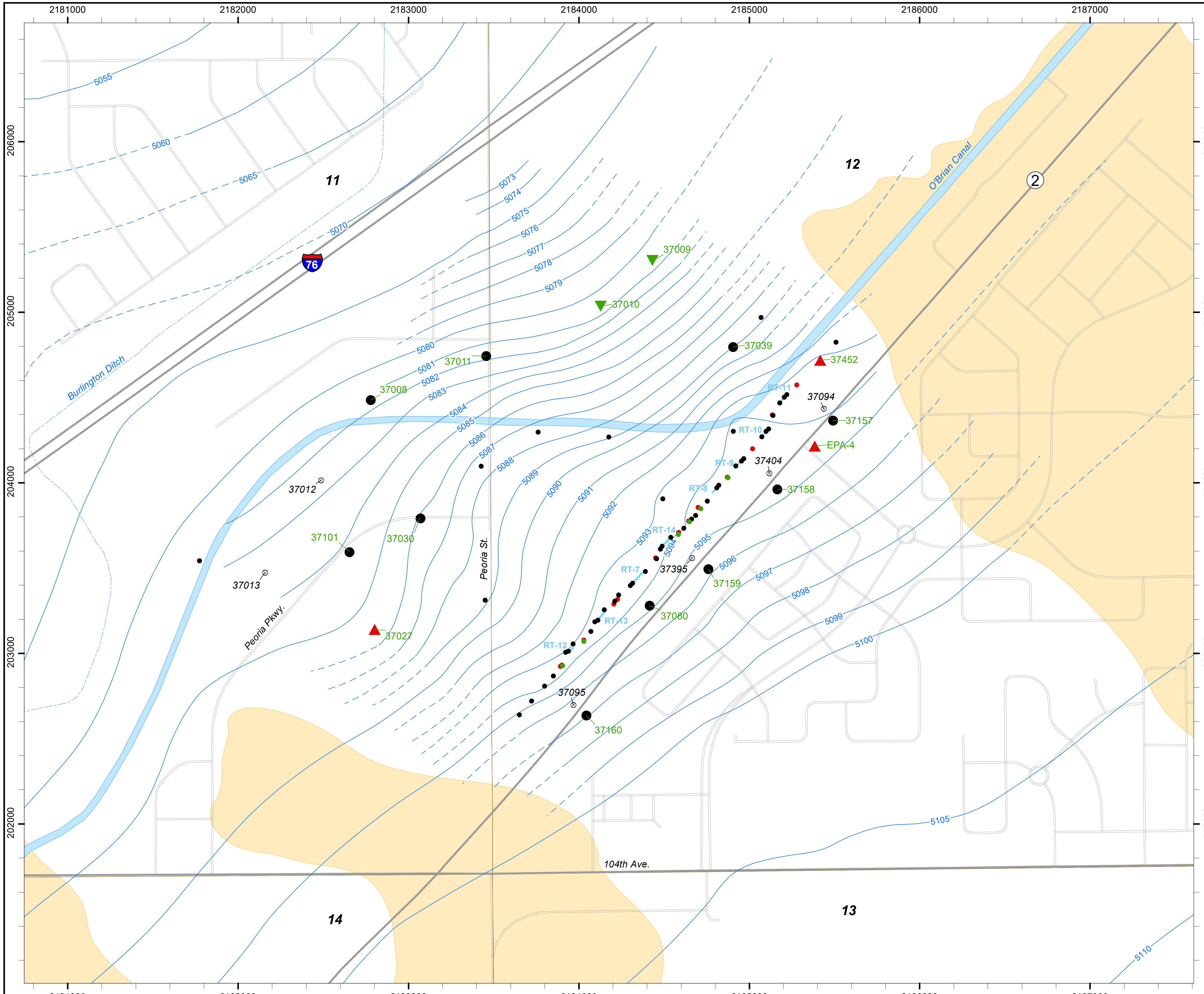
Northern Pathway Downgradient Performance Wells - NNDNPA
2022-10-01 to 2023-09-30
0.1
0.01
0.001
0.005 CSRG
Concentration (µg/L)
37101
37030
37008
37011
37010
37009
37039
Well Number
Average
Single Result
All Below MRL



Northern Pathway Upgradient Performance Wells - SO4
2022-10-01 to 2023-09-30
Concentration (µg/L)
1000000
100000
540000 CSRG
37160
37080
37159
37158
EPA-4
37157
Well Number
Average
Single Result



Northern Pathway Downgradient Performance Wells - SO4
2022-10-01 to 2023-09-30
Concentration (µg/L)
1000000
100000
540000 CSRG
37101
37030
37008
37011
37010
37009
37039
Well Number
Average
Single Result



Legend

- Unsaturated Alluvium
- Section Lines
- Lakes, Ponds, Rivers
- Water elevation contour - 1-foot interval
- Inferred water elevation contour
- Ditches
- Recharge Trench
- Light Duty Roads
- Primary Roads
- Monitoring Wells
- Performance Water Quality Wells
- Extraction Wells
- Replaced Monitoring Wells

Note: Water levels were measured in FY23 Quarter 2.

Upgradient and Downgradient Performance Well Water Quality

- Analyte Detected Above the CSRG - Increasing Trend Noted
- Analyte Detected Above the CSRG - Decreasing Trend Noted
- Analyte Detected - Showing Stable or No Discernible Trend
- Analyte Not Detected

Notes:
1. Trends are depicted for the 10 year period FY14 - FY23.
2. Time versus concentration charts for Performance Water Quality wells are presented following this map.

N

0 300 600 Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

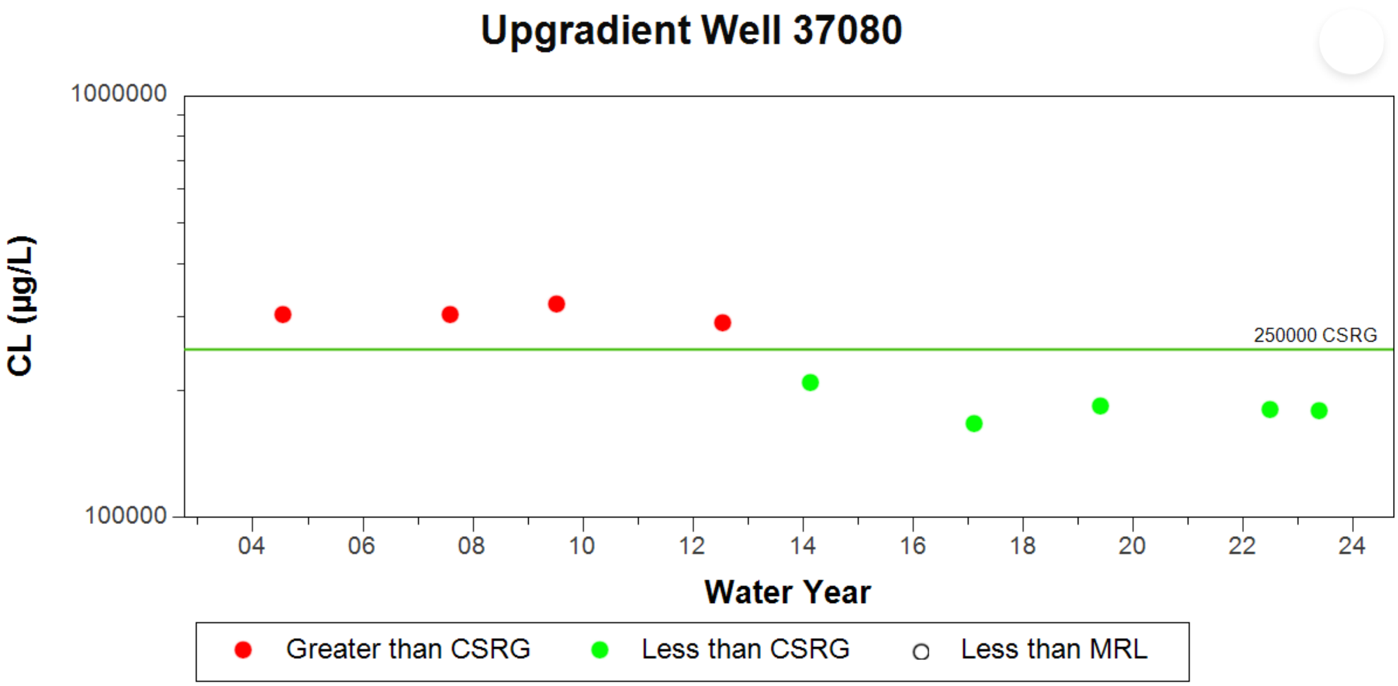
Program Manager
Rocky Mountain Arsenal

U.S. Army • COMMITTED TO PROTECTION OF THE ENVIRONMENT •

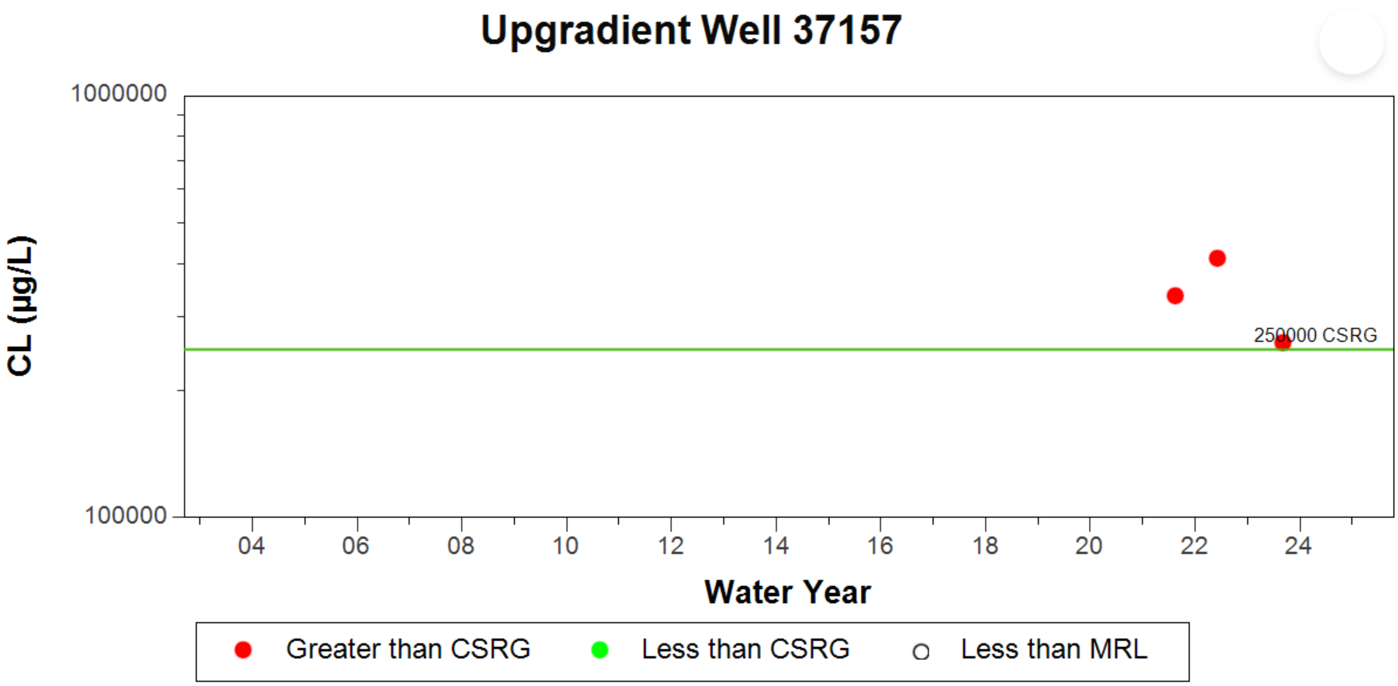
Figure G-12

Chloride Concentration
Trends in Performance Wells,
Northern Pathway Treatment System

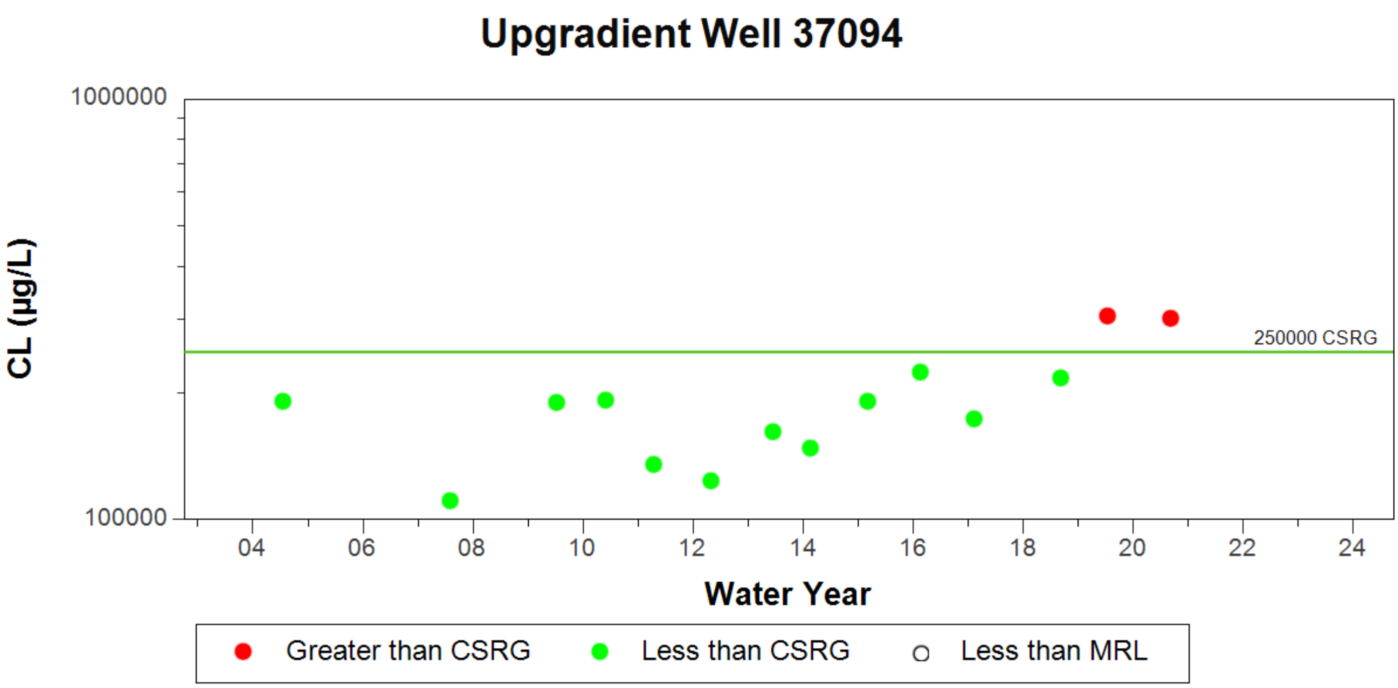
M:\projects\oars\fy23\mxds_NP_FY23_CL.mxd
8/8/2024

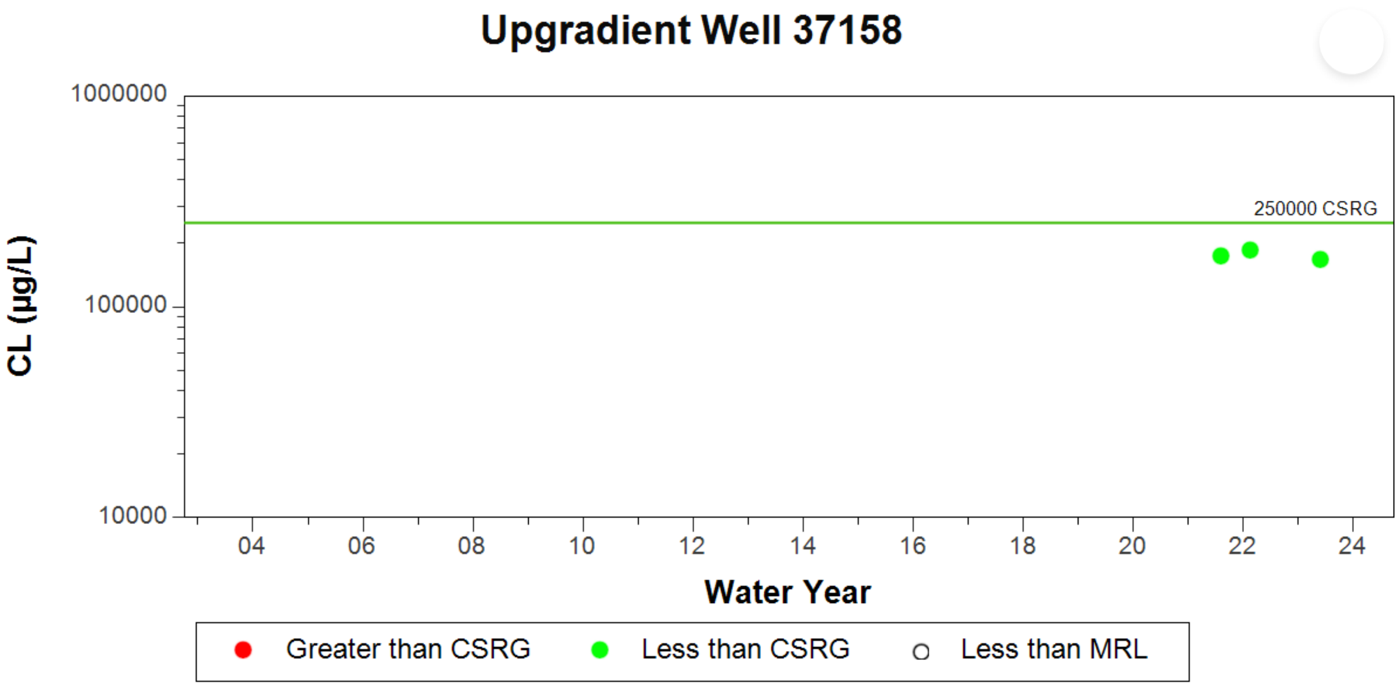


Upgradient Well 37080
1000000
100000
CL (µg/L)
250000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

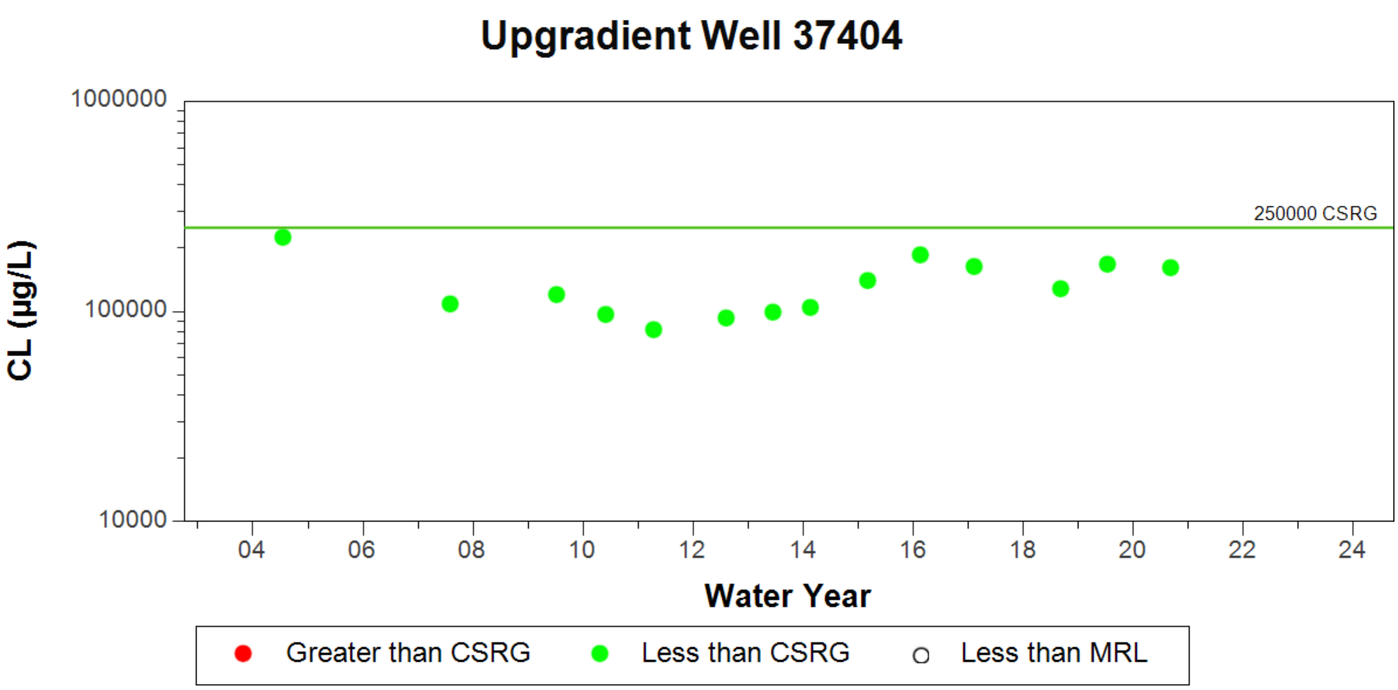


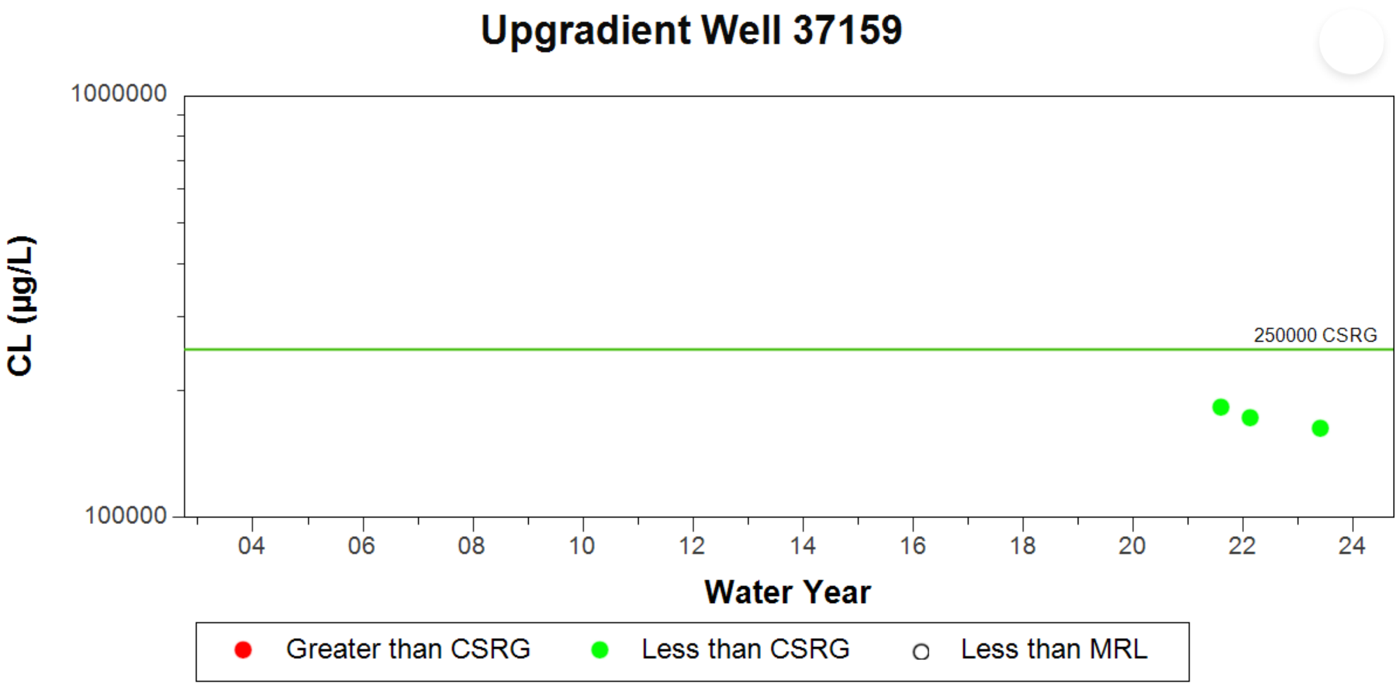
In FY20, well 37094 was replaced by well 37157.



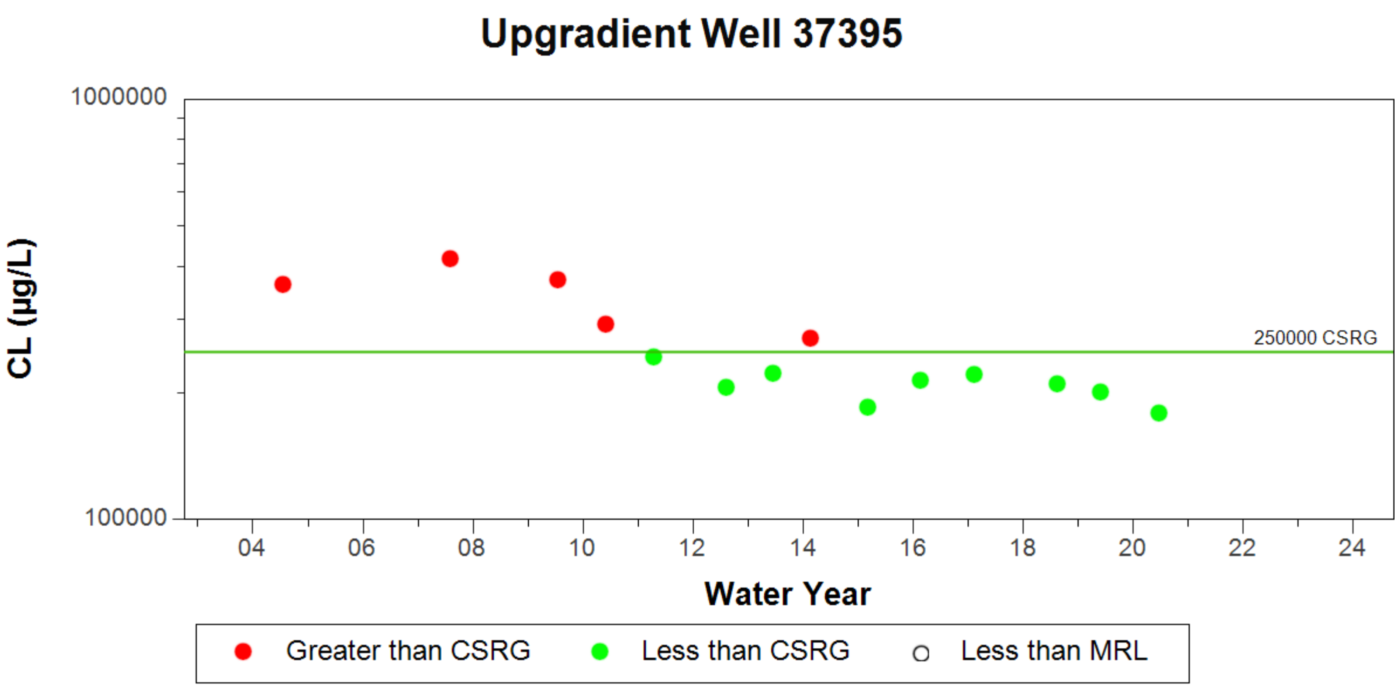


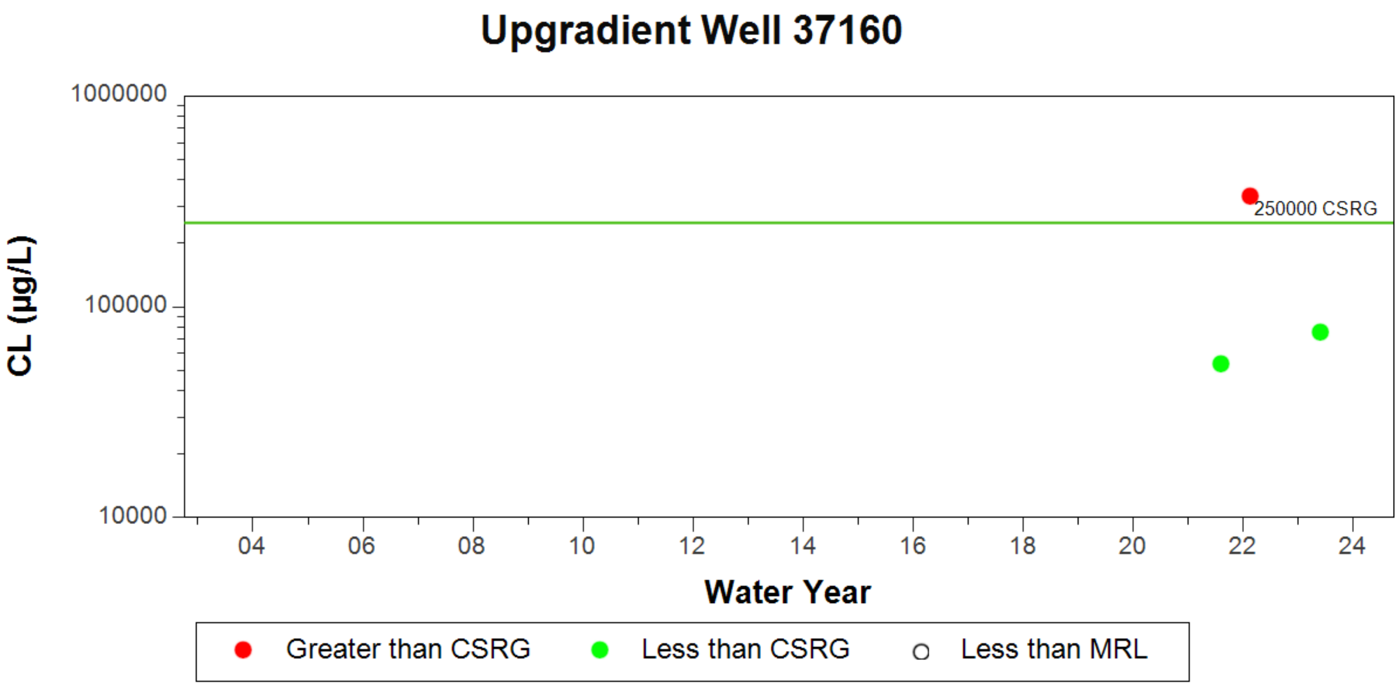
In FY20, well 37404 was replaced by well 37158.



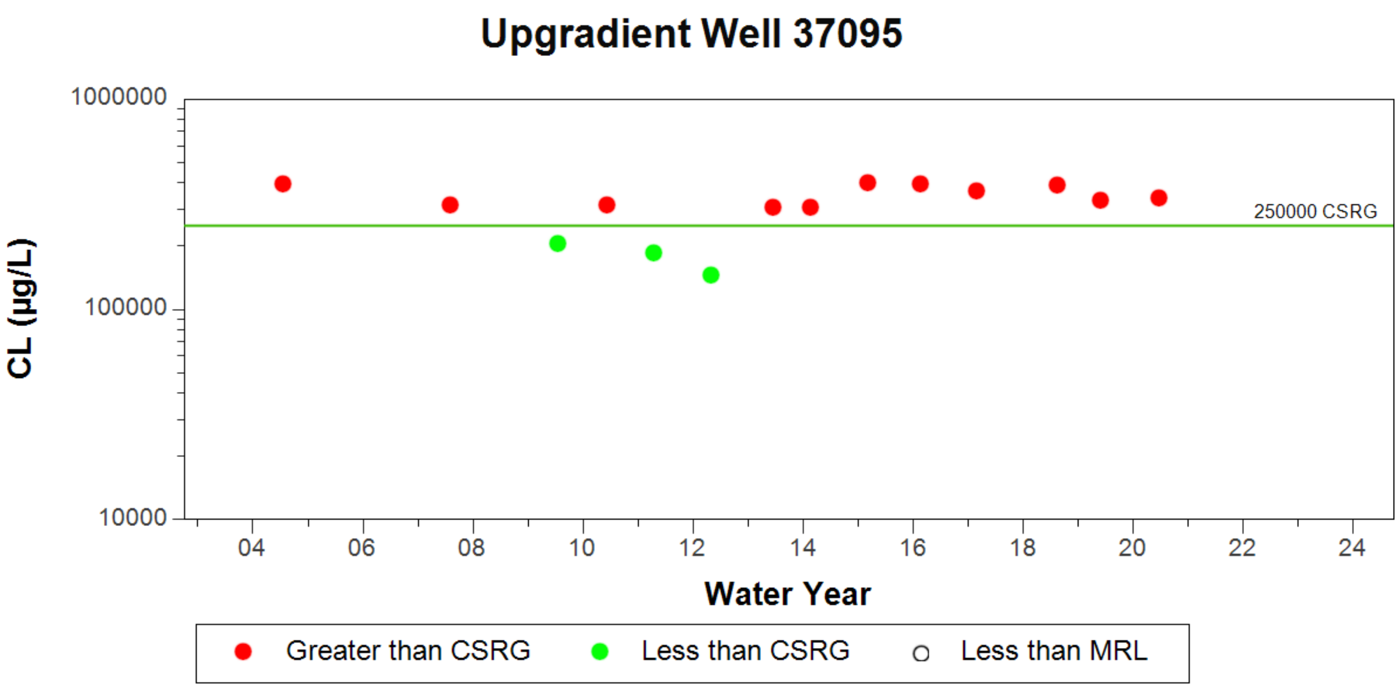


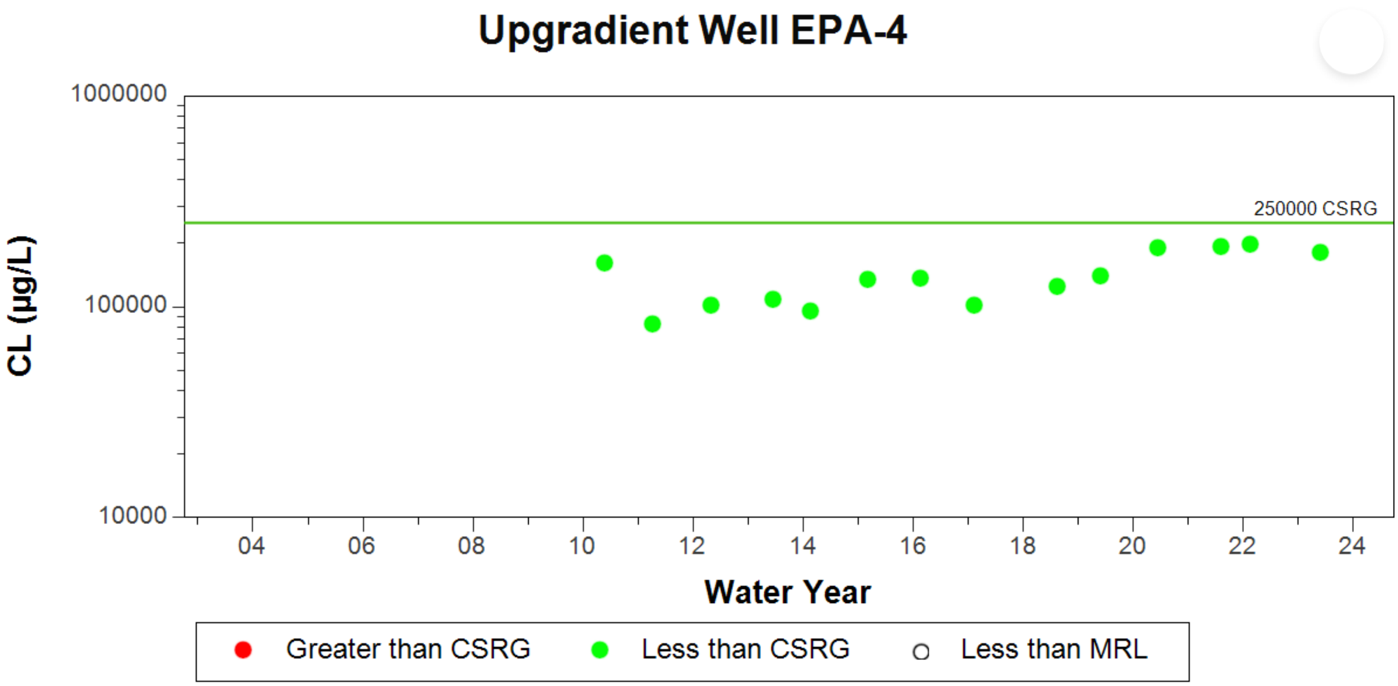
In FY20, well 37395 was replaced by well 37159.



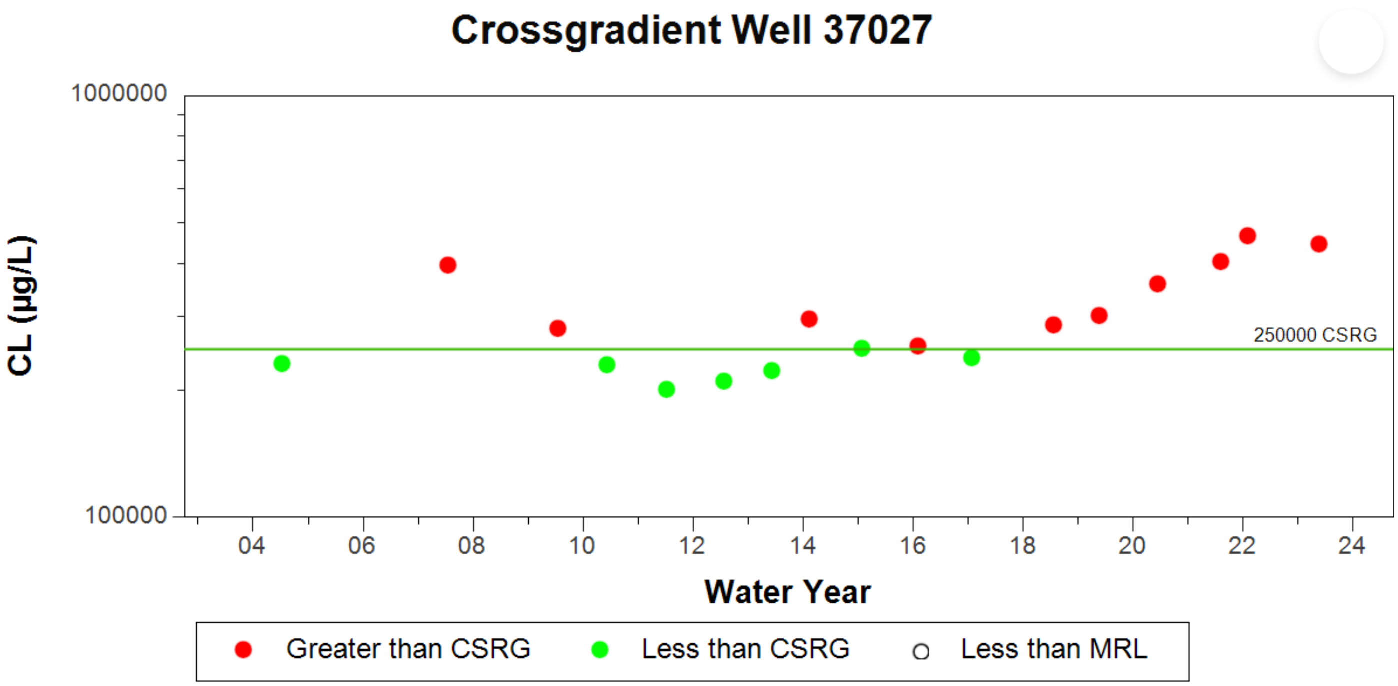


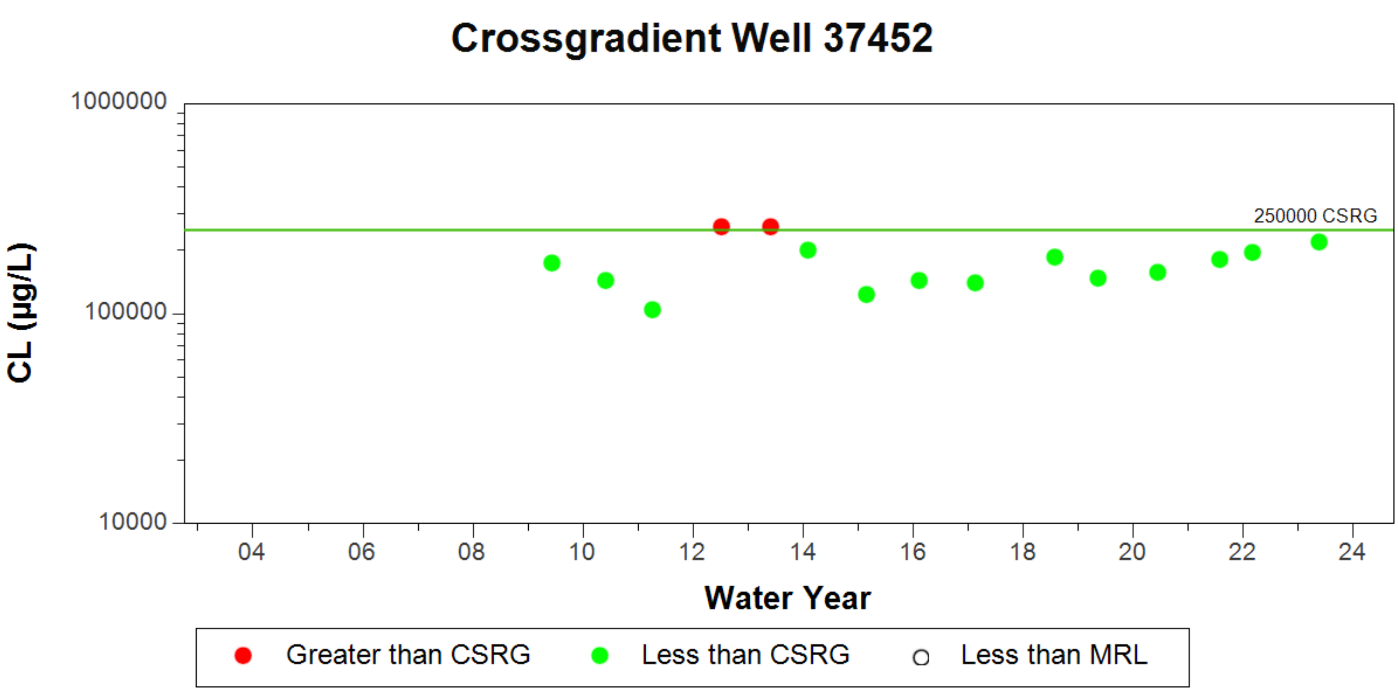
In FY20, well 37095 was replaced by well 37160.

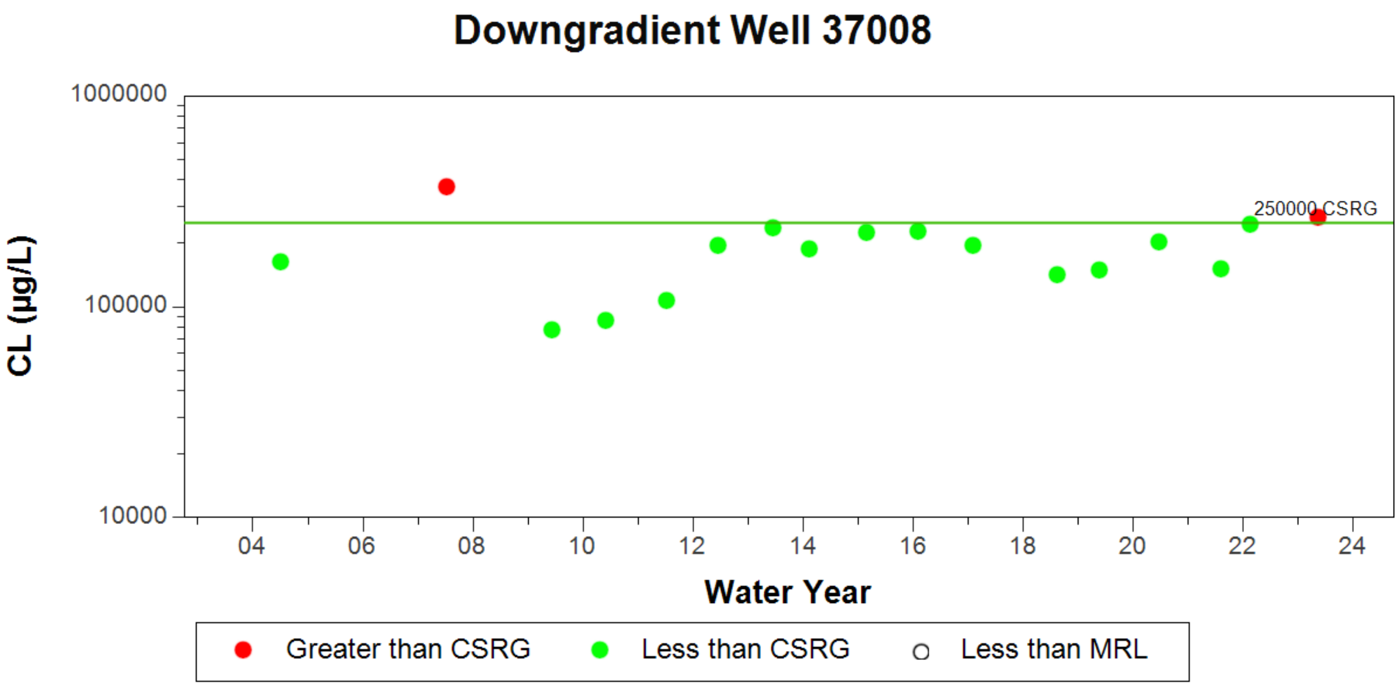




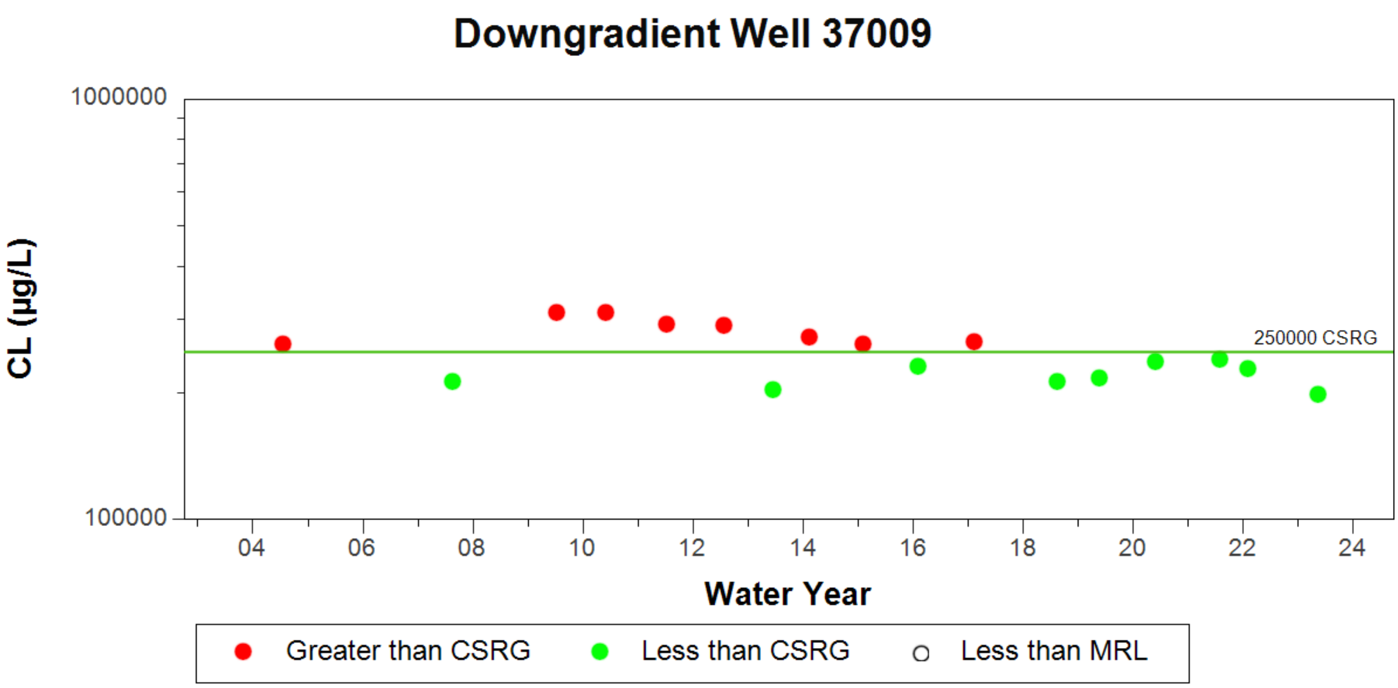
Upgradient Well EPA-4
1000000
100000
10000
250000 CSRG
CL (µg/L)
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL


Crossgradient Well 37027
1000000
100000
CL (µg/L)
250000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL


Crossgradient Well 37452
1000000
100000
10000
CL (µg/L)
250000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

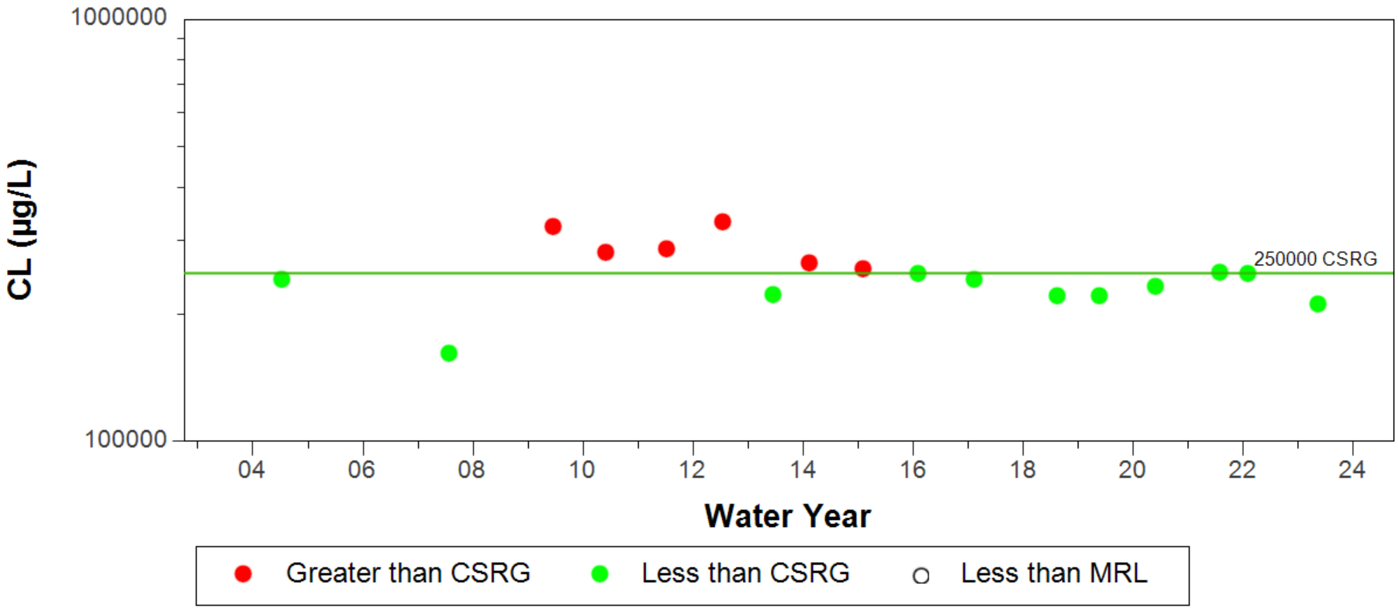


Downgradient Well 37008
1000000
100000
10000
CL (µg/L)
250000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

