Third Quarter 2022
Groundwater, Surface Water Sampling, and Analysis Report

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Prepared for:
Clark County, Washington, and
Washington State Department of Ecology

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(Electronic files provided on enclosed CD)

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(Electronic files provided on enclosed CD)

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1 INTRODUCTION

This report documents the results of third quarter 2022 groundwater and surface water monitoring at the Camp Bonneville Military Reservation (Camp Bonneville) in Vancouver, Washington (Figure 1). The work was performed by PBS Engineering and Environmental Inc. (PBS) under contract to Clark County (County).

Groundwater and surface water monitoring was performed in accordance with the Health and Safety Plan for Groundwater and Surface Water Monitoring Activities (HASP),[1] the Supplemental Groundwater and Surface Water Remedial Investigation Sampling and Analysis Plan and Quality Assurance Project Plan (SAP/QAPP),[2] and Amendment #1 to the SAP/QAPP.[3] Laboratory analytical services were provided by Anatek Labs located in Moscow, Idaho, under contract with PBS.

Acronyms used in this report are defined on first use. Please refer to Appendix A for a list of acronyms and abbreviations.

2 Site Background

2.1 Site History[4]

Camp Bonneville comprises approximately 3,840 acres and is in southwestern Washington, approximately 10 miles northeast of Vancouver (Figure 1). The United States Army used Camp Bonneville for live fire of small arms, assault weapons, artillery, and field and air defense artillery between 1910 and 1995. Since 1947, Camp Bonneville has also provided training for a variety of military and nonmilitary units including the National Guard; Army Reserves; Air Force; and federal, state, and local law enforcement agencies.

In July 1995, Camp Bonneville was selected for closure under the 1995 Base Realignment and Closure (BRAC) process, and transferred to the County for public benefit, education, law enforcement training, and parks. Transfer of Camp Bonneville to the Trust for Public Land, and subsequently to the County, began in 2006. On October 3, 2006, the County entered a Prospective Purchaser Consent Decree with the Washington State Department of Ecology (Ecology) that required investigating and remediating the site.

Ordnance and explosive (OE) items were found within Camp Bonneville's boundaries, and removal efforts of OE were performed, with a few ongoing efforts. Some of the OE items were determined to be unexploded ordnance (UXO). Current activities include assessment and management of OE and UXO by qualified munitions contractors with knowledge and experience in military ordnance, ordnance components, explosives location, identification, render safe, recovery and removal, transportation, and disposal safety precautions. The historical use and storage of OE and UXO have impacted groundwater at Camp Bonneville, and monitoring these impacts is the purpose of this monitoring event.

2.2 Camp Bonneville Geology

Camp Bonneville is situated north of the Portland Basin in the foothills of the Cascade Range. The general area consists of Eocene and Miocene volcanic and sedimentary rocks, with Holocene sedimentary rocks in valleys

[1] PBS Engineering and Environmental Inc. (November 16, 2017). *Health and Safety Plan for Groundwater and Surface Water Monitoring Activities*.
[2] PBS Engineering and Environmental Inc. (February 22, 2018). *Supplemental Groundwater and Surface Water Remedial Investigation Sampling and Analysis Plan and Quality Assurance Project Plan, Remedial Action Units 2C and 3, Camp Bonneville, 23201 NE Pluss Road, Vancouver, Washington 98682*.
[3] PBS Engineering and Environmental Inc. (March 5, 2019). *Amendment #1 – Changes to Table 4-1A and 4-1B in the Supplemental Groundwater and Surface Water Remedial Investigation Sampling and Analysis Plan and Quality Assurance Project Plan, Remedial Action Units 2C and 3, Dated February 2018, Camp Bonneville, Vancouver, Washington*.
[4] Shannon & Wilson. (1999). *Multi-Sites Investigation Report, Camp Bonneville, Vancouver, Washington,* (Vol. 1). Contract No. DACA67-94-D-1014.

and areas where gravels of the Troutdale Formation can be found.[5] The geology at Camp Bonneville can be divided into three general areas that correspond approximately to topographic divisions.[6]

Lacamas Creek flows through Camp Bonneville from the northeast to southwest. The area west of Lacamas Creek comprises a series of predominantly gravelly and semi-consolidated conglomerate with scattered lenses and stringers of sand (Upper Troutdale formation). Underlying this formation and comprising the area to the north and east of Lacamas Creek are folded and faulted basalt flows, flow breccia, and pyroclastic and andesitic rocks.

The northwest portion of the site is located on a terrace where the land slopes down from the west, north, and east. Two tributaries exit ravines at the north end of the terrace and drain across the western edge to become North Fork Lacamas Creek. The terraced area likely resulted from an accumulation of material historically transported by the tributaries, contributing to the predominantly low- to medium-plasticity clay observed in the borings for the wells installed in this area. According to the boring logs in the landfill/demolition area (Landfill 4/Demolition Area 1), competent bedrock (andesite) was encountered between 440 and 460 feet above mean sea level (amsl), which is approximately 50 to 75 feet below ground surface (bgs). Sub-rounded and sub-angular gravel in the borings point to colluvial deposition of the soil.

The southwest corner of Camp Bonneville is where Lacamas Creek exits the site. The valley floor along Lacamas Creek contains unconsolidated silt, sand, and gravel valley fill, with some clay.

3 SITEWIDE GROUNDWATER MONITORING PROGRAM

3.1 Project Objectives

The overall objectives of site investigations at Camp Bonneville have been to identify contaminated areas and determine the next appropriate steps toward their restoration. Contaminated areas at Camp Bonneville have been divided into five remedial action units (RAU) that are differentiated by the nature of a contaminant. This quarterly report describes the results of ongoing monitoring of RAU 2C (sitewide groundwater) to assist with achieving the goal of site restoration.

Two areas associated with RAU 2C are currently being monitored, which include Landfill 4/Demolition Area 1, located in the northwest portion of the site, and Base Boundary at Lacamas Creek (Base Boundary), located in the southwest portion of the site (Figure 2). Wells have been installed in these areas to monitor shallow and deeper groundwater zones to maximum depths of approximately 75 feet bgs.

3.2 Chemicals of Potential Concern

Historical uses of Camp Bonneville’s upgradient areas include firing ranges, landfills, open burning locations, open detonation locations, and general maintenance facilities. Chemicals of potential concern (COPCs) include artillery propellants, high explosives residue, missile/rocket propellants, petroleum hydrocarbons, semi-volatile organic compounds (SVOCs), volatile organic compounds (VOCs), and metals. A summary of COPCs is provided in the SAP/QAPP, along with specific analytes and laboratory analysis methods, sample container types, preservation techniques, holding times, and data quality objectives (DQOs).

[5] Phillips, W.M. (1987). [Map]. Geologic Map of the Vancouver Quadrangle, Washington and Oregon: Washington Division of Geology and Earth Resources Open File Report 87-10, scale 1:100,000.
[6] Otak, Inc. (September 1998, 2nd Revision 15 November 2005). *Camp Bonneville Reuse Plan.* Prepared for The Camp Bonneville Local Redevelopment Authority (LRA).

Results from long-term monitoring indicate analysis for specific COPCs is warranted to assess contaminant levels throughout Camp Bonneville and to determine if impacts are leaving the site. For RAU 2C (analyzed at Landfill 4/Demolition Area 1 and Base Boundary), the COPC list for quarterly monitoring is as follows:

- Explosives by Environmental Protection Agency (EPA) Method 8330
- Perchlorate by EPA Method 6850
- VOCs by EPA Method 8260
- Field measurements of temperature, specific conductivity, dissolved oxygen (DO), pH, oxidation reduction potential (ORP), turbidity, and depth to water levels

For each quarter, analysis for the following COPCs occurs at three on-site water supply wells:

- Explosives by EPA Method 8330
- Perchlorate by EPA Method 6850
- VOCs by EPA Method 8260
- Field measurements of temperature, specific conductivity, DO, pH, and ORP

In the third quarter of each year, three surface water samples are collected to determine if groundwater is impacting surface water at the site. The COPC list for the surface water samples is as follows:

- 1,3,5-Trinitro-1,3,5-triazinane (RDX) by EPA Method 8330
- Perchlorate by EPA Method 6850
- Field measurements of temperature, specific conductivity, DO, pH, ORP, and turbidity
- Observations of stream conditions are noted on the field form

In the fourth quarter of each year, analysis for the following additional COPCs occurs at the Base Boundary wells:

- Priority pollutant metals by EPA Methods 6020/7470
- SVOCs by EPA Method 8270

3.3 Monitoring Program Locations

The current RAU 2C Camp Bonneville monitoring program requires groundwater sampling and analysis for 28 monitoring wells, shown on Figure 3 (Base Boundary) and Figure 4 (Landfill 4/Demolition Area 1). In addition, three water supply wells are sampled quarterly, and three surface water locations are sampled annually.

3.3.1 Monitoring Well Information[7]

Over the years, different numerical designations have been assigned to monitoring wells at the investigation areas. PBS uses the numbering system assigned by the US Army Center for Health Promotion and Preventive Medicine (CHPPM) in prior remedial investigation (RI) reports. Table 1 provides well information, including the monitoring well numbers used by PBS, Ecology well tag numbers, and well identification numbers for the Base Boundary and Landfill 4/Demolition Area 1 wells. The table also identifies the investigation area for each well along with total depth, screened interval, and top-of-casing elevation.

The monitoring wells located at Base Boundary and Landfill 4/Demolition Area 1 are listed below (S or A = shallow well; D or B = deeper well) according to the CHPPM numbers.

[7] PBS Engineering and Environmental Inc. (August 16, 2004b). *Monitoring Well Installation Report, Landfill 4/Lacamas Creek: Camp Bonneville, Vancouver, Washington.*

- Base Boundary
  - Paired Monitoring Wells: LC-MW01S and LC-MW01D
  - Paired Monitoring Wells: LC-MW02S and LC-MW02D
  - Paired Monitoring Wells: LC-MW03S and LC-MW03D
  - Paired Monitoring Wells: LC-MW04S and LC-MW04D
  - Paired Monitoring Wells: LC-MW09S and LC-MW09D
- Landfill 4/Demolition Area 1
  - Monitoring Well L4-MW17
  - Monitoring Well L4-MW18
  - Paired Monitoring Wells: L4-MW01A and L4-MW01B
  - Paired Monitoring Wells: L4-MW02A and L4-MW02B
  - Paired Monitoring Wells: L4-MW03A and L4-MW03B
  - Monitoring Well L4-MW04A
  - Monitoring Well L4-MW05A
  - Monitoring Well L4-MW07B
  - Paired Monitoring Wells: L4-MW08A and L4-MW08B
  - Paired Monitoring Wells: L4-MW09A and L4-MW09B
  - Paired Monitoring Wells: L4-MW10A and L4-MW10B
  - Monitoring Well L4-MW11B

3.4 Third quarter 2022 Scope of Work

Monitoring activities include the following:

- Depth to water measurements from the currently sampled monitoring well network
- Collection and analysis of groundwater samples from select wells in Landfill 4/Demolition Area 1 and Base Boundary
- Collection and analysis of groundwater samples from three drinking water wells, one each at the Bonneville and Killpack cantonments, and one from the FBI range
- Collection and analysis of surface water samples from three locations: where Lacamas Creek exits the site, at the confluence of Lacamas Creek and North Fork Lacamas Creek, and on Lacamas Creek downstream from Landfill 4/Demolition Area 1

This monitoring is conducted in accordance with the project SAP/QAPP. The analytical results obtained from quarterly monitoring are compared with cleanup levels established by Ecology under the Model Toxics Control Act (MTCA)[8] to determine if the groundwater or surface water potentially poses an unacceptable environmental risk to human health or the environment. All data are stored in an Earthsoft Environmental Quality Information System (EQuIS) electronic database that includes data from 2007 to present.

4 RECENT MONITORING ACTIVITIES

Groundwater samples were collected from the 10 monitoring wells located at Base Boundary (Figure 3) on September 27 and 28, 2022. A field duplicate sample (labeled 03Q22LCMW140W) was collected from monitoring well LC-MW02D. An additional volume of groundwater was collected from monitoring well LC-MW02S for laboratory matrix spike/matrix spike duplicate (MS/MSD) analysis.

Groundwater samples were collected from 18 monitoring wells at Landfill 4/Demolition Area 1 (Figure 4) from September 28 to October 3, 2022. Two field duplicate samples (labeled 03Q22L4MW145W and

[8] http://apps.leg.wa.gov/WAC/default.aspx?cite=173-340

03Q22L4MW150W) were collected from monitoring wells L4-MW1A and L4-MW4A respectively. An additional volume of groundwater was collected from monitoring well L4-MW18 for MS/MSD analysis.

Drinking water well samples were collected from Killpack and FBI. A duplicate sample (labeled 03Q22DUPW) was collected at well FBI. An additional volume of groundwater was collected from Killpack for MS/MSD analysis.

Surface water samples were collected from the three surface water locations. A duplicate sample (labeled 03Q22DP05SW) was collected at location LC03. Additional volume was collected from LC15 for MS/MSD analysis.

Samples were collected in new laboratory-supplied sample containers directly from the end of the dedicated pump discharge hose. Groundwater samples requiring preservatives were collected in sample bottles filled with the appropriate amounts of preservative solution by the contract laboratory.

The locations were sampled in accordance with the procedures established in the SAP/QAPP. Additional sampling details are provided below.

4.1 Sample Collection

A low-flow, minimal-drawdown technique was employed for monitoring well groundwater purging and sampling using dedicated Solinst bladder pumps constructed of a polyvinyl chloride (PVC) or stainless-steel body and a Teflon bladder. The low-flow purging technique is described in the SAP/QAPP. Low-flow sampling minimizes disturbance to the aquifer and is designed to ensure that representative samples are collected from the wells.

Drinking water well sample collection occurred following purging the wells for 5 minutes, then collecting samples directly from the closest spigot to the well.

Surface water samples were collected following procedures described in the SAP/QAPP.

4.2 Quality Assurance/Quality Control Samples

Duplicate samples were collected at a frequency of at least one per every 10 samples and at least one per area, with one collected from Base Boundary, two from Landfill 4/Demolition Area 1, one from drinking water wells, and one from surface water. MS/MSD samples were collected at a frequency of at least one per every 20 samples and one per area. Trip blanks were submitted with all shipments containing samples for VOC analysis. Dedicated pumps in the wells at Base Boundary and Landfill 4/Demolition Area 1 and the drinking water wells eliminate the need for equipment blanks.

4.3 Deviations from SAP/QAPP

This section is intended to discuss deviations from established protocols as well as to note unusual conditions or equipment issues encountered. There was no power supply to Bonneville and a sample could not be collected from this location. Field parameters were not collected from drinking water wells during this sampling event.

4.4 Investigation-Derived Waste (IDW)

Gloves and other disposable field supplies were disposed as solid waste. Purged groundwater was placed in 55-gallon drums that were sealed, labeled, and placed in the maintenance shed area. The drums will be picked up later for proper disposal.

5 MONITORING RESULTS

5.1 Base Boundary at Lacamas Creek

Groundwater elevations and field parameters are provided in Table 2 for the third quarter 2022. Figure 5A illustrates groundwater contours and flow direction for the Base Boundary shallow wells, and Figure 5B for the Base Boundary deep wells.

Table 3 summarizes analytical results for the contaminants of concern (COCs) at Base Boundary. Of the 10 wells in the base boundary area, there were no COCs detected above the laboratory method reporting limits (MRLs), except for acetone in well LC-MW02S. As discussed in Section 6, the acetone detection is from external contamination and not representative of aquifer conditions.

5.2 Landfill 4/Demolition Area 1

Groundwater elevations are provided in Table 2 for the third quarter 2022. Figure 6A illustrates groundwater contours and flow direction for the Landfill 4 shallow wells, and Figure 6B for the Landfill 4 deep wells.

Wells L4-MW17 and L4-MW18 are located topographically downgradient from the Landfill 4 area and are not included in groundwater flow discussion. Monitoring well L4-MW07B is screened in the same area of the aquifer as the other deep wells at the Landfill 4 area (above bedrock) and is included in the deep groundwater flow discussion.

Table 3 summarizes analytical results for the COCs at Landfill 4/Demolition Area 1.

Of the wells in the Landfill 4/Demolition Area 1 area, 12 had one or more detections of perchlorate or RDX that exceeded MTCA Method B cleanup levels (see Table 3), and four wells had VOC detections. The results are discussed further in Section 8.

5.3 Drinking Water Wells

Table 4 summarizes analytical results for the COCs at the drinking water wells. There were no detections above MRLs in the two analyzed samples.

5.4 Surface Water Samples

Table 5 summarizes analytical results for the COCs at surface water sample locations. There were no detections above MRLs in the three analyzed samples.

6 DATA QUALITY REVIEW AND VALIDATION

The overall DQO is to provide data of known and sufficient quality to evaluate the physical extent and concentration ranges of COPCs from analysis of groundwater samples, and to assure compliance with environmental and health-related agencies. DQOs for laboratory analysis are presented in the SAP/QAPP. Laboratory analytical data were evaluated with respect to quality assurance objectives for precision, accuracy, representativeness, comparability, and completeness. The third quarter data met the following criteria:

- Analytical data were received from the laboratory in an electronic data deliverable (EDD) format that was imported into an electronic database
- Qualifiers from the laboratory were included as well as any qualifiers resulting from data validation procedures conducted by PBS
- The project specifications were met for all analytes, indicating that the sampling and analysis procedures were reproducible

- The laboratory report narratives state that all quality control parameters that affect sample analysis were met, except as noted in Section 6.7 below

6.1 Data Validation

All analytical data were validated at a Level II review standard. Level II validation and reporting includes a brief narrative of the laboratory data along with presentation of the sample results and related quality assurance/quality control (QA/QC) analyses. Additionally, at least 20% of the analytical data (9 of 43 samples) were validated at a Level III review standard. Level III validation adds the following list to the reporting (not all method requirements are applicable to each analysis in this sampling event):

- Internal standards
- Blank association
- Serial dilution results
- Post-digestion spike results
- Gas chromatography/mass spectrometer (GC/MS) tune table
- Initial calibration table
- Continuing calibration verifications
- Calibration blanks
- Column confirmation
- Instrument run log
- Interference check solution A/interference check solution AB (ICSA/AB), contract required detection limit (CRDL), method detection limit/instrument detection limit (MDL/IDL) form

These data validation levels follow the criteria in the EPA's *Data Quality Objectives for Remedial Response Activities Development Process*,[9] National Technical Information Service.

6.2 Presentation of Data

Samples were collected over five days with four sample submissions. Samples were placed in eight sample delivery groups (SDGs) by Anatek. The SDGs were processed as a Level II data package. Anatek provided a Level III data package for the three methods analyzed during this sampling event (EPA Method 6850, EPA Method 8260, EPA Method 8330) and provided the data as individual reports per method. The following SDGs were processed by Anatek:

- MCI1004
- MCI1011
- MCJ0009
- MCJ0011
- MCJ0031
- MCJ0133
- MCJ0141
- MCJ0187

Laboratory reports are included on a compact disc (CD) with the printed third quarter report and are in the electronic version of the report. The Level II data packages are found in Appendix C, and the Level III data packages are found in Appendix D.

[9] Environmental Protection Agency (EPA). (1987b). *Data Quality Objectives for Remedial Response Activities-Development Process.* EPA/540/G-87/003, OSWER Directive 9355.07B, EPA, Washington, DC (PB88-131370).

6.3 Sample Handling and Control

The chain-of-custody forms indicate that samples were maintained under proper custody. Forms were signed upon release from the field and receipt at the laboratory. Samples were received by the laboratory at temperatures within acceptable limits and with proper preservation. All reported analytical results were performed within applicable method-specified holding times, except for VOC analysis in samples 03Q22L4MW02AW, 03Q22L4MW02BW, 03Q22L4MW04AW, 03Q22L4MW08AW, 03Q22L4MW08BW, 03Q22L4MW09BW, 03Q22L4MW10AW, 03Q22L4MW10BW, 03Q22L4MW11BW, and 03Q22L4MW150W. Laboratory quality control was outside limits following initial VOC analysis for these samples and reanalysis was required. There was insufficient time to reanalyze the samples within holding time. The reanalysis is not expected to negatively affect sample quality; however, VOC detections for these samples should be considered estimated and include the qualifier "J."

6.4 Field Quality Control Sample Assessment

6.4.1 Trip Blanks

Trip blanks and groundwater samples for VOC analysis were consolidated daily into one cooler for shipment to the laboratory. Trip blanks were included daily from September 27 to October 3, 2022. All trip blanks were analyzed for VOCs and there were no detections, except for carbon disulfide and methylene chloride in the trip blank from September 29, 2022, and acetone in the trip blank from October 3, 2022. Carbon disulfide and methylene chloride were not detected in samples analyzed during this sampling event; therefore, the detections do not affect quality and the data are considered valid. Acetone was detected in wells LC-MW02S and L4-MW10A at concentrations less than the trip blank detection; therefore, these detections are not considered representative of aquifer conditions and should include the qualifier "J" and be considered estimates.

6.4.2 Duplicates

Duplicate samples were collected from the four study areas (Base Boundary, Landfill 4/Demolition Area 1, drinking water wells, surface water). These samples were analyzed for the same constituents as the source samples.

The relative percent difference (RPD) was calculated as the difference between the values divided by the average of the values. For samples with results greater than five times the practical quantitation limit (PQL), an RPD of less than 20% is considered good duplication. For samples with results less than five times the PQL, the difference between the sample and its duplicate must be less than the PQL to meet the quality assurance acceptance criteria. A significant difference between duplicate values for a few parameters would indicate potential problems with the precision of specific analyses. A significant difference for many parameters would indicate potential problems with the sample collection procedures. The following are the results of duplicate sampling for this event:

- **Base Boundary at Lacamas Creek Duplicate**
  The field duplicate analysis for well LC-MW02D met quality control requirements.
- **Landfill 4/Demolition Area 1 Duplicate**
  The field duplicate analyses for well L4-MW01A met quality control requirements. The field duplicate analysis for well L4-MW04A met quality control requirements, except for RDX that had an RPD of 23%. RDX results for this well should be considered estimated and include the qualifier "J."
- **Drinking Water Well Duplicate**
  The field duplicate analysis for well FBI met quality control requirements.
- **Surface Water Duplicate**
  The field duplicate analysis for location LC03 met quality control requirements.

6.5 Method Reporting Limits

All samples either met laboratory specified MRLs as presented in the project SAP/QAPP or were detected with elevated MRLs due to high analyte concentrations.

6.6 Field Data Quality Assessment

There are no specific DQOs for the measurement of field parameters (temperature, pH, ORP, conductivity, DO, and turbidity). Temperature, pH, ORP, conductivity, and DO were measured during purging. Turbidity was measured during sample collection. The PBS standard operating procedure (SOP) for low-flow groundwater sampling describes the acceptable criteria for the measurement of field parameters. A copy of the SOP is provided in the SAP/QAPP.

