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Savannah River Site

**2024 Effectiveness Monitoring Report (EMR) for Monitored
Natural Attenuation (MNA) at the L-Area Southern
Groundwater (LASG) Operable Unit (OU) (U)**

Data from 2022 through 2023

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LIST OF ACRONYMS AND ABBREVIATIONS

~	approximately
4Q	fourth quarter
ac	acre
amsl	above mean sea level
cm	centimeter
DQOs	data quality objectives
EMP	Effectiveness Monitoring Plan
EMR	Effectiveness Monitoring Report
FFA	Federal Facility Agreement
ft	foot, feet
in	inch, inches
GAU	Gordon aquifer
GCU	Gordon confining unit
ha	hectare, hectares
KSZ	key source zone
KSZCL	key source zone contaminant level
LAOCB	L-Area Oil and Chemical Basin
LASG	L-Area Southern Groundwater
LAZ	lower aquifer zone
LRSB	L-Area Reactor Seepage Basin
LUC	land use control
m	meter, meters
µg/L	microgram per liter
MCL	maximum contaminant level
MNA	monitored natural attenuation
NBN	no building number
NTU	nephelometric turbidity unit
OU	operable unit
PCE	tetrachloroethylene
pCi/mL	picocuries per milliliter
RA	remedial action
RCRA	Resource Conservation and Recovery Act
RFI/RI	RCRA Facility Investigation/Remedial Investigation
ROD	Record of Decision
SCDES	South Carolina Department of Environmental Services ¹
SRNS	Savannah River Nuclear Solutions, LLC
SRS	Savannah River Site
TC	tan clay
TCE	trichloroethylene
UAZ	upper aquifer zone
USDOE	United States Department of Energy

¹ South Carolina Department of Environmental Services (SCDES) was known as South Carolina Department of Health and Environmental Control (SCDHEC) prior to July 1, 2024.

LIST OF ACRONYMS AND ABBREVIATIONS (*continued; end*)

USEPA	United States Environmental Protection Agency
UTRA	Upper Three Runs aquifer
VOC	volatile organic compound
WSRC	Washington Savannah River Company

1.0 INTRODUCTION

The L-Area Southern Groundwater (LASG) Operable Unit (OU) is listed as a Resource Conservation and Recovery Act (RCRA) 3004(u) Solid Waste Management Unit/Comprehensive Environmental Response, Compensation, and Liability Act unit in Appendix C of the Federal Facility Agreement (FFA) (1993) for the Savannah River Site (SRS). The selected remedy for the LASG OU is Monitored Natural Attenuation (MNA) with Land Use Controls (LUCs²). Sampling optimizations that were developed and approved in the 2012 Biennial Effectiveness Monitoring Report (EMR) (Savannah River Nuclear Solutions, LLC [SRNS] 2012) started in fourth quarter (4Q) 2012. All LUC boundary wells and plume wells, except those exceeding volatile organic compound (VOC) maximum contaminant levels (MCLs), are sampled biennially instead of annually. Also, EMRs are produced on a 4-year cycle with an interim 2-year supplemental data summary report in letter format. The *Biennial Effectiveness Monitoring Report (Sampling Summary) for the Monitored Natural Attenuation at the L-Area Southern Groundwater Operable Unit, 2020 through 2021* (SRNS 2022) was the last report submitted for regulatory review.

These sampling optimizations and reporting requirements are documented in the *Addendum to the Monitored Natural Attenuation Effectiveness Monitoring Plan for the L-Area Southern Groundwater Operable Unit (NBN)* (SRNS 2013) as approved by the U.S. Environmental Protection Agency (USEPA) and the South Carolina Department of Environmental Services (SCDES). This EMR covers data collected during 2022 and 2023.

2.0 OPERABLE UNIT DESCRIPTION AND HISTORY

L Area is located in the south-central portion of the SRS in Barnwell County, South Carolina (Figure 1). The L-Area Reactor operated from 1954 to 1968 and 1984 to 1988. L Lake, constructed in 1985 as a cooling pond for L-Reactor, covers approximately 419 hectares (ha) (1,035 acres [ac]) and contains approximately 7-billion gallons of water. The LASG OU encompasses all of the groundwater from the L-Area groundwater divide south to L Lake (Figure 2). The original pre-work plan characterization at LASG OU covered about 505.8 ha (1,250 ac) and included several remediated/depleted source units that supported past production

² LUCs were formerly referred to as institutional controls in older SRS remedy documents.

activities. Past activities at the remediated/depleted source units have resulted in groundwater contamination beneath LASG OU. Contaminants include plumes of tritium, tetrachloroethylene (PCE), and trichloroethylene (TCE).

2.1 Remedial Action Requirements and Objectives

As stated in the LASG OU Record of Decision (ROD) (Washington Savannah River Company [WSRC] 2007), the scope of the LASG OU remedial action (RA) is limited to local groundwater in three known contaminant plumes. The plumes include a tritium plume west of the reactor and two commingled VOC and tritium plumes south of the reactor (Figure 2). The selected remedy for the LASG OU is MNA/LUCs. The components of MNA/LUCs at the LASG OU include the following:

- LUCs at LASG OU will consist of general site access controls, groundwater use restrictions, the SRS Site Use/Site Clearance program, and deed restrictions and notifications.
- Contaminant concentrations in local groundwater will be reduced below remedial goals (MCLs/applicable or relevant and appropriate requirements) by natural attenuation processes including dispersion, dilution, and radioactive decay.
- The long-term monitoring of groundwater conditions in the plumes and surface water conditions in L Lake will allow an evaluation of the performance of the selected remedy and changing conditions in LASG OU.

The remedial action objectives for LASG OU are as follows:

- Prevent human exposure to groundwater above MCLs.
- Treat and/or mitigate groundwater contaminated above MCLs to reduce the discharge of groundwater with contaminants above MCLs to L Lake.

2.2 Land Use Control Boundary and Monitoring Network

The area in which groundwater contamination exceeds applicable MCLs is depicted on Figure 2 and is within the LUC area. Comprising approximately 384.4 ha (950 ac), the LUC area includes all groundwater contaminated above MCLs within the OU and under adjacent portions of L Lake. Restrictions on the use of groundwater within this LUC boundary will be enforced as long as contaminant levels exceed MCLs.

As outlined in the Addendum to the Effectiveness Monitoring Plan (EMP) (SRNS 2013), the monitoring network at LASG OU includes 26 monitoring wells and 5 surface water stations that are analyzed for tritium and/or PCE and TCE (Figure 2) (Table 1).

3.0 SITE HYDROGEOLOGY

3.1 Physiographic Setting

The LASG OU LUC boundary is located southeast of the L-Area groundwater divide and includes a portion of L Lake. Topographic relief in this area ranges between approximately 57.9 meters (m) (190 feet [ft]) and 76.2 m (260 ft) above mean sea level (amsl) and slopes to the south and southeast towards L Lake (Figure 2). L Lake is fed from surface water associated with Steel Creek that originates near P Area. L Lake encompasses an area of approximately 419 ha (1,035 ac) and occupies a significant part of the LASG OU LUC boundary.

3.2 Hydrogeologic Setting

A detailed description of the hydrostratigraphic units relevant to the LASG OU can be found in the RCRA Facility Investigation/Remedial Investigation (RFI/RI) Report (WSRC 2005) and in the L-Area Groundwater Hydrogeologic Conceptual Model Report (WSRC 2002).

The Floridan aquifer system is the aquifer system of concern within the LASG OU area. The system is divided into two aquifer units separated by a confining unit. From top to bottom, they are known as the Upper Three Runs Aquifer (UTRA), the Gordon Confining Unit (GCU), and the Gordon Aquifer (GA).

The UTRA occurs between the water table surface and the GCU. The UTRA is divided into two aquifer zones by an informal aquitard referred to as the “tan clay” (TC) confining zone. From top to bottom they are known as the upper aquifer zone (UAZ) of the UTRA, the TC, and the lower aquifer zone (LAZ) of the UTRA. A general schematic of the hydrostratigraphic and geologic units at SRS can be seen in Figure 3. A schematic of the UTRA and GA pertinent to LASG OU can be seen in the cross section of the western tritium plume discussed in Section 4.3 (Figure 4).

4.0 MONITORING AND REPORTING

The long-term monitoring of groundwater conditions in the plumes and surface water conditions in L Lake will ensure that the expected natural attenuation processes including dispersion, dilution, and radioactive decay are performing as modeled and contaminant concentrations are decreasing as predicted.

The monitoring data quality objectives (DQOs), listed below, form the basis for the LASG OU monitoring program.

DQO #1: Perform monitoring to ensure that the plumes' lateral movement is trending in a manner consistent with the conceptual flow path to L Lake as predicted by the model.

DQO #2: Perform monitoring to ensure that the plumes' vertical movement is trending in a manner consistent with the conceptual flow path as predicted by the model.

DQO #3: Perform monitoring to ensure that the plumes' contaminants (tritium and VOCs) are trending to lower concentration/activity as they approach L Lake in the groundwater.

DQO #4: Perform surface water monitoring to ensure that the plumes' contaminants (tritium and VOCs) are below regulatory thresholds and are not trending to higher concentration/activity as they leave L Lake at the dam to ensure protection of downstream receptors.

DQO #5: Perform groundwater monitoring to ensure that there are no releases of contaminants from unknown or existing sources and that existing remediated or depleted sources are under control.

Groundwater monitoring for both the L-Area Oil and Chemical Basin (LAOCB) and the L-Reactor Seepage Basin (LRSB) are included as part of the LASG OU monitoring program. In accordance with the Addendum to the EMP (SRNS 2013), performance monitoring of the LAOCB and the LRSB is completed on a five-year cycle. The first performance monitoring occurred in 2012, and the data results were submitted with the Biennial EMR Sampling Summary, which was submitted on June 25, 2014 (SRNS 2014). To align with the schedule for submittal of the LAOCB Five-Year Remedy Review Reports, the second sampling for the LAOCB and LRSB

occurred in 2016 and 2020 and results were submitted in subsequent LASG OU data sampling summary reports (SRNS 2018; SRNS 2022). Future sampling will occur during the years 2025, 2030, etc. The next performance monitoring sampling for the LAOCB and the LRSB is scheduled for 2025 and will be reported in the next LASG OU data sampling summary report to be submitted in 2026.

4.1 Groundwater Elevation Measurements and Groundwater Flow Direction

In 4Q2023 water table groundwater elevation measurements ranged from 66.93 m (219.58 ft) amsl in the source area at station LDB 3 to 56.11 m (184.09 ft) amsl on the western edge of the LUC boundary at station LSW 12DL. L Lake is maintained at an elevation of approximately 58 m (190 ft) amsl. The lake influences groundwater flow as it recharges groundwater in the UTRA at elevations below 58 m (190 ft) amsl (in the southwestern portion of the area). This is demonstrated in Figure 5, as flow moves towards LSW 12DL rather than towards L Lake. Hydrographs for each well are available in Appendix A.

Within the LASG OU LUC boundary, groundwater flows from L Area (~ [approximately] 67 m [~220 ft] amsl) towards the south and southwest toward L Lake and Pen Branch (minimum measurement of 57.95 m [178 ft] amsl). Figure 5 shows the groundwater elevation within the UAZ. The LAZ water elevations are similar to or slightly lower than the UAZ (Appendix A) and are only located in the western tritium plume; therefore, are not mapped. Groundwater flow in the GA is to the southwest (Figure 6). Water level measurements from monitoring wells in 4Q2023 were approximately 0.18 m (0.6 ft) to 1.4 m (4.6 ft) higher than 4Q2022 measurements.

Based on water elevation data in co-located well clusters, there is very little difference (average of 0.2 m [0.6 ft]) in the hydraulic head measurements within the UTRA from the UAZ to the LAZ (across the TC). There is a consistent downward gradient of approximately 5.7 – 7.3 m (19 – 24 ft) difference in hydraulic heads between the UTRA and the GA (across the GCU). Appendix A presents hydrographs of the water elevations for all the wells.

4.1.1 Recharge and Precipitation Measurements

Recharge entering the groundwater can be estimated from precipitation data. The amount of precipitation generally entering the groundwater as recharge is typically one-third of total

precipitation (Aadland, et. al 1995). A comparison of monthly rainfall for 2020 through 2023 and the 20-year monthly average is shown in Figure 7.

Total precipitation in 2020, 2022, and 2023 at L Area were above the 20-year average of 124.66 centimeter (cm) (49.08 inch [in]), with 2023 precipitation 46 cm (18.1 in) above average. Total precipitation during 2021 was slightly below average at 114.38 cm (45.03 in).

The increased rainfall over most of the previous 11 years has kept water elevations elevated as shown in the hydrographs in Appendix A, and the potentiometric surfaces and groundwater flow paths have remained consistent with previous years.

4.2 Groundwater and Surface Water Compliance

The objective of monitoring at the LASG OU is to assess compliance with the MCLs within and at the LUC boundary and compliance with the Key Source Zone Contaminant Levels (KSZCLs) at the Key Source Zone (KSZ) monitoring wells (Figure 2). LUC boundary well results are compared to MCLs to verify that the plumes are still within the LUC area. In addition, KSZCL values (see Table B-1) are used to identify where source zone wells exhibit increasing concentrations. KSZCL values are well-specific and are calculated as 150% of the observed maximum between the 2005 and 2007 results. If results at the KSZ monitoring wells exceed these values, then a confirmation sample will be collected, and the frequency of sampling will be increased to quarterly for one year. If an increasing trend is observed, a meeting with the USEPA, SCDES, and US Department of Energy (USDOE) will be convened to discuss the results and whether other remediation alternatives should be considered. Similarly, if a LUC boundary well exceeds an MCL for a contaminant, a confirmatory sample will be collected and a meeting with the USEPA, SCDES, and USDOE will be convened for discussion.

4.3 Groundwater and Surface Water Results

Appendix B (Table B-1) provides the sampling results for groundwater and surface water. In accordance with the Addendum to the EMP (SRNS 2013), all monitoring wells and surface water stations are sampled during odd numbered years. During even numbered years, only KSZ monitoring wells, wells known to have exceeded the MCL for VOCs in the previous year, and all

surface water stations are sampled. One of the 67 samples collected during 2023 had turbidity levels exceed 15 nephelometric turbidity units (NTUs) (well LSW 8DU at a turbidity of 33.2 NTUs). This well is sampled with a HydraSleeve, which collects a grab sample within the screen zone, so there is no purging of groundwater to help reduce turbidity. However, elevated turbidity does not affect VOC and tritium results. Thus, all sample results with elevated turbidity are considered valid. Appendix C provides time-series plots of all the wells for tritium, PCE, and TCE.

4.3.1 Tritium

Tritium was detected in approximately three-fourths of all the samples collected (30 of 41) in 2022 and 2023. Only three wells exceeded the 20 picocuries/milliliter (pCi/mL) MCL (LSW 9DL, LSW 25DL, and LSW031DL). None of the exceedances were observed in any of the LUC boundary wells. The KSZ monitoring wells were all below their KSZCLs and also below MCLs. All KSZ monitoring wells continue a decreasing concentration trend. Stations LSW 25DL and LSW031DL continue to display the highest tritium concentrations at the LASG OU but displayed decreasing concentrations (Appendix C, pages C-50 and C-56). These wells are located downgradient of the source areas, are located in the heart of the southwest and southeast tritium plumes, respectively, and capture the plume as it migrates southward towards L Lake. Upgradient wells have decreased in concentration, and all three tritium plumes have decreased in size. All the remaining monitoring wells have shown either an overall decreasing or steady trend in tritium concentrations as presented in Appendix C. Figure 8 shows the extent of the tritium plumes and also displays the plumes from 4Q2009 as a comparison. Figure 4 shows a cross-sectional view of the western tritium plume.

None of the five surface water stations exceeded the tritium MCL in 2022 or 2023. The highest tritium surface water concentration was detected just below the MCL of 20 pCi/mL at station SC20 with a concentration of 19.1 pCi/mL where the sample is obtained from Steel Creek before entering L Lake at the northeast. Contamination at station SC20 originates upgradient in Steel Creek from P Area. Surface water concentrations downgradient from the three tritium plumes are far below the MCL, with a maximum concentration of 2.55 pCi/mL at station SC23 in 2022. The surface water discharging from L Lake (SC27) is not contaminated above the MCL and displays lower

concentrations (2.01 pCi/mL) than the water entering L Lake at station SC20 (19.1 pCi/mL). The trend at SC27 continues to decrease as shown in Appendix C, page C-62.

Modeling predicted that the maximum discharge of tritium into L-Lake would have occurred around 2015 to 2018 (WSRC 2004). As of this report period, the highest tritium concentration in surface water at locations where the plumes are discharging to L Lake (stations SC23, SC24, and SC25) was 2.55 pCi/mL at station SC23 where the southeastern plume enters L Lake. This station has generally shown a decreasing trend over the past four years (see page C-59 in Appendix C) and concentrations remain significantly below the expected maximum discharge concentration (~15,000 pCi/mL for 2018/2019) as plotted in the Modeling Report (WSRC 2004) (Figure 9). As groundwater and the contaminant plumes continue to migrate towards L Lake, concentrations at surface water stations (especially SC23 and SC24) may increase. However, all surface water station time series plots display decreasing trends, including the surface water data at SC27 located at the L Lake dam discharge to Steel Creek, indicating that the maximum discharge of tritium appears to have already occurred. Given the half-life of tritium of 12.3 years, this data indicates that the tritium flux into L Lake from both sources (L Area and P Area [upgradient Steel Creek]) has likely peaked.

4.3.2 *Tetrachloroethylene (PCE)*

PCE was detected in about a third of the samples collected (10 out of 29 samples) in 2022 and 2023. Of the detections, only five samples from three wells (LAC 8DL, LSW 25DL, and LSW030DL) were above the 5 microgram per liter ($\mu\text{g/L}$) MCL. The LUC boundary well (LSW032DL) that was sampled for PCE was non-detect. All KSZ monitoring wells were below the MCL of 5 $\mu\text{g/L}$. Concentrations at KSZ well LAC 8DL continue to decline (Appendix C, page C-3) and did not exceed the KSZCL (90 $\mu\text{g/L}$); however, concentrations in 2023 increased to above the MCL to 5.43 $\mu\text{g/L}$ from the 2022 concentration of 1.95 $\mu\text{g/L}$. This is likely due to the increased water elevations mobilizing residual contamination in the vadose zone. The other two KSZ monitoring wells (LSB 4 and LDB 3) were non-detect or below the MCL for PCE during both years.

The overall maximum PCE concentration at LASG OU was 68.4 µg/L during 2022 at station LSW 25DL, which is located downgradient of the source area. Concentrations increased slightly at LSW 25DL, but decreased in 2023 to 61.6 µg/L (Appendix C, page C-10). The observed concentrations of PCE in this well exhibit no apparent decrease or increase in trend since monitoring began. Concentrations at well LSW030DL also increased slightly in 2022 and decreased in 2023, but concentrations are less than historical levels. The PCE trend in this well has shown a decrease even though the last result spiked higher than previously observed. Station LAW 2C, located upgradient of LSW 25DL, continued to be non-detect during 2022 and 2023. Station LSW026DL on the western edge of the PCE plume continued a downward trend below MCLs. Station LSW029DL, which is the westernmost well that is monitoring the PCE plume, did not detect PCE during 2022 or 2023. In the future, if PCE concentrations at well LSW026DL become higher than concentrations at LSW 25DL and LSW030DL, an additional surface water sample location in L Lake will be collected at the powerline road crossing located south of station LSW026DL. As of this report period, concentrations at LSW 25DL continue to be greater and concentrations at LSW026DL are still below MCLs; therefore, no additional surface water samples will be collected. Figure 10 shows the extent of the PCE plumes with the 4Q2009 plumes for comparison. Results in 2022 and 2023 have remained constant or decreased from previous year's results (Appendix C).