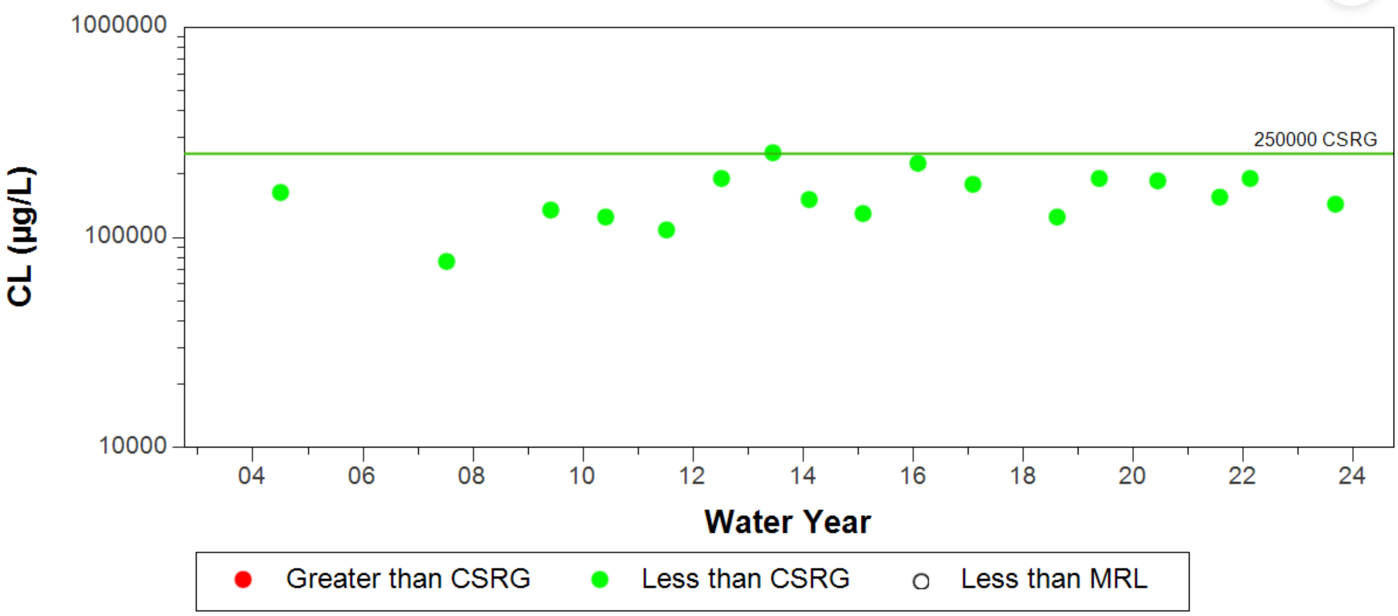


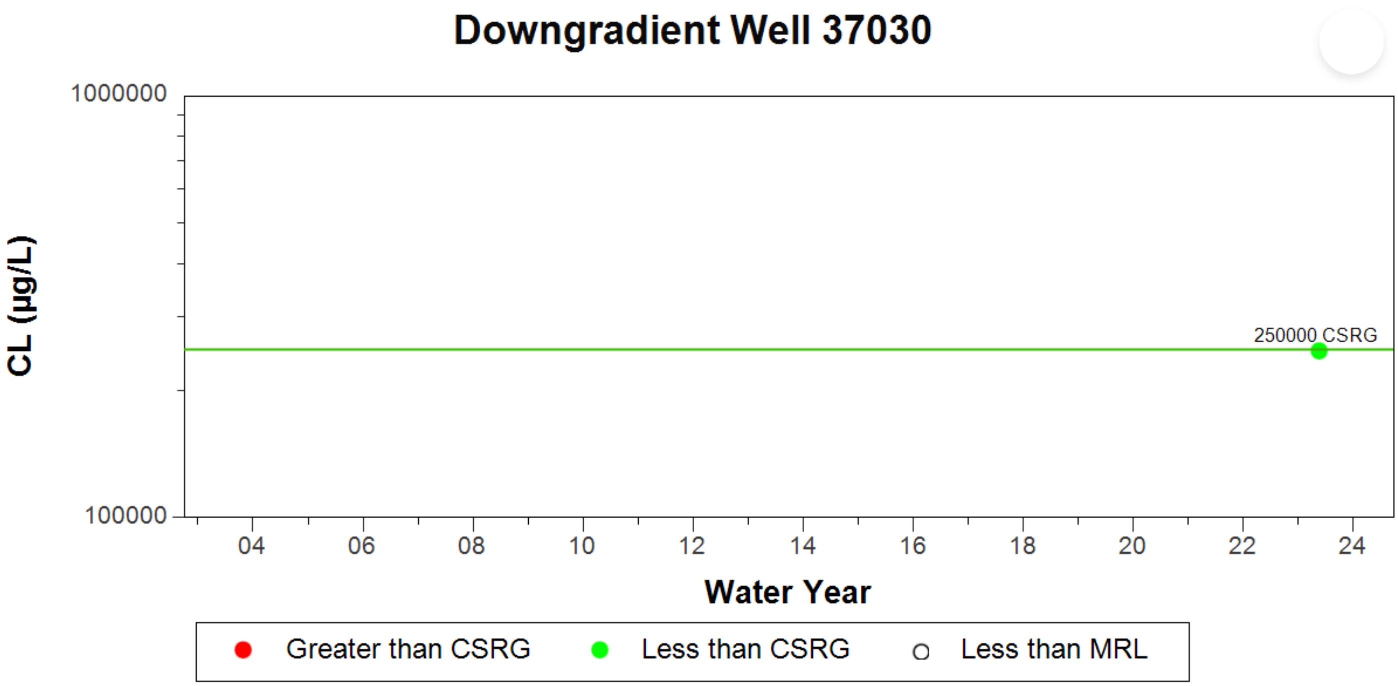
Downgradient Well 37009
1000000
100000
CL (µg/L)
250000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

Downgradient Well 37010

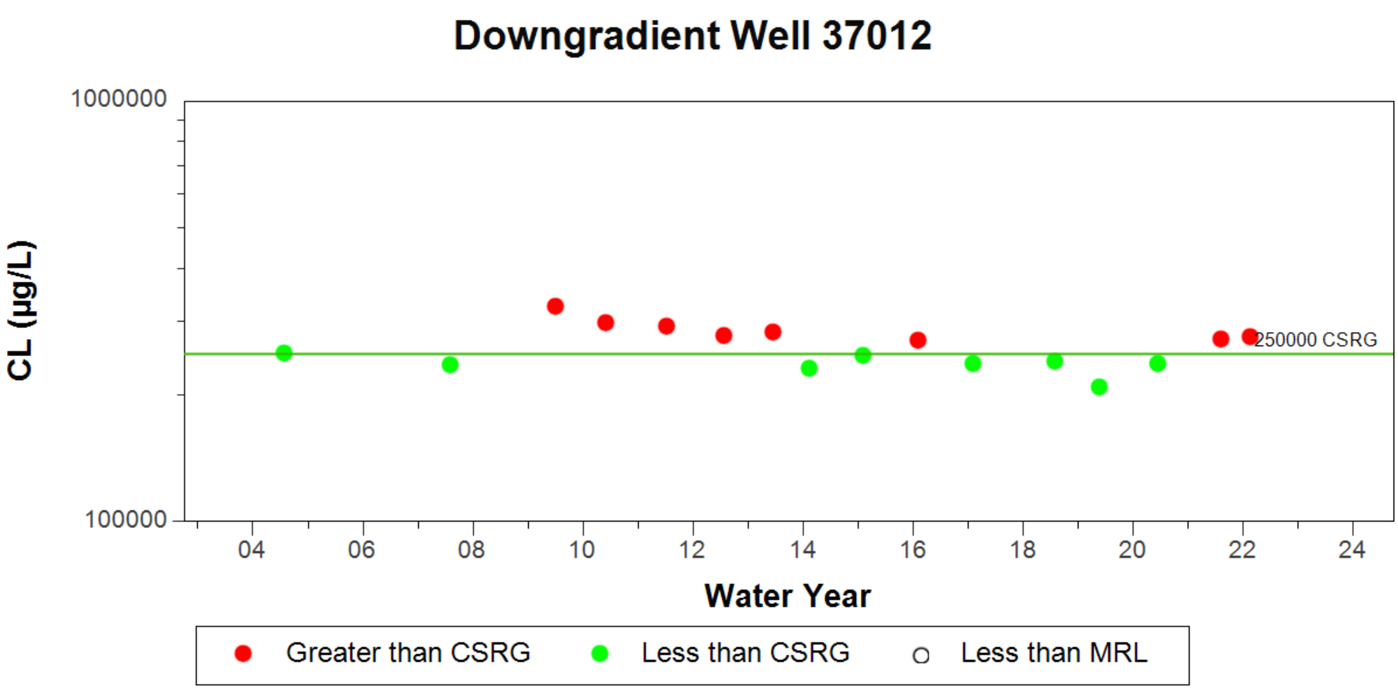


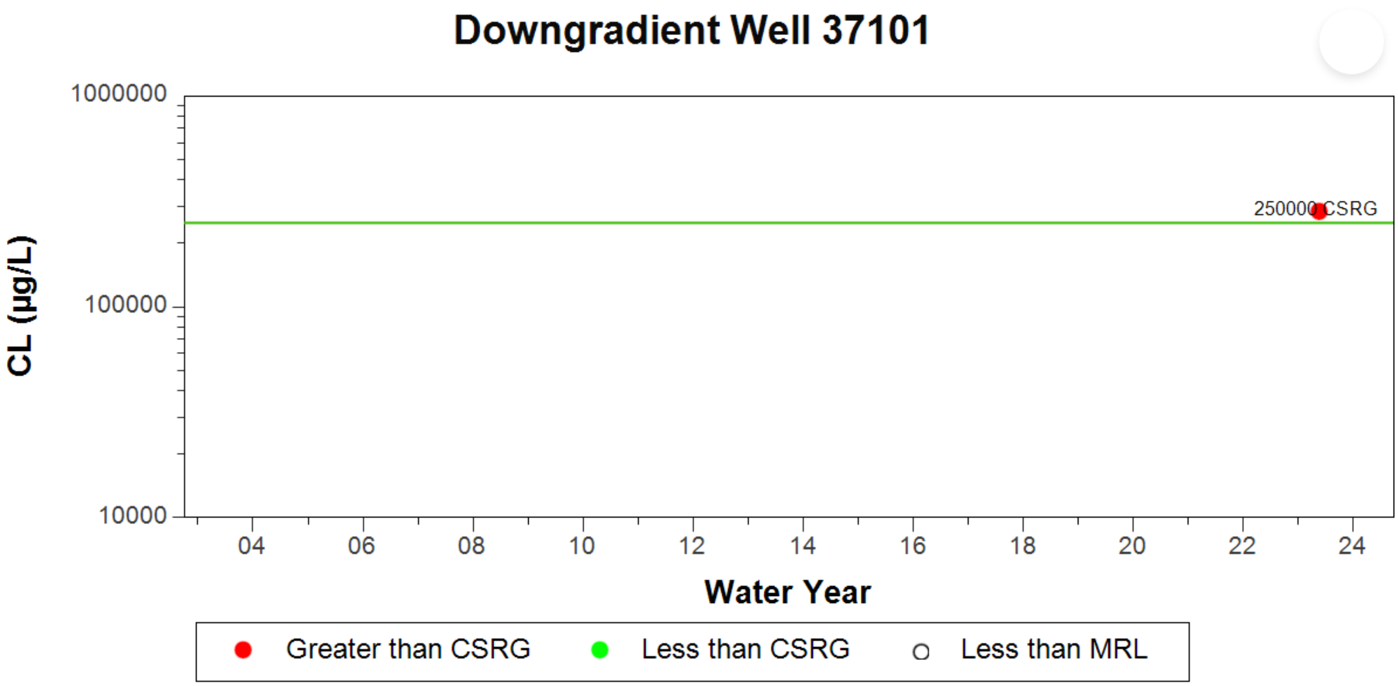
Downgradient Well 37011



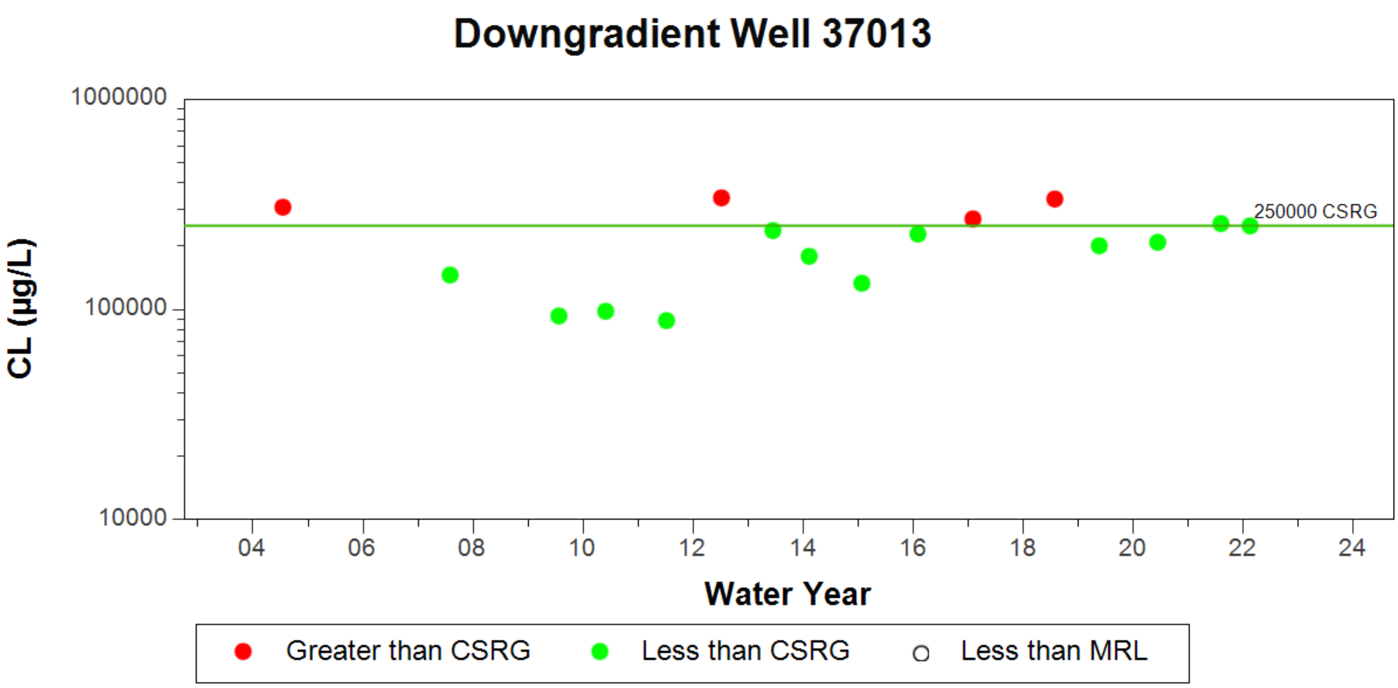


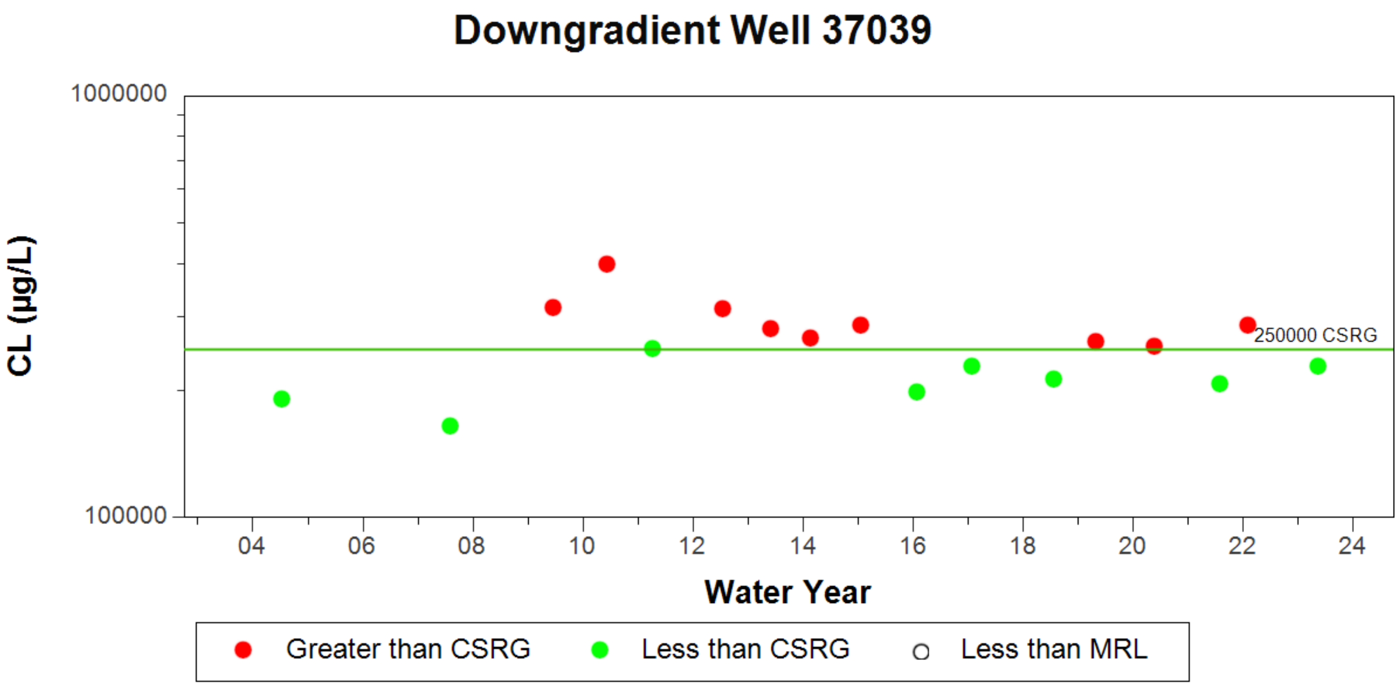
In FY22, well 37012 was replaced by well 37030.
Prior to FY22, well 37012 did not show an increasing trend.





In FY22, well 37013 was replaced by well 37101.
Prior to FY22, well 37013 did not show an increasing trend.





Downgradient Well 37039
1000000
100000
CL (µg/L)
250000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

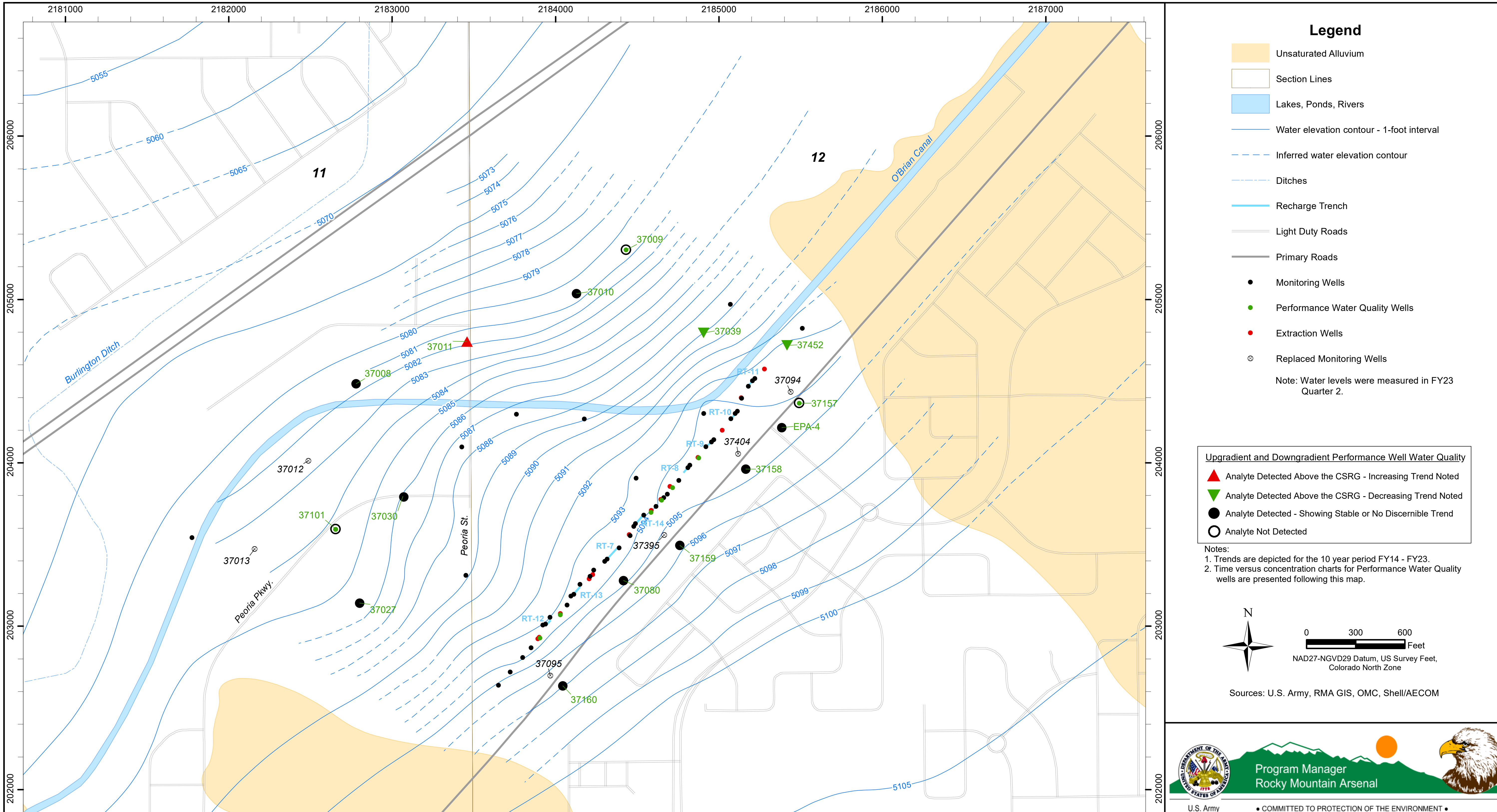
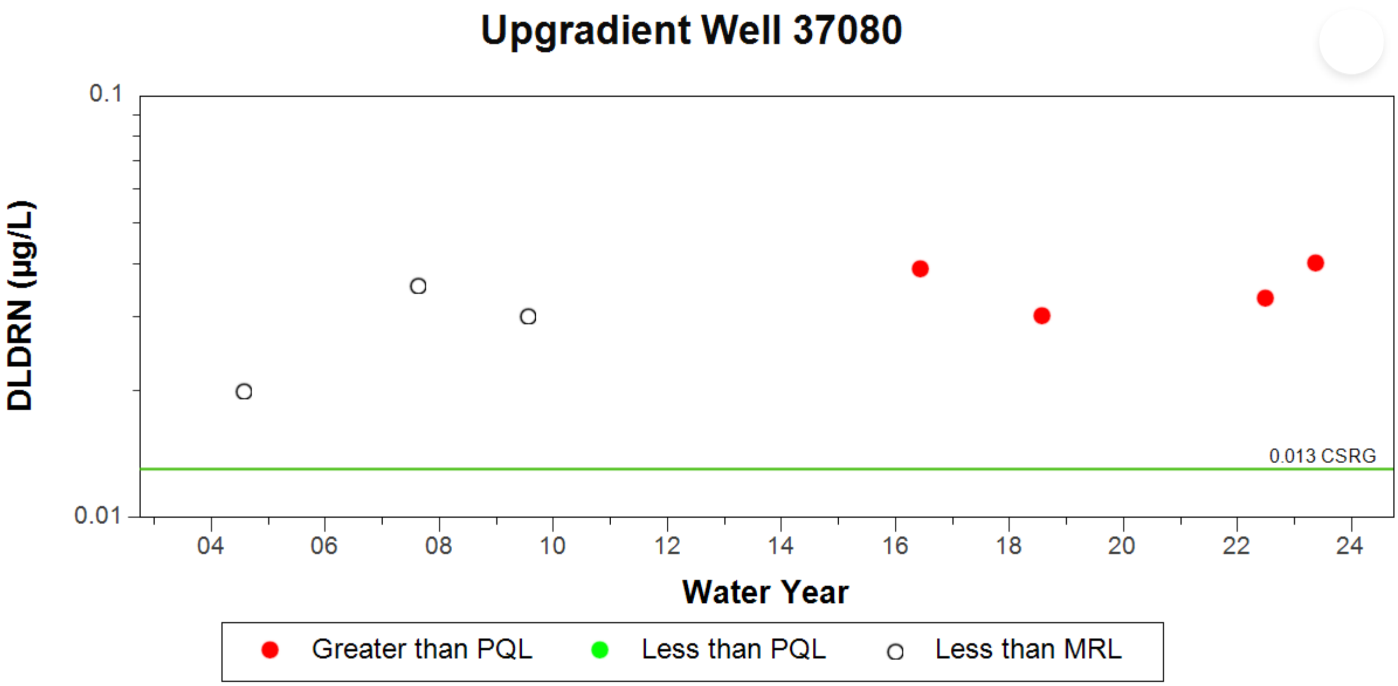


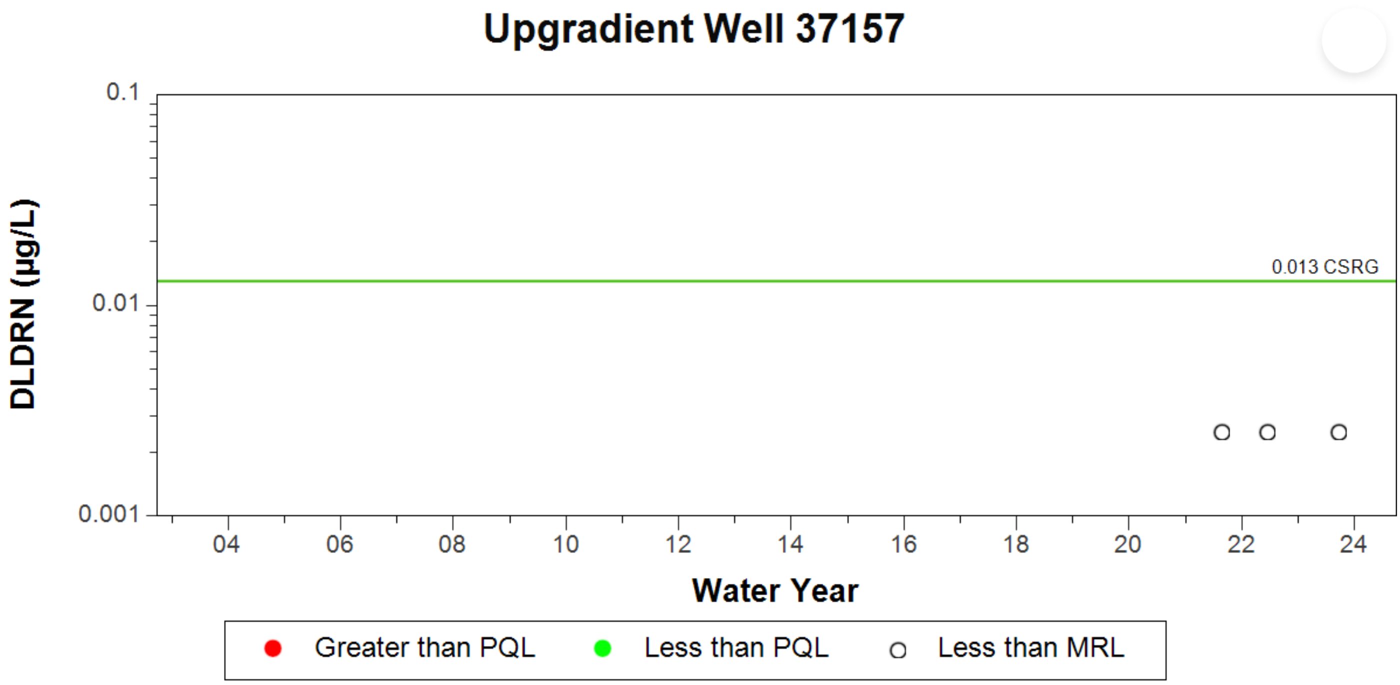
Figure G-13

Dieldrin Concentration
Trends in Performance Wells,
Northern Pathway Treatment System

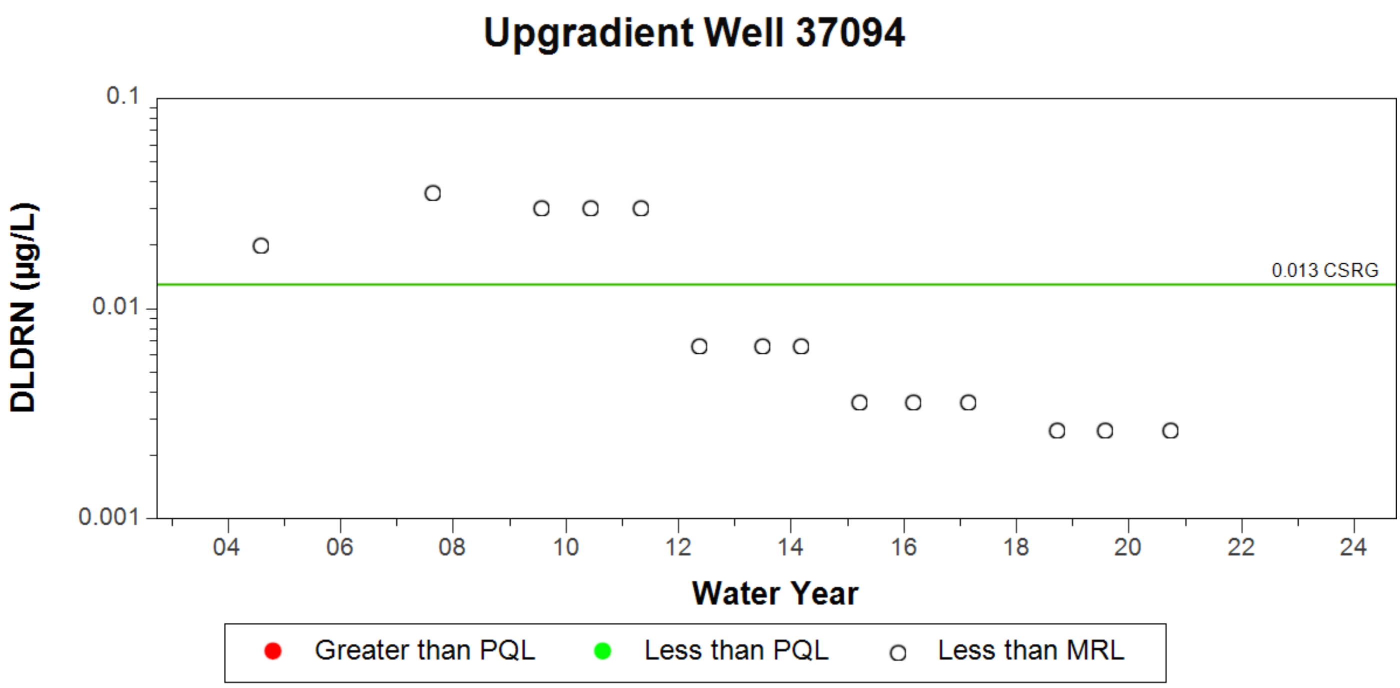
M:\projects\oars\fy23\mxds_NP_FY23_DLDRN.mxd
8/8/2024

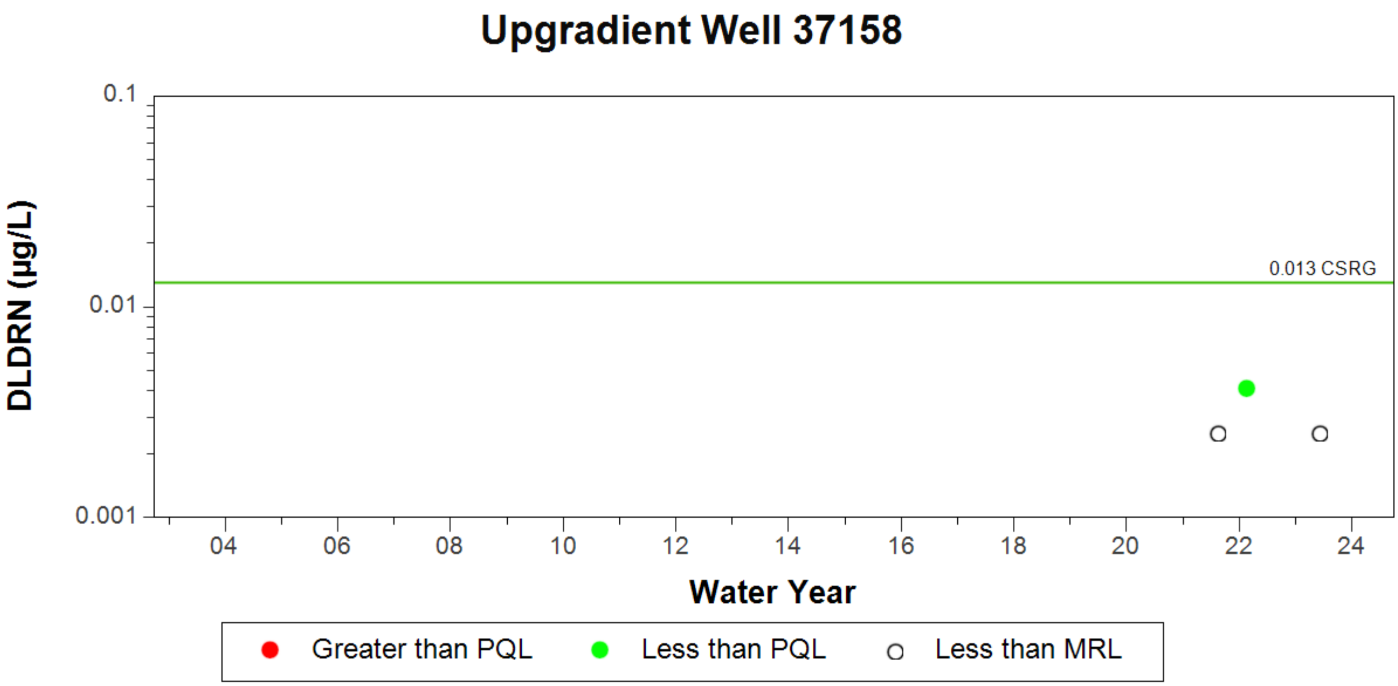


Upgradient Well 37080
DLDRN (µg/L)
0.1
0.01
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

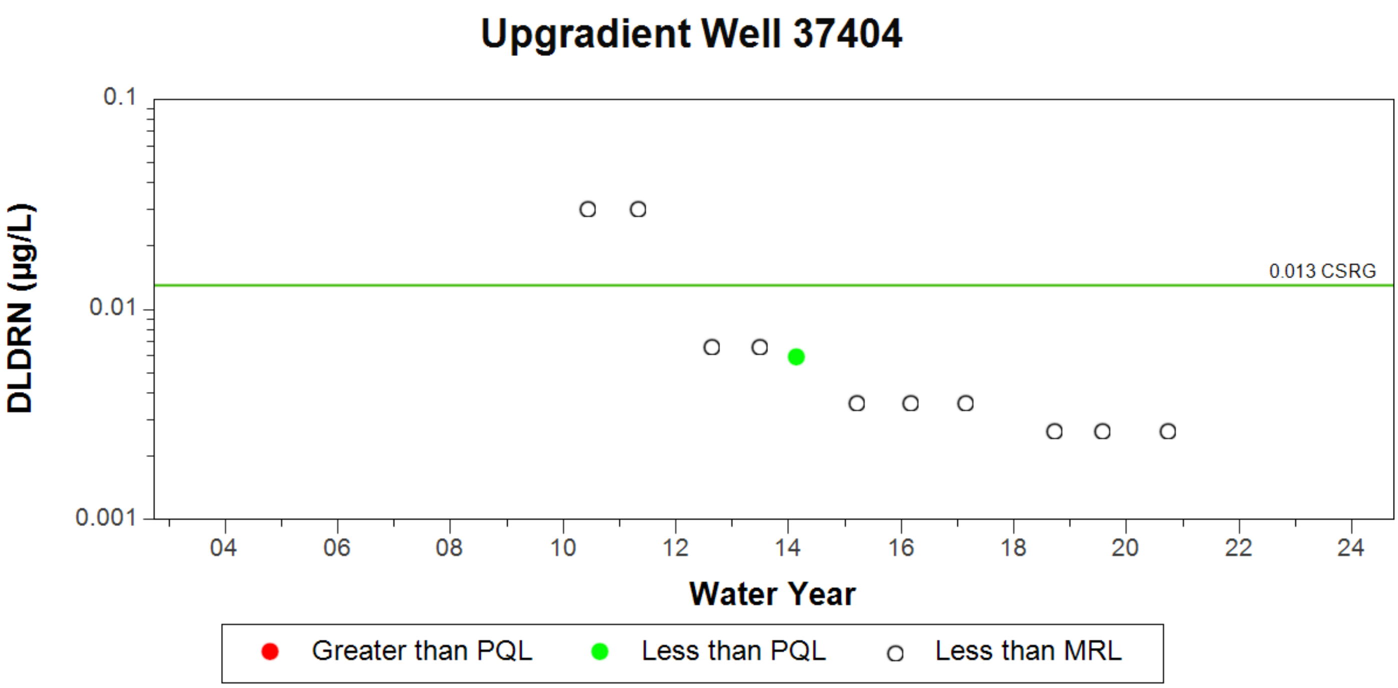


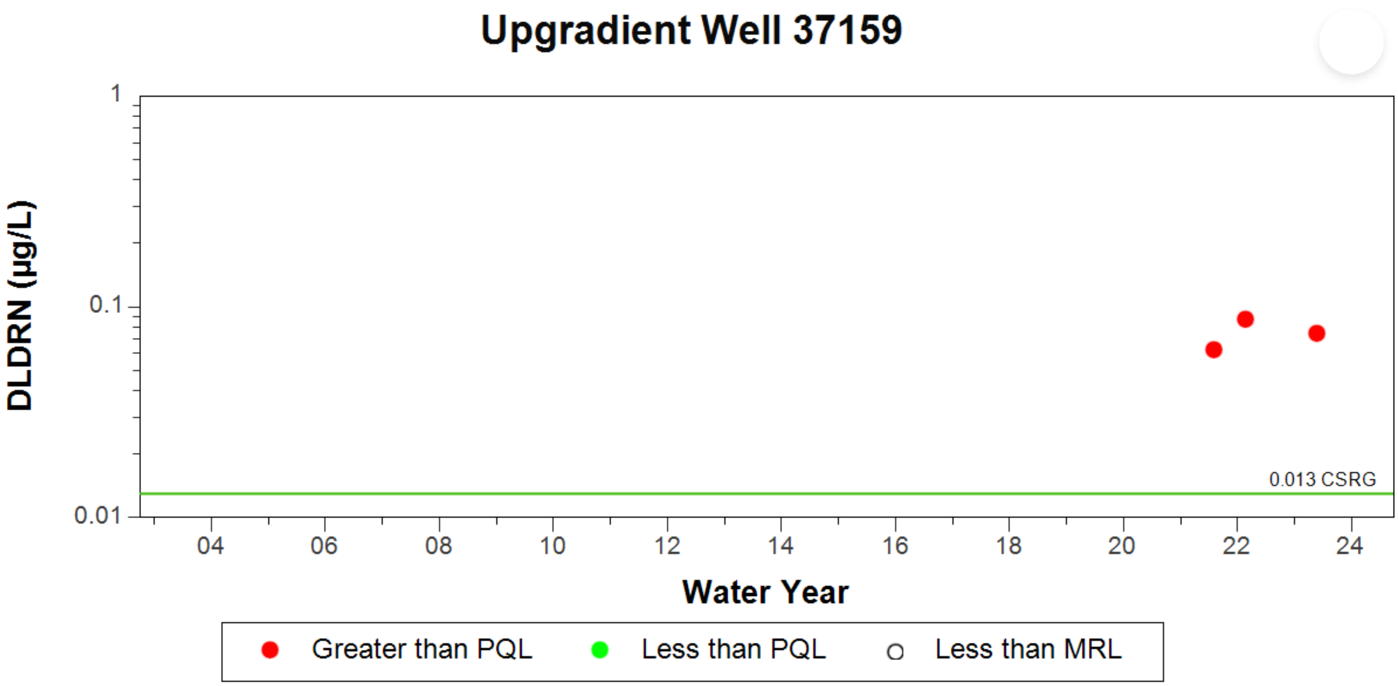
In FY20, well 37094 was replaced by well 37157.



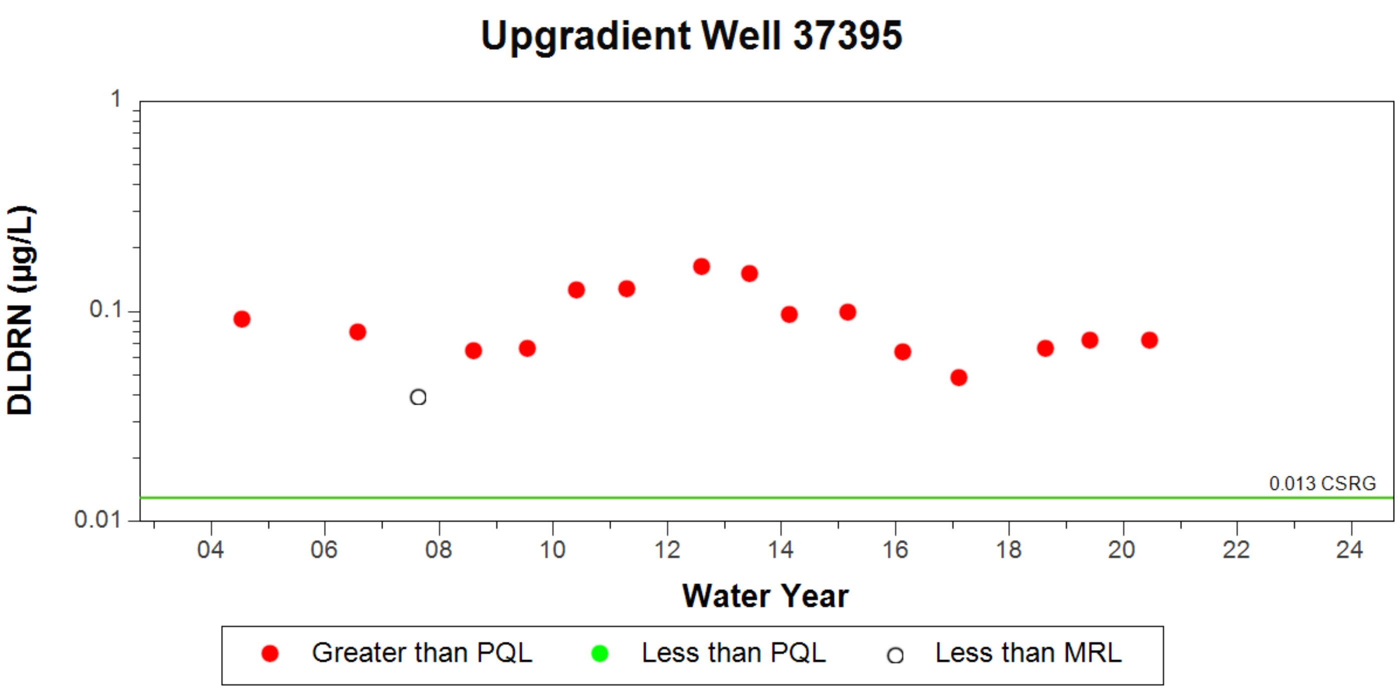


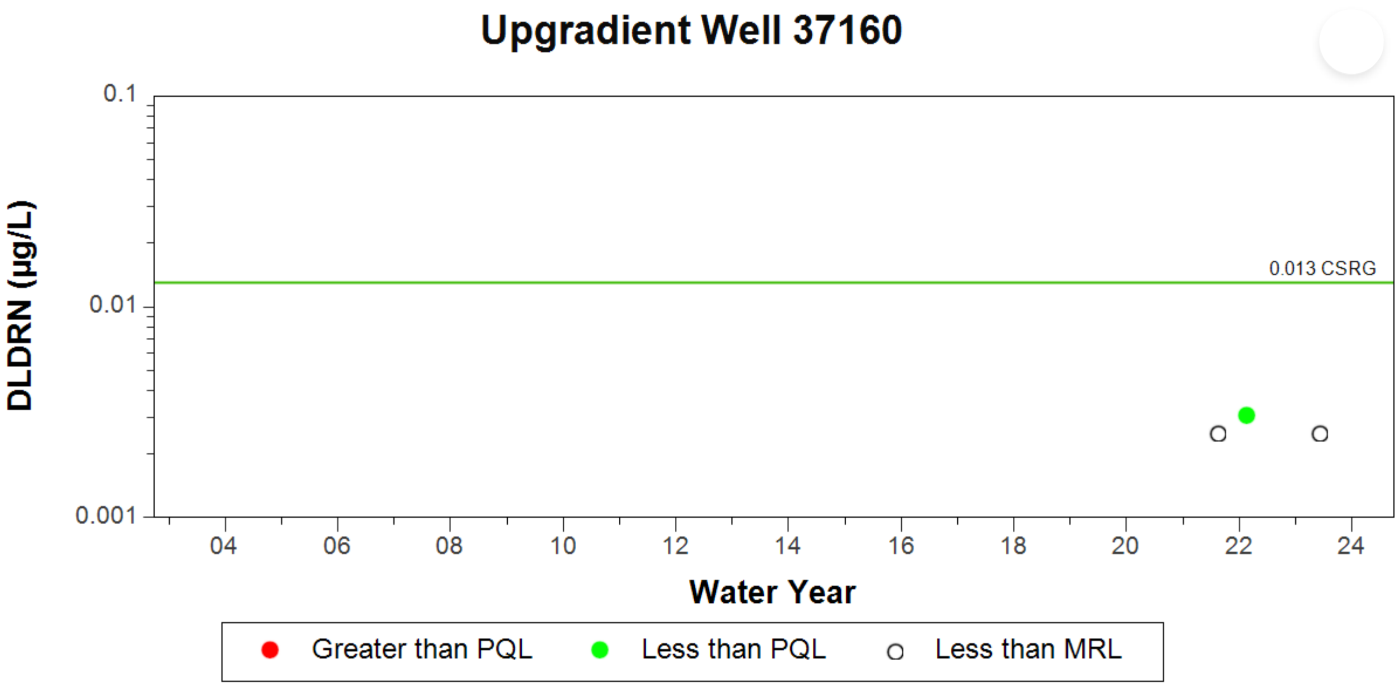
In FY20, well 37404 was replaced by well 37158.



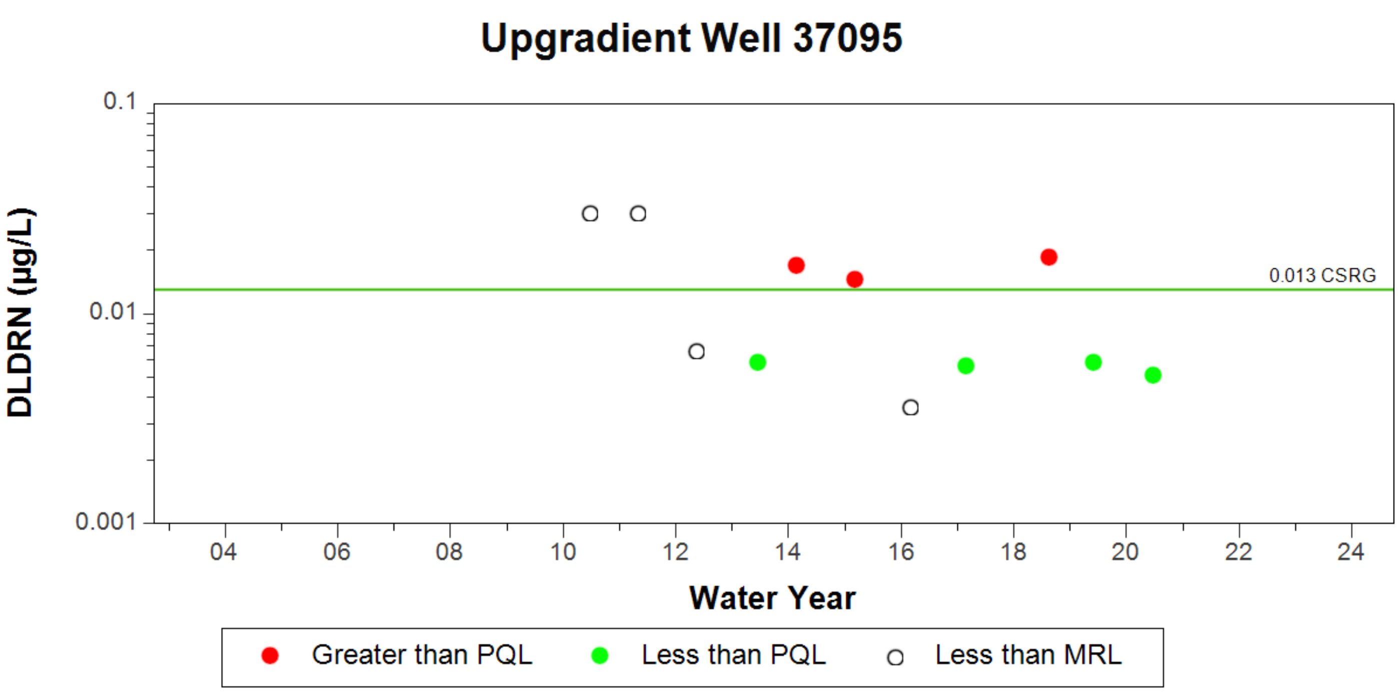


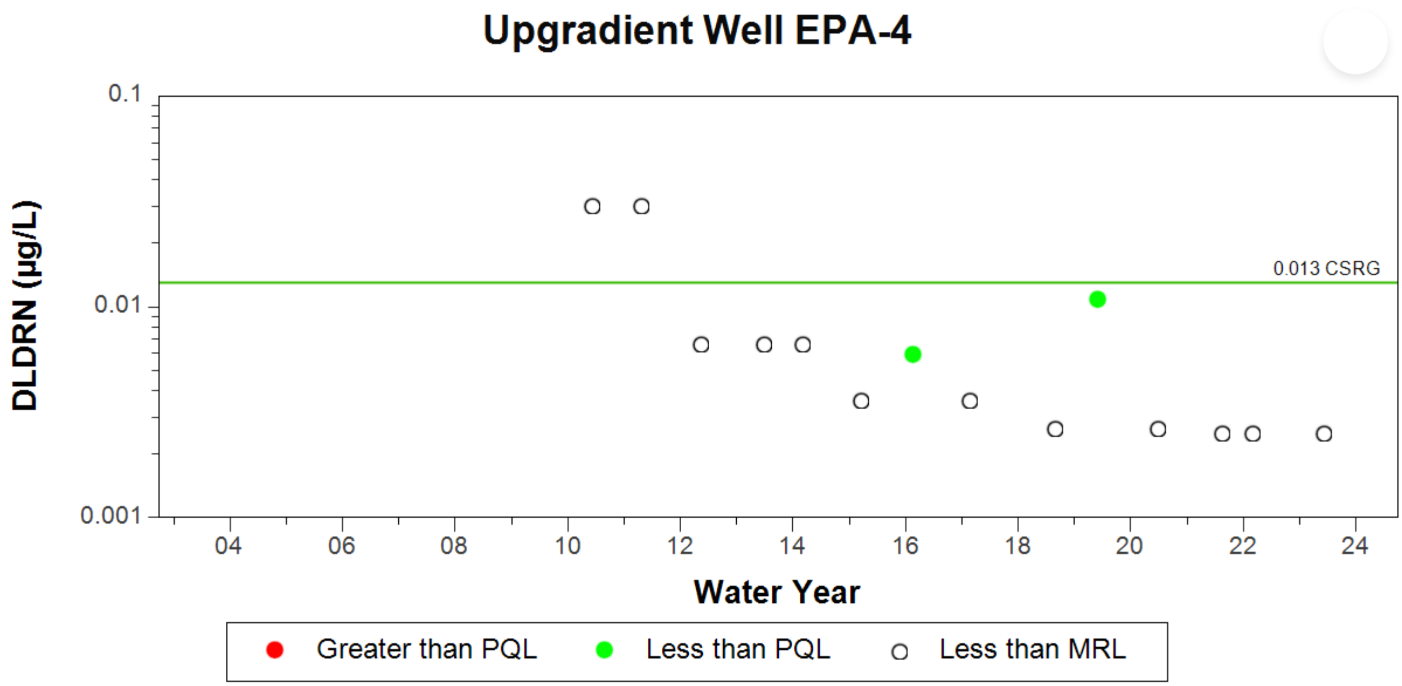
In FY20, well 37395 was replaced by well 37159.