6.7 Laboratory Quality Control Assessment

The analytical data quality evaluations performed by Anatek are presented in the laboratory analysis reports in Appendix B and Appendix C (provided on the enclosed CD). Analytical results requiring qualification are flagged by the laboratory with codes describing data quality anomalies. Case narratives describing sample receipt, identification, and general comments by laboratory personnel are included in each report.

6.7.1 Laboratory Quality Control Samples/Indicators

6.7.1.1 Blanks

There were no detections of target compounds in the method blanks for analyses reported for this sampling event.

6.7.1.2 Laboratory Control Samples

Laboratory control sample (LCS) recoveries were within specified control limits. The LCS/LCSD RPD was within control limits for all analytes. The data are considered accurate and valid.

6.7.1.3 Matrix Spike/Matrix Spike Duplicates

MS/MSD recoveries and RPDs for MS/MSD pairs were within specified control limits, except for the following:

- MS or MSD recoveries were below the lower control limits (biased low) for dibromomethane in batch BCJ0275 and methyl-t-butyl ether (MTBE), trans-1,3-dichloropropene, and 2,2-dichloropropane in batch BCJ0323. LCS/LCSD recoveries were within control limits, and the affected samples were non-detect for these compounds; therefore, the data are considered accurate and valid.
- The MS/MSD recoveries were above the upper control limit (biased high) for perchlorate in batch BCJ0754 and chloroethane in batch BCJ0323. The LCS/LCSD recoveries were within control limits indicating the instruments were working correctly; therefore, accuracy is not expected to be affected and the data are considered accurate and valid.
- The MS/MSD RPD for MTBE, trans-1,3-dichloropropene, and 2,2-dichloropropane were outside control limits. The LCS/LCSD recoveries were within control limits indicating the instruments were working correctly; therefore, accuracy is not expected to be affected and the data are considered accurate and valid.

6.7.1.4 Surrogates

Surrogate recoveries from VOC and explosives analyses were within specified control limits; therefore, the data are considered accurate and valid.

6.7.1.5 Internal Standards

Internal standard issues were not noted in the SDGs.

6.7.2 Level III Data Review

The data package for the SDGs receiving Level III data reporting was reviewed for adherence to method criteria that exceed Level II reporting. There were no deviations from method criteria.

7 HYDROGEOLOGY DISCUSSION

7.1 Base Boundary/Lacamas Creek

The third quarter 2022 shallow and deep monitoring well groundwater contours are shown on Figures 5A and 5B. Shallow (S) wells have screen intervals between 15 and 20 feet bgs with 5-foot length screens, and deep (D) wells have screen intervals between 30 and 40 feet bgs with 10-foot length screens. Well pairs have demonstrated a downward vertical gradient for measurements available in the EQuIS database (since 2008 or well installation), except for well pair LC-MW09S/LC-MW09D, which did not have a vertical gradient in September 2018. The calculated groundwater flow direction is to the north-northwest, or north-northeast, which is consistent with historical trends.

7.2 Landfill 4/Demolition Area 1

The wells near and within the Landfill 4/Demolition Area 1 area are illustrated in Figure 4. The hydrogeology discussion for this area includes six pairs of nested wells in A/B pairs, shallow wells L4-MW04A and L4-MW05A, and deep wells L4-MW07B and L4-MW11B. Wells L4-MW17 and L4-MW18 are located topographically downgradient from the Landfill 4/Demolition Area 1 area and are considered sentinel wells; they are not included in the following discussion.

Groundwater elevations and contours are shown on Figures 6A and 6B in support of the following groundwater observations:

- For the 8 wells in grouping A, there is a consistent high groundwater elevation in upgradient eastern well L4-MW01A and a westerly groundwater flow direction. From there, groundwater demonstrates a divergent radial flow pattern, generally following the topographic contour, from the northwest (toward L4-MW04A) to southwest (toward well L4-MW05A) directions, which is consistent with historical trends.
- For the 8 wells in grouping B, there is a consistent high groundwater elevation in upgradient eastern well L4-MW01B. Groundwater flow direction is primarily to the west with slight fluctuations from the west-northwest to west-southwest and is consistently toward North Fork Lacamas Creek. Groundwater flow is primarily south-southwest (toward L4-MW07B) of the main Landfill 4/Demolition Area 1 area, which is consistent with historical trends.
- The well pairs demonstrated vertical gradients as follows:
  - L4-MW01A/L4-MW01B: Upward (since second quarter 2008)
  - L4-MW02A/L4-MW02B: Downward (since second quarter 2008)
  - L4-MW03A/L4-MW03B: Downward (since second quarter 2008)
  - L4-MW08A/L4-MW08B: Downward (since installation in third quarter 2017)
  - L4-MW09A/L4-MW09B: Downward (since installation in third quarter 2017)
  - L4-MW10A/L4-MW10B: Downward (since installation in third quarter 2017)

8 WATER QUALITY DATA ANALYSIS

The laboratory results for COCs were compared to previous quarterly monitoring events, along with groundwater elevation, to identify trends in the data. The monitoring events included in the trend analysis cover the period of March 2015 to present for Base Boundary and Landfill 4/Demolition Area 1. Data from March 2007 are currently available in the EQuIS database for specific COCs; however, this section focuses on recent trends only. These monitoring events encompass the range of seasonal climatic (rainfall and temperature) and groundwater level variations.

The Base Boundary monitoring wells samples have had no reproducible detections above laboratory MRLs in the monitoring period from 2015 to present; therefore, these locations are not included in this trend discussion.

Groundwater concentration trends for Landfill 4/Demolition Area 1 are discussed below. Analytical results are discussed for 16 wells in the Landfill 4/Demolition Area 1 area.

8.1 Spatial Distribution of Perchlorate and RDX

Perchlorate and RDX are the only two compounds consistently detected above MTCA Method B cleanup levels in multiple wells in the Landfill 4/Demolition Area 1 area. Isocontours of perchlorate concentrations in shallow (A) and deep (B) wells are illustrated in Figures 7A and 7B, and isocontours of RDX concentrations in shallow and deep wells are illustrated in Figures 8A and 8B.

8.1.1 Perchlorate

The highest perchlorate concentration in shallow wells is located at well L4-MW09A and decreases in all directions. The highest perchlorate concentration in deep wells is located at well L4-MW11B, with upgradient well L4-MW02B having the second-highest concentration and wells to the north (L4-MW09B, L4-MW10B) having higher concentrations than those south (L4-MW03B) or east (L4-MW01B). The shallow and deep groundwater flow direction near these wells is generally to the west with a southwest component near wells L4-MW02A/B.

8.1.2 RDX

The highest RDX concentration in shallow wells is located at well L4-MW08A. Shallow groundwater flow near well L4-MW08A is generally toward well L4-MW04A, and RDX concentrations have generally demonstrated an increasing trend in well L4-MW04A. The highest RDX concentration in deep wells is located at well L4-MW11B, with upgradient well L4-MW02B having the second-highest concentration.

8.2 Perchlorate and RDX Concentration Trend Analysis

Trend graphs for perchlorate and RDX concentrations from 2007 to present are included in Appendix D. The trend charts are provided as one chart each for perchlorate and RDX in shallow (A) and deep (B) wells (four charts total), and per-well charts with perchlorate, RDX, and groundwater elevation shown. Wells must have at least two detections above the MRL for that analyte to be graphed.

The MTCA Method B cleanup levels are 11.0 micrograms per liter (µg/L) for perchlorate and 1.10 µg/L for RDX. Please note that Ecology requests that graphs showing wells with detections need to also include data points for non-detections in those wells, recorded as one-half the MRL for that analyte.

Data from 2015 to present were examined for statistically significant trends by using a Mann-Kendall trend analysis in ProUCL version 5.1. Data were imported into ProUCL directly from EQuIS with non-detect data at the reporting limit. RDX was not detected over this time interval in well L4-MW07B, so it is not included in this discussion.

The Mann-Kendall trend analysis was performed with the null hypothesis that an upward or downward trend is not present in the data, and with the alternate hypothesis that a trend exists. The data are analyzed by comparing every new value with every preceding value to see if there are consistent increasing or decreasing trends within a set level of confidence. If the analysis is above the set level of confidence, the null hypothesis is rejected; otherwise, a trend cannot be determined.

The following wells demonstrated a statistically significant increasing trend at a 95% confidence level:

Perchlorate

- L4-MW04A
- L4-MW11B

RDX

- L4-MW04A
- L4-MW08B
- L4-MW10B
- L4-MW11B

The following wells demonstrated a statistically significant decreasing trend at a 95% confidence level:

Perchlorate

- L4-MW01B
- L4-MW02B
- L4-MW03A
- L4-MW05A
- L4-MW08A
- L4-MW09A
- L4-MW10A

RDX

- L4-MW02A
- L4-MW02B
- L4-MW03A
- L4-MW08A
- L4-MW09A
- L4-MW09B
- L4-MW10A

The following wells did not demonstrate a statistically significant trend over the analyzed time interval:

Perchlorate

- L4-MW01A
- L4-MW02A
- L4-MW03B
- L4-MW07B
- L4-MW08B
- L4-MW09B
- L4-MW10A
- L4-MW10B

RDX

- L4-MW01A
- L4-MW03B
- L4-MW05A

There are no apparent correlations between the variation of perchlorate or RDX concentrations in groundwater and seasonal variation in groundwater elevations in the six wells sampled at Landfill 4/Demolition Area 1.

9 FUTURE ACTIVITIES

The next scheduled sampling event will occur in the fourth quarter 2022.

PBS Engineering and Environmental Inc. is pleased to present the results of the third quarter 2022 groundwater sampling event. Please contact the undersigned if there are any questions.

Sincerely,
PBS Engineering and Environmental Inc.

Digitally signed by Scott Braunsten
Date: 2023.01.23
11:27:44 -08'00'

Scott Braunsten, LG — Date
Senior Geologist

Digitally signed by Melanie L. Young
Date: 2023.01.23
11:42:24 -08'00'

Melanie Young, PE — Date
Senior Engineer

Digitally signed by Thomas Mergy
Date: 2023.01.30
08:37:43 -08'00'

Thomas Mergy, LHG — Date
Principal Hydrogeologist

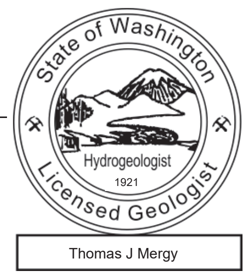

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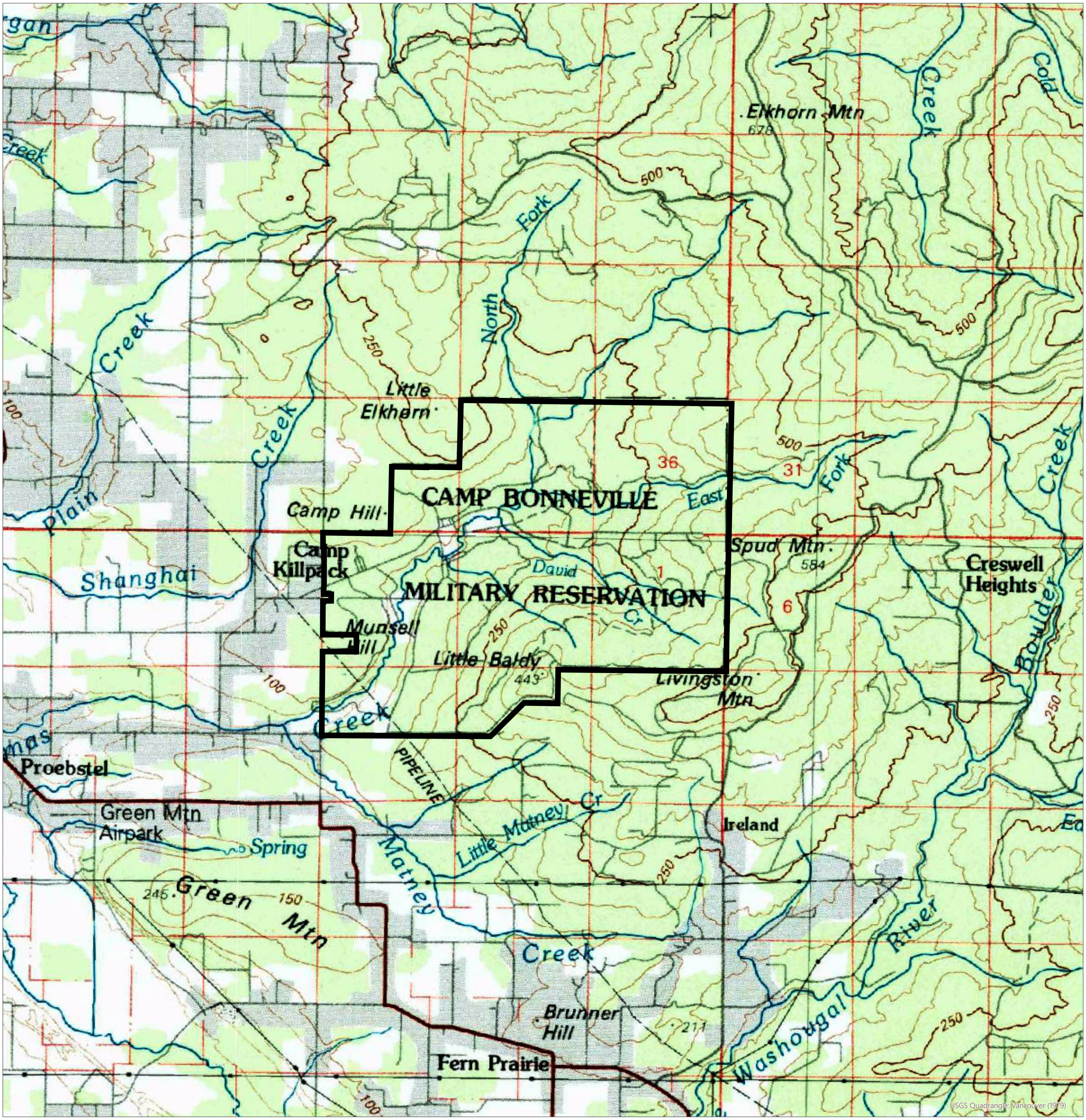
Figure 8B. Deep Landfill 4 Monitoring Wells: RDX Concentrations, 3rd Quarter 2022



Site Vicinity

Camp Bonneville Military Reservation

23201 NE Pluss Road Vancouver, Washington

Date: January 2023 | Project: 76151.011

Figure: 1

Site Boundary

N

1 INCH = 1 MILE

0 1 Miles

PBS

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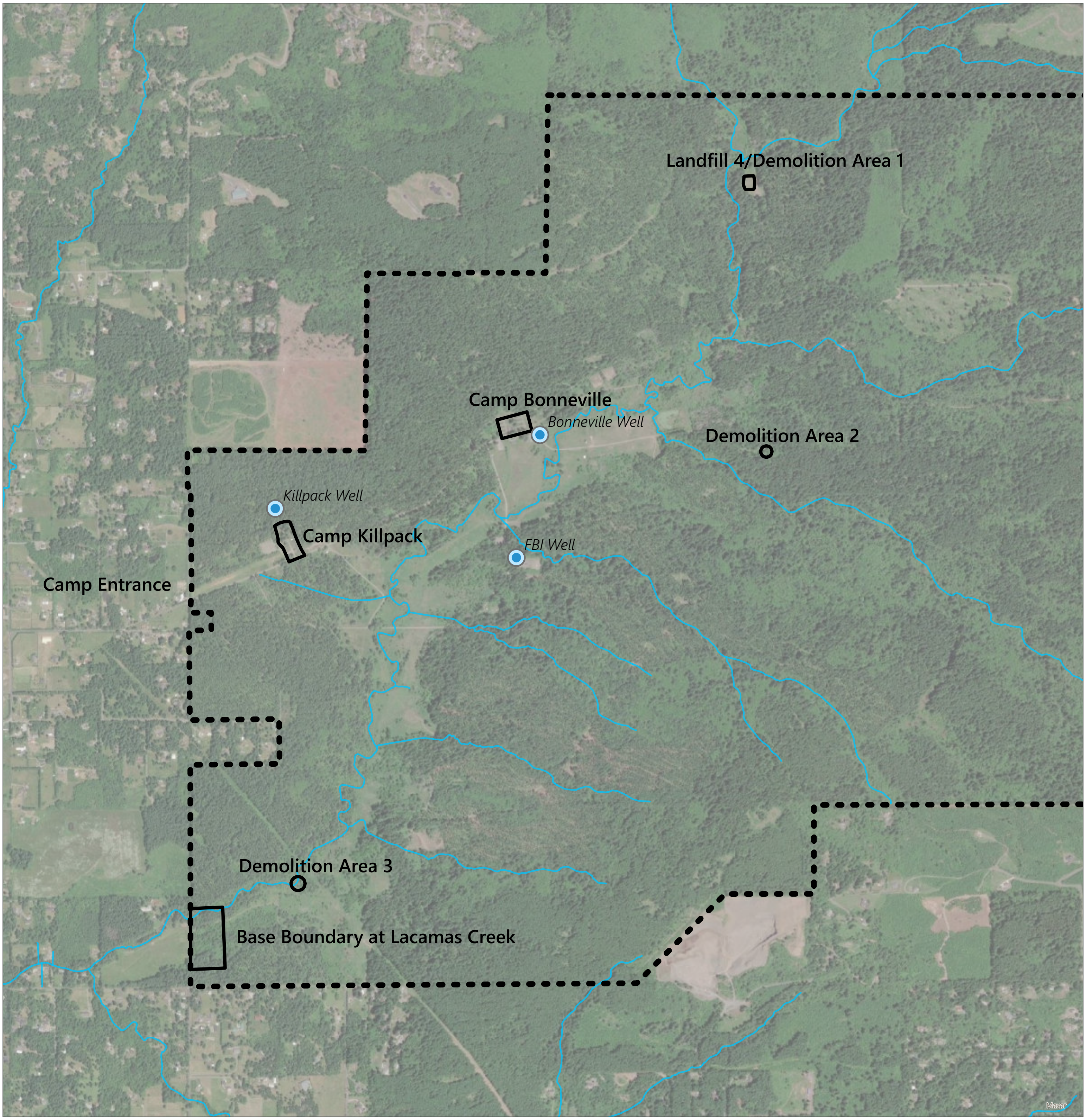

Site Map

Camp Bonneville Military Reservation
23201 NE Pluss Road Vancouver, Washington
Date: January 2023 | Project: 76151.011

Figure: 2

Water Supply Wells
Camp Bonneville Areas
Waterways
Site Boundary

N

1 INCH = 2,000 FEET
0 2,000 Feet

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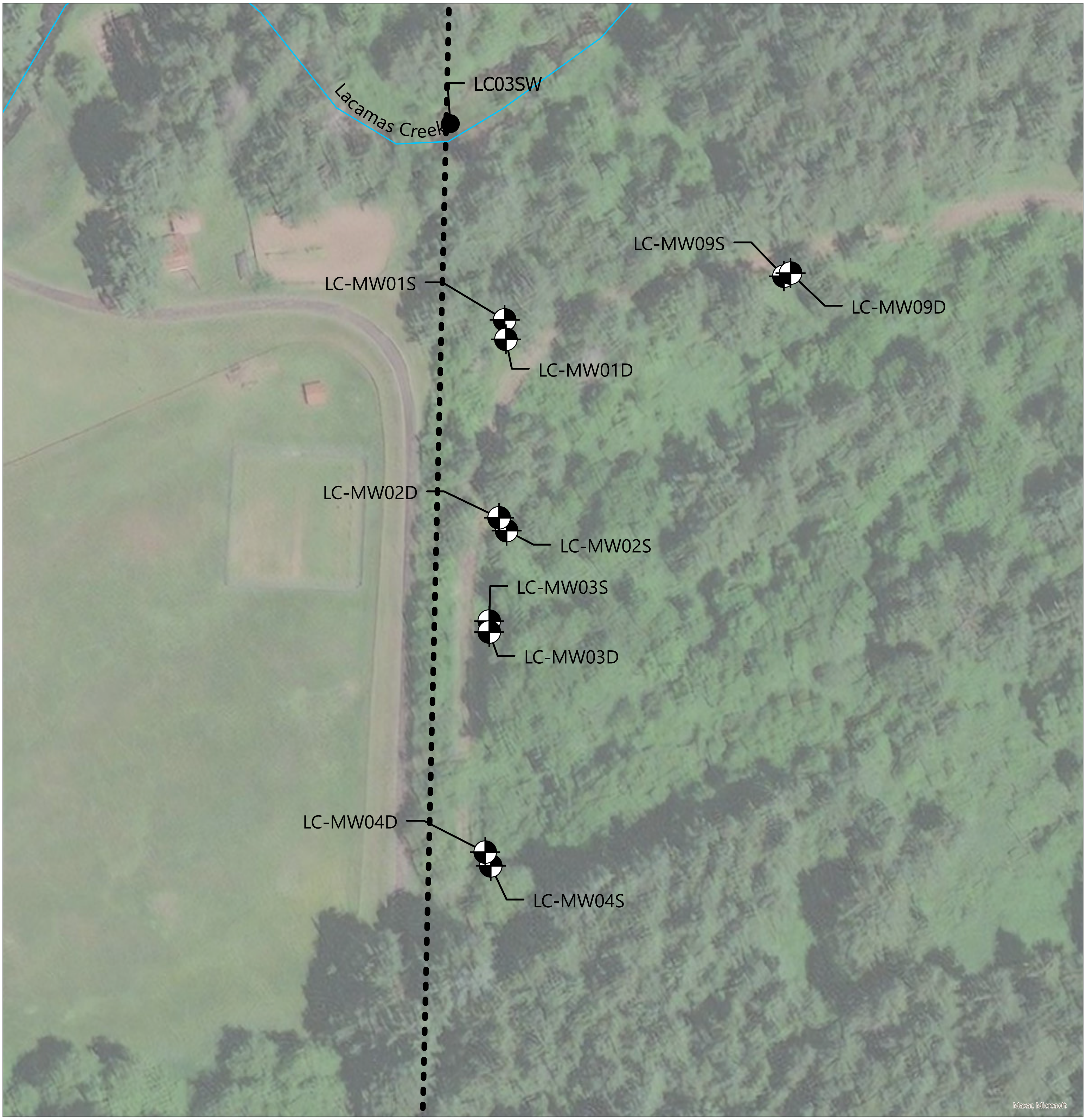

