GWET System Effectiveness Evaluation

Arkema Inc. Facility
Portland, OR

PREPARED FOR
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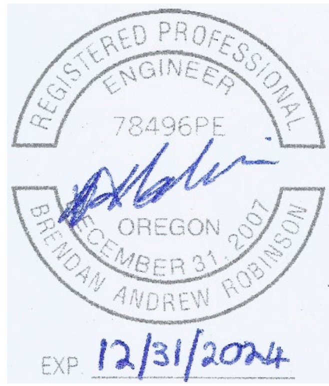
PROFESSIONAL ENGINEER'S CERTIFICATION

I, Brendan Andrew Robinson, Licensed Professional Engineer in the State of Oregon, hereby certify to the best of my knowledge and belief that this document is true and correct and has been prepared in accordance with general industry standards and applicable federal, state, and local requirements, and hereunto set out hand and affix my seal this 29th day of March 2024.



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ACRONYMS AND ABBREVIATIONS

Acronyms	Description
Arkema	Arkema Inc.
COC	constituent of concern
DEQ	Oregon Department of Environmental Quality
ERM	Environmental Resources Management, Inc.
EW	extraction well
FDR	Final Design Report
ft	feet
GCC	gradient control cluster
GEE	Groundwater Extraction Enhancement
gpm	gallons per minute
GW SCM	Groundwater Source Control Measure
GWBW	groundwater barrier wall
GWET	Groundwater Extraction and Treatment
I/O	Input/output
LSS	Legacy Site Services LLC
MK	Mann-Kendall
MPR	Monthly Progress Report
NAVD88	North American Vertical Datum of 1988
Odin	Odin Construction
PDI	Preliminary Design Investigation
PMP	Performance Monitoring Plan
RFI	Request for Information
RW	recovery well
SEE	System Effectiveness Evaluation
Site	Former Arkema Portland Plant located at 6400 NW Front Avenue in Portland, Oregon
TCZ	Target Capture Zone
TCZO	Target Capture Zone Objectives
USEPA	United States Environmental Protection Agency

RESPONSES TO AGENCY COMMENTS

Legacy Site Services LLC (LSS) received the following comments on 3 April 2023 in response to the Quarter 4 2022 Groundwater Monitoring Report and the comments received on 30 June 2023 in response to the 2022 System Effectiveness Evaluation (SEE) report submitted to the Oregon Department of Environmental Quality (DEQ). Environmental Resources Management, Inc. (ERM) has prepared these responses on behalf of LSS and presented them below.

DEQ GENERAL COMMENTS

1. Several data quality issues were noted in the Quarter 4 2022 Groundwater Monitoring Report. Most of these appear to be laboratory errors; however, detected concentrations of certain VOCs in rinsate blanks could indicate field quality control issues.

LSS/ERM Response:

LSS/ERM have noted the comment. As the Quarter 2, 2023 Groundwater Monitoring Report described, ERM identified that the Eurofins laboratory-provided deionized (DI) water used onsite for decontamination and rinsate sample collection contained detections of analytes similar to those identified in the rinsate blank samples. During the Quarter 3, 2023 groundwater sampling event, ERM utilized lab-purged DI water as recommended by Eurofins laboratory. As the Quarter 3, 2023 Groundwater Monitoring Report described, there were no detected concentrations in the rinsate or DI water samples for that event.

2. There appear to be some significant increases in chloride concentrations on both sides of the groundwater barrier wall (GWBW) in the shallow, intermediate, and deep zones at groundwater control cluster 6 (GCC6) and proximal wells. These increasing chloride concentrations coupled with significant mounding of groundwater behind the GWBW in these hydrogeologic zones could suggest that chloride is being pushed around the GWBW. The DEQ notes that magnitude of chloride concentration increases outside of the GWBW are generally lower compared to inside the GWBW, and chloride concentrations in PA-16i are comparable to November 2019. Hopefully, operation of the groundwater extraction enhancement (GEE) system will result on inward hydraulic gradients across the GWBW and trends in chloride concentrations at the GCC6 and proximal wells reverse. LSS should discuss these observations in the forthcoming system effectiveness evaluation (SEE).

LSS/ERM Response:

See Section 7.4.2 for a discussion on chloride observations in 2023.

3. Chlorobenzene concentrations in PA-30d (behind the GWBW) increased significantly (by an order of magnitude) compared to previous monitoring events, but there does not appear to be a corresponding chlorobenzene increase in PA-19d (outside of GWBW). LSS should discuss this observation in the forthcoming SEE.

LSS/ERM Response:

Non-detect and stable chlorobenzene concentrations at GCC2 (PA-19D outside of GWBW) indicate that containment by the GWET system and the GWBW is effectively preventing chlorobenzene migration towards the river. See Section 7.4.2 for further discussion on chlorobenzene concentrations.

DEQ SPECIFIC COMMENTS

1. Section 1.2, Background. In this section the following is stated "The GW SCM and GWET system, including the newly constructed GEE system." DEQ notes that the GEE is an enhancement to the GWET system not a system of its own.

LSS/ERM Response:

LSS/ERM have noted the comment.

2. Section 1.2.2., Groundwater Source Control Measures. Recovery wells (RWs) that were part of the GWET system are not identified as a primary component of the GW CSM. DEQ requests that the section be revised to clarify that select RWs are still functioning as components of the GWET system.

LSS/ERM Response:

LSS/ERM will identify recovery wells (RWs) still functioning as part of the GWET system as components of the system in future reports.

3. Section 1.2.2., Groundwater Source Control Measures. In this section it is mentioned that "Hydraulic gradients across the GWBW are evaluated through data collected from a network of 36 piezometers used to monitor the groundwater elevation in the Shallow, Intermediate, and Deep Zones. These hydraulic gradients are used to evaluate hydraulic capture performance in the vicinity of the GWBW." This statement seems to conflict with the Monthly Performance Monitoring Report statement that "One new monitoring well was installed in each of the seven extraction trenches for manual water level measurement. These data were used to prepare horizontal and vertical potentiometric surface maps representing potentiometric differences between the alluvial sequences, and to generate spatial and temporal hydrographs to evaluate hydraulic capture." DEQ requests that the text be revised in one of these documents to clarify the monitoring points and data used to evaluate the GW SCM.

LSS/ERM Response:

LSS/ERM have noted the comment. We have revised the Quarterly Groundwater Monitoring Reports as of Quarter 1, 2023.

4. Section 2.4, Groundwater Level Measurements. Lab and rinsate blanks seem to have been compromised by select VOCs. DEQ requests some explanation of why these issues occurred and actions that may be implemented to limit the likelihood of their recurrence in the future.

LSS/ERM Response:

LSS/ERM have noted the comment. See response to the DEQ General Comment 1 above.

5. Figure 1, Site Layout. The extraction trenches are a feature in the legend but are not visible on the figure. DEQ requests that they be added.

LSS/ERM Response:
LSS/ERM added extraction trenches to the figures in the Q1, Q2, and Q3 Groundwater Monitoring Reports, and they will be visible on all site layout figures moving forward.

6. Figure 1, Site Layout. Monitoring well MWA-81i is mislabelled on the figure.

LSS/ERM Response:

Monitoring well MWA-81i has been updated and accurately labeled on Figure 1, Site Layout.

7. Appendix D, Prior Groundwater Monitoring Program Data Tables and Graphs. Several plots appear to be composed completely of non-detect results.

LSS/ERM Response:

LSS/ERM have noted the comment noted. We have removed the graphs composed of all non-detect results.

ADDITIONAL DEQ COMMENTS

1. The Legacy/ERM response to DEQ's 6 July 2022 Specific Comments No. 7 and No. 8 on the 2021 GWET SEE, and the information provided in Section 7.4.2 of the 2022 GWET SEE intended to address these comments are inadequate. DEQ has the following comments:
   A. The first bullet in Section 7.4.2 of the 2022 GWET SEE states "No increases in chloride at GCC2 and GCC3 were observed in Deep Zone wells on either side of the GWBW (PA-30D and PA-21D) within each well cluster, indicating that the GWBW is effectively preventing plume migration." DEQ clarifies that chloride concentrations on the riverside of GCC2 (PA-19D) are increasing. As we previously noted, there is a concentration gradient from PA-30D (interior of GCC2) to PA-19D (exterior of GCC2), chloride concentrations continue to increase on the riverside of the GWBW at GCC2, there have been consistent downward vertical hydraulic gradients at GCC2, and PA-19D and PA-30D are both screened at the base of the groundwater barrier wall (GWBW) close to the basalt water barring zone. Legacy/ERM have provided no information or evaluation that would support a conclusion that the GWBW is effectively preventing plume migration for chloride at GCC2.

   LSS/ERM Response:

See Section 7.4.2 for a discussion of chloride concentrations at GCC2.

   B. The 2022 SEE does not provide any discussion of chloride concentrations at PA-26D or the potential for chloride migration below and/or around the groundwater barrier wall.

   LSS/ERM Response:

See Section 7.4.2 for a discussion on chloride concentrations at PA-26D.

2. "Section 9, Recommendations. The last bullet that states "As outlined in Section 8 above, the annual groundwater monitoring data evaluation concluded that increasing concentrations identified are sporadic and overall conclusions are consistent with previous evaluations, which indicated that mounding behind the GWBW is not causing significant migration of COCs." Is not supported by the data presented earlier in the SEE that indicate concentrations of chloride (PA-19D), chlorobenzene (MWA-31i[D]), and perchlorate (MWA-56D and 58D) are increasing in

select areas outside the GWBW. Additionally, there are indications of changes to chemical conditions within the GWBW such as chloride (PA-08 and PA-20D) and chlorobenzene (PA-30D)."

LSS/ERM Response:

See Section 7.4.2 for a discussion on chloride, chlorobenzene, and perchlorate.

1. INTRODUCTION

Environmental Resources Management, Inc. (ERM) has prepared this Groundwater Extraction and Treatment (GWET) System Effectiveness Evaluation (SEE) report on behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc. (Arkema), for the former their Arkema Portland, OR facility located at 6400 NW Front Avenue (Site). The primary objectives of this report are to address the Oregon Department of Environmental Quality's (DEQ's) comments from the previous report and to provide updates associated with system optimization conducted in this reporting period (February 2023 through December 2023).

ERM has provided a Site Location Map as Figure 1 and a Study Area Layout Map as Figure 2. The Study Area we discuss in this report generally consists of the Target Capture Zone (TCZ) for the Groundwater Source Control Measure (GW SCM) within Lots 3 and 4 that we presented in the Revised Final Performance Monitoring Plan [PMP]—Groundwater Source Control Measure (ERM 2014). The original GWET system was unable to meet the Target Capture Zone Objectives (TCZO). Between 2019 and 2021, we completed a Preliminary Design Investigation (PDI) presenting groundwater extraction enhancement (GEE) alternatives and a preliminary design of the preferred alternative (ERM 2021b). The DEQ approved the Final Design Report (FDR; ERM 2022b) in July 2022. As part of GEE implementation, seven groundwater extraction trenches consisting of two extraction wells each were installed between July 2022 and October 2022, replacing the existing 18 recovery wells (RWs) and leaving 4 existing RWs that were productive. The updated GW SCM now consists of seven groundwater extraction trenches with two extraction wells each (ERM 2022b), four groundwater RWs, a groundwater barrier wall (GWBW), and the GWET Plant. Collectively, we refer to these components as the GW SCM.

The SEE provides an update on the current performance of the GW SCM, discusses corrective actions implemented to improve the performance of the GW SCM, evaluates the extent of capture currently achieved by the GW SCM, and proposes actions to improve hydraulic capture. Additionally, Section 7 presents the annual groundwater monitoring data evaluation. This includes an assessment of historical and current groundwater analytical trends in the vicinity of the GWBW.

2. BACKGROUND

The current GW SCM at the Site consists of:

- A GWBW to physically separate the affected upland portions and in-water portions of the Site;
- A groundwater extraction system intended to induce inverse gradients across the GWBW within the TCZ (ERM 2014); and
- Management of extracted groundwater using the GWET Plant, with treated effluent discharged to the Willamette River under a National Pollutant Discharge Elimination System Permit.

The GWET system was updated in 2022 because the original system was unable to meet the TCZOs. The original GWET system was comprised of 13 groundwater RWs screened in the Shallow Zone and nine RWs screened in the Intermediate Zone. Seven groundwater extraction trenches were installed, each with two extraction wells (EWs), in the summer and fall of 2022 as part of GEE implementation (Figure 2). Each extraction trench was backfilled with a sand mixture designed to have greater hydraulic conductivity than the native alluvium while retaining the fine sand in the native alluvium. Each trench is fitted with U-shaped extraction piping consisting of two vertically screened sections connected by a 30-foot-long horizontal screened section that intercepts groundwater in the Shallow and Intermediate Zones. The newly installed extraction trench system provides approximately 10 times the overall saturated surface area of the original GWET system, greatly increasing the system’s ability to capture and treat groundwater within TCZ (ERM 2022b).

The current GWET system consists of:

- Four RWs screened in the Shallow Zone (RW-14, RW-22, RW-23, and RW-25) from prior to the implementation of the GEE project;
- The groundwater extraction trenches that replaced 18 RWs as part of GW SCM enhancements described in the FDR (ERM 2022b); the 18 non-pumping RWs were upgraded in 2023 to operate as transducers to provide additional groundwater elevation data; ERM has incorporated these data into the potentiometric surface maps in the Monthly Progress Reports (Appendix A);
- Seven groundwater extraction trenches comprising two EWs each (EW-1 through EW-14) screened through both the Shallow and Intermediate Zones; one new monitoring well was installed in each of the seven extraction trenches for manual water level measurement; and
- A groundwater treatment system that employs:
    - A chemical precipitation train equipped with a reactor, pH adjustment, coagulant feed, clarifier, and multiple pressure filters. Holding tanks contain the residual solids that result from the precipitation process, mechanically thickens them, and dewaters them prior to transport and offsite disposal.
    - Biological treatment within a fluidized bed reactor. This train includes biological digestion of contaminants followed by two stages of filtration (gravity and bag) to remove excess biological solids, which are then contained in storage, mechanically thickened, dewatered, and transported offsite for disposal.
    - A bag filter followed by three liquid-phase granular activated carbon vessels in series.

A network of 54 piezometers is used to monitor the groundwater elevation in the Shallow, Intermediate, and Deep Zones. These data are used to evaluate the hydraulic gradients across the GWBW and to control the operation of the adjacent groundwater extraction trenches and RWs as described in the United States Environmental Protection Agency (USEPA)-approved PMP (ERM 2014) and the USEPA- and DEQ-approved FDR (ERM 2022b). Figure 2 shows the location of the GWET wells, gradient control clusters (GCCs), and the GWBW.

3. GWET SYSTEM OPERATING STATUS

GWET startup and optimization commenced in May 2014. Approximately 101 million gallons of groundwater have since been extracted, treated, and discharged by the end of December 2023. The GWET system has achieved an average influent flow rate of 37.16 gallons per minute (gpm), and its 2023 operational average influent flow rate was 55.49 gpm. During the reporting period when the GWET system was operational, uptime was approximately 85 percent, which is less than the 98 percent reported in the 2022 SEE Report (ERM 2022a), due to system repairs, conveyance line upgrades, and upsets and improvements in the solids handling system due to higher flows. Of the 15 percent downtime during the reporting period, 9 percent of the reporting period was due to planned outages for system repairs and planned maintenance. 6 percent of the reporting period was unplanned downtime.

No National Pollutant Discharge Elimination System permit violations have occurred since the GWET system began operating in a continuous flow-through mode in September 2015.

Details of GWET system operations, system interruptions, and the resolution of specific issues were reported to the DEQ via email correspondence.

All planned and unplanned shutdowns during the reporting period were less than 13 consecutive days and were reported to the DEQ via email.

3.1 GROUNDWATER RECOVERY AND HYDRAULIC MONITORING EQUIPMENT

The GWET system is designed to achieve the TCZOs. Performance is evaluated with respect to the TCZOs in real-time using piezometers equipped with pressure transducers and monthly manual groundwater elevation measurements. The pressure transducers have been arranged in a series of six GCCs along the length of the GWBW.

The hydraulic monitoring data demonstrate that the monitoring system is effective at controlling RW operations and providing data for evaluating hydraulic containment. These data are also combined with manual potentiometric surface measurements to gather Site-wide groundwater elevations in addition to pressure transducer data which, in turn, is used to calibrate transducers. Transducers are manually measured when groundwater elevations are shown to be anomalous or during the monthly event if there is uncertainty in the transducers’ results due to fluctuations or an otherwise errant signal.

3.2 GRADIENT MONITORING AND RW CONTROL TRANSDUCER MALFUNCTION

Gradient monitoring and RW operations were historically interrupted intermittently due to sporadic failure of the pressure transducers, which limited the ability to continuously monitor groundwater elevations in piezometers and to operate some RWs. RW groundwater elevation data is required to operate the pumps safely (e.g., provide instrumentation data for low-level alarms/shutoff). Upgrades to the transducers that were implemented in 2017 to 2019 improved transducers performance, with limited failures and malfunctions reported in 2023 as compared to prior to 2019. The existing transducers equipment and maintenance practices allow for sufficient groundwater elevation data to effectively operate the groundwater extraction system, reduce interruptions pumping operations, and to evaluate the GW SCM capture objectives.

Twelve transducers had issues, making them inoperable for longer than 1 month during the reporting period. The transducers experienced faults or were determined to be out of calibration for 1 month or longer during the reporting period. These transducers have been repaired and are back online:

- PA-07
- PA-16i
- PA-20d
- PA-26d
- PA-14i
- PA-29i
- MWA-8i
- PA-11i
- RW-15
- RW-11i
- RW-18
- PA-06

Ongoing maintenance of the transducers to prevent failures includes conducting visual pressure transducer integrity checks and replacing transducers as necessary. Transducers are typically inspected within 1 week of an issue being identified and typically repaired within 1 week to 1 month depending on whether a transducer replacement is required or not.

3.3 EXTRACTION AND RW OPERATIONS

A summary of well operations is included in Tables 1a and 1b. All trenches were in operation during every month of the year with exception to outages as we have detailed below. All groundwater extraction trenches contain two EWs. Depending on extraction capacity and due to the hydraulic connectivity of these two paired trench wells, EWs are occasionally not operated in the same extraction trench at the same time.

The following four legacy RWs remain in operation due to sufficient recovery capacity.

- RW-14
- RW-22
- RW-23
- RW-25

As part of the planned extraction enhancement activities implemented in 2022, the remaining RWs were taken out of service, retrofitted with pressure transducers, and are now being used as water level monitoring wells.

- RW-08

- RW-09i
- RW-13i
- RW-24i
- RW-05
- RW-06i
- RW-07
- RW-10
- RW-11i
- RW-12
- RW-15
- RW-16i
- RW-17
- RW-18
- RW-19i
- RW-20
- RW-21i
- RW-26i

4. CAPTURE ZONE ANALYSIS

As ERM discussed in the PMP (ERM 2014), the capture zone evaluation criteria was developed using the USEPA's six steps to evaluate hydraulic capture (USEPA 2008).

- **Step 1:** Review Site data and Site conceptual model and remedy objectives
- **Step 2:** Define Site-specific TCZ(s)
- **Step 3:** Interpret groundwater elevations-potentiometric surface maps (horizontal), groundwater elevation difference maps (vertical), and groundwater elevation pairs (gradient control points)
- **Step 4:** Perform calculations including estimated flow rate calculation, capture zone width calculation (can include drawdown calculation), and model (analytical or numerical) to simulate groundwater elevations in conjunction with particle tracking and/or transport modeling
- **Step 5:** Evaluate concentration trends
- **Step 6:** Interpret actual capture based on Steps 1 through 5, compare them to TCZ(s), and assess uncertainties and data gaps

Per the PMP and USEPA steps mentioned above, capture is evaluated consistent with the PMP and Steps 1 through 3 of the USEPA guidance, including Site data review, Site-specific TCZ determination, and groundwater elevations interpretation through both potentiometric surface and vertical difference maps. Steps 4 through 6 were not applicable in 2023 and the evaluation of Steps 4 through 6 may begin in 2024.

4.1 GROUNDWATER ELEVATIONS

In accordance with the PMP, groundwater elevations are being monitored using the transducers and monthly manual groundwater elevation gauging. Potentiometric surface maps developed from monthly measurements are being used to evaluate groundwater flow directions. ERM has provided monthly Shallow, Intermediate, and Deep Zones potentiometric surface maps; vertical difference maps; horizontal gradients; and vertical gradient hydrographs in Appendix A.

The ambient groundwater flow direction in the Shallow, Intermediate, and Deep Zones is generally from the western Site boundary of NW Front Ave, toward the Willamette River. Potentiometric maps (Appendix A) indicate localized groundwater movement to the extraction trenches due to GW SCM pumping, and cones of depression are apparent around each groundwater extraction trench. Horizontal gradients at the Site were generally trending toward inward in 2023 at the Shallow, Intermediate, and Deep Zones.

Vertical gradients at the Site were generally mixed in 2023 and fluctuated from upward to downward at most monitoring locations, generally in response to changes in river stage. Downward vertical gradients are greatest and most consistent from the Shallow to Intermediate Zones at GCC1 because of the localized pressure zone ERM discussed in the PDI Report (ERM 2021a). These gradients are the result of a localized low-permeability clayey silt layer that impedes vertical flow between the Shallow Zone and the Intermediate Zone. See Appendix A for vertical and horizontal gradient maps from February 2023 through December 2023.

4.1.1 GWET WELLS EXTRACTION RATES AND RELATIONSHIP WITH SEASONAL CONDITIONS

The Willamette River stage elevation at the Site varied between a low of approximately 4.71 feet (ft) North American Vertical Datum of 1988 (NAVD88) in October 2023 to a high of 15.14 ft NAVD88 in May 2023. The average river elevation was 9.93 ft NAVD88. The tidal oscillation in the Willamette River shows an amplitude of approximately 3.9 ft in the low stage season (fall to early winter) and an amplitude of 2.1 ft during the high stage (spring to early summer) season.

Average Monthly Pumping Rates and Average Operational[1] Monthly Pumping Rate charts (Figures 3a and 3b) present the operational average monthly extraction rates and the average monthly extraction rates for the entire groundwater pumping network from March 2021 through December 2023, the Willamette River stage, and the average interior Shallow and Intermediate Zones groundwater elevations. Tables 1a and 1b present average and operational average flow rates for each RW and EW, respectively, for each month from February 2023 through December 2023. Average Shallow and Intermediate Zones groundwater elevations were calculated using an average of interior well transducer groundwater elevation data over the course of each month. For the Shallow Zone calculation, PA-04 was excluded, as it is within a geologically constrained, localized, high-pressure zone and is not representative of the overall Shallow Zone groundwater elevation in the Study Area (ERM 2021a).

Figures 3a and 3b demonstrate a continued correlation between river and groundwater elevations in both the Shallow and Intermediate Zones. It also demonstrates a historical correlation between groundwater elevation and groundwater extraction rates during pumping operations that may remain once the TCZOs are met.

The GWET system monthly average extraction rates have varied during the reporting period from a low of 28.78 gpm in July 2023 to a high of 45.49 gpm in August 2023. The operational average extraction rates during the reporting period had a low of 41.45 gpm in April 2023 and a high of 73.30 gpm in February 2023. For reference, the operational average prior to GEE implementation in 2022 ranged from a low of 1.47 gpm to a high of 13.21 gpm. This represents an increase of approximately 40 gpm in the minimum operational extraction rates and over 60 gpm in maximum operational extraction rates between 2022 and 2023. The average river elevation for the reporting period was 9.37 ft, 0.89 ft lower than the previous reporting period (10.26 ft in 2022).

Operational extraction rates from the trenches in 2023 were limited based on trench flow capacity and backpressure in the conveyance line that were observed at higher flows (e.g., above approximately 50 gpm). The extraction trench flow capacity limitations were attributed to biological, chemical, or physical (e.g., silt infiltration) factors of the trench backfill. Backpressure in the conveyance line was attributed to fouling as well as excessive friction loss at higher flows in the 3-inch conveyance line.

[1] Operational average flowrate is the average flowrate while the GWET system is operational. Average flowrate is the average daily flowrate throughout the entire reporting period regardless of whether the system is operational or not

Redevelopment of EW trenches 1, 4, and 6 was completed on 9 October 2023 using surging and over-pumping methods. Following initial success as a method for removing fine silts from the filter pack, turbidities did not substantially improve. Redevelopment methods were reevaluated following the October effort, and a redevelopment effort using Hydropuls® (compressed nitrogen gas released in pulses) is planned in early 2024.

Upgrades to the conveyance line infrastructure for are planned Q1 2024 as part of final construction completion and warranty repairs. These upgrades include installing additional cleanouts and reconfiguring the conveyance line connections to EW trenches 5, 6, and 7.

4.1.2 CONCLUSIONS RELATED TO THE TCZOS

Groundwater extraction rates increased compared to historical rates as the groundwater extraction trenches were brought online. Horizontal and vertical gradient analyses during the reporting period indicate that the TCZOs are not being fully achieved as of the end of the reporting period. In Q1 2024, the Intermediate Zone trunk line will be reconfigured to connect to trenches 5, 6, and 7 to increase pumping rates from the southern end of the barrier wall; this realignment will alleviate some of the backpressure observed in the system. Additionally, redevelopment of the groundwater extraction trenches is currently planned for Q1 2024. Following these upgrades, additional progress towards achieving the TCZOs is anticipated in Q2 or Q3 2024.

As higher groundwater extraction rates can be sustained (e.g., greater than or equal to approximately 60 gpm), it is anticipated it will take a period of several months to lower groundwater elevations in the Shallow and Intermediate Zones behind the GWBW such that they are lower than groundwater elevations downgradient of the GWBW in the entire TCZ. Results from the December 2023 MPR, and to a lesser extent the October and November 2023 MPRs, indicate that the groundwater mound on the north end of the GWBW in the vicinity of Trenches 1, 2, and 3 have been substantially dewatered.

Compliance will continue to be monitored with the TCZOs in MPRs in 2024 as well as in the 2024 SEE Report.

5. GROUNDWATER FLOW MODEL

ERM originally a developed three-dimensional groundwater model for LSS to support the design and installation of their GWBW and GWET system. The model has not been approved by all stakeholders for use in evaluating the TCZOs. LSS and the DEQ agreed to rely on empirical data to evaluate the TCZOs, and the DEQ-approved PMP (ERM 2014) was developed based on this principle. Performance of the GW SCM following implementation of additional extraction will continue to be empirically evaluated. The model is, however, a useful tool for simulating how various groundwater extraction systems may perform at the Site with the purpose of achieving the TCZOs.

As ERM discussed in the 2018 SEE (ERM 2018), LSS's current three-dimensional model was calibrated in steady-state and transient conditions to match the individual RW pumping tests that had been conducted at the Site in 2015. The groundwater model was further updated in 2018, and the results were presented in the 2018 SEE. The model was used to evaluate for potential system flows required for hydraulic capture under dry, wet, and average seasonal flow conditions and to evaluate the effects of different RW configurations (e.g., Deep Zone RWs), with respect to meeting the TCZOs.

In 2020 and 2021, LSS's groundwater flow model was updated and utilized to evaluate alternatives for additional groundwater extraction. The updates involved hydraulic conductivity modification and boundary condition updates based on additional data collected during the PDI. ERM completed a high- and low-stage model verification for the conceptual design assessment to produce results reflective of the variable groundwater conditions within the Study Area (ERM 2021b). The model produced simulated groundwater elevations and extraction rates associated with the proposed expanded extraction system operating under steady-state conditions. A detailed description of model updates, verification, and results are discussed in the FDR (ERM 2022b). Based on the groundwater model, an average extraction of 60 gpm is necessary for the GWET system to achieve the TCZOs. Higher flows were projected to be necessary to dewater the groundwater mound that has accumulated behind the GWBW, and as we discussed above, in December 2023, flow rates at trenches 1, 2, and 3 dewatered the groundwater mound that accumulated behind the north end of the GWBW. More time at sustained higher flow rates is necessary to determine the long-term required flow rate to meet operational objectives.

6. SYSTEM OPTIMIZATION

The key objective of the GW SCM is to achieve the TCZOs. LSS took numerous steps in 2023 to meet these goals, as ERM has outlined below.

6.1 GEE PROJECT AND RELATED 2023 EFFORTS

Following the implementation and startup of the extraction trenches in 2022, the GWET system was upgraded and optimized in 2023 to further increase pumping rates, meet design specifications, and mitigate health and safety hazards.

New Grundfos Model 7S05-11 pumps were unavailable for procurement during the initial implementation of the project in 2022. Existing Grundfos Model 7S05-11 pumps were pulled and cleaned onsite from the RWs and then installed them in the new EWs. New Grundfos Model 750-11 pumps had been delivered on 6 April 2023. A torque arrestor and mount arrestor were added to the well pump hoses to prevent damage to the pumps, but this was not included in the specifications within in the FDR.

The EW lids supplied by Odin did not include a gutter system to prevent rainwater from leaking into the vaults. LSS had new vault lids subsequently supplied by Odin and installed them on 26 October 2023. These vault lids are larger in size and allow for easier maintenance access.

During construction in 2022, all EWs were plumbed to the primary conveyance line, previously used for Shallow Zone based RWs (Shallow conveyance line). This conveyance line proved to be undersized, likely due to accumulating minor losses and/or accumulation of sludge in the line, and an event in January 2024 is planned to connect EWs in Trenches 5, 6, and 7 to the currently out-of-use conveyance line for Intermediate Zone based RWs (intermediate conveyance line).

6.2 GWET SYSTEM SHUTDOWNS, MAINTENANCE, AND UPGRADES

The GWET system operated within permit conditions during the reporting period. Shutdowns, maintenance, and upgrades occurred during the reporting period to further optimize the system to meet the TCZOs. Due to the increase of flow rates from the GEE system, solids handling issues arose, decreasing GWET system uptime. The solids handling issues ERM has mentioned below include upsets in the handling of solids in the clarifier, filter press, and solids handling tanks due to variable solids and flowrates coming from new EWs. For brevity, we have referred to all of these issues as "solids handling issues.". Shutdowns and maintenance upgrade activities for 2023 are listed below:

- **10 February 2023:** ERM, on behalf of LSS, shut down the well field due to plate separator maintenance and discharge restarting on 10 February 2023.
- **27 February 2023:** ERM, on behalf of LSS, procured a mini-bulk system for storing coagulant. Previously, frequent tote deliveries were necessary as was manual labor to handle the coagulant. The mini-bulk system has a larger, refillable tank that reduces risk for operators and is more resilient to supply chain issues.
- **16 March 2023:** ERM, on behalf of LSS, shut down the well field due to pressure filter maintenance and restarted discharge on 17 March 2023.

- **17 to 18 March 2023:** ERM, on behalf of LSS, shut down the plant to clean the pressure filter vessels.
- **27 March 2023:** ERM, on behalf of LSS, shut down the well field following initial communications from Eurofins laboratory of elevated DDx concentrations (sum of 2,4- and 4,4-dichloro-diphenyl-dichloroethane, 2,4- and 4,4-dichloro-diphenyl-dichloroethethylene, and 2,4- and 4,4-dichloro-diphenyl-trichloroethane) in the effluent sample from 16 March 2023. Following a second analysis of the sample and investigation by Eurofins, we determined that the effluent detections were a result of cross contamination and were not valid. We restarted discharge on 30 March 2023.
- **4 April 2023:** ERM, on behalf of LSS, shut down the GWET system due to well vault maintenance and restarted discharge on the same day.
- **5 April 2023:** ERM, on behalf of LSS, shut down the GWET system due to pressure filter maintenance and restarted discharge on the same day.
- **18 April to 18 May 2023:** Cochran Electric installed local control panels at the Motor Control Centers to enable connection of legacy RWs to transducers. Cochran performed this work through the remainder of the month of April and into May.
- **22 April 2023:** ERM, on behalf of LSS, shut down the GWET system due to pressure filter maintenance. We notified the DEQ of the shut down and restarted discharge on the same day.
- **4 May 2023:** ERM, on behalf of LSS, shut down the well field due to the system repairs described below and restarted discharge on 16 May 2023.
- **8 to 12 May 2023:** Odin completed well vault plumbing repairs and installed digital flow meters in EW trenches.
- **24 May 2023:** ERM, on behalf of LSS, shut down the GWET system due to chemical pump issues and restarted continuous discharge on 25 May 2023.
- **31 May 2023:** ERM, on behalf of LSS, shut down the GWET system due to solids handling system issues and restarted discharge on the same day.
- **8 June 2023:** ERM, on behalf of LSS, shut down the GWET system due to solids handling system issues and restarted discharge on the same day.
- **29 June 2023:** ERM, on behalf of LSS, shut down the GWET system due to pressure filter maintenance and restarted discharge on the same day.
- **10 July 2023:** ERM, on behalf of LSS, shut down the GWET system due to a failed battery and restarted discharge on 11 July 2023.
- **14 July 2023:** ERM, on behalf of LSS, shut down the GWET system due to pressure filter media changeout and restarted discharge on 23 July 2023.
- **20 August 2023:** ERM, on behalf of LSS, shut down the GWET system due to solids handling maintenance. We notified the DEQ of the shut down and restarted discharge on the same day.
- **22 August 2023:** ERM, on behalf of LSS, shut down the GWET system due to maintenance on the solids handling system. We notified the DEQ of the shut down and restarted discharge on 24 August 2023.

- **21 September 2023:** ERM, on behalf of LSS, shut down the GWET system due to equipment maintenance and restarted discharge on 22 September 2023.
- **2 to 9 October 2023:** Cascade completed redevelopment efforts to EW trenches 1, 4, and 6.
- **16 October 2023:** ERM, on behalf of LSS, shut down the GWET system due to maintenance on the solids handling system and restarted discharge on the same day.
- **10 November 2023:** ERM, on behalf of LSS, shut down the GWET system due to maintenance on the solids handling system and restarted discharge on the same day.
- **14 November 2023:** ERM, on behalf of LSS, shut down the GWET system due to maintenance on the solids handling system and restarted discharge on the same day.
- **29 November 2023:** ERM, on behalf of LSS, shut down the GWET system due to the Tank T-3 level sensor failing and restarted discharge on 4 December 2023.
- **1 December 2023:** ERM, on behalf of LSS, retrofit cleanouts in the wellfield with camlocks.
- **12 December 2023:** ERM, on behalf of LSS, shut down the GWET system due to conveyance line maintenance and restarted discharge on 15 December 2023.
- **13 to 15 December 2023:** Telluric completed line jetting of the Shallow Zone trunk line.

6.3 SYSTEM OPTIMIZATION EFFORTS IN 2023

During the first full year of GEE operations, several optimization efforts were taken to improve GWET plant and well field operations. Increased flow rates from the GEE initially limited operations in the GWET plant, which was resolved through a series of efforts listed in the following.

- Improving solids handlings via dosing trials of coagulant and polymer
- Replacing pressure filter media that fouled due to higher solids concentrations initially seen in the well field
- Modifying pump maintenance schedules due to greater fouling because of higher flow rates at greater solids concentrations
- Redeveloping EWs trenches showing considerable silt build up (trenches 1, 4, and 6)
- Jetting Shallow conveyance line showing considerable backpressures due to solids build up
- Planning to reconnect the intermediate conveyance line to trench 5, 6, and 7 EWs in Q1 2024

6.4 SYSTEM OPTIMIZATION CONCLUSION

EW trench extraction and hydrograph analysis show an increase in groundwater extraction rates compared to the legacy system. Within the Site alluvial sequence, potentiometric maps indicate the GW SCM is producing localized areas of hydraulic capture throughout the TCZ, primarily near the northern end of the GWBW. The analysis of horizontal gradients suggests that gradients are either inward or trending toward inward, primarily GCCs in the Shallow, Intermediate, and Deep Zones. The groundwater extraction flow rate is limited by groundwater elevation, influence of back pressure in the trunk line, and fouling of the EWs within the trenches. Solids handling was resolved in early 2023 through chemical trials, cleaning pressure filters, and replacing media in July 2023. The upgrades planned for 2024 include work to permanently connect three of the trenches to the intermediate trunk line, line jetting the Shallow and Intermediate trunk lines, and redeveloping the trenches. More time at elevated extraction rates is necessary to evaluate whether GWET objectives are being met systemwide. The new EWs will continue to be optimized, including pump maintenance/upgrades, well redevelopment, and trunk lines configuration to meet the TCZOs.

7. ANNUAL GROUNDWATER MONITORING DATA EVALUATION

7.1 GROUNDWATER ANALYTICAL PROGRAM

Quarterly groundwater monitoring was implemented in accordance with the DEQ's 31 May 2019 comments on the 2018 SEE Report (ERM 2018) and subsequent meeting held on 2 July 2019. The table below outlines the sampling and submittal dates related to groundwater monitoring in 2023.

Report	Sampling Dates	Report Submittal Date
2023 Quarter 1	3/6–3/9	6/15/2023
2023 Quarter 2	6/13–6/16	9/21/2023
2023 Quarter 3	8/21–8/24	12/1/2023
2023 Quarter 4	12/10–12/13	3/15/2024

7.2 BACKGROUND

Starting with the 2020 groundwater data collected, included in the 2020 SEE Report, a historical assessment (2007 to 2010) and current (2019 to present) groundwater analytical data in the vicinity of the GWBW has been included as part of this assessment to evaluate changes in groundwater contaminants of concern (COCs) concentrations due to the operation the GWET system between 2014 and present. The statistical evaluation of historical and current groundwater data for the following COCs has been conducted.

- Chloride
- Chlorobenzene
- Hexavalent chromium
- Perchlorate
- DDx (sum of 2,4- and 4,4-dichloro-diphenyl-dichloroethane, 2,4- and 4,4-dichloro-diphenyl-dichloroethethylene, and 2,4- and 4,4-dichloro-diphenyl-trichloroethane)

Following the DEQ's 19 July 2021 review of the GWET System Effectiveness Evaluation (2021 SEE; ERM 2021d), a memorandum was submitted on 9 September 2021 regarding monitoring program modifications. On 14 September 2021, the DEQ approved the reduced monitoring program focusing on areas of potential migration of chlorobenzene, perchlorate, and chloride around the ends of the GWBW in the Shallow, Intermediate, and Deep Zones. This reduced program will be conducted until the TCZOs are met. Table 2 is a matrix summarizing the groundwater monitoring program.

Starting with the 2022 SEE Report, the areas of focus for this evaluation from nine regions to six GCCs has been revised as requested by the DEQ.

ERM has presented the results of the 2023 evaluation in Appendix B, Tables B1 through B7 and has presented the summary of overall trends by GCC, hydrogeological zone, and compound in Table 3. The results, with inclusion of 2023 sample results, are largely consistent with those presented in the 2022 SEE Report. Table 3 highlights changes in statistical trends between 2022 and 2023, and we discuss these further in the sections below.

7.3 STATISTICAL DATA EVALUATION METHODOLOGY

On behalf of LSS, ERM evaluated groundwater analytical data in general accordance with the 2020 data evaluation presented in the 2020 SEE (ERM 2021d) and implemented in it the 2020, 2021, and 2022 SEEs. The hydrogeological zone (Shallow, Intermediate, and Deep Zones) and spatial region relative to the six GCCs presents the evaluation. Figure 4 depicts the sampled monitoring well locations relative to each of the GCCs evaluated.

The following statistical evaluations were performed.

- **Order of Magnitude Change:** Maximum concentrations from the study period (2007 to 2023) were evaluated for the presence of an order of magnitude change between historical (2007 to 2010) and current (2019 to 2023) conditions. This has been categorized as follows.
  - **Increase:** The current concentration was at least an order of magnitude greater than the historical concentration.
  - **Decrease:** The current concentration was at least an order of magnitude less than the historical concentration.
  - **None:** The current concentration was the same order of magnitude as the historical concentration.
  - **N/A:** Either the detection status differs between historical and current concentrations, both concentrations were non-detect, or historical concentrations do not exist.
- **Detect Status Change:** The change in detection status between historical (2007 to 2010) and current (2019 to 2023) data were evaluated. They have been categorized as follows.
  - **Non-Detect to Detect:** The status changed from non-detect to detect.
  - **Detect to Non-Detect:** The status changed from detect to non-detect.
  - **Non-Detect to Detect, High Historical Detection Limit:** The historical detection limit was greater than the current detection.
  - **Detect to Non-Detect, High Current Detection Limit:** The current detection limit was greater than the historical detection.
  - **None:** The same detection status was between historical and current.
  - **N/A:** No historical data was available for comparison.
- **Statistical Trend (Study Period and Current):** Mann-Kendall (MK)trends were calculated at 95 percent confidence with minimum data requirements of at least five detected values and 50 percent detection frequency for the combined study period (2007 to 2023) and current (2019 to 2023) data sets (Appendix C). Guidance recommends that trend tests be performed with at least eight detected data points to allow for a reasonable amount of confidence in results (USEPA 2009), but it is mathematically possible to carry out the test with five detected samples. The consequence of using the minimum sample size is that there is a greater chance of concluding that there is no trend despite there being one (USEPA 2009). If a data set comprises more than 50 percent of non-detect values, the loss of information is considered too great to support a reliable analysis of trends, so an MK test was not performed. The trends have been categorized as follows:
  - **Stable, Increasing, or Decreasing:** The trend criteria was met and calculated.

- **Insufficient Detects or Insufficient Samples or Insufficient Frequency of Detects:** The minimum data requirements were not met and the trend was not calculated.
- **N/A:** No historical data was available for comparison.

7.4 STATISTICAL DATA EVALUATION RESULTS

On behalf of LSS, ERM evaluated chloride, chlorobenzene, and perchlorate concentration trends using study period (2007 to 2023) and current (2019 to 2023) data for each hydrogeological zone (Shallow, Intermediate, and Deep). Additionally, we evaluated concentration trends based upon spatial location relative to the GWBW in GCCs and classified them as follows (Figure 4).

- **GCC1 and Proximal Wells:** This includes four Shallow, three Intermediate, and two Deep Zone wells located between the groundwater treatment plant and the GWBW.
- **GCC2:** This includes two Deep Zone wells located south of GCC1, within and outside of the GWBW.
- **GCC3:** This includes two Deep Zone wells located south of GCC2, within and outside of the GWBW.
- **GCC4 and Proximal Wells:** This includes three Deep Zone wells located south of GCC3, within and outside of the GWBW.
- **GCC5 and Proximal Wells:** This includes three Deep Zone wells located at the most southeast corner of the site, including monitoring wells within and outside of the GWBW.
- **GCC6 and Proximal Wells:** This includes four Shallow, four Intermediate, and two Deep Zone wells located west of GCC5, including monitoring wells within and outside of the GWBW.
- **Wells Distal from the GWBW and GCC:** This includes one Deep Zone well located west of GCC3.

The resulting trend evaluation is presented in Appendix B, Tables B1 through B7 and summarized in Table 3. Appendix D details statistical evaluation results for individual well COCs, including MK test results and sample distribution status.

7.4.1 CHANGES IN TRENDS WITH INCLUSION OF 2023 DATA

The results of the evaluation indicate that limited isolated increases (e.g., order of magnitude increase or calculated increasing trend) are present.

As Table 3 outlines, most concentrations are either stable or decreasing, indicating that there have been no significant lateral or vertical changes in contaminant distribution. The changes in trends resulting from the inclusion of 2023 data are as follows.

- **GCC1 and Proximal Wells:**
  - **Chloride, Deep Zone:** The current stable trend at PA-27D changed to decreasing, and a trend could not be calculated at PA-18D due to insufficient detect results.
  - **Chlorobenzene, Intermediate Zone:** The current stable trend at PA-10I changed to increasing. The concentrations in PA-32I were stable, and a trend could not be calculated at PA-17IR due to insufficient results.

- **GCC2:**
  - **Chlorobenzene, Deep Zone:** The current stable trend at PA-30D (GWBW interior) changed to increasing, and the previously decreasing trend at PA-19D (GWBW exterior) changed to stable.
- **GCC3:**
  - **Chloride, Deep Zone:** The current stable trend at in PA-21D changed to decreasing, and the current increasing trend identified at PA-20D changed to stable.
- **GCC 6 and Proximal Wells:**
  - **Chloride, Deep Zone:** The current stable trend at PA-26D changed to increasing, and PA-25D continues to exhibit a current stable trend.

7.4.2 CHLORIDE AND PERCHLORATE PLUMES

In response to the 2021 SEE (ERM 2021d) and the Q4 2022 Groundwater Monitoring Report (ERM 2023), the DEQ requested further discussion regarding the effectiveness of the GWET system in containing perchlorate, chloride, and chlorobenzene plumes from migrating beneath the GWBW, particularly in the Deep Zone in GCC2 and GCC3.

- **Chlorobenzene:** Concentration trends at most GCCs could not be established, because there were not enough detected results to create a statistical trend. An increasing concentration trend was identified in GCC2 at PA-30D (GWBW interior). Despite the increasing trend at PA-30D, a stable chlorobenzene concentration trend at PA-19D (GWBW exterior) indicates that containment by the GWET and the GWBW is effectively preventing chlorobenzene migration beneath the GWBW towards the river.
- **Chloride:** ERM identified increasing concentration trends in the Deep Zone in GCC2 (PA-19D, GWBW exterior), GCC5 and Proximal Wells (PA-23D, GWBW interior), and GCC6 and Proximal Wells (PA-26D, GWBW exterior). The concentration trends at the complementary deep zone wells on the interior side of the GWBW at GCC2 (PA-30D) and GCC6 and Proximal Wells (PA-25D) have remained stable. The concentration trends at Deep Zone wells on the exterior side of the GWBW at GCC5 and Proximal Wells (MWA-31I[D] and PA-24D) were stable and decreasing, respectively, indicating that the GWBW is effectively preventing chloride migration towards the river. Generally, chloride concentrations in the Shallow, Intermediate, and Deep Zones are stable or decreasing.
- **Perchlorate:** Concentration trends at most GCCs could not be established, because there were not enough detected results to create a statistical trend. The concentrations in the Deep Zone remain primarily non-detect with the exception of a single increasing concentration trend at MWA-56D in the GCC4 region, on the GWBW exterior. The concentration trends continue decreasing at the complementary, interior Deep Zone well PA-22D, indicating that the increasing concentration trend observed at MWA-56D is likely from a proximal source on the exterior side of GCC4. The current concentrations decreased by an order of magnitude compared to historical records, and the concentration trends are stable at MWA-58D (GCC4, GWBW exterior and southeast of MWA-56D), suggesting that the nearby perchlorate plume impacting MWA-56D is not migrating southeast. Generally, the concentration trends in the

Shallow, Intermediate, and Deep Zones could not be established due to insufficient detects apart from one decreasing trend (GCC3) and three stable trends (GCC3, GCC5 and Proximal Wells, and GCC6 and Proximal Wells).

While the inclusion of the 2023 dataset suggests that no significant changes in the horizontal or lateral distribution of the contamination have occurred, additional decreasing concentrations were observed, particularly at GCC3. These decreasing concentration trends along the GWBW in conjunction with groundwater flow depicted on the potentiometric surface maps ERM has included in Appendix A indicate the GWBW is functioning to impede groundwater flow. As noted above, the GWET system is undergoing continuous optimization and upgrades, and is expected to be able to continue to increase groundwater extraction capacity over the legacy RW system. Additional work is being performed to increase extraction capacity to meet the TCZOs in 2024. The limited, isolated increasing trends will be further evaluated as part of the upcoming Data Gaps Investigation and the implementation of Interim Removal Action Measure (IRAM) #1 proposed for the DNAPL in the Acid Plant Area.

8. CONCLUSIONS

8.1 2023 GWET SEE RESULTS

- The GWET system is operating within permit conditions and is effectively treating extracted groundwater prior to discharge to the Willamette River.
- The GWBW is functioning to impede groundwater flow.
- Improvements to the GWET system are continuously being made and will continue through 2024 to maximize treatment capacity, efficacy, and safety.

8.2 GWET SEE GROUNDWATER RECOVERY AND HYDRAULIC MONITORING EQUIPMENT RESULTS

- The groundwater recovery equipment operating limitations related to transducer failure and electrical malfunction were resolved via changes made in 2019, and they continue to be effective.
- The new EWs and trenches installed in 2022 as part of the GEE increased the GWET's ability to remove groundwater within the TCZ, and horizontal gradient trends at the GCCs are either inward or trending toward inward as demonstrated in the MPRs (e.g., achieving or trending towards achieving the TCZOs).
- In order to optimize the average system influent flow rate, the jetting of the Shallow Zone trunk line was completed in December 2023, increasing the operational average flow rate from the prior 33 gpm to 55 gpm. It is expected that the additional optimization efforts ERM has detailed below in 2024 will continue this trend.
- Q1 2024 EW trenches 1, 4, and 6 will be redeveloped to mitigate biofouling and sediment build up within the well screens.
- The Q1 2024 trunk line will be reconfigured to connect Trenches 5, 6, and 7 to the Intermediate Zone conveyance line to mitigate back pressure on pumping rates.

8.3 GROUNDWATER MONITORING DATA EVALUATION RESULTS

- An evaluation of the current groundwater conditions was performed and included the 2023 data to determine if the current GWET system operating conditions were causing changes in the lateral or vertical distribution of contaminants. Per the 2023 data, there were limited changes in statistical trends, as summarized in Section 7.4.1 above. As ERM has indicated above, the limited isolated increasing trends will be further evaluated as part of the upcoming Data Gaps Investigation and the implementation of IRAMs to address the residual source areas, with IRAM #1 (DNAPL in Acid Plant Area) as the top priority for 2024 to 2025. Performance monitoring will continue in accordance with the 2021 agreement with the DEQ.

9. RECOMMENDATIONS

ERM makes the following recommendations with respect to this evaluation of the effectiveness of the GWET system.

- Continue to evaluate EW, RW, and transducer performance and troubleshoot and repair them as necessary to maximize pump uptime and the data collected by the transducers.
- Continue to upgrade the GWET Plant infrastructure and processes to manage the necessary increased flow rates to achieve the TCZOs.
- Complete extraction trench troubleshooting throughout 2024 to maximize trench extraction rates until the TCZOs are achieved. Once the TCZOs are achieved, the flow rates will be reduced to the minimum viable pumping rate necessary to maintain the TCZOs (e.g., maintain inward gradients).

As ERM has outlined in Section 8 above, the annual groundwater monitoring data evaluation concluded that the increasing concentrations have been identified as sporadic, and the overall conclusions are consistent with previous evaluations, which indicate that the mounding behind the GWBW is not causing the significant migration of COCs. Groundwater monitoring will continue as part of the upcoming Data Gaps Investigation and the implementation of IRAMs to address the residual source areas, with IRAM #1 (DNAPL in Acid Plant Area) as the top priority for 2024 to 2025.

10. REFERENCES

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TABLES

Table 1a
Average Monthly Recovery Well Extraction Rates
System Effectiveness Evaluation
Arkema Inc.
Portland, OR

Trench	Well ID	Average Monthly Extraction Rates (gpm)																					
		Feb-23		Mar-23		Apr-23		May-23		Jun-23		Jul-23		Aug-23		Sep-23		Oct-23		Nov-23		Dec-23	
Recovery wells	**RW-14**	1.73	5.93	0.78	3.99	0.83	3.14	0[1]	0.75	0[1]	0.76	0[1]	1.03	0.09	2.68	0.12	1.33	0.15	1.03	0.20	1.27	0.57	2.17
	RW-22	0[1]		0[1]		0[1]		0[1]		0[1]		0[1]		0.07		0.03		0.06		0.09		0.11	
	RW-23	2.61		1.38		0.89		0.75		0.76		1.03		0.74		0.19		0[2]		0[2]		0[2]	
	RW-25	1.59		1.83		1.42		0[1]		0[1]		0[1]		1.78		0.99		0.82		0.98		1.49	
Trench 1	**EW-01**	3.92	4.45	8.05	8.05	7.08	7.22	2.77	4.20	3.42	5.91	3.11	3.19	2.45	2.45	0.54	0.91	0[2]	1.18	0.19	0.97	1.11	1.11
	EW-02	0.53		0[1]		0.14		1.43		2.49		0.08		0[2]		0.37		1.18		0.78		0[2]	
Trench 2	**EW-03**	2.02	6.26	4.11	8.93	5.53	12.21	1.59	3.61	0.16	3.56	0[1]	2.11	1.71	1.90	4.35	9.68	2.20	9.35	5.65	9.81	3.37	9.52
	EW-04	4.24		4.82		6.68		2.02		3.40		2.11		0.19		5.33		7.15		4.16		6.15	
Trench 3	**EW-05**	4.65	9.69	2.40	7.48	0.55	0.55	2.10	3.37	0.91	5.68	4.08	4.24	12.04	13.60	13.88	15.18	14.58	14.58	8.90	11.14	8.01	9.94
	EW-06	5.04		5.08		0[1]		1.27		4.77		0.16		1.56		1.30		0[2]		2.24		1.93	
Trench 4	**EW-07**	1.56	3.85	2.13	2.44	1.49	1.49	3.98	5.49	1.23	4.76	0.48	3.96	4.68	5.25	0.01	2.63	0.03	0.95	0.44	1.98	1.09	2.45
	EW-08	2.29		0.31		0[1]		1.51		3.53		3.48		0.57		2.62		0.92		1.54		1.36	
Trench 5	**EW-09**	5.28	5.81	0.01	0.01	0[1]	0.00	1.65	3.04	0.78	4.65	3.09	4.36	4.89	5.36	2.81	2.81	1.57	1.57	1.04	1.57	1.30	2.05
	EW-10	0.53		0[1]		0[1]		1.39		3.87		1.27		0.47		0[1]		0[2]		0.53		0.75	
Trench 6	**EW-11**	0.97	4.27	0[1]	0.02	0[1]	0.00	1.26	4.53	3.45	3.60	1.84	1.90	0.35	1.29	0.06	0.81	0[2]	0.53	1.24	1.26	1.78	1.83
	EW-12	3.30		0.02		0[1]		3.27		0.15		0.06		0.94		0.75		0.53		0.02		0.05	
Trench 7	**EW-13**	4.99	5.12	5.85	5.85	5.00	5.00	3.90	8.57	0.33	10.72	0.67	7.99	7.65	12.96	4.90	10.20	2.61	7.03	3.32	6.89	1.28	5.75
	EW-14	0.13		0[1]		0[1]		4.67		10.39		7.32		5.31		5.30		4.42		3.57		4.47	
Total Trench Recovery		39.45		32.78		26.47		32.81		38.88		27.75		42.81		42.22		35.19		33.62		32.65	
Total Extraction		45.38		36.77		29.61		33.56		39.64		28.78		45.49		43.55		36.22		34.89		34.82	

Notes:
Shaded cells indicate recovery/extraction well was off
[1]Extraction wells off due to equipment issue
[2]Extraction well off due to low water table

Table 1b
Average Operational Monthly Recovery Well Extraction Rates
System Effectiveness Evaluation
Arkema Inc.
Portland, OR

Trench	Well ID	Average Operational Monthly Extraction Rates (gpm)																					
		Feb-23		Mar-23		Apr-23		May-23		Jun-23		Jul-23		Aug-23		Sep-23		Oct-23		Nov-23		Dec-23	
Recovery wells	RW-14	2.21	7.56	0.84	4.27	1.04	4.09	0[1]	2.63	0[1]	2.09	0[1]	1.52	0.09	2.68	0.12	1.45	0.16	1.09	0.21	1.31	0.77	3.44
	RW-22	0[1]		0[1]		0[1]		0[1]		0[1]		0[1]		0.07		0.03		0.06		0.09		0.37	
	RW-23	3.32		1.47		1.27		2.59		2.09		1.52		0.74		0.31		0[2]		0[2]		0[2]	
	RW-25	2.03		1.96		1.78		0.04		0[1]		0[1]		1.78		0.99		0.87		1.01		2.30	
Trench 1	EW-01	9.97	13.67	8.61	8.61	7.59	9.68	4.29	7.06	5.13	8.69	4.19	5.03	2.53	2.53	1.35	2.03	0.00	1.59	0.95	1.92	1.50	1.50
	EW-02	3.70		0[1]		2.09		2.77		3.56		0.84		0[2]		0.68		1.59		0.97		0[2]	
Trench 2	EW-03	2.57	7.96	4.39	9.54	5.93	13.09	2.46	5.60	2.36	5.76	0[1]	2.85	1.90	3.85	4.35	10.75	3.41	10.56	5.85	10.15	7.47	14.81
	EW-04	5.39		5.15		7.16		3.14		3.40		2.85		1.95		6.40		7.15		4.30		7.34	
Trench 3	EW-05	5.91	12.32	5.31	11.14	3.31	3.31	4.06	6.52	4.57	9.87	5.75	8.30	12.44	16.15	13.88	19.47	14.58	14.58	12.71	18.32	13.79	19.22
	EW-06	6.41		5.83		0[1]		2.46		5.30		2.55		3.71		5.59		0[1]		5.61		5.43	
Trench 4	EW-07	3.64	6.55	5.08	6.98	4.47	4.47	7.70	10.46	6.17	10.09	3.00	8.14	5.01	8.52	0.10	2.81	0.78	2.20	1.45	3.46	2.81	5.45
	EW-08	2.91		1.90		0[1]		2.76		3.92		5.14		3.51		2.71		1.42		2.01		2.64	
Trench 5	EW-09	6.72	8.82	0.35	0.35	0[1]	0.00	3.21	5.89	3.90	8.20	4.17	8.11	5.06	7.95	2.81	2.81	1.57	1.57	1.56	3.15	2.37	4.49
	EW-10	2.10		0[1]		0[1]		2.68		4.30		3.94		2.89		0[1]		0[1]		1.59		2.12	
Trench 6	EW-11	3.88	9.66	0[1]	0.69	0[1]	0.00	2.44	8.78	3.45	5.72	2.48	2.97	1.57	2.74	0.42	1.32	0[1]	1.09	1.28	1.91	2.13	3.75
	EW-12	5.78		0.69		0[1]		6.34		2.27		0.49		1.17		0.90		1.09		0.63		1.62	
Trench 7	EW-13	6.35	6.76	6.26	6.26	6.81	6.81	5.75	14.80	4.92	15.31	2.61	12.47	7.91	14.01	8.64	17.01	5.78	12.64	4.53	8.22	3.06	8.39
	EW-14	0.41		0[1]		0[1]		9.05		10.39		9.86		6.10		8.37		6.86		3.69		5.33	
Total Trench Recovery		65.74		43.57		37.36		59.11		63.64		47.87		55.75		56.20		44.23		47.13		57.61	
Total Extraction		73.30		47.84		41.45		61.74		65.73		49.39		58.43		57.65		45.32		48.44		61.05	

Notes:
Shaded cells indicate recovery/extraction well was off
[1]Extraction wells off due to equipment issue
[2]Extraction well off due to low water table

Table 2
2023 Groundwater Sample Summary
System Effectiveness Evaluation
Arkema Inc. Facility
Portland, OR

Analyte	Chlorobenzene					DDx					Chloride					Perchlorate					Hexavalent Chromium				
Location ID	**Q1 2023**	**Q2 2023**	**Q3 2023**	**Q4 2023**	**Total Samples**	**Q1 2023**	**Q2 2023**	**Q3 2023**	**Q4 2023**	**Total Samples**	**Q1 2023**	**Q2 2023**	**Q3 2023**	**Q4 2023**	**Total Samples**	**Q1 2023**	**Q2 2023**	**Q3 2023**	**Q4 2023**	**Total Samples**	**Q1 2022**	**Q2 2023**	**Q3 2023**	**Q4 2023**	**Total Samples**
MWA-02	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-15r	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-18	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-19	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-20	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-22	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-24	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-29	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-30	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-33	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-40	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-41	--	--	--	--	**0**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
MWA-42	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-46	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-47	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-61	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
MWA-63	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
MWA-69	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	X	--	--	--	**1**	--	--	--	--	**0**
MWA-82	--	--	--	--	**0**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-03	--	--	--	--	**0**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-04	--	--	--	--	**0**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-05	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
PA-06	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
PA-07	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
PA-08	--	--	--	--	**0**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-09	--	--	--	--	**0**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-28	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
PA-31	--	--	--	--	**0**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-36	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
PA-38	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--		**0**	--	--	--	--	**0**
PA-42	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--		**0**	--	--	--	--	**0**
MWA-08i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--		**0**	--	--	--	--	**0**
MWA-32i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--		**0**	--	--	--	--	**0**
MWA-34i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--		**0**	--	--	--	--	**0**
MWA-49i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--		**0**	--	--	--	--	**0**
MWA-51i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--		**0**	--	--	--	--	**0**
MWA-53i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--		**0**	--	--	--	--	**0**
MWA-54i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--		**0**	--	--	--	--	**0**
MWA-64i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--		**0**	--	--	--	--	**0**
MWA-66i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--		**0**	--	--	--	--	**0**
MWA-70i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--		**0**	--	--	--	--	**0**
MWA-81i	--	--	--	--	**0**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-10i	--	--	--	--	**0**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-11i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
PA-12i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
PA-13i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
PA-14i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
PA-15i	--	--	--	--	**0**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-16i	--	--	--	--	**0**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-17iR	--	--	--	--	**0**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-29i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
PA-32i	--	--	--	--	**0**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-37i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
PA-39i	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**	--	--	--	--	**0**
PA-44i	--	--	--	--	**0**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
MWA-11i(d)	--	--	--	--	**0**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
MWA-31i(d)	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
MWA-56d	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
MWA-58d	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-18d	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-19d	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-20d	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-21d	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-22d	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-23d	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-24d	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-25d	--	--	--	--	**0**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-26d	--	--	--	--	**0**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-27d	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**
PA-30d	X	X	X	X	**4**	--	--	--	--	**0**	X	X	X	X	**4**	X	X	X	X	**4**	--	--	--	--	**0**

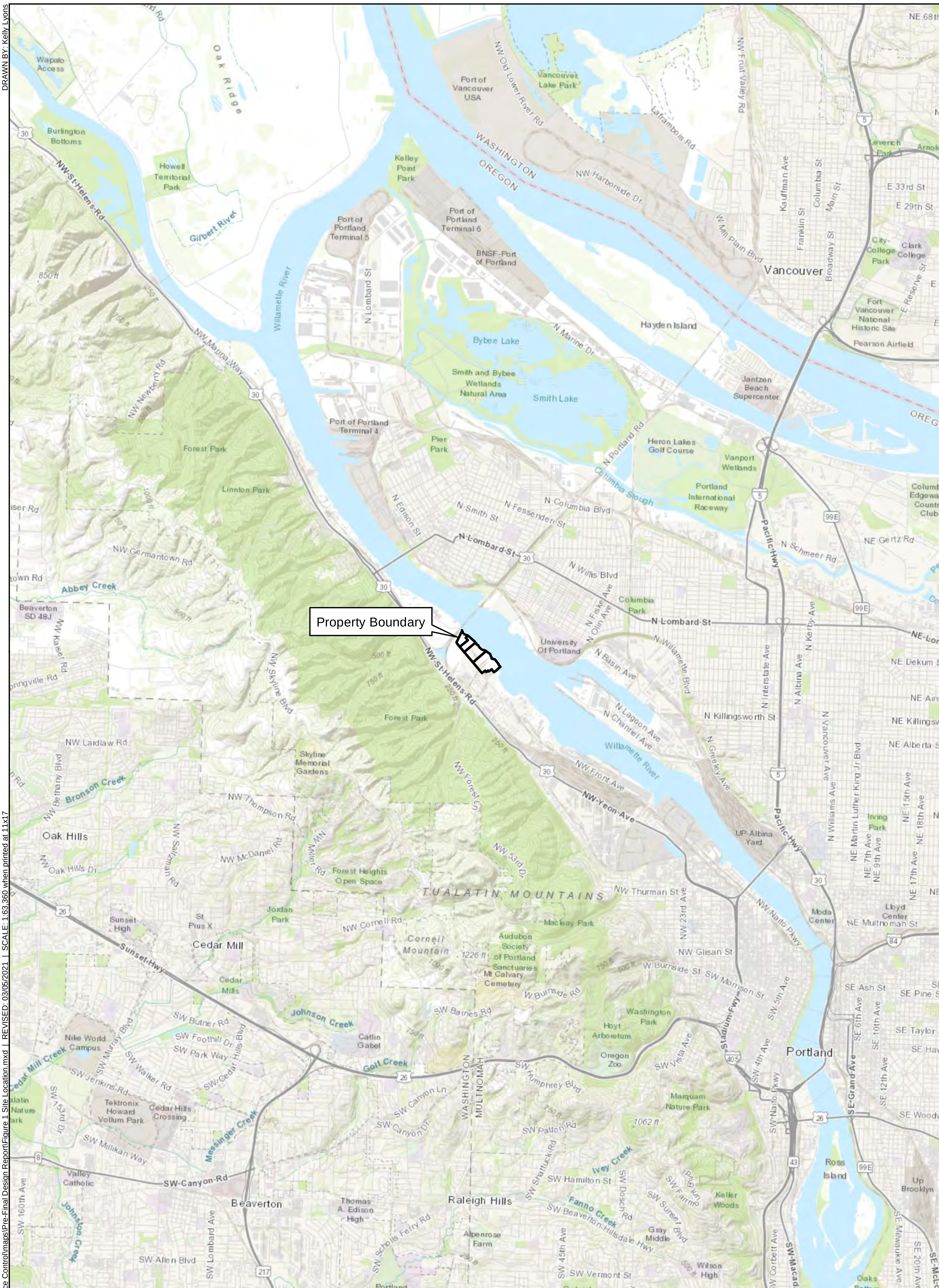
Table 3
Groundwater Concentration Trend Summary (Gradient Control Cluster, Hydrogeological Zone, and Compound)
System Effectiveness Evaluation
Arkema Inc.
Portland, OR

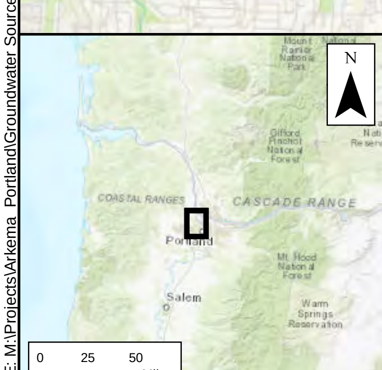
Region	Hydrogeological Zone (# of wells)	Chloride		Chlorobenzene		Perchlorate	
		Statistical Evaluation Results	Notes	Statistical Evaluation Results	Notes	Statistical Evaluation Results	Notes
GCC1 and Proximal Wells Historical data limited to MWA - 63	*Shallow (4)*	**Current decreasing trend (PA-03, PA-04, PA-31).** Current chloride concentration trend at MWA-63 is stable with a decreasing Study Period trend, with an overall order of magnitude decrease in concentration over the Study Period.		Trend could not be calculated due to insufficient detect results.		Trend could not be calculated due to insufficient detect results.	
	Intermediate (3)	**Current decreasing trend (PA-10I, PA-17IR, PA-32I).**		**Increasing Current Trend (PA-10I).** Current chlorobenzene concentration at PA-32I is stable. Trend could not be calculated at PA-17IR due to insufficient detects.	PA-10I concentrations increased from 0.37 to 5.7 µg/L between 2019 and 2023	Trend could not be calculated due to insufficient detect results.	
	Deep (2)	**Current Decreasing trend (PA-27D).** Trend could not be calculated at PA-18D due to insufficient detect results		Trend could not be calculated due to insufficient detect results.		Trend could not be calculated due to insufficient detect results.	
GCC2 Historical data data not available	*Deep (2)*	**Increasing Current Trend (PA-19D).** Current chloride concentration trend at PA-30D is stable.	PA-19D current concentrations increased from 94,000 to 360,000 µg/L between 2019 and 2023	**Current increasing trend (PA-30D).** Current concentration trend at PA-19D is stable.	PA-30D current concentration increased from 3,500 to 26,000 µg/L between 2019 and 2023.	Trend could not be calculated due to insufficient detect results.	
GCC3 Historical data not available	*Deep (2)*	**Current decreasing trend (PA-21D).** Current chloride concentration at PA-20D is stable.		**Current decreasing trend (PA-20D and PA-21D)**		**Current decreasing trend (PA-21D).** Current chloride concentration at PA-20D is stable.	
GCC4 and Proximal Wells Historical data limited to MWA-56D and MWA-58D	*Deep (3)*	**Current trends are decreasing (MWA-56D and PA-22D).** MWA-58D has a stable current trend and, along with MWA-56D, displays a decreasing study period trend.		Trend could not be calculated due to insufficient detect results.		**Order of magnitude concentration increase from historical to current period identified at MWA-56D.** Current and Study Period trends are increasing at MWA-56D. Decreasing current trend identified at PA-22D. Stable current and study period trend and order of magnitude decrease in concentration from historical to current period at MWA-58D.	MWA-56D perchlorate concentration is an order of magnitude greater (2,430 to 15,000 µg/L) than historical max.
GCC5 and Proximal Wells Historical data limited to MWA-31I(D)	*Deep (3)*	**Decreasing current trend (PA-24D).** PA-23D has a an increasing current trend. MWA-31I(D) displays a stable current and decreasing study period trend.	PA-23D Chloride concentrations increased from 12,500 to 30,000,000 between 2019 and 2023	Trend could not be calculated due to insufficient detect results.		**Order of magnitude concentration increase from historical to current period identified at MWA-31I(D).** Study Period and current trends remain stable at MWA-31I(D). Trends could not be established for remaining wells in well cluster due to insufficient detect results.	MWA-31I(D) current perchlorate concentration is an order of magnitude greater (5,730 to 100,000 µg/L) than historical max.
GCC6 and Proximal Wells Historical data limited to MWA-41	*Shallow (4)*	Current trends are stable, with the exception of MWA-82 that has a decreasing current trend and MWA-41 which displays a decreasing Study Period trend.		Trend could not be calculated due to insufficient detect results.		Trend could not be calculated due to insufficient detect results except for stable current trend at MWA-82.	
	Intermediate (4)	Current stable trend, with exception of PA-44I that has a decreasing current trend.		Trend could not be calculated due to insufficient detect results.		Trend could not be calculated due to insufficient detect results.	
	Deep (2)	**Increasing current trend (PA-26D).** PA-25D has stable current trend.	PA-26D current concentrations increased from 6,500 to 74,000 µg/L between 2019 and 2023	Trend could not be calculated due to insufficient detect results.		Trend could not be calculated due to insufficient detect results.	
Wells Distal from GWBW and GCCs Historical data available for MWA-11I(D)	*Deep (1)*	Current and Study Period trends are stable.		Current and Study Period trends are stable.		Trend could not be calculated due to insufficient detect results.	
Riverside South	*Shallow (3)*	Concentrations have decreased by at least an order of magnitude and/or are stable or Trend could not be calculated due to insufficient detect results.		Either insufficient detections - trend could not be calculated due to a high number of non-detect results (MWA-29 and MWA-47). Insufficient samples for calculation of current statistical trend (MWA-30).		Either insufficient detections - trend could not be calculated due to a high number of non-detect results (MWA-29 and MWA-47). Insufficient samples for calculation of current statistical trend (MWA-30).	
	Intermediate (3)	Concentrations have decreased by at least an order of magnitude and/or are stable or decreasing.		Insufficient detections - Trend could not be calculated due to insufficient detect results.		Insufficient detections - Trend could not be calculated due to insufficient detect results.	
	Deep (2)	Current and Study Periodal stable trend.		Insufficient detections - Trend could not be calculated due to insufficient detect results.		**Order of magnitude increase/stable trend (MWA-31I(D)).** Maximum concentrations increased from 5,730 to 100,000 µg/L between 2007 to 2021.	Maximum perchlorate concentrations increased by two orders of magnitude between 2007 and 2021; however, current concentrations are stable due to fluctuations in concentrations between 2019 and 2021.
Upgradient Interior	*Shallow (3)*	Current and Study Periodal stable trend with exception of MWA-33 (decreasing).		Concentrations stable or Trend could not be calculated due to insufficient detect results.		Insufficient detections - Trend could not be calculated due to insufficient detect results.	
	Intermediate (1)	Current and Study Periodal stable trend.		Insufficient detections - Trend could not be calculated due to insufficient detect results.		Insufficient detections - Trend could not be calculated due to insufficient detect results.	

Notes:
Change in trend(s) to increasing with inclusion of 2023 data set
Change in trend(s) to stable or decreasing with inclusion of 2023 data set
Order of magnitude increase: The current concentration is at least an order of magnitude greater than the maximum historical concentration, and Study Period concentration trends are increasing.
Increasing concentrations - **no change from 2022 results**
Decreasing, stable, or primarily non-detect concentrations - **no change from 2022 results**
Order of magnitude increase: The current concentration is at least an order of magnitude greater than the maximum historical concentration. Current and Study Period concentration trends are stable - **no change from 2022 results**
Insufficient number of samples collected for calculation of trend (no color)
Historical Period includes dates from 2007 - 2010
Study Period includes dates from 2007 - Q4 2023
Current Period includes dates from Q4 2019 - Q4 2023

ERM

FIGURES





Legend

— Parcel and Property Boundaries

N

0 1 2

Miles

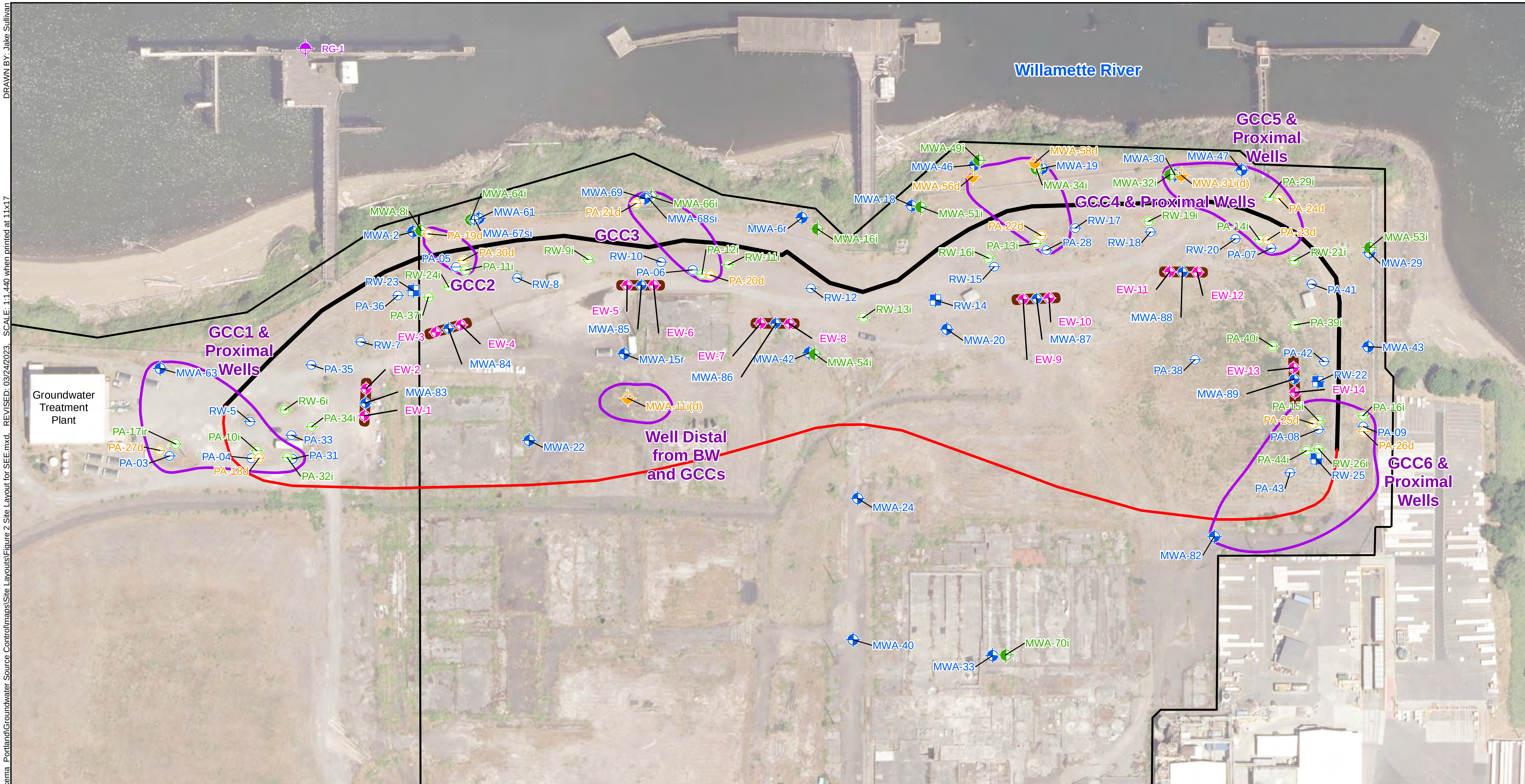
Figure 1
Site Location
System Effectiveness Evaluation
Groundwater Source Control Measure
Former Arkema Inc. Facility Portland, Oregon

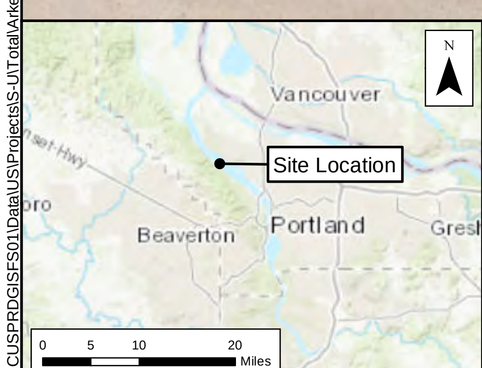
Environmental Resources Management
www.erm.com
ERM

Source: Esri - World Topoographic Map; NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

DRAWN BY: Kelly Lyons

FILE: M:\Projects\Arkema_Portland\Groundwater Source Control\maps\Pre-Final Design Report\Figure 1 Site Location.mxd | REVISED: 03/05/2021 | SCALE: 1:63,360 when printed at 11x17





Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Shallow Zone Recovery Well
- Intermediate Zone Recovery Well
- River Gauge
- Trench Extraction Well
- Target Capture Zone
- Barrier Wall Alignment
- Parcel and Property Boundaries
- gradientclusters
- Extraction Trench (Not To Scale)

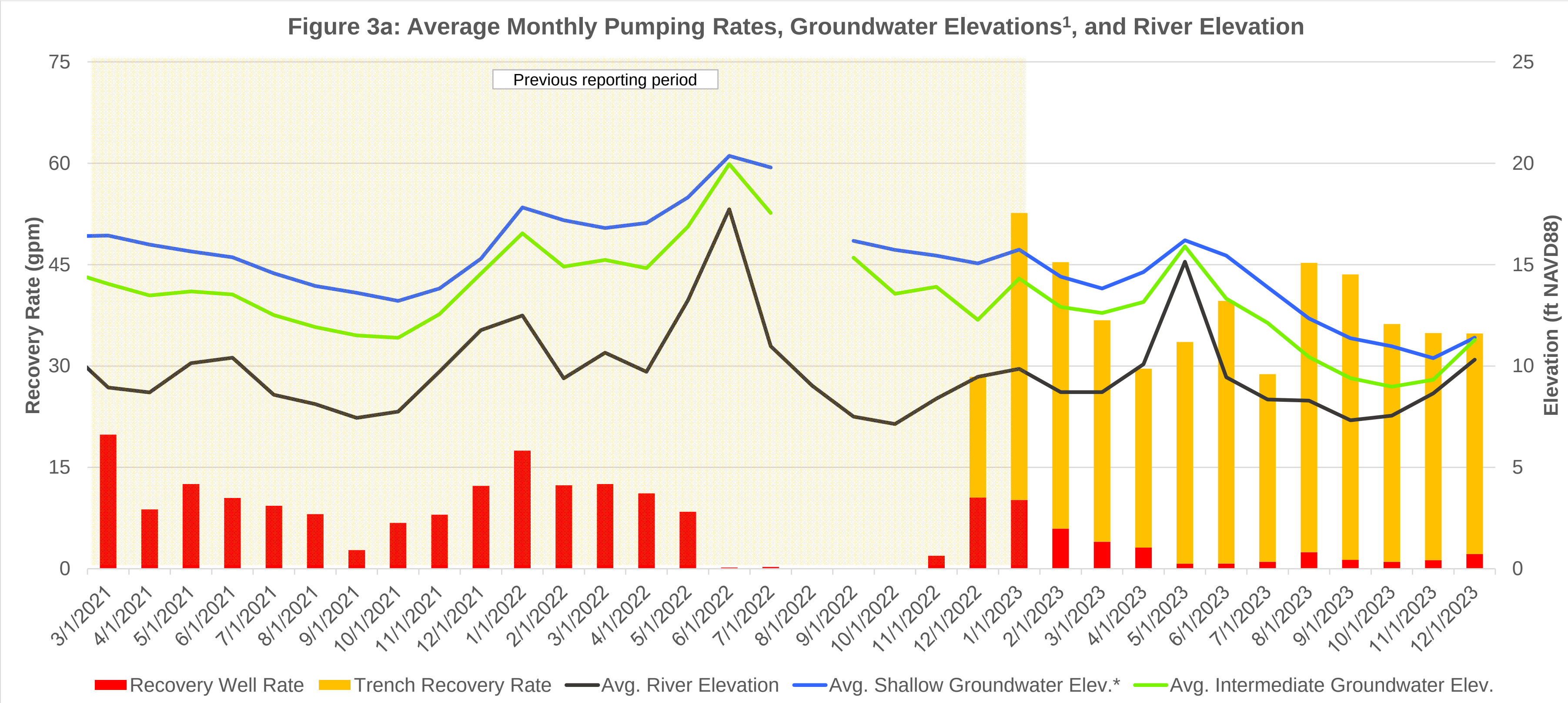
0 120 240
Feet

Figure 2
Site Layout
System Effectiveness Evaluation
Groundwater Source Control Measure
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

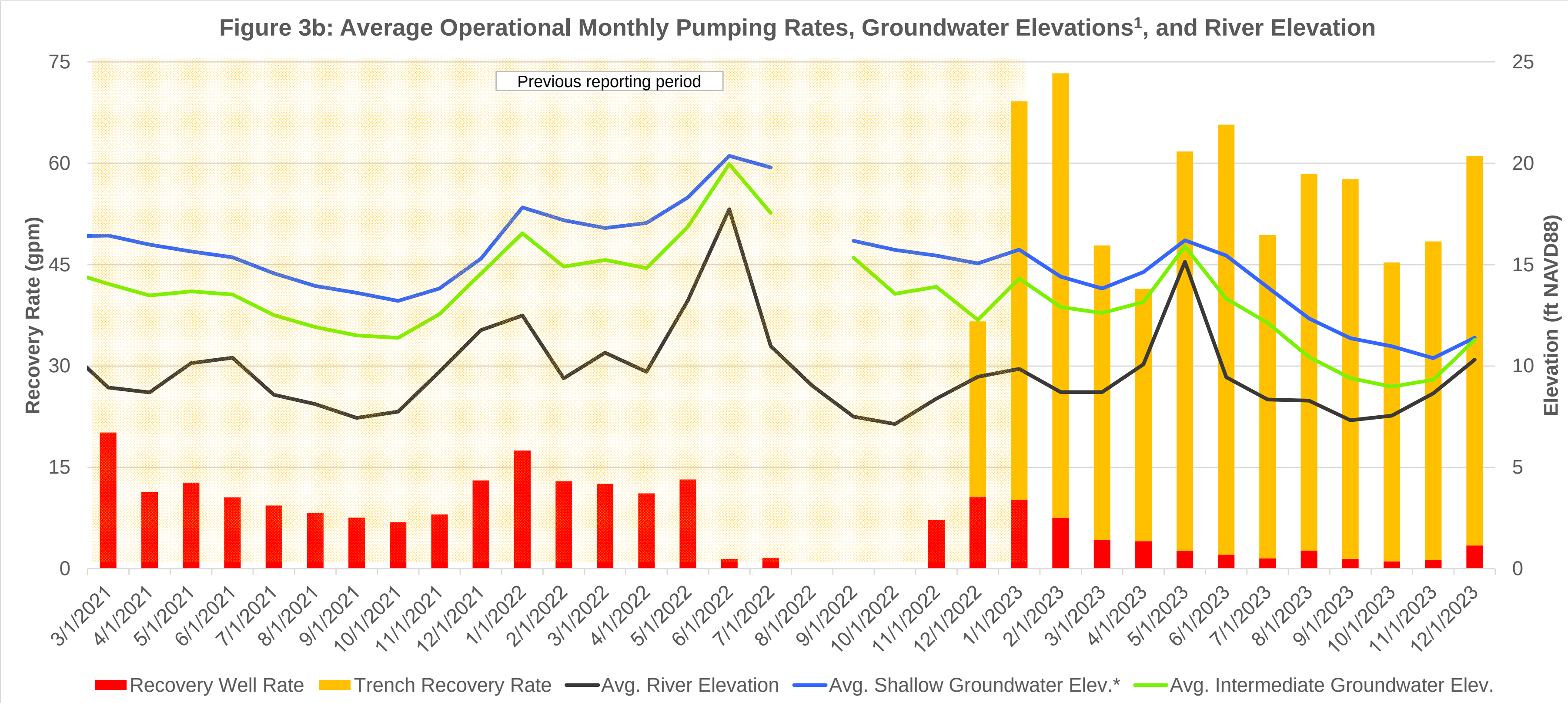
\\SCUSPRDGISFS01\Data\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\Site Layouts\Figure 2 Site Layout for SEE.mxd REVISED: 03/24/2023 SCALE: 1:1,440 when printed at 11x17 DRAWN BY: Jake Sullivan

Source: City of Portland Aerial Imagery, flown Summer 2021; NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



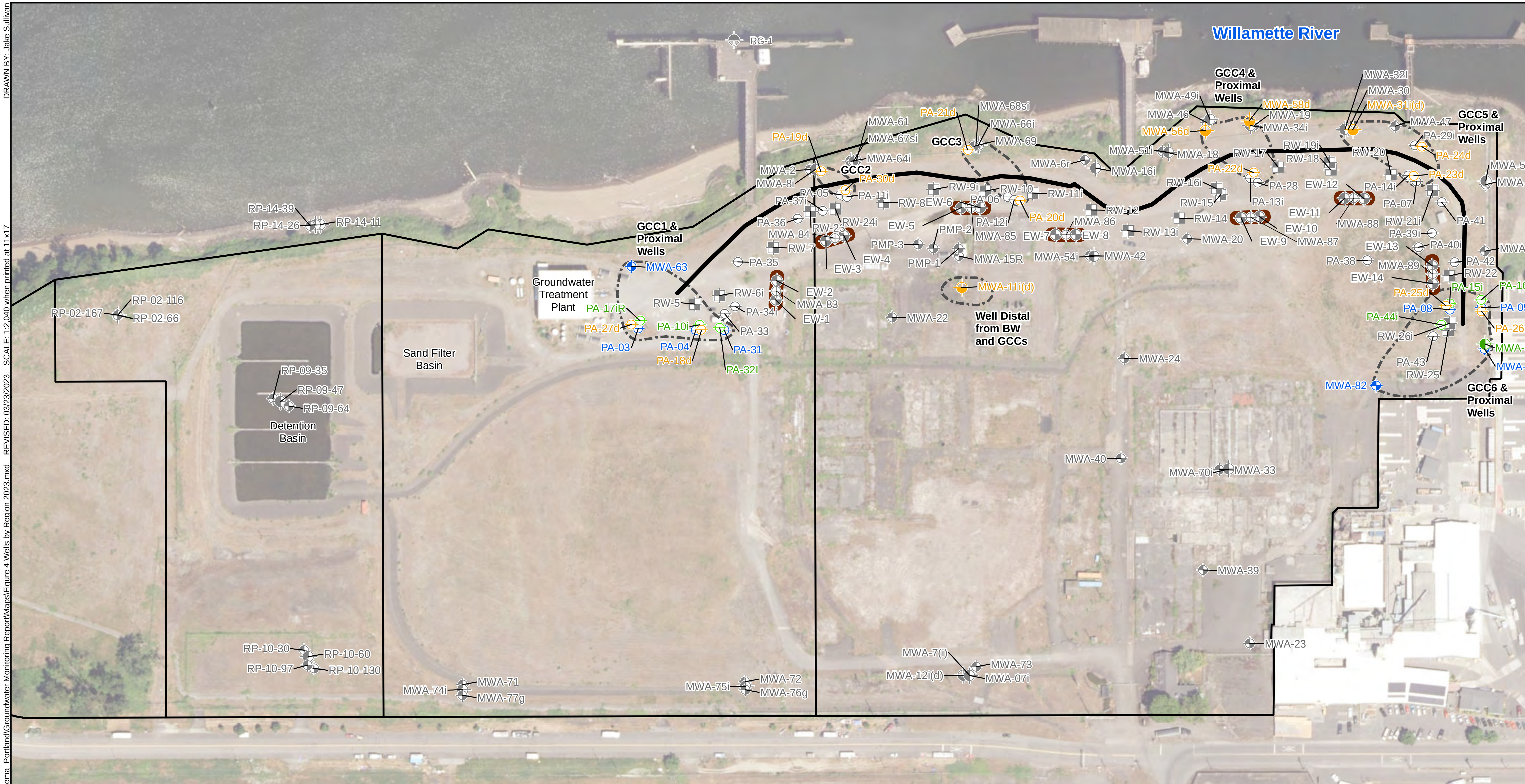
[1] Average groundwater elevations during trench construction from July through October were caculated using data sourced from manual and transducer values, dependent on data variablity and accuracy. Transdcuers were off for August 2022 and no manual water levels were recorded.

*The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the whole aquifer.



[1] Average groundwater elevations during trench construction from July through October were caculated using data sourced from manual and transducer values, dependent on data variablity and accuracy. Transdcuers were off for August 2022 and no manual water levels were recorded.

*The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the whole aquifer.



\\SCUSPRDGISFS01\Data\US\Projects\S-U\Total\Arkema_Portland\Groundwater Monitoring Report\Maps\Figure 4 Wells by Region 2023.mxd REVISED: 03/23/2023 SCALE: 1:2,040 when printed at 11x17 DRAWN BY: Jake Sullivan

Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Monitoring Well, Deep
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Piezometer, Deep
- River Gauge
- Shallow-Intermediate Zone Monitoring Well
- Extraction Trench (Not To Scale)
- Barrier Wall Alignment
- Parcel and Property Boundaries
- Well Regions

Notes:
Greyed out locations not sampled.
GCC = Gradient Control Cluster.
GWBW = Ground water barrier wall.

N

0 170 340
Feet

Figure 4
Wells by Region
System Effectiveness Evaluation
Groundwater Source Control Measure
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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Source: City of Portland Aerial Imagery, flown Summer 2021; NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl

ERM

APPENDIX A POTENTIOMETRIC SURFACE AND VERTICAL DIFFERENCE MAPS AND HORIZONTAL AND VERTICAL GRADIENT HYDROGRAPHS

ERM

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Memo

To	Katie Daugherty, Oregon Department of Environmental Quality
From	Brendan Robinson, PE, ERM-West, Inc.
Date	15 March 2023
Reference	0682894 Phase 204
Subject	January 2023 GW SCM Monthly Performance Monitoring Report

1. INTRODUCTION

ERM-West, Inc. (ERM) prepared this Monthly Performance Monitoring Report (MPR) on behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc. (Arkema), for the former Arkema Portland Plant (the Site) at 6400 NW Front Avenue in Portland, Oregon. The Oregon Department of Environmental Quality (ODEQ), in its letter dated 31 May 2019 and in the subsequent meeting with LSS and ERM on 2 July 2019, requested that LSS initiate monthly status reports associated with the onsite groundwater source control measure (GW SCM) consistent with the Performance Monitoring Plan (PMP; ERM 2014) beginning July 2019. The 2014 PMP was prepared pursuant to the Order on Consent issued by ODEQ, signed on 31 October 2008 (ODEQ No. LQVC-NWR-08-04; Consent Order). The purpose of the PMP was to present the monitoring, reporting, and adaptive management processes used during implementation of the GW SCM. On 30 November 2021, ODEQ directed LSS that following the October 2021 MPR, MPRs would be suspended pending the implementation of the Groundwater Extraction Enhancement (GEE) system in 2022. During that time, ODEQ requested monthly schedule updates in lieu of MPRs. The GEE system was started on 27 November 2022, and MPR writing restarted in December 2022. The purpose of the GEE system is to install new extraction capacity to achieve the Capture Zone Objectives.

This January 2023 MPR summarizes the GW SCM performance monitoring data collected in January 2023. This report assesses the current gradient status and proposes system improvements to meet the Capture Zone Objectives set in the PMP.

2. GROUNDWATER SOURCE CONTROL IMPLEMENTATION

A detailed description of the design and implementation of the GW SCM is provided in the *Revised Upland Feasibility Study Work Plan* (ERM 2017); however, a brief description of the GW SCM is provided here. In February 2009, ODEQ and the U.S. Environmental Protection Agency (USEPA) approved the general approach for the GW SCM. This approach included installation of a groundwater barrier wall (GWBW), groundwater recovery wells, and a Groundwater Extraction and Treatment (GWET) system, with treated water discharged to the Willamette River. ODEQ and USEPA approved the *Groundwater Barrier Wall Final Design* (ERM 2012) on 7 August 2012. Construction of the GWBW began in May 2012 and was completed in December 2012. ODEQ approved the *Groundwater Extraction and Treatment System Final Design* (ERM 2013) on 2 April

2013. Construction of the GWET system began in December 2012 and was completed in December 2013.

GWET startup and optimization commenced in May 2014. The GW SCM at the Site consists of the following primary components (Figure 1):

1. A GWBW to physically separate the affected upland portions and in-water portions of the Site.

2. Hydraulic control to minimize flow of groundwater containing unacceptable concentrations of constituents of potential concern (COPCs) around, over, and under the GWBW.

3. Management of extracted groundwater through the GWET system, with treated effluent discharged to the Willamette River under a National Pollutant Discharge Elimination System (NPDES) Permit.

On 1 September 2018, ERM submitted the *Draft GWET System Effectiveness Evaluation* (Draft SEE Report; ERM 2018). The Draft SEE Report provided an update on the corrective actions implemented to improve the performance of the GWET system, evaluate the extent of capture, and propose actions to improve hydraulic capture. Additional data requested by ODEQ were submitted on 26 October 2018.

The key objective of the GW SCM is to achieve hydraulic containment of the alluvial sequence within the Target Capture Zone at the Site to prevent the flow of COPCs to the Willamette River. The Site alluvial aquifer sequence within the Target Capture Zone consists of the Shallow Zone, Intermediate Zone, and the Deep Zone. Site hydraulic conditions are variable and subject to both seasonal and daily tidal fluctuations.

The hydraulic control component formerly consisted of 22 recovery wells (RWs) prior to the implementation of the GEE. Of the 22 pre-existing RWs, four were retained for active pumping. The remaining 18 former RWs had pumps removed but will retain their pressure transducers so that they can continuously collect high-resolution groundwater elevation data. The 18 former RW pressure transducers are currently unable to be connected to the rest of the system until additional upgrades are performed that are currently planned for Q2 2023. The hydraulic control system now consists of the four remaining active RWs, as well as seven groundwater extraction trenches that each contain two extraction wells (EWs). Each trench is 50 feet deep, 50 feet long, and 3 feet wide and is filled with an engineered backfill. More information about the groundwater extraction trenches is provided in the *Final Design Report* (ERM 2022). The gradient control-monitoring network consisting of six gradient control clusters (GCCs) with each cluster containing six monitoring points. Within each RW, EW, and GCC location, pressure transducers are continuously collecting high-resolution groundwater elevation data. Each GCC contains three transducers interior to the wall and three transducers exterior to the wall screened in the Shallow, Intermediate, and Deep aquifers at the Site.

3. HYDRAULIC CONTAINMENT MONITORING PROGRAM

As described in the PMP, the purpose of hydraulic monitoring (i.e., groundwater elevation data) is to provide sufficient data to demonstrate an inward hydraulic gradient across the GWBW and to evaluate the effective hydraulic capture produced by the GW SCM.

Monitoring requirements were established in the PMP to demonstrate GWET effectiveness. The Site monitoring program includes groundwater elevation data (manual and transducer measurements) collected from the 36 monitoring points located within six GCCs spaced across the GWBW, with piezometers interior and exterior to the wall, throughout the alluvial sequence; and groundwater elevation and flow rate data from the four remaining active RWs and 14 EWs. High-resolution groundwater elevation data (transducer measurements) will be possible from the 18 inactive RWs that will no longer be operated, but will have transducers, after electrical upgrades are performed in 2023. Additionally, one new monitoring well was installed in each of the seven extraction trenches for manual water level measurement. These data were used to prepare horizontal and vertical potentiometric surface maps representing potentiometric differences between the alluvial sequences, and to generate spatial and temporal hydrographs to evaluate hydraulic capture.

3.1 Groundwater Elevation Monitoring

Groundwater elevation monitoring was completed on 13 January 2023. Manual groundwater elevations were measured at wells that were experiencing transducer mechanical issues or that were offline during the groundwater elevation measurement event. Manual groundwater elevation measurements were completed for all inactive RWs used. Manual water level measurements for these wells were completed to evaluate transducer data accuracy. Specific issues are addressed in Attachment A-1.

As detailed in Attachments A-1 and A-2, during January 2023, the following transducers were:

<u>Awaiting system upgrades for transducer re-installation:</u>

- RW-05
- RW-06i
- RW-07
- RW-08
- RW-09i
- RW-10
- RW-11i
- RW-12
- RW-13i
- RW-15
- RW-16i
- RW-17

- RW-18
- RW-19i
- RW-20
- RW-21i
- RW-24i
- RW-26i

Fully out of service pending repairs:

- PA-20d
- PA-07
- PA-26d
- PA-16i

Out of service for less than 1 day:

- PA-21d
- PA-25d

All other transducers were operational during the entire month of January except for a brief power outage on 16 January that caused transducers to be inactive. Transducers that are fully out of service pending repairs are awaiting new transducers that have already been ordered but are backordered. They are expected to be replaced in April 2023.

3.2 Horizontal and Vertical Gradients at Gradient Control Points

As described above, GCC locations collect high-resolution groundwater elevation data using transducers. Transducer data are filtered to remove anomalous data from monitoring points due to potential equipment failures, such as transducer malfunctions, power outages, or updates to the GWET programmable logic controller (PLC) system, which controls and houses all the operational data. These specific issues and time periods are summarized in Table A-1 in Attachment A. The following flags are applied to filter anomalous data:

- Groundwater elevations had a change greater than 1.5 feet within 1 hour
- Groundwater elevation measurements that were found to be greater than 50 feet, or less than 1 foot
- Calculated groundwater elevation slope indicates no change between consecutive measurements indicating a transducer malfunction
- Manually flagging data that are inconsistent with the typical nature of the well

- Periods where transducer power supply was deactivated for work on interconnected electrical systems

After January 2023 flagged data were removed, the Serfes (1991) method was used to account for tidal variations as described in the PMP. Using Serfes corrected data, both horizontal and vertical gradients were calculated and plotted over time (Attachment B). Groundwater elevations, horizontal gradients, and vertical gradients from 13 January 2023 are shown below at each GCC (Table 1-1 and Table 1-2).

Table 1-1. January Horizontal Gradients

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
GCC1	Shallow	PA-03	30.37	PA-04	30.87	-0.005
	Intermediate	PA-17iR	14.35	PA-10i	15.84	-0.014
	Deep	PA-27d	13.57	PA-18d	14.28	-0.006
GCC2	Shallow	MWA-2	11.60	PA-05	15.89	-0.063
	Intermediate	MWA-8i	11.70	PA-11i	15.37	-0.050
	Deep	PA-19d	10.62	PA-30d	13.20	-0.048
GCC3	Shallow	MWA-69	12.11	PA-06	16.78	-0.044
	Intermediate	MWA-66i	11.49	PA-12i	16.90	-0.048
	Deep	PA-21d	10.93	PA-20d [M]	13.07	-0.017
GCC4	Shallow	MWA-19	11.50	PA-28	16.29	-0.047
	Intermediate	MWA-34i	13.49	PA-13i	12.91	0.006
	Deep	MWA-58d	11.25	PA-22d	12.49	-0.014
GCC5	Shallow	MWA-47	12.71	PA-07 [M]	15.05	-0.023
	Intermediate	PA-29i	11.10	PA-14i	12.78	-0.031
	Deep	PA-24d	10.34	PA-23d	13.34	-0.057
GCC6	Shallow	PA-09	13.18	PA-08	14.30	-0.020
	Intermediate	PA-16i [M]	12.48	PA-15i	13.23	-0.014
	Deep	PA-26d [M]	12.99	PA-25d	13.60	-0.010

Notes:

Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.

Horizontal gradient calculated as (Exterior Elevation – Interior Elevation) / Horizontal distance.

ft NAVD88 = feet North American Vertical Datum of 1988

[M] = manual groundwater elevation measurement

Table 1-2. December Vertical Gradients

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
Interior	SZ-IZ	GCC1	PA-04	30.87	PA-10i	15.84	1.02
		GCC2	PA-05	15.89	PA-11i	15.37	-0.01
		GCC3	PA-06	16.78	PA-12i	16.90	0.04
		GCC4	PA-28	16.29	PA-13i	12.91	-0.22
		GCC5	PA-07 ^{M}	15.05	PA-14i	12.78	0.13
		GCC6	PA-08	14.30	PA-15i	13.23	0.05
	IZ-DZ	GCC1	PA-10i	15.84	PA-18d	14.28	0.12
		GCC2	PA-11i	15.37	PA-30d	13.20	0.70
		GCC3	PA-12i	16.90	PA-20d ^{M}	13.07	0.04
		GCC4	PA-13i	12.91	PA-22d	12.49	0.10
		GCC5	PA-14i	12.78	PA-23d	13.34	0.02
		GCC6	PA-15i	13.23	PA-25d	13.60	-0.01
Exterior	SZ-IZ	GCC1	PA-03	30.37	PA-17iR	14.35	1.52
		GCC2	MWA-2	11.60	MWA-8i	11.70	0.05
		GCC3	MWA-69	12.11	MWA-66i	11.49	-0.01
		GCC4	MWA-19	11.50	MWA-34i	13.49	0.53
		GCC5	MWA-47	12.71	PA-29i	11.10	0.24
		GCC6	PA-09	13.18	PA-16i ^{M}	12.48	0.079
	IZ-DZ	GCC1	PA-17iR	14.35	PA-27d	13.57	0.21
		GCC2	MWA-8i	11.70	PA-19d	10.62	0.31
		GCC3	MWA-66i	11.49	PA-21d	10.93	0.19
		GCC4	MWA-34i	13.49	MWA-58d	11.25	0.02
		GCC5	PA-29i	11.10	PA-24d	10.34	-0.01
		GCC6	PA-16i ^{M}	12.48	PA-26d ^{M}	12.99	-0.01

Notes:

Positive vertical gradient indicates a downward hydraulic gradient.

Vertical gradient calculated as (Upper Elevation – Lower Elevation) / Screen Midpoint distance.

ft NAVD88 = feet North American Vertical Datum of 1988

SZ = Shallow Zone

IZ = Intermediate Zone

DZ = Deep Zone

^{M} = manual groundwater elevation measurement

3.3 Potentiometric Surface, Groundwater Elevation Difference Maps, and Groundwater Flow Directions

As described in the PMP, potentiometric surface maps are used to evaluate flow paths. Vertical gradients are also used as an additional line of evidence to evaluate hydraulic containment. Groundwater elevation data collected on 13 January 2023 were used to prepare potentiometric surface maps based on manual measurements and averaged transducer groundwater elevations (Figures 2 through 4) and vertical difference maps (Figures 5 and 6).

The generalized flow direction indicated by the potentiometric surface maps show overall groundwater flow toward the GWBW. The Shallow and Intermediate Zones potentiometric maps (Figures 2 and 3) indicate localized groundwater movement to some of the extraction trenches due to GW SCM pumping. Only some of the EWs were active at the time of the water level event, and some still have only been operating for a short time. However, initial results show that a slight cone of depression has been generated at the trench wells that had been on for the longest period and at the highest rate leading up to the groundwater level gauging event (e.g., EW-11 and EW-12). Additionally, for wells that were not in operation for a long period, slight groundwater depressions are shown on Figures 2 and 3.

A potentiometric separation is still noticeable exterior to the GWBW, indicating the barrier wall is functioning by impeding groundwater flow. The Deep Zone potentiometric map also indicates flow toward the GWBW (Figure 4). River elevations are shown on the potentiometric surface maps in an inset (Figures 2 through 4) and depict stage movement within the month corresponding with the MPR. Vertical gradients were calculated for each vertical well pair using these groundwater elevations and are plotted on Figures 5 and 6.

Vertical groundwater gradients interior to the GWBW between the Shallow and Intermediate Zones were mixed in January 2023 with GCC2 and GCC4 being upward, and GCC1, GCC3, GCC5, and GCC6 being downward (Figure 5). Vertical groundwater gradients are also depicted in Attachment B. The magnitude of the gradient is much greater at GCC1 than other monitoring locations due to the influence from a localized high-pressure zone near GCC1 where vertical groundwater flow is impeded by a localized confining unit (Figure 2). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were generally downward with exception to GCC3, as shown on Figure 5 and in Attachment B.

Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were downward with exception to GCC6. The direction of vertical gradients exterior to the GWBW were mixed with GCC5 and GCC6 being upward, and GCC1 to GCC4 being downward, as shown on Figure 6 and Attachment B.

The river elevation in January 2023 varied with an average of 10.06 feet NAVD88, maximum of 12.89 feet NAVD88, and minimum of 6.81 feet NAVD88.

3.3.1 GWET System Performance

The GWET operated within permit conditions during the reporting period. There were four brief unplanned shutdowns:

- 2 January 2023: The well-field was shut down at 0810 on 2 January due to an upset in the solids handling system. The issue was resolved on 3 January and the system was restarted at 1010.
- 14 January 2023: The well-field was shut down at 0230 on 14 January due to an upset in the solids handling system. The issue was resolved on 15 January, and the well-field was restarted at 1130.
- 15 January 2023: The well-field was shut down at 1235 due to a brief power fluctuation. The well-field was restarted on 16 January.
- 27 January 2023: The well-field was shut down at 0130 due to a pump failure and was restarted at 0530.

There were no upgrades to the GWET plant in the month of January 2023.

3.3.2 Recovery Well and Extraction Well Performance

In January 2023, the average system influent flow rate was 69.16 gallons per minute (gpm) during operational periods, compared to approximately 38.00 gpm in the December 2022 period. The EWs were operated at partial pump power to pre-emptively limit flow to the GWET system while the solids handling process was optimized. As of 26 January, ERM has fully executed the Trench Startup Standard Operating Procedure to turn on additional wells. Moving forward, ERM will optimize the extraction rates within the system and increase flow rates at operational wells, until the extraction rates specified in the *Final Design Report* (ERM 2022) are achieved, or until the Capture Zone Objectives are met.

Table 1-3. Recovery Well Pumping Rates[1]

Recovery Well	December 2022 Average Pumping Rate (gpm)
RW-14	2.33
RW-22 *	0.00
RW-23	4.89
RW-25	2.97
EW-01 **	3.58
EW-02 **	5.10
EW-03 **	3.60
EW-04 **	2.94
EW-05 **	7.06
EW-06 **	3.34

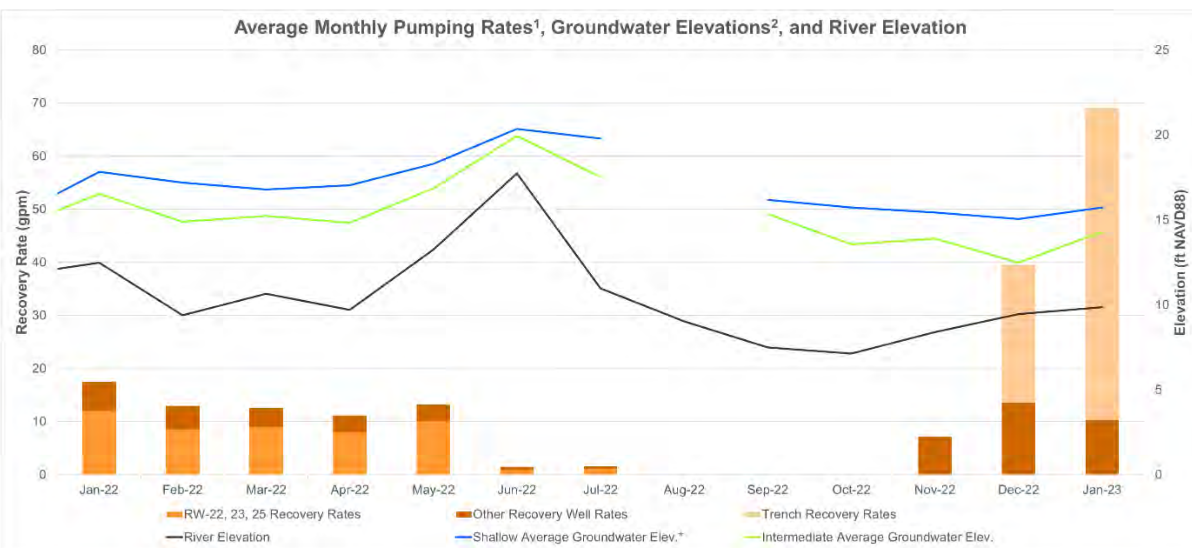
Recovery Well	December 2022 Average Pumping Rate (gpm)
EW-07 **	2.71
EW-08 **	3.25
EW-09 **	5.06
EW-10 **	1.95
EW-11	4.79
EW-12	6.45
EW-13 **	7.30
EW-14 **	1.85
Total	**69.16**

Notes:

1 = Flow rates are calculated based on the period of the month during which the recovery wells were operational

** = Recovery wells not in service*

*** = Recovery wells not in service part of the month*



Notes:

1 = Following installation of trenches in Summer 2022, RW-22, 23, and 25 recovery rates are now grouped together with the other remaining recovery well (RW-14) starting in November 2022.

2 = Average groundwater elevations are calculated using interior wells—the well-field was powered down in August preventing the measurement of the groundwater.

** = The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the whole aquifer.*

Figure 1-1. Monthly Pumping Rate Contribution

3.3.3 Recommendations for Extraction System Optimization

Recovery rates from the start of the system indicate that the active RWs and EWs are operating as designed. The EWs have been turned on in accordance with the plan outlined in the Trench Startup Standard Operating Procedure included in the *Final Design Report* (ERM 2022). The extraction rates throughout the GWET system will continue to be optimized to meet Target Capture Objectives.

4. ANALYTICAL PROGRAM

Quarterly groundwater monitoring was implemented in accordance with the ODEQ-approved Arkema Quarterly Groundwater Monitoring Work Plan dated October 2019 and the ODEQ-approved reduced scope described in the 2021 monitoring program modification request memorandum dated 9 September 2021. The table below outlines sampling dates and submittal dates related to groundwater monitoring since the implementation of the reduced scope. The Quarterly Monitoring Reports present results from these sampling events.

Report	Sampling Dates	Report Submittal Date
2021 Quarter 3	9/21/2021–9/24/2021	1/14/2022
2021 Quarter 4	12/13/2021–12/16/2021	4/20/2022
2022 Quarter 1	3/14/2022–3/17/2022	6/15/2022
2022 Quarter 2	6/6/2022–6/9/2022	9/12/2022
2022 Quarter 4	11/7/2022–11/10/2022	2/17/2023
2023 Quarter 1	3/6/2023–3/10/2023	6/15/2023 *

** = estimated dates*

5. SUMMARY AND CONCLUSIONS

This report presents a summary of the GW SCM operation, maintenance, and monitoring activities conducted at the Site in January 2023 and documents results from system monitoring. The following summarizes ERM’s observations and conclusions drawn from collected data.

5.1 Groundwater Flow

- Horizontal gradients across the GWBW are generally outward toward the river; however, groundwater elevations show a noticeable separation interior and exterior of the GWBW, indicating the GWBW is functioning via impeding groundwater flow. Before installation of the GEE system, inward gradients were periodically observed at some monitoring locations. It is yet to be determined whether an inward gradient has been produced through increased pumping rates. Initial results indicate that the GWET is generating localized areas of sustained groundwater capture that are anticipated to expand with longer operations.

- Vertical groundwater gradients interior to the GWBW between the Shallow and Intermediate Zones were downward in January 2023 with exception to GCC2 and GCC4 (Figure 5). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were also downward with the exception of GCC3. Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were downward with exception to GCC6. The direction of vertical gradients exterior to the GWBW were downward with the exception of GCC5 and GCC6 (Figure 6).

- River elevations have generally been decreasing since June 2022, with increases since the beginning of November 2022. In 2022, the average river elevation was 10.48 feet NAVD88 with a maximum monthly average elevation of 17.73 feet NAVD88 in June 2022 and a minimum monthly average elevation of 7.14 feet NAVD88 in October 2022 (Figure 1-1). The river elevation in January 2023 was 10.06 feet NAVD88.

- Within the Site alluvial sequence, potentiometric maps indicate the GW SCM could be producing localized areas of hydraulic capture around trenches that were active during the water level event; however, more time at elevated extraction rates will be required to evaluate whether GWET objectives are being met.

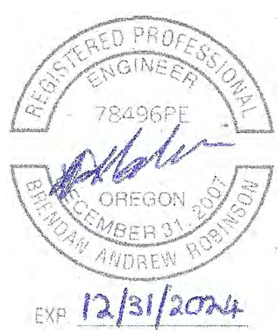
5.2 Groundwater Extraction

Based on January 2023 extraction and relevant hydrograph analysis, the EWs and RWs are operating as designed. Further evaluation of the system with respect to the Capture Zone Objectives will be conducted once all pumps are operating at their design rates for an extended period.

5.3 Recommendations and Future Work

ERM will continue to optimize new EWs. Any additional modifications to the system to meet capture objectives will be included in subsequent Monthly Progress Reports. The project schedule provided as Attachment C summarizes activities planned for the immediate future.

Regards,



Brendan Robinson, PE
Partner

6. REFERENCES

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FIGURES

Figure 1: Site Layout

Figure 2: January 2023 Shallow Zone Groundwater Contours

Figure 3: January 2023 Intermediate Zone Groundwater Contours

Figure 4: January 2023 Deep Zone Groundwater Contours

Figure 5: January 2023 Shallow to Intermediate Zone Vertical Head Difference

Figure 6: January 2023 Intermediate to Deep Zone Vertical Head Difference

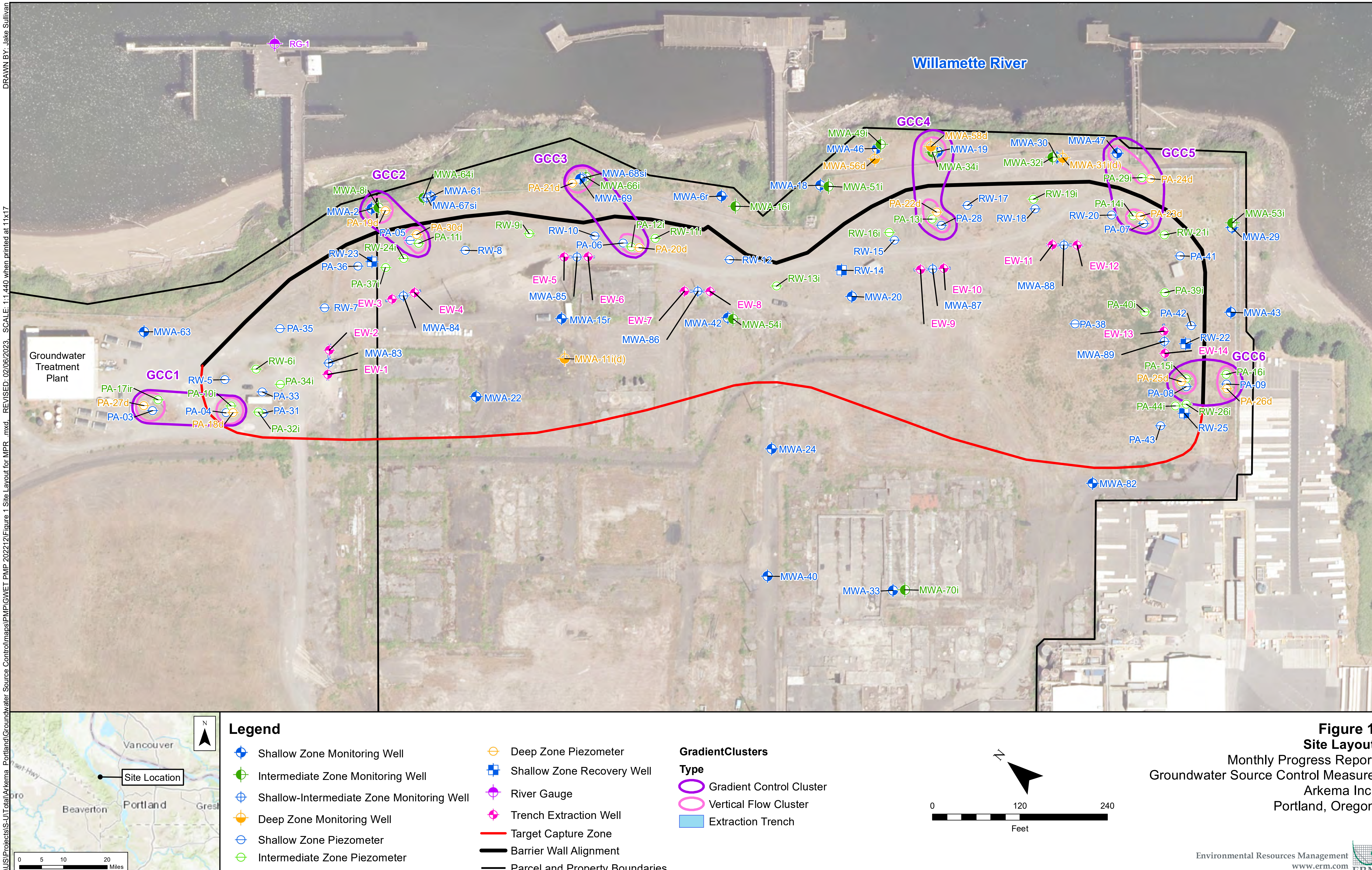


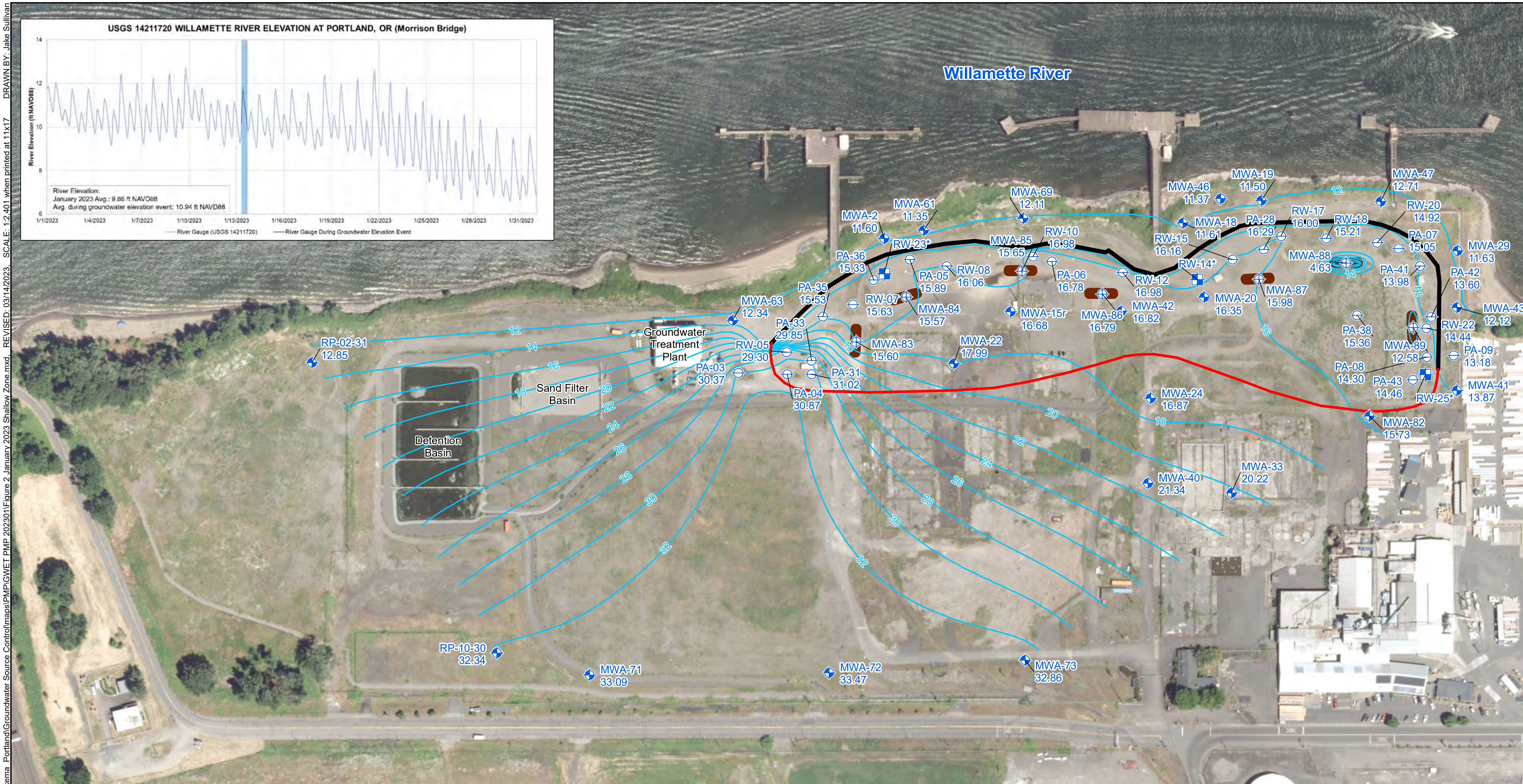
Figure 1
Site Layout
Monthly Progress Report
Groundwater Source Control Measure
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

DRAWN BY: Jake Sullivan

M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 202212\Figure 1 Site Layout for MPR .mxd REVISED: 02/06/2023 SCALE: 1:1,440 when printed at 11x17

Source: City of Portland Aerial Imagery, flown Summer 2021; NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Shallow Zone Piezometer
- Shallow Zone Monitoring Well
- Active Recovery Well; Not Used During Contouring
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Shallow Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Extraction Trench (Not To Scale)
- Target Capture Zone
- Barrier Wall Alignment

Notes:
* Value not used for contouring.
Water levels collected January, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 200 400
Feet

Figure 2
January 2023 Shallow Zone Groundwater Contours
Monthly Performance Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

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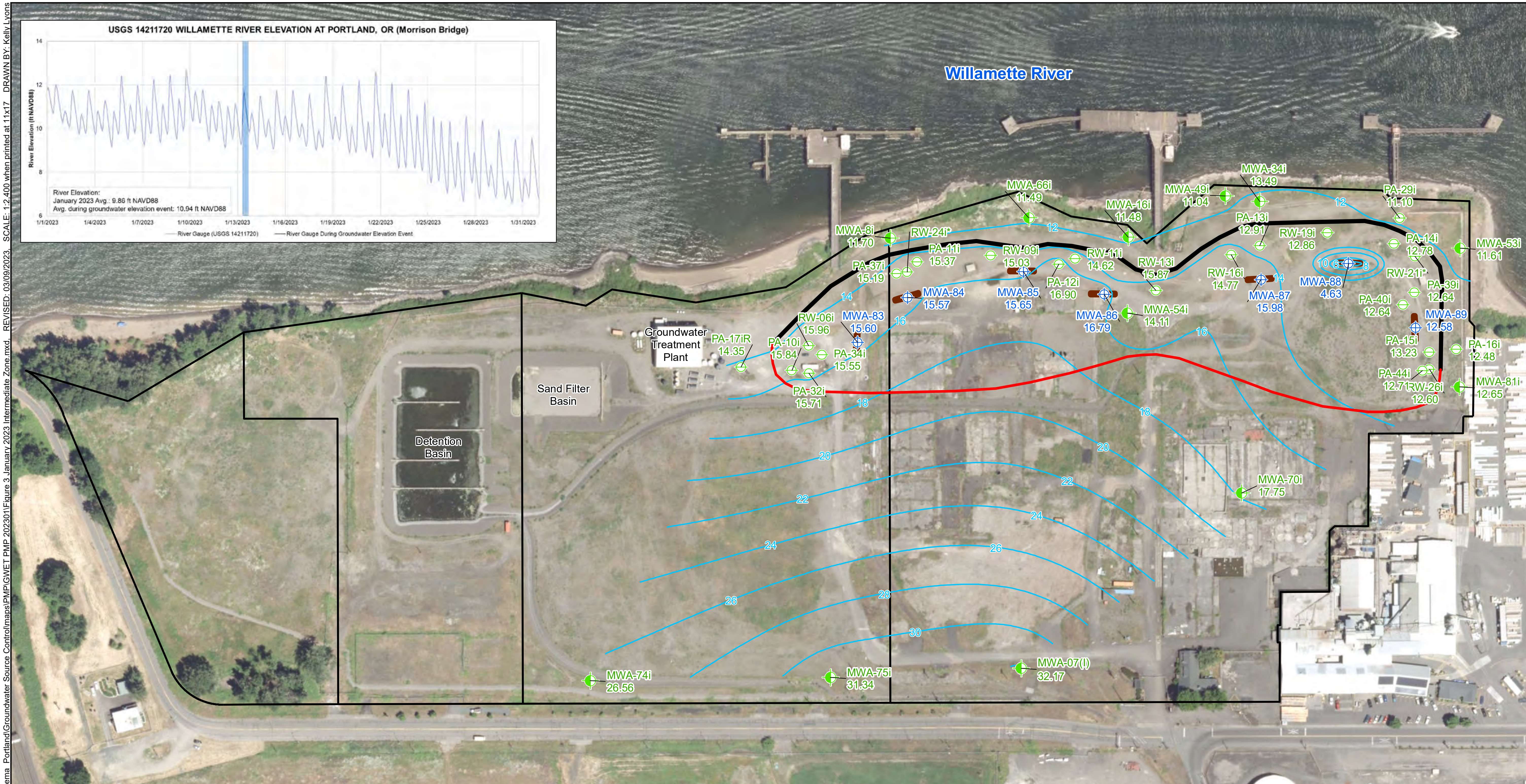
\\SCUSPRDGISFS01\Data\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 2023\01\Figure 2 January 2023 Shallow Zone.mxd REVISED: 03/14/2023 SCALE: 1:2,401 when printed at 11x17 DRAWN BY: Jake Sullivan

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Intermediate Zone Piezometer
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Intermediate Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Extraction Trench (Not To Scale)
- Target Capture Zone
- Barrier Wall Alignment

Notes:
* Value not used for contouring.
Water levels collected January, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 200 400
Feet

Figure 3
January 2023 Intermediate Zone Groundwater Contours
Monthly Performance Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

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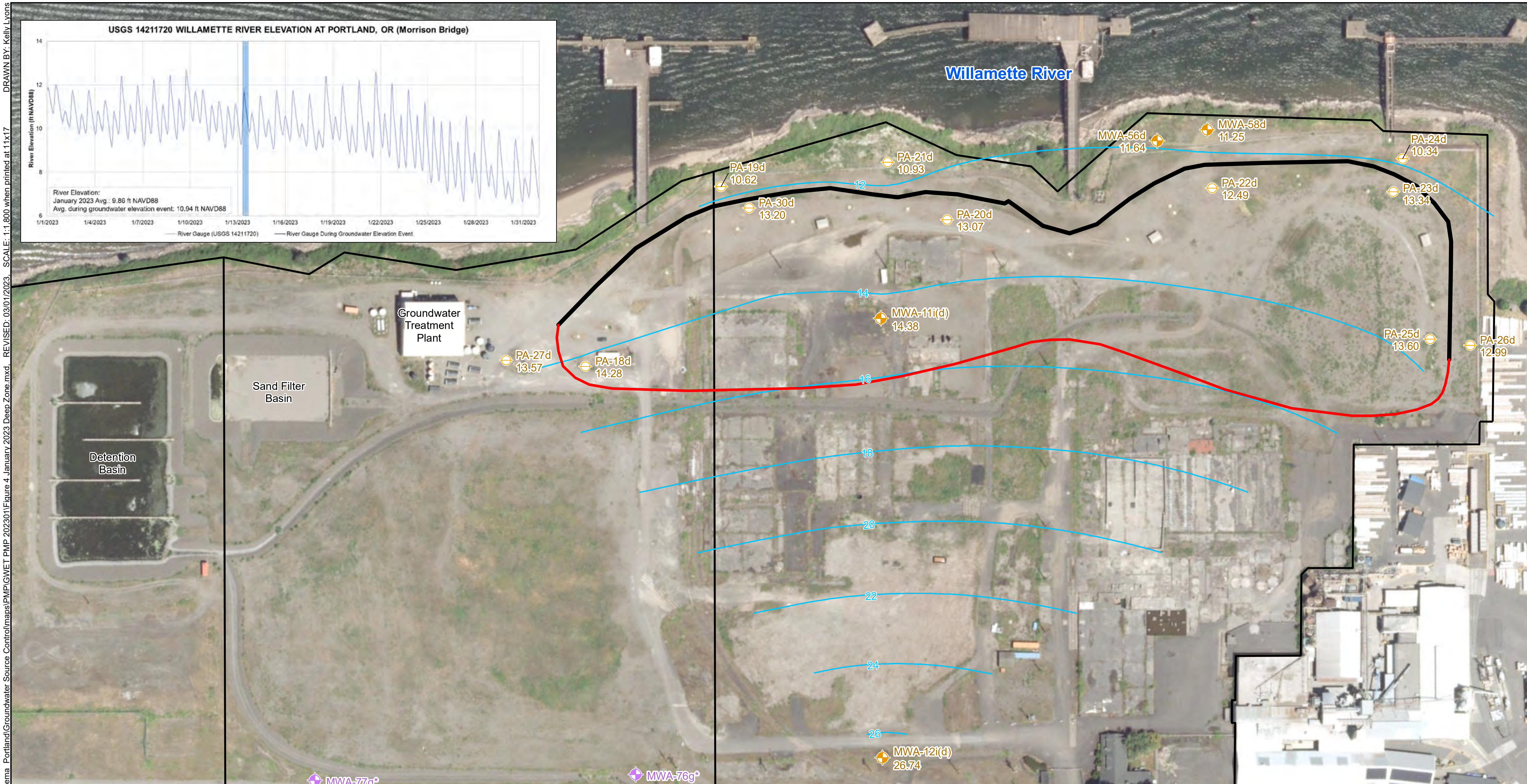
\\SCUSPRDGISFS01\Data\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 2023\01\Figure 3 January 2023 Intermediate Zone.mxd REVISED: 03/09/2023 SCALE: 1:2,400 when printed at 11x17 DRAWN BY: Kelly Lyons

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Deep Zone Piezometer
- Deep Zone Monitoring Well
- Gravel Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Deep Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment

Notes:
* Value not used for contouring.
Gravel zone wells not used in contouring.
Water levels collected January, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N
0 150 300
Feet

Figure 4
January 2023 Deep Zone Groundwater Contours
Monthly Performance Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

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\\SCUSPRDGISFS01\Data\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 2023\01\Figure 4 January 2023 Deep Zone.mxd REVISED: 03/01/2023 SCALE: 1:1,800 when printed at 11x17 DRAWN BY: Kelly Lyons

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Shallow Zone Recovery Well
- Trench Extraction Well
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as shallow zone minus intermediate zone potentiometric surfaces.
Water levels collected January, 2023.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 5
January 2023 Shallow to Intermediate Zone Vertical Head Difference
Monthly Performance Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

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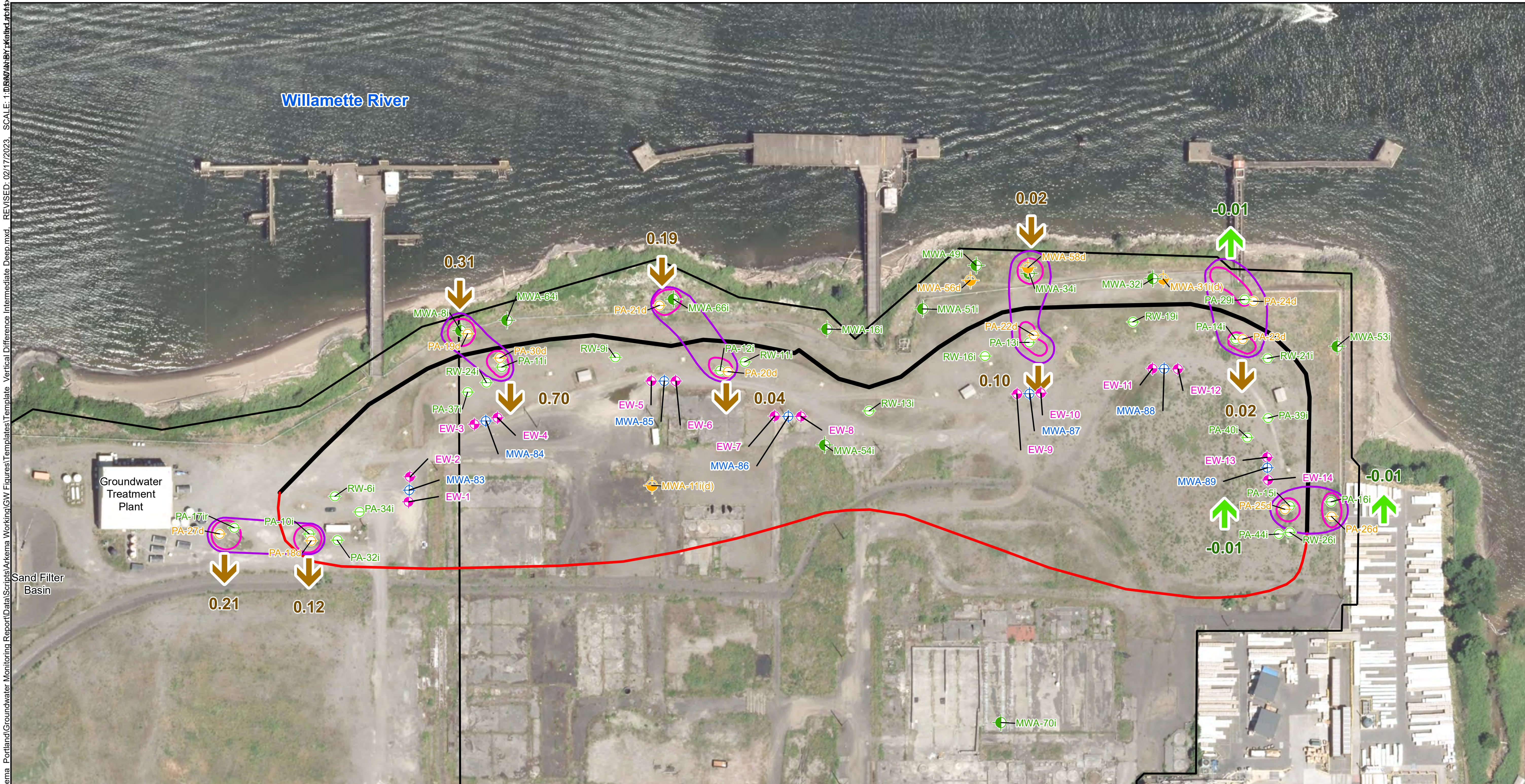
NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Shallow-Intermediate Zone Monitoring Well
- Trench Extraction Well
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as intermediate zone minus deep zone potentiometric surfaces.
Water levels collected January, 2023.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 6
January 2023 Intermediate to Deep Zone Vertical Head Difference
Monthly Performance Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

\\SCUSPRDGISFS01\Data\US\Projects\S-U\Total\Arkema_Portland\Groundwater Monitoring Report\Data\Scripts\Arkema Working\GW Figures\Templates\Template_Vertical Difference Intermediate Deep.mxd REVISED: 02/17/2023 SCALE: 1:1,560 when printed at 11x17

ATTACHMENT A-1 TRANSDUCER FLAGS

Attachment A-1. Transducer Flags

Table A-1
Transducer Malfunction Log: January 2023
Arkema Inc. Facility
Portland, Oregon

Gradient Cluster	Transducer	Interval	Date Range		Issue and Repairs Performed
3	PA-20d	Deep	1/4/2023	1/31/2023	LOTO at EW-05 to swap I/O card. Transducer was not able to be restarted.
3	PA-21d	Deep	1/4/2023	1/4/2023	LOTO at EW-05 to swap I/O card.
5	PA-07	Shallow	1/4/2023	1/31/2023	Troubleshooting occurred. Transducer needs to be replaced.
6	PA-25d	Deep	1/11/2023	1/11/2023	Recalibrated transducer.
6	PA-26d	Deep	1/11/2023	1/31/2023	Recalibrated transducer. Transducer needs to be replaced.
6	PA-16i	Intermediate	12/16/2023	1/31/2023	Troubleshooting occurred. Transducer needs to be replaced.

Notes:
I/O = input/output
LOTO = lockout/tagout
VFD = variable frequency drive

ATTACHMENT A-2 RECOVERY WELL STATUS

Attachment A-2. Recovery Well Status

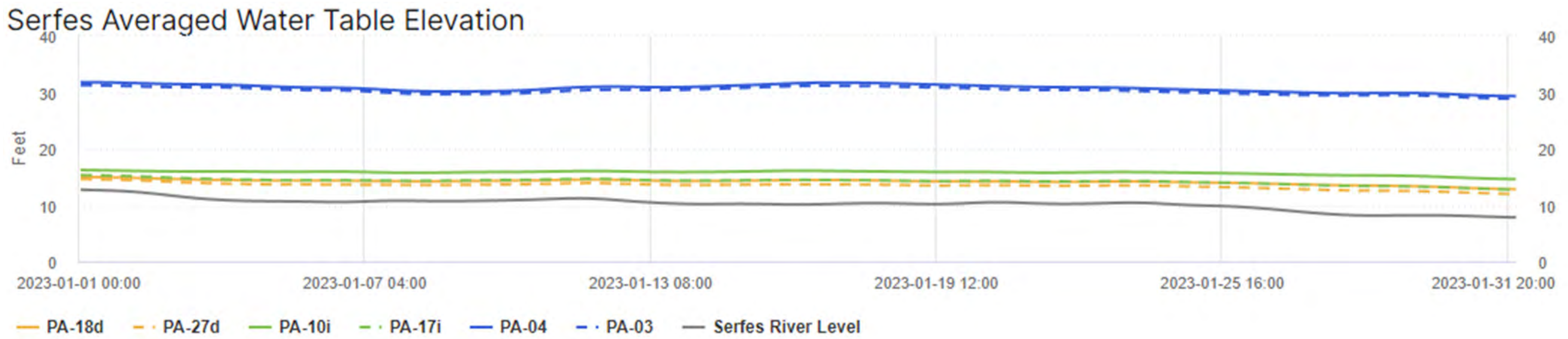
Table A-2
Recovery Well Status: January 2023
Arkema Inc. Facility
Portland, Oregon

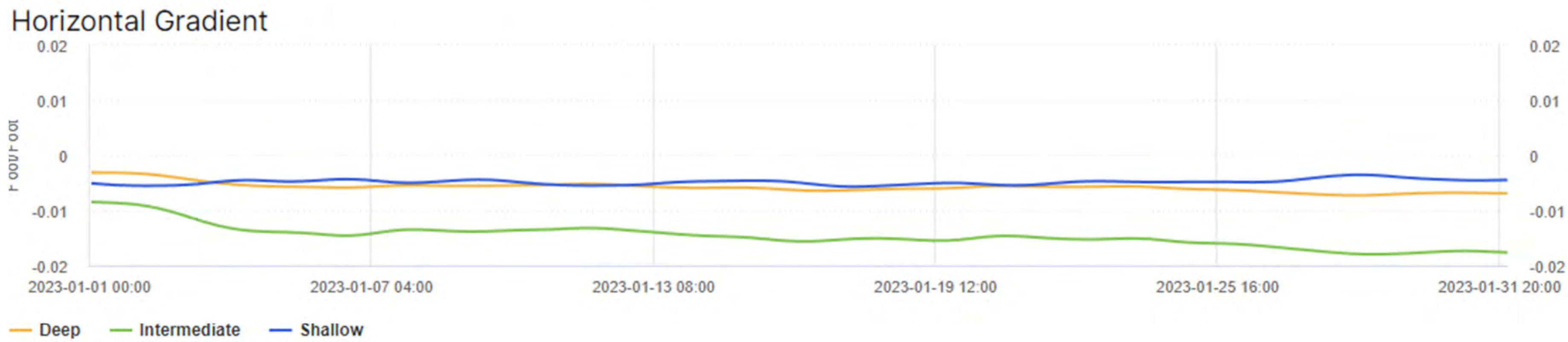
Recovery Well ID	Status as of 01/31/2023 (active or inactive)	Issue	Actions to get online	Expected date back online	Transducer Status	Totalizer Status	Average Flow Rate (gpm)****	Overall Extraction Rate	Notes
RW-05	Inactive	None	Will not be placed back online	N/A	Good	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-06i	Inactive	None	Will not be placed back online	N/A	Good	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-07	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-08	Inactive	None	Will not be placed back online	N/A	Not Connected	Good	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-09i	Inactive	None	Will not be placed back online	N/A	Not Connected	Good	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-10	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-11i	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-12	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-13i	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-14	Active	None	N/A	N/A	Not Connected	Good	2.33	M	In service on 11/27/22
RW-15	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-16i	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-17	Inactive	None	Will not be placed back online	N/A	Not Connected	Good	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-18	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-19i	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-20	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-21i	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-22	Active	None	Replace totalizer	N/A	Good	Bad	0.00	OFF*	Totalizer failed, will be replaced
RW-23	Active	None	N/A	N/A	Good	Good	4.89	G	In service on 11/27/22
RW-24i	Inactive	None	Will not be placed back online	N/A	Not Connected	Good	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-25	Active	None	N/A	N/A	Good	Good	2.97	M	In service on 11/27/22
RW-26i	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
EW-01	Active	None	N/A	N/A	Good	Good	3.58	G	In service on 12/9/22
EW-02	Active	None	N/A	N/A	Good	Good	5.10	G	In service on 12/9/22
EW-03	Active	None	N/A	N/A	Good	Good	3.60	G	In service on 1/23/23
EW-04	Active	None	N/A	N/A	Good	Good	2.94	M	In service on 1/23/23
EW-05	Active	None	N/A	N/A	Good	Good	7.06	G	In service on 1/13/23
EW-06	Active	None	N/A	N/A	Good	Good	3.34	G	In service on 1/13/23
EW-07	Active	None	N/A	N/A	Good	Good	2.71	M	In service on 1/23/23
EW-08	Active	None	N/A	N/A	Good	Good	3.25	G	In service on 1/26/23
EW-09	Active	None	N/A	N/A	Good	Good	5.06	G	In service on 12/15/22
EW-10	Active	None	N/A	N/A	Good	Good	1.95	G	In service on 12/15/22
EW-11	Active	None	N/A	N/A	Good	Good	4.79	G	In service on 12/4/22
EW-12	Active	None	N/A	N/A	Good	Good	6.45	G	In service on 12/4/22
EW-13	Active	None	N/A	N/A	Good	Good	7.30	G	In service on 1/5/23
EW-14	Active	None	N/A	N/A	Good	Good	1.85	M	In service on 1/5/23

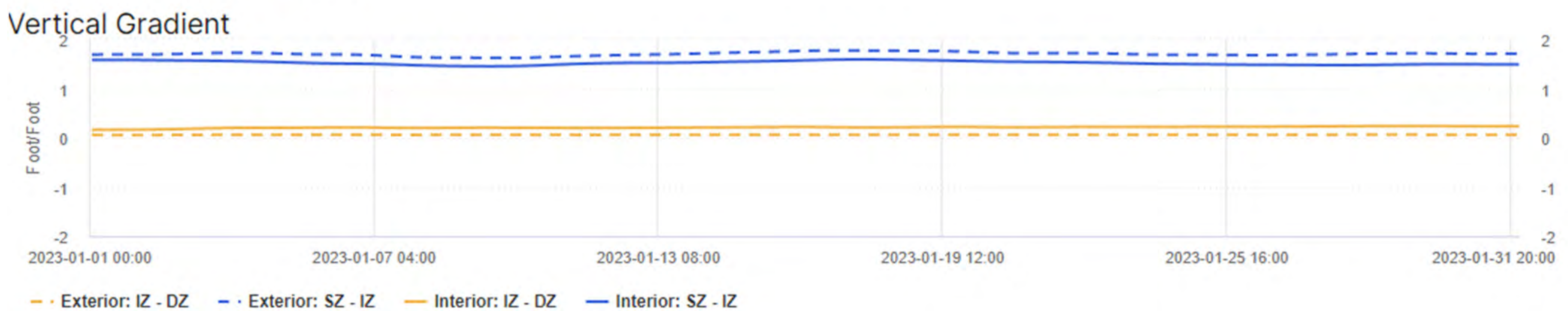
Notes:
** Recovery wells not in service*
*** Recovery wells in service part of the month*
**** = Off due to locked out and tagged out during part of the month*
***** = Average flow rate taken from date placed in service*
G = good pumping, greater than 3.0 gpm
gpm = gallons per minute
M = moderate pumping, greater than 1.0 gpm and less than 3.0
P = poor pumping, less than 1.0 gpm
VFD = variable frequency drive
PA = piezometer

ATTACHMENT B GRADIENT HYDROGRAPHS

GCC1







Notes:
Positive horizontal gradient indicates inward hydraulic gradient across the GWBW.
Positive vertical gradient indicates downward flow.
Horizontal gradient calculated as Exterior – Interior.

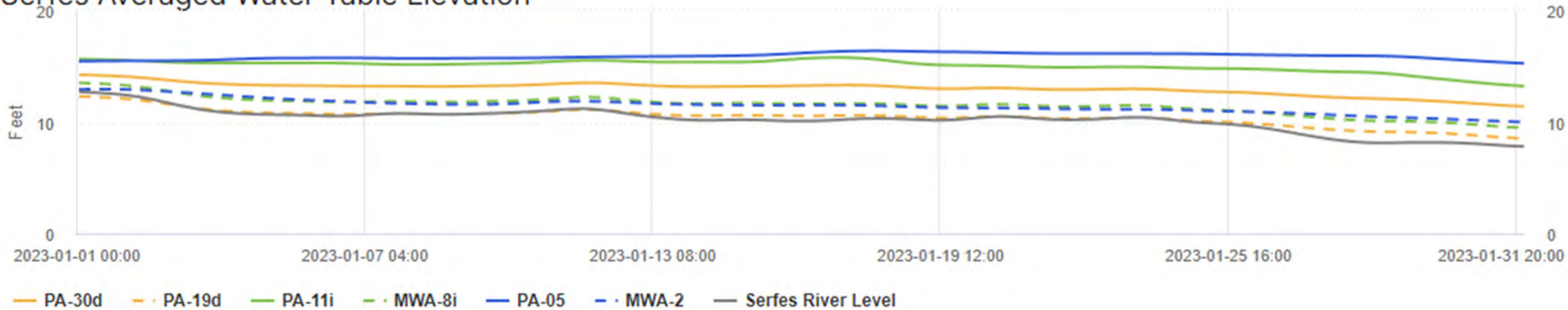
- Interior: Upland of the GWBW
- Exterior: Riverside of the GWBW

Vertical gradient calculated as Shallow - Intermediate and Intermediate - Deep
SZ= Shallow Zone
IZ= Intermediate Zone
DZ= Deep Zone

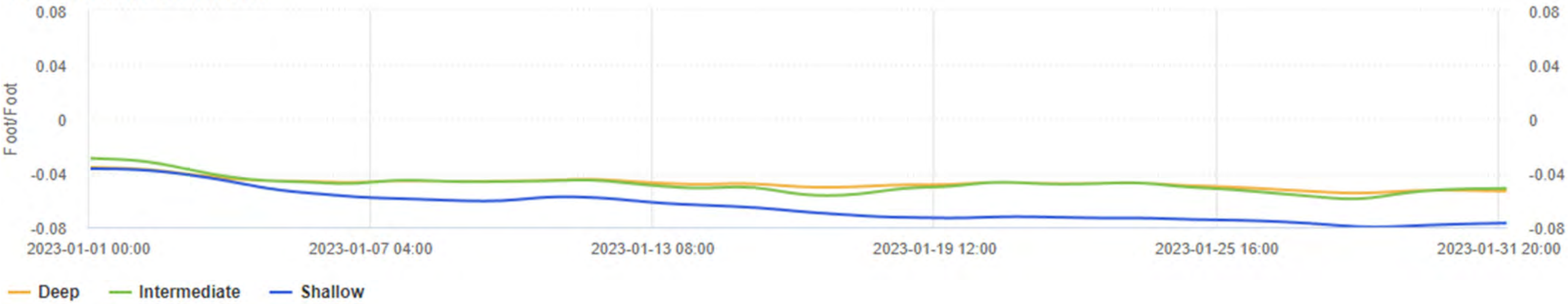
ERM

GCC2

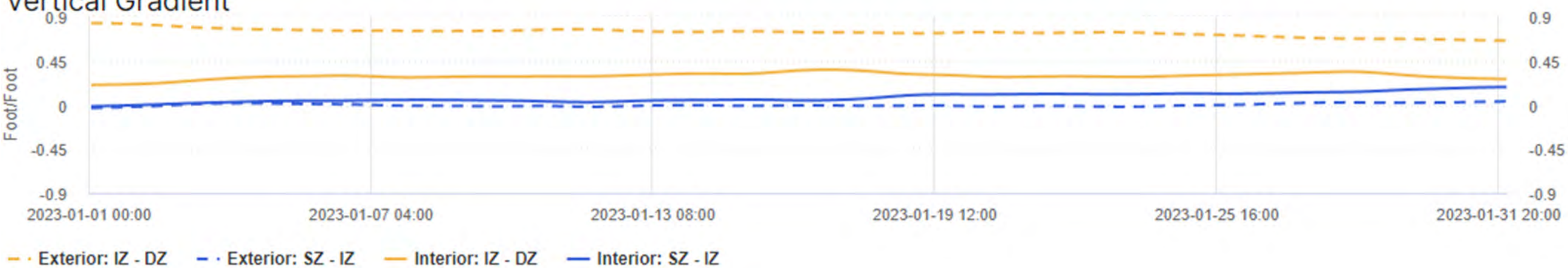
Serfes Averaged Water Table Elevation



Horizontal Gradient



Vertical Gradient



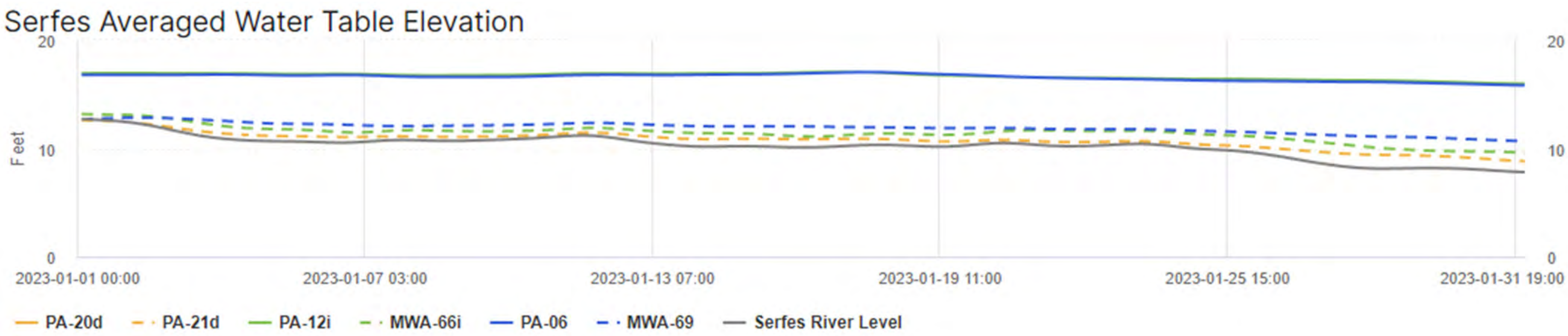
Notes:
Positive horizontal gradient indicates inward hydraulic gradient across the GWBW.
Positive vertical gradient indicates downward flow.
Horizontal gradient calculated as Exterior – Interior.

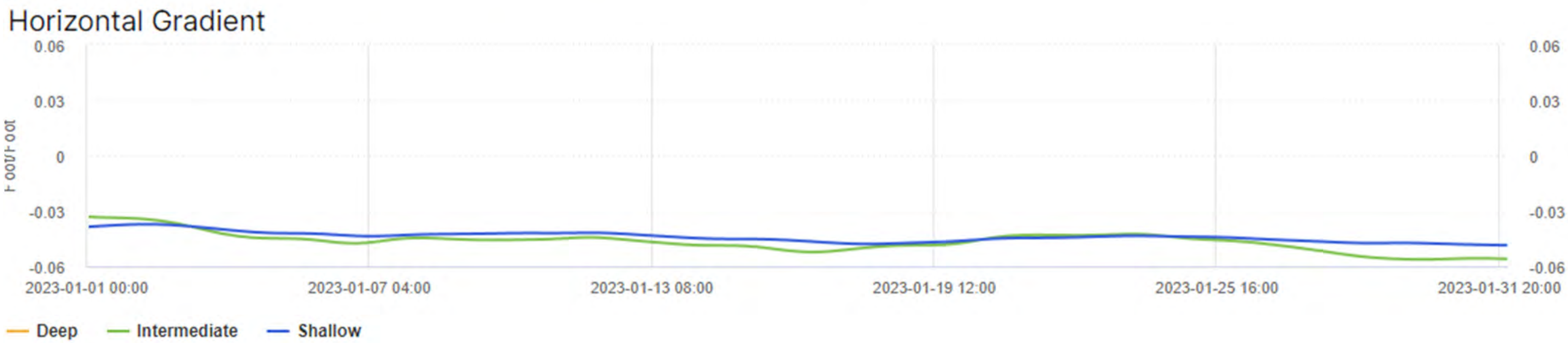
- Interior: Upland of the GWBW
- Exterior: Riverside of the GWBW

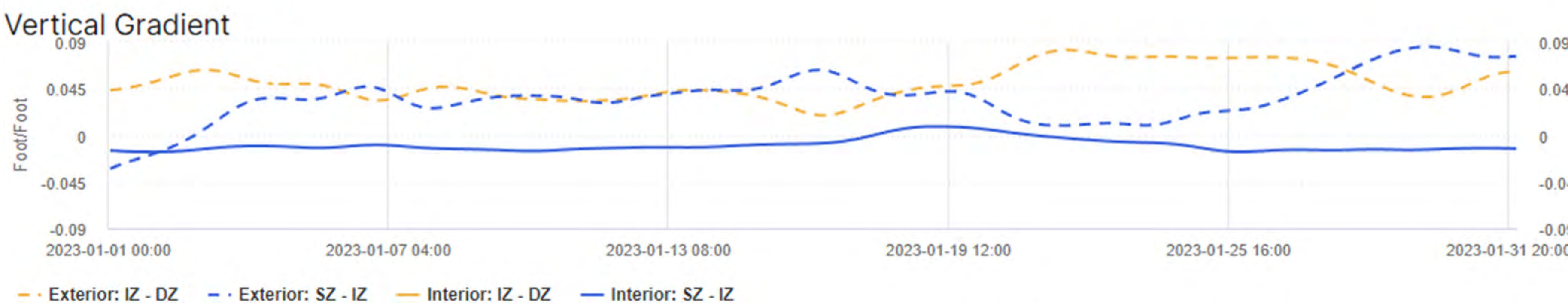
Vertical gradient calculated as Shallow - Intermediate and Intermediate - Deep
SZ= Shallow Zone
IZ= Intermediate Zone
DZ= Deep Zone

ERM

GCC3







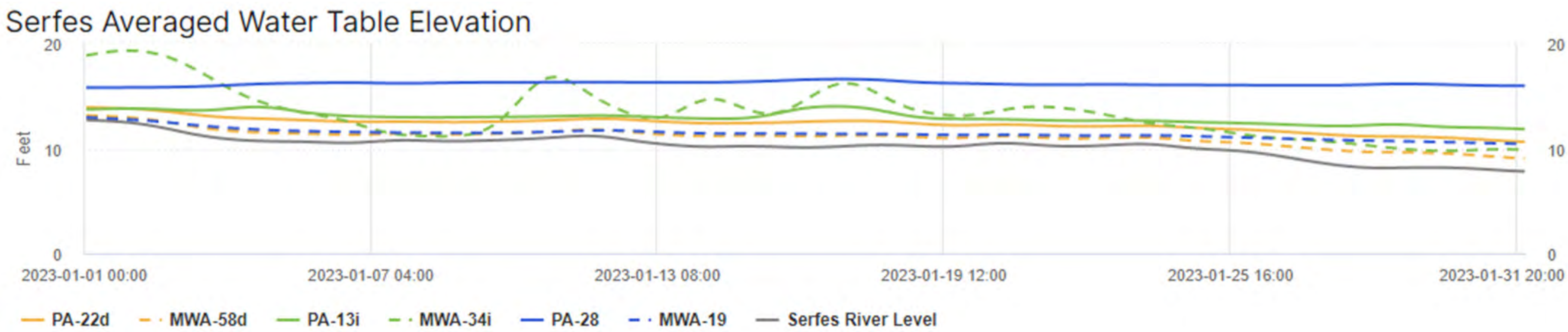
Notes:
Positive horizontal gradient indicates inward hydraulic gradient across the GWBW.
Positive vertical gradient indicates downward flow.
Horizontal gradient calculated as Exterior – Interior.

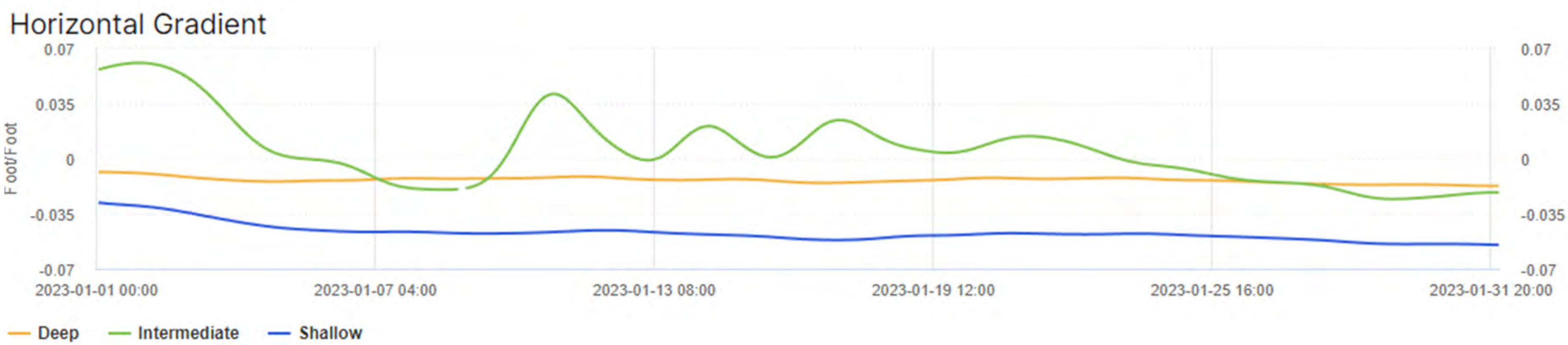
- Interior: Upland of the GWBW
- Exterior: Riverside of the GWBW

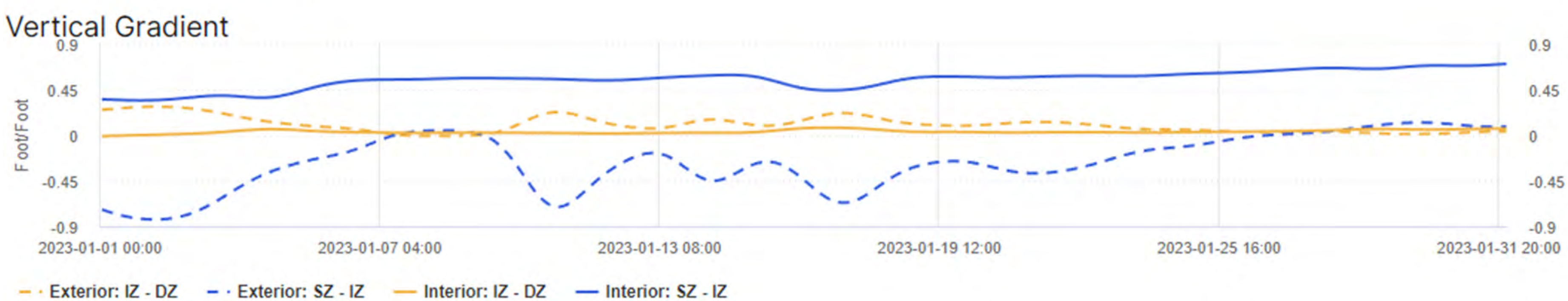
Vertical gradient calculated as Shallow - Intermediate and Intermediate - Deep
SZ= Shallow Zone
IZ= Intermediate Zone
DZ= Deep Zone

ERM

GCC4







Notes:
Positive horizontal gradient indicates inward hydraulic gradient across the GWBW.
Positive vertical gradient indicates downward flow.
Horizontal gradient calculated as Exterior – Interior.

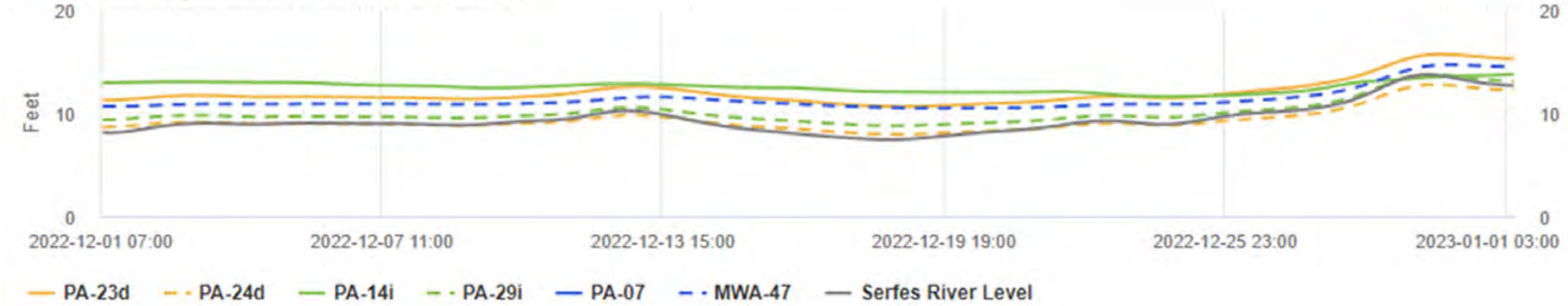
- Interior: Upland of the GWBW
- Exterior: Riverside of the GWBW

Vertical gradient calculated as Shallow - Intermediate and Intermediate - Deep
SZ= Shallow Zone
IZ= Intermediate Zone
DZ= Deep Zone

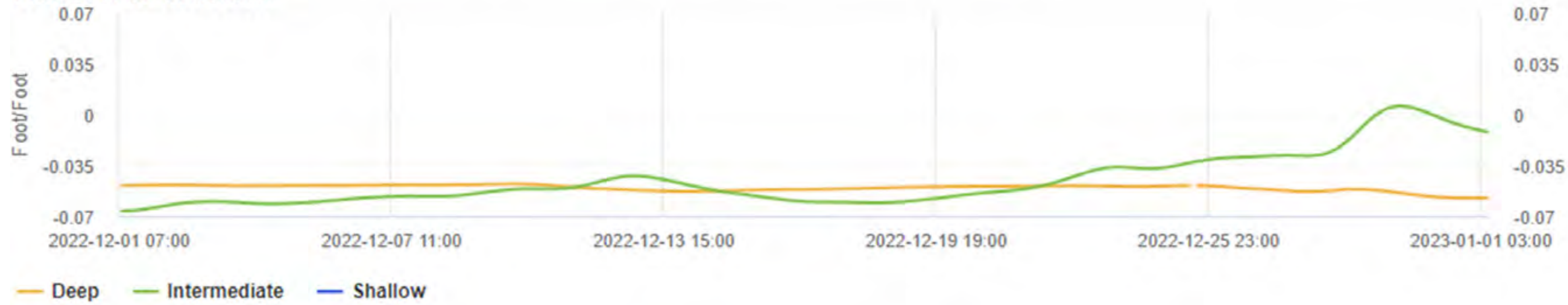
ERM

GCC5

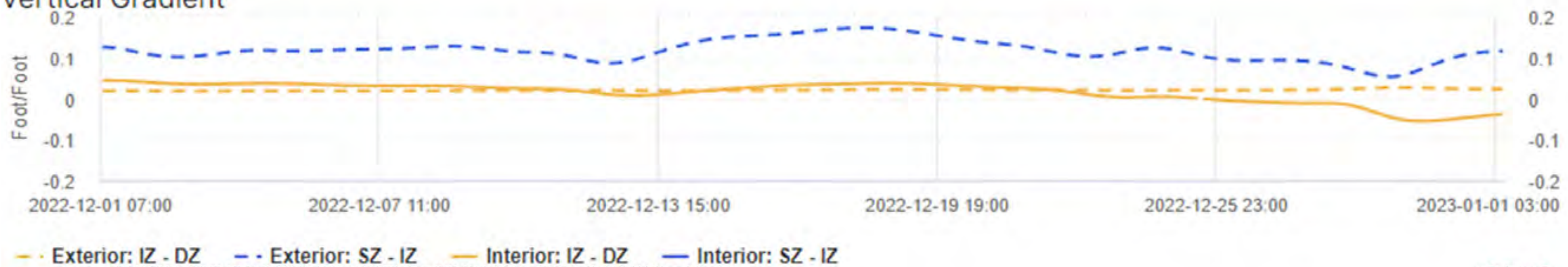
Serfes Averaged Water Table Elevation



Horizontal Gradient



Vertical Gradient



SZ= Shallow Zone
IZ= Intermediate Zone

ERM

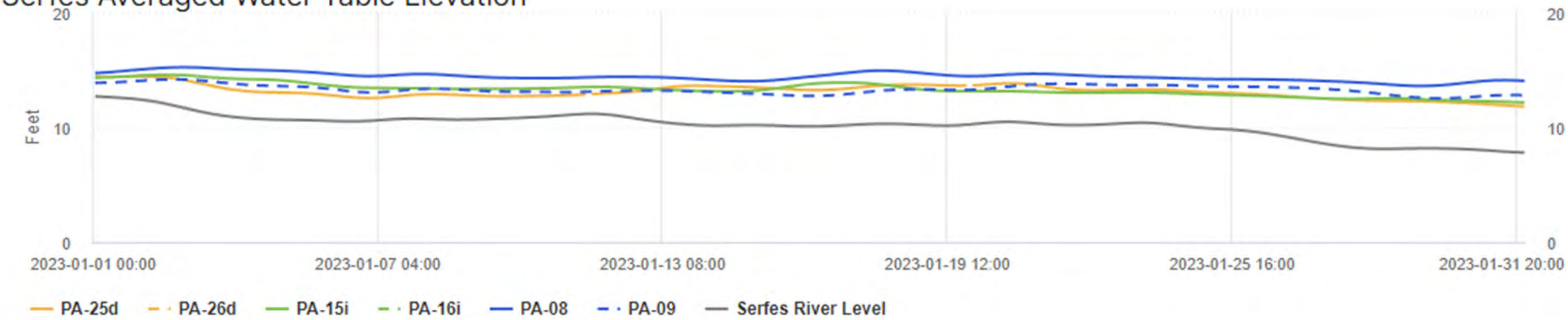
Notes:
Positive horizontal gradient indicates inward hydraulic gradient across the GWBW.
Positive vertical gradient indicates downward flow.
Horizontal gradient calculated as Exterior – Interior.

- Interior: Upland of the GWBW
- Exterior: Riverside of the GWBW

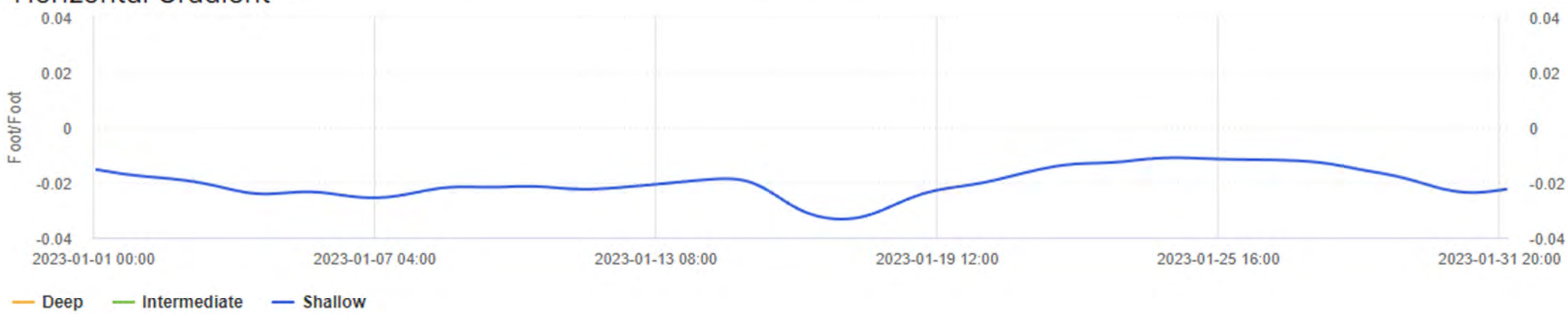
Vertical gradient calculated as Shallow - Intermediate and Intermediate - Deep
SZ= Shallow Zone
IZ= Intermediate Zone
DZ= Deep Zone

GCC6

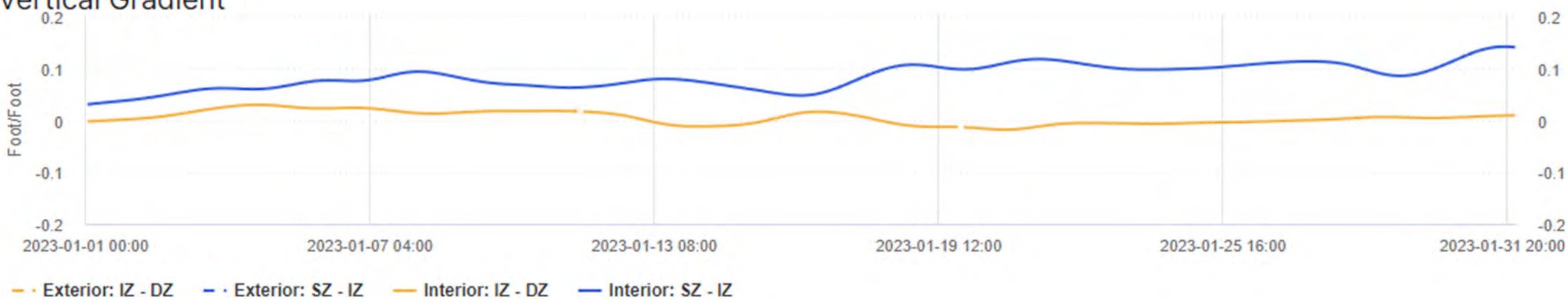
Serfes Averaged Water Table Elevation



Horizontal Gradient



Vertical Gradient



Notes:
Positive horizontal gradient indicates inward hydraulic gradient across the GWBW.
Positive vertical gradient indicates downward flow.
Horizontal gradient calculated as Exterior – Interior.

