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DEPARTMENT OF ENERGY
Environmental Management Los Alamos Field Office (EM-LA)
Los Alamos, New Mexico 87544

EMLA-2022-BF118-02-001

June 30, 2022

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NMED Hazardous Waste Bureau

Mr. Rick Shean
Bureau Chief
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505-6313

Subject: Submittal of the Annual Progress Report on Chromium Plume Control Interim Measure Performance, July 2021 through March 2022

Dear Mr. Shean:

Enclosed please find two hard copies with electronic files of the "Annual Progress Report on Chromium Plume Control Interim Measure Performance, July 2021 through March 2022." This progress report presents data and results from July 2021 through March 2022 and provides information on operations during the period, data from performance monitoring wells, and information pertaining to longer-term changes in the hydraulics and water-table structure in response to the interim measure (IM). This progress report is being submitted to fulfill fiscal year 2022 Milestone 3 in Appendix B of the 2016 Compliance Order on Consent (Consent Order).

If you have any questions, please contact Vicky Freedman at (505) 546-1679 (vicky.freedman@em-la.doe.gov) or Cheryl Rodriguez at (505) 414-0450 (cheryl.rodriguez@em.doe.gov).

Sincerely,

ARTURO DURAN

Digitally signed by ARTURO DURAN
Date: 2022.06.29 16:08:45 -06'00'

Arturo Q. Duran
Compliance and Permitting Manager
U.S. Department of Energy
Environmental Management
Los Alamos Field Office

Enclosures:

1. Two hard copies with electronic files – Annual Progress Report on Chromium Plume Control Interim Measure Performance, July 2021 through March 2022 (EM2022-0355)

cc (letter with hard-copy enclosure[s]):
Cheryl Rodriguez, EM-LA

cc (letter with CD/DVD enclosure[s]):
Laurie King, EPA Region 6, Dallas, TX
Raymond Martinez, San Ildefonso Pueblo, NM
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June 2022
EM2022-0355

Annual Progress Report on Chromium Plume Control Interim Measure Performance, July 2021 through March 2022

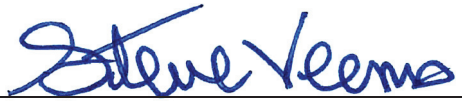
N3B Los Alamos

EM2022-0355

Annual Progress Report on Chromium Plume Control Interim Measure Performance, July 2021 through March 2022

June 2022

Responsible program director:

Steve Veenis		Program Director	Water Program	6/21/22
Printed Name	Signature	Title	Organization	Date

Responsible N3B representative:

Troy Thomson		Program Manager	N3B Environmental Remediation Program	6/22/22
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CONTENTS

1.0 INTRODUCTION 1
2.0 INTERIM MEASURE OPERATIONS 1
2.1 Operations and Testing 1
2.1.1 System Operations 2
2.1.2 Routine and Nonroutine Activities 2
2.1.3 Chromium Mass Removal 2
3.0 PERFORMANCE MONITORING RESULTS 2
3.1 Sampling 2
3.2 Monitoring Results 3
3.3 Water-Table Map 3
4.0 DISCUSSION 5
5.0 RECOMMENDATIONS 5
6.0 REFERENCES AND MAP DATA SOURCES 5
6.1 References 5
6.2 Map Data Sources 5

Figures

Figure 1.0-1 Chromium project area map 7
Figure 2.1-2 Injection well flow rates and water levels for CrIN-1, CrIN-2, CrIN-3, CrIN-4, and CrIN-5 from July 1, 2021, through March 31, 2022 10
Figure 3.2-1 Time-series plots for R-11 13
Figure 3.2-2 Time-series plots for R-35a (deeper R-35 location) 14
Figure 3.2-3 Time-series plots for R-35b (shallower R-35 location) 15
Figure 3.2-4 Time-series plots for R-44 screen 1 16
Figure 3.2-5 Time-series plots for R-44 screen 2 17
Figure 3.2-6 Time-series plots for R-45 screen 1 18
Figure 3.2-7 Time-series plots for R-45 screen 2 19
Figure 3.2-8 Time-series plots for R-50 screen 1 20
Figure 3.2-9 Time-series plots for R-50 screen 2 21
Figure 3.2-10 Time-series plots for R-61 screen 1 22
Figure 3.2-11 Time-series plots for SIMR-2 23
Figure 3.2-12 Time-series plots for R-70 screen 1 24
Figure 3.2-13 Time-series plots for R-70 screen 2 25
Figure 3.2-14 Time-series plots for CrPZ-1 26
Figure 3.2-15 Time-series plots for CrPZ-2a 27
Figure 3.2-16 Time-series plots for CrPZ-3 28
Figure 3.2-17 Time-series plots for CrPZ-4 29
Figure 3.2-18 Time-series plots for CrPZ-5 30
Figure 3.2-19 Time-series plots for CrEX-1 31

Figure 3.2-20 Time-series plots for CrEX-2 32
Figure 3.2-21 Time-series plots for CrEX-3 33
Figure 3.2-22 Time-series plots for CrEX-4 34
Figure 3.2-23 Time-series plots for CrEX-5 35
Figure 3.2-24 Time-series plots of tracer detections for R-50 screen 1 36
Figure 3.2-25 Time-series plots of tracer detections for R-44 screen 1 36
Figure 3.3-1 Baseline water table for May 1, 2020 37
Figure 3.3-2 Water table for June 15, 2021 38
Figure 3.3-3 Water table for November 1, 2021 39

Tables

Table 2.1-1 Operations and Maintenance Activity Summary 41
Table 2.1-2 Quarterly Injection Well Treated Water Total Volumes 45
Table 2.1-3 Interim Measure Chromium Mass Removal Estimates 46
Table 3.1-1 Performance Monitoring Locations and Analyte Suites, Including Tracers that Have Been or Will Be Deployed in Monitoring Wells, Piezometers, and Injection Wells in the Project Area 47

Appendices

Appendix A Analytical Water Quality Data Collected under the Interim Facility-Wide Groundwater Monitoring Plan (on CD included with this document)

Appendix B Analytical Water Quality Data Collected from Chromium Treatment Unit Influent and Effluent (on CD included with this document)

Appendix C Chromium Interim Measure Extraction and Injection Flow Data (on CD included with this document)

Appendix D Los Alamos County Well Pumping Data (on CD included with this document)

1.0 INTRODUCTION

This progress report on the chromium plume control interim measure (IM) performance builds upon previous IM performance progress reports by providing information on IM activities, as well as results from July 2021 through March 2022. It also includes some descriptions of groundwater chemistry in plume locations as early as 2009 and continuing through early IM startup phases performed in late 2016 and early 2017. This report fulfills the reporting requirements in the April 2018 “Chromium Plume Control Interim Measure Performance Monitoring Work Plan” (LANL 2018, 603010). The monitoring is conducted to evaluate performance of the IM conducted under the May 2015 “Interim Measures Work Plan for Chromium Plume Control” (LANL 2015, 600458) and Appendix C of the June 2016 Compliance Order on Consent (Consent Order).The primary objective of the IM is to prevent migration of the plume beyond the Los Alamos National Laboratory (LANL or the Laboratory) boundary. Meeting this objective entailed reduction of chromium concentrations to 50 µg/L or less (the New Mexico Water Quality Control Commission groundwater standard) at monitoring well R-50. This objective was achieved over an operational period of approximately 3 yr.

The IM was also designed to control eastward migration of the plume. Results from eastern area operations are currently being evaluated and will be documented in the future. New monitoring wells in the southern and eastern areas are expected to further enhance analysis.

IM operations during this reporting period included pumping from five chromium plume extraction wells, CrEX-1, CrEX-2, CrEX-3, CrEX-4, and CrEX-5; treatment with ion exchange (IX) to remove chromium; and injection of treated water into five injection wells, CrIN-1, CrIN-2, CrIN-3, CrIN-4, and CrIN-5 (Figure 1.0-1). The operational configuration varied during the reporting period, and wells were taken offline and brought online for various reasons, as described in section 2.1 of this progress report.

The progress report provides supporting data in the following appendices (on CD included with this document):

- Appendix A provides analytical water quality data collected under the Interim Facility-Wide Groundwater Monitoring Plan for the period of record updated with this progress report (July 2021 through March 2022).
- Appendix B provides analytical water quality data collected from the chromium treatment units’ influent and effluent streams for the full period of operation of these units (starting in 2016).
- Appendix C provides chromium IM extraction and injection flow data for the period of record updated with this progress report (July 2021 through March 2022).
- Appendix D provides Los Alamos County well pumping data for the period of record updated with this progress report (July 2021 through March 2022).

2.0 INTERIM MEASURE OPERATIONS

This section provides a discussion of IM operations.

2.1 Operations and Testing

Table 2.1-1 presents significant operational and maintenance activities from July 2021 through March 2022.

Figure 2.1-1 provides flow rates for the CrEX wells. Figure 2.1-2 provides injection well flow rates and water levels. Table 2.1-2 presents quarterly injection well treated total water volumes.

2.1.1 System Operations

Table 2.1-1 presents the specific operation of each extraction and injection well and chromium treatment unit (CTUA and CTUC), as well as shutdowns that may have occurred during the period.

2.1.2 Routine and Nonroutine Activities

Table 2.1-1 also describes additional activities, including major maintenance and IX vessel changeouts.

2.1.3 Chromium Mass Removal

Although mass removal rates and efficiency are not directly related to IM performance, they may provide insights into observed plume response. Table 2.1-3 presents estimates for chromium mass removal for the IM to date.

3.0 PERFORMANCE MONITORING RESULTS

The “Interim Measures Work Plan for Chromium Plume Control” states that performance monitoring will be conducted to evaluate plume response associated with IM operations and to guide adjustments in operational strategies (LANL 2015, 600458). Water quality results and water level data are presented in this section.

3.1 Sampling

The following monitoring wells are sampled monthly for performance monitoring of the IM:

- R-11
- R-35a and R-35b
- R-44 screens 1 and 2
- R-45 screens 1 and 2
- R-50 screens 1 and 2
- R-61 screen 1
- R-70 screens 1 and 2
- SIMR-2

Five piezometers located within the chromium plume area (CrPZ-1, CrPZ-2a, CrPZ-3, CrPZ-4, and CrPZ-5) are sampled quarterly. The piezometers were incorporated under the “Interim Facility-Wide Groundwater Monitoring Plan for the 2022 Monitoring Year, October 2021–September 2022” (N3B 2021, 701449). Prior to October 1, 2021, the piezometer data was considered screening-level.

Figure 1.0-1 shows the locations of the wells and piezometers in the chromium project area.

A monthly sampling and analysis is conducted for the performance monitoring wells listed in Table 3.1-1. A quarterly frequency is employed for the piezometers. Low-level tritium analysis is conducted on a quarterly or semiannual basis. Table 3.1-1 provides a description of analytes and suites for the IM performance-monitoring wells and piezometers and presents the sampling frequency for each constituent or suite category.

3.2 Monitoring Results

Time-series plots for the performance-monitoring wells and piezometers are provided as Figures 3.2-1 through 3.2-18. Plots with data from extraction wells are also included as Figures 3.2-19 through 3.2-23. Figures 3.2-24 through 3.2-25 provide tracer chemistry results for a few wells related to recent tracer tests.

The date of the first data shown for the plots varies based on the period in which data are available for each well. For this progress report, plots generally begin in 2009, although the starting date is more recent for wells that were more recently constructed. Timeframes for plots that focus upon tracer detections and activity are generally curtailed to highlight relevant activity. Similarly, the starting date is adjusted latter for tracer test figures. For each performance-monitoring well or piezometer, two plots are provided that include a subset of key constituents—perchlorate, nitrate, sulfate, tritium, and chloride—which are found within the chromium plume and exhibit trends related to the area or the IM. Each plot also shows the hydrograph of water levels for the well for context. A full data set from the performance-monitoring wells for the period of record updated with this progress report is provided as Appendix A (on CD included with this document).

The time-series plots provide timelines for the approximate startups of eastern and southern portions of the IM system injection. The start of the southern injection in January 2017 represents the significant startup for CrIN-4 and CrIN-5. The start of the eastern injection in November 2019 represents the significant startups of CrIN-1 and CrIN-2. The CrIN-3 startup in late 2017 is not portrayed in the plots. The essential mission critical activities (EMCA) work pause (due to COVID-19 restrictions) is also approximated in the plots.

3.3 Water-Table Map

Water-table maps are presented as an additional line of evidence in evaluating IM performance and in interpreting potential changes in concentrations of key constituents in performance-monitoring wells and piezometers. Long-term pumping and injection at IM infrastructure wells may affect the structure of the water table over time in the form of drawdown around extraction wells and mounding around injection wells. The relationship between changes in the water table, chromium concentrations, and tracer breakthrough provides insights into overall IM performance.

For this progress report, three water-table maps are provided. Figure 3.3-1 depicts a baseline case (May 1, 2020) when the IM was paused for several months beginning on March 25, 2020. Figures 3.3-2 and 3.3-3 depict two time points (June 15 and November 1, 2021) representing the water level condition immediately preceding and during this progress report's focus period, respectively. The potentiometric water level contours are based on synoptic data sets (i.e., measurements taken as close as possible in time to one another). The water level data used for each map is the first groundwater level measurement taken on each day, which is typically at 1:00 or 1:01 a.m. Where multiple screens are present, only the upper screen data are used. The only shallow (water table) screen data point intentionally excluded from use in the data set is R-36, given the uncertainty in its water level measurements.

Regional aquifer surface contours were drawn by hand using the three-point method as described by U.S. Environmental Protection Agency guidance (https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=287064&Lab=NRMRL). In this method, adjacent wells are grouped into triplets, and a gradient vector is calculated for each set of triplets using the method of Heath (https://pubs.usgs.gov/wsp/2220/report.pdf). This method assumes that

- the water table surface is planar,
- flow is mostly horizontal, and
- there is no pumping or injection within a triplet.

Since these assumptions are not always appropriate, some interpretation is necessary to produce a realistic potentiometric surface.

The baseline potentiometric surface (May 1, 2020) represents a time period when no pumping or injection was taking place, and that was over 1 month after shutdown to allow for recovery. This map demonstrates a dominant west-to-east hydraulic gradient. In the region upgradient of the chromium plume (i.e., west of wells R-61 and CrPZ-5), the hydraulic gradient is approximately 10× to 100× steeper than it is within the chromium plume area. Within the area of the IM wells, the water table is at elevations between 5831 and 5833 feet above mean sea level (ft amsl).

The synoptic water table map for June 15, 2021, shows a time when the IM was being operated approximately as follows:

- CrEX-1, CrEX-2, CrEX-4, and CrEX-5 were pumping at rates from 60 to 70 gallons per minute (gpm).
- CrEX-3 was pumping at 22 gpm.
- CrIN-1, CrIN-2, CrIN-4, and CrIN-5 were injecting at rates from 55 to 65 gpm.
- CrIN-3 was injecting at 31 gpm.

This map is similar to the baseline map in the upgradient portion. Water table elevations have not changed significantly, and the hydraulic gradient is similarly steep to the west of wells R-61, CrPZ-5, and R-62. In the chromium plume area, changes to the potentiometric surface relative to baseline are evident. Well data suggest a cone of depression encompassing CrEX-2 and CrEX-4, with an elevation below 5830 ft amsl. Additionally, hydraulic gradients have reversed in the vicinity of CrEX-1, CrEX-3, and CrEX-5. The approximate location of the 5830.5-ft contour suggests that a moderate ridge of groundwater has developed approximately in line with the injection wells.

The synoptic water table on November 1, 2021, appears overall similar to that of the June 15 water table. The only differences in system operation between these two maps are that in November, CrEX-1 and CrIN-3 were off, and CrEX-3 was operating at around 12 gpm rather than at about 22 gpm. Generally, the two most prominent features of the June water table map—the cone of depression around CrEX-2 and CrEX-4 and the ridge near the CrIN wells—are still present on November 1. Relative to the June map, the cone of depression encompassing CrEX-2 and CrEX-4 is slightly lower at approximately 5829 ft amsl. The ridge along the CrIN wells is outlined by the 5830-ft contour. One apparent change between the June and November maps is the presence of a closed 5830-ft contour around R-70 and R-35b. This closed contour is based on a head measurement of 5829.96 ft amsl at R-45.

4.0 DISCUSSION

This progress report is intended to be a compilation of data collected during the reporting period. For a discussion of the interpretation of these data and other information for the purpose of prioritizing future data collection activities, see the Consent Order milestone titled Chromium Interim Measures and Characterization Work Plan, due to the New Mexico Environment Department (NMED) by September 30, 2022. This document is currently being prepared.

5.0 RECOMMENDATIONS

This progress report presents information that is useful for future decision-making on IM operations and data needs. The Consent Order milestone titled Chromium Interim Measures and Characterization Work Plan, due to NMED by September 30, 2022, will provide recommendations on future data collection needs and prioritization based on an analysis of data gaps. This document is currently being prepared.

6.0 REFERENCES AND MAP DATA SOURCES

6.1 References

The following reference list includes documents cited in this report. Parenthetical information following each reference provides the author(s), publication date, and ERID, ESHID, or EMID. ERIDs were assigned by Los Alamos National Laboratory's (the Laboratory's) Associate Directorate for Environmental Management (IDs through 599999); ESHIDs were assigned by the Laboratory's Associate Directorate for Environment, Safety, and Health (IDs 600000 through 699999); and EMIDs are assigned by N3B (IDs 700000 and above).

LANL (Los Alamos National Laboratory), May 2015. "Interim Measures Work Plan for Chromium Plume Control," Los Alamos National Laboratory document LA-UR-15-23126, Los Alamos, New Mexico. (LANL 2015, 600458)

LANL (Los Alamos National Laboratory), April 2018. "Chromium Plume Control Interim Measure Performance Monitoring Work Plan," Los Alamos National Laboratory document LA-UR-18-23082, Los Alamos, New Mexico. (LANL 2018, 603010)

N3B (Newport News Nuclear BWXT-Los Alamos, LLC), May 2021. "Interim Facility-Wide Groundwater Monitoring Plan for the 2022 Monitoring Year, October 2021–September 2022," Newport News Nuclear BWXT-Los Alamos, LLC, document EM2021-0131, Los Alamos, New Mexico. (N3B 2021, 701449)

6.2 Map Data Sources

Hillshade; Los Alamos National Laboratory, ER-ES, As published; \\slip\gis\Data\HYP\LiDAR\2014\Bare_Earth\BareEarth_DEM_Mosaic.gdb; 2014.

Unpaved roads; Los Alamos National Laboratory, ER-ES, As published, GIS projects folder; \\slip\gis\GIS\Projects\14-Projects\14-0062\project_data.gdb\digitized_site_features\digitized_roads; 2017.

Drainage channel; Los Alamos National Laboratory, ER-ES, As published, GIS projects folder; \\slip\gis\GIS\Projects\15-Projects\15-0080\project_data.gdb\correct_drainage; 2017.

Structures; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 29 November 2010.

Paved Road Arcs; Los Alamos National Laboratory, FWO Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 29 November 2010.

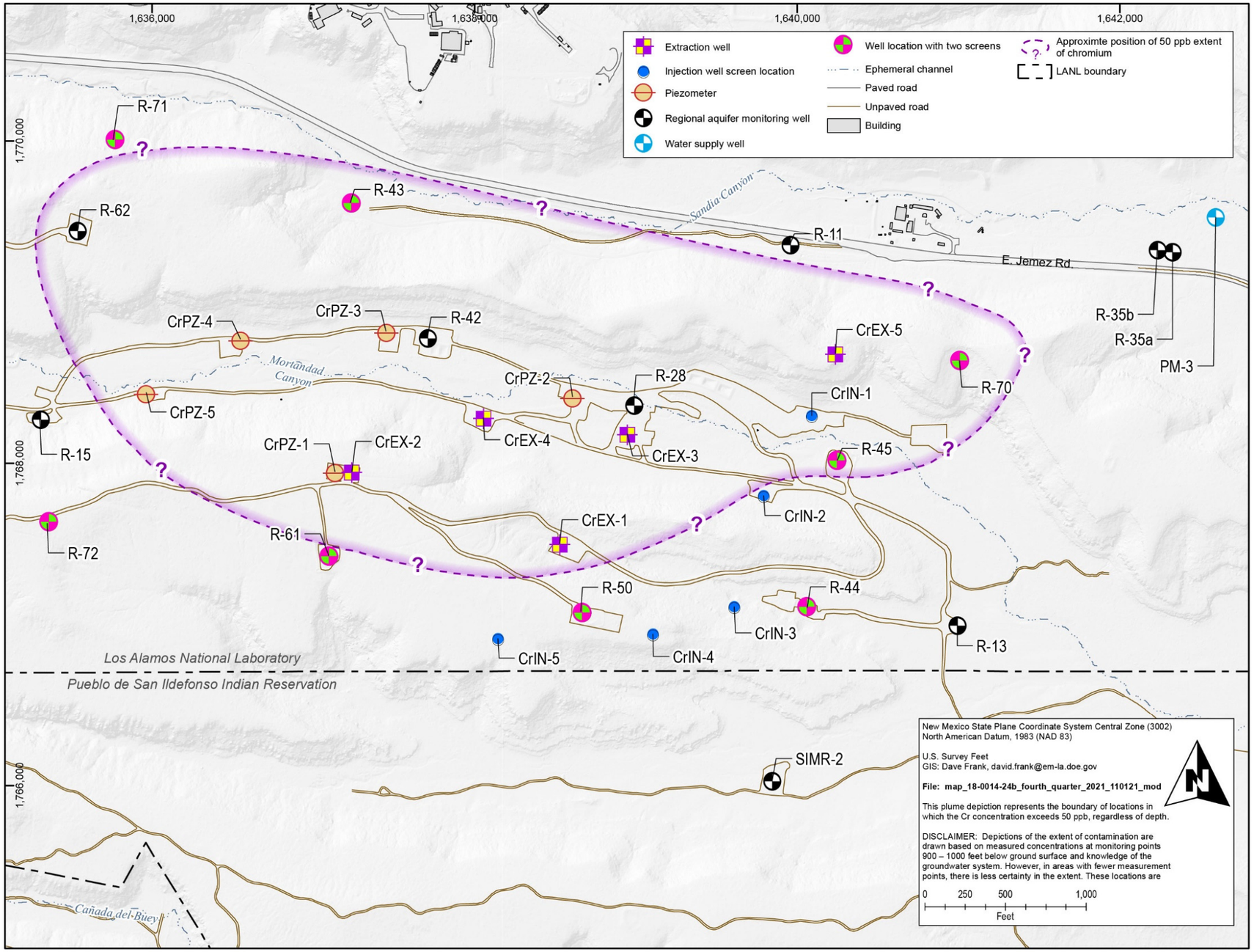
Chromium plume > 50 ppb; Los Alamos National Laboratory, ER-ES, As published; \\slip\gis\GIS\Projects\13-Projects\13-0065\shp\chromium_plume_2.shp; 2018.

Regional groundwater contour May 2017, 4-ft interval; Los Alamos National Laboratory, ER-ES, As published; \\slip\gis\GIS\Projects\16-Projects\16-0027\project_data.gdb\line\contour_wl2017may_2ft; 2017.

Regional groundwater contour November 2017, 2-ft interval; Los Alamos National Laboratory, ER-ES, As published; \\slip\gis\GIS\Projects\16-Projects\16-0027\project_data.gdb\line\contour_wl2017nov_2ft; 2017.

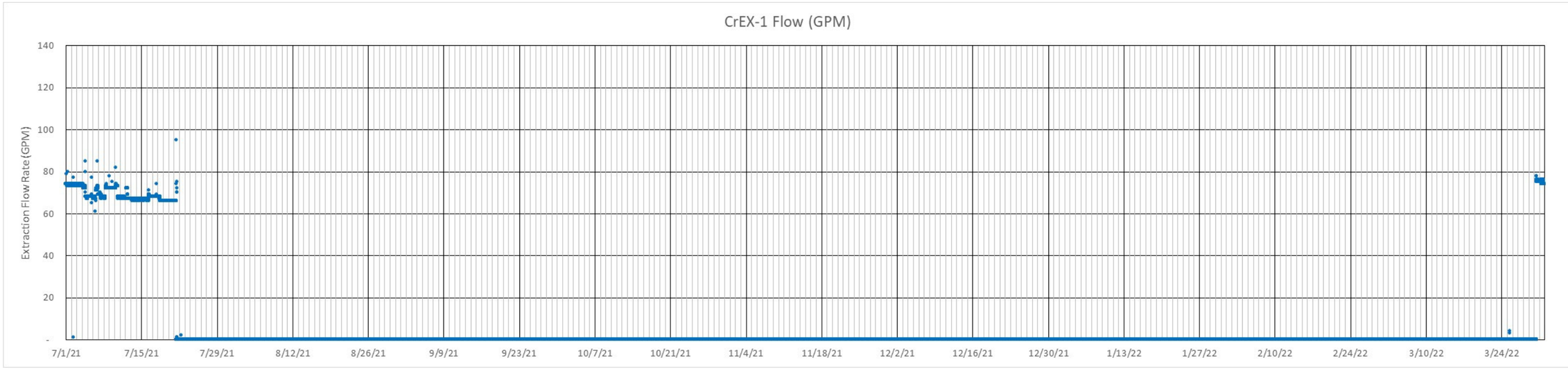
Point features; As published; EIM data pull; 2017.