Monitoring Wells and Surface Water Sample Locations Near Base Boundary

Camp Bonneville Military Reservation

23201 NE Pluss Road Vancouver, Washington

Date: January 2023 | Project: 76151.011

Figure: 3

Surface Water Sample Location

Monitoring Well Locations

Site Boundary

Waterways

N

1 INCH = 100 FEET

0 100 Feet

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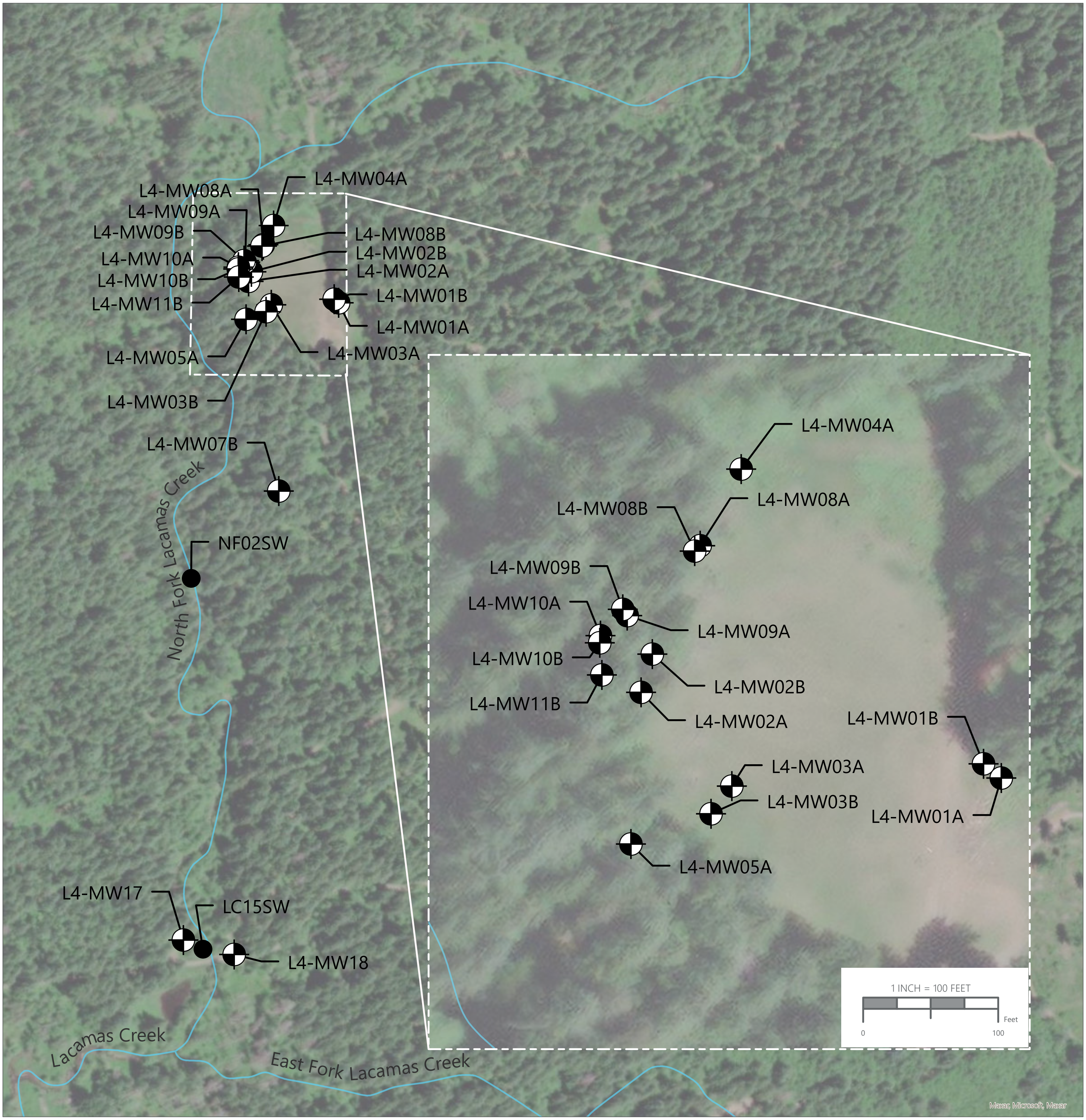

Monitoring Wells and Surface Water Sample Locations near Landfill 4

Camp Bonneville Military Reservation

23201 NE Pluss Road Vancouver, Washington

Date: January 2023 | Project: 76151.011

Figure: 4

Groundwater Monitoring Wells

Surface Water Sample Location

Waterways

N

1 INCH = 400 FEET

0 400 Feet

PBS

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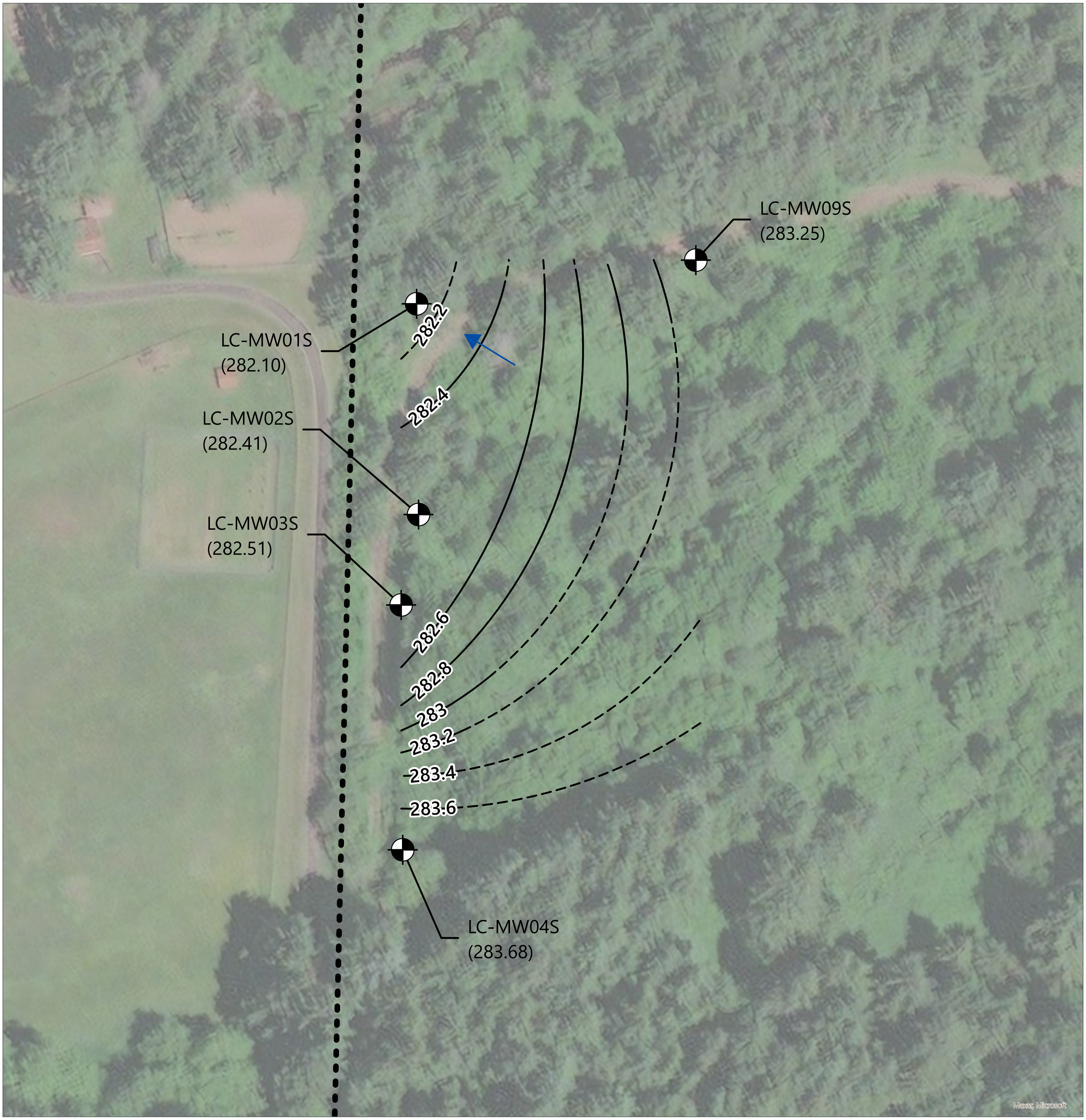

Shallow Base Boundary Monitoring Wells: Groundwater Elevation

3rd Quarter 2022

23201 NE Pluss Road Vancouver, Washington

Date: January 2023 | Project: 76151.011

Figure: 5A

- General Direction of Flow
- Well Locations (Groundwater Elevation in Feet amsl)
- Groundwater Elevation Contour
- Inferred Groundwater Elevation Contour
- Site Boundary

N

1 INCH = 100 FEET

0 100 Feet

PBS

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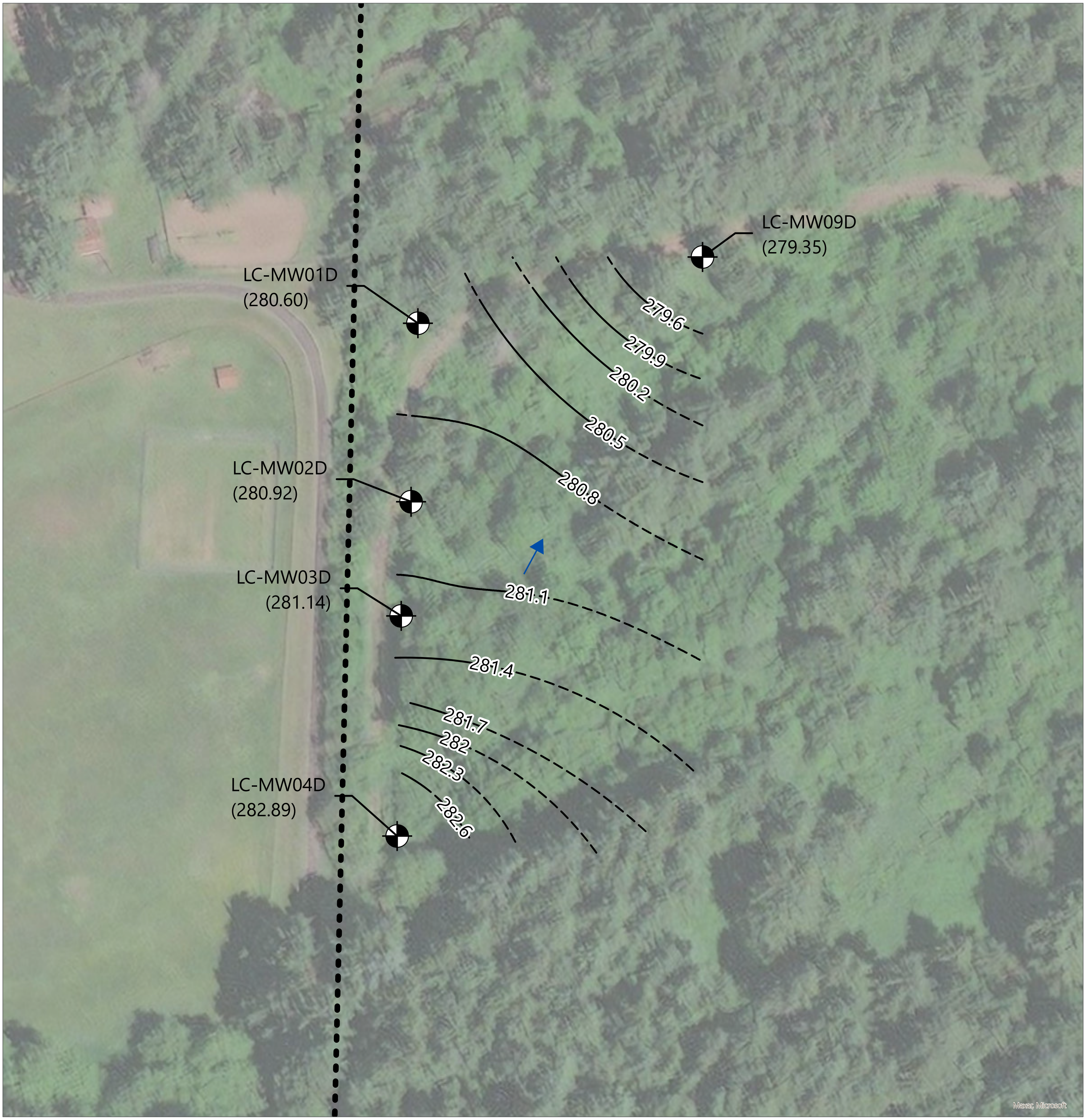

Deep Base Boundary Monitoring Wells: Groundwater Elevation

3rd Quarter 2022

23201 NE Pluss Road Vancouver, Washington

Date: January 2023 | Project: 76151.011

Figure: 5B

Groundwater Flow Direction
Well Locations (Groundwater Elevation in Feet amsl)
Site Boundary
Groundwater Elevation Contour
Inferred Groundwater Elevation Contour

N

1 INCH = 100 FEET
0 100 Feet

PBS

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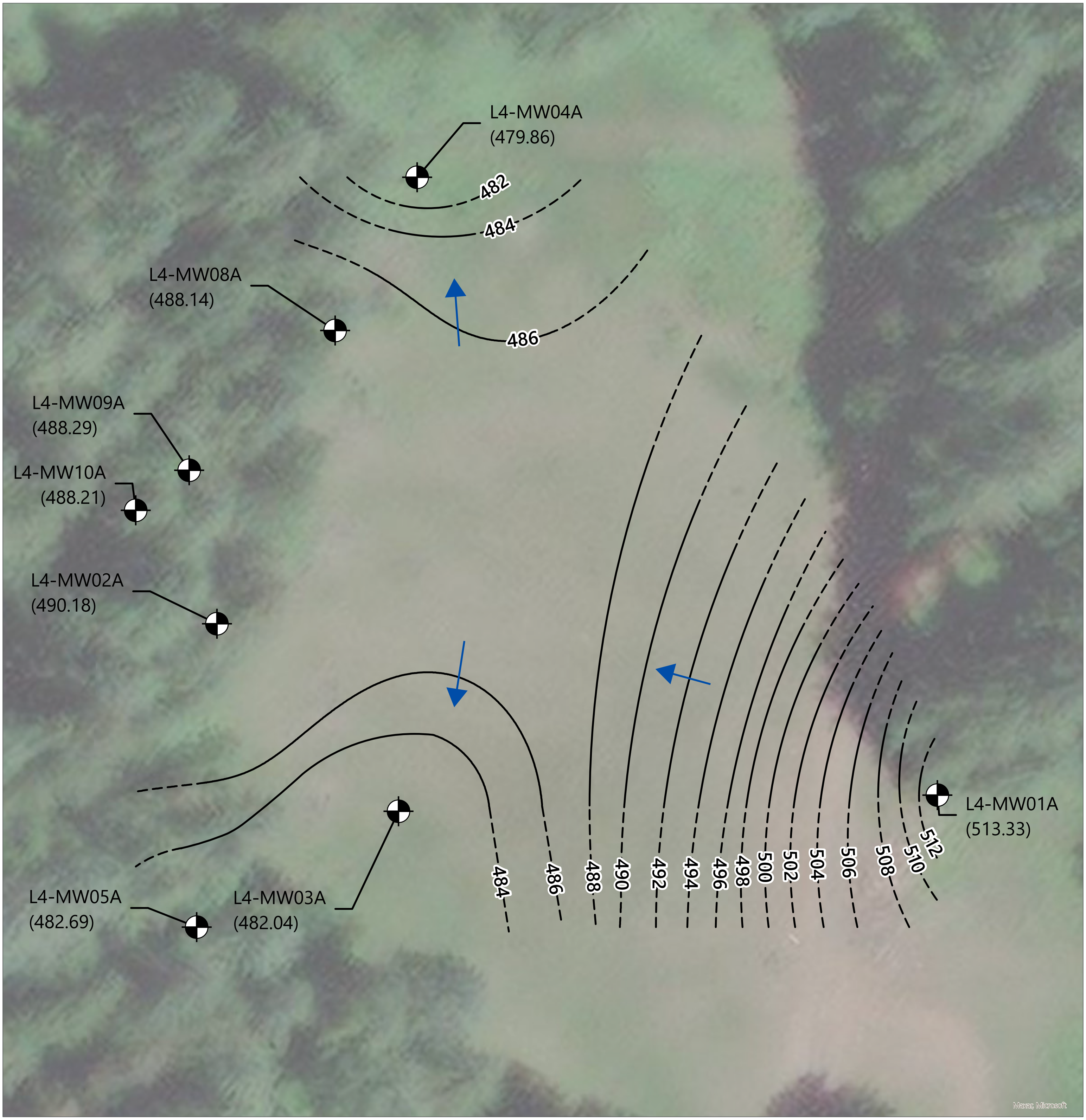


Shallow Landfill 4 Monitoring Wells: Groundwater Elevation

3rd Quarter 2022

23201 NE Pluss Road Vancouver, Washington

Date: January 2023 | Project: 76151.011

Figure: 6A

- Groundwater Flow Direction
- Well Locations (Groundwater Elevation in Feet amsl)
- Groundwater Contours
- Inferred Groundwater Contours

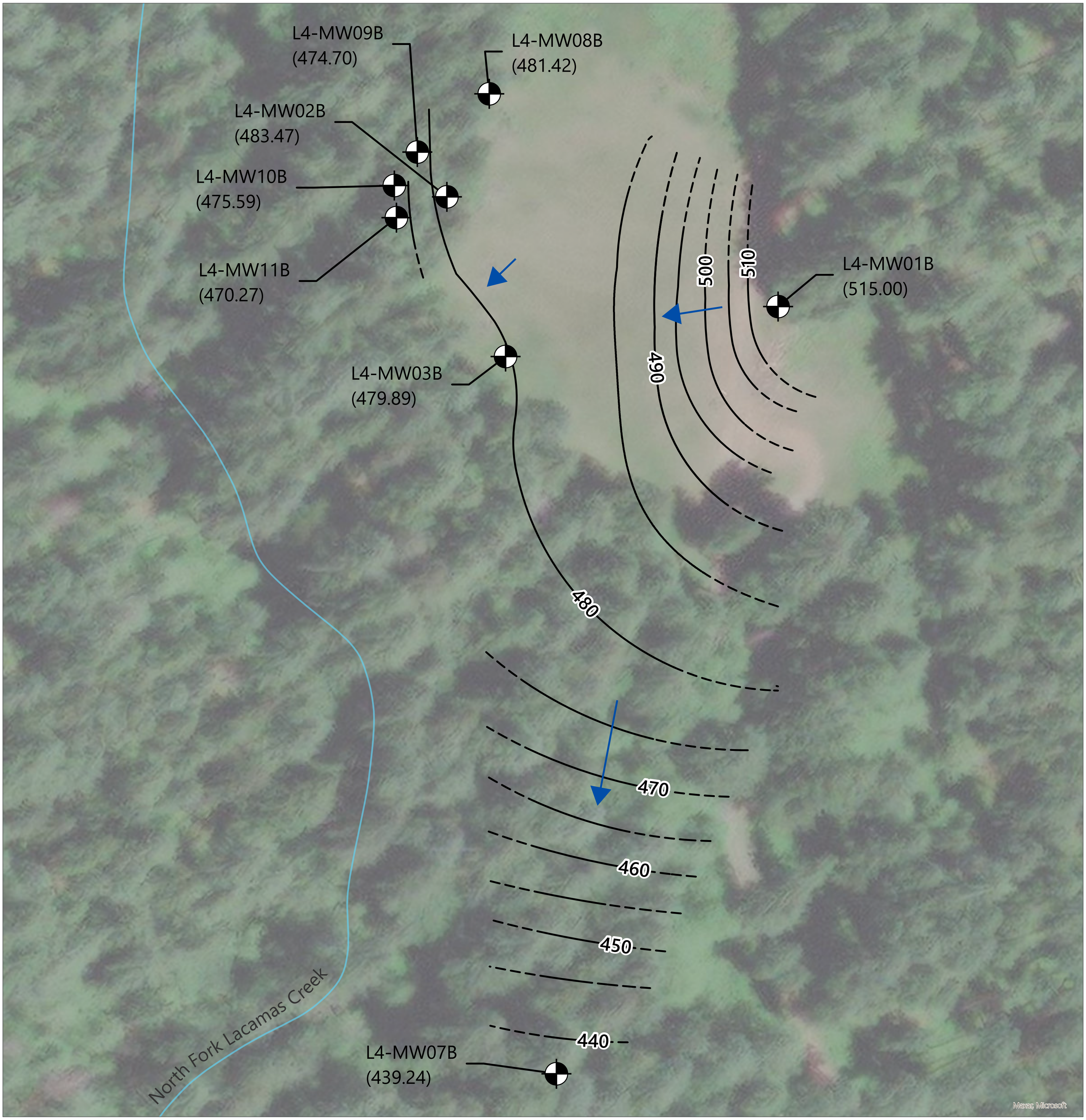
N

1 INCH = 50 FEET

0 50 Feet

PBS

NAD 1983 2011 StatePlane Washington South FIPS 4602 Ft US | L:\Projects\76000\76100-76199\76151_Camp Bonneville, Vancouver\DWG\GIS\22Q3\76151.011_CampB_22Q3.aprx | 1/9/2023 2:20 PM



Deep Landfill 4 Monitoring Wells: Groundwater Elevation

3rd Quarter 2022

23201 NE Pluss Road Vancouver, Washington

Date: January 2023 | Project: 76151.011

Figure: 6B

- Groundwater Flow Direction
- Well Locations (Groundwater Elevation in Feet amsl)
- Waterways
- Groundwater Contours
- Inferred Groundwater Contours