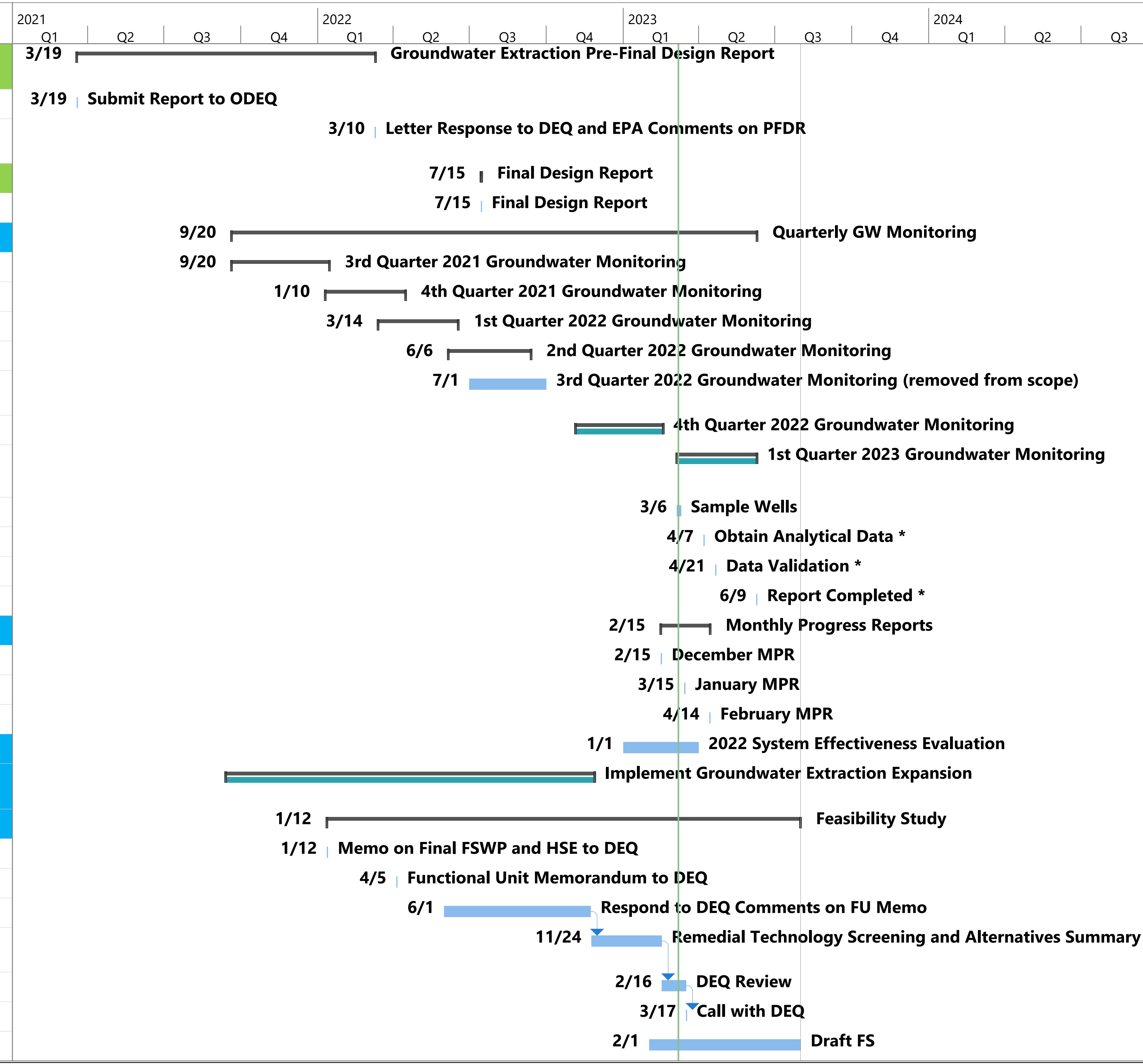
- Interior: Upland of the GWBW
- Exterior: Riverside of the GWBW

Vertical gradient calculated as Shallow - Intermediate and Intermediate - Deep
SZ= Shallow Zone
IZ= Intermediate Zone
DZ= Deep Zone

ERM

ATTACHMENT C PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**Groundwater Extraction Pre-Final Design Report**	**255 days**	**Fri 3/19/21**	**Thu 3/10/22**
2	*Submit Report to ODEQ*	*1 day*	*Fri 3/19/21*	*Fri 3/19/21*
3	*Letter Response to DEQ and EPA Comments on PFDR*	*1 day*	*Thu 3/10/22*	*Thu 3/10/22*
4	**Final Design Report**	**1 day**	**Fri 7/15/22**	**Fri 7/15/22**
5	*Final Design Report*	*1 day*	*Fri 7/15/22*	*Fri 7/15/22*
6	**Quarterly GW Monitoring**	**453 days**	**Mon 9/20/21**	**Fri 6/9/23**
7	*3rd Quarter 2021 Groundwater Monitoring*	*85 days*	*Mon 9/20/21*	*Fri 1/14/22*
12	*4th Quarter 2021 Groundwater Monitoring*	*70 days*	*Mon 1/10/22*	*Fri 4/15/22*
16	*1st Quarter 2022 Groundwater Monitoring*	*70 days*	*Mon 3/14/22*	*Fri 6/17/22*
21	*2nd Quarter 2022 Groundwater Monitoring*	*71 days*	*Mon 6/6/22*	*Mon 9/12/22*
26	*3rd Quarter 2022 Groundwater Monitoring (removed from scope)*	*66 days*	*Fri 7/1/22*	*Fri 9/30/22*
27	*4th Quarter 2022 Groundwater Monitoring*	*78 days*	*Sat 11/5/22*	*Fri 2/17/23*
32	**1st Quarter 2023 Groundwater Monitoring**	**70 days**	**Mon 3/6/23**	**Fri 6/9/23**
33	*Sample Wells*	*5 days*	*Mon 3/6/23*	*Fri 3/10/23*
34	Obtain Analytical Data *	1 day	Fri 4/7/23	Fri 4/7/23
35	Data Validation *	1 day	Fri 4/21/23	Fri 4/21/23
36	Report Completed *	1 day	Fri 6/9/23	Fri 6/9/23
37	**Monthly Progress Reports**	**43 days**	**Wed 2/15/23**	**Fri 4/14/23**
38	*December MPR*	*1 day*	*Wed 2/15/23*	*Wed 2/15/23*
39	January MPR	1 day	Wed 3/15/23	Wed 3/15/23
40	February MPR	1 day	Fri 4/14/23	Fri 4/14/23
41	**2022 System Effectiveness Evaluation**	**66 days**	**Sun 1/1/23**	**Fri 3/31/23**
42	**Implement Groundwater Extraction Expansion**	**317 days**	**Mon 9/13/21**	**Sun 11/27/22**
50	**Feasibility Study**	**407 days**	**Wed 1/12/22**	**Mon 7/31/23**
51	*Memo on Final FSWP and HSE to DEQ*	*1 day*	*Wed 1/12/22*	*Wed 1/12/22*
52	*Functional Unit Memorandum to DEQ*	*1 day*	*Tue 4/5/22*	*Tue 4/5/22*
53	*Respond to DEQ Comments on FU Memo*	*126 days*	*Wed 6/1/22*	*Tue 11/22/22*
54	*Remedial Technology Screening and Alternatives Summary*	*62 days*	*Thu 11/24/22*	*Wed 2/15/23*
55	DEQ Review	21 days	Thu 2/16/23	Thu 3/16/23
56	Call with DEQ	1 day	Fri 3/17/23	Fri 3/17/23
57	Draft FS	129 days	Wed 2/1/23	Mon 7/31/23



Project: MPR Schedule dec_ajg
Date: Wed 3/8/23

Task	Project Summary	Manual Task	Start-only	Deadline
Split	Inactive Task	Duration-only	Finish-only	Progress
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Manual Progress
Summary	Inactive Summary	Manual Summary	External Milestone	

* - Indicates dates that are tentative

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Memo

To	Katie Daugherty, Oregon Department of Environmental Quality
From	Brendan Robinson, PE, Environmental Resources Management, Inc.
Date	14 April 2023
Reference	0682894 Phase 204
Subject	February 2023 GW SCM Monthly Performance Monitoring Report

1. INTRODUCTION

Environmental Resources Management, Inc. (ERM) prepared this Monthly Performance Monitoring Report (MPR) on behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc. (Arkema), for the former Arkema Portland Plant (the Site) at 6400 NW Front Avenue in Portland, Oregon. The Oregon Department of Environmental Quality (ODEQ), in its letter dated 31 May 2019 and in the subsequent meeting with LSS and ERM on 2 July 2019, requested that LSS initiate monthly status reports associated with the onsite groundwater source control measure (GW SCM) consistent with the Performance Monitoring Plan (PMP; ERM 2014) beginning July 2019. The 2014 PMP was prepared pursuant to the Order on Consent issued by ODEQ, signed on 31 October 2008 (ODEQ No. LQVC-NWR-08-04; Consent Order). The purpose of the PMP was to present the monitoring, reporting, and adaptive management processes used during implementation of the GW SCM. On 30 November 2021, ODEQ directed LSS that following the October 2021 MPR, MPRs would be suspended pending the implementation of the Groundwater Extraction Enhancement (GEE) system in 2022. During that time, ODEQ requested monthly schedule updates in lieu of MPRs. The GEE system was started on 27 November 2022, and MPR writing restarted in December 2022. The purpose of the GEE system is to install new extraction capacity to achieve the Capture Zone Objectives.

This February 2023 MPR summarizes the GW SCM performance monitoring data collected in February 2023. This report assesses the current gradient status and proposes system improvements to meet the Capture Zone Objectives set in the PMP.

2. GROUNDWATER SOURCE CONTROL IMPLEMENTATION

A detailed description of the design and implementation of the GW SCM is provided in the *Revised Upland Feasibility Study Work Plan* (ERM 2017); however, a brief description of the GW SCM is provided here. In February 2009, ODEQ and the U.S. Environmental Protection Agency (USEPA) approved the general approach for the GW SCM. This approach included installation of a groundwater barrier wall (GWBW), groundwater recovery wells, and a Groundwater Extraction and Treatment (GWET) system, with treated water discharged to the Willamette River. ODEQ and USEPA approved the *Groundwater Barrier Wall Final Design* (ERM 2012) on 7 August 2012. Construction of the GWBW began in May 2012 and was completed in December 2012. ODEQ approved the *Groundwater Extraction and Treatment System Final Design* (ERM 2013) on 2 April

2013. Construction of the GWET system began in December 2012 and was completed in December 2013.

GWET startup and optimization commenced in May 2014. The GW SCM at the Site consists of the following primary components (Figure 1):

1. A GWBW to physically separate the affected upland portions and in-water portions of the Site.
2. Hydraulic control to minimize flow of groundwater containing unacceptable concentrations of constituents of potential concern (COPCs) around, over, and under the GWBW.
3. Management of extracted groundwater through the GWET system, with treated effluent discharged to the Willamette River under a National Pollutant Discharge Elimination System (NPDES) Permit.

On 1 September 2018, ERM submitted the *Draft GWET System Effectiveness Evaluation* (Draft SEE Report; ERM 2018). The Draft SEE Report provided an update on the corrective actions implemented to improve the performance of the GWET system, evaluate the extent of capture, and propose actions to improve hydraulic capture. Additional data requested by ODEQ were submitted on 26 October 2018.

The key objective of the GW SCM is to achieve hydraulic containment of the alluvial sequence within the Target Capture Zone at the Site to prevent the flow of COPCs to the Willamette River. The Site alluvial aquifer sequence within the Target Capture Zone consists of the Shallow Zone, Intermediate Zone, and the Deep Zone. Site hydraulic conditions are variable and subject to both seasonal and daily tidal fluctuations.

The hydraulic control component formerly consisted of 22 recovery wells (RWs) prior to the implementation of the GEE. Of the 22 pre-existing RWs, four were retained for active pumping. The remaining 18 former RWs had pumps removed but will retain their pressure transducers so that they can continuously collect high-resolution groundwater elevation data. The 18 former RW pressure transducers are currently unable to be connected to the rest of the system until additional upgrades are performed that are currently planned for Q2 2023. The hydraulic control system now consists of the four remaining active RWs, as well as seven groundwater extraction trenches that each contain two extraction wells (EWs). Each trench is 50 feet deep, 50 feet long, and 3 feet wide and is filled with an engineered backfill. More information about the groundwater extraction trenches is provided in the *Final Design Report* (ERM 2022). The gradient control-monitoring network consisting of six gradient control clusters (GCCs) with each cluster containing six monitoring points. Within each RW, EW, and GCC location, pressure transducers are continuously collecting high-resolution groundwater elevation data. Each GCC contains three transducers interior to the wall and three transducers exterior to the wall screened in the Shallow, Intermediate, and Deep aquifers at the Site.

3. HYDRAULIC CONTAINMENT MONITORING PROGRAM

As described in the PMP, the purpose of hydraulic monitoring (i.e., groundwater elevation data) is to provide sufficient data to demonstrate an inward hydraulic gradient across the GWBW and to evaluate the effective hydraulic capture produced by the GW SCM.

Monitoring requirements were established in the PMP to demonstrate GWET effectiveness. The Site monitoring program includes groundwater elevation data (manual and transducer measurements) collected from the 36 monitoring points located within six GCCs spaced across the GWBW, with piezometers interior and exterior to the wall, throughout the alluvial sequence; and groundwater elevation and flow rate data from the four remaining active RWs and 14 EWs. High-resolution groundwater elevation data (transducer measurements) will be possible from the 18 inactive RWs that will no longer be operated, but will have transducers, after electrical upgrades are performed in Q2 2023. Additionally, one new monitoring well was installed in each of the seven extraction trenches for manual water level measurement. These data were used to prepare horizontal and vertical potentiometric surface maps representing potentiometric differences between the alluvial sequences, and to generate spatial and temporal hydrographs to evaluate hydraulic capture.

3.1 Groundwater Elevation Monitoring

Groundwater elevation monitoring was completed on 15 February 2023. Manual groundwater elevations were measured at wells that were experiencing transducer mechanical issues or that were offline during the groundwater elevation measurement event. Manual groundwater elevation measurements were completed for all inactive RWs used. Manual water level measurements for these wells were completed to evaluate transducer data accuracy. Specific issues are addressed in Attachment A-1.

As detailed in Attachments A-1 and A-2, during February 2023, the following transducers were:

Awaiting system upgrades for transducer re-installation:

- RW-05
- RW-06i
- RW-07
- RW-08
- RW-09i
- RW-10
- RW-11i
- RW-12
- RW-13i
- RW-15
- RW-16i
- RW-17

- RW-18
- RW-19i
- RW-20
- RW-21i
- RW-24i
- RW-26i

Fully out of service pending repairs:

- PA-07
- PA-14i
- PA-16i
- PA-20d
- PA-26d
- PA-29i

Out of service for less than 1 day:

- PA-06

All other transducers were operational during the entire month of February. Transducers that are fully out of service pending repairs are awaiting new transducers that have already been ordered but are backordered. They are expected to be replaced in April 2023.

Water levels in wells with transducers that were fully out of service pending repairs or waiting for additional system upgrades were taken manually.

3.2 Horizontal and Vertical Gradients at Gradient Control Points

As described above, GCC locations collect high-resolution groundwater elevation data using transducers. Transducer data are filtered to remove anomalous data from monitoring points due to potential equipment failures, such as transducer malfunctions, power outages, or updates to the GWET programmable logic controller (PLC) system, which controls and houses all the operational data. These specific issues and time periods are summarized in Table A-1 in Attachment A. The following flags are applied to filter anomalous data:

- Groundwater elevations had a change greater than 1.5 feet within 1 hour
- Groundwater elevation measurements that were found to be greater than 50 feet, or less than 1 foot

- Calculated groundwater elevation slope indicates no change between consecutive measurements indicating a transducer malfunction
- Manually flagging data that are inconsistent with the typical nature of the well
- Periods where transducer power supply was deactivated for work on interconnected electrical systems

After February 2023 flagged data were removed, the Serfes (1991) method was used to account for tidal variations as described in the PMP. Using Serfes corrected data, both horizontal and vertical gradients were calculated and plotted over time (Attachment B). Groundwater elevations, horizontal gradients, and vertical gradients from 15 February 2023 are shown below at each GCC (Table 1-1 and Table 1-2). The water elevation taken during the groundwater level gauging event at PA-12i was excluded from gradient calculations and potentiometric surface maps due to being anomalous.

Table 1-1. February Horizontal Gradients

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
GCC1	Shallow	PA-03	27.92	PA-04	28.32	-0.004
	Intermediate	PA-17iR	12.41	PA-10i	14.03	-0.016
	Deep	PA-27d	11.65	PA-18d	12.22	-0.005
GCC2	Shallow	MWA-2	9.34	PA-05	13.57	-0.062
	Intermediate	MWA-8i	9.43	PA-11i	11.13	-0.023
	Deep	PA-19d	8.45	PA-30d	10.75	-0.043
GCC3	Shallow	MWA-69	10.17	PA-06	13.87	-0.035
	Intermediate	MWA-66i	9.21	PA-12i	*	**
	Deep	PA-21d	8.73	PA-20d ^{M}	11.22	-0.020
GCC4	Shallow	MWA-19	9.93	PA-28	15.87	-0.059
	Intermediate	MWA-34i	9.68	PA-13i	12.23	-0.028
	Deep	MWA-58d	9.21	PA-22d	10.58	-0.015
GCC5	Shallow	MWA-47	10.64	PA-07 ^{M}	15.03	-0.042
	Intermediate	PA-29i	9.67	PA-14i	12.15	-0.046
	Deep	PA-24d	8.38	PA-23d	11.07	-0.051
GCC6	Shallow	PA-09	12.07	PA-08	13.60	-0.027
	Intermediate	PA-16i ^{M}	10.80	PA-15i	12.35	-0.028
	Deep	PA-26d ^{M}	10.98	PA-25d	11.85	-0.014

Notes:
Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.
Horizontal gradient calculated as (Exterior Elevation – Interior Elevation) / Horizontal distance.
ft NAVD88 = feet North American Vertical Datum of 1988
^{M} = manual groundwater elevation measurement
** = anomalous groundwater elevation*
*** = horizontal gradient cannot be calculated due to anomalous elevation reading*

Table 1-2. February Vertical Gradients

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
Interior	SZ-IZ	GCC1	PA-04	28.32	PA-10i	14.03	0.99
		GCC2	PA-05	13.57	PA-11i	11.13	-0.01
		GCC3	PA-06	13.87	PA-12i	*	**
		GCC4	PA-28	15.87	PA-13i	12.23	0.03
		GCC5	PA-07 ^{M}	15.03	PA-14i	12.15	0.08
		GCC6	PA-08	13.60	PA-15i	12.35	0.09
	IZ-DZ	GCC1	PA-10i	14.03	PA-18d	12.22	0.12
		GCC2	PA-11i	11.13	PA-30d	10.75	0.63
		GCC3	PA-12i	*	PA-20d ^{M}	11.22	**
		GCC4	PA-13i	12.23	PA-22d	10.58	0.02
		GCC5	PA-14i	12.15	PA-23d	11.07	0.03
		GCC6	PA-15i	12.35	PA-25d	11.85	-0.01
Exterior	SZ-IZ	GCC1	PA-03	27.92	PA-17iR	12.41	1.44
		GCC2	MWA-2	9.34	MWA-8i	9.43	0.21
		GCC3	MWA-69	10.17	MWA-66i	9.21	-0.05
		GCC4	MWA-19	9.93	MWA-34i	9.68	0.57
		GCC5	MWA-47	10.64	PA-29i	9.67	0.30
		GCC6	PA-09	12.07	PA-16i ^{M}	10.80	0.10
	IZ-DZ	GCC1	PA-17iR	12.41	PA-27d	11.65	0.24
		GCC2	MWA-8i	9.43	PA-19d	8.45	0.05
		GCC3	MWA-66i	9.21	PA-21d	8.73	0.16
		GCC4	MWA-34i	9.68	MWA-58d	9.21	0.09
		GCC5	PA-29i	9.67	PA-24d	8.38	0.03
		GCC6	PA-16i ^{M}	10.80	PA-26d ^{M}	10.98	0.01

Notes:
Positive vertical gradient indicates a downward hydraulic gradient.

Vertical gradient calculated as (Upper Elevation – Lower Elevation) / Screen Midpoint distance.

ft NAVD88 = feet North American Vertical Datum of 1988

SZ = Shallow Zone

IZ = Intermediate Zone

DZ = Deep Zone

^{M} = manual groundwater elevation measurement

** = anomalous groundwater elevation*

*** = vertical gradient cannot be calculated due to anomalous elevation reading*

3.3 Potentiometric Surface, Groundwater Elevation Difference Maps, and Groundwater Flow Directions

As described in the PMP, potentiometric surface maps are used to evaluate flow paths. Vertical gradients are also used as an additional line of evidence to evaluate hydraulic containment. Groundwater elevation data collected on 15 February 2023 were used to prepare potentiometric surface maps based on manual measurements and averaged transducer groundwater elevations (Figures 2 through 4) and vertical difference maps (Figures 5 and 6).

The generalized flow direction indicated by the potentiometric surface maps show overall groundwater flow toward the GWBW. The Shallow and Intermediate Zones potentiometric maps (Figures 2 and 3) indicate localized groundwater movement to some of the extraction trenches due to GW SCM pumping. Only some of the EWs were active at the time of the water level event. However, hydraulic influence is apparent near GCC1, and a cone of depression is developing around GCC3 and GCC4. Additional evidence of capture is anticipated as ongoing pumping occurs.

A potentiometric separation is still noticeable exterior to the GWBW, indicating the barrier wall is functioning by impeding groundwater flow. The Deep Zone potentiometric map also indicates flow toward the GWBW (Figure 4). River elevations are shown on the potentiometric surface maps in an inset (Figures 2 through 4) and depict stage movement within the month corresponding with the MPR. Vertical gradients were calculated for each vertical well pair using these groundwater elevations and are plotted on Figures 5 and 6.

Vertical groundwater gradients interior to the GWBW between the Shallow and Intermediate Zones were generally downward in February 2023 with GCC2 being upward, and GCC1, GCC4, GCC5, and GCC6 being downward (Figure 5). The vertical groundwater gradients at GCC3 on the interior of the wall was unable to be calculated due to an anomalous groundwater elevation reading at PA-12i. PA-12i will be re-calibrated so that vertical gradients at GCC3 can be calculated in the future and presented in subsequent MPRs. Vertical groundwater gradients are also depicted in Attachment B. The magnitude of the gradient is much greater at GCC1 than other monitoring locations due to the influence from a localized high-pressure zone near GCC1 where vertical groundwater flow is impeded by a localized confining unit (Figure 2). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were generally downward with exception to GCC3, as shown on Figure 5 and in Attachment B.

Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were downward with exception to GCC6. The direction of vertical gradients exterior to the GWBW were downward, as shown on Figure 6 and Attachment B.

The river elevation in February 2023 varied with an average of 8.71 feet NAVD88, maximum of 11.75 feet NAVD88, and minimum of 6.58 feet NAVD88.

3.3.1 GWET System Performance

The GWET operated within permit conditions during the reporting period. There were two brief unplanned shutdowns:

- 10 February 2023: The well field was shut down at 0800 to clean the plate separator and inspect pressure filter media. The well field was restarted at 1300.
- 22 February 2023: The well field was shut down in the afternoon due to elevated DDx concentrations detected in an internal check sample. The concentration of DDx was below the permit level, and the plant was placed into recirculation mode. The carbon vessels were backwashed to address the elevated DDx concentrations. The plant was restarted on 1 March 2023 at 0645 after receiving follow-up internal check samples showed that backwashing efforts were successful at reducing DDx concentrations.

On 27 February 2023, ERM procured a mini-bulk system for storing coagulant. Previously, frequent tote deliveries were required and manual labor was required to handle the coagulant. The mini-bulk system has a larger, refillable tank that reduces risk for operators and is more resilient to supply chain issues. There were no other upgrades to the GWET plant in the month of February 2023.

3.3.2 Recovery Well and Extraction Well Performance

In February 2023, the average system influent flow rate was 73.32 gallons per minute (gpm) during operational periods, compared to 69.16 gpm in the January 2023 period. The increase in flow rate is largely due to the replacement of a ½ hp pump with a 1 hp pump at EW-01 along with a decrease in extraction rates observed at the historical recovery wells. During February 2023, eight of the 14 EWs were periodically down for maintenance. These pumps were removed from this historical recovery wells and placed in the EWs after trench construction due to supply chain issues procuring new pumps. New pumps are expected to arrive at the Site in May 2023. The root cause of the pump failures is being investigated, and the contractor who constructed the extraction trenches (Odin Construction) is being engaged as needed to perform repairs. ERM does not anticipate that these repairs will inhibit the GWET plant's operational goal of generating inward gradient in the long term. ERM is currently in the process of optimizing extraction rates within the system to increase flow rates at each operational well until the extraction rates specified in the *Final Design Report* (ERM 2022) are achieved, or until the Capture Zone Objectives are met.

Table 1-3. Recovery Well Pumping Rates[1]

Recovery Well	February 2023 Average Pumping Rate (gpm) **
RW-14	2.21

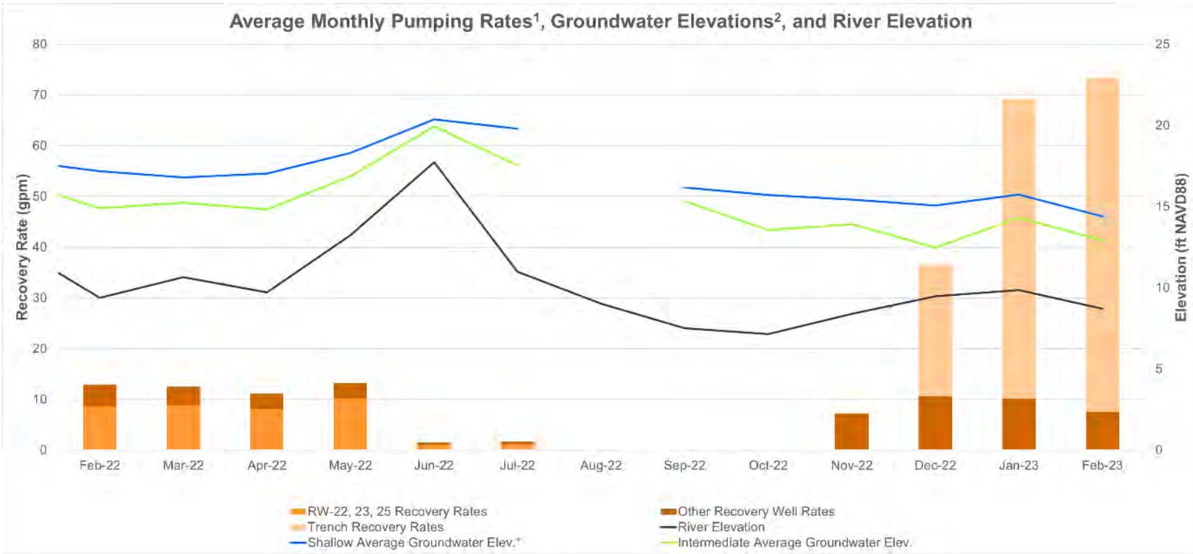
Recovery Well	February 2023 Average Pumping Rate (gpm) **
RW-22 *	0.00
RW-23	3.32
RW-25	2.03
EW-01	9.97
EW-02	3.70
EW-03	2.57
EW-04	5.39
EW-05	5.91
EW-06	6.41
EW-07	3.64
EW-08	2.91
EW-09	6.72
EW-10	2.10
EW-11	3.88
EW-12	5.78
EW-13	6.35
EW-14	0.41
Total	**73.32**

Notes:

[1] = Flow rates are calculated based on the period of the month during which the recovery wells were operational

** = Recovery well not in service*

*** = All recovery and extraction wells not in service for part of the month*



Notes:

[1] = Following installation of trenches in Summer 2022, RW-22, 23, and 25 recovery rates are now grouped together with the other remaining recovery well (RW-14) starting in November 2022.

[2] = Average groundwater elevations are calculated using interior wells—the well field was powered down in August preventing the measurement of the groundwater.

** = The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the whole aquifer.*

Figure 1-1. Monthly Pumping Rate Contribution

3.3.3 Recommendations for Extraction System Optimization

Recovery rates from the start of the system indicate that the active RWs and EWs are operating as designed with the exception of the troubleshooting discussed above. The EWs have been started in accordance with the plan outlined in the Trench Startup Standard Operating Procedure included in the *Final Design Report* (ERM 2022). The extraction rates throughout the GWET system will continue to be optimized to meet Target Capture Objectives. Additional maintenance and/or replacement of the historical EW pumps will occur to mitigate potential pump failures.

4. ANALYTICAL PROGRAM

Quarterly groundwater monitoring was implemented in accordance with the ODEQ-approved Arkema Quarterly Groundwater Monitoring Work Plan dated October 2019 and the ODEQ-approved reduced scope described in the 2021 monitoring program modification request memorandum dated 9 September 2021. The table below outlines sampling dates and submittal dates related to groundwater monitoring since the implementation of the reduced scope. The Quarterly Monitoring Reports present results from these sampling events.

Report	Sampling Dates	Report Submittal Date
2021 Quarter 3	9/21/2021–9/24/2021	1/14/2022
2021 Quarter 4	12/13/2021–12/16/2021	4/20/2022

Report	Sampling Dates	Report Submittal Date
2022 Quarter 1	3/14/2022–3/17/2022	6/15/2022
2022 Quarter 2	6/6/2022–6/9/2022	9/12/2022
2022 Quarter 4	11/7/2022–11/10/2022	2/17/2023
2023 Quarter 1	3/6/2023–3/10/2023	6/15/2023 *

** = estimated dates*

5. SUMMARY AND CONCLUSIONS

This report presents a summary of the GW SCM operation, maintenance, and monitoring activities conducted at the Site in February 2023 and documents results from system monitoring. The following summarizes ERM's observations and conclusions drawn from collected data.

5.1 Groundwater Flow

- Horizontal gradients across the GWBW are generally outward toward the river; however, groundwater elevations show a noticeable separation interior and exterior of the GWBW, indicating the GWBW is functioning via impeding groundwater flow. Before installation of the GEE system, inward gradients were periodically observed at some monitoring locations. It is yet to be determined whether a long-term inward gradient has been produced through increased pumping rates, but initial indications show that the GWET is generating localized areas of sustained groundwater capture that are anticipated to expand with longer operations.

- Vertical groundwater gradients interior to the GWBW between the Shallow and Intermediate Zones were downward in February 2023 with exception to GCC2 (Figure 5). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were also downward except for GCC3. Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were downward with exception to GCC6. The direction of vertical gradients exterior to the GWBW were downward (Figure 6).

- River elevations have generally been decreasing since reporting resumed in December 2022. In 2022, the average river elevation was 10.48 feet NAVD88 with a maximum monthly average elevation of 17.73 feet NAVD88 in June 2022 and a minimum monthly average elevation of 7.14 feet NAVD88 in October 2022 (Figure 1-1). The average river elevation in February 2023 was 8.71 feet NAVD88 with a minimum elevation of 6.58 feet NAVD88 and a maximum elevation of 11.75 feet NAVD88.

- Within the Site alluvial sequence, potentiometric maps indicate the GW SCM could be producing localized areas of hydraulic capture around trenches that were active during the water level event; however, more time at elevated extraction rates will be required to evaluate whether GWET objectives are being met.

5.2 Groundwater Extraction

Based on February 2023 extraction and relevant hydrograph analysis, the EWs and RWs are operating as designed. Further evaluation of the system with respect to the Capture Zone Objectives will be conducted once all pumps are operating at their design rates for an extended period.

5.3 Recommendations and Future Work

ERM will continue to optimize new EWs. Any additional modifications to the system to meet capture objectives will be included in subsequent Monthly Progress Reports. The project schedule provided as Attachment C summarizes activities planned for the immediate future.

Regards,

Brendan Robinson, PE
Partner

6. REFERENCES

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Serfes, Michael. 1991. “Determining the Mean Hydraulic Gradient of Ground Water Affected by Tidal Fluctuations.” *Groundwater*, Vol. 29. No 4. July–August 1991.

FIGURES

Figure 1: Site Layout

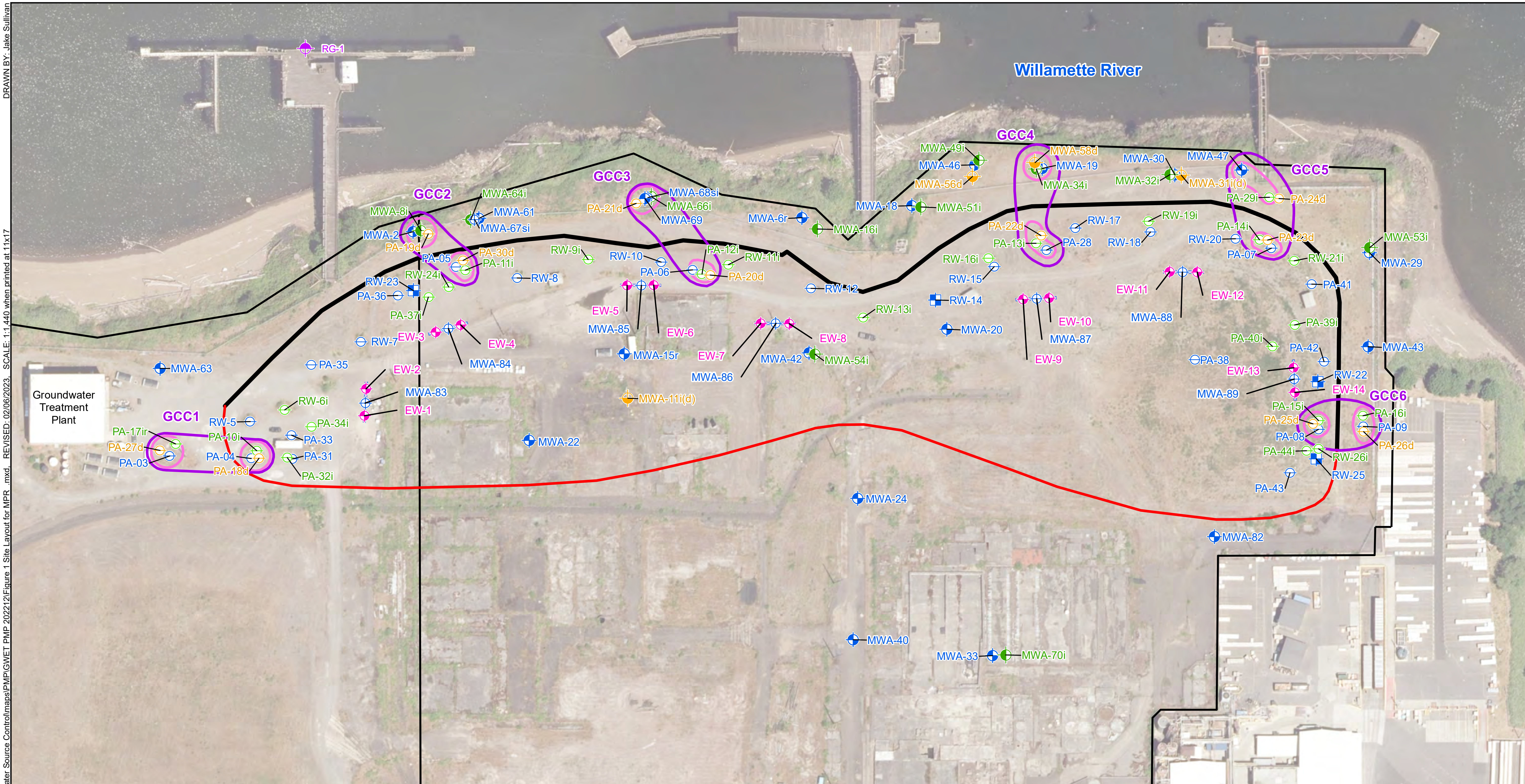
Figure 2: February 2023 Shallow Zone Groundwater Contours

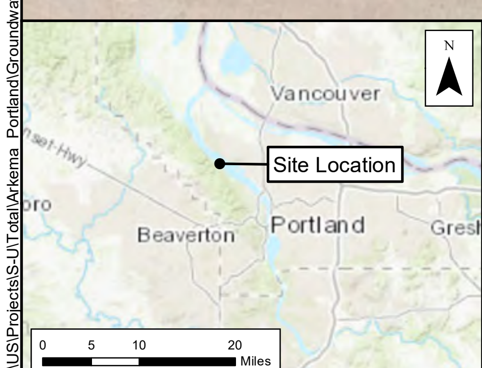
Figure 3: February 2023 Intermediate Zone Groundwater Contours

Figure 4: February 2023 Deep Zone Groundwater Contours

Figure 5: February 2023 Shallow to Intermediate Zone Vertical Head Difference

Figure 6: February 2023 Intermediate to Deep Zone Vertical Head Difference





Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Shallow Zone Recovery Well
- River Gauge
- Trench Extraction Well
- Target Capture Zone
- Barrier Wall Alignment
- Parcel and Property Boundaries

GradientClusters

Type

- Gradient Control Cluster
- Vertical Flow Cluster
- Extraction Trench

N

0 120 240

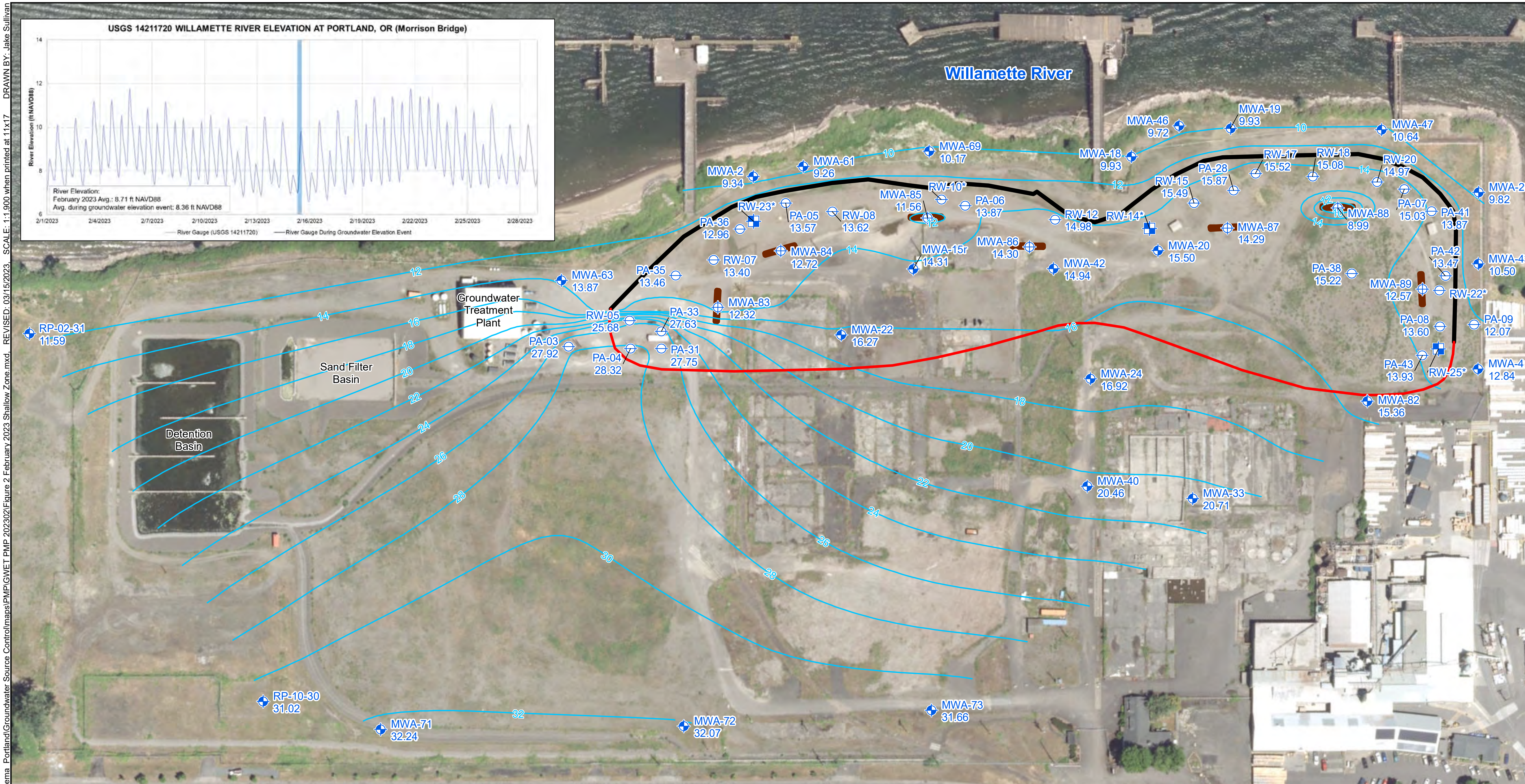
Feet

Figure 1
Site Layout
Monthly Progress Report
Groundwater Source Control Measure
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

Source: City of Portland Aerial Imagery, flown Summer 2021; NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 202212\Figure 1 Site Layout for MPR .mxd. REVISED: 02/06/2023. SCALE: 1:1,440 when printed at 11x17 DRAWN BY: Jake Sullivan



Legend

- Shallow Zone Piezometer
- Shallow Zone Monitoring Well
- Active Recovery Well; Not Used During Contouring
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Shallow Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Extraction Trench (Not To Scale)
- Target Capture Zone
- Barrier Wall Alignment

Notes:
* Value not used for contouring.
Water levels collected February, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

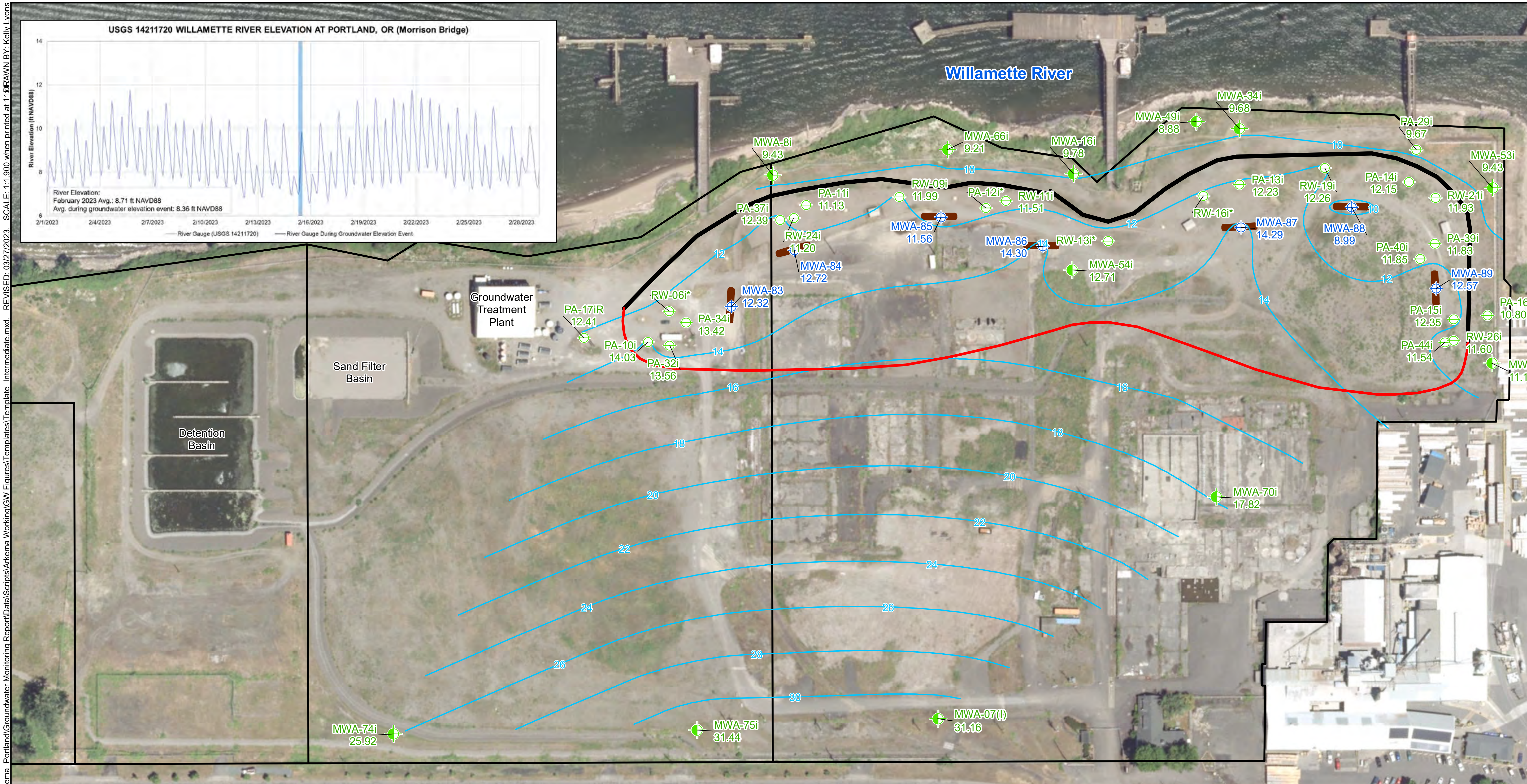
0 160 320
Feet

Figure 2
February 2023 Shallow Zone Groundwater Contours
Monthly Performance Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

\\SCUSPRDGISFS01\Data\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 202302\Figure 2 February 2023 Shallow Zone.mxd REVISED: 03/15/2023 SCALE: 1:1,900 when printed at 11x17 DRAWN BY: Jake Sullivan

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Intermediate Zone Piezometer
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected February, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

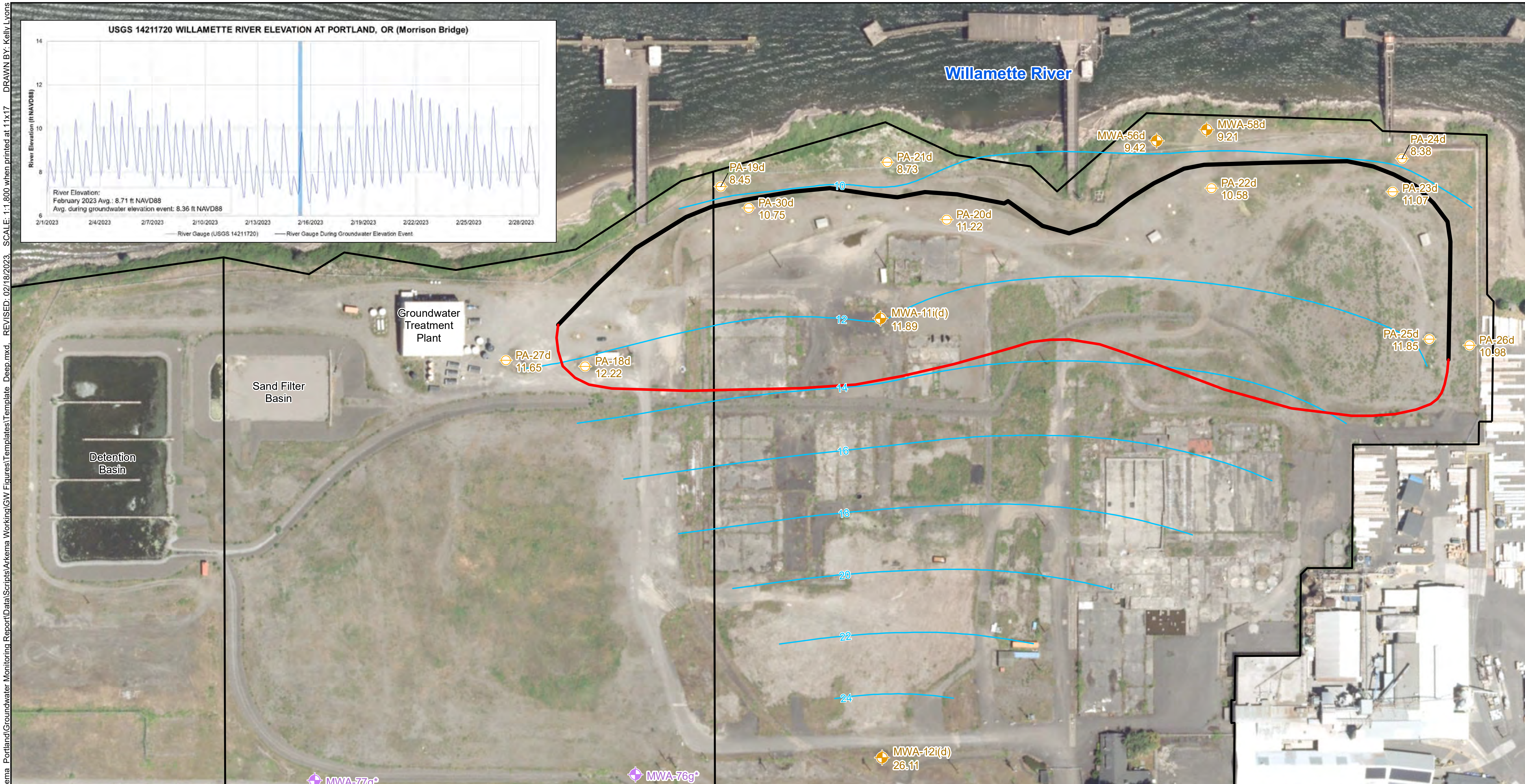
0 160 320
Feet

Figure 3
February 2023 Intermediate Zone Groundwater Contours
Monthly Performance Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

\\SCUSPRDGISFS01\Data\US\Projects\S-U\Total\Arkema_Portland\Groundwater Monitoring Report\Data\Scripts\Arkema Working\GW Figures\Templates\Template_Intermediate.mxd, REVISED: 03/27/2023, SCALE: 1:1,900 when printed at 11x17, DRAWN BY: Kelly Lyons



Legend

- Deep Zone Piezometer
- Deep Zone Monitoring Well
- Gravel Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Deep Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment

Notes:
* Value not used for contouring.
Gravel zone wells not used in contouring.
Water levels collected February, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 150 300
Feet

Figure 4
February 2023 Deep Zone Groundwater Contours
Monthly Performance Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

\\SCUSPRDGISFS01\Data\US\Projects\S-U\Total\Arkema_Portland\Groundwater Monitoring Report\Data\Scripts\Arkema Working\GW Figures\Templates\Template_Deep.mxd REVISED: 02/18/2023 SCALE: 1:1,800 when printed at 11x17 DRAWN BY: Kelly Lyons

Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Shallow Zone Recovery Well
- Trench Extraction Well
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as shallow zone minus intermediate zone potentiometric surfaces.
Water levels collected February, 2023.
Aerial Photo: City of Portland, Summer 2017.

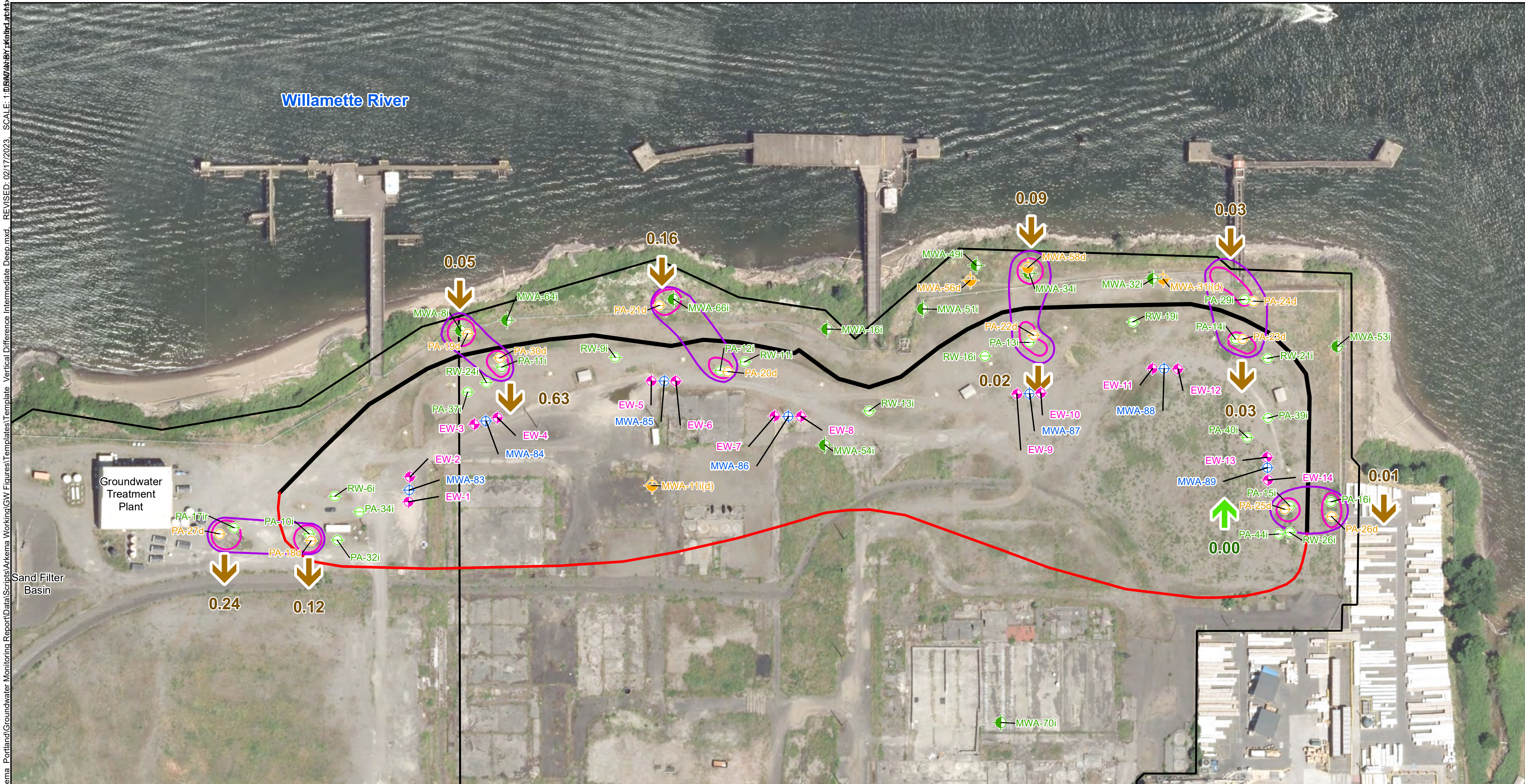
N

0 130 260
Feet

Figure 5
February 2023 Shallow to Intermediate Zone Vertical Head Difference
Monthly Performance Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Shallow-Intermediate Zone Monitoring Well
- Trench Extraction Well
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as intermediate zone minus deep zone potentiometric surfaces.
Water levels collected February, 2023.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 6
February 2023 Intermediate to Deep Zone Vertical Head Difference
Monthly Performance Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

\\SCUSPRDGISFS01\Data\US\Projects\S-U\Total\Arkema_Portland\Groundwater Monitoring Report\Data\Scripts\Arkema Working\GW Figures\Templates\Template_Vertical Difference Intermediate Deep.mxd REVISED: 02/17/2023 SCALE: 1:1,560 when printed at 11x17

ATTACHMENT A-1 TRANSDUCER FLAGS

Attachment A-1. Transducer Flags

Table A-1
Transducer Malfunction Log: February 2023
Arkema Inc. Facility
Portland, Oregon

Gradient Cluster	Transducer	Interval	Date Range		Issue and Repairs Performed
5	PA-06	Shallow	2/14/2023	2/14/2023	LOTO at EW-03 to perform maintenance.
5	PA-07	Shallow	1/4/2023	2/28/2023	Troubleshooting occurred. Transducer needs to be replaced.
5	PA-14i	Intermediate	2/8/2023	2/28/2023	LOTO at EW-11. EW-11 remains locked out due to safety concerns from faulty connections in vault.
6	PA-16i	Intermediate	12/16/2023	2/28/2023	Troubleshooting occurred. Transducer needs to be replaced.
3	PA-20d	Deep	1/4/2023	2/28/2023	LOTO at EW-05 to swap I/O card. Transducer needs to be replaced.
6	PA-26d	Deep	1/11/2023	2/28/2023	Recalibrated transducer. Transducer needs to be replaced.
5	PA-29i	Intermediate	2/8/2023	2/28/2023	LOTO at EW-11. EW-11 remains locked out due to safety concerns from faulty connections in vault.

Notes:
I/O = input/output
LOTO = lockout/tagout
VFD = variable frequency drive

ATTACHMENT A-2 RECOVERY WELL STATUS

Attachment A-2. Recovery Well Status

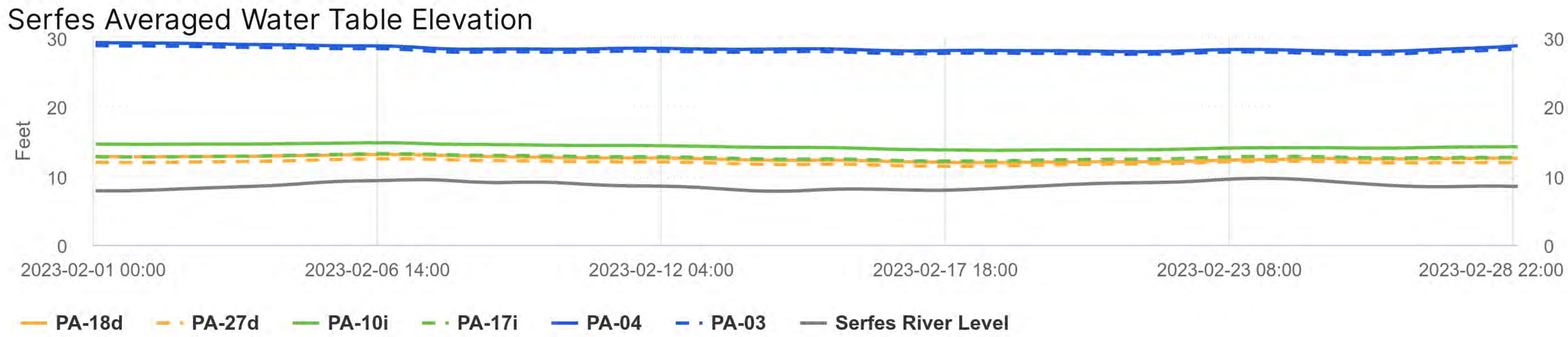
Table A-2
Recovery Well Status: February 2023
Arkema Inc. Facility
Portland, Oregon

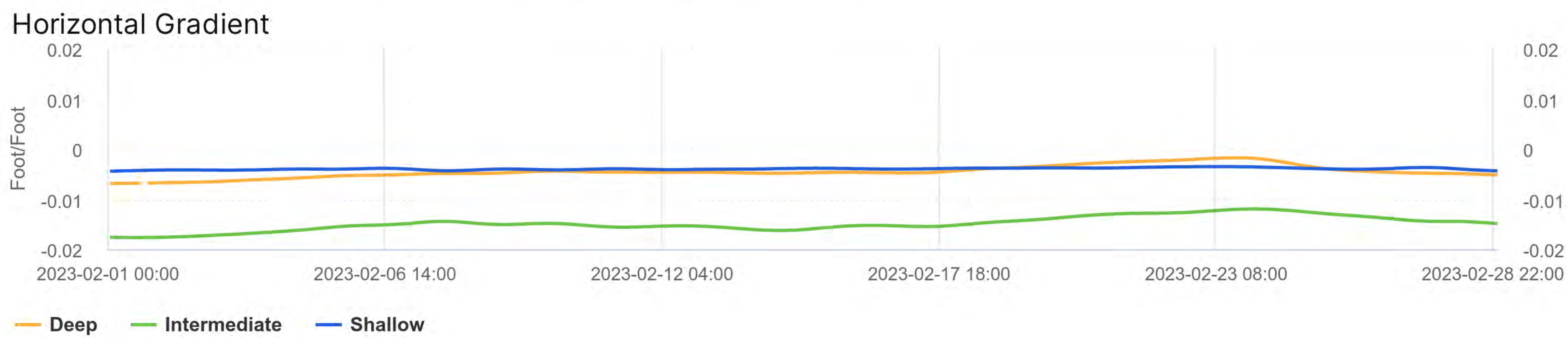
Recovery Well ID	Status as of 2/28/2023 (active or inactive)	Issue	Actions to get online	Expected date back online	Transducer Status	Totalizer Status	Average Flow Rate (gpm)	Overall Extraction Rate	Notes
RW-05	Inactive	None	Will not be placed back online	N/A	Good	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-06i	Inactive	None	Will not be placed back online	N/A	Good	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-07	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-08	Inactive	None	Will not be placed back online	N/A	Not Connected	Good	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-09i	Inactive	None	Will not be placed back online	N/A	Not Connected	Good	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-10	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-11i	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-12	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-13i	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-14	Active	None	N/A	N/A	Not Connected	Good	2.21	M	
RW-15	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-16i	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-17	Inactive	None	Will not be placed back online	N/A	Not Connected	Good	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-18	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-19i	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-20	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-21i	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-22	Active	None	Replace totalizer	N/A	Good	Bad	0.00	OFF*	Totalizer failed, will be replaced
RW-23	Active	None	N/A	N/A	Good	Good	3.32	G	
RW-24i	Inactive	None	Will not be placed back online	N/A	Not Connected	Good	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-25	Active	None	N/A	N/A	Good	Good	2.03	M	
RW-26i	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
EW-01	Active	None	N/A	N/A	Good	Good	9.97	G	
EW-02	Inactive	None	N/A	N/A	Good	Good	3.70	G	Motor fault, under investigation
EW-03	Active	None	N/A	N/A	Good	Good	2.57	M	
EW-04	Active	None	N/A	N/A	Good	Good	5.39	G	
EW-05	Active	None	N/A	N/A	Good	Good	5.91	G	
EW-06	Active	None	N/A	N/A	Good	Good	6.41	G	
EW-07	Active	None	N/A	N/A	Good	Good	3.64	G	
EW-08	Active	None	N/A	N/A	Good	Good	2.91	M	
EW-09	Active	None	N/A	N/A	Good	Good	6.72	G	
EW-10	Inactive	None	N/A	N/A	Good	Good	2.10	M	Motor fault, under investigation
EW-11	Inactive	None	N/A	N/A	Good	Good	3.88	G	Motor fault, under investigation
EW-12	Active	None	N/A	N/A	Good	Good	5.78	G	
EW-13	Active	None	N/A	N/A	Good	Good	6.35	G	
EW-14	Inactive	None	N/A	N/A	Good	Good	0.41	M	Motor fault, under investigation

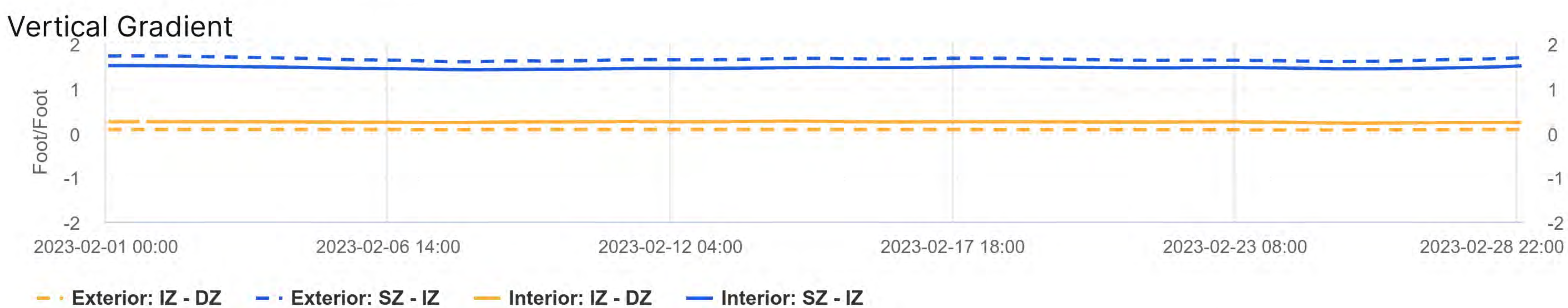
Notes:
** Recovery wells not in service*
G = good pumping, greater than 3.0 gpm
gpm = gallons per minute
M = moderate pumping, greater than 1.0 gpm and less than 3.0
P = poor pumping, less than 1.0 gpm
VFD = variable frequency drive
PA = piezometer

ATTACHMENT B GRADIENT HYDROGRAPHS

GCC1 Gradient Control Cluster 1



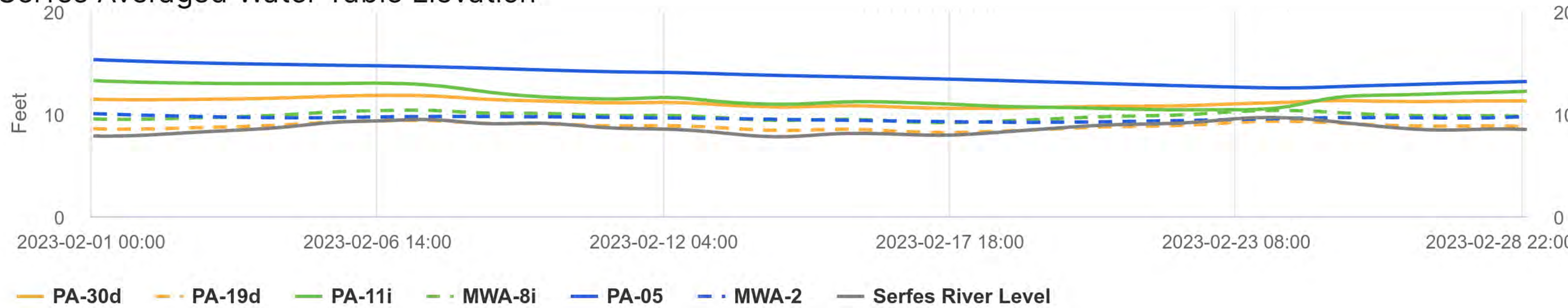




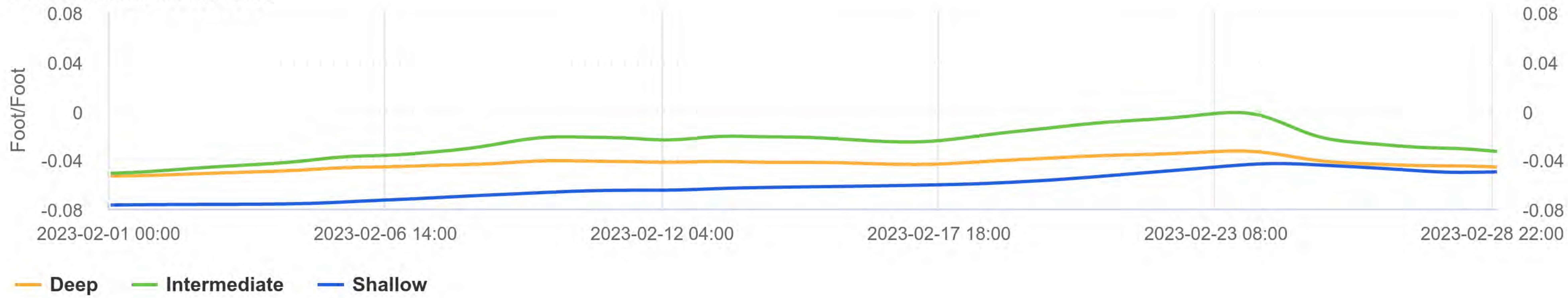
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

GCC2 Gradient Control Cluster 2

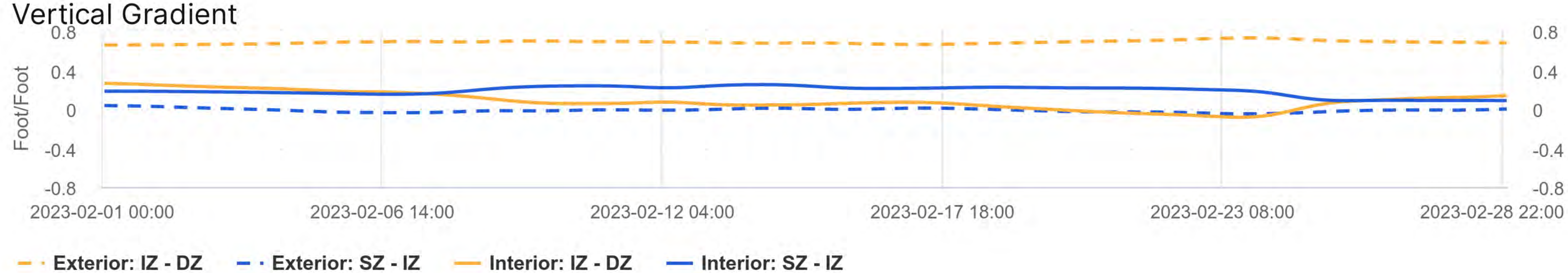
Serfes Averaged Water Table Elevation



Horizontal Gradient



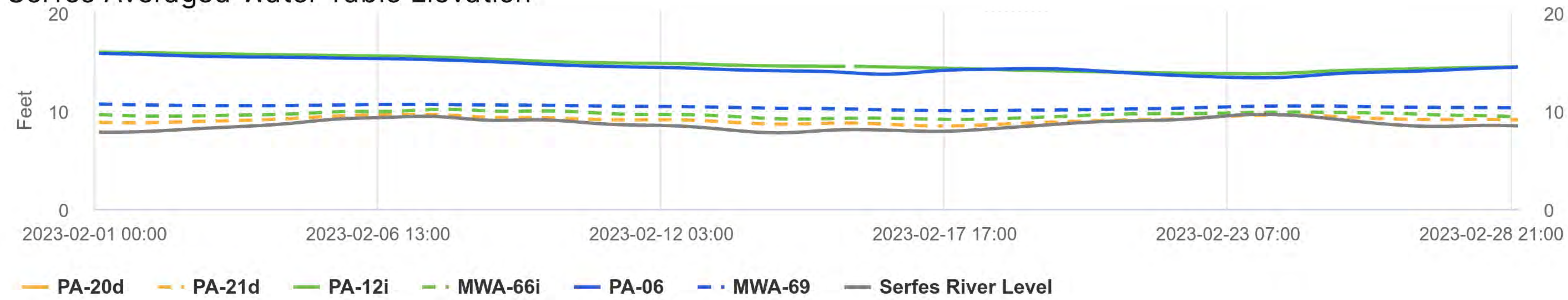
Vertical Gradient



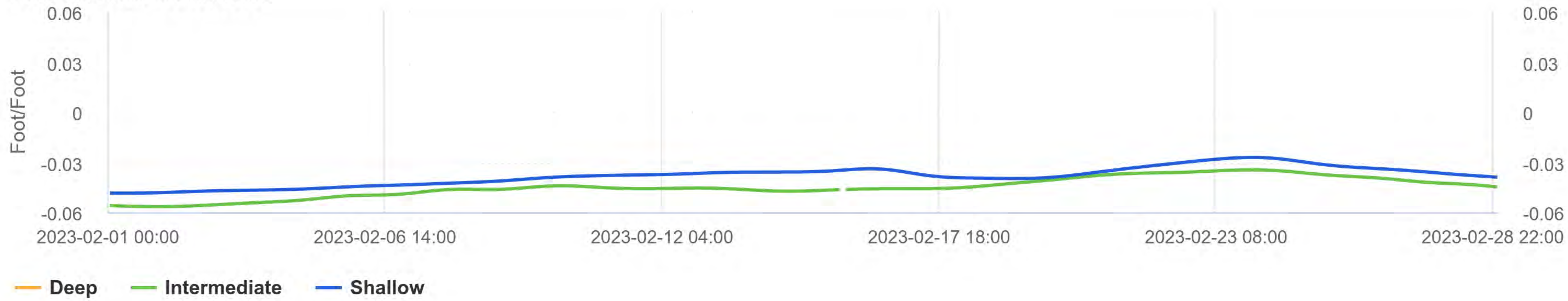
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

GCC3 Gradient Control Cluster 3

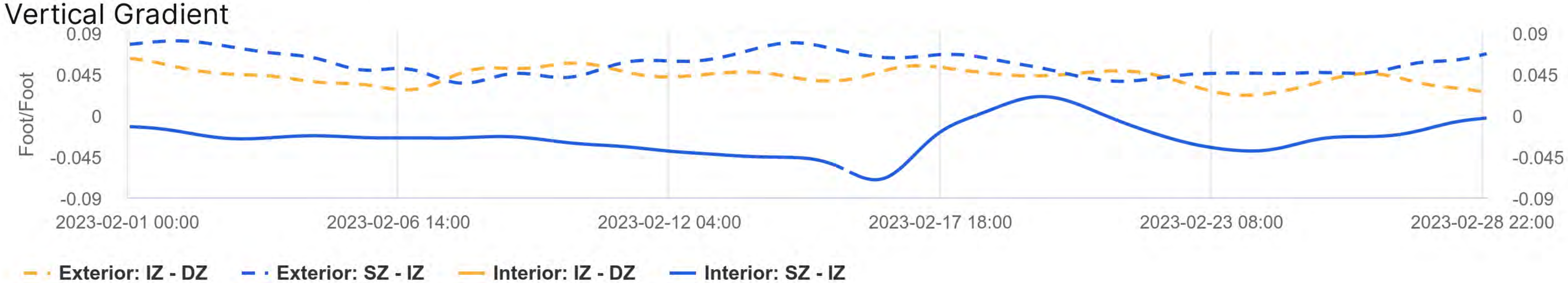
Serfes Averaged Water Table Elevation



Horizontal Gradient



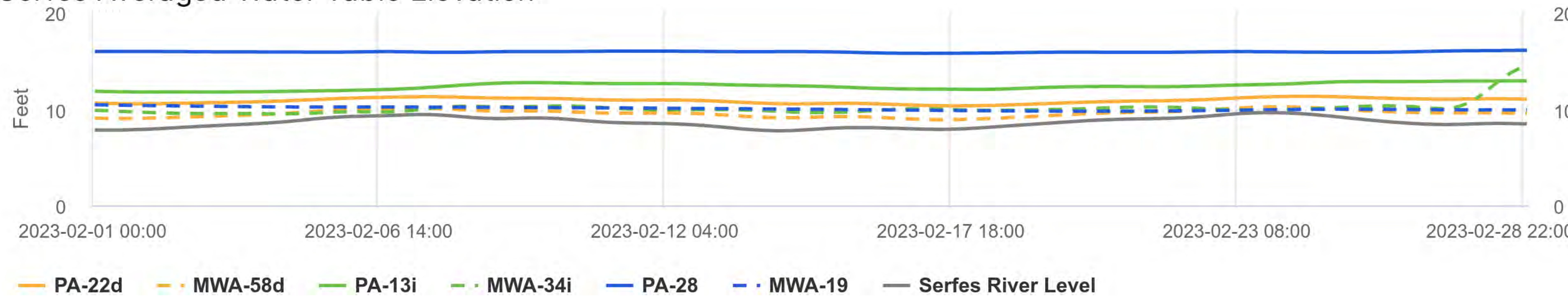
Vertical Gradient



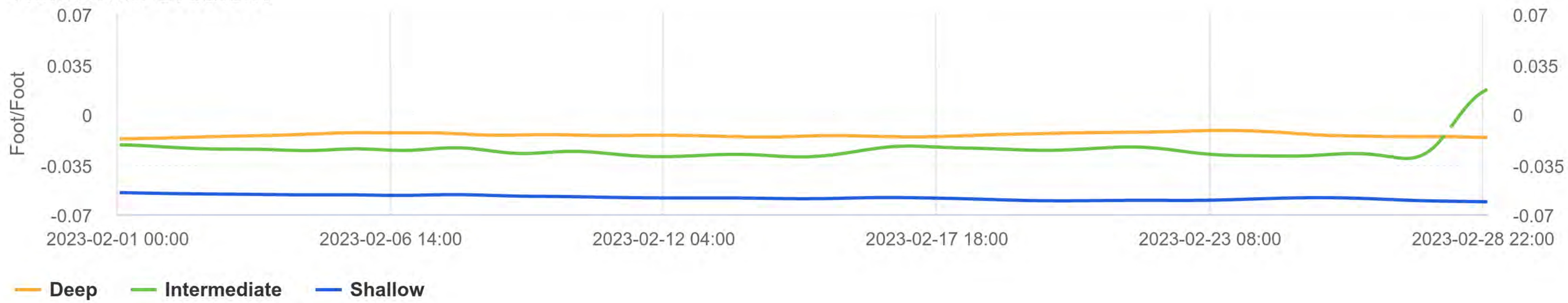
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

GCC4 Gradient Control Cluster 4

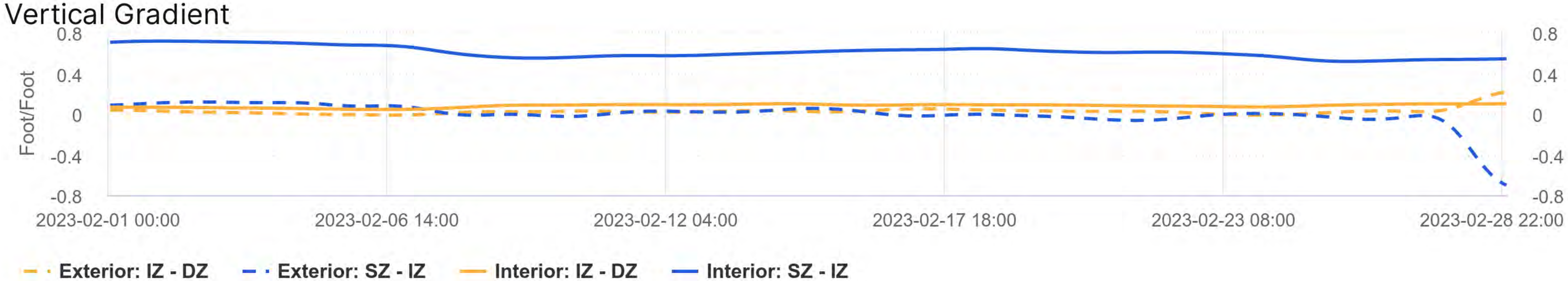
Serfes Averaged Water Table Elevation



Horizontal Gradient



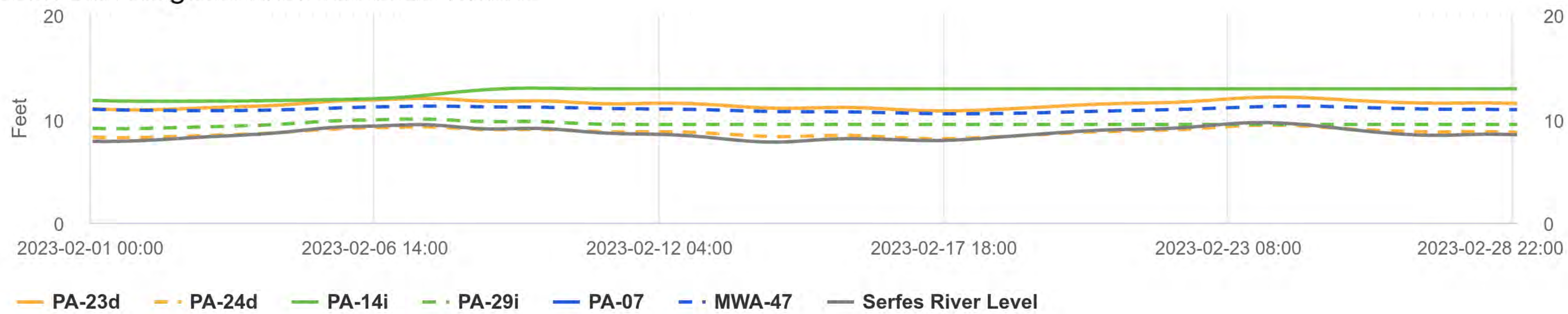
Vertical Gradient



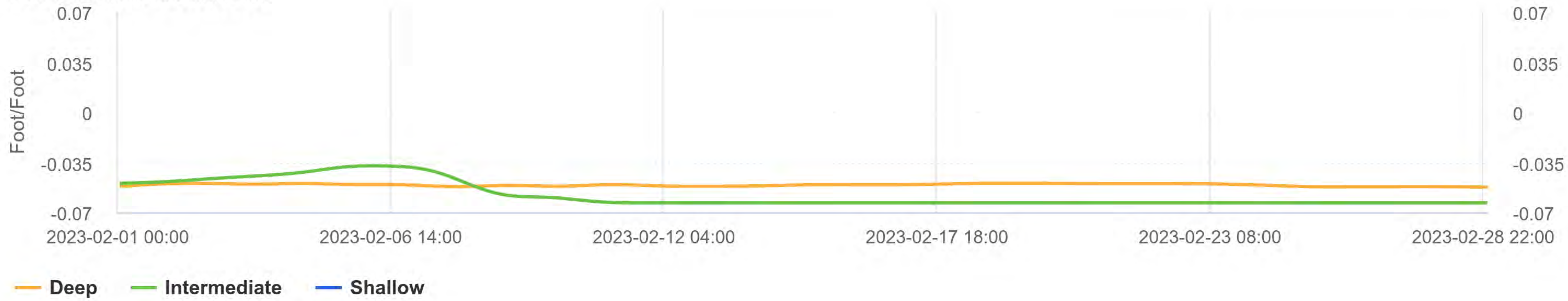
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

GCC5 Gradient Control Cluster 5

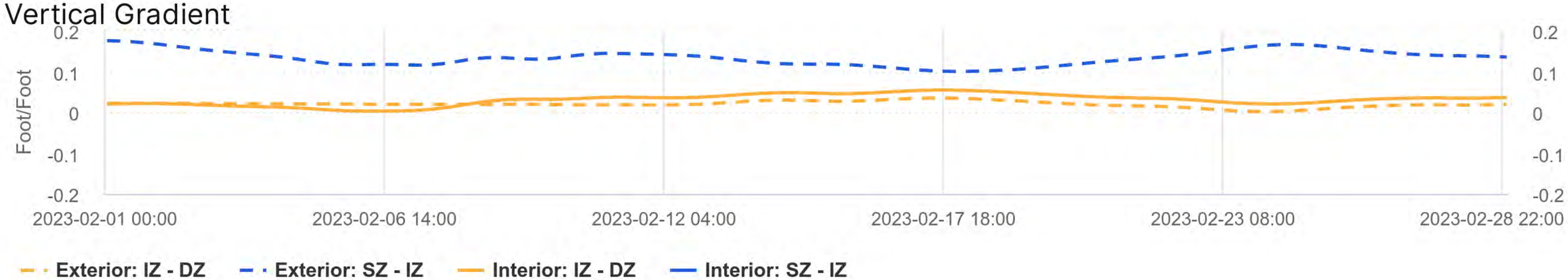
Serfes Averaged Water Table Elevation



Horizontal Gradient



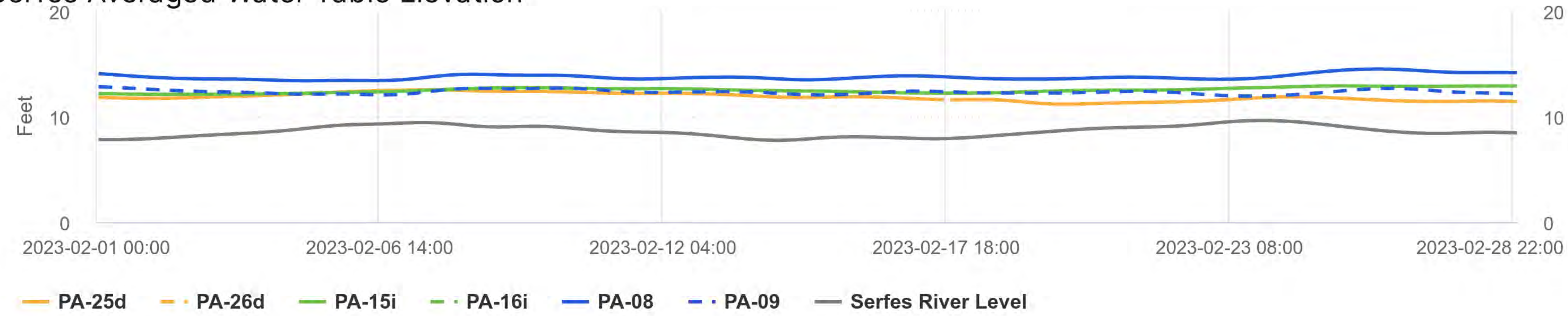
Vertical Gradient



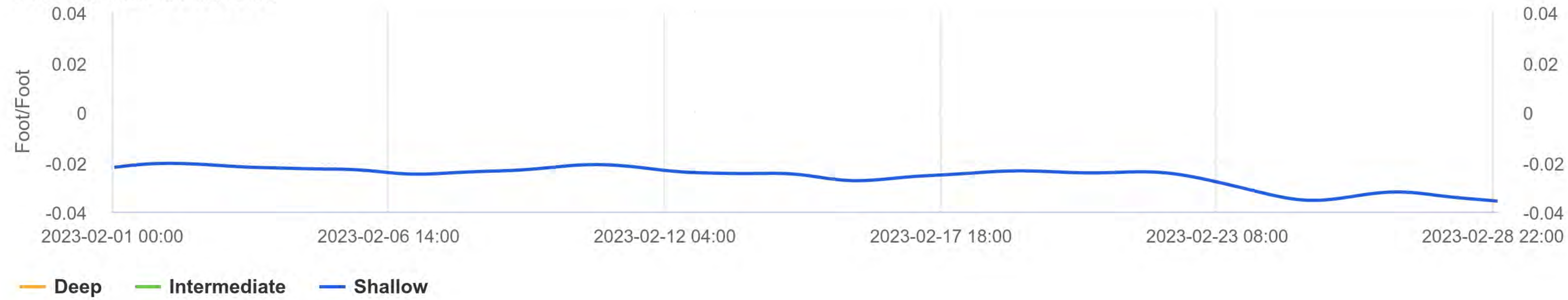
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

GCC6 Gradient Control Cluster 6

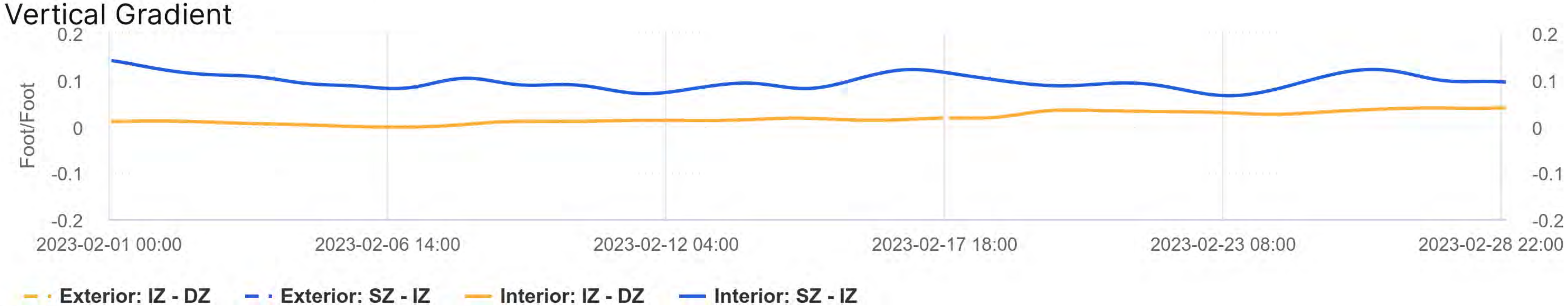
Serfes Averaged Water Table Elevation



Horizontal Gradient



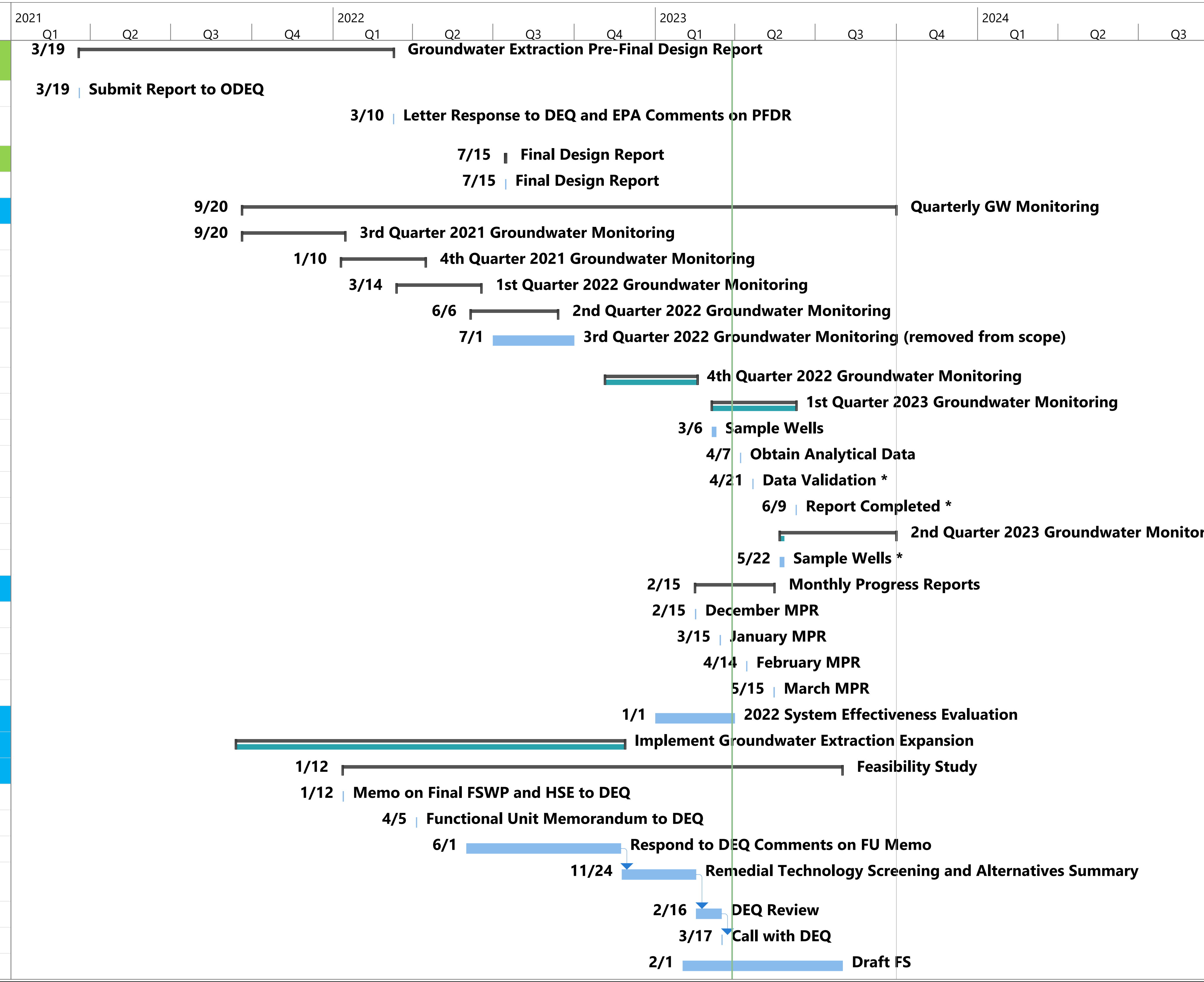
Vertical Gradient



Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

ATTACHMENT C PROJECT SCHEDULE

ID	Task Name	Duration	Start
1	**Groundwater Extraction Pre-Final Design Report**	**255 days**	**Fri 3/19/21**
2	*Submit Report to ODEQ*	*1 day*	*Fri 3/19/21*
3	*Letter Response to DEQ and EPA Comments on PFDR*	*1 day*	*Thu 3/10/22*
4	**Final Design Report**	**1 day**	**Fri 7/15/22**
5	*Final Design Report*	*1 day*	*Fri 7/15/22*
6	**Quarterly GW Monitoring**	**533 days**	**Mon 9/20/21**
7	*3rd Quarter 2021 Groundwater Monitoring*	*85 days*	*Mon 9/20/21*
12	*4th Quarter 2021 Groundwater Monitoring*	*70 days*	*Mon 1/10/22*
16	*1st Quarter 2022 Groundwater Monitoring*	*70 days*	*Mon 3/14/22*
21	*2nd Quarter 2022 Groundwater Monitoring*	*71 days*	*Mon 6/6/22*
26	*3rd Quarter 2022 Groundwater Monitoring (removed from scope)*	*66 days*	*Fri 7/1/22*
27	*4th Quarter 2022 Groundwater Monitoring*	*78 days*	*Sat 11/5/22*
32	**1st Quarter 2023 Groundwater Monitoring**	**70 days**	**Mon 3/6/23**
33	*Sample Wells*	*5 days*	*Mon 3/6/23*
34	*Obtain Analytical Data*	*1 day*	*Fri 4/7/23*
35	Data Validation *	1 day	Fri 4/21/23
36	Report Completed *	1 day	Fri 6/9/23
37	**2nd Quarter 2023 Groundwater Monitoring**	**96 days**	**Mon 5/22/23**
38	Sample Wells *	5 days	Mon 5/22/23
39	**Monthly Progress Reports**	**64 days**	**Wed 2/15/23**
40	*December MPR*	*1 day*	*Wed 2/15/23*
41	*January MPR*	*1 day*	*Wed 3/15/23*
42	February MPR	1 day	Fri 4/14/23
43	March MPR	1 day	Mon 5/15/23
44	**2022 System Effectiveness Evaluation**	**66 days**	**Sun 1/1/23**
45	**Implement Groundwater Extraction Expansi**	**317 days**	**Mon 9/13/21**
53	**Feasibility Study**	**407 days**	**Wed 1/12/22**
54	*Memo on Final FSWP and HSE to DEQ*	*1 day*	*Wed 1/12/22*
55	*Functional Unit Memorandum to DEQ*	*1 day*	*Tue 4/5/22*
56	*Respond to DEQ Comments on FU Memo*	*126 days*	*Wed 6/1/22*
57	*Remedial Technology Screening and Alternatives Summary*	*62 days*	*Thu 11/24/22*
58	*DEQ Review*	*21 days*	*Thu 2/16/23*
59	*Call with DEQ*	*1 day*	*Fri 3/17/23*
60	Draft FS	129 days	Wed 2/1/23



Project: MPR Schedule
Date: Wed 3/29/23

Task | Project Summary | Manual Task | Start-only | Deadline
Split | Inactive Task | Duration-only | Finish-only | Progress
Milestone | Inactive Milestone | Manual Summary Rollup | External Tasks | Manual Progress
Summary | Inactive Summary | Manual Summary | External Milestone

* - Indicates dates that are tentative

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Memo

To	Katie Daugherty, Oregon Department of Environmental Quality
From	Brendan Robinson, PE, Environmental Resources Management, Inc.
Date	16 May 2023
Reference	0682894 Phase 204
Subject	March 2023 GW SCM Monthly Performance Monitoring Report

1. INTRODUCTION

Environmental Resources Management, Inc. (ERM) prepared this Monthly Performance Monitoring Report (MPR) on behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc. (Arkema), for the former Arkema Portland Plant (the Site) at 6400 NW Front Avenue in Portland, Oregon. The Oregon Department of Environmental Quality (ODEQ), in its letter dated 31 May 2019 and in the subsequent meeting with LSS and ERM on 2 July 2019, requested that LSS initiate monthly status reports associated with the onsite groundwater source control measure (GW SCM) consistent with the Performance Monitoring Plan (PMP; ERM 2014) beginning July 2019. The 2014 PMP was prepared pursuant to the Order on Consent issued by ODEQ, signed on 31 October 2008 (ODEQ No. LQVC-NWR-08-04; Consent Order). The purpose of the PMP was to present the monitoring, reporting, and adaptive management processes used during implementation of the GW SCM. On 30 November 2021, ODEQ directed LSS that following the October 2021 MPR, MPRs would be suspended pending the implementation of the Groundwater Extraction Enhancement (GEE) project in 2022. During that time, ODEQ requested monthly schedule updates in lieu of MPRs. The trench wells installed as part of the GEE project was started on 27 November 2022, and MPR writing restarted in December 2022. The purpose of the GEE project was to install new extraction capacity to achieve the Capture Zone Objectives.

This March 2023 MPR summarizes the GW SCM performance monitoring data collected in March 2023. This report assesses the current gradient status and proposes system improvements to meet the Capture Zone Objectives set in the PMP.

2. GROUNDWATER SOURCE CONTROL IMPLEMENTATION

A detailed description of the design and implementation of the GW SCM is provided in the *Revised Upland Feasibility Study Work Plan* (ERM 2017); however, a brief description of the GW SCM is provided here. In February 2009, ODEQ and the U.S. Environmental Protection Agency (USEPA) approved the general approach for the GW SCM. This approach included installation of a groundwater barrier wall (GWBW), groundwater recovery wells, and a Groundwater Extraction and Treatment (GWET) system, with treated water discharged to the Willamette River. ODEQ and USEPA approved the *Groundwater Barrier Wall Final Design* (ERM 2012) on 7 August 2012. Construction of the GWBW began in May 2012 and was completed in December 2012. ODEQ approved the *Groundwater Extraction and Treatment System Final Design* (ERM 2013) on 2 April

2013. Construction of the GWET system began in December 2012 and was completed in December 2013.

GWET startup and optimization commenced in May 2014. The GW SCM at the Site consists of the following primary components (Figure 1):

1. A GWBW to physically separate the affected upland portions and in-water portions of the Site.

2. Hydraulic control to minimize flow of groundwater containing unacceptable concentrations of constituents of potential concern (COPCs) around, over, and under the GWBW.

3. Management of extracted groundwater through the GWET system, with treated effluent discharged to the Willamette River under a National Pollutant Discharge Elimination System (NPDES) Permit.

On 1 September 2018, ERM submitted the *Draft GWET System Effectiveness Evaluation* (Draft SEE Report; ERM 2018). The Draft SEE Report provided an update on the corrective actions implemented to improve the performance of the GWET system, evaluate the extent of capture, and propose actions to improve hydraulic capture. Additional data requested by ODEQ were submitted on 26 October 2018.

The key objective of the GW SCM is to achieve hydraulic containment of the alluvial sequence within the Target Capture Zone at the Site to prevent the flow of COPCs to the Willamette River. The Site alluvial aquifer sequence within the Target Capture Zone consists of the Shallow Zone, Intermediate Zone, and the Deep Zone. Site hydraulic conditions are variable and subject to both seasonal and daily tidal fluctuations.

The hydraulic control component formerly consisted of 22 recovery wells (RWs) prior to the implementation of the GEE. Of the 22 pre-existing RWs, four were retained for active pumping. The remaining 18 former RWs had pumps removed but will retain their pressure transducers so that they can continuously collect high-resolution groundwater elevation data. The 18 former RW pressure transducers are currently unable to be connected to the rest of the system until additional upgrades are performed that are currently planned for Q2 2023. The hydraulic control system now consists of the four remaining active RWs, as well as seven groundwater extraction trenches that each contain two extraction wells (EWs). Each trench is 50 feet deep, 50 feet long, and 3 feet wide and is filled with an engineered backfill. More information about the groundwater extraction trenches is provided in the *Final Design Report* (ERM 2022). The gradient control-monitoring network consisting of six gradient control clusters (GCCs) with each cluster containing six monitoring points. Within each RW, EW, and GCC location, pressure transducers are continuously collecting high-resolution groundwater elevation data. Each GCC contains three transducers interior to the wall and three transducers exterior to the wall screened in the Shallow, Intermediate, and Deep aquifers at the Site.

3. HYDRAULIC CONTAINMENT MONITORING PROGRAM

As described in the PMP, the purpose of hydraulic monitoring (i.e., groundwater elevation data) is to provide sufficient data to demonstrate an inward hydraulic gradient across the GWBW and to evaluate the effective hydraulic capture produced by the GW SCM.

Monitoring requirements were established in the PMP to demonstrate GWET effectiveness. The Site monitoring program includes groundwater elevation data (manual and transducer measurements) collected from the 36 monitoring points located within six GCCs spaced across the GWBW, with piezometers interior and exterior to the wall, throughout the alluvial sequence; and groundwater elevation and flow rate data from the four remaining active RWs and 14 EWs. High-resolution groundwater elevation data (transducer measurements) will be possible from the 18 inactive RWs that will no longer be operated, but will have transducers, after electrical upgrades are performed in Q2 2023. Additionally, one new monitoring well was installed in each of the seven extraction trenches for manual water level measurement. These data were used to prepare horizontal and vertical potentiometric surface maps representing potentiometric differences between the alluvial sequences, and to generate spatial and temporal hydrographs to evaluate hydraulic capture.

3.1 Groundwater Elevation Monitoring

Groundwater elevation monitoring was completed on 5 March 2023. Manual groundwater elevations were measured at wells that were experiencing transducer mechanical issues or that were offline during the groundwater elevation measurement event. Manual groundwater elevation measurements were completed for all inactive RWs used. Manual water level measurements for these wells were completed to evaluate transducer data accuracy. Specific issues are addressed in Attachment A-1.

As detailed in Attachments A-1 and A-2, during March 2023, the following transducers were:

<u>Awaiting system upgrades for transducer re-installation:</u>

- RW-05
- RW-06i
- RW-07
- RW-08
- RW-09i
- RW-10
- RW-11i
- RW-12
- RW-13i
- RW-15
- RW-16i
- RW-17

- RW-18
- RW-19i
- RW-20
- RW-21i
- RW-24i
- RW-26i

Fully out of service pending repairs:

- PA-07
- PA-14i
- PA-16i
- PA-29i
- PA-20d
- PA-26d

Out of service for a period but returned to full operation:

- PA-05
- MWA-2
- PA-17i

All other transducers were operational during the entire month of March. Transducers that are fully out of service pending repairs are awaiting new transducers that have already been ordered but are backordered. They are expected to be replaced in April 2023.

Water levels in wells with transducers that were fully out of service pending repairs or waiting for additional system upgrades were taken manually.

3.2 Horizontal and Vertical Gradients at Gradient Control Points

As described above, GCC locations collect high-resolution groundwater elevation data using transducers. Transducer data are filtered to remove anomalous data from monitoring points due to potential equipment failures, such as transducer malfunctions, power outages, or updates to the GWET programmable logic controller (PLC) system, which controls and houses all the operational data. These specific issues and time periods are summarized in Table A-1 in Attachment A. The following flags are applied to filter anomalous data:

- Groundwater elevations had a change greater than 1.5 feet within 1 hour

- Groundwater elevation measurements that were found to be greater than 50 feet, or less than 1 foot
- Calculated groundwater elevation slope indicates no change between consecutive measurements indicating a transducer malfunction
- Manually flagging data that are inconsistent with the typical nature of the well
- Periods where transducer power supply was deactivated for work on interconnected electrical systems

After March 2023 flagged data were removed, the Serfes (1991) method was used to account for tidal variations as described in the PMP. Using Serfes corrected data, both horizontal and vertical gradients were calculated and plotted over time (Attachment B). Groundwater elevations, horizontal gradients, and vertical gradients from 5 March 2023 are shown below at each GCC (Table 1-1 and Table 1-2). The water elevation taken during the groundwater level gauging event at PA-16i was excluded from gradient calculations and potentiometric surface maps due to being anomalous.

Table 1-1. March Horizontal Gradients

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
GCC1	Shallow	PA-03	28.74	PA-04	29.22	-0.005
	Intermediate	PA-17iR	12.64	PA-10i	13.91	-0.012
	Deep	PA-27d	11.52	PA-18d	11.98	-0.004
GCC2	Shallow	MWA-2	9.38	PA-05	13.19	-0.056
	Intermediate	MWA-8i	9.71	PA-11i	12.26	-0.035
	Deep	PA-19d	8.31	PA-30d	11.24	-0.054
GCC3	Shallow	MWA-69	10.02	PA-06	14.53	-0.042
	Intermediate	MWA-66i	9.05	PA-12i *M*	13.93	-0.043
	Deep	PA-21d	8.62	PA-20d *M*	11.21	-0.020
GCC4	Shallow	MWA-19	9.85	PA-28	16.08	-0.062
	Intermediate	MWA-34i	9.94	PA-13i	12.91	-0.033
	Deep	MWA-58d	9.51	PA-22d	11.00	-0.017
GCC5	Shallow	MWA-47	10.82	PA-07 *M*	15.30	-0.043
	Intermediate	PA-29i *M*	9.59	PA-14i *M*	12.75	-0.059
	Deep	PA-24d	8.28	PA-23d	10.98	-0.051
GCC6	Shallow	PA-09	12.06	PA-08	13.53	-0.026
	Intermediate	PA-16i *M*	*	PA-15i	12.51	**
	Deep	PA-26d *M*	11.90	PA-25d	10.99	0.014

Notes:
Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.
Horizontal gradient calculated as (Exterior Elevation – Interior Elevation) / Horizontal distance.
ft NAVD88 = feet North American Vertical Datum of 1988
M = manual groundwater elevation measurement
** = anomalous groundwater elevation*
*** = horizontal gradient cannot be calculated due to anomalous elevation reading*

Table 1-2. March Vertical Gradients

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
Interior	SZ-IZ	GCC1	PA-04	29.22	PA-10i	13.91	1.03
		GCC2	PA-05	13.19	PA-11i	12.26	-0.02
		GCC3	PA-06	14.53	PA-12i M	13.93	0.06
		GCC4	PA-28	16.08	PA-13i	12.91	-0.01
		GCC5	PA-07 M	15.30	PA-14i M	12.75	0.10
		GCC6	PA-08	13.53	PA-15i	12.51	-0.36
	IZ-DZ	GCC1	PA-10i	13.91	PA-18d	11.98	0.17
		GCC2	PA-11i	12.26	PA-30d	11.24	0.90
		GCC3	PA-12i M	13.93	PA-20d M	11.21	0.03
		GCC4	PA-13i	12.91	PA-22d	11.00	0.02
		GCC5	PA-14i M	12.75	PA-23d	10.98	0.03
		GCC6	PA-15i	12.51	PA-25d	10.99	0.14
Exterior	SZ-IZ	GCC1	PA-03	28.74	PA-17iR	12.64	1.55
		GCC2	MWA-2	9.38	MWA-8i	9.71	0.08
		GCC3	MWA-69	10.02	MWA-66i	9.05	0.06
		GCC4	MWA-19	9.85	MWA-34i	9.94	0.50
		GCC5	MWA-47	10.82	PA-29i M	9.59	0.27
		GCC6	PA-09	12.06	PA-16i M	*	**
	IZ-DZ	GCC1	PA-17iR	12.64	PA-27d	11.52	0.26
		GCC2	MWA-8i	9.71	PA-19d	8.31	0.15
		GCC3	MWA-66i	9.05	PA-21d	8.62	0.14
		GCC4	MWA-34i	9.94	MWA-58d	9.51	0.10
		GCC5	PA-29i M	9.59	PA-24d	8.28	0.05
		GCC6	PA-16i M	*	PA-26d M	11.90	**

Notes:
Positive vertical gradient indicates a downward hydraulic gradient.

Vertical gradient calculated as (Upper Elevation – Lower Elevation) / Screen Midpoint distance.
ft NAVD88 = feet North American Vertical Datum of 1988
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone
^{M} = manual groundwater elevation measurement
** = anomalous groundwater elevation*
*** = vertical gradient cannot be calculated due to anomalous elevation reading*

3.3 Potentiometric Surface, Groundwater Elevation Difference Maps, and Groundwater Flow Directions

As described in the PMP, potentiometric surface maps are used to evaluate flow paths. Vertical gradients are also used as an additional line of evidence to evaluate hydraulic containment. Groundwater elevation data collected on 5 March 2023 were used to prepare potentiometric surface maps based on manual measurements and averaged transducer groundwater elevations (Figures 2 through 4) and vertical difference maps (Figures 5 and 6).

The generalized flow direction indicated by the potentiometric surface maps show overall groundwater flow toward the GWBW. The Shallow and Intermediate Zones potentiometric maps (Figures 2 and 3) indicate localized groundwater movement to some of the extraction trenches due to GW SCM pumping. Only some of the EWs were active at the time of the water level event, primarily on the northern portion of the Site. However, hydraulic influence is apparent near GCC1 and GCC2, and a cone of depression is developing around GCC2 and GCC3. Additional evidence of capture is anticipated as ongoing pumping occurs.

A potentiometric separation is still noticeable exterior to the GWBW, indicating the barrier wall is functioning by impeding groundwater flow. The Deep Zone potentiometric map also indicates flow toward the GWBW (Figure 4). River elevations are shown on the potentiometric surface maps in an inset (Figures 2 through 4) and depict stage movement within the month corresponding with the MPR. Vertical gradients were calculated for each vertical well pair using these groundwater elevations and are plotted on Figures 5 and 6.

Vertical groundwater gradients interior to the GWBW between the Shallow and Intermediate Zones were mixed in March 2023 with GCC2, GCC4, and GCC6 being upward, and GCC1, GCC3, and GCC5 being downward (Figure 5). Vertical groundwater gradients are also depicted in Attachment B. The magnitude of the gradient is much greater at GCC1 than other monitoring locations due to the influence from a localized high-pressure zone near GCC1 where vertical groundwater flow is impeded by a localized confining unit (Figure 2). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were downward with as shown on Figure 5 and in Attachment B. The vertical groundwater gradient at GCC6 on the exterior of the wall were unable to be calculated due to an anomalous groundwater elevation reading at PA-16i. PA-16i will be re-calibrated so that vertical gradients at GCC6 can be calculated in the future and presented in subsequent MPRs.

Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were downward with exception to GCC6, where the gradient could not be calculated due to an anomalous reading at PA-16i. The direction of vertical gradients exterior to the GWBW were downward, as shown on Figure 6 and Attachment B.

The river elevation in March 2023 varied with an average of 8.71 feet NAVD88, maximum of 11.58 feet NAVD88, and minimum of 6.52 feet NAVD88.

3.3.1 GWET System Performance

The GWET operated within permit conditions during the reporting period. There were two shutdowns:

- 16 March 2023: A planned shutdown to clean the pressure filters.
- 27 March 2023: An unplanned shutdown due to an elevated DDx detection in the compliance samples collected on Thursday, March 16. Real-time water quality indicators (i.e., turbidity) indicated that the effluent quality should be within discharge permit limits. Eurofins re-extracted and reran the effluent sample, outside of hold time, and results were non-detect. After investigation, Eurofins determined that DDx concentrations in the influent samples are currently high enough that there is a potential for cross contamination in the adjacent (effluent) sample during extraction. Eurofins' conclusions are attached in the report in Appendix D. The plant was restarted on 30 March. In the future, influent samples will be run after effluent samples to reduce the risk of cross contamination.

There were no upgrades to the GWET plant in the month of March 2023.

3.3.2 Recovery Well and Extraction Well Performance

In March 2023, the average system influent flow rate was 47.83 gallons per minute (gpm) during operational periods, compared to 73.32 gpm in the February 2023 period. This decrease in flow rate is largely due to the 4 extraction wells that were not active during the month of March. Additionally, 2 extraction wells were operating at reduced recovery rates due to electrical issues. During March 2023, nine of the 14 EWs were periodically down for maintenance. These pumps were removed from this historical recovery wells and placed in the EWs after trench construction due to supply chain issues procuring new pumps. New pumps are expected to arrive at the Site in May 2023. The root cause of the pump failures are being investigated, and the contractor who constructed the extraction trenches (Odin Construction) is being engaged as needed to perform repairs and is expected to perform these repairs in May 2023 when the new pumps arrive. ERM does not anticipate that these repairs will inhibit the GWET plant's operational goal of generating inward gradient in the long term. ERM is currently in the process of optimizing extraction rates within the system to increase flow rates at each operational well until the extraction rates specified in the *Final Design Report* (ERM 2022) are achieved, or until the Capture Zone Objectives are met.

Table 1-3. Recovery Well Pumping Rates[1]

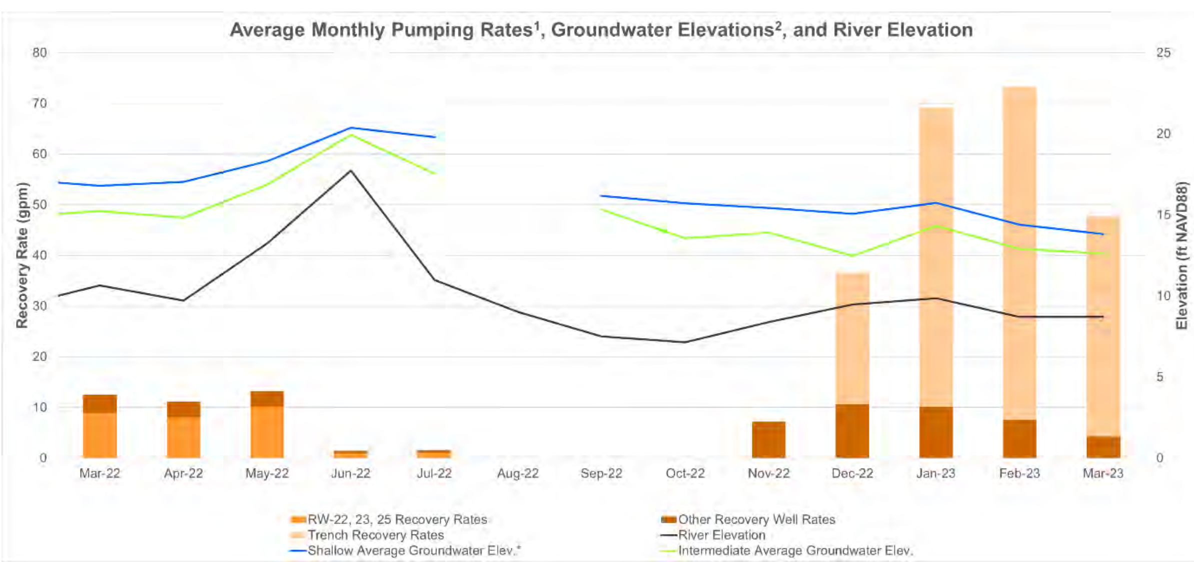
Recovery Well	March 2023 Average Pumping Rate (gpm)
RW-14	0.84
RW-22 *	0.00

Recovery Well	March 2023 Average Pumping Rate (gpm)
RW-23	1.47
RW-25	1.96
EW-01	8.61
EW-02 *	0.00
EW-03	4.39
EW-04	5.15
EW-05	5.31
EW-06	5.83
EW-07	5.08
EW-08	1.90
EW-09	0.35
EW-10 *	0.00
EW-11 *	0.00
EW-12	0.69
EW-13	6.26
EW-14 *	0.00
Total	**47.83**

Notes:

[1] = Flow rates are calculated based on the period of the month during which the recovery wells were operational

** = Recovery well not in service during reporting period*



Notes:

[1] = Following installation of trenches in Summer 2022, RW-22, 23, and 25 recovery rates are now grouped together with the other remaining recovery well (RW-14) starting in November 2022.

[2] = Average groundwater elevations are calculated using interior wells—the well field was powered down in August preventing the measurement of the groundwater.

** = The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the whole aquifer.*

Figure 1-1. Monthly Pumping Rate Contribution

3.3.3 Recommendations for Extraction System Optimization

Recovery rates from the start of the system indicate that the active RWs and EWs are operating as designed with the exception of the troubleshooting discussed above. The EWs have been started in accordance with the plan outlined in the Trench Startup Standard Operating Procedure included in the *Final Design Report* (ERM 2022). The extraction rates throughout the GWET system will continue to be optimized to meet Target Capture Objectives. Additional maintenance and/or replacement of the historical EW pumps will occur to mitigate potential pump failures.

4. ANALYTICAL PROGRAM

Quarterly groundwater monitoring was implemented in accordance with the ODEQ-approved Arkema Quarterly Groundwater Monitoring Work Plan dated October 2019 and the ODEQ-approved reduced scope described in the 2021 monitoring program modification request memorandum dated 9 September 2021. The table below outlines sampling dates and submittal dates related to groundwater monitoring since the implementation of the reduced scope. The Quarterly Monitoring Reports present results from these sampling events.

Report	Sampling Dates	Report Submittal Date
2021 Quarter 3	9/21/2021–9/24/2021	1/14/2022
2021 Quarter 4	12/13/2021–12/16/2021	4/20/2022
2022 Quarter 1	3/14/2022–3/17/2022	6/15/2022
2022 Quarter 2	6/6/2022–6/9/2022	9/12/2022
2022 Quarter 4	11/7/2022–11/10/2022	2/17/2023
2023 Quarter 1	3/6/2023–3/10/2023	6/12/2023

5. SUMMARY AND CONCLUSIONS

This report presents a summary of the GW SCM operation, maintenance, and monitoring activities conducted at the Site in March 2023 and documents results from system monitoring. The following summarizes ERM's observations and conclusions drawn from collected data.

5.1 Groundwater Flow

- Horizontal gradients across the GWBW are generally outward toward the river; however, groundwater elevations show a noticeable separation interior and exterior of the GWBW, indicating the GWBW is functioning via impeding groundwater flow. Before installation of the GEE project, inward gradients were periodically observed at some monitoring locations. It is yet to be determined whether a long-term inward gradient has been produced through increased pumping rates, but initial indications show that the GWET is generating localized areas of sustained groundwater capture that are anticipated to expand with longer operations.

- Vertical groundwater gradients interior to the GWBW between the Shallow and Intermediate Zones were mixed in March 2023 with GCC1, GCC3, and GCC5 being downward and the remaining being upward (Figure 5). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were also downward. Interior and exterior of the GWBW vertical gradients between the Intermediate and Deep Zones were downward (Figure 6).
- River elevations have generally been stable since reporting resumed in December 2022. In 2022, the average river elevation was 10.48 feet NAVD88 with a maximum monthly average elevation of 17.73 feet NAVD88 in June 2022 and a minimum monthly average elevation of 7.14 feet NAVD88 in October 2022. The average river elevation in March 2023 was 8.71 feet NAVD88 with a minimum elevation of 6.52 feet NAVD88 and a maximum elevation of 11.58 feet NAVD88.
- Within the Site alluvial sequence, potentiometric maps indicate the GW SCM could be producing localized areas of hydraulic capture around trenches that were active during the water level event; however, more time at elevated extraction rates will be required to evaluate whether GWET objectives are being met.

5.2 Groundwater Extraction

Based on March 2023 extraction and relevant hydrograph analysis, the EWs and RWs are operating as designed. Further evaluation of the system with respect to the Capture Zone Objectives will be conducted once all pumps are operating at their design rates for an extended period.

5.3 Recommendations and Future Work

ERM will continue to optimize new EWs. Any additional modifications to the system to meet capture objectives will be included in subsequent Monthly Progress Reports. The project schedule provided as Attachment C summarizes activities planned for the immediate future.

Regards,

REGISTERED PROFESSIONAL ENGINEER
78496PE
OREGON
DECEMBER 31, 2007
BRENDAN ANDREW ROBINSON
EXP. 12/31/2024

Brendan Robinson, PE
Partner

6. REFERENCES

ERM (ERM-West, Inc.). 2012. *Arkema Portland Groundwater Source Control Measure, Groundwater Barrier Wall Final Design, Arkema Inc., Portland, Oregon*. July 2012.

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Serfes, Michael. 1991. “Determining the Mean Hydraulic Gradient of Ground Water Affected by Tidal Fluctuations.” *Groundwater*, Vol. 29. No 4. July–August 1991.

FIGURES

Figure 1: Site Layout

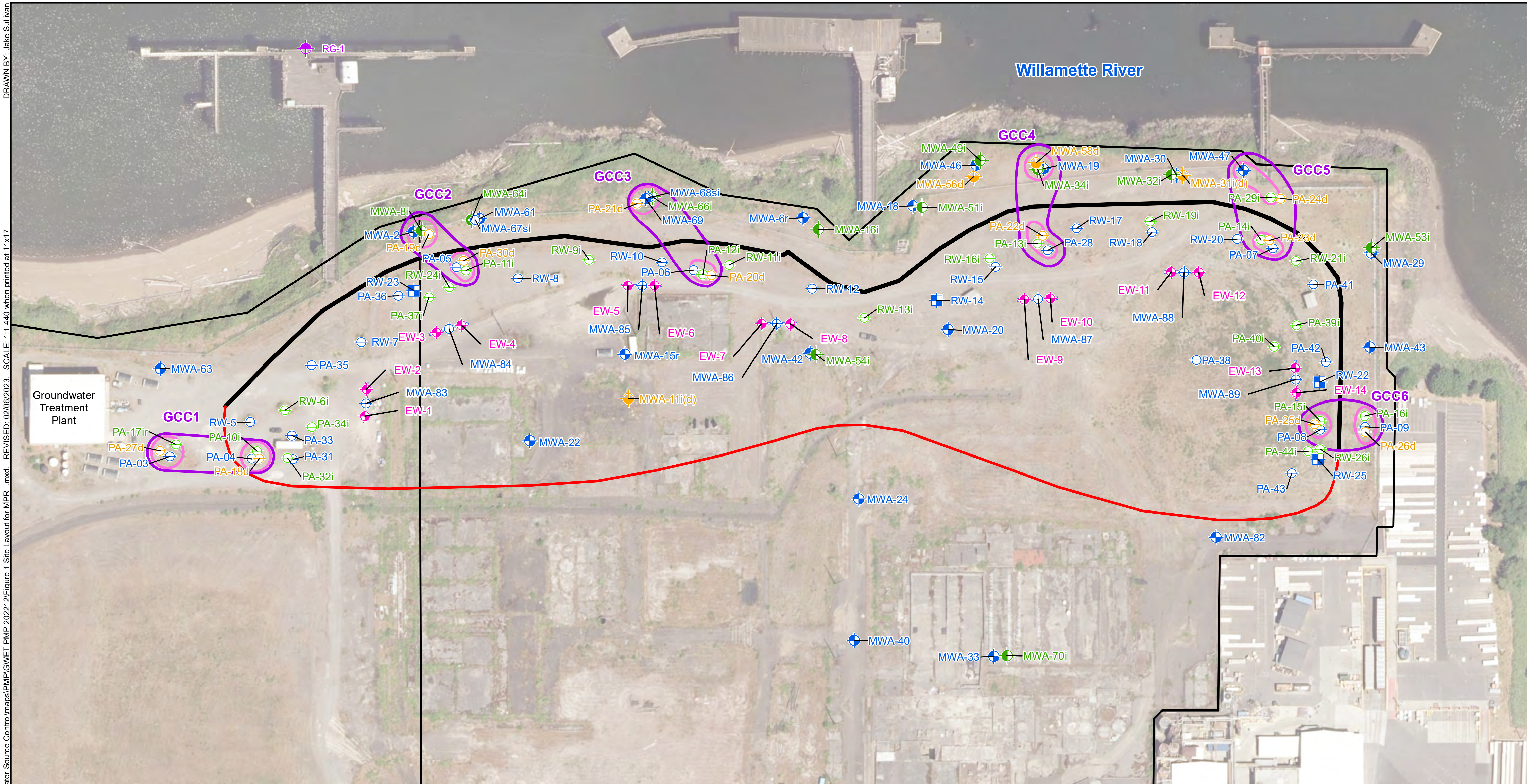
Figure 2: March 2023 Shallow Zone Groundwater Contours

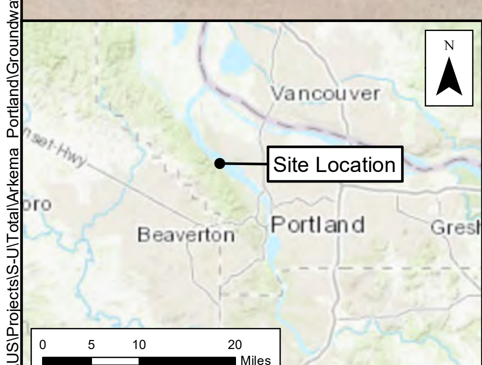
Figure 3: March 2023 Intermediate Zone Groundwater Contours

Figure 4: March 2023 Deep Zone Groundwater Contours

Figure 5: March 2023 Shallow to Intermediate Zone Vertical Head Difference

Figure 6: March 2023 Intermediate to Deep Zone Vertical Head Difference





Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Shallow Zone Recovery Well
- River Gauge
- Trench Extraction Well
- Target Capture Zone
- Barrier Wall Alignment
- Parcel and Property Boundaries

GradientClusters

Type

- Gradient Control Cluster
- Vertical Flow Cluster
- Extraction Trench

N

0 120 240

Feet

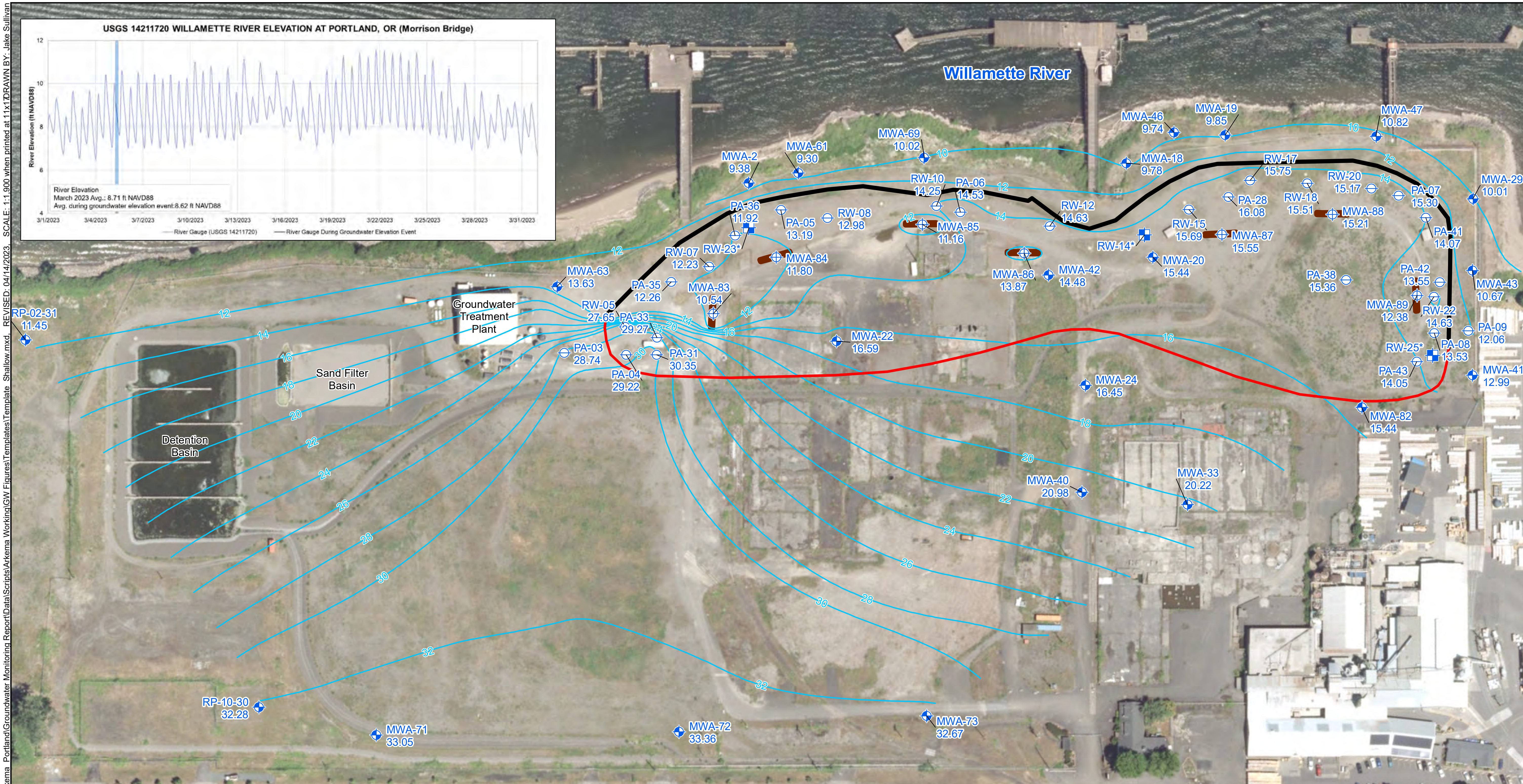
Figure 1
Site Layout
Monthly Progress Report
Groundwater Source Control Measure
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

DRAWN BY: Jake Sullivan

M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 202212\Figure 1 Site Layout for MPR .mxd REVISED: 02/06/2023 SCALE: 1:1,440 when printed at 11x17

Source: City of Portland Aerial Imagery, flown Summer 2021; NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Shallow Zone Piezometer
- Shallow Zone Monitoring Well
- Active Recovery Well; Not Used During Contouring
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Shallow Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected March, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 2
March 2023 Shallow Zone Groundwater Contours
Monthly Performance Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

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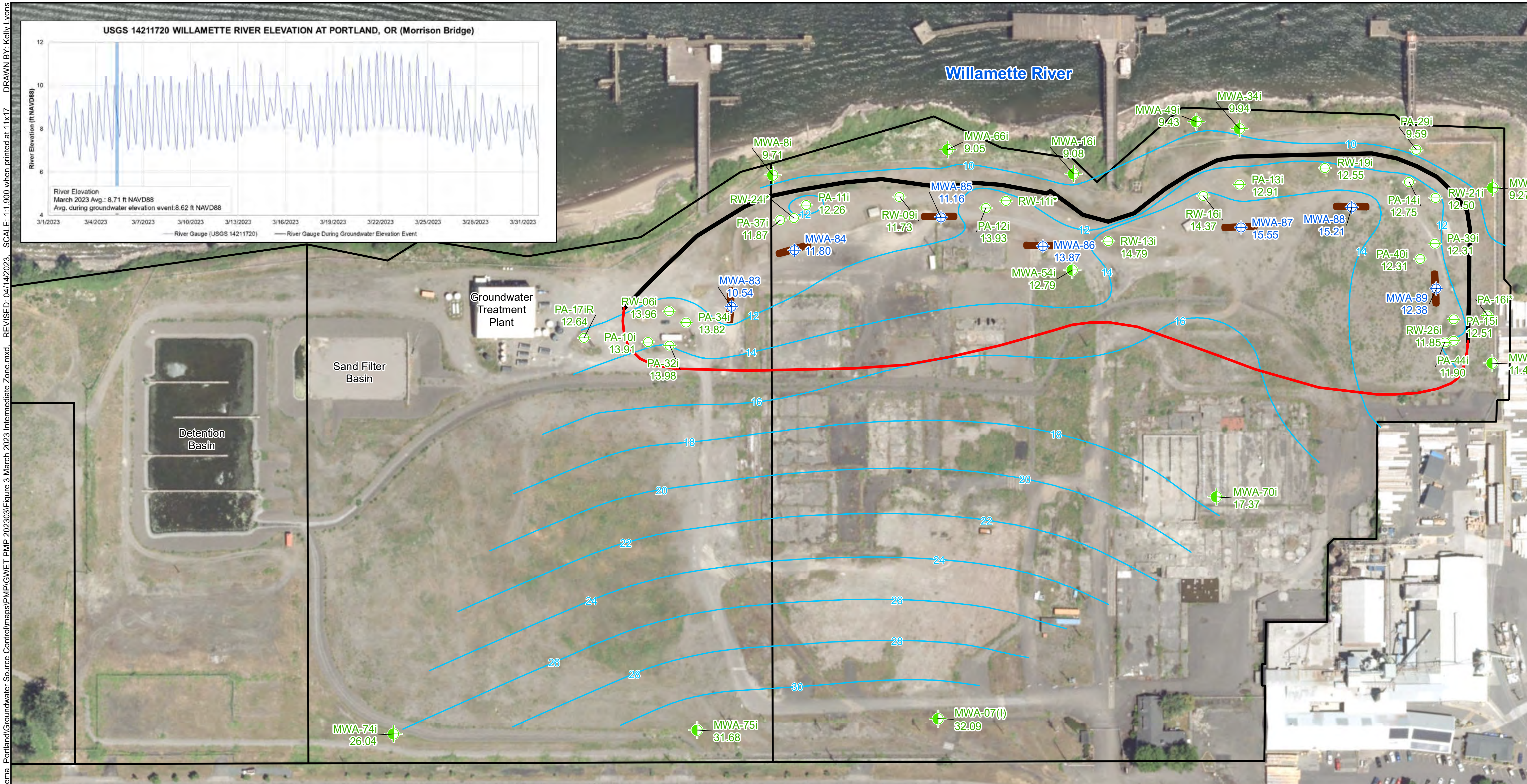


Legend

- Intermediate Zone Piezometer
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected March, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

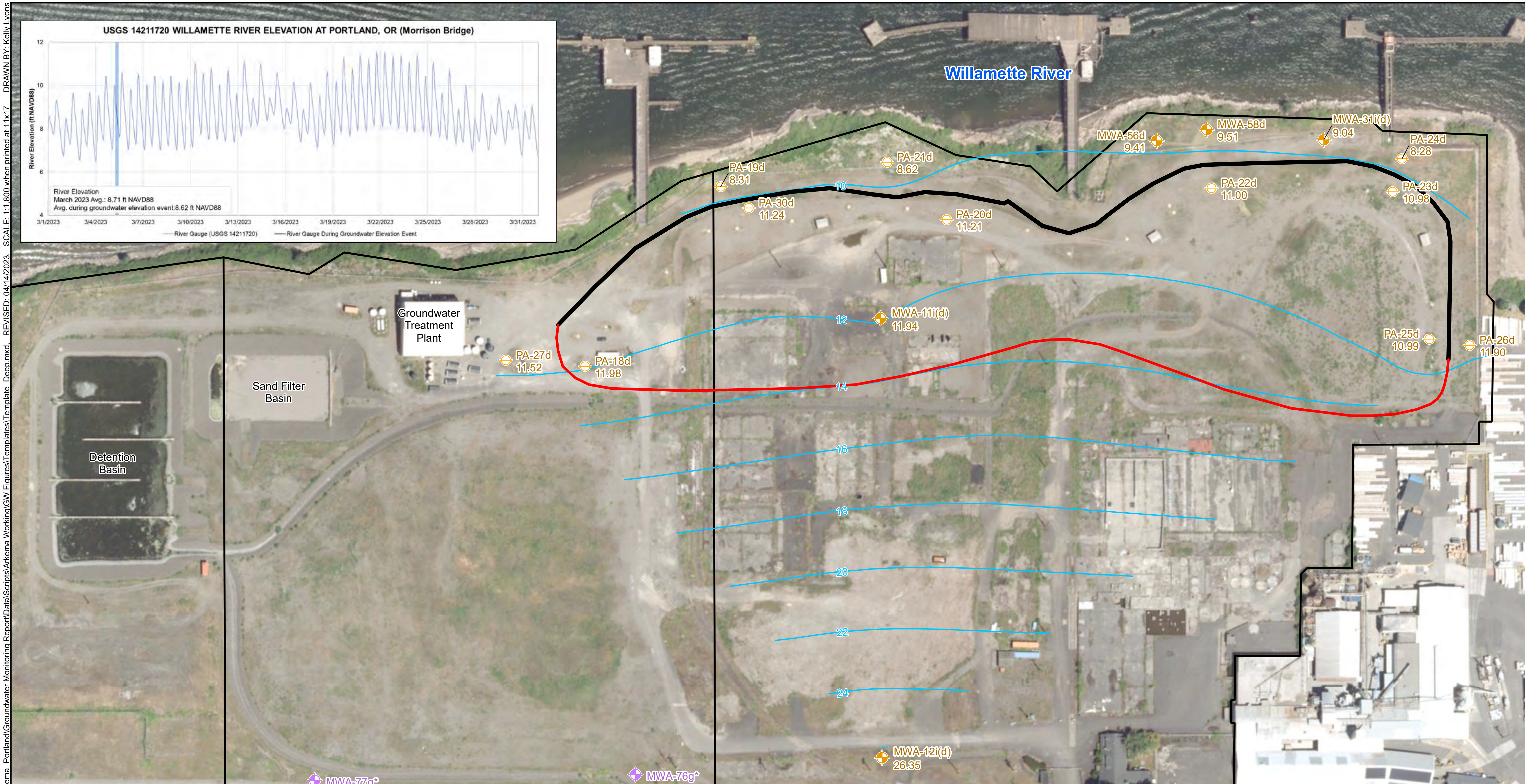
0 160 320
Feet

Figure 3
March 2023 Intermediate Zone Groundwater Contours
Monthly Performance Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

\\SCUSPRDGISFS01\Data\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 202303\Figure 3 March 2023 Intermediate Zone.mxd, REVISED: 04/14/2023, SCALE: 1:1,900 when printed at 11x17, DRAWN BY: Kelly Lyons



Legend

- Deep Zone Piezometer
- Deep Zone Monitoring Well
- Gravel Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Deep Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment

Notes:
* Value not used for contouring.
Gravel zone wells not used in contouring.
Water levels collected March, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 150 300
Feet

Figure 4
March 2023 Deep Zone Groundwater Contours
Monthly Performance Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

\\SCUSPRDGISFS01\Data\US\Projects\S-U\Total\Arkema_Portland\Groundwater Monitoring Report\Data\Scripts\Arkema Working\GW Figures\Templates\Template_Deep.mxd REVISED: 04/14/2023 SCALE: 1:1,800 when printed at 11x17 DRAWN BY: Kelly Lyons

Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Shallow Zone Recovery Well
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as shallow zone minus intermediate zone potentiometric surfaces.
Water levels collected March, 2023.
Aerial Photo: City of Portland, Summer 2017.

0 130 260
Feet

Figure 5
March 2023 Shallow to Intermediate Zone Vertical Head Difference
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

Legend

- Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as intermediate zone minus deep zone potentiometric surfaces.
Water levels collected March, 2023.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 6
March 2023 Intermediate to Deep Zone Vertical Head Difference
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

\\SCUSPRDGISFS01\Data\US\Projects\S-U\Total\Arkema_Portland\Groundwater Monitoring Report\Data\Scripts\Arkema Working\GW Figures\Templates\Template_Vertical Difference Intermediate Deep.mxd, REVISED: 03/23/2023, SCALE: 1:1,560 when printed at 11x17

ATTACHMENT A-1 TRANSDUCER FLAGS

Attachment A-1. Transducer Flags

Table A-1
Transducer Malfunction Log: March 2023
Arkema Inc. Facility
Portland, Oregon

Gradient Cluster	Transducer	Interval	Date Range		Issue and Repairs Performed
6	PA-16i	Intermediate	12/16/2023	3/31/2023	Troubleshooting occurred. Transducer needs to be replaced.
5	PA-07	Shallow	1/4/2023	3/31/2023	Troubleshooting occurred. Transducer needs to be replaced.
3	PA-20d	Deep	1/4/2023	3/31/2023	LOTO at EW-05 to swap I/O card. Transducer needs to be replaced.
6	PA-26d	Deep	1/11/2023	3/31/2023	Recalibrated transducer. Transducer needs to be replaced.
5	PA-14i	Intermediate	2/8/2023	3/31/2023	LOTO at EW-11. EW-11 remains locked out due to safety concerns from faulty connections in vault.
5	PA-29i	Intermediate	2/8/2023	3/31/2023	LOTO at EW-11. EW-11 remains locked out due to safety concerns from faulty connections in vault.
1	PA-17i	Intermediate	3/8/2023	3/10/2023	Loose wire. Transducer repaired and back in operation.
2	PA-05	Shallow	3/20/2023	3/30/2023	Troubleshooting occurred. Transducer recalibrated and back in operation.
2	MWA-2	Shallow	3/20/2023	3/30/2023	Troubleshooting occurred. Transducer recalibrated and back in operation.

Notes:
I/O = input/output
LOTO = lockout/tagout
VFD = variable frequency drive

ATTACHMENT A-2 RECOVERY WELL STATUS

Attachment A-2. Recovery Well Status

Table A-2
Recovery Well Status: March 2023
Arkema Inc. Facility
Portland, Oregon

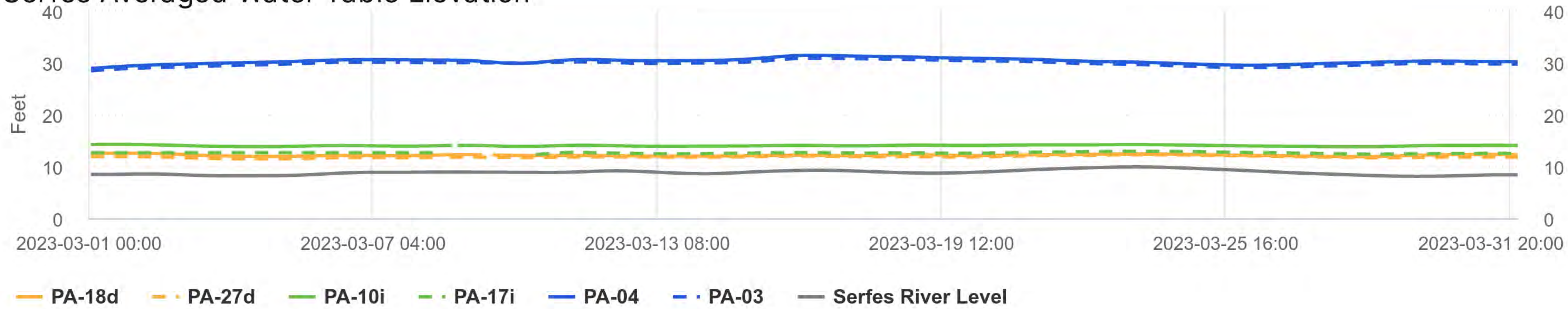
Recovery Well ID	Status as of 3/31/2023 (active or inactive)	Issue	Actions to get online	Expected date back online	Transducer Status	Totalizer Status	Average Flow Rate (gpm)****	Overall Extraction Rate	Notes
RW-05	Inactive	None	Will not be placed back online	N/A	Good	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-06i	Inactive	None	Will not be placed back online	N/A	Good	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-07	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-08	Inactive	None	Will not be placed back online	N/A	Not Connected	Good	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-09i	Inactive	None	Will not be placed back online	N/A	Not Connected	Good	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-10	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-11i	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-12	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-13i	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-14	Active	None	N/A	N/A	Not Connected	Good	0.84	P	
RW-15	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-16i	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-17	Inactive	None	Will not be placed back online	N/A	Not Connected	Good	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-18	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-19i	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-20	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-21i	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-22	Active	None	Replace totalizer	N/A	Good	Bad	0.00	OFF*	Totalizer failed, will be replaced
RW-23	Active	None	N/A	N/A	Good	Good	1.47	M	
RW-24i	Inactive	None	Will not be placed back online	N/A	Not Connected	Good	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-25	Active	None	N/A	N/A	Good	Good	1.96	M	
RW-26i	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
EW-01	Active	None	N/A	N/A	Good	Good	8.61	G	
EW-02	Inactive	None	N/A	N/A	Good	Good	0.00	OFF*	Motor fault, under investigation
EW-03	Active	None	N/A	N/A	Good	Good	4.39	G	
EW-04	Active	None	N/A	N/A	Good	Good	5.15	G	
EW-05	Inactive	None	N/A	N/A	Good	Good	5.31	G	Motor fault, under investigation
EW-06	Inactive	None	N/A	N/A	Good	Good	5.83	G	Motor fault, under investigation
EW-07	Inactive	None	N/A	N/A	Good	Good	5.08	G	Motor fault, under investigation
EW-08	Inactive	None	N/A	N/A	Good	Good	1.90	M	Motor fault, under investigation
EW-09	Inactive	None	N/A	N/A	Good	Good	0.35	P	Motor fault, under investigation
EW-10	Inactive	None	N/A	N/A	Good	Good	0.00	OFF*	Motor fault, under investigation
EW-11	Inactive	None	N/A	N/A	Good	Good	0.00	OFF*	Motor fault, under investigation
EW-12	Inactive	None	N/A	N/A	Good	Good	0.69	P	Motor fault, under investigation
EW-13	Active	None	N/A	N/A	Good	Good	6.26	G	
EW-14	Inactive	None	N/A	N/A	Good	Good	0.00	OFF*	Motor fault, under investigation

Notes:
** Recovery wells not in service*
*** Recovery wells in service part of the month*
**** = Off due to locked out and tagged out during part of the month*
G = good pumping, greater than 3.0 gpm
gpm = gallons per minute
M = moderate pumping, greater than 1.0 gpm and less than 3.0
P = poor pumping, less than 1.0 gpm
VFD = variable frequency drive
PA = piezometer

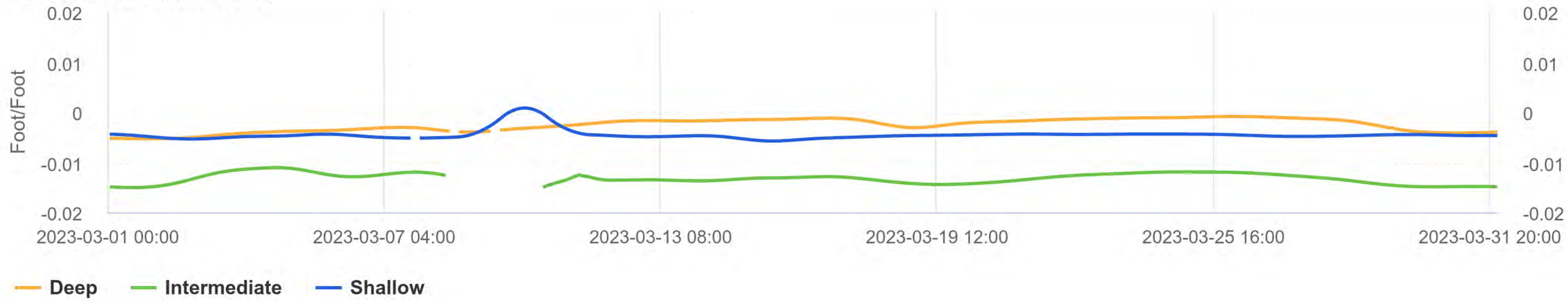
ATTACHMENT B GRADIENT HYDROGRAPHS

Gradient Control Cluster 1

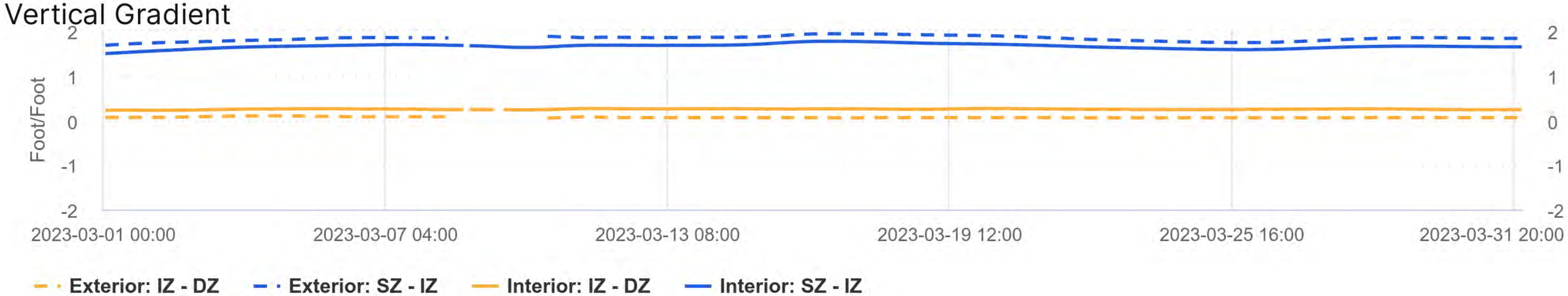
Serfes Averaged Water Table Elevation



Horizontal Gradient

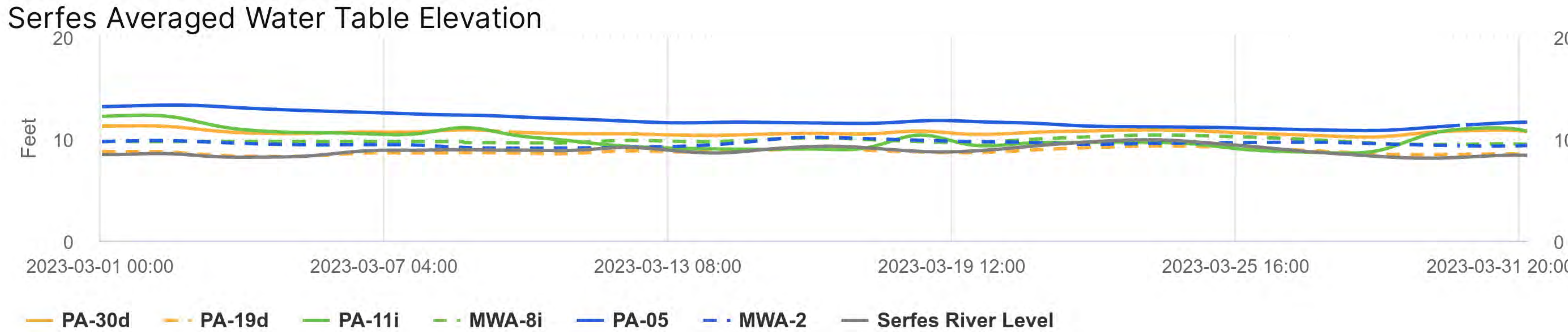


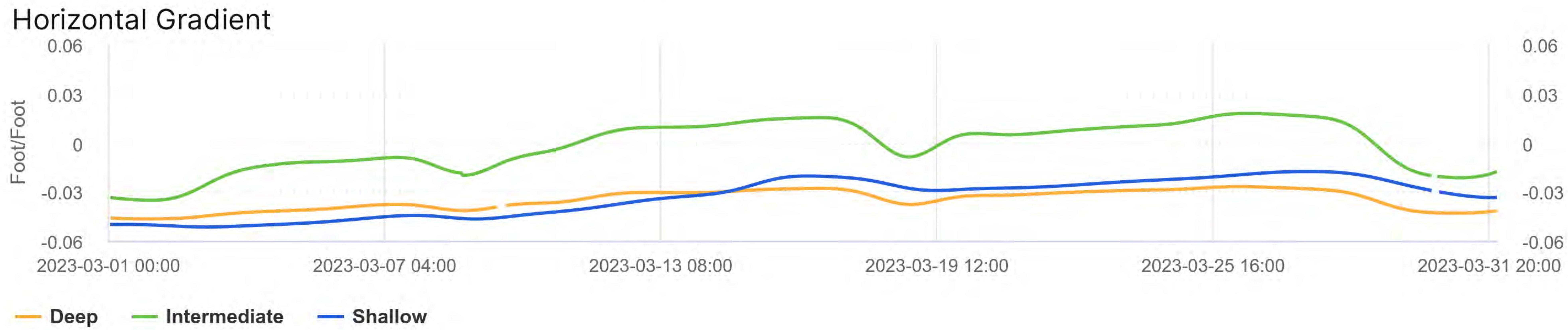
Vertical Gradient

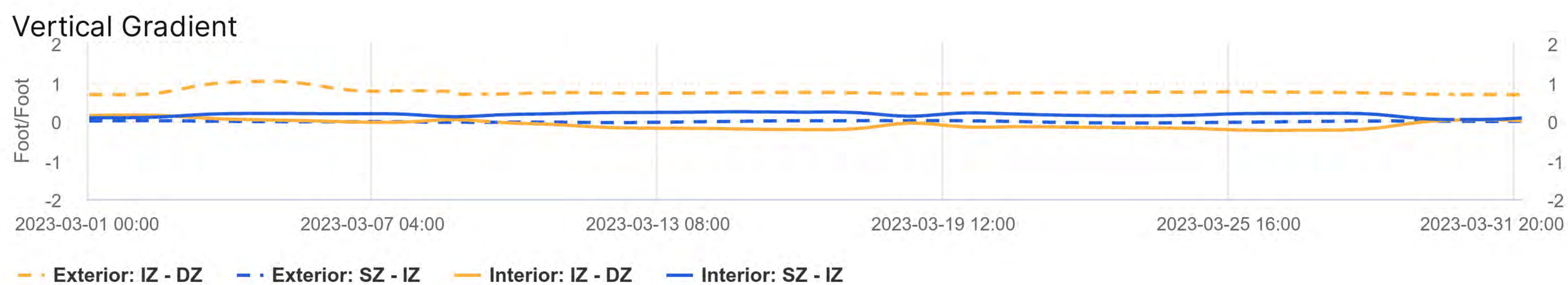


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 2



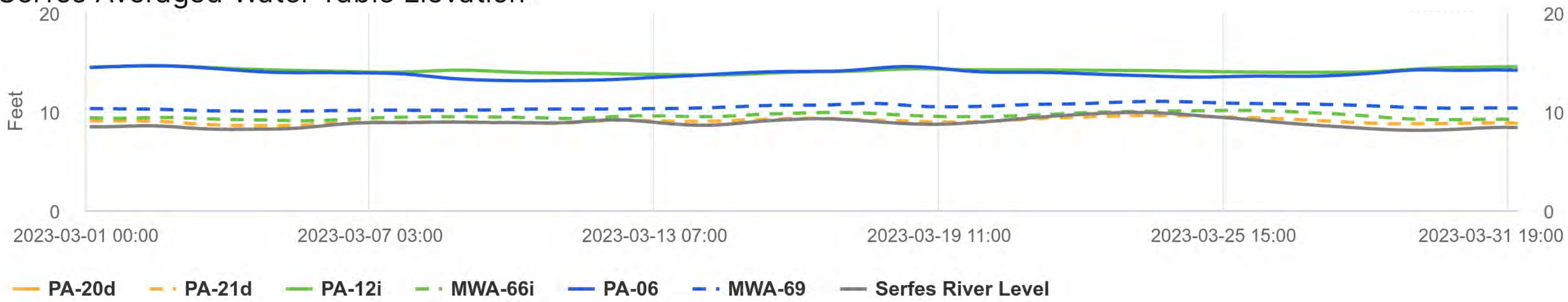




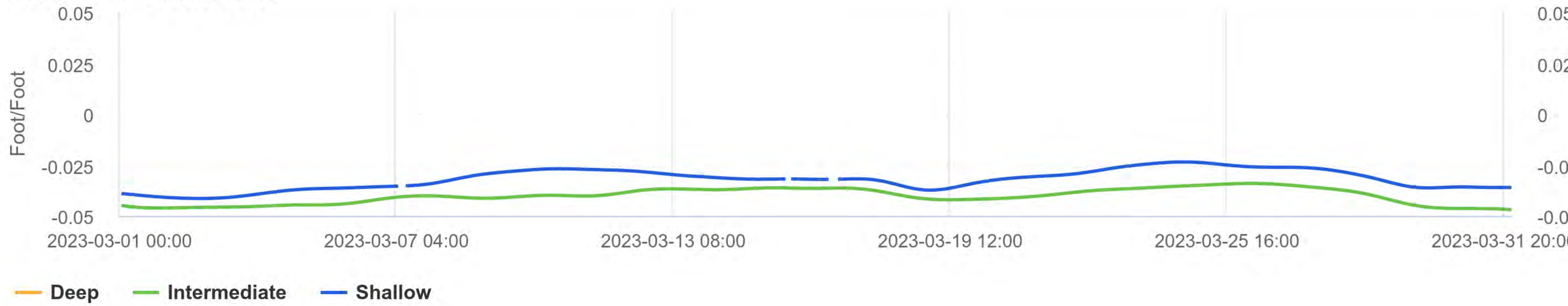
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 3

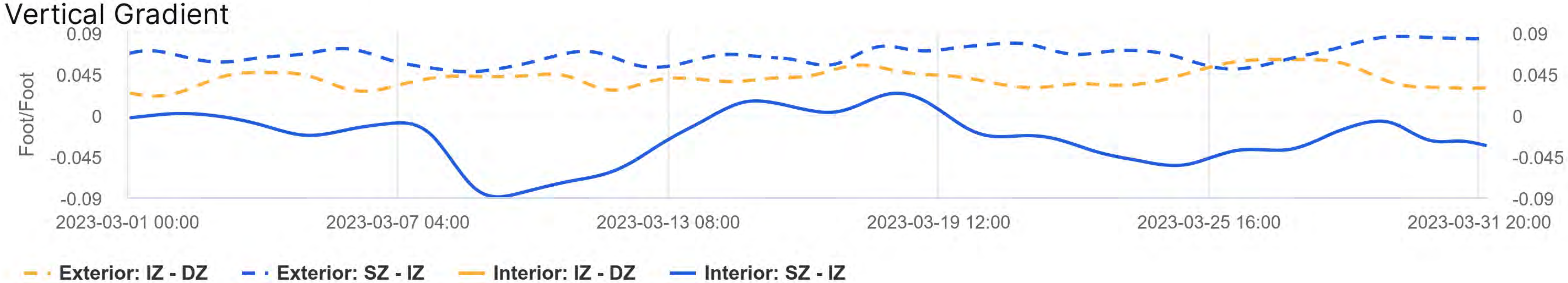
Serfes Averaged Water Table Elevation



Horizontal Gradient



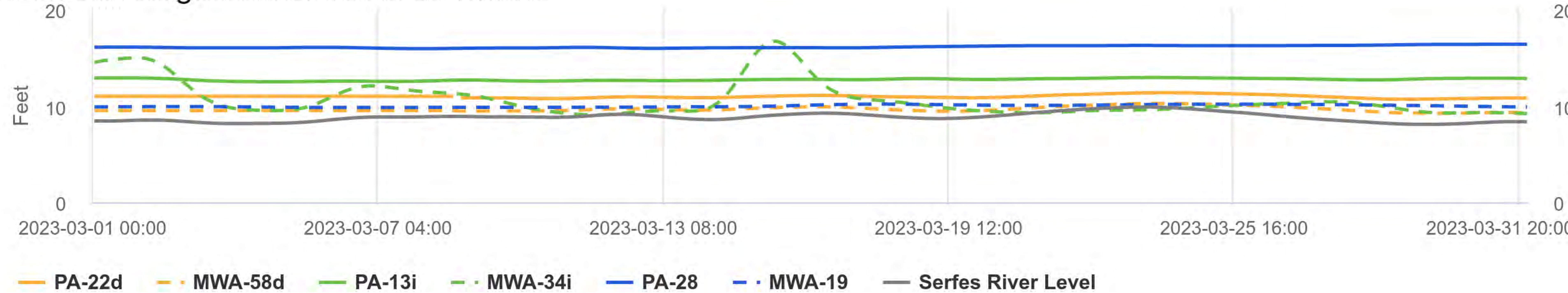
Vertical Gradient



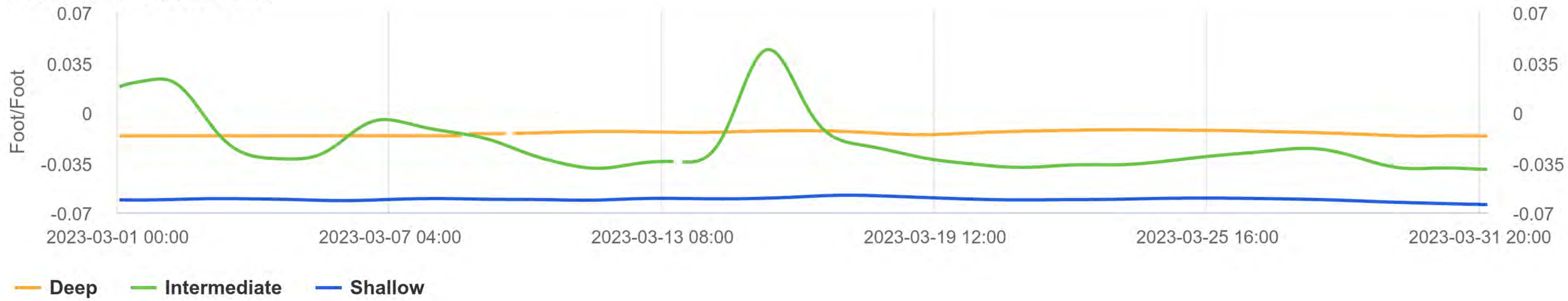
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 4

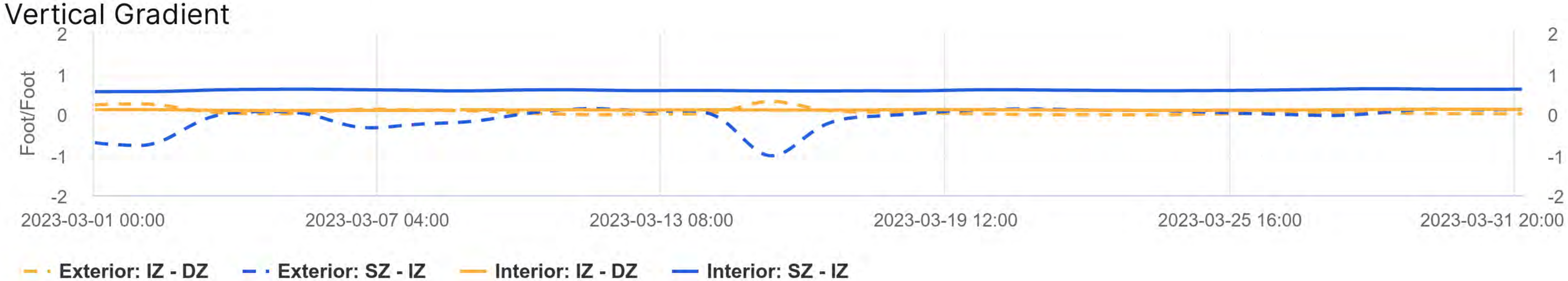
Serfes Averaged Water Table Elevation



Horizontal Gradient

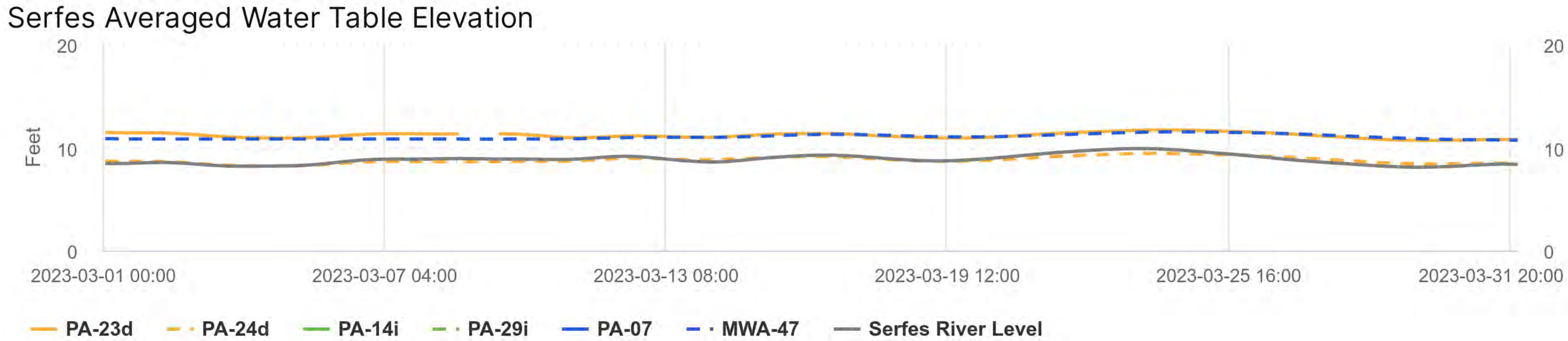


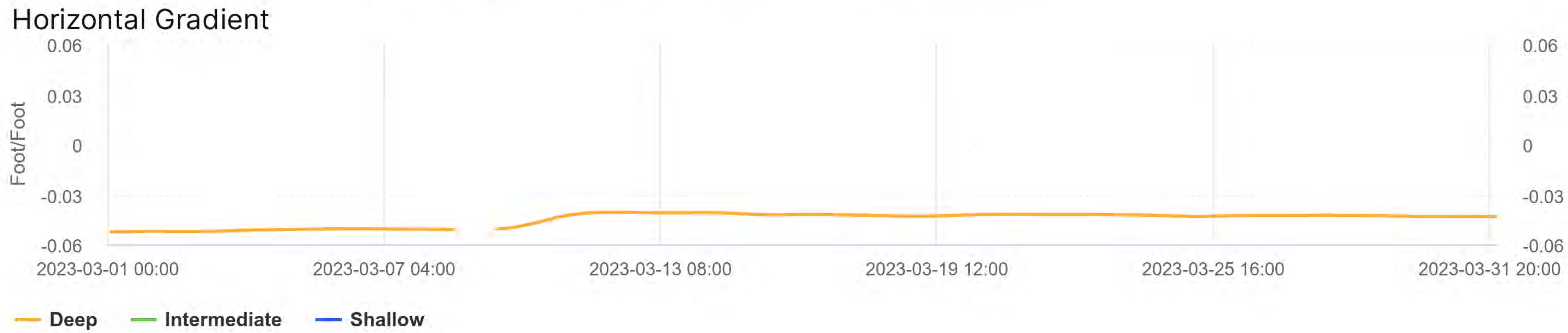
Vertical Gradient



Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 5

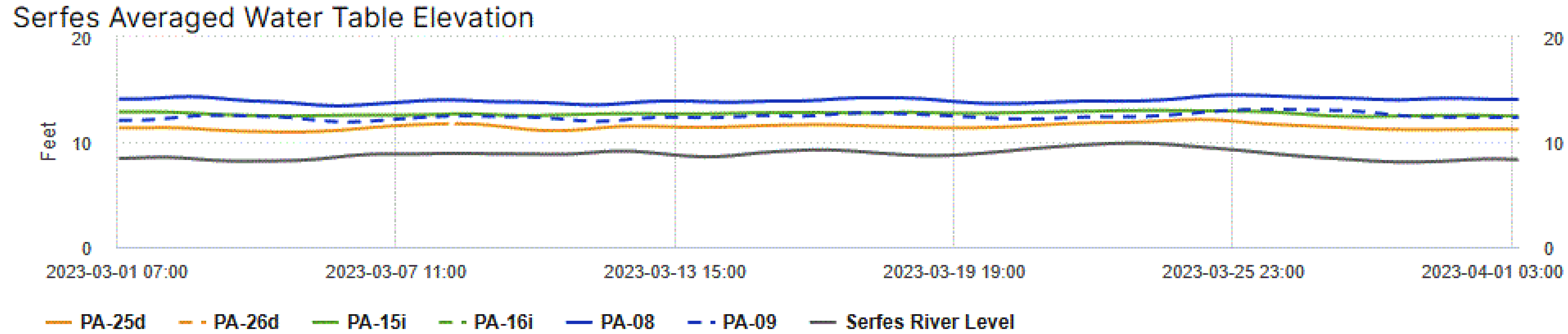


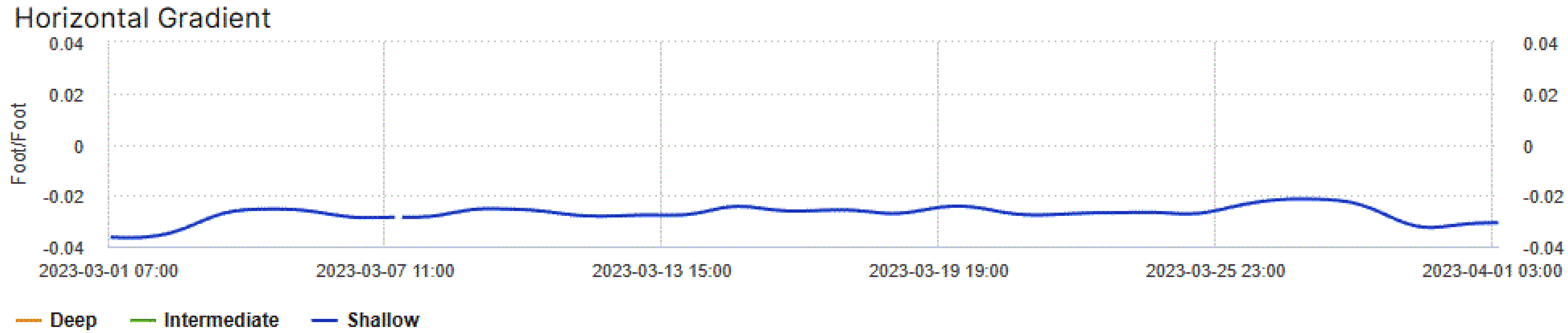


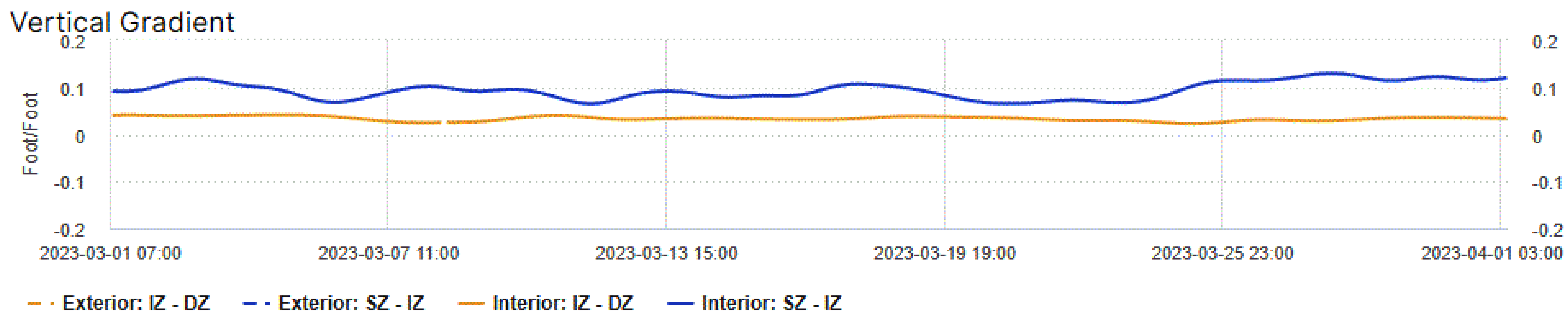
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW

SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 6



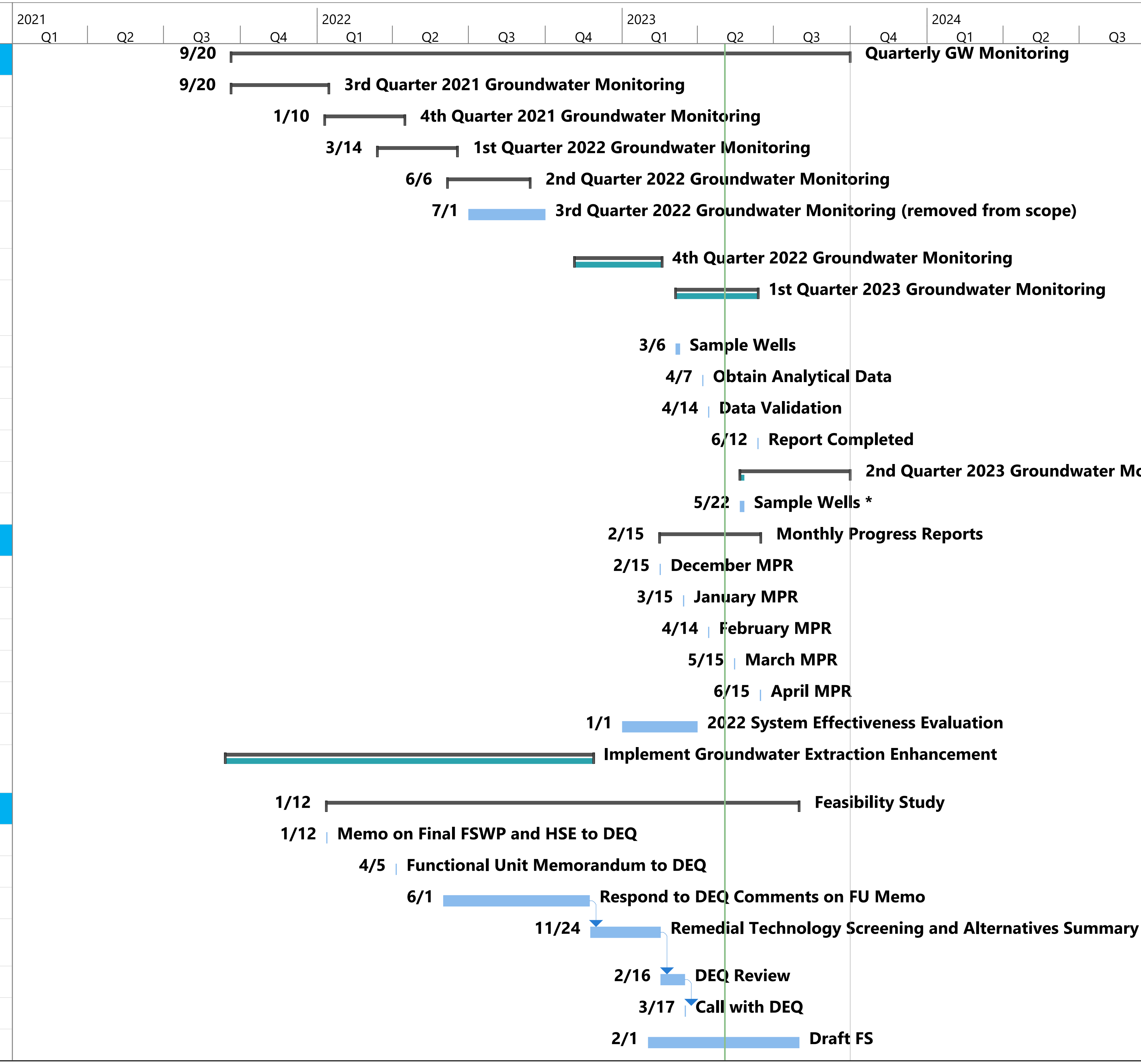




Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

ATTACHMENT C PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**Quarterly GW Monitoring**	**533 days**	**Mon 9/20/21**	**Sat 9/30/23**
2	*3rd Quarter 2021 Groundwater Monitoring*	*85 days*	*Mon 9/20/21*	*Fri 1/14/22*
7	*4th Quarter 2021 Groundwater Monitoring*	*70 days*	*Mon 1/10/22*	*Fri 4/15/22*
11	*1st Quarter 2022 Groundwater Monitoring*	*70 days*	*Mon 3/14/22*	*Fri 6/17/22*
16	*2nd Quarter 2022 Groundwater Monitoring*	*71 days*	*Mon 6/6/22*	*Mon 9/12/22*
21	*3rd Quarter 2022 Groundwater Monitoring (removed from scope)*	*66 days*	*Fri 7/1/22*	*Fri 9/30/22*
22	*4th Quarter 2022 Groundwater Monitoring*	*78 days*	*Sat 11/5/22*	*Fri 2/17/23*
27	**1st Quarter 2023 Groundwater Monitoring**	**71 days**	**Mon 3/6/23**	**Mon 6/12/23**
28	*Sample Wells*	*5 days*	*Mon 3/6/23*	*Fri 3/10/23*
29	*Obtain Analytical Data*	*1 day*	*Fri 4/7/23*	*Fri 4/7/23*
30	*Data Validation*	*1 day*	*Fri 4/14/23*	*Fri 4/14/23*
31	Report Completed	1 day	Mon 6/12/23	Mon 6/12/23
32	**2nd Quarter 2023 Groundwater Monitoring**	**96 days**	**Mon 5/22/23**	**Sat 9/30/23**
33	Sample Wells *	5 days	Mon 5/22/23	Fri 5/26/23
34	**Monthly Progress Reports**	**87 days**	**Wed 2/15/23**	**Thu 6/15/23**
35	*December MPR*	*1 day*	*Wed 2/15/23*	*Wed 2/15/23*
36	*January MPR*	*1 day*	*Wed 3/15/23*	*Wed 3/15/23*
37	*February MPR*	*1 day*	*Fri 4/14/23*	*Fri 4/14/23*
38	March MPR	1 day	Mon 5/15/23	Mon 5/15/23
39	April MPR	1 day	Thu 6/15/23	Thu 6/15/23
40	***2022 System Effectiveness Evaluation***	***66 days***	***Sun 1/1/23***	***Fri 3/31/23***
41	***Implement Groundwater Extraction Enhancement***	***317 days***	***Mon 9/13/21***	***Sun 11/27/22***
49	**Feasibility Study**	**407 days**	**Wed 1/12/22**	**Mon 7/31/23**
50	*Memo on Final FSWP and HSE to DEQ*	*1 day*	*Wed 1/12/22*	*Wed 1/12/22*
51	*Functional Unit Memorandum to DEQ*	*1 day*	*Tue 4/5/22*	*Tue 4/5/22*
52	*Respond to DEQ Comments on FU Memo*	*126 days*	*Wed 6/1/22*	*Tue 11/22/22*
53	*Remedial Technology Screening and Alternatives Summary*	*62 days*	*Thu 11/24/22*	*Wed 2/15/23*
54	*DEQ Review*	*21 days*	*Thu 2/16/23*	*Thu 3/16/23*
55	*Call with DEQ*	*1 day*	*Fri 3/17/23*	*Fri 3/17/23*
56	Draft FS	129 days	Wed 2/1/23	Mon 7/31/23



Project: MPR Schedule dec_ajg
Date: Thu 5/4/23

Task		Project Summary		Manual Task		Start-only		Deadline	
Split		Inactive Task		Duration-only		Finish-only		Progress	
Milestone	◆	Inactive Milestone		Manual Summary Rollup		External Tasks		Manual Progress	
Summary		Inactive Summary		Manual Summary		External Milestone	◆		

* - Indicates dates that are tentative

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Memo

To	Katie Daugherty, Oregon Department of Environmental Quality
From	Brendan Robinson, PE, Environmental Resources Management, Inc.
Date	16 June 2023
Reference	0682894 Phase 204
Subject	April 2023 GW SCM Monthly Performance Monitoring Report

1. INTRODUCTION

Environmental Resources Management, Inc. (ERM) prepared this Monthly Performance Monitoring Report (MPR) on behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc. (Arkema), for the former Arkema Portland Plant (the Site) at 6400 NW Front Avenue in Portland, Oregon. The Oregon Department of Environmental Quality (ODEQ), in its letter dated 31 May 2019 and in the subsequent meeting with LSS and ERM on 2 July 2019, requested that LSS initiate monthly status reports associated with the onsite groundwater source control measure (GW SCM) consistent with the Performance Monitoring Plan (PMP; ERM 2014) beginning July 2019. The 2014 PMP was prepared pursuant to the Order on Consent issued by ODEQ, signed on 31 October 2008 (ODEQ No. LQVC-NWR-08-04; Consent Order). The purpose of the PMP was to present the monitoring, reporting, and adaptive management processes used during implementation of the GW SCM. On 30 November 2021, ODEQ directed LSS that following the October 2021 MPR, MPRs would be suspended pending the implementation of the Groundwater Extraction Enhancement (GEE) project in 2022. During that time, ODEQ requested monthly schedule updates in lieu of MPRs. The trench wells installed as part of the GEE project was started on 27 November 2022, and MPR writing restarted in December 2022. The purpose of the GEE project was to install new extraction capacity to achieve the Capture Zone Objectives.