Technical Area Boundaries; Los Alamos National Laboratory, Site Planning & Project Initiation Group, Infrastructure Planning Office; September 2007; as published 13 August 2010



Note: Initial reportable sampling for new wells R-71 and R-72 occurred during this document's reporting period.

Figure 1.0-1 Chromium project area map



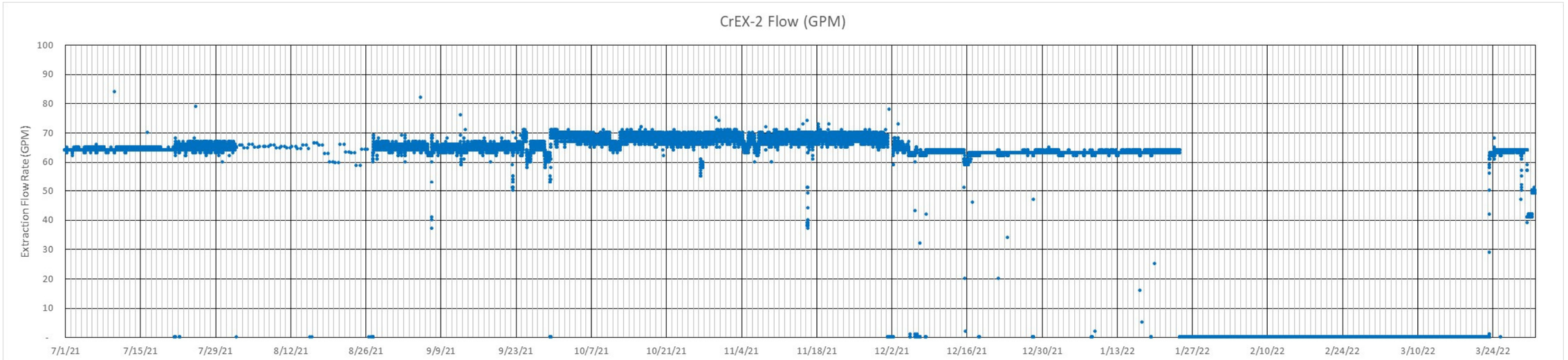
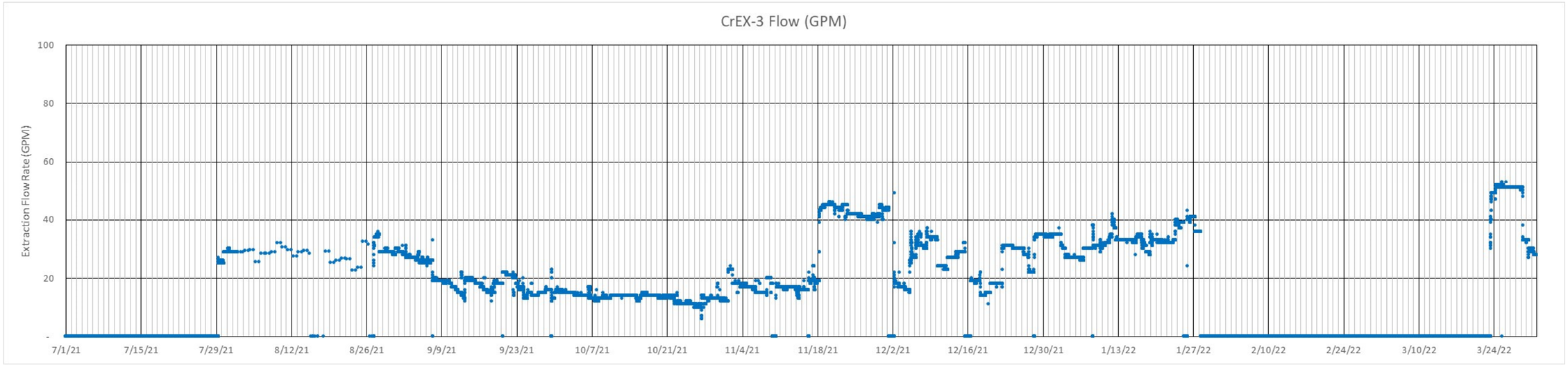


Figure 2.1-1 Flow rates for the CrEX wells for July 1, 2021, through March 31, 2022



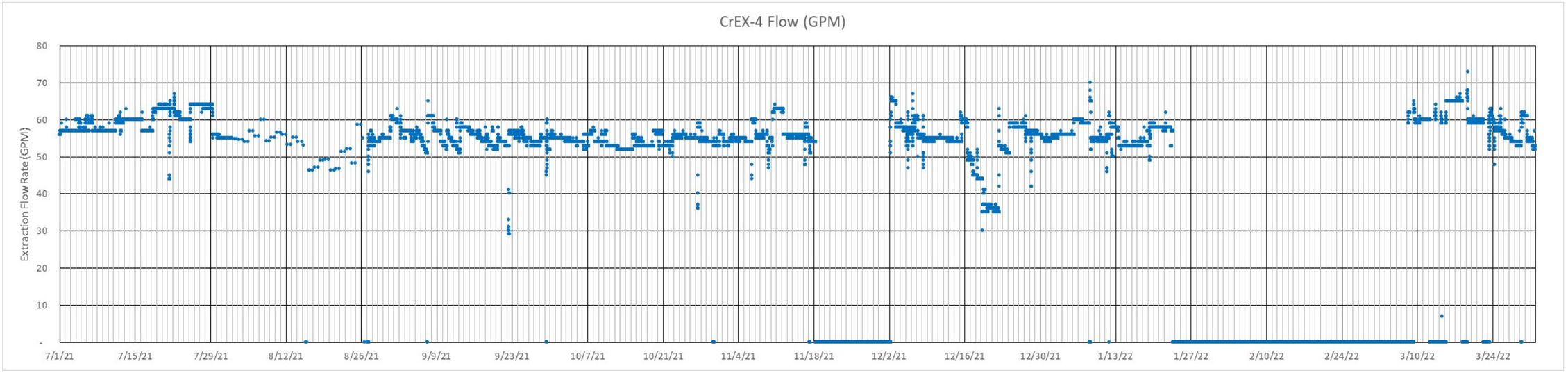


Figure 2.1-1 (continued) **Flow rates for the CrEX wells for July 1, 2021, through March 31, 2022**

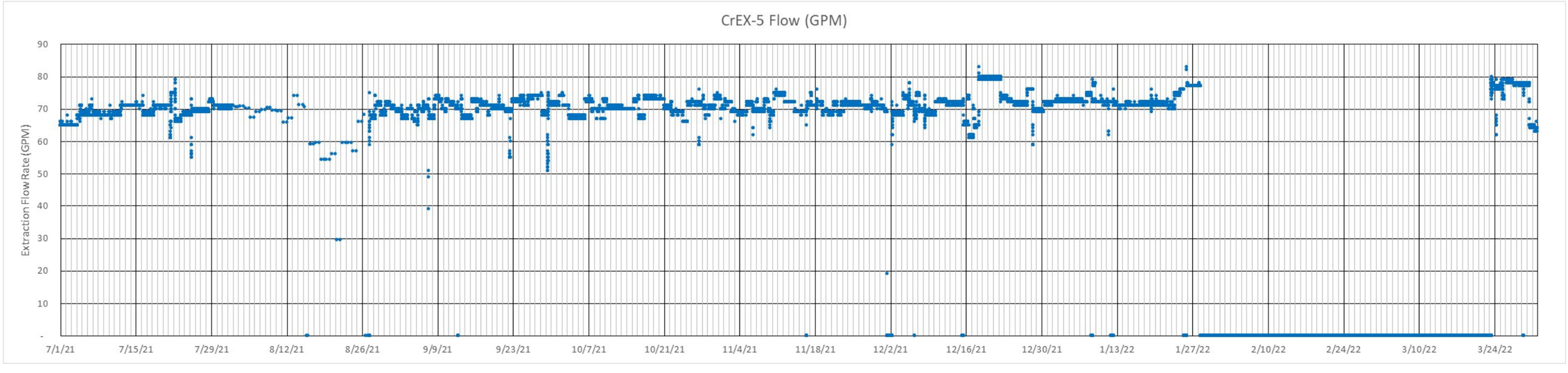


Figure 2.1-1 (continued) **Flow rates for the CrEX wells for July 1, 2021, through March 31, 2022**

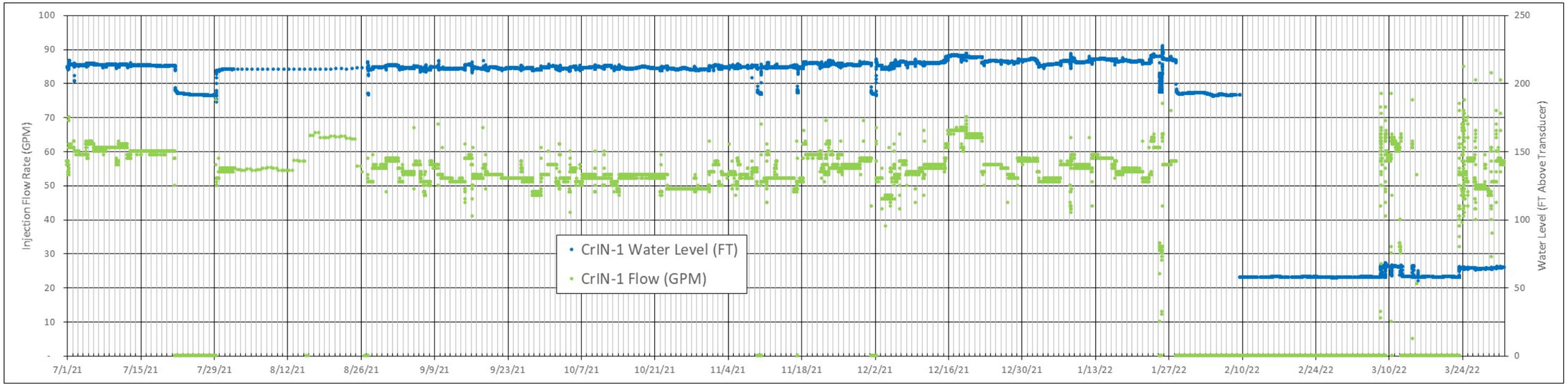
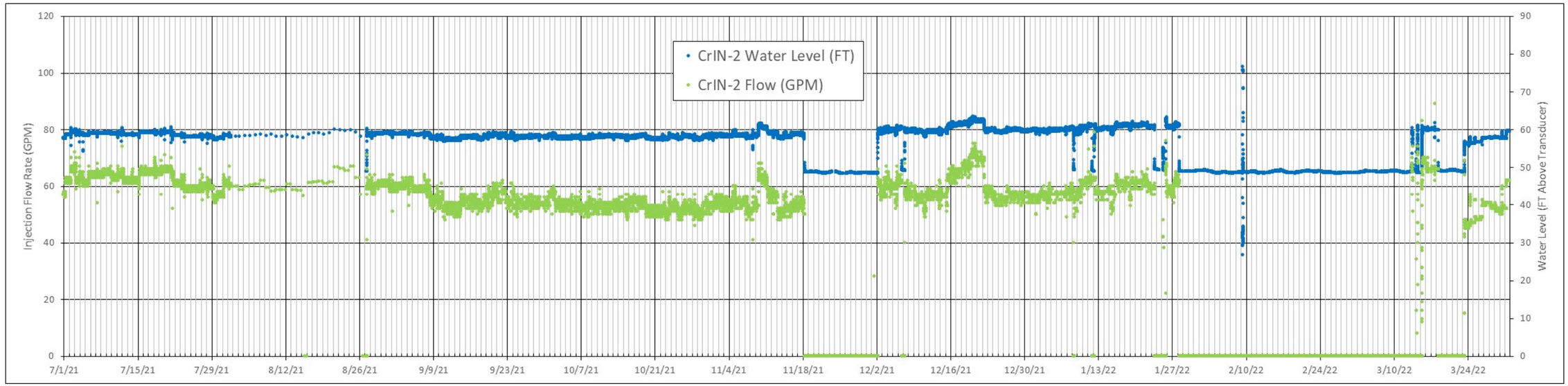


Figure 2.1-2 **Injection well flow rates and water levels for CrIN-1, CrIN-2, CrIN-3, CrIN-4, and CrIN-5 from July 1, 2021, through March 31, 2022**



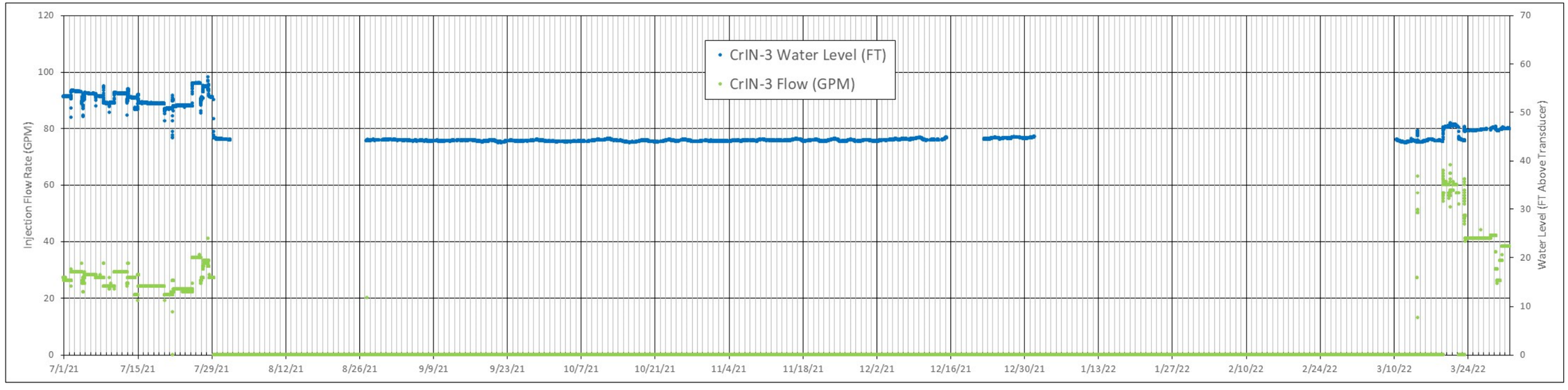
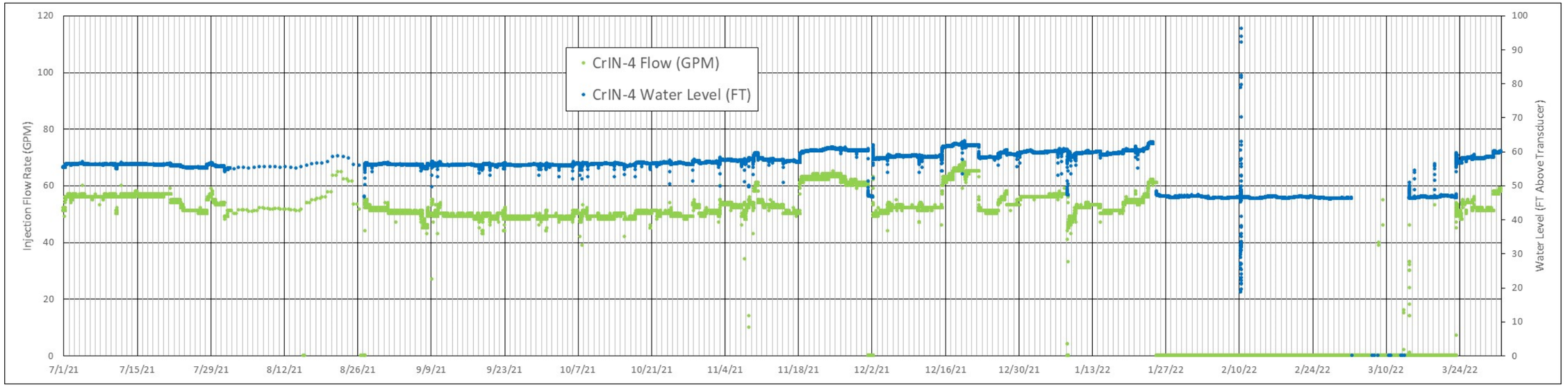


Figure 2.1-2 (continued) Injection well flow rates and water levels for CrIN-1, CrIN-2, CrIN-3, CrIN-4, and CrIN-5 from July 1, 2021, through March 31, 2022



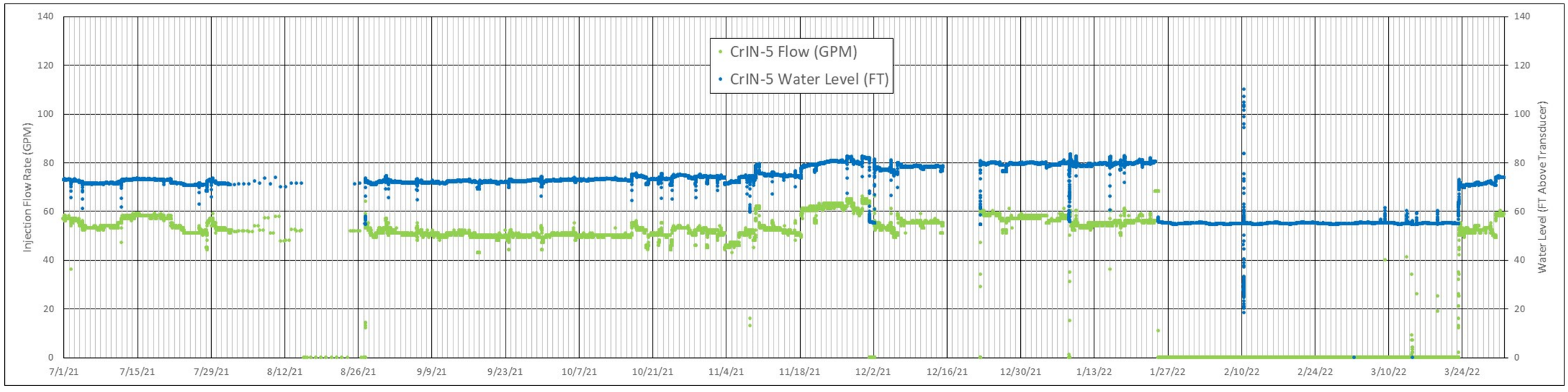
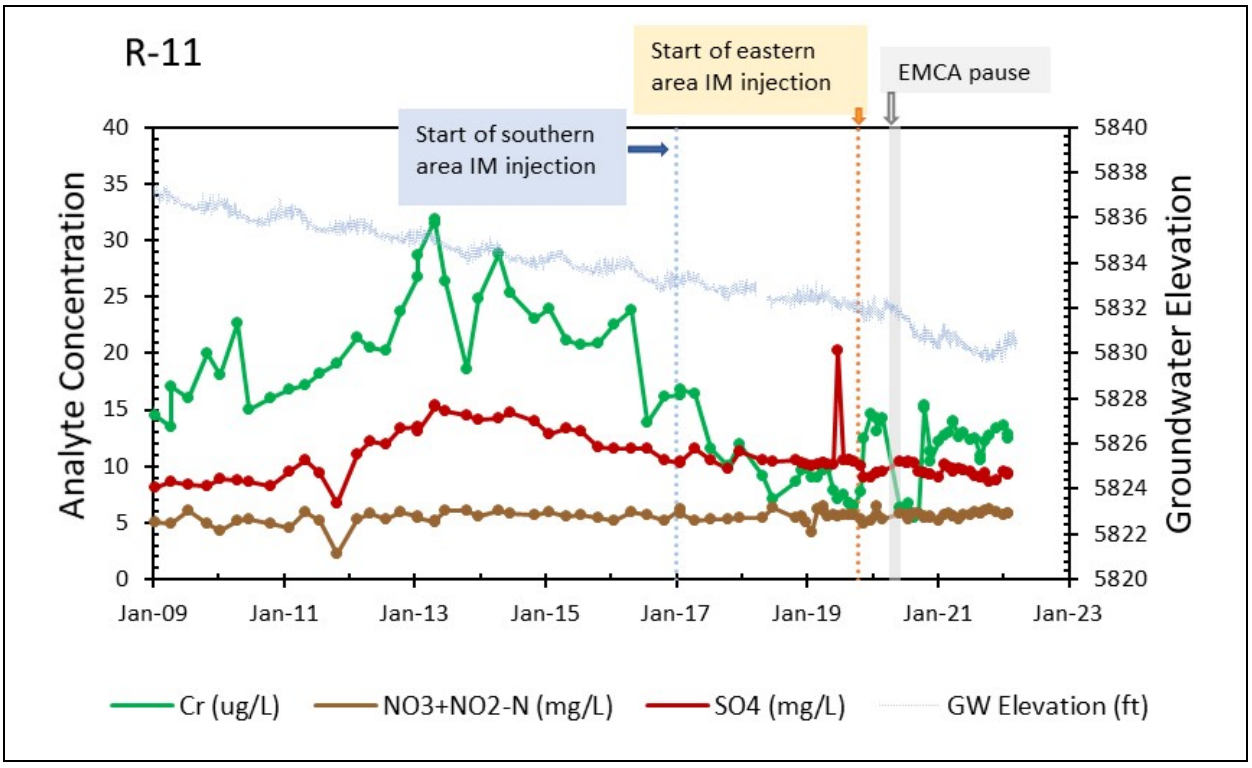
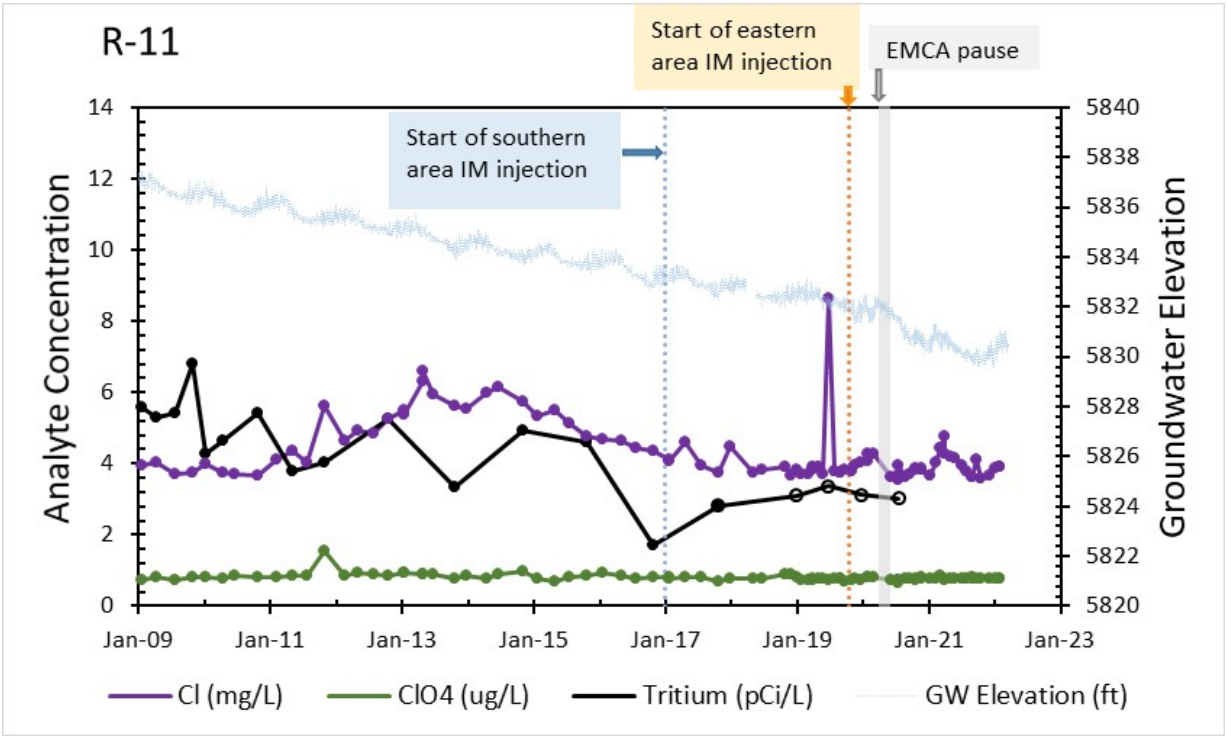