N

1 INCH = 100 FEET

0 100 Feet

PBS

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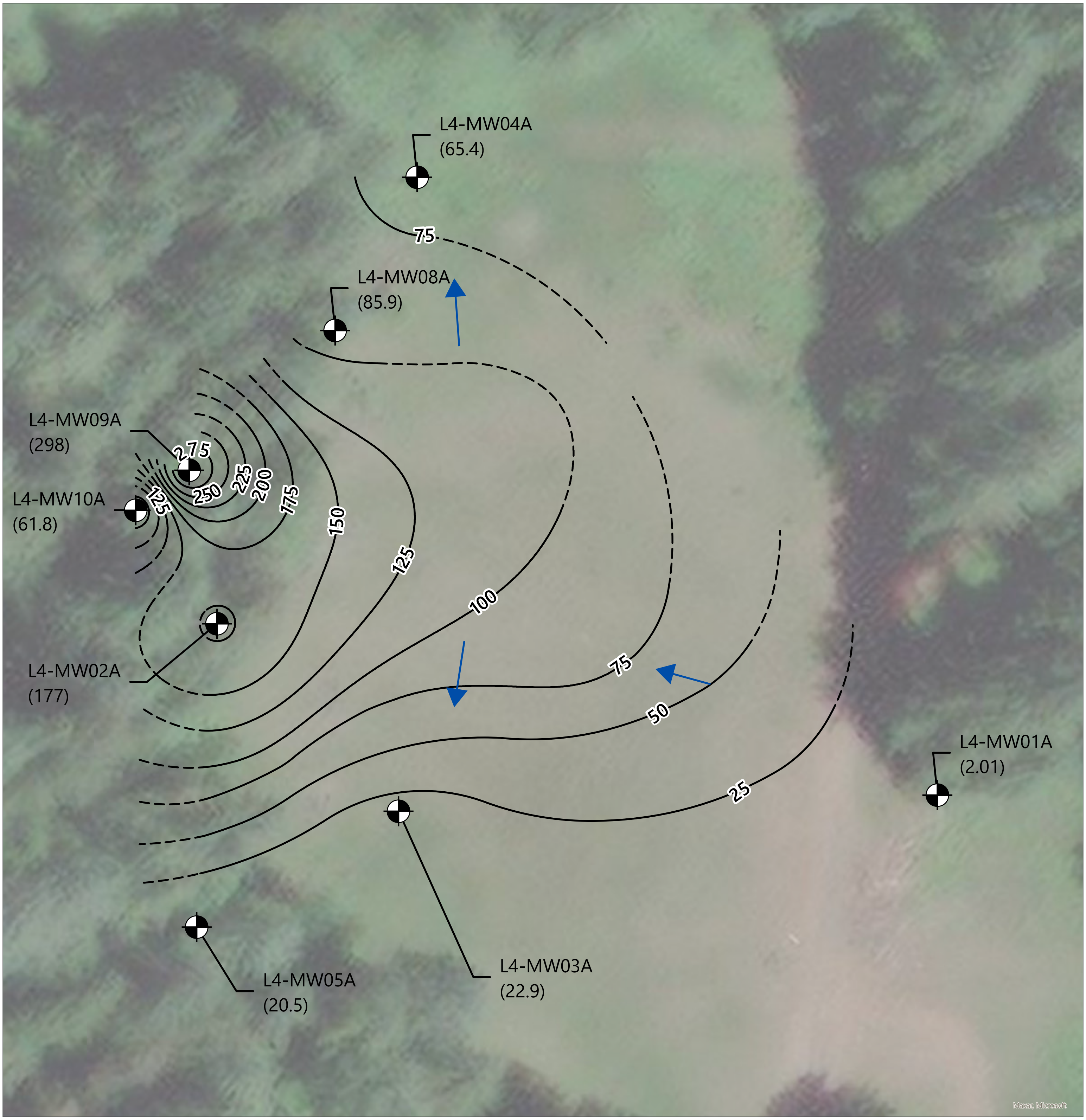

Shallow Landfill 4 Monitoring Wells: Perchlorate Concentrations

3rd Quarter 2022

23201 NE Pluss Road Vancouver, Washington

Date: January 2023 | Project: 76151.011

Figure: 7A

Groundwater Flow Direction

Well Locations (Perchlorate Concentrations, µg/L)

Concentration Contours

Inferred Concentration Contours

N

1 INCH = 50 FEET

0 50 Feet

PBS

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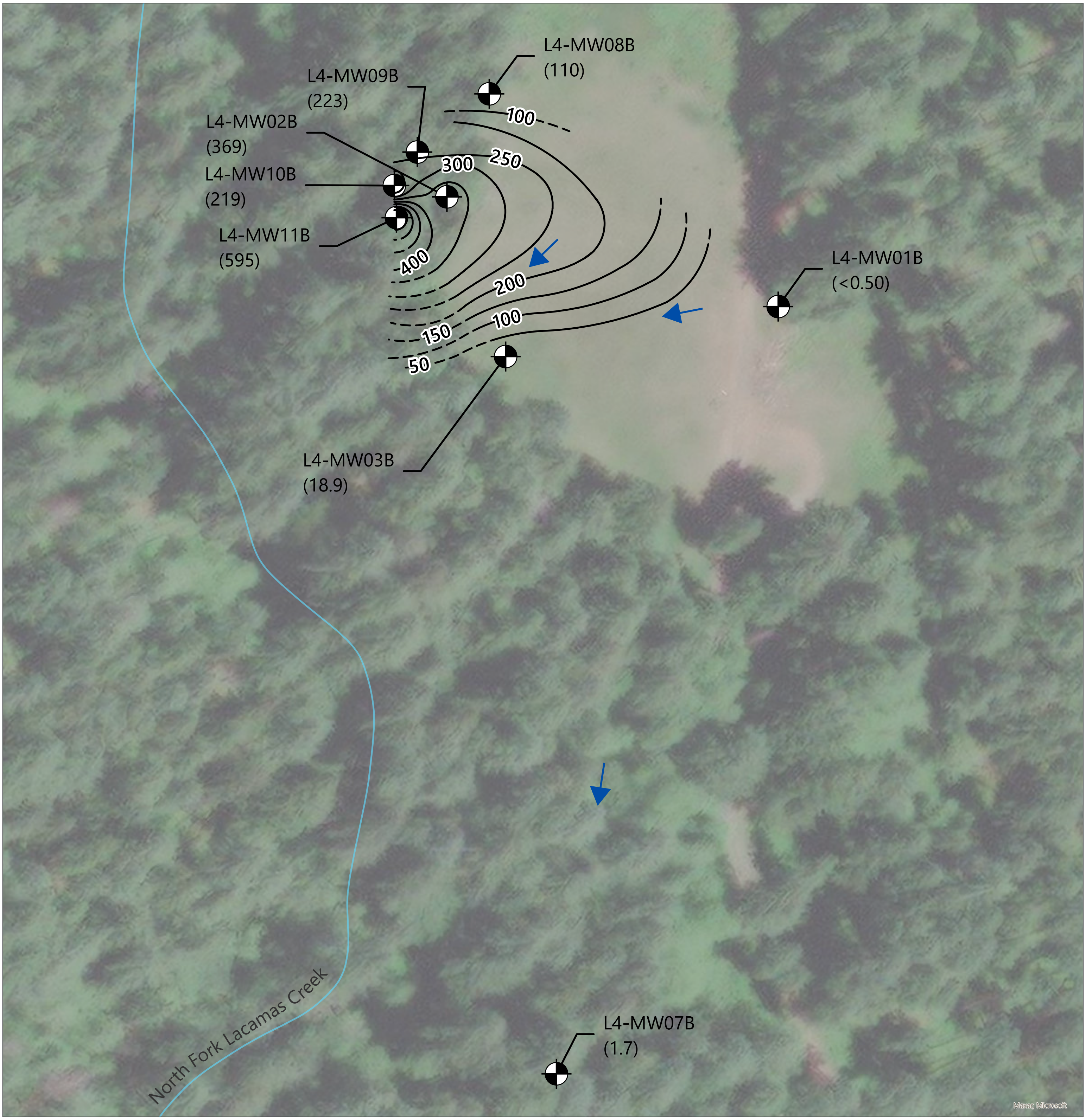

Deep Landfill 4 Monitoring Wells: Perchlorate Concentrations

3rd Quarter 2022

23201 NE Pluss Road Vancouver, Washington

Date: January 2023 | Project: 76151.011

Figure: 7B

Groundwater Flow Direction

Well Locations (Perchlorate Concentration, µg/L)

Concentration Contours

Inferred Concentration Contours

Waterways

N

1 INCH = 100 FEET

0 100 Feet

PBS

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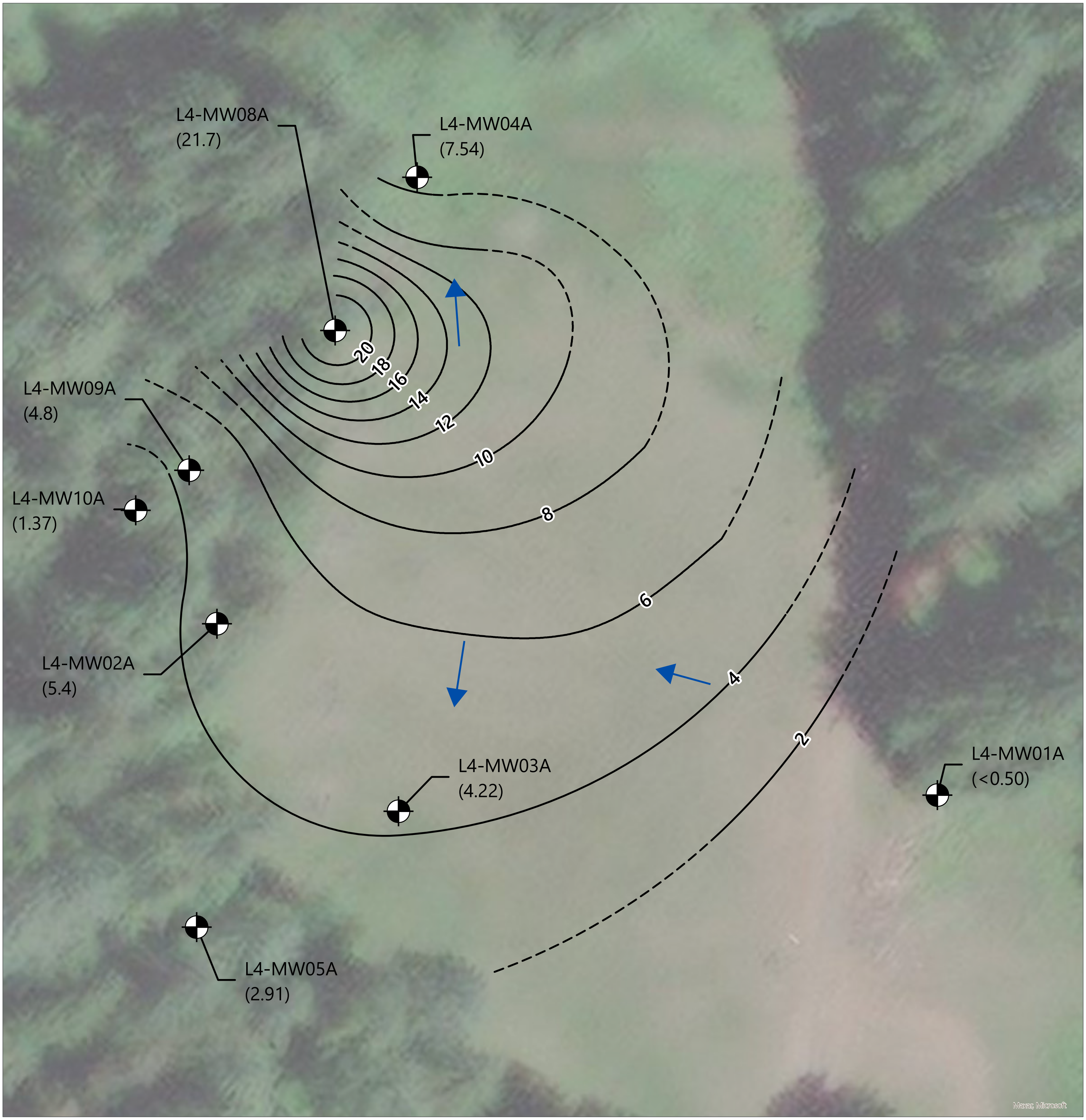

Shallow Landfill 4 Monitoring Wells: RDX Concentrations

3rd Quarter 2022

23201 NE Pluss Road Vancouver, Washington

Date: January 2023 | Project: 76151.011

Figure: 8A

Groundwater Flow Direction

Well Locations (RDX Concentrations, µg/L)

Concentration Contours

N

1 INCH = 50 FEET

0 50 Feet

PBS

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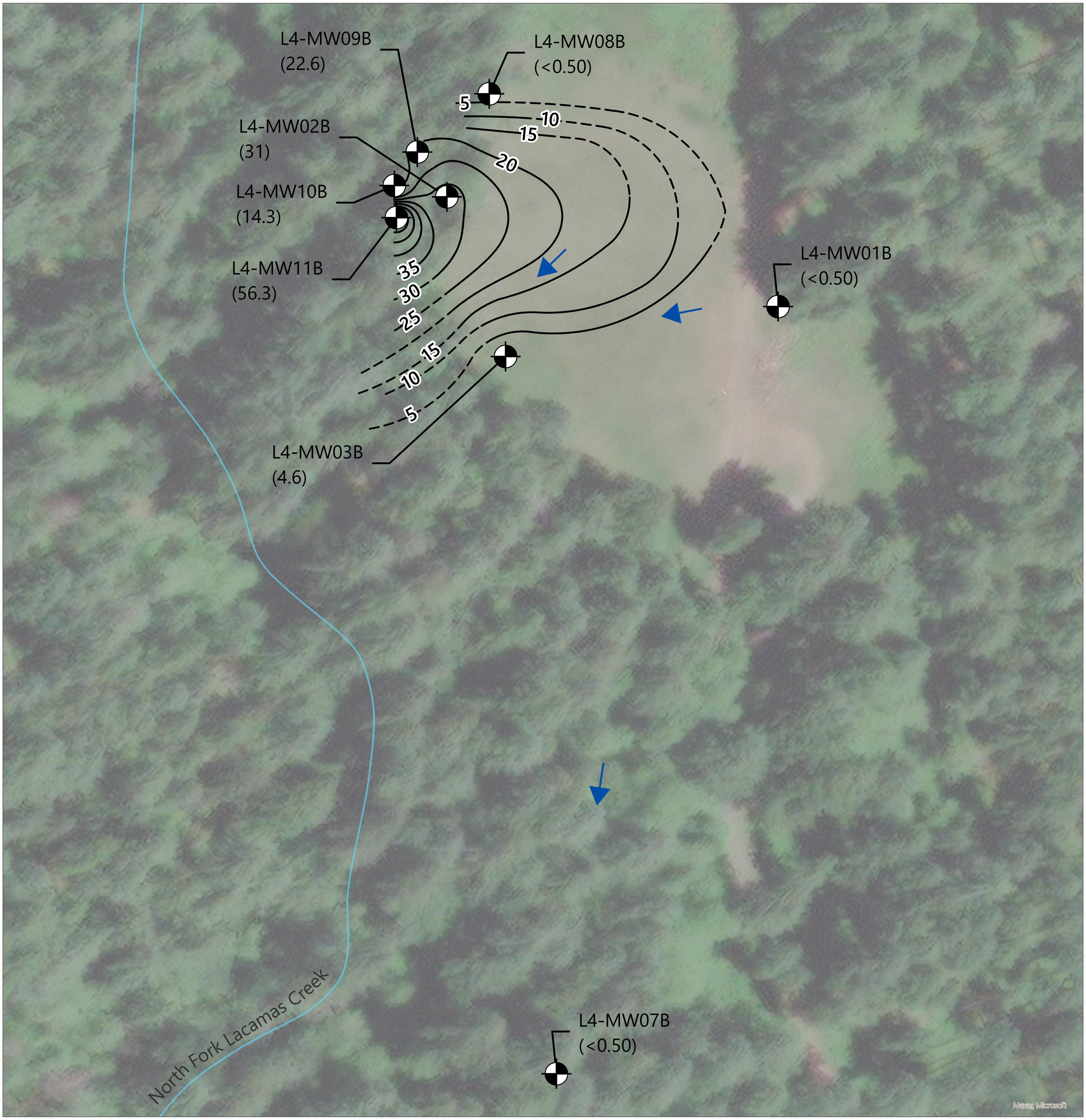

Deep Landfill 4 Monitoring Wells: RDX Concentrations

3rd Quarter 2022

23201 NE Pluss Road Vancouver, Washington

Date: January 2023 | Project: 76151.011

Figure: 8B

Groundwater Flow Direction
Well Locations (RDX Concentrations, µg/L)
Concentration Contours
Inferred Concentration Contours
Waterways

N

1 INCH = 100 FEET
0 100 Feet

PBS

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Tables

Table 1. Well Number and Construction Details
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Table 3. Constituents Detected in Groundwater, 3rd Quarter 2022
Table 4. Constituents Detected in Water Supply Wells, 3rd Quarter 2022
Table 5. Constituents Analyzed in Surface Water - 3rd Quarter 2022

Table 1. Well Number and Construction Details

Camp Bonneville, Vancouver, Washington

	Well No. in PBS Work Contract	Ecology Well Tag No.	Well Location	Measured Total Depth (feet)*	Well Log Total Depth (feet)**	Screened Interval (feet)***	Top of PVC Casing Elevation (feet amsl)	Well No. on Steel Casings/Caps (CHPPM No.)
Base Boundary	LC-MW01S	AHA-359	Lacamas Creek	22.71	23.00	10–20	290.15	LC-MW01S
	LC-MW01D	AHA-358	Lacamas Creek	42.21	42.50	29.5–39.5	290.26	LC-MW01D
	LC-MW02S	AHA-364	Lacamas Creek	17.46	17.70	10–15	291.15	LC-MW02S
	LC-MW02D	AHA-357	Lacamas Creek	37.83	38.10	25–35	291.57	LC-MW02D
	LC-MW03S	AHA-363	Lacamas Creek	20.09	20.35	13–18	290.87	LC-MW03S
	LC-MW03D	AHA-362	Lacamas Creek	39.36	39.48	27–37	290.93	LC-MW03D
	LC-MW04S	AHA-375	Lacamas Creek	16.49	16.80	9–14	291.63	LC-MW04S
	LC-MW04D	AHA-361	Lacamas Creek	37.03	37.13	24.5–34.5	291.79	LC-MW04D
	LC-MW09S	BJH-382	Lacamas Creek	22.05	22.38	15-20	293.52	LC-MW09S
	LC-MW09D	BJH-380	Lacamas Creek	41.60	42.27	30-40	294.10	LC-MW09D
Landfill 4 / Demolition Area 1	L4-MW01A	N/A	Landfill 4	30.17	30.40	17–27	531.43	L4-MW01A
	L4-MW01B	AGL-482	Landfill 4	55.54	56.00	43–53	529.57	L4-MW01B
	L4-MW02A	N/A	Landfill 4	40.21	40.20	27–37	519.97	L4-MW02A
	L4-MW02B	AGL-483	Landfill 4	74.97	75.00	62–72	521.70	L4-MW02B
	L4-MW03A	AGL-466	Landfill 4	48.71	49.00	41–46	514.90	L4-MW03A
	L4-MW03B	AGL-484	Landfill 4	61.85	63.00	50–60	511.49	L4-MW03B
	L4-MW04A	AGL-465	Landfill 4	46.44	46.00	33–43	511.84	L4-MW04A
	L4-MW05A	AGL-467	Landfill 4	36.63	36.00	28–33	509.74	L4-MW05A
	L4-MW07B	N/A	Landfill 4	58.86	58.90	46–56	480.49	L4-MW07B
	L4-MW08A	BJH-379	Landfill 4	40.72	40.31	28-38	515.52	L4-MW08A
	L4-MW08B	BJH-378	Landfill 4	67.41	67.31	55-65	515.72	L4-MW08B
	L4-MW09A	BJH-377	Landfill 4	42.45	42.43	30-40	523.00	L4-MW09A
	L4-MW09B	BJH-376	Landfill 4	77.65	77.36	65-75	523.27	L4-MW09B
	L4-MW10A	BJH-375	Landfill 4	42.71	42.43	30-40	523.05	L4-MW10A
	L4-MW10B	BJH-374	Landfill 4	77.30	77.17	65-75	522.48	L4-MW10B
	L4-MW11B	BJH-373	Landfill 4	77.57	77.27	65-75	522.29	L4-MW11B
	L4-MW17	ALB-252	Landfill 4	17.17	17.67	5–15	361.48	L4-MW17
	L4-MW18	ALB-251	Landfill 4	22.60	22.01	10–20	362.84	L4-MW18

Notes:
* = depth in feet measured from top of well PVC casing in December 2007 and August 2017; sediment present at bottom of some casings
** = casing depth in feet recorded on well log; measured from top of PVC casing
*** = screened interval reported on well completion logs; feet below ground surface
amsl = above mean sea level
N/A = not available

Table 2. Field Parameters for Groundwater Samples at Base Boundary and Landfill 4/Demolition Area 1, 3rd Quarter 2022

Camp Bonneville, Vancouver, Washington

	Sample ID	Date Sampled	Depth to Water	Water Elevation	Dissolved Oxygen	Oxidation Reduction Potential	pH	Specific Conductivity	Temperature	Turbidity
			feet below TOC	feet amsl*	mg/L	millivolts	pH units	µS/cm	degrees Celsius	NTU
Base Boundary	03Q22LCMW01DW	9/27/2022	9.66	280.60	8.00	131.6	6.03	91	13.0	0.22
	03Q22LCMW01SW	9/27/2022	8.05	282.10	7.19	135.2	5.83	89	12.3	0.3
	03Q22LCMW02DW	9/27/2022	10.65	280.92	8.87	134.9	6.04	94	12.6	0.2
	03Q22LCMW02SW	9/27/2022	8.74	282.41	8.74	154.2	5.69	89	12.2	0.26
	03Q22LCMW03DW	9/28/2022	9.79	281.14	8.37	149.5	5.80	98	11.2	0.02
	03Q22LCMW03SW	9/27/2022	8.36	282.51	8.88	148.0	5.87	101	11.9	0.02
	03Q22LCMW04DW	9/28/2022	8.90	282.89	7.43	139.9	6.23	98	13.5	0.02
	03Q22LCMW04SW	9/28/2022	7.95	283.68	6.46	166.9	5.37	92	12.6	0.00
	03Q22LCMW09DW	9/27/2022	14.75	279.35	6.85	126.4	5.88	97	11.7	1.70
	03Q22LCMW09SW	9/27/2022	10.27	283.25	7.35	123.6	5.68	87	12.2	0.44
Landfill 4 / Demolition Area 1	03Q22L4MW01AW	9/29/2022	18.10	513.33	7.99	250.2	4.49	25	11.2	0.02
	03Q22L4MW01BW	9/29/2022	14.57	515.00	10.16	256.2	4.72	26	10.8	0.02
	03Q22L4MW02AW	9/30/2022	29.79	490.18	9.50	315.9	4.11	22	11.0	0.02
	03Q22L4MW02BW	9/30/2022	38.23	483.47	4.80	230.3	4.76	43	12.1	39.4
	03Q22L4MW03AW	10/3/2022	32.86	482.04	8.19	208.0	4.41	22	11.1	0.02
	03Q22L4MW03BW	10/3/2022	31.60	479.89	7.65	210.6	5.07	48	11.8	0.02
	03Q22L4MW04AW	9/29/2022	31.98	479.86	6.24	274.8	4.47	16	10.6	1.36
	03Q22L4MW05AW	10/3/2022	27.05	482.69	7.15	226.5	4.64	28	10.9	--
	03Q22L4MW07BW	9/29/2022	41.25	439.24	7.39	200.6	4.83	33	10.1	0.02
	03Q22L4MW08AW	9/29/2022	27.38	488.14	7.25	259.1	4.38	17	11.4	0.86
	03Q22L4MW08BW	9/29/2022	34.30	481.42	3.24	163.2	5.54	65	11.8	1.13
	03Q22L4MW09AW	9/30/2022	34.71	488.29	7.64	271.1	4.11	20	11.3	0.88
	03Q22L4MW09BW	9/30/2022	48.57	474.70	1.00	267.1	4.60	31	11.5	0.02
	03Q22L4MW10AW	9/30/2022	34.84	488.21	7.04	281.5	4.36	21	11.9	2.84
	03Q22L4MW10BW	9/30/2022	46.89	475.59	3.40	256.8	5.29	50	12.1	3.01
	03Q22L4MW11BW	9/30/2022	52.02	470.27	3.58	286.2	4.59	26	12.6	0.02
	03Q22L4MW17W	9/28/2022	12.65	348.87	4.67	107.1	6.59	243	13.9	0.02
	03Q22L4MW18W	9/28/2022	13.11	349.74	8.31	155.4	5.45	135	11.9	1.87
Surface Water	03Q22LC03SW	9/28/2022	--	--	10.17	148.4	6.41	77	15.9	11.6
	03Q22LC15SW	9/28/2022	--	--	12.10	161.9	6.41	70	13.7	0.21
	03Q22NF02SW	9/29/2022	--	--	12.18	214.0	6.49	72	13.7	23.7