This April 2023 MPR summarizes the GW SCM performance monitoring data collected in April 2023. This report assesses the current gradient status and proposes system improvements to meet the Capture Zone Objectives set in the PMP.

2. GROUNDWATER SOURCE CONTROL IMPLEMENTATION

A detailed description of the design and implementation of the GW SCM is provided in the *Revised Upland Feasibility Study Work Plan* (ERM 2017); however, a brief description of the GW SCM is provided here. In February 2009, ODEQ and the U.S. Environmental Protection Agency (USEPA) approved the general approach for the GW SCM. This approach included installation of a groundwater barrier wall (GWBW), groundwater recovery wells, and a Groundwater Extraction and Treatment (GWET) system, with treated water discharged to the Willamette River. ODEQ and USEPA approved the *Groundwater Barrier Wall Final Design* (ERM 2012) on 7 August 2012. Construction of the GWBW began in May 2012 and was completed in December 2012. ODEQ approved the *Groundwater Extraction and Treatment System Final Design* (ERM 2013) on 2 April

2013. Construction of the GWET system began in December 2012 and was completed in December 2013.

GWET startup and optimization commenced in May 2014. The GW SCM at the Site consists of the following primary components (Figure 1):

1. A GWBW to physically separate the affected upland portions and in-water portions of the Site.

2. Hydraulic control to minimize flow of groundwater containing unacceptable concentrations of constituents of potential concern (COPCs) around, over, and under the GWBW.

3. Management of extracted groundwater through the GWET system, with treated effluent discharged to the Willamette River under a National Pollutant Discharge Elimination System (NPDES) Permit.

On 1 September 2018, ERM submitted the *Draft GWET System Effectiveness Evaluation* (Draft SEE Report; ERM 2018). The Draft SEE Report provided an update on the corrective actions implemented to improve the performance of the GWET system, evaluate the extent of capture, and propose actions to improve hydraulic capture. Additional data requested by ODEQ were submitted on 26 October 2018.

The key objective of the GW SCM is to achieve hydraulic containment of the alluvial sequence within the Target Capture Zone at the Site to prevent the flow of COPCs to the Willamette River. The Site alluvial aquifer sequence within the Target Capture Zone consists of the Shallow Zone, Intermediate Zone, and the Deep Zone. Site hydraulic conditions are variable and subject to both seasonal and daily tidal fluctuations.

The hydraulic control component formerly consisted of 22 recovery wells (RWs) prior to the implementation of the GEE. Of the 22 pre-existing RWs, four were retained for active pumping. The remaining 18 former RWs had pumps removed but will retain their pressure transducers so that they can continuously collect high-resolution groundwater elevation data. The 18 former RW pressure transducers are currently unable to be connected to the rest of the system until additional upgrades are performed that are currently planned for Q2 2023. The hydraulic control system now consists of the four remaining active RWs, as well as seven groundwater extraction trenches that each contain two extraction wells (EWs). Each trench is 50 feet deep, 50 feet long, and 3 feet wide and is filled with an engineered backfill. More information about the groundwater extraction trenches is provided in the *Final Design Report* (ERM 2022). The gradient control-monitoring network consisting of six gradient control clusters (GCCs) with each cluster containing six monitoring points. Within each RW, EW, and GCC location, pressure transducers are continuously collecting high-resolution groundwater elevation data. Each GCC contains three transducers interior to the wall and three transducers exterior to the wall screened in the Shallow, Intermediate, and Deep aquifers at the Site.

3. HYDRAULIC CONTAINMENT MONITORING PROGRAM

As described in the PMP, the purpose of hydraulic monitoring (i.e., groundwater elevation data) is to provide sufficient data to demonstrate an inward hydraulic gradient across the GWBW and to evaluate the effective hydraulic capture produced by the GW SCM.

Monitoring requirements were established in the PMP to demonstrate GWET effectiveness. The Site monitoring program includes groundwater elevation data (manual and transducer measurements) collected from the 36 monitoring points located within six GCCs spaced across the GWBW, with piezometers interior and exterior to the wall, throughout the alluvial sequence; and groundwater elevation and flow rate data from the four remaining active RWs and 14 EWs. High-resolution groundwater elevation data (transducer measurements) will be possible from the 18 inactive RWs that will no longer be operated, but will have transducers, after electrical upgrades are completed in May 2023. Additionally, one new monitoring well was installed in each of the seven extraction trenches for manual water level measurement. These data were used to prepare horizontal and vertical potentiometric surface maps representing potentiometric differences between the alluvial sequences, and to generate spatial and temporal hydrographs to evaluate hydraulic capture.

3.1 Groundwater Elevation Monitoring

Groundwater elevation monitoring was completed on 14 April 2023. Manual groundwater elevations were measured at wells that were experiencing transducer mechanical issues or that were offline during the groundwater elevation measurement event. Manual groundwater elevation measurements were completed for all inactive RWs used. Manual water level measurements for these wells were completed to evaluate transducer data accuracy. Specific issues are addressed in Attachment A-1.

As detailed in Attachments A-1 and A-2, during April 2023, the following transducers were:

Awaiting system upgrades for transducer re-installation:

- RW-05
- RW-06i
- RW-07
- RW-08
- RW-09i
- RW-10
- RW-11i
- RW-12
- RW-13i
- RW-15
- RW-16i
- RW-17

- RW-18
- RW-19i
- RW-20
- RW-21i
- RW-24i
- RW-26i

Fully out of service pending repairs:

- PA-07
- PA-16i
- MWA-8i
- PA-11i
- PA-14i
- PA-29i

Out of service for a period but returned to full operation following replacement:

- PA-20d
- PA-26d

Out of service for a period due to wellfield operations and upgrades:

- PA-03
- PA-04
- PA-15i
- PA-25d

Additionally, on 17 April 2023, Cochran Electric mobilized to the Site to install a Local Control Panel (LCP) in each of the Motor Control Centers (MCCs). These electrical upgrades, when completed in May 2023, will enable the wells awaiting system upgrades to be used as piezometers, and will allow for the more rapid repair of the other transducers in the system. These upgrades caused periodic outages at transducers as portions of the well-field were locked out to enable safe construction.

3.2 Horizontal and Vertical Gradients at Gradient Control Points

As described above, GCC locations collect high-resolution groundwater elevation data using transducers. Transducer data are filtered to remove anomalous data from monitoring points due to potential equipment failures, such as transducer malfunctions, power outages, or updates to the GWET programmable logic controller (PLC) system, which controls and houses all the operational data. These specific issues and time periods are summarized in Table A-1 in Attachment A. The following flags are applied to filter anomalous data:

- Groundwater elevations had a change greater than 1.5 feet within 1 hour
- Groundwater elevation measurements that were found to be greater than 50 feet, or less than 1 foot
- Calculated groundwater elevation slope indicates no change between consecutive measurements indicating a transducer malfunction
- Manually flagging data that are inconsistent with the typical nature of the well
- Periods where transducer power supply was deactivated for work on interconnected electrical systems

After April 2023 flagged data were removed, the Serfes (1991) method was used to account for tidal variations as described in the PMP. Using Serfes corrected data, both horizontal and vertical gradients were calculated and plotted over time (Attachment B). Groundwater elevations, horizontal gradients, and vertical gradients from 14 April 2023 are shown below at each GCC (Table 1-1 and Table 1-2). The water elevation taken during the groundwater level gauging event at PA-06 was excluded from gradient calculations and potentiometric surface maps due to being anomalous.

Table 1-1. April Horizontal Gradients

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
GCC1	Shallow	PA-03	31.65	PA-04	32.15	-0.005
	Intermediate	PA-17iR	14.19	PA-10i	15.12	-0.009
	Deep	PA-27d	13.57	PA-18d	13.51	0.000
GCC2	Shallow	MWA-2	10.85	PA-05 *M*	11.67	-0.012
	Intermediate	MWA-8i	11.87	PA-11i *M*	12.23	-0.005
	Deep	PA-19d	10.95	PA-30d	12.15	-0.022
GCC3	Shallow	MWA-69	11.68	PA-06	*	**
	Intermediate	MWA-66i	11.94	PA-12i	15.03	-0.027
	Deep	PA-21d	11.32	PA-20d *M*	11.75	-0.003
GCC4	Shallow	MWA-19	11.10	PA-28 *M*	16.66	-0.055
	Intermediate	MWA-34i	12.72	PA-13i	14.07	-0.015

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
	Deep	MWA-58d	12.15	PA-22d	12.93	-0.009
GCC5	Shallow	MWA-47	13.02	PA-07 *M*	16.34	-0.032
	Intermediate	PA-29i *M*	12.15	PA-14i *M*	14.40	-0.042
	Deep	PA-24d	11.21	PA-23d	13.57	-0.044
GCC6	Shallow	PA-09	13.92	PA-08	14.95	-0.019
	Intermediate	PA-16i *M*	13.05	PA-15i	13.86	-0.015
	Deep	PA-26d *M*	13.53	PA-25d	13.36	0.003

Notes:
Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.
Horizontal gradient calculated as (Exterior Elevation – Interior Elevation) / Horizontal distance.
ft NAVD88 = feet North American Vertical Datum of 1988
M = manual groundwater elevation measurement
** = anomalous groundwater elevation*
*** = horizontal gradient cannot be calculated due to anomalous elevation reading*

Table 1-2. April Vertical Gradients

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
Interior	SZ-IZ	GCC1	PA-04	32.15	PA-10i	15.12	1.72
		GCC2	PA-05 *M*	11.67	PA-11i *M*	12.23	-0.05
		GCC3	PA-06	*	PA-12i	15.03	**
		GCC4	PA-28 *M*	16.66	PA-13i	14.07	0.40
		GCC5	PA-07 *M*	16.34	PA-14i *M*	14.40	0.20
		GCC6	PA-08	14.95	PA-15i	13.86	0.08
	IZ-DZ	GCC1	PA-10i	15.12	PA-18d	13.51	0.21
		GCC2	PA-11i *M*	12.23	PA-30d	12.15	0.01
		GCC3	PA-12i	15.03	PA-20d *M*	11.75	0.17
		GCC4	PA-13i	14.07	PA-22d	12.93	0.06
		GCC5	PA-14i *M*	14.40	PA-23d	13.57	0.02
		GCC6	PA-15i	13.86	PA-25d	13.36	0.01

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
Exterior	SZ-IZ	GCC1	PA-03	31.65	PA-17iR	14.19	1.11
		GCC2	MWA-2	10.85	MWA-8i	11.87	-0.06
		GCC3	MWA-69	11.68	MWA-66i	11.94	-0.02
		GCC4	MWA-19	11.10	MWA-34i	12.72	-0.19
		GCC5	MWA-47	13.02	PA-29i [M]	12.15	0.07
		GCC6	PA-09	13.92	PA-16i [M]	13.05	0.06
	IZ-DZ	GCC1	PA-17iR	14.19	PA-27d	13.57	0.10
		GCC2	MWA-8i	11.87	PA-19d	10.95	0.59
		GCC3	MWA-66i	11.94	PA-21d	11.32	0.05
		GCC4	MWA-34i	12.72	MWA-58d	12.15	0.02
		GCC5	PA-29i [M]	12.15	PA-24d	11.21	0.02
		GCC6	PA-16i [M]	13.05	PA-26d [M]	13.53	-0.01

Notes:
Positive vertical gradient indicates a downward hydraulic gradient.
Vertical gradient calculated as (Upper Elevation – Lower Elevation) / Screen Midpoint distance.
ft NAVD88 = feet North American Vertical Datum of 1988
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone
[M] = manual groundwater elevation measurement
** = anomalous groundwater elevation*
*** = vertical gradient cannot be calculated due to anomalous elevation reading*

3.3 Potentiometric Surface, Groundwater Elevation Difference Maps, and Groundwater Flow Directions

As described in the PMP, potentiometric surface maps are used to evaluate flow paths. Vertical gradients are also used as an additional line of evidence to evaluate hydraulic containment. Groundwater elevation data collected on 14 April 2023 were used to prepare potentiometric surface maps based on manual measurements and averaged transducer groundwater elevations (Figures 2 through 4) and vertical difference maps (Figures 5 and 6).

The generalized flow direction indicated by the potentiometric surface maps show overall groundwater flow toward the GWBW. The Shallow and Intermediate Zones potentiometric maps (Figures 2 and 3) indicate localized groundwater movement to some of the extraction trenches due to GW SCM pumping, primarily along the northern edge of the GWBW, where pump operation has been the steadiest. Additionally, in the intermediate zone, the observed groundwater elevation depression along the north end of the barrier appears to be migrating toward the two northernmost trenches. Only some of the EWs were active at the time of the water level event, primarily on the northern portion of the Site. Hydraulic influence is apparent near GCC1 and GCC2, and a cone of depression is developing that extends to GCC3. Additional evidence of capture is anticipated as ongoing pumping occurs.

A potentiometric separation is still noticeable exterior to the GWBW, indicating the barrier wall is functioning by impeding groundwater flow. The Deep Zone potentiometric map also indicates flow toward the GWBW (Figure 4), with exception to GCC1 and GCC6, where groundwater elevations are demonstrating a slight inward gradient from the river. In the past two months, inward gradient has been demonstrated at GCC1 and GCC6 intermittently, and are trending in that direction (Attachment B-2). River elevations are shown on the potentiometric surface maps in an inset (Figures 2 through 4) and depict stage movement within the month corresponding with the MPR. Vertical gradients were calculated for each vertical well pair using these groundwater elevations and are plotted on Figures 5 and 6.

Vertical groundwater gradients interior to the GWBW between the Shallow and Intermediate Zones were generally downward in April 2023 with GCC2 being upward, and the remainder being downward (Figure 5). The vertical groundwater gradient at GCC3 on the interior of the wall were unable to be calculated due to an anomalous groundwater elevation reading at PA-06. PA-06 will be re-calibrated so that vertical gradients at GCC6 can be calculated in the future and presented in subsequent MPRs. Vertical groundwater gradients are also depicted in Attachment B. The magnitude of the gradient is much greater at GCC1 than other monitoring locations due to the influence from a localized high-pressure zone near GCC1 where vertical groundwater flow is impeded by a localized confining unit (Figure 2). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were mixed with GCC2, GCC3, and GCC4 being upward and GCC1, GCC5, and GCC6 being downward as shown on Figure 5 and in Attachment B.

Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were downward. The direction of vertical gradients exterior to the GWBW were downward with exception to GCC6, as shown on Figure 6 and Attachment B.

The river elevation in April 2023 varied with an average of 10.09 feet NAVD88, maximum of 12.50 feet NAVD88, and minimum of 6.75 feet NAVD88.

3.3.1 GWET System Performance

The GWET operated within permit conditions during the reporting period. There were two shutdowns:

- 04 April 2023: A brief unplanned shutdown due to flooding in a vault.
- 05 April 2023: A brief unplanned shutdown due to a high-pressure alarm in the pressure filters. The pressure filters were cleaned, backwashed, and returned to service.
- 22 April 2023: An unplanned shutdown to clean the pressure filters. The wellfield was shut down at 1440 on 22 April. The pressure filters were more thoroughly cleaned and backwashed, and the system was restarted on 25 April 2023.

On 17 April 2023, Cochran Electric mobilized to the Site to install LCPs in the MCCs onsite. Work by Cochran was performed through the remainder of the month of April, and transducers at all transducers awaiting an upgrade are anticipated to be online for the May groundwater level monitoring event. There were no other upgrades to the GWET plant in the month of April 2023.

3.3.2 Recovery Well and Extraction Well Performance

In April 2023, the average system influent flow rate was 41.44 gallons per minute (gpm) during operational periods, compared to 73.32 gpm in the February 2023 period. This decrease in flow rate is largely due to the eight EWs that were not active during the month of April. Additionally, during April 2023, 4 of the 14 EWs were periodically down for maintenance. The two EWs that were operating at reduced pumping rates due to electrical problems were fixed by replacing pumps, motors, and cable leads at each location. New pumps, motors, and cable leads are expected to arrive at the Site in May 2023 and will be installed upon receipt. The root cause of the eight inactive EWs are primarily the use of old pumps, motors, and cables leads in each extraction well causing motor faults. Additionally, two of the wells that were not active during April were inactive due to electrical issues during installation. The extraction trench installation contractor (Odin Construction) is being engaged to perform electrical repairs, upgrade vaults to prevent potential future issues, and is expected to perform these repairs in May 2023 when the new pumps arrive. ERM does not anticipate that these repairs will inhibit the GWET plant's operational goal of generating inward gradient in the long term. ERM is currently in the process of optimizing extraction rates within the system to increase flow rates at each operational well until the extraction rates specified in the *Final Design Report* (ERM 2022) are achieved, or until the Capture Zone Objectives are met.

Table 1-3. Recovery Well Pumping Rates[1]

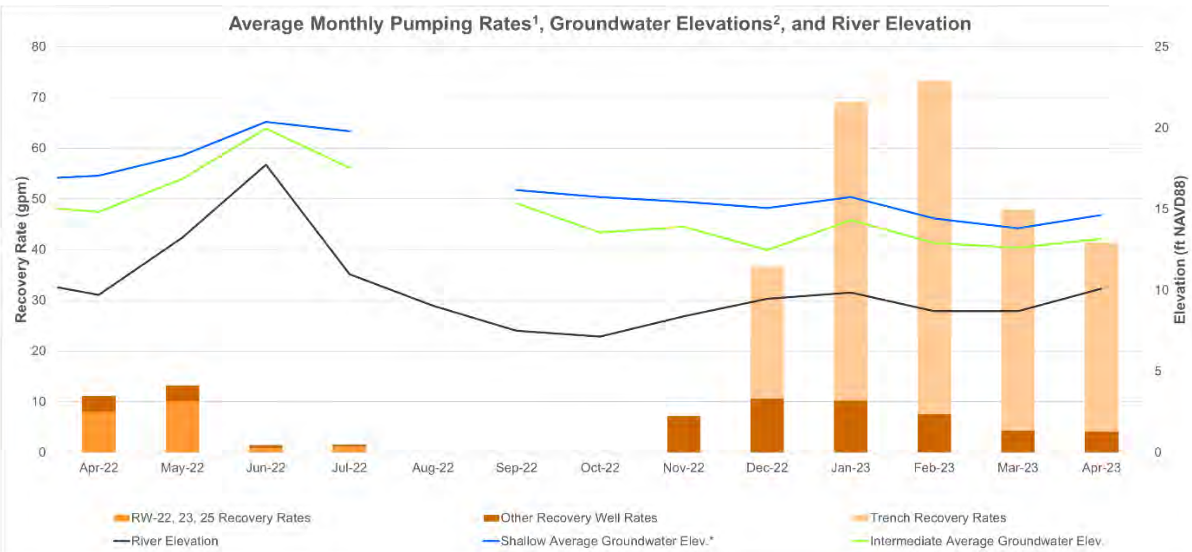
Recovery Well	April 2023 Average Pumping Rate (gpm)
RW-14	1.04
RW-22 *	0.00
RW-23	1.27
RW-25	1.78
EW-01	7.59
EW-02	2.09
EW-03	5.93
EW-04	7.16
EW-05	3.31
EW-06 *	0.00
EW-07	4.47
EW-08 *	0.00
EW-09 *	0.00
EW-10 *	0.00
EW-11 *	0.00
EW-12 *	0.00

Recovery Well	April 2023 Average Pumping Rate (gpm)
EW-13	6.81
EW-14 *	0.00
Total	**41.44**

Notes:

1 = Flow rates are calculated based on the period of the month during which the recovery wells were operational

** = Recovery well not in service during reporting period*



Notes:

1 = Following installation of trenches in Summer 2022, RW-22, 23, and 25 recovery rates are now grouped together with the other remaining recovery well (RW-14) starting in November 2022.

2 = Average groundwater elevations are calculated using interior wells—the well field was powered down in August preventing the measurement of the groundwater.

** = The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the whole aquifer.*

Figure 1-1. Monthly Pumping Rate Contribution

3.3.3 Recommendations for Extraction System Optimization

Recovery rates from the start of the system indicate that the active RWs and EWs are operating as designed except for the troubleshooting discussed above. The extraction rates throughout the GWET system will continue to be optimized to meet Target Capture Objectives following the mobilization of contractors to perform system repairs. Replacements for all EW pumps have been ordered and will mitigate potential pump failures.

4. ANALYTICAL PROGRAM

Quarterly groundwater monitoring was implemented in accordance with the ODEQ-approved Arkema Quarterly Groundwater Monitoring Work Plan dated October 2019 and the ODEQ-approved reduced scope described in the 2021 monitoring program modification request memorandum dated 9 September 2021. The table below outlines sampling dates and submittal dates related to groundwater monitoring since the implementation of the reduced scope. The Quarterly Monitoring Reports present results from these sampling events.

Report	Sampling Dates	Report Submittal Date
2021 Quarter 3	9/21/2021–9/24/2021	1/14/2022
2021 Quarter 4	12/13/2021–12/16/2021	4/20/2022
2022 Quarter 1	3/14/2022–3/17/2022	6/15/2022
2022 Quarter 2	6/6/2022–6/9/2022	9/12/2022
2022 Quarter 4	11/7/2022–11/10/2022	2/17/2023
2023 Quarter 1	3/6/2023–3/10/2023	6/12/2023
2023 Quarter 2*	6/12/2023–6/16/2023	9/15/2023

* dates are tentative

5. SUMMARY AND CONCLUSIONS

This report presents a summary of the GW SCM operation, maintenance, and monitoring activities conducted at the Site in April 2023 and documents results from system monitoring. The following summarizes ERM's observations and conclusions drawn from collected data.

5.1 Groundwater Flow

- Horizontal gradients across the GWBW are generally outward toward the river; however, groundwater elevations show a noticeable separation interior and exterior of the GWBW, indicating the GWBW is functioning via impeding groundwater flow. Before installation of the GEE project, inward gradients were periodically observed at some monitoring locations. It is yet to be determined whether a long-term inward gradient has been produced through increased pumping rates, but the GWET is generating localized areas of sustained groundwater capture that are anticipated to expand with longer operations. Additionally, sustained capture has led to an increase in the overall horizontal gradients observed in all zones Attachment B-2 and inward gradient at the ends of the GWBW in the Deep Zone.

- Vertical groundwater gradients interior to the GWBW between the Shallow and Intermediate Zones were generally downward in April 2023 with GCC1, GCC4, GCC5, and GCC6 being downward and the GCC2 being upward (Figure 5). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were mixed with GCC2, GCC3, and GCC4 being upward and the remaining being downward. Interior and exterior of the GWBW vertical gradients between the Intermediate and Deep Zones were downward except for the exterior of GCC6 which was upward (Figure 6).

- River elevations have generally been stable since reporting resumed in December 2022. The average river elevation in April 2023 was 10.09 feet NAVD88 with a minimum elevation of 6.75 feet NAVD88 and a maximum elevation of 12.50 feet NAVD88. The river level average since the beginning of 2023 is 9.35 ft NAVD88. Changes in river levels are not expected to have materially impacted progress toward Target Capture Objectives.

- Within the Site alluvial sequence, potentiometric maps indicate the GW SCM are to be producing localized areas of hydraulic capture at GCC1 and GCC2 in the Shallow Zone; however, more time at elevated extraction rates will be required to evaluate whether GWET objectives are being met system-wide.

5.2 Groundwater Extraction

Based on April 2023 extraction and relevant hydrograph analysis, the trenches are functioning as designed, and the EWs and RWs are being repaired and upgraded so they will operate as designed. Higher flow rates are anticipated in May after upgrades are completed. Further evaluation of the system with respect to the Capture Zone Objectives will be conducted once all pumps are operating at their design rates for an extended period.

5.3 Recommendations and Future Work

ERM will continue to optimize new EWs. Any additional modifications to the system to meet capture objectives will be included in subsequent Monthly Progress Reports. The project schedule provided as Attachment C summarizes activities planned for the immediate future.

Regards,

REGISTERED PROFESSIONAL ENGINEER
78496PE
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DECEMBER 31, 2007
BRENDAN ANDREW ROBINSON
EXP. 12/31/2024

Brendan Robinson, PE
Partner

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FIGURES

Figure 1: Site Layout

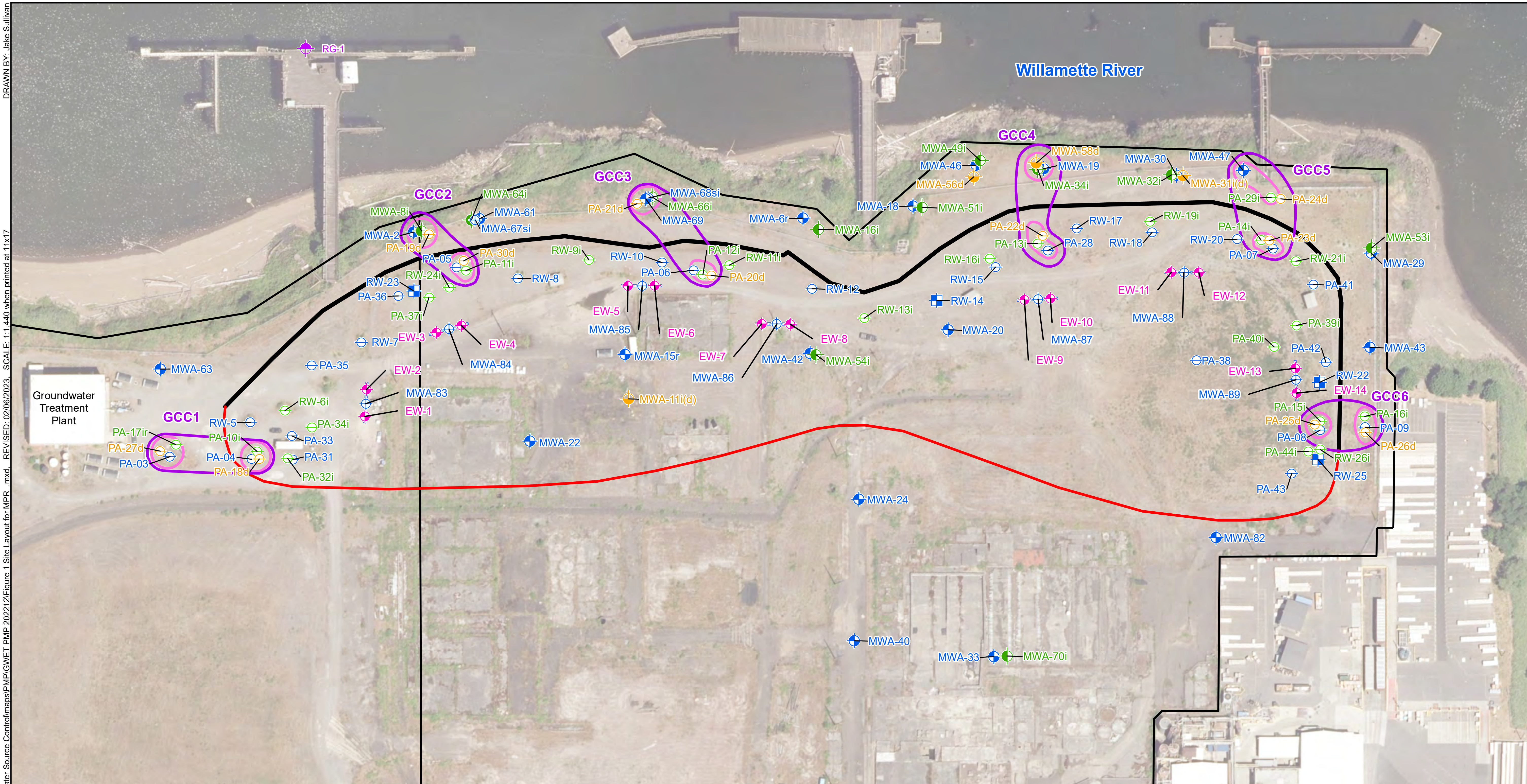
Figure 2: April 2023 Shallow Zone Groundwater Contours

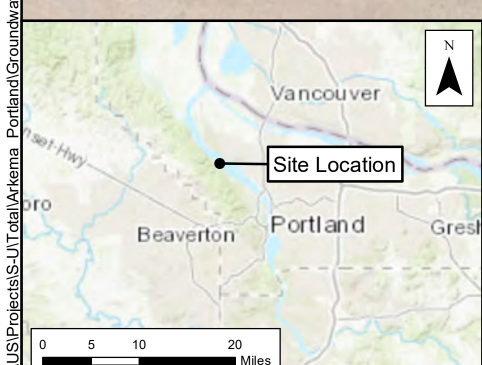
Figure 3: April 2023 Intermediate Zone Groundwater Contours

Figure 4: April 2023 Deep Zone Groundwater Contours

Figure 5: April 2023 Shallow to Intermediate Zone Vertical Head Difference

Figure 6: April 2023 Intermediate to Deep Zone Vertical Head Difference





Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Shallow Zone Recovery Well
- River Gauge
- Trench Extraction Well
- Target Capture Zone
- Barrier Wall Alignment
- Parcel and Property Boundaries

GradientClusters

Type

- Gradient Control Cluster
- Vertical Flow Cluster
- Extraction Trench

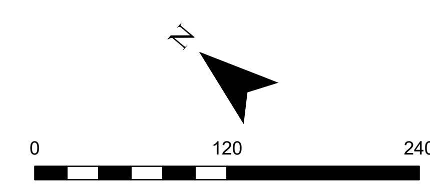
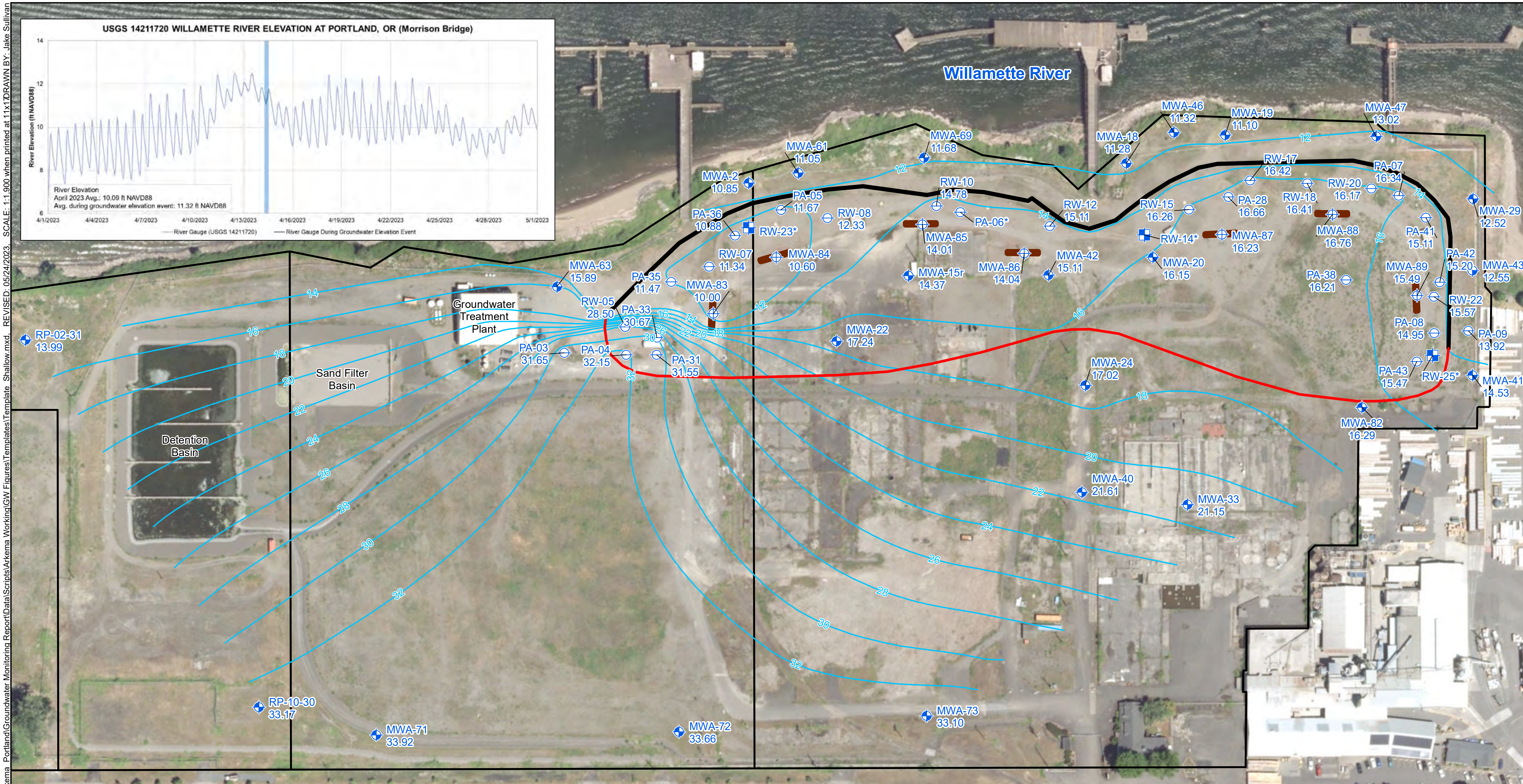


Figure 1
Site Layout
Monthly Progress Report
Groundwater Source Control Measure
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

Source: City of Portland Aerial Imagery, flown Summer 2021; NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Shallow Zone Piezometer
- Shallow Zone Monitoring Well
- Active Recovery Well; Not Used During Contouring
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Shallow Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected April, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 2
April 2023 Shallow Zone Groundwater Contours
Monthly Performance Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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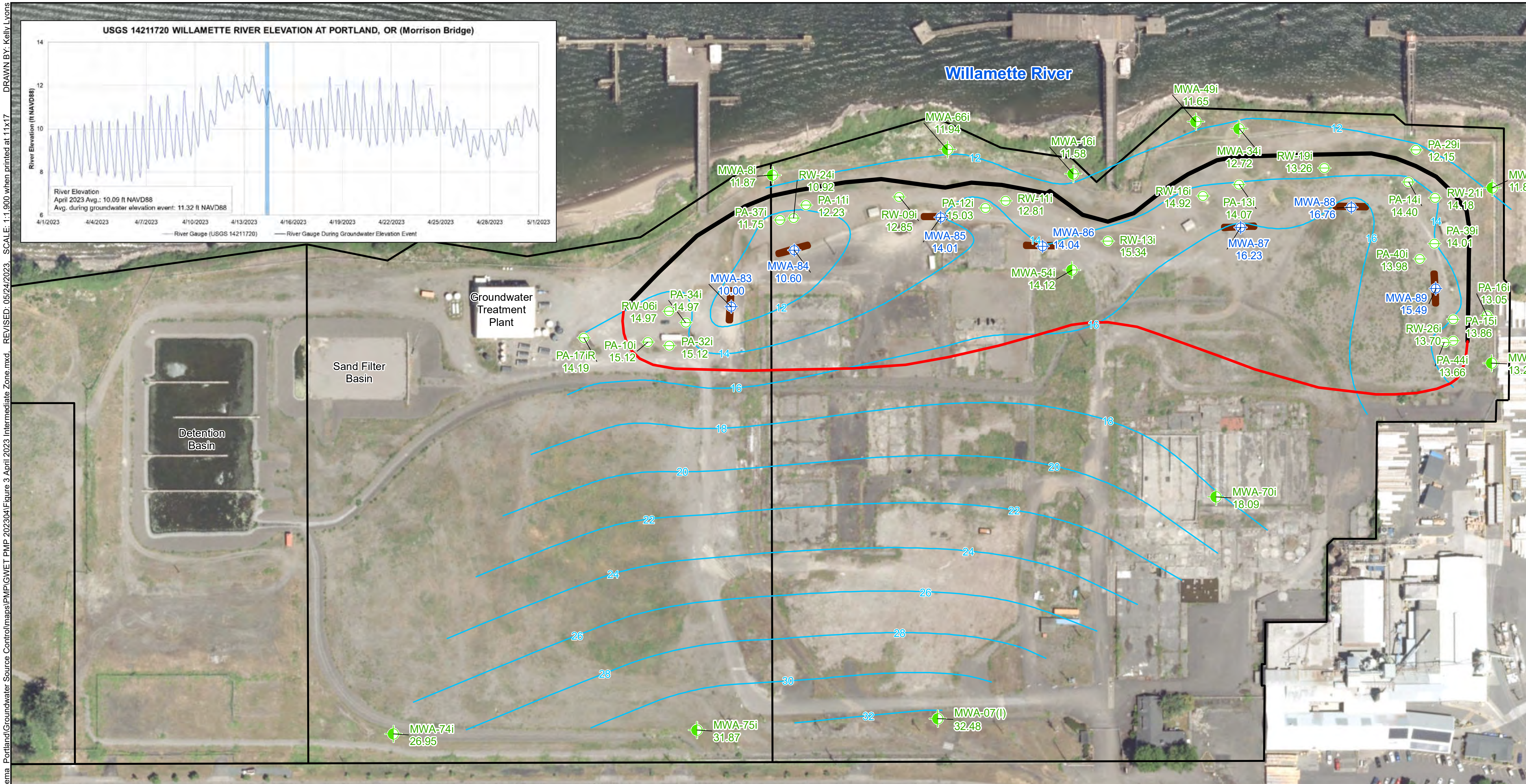

Legend

- Intermediate Zone Piezometer
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected April, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

Figure 3
April 2023 Intermediate Zone Groundwater Contours
Monthly Performance Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

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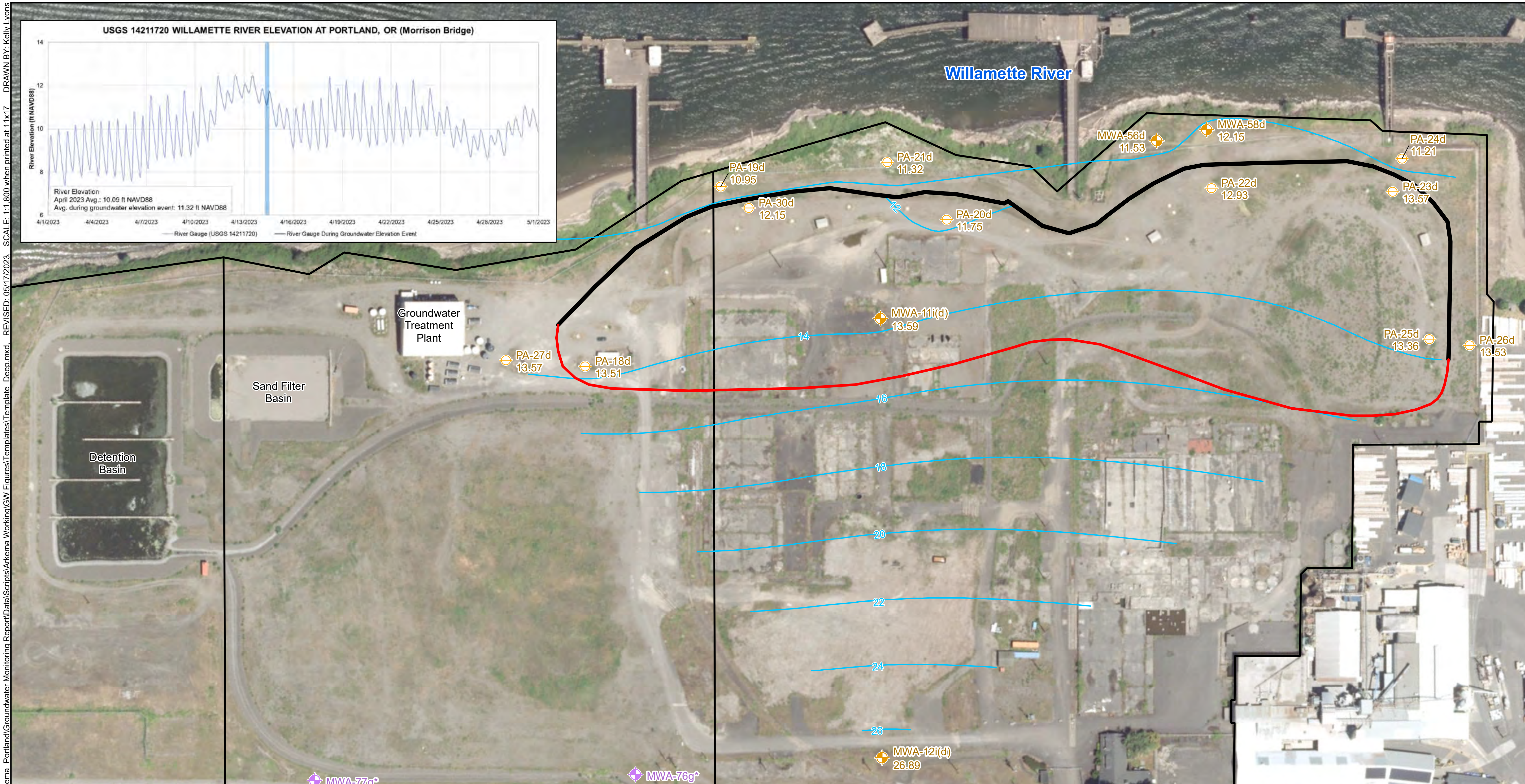
NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Deep Zone Piezometer
- Deep Zone Monitoring Well
- Gravel Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Deep Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment

Notes:
* Value not used for contouring.
Gravel zone wells not used in contouring.
Water levels collected April, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 150 300
Feet

Figure 4
April 2023 Deep Zone Groundwater Contours
Monthly Performance Report
Groundwater Source Control Measures
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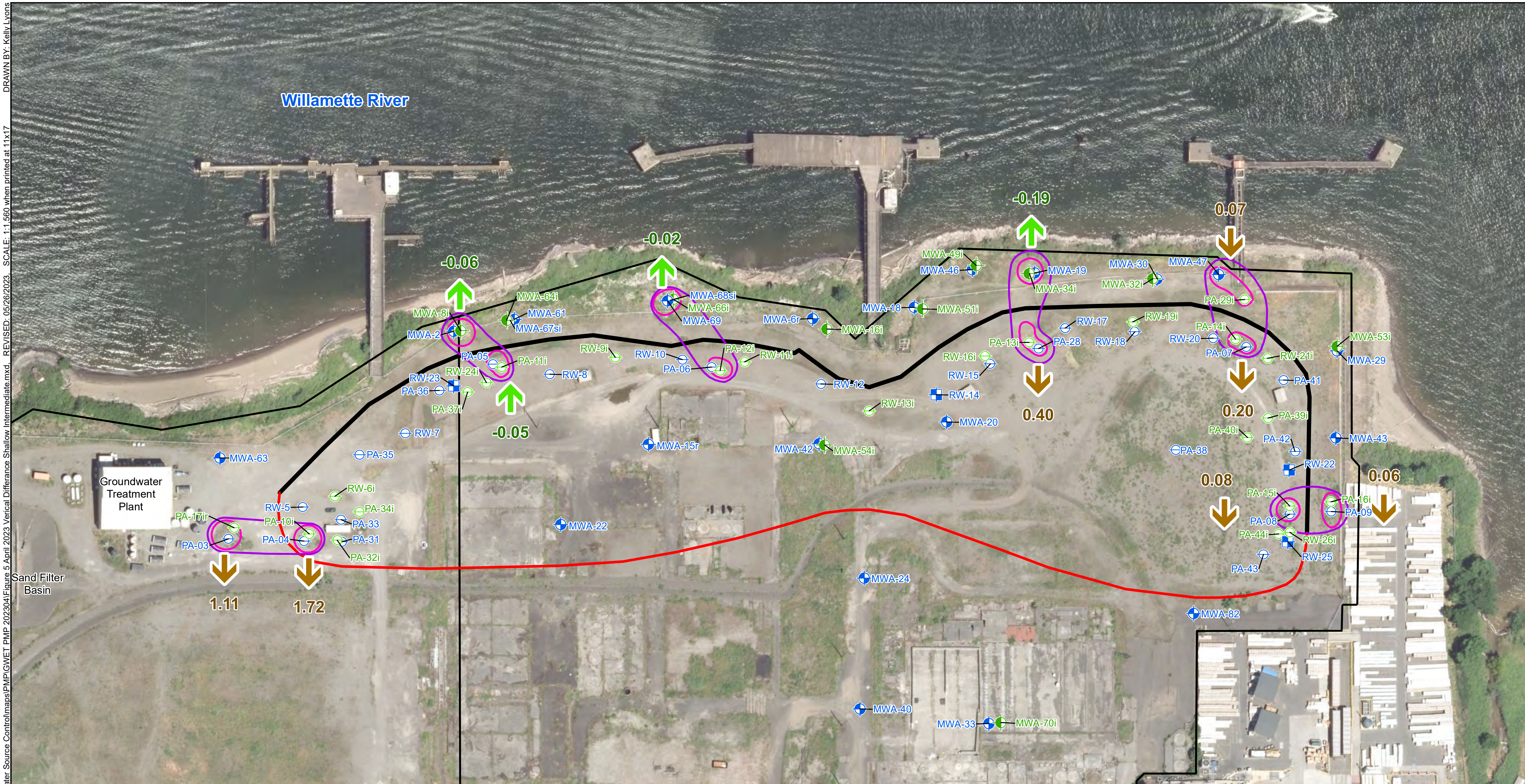
NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

\\SCUSPRDGISFS01\Data\US\Projects\S-U\Total\Arkema_Portland\Groundwater Monitoring Report\Data\Scripts\Arkema Working\GW Figures\Templates\Template_Deep.mxd REVISED: 05/17/2023 SCALE: 1:1,800 when printed at 11x17 DRAWN BY: Kelly Lyons



M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 202304\Figure 5 April 2023 Vertical Difference Shallow Intermediate.mxd REVISED: 05/26/2023 SCALE: 1:1,560 when printed at 11x17 DRAWN BY: Kelly Lyons

Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Shallow Zone Recovery Well
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as shallow zone minus intermediate zone potentiometric surfaces.
Water levels collected April, 2023.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 5
April 2023 Shallow to Intermediate Zone Vertical Head Difference
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

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DRAWN BY: Kelly Lyons SCALE: 1:1,560 when printed at 11x17 REVISED: 05/24/2023 M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 2023\04\Figure 6 April 2023 Vertical Difference Intermediate Deep.mxd

Legend

- Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as intermediate zone minus deep zone potentiometric surfaces.
Water levels collected April, 2023.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 6
April 2023 Intermediate to Deep Zone Vertical Head Difference
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

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ATTACHMENT A-1 TRANSDUCER FLAGS

Attachment A-1. Transducer Flags

Table A-1
Transducer Malfunction Log: April 2023
Arkema Inc. Facility
Portland, Oregon

Gradient Cluster	Transducer	Interval	Date Range		Issue and Repairs Performed
5	PA-07	Shallow	1/4/2023	4/30/2023	Transducers replaced. Still not operational. Under further investigation.
6	PA-16i	Intermediate	12/16/2023	4/30/2023	Transducers replaced. Still not operational. Under further investigation.
2	MWA-8i	Intermediate	4/4/2023	4/30/2023	LOTO at EW-06. EW-06 remains locked out due to safety concerns from faulty connections in vault.
2	PA-11i	Intermediate	4/4/2023	4/30/2023	LOTO at EW-06. EW-06 remains locked out due to safety concerns from faulty connections in vault.
5	PA-14i	Intermediate	2/8/2023	4/30/2023	LOTO at EW-11. EW-11 remains locked out due to safety concerns from faulty connections in vault.
5	PA-29i	Intermediate	2/8/2023	4/30/2023	LOTO at EW-11. EW-11 remains locked out due to safety concerns from faulty connections in vault.
3	PA-20d	Deep	1/4/2023	4/19/2023	Transducer replaced.
6	PA-26d	Deep	1/11/2023	4/19/2023	Transducer replaced.

Notes:
I/O = input/output
LOTO = lockout/tagout
VFD = variable frequency drive

ATTACHMENT A-2 RECOVERY WELL STATUS

Attachment A-2. Recovery Well Status

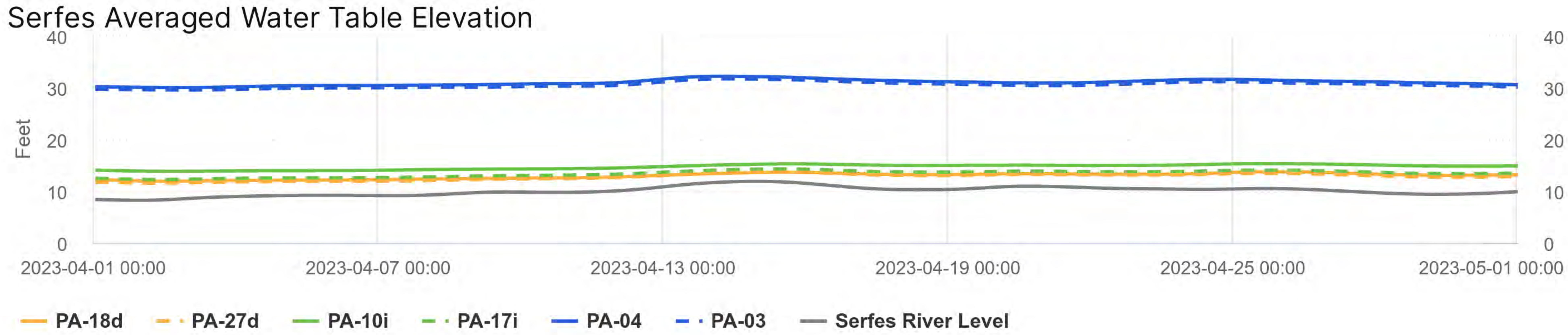
Table A-2
Recovery Well Status: April 2023
Arkema Inc. Facility
Portland, Oregon

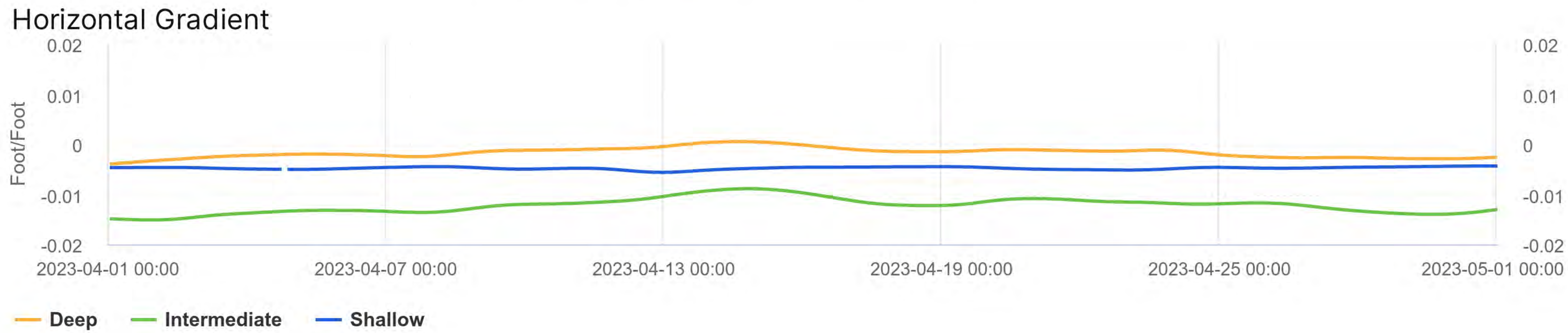
Recovery Well ID	Status as of 4/30/2023 (active or inactive)	Issue	Actions to get online	Expected date back online	Transducer Status	Totalizer Status	Average Flow Rate (gpm)	Overall Extraction Rate	Notes
RW-05	Inactive	None	Will not be placed back online	N/A	Good	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-06i	Inactive	None	Will not be placed back online	N/A	Good	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-07	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-08	Inactive	None	Will not be placed back online	N/A	Not Connected	Good	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-09i	Inactive	None	Will not be placed back online	N/A	Not Connected	Good	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-10	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-11i	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-12	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-13i	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-14	Active	None	N/A	N/A	Not Connected	Good	1.04	M	
RW-15	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-16i	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-17	Inactive	None	Will not be placed back online	N/A	Not Connected	Good	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-18	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-19i	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-20	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-21i	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-22	Inactive	Totalizer failure	Replace totalizer	N/A	Good	Bad	0.00	OFF*	Totalizer failed, will be replaced
RW-23	Active	None	N/A	N/A	Good	Good	1.27	M	
RW-24i	Inactive	None	Will not be placed back online	N/A	Not Connected	Good	0.00	OFF*	Will be operated as piezometer; pending upgrades
RW-25	Active	None	N/A	N/A	Good	Good	1.78	M	
RW-26i	Inactive	None	Will not be placed back online	N/A	Not Connected	Removed	0.00	OFF*	Will be operated as piezometer; pending upgrades
EW-01	Active	None	N/A	N/A	Good	Good	7.59	G	
EW-02	Inactive	Motor fault	Replace motor, pump, and cable	N/A	Good	Good	2.09	M	Pumps, motors, and cables need replacement
EW-03	Active	None	N/A	N/A	Good	Good	5.93	G	
EW-04	Active	None	N/A	N/A	Good	Good	7.16	G	
EW-05	Active	None	N/A	N/A	Good	Good	3.31	G	
EW-06	Inactive	Motor fault	Replace motor, pump, and cable	N/A	Good	Good	0.00	OFF*	Pumps, motors, and cables need replacement
EW-07	Active	None	N/A	N/A	Good	Good	4.47	G	
EW-08	Inactive	Motor fault	Replace motor, pump, and cable	N/A	Good	Good	0.00	OFF*	Pumps, motors, and cables need replacement
EW-09	Inactive	Motor fault	Replace motor, pump, and cable	N/A	Good	Good	0.00	OFF*	Pumps, motors, and cables need replacement
EW-10	Inactive	Motor fault	Replace motor, pump, and cable	N/A	Good	Good	0.00	OFF*	Pumps, motors, and cables need replacement
EW-11	Inactive	Motor fault	Replace motor, pump, and cable	N/A	Good	Good	0.00	OFF*	Pumps, motors, and cables need replacement
EW-12	Inactive	Motor fault	Replace motor, pump, and cable	N/A	Good	Good	0.00	OFF*	Pumps, motors, and cables need replacement
EW-13	Active	None	N/A	N/A	Good	Good	6.81	G	
EW-14	Inactive	Motor fault	Replace motor, pump, and cable	N/A	Good	Good	0.00	OFF*	Pumps, motors, and cables need replacement

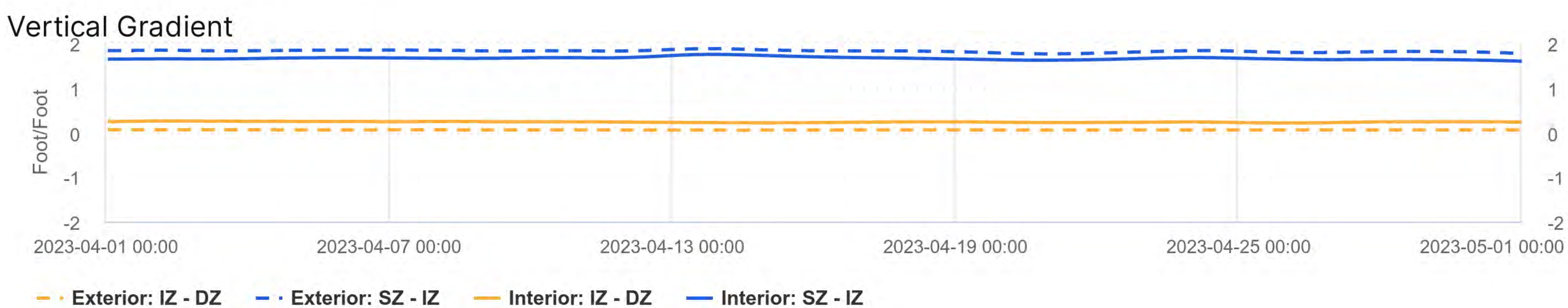
Notes:
** Recovery wells not in service*
*** Recovery wells in service part of the month*
G = good pumping, greater than 3.0 gpm
gpm = gallons per minute
M = moderate pumping, greater than 1.0 gpm and less than 3.0
P = poor pumping, less than 1.0 gpm
VFD = variable frequency drive
PA = piezometer

ATTACHMENT B GRADIENT HYDROGRAPHS

Gradient Control Cluster 1

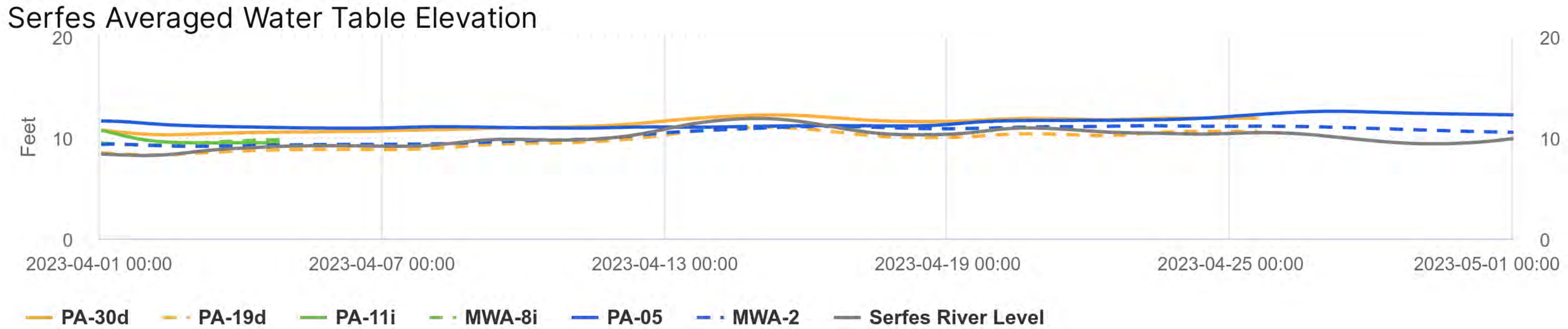


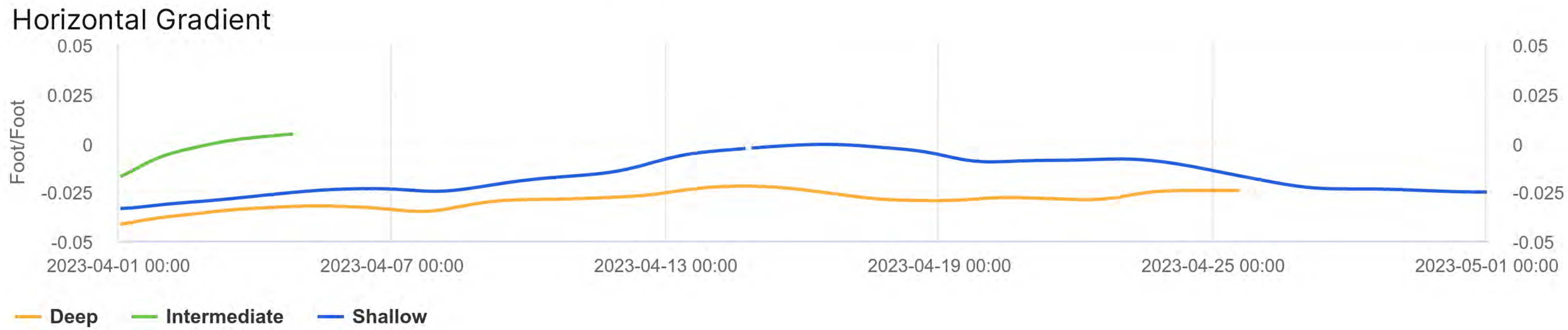


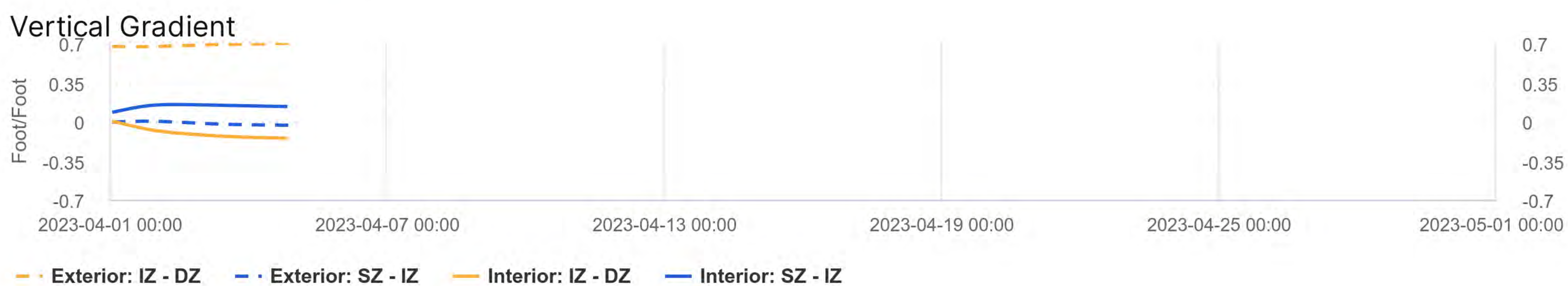


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 2



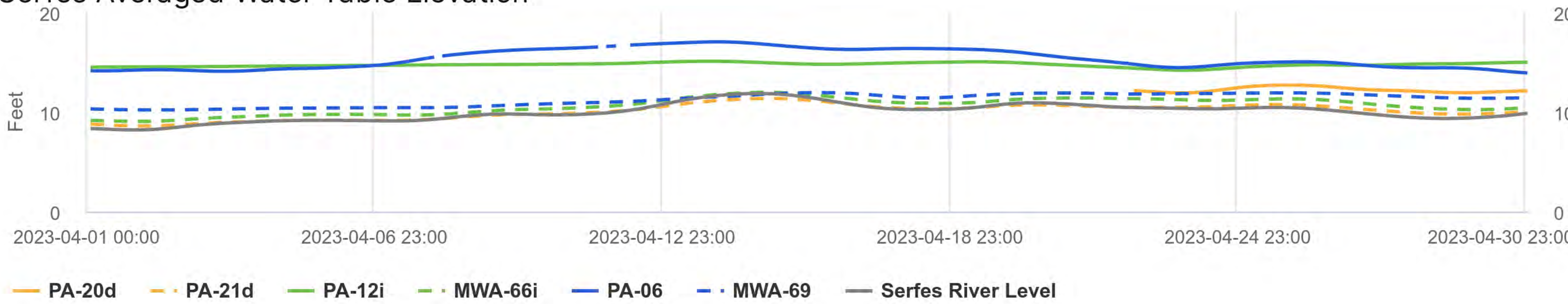




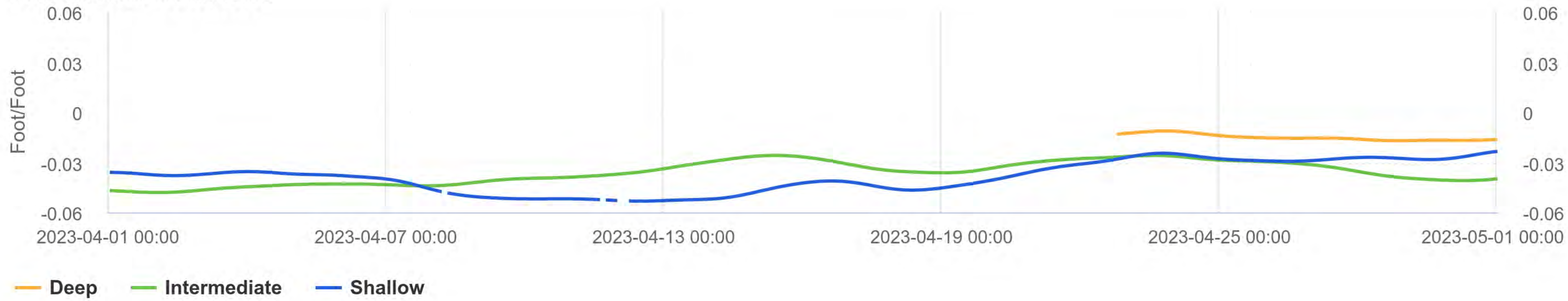
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 3

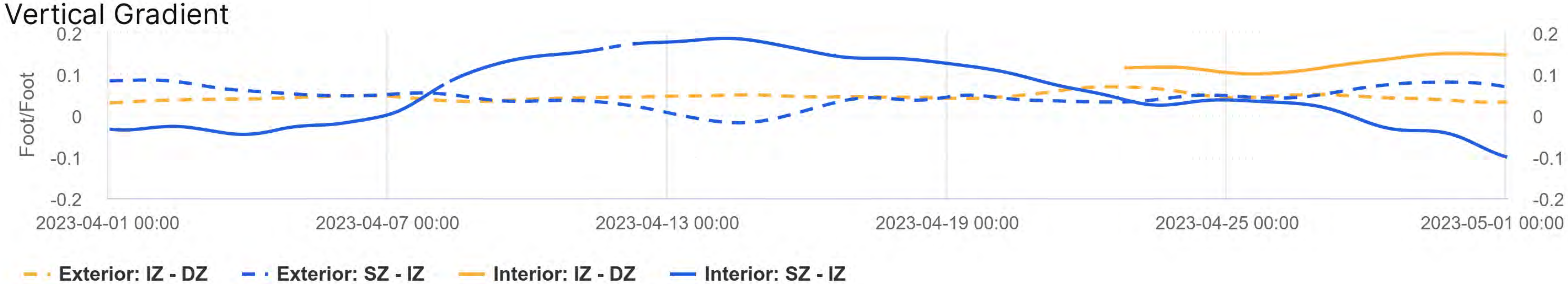
Serfes Averaged Water Table Elevation



Horizontal Gradient

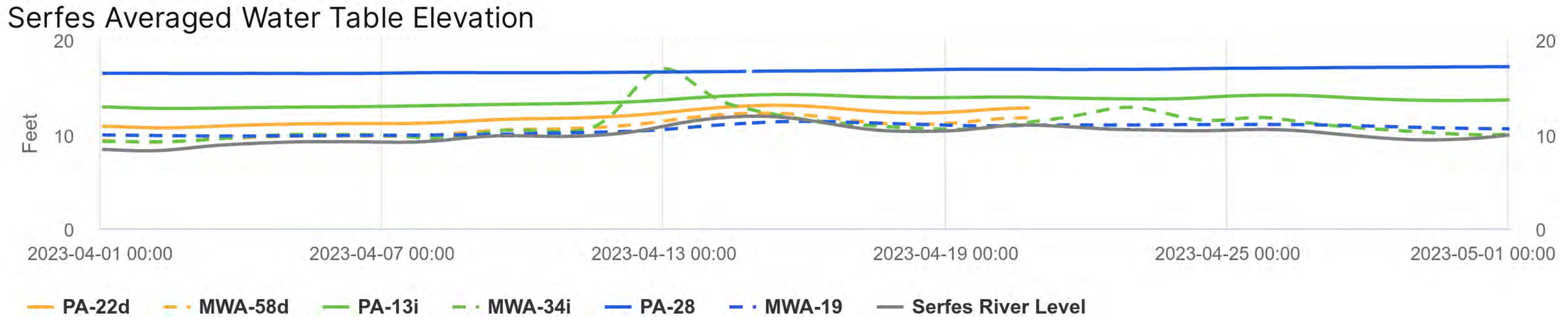


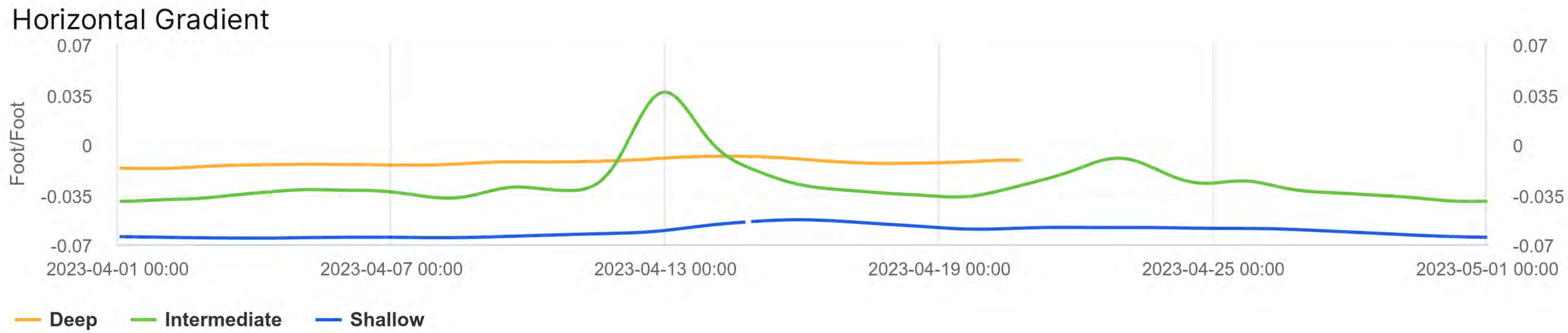
Vertical Gradient

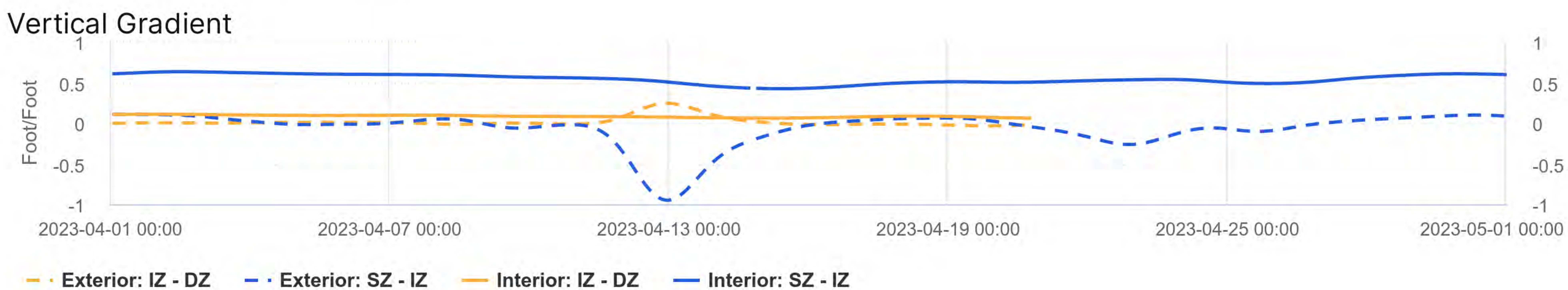


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 4



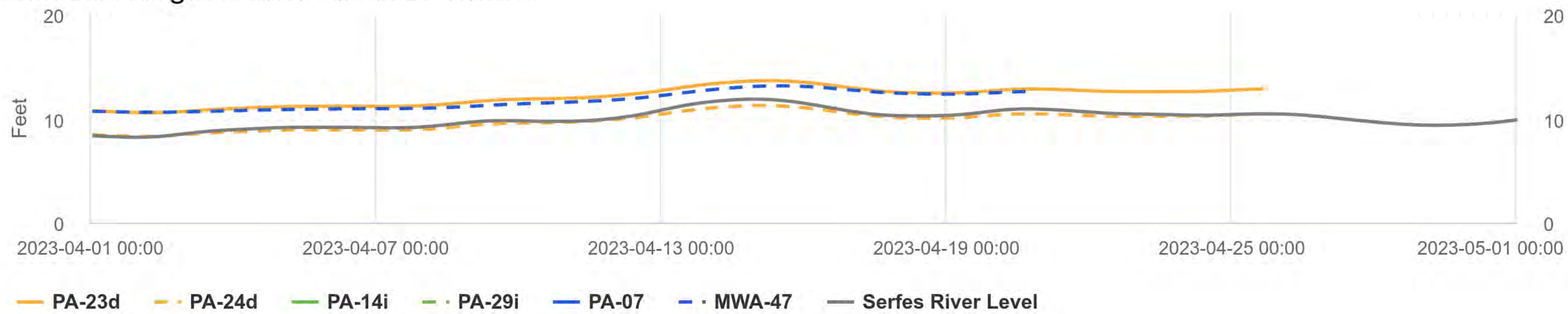




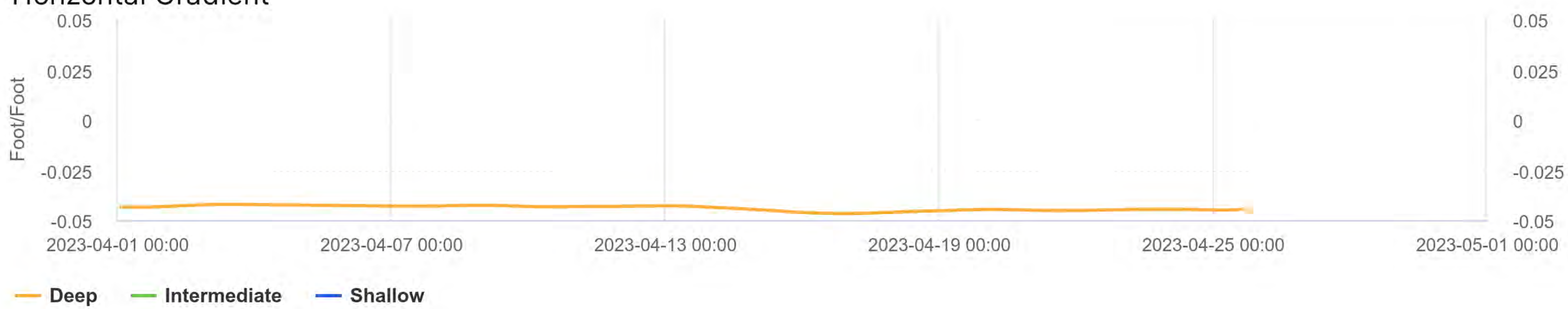
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 5

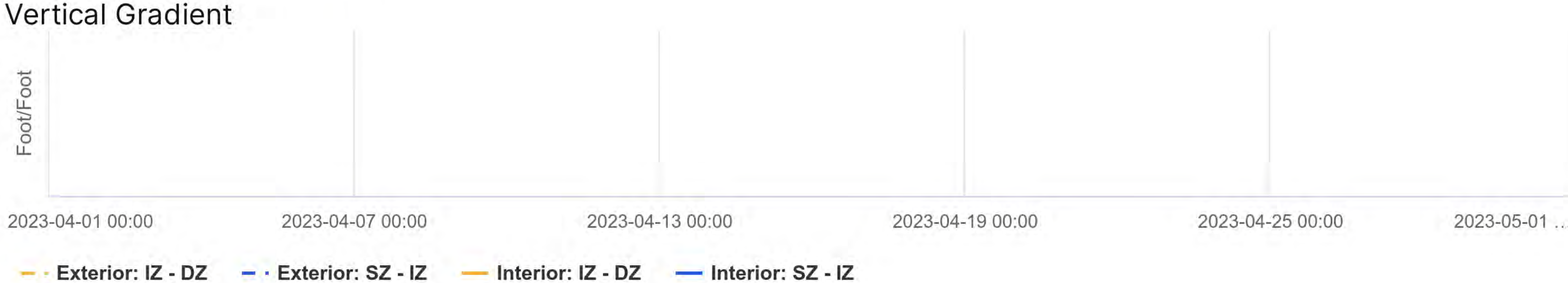
Serfes Averaged Water Table Elevation



Horizontal Gradient



Vertical Gradient

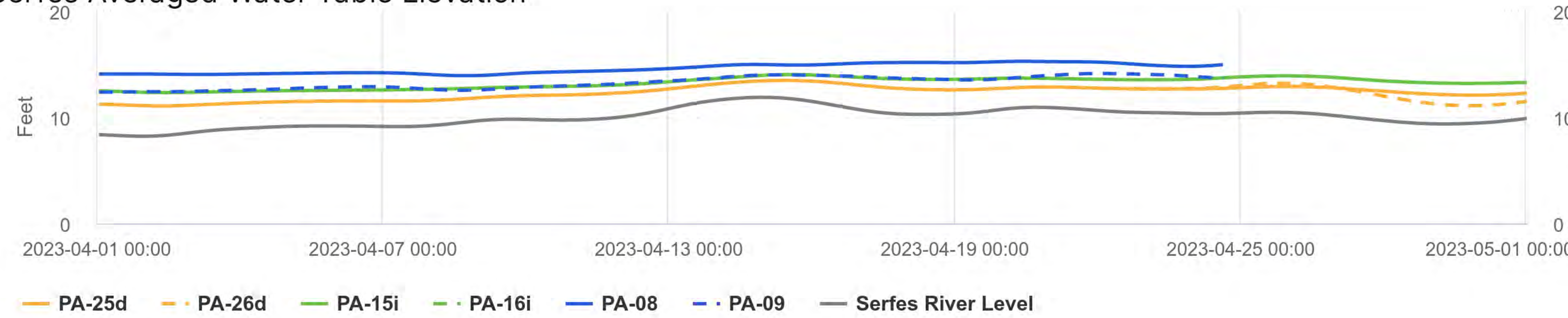


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW

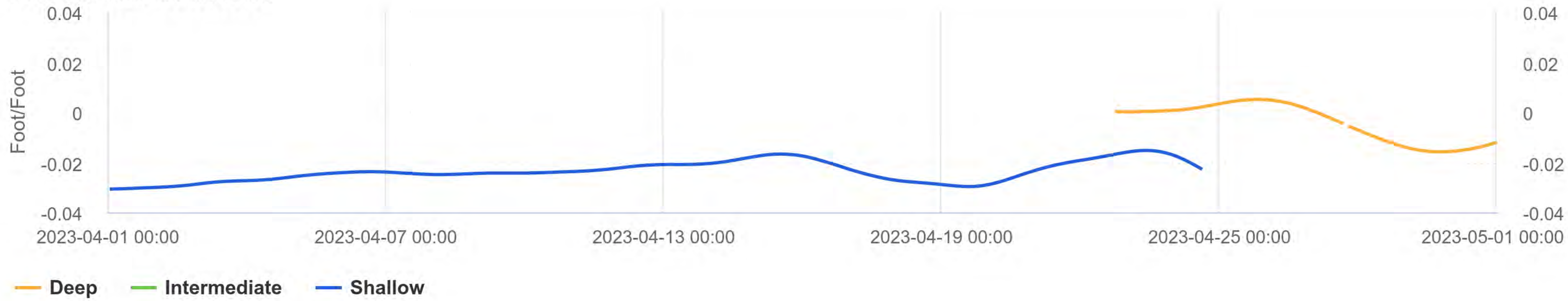
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 6

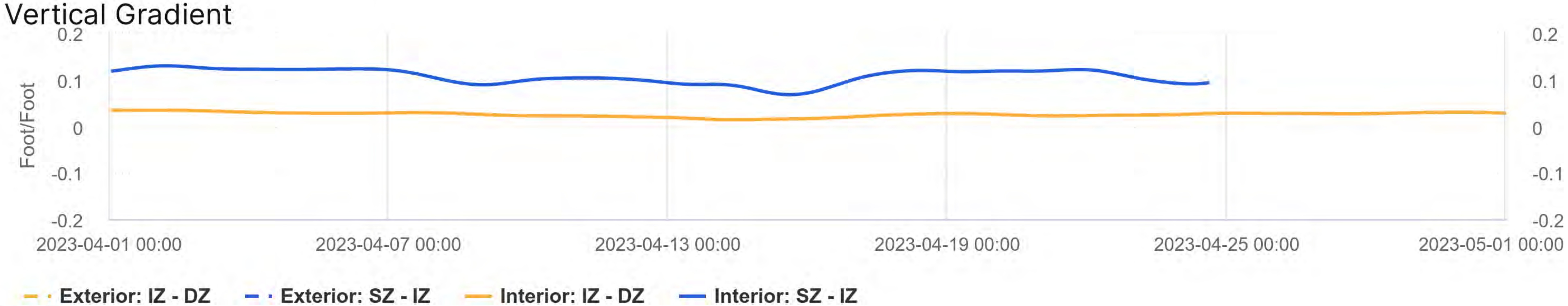
Serfes Averaged Water Table Elevation



Horizontal Gradient



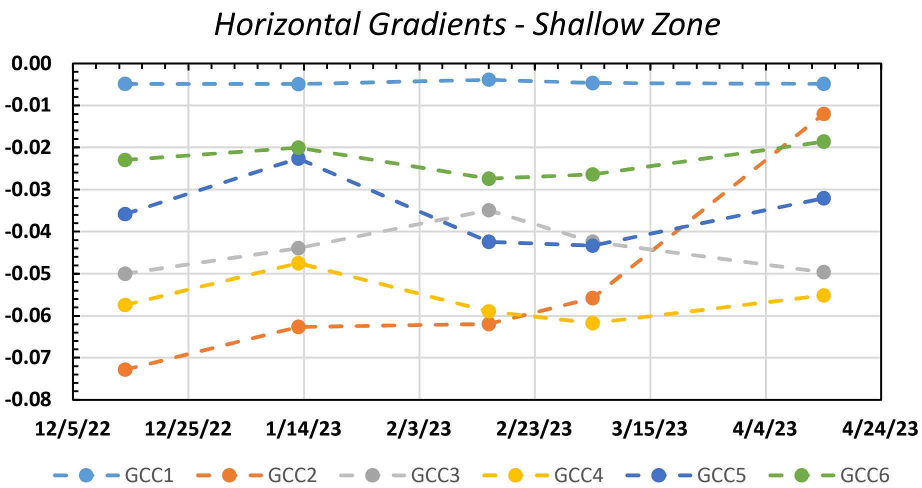
Vertical Gradient

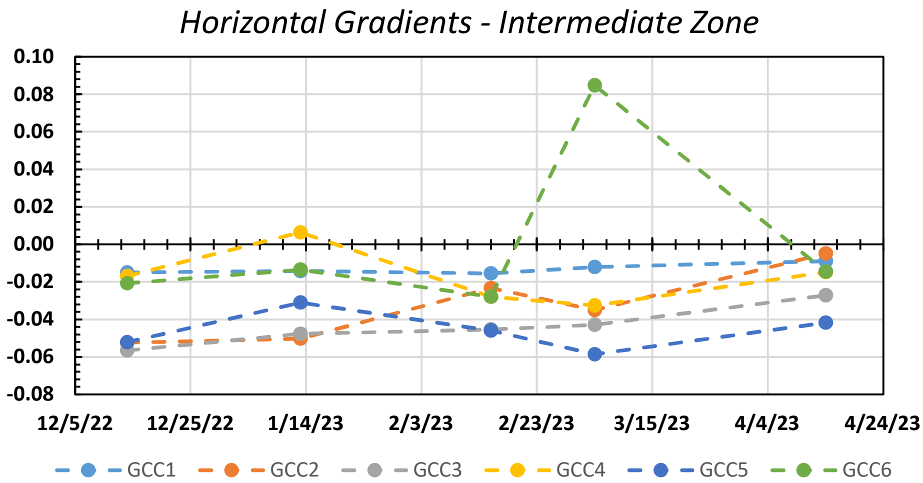


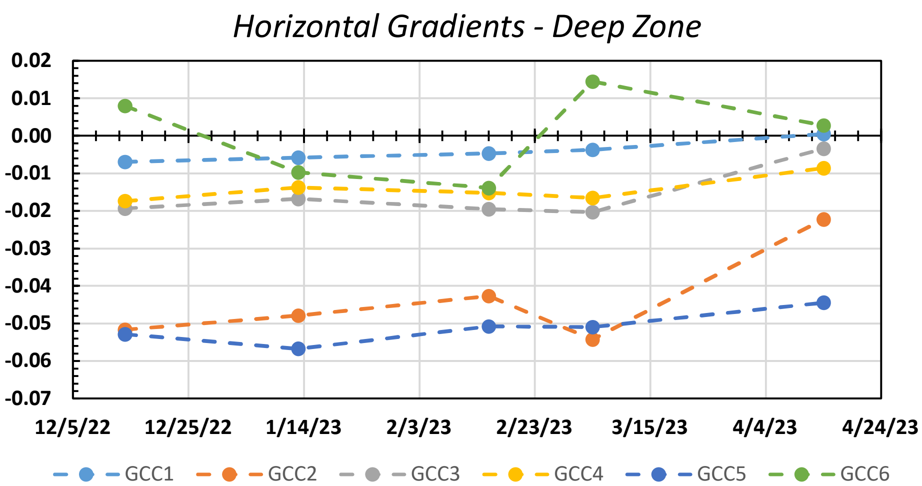
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Attachment B-2

Horizontal Gradients Summary: April 2023
Arkema Inc. Facility
Portland, Oregon

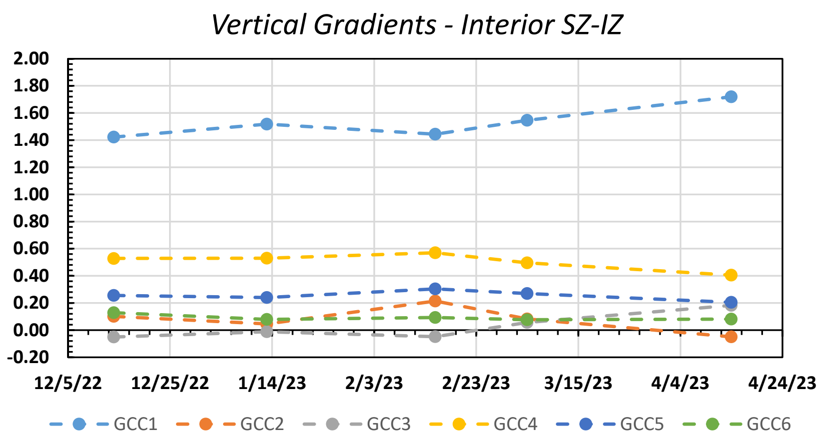


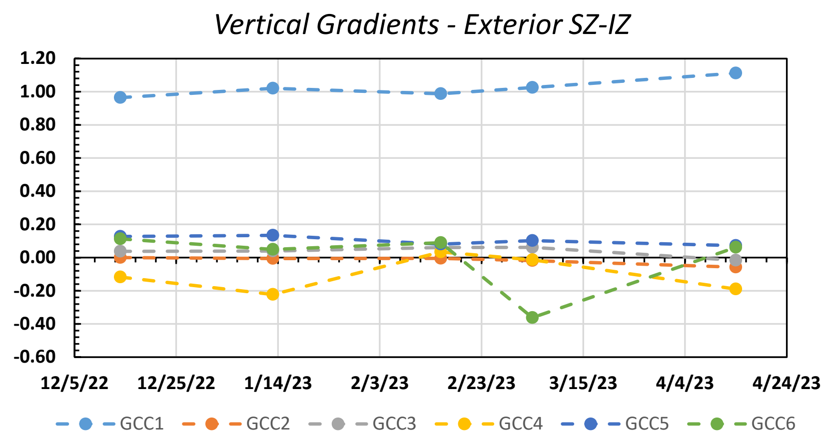


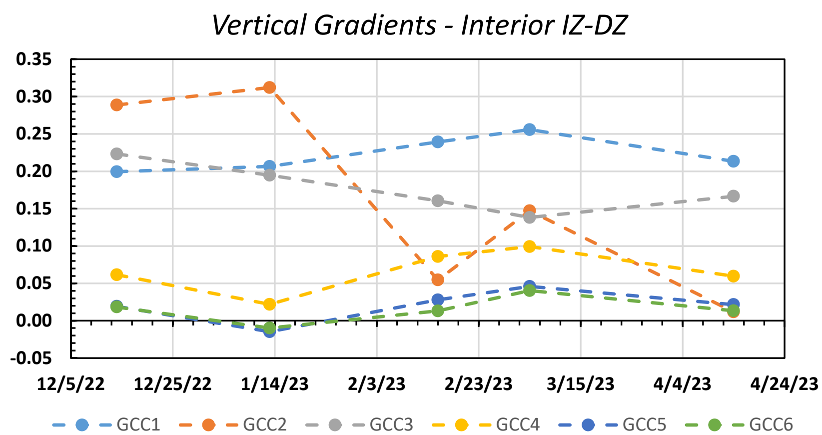


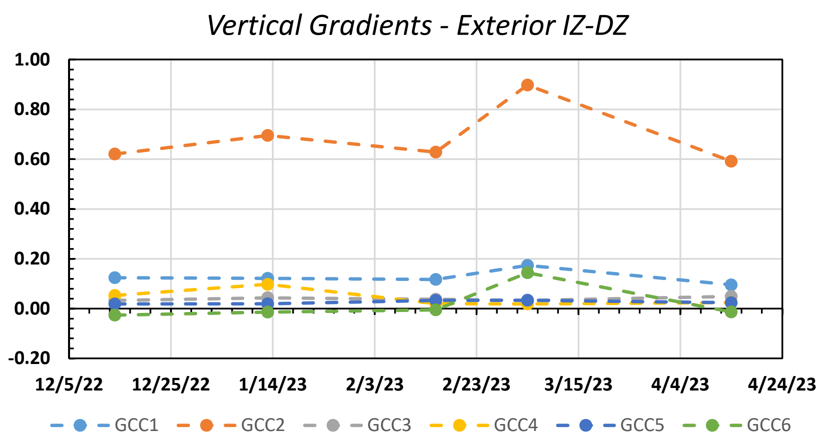
Attachment B-3

Vertical Gradients Summary: April 2023
Arkema Inc. Facility
Portland, Oregon



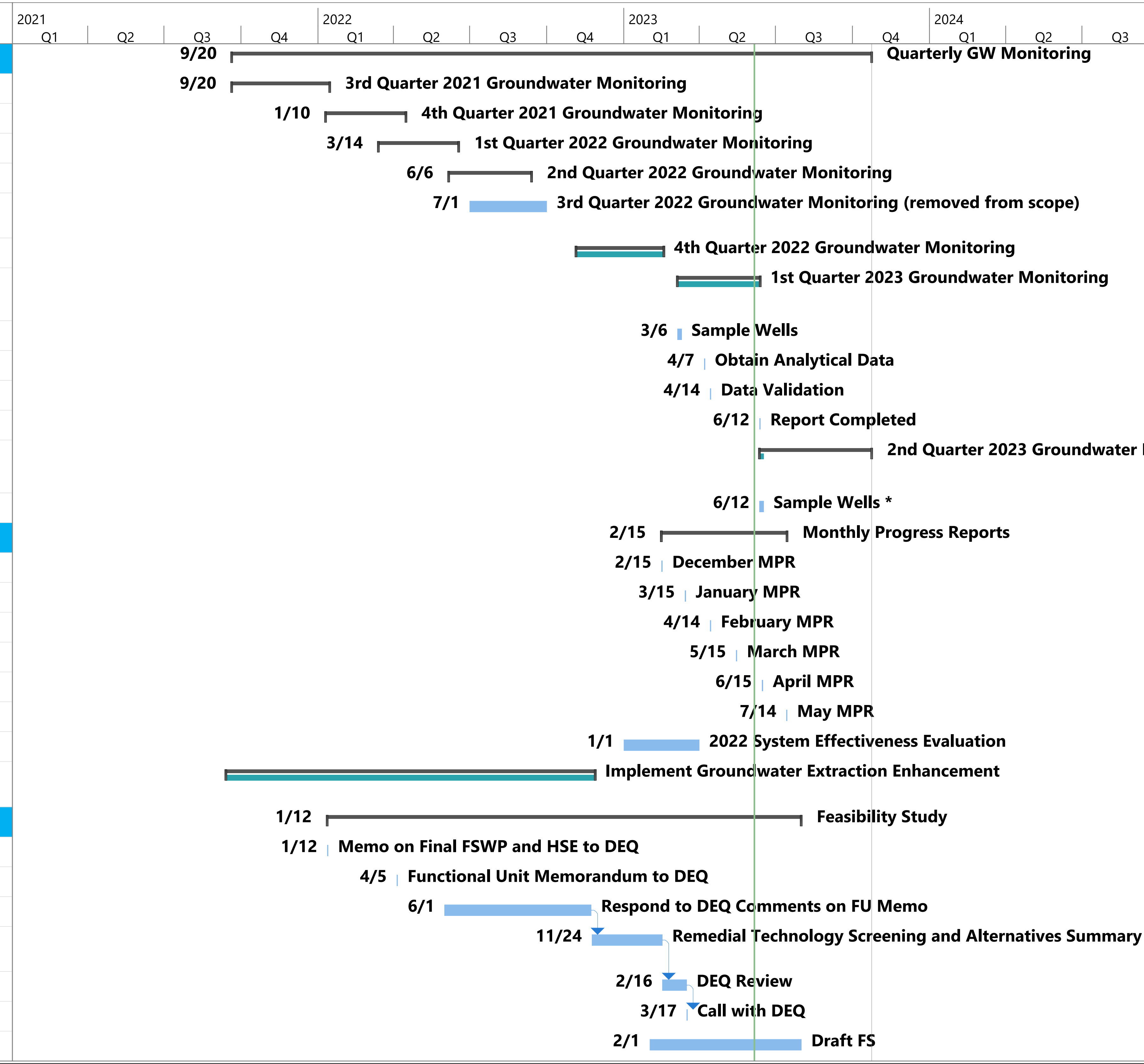






ATTACHMENT C PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**Quarterly GW Monitoring**	**549 days**	**Mon 9/20/21**	**Mon 10/23/23**
2	*3rd Quarter 2021 Groundwater Monitoring*	*85 days*	*Mon 9/20/21*	*Fri 1/14/22*
7	*4th Quarter 2021 Groundwater Monitoring*	*70 days*	*Mon 1/10/22*	*Fri 4/15/22*
11	*1st Quarter 2022 Groundwater Monitoring*	*70 days*	*Mon 3/14/22*	*Fri 6/17/22*
16	*2nd Quarter 2022 Groundwater Monitoring*	*71 days*	*Mon 6/6/22*	*Mon 9/12/22*
21	*3rd Quarter 2022 Groundwater Monitoring (removed from scope)*	*66 days*	*Fri 7/1/22*	*Fri 9/30/22*
22	*4th Quarter 2022 Groundwater Monitoring*	*78 days*	*Sat 11/5/22*	*Fri 2/17/23*
27	**1st Quarter 2023 Groundwater Monitoring**	**71 days**	**Mon 3/6/23**	**Mon 6/12/23**
28	*Sample Wells*	*5 days*	*Mon 3/6/23*	*Fri 3/10/23*
29	*Obtain Analytical Data*	*1 day*	*Fri 4/7/23*	*Fri 4/7/23*
30	*Data Validation*	*1 day*	*Fri 4/14/23*	*Fri 4/14/23*
31	*Report Completed*	*1 day*	*Mon 6/12/23*	*Mon 6/12/23*
32	**2nd Quarter 2023 Groundwater Monitoring ***	**96 days**	**Mon 6/12/23**	**Fri 9/15/23**
33	Sample Wells *	5 days	Mon 6/12/23	Fri 6/16/23
34	**Monthly Progress Reports**	**108 days**	**Wed 2/15/23**	**Fri 7/14/23**
35	*December MPR*	*1 day*	*Wed 2/15/23*	*Wed 2/15/23*
36	*January MPR*	*1 day*	*Wed 3/15/23*	*Wed 3/15/23*
37	*February MPR*	*1 day*	*Fri 4/14/23*	*Fri 4/14/23*
38	*March MPR*	*1 day*	*Mon 5/15/23*	*Mon 5/15/23*
39	April MPR	1 day	Thu 6/15/23	Thu 6/15/23
40	May MPR	1 day	Fri 7/14/23	Fri 7/14/23
41	***2022 System Effectiveness Evaluation***	***66 days***	***Sun 1/1/23***	***Fri 3/31/23***
42	***Implement Groundwater Extraction Enhancement***	***317 days***	***Mon 9/13/21***	***Sun 11/27/22***
50	**Feasibility Study**	**407 days**	**Wed 1/12/22**	**Mon 7/31/23**
51	*Memo on Final FSWP and HSE to DEQ*	*1 day*	*Wed 1/12/22*	*Wed 1/12/22*
52	*Functional Unit Memorandum to DEQ*	*1 day*	*Tue 4/5/22*	*Tue 4/5/22*
53	*Respond to DEQ Comments on FU Memo*	*126 days*	*Wed 6/1/22*	*Tue 11/22/22*
54	*Remedial Technology Screening and Alternatives Summary*	*62 days*	*Thu 11/24/22*	*Wed 2/15/23*
55	*DEQ Review*	*21 days*	*Thu 2/16/23*	*Thu 3/16/23*
56	*Call with DEQ*	*1 day*	*Fri 3/17/23*	*Fri 3/17/23*
57	Draft FS	129 days	Wed 2/1/23	Mon 7/31/23



Project: MPR Schedule dec_ajg
Date: Tue 6/6/23

Task	Project Summary	Manual Task	Start-only	Deadline
Split	Inactive Task	Duration-only	Finish-only	Progress
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Manual Progress
Summary	Inactive Summary	Manual Summary	External Milestone	

* - Indicates dates that are tentative

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Fax: +1 503 488 5142

www.erm.com

ERM

Memo

To	Katie Daugherty, Oregon Department of Environmental Quality
From	Brendan Robinson, PE, Environmental Resources Management, Inc.
Date	14 July 2023
Reference	0682894 Phase 204
Subject	May 2023 GW SCM Monthly Performance Monitoring Report

1. INTRODUCTION

Environmental Resources Management, Inc. (ERM) prepared this Monthly Performance Monitoring Report (MPR) on behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc. (Arkema), for the former Arkema Portland Plant (the Site) at 6400 NW Front Avenue in Portland, Oregon. The Oregon Department of Environmental Quality (ODEQ), in its letter dated 31 May 2019 and in the subsequent meeting with LSS and ERM on 2 July 2019, requested that LSS initiate monthly status reports associated with the onsite groundwater source control measure (GW SCM) consistent with the Performance Monitoring Plan (PMP; ERM 2014) beginning July 2019. The 2014 PMP was prepared pursuant to the Order on Consent issued by ODEQ, signed on 31 October 2008 (ODEQ No. LQVC-NWR-08-04; Consent Order). The purpose of the PMP was to present the monitoring, reporting, and adaptive management processes used during implementation of the GW SCM. On 30 November 2021, ODEQ directed LSS that following the October 2021 MPR, subsequent MPRs would be suspended pending the implementation of the Groundwater Extraction Enhancement (GEE) project in 2022. During that time, ODEQ requested monthly schedule updates in lieu of MPRs. The trench wells installed as part of the GEE project were started on 27 November 2022, and MPR writing restarted in December 2022. The purpose of the GEE project was to install new extraction capacity to achieve the Capture Zone Objectives.

This May 2023 MPR summarizes the GW SCM performance monitoring data collected in May 2023. This report assesses the current gradient status and proposes system improvements to meet the Capture Zone Objectives set in the PMP.

2. GROUNDWATER SOURCE CONTROL IMPLEMENTATION

A detailed description of the design and implementation of the GW SCM is provided in the *Revised Upland Feasibility Study Work Plan* (ERM 2017); however, a brief description of the GW SCM is provided here. In February 2009, ODEQ and the U.S. Environmental Protection Agency (USEPA) approved the general approach for the GW SCM. This approach included installation of a groundwater barrier wall (GWBW), groundwater recovery wells, and a Groundwater Extraction and Treatment (GWET) system, with treated water discharged to the Willamette River. ODEQ and USEPA approved the *Groundwater Barrier Wall Final Design* (ERM 2012) on 7 August 2012. Construction of the GWBW began in May 2012 and was completed in December 2012. ODEQ approved the *Groundwater Extraction and Treatment System Final Design* (ERM 2013) on 2 April

2013. Construction of the GWET system began in December 2012 and was completed in December 2013.

GWET startup and optimization commenced in May 2014. The GW SCM at the Site consists of the following primary components (Figure 1):

1. A GWBW to physically separate the affected upland portions and in-water portions of the Site.

2. Hydraulic control to minimize flow of groundwater containing unacceptable concentrations of constituents of potential concern (COPCs) around, over, and under the GWBW.

3. Management of extracted groundwater through the GWET system, with treated effluent discharged to the Willamette River under a National Pollutant Discharge Elimination System (NPDES) Permit.

On 1 September 2018, ERM submitted the *Draft GWET System Effectiveness Evaluation* (Draft SEE Report; ERM 2018). The Draft SEE Report provided an update on the corrective actions implemented to improve the performance of the GWET system, evaluate the extent of capture, and propose actions to improve hydraulic capture. Additional data requested by ODEQ were submitted on 26 October 2018.

The key objective of the GW SCM is to achieve hydraulic containment of the alluvial sequence within the Target Capture Zone at the Site to prevent the flow of COPCs to the Willamette River. The Site alluvial aquifer sequence within the Target Capture Zone consists of the Shallow Zone, Intermediate Zone, and the Deep Zone. Site hydraulic conditions are variable and subject to both seasonal and daily tidal fluctuations.

The hydraulic control component formerly consisted of 22 recovery wells (RWs) prior to the implementation of the GEE. Of the 22 pre-existing RWs, four were retained for active pumping. The remaining 18 former RWs had pumps removed but retained their pressure transducers so that they can continuously collect high-resolution groundwater elevation data. The 18 former RW pressure transducers were unable to be connected to the rest of the system until additional upgrades were performed in early May. The transducers in those wells were activated and recalibrated throughout the month of May and are now continuously recording high-resolution groundwater elevation data. The hydraulic control system now consists of the four remaining active RWs, as well as seven groundwater extraction trenches that each contain two extraction wells (EWs). Each trench is 50 feet deep, 50 feet long, and 3 feet wide and is filled with an engineered backfill. More information about the groundwater extraction trenches is provided in the *Final Design Report* (ERM 2022). The gradient control-monitoring network consisting of six gradient control clusters (GCCs) with each cluster containing six monitoring points. Within each RW, EW, and GCC location, pressure transducers are continuously collecting high-resolution groundwater elevation data. Each GCC contains three transducers interior to the wall and three transducers exterior to the wall screened in the Shallow, Intermediate, and Deep aquifers at the Site.

3. HYDRAULIC CONTAINMENT MONITORING PROGRAM

As described in the PMP, the purpose of hydraulic monitoring (i.e., groundwater elevation data) is to provide sufficient data to demonstrate an inward hydraulic gradient across the GWBW and to evaluate the effective hydraulic capture produced by the GW SCM.

Monitoring requirements were established in the PMP to demonstrate GWET effectiveness. The Site monitoring program includes groundwater elevation data (manual and transducer measurements) collected from the 36 monitoring points located within six GCCs spaced across the GWBW, with piezometers interior and exterior to the wall, throughout the alluvial sequence; and groundwater elevation and flow rate data from the four remaining active RWs and 14 EWs. High-resolution groundwater elevation data is also collected from the 18 inactive RWs. Additionally, one new monitoring well was installed in each of the seven extraction trenches for manual water level measurement. These data were used to prepare horizontal and vertical potentiometric surface maps representing potentiometric differences between the alluvial sequences, and to generate spatial and temporal hydrographs to evaluate hydraulic capture.

3.1 Groundwater Elevation Monitoring

Groundwater elevation monitoring was completed on 17 May 2023. Manual groundwater elevations were measured at wells that were experiencing transducer mechanical issues or that were offline during the groundwater elevation measurement event. All inactive RWs were manually measured in the month of May to affirm proper calibration. Manual water levels for those RWs are reported. Additionally, all transducers in inactive RWs were down until upgrades were completed and transducers were sequentially turned on. Specific issues are addressed in Attachment A-1.

As detailed in Attachments A-1 and A-2, during May 2023, the following transducers were:

<u>Fully out of service pending repairs:</u>

- PA-06
- RW-11i
- RW-15

<u>Out of service for a period but returned to full operation:</u>

- PA-07
- MWA-2
- MWA-47
- PA-16i
- MWA-8i
- PA-11i

- PA-14i
- PA-29i
- PA-24d

3.2 Horizontal and Vertical Gradients at Gradient Control Points

As described above, GCC locations collect high-resolution groundwater elevation data using transducers. Transducer data are filtered to remove anomalous data from monitoring points due to potential equipment failures, such as transducer malfunctions, power outages, or updates to the GWET programmable logic controller (PLC) system, which controls and houses all the operational data. These specific issues and time periods are summarized in Table A-1 in Attachment A. The following flags are applied to filter anomalous data:

- Groundwater elevations had a change greater than 1.5 feet within 1 hour
- Groundwater elevation measurements that were found to be greater than 50 feet, or less than 1 foot
- Calculated groundwater elevation slope indicates no change between consecutive measurements indicating a transducer malfunction
- Manually flagging data that are inconsistent with the typical nature of the well
- Periods where transducer power supply was deactivated for work on interconnected electrical systems

After May 2023 flagged data were removed, the Serfes (1991) method was used to account for tidal variations as described in the PMP. Using Serfes corrected data, both horizontal and vertical gradients were calculated and plotted over time (Attachment B). Groundwater elevations, horizontal gradients, and vertical gradients from 17 May 2023 are shown below at each GCC (Table 1-1 and Table 1-2). The water elevation taken during the groundwater level gauging event at PA-08 was excluded from gradient calculations and potentiometric surface maps due to being anomalous.

Table 1-1. May Horizontal Gradients

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
GCC1	Shallow	PA-03	28.67	PA-04	28.85	-0.002
	Intermediate	PA-17iR	17.90	PA-10i	17.93	0.000
	Deep	PA-27d	17.39	PA-18d	16.90	0.004
GCC2	Shallow	MWA-2 *M*	16.66	PA-05	14.30	0.035
	Intermediate	MWA-8i	17.21	PA-11i	15.80	0.019
	Deep	PA-19d	16.98	PA-30d	16.36	0.011
GCC3	Shallow	MWA-69	17.06	PA-06	14.49	0.024

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
	Intermediate	MWA-66i	16.10	PA-12i	15.43	0.006
	Deep	PA-21d	16.85	PA-20d	16.23	0.005
GCC4	Shallow	MWA-19	17.45	PA-28	17.53	-0.001
	Intermediate	MWA-34i	16.54	PA-13i	16.40	0.002
	Deep	MWA-58d	16.38	PA-22d	17.14	-0.008
GCC5	Shallow	MWA-47 [M]	17.02	PA-07	17.68	-0.006
	Intermediate	PA-29i	17.46	PA-14i	15.83	0.030
	Deep	PA-24d [M]	17.26	PA-23d	16.39	0.016
GCC6	Shallow	PA-09	17.66	PA-08	*	**
	Intermediate	PA-16i	17.59	PA-15i	16.80	0.014
	Deep	PA-26d	18.12	PA-25d	18.06	0.001

Notes:
Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.
Horizontal gradient calculated as (Exterior Elevation – Interior Elevation) / Horizontal distance.
ft NAVD88 = feet North American Vertical Datum of 1988
[M] = manual groundwater elevation measurement
** = anomalous groundwater elevation*
*** = horizontal gradient cannot be calculated due to anomalous elevation reading*

Table 1-2. May Vertical Gradients

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
Interior	SZ-IZ	GCC1	PA-04	28.85	PA-10i	17.93	1.10
		GCC2	PA-05	14.30	PA-11i	15.80	-0.13
		GCC3	PA-06	14.49	PA-12i	15.43	-0.04
		GCC4	PA-28	17.53	PA-13i	16.40	0.18
		GCC5	PA-07	17.68	PA-14i	15.83	0.20
		GCC6	PA-08	*	PA-15i	16.80	**
	IZ-DZ	GCC1	PA-10i	17.93	PA-18d	16.90	0.14
		GCC2	PA-11i	15.80	PA-30d	16.36	-0.08
		GCC3	PA-12i	15.43	PA-20d	16.23	-0.04
		GCC4	PA-13i	16.40	PA-22d	17.14	-0.04
		GCC5	PA-14i	15.83	PA-23d	16.39	-0.01
		GCC6	PA-15i	16.80	PA-25d	18.06	-0.03

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
Exterior	SZ-IZ	GCC1	PA-03	28.67	PA-17iR	17.90	0.69
		GCC2	MWA-2 M	16.66	MWA-8i	17.21	-0.03
		GCC3	MWA-69	17.06	MWA-66i	16.10	0.06
		GCC4	MWA-19	17.45	MWA-34i	16.54	0.09
		GCC5	MWA-47 M	17.02	PA-29i	17.46	-0.04
		GCC6	PA-09	17.66	PA-16i	17.59	0.00
	IZ-DZ	GCC1	PA-17iR	17.90	PA-27d	17.39	0.08
		GCC2	MWA-8i	17.21	PA-19d	16.98	0.15
		GCC3	MWA-66i	16.10	PA-21d	16.85	-0.06
		GCC4	MWA-34i	16.54	MWA-58d	16.38	0.01
		GCC5	PA-29i	17.46	PA-24d M	17.26	0.01
		GCC6	PA-16i	17.59	PA-26d	18.12	-0.01

Notes:
Positive vertical gradient indicates a downward hydraulic gradient.
Vertical gradient calculated as (Upper Elevation – Lower Elevation) / Screen Midpoint distance.
ft NAVD88 = feet North American Vertical Datum of 1988
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone
M = manual groundwater elevation measurement
** = anomalous groundwater elevation*
*** = vertical gradient cannot be calculated due to anomalous elevation reading*

3.3 Potentiometric Surface, Groundwater Elevation Difference Maps, and Groundwater Flow Directions

As described in the PMP, potentiometric surface maps are used to evaluate flow paths. Vertical gradients are also used as an additional line of evidence to evaluate hydraulic containment. Groundwater elevation data collected on 17 May 2023 were used to prepare potentiometric surface maps based on manual measurements and averaged transducer groundwater elevations (Figures 2 through 4) and vertical difference maps (Figures 5 and 6).

The generalized flow direction indicated by the potentiometric surface maps shows overall groundwater flow both toward and away from the GWBW. The Shallow and Intermediate Zones potentiometric maps (Figures 2 and 3) indicate localized groundwater movement to the extraction trenches due to GW SCM pumping, and inward gradient sporadically along the length of the barrier wall. The impact is greatest along the northern edge of the GWBW, where pump operation has been the steadiest. Additionally, in both the Shallow and the Intermediate Zones, the general flow path of water near the north end of the GWBW is migrating toward the two northernmost trenches. Hydraulic influence is apparent at GCC1 and GCC2, and a cone of depression is developing that extends to GCC4. Another cone of depression is also beginning to develop at the southern edge of the barrier wall at GCC5 and GCC6. Additional evidence of capture is anticipated as ongoing pumping occurs.

A potentiometric separation is still noticeable exterior to the GWBW, indicating the barrier wall is functioning by impeding groundwater flow. The Deep Zone potentiometric map also indicates flow away from the GWBW (Figure 4), as groundwater elevations are demonstrating a slight inward gradient from the river at all locations except GCC4. Over the past few months, inward gradient had been demonstrated at GCC1 and GCC6 intermittently and were trending in that direction (Attachment B-2). This month represents a continuation of that trend with all GCCs showing inward gradient in the Deep Zone except GCC4. River elevations are shown on the potentiometric surface maps in an inset (Figures 2 through 4) and depict stage movement within the month corresponding with the MPR. The river elevation in May 2023 varied with an average of 15.14 feet NAVD88, maximum of 18.43 feet NAVD88, and minimum of 9.91 feet NAVD88. The groundwater elevation in May 2023 was higher than previous months consistent with historical seasonal variation. It is possible that the increased river stage may be contributing to observations of inward gradients in addition to pumping activity.

Vertical gradients were calculated for each vertical well pair using these groundwater elevations and are plotted on Figures 5 and 6. Vertical groundwater gradients interior to the GWBW between the Shallow and Intermediate Zones were mixed in May 2023 with GCC2 and GCC3 being upward, and the remainder being downward (Figure 5). The vertical groundwater gradient at GCC6 interior of the wall was unable to be calculated due to an anomalous groundwater elevation reading at PA-08. PA-08 will be recalibrated so that vertical gradients at GCC6 can be calculated in the future and presented in subsequent MPRs. Vertical groundwater gradients are also depicted in Attachment B. The magnitude of the gradient is much greater at GCC1 than other monitoring locations due to the influence from a localized high-pressure zone near GCC1 where vertical groundwater flow is impeded by a localized confining unit (Figure 2). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were mixed with GCC2 and GCC5 being upward and GCC1, GCC3, GCC4, and GCC6 being downward as shown on Figure 5 and in Attachment B.

Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were upward with exception to GCC1. The direction of vertical gradients exterior to the GWBW were mixed with GCC3 and GCC6 being upward and the remaining being downward, as shown on Figure 6 and Attachment B.

3.3.1 GWET System Performance

The GWET system operated within permit conditions during the reporting period. There were three shutdowns:

- 4 May 2023: A planned shutdown to repair ongoing issues in the wellfield. Odin mobilized to the Site and repaired vaults, replaced pumps, and Cochran mobilized to complete electrical upgrades to enable use of inactive RWs as piezometers. The wellfield was restarted on 16 May.

- 24 May 2023: An unplanned shutdown due to issues with caustic feed pump. The wellfield was restarted the same afternoon.
- 31 May 2023: An unplanned shutdown due to issues with a coagulant feed pump. The wellfield was restarted the same evening.

There were no upgrades to the GWET system in the month of May 2023.

3.3.2 Recovery Well and Extraction Well Performance

In May 2023, the average system influent flow rate was 61.71 gallons per minute (gpm) during operational periods, compared to 41.44 gpm in the April 2023 period. This increase in flow rate is largely due to the replacement of wellfield pumps that were underperforming. The extraction trench installation contractor (Odin Construction) also performed electrical repairs and upgraded vaults to prevent potential future issues in May 2023. Flow rates in the system are currently limited by the fouling in the GWET system's pressure filters. A media changeout is being planned that will enable the system to run at higher rates. ERM is currently in the process of optimizing extraction rates within the system to increase flow rates at each operational well until the extraction rates specified in the *Final Design Report* (ERM 2022) are achieved, or until the Capture Zone Objectives are met.

Table 1-3. Recovery Well Pumping Rates[1]

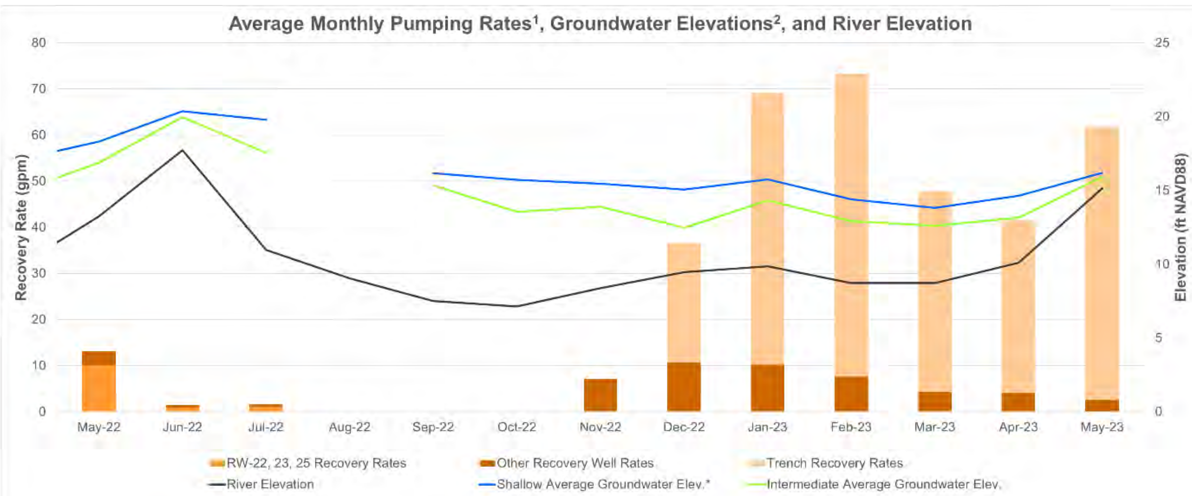
Recovery Well	May 2023 Average Pumping Rate (gpm)
RW-14	0.00
RW-22 *	0.00
RW-23	2.59
RW-25	0.00
EW-01	4.29
EW-02	2.77
EW-03	2.46
EW-04	3.14
EW-05	4.06
EW-06 *	2.46
EW-07	7.70
EW-08 *	2.76
EW-09 *	3.21
EW-10 *	2.68
EW-11 *	2.44
EW-12 *	6.34
EW-13	5.75
EW-14 *	9.05

Recovery Well	May 2023 Average Pumping Rate (gpm)
Total	**61.71**

Notes:

[1] = Flow rates are calculated based on the period of the month during which the recovery wells were operational.

** = Recovery well not in service during reporting period.*



Notes:

[1] = Following installation of trenches in Summer 2022, RW-22, 23, and 25 recovery rates are now grouped together with the other remaining recovery well (RW-14) starting in November 2022.

[2] = Average groundwater elevations are calculated using interior wells—the wellfield was powered down in August preventing the measurement of the groundwater.

** = The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the whole aquifer.*

Figure 1-1. Monthly Pumping Rate Contribution

3.3.3 Recommendations for Extraction System Optimization

Recovery rates from the start of the system indicate that the active RWs and EWs are operating as designed except for the troubleshooting discussed above. The extraction rates throughout the GWET system will continue to be optimized to meet Target Capture Objectives.

4. ANALYTICAL PROGRAM

Quarterly groundwater monitoring was implemented in accordance with the ODEQ-approved Arkema Quarterly Groundwater Monitoring Work Plan dated October 2019 and the ODEQ-approved reduced scope described in the 2021 monitoring program modification request memorandum dated 9 September 2021. The table below outlines sampling dates and submittal dates related to groundwater monitoring since the implementation of the reduced scope. The Quarterly Monitoring Reports present results from these sampling events.

Report	Sampling Dates	Report Submittal Date
2021 Quarter 3	9/21/2021–9/24/2021	1/14/2022
2021 Quarter 4	12/13/2021–12/16/2021	4/20/2022
2022 Quarter 1	3/14/2022–3/17/2022	6/15/2022
2022 Quarter 2	6/6/2022–6/9/2022	9/12/2022
2022 Quarter 4	11/7/2022–11/10/2022	2/17/2023
2023 Quarter 1	3/6/2023–3/10/2023	6/12/2023
2023 Quarter 2	6/12/2023–6/16/2023	9/15/2023 *

* dates are tentative

5. SUMMARY AND CONCLUSIONS

This report presents a summary of the GW SCM operation, maintenance, and monitoring activities conducted at the Site in May 2023 and documents results from system monitoring. The following summarizes ERM's observations and conclusions drawn from collected data.

5.1 Groundwater Flow

- Horizontal gradients across the GWBW are mixed, with some localized areas of inward gradients. Additionally, groundwater elevations show a noticeable separation interior and exterior of the GWBW, indicating the GWBW is functioning via impeding groundwater flow. It is yet to be determined whether a long-term inward gradient has been produced through increased pumping rates, but the GWET system is generating localized areas of sustained groundwater capture. These areas are anticipated to expand with longer operations and have resulted in inward gradients at some locations. Sustained capture has led to an increase in the overall horizontal gradients observed in all zones (Attachment B-2) and inward gradient in nearly all GCCs in the Deep Zone.

- Vertical groundwater gradients interior to the GWBW between the Shallow and Intermediate Zones were generally downward in May 2023 with GCC1, GCC4, GCC5, and GCC6 being downward and GCC2 and GCC3 being upward (Figure 5). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were mixed with GCC2 and GCC5 being upward and the remaining being downward. Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were upward except for GCC1, which was downward (Figure 6). Exterior of the GWBW vertical gradients between the Intermediate and Deep Zones were downward except for GCC3 and GCC6, which were upward.

- River elevations increased between April and May 2023. The average river elevation in April 2023 was 10.09 feet NAVD while the average river elevation in May 2023 was 15.14 feet NAVD88 with a minimum elevation of 9.91 feet NAVD88 and a maximum elevation of 18.43 feet NAVD88.

- Within the Site alluvial sequence, potentiometric maps indicate the GW SCM are to be producing localized areas of hydraulic capture throughout the Target Capture Zone; however, more time at elevated extraction rates will be required to evaluate whether GWET objectives are being met system wide.

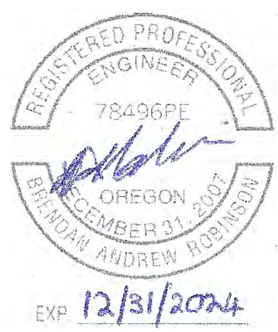
5.2 Groundwater Extraction

Based on May 2023 extraction and relevant hydrograph analysis, the trenches are functioning as designed. Flow rates have become more steady as a result of the repairs in the wellfield in May 2023. Further evaluation of the system with respect to the Capture Zone Objectives will be conducted once all pumps are operating at their design rates for an extended period.

5.3 Recommendations and Future Work

ERM will continue to optimize new EWs. Any additional modifications to the system to meet capture objectives will be included in subsequent Monthly Performance Monitoring Report. The project schedule provided as Attachment C summarizes activities planned for the immediate future.

Regards,



Brendan Robinson, PE
Partner

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FIGURES

Figure 1: Site Layout

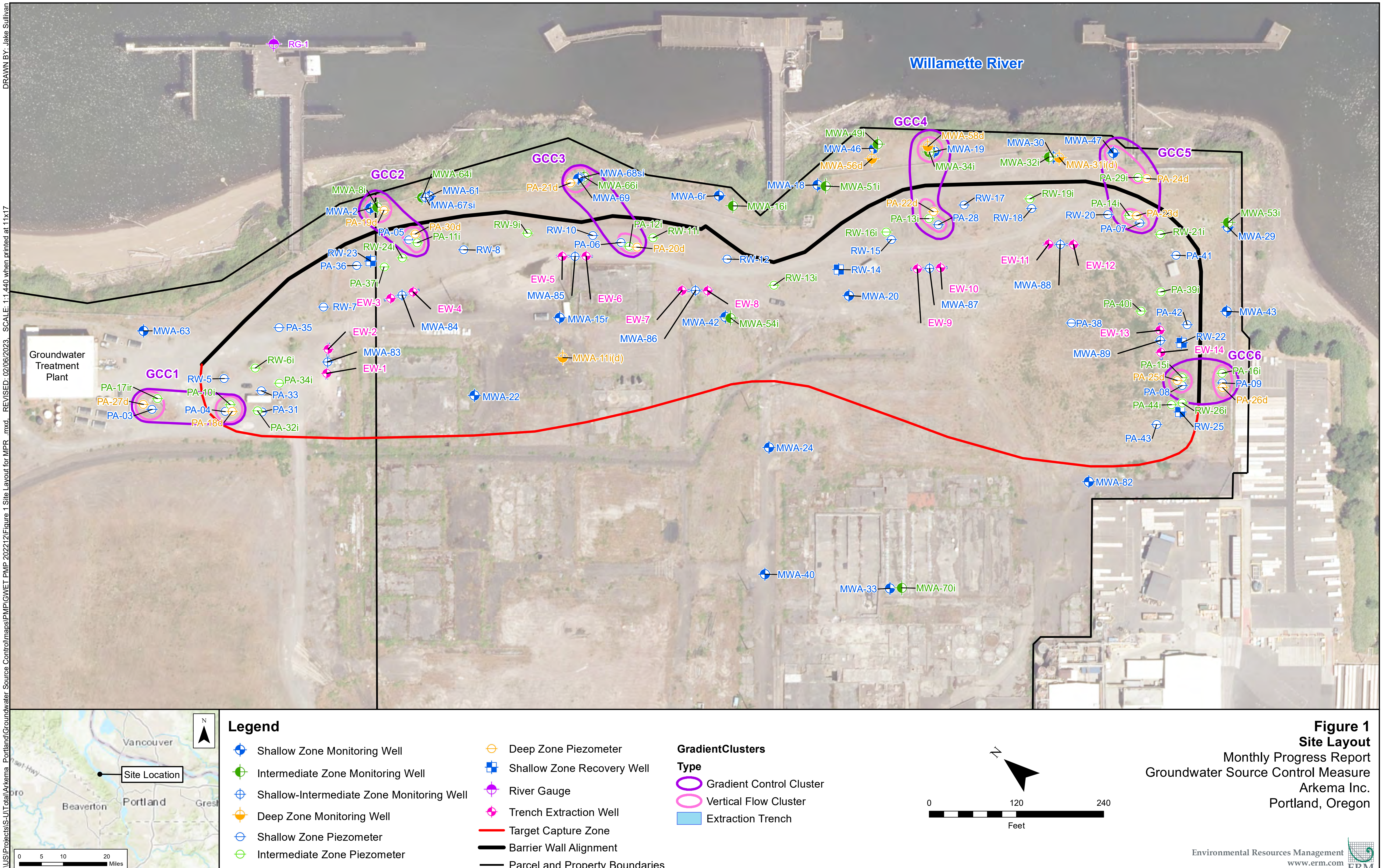
Figure 2: May 2023 Shallow Zone Groundwater Contours

Figure 3: May 2023 Intermediate Zone Groundwater Contours

Figure 4: May 2023 Deep Zone Groundwater Contours

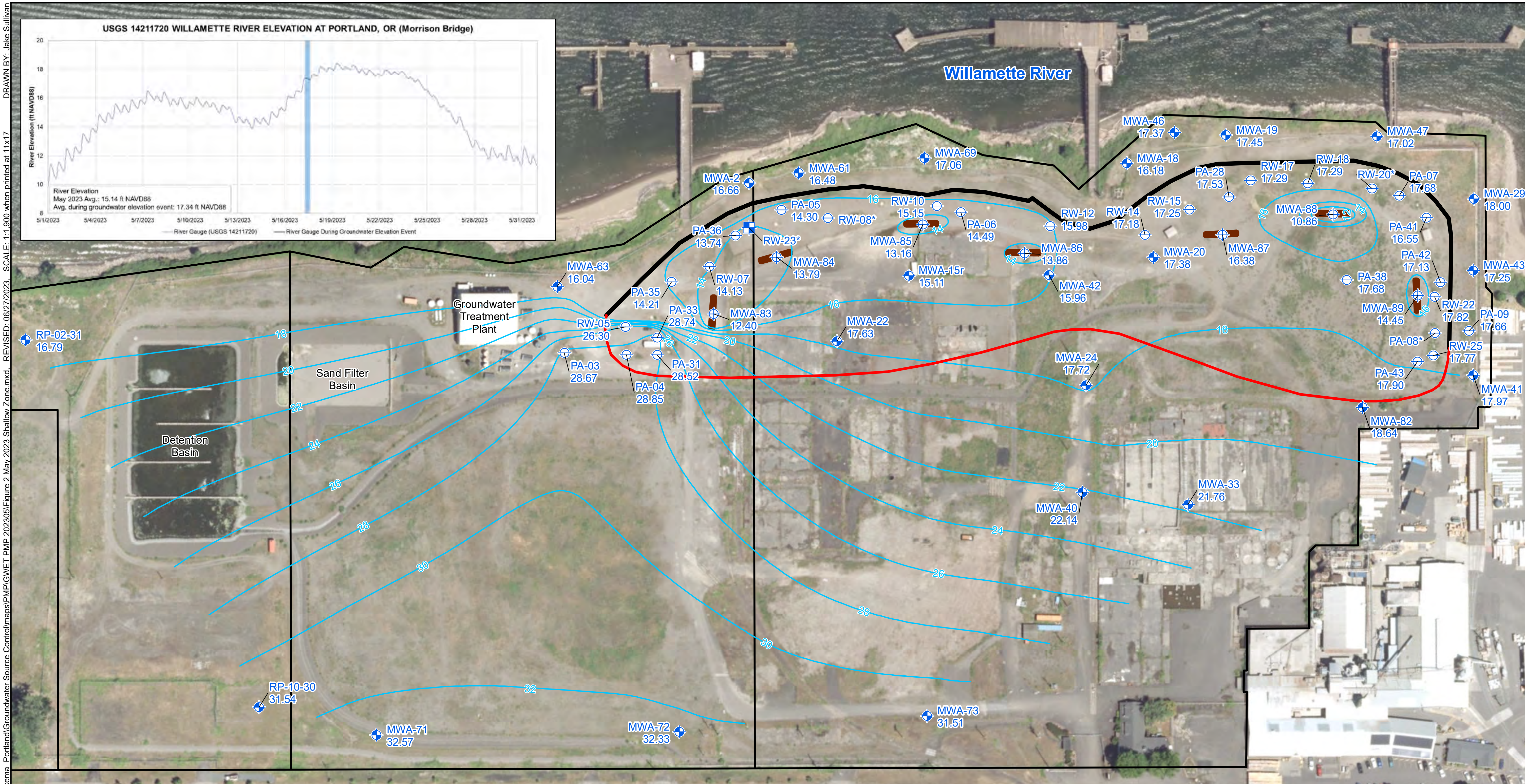
Figure 5: May 2023 Shallow to Intermediate Zone Vertical Head Difference

Figure 6: May 2023 Intermediate to Deep Zone Vertical Head Difference



Source: City of Portland Aerial Imagery, flown Summer 2021; NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

\\SCUSPRDGISFS01\Data\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 202305\Figure 2 May 2023 Shallow Zone.mxd REVISED: 06/27/2023 SCALE: 1:1,900 when printed at 11x17 DRAWN BY: Jake Sullivan



Legend

- Shallow Zone Piezometer
- Shallow Zone Monitoring Well
- Active Recovery Well; Not Used During Contouring
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Shallow Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected May, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 2
May 2023 Shallow Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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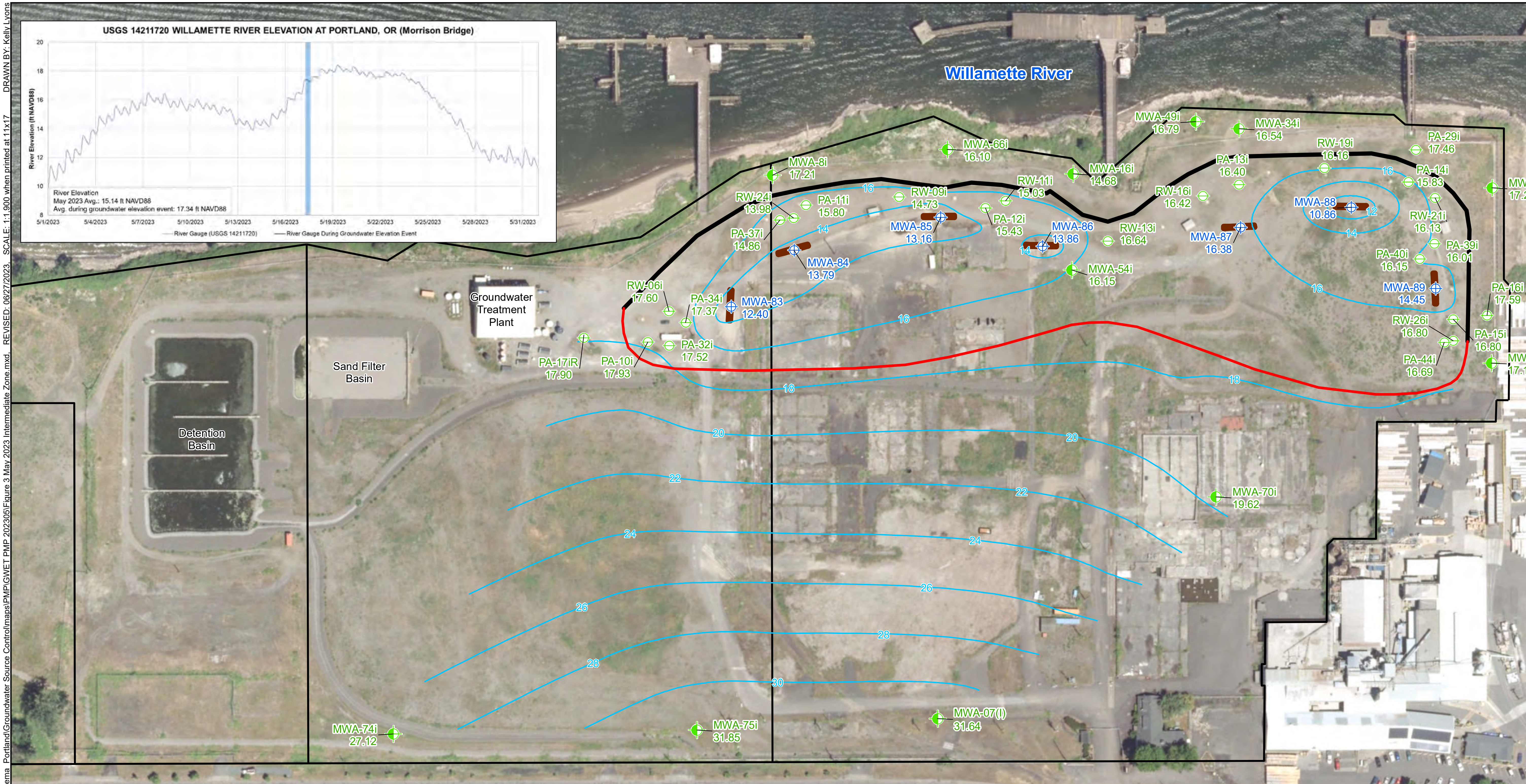
NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Intermediate Zone Piezometer
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected May, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

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0 160 320
Feet

Figure 3
May 2023 Intermediate Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

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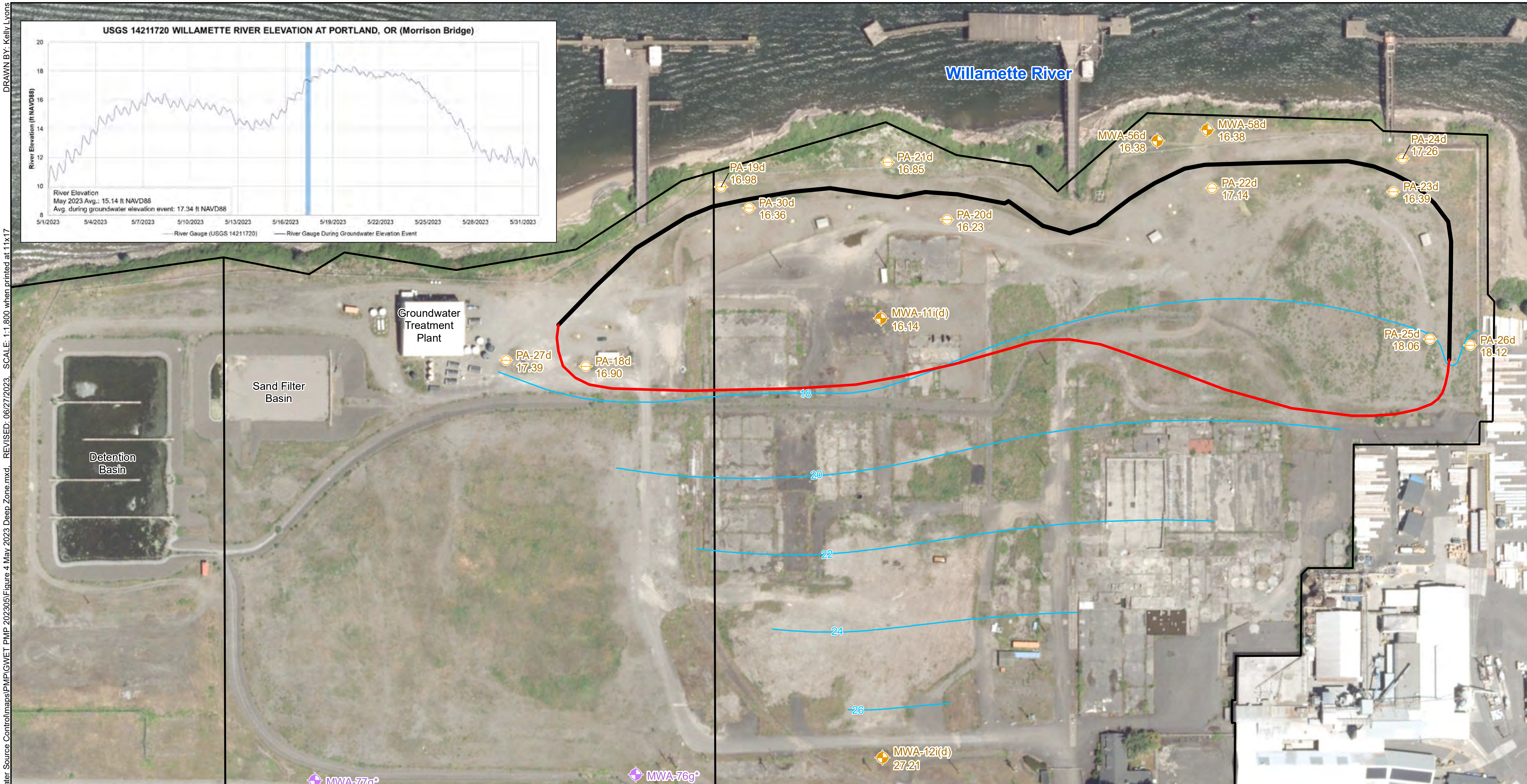
\\SCUSPRDGISFS01\Data\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 202305\Figure 3 May 2023 Intermediate Zone.mxd, REVISED: 06/27/2023, SCALE: 1:1,900 when printed at 11x17 DRAWN BY: Kelly Lyons

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



DRAWN BY: Kelly Lyons

M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 202305\Figure 4 May 2023 Deep Zone.mxd, REVISED: 06/27/2023, SCALE: 1:1,800 when printed at 11x17

Legend

- Deep Zone Piezometer
- Deep Zone Monitoring Well
- Gravel Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Deep Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment

Notes:
* Value not used for contouring.
Gravel zone wells not used in contouring.
Water levels collected May, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 150 300
Feet

Figure 4
May 2023 Deep Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Shallow Zone Recovery Well
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as shallow zone minus intermediate zone potentiometric surfaces.
Water levels collected May, 2023.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 5
May 2023 Shallow to Intermediate Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

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M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 202305\Figure 5 May 2023 Vertical Difference Shallow Intermediate.mxd REVISED: 06/27/2023 SCALE: 1:1,560 when printed at 11x17 DRAWN BY: Kelly Lyons

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

Legend

- Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as intermediate zone minus deep zone potentiometric surfaces.
Water levels collected May, 2023.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 6
May 2023 Intermediate to Deep Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 202305\Figure 6 May 2023 Vertical Difference Intermediate Deep.mxd, REVISED: 06/27/2023, SCALE: 1:1,560 when printed at 11x17 DRAWN BY: Kelly Lyons

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

ATTACHMENT A-1 TRANSDUCER FLAGS

Attachment A-1. Transducer Flags

Table A-1
Transducer Malfunction Log: May 2023
Arkema Inc. Facility
Portland, Oregon

Gradient Cluster	Transducer	Interval	Date Range		Issue and Repairs Performed
3	PA-06	Shallow	5/23/2023	5/31/2023	PLC logic issue.
5	PA-07	Shallow	1/4/2023	5/16/2023	Wiring issues resolved.
2	MWA-2	Shallow	5/11/2023	5/22/2023	Non-operational following energized well-field. PLC logic issue.
5	MWA-47	Shallow	5/11/2023	5/23/2023	Non-operational following energized well-field. Replaced transducer and recalibrated.
N/A	RW-15	Shallow	Not started		Transducer turned on following upgrades, but found to be non-operational. Under further investigation.
N/A	RW-11i	Intermediate	Not started		Transducer turned on following upgrades, but found to be non-operational. Under further investigation.
6	PA-16i	Intermediate	12/16/2023	5/16/2023	I/O card issue. Transducer turned on following upgrades.
2	MWA-8i	Intermediate	4/4/2023	5/11/2023	LOTO for well-field repairs. Repairs performed and LOTO status removed.
2	PA-11i	Intermediate	4/4/2023	5/11/2023	LOTO for well-field repairs. Repairs performed and LOTO status removed.
5	PA-14i	Intermediate	2/8/2023	5/11/2023	LOTO for well-field repairs. Repairs performed and LOTO status removed.
5	PA-29i	Intermediate	2/8/2023	5/11/2023	LOTO for well-field repairs. Repairs performed and LOTO status removed.
5	PA-24d	Deep	5/11/2023	5/23/2023	Non-operational following energized well-field. PLC logic issue.

Notes:
I/O = input/output
LOTO = lockout/tagout
VFD = variable frequency drive

ATTACHMENT A-2 RECOVERY WELL STATUS

Attachment A-2. Recovery Well Status

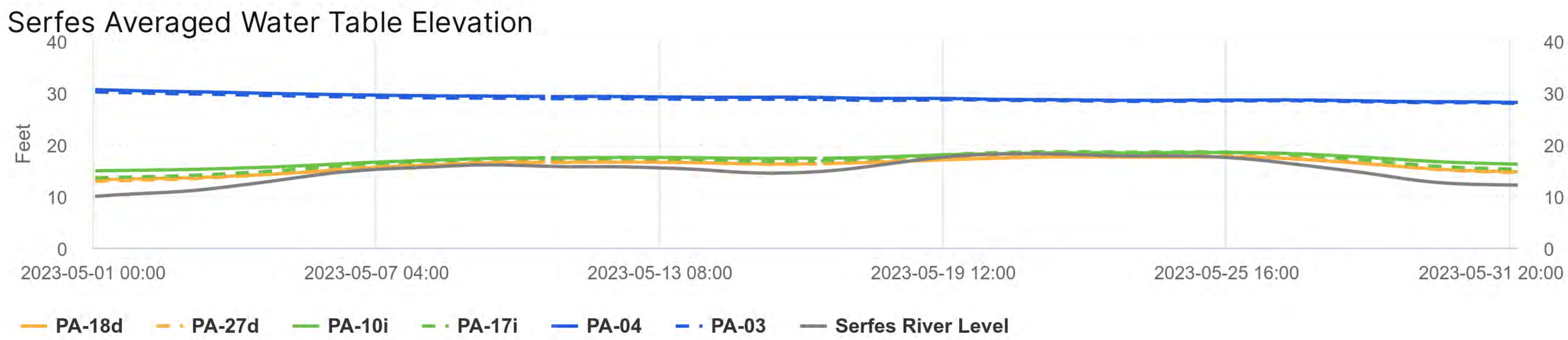
Table A-2
Recovery Well Status: May 2023
Arkema Inc. Facility
Portland, Oregon

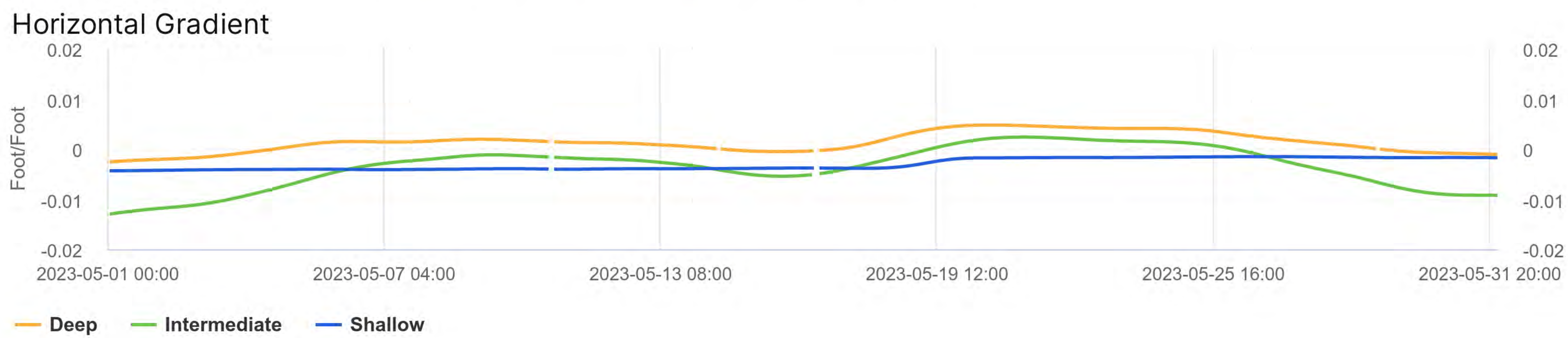
Recovery Well ID	Status as of 5/31/2023 (active or inactive)	Issue	Actions to get online	Expected date back online	Transducer Status	Totalizer Status	Average Flow Rate (gpm)	Overall Extraction Rate	Notes
RW-14	Inactive	None	N/A	N/A	Good	Good	0.00	OFF*	Well turned off due to sufficient flow from other wells
RW-22	Inactive	Totalizer failure	Replace totalizer	N/A	Good	Bad	0.00	OFF*	Totalizer failed, will be replaced
RW-23	Active	None	N/A	N/A	Good	Good	2.59	M	
RW-25	Inactive	None	N/A	N/A	Good	Good	0.00	OFF*	Well turned off due to sufficient flow from other wells
EW-01	Active	None	N/A	N/A	Good	Good	4.29	G	
EW-02	Active	None	N/A	N/A	Good	Good	2.77	M	
EW-03	Active	None	N/A	N/A	Good	Good	2.46	M	
EW-04	Active	None	N/A	N/A	Good	Good	3.14	G	
EW-05	Active	None	N/A	N/A	Good	Good	4.06	G	
EW-06	Active	None	N/A	N/A	Good	Good	2.46	M	
EW-07	Active	None	N/A	N/A	Good	Good	7.70	G	
EW-08	Active	None	N/A	N/A	Good	Good	2.76	M	
EW-09	Active	None	N/A	N/A	Good	Good	3.21	G	
EW-10	Active	None	N/A	N/A	Good	Good	2.68	M	
EW-11	Active	None	N/A	N/A	Good	Good	2.44	M	
EW-12	Active	None	N/A	N/A	Good	Good	6.34	G	
EW-13	Active	None	N/A	N/A	Good	Good	5.75	G	
EW-14	Active	None	N/A	N/A	Good	Good	9.05	G	

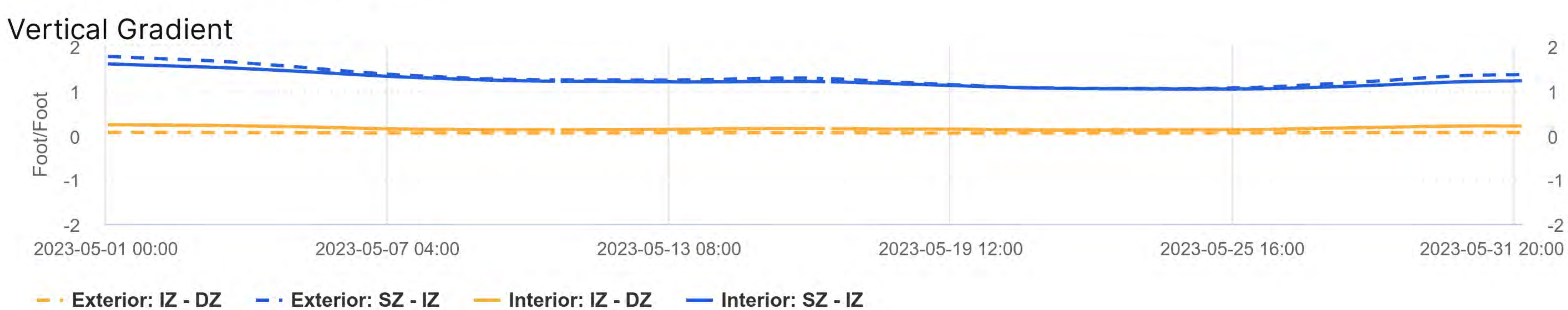
Notes:
** Recovery wells not in service*
*** Recovery wells in service part of the month*
G = good pumping, greater than 3.0 gpm
gpm = gallons per minute
M = moderate pumping, greater than 1.0 gpm and less than 3.0
P = poor pumping, less than 1.0 gpm
VFD = variable frequency drive
PA = piezometer

ATTACHMENT B-1 GRADIENT HYDROGRAPHS

Gradient Control Cluster 1

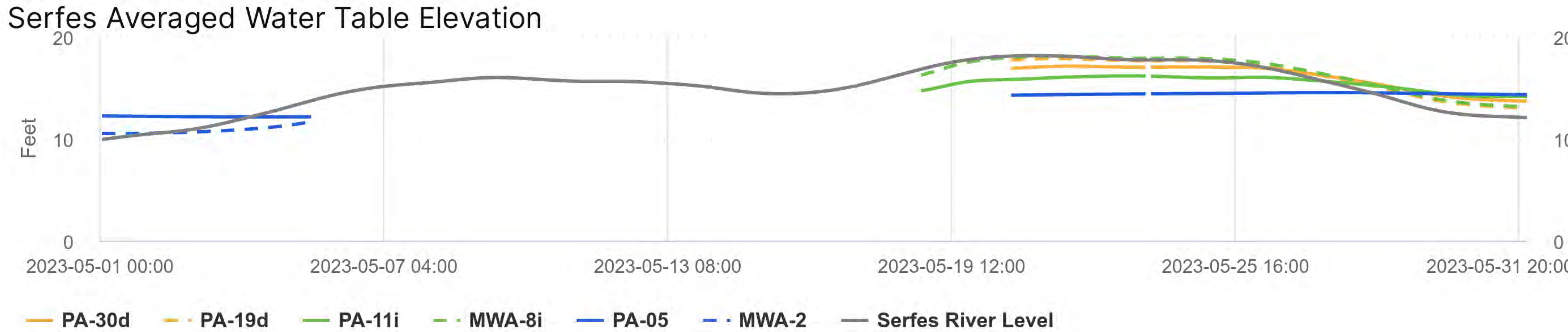


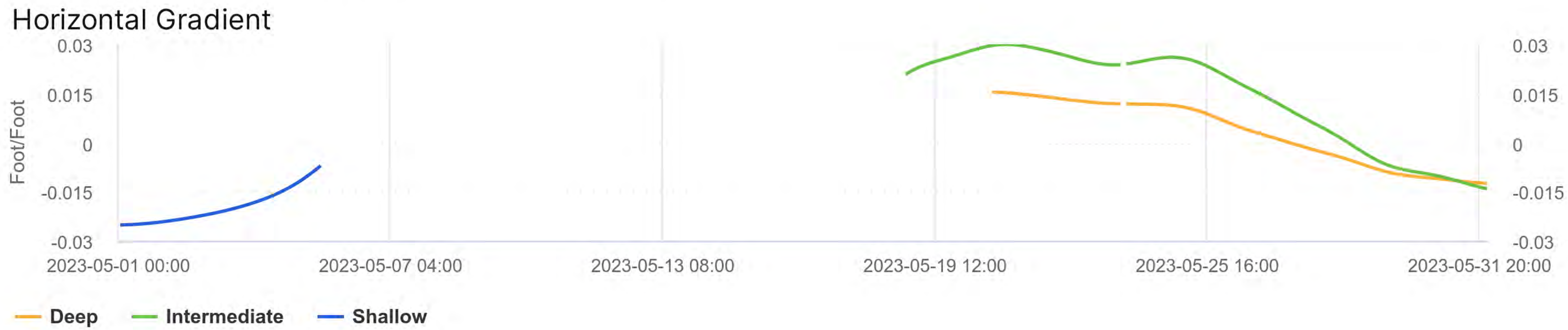


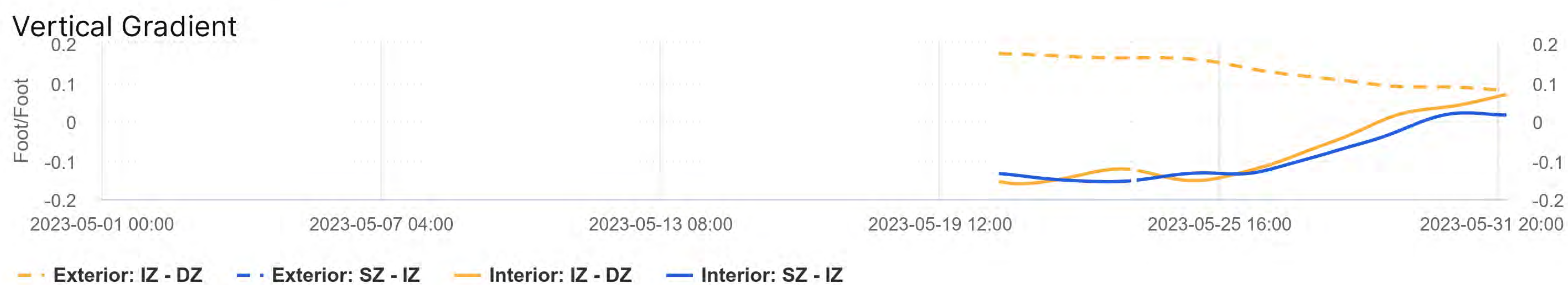


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 2



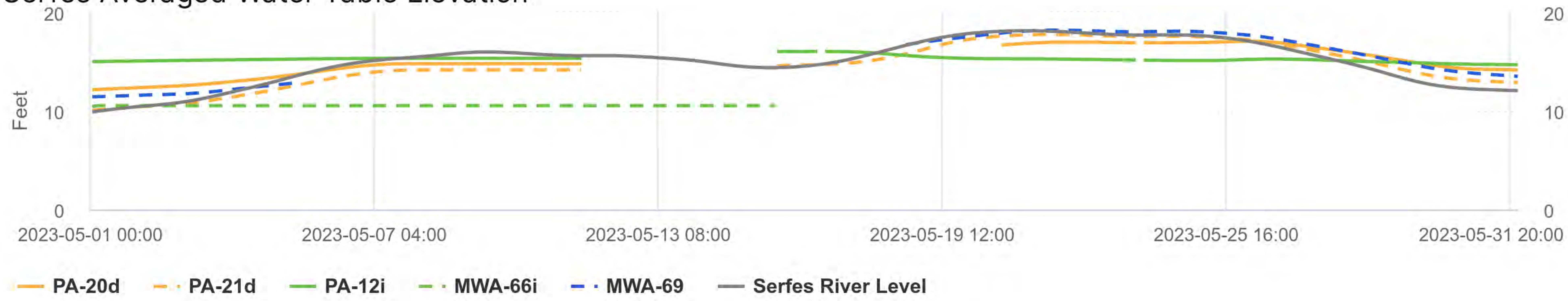




Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

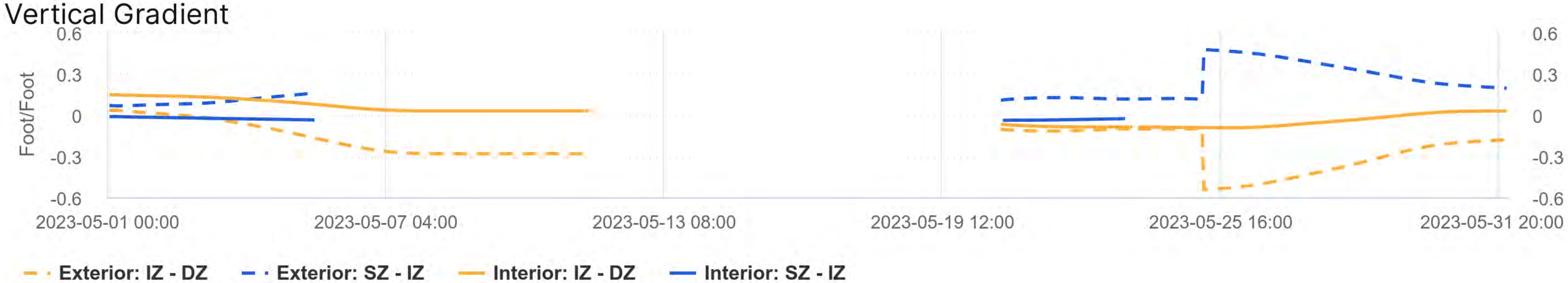
Gradient Control Cluster 3

Serfes Averaged Water Table Elevation



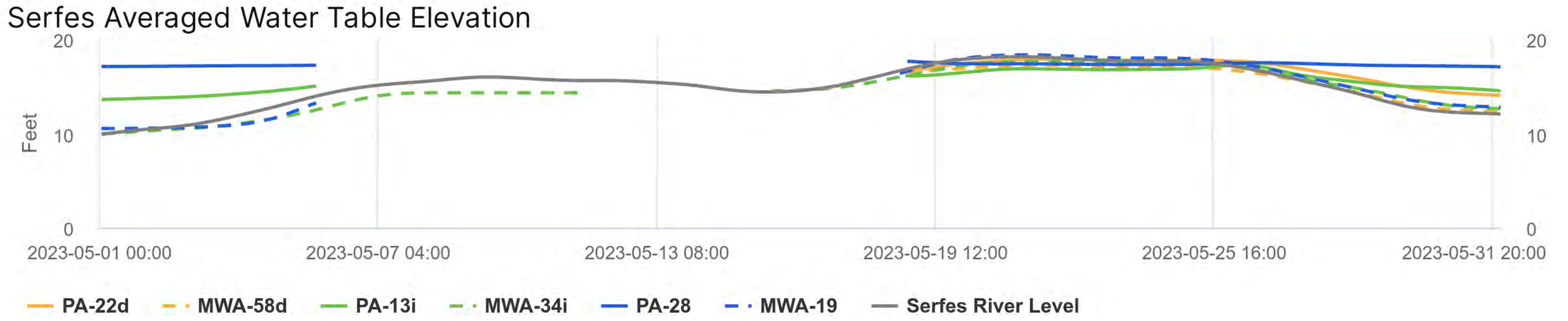
Horizontal Gradient

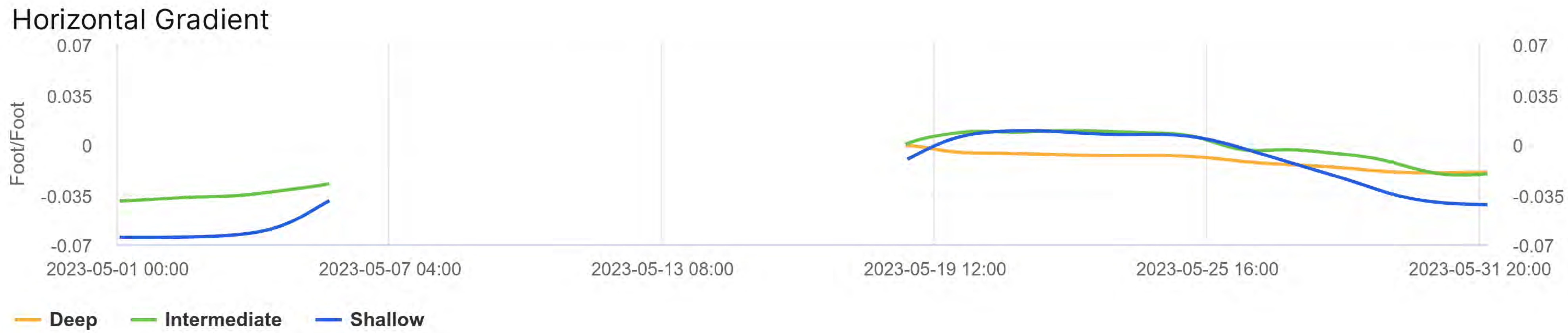
Vertical Gradient

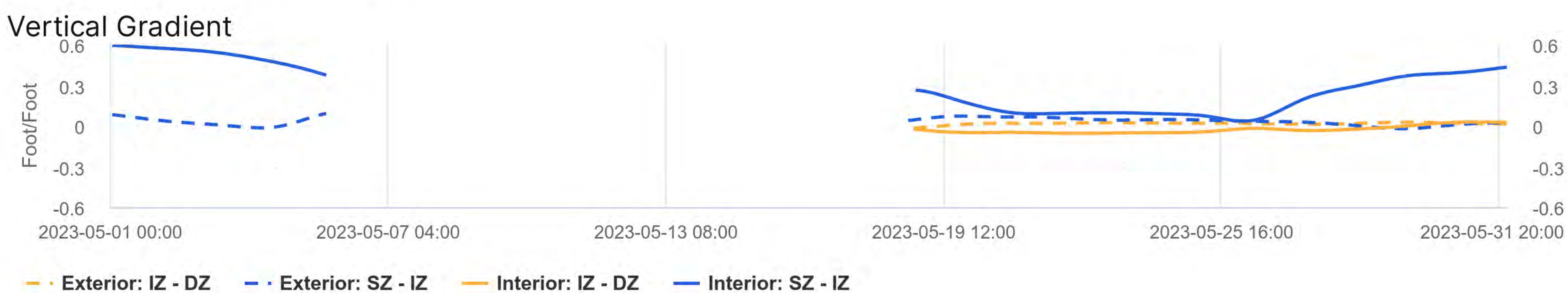


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 4

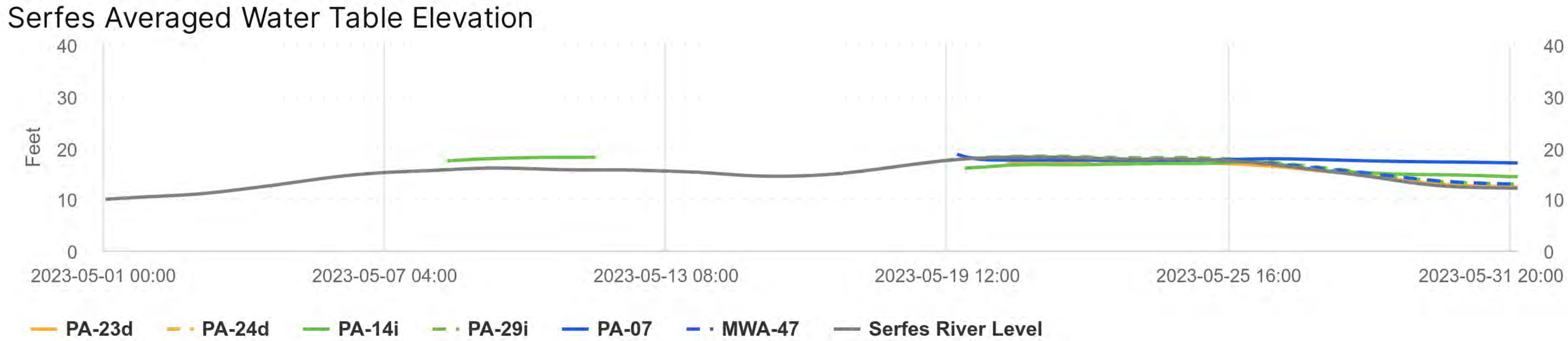


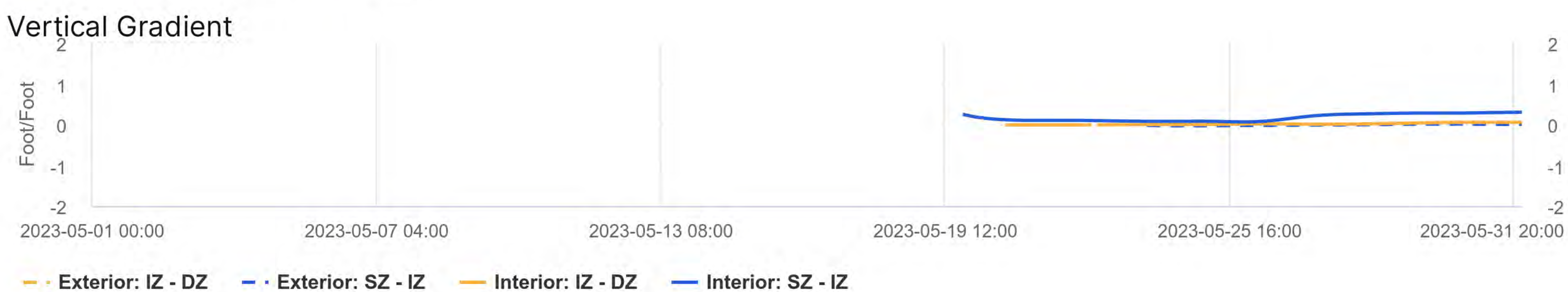




Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 5

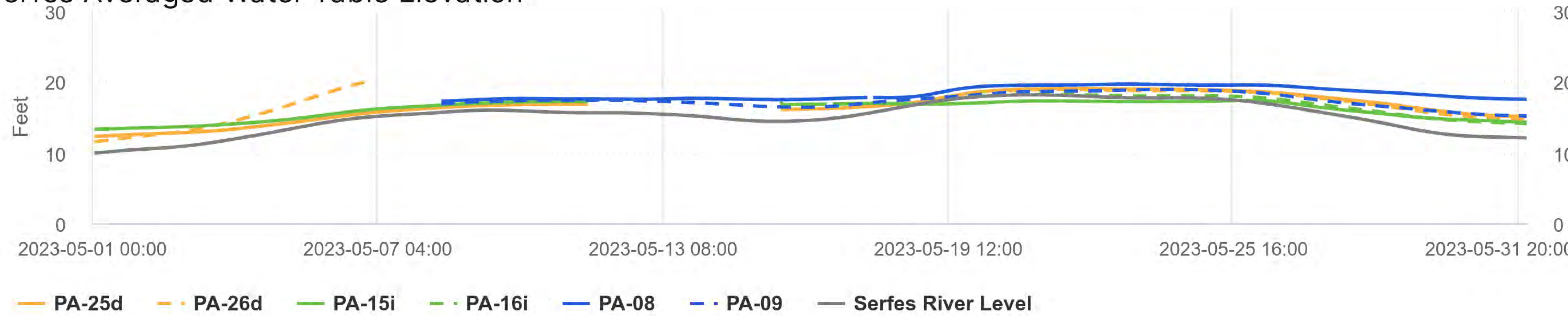




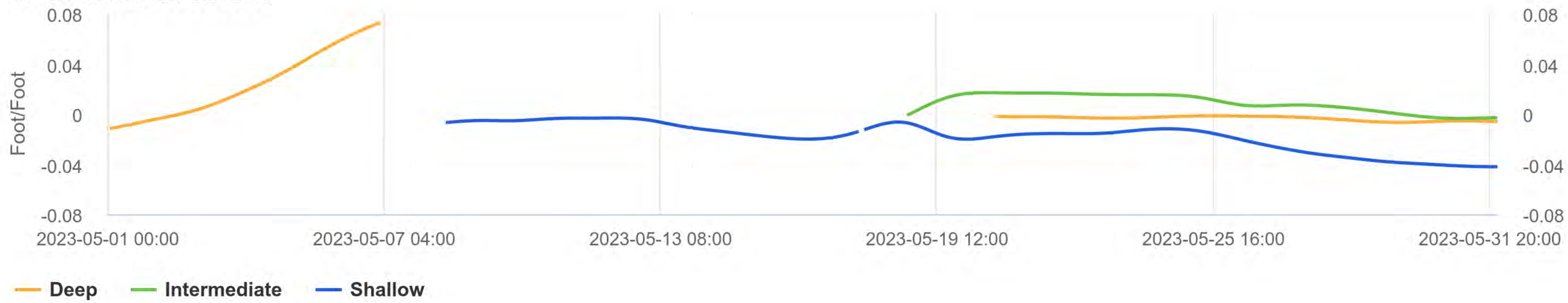
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 6

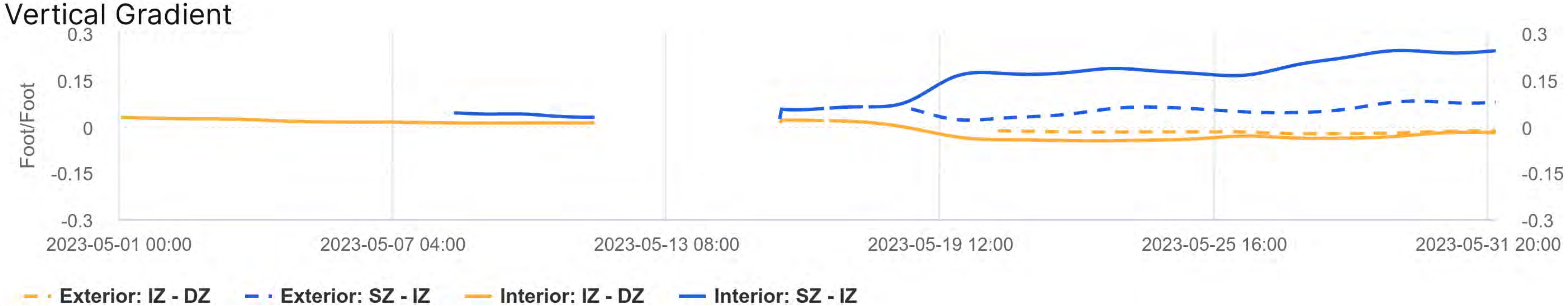
Serfes Averaged Water Table Elevation



Horizontal Gradient



Vertical Gradient

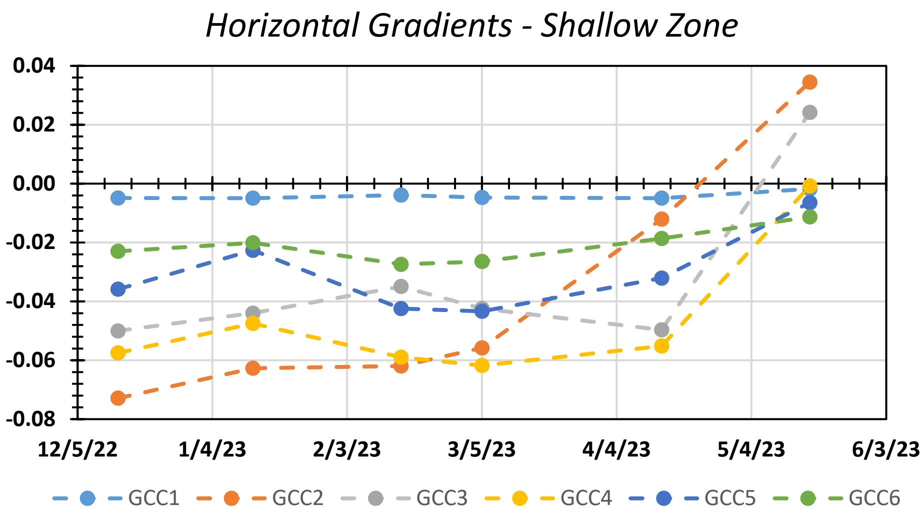


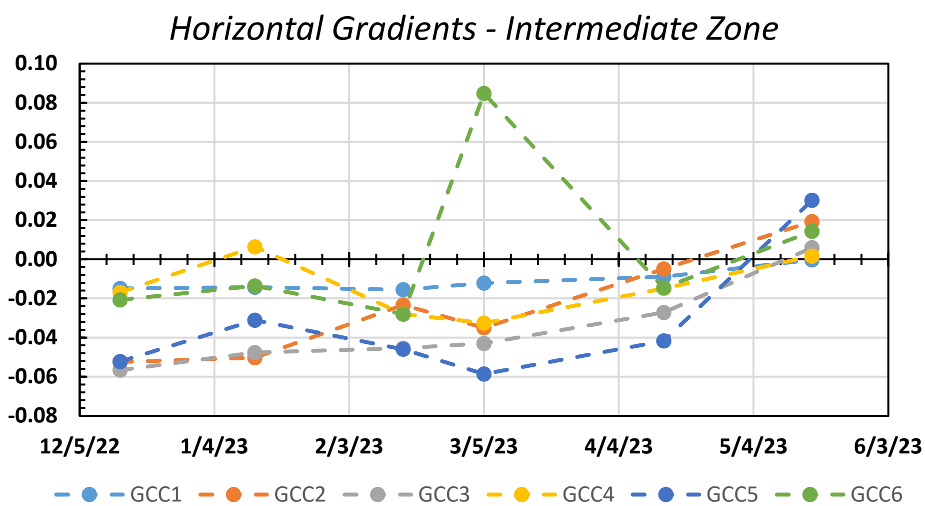
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

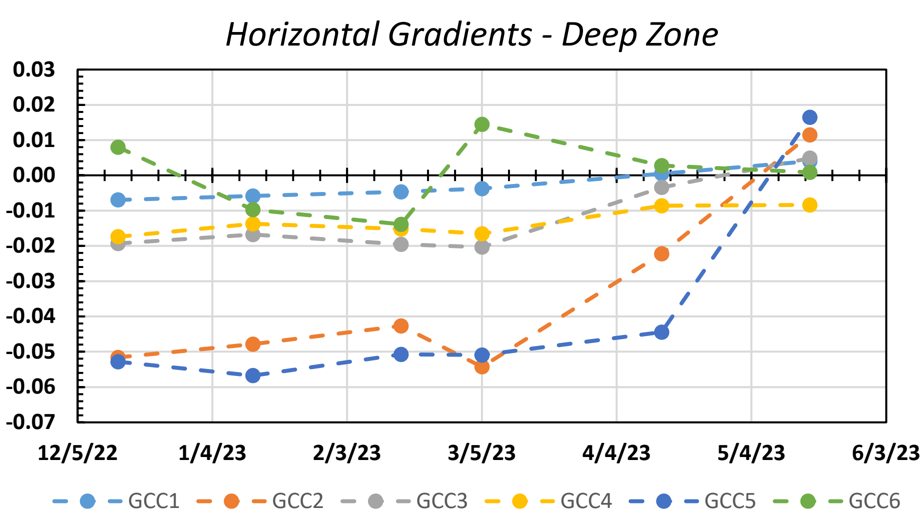
ATTACHMENT B-2 HORIZONTAL GRADIENTS

Attachment B-2

Horizontal Gradients Summary: May 2023
Arkema Inc. Facility
Portland, Oregon



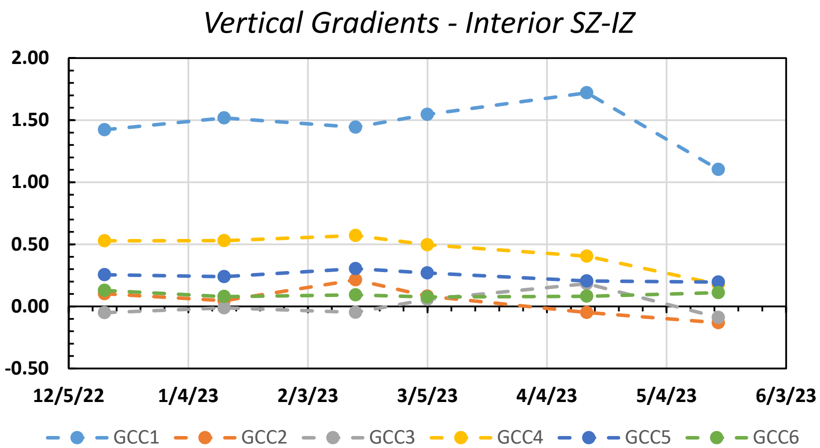


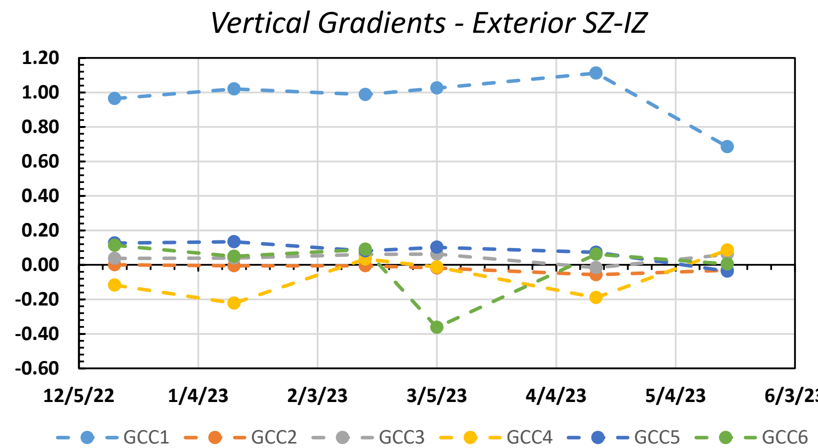


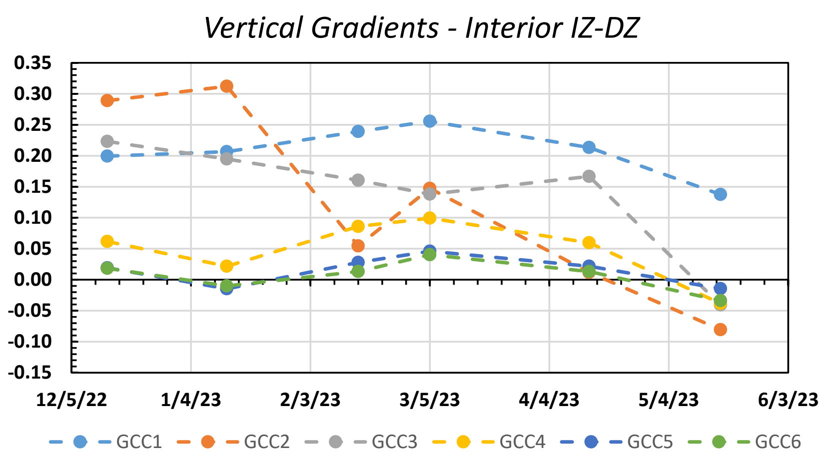
ATTACHMENT B-3 VERTICAL GRADIENTS

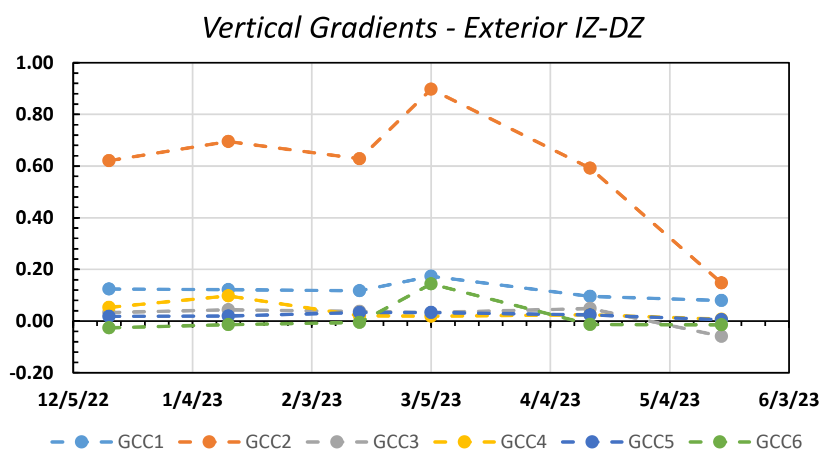
Attachment B-3

Vertical Gradients Summary: May 2023
Arkema Inc. Facility
Portland, Oregon



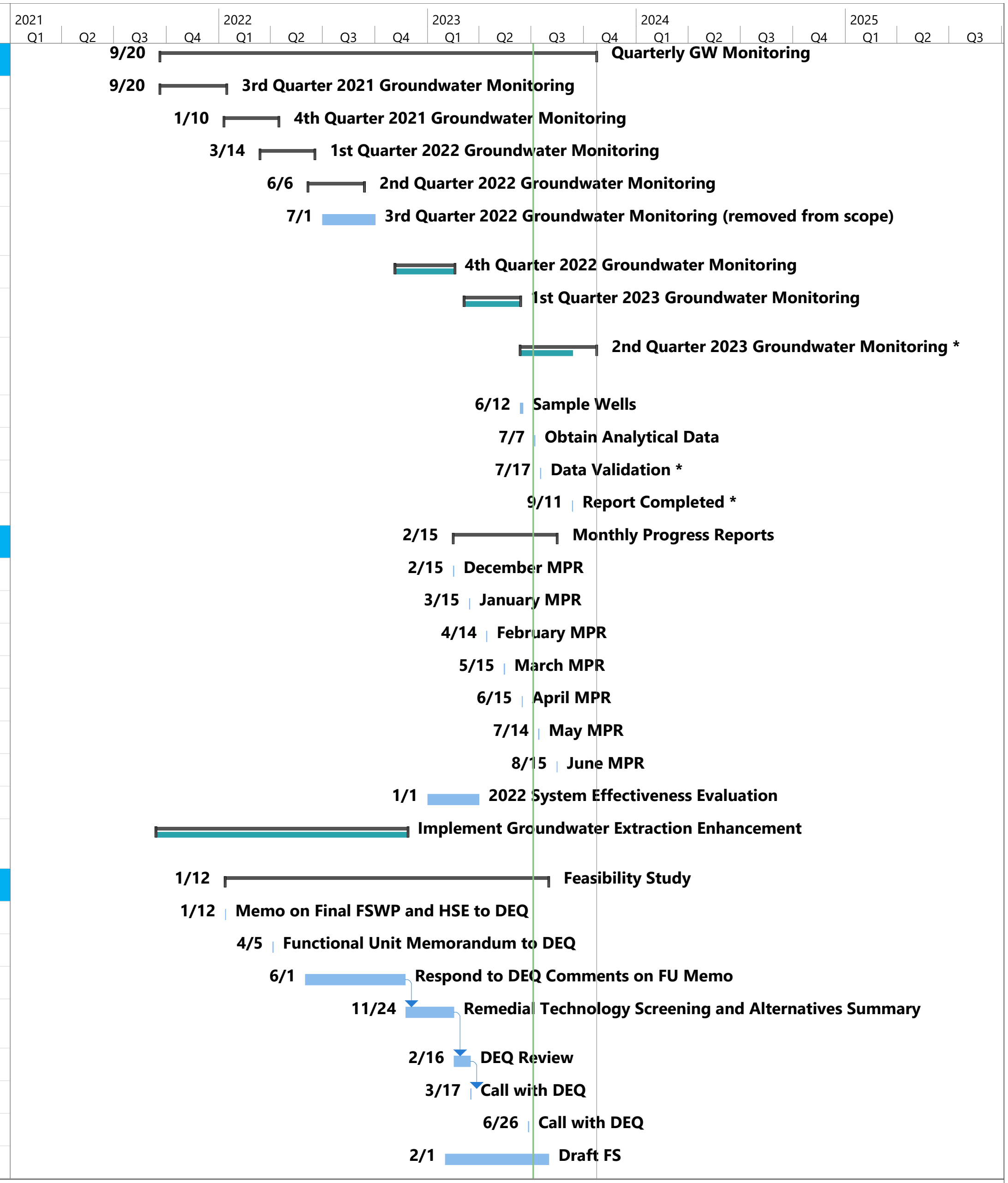






ATTACHMENT C PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**Quarterly GW Monitoring**	**549 days**	**Mon 9/20/21**	**Mon 10/23/23**
2	*3rd Quarter 2021 Groundwater Monitoring*	*85 days*	*Mon 9/20/21*	*Fri 1/14/22*
7	*4th Quarter 2021 Groundwater Monitoring*	*70 days*	*Mon 1/10/22*	*Fri 4/15/22*
11	*1st Quarter 2022 Groundwater Monitoring*	*70 days*	*Mon 3/14/22*	*Fri 6/17/22*
16	*2nd Quarter 2022 Groundwater Monitoring*	*71 days*	*Mon 6/6/22*	*Mon 9/12/22*
21	*3rd Quarter 2022 Groundwater Monitoring (removed from scope)*	*66 days*	*Fri 7/1/22*	*Fri 9/30/22*
22	*4th Quarter 2022 Groundwater Monitoring*	*78 days*	*Sat 11/5/22*	*Fri 2/17/23*
27	*1st Quarter 2023 Groundwater Monitoring*	*71 days*	*Mon 3/6/23*	*Mon 6/12/23*
32	**2nd Quarter 2023 Groundwater Monitoring ***	**96 days**	**Mon 6/12/23**	**Mon 10/23/23**
33	Sample Wells	5 days	Mon 6/12/23	Fri 6/16/23
34	Obtain Analytical Data	1 day	Fri 7/7/23	Fri 7/7/23
35	Data Validation *	1 day	Mon 7/17/23	Mon 7/17/23
36	Report Completed *	1 day	Mon 9/11/23	Mon 9/11/23
37	**Monthly Progress Reports**	**130 days**	**Wed 2/15/23**	**Tue 8/15/23**
38	*December MPR*	*1 day*	*Wed 2/15/23*	*Wed 2/15/23*
39	*January MPR*	*1 day*	*Wed 3/15/23*	*Wed 3/15/23*
40	*February MPR*	*1 day*	*Fri 4/14/23*	*Fri 4/14/23*
41	*March MPR*	*1 day*	*Mon 5/15/23*	*Mon 5/15/23*
42	*April MPR*	*1 day*	*Thu 6/15/23*	*Thu 6/15/23*
43	May MPR	1 day	Fri 7/14/23	Fri 7/14/23
44	June MPR	1 day	Tue 8/15/23	Tue 8/15/23
45	***2022 System Effectiveness Evaluation***	***66 days***	***Sun 1/1/23***	***Fri 3/31/23***
46	***Implement Groundwater Extraction Enhancement***	***317 days***	***Mon 9/13/21***	***Sun 11/27/22***
54	**Feasibility Study**	**407 days**	**Wed 1/12/22**	**Mon 7/31/23**
55	*Memo on Final FSWP and HSE to DEQ*	*1 day*	*Wed 1/12/22*	*Wed 1/12/22*
56	*Functional Unit Memorandum to DEQ*	*1 day*	*Tue 4/5/22*	*Tue 4/5/22*
57	*Respond to DEQ Comments on FU Memo*	*126 days*	*Wed 6/1/22*	*Tue 11/22/22*
58	*Remedial Technology Screening and Alternatives Summary*	*62 days*	*Thu 11/24/22*	*Wed 2/15/23*
59	*DEQ Review*	*21 days*	*Thu 2/16/23*	*Thu 3/16/23*
60	*Call with DEQ*	*1 day*	*Fri 3/17/23*	*Fri 3/17/23*
61	*Call with DEQ*	*1 day*	*Mon 6/26/23*	*Mon 6/26/23*
62	Draft FS	129 days	Wed 2/1/23	Mon 7/31/23



Arkema Portland
Monthly Progress Report
Attachment C

Task	Project Summary	Manual Task	Start-only	Deadline
Split	Inactive Task	Duration-only	Finish-only	Progress
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Manual Progress
Summary	Inactive Summary	Manual Summary	External Milestone	

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Memo

To	Katie Daugherty, Oregon Department of Environmental Quality
From	Brendan Robinson, PE, Environmental Resources Management, Inc.
Date	15 August 2023
Reference	0682894 Phase 204
Subject	June 2023 GW SCM Monthly Performance Monitoring Report

1. INTRODUCTION

Environmental Resources Management, Inc. (ERM) prepared this Monthly Performance Monitoring Report (MPR) on behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc. (Arkema), for the former Arkema Portland Plant (the Site) at 6400 NW Front Avenue in Portland, Oregon. The Oregon Department of Environmental Quality (ODEQ), in its letter dated 31 May 2019 and in the subsequent meeting with LSS and ERM on 2 July 2019, requested that LSS initiate monthly status reports associated with the onsite groundwater source control measure (GW SCM) consistent with the Performance Monitoring Plan (PMP; ERM 2014) beginning July 2019. The 2014 PMP was prepared pursuant to the Order on Consent issued by ODEQ, signed on 31 October 2008 (ODEQ No. LQVC-NWR-08-04; Consent Order). The purpose of the PMP was to present the monitoring, reporting, and adaptive management processes used during implementation of the GW SCM. On 30 November 2021, ODEQ directed LSS that following the October 2021 MPR, subsequent MPRs would be suspended pending the implementation of the Groundwater Extraction Enhancement (GEE) project in 2022. During that time, ODEQ requested monthly schedule updates in lieu of MPRs. The trench wells installed as part of the GEE project were started on 27 November 2022, and MPR writing restarted in December 2022. The purpose of the GEE project was to install new extraction capacity to achieve the Capture Zone Objectives.