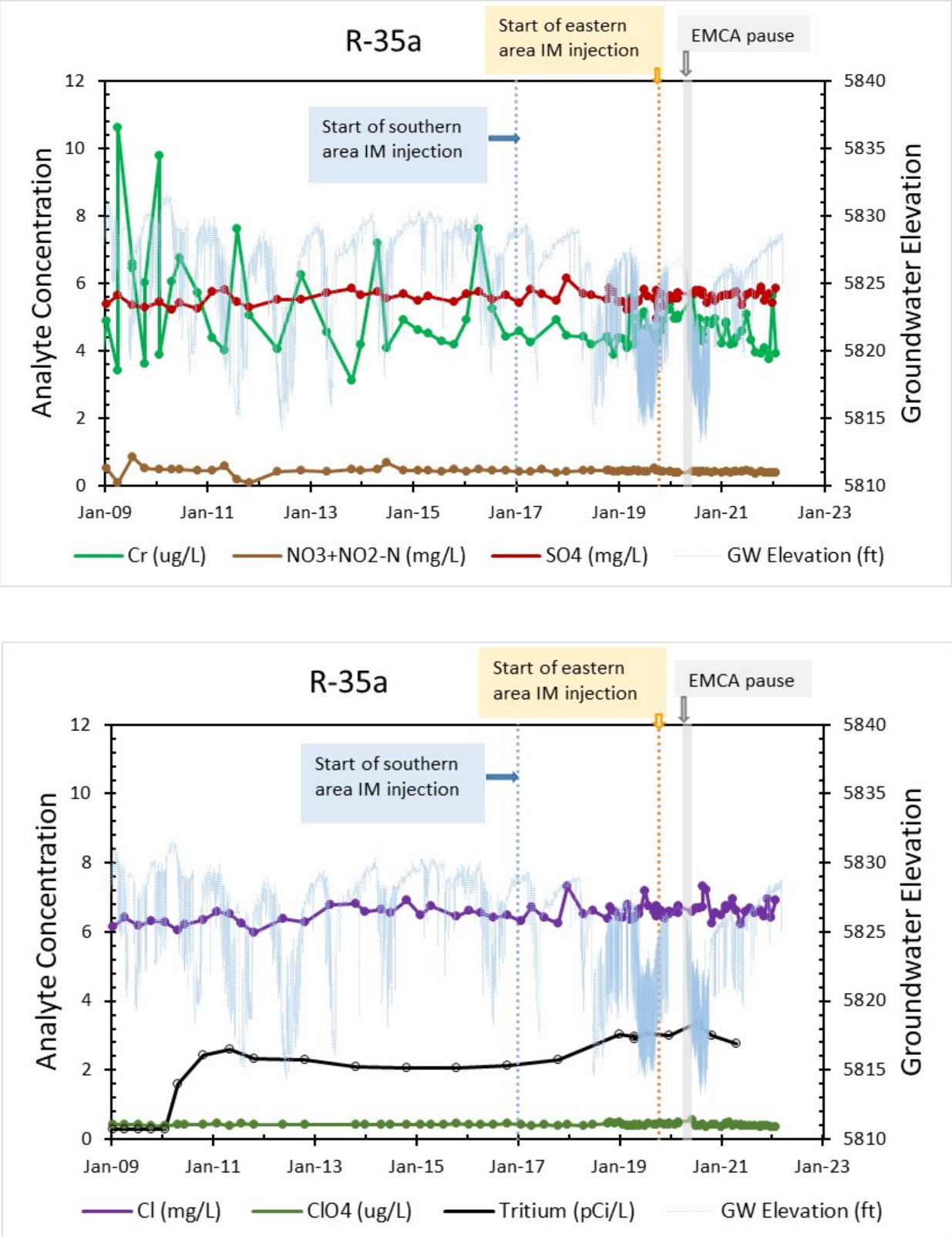
Figure 2.1-2 (continued) Injection well flow rates and water levels for CrIN-1, CrIN-2, CrIN-3, CrIN-4, and CrIN-5 from July 1, 2021, through March 31, 2022





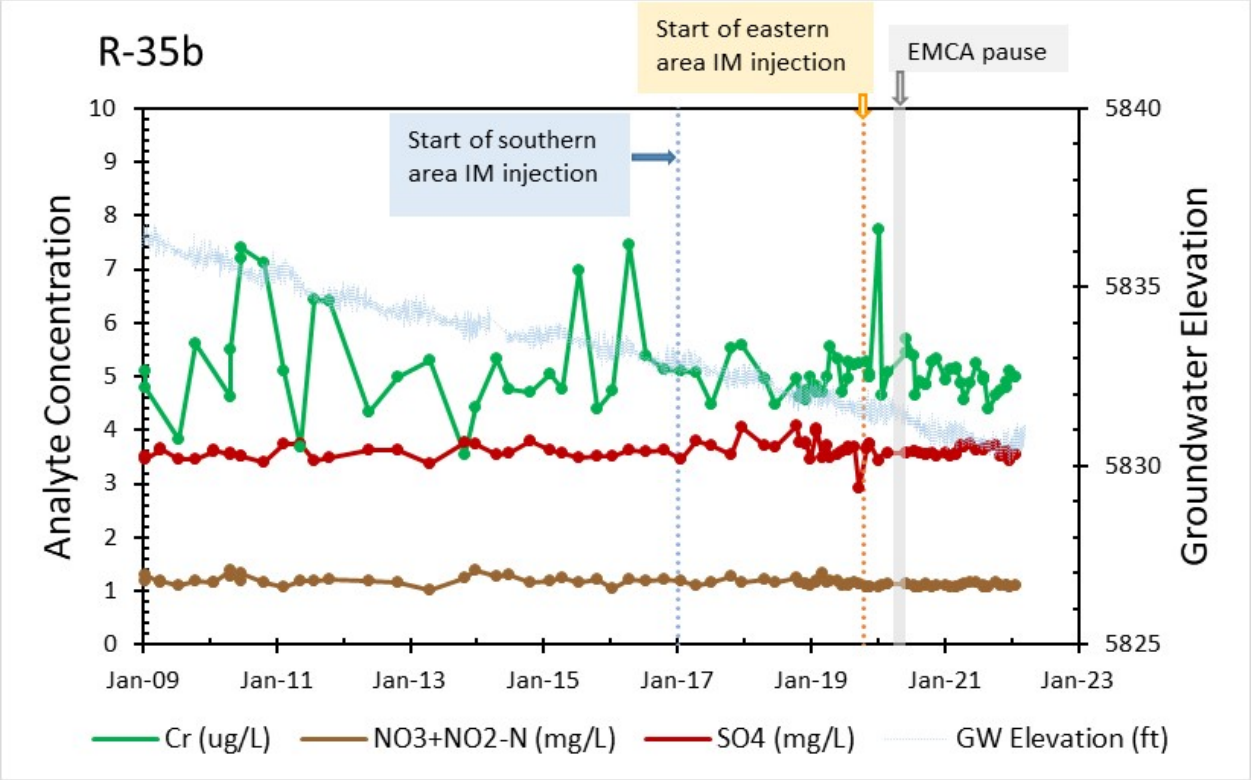
Notes: Open symbols represent nondetection results and solid symbols represent detection results at the plotted value. The background for chromium is 7.48 µg/L. Groundwater elevations represent raw data (without barometric adjustment).

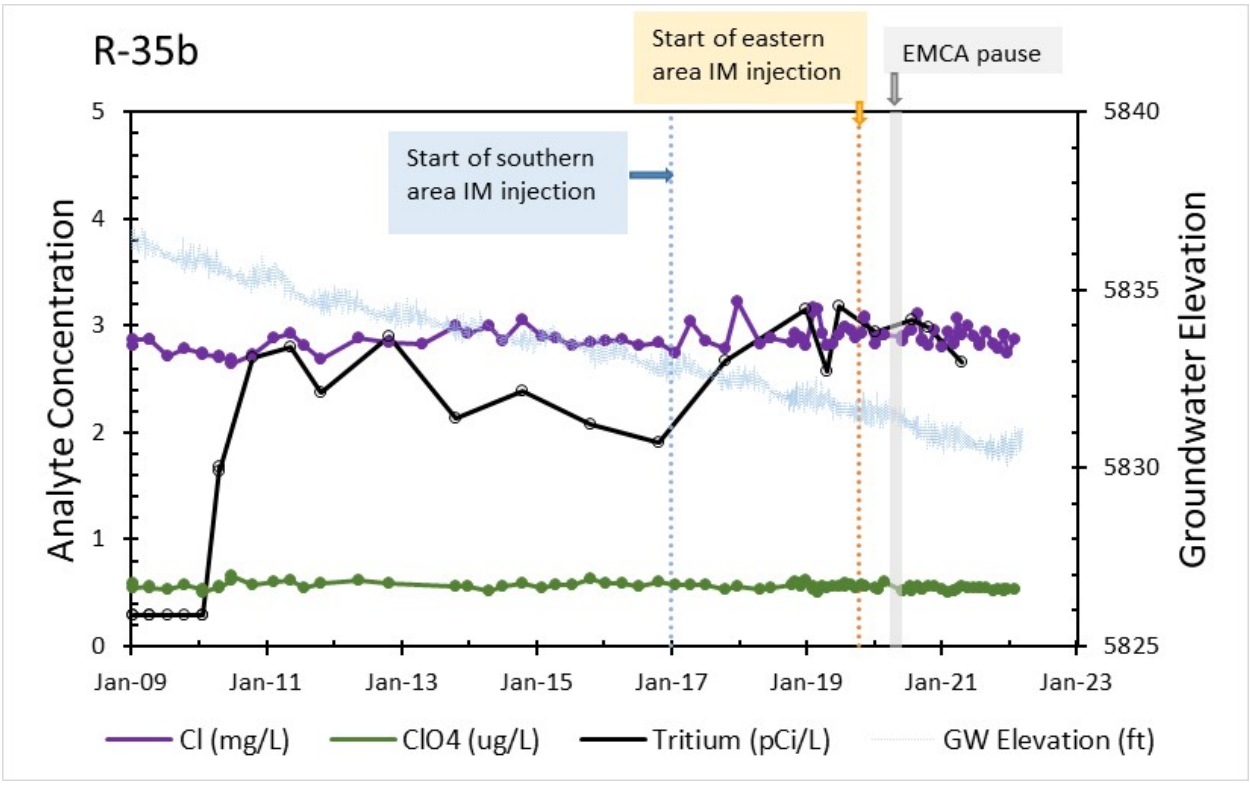
Figure 3.2-1 Time-series plots for R-11



Notes: Open symbols represent nondetection results and solid symbols represent detection results at the plotted value. The background for chromium is 7.48 µg/L. Groundwater elevations represent raw data (without barometric adjustment).

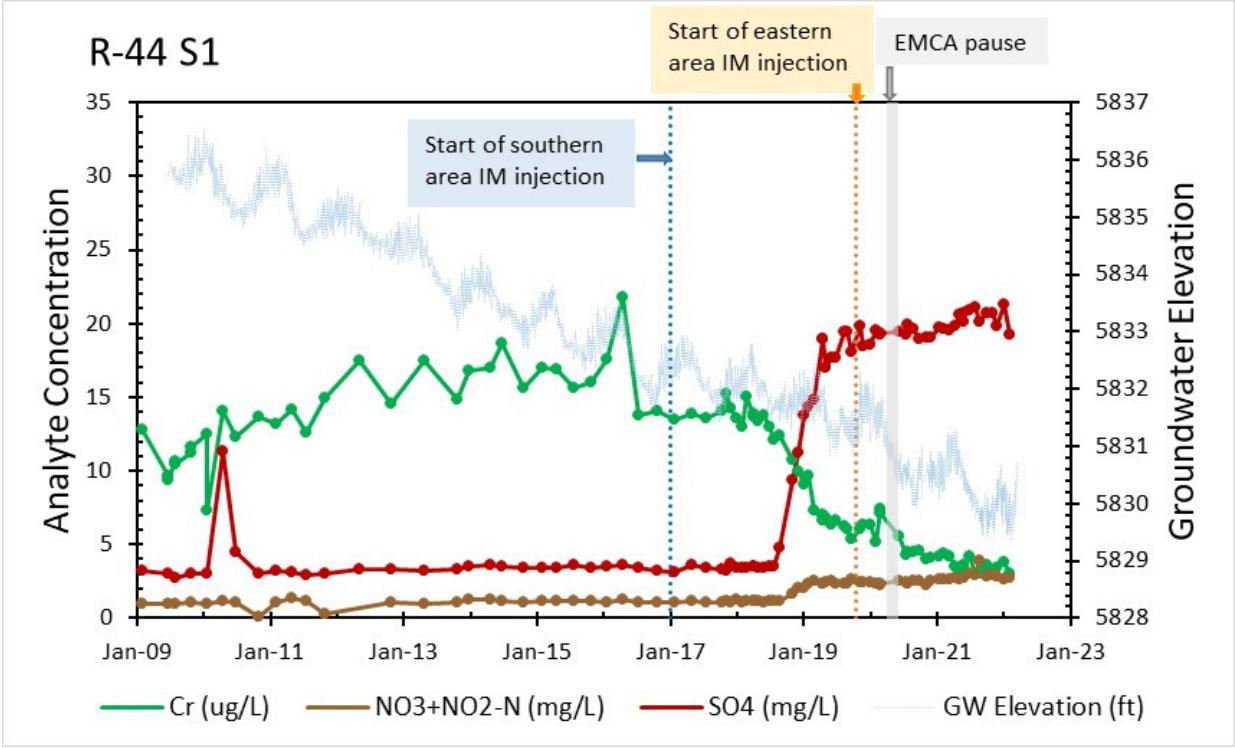
Figure 3.2-2 Time-series plots for R-35a (deeper R-35 location)

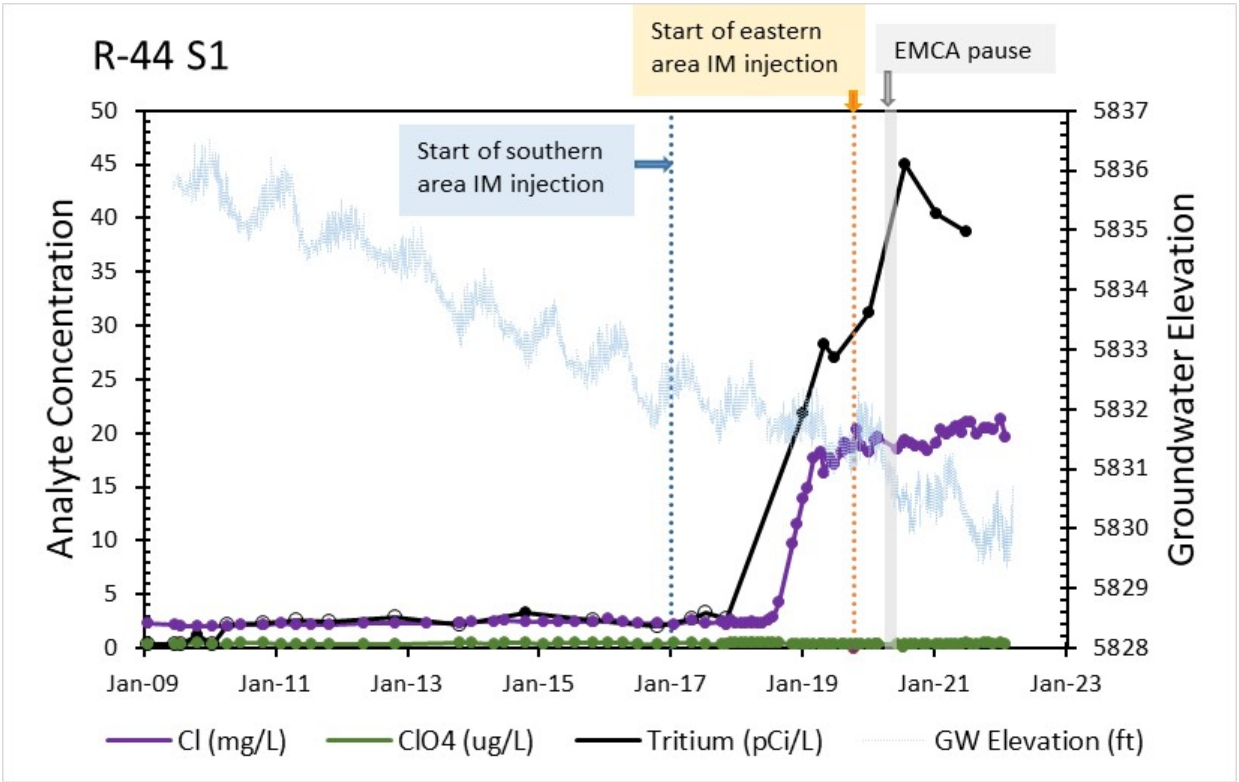




Notes: Open symbols represent nondetection results and solid symbols represent detection results at the plotted value. The background for chromium is 7.48 µg/L. Groundwater elevations represent raw data (without barometric adjustment).

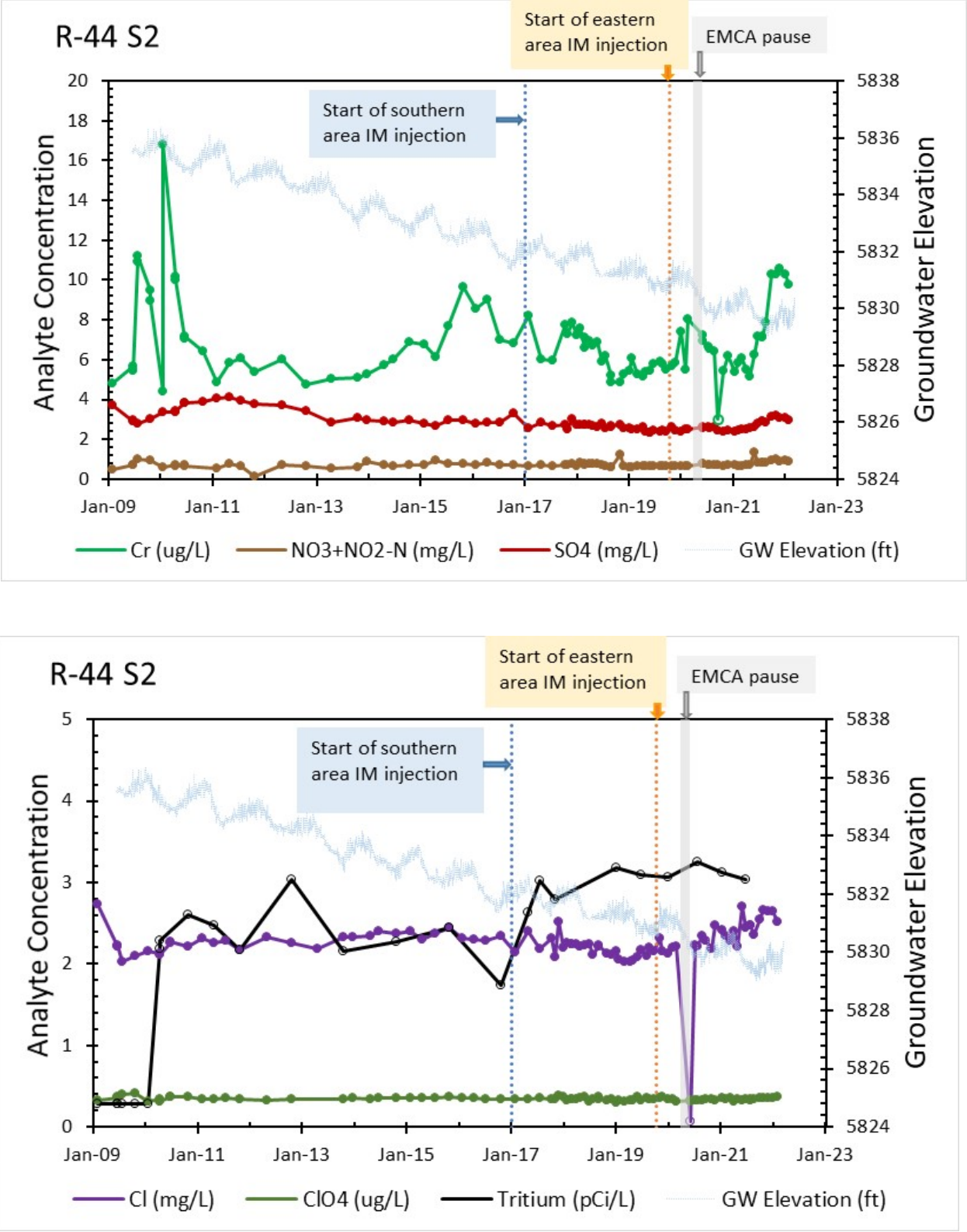
Figure 3.2-3 Time-series plots for R-35b (shallower R-35 location)





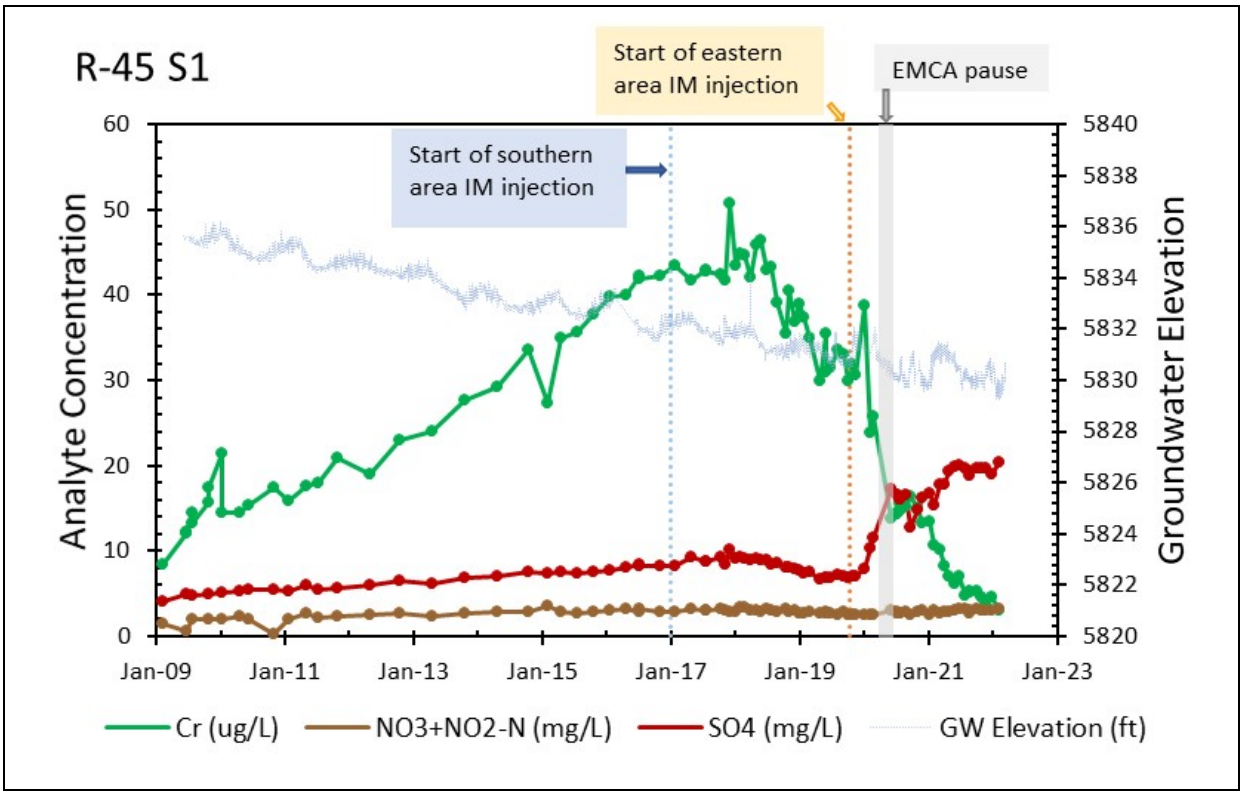
Notes: Open symbols represent nondetection results and solid symbols represent detection results at the plotted value. The background for chromium is 7.48 µg/L. Groundwater elevations represent raw data (without barometric adjustment). S1 = Screen 1.