Field parameters were measured using a YSI Pro and a flow-through cell, with the exception of turbidity, which was measured using an HF Scientific TPW Meter

* water level in feet above mean sea level, relative to top of PVC casing elevation survey

TOC = top of casing

amsl = above mean sea level

mg/L = milligrams per liter

µS/cm = micro-siemens per centimeter

NTU = Nephelometric Turbidity Units

Water level measurements are not collected from the Water Wells

Table 3. Constituents Detected in Groundwater, 3rd Quarter 2022

Camp Bonneville, Vancouver, Washington

Analyte	MTCA Method B Std. Cleanup	LCMW01D	LCMW01S	LCMW02D	LCMW02D Duplicate		LCMW02S	LCMW03D	LCMW03S	LCMW04D	LCMW04S	LCMW09D	LCMW09S
		9/27/2022	9/27/2022	9/27/2022	9/27/2022	RPD (<20%)	9/27/2022	9/28/2022	9/27/2022	9/28/2022	9/28/2022	9/27/2022	9/27/2022
Explosives (µg/L)													
2,4-Dinitrotoluene	0.28	< 0.100	< 0.100	< 0.100	< 0.100	Acceptable	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
HMX	800	< 0.500	< 0.500	< 0.500	< 0.500	Acceptable	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500
RDX	1.10	< 0.100	< 0.100	< 0.100	< 0.100	Acceptable	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
Remaining Explosives	Varies	ND	ND	ND	ND	Acceptable	ND	ND	ND	ND	ND	ND	ND
Perchlorate (µg/L)													
Perchlorate	11.0	< 0.500	< 0.500	< 0.500	< 0.500	Acceptable	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500
Volatile Organic Compounds (µg/L)													
1,1,1-Trichloroethane	16,000	< 0.500	< 0.500	< 0.500	< 0.500	Acceptable	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500
1,1,2,2-Tetrachloroethane	0.220	< 0.500	< 0.500	< 0.500	< 0.500	Acceptable	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500
1,1-Dichloroethane	7.7	< 0.500	< 0.500	< 0.500	< 0.500	Acceptable	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500
1,1-Dichloroethene	400	< 0.500	< 0.500	< 0.500	< 0.500	Acceptable	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500
Acetone	7,200	< 2.50	< 2.50	< 2.50	< 2.50	Acceptable	2.92	< 2.50	< 2.50	< 2.50	< 2.50	< 2.50	< 2.50
Dichlorodifluoromethane	1,600	< 0.500	< 0.500	< 0.500	< 0.500	Acceptable	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500
Remaining VOCs	Varies	ND	ND	ND	ND	Acceptable	ND	ND	ND	ND	ND	ND	ND

Notes:

µg/L = micrograms per liter
< = not detected above the indicated method reporting limit
BOLD = exceeds cleanup values
Acceptable = No detection in original or duplicate, or the difference in detection values is less than the reporting limit
ND = not detected
RPD = relative percent different

Table 3. Constituents Detected in Groundwater, 3rd Quarter 2022

Camp Bonneville, Vancouver, Washington

Analyte	MTCA Method B Std. Cleanup	L4MW01A	L4MW01A Duplicate		L4MW01B	L4MW02A	L4MW02B	L4MW03A	L4MW03B	L4MW04A	L4MW04A Duplicate		L4MW05A
		9/29/2022	9/29/2022	RPD (<20%)	9/29/2022	9/30/2022	9/30/2022	10/3/2022	10/3/2022	9/29/2022	9/29/2022	RPD (<20%)	10/3/2022
Explosives (µg/L)													
2,4-Dinitrotoluene	0.28	< 0.100	< 0.100	Acceptable	< 0.100	< 0.100	**0.284**	< 0.100	< 0.100	< 0.100	< 0.100	Acceptable	< 0.100
HMX	800	< 0.500	< 0.500	Acceptable	< 0.500	2.36	6.00	< 0.500	< 0.500	< 0.500	< 0.500	Acceptable	< 0.500
RDX	1.10	0.217	0.187	15%	< 0.100	**5.40**	**31.0**	**4.22**	**4.60**	**7.54**	**5.97**	23%	**2.91**
Remaining Explosives	Varies	ND	ND	Acceptable	ND	ND	ND	ND	ND	ND	ND	Acceptable	ND
Perchlorate (µg/L)													
Perchlorate	11.0	2.01	2.09	4%	< 0.500	**177**	**369**	**22.9**	**18.9**	**65.4**	**69.5**	6%	**20.5**
Volatile Organic Compounds (µg/L)													
1,1,1-Trichloroethane	16,000	< 0.500	< 0.500	Acceptable	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	Acceptable	< 0.500
1,1,2,2-Tetrachloroethane	0.220	< 0.500	< 0.500	Acceptable	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	Acceptable	< 0.500
1,1-Dichloroethane	7.7	< 0.500	< 0.500	Acceptable	< 0.500	< 0.500	0.980	< 0.500	< 0.500	< 0.500	< 0.500	Acceptable	< 0.500
1,1-Dichloroethene	400	< 0.500	< 0.500	Acceptable	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	Acceptable	< 0.500
Acetone	7,200	< 2.50	< 2.50	Acceptable	< 2.50	< 2.50	< 2.50	< 2.50	< 2.50	< 2.50	< 2.50	Acceptable	< 2.50
Dichlorodifluoromethane	1,600	< 0.500	< 0.500	Acceptable	< 0.500	< 0.500	1.09	< 0.500	< 0.500	< 0.500	< 0.500	Acceptable	< 0.500
Remaining VOCs	Varies	ND	ND	Acceptable	ND	ND	ND	ND	ND	ND	ND	Acceptable	ND

Notes:

µg/L = micrograms per liter
< = not detected above the indicated method reporting limit
BOLD = exceeds cleanup values
Acceptable = No detection in original or duplicate, or the difference in detection values is less than the reporting limit
ND = not detected
RPD = relative percent different

Table 3. Constituents Detected in Groundwater, 3rd Quarter 2022

Camp Bonneville, Vancouver, Washington

Analyte	MTCA Method B Std. Cleanup	L4MW07B 9/29/2022	L4MW08A 9/29/2022	L4MW08B 9/29/2022	L4MW09A 9/30/2022	L4MW09B 9/30/2022	L4MW10A 9/30/2022	L4MW10B 9/30/2022	L4MW11B 9/30/2022	L4MW17 9/28/2022	L4MW18 9/28/2022
Explosives (µg/L)											
2,4-Dinitrotoluene	0.28	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
HMX	800	< 0.500	1.15	< 0.500	1.42	1.89	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500
RDX	1.10	< 0.100	**21.7**	0.338	**4.80**	**22.6**	**1.37**	**14.3**	**56.3**	< 0.100	< 0.100
Remaining Explosives	Varies	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Perchlorate (µg/L)											
Perchlorate	11.0	1.70	**85.9**	**110**	**298**	**223**	**61.8**	**219**	**595**	< 0.500	< 0.500
Volatile Organic Compounds (µg/L)											
1,1,1-Trichloroethane	16,000	< 0.500	< 0.500	< 0.500	< 0.500	3.32	< 0.500	2.74	1.84	< 0.500	< 0.500
1,1,2,2-Tetrachloroethane	0.220	< 0.500	< 0.500	< 0.500	< 0.500	**1.18**	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500
1,1-Dichloroethane	7.7	< 0.500	< 0.500	< 0.500	< 0.500	5.87	< 0.500	5.56	4.52	< 0.500	< 0.500
1,1-Dichloroethene	400	< 0.500	< 0.500	< 0.500	< 0.500	4.18	< 0.500	6.26	2.78	< 0.500	< 0.500
Acetone	7,200	< 2.50	< 2.50	< 2.50	< 2.50	< 2.50	3.27	< 2.5	< 2.50	< 2.50	< 2.50
Dichlorodifluoromethane	1,600	< 0.500	< 0.500	< 0.500	< 0.500	**10.5**	< 0.500	15.900	7.45	< 0.500	< 0.500
Remaining VOCs	Varies	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Notes:

µg/L = micrograms per liter

< = not detected above the indicated method reporting limit

BOLD = exceeds cleanup values

Acceptable = No detection in original or duplicate, or the difference in detection values is less than the reporting limit

ND = not detected

RPD = relative percent different

Table 4. Constituents Detected in Water Supply Wells, 3rd Quarter 2022

Camp Bonneville, Vancouver, Washington

Analyte	MTCA Method B Std. Cleanup	FBI	FBI Duplicate		Killpack
		10/3/2022	10/3/2022	RPD (<20%)	10/3/2022
Explosives (µg/L)					
All Explosives	Varies	ND	ND	Acceptable	ND
Perchlorate (µg/L)					
Perchlorate	11.0	< 0.500	< 0.500	Acceptable	< 0.500
Volatile Organic Compounds (µg/L)					
All VOCs	Varies	ND	ND	Acceptable	ND

Notes:

µg/L = micrograms per liter
< = not detected above the indicated method reporting limit
Acceptable = No detection in original or duplicate, or the difference in detection values is less than the reporting limit
ND = not detected
RPD = relative percent difference

Table 5. Constituents Analyzed in Surface Water - 3rd Quarter 2022

Camp Bonneville, Vancouver, Washington

Analyte	MTCA Method B Std. Cleanup	LC03	LC03 Duplicate		LC15	NF02
		9/28/2022	9/28/2022	RPD (<20%)	9/28/2022	9/29/2022
Perchlorate (µg/L)						
Perchlorate	11.0	< 0.500	< 0.500	Acceptable	< 0.500	< 0.500
Explosives (µg/L)						
RDX	1.10	< 0.100	< 0.100	Acceptable	< 0.100	< 0.100

Notes:

The most stringent MTCA Method B Standard value is used

µg/L = micrograms per liter

BOLD = exceeds cleanup values

RPD = relative percent different

< = not detected above the indicated MRL

Acceptable = No detection in original or duplicate

Appendix A
List of Acronyms and Abbreviations

List of Acronyms and Abbreviations

amsl	above mean sea level
AP	ammonium perchlorate
bgs	below ground surface
CD	compact disc
BRAC	Base Realignment and Closure
CHPPM	US Army Center for Health Promotion and Preventative Medicine
COC	contaminants of concern
COPC	chemical of potential concern
DNR	State of Washington Department of Natural Resources
DO	dissolved oxygen
DQO	data quality objectives
EDD	electronic data deliverable
EPA	US Environmental Protection Agency
GC/MS	gas chromatography/mass spectrometer
HASP	health and safety plan
HE	high explosives 2,4 DNT, 2,6 DNT
HMX	octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
IC	ion chromatography
IDW	investigation-derived waste
LCS	laboratory control spike
µg/L	micrograms per liter (approximately equal ppb)
µm	micrometer
MDL	method detection limit
mg/L	milligrams per liter (approximately equal ppm)
mL	milliliters
MRL	method reporting limit
MS	matrix spike
MSD	matrix spike duplicate
MTCA	Washington Model Toxics Control Act (Chapter 173-340 WAC)
NG	nitroglycerine
OE	ordinance and explosives
ORP	oxidation reduction potential
PA	picric acid
PAH	polycyclic aromatic hydrocarbons
PBS	PBS Engineering and Environmental Inc.
PCBs	polychlorinated biphenyls
PES	polyethersulfone
PETN	pentaerythitol tetranitrate
ppb	parts per billion
ppm	parts per million

PQL	practical quantitation limit
PVC	polyvinyl chloride
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine (Cyclonite)
RI	remedial investigation
RPD	relative percent difference
SAP	sampling and analysis plan
SDG	sample delivery groups
SDS	sample data sheets
SI	site investigation
SOP	standard operating procedure
SOW	statement of work
SVOC	semi-volatile organic compound
TBD	to be determined
TIC	tentatively identified compound
TNT	2,4,6-trinitrotoluene
TOC	total organic carbon
TPH	total petroleum hydrocarbons
USACE	United States Army Corps of Engineers
UXO	unexploded ordnance
VOC	volatile organic compound

Appendix B

Anantek, Level II Data Package

(Electronic files provided on enclosed CD)

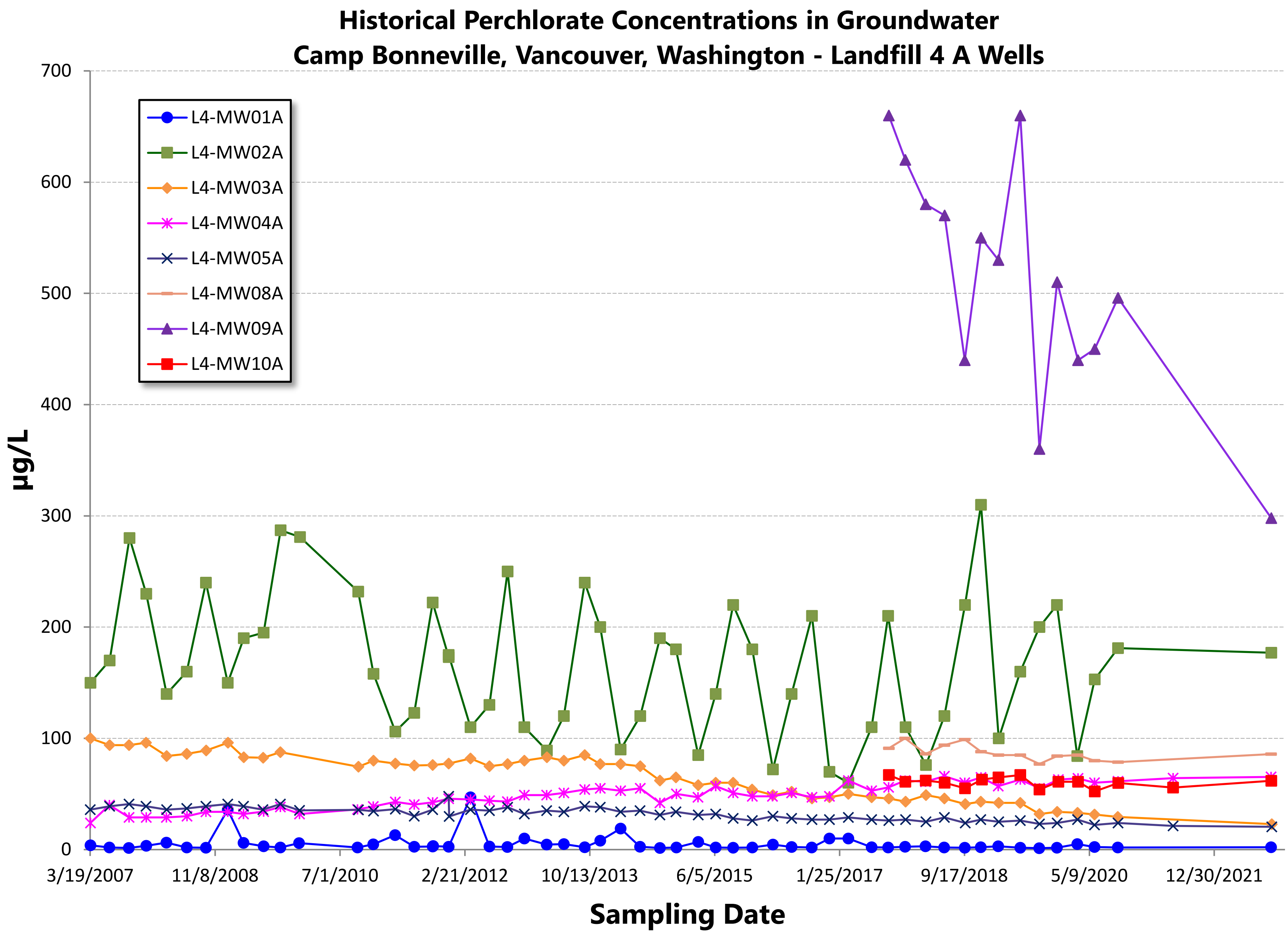
Appendix C

Anatek, Level III Data Package

(Electronic files provided on enclosed CD)

Appendix D

Trend Graphs



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January 2023
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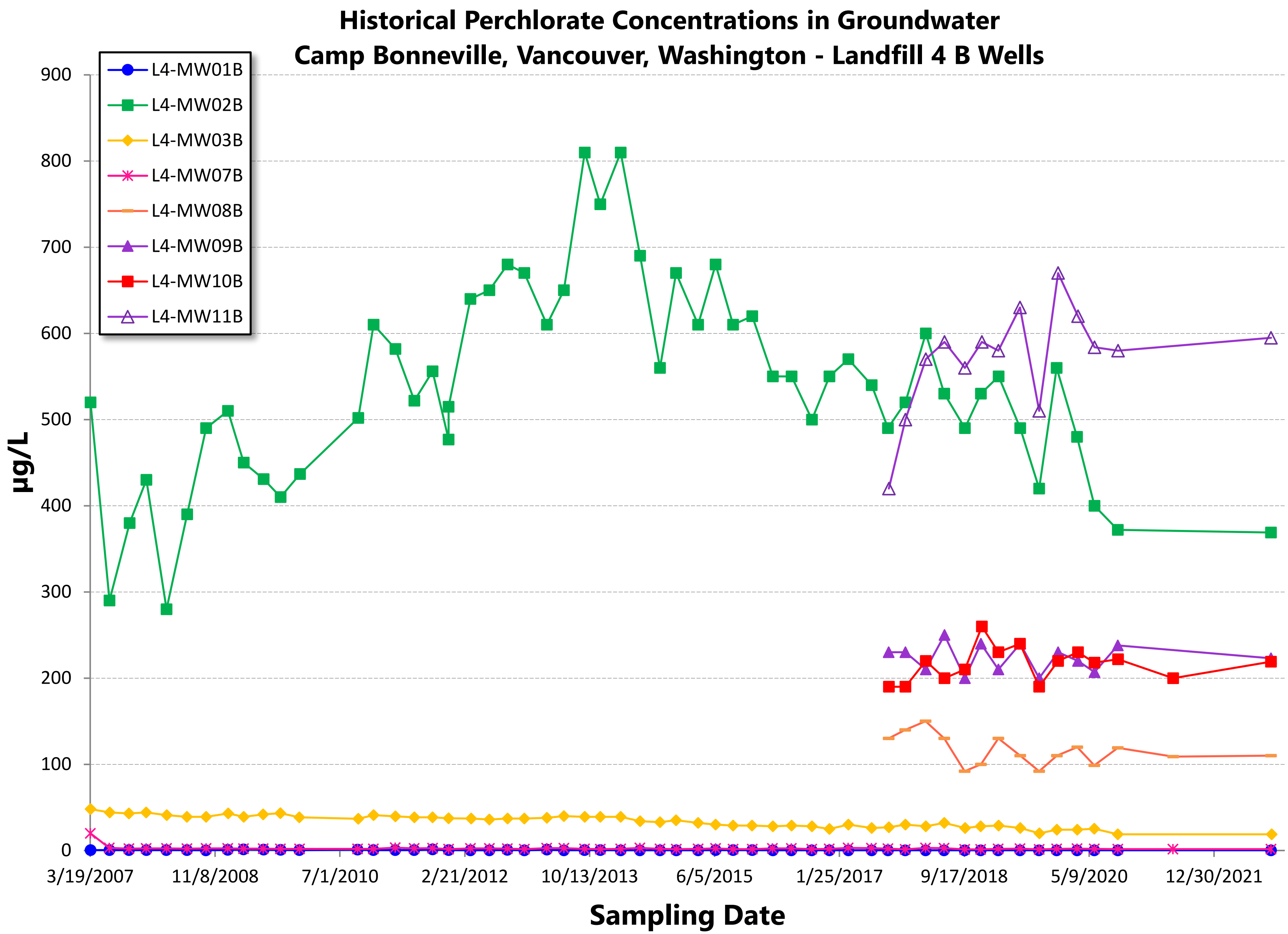