This June 2023 MPR summarizes the GW SCM performance monitoring data collected in June 2023. This report assesses the current gradient status and proposes system improvements to meet the Capture Zone Objectives set in the PMP.

2. GROUNDWATER SOURCE CONTROL IMPLEMENTATION

A detailed description of the design and implementation of the GW SCM is provided in the *Revised Upland Feasibility Study Work Plan* (ERM 2017); however, a brief description of the GW SCM is provided here. In February 2009, ODEQ and the U.S. Environmental Protection Agency (USEPA) approved the general approach for the GW SCM. This approach included installation of a groundwater barrier wall (GWBW), groundwater recovery wells, and a Groundwater Extraction and Treatment (GWET) system, with treated water discharged to the Willamette River. ODEQ and USEPA approved the *Groundwater Barrier Wall Final Design* (ERM 2012) on 7 August 2012. Construction of the GWBW began in May 2012 and was completed in December 2012. ODEQ approved the *Groundwater Extraction and Treatment System Final Design* (ERM 2013) on 2 April

2013. Construction of the GWET system began in December 2012 and was completed in December 2013.

GWET startup and optimization commenced in May 2014. The GW SCM at the Site consists of the following primary components (Figure 1):

1. A GWBW to physically separate the affected upland portions and in-water portions of the Site.

2. Hydraulic control to minimize flow of groundwater containing unacceptable concentrations of constituents of potential concern (COPCs) around, over, and under the GWBW.

3. Management of extracted groundwater through the GWET system, with treated effluent discharged to the Willamette River under a National Pollutant Discharge Elimination System (NPDES) Permit.

On 1 September 2018, ERM submitted the *Draft GWET System Effectiveness Evaluation* (Draft SEE Report; ERM 2018). The Draft SEE Report provided an update on the corrective actions implemented to improve the performance of the GWET system, evaluate the extent of capture, and propose actions to improve hydraulic capture. Additional data requested by ODEQ were submitted on 26 October 2018.

The key objective of the GW SCM is to achieve hydraulic containment of the alluvial sequence within the Target Capture Zone at the Site to prevent the flow of COPCs to the Willamette River. The Site alluvial aquifer sequence within the Target Capture Zone consists of the Shallow Zone, Intermediate Zone, and the Deep Zone. Site hydraulic conditions are variable and subject to both seasonal and daily tidal fluctuations.

The hydraulic control component formerly consisted of 22 recovery wells (RWs) prior to the implementation of the GEE. Of the 22 pre-existing RWs, four were retained for active pumping. The remaining 18 former RWs had pumps removed but retained their pressure transducers so that they can continuously collect high-resolution groundwater elevation data. The hydraulic control system now consists of the four remaining active RWs, as well as seven groundwater extraction trenches that each contain two extraction wells (EWs). Each trench is 50 feet deep, 50 feet long, and 3 feet wide and is filled with an engineered backfill. More information about the groundwater extraction trenches is provided in the *Final Design Report* (ERM 2022). The gradient control-monitoring network consisting of six gradient control clusters (GCCs) with each cluster containing six monitoring points. Within each RW, EW, and GCC location, pressure transducers are continuously collecting high-resolution groundwater elevation data. Each GCC contains three transducers interior to the wall and three transducers exterior to the wall screened in the Shallow, Intermediate, and Deep aquifers at the Site.

3. HYDRAULIC CONTAINMENT MONITORING PROGRAM

As described in the PMP, the purpose of hydraulic monitoring (i.e., groundwater elevation data) is to provide sufficient data to demonstrate an inward hydraulic gradient across the GWBW and to evaluate the effective hydraulic capture produced by the GW SCM.

Monitoring requirements were established in the PMP to demonstrate GWET effectiveness. The Site monitoring program includes groundwater elevation data (manual and transducer measurements) collected from the 36 monitoring points located within six GCCs spaced across the GWBW, with piezometers interior and exterior to the wall, throughout the alluvial sequence; and groundwater elevation and flow rate data from the four remaining active RWs and 14 EWs. High-resolution groundwater elevation data is also collected from the 18 inactive RWs. Additionally, one new monitoring well was installed in each of the seven extraction trenches for manual water level measurement. These data were used to prepare horizontal and vertical potentiometric surface maps representing potentiometric differences between the alluvial sequences, and to generate spatial and temporal hydrographs to evaluate hydraulic capture.

3.1 Groundwater Elevation Monitoring

Groundwater elevation monitoring was completed on 9 June 2023. Manual groundwater elevations were measured at wells that were experiencing transducer mechanical issues or that were offline during the groundwater elevation measurement event. All inactive RWs were manually measured in the month of June to affirm proper calibration. Manual water levels for those RWs are reported. Additionally, all transducers in inactive RWs were down until upgrades were completed and transducers were sequentially turned on. Specific issues are addressed in Attachment A-1.

As detailed in Attachments A-1 and A-2, during June 2023, the following transducers were:

<u>Fully out of service pending repairs:</u>

- RW-11i
- RW-15

<u>Out of service for a period but returned to full operation:</u>

- PA-17i
- RW-18

3.2 Horizontal and Vertical Gradients at Gradient Control Points

As described above, GCC locations collect high-resolution groundwater elevation data using transducers. Transducer data are filtered to remove anomalous data from monitoring points due to potential equipment failures, such as transducer malfunctions, power outages, or updates to the GWET programmable logic controller (PLC) system, which controls and houses all the operational data. These specific issues and time periods are summarized in Table A-1 in Attachment A. The following flags are applied to filter anomalous data:

- Groundwater elevations had a change greater than 1.5 feet within 1 hour
- Groundwater elevation measurements that were found to be greater than 50 feet, or less than 1 foot
- Calculated groundwater elevation slope indicates no change between consecutive measurements indicating a transducer malfunction

- Manually flagging data that are inconsistent with the typical nature of the well
- Periods where transducer power supply was deactivated for work on interconnected electrical systems

After June 2023 flagged data were removed, the Serfes (1991) method was used to account for tidal variations as described in the PMP. Using Serfes corrected data, both horizontal and vertical gradients were calculated and plotted over time (Attachment B). Groundwater elevations, horizontal gradients, and vertical gradients from 9 June 2023 are shown below at each GCC (Table 1-1 and Table 1-2). The water elevation taken during the groundwater level gauging event at PA-12i and PA-23d was excluded from gradient calculations and potentiometric surface maps due to being anomalous.

Table 1-1. June Horizontal Gradients

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
GCC1	Shallow	PA-03	27.32	PA-04	27.49	-0.002
	Intermediate	PA-17iR	14.15	PA-10i	15.24	-0.010
	Deep	PA-27d	13.48	PA-18d	13.72	-0.002
GCC2	Shallow	MWA-2	11.53	PA-05	13.65	-0.031
	Intermediate	MWA-8i	12.03	PA-11i	13.22	-0.016
	Deep	PA-19d	11.94	PA-30d	12.77	-0.015
GCC3	Shallow	MWA-69	12.21	PA-06	15.98	-0.035
	Intermediate	MWA-66i	11.02	PA-12i	*	**
	Deep	PA-21d	11.82	PA-20d	13.40	-0.012
GCC4	Shallow	MWA-19	11.95	PA-28	16.68	-0.047
	Intermediate	MWA-34i	11.25	PA-13i	14.15	-0.032
	Deep	MWA-58d	11.27	PA-22d	13.10	-0.020
GCC5	Shallow	MWA-47 *M*	11.47	PA-07	16.48	-0.048
	Intermediate	PA-29i	11.88	PA-14i	14.09	-0.041
	Deep	PA-24d *M*	11.07	PA-23d	*	**
GCC6	Shallow	PA-09	13.91	PA-08	16.83	-0.053
	Intermediate	PA-16i	13.23	PA-15i	13.67	-0.008
	Deep	PA-26d	13.70	PA-25d	14.12	-0.007

Notes:

Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.

Horizontal gradient calculated as (Exterior Elevation – Interior Elevation) / Horizontal distance.

** = anomalous groundwater elevation; ** = horizontal gradient cannot be calculated due to anomalous elevation reading; ft NAVD88 = feet North American Vertical Datum of 1988; M = manual groundwater elevation measurement*

Table 1-2. June Vertical Gradients

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
Interior	SZ-IZ	GCC1	PA-04	27.49	PA-10i	15.24	1.24
		GCC2	PA-05	13.65	PA-11i	13.22	0.04
		GCC3	PA-06	15.98	PA-12i	*	**
		GCC4	PA-28	16.68	PA-13i	14.15	0.40
		GCC5	PA-07	16.48	PA-14i	14.09	0.25
		GCC6	PA-08	16.83	PA-15i	13.67	0.24
	IZ-DZ	GCC1	PA-10i	15.24	PA-18d	13.72	0.20
		GCC2	PA-11i	13.22	PA-30d	12.77	0.06
		GCC3	PA-12i	*	PA-20d	13.40	**
		GCC4	PA-13i	14.15	PA-22d	13.10	0.05
		GCC5	PA-14i	14.09	PA-23d	*	**
		GCC6	PA-15i	13.67	PA-25d	14.12	-0.01
Exterior	SZ-IZ	GCC1	PA-03	27.32	PA-17iR	14.15	0.84
		GCC2	MWA-2	11.53	MWA-8i	12.03	-0.03
		GCC3	MWA-69	12.21	MWA-66i	11.02	0.08
		GCC4	MWA-19	11.95	MWA-34i	11.25	0.07
		GCC5	MWA-47 ^{M}	11.47	PA-29i	11.88	-0.03
		GCC6	PA-09	13.91	PA-16i	13.23	0.05
	IZ-DZ	GCC1	PA-17iR	14.15	PA-27d	13.48	0.10
		GCC2	MWA-8i	12.03	PA-19d	11.94	0.06
		GCC3	MWA-66i	11.02	PA-21d	11.82	-0.06
		GCC4	MWA-34i	11.25	MWA-58d	11.27	0.00
		GCC5	PA-29i	11.88	PA-24d ^{M}	11.07	0.02
		GCC6	PA-16i	13.23	PA-26d	13.70	-0.01

Notes:

Positive vertical gradient indicates a downward hydraulic gradient.

Vertical gradient calculated as (Upper Elevation – Lower Elevation) / Screen Midpoint distance.

** = anomalous groundwater elevation; ** = vertical gradient cannot be calculated due to anomalous elevation reading; DZ = Deep Zone; ft NAVD88 = feet North American Vertical Datum of 1988; IZ = Intermediate Zone; ^{M} = manual groundwater elevation measurement; SZ = Shallow Zone*

3.3 Potentiometric Surface, Groundwater Elevation Difference Maps, and Groundwater Flow Directions

As described in the PMP, potentiometric surface maps are used to evaluate flow paths. Vertical gradients are also used as an additional line of evidence to evaluate hydraulic containment. Groundwater elevation data collected on 9 June 2023 were used to prepare potentiometric surface maps based on manual measurements and averaged transducer groundwater elevations (Figures 2 through 4) and vertical difference maps (Figures 5 and 6).

The generalized flow direction indicated by the potentiometric surface maps shows overall groundwater flow both toward and away from the GWBW, depending on location. The Shallow and Intermediate Zones potentiometric maps (Figures 2 and 3) indicate localized groundwater movement to the extraction trenches due to GW SCM pumping, and inward gradients sporadically along the length of the barrier wall. Localized evidence of capture zones is apparent around all of the groundwater extraction trenches except for Trench 4, and the trend of the groundwater elevation data suggests they will continue to expand and intersect. Additional evidence of capture is anticipated as ongoing pumping occurs.

A potentiometric separation is still noticeable exterior to the GWBW, indicating the barrier wall is functioning by impeding groundwater flow. Groundwater elevations are demonstrating a slight gradient toward the river.

Horizontal groundwater gradients for the Shallow, Intermediate, and Deep Zones indicated a negative gradient at all GCCs (Attachment B-2). However, the trend of progress toward inward gradient has continued over the past few months. River elevations are shown on the potentiometric surface maps in an inset (Figures 2 through 4) and depict stage movement within the month corresponding with the MPR. The river elevation in June 2023 varied with an average of 9.45 feet NAVD88, maximum of 12.70 feet NAVD88, and minimum of 6.01 feet NAVD88.

Vertical gradients were calculated for each vertical well pair using these groundwater elevations and are plotted on Figures 5 and 6. Vertical groundwater gradients interior to the GWBW between the Shallow and Intermediate Zones were downward in June 2023 (Figure 5). The vertical groundwater gradient at GCC3 interior of the wall was unable to be calculated due to an anomalous groundwater elevation reading at PA-12i. PA-12i will be recalibrated so that vertical gradients at GCC3 can be calculated in the future and presented in subsequent MPRs. Vertical groundwater gradients are also depicted in Attachment B. The magnitude of the gradient is much greater at GCC1 than other monitoring locations due to the influence from a localized high-pressure zone near GCC1 where vertical groundwater flow is impeded by a localized confining unit (Figure 2). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were mixed with GCC2 and GCC5 being upward and GCC1, GCC3, GCC4, and GCC6 being downward as shown on Figure 5 and in Attachment B.

Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were downward with exception to GCC6. The direction of vertical gradients exterior to the GWBW were mixed with GCC3, GCC4, and GCC6 being upward and the remaining being downward, as shown on Figure 6 and Attachment B. The vertical groundwater gradient at GCC3 and GCC5 interior of the wall was unable to be calculated due to an anomalous groundwater elevation reading at PA-12i and PA-23d.

3.3.1 GWET System Performance

The GWET system operated within permit conditions during the reporting period. There were two shutdowns:

- 8 June 2023: An unplanned shutdown due to issues with a coagulant feed pump. The wellfield was restarted the same day.
- 29 June 2023: A planned shutdown to clean the plate separator. The wellfield was restarted the same day.

There were no upgrades to the GWET system in the month of June 2023. Flow rates in the system are currently limited by the fouling in the GWET system's pressure filters. A media changeout is planned for July and will enable the system to treat higher rates.

3.3.2 Recovery Well and Extraction Well Performance

In June 2023, the average system influent flow rate was 65.71 gallons per minute (gpm) during operational periods, compared to 61.74 gpm in the May 2023 period. This increase in flow rate is largely due to the replacement of wellfield pumps that were underperforming. ERM is currently in the process of optimizing extraction rates within the system to increase flow rates at each operational well until the extraction rates specified in the *Final Design Report* (ERM 2022) are achieved, the wells are producing the maximum quantity of water possible, or until the Capture Zone Objectives are met.

Table 1-3. Recovery Well Pumping Rates[1]

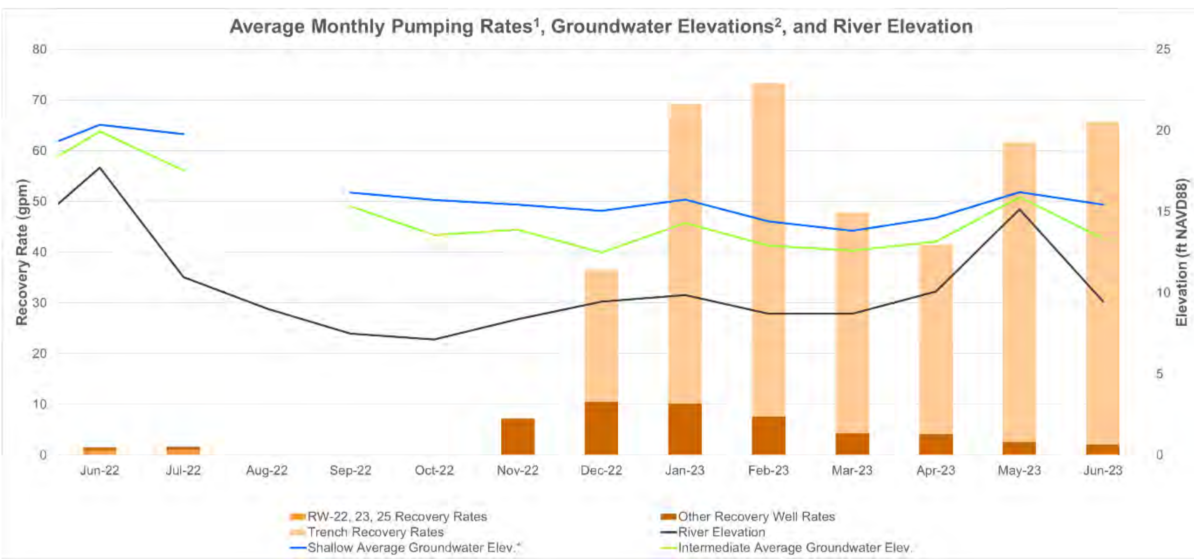
Recovery Well	June 2023 Average Pumping Rate (gpm)
RW-14*	0.00
RW-22*	0.00
RW-23	2.09
RW-25*	0.00
EW-01	5.13
EW-02	3.56
EW-03	2.36
EW-04	3.40
EW-05	4.57
EW-06	5.30
EW-07	6.17
EW-08	3.92
EW-09	3.90
EW-10	4.30
EW-11	3.45

Recovery Well	June 2023 Average Pumping Rate (gpm)
EW-12	2.27
EW-13	4.92
EW-14	10.39
Total	**65.71**

Notes:

[1] = Flow rates are calculated based on the period of the month during which the recovery wells were operational.

** = Recovery well not in service during reporting period.*



Notes:

[1] = Following installation of trenches in Summer 2022, RW-22, 23, and 25 recovery rates are now grouped together with the other remaining recovery well (RW-14) starting in November 2022.

[2] = Average groundwater elevations are calculated using interior wells—the wellfield was powered down in August preventing the measurement of the groundwater.

** = The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the whole aquifer.*

Figure 1-1. Monthly Pumping Rate Contribution

3.3.3 Recommendations for Extraction System Optimization

Recovery rates from the start of the system indicate that the active RWs and EWs are operating as designed except for the troubleshooting discussed above. The extraction rates throughout the GWET system will continue to be optimized to meet Target Capture Objectives.

4. ANALYTICAL PROGRAM

Quarterly groundwater monitoring was implemented in accordance with the ODEQ-approved Arkema Quarterly Groundwater Monitoring Work Plan dated October 2019 and the ODEQ-approved reduced scope described in the 2021 monitoring program modification request memorandum dated 9 September 2021. The table below outlines sampling dates and submittal dates related to groundwater monitoring since the implementation of the reduced scope. The Quarterly Monitoring Reports present results from these sampling events.

Report	Sampling Dates	Report Submittal Date
2021 Quarter 3	9/21/2021–9/24/2021	1/14/2022
2021 Quarter 4	12/13/2021–12/16/2021	4/20/2022
2022 Quarter 1	3/14/2022–3/17/2022	6/15/2022
2022 Quarter 2	6/6/2022–6/9/2022	9/12/2022
2022 Quarter 4	11/7/2022–11/10/2022	2/17/2023
2023 Quarter 1	3/6/2023–3/10/2023	6/12/2023
2023 Quarter 2	6/12/2023–6/16/2023	9/22/2023
2023 Quarter 3	8/21/2023–8/24/2023	11/24/2023*

* Dates are tentative.

5. SUMMARY AND CONCLUSIONS

This report presents a summary of the GW SCM operation, maintenance, and monitoring activities conducted at the Site in June 2023 and documents results from system monitoring. The following summarizes ERM's observations and conclusions drawn from collected data.

5.1 Groundwater Flow

- Horizontal gradients across the GWBW are generally indicating an outward gradient toward the river (Attachment B-2). Additionally, groundwater elevations show a noticeable separation interior and exterior of the GWBW, indicating the GWBW is functioning via impeding groundwater flow.

- Vertical groundwater gradients interior to the GWBW between the Shallow and Intermediate Zones were downward in June 2023 (Figure 5). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were mixed with GCC2 and GCC5 being upward and the remaining being downward. Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were upward except for GCC6, which was downward (Figure 6). Exterior of the GWBW vertical gradients between the Intermediate and Deep Zones were mixed with GCC3, GCC4, and GCC6 being upward and the remaining being downward.

- The average river elevation in June 2023 was 9.45 feet NAVD with a minimum elevation of 6.01 feet NAVD88 and a maximum elevation of 12.70 feet NAVD88, considerably lower than the average river elevation in May 2023 of 15.14 feet NAVD88.

5.2 Groundwater Extraction

Based on June 2023 extraction and relevant hydrograph analysis, the trenches are functioning as designed. As discussed in Section 3.3.2, the flow rate in the system is currently being constrained by the GWET system's pressure filters. A media changeout event is scheduled in July 2022 and is expected to resolve this issue. Within the Site alluvial sequence, potentiometric maps indicate the GW SCM are to be producing localized areas of hydraulic capture throughout the Target Capture Zone; however, more time at elevated extraction rates will be required to evaluate whether GWET objectives are being met system wide.

Flow rates have become steadier as a result of the repairs in the wellfield in June 2023. Further evaluation of the system with respect to the Capture Zone Objectives will be conducted once all pumps are operating at their design rates for an extended period.

5.3 Recommendations and Future Work

ERM will continue to optimize new EWs. Any additional modifications to the system to meet capture objectives will be included in subsequent Monthly Performance Monitoring Report. The project schedule provided as Attachment C summarizes activities planned for the immediate future.

Regards,

REGISTERED PROFESSIONAL ENGINEER
78496PE
OREGON
DECEMBER 31, 2007
BRENDAN ANDREW ROBINSON
EXP. 12/31/2024

Brendan Robinson, PE
Partner

6. REFERENCES

ERM (ERM-West, Inc.). 2012. *Arkema Portland Groundwater Source Control Measure, Groundwater Barrier Wall Final Design, Arkema Inc., Portland, Oregon*. July 2012.

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Serfes, Michael. 1991. "Determining the Mean Hydraulic Gradient of Ground Water Affected by Tidal Fluctuations." *Groundwater*, Vol. 29. No 4. July–August 1991.

FIGURES

Figure 1: Site Layout

Figure 2: June 2023 Shallow Zone Groundwater Contours

Figure 3: June 2023 Intermediate Zone Groundwater Contours

Figure 4: June 2023 Deep Zone Groundwater Contours

Figure 5: June 2023 Shallow to Intermediate Zone Vertical Head Difference

Figure 6: June 2023 Intermediate to Deep Zone Vertical Head Difference

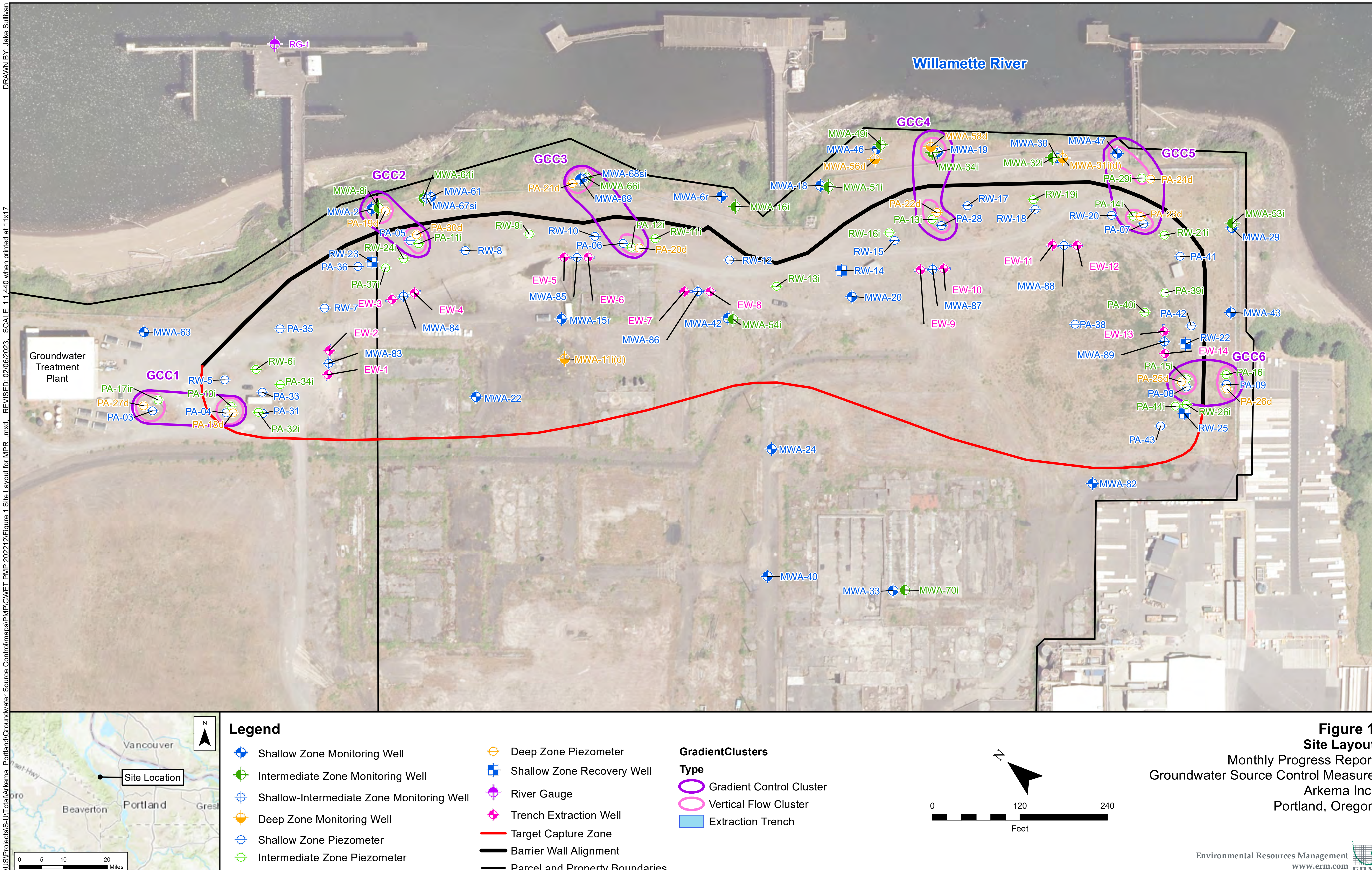
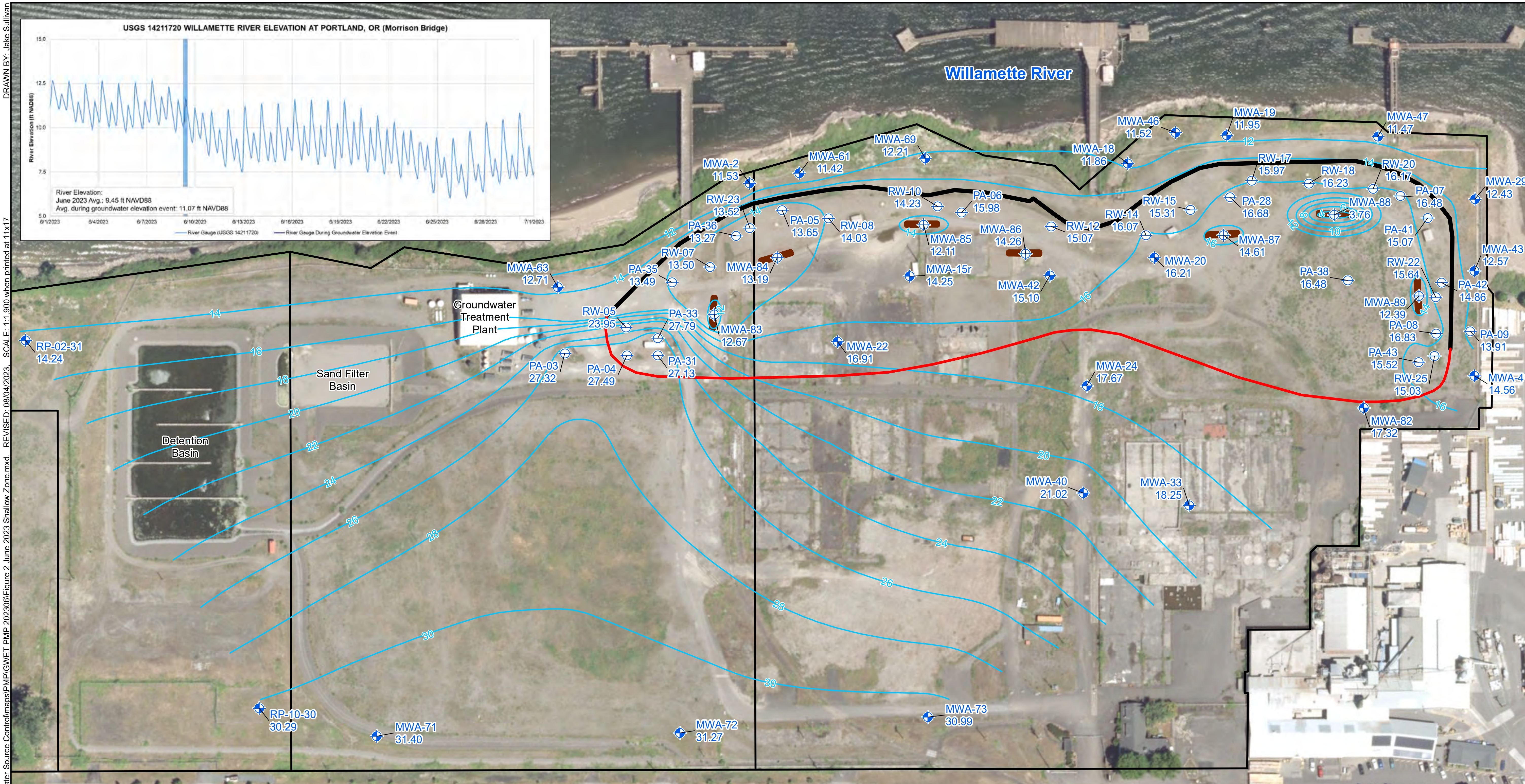


Figure 1
Site Layout
Monthly Progress Report
Groundwater Source Control Measure
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com

Source: City of Portland Aerial Imagery, flown Summer 2021; NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Shallow Zone Piezometer
- Shallow Zone Monitoring Well
- Active Recovery Well; Not Used During Contouring
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Shallow Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected June, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

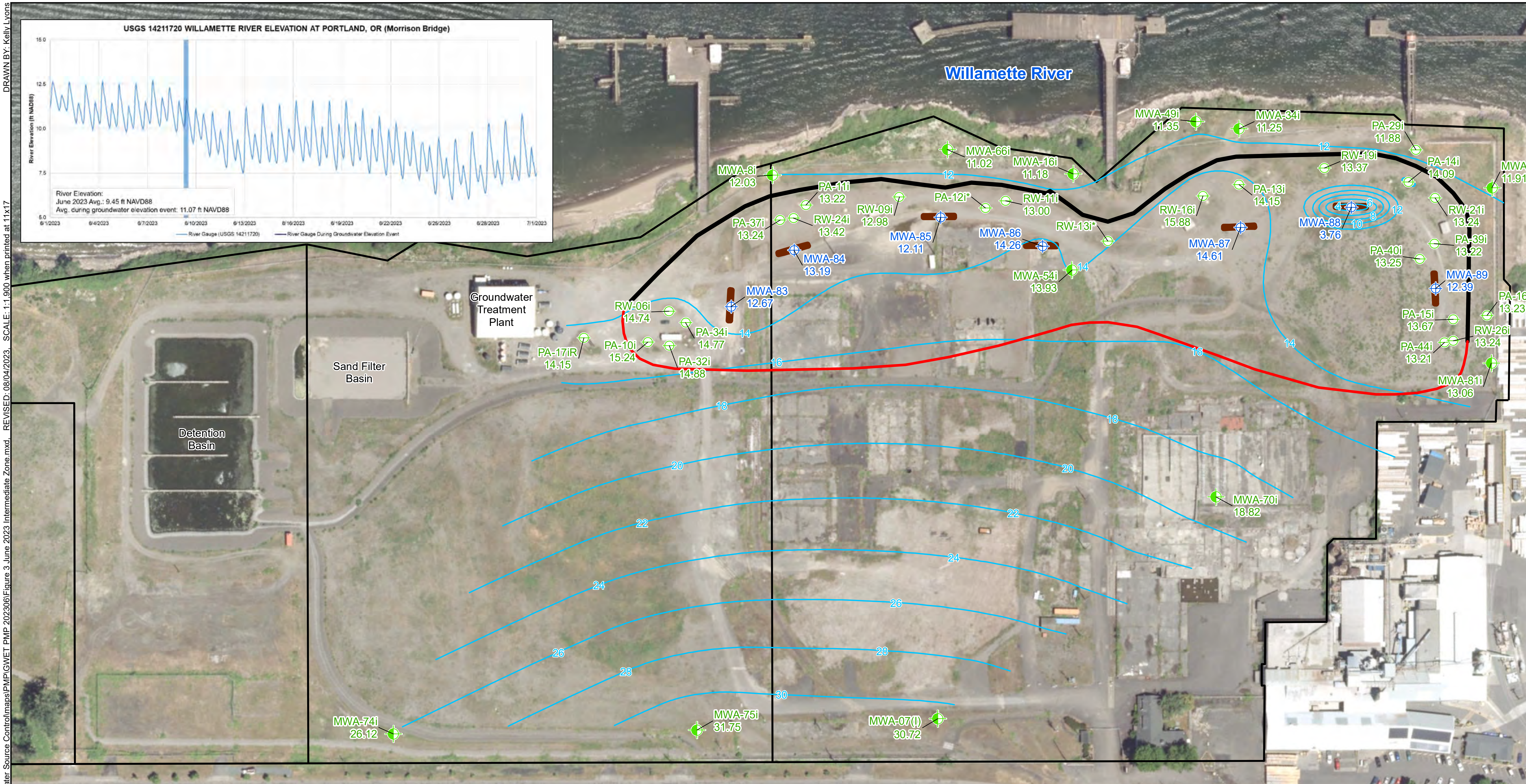
N

0 160 320
Feet

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

Figure 2
June 2023 Shallow Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM



Legend

- Intermediate Zone Piezometer
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected June, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 3
June 2023 Intermediate Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

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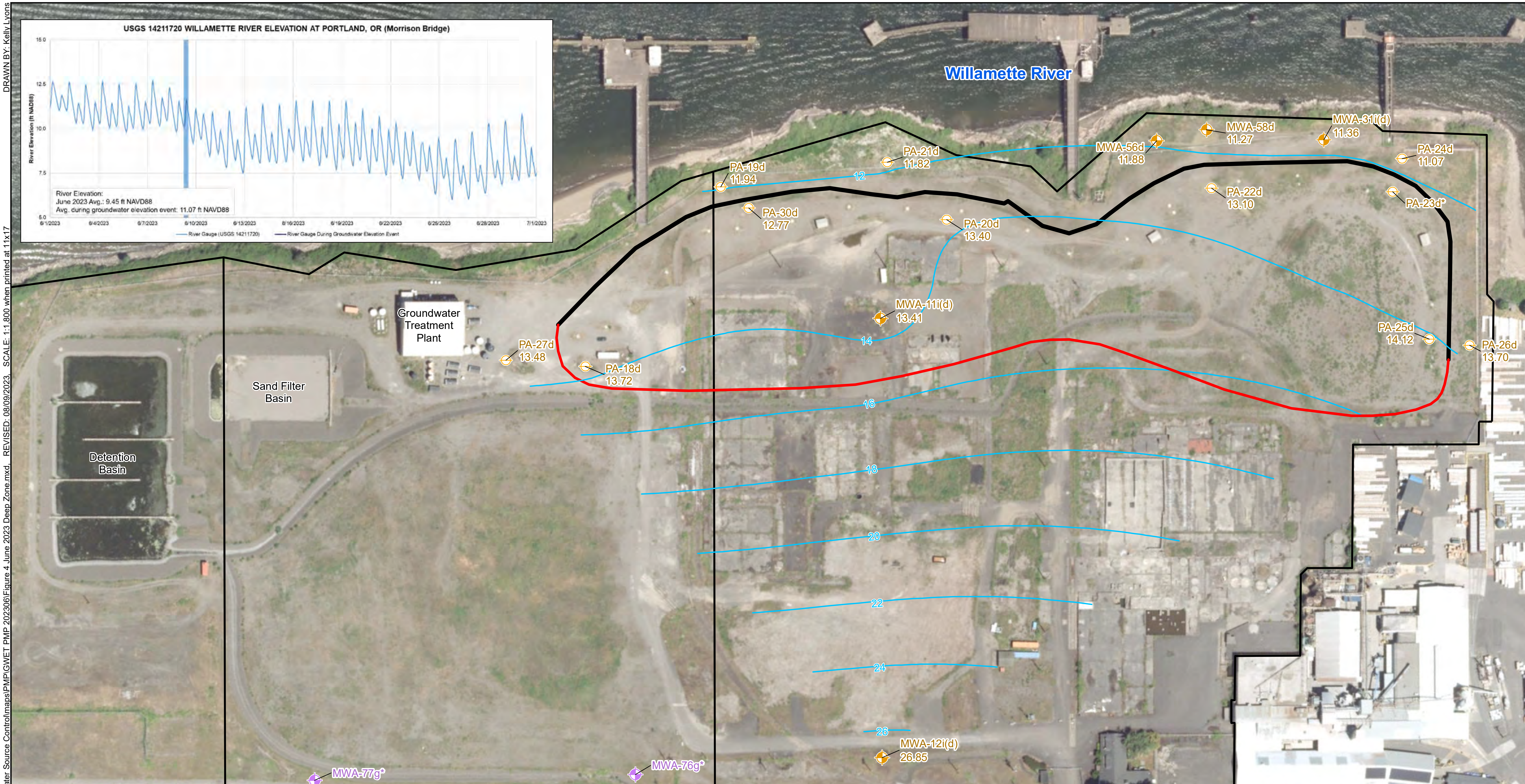

Legend

- Deep Zone Piezometer
- Deep Zone Monitoring Well
- Gravel Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Deep Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment

Notes:
* Value not used for contouring.
Gravel zone wells not used in contouring.
Water levels collected June, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 150 300
Feet

Figure 4
June 2023 Deep Zone Groundwater Contours
Monthly Performance Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

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NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Shallow Zone Recovery Well
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Vertical Gradient not calculated due to anomalous groundwater elevation reading
- Downward Flow
- Upward Flow

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as shallow zone minus intermediate zone potentiometric surfaces.
Water levels collected June, 2023.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260

Feet

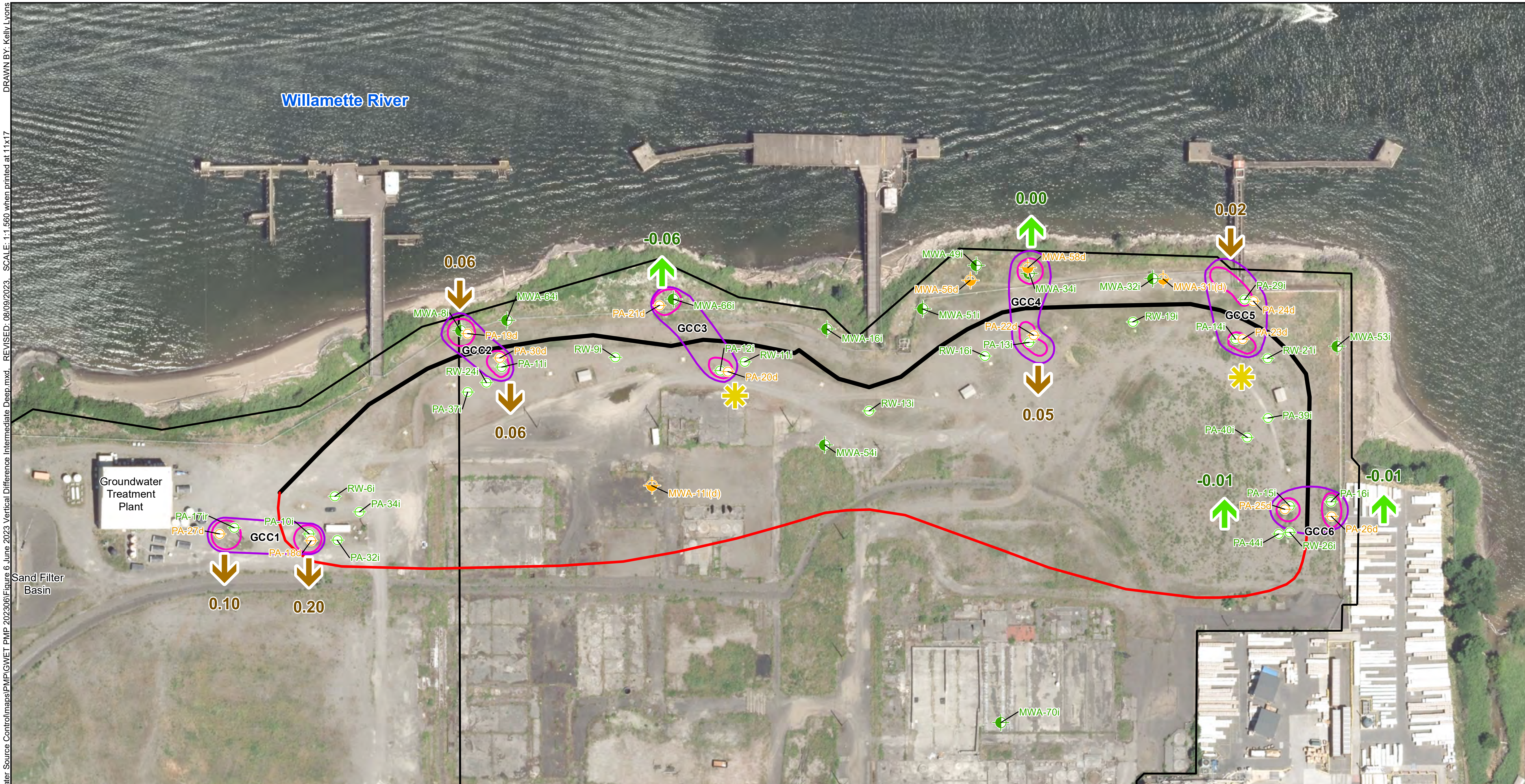
Figure 5

June 2023 Shallow to Intermediate Zone Vertical Head Difference

Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Vertical Gradient not calculated due to anomalous groundwater elevation reading
- Downward Flow
- Upward Flow

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as intermediate zone minus deep zone potentiometric surfaces.
Water levels collected June, 2023.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 6
June 2023 Intermediate to Deep Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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ERM

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NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

ATTACHMENT A-1 TRANSDUCER FLAGS

Attachment A-1. Transducer Flags

Table A-1
Transducer Malfunction Log: June 2023
Arkema Inc. Facility
Portland, Oregon

Gradient Cluster	Transducer	Interval	Date Range		Issue and Repairs Performed
N/A	RW-15	Shallow	Not started		Transducer turned on following upgrades, but found to be non-operational. Replaced transducer ordered.
N/A	RW-11i	Intermediate	Not started		Transducer turned on following upgrades, but found to be non-operational. Replaced transducer ordered.
N/A	RW-18	Shallow	6/14/2023	6/21/2023	Transducer turned on following upgrades, but found to be non-operational. Replaced transducer.
1	PA-17i	Intermediate	6/22/2023	6/24/2023	Transducer faulted. Replaced transducer.

Notes:

I/O = input/output

LOTO = lockout/tagout

VFD = variable frequency drive

ATTACHMENT A-2 RECOVERY WELL STATUS

Attachment A-2. Recovery Well Status

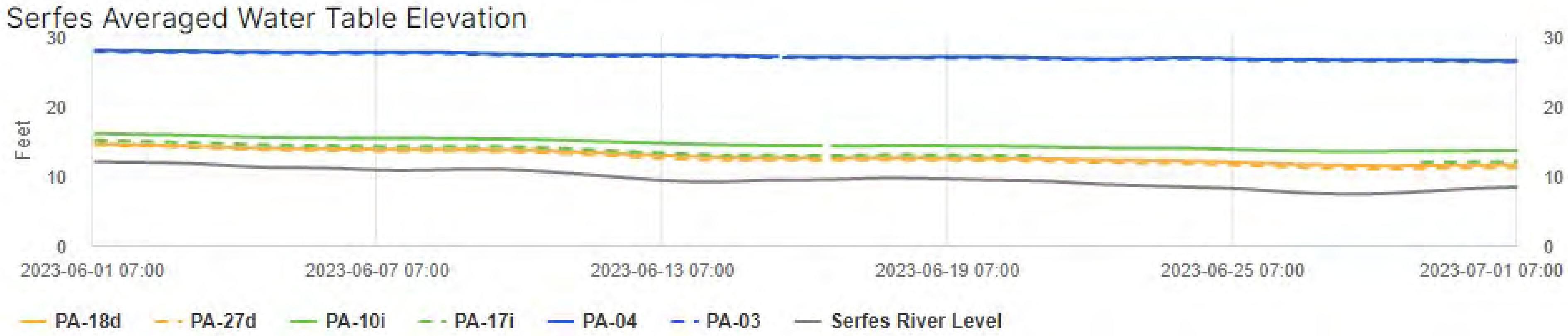
Table A-2
Recovery Well Status: June 2023
Arkema Inc. Facility
Portland, Oregon

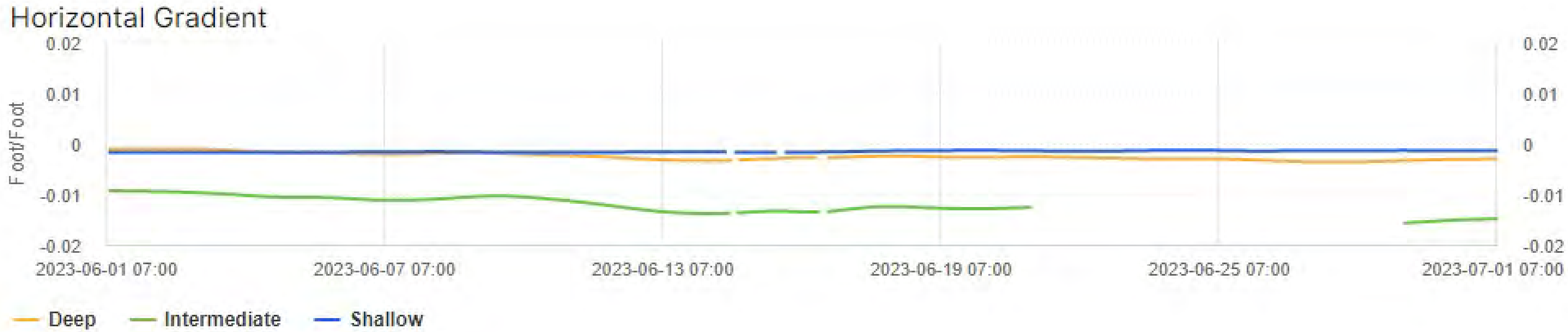
Recovery Well ID	Status as of 5/31/2023 (active or inactive)	Issue	Actions to get online	Expected date back online	Transducer Status	Totalizer Status	Average Flow Rate (gpm)	Overall Extraction Rate	Notes
RW-14	Inactive	None	N/A	N/A	Good	Good	0.00	OFF*	Well turned off due to sufficient flow from other wells
RW-22	Inactive	Totalizer failure	Replace totalizer	N/A	Good	Bad	0.00	OFF*	Totalizer failed, will be replaced
RW-23	Active	None	N/A	N/A	Good	Good	2.09	M	
RW-25	Inactive	None	N/A	N/A	Good	Good	0.00	OFF*	Well turned off due to sufficient flow from other wells
EW-01	Active	None	N/A	N/A	Good	Good	5.13	G	
EW-02	Active	None	N/A	N/A	Good	Good	3.56	G	
EW-03	Active	None	N/A	N/A	Good	Good	2.36	M	
EW-04	Active	None	N/A	N/A	Good	Good	3.40	G	
EW-05	Active	None	N/A	N/A	Good	Good	4.57	G	
EW-06	Active	None	N/A	N/A	Good	Good	5.30	G	
EW-07	Active	None	N/A	N/A	Good	Good	6.17	G	
EW-08	Active	None	N/A	N/A	Good	Good	3.92	G	
EW-09	Active	None	N/A	N/A	Good	Good	3.90	G	
EW-10	Active	None	N/A	N/A	Good	Good	4.30	G	
EW-11	Active	None	N/A	N/A	Good	Good	3.45	G	
EW-12	Active	None	N/A	N/A	Good	Good	2.27	M	
EW-13	Active	None	N/A	N/A	Good	Good	4.92	G	
EW-14	Active	None	N/A	N/A	Good	Good	10.39	G	

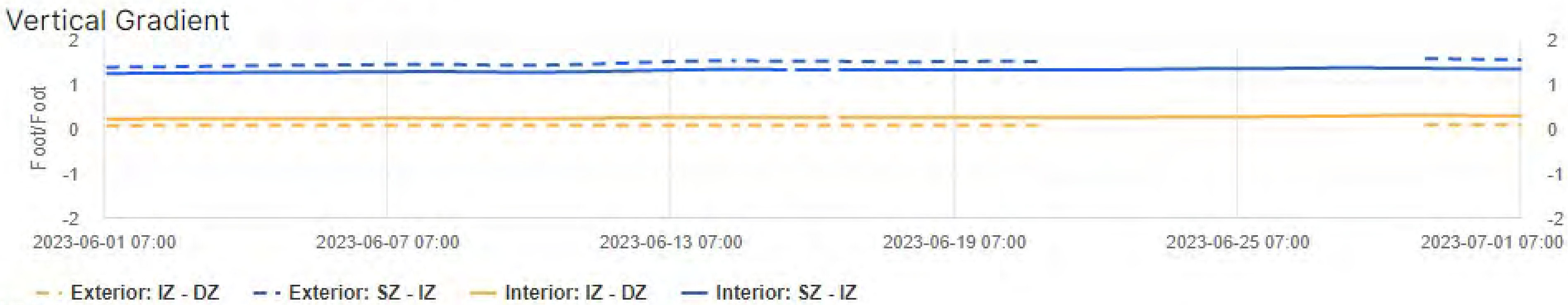
Notes:
** Recovery wells not in service*
*** Recovery wells in service part of the month*
G = good pumping, greater than 3.0 gpm
gpm = gallons per minute
M = moderate pumping, greater than 1.0 gpm and less than 3.0
P = poor pumping, less than 1.0 gpm
VFD = variable frequency drive
PA = piezometer

ATTACHMENT B-1 GRADIENT HYDROGRAPHS

Gradient Control Cluster 1



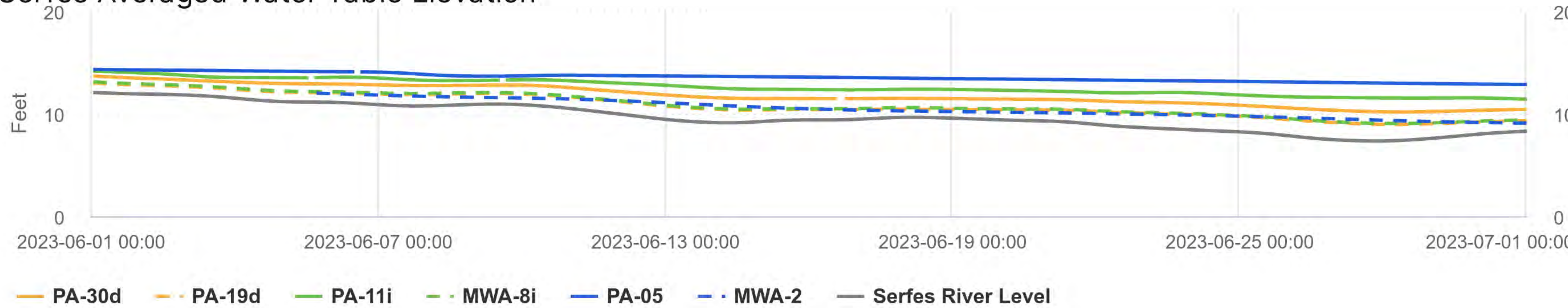




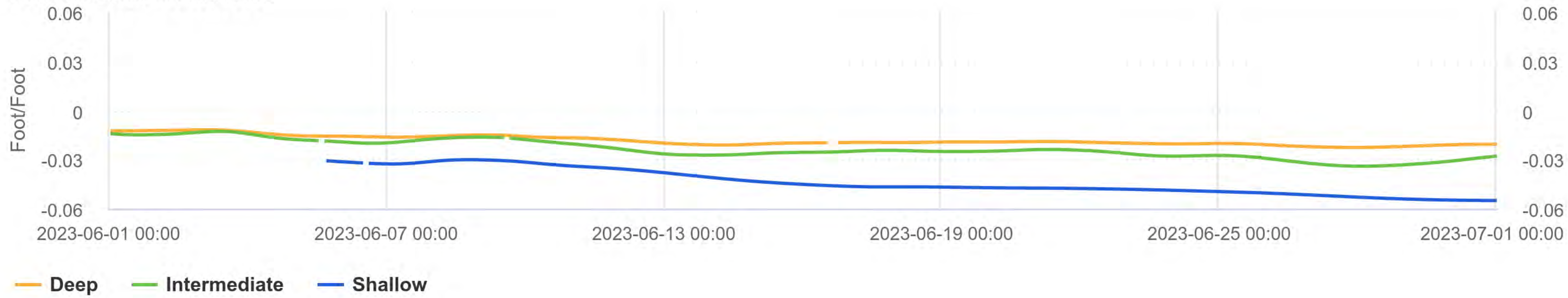
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 2

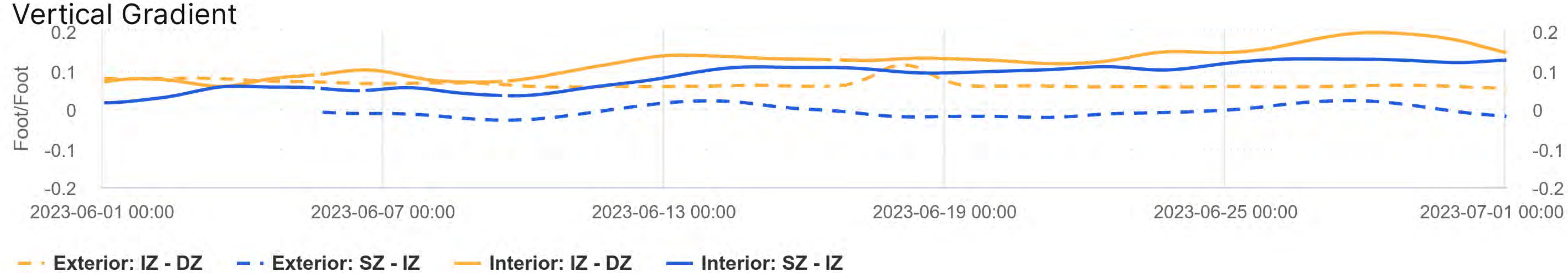
Serfes Averaged Water Table Elevation



Horizontal Gradient



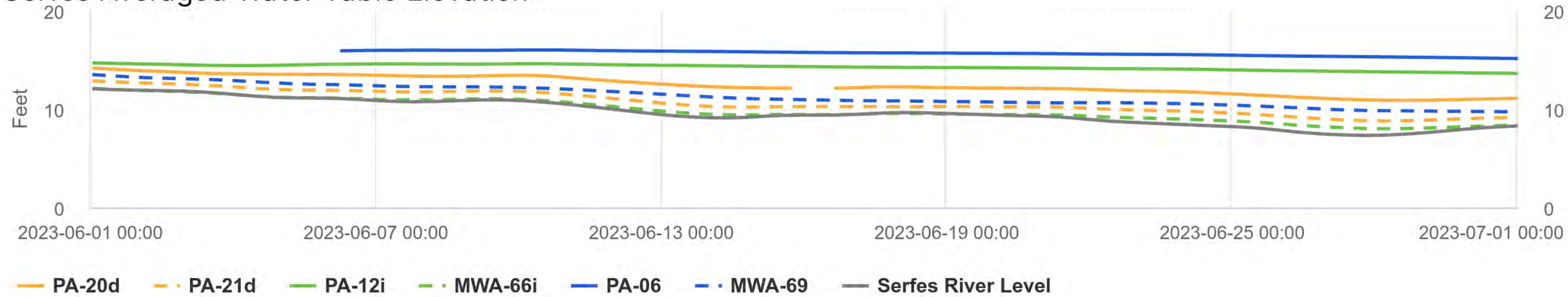
Vertical Gradient



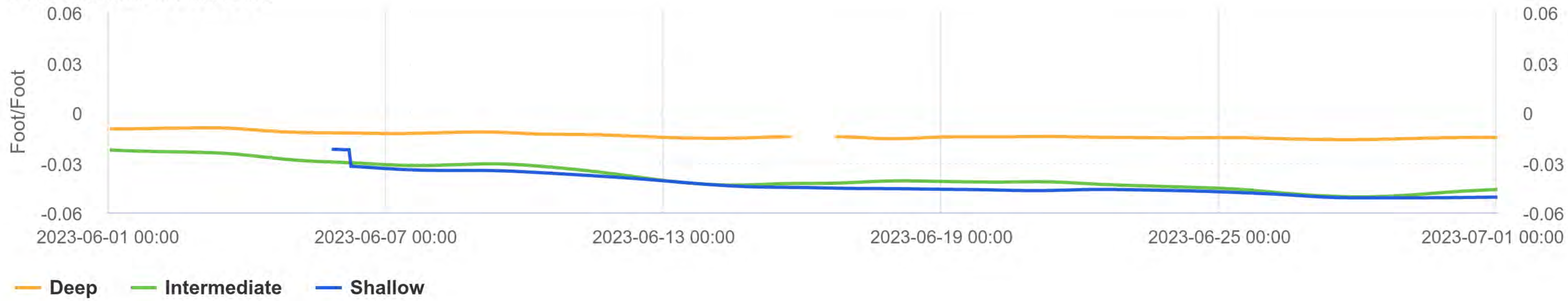
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 3

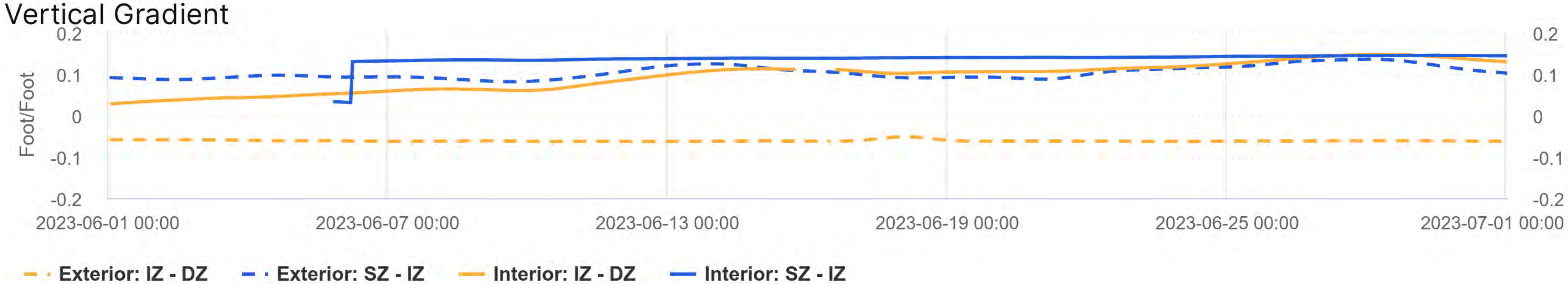
Serfes Averaged Water Table Elevation



Horizontal Gradient



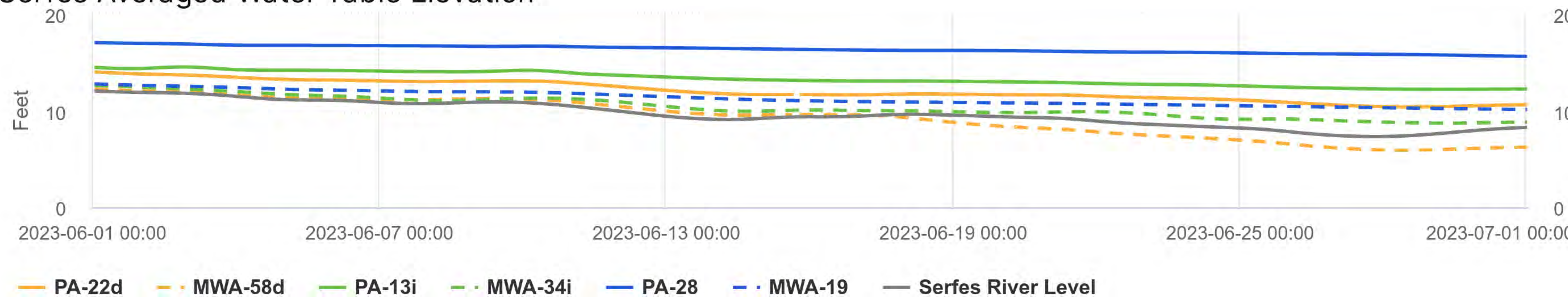
Vertical Gradient



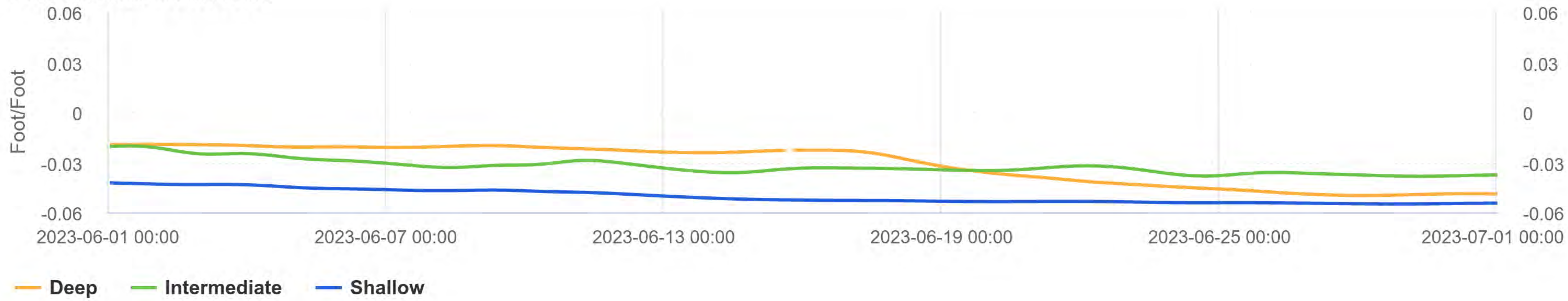
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 4

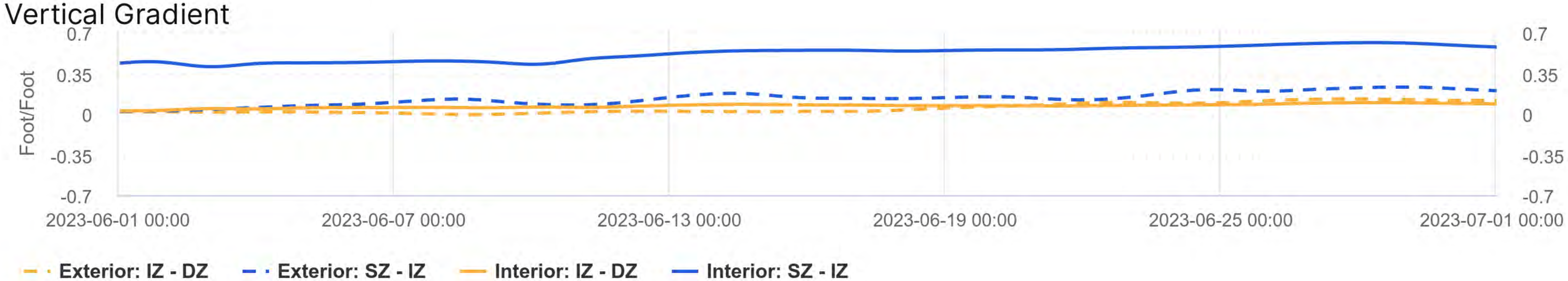
Serfes Averaged Water Table Elevation



Horizontal Gradient

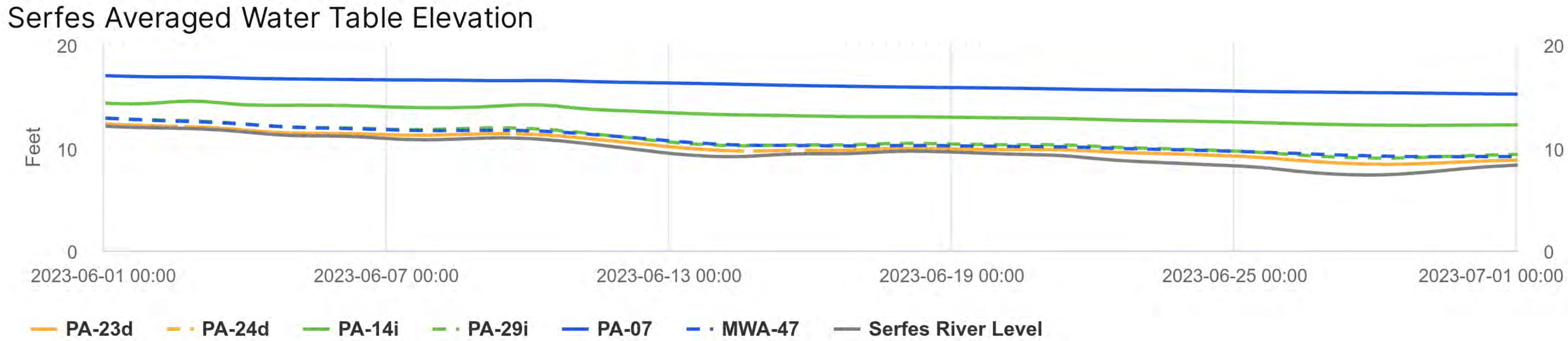


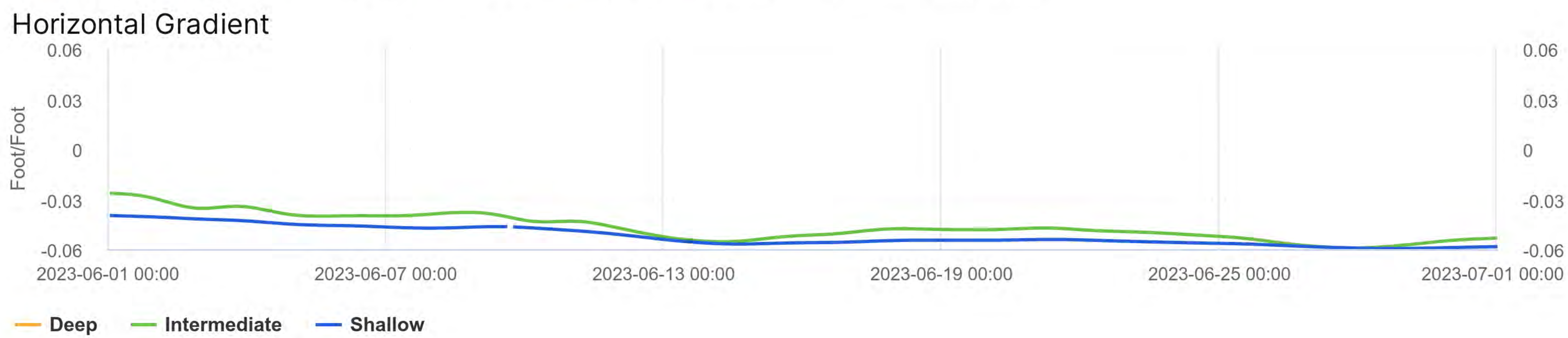
Vertical Gradient

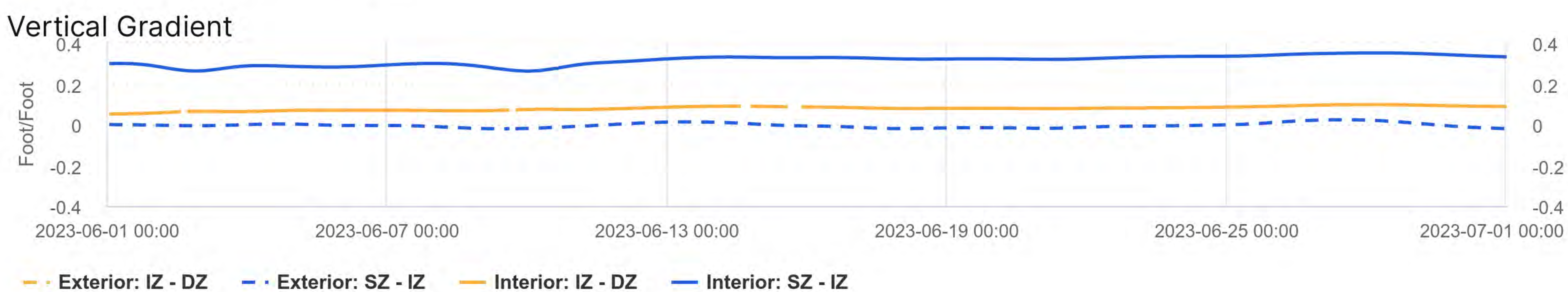


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 5



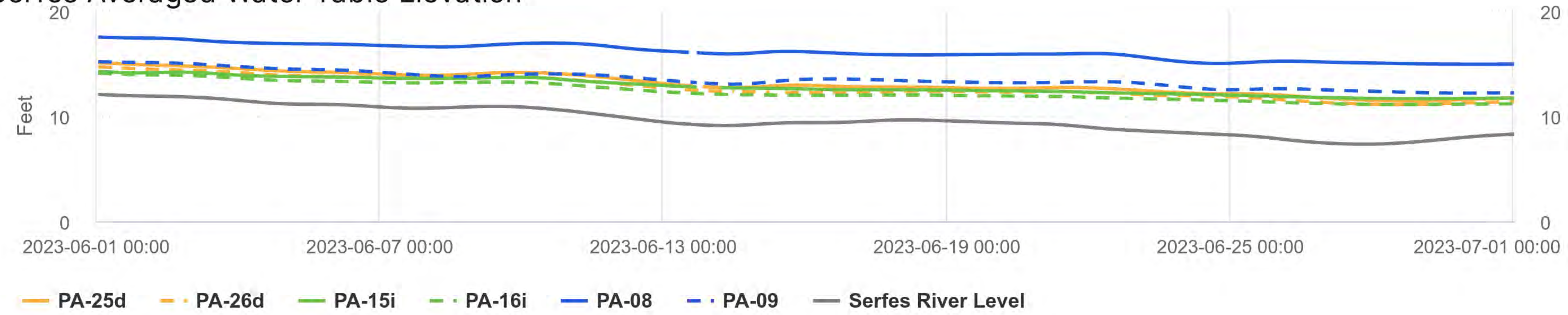




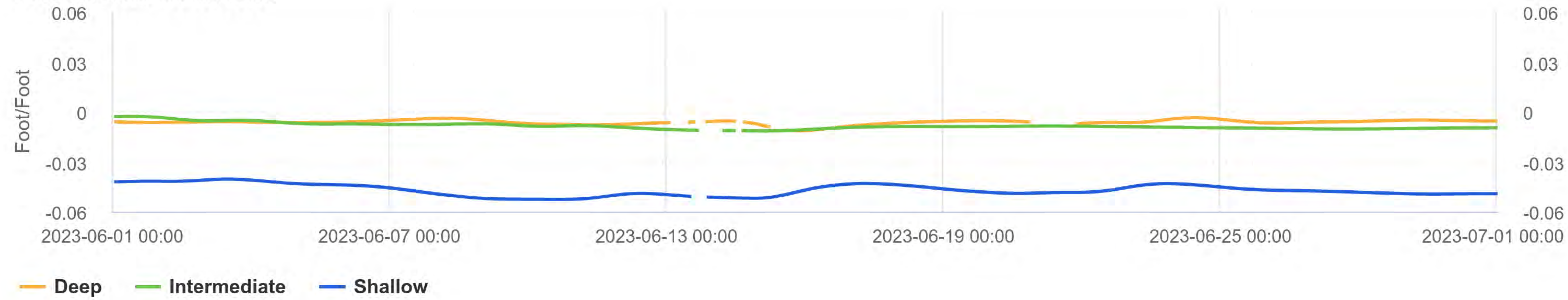
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 6

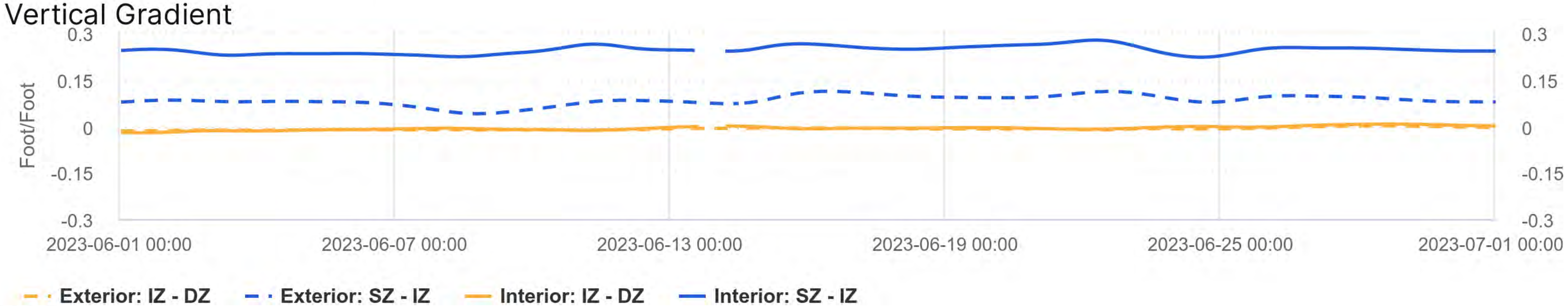
Serfes Averaged Water Table Elevation



Horizontal Gradient



Vertical Gradient

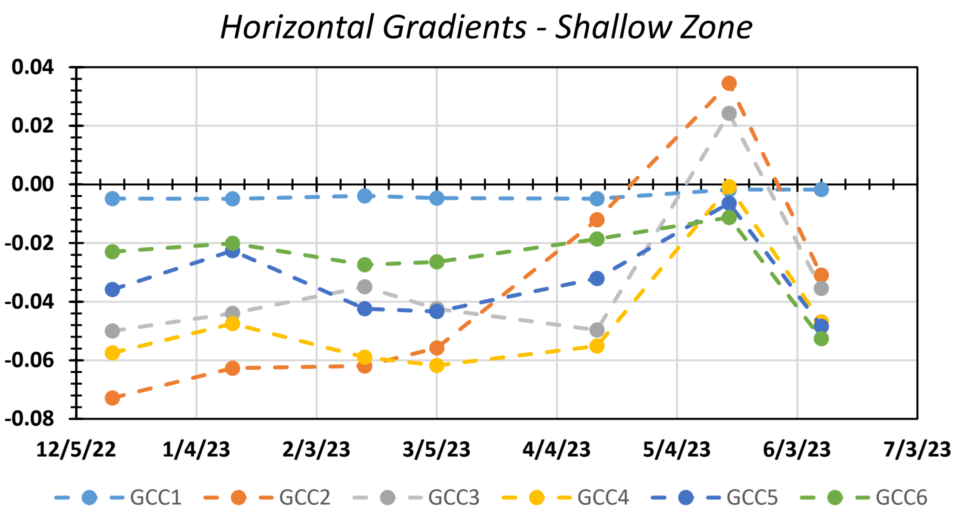


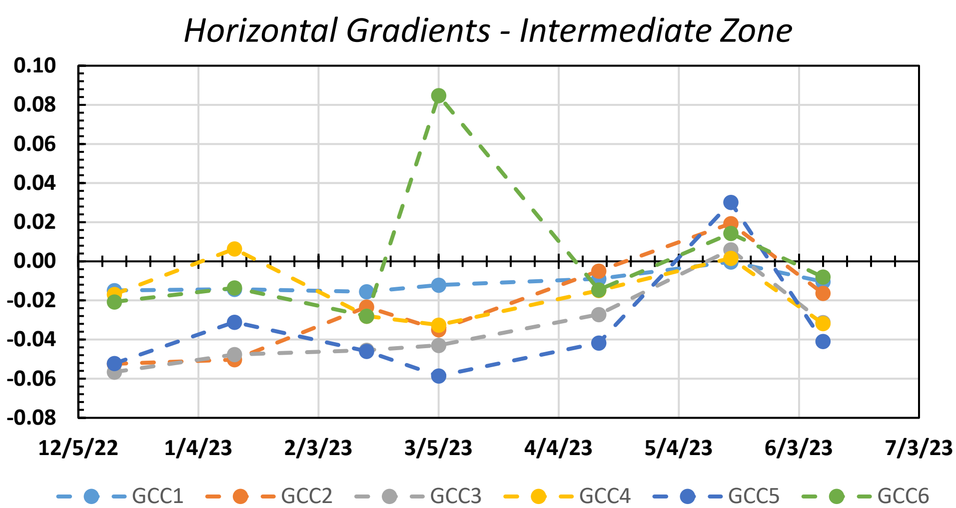
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

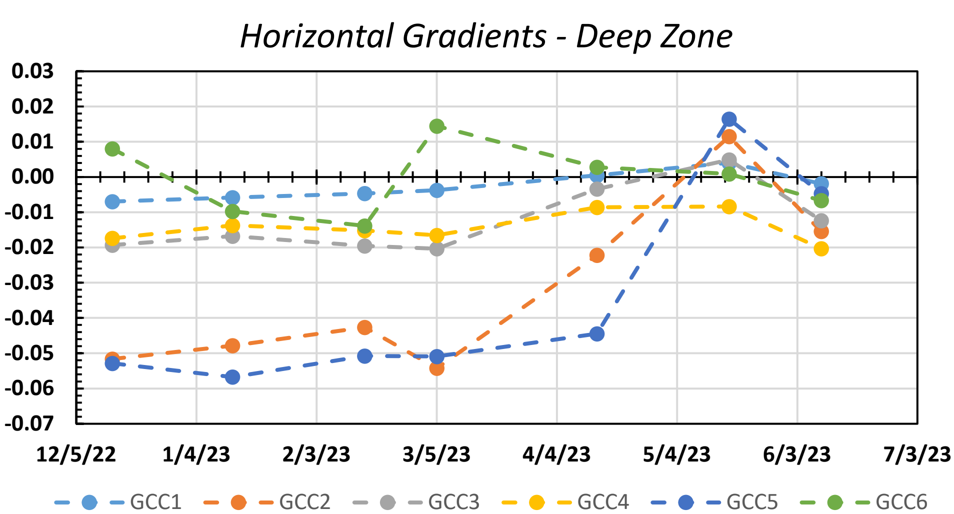
ATTACHMENT B-2 HORIZONTAL GRADIENTS

Attachment B-2

Horizontal Gradients Summary: June 2023
Arkema Inc. Facility
Portland, Oregon



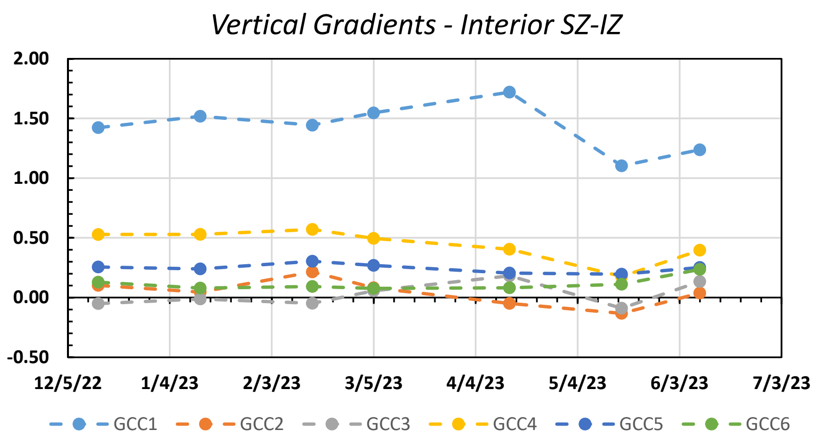


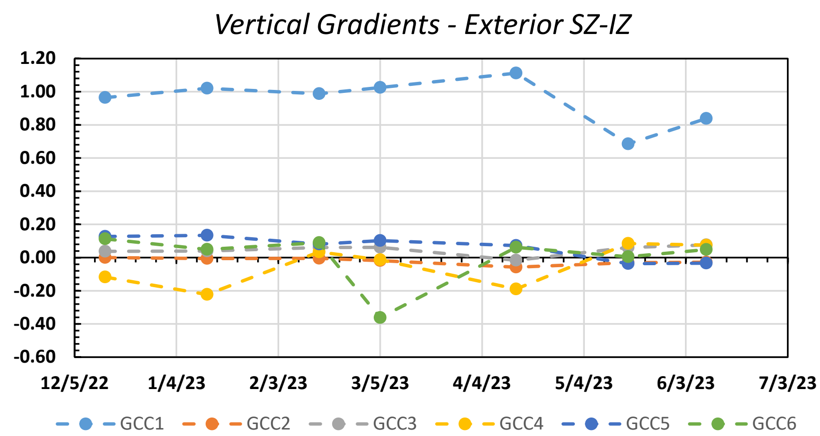


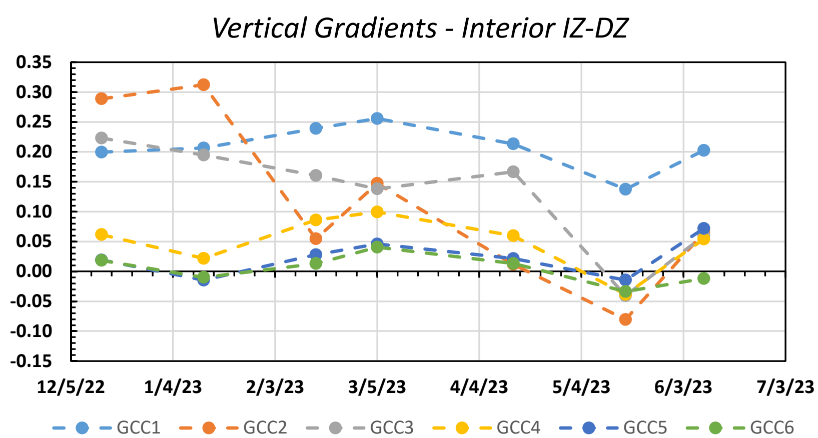
ATTACHMENT B-3 VERTICAL GRADIENTS

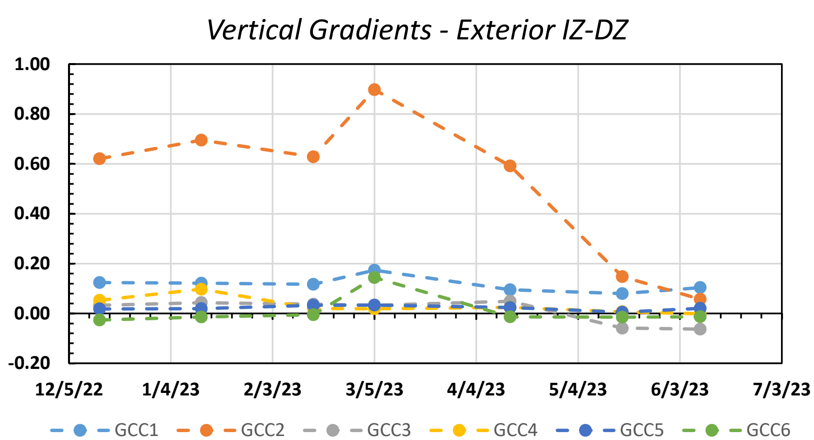
Attachment B-3

Vertical Gradients Summary: June 2023
Arkema Inc. Facility
Portland, Oregon



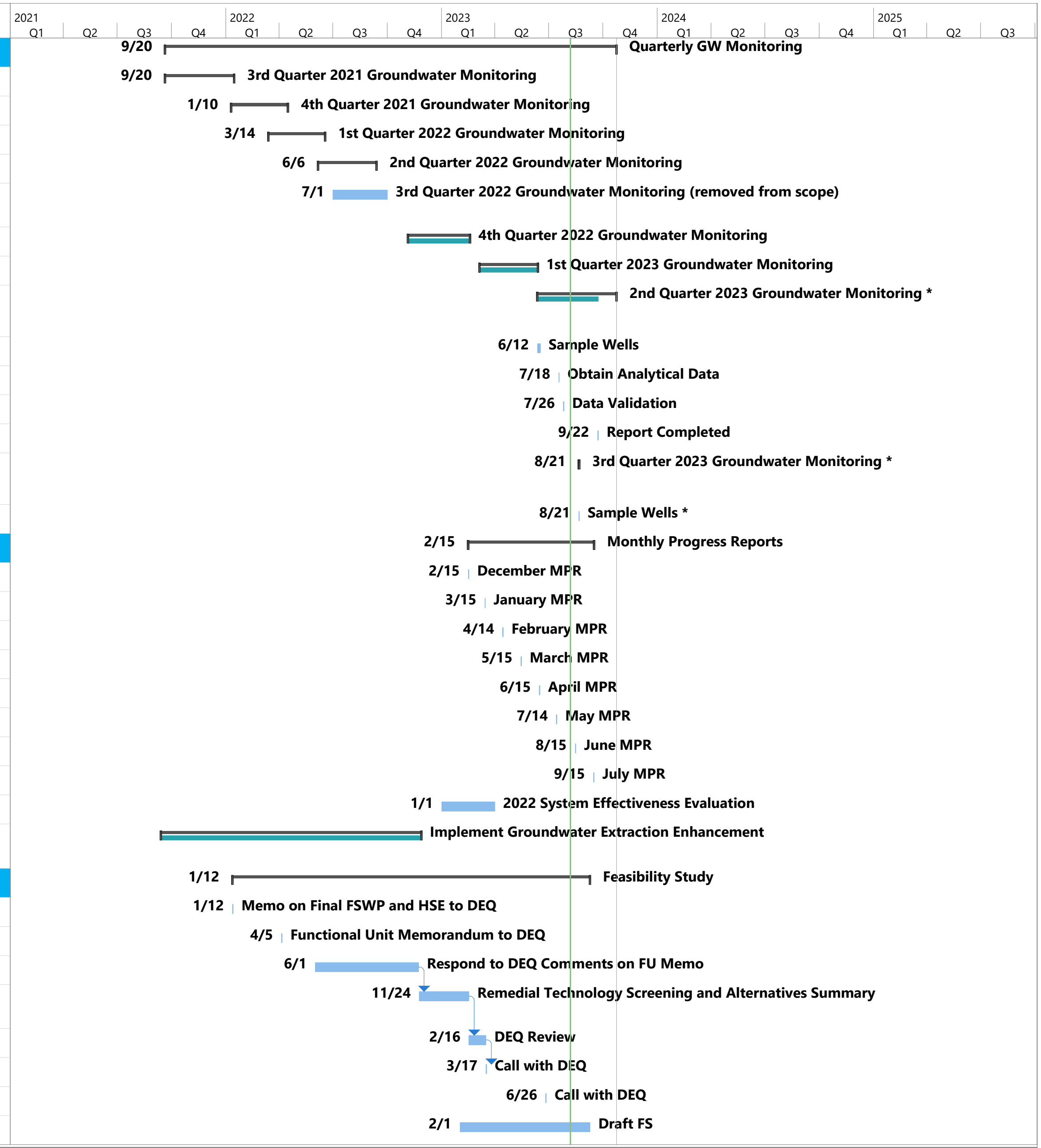






ATTACHMENT C PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**Quarterly GW Monitoring**	**549 days**	**Mon 9/20/21**	**Mon 10/23/23**
2	3rd Quarter 2021 Groundwater Monitoring	85 days	Mon 9/20/21	Fri 1/14/22
7	4th Quarter 2021 Groundwater Monitoring	70 days	Mon 1/10/22	Fri 4/15/22
11	1st Quarter 2022 Groundwater Monitoring	70 days	Mon 3/14/22	Fri 6/17/22
16	2nd Quarter 2022 Groundwater Monitoring	71 days	Mon 6/6/22	Mon 9/12/22
21	3rd Quarter 2022 Groundwater Monitoring (removed from scope)	66 days	Fri 7/1/22	Fri 9/30/22
22	4th Quarter 2022 Groundwater Monitoring	78 days	Sat 11/5/22	Fri 2/17/23
27	1st Quarter 2023 Groundwater Monitoring	71 days	Mon 3/6/23	Mon 6/12/23
32	**2nd Quarter 2023 Groundwater Monitoring ***	**96 days**	**Mon 6/12/23**	**Mon 10/23/23**
33	Sample Wells	5 days	Mon 6/12/23	Fri 6/16/23
34	Obtain Analytical Data	1 day	Tue 7/18/23	Tue 7/18/23
35	Data Validation	1 day	Wed 7/26/23	Wed 7/26/23
36	Report Completed	1 day	Fri 9/22/23	Fri 9/22/23
37	**3rd Quarter 2023 Groundwater Monitoring ***	**1 day**	**Mon 8/21/23**	**Mon 8/21/23**
38	Sample Wells *	1 day	Mon 8/21/23	Mon 8/21/23
39	**Monthly Progress Reports**	**153 days**	**Wed 2/15/23**	**Fri 9/15/23**
40	December MPR	1 day	Wed 2/15/23	Wed 2/15/23
41	January MPR	1 day	Wed 3/15/23	Wed 3/15/23
42	February MPR	1 day	Fri 4/14/23	Fri 4/14/23
43	March MPR	1 day	Mon 5/15/23	Mon 5/15/23
44	April MPR	1 day	Thu 6/15/23	Thu 6/15/23
45	May MPR	1 day	Fri 7/14/23	Fri 7/14/23
46	June MPR	1 day	Tue 8/15/23	Tue 8/15/23
47	July MPR	1 day	Fri 9/15/23	Fri 9/15/23
48	2022 System Effectiveness Evaluation	66 days	Sun 1/1/23	Fri 3/31/23
49	Implement Groundwater Extraction Enhancement	317 days	Mon 9/13/21	Sun 11/27/22
57	**Feasibility Study**	**436 days**	**Wed 1/12/22**	**Fri 9/8/23**
58	Memo on Final FSWP and HSE to DEQ	1 day	Wed 1/12/22	Wed 1/12/22
59	Functional Unit Memorandum to DEQ	1 day	Tue 4/5/22	Tue 4/5/22
60	Respond to DEQ Comments on FU Memo	126 days	Wed 6/1/22	Tue 11/22/22
61	Remedial Technology Screening and Alternatives Summary	62 days	Thu 11/24/22	Wed 2/15/23
62	DEQ Review	21 days	Thu 2/16/23	Thu 3/16/23
63	Call with DEQ	1 day	Fri 3/17/23	Fri 3/17/23
64	Call with DEQ	1 day	Mon 6/26/23	Mon 6/26/23
65	Draft FS	158 days	Wed 2/1/23	Fri 9/8/23



Arkema Portland
Monthly Progress Report
Attachment C

Task	Project Summary	Manual Task	Start-only
Split	Inactive Task	Duration-only	Finish-only
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks
Summary	Inactive Summary	Manual Summary	External Milestone
Deadline	Progress	Manual Progress	

* - Indicates dates that are tentative

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Memo

To	Katie Daugherty, Oregon Department of Environmental Quality
From	Brendan Robinson, PE, Environmental Resources Management, Inc.
Date	15 September 2023
Reference	0682894 Phase 204
Subject	July 2023 GW SCM Monthly Performance Monitoring Report

1. INTRODUCTION

Environmental Resources Management, Inc. (ERM) prepared this Monthly Performance Monitoring Report (MPR) on behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc. (Arkema), for the former Arkema Portland Plant (the Site) at 6400 NW Front Avenue in Portland, Oregon. The Oregon Department of Environmental Quality (ODEQ), in its letter dated 31 May 2019 and in the subsequent meeting with LSS and ERM on 2 July 2019, requested that LSS initiate monthly status reports associated with the onsite groundwater source control measure (GW SCM) consistent with the Performance Monitoring Plan (PMP; ERM 2014) beginning July 2019. The 2014 PMP was prepared pursuant to the Order on Consent issued by ODEQ, signed on 31 October 2008 (ODEQ No. LQVC-NWR-08-04; Consent Order). The purpose of the PMP was to present the monitoring, reporting, and adaptive management processes used during implementation of the GW SCM. On 30 November 2021, ODEQ directed LSS that following the October 2021 MPR, subsequent MPRs would be suspended pending the implementation of the Groundwater Extraction Enhancement (GEE) project in 2022. During that time, ODEQ requested monthly schedule updates in lieu of MPRs. The trench wells installed as part of the GEE project were started on 27 November 2022, and MPR writing restarted in December 2022. The purpose of the GEE project was to install new extraction capacity to achieve the Capture Zone Objectives.

This July 2023 MPR summarizes the GW SCM performance monitoring data collected in July 2023. This report assesses the current gradient status and proposes system improvements to meet the Capture Zone Objectives set in the PMP.

2. GROUNDWATER SOURCE CONTROL IMPLEMENTATION

A detailed description of the design and implementation of the GW SCM is provided in the *Revised Upland Feasibility Study Work Plan* (ERM 2017); however, a brief description of the GW SCM is provided here. In February 2009, ODEQ and the U.S. Environmental Protection Agency (USEPA) approved the general approach for the GW SCM. This approach included installation of a groundwater barrier wall (GWBW), groundwater recovery wells, and a Groundwater Extraction and Treatment (GWET) system, with treated water discharged to the Willamette River. ODEQ and USEPA approved the *Groundwater Barrier Wall Final Design* (ERM 2012) on 7 August 2012. Construction of the GWBW began in May 2012 and was completed in December 2012. ODEQ approved the *Groundwater Extraction and Treatment System Final Design* (ERM 2013) on 2 April

2013. Construction of the GWET system began in December 2012 and was completed in December 2013.

GWET startup and optimization commenced in May 2014. The GW SCM at the Site consists of the following primary components (Figure 1):

1. A GWBW to physically separate the affected upland portions and in-water portions of the Site.

2. Hydraulic control to minimize flow of groundwater containing unacceptable concentrations of constituents of potential concern (COPCs) around, over, and under the GWBW.

3. Management of extracted groundwater through the GWET system, with treated effluent discharged to the Willamette River under a National Pollutant Discharge Elimination System (NPDES) Permit.

On 1 September 2018, ERM submitted the *Draft GWET System Effectiveness Evaluation* (Draft SEE Report; ERM 2018). The Draft SEE Report provided an update on the corrective actions implemented to improve the performance of the GWET system, evaluate the extent of capture, and propose actions to improve hydraulic capture. Additional data requested by ODEQ were submitted on 26 October 2018.

The key objective of the GW SCM is to achieve hydraulic containment of the alluvial sequence within the Target Capture Zone at the Site to prevent the flow of COPCs to the Willamette River. The Site alluvial aquifer sequence within the Target Capture Zone consists of the Shallow Zone, Intermediate Zone, and the Deep Zone. Site hydraulic conditions are variable and subject to both seasonal and daily tidal fluctuations.

The hydraulic control component formerly consisted of 22 recovery wells (RWs) prior to the implementation of the GEE. Of the 22 pre-existing RWs, four were retained for active pumping. The remaining 18 former RWs had pumps removed but retained their pressure transducers so that they can continuously collect high-resolution groundwater elevation data. The hydraulic control system now consists of the four remaining active RWs, as well as seven groundwater extraction trenches that each contain two extraction wells (EWs). Each trench is 50 feet deep, 50 feet long, and 3 feet wide and is filled with an engineered backfill. More information about the groundwater extraction trenches is provided in the *Final Design Report* (ERM 2022). The gradient control-monitoring network consists of six gradient control clusters (GCCs) with each cluster containing six monitoring points. Within each RW, EW, and GCC location, pressure transducers are continuously collecting high-resolution groundwater elevation data. Each GCC contains three transducers interior to the wall and three transducers exterior to the wall screened in the Shallow, Intermediate, and Deep aquifers at the Site.

3. HYDRAULIC CONTAINMENT MONITORING PROGRAM

As described in the PMP, the purpose of hydraulic monitoring (i.e., groundwater elevation data) is to provide sufficient data to demonstrate an inward hydraulic gradient across the GWBW and to evaluate the effective hydraulic capture produced by the GW SCM.

Monitoring requirements were established in the PMP to demonstrate GWET effectiveness. The Site monitoring program includes groundwater elevation data (manual and transducer measurements) collected from the 36 monitoring points located within six GCCs spaced across the GWBW, with piezometers interior and exterior to the wall, throughout the alluvial sequence; and groundwater elevation and flow rate data from the four remaining active RWs and 14 EWs. High-resolution groundwater elevation data is also collected from the 18 inactive RWs. Additionally, one new monitoring well was installed in each of the seven extraction trenches for manual water level measurement. These data were used to prepare horizontal and vertical potentiometric surface maps representing potentiometric differences between the alluvial sequences, and to generate spatial and temporal hydrographs to evaluate hydraulic capture.

3.1 Groundwater Elevation Monitoring

Groundwater elevation monitoring was completed on 19 July 2023. Manual groundwater elevations were measured at wells that were experiencing transducer mechanical issues or that were offline during the groundwater elevation measurement event. All inactive RWs were manually measured in the month of July to affirm proper calibration. Manual water levels for those RWs are reported. Additionally, all transducers in inactive RWs were down until upgrades were completed and transducers were sequentially turned on. Specific issues are addressed in Attachment A-1.

As detailed in Attachments A-1 and A-2, during July 2023, the following transducers were:

<u>Fully out of service pending repairs:</u>

- RW-11i
- RW-15

<u>Out of service for a period but returned to full operation:</u>

- RW-25

3.2 Horizontal and Vertical Gradients at Gradient Control Points

As described above, GCC locations collect high-resolution groundwater elevation data using transducers. Transducer data are filtered to remove anomalous data from monitoring points due to potential equipment failures, such as transducer malfunctions, power outages, or updates to the GWET programmable logic controller (PLC) system, which controls and houses all the operational data. These specific issues and time periods are summarized in Table A-1 in Attachment A. The following flags are applied to filter anomalous data:

- Groundwater elevations had a change greater than 1.5 feet within 1 hour
- Groundwater elevation measurements that were found to be greater than 50 feet, or less than 1 foot
- Calculated groundwater elevation slope indicates no change between consecutive measurements indicating a transducer malfunction
- Manually flagging data that are inconsistent with the typical nature of the well

- Periods where transducer power supply was deactivated for work on interconnected electrical systems

After July 2023 flagged data were removed, the Serfes (1991) method was used to account for tidal variations as described in the PMP. Using Serfes corrected data, both horizontal and vertical gradients were calculated and plotted over time (Attachment B). Groundwater elevations, horizontal gradients, and vertical gradients from 19 July 2023 are shown below at each GCC (Table 1-1 and Table 1-2). The water elevation taken during the groundwater level gauging event at PA-08 was excluded from gradient calculations and potentiometric surface maps due to being anomalous.

Table 1-1. July Horizontal Gradients

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
GCC1	Shallow	PA-03	25.75	PA-04	25.88	-0.001
	Intermediate	PA-17iR	12.09	PA-10i	13.54	-0.014
	Deep	PA-27d	11.26	PA-18d	11.73	-0.004
GCC2	Shallow	MWA-2	9.01	PA-05	12.52	-0.051
	Intermediate	MWA-8i	9.58	PA-11i	11.61	-0.028
	Deep	PA-19d	9.53	PA-30d	10.81	-0.024
GCC3	Shallow	MWA-69	9.42	PA-06 M	12.83	-0.032
	Intermediate	MWA-66i	8.55	PA-12i	13.54	-0.044
	Deep	PA-21d	9.42	PA-20d	11.69	-0.018
GCC4	Shallow	MWA-19	9.76	PA-28	15.19	-0.054
	Intermediate	MWA-34i	9.01	PA-13i	12.73	-0.041
	Deep	MWA-58d M	8.81	PA-22d	11.03	-0.025
GCC5	Shallow	MWA-47	9.19	PA-07	14.87	-0.055
	Intermediate	PA-29i	9.50	PA-14i	12.70	-0.059
	Deep	PA-24d	8.79	PA-23d	10.21	-0.027
GCC6	Shallow	PA-09	12.37	PA-08	*	**
	Intermediate	PA-16i	11.25	PA-15i	11.98	-0.013
	Deep	PA-26d	11.63	PA-25d	12.01	-0.006

Notes:

Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.

Horizontal gradient calculated as (Exterior Elevation – Interior Elevation) / Horizontal distance.

** = anomalous groundwater elevation; ** = horizontal gradient cannot be calculated due to anomalous elevation reading; ft NAVD88 = feet North American Vertical Datum of 1988; M = manual groundwater elevation measurement*

Table 1-2. July Vertical Gradients

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
Interior	SZ-IZ	GCC1	PA-04	25.88	PA-10i	13.54	1.25
		GCC2	PA-05	12.52	PA-11i	11.61	0.08
		GCC3	PA-06 [M]	12.83	PA-12i	13.54	-0.07
		GCC4	PA-28	15.19	PA-13i	12.73	0.38
		GCC5	PA-07	14.87	PA-14i	12.70	0.23
		GCC6	PA-08	*	PA-15i	11.98	**
	IZ-DZ	GCC1	PA-10i	13.54	PA-18d	11.73	0.24
		GCC2	PA-11i	11.61	PA-30d	10.81	0.12
		GCC3	PA-12i	13.54	PA-20d	11.69	0.09
		GCC4	PA-13i	12.73	PA-22d	11.03	0.09
		GCC5	PA-14i	12.70	PA-23d	10.21	0.06
		GCC6	PA-15i	11.98	PA-25d	12.01	0.00
Exterior	SZ-IZ	GCC1	PA-03	25.75	PA-17iR	12.09	0.87
		GCC2	MWA-2	9.01	MWA-8i	9.58	-0.03
		GCC3	MWA-69	9.42	MWA-66i	8.55	0.06
		GCC4	MWA-19	9.76	MWA-34i	9.01	0.11
		GCC5	MWA-47	9.19	PA-29i	9.50	-0.03
		GCC6	PA-09	12.37	PA-16i	11.25	0.08
	IZ-DZ	GCC1	PA-17iR	12.09	PA-27d	11.26	0.13
		GCC2	MWA-8i	9.58	PA-19d	9.53	0.03
		GCC3	MWA-66i	8.55	PA-21d	9.42	-0.07
		GCC4	MWA-34i	9.01	MWA-58d [M]	8.81	0.01
		GCC5	PA-29i	9.50	PA-24d	8.79	0.02
		GCC6	PA-16i	11.25	PA-26d	11.63	-0.01

Notes:

Positive vertical gradient indicates a downward hydraulic gradient.

Vertical gradient calculated as (Upper Elevation – Lower Elevation) / Screen Midpoint distance.

** = anomalous groundwater elevation; ** = vertical gradient cannot be calculated due to anomalous elevation reading; DZ = Deep Zone; ft NAVD88 = feet North American Vertical Datum of 1988; IZ = Intermediate Zone; [M] = manual groundwater elevation measurement; SZ = Shallow Zone*

3.3 Potentiometric Surface, Groundwater Elevation Difference Maps, and Groundwater Flow Directions

As described in the PMP, potentiometric surface maps are used to evaluate flow paths. Vertical gradients are also used as an additional line of evidence to evaluate hydraulic containment. Groundwater elevation data collected on 19 July 2023 were used to prepare potentiometric surface maps based on manual measurements and averaged transducer groundwater elevations (Figures 2 through 4) and vertical difference maps (Figures 5 and 6).

The generalized flow direction indicated by the potentiometric surface maps shows overall groundwater flow both toward and away from the GWBW, depending on location. The Shallow and Intermediate Zones potentiometric maps (Figures 2 and 3) indicate localized groundwater movement to the extraction trenches due to GW SCM pumping, and inward gradients sporadically along the length of the barrier wall. Localized evidence of capture zones is apparent around all the groundwater extraction trenches, and the trend of the groundwater elevation data suggests they will continue to expand and intersect. Additional evidence of capture is anticipated as ongoing pumping occurs.

A potentiometric separation is still noticeable exterior to the GWBW, indicating the barrier wall is functioning by impeding groundwater flow. Groundwater elevations are demonstrating a slight gradient toward the river.

Horizontal groundwater gradients for the Shallow, Intermediate, and Deep Zones indicated an outward gradient at all GCCs (Attachment B-2) in July 2023. There is a trend of decreasing outward gradient at GCC1, and other GCCs indicate occasional inward gradients over the last few months. River elevations are shown on the potentiometric surface maps in an inset (Figures 2 through 4) and depict stage movement within the month corresponding with the MPR. The river elevation in July 2023 varied with an average of 8.35 feet NAVD88, maximum of 11.69 feet NAVD88, and minimum of 5.81 feet NAVD88. Trends toward inward gradients are anticipated to continue during the upcoming seasonal river stage increases in fall and winter.

Vertical gradients were calculated for each vertical well pair using these groundwater elevations and are plotted on Figures 5 and 6. Vertical groundwater gradients interior to the GWBW between the Shallow and Intermediate Zones were mixed with GCC1, GCC2, GCC4, and GCC5 being upward and GCC3 being downward (Figure 5). The vertical groundwater gradient at GCC6 interior of the wall was unable to be calculated due to an anomalous groundwater elevation reading at PA-08. PA-08 will be recalibrated so that vertical gradients at GCC6 can be calculated in the future and presented in subsequent MPRs. Vertical groundwater gradients are also depicted in Attachment B. The magnitude of the gradient is much greater at GCC1 than other monitoring locations due to the influence from a localized high-pressure zone near GCC1 where vertical groundwater flow is impeded by a localized confining unit (Figure 2). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were mixed with GCC2 and GCC5 being upward and GCC1, GCC3, GCC4, and GCC6 being downward as shown on Figure 5 and in Attachment B.

Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were downward with the exception of GCC6. The direction of vertical gradients exterior to the GWBW were mixed with GCC1, GCC2, GCC4, and GCC5 being downward and the remaining being upward, as shown on Figure 6 and Attachment B.

3.3.1 GWET System Performance

The GWET system operated within permit conditions during the reporting period. There were three shutdowns:

- 10 July 2023: An unplanned shutdown due to a failed UPS battery in the main control panel. The wellfield was restarted the following day after the battery was replaced.
- 15 July 2023: A planned 7-day shutdown for pressure filter maintenance.
- 23 July 2023: The wellfield was restarted after the pressure filter maintenance scope of work was completed. An unplanned shutdown occurred during startup due to the differential pressure for the pressure filters reaching the setpoint for shutdown. The wellfield was restarted the following morning.

There were no upgrades to the GWET system in the month of July 2023.

3.3.2 Recovery Well and Extraction Well Performance

The average system influent flow rate was 28.80 gallons per minute (gpm) for the entire month of July 2023, including nonoperational periods. The average influent flow during operational periods was 49.39 gpm. The groundwater extraction rate and influent flowrates were restricted in the first half of July due to pressure filter fouling. The pressure filter media was replaced between 15 July to 22 July, shutting down the GWET system. The average daily flow rate prior to pressure filter replacement was 34.10 gpm and after replacement was 45.30 gpm. LSS is currently in the process of optimizing extraction rates within the system to increase flow rates at each operational well until either the extraction rates specified in the *Final Design Report* (ERM 2022) are achieved, the wells are producing the maximum quantity of water possible, or until the Capture Zone Objectives are met.

Table 1-3. Recovery Well Pumping Rates

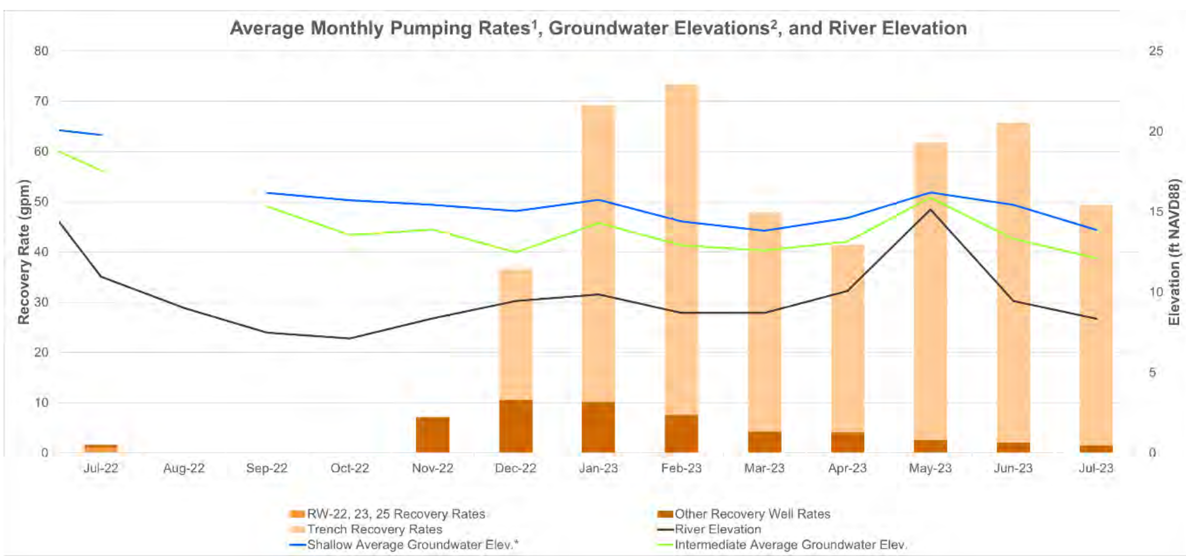
Recovery Well	July 2023 Average Operational Pumping Rate (gpm)	July 2023 Average Pumping Rate (gpm)
RW-14*	0.00	0.00
RW-22*	0.00	0.00
RW-23	1.52	1.03
RW-25*	0.00	0.00
EW-01	4.19	3.11
EW-02	0.84	0.08
EW-03*	0.00	0.00
EW-04	2.85	2.11
EW-05	5.75	4.08

Recovery Well	July 2023 Average Operational Pumping Rate (gpm)	July 2023 Average Pumping Rate (gpm)
EW-06	2.55	0.16
EW-07	3.00	0.48
EW-08	5.14	3.48
EW-09	4.17	3.09
EW-10	3.94	1.27
EW-11	2.48	1.84
EW-12	0.49	0.06
EW-13	2.61	0.67
EW-14	9.86	7.32
Total	**49.39**	**28.80**

Notes:

** = Recovery well not in service during reporting period.*

gpm = gallon per minute



Notes:

[1] = Following installation of trenches in Summer 2022, RW-22, 23, and 25 recovery rates are now grouped together with the other remaining recovery well (RW-14) starting in November 2022.

[2] = Average groundwater elevations are calculated using interior wells—the wellfield was powered down in August preventing the measurement of the groundwater.

** = The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the whole aquifer.*

ft NAVD88 = feet North American Vertical Datum of 1988

Figure 1-1. Monthly Pumping Rate Contribution

3.3.3 Recommendations for Extraction System Optimization

Recovery rates from the start of the system indicate that the active RWs and EWs are operating as designed except for the troubleshooting discussed above. The extraction rates throughout the GWET system will continue to be optimized to meet Target Capture Objectives.

4. ANALYTICAL PROGRAM

Quarterly groundwater monitoring was implemented in accordance with the ODEQ-approved Arkema Quarterly Groundwater Monitoring Work Plan dated October 2019 and the ODEQ-approved reduced scope described in the 2021 monitoring program modification request memorandum dated 9 September 2021. The table below outlines sampling dates and submittal dates related to groundwater monitoring since the implementation of the reduced scope. The Quarterly Monitoring Reports present results from these sampling events.

Report	Sampling Dates	Report Submittal Date
2021 Quarter 3	9/21/2021–9/24/2021	1/14/2022
2021 Quarter 4	12/13/2021–12/16/2021	4/20/2022
2022 Quarter 1	3/14/2022–3/17/2022	6/15/2022
2022 Quarter 2	6/6/2022–6/9/2022	9/12/2022
2022 Quarter 4	11/7/2022–11/10/2022	2/17/2023
2023 Quarter 1	3/6/2023–3/10/2023	6/12/2023
2023 Quarter 2	6/12/2023–6/16/2023	9/22/2023
2023 Quarter 3	8/21/2023–8/24/2023	11/24/2023*

* Dates are tentative.

5. SUMMARY AND CONCLUSIONS

This report presents a summary of the GW SCM operation, maintenance, and monitoring activities conducted at the Site in July 2023 and documents results from system monitoring. The following summarizes ERM's observations and conclusions drawn from collected data.

5.1 Groundwater Flow

- Horizontal gradients across the GWBW are generally indicating an outward gradient toward the river (Attachment B-2). Additionally, groundwater elevations show a noticeable separation of the interior and exterior of the GWBW, indicating the GWBW is functioning via impeding groundwater flow.

- Vertical groundwater gradients interior to the GWBW between the Shallow and Intermediate Zones were mixed with GCC1, GCC2, GCC4, and GCC5 being downward and GCC3 being upward (Figure 5). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were mixed with GCC2 and GCC5 being upward and GCC1, GCC3, GCC4, and GCC6 being downward.

- Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were downward with the exception of GCC6. The direction of vertical gradients exterior to the GWBW were mixed with GCC1, GCC2, GCC4, and GCC5 being downward and the remaining being upward, as shown on Figure 6.
- The average river elevation in July 2023 was 8.35 feet NAVD 88 with a minimum elevation of 5.81 feet NAVD88 and a maximum elevation of 11.69 feet NAVD88, lower than the average river elevation in June 2023 of 9.45 feet NAVD88.

5.2 Groundwater Extraction

Based on July 2023 extraction and relevant hydrograph analysis, the trenches are functioning as designed. Within the Site alluvial sequence, potentiometric maps indicate the GW SCM is producing localized areas of hydraulic capture throughout the Target Capture Zone; however, more time at elevated extraction rates will be required to evaluate whether GWET objectives are being met system wide.

Flow rates have become more consistent as a result of the repairs in the wellfield in May and June 2023. The pressure filters are no longer limiting flow rate capacity. Prior to pressure filter maintenance average flow rates were 34.10 gpm and after maintenance average flow rates were 45.30 gpm. The flow rate is currently limited by a combination of ground water elevation, influence of back pressure in the trunk line, and fouling of the EWs within the trenches. Further evaluation of the system with respect to the Capture Zone Objectives will be conducted once all pumps are operating at their design rates for an extended period.

5.3 Recommendations and Future Work

ERM will continue to optimize new EWs, including pump maintenance/upgrades, redevelopment of the wells, and potential trunk line configuration. Any additional modifications to the system to meet capture objectives will be included in subsequent Monthly Performance Monitoring Report. The project schedule provided as Attachment C summarizes activities planned for the immediate future.

Regards,

Brendan Robinson, PE
Partner

6. REFERENCES

ERM (ERM-West, Inc.). 2012. *Arkema Portland Groundwater Source Control Measure, Groundwater Barrier Wall Final Design, Arkema Inc., Portland, Oregon*. July 2012.

_____. 2013. *Arkema Portland Groundwater Source Control Measure, Groundwater Extraction and Treatment Final Design, Arkema Inc., Portland, Oregon*. March 2013.

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_____. 2022. *Final Design Report, Arkema Inc. Facility, Portland, Oregon.* May 2022.

ODEQ (Oregon Department of Environmental Quality). 2019. DEQ Review "Draft GWET System Effectiveness Evaluation Report," Arkema Facility, ECSI #398. 31 May 2019.

Serfes, Michael. 1991. "Determining the Mean Hydraulic Gradient of Ground Water Affected by Tidal Fluctuations." *Groundwater*, Vol. 29. No 4. July–August 1991.

FIGURES

Figure 1: Site Layout

Figure 2: July 2023 Shallow Zone Groundwater Contours

Figure 3: July 2023 Intermediate Zone Groundwater Contours

Figure 4: July 2023 Deep Zone Groundwater Contours

Figure 5: July 2023 Shallow to Intermediate Zone Vertical Head Difference

Figure 6: July 2023 Intermediate to Deep Zone Vertical Head Difference

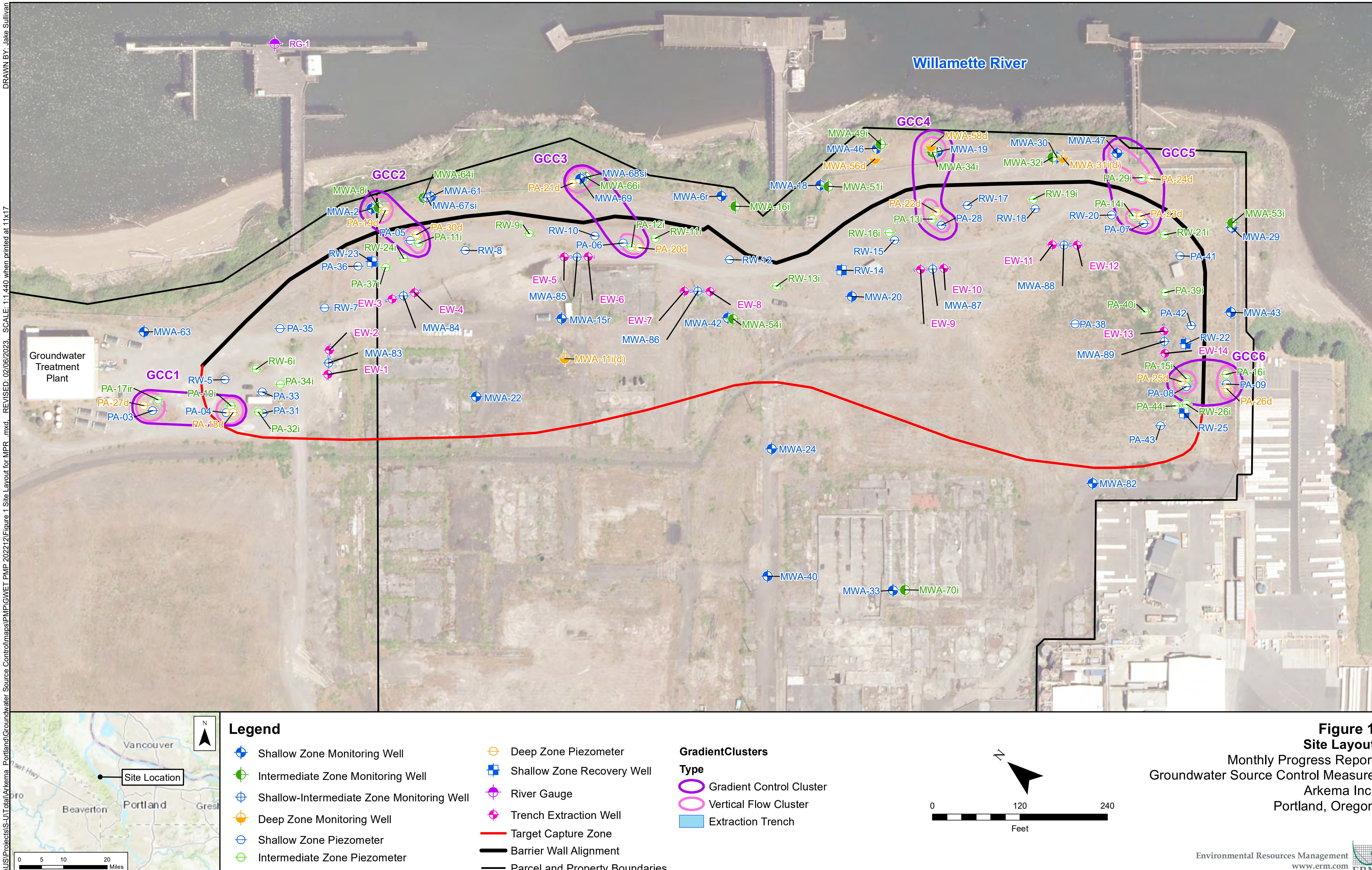
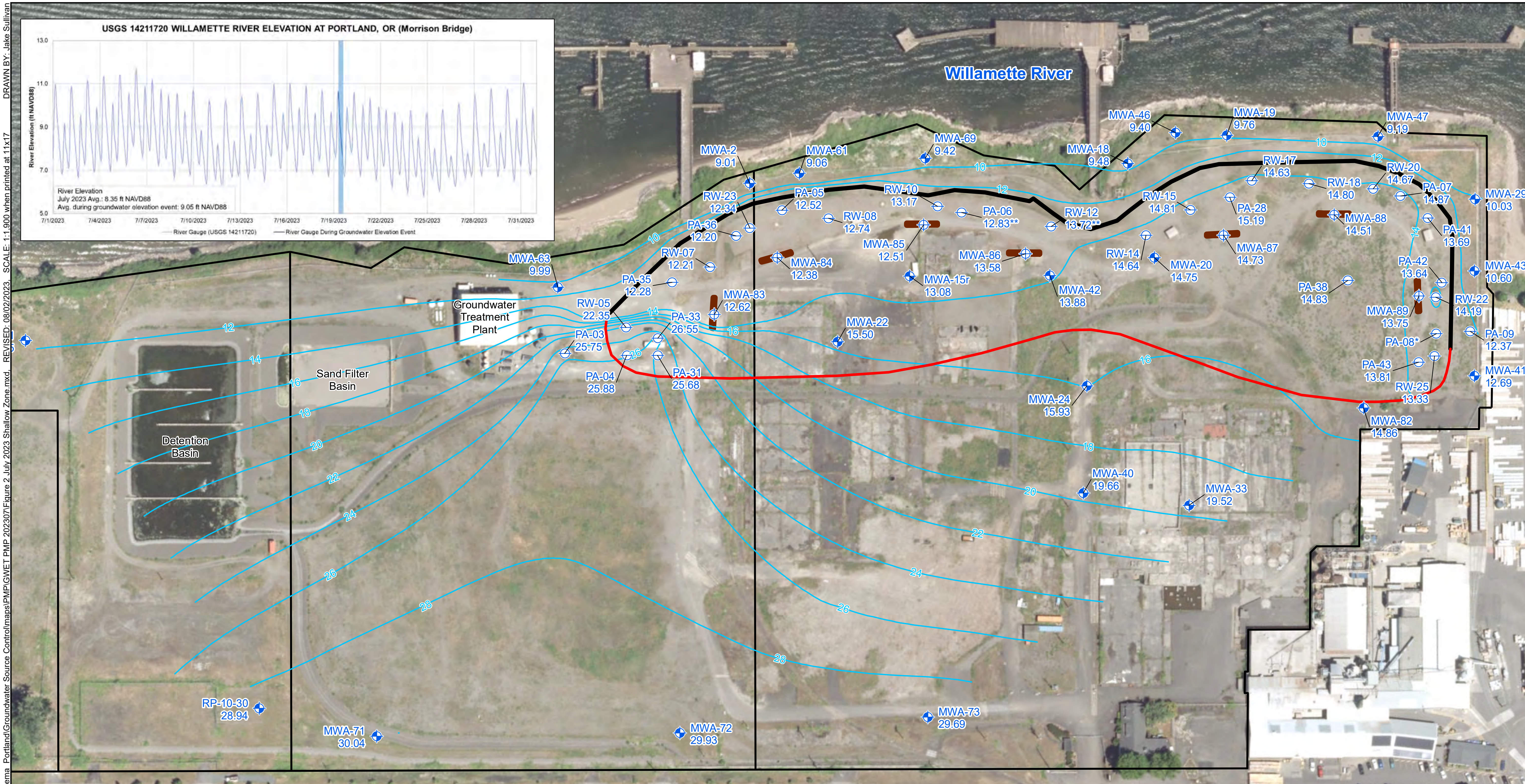


Figure 1
Site Layout
Monthly Progress Report
Groundwater Source Control Measure
Arkema Inc.
Portland, Oregon

DRAWN BY: Jake Sullivan

M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 202212\Figure 1 Site Layout for MPR .mxd   REVISED: 02/06/2023   SCALE: 1:1,440 when printed at 11x17

Source: City of Portland Aerial Imagery, flown Summer 2021; NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Shallow Zone Piezometer
- Shallow Zone Monitoring Well
- Active Recovery Well; Not Used During Contouring
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Shallow Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
** Transducer out of calibration during water level event, transducer WTE corrected using re-calibration offset from July 28, 2023.
Water levels collected July 19, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

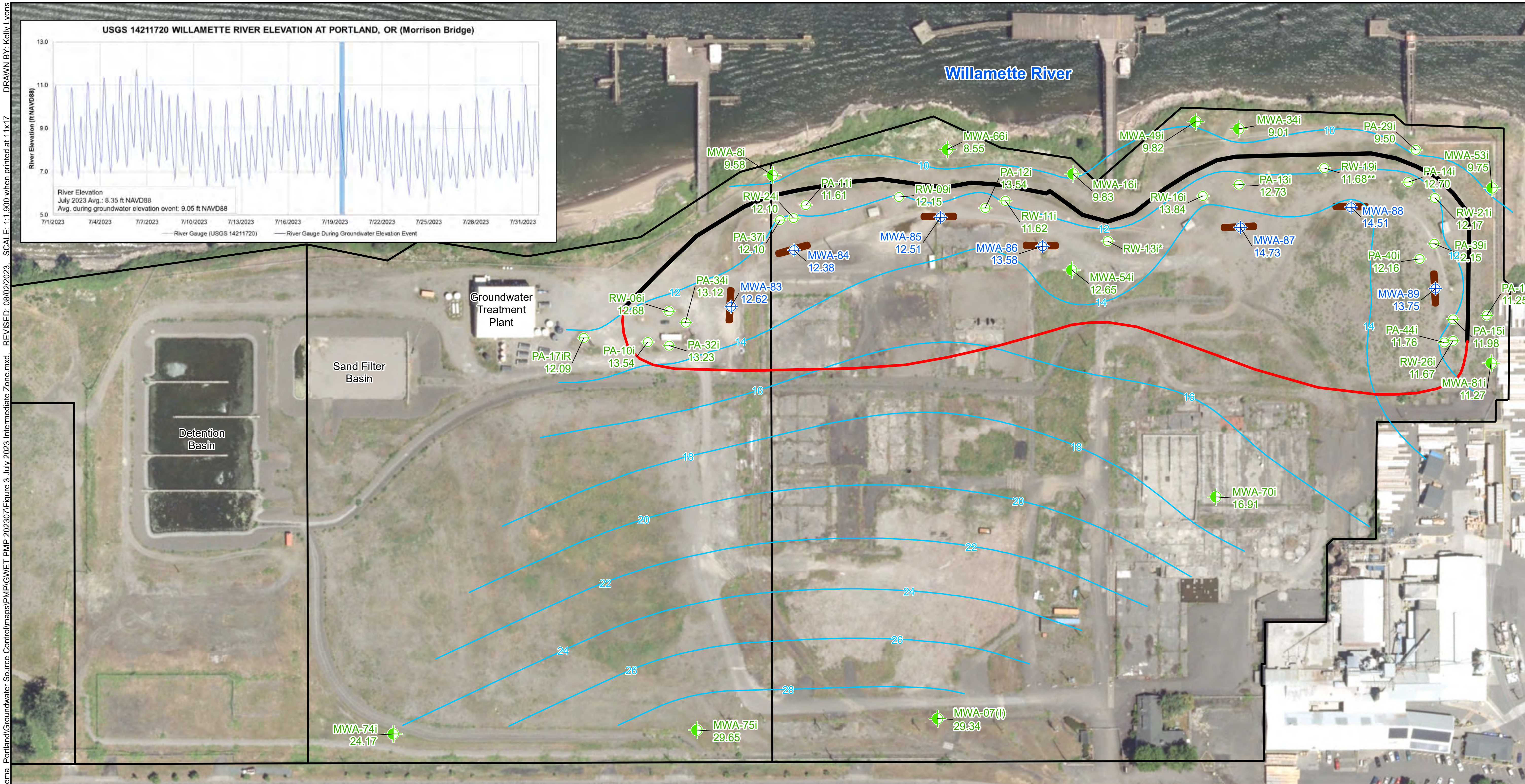
0 160 320
Feet

Figure 2
July 2023 Shallow Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

\\SCUSPRDGISFS01\Data\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 202307\Figure 2 July 2023 Shallow Zone.mxd REVISED: 08/02/2023 SCALE: 1:1,900 when printed at 11x17 DRAWN BY: Jake Sullivan



\\SCUSPRDGISFS01\Data\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 202307\Figure 3 July 2023 Intermediate Zone.mxd. REVISED: 08/02/2023. SCALE: 1:1,900 when printed at 11x17 DRAWN BY: Kelly Lyons

Legend

- Intermediate Zone Piezometer
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
** Transducer out of calibration during water level event, transducer WTE corrected using re-calibration offset from July 28, 2023.
Water levels collected July 19, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 3
July 2023 Intermediate Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

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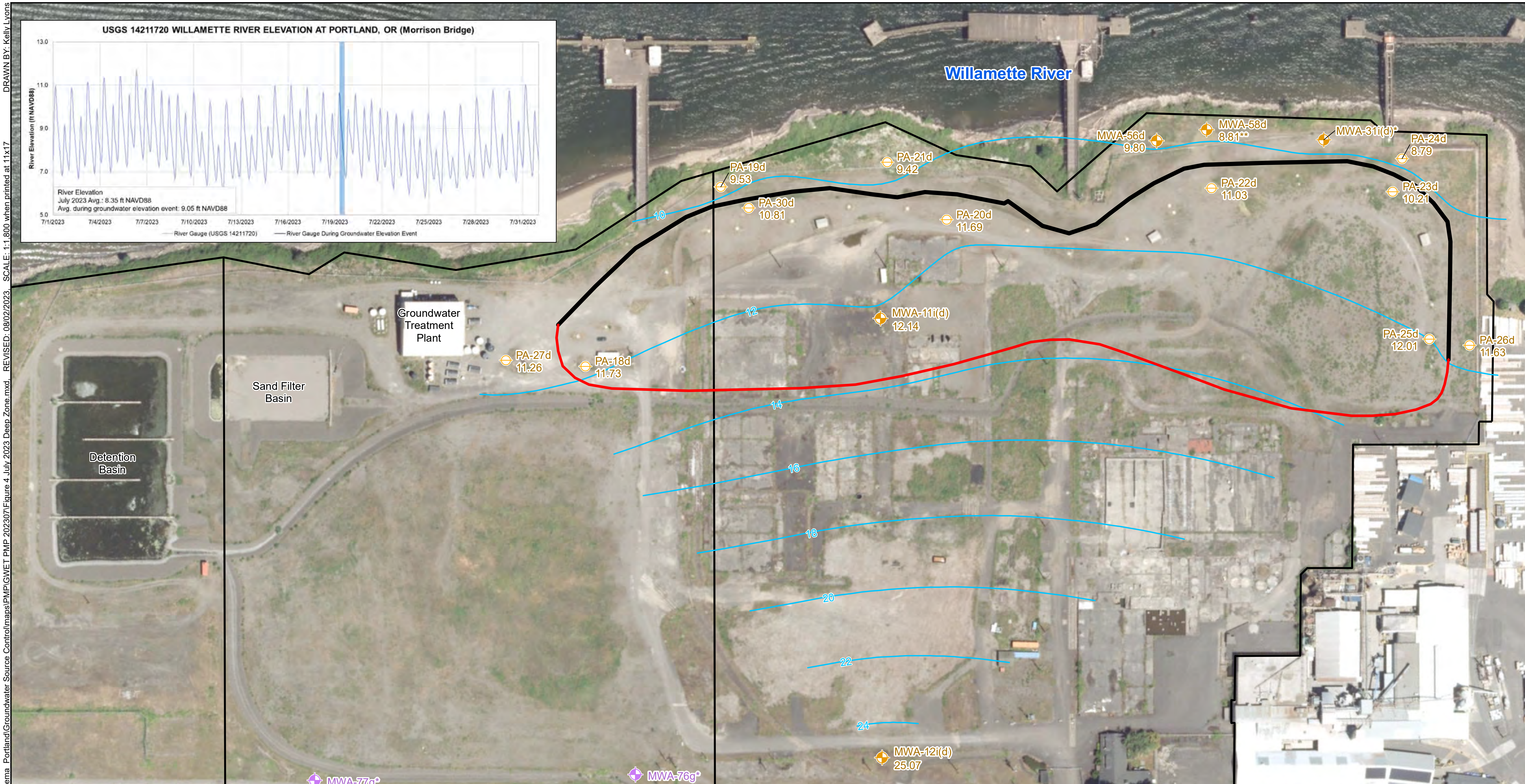
NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Deep Zone Piezometer
- Deep Zone Monitoring Well
- Gravel Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Deep Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment

Notes:
* Value not used for contouring.
** Transducer out of calibration during water level event, transducer WTE corrected using re-calibration offset from July 28, 2023.
Gravel zone wells not used in contouring.
Water levels collected July 19, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 150 300
Feet

Figure 4
July 2023 Deep Zone Groundwater Contours
Monthly Performance Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

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NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

\\SCUSPRDGISFS01\Data\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 202307\Figure 4 July 2023 Deep Zone.mxd. REVISED: 08/02/2023. SCALE: 1:1,800 when printed at 11x17 DRAWN BY: Kelly Lyons

Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Shallow Zone Recovery Well
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as shallow zone minus intermediate zone potentiometric surfaces.
Water levels collected July, 2023.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 5
July 2023 Shallow to Intermediate Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

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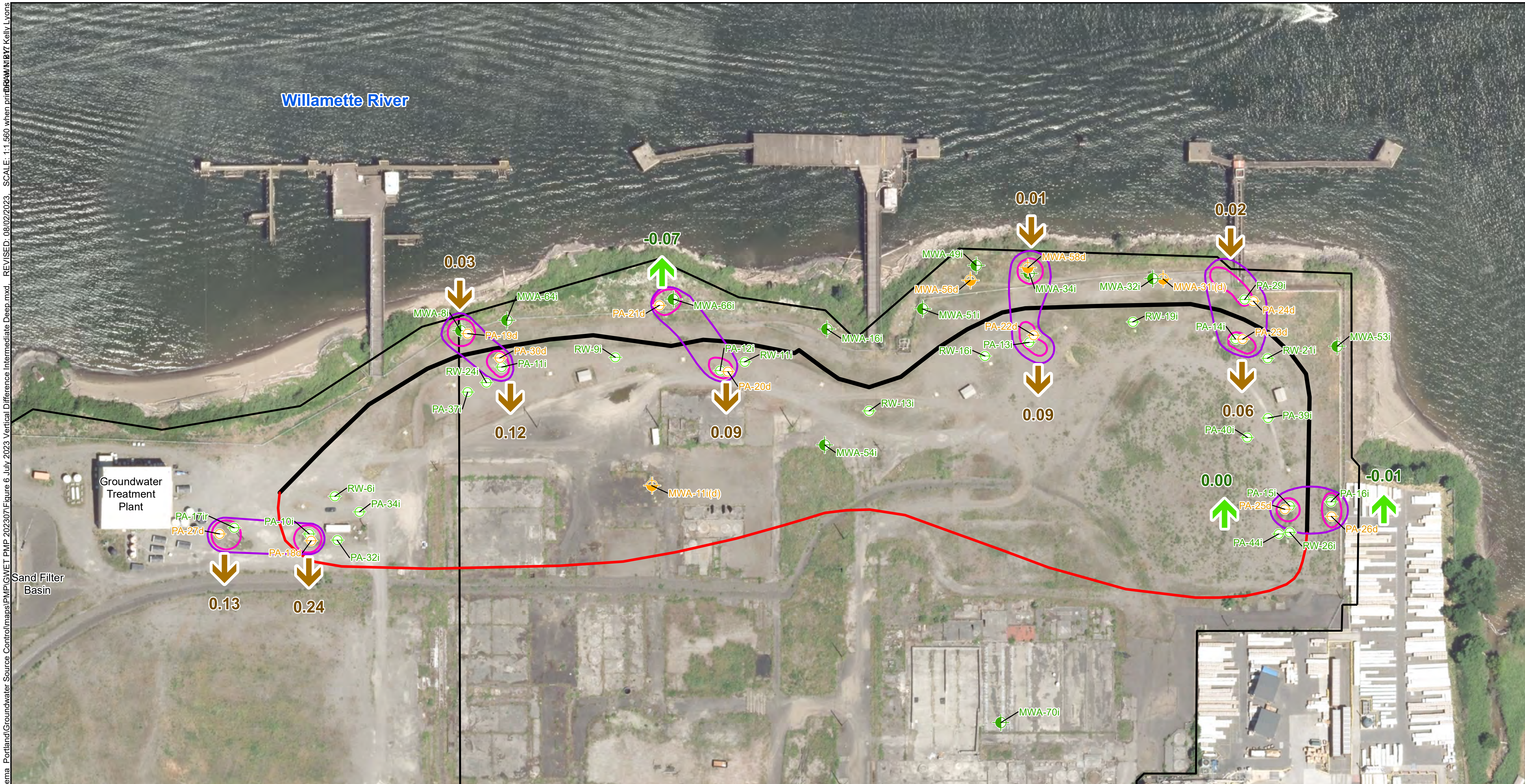
NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

\\SCUSPRDGISFS01\Data\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 202307\Figure 5 July 2023 Vertical Difference Shallow Intermediate.mxd REVISED: 08/02/2023 SCALE: 1:1,560 when printed at 11x17 DRAWN BY: Kelly Lyons



Legend

- Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as intermediate zone minus deep zone potentiometric surfaces.
Water levels collected July, 2023.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 6
July 2023 Intermediate to Deep Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

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NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

\\SCUSPRDGISFS01\Data\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 2023\07\Figure 6 July 2023 Vertical Difference Intermediate Deep.mxd REVISED: 08/02/2023 SCALE: 1:1,560 when printed DRAWN BY: Kelly Lyons

ATTACHMENT A-1 TRANSDUCER FLAGS

Attachment A-1. Transducer Flags

Table A-1
Transducer Malfunction Log: July 2023
Arkema Inc. Facility
Portland, Oregon

Gradient Cluster	Transducer	Interval	Date Range	Issue and Repairs Performed
N/A	RW-15	Shallow	Not started	Transducer turned on following upgrades, but found to be non-operational. Replaced transducer ordered.
N/A	RW-11i	Intermediate	Not started	Transducer turned on following upgrades, but found to be non-operational. Replaced transducer ordered.