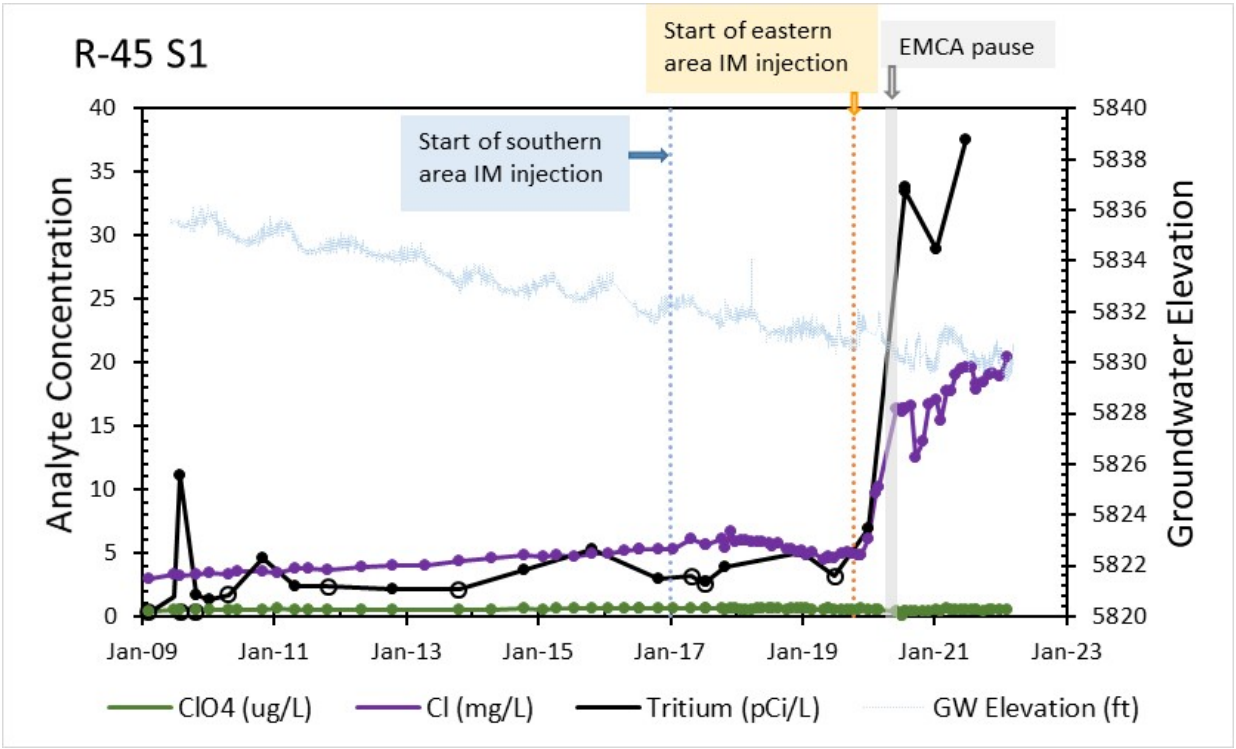
Figure 3.2-4 Time-series plots for R-44 screen 1



Notes: Open symbols represent nondetection results and solid symbols represent detection results at the plotted value. The background for chromium is 7.48 µg/L. Groundwater elevations represent raw data (without barometric adjustment). S2 = Screen 2

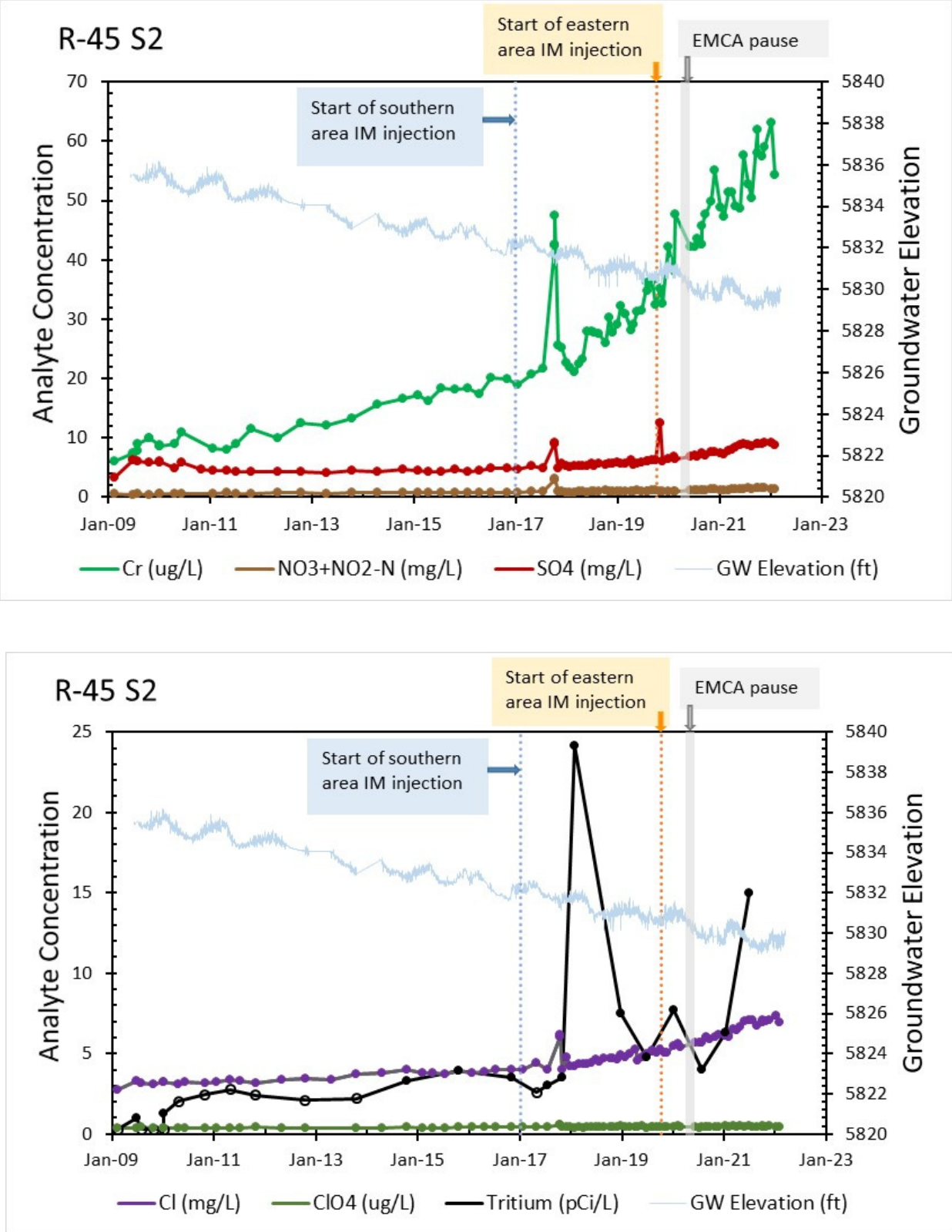
Figure 3.2-5 Time-series plots for R-44 screen 2





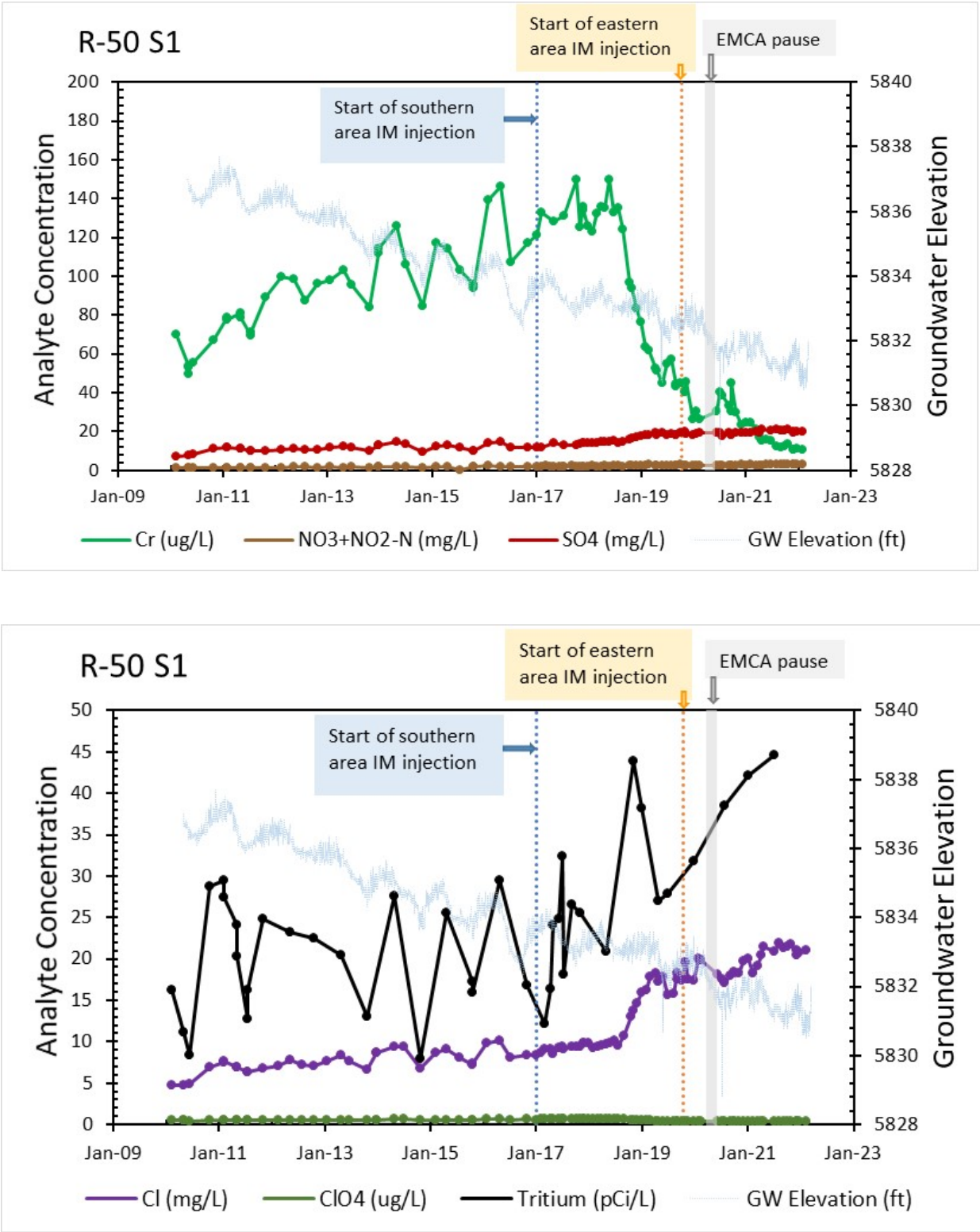
Notes: Open symbols represent nondetection results and solid symbols represent detection results at the plotted value. The background for chromium is 7.48 µg/L. Groundwater elevations represent raw data (without barometric adjustment). S1 = Screen 1.

Figure 3.2-6 Time-series plots for R-45 screen 1



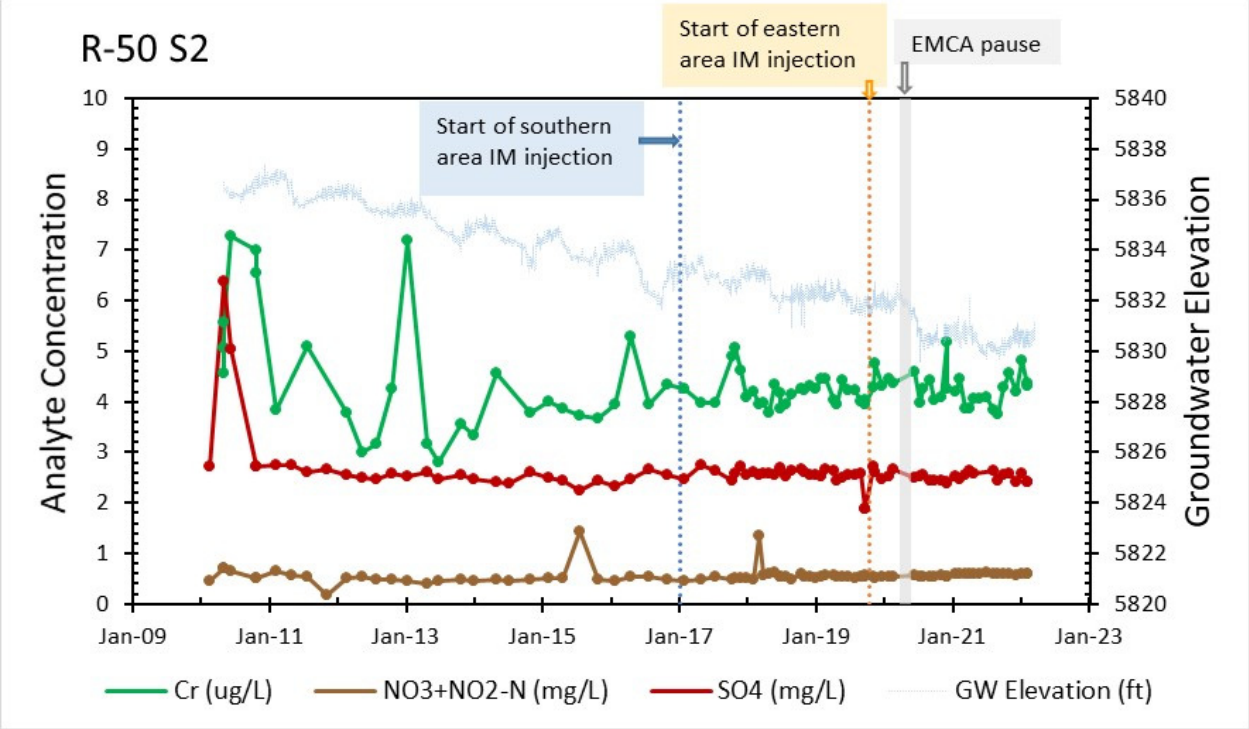
Notes: Open symbols represent nondetection results and solid symbols represent detection results at the plotted value. The background for chromium is 7.48 µg/L. Groundwater elevations represent raw data (without barometric adjustment). S2 = Screen 2.

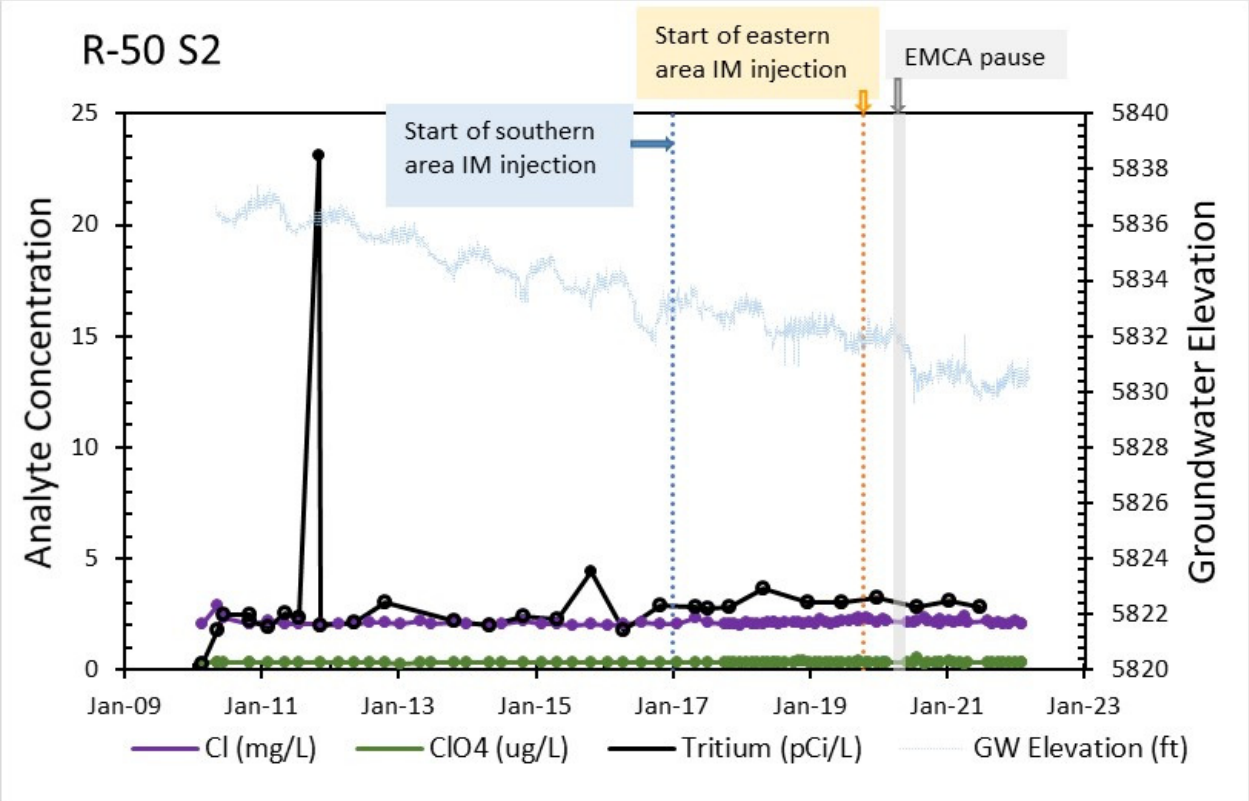
Figure 3.2-7 Time-series plots for R-45 screen 2



Notes: Solid symbols represent detection results at the plotted value. The background for chromium is 7.48 µg/L. Groundwater elevations represent raw data (without barometric adjustment). S1 = Screen 1.

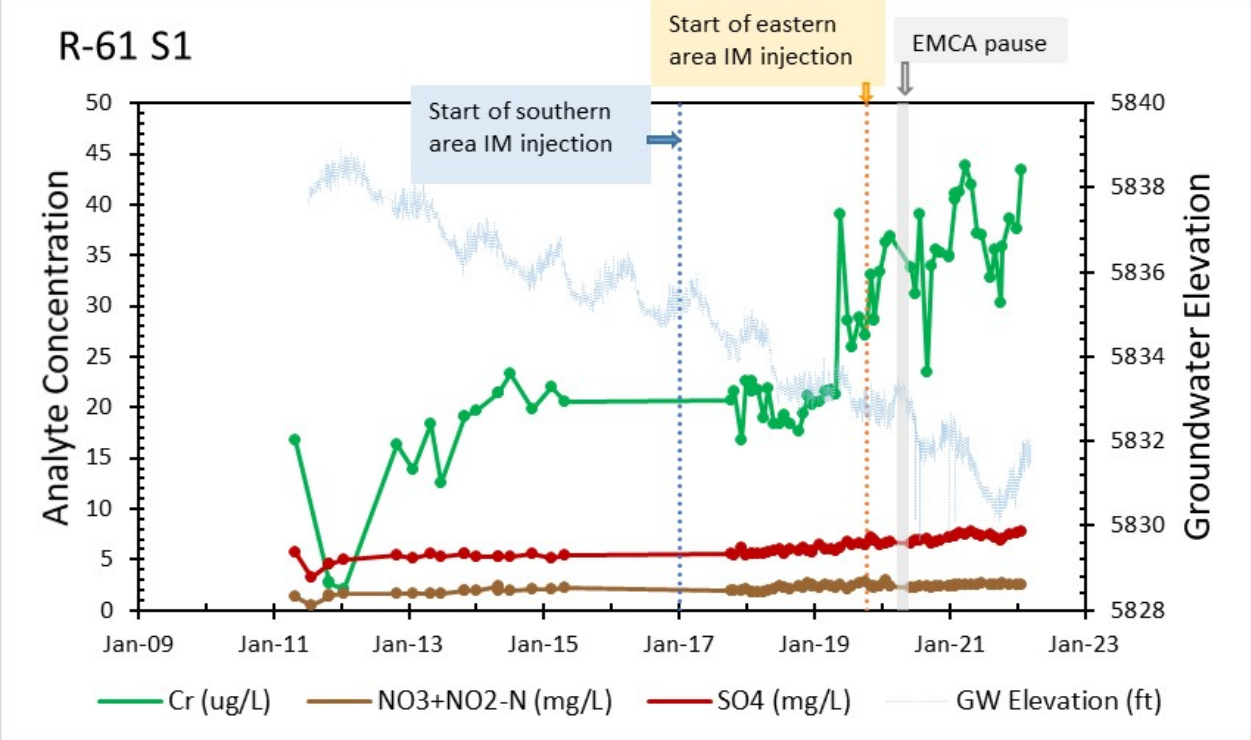
Figure 3.2-8 Time-series plots for R-50 screen 1

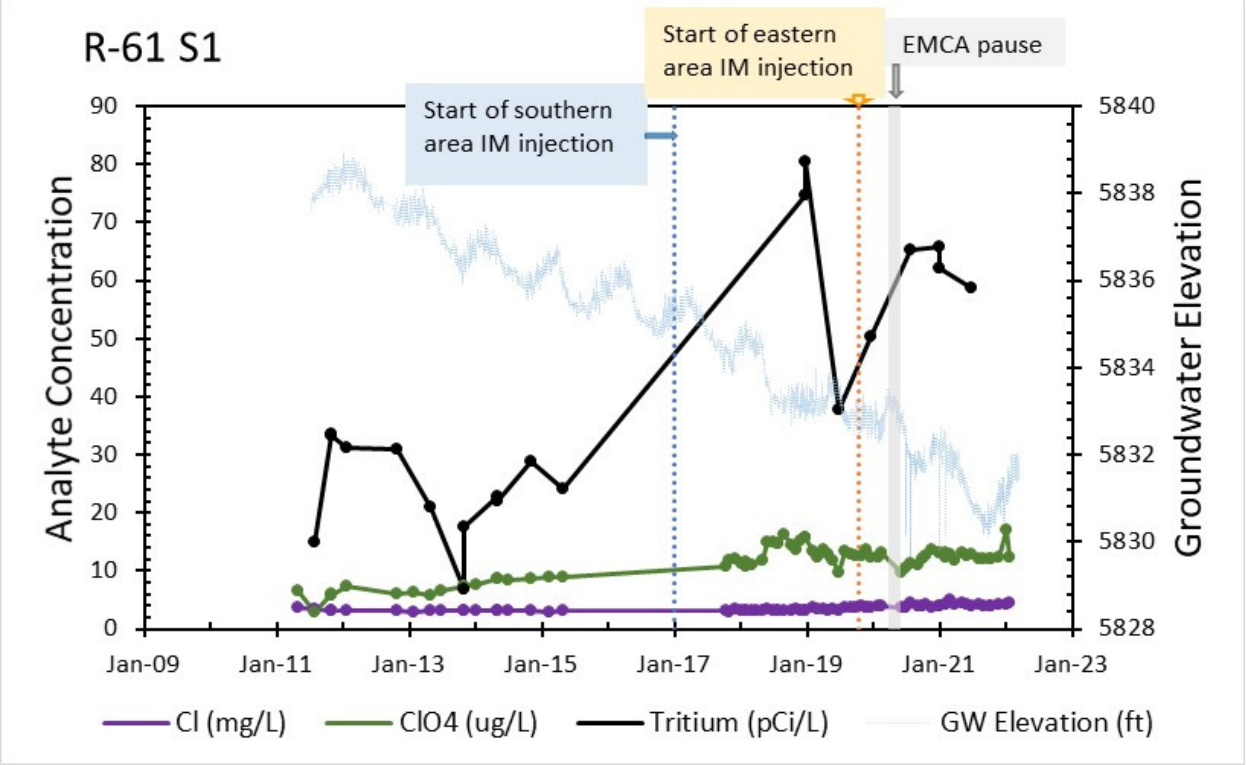




Notes: Open symbols represent nondetection results and solid symbols represent detection results at the plotted value. The background for chromium is 7.48 µg/L. Groundwater elevations represent raw data (without barometric adjustment). S2 = Screen 2.

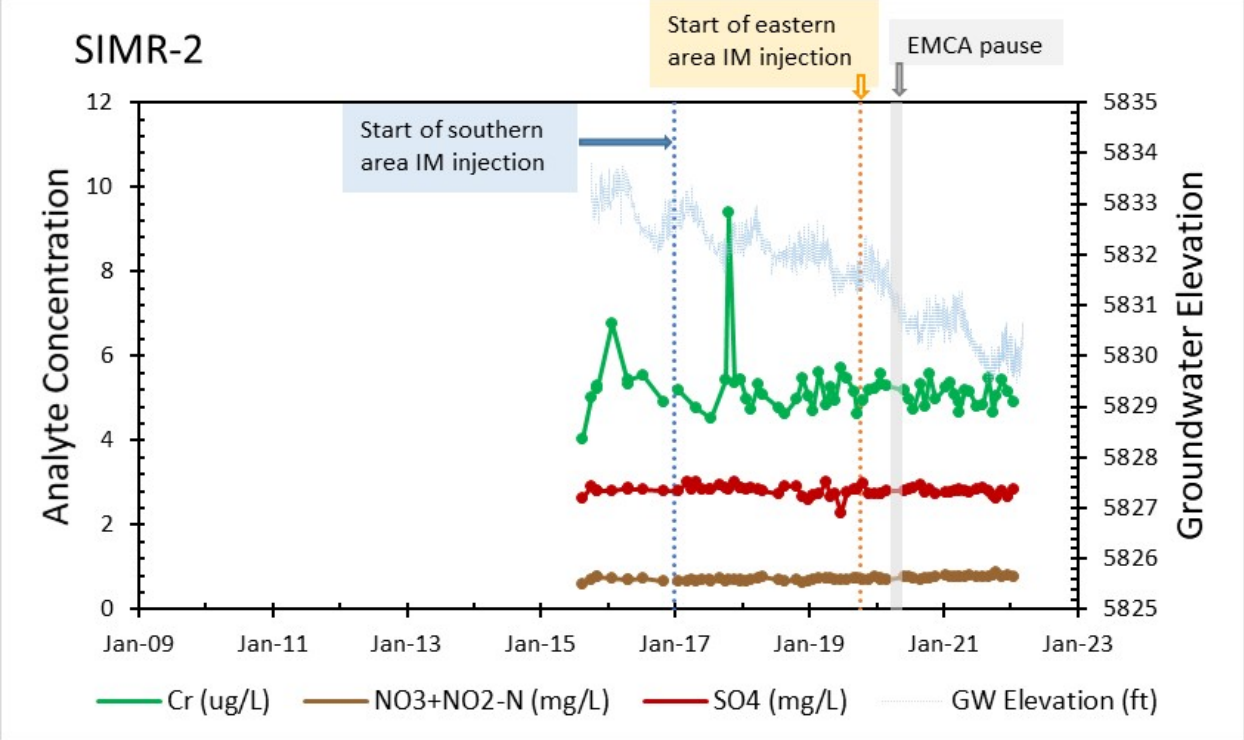
Figure 3.2-9 Time-series plots for R-50 screen 2

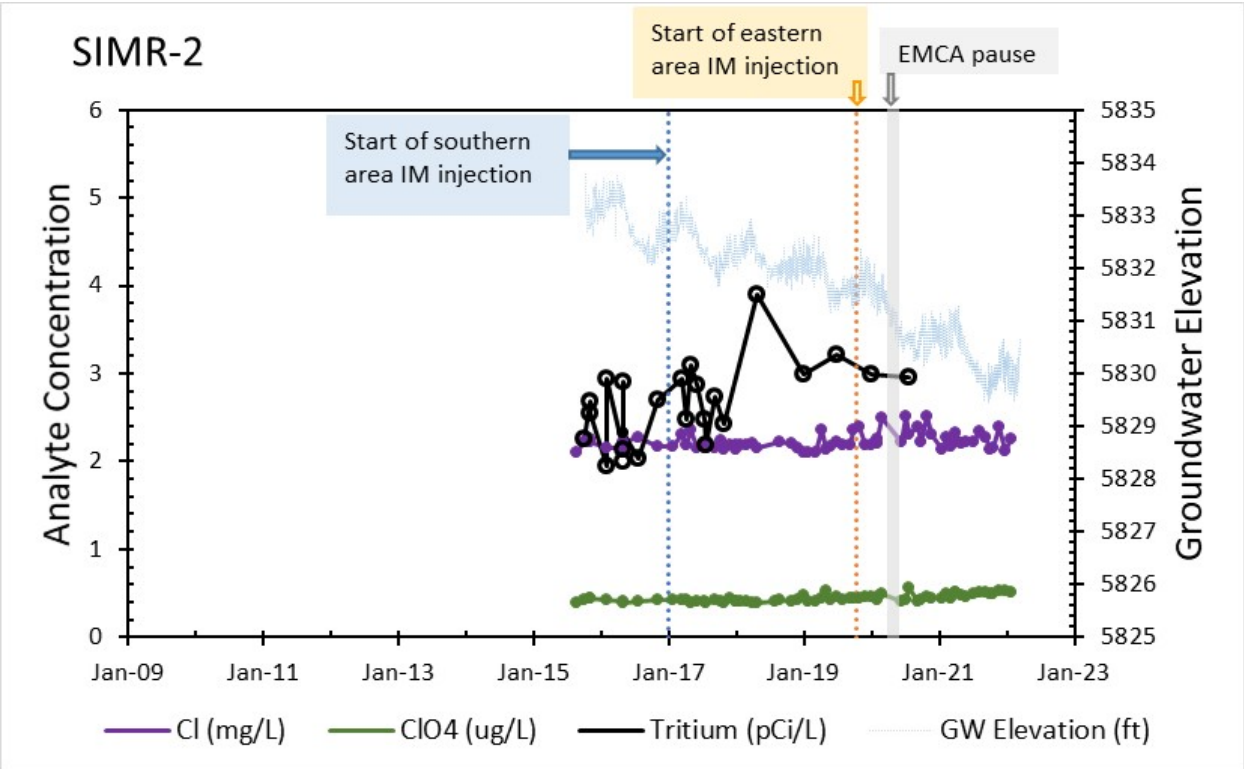




Notes: Solid symbols represent detection results at the plotted value. The background for chromium is 7.48 µg/L. Groundwater elevations represent raw data (without barometric adjustment). Data for certain constituents at R-61 S1 have historically been nonrepresentative of aquifer conditions because of locally reducing conditions around the well. Current data are considered useful for the purposes of this performance monitoring report. S1 = Screen 1.