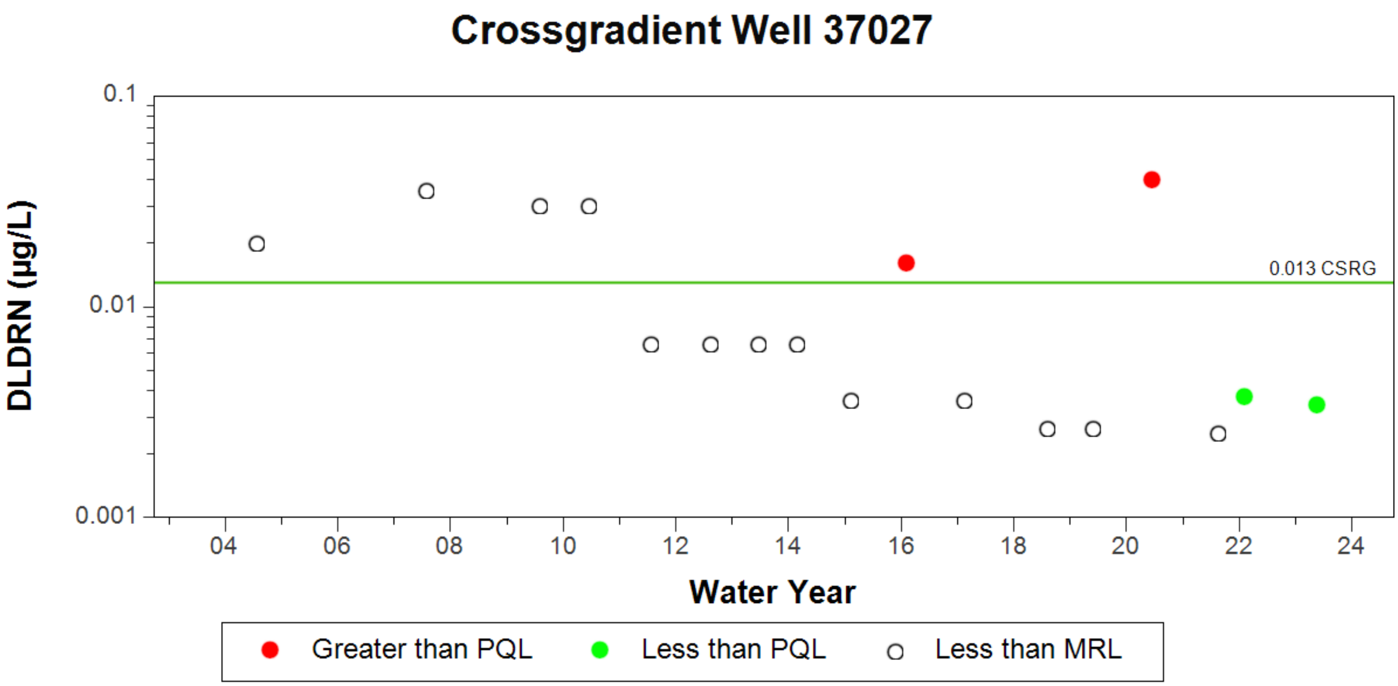


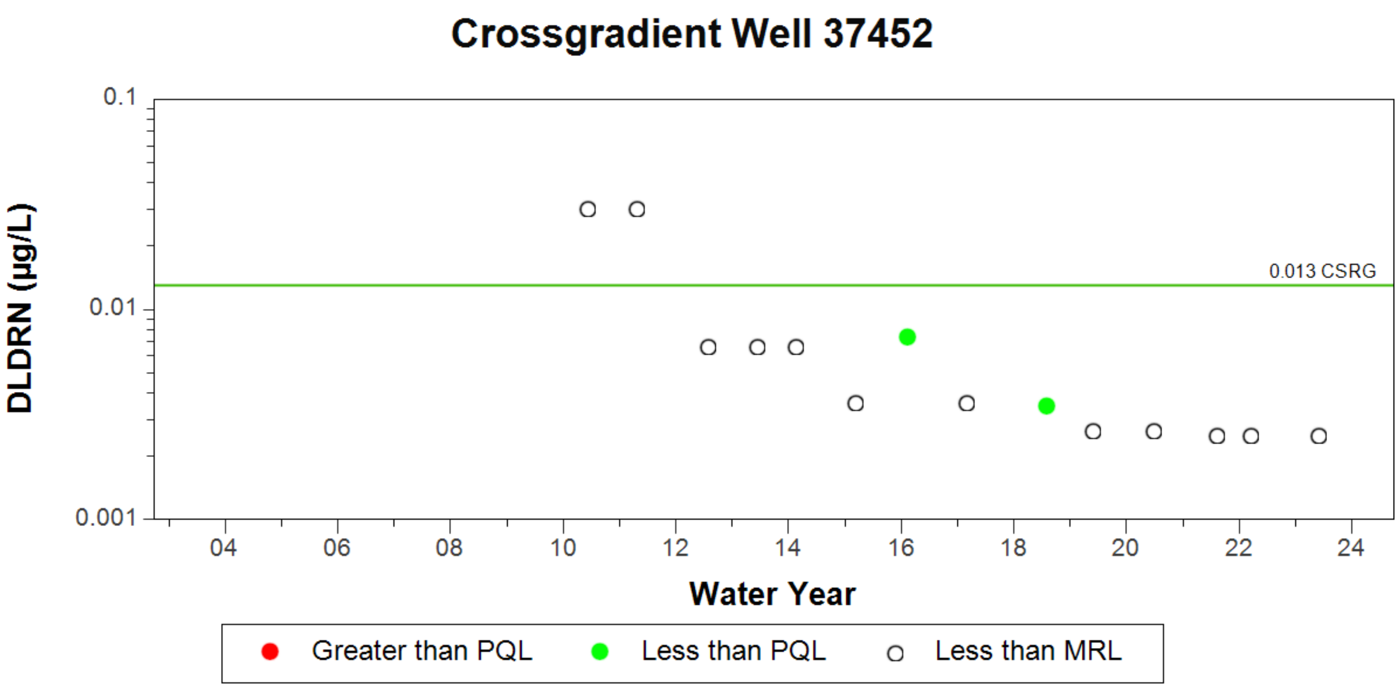


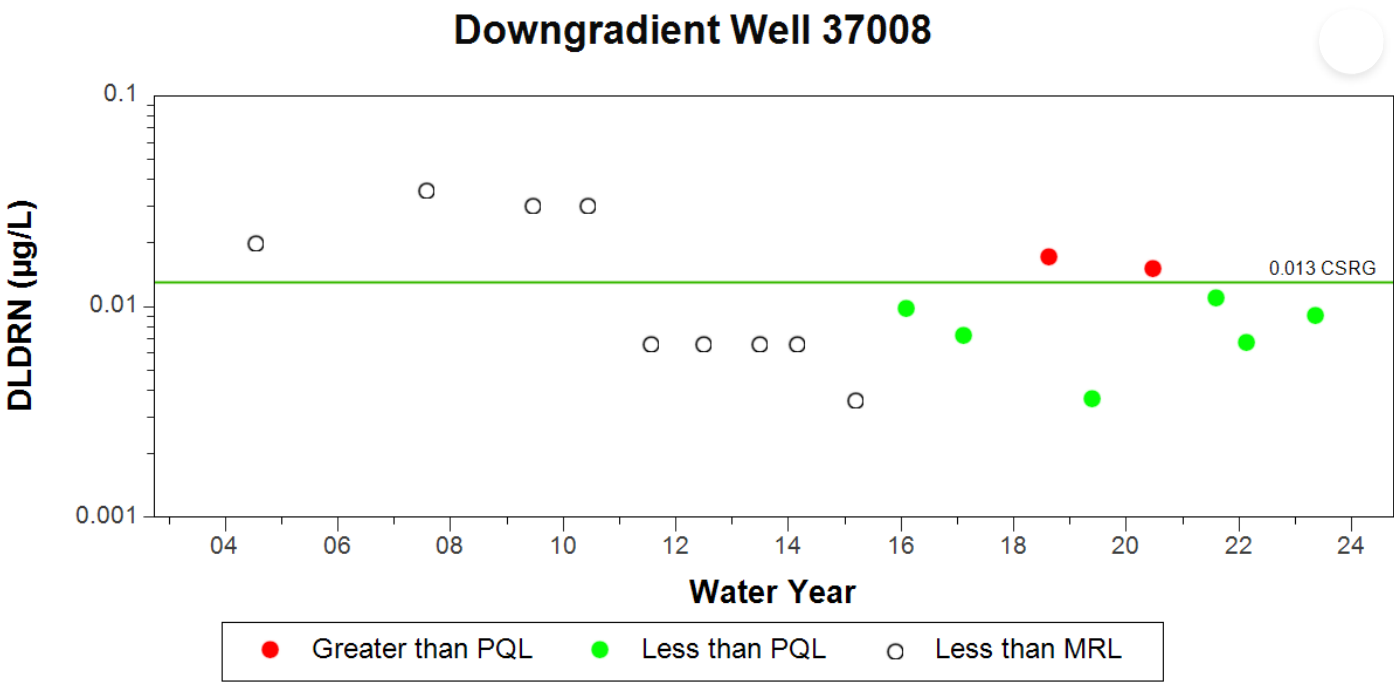
In FY20, well 37095 was replaced by well 37160.



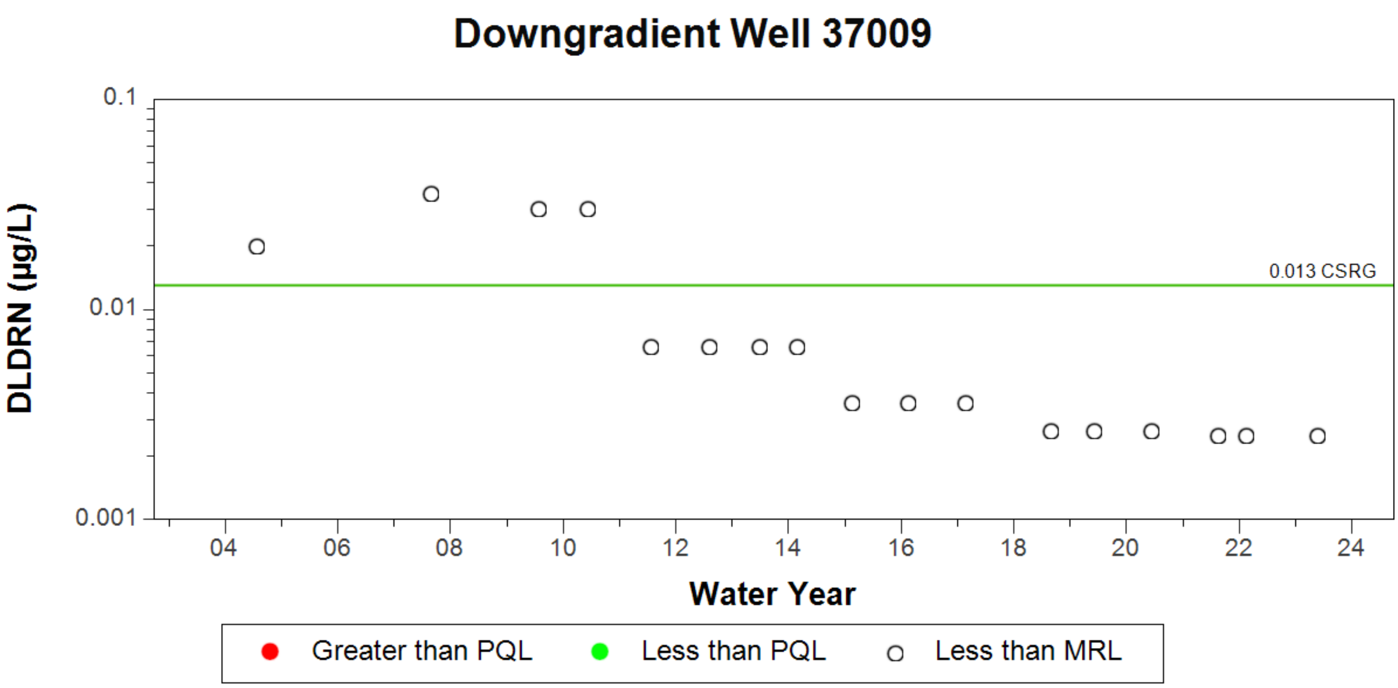

Upgradient Well EPA-4
DLDRN (µg/L)
0.1
0.01
0.001
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL


Crossgradient Well 37027
DLDRN (µg/L)
0.1
0.01
0.001
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

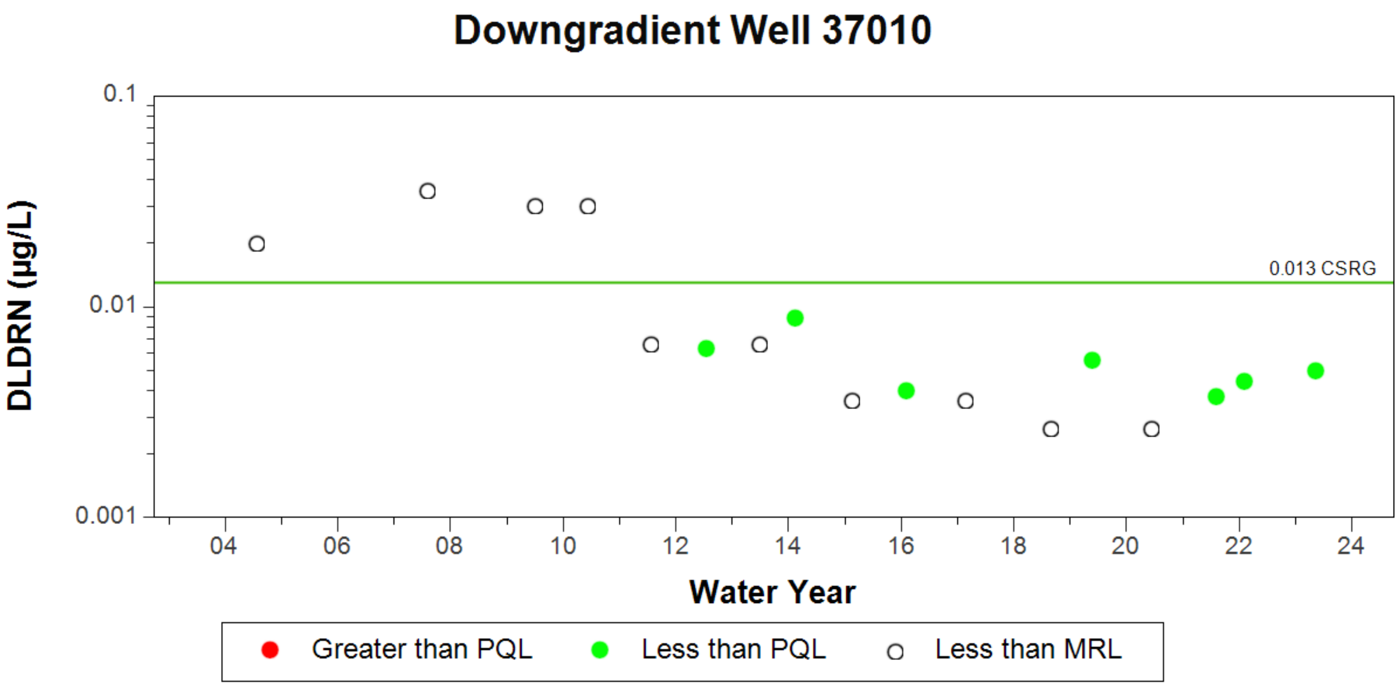

Crossgradient Well 37452
DLDRN (µg/L)
0.1
0.01
0.001
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

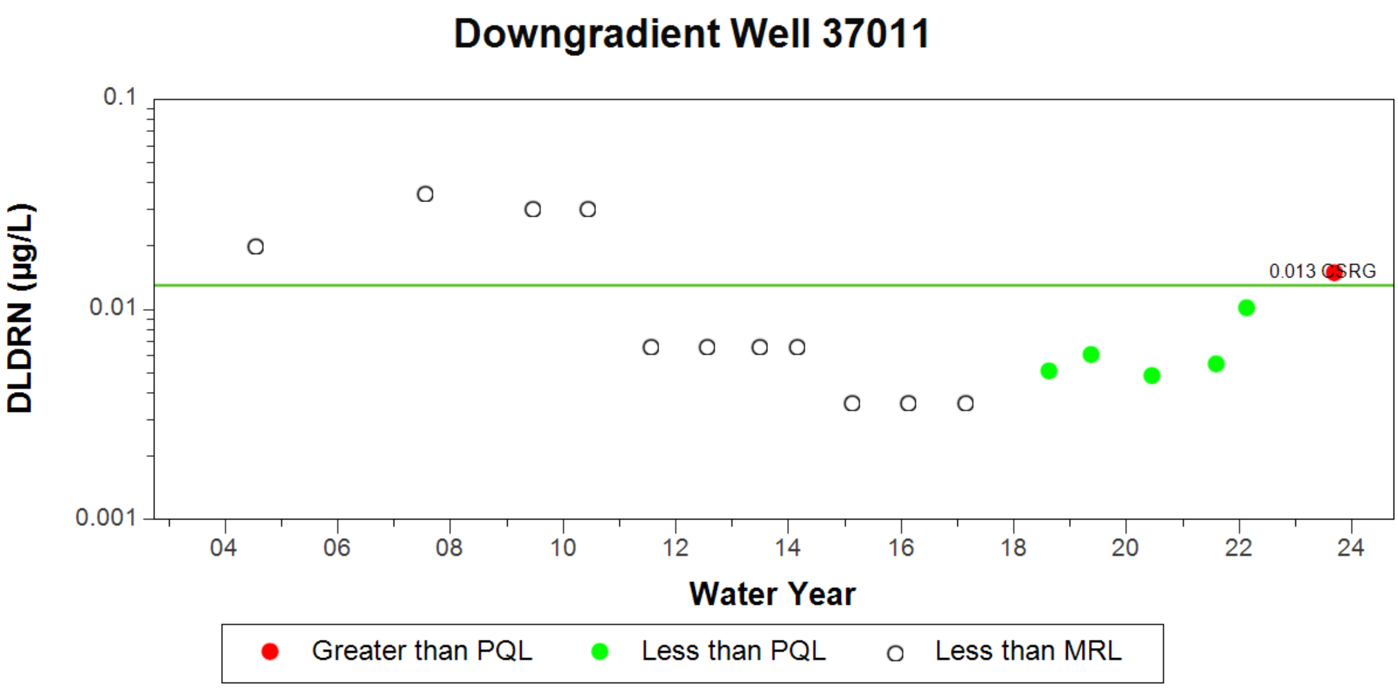


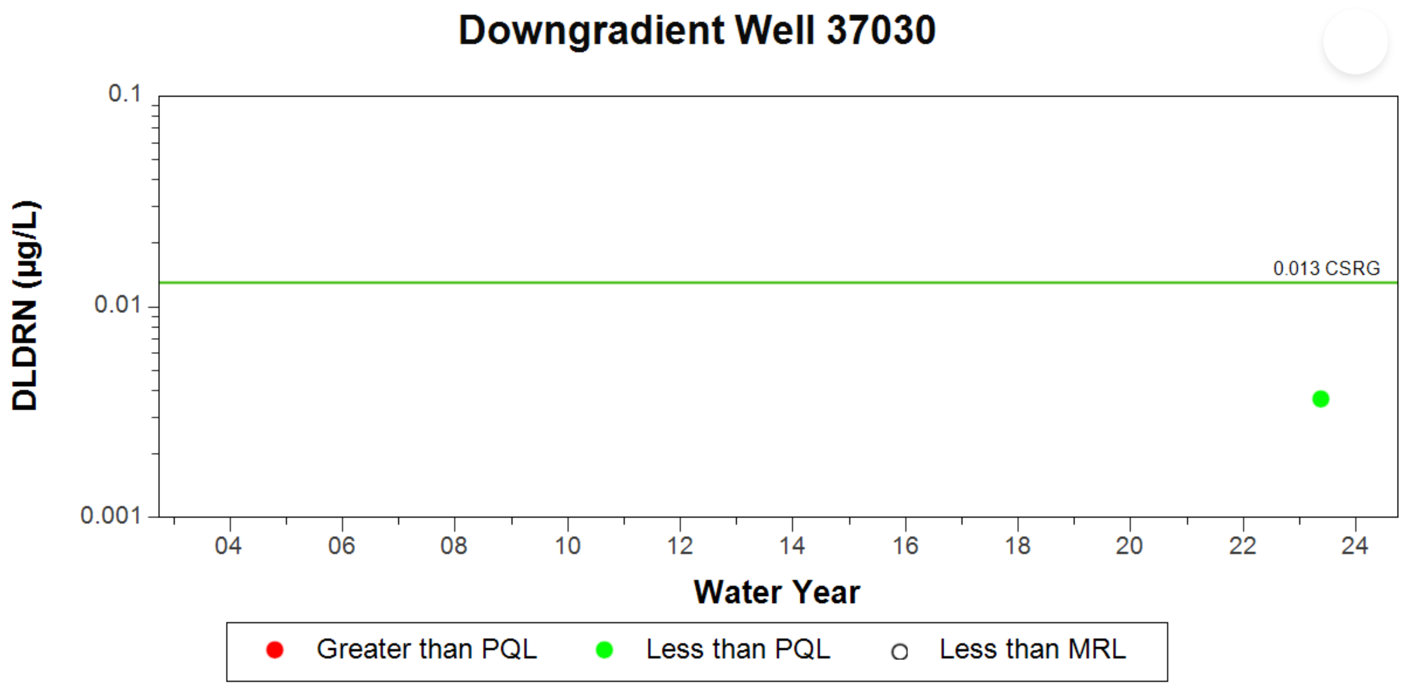
Downgradient Well 37008
DLDRN (µg/L)
0.1
0.01
0.001
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL



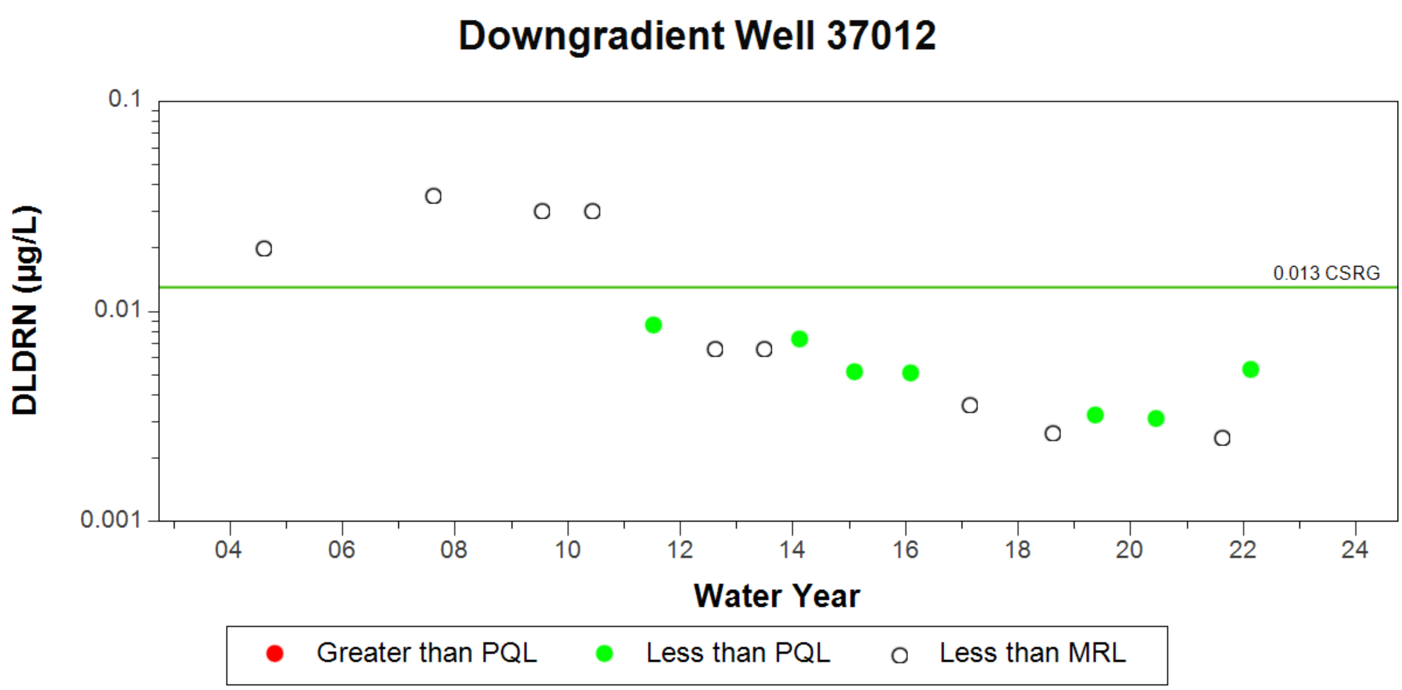
Downgradient Well 37009
DLDRN (µg/L)
0.1
0.01
0.001
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

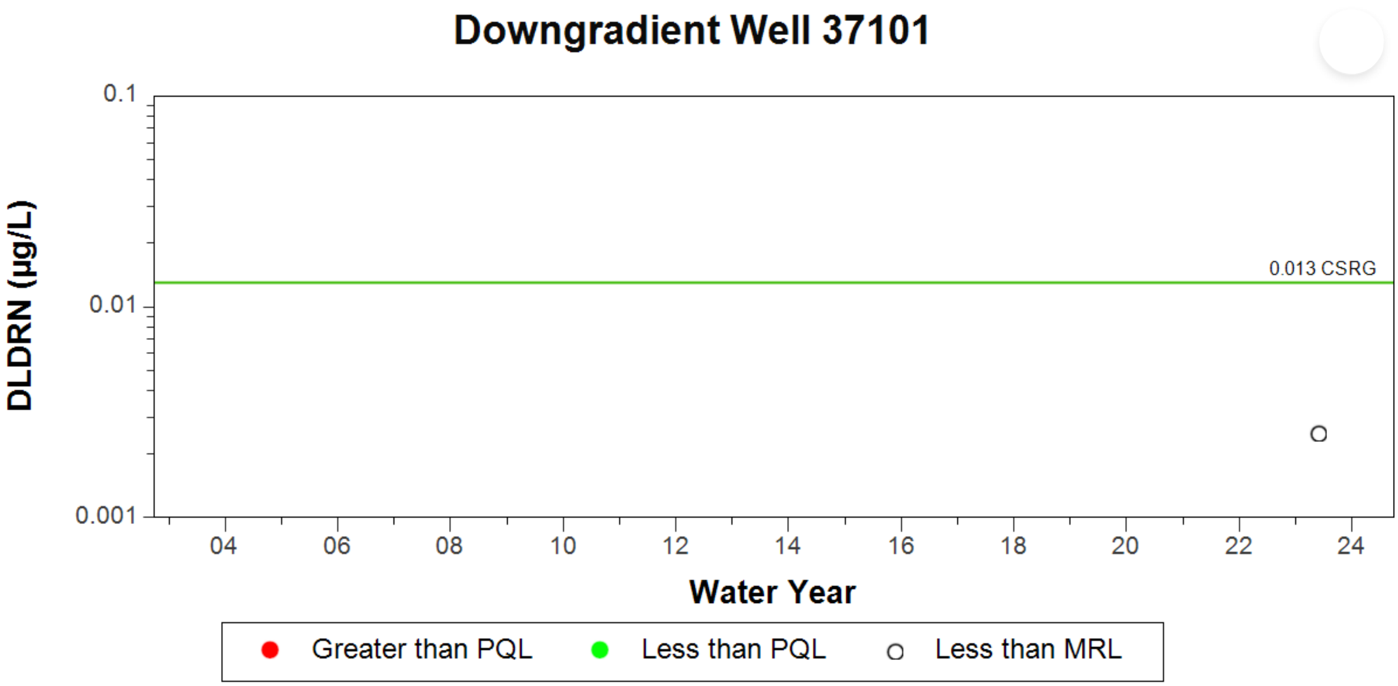

Downgradient Well 37010
DLDRN (µg/L)
0.1
0.01
0.001
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL


Downgradient Well 37011
DLDRN (µg/L)
0.1
0.01
0.001
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL

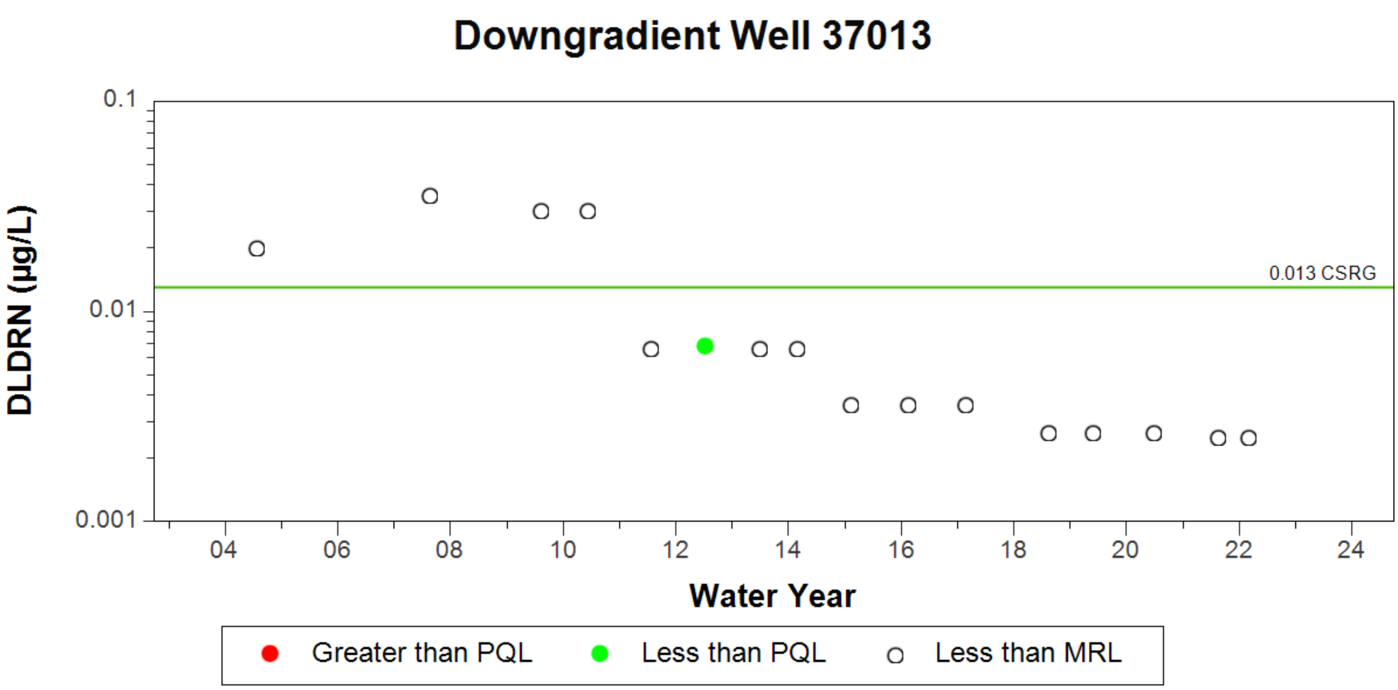


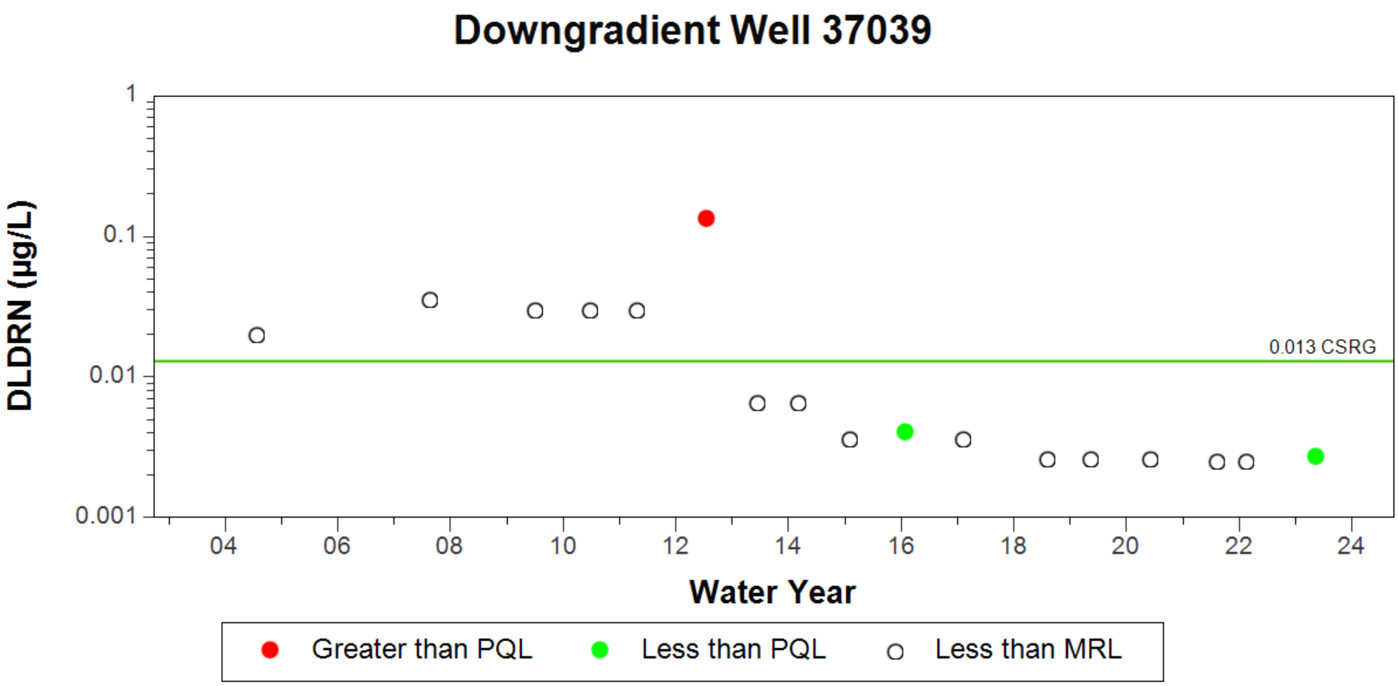
In FY22, well 37012 was replaced by well 37030.
Prior to FY22, well 37012 did not show an increasing trend.



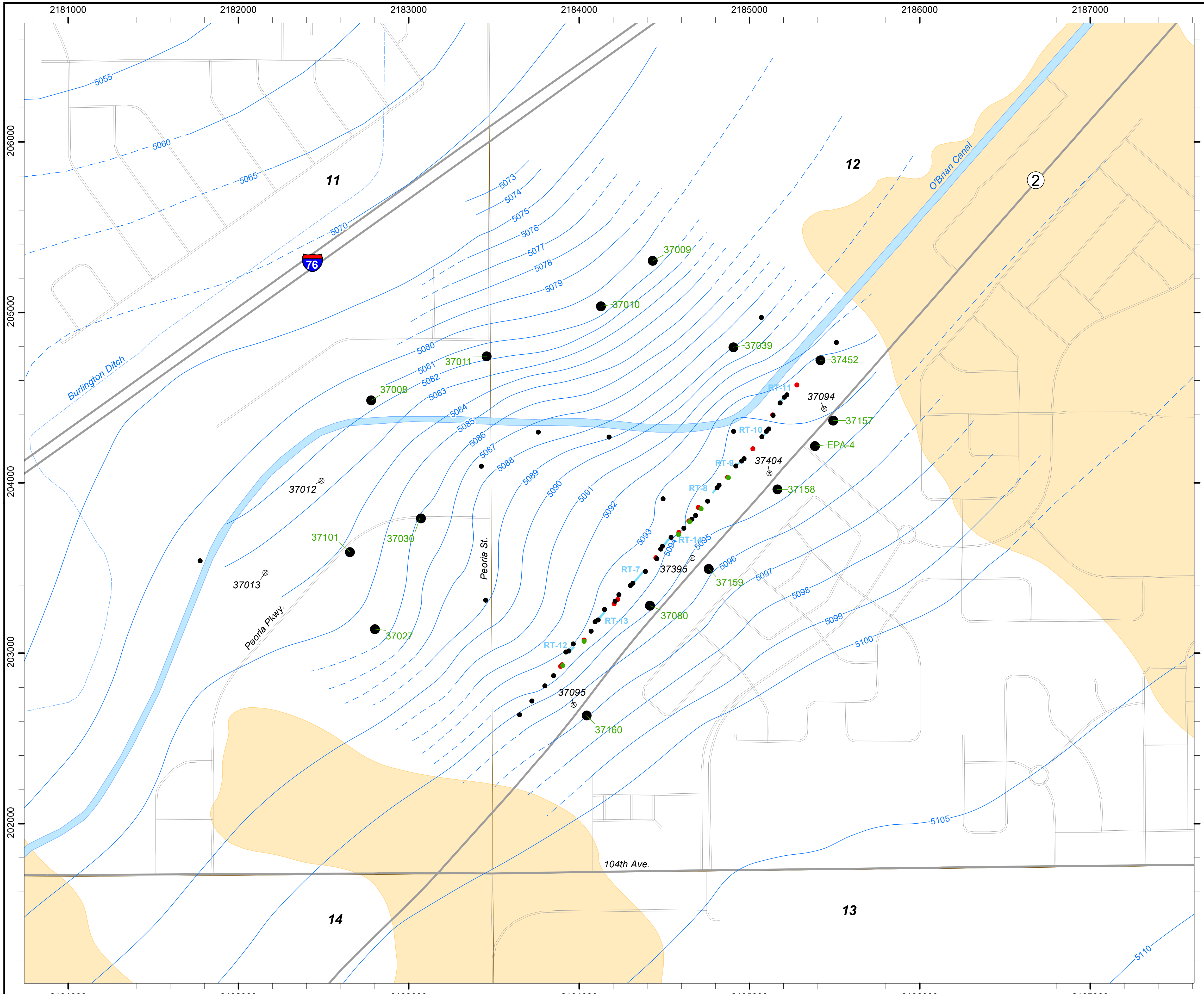


In FY22, well 37013 was replaced by well 37101.
Prior to FY22, well 37013 did not show an increasing trend.





Downgradient Well 37039
DLDRN (µg/L)
1
0.1
0.01
0.001
0.013 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than PQL
Less than PQL
Less than MRL



Legend

- Unsaturated Alluvium
- Section Lines
- Lakes, Ponds, Rivers
- Water elevation contour - 1-foot interval
- Inferred water elevation contour
- Ditches
- Recharge Trench
- Light Duty Roads
- Primary Roads
- Monitoring Wells
- Performance Water Quality Wells
- Extraction Wells
- Replaced Monitoring Wells

Note: Water levels were measured in FY23 Quarter 2.

Upgradient and Downgradient Performance Well Water Quality

- Analyte Detected Above the CSRG - Increasing Trend Noted
- Analyte Detected Above the CSRG - Decreasing Trend Noted
- Analyte Detected - Showing Stable or No Discernible Trend
- Analyte Not Detected

Notes:
1. Trends are depicted for the 10 year period FY14 - FY23.
2. Time versus concentration charts for Performance Water Quality wells are presented following this map.

N

0 300 600 Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

Program Manager
Rocky Mountain Arsenal

U.S. Army

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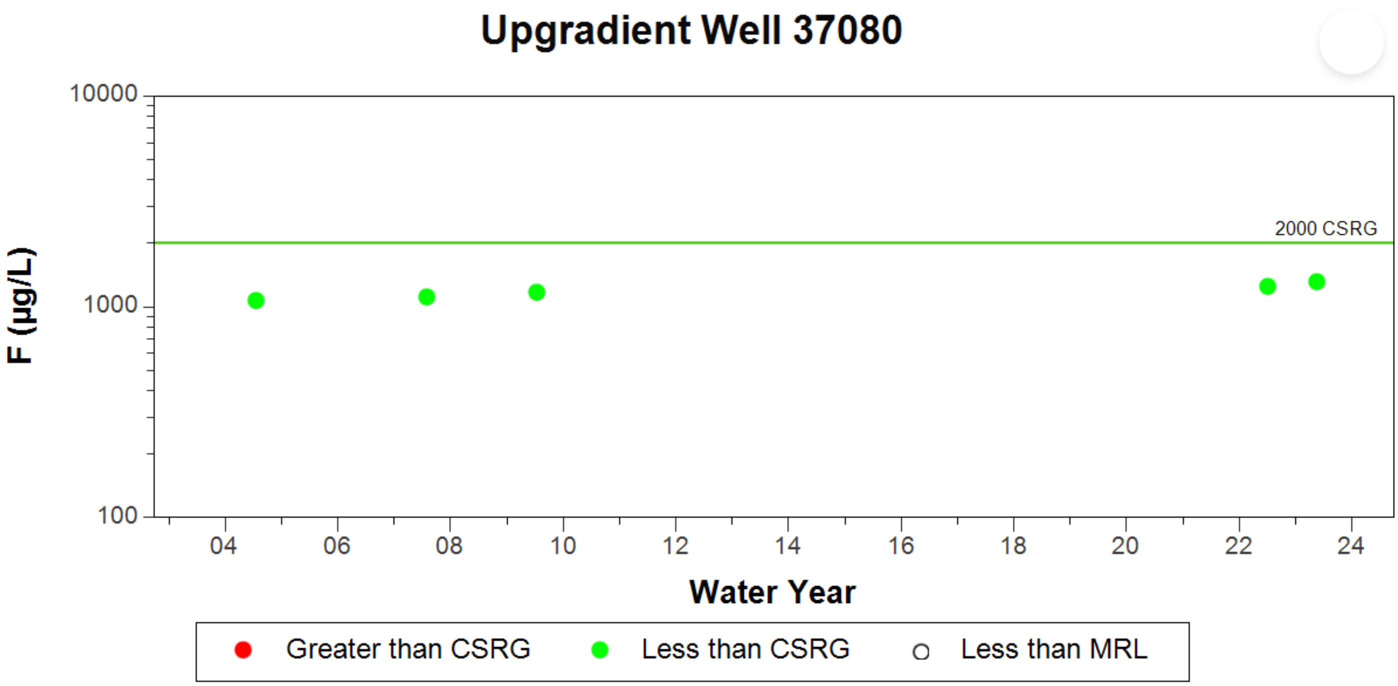
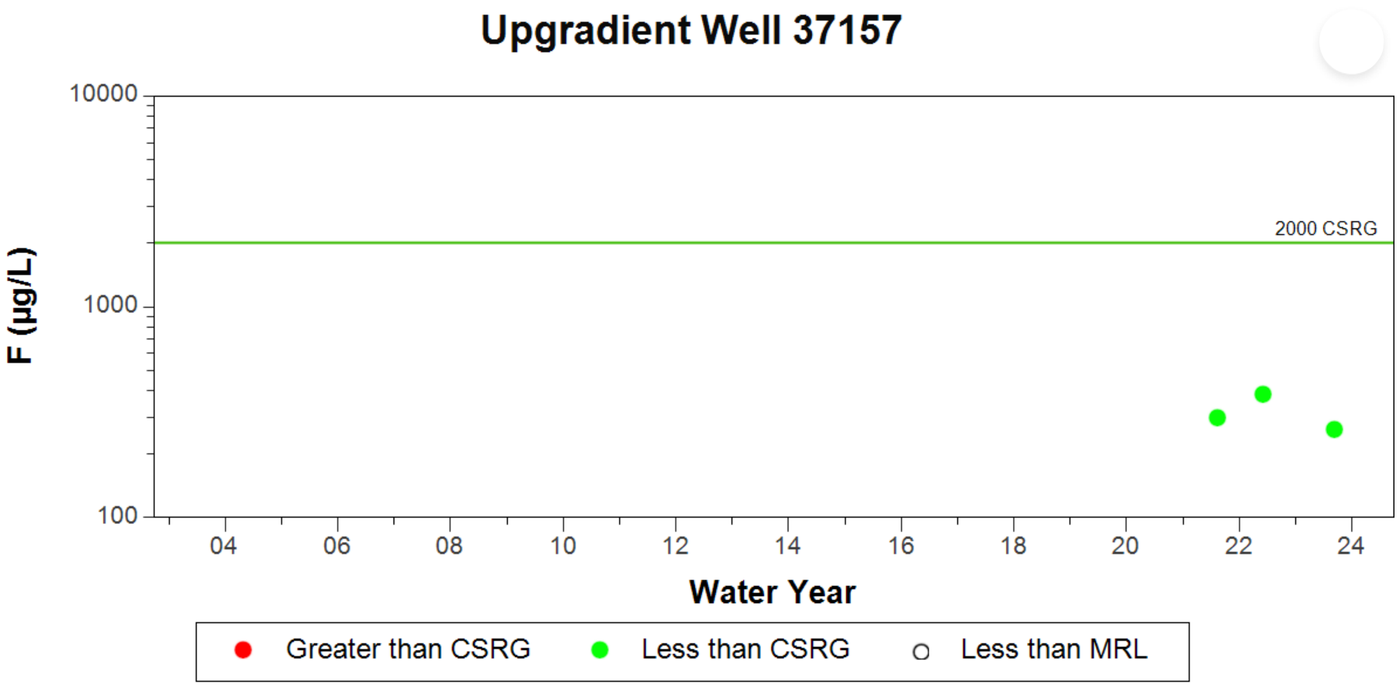
Figure G-14

Fluoride Concentration
Trends in Performance Wells,
Northern Pathway Treatment System

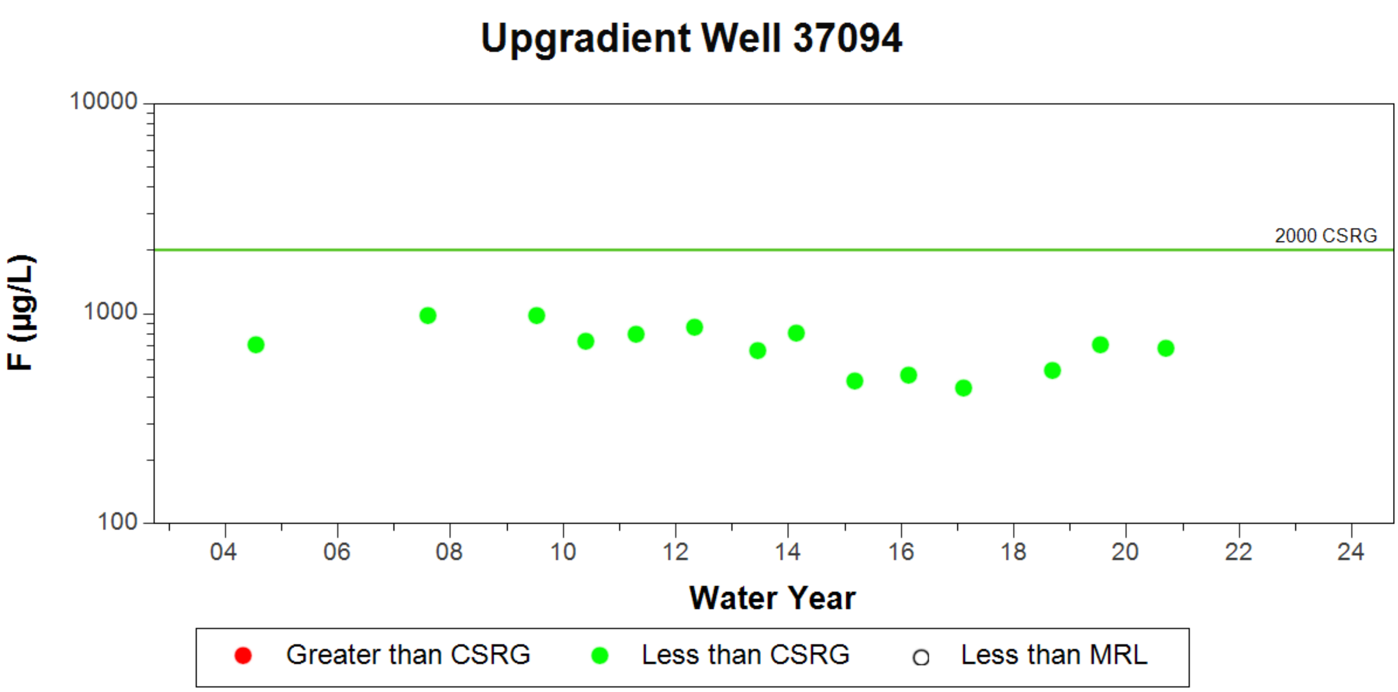
M:\projects\oars\fy23\mxds_NP_FY23_F.mxd
8/8/2024