Notes:

I/O = input/output

LOTO = lockout/tagout

VFD = variable frequency drive

ATTACHMENT A-2 RECOVERY WELL STATUS

Attachment A-2. Recovery Well Status

Table A-2
Recovery Well Status: June 2023
Arkema Inc. Facility
Portland, Oregon

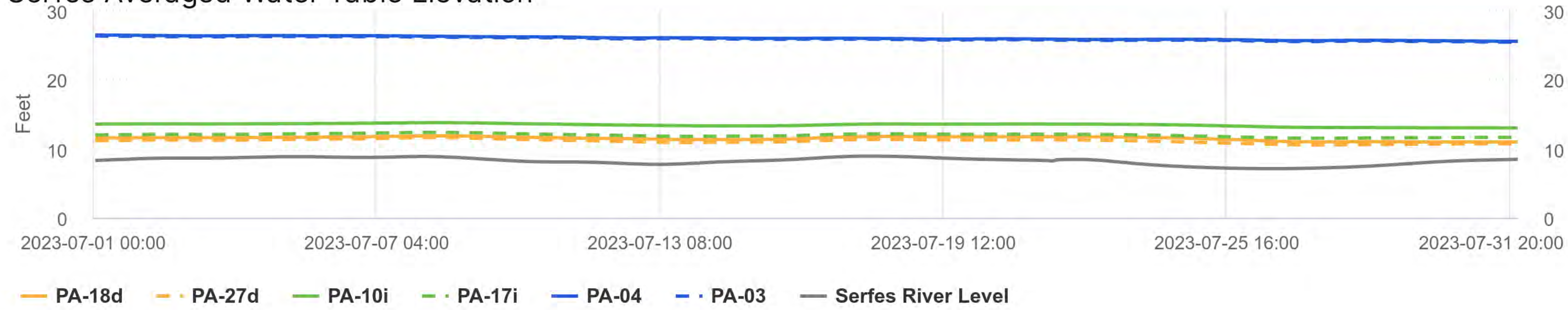
Recovery Well ID	Status as of 5/31/2023 (active or inactive)	Issue	Actions to get online	Expected date back online	Transducer Status	Totalizer Status	Average Flow Rate (gpm)	Overall Extraction Rate	Notes
RW-14	Inactive	None	N/A	N/A	Good	Good	0.00	OFF*	Well turned off due to sufficient flow from other wells
RW-22	Inactive	Totalizer failure	Replace totalizer	N/A	Good	Bad	0.00	OFF*	Totalizer failed, will be replaced
RW-23	Active	None	N/A	N/A	Good	Good	2.09	M	
RW-25	Inactive	None	N/A	N/A	Good	Good	0.00	OFF*	Well turned off due to sufficient flow from other wells
EW-01	Active	None	N/A	N/A	Good	Good	5.13	G	
EW-02	Active	None	N/A	N/A	Good	Good	3.56	G	
EW-03	Active	None	N/A	N/A	Good	Good	2.36	M	
EW-04	Active	None	N/A	N/A	Good	Good	3.40	G	
EW-05	Active	None	N/A	N/A	Good	Good	4.57	G	
EW-06	Active	None	N/A	N/A	Good	Good	5.30	G	
EW-07	Active	None	N/A	N/A	Good	Good	6.17	G	
EW-08	Active	None	N/A	N/A	Good	Good	3.92	G	
EW-09	Active	None	N/A	N/A	Good	Good	3.90	G	
EW-10	Active	None	N/A	N/A	Good	Good	4.30	G	
EW-11	Active	None	N/A	N/A	Good	Good	3.45	G	
EW-12	Active	None	N/A	N/A	Good	Good	2.27	M	
EW-13	Active	None	N/A	N/A	Good	Good	4.92	G	
EW-14	Active	None	N/A	N/A	Good	Good	10.39	G	

Notes:
** Recovery wells not in service*
*** Recovery wells in service part of the month*
G = good pumping, greater than 3.0 gpm
gpm = gallons per minute
M = moderate pumping, greater than 1.0 gpm and less than 3.0
P = poor pumping, less than 1.0 gpm
VFD = variable frequency drive
PA = piezometer

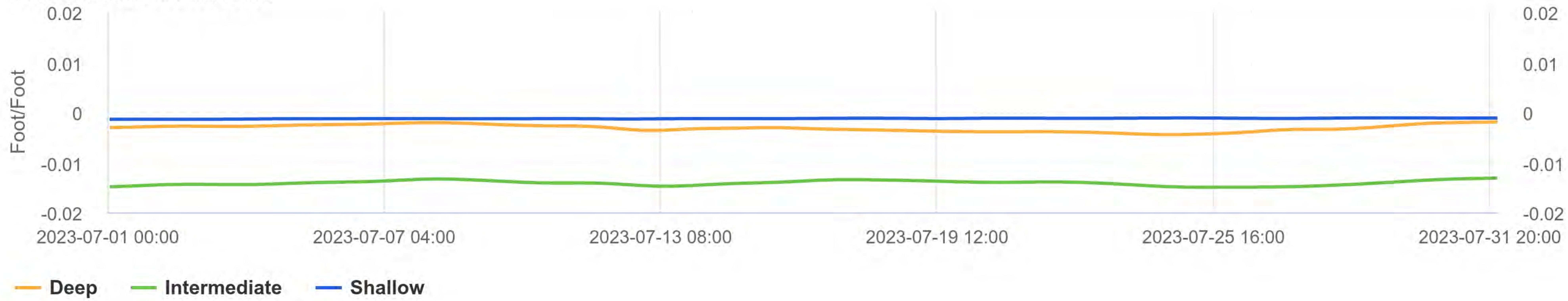
ATTACHMENT B-1 GRADIENT HYDROGRAPHS

Gradient Control Cluster 1

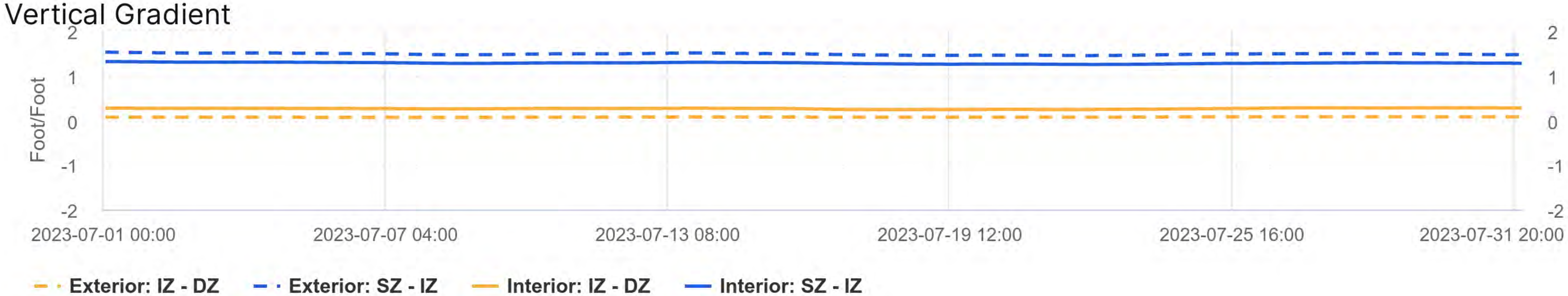
Serfes Averaged Water Table Elevation



Horizontal Gradient

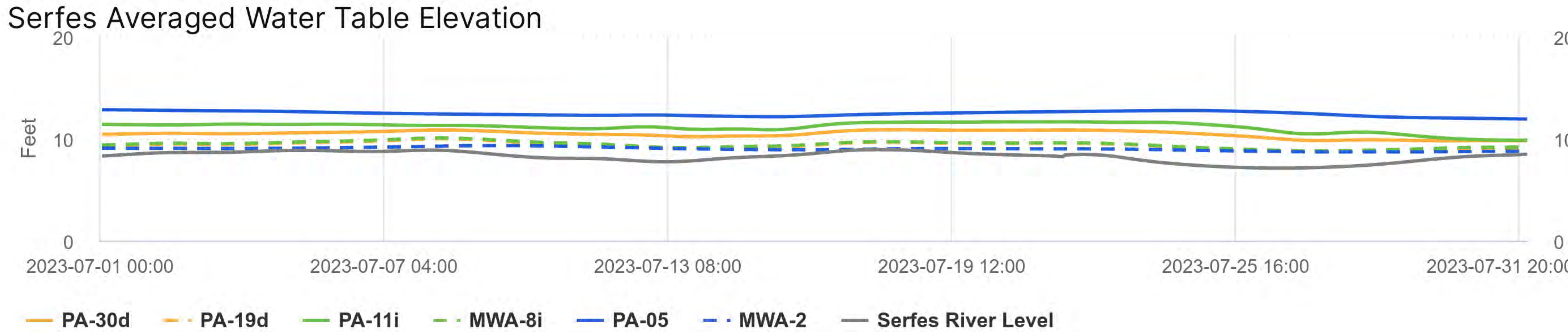


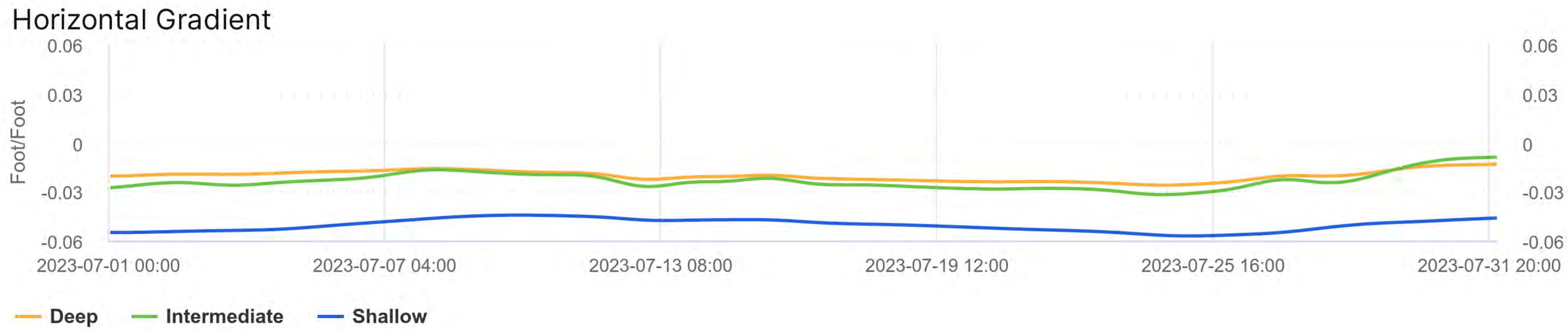
Vertical Gradient

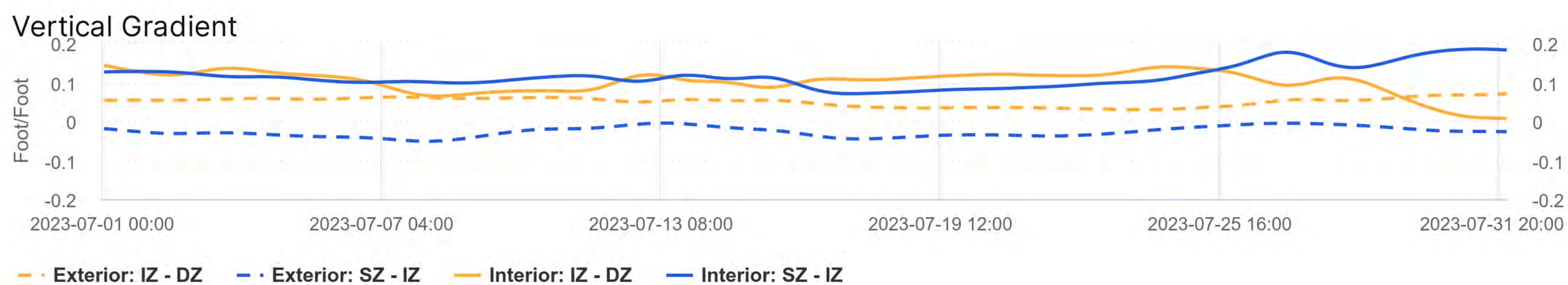


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 2

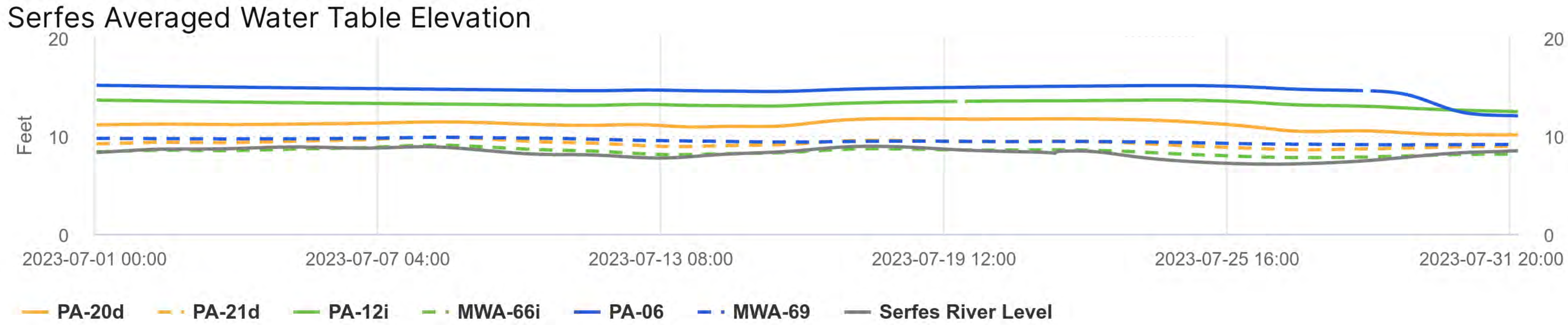


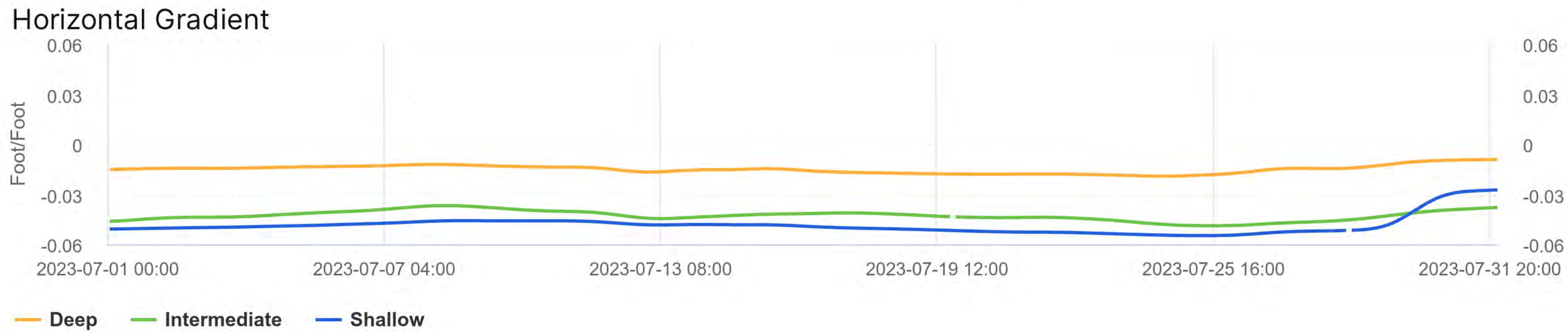


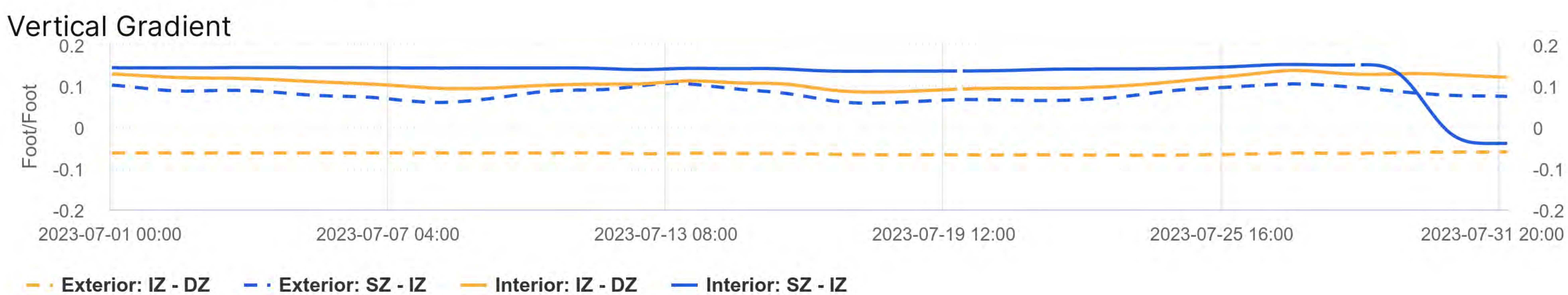


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 3



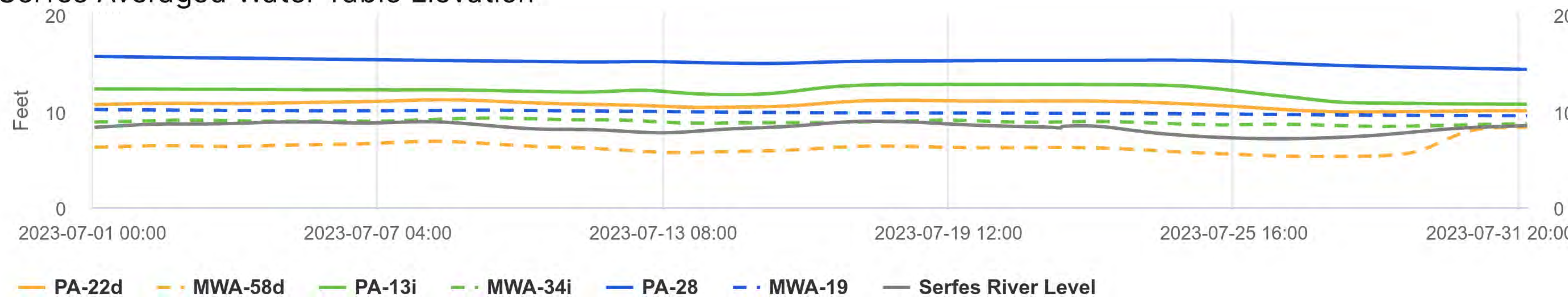




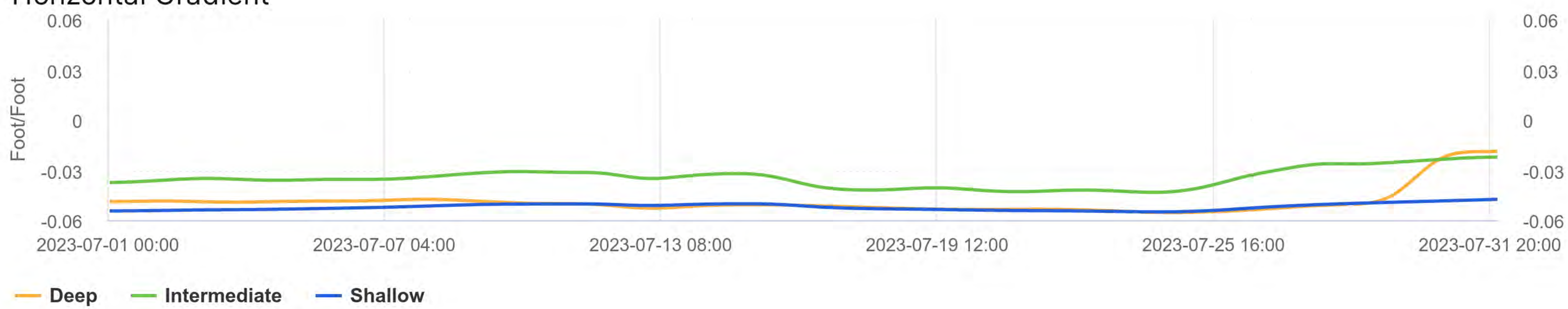
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 4

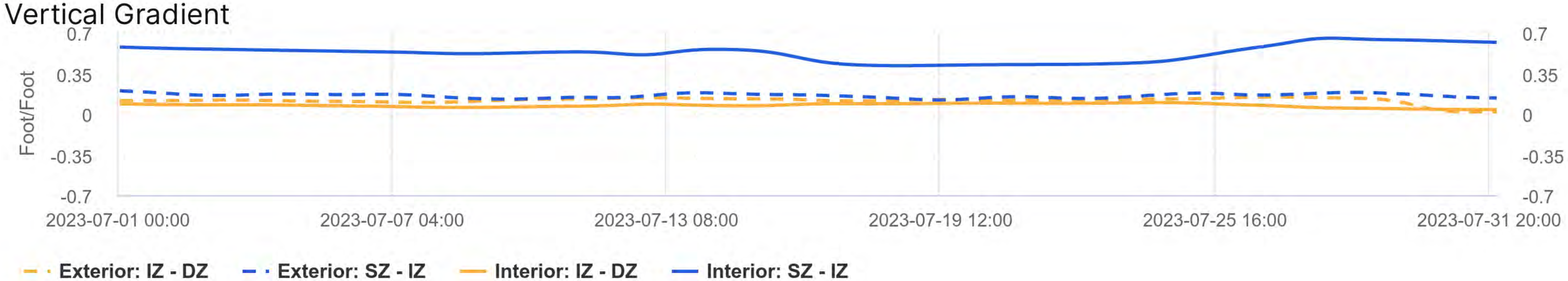
Serfes Averaged Water Table Elevation



Horizontal Gradient



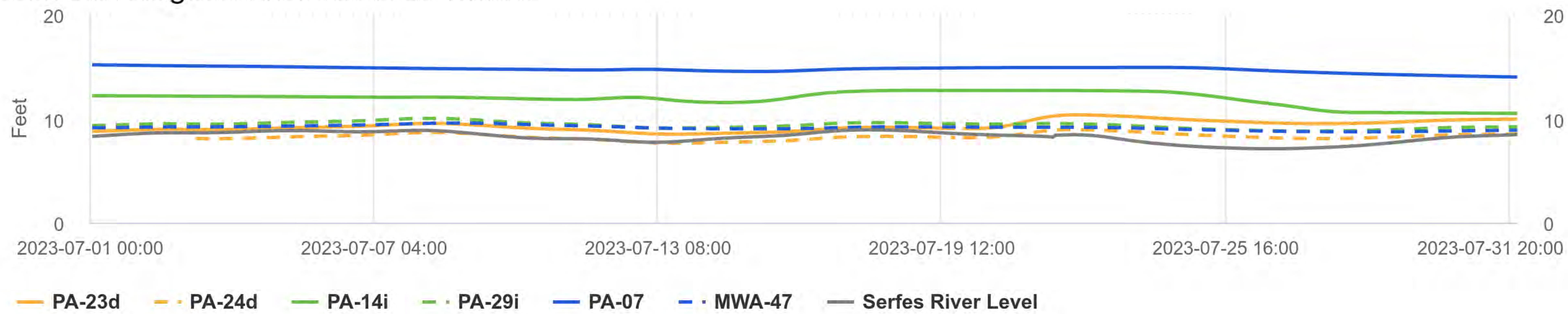
Vertical Gradient



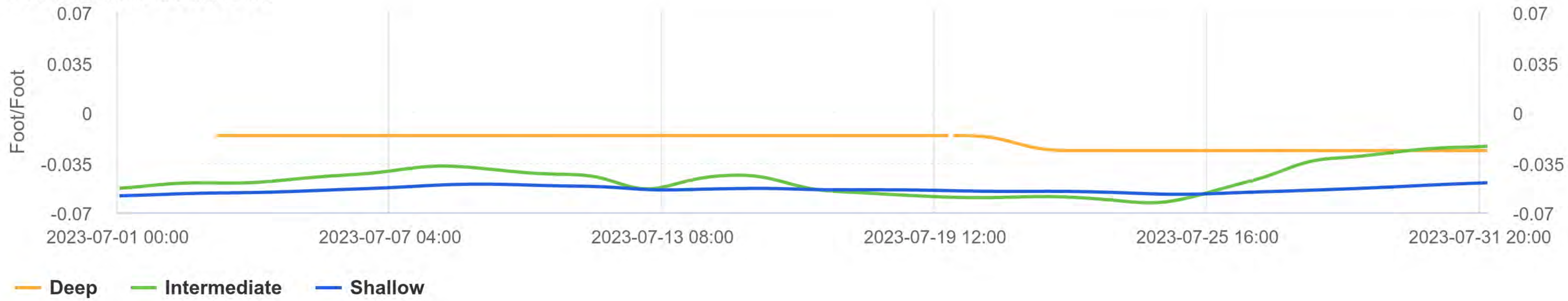
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 5

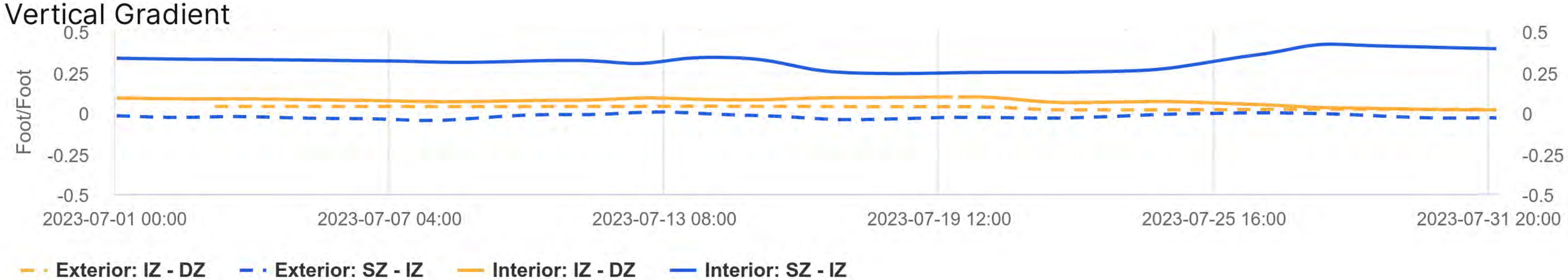
Serfes Averaged Water Table Elevation



Horizontal Gradient



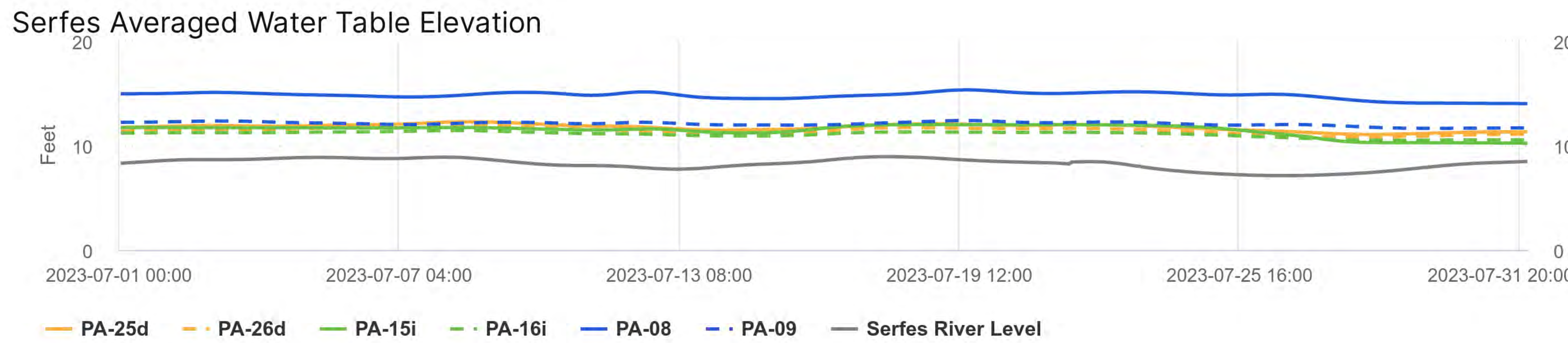
Vertical Gradient

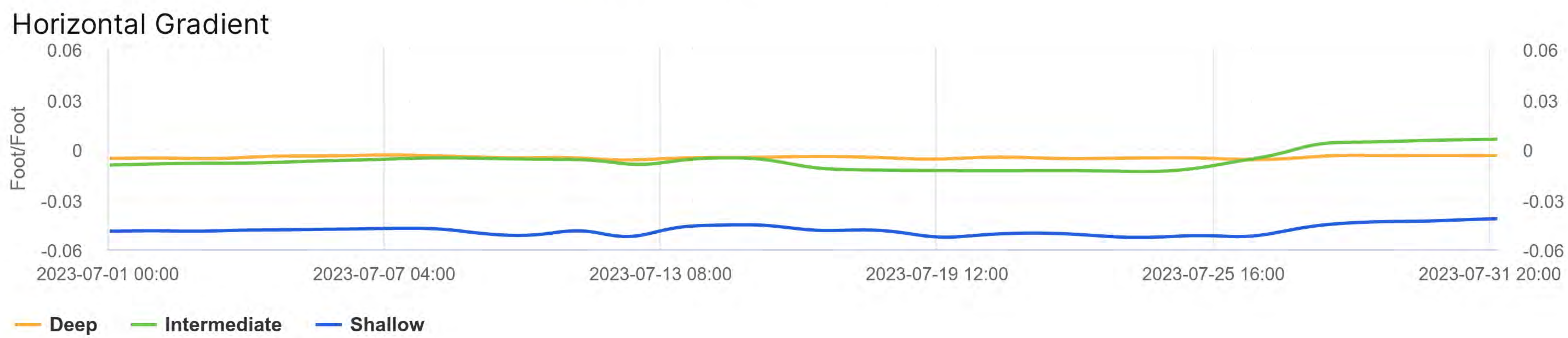


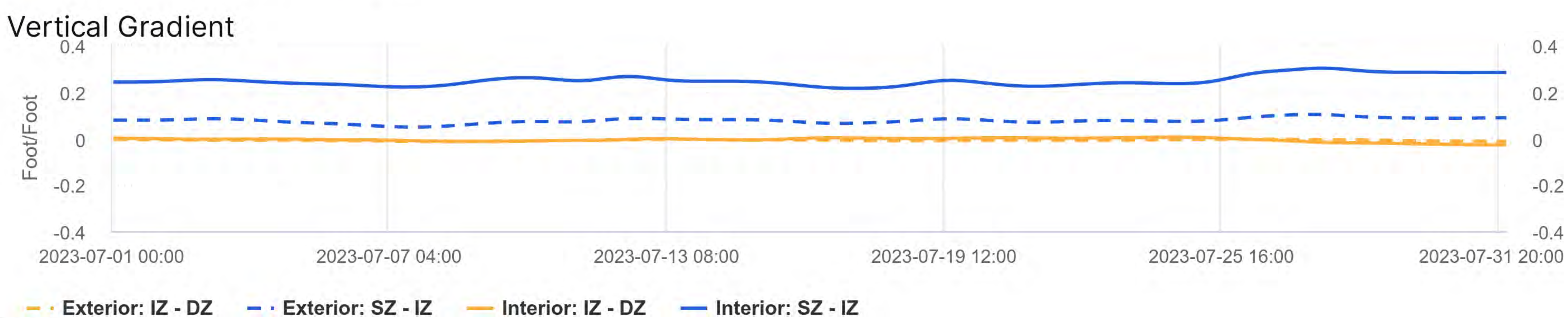
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW

SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 6





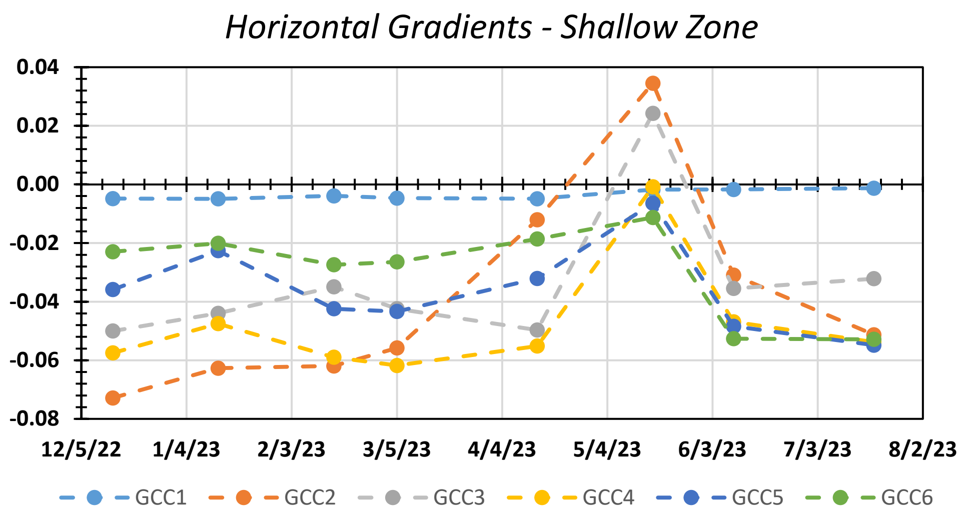


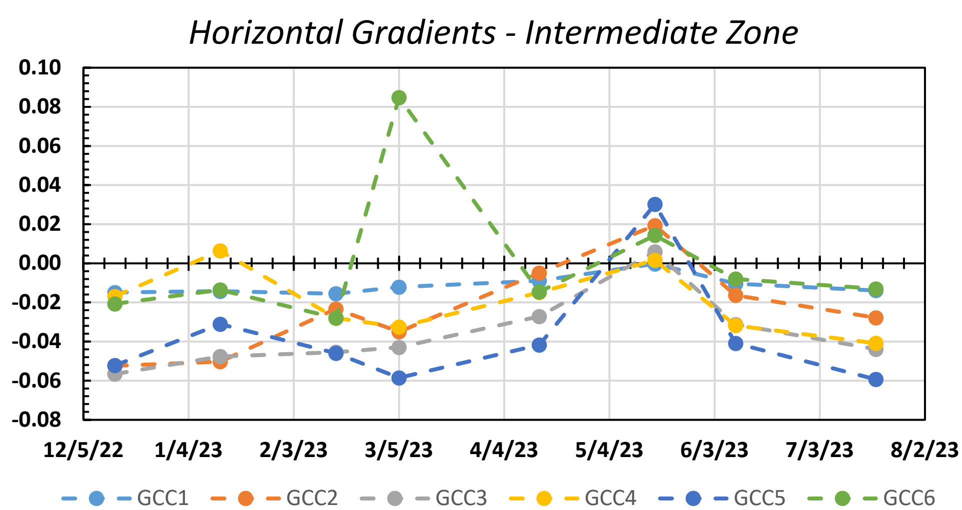
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

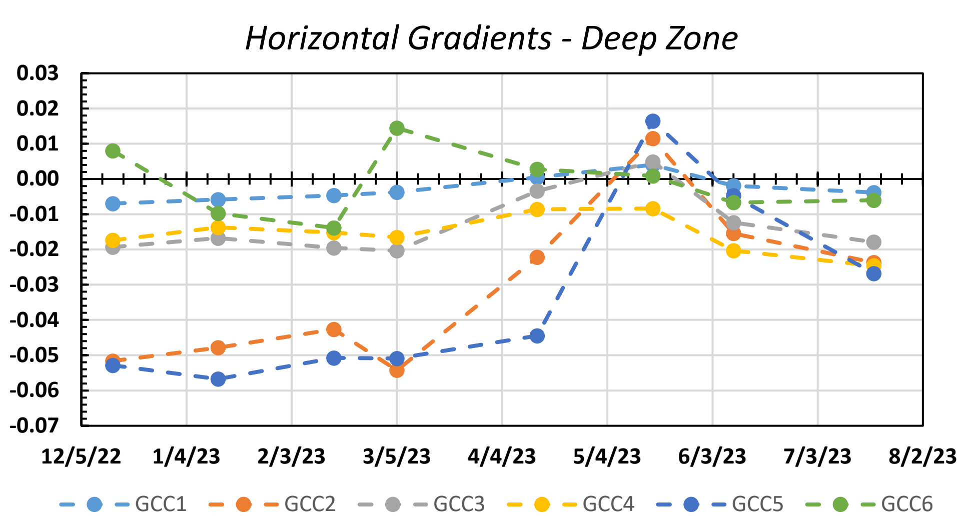
ATTACHMENT B-2 HORIZONTAL GRADIENTS

Attachment B-2

Horizontal Gradients Summary: July 2023
Arkema Inc. Facility
Portland, Oregon



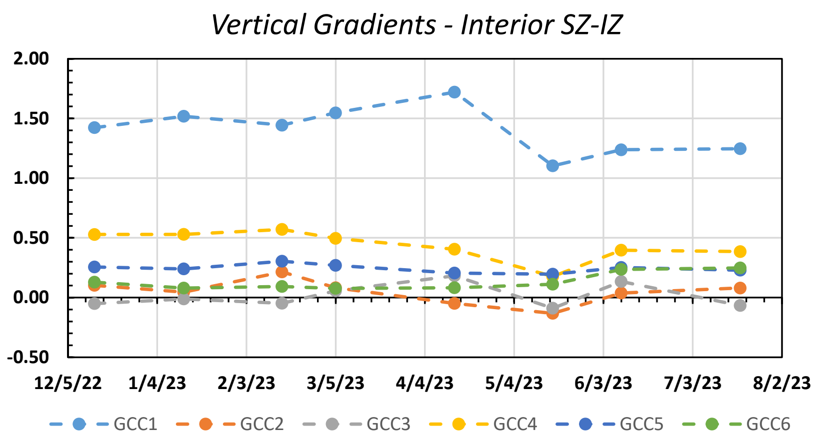


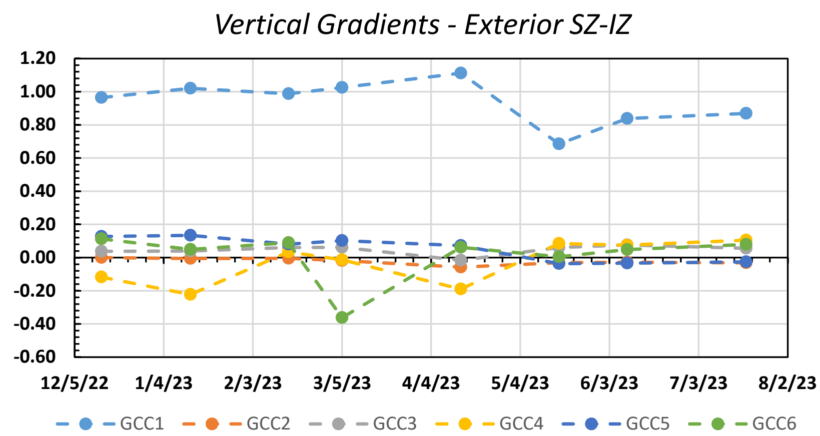


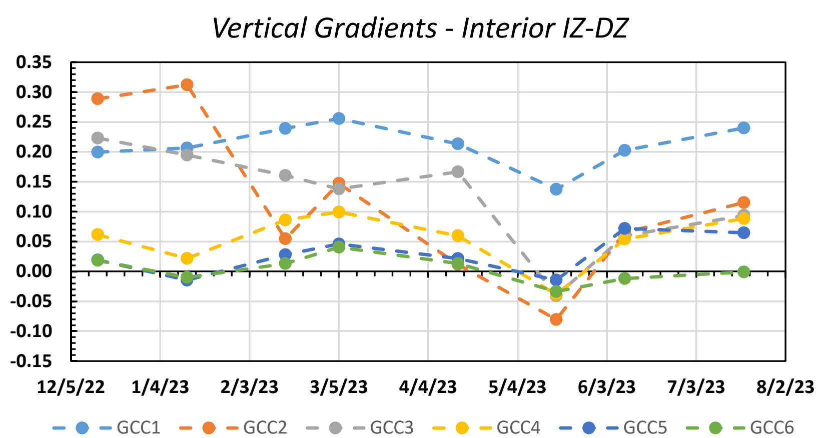
ATTACHMENT B-3 VERTICAL GRADIENTS

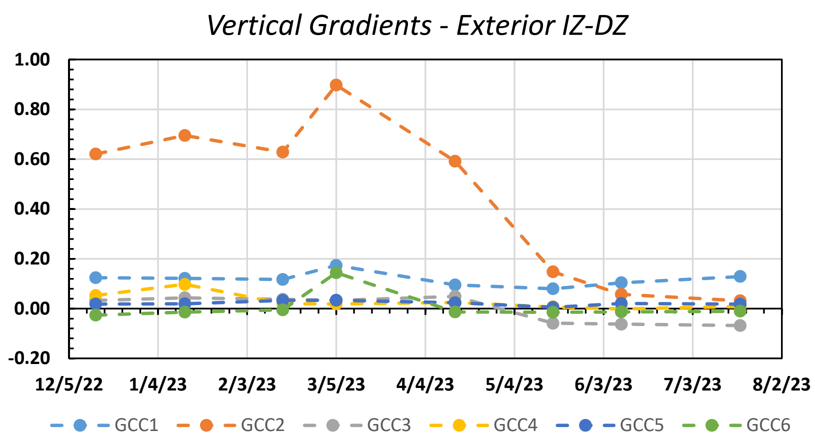
Attachment B-3

Vertical Gradients Summary: July 2023
Arkema Inc. Facility
Portland, Oregon



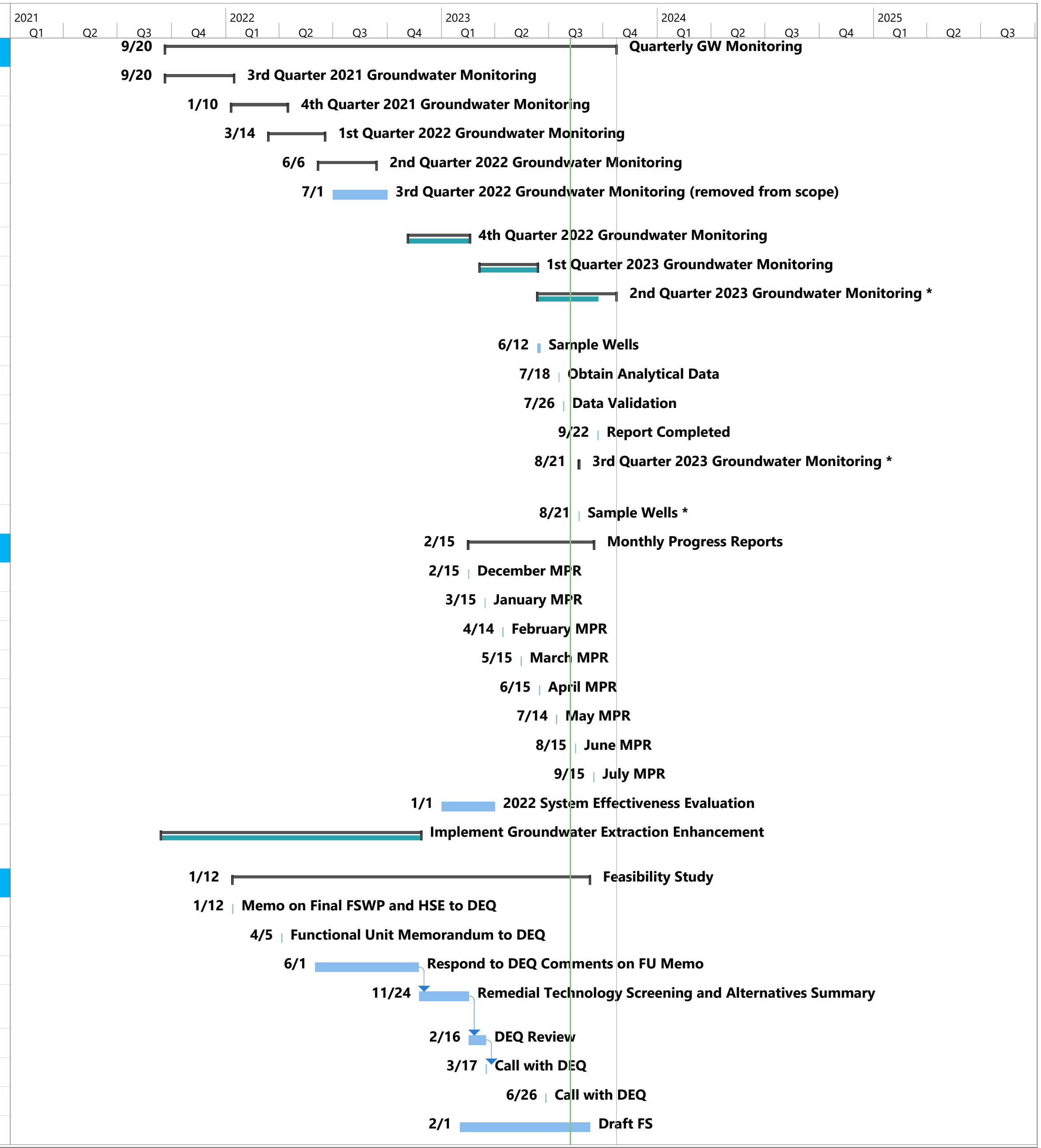






ATTACHMENT C PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**Quarterly GW Monitoring**	**549 days**	**Mon 9/20/21**	**Mon 10/23/23**
2	*3rd Quarter 2021 Groundwater Monitoring*	*85 days*	*Mon 9/20/21*	*Fri 1/14/22*
7	*4th Quarter 2021 Groundwater Monitoring*	*70 days*	*Mon 1/10/22*	*Fri 4/15/22*
11	*1st Quarter 2022 Groundwater Monitoring*	*70 days*	*Mon 3/14/22*	*Fri 6/17/22*
16	*2nd Quarter 2022 Groundwater Monitoring*	*71 days*	*Mon 6/6/22*	*Mon 9/12/22*
21	*3rd Quarter 2022 Groundwater Monitoring (removed from scope)*	*66 days*	*Fri 7/1/22*	*Fri 9/30/22*
22	*4th Quarter 2022 Groundwater Monitoring*	*78 days*	*Sat 11/5/22*	*Fri 2/17/23*
27	*1st Quarter 2023 Groundwater Monitoring*	*71 days*	*Mon 3/6/23*	*Mon 6/12/23*
32	**2nd Quarter 2023 Groundwater Monitoring ***	**96 days**	**Mon 6/12/23**	**Mon 10/23/23**
33	*Sample Wells*	*5 days*	*Mon 6/12/23*	*Fri 6/16/23*
34	*Obtain Analytical Data*	*1 day*	*Tue 7/18/23*	*Tue 7/18/23*
35	*Data Validation*	*1 day*	*Wed 7/26/23*	*Wed 7/26/23*
36	Report Completed	1 day	Fri 9/22/23	Fri 9/22/23
37	**3rd Quarter 2023 Groundwater Monitoring ***	**1 day**	**Mon 8/21/23**	**Mon 8/21/23**
38	Sample Wells *	1 day	Mon 8/21/23	Mon 8/21/23
39	**Monthly Progress Reports**	**153 days**	**Wed 2/15/23**	**Fri 9/15/23**
40	*December MPR*	*1 day*	*Wed 2/15/23*	*Wed 2/15/23*
41	*January MPR*	*1 day*	*Wed 3/15/23*	*Wed 3/15/23*
42	*February MPR*	*1 day*	*Fri 4/14/23*	*Fri 4/14/23*
43	*March MPR*	*1 day*	*Mon 5/15/23*	*Mon 5/15/23*
44	*April MPR*	*1 day*	*Thu 6/15/23*	*Thu 6/15/23*
45	*May MPR*	*1 day*	*Fri 7/14/23*	*Fri 7/14/23*
46	June MPR	1 day	Tue 8/15/23	Tue 8/15/23
47	July MPR	1 day	Fri 9/15/23	Fri 9/15/23
48	***2022 System Effectiveness Evaluation***	***66 days***	***Sun 1/1/23***	***Fri 3/31/23***
49	***Implement Groundwater Extraction Enhancement***	***317 days***	***Mon 9/13/21***	***Sun 11/27/22***
57	**Feasibility Study**	**436 days**	**Wed 1/12/22**	**Fri 9/8/23**
58	*Memo on Final FSWP and HSE to DEQ*	*1 day*	*Wed 1/12/22*	*Wed 1/12/22*
59	*Functional Unit Memorandum to DEQ*	*1 day*	*Tue 4/5/22*	*Tue 4/5/22*
60	*Respond to DEQ Comments on FU Memo*	*126 days*	*Wed 6/1/22*	*Tue 11/22/22*
61	*Remedial Technology Screening and Alternatives Summary*	*62 days*	*Thu 11/24/22*	*Wed 2/15/23*
62	*DEQ Review*	*21 days*	*Thu 2/16/23*	*Thu 3/16/23*
63	*Call with DEQ*	*1 day*	*Fri 3/17/23*	*Fri 3/17/23*
64	*Call with DEQ*	*1 day*	*Mon 6/26/23*	*Mon 6/26/23*
65	Draft FS	158 days	Wed 2/1/23	Fri 9/8/23



Arkema Portland
Monthly Progress Report
Attachment C

Task	Project Summary	Manual Task	Start-only
Split	Inactive Task	Duration-only	Finish-only
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks
Summary	Inactive Summary	Manual Summary	External Milestone
Deadline	Progress	Manual Progress	

* - Indicates dates that are tentative

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Memo

To	Katie Daugherty, Oregon Department of Environmental Quality
From	Brendan Robinson, PE, Environmental Resources Management, Inc.
Date	16 October 2023
Reference	0682894 Phase 204
Subject	August 2023 GW SCM Monthly Performance Monitoring Report

1. INTRODUCTION

Environmental Resources Management, Inc. (ERM) prepared this Monthly Performance Monitoring Report (MPR) on behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc. (Arkema), for the former Arkema Portland Plant (the Site) at 6400 NW Front Avenue in Portland, Oregon. The Oregon Department of Environmental Quality (ODEQ), in its letter dated 31 May 2019 and in the subsequent meeting with LSS and ERM on 2 July 2019, requested that LSS initiate monthly status reports associated with the onsite groundwater source control measure (GW SCM) consistent with the Performance Monitoring Plan (PMP; ERM 2014) beginning July 2019. The 2014 PMP was prepared pursuant to the Order on Consent issued by ODEQ, signed on 31 October 2008 (ODEQ No. LQVC-NWR-08-04; Consent Order). The purpose of the PMP was to present the monitoring, reporting, and adaptive management processes used during implementation of the GW SCM. On 30 November 2021, ODEQ directed LSS that following the October 2021 MPR, subsequent MPRs would be suspended pending the implementation of the Groundwater Extraction Enhancement (GEE) project in 2022. During that time, ODEQ requested monthly schedule updates in lieu of MPRs. The trench wells installed as part of the GEE project were started on 27 November 2022, and MPR writing restarted in December 2022. The purpose of the GEE project was to install new extraction capacity to achieve the Capture Zone Objectives.

This August 2023 MPR summarizes the GW SCM performance monitoring data collected in August 2023. This report assesses the current gradient status and proposes system improvements to meet the Capture Zone Objectives set in the PMP.

2. GROUNDWATER SOURCE CONTROL IMPLEMENTATION

A detailed description of the design and implementation of the GW SCM is provided in the *Revised Upland Feasibility Study Work Plan* (ERM 2017); however, a brief description of the GW SCM is provided here. In February 2009, ODEQ and the U.S. Environmental Protection Agency (USEPA) approved the general approach for the GW SCM. This approach included installation of a groundwater barrier wall (GWBW), groundwater recovery wells, and a Groundwater Extraction and Treatment (GWET) system, with treated water discharged to the Willamette River. ODEQ and USEPA approved the *Groundwater Barrier Wall Final Design* (ERM 2012) on 7 August 2012. Construction of the GWBW began in May 2012 and was completed in December 2012. ODEQ approved the *Groundwater Extraction and Treatment System Final Design* (ERM 2013) on 2 April 2013. Construction of the GWET system began in December 2012 and was completed in December 2013.

GWET startup and optimization commenced in May 2014. The GW SCM at the Site consists of the following primary components (Figure 1):

1. A GWBW to physically separate the affected upland portions and in-water portions of the Site.

2. Hydraulic control to minimize flow of groundwater containing unacceptable concentrations of constituents of potential concern (COPCs) around, over, and under the GWBW.

3. Management of extracted groundwater through the GWET system, with treated effluent discharged to the Willamette River under a National Pollutant Discharge Elimination System (NPDES) Permit.

On 1 September 2018, ERM submitted the *Draft GWET System Effectiveness Evaluation* (Draft SEE Report; ERM 2018). The Draft SEE Report provided an update on the corrective actions implemented to improve the performance of the GWET system, evaluate the extent of capture, and propose actions to improve hydraulic capture. Additional data requested by ODEQ were submitted on 26 October 2018.

The key objective of the GW SCM is to achieve hydraulic containment of the alluvial sequence within the Target Capture Zone at the Site to prevent the flow of COPCs to the Willamette River. The Site alluvial aquifer sequence within the Target Capture Zone consists of the Shallow Zone, Intermediate Zone, and the Deep Zone. Site hydraulic conditions are variable and subject to both seasonal and daily tidal fluctuations.

The hydraulic control component formerly consisted of 22 recovery wells (RWs) prior to the implementation of the GEE. Of the 22 pre-existing RWs, four were retained for active pumping. The remaining 18 former RWs had pumps removed but retained their pressure transducers so that they can continuously collect high-resolution groundwater elevation data. The hydraulic control system now consists of the four remaining active RWs, as well as seven groundwater extraction trenches that each contain two extraction wells (EWs). Each trench is 50 feet deep, 50 feet long, and 3 feet wide and is filled with an engineered backfill. More information about the groundwater extraction trenches is provided in the *Final Design Report* (ERM 2022). The gradient control-monitoring network consists of six gradient control clusters (GCCs) with each cluster containing six monitoring points. Within each RW, EW, and GCC location, pressure transducers are continuously collecting high-resolution groundwater elevation data. Each GCC contains three transducers interior to the wall and three transducers exterior to the wall screened in the Shallow, Intermediate, and Deep aquifers at the Site.

3. HYDRAULIC CONTAINMENT MONITORING PROGRAM

As described in the PMP, the purpose of hydraulic monitoring (i.e., groundwater elevation data) is to provide sufficient data to demonstrate an inward hydraulic gradient across the GWBW and to evaluate the effective hydraulic capture produced by the GW SCM.

Monitoring requirements were established in the PMP to demonstrate GWET effectiveness. The Site monitoring program includes groundwater elevation data (manual and transducer measurements) collected from the 36 monitoring points located within six GCCs spaced across the GWBW, with piezometers interior and exterior to the wall, throughout the alluvial sequence; and groundwater elevation and flow rate data from the four remaining active RWs and 14 EWs. High-resolution groundwater elevation data is also collected from the 18 inactive RWs. Additionally, one new monitoring well was installed in each of the seven extraction trenches for manual water level measurement. This data were used to prepare horizontal and vertical potentiometric surface maps representing potentiometric differences between the alluvial sequences, and to generate spatial and temporal hydrographs to evaluate hydraulic capture.

3.1 Groundwater Elevation Monitoring

Groundwater elevation monitoring was completed on 18 August 2023. Manual groundwater elevations were measured at wells that were experiencing transducer mechanical issues or that were offline during the groundwater elevation measurement event. All inactive RWs were manually measured in the month of August to affirm proper calibration. Manual water levels for those RWs are reported. Additionally, all transducers in inactive RWs were down until upgrades were completed and transducers were sequentially turned on. Specific issues are addressed in Attachment A-1.

As detailed in Attachments A-1 and A-2, during August 2023, the following transducers were:

Fully out of service pending repairs:

Out of service for a period but returned to full operation:

- RW-11i
- RW-15

3.2 Horizontal and Vertical Gradients at Gradient Control Points

As described above, GCC locations collect high-resolution groundwater elevation data using transducers. Transducer data are filtered to remove anomalous data from monitoring points due to potential equipment failures, such as transducer malfunctions, power outages, or updates to the GWET programmable logic controller (PLC) system, which controls and houses all the operational data. These specific issues and time periods are summarized in Table A-1 in Attachment A. The following flags are applied to filter anomalous data:

- Groundwater elevations had a change greater than 1.5 feet within 1 hour
- Groundwater elevation measurements that were found to be greater than 50 feet, or less than 1 foot
- Calculated groundwater elevation slope indicates no change between consecutive measurements indicating a transducer malfunction
- Manually flagging data that are inconsistent with the typical nature of the well
- Periods where transducer power supply was deactivated for work on interconnected electrical systems

After August 2023 flagged data were removed, the Serfes (1991) method was used to account for tidal variations as described in the PMP. Using Serfes corrected data, both horizontal and vertical gradients were calculated and plotted over time (Attachment B). Groundwater elevations, horizontal gradients, and vertical gradients from 18 August 2023 are shown below at each GCC (Table 1-1 and Table 1-2). The water elevation taken during the groundwater level gauging event at PA-12i and PA-23d was excluded from gradient calculations and potentiometric surface maps due to being anomalous.

Table 1-1. August Horizontal Gradients

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
GCC1	Shallow	PA-03	25.15	PA-04	25.25	-0.001
	Intermediate	PA-17iR	11.63	PA-10i	12.73	-0.011
	Deep	PA-27d	10.75	PA-18d	10.80	0.000
GCC2	Shallow	MWA-2	8.75	PA-05 ^{M}	11.07	-0.034
	Intermediate	MWA-8i	9.46	PA-11i ^{M}	9.18	0.004
	Deep	PA-19d	9.33	PA-30d	9.65	-0.006
GCC3	Shallow	MWA-69	8.86	PA-06 ^{M}	10.31	-0.014
	Intermediate	MWA-66i	8.40	PA-12i	*	**
	Deep	PA-21d	9.13	PA-20d	9.49	-0.003
GCC4	Shallow	MWA-19	9.39	PA-28	13.48	-0.041
	Intermediate	MWA-34i	8.58	PA-13i	10.44	-0.020
	Deep	MWA-58d	8.65	PA-22d	10.01	-0.015
GCC5	Shallow	MWA-47	9.04	PA-07	13.21	-0.040
	Intermediate	PA-29i	9.51	PA-14i	10.33	-0.015
	Deep	PA-24d	8.83	PA-23d	10.26	-0.027
GCC6	Shallow	PA-09	11.16	PA-08	13.05	-0.034
	Intermediate	PA-16i	10.42	PA-15i	10.00	0.007
	Deep	PA-26d	11.21	PA-25d	11.34	-0.002

Notes:

Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.

Horizontal gradient calculated as (Exterior Elevation – Interior Elevation) / Horizontal distance.

** = anomalous groundwater elevation; ** = horizontal gradient cannot be calculated due to anomalous elevation reading; ft NAVD88 = feet North American Vertical Datum of 1988; ^{M} = manual groundwater elevation measurement*

Table 1-2. August Vertical Gradients

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
Interior	SZ-IZ	GCC1	PA-04	25.25	PA-10i	12.73	1.26
		GCC2	PA-05 ^{M}	11.07	PA-11i ^{M}	9.18	0.17
		GCC3	PA-06 ^{M}	10.31	PA-12i	*	**
		GCC4	PA-28	13.48	PA-13i	10.44	0.48
		GCC5	PA-07	13.21	PA-14i	10.33	0.30
		GCC6	PA-08	13.05	PA-15i	10.00	0.227
	IZ-DZ	GCC1	PA-10i	12.73	PA-18d	10.80	0.26
		GCC2	PA-11i ^{M}	9.18	PA-30d	9.65	-0.07
		GCC3	PA-12i	10.21	PA-20d	*	**

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
		GCC4	PA-13i	10.44	PA-22d	10.01	0.02
		GCC5	PA-14i	10.33	PA-23d	10.26	0.00
		GCC6	PA-15i	10.00	PA-25d	11.34	-0.04
Exterior	SZ-IZ	GCC1	PA-03	25.15	PA-17iR	11.63	0.86
		GCC2	MWA-2	8.75	MWA-8i	9.46	-0.04
		GCC3	MWA-69	8.86	MWA-66i	8.40	0.03
		GCC4	MWA-19	9.39	MWA-34i	8.58	0.12
		GCC5	MWA-47	9.04	PA-29i	9.51	-0.04
		GCC6	PA-09	11.16	PA-16i	10.42	0.05
	IZ-DZ	GCC1	PA-17iR	11.63	PA-27d	10.75	0.14
		GCC2	MWA-8i	9.46	PA-19d	9.33	0.08
		GCC3	MWA-66i	8.40	PA-21d	9.13	-0.06
		GCC4	MWA-34i	8.58	MWA-58d	8.65	0.00
		GCC5	PA-29i	9.51	PA-24d	8.83	0.02
		GCC6	PA-16i	10.42	PA-26d	11.21	-0.02

Notes:

Positive vertical gradient indicates a downward hydraulic gradient.

Vertical gradient calculated as (Upper Elevation – Lower Elevation) / Screen Midpoint distance.

** = anomalous groundwater elevation; ** = vertical gradient cannot be calculated due to anomalous elevation reading; DZ = Deep Zone; ft NAVD88 = feet North American Vertical Datum of 1988; IZ = Intermediate Zone; ^{M} = manual groundwater elevation measurement; SZ = Shallow Zone*

3.3 Potentiometric Surface, Groundwater Elevation Difference Maps, and Groundwater Flow Directions

As described in the PMP, potentiometric surface maps are used to evaluate flow paths. Vertical gradients are also used as an additional line of evidence to evaluate hydraulic containment. Groundwater elevation data collected on 18 August 2023 were used to prepare potentiometric surface maps based on manual measurements and averaged transducer groundwater elevations (Figures 2 through 4) and vertical difference maps (Figures 5 and 6).

The generalized flow direction indicated by the potentiometric surface maps shows overall groundwater flow from upgradient toward the GWBW. The Shallow and Intermediate Zones potentiometric maps (Figures 2 and 3) indicate localized groundwater movement to the extraction trenches due to GW SCM pumping, and inward gradients observed sporadically along the length of the barrier wall. Localized cones of depression are apparent around all the groundwater extraction trenches. Decreasing groundwater elevation data trends suggest the cones of depression will continue to expand and intersect. Between March 2023, when river water elevations were at a Spring maximum, and August 2023, consistent cones of depression have expanded substantially on the south end of site and are beginning to overlap. This correlates to the areas where pumping has been more consistent. Additionally, cones of depression in the northern portion of the site that had been established in March are growing in the southward direction.

These cones of depression are primarily observed in the Shallow and Intermediate Zones, and are expected to continue to expand as pumping continues.

A potentiometric separation is still noticeable exterior to the GWBW, indicating the barrier wall is functioning by impeding groundwater flow. Groundwater elevations are demonstrating a slight gradient toward the river.

Horizontal groundwater gradient observations for the Shallow, Intermediate, and Deep Zones indicate that the increased pumping rates in 2023 are positively affecting the horizontal gradients (Attachment B-2). The horizontal gradient at the Intermediate Zone at GCC2 and GCC6 indicated an inward gradient in August 2023, and GCC1, GCC3, GCC4, and GCC5 in the intermediate zone are approaching inward gradient. There is an overall trend of decreasing outward gradients, and some GCCs indicate occasional inward gradients since May 2023. River elevations are shown on the potentiometric surface maps in an inset (Figures 2 through 4) and depict stage movement within the month corresponding with the MPR. The river elevation in August 2023 varied with an average of 8.29 feet NAVD88, maximum of 11.37 feet NAVD88, and minimum of 5.81 feet NAVD88. Historically, the river elevation is at its highest in May and decreases until its lowest in October, making it more challenging during these months to achieve inward gradients. Trends toward inward gradients are anticipated to increase during the upcoming seasonal river stage increases in fall and winter.

Vertical gradients were calculated for each vertical well pair using these groundwater elevations and are plotted on Figures 5 and 6. Vertical groundwater gradients interior to the GWBW between the Shallow and Intermediate Zones were downward (Figure 5). The vertical groundwater gradient at GCC3 interior of the wall was unable to be calculated due to an anomalous groundwater elevation reading at PA-12i. PA-12i will be recalibrated so that vertical gradients at GCC3 can be calculated in the future and presented in subsequent MPRs. Vertical groundwater gradients are also depicted in Attachment B-2. The magnitude of the gradient is much greater at GCC1 than other monitoring locations due to the influence from a localized high-pressure zone near GCC1 where vertical groundwater flow is impeded by a localized confining unit (Figure 2). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were mixed with GCC2 and GCC5 being upward and GCC1, GCC3, GCC4, and GCC6 being downward as shown on Figure 5 and in Attachment B-2.

Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were mixed with GCC1, GCC4, and GCC5 being downward and the remaining upward. This is a continuation of the downward trend of vertical gradients interior of the wall between the Intermediate and Deep Zones. The vertical groundwater gradient at GCC3 interior of the wall was unable to be calculated due to an anomalous groundwater elevation reading at PA-12i. The direction of vertical gradients exterior to the GWBW were mixed with GCC1, GCC2, and GCC5 being downward and the remaining being upward, as shown on Figure 6 and Attachment B.

3.3.1 GWET System Performance

The GWET system operated within permit conditions during the reporting period. There was one shutdown:

- Sunday, 20 August 2023: A planned shutdown in the morning to reconfigure sludge piping from the clarifier to tank T-7 and in preparation to change out spent filter fabric on the filter press plates. Well field was restarted in the afternoon.

There were no upgrades to the GWET system in the month of August 2023.

3.3.2 Recovery Well and Extraction Well Performance

The average system influent flow rate was 45.27 gallons per minute (gpm) for the entire month of August 2023, including non-operational periods. The average influent flow during operational periods was 58.42 gpm. LSS is currently in the process of optimizing extraction rates within the system to increase flow rates at each operational well until either the extraction rates specified in the *Final Design Report* (ERM 2022) are achieved, the wells are producing the maximum quantity of water possible, or until the Capture Zone Objectives are met. In recent months, the pumping rates at historically productive wells have decreased. Redevelopment of six extraction wells (i.e., three trenches) is planned for October. The goal of the redevelopment is to increase pumping rates. Additionally, back pressure through the trunk line from the wellfield to the GWET plant appears to be a limiting factor in groundwater extraction. LSS is currently evaluating options for reconfonfiguration of the trunk line to mitigate back pressure effects on pumping rates.

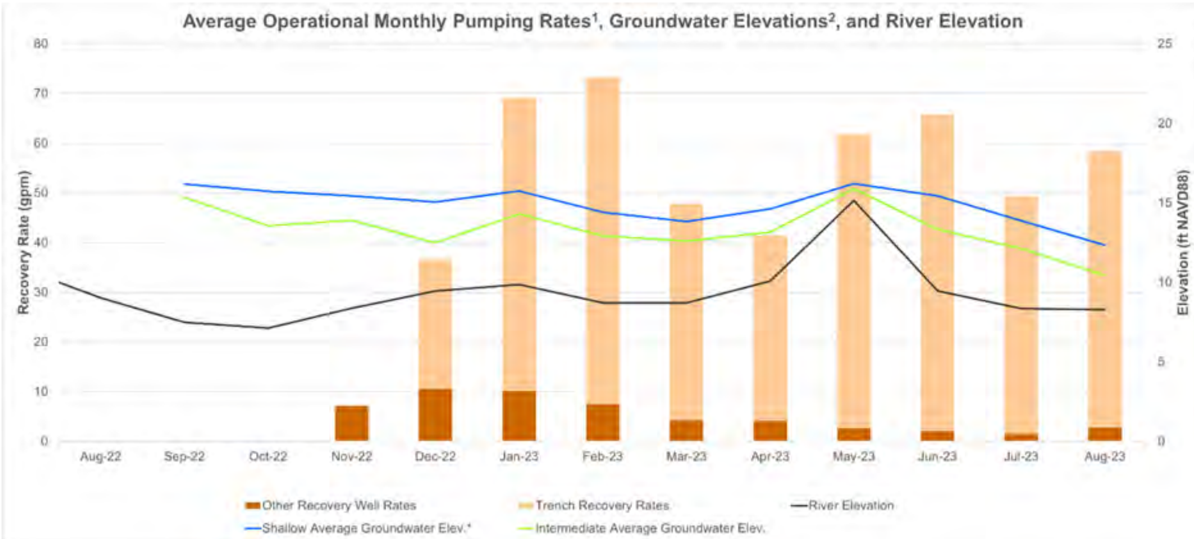
Table 1-3. Recovery Well Pumping Rates

Recovery Well	August 2023 Average Operational Pumping Rate (gpm)	August 2023 Average Monthly Pumping Rate (gpm)
RW-14	0.09	0.07
RW-22	0.07	0.05
RW-23	0.74	0.72
RW-25	1.78	1.61
EW-01	2.53	2.45
EW-02 *	0.00	0.00
EW-03	1.90	1.71
EW-04	1.95	0.19
EW-05	12.44	12.04
EW-06	3.71	1.56
EW-07	5.01	4.68
EW-08	3.51	0.57
EW-09	5.06	4.89
EW-10	2.89	0.47
EW-11	1.57	0.35
EW-12	1.17	0.94
EW-13	7.91	7.65
EW-14	6.10	5.31
Total	**58.42**	**45.27**

Notes:

** = Recovery well not in service during reporting period.*

gpm = gallon per minute



Notes:

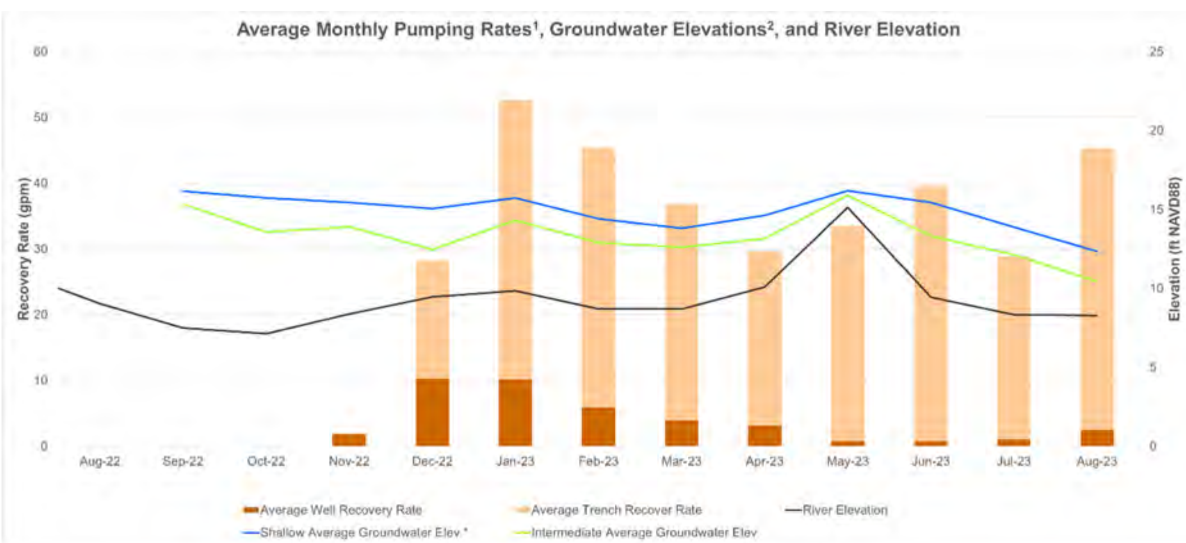
[1] = Following installation of trenches in Summer 2022, RW-22, 23, and 25 recovery rates are now grouped together with the other remaining recovery well (RW-14) starting in November 2022.

[2] = Average groundwater elevations are calculated using interior wells—the wellfield was powered down in August 2022 preventing the measurement of the groundwater.

** = The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the whole aquifer.*

ft NAVD88 = feet North American Vertical Datum of 1988

Figure 1-1. Operational Monthly Pumping Rate



Notes:

[1] = Following installation of trenches in Summer 2022, RW-22, 23, and 25 recovery rates are now grouped together with the other remaining recovery well (RW-14) starting in November 2022.

[2] = Average groundwater elevations are calculated using interior wells—the wellfield was powered down in August 2022 preventing the measurement of the groundwater.

** = The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the whole aquifer.*

ft NAVD88 = feet North American Vertical Datum of 1988

Figure 1-2. Average Monthly Pumping Rate

3.3.3 Recommendations for Extraction System Optimization

Recovery rates from the start of the system indicate that the active RWs and EWs are operating as designed except for the troubleshooting discussed above. The extraction rates throughout the GWET system will continue to be optimized to meet Target Capture Objectives.

4. ANALYTICAL PROGRAM

Quarterly groundwater monitoring was implemented in accordance with the ODEQ-approved Arkema Quarterly Groundwater Monitoring Work Plan dated October 2019 and the ODEQ-approved reduced scope described in the 2021 monitoring program modification request memorandum dated 9 September 2021. The table below outlines sampling dates and submittal dates related to groundwater monitoring since the implementation of the reduced scope. The Quarterly Monitoring Reports present results from these sampling events.

Report	Sampling Dates	Report Submittal Date
2021 Quarter 3	9/21/2021–9/24/2021	1/14/2022
2021 Quarter 4	12/13/2021–12/16/2021	4/20/2022
2022 Quarter 1	3/14/2022–3/17/2022	6/15/2022
2022 Quarter 2	6/6/2022–6/9/2022	9/12/2022
2022 Quarter 4	11/7/2022–11/10/2022	2/17/2023
2023 Quarter 1	3/6/2023–3/10/2023	6/12/2023
2023 Quarter 2	6/12/2023–6/16/2023	9/22/2023
2023 Quarter 3	8/21/2023–8/24/2023	12/8/2023
2023 Quarter 4	12/11/2023–12/14/2023 *	4/8/2023*

* Dates are tentative.

5. SUMMARY AND CONCLUSIONS

This report presents a summary of the GW SCM operation, maintenance, and monitoring activities conducted at the Site in August 2023 and documents results from system monitoring. The following summarizes ERM's observations and conclusions drawn from collected data.

5.1 Groundwater Flow

- Horizontal groundwater gradients for the Shallow, Intermediate, and Deep Zones indicate that the GCC's have increased since June 2023, except for the horizontal gradient in GCC5 in the Deep Zone (Attachment B-2). Additionally, groundwater elevations show a noticeable separation of the interior and exterior of the GWBW, indicating the GWBW is functioning via impeding groundwater flow. All horizontal gradients except GCC5 in the Deep Zone are trending towards achieving inward gradients.

- Vertical groundwater gradients interior to the GWBW between the Shallow and Intermediate Zones were downward (Figure 5). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were mixed with GCC2 and GCC5 being upward and GCC1, GCC3, GCC4, and GCC6 being downward.

- Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were mixed with GCC1, GCC4, and GG5 being downward and GCC2 and GCC6 upward. The direction of vertical gradients exterior to the GWBW were mixed with GCC1, GCC2, and GCC5 being downward and the remaining being upward, as shown on Figure 6.

- The average river elevation in August 2023 was 8.29 feet NAVD 88 with a minimum elevation of 5.81 feet NAVD88 and a maximum elevation of 11.37 feet NAVD88. The seasonal river level elevation trends indicate a seasonal high in May and a seasonal low in October.

5.2 Groundwater Extraction

Based on August 2023 extraction and relevant hydrograph analysis, the trenches are functioning to allow for increased groundwater extraction rates. Within the Site alluvial sequence, potentiometric maps indicate the GW SCM is producing localized areas of hydraulic capture throughout the Target Capture Zone; however, more time at elevated extraction rates will be required to evaluate whether GWET objectives are being met system wide.

The groundwater extraction flow rate is currently limited by a combination of ground water elevation, influence of back pressure in the trunk line, and fouling of the EWs within the trenches. Currently, water from Trench 7 is being re-routed via overland hoses to intermediate trunk lines to limit the influence on back pressure in the main trunk line on production rates. Further evaluation of the system with respect to the Capture Zone Objectives will be conducted once all pumps are operating at their design rates for an extended period.

5.3 Recommendations and Future Work

ERM will continue to optimize new EWs, including pump maintenance/upgrades, redevelopment of the wells, and potential trunk line configuration. Any additional modifications to the system to meet capture objectives will be included in subsequent Monthly Performance Monitoring Report. The project schedule provided as Attachment C summarizes activities planned for the immediate future.

Regards,

Brendan Robinson, PE
Partner

6. REFERENCES

ERM (ERM-West, Inc.). 2012. *Arkema Portland Groundwater Source Control Measure, Groundwater Barrier Wall Final Design, Arkema Inc., Portland, Oregon*. July 2012.

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Serfes, Michael. 1991. "Determining the Mean Hydraulic Gradient of Ground Water Affected by Tidal Fluctuations." *Groundwater*, Vol. 29. No 4. July–August 1991.

FIGURES

Figure 1: Site Layout

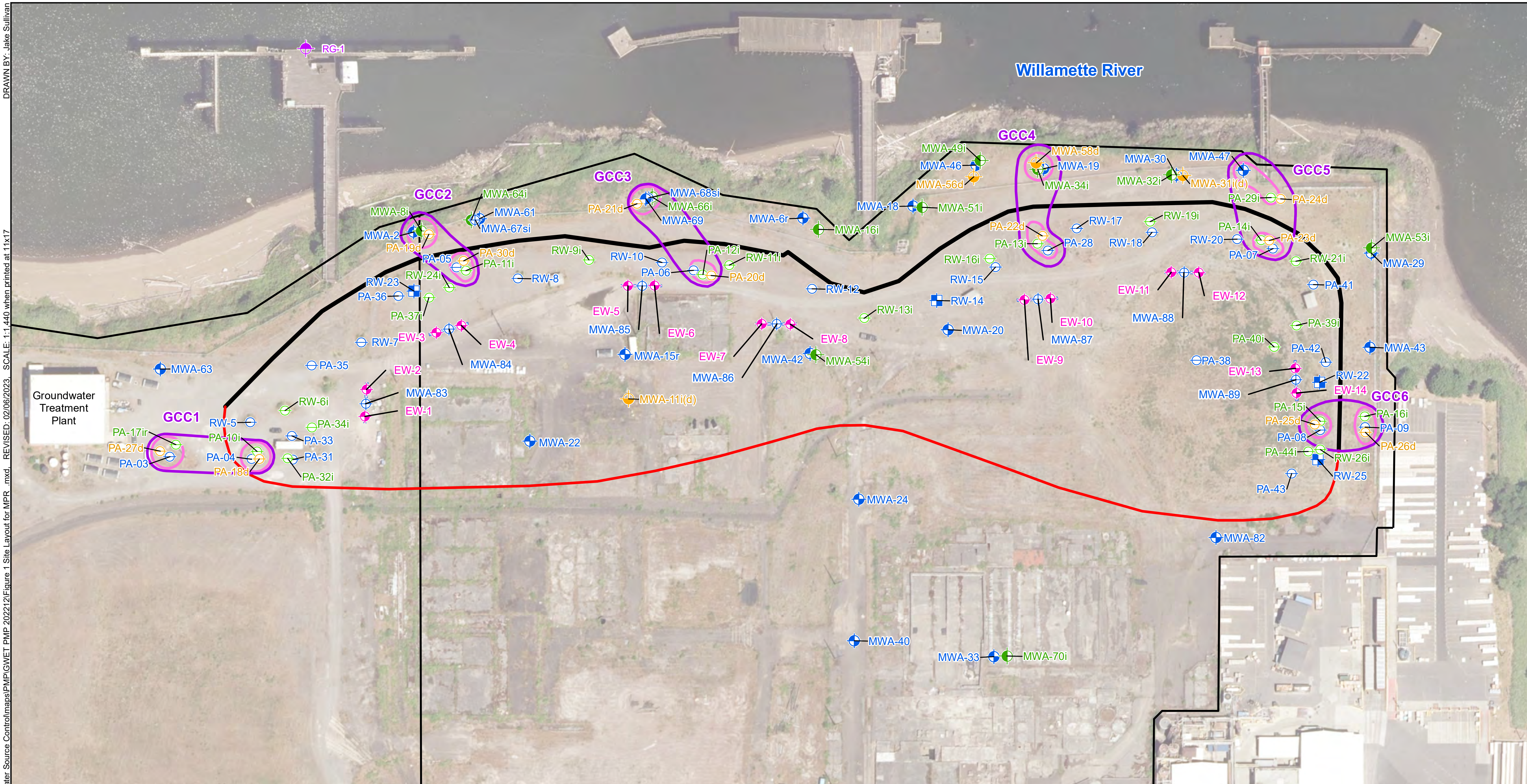
Figure 2: July 2023 Shallow Zone Groundwater Contours

Figure 3: July 2023 Intermediate Zone Groundwater Contours

Figure 4: July 2023 Deep Zone Groundwater Contours

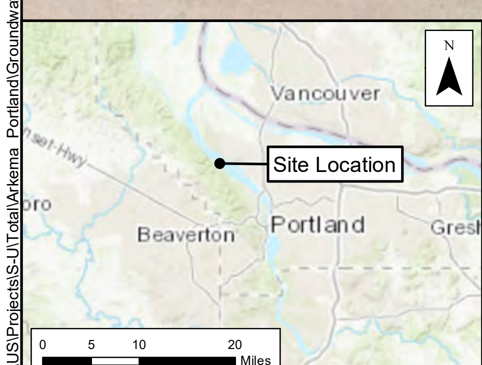
Figure 5: July 2023 Shallow to Intermediate Zone Vertical Head Difference

Figure 6: July 2023 Intermediate to Deep Zone Vertical Head Difference



DRAWN BY: Jake Sullivan

M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 202212\Figure 1 Site Layout for MPR_.mxd. REVISED: 02/06/2023. SCALE: 1:1,440 when printed at 11x17



Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Shallow Zone Recovery Well
- River Gauge
- Trench Extraction Well
- Target Capture Zone
- Barrier Wall Alignment
- Parcel and Property Boundaries

GradientClusters

Type

- Gradient Control Cluster
- Vertical Flow Cluster
- Extraction Trench

N

0 120 240

Feet

Figure 1

Site Layout

Monthly Progress Report

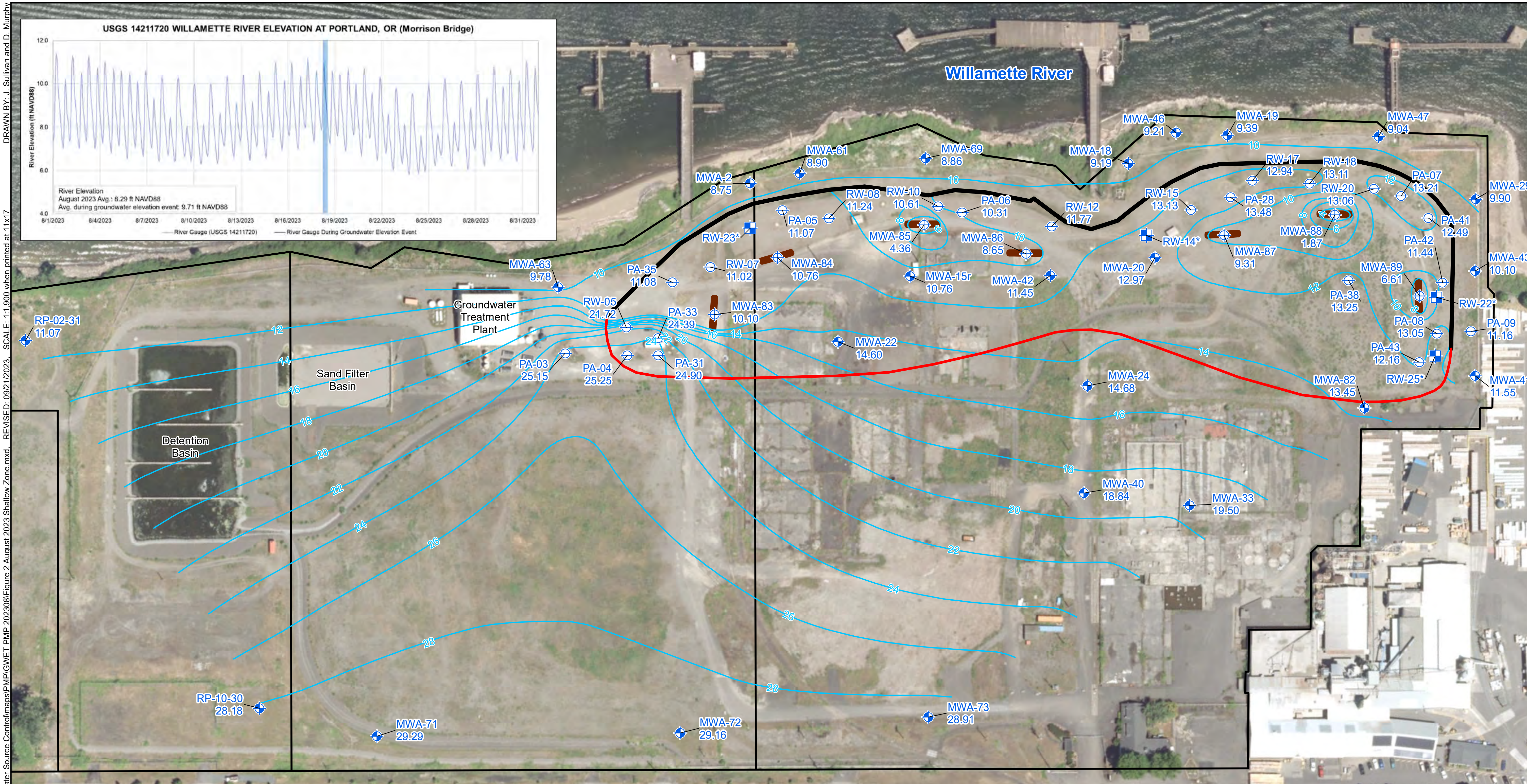
Groundwater Source Control Measure

Arkema Inc.

Portland, Oregon

Environmental Resources Management
www.erm.com

Source: City of Portland Aerial Imagery, flown Summer 2021; NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Shallow Zone Piezometer
- Shallow Zone Monitoring Well
- Active Recovery Well; Not Used During Contouring
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Shallow Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected August 18, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

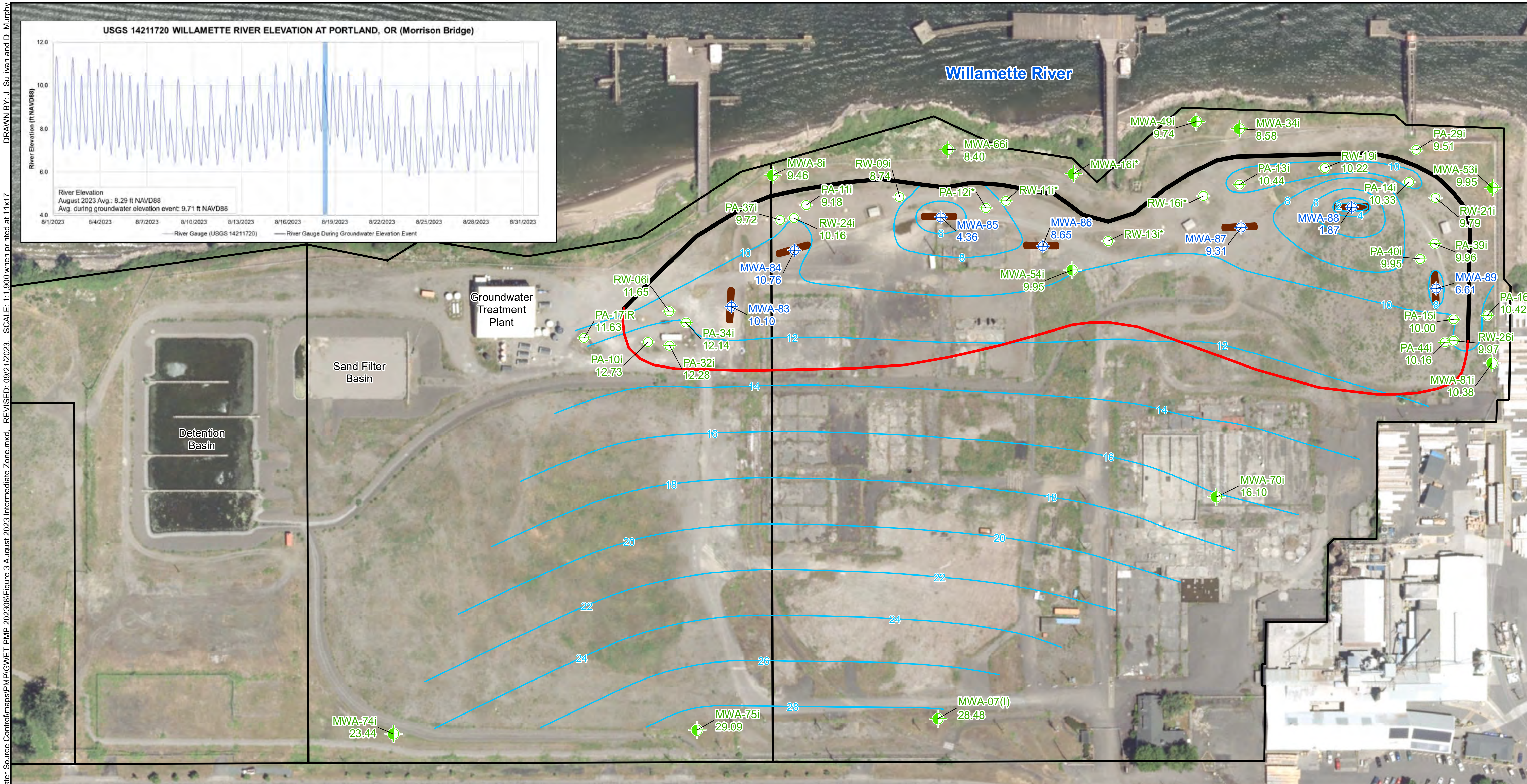
N

0 160 320
Feet

Figure 2
August 2023 Shallow Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



DRAWN BY: J. Sullivan and D. Murphy

M:\US\Projects\S-U\Total\Arkema Portland\Groundwater Source Control\maps\PMP\GWET PMP 202308\Figure 3 August 2023 Intermediate Zone.mxd. REVISED: 09/21/2023. SCALE: 1:1,900 when printed at 11x17

Legend

- Intermediate Zone Piezometer
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Intermediate Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected August 18, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

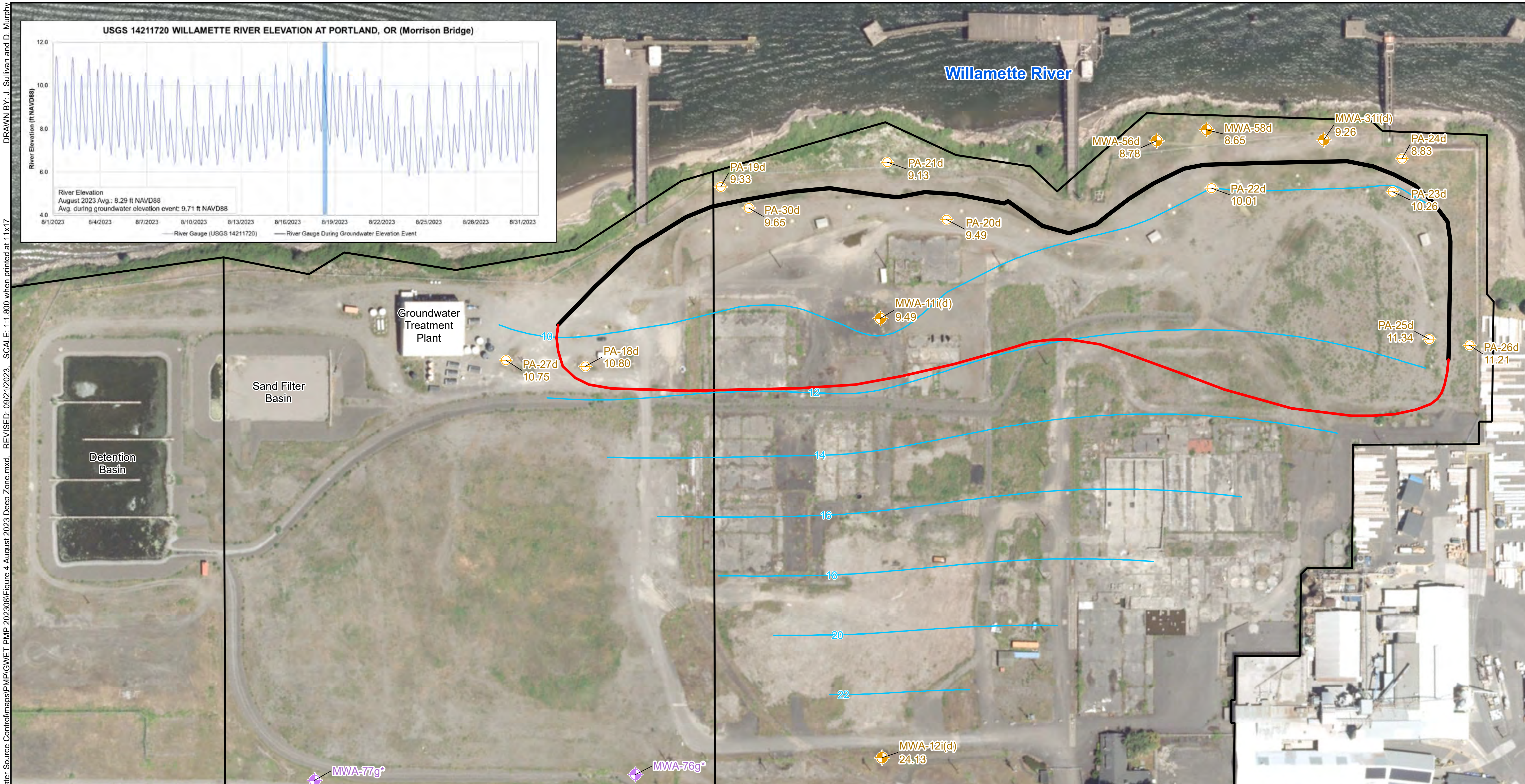
N

0 160 320
Feet

Figure 3
August 2023 Intermediate Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Deep Zone Piezometer
- Deep Zone Monitoring Well
- Gravel Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Deep Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment

Notes:
* Value not used for contouring.
Gravel zone wells not used in contouring.
Water levels collected August 18, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 150 300
Feet

Figure 4
August 2023 Deep Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 202308\Figure 5 August 2023 Vertical Difference Shallow Intermediate.mxd REVISED: 09/21/2023 SCALE: 1:1,560 when printed at DRAWN BY: J. Sullivan and D. Murphy

Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Shallow Zone Recovery Well
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Vertical Gradient not calculated due to anomalous groundwater elevation reading
- Downward Flow
- Upward Flow

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as shallow zone minus intermediate zone potentiometric surfaces.
Water levels collected August 18, 2023.
Aerial Photo: City of Portland, Summer 2017.

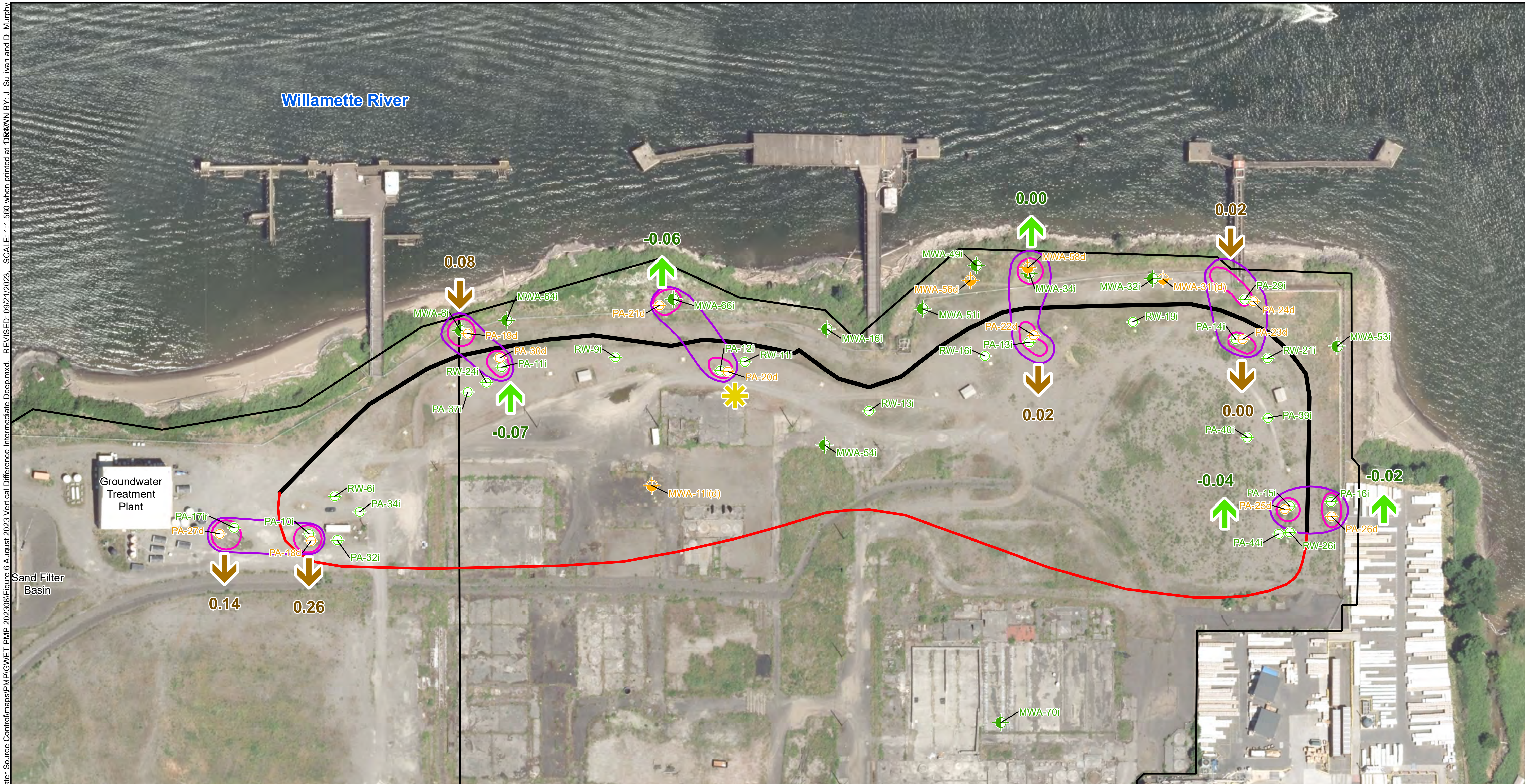
N

0 130 260
Feet

Figure 5
August 2023 Shallow to Intermediate Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Vertical Gradient not calculated due to anomalous groundwater elevation reading
- Downward Flow
- Upward Flow

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as intermediate zone minus deep zone potentiometric surfaces.
Water levels collected August 18, 2023.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 6
August 2023 Intermediate to Deep Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

ATTACHMENT A-1 TRANSDUCER FLAGS

Attachment A-1. Transducer Flags

Table A-1
Transducer Malfunction Log: August 2023
Arkema Inc. Facility
Portland, Oregon

Gradient Cluster	Transducer	Interval	Date Range		Issue and Repairs Performed
N/A	RW-15	Shallow		- 8/18/23	Transducer turned on following upgrades, but found to be non-operational. Replaced on 8/18/23.
N/A	RW-11i	Intermediate		- 8/18/23	Transducer turned on following upgrades, but found to be non-operational. Replaced on 8/18/23.

Notes:

I/O = input/output

LOTO = lockout/tagout

VFD = variable frequency drive

ATTACHMENT A-2 RECOVERY WELL STATUS

Attachment A-2. Recovery Well Status

Table A-2
Recovery Well Status: August 2023
Arkema Inc. Facility
Portland, Oregon

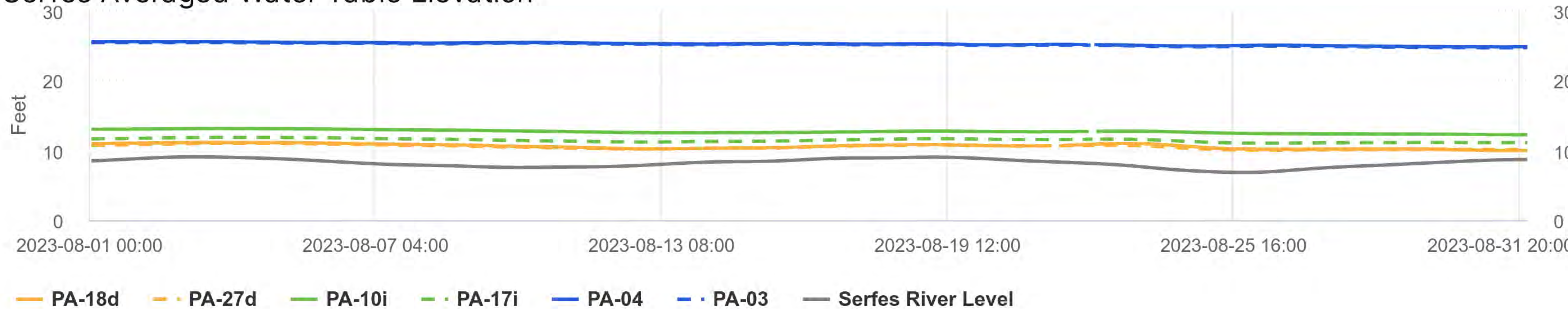
Recovery Well ID	Status as of 8/31/2023 (active or inactive)	Issue	Actions to get online	Expected date back online	Transducer Status	Totalizer Status	Average Flow Rate (gpm)	Overall Extraction Rate	Notes
RW-14	Active	None	N/A	N/A	Good	Good	0.09	P	
RW-22	Active	None	N/A	N/A	Good	Good	0.07	P	
RW-23	Active	None	N/A	N/A	Good	Good	0.74	P	
RW-25	Active	None	N/A	N/A	Good	Good	1.78	M	
EW-01	Active	None	N/A	N/A	Good	Good	2.53	M	
EW-02	Active	None	N/A	N/A	Good	Good	0.00	OFF*	Insufficient recharge at trench, redevelopment planned
EW-03	Active	None	N/A	N/A	Good	Good	1.90	M	
EW-04	Active	None	N/A	N/A	Good	Good	1.95	M	
EW-05	Active	None	N/A	N/A	Good	Good	12.44	G	
EW-06	Active	None	N/A	N/A	Good	Good	3.71	G	
EW-07	Active	None	N/A	N/A	Good	Good	5.01	G	
EW-08	Active	None	N/A	N/A	Good	Good	3.51	G	
EW-09	Active	None	N/A	N/A	Good	Good	5.06	G	
EW-10	Active	None	N/A	N/A	Good	Good	2.89	M	
EW-11	Active	None	N/A	N/A	Good	Good	1.57	M	
EW-12	Active	None	N/A	N/A	Good	Good	1.17	M	
EW-13	Active	None	N/A	N/A	Good	Good	7.91	G	
EW-14	Active	None	N/A	N/A	Good	Good	6.10	G	

Notes:
** Recovery wells not in service*
*** Recovery wells in service part of the month*
G = good pumping, greater than 3.0 gpm
gpm = gallons per minute
M = moderate pumping, greater than 1.0 gpm and less than 3.0
P = poor pumping, less than 1.0 gpm
VFD = variable frequency drive
PA = piezometer

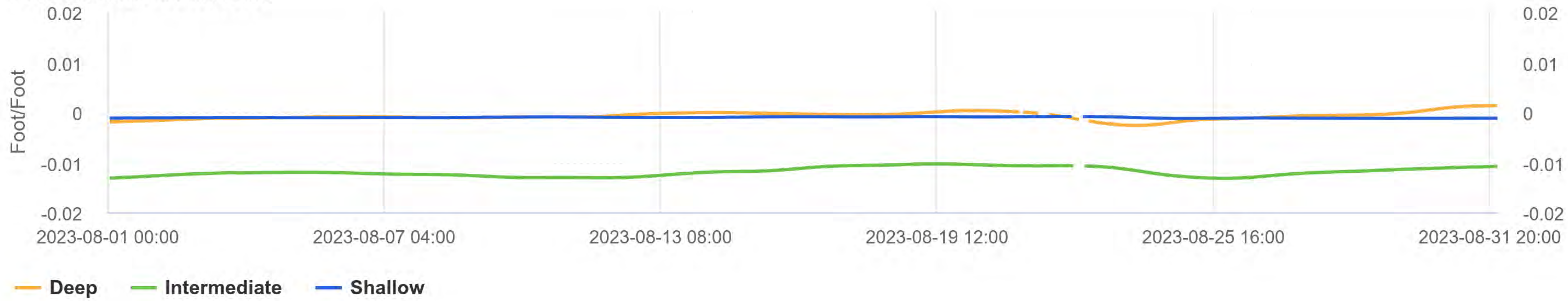
ATTACHMENT B-1 GRADIENT HYDROGRAPHS

Gradient Control Cluster 1

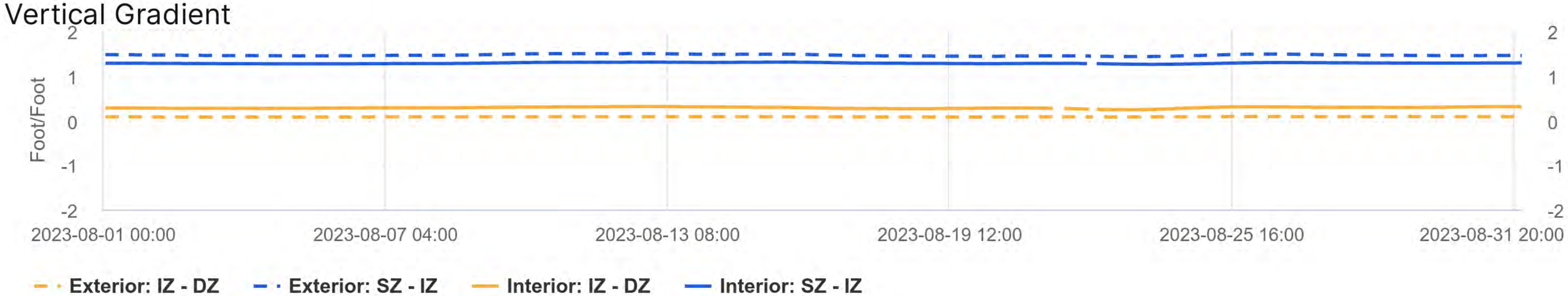
Serfes Averaged Water Table Elevation



Horizontal Gradient

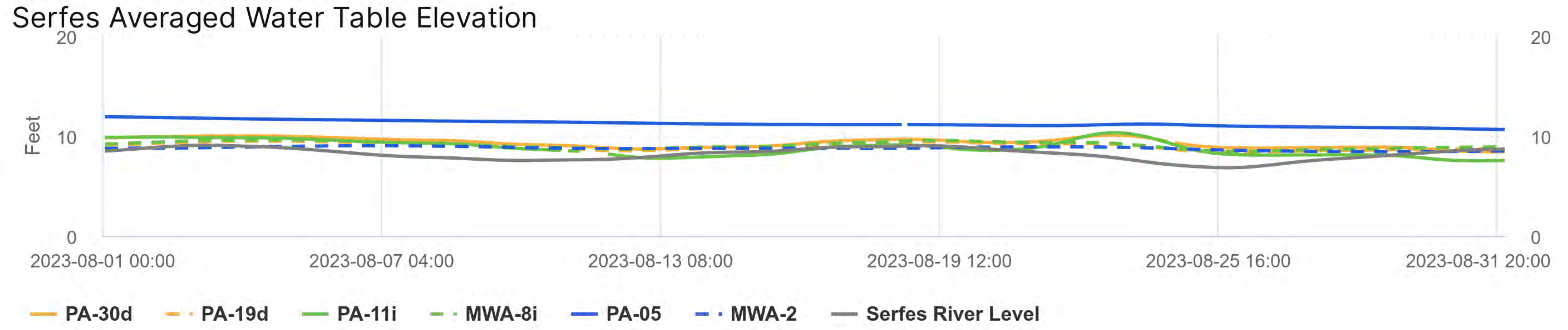


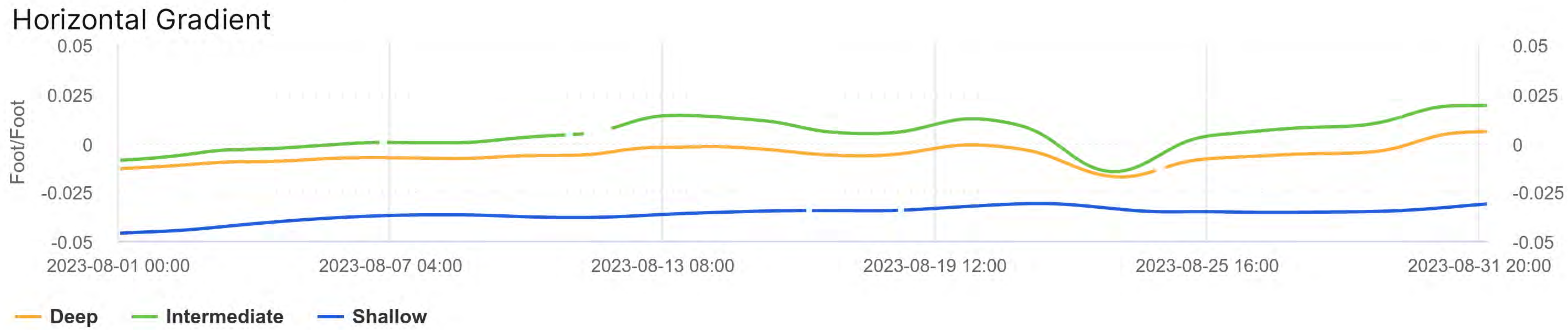
Vertical Gradient

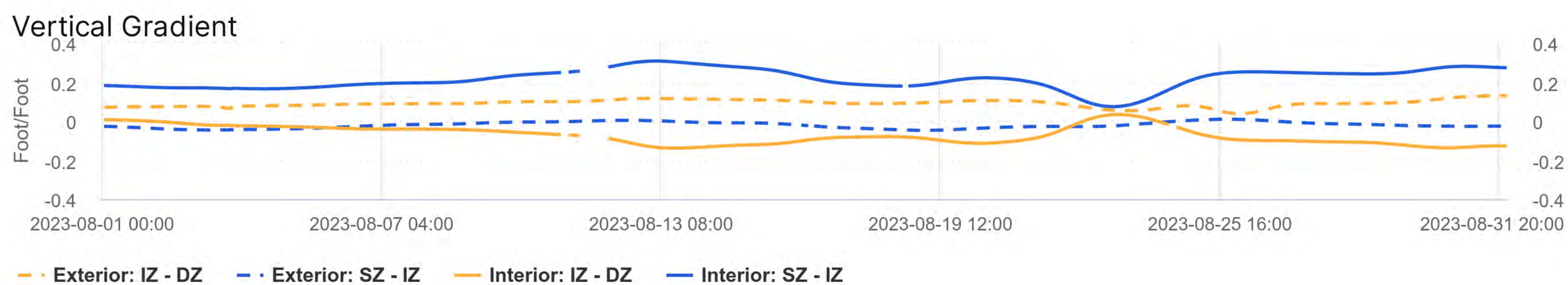


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 2



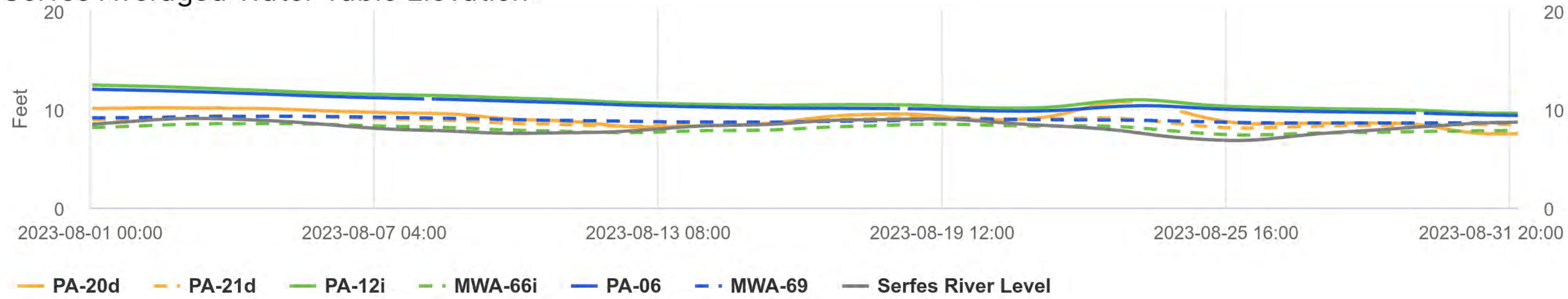




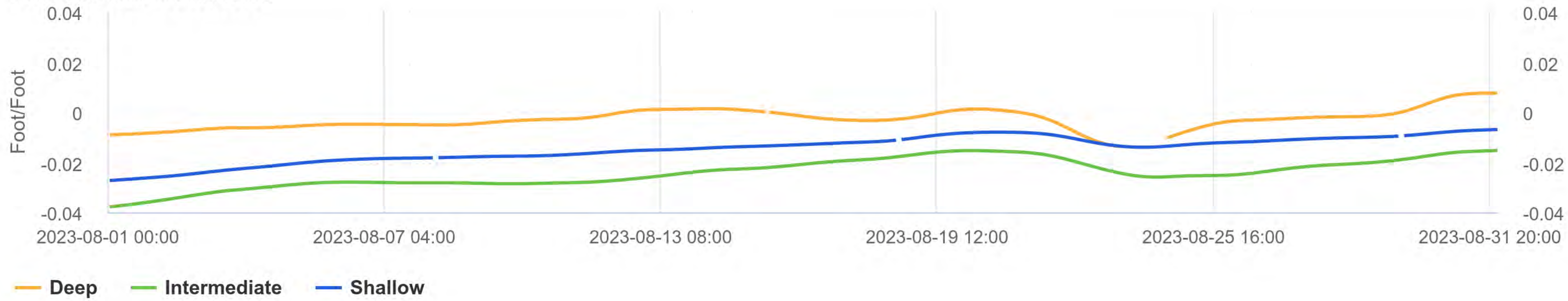
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 3

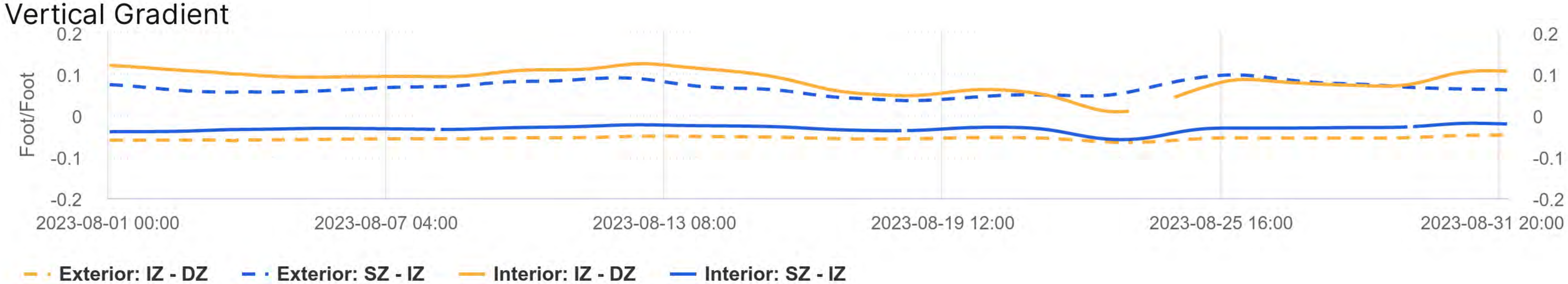
Serfes Averaged Water Table Elevation



Horizontal Gradient

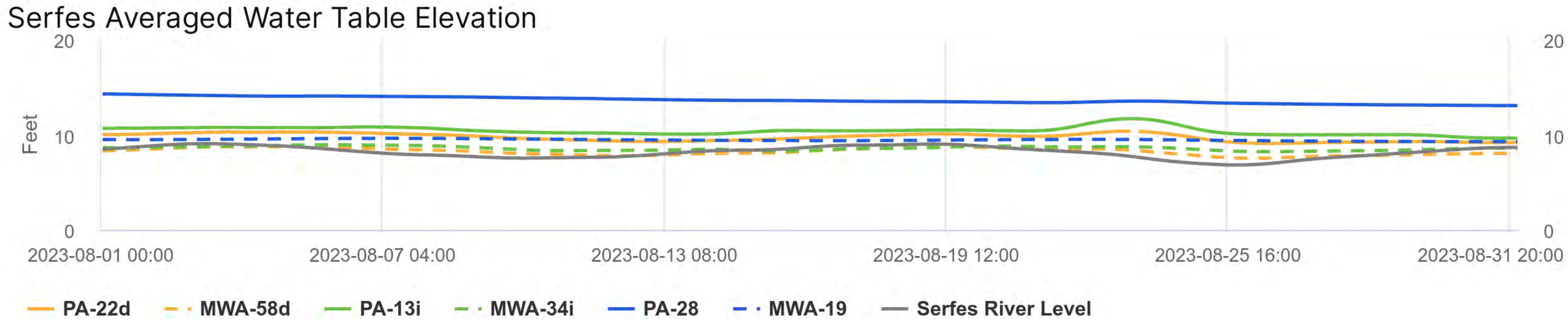


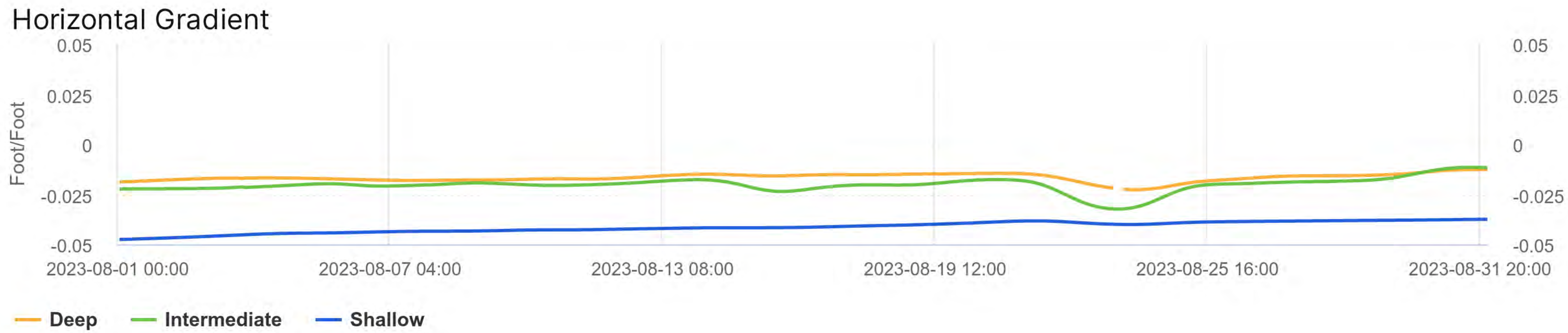
Vertical Gradient

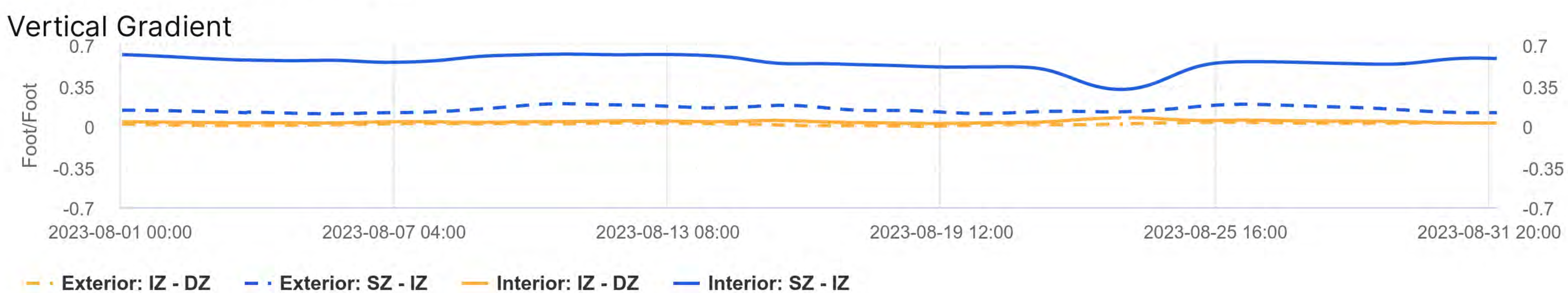


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 4

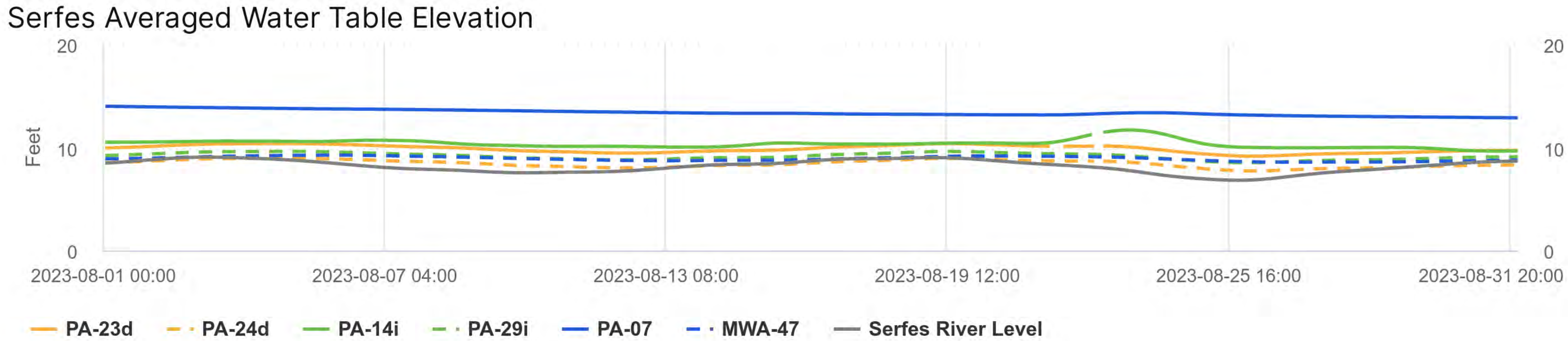


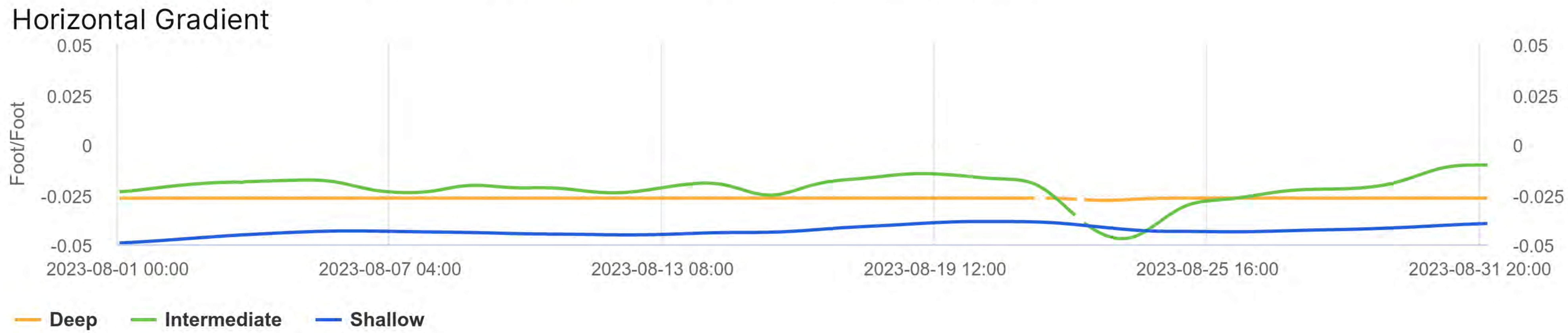


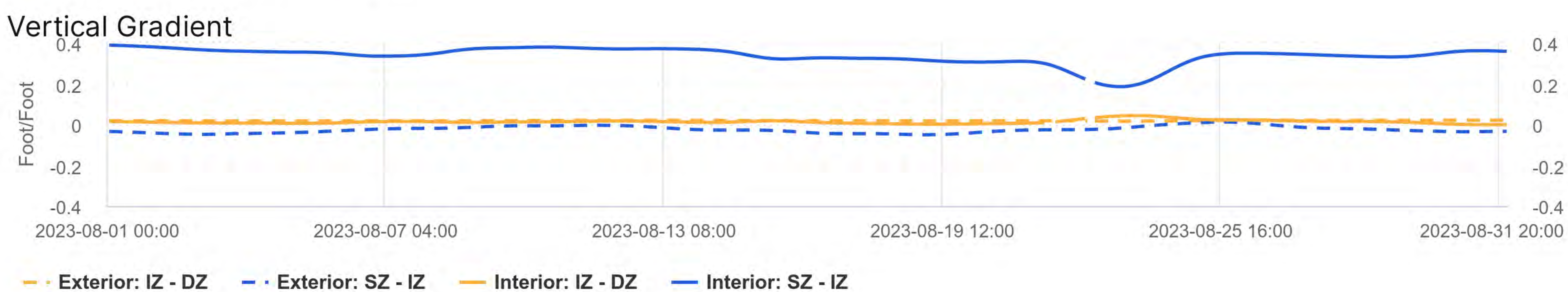


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 5



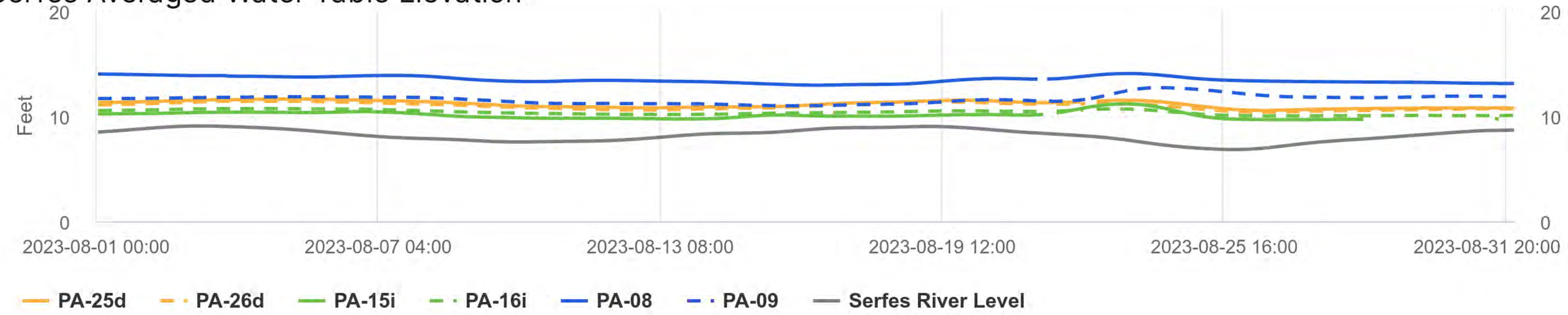




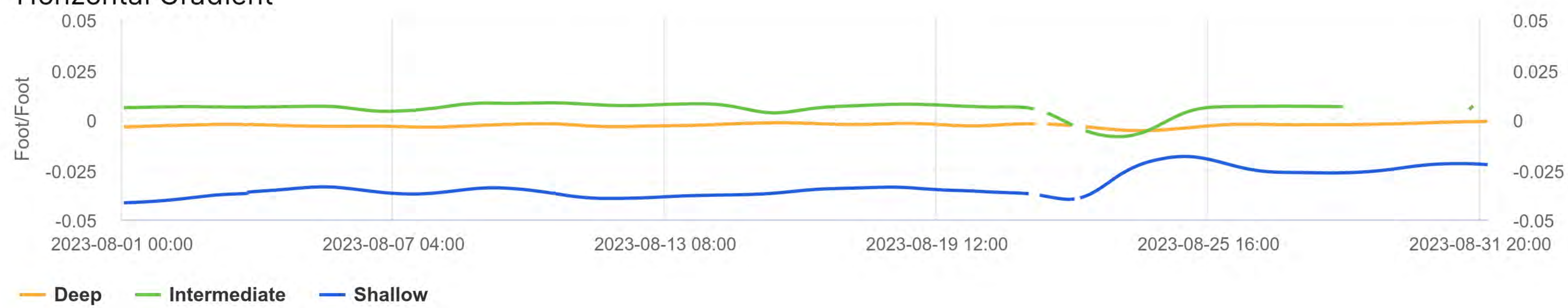
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 6

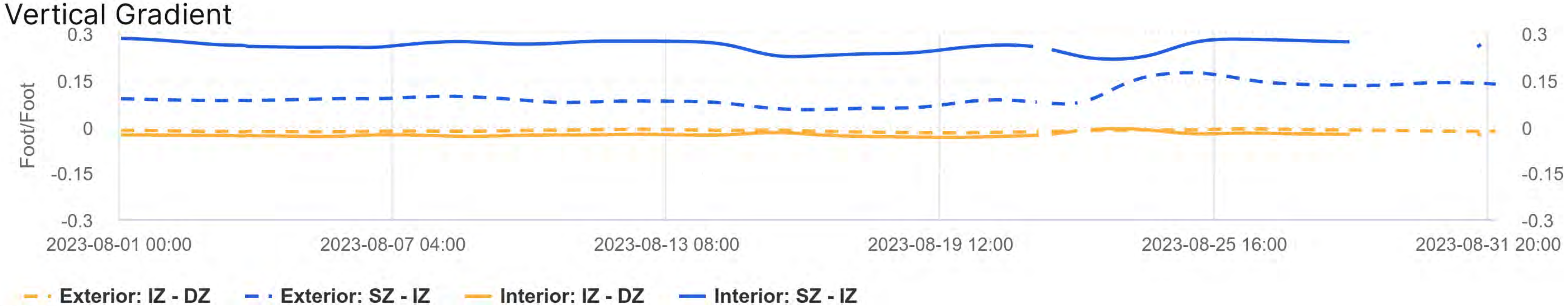
Serfes Averaged Water Table Elevation



Horizontal Gradient



Vertical Gradient

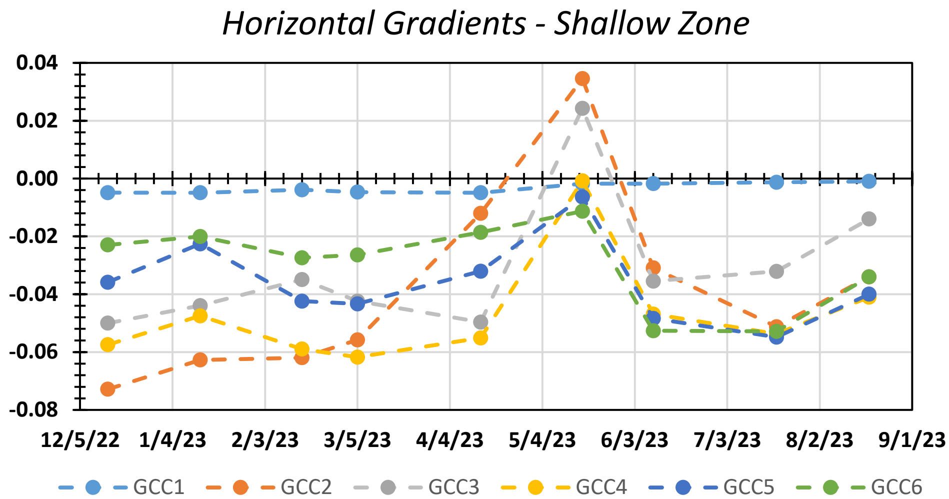


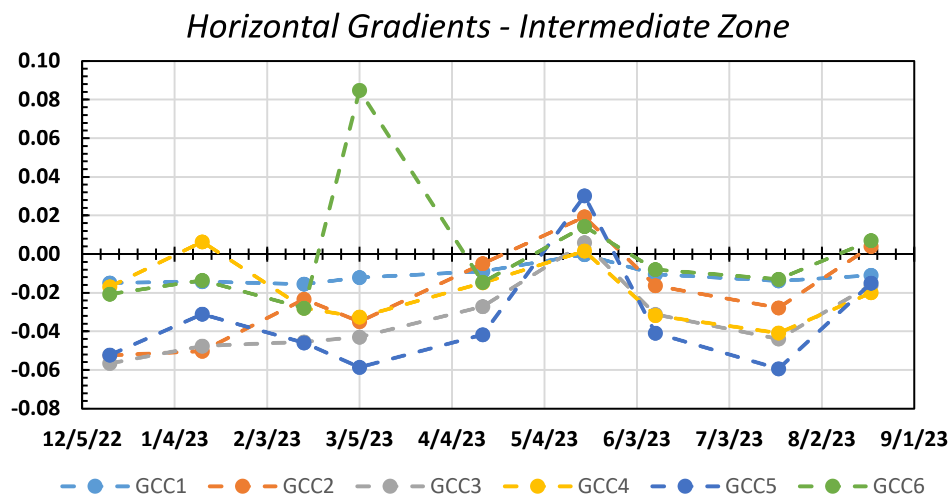
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

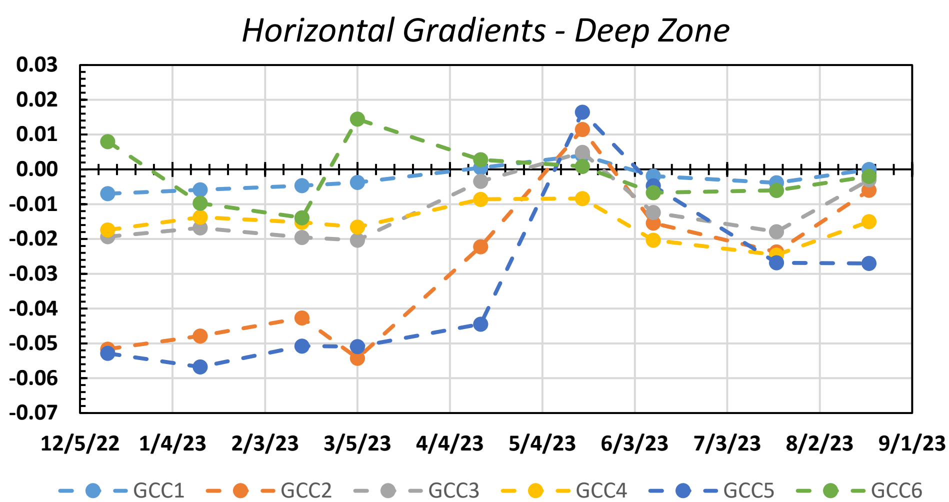
ATTACHMENT B-2 HORIZONTAL GRADIENTS

Attachment B-2

Horizontal Gradients Summary: August 2023
Arkema Inc. Facility
Portland, Oregon





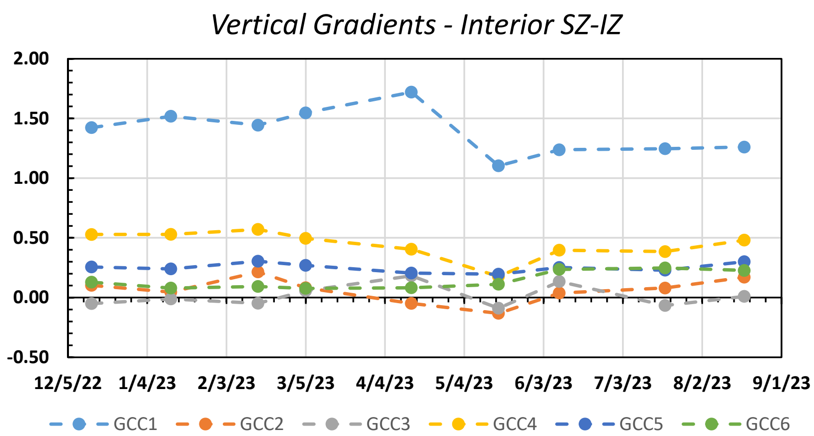


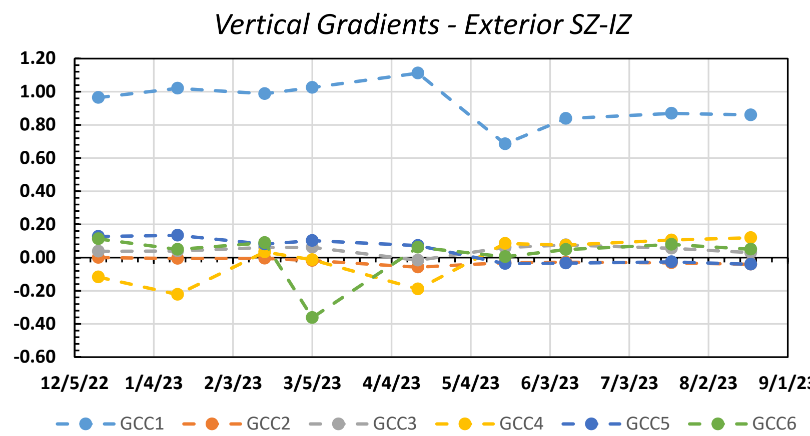
Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.

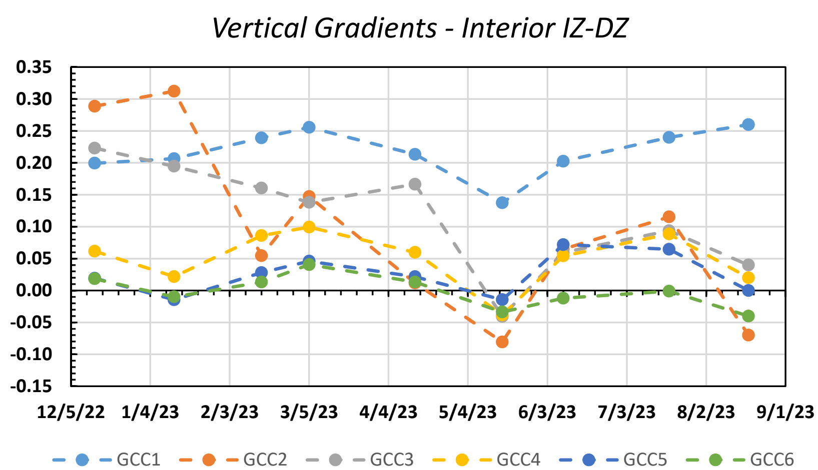
ATTACHMENT B-3 VERTICAL GRADIENTS

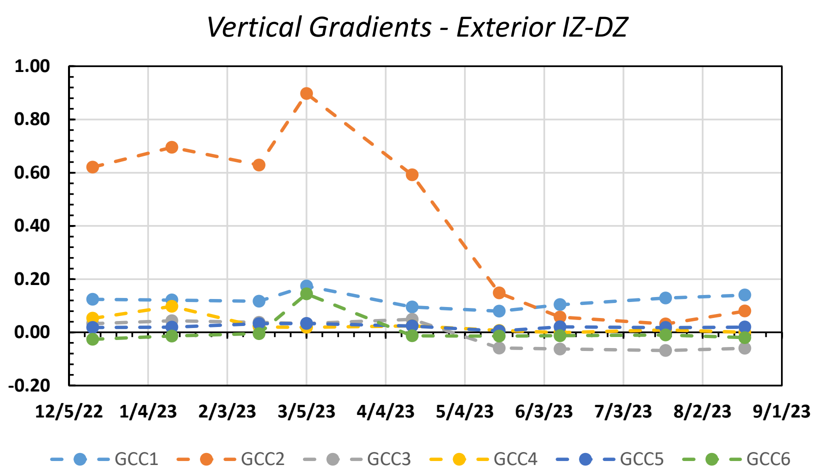
Attachment B-3

Vertical Gradients Summary: August 2023
Arkema Inc. Facility
Portland, Oregon





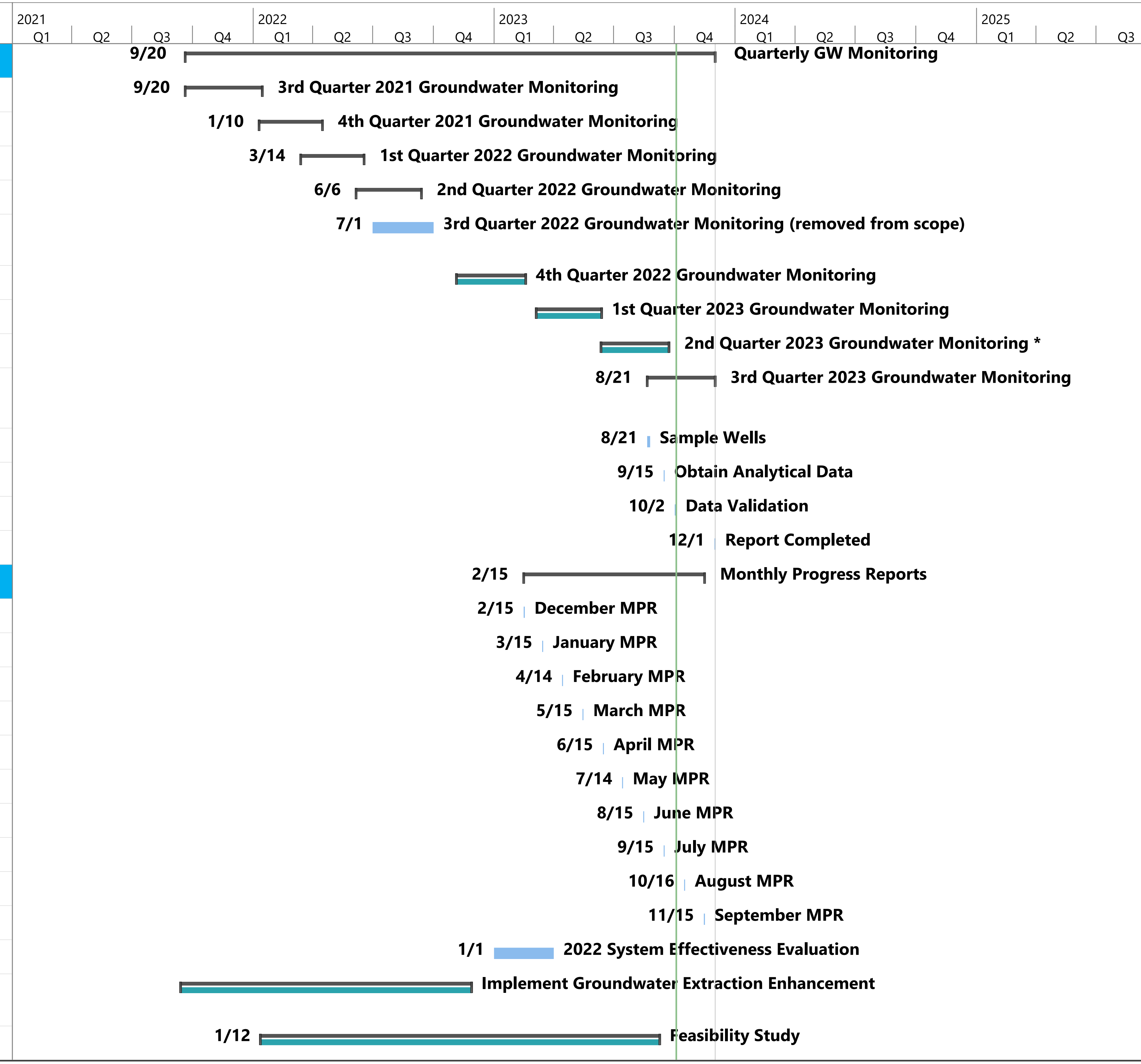




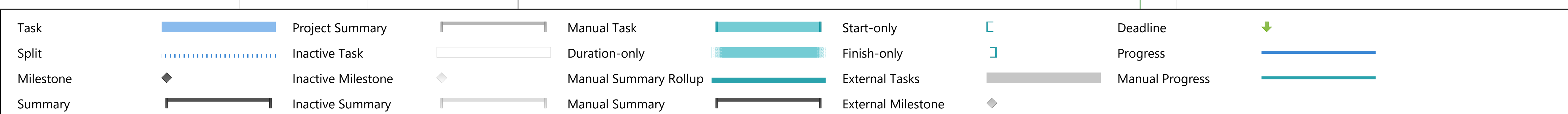
Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW

ATTACHMENT C PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**Quarterly GW Monitoring**	**578 days**	**Mon 9/20/21**	**Fri 12/1/23**
2	*3rd Quarter 2021 Groundwater Monitoring*	*85 days*	*Mon 9/20/21*	*Fri 1/14/22*
7	*4th Quarter 2021 Groundwater Monitoring*	*70 days*	*Mon 1/10/22*	*Fri 4/15/22*
11	*1st Quarter 2022 Groundwater Monitoring*	*70 days*	*Mon 3/14/22*	*Fri 6/17/22*
16	*2nd Quarter 2022 Groundwater Monitoring*	*71 days*	*Mon 6/6/22*	*Mon 9/12/22*
21	*3rd Quarter 2022 Groundwater Monitoring (removed from scope)*	*66 days*	*Fri 7/1/22*	*Fri 9/30/22*
22	*4th Quarter 2022 Groundwater Monitoring*	*78 days*	*Sat 11/5/22*	*Fri 2/17/23*
27	*1st Quarter 2023 Groundwater Monitoring*	*71 days*	*Mon 3/6/23*	*Mon 6/12/23*
32	*2nd Quarter 2023 Groundwater Monitoring **	*75 days*	*Mon 6/12/23*	*Fri 9/22/23*
37	**3rd Quarter 2023 Groundwater Monitoring**	**75 days**	**Mon 8/21/23**	**Fri 12/1/23**
38	Sample Wells	4 days	Mon 8/21/23	Thu 8/24/23
39	Obtain Analytical Data	1 day	Fri 9/15/23	Fri 9/15/23
40	Data Validation	1 day	Mon 10/2/23	Mon 10/2/23
41	Report Completed	1 day	Fri 12/1/23	Fri 12/1/23
42	**Monthly Progress Reports**	**196 days**	**Wed 2/15/23**	**Wed 11/15/23**
43	*December MPR*	*1 day*	*Wed 2/15/23*	*Wed 2/15/23*
44	*January MPR*	*1 day*	*Wed 3/15/23*	*Wed 3/15/23*
45	*February MPR*	*1 day*	*Fri 4/14/23*	*Fri 4/14/23*
46	*March MPR*	*1 day*	*Mon 5/15/23*	*Mon 5/15/23*
47	*April MPR*	*1 day*	*Thu 6/15/23*	*Thu 6/15/23*
48	*May MPR*	*1 day*	*Fri 7/14/23*	*Fri 7/14/23*
49	*June MPR*	*1 day*	*Tue 8/15/23*	*Tue 8/15/23*
50	*July MPR*	*1 day*	*Fri 9/15/23*	*Fri 9/15/23*
51	August MPR	1 day	Mon 10/16/23	Mon 10/16/23
52	September MPR	1 day	Wed 11/15/23	Wed 11/15/23
53	***2022 System Effectiveness Evaluation***	***66 days***	***Sun 1/1/23***	***Fri 3/31/23***
54	***Implement Groundwater Extraction Enhancement***	***317 days***	***Mon 9/13/21***	***Sun 11/27/22***
62	***Feasibility Study***	***436 days***	***Wed 1/12/22***	***Fri 9/8/23***



Arkema Portland
Monthly Progress Report
Attachment C



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Memo

To	Katie Daugherty, Oregon Department of Environmental Quality
From	Brendan Robinson, PE, Environmental Resources Management, Inc.
Date	15 November 2023
Reference	0682894 Phase 204
Subject	September 2023 GW SCM Monthly Performance Monitoring Report

1. INTRODUCTION

Environmental Resources Management, Inc. (ERM) prepared this Monthly Performance Monitoring Report (MPR) on behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc. (Arkema), for the former Arkema Portland Plant (the Site) at 6400 NW Front Avenue in Portland, Oregon. The Oregon Department of Environmental Quality (ODEQ), in its letter dated 31 May 2019 and in the subsequent meeting with LSS and ERM on 2 July 2019, requested that LSS initiate monthly status reports associated with the onsite groundwater source control measure (GW SCM) consistent with the Performance Monitoring Plan (PMP; ERM 2014) beginning July 2019. The 2014 PMP was prepared pursuant to the Order on Consent issued by ODEQ, signed on 31 October 2008 (ODEQ No. LQVC-NWR-08-04; Consent Order). The purpose of the PMP was to present the monitoring, reporting, and adaptive management processes used during implementation of the GW SCM. On 30 November 2021, ODEQ directed LSS that following the October 2021 MPR, subsequent MPRs would be suspended pending the implementation of the Groundwater Extraction Enhancement (GEE) project in 2022. During that time, ODEQ requested monthly schedule updates in lieu of MPRs. The trench wells installed as part of the GEE project were started on 27 November 2022, and MPR writing restarted in December 2022. The purpose of the GEE project was to install new extraction capacity to achieve the Capture Zone Objectives.

This September 2023 MPR summarizes the GW SCM performance monitoring data collected in September 2023. This report assesses the current gradient status and proposes system improvements to meet the Capture Zone Objectives set in the PMP.

2. GROUNDWATER SOURCE CONTROL IMPLEMENTATION

A detailed description of the design and implementation of the GW SCM is provided in the *Revised Upland Feasibility Study Work Plan* (ERM 2017); however, a brief description of the GW SCM is provided here. In February 2009, ODEQ and the U.S. Environmental Protection Agency (USEPA) approved the general approach for the GW SCM. This approach included installation of a groundwater barrier wall (GWBW), groundwater recovery wells, and a Groundwater Extraction and Treatment (GWET) system, with treated water discharged to the Willamette River. ODEQ and USEPA approved the *Groundwater Barrier Wall Final Design* (ERM 2012) on 7 August 2012. Construction of the GWBW began in May 2012 and was completed in December 2012. ODEQ approved the *Groundwater Extraction and Treatment System Final Design* (ERM 2013) on 2 April

2013. Construction of the GWET system began in December 2012 and was completed in December 2013.

GWET startup and optimization commenced in May 2014. The GW SCM at the Site consists of the following primary components (Figure 1):

1. A GWBW to physically separate the affected upland portions and in-water portions of the Site.

2. Hydraulic control to minimize flow of groundwater containing unacceptable concentrations of constituents of potential concern (COPCs) around, over, and under the GWBW.

3. Management of extracted groundwater through the GWET system, with treated effluent discharged to the Willamette River under a National Pollutant Discharge Elimination System (NPDES) Permit.

On 1 September 2018, ERM submitted the *Draft GWET System Effectiveness Evaluation* (Draft SEE Report; ERM 2018). The Draft SEE Report provided an update on the corrective actions implemented to improve the performance of the GWET system, evaluate the extent of capture, and propose actions to improve hydraulic capture. Additional data requested by ODEQ were submitted on 26 October 2018.

The key objective of the GW SCM is to achieve hydraulic containment of the alluvial sequence within the Target Capture Zone at the Site to prevent the flow of COPCs to the Willamette River. The Site alluvial aquifer sequence within the Target Capture Zone consists of the Shallow Zone, Intermediate Zone, and the Deep Zone. Site hydraulic conditions are variable and subject to both seasonal and daily tidal fluctuations.

The hydraulic control component formerly consisted of 22 recovery wells (RWs) prior to the implementation of the GEE. Of the 22 pre-existing RWs, four were retained for active pumping. The remaining 18 former RWs had pumps removed but retained their pressure transducers so that they can continuously collect high-resolution groundwater elevation data. The hydraulic control system now consists of the four remaining active RWs, as well as seven groundwater extraction trenches that each contain two extraction wells (EWs). Each trench is 50 feet deep, 50 feet long, and 3 feet wide and is filled with an engineered backfill. More information about the groundwater extraction trenches is provided in the *Final Design Report* (ERM 2022). The gradient control-monitoring network consists of six gradient control clusters (GCCs) with each cluster containing six monitoring points. Within each RW, EW, and GCC location, pressure transducers are continuously collecting high-resolution groundwater elevation data. Each GCC contains three transducers interior to the wall and three transducers exterior to the wall screened in the Shallow, Intermediate, and Deep aquifers at the Site.

3. HYDRAULIC CONTAINMENT MONITORING PROGRAM

As described in the PMP, the purpose of hydraulic monitoring (i.e., groundwater elevation data) is to provide sufficient data to demonstrate an inward hydraulic gradient across the GWBW and to evaluate the effective hydraulic capture produced by the GW SCM.

Monitoring requirements were established in the PMP to demonstrate GWET effectiveness. The Site monitoring program includes groundwater elevation data (manual and transducer measurements) collected from the 36 monitoring points located within six GCCs spaced across the GWBW, with piezometers interior and exterior to the wall, throughout the alluvial sequence; and groundwater elevation and flow rate data from the four remaining active RWs and 14 EWs. High-resolution groundwater elevation data is also collected from the 18 inactive RWs. Additionally, one new monitoring well was installed in each of the seven extraction trenches for manual water level measurement. These data were used to prepare horizontal and vertical potentiometric surface maps representing potentiometric differences between the alluvial sequences, and to generate spatial and temporal hydrographs to evaluate hydraulic capture.

3.1 Groundwater Elevation Monitoring

Groundwater elevation monitoring was completed on 15 September 2023. Manual groundwater elevations were measured at wells that were experiencing transducer mechanical issues or that were offline during the groundwater elevation measurement event. All inactive RWs were manually measured in the month of September to affirm proper calibration. Manual water levels for those RWs are reported. Additionally, all transducers in inactive RWs were down until upgrades were completed and transducers were sequentially turned on. Specific issues are addressed in Attachment A-1.

As detailed in Attachments A-1 and A-2, during September 2023, the following transducers were:

<u>Fully out of service pending repairs:</u>

- PA-11i
- PA-06

<u>Out of service for a period but returned to full operation:</u>

- PA-15i
- RW-08

3.2 Horizontal and Vertical Gradients at Gradient Control Points

As described above, GCC locations collect high-resolution groundwater elevation data using transducers. Transducer data are filtered to remove anomalous data from monitoring points due to potential equipment failures, such as transducer malfunctions, power outages, or updates to the GWET programmable logic controller (PLC) system, which controls and houses all the operational data. These specific issues and time periods are summarized in Table A-1 in Attachment A. The following flags are applied to filter anomalous data:

- Groundwater elevations had a change greater than 1.5 feet within 1 hour
- Groundwater elevation measurements that were found to be greater than 50 feet, or less than 1 foot

- Calculated groundwater elevation slope indicates no change between consecutive measurements indicating a transducer malfunction
- Manually flagging data that are inconsistent with the typical nature of the well
- Periods where transducer power supply was deactivated for work on interconnected electrical systems

After September 2023 flagged data were removed, the Serfes (1991) method was used to account for tidal variations as described in the PMP. Using Serfes corrected data, both horizontal and vertical gradients were calculated and plotted over time (Attachment B). Groundwater elevations, horizontal gradients, and vertical gradients from 15 September 2023 are shown below at each GCC (Table 1-1 and Table 1-2). The water elevation taken during the groundwater level gauging event at PA-11i was excluded from gradient calculations and potentiometric surface maps due to being anomalous.

Table 1-1. September Horizontal Gradients

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
GCC1	Shallow	PA-03	24.44	PA-04	24.56	-0.001
	Intermediate	PA-17iR	10.49	PA-10i	11.68	-0.011
	Deep	PA-27d	9.40	PA-18d	9.39	0.000
GCC2	Shallow	MWA-2	7.88	PA-05	9.85	-0.029
	Intermediate	MWA-8i	7.97	PA-11i	*	**
	Deep	PA-19d	7.80	PA-30d	7.81	0.000
GCC3	Shallow	MWA-69	7.86	PA-06	8.72	-0.008
	Intermediate	MWA-66i	6.92	PA-12i ^{M}	8.97	-0.018
	Deep	PA-21d	7.58	PA-20d	7.31	0.002
GCC4	Shallow	MWA-19	9.01	PA-28	12.75	-0.037
	Intermediate	MWA-34i	7.87	PA-13i	9.47	-0.018
	Deep	MWA-58d	7.09	PA-22d	8.48	-0.015
GCC5	Shallow	MWA-47	8.08	PA-07	12.56	-0.043
	Intermediate	PA-29i	8.16	PA-14i	9.52	-0.025
	Deep	PA-24d	7.32	PA-23d	8.75	-0.027
GCC6	Shallow	PA-09	10.70	PA-08	12.80	-0.038
	Intermediate	PA-16i	9.55	PA-15i	9.17	0.007
	Deep	PA-26d	9.90	PA-25d	10.02	-0.002

Notes:

Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.

Horizontal gradient calculated as (Exterior Elevation – Interior Elevation) / Horizontal distance.

** = anomalous groundwater elevation; ** = horizontal gradient cannot be calculated due to anomalous elevation reading; ft NAVD88 = feet North American Vertical Datum of 1988; ^{M} = manual groundwater elevation measurement*

Table 1-2. September Vertical Gradients

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
Interior	SZ-IZ	GCC1	PA-04	24.56	PA-10i	11.68	1.30
		GCC2	PA-05	9.85	PA-11i	6.45	0.30
		GCC3	PA-06	8.72	PA-12i ^{M}	8.97	-0.02
		GCC4	PA-28	12.75	PA-13i	9.47	0.51
		GCC5	PA-07	12.56	PA-14i	9.52	0.32
		GCC6	PA-08	12.80	PA-15i	9.17	0.27
	IZ-DZ	GCC1	PA-10i	11.68	PA-18d	9.39	0.30
		GCC2	PA-11i	*	PA-30d	7.81	**
		GCC3	PA-12i	8.97	PA-20d	7.31	0.08
		GCC4	PA-13i	9.47	PA-22d	8.48	0.05
		GCC5	PA-14i	9.52	PA-23d	8.75	0.02
		GCC6	PA-15i	9.17	PA-25d	10.02	-0.02
Exterior	SZ-IZ	GCC1	PA-03	24.44	PA-17iR	10.49	0.89
		GCC2	MWA-2	7.88	MWA-8i	7.97	-0.01
		GCC3	MWA-69	7.86	MWA-66i	6.92	0.07
		GCC4	MWA-19	9.01	MWA-34i	7.87	0.18
		GCC5	MWA-47	8.08	PA-29i	8.16	-0.01
		GCC6	PA-09	10.70	PA-16i	9.55	0.08
	IZ-DZ	GCC1	PA-17iR	10.49	PA-27d	9.40	0.17
		GCC2	MWA-8i	7.97	PA-19d	7.80	0.11
		GCC3	MWA-66i	6.92	PA-21d	7.58	-0.05
		GCC4	MWA-34i	7.87	MWA-58d	7.09	0.03
		GCC5	PA-29i	8.16	PA-24d	7.32	0.02
		GCC6	PA-16i	9.55	PA-26d	9.90	-0.01

Notes:

Positive vertical gradient indicates a downward hydraulic gradient.

Vertical gradient calculated as (Upper Elevation – Lower Elevation) / Screen Midpoint distance.

** = anomalous groundwater elevation; ** = vertical gradient cannot be calculated due to anomalous elevation reading; DZ = Deep Zone; ft NAVD88 = feet North American Vertical Datum of 1988; IZ = Intermediate Zone; ^{M} = manual groundwater elevation measurement; SZ = Shallow Zone*

3.3 Potentiometric Surface, Groundwater Elevation Difference Maps, and Groundwater Flow Directions

As described in the PMP, potentiometric surface maps are used to evaluate flow paths. Vertical gradients are also used as an additional line of evidence to evaluate hydraulic containment. Groundwater elevation data collected on 15 September 2023 were used to prepare potentiometric surface maps based on manual measurements and averaged transducer groundwater elevations (Figures 2 through 4) and vertical difference maps (Figures 5 and 6).

The generalized flow direction indicated by the potentiometric surface maps shows overall groundwater flow from upgradient toward the GWBW. Potentiometric maps (Figures 2, 3, and 4) indicate localized groundwater movement to the extraction trenches due to GW SCM pumping, and cones of depression are apparent around each groundwater extraction trench. No inward gradients were observed in the Shallow Zone in September 2023; however, horizontal gradient trends over time (see Attachment B-2) show horizontal gradients trending toward inward gradients at all GCCs.

In September 2023, horizontal gradients in the Intermediate Zone were inward at GCC2 and GCC6, and GCC4 is approaching an inward gradient. Intermediate Zone horizontal gradient trends over time (see Attachment B-2) show horizontal gradients trending toward inward gradients at all GCCs.

River elevations are shown over time on Figure 1-1 below, and also for the month corresponding with this MPR on the potentiometric surface maps in an inset (Figures 2 through 4) and depict stage movement within the month. The river elevation in September 2023 varied with an average of 7.33 feet NAVD 88 with a minimum elevation of 4.89 feet NAVD88 and a maximum elevation of 11.19 feet NAVD88. Historically, the river elevation is at its highest in May and decreases until its lowest in October, making it more challenging during late summer and fall months to achieve inward gradients. As the wet season begins, the river is expected to rise, increasing the elevation of groundwater downgradient of the GWBW. Depending on how much groundwater elevations upgradient of the GWBW rise with exterior groundwater elevations, there may be increasing trends toward inward horizontal gradients at all GCCs throughout the wet season. A potentiometric separation is still noticeable exterior to the GWBW, indicating that it is functioning by impeding groundwater flow.

Vertical gradients were calculated for each vertical well pair and are plotted on Figures 5 and 6. Vertical groundwater gradients interior to the GWBW between the Shallow and Intermediate Zones were mixed, with GCC3 being upward and the remaining downward (Figure 5). The vertical groundwater gradient at GCC2 interior of the wall was unable to be calculated due to an anomalous groundwater elevation reading at PA-11i. PA-11i will be recalibrated so that vertical gradients at GCC3 can be calculated in the future and presented in subsequent MPRs. Vertical groundwater gradients are also depicted in Attachment B-3. The magnitude of the gradient is much greater at GCC1 than other monitoring locations due to the influence from a localized high-pressure zone near GCC1 where vertical groundwater flow is impeded by a localized confining unit (Figure 2). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were mixed with GCC2 and GCC5 being upward and GCC1, GCC3, GCC4, and GCC6 being downward as shown on Figure 5 and in Attachment B-2.

Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were mixed with GCC6 being upward and the remaining downward. This is a continuation of the downward trend of vertical gradients interior of the wall between the Intermediate and Deep Zones. The vertical groundwater gradient at GCC2 interior of the wall was unable to be calculated due to an anomalous groundwater elevation reading at PA-11i. The direction of vertical gradients exterior to the GWBW were mixed with GCC3 and GCC6 being upward and the remaining downward, as shown on Figure 6 and Attachment B.

3.3.1 GWET System Performance

The GWET system operated within permit conditions during the reporting period. There was one shutdown:

- Thursday, 21 September 2023: A planned shutdown to reconfigure plumbing at the plate separator. Well field was restarted later the same day.

There were no upgrades to the GWET system in the month of September 2023.

3.3.2 Recovery Well and Extraction Well Performance

The average system influent flow rate was 43.54 gallons per minute (gpm) for the entire month of September 2023, including non-operational periods. The average influent flow during operational periods was 57.66 gpm. LSS is currently in the process of optimizing extraction rates within the system to increase flow rates at each operational well until either the extraction rates specified in the *Final Design Report* (ERM 2022) are achieved, the wells are producing the maximum quantity of water possible, or until the Capture Zone Objectives are met. In recent months, the pumping rates at historically productive wells have decreased. Additionally, back pressure through the trunk line from the wellfield to the GWET plant appears to be a limiting factor in groundwater extraction. The backpressure is believed to be caused by fouling of the trunk line. LSS is currently evaluating options to reconfigure the trunk line to mitigate back pressure effects on pumping rates, as well as jetting of the shallow and intermediate trunk lines. A limited trial redevelopment is planned in October 2023, followed by site-wide redevelopment in Q1 2024.

Table 1-3. Recovery Well Pumping Rates

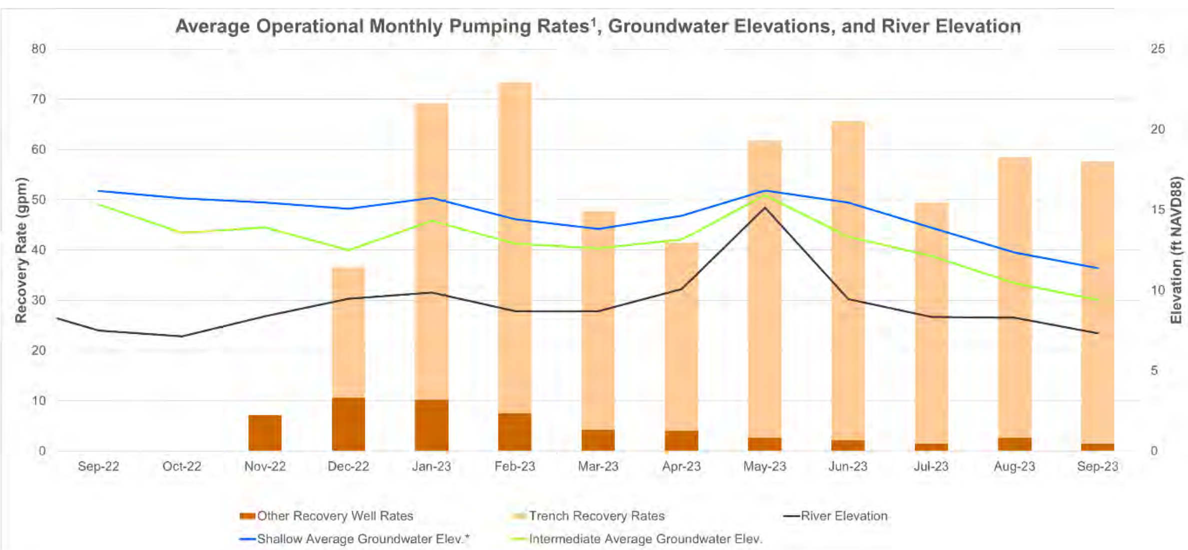
Recovery Well	September 2023 Average Operational Pumping Rate (gpm)	September 2023 Average Monthly Pumping Rate (gpm)
RW-14	0.12	0.12
RW-22	0.03	0.03
RW-23	0.31	0.19
RW-25	0.99	0.99
EW-01	1.35	0.54
EW-02	0.68	0.37

Recovery Well	September 2023 Average Operational Pumping Rate (gpm)	September 2023 Average Monthly Pumping Rate (gpm)
EW-03	4.35	4.35
EW-04	6.40	5.33
EW-05	13.88	13.88
EW-06	5.59	1.30
EW-07	0.10	0.01
EW-08	2.71	2.62
EW-09	2.81	2.81
EW-10*	0.00	0.00
EW-11	0.42	0.06
EW-12	0.90	0.75
EW-13	8.64	4.90
EW-14	8.37	5.30
Total	**57.66**	**43.54**

Notes:

** = Recovery well not in service during reporting period.*

gpm = gallon per minute



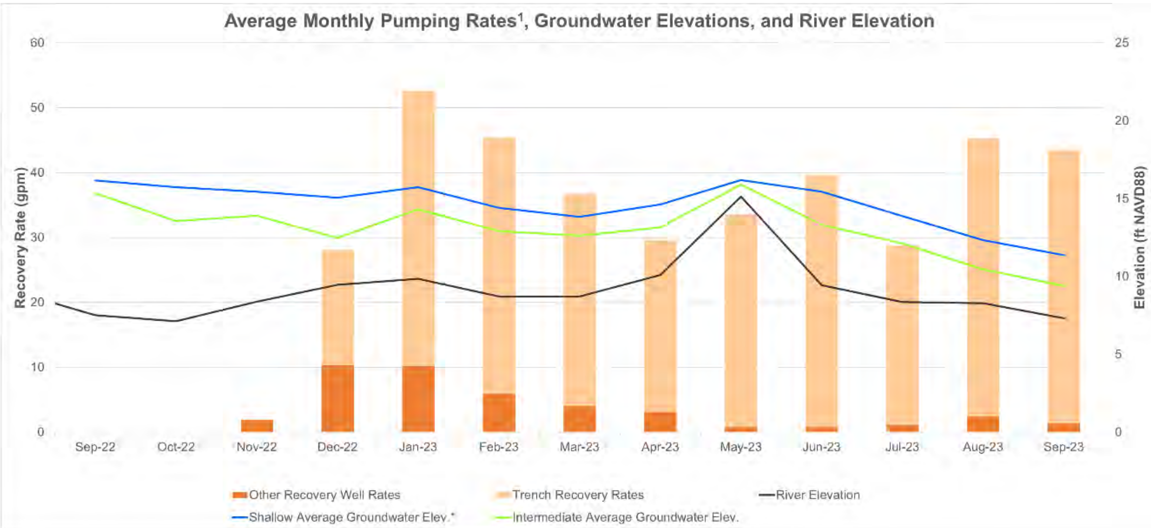
Notes:

[1] = Following installation of trenches in Summer 2022, RW-22, 23, and 25 recovery rates are now grouped together with the other remaining recovery well (RW-14) starting in November 2022.

** = The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the whole aquifer.*

ft NAVD88 = feet North American Vertical Datum of 1988

Figure 1-1. Operational Monthly Pumping Rate



Notes:

[1] = Following installation of trenches in Summer 2022, RW-22, 23, and 25 recovery rates are now grouped together with the other remaining recovery well (RW-14) starting in November 2022.

** = The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the whole aquifer.*

ft NAVD88 = feet North American Vertical Datum of 1988

Figure 1-2. Average Monthly Pumping Rate

3.3.3 Recommendations for Extraction System Optimization

Recovery rates from the start of the system indicate that the active RWs and EWs are operating as designed except for the troubleshooting discussed above. The extraction rates throughout the GWET system will continue to be optimized to meet Target Capture Objectives.

4. ANALYTICAL PROGRAM

Quarterly groundwater monitoring was implemented in accordance with the ODEQ-approved Arkema Quarterly Groundwater Monitoring Work Plan dated October 2019 and the ODEQ-approved reduced scope described in the 2021 monitoring program modification request memorandum dated 9 September 2021. The table below outlines sampling dates and submittal dates related to groundwater monitoring since the implementation of the reduced scope. The Quarterly Monitoring Reports present results from these sampling events.

Report	Sampling Dates	Report Submittal Date
2021 Quarter 3	9/21/2021–9/24/2021	1/14/2022
2021 Quarter 4	12/13/2021–12/16/2021	4/20/2022
2022 Quarter 1	3/14/2022–3/17/2022	6/15/2022
2022 Quarter 2	6/6/2022–6/9/2022	9/12/2022
2022 Quarter 4	11/7/2022–11/10/2022	2/17/2023
2023 Quarter 1	3/6/2023–3/10/2023	6/12/2023

Report	Sampling Dates	Report Submittal Date
2023 Quarter 2	6/12/2023–6/16/2023	9/22/2023
2023 Quarter 3	8/21/2023–8/24/2023	12/1/2023
2023 Quarter 4	12/11/2023–12/14/2023*	4/8/2023*

* Dates are tentative.

5. SUMMARY AND CONCLUSIONS

This report presents a summary of the GW SCM operation, maintenance, and monitoring activities conducted at the Site in September 2023 and documents results from system monitoring. The following summarizes ERM's observations and conclusions drawn from collected data.

5.1 Groundwater Flow

- Horizontal groundwater gradients provided in Attachment B-2 for the Shallow, Intermediate, and Deep Zones indicate that the most GCCs are either inward, or trending toward inward, at most GCCs. Additionally, groundwater elevations show a noticeable separation of the interior and exterior of the GWBW, indicating the GWBW is functioning via impeding groundwater flow. All horizontal gradients except GCC5 in the Deep Zone are trending toward achieving inward gradients.

- Vertical groundwater gradients interior to the GWBW between the Shallow and Intermediate Zones were mixed, with GCC3 being upward and the remaining downward (Figure 5). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were mixed with GCC2 and GCC5 being upward and GCC1, GCC3, GCC4, and GCC6 being downward.

- Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were mixed with GCC6 being upward and the remaining downward. The direction of vertical gradients exterior to the GWBW were mixed with GCC3 and GCC6 being upward and the remaining downward, as shown on Figure 6.

- The average river elevation in September 2023 was 7.33 feet NAVD 88 with a minimum elevation of 4.89 feet NAVD88 and a maximum elevation of 11.19 feet NAVD88. The seasonal river level elevation trends indicate a seasonal high in May and a seasonal low in October.

5.2 Groundwater Extraction

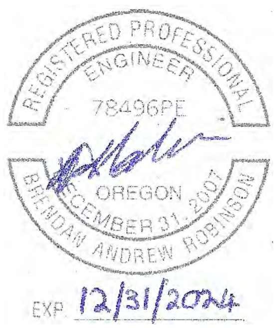
Based on September 2023 extraction and relevant hydrograph analysis, the trenches are functioning to allow for increased groundwater extraction rates compared to the legacy system. Within the Site alluvial sequence, potentiometric maps indicate the GW SCM is producing localized areas of hydraulic capture throughout the Target Capture Zone. The analysis of horizontal gradients provided in Attachment B-2 suggests that gradients are either inward, or trending toward inward, at most GCCs in the Shallow, Intermediate and Deep Zones. More time at elevated extraction rates will be required to evaluate whether GWET objectives are being met system wide. As the wet season begins, the river is expected to rise, increasing the elevation of groundwater downgradient of the GWBW. Depending on how much groundwater elevations upgradient of the GWBW rise, there may be increasing trends toward inward horizontal gradients at all GCCs.

The groundwater extraction flow rate is currently limited by a combination of groundwater elevation, influence of back pressure in the trunk line, and fouling of the EWs within the trenches. Currently, water from Trench 7 is being re-routed via overland hoses to intermediate trunk lines to limit the influence on back pressure in the main trunk line on production rates. Plans to permanently connect three of the trenches to the intermediate trunk line, and line jetting of the shallow and intermediate trunks lines are planned for Q4 2023.

5.3 Recommendations and Future Work

ERM will continue to optimize new EWs, including pump maintenance/upgrades, redevelopment of the wells, and potential trunk line configuration. Any additional modifications to the system to meet capture objectives will be included in subsequent MPRs. The project schedule provided as Attachment C summarizes activities planned for the immediate future.

Regards,



Brendan Robinson, PE
Partner

6. REFERENCES

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FIGURES

Figure 1: Site Layout

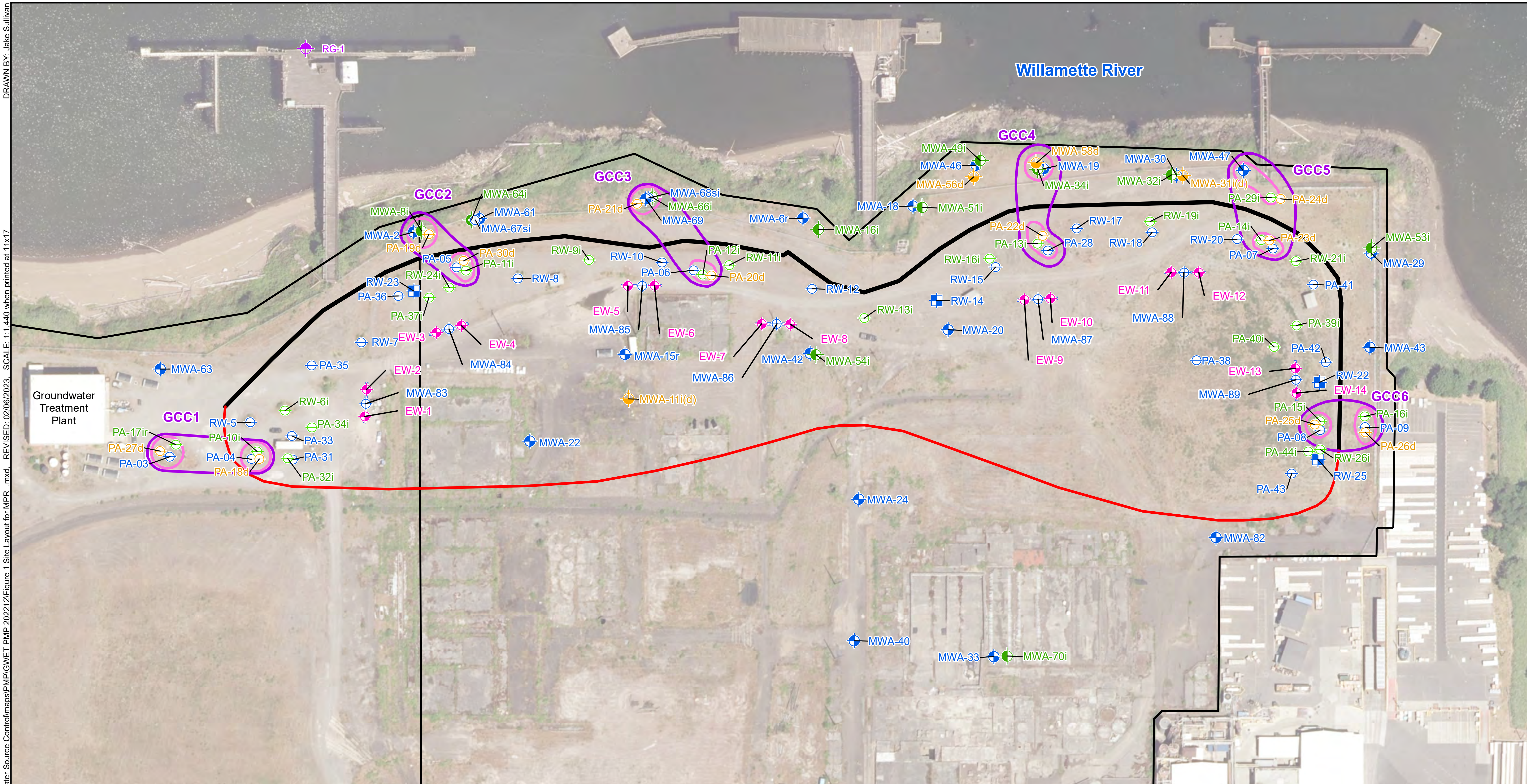
Figure 2: September 2023 Shallow Zone Groundwater Contours

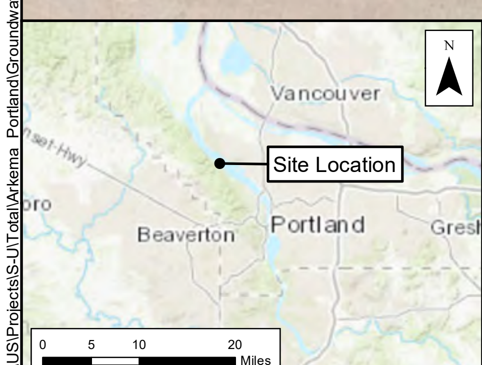
Figure 3: September 2023 Intermediate Zone Groundwater Contours

Figure 4: September 2023 Deep Zone Groundwater Contours

Figure 5: September 2023 Shallow to Intermediate Zone Vertical Head Difference

Figure 6: September 2023 Intermediate to Deep Zone Vertical Head Difference





Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Shallow Zone Recovery Well
- River Gauge
- Trench Extraction Well
- Target Capture Zone
- Barrier Wall Alignment
- Parcel and Property Boundaries

GradientClusters

Type

- Gradient Control Cluster
- Vertical Flow Cluster
- Extraction Trench

N

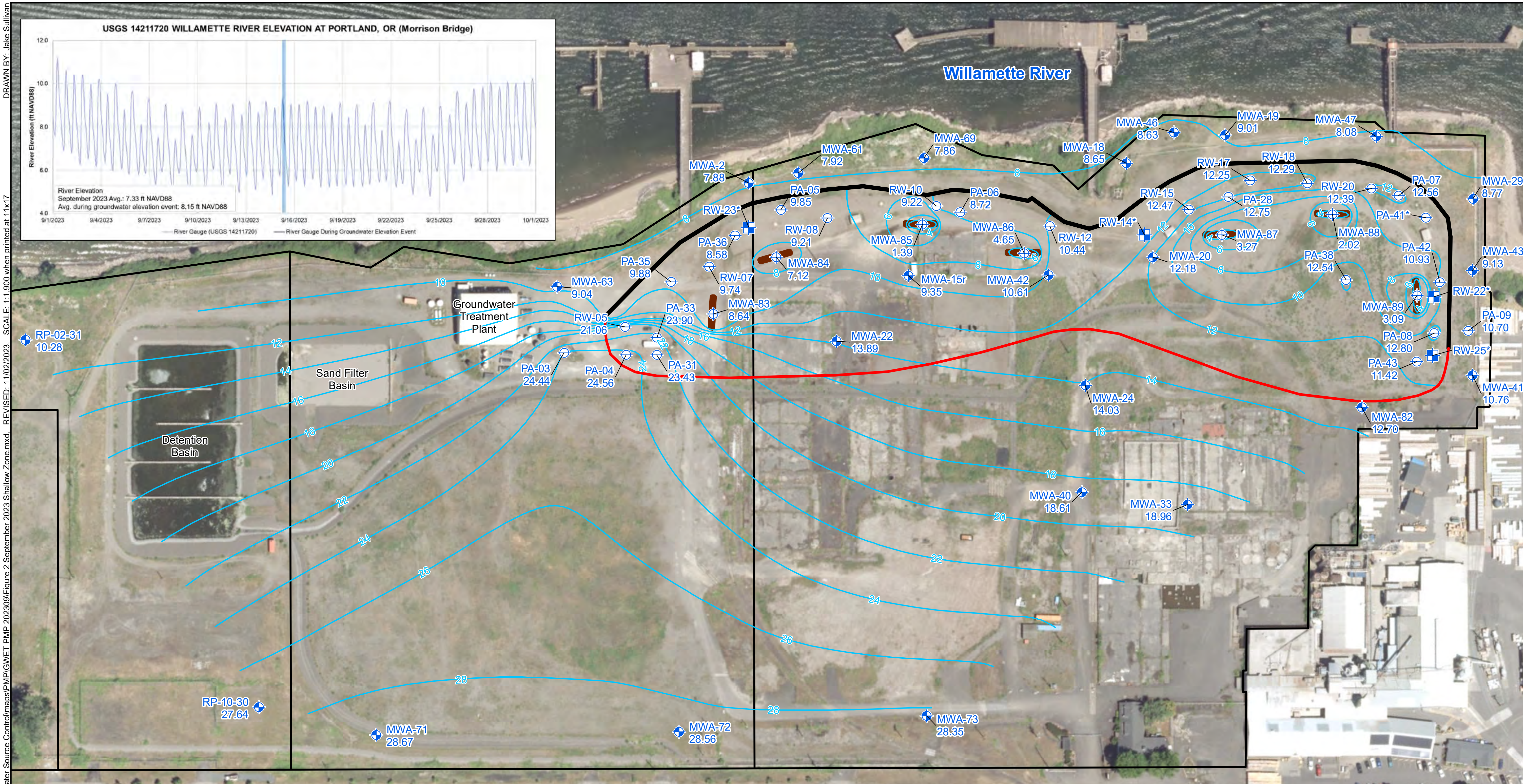
0 120 240

Feet

Figure 1
Site Layout
Monthly Progress Report
Groundwater Source Control Measure
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

Source: City of Portland Aerial Imagery, flown Summer 2021; NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



DRAWN BY: Jake Sullivan

SCALE: 1:1,900 when printed at 11x17

REVISED: 11/02/2023

M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 202309\Figure 2 September 2023 Shallow Zone.mxd

Legend

- Shallow Zone Piezometer
- Shallow Zone Monitoring Well
- Active Recovery Well; Not Used During Contouring
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Shallow Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected September 15, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

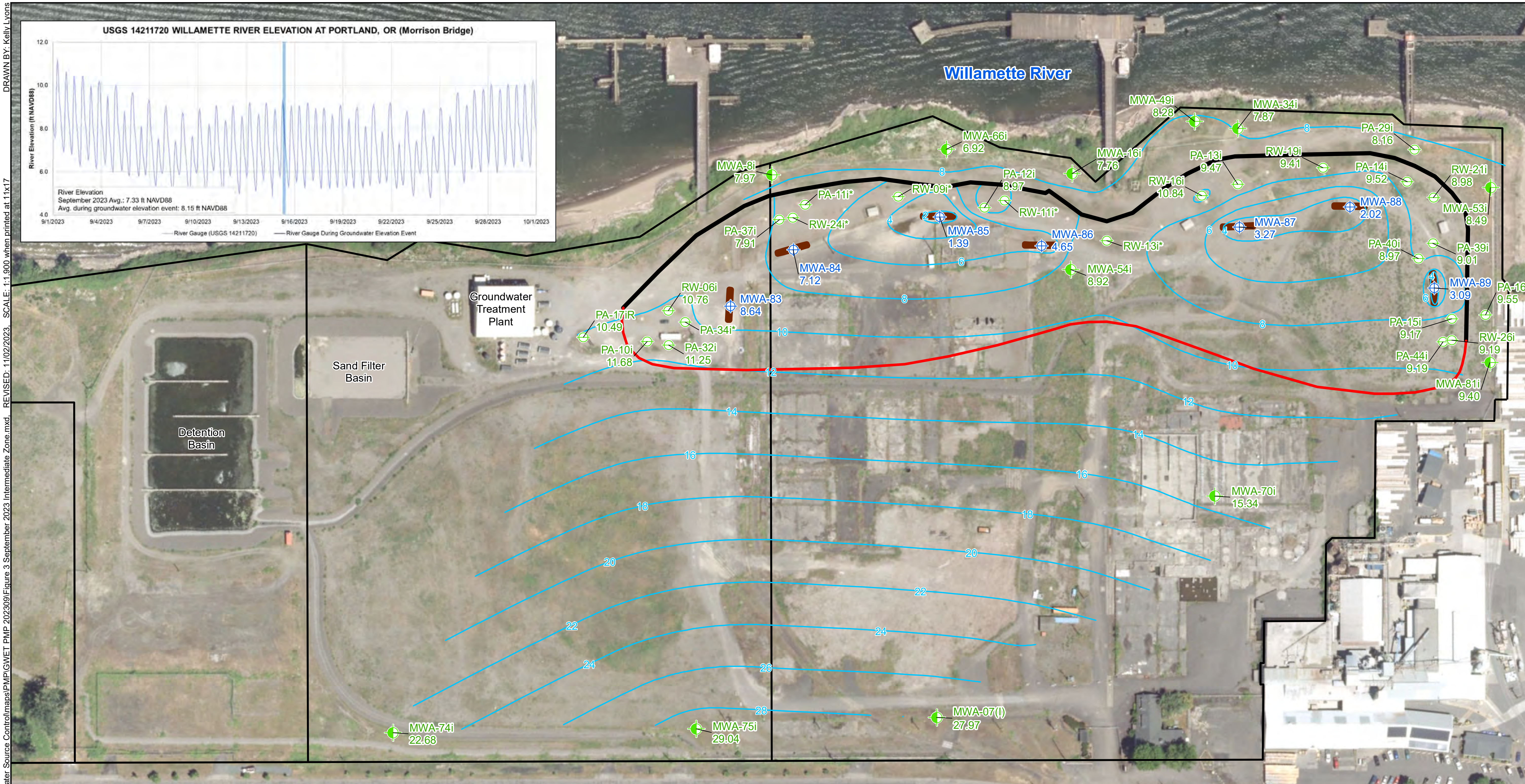
NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

Figure 2

September 2023 Shallow Zone Groundwater Contours

Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM



Legend

- Intermediate Zone Piezometer
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected September 15, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

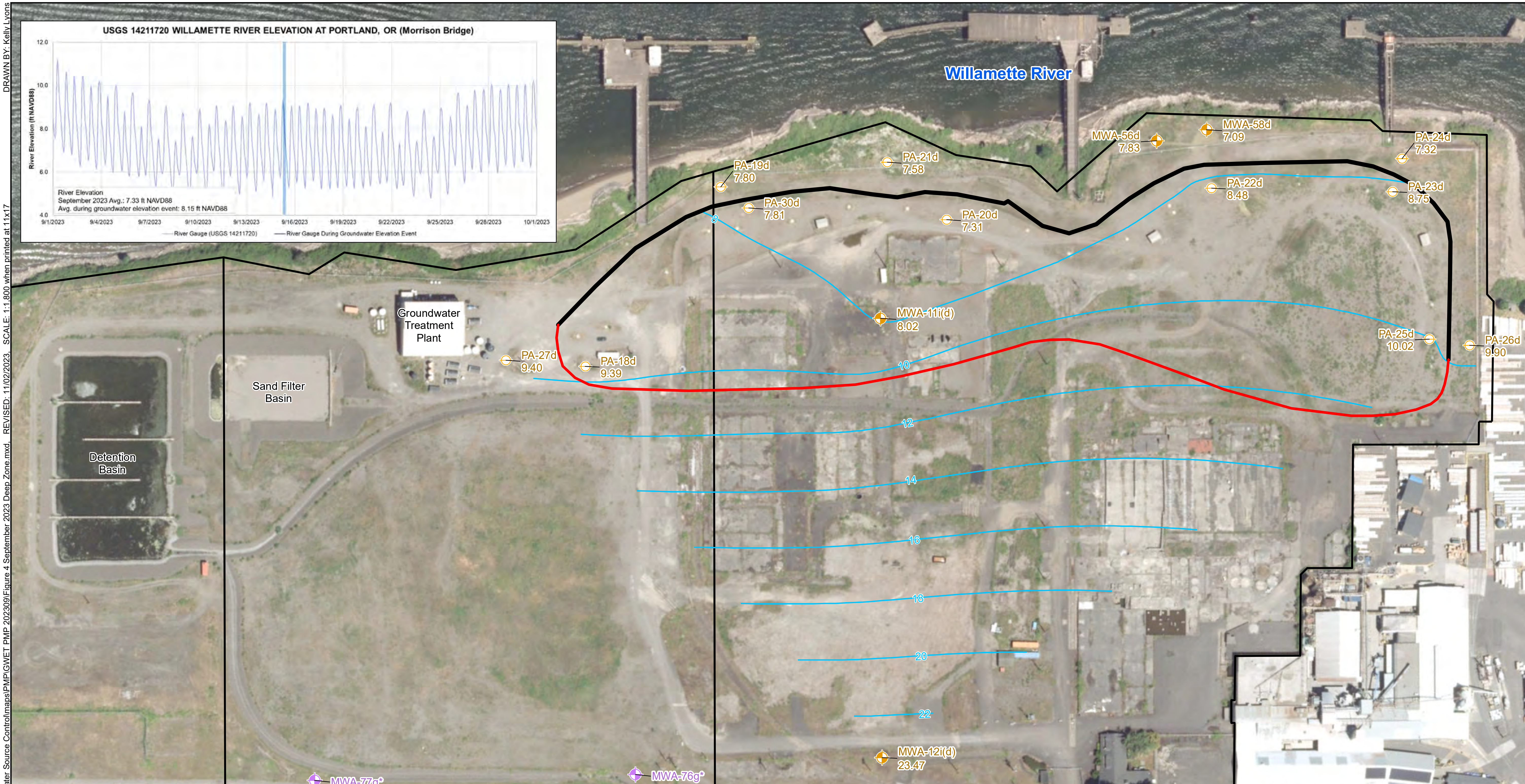
0 160 320
Feet

Figure 3
September 2023 Intermediate Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

M:\US\Projects\S-U\Total\Arkema Portland\Groundwater Source Control\maps\PMP\GWET PMP 202309\Figure 3 September 2023 Intermediate Zone.mxd. REVISED: 11/02/2023. SCALE: 1:1,900 when printed at 11x17 DRAWN BY: Kelly Lyons

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



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Legend

- Deep Zone Piezometer
- Deep Zone Monitoring Well
- Gravel Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Deep Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment

Notes:
* Value not used for contouring.
Gravel zone wells not used in contouring.
Water levels collected September 15, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 150 300
Feet

Figure 4
September 2023 Deep Zone Groundwater Contours
Monthly Performance Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 202309\Figure 5 September 2023 Vertical Difference Shallow Intermediate.mxd REVISED: 11/02/2023 SCALE: 1:1,560 when printed at 11x17 DRAWN BY: Kelly Lyons

Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Shallow Zone Recovery Well
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Vertical Gradient not calculated due to anomalous groundwater elevation reading
- Downward Flow
- Upward Flow

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as shallow zone minus intermediate zone potentiometric surfaces.
Water levels collected September 15, 2023.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 5
September 2023 Shallow to Intermediate Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

Legend

- Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Vertical Gradient not calculated due to anomalous groundwater elevation reading
- Downward Flow
- Upward Flow

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as intermediate zone minus deep zone potentiometric surfaces.
Water levels collected September 15, 2023.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 6
September 2023 Intermediate to Deep Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 202309\Figure 6 September 2023 Vertical Difference Intermediate Deep.mxd. REVISED: 11/02/2023. SCALE: 1:1,560 when printed at 11x17 DRAWN BY: Kelly Lyons

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

ATTACHMENT A-1 TRANSDUCER FLAGS

Attachment A-1. Transducer Flags

Table A-1
Transducer Malfunction Log: September 2023
Arkema Inc. Facility
Portland, Oregon

Gradient Cluster	Transducer	Interval	Date Range		Issue and Repairs Performed
GCC2	PA-11i	Intermediate	9/1/2023	Present	Transducer faulted, new transducer ordered.
GCC3	PA-06	Shallow	9/21/2023	Present	Noise due to animal chewing through signal cable. Investigation in progress.
N/A	RW-08	Intermediate	9/29/2023	Present	Transducer was lowered and recalibrated.
GCC6	PA-15i	Intermediate	9/1/2023	9/6/2023	Transducer faulted, requires investigation.