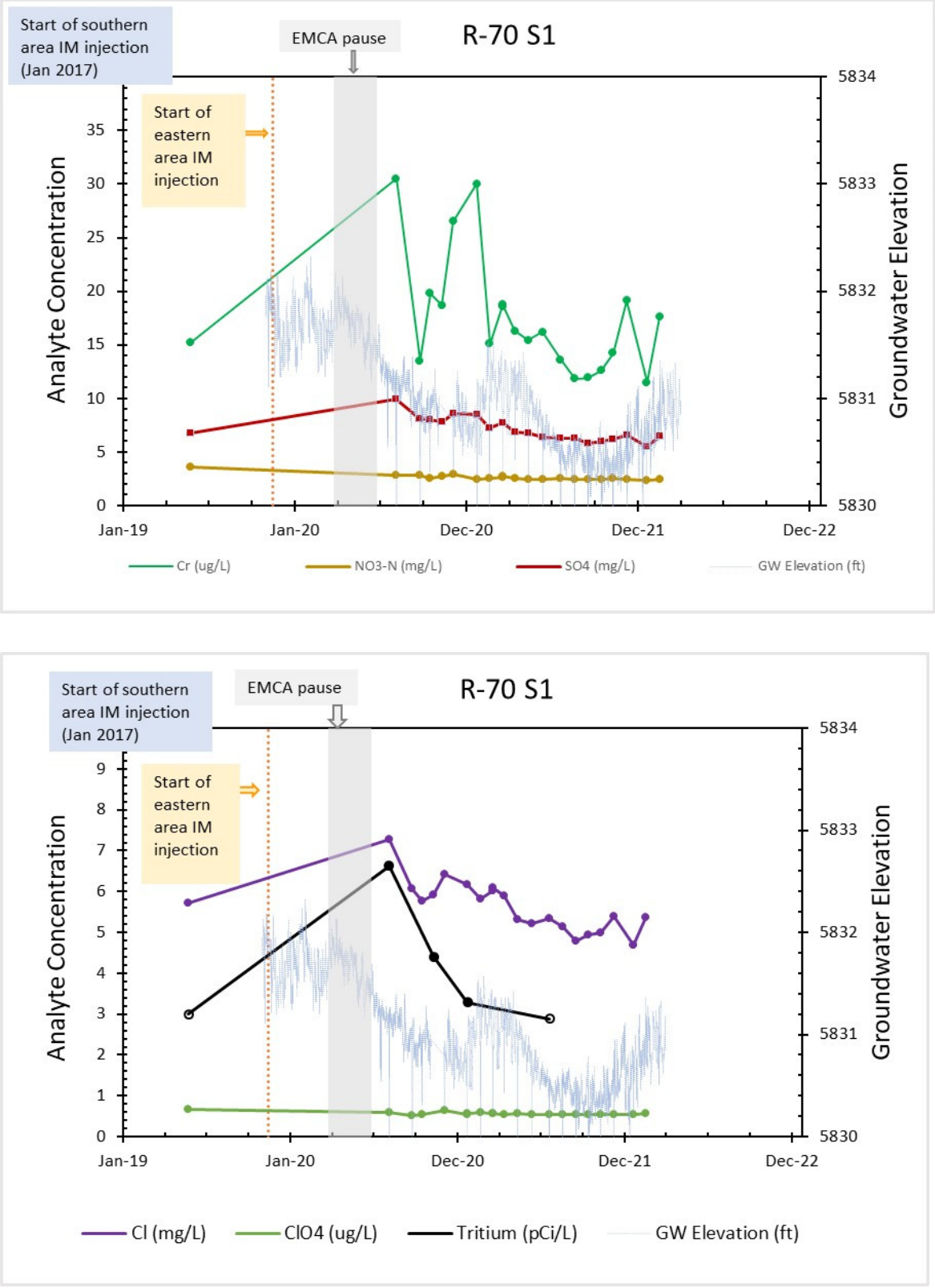
Figure 3.2-10 Time-series plots for R-61 screen 1





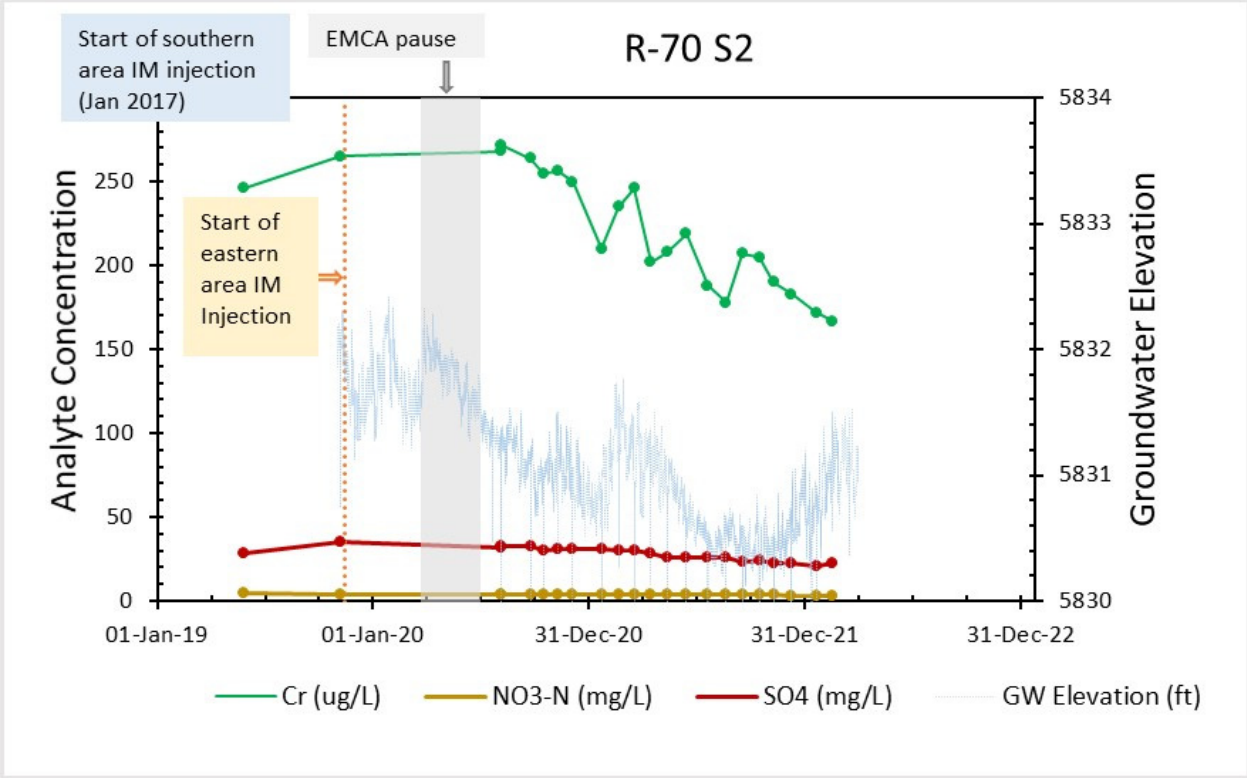
Notes: Open symbols represent nondetection results and solid symbols represent detection results at the plotted value. The background for chromium is 7.48 µg/L. Groundwater elevations represent raw data (without barometric adjustment). Data for certain constituents at R-61 S1 have historically been nonrepresentative of aquifer conditions because of locally reducing conditions around the well. Current data are considered useful for the purposes of this performance monitoring report.
S1 = Screen 1.

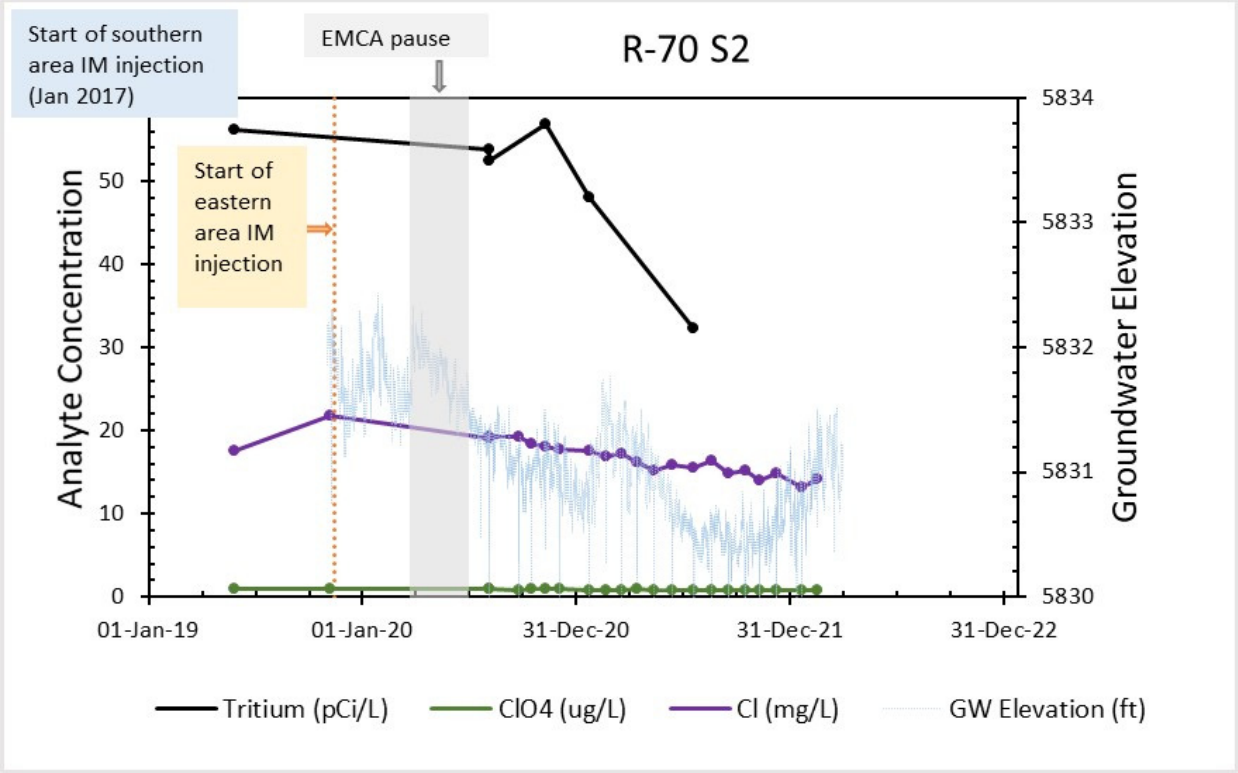
Figure 3.2-11 Time-series plots for SIMR-2



Notes: Open symbols represent nondetection results and solid symbols represent detection results at the plotted value. The background for chromium is 7.48 µg/L. Groundwater elevations represent raw data (without barometric adjustment). S1 = Screen 1.

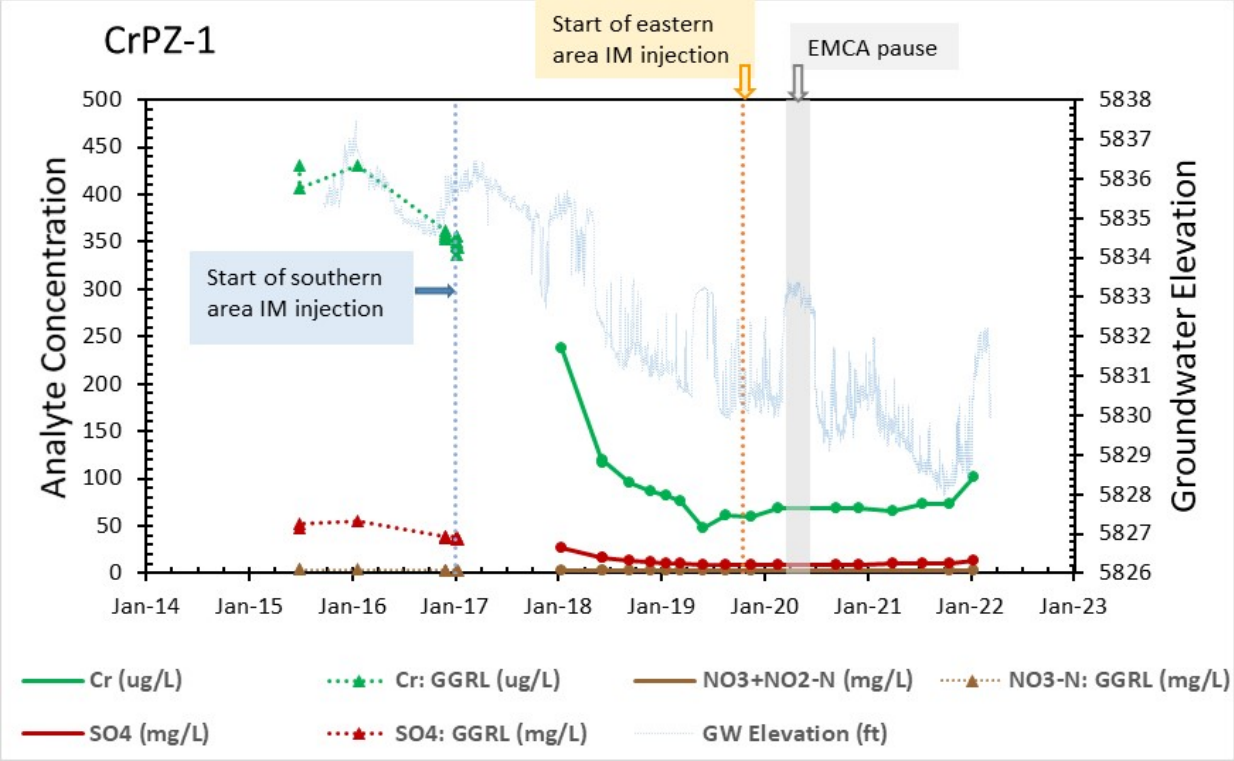
Figure 3.2-12 Time-series plots for R-70 screen 1

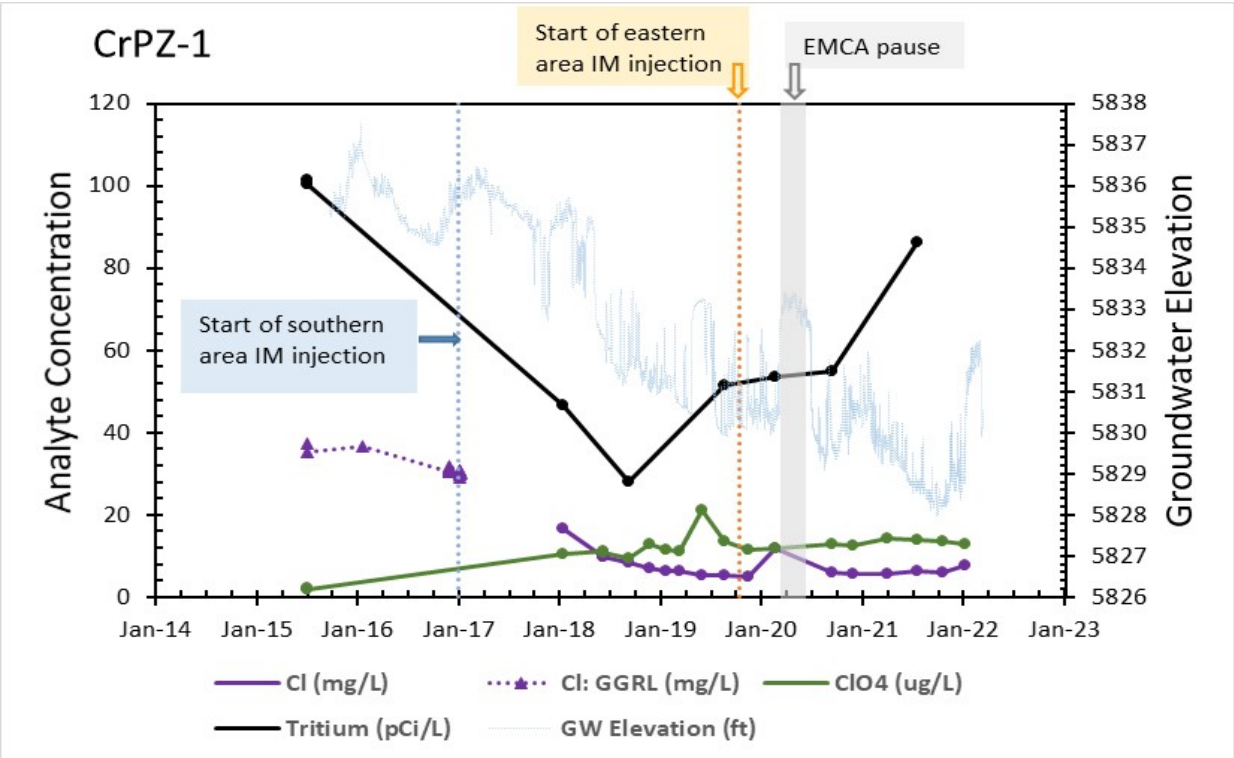




Notes: Solid symbols represent detection results at the plotted value. The background for chromium is 7.48 µg/L. Groundwater elevations represent raw data (without barometric adjustment). S2 = Screen 2.

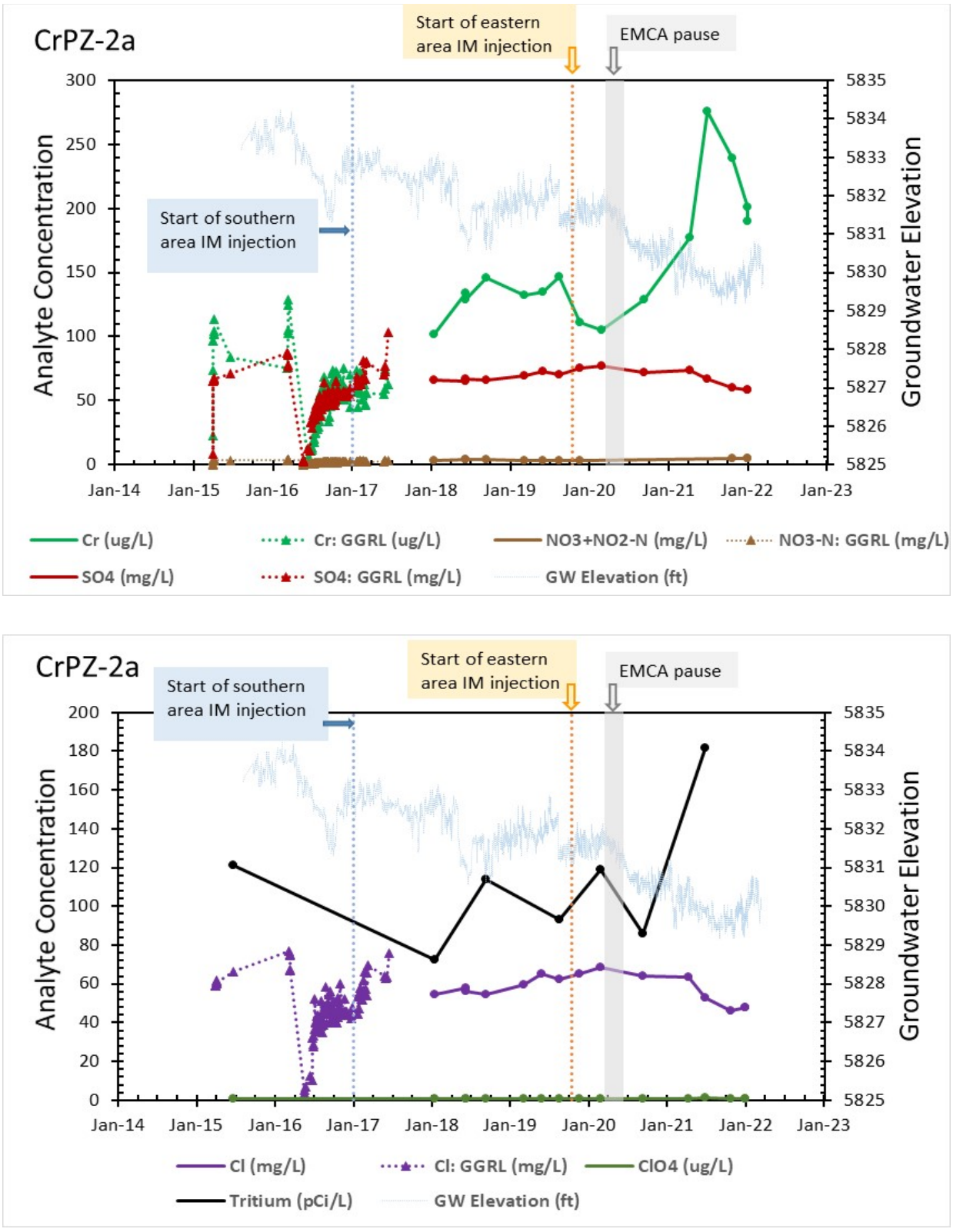
Figure 3.2-13 Time-series plots for R-70 screen 2





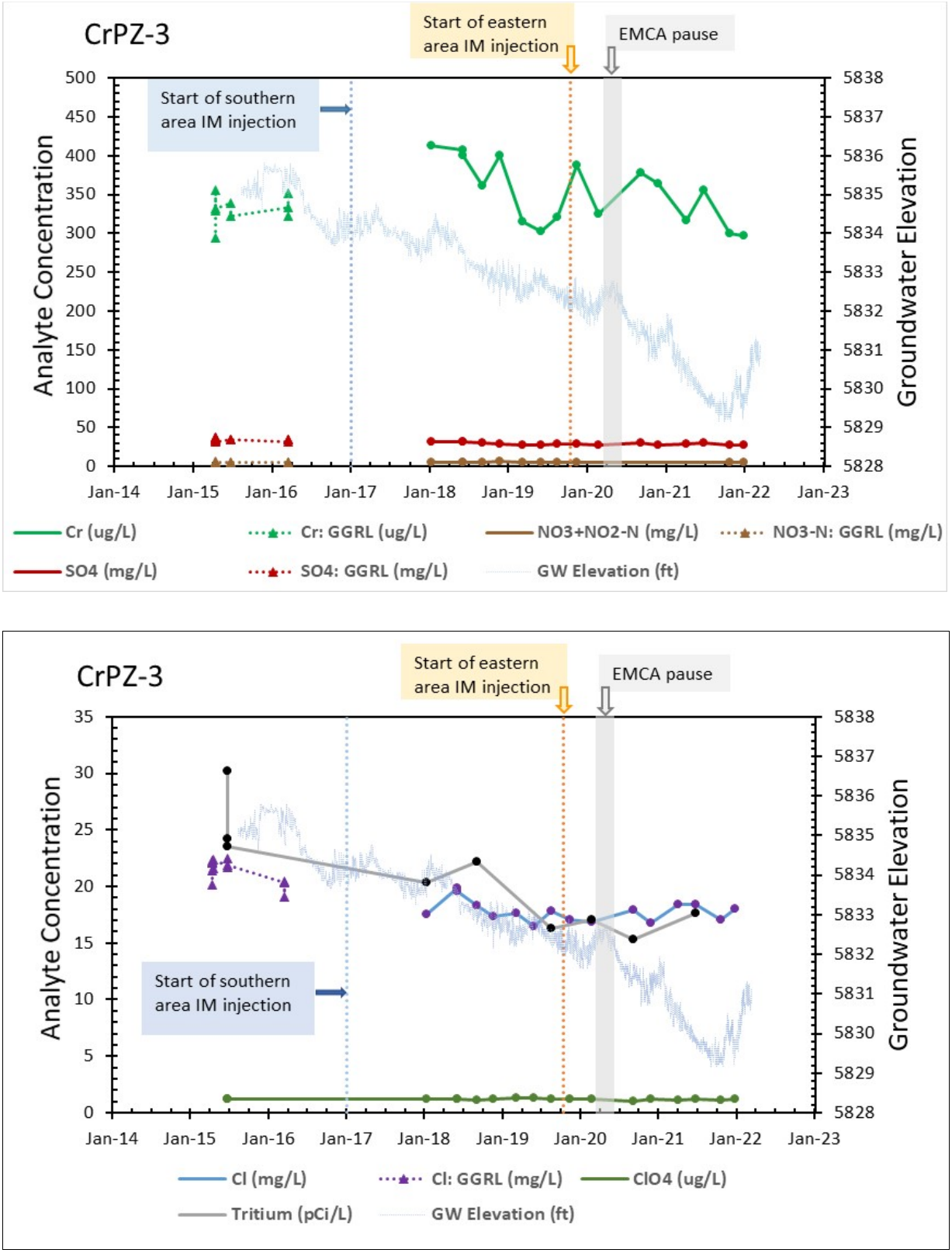
Notes: Solid symbols represent detection results at the plotted value. The background for chromium is 7.48 µg/L. Data represented by triangles and dashed lines indicate screening-level data analyzed at LANL's Geochemistry and Geomaterials Research Laboratories (GGRL). Groundwater elevations represent raw data (without barometric adjustment).