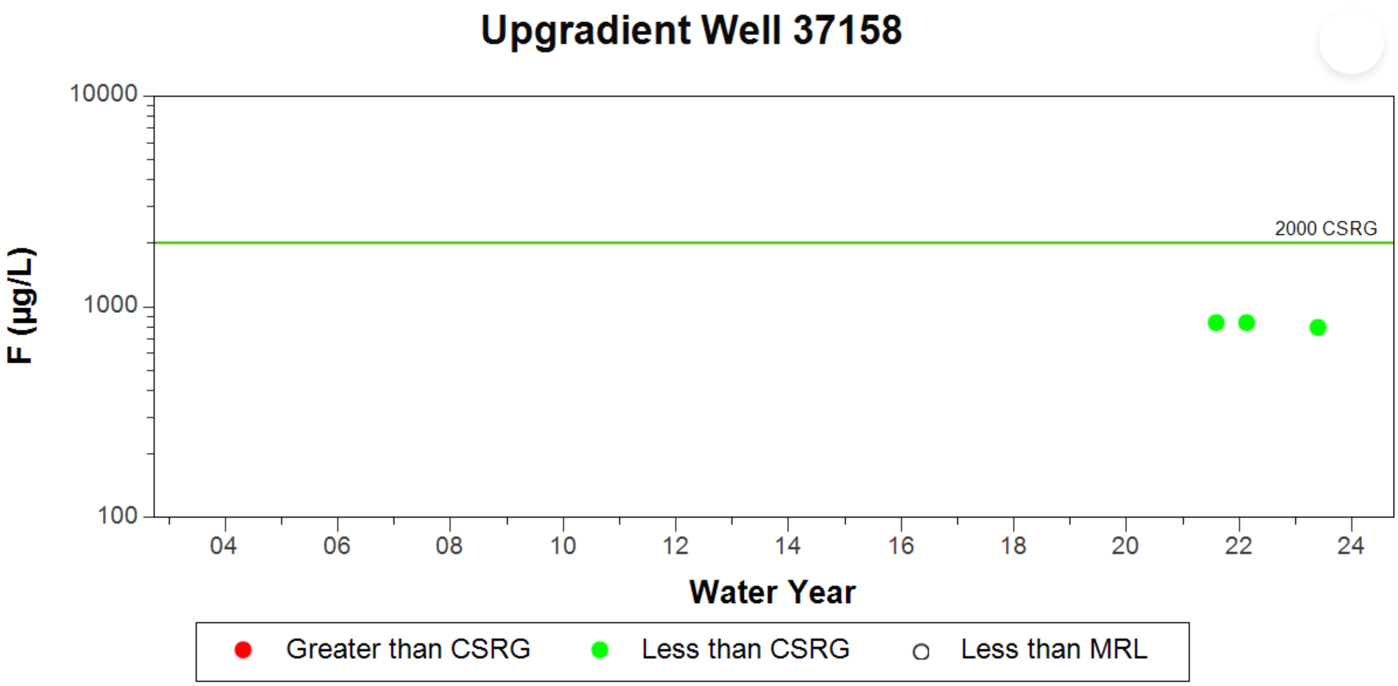


Upgradient Well 37080
F (µg/L)
10000
1000
100
2000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

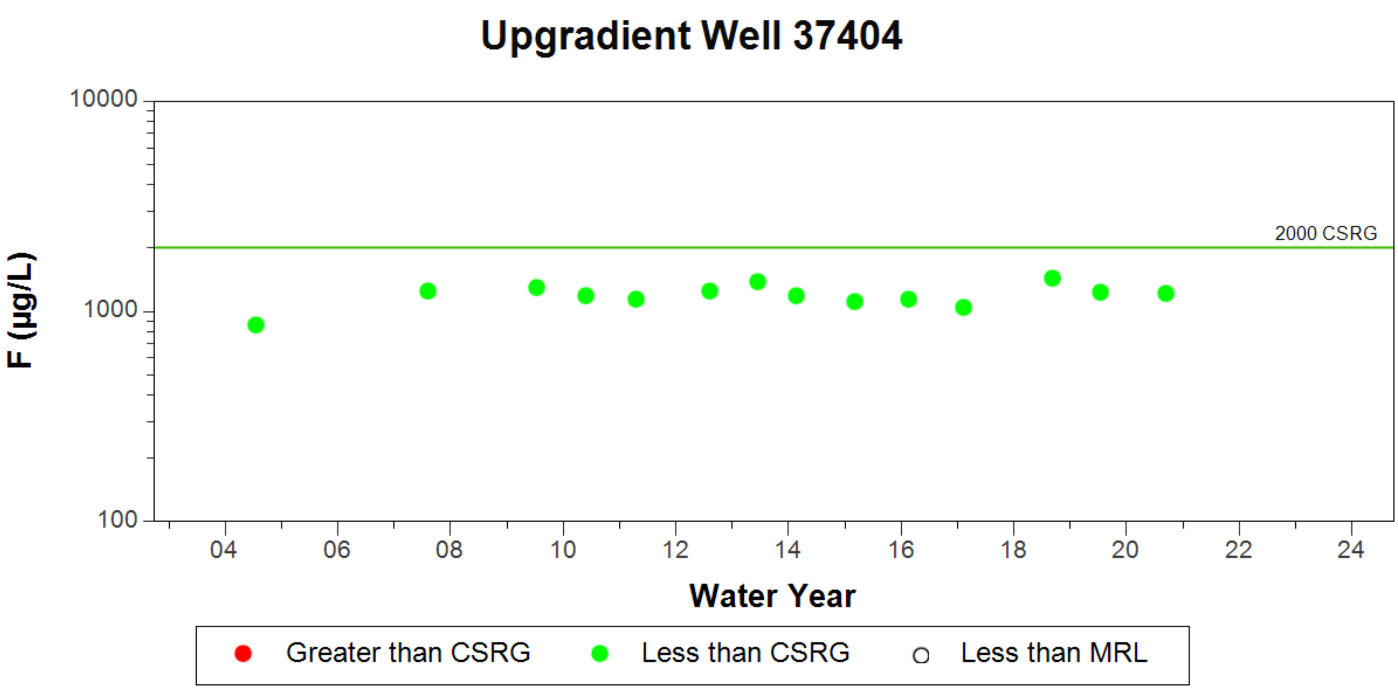


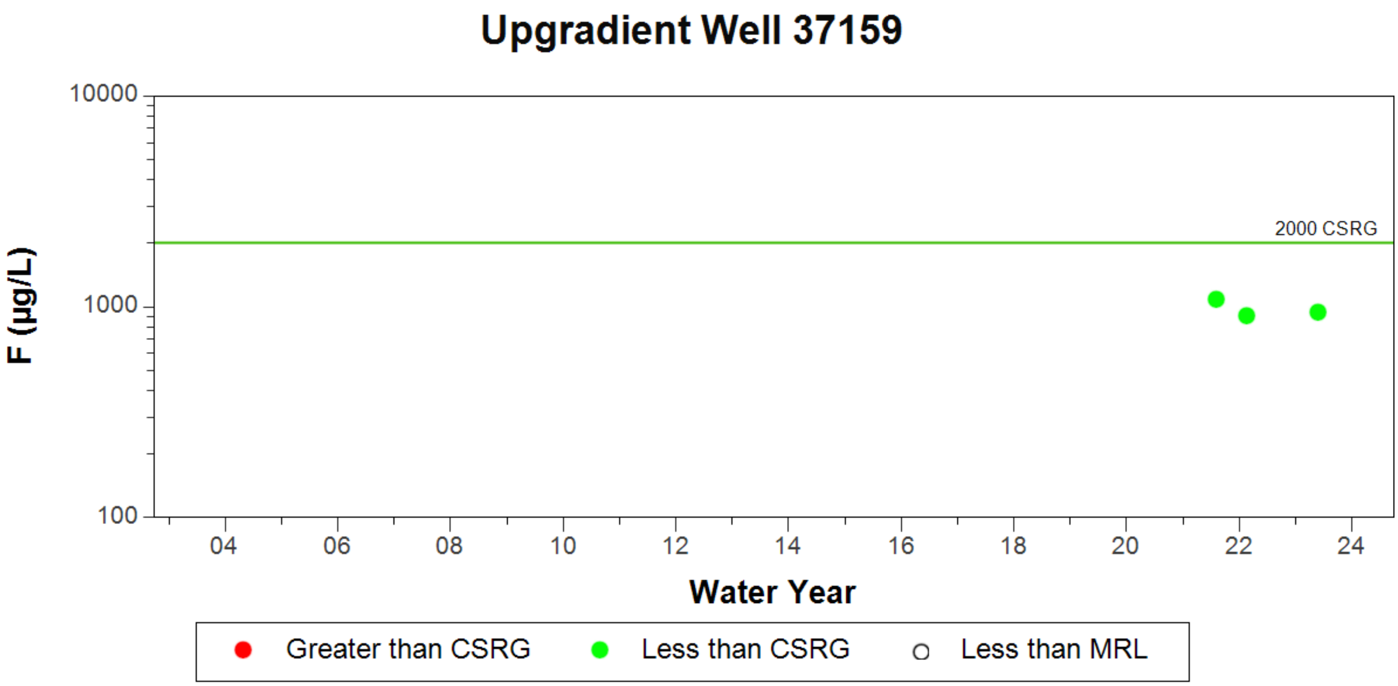
In FY20, well 37094 was replaced by well 37157.



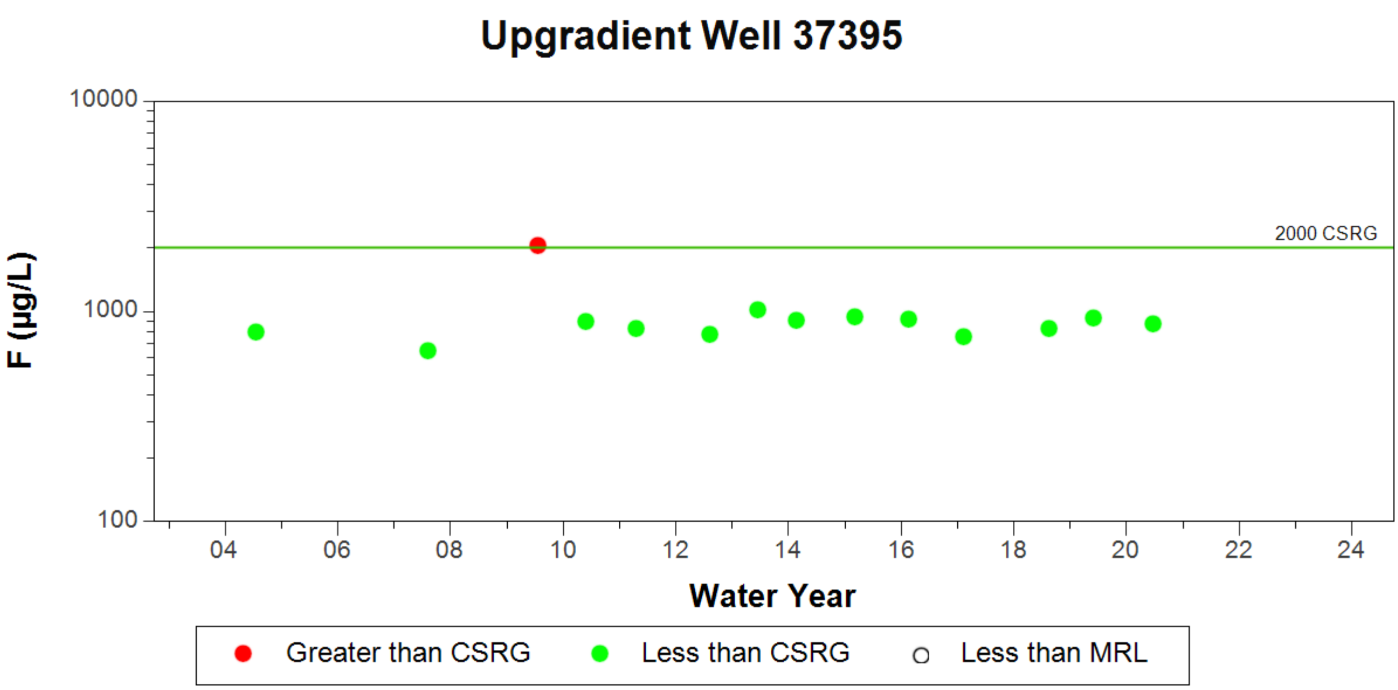


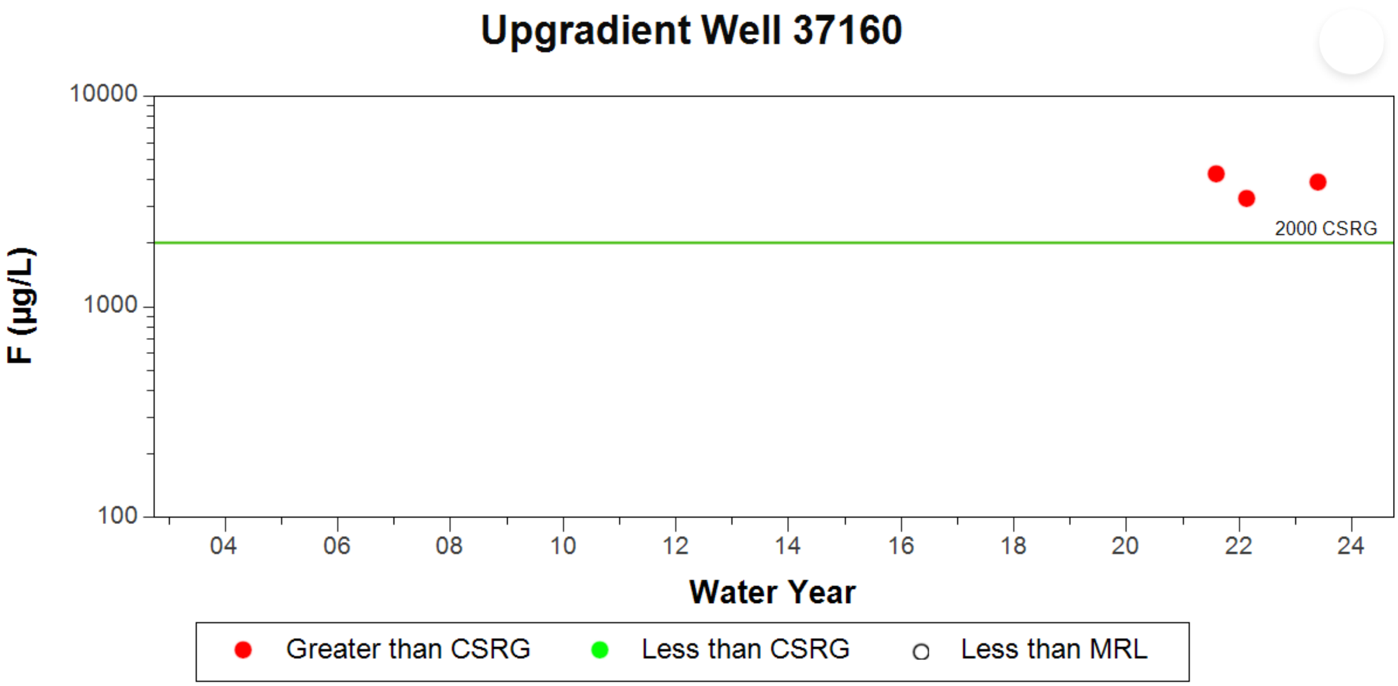
In FY20, well 37404 was replaced by well 37158.



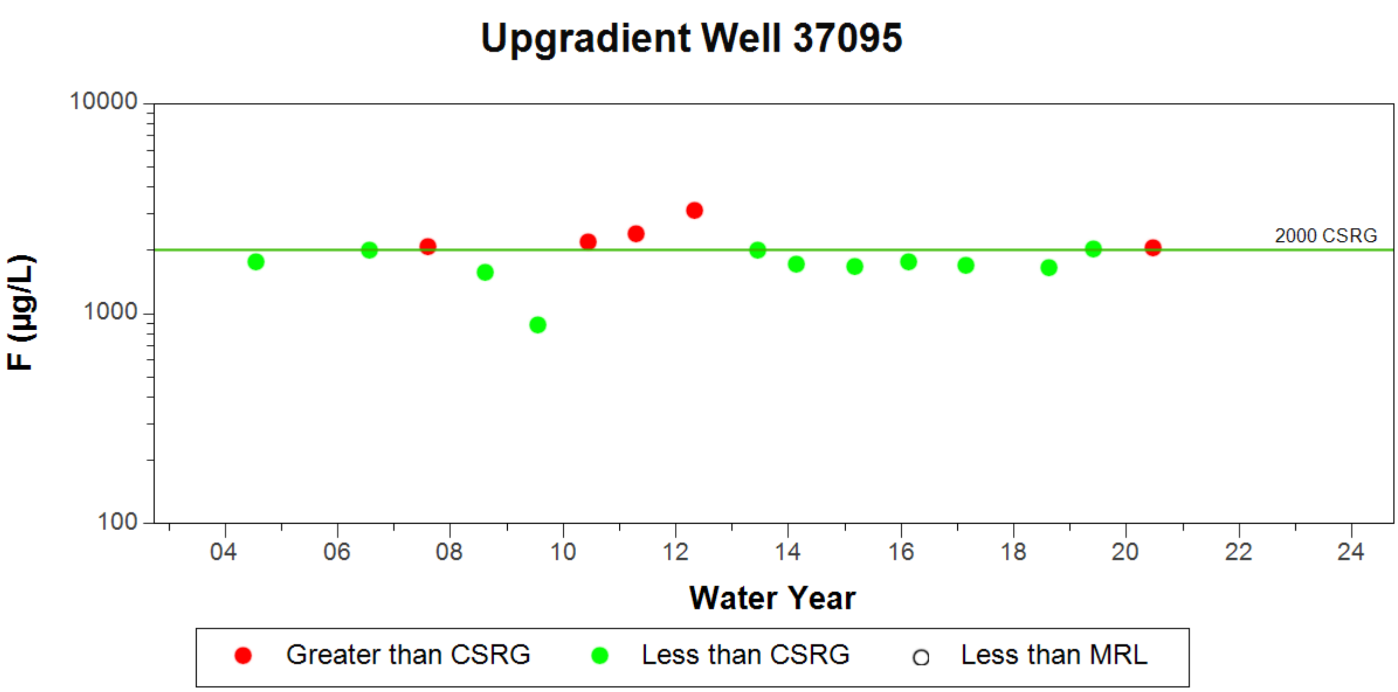


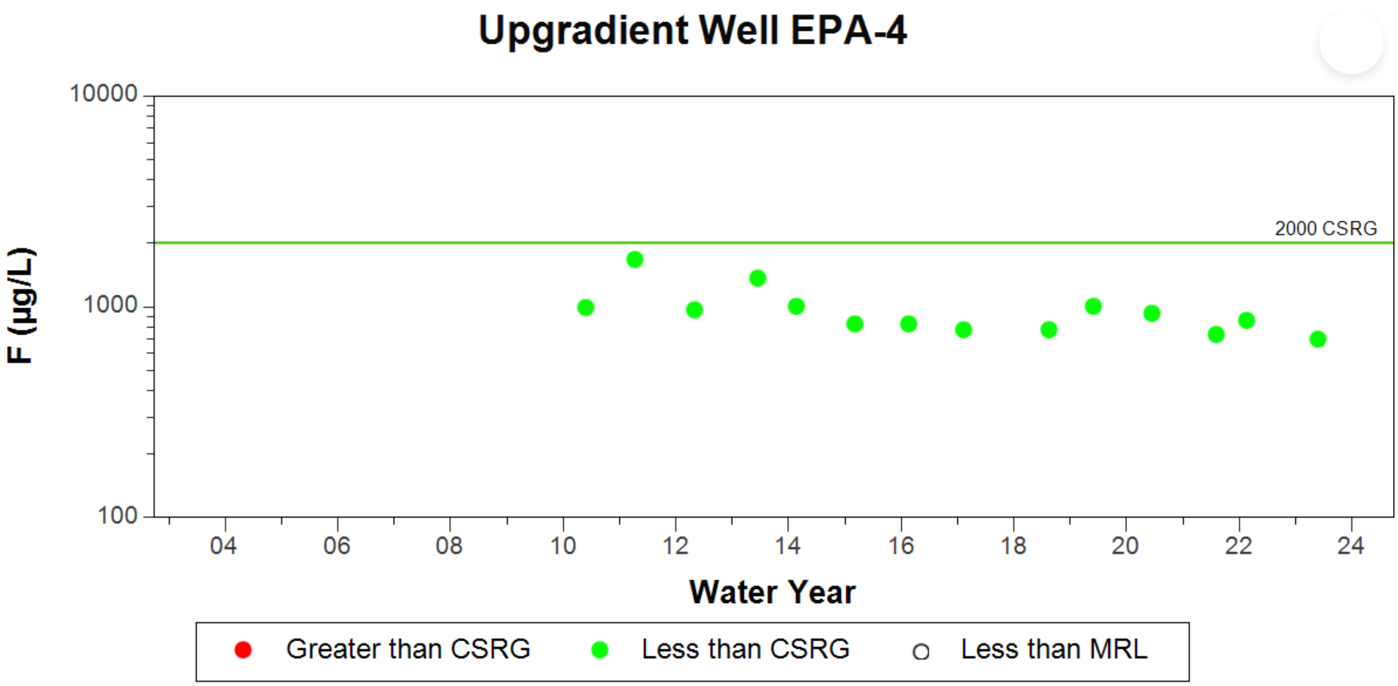
In FY20, well 37395 was replaced by well 37159.



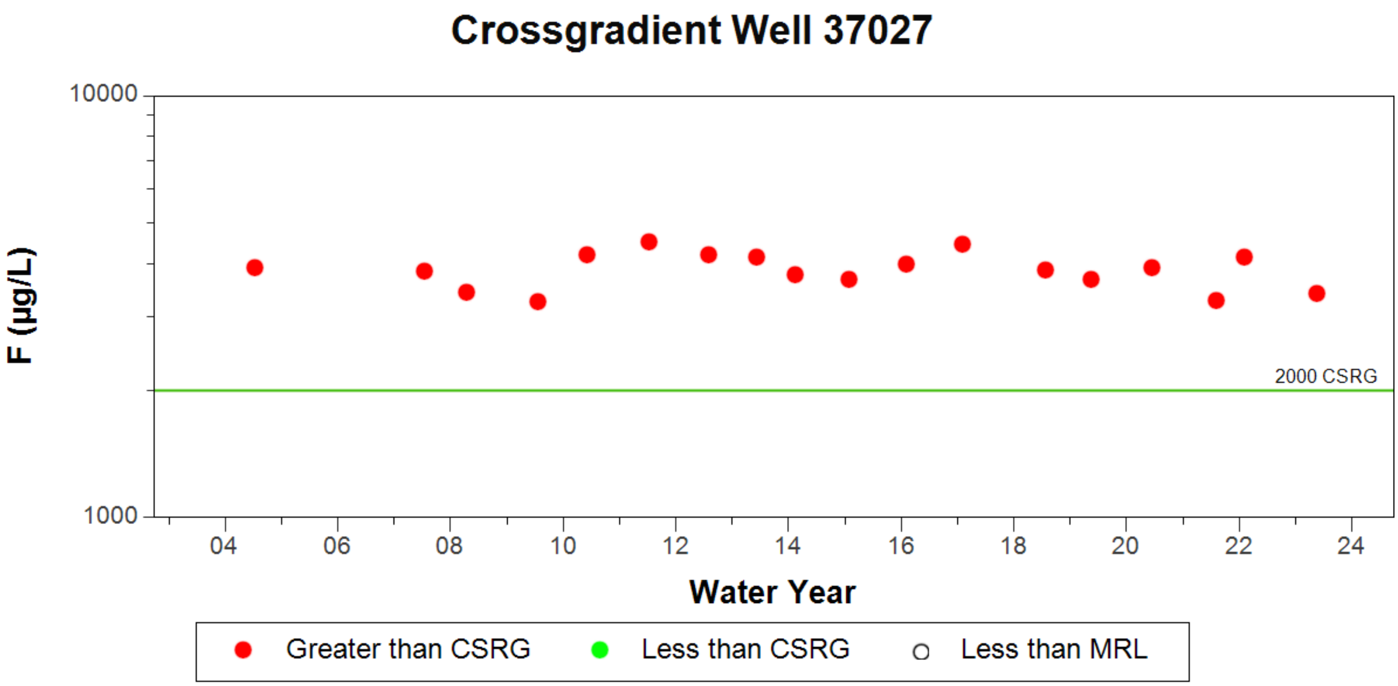


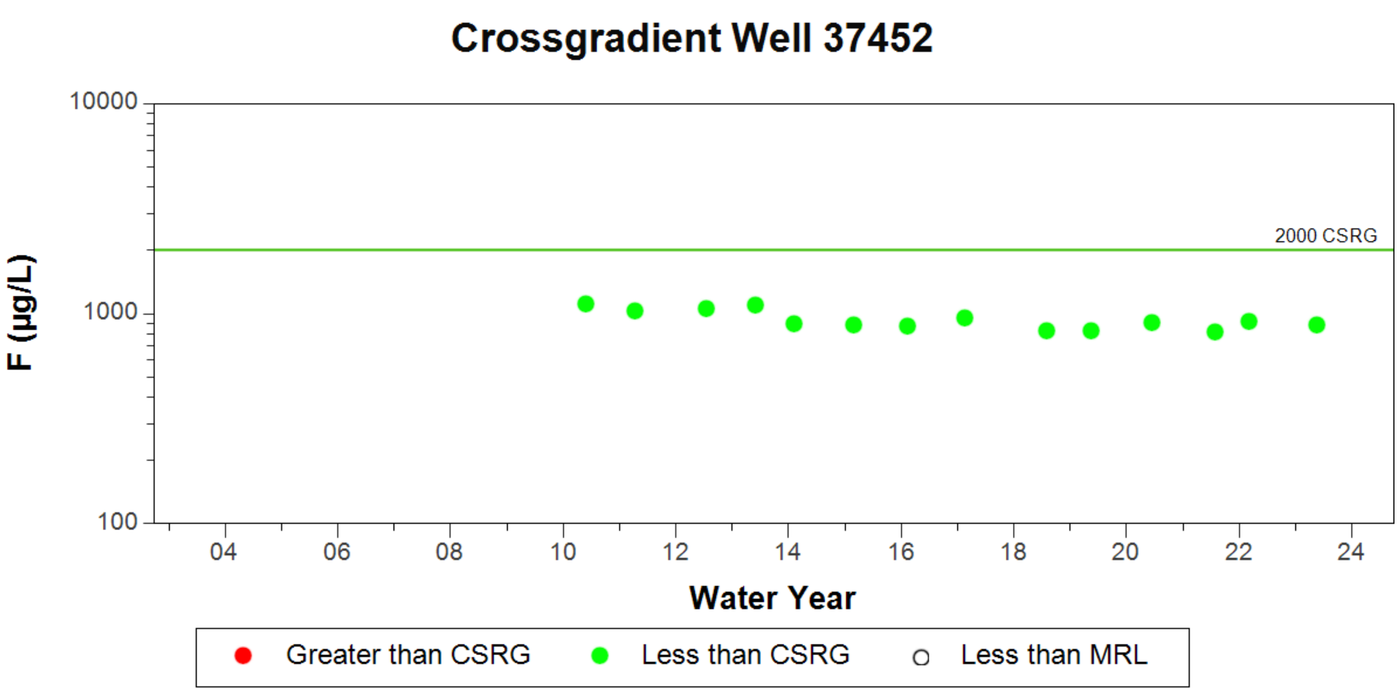
In FY20, well 37095 was replaced by well 37160.

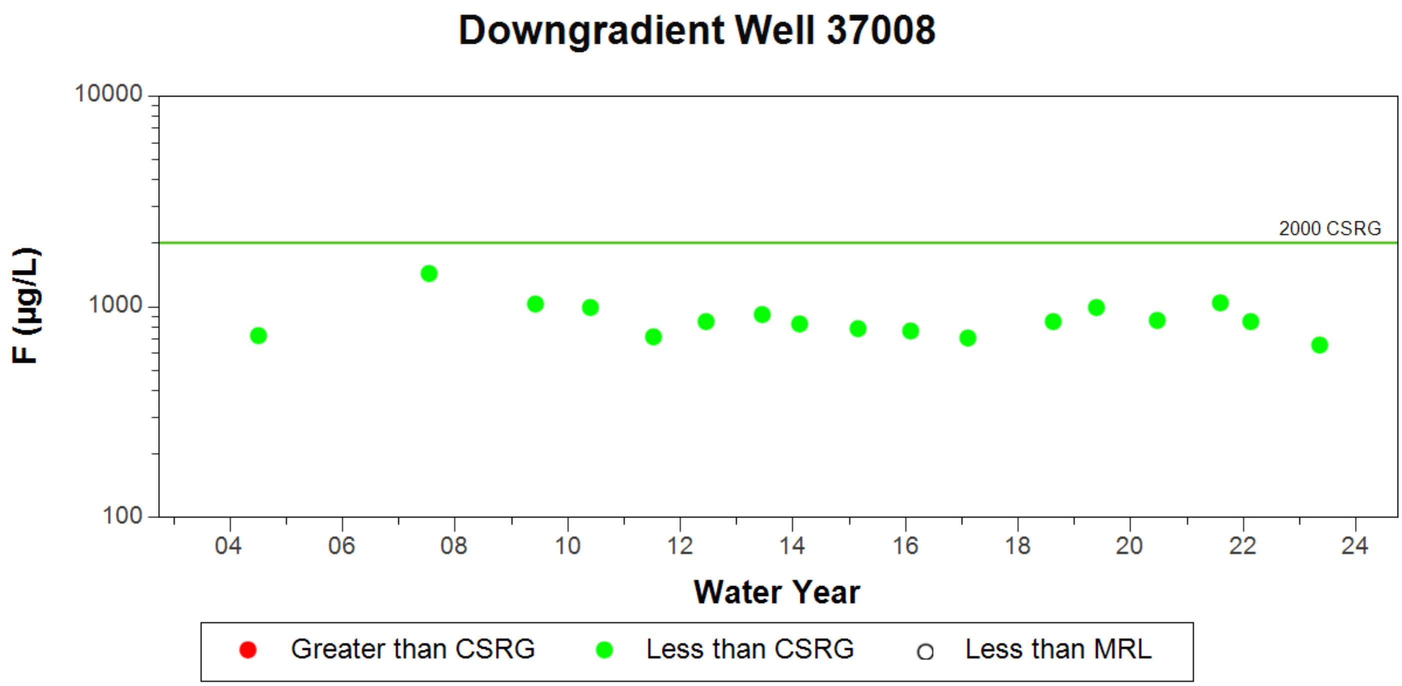


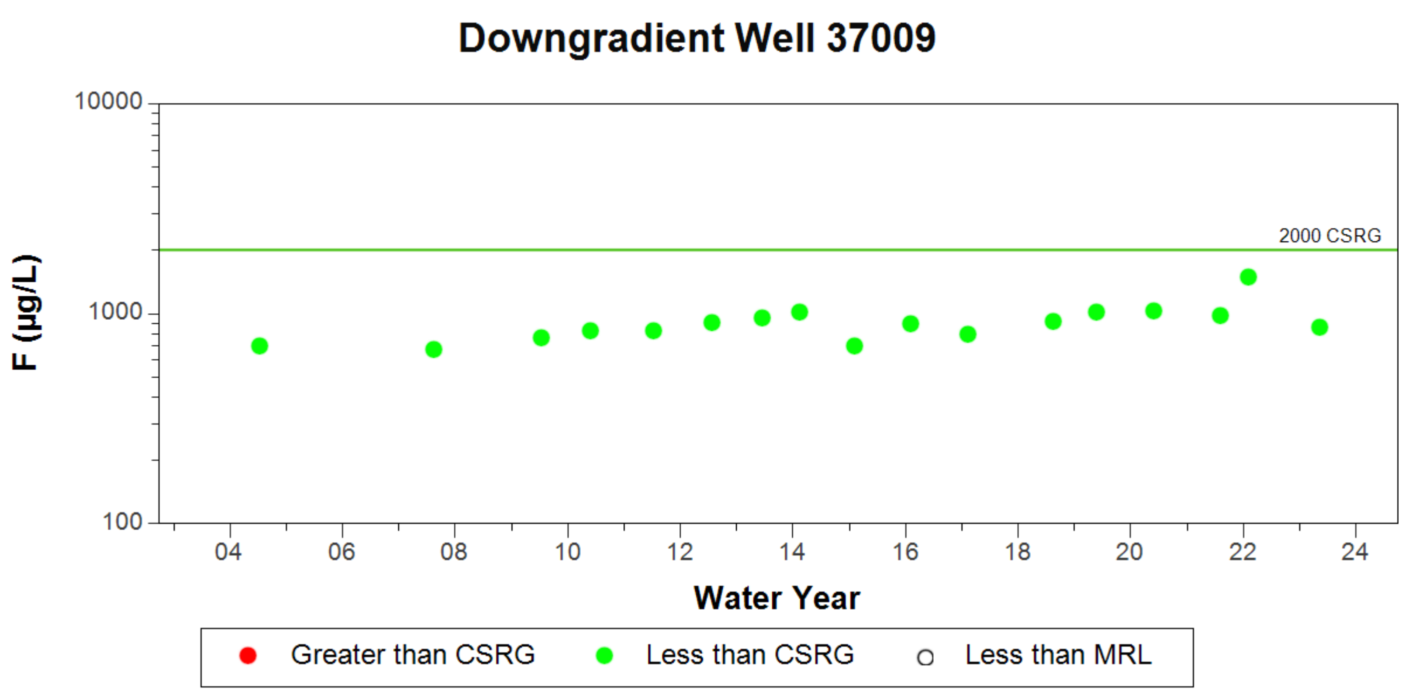


Upgradient Well EPA-4
F (µg/L)
10000
1000
100
2000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

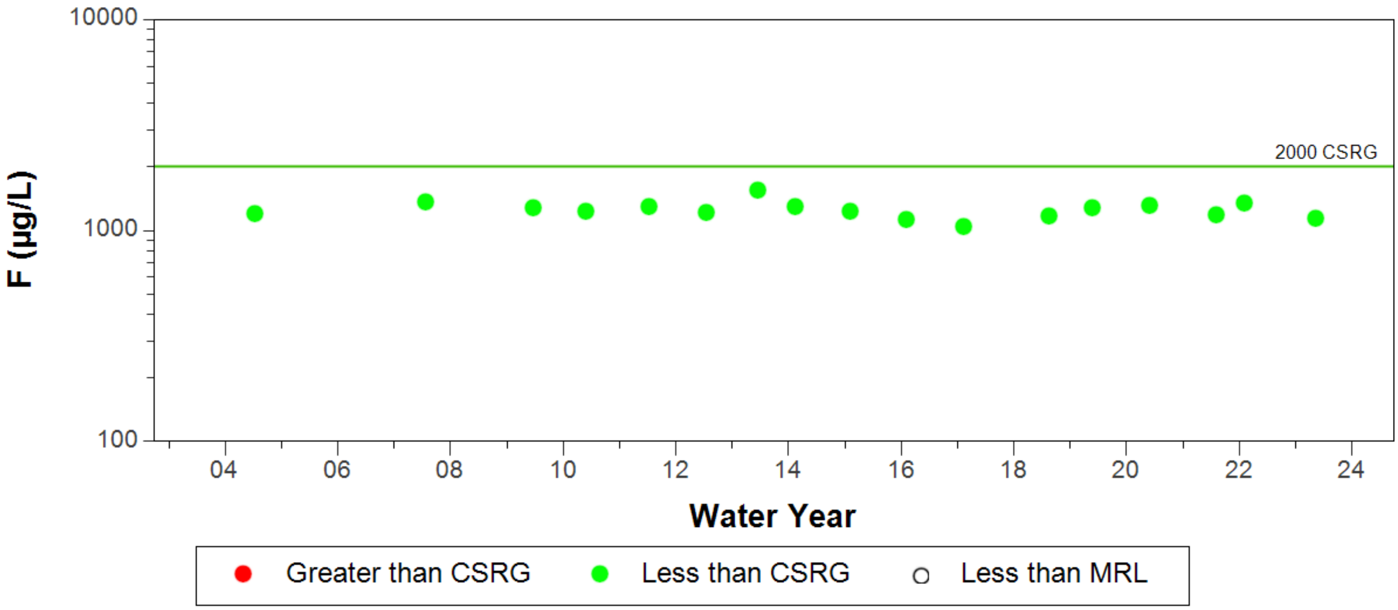

Crossgradient Well 37027
10000
1000
F (µg/L)
2000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL


Crossgradient Well 37452
10000
1000
100
F (µg/L)
2000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

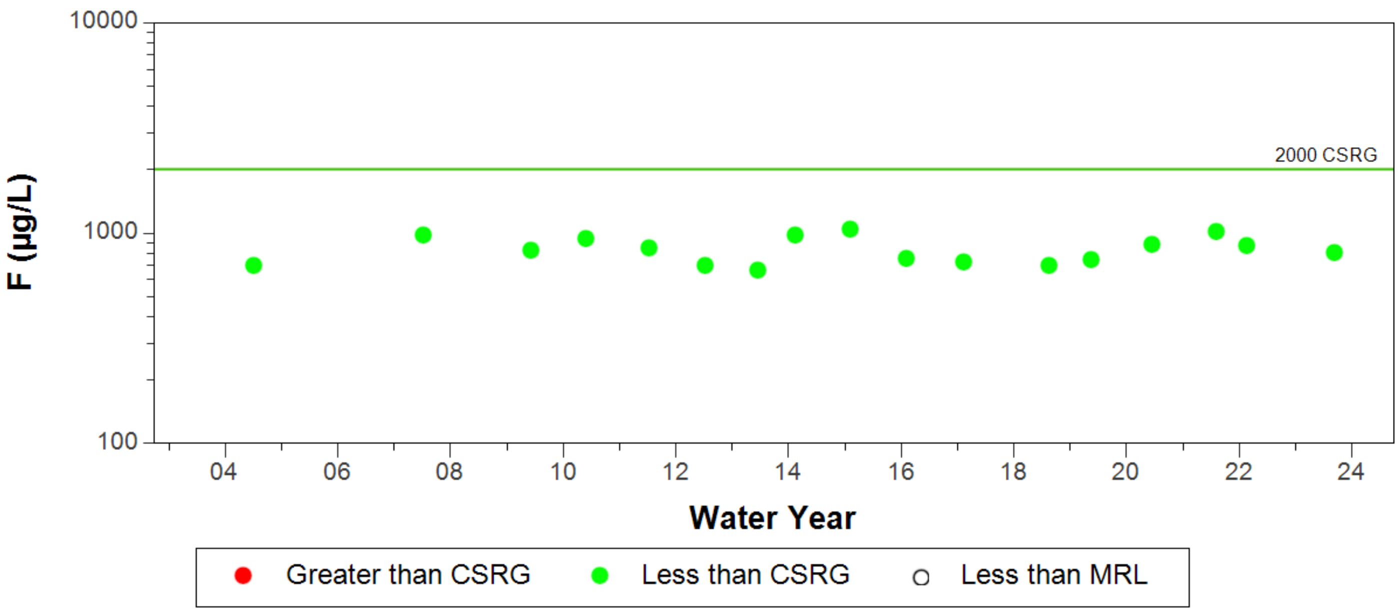

Downgradient Well 37008
10000
1000
100
2000 CSRG
F (µg/L)
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

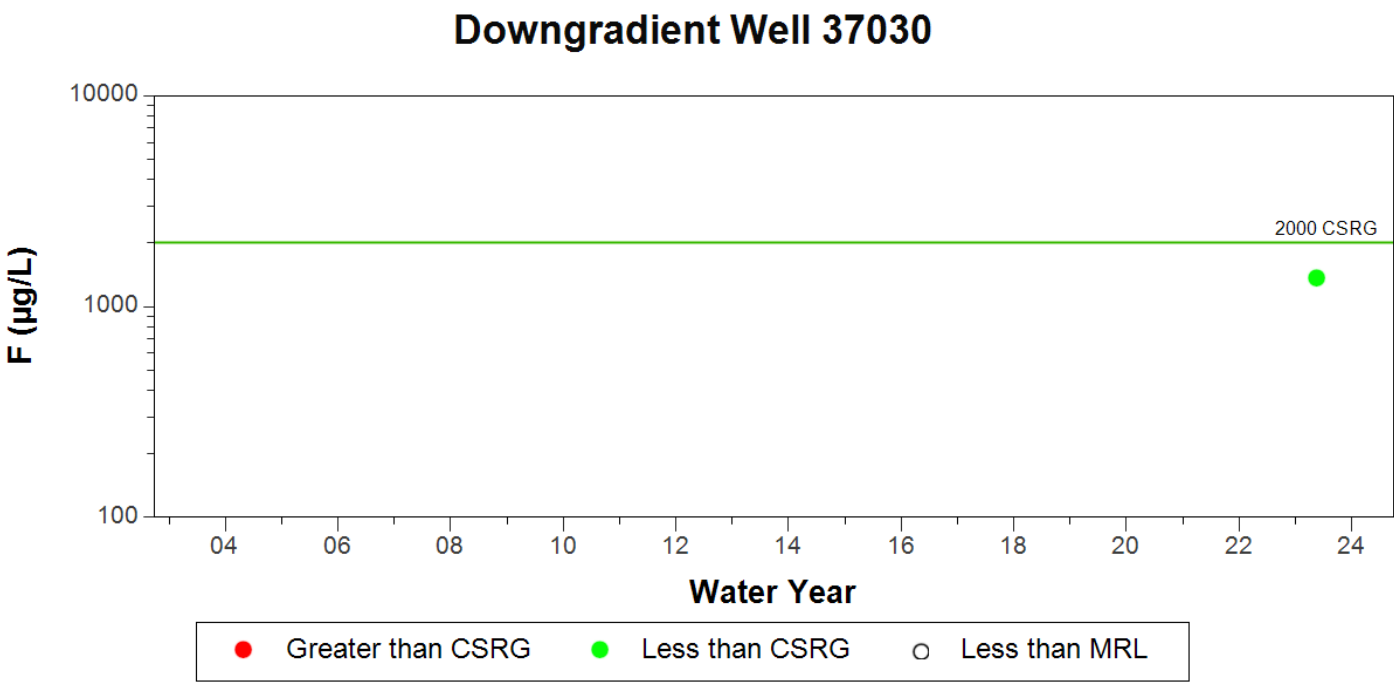

Downgradient Well 37009
10000
1000
100
2000 CSRG
F (µg/L)
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

Downgradient Well 37010

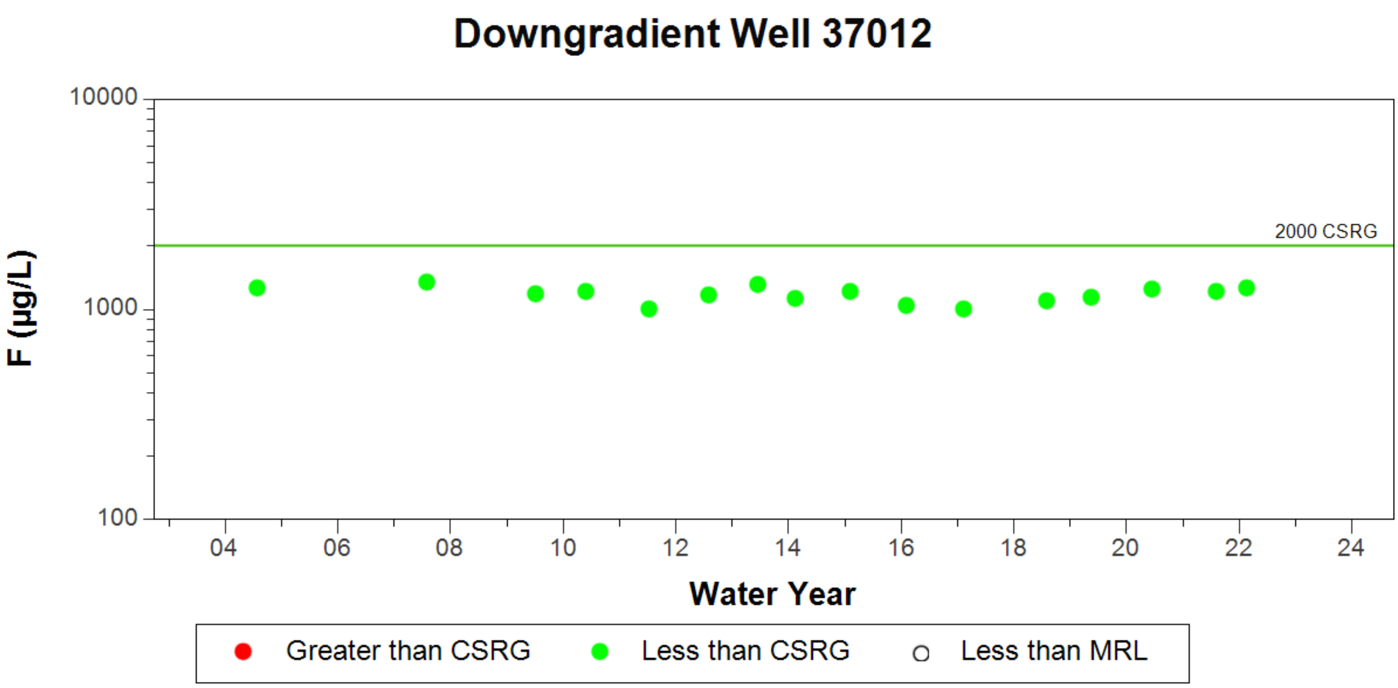


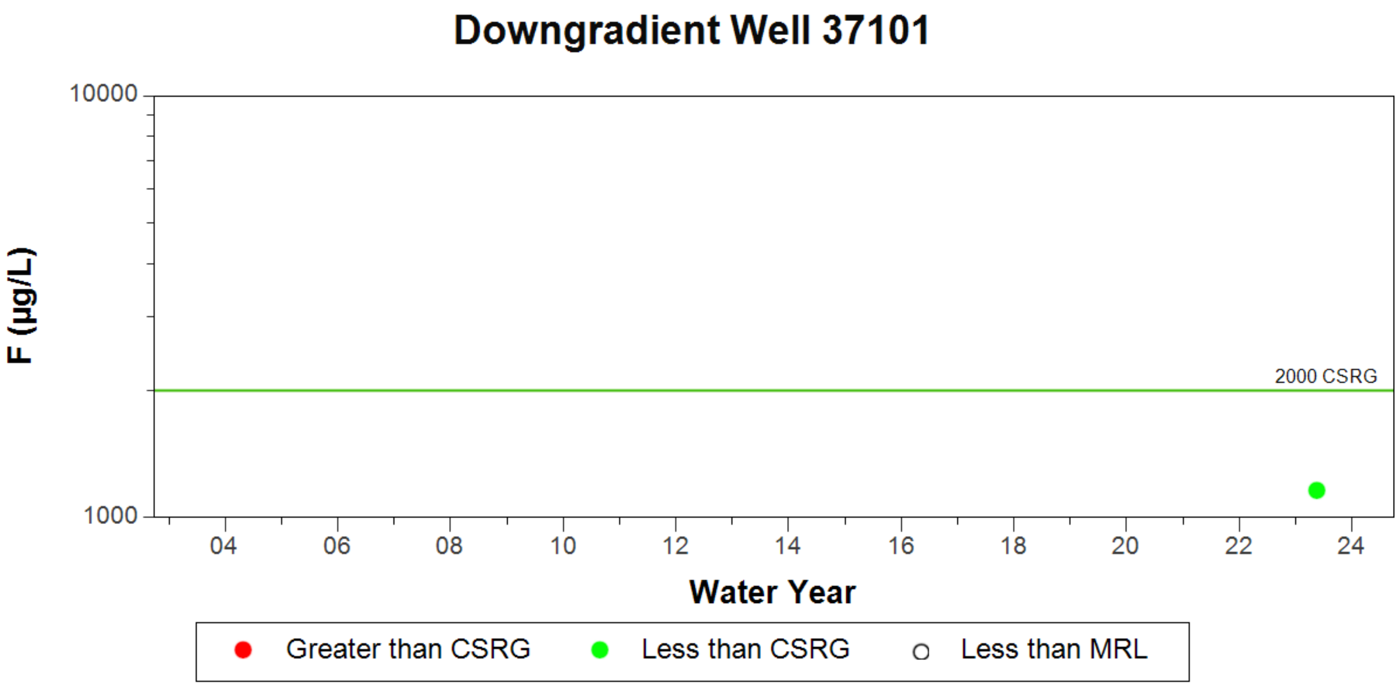
Downgradient Well 37011



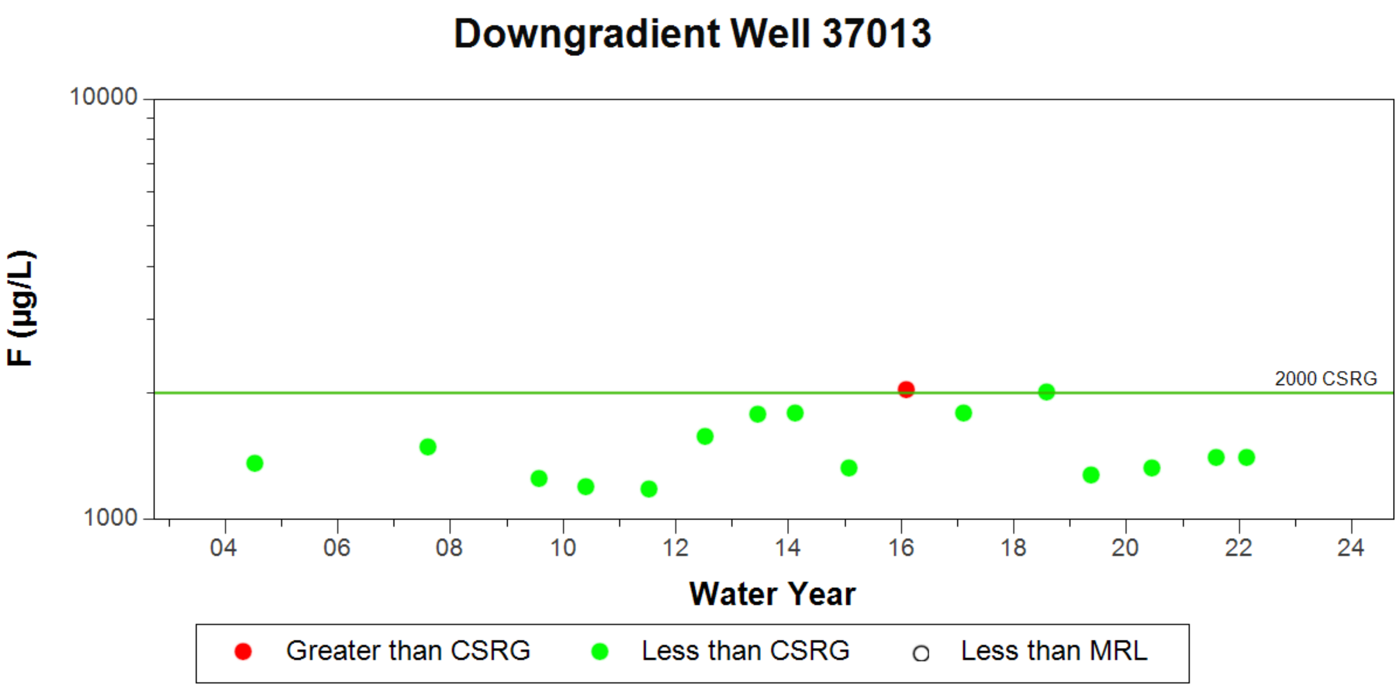


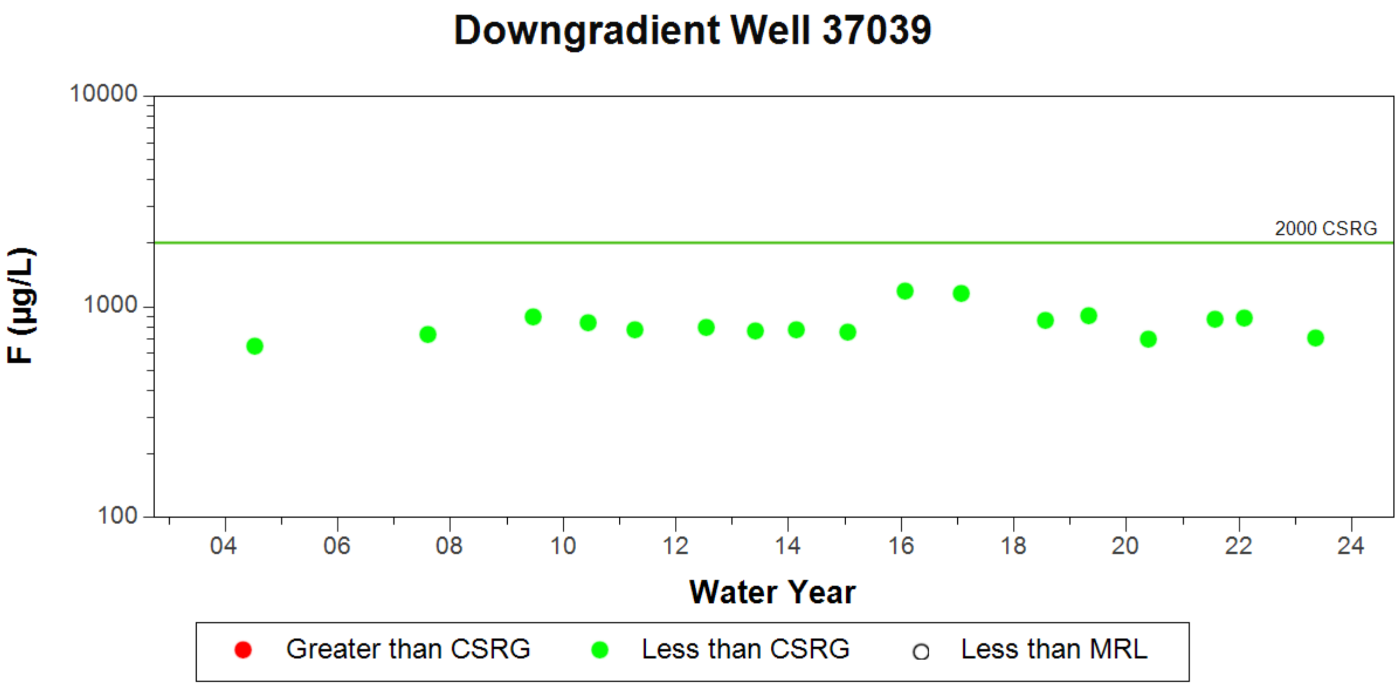
In FY22, well 37012 was replaced by well 37030.
Prior to FY22, well 37012 did not show an increasing trend.