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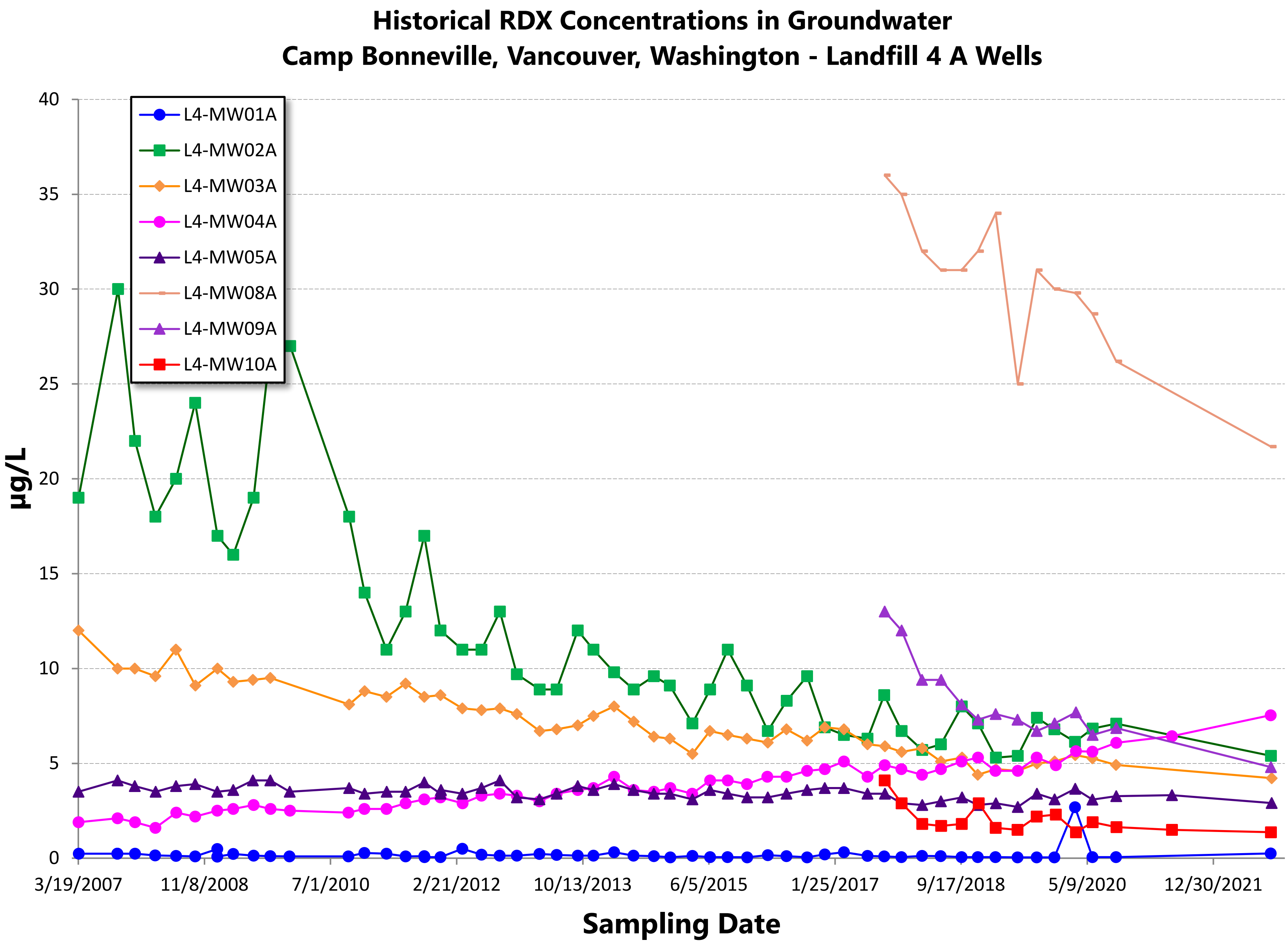

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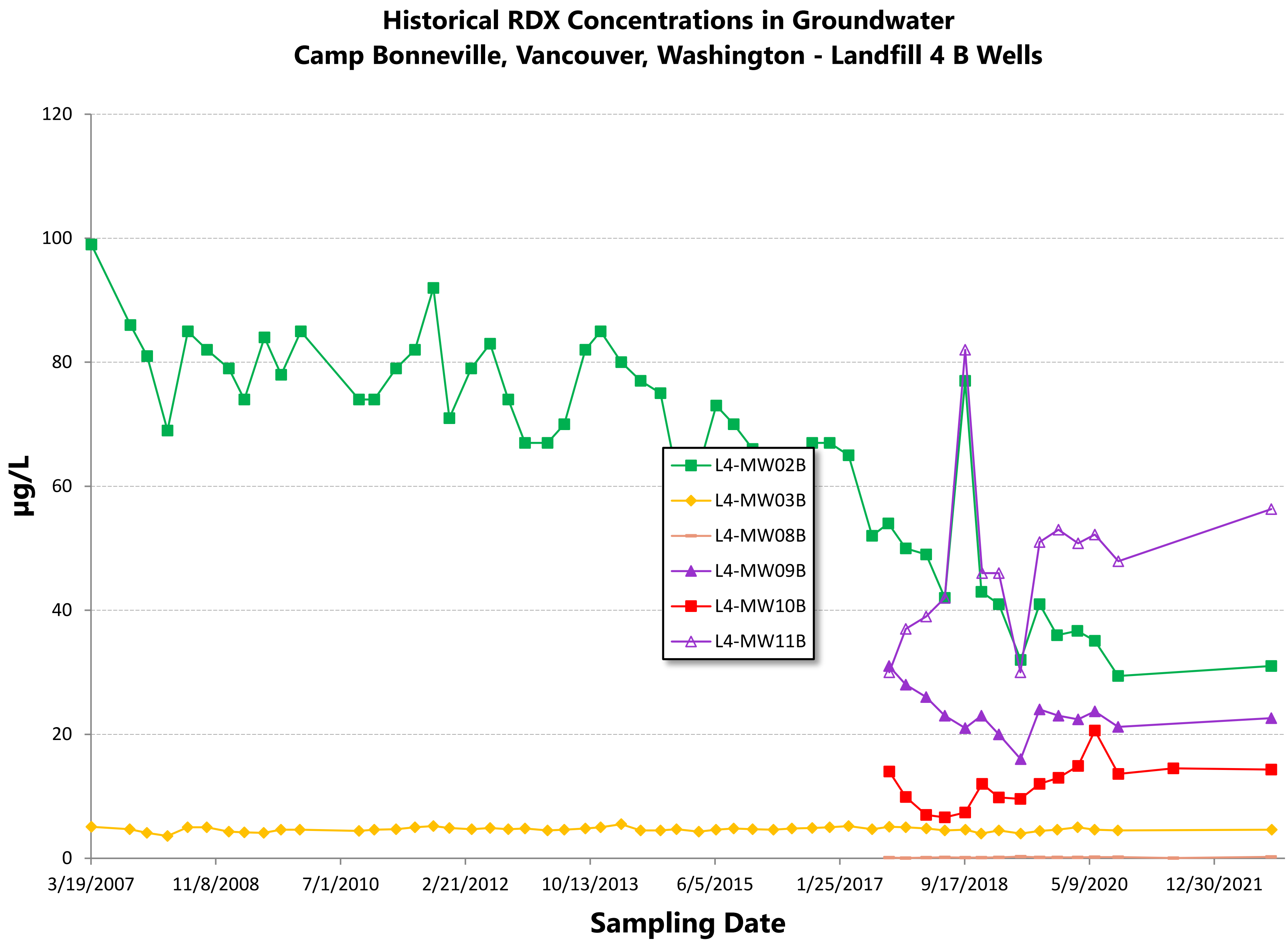

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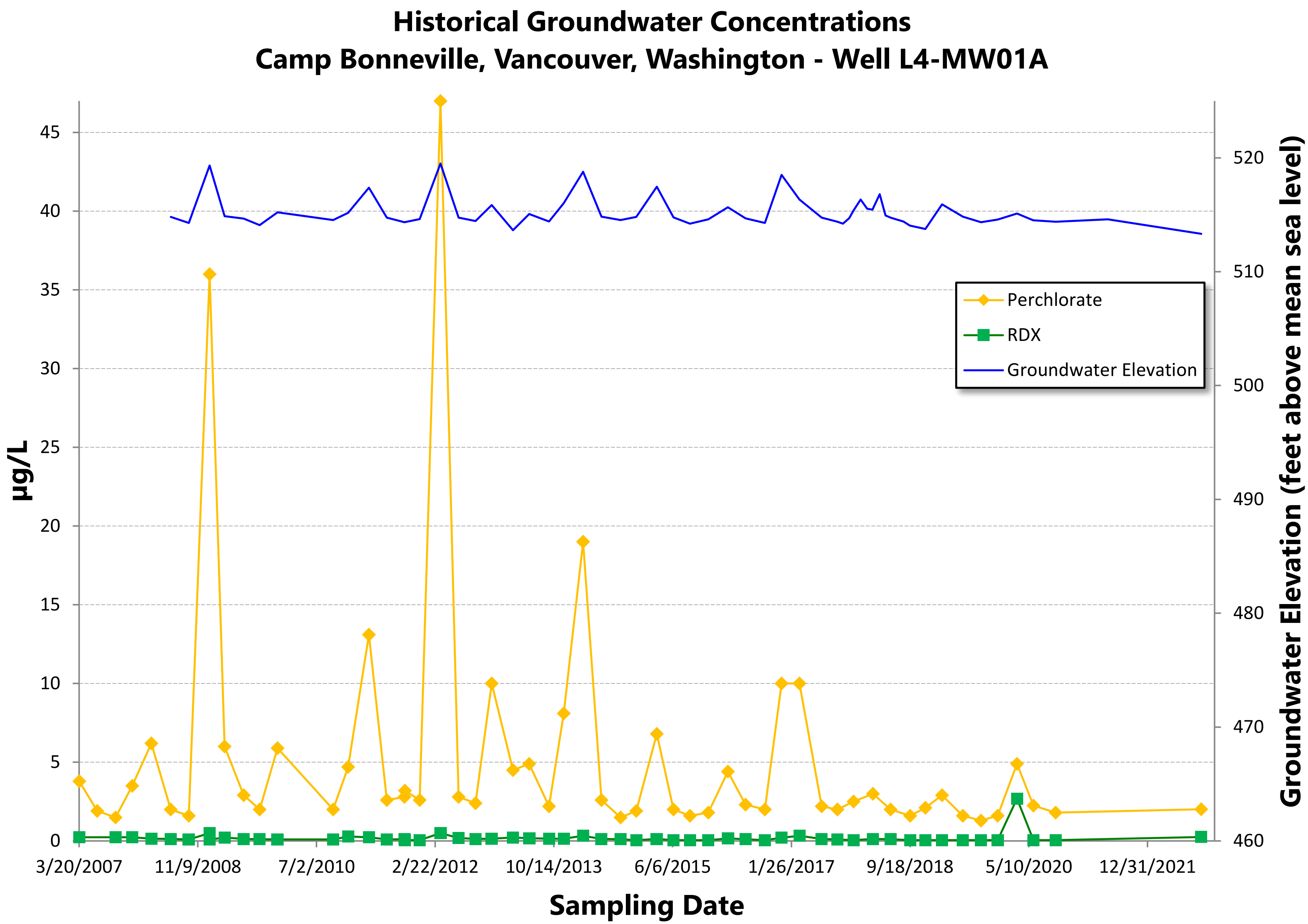

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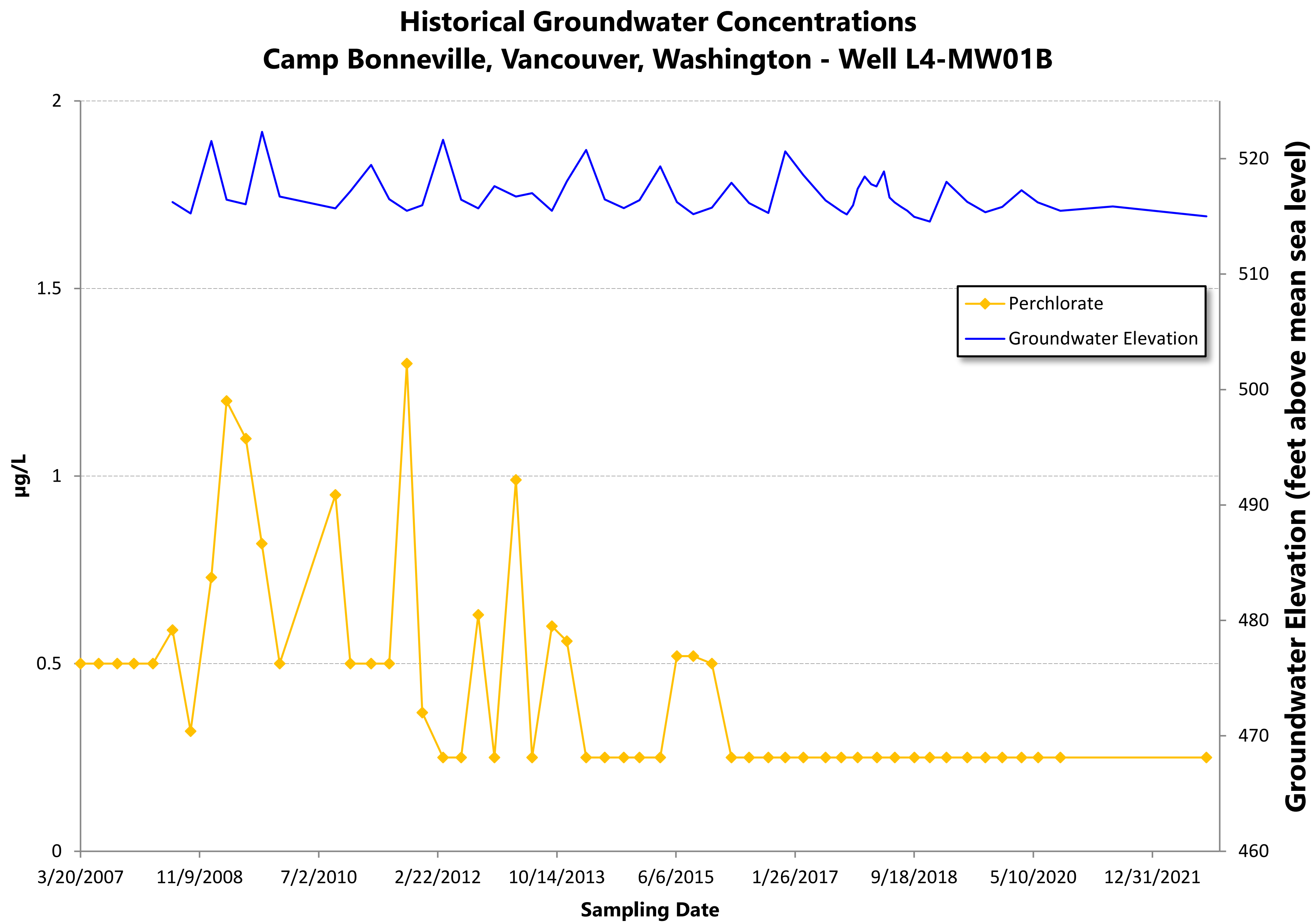
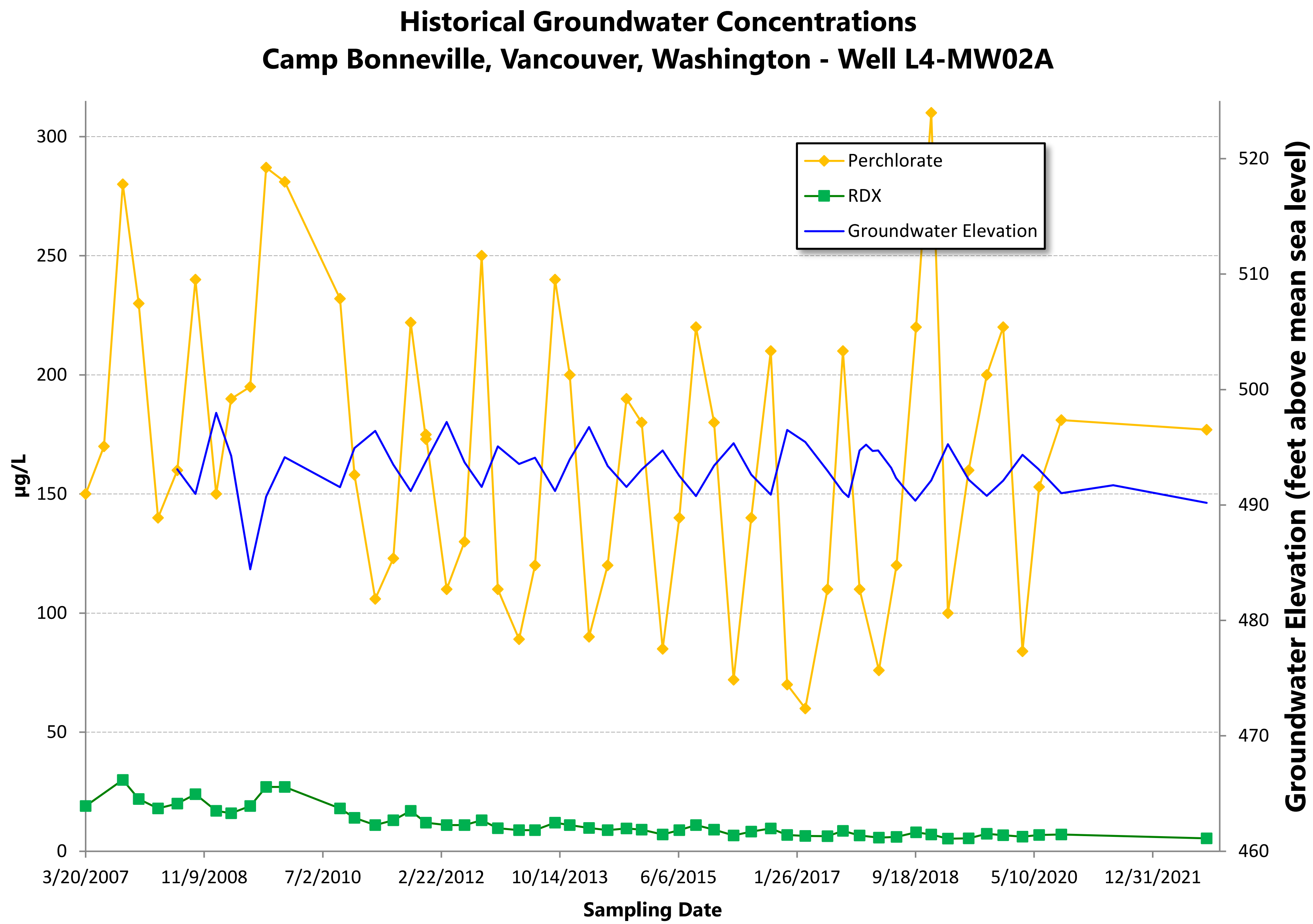

Historical Groundwater Concentrations
Camp Bonneville, Vancouver, Washington - Well L4-MW01B
µg/L
2
1.5
1
0.5
0
Groundwater Elevation (feet above mean sea level)
520
510
500
490
480
470
460
Perchlorate
Groundwater Elevation
3/20/2007
11/9/2008
7/2/2010
2/22/2012
10/14/2013
6/6/2015
1/26/2017
9/18/2018
5/10/2020
12/31/2021
Sampling Date



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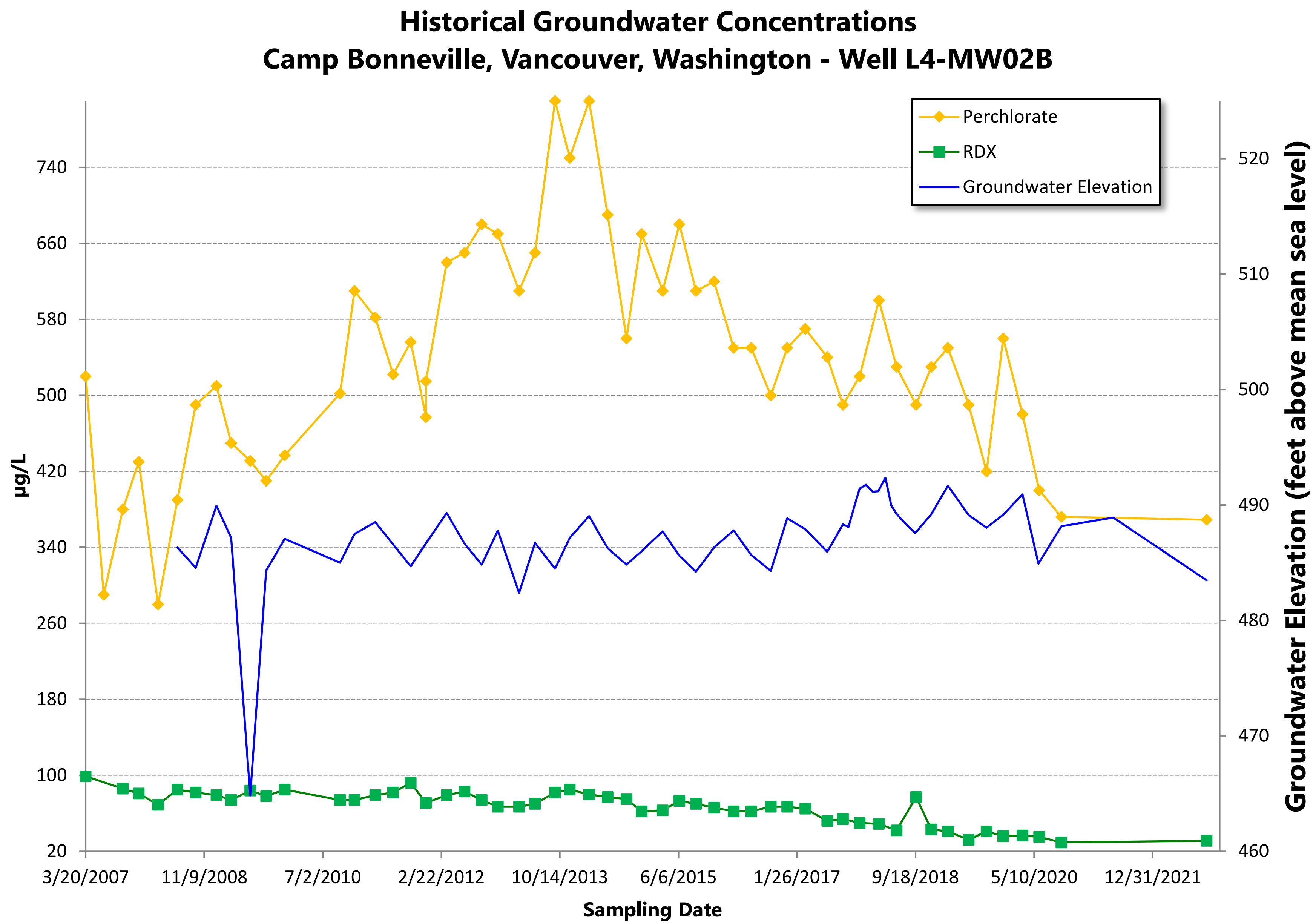