Modeling predicted that the maximum discharge of PCE into L Lake would have occurred around 2014 to 2016 (WSRC 2004). To date, all surface water samples have been non-detect, with the exception of only one sample with detection below 1 µg/L (SC24 in 2010). PCE was not detected in surface water during 2022 or 2023. Concentrations remain far below the expected maximum discharge concentration for PCE (~150 µg/L for 2018/2019) as plotted in the Modeling Report (WSRC 2004) (Figure 11). With concentrations not greatly increasing in the southwest plume, a significant increase in surface water PCE concentration is not expected.

4.3.3 *Trichloroethylene (TCE)*

TCE was detected in only six (6) of 31 samples, but all were below the 5 µg/L MCL. These detections are from stations LAC 8DL, LSW 25DL, and LSW030DL. LAC 8DL is a KSZ monitoring well and continued an overall downward trend below the TCE 5 µg/L MCL; however concentrations did increase in 2023. LAC 8DL had a maximum concentration of 1.49 µg/L during

2023, and also did not exceed the KSZCL (31.5 µg/L). TCE had the highest concentration in the southwest plume at well LSW030DL with a maximum concentration of 3.56 µg/L in 2022. TCE was not detected at the LUC boundary well, LSW032DL. Results in 2022 and 2023 have remained consistent with results from the previous six years (Appendix C).

Modeling predicted that the maximum discharge of TCE into L Lake would have occurred around 2014 to 2016 (WSRC 2004). TCE was not detected in surface water during 2022 or 2023. To date, all surface water samples have been non-detect or below the MCL for TCE and concentrations remain below the predicted maximum discharge concentration for TCE (~30 µg/L for 2022/2023) as plotted in the Modeling Report (WSRC 2004) (Figure 11). Based on monitoring well TCE concentrations that are below the MCL, it is expected that surface water TCE concentration will remain non-detect.

5.0 CONCLUSIONS

Sampling results of all wells in the monitoring network show the distribution of contamination is consistent with previous observations. The increased or near average rainfall over the last seven years has kept water elevations relatively constant, and the potentiometric surfaces and groundwater flow paths have remained consistent with previous years. Overall, contaminant levels of tritium, PCE, and TCE are decreasing without increasing flux to L Lake as predicted by earlier modeling (WSRC 2004). All three contaminant plumes (tritium, PCE, and TCE) have decreased in size compared to previous years. TCE was not detected above MCLs in 2022 or 2023. Tritium was the only contaminant detected at any of the LUC boundary wells, but at low levels below the MCL. All of the contaminant levels for the KSZ monitoring wells were below their respective KSZCLs.

With the overall decreasing trends in groundwater and surface water contaminant concentrations, the decreasing size of the plumes, and a decreasing trend in contaminant levels discharging from L Lake, the MNA/LUCs remedy is functioning as designed and is effective in reducing the groundwater contaminants to levels below MCLs and preventing human exposure to groundwater above MCLs. The remedy remains protective of downstream surface water in Steel Creek as surface water discharging from L Lake (SC 27) is not above MCLs and continues a decreasing trend.

6.0 REFERENCES

Aadland, Rolf K., J. A. Gellici, and P. A. Thayer, 1995. *Hydrogeologic Framework of West-Central South Carolina*, Water Resources Division Report 5, South Carolina Department of Natural Resources, Columbia, SC 29201

FFA, 1993. *Federal Facility Agreement for the Savannah River Site*, Administrative Docket No. 89-05-FF (Effective Date: August 16, 1993)

SRNS, 2012. *Biennial Effectiveness Monitoring Report (EMR) for Monitored Natural Attenuation (MNA) at the L-Area Southern Groundwater (LASG) Operable Unit (OU) (U), 2010 through 2011*, SRNS-RP-2012-00169, Rev. 0, June, Savannah River Nuclear Solutions, Savannah River Site, Aiken, SC

SRNS, 2013. *Addendum to the Monitored Natural Attenuation Effectiveness Monitoring Plan for the L-Area Southern Groundwater Operable Unit (NBN) (U)*, SRNS-RP-2012-00857, Rev. 1, May, Savannah River Nuclear Solutions, Savannah River Site, Aiken, SC

SRNS, 2014. *Biennial Effectiveness Monitoring Report (Sampling Summary) for the Monitored Natural Attenuation at the L-Area Southern Groundwater Operable Unit, 2012 through 2013*, ACP-14-169, June 25, 2014, Savannah River Nuclear Solutions, Savannah River Site, Aiken, SC

SRNS, 2018. *Biennial Effectiveness Monitoring Report (Sampling Summary) for the Monitored Natural Attenuation at the L-Area Southern Groundwater Operable Unit, 2016 through 2017*, IACD-18-156, June 20, 2018, Savannah River Nuclear Solutions, Savannah River Site, Aiken, SC

SRNS, 2022. *Biennial Effectiveness Monitoring Report (Sampling Summary) for the Monitored Natural Attenuation at the L-Area Southern Groundwater Operable Unit, 2020 through 2021*, IACD-22-172, August 25, 2022, Savannah River Nuclear Solutions, Savannah River Site, Aiken, SC

WSRC, 2002. *L-Area Southern Groundwater Hydrogeologic Conceptual Model (U)*, WSRC-RP-2002-4179, Rev. 1, December, Washington Savannah River Company, Savannah River Site, Aiken, SC

WSRC, 2004. *Groundwater Flow and Transport Model of the L-Area Southern Groundwater Operable Unit (U)*, WSRC-RP-2004-4082, Rev. 0, June, Washington Savannah River Company, Savannah River Site, Aiken SC

WSRC, 2005. *Resource Conservation and Recovery Act Facility Investigation/Remedial Investigation for the L-Area Southern Groundwater Operable Unit (U)*, WSRC-RP-2003-4171, Rev. 1.1, July, Washington Savannah River Company, Savannah River Site, Aiken, SC

WSRC, 2007. *Record of Decision Remedial Alternative Selection for the L-Area Southern Groundwater Operable Unit (NBN) (U)*, WSRC-RP-2006-4052, Rev. 1.1, March, Washington Savannah River Company, Savannah River Site, Aiken, SC

Table 1. LASG OU MNA Monitoring Network

Count	Station	Aquifer	Plume	Station Use	Lab Analyses	Odd Years Sampling	Even Years Sampling	Ground Elevation (ft amsl)	Screen Zone (ft amsl)	
									Top	Bottom
1	LAC 8DL	UAZ	Southeast Plume	KSZ Monitoring Well	Tritium, VOCs	X	X	234	190.4	180.4
2	LAW 2C	UAZ	Southwest Plume	Monitoring Well	Tritium, VOCs	X	If VOCs are detected in Previous Odd Year	222.2	191.2	171.2
3	LDB 3	UAZ	Southwest Plume	KSZ Monitoring Well	Tritium, VOCs	X	X	251.2	219.3	199.3
4	LSB 4	UAZ	Southeast Plume	KSZ Monitoring Well	Tritium, VOCs	X	X	229.5	221.5	191.5
5	LSP 8DU	UAZ	Southwest Plume	Monitoring Well	Tritium, VOCs	X	If VOCs are detected in Previous Odd Year	247.14	210.04	195.04
6	LSW 2DL	UAZ	Southeast Plume	Monitoring Well	Tritium, VOCs	X	If VOCs are detected in Previous Odd Year	199.63	150.29	144.63
7	LSW 8C	LAZ	Western Plume	Monitoring Well	Tritium	X		249.5	108.71	103.04
8	LSW 8DL	UAZ	Western Plume	Monitoring Well	Tritium	X		249.5	164.5	158.83
9	LSW 9C	LAZ	Western Plume	Monitoring Well	Tritium	X		222.48	89.08	83.38
10	LSW 9DL	UAZ	Western Plume	Monitoring Well	Tritium	X		222.48	129.78	124.08
11	LSW 12C	LAZ	Western Plume	LUC Boundary Monitoring Well	Tritium	X		233.62	92.61	86.91
12	LSW 12DL	UAZ	Western Plume	LUC Boundary Monitoring Well	Tritium	X		233.62	148.62	142.92
13	LSW 14C	LAZ	Western Plume	Monitoring Well	Tritium	X		202.45	105.47	99.77
14	LSW 14DL	UAZ	Western Plume	Monitoring Well	Tritium	X		202.45	156.45	150.75
15	LSW 24A	GAU	Southwest Plume	Monitoring Well	Tritium, VOCs	X	If VOCs are detected in Previous Odd Year	200.04	-24.64	-29.65
16	LSW 25DL	UAZ	Southwest Plume	Monitoring Well	Tritium, VOCs	X	If VOCs are detected in Previous Odd Year	200.39	155.39	150.39
17	LSW002AR	GAU	Southeast Plume	Monitoring Well	Tritium, VOCs	X	If VOCs are detected in Previous Odd Year	198.97	8.97	3.97
18	LSW014A	GAU	Western Plume	Monitoring Well	Tritium	X		206.12	33.12	28.12
19	LSW026DL	UAZ	Southwest Plume	Monitoring Well	Tritium, VOCs	X	If VOCs are detected in Previous Odd Year	214.55	149.55	144.55
20	LSW027A	GAU	Western Plume	LUC Boundary Monitoring Well	Tritium	X		195.02	29.02	24.02
21	LSW027C	LAZ	Western Plume	LUC Boundary Monitoring Well	Tritium	X		194.78	118.28	113.28
22	LSW028C	LAZ	Western Plume	Monitoring Well	Tritium	X		200.96	90.96	85.96
23	LSW029DL	UAZ	Western Plume	Monitoring Well	Tritium, VOCs	X	If VOCs are detected in Previous Odd Year	202.34	136.84	131.84
24	LSW030DL	UAZ	Southwest Plume	Monitoring Well	Tritium, VOCs	X	If VOCs are detected in Previous Odd Year	202.55	153.55	148.55
25	LSW031DL	UAZ	Southeast Plume	Monitoring Well	Tritium, VOCs	X	If VOCs are detected in Previous Odd Year	206.58	152.58	147.58
26	LSW032DL	UAZ	Southeast Plume	LUC Boundary Monitoring Well	Tritium, VOCs	X	If VOCs are detected in Previous Odd Year	206.66	166.66	161.66
27	SC20	UAZ	Surface Water	Surface Water	Tritium, VOCs	X	X			
28	SC23	UAZ	Surface Water	Surface Water	Tritium, VOCs	X	X			
29	SC24	UAZ	Surface Water	Surface Water	Tritium, VOCs	X	X			
30	SC25	UAZ	Surface Water	Surface Water	Tritium, VOCs	X	X			
31	SC27	UAZ	Surface Water	Surface Water	Tritium, VOCs	X	X			

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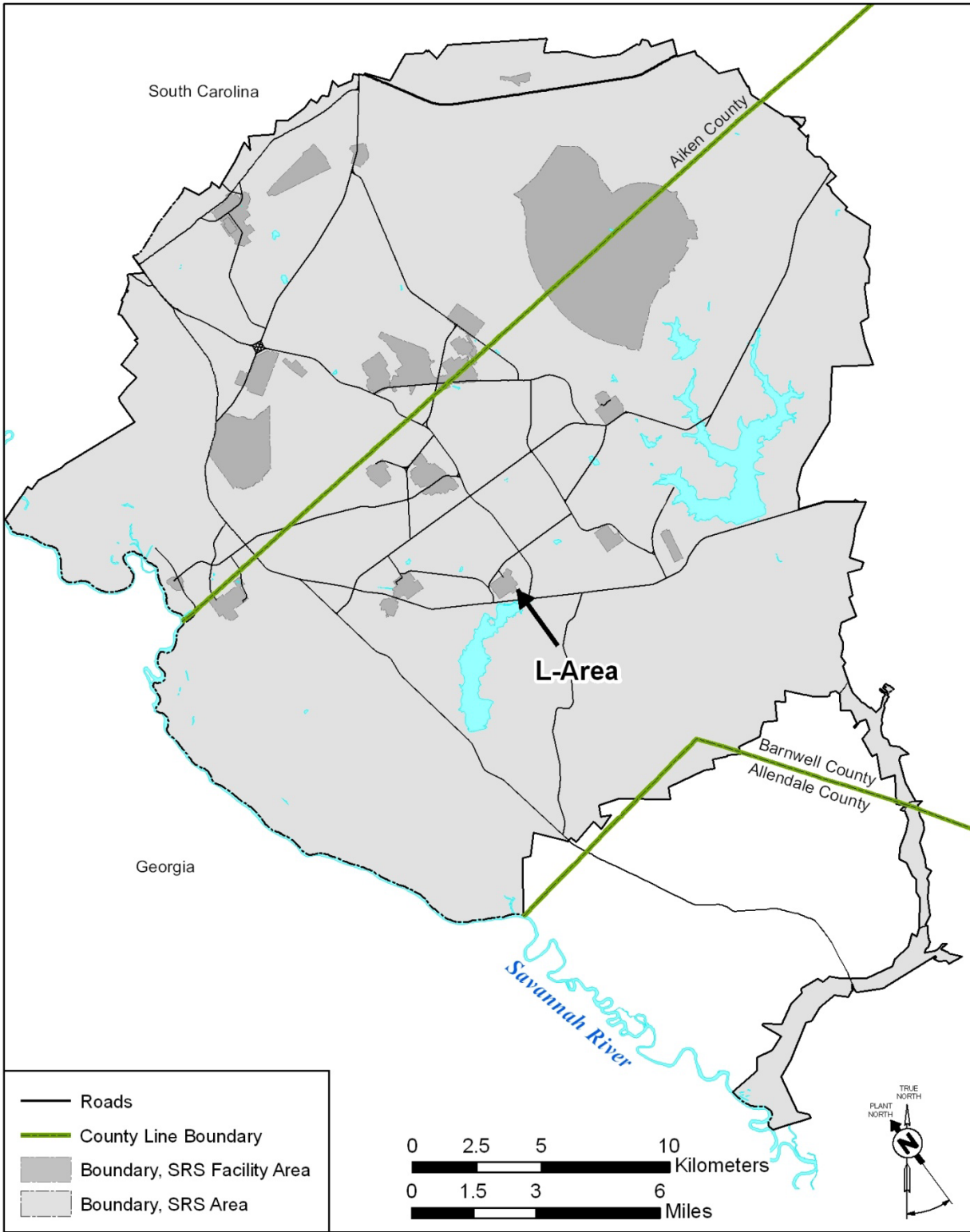


Figure 1. Location of L Area at the SRS

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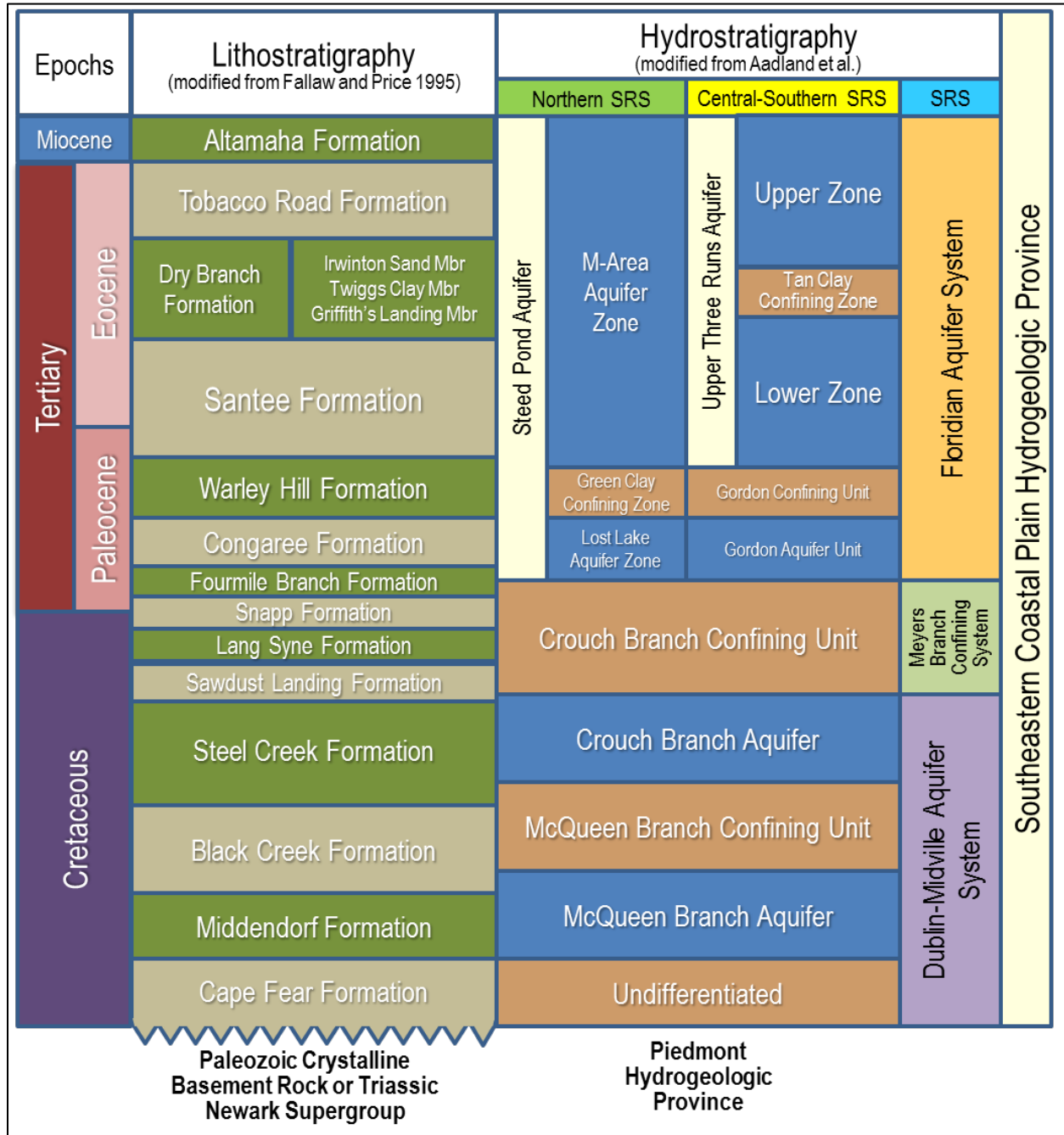