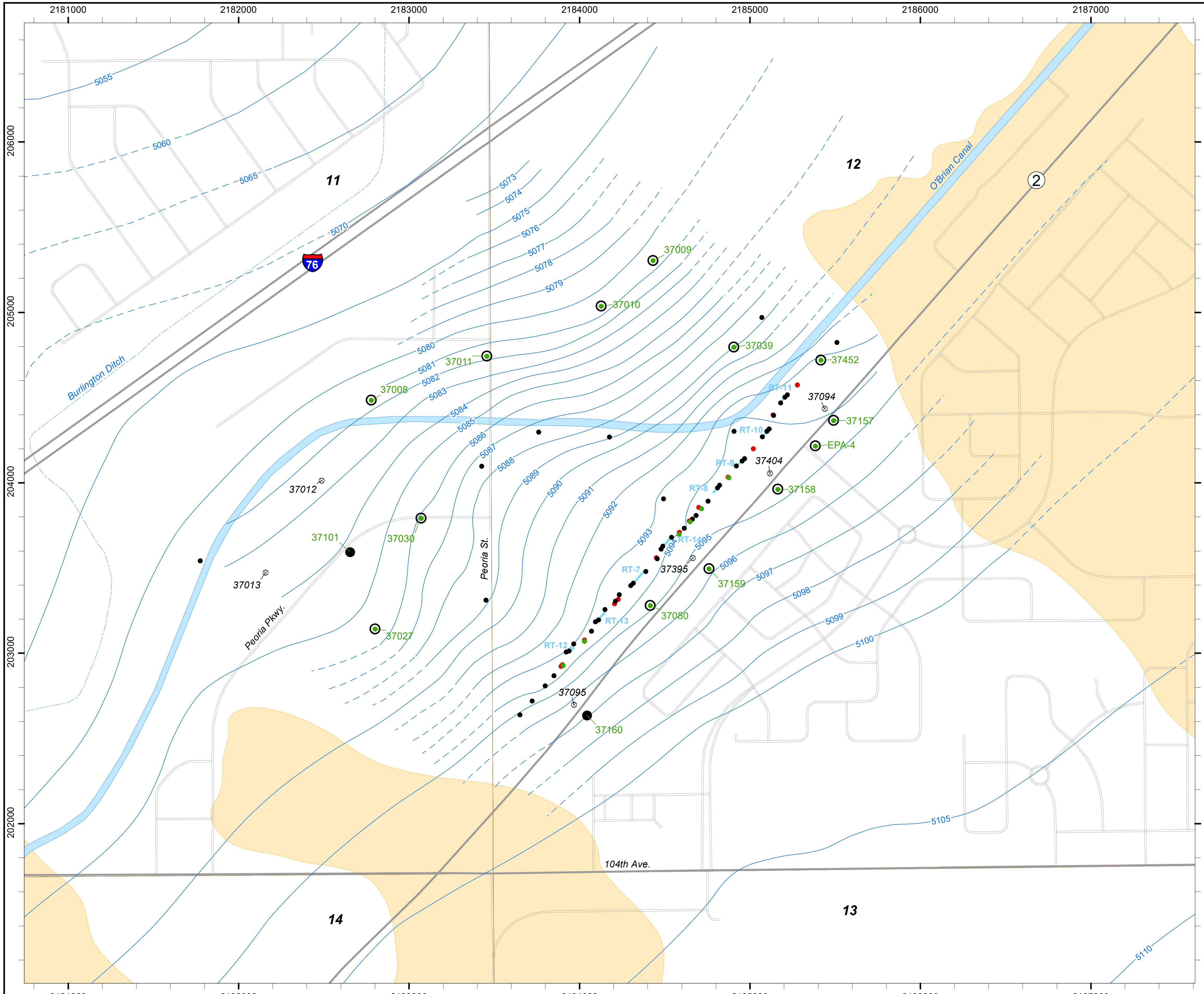


In FY22, well 37013 was replaced by well 37101.
Prior to FY22, well 37013 did not show an increasing trend.





Downgradient Well 37039
10000
1000
100
F (µg/L)
2000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



Legend

- Unsaturated Alluvium
- Section Lines
- Lakes, Ponds, Rivers
- Water elevation contour - 1-foot interval
- Inferred water elevation contour
- Ditches
- Recharge Trench
- Light Duty Roads
- Primary Roads
- Monitoring Wells
- Performance Water Quality Wells
- Extraction Wells
- Replaced Monitoring Wells

Note: Water levels were measured in FY23 Quarter 2.

Upgradient and Downgradient Performance Well Water Quality

- Analyte Detected Above the CSRG - Increasing Trend Noted
- Analyte Detected Above the CSRG - Decreasing Trend Noted
- Analyte Detected - Showing Stable or No Discernible Trend
- Analyte Not Detected

Notes:
1. Trends are depicted for the 10 year period FY14 - FY23.
2. Time versus concentration charts for Performance Water Quality wells are presented following this map.

N

0 300 600 Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

Program Manager Rocky Mountain Arsenal

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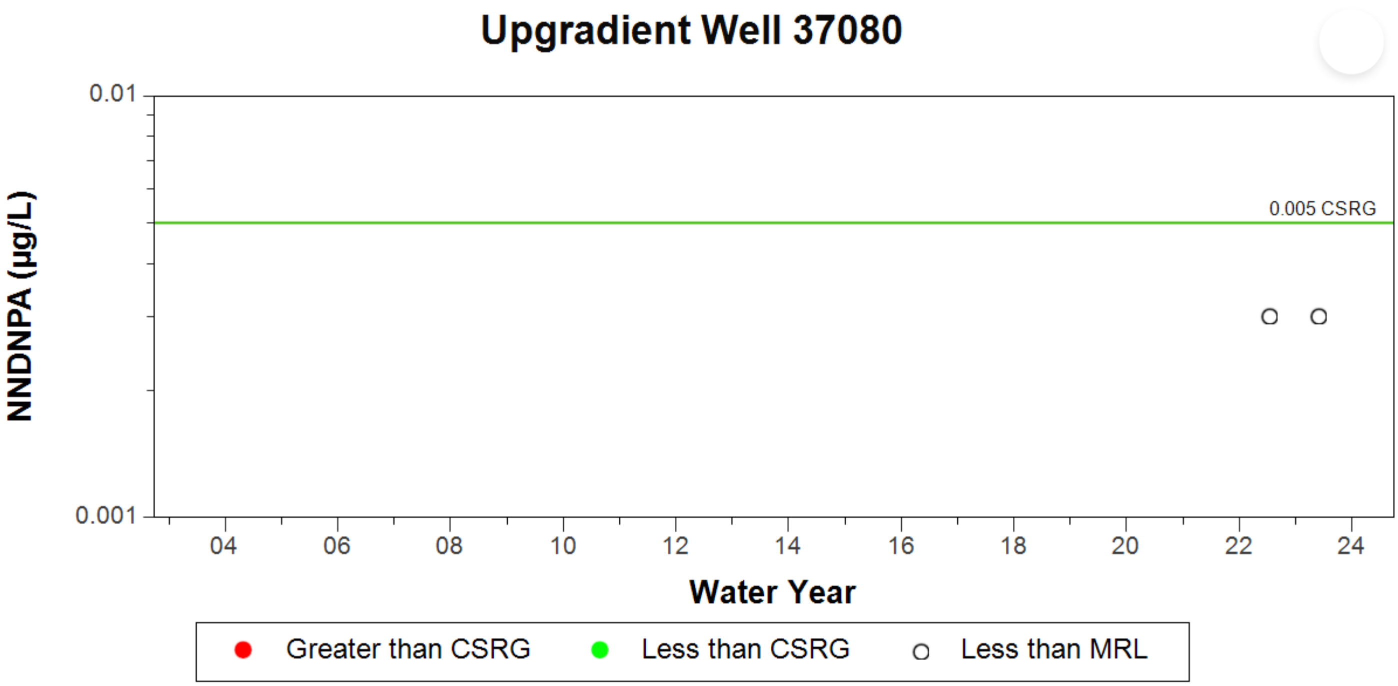
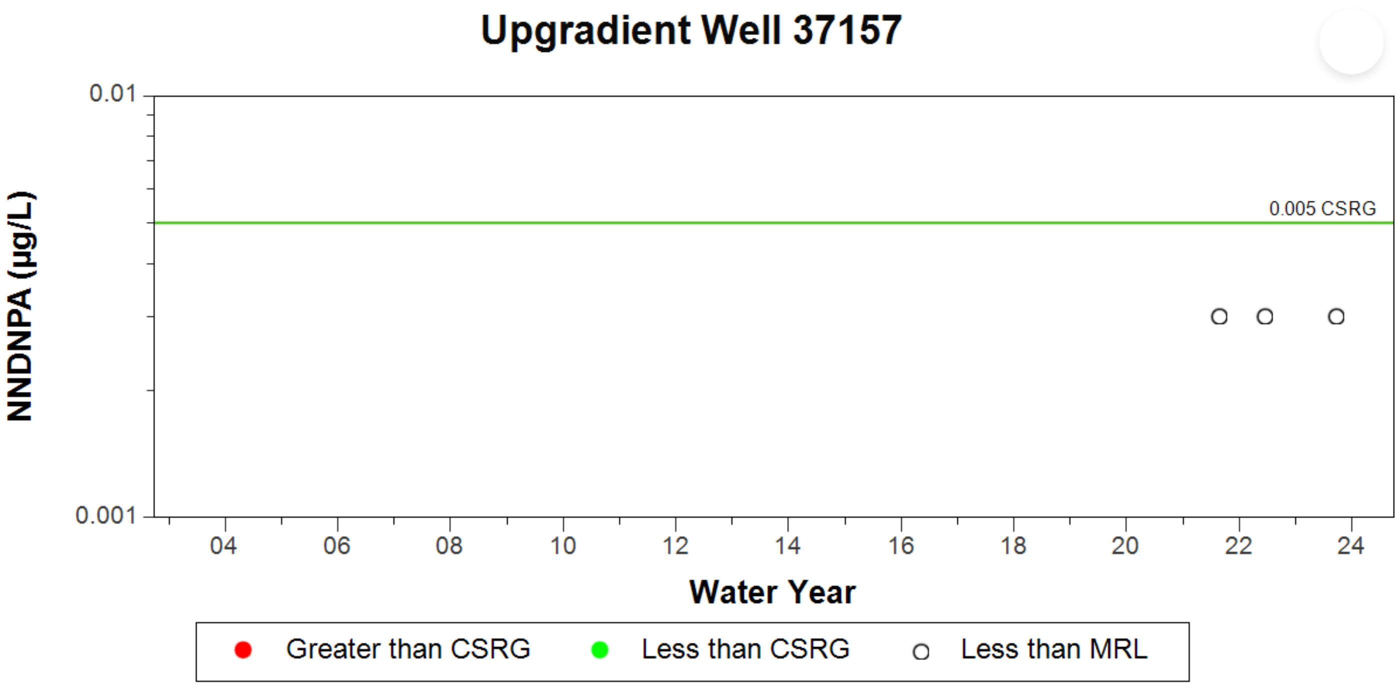
Figure G-15

n-Nitrosodi-n-propylamine Concentration Trends in Performance Wells, Northern Pathway Treatment System

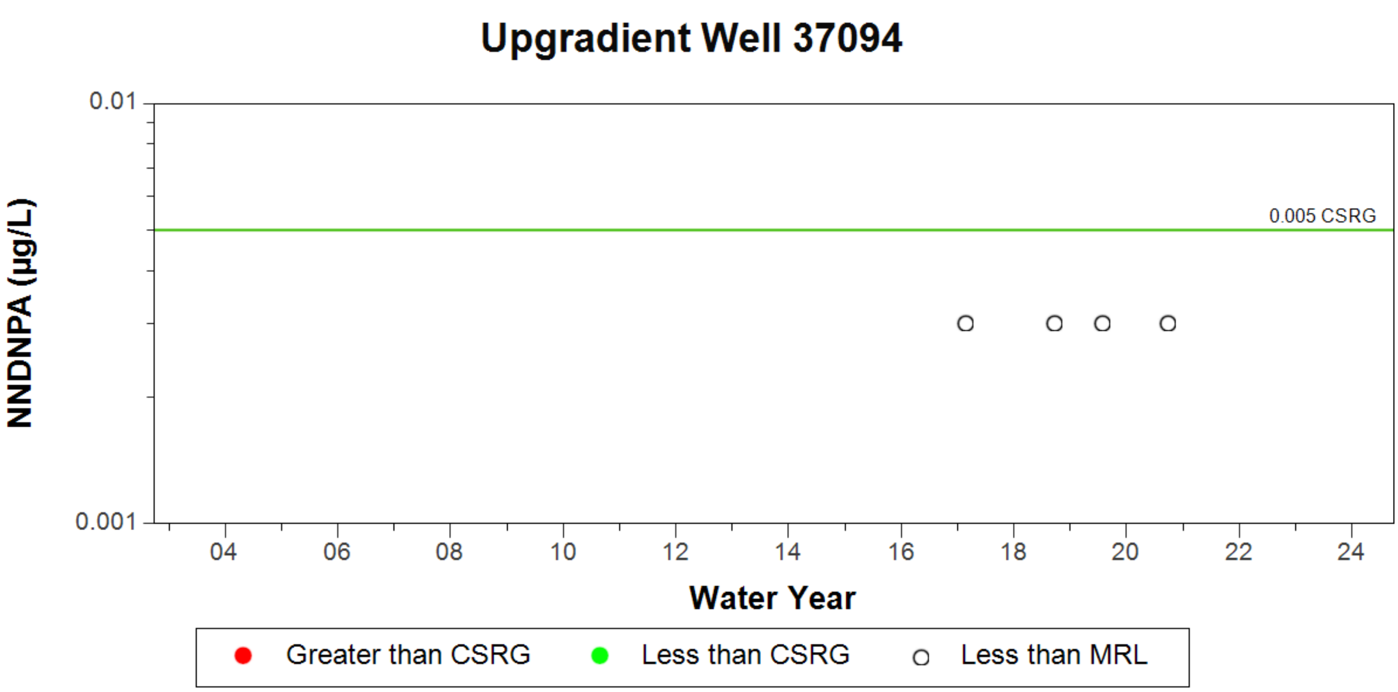
M:\projects\oars\fy23\mxds_NP_FY23_NNDNPA.mxd
8/8/2024

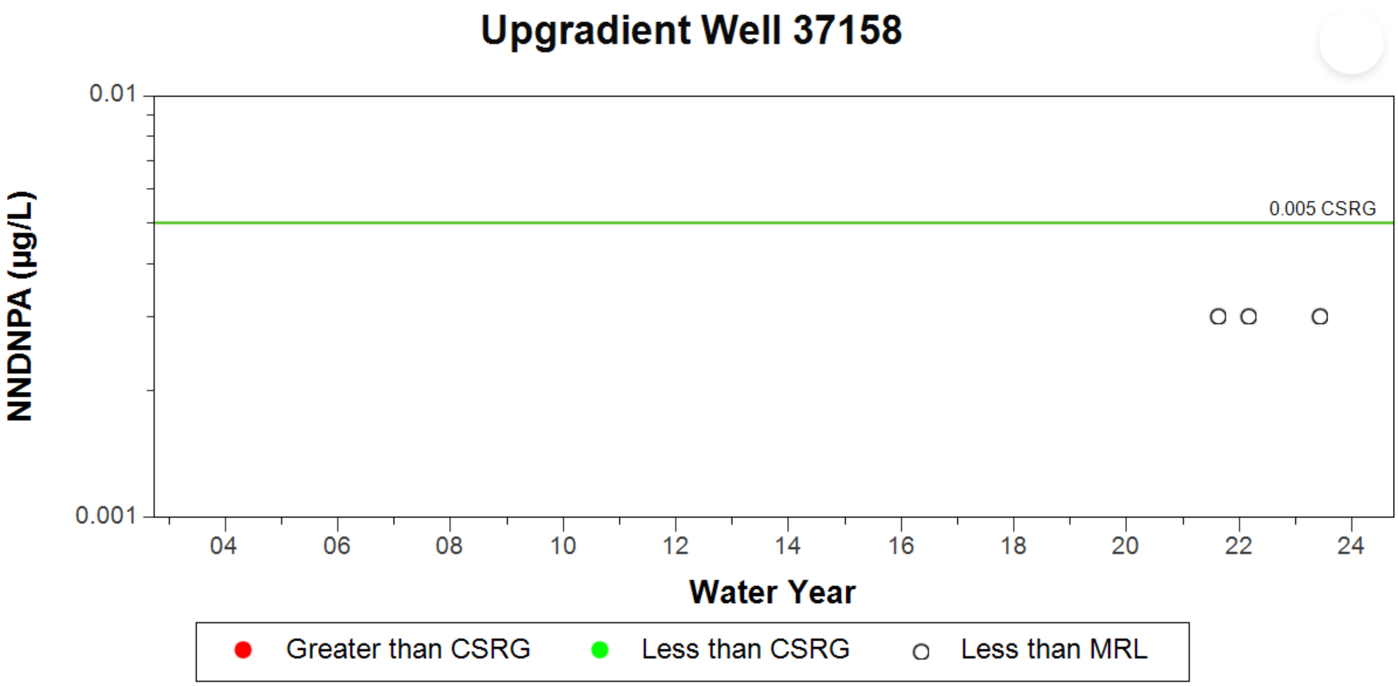


Upgradient Well 37080
NNDNPA (µg/L)
0.01
0.001
0.005 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

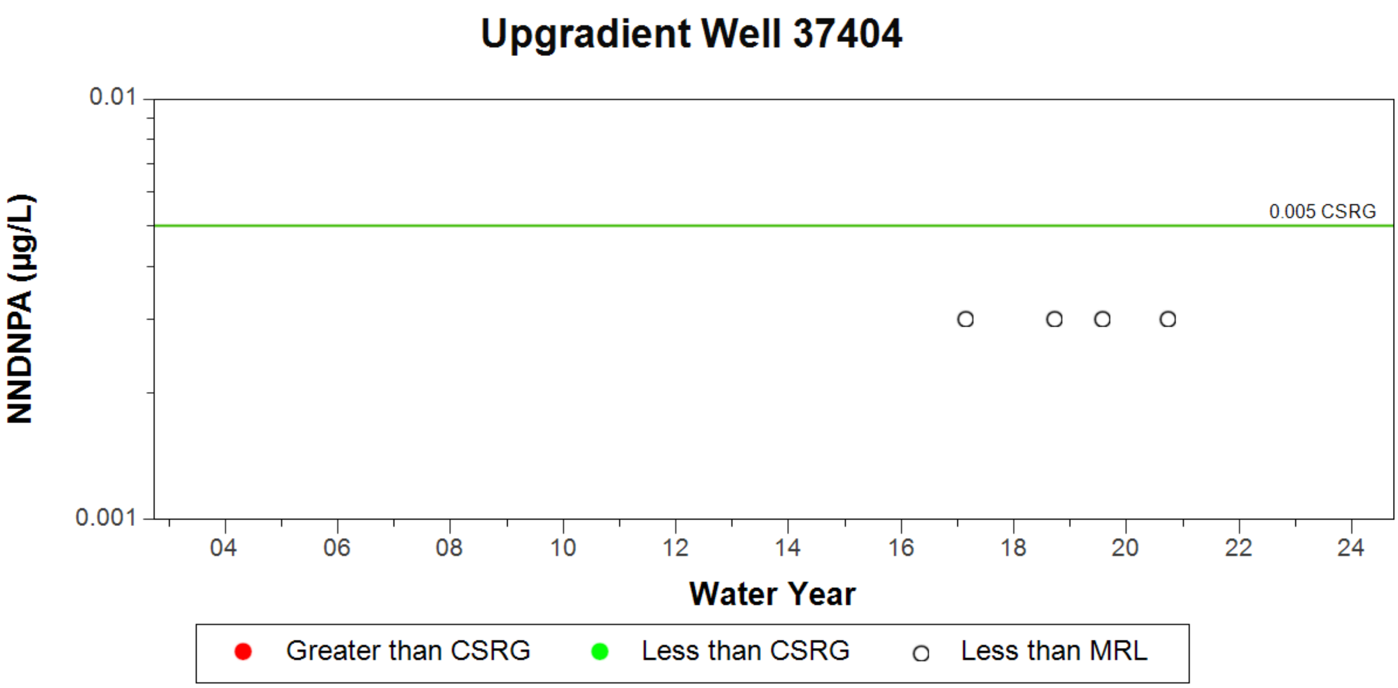


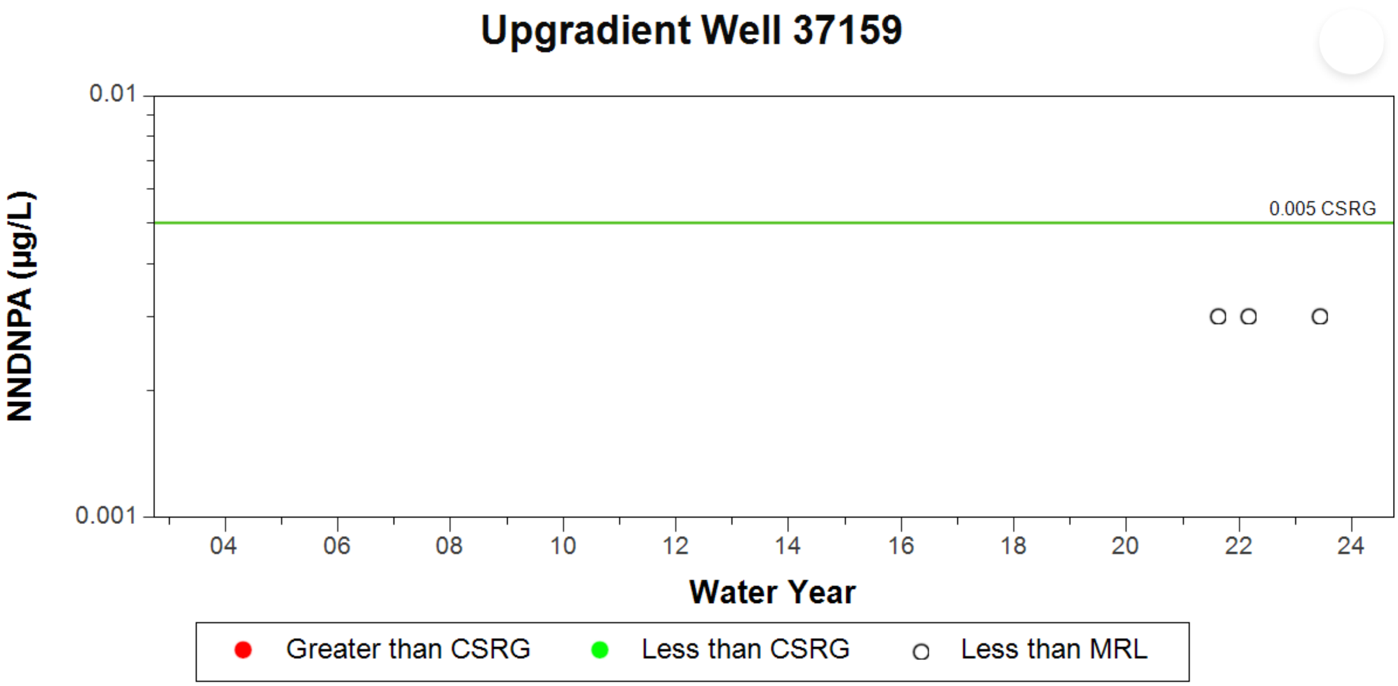
In FY20, well 37094 was replaced by well 37157.



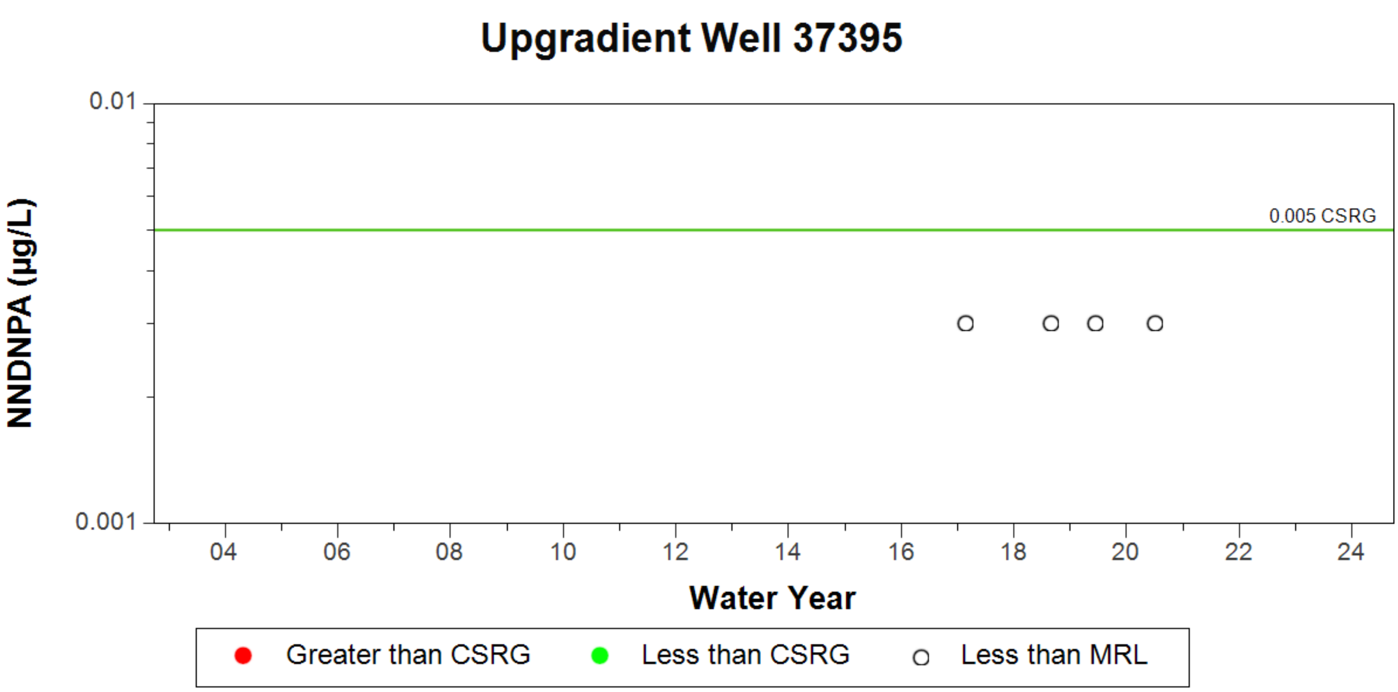


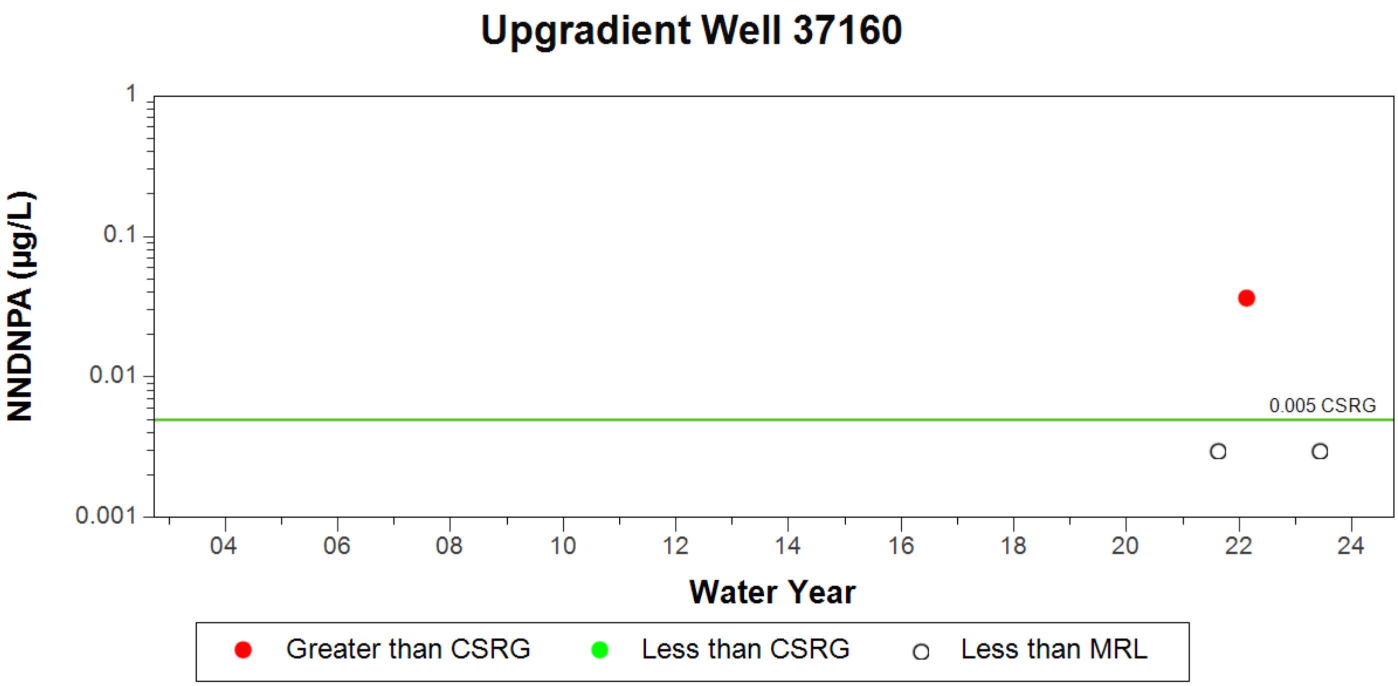
In FY20, well 37404 was replaced by well 37158.



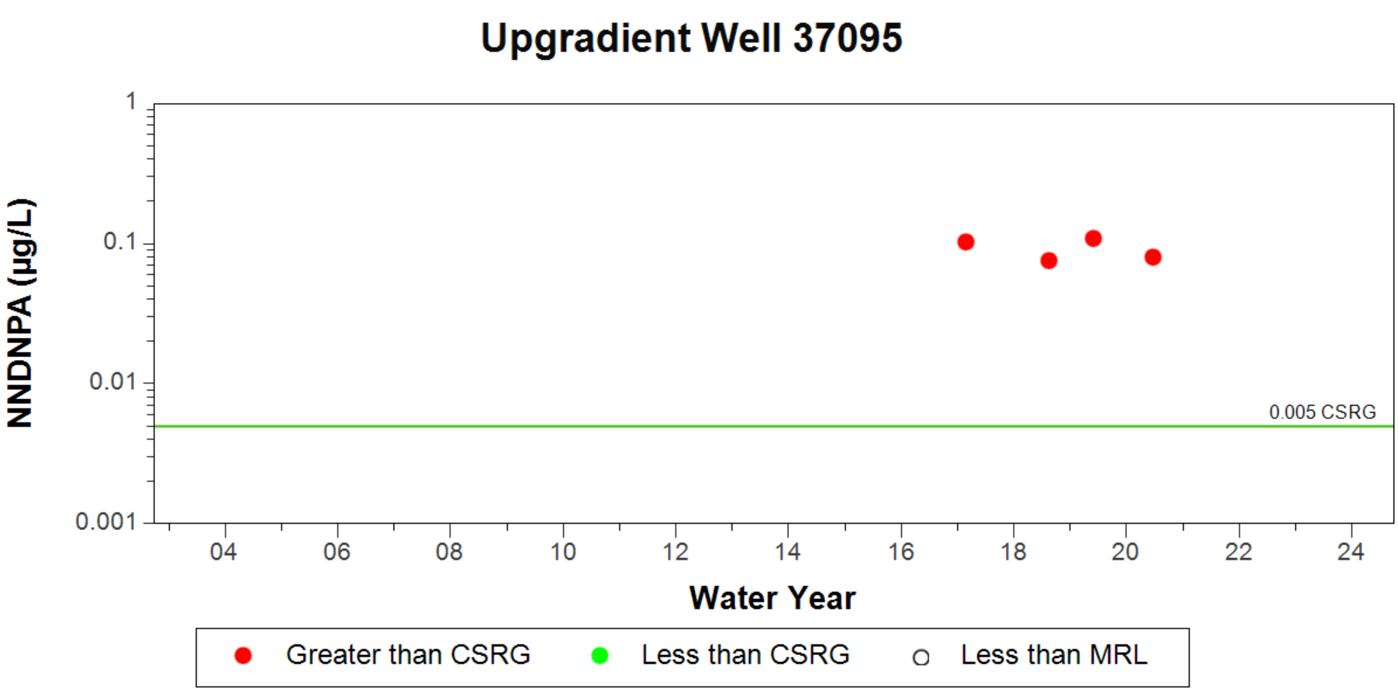


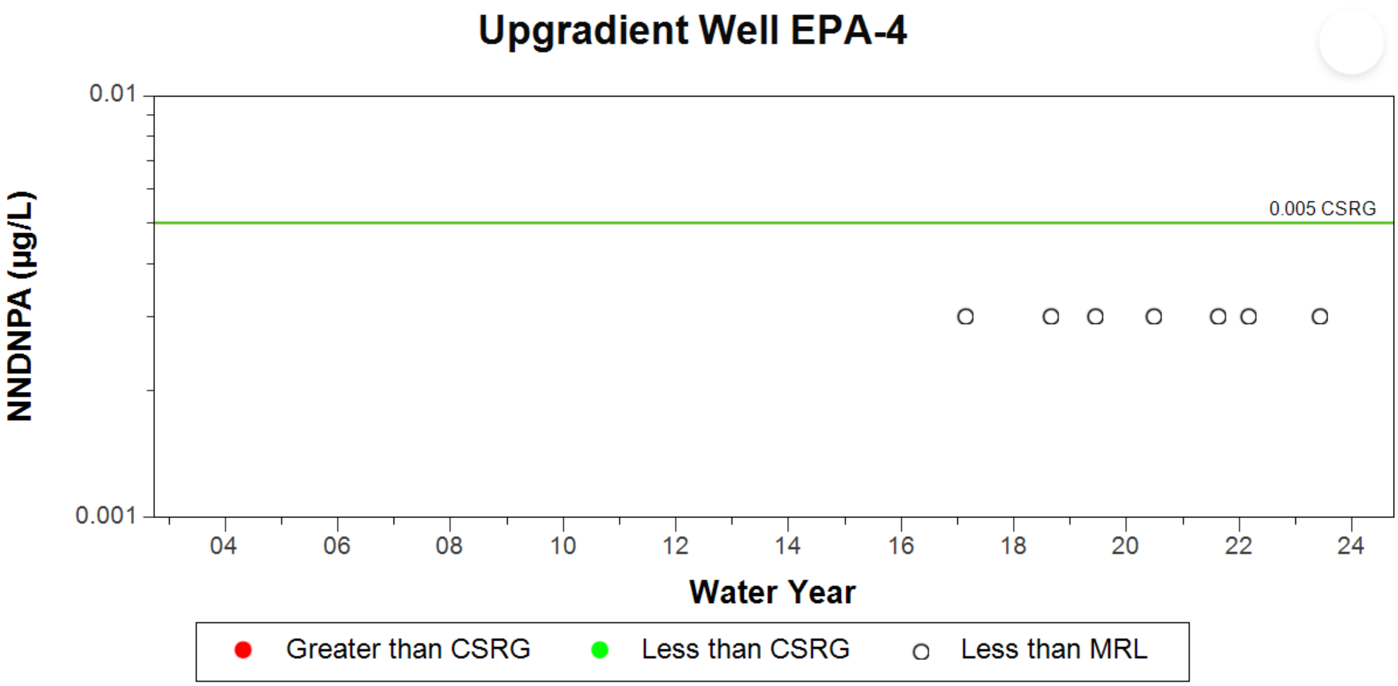
In FY20, well 37395 was replaced by well 37159.



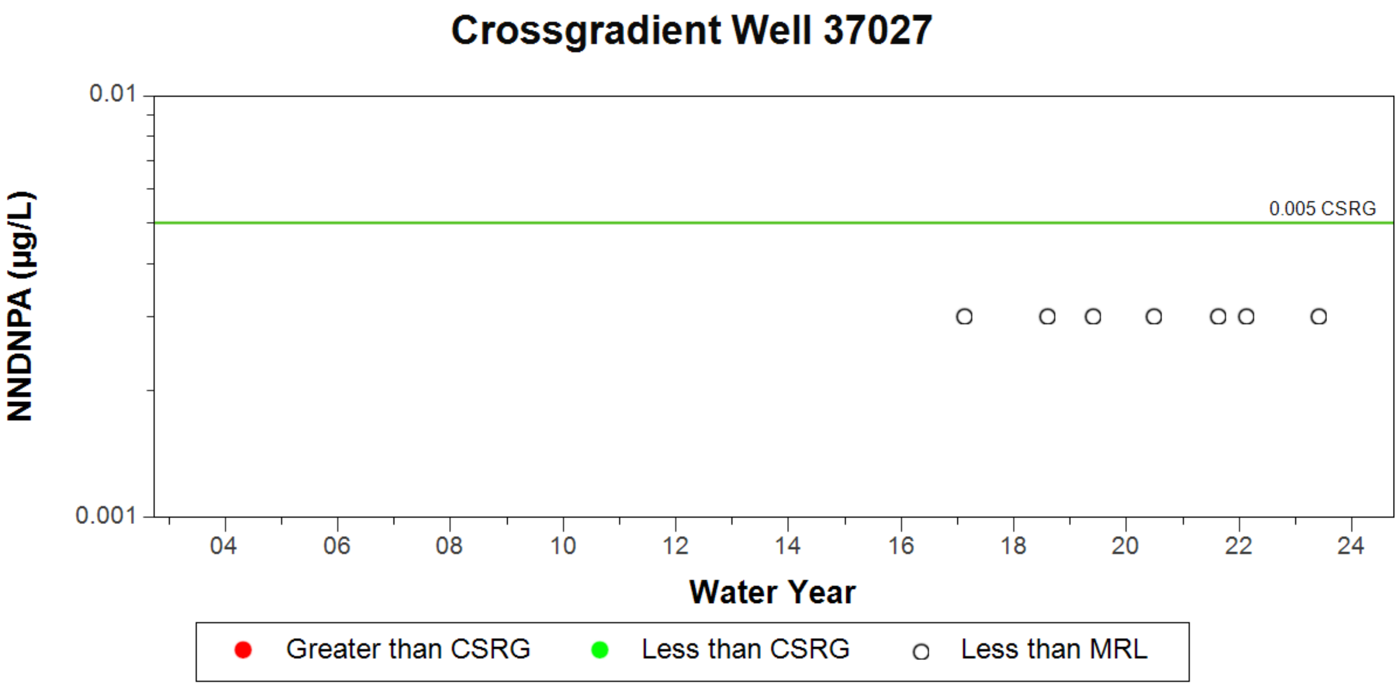


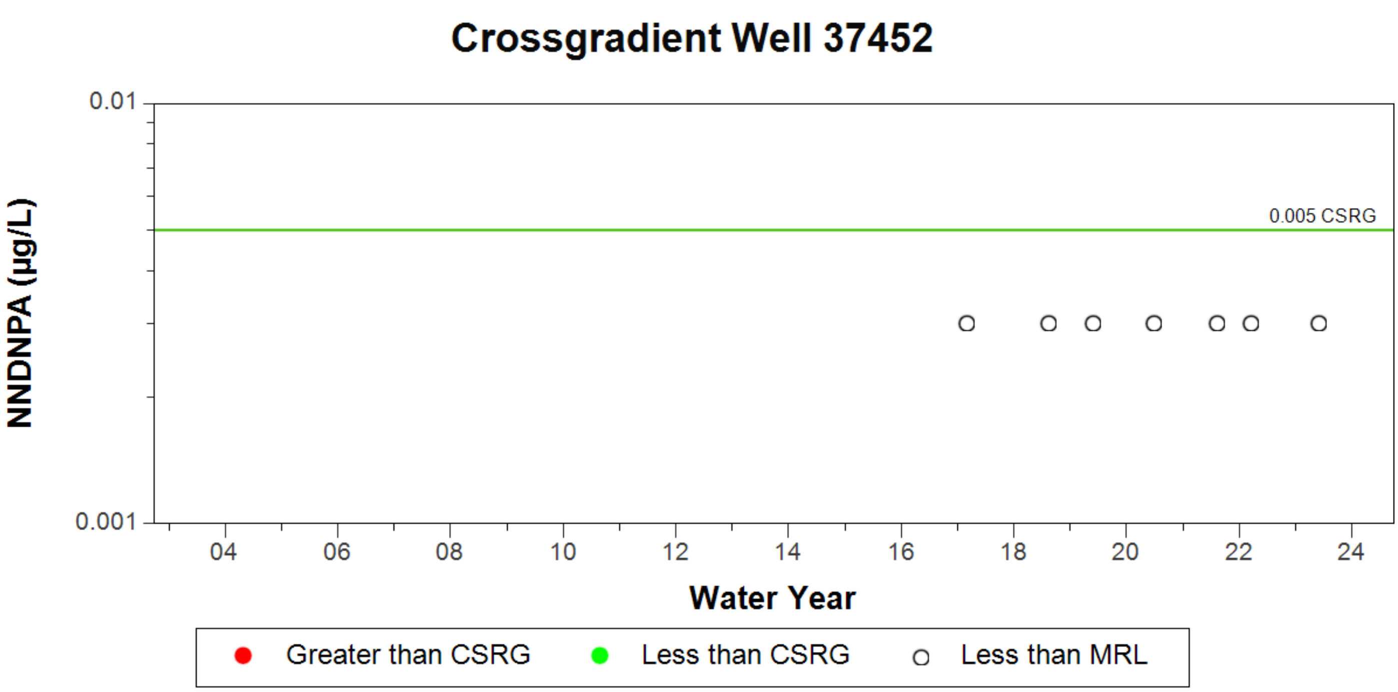
In FY20, well 37095 was replaced by well 37160.