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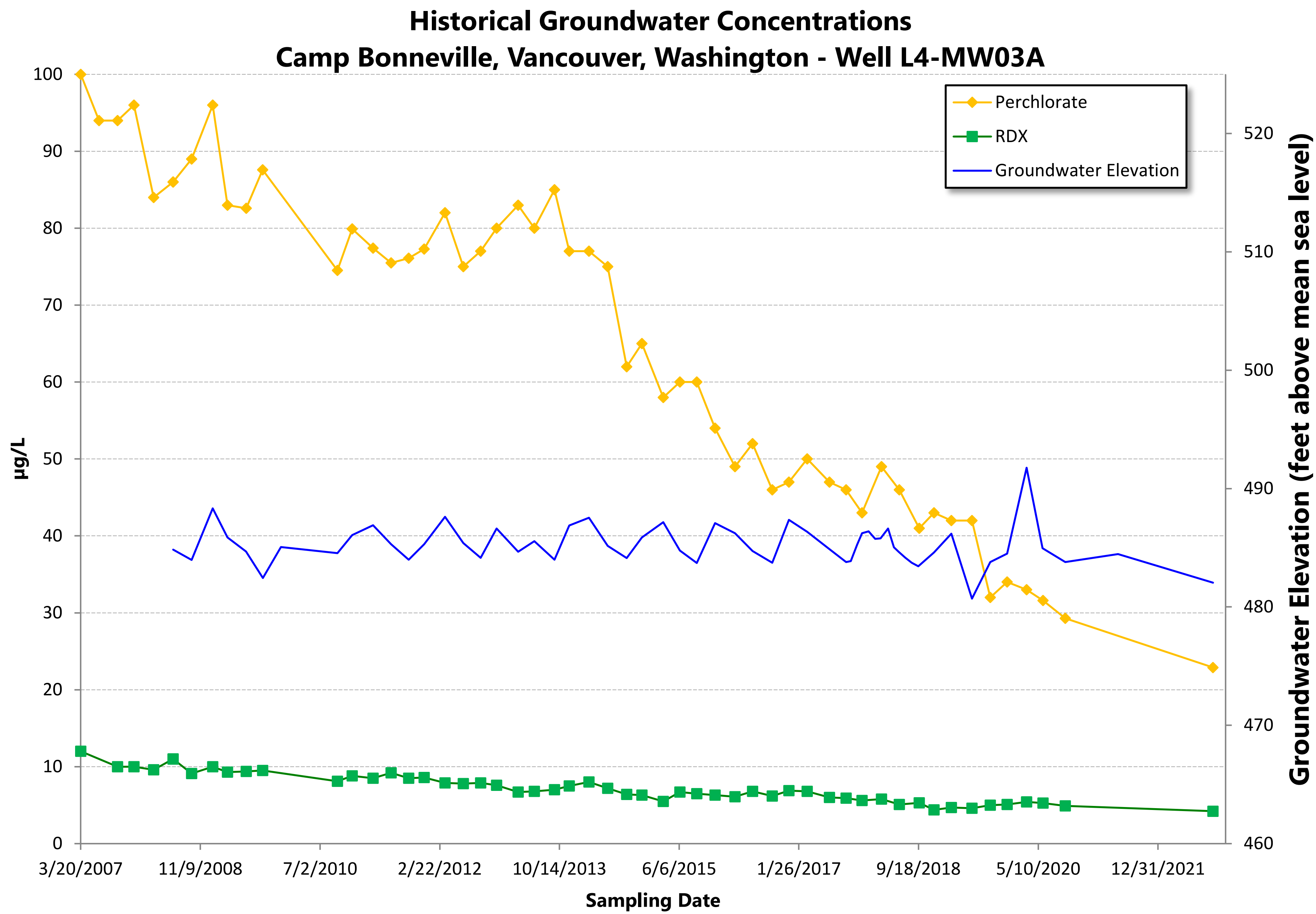

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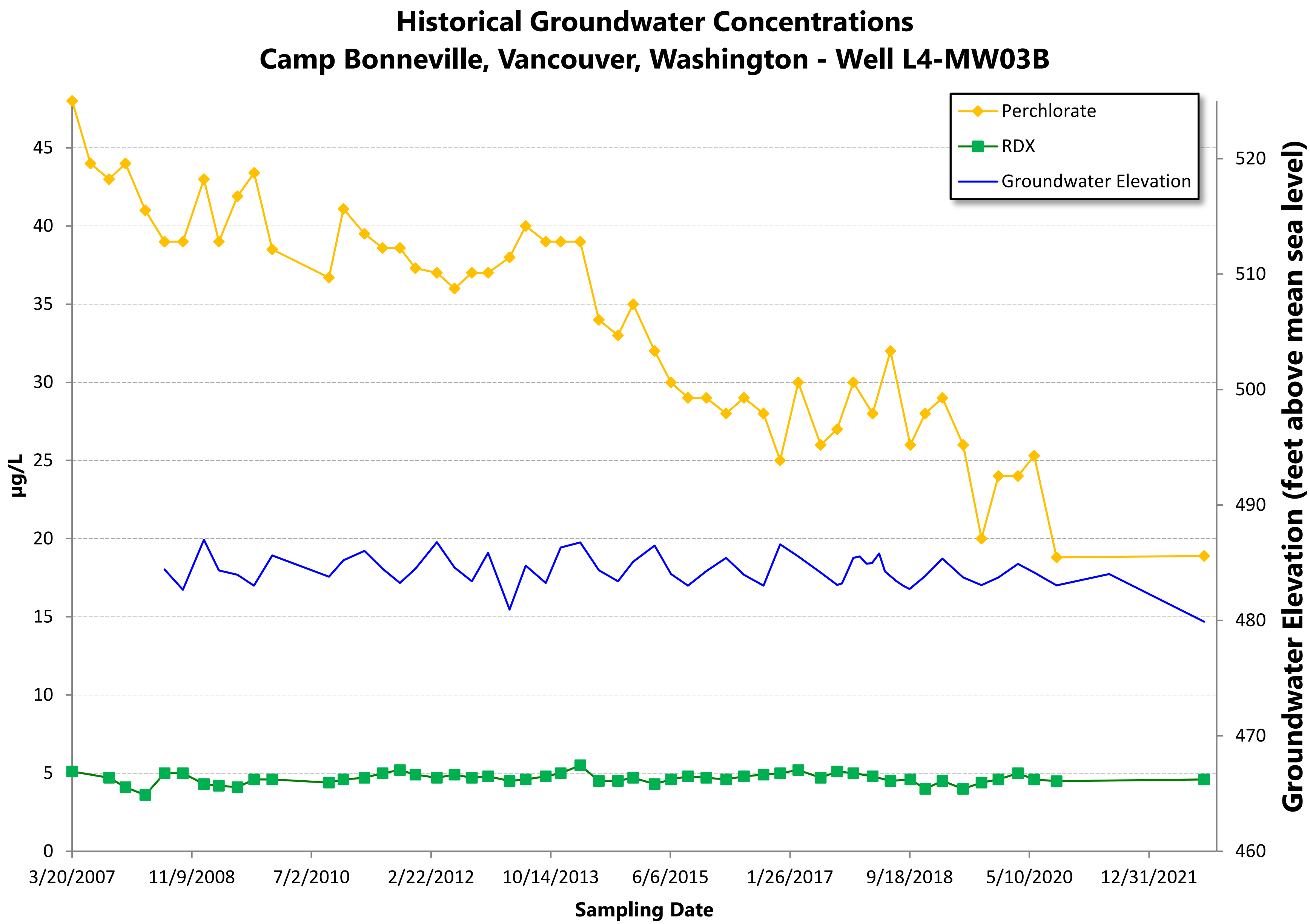

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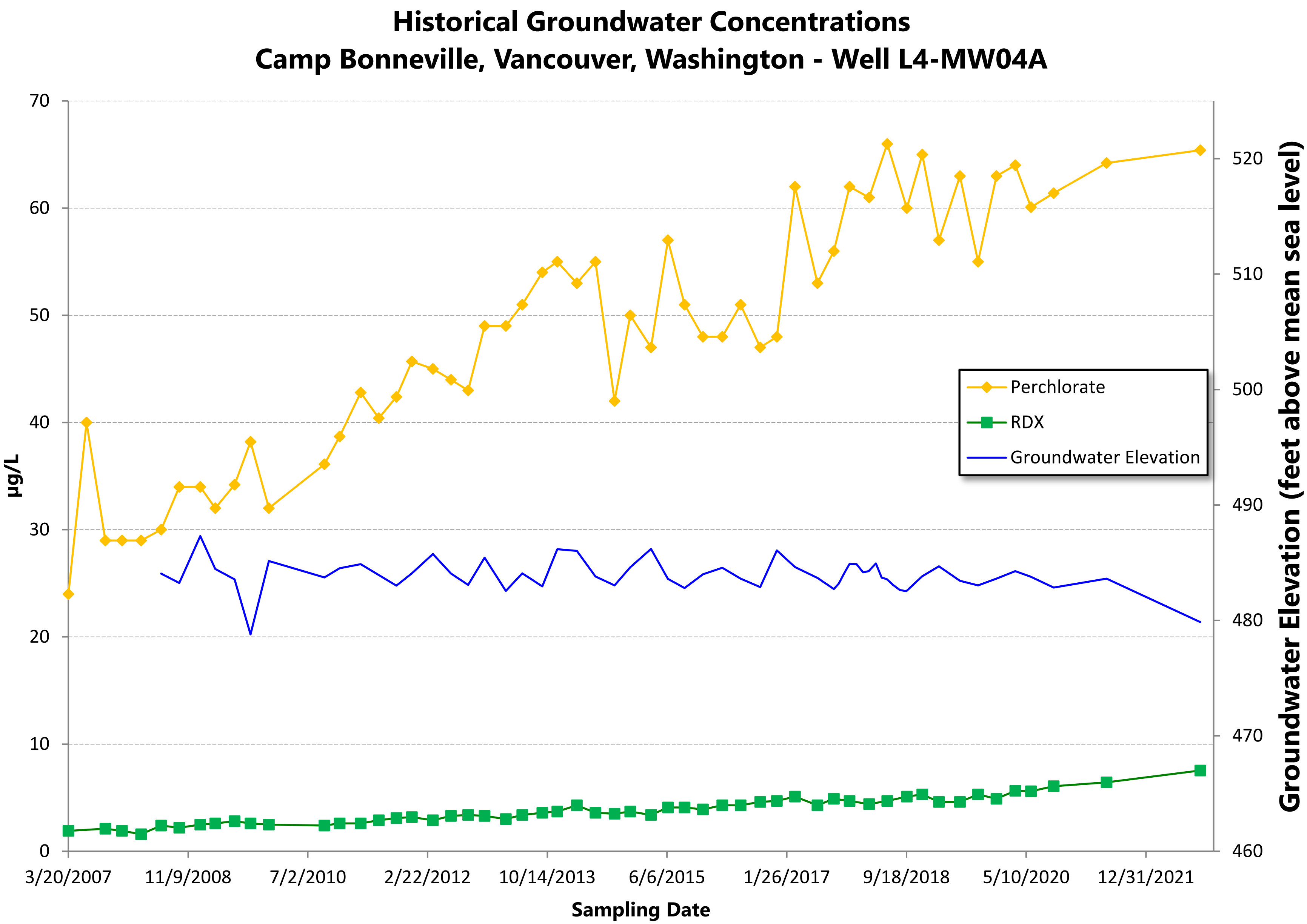

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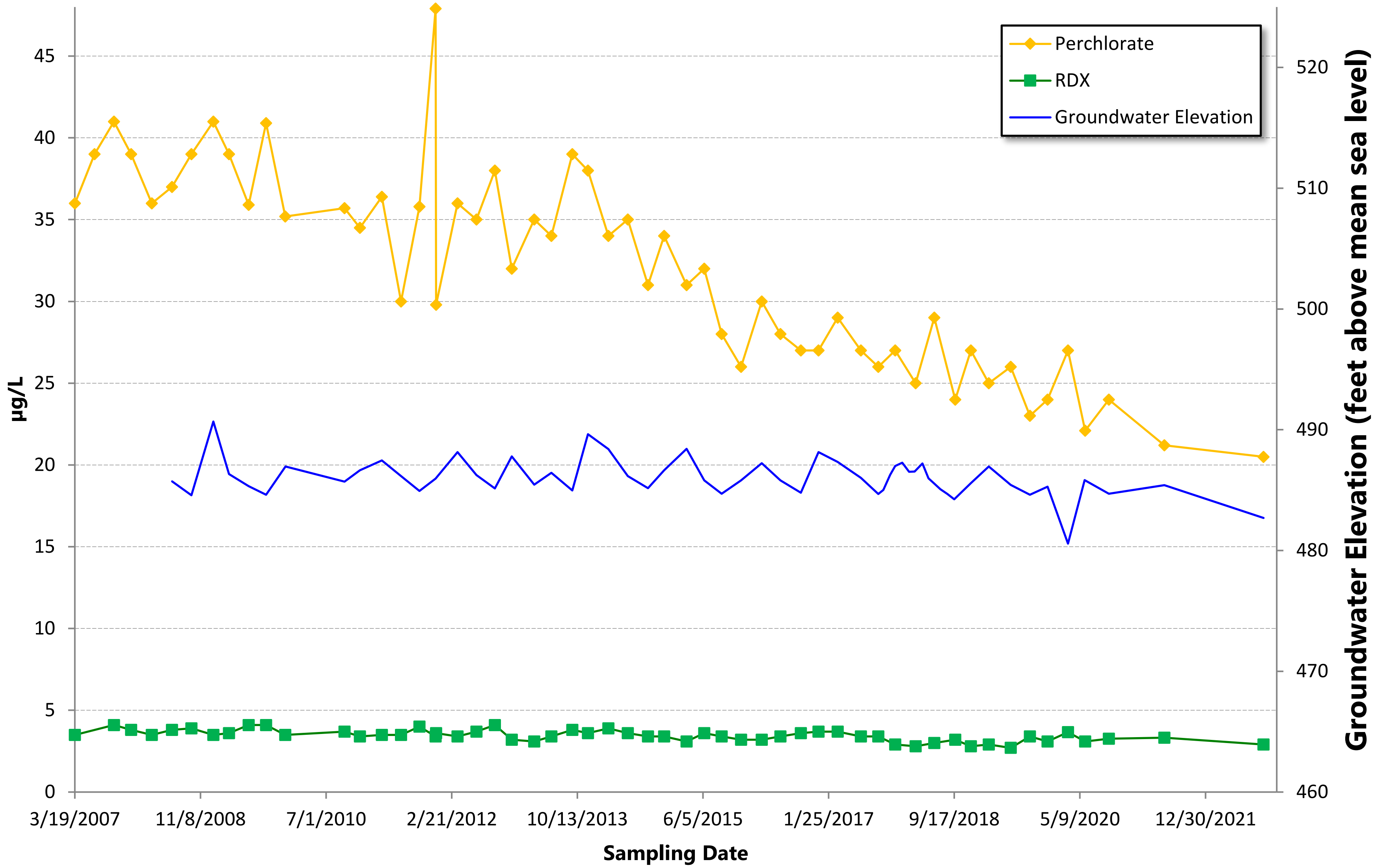
Historical Groundwater Concentrations
Camp Bonneville, Vancouver, Washington - Well L4-MW05A



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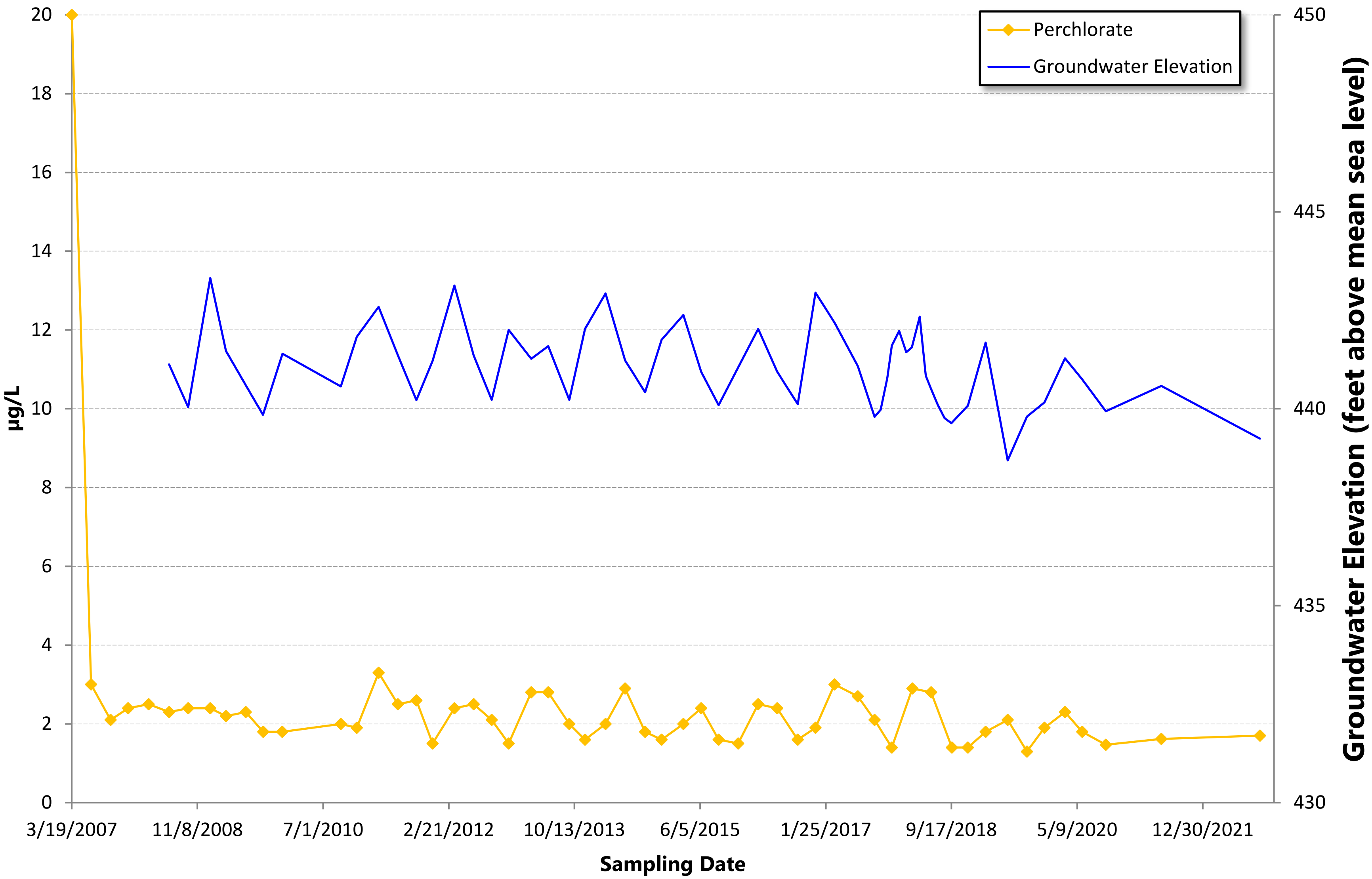
Historical Groundwater Concentrations
Camp Bonneville, Vancouver, Washington - Well L4-MW07B



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January 2023

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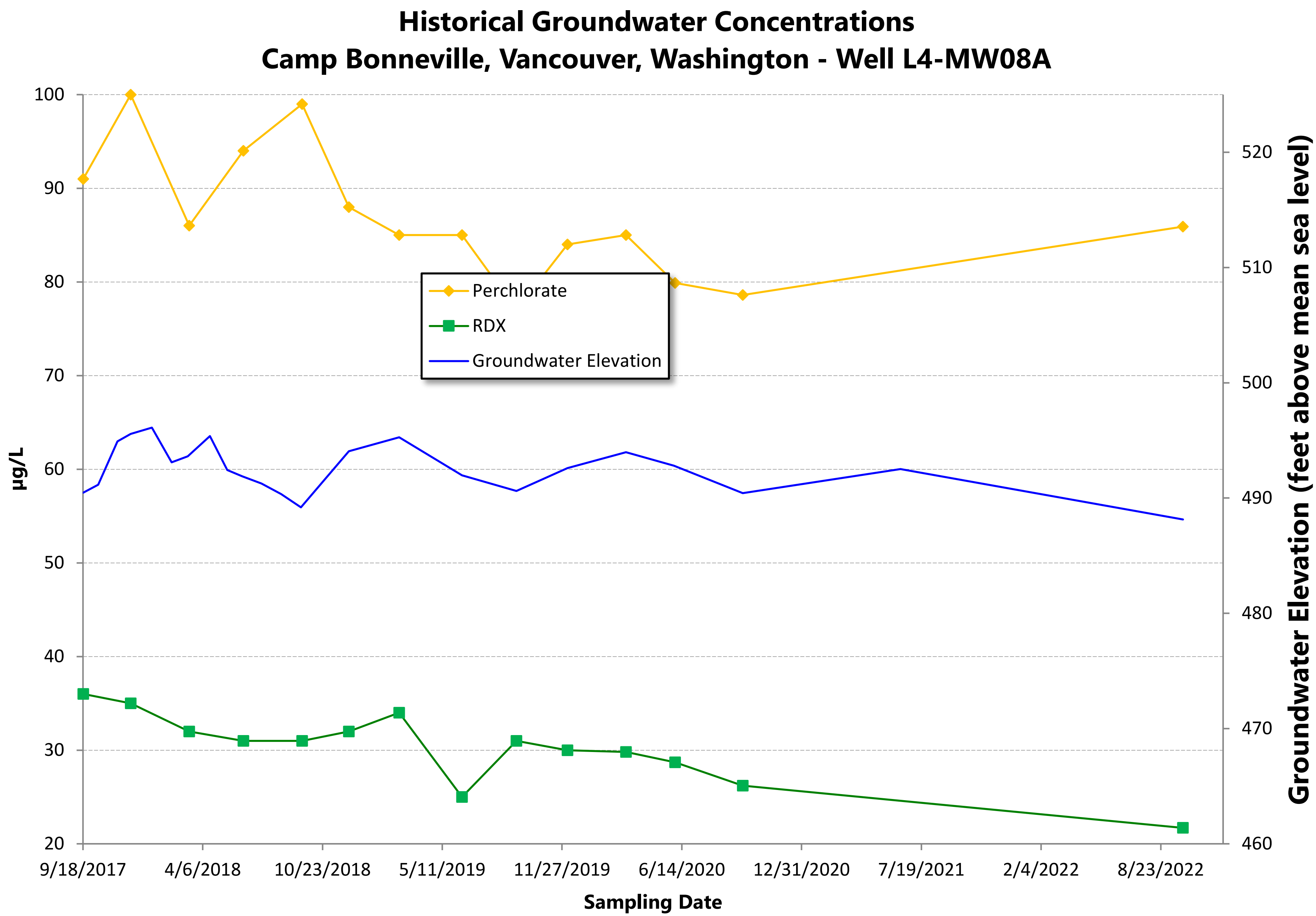