Figure 3. Lithostratigraphic and Hydrostratigraphic Units at SRS

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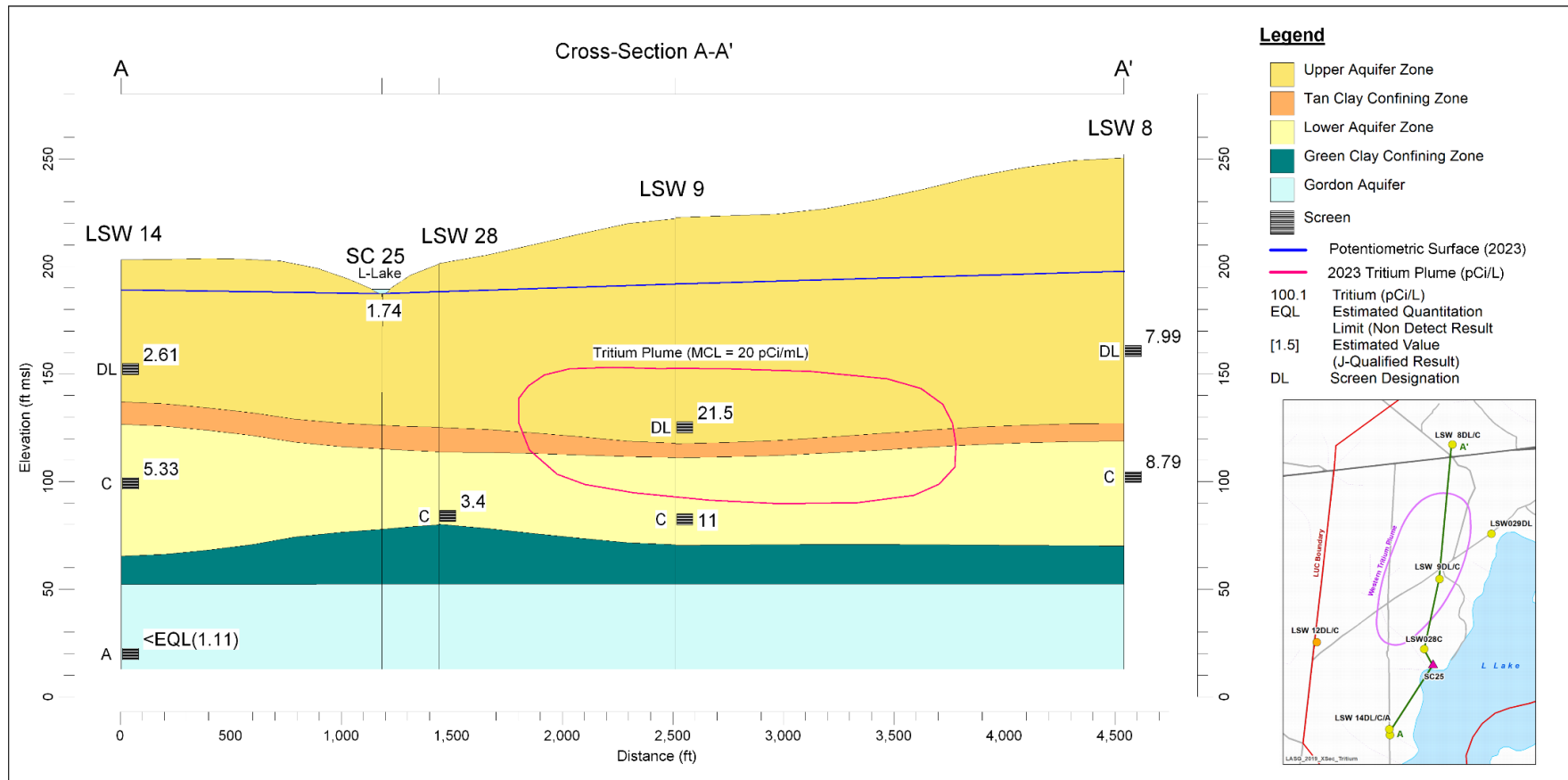


Figure 4. LASG OU Western Tritium Plume Cross Section (4Q2023)

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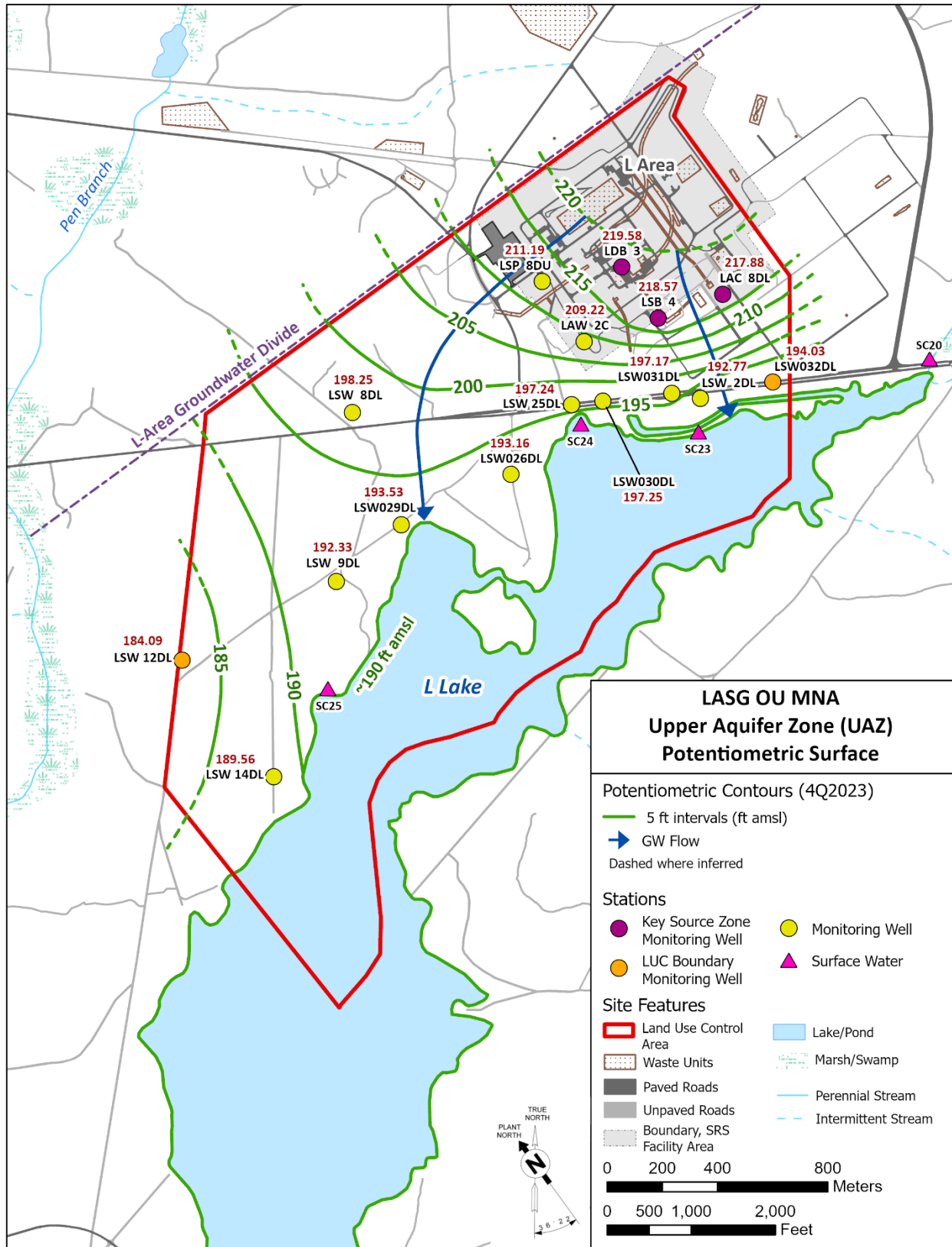


Figure 5. Potentiometric Surface of the Upper Aquifer Zone (4Q2023)

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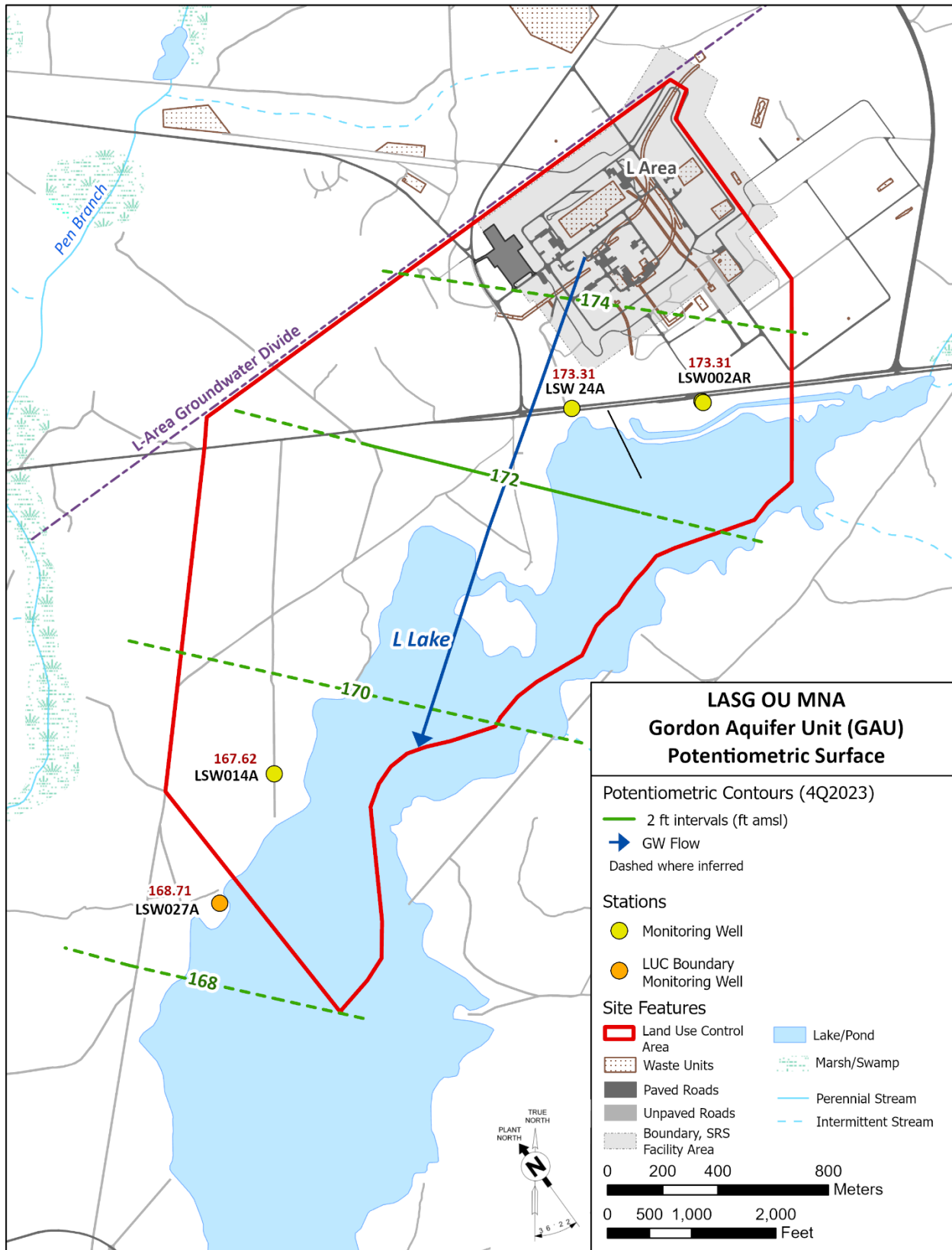


Figure 6. Potentiometric Surface of the Gordon Aquifer Unit (4Q2023)

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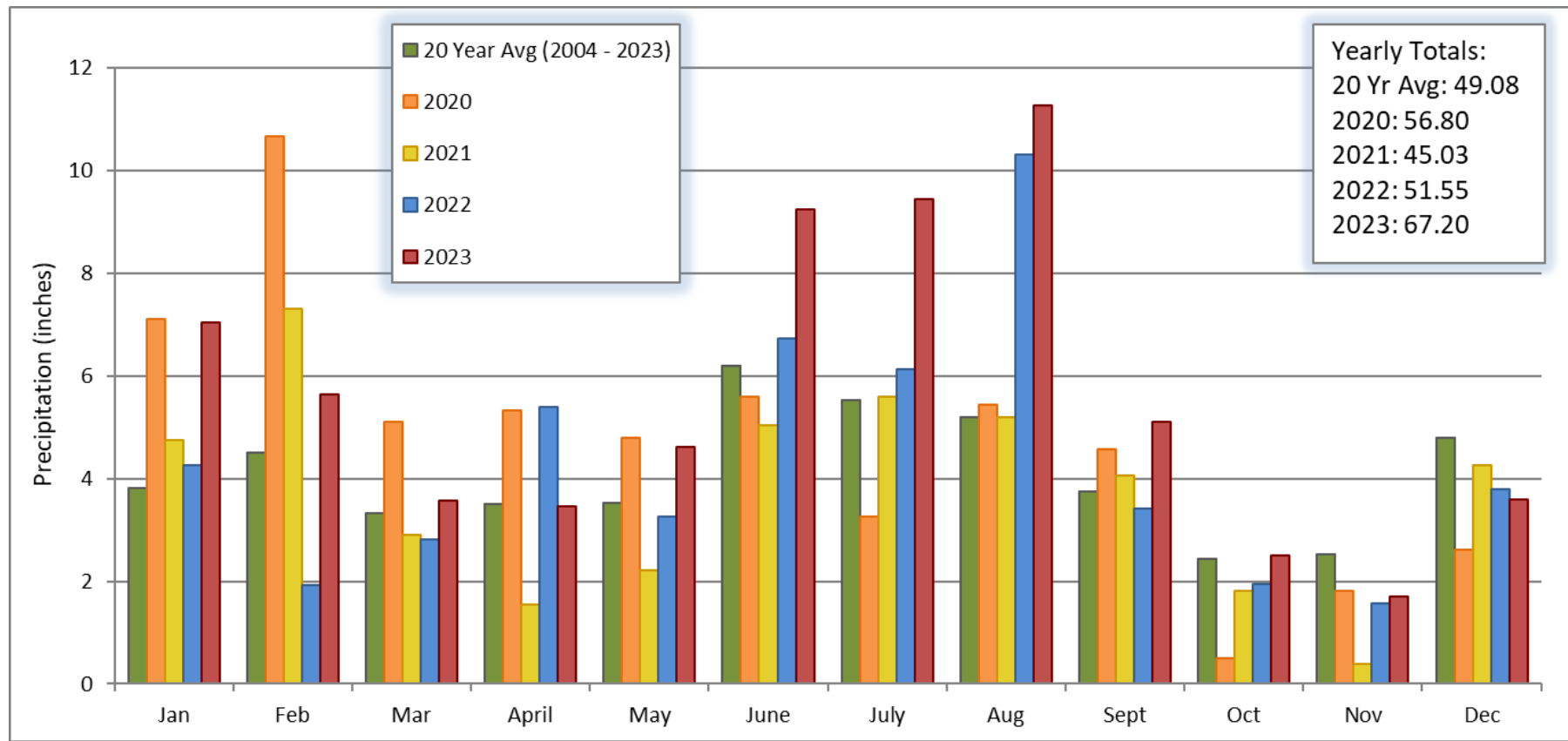


Figure 7. Monthly Rainfall Measurements During 2020, 2021, 2022, and 2023 Compared with 20-year Averages in the Vicinity of L Area

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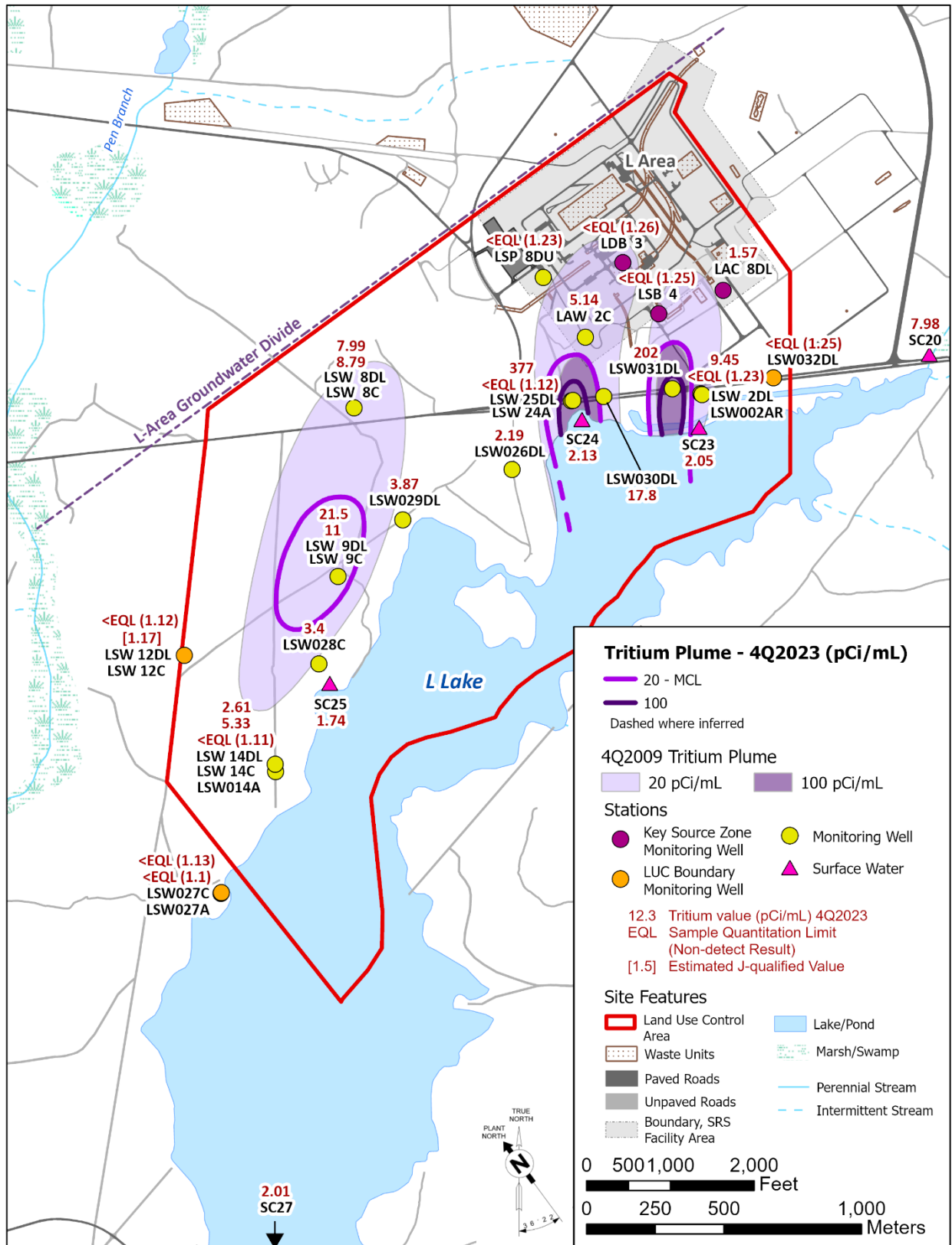


Figure 8. LASG OU Tritium Plume (4Q2023)