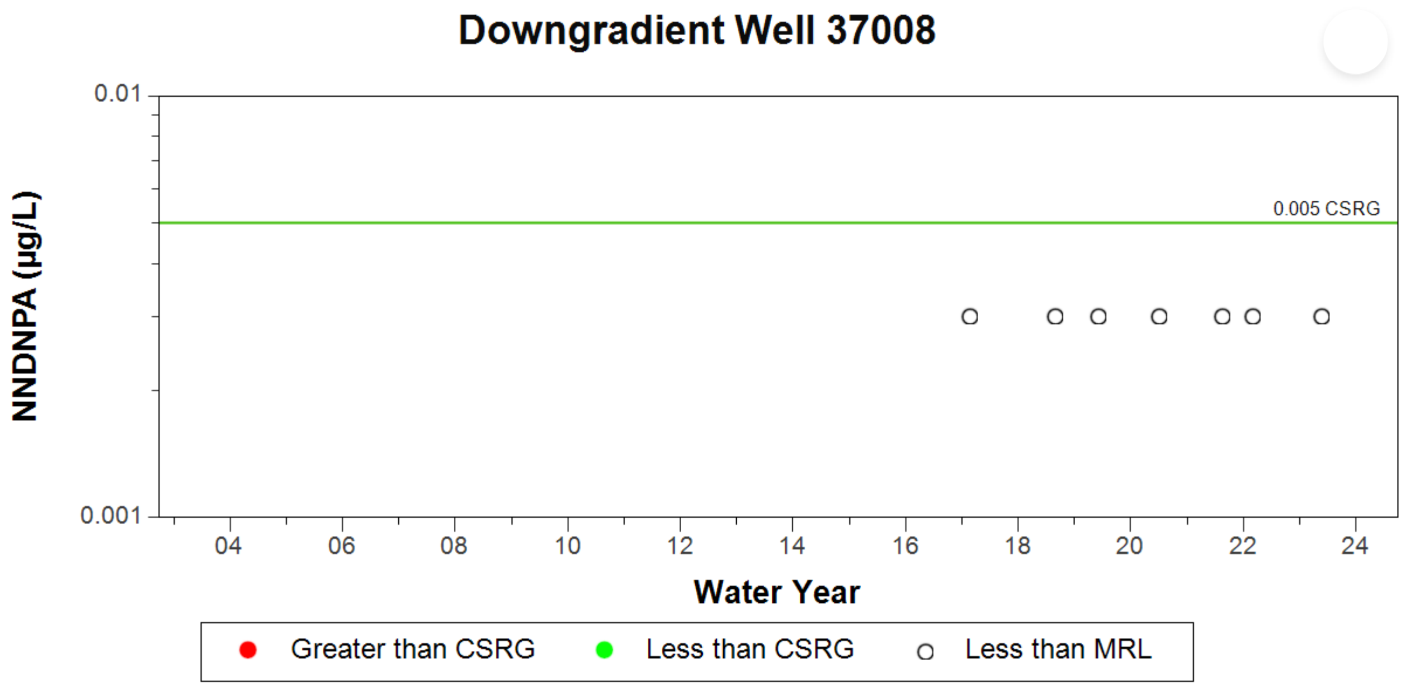


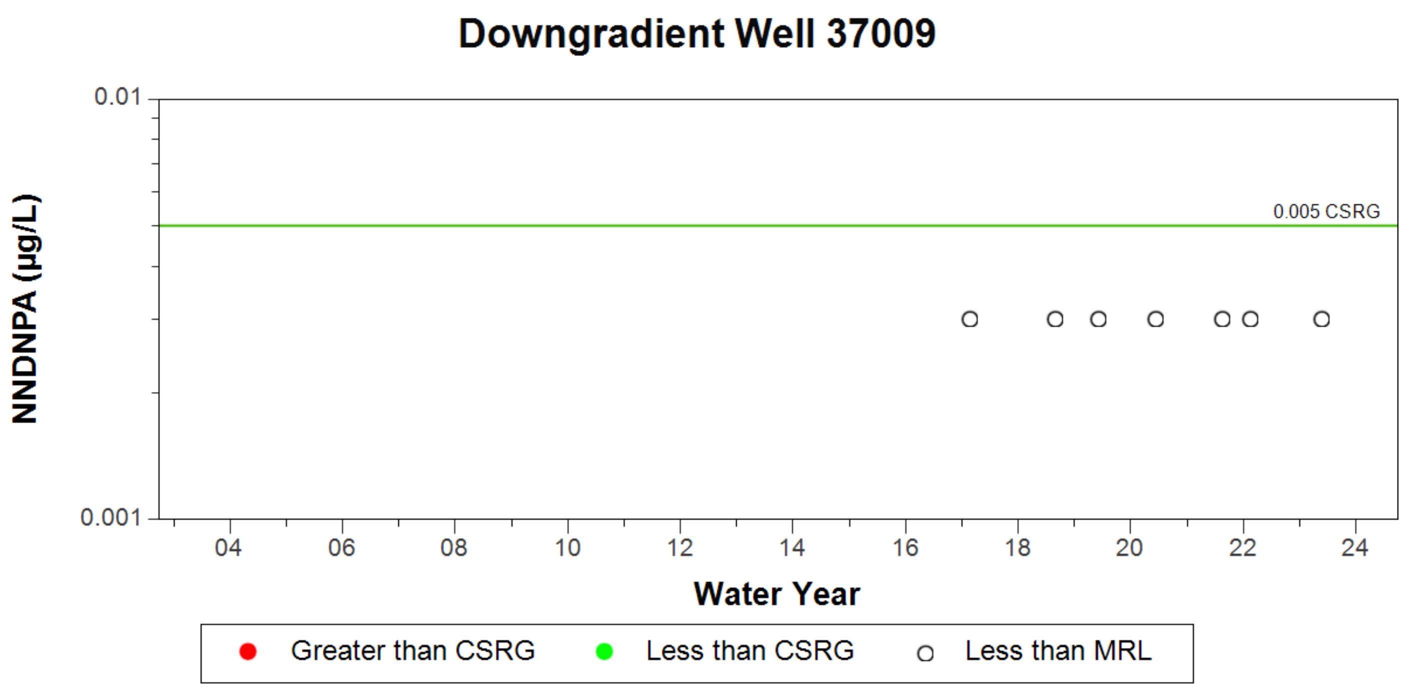


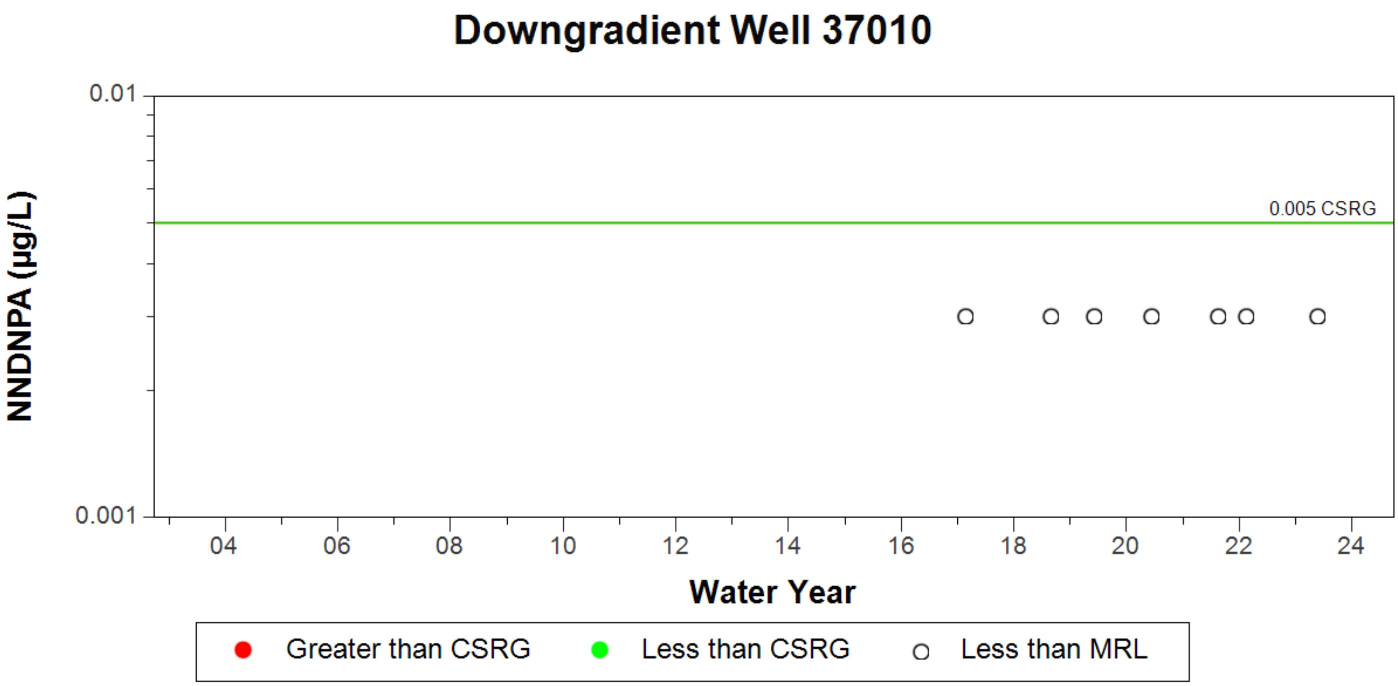
Upgradient Well EPA-4
NNDNPA (µg/L)
0.01
0.001
0.005 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL


Crossgradient Well 37027
NNDNPA (µg/L)
0.01
0.001
0.005 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

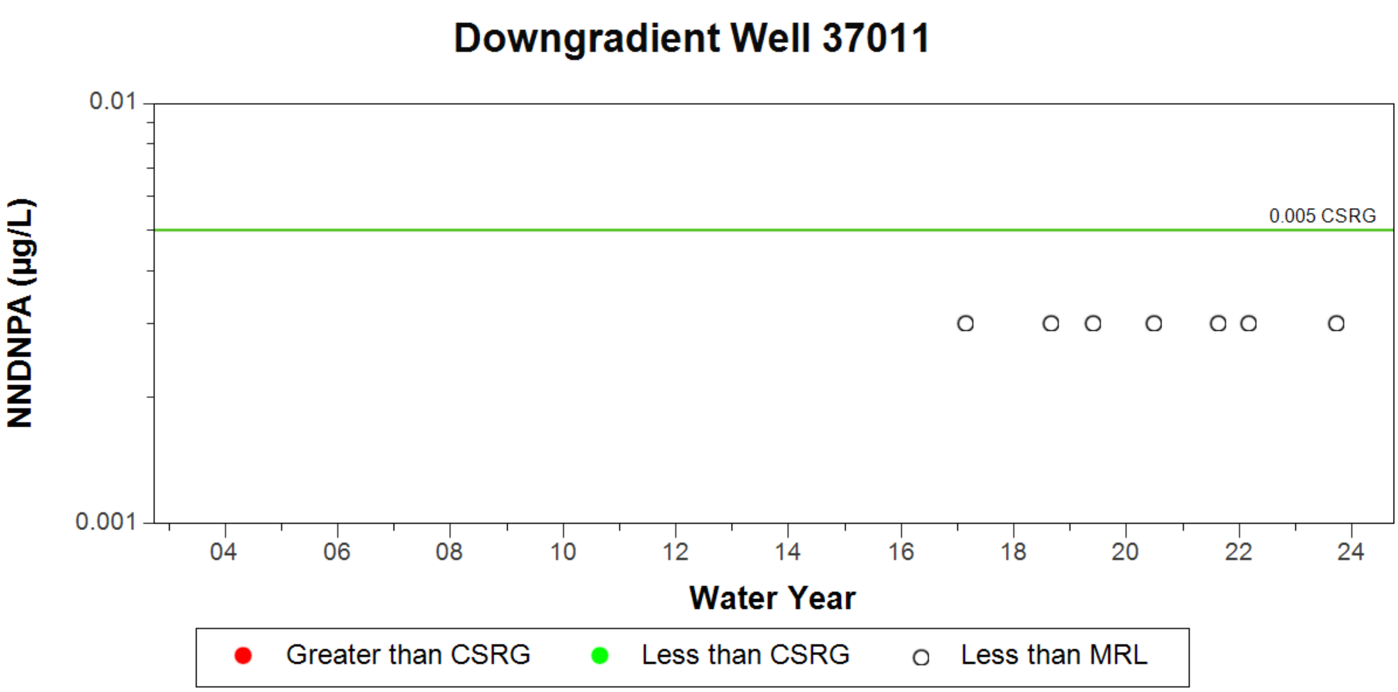

Crossgradient Well 37452
NNDNPA (µg/L)
0.01
0.001
0.005 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL


Downgradient Well 37008
NNDNPA (µg/L)
0.01
0.001
0.005 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

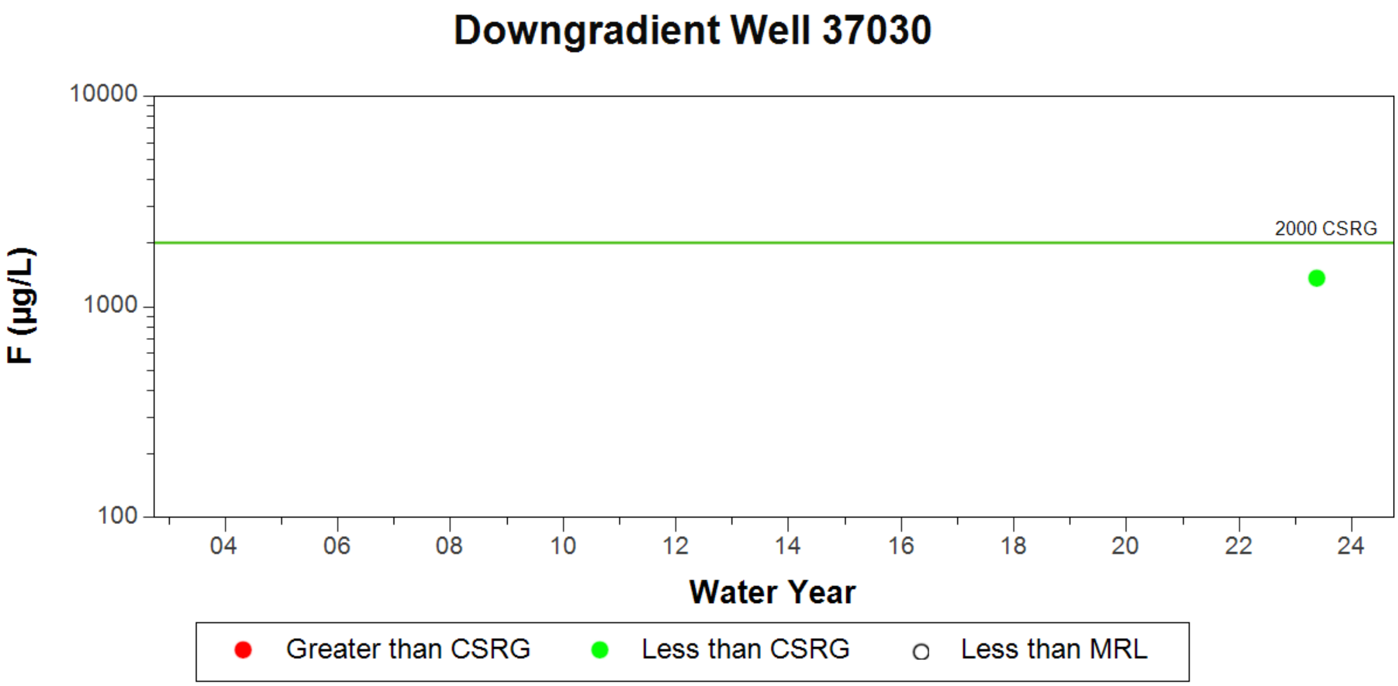

Downgradient Well 37009
NNDNPA (µg/L)
0.01
0.001
0.005 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



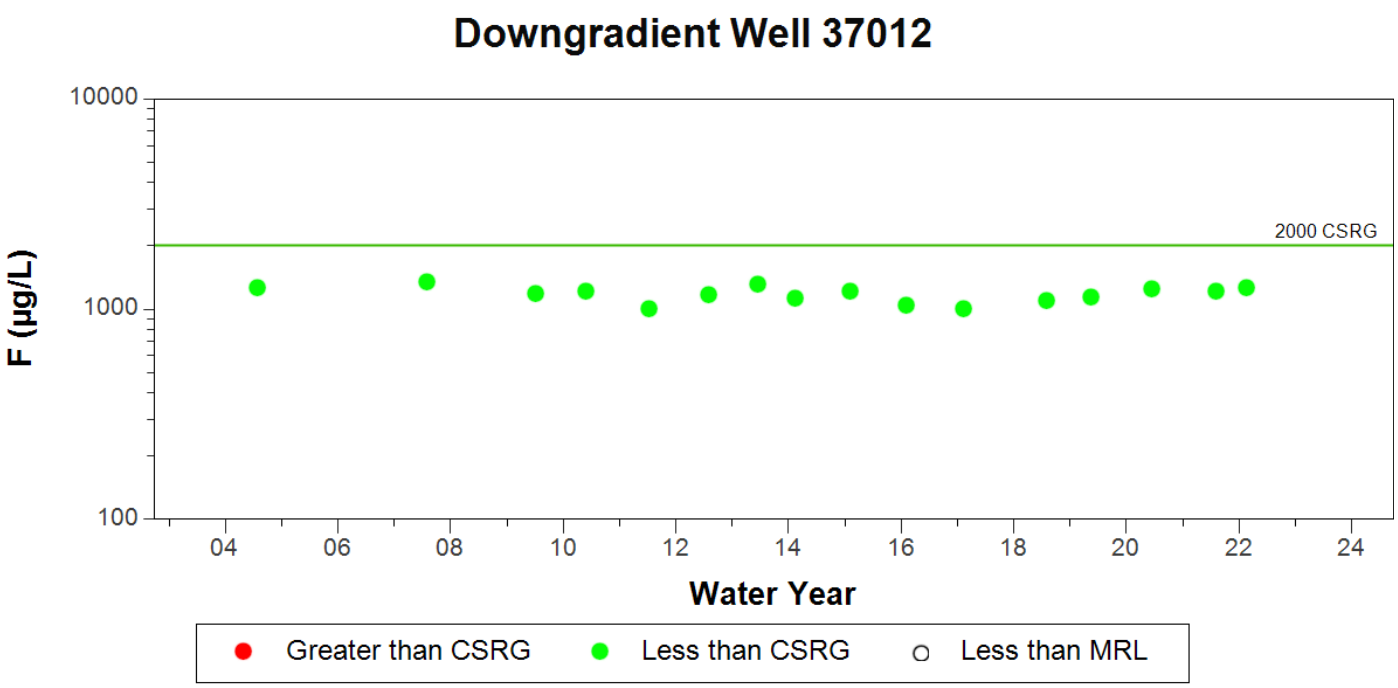
Downgradient Well 37010
NNDNPA (µg/L)
0.01
0.001
0.005 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

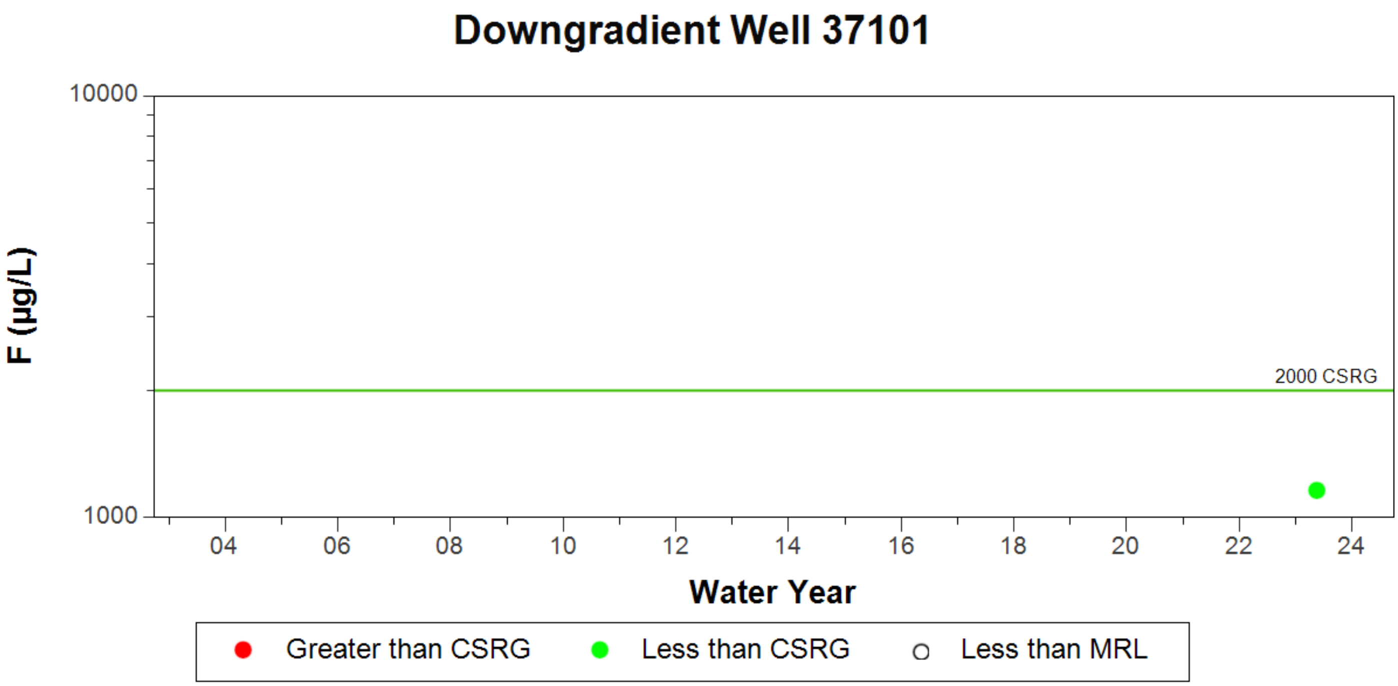


Downgradient Well 37011
NNDNPA (µg/L)
0.01
0.001
0.005 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

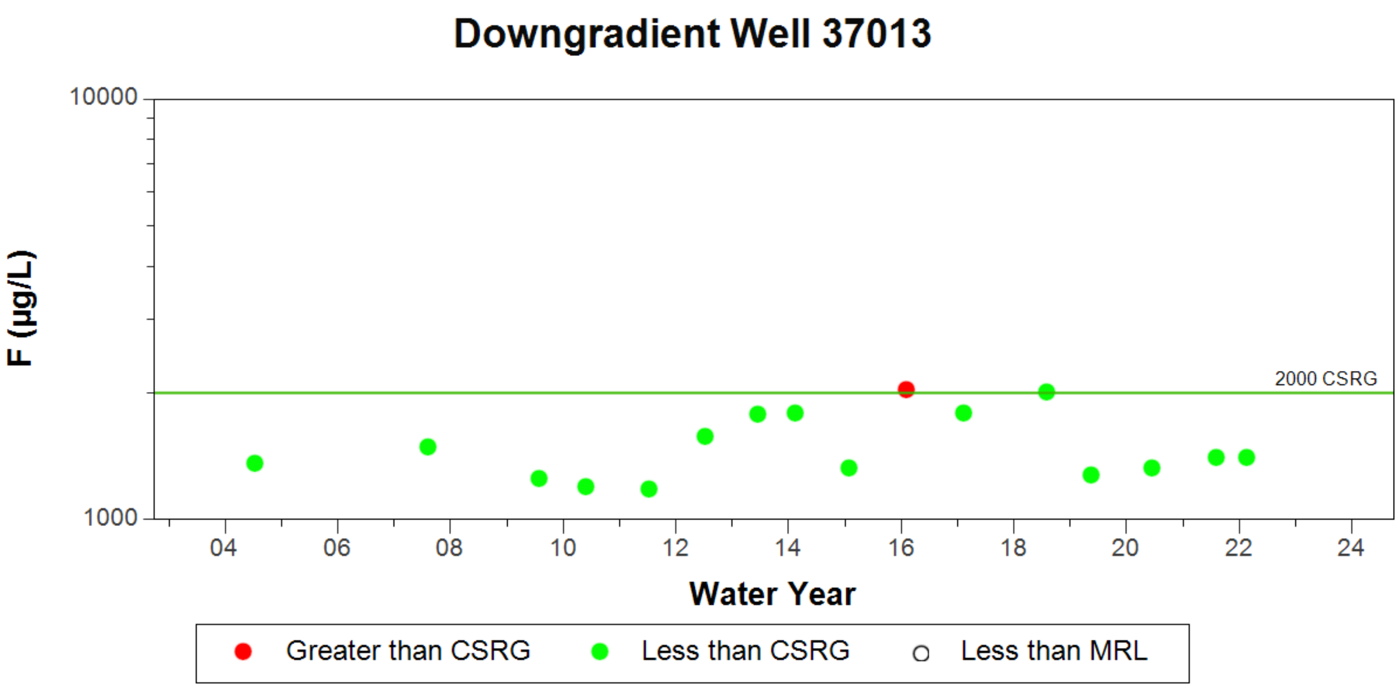


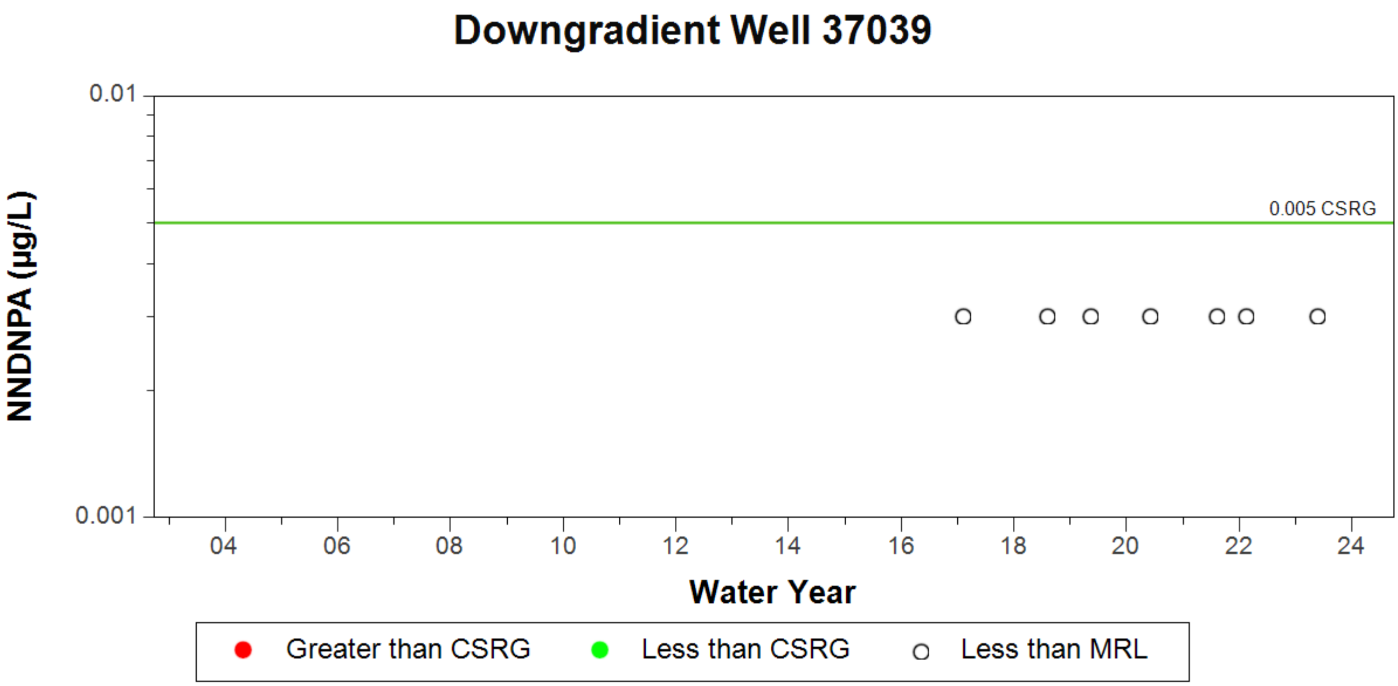
In FY22, well 37012 was replaced by well 37030.
Prior to FY22, well 37012 did not show an increasing trend.



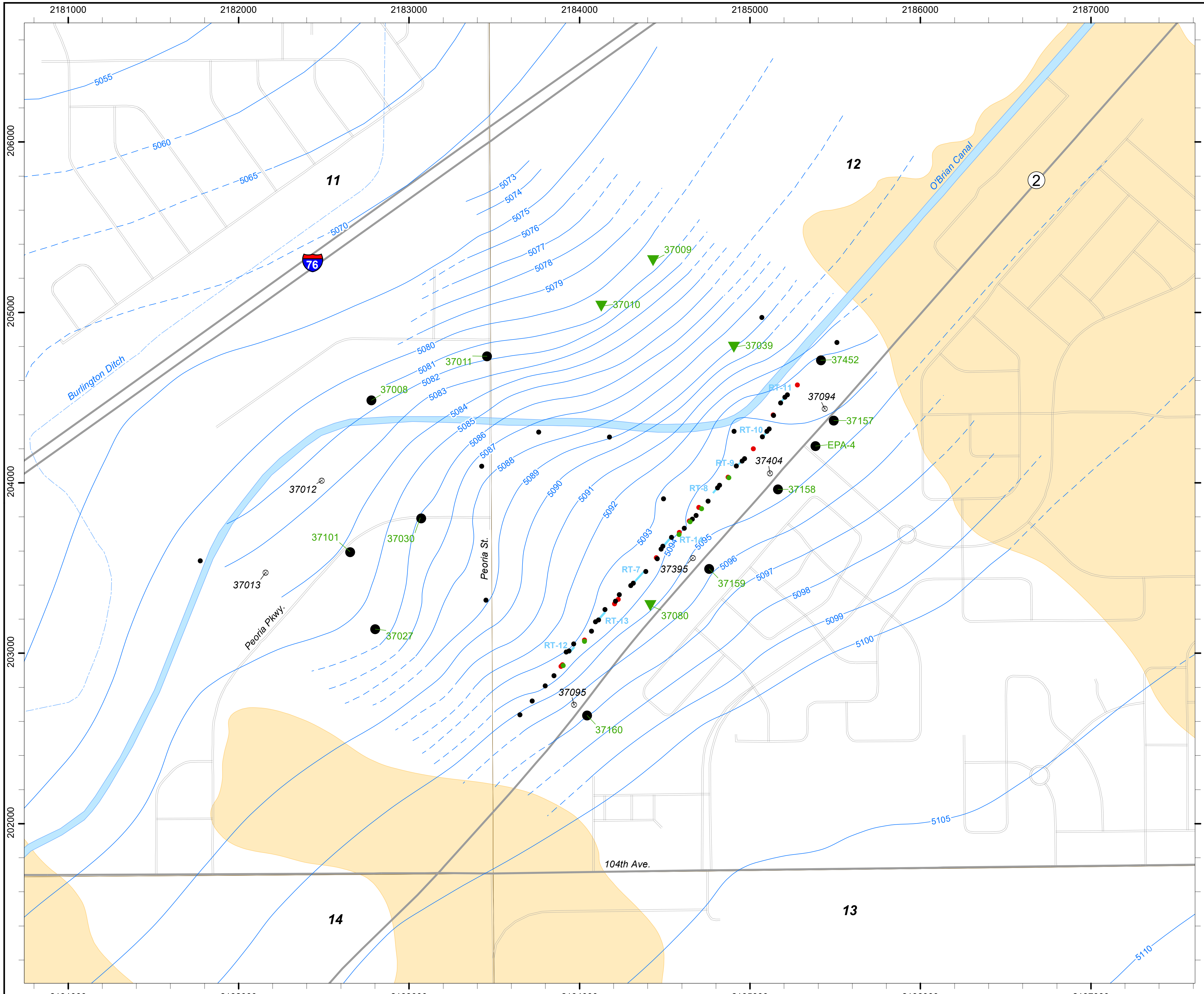


In FY22, well 37013 was replaced by well 37101.
Prior to FY22, well 37013 did not show an increasing trend.





Downgradient Well 37039
0.01
0.001
0.005 CSRG
NNDNPA (µg/L)
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



Legend

- Unsaturated Alluvium
- Section Lines
- Lakes, Ponds, Rivers
- Water elevation contour - 1-foot interval
- Inferred water elevation contour
- Ditches
- Recharge Trench
- Light Duty Roads
- Primary Roads
- Monitoring Wells
- Performance Water Quality Wells
- Extraction Wells
- Replaced Monitoring Wells

Note: Water levels were measured in FY23 Quarter 2.

Upgradient and Downgradient Performance Well Water Quality

- Analyte Detected Above the CSRG - Increasing Trend Noted
- Analyte Detected Above the CSRG - Decreasing Trend Noted
- Analyte Detected - Showing Stable or No Discernible Trend
- Analyte Not Detected

Notes:
1. Trends are depicted for the 10 year period FY14 - FY23.
2. Time versus concentration charts for Performance Water Quality wells are presented following this map.

N

0 300 600 Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

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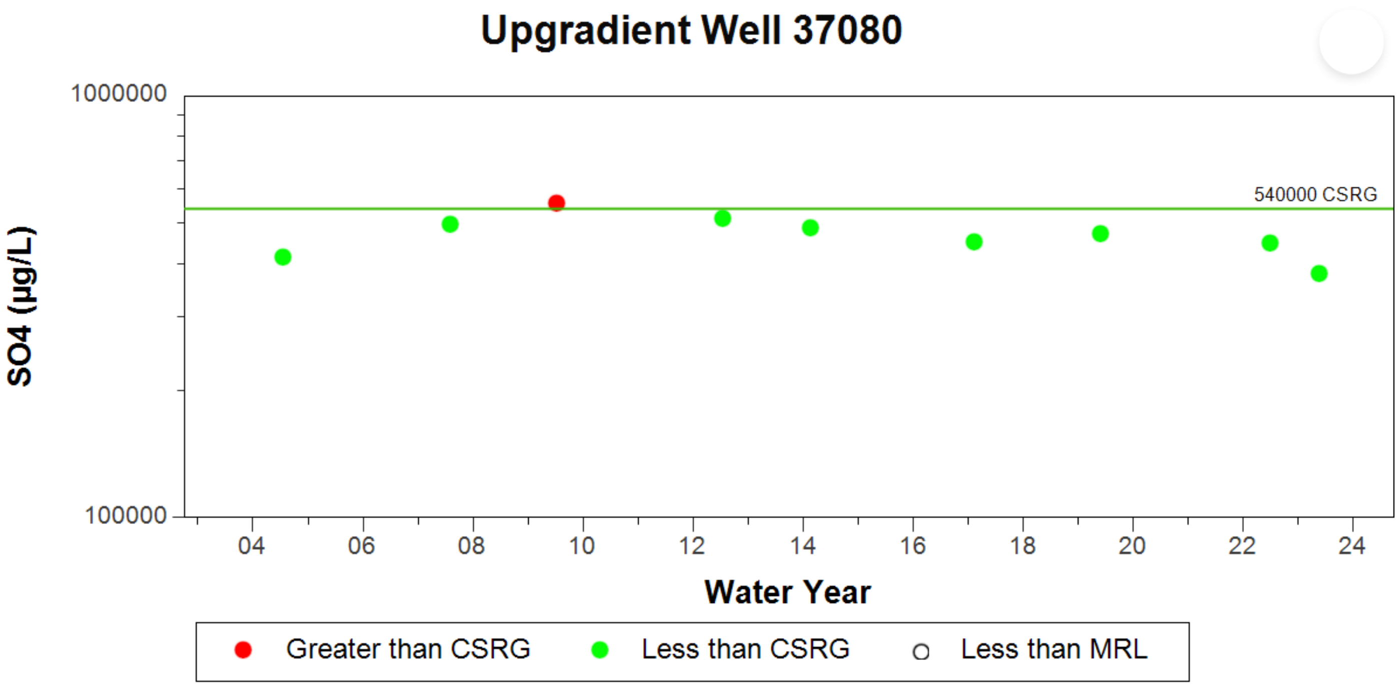
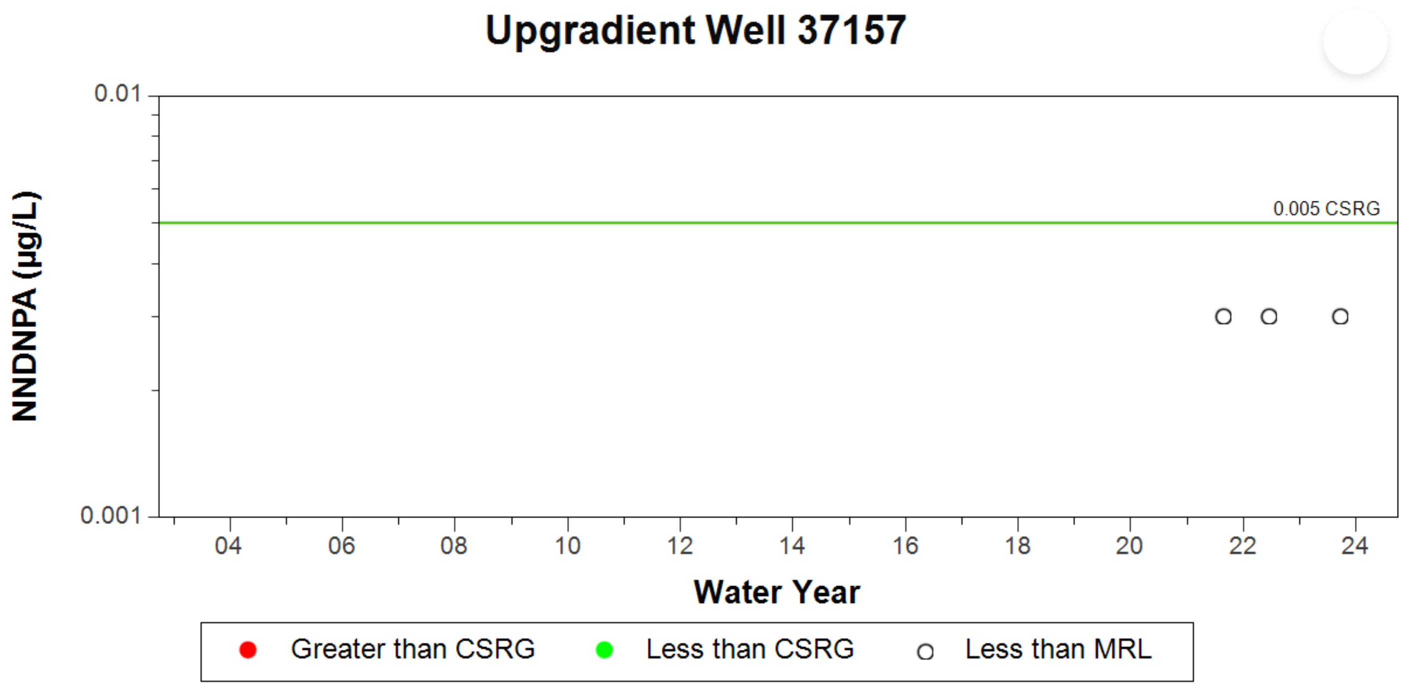
Figure G-16

Sulfate Concentration Trends in Performance Wells, Northern Pathway Treatment System

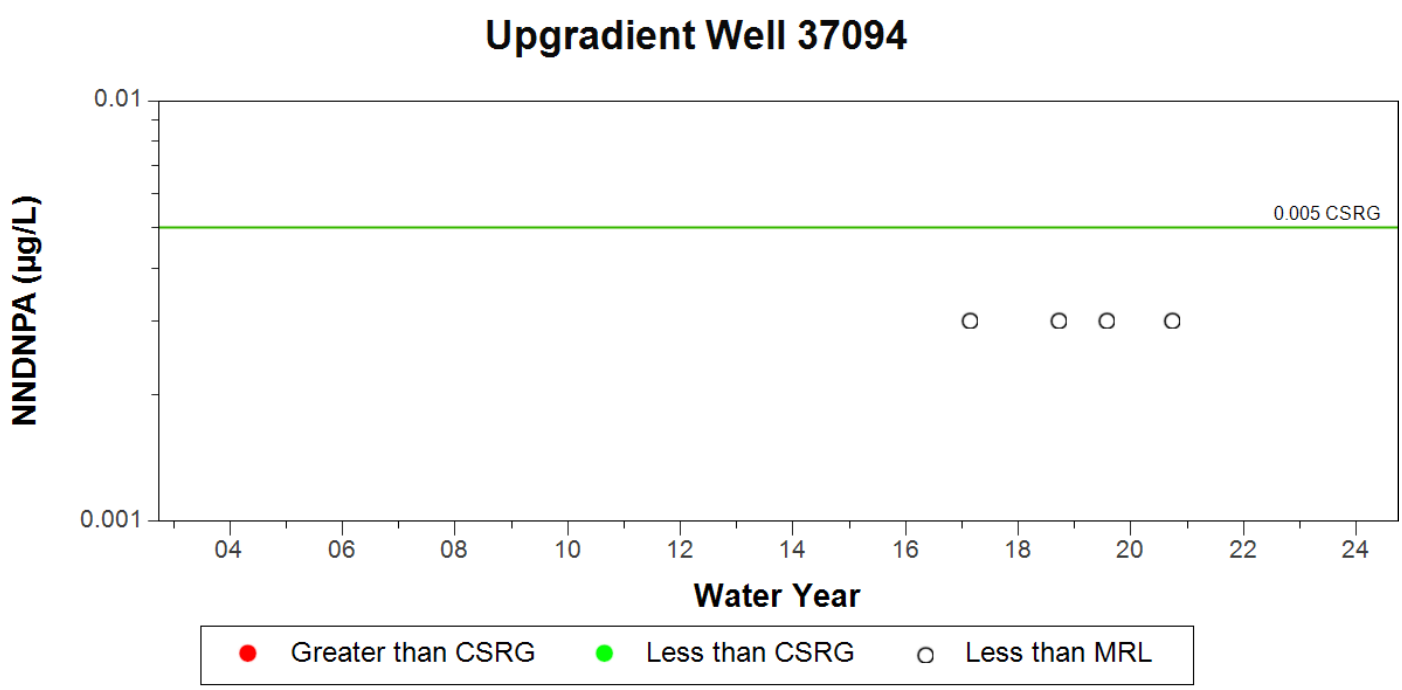
M:\projects\oars\fy23\mxds_NP_FY23_SO4.mxd
8/8/2024

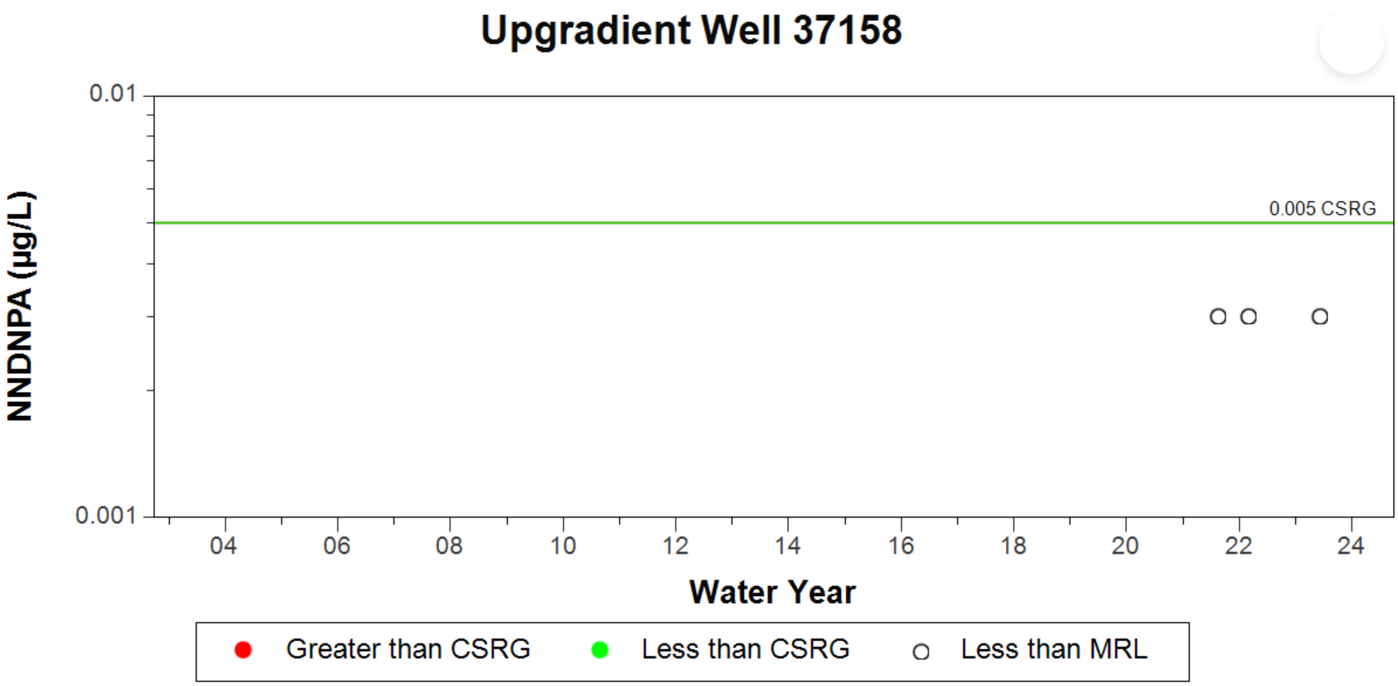


Upgradient Well 37080
1000000
100000
540000 CSRG
SO4 (µg/L)
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

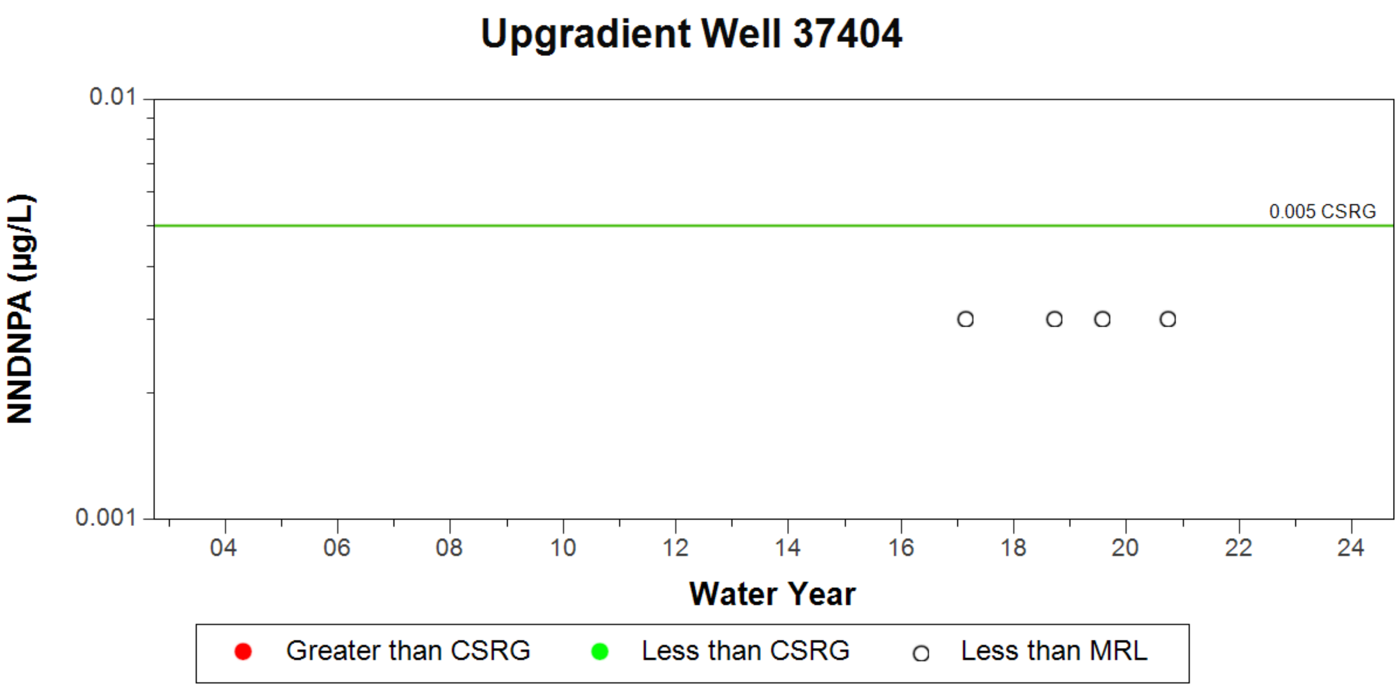


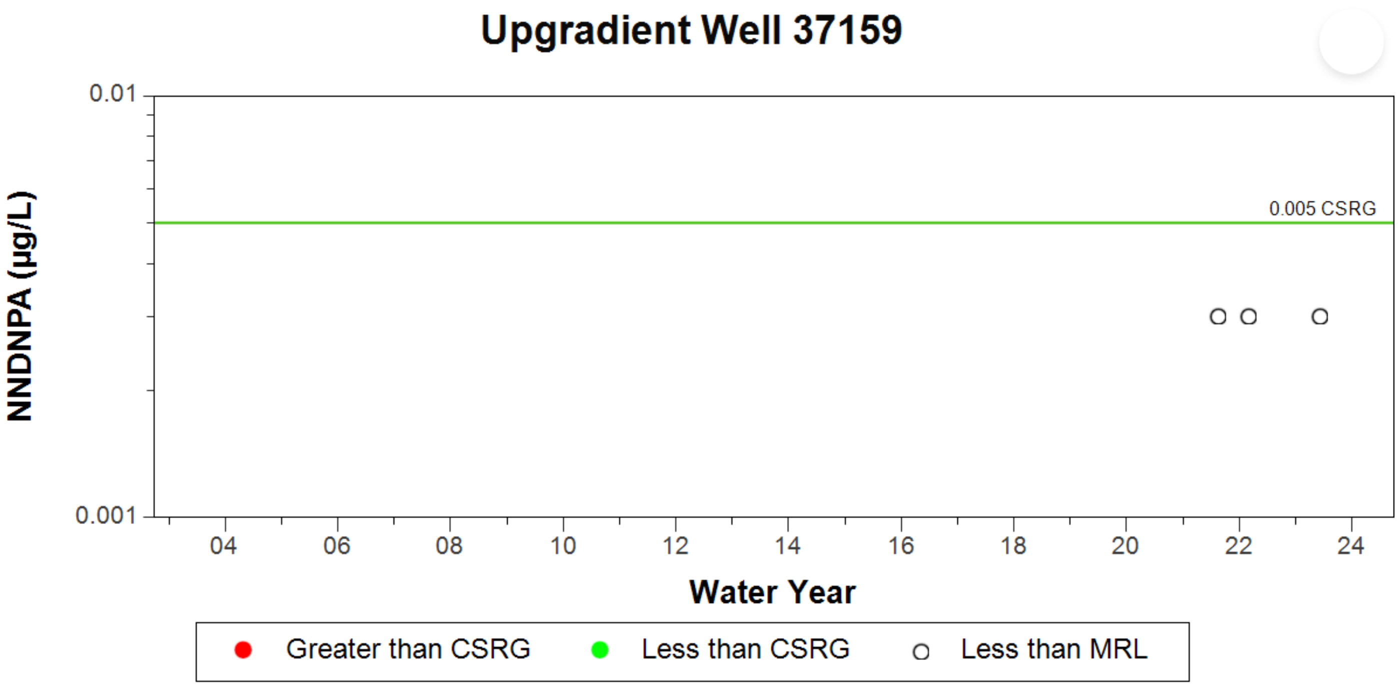
In FY20, well 37094 was replaced by well 37157.



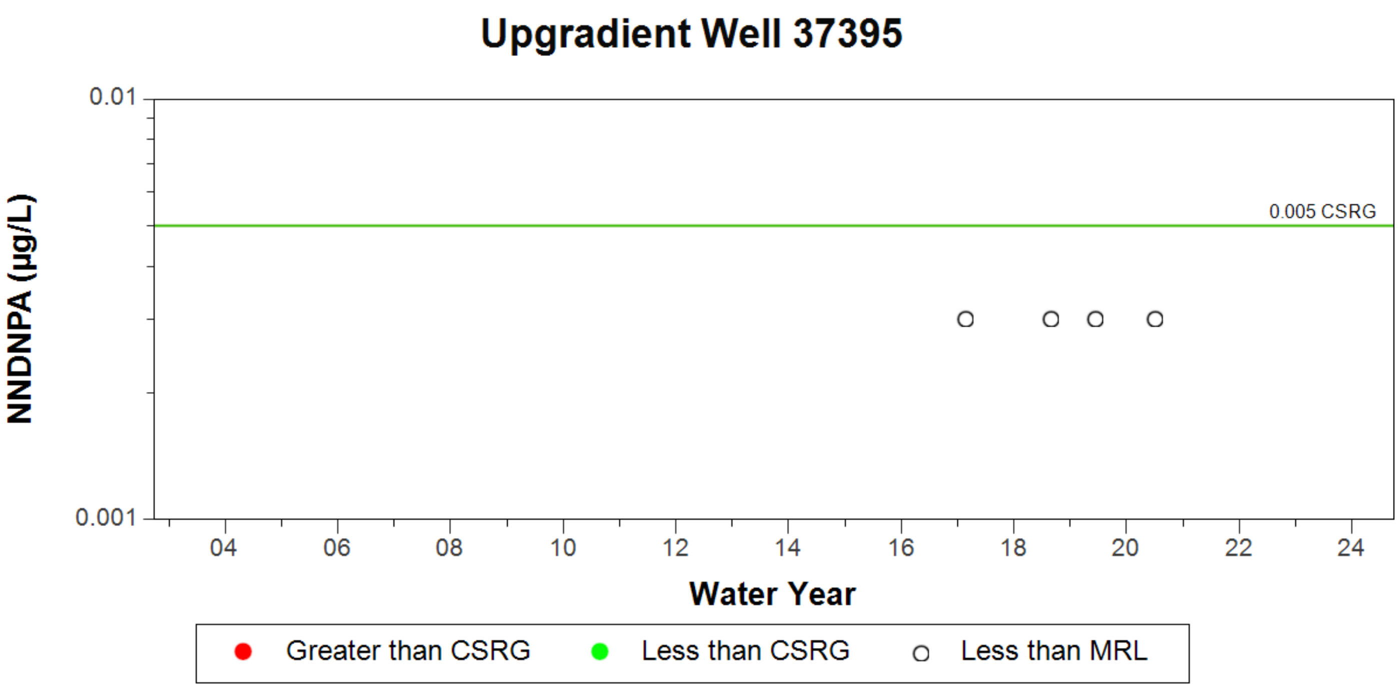


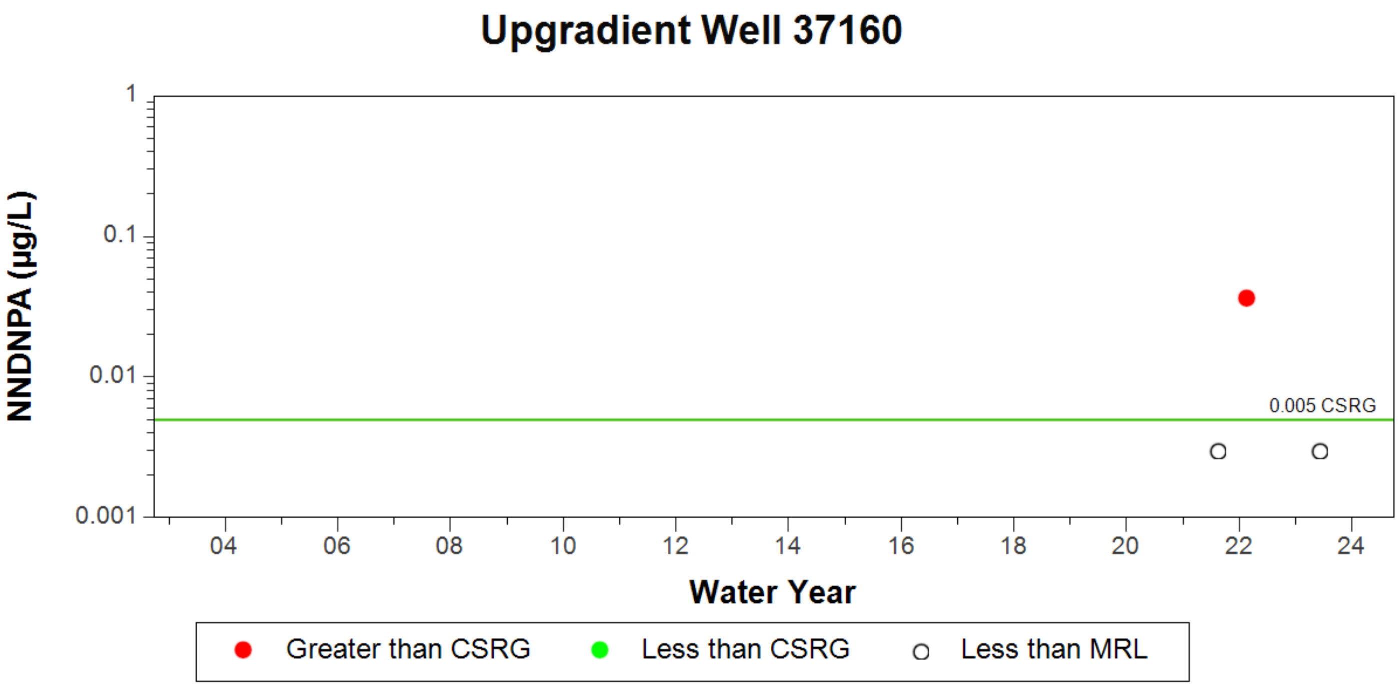
In FY20, well 37404 was replaced by well 37158.