Figure 3.2-14 Time-series plots for CrPZ-1



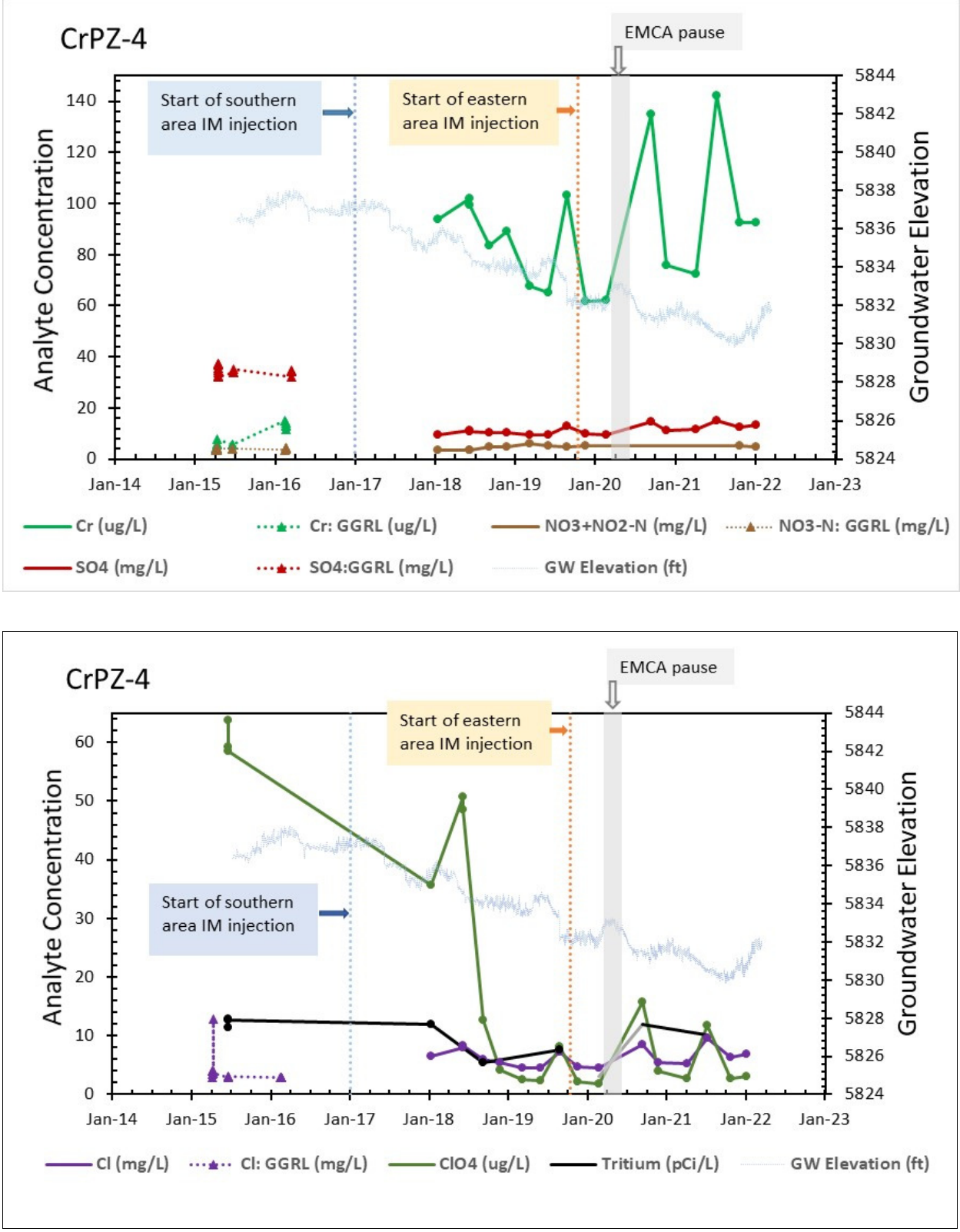
Notes: Solid symbols represent detection results at the plotted value. The background for chromium is 7.48 µg/L. Data represented by triangles and dashed lines indicate screening-level data analyzed at GGRL. Groundwater elevations represent raw data (without barometric adjustment).

Figure 3.2-15 Time-series plots for CrPZ-2a



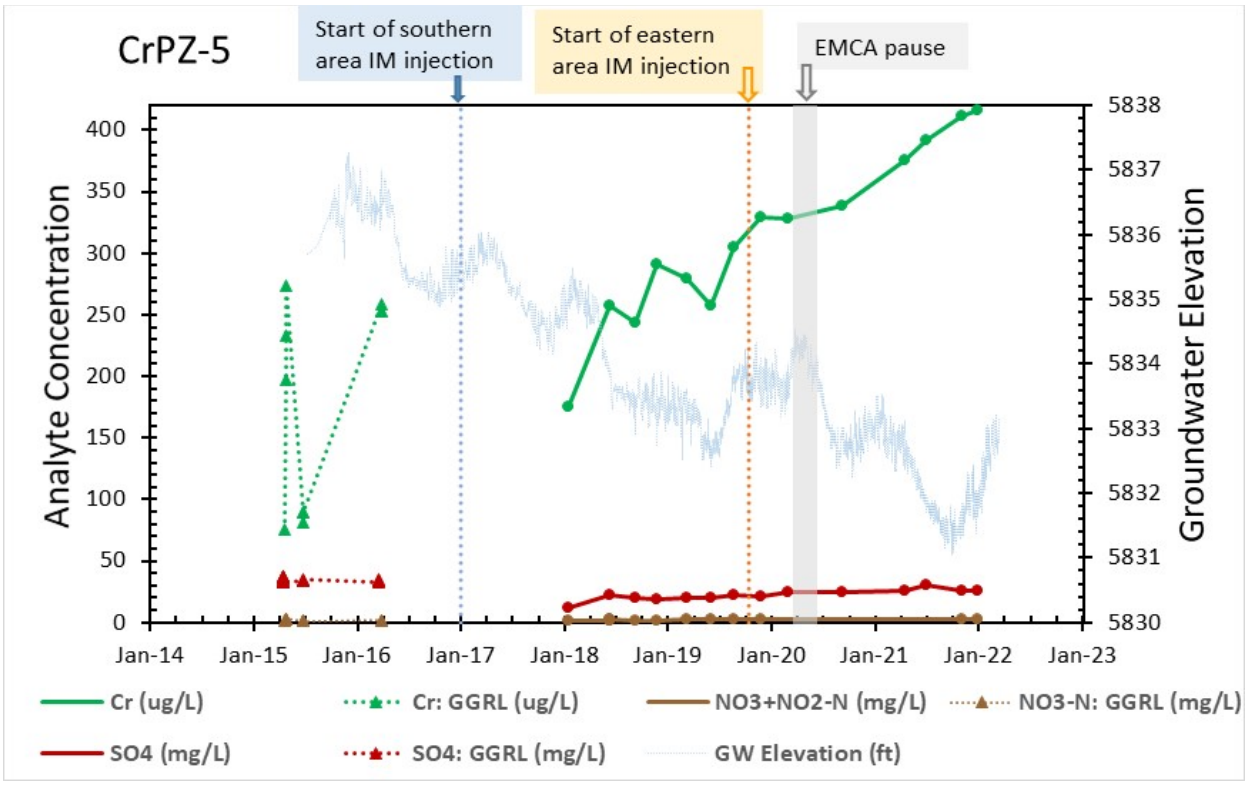
Notes: Solid symbols represent detection results at the plotted value. The background for chromium is 7.48 µg/L. Data represented by triangles and dashed lines indicate screening-level data analyzed at GGRL. Groundwater elevations represent raw data (without barometric adjustment).

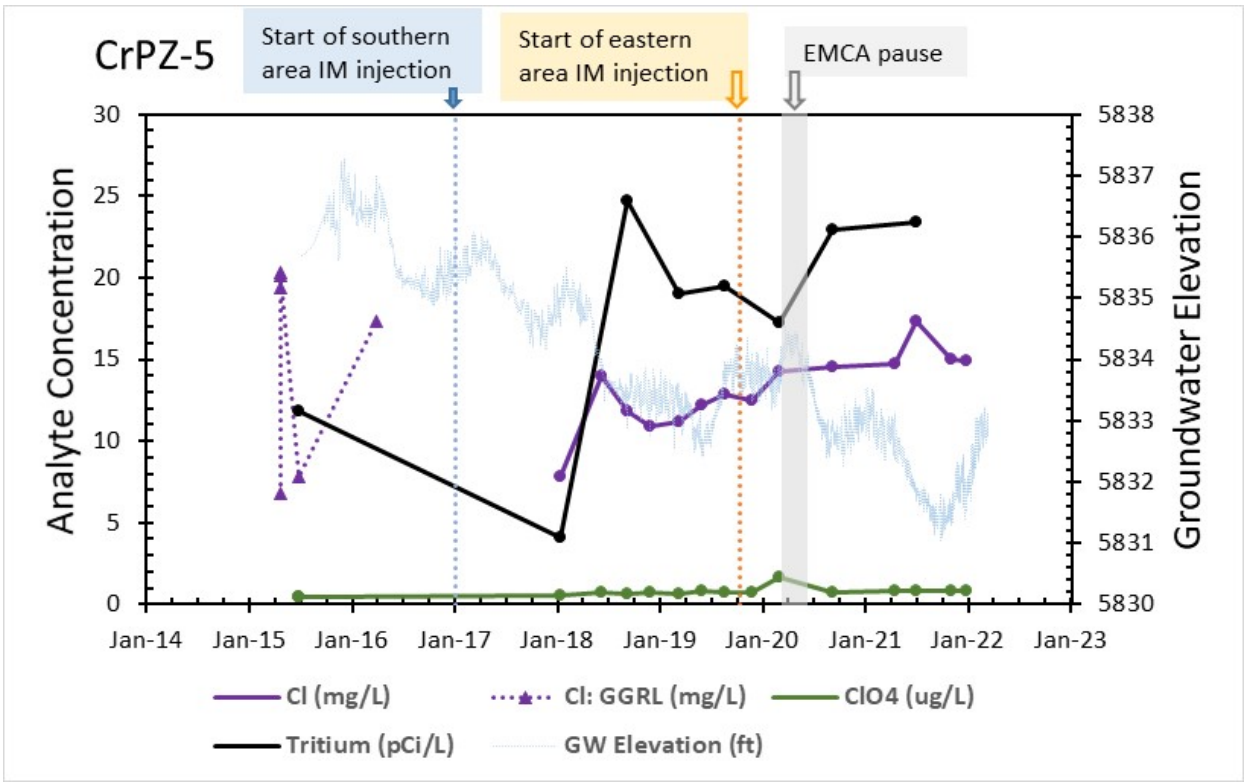
Figure 3.2-16 Time-series plots for CrPZ-3



Notes: Solid symbols represent detection results at the plotted value. The background for chromium is 7.48 µg/L. Data represented by triangles and dashed lines indicate screening-level data analyzed at GGRL. Groundwater elevations represent raw data (without barometric adjustment).

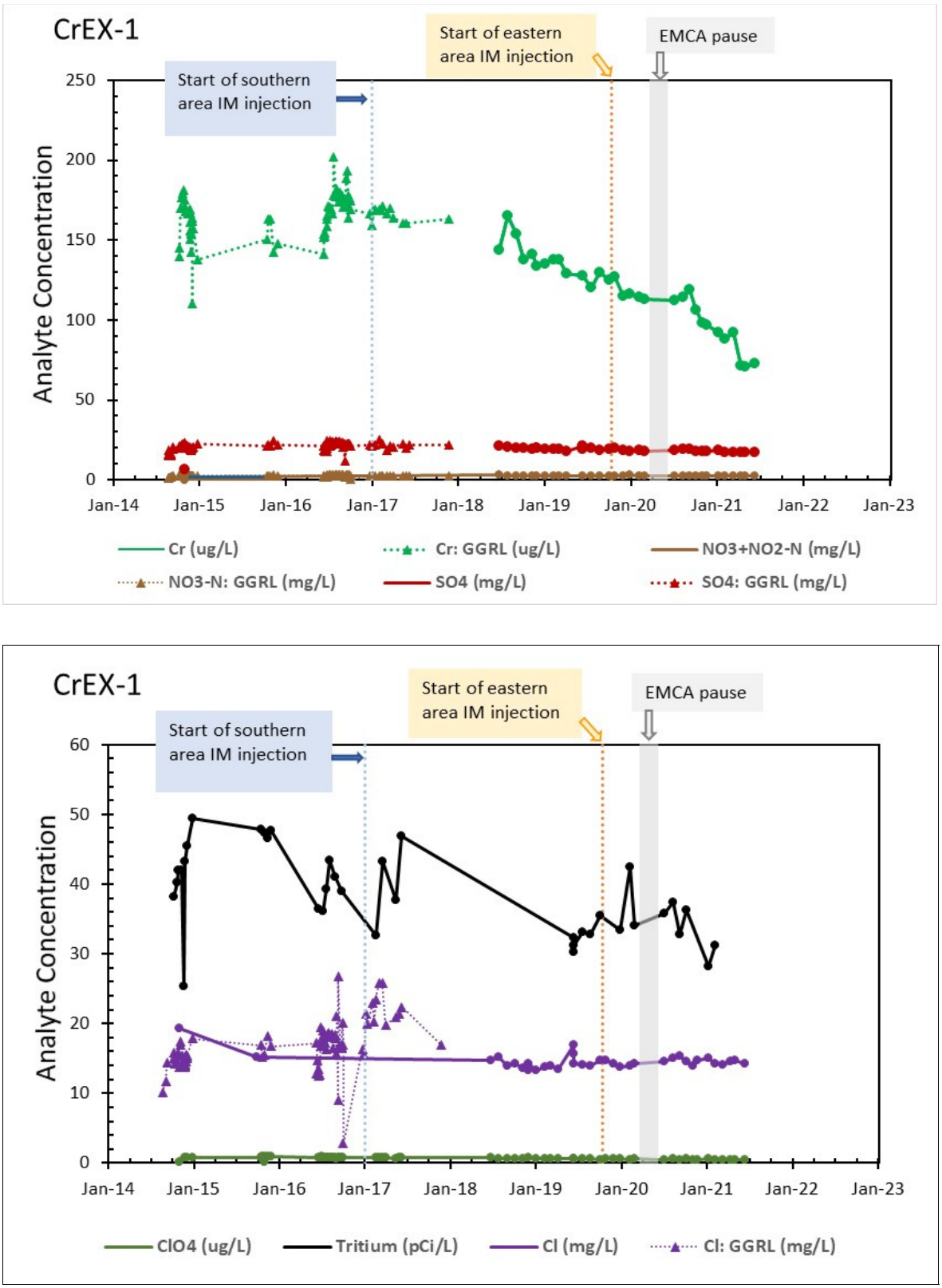
Figure 3.2-17 Time-series plots for CrPZ-4





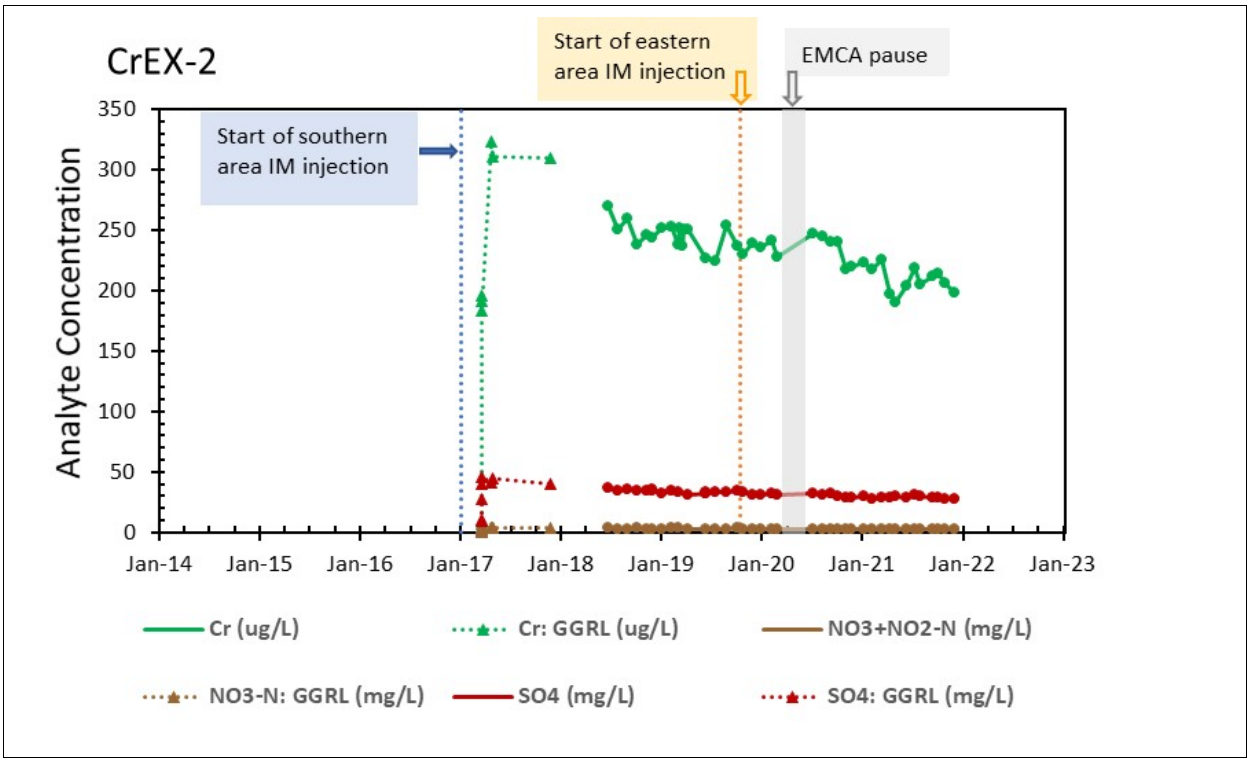
Notes: Solid symbols represent detection results at the plotted value. The background for chromium is 7.48 µg/L. Data represented by triangles and dashed lines indicate screening-level data analyzed at GGRL. Groundwater elevations represent raw data (without barometric adjustment).

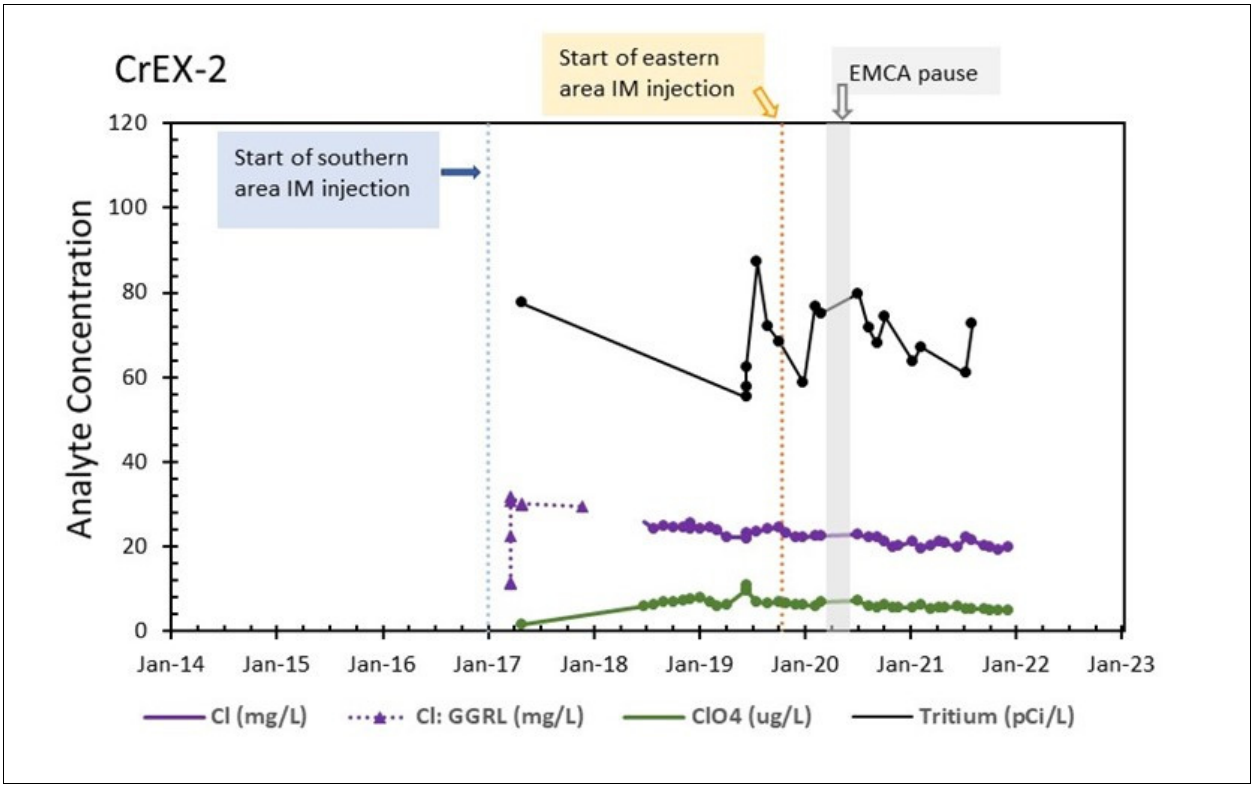
Figure 3.2-18 Time-series plots for CrPZ-5



Notes: Open symbols represent nondetection results and solid symbols represent detection results at the plotted value. The background for chromium is 7.48 µg/L. Data represented by triangles and dashed lines indicate screening-level data analyzed at GGRL. Groundwater elevations represent raw data (without barometric adjustment).