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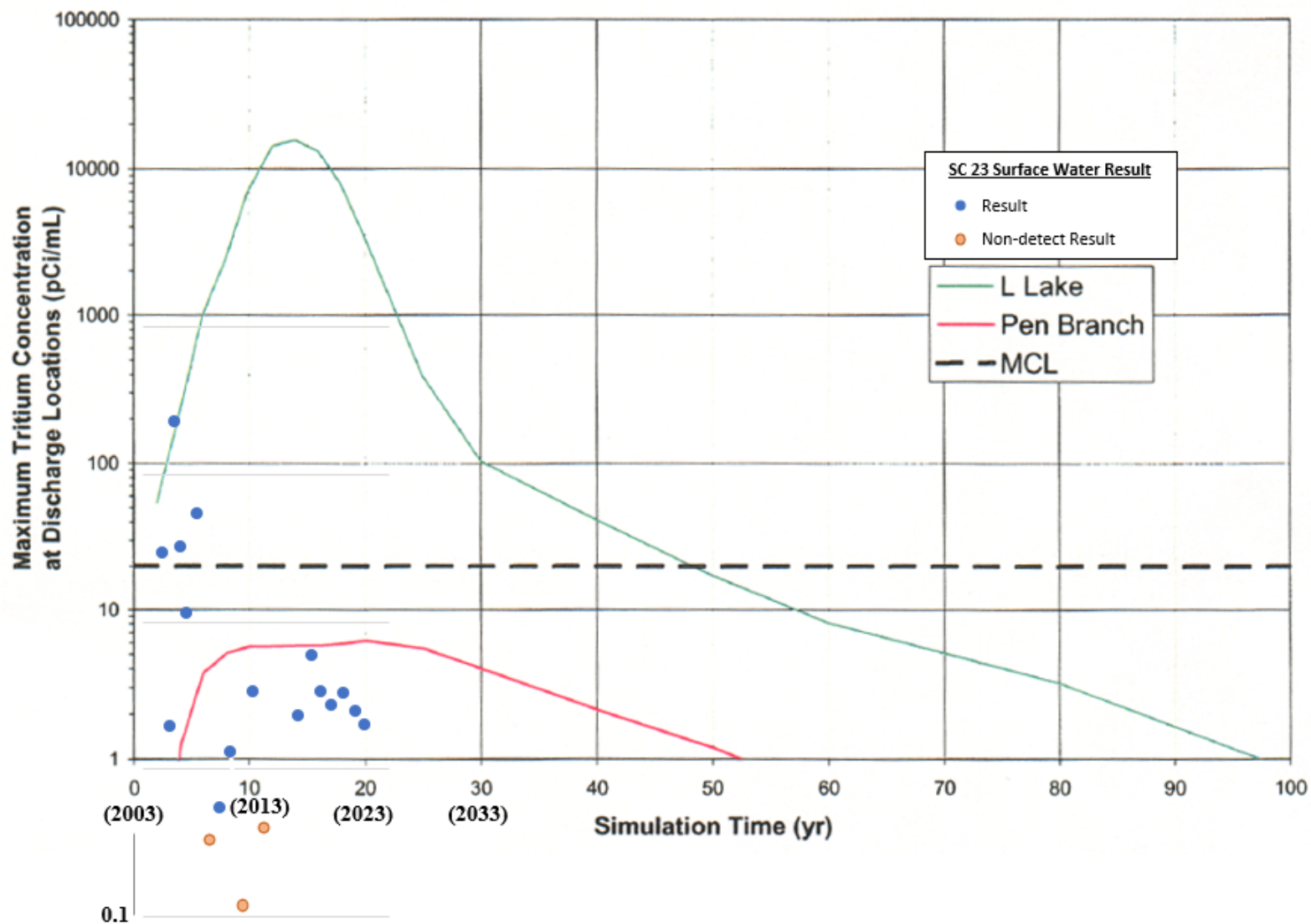


Figure 9. Modeled Maximum Concentration of Tritium at Discharge Locations with SC23 Tritium Values

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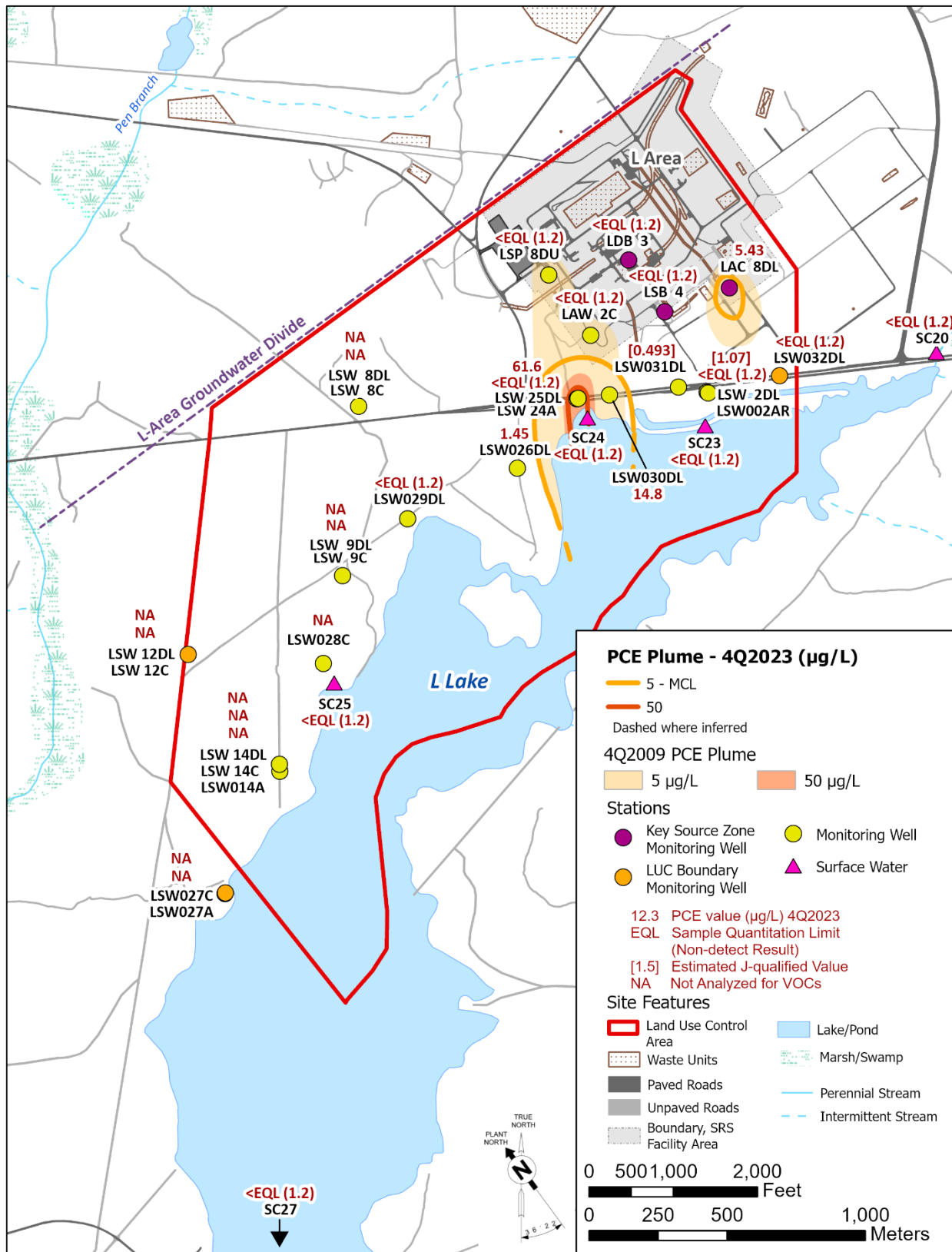
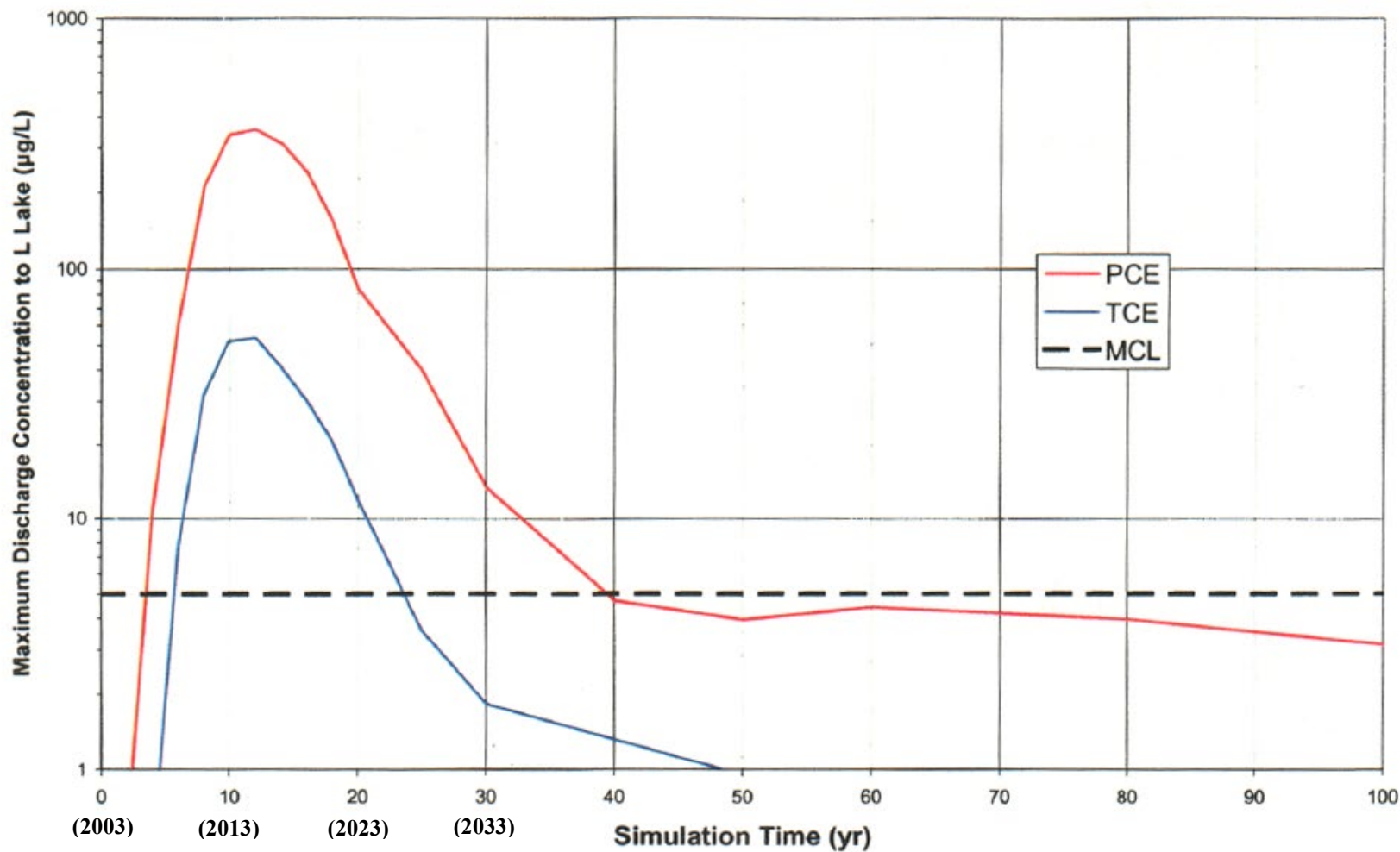


Figure 10. LASG OU PCE Plume (4Q2023)

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Note: No detections of PCE have been observed in surface water; therefore, no data is shown on the graph similar to Figure 9.

Figure 11. Modeled Maximum Concentration of VOCs at L-Lake Discharge Locations

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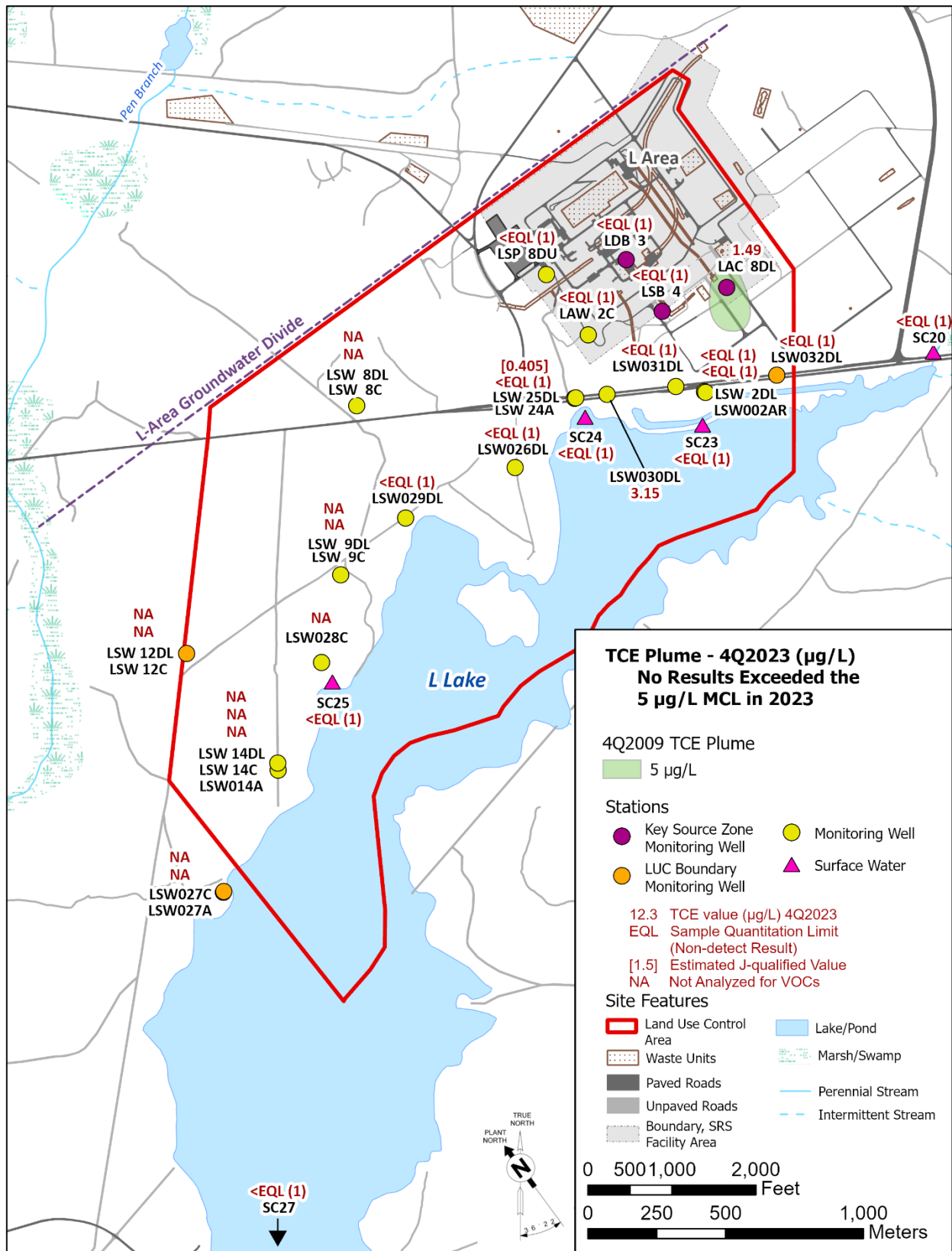


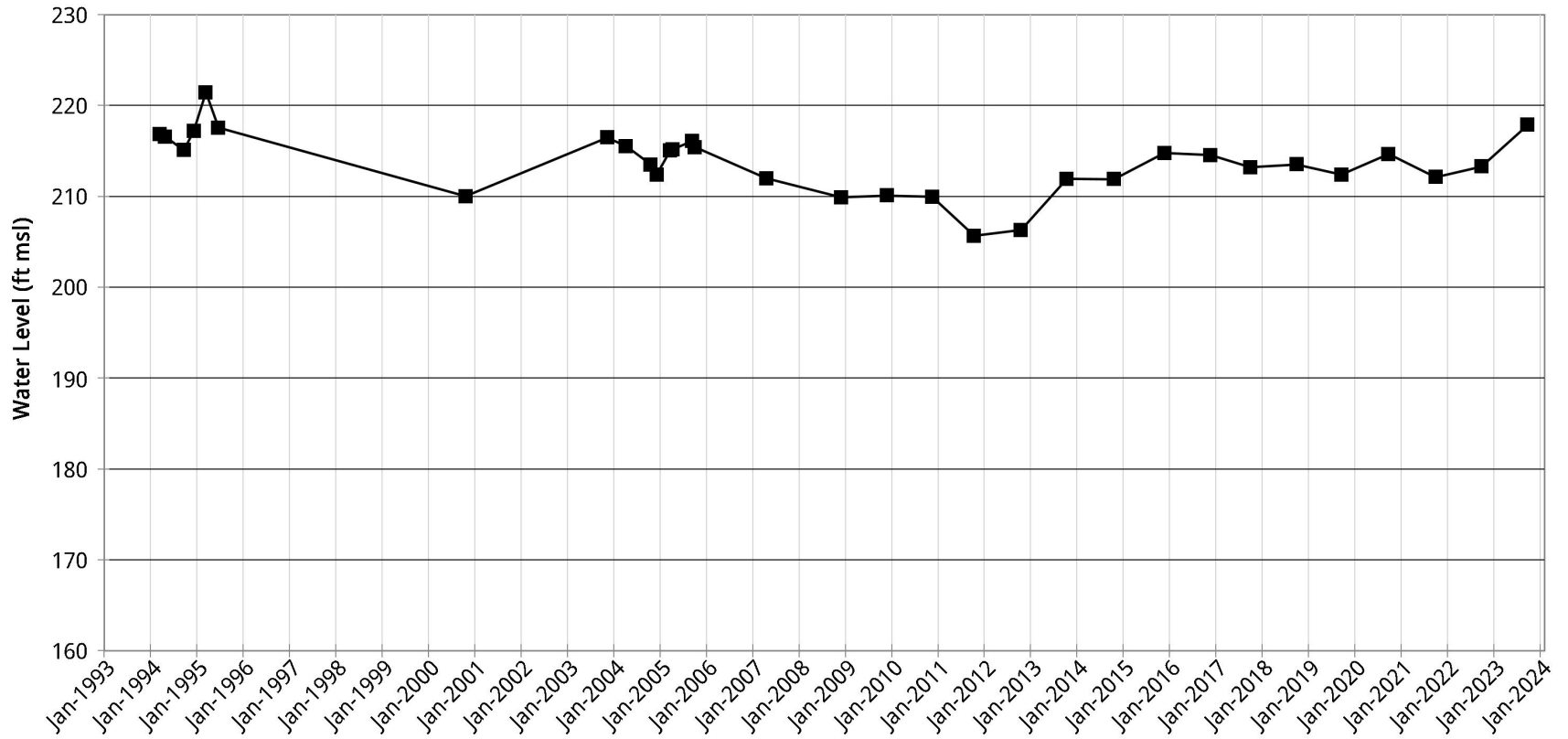
Figure 12. LASG OU TCE Plume (4Q2023)