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January 2023
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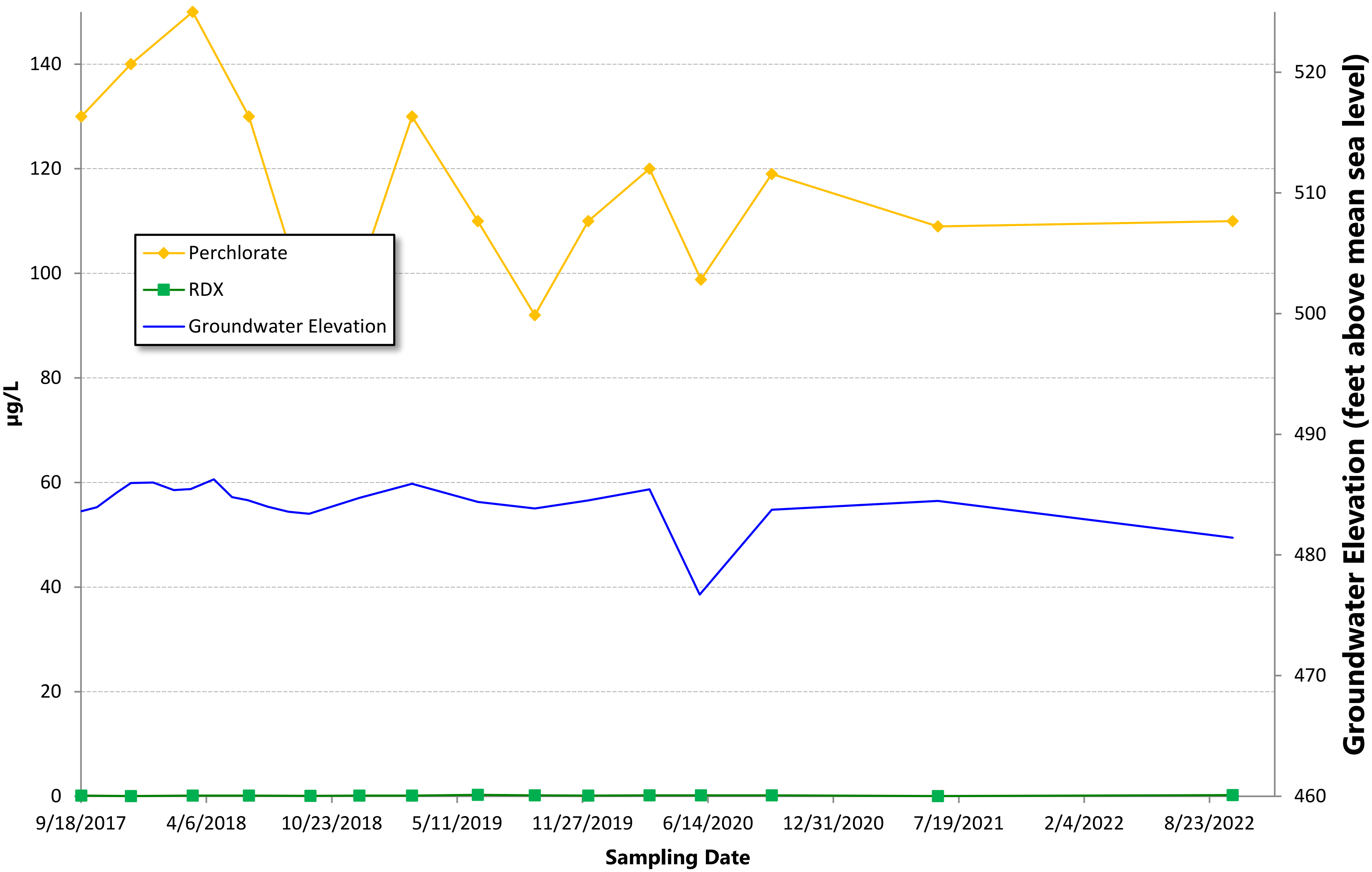
Historical Groundwater Concentrations
Camp Bonneville, Vancouver, Washington - Well L4-MW08B



January 2023

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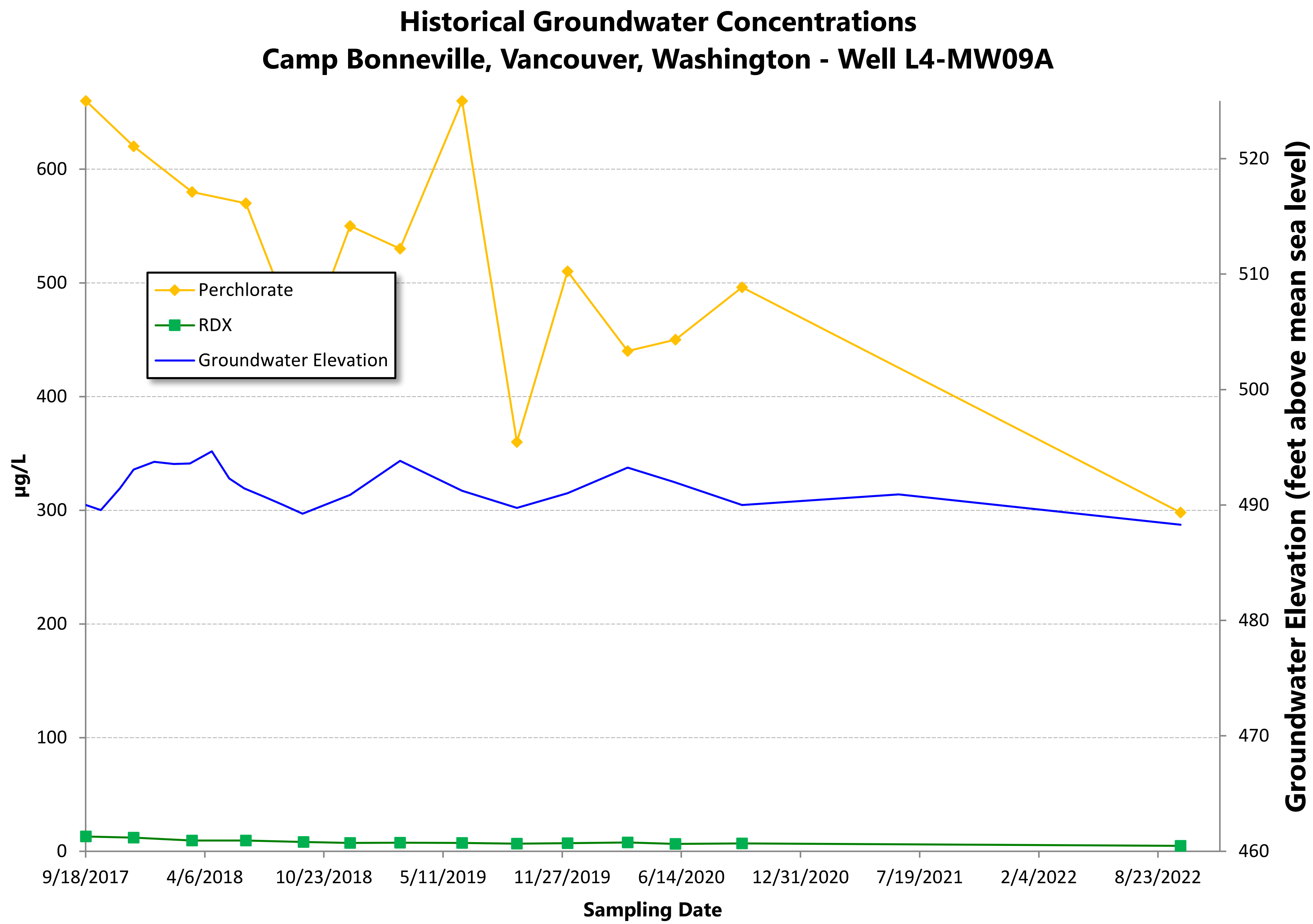

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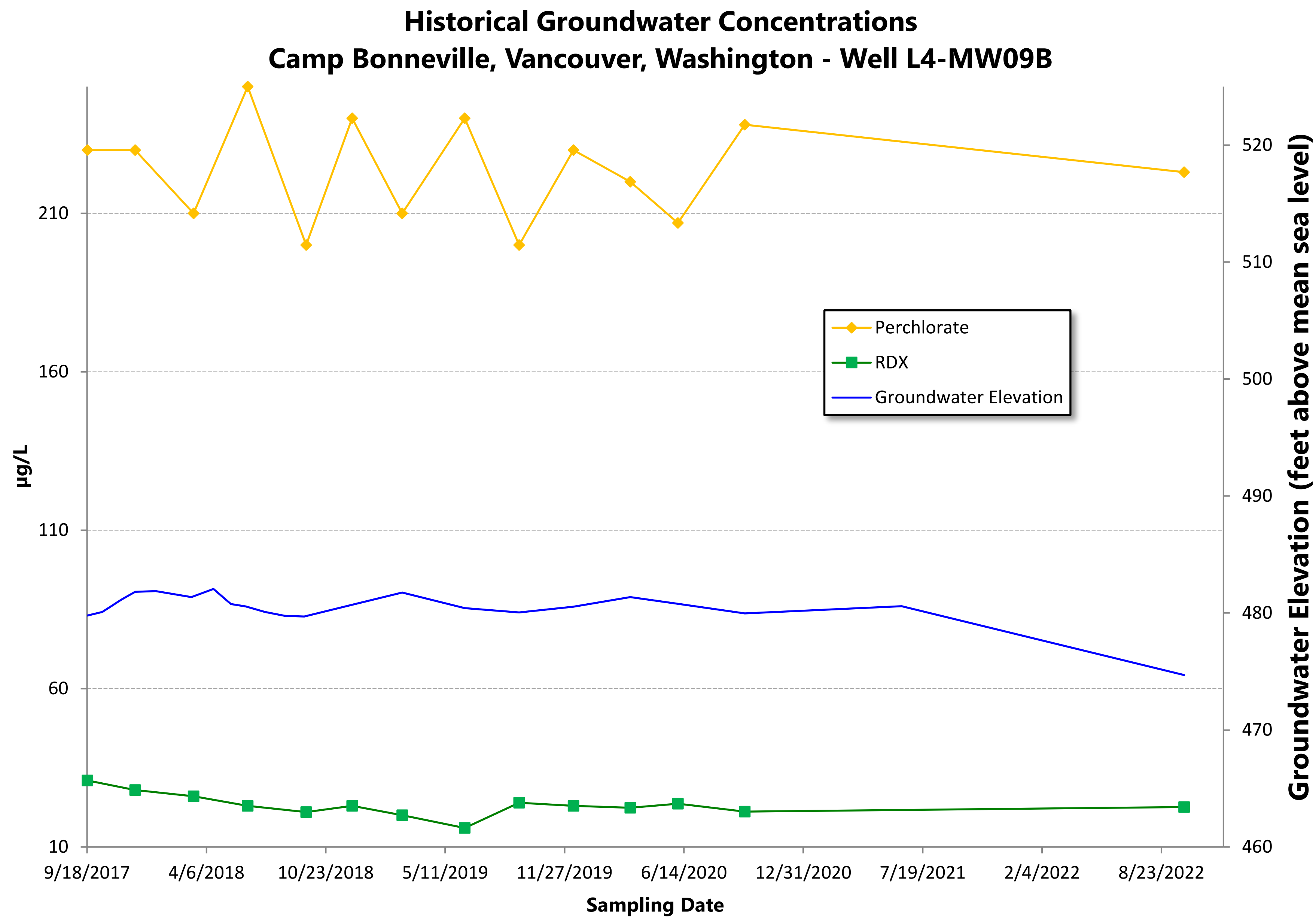
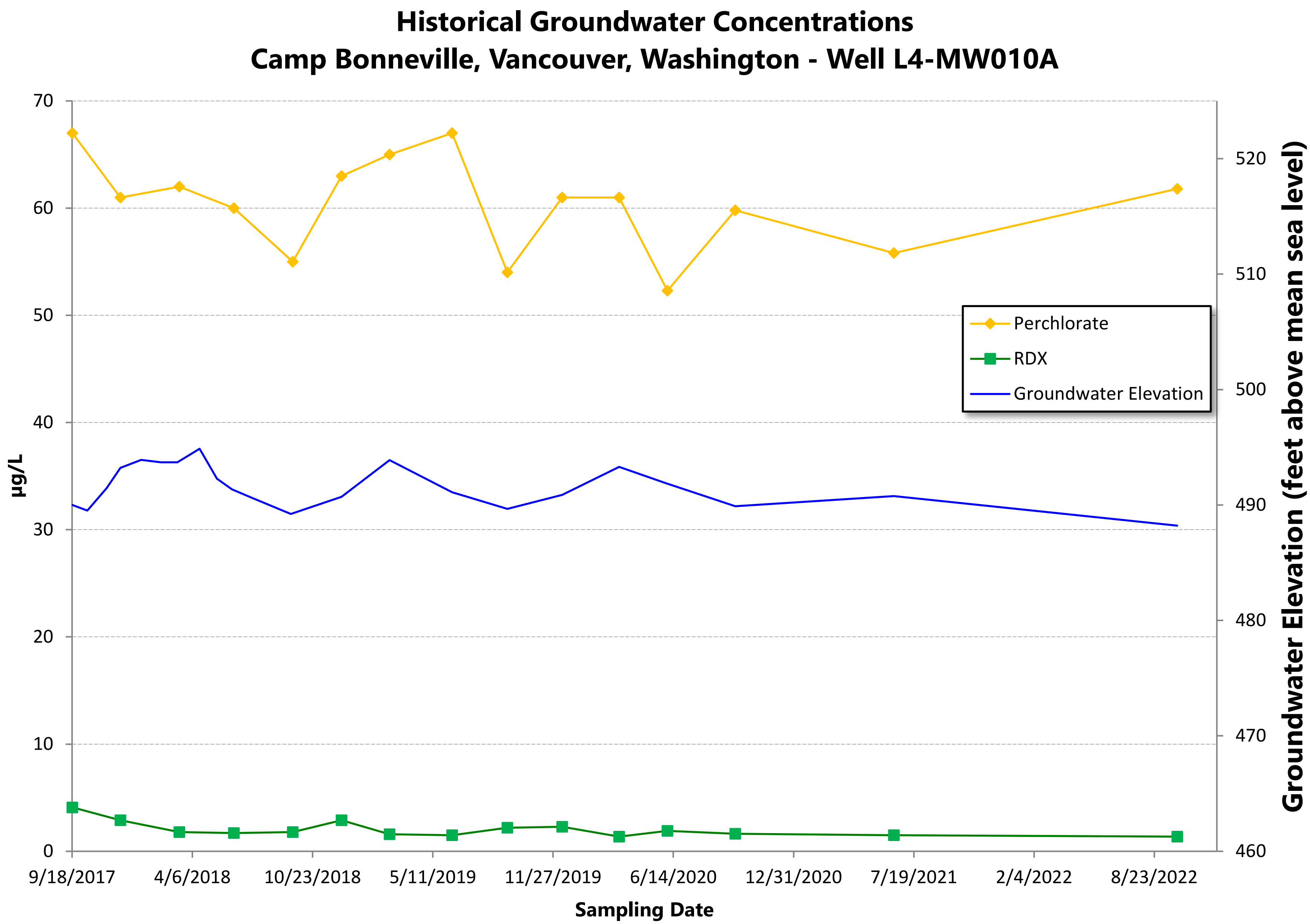

Historical Groundwater Concentrations
Camp Bonneville, Vancouver, Washington - Well L4-MW09B
µg/L
210
160
110
60
10
Groundwater Elevation (feet above mean sea level)
520
510
500
490
480
470
460
Perchlorate
RDX
Groundwater Elevation
9/18/2017
4/6/2018
10/23/2018
5/11/2019
11/27/2019
6/14/2020
12/31/2020
7/19/2021
2/4/2022
8/23/2022
Sampling Date



January 2023
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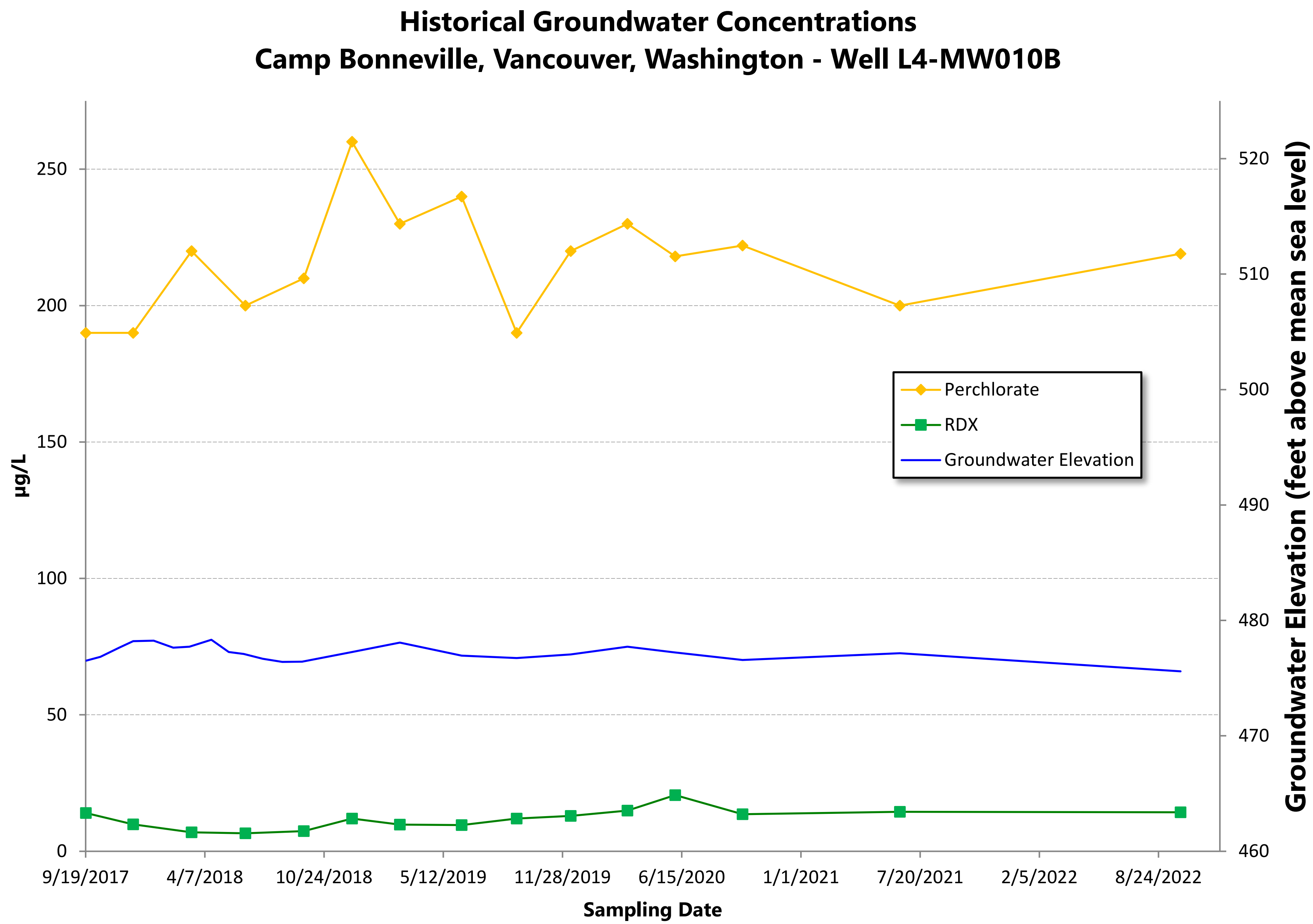
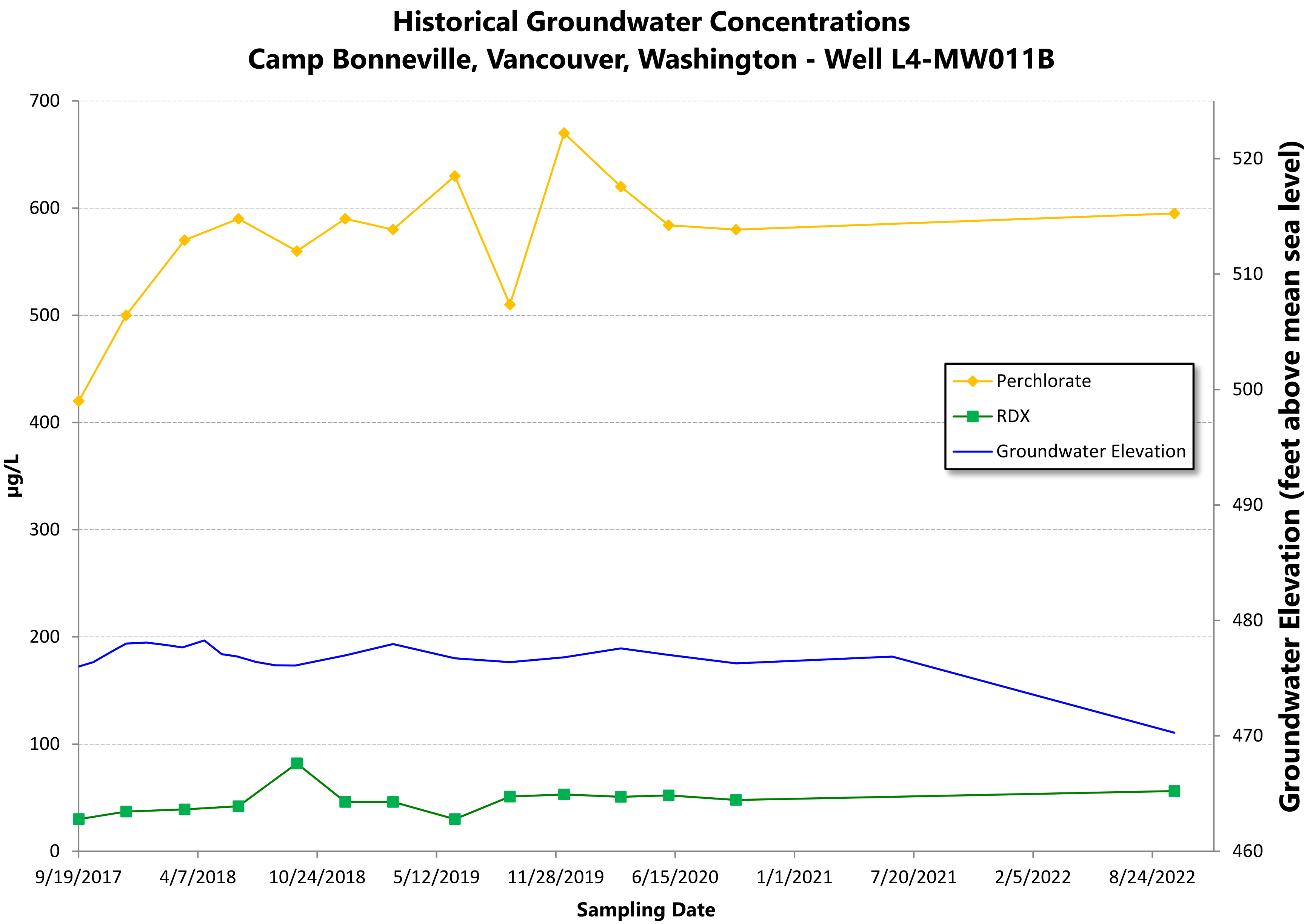


January 2023
PBS Project 76151.011



PBS

January 2023
PBS Project 76151.011