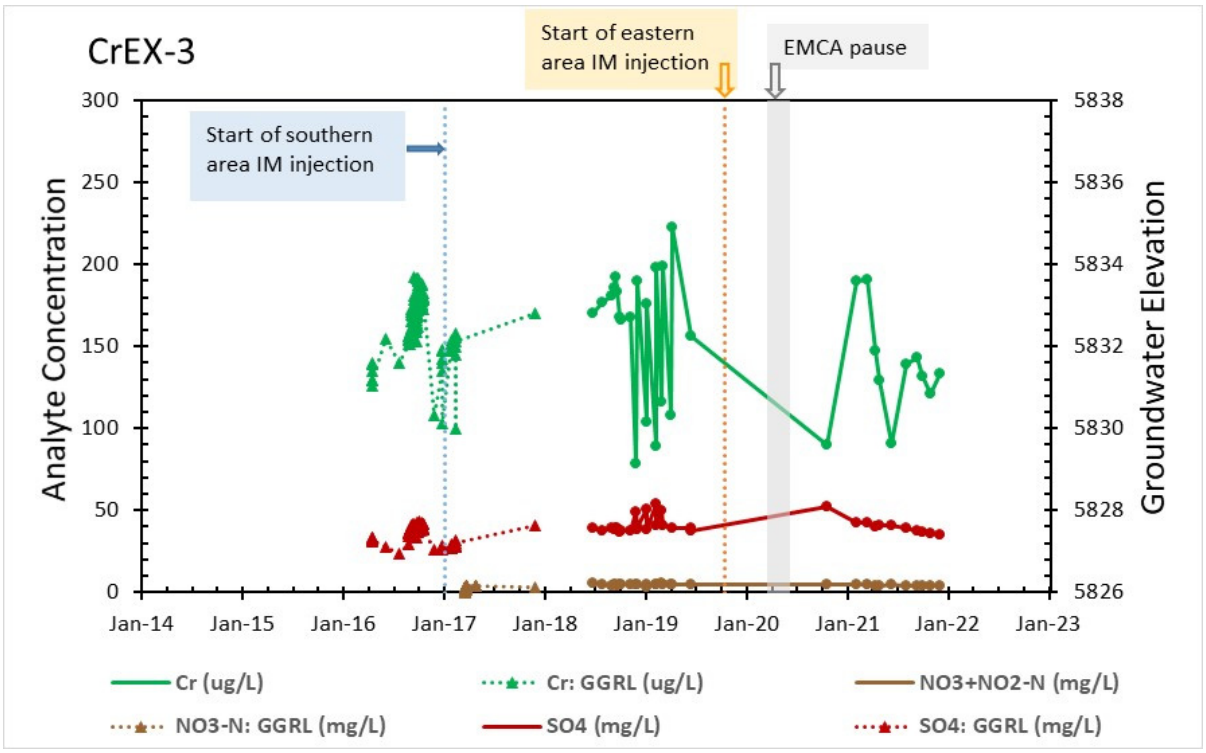
Figure 3.2-19 Time-series plots for CrEX-1

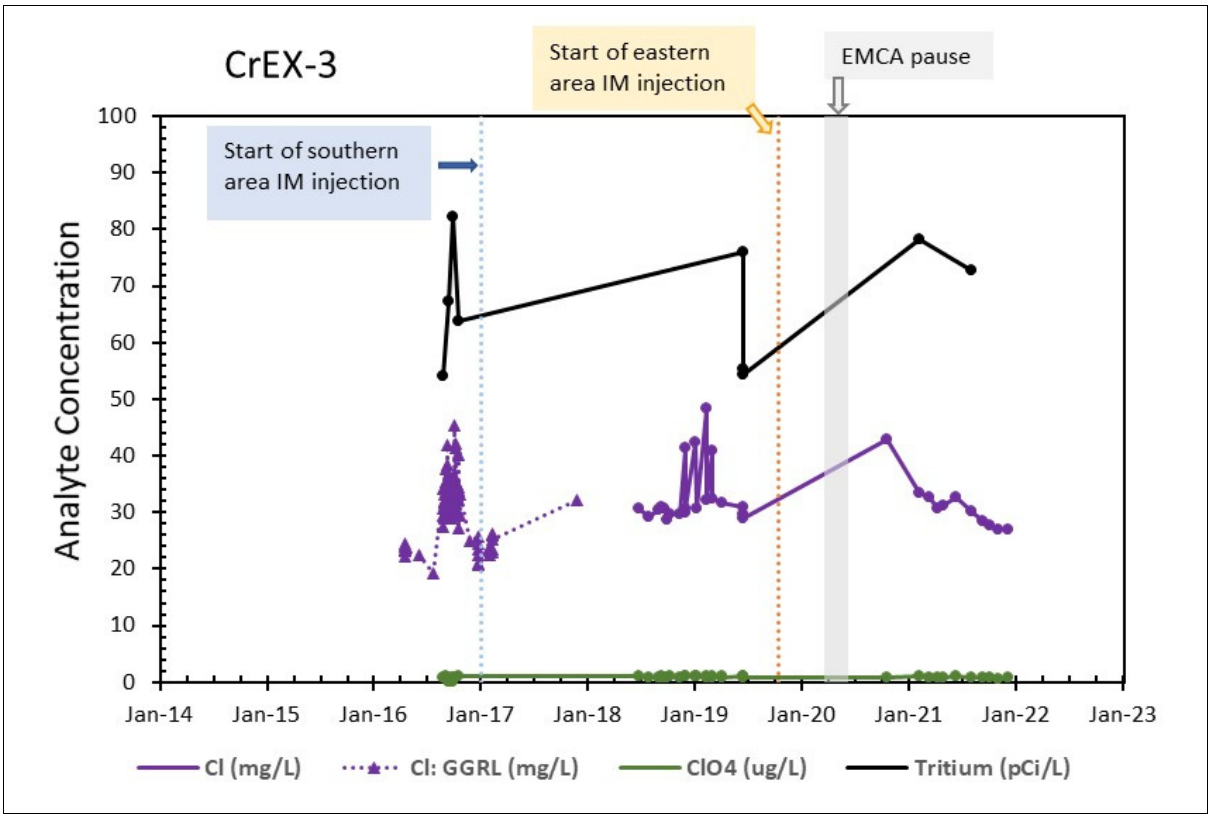




Notes: Solid symbols represent detection results at the plotted value. The background for chromium is 7.48 µg/L. Data represented by triangles and dashed lines indicate screening-level data analyzed at GGRL. Groundwater elevations represent raw data (without barometric adjustment).

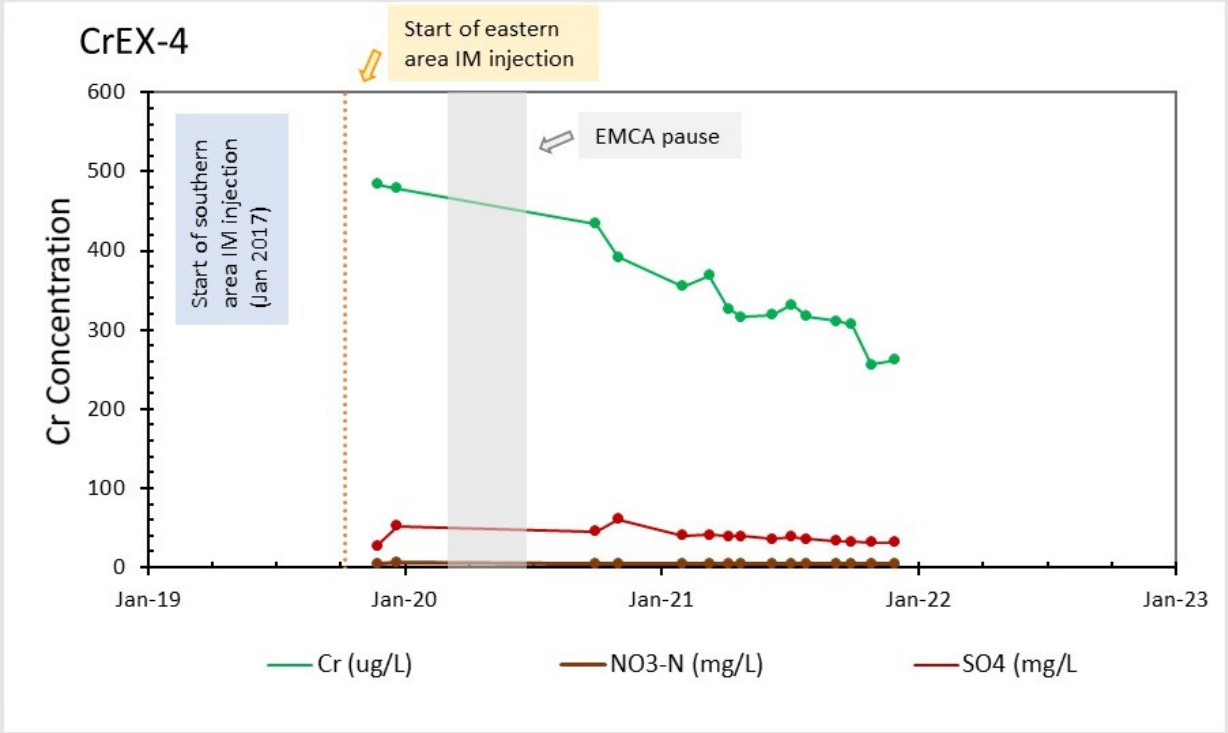
Figure 3.2-20 Time-series plots for CrEX-2

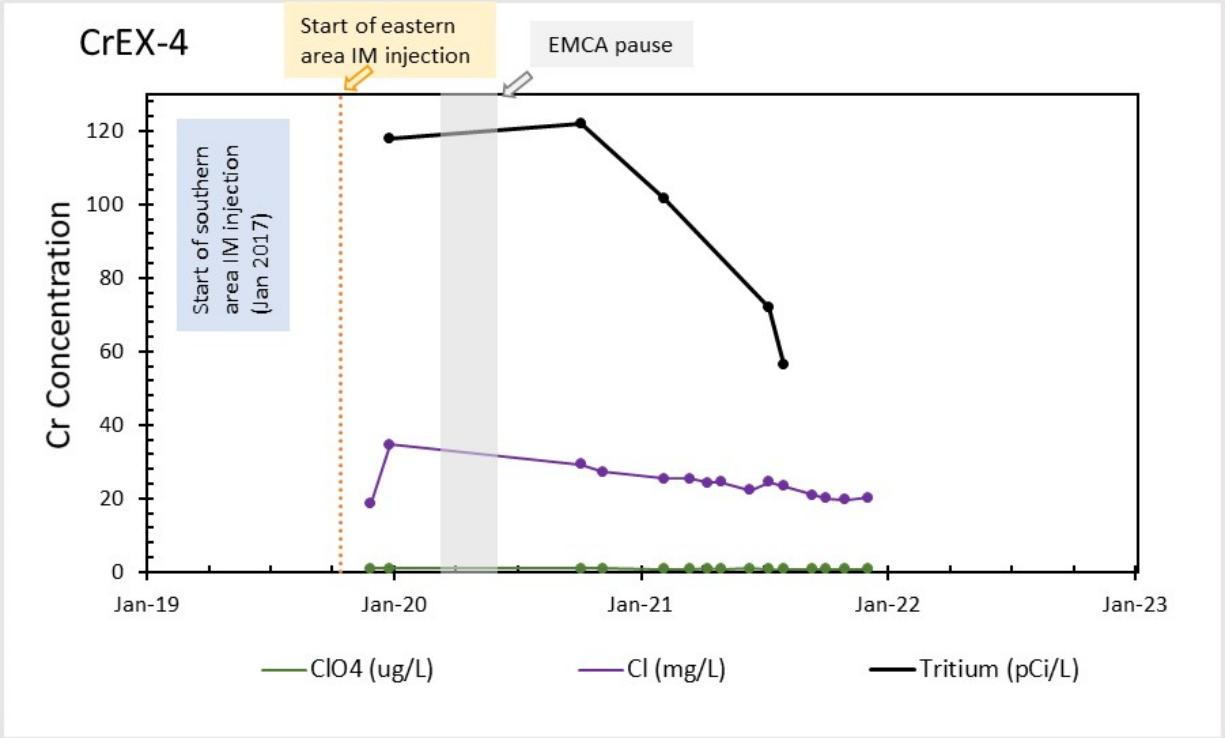




Notes: Solid symbols represent detection results at the plotted value. The background for chromium is 7.48 µg/L. Data represented by triangles and dashed lines indicate screening-level data analyzed at GGRL. Groundwater elevations represent raw data (without barometric adjustment).

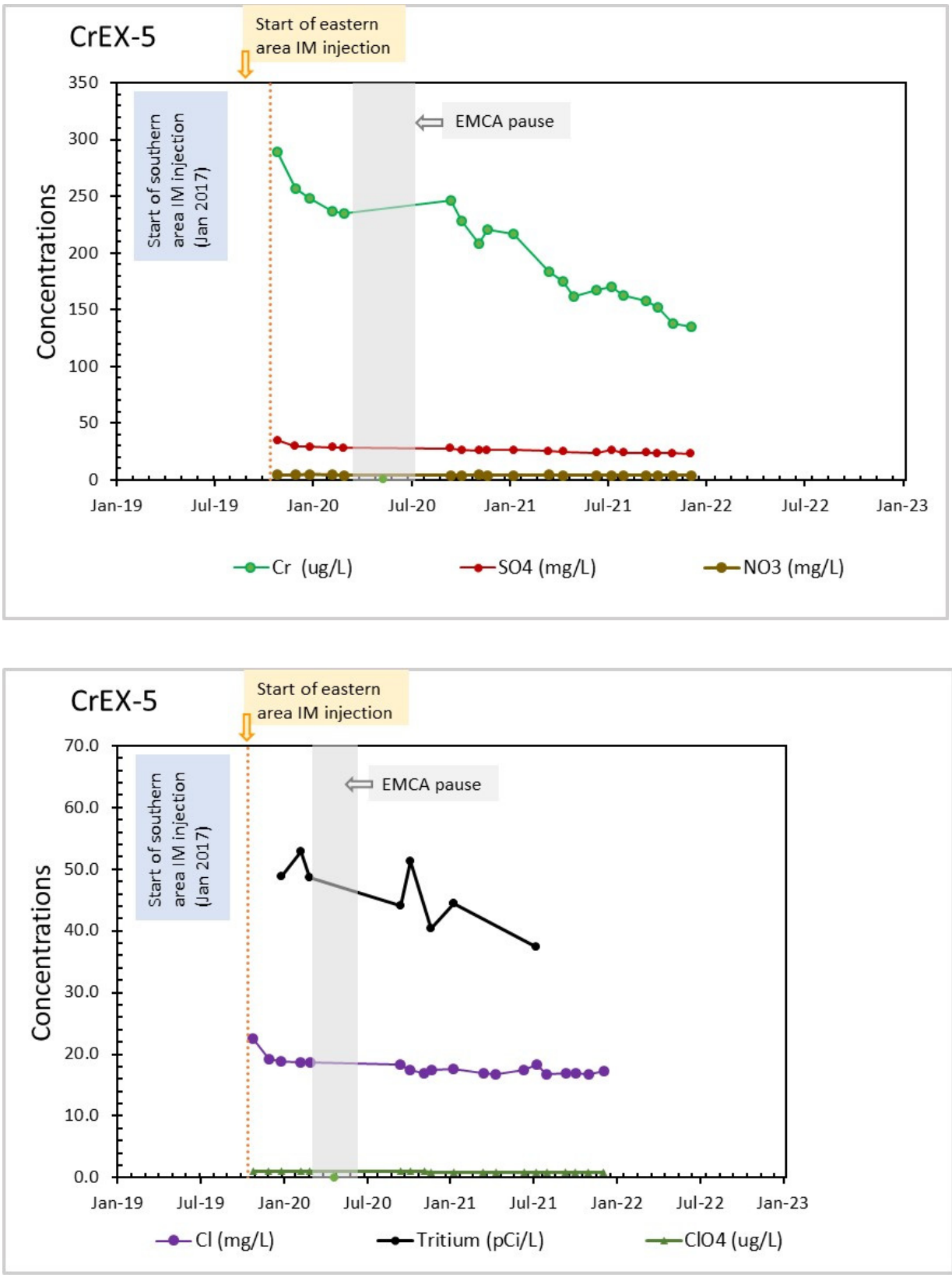
Figure 3.2-21 Time-series plots for CrEX-3





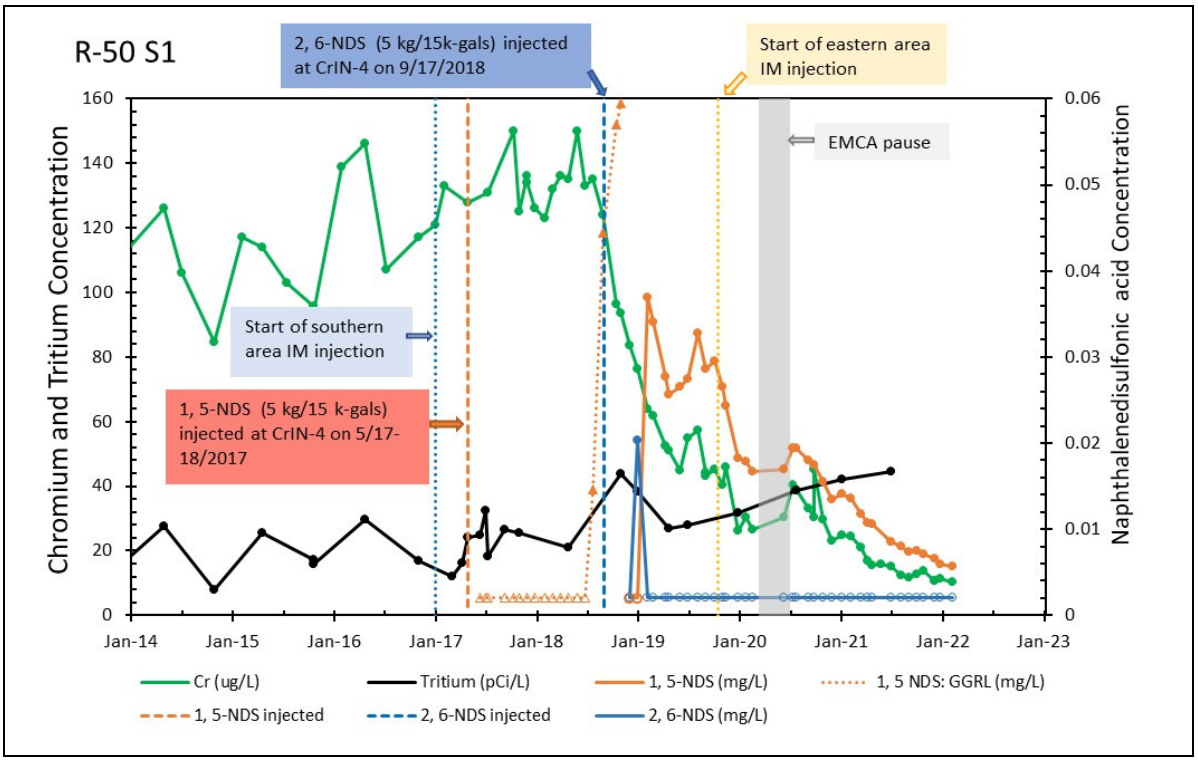
Notes: Solid symbols represent detection results at the plotted value. The background for chromium is 7.48 µg/L. Groundwater elevations represent raw data (without barometric adjustment).

Figure 3.2-22 Time-series plots for CrEX-4



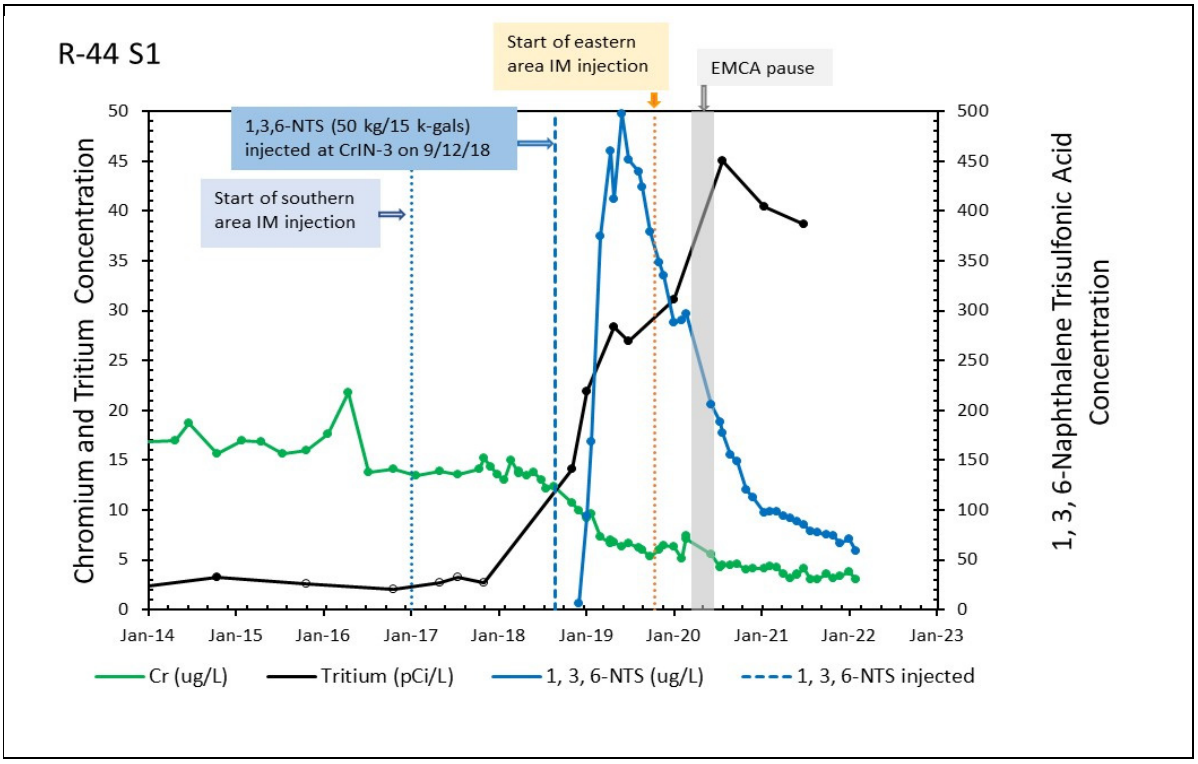
Notes: Solid symbols represent detection results at the plotted value. The background for chromium is 7.48 µg/L. Groundwater elevations represent raw data (without barometric adjustment).

Figure 3.2-23 Time-series plots for CrEX-5



Notes: Open symbols represent nondetection results and solid symbols represent detection results at the plotted value. The background for chromium is 7.48 µg/L. Groundwater elevations represent raw data (without barometric adjustment).

Figure 3.2-24 Time-series plots of tracer detections for R-50 screen 1



Notes: Open symbols represent nondetection results and solid symbols represent detection results at the plotted value. The background for chromium is 7.48 µg/L. Groundwater elevations represent raw data (without barometric adjustment).