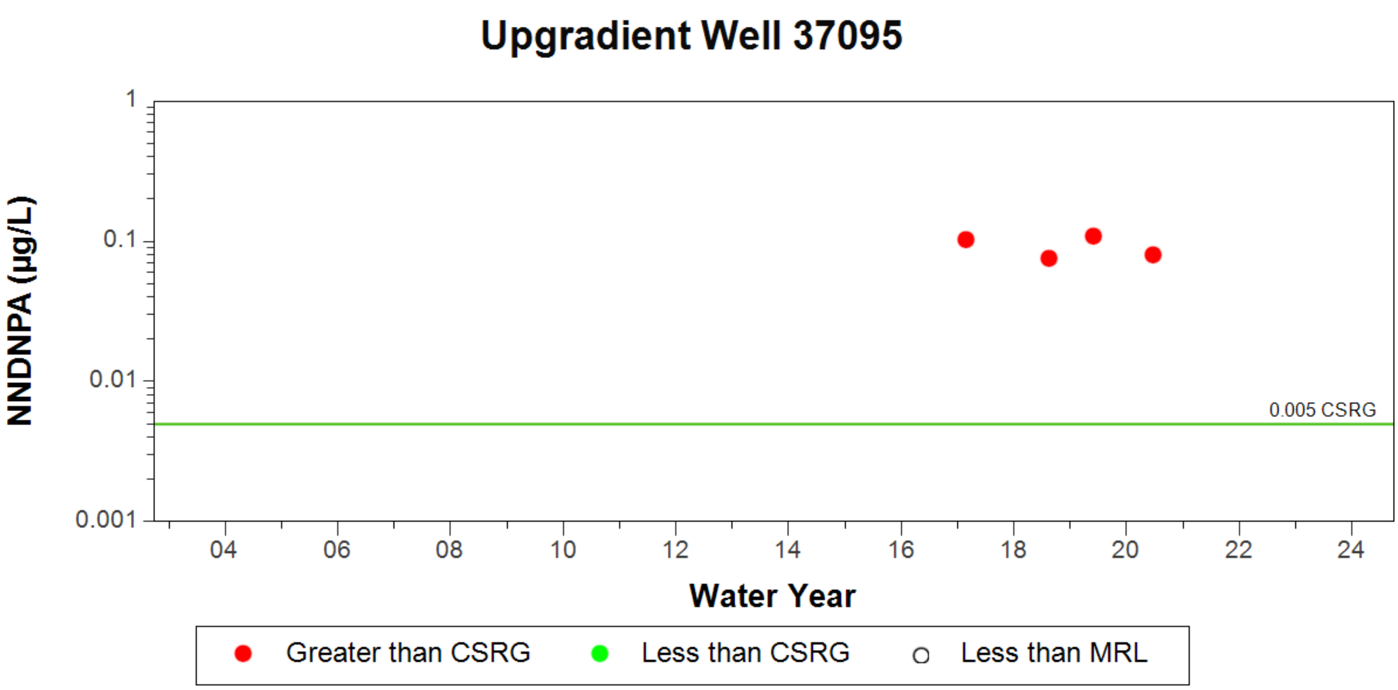


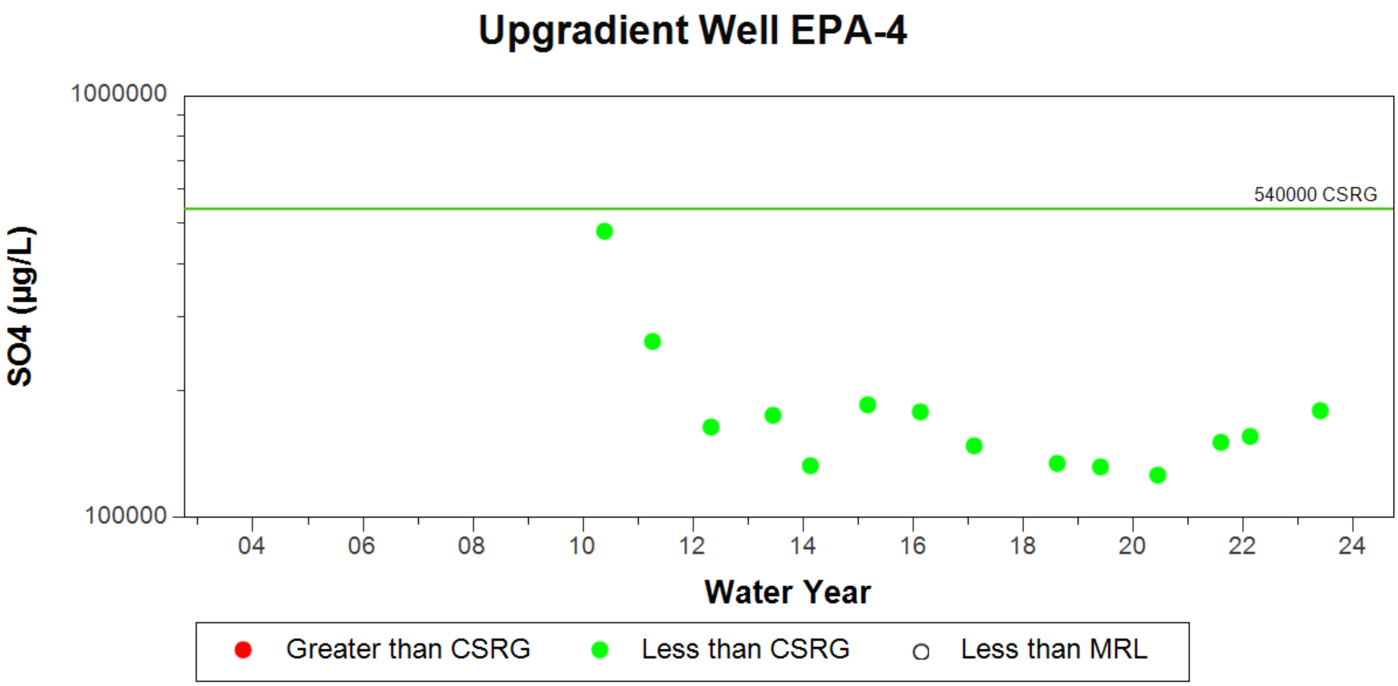
In FY20, well 37395 was replaced by well 37159.



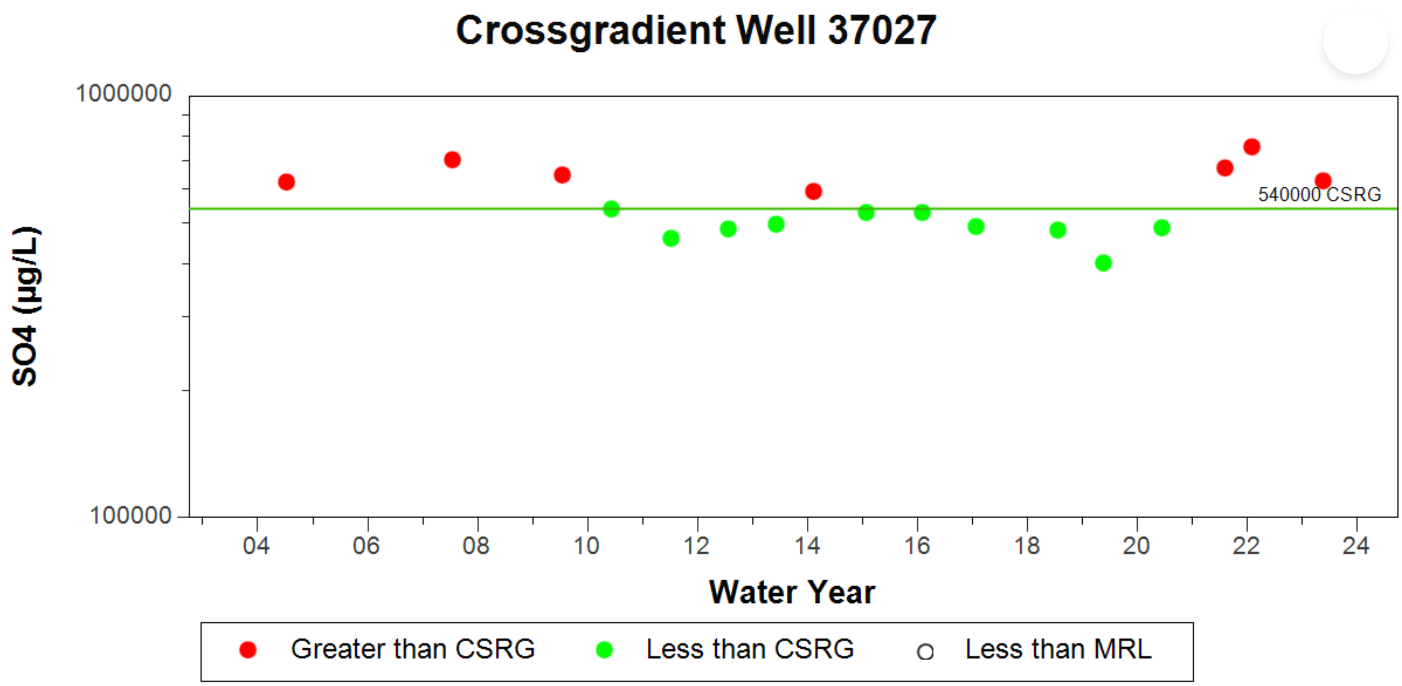


In FY20, well 37095 was replaced by well 37160.

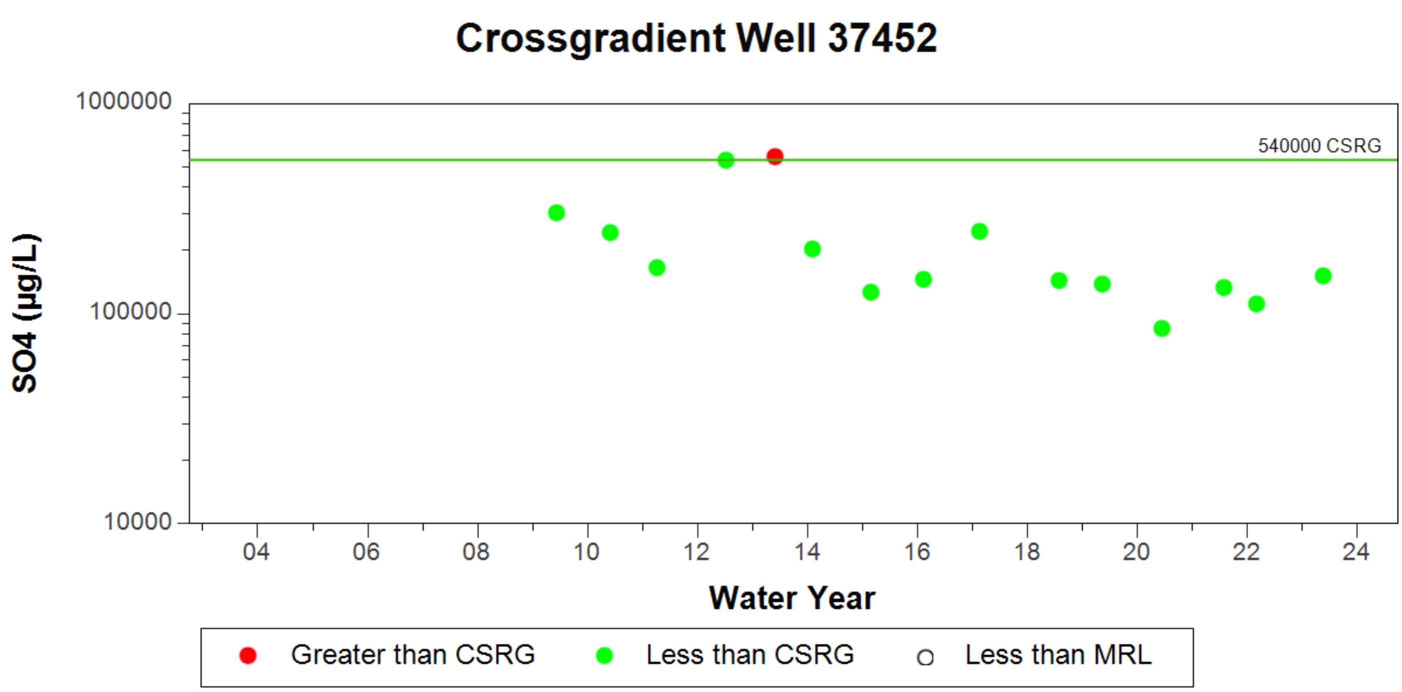




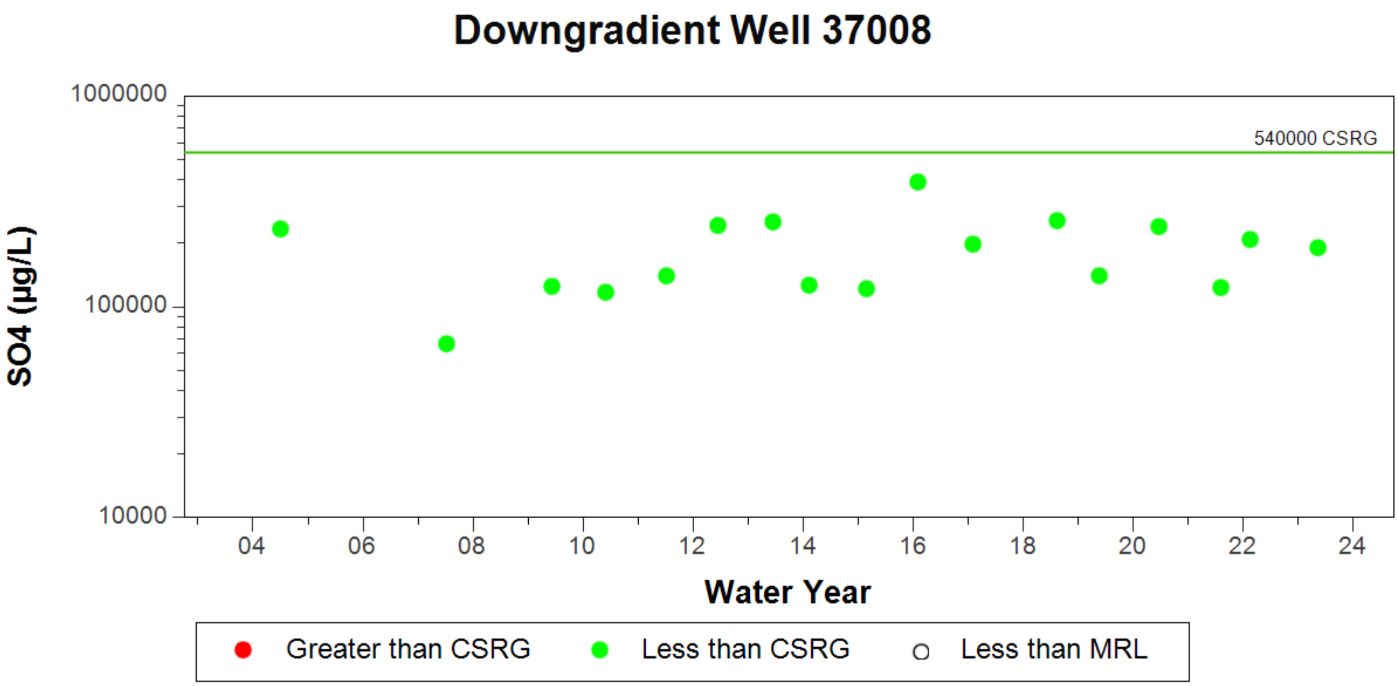
Upgradient Well EPA-4
1000000
540000 CSRG
SO4 (µg/L)
100000
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



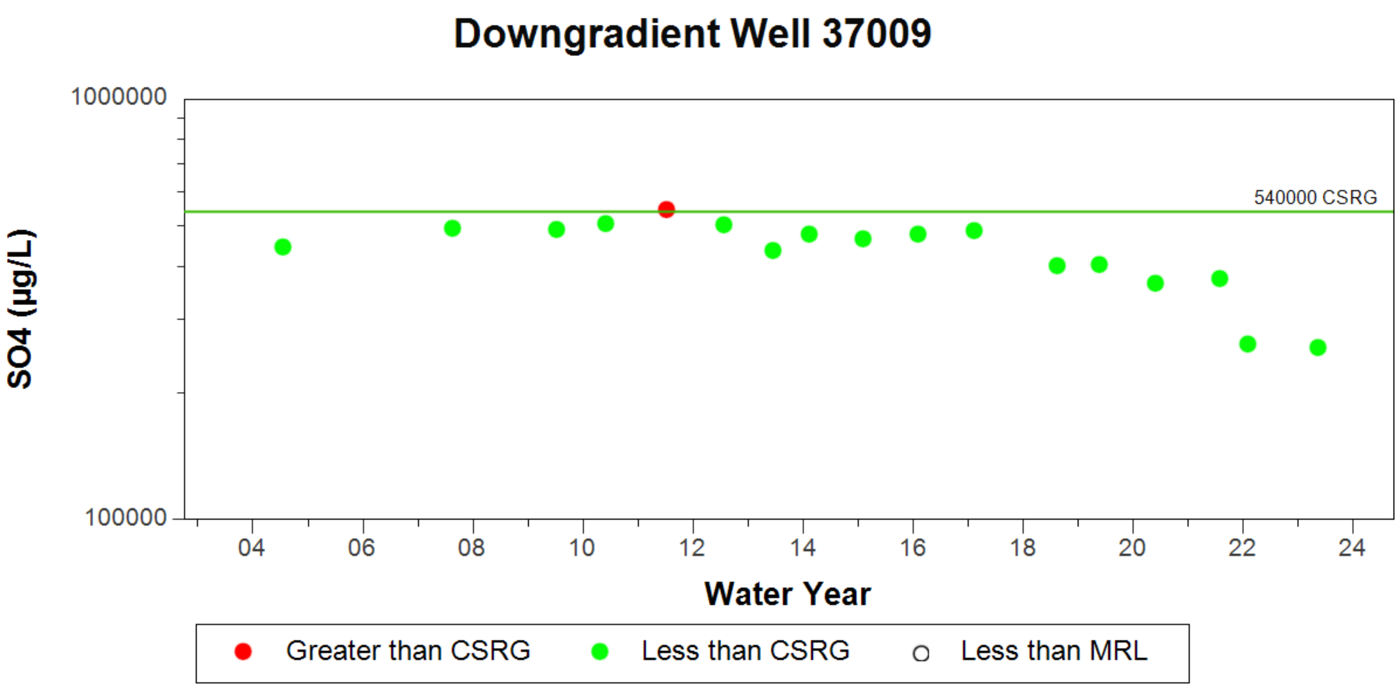
Crossgradient Well 37027
1000000
100000
SO4 (µg/L)
540000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL



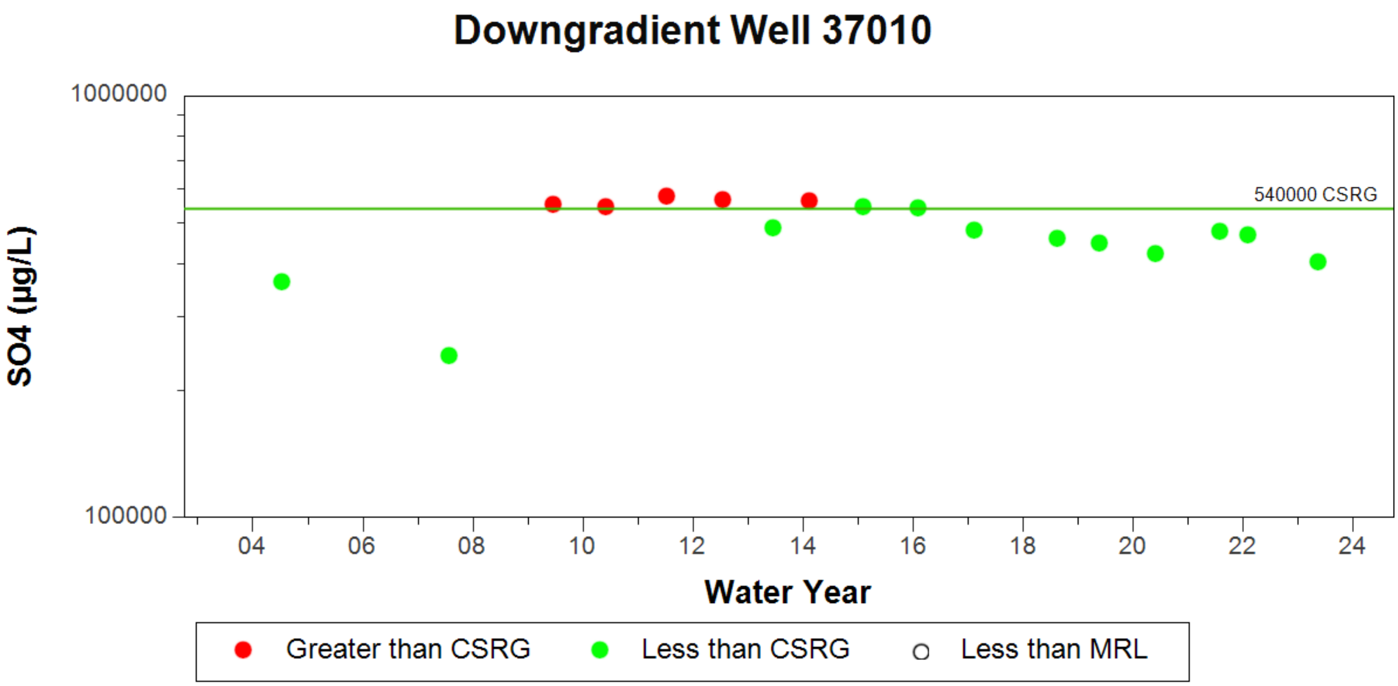
Crossgradient Well 37452
1000000
100000
10000
SO4 (µg/L)
540000 CSRG
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

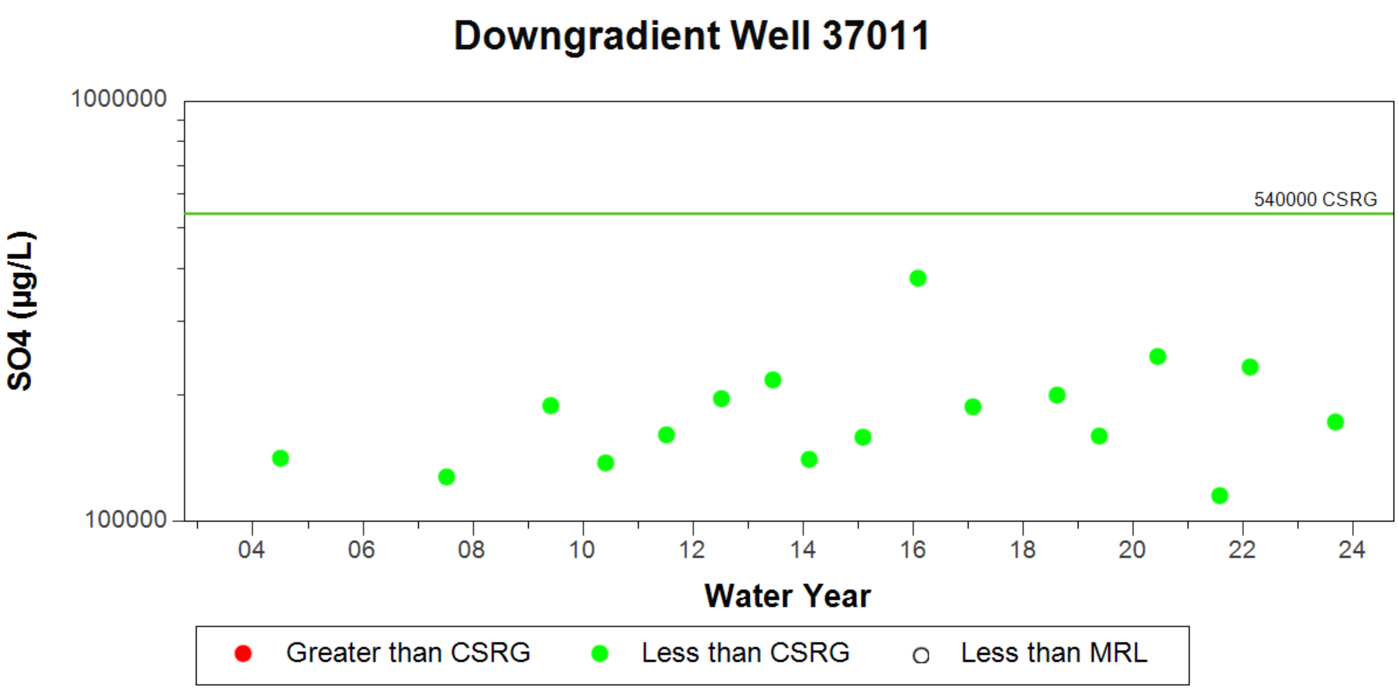


Downgradient Well 37008
1000000
100000
10000
540000 CSRG
SO4 (µg/L)
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

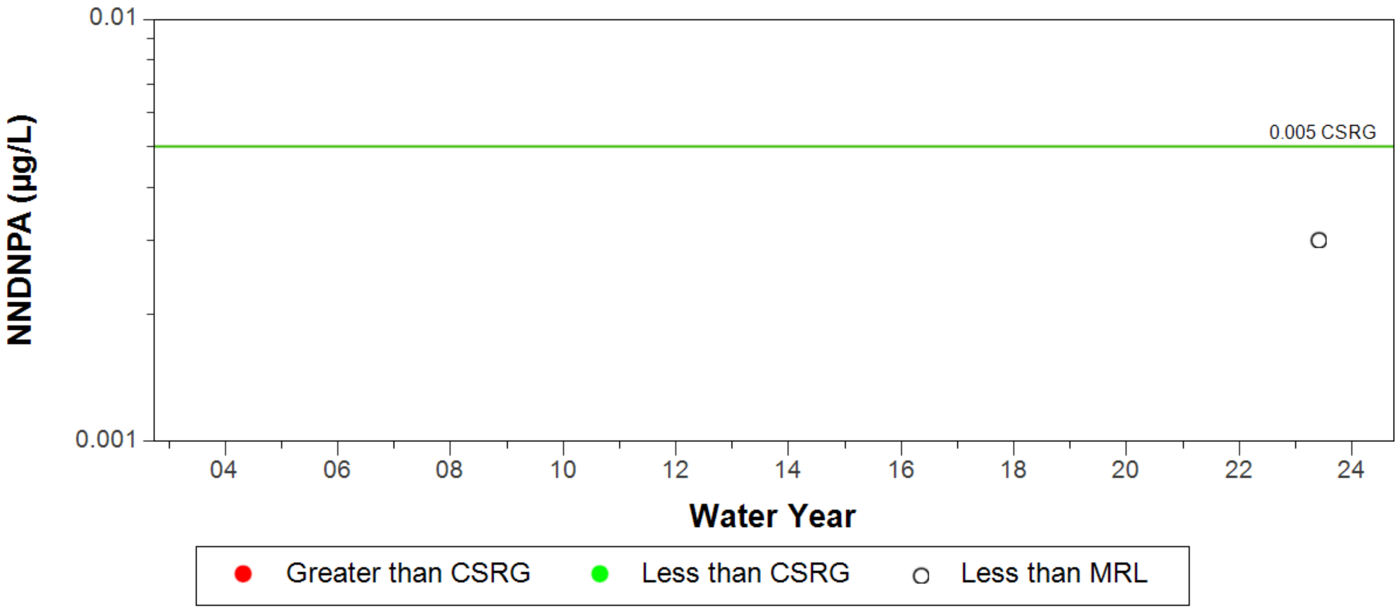


Downgradient Well 37009
1000000
100000
540000 CSRG
SO4 (µg/L)
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL


Downgradient Well 37010
1000000
100000
540000 CSRG
SO4 (µg/L)
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

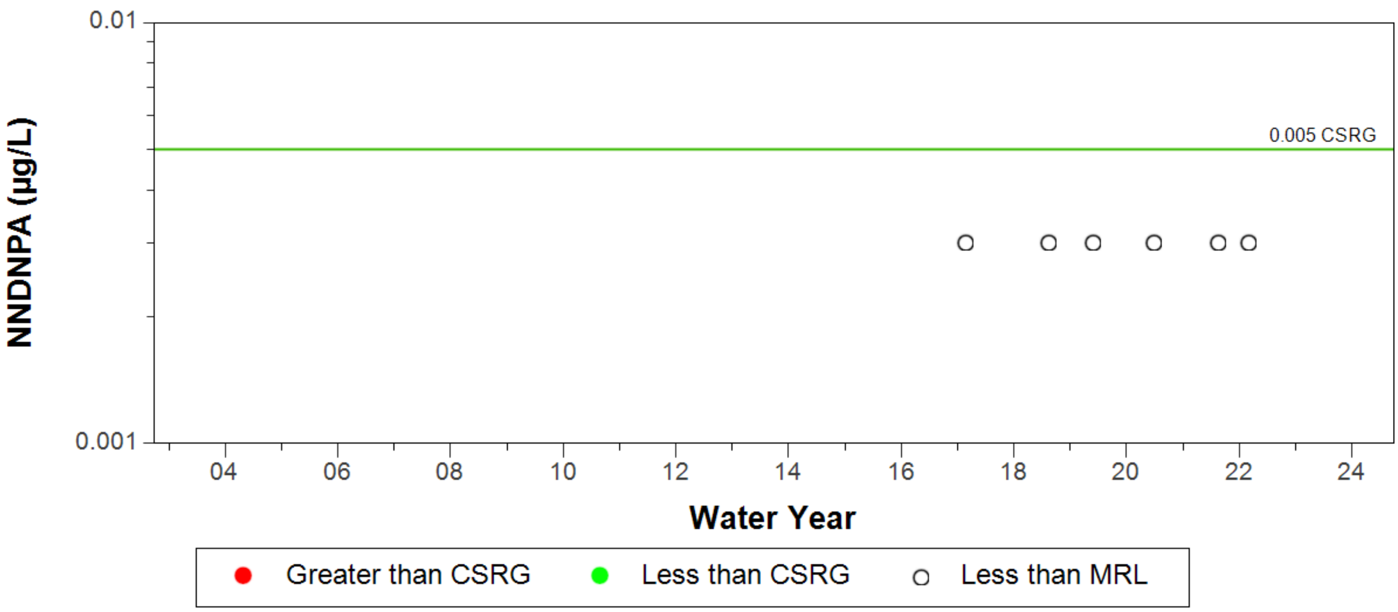

Downgradient Well 37011
1000000
100000
540000 CSRG
SO4 (µg/L)
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

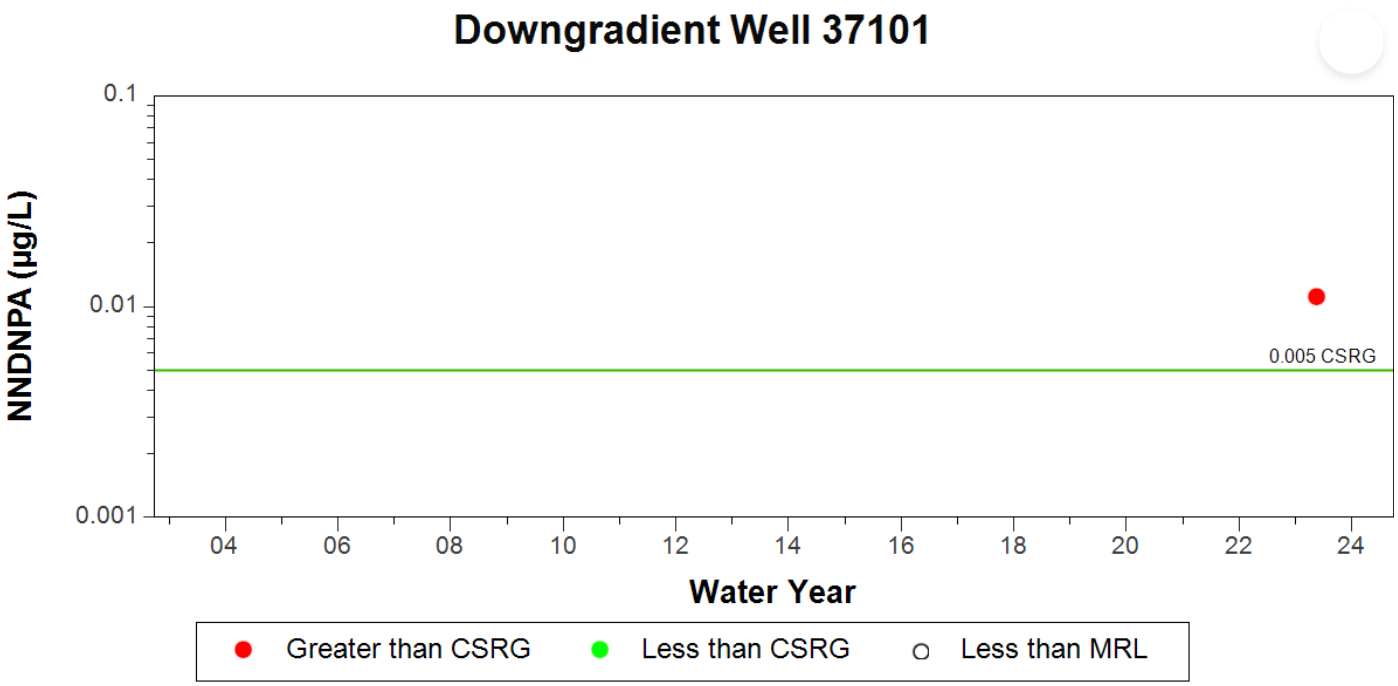
Downgradient Well 37030



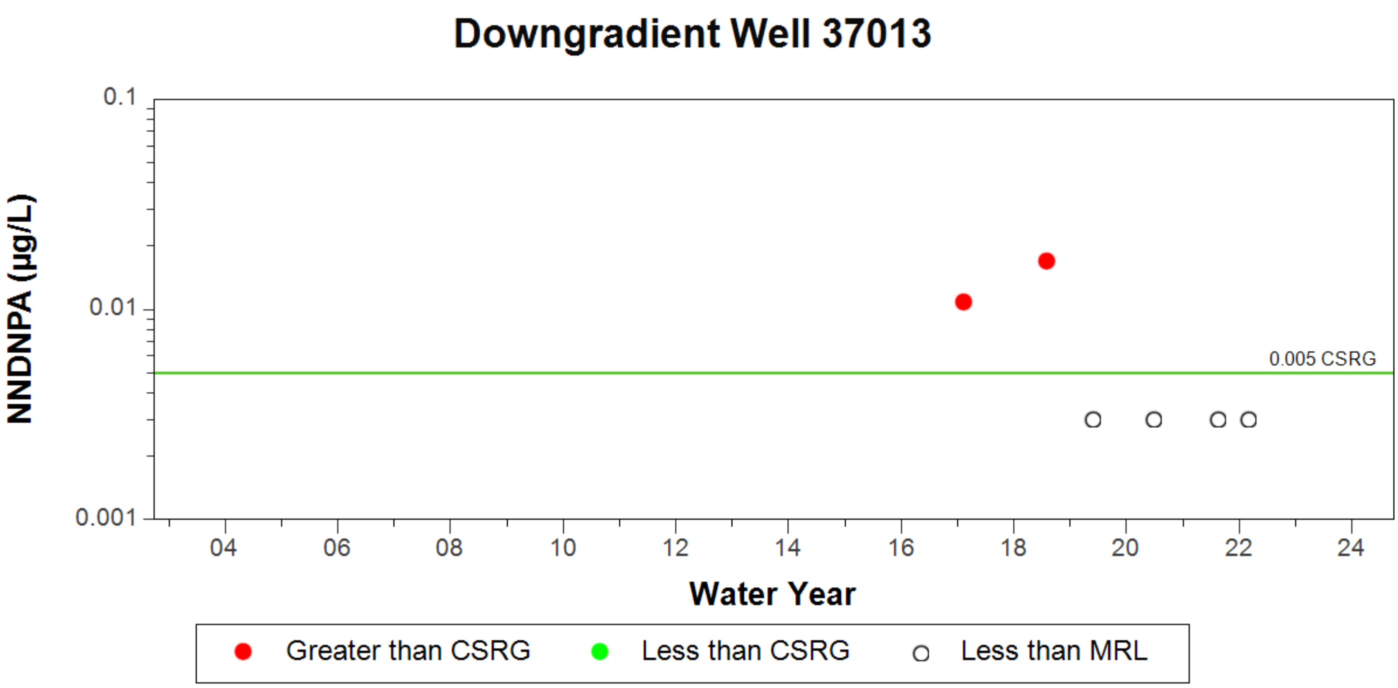
In FY22, well 37012 was replaced by well 37030.
Prior to FY22, well 37012 did not show an increasing trend.

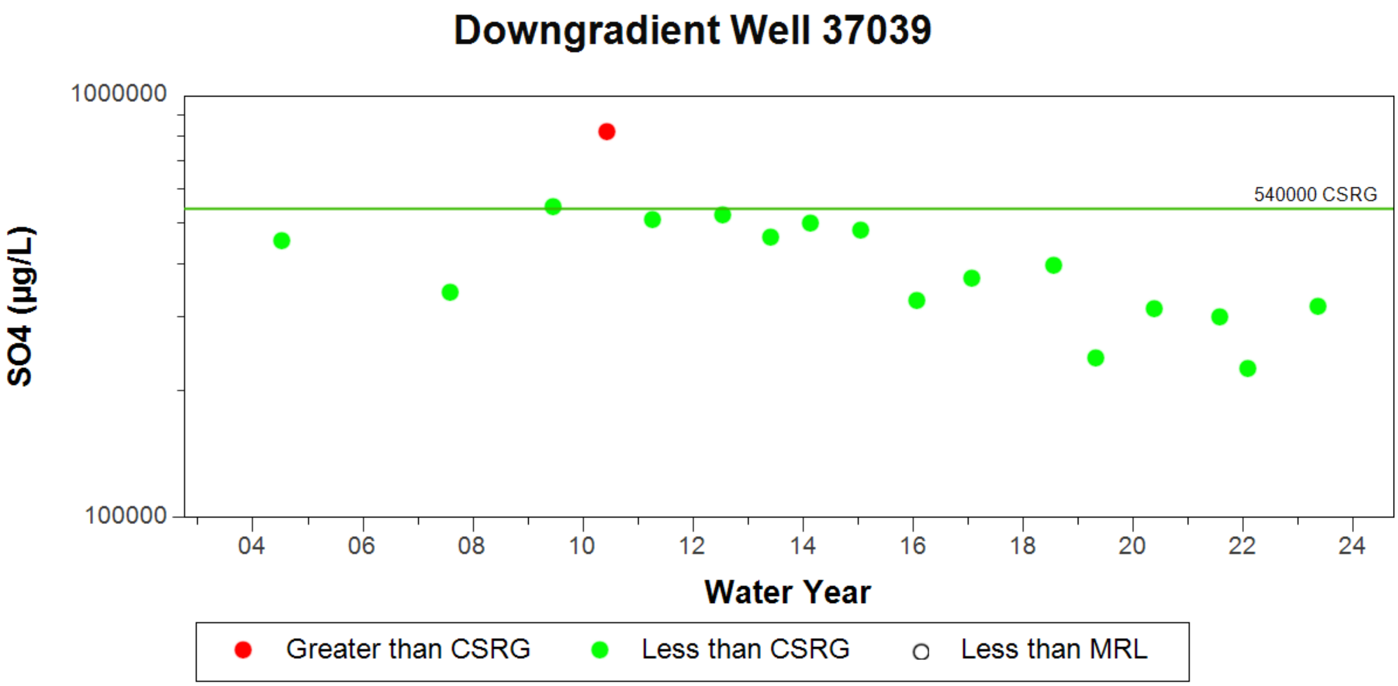
Downgradient Well 37012





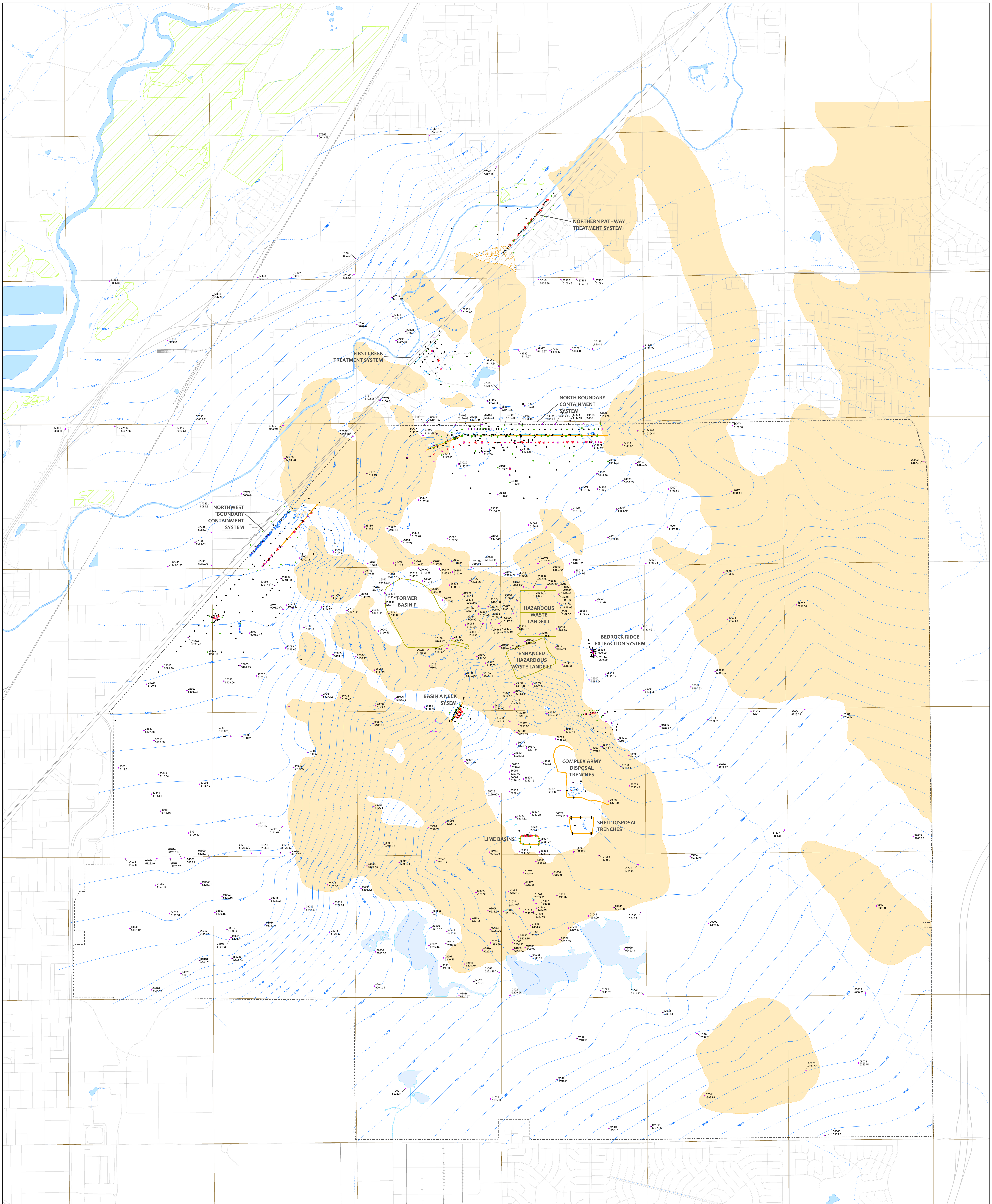
In FY22, well 37013 was replaced by well 37101.
Prior to FY22, well 37013 did not show an increasing trend.





Downgradient Well 37039
1000000
100000
540000 CSRG
SO4 (µg/L)
04
06
08
10
12
14
16
18
20
22
24
Water Year
Greater than CSRG
Less than CSRG
Less than MRL

Appendix H
Site-Wide Monitoring
Figures and Documentation



Legend

Section Lines	Intermittent streams	Monitoring Wells
Low Permeability Alluvial Sediments	Ditches	Extraction Wells
Project Boundary	Slurry Walls	Performance Wells
Lakes, Ponds, Rivers	Recharge Trenches	Extraction Well
Gravel Pits	Light Duty Roads	Recharge Well
	Primary Roads	Other Wells

N

1 inch = 1,109 feet

0 1,000 2,000 3,000
Feet

Sources: U.S. Army, RMA GIS, Navarro, Shell/AECOM

Note: Wells presented here represent the site-wide monitoring network. Site-specific water level maps are presented in the appendices of the report.