Notes:

I/O = input/output

LOTO = lockout/tagout

VFD = variable frequency drive

ATTACHMENT A-2 RECOVERY WELL STATUS

Attachment A-2. Recovery Well Status

Table A-2
Recovery Well Status: September 2023
Arkema Inc. Facility
Portland, Oregon

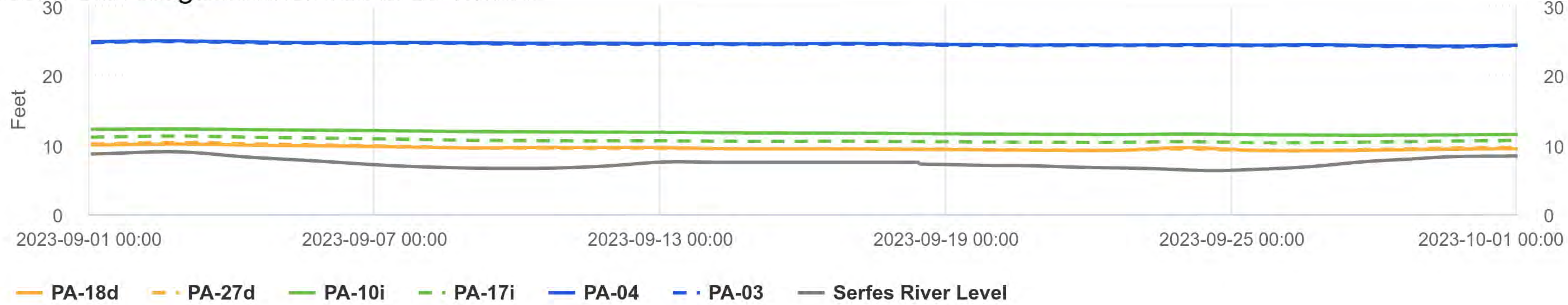
Recovery Well ID	Status as of 9/30/2023 (active or inactive)	Issue	Actions to get online	Expected date back online	Transducer Status	Totalizer Status	Average Flow Rate (gpm)	Overall Extraction Rate	Notes
RW-14	Active	None	N/A	N/A	Good	Good	0.12	P	
RW-22	Active	None	N/A	N/A	Good	Good	0.03	P	
RW-23	Active	None	N/A	N/A	Good	Good	0.31	P	
RW-25	Active	None	N/A	N/A	Good	Good	0.99	P	
EW-01	Active	None	N/A	N/A	Good	Good	1.35	M	
EW-02	Active	None	N/A	N/A	Good	Good	0.68	P	
EW-03	Active	None	N/A	N/A	Good	Good	4.35	G	
EW-04	Active	None	N/A	N/A	Good	Good	6.40	G	
EW-05	Active	None	N/A	N/A	Good	Good	13.88	G	
EW-06	Active	None	N/A	N/A	Good	Good	5.59	G	
EW-07	Active	None	N/A	N/A	Good	Good	0.10	P	
EW-08	Active	None	N/A	N/A	Good	Good	2.71	M	
EW-09	Active	None	N/A	N/A	Good	Good	2.81	M	
EW-10	Inactive	None	N/A	N/A	Good	Good	0.00	OFF*	Off due to low water levels in trench
EW-11	Active	None	N/A	N/A	Good	Good	0.42	P	
EW-12	Active	None	N/A	N/A	Good	Good	0.90	P	
EW-13	Active	None	N/A	N/A	Good	Good	8.64	G	
EW-14	Active	None	N/A	N/A	Good	Good	8.37	G	

Notes:
** Recovery wells not in service*
*** Recovery wells in service part of the month*
G = good pumping, greater than 3.0 gpm
gpm = gallons per minute
M = moderate pumping, greater than 1.0 gpm and less than 3.0
P = poor pumping, less than 1.0 gpm
VFD = variable frequency drive
PA = piezometer

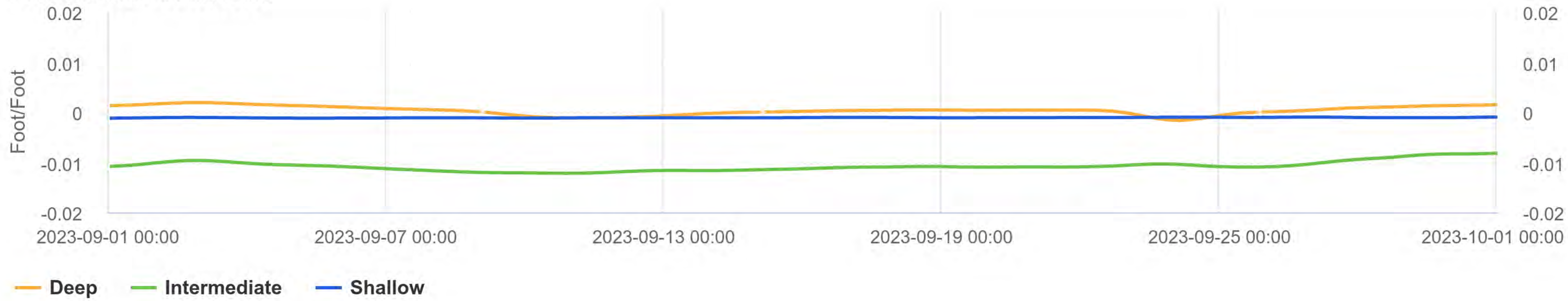
ATTACHMENT B-1 GRADIENT HYDROGRAPHS

Gradient Control Cluster 1

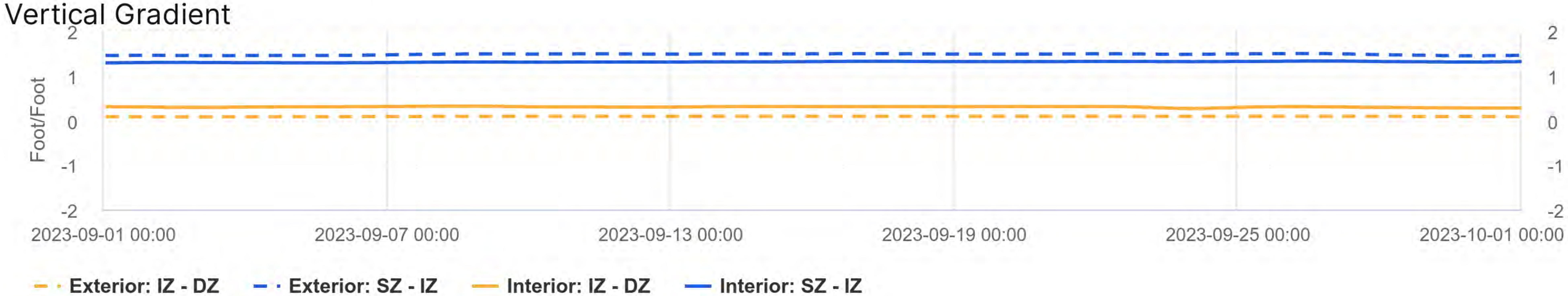
Serfes Averaged Water Table Elevation



Horizontal Gradient

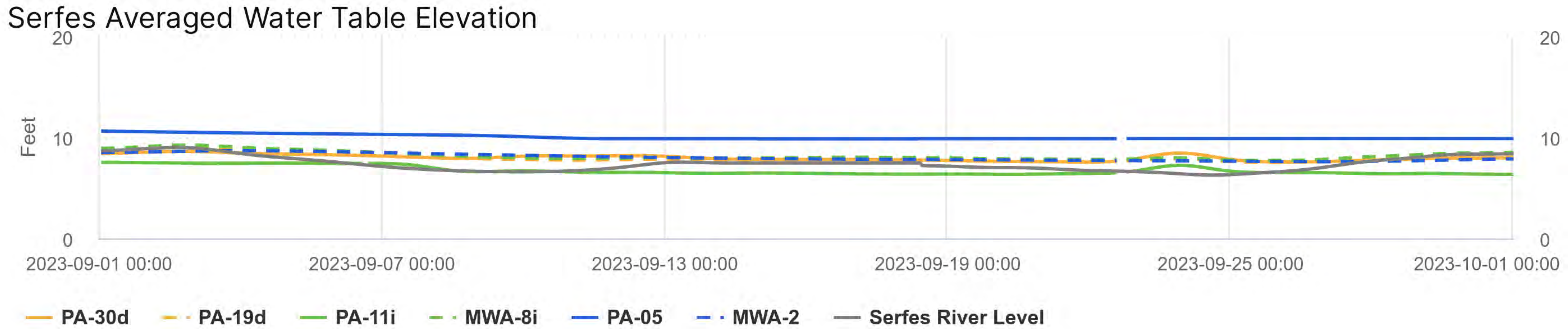


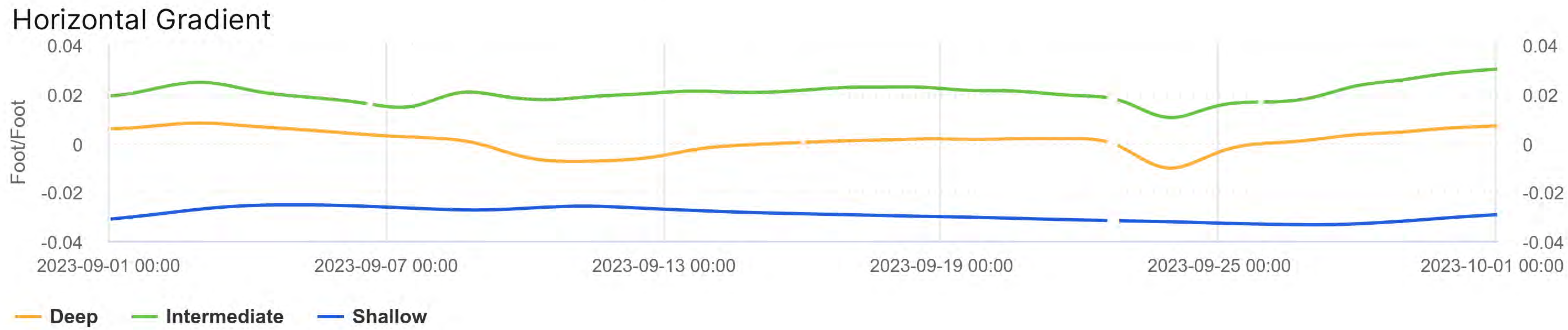
Vertical Gradient

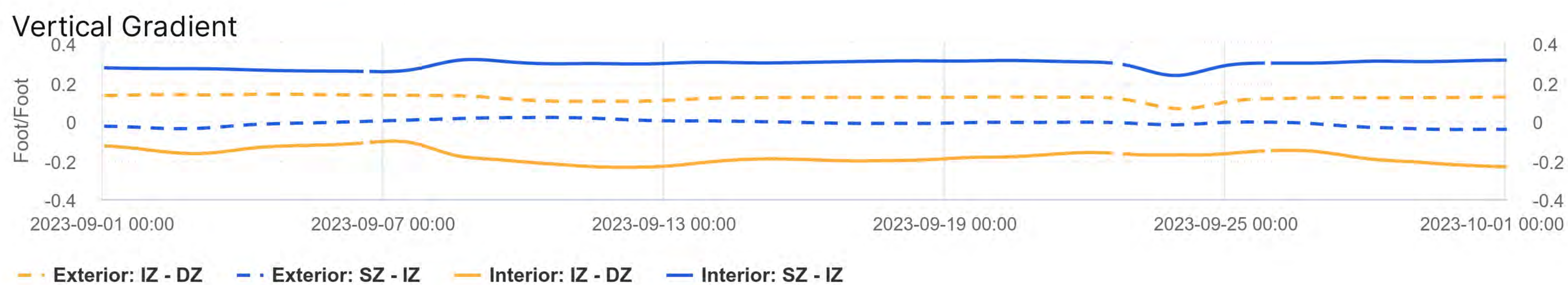


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 2

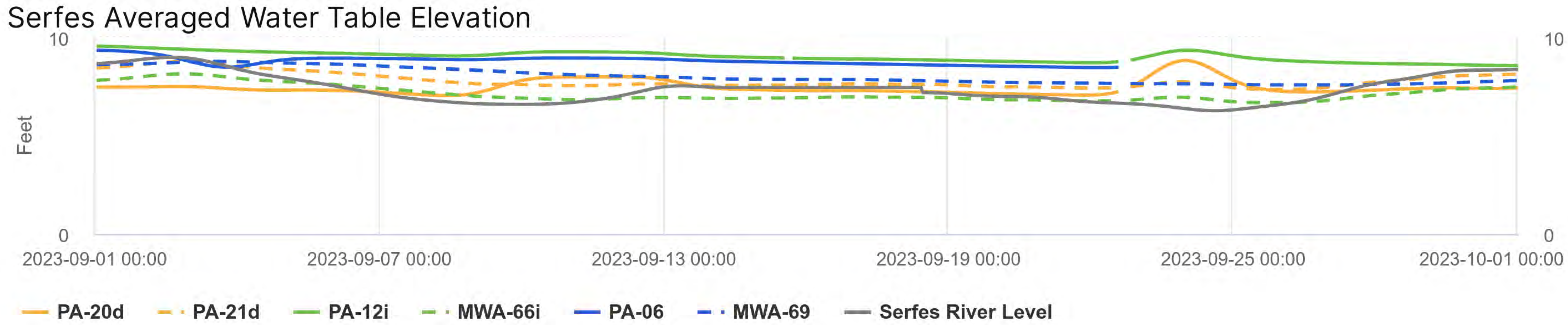


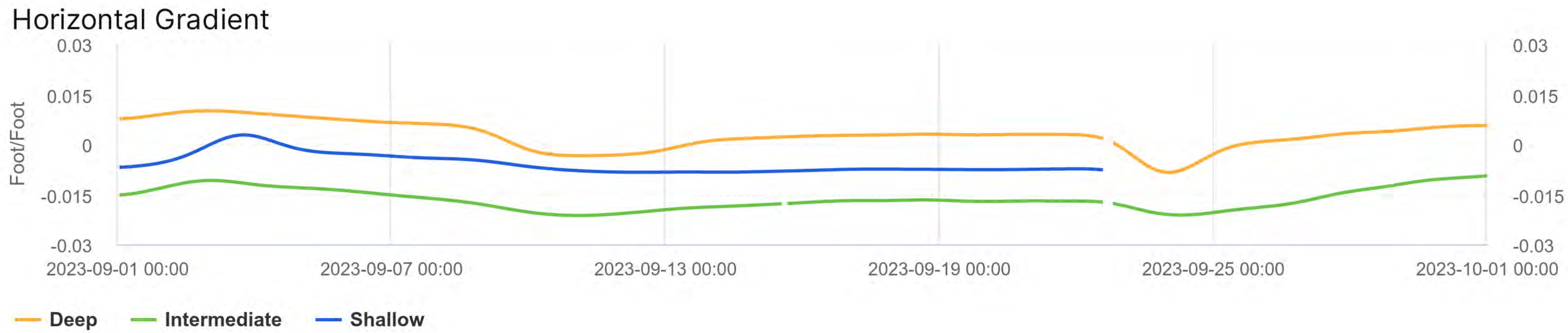


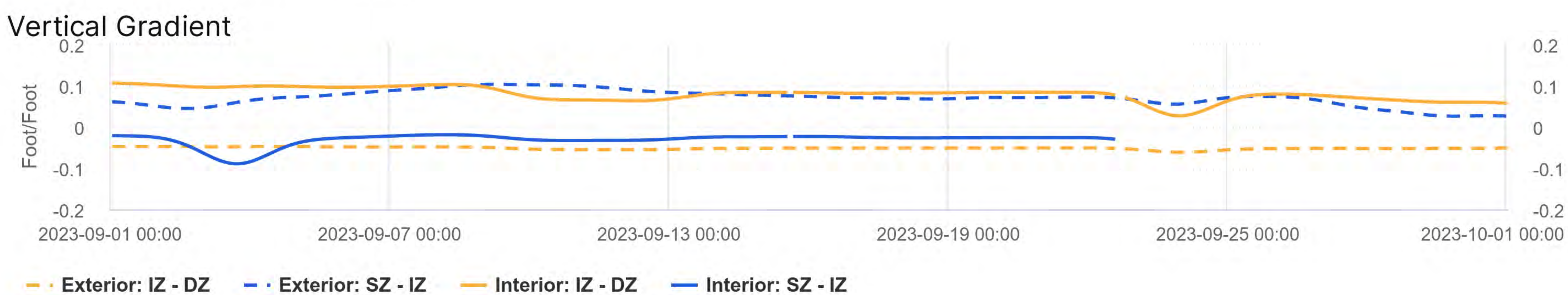


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 3



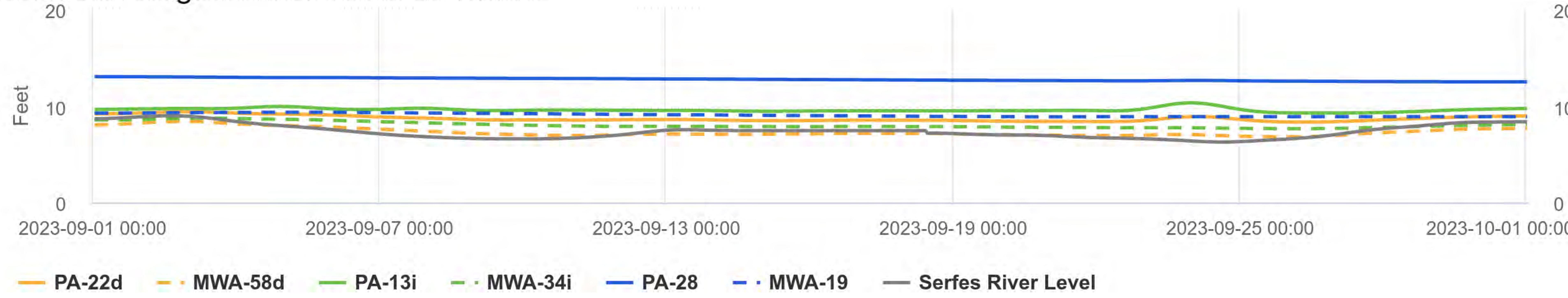




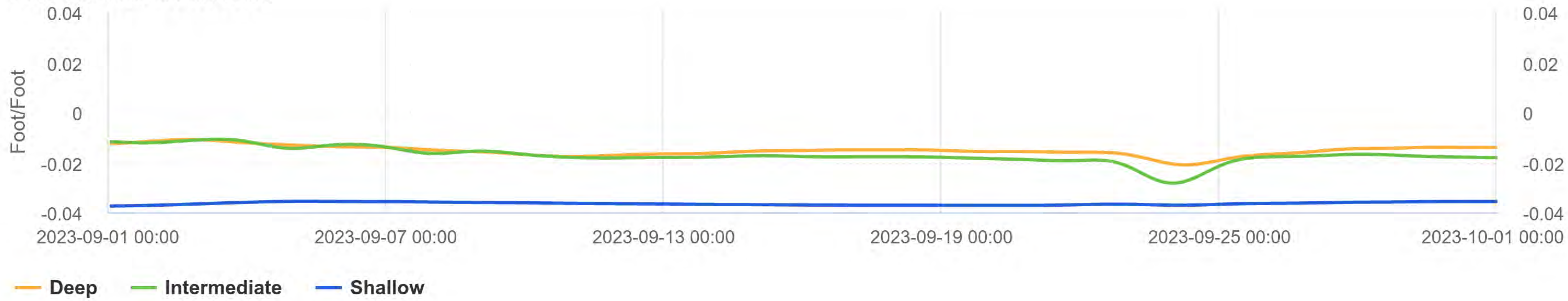
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 4

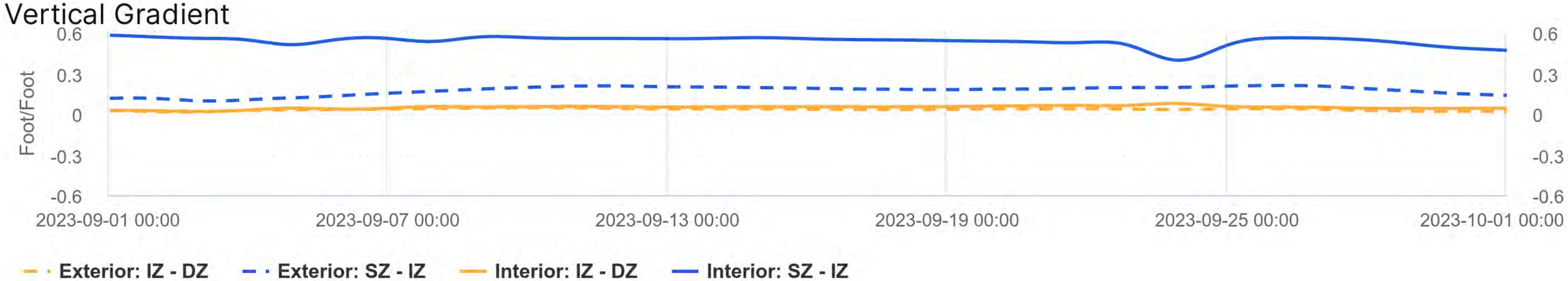
Serfes Averaged Water Table Elevation



Horizontal Gradient

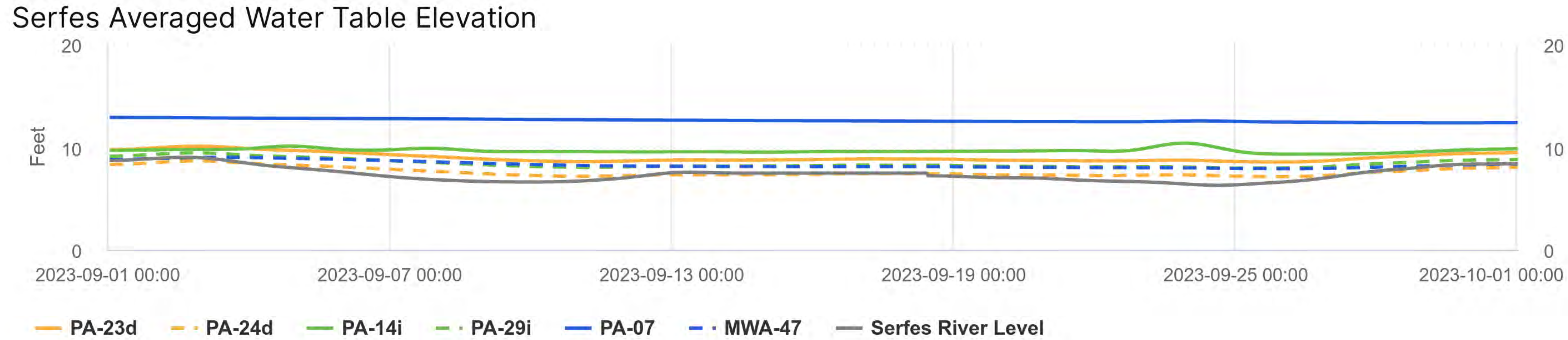


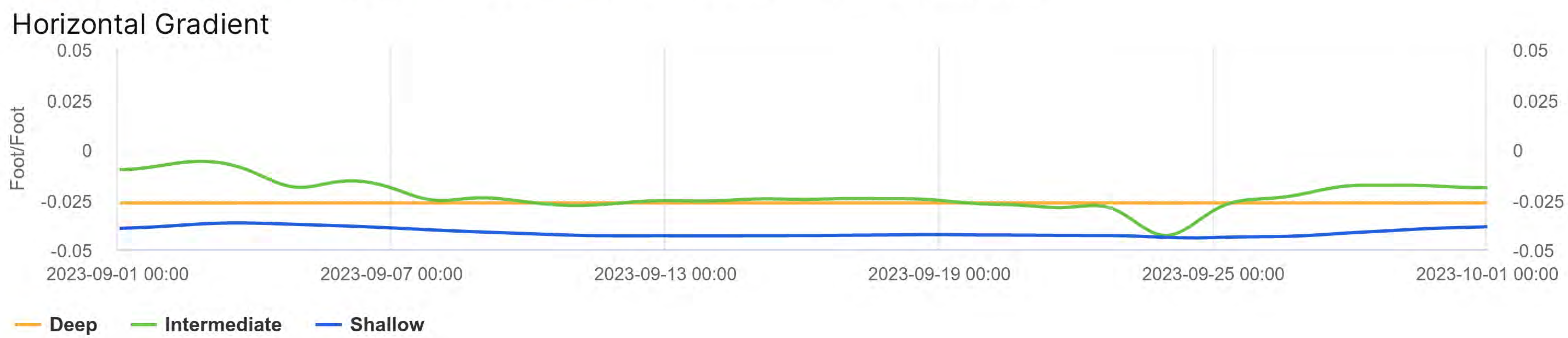
Vertical Gradient

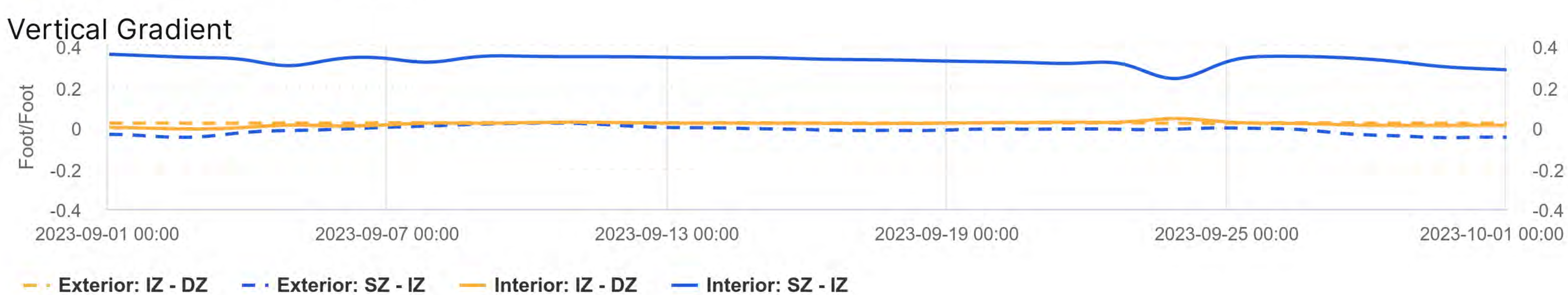


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 5





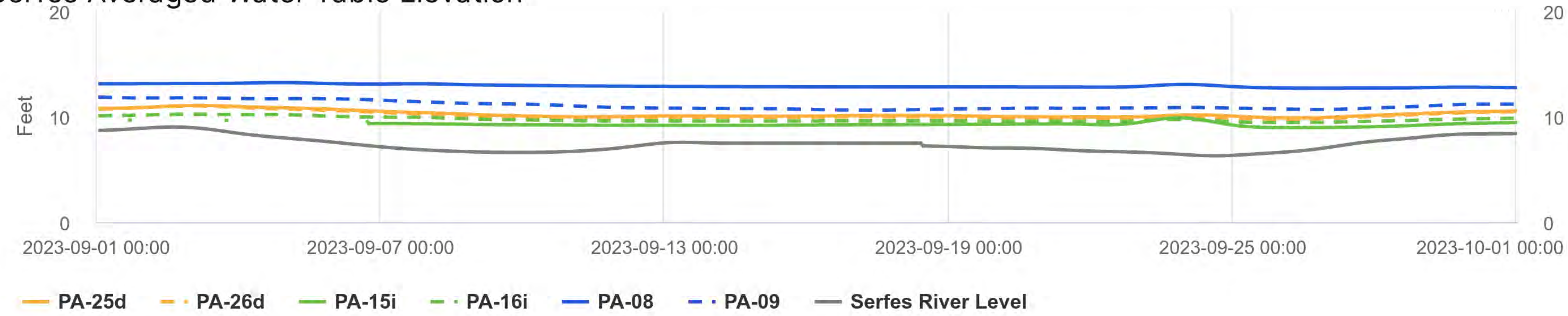


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW

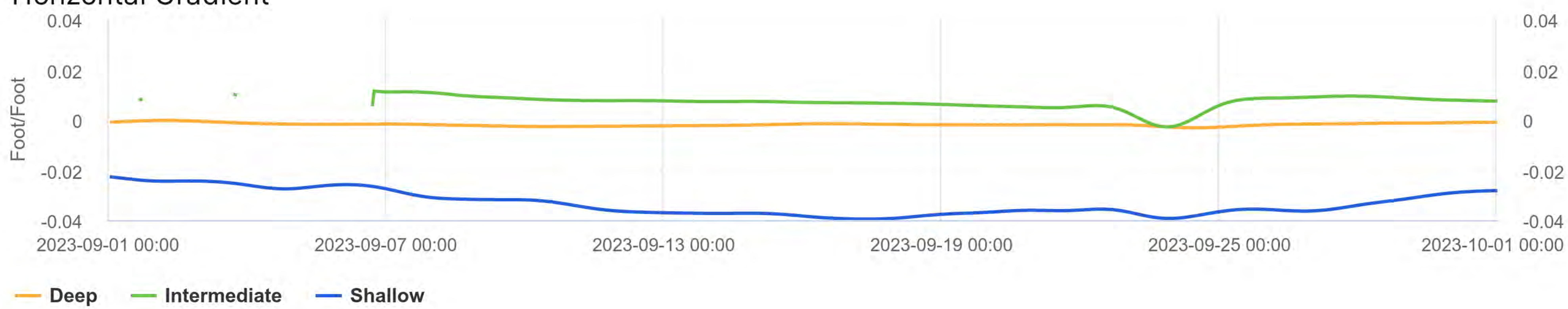
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 6

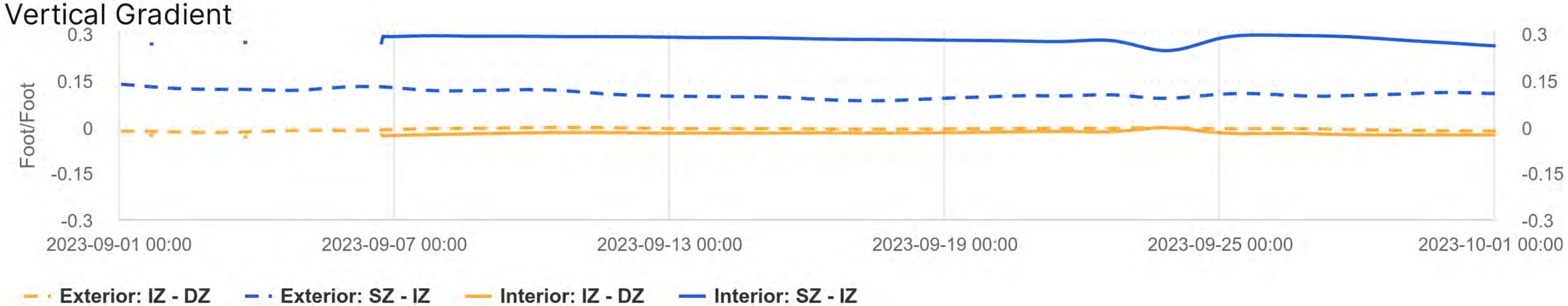
Serfes Averaged Water Table Elevation



Horizontal Gradient



Vertical Gradient

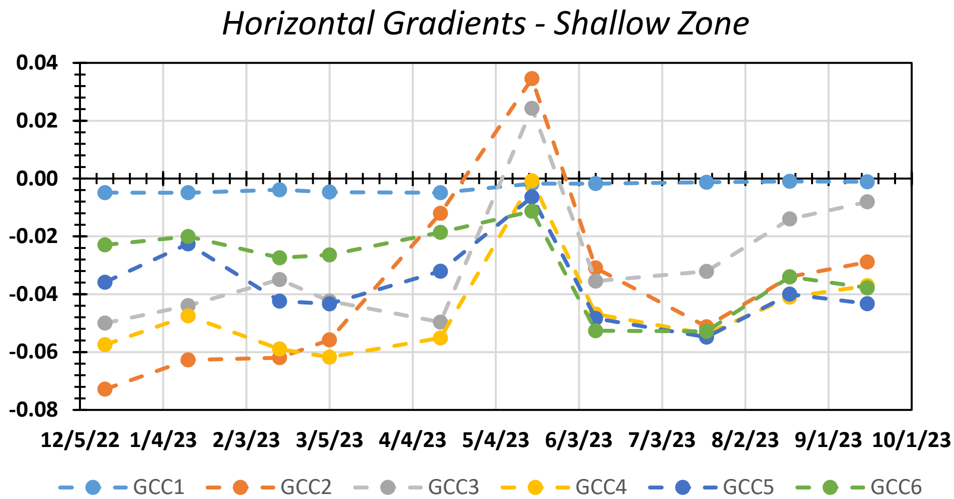


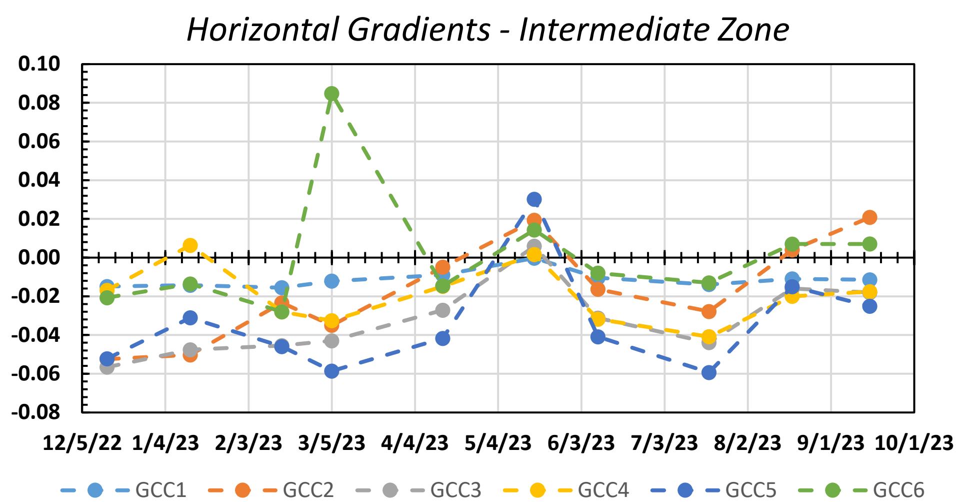
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

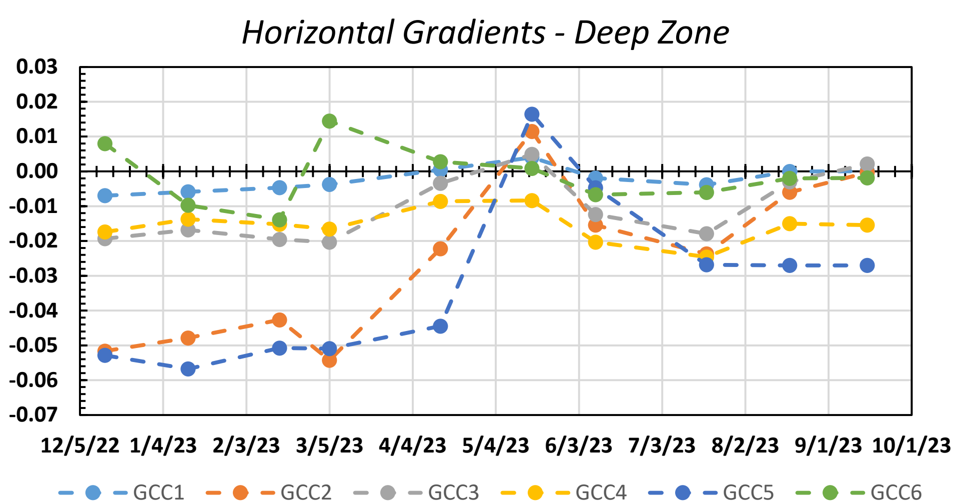
ATTACHMENT B-2 HORIZONTAL GRADIENTS

Attachment B-2

Horizontal Gradients Summary: September 2023
Arkema Inc. Facility
Portland, Oregon





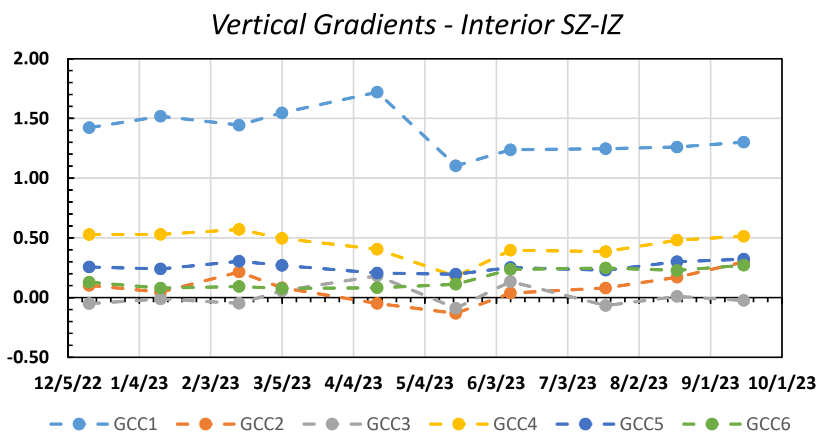


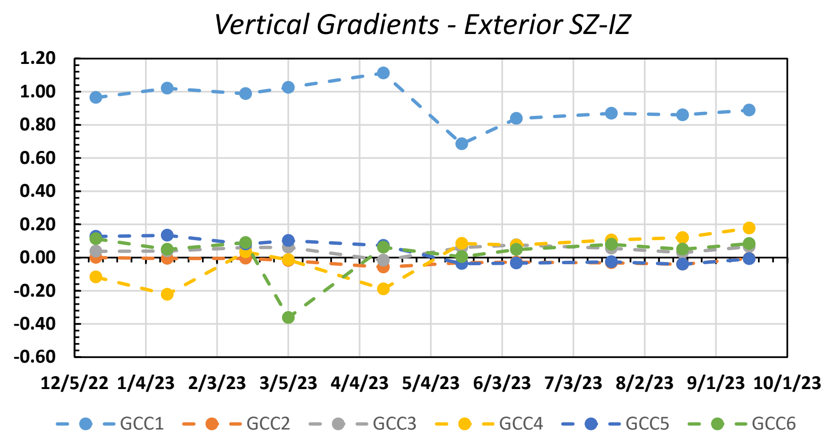
Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.

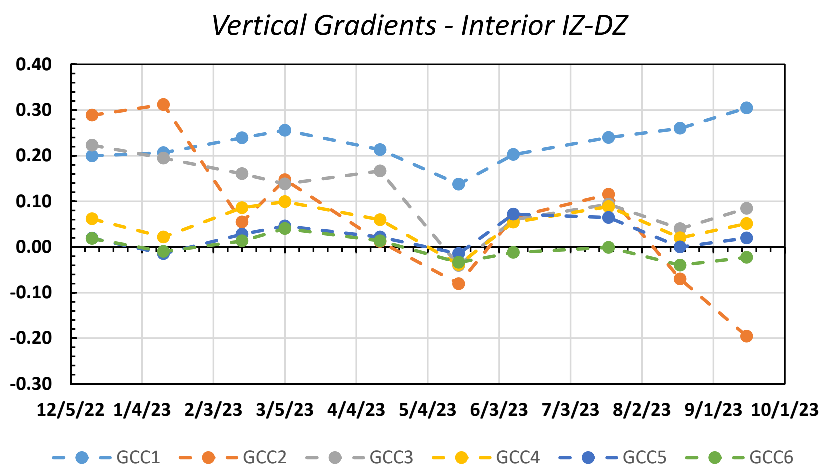
ATTACHMENT B-3 VERTICAL GRADIENTS

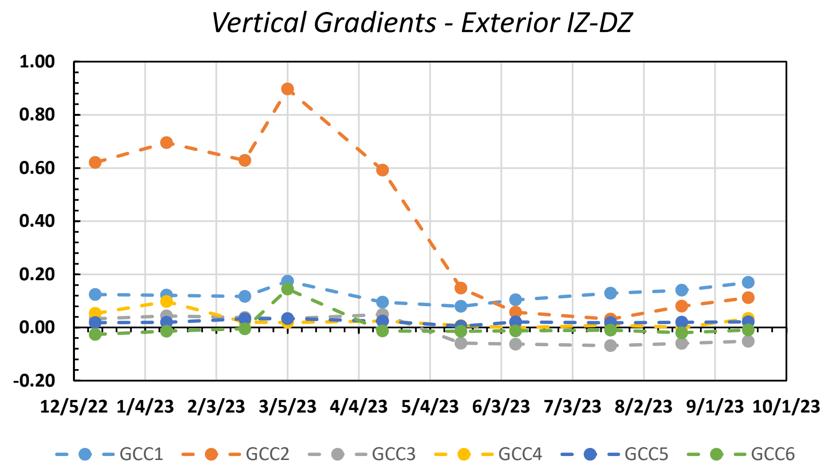
Attachment B-3

Vertical Gradients Summary: September 2023
Arkema Inc. Facility
Portland, Oregon



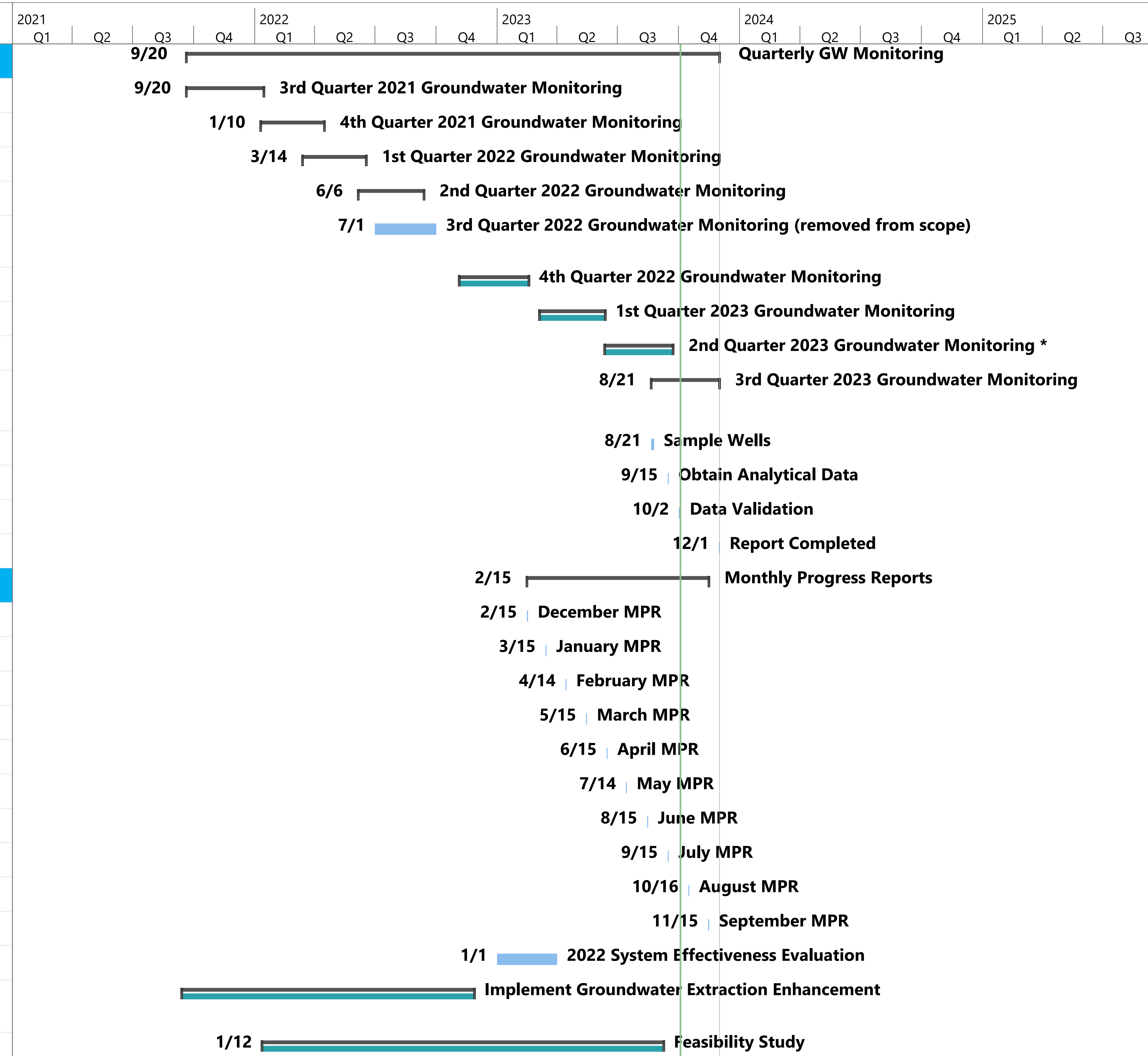






ATTACHMENT C PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**Quarterly GW Monitoring**	**578 days**	**Mon 9/20/21**	**Fri 12/1/23**
2	*3rd Quarter 2021 Groundwater Monitoring*	*85 days*	*Mon 9/20/21*	*Fri 1/14/22*
7	*4th Quarter 2021 Groundwater Monitoring*	*70 days*	*Mon 1/10/22*	*Fri 4/15/22*
11	*1st Quarter 2022 Groundwater Monitoring*	*70 days*	*Mon 3/14/22*	*Fri 6/17/22*
16	*2nd Quarter 2022 Groundwater Monitoring*	*71 days*	*Mon 6/6/22*	*Mon 9/12/22*
21	*3rd Quarter 2022 Groundwater Monitoring (removed from scope)*	*66 days*	*Fri 7/1/22*	*Fri 9/30/22*
22	*4th Quarter 2022 Groundwater Monitoring*	*78 days*	*Sat 11/5/22*	*Fri 2/17/23*
27	*1st Quarter 2023 Groundwater Monitoring*	*71 days*	*Mon 3/6/23*	*Mon 6/12/23*
32	*2nd Quarter 2023 Groundwater Monitoring **	*75 days*	*Mon 6/12/23*	*Fri 9/22/23*
37	**3rd Quarter 2023 Groundwater Monitoring**	**75 days**	**Mon 8/21/23**	**Fri 12/1/23**
38	Sample Wells	4 days	Mon 8/21/23	Thu 8/24/23
39	Obtain Analytical Data	1 day	Fri 9/15/23	Fri 9/15/23
40	Data Validation	1 day	Mon 10/2/23	Mon 10/2/23
41	Report Completed	1 day	Fri 12/1/23	Fri 12/1/23
42	**Monthly Progress Reports**	**196 days**	**Wed 2/15/23**	**Wed 11/15/23**
43	*December MPR*	*1 day*	*Wed 2/15/23*	*Wed 2/15/23*
44	*January MPR*	*1 day*	*Wed 3/15/23*	*Wed 3/15/23*
45	*February MPR*	*1 day*	*Fri 4/14/23*	*Fri 4/14/23*
46	*March MPR*	*1 day*	*Mon 5/15/23*	*Mon 5/15/23*
47	*April MPR*	*1 day*	*Thu 6/15/23*	*Thu 6/15/23*
48	*May MPR*	*1 day*	*Fri 7/14/23*	*Fri 7/14/23*
49	*June MPR*	*1 day*	*Tue 8/15/23*	*Tue 8/15/23*
50	*July MPR*	*1 day*	*Fri 9/15/23*	*Fri 9/15/23*
51	August MPR	1 day	Mon 10/16/23	Mon 10/16/23
52	September MPR	1 day	Wed 11/15/23	Wed 11/15/23
53	***2022 System Effectiveness Evaluation***	***66 days***	***Sun 1/1/23***	***Fri 3/31/23***
54	***Implement Groundwater Extraction Enhancement***	***317 days***	***Mon 9/13/21***	***Sun 11/27/22***
62	***Feasibility Study***	***436 days***	***Wed 1/12/22***	***Fri 9/8/23***



Arkema Portland
Monthly Progress Report
Attachment C

Task	Project Summary	Manual Task	Start-only	Deadline
Split	Inactive Task	Duration-only	Finish-only	Progress
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Manual Progress
Summary	Inactive Summary	Manual Summary	External Milestone	

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Memo

To	Katie Daugherty, Oregon Department of Environmental Quality
From	Brendan Robinson, PE, Environmental Resources Management, Inc.
Date	15 December 2023
Reference	0682894 Phase 204
Subject	October 2023 GW SCM Monthly Performance Monitoring Report

1. INTRODUCTION

Environmental Resources Management, Inc. (ERM) prepared this Monthly Performance Monitoring Report (MPR) on behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc. (Arkema), for the former Arkema Portland Plant (the Site) at 6400 NW Front Avenue in Portland, Oregon. The Oregon Department of Environmental Quality (ODEQ), in its letter dated 31 May 2019 and in the subsequent meeting with LSS and ERM on 2 July 2019, requested that LSS initiate monthly status reports associated with the onsite groundwater source control measure (GW SCM) consistent with the Performance Monitoring Plan (PMP; ERM 2014) beginning July 2019. The 2014 PMP was prepared pursuant to the Order on Consent issued by ODEQ, signed on 31 October 2008 (ODEQ No. LQVC-NWR-08-04; Consent Order). The purpose of the PMP was to present the monitoring, reporting, and adaptive management processes used during implementation of the GW SCM. On 30 November 2021, ODEQ directed LSS that following the October 2021 MPR, subsequent MPRs would be suspended pending the implementation of the Groundwater Extraction Enhancement (GEE) project in 2022. During that time, ODEQ requested monthly schedule updates in lieu of MPRs. The trench wells installed as part of the GEE project were started on 27 November 2022, and MPR writing restarted in December 2022. The purpose of the GEE project was to install new extraction capacity to achieve the Capture Zone Objectives.

This October 2023 MPR summarizes the GW SCM performance monitoring data collected in October 2023. This report assesses the current gradient status and proposes system improvements to meet the Capture Zone Objectives set in the PMP.

2. GROUNDWATER SOURCE CONTROL IMPLEMENTATION

A detailed description of the design and implementation of the GW SCM is provided in the *Revised Upland Feasibility Study Work Plan* (ERM 2017); however, a brief description of the GW SCM is provided here. In February 2009, ODEQ and the U.S. Environmental Protection Agency (USEPA) approved the general approach for the GW SCM. This approach included installation of a groundwater barrier wall (GWBW), groundwater recovery wells, and a Groundwater Extraction and Treatment (GWET) system, with treated water discharged to the Willamette River. ODEQ and USEPA approved the *Groundwater Barrier Wall Final Design* (ERM 2012) on 7 August 2012. Construction of the GWBW began in May 2012 and was completed in December 2012. ODEQ approved the *Groundwater Extraction and Treatment System Final Design* (ERM 2013) on 2 April

2013. Construction of the GWET system began in December 2012 and was completed in December 2013.

GWET startup and optimization commenced in May 2014. The GW SCM at the Site consists of the following primary components (Figure 1):

1. A GWBW to physically separate the affected upland portions and in-water portions of the Site.

2. Hydraulic control to minimize flow of groundwater containing unacceptable concentrations of constituents of potential concern (COPCs) around, over, and under the GWBW.

3. Management of extracted groundwater through the GWET system, with treated effluent discharged to the Willamette River under a National Pollutant Discharge Elimination System (NPDES) Permit.

On 1 September 2018, ERM submitted the *Draft GWET System Effectiveness Evaluation* (Draft SEE Report; ERM 2018). The Draft SEE Report provided an update on the corrective actions implemented to improve the performance of the GWET system, evaluate the extent of capture, and propose actions to improve hydraulic capture. Additional data requested by ODEQ were submitted on 26 October 2018.

The key objective of the GW SCM is to achieve hydraulic containment of the alluvial sequence within the Target Capture Zone at the Site to prevent the flow of COPCs to the Willamette River. The Site alluvial aquifer sequence within the Target Capture Zone consists of the Shallow Zone, Intermediate Zone, and the Deep Zone. Site hydraulic conditions are variable and subject to both seasonal and daily tidal fluctuations.

The hydraulic control component formerly consisted of 22 recovery wells (RWs) prior to the implementation of the GEE. Of the 22 pre-existing RWs, four were retained for active pumping. The remaining 18 former RWs had pumps removed but retained their pressure transducers so that they can continuously collect high-resolution groundwater elevation data. The hydraulic control system now consists of the four remaining active RWs, as well as seven groundwater extraction trenches that each contain two extraction wells (EWs). Each trench is 50 feet deep, 50 feet long, and 3 feet wide and is filled with an engineered backfill. More information about the groundwater extraction trenches is provided in the *Final Design Report* (ERM 2022). The gradient control-monitoring network consists of six gradient control clusters (GCCs) with each cluster containing six monitoring points. Within each RW, EW, and GCC location, pressure transducers are continuously collecting high-resolution groundwater elevation data. Each GCC contains three transducers interior to the wall and three transducers exterior to the wall screened in the Shallow, Intermediate, and Deep aquifers at the Site.

3. HYDRAULIC CONTAINMENT MONITORING PROGRAM

As described in the PMP, the purpose of hydraulic monitoring (i.e., groundwater elevation data) is to provide sufficient data to demonstrate an inward hydraulic gradient across the GWBW and to evaluate the effective hydraulic capture produced by the GW SCM.

Monitoring requirements were established in the PMP to demonstrate GWET effectiveness. The Site monitoring program includes groundwater elevation data (manual and transducer measurements) collected from the 36 monitoring points located within six GCCs spaced across the GWBW, with piezometers interior and exterior to the wall, throughout the alluvial sequence; and groundwater elevation and flow rate data from the four remaining active RWs and 14 EWs. High-resolution groundwater elevation data is also collected from the 18 inactive RWs. Additionally, one new monitoring well was installed in each of the seven extraction trenches for manual water level measurement. These data were used to prepare horizontal and vertical potentiometric surface maps representing potentiometric differences between the alluvial sequences, and to generate spatial and temporal hydrographs to evaluate hydraulic capture.

3.1 Groundwater Elevation Monitoring

Groundwater elevation monitoring was completed on 20 October 2023. Manual groundwater elevations were measured at wells that were experiencing transducer mechanical issues or that were offline during the groundwater elevation measurement event. All inactive RWs were manually measured in the month of September to affirm proper calibration. Manual water levels for those RWs are reported. Additionally, all transducers in inactive RWs were down until upgrades were completed and transducers were sequentially turned on. Specific issues are addressed in Attachment A-1.

As detailed in Attachments A-1 and A-2, during October 2023, the following transducers were:

<u>Fully out of service pending repairs:</u>

- PA-11i

PA-11i has a faulted transducer and a replacement transducer has been ordered.

<u>Out of service for a period but returned to full operation:</u>

- PA-23d
- RW-18
- PA-06

PA-23d had a faulted transducer, signal wire was repaired on 30 October 2023. RW-18 had the transducer lowered and recalibrated on 30 October 2023. PA-06 had a signal wire issue that was repaired on 8 October 2023.

3.2 Horizontal and Vertical Gradients at Gradient Control Points

As described above, GCC locations collect high-resolution groundwater elevation data using transducers. Transducer data are filtered to remove anomalous data from monitoring points due to potential equipment failures, such as transducer malfunctions, power outages, or updates to the GWET programmable logic controller (PLC) system, which controls and houses all the operational data. These specific issues and time periods are summarized in Table A-1 in Attachment A. The following flags are applied to filter anomalous data:

- Groundwater elevations had a change greater than 1.5 feet within 1 hour
- Groundwater elevation measurements that were found to be greater than 50 feet, or less than 1 foot
- Calculated groundwater elevation slope indicates no change between consecutive measurements indicating a transducer malfunction
- Manually flagging data that are inconsistent with the typical nature of the well
- Periods where transducer power supply was deactivated for work on interconnected electrical systems

After October 2023 flagged data were removed, the Serfes (1991) method was used to account for tidal variations as described in the PMP. Using Serfes corrected data, both horizontal and vertical gradients were calculated and plotted over time (Attachment B). Groundwater elevations, horizontal gradients, and vertical gradients from 20 October 2023 are shown below at each GCC (Table 1-1 and Table 1-2).

Table 1-1. October Horizontal Gradients

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
GCC1	Shallow	PA-03	24.31	PA-04	24.41	-0.001
	Intermediate	PA-17iR	10.41	PA-10i	11.13	-0.007
	Deep	PA-27d	9.40	PA-18d	9.12	0.002
GCC2	Shallow	MWA-2	8.13	PA-05 *M*	6.55	0.023
	Intermediate	MWA-8i	8.41	PA-11i *M*	7.11	0.018
	Deep	PA-19d	8.22	PA-30d	7.77	0.008
GCC3	Shallow	MWA-69	7.76	PA-06 *M*	8.28	-0.005
	Intermediate	MWA-66i	7.39	PA-12i	8.20	-0.007
	Deep	PA-21d	8.04	PA-20d	7.27	0.006
GCC4	Shallow	MWA-19	8.59	PA-28	12.28	-0.037
	Intermediate	MWA-34i	8.84	PA-13i	9.71	-0.010
	Deep	MWA-58d	7.60	PA-22d	8.91	-0.015
GCC5	Shallow	MWA-47	8.45	PA-07	12.22	-0.036
	Intermediate	PA-29i	8.70	PA-14i	9.78	-0.020
	Deep	PA-24d	7.91	PA-23d	*	**
GCC6	Shallow	PA-09	11.23	PA-08	12.75	-0.027
	Intermediate	PA-16i	9.83	PA-15i	9.45	0.007
	Deep	PA-26d	10.38	PA-25d	10.46	-0.001

Notes:

Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.

Horizontal gradient calculated as (Exterior Elevation – Interior Elevation) / Horizontal distance.

** = anomalous groundwater elevation; ** = horizontal gradient cannot be calculated due to anomalous elevation reading; ft NAVD88 = feet North American Vertical Datum of 1988; M = manual groundwater elevation measurement*

Table 1-2. October Vertical Gradients

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
Interior	SZ-IZ	GCC1	PA-04	24.41	PA-10i	11.13	1.34
		GCC2	PA-05 M	6.55	PA-11i M	7.11	-0.05
		GCC3	PA-06 M	8.28	PA-12i	8.20	0.01
		GCC4	PA-28	12.28	PA-13i	9.71	0.40
		GCC5	PA-07	12.22	PA-14i	9.78	0.26
		GCC6	PA-08	12.75	PA-15i	9.45	0.246
	IZ-DZ	GCC1	PA-10i	11.13	PA-18d	9.12	0.27
		GCC2	PA-11i M	7.11	PA-30d	7.77	-0.09
		GCC3	PA-12i	8.20	PA-20d	7.27	0.05
		GCC4	PA-13i	9.71	PA-22d	8.91	0.04
		GCC5	PA-14i	9.78	PA-23d	*	**
		GCC6	PA-15i	9.45	PA-25d	10.46	-0.03
Exterior	SZ-IZ	GCC1	PA-03	24.31	PA-17iR	10.41	0.88
		GCC2	MWA-2	8.13	MWA-8i	8.41	-0.02
		GCC3	MWA-69	7.76	MWA-66i	7.39	0.03
		GCC4	MWA-19	8.59	MWA-34i	8.84	-0.04
		GCC5	MWA-47	8.45	PA-29i	8.70	-0.02
		GCC6	PA-09	11.23	PA-16i	9.83	0.10
	IZ-DZ	GCC1	PA-17iR	10.41	PA-27d	9.40	0.16
		GCC2	MWA-8i	8.41	PA-19d	8.22	0.12
		GCC3	MWA-66i	7.39	PA-21d	8.04	-0.05
		GCC4	MWA-34i	8.84	MWA-58d	7.60	0.05
		GCC5	PA-29i	8.70	PA-24d	7.91	0.02
		GCC6	PA-16i	9.83	PA-26d	10.38	-0.01

Notes:

Positive vertical gradient indicates a downward hydraulic gradient.

Vertical gradient calculated as (Upper Elevation – Lower Elevation) / Screen Midpoint distance.

** = anomalous groundwater elevation; ** = vertical gradient cannot be calculated due to anomalous elevation reading; DZ = Deep Zone; ft NAVD88 = feet North American Vertical Datum of 1988; IZ = Intermediate Zone; ^{M} = manual groundwater elevation measurement; SZ = Shallow Zone*

3.3 Potentiometric Surface, Groundwater Elevation Difference Maps, and Groundwater Flow Directions

As described in the PMP, potentiometric surface maps are used to evaluate flow paths. Vertical gradients are also used as an additional line of evidence to evaluate hydraulic containment. Groundwater elevation data collected on 20 October 2023 were used to prepare potentiometric surface maps based on manual measurements and averaged transducer groundwater elevations (Figures 2 through 4) and vertical difference maps (Figures 5 and 6).

The generalized flow direction indicated by the potentiometric surface maps shows overall groundwater flow from upgradient toward the GWBW. Potentiometric maps (Figures 2, 3, and 4) indicate localized groundwater movement to the extraction trenches due to GW SCM pumping, and cones of depression are apparent around each groundwater extraction trench. Inward gradient was observed in the Shallow Zone at GCC2 in October 2023. As shown in Attachment B-2, Shallow Zone horizontal gradient trends over time are trending toward inward at all GCCs.

In October 2023, horizontal gradients in the Intermediate Zone were inward at GCC2 and GCC6. Intermediate Zone horizontal gradient trends over time (see Attachment B-2) show horizontal gradients trending toward inward gradients at all GCCs. The horizontal gradient in the Deep Zone were inward at GCC1, GCC2, and GCC3. The horizontal gradient in the Deep Zone at GCC5 was unable to be calculated due to an anomalous groundwater elevation reading at PA-23d.

River elevations are shown over time on Figure 1-1 and 1-2 below, and also for the month corresponding with this MPR on the potentiometric surface maps in an inset (Figures 2 through 4) and depict stage movement within the month. The river elevation in October 2023 varied with an average of 7.55 feet NAVD 88 with a minimum elevation of 4.71 feet NAVD88 and a maximum elevation of 10.37 feet NAVD88. Historically, the river elevation is at its highest in May and decreases until its lowest in October, making it more challenging during late summer and fall months to achieve inward gradients. As the wet season begins, the river is expected to rise, increasing the elevation of groundwater downgradient of the GWBW. Depending on how much groundwater elevations upgradient of the GWBW rise with exterior groundwater elevations, there may be increasing trends toward inward horizontal gradients at all GCCs throughout the wet season. A potentiometric separation is still noticeable exterior to the GWBW, indicating that it is functioning by impeding groundwater flow.

Vertical gradients were calculated for each vertical well pair and are plotted on Figures 5 and 6. Vertical groundwater gradients interior to the GWBW between the Shallow and Intermediate Zones were primarily downward, with GCC2 being upward and the remaining downward (Figure 5). Vertical groundwater gradients are also depicted in Attachment B-3. The magnitude of the gradient is much greater at GCC1 than other monitoring locations due to the influence from a localized high-pressure zone near GCC1 where vertical groundwater flow is impeded by a localized confining unit (Figure 2). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were mixed with GCC2, GCC4, and GCC5 being upward and GCC1, GCC3, and GCC6 being downward as shown on Figure 5 and in Attachment B-2.

Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were mixed with GCC2 and GCC6 being upward and the remaining downward. The vertical groundwater gradient at GCC5 interior of the wall was unable to be calculated due to an anomalous groundwater elevation reading at PA-23d. PA-23d will be recalibrated so that vertical gradients at GCC5 can be calculated in the future and presented in subsequent MPRs. The direction of vertical gradients exterior to the GWBW were mixed with GCC3 and GCC6 being upward and the remaining downward, as shown on Figure 6 and Attachment B.

3.3.1 GWET System Performance

The GWET system operated within permit conditions during the reporting period. There was one shutdown:

- Monday, 16 October 2023: A planned shutdown to clean the plate separator. Well field was restarted 2 hours later.

There were no upgrades to the GWET system in the month of October 2023.

3.3.2 Recovery Well and Extraction Well Performance

The average system influent flow rate was 36.21 gallons per minute (gpm) for the entire month of October 2023, including non-operational periods. The average influent flow during operational periods was 45.32 gpm. LSS is currently in the process of optimizing extraction rates within the system to increase flow rates at each operational well until either the extraction rates specified in the *Final Design Report* (ERM 2022) are achieved, the wells are producing the maximum quantity of water possible, or until the Capture Zone Objectives are met. In recent months, the pumping rates at historically productive wells has decreased due to lower groundwater elevations. Additionally, back pressure through the trunk line from the wellfield to the GWET plant appears to be a limiting factor in groundwater extraction. The backpressure is believed to be caused by fouling of the trunk line. LSS is currently evaluating options to reconfigure the trunk line to mitigate back pressure effects on pumping rates, as well as jetting of the shallow and intermediate trunk lines. During October 2023, EW-01, EW-02, EW-07, EW-08, EW11, and EW-12 were redeveloped. The traditional surging and purging redevelopment methods demonstrated limited success at liberating entrained silt in the EWs. Alternative Site-wide EW redevelopment is planned for Q1 2024.

Table 1-3. Recovery Well Pumping Rates

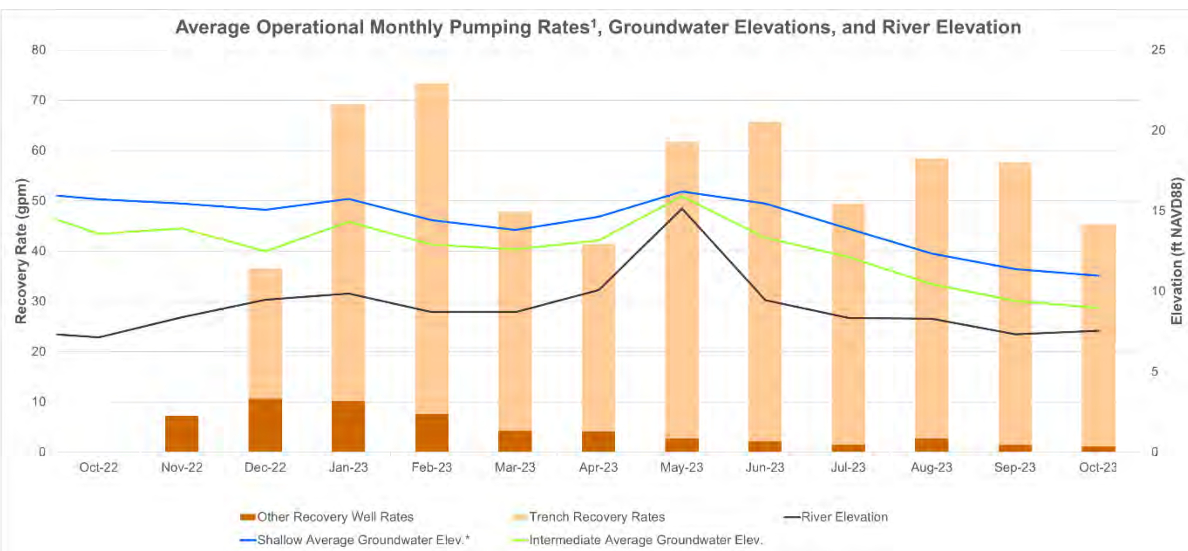
Recovery Well	October 2023 Average Operational Pumping Rate (gpm)	October 2023 Average Monthly Pumping Rate (gpm)
RW-14	0.16	0.15
RW-22	0.06	0.06
RW-23*	0.00	0.00
RW-25	0.87	0.82
EW-01*	0.00	0.00
EW-02	1.59	1.18
EW-03	3.41	2.20

Recovery Well	October 2023 Average Operational Pumping Rate (gpm)	October 2023 Average Monthly Pumping Rate (gpm)
EW-04	7.15	7.15
EW-05	14.58	14.58
EW-06*	0.00	0.00
EW-07	0.78	0.03
EW-08	1.42	0.92
EW-09	1.57	1.57
EW-10*	0.00	0.00
EW-11*	0.00	0.00
EW-12	1.09	0.53
EW-13	5.78	2.61
EW-14	6.86	4.42
Total	**45.32**	**36.21**

Notes:

** = Recovery well not in service during reporting period.*

gpm = gallon per minute



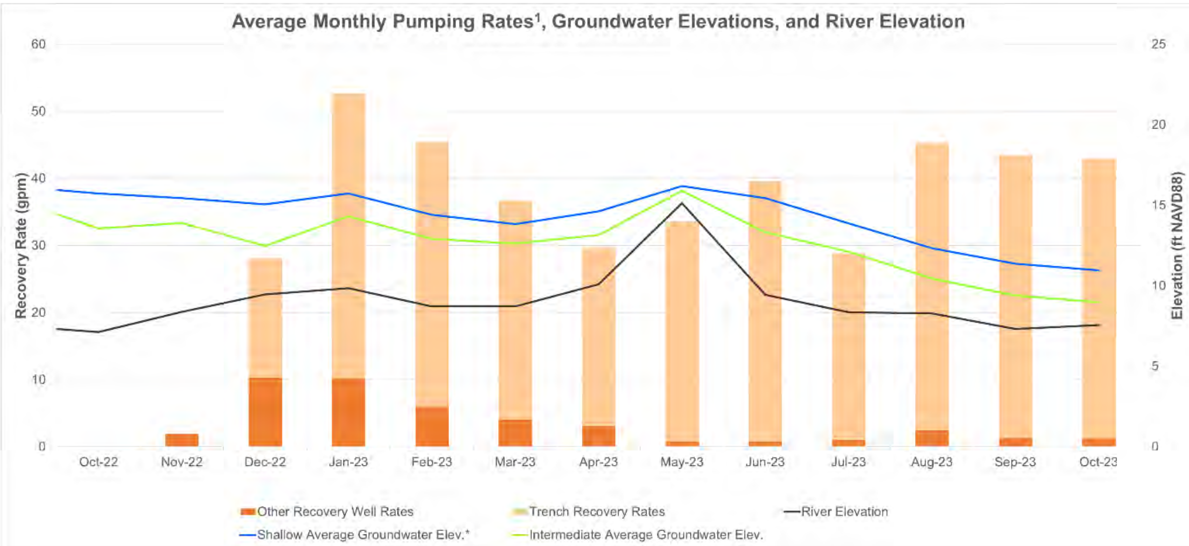
Notes:

[1] = Following installation of trenches in Summer 2022, RW-22, 23, and 25 recovery rates are now grouped together with the other remaining recovery well (RW-14) starting in November 2022.

** = The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the whole aquifer.*

ft NAVD88 = feet North American Vertical Datum of 1988

Figure 1-1. Operational Monthly Pumping Rate



Notes:

[1] = Following installation of trenches in Summer 2022, RW-22, 23, and 25 recovery rates are now grouped together with the other remaining recovery well (RW-14) starting in November 2022.

** = The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the whole aquifer.*

ft NAVD88 = feet North American Vertical Datum of 1988

Figure 1-2. Average Monthly Pumping Rate

3.3.3 Recommendations for Extraction System Optimization

Recovery rates from the start of the system indicate that the active RWs and EWs are operating as designed except for the troubleshooting discussed above. The extraction rates throughout the GWET system will continue to be optimized to meet Target Capture Objectives.

4. ANALYTICAL PROGRAM

Quarterly groundwater monitoring was implemented in accordance with the ODEQ-approved Arkema Quarterly Groundwater Monitoring Work Plan dated October 2019 and the ODEQ-approved reduced scope described in the 2021 monitoring program modification request memorandum dated 9 September 2021. The table below outlines sampling dates and submittal dates related to groundwater monitoring since the implementation of the reduced scope. The Quarterly Monitoring Reports present results from these sampling events.

Report	Sampling Dates	Report Submittal Date
2021 Quarter 3	9/21/2021–9/24/2021	1/14/2022
2021 Quarter 4	12/13/2021–12/16/2021	4/20/2022
2022 Quarter 1	3/14/2022–3/17/2022	6/15/2022
2022 Quarter 2	6/6/2022–6/9/2022	9/12/2022
2022 Quarter 4	11/7/2022–11/10/2022	2/17/2023

Report	Sampling Dates	Report Submittal Date
2023 Quarter 1	3/6/2023–3/10/2023	6/12/2023
2023 Quarter 2	6/12/2023–6/16/2023	9/22/2023
2023 Quarter 3	8/21/2023–8/24/2023	12/1/2023
2023 Quarter 4	12/11/2023–12/14/2023	4/8/2023*

* Dates are tentative.

5. SUMMARY AND CONCLUSIONS

This report presents a summary of the GW SCM operation, maintenance, and monitoring activities conducted at the Site in October 2023 and documents results from system monitoring. The following summarizes ERM's observations and conclusions drawn from collected data.

5.1 Groundwater Flow

- Horizontal groundwater gradients provided in Attachment B-2 for the Shallow, Intermediate, and Deep Zones indicate that most GCCs are either inward, or trending toward inward. Additionally, groundwater elevations show a noticeable difference in elevation across the GWBW, indicating the GWBW is functioning via impeding groundwater flow. The horizontal gradient at GCC1, GCC2, and GCC3 are inward and the rest of the GCCs are trending toward achieving inward gradients.

- Vertical groundwater gradients interior of the GWBW between the Shallow and Intermediate Zones were generally downward, with GCC2 being upward and the remaining downward (Figure 5). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were mixed with GCC2, GCC4, and GCC5 being upward and GCC1, GCC3, and GCC6 being downward.

- Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were mixed with GCC2 and GCC6 being upward and the remaining downward. The direction of vertical gradients exterior to the GWBW were mixed with GCC3 and GCC6 being upward and the remaining downward, as shown on Figure 6.

- The average river elevation in October 2023 was 7.55 feet NAVD 88 with a minimum elevation of 4.71 feet NAVD88 and a maximum elevation of 10.37 feet NAVD88. The seasonal river level elevation trends indicate a seasonal high in May and a seasonal low in October.

5.2 Groundwater Extraction

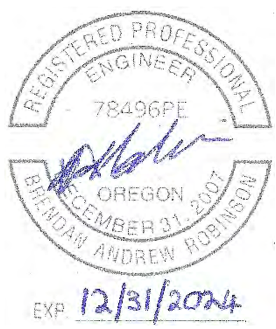
Based on October 2023 extraction and relevant hydrograph analysis, the trenches are achieving increased groundwater extraction rates compared to the legacy system. Within the Site alluvial sequence, potentiometric maps indicate the GW SCM is producing localized areas of hydraulic capture throughout the Target Capture Zone. The analysis of horizontal gradients provided in Attachment B-2 suggests that gradients are either inward, or trending toward inward, at most GCCs in the Shallow, Intermediate and Deep Zones. More time at elevated extraction rates will be required to evaluate whether GWET objectives are being met system wide. As the wet season begins, the river is expected to rise, increasing the elevation of groundwater downgradient of the GWBW. Depending on how much groundwater elevations upgradient of the GWBW rise, there may be increasing trends toward inward horizontal gradients at all GCCs.

The groundwater extraction flow rate is currently limited by a combination of groundwater elevation, influence of back pressure in the trunk line, and fouling of the EWs within the trenches. Currently, water from Trench 7 is being re-routed via overland hoses to intermediate trunk lines to limit the influence on back pressure in the main trunk line on production rates. Plans to permanently connect three of the trenches to the intermediate trunk line, and line jetting of the shallow and intermediate trunks lines, are planned for Q4 2023.

5.3 Recommendations and Future Work

ERM will continue to optimize new EWs, including pump maintenance/upgrades, redevelopment of the wells, and potential trunk line configuration. Any additional modifications to the system to meet capture objectives will be included in subsequent MPRs. The project schedule provided as Attachment C summarizes activities planned for the immediate future.

Regards,



Brendan Robinson, PE
Partner

6. REFERENCES

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FIGURES

Figure 1: Site Layout

Figure 2: October 2023 Shallow Zone Groundwater Contours

Figure 3: October 2023 Intermediate Zone Groundwater Contours

Figure 4: October 2023 Deep Zone Groundwater Contours

Figure 5: October 2023 Shallow to Intermediate Zone Vertical Head Difference

Figure 6: October 2023 Intermediate to Deep Zone Vertical Head Difference

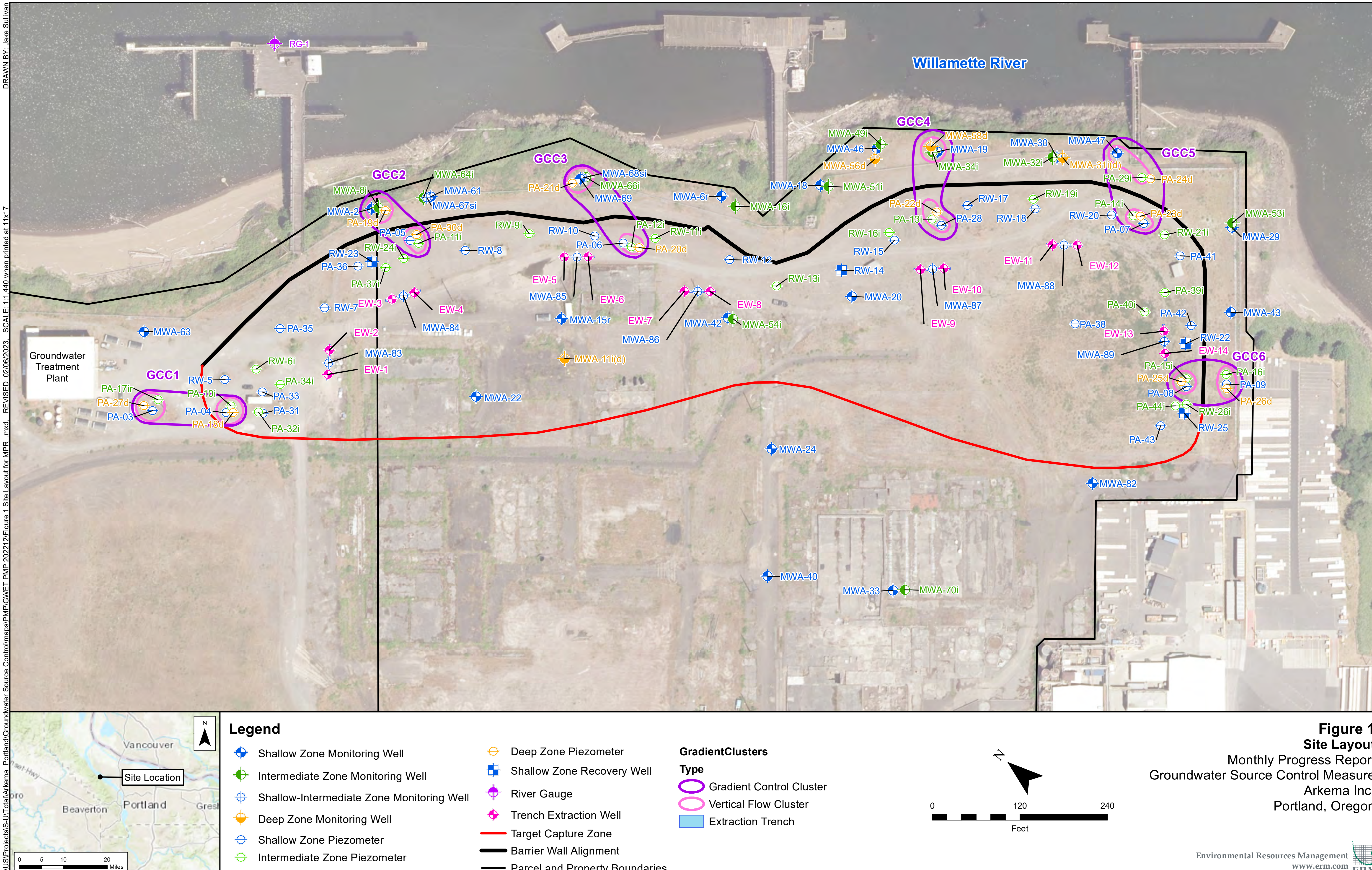
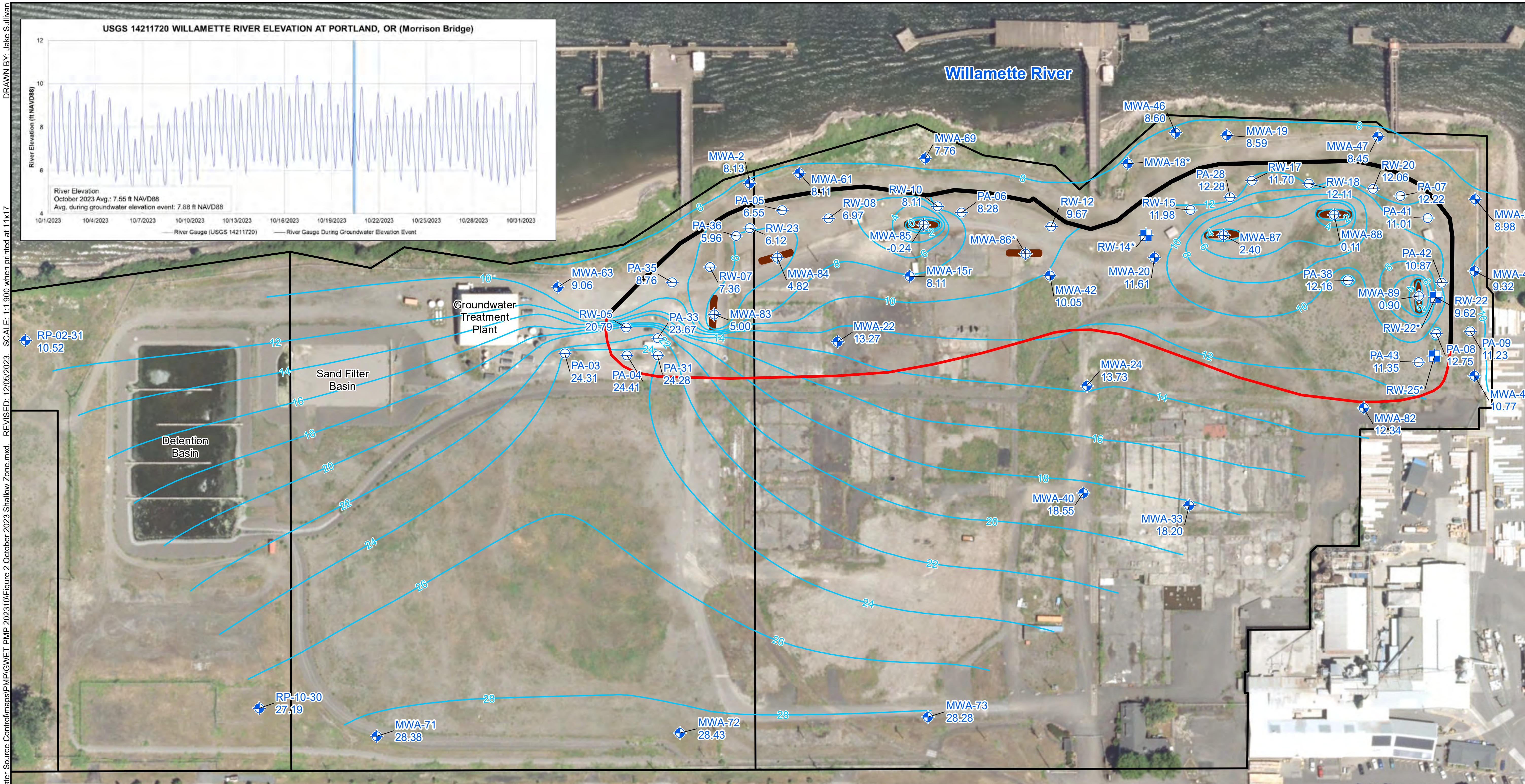


Figure 1
Site Layout
Monthly Progress Report
Groundwater Source Control Measure
Arkema Inc.
Portland, Oregon

Source: City of Portland Aerial Imagery, flown Summer 2021; NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 202310\Figure 2 October 2023 Shallow Zone.mxd. REVISED: 12/05/2023. SCALE: 1:1,900 when printed at 11x17 DRAWN BY: Jake Sullivan

Legend

- Shallow Zone Piezometer
- Shallow Zone Monitoring Well
- Active Recovery Well; Not Used During Contouring
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Shallow Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected October, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 2
October 2023 Shallow Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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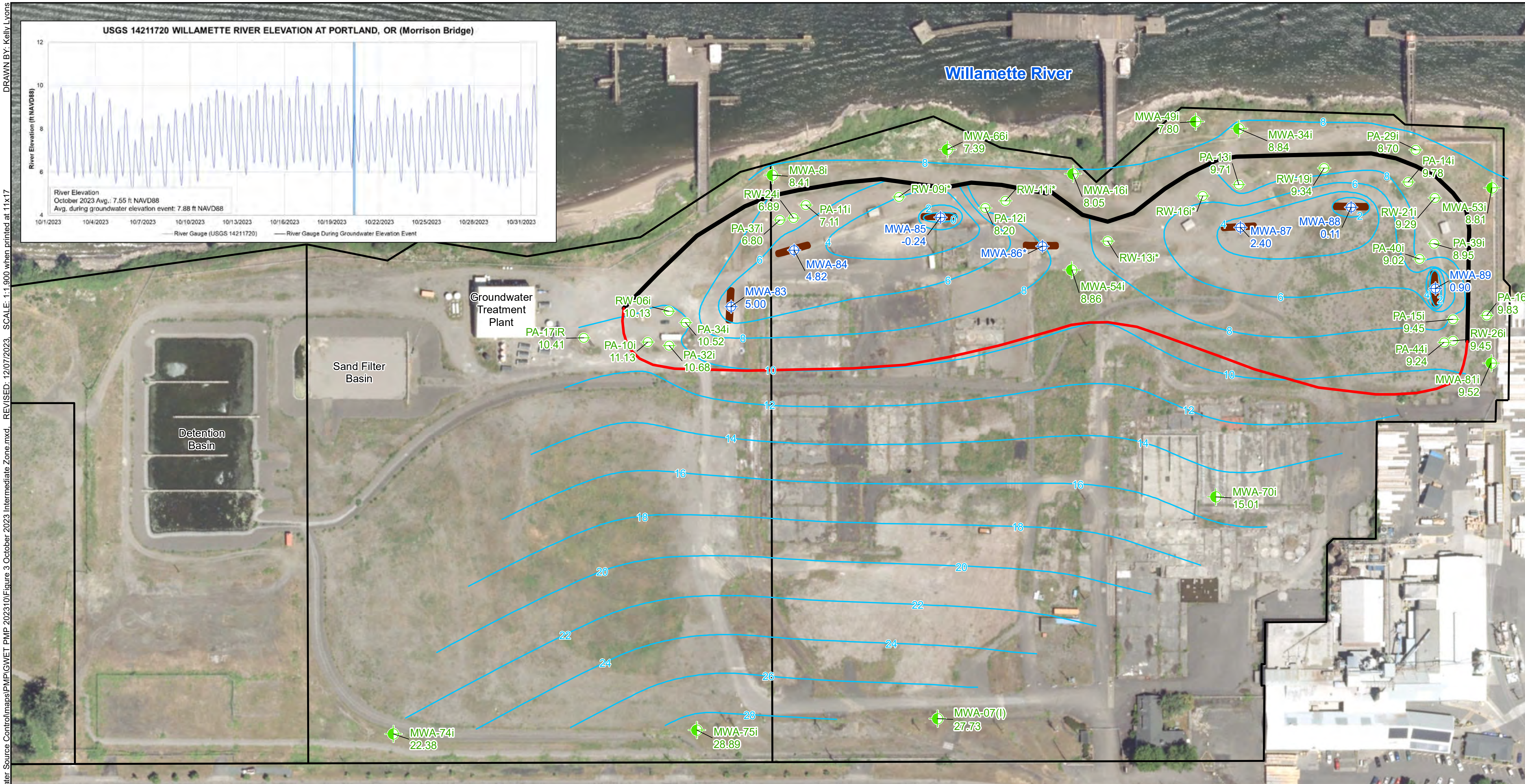
NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Intermediate Zone Piezometer
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected October, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 3
October 2023 Intermediate Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

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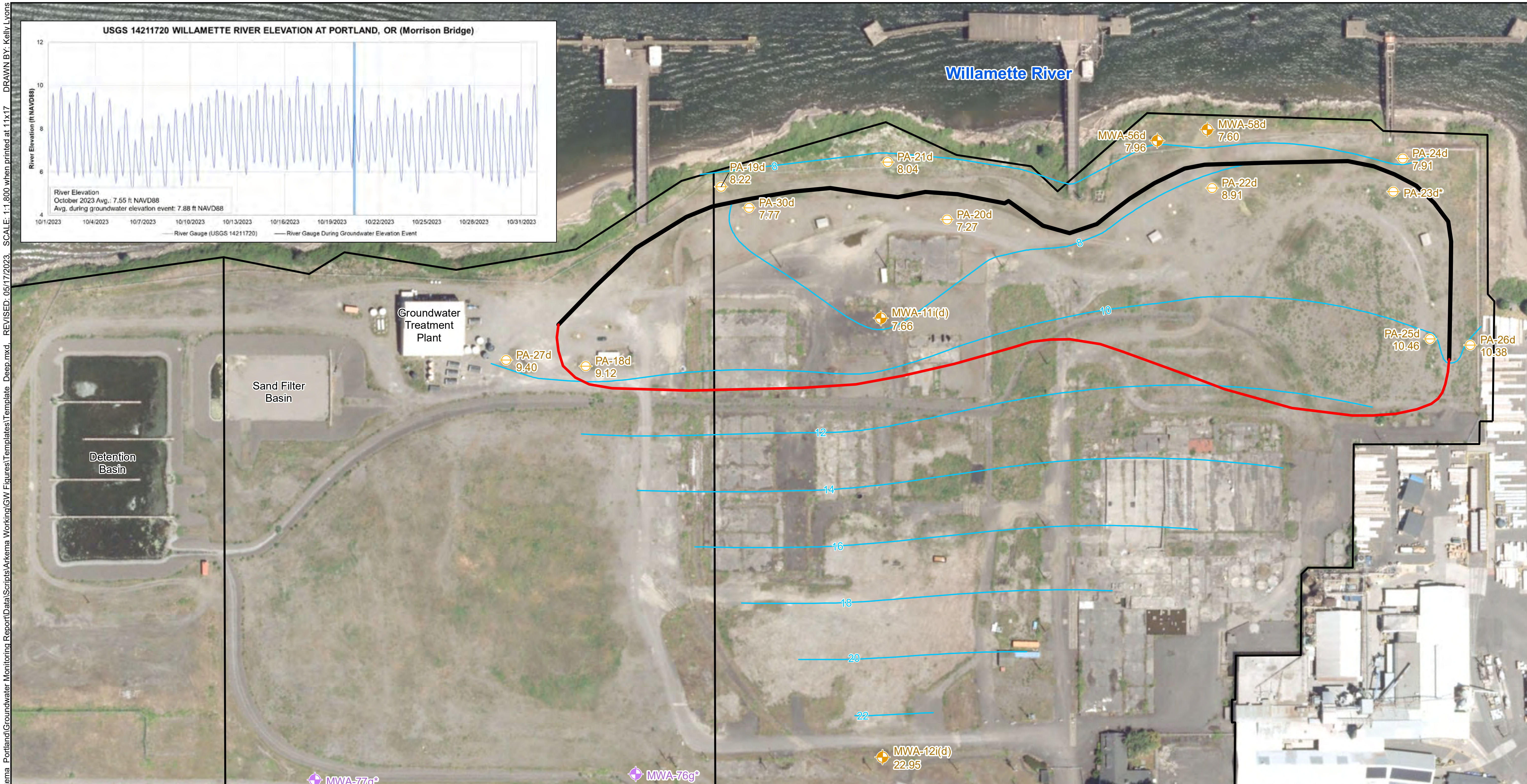
NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 202310\Figure 3 October 2023 Intermediate Zone.mxd   REVISED: 12/07/2023   SCALE: 1:1,900 when printed at 11x17   DRAWN BY: Kelly Lyons



Legend

- Deep Zone Piezometer
- Deep Zone Monitoring Well
- Gravel Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Deep Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment

Notes:
* Value not used for contouring.
Gravel zone wells not used in contouring.
Water levels collected October, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 150 300
Feet

Figure 4
October 2023 Deep Zone Groundwater Contours
Monthly Performance Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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\\SCUSPRDGISFS01\Data\US\Projects\S-U\Total\Arkema_Portland\Groundwater Monitoring Report\Data\Scripts\Arkema Working\GW Figures\Templates\Template_Deep.mxd REVISED: 05/17/2023 SCALE: 1:1,800 when printed at 11x17 DRAWN BY: Kelly Lyons

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Shallow Zone Recovery Well
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as shallow zone minus intermediate zone potentiometric surfaces.
Water levels collected October, 2023.
Aerial Photo: City of Portland, Summer 2017.

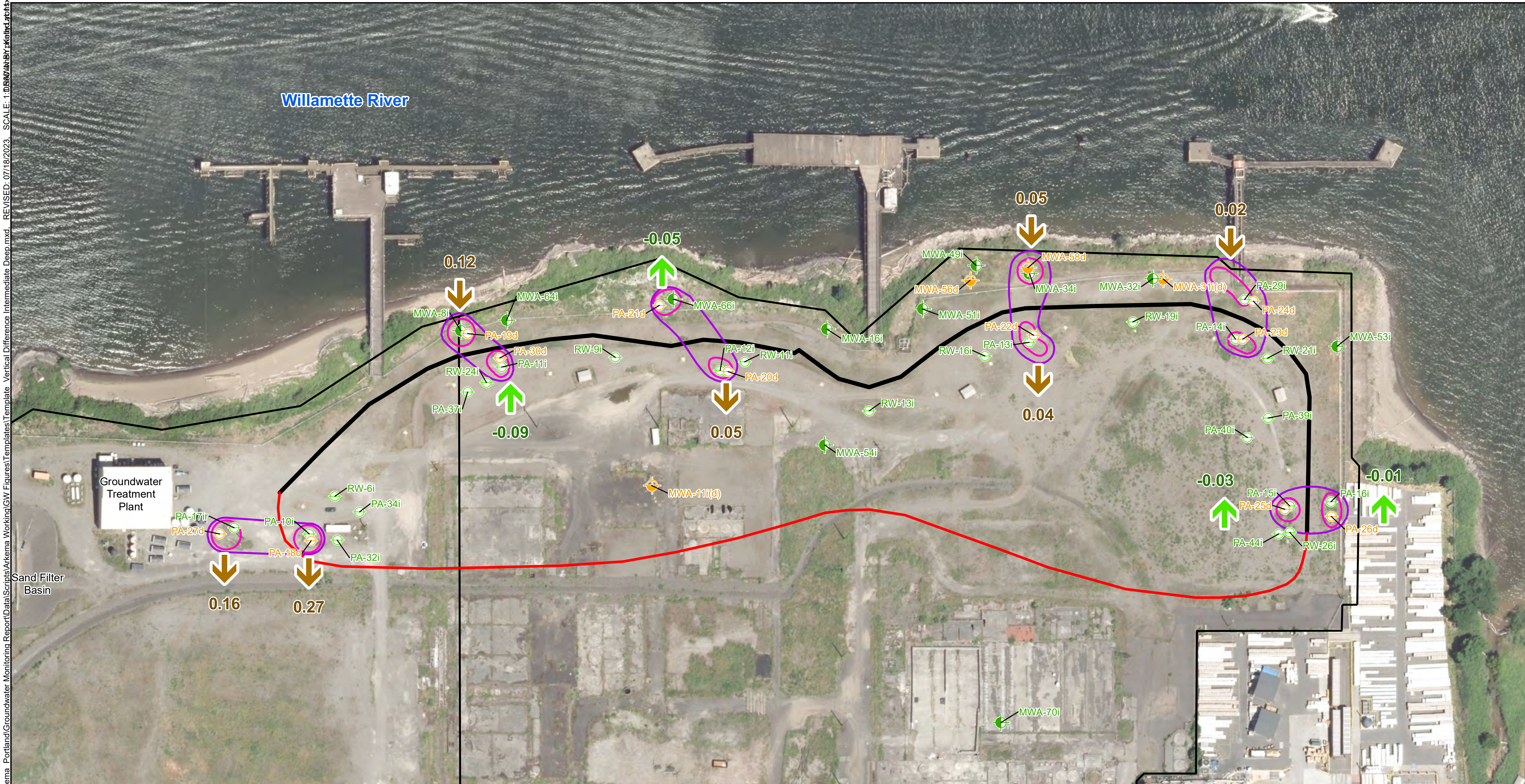
0 130 260
Feet

Figure 5
October 2023 Shallow to Intermediate Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

\\SCUSPRDGISFS01\Data\US\Projects\S-U\Total\Arkema_Portland\Groundwater Monitoring Report\Data\Scripts\Arkema Working\GW Figures\Templates\Template_Vertical Difference Intermediate Deep.mxd, REVISED: 07/18/2023, SCALE: 1:1,560 when printed at 11x17



Legend

- Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as intermediate zone minus deep zone potentiometric surfaces.
Water levels collected October, 2023.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 6
October 2023 Intermediate to Deep Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

ATTACHMENT A-1 TRANSDUCER FLAGS

Attachment A-1. Transducer Flags

Table A-1
Transducer Malfunction Log: October 2023
Arkema Inc. Facility
Portland, Oregon

Gradient Cluster	Transducer	Interval	Date Range		Issue and Repairs Performed
GCC2	PA-11i	Intermediate	9/1/2023	Present	Transducer faulted, new transducer ordered.
GCC3	PA-06	Shallow	9/21/2023	10/8/2023	Animal chewed through signal cable, wire replaced.
N/A	RW-18	Intermediate	9/29/2023	10/30/2023	Transducer was lowered and recalibrated.
GCC5	PA-23d	Intermediate	10/18/2023	10/30/2023	Transducer faulted. Repaired signal wire and recalibrated.

Notes:

I/O = input/output

LOTO = lockout/tagout

VFD = variable frequency drive

ATTACHMENT A-2 RECOVERY WELL STATUS

Attachment A-2. Recovery Well Status

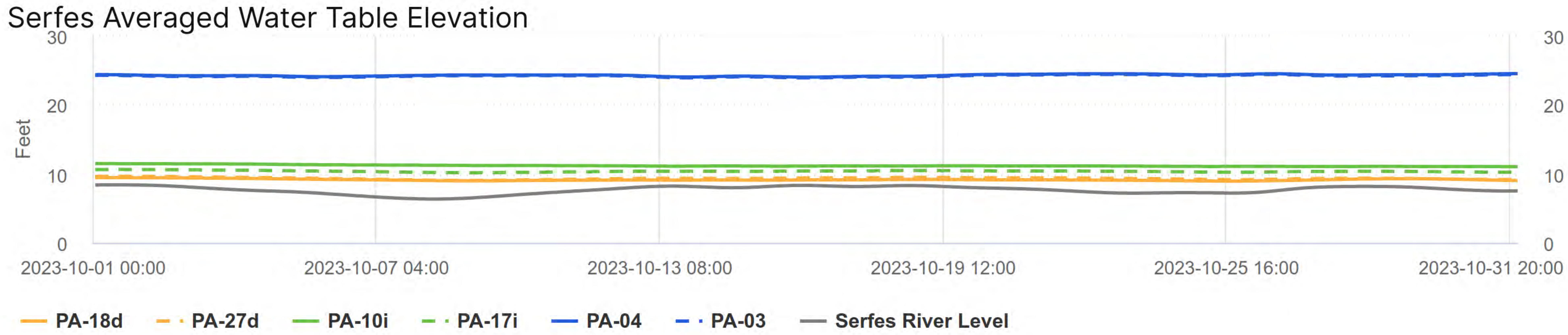
Table A-2
Recovery Well Status: October 2023
Arkema Inc. Facility
Portland, Oregon

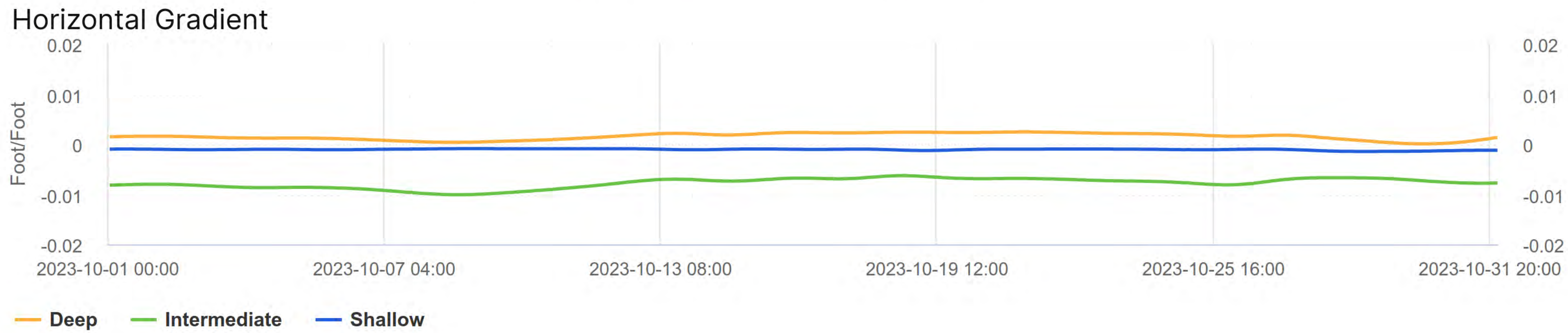
Recovery Well ID	Status as of 9/30/2023 (active or inactive)	Issue	Actions to get online	Expected date back online	Transducer Status	Totalizer Status	Average Flow Rate (gpm)	Overall Extraction Rate	Notes
RW-14	Active	None	N/A	N/A	Good	Good	0.16	P	
RW-22	Active	None	N/A	N/A	Good	Good	0.06	P	
RW-23	Active	None	N/A	N/A	Good	Good	0.00	OFF*	Off due to low water levels in trench
RW-25	Active	None	N/A	N/A	Good	Good	0.87	P	
EW-01	Active	None	N/A	N/A	Good	Good	0.00	OFF*	Off due to low water levels in trench
EW-02	Active	None	N/A	N/A	Good	Good	1.59	M	
EW-03	Active	None	N/A	N/A	Good	Good	3.41	G	
EW-04	Active	None	N/A	N/A	Good	Good	7.15	G	
EW-05	Active	None	N/A	N/A	Good	Good	14.58	G	
EW-06	Active	None	N/A	N/A	Good	Good	0.00	OFF*	Off due to low water levels in trench
EW-07	Active	None	N/A	N/A	Good	Good	0.78	P	
EW-08	Active	None	N/A	N/A	Good	Good	1.42	M	
EW-09	Active	None	N/A	N/A	Good	Good	1.57	M	
EW-10	Inactive	None	N/A	N/A	Good	Good	0.00	OFF*	Off due to low water levels in trench
EW-11	Active	None	N/A	N/A	Good	Good	0.00	OFF*	Off due to ground fault and broken impeller within pump
EW-12	Active	None	N/A	N/A	Good	Good	1.09	M	
EW-13	Active	None	N/A	N/A	Good	Good	5.78	G	
EW-14	Active	None	N/A	N/A	Good	Good	6.86	G	

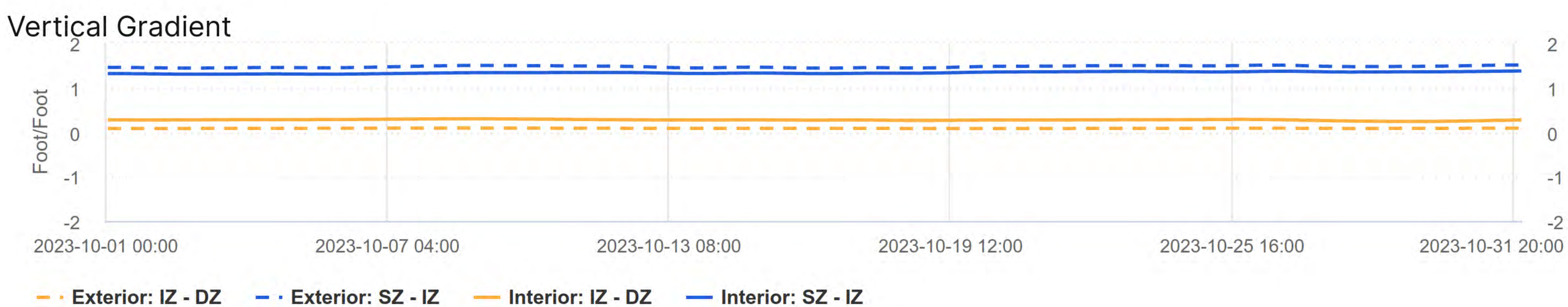
Notes:
** Recovery wells not in service*
*** Recovery wells in service part of the month*
G = good pumping, greater than 3.0 gpm
gpm = gallons per minute
M = moderate pumping, greater than 1.0 gpm and less than 3.0
P = poor pumping, less than 1.0 gpm
VFD = variable frequency drive
PA = piezometer

ATTACHMENT B-1 GRADIENT HYDROGRAPHS

Gradient Control Cluster 1

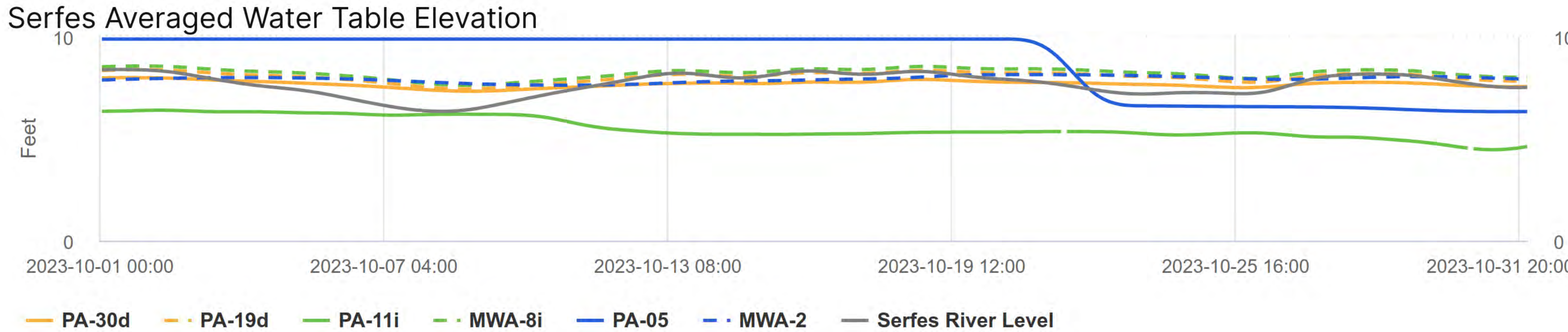


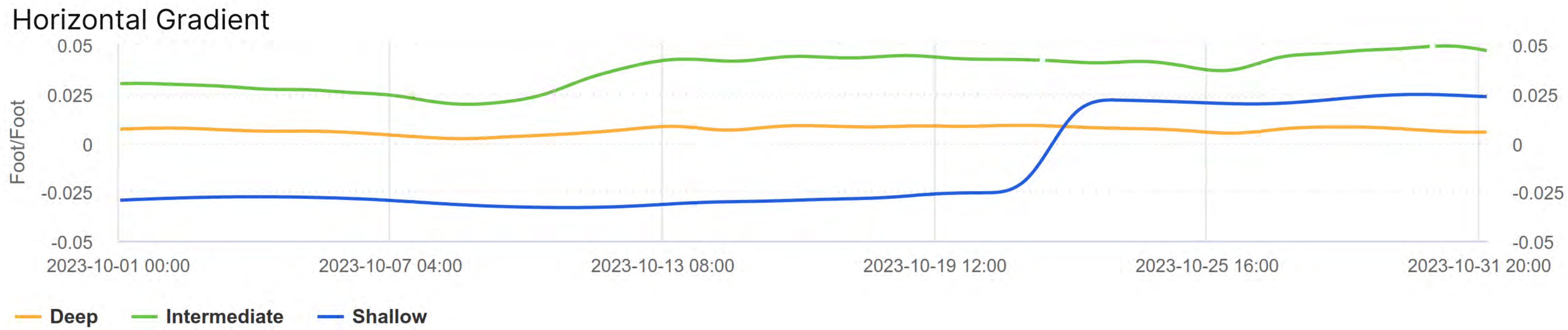


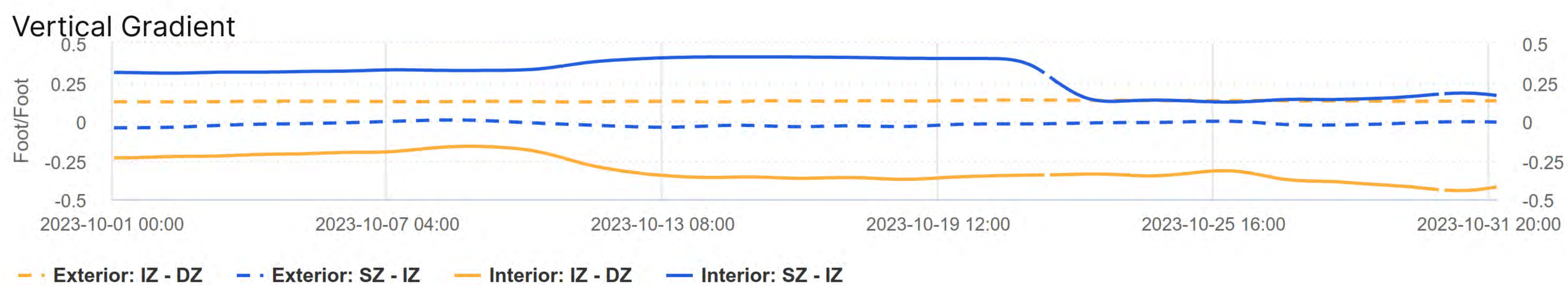


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 2

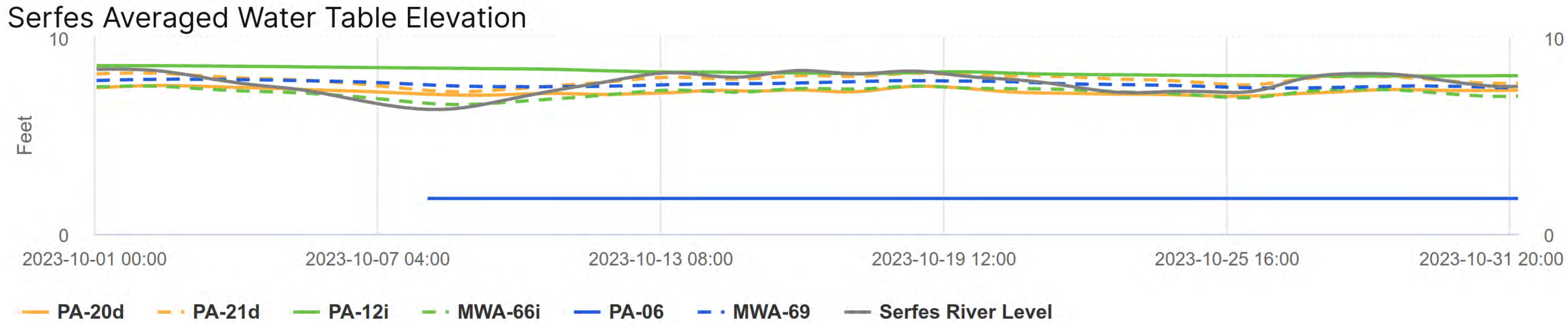


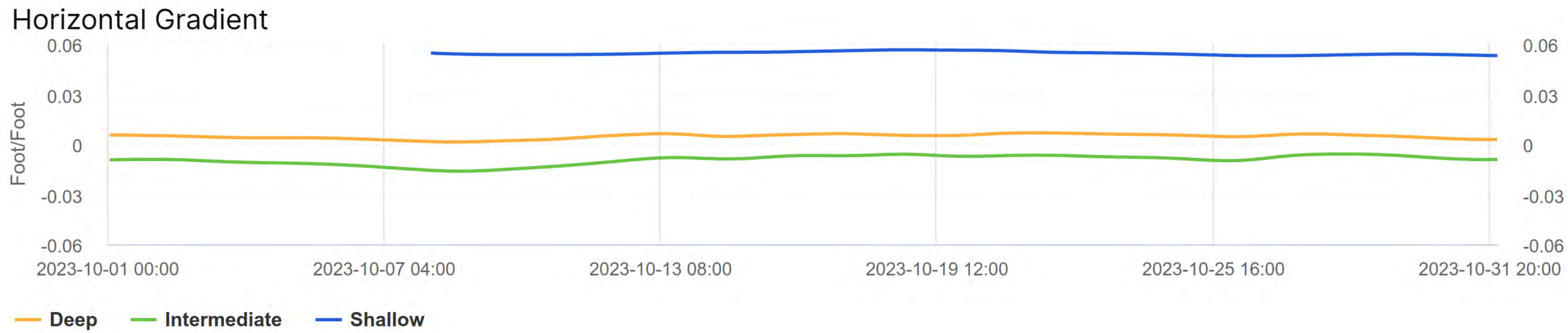


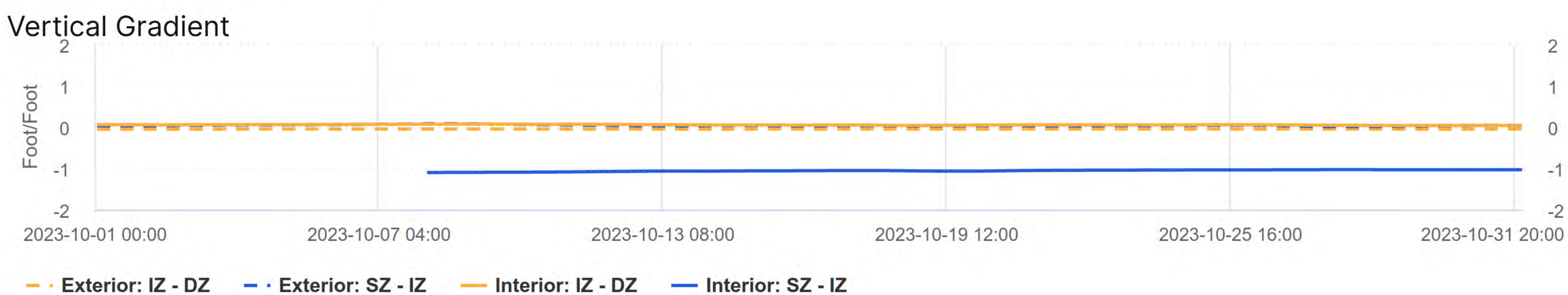


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 3



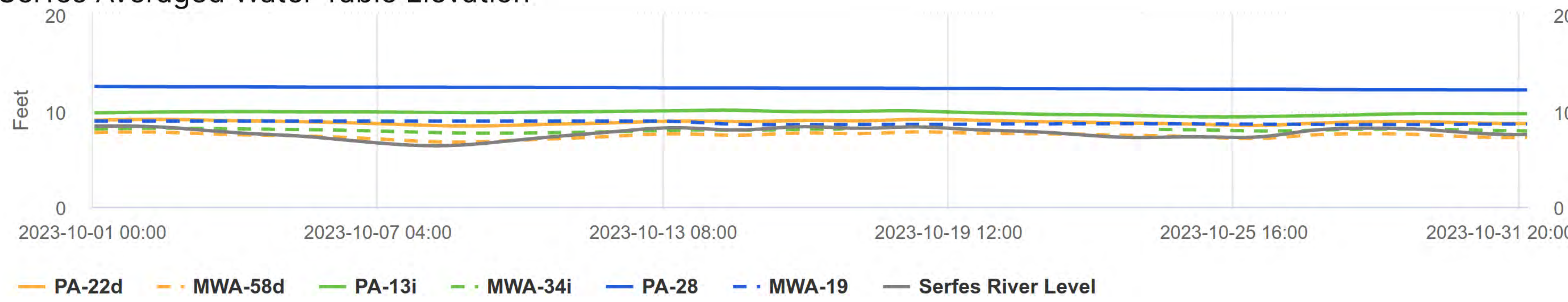




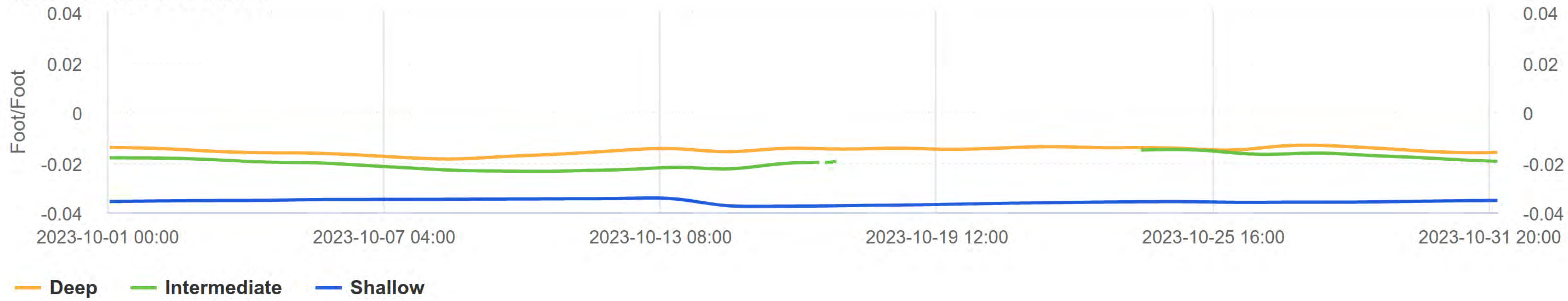
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 4

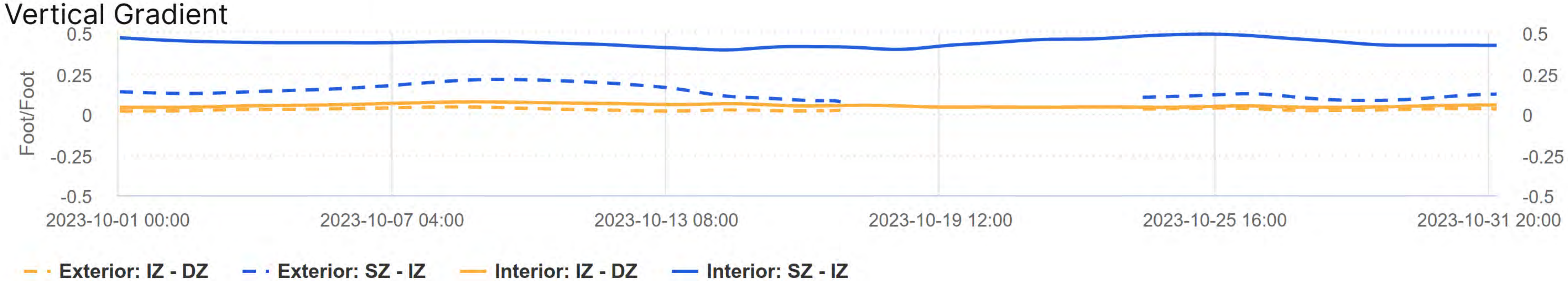
Serfes Averaged Water Table Elevation



Horizontal Gradient



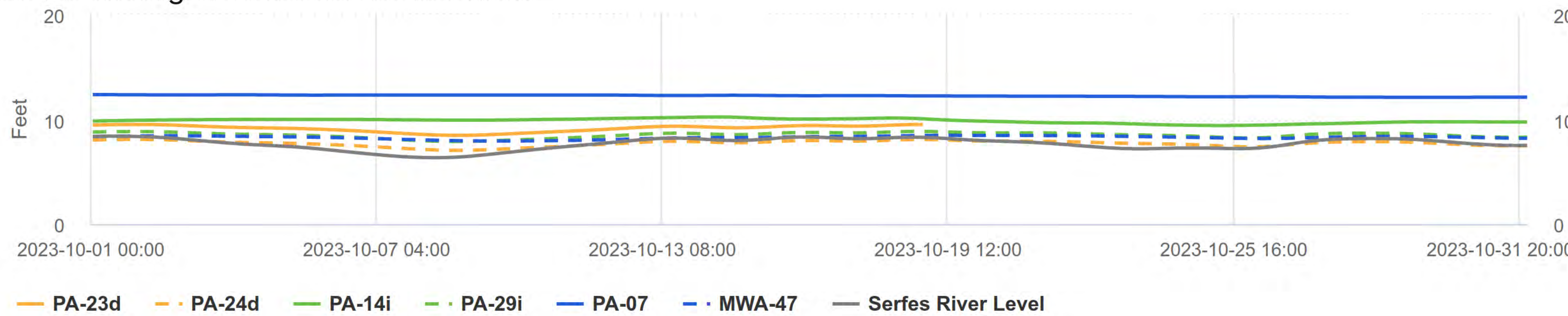
Vertical Gradient



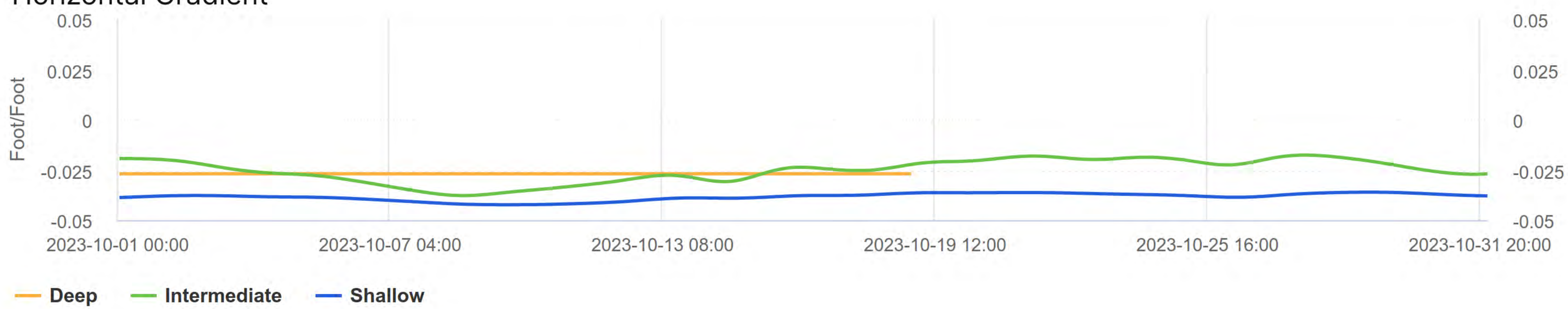
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 5

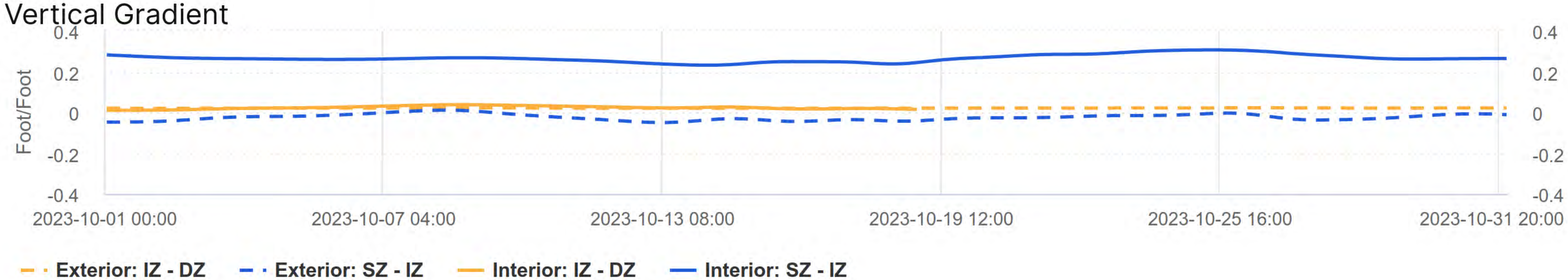
Serfes Averaged Water Table Elevation



Horizontal Gradient

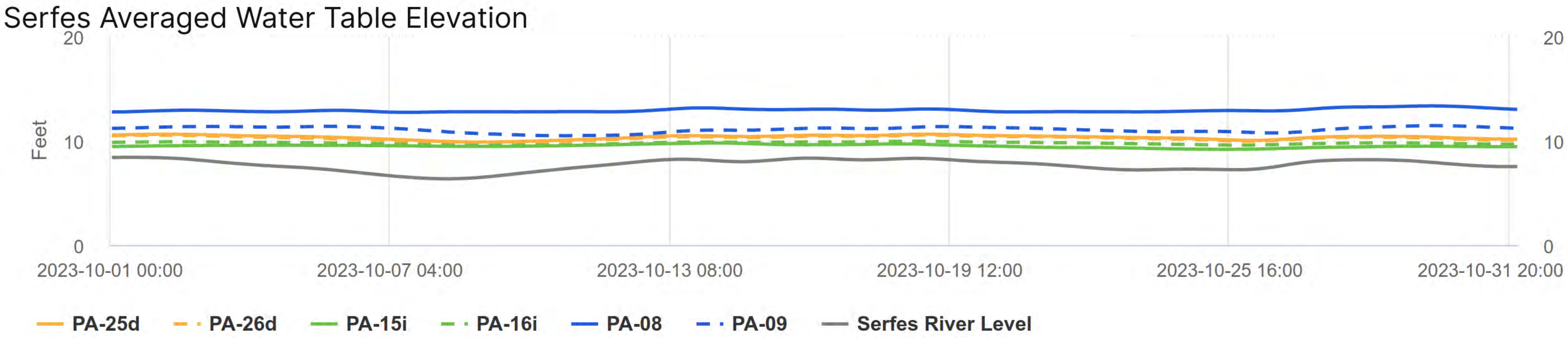


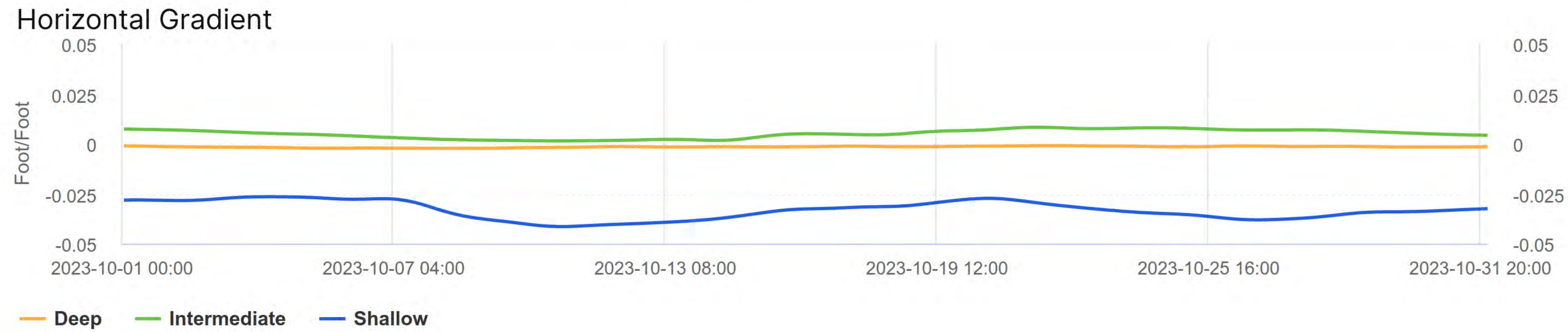
Vertical Gradient

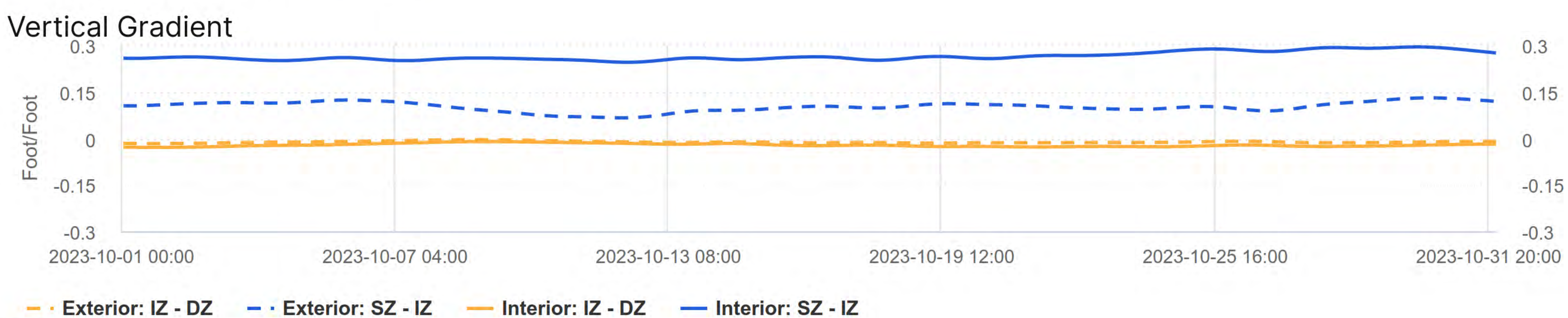


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 6





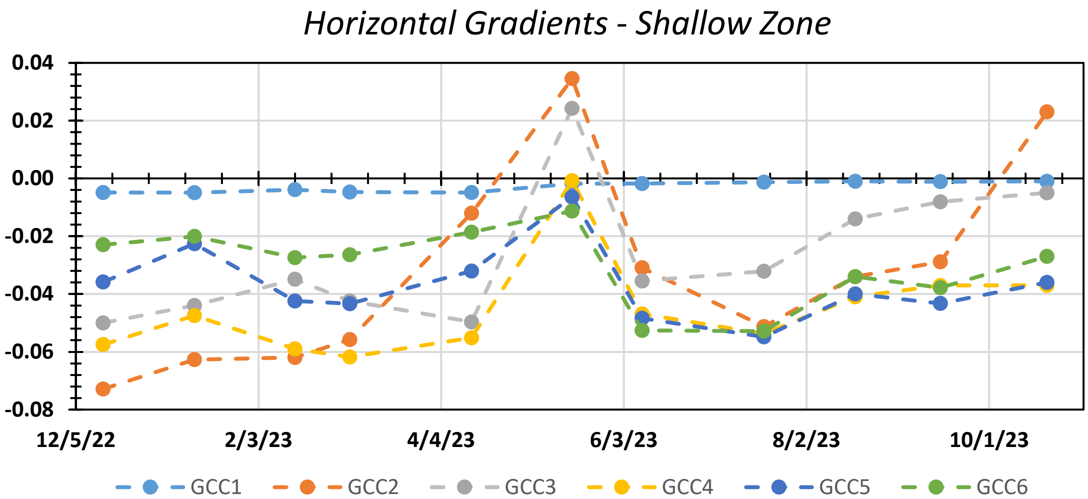


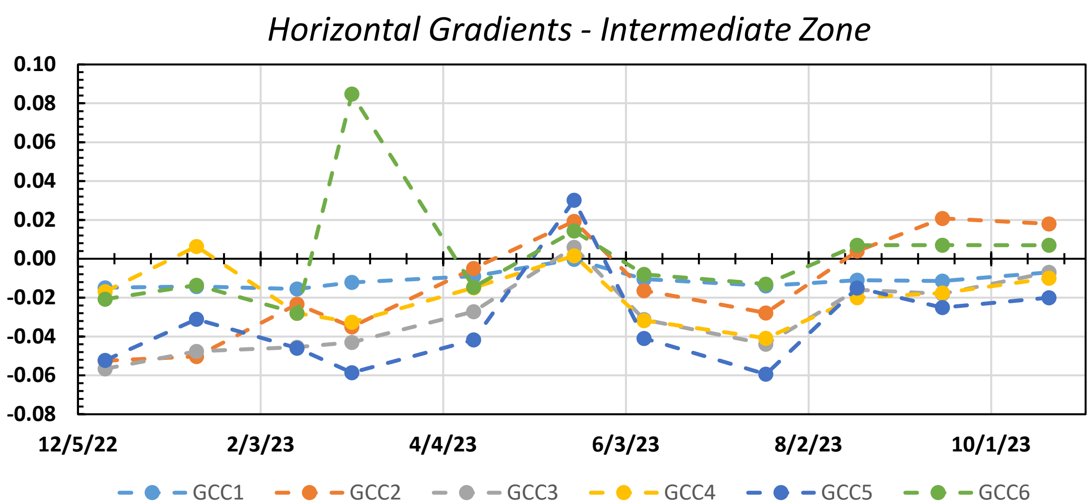
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

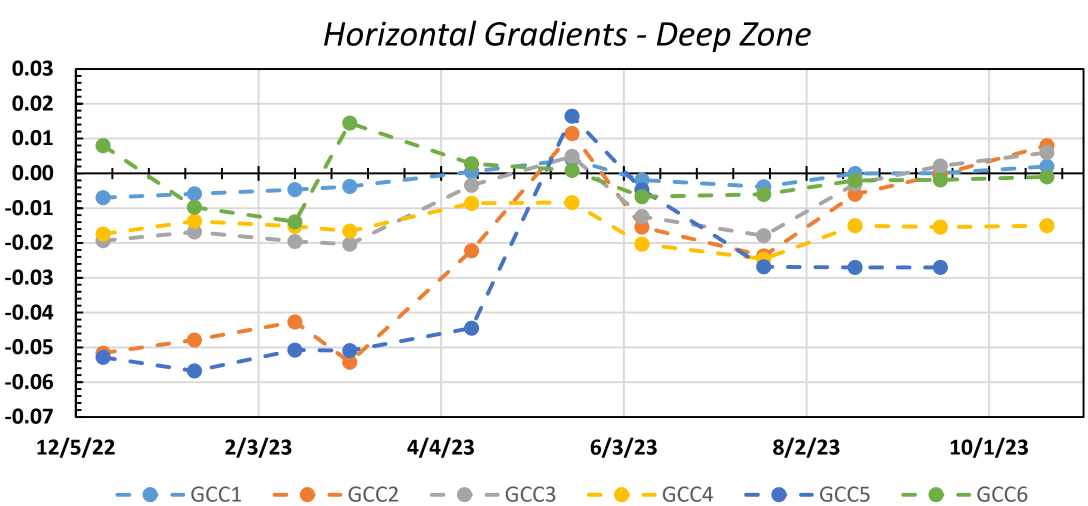
ATTACHMENT B-2 HORIZONTAL GRADIENTS

Attachment B-2

Horizontal Gradients Summary: October 2023
Arkema Inc. Facility
Portland, Oregon





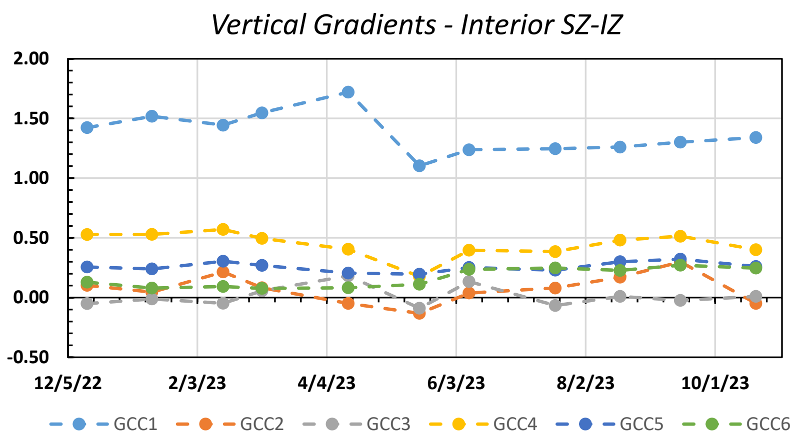


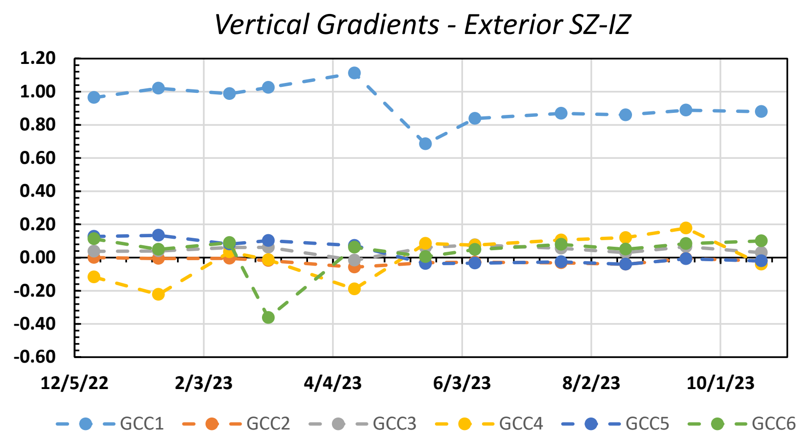
Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.

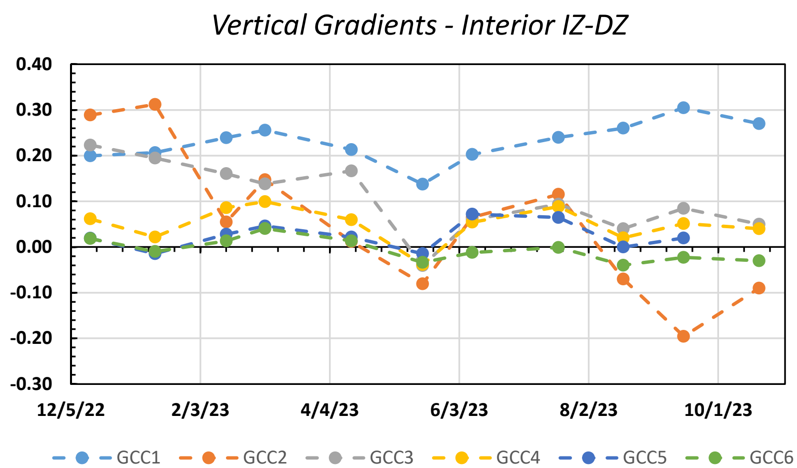
ATTACHMENT B-3 VERTICAL GRADIENTS

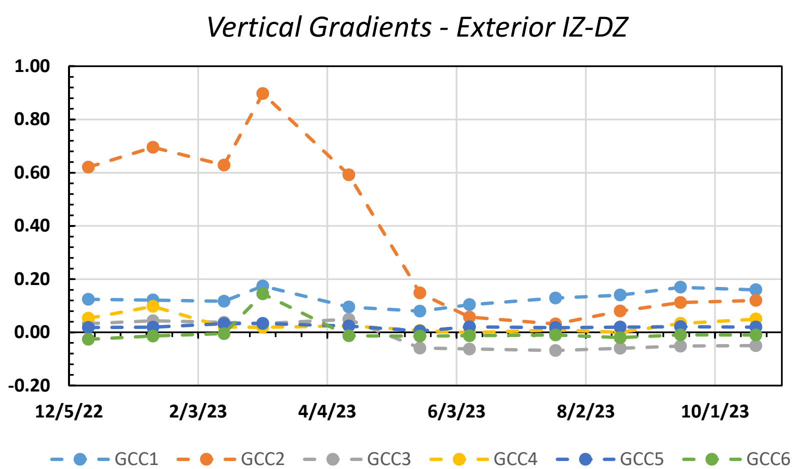
Attachment B-3

Vertical Gradients Summary: October 2023
Arkema Inc. Facility
Portland, Oregon



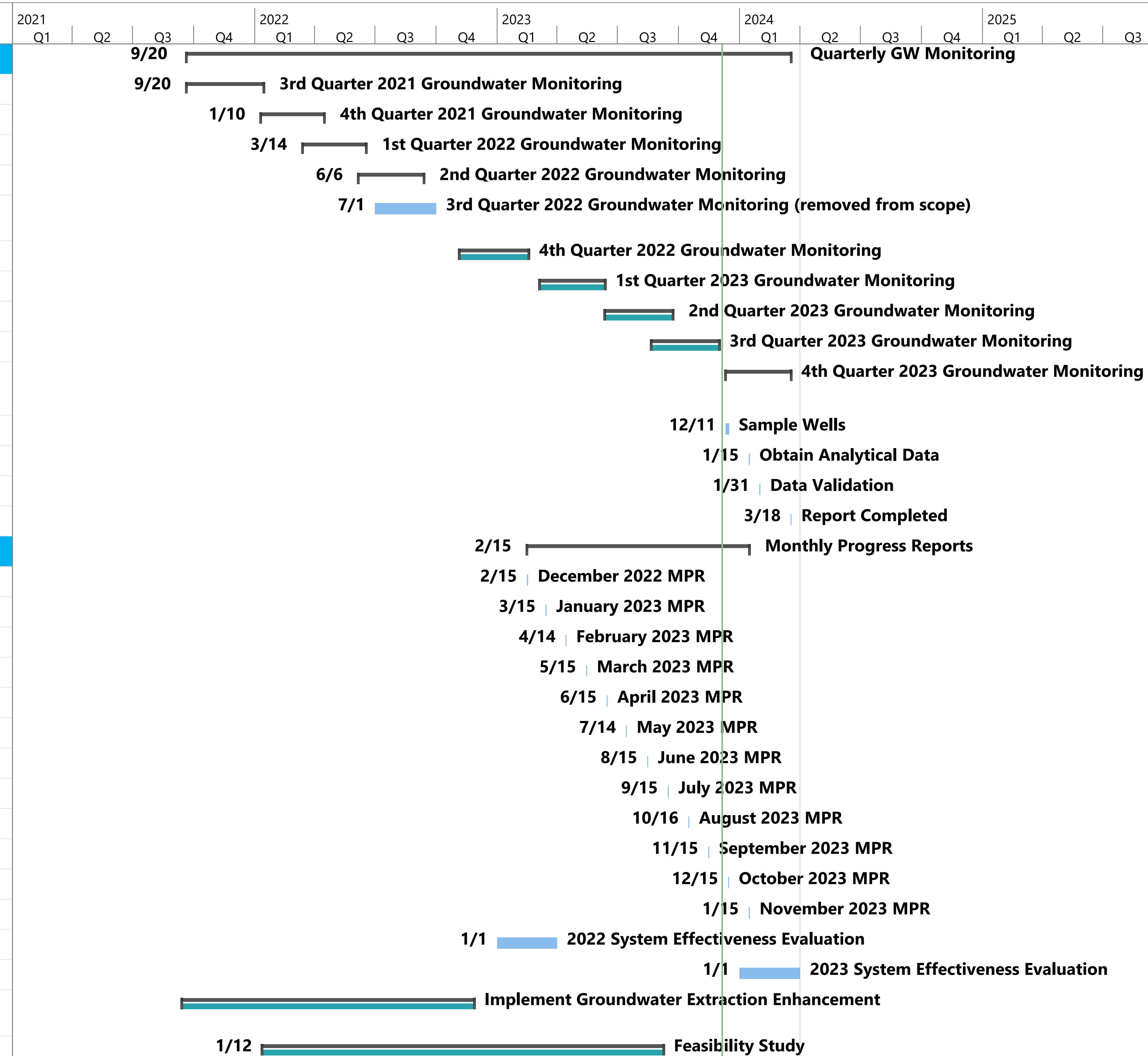






ATTACHMENT C PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**Quarterly GW Monitoring**	**654 days**	**Mon 9/20/21**	**Mon 3/18/24**
2	*3rd Quarter 2021 Groundwater Monitoring*	*85 days*	*Mon 9/20/21*	*Fri 1/14/22*
7	*4th Quarter 2021 Groundwater Monitoring*	*70 days*	*Mon 1/10/22*	*Fri 4/15/22*
11	*1st Quarter 2022 Groundwater Monitoring*	*70 days*	*Mon 3/14/22*	*Fri 6/17/22*
16	*2nd Quarter 2022 Groundwater Monitoring*	*71 days*	*Mon 6/6/22*	*Mon 9/12/22*
21	*3rd Quarter 2022 Groundwater Monitoring (removed from scope)*	*66 days*	*Fri 7/1/22*	*Fri 9/30/22*
22	*4th Quarter 2022 Groundwater Monitoring*	*78 days*	*Sat 11/5/22*	*Fri 2/17/23*
27	*1st Quarter 2023 Groundwater Monitoring*	*71 days*	*Mon 3/6/23*	*Mon 6/12/23*
32	*2nd Quarter 2023 Groundwater Monitoring*	*75 days*	*Mon 6/12/23*	*Fri 9/22/23*
37	*3rd Quarter 2023 Groundwater Monitoring*	*75 days*	*Mon 8/21/23*	*Fri 12/1/23*
42	**4th Quarter 2023 Groundwater Monitoring ***	**71 days**	**Mon 12/11/23**	**Mon 3/18/24**
43	Sample Wells	5 days	Mon 12/11/23	Fri 12/15/23
44	Obtain Analytical Data	1 day	Mon 1/15/24	Mon 1/15/24
45	Data Validation	1 day	Wed 1/31/24	Wed 1/31/24
46	Report Completed	1 day	Mon 3/18/24	Mon 3/18/24
47	**Monthly Progress Reports**	**239 days**	**Wed 2/15/23**	**Mon 1/15/24**
48	*December 2022 MPR*	*1 day*	*Wed 2/15/23*	*Wed 2/15/23*
49	*January 2023 MPR*	*1 day*	*Wed 3/15/23*	*Wed 3/15/23*
50	*February 2023 MPR*	*1 day*	*Fri 4/14/23*	*Fri 4/14/23*
51	*March 2023 MPR*	*1 day*	*Mon 5/15/23*	*Mon 5/15/23*
52	*April 2023 MPR*	*1 day*	*Thu 6/15/23*	*Thu 6/15/23*
53	*May 2023 MPR*	*1 day*	*Fri 7/14/23*	*Fri 7/14/23*
54	*June 2023 MPR*	*1 day*	*Tue 8/15/23*	*Tue 8/15/23*
55	*July 2023 MPR*	*1 day*	*Fri 9/15/23*	*Fri 9/15/23*
56	*August 2023 MPR*	*1 day*	*Mon 10/16/23*	*Mon 10/16/23*
57	*September 2023 MPR*	*1 day*	*Wed 11/15/23*	*Wed 11/15/23*
58	October 2023 MPR	1 day	Fri 12/15/23	Fri 12/15/23
59	November 2023 MPR	1 day	Mon 1/15/24	Mon 1/15/24
60	***2022 System Effectiveness Evaluation***	***66 days***	***Sun 1/1/23***	***Fri 3/31/23***
61	2023 System Effectiveness Evaluation	66 days	Mon 1/1/24	Sun 3/31/24
62	***Implement Groundwater Extraction Enhancement***	***317 days***	***Mon 9/13/21***	***Sun 11/27/22***
70	***Feasibility Study***	***436 days***	***Wed 1/12/22***	***Fri 9/8/23***



Arkema Portland
Monthly Progress Report
Attachment C

Task	Project Summary	Manual Task	Start-only	Deadline
Split	Inactive Task	Duration-only	Finish-only	Progress
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Manual Progress
Summary	Inactive Summary	Manual Summary	External Milestone	

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Portland, OR 97204
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F +1 503 488 5142
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MEMO

TO	Katie Daugherty, Oregon Department of Environmental Quality
FROM	Brendan Robinson, PE, Environmental Resources Management, Inc.
DATE	15 January 2024
REFERENCE	0719595 Phase 106
SUBJECT	November 2023 GW SCM Monthly Performance Monitoring Report

1. INTRODUCTION

Environmental Resources Management, Inc. (ERM) prepared this Monthly Performance Monitoring Report (MPR) on behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc. (Arkema), for the former Arkema Portland Plant (the Site) at 6400 NW Front Avenue in Portland, Oregon. The Oregon Department of Environmental Quality (ODEQ), in its letter dated 31 May 2019 and in the subsequent meeting with LSS and ERM on 2 July 2019, requested that LSS initiate monthly status reports associated with the onsite groundwater source control measure (GW SCM) consistent with the Performance Monitoring Plan (PMP; ERM 2014) beginning July 2019. The 2014 PMP was prepared pursuant to the Order on Consent issued by ODEQ, signed on 31 October 2008 (ODEQ No. LQVC-NWR-08-04; Consent Order). The purpose of the PMP was to present the monitoring, reporting, and adaptive management processes used during implementation of the GW SCM. On 30 November 2021, ODEQ directed LSS that following the October 2021 MPR, subsequent MPRs would be suspended pending the implementation of the Groundwater Extraction Enhancement (GEE) project in 2022. During that time, ODEQ requested monthly schedule updates in lieu of MPRs. The trench wells installed as part of the GEE project were started on 27 November 2022, and MPR writing restarted in December 2022. The purpose of the GEE project was to install new extraction capacity to achieve the Capture Zone Objectives.

This November 2023 MPR summarizes the GW SCM performance monitoring data collected in November 2023. This report assesses the current gradient status and proposes system improvements to meet the Capture Zone Objectives set in the PMP.

2. GROUNDWATER SOURCE CONTROL IMPLEMENTATION

A detailed description of the design and implementation of the GW SCM is provided in the Revised Upland Feasibility Study Work Plan (ERM 2017); however, a brief description of the GW SCM is provided here. In February 2009, ODEQ and the U.S.

Environmental Protection Agency (USEPA) approved the general approach for the GW SCM. This approach included installation of a groundwater barrier wall (GWBW), groundwater recovery wells, and a Groundwater Extraction and Treatment (GWET) system, with treated water discharged to the Willamette River. ODEQ and USEPA approved the Groundwater Barrier Wall Final Design (ERM 2012) on 7 August 2012. Construction of the GWBW began in May 2012 and was completed in December 2012. ODEQ approved the Groundwater Extraction and Treatment System Final Design (ERM 2013) on 2 April 2013. Construction of the GWET system began in December 2012 and was completed in December 2013.

GWET startup and optimization commenced in May 2014. The GW SCM at the Site consists of the following primary components (Figure 1):

1. A GWBW to physically separate the affected upland portions and in-water portions of the Site.
2. Hydraulic control to minimize flow of groundwater containing unacceptable concentrations of constituents of potential concern (COPCs) around, over, and under the GWBW.
3. Management of extracted groundwater through the GWET system, with treated effluent discharged to the Willamette River under a National Pollutant Discharge Elimination System (NPDES) Permit.

On 1 September 2018, ERM submitted the Draft GWET System Effectiveness Evaluation (Draft SEE Report; ERM 2018). The Draft SEE Report provided an update on the corrective actions implemented to improve the performance of the GWET system, evaluate the extent of capture, and propose actions to improve hydraulic capture. Additional data requested by ODEQ were submitted on 26 October 2018.

The key objective of the GW SCM is to achieve hydraulic containment of the alluvial sequence within the Target Capture Zone at the Site to prevent the flow of COPCs to the Willamette River. The Site alluvial aquifer sequence within the Target Capture Zone consists of the Shallow Zone, Intermediate Zone, and the Deep Zone. Site hydraulic conditions are variable and subject to both seasonal and daily tidal fluctuations.

The hydraulic control component formerly consisted of 22 recovery wells (RWs) prior to the implementation of the GEE. Of the 22 pre-existing RWs, four were retained for active pumping. The remaining 18 former RWs had pumps removed but retained their pressure transducers so that they can continuously collect high-resolution groundwater elevation data. The hydraulic control system now consists of the four remaining active RWs, as well as seven groundwater extraction trenches that each contain two extraction wells (EWs). Each trench is 50 feet deep, 50 feet long, and 3 feet wide and is filled with an engineered backfill. More information about the groundwater extraction trenches is provided in the Final Design Report (ERM 2022). The gradient control-monitoring network consists of six gradient control clusters (GCCs) with each cluster containing six monitoring points. Within each RW, EW, and GCC location, pressure transducers are continuously collecting high-resolution groundwater elevation data. Each GCC contains three transducers interior to the wall and three transducers exterior to the wall screened in the Shallow, Intermediate, and Deep Aquifers at the Site.

3. HYDRAULIC CONTAINMENT MONITORING PROGRAM

As described in the PMP, the purpose of hydraulic monitoring (i.e., groundwater elevation data) is to provide sufficient data to demonstrate an inward hydraulic gradient across the GWBW and to evaluate the effective hydraulic capture produced by the GW SCM.

Monitoring requirements were established in the PMP to demonstrate GWET effectiveness. The Site monitoring program includes groundwater elevation data (manual and transducer measurements) collected from the 36 monitoring points located within six GCCs spaced across the GWBW, with piezometers interior and exterior to the wall, throughout the alluvial sequence; and groundwater elevation and flow rate data from the four remaining active RWs and 14 EWs. High-resolution groundwater elevation data is also collected from the 18 inactive RWs. Additionally, one new monitoring well was installed in each of the seven extraction trenches for manual water level measurement. These data were used to prepare horizontal and vertical potentiometric surface maps representing potentiometric differences between the alluvial sequences, and to generate spatial and temporal hydrographs to evaluate hydraulic capture.

3.1 GROUNDWATER ELEVATION MONITORING

Groundwater elevation monitoring was completed on 15 November 2023. Manual groundwater elevations were measured at wells that were experiencing transducer mechanical issues or that were offline during the groundwater elevation measurement event. All inactive RWs were manually measured in the month of June to affirm proper calibration. Manual water levels for those RWs are reported. Additionally, all transducers in inactive RWs were down until upgrades were completed and transducers were sequentially turned on. Specific issues are addressed in Attachment A-1.

As detailed in Attachments A-1 and A-2, during November 2023, the following transducers were:

<u>Fully out of service pending repairs:</u>

- PA-11i

PA-11i has a faulted transducer and a replacement transducer has been ordered.

<u>Out of service for a period but returned to full operation:</u>

- PA-06

PA-06 continued to have signal wire issues and was rechecked and repaired on 4 November 2023.

3.2 HORIZONTAL AND VERTICAL GRADIENTS AT GRADIENT CONTROL POINTS

As described above, GCC locations collect high-resolution groundwater elevation data using transducers. Transducer data are filtered to remove anomalous data from monitoring points due to potential equipment failures, such as transducer malfunctions, power outages, or updates to the GWET programmable logic controller (PLC) system, which controls and houses all the operational data. These specific issues and time periods are summarized in Table A-1 in Attachment A. The following flags are applied to filter anomalous data:

- Groundwater elevations had a change greater than 1.5 feet within 1 hour
- Groundwater elevation measurements that were found to be greater than 50 feet, or less than 1 foot
- Calculated groundwater elevation slope indicates no change between consecutive measurements indicating a transducer malfunction
- Manually flagging data that are inconsistent with the typical nature of the well
- Periods where transducer power supply was deactivated for work on interconnected electrical systems

After November 2023 flagged data were removed, the Serfes (1991) method was used to account for tidal variations as described in the PMP. Using Serfes corrected data, both horizontal and vertical gradients were calculated and plotted over time (Attachment B). Groundwater elevations, horizontal gradients, and vertical gradients from 15 November 2023 are shown below at each GCC (Table 1-1 and Table 1-2).

TABLE 1-1 NOVEMBER HORIZONTAL GRADIENTS

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
GCC1	Shallow	PA-03	26.23	PA-04	26.42	-0.002
	Intermediate	PA-17iR	11.14	PA-10i	11.61	-0.005
	Deep	PA-27d	10.34	PA-18d	9.92	0.003
GCC2	Shallow	MWA-2	8.98	PA-05^M	5.63	0.049
	Intermediate	MWA-8i	9.62	PA-11i^M	7.86	0.024
	Deep	PA-19d	9.42	PA-30d	8.75	0.013
GCC3	Shallow	MWA-69	8.41	PA-06	8.05	0.003
	Intermediate	MWA-66i	8.59	PA-12i	8.38	0.002
	Deep	PA-21d	9.26	PA-20d	8.23	0.008

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
GCC4	Shallow	MWA-19	9.32	PA-28	12.12	-0.028
	Intermediate	MWA-34i	9.10	PA-13i	10.21	-0.012
	Deep	MWA-58d	8.91	PA-22d	9.90	-0.011
GCC5	Shallow	MWA-47	9.38	PA-07	12.21	-0.027
	Intermediate	PA-29i	9.86	PA-14i	10.28	-0.008
	Deep	PA-24d	9.13	PA-23d	10.18	-0.020
GCC6	Shallow	PA-09	11.50	PA-08	*	**
	Intermediate	PA-16i	10.49	PA-15i	10.02	0.009
	Deep	PA-26d	11.45	PA-25d	11.64	-0.003

Notes:
Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.
Horizontal gradient calculated as (Exterior Elevation – Interior Elevation) / Horizontal distance.
* = anomalous groundwater elevation; ** = horizontal gradient cannot be calculated due to anomalous elevation reading; ft NAVD88 = feet North American Vertical Datum of 1988;
M = manual groundwater elevation measurement

TABLE 1-2 NOVEMBER VERTICAL GRADIENTS

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
Interior	SZ-IZ	GCC1	PA-04	26.42	PA-10i	11.61	1.50
		GCC2	PA-05[M]	5.63	PA-11i[M]	7.86	-0.20
		GCC3	PA-06	8.05	PA-12i	8.38	-0.03
		GCC4	PA-28	12.12	PA-13i	10.21	0.30
		GCC5	PA-07	12.21	PA-14i	10.28	0.20
		GCC6	PA-08	*	PA-15i	10.02	**
	IZ-DZ	GCC1	PA-10i	11.61	PA-18d	9.92	0.22
		GCC2	PA-11i[M]	7.86	PA-30d	8.75	-0.13
		GCC3	PA-12i	8.38	PA-20d	8.23	0.01
		GCC4	PA-13i	10.21	PA-22d	9.90	0.02
		GCC5	PA-14i	10.28	PA-23d	10.18	0.00
		GCC6	PA-15i	10.02	PA-25d	11.64	-0.04

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
Exterior	SZ-IZ	GCC1	PA-03	26.23	PA-17iR	11.14	0.96
		GCC2	MWA-2	8.98	MWA-8i	9.62	-0.04
		GCC3	MWA-69	8.41	MWA-66i	8.59	-0.01
		GCC4	MWA-19	9.32	MWA-34i	9.10	0.03
		GCC5	MWA-47	9.38	PA-29i	9.86	-0.04
		GCC6	PA-09	11.50	PA-16i	10.49	0.07
	IZ-DZ	GCC1	PA-17iR	11.14	PA-27d	10.34	0.12
		GCC2	MWA-8i	9.62	PA-19d	9.42	0.12
		GCC3	MWA-66i	8.59	PA-21d	9.26	-0.05
		GCC4	MWA-34i	9.10	MWA-58d	8.91	0.01
		GCC5	PA-29i	9.86	PA-24d	9.13	0.02
		GCC6	PA-16i	10.49	PA-26d	11.45	-0.03

Notes:
Positive vertical gradient indicates a downward hydraulic gradient.
Vertical gradient calculated as (Upper Elevation – Lower Elevation) / Screen Midpoint distance.
* = anomalous groundwater elevation; ** = vertical gradient cannot be calculated due to anomalous elevation reading; DZ = Deep Zone; ft NAVD88 = feet North American Vertical Datum of 1988; IZ = Intermediate Zone; M = manual groundwater elevation measurement; SZ = Shallow Zone

3.3 POTENTIOMETRIC SURFACE, GROUNDWATER ELEVATION DIFFERENCE MAPS, AND GROUNDWATER FLOW DIRECTIONS

As described in the PMP, potentiometric surface maps are used to evaluate flow paths. Vertical gradients are also used as an additional line of evidence to evaluate hydraulic containment. Groundwater elevation data collected on 15 November 2023 were used to prepare potentiometric surface maps based on manual measurements and averaged transducer groundwater elevations (Figures 2 through 4) and vertical difference maps (Figures 5 and 6).

The generalized flow direction indicated by the potentiometric surface maps shows overall groundwater flow from upgradient toward the GWBW. Potentiometric maps (Figures 2, 3, and 4) indicate localized groundwater movement to the extraction trenches due to GW SCM pumping, and cones of depression are apparent around each groundwater extraction trench. Inward gradient was observed in the Shallow Zone at GCC2 and GCC3 in November 2023. As shown in Attachment B-2, Shallow Zone horizontal gradient trends over time are trending toward inward at all GCCs except GCC6.

In November 2023, horizontal gradients in the Intermediate Zone were inward at GCC2, GCC3, and GCC6. Intermediate Zone horizontal gradient trends over time (see Attachment B-2) show horizontal gradients trending toward inward gradients at all GCCs except GCC4. The horizontal gradients in the Deep Zone were inward at GCC1, GCC2, and GCC3.

River elevations are shown over time on Figure 1-1 and 1-2 below, and also for the month corresponding with this MPR on the potentiometric surface maps in an inset (Figures 2 through 4) and depict stage movement within the month. The river elevation in November 2023 varied with an average of 8.65 feet NAVD88 with a minimum elevation of 6.12 feet NAVD88 and a maximum elevation of 11.58 feet NAVD88, a lower maximum than in November 2022 (12.19 feet NAVD88). Historically, the river elevation is at its highest in May and decreases until its lowest in October, making it more challenging during late summer and fall months to achieve inward gradients. As the wet season continues, the river is expected to rise, increasing the elevation of groundwater downgradient of the GWBW. Depending on how much groundwater elevations upgradient of the GWBW rise with exterior groundwater elevations, there may be increasing trends toward inward horizontal gradients at all GCCs throughout the wet season.

The river level has begun rising since a low in October 2023, and horizontal gradients are continuing to improve. Additionally, as can be seen in Figures 1-1 and 1-2 below, the difference between the river level elevation and shallow and intermediate groundwater averages has been steadily decreasing. The difference between average shallow groundwater elevations and river level elevation were 7.05 ft and 1.85 ft in November 2022 and November 2023, respectively. A potentiometric separation is still noticeable exterior to the GWBW, indicating that it is functioning by impeding groundwater flow.

Vertical gradients were calculated for each vertical well pair and are plotted on Figures 5 and 6. Vertical groundwater gradients interior to the GWBW between the Shallow and Intermediate Zones were mixed, with GCC2 and GCC3 being upward and the remaining downward (Figure 5). The vertical groundwater gradient at GCC6 interior of the wall was unable to be calculated due to an anomalous groundwater elevation reading at PA-08. PA-08 will be recalibrated so that vertical gradients at GCC6 can be calculated in the future and presented in subsequent MPRs. Vertical groundwater gradients are also depicted in Attachment B-3. The magnitude of the gradient is much greater at GCC1 than other monitoring locations due to the influence from a localized high-pressure zone near GCC1 where vertical groundwater flow is impeded by a localized confining unit (Figure 2). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were mixed with GCC2, GCC3, and GCC5 being upward and GCC1, GCC4, and GCC6 being downward as shown on Figure 5 and in Attachment B-2.

Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were mixed with GCC2 and GCC6 being upward and the remaining downward. The direction of vertical gradients exterior to the GWBW were mixed with GCC3 and GCC6 being upward and the remaining downward, as shown on Figure 6 and Attachment B.

3.3.1 GWET SYSTEM PERFORMANCE

The GWET system operated within permit conditions during the reporting period. There were three shutdowns:

- 14 November 2023: ERM, on behalf of LSS, shut down the GWET system due to maintenance on the solids handling system, discharge was restarted 2 hours later.
- 29 November 2023: ERM, on behalf of LSS, shut down the GWET system due to the Tank T-3 level sensor failing and for conveyance line and electrical maintenance. The ODEQ was notified of the shutdown, and discharge was restarted on 4 December.

There were no upgrades to the GWET system in the month of November 2023.

3.3.2 RECOVERY WELL AND EXTRACTION WELL PERFORMANCE

The average system influent flow rate was 34.88 gallons per minute (gpm) for the entire month of November 2023, including non-operational periods. The average influent flow during operational periods was 48.44 gpm. LSS is currently in the process of optimizing extraction rates within the system to increase flow rates at each operational well until either the extraction rates specified in the *Final Design Report* (ERM 2022) are achieved, the wells are producing the maximum quantity of water possible, or until the Capture Zone Objectives are met. In recent months, the pumping rates at historically productive wells have decreased due to lower groundwater elevations. Additionally, back pressure through the trunk line from the wellfield to the GWET plant appears to be a limiting factor in groundwater extraction. The backpressure is believed to be caused by fouling of the trunk line. LSS is currently evaluating options to reconfigure the trunk line to mitigate back pressure effects on pumping rates, as well as jetting of the shallow and intermediate trunk lines. Site-wide EW redevelopment is planned for Q1 2024.

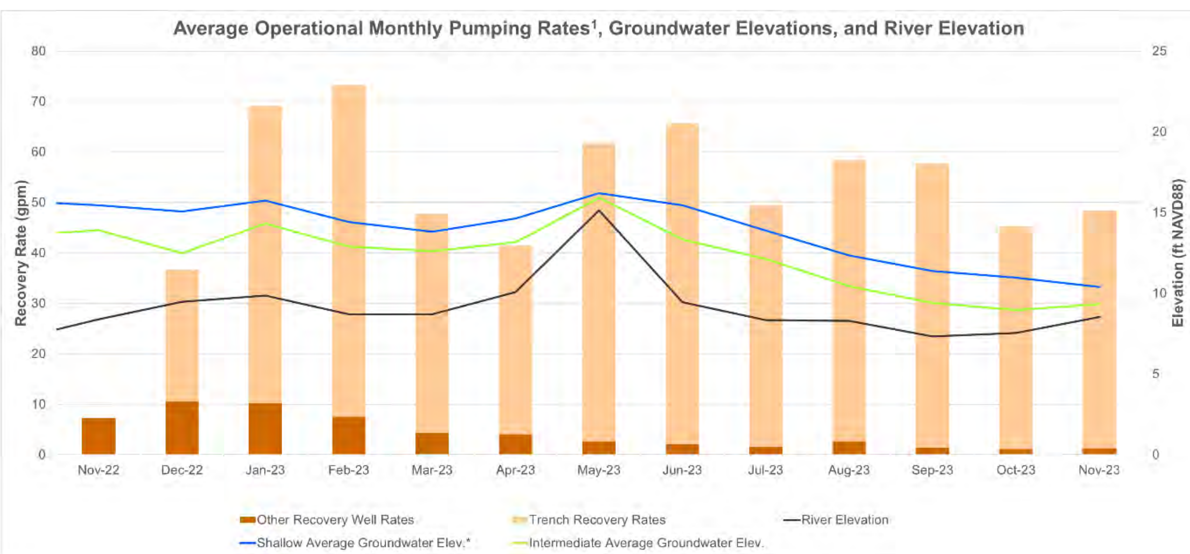
TABLE 1-3 RECOVERY WELL PUMPING RATES

Recovery Well	November 2023 Average Operational Pumping Rate (gpm)	November 2023 Average Monthly Pumping Rate (gpm)
RW-14	0.21	0.20
RW-22	0.09	0.09
RW-23*	0.00	0.00
RW-25	1.01	0.98

Recovery Well	November 2023 Average Operational Pumping Rate (gpm)	November 2023 Average Monthly Pumping Rate (gpm)
EW-01	0.95	0.19
EW-02	0.97	0.78
EW-03	5.85	5.65
EW-04	4.30	4.16
EW-05	12.71	8.90
EW-06	5.61	2.24
EW-07	1.45	0.44
EW-08	2.01	1.54
EW-09	1.56	1.04
EW-10	1.59	0.53
EW-11	1.28	1.24
EW-12	0.63	0.02
EW-13	4.53	3.32
EW-14	3.69	3.57
Total	48.44	34.88

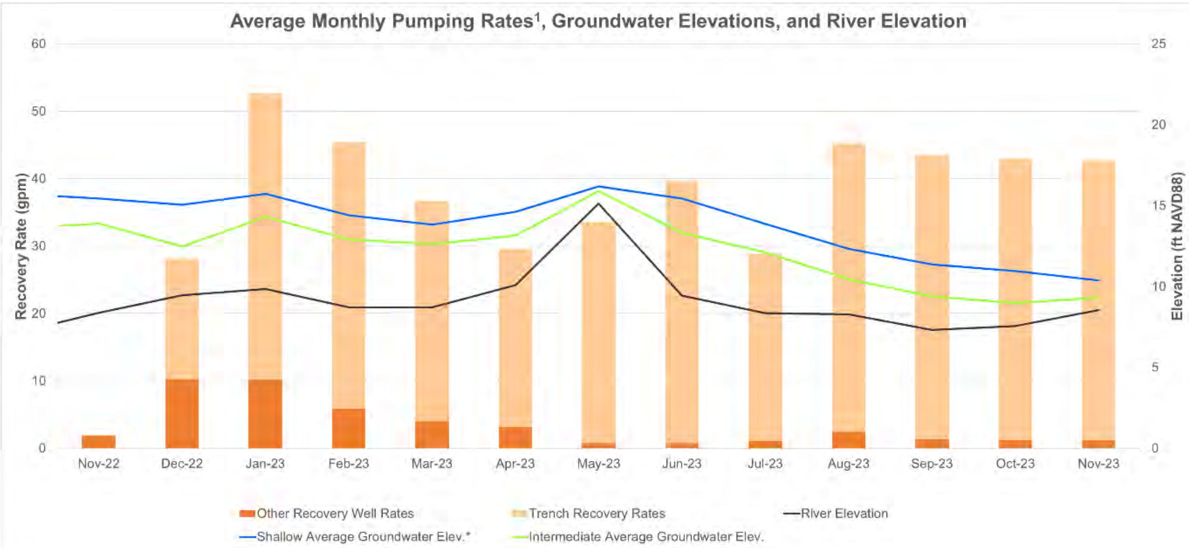
Notes:
* = Recovery well not in service during reporting period.
gpm = gallon per minute

FIGURE 1-1 OPERATIONAL MONTHLY PUMPING RATE



Notes:
[1] = Following installation of trenches in Summer 2022, RW-22, 23, and 25 recovery rates are now grouped together with the other remaining recovery well (RW-14) starting in November 2022.
* = The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the whole aquifer.
ft NAVD88 = feet North American Vertical Datum of 1988

FIGURE 1-2 AVERAGE MONTHLY PUMPING RATE



Notes:
[1] = Following installation of trenches in Summer 2022, RW-22, 23, and 25 recovery rates are now grouped together with the other remaining recovery well (RW-14) starting in November 2022.
* = The shallow average groundwater elevation is calculated without PA-04 due to its groundwater elevations being unrepresentative of the whole aquifer.
ft NAVD88 = feet North American Vertical Datum of 1988

3.3.3 RECOMMENDATIONS FOR EXTRACTION SYSTEM OPTIMIZATION

Recovery rates from the start of the system indicate that the active RWs and EWs are operating as designed except for the troubleshooting discussed above. The extraction rates throughout the GWET system will continue to be optimized to meet Target Capture Objectives.

4. ANALYTICAL PROGRAM

Quarterly groundwater monitoring was implemented in accordance with the ODEQ-approved Arkema Quarterly Groundwater Monitoring Work Plan dated October 2019 and the ODEQ-approved reduced scope described in the 2021 monitoring program modification request memorandum dated 9 September 2021. The table below outlines sampling dates and submittal dates related to groundwater monitoring since the implementation of the reduced scope. The Quarterly Monitoring Reports present results from these sampling events.

Report	Sampling Dates	Report Submittal Date
2021 Quarter 3	9/21/2021–9/24/2021	1/14/2022
2021 Quarter 4	12/13/2021–12/16/2021	4/20/2022
2022 Quarter 1	3/14/2022–3/17/2022	6/15/2022
2022 Quarter 2	6/6/2022–6/9/2022	9/12/2022
2022 Quarter 4	11/7/2022–11/10/2022	2/17/2023
2023 Quarter 1	3/6/2023–3/10/2023	6/12/2023
2023 Quarter 2	6/12/2023–6/16/2023	9/22/2023
2023 Quarter 3	8/21/2023–8/24/2023	12/1/2023
2023 Quarter 4	12/11/2023–12/14/2023	4/8/2023*

* Dates are tentative.

5. SUMMARY AND CONCLUSIONS

This report presents a summary of the GW SCM operation, maintenance, and monitoring activities conducted at the Site in November 2023 and documents results from system monitoring. The following summarizes ERM's observations and conclusions drawn from collected data.