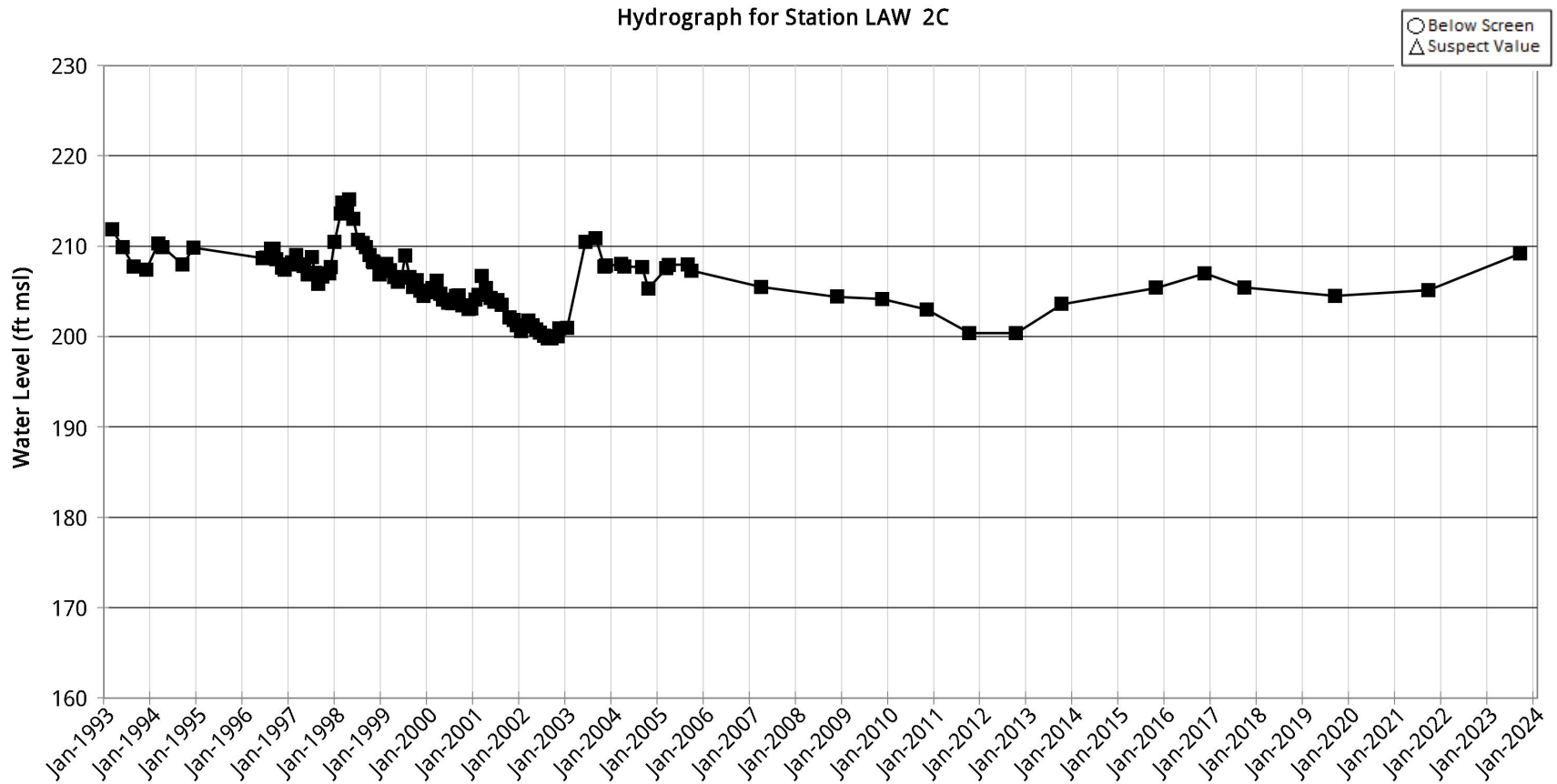
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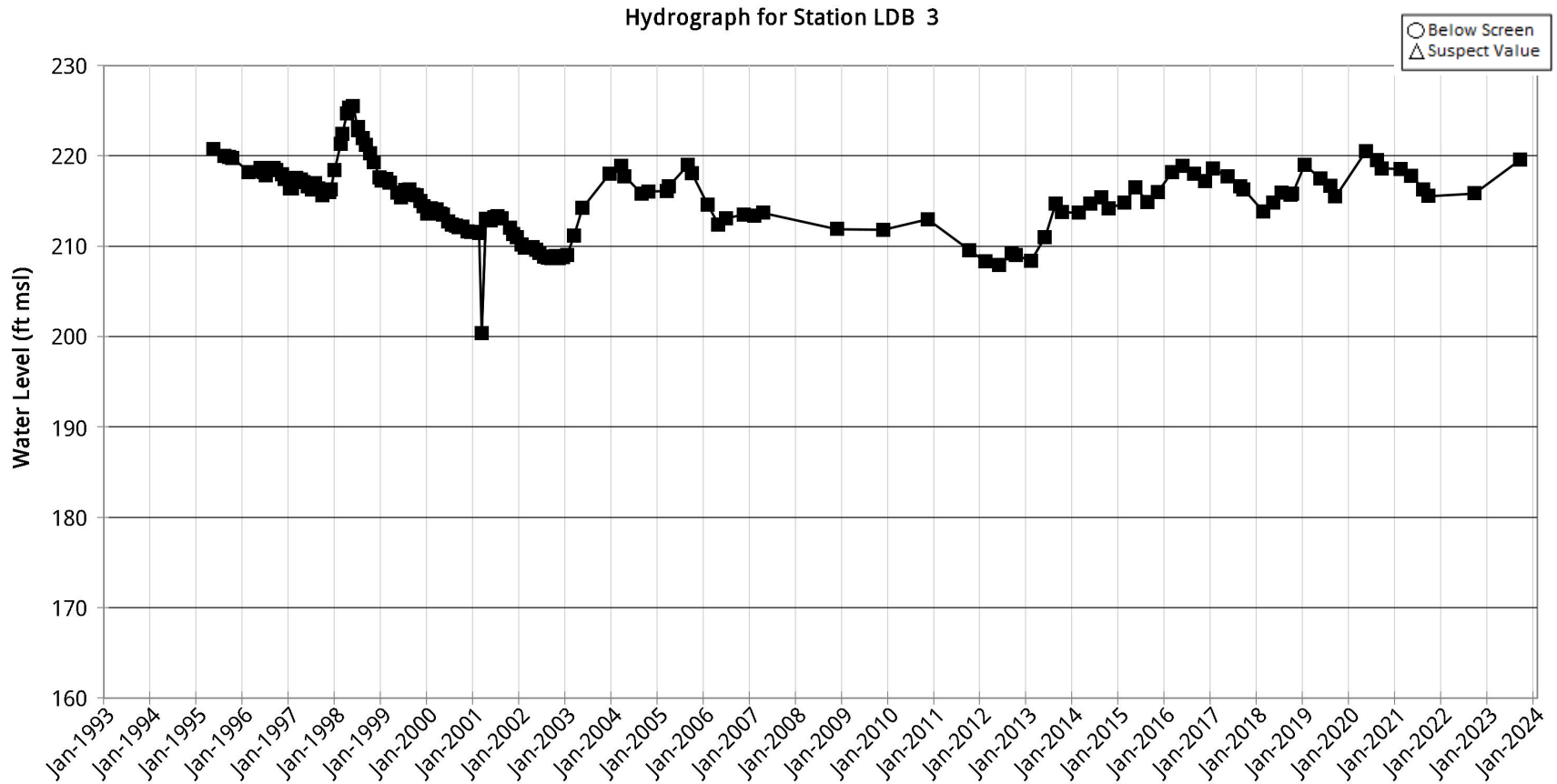
Appendix A
Hydrographs

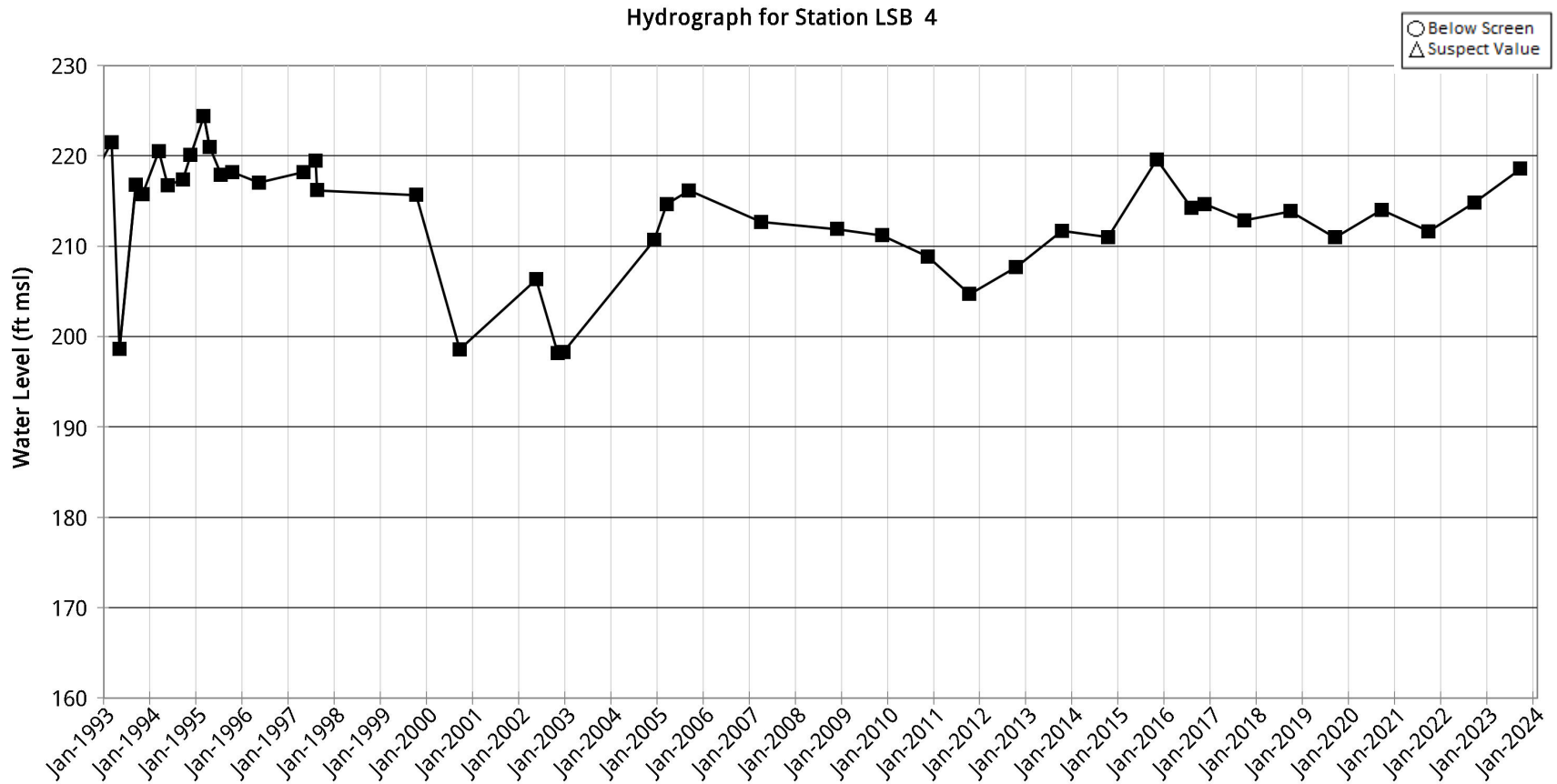
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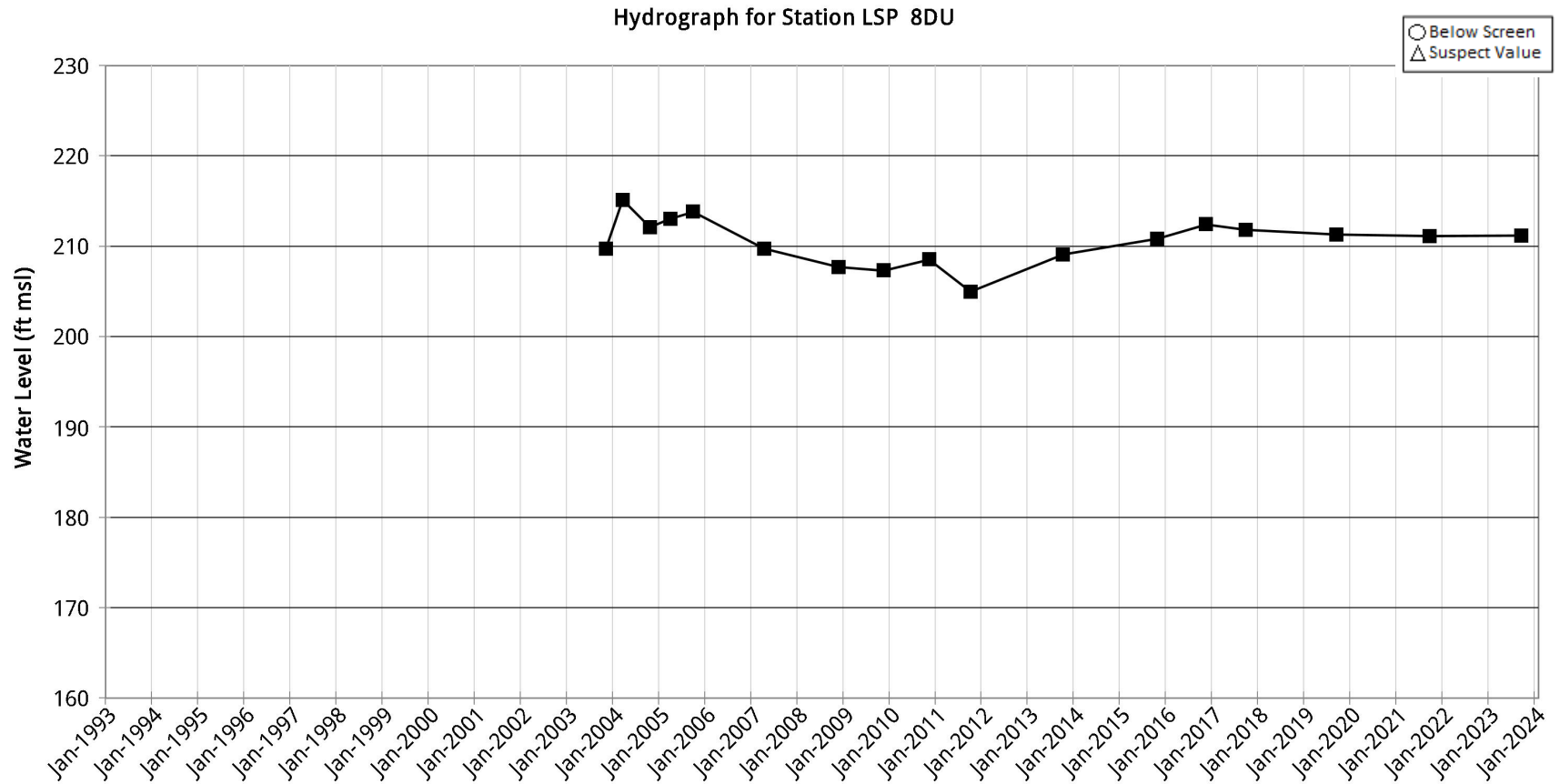
Hydrograph for Station LAC 8DL

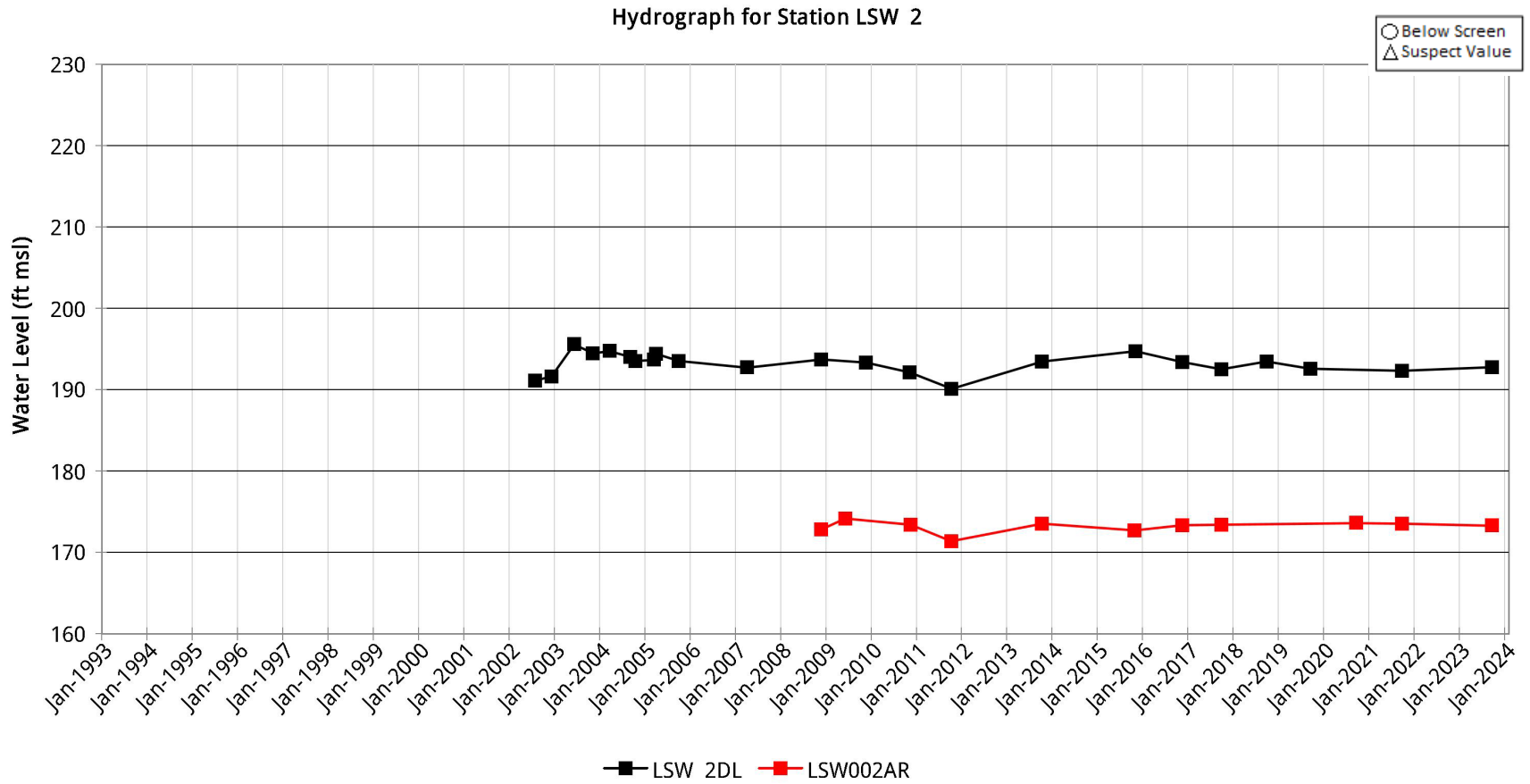


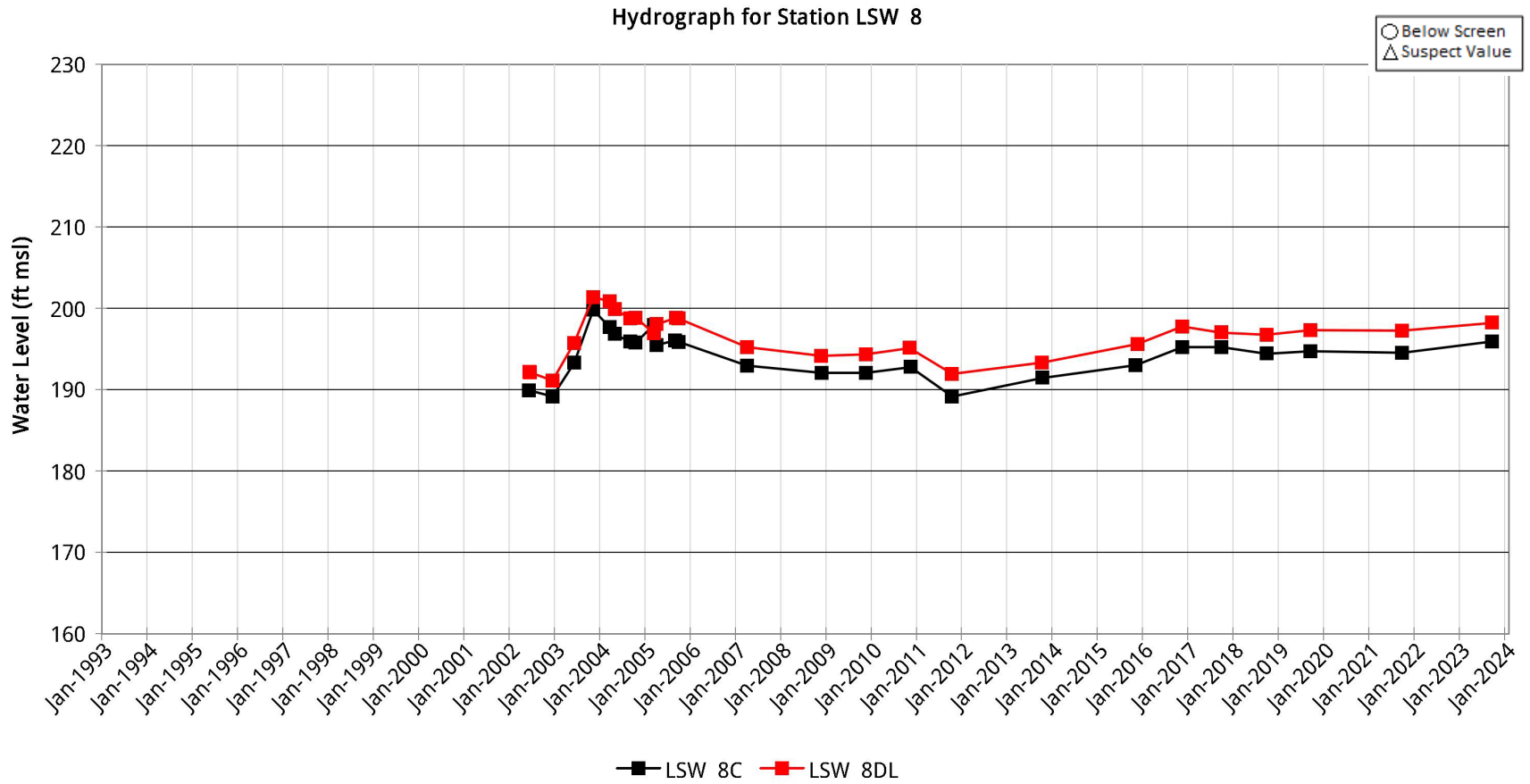


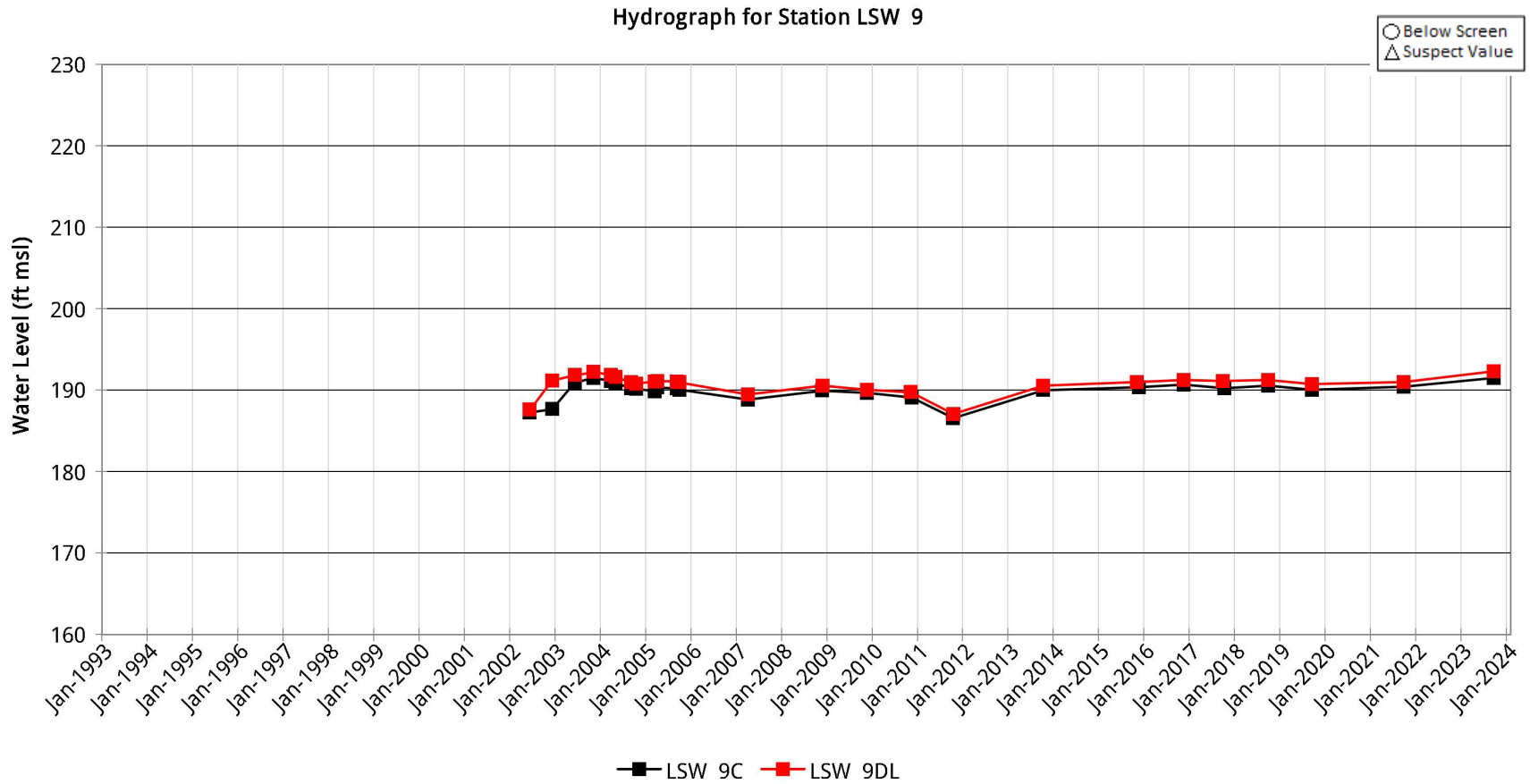


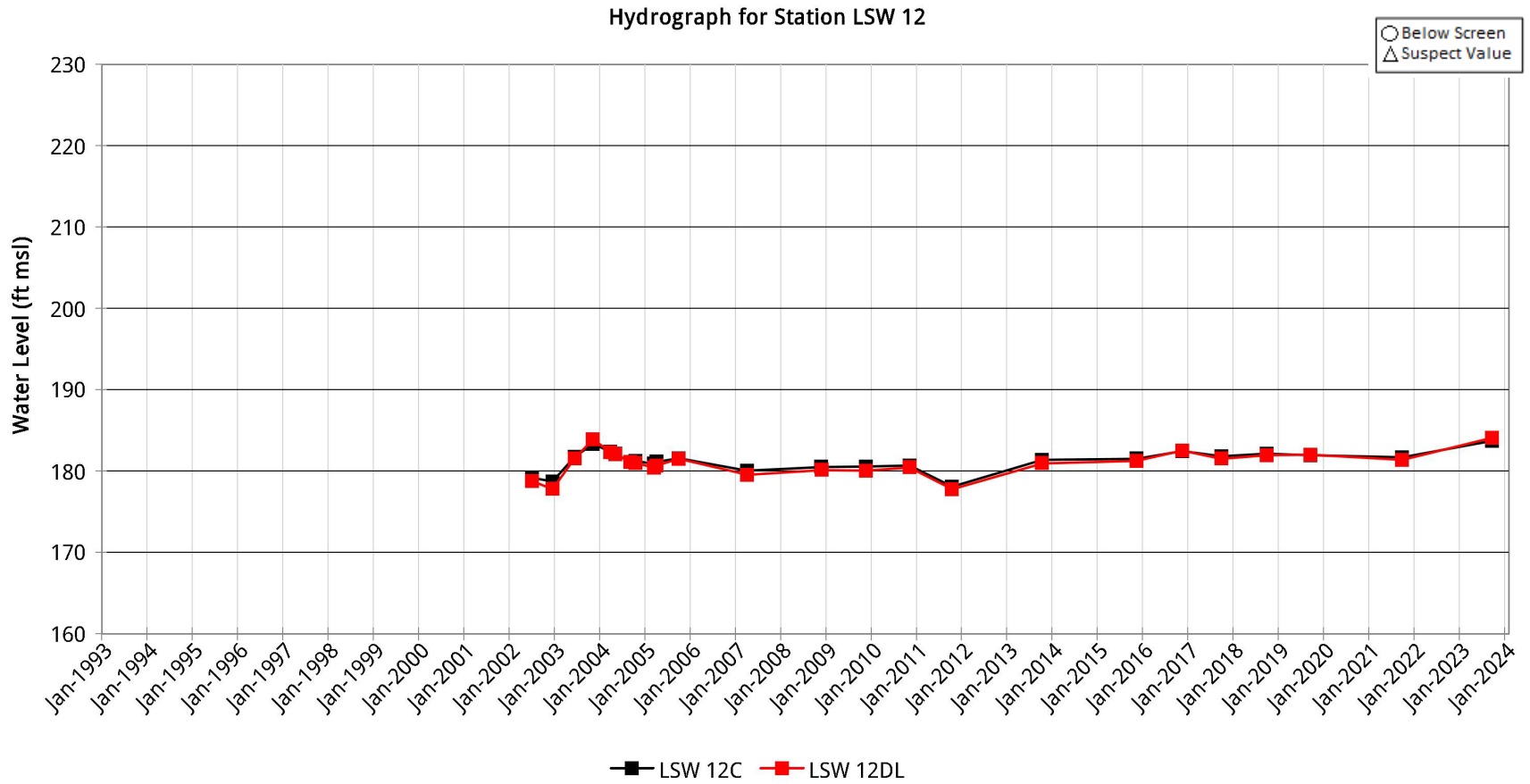


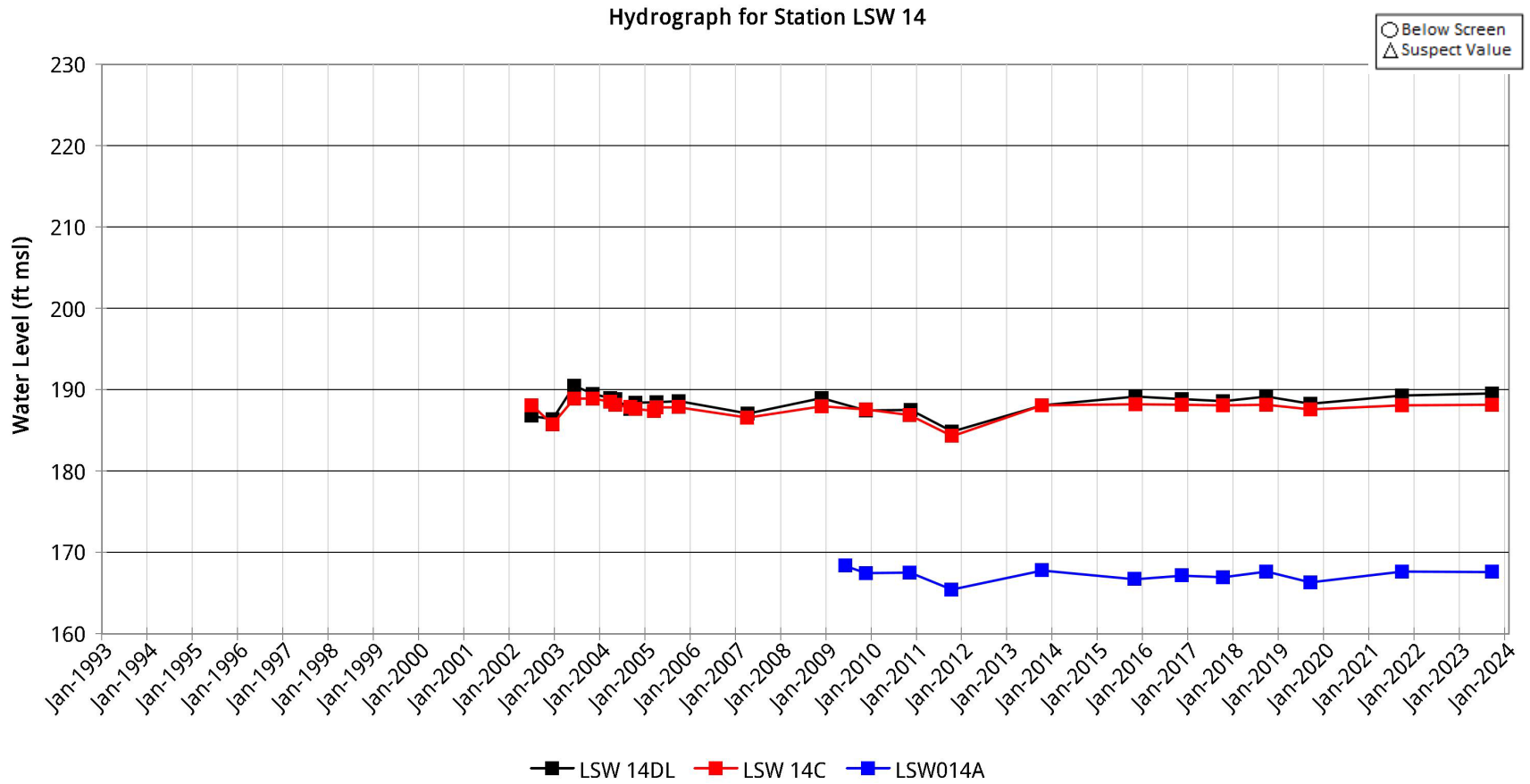


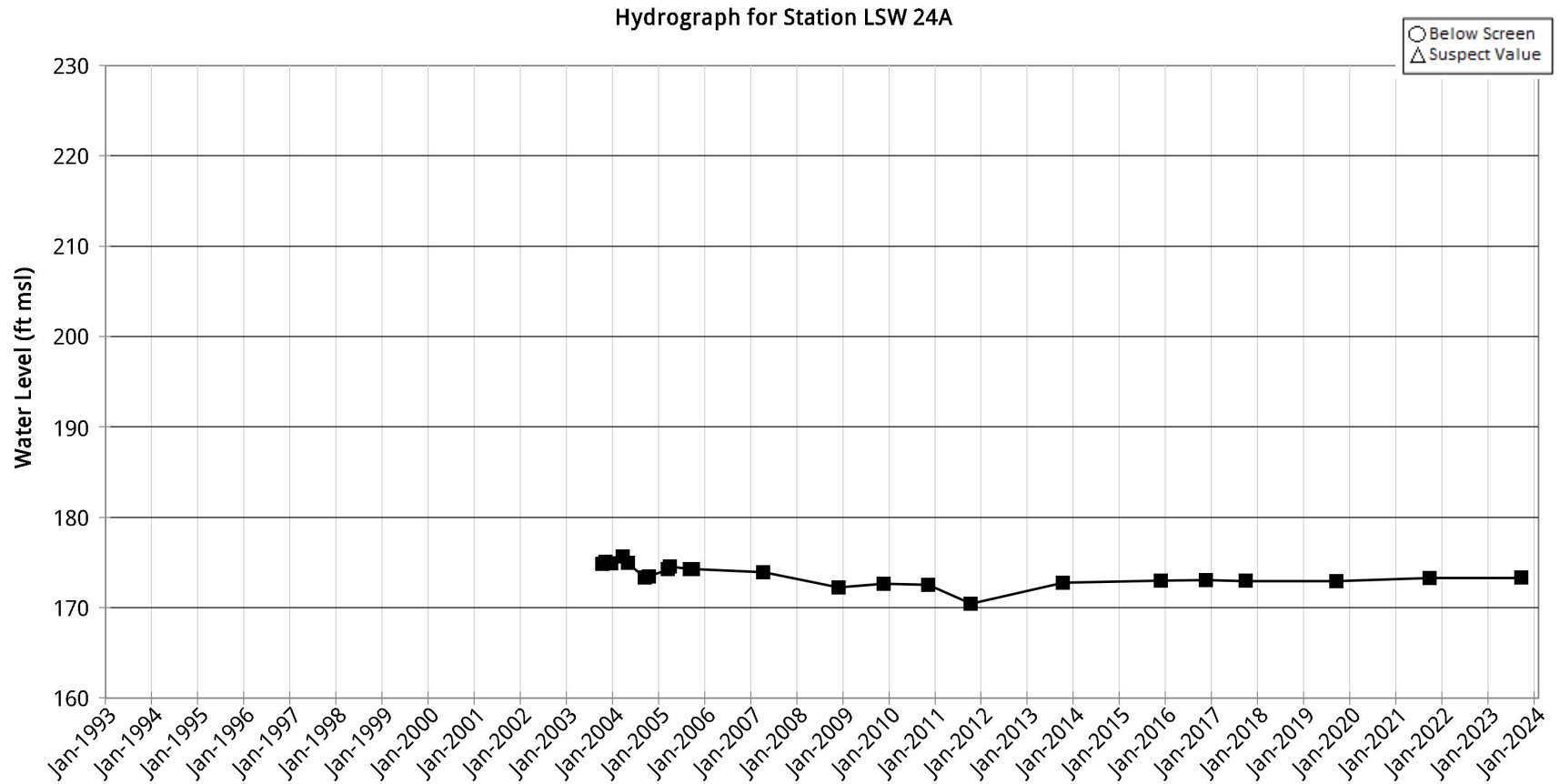


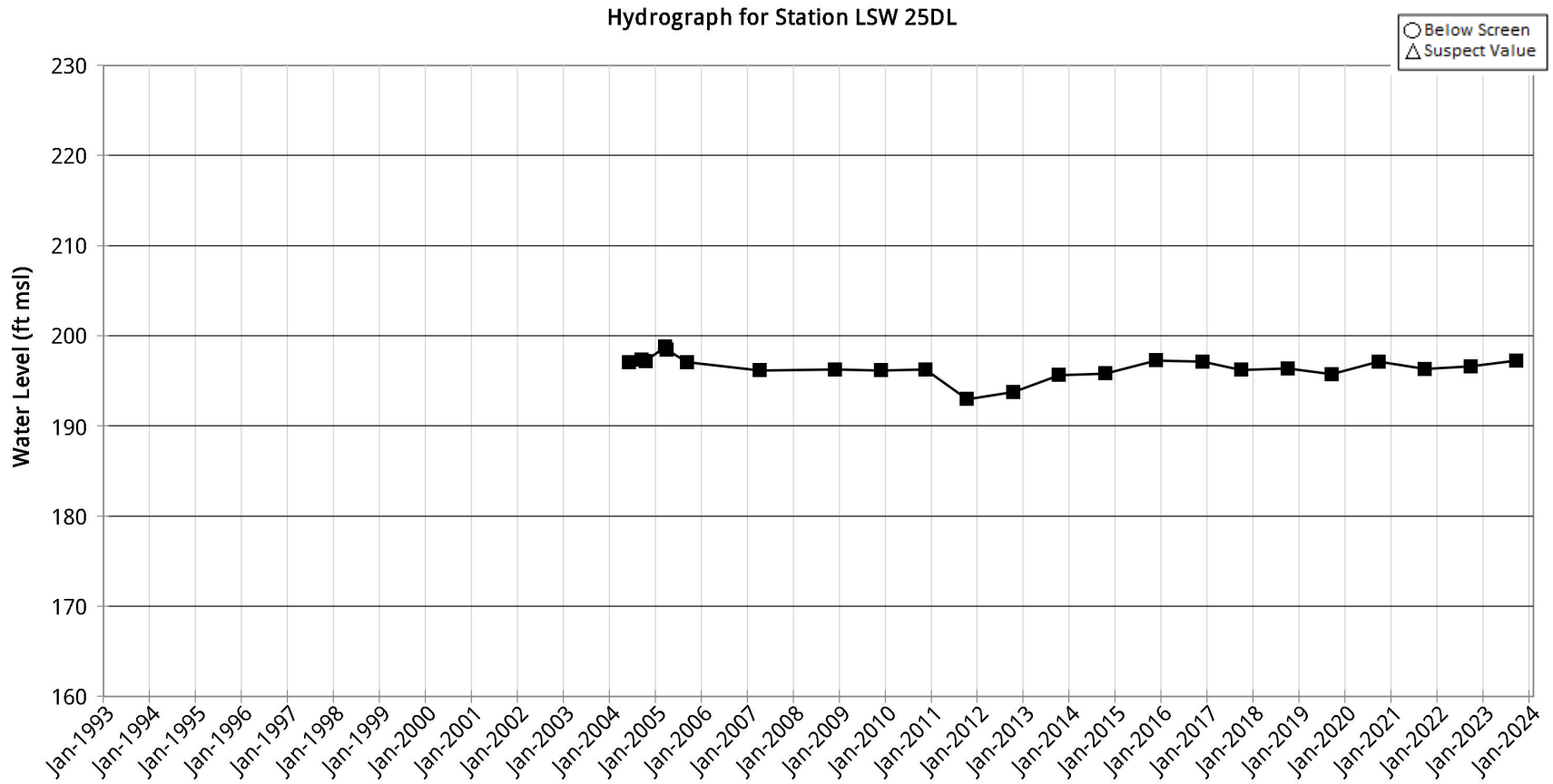


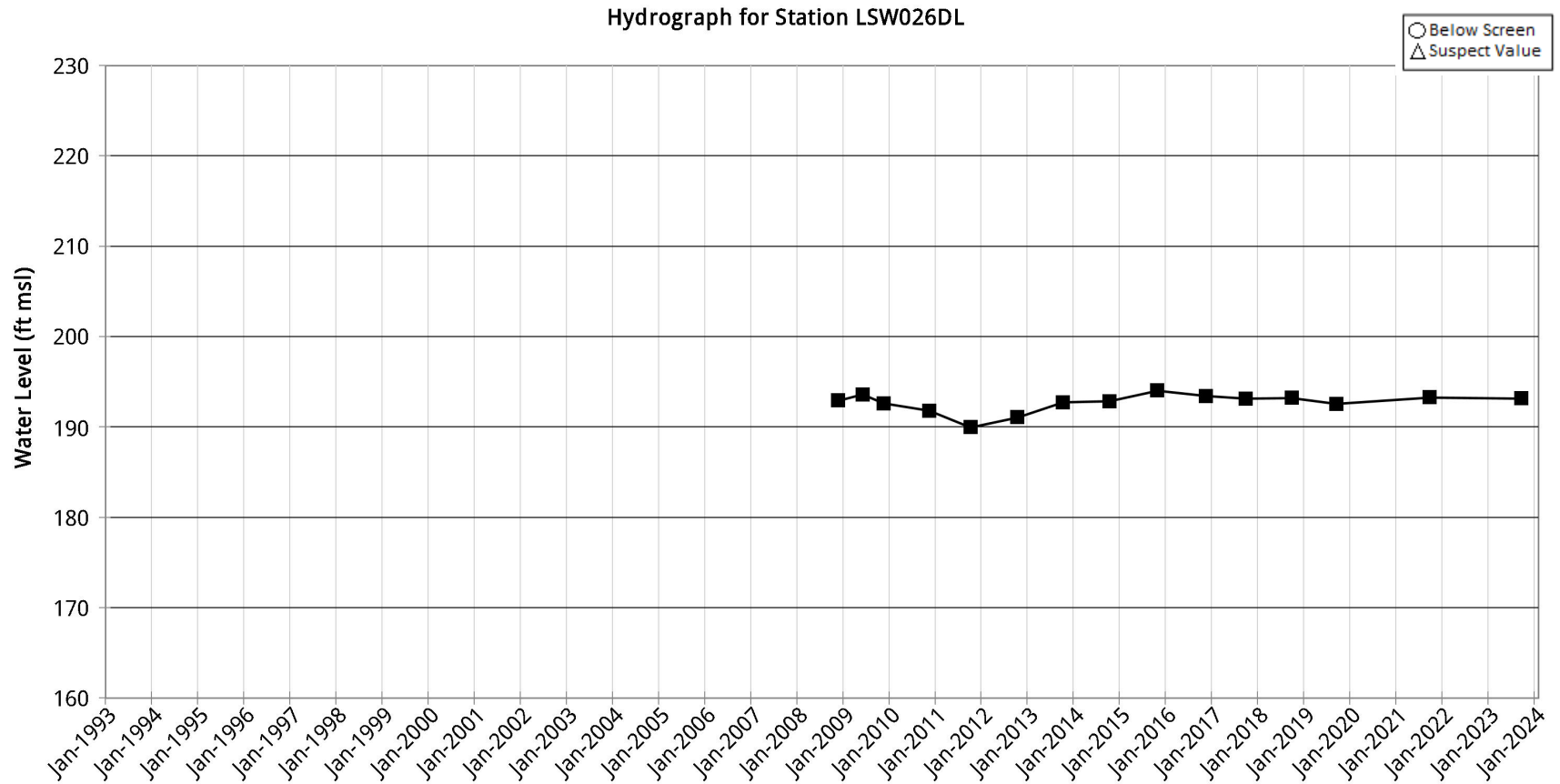


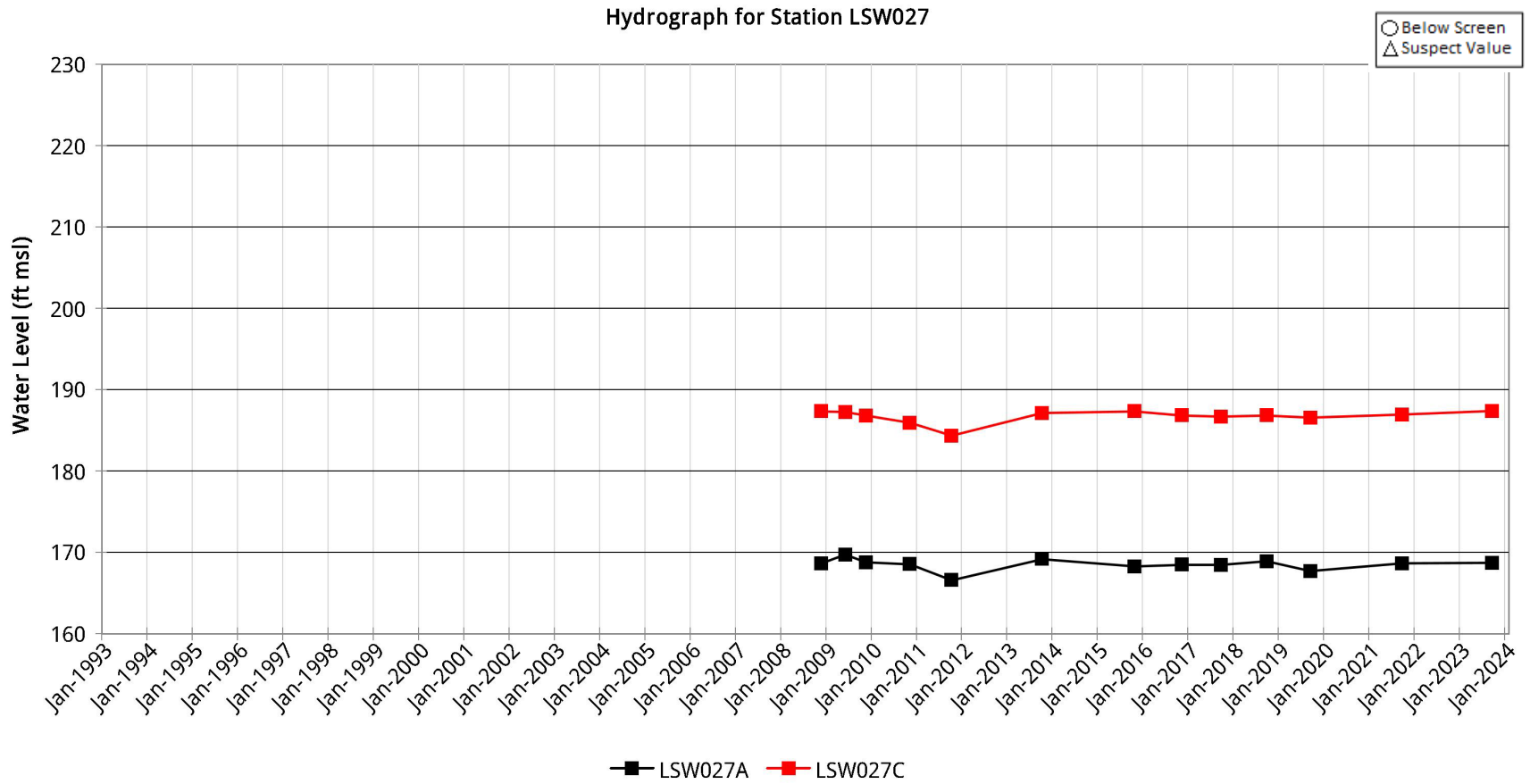


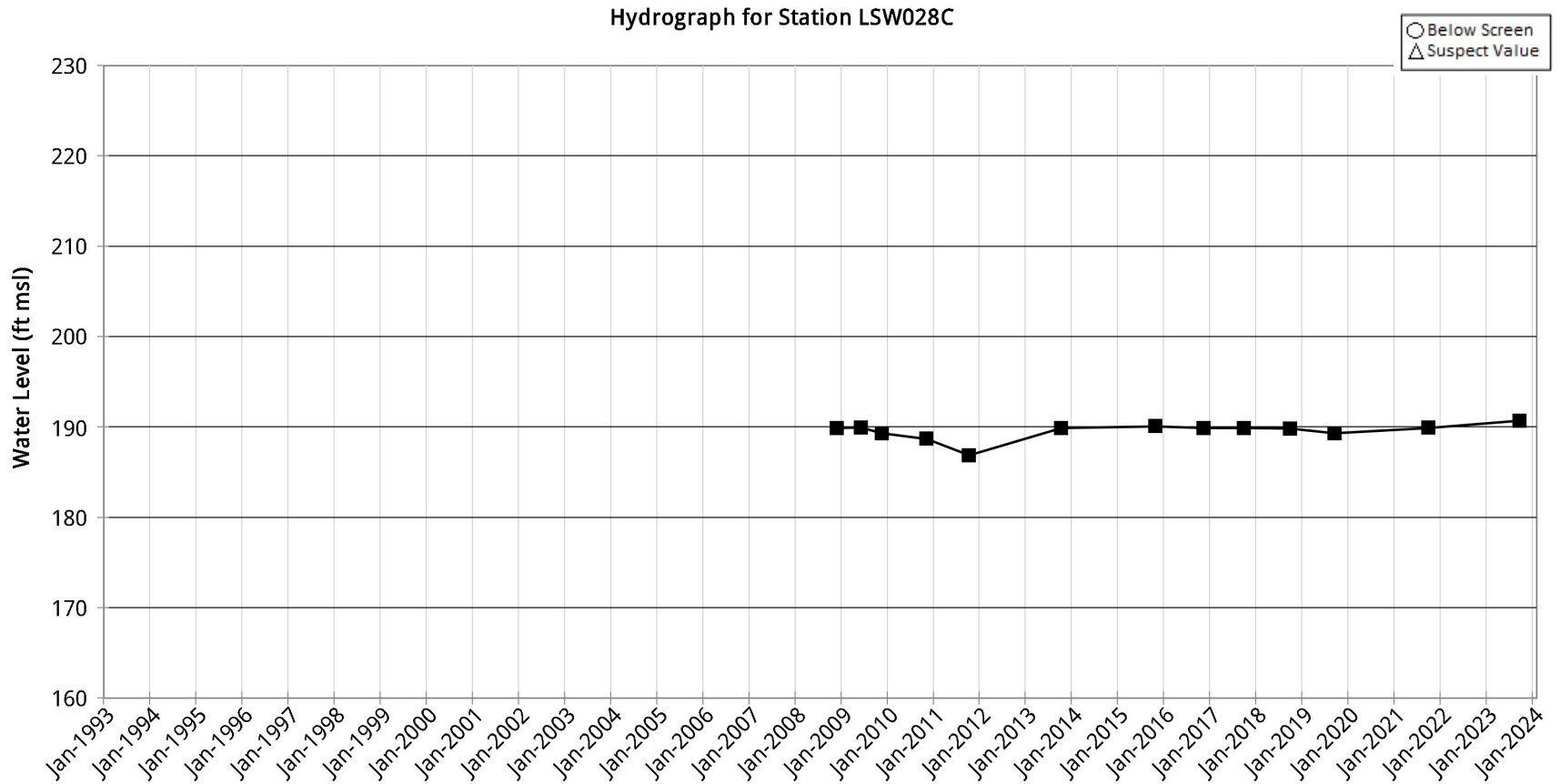




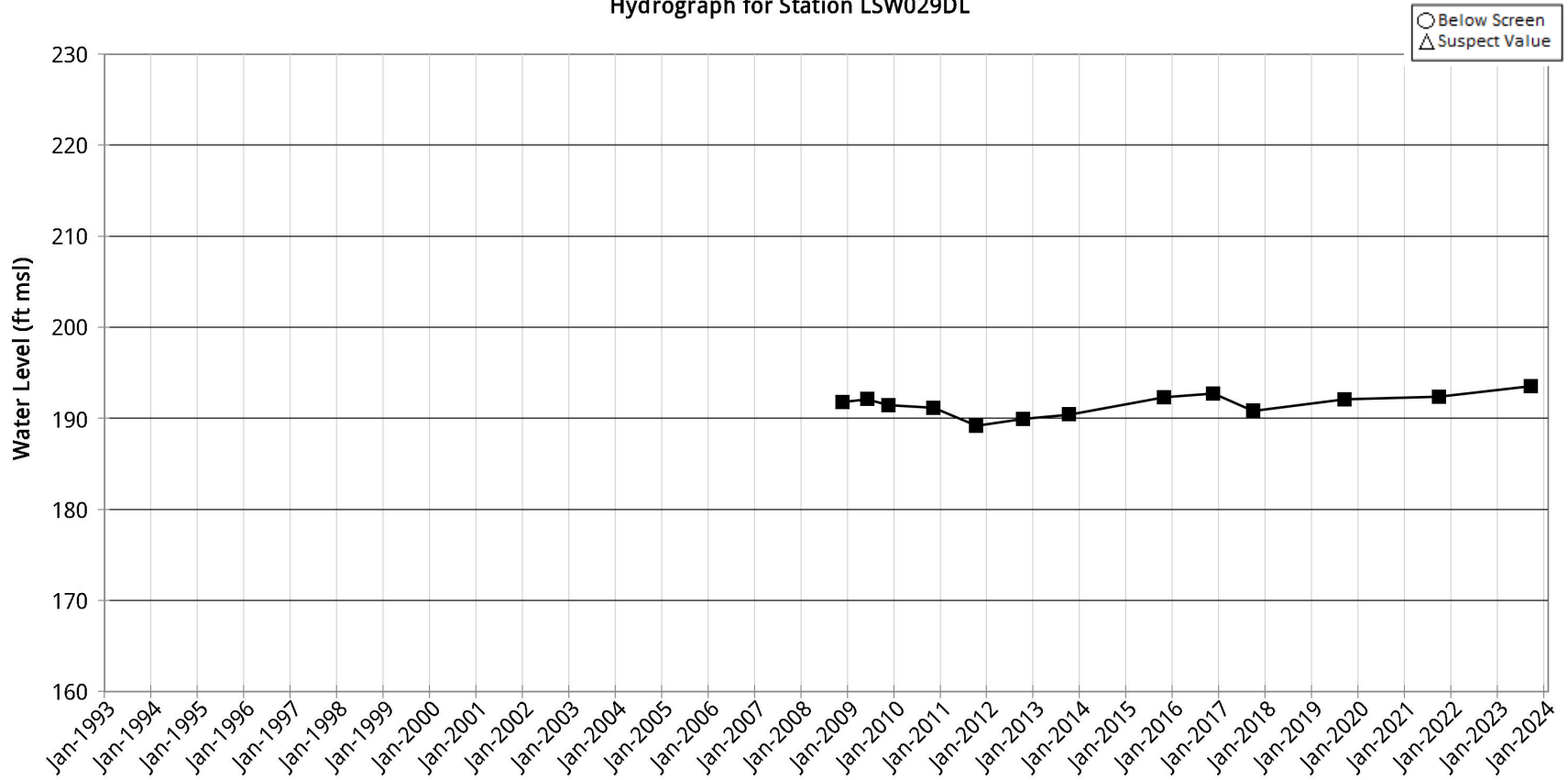


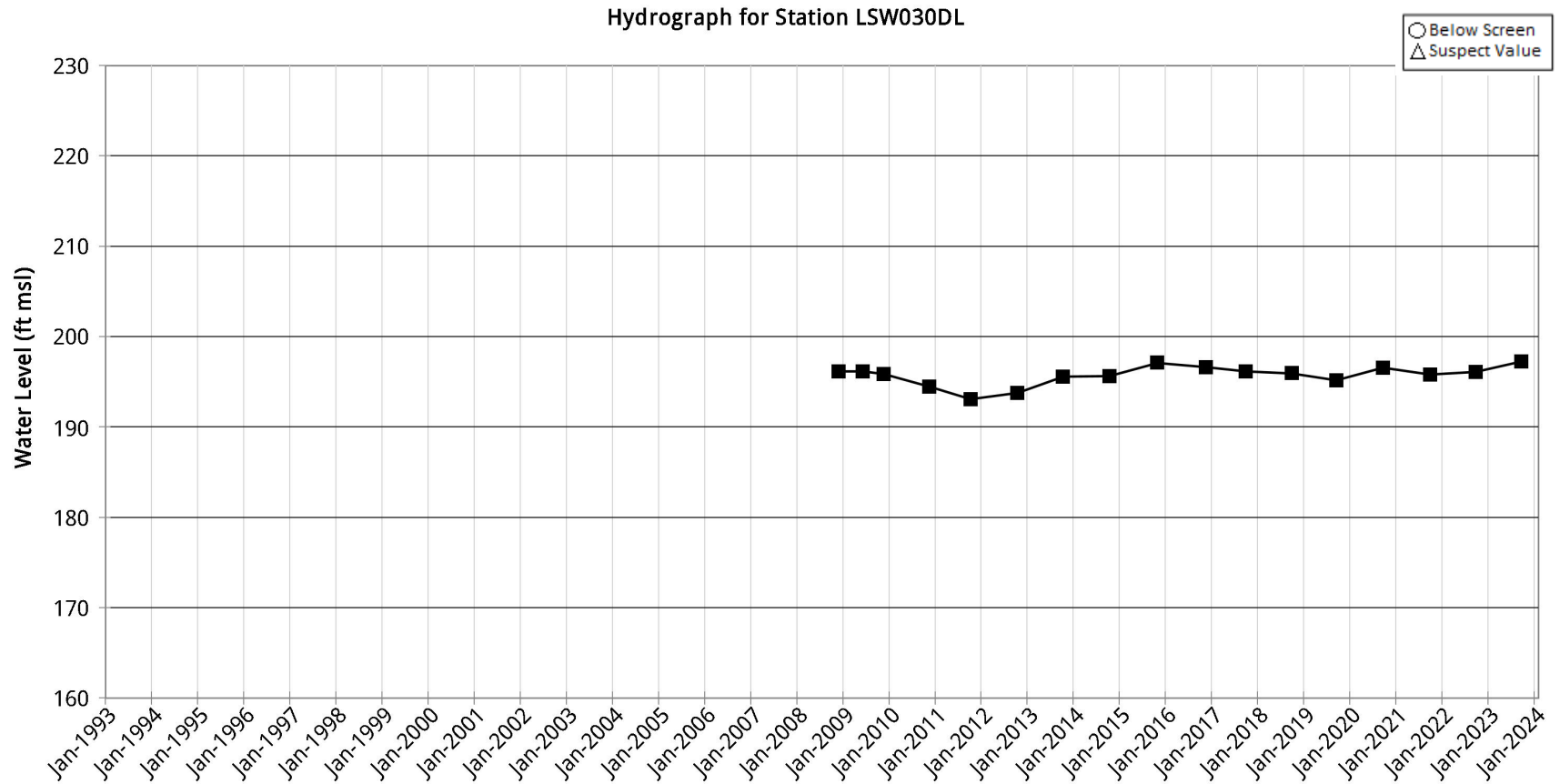




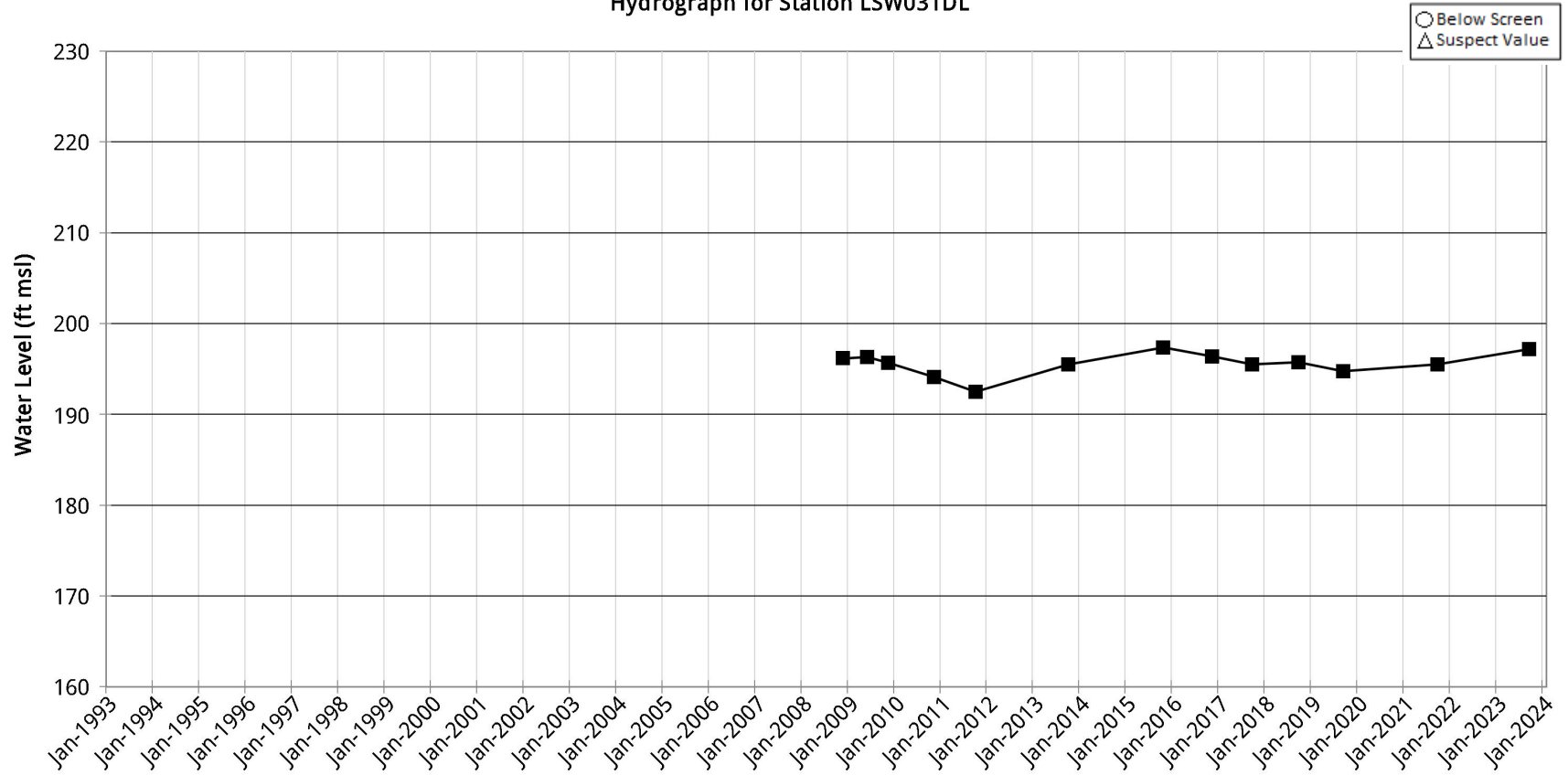


Hydrograph for Station LSW029DL

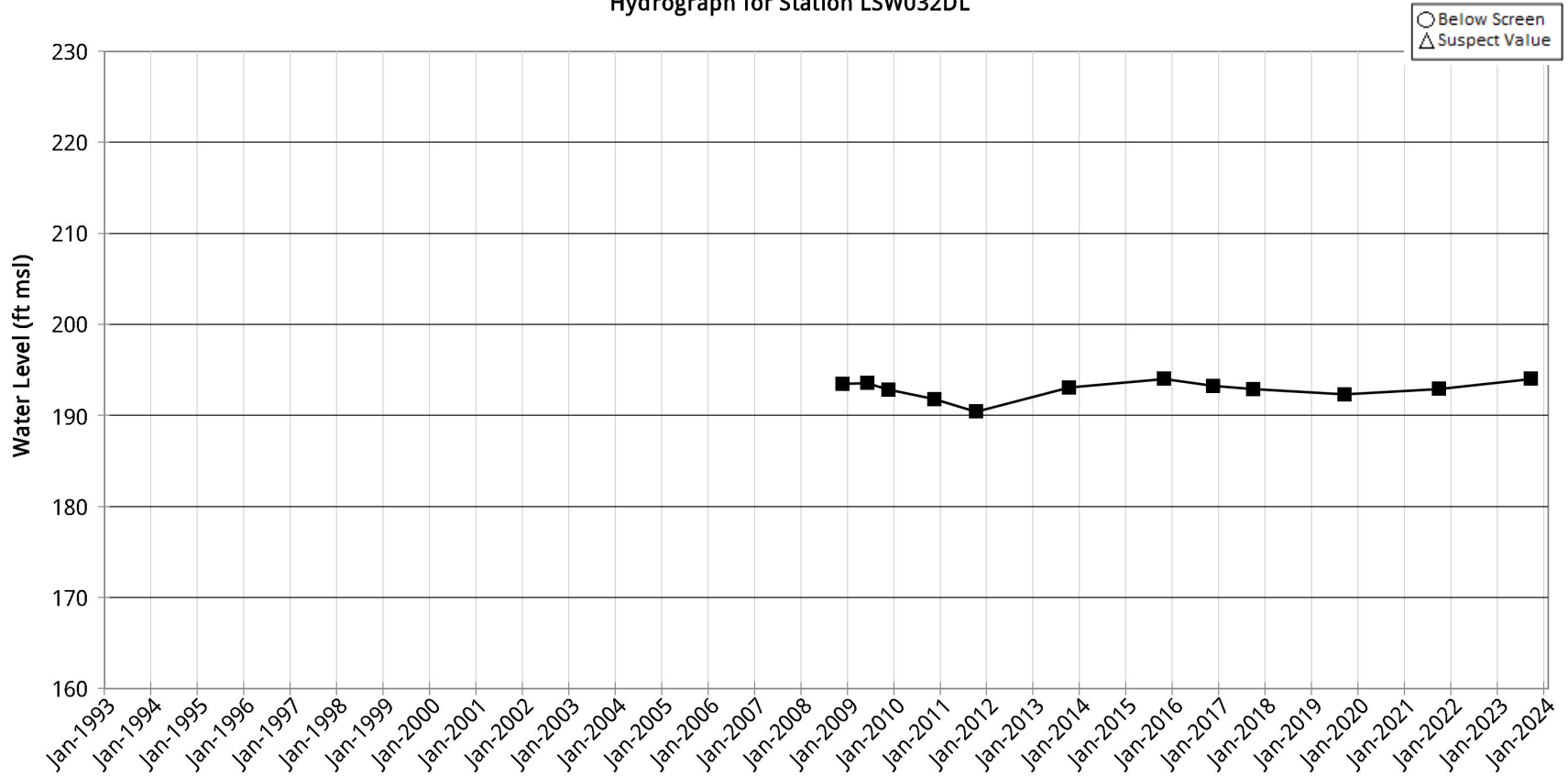




Hydrograph for Station LSW031DL



Hydrograph for Station LSW032DL



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Appendix B

Groundwater and Surface Water Monitoring Results

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Key to Reading the Table

The following abbreviations may appear in the data table:

Laboratories Available for Use During 2022 - 2023

EAI	Enthalpy Analytical, Inc
EBL	Environmental Bioassay Lab
GEL	General Engineering Lab
PACE	Pace Analytical Energy Services, LLC
SHE	Shealy Environmental Services, Inc
TAL	TestAmerica Laboratories, Inc

Nomenclature

amsl	above mean sea level
EQL	sample-specific estimated quantitation limit
GA	Gordon Aquifer
KSZ	Key Source Zone
KSZCL	Key Source Zone Concentration Limit
LAZ	Lower Aquifer Zone
MCL	Maximum Contaminant Level
TC	Tan Clay
UAZ	Upper Aquifer Zone
UTRA	Upper Three Runs Aquifer

Units

deg. C	degrees Celsius
gal	gallons
ft	feet
mg/L	milligrams per liter
msl	mean sea level
NTU	nephelometric turbidity unit
pCi/mL	picocuries per milliliter
pH	pH unit
ug/L	micrograms per liter

Field Conditions

A	Pump is surging excessively; aerated
B	blank sample was collected
C	well is continuously pumping
D	well is dry-no sample or field data collected
E	equipment blank was collected
I	well went dry during sampling; field data collected but insufficient water to collect all samples
L	well went dry before sampling began; only depth to water can be determined
N	well was not stabilized before sampling began
P	inaccessibility or mechanical failure prevented sample collection and field analysis of the water
S	no water in standpipe; for water level events only
T	samples were collected, but some samples were not sent to the laboratory due to high turbidity
W	unable to sample well because of stabilization or sampling equipment failure; water-level measurements were obtained
X	well went dry during purging; samples collected after well recovered measurements obtained
0	OK
1	Pump Dry
2	Sampled after recovery
3	Gallons purged through sample port
4	DI water taken from 772-7B
5	High turbidity
6	Flow meter leaking
7	Pump failure
8	Flow meter not operating
9	# gallons added
10	Well is inaccessible, well can not be Sampled
11	Well abandoned
12	No water to surface
13	Field measurements only
14	Not all samples were collected
15	Equipment failure
16	No water in standpipe
17	Bailed well
18	Water level tape not long enough
19	Well not sampled, maintenance required
20	Well sampled, maintenance required
21	Measurement Exceeded Criteria

Table B-1. L-Area Southern Groundwater OU MNA Monitoring Results, 2022 - 2023

See insert on the next page

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**Table B-1.
L-Area Southern Groundwater OU MNA
Monitoring Results, 2022 - 2023**

				Field Data								Analytical Data						
				SAMPLE COLLECTION DATE	DEPTH TO WATER	SAMPLING EVENT WATER ELEVATION	PH	TURBIDITY	WATER TEMPERATURE	TOTAL ALKALINITY (AS CaCO3)	Constituent	FIELD CONDITIONS	TRITIUM	Well Specific KSZCL for Tritium	TETRACHLOROETHYLENE (PCE)	Well Specific KSZCL for Tetrachloroethylene	TRICHLOROETHYLENE (TCE)	Well Specific KSZCL for Trichloroethylene
Station	Well Use	Secondary Well Use	Aquifer Zone	day-month-year	ft	ft amsl	pH	NTU	degC	mg/L	MCL Unit		pCi/mL	pCi/mL	ug/L	ug/L	ug/L	ug/L
LAC 8DL	Southeast Plume Monitoring Well	Key Source Zone Monitoring Well	UAZ UTRA	17-Oct-2022	23.1	213.3	4.9	0.2	20.2	0			1.93	102.75	1.95	90	[0.379]	31.5
LAC 8DL	Southeast Plume Monitoring Well	Key Source Zone Monitoring Well	UAZ UTRA	16-Oct-2023	18.52	217.88	4.6	0.8	19.8	0			1.57	102.75	5.43	90	1.49	31.5
LSB 4	Southeast Plume Monitoring Well	Key Source Zone Monitoring Well	UAZ UTRA	17-Oct-2022	16.78	214.82	4.5	0.4	22	0			<EQL (1.09)	137.7	1.2	NA	<EQL (1)	
LSB 4	Southeast Plume Monitoring Well	Key Source Zone Monitoring Well	UAZ UTRA	16-Oct-2023	13.03	218.57	4.8	0.72	20.3	0			<EQL (1.25)	137.7	<EQL (1.2)	NA	<EQL (1)	
LSW 2DL	Southeast Plume Monitoring Well		UAZ UTRA	16-Oct-2023	8.47	192.77	5.7	5.2	19.7	7			9.45		[1.07]		<EQL (1)	
LSW002AR	Southeast Plume Monitoring Well		GA	16-Oct-2023	28.02	173.31	6.3	4.43	17.1	23			<EQL (1.23)		<EQL (1.2)		<EQL (1)	
LSW031DL	Southeast Plume Monitoring Well		UAZ UTRA	16-Oct-2023	12	197.17	5.8	1.2	21.7	8			198		[0.493]		<EQL (1)	
LSW032DL	Southeast Plume Monitoring Well	LUC Boundary Monitoring Well	UAZ UTRA	16-Oct-2023	14.9	194.03	5.7	0.7	20.5	6			<EQL (1.25)		<EQL (1.2)		<EQL (1)	
LAW 2C	Southwest Plume Monitoring Well		UAZ UTRA	16-Oct-2023	14.78	209.22	4.6	0.7	21	0			5.14		<EQL (1.2)		<EQL (1)	
LDB 3	Southwest Plume Monitoring Well	Key Source Zone Monitoring Well	UAZ UTRA	17-Oct-2022	37.55	215.85	6	1.8	26.3	24			[0.738]	282	<EQL (1.2)	NA	<EQL (1)	NA
LDB 3	Southwest Plume Monitoring Well	Key Source Zone Monitoring Well	UAZ UTRA	16-Oct-2023	33.82	219.58	5.8	1.5	26	27			<EQL (1.26)	282	<EQL (1.2)	NA	<EQL (1)	NA
LSP 8DU	Southwest Plume Monitoring Well		UAZ UTRA	16-Oct-2023	38.53	211.19	4.6	33.2	17.5	0			<EQL (1.23)		<EQL (1.2)		<EQL (1)	
LSW 24A	Southwest Plume Monitoring Well		GA	16-Oct-2023	29.23	173.31	5.6	0.8	16.2	9			<EQL (1.12)		<EQL (1.2)		<EQL (1)	
LSW 25DL	Southwest Plume Monitoring Well		UAZ UTRA	17-Oct-2022	6.47	196.61	4.8	0.2	19.9	0			392		68.4		[0.508]	
LSW 25DL	Southwest Plume Monitoring Well		UAZ UTRA	16-Oct-2023	5.84	197.24	4.9	1.3	17.9	0			377		61.6		[0.405]	
LSW026DL	Southwest Plume Monitoring Well		UAZ UTRA	16-Oct-2023	23.97	193.16	4.6	1.7	16.9	0			2.19		1.45		<EQL (1)	
LSW030DL	Southwest Plume Monitoring Well		UAZ UTRA	17-Oct-2022	9.07	196.08	5.7	1.5	23.2	9			18.6		16.7		3.56	
LSW030DL	Southwest Plume Monitoring Well		UAZ UTRA	16-Oct-2023	7.9	197.25	5.8	1.4	19.8	10			17.8		14.8		3.15	
LSW 8C	Western Plume Monitoring Well		LAZ UTRA	16-Oct-2023	55.8	195.95	5.6	8.9	19.3	7			8.79		NS		NS	
LSW 8DL	Western Plume Monitoring Well		UAZ UTRA	16-Oct-2023	53.5	198.25	5.1	10	19.1	3			7.99		NS		NS	
LSW 9C	Western Plume Monitoring Well		LAZ UTRA	16-Oct-2023	33.04	191.52	6.7	1.9	19.4	34			11		NS		NS	
LSW 9DL	Western Plume Monitoring Well		UAZ UTRA	16-Oct-2023	32.23	192.33	5.9	3	19.7	4			21.5		NS		NS	
LSW 12C	Western Plume Monitoring Well	LUC Boundary Monitoring Well	LAZ UTRA	16-Oct-2023	52.03	183.71	7.2	2.4	18.9	97			[1.17]		NS		NS	
LSW 12DL	Western Plume Monitoring Well	LUC Boundary Monitoring Well	UAZ UTRA	16-Oct-2023	51.65	184.09	6.1	1.2	18.7	12			<EQL (1.12)		NS		NS	
LSW 14C	Western Plume Monitoring Well		LAZ UTRA	16-Oct-2023	16.54	188.13	7.4	1.6	20.3	90			5.33		NS		NS	
LSW 14DL	Western Plume Monitoring Well		UAZ UTRA	16-Oct-2023	15.11	189.56	4.9	0.9	20.4	0			2.61		NS		NS	
LSW014A	Western Plume Monitoring Well		GA	16-Oct-2023	41.31	167.62	6	9.9	19.4	15			<EQL (1.11)		NS		NS	
LSW027A	Western Plume Monitoring Well	LUC Boundary Monitoring Well	GA	16-Oct-2023	28.89	168.71	6.5	12.7	17.2	17			<EQL (1.1)		NS		NS	
LSW027C	Western Plume Monitoring Well	LUC Boundary Monitoring Well	LAZ UTRA	16-Oct-2023	10.45	187.41	7.3	0.7	20.8	46			<EQL (1.13)		NS		NS	
LSW028C	Western Plume Monitoring Well		LAZ UTRA	16-Oct-2023	13.17	190.71	7.5	0.9	20.1	81			3.4		NS		NS	
LSW029DL	Western Plume Monitoring Well		UAZ UTRA	16-Oct-2023	11.5	193.53	6.1	2.8	18.7	32			3.87		<EQL (1.2)		<EQL (1)	
SC20	Surface Water			20-Dec-2022	NS	NS	6.6	6.2	9	13			19.1		<EQL (1.2)		<EQL (1)	
SC20	Surface Water			17-Oct-2023	NS	NS	7.3	8.2	16	11			7.98		<EQL (1.2)		<EQL (1)	
SC23	Surface Water			20-Dec-2022	NS	NS	6.8	2.1	10.8	16			2.55		<EQL (1.2)		<EQL (1)	
SC23	Surface Water			17-Oct-2023	NS	NS	7.5	1.8	18.4	15			2.05		<EQL (1.2)		<EQL (1)	
SC24	Surface Water			20-Dec-2022	NS	NS	6.9	1.8	11.8	14			2.2		<EQL (1.2)		<EQL (1)	
SC24	Surface Water			17-Oct-2023	NS	NS	7.2	12.8	18.3	13			2.13		<EQL (1.2)		<EQL (1)	
SC25	Surface Water			20-Dec-2022	NS	NS	6.8	1.6	12.1	16			2.25		<EQL (1.2)		<EQL (1)	
SC25	Surface Water			17-Oct-2023	NS	NS	7.1	2.5	18.9	13			1.74		<EQL (1.2)		<EQL (1)	
SC27	Surface Water			20-Dec-2022	NS	NS	6.6	3.7	13.4	21			2.3		<EQL (1.2)		<EQL (1)	
SC27	Surface Water			17-Oct-2023	NS	NS	6.4	2.6	16.1	4			2.01		<EQL (1.2)		<EQL (1)	

Explanation
 RCOC = Refined Constituent of Concern
 MCL = maximum concentration limit based on Environmental Protection Agency Primary Drinking Water Standards.
 LUC = Land Use Control
 [KSZCL = 'Key Source Zone Concentration Limit' which is equivalent to 150% of maximum value observed for KSZ monitoring wells between 2005 and 2007 monitoring period.
 [##] EPA Functional Guideline Code of 'J' was applied to the result, indicating an estimated quantity.
 <EQL(##) Constituent was below detection. The sample-specific Estimated Quantitation Limit is in parentheses.
 Result exceeds the KSZCL for KSZ wells, or exceeds the MCL for surface water locations
 Result is between the MCL and the KSZCL for KSZ wells, and exceeds the MCL for all other wells.
 Result Rejected.
 Result is less than the applicable limit and without EPA Functional Guideline qualifiers.
 NS Requested to be sampled but was not. See comments as to why not.
 Blue Text Not a required sample analysis.
 BOLD Turbidity level exceeds the sample quality limit of 15 NTU

Appendix C
Time-Series Plots

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