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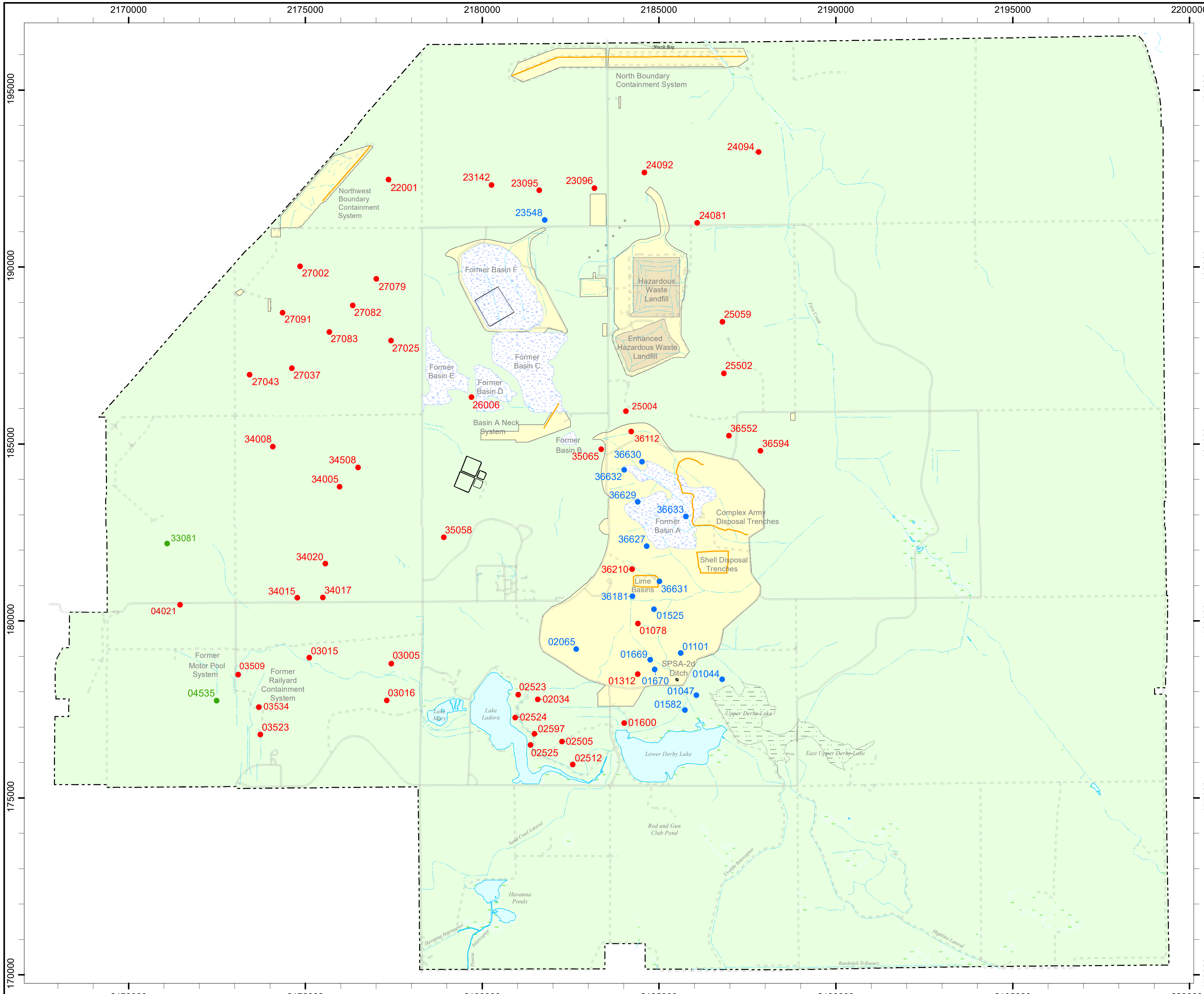
Figure H-1

FY23 Site-Wide Potentiometric Surface
of the Unconfined Flow System

M:\projects\oars\fy23\mxds_regional_workmapFY23_Rev0.mxd
8/9/2024



Legend

- USFWS Managed
- Army Maintained Areas
- Hazardous Waste Landfill, & Enhanced Hazardous Waste Landfill
- Historic Basins
- Section Lines
- Lakes and Ponds
- Dry Lakes/Ponds
- Wetlands
- Intermittent Streams
- Ditches, Canals
- Slurry Walls
- Paved Roads
- Unimproved Roads
- Water Quality Tracking Wells (Sampled Twice in 5 Years)
- Water Quality Tracking Wells (Sampled Once in 5 Years)
- Water Quality Tracking Wells (Sampled Annually)

N

0 1,000 2,000 3,000 Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

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Figure H-2

Water Quality Tracking Monitoring Network

M:\projects\oars\fy23\mxds_wq_tracking_well_location.mxd
6/25/2024

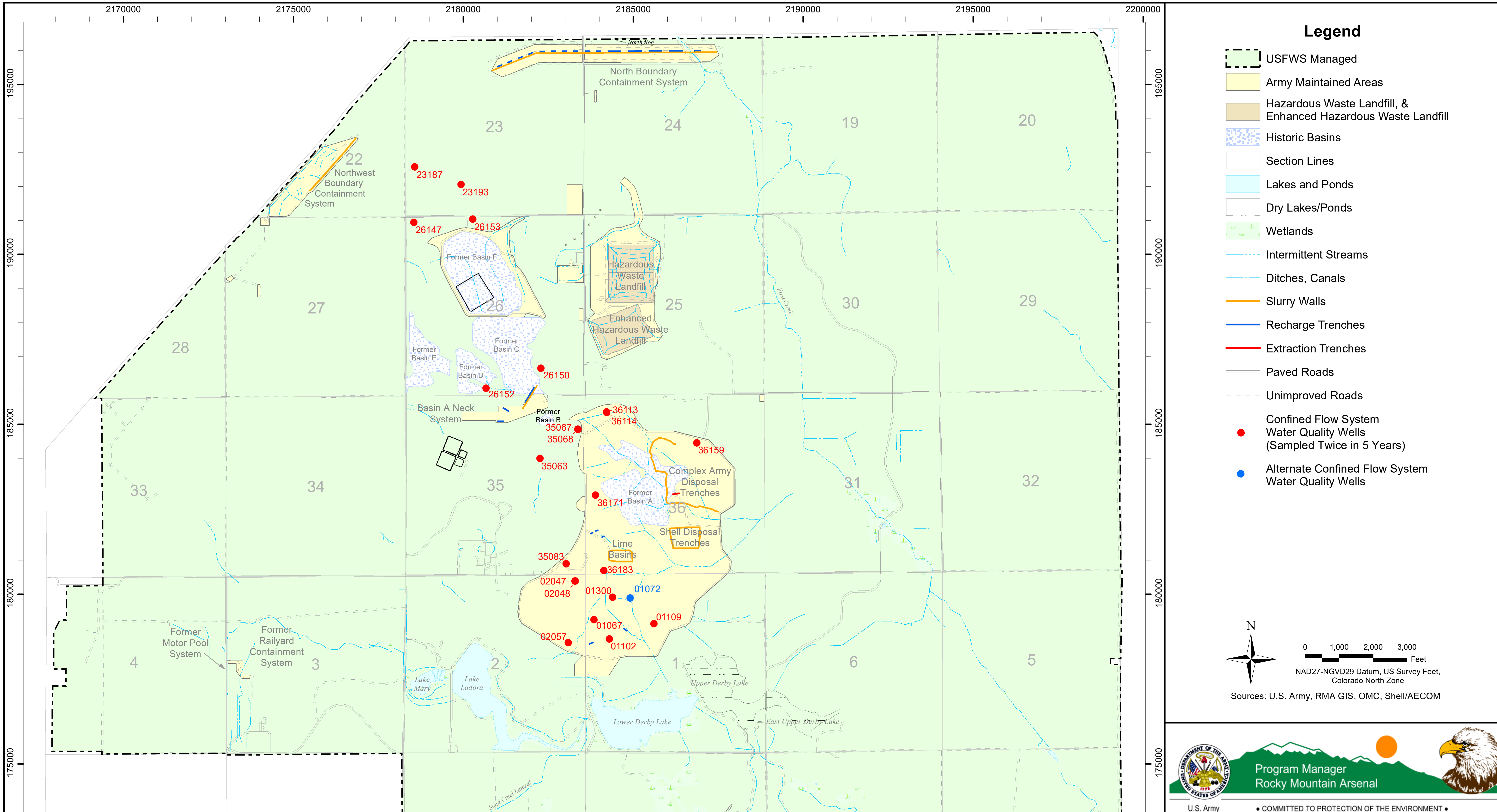
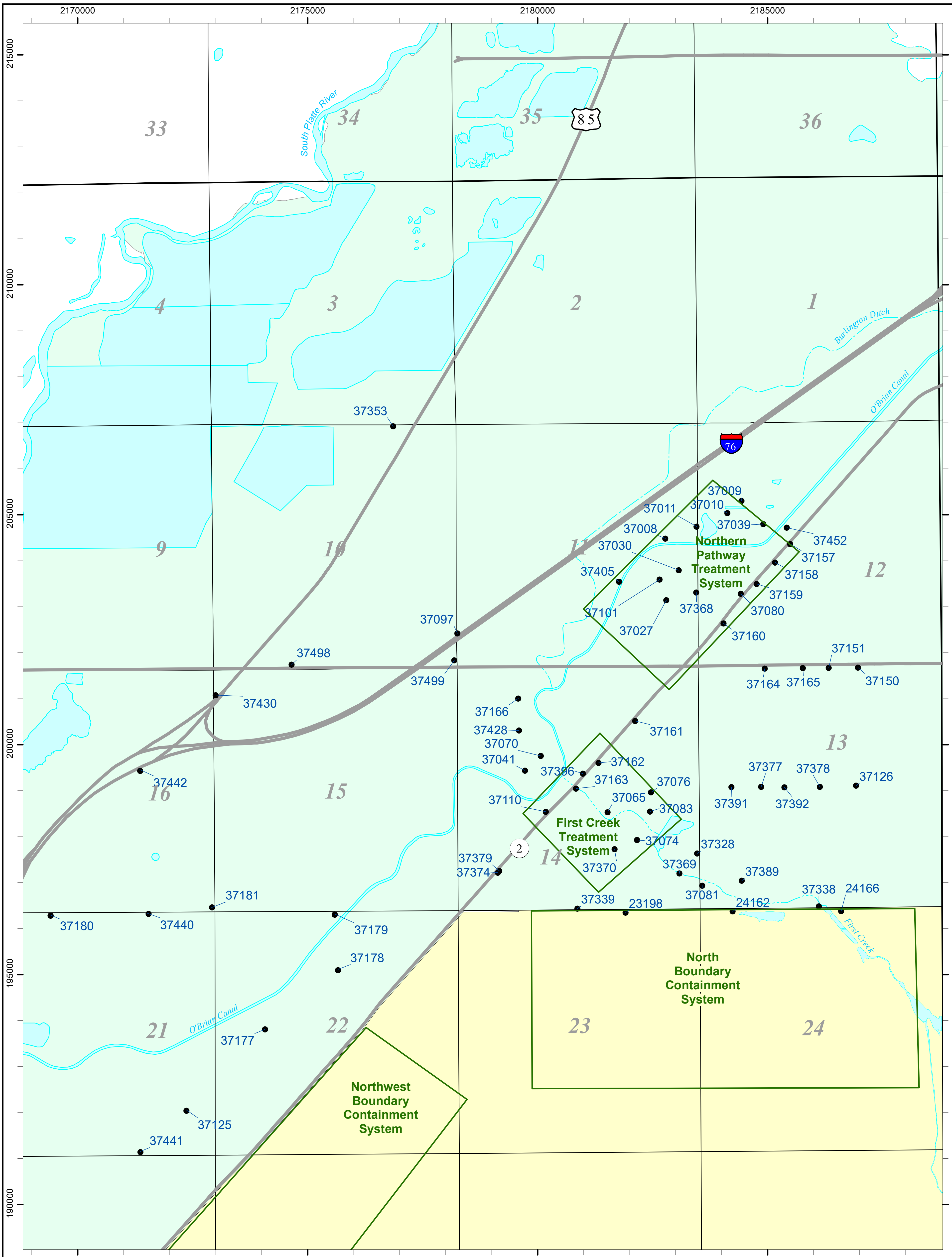


Figure H-3

Confined Flow System
Water Quality Monitoring Network



Legend

- Rocky Mountain Arsenal (On-Post Operable Unit)
- Off-Post Study Area
- Operational Areas
- Lakes, Ponds, Rivers
- Intermittent Streams
- Ditches, Canals
- Primary Roads
- Section Lines
- Township & Range Lines
- CSRG Exceedance Monitoring Wells

N

0 500 1,000 2,000 3,000
Feet

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

Sources: U.S. Army, RMA GIS, OMC, Shell/AECOM

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Figure H-4

Off-Post CSRG Exceedance
Monitoring Network

M:\projects\oars\fy23\mxds\OP_Exceedance_well_fy23.mxd
8/9/2024

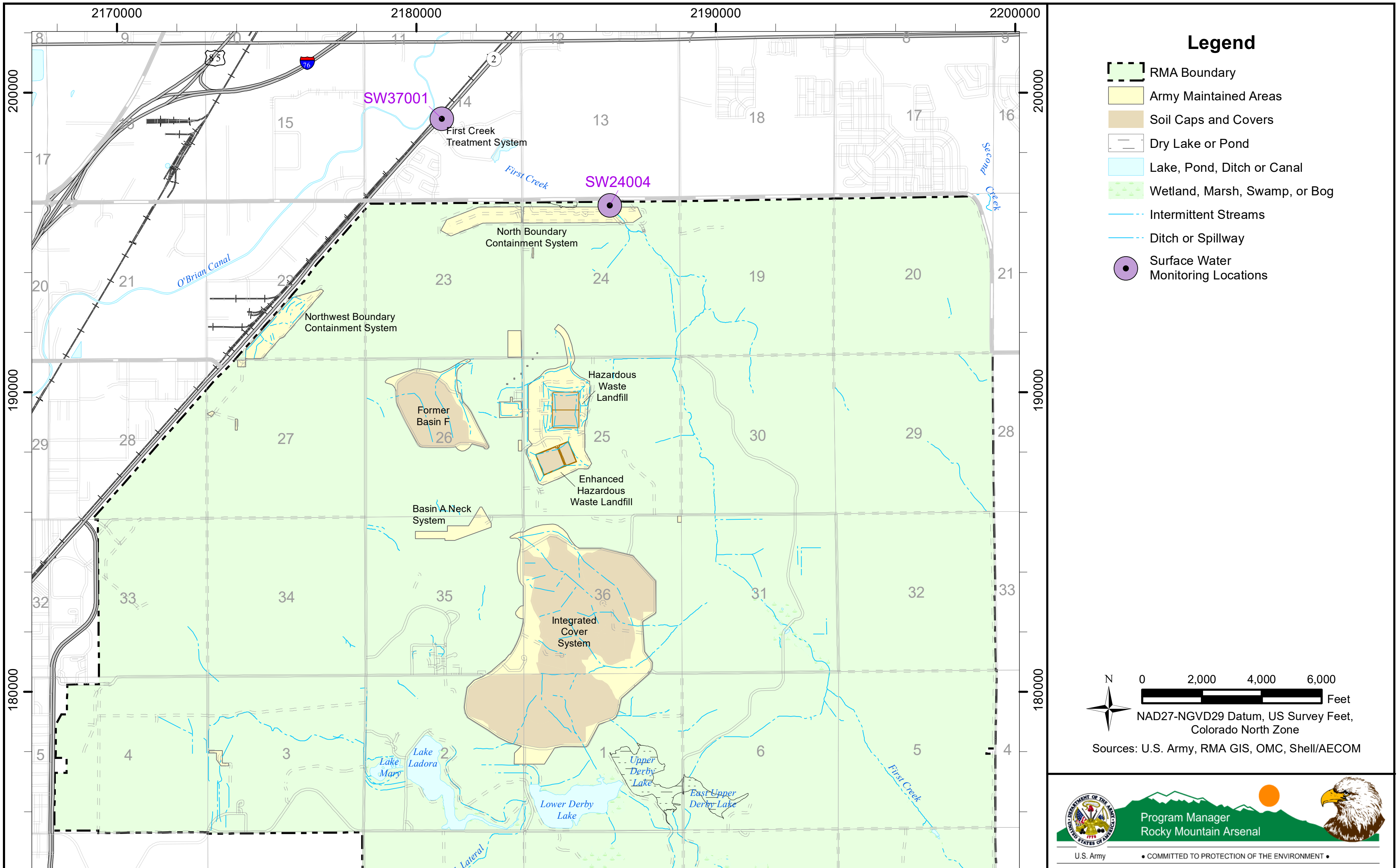

Figure H-5

Off-Post Surface Water Monitoring Locations

M:\projects\oars\fy23\mxds_surf_wat_mon_locs_fy23.mxd
8/9/2024

Appendix I

FY23 Data Quality Assurance/Quality Control

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Appendix I1

System-Specific Quality Assurance Review

APPENDIX I1
SYSTEM-SPECIFIC QUALITY ASSURANCE REVIEW

I1.1 NWBCS QUALITY ASSURANCE REVIEW

The purpose of the data review is to evaluate data quality with respect to the established DQOs. Components of the data review process include: 1) evaluating the data against the data quality indicators precision, bias, representativeness, completeness, sensitivity, and comparability; 2) review of field and laboratory QC results; and 3) evaluating the data for suitability based on the intended use. The data review has determined that the data quality meets or exceeds the established DQOs and is of the correct type, quality, and quantity to support the intended use.

I1.1.1 Precision

A total of 17 duplicate analyses were performed. The review found all investigative/duplicate samples to be comparable. Information related to precision at the NWBCS is included on the attached data CD.

I1.1.2 Accuracy/Bias

The average recovery rate for the 68 FY23 MS and LCS analyses was 96.6 and 96.8 percent, respectively. Recovery rates outside the lower or upper limits were observed in two MS analyses and were observed in two LCS analyses. The recovery rates were observed outside both the MS and LCS evaluation limits for a single analysis. Recovery rates outside the limits for both MS and LCS will be designated with a “Z” data qualifier.

The data are considered acceptable for their intended use and no additional action is considered necessary. The MS and LCS sample results are included on the attached data CD.

I1.1.3 Representativeness

A review of field and laboratory documentation determined that samples were collected and analyzed as specified. Field instruments utilized to collect field measurements were calibrated according to the respective instrument manual and recorded in the Groundwater Sampling Calibration Record database. As a result, the data appropriately reflects the operation of the NWBCS for FY23.

I1.1.4 Completeness

Completeness was calculated at 92 percent. The criterion for the completeness calculation to exceed 90 percent was achieved.

I1.1.5 Comparability

Standard techniques were utilized to collect and analyze samples and the data were reported in the appropriate units. The analytical results reported are equivalent to data obtained from similar analyses and the MRLs met the project goals.

I1.1.6 Sensitivity

Method blank samples were analyzed for each analytical lot. There were 488 method blank analyses for NWBCS lots. There was one detection for methylene chloride above the MRL. The associated lot impacted two NWBCS samples. Both samples were given less than value, so no further action is required. Sensitivity is considered acceptable.

I1.1.7 Field QC Samples

A total of 9 field blank analyses and 13 rinse blank analyses were performed. No field or rinse blanks were detected above the MRL. The data are considered acceptable for their intended use and no additional action is considered necessary. QC sample information is included on the attached data CD.

I1.1.8 Data Usability Evaluation

A data usability evaluation was conducted on 149 records. The evaluation identified no statistical outliers, 34 decreasing analyte concentration trends, and 8 increasing analyte concentration trends. A listing of the identified outliers and trends is included on the attached data CD in the Data Usability subfolder.

The evaluation did not positively identify data quality issues; thus, the data are considered to be of acceptable quality and meets or exceeds the established data quality objectives. The data are of the correct type, quality, and quantity to support the intended use.

I1.2 NBCS QUALITY ASSURANCE SUMMARY

The purpose of the data review is to evaluate data quality with respect to the established DQOs. Components of the data review process include: 1) evaluating the data against the data quality indicators precision, bias, representativeness, completeness, sensitivity, and comparability; 2) review of field and laboratory QC results; and 3) evaluating the data for suitability based on the intended use. The data review has determined that the data quality meets or exceeds the established DQOs and is of the correct type, quality, and quantity to support the intended use.

I1.2.1 Precision

A total of 70 duplicate analyses were performed. All duplicate analysis pair were determined to be comparable. Information related to precision at the NBCS is included on the attached data CD.

I1.2.2 Accuracy/Bias

The average recovery rate for the 258 FY23 MS and LCS analyses was 91.5 and 98.8 percent, respectively. Recovery rates outside the lower or upper limits were observed in two MS analyses and eight LCS analyses. A single recovery was observed outside both the MS and LCS evaluation limits. Recovery rates outside the limits for both MS and LCS will be designated with a “Z” data qualifier.

Analyst comments in the data package for Lot AMBY identified malathion recovery at +25.5% in continuing calibration curve. Malathion was not detected or reported in the associated samples, so no corrective action was required. The data are considered acceptable for their intended use and no additional action in addition to the data qualification is considered necessary. The MS and LCS sample results are included on the attached data CD.

I1.2.3 Representativeness

A review of field and laboratory documentation determined that samples were collected and analyzed as specified. Field instruments utilized to collect field measurements were calibrated according to the respective instrument manual and recorded in the Groundwater Sampling Calibration Record database. As a result, the data appropriately reflects the operation of the NBCS for FY23.

I1.2.4 Completeness

Completeness was calculated at 97 percent. The criterion for the completeness calculation to exceed 90 percent was achieved.

I1.2.5 Comparability

Standard techniques were utilized to collect and analyze samples and the data were reported in the appropriate units. The analytical results reported are equivalent to data obtained from similar analyses and the MRLs met the project goals.

I1.2.6 Sensitivity

Method blank samples were analyzed for each analytical lot. A total of 365 method blank analyses with no detections above the MRL. Sensitivity is considered acceptable.

I1.2.7 Field QC Samples

A total of 32 field blank analyses and 57 rinse blank analyses were performed. There was one field blank and one rinse blank detection above the MRL. The associated investigative analyses do not require data qualification as both were greater than the blank value. The data are considered acceptable for their intended use and no additional action is considered necessary. QC sample information is included on the attached data CD.

I1.2.8 Data Usability Evaluation

A data usability evaluation was conducted on 695 records. The evaluation identified one statistical outliers, 43 decreasing analyte concentration trends, and 37 increasing analyte concentration trends. A listing of the identified outlier and trends is included on the attached data CD in the Data Usability subfolder.

The evaluation did not positively identify data quality issues; thus, the data are considered to be of acceptable quality and meets or exceeds the established data quality objectives. The data are of the correct type, quality, and quantity to support the intended use.

I1.3 BANS QUALITY ASSURANCE SUMMARY

The purpose of the data review is to evaluate data quality with respect to the established DQOs. Components of the data review process include: 1) evaluating the data against the data quality indicators precision, bias, representativeness, completeness, sensitivity, and comparability; 2) reviewing field and laboratory QC results; and 3) evaluating the data for suitability based on the intended use. The data review for BANS includes BRES, CADT, and Lime Basin's data. The data review has determined that the data quality meets or exceeds the established DQOs and is of the correct type, quality, and quantity to support the intended use.

I1.3.1 Precision

A total of 59 duplicate analyses were performed. All duplicate analyses were determined to be comparable. The data are considered acceptable for their intended use and no additional action in addition to the data qualification is considered necessary. Information related to precision at the BANS is included on the attached data CD.

I1.3.2 Accuracy/Bias

The average recovery rate for the 259 FY23 MS and LCS analyses was 90.1 and 96.6 percent, respectively. Recovery rates outside the lower or upper limits were observed in five MS analyses and no LCS analyses. There were no recovery rates observed outside both the MS and LCS evaluation limits.

The data are considered acceptable for their intended use. The MS and LCS sample results are included on the attached data CD.

I1.3.3 Representativeness

A review of field and laboratory documentation determined that samples were collected and analyzed as specified. Field instruments utilized to collect field measurements were calibrated according to the respective instrument manual and recorded in the Groundwater Sampling Calibration Record database. As a result, the data appropriately reflects the operation of the BANS for FY23.

I1.3.4 Completeness

Completeness was calculated at 98 percent. The criterion for the completeness calculation to exceed 90 percent was achieved.

I1.3.5 Comparability

Standard techniques were utilized to collect and analyze samples and the data were reported in the appropriate units. The analytical results reported are equivalent to data obtained from similar analyses and the MRLs met the project goals.

I1.3.6 Sensitivity

Method blank samples were analyzed for each analytical lot. There were 780 method blank analyses for BANS lots with no detections above the MRL. Sensitivity is considered acceptable.

I1.3.7 Field QC Samples

A total of 33 field blank analyses and 40 rinse blank analyses were performed. There was one rinse blank detection above the MRL. The associated investigative analysis does not require data qualification as it was greater than the blank value. The data are considered acceptable for their intended use. QC sample information is included on the attached data CD.

I1.3.8 Data Usability Evaluation

A data usability evaluation was conducted on 1,053 records. The evaluation identified no statistical outliers, 122 decreasing analyte concentration trends, and 60 increasing analyte concentration trends. A listing of the identified outliers and trends is included on the attached data CD in the Data Usability subfolder.

The evaluation did not positively identify data quality issues; thus, the data are considered to be of acceptable quality and meets or exceeds the established data quality objectives. The data are of the correct type, quality, and quantity to support the intended use.

I1.4 FCTS QUALITY ASSURANCE SUMMARY

The purpose of the data review is to evaluate data quality with respect to the established DQOs. Components of the data review process include; 1) evaluating the data against the data quality indicators precision, bias, representativeness, completeness, sensitivity, and comparability; 2) review of field and laboratory QC results; and 3) evaluating the data for suitability based on the intended use. The data review has determined that the data quality meets or exceeds the established DQOs and is of the correct type, quality, and quantity to support the intended use.

I1.4.1 Precision

A total of 43 duplicate analyses were performed. The review found one investigative/duplicate pair to be non-comparable. The non-comparable investigative and duplicate data will be assigned a “Z” data qualifier with the comment “Duplicate and investigative values are not comparable”.

Analyst comments in the associated data package, ALXA, noted multiple analytes had recoveries outside of standard limits in the matrix spike but this was due to matrix interference. The data are considered acceptable for their intended use. Information related to monitoring programs precision is included on the attached data CD.

I1.4.2 Accuracy/Bias

The average recovery rate for the 177 FY23 MS and LCS analyses was 95.8 and 98.05 percent, respectively. Recovery rates outside the lower or upper limits were observed in eight MS analyses and no LCS analyses. There were no recovery rates observed outside both the MS and LCS evaluation limits. The data are considered acceptable for their intended use. MS and LCS sample results are included on the attached data CD.

I1.4.3 Representativeness

A review of field and laboratory documentation determined that samples were collected and analyzed as specified. Field instruments utilized to collect field measurements were calibrated according to the respective instrument manual and recorded in the Groundwater Sampling Calibration Record database. As a result, the data appropriately reflects the operation of the FCTS for FY23.

I1.4.4 Completeness

Completeness was calculated at 96 percent. The criterion for the completeness calculation to exceed 90 percent was achieved.

I1.4.5 Comparability

Standard techniques were utilized to collect and analyze samples and the data were reported in the appropriate units. The analytical results reported are equivalent to data obtained from similar analyses and the MRLs met the project goals.

I1.4.6 Sensitivity

Method blank samples were analyzed for each analytical lot. There were 416 method blank analyses for the monitoring program with no detections above the MRL. Sensitivity is considered acceptable.

I1.4.7 Field QC Samples

A total of 29 field blank and 29 rinse blank samples were collected. There was one field blank detection above the MRL. The associated investigative analysis does not require data qualification as it was below the MRL. The data are considered acceptable for their intended use. QC sample information is included on the attached data CD.

I1.4.8 Data Usability Evaluation

A data usability evaluation was conducted on 416 records. The evaluation identified no statistical outlier, 39 decreasing analyte concentration trends, and 9 increasing analyte concentration trends. A listing of the identified outliers and trends is included on the attached data CD in the Data Usability subfolder.

The evaluation did not positively identify data quality issues; thus, the data are considered to be of acceptable quality and meets or exceeds the established data quality objectives. The data are of the correct type, quality, and quantity to support the intended use.

I1.5 NPTS QUALITY ASSURANCE SUMMARY

The purpose of the data review is to evaluate data quality with respect to the established DQOs. Components of the data review process include; 1) evaluating the data against the data quality indicators precision, bias, representativeness, completeness, sensitivity, and comparability; 2) review of field and laboratory QC results; and 3) evaluating the data for suitability based on the intended use. The data review has determined that the data quality meets or exceeds the established DQOs and is of the correct type, quality, and quantity to support the intended use.

I1.5.1 Precision

A total of 122 duplicate analyses were performed. All duplicate analyses pairs were determined to be comparable. The data are considered acceptable for their intended use. Information related to monitoring programs precision is included on the attached data CD.

I1.5.2 Accuracy/Bias

The average recovery rate for the 307 FY23 MS and LCS analyses was 96.4 and 95.8 percent, respectively. Recovery rates outside the lower or upper limits were observed in seven MS analyses and four LCS analyses. There were no recovery rates observed outside both the MS and LCS evaluation limits. The data are considered acceptable for their intended use. MS and LCS sample results are included on the attached data CD.

I1.5.3 Representativeness

A review of field and laboratory documentation determined that samples were collected and analyzed as specified. Field instruments utilized to collect field measurements were calibrated according to the respective instrument manual and recorded in the Groundwater Sampling Calibration Record database. As a result, the data appropriately reflects the operation of the NPTS for FY23.

I1.5.4 Completeness

Completeness was calculated at 98 percent. The criterion for the completeness calculation to exceed 90 percent was achieved.

I1.5.5 Comparability

Standard techniques were utilized to collect and analyze samples and the data were reported in the appropriate units. The analytical results reported are equivalent to data obtained from similar analyses and the MRLs met the project goals.

I1.5.6 Sensitivity

Method blank samples were analyzed for each analytical lot. There were 511 method blank analyses for the monitoring program. There was one detection for methylene chloride above the MRL. The associated lot impacted four NWBCS samples. All samples were reported at less than value the MRL, so no further action is required. Sensitivity is considered acceptable.

I1.5.7 Field QC Samples

A total of 51 field blank and 66 rinse blank samples were collected. No blanks had detections above the MRL. The data are considered acceptable for their intended use. QC sample information is included on the attached data CD.

I1.5.8 Data Usability Evaluation

A data usability evaluation was conducted on 870 records. The evaluation identified a single statistical outlier, 52 decreasing analyte concentration trends, and 7 increasing analyte concentration trends. A listing of the identified outliers and trends is included on the attached data CD in the Data Usability subfolder.

The evaluation did not positively identify data quality issues; thus, the data are considered to be of acceptable quality and meets or exceeds the established data quality objectives. The data are of the correct type, quality, and quantity to support the intended use.

I1.6 WATER QUALITY TRACKING QUALITY ASSURANCE REVIEW

The purpose of the data review is to evaluate data quality with respect to the DQOs. Components of the data review process include: 1) evaluating the data against the data quality indicators precision, bias, representativeness, completeness, sensitivity, and comparability; 2) reviewing field and laboratory QC results; and 3) evaluating the data for suitability based on the intended use. The data review for post shut off monitoring includes MPS/ICS data. The data review has determined that the data quality meets or exceeds the established DQOs and is of the correct type, quality, and quantity to support the intended use.

I1.6.1 Precision

Due to the limited amount of sampling in this sector, duplicate samples were not collected.

I1.6.2 Accuracy/Bias

The average recovery rate for 13 MS and LCS analysis was 101.46 and 97.2 percent, respectively. Recovery rates outside the lower or upper limits were observed no LCS analyses and no MS analyses. There were no recovery rates observed outside both the MS and LCS evaluation limits. The data are considered acceptable for their intended use. The MS and LCS sample results are included on the attached data CD.

I1.6.3 Representativeness

A review of field and laboratory documentation determined that samples were collected and analyzed as specified. Field instruments utilized to collect field measurements were calibrated according to the respective instrument manual and recorded in the Groundwater Sampling Calibration Record database. As a result, the data appropriately reflects the status of Water Quality Tracking for FY23.

I1.6.4 Completeness

No surface water analyses were rejected. Completeness was calculated at 100 percent. The criterion for the completeness calculation to exceed 90 percent was achieved.

I1.6.5 Comparability

Standard techniques were utilized to collect and analyze samples and the data were reported in the appropriate units. The analytical results reported are equivalent to data obtained from similar analyses and the MRLs met the project goals.

I1.6.6 Sensitivity

Method blank samples were analyzed for each analytical lot. Method blank analyses for the 22 MPS/ICS lots had no detections above the MRL. Sensitivity is considered acceptable.

I1.6.7 Field QC Samples

Due to the limited amount of sampling in this sector, no field QC samples were collected.

I1.6.8 Data Usability Evaluation

A data usability evaluation was conducted on two records. The evaluation identified no statistical outliers or analyte concentration trends. A listing of the data usability evaluation is included on the attached data CD in the Data Usability subfolder.

The evaluation did not positively identify data quality issues; thus, the data are considered to be of acceptable quality and meets or exceeds the established data quality objectives. The data are of the correct type, quality, and quantity to support the intended use.

Appendix I2

Laboratory Codes, Flag Codes, and Chemical Codes

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Laboratory and Organization Codes

Code	Description
AR	Applied Research and Development Laboratory, Inc.
GS	U.S. Geological Survey
NR	Navarro Research and Engineering, Inc.
SA	South Adams County Water and Sanitation District
TO	Tri-County Health Department
WG	URS (formerly Washington Group International)

Flag Codes

Code	Description
@	Value is estimated. To be used only when result is above the reporting limit of the method and the sample cannot be diluted and reanalyzed (i.e., volatile organics in air), and when the LCS, MS, and surrogate results are below the MRL but are "real."
B	Analyte found in blank as well as sample. This flagging code is to be used for analytes which are found and quantitated above the Reporting Limit (RL) or at higher-than-normal background levels in the method blank and also in analytical samples.
D	Duplicate sample or test name. This flagging code is to be used to distinguish analytical results when duplicate analyses are requested. This flagging code should be used for the second (duplicate) sample only.
F	Sample filtered before analysis. This flagging code is to be used when the results of filtered samples are to be differentiated from non-filtered samples, or when (required) filtering of samples is a deviation from the SOP.
G	Analyte found in rinse blank as well as in field sample.
I	Sample results may be biased high or low based on QC results.

Chemical Codes

111TCE 1,1,1-Trichloroethane
112TCE 1,1,2-Trichloroethane
11DCE 1,1-Dichloroethylene
11DCLE 1,1-Dichloroethane
124TCB 1,2,4-Trichlorobenzene
12DCLB 1,2-Dichlorobenzene
12DCLE 1,2-Dichloroethane
12DCLP 1,2-Dichloropropane
12DMB 1,2-Dimethylbenzene
13DCLB 1,3-Dichlorobenzene
14DCLB 1,4-Dichlorobenzene
14DIOX 1,4-Dioxane
245TCP 2,4,5-Trichlorophenol
246TCP 2,4,6-Trichlorophenol
24DCLP 2,4-Dichlorophenol
24DMPN 2,4-Dimethylphenol
24DNP 2,4-Dinitrophenol
24DNT 2,4-Dinitrotoluene
26DNT 2,6-Dinitrotoluene
2CLP 2-Chlorophenol
2CNAP 2-Chloronaphthalene
2MNAP 2-Methylnaphthalene
2MP 2-Methylphenol
2NANIL 2-Nitroaniline
2NP 2-Nitrophenol
33DCBD .... 3,3'-Dichlorobenzidine
34MPH 3,4-Methylphenol
3NANIL 3-Nitroaniline
46DN2C 2-Methyl-4,6-dinitrophenol
4BRPPE .... 4-Bromophenylphenyl ether
4CANIL 4-Chloroaniline
4CL3C 3-Methyl-4-chlorophenol
4CLPPE .... 4-Chlorophenylphenyl ether
4NANIL 4-Nitroaniline
4NP 4-Nitrophenol
ABHC .... alpha-Benzenehexachloride
ACET .... Acetone
ACLDAN .... alpha-Chlordane
ACRYLO .... Acrylonitrile
AENSLF .... alpha-Endosulfan
AG .... Silver
AL .... Aluminum
ALDRN .... Aldrin

ANAPNE	Acenaphthene
ANAPYL	Acenaphthylene
ANTRC	Anthracene
AS	Arsenic
ATZ	Atrazine
B2CEXM	Bis (2-chloroethoxy) methane
B2CIPE	Bis (2-chloroisopropyl) ether
B2CLEE	Bis (2-chloroethyl) ether
B2EHP	Bis (2-ethylhexyl) phthalate
BA	Barium
BAANTR	Benzo[A]anthracene
BAPYR	Benzo[A]pyrene
BBFANT	Benzo[B]fluoranthene
BBHC	beta-Benzenehexachloride
BBZP	Butylbenzyl phthalate
BCHPD	Bicyclo[2,2,1]hepta-2,5-diene
BE	Beryllium
BENSLF	beta-Endosulfan
BGHIPY	Benzo[G,H,I]perylene
BKFANT	Benzo[K]fluoranthene
BRDCLM	Bromodichloromethane
BTZ	Benzothiazole
C12DCE	cis-1,2-Dichloroethylene
C13DCP	cis-1,3-Dichloropropylene
C2H3CL	Chloroethene/Vinyl chloride
C2H5CL	Chloroethane
C6H6	Benzene
CA	Calcium
CCL2F2	Dichlorodifluoromethane
CCL3F	Trichlorofluoromethane
CCL4	Carbon tetrachloride
CD	Cadmium
CH2CL2	Methylene chloride
CH3BR	Bromomethane
CH3CL	Chloromethane
CHBR3	Bromoform
CHCL3	Chloroform
CHRY	Chrysene
CL	Chloride
CL6BZ	Hexachlorobenzene
CL6CP	Hexachlorocyclopentadiene
CL6ET	Hexachloroethane
CLC6H5	Chlorobenzene
CO	Cobalt
CPMS	Chlorophenylmethyl sulfide
CPMSO	Chlorophenylmethyl sulfoxide

CPMSO2 .... Chlorophenylmethyl sulfone
CR .... Chromium
CS2 .... Carbon disulfide
CU .... Copper
DBAHA .... Dibenz[A,H]anthracene
DBCP .... Dibromochloropropane
DBHC .... delta-Benzenehexachloride
DBRCLM .... Dibromochloromethane
DBZFUR .... Dibenzofuran
DCPD .... Dicyclopentadiene
DDVP .... Vapona
DEP .... Diethyl phthalate
DIMP .... Diisopropylmethyl phosphonate
DITH .... Dithiane
DLDRN .... Dieldrin
DMDS .... Dimethyl disulfide
DMMP .... Dimethylmethylphosphate
DMP .... Dimethyl phthalate
DNBP .... Di-N-butyl phthalate
DNOP .... Di-N-octyl phthalate
ENDRN .... Endrin
ENDRNA .... Endrin aldehyde
ENDRNK .... Endrin ketone
ESFSO4 .... Endosulfan sulfate
ETC6H5 .... Ethylbenzene
F .... Fluoride
FANT .... Fluoranthene
FE .... Iron
FLRENE .... Fluorene
GCLDAN .... gamma-Chlordane
HCBD .... Hexachlorobutadiene
HG .... Mercury
HPCL .... Heptachlor
HPCLE .... Heptachlor epoxide
ICDPYR .... Indeno[1,2,3-C,D]pyrene
ISODR .... Isodrin
ISOPHR .... Isophorene
K .... Potassium
LIN .... Lindane
MEC6H5 .... Toluene
MEK .... Methylethyl ketone

MEXCLR .... Methoxychlor
MG .... Magnesium
MIBK .... Methylisobutyl ketone
MLTHN .... Malathion
MN .... Manganese
MNBK .... Methyl-N-butyl ketone
NA .... Sodium
NAP .... Naphthalene
NB .... Nitrobenzene
NI .... Nickel
NDMA or NNDMEA .... n-Nitrosodimethylamine
NNDNPA .... n-Nitrosodi-n-propylamine
NNDPA .... n-Nitrosodiphenylamine
NO3 .... Nitrate
OXAT 1,4-Oxathiane
PB .... Lead
PCP .... Pentachlorophenol
PHANTR .... Phenanthrene
PHENOL .... Phenol
PPDDD .... Dichlorophenyldichloroethane
PPDDE .... Dichlorophenyldichloroethene
PPDDT .... Dichlorophenyltrichloroethane
PRTHN .... Parathion
PYR .... Pyrene
SB .... Antimony
SE .... Selenium
SO4 .... Sulfate
STYR .... Styrene
SULFID .... Sulfide
SUPONA .... Supona
T12DCE trans-1,2-Dichloroethene
T13DCP trans-1,3-Dichloropropene
TCLEA 1,1,2,2-Tetrachloroethane
TCLEE .... Tetrachloroethylene
TL .... Thallium
TOC .... Total organic carbon
TOX .... Total organic halogens
TRCLE .... Trichloroethylene
TXPHEN .... Toxaphene
V .... Vanadium
XYLEN .... Xylenes
ZN .... Zinc

Appendix I3

Statistical Computational Guidelines

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Statistical Computational Guidelines

Note: No stat codes were applied to any data in the FY23 quarterly effluent reports. All other calculations and data reporting procedures still apply whenever applicable.

Effluent water was analyzed at each treatment plant, and the results were monitored for compliance with the containment system remediation goals (CSRGs) or the practical quantitation limits (PQLs) as listed in the Record of Decision in 1996 (as modified). All of the analytical results were printed in the data listings. As described in the preface, a quarterly average was computed for the past four quarters at each plant and then a moving average was calculated and listed in the summary tables for each plant.

1. Generally, specific analytical methods with reporting limits (RLs) less than respective CSRG values were used to analyze specific compounds. Sometimes GC/MS methods, which are typically used to detect general volatile chemicals, also produce results for non-specified analytes, like DBCP. When that occurs, the **G1** stat code is applied to the non-specified data.

Note: All analytical results with values greater than the RL are called "hits" and are included in all computations regardless of the analytical method used.

2. One-half the RL value was used to compute averages for samples with values less than the RL.

3. If there were multiple samples in a given quarter, an average for the quarter was first computed. The moving average was then computed by summing the last four quarterly averages and then dividing by four.

4. Guidelines for computing daily averages for multiple samples taken on the same day:

   a. If multiple samples were taken on the same day, and if all results were "less than the RL," then the lowest RL value was used to compute averages. The higher RL values or duplicate RL values were coded with stat code **G2** and excluded from any computations.

   b. If multiple samples were taken on the same day, and if some results were "less than the RL" and some results were "hits" with values greater than the RL, then both results were used to compute averages (using one-half the RL for samples with values less than the RL).

   c. If multiple samples were taken on the same day, and if there were sample results "less than the RL" where the RL was greater than "hits" from a different method, then the results "less than the RL" were coded with stat code **G3** and excluded from any computations.

d. For multiple hits on the same day, all of the values were used to compute averages. A daily average was first computed and this daily average was then used to compute an average for the quarter.

5. Sample results with a Boolean of "GT" are coded with stat code **G4** and excluded from any computations.
6. Analytical data in the Rocky Mountain Arsenal Environmental Database is subject to updates as a result of continuing quality assurance review. This report reflects the most recent status of analytical data in the database.

Appendix J

FY23 ACHD Off-Post Private Well Sampling Program Report

ERRATA

Page 2, Table 1. The concentration of 1,4-dioxane for well 541A should be 0.288 micrograms per liter (ug/L) and not 1.288 ug/L.

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ADAMS COUNTY
HEALTH DEPARTMENT
Your Health. Our Mission.

November 30, 2023

Scott E. Greene
US Army RMA Committee Coordinator
6550 Gateway Road
Commerce City, Colorado 80022-1748

RE: Private Well Monitoring Program Annual Summary for Fiscal Year 2023

Dear Mr. Greene,

The Adams County Health Department (ACHD) has conducted private well monitoring in select off-post areas of the Rocky Mountain Arsenal (RMA) for the fiscal year 2023 in accordance with Article III, Subsection 1, of the Memorandum of Agreement between the ACHD and the Program Manager for the Rocky Mountain Arsenal (PMRMA) executed on April, 2023. The focus of this year's sampling effort was to identify and sample unconfined wells in the area downgradient from the Northwest Boundary treatment system, Dieldrin Plume and wells along Brighton Road. The area continues to experience significant changes in land use from agricultural to industrial/commercial so numerous historically identified irrigation or other unconfined wells have been removed/closed thus limiting access to water sampling via operating wells.

Please find attached a summary table of the private well sampling effort (Table 1) along with summary information describing new well applications and quarterly private well change of ownership as reported in letters provided to the PMRMA regularly during FY23.

Should you have any questions regarding the information contained herein please feel free to contact me at jchisholm@adcogov.org.

Sincerely,

Joseph Chisholm

Joseph Chisholm
Rocky Mountain Arsenal Field Specialist
Adams County Health Department
(720) 375-1242
jchisholm@adcogov.org

cc: David Connolly, USEPA
Susan Newton, CDPHE
Joseph Chisholm, Adams County Health Department
Scott Ache, Navarro
Kelly Cable, PMP, AECOM
Carol Rieger, PG, Navarro

Table 1: Off-Post Groundwater Private Well Monitoring Results for FY-2023					
Aquifer	**Well ID**	**Date Sampled**	**DIMP (ug/L)**	**1,4-DX (ug/L)**	**Dieldrin (ug/L)**
Alluvial	359C	8/29/2023	<0.5	n/a	n/a
	634A	9/6/2023	<0.5	n/a	<0.00252
	989A	9/7/2023	<0.5	n/a	**0.00943**
	981B	9/12/2023	**2.1**	<0.075	n/a
	541A	9/13/2023	**1.29**	**1.288**	n/a
Arapahoe	1334H	8/29/2023	**0.9**	n/a	n/a
	359D	8/29/2023	**11.9**	n/a	n/a
	983A	9/6/2023	**0.853**	n/a	n/a
	896A	9/7/2023	<0.5	n/a	n/a
	640B	9/12/2023	<0.5	n/a	n/a
	982A	9/12/2023	<0.5	n/a	n/a
Notes	ug/L: micrograms per Liter				
	Sampling locations based on general input from the parties and well owner cooperation.				

Additional Analysis or Detections:

site_id	test_name	boolean	Data	uom	flag_code	anal_meth_no
634A	HPCLE	LT	0.00321	UGL		UH63

Well Notification Area Changes:

The query seeks to identify any changes to existing well status or the permitting of new wells in Township 2.0 S, Range 67.0W, Sections 2, 3, 9, 10, 11, 12, 13, 14, 15 and portions of 1, 4, 16, 21, 22 and 28 and Township 1.0 S, Range 67.0W, portions of sections 34 and 35.

Well 982A contact information has been updated to Rogelio Ronquillo, 10791 Brighton Rd, Henderson, CO 80640.

Well 983A contact information has been updated to Mrs. Rafaela and Mr. Jesus Lopez, 10765 Brighton Road, Brighton, CO 80640.

Well 981B contact information has been updated to Mr. Saul Ronquillo, 10630 Brighton Road, Brighton, CO 80640.

1 Permit change, application, or notice of expiration, in FY2023

- Permit application for monitoring hole – SACWSD

Appendix K

FY23 Annual Well Networks Update Report

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Appendix K

FY23 Annual Well Networks Update Report

The FY23 Annual Well Networks Update Summary includes information on newly installed wells, closed wells, damaged/repaired network wells, and updates to the Rocky Mountain Arsenal Environmental Database (RMAED) wellinfo, wellextra, well_networks_2, and mapfile tables from October 1, 2022 through September 30, 2023.

LTMP WELLS INSTALLED

Lithologic borehole and construction logs are included in this appendix.

Well ID	Applicable OCN or Plan	Date Installed
NWBCS Offpost		
37181	OCN-LTMP-2022-006 Well added to the Off-Post CSRG monitoring network downgradient of NWBCS	3/27/2023

LTMP NETWORK WELLS DAMAGED AND REPAIRED

- Not applicable in FY23.

LTMP NETWORK WELLS CLOSED OR CANCELED

- Not applicable in FY23.

NON-NETWORK WELLS DAMAGED/REPAIRED/CLOSED

- Not applicable in FY23.

LTMP NETWORK WELLS CLOSED OR CANCELED

- Not applicable in FY23.

NETWORK WELLS WITH UPDATED PURPOSES, ANALYTES, OR FREQUENCIES

Changes to well purposes, sampling frequencies, and analytes are managed in the Sampling Plan tab in the web application RMA Water. Changes are justified by LTMP Operational Change Notices, Short-Term Sampling and Analysis Plans, and Water Team agreements. The following RMA Water database tables are updated when changes occur:

- well_networks_2
- well_networks_2_hist
- well_network_purp
- well_network_purp_ hist
- well_networks_analyte
- well_networks_analyte hist
- well_networks_category
- well_networks_category_hist

During FY23, the wells in the following table were updated with additional or revised purposes, sampling frequencies, or analytes in RMAED.

Well ID	Applicable OCN	New Purpose	New Analytes	New Frequency	Date of Update
37030 37101	OCN-LTMP-2023-001 Wells added to the Off-Post CSRG monitoring network downgradient of NWBCS	CSRG Exceedance Network	NPTS CSRG Analyte List, 1-4,Dioxane	Twice in Five Years	5/1/2023
		Off-Post Water Level Network	NA	Annual	
37181	OCN-LTMP-2022-006 Well added to the Off-Post CSRG monitoring network downgradient of NWBCS	CSRG Exceedance Network	Dieldrin	Twice in Five Years	6/14/2023

FIELD BOREHOLE LOG

Site ID: 37181	Page **1** of **3**
Project Name: **NWBCS Off-Post Well Installation**	Diameter of hole (in): **10.5**
Completion depth: **37.2** / Well Installation: Yes ☒ No ☐	Date completed: **3/27/2023**
Equipment and drilling method: **CME-55 hollow-stem auger rig**	
Initial water level (ft): **25 ft (approx.)**	Final water level (ft): **N/A**
Drilling company: **Site Services Drilling** / Driller: **Josh Anderson**	No. Samples: **N/A**
Bit type: **HSA with spade cutterhead** / Sampler type: **N/A**	Diameter (in): **N/A**
Auger Inner/Outer Diameter (in): **6.25/10.13**	Bit Diameter (in): **10.5**
Field Geologist (Name)/Date: **Carol Rieger**	Checked by (Name): **Mike Jones**
Signature: Carol Rieger	Signature:

Lithology Logged: ☐ Core ☒ Cuttings from auger ☐ Cuttings from Cyclone

Depth (ft)	Well Completion	Sample Interval	Recovery (ft/ft)	Blow Count	Soil/Rock Description	Description (USCS Abbreviations, Moisture, Consistency/Density, Munsell Color, Cementation, Texture, Structures, Sorting, Comments, etc.)
0						0-7 ft – Light brown well-graded fine silty sand with clay, dry
2						
4						
6						
7						7-12 ft – Medium brown silty and fine sandy clay, non-plastic, trace moisture
8						
10						

Site ID: **37181**	
Project Name: **NWBCS Off-Post Well Installation**	Page **2** of **3**

Depth (ft)	Well Completion	Sample Interval	Recovery (ft/ft)	Blow Count	Soil/Rock Description	Description (USCS Abbreviations, Moisture, Consistency/Density, Munsell Color, Cementation, Texture, Structures, Sorting, Comments, etc.)
10						
12						12-16 ft – Dark brown silty clay, low plasticity, trace moisture. Note that chemical odor was noticeable beginning at 15-16 ft bgs.
14						
16						16-20 ft – Medium brown clayey sand with gravel and cobbles, trace moisture. Note trace chemical odor.
18						
20						20-25 ft – Medium brown coarse sand and gravel, unconsolidated/loose, trace moisture. No odor at 25 ft bgs.
22						
24						
26						25-36 ft – Medium brown coarse sand and gravel, unconsolidated/loose, wet; cobbles more abundant at 32-36 ft bgs. No odor.
28						

Site ID: **37181**

Project Name: **NWBCS Off-Post Well Installation**

Depth (ft)	Well Completion	Sample Interval	Recovery (ft/ft)	Blow Count	Soil/Rock Description	Description (USCS Abbreviations, Moisture, Consistency/Density, Munsell Color, Cementation, Texture, Structures, Sorting, Comments, etc.)
28						25-36 ft – Medium brown coarse sand and gravel, unconsolidated/loose, wet; cobbles more abundant at 32-36 ft bgs
30						
32						
34						
36						36-37.2 ft – Collected core for 1.2 feet, blow count = 92 36-36.9 – Same as 25-36 ft bgs
38						36.9-37.2 – Dark gray-brown clay/claystone, with orange oxidation, dense, dry; WEATHERED BEDROCK Depth to water = 25 ft bgs Weathered Bedrock = 36.9 ft bgs Total borehole depth = 37.2 ft bgs
40						
42						
44						
46						

WELL CONSTRUCTION LOG

Well No.: 37181

Project Name: **NWBCS Off-Post Well Installation**

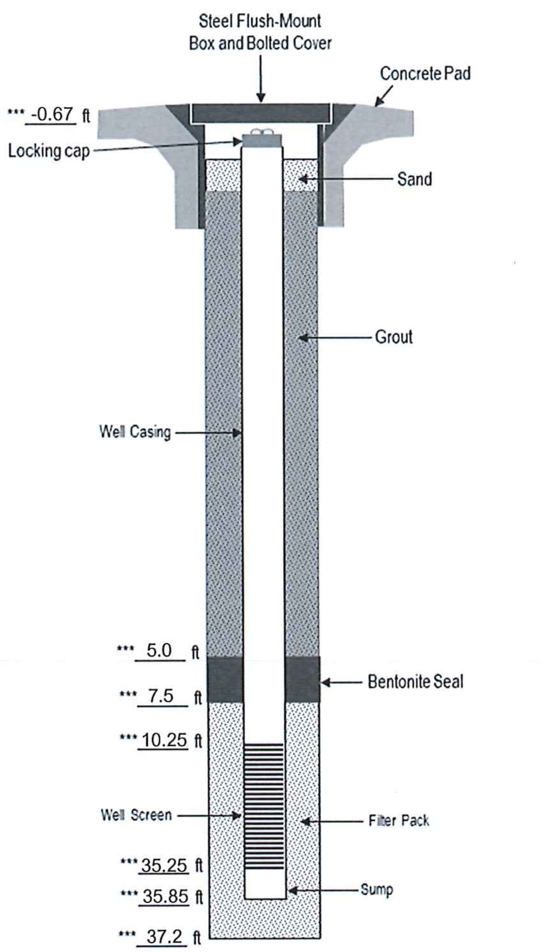
Date: **3/27/2023**

Field Geologist (Name): **Carol Rieger**

QA Checked by (Name): **Mike Jones**

Signature: Carol Rieger

Signature:



* Water added to aid drilling

** Water added during well construction OTHER THAN for grout or bentonite

*** Feet below ground surface

Measuring point is from ground surface unless otherwise noted.

Drilling Summary

Total depth (ft): **37.2**

Borehole diameter (in): **10.5**

Drilling company: **Site Services Drilling**

Driller: **Josh Anderson**

Rig type: **CME-55 hollow-stem auger rig**

Drilling Method

- ☒ Hollow-stem auger
- ☐ Air rotary
- ☐ Air rotary/driven casing
- ☐ Mud rotary
- ☐ Other (describe):

Drilling water (if applicable)* (gal): **0**

Well Construction Details

Grout Quantity (gal): **5**	Type: **Bentonite cement**	
Filter Pack (# bags): **14**	Sand type: **Colorado Silica 10/20**	
Bentonite: **2 bags**	Size: **crumbles**	Type: **CETCO**

Construction water** (gal): **2**

Depths

Measured internal well depth (ft): **35.85, below ground surface**

Stick-up (ft): **-0.67, below ground surface**

Screen and Casing

Screen Length (ft): **25**	Casing Length (ft): **9.58**
I.D. (in): **4.0**	O.D. (in): **4.5 (5.5 w/pre-packed screen)**

Slot size: **0.010**

Screen Type: **Schedule 40 PVC – slotted, pre-packed**

Casing Schedule: **40 PVC**

Initial water level (ft TOC): **27.23**

Comments: Well bottom end cap is 0.6 ft in length. Well screen pre-packed with 10/20 silica sand in five 5-ft lengths.