5.1 GROUNDWATER FLOW

- Horizontal groundwater gradients provided in Attachment B-2 for the Shallow, Intermediate, and Deep Zones indicate that most GCCs are either inward, or trending toward inward. Additionally, groundwater elevations show a noticeable difference in elevation across the GWBW, indicating the GWBW is functioning via impeding groundwater flow.
- Vertical groundwater gradients interior of the GWBW between the Shallow and Intermediate Zones were mixed, with GCC2 and GCC3 being upward and the remaining downward (Figure 5). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were mixed with GCC2, GCC3, and GCC5 being upward and GCC1, GCC4, and GCC6 being downward.
- Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were mixed with GCC2 and GCC6 being upward and the remaining downward. The direction of vertical gradients exterior to the GWBW were mixed with GCC3 and GCC6 being upward and the remaining downward, as shown on Figure 6.
- The average river elevation in November 2023 was 8.65 feet NAVD88 with a minimum elevation of 6.12 feet NAVD88 and a maximum elevation of 11.58 feet NAVD88. The seasonal river level elevation trends indicate a seasonal high in May

and a seasonal low in October. As the river levels come up over the next few months, horizontal gradients across the wall are anticipated to improve.

5.2 GROUNDWATER EXTRACTION

Based on November 2023 extraction and relevant hydrograph analysis, the trenches are achieving increased groundwater extraction rates compared to the legacy system. Within the Site alluvial sequence, potentiometric maps indicate the GW SCM is producing localized areas of hydraulic capture throughout the Target Capture Zone. The analysis of horizontal gradients provided in Attachment B-2 suggests that gradients are either inward, or trending toward inward, at most GCCs in the Shallow, Intermediate and Deep Zones. More time at elevated extraction rates will be required to evaluate whether GWET objectives are being met system wide. As the wet season begins, the river is expected to rise, increasing the elevation of groundwater downgradient of the GWBW. Depending on how much groundwater elevations upgradient of the GWBW rise, there may be increasing trends toward inward horizontal gradients at all GCCs.

The groundwater extraction flow rate is currently limited by a combination of groundwater elevation, influence of back pressure in the trunk line, and fouling of the EWs within the trenches. Currently, water from Trench 7 is being re-routed via overland hoses to intermediate trunk lines to limit the influence on back pressure in the main trunk line on production rates. Plans to permanently connect three of the trenches to the intermediate trunk line, and line jetting of the shallow and intermediate trunks lines, are planned for Q4 2023, as well as redevelopment of the trenches in 2024.

5.3 RECOMMENDATIONS AND FUTURE WORK

ERM will continue to optimize new EWs, including pump maintenance/upgrades, redevelopment of the wells, and potential trunk line configuration. Any additional modifications to the system to meet capture objectives will be included in subsequent MPRs. The project schedule provided as Attachment C summarizes activities planned for the immediate future.

Regards,

REGISTERED PROFESSIONAL ENGINEER
78496PE
OREGON
DECEMBER 31, 2007
BRENDAN ANDREW ROBINSON
EXP. 12/31/2024

Brendan Robinson, PE
Partner

6. References

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FIGURES

FIGURE 1: SITE LAYOUT

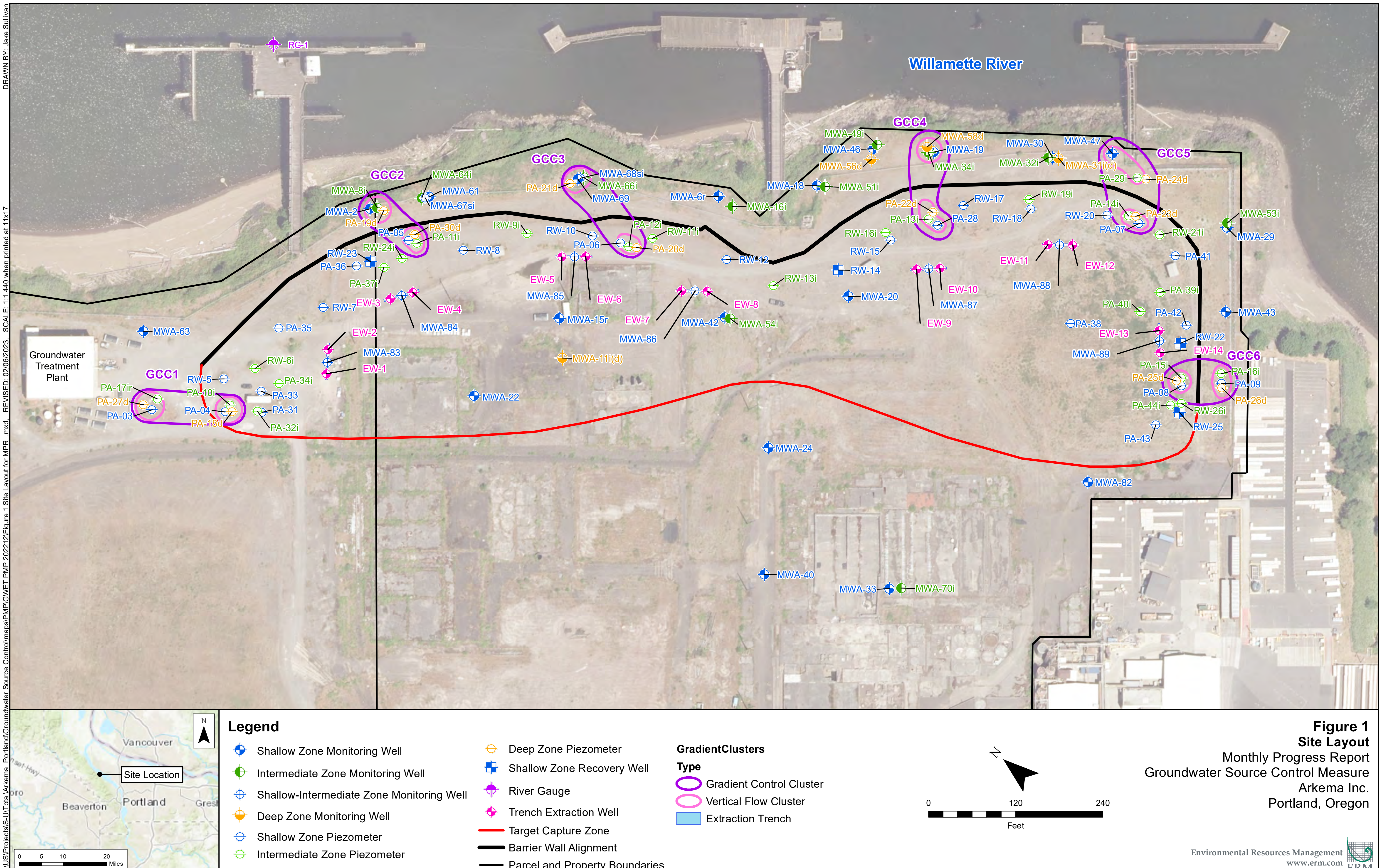
FIGURE 2: NOVEMBER 2023 SHALLOW ZONE GROUNDWATER CONTOURS

FIGURE 3: NOVEMBER 2023 INTERMEDIATE ZONE GROUNDWATER CONTOURS

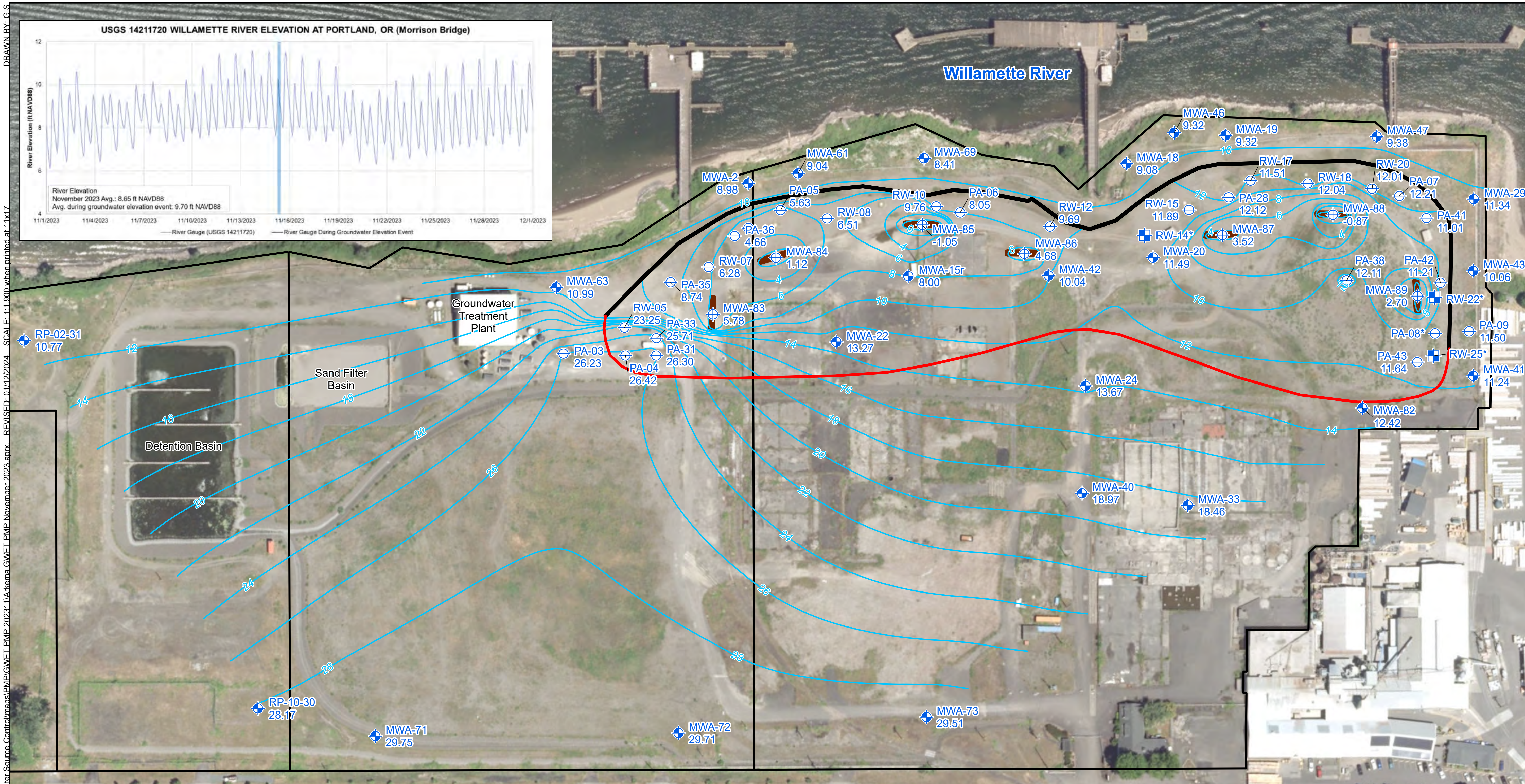
FIGURE 4: NOVEMBER 2023 DEEP ZONE GROUNDWATER CONTOURS

FIGURE 5: NOVEMBER 2023 SHALLOW TO INTERMEDIATE ZONE VERTICAL HEAD DIFFERENCE

FIGURE 6: NOVEMBER 2023 INTERMEDIATE TO DEEP ZONE VERTICAL HEAD DIFFERENCE



Source: City of Portland Aerial Imagery, flown Summer 2021; NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Shallow Zone Piezometer
- Shallow Zone Monitoring Well
- Active Recovery Well; Not Used During Contouring
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Shallow Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
MWA-86: Well is dry. Bottom of well elevation used for contouring.
Water levels collected November 15, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

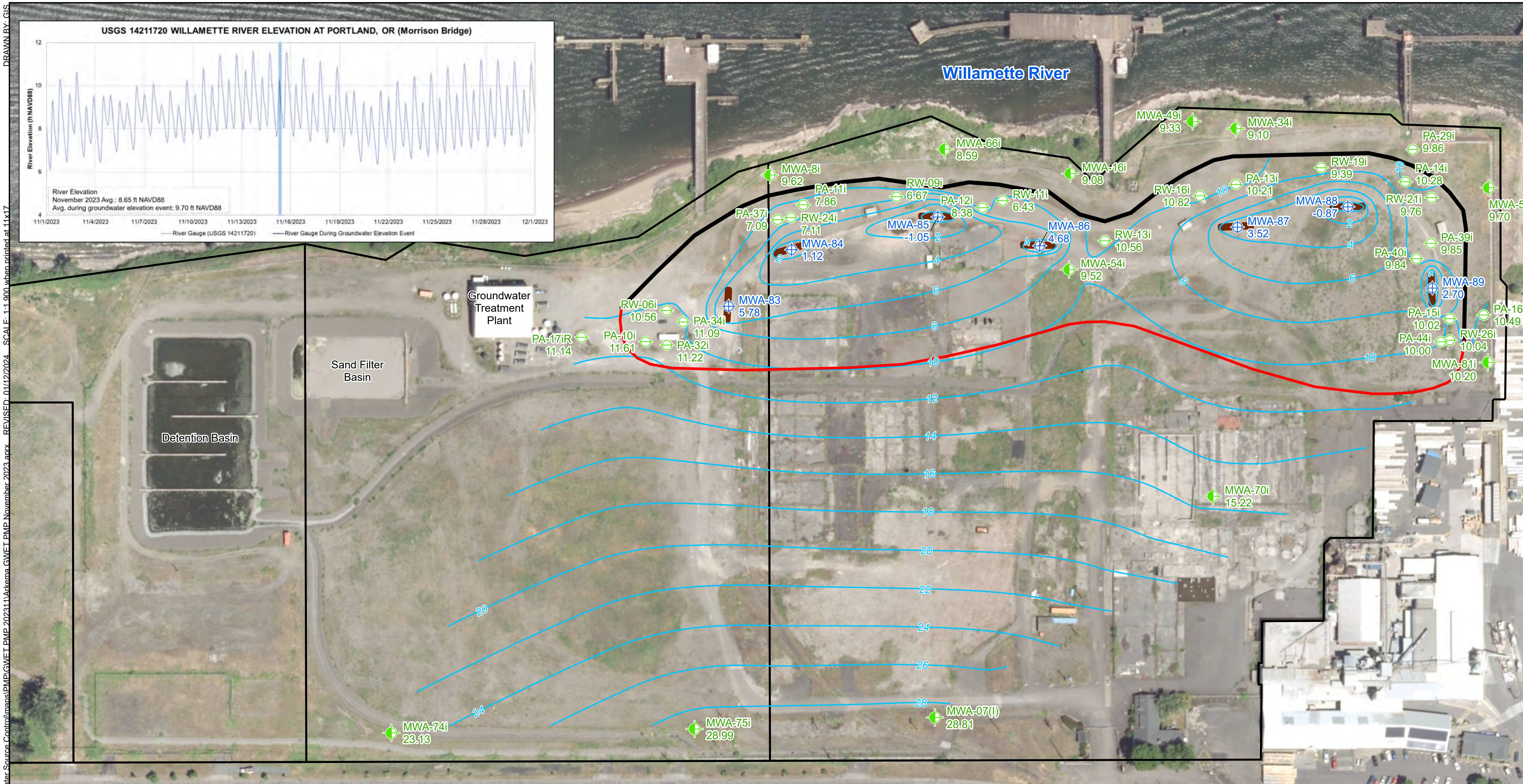
N

0 160 320
Feet

Figure 2
November 2023 Shallow Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Intermediate Zone Piezometer
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Intermediate Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
MWA-86: Well is dry. Bottom of well elevation used for contouring.
Water levels collected November 15, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

0 160 320
Feet

Figure 3
November 2023 Intermediate Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

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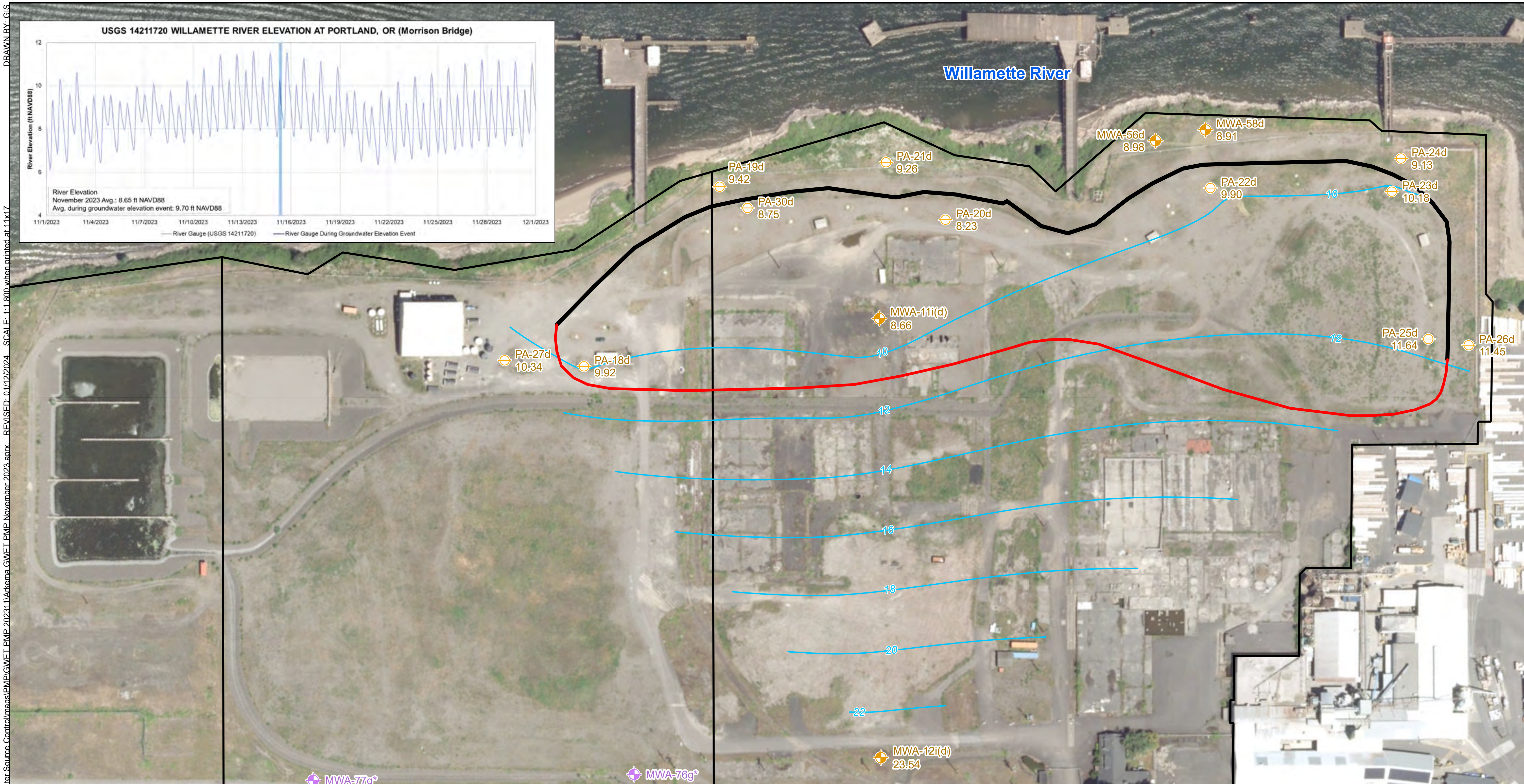

Legend

- Deep Zone Piezometer
- Deep Zone Monitoring Well
- Gravel Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Deep Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment

Notes:
* Value not used for contouring.
Gravel zone wells not used in contouring.
Water levels collected November 15, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 150 300
Feet

Figure 4
November 2023 Deep Zone Groundwater Contours
Monthly Performance Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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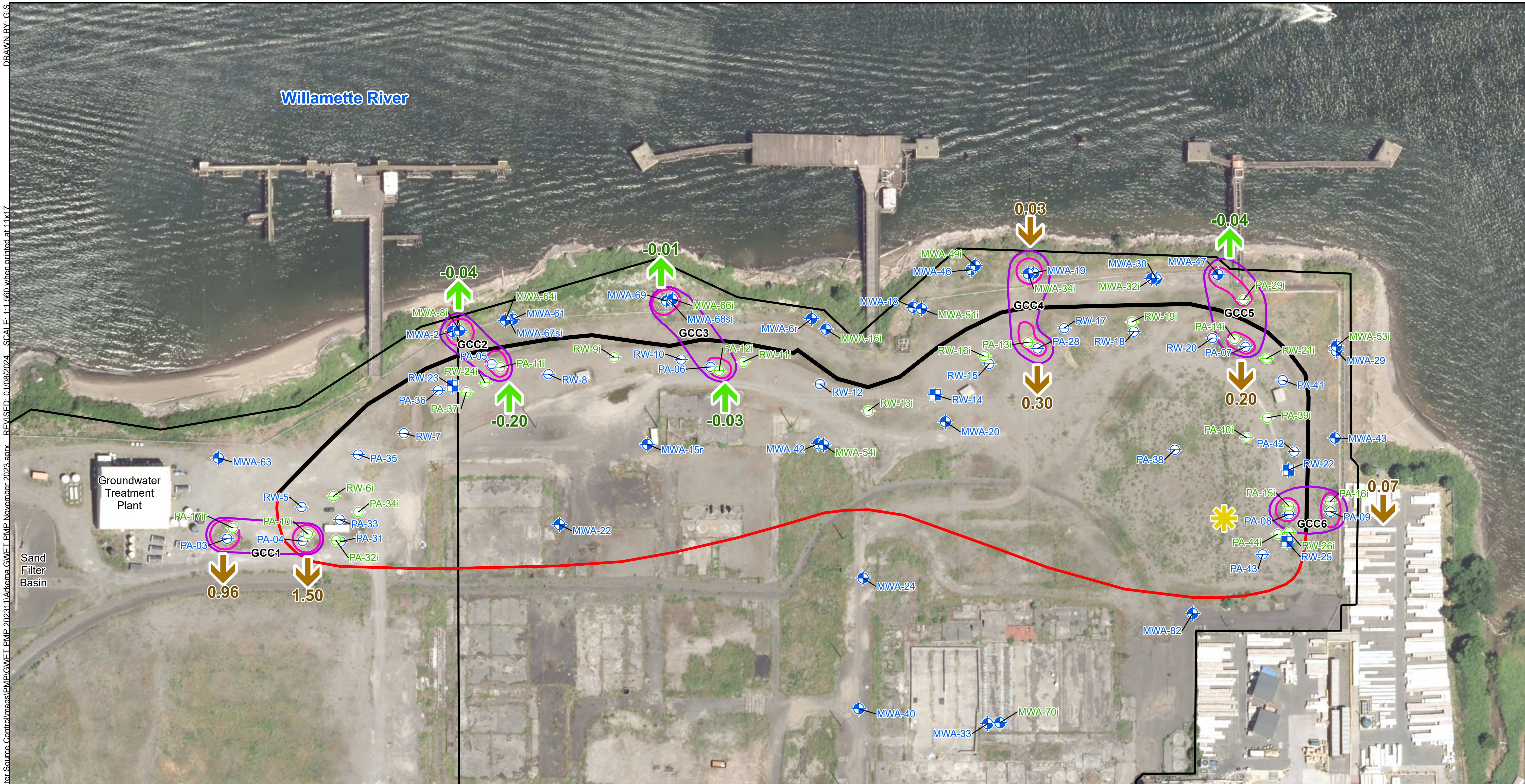
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Shallow Zone Recovery Well
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Vertical Gradient not calculated due to anomalous groundwater elevation reading
- Downward Flow
- Upward Flow

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as shallow zone minus intermediate zone potentiometric surfaces.
Water levels collected November 15, 2023.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 5
November 2023 Shallow to Intermediate Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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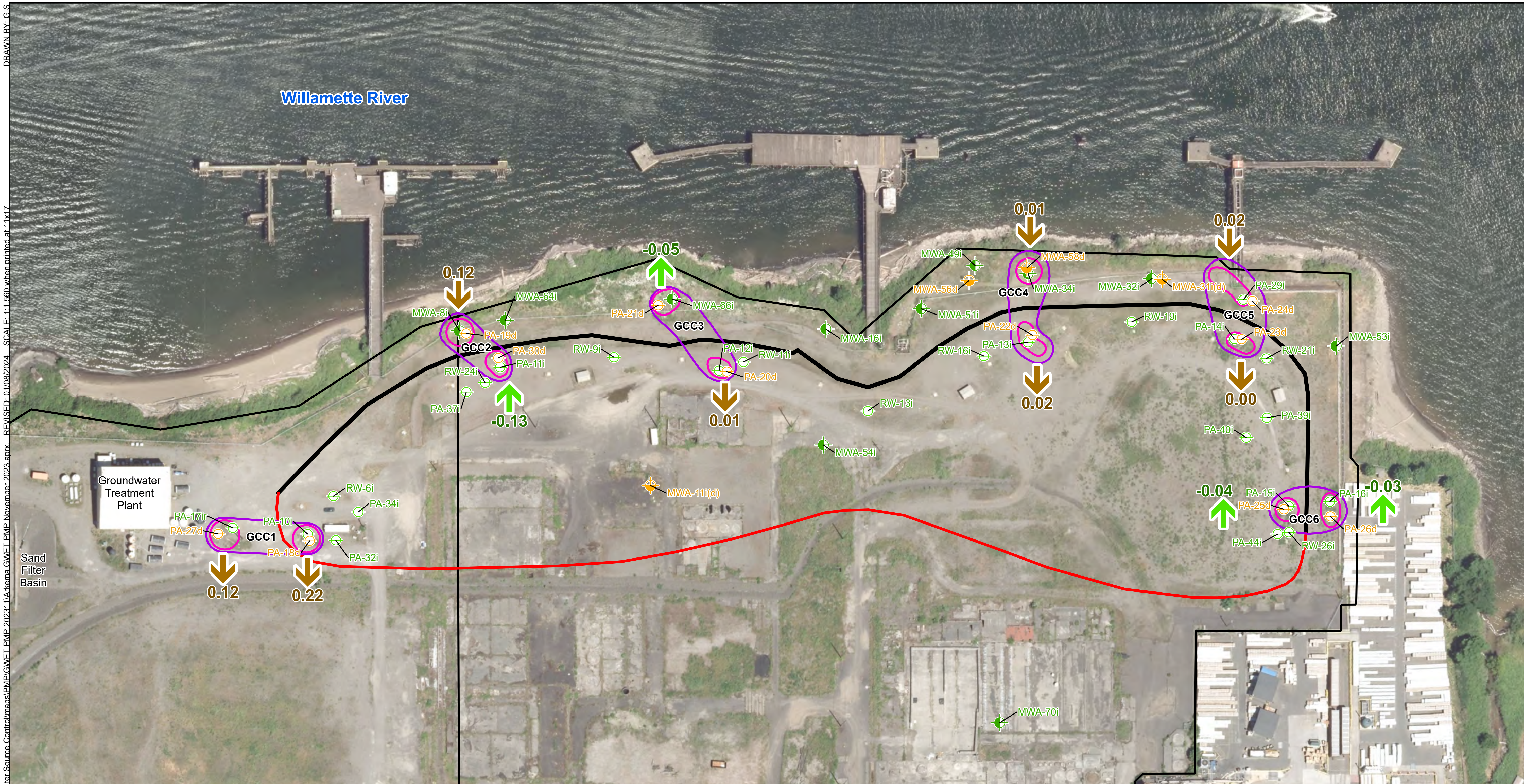
M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 2023\11\Arkema GWET PMP November 2023.aprx REVISED: 01/08/2024 SCALE: 1:1,550 when printed at 11x17 DRAWN BY: GIS

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as intermediate zone minus deep zone potentiometric surfaces.
Water levels collected November 15, 2023.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 6
November 2023 Intermediate to Deep Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 202311\Arkema GWET PMP November 2023.aprx REVISED: 01/08/2024 SCALE: 1:1,560 when printed at 11x17 DRAWN BY: GIS

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

ERM

ATTACHMENT A-1 TRANSDUCER FLAGS

Attachment A-1. Transducer Flags

Table A-1
Transducer Malfunction Log: November 2023
Arkema Inc. Facility
Portland, Oregon

Gradient Cluster	Transducer	Interval	Date Range		Issue and Repairs Performed
GCC2	PA-11i	Intermediate	9/1/2023	Present	Transducer faulted, new transducer ordered.
GCC3	PA-06	Shallow	9/21/2023	11/4/2023	Animal chewed through signal cable, cable repaired, and signal checked.

ERM

ATTACHMENT A-2 RECOVERY WELL STATUS

Attachment A-2. Recovery Well Status

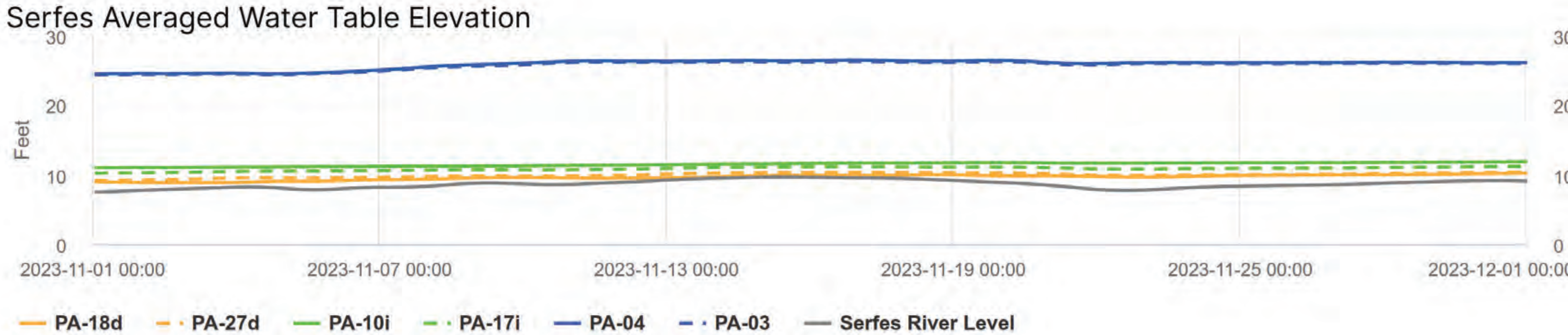
Table A-2
Recovery Well Status: November 2023
Arkema Inc. Facility
Portland, Oregon

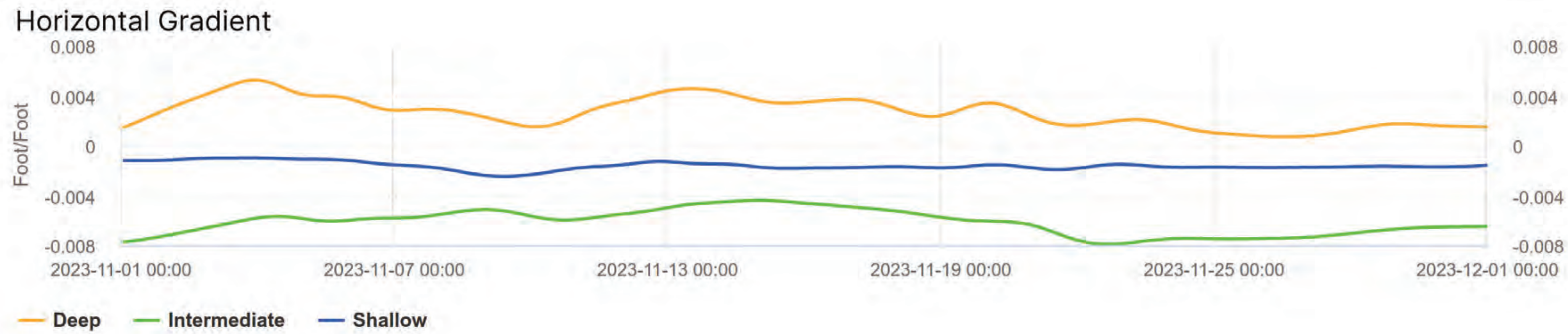
Recovery Well ID	Status as of 11/30/2023 (active or inactive)	Issue	Actions to get online	Expected date back online	Transducer Status	Totalizer Status	Average Operational Flow Rate (gpm)	Overall Extraction Rate	Notes
RW-14	Active	None	N/A	N/A	Good	Good	0.21	P	
RW-22	Active	None	N/A	N/A	Good	Good	0.09	P	
RW-23	Inactive	None	N/A	N/A	Good	Good	0.00	OFF*	Off due to low water levels
RW-25	Active	None	N/A	N/A	Good	Good	1.01	M	
EW-01	Active	None	N/A	N/A	Good	Good	0.95	P	
EW-02	Active	None	N/A	N/A	Good	Good	0.97	P	
EW-03	Active	None	N/A	N/A	Good	Good	5.85	G	
EW-04	Active	None	N/A	N/A	Good	Good	4.30	G	
EW-05	Active	None	N/A	N/A	Good	Good	12.71	G	
EW-06	Active	None	N/A	N/A	Good	Good	5.61	G	
EW-07	Active	None	N/A	N/A	Good	Good	1.45	M	
EW-08	Active	None	N/A	N/A	Good	Good	2.01	M	
EW-09	Active	None	N/A	N/A	Good	Good	1.56	M	
EW-10	Active	None	N/A	N/A	Good	Good	1.59	M	
EW-11	Active	None	N/A	N/A	Good	Good	1.28	M	
EW-12	Active	None	N/A	N/A	Good	Good	0.63	P	
EW-13	Active	None	N/A	N/A	Good	Good	4.53	G	
EW-14	Active	None	N/A	N/A	Good	Good	3.69	G	

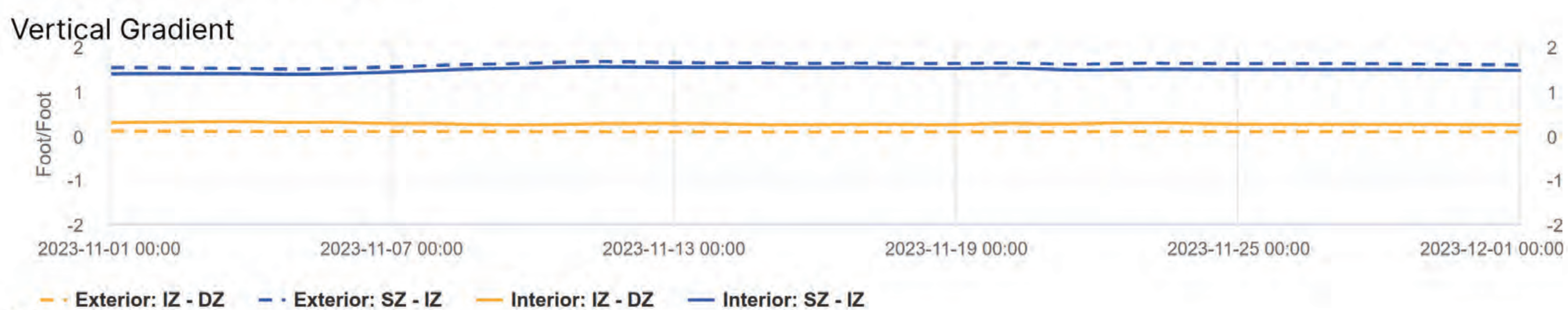
Notes:
* Recovery wells not in service
G = good pumping, greater than 3.0 gpm
gpm = gallons per minute
M = moderate pumping, greater than 1.0 gpm and less than 3.0
P = poor pumping, less than 1.0 gpm

ATTACHMENT B-1 GRADIENT HYDROGRAPHS

Gradient Control Cluster 1



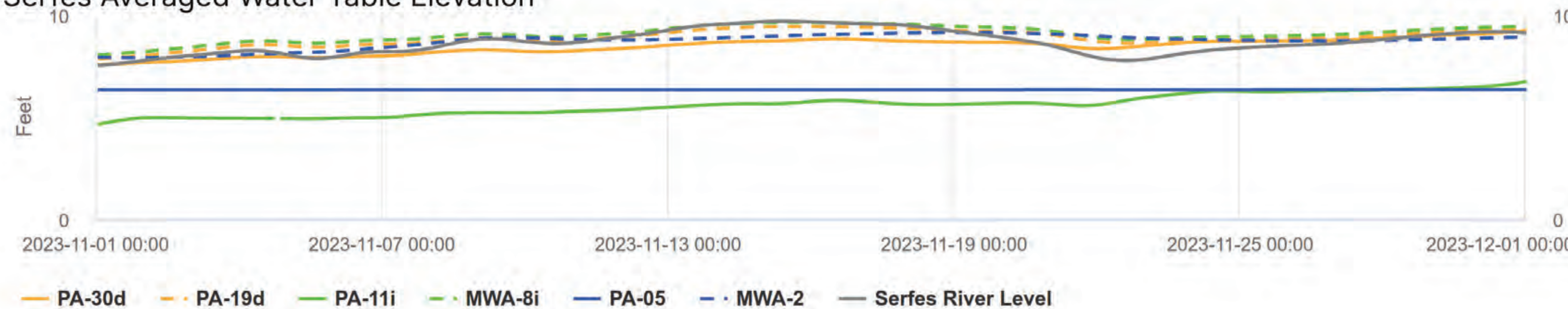




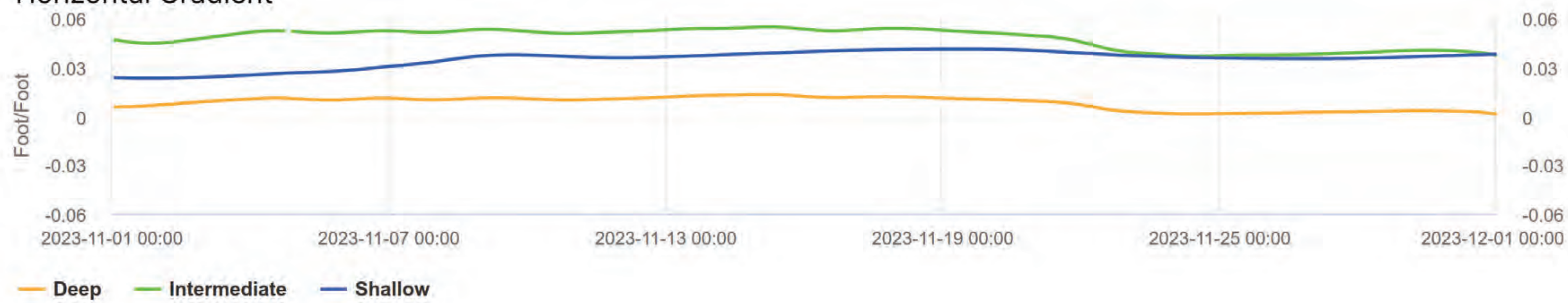
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 2

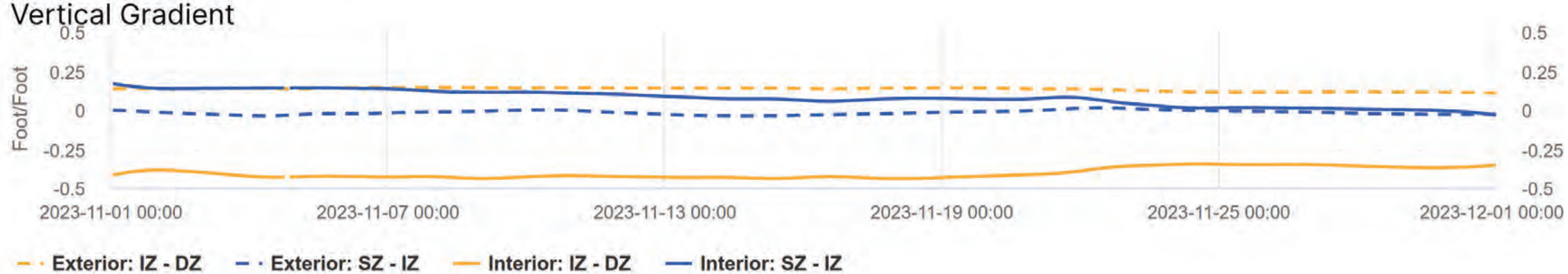
Serfes Averaged Water Table Elevation



Horizontal Gradient



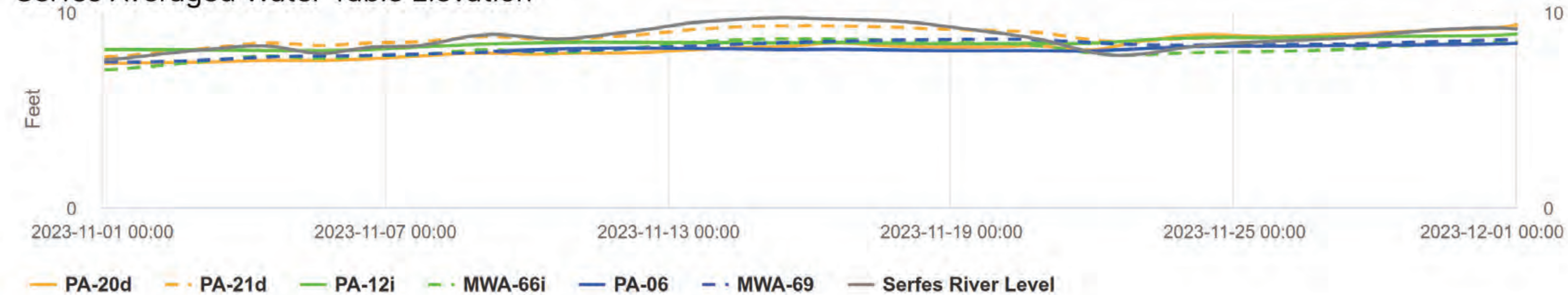
Vertical Gradient



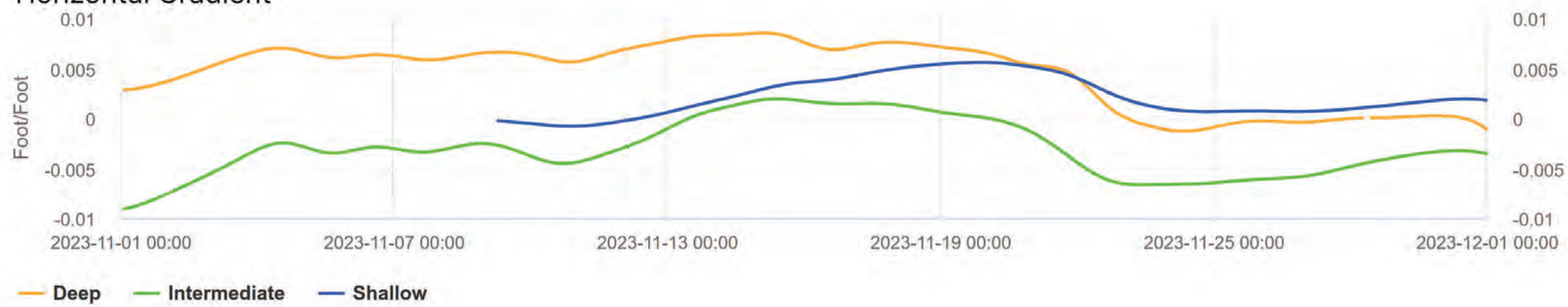
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 3

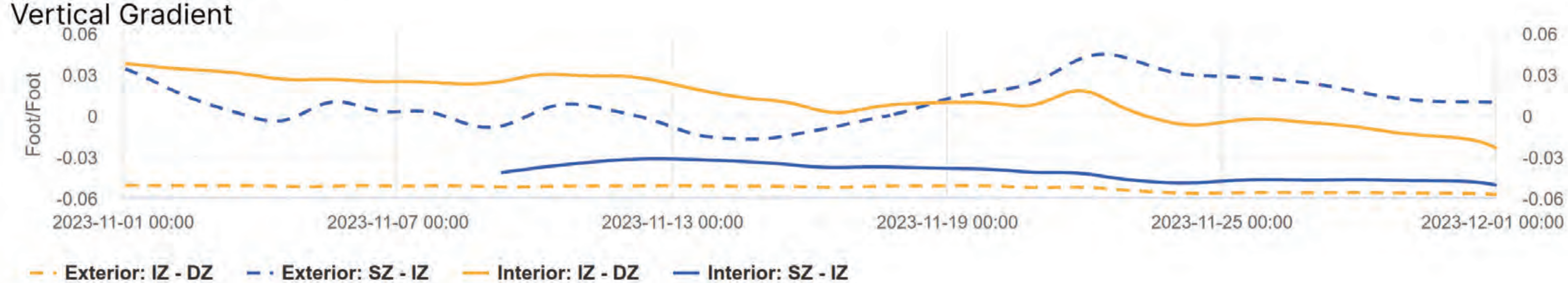
Serfes Averaged Water Table Elevation



Horizontal Gradient



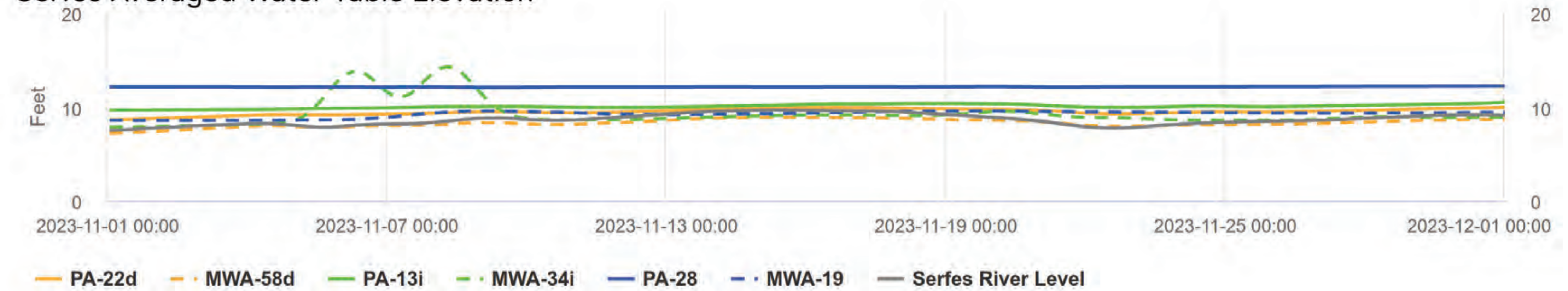
Vertical Gradient



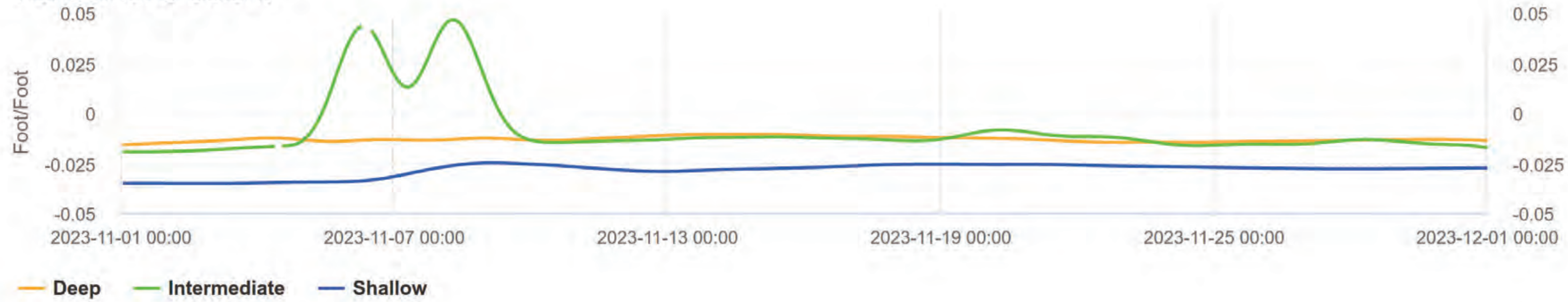
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 4

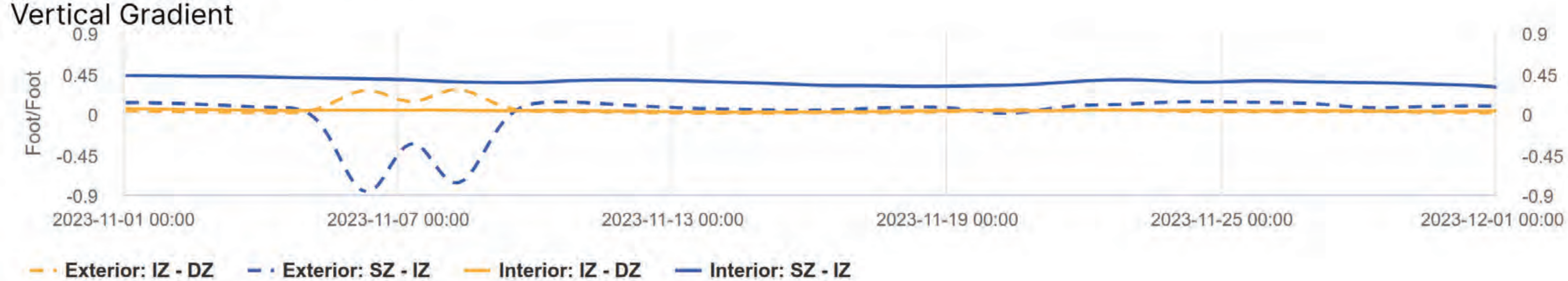
Serfes Averaged Water Table Elevation



Horizontal Gradient



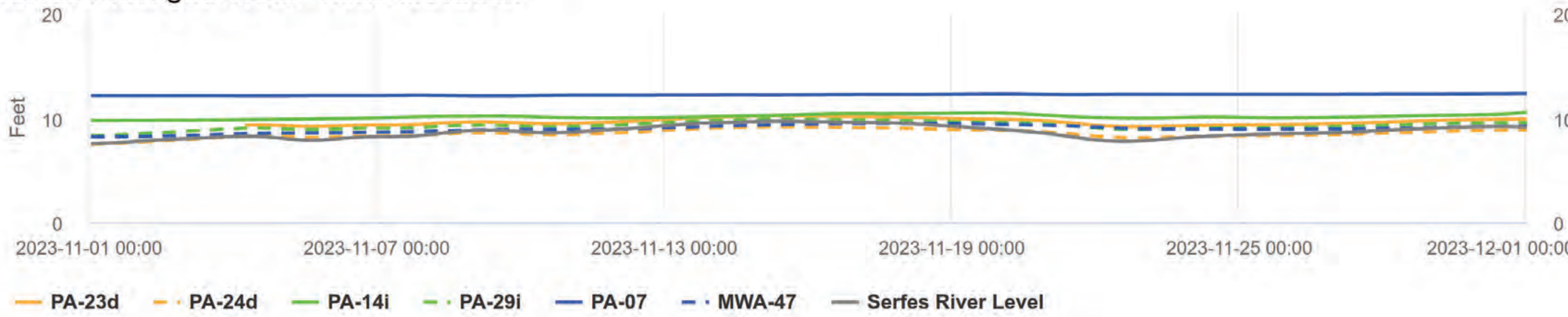
Vertical Gradient



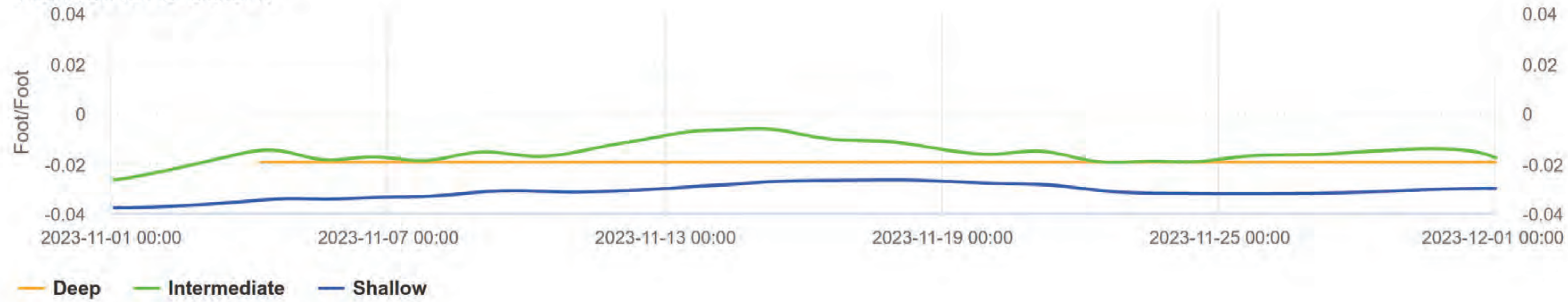
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 5

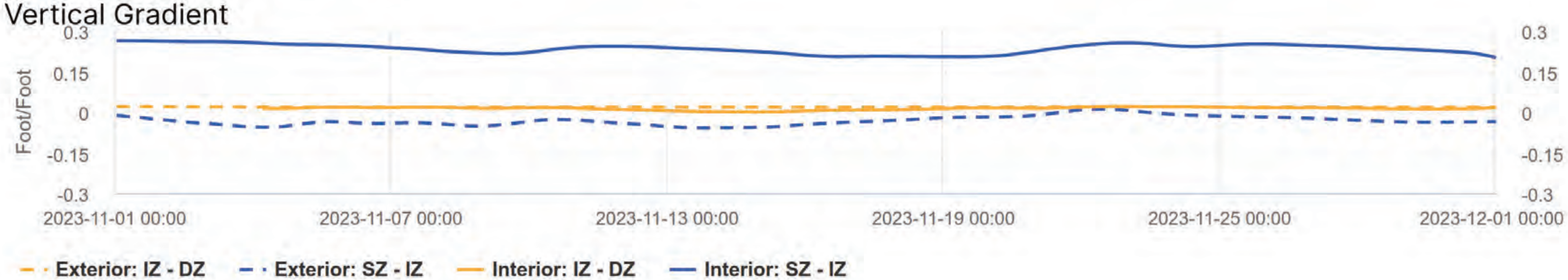
Serfes Averaged Water Table Elevation



Horizontal Gradient



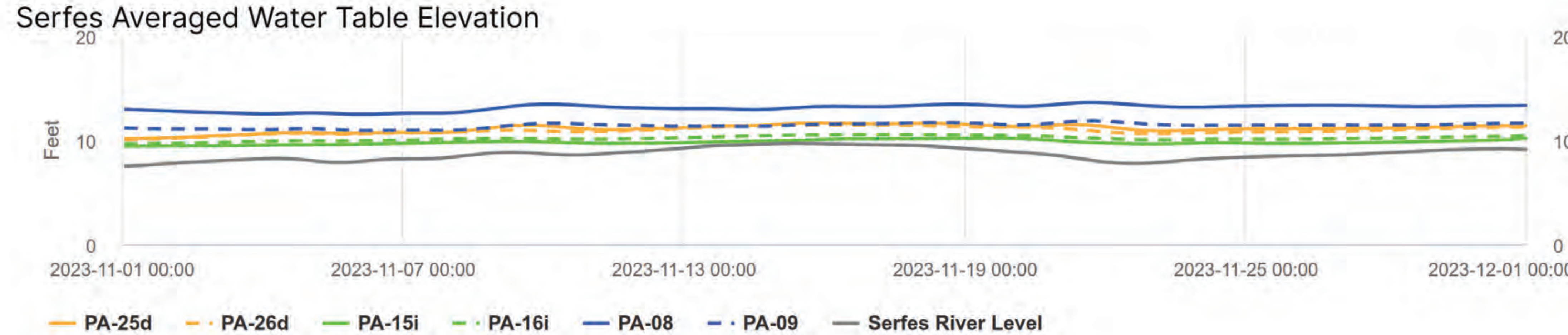
Vertical Gradient

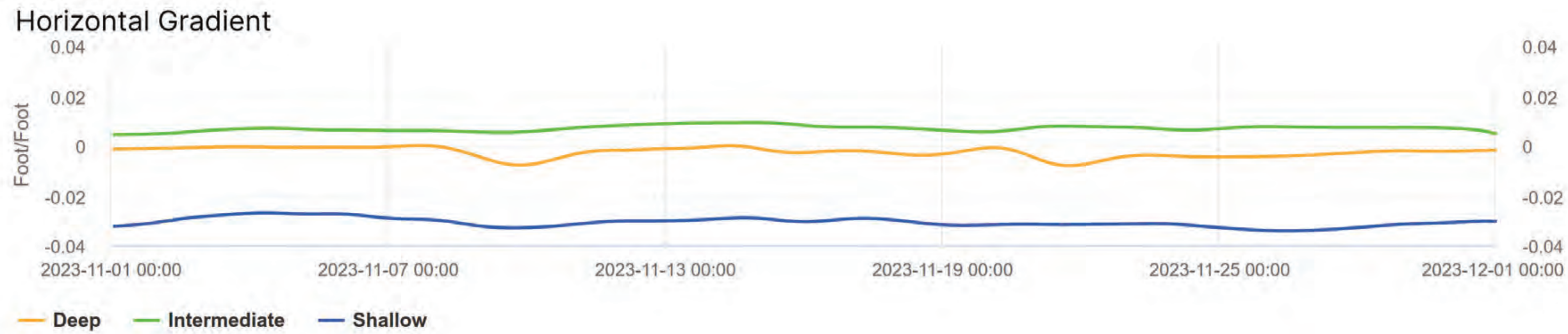


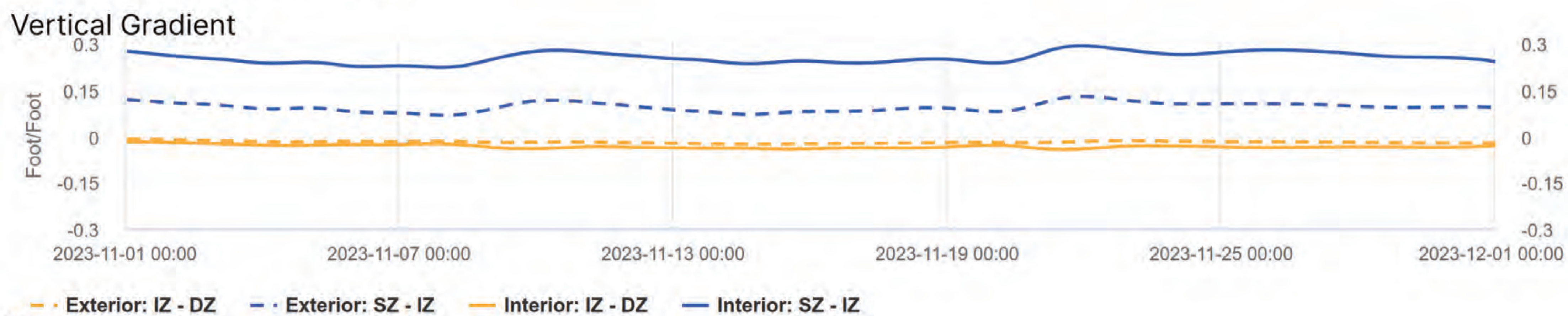
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW

SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 6





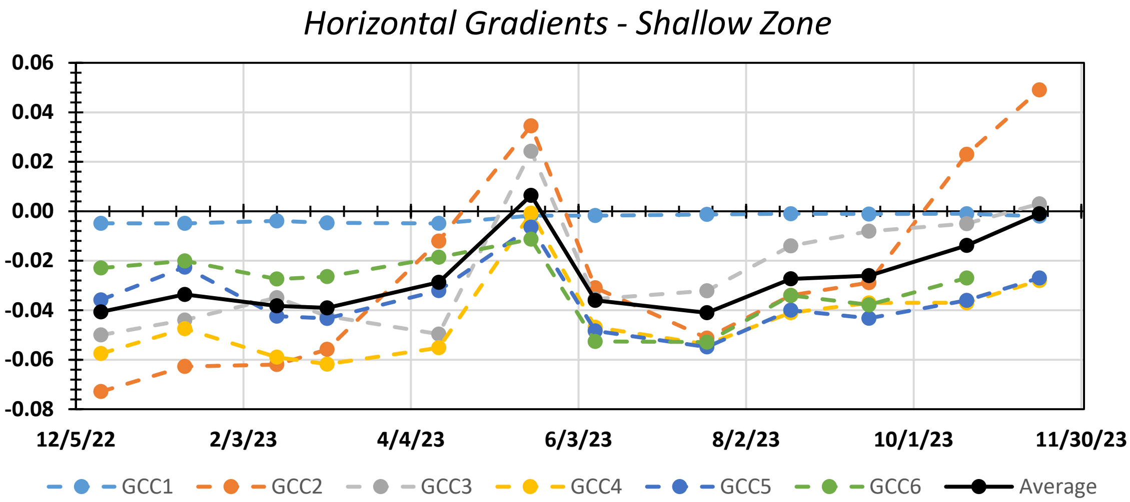


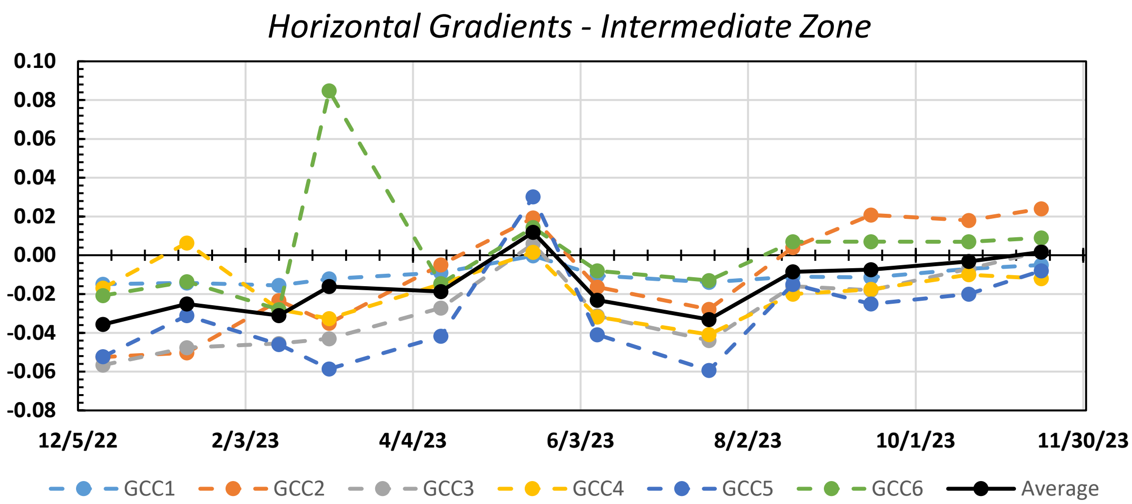
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

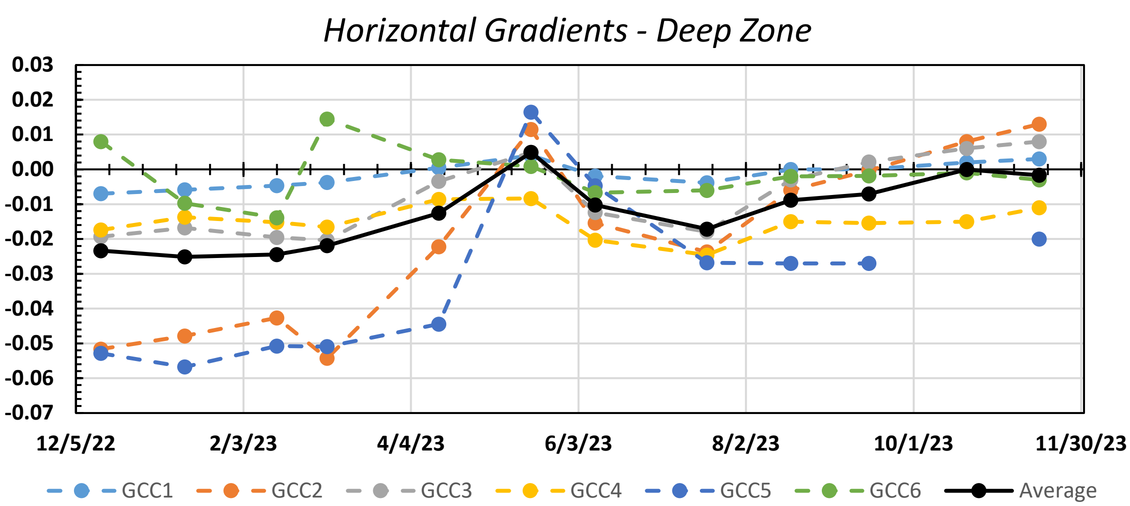
ATTACHMENT B-2 HORIZONTAL GRADIENTS

Attachment B-2

Horizontal Gradients Summary: November 2023
Arkema Inc. Facility
Portland, Oregon







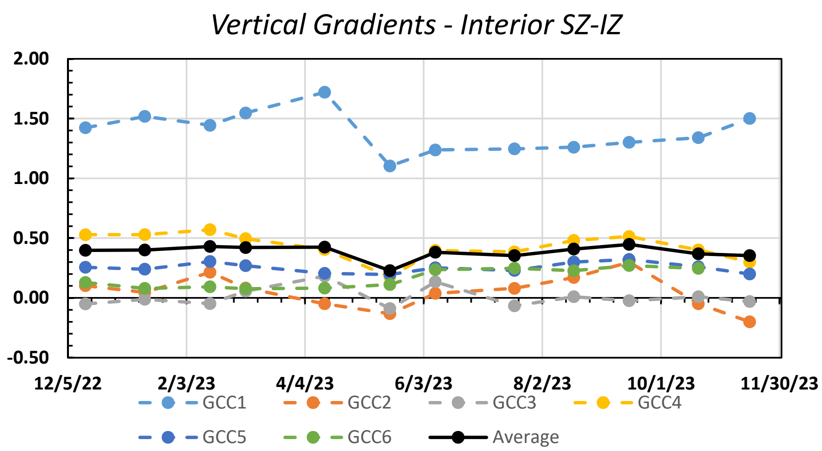
Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.

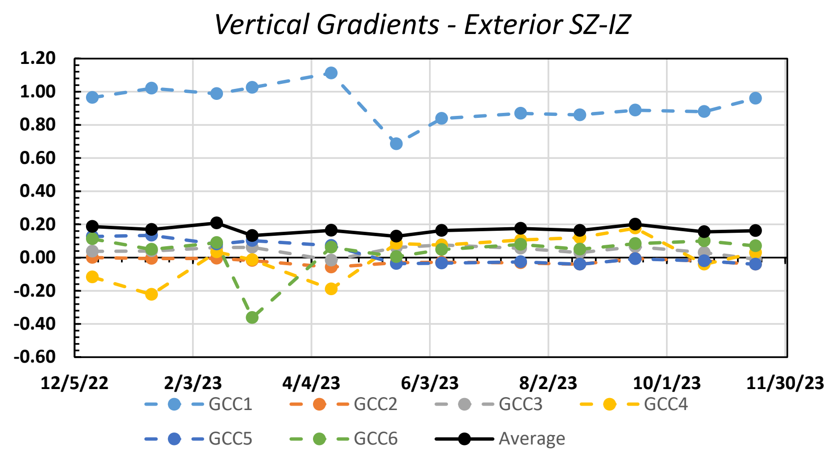
ERM

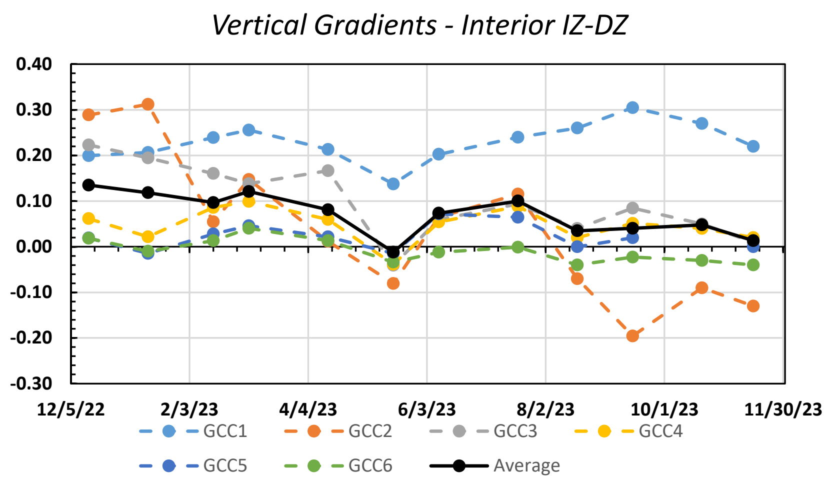
ATTACHMENT B-3 VERTICAL GRADIENTS

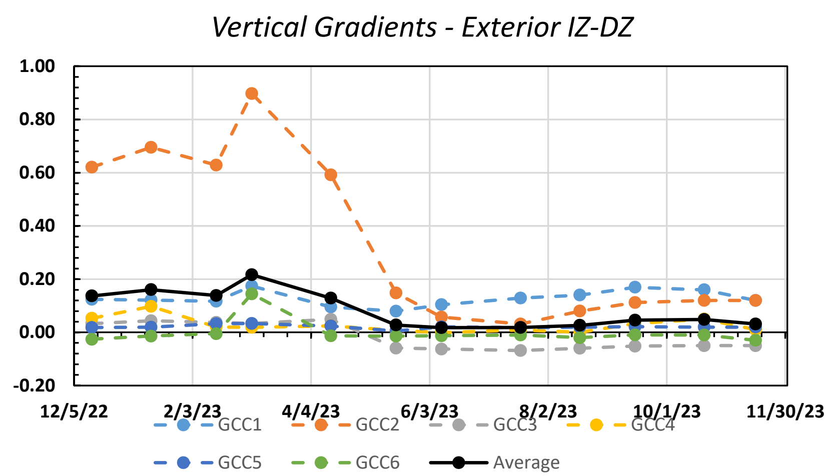
Attachment B-3

Vertical Gradients Summary: November 2023
Arkema Inc. Facility
Portland, Oregon









ATTACHMENT C PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**Quarterly GW Monitoring**	**654 days**	**Mon 9/20/21**	**Mon 3/18/24**
2	*3rd Quarter 2021 Groundwater Monitoring*	*85 days*	*Mon 9/20/21*	*Fri 1/14/22*
7	*4th Quarter 2021 Groundwater Monitoring*	*70 days*	*Mon 1/10/22*	*Fri 4/15/22*
11	*1st Quarter 2022 Groundwater Monitoring*	*70 days*	*Mon 3/14/22*	*Fri 6/17/22*
16	*2nd Quarter 2022 Groundwater Monitoring*	*71 days*	*Mon 6/6/22*	*Mon 9/12/22*
21	*3rd Quarter 2022 Groundwater Monitoring (removed from scope)*	*66 days*	*Fri 7/1/22*	*Fri 9/30/22*
22	*4th Quarter 2022 Groundwater Monitoring*	*78 days*	*Sat 11/5/22*	*Fri 2/17/23*
27	*1st Quarter 2023 Groundwater Monitoring*	*71 days*	*Mon 3/6/23*	*Mon 6/12/23*
32	*2nd Quarter 2023 Groundwater Monitoring*	*75 days*	*Mon 6/12/23*	*Fri 9/22/23*
37	*3rd Quarter 2023 Groundwater Monitoring*	*75 days*	*Mon 8/21/23*	*Fri 12/1/23*
42	**4th Quarter 2023 Groundwater Monitoring ***	**71 days**	**Mon 12/11/23**	**Mon 3/18/24**
43	*Sample Wells*	*5 days*	*Mon 12/11/23*	*Fri 12/15/23*
44	Obtain Analytical Data	1 day	Mon 1/15/24	Mon 1/15/24
45	Data Validation	1 day	Wed 1/31/24	Wed 1/31/24
46	Report Completed	1 day	Mon 3/18/24	Mon 3/18/24
47	**Monthly Progress Reports**	**262 days**	**Wed 2/15/23**	**Thu 2/15/24**
48	*December 2022 MPR*	*1 day*	*Wed 2/15/23*	*Wed 2/15/23*
49	*January 2023 MPR*	*1 day*	*Wed 3/15/23*	*Wed 3/15/23*
50	*February 2023 MPR*	*1 day*	*Fri 4/14/23*	*Fri 4/14/23*
51	*March 2023 MPR*	*1 day*	*Mon 5/15/23*	*Mon 5/15/23*
52	*April 2023 MPR*	*1 day*	*Thu 6/15/23*	*Thu 6/15/23*
53	*May 2023 MPR*	*1 day*	*Fri 7/14/23*	*Fri 7/14/23*
54	*June 2023 MPR*	*1 day*	*Tue 8/15/23*	*Tue 8/15/23*
55	*July 2023 MPR*	*1 day*	*Fri 9/15/23*	*Fri 9/15/23*
56	*August 2023 MPR*	*1 day*	*Mon 10/16/23*	*Mon 10/16/23*
57	*September 2023 MPR*	*1 day*	*Wed 11/15/23*	*Wed 11/15/23*
58	*October 2023 MPR*	*1 day*	*Fri 12/15/23*	*Fri 12/15/23*
59	November 2023 MPR	1 day	Mon 1/15/24	Mon 1/15/24
60	December 2023 MPR	1 day	Thu 2/15/24	Thu 2/15/24
61	***2022 System Effectiveness Evaluation***	***66 days***	***Sun 1/1/23***	***Fri 3/31/23***
62	2023 System Effectiveness Evaluation	66 days	Mon 1/1/24	Sun 3/31/24
63	***Implement Groundwater Extraction Enhancement***	***317 days***	***Mon 9/13/21***	***Sun 11/27/22***
71	***Feasibility Study***	***436 days***	***Wed 1/12/22***	***Fri 9/8/23***

Arkema Portland
Monthly Progress Report
Attachment C

Legend				
Task	Project Summary	Manual Task	Start-only	Deadline
Split	Inactive Task	Duration-only	Finish-only	Progress
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Manual Progress
Summary	Inactive Summary	Manual Summary	External Milestone	

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MEMO

TO	Katie Daugherty, Oregon Department of Environmental Quality
FROM	Brendan Robinson, PE, Environmental Resources Management, Inc.
DATE	15 February 2024
REFERENCE	0719595 Phase 106
SUBJECT	December 2023 GW SCM Monthly Performance Monitoring Report

1. INTRODUCTION

Environmental Resources Management, Inc. (ERM) prepared this Monthly Performance Monitoring Report (MPR) on behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc. (Arkema), for the former Arkema Portland Plant (the Site) at 6400 NW Front Avenue in Portland, Oregon. The Oregon Department of Environmental Quality (ODEQ), in its letter dated 31 May 2019 and in the subsequent meeting with LSS and ERM on 2 July 2019, requested that LSS initiate monthly status reports associated with the onsite groundwater source control measure (GW SCM) consistent with the Performance Monitoring Plan (PMP; ERM 2014) beginning July 2019. The 2014 PMP was prepared pursuant to the Order on Consent issued by ODEQ, signed on 31 October 2008 (ODEQ No. LQVC-NWR-08-04; Consent Order). The purpose of the PMP was to present the monitoring, reporting, and adaptive management processes used during implementation of the GW SCM. On 30 November 2021, ODEQ directed LSS that following the October 2021 MPR, subsequent MPRs would be suspended pending the implementation of the Groundwater Extraction Enhancement (GEE) project in 2022. During that time, ODEQ requested monthly schedule updates in lieu of MPRs. The trench wells installed as part of the GEE project were started on 27 November 2022, and MPR writing restarted in December 2022. The purpose of the GEE project was to install new extraction capacity to achieve the Capture Zone Objectives.

This December 2023 MPR summarizes the GW SCM performance monitoring data collected in December 2023. This report assesses the current gradient status and proposes system improvements to meet the Capture Zone Objectives set in the PMP.

2. GROUNDWATER SOURCE CONTROL IMPLEMENTATION

A detailed description of the design and implementation of the GW SCM is provided in the Revised Upland Feasibility Study Work Plan (ERM 2017); however, a brief description of the GW SCM is provided here. In February 2009, ODEQ and the U.S.

Environmental Protection Agency (USEPA) approved the general approach for the GW SCM. This approach included installation of a groundwater barrier wall (GWBW), groundwater recovery wells, and a Groundwater Extraction and Treatment (GWET) system, with treated water discharged to the Willamette River. ODEQ and USEPA approved the Groundwater Barrier Wall Final Design (ERM 2012) on 7 August 2012. Construction of the GWBW began in May 2012 and was completed in December 2012. ODEQ approved the Groundwater Extraction and Treatment System Final Design (ERM 2013) on 2 April 2013. Construction of the GWET system began in December 2012 and was completed in December 2013.

GWET startup and optimization commenced in May 2014. The GW SCM at the Site consists of the following primary components (Figure 1):

1. A GWBW to physically separate the affected upland portions and in-water portions of the Site.
2. Hydraulic control to minimize flow of groundwater containing unacceptable concentrations of constituents of potential concern (COPCs) around, over, and under the GWBW.
3. Management of extracted groundwater through the GWET system, with treated effluent discharged to the Willamette River under a National Pollutant Discharge Elimination System (NPDES) Permit.

On 1 September 2018, ERM submitted the Draft GWET System Effectiveness Evaluation (Draft SEE Report; ERM 2018). The Draft SEE Report provided an update on the corrective actions implemented to improve the performance of the GWET system, evaluate the extent of capture, and propose actions to improve hydraulic capture. Additional data requested by ODEQ were submitted on 26 October 2018.

The key objective of the GW SCM is to achieve hydraulic containment of the alluvial sequence within the Target Capture Zone at the Site to prevent the flow of COPCs to the Willamette River. The Site alluvial aquifer sequence within the Target Capture Zone consists of the Shallow Zone, Intermediate Zone, and the Deep Zone. Site hydraulic conditions are variable and subject to both seasonal and daily tidal fluctuations.

The hydraulic control component formerly consisted of 22 recovery wells (RWs) prior to the implementation of the GEE. Of the 22 pre-existing RWs, four were retained for active pumping. The remaining 18 former RWs had pumps removed but retained their pressure transducers so that they can continuously collect high-resolution groundwater elevation data. The hydraulic control system now consists of the four remaining active RWs, as well as seven groundwater extraction trenches that each contain two extraction wells (EWs). Each trench is 50 feet deep, 50 feet long, and 3 feet wide and is filled with an engineered backfill. More information about the groundwater extraction trenches is provided in the Final Design Report (ERM 2022). The gradient control-monitoring network consists of six gradient control clusters (GCCs) with each cluster containing six monitoring points. Within each RW, EW, and GCC location, pressure transducers are continuously collecting high-resolution groundwater elevation data. Each GCC contains three transducers interior to the wall and three transducers exterior to the wall screened in the Shallow, Intermediate, and Deep Aquifers at the Site.

3. HYDRAULIC CONTAINMENT MONITORING PROGRAM

As described in the PMP, the purpose of hydraulic monitoring (i.e., groundwater elevation data) is to provide sufficient data to demonstrate an inward hydraulic gradient across the GWBW and to evaluate the effective hydraulic capture produced by the GW SCM.

Monitoring requirements were established in the PMP to demonstrate GWET effectiveness. The Site monitoring program includes groundwater elevation data (manual and transducer measurements) collected from the 36 monitoring points located within six GCCs spaced across the GWBW, with piezometers interior and exterior to the wall, throughout the alluvial sequence; and groundwater elevation and flow rate data from the four remaining active RWs and 14 EWs. High-resolution groundwater elevation data is also collected from the 18 inactive RWs. Additionally, one new monitoring well was installed in each of the seven extraction trenches for manual water level measurement. These data were used to prepare horizontal and vertical potentiometric surface maps representing potentiometric differences between the alluvial sequences, and to generate spatial and temporal hydrographs to evaluate hydraulic capture.

3.1 GROUNDWATER ELEVATION MONITORING

Groundwater elevation monitoring was completed on 8 December 2023. Manual groundwater elevations were measured at wells that were experiencing transducer mechanical issues or that were offline during the groundwater elevation measurement event. All inactive RWs were manually measured in the month of June to affirm proper calibration. Manual water levels for those RWs are reported. Additionally, all transducers in inactive RWs were down until upgrades were completed and transducers were sequentially turned on. Specific issues are addressed in Attachment A-1.

As detailed in Attachments A-1 and A-2, during December 2023, the following transducers were:

<u>Fully out of service pending repairs:</u>

- N/A

<u>Out of service for a period but returned to full operation:</u>

- PA-06
- PA-11i
- PA-07

PA-06 had a faulted transducer, signal wire repaired, and recalibrated on 7 December 2023. PA-11i had a faulted transducer replaced on 13 December 2023. PA-07 had a faulted transducer replaced on 22 December 2023.

3.2 HORIZONTAL AND VERTICAL GRADIENTS AT GRADIENT CONTROL POINTS

As described above, GCC locations collect high-resolution groundwater elevation data using transducers. Transducer data are filtered to remove anomalous data from monitoring points due to potential equipment failures, such as transducer malfunctions, power outages, or updates to the GWET programmable logic controller (PLC) system, which controls and houses all the operational data. These specific issues and time periods are summarized in Table A-1 in Attachment A. The following flags are applied to filter anomalous data:

- Groundwater elevations had a change greater than 1.5 feet within 1 hour
- Water column depth measurements that were found to be greater than 50 feet, or less than 1 foot
- Calculated groundwater elevation slope indicates no change between consecutive measurements indicating a transducer malfunction
- Manually flagging data that are inconsistent with the typical nature of the well
- Periods where transducer power supply was deactivated for work on interconnected electrical systems

After December 2023 flagged data were removed, the Serfes (1991) method was used to account for tidal variations as described in the PMP. Using Serfes corrected data, both horizontal and vertical gradients were calculated and plotted over time (Attachment B). Groundwater elevations, horizontal gradients, and vertical gradients from 8 December 2023 are shown below at each GCC (Table 1-1 and Table 1-2).

TABLE 1-1 DECEMBER HORIZONTAL GRADIENTS

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
GCC1	Shallow	PA-03	30.49	PA-04	31.02	-0.005
	Intermediate	PA-17iR	12.60	PA-10i	13.05	-0.004
	Deep	PA-27d	12.07	PA-18d	12.14	-0.001
GCC2	Shallow	MWA-2	11.32	PA-05	6.93	0.064
	Intermediate	MWA-8i	11.46	PA-11i[M]	10.28	0.016
	Deep	PA-19d	11.29	PA-30d	10.98	0.006
GCC3	Shallow	MWA-69	9.99	PA-06	9.86	0.001

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
	Intermediate	MWA-66i	10.41	PA-12i	9.99	0.004
	Deep	PA-21d	11.16	PA-20d	10.90	0.002
GCC4	Shallow	MWA-19	11.18	PA-28	12.46	-0.013
	Intermediate	MWA-34i	*	PA-13i	12.01	**
	Deep	MWA-58d	10.76	PA-22d	11.82	-0.012
GCC5	Shallow	MWA-47	11.44	PA-07	12.65	-0.012
	Intermediate	PA-29i	11.59	PA-14i	11.95	-0.007
	Deep	PA-24d	10.86	PA-23d	11.91	-0.020
GCC6	Shallow	PA-09	13.10	PA-08	14.52	-0.026
	Intermediate	PA-16i	12.05	PA-15i	11.69	0.007
	Deep	PA-26d	13.22	PA-25d	13.74	-0.008

Notes:
Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.
Horizontal gradient calculated as (Exterior Elevation – Interior Elevation) / Horizontal distance.
* = anomalous groundwater elevation; ** = horizontal gradient cannot be calculated due to anomalous elevation reading; ft NAVD88 = feet North American Vertical Datum of 1988;
M = manual groundwater elevation measurement

TABLE 1-2 DECEMBER VERTICAL GRADIENTS

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
Interior	SZ-IZ	GCC1	PA-04	31.02	PA-10i	13.05	1.82
		GCC2	PA-05	6.93	PA-11i[M]	10.28	-0.29
		GCC3	PA-06	9.86	PA-12i	9.99	-0.01
		GCC4	PA-28	12.46	PA-13i	12.01	0.07
		GCC5	PA-07	12.65	PA-14i	11.95	0.07
		GCC6	PA-08	14.52	PA-15i	11.69	0.211
	IZ-DZ	GCC1	PA-10i	13.05	PA-18d	12.14	0.12
		GCC2	PA-11i[M]	10.28	PA-30d	10.98	-0.10
		GCC3	PA-12i	9.99	PA-20d	10.90	-0.05
		GCC4	PA-13i	12.01	PA-22d	11.82	0.01

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
		GCC5	PA-14i	11.95	PA-23d	11.91	0.00
		GCC6	PA-15i	11.69	PA-25d	13.74	-0.05
Exterior	SZ-IZ	GCC1	PA-03	30.49	PA-17iR	12.60	1.14
		GCC2	MWA-2	11.32	MWA-8i	11.46	-0.01
		GCC3	MWA-69	9.99	MWA-66i	10.41	-0.03
		GCC4	MWA-19	11.18	MWA-34i	*	**
		GCC5	MWA-47	11.44	PA-29i	11.59	-0.01
		GCC6	PA-09	13.10	PA-16i	12.05	0.07
	IZ-DZ	GCC1	PA-17iR	12.60	PA-27d	12.07	0.08
		GCC2	MWA-8i	11.46	PA-19d	11.29	0.11
		GCC3	MWA-66i	10.41	PA-21d	11.16	-0.06
		GCC4	MWA-34i	*	MWA-58d	10.76	**
		GCC5	PA-29i	11.59	PA-24d	10.86	0.02
		GCC6	PA-16i	12.05	PA-26d	13.22	-0.03

Notes:
Positive vertical gradient indicates a downward hydraulic gradient.
Vertical gradient calculated as (Upper Elevation – Lower Elevation) / Screen Midpoint distance.
* = anomalous groundwater elevation; ** = vertical gradient cannot be calculated due to anomalous elevation reading; DZ = Deep Zone; ft NAVD88 = feet North American Vertical Datum of 1988; IZ = Intermediate Zone; M = manual groundwater elevation measurement; SZ = Shallow Zone

3.3 POTENTIOMETRIC SURFACE, GROUNDWATER ELEVATION DIFFERENCE MAPS, AND GROUNDWATER FLOW DIRECTIONS

As described in the PMP, potentiometric surface maps are used to evaluate flow paths. Vertical gradients are also used as an additional line of evidence to evaluate hydraulic containment. Groundwater elevation data collected on 8 December 2023 were used to prepare potentiometric surface maps based on manual measurements and averaged transducer groundwater elevations (Figures 2 through 4) and vertical difference maps (Figures 5 and 6).

The generalized flow direction indicated by the potentiometric surface maps shows overall groundwater flow from upgradient toward the GWBW. Potentiometric maps (Figures 2, 3, and 4) indicate localized groundwater movement to the extraction trenches due to GW SCM pumping, and cones of depression are apparent around each groundwater extraction trench. Inward gradient was observed in the Shallow Zone at

GCC2 and GCC3 in December 2023. As shown in Attachment B-2, Shallow Zone horizontal gradient trends over time are trending toward inward at all GCCs except GCC6.

In December 2023, horizontal gradients in the Intermediate Zone were inward at GCC2, GCC3, and GCC6. Intermediate Zone horizontal gradient trends over time (see Attachment B-2) show horizontal gradients trending toward inward gradients at all GCCs. The horizontal gradients in the Deep Zone were inward at GCC2 and GCC3.

River elevations are shown over time on Figure 1-1 and 1-2 below, and also for the month corresponding with this MPR on the potentiometric surface maps in an inset (Figures 2 through 4) and depict stage movement within the month. The river elevation in December 2023 varied with an average of 10.31 feet NAVD88 with a minimum elevation of 7.17 feet NAVD88 and a maximum elevation of 13.31 feet NAVD88, a lower maximum than in December 2022 (15.07 feet NAVD88). Historically, the river elevation is at its highest in May and decreases until its lowest in October, making it more challenging during late summer and fall months to achieve inward gradients. As the wet season continues, the river is expected to rise, increasing the elevation of groundwater downgradient of the GWBW. Depending on how much groundwater elevations upgradient of the GWBW rise with exterior groundwater elevations, there may be increasing trends toward inward horizontal gradients at all GCCs throughout the wet season.

The river level has begun rising since a low in October 2023, and horizontal gradients are continuing to improve. Additionally, as can be seen in Figures 1-1 and 1-2 below, the difference between the river level elevation and Shallow and Intermediate Zone groundwater averages has been steadily decreasing. The difference between average interior Shallow Zone groundwater elevations and river level elevation were 5.59 ft and 1.09 ft in December 2022 and December 2023, respectively. A potentiometric separation is still noticeable exterior to the GWBW, indicating that it is functioning by impeding groundwater flow.

Vertical gradients were calculated for each vertical well pair and are plotted on Figures 5 and 6. Vertical groundwater gradients interior to the GWBW between the Shallow and Intermediate Zones were mixed, with GCC2 and GCC3 being upward and the remaining downward (Figure 5). Vertical groundwater gradients are also depicted in Attachment B-3. The magnitude of the gradient is much greater at GCC1 than other monitoring locations due to the influence from a localized high-pressure zone near GCC1 where vertical groundwater flow is impeded by a localized confining unit (Figure 2). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were mixed with GCC2, GCC3, and GCC5 being upward and GCC1 and GCC6 being downward as shown on Figure 5 and in Attachment B-2.

The vertical groundwater gradient at GCC4 was unable to be calculated due to an anomalous groundwater elevation reading at MWA-34i. Compared to other wells in the

Intermediate Zone, the rate of change of the water level elevation at MWA-34i during large rainfall events is much higher and will be investigated.

Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were mixed with GCC2, GCC3, and GCC6 being upward and the remaining downward. The direction of vertical gradients exterior to the GWBW were mixed with GCC3 and GCC6 being upward and the remaining downward, as shown on Figure 6 and Attachment B. The vertical groundwater gradient at GCC4 exterior of the wall was unable to be calculated due to an anomalous groundwater elevation reading at and MWA-34i as previously discussed.

3.3.1 GWET SYSTEM PERFORMANCE

The GWET system operated within permit conditions during the reporting period. There were three shutdowns:

- 29 November 2023: ERM, on behalf of LSS, shut down the GWET system due to the Tank T-3 level sensor failing. The ODEQ was notified of the shutdown, and discharge was restarted on 4 December 2023.
- 12 December 2023: ERM, on behalf of LSS, shut down the GWET system due to conveyance line maintenance. The ODEQ was notified of the shutdown, and discharge was restarted on 15 December 2023.
- 18 December 2023: ERM, on behalf of LSS, shut down the GWET system due to solids handling maintenance, and discharge was restarted later that day.

There were no upgrades to the GWET system in the month of December 2023.

3.3.2 RECOVERY WELL AND EXTRACTION WELL PERFORMANCE

The average system influent flow rate was 34.82 gallons per minute (gpm) for the entire month of December 2023, including non-operational periods. The average influent flow during operational periods was 61.04 gpm. Jetting of the Shallow Zone trunk line was completed on 15 December 2023. Prior to line jetting the operational average flow rate was 33.13 gpm. After line jetting the operational average flow rate was 55.20 gpm with flows as high as 90 gpm observed immediately after startup. LSS is currently in the process of optimizing extraction rates within the system to increase flow rates at each operational well until either the extraction rates specified in the *Final Design Report* (ERM 2022) are achieved, the wells are producing the maximum quantity of water possible, or until the Capture Zone Objectives are met.

In late summer months, the pumping rates at historically productive wells have decreased due to lower groundwater elevations. Additionally, back pressure through the Shallow Zone trunk line from the wellfield to the GWET plant appears to be a limiting factor in groundwater extraction. The trunk line will be reconfigured to connect trenches 5, 6, and 7 to the currently unused Intermediate Zone conveyance line to mitigate back pressure effects on pumping rates. Site-wide redevelopment of the EW in the extraction trenches is planned for Q1 2024 to mitigate the biofouling and turbidity within the EWs that is affecting flow rates.

TABLE 1-3 RECOVERY WELL PUMPING RATES

Recovery Well	December 2023 Average Operational Pumping Rate (gpm)	December 2023 Average Monthly Pumping Rate (gpm)
RW-14	0.77	0.57
RW-22	0.37	0.11
RW-23*	0.00	0.00
RW-25	2.30	1.49
EW-01	1.50	1.11
EW-02*	0.00	0.00
EW-03	7.47	3.37
EW-04	7.34	6.15
EW-05	13.79	8.01
EW-06	5.43	1.93
EW-07	2.81	1.09
EW-08	2.64	1.36
EW-09	2.37	1.30
EW-10	2.12	0.75
EW-11	2.13	1.78
EW-12	1.62	0.05
EW-13	3.06	1.28
EW-14	5.33	4.47
Total	61.04	34.82

Notes:
* = Recovery well not in service during reporting period.
gpm = gallon per minute

FIGURE 1-1 OPERATIONAL MONTHLY PUMPING RATE

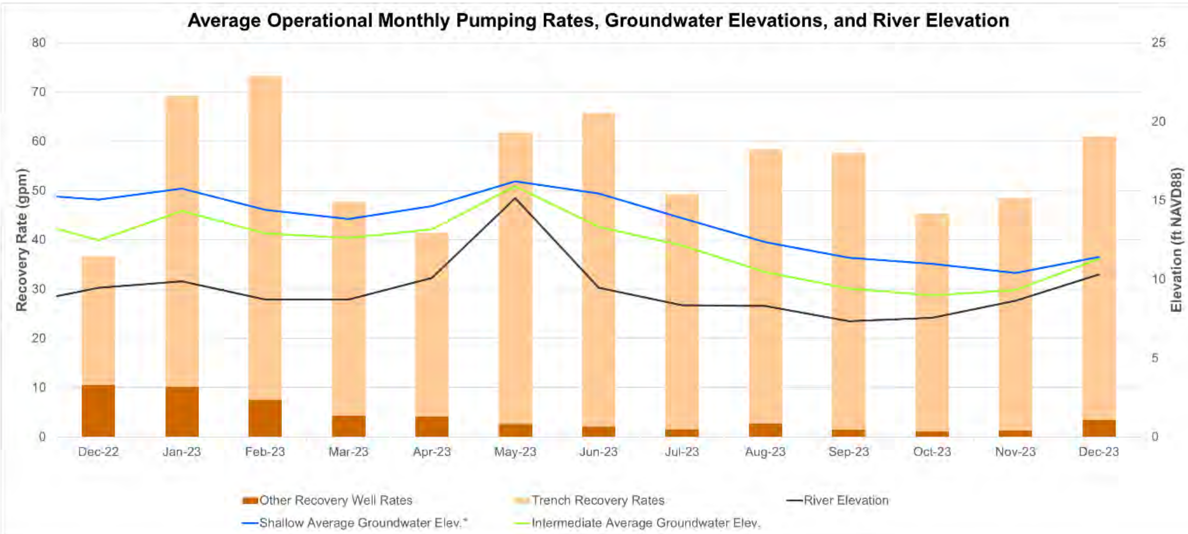
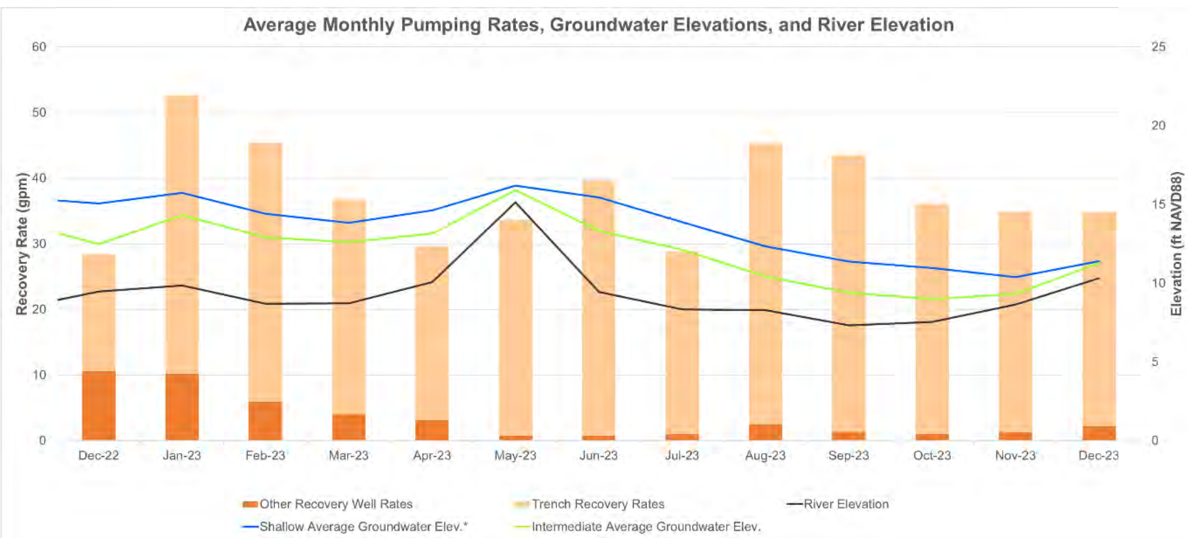


FIGURE 1-2 AVERAGE MONTHLY PUMPING RATE



3.3.3 RECOMMENDATIONS FOR EXTRACTION SYSTEM OPTIMIZATION

Recovery rates from the start of the system indicate that the active RWs and EWs are operating as designed except for the troubleshooting discussed above. The extraction rates throughout the GWET system will continue to be optimized to meet Target Capture Objectives.

4. ANALYTICAL PROGRAM

Quarterly groundwater monitoring was implemented in accordance with the ODEQ-approved Arkema Quarterly Groundwater Monitoring Work Plan dated October 2019 and the ODEQ-approved reduced scope described in the 2021 monitoring program modification request memorandum dated 9 September 2021. The table below outlines sampling dates and submittal dates related to groundwater monitoring since the implementation of the reduced scope. The Quarterly Monitoring Reports present results from these sampling events.

Report	Sampling Dates	Report Submittal Date
2021 Quarter 3	9/21/2021–9/24/2021	1/14/2022
2021 Quarter 4	12/13/2021–12/16/2021	4/20/2022
2022 Quarter 1	3/14/2022–3/17/2022	6/15/2022
2022 Quarter 2	6/6/2022–6/9/2022	9/12/2022
2022 Quarter 4	11/7/2022–11/10/2022	2/17/2023
2023 Quarter 1	3/6/2023–3/10/2023	6/12/2023
2023 Quarter 2	6/12/2023–6/16/2023	9/22/2023
2023 Quarter 3	8/21/2023–8/24/2023	12/1/2023
2023 Quarter 4	12/11/2023–12/14/2023	3/15/2024
2024 Quarter 1	2/26/2024–2/29/2024	5/29/2024 *

* Dates are tentative.

5. SUMMARY AND CONCLUSIONS

This report presents a summary of the GW SCM operation, maintenance, and monitoring activities conducted at the Site in December 2023 and documents results from system monitoring. The following summarizes ERM's observations and conclusions drawn from collected data.

5.1 GROUNDWATER FLOW

- Horizontal groundwater gradients provided in Attachment B-2 for the Shallow, Intermediate, and Deep Zones indicate that most GCCs are either inward, or trending toward inward. Additionally, groundwater elevations show a noticeable difference in elevation across the GWBW, indicating the GWBW is functioning via impeding groundwater flow.
- Vertical groundwater gradients interior of the GWBW between the Shallow and Intermediate Zones were mixed, with GCC2 and GCC3 being upward and the remaining downward (Figure 5). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were mixed with GCC2, GCC3, GCC5 being upward and GCC1 and GCC6 being downward.
- Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were mixed with GCC2, GCC3, and GCC6 being upward and the remaining downward. The direction of vertical gradients exterior to the GWBW were mixed

with GCC3 and GCC6 being upward and the remaining downward, as shown on Figure 6.

- The average river elevation in December 2023 was 10.31 feet NAVD88 with a minimum elevation of 7.17 feet NAVD88 and a maximum elevation of 13.31 feet NAVD88. The seasonal river level elevation trends indicate a seasonal high in May and a seasonal low in October. As the river levels seasonal rise during the late winter and spring months, horizontal gradients across the wall are anticipated to improve.

5.2 GROUNDWATER EXTRACTION

Based on December 2023 extraction and relevant hydrograph analysis, the trenches are achieving increased groundwater extraction rates compared to the legacy system. Within the Site alluvial sequence, potentiometric maps indicate the GW SCM is producing localized areas of hydraulic capture throughout the Target Capture Zone. The analysis of horizontal gradients provided in Attachment B-2 suggests that gradients are either inward, or trending toward inward, at most GCCs in the Shallow, Intermediate and Deep Zones. More time at elevated extraction rates will be required to evaluate whether GWET objectives are being met system wide. As the wet season continues, the river elevation is expected to rise, increasing the elevation of groundwater downgradient of the GWBW.

The groundwater extraction flow rate is currently limited by a combination of groundwater elevation, influence of back pressure in the trunk line, and fouling of the EWs within the trenches. In November and December 2023, water from Trench 7 was routed via overland hoses to the Intermediate Zone trunk line to reduce the effects of back pressure in the Shallow Zone trunk line on pumping rates. Work to connect three of the trenches to the Intermediate Zone trunk line and redevelop the trenches are planned for January 2024.

5.3 RECOMMENDATIONS AND FUTURE WORK

LSS will continue to optimize new EWs, including pump maintenance/upgrades, redevelopment of the wells, and trunk line configuration. Additional modifications to the system, if needed to meet capture objectives, will be included in subsequent MPRs. The project schedule provided as Attachment C summarizes planned activities.

Regards,

Brendan Robinson, PE
Partner

REGISTERED PROFESSIONAL ENGINEER
78496PE
OREGON
DECEMBER 31, 2007
BRENDAN ANDREW ROBINSON
EXP. 12/31/2024

FIGURES

FIGURE 1: SITE LAYOUT

FIGURE 2: DECEMBER 2023 SHALLOW ZONE GROUNDWATER CONTOURS

FIGURE 3: DECEMBER 2023 INTERMEDIATE ZONE GROUNDWATER CONTOURS

FIGURE 4: DECEMBER 2023 DEEP ZONE GROUNDWATER CONTOURS

FIGURE 5: DECEMBER 2023 SHALLOW TO INTERMEDIATE ZONE VERTICAL HEAD DIFFERENCE

FIGURE 6: DECEMBER 2023 INTERMEDIATE TO DEEP ZONE VERTICAL HEAD DIFFERENCE

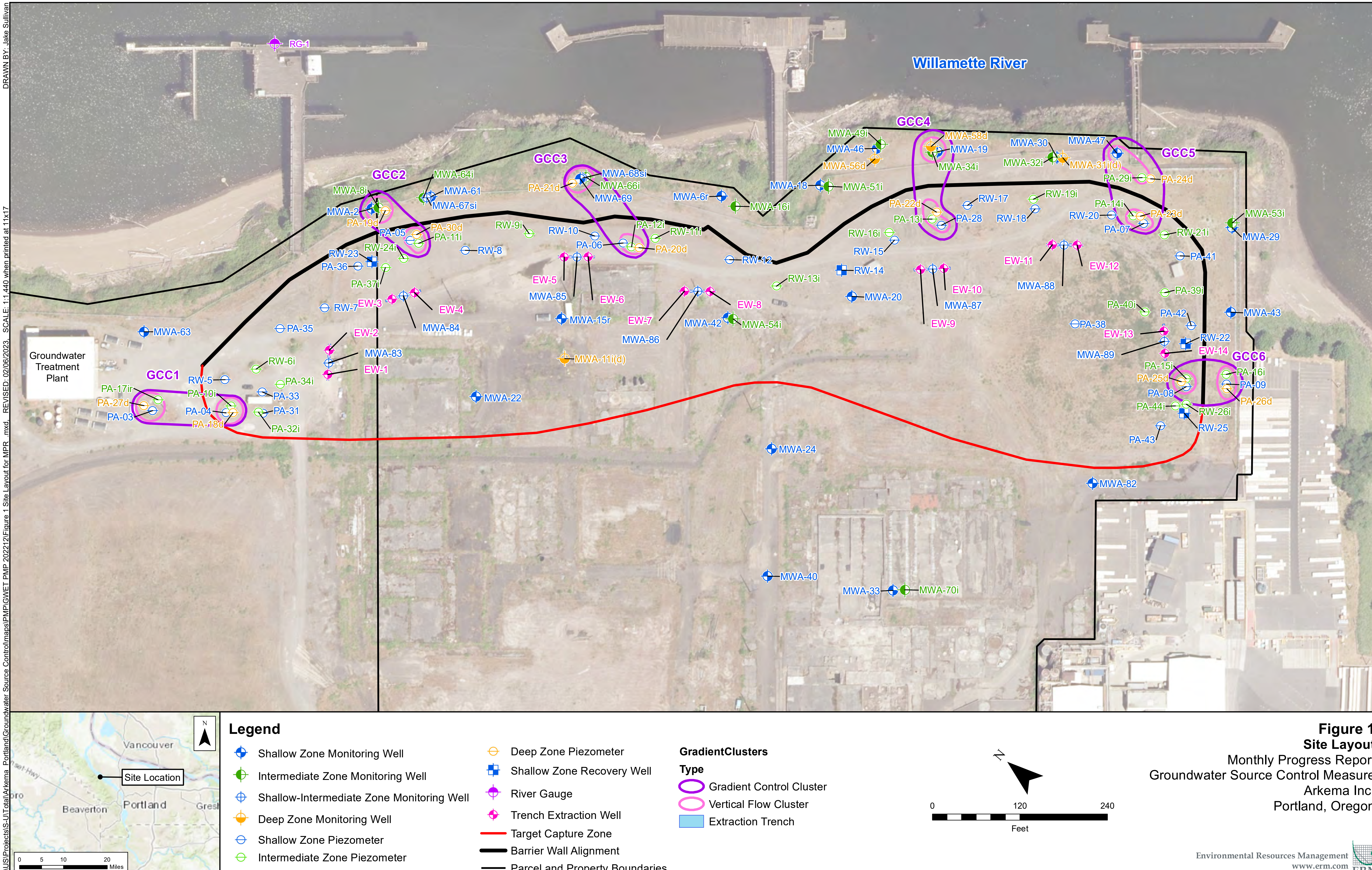


Figure 1
Site Layout
Monthly Progress Report
Groundwater Source Control Measure
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

Source: City of Portland Aerial Imagery, flown Summer 2021; NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

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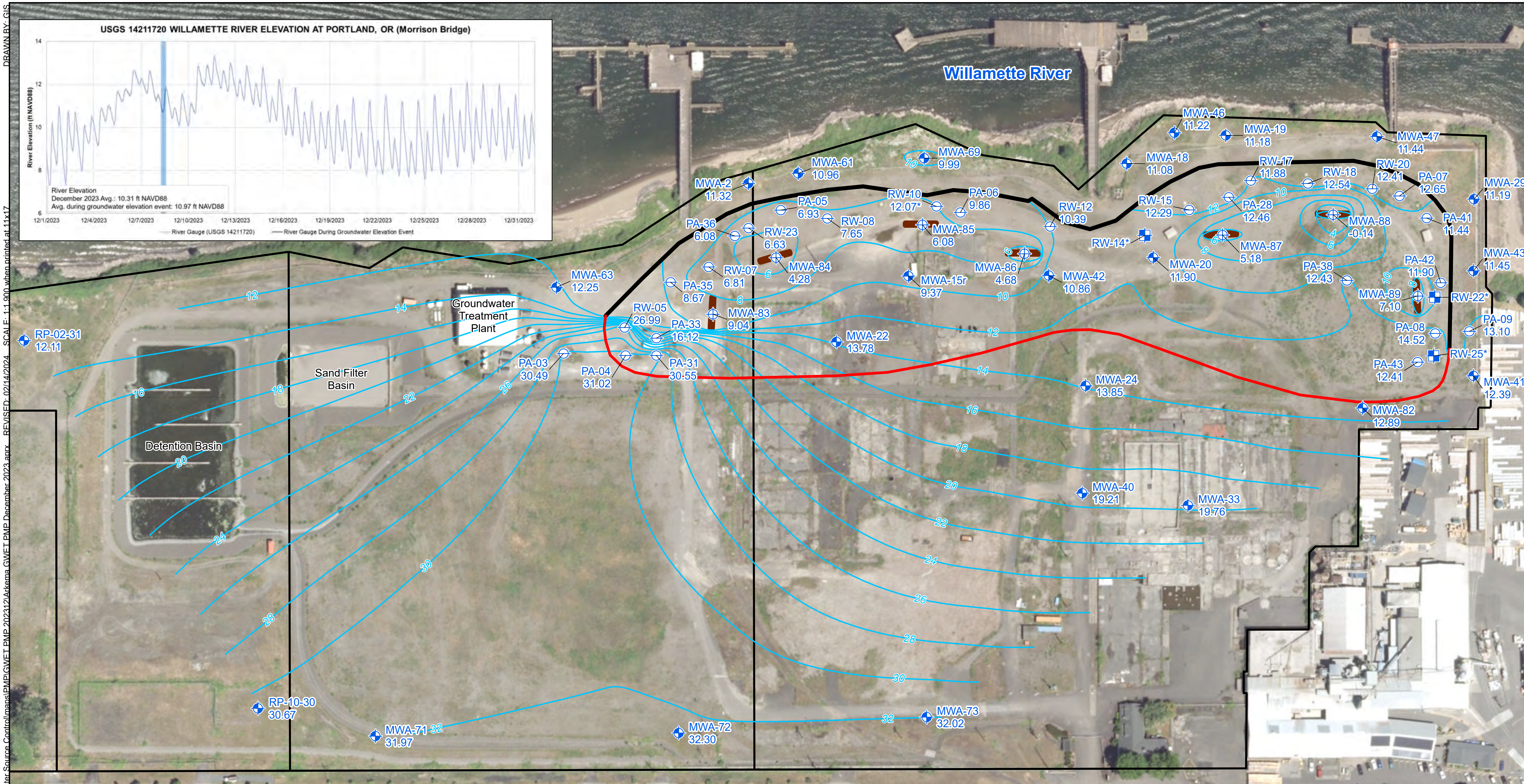

Legend

- Shallow Zone Piezometer
- Shallow Zone Monitoring Well
- Active Recovery Well; Not Used During Contouring
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Shallow Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected December 8, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 2

December 2023 Shallow Zone Groundwater Contours

Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

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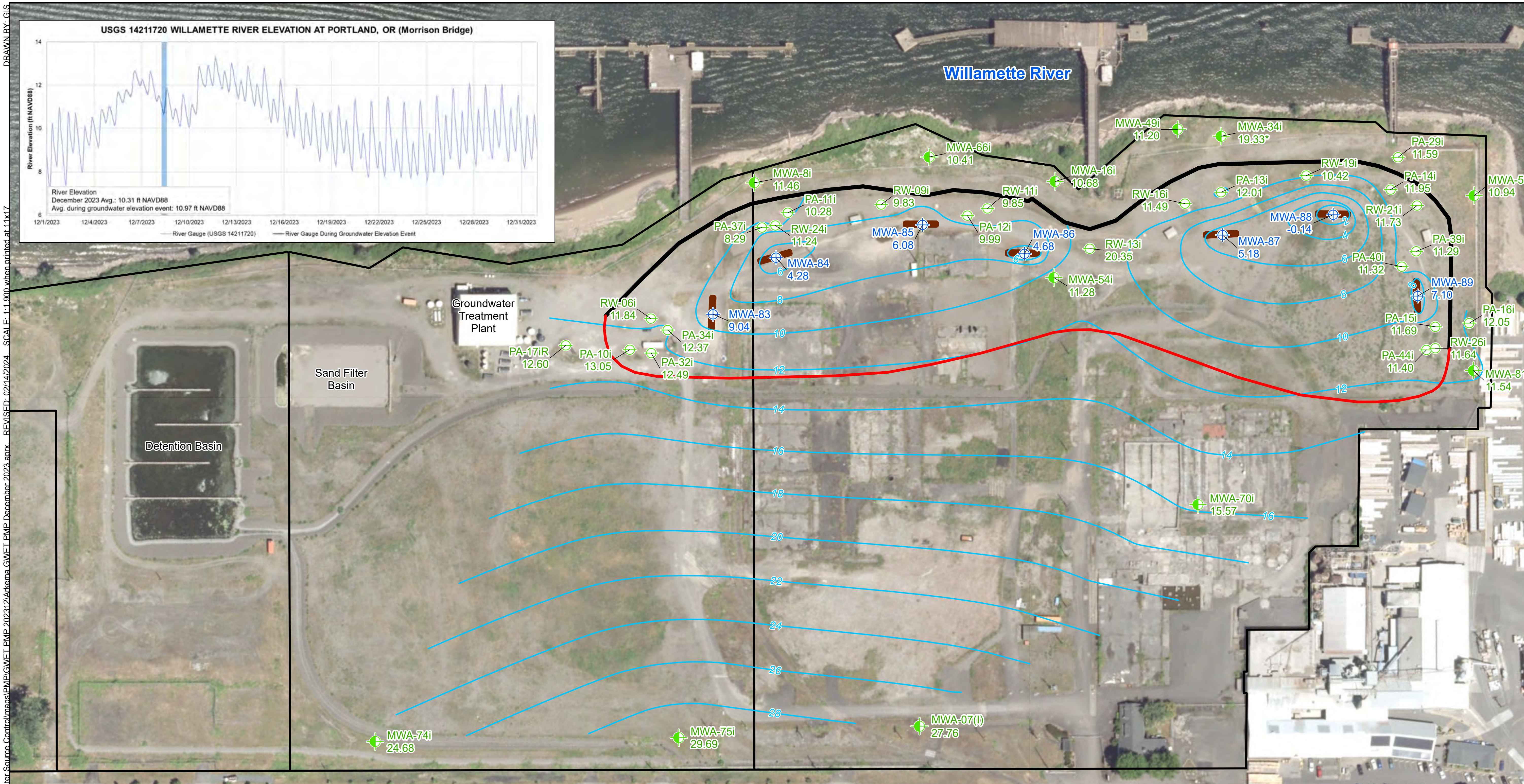

Legend

- Intermediate Zone Piezometer
- Intermediate Zone Monitoring Well
- Shallow-Intermediate Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Intermediate Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment
- Extraction Trench (Not To Scale)

Notes:
* Value not used for contouring.
Water levels collected December 8, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

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Feet

Figure 3
December 2023 Intermediate Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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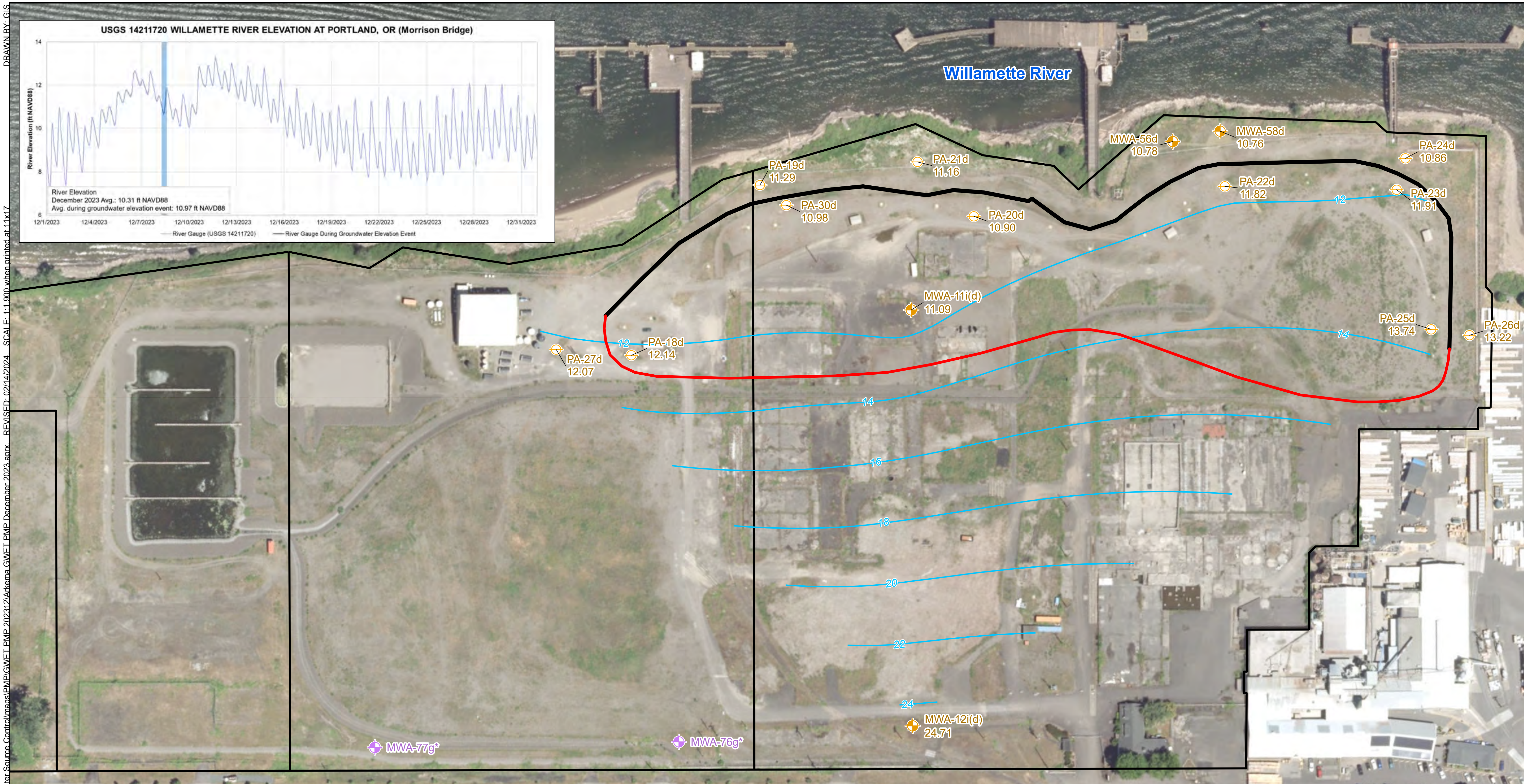

Legend

- Deep Zone Piezometer
- Deep Zone Monitoring Well
- Gravel Zone Monitoring Well
- 27.70 Groundwater Elevation (ft NAVD88)
- Deep Zone Groundwater Contours (ft NAVD88) Dashed where Inferred
- Target Capture Zone
- Barrier Wall Alignment

Notes:
* Value not used for contouring.
Gravel zone wells not used in contouring.
Water levels collected December 8, 2023.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

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Feet

Figure 4
December 2023 Deep Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

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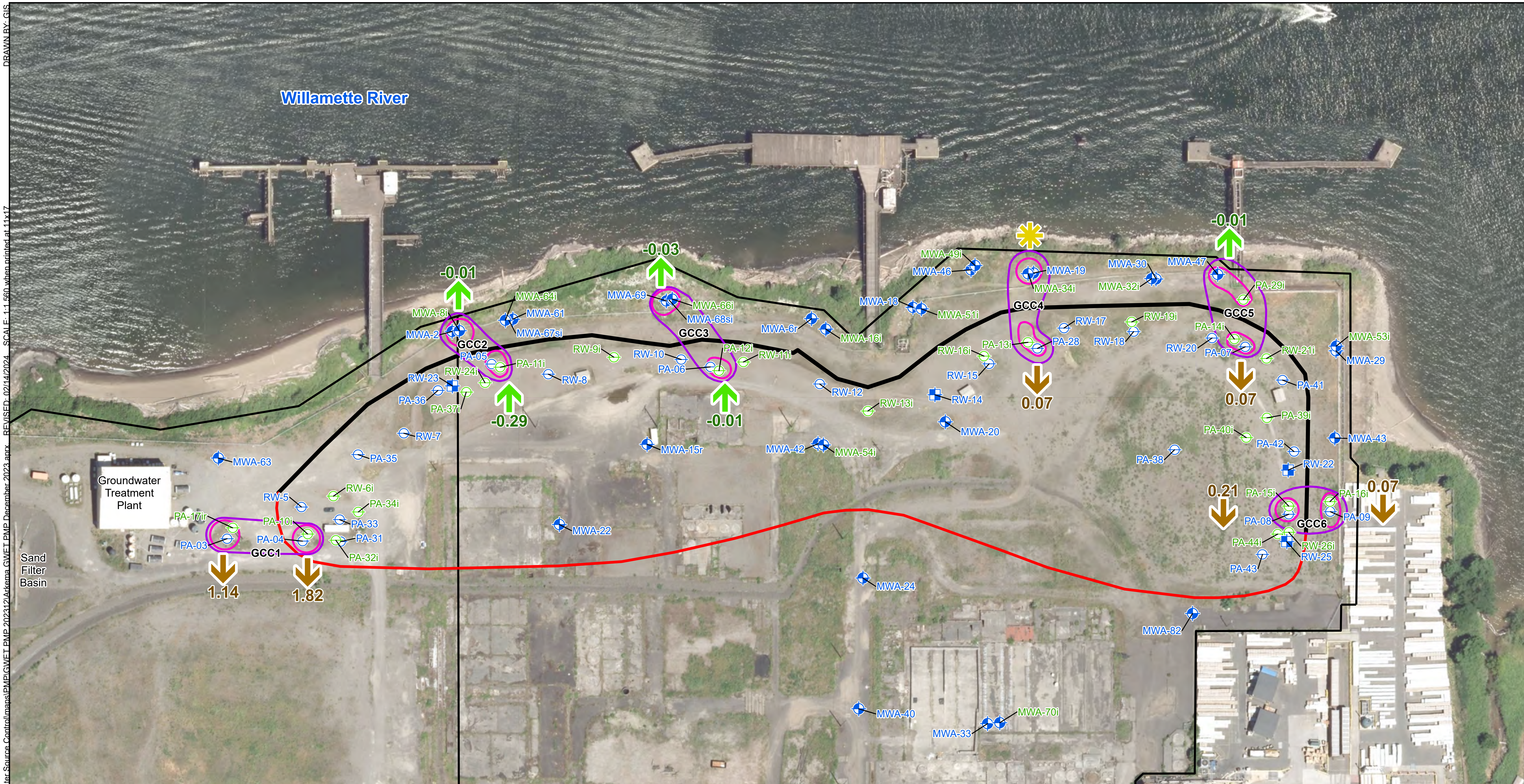
NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



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Legend

- Shallow Zone Monitoring Well
- Intermediate Zone Monitoring Well
- Shallow Zone Piezometer
- Intermediate Zone Piezometer
- Shallow Zone Recovery Well
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow
- Vertical Gradient not calculated due to anomalous groundwater elevation reading

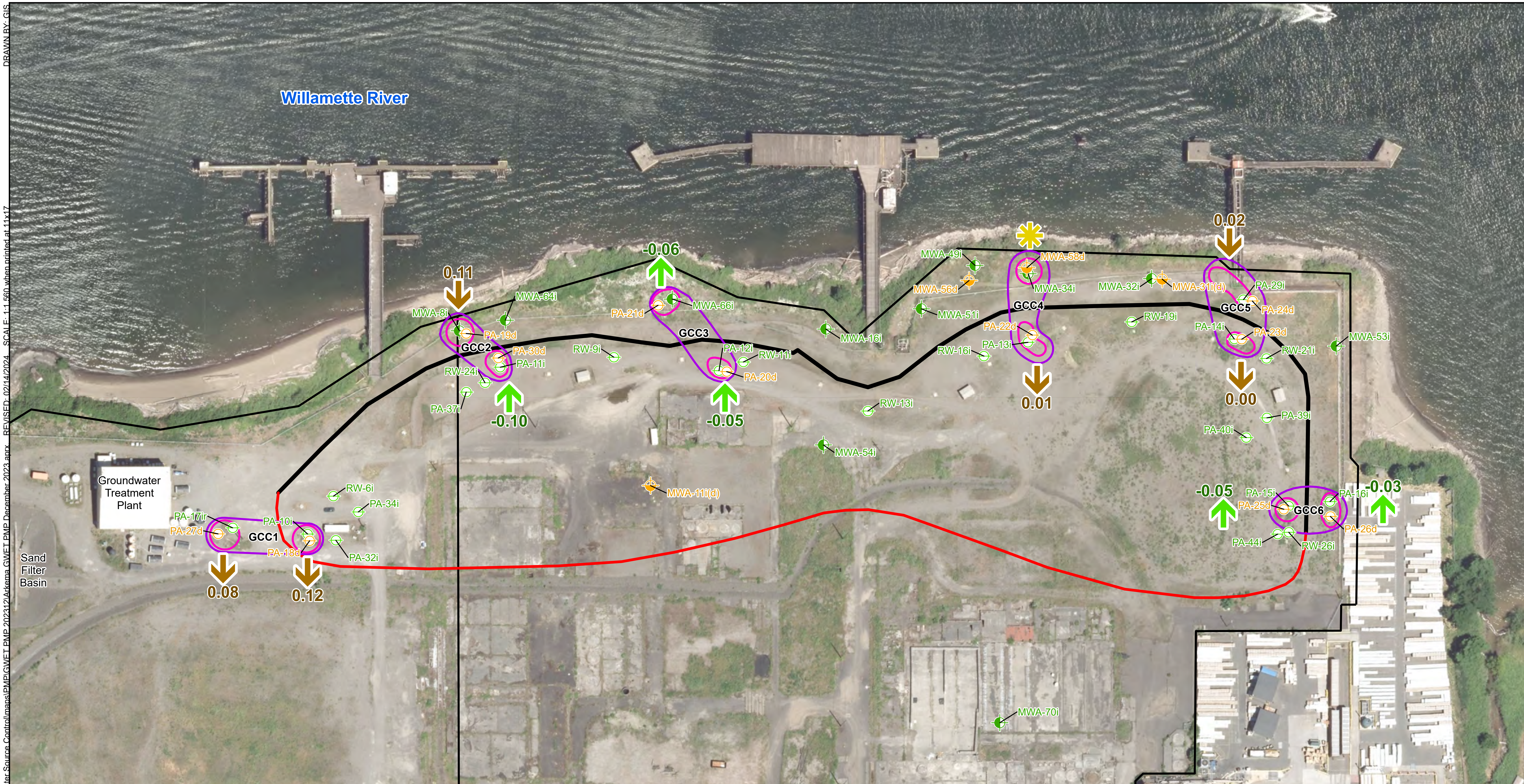
Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as shallow zone minus intermediate zone potentiometric surfaces.
Water levels collected December 8, 2023.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 5
December 2023 Shallow to Intermediate Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl



Legend

- Intermediate Zone Monitoring Well
- Deep Zone Monitoring Well
- Intermediate Zone Piezometer
- Deep Zone Piezometer
- Target Capture Zone
- Barrier Wall Alignment
- Gradient Control Cluster
- Vertical Flow Cluster
- Downward Flow
- Upward Flow
- Vertical Gradient not calculated due to anomalous groundwater elevation reading

Notes:
Brown gradient: Downward flow.
Green gradient: Upward flow.
Vertical gradient calculated as intermediate zone minus deep zone potentiometric surfaces.
Water levels collected December 8, 2023.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 6
December 2023 Intermediate to Deep Zone Vertical Head Difference
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
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NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

ERM

ATTACHMENT A-1 TRANSDUCER FLAGS

Attachment A-1. Transducer Flags

Table A-1
Transducer Malfunction Log: December 2023
Arkema Inc. Facility
Portland, Oregon

Gradient Cluster	Transducer	Interval	Date Range		Issue and Repairs Performed
GCC2	PA-11i	Intermediate	9/1/2023	12/13/2023	Transducer replaced and recalibrated.
GCC3	PA-06	Shallow	9/21/2023	12/7/2023	Transducer faulted, signal wire repaired, and recalibrated.
GCC5	PA-07	Shallow	12/16/2023	12/22/2023	Transducer replaced and recalibrated.

Notes:

I/O = input/output

LOTO = lockout/tagout

VFD = variable frequency drive

ERM

ATTACHMENT A-2 RECOVERY WELL STATUS

Attachment A-2. Recovery Well Status

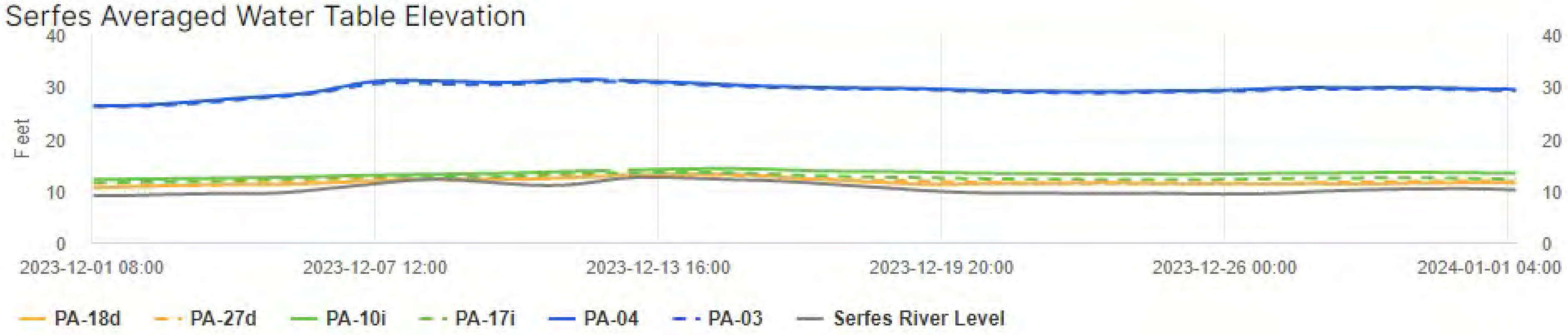
Table A-2
Recovery Well Status: December 2023
Arkema Inc. Facility
Portland, Oregon

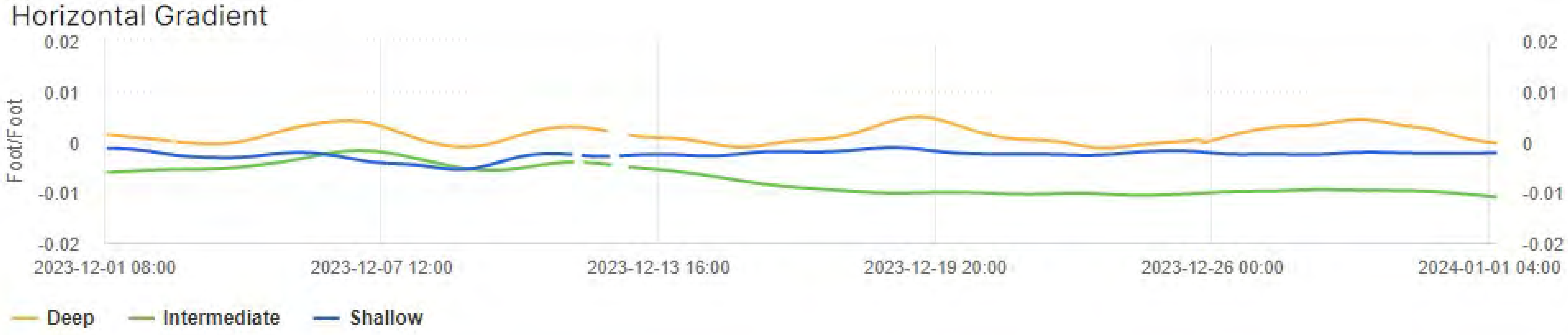
Recovery Well ID	Status as of 12/31/2023 (active or inactive)	Issue	Actions to get online	Expected date back online	Transducer Status	Totalizer Status	Average Operational Flow Rate (gpm)	Overall Extraction Rate	Notes
RW-14	Active	None	N/A	N/A	Good	Good	0.77	P	
RW-22	Active	None	N/A	N/A	Good	Good	0.37	P	
RW-23	Inactive	None	N/A	N/A	Good	Good	0.00	OFF*	Off due to low water levels
RW-25	Active	None	N/A	N/A	Good	Good	2.30	M	
EW-01	Active	None	N/A	N/A	Good	Good	1.50	M	
EW-02	Inactive	None	N/A	N/A	Good	Good	0.00	OFF*	Off due to pump fouling
EW-03	Active	None	N/A	N/A	Good	Good	7.47	G	
EW-04	Active	None	N/A	N/A	Good	Good	7.34	G	
EW-05	Active	None	N/A	N/A	Good	Good	13.79	G	
EW-06	Active	None	N/A	N/A	Good	Good	5.43	G	
EW-07	Active	None	N/A	N/A	Good	Good	2.81	M	
EW-08	Active	None	N/A	N/A	Good	Good	2.64	M	
EW-09	Active	None	N/A	N/A	Good	Good	2.37	M	
EW-10	Active	None	N/A	N/A	Good	Good	2.12	M	
EW-11	Active	None	N/A	N/A	Good	Good	2.13	M	
EW-12	Active	None	N/A	N/A	Good	Good	1.62	M	
EW-13	Active	None	N/A	N/A	Good	Good	3.06	G	
EW-14	Active	None	N/A	N/A	Good	Good	5.33	G	

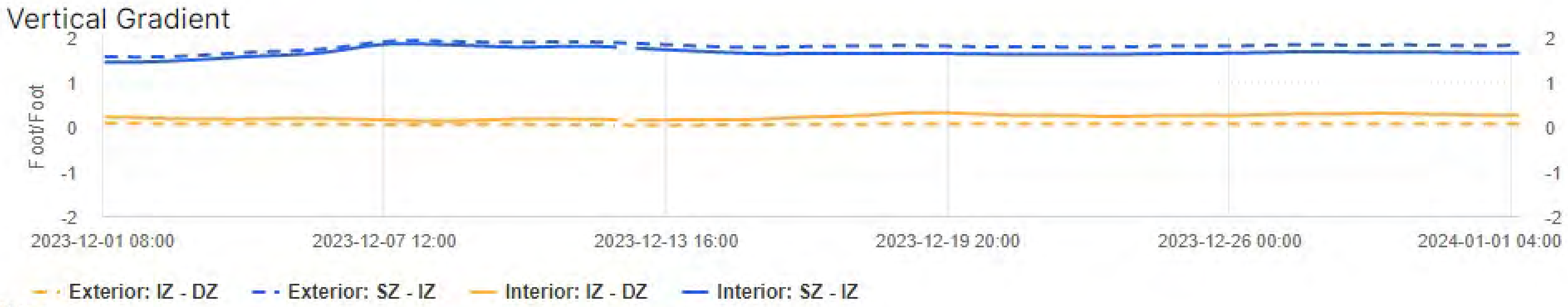
Notes:
** Recovery wells not in service*
*** Recovery wells in service part of the month*
G = good pumping, greater than 3.0 gpm
gpm = gallons per minute
M = moderate pumping, greater than 1.0 gpm and less than 3.0
P = poor pumping, less than 1.0 gpm
VFD = variable frequency drive
PA = piezometer

ATTACHMENT B-1 GRADIENT HYDROGRAPHS

Gradient Control Cluster 1

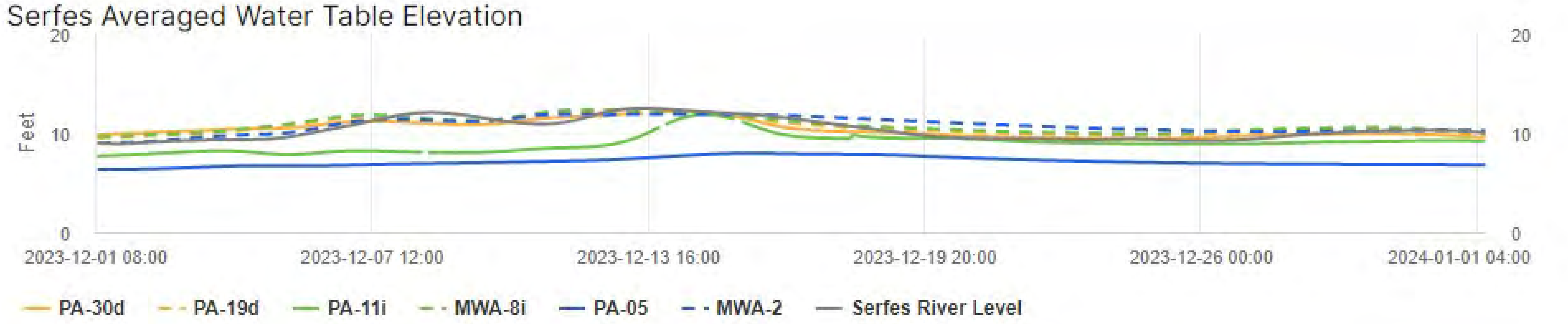


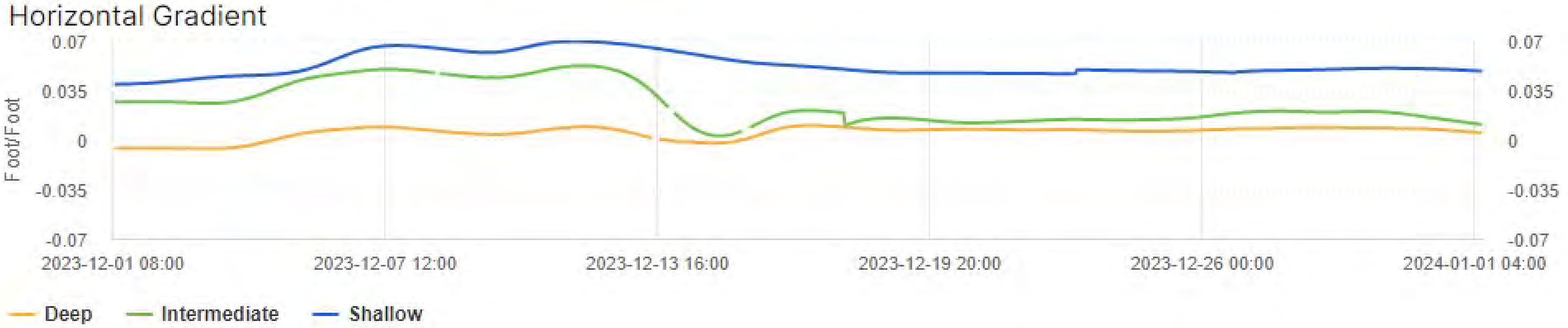


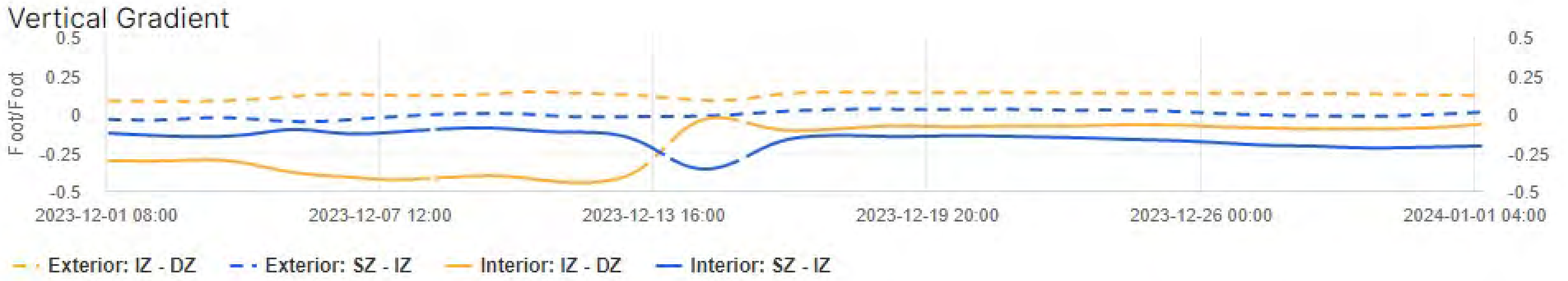


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 2

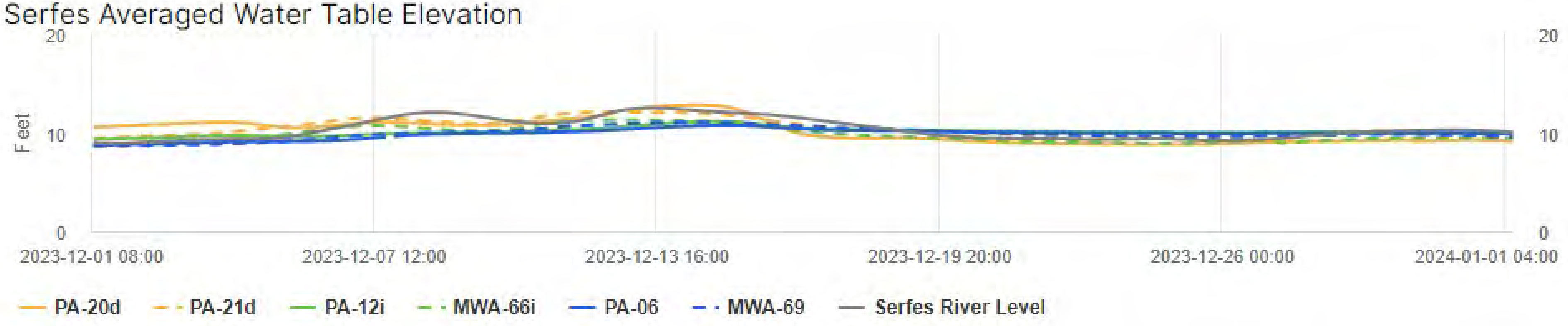


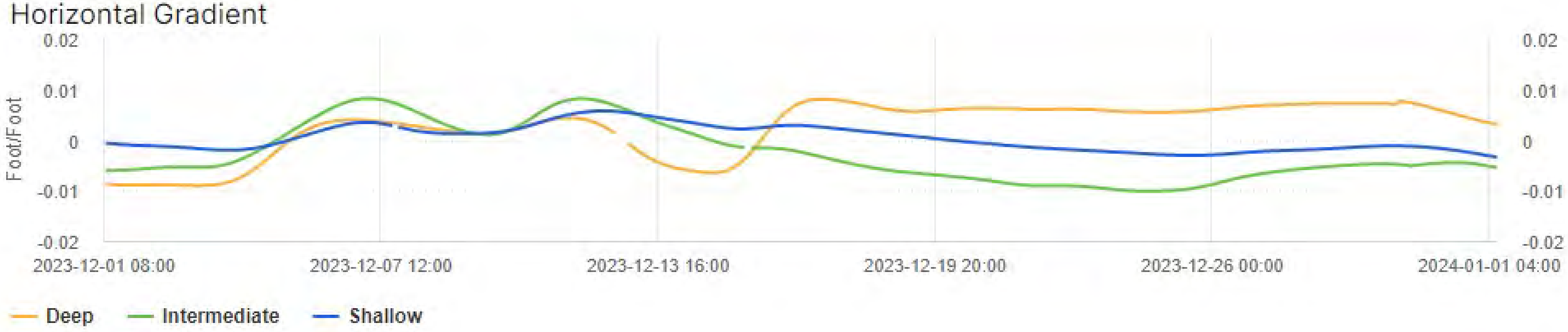


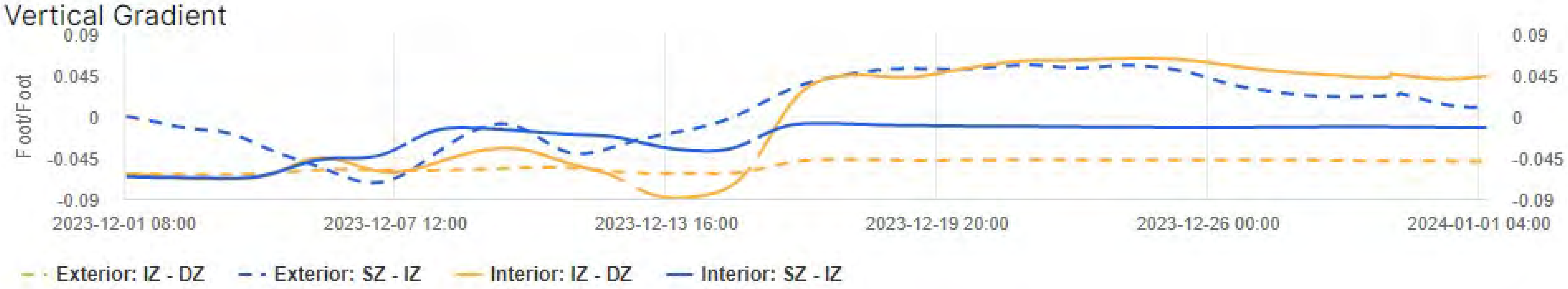


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 3



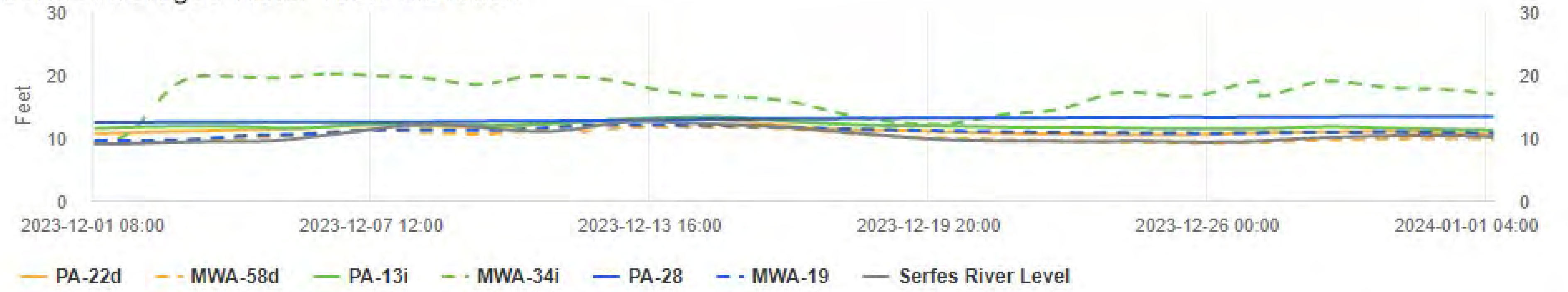




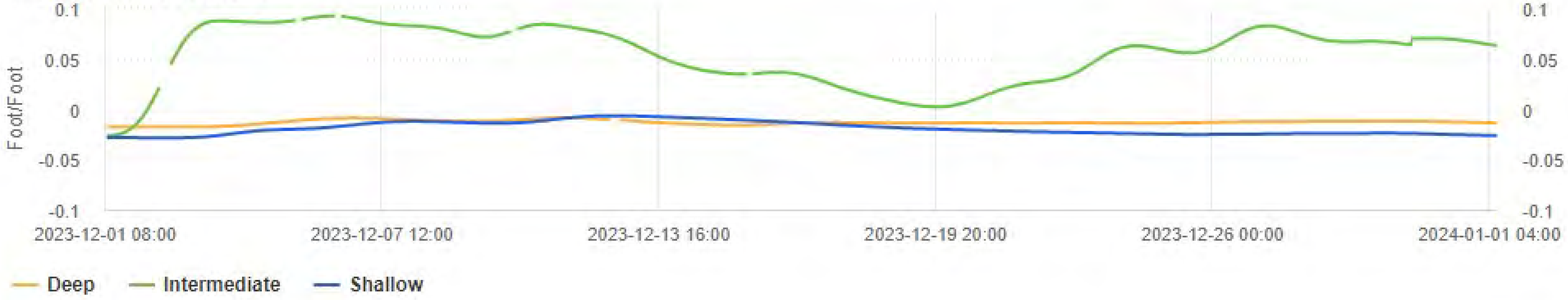
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 4

Serfes Averaged Water Table Elevation



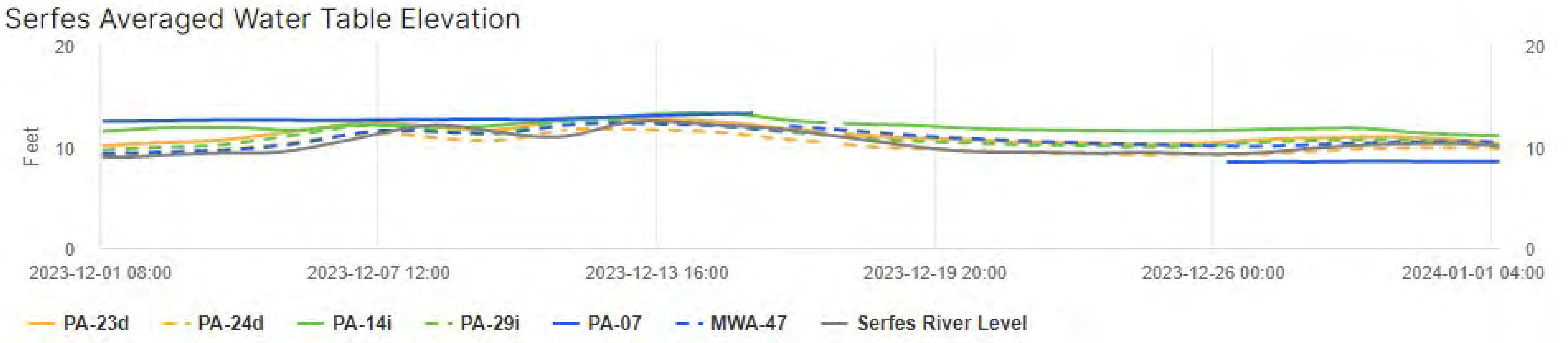
Horizontal Gradient

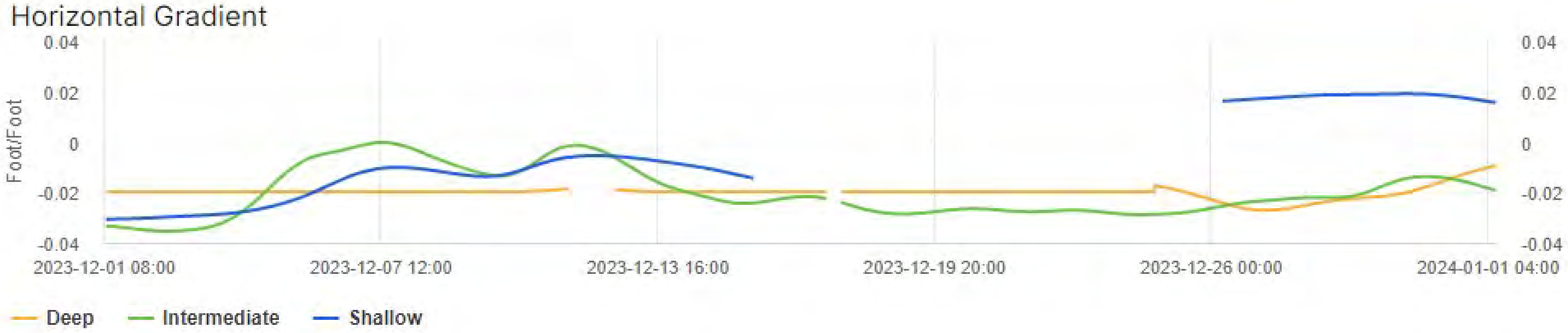


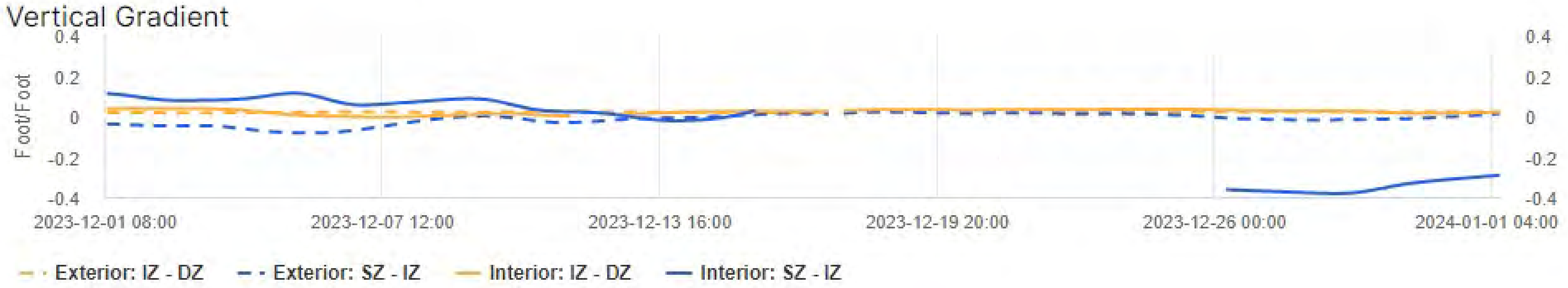
Vertical Gradient

Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 5



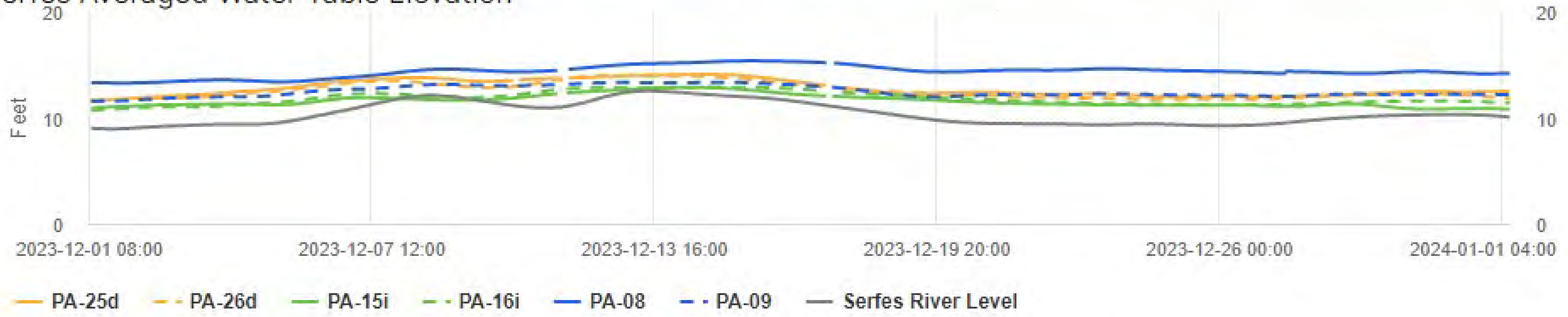




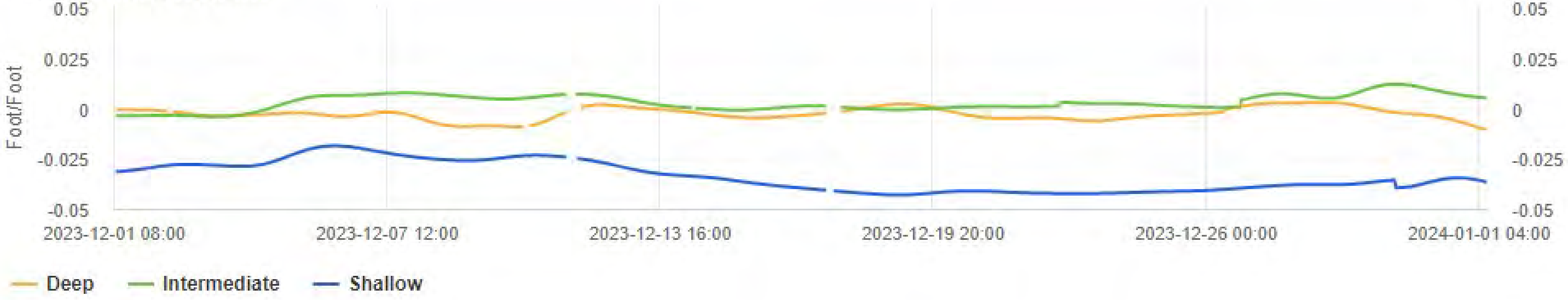
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 6

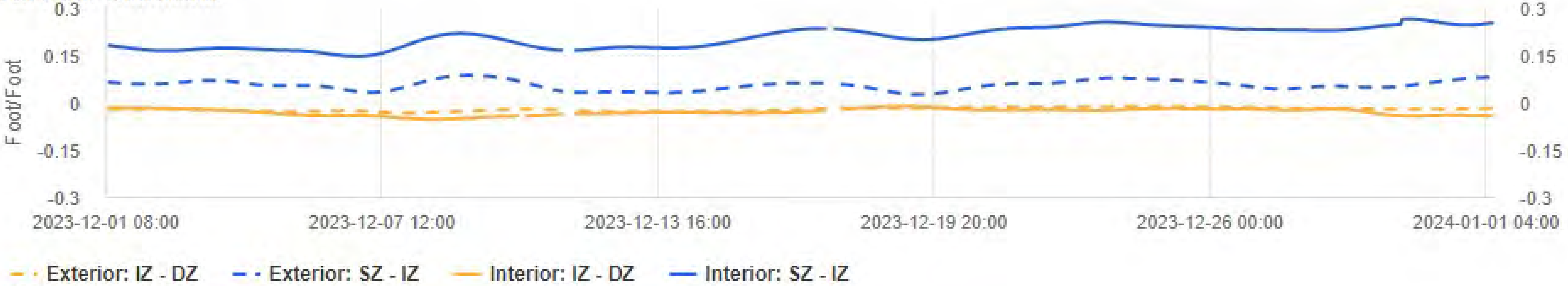
Serfes Averaged Water Table Elevation



Horizontal Gradient



Vertical Gradient

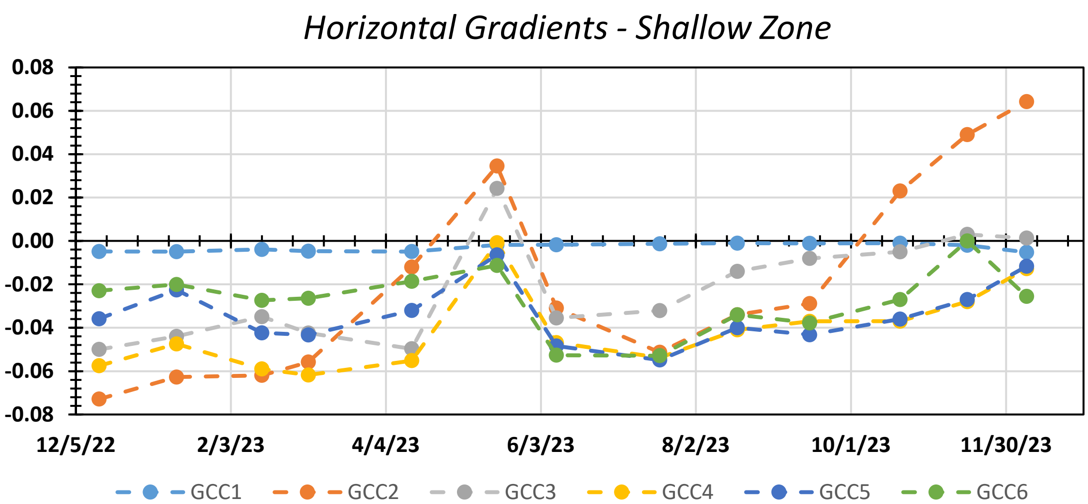


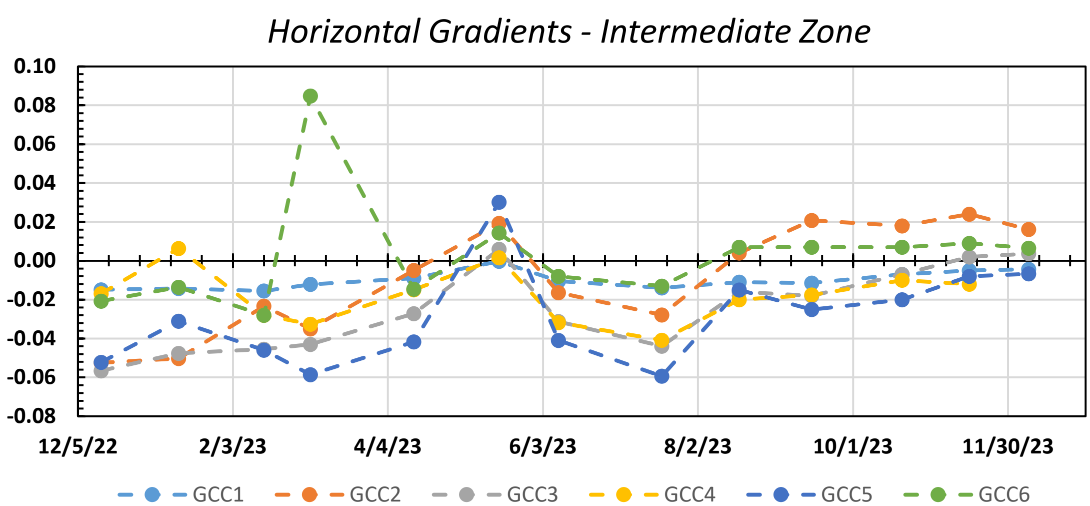
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside of the GWBW
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

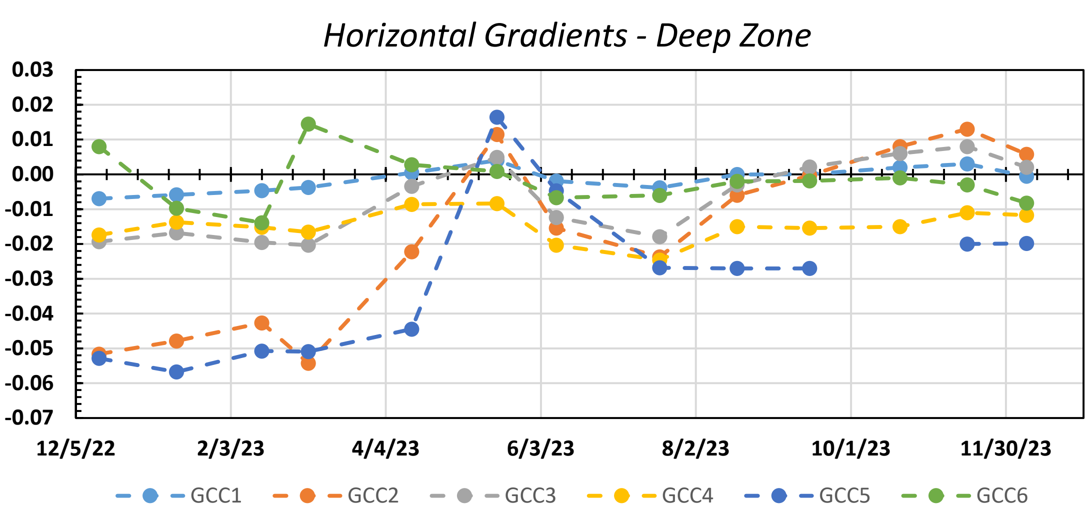
ATTACHMENT B-2 HORIZONTAL GRADIENTS

Attachment B-2

Horizontal Gradients Summary: December 2023
Arkema Inc. Facility
Portland, Oregon





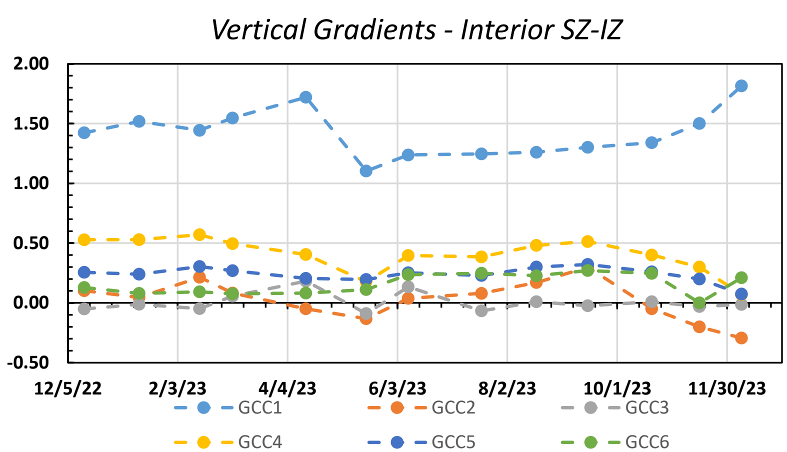


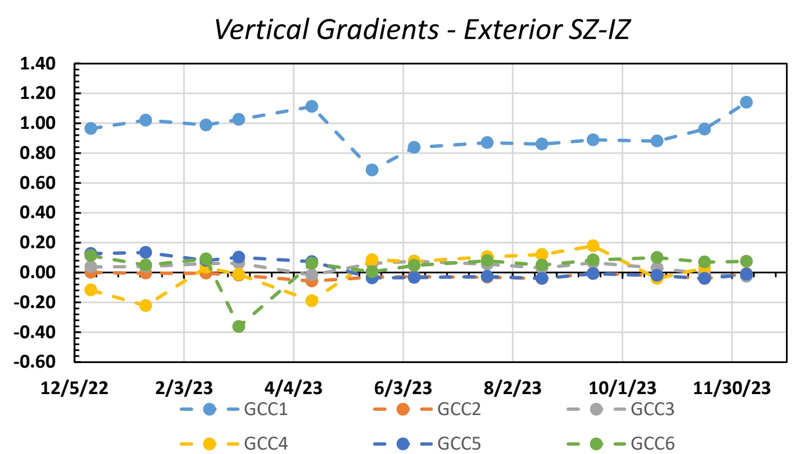
Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.

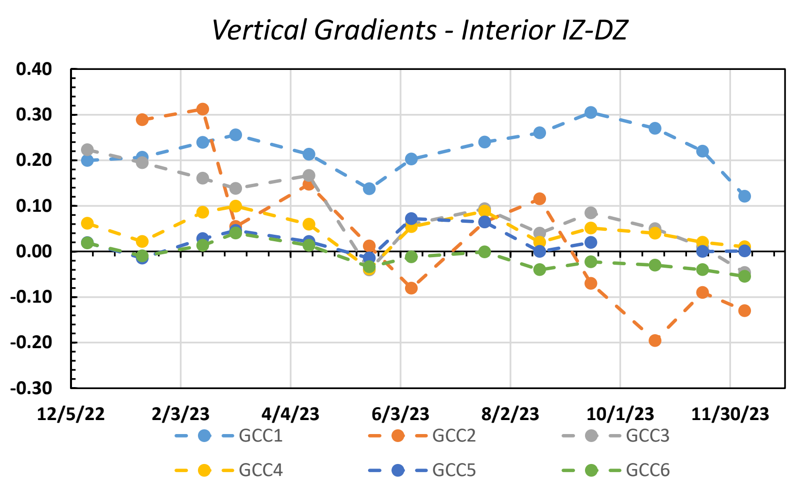
ATTACHMENT B-3 VERTICAL GRADIENTS

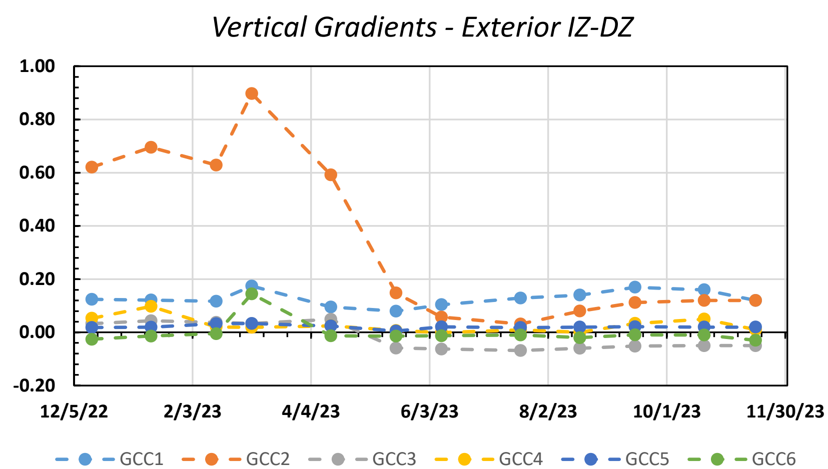
Attachment B-3

Vertical Gradients Summary: December 2023
Arkema Inc. Facility
Portland, Oregon





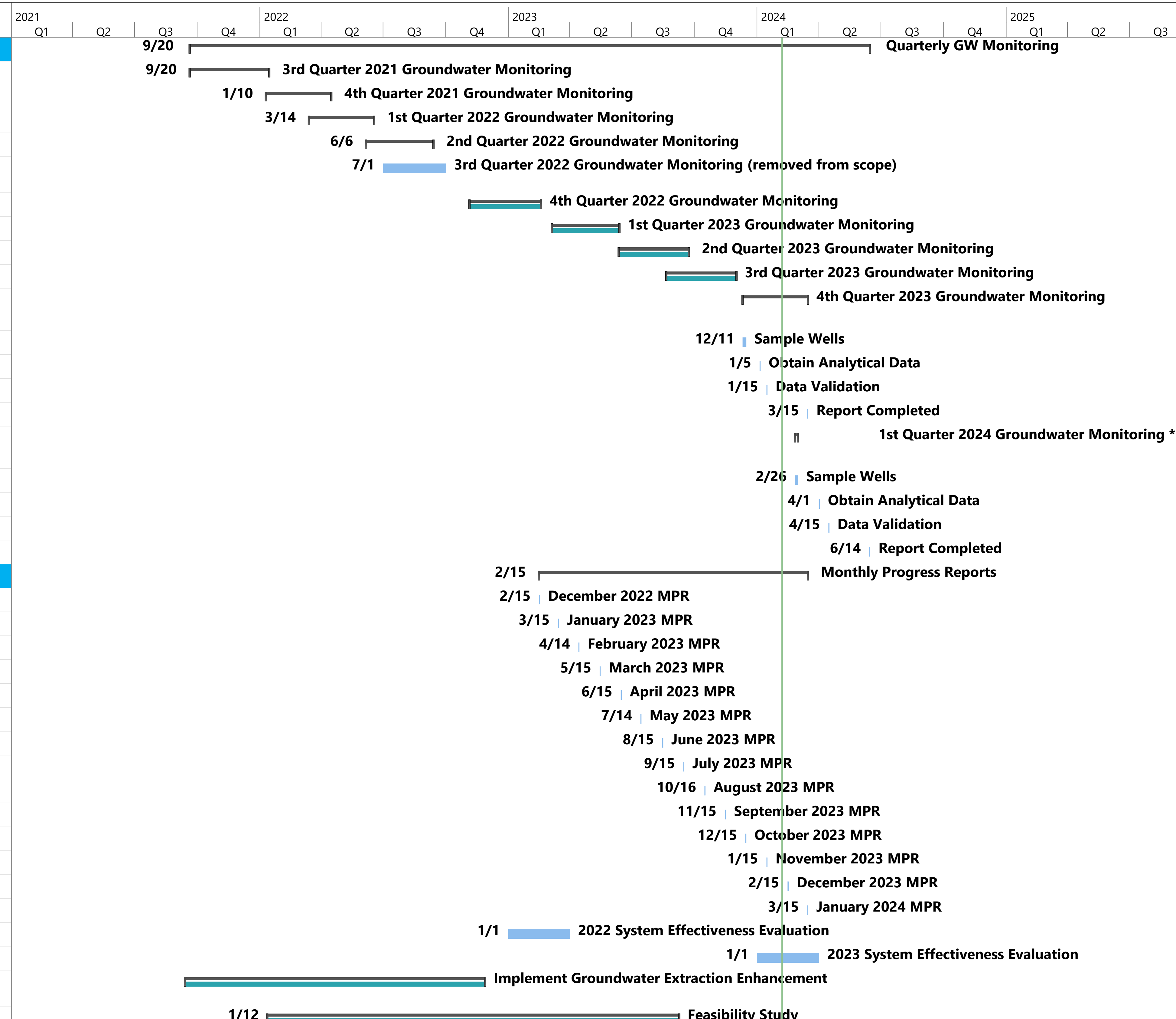




ERM

ATTACHMENT C PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**Quarterly GW Monitoring**	**719 days**	**Mon 9/20/21**	**Fri 6/14/24**
2	*3rd Quarter 2021 Groundwater Monitoring*	*85 days*	*Mon 9/20/21*	*Fri 1/14/22*
7	*4th Quarter 2021 Groundwater Monitoring*	*70 days*	*Mon 1/10/22*	*Fri 4/15/22*
11	*1st Quarter 2022 Groundwater Monitoring*	*70 days*	*Mon 3/14/22*	*Fri 6/17/22*
16	*2nd Quarter 2022 Groundwater Monitoring*	*71 days*	*Mon 6/6/22*	*Mon 9/12/22*
21	*3rd Quarter 2022 Groundwater Monitoring (removed from scope)*	*66 days*	*Fri 7/1/22*	*Fri 9/30/22*
22	*4th Quarter 2022 Groundwater Monitoring*	*78 days*	*Sat 11/5/22*	*Fri 2/17/23*
27	*1st Quarter 2023 Groundwater Monitoring*	*71 days*	*Mon 3/6/23*	*Mon 6/12/23*
32	*2nd Quarter 2023 Groundwater Monitoring*	*75 days*	*Mon 6/12/23*	*Fri 9/22/23*
37	*3rd Quarter 2023 Groundwater Monitoring*	*75 days*	*Mon 8/21/23*	*Fri 12/1/23*
42	**4th Quarter 2023 Groundwater Monitoring**	**70 days**	**Mon 12/11/23**	**Fri 3/15/24**
43	*Sample Wells*	*5 days*	*Mon 12/11/23*	*Fri 12/15/23*
44	Obtain Analytical Data	1 day	Fri 1/5/24	Fri 1/5/24
45	Data Validation	1 day	Mon 1/15/24	Mon 1/15/24
46	Report Completed	1 day	Fri 3/15/24	Fri 3/15/24
47	**1st Quarter 2024 Groundwater Monitoring ***	**4 days**	**Mon 2/26/24**	**Thu 2/29/24**
48	Sample Wells	4 days	Mon 2/26/24	Thu 2/29/24
49	Obtain Analytical Data	1 day	Mon 4/1/24	Mon 4/1/24
50	Data Validation	1 day	Mon 4/15/24	Mon 4/15/24
51	Report Completed	1 day	Fri 6/14/24	Fri 6/14/24
52	**Monthly Progress Reports**	**283 days**	**Wed 2/15/23**	**Fri 3/15/24**
53	*December 2022 MPR*	*1 day*	*Wed 2/15/23*	*Wed 2/15/23*
54	*January 2023 MPR*	*1 day*	*Wed 3/15/23*	*Wed 3/15/23*
55	*February 2023 MPR*	*1 day*	*Fri 4/14/23*	*Fri 4/14/23*
56	*March 2023 MPR*	*1 day*	*Mon 5/15/23*	*Mon 5/15/23*
57	*April 2023 MPR*	*1 day*	*Thu 6/15/23*	*Thu 6/15/23*
58	*May 2023 MPR*	*1 day*	*Fri 7/14/23*	*Fri 7/14/23*
59	*June 2023 MPR*	*1 day*	*Tue 8/15/23*	*Tue 8/15/23*
60	*July 2023 MPR*	*1 day*	*Fri 9/15/23*	*Fri 9/15/23*
61	*August 2023 MPR*	*1 day*	*Mon 10/16/23*	*Mon 10/16/23*
62	*September 2023 MPR*	*1 day*	*Wed 11/15/23*	*Wed 11/15/23*
63	*October 2023 MPR*	*1 day*	*Fri 12/15/23*	*Fri 12/15/23*
64	*November 2023 MPR*	*1 day*	*Mon 1/15/24*	*Mon 1/15/24*
65	December 2023 MPR	1 day	Thu 2/15/24	Thu 2/15/24
66	January 2024 MPR	1 day	Fri 3/15/24	Fri 3/15/24
67	***2022 System Effectiveness Evaluation***	***66 days***	***Sun 1/1/23***	***Fri 3/31/23***
68	2023 System Effectiveness Evaluation	66 days	Mon 1/1/24	Sun 3/31/24
69	***Implement Groundwater Extraction Enhancement***	***317 days***	***Mon 9/13/21***	***Sun 11/27/22***
77	***Feasibility Study***	***436 days***	***Wed 1/12/22***	***Fri 9/8/23***



Arkema Portland
Monthly Progress Report
Attachment C

Task		Project Summary		Manual Task		Start-only		Deadline	
Split		Inactive Task		Duration-only		Finish-only		Progress	
Milestone		Inactive Milestone		Manual Summary Rollup		External Tasks		Manual Progress	
Summary		Inactive Summary		Manual Summary		External Milestone			

ERM

APPENDIX B STATISTICAL DATA EVALUATION SUMMARY (TABLES B1 THROUGH B7)

Table B1
Statistical Data Evaluation Summary - GCC1 & Proximal Wells
System Effectiveness Evaluation
Arkema Inc.
Portland, OR

Analyte	Cluster	Aquifer Zone	Location	Unit	Number of Samples Historical (2007-2010)	Number of Samples Current (2019-2023)	Total Number of Samples	Historical Max Conc (2007-2010)	Current Max Conc (2019-2023)	Order of Magnitude Change	Detect Status Change	Study Period Trend (2007-2023)	Statistical Trend Current (2019-2023)
Chloride	GCC1 & Proximal Wells	Deep	PA-18D	ug/L	0	4	4		80000	N/A	N/A	N/A	Insufficient samples
Chloride	GCC1 & Proximal Wells	Deep	PA-27D	ug/L	0	15	15		1150000	N/A	N/A	N/A	Decreasing
Chloride	GCC1 & Proximal Wells	Intermediate	PA-10I	ug/L	0	15	15		1300000	N/A	N/A	N/A	Decreasing
Chloride	GCC1 & Proximal Wells	Intermediate	PA-17IR	ug/L	0	15	15		73600	N/A	N/A	N/A	Decreasing
Chloride	GCC1 & Proximal Wells	Intermediate	PA-32I	ug/L	0	15	15		170000	N/A	N/A	N/A	Decreasing
Chloride	GCC1 & Proximal Wells	Shallow	MWA-63	ug/L	4	15	19	690000	83000	Decrease	None	Decreasing	Stable
Chloride	GCC1 & Proximal Wells	Shallow	PA-03	ug/L	0	15	15		10000	N/A	N/A	N/A	Decreasing
Chloride	GCC1 & Proximal Wells	Shallow	PA-04	ug/L	0	15	15		14300	N/A	N/A	N/A	Decreasing
Chloride	GCC1 & Proximal Wells	Shallow	PA-31	ug/L	0	15	15		10500	N/A	N/A	N/A	Decreasing
Chlorobenzene	GCC1 & Proximal Wells	Deep	PA-18D	ug/L	0	4	4		<0.44	N/A	N/A	N/A	Insufficient samples
Chlorobenzene	GCC1 & Proximal Wells	Deep	PA-27D	ug/L	0	15	15		3.5	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	GCC1 & Proximal Wells	Intermediate	PA-10I	ug/L	0	15	15		5.7	N/A	N/A	N/A	Increasing
Chlorobenzene	GCC1 & Proximal Wells	Intermediate	PA-17IR	ug/L	0	15	15		24	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	GCC1 & Proximal Wells	Intermediate	PA-32I	ug/L	0	15	15		<0.7	N/A	N/A	N/A	Stable
Chlorobenzene	GCC1 & Proximal Wells	Shallow	MWA-63	ug/L	4	15	19	<100	<44	N/A	None	Insufficient detects	Insufficient detects
Chlorobenzene	GCC1 & Proximal Wells	Shallow	PA-03	ug/L	0	15	15		<0.44	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	GCC1 & Proximal Wells	Shallow	PA-04	ug/L	0	15	15		<2	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	GCC1 & Proximal Wells	Shallow	PA-31	ug/L	0	15	15		<0.44	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Deep	PA-18D	ug/L	0	4	4		<40	N/A	N/A	N/A	Insufficient samples
Perchlorate	GCC1 & Proximal Wells	Deep	PA-27D	ug/L	0	15	15		<95	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Intermediate	PA-10I	ug/L	0	15	15		<95	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Intermediate	PA-17IR	ug/L	0	15	15		<190	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Intermediate	PA-32I	ug/L	0	15	15		<190	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Shallow	MWA-63	ug/L	4	15	19	<8	13	N/A	ND to Dete	Insufficient detects	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Shallow	PA-03	ug/L	0	15	15		<95	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Shallow	PA-04	ug/L	0	15	15		<48	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Shallow	PA-31	ug/L	0	15	15		<100	N/A	N/A	N/A	Insufficient detects

Notes:

[a]Order of Magnitude Change:
Increase: The current concentration is at least an order of magnitude greater than the historical concentration.
Decrease: The current concentration is at least an order of magnitude less than the historical concentration.
None: The current concentration is not an order of magnitude greater or less than the historical concentration.
N/A: Either the detection status differs between historical and current concentrations, both concentrations are non-detect, or historical concentrations do not exist

[b]Detect Status Change:
Detect to non-detect: Status change from detect to non-detect.
Non-detect to detect, high current detection limit: Current detection limit was greater than historical detection.
Detect to non-detect, high historical detection limit: Historical detection limit was greater than current detection.
None: Same detection status between historical and current.
N/A: No historical data was collected for comparison.

[c]Statistical Trend (Historical and Current):
Stable, increasing, or decreasing: Trend criteria was met and calculated.
Insufficient detects/Insufficient samples/ Insufficient FOD: Trend criteria was not met and not calculated.
N/A: No historical data is available for comparison.

ug/L = micrograms per liter
N/A = not applicable
ND = non-detect

Table B2
Statistical Data Evaluation Summary - GCC2
System Effectiveness Evaluation
Arkema Inc.
Portland, OR

Analyte	Cluster	Aquifer Zone	Location	Unit	Number of Samples Historical (2007-2010)	Number of Samples Current (2019-2023)	Total Number of Samples	Historical Max Conc (2007-2010)	Current Max Conc (2019-2023)	Order of Magnitude Change	Detect Status Change	Study Period Trend (2007-2023)	Statistical Trend Current (2019-2023)
Chloride	GCC2	Deep	PA-19D	ug/L	0	15	15		360000	N/A	N/A	N/A	Increasing
Chloride	GCC2	Deep	PA-30D	ug/L	0	15	15		540000	N/A	N/A	N/A	Stable
Chlorobenzene	GCC2	Deep	PA-19D	ug/L	0	14	14		12000	N/A	N/A	N/A	Stable
Chlorobenzene	GCC2	Deep	PA-30D	ug/L	0	14	14		26000	N/A	N/A	N/A	Increasing
Perchlorate	GCC2	Deep	PA-19D	ug/L	0	15	15		<200	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC2	Deep	PA-30D	ug/L	0	15	15		<200	N/A	N/A	N/A	Insufficient detects

Notes:
[a]Order of Magnitude Change:
Increase: The current concentration is at least an order of magnitude greater than the historical concentration.
Decrease: The current concentration is at least an order of magnitude less than the historical concentration.
None: The current concentration is not an order of magnitude greater or less than the historical concentration.
N/A: Either the detection status differs between historical and current concentrations, both concentrations are non-detect, or historical concentrations do not exist.

[b]Detect Status Change:
Detect to non-detect: Status change from detect to non-detect.
Non-detect to detect, high current detection limit: Current detection limit was greater than historical detection.
Detect to non-detect, high historical detection limit: Historical detection limit was greater than current detection.
None: Same detection status between historical and current.
N/A: No historical data was collected for comparison.

[c]Statistical Trend (Historical and Current):
Stable, increasing, or decreasing: Trend criteria was met and calculated.
Insufficient detects/Insufficient samples/ Insufficient FOD: Trend criteria was not met and not calculated.
N/A: No historical data is available for comparison.

ug/L = micrograms per liter
N/A = not applicable
ND = non-detect

Table B3
Statistical Data Evaluation Summary - GCC3
System Effectiveness Evaluation
Arkema Inc.
Portland, OR

Analyte	Cluster	Aquifer Zone	Location	Unit	Number of Samples Historical (2007-2010)	Number of Samples Current (2019-2023)	Total Number of Samples	Historical Max Conc (2007-2010)	Current Max Conc (2019-2023)	Order of Magnitude Change	Detect Status Change	Study Period Trend (2007-2023)	Statistical Trend Current (2019-2023)
Chloride	GCC3	Deep	PA-20D	ug/L	0	15	15		1200000	N/A	N/A	N/A	Stable
Chloride	GCC3	Deep	PA-21D	ug/L	0	15	15		463000	N/A	N/A	N/A	Decreasing
Chlorobenzene	GCC3	Deep	PA-20D	ug/L	0	15	15		41	N/A	N/A	N/A	Decreasing
Chlorobenzene	GCC3	Deep	PA-21D	ug/L	0	15	15		49000	N/A	N/A	N/A	Decreasing
Perchlorate	GCC3	Deep	PA-20D	ug/L	0	15	15		140	N/A	N/A	N/A	Stable
Perchlorate	GCC3	Deep	PA-21D	ug/L	0	15	15		2400	N/A	N/A	N/A	Decreasing

Notes:
[a]Order of Magnitude Change:
Increase: The current concentration is at least an order of magnitude greater than the historical concentration.
Decrease: The current concentration is at least an order of magnitude less than the historical concentration.
None: The current concentration is not an order of magnitude greater or less than the historical concentration.
N/A: Either the detection status differs between historical and current concentrations, both concentrations are non-detect, or historical concentrations do not exist.

[b]Detect Status Change:
Detect to non-detect: Status change from detect to non-detect.
Non-detect to detect, high current detection limit: Current detection limit was greater than historical detection.
Detect to non-detect, high historical detection limit: Historical detection limit was greater than current detection.
None: Same detection status between historical and current.
N/A: No historical data was collected for comparison.

[c]Statistical Trend (Historical and Current):
Stable, increasing, or decreasing: Trend criteria was met and calculated.
Insufficient detects/Insufficient samples/ Insufficient FOD: Trend criteria was not met and not calculated.
N/A: No historical data is available for comparison.

ug/L = micrograms per liter
N/A = not applicable
ND = non-detect

Table B4
Statistical Data Evaluation Summary - GCC4 & Proximal Wells
System Effectiveness Evaluation
Arkema Inc.
Portland, OR

Analyte	Cluster	Aquifer Zone	Location	Unit	Number of Samples Historical (2007-2010)	Number of Samples Current (2019-2023)	Total Number of Samples	Historical Max Conc (2007-2010)	Current Max Conc (2019-2023)	Order of Magnitude Change	Detect Status Change	Study Period Trend (2007-2023)	Statistical Trend Current (2019-2023)
Chloride	GCC4 & Proximal Wells	Deep	MWA-56D	ug/L	4	15	19	27900000	26000000	None	None	Decreasing	Decreasing
Chloride	GCC4 & Proximal Wells	Deep	MWA-58D	ug/L	4	15	19	53600000	29000000	None	None	Decreasing	Stable
Chloride	GCC4 & Proximal Wells	Deep	PA-22D	ug/L	0	15	15		10200000	N/A	N/A	N/A	Decreasing
Chlorobenzene	GCC4 & Proximal Wells	Deep	MWA-56D	ug/L	4	15	19	<5	<4.4	N/A	None	Insufficient detects	Insufficient detects
Chlorobenzene	GCC4 & Proximal Wells	Deep	MWA-58D	ug/L	4	15	19	<2.5	<4.4	N/A	None	Insufficient detects	Insufficient detects
Chlorobenzene	GCC4 & Proximal Wells	Deep	PA-22D	ug/L	0	15	15		<0.44	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC4 & Proximal Wells	Deep	MWA-56D	ug/L	4	15	19	2430	15000	Increase	None	Increasing	Increasing
Perchlorate	GCC4 & Proximal Wells	Deep	MWA-58D	ug/L	4	15	19	128000	61000	Decrease	None	Stable	Stable
Perchlorate	GCC4 & Proximal Wells	Deep	PA-22D	ug/L	0	15	15		54000	N/A	N/A	N/A	Decreasing

Notes:
[a]Order of Magnitude Change:
Increase: The current concentration is at least an order of magnitude greater than the historical concentration.
Decrease: The current concentration is at least an order of magnitude less than the historical concentration.
None: The current concentration is not an order of magnitude greater or less than the historical concentration.
N/A: Either the detection status differs between historical and current concentrations, both concentrations are non-detect, or historical concentrations do not exist.

[b]Detect Status Change:
Detect to non-detect: Status change from detect to non-detect.
Non-detect to detect, high current detection limit: Current detection limit was greater than historical detection.
Detect to non-detect, high historical detection limit: Historical detection limit was greater than current detection.
None: Same detection status between historical and current.
N/A: No historical data was collected for comparison.

[c]Statistical Trend (Historical and Current):
Stable, increasing, or decreasing: Trend criteria was met and calculated.
Insufficient detects/Insufficient samples/ Insufficient FOD: Trend criteria was not met and not calculated.
N/A: No historical data is available for comparison.

ug/L = micrograms per liter
N/A = not applicable
ND = non-detect

Table B5
Statistical Data Evaluation Summary - GCC5 & Proximal Wells
System Effectiveness Evaluation
Arkema Inc.
Portland, OR

Analyte	Cluster	Aquifer Zone	Location	Unit	Number of Samples Historical (2007-2010)	Number of Samples Current (2019-2023)	Total Number of Samples	Historical Max Conc (2007-2010)	Current Max Conc (2019-2023)	Order of Magnitude Change	Detect Status Change	Study Period Trend (2007-2023)	Statistical Trend Current (2019-2023)
Chloride	GCC5 & Proximal Wells	Deep	MWA-31I(D)	ug/L	4	15	19	54300000	30000000	None	None	Decreasing	Stable
Chloride	GCC5 & Proximal Wells	Deep	PA-23D	ug/L	0	15	15		30000000	N/A	N/A	N/A	Increasing
Chloride	GCC5 & Proximal Wells	Deep	PA-24D	ug/L	0	15	15		46000000	N/A	N/A	N/A	Decreasing
Chlorobenzene	GCC5 & Proximal Wells	Deep	MWA-31I(D)	ug/L	4	15	19	<2.5	<1	N/A	None	Insufficient FOD	Insufficient detects
Chlorobenzene	GCC5 & Proximal Wells	Deep	PA-23D	ug/L	0	15	15		2.8	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	GCC5 & Proximal Wells	Deep	PA-24D	ug/L	0	15	15		<0.44	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC5 & Proximal Wells	Deep	MWA-31I(D)	ug/L	4	15	19	5730	100000	Increase	None	Stable	Stable
Perchlorate	GCC5 & Proximal Wells	Deep	PA-23D	ug/L	0	15	15		<1000	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC5 & Proximal Wells	Deep	PA-24D	ug/L	0	15	15		<400	N/A	N/A	N/A	Insufficient detects

Notes:
[a]Order of Magnitude Change:
Increase: The current concentration is at least an order of magnitude greater than the historical concentration.
Decrease: The current concentration is at least an order of magnitude less than the historical concentration.
None: The current concentration is not an order of magnitude greater or less than the historical concentration.
N/A: Either the detection status differs between historical and current concentrations, both concentrations are non-detect, or historical concentrations do not exist.

[b]Detect Status Change:
Detect to non-detect: Status change from detect to non-detect.
Non-detect to detect, high current detection limit: Current detection limit was greater than historical detection.
Detect to non-detect, high historical detection limit: Historical detection limit was greater than current detection.
None: Same detection status between historical and current.
N/A: No historical data was collected for comparison.

[c]Statistical Trend (Historical and Current):
Stable, increasing, or decreasing: Trend criteria was met and calculated.
Insufficient detects/Insufficient samples/ Insufficient FOD: Trend criteria was not met and not calculated.
N/A: No historical data is available for comparison.

ug/L = micrograms per liter
N/A = not applicable
ND = non-detect

Table B6
Statistical Data Evaluation Summary - GCC6 & Proximal Wells
System Effectiveness Evaluation
Arkema Inc.
Portland, OR

Analyte	Cluster	Aquifer Zone	Location	Unit	Number of Samples Historical (2007-2010)	Number of Samples Current (2019-2023)	Total Number of Samples	Historical Max Conc (2007-2010)	Current Max Conc (2019-2023)	Order of Magnitude Change	Detect Status Change	Study Period Trend (2007-2023)	Statistical Trend Current (2019-2023)
Chloride	GCC6 & Proximal Wells	Deep	PA-25D	ug/L	0	15	15		34000	N/A	N/A	N/A	Stable
Chloride	GCC6 & Proximal Wells	Deep	PA-26D	ug/L	0	15	15		74000	N/A	N/A	N/A	Increasing
Chloride	GCC6 & Proximal Wells	Intermediate	MWA-81I	ug/L	0	15	15		610000	N/A	N/A	N/A	Stable
Chloride	GCC6 & Proximal Wells	Intermediate	PA-15I	ug/L	0	15	15		850000	N/A	N/A	N/A	Stable
Chloride	GCC6 & Proximal Wells	Intermediate	PA-16I	ug/L	0	15	15		530000	N/A	N/A	N/A	Stable
Chloride	GCC6 & Proximal Wells	Intermediate	PA-44I	ug/L	0	15	15		370000	N/A	N/A	N/A	Decreasing
Chloride	GCC6 & Proximal Wells	Shallow	MWA-41	ug/L	4	15	19	26600	21000	None	None	Decreasing	Stable
Chloride	GCC6 & Proximal Wells	Shallow	MWA-82	ug/L	0	15	15		34800	N/A	N/A	N/A	Decreasing
Chloride	GCC6 & Proximal Wells	Shallow	PA-08	ug/L	0	15	15		770000	N/A	N/A	N/A	Stable
Chloride	GCC6 & Proximal Wells	Shallow	PA-09	ug/L	0	15	15		199000	N/A	N/A	N/A	Stable
Chlorobenzene	GCC6 & Proximal Wells	Deep	PA-25D	ug/L	0	15	15		<0.44	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Deep	PA-26D	ug/L	0	16	16		0.71	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Intermediate	MWA-81I	ug/L	0	15	15		<0.44	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Intermediate	PA-15I	ug/L	0	15	15		<2.5	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Intermediate	PA-16I	ug/L	0	16	16		<0.44	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Intermediate	PA-44I	ug/L	0	15	15		<0.44	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Shallow	MWA-41	ug/L	0	15	15		<0.44	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Shallow	MWA-82	ug/L	0	15	15		<0.44	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Shallow	PA-08	ug/L	0	15	15		<0.6	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Shallow	PA-09	ug/L	0	16	16		<0.44	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Deep	PA-25D	ug/L	0	15	15		<9.5	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Deep	PA-26D	ug/L	0	15	15		<9.5	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Intermediate	MWA-81I	ug/L	0	15	15		<10	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Intermediate	PA-15I	ug/L	0	15	15		<48	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Intermediate	PA-16I	ug/L	0	15	15		<48	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Intermediate	PA-44I	ug/L	0	15	15		390	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Shallow	MWA-41	ug/L	4	15	19	<4	<2	N/A	None	Insufficient detects	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Shallow	MWA-82	ug/L	0	15	15		530	N/A	N/A	N/A	Stable
Perchlorate	GCC6 & Proximal Wells	Shallow	PA-08	ug/L	0	15	15		<48	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Shallow	PA-09	ug/L	0	15	15		120	N/A	N/A	N/A	Insufficient detects

Notes:
[a]Order of Magnitude Change:
Increase: The current concentration is at least an order of magnitude greater than the historical concentration.
Decrease: The current concentration is at least an order of magnitude less than the historical concentration.
None: The current concentration is not an order of magnitude greater or less than the historical concentration.
N/A: Either the detection status differs between historical and current concentrations, both concentrations are non-detect, or historical concentrations do not exist.

[b]Detect Status Change:
Detect to non-detect: Status change from detect to non-detect.
Non-detect to detect, high current detection limit: Current detection limit was greater than historical detection.
Detect to non-detect, high historical detection limit: Historical detection limit was greater than current detection.
None: Same detection status between historical and current.
N/A: No historical data was collected for comparison.

[c]Statistical Trend (Historical and Current):
Stable, increasing, or decreasing: Trend criteria was met and calculated.
Insufficient detects/Insufficient samples/ Insufficient FOD: Trend criteria was not met and not calculated.
N/A: No historical data is available for comparison.

ug/L = micrograms per liter
N/A = not applicable
ND = non-detect

Table B7
Statistical Data Evaluation Summary - Well Distal from BW and GCCs
System Effectiveness Evaluation
Arkema Inc.
Portland, OR

Analyte	Cluster	Aquifer Zone	Location	Unit	Number of Samples Historical (2007-2010)	Number of Samples Current (2019-2023)	Total Number of Samples	Historical Max Conc (2007-2010)	Current Max Conc (2019-2023)	Order of Magnitude Change	Detect Status Change	Study Period Trend (2007-2023)	Statistical Trend Current (2019-2023)
Chloride	Well Distal from BW and GCCs	Deep	MWA-11I(D)	ug/L	4	15	19	1210000	2200000	None	None	Stable	Stable
Chlorobenzene	Well Distal from BW and GCCs	Deep	MWA-11I(D)	ug/L	4	15	19	1.92	7	None	None	Stable	Stable
Perchlorate	Well Distal from BW and GCCs	Deep	MWA-11I(D)	ug/L	4	15	19	<8	<48	N/A	None	Insufficient detects	Insufficient detects

Notes:
[a]Order of Magnitude Change:
Increase: The current concentration is at least an order of magnitude greater than the historical concentration.
Decrease: The current concentration is at least an order of magnitude less than the historical concentration.
None: The current concentration is not an order of magnitude greater or less than the historical concentration.
N/A: Either the detection status differs between historical and current concentrations, both concentrations are non-detect, or historical concentrations do not exist.

[b]Detect Status Change:
Detect to non-detect: Status change from detect to non-detect.
Non-detect to detect, high current detection limit: Current detection limit was greater than historical detection.
Detect to non-detect, high historical detection limit: Historical detection limit was greater than current detection.
None: Same detection status between historical and current.
N/A: No historical data was collected for comparison.

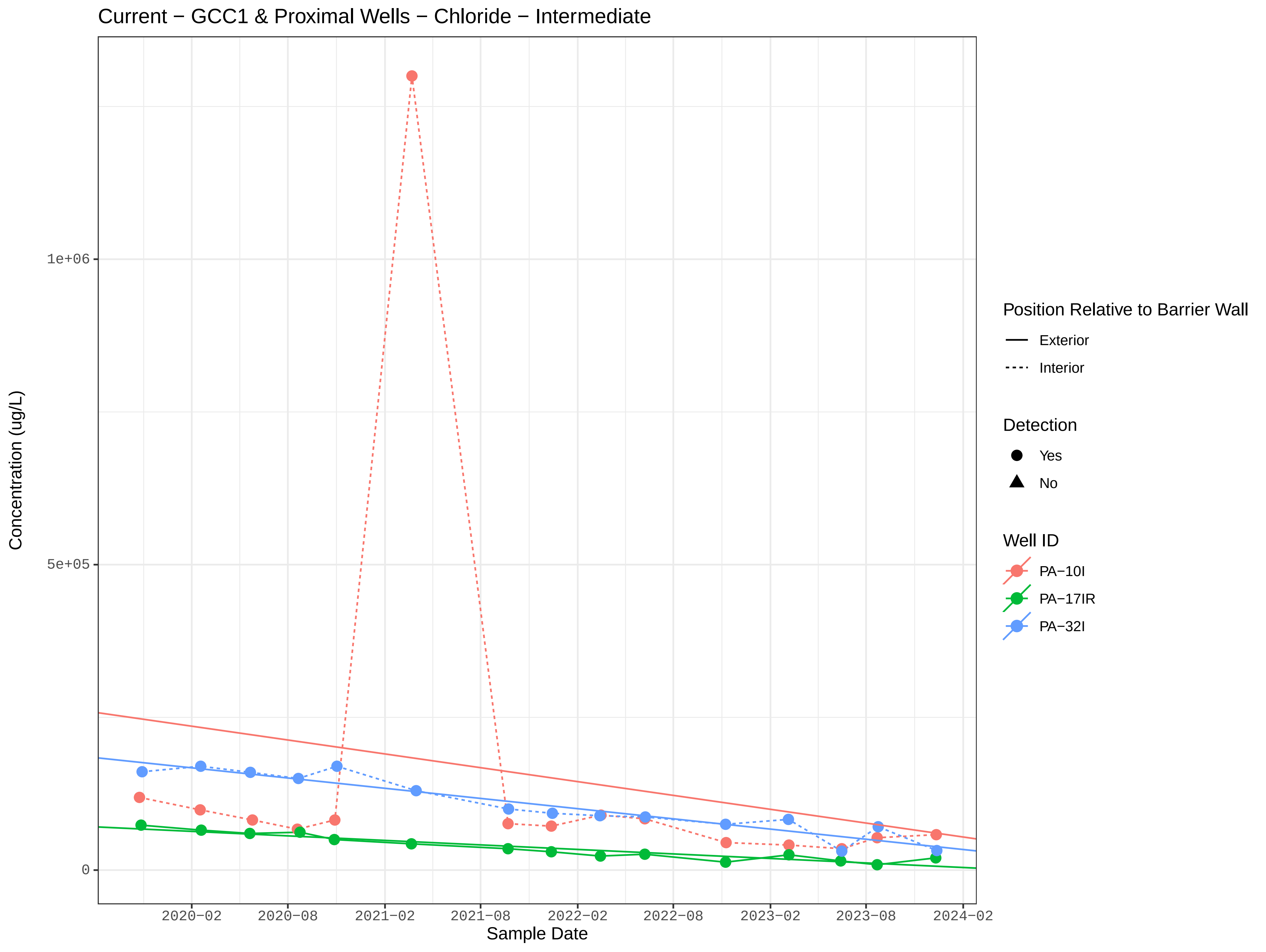
[c]Statistical Trend (Historical and Current):
Stable, increasing, or decreasing: Trend criteria was met and calculated.
Insufficient detects/Insufficient samples/ Insufficient FOD: Trend criteria was not met and not calculated.
N/A: No historical data is available for comparison.

ug/L = micrograms per liter
N/A = not applicable
ND = non-detect

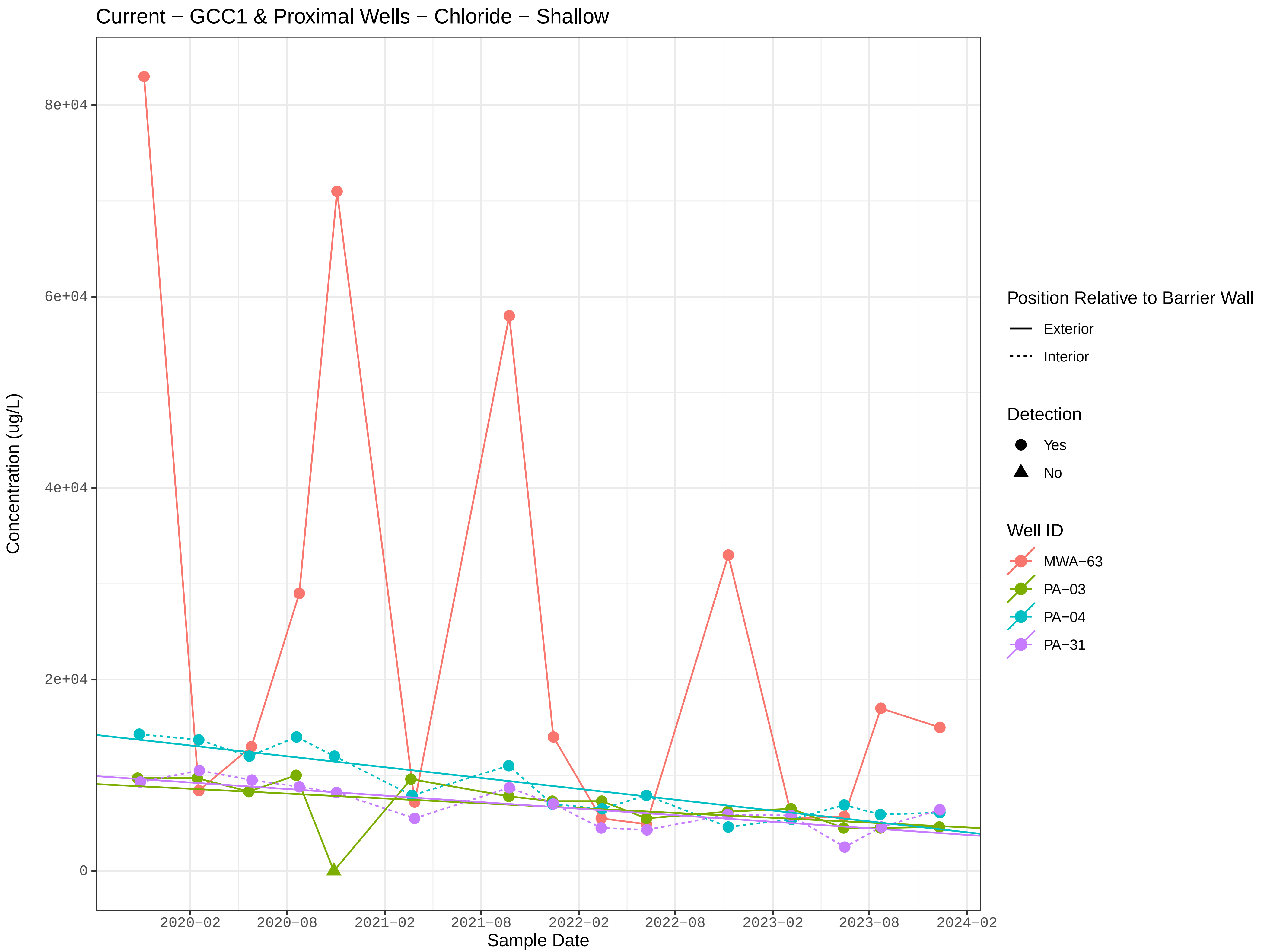
ERM

APPENDIX C MANN-KENDALL SCATTERPLOTS AND TREND ANALYSIS

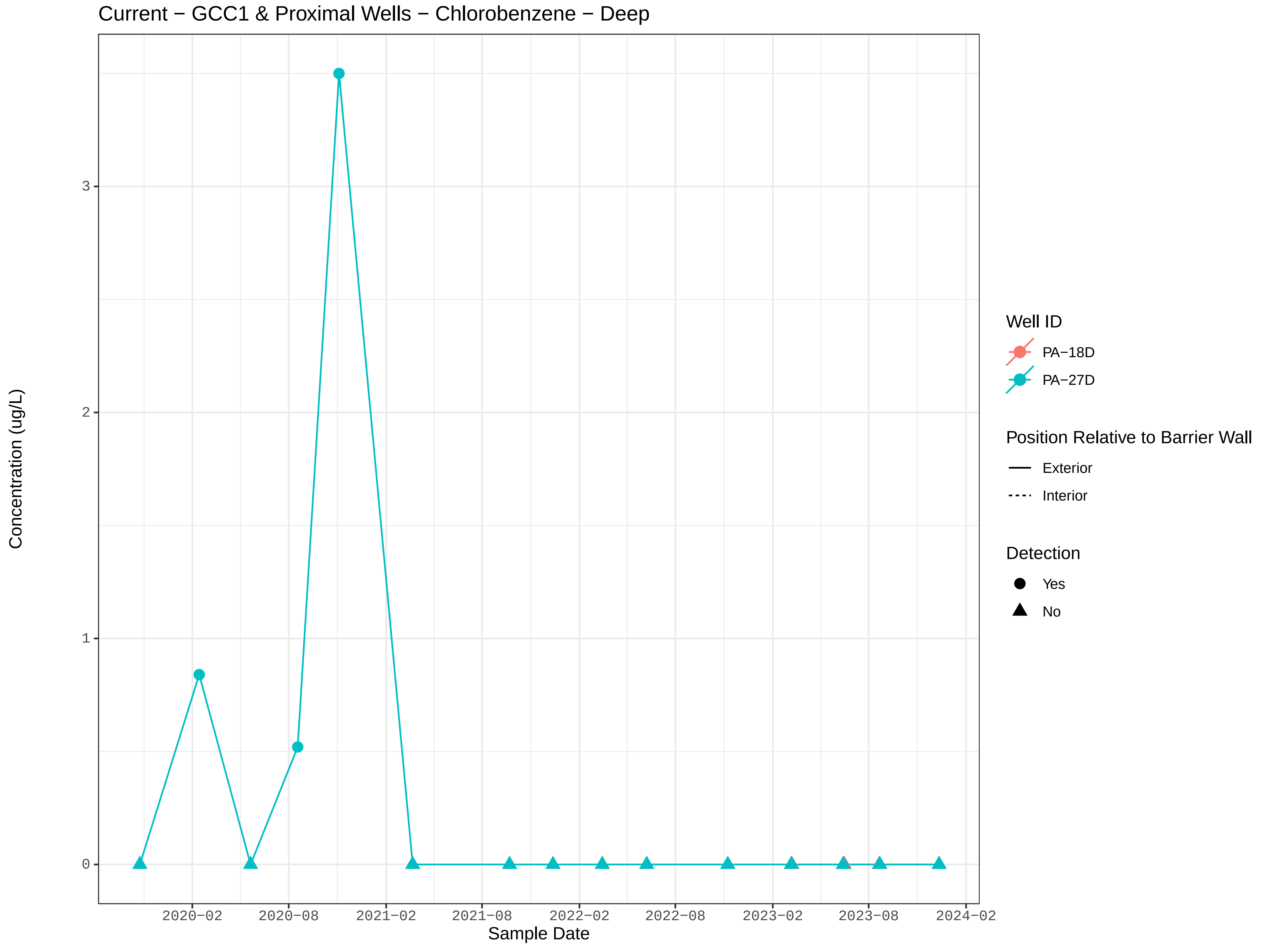
Current − GCC1 & Proximal Wells − Chloride − Deep



Current − GCC1 & Proximal Wells − Chloride − Intermediate
Concentration (ug/L)
1e+06
5e+05
0
2020−02
2020−08
2021−02
2021−08
2022−02
2022−08
2023−02
2023−08
2024−02
Sample Date
Position Relative to Barrier Wall
Exterior
Interior
Detection
Yes
No
Well ID
PA−10I
PA−17IR
PA−32I

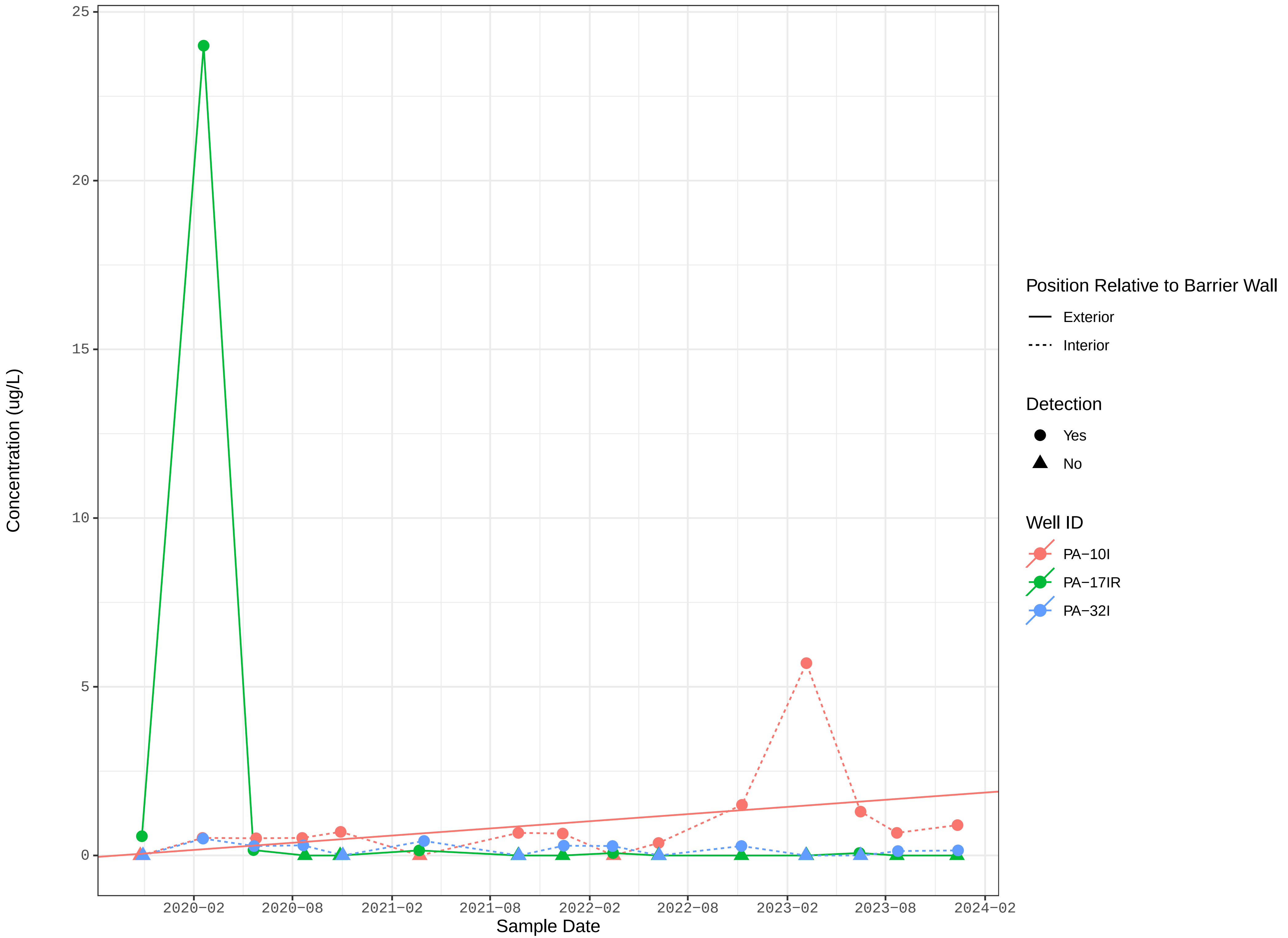


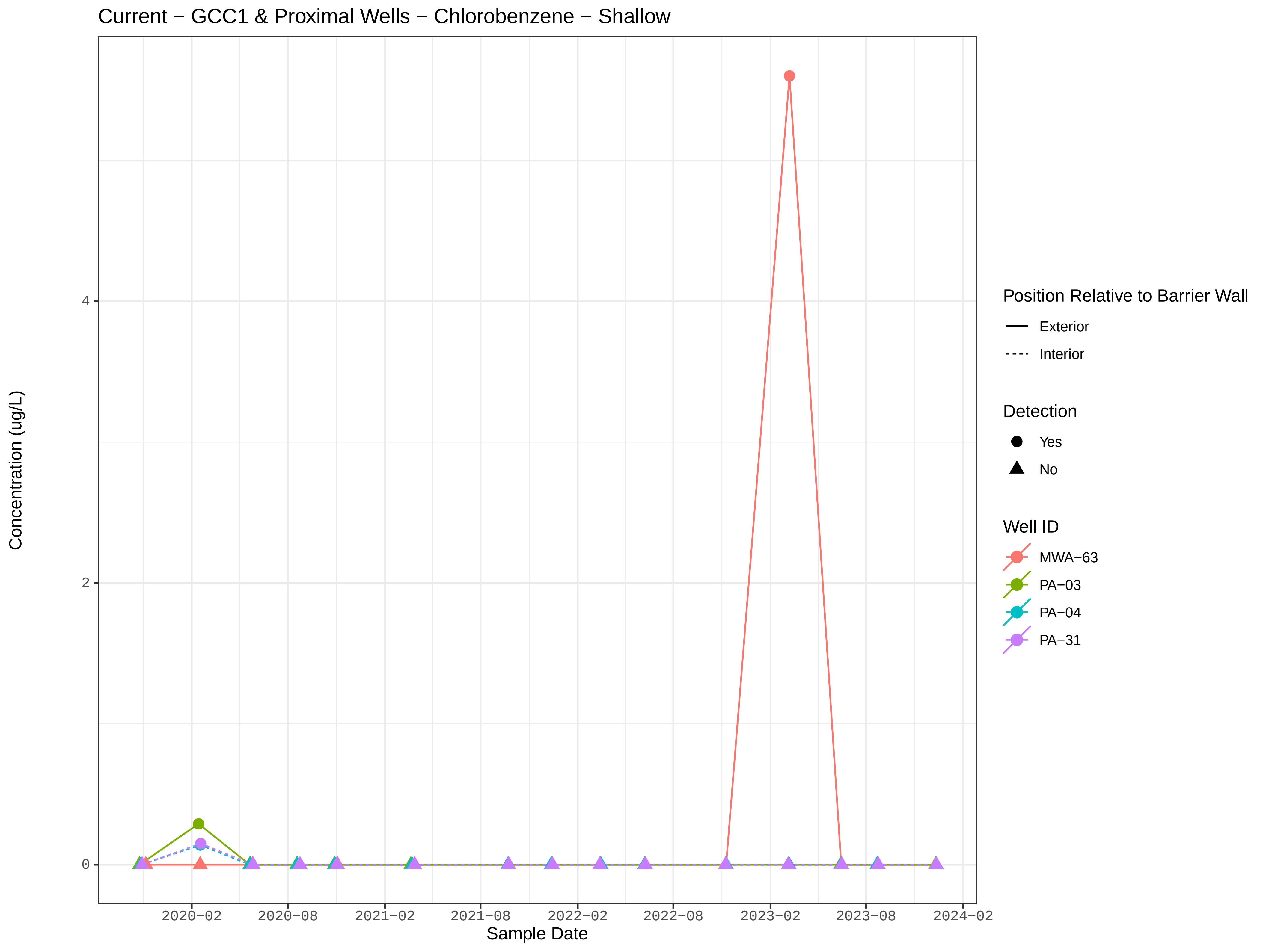
Current − GCC1 & Proximal Wells − Chloride − Shallow
Concentration (ug/L)
8e+04
6e+04
4e+04
2e+04
0
2020−02
2020−08
2021−02
2021−08
2022−02
2022−08
2023−02
2023−08
2024−02
Sample Date
Position Relative to Barrier Wall
Exterior
Interior
Detection
Yes
No
Well ID
MWA−63
PA−03
PA−04
PA−31

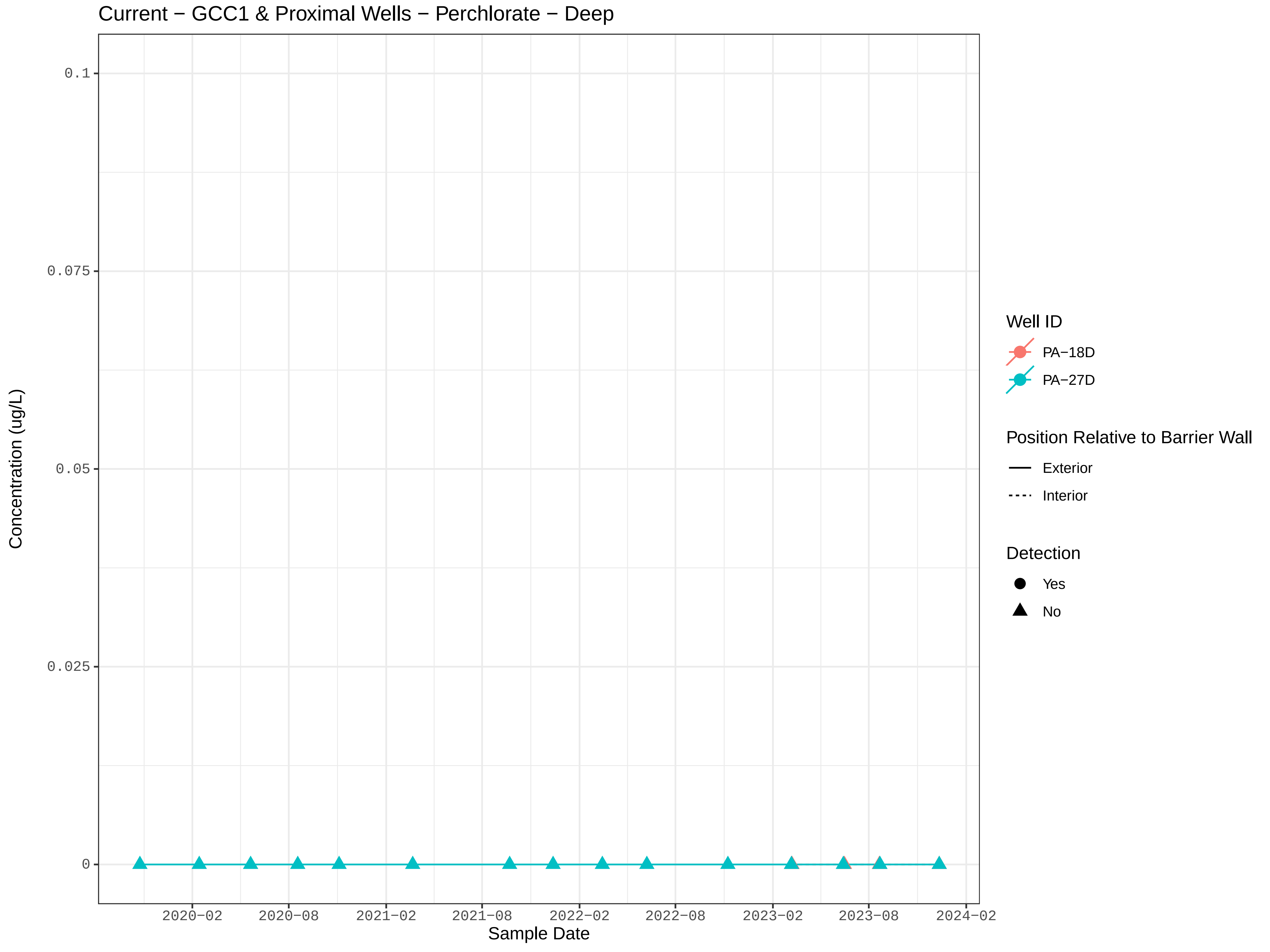


Current − GCC1 & Proximal Wells − Chlorobenzene − Deep
Concentration (ug/L)
0
1
2
3
2020−02
2020−08
2021−02
2021−08
2022−02
2022−08
2023−02
2023−08
2024−02
Sample Date
Well ID
PA−18D
PA−27D
Position Relative to Barrier Wall
Exterior
Interior
Detection
Yes
No

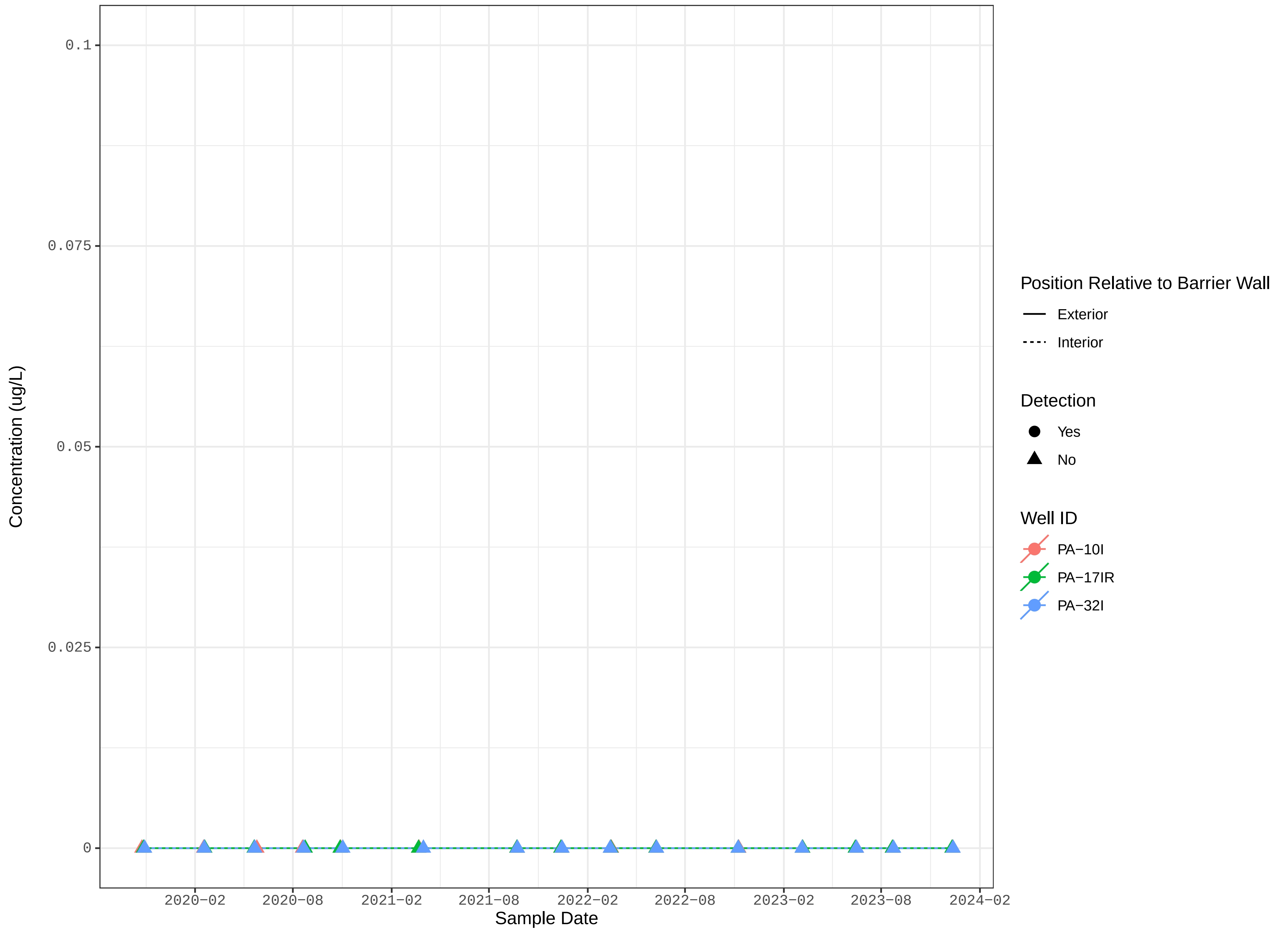
Current − GCC1 & Proximal Wells − Chlorobenzene − Intermediate



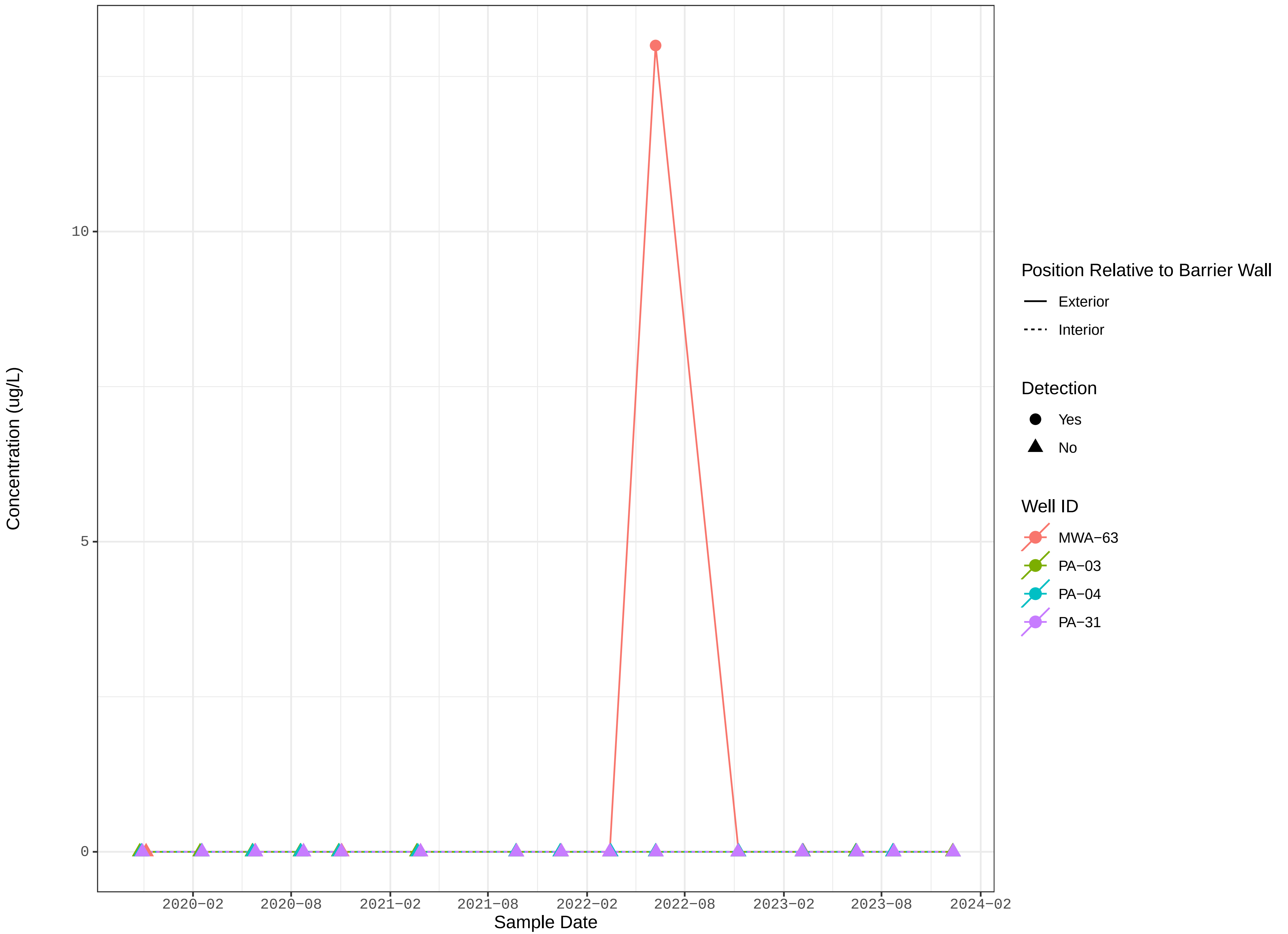

Current − GCC1 & Proximal Wells − Chlorobenzene − Shallow
Concentration (ug/L)
4
2
0
2020−02
2020−08
2021−02
2021−08
2022−02
2022−08
2023−02
2023−08
2024−02
Sample Date
Position Relative to Barrier Wall
Exterior
Interior
Detection
Yes
No
Well ID
MWA−63
PA−03
PA−04
PA−31

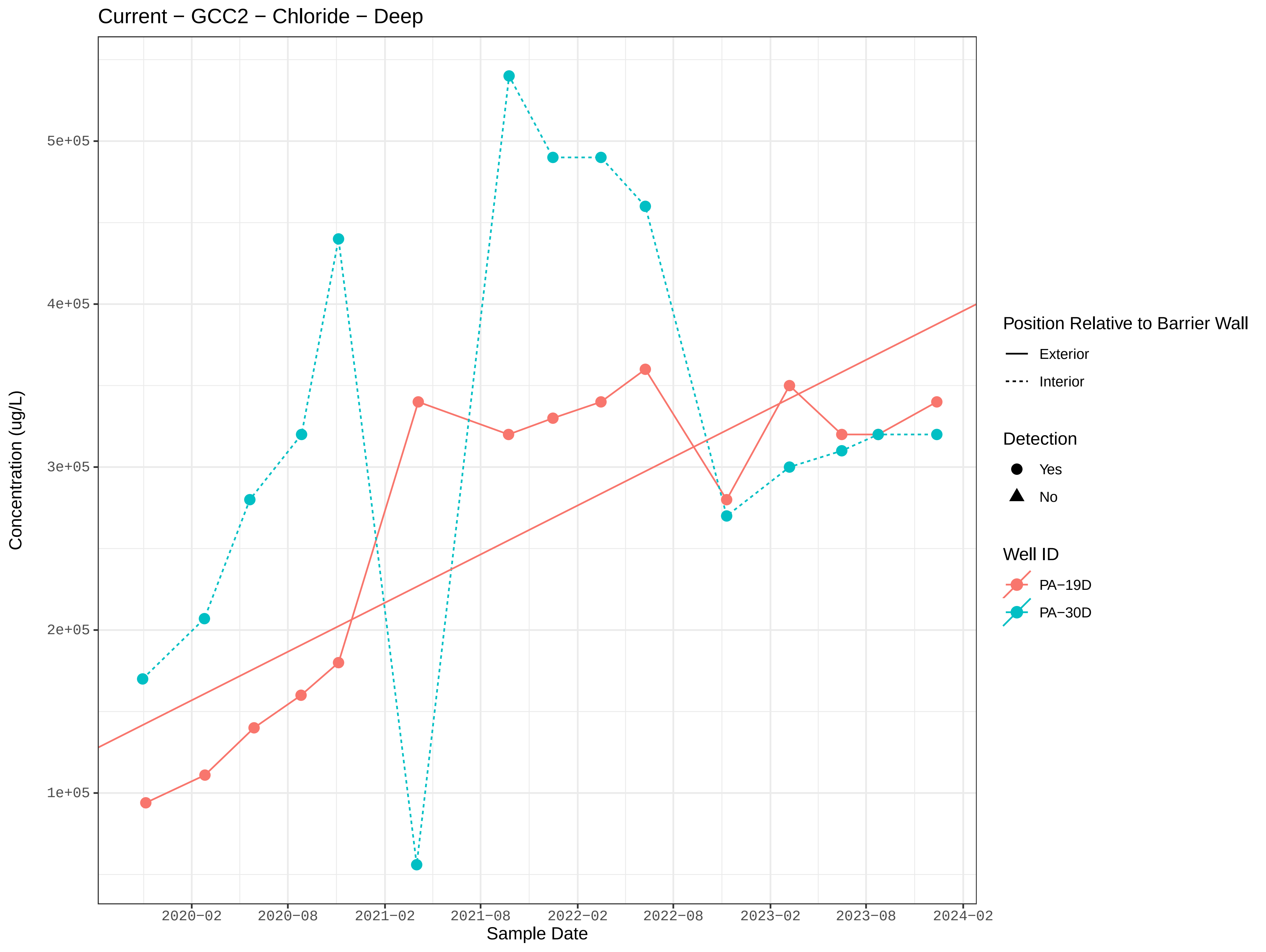

Current − GCC1 & Proximal Wells − Perchlorate − Deep
Concentration (ug/L)
0.1
0.075
0.05
0.025
0
2020−02
2020−08
2021−02
2021−08
2022−02
2022−08
2023−02
2023−08
2024−02
Sample Date
Well ID
PA−18D
PA−27D
Position Relative to Barrier Wall
Exterior
Interior
Detection
Yes
No

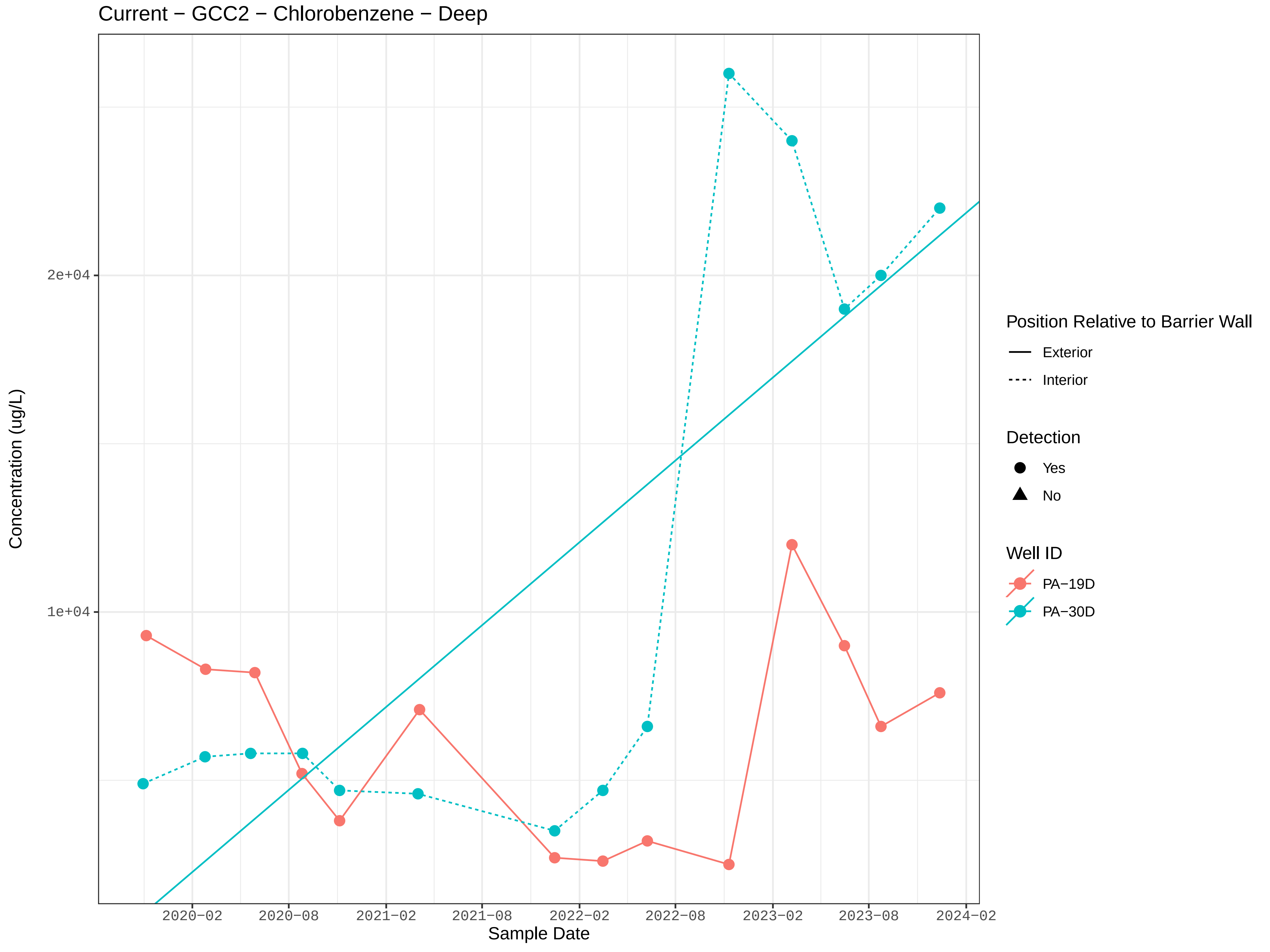
Current − GCC1 & Proximal Wells − Perchlorate − Intermediate



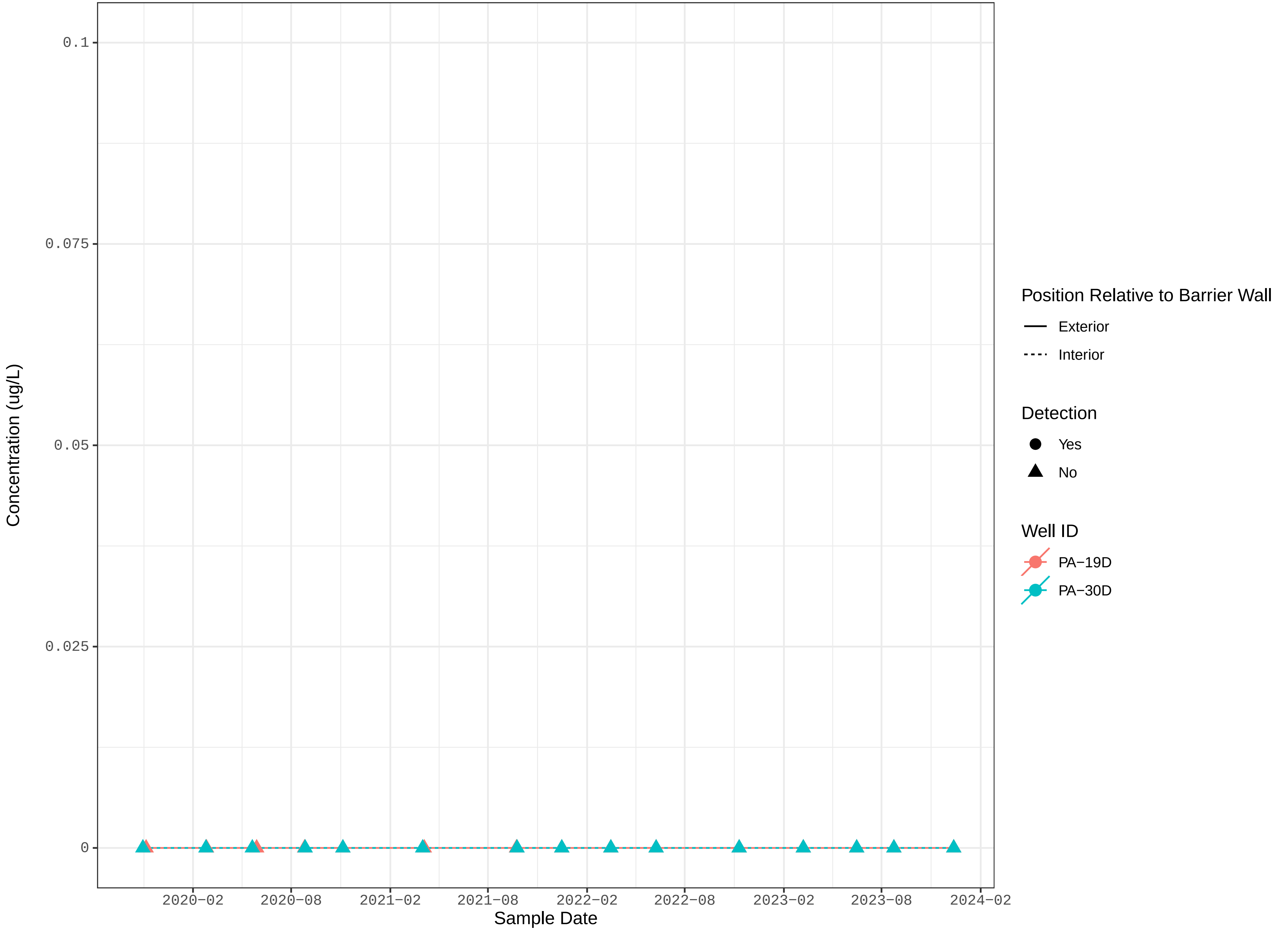
Current − GCC1 & Proximal Wells − Perchlorate − Shallow



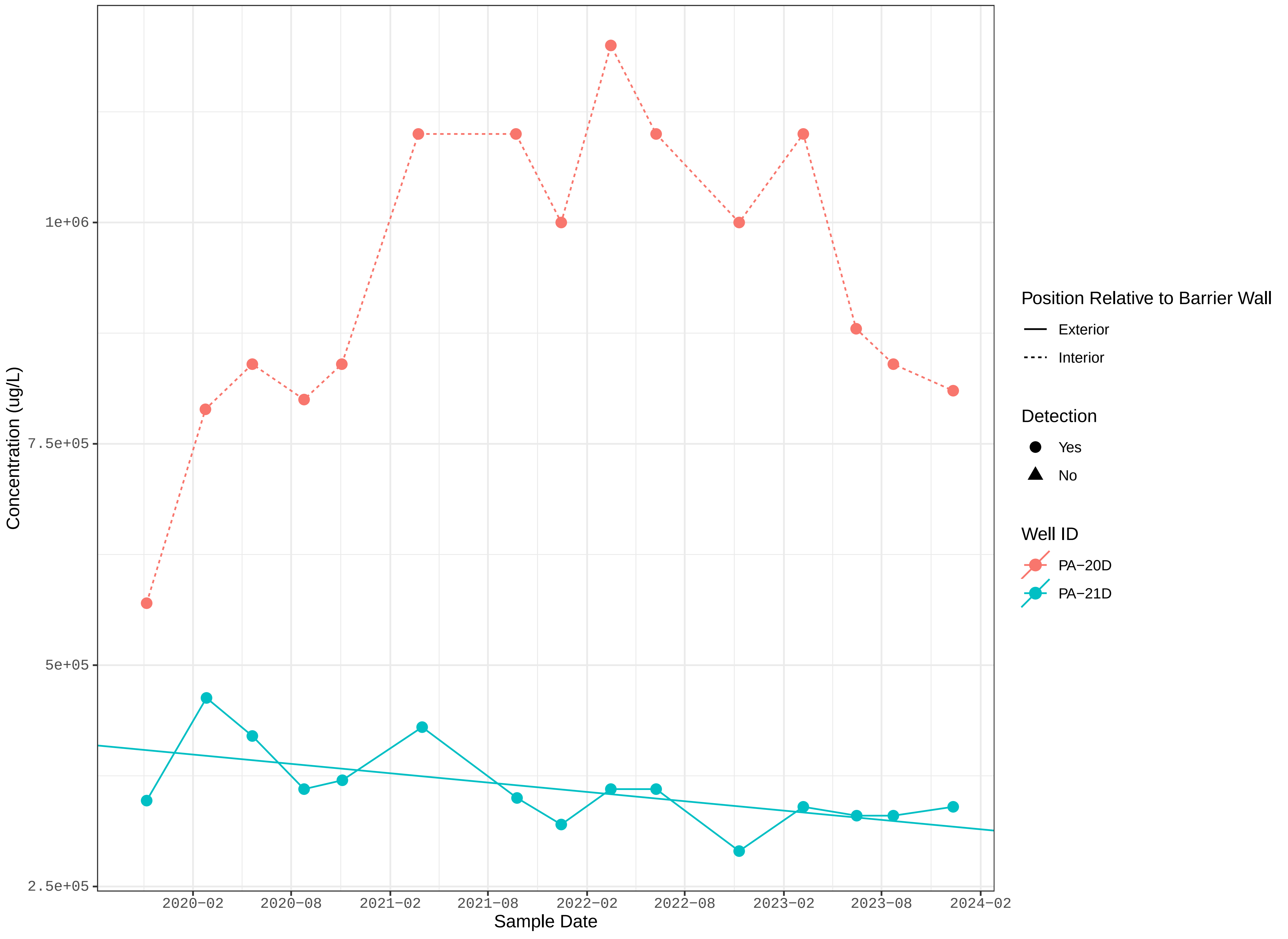

Current − GCC2 − Chloride − Deep
Concentration (ug/L)
5e+05
4e+05
3e+05
2e+05
1e+05
2020−02
2020−08
2021−02
2021−08
2022−02
2022−08
2023−02
2023−08
2024−02
Sample Date
Position Relative to Barrier Wall
Exterior
Interior
Detection
Yes
No
Well ID
PA−19D
PA−30D


Current − GCC2 − Chlorobenzene − Deep
Concentration (ug/L)
2e+04
1e+04
2020−02
2020−08
2021−02
2021−08
2022−02
2022−08
2023−02
2023−08
2024−02
Sample Date
Position Relative to Barrier Wall
Exterior
Interior
Detection
Yes
No
Well ID
PA−19D
PA−30D

Current − GCC2 − Perchlorate − Deep

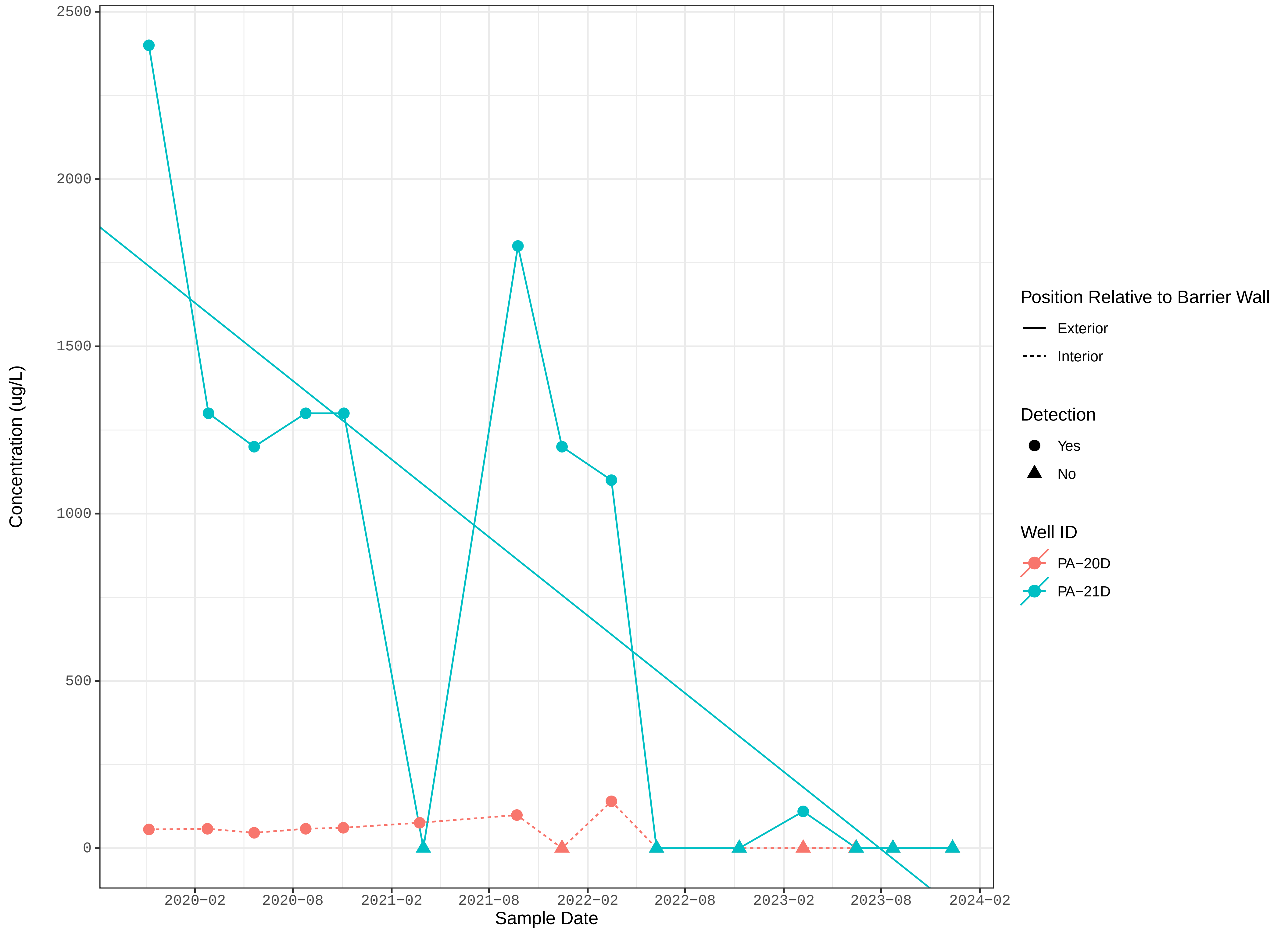


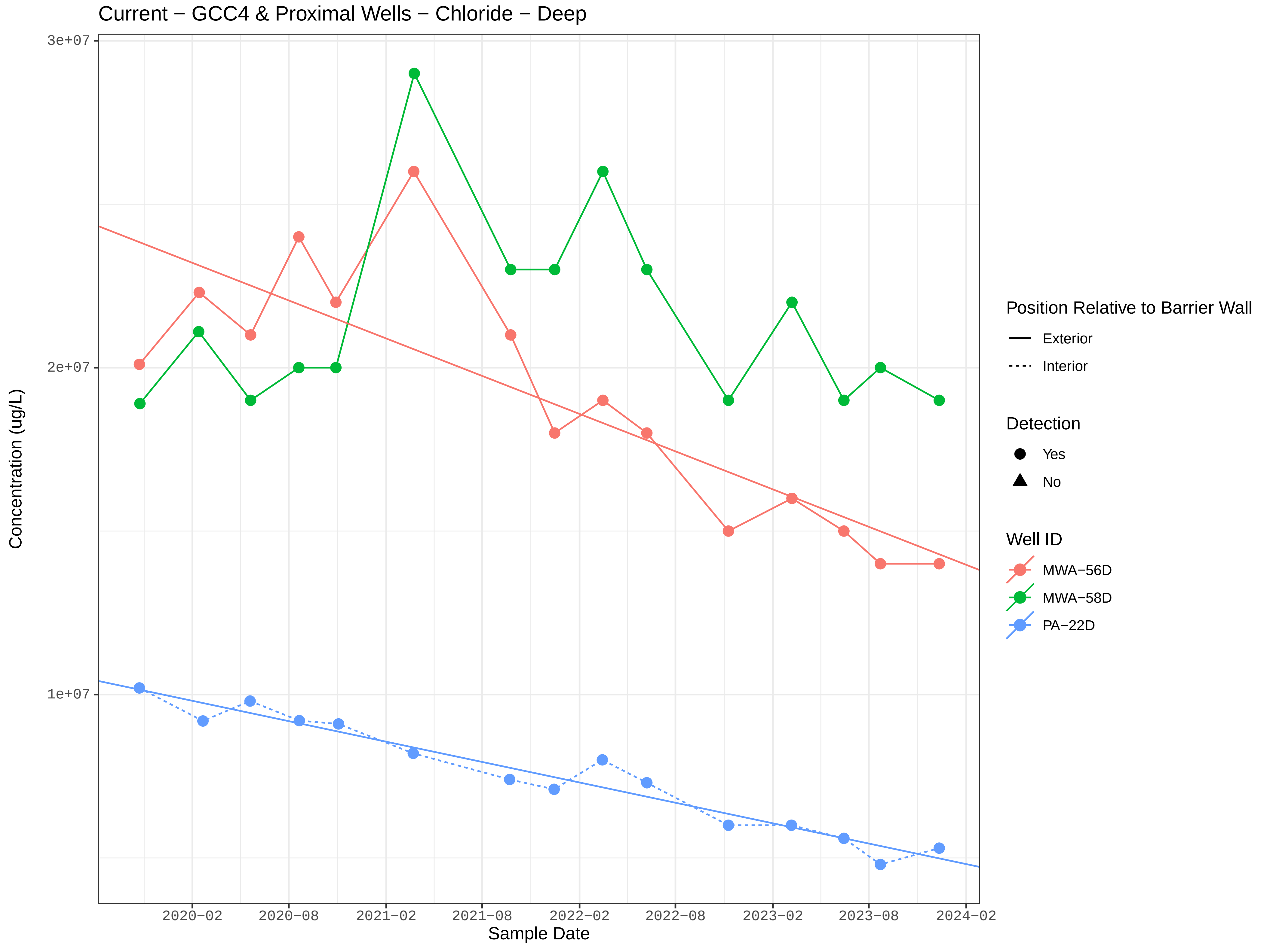
Current − GCC3 − Chloride − Deep




Current − GCC3 − Chlorobenzene − Deep
Concentration (ug/L)
5e+04
4e+04
3e+04
2e+04
1e+04
0
2020−02
2020−08
2021−02
2021−08
2022−02
2022−08
2023−02
2023−08
2024−02
Sample Date
Position Relative to Barrier Wall
Exterior
Interior
Detection
Yes
No
Well ID
PA−20D
PA−21D

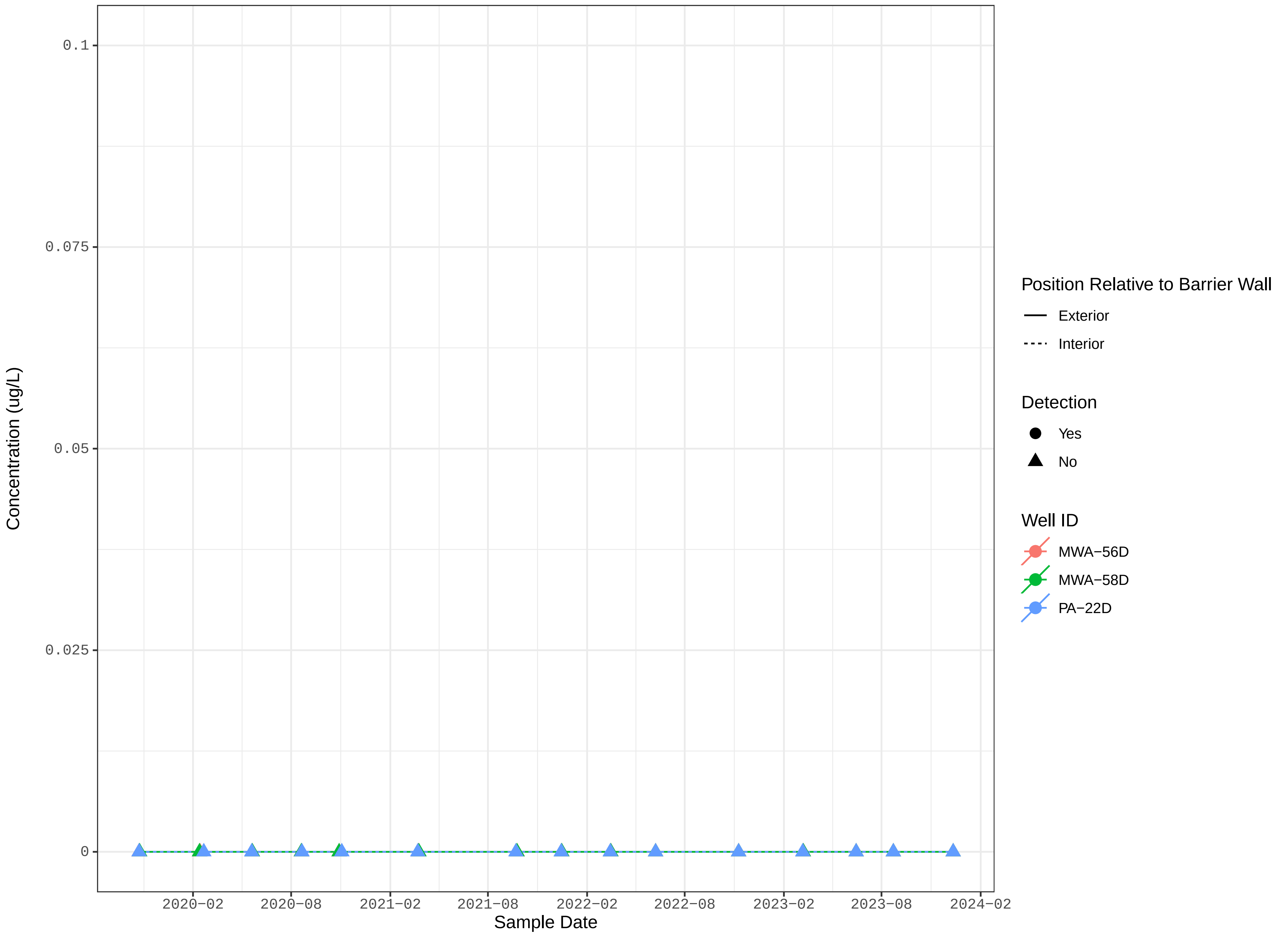
Current − GCC3 − Perchlorate − Deep



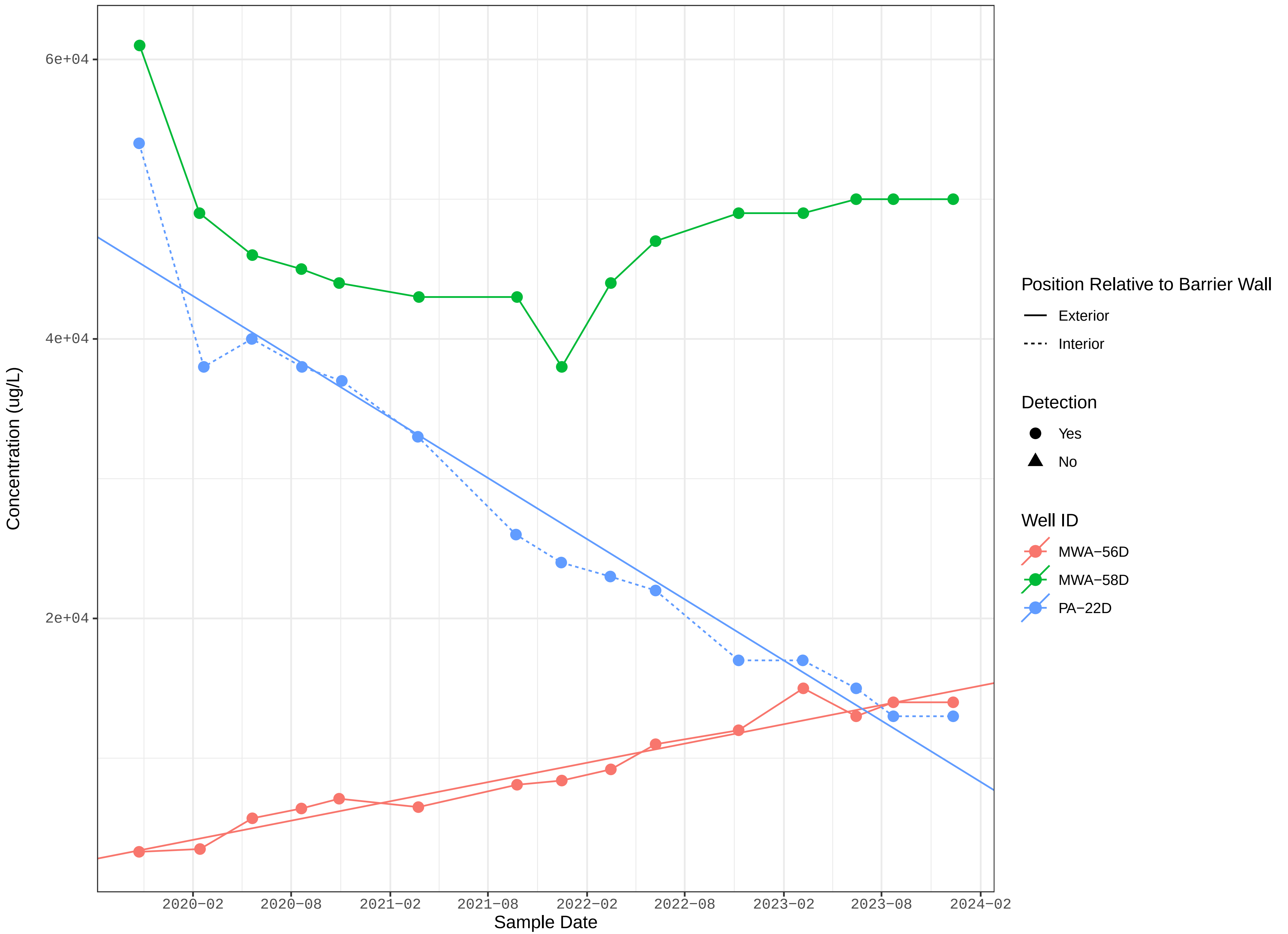


Current − GCC4 & Proximal Wells − Chloride − Deep
3e+07
2e+07
1e+07
Concentration (ug/L)
2020−02
2020−08
2021−02
2021−08
2022−02
2022−08
2023−02
2023−08
2024−02
Sample Date
Position Relative to Barrier Wall
Exterior
Interior
Detection
Yes
No
Well ID
MWA−56D
MWA−58D
PA−22D

Current − GCC4 & Proximal Wells − Chlorobenzene − Deep

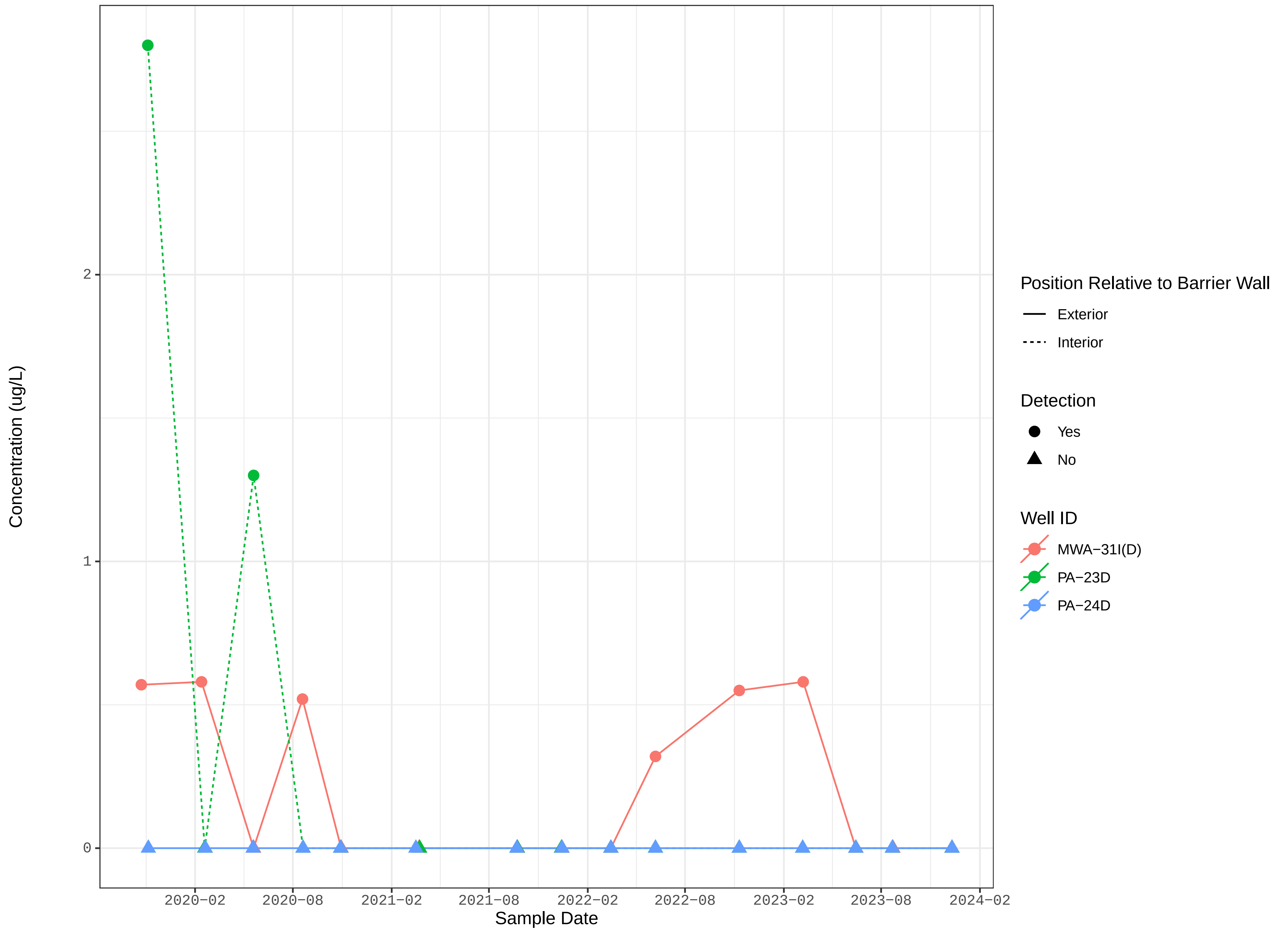


Current − GCC4 & Proximal Wells − Perchlorate − Deep

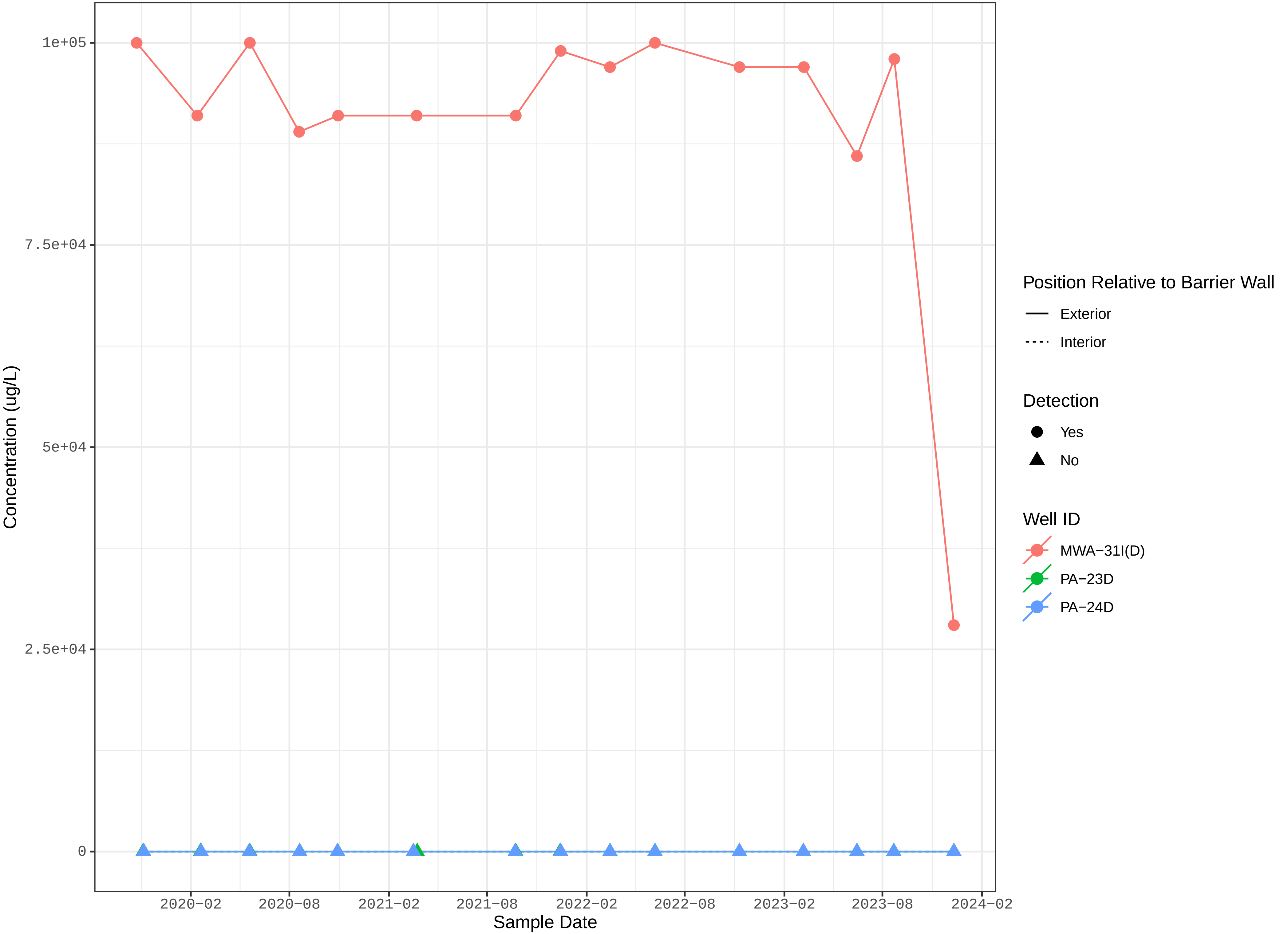


Current − GCC5 & Proximal Wells − Chloride − Deep

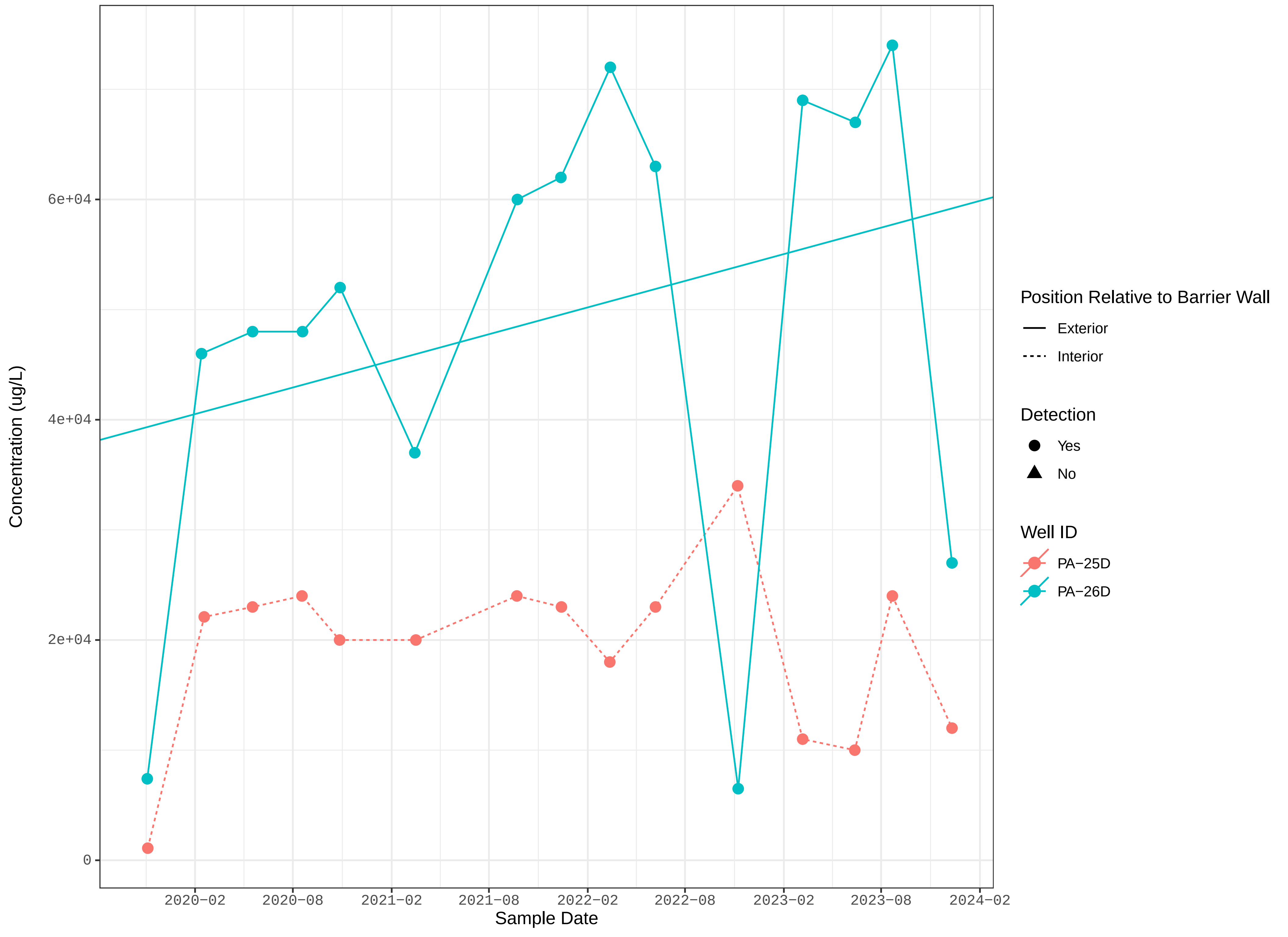
Current − GCC5 & Proximal Wells − Chlorobenzene − Deep



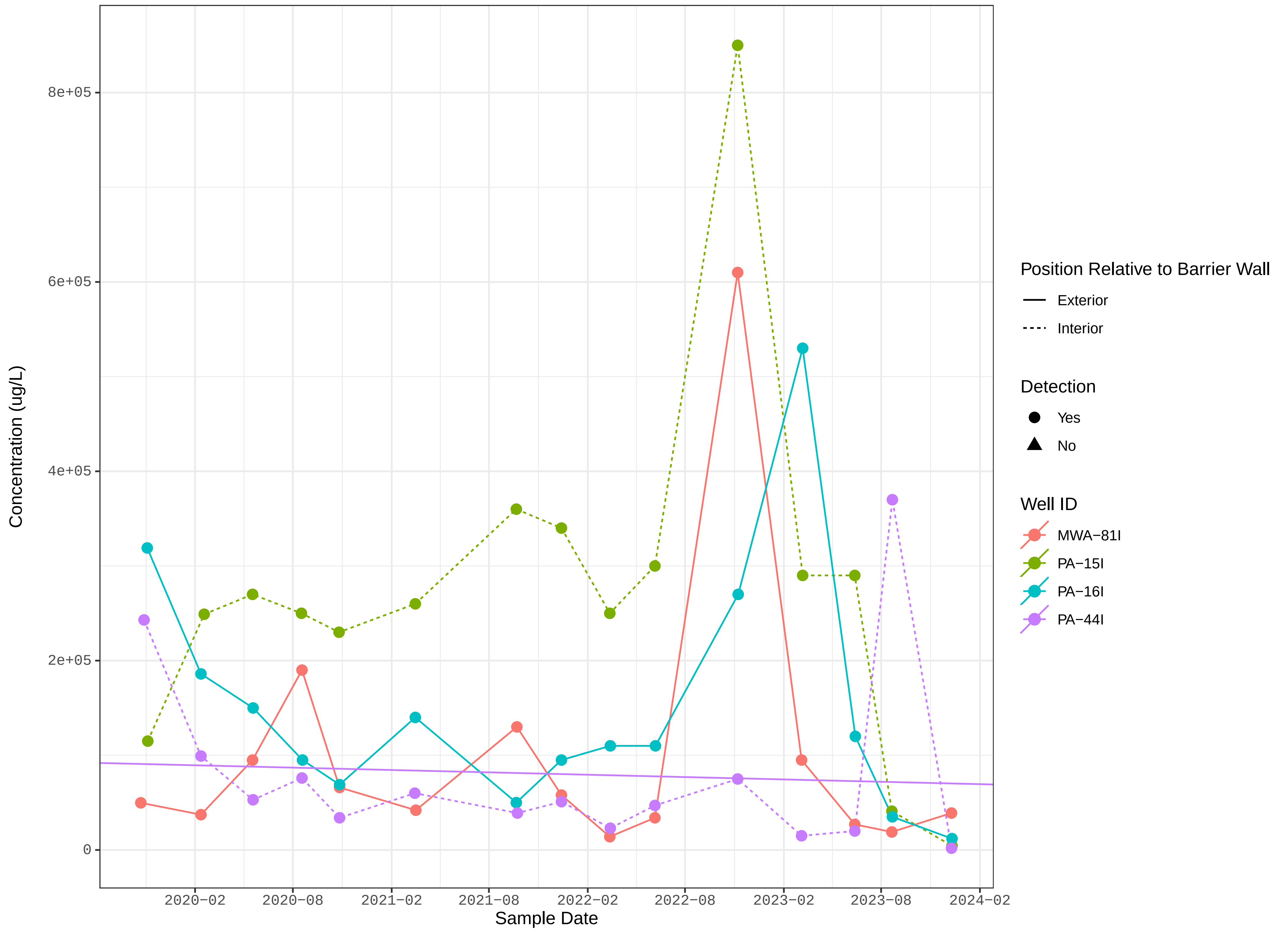
Current − GCC5 & Proximal Wells − Perchlorate − Deep



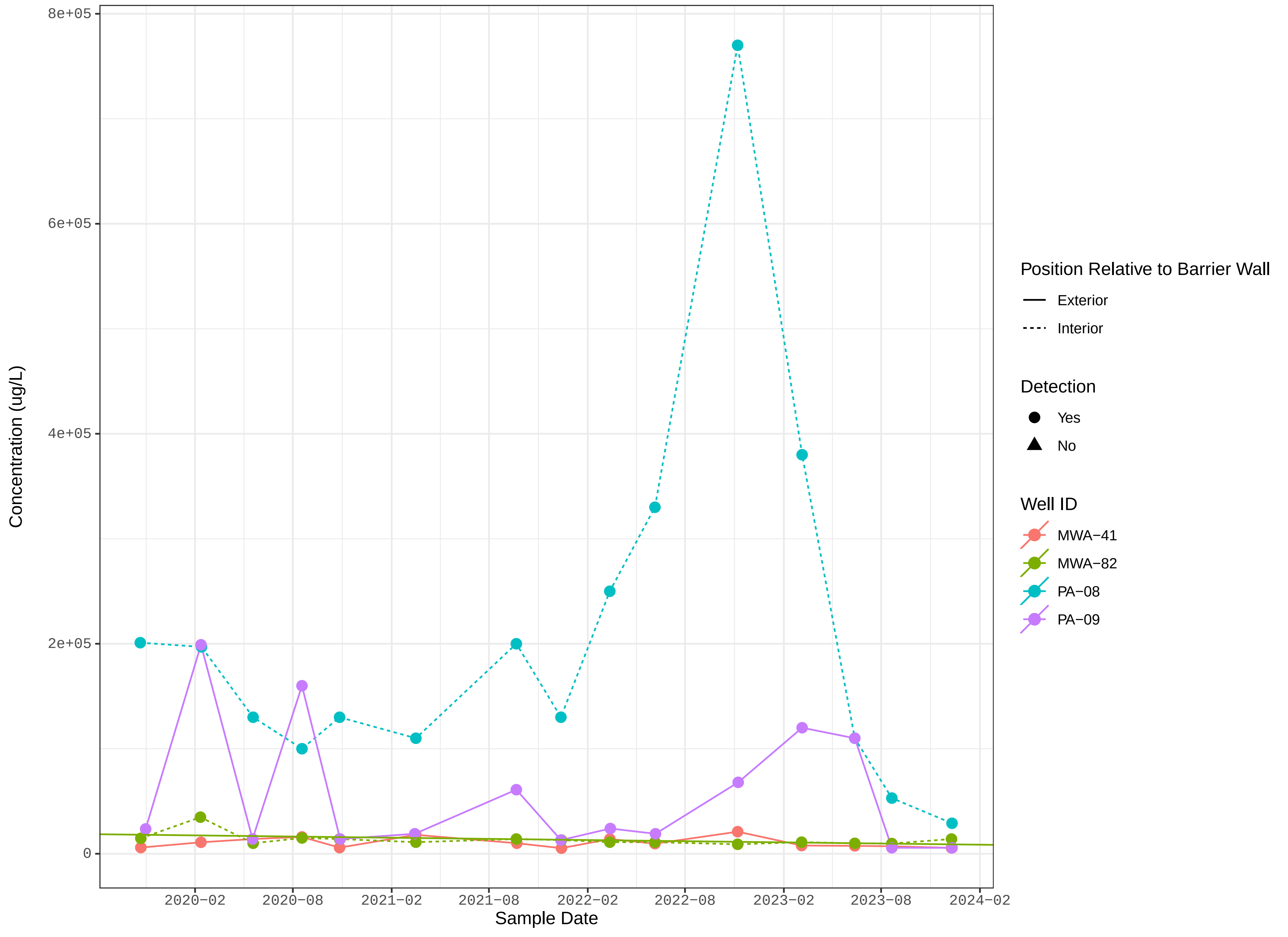
Current − GCC6 & Proximal Wells − Chloride − Deep



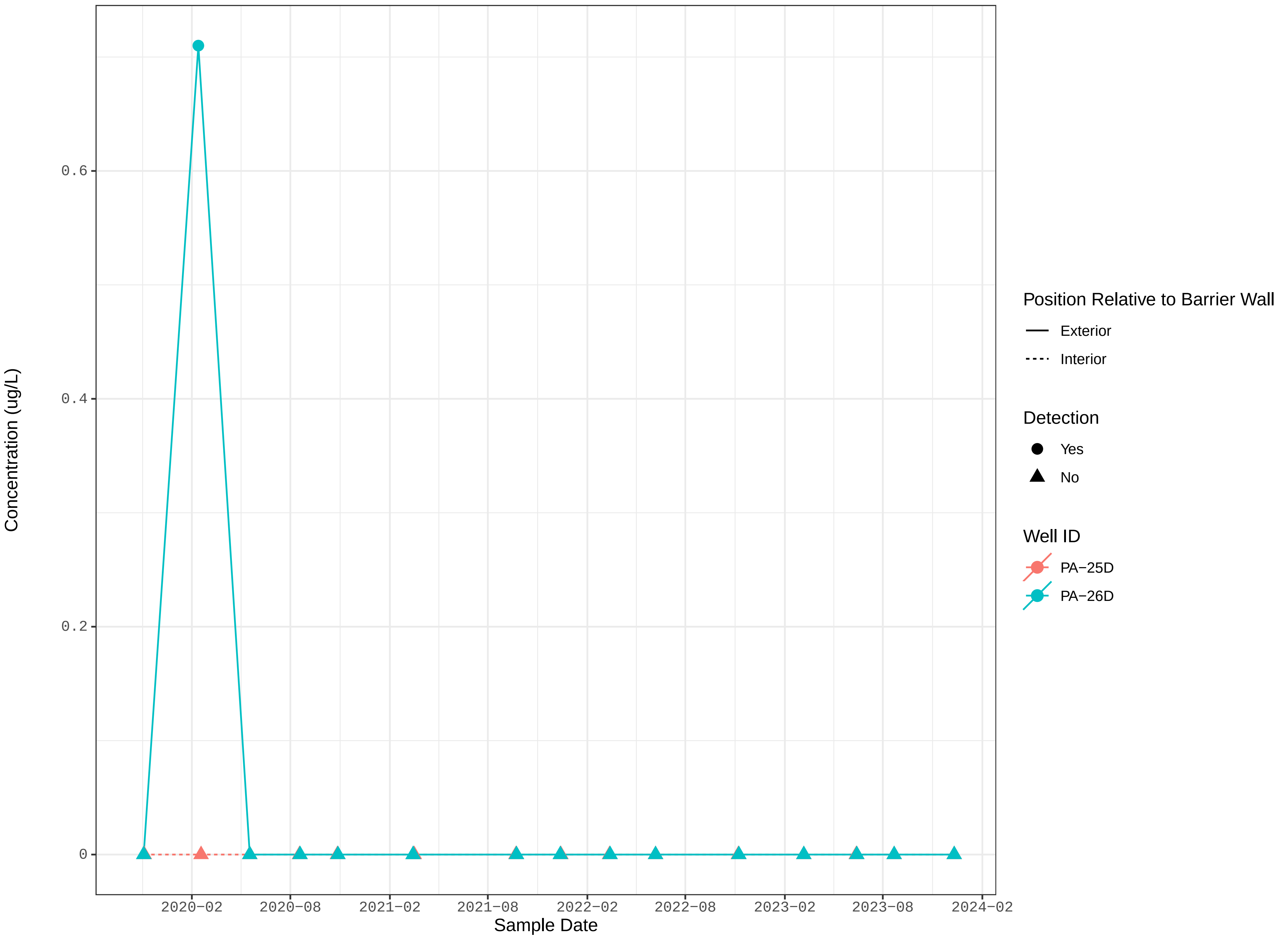
Current − GCC6 & Proximal Wells − Chloride − Intermediate



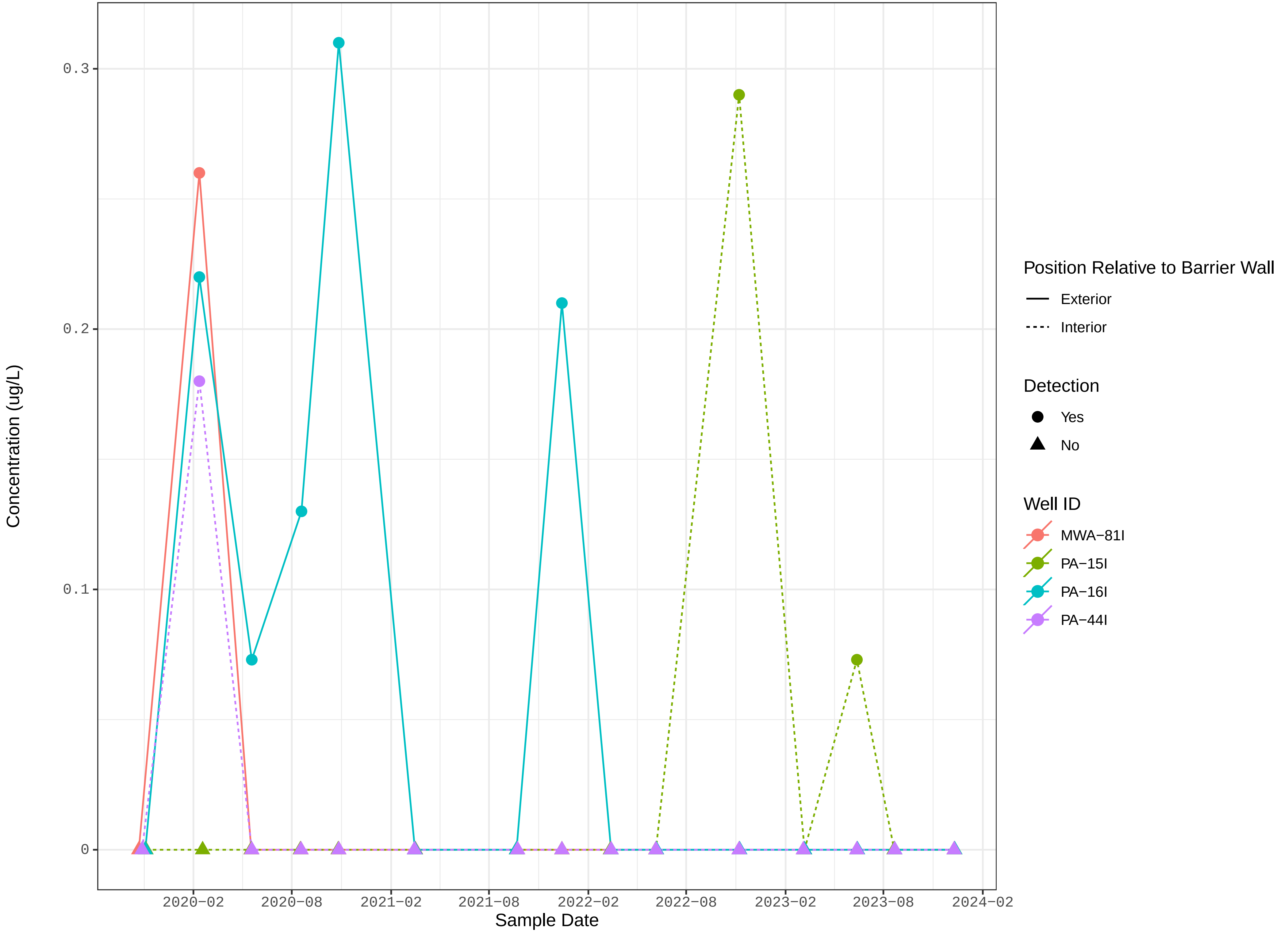
Current − GCC6 & Proximal Wells − Chloride − Shallow



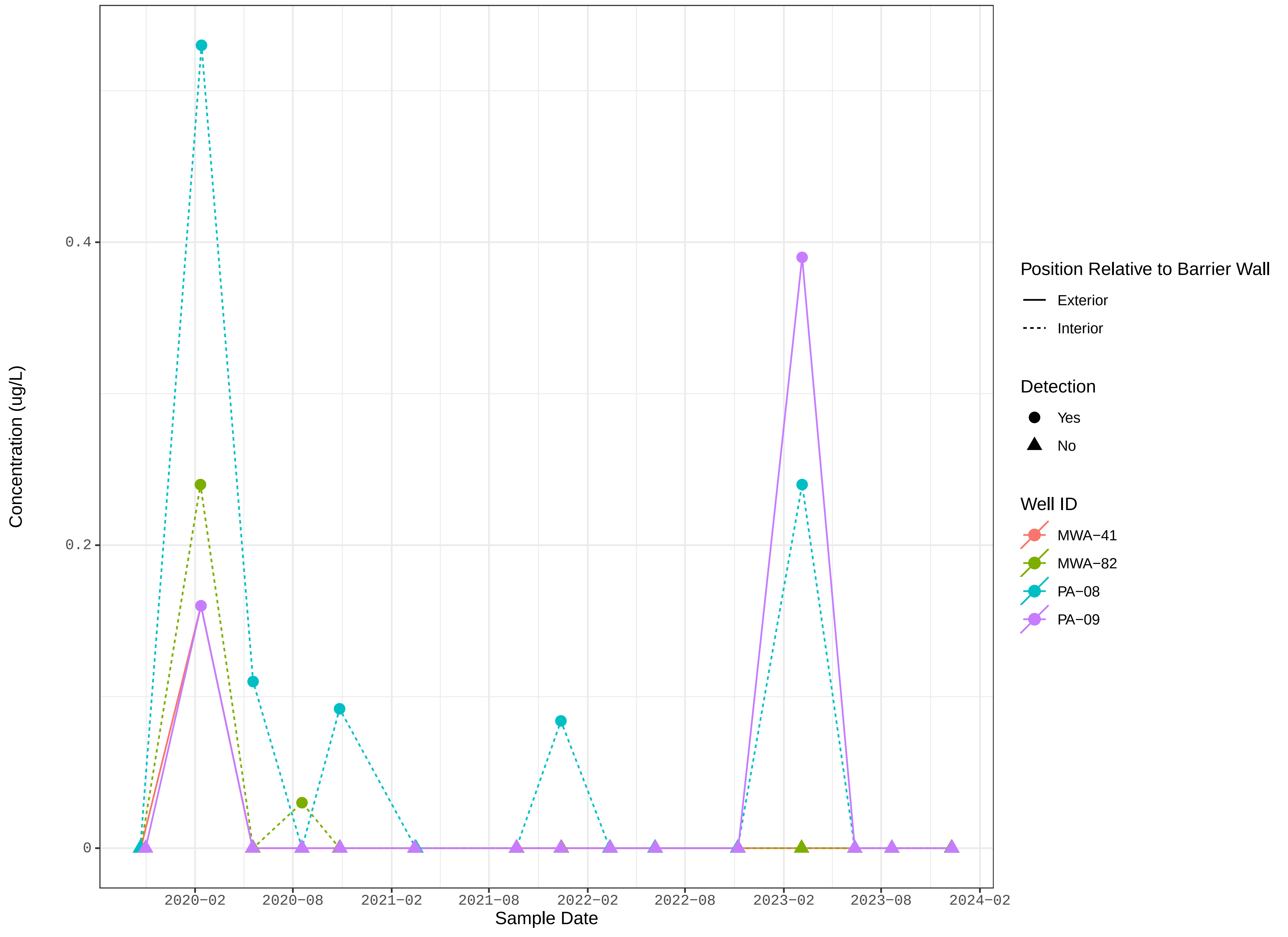
Current − GCC6 & Proximal Wells − Chlorobenzene − Deep



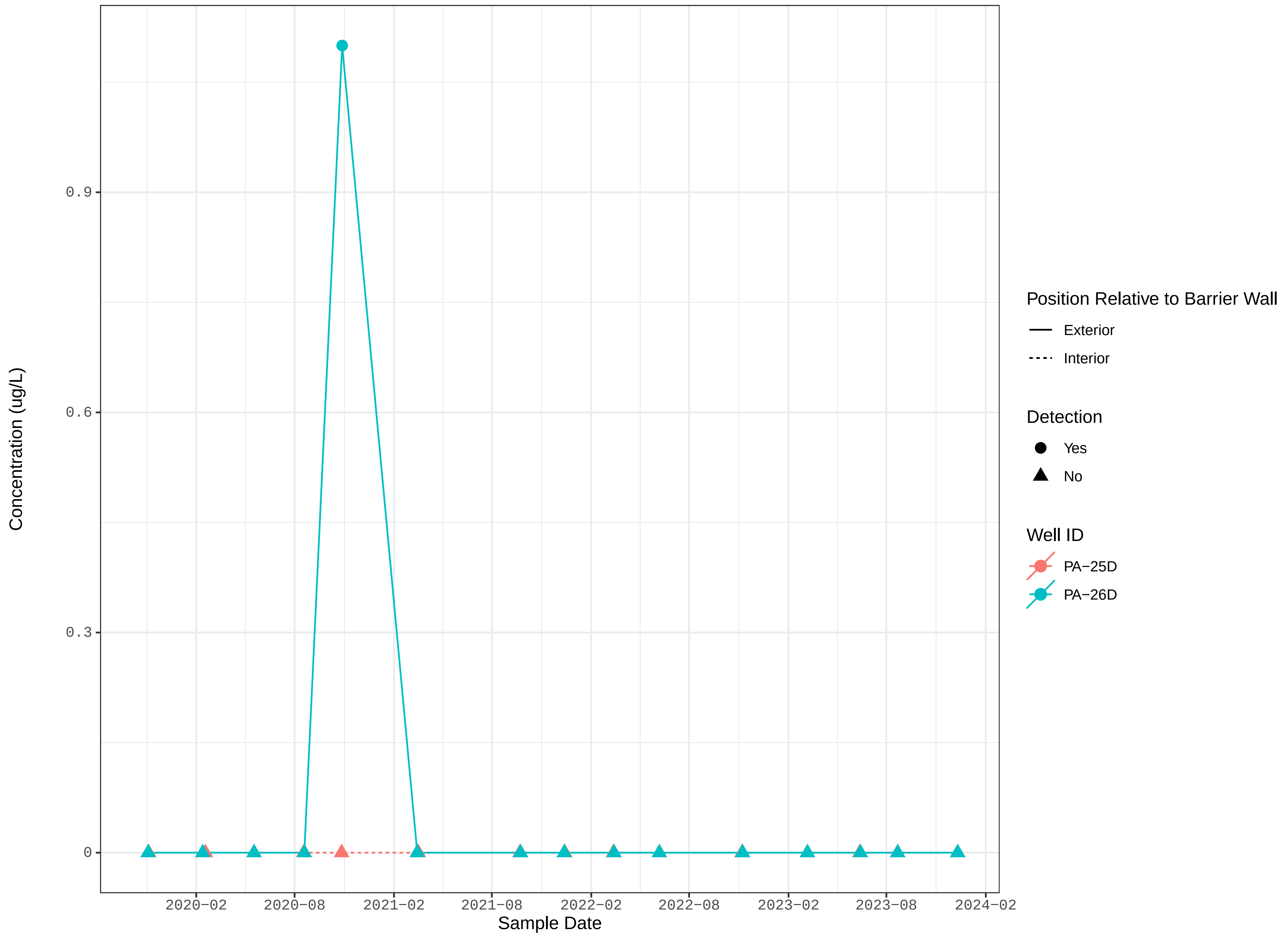
Current − GCC6 & Proximal Wells − Chlorobenzene − Intermediate



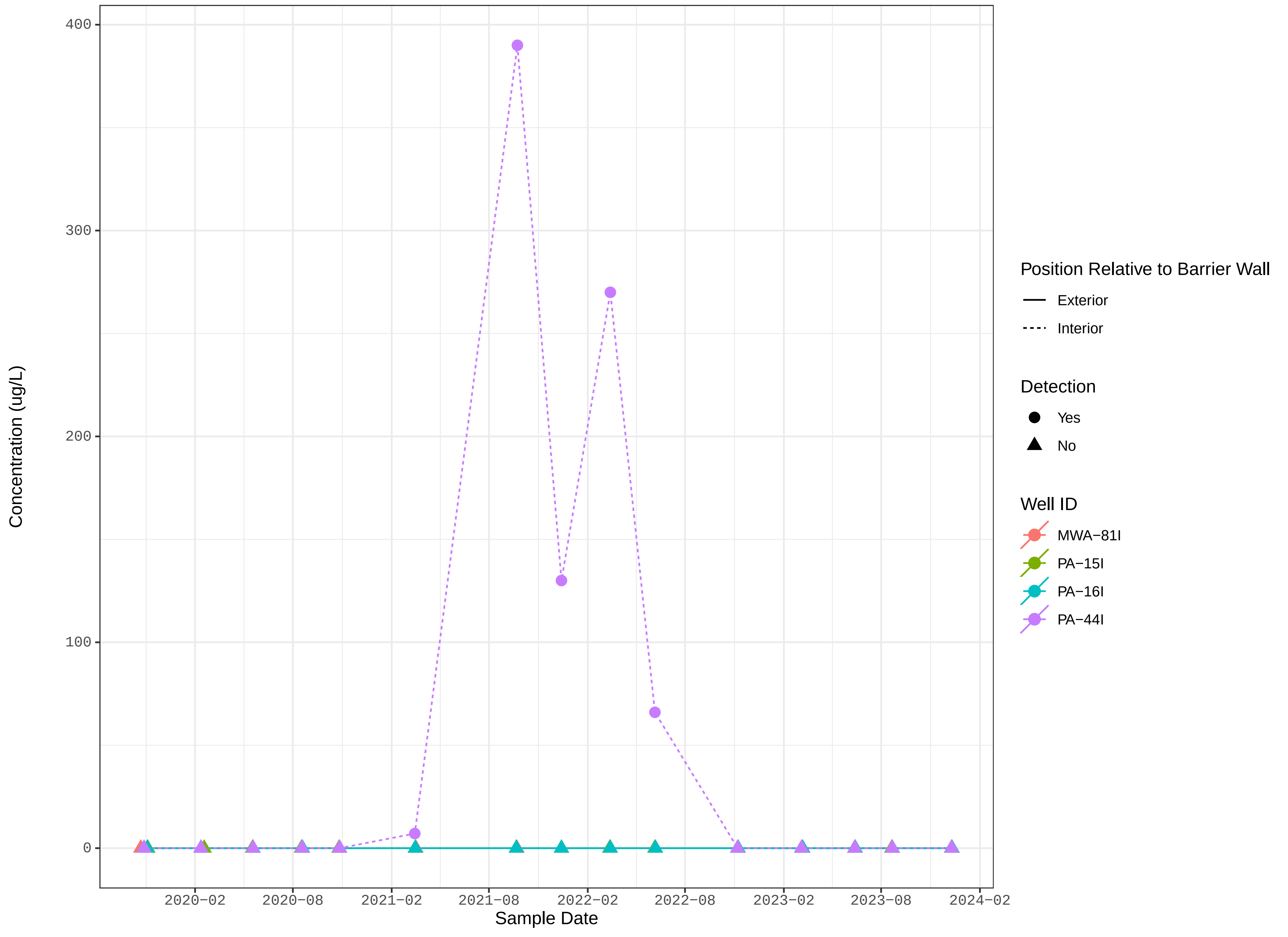
Current − GCC6 & Proximal Wells − Chlorobenzene − Shallow

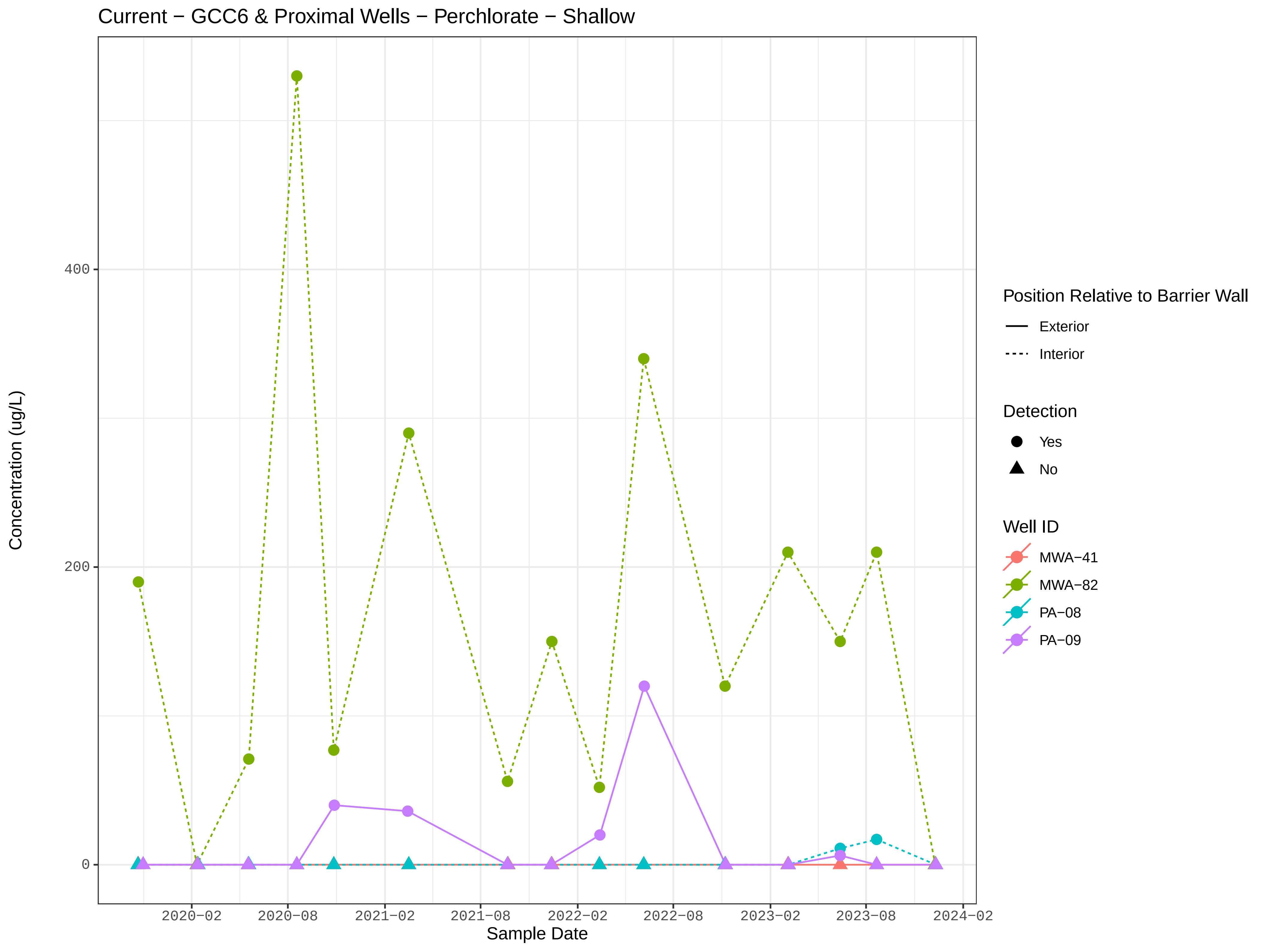


Current − GCC6 & Proximal Wells − Perchlorate − Deep

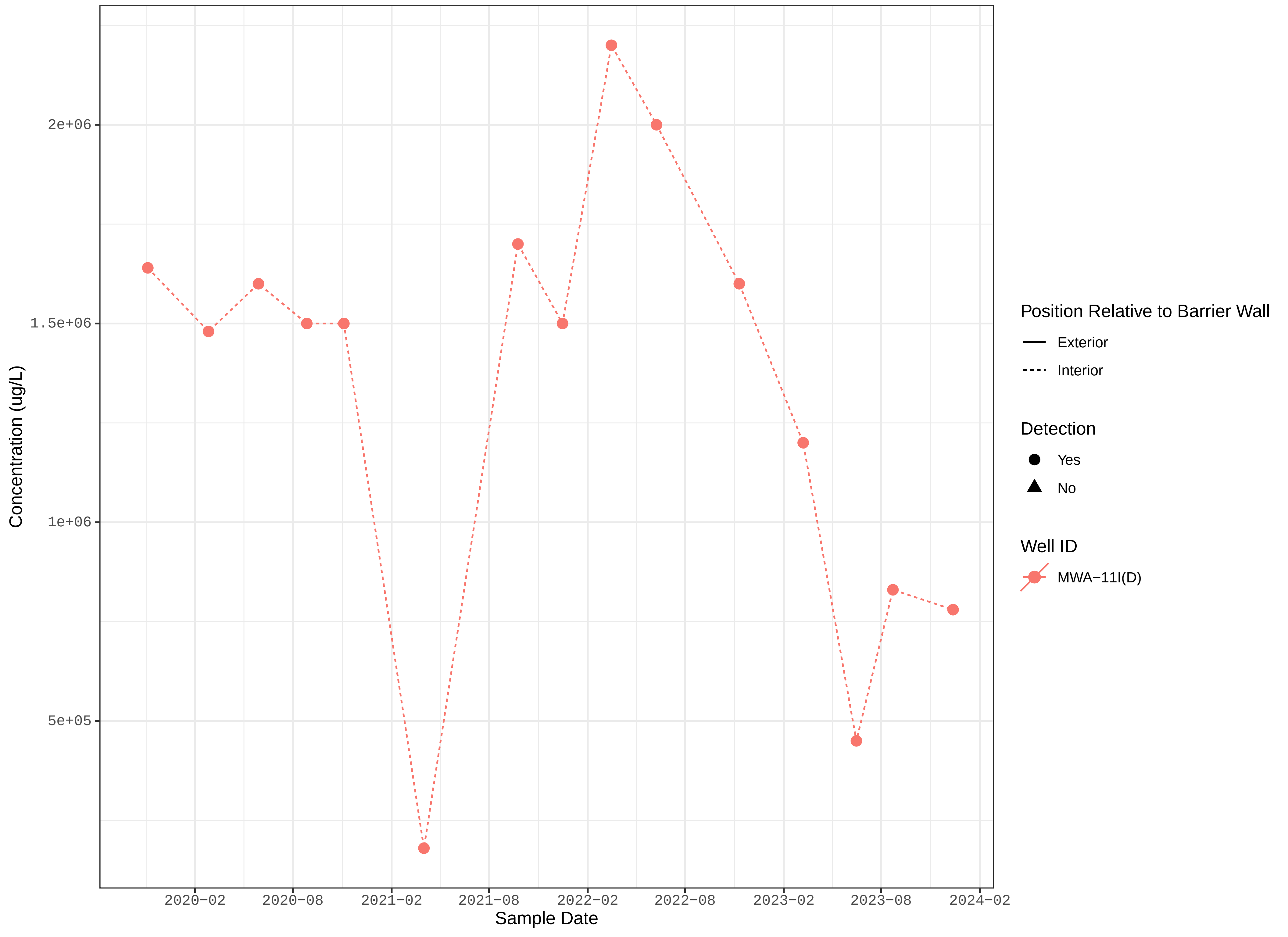


Current − GCC6 & Proximal Wells − Perchlorate − Intermediate

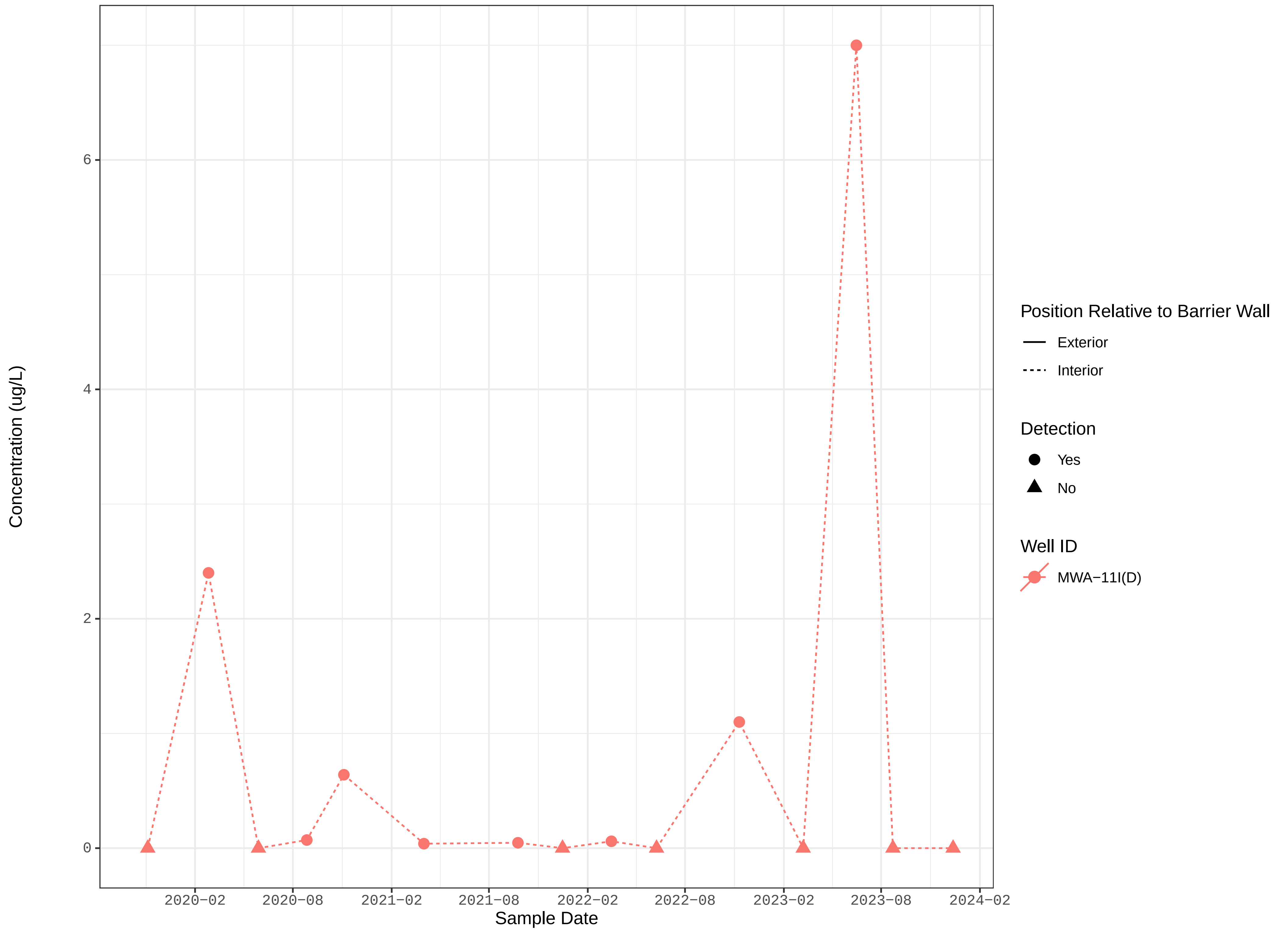



Current − GCC6 & Proximal Wells − Perchlorate − Shallow
Concentration (ug/L)
400
200
0
2020−02
2020−08
2021−02
2021−08
2022−02
2022−08
2023−02
2023−08
2024−02
Sample Date
Position Relative to Barrier Wall
Exterior
Interior
Detection
Yes
No
Well ID
MWA−41
MWA−82
PA−08
PA−09

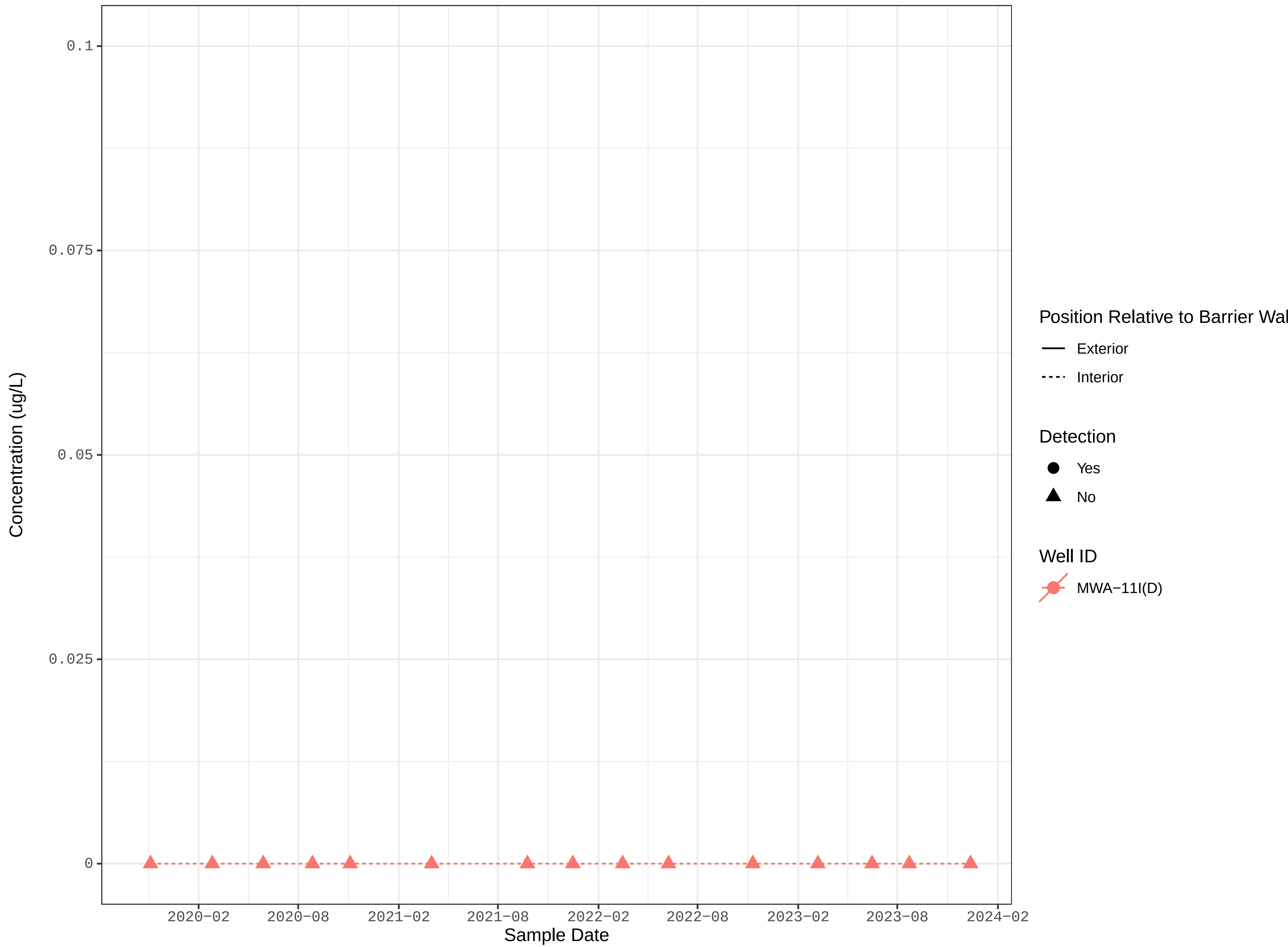
Current − Well Distal from BW and GCCs − Chloride − Deep



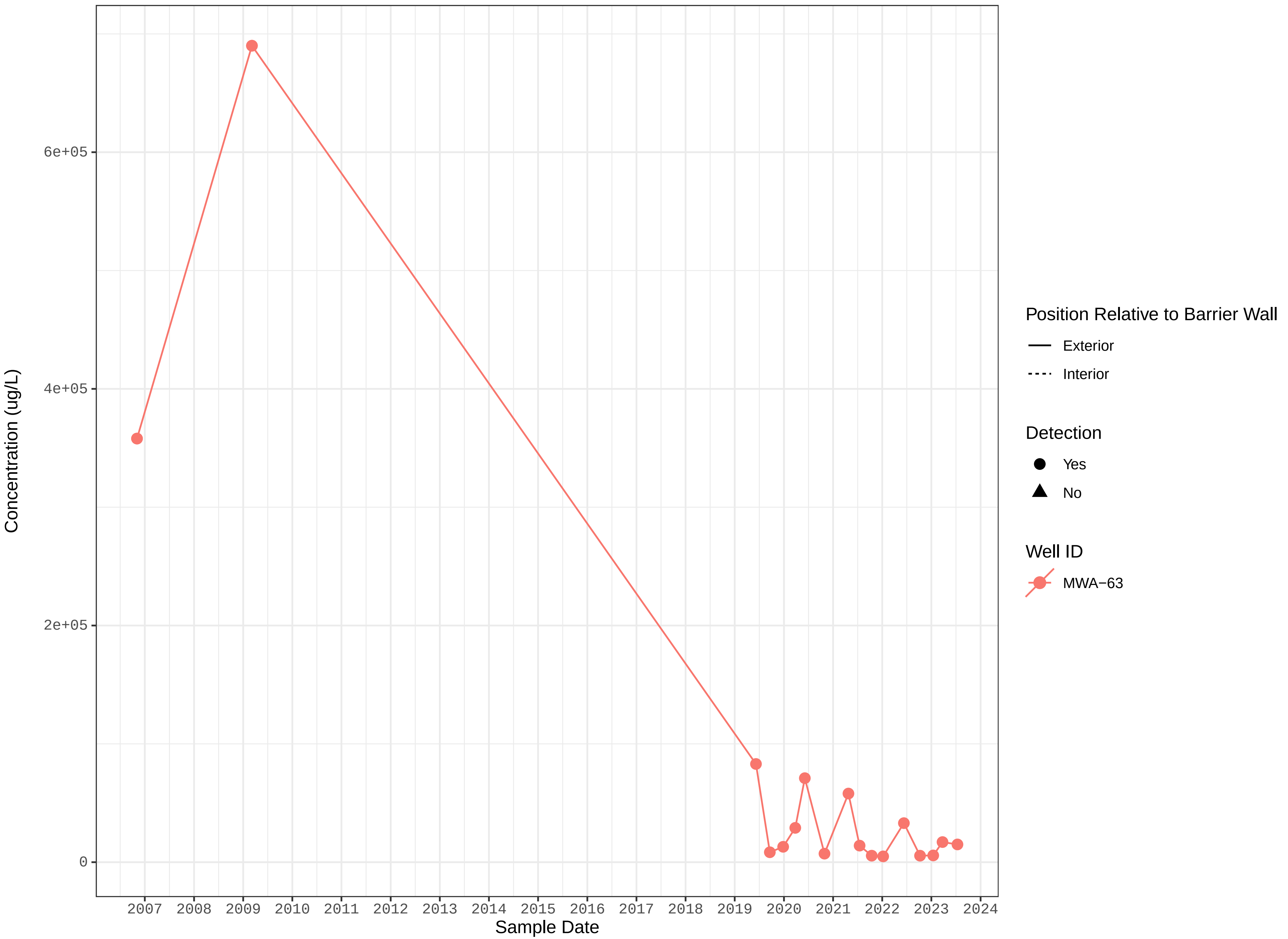
Current − Well Distal from BW and GCCs − Chlorobenzene − Deep



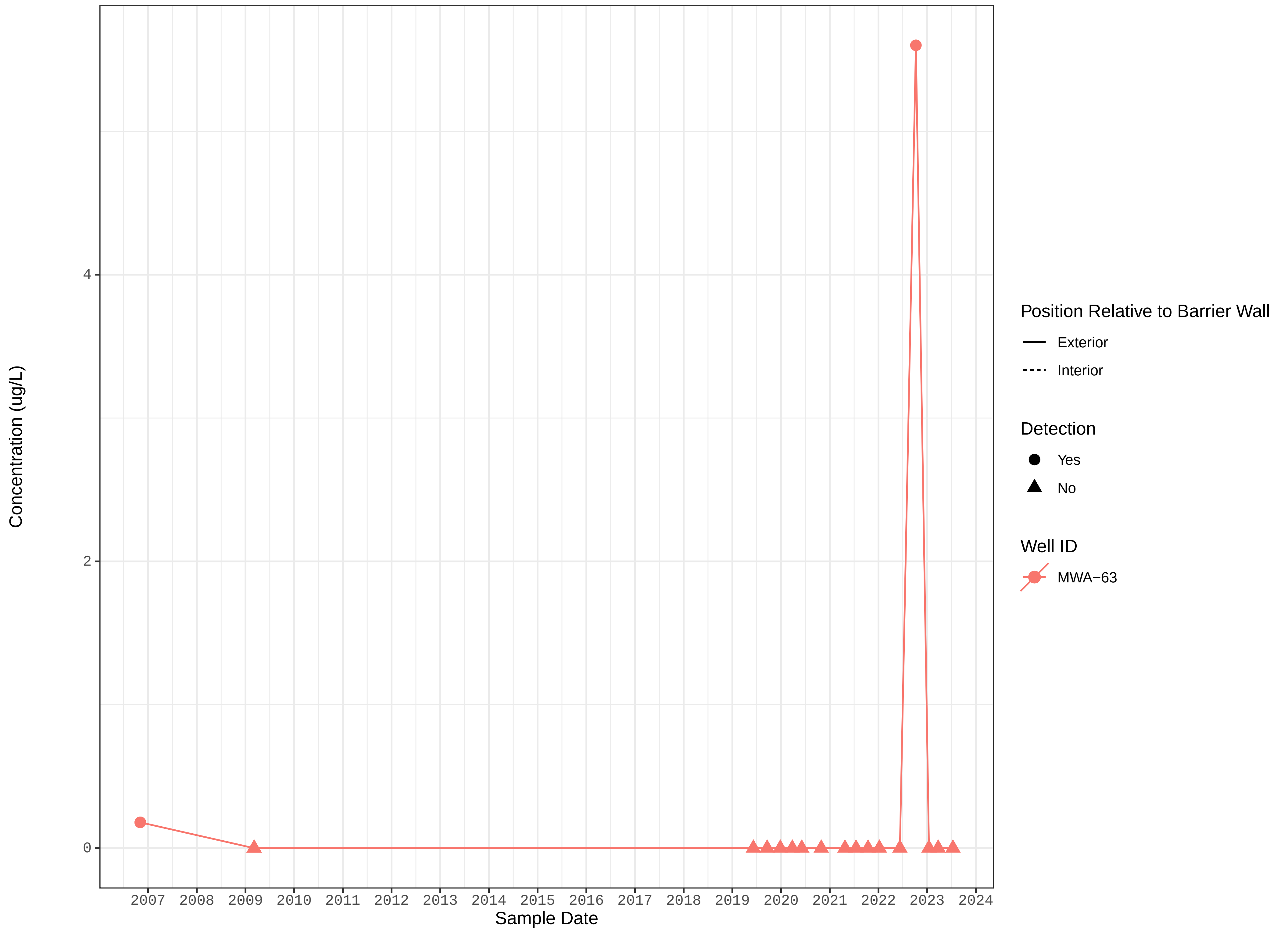
Current − Well Distal from BW and GCCs − Perchlorate − Deep

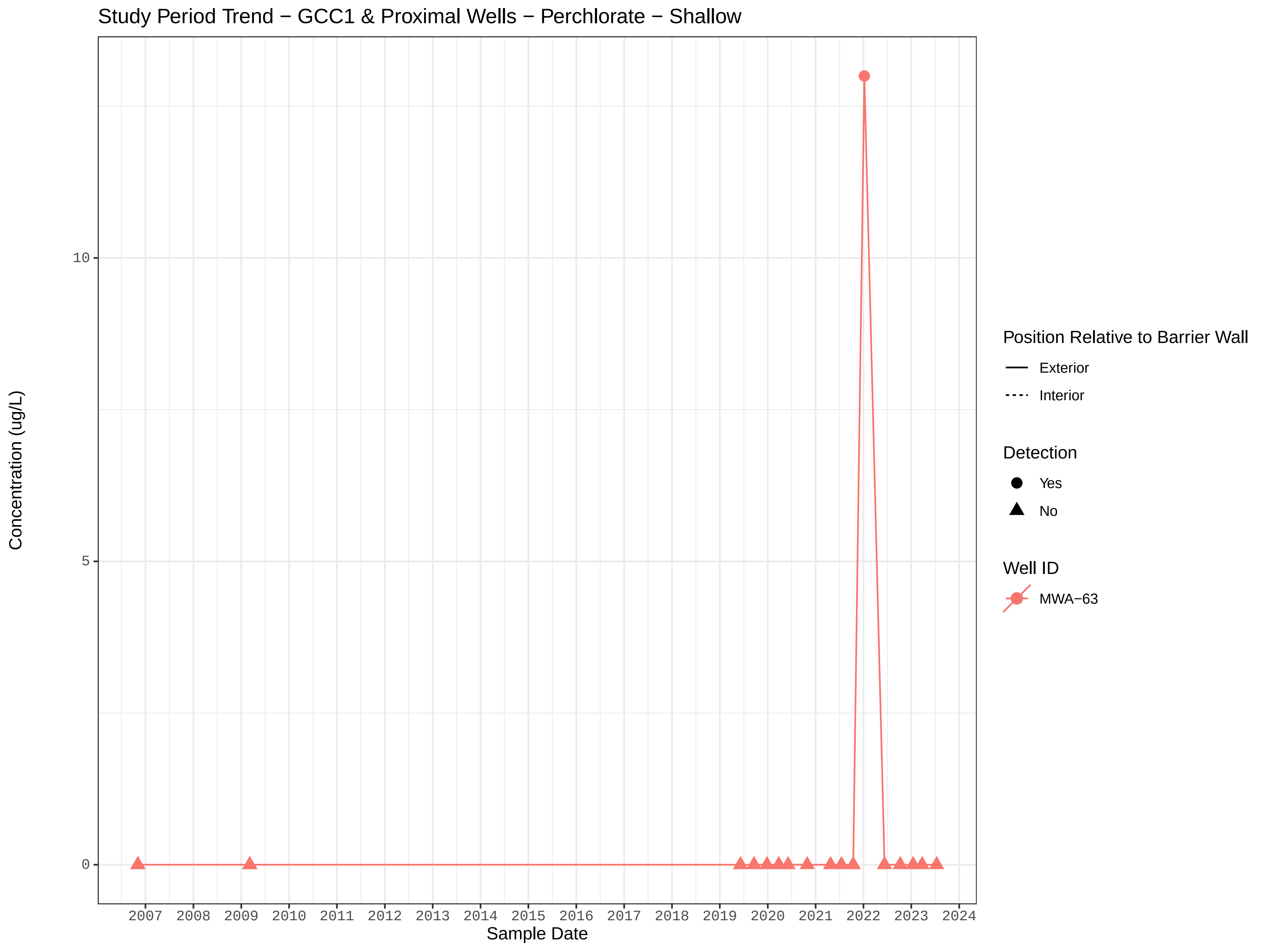


Study Period Trend − GCC1 & Proximal Wells − Chloride − Shallow

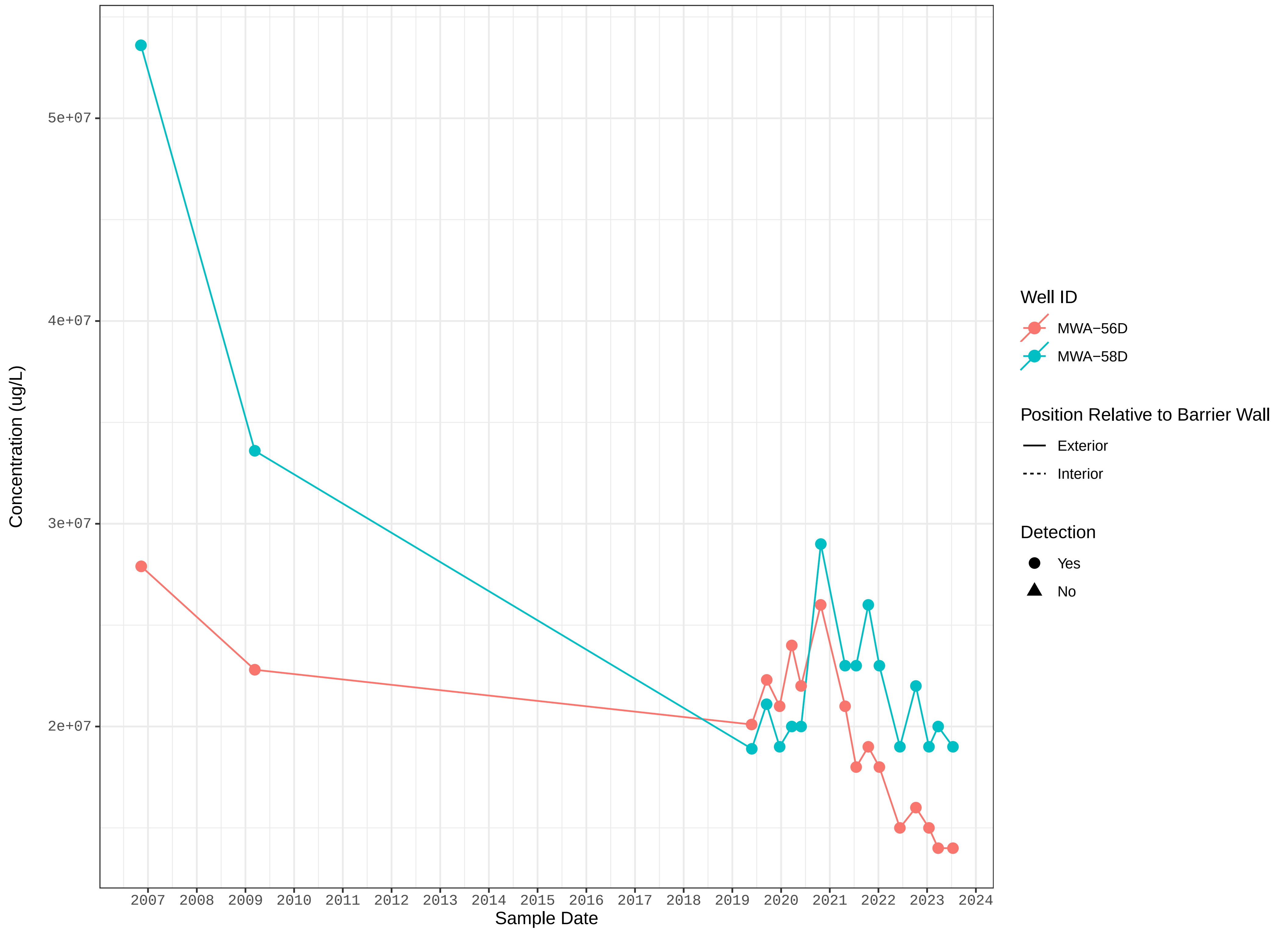


Study Period Trend − GCC1 & Proximal Wells − Chlorobenzene − Shallow

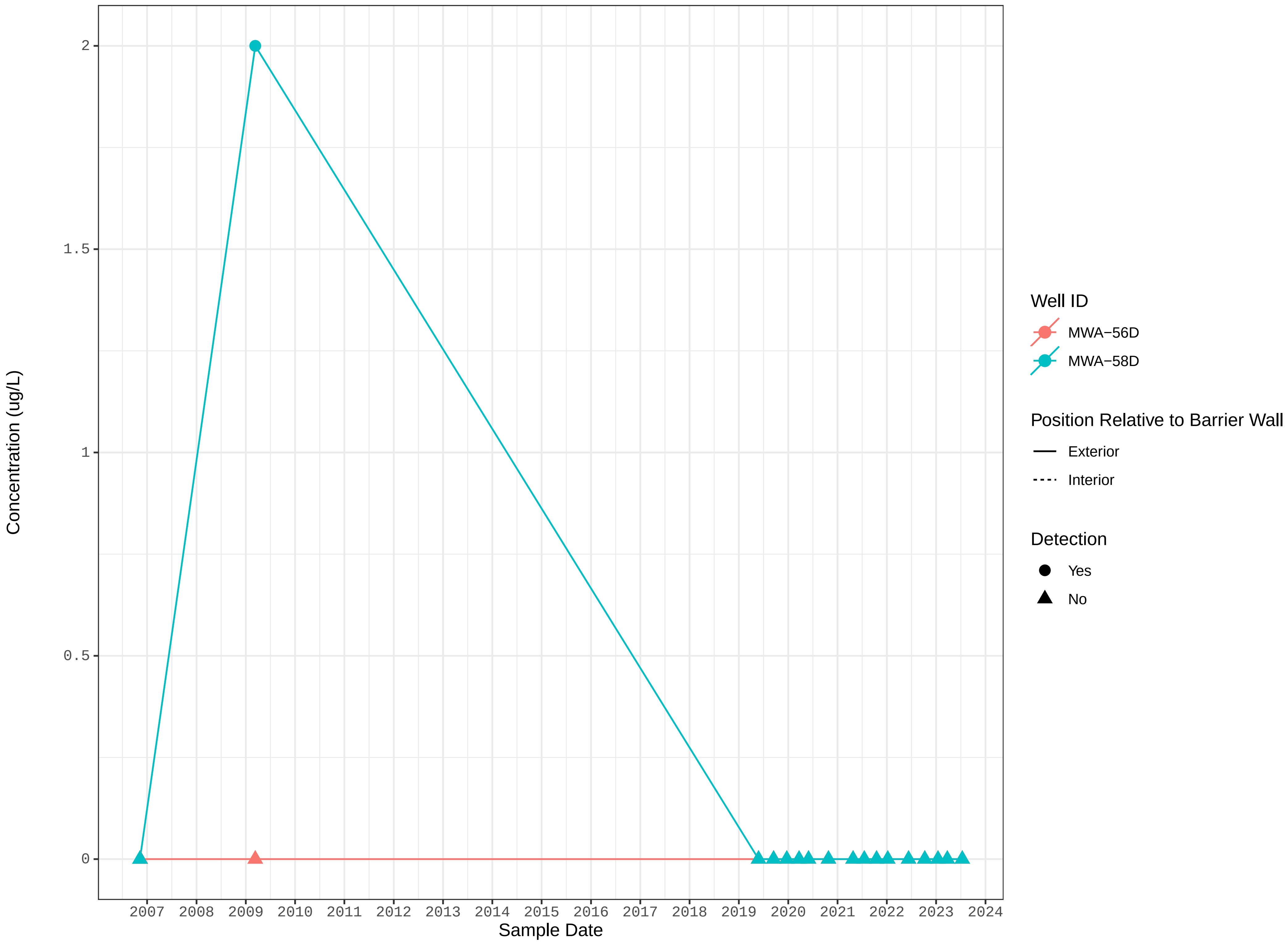



Study Period Trend − GCC1 & Proximal Wells − Perchlorate − Shallow
Concentration (ug/L)
0
5
10
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Sample Date
Position Relative to Barrier Wall
Exterior
Interior
Detection
Yes
No
Well ID
MWA−63

Study Period Trend − GCC4 & Proximal Wells − Chloride − Deep

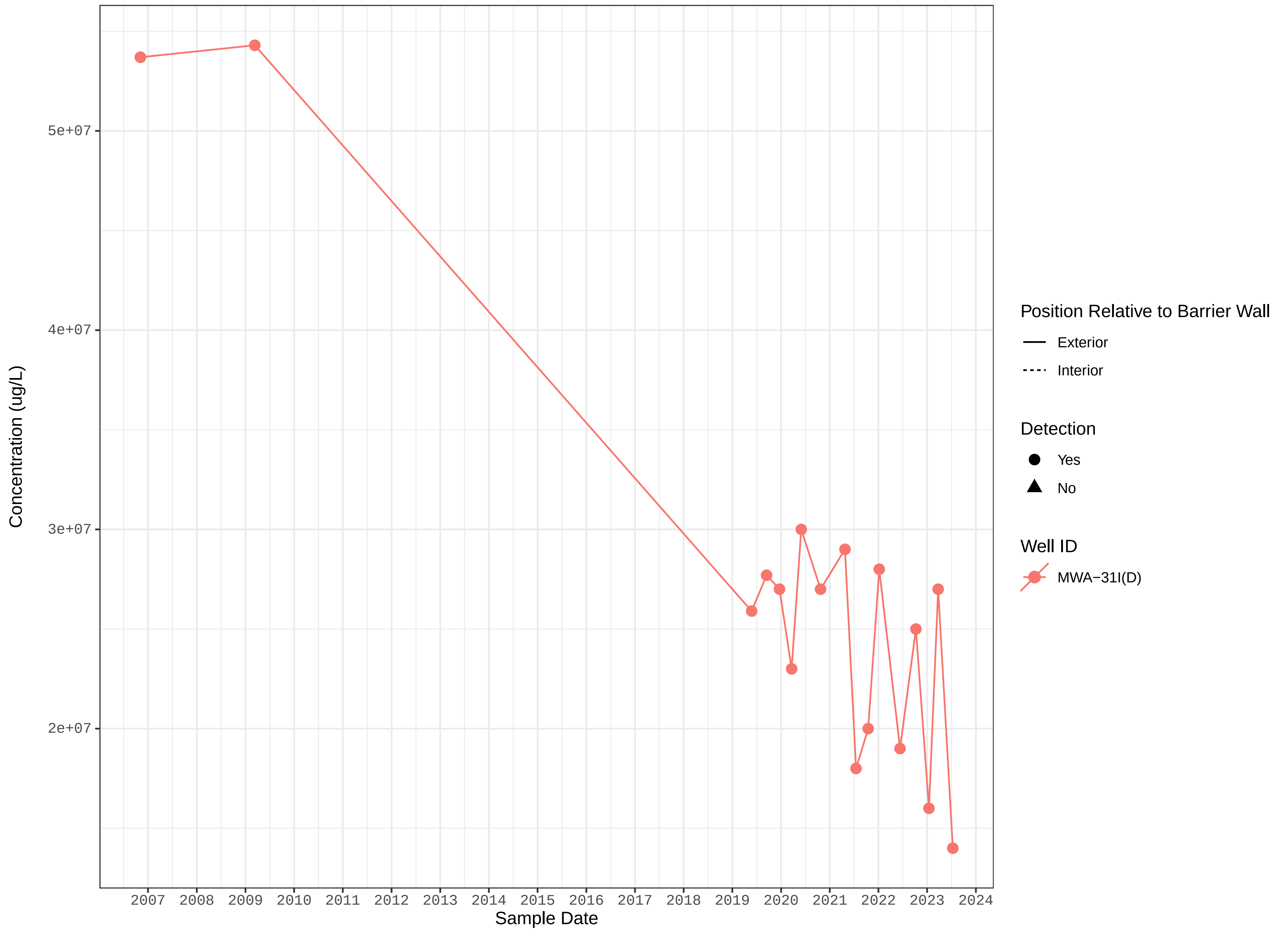


Study Period Trend − GCC4 & Proximal Wells − Chlorobenzene − Deep

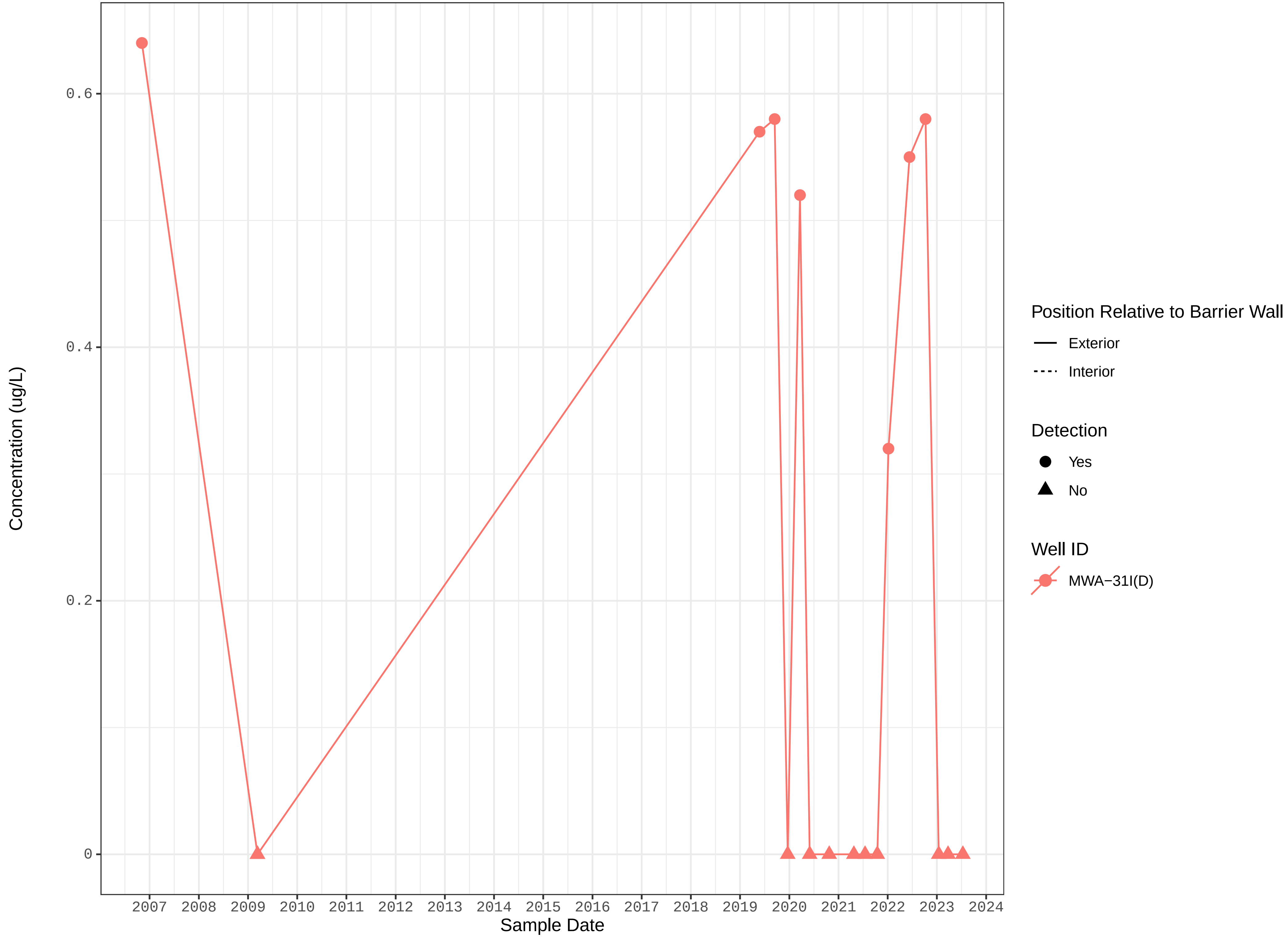


Study Period Trend − GCC4 & Proximal Wells − Perchlorate − Deep

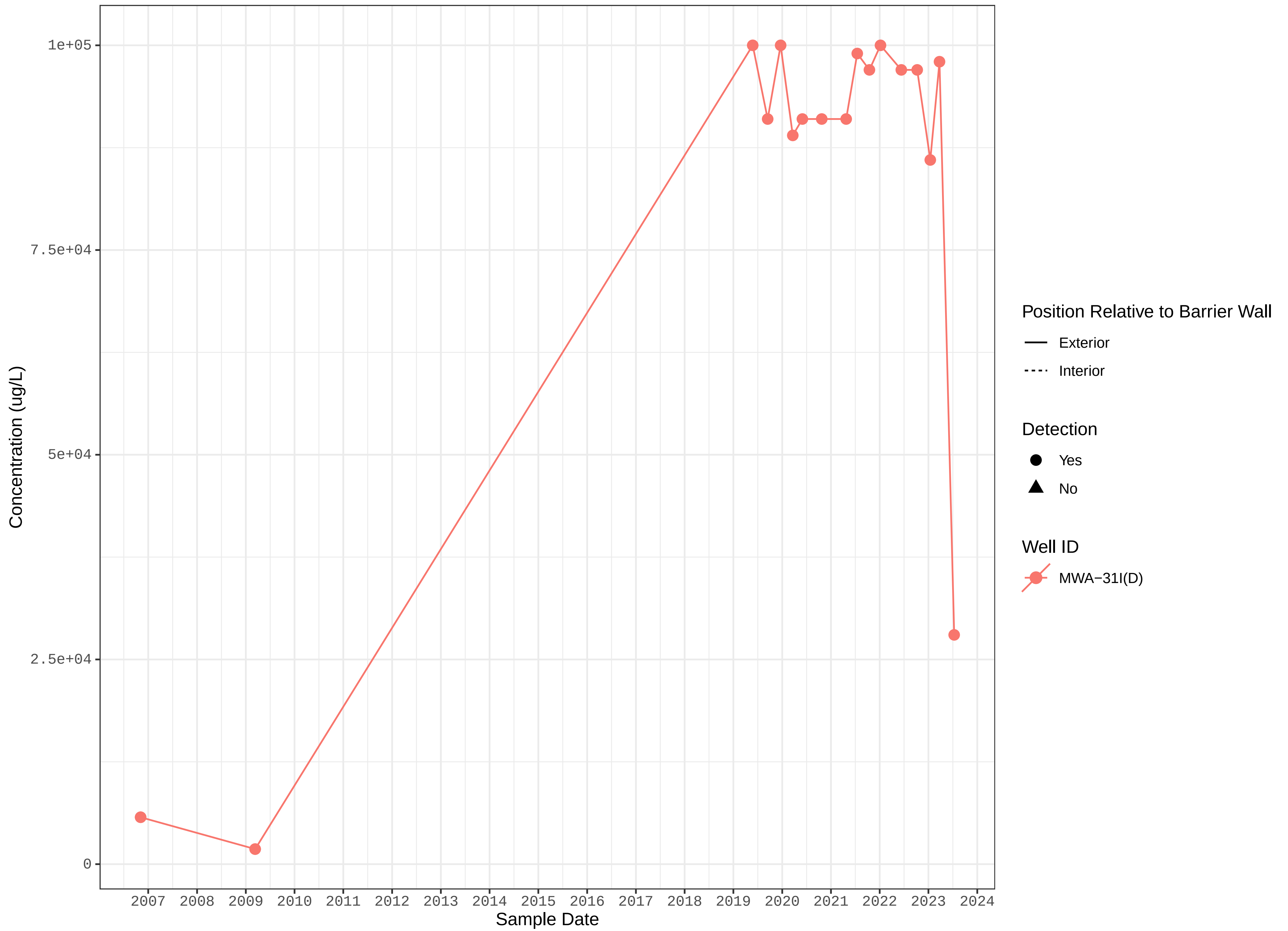
Study Period Trend − GCC5 & Proximal Wells − Chloride − Deep