Figure 3.2-25 Time-series plots of tracer detections for R-44 screen 1

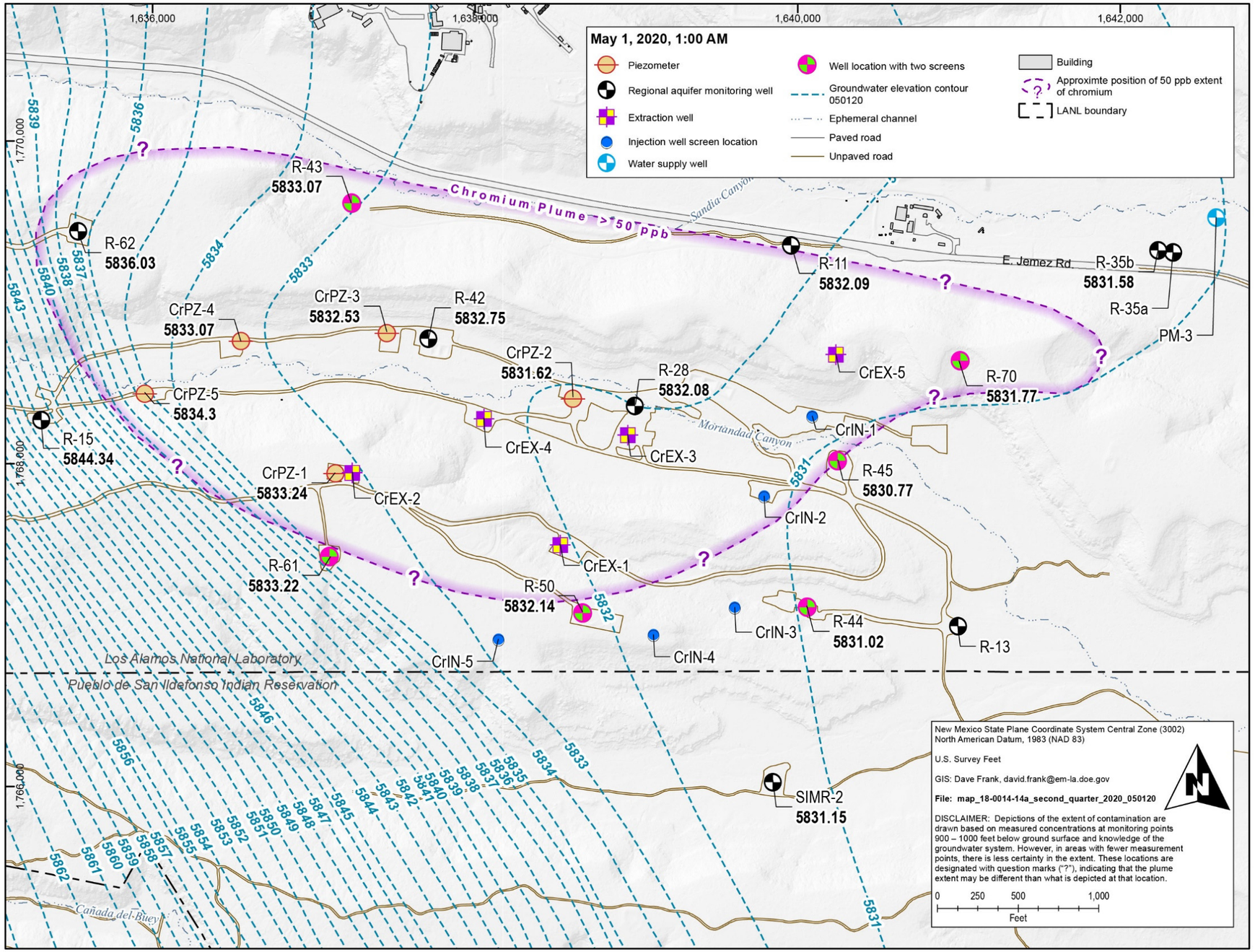


Figure 3.3-1 Baseline water table for May 1, 2020

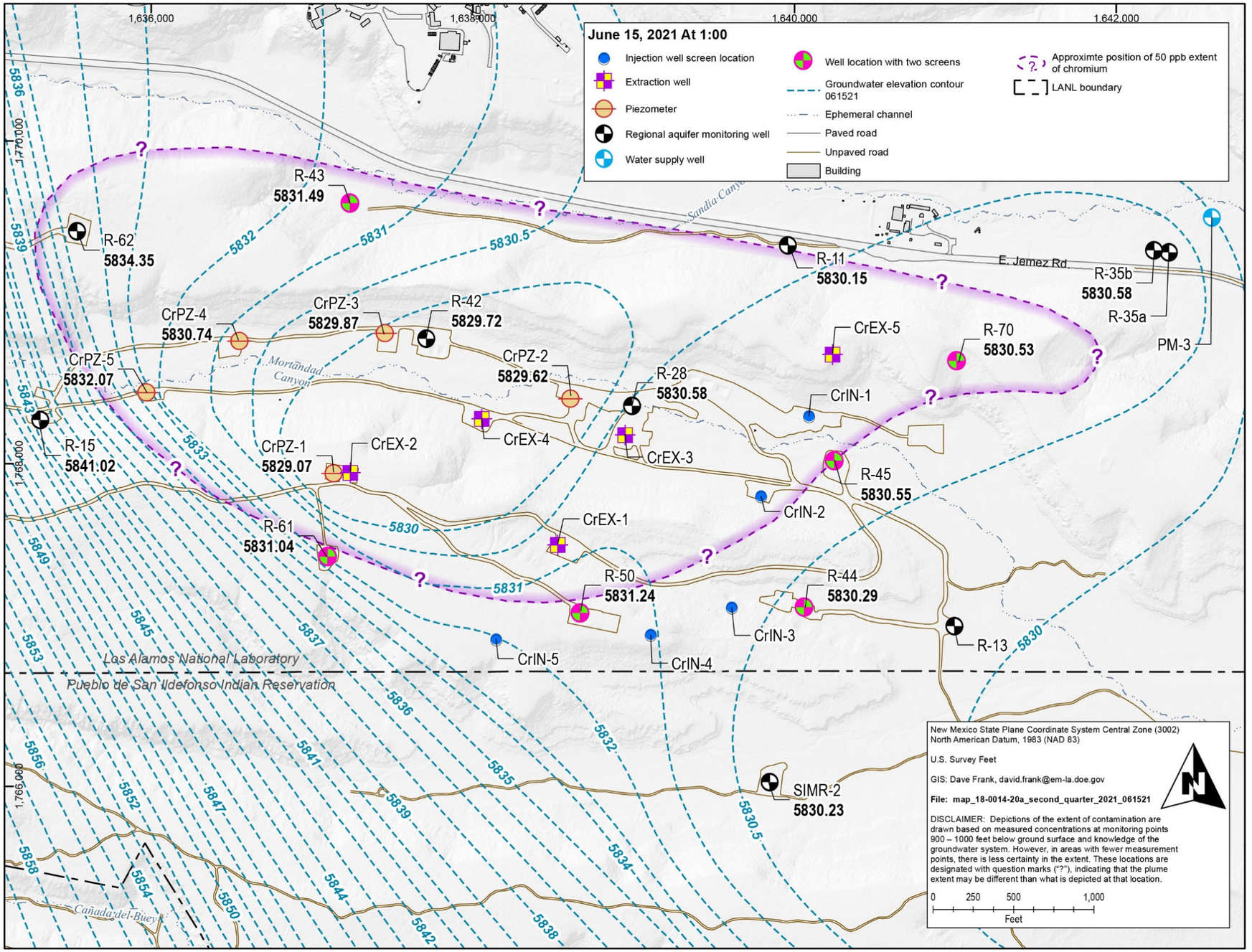


Figure 3.3-2 Water table for June 15, 2021

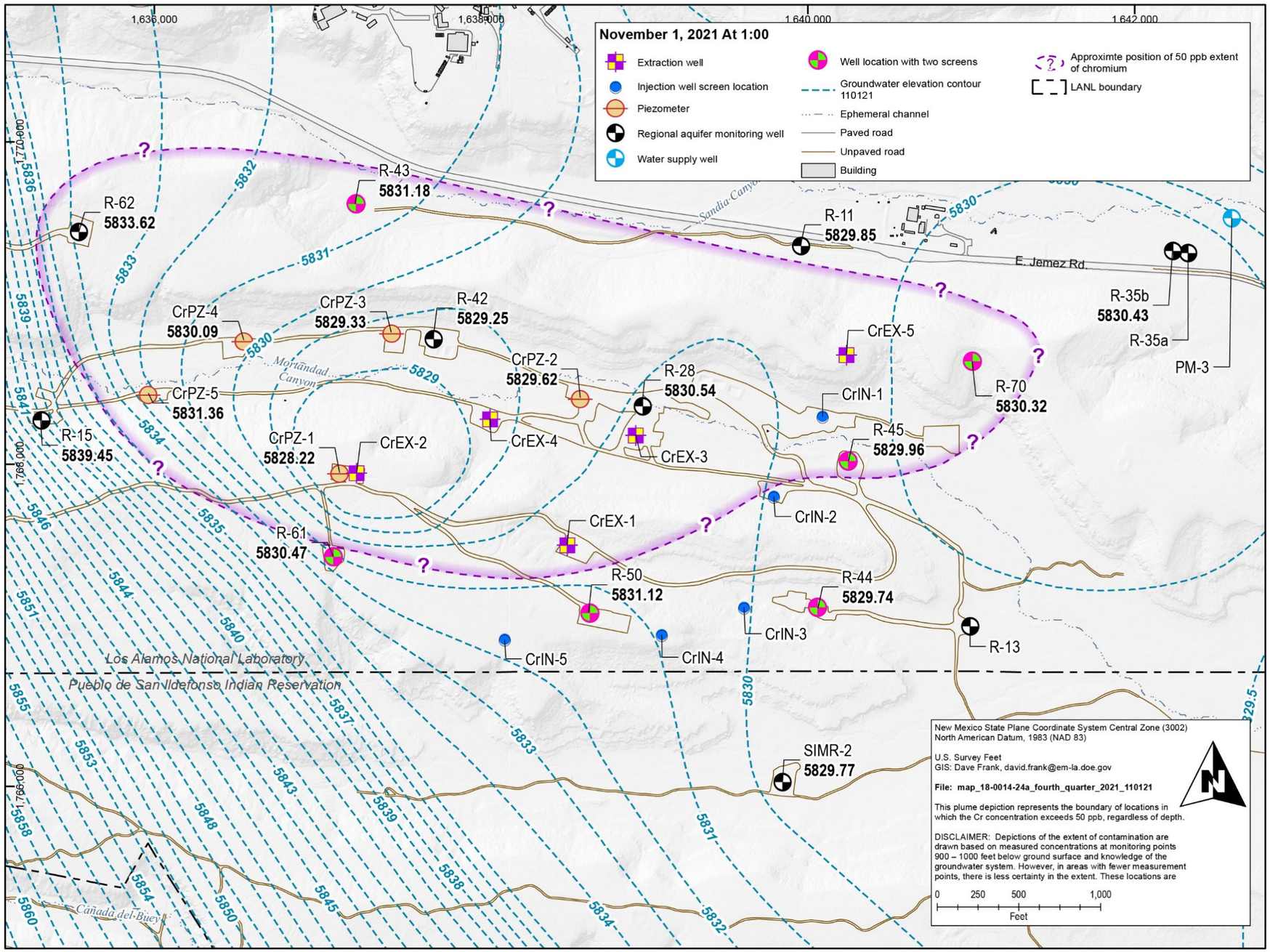


Figure 3.3-3 Water table for November 1, 2021

Table 2.1-1
Operations and Maintenance Activity Summary

Maintenance Date	Elements Involved	Operation/Maintenance Description
7/1/2021 through 7/21/2021	CrEX-1, CrEX-2, CrEX-4, CrEX-5, CTUA, CTUC, CrIN-1, CrIN-2, CrIN-3, CrIN-4, CrIN-5 CrEX-3	Extraction, treatment, and injection of treated groundwater occurred per operational plan. CrEX-3 turned off after wellhead sampling on 6/30/2021.
7/21/2021	CTUA	IX vessel exchanges were completed as follows because of an increase in the amount of hexavalent chromium at the primary IX vessel effluent as determined via Hach instrument analysis: • Treatment train A – replaced resin in primary IX vessel; swapped primary vessel into secondary service; swapped previous secondary vessel into primary service. • Treatment train B – replaced resin in primary IX vessel; swapped primary vessel into secondary service; swapped previous secondary vessel into primary service. • Treatment train C – replaced resin in primary IX vessel; swapped primary vessel into secondary service; swapped previous secondary vessel into primary service. Replaced both influent bags and all three effluent filter bags.
7/21/2021 through 7/29/2021	CrEX-2, CrEX-4, CrEX-5, CTUA, CTUC, CrIN-2, CrIN-3, CrIN-4, CrIN-5 CrEX-1, CrIN-1	Extraction, treatment, and injection of treated groundwater occurred per operational plan. CrEX-1 would not come back on after vessel swap. CrEX-1 would remain off for the remainder of Quarter 3 2021. CrIN-1 turned off to balance system.
7/25/2021	CTUC	IX vessel exchanges were completed as follows because of an increase in the amount of hexavalent chromium at the primary IX vessel effluent as determined via Hach instrument analysis: • Treatment train A – replaced resin in primary IX vessel; swapped primary vessel into secondary service; swapped previous secondary vessel into primary service. • Treatment train B – replaced resin in primary IX vessel; swapped primary vessel into secondary service; swapped previous secondary vessel into primary service. Replaced both influent bags.
7/29/2021	CrEX-3, CrIN-1, CrIN-3	CrEX-3 turned on. Turned off CrIN-3 and turned on CrIN-1 for system balancing.
7/29/2021 through 8/16/2021	CrEX-2, CrEX-3, CrEX-4, CrEX-5, CTUA, CTUC, CrIN-1, CrIN-2, CrIN-4, CrIN-5	Extraction, treatment, and injection of treated groundwater occurred per operational plan.
8/15/2021 through 8/16/2021	CrEX-2, CrEX-3, CrEX-4, CrEX-5, CTUA, CTUC, CrIN-1, CrIN-2, CrIN-4, CrIN-5	Lightning storm and power outage to Mortandad Canyon on evening of 8/15/2021. Entire system down overnight. Restarted system on 8/16/2021. CrIN-5 offline due to uninterrupted power supply failure related to lightning.
8/16/2021 through 8/24/2021	CrEX-2, CrEX-3, CrEX-4, CrEX-5, CTUA, CTUC, CrIN-1, CrIN-2, CrIN-4	Extraction, treatment, and injection of treated groundwater occurred per operational plan.

Table 2.1-1 (continued)

Maintenance Date	Elements Involved	Operation/Maintenance Description
8/20/2021	CTUA	IX vessel exchanges were completed as follows because of an increase in the amount of hexavalent chromium at the primary IX vessel effluent as determined via Hach instrument analysis: • Treatment train A – replaced resin in primary IX vessel; swapped primary vessel into secondary service; swapped previous secondary vessel into primary service. • Treatment train B – replaced resin in primary IX vessel; swapped primary vessel into secondary service; swapped previous secondary vessel into primary service. • Treatment train C – replaced resin in primary IX vessel; swapped primary vessel into secondary service; swapped previous secondary vessel into primary service. Replaced both influent bags and all three effluent filter bags
8/24/2021	CrIN-5	Repaired CrIN-5 electrical issue and turned well back on.
8/25/2021	CTUC	IX vessel exchanges were completed as follows because of an increase in the amount of hexavalent chromium at the primary IX vessel effluent as determined via Hach instrument analysis: • Treatment train A – replaced resin in primary IX vessel; swapped primary vessel into secondary service; swapped previous secondary vessel into primary service. • Treatment train B – replaced resin in primary IX vessel; swapped primary vessel into secondary service; swapped previous secondary vessel into primary service. Replaced both influent bags and both effluent filter bags.
8/26/2021 through 8/27/2021	CrEX-2, CrEX-3, CrEX-4, CrEX-5, CTUA, CTUC, CrIN-1, CrIN-2, CrIN-4, CrIN-5	Lightning storm and power outage to Mortandad Canyon on evening of 8/26/2021. Entire system down overnight. Restarted system on 8/27/2021.
8/27/2021 through 9/22/2021	CrEX-2, CrEX-3, CrEX-4, CrEX-5, CTUA, CTUC, CrIN-1, CrIN-2, CrIN-4, CrIN-5	Extraction, treatment, and injection of treated groundwater occurred per operational plan.
9/22/2021	CTUC	IX vessel exchanges were completed as follows because of an increase in the amount of hexavalent chromium at the primary IX vessel effluent as determined via Hach instrument analysis: • Treatment train A – replaced resin in primary IX vessel; swapped primary vessel into secondary service; swapped previous secondary vessel into primary service. • Treatment train B – replaced resin in primary IX vessel; swapped primary vessel into secondary service; swapped previous secondary vessel into primary service. Replaced both influent bags and both effluent filter bags.
9/22/2021 through 9/29/2021	CrEX-2, CrEX-3, CrEX-4, CrEX-5, CTUA, CTUC, CrIN-1, CrIN-2, CrIN-4, CrIN-5	Extraction, treatment, and injection of treated groundwater occurred per operational plan.

Table 2.1-1 (continued)

Maintenance Date	Elements Involved	Operation/Maintenance Description
9/29/2021	CTUA	IX vessel exchanges were completed as follows because of an increase in the amount of hexavalent chromium at the primary IX vessel effluent as determined via Hach instrument analysis: • Treatment train A – replaced resin in primary IX vessel; swapped primary vessel into secondary service; swapped previous secondary vessel into primary service. • Treatment train B – replaced resin in primary IX vessel; swapped primary vessel into secondary service; swapped previous secondary vessel into primary service. • Treatment train C – replaced resin in primary IX vessel; swapped primary vessel into secondary service; swapped previous secondary vessel into primary service. Replaced both influent bags and all three effluent filter bags.
9/29/2021 through 9/30/2021	CrEX-2, CrEX-3, CrEX-4, CrEX-5, CTUA, CTUC, CrIN-1, CrIN-2, CrIN-4, CrIN-5	Extraction, treatment, and injection of treated groundwater occurred per operational plan.
10/1/2021 through 10/27/2021	CrEX-2, CrEX-3, CrEX-4, CrEX-5, CTUA, CTUC, CrIN-1, CrIN-2, CrIN-4, CrIN-5	Extraction, treatment, and injection of treated groundwater occurred per operational plan.
10/27/2021	CTUC	IX vessel exchanges were completed as follows because of an increase in the amount of hexavalent chromium at the primary IX vessel effluent as determined via Hach instrument analysis: • Treatment train A – replaced resin in primary IX vessel; swapped primary vessel into secondary service; swapped previous secondary vessel into primary service. • Treatment train B – replaced resin in primary IX vessel; swapped primary vessel into secondary service; swapped previous secondary vessel into primary service. Both influent bags replaced.
10/27/2021 through 11/18/2021	CrEX-2, CrEX-3, CrEX-4, CrEX-5, CTUA, CTUC, CrIN-1, CrIN-2, CrIN-4, CrIN-5	Extraction, treatment, and injection of treated groundwater occurred per operational plan.
11/18/2021 through 12/1/2021	CrEX-4, CrIN-2 CrEX-2, CrEX-3, CrEX-5, CTUA, CTUC, CrIN-1, CrIN-4, CrIN-5	CrEX-4 turned off due to a dual-wall pipe containment alarm. CrIN-2 also turned off to balance flow. Extraction, treatment, and injection of treated groundwater occurred per operational plan.
12/1/2021	Entire system	Turned off all extraction wells, injection wells, and treatment units for cybersecurity remote updates. Reset CrEX-4 dual-wall pipe containment alarm.
12/2/2021 through 12/8/2021	CrEX-2, CrEX-3, CrEX-4, CrEX-5, CTUA, CTUC, CrIN-1, CrIN-2, CrIN-4, CrIN-5	Extraction, treatment, and injection of treated groundwater occurred per operational plan.
12/8/2021	CTUC	IX vessel exchanges were completed as follows because of an increase in the amount of hexavalent chromium at the primary IX vessel effluent as determined via Hach instrument analysis:

Table 2.1-1 (continued)

Maintenance Date	Elements Involved	Operation/Maintenance Description
		• Treatment train A – replaced resin in primary IX vessel; swapped primary vessel into secondary service; swapped previous secondary vessel into primary service. • Treatment train B – replaced resin in primary IX vessel; swapped primary vessel into secondary service; swapped previous secondary vessel into primary service. Both influent bags replaced.
12/8/2021 through 12/15/2021	CrEX-2, CrEX-3, CrEX-4, CrEX-5, CTUA, CTUC, CrIN-1, CrIN-2, CrIN-4, CrIN-5	Extraction, treatment, and injection of treated groundwater occurred per operational plan.
12/15/2021	CrIN-5	CrIN-5 turned off due to an uninterrupted power supply issue. All other wells remained operating.
12/15/2021 through 12/22/2021	CrEX-2, CrEX-3, CrEX-4, CrEX-5, CTUA, CTUC, CrIN-1, CrIN-2, CrIN-4	Extraction, treatment, and injection of treated groundwater occurred per operational plan.
12/22/2021	CrIN-5	CrIN-5 electrical issue repaired and well brought back online
12/22/2021 through 12/28/2021	CrEX-2, CrEX-3, CrEX-4, CrEX-5, CTUA, CTUC, CrIN-1, CrIN-2, CrIN-4, CrIN-5	Extraction, treatment, and injection of treated groundwater occurred per operational plan.
12/28/2021	CTUA	IX vessel exchanges were completed as follows because of an increase in the amount of hexavalent chromium at the primary IX vessel effluent as determined via Hach instrument analysis: • Treatment train A – replaced resin in primary IX vessel; swapped primary vessel into secondary service; swapped previous secondary vessel into primary service. • Treatment train B – replaced resin in primary IX vessel; swapped primary vessel into secondary service; swapped previous secondary vessel into primary service. • Treatment train C – replaced resin in primary IX vessel; swapped primary vessel into secondary service; swapped previous secondary vessel into primary service. Both influent and all three effluent filter bags replaced.
12/28/2021 through 12/3120/21	CrEX-2, CrEX-3, CrEX-4, CrEX-5, CTUA, CTUC, CrIN-1, CrIN-2, CrIN-4, CrIN-5	Extraction, treatment, and injection of treated groundwater occurred per operational plan.
1/1/2022 through 1/23/2022	CrEX-2, CrEX-3, CrEX-4, CrEX-5, CTUA, CTUC, CrIN-1, CrIN-2, CrIN-4, CrIN-5	Extraction, treatment, and injection of treated groundwater occurred per operational plan.
1/23/2022	CrEX-4, CrIN-2 CrEX-2, CrEX-3, CrEX-5, CTUA, CTUC, CrIN-3, CrIN-4, CrIN-5	CrEX-4 turned off due to a dual-wall pipe containment alarm. CrIN-2 also turned off to balance flow. Extraction, treatment, and injection of treated groundwater occurred per operational plan.
1/23/2022 through 1/24/2022	CrEX-2, CrEX-3, CrEX-5, CTUA, CTUC, CrIN-3, CrIN-4, CrIN-5	Extraction, treatment, and injection of treated groundwater occurred per operational plan.

Table 2.1-1 (continued)

Maintenance Date	Elements Involved	Operation/Maintenance Description
1/24/2022	Entire system	Turned off all extraction wells, injection wells, and treatment units for cybersecurity remote updates.
1/25/2022 through 1/28/2022	CrEX-3, CrEX-5, CTUA, CTUC, CrIN-1, CrIN-2,	Extraction, treatment, and injection of treated groundwater occurred per operational plan
1/28/2022 through 3/8/2022	Entire system	Turned off all extraction wells, injection wells, and treatment units in preparation for aquifer testing at CrEX-1 following pump replacement at CrEX-1.
2/9/2022 through 2/10/2022	CrIN-1, CrIN-2, CrIN-3, CrIN-4, CrIN-5	Backflush/maintenance pumping conducted at all CrIN well locations. Treatment system remains off.
3/6/2022	CrEX-1	Pump replacement at CrEX-1 finished.
3/8/2022 through 3/11/2022	CrEX-4, CTUC, CrIN-1	Extraction, treatment, and injection of treated groundwater occurred per phased startup plan.
3/12/2022	Entire system	All extraction wells, injection wells, and treatment units off for phased startup.
3/13/2022 through 3/17/2022	CrEX-4, CTUC, CrIN-2	Extraction, treatment, and injection of treated groundwater occurred per phased startup plan.
3/18/2022	Entire system	All extraction wells, injection wells, and treatment units off for phased startup.
3/19/2022 through 3/22/2022	CrEX-4, CTUC, CrIN-3	Extraction, treatment, and injection of treated groundwater occurred per phased startup plan.
3/22/2022	Entire system	All extraction wells, injection wells, and treatment units off for phased startup.
3/23/2022 through 3/30/2022	CrEX-2, CrEX-3, CrEX-4, CrEX-5, CTUA, CTUC, CrIN-1, CrIN-2, CrIN-3, CrIN-4, CrIN-5	Extraction, treatment, and injection of treated groundwater occurred per operational plan. Entire treatment system back online with the exception of CrEX-1.
3/30/2022 through 3/31/2022	CrEX-1, CrEX-2, CrEX-3, CrEX-4, CrEX-5, CTUA, CTUC, CrIN-1, CrIN-2, CrIN-3, CrIN-4, CrIN-5	Extraction, treatment, and injection of treated groundwater occurred per operational plan. Entire treatment system back online. CrEX-1 difficulties with phase/rotation remedied.

Table 2.1-2
Quarterly Injection Well Treated Water Total Volumes

Period	CrIN-1 (gal.)	CrIN-2 (gal.)	CrIN-3 (gal.)	CrIN-4 (gal.)	CrIN-5 (gal.)
3rd Quarter 2021	6,717,160	7,783,165	1,074,764	6,867,079	6,202,973
4th Quarter 2021	7,045,492	6,212,707	0	7,034,028	6,497,684
1st Quarter 2022	3,081,557	3,039,073	739,917	2,542,259	2,607,898

Table 2.1-3
Interim Measure Chromium Mass Removal Estimates

Quarter	Average Hach Hexavalent-Chromium (ppb)	Volume Extracted and Treated (gal.)	Chromium Removed (kg)	Chromium Removed (lb)[a]
4th Qtr 2016	180	665,267	0.5	1.0
1st Qtr 2017	181	6,226,097	4.3	9.4
2nd Qtr 2017	184	4,952,226	3.4	7.6
3rd Qtr 2017	284	95,471	0.1	0.2
4th Qtr 2017	237	5,599,138	5.0	11.1
1st Qtr 2018	237	3,045,820	2.7	6.0
2nd Qtr 2018	227	13,360,000	11.5	25.3
3rd Qtr 2018	223	20,776,913	17.5	38.7
4th Qtr 2018	206	20,442,977	15.9	35.1
1st Qtr 2019	204	19,553,753	15.1	33.3
2nd Qtr 2019	193	8,434,861	6.2	13.6
3rd Qtr 2019	190	15,574,060	11.2	24.7
4th Qtr 2019	208	24,066,243	18.9	41.8
1st Qtr 2020	215	27,198,274	22.1	48.8
2nd Qtr 2020	0	0	0.0	0.0
3rd Qtr 2020	183	14,980,866	10.4	22.9
4th Qtr 2020	223	24,336,996	20.5	45.3
1st Qtr 2021	201	25,836,790	19.7	43.3
2nd Qtr 2021	217	35,220,210	28.9	63.8
3rd Qtr 2021	223	29,251,727	24.7	54.4
4th Qtr 2021	214	26,523,831	21.5	47.4
1st Qtr 2022	212	12,133,616	9.7	21.5
Total	n/a[b]	**338,275,136**	**269.9**	**595.1**

[a] Kilogram to pound conversions are subject to rounding errors due to the number of significant figures used.

[b] n/a = Not applicable.

Table 3.1-1
Performance Monitoring Locations and Analyte Suites,
Including Tracers that Have Been or Will Be Deployed in
Monitoring Wells, Piezometers, and Injection Wells in the Project Area

Location	Metals	Low-Level Tritium	General Inorganics[a]	Naphthalene Sulfonate Tracers	Sodium Bromide Tracer	Sodium Perrhenate Tracer	Deuterated Water Tracer
R-11	M[b]	S[c]	M	M	M	M	M
R-35a	M	S	M	M	M	M	M
R-35b	M	S	M	M	M	M	M
R-44 S1[d]	M	Q[e]	M	M	M	M	—[f]
R-44 S2[g]	M	Q	M	M	M	M	—
R-45 S1	M	Q	M	M	M	M	M
R-45 S2	M	Q	M	M	M	M	M
R-50 S1	M	Q	M	M	M	—	—
R-50 S2	M	Q	M	M	M	—	—
R-61 S1	M	Q	M	M	M	—	—
R-70 S1	M	Q	M	M	M	M	M
R-70 S2	M	Q	M	M	M	M	M
SIMR-2	M	S	M	M	M	—	—
CrPZ-1	Q	Q	Q	—	Q	—	—
CrPZ-2a	Q	Q	Q	—	Q	—	—
CrPZ-3	Q	Q	Q	—	Q	—	—
CrPZ-4	Q	Q	Q	—	Q	—	—
CrPZ-5	Q	Q	Q	—	Q	—	—

[a] Includes nitrate, sulfate, and perchlorate.

[b] M = Monthly.

[c] S = Semiannually.

[d] S1= Screen 1.

[e] = Q = Quarterly.

[f] Not analyzed at the noted location.

[g] S2 = Screen 2.

Appendix A

Analytical Water Quality Data Collected under the Interim Facility-Wide Groundwater Monitoring Plan (on CD included with this document)

Appendix B

Analytical Water Quality Data Collected from Chromium Treatment Unit Influent and Effluent (on CD included with this document)

Appendix C

Chromium Interim Measure Extraction and Injection Flow Data
(on CD included with this document)

Appendix D

Los Alamos County Well Pumping Data
(on CD included with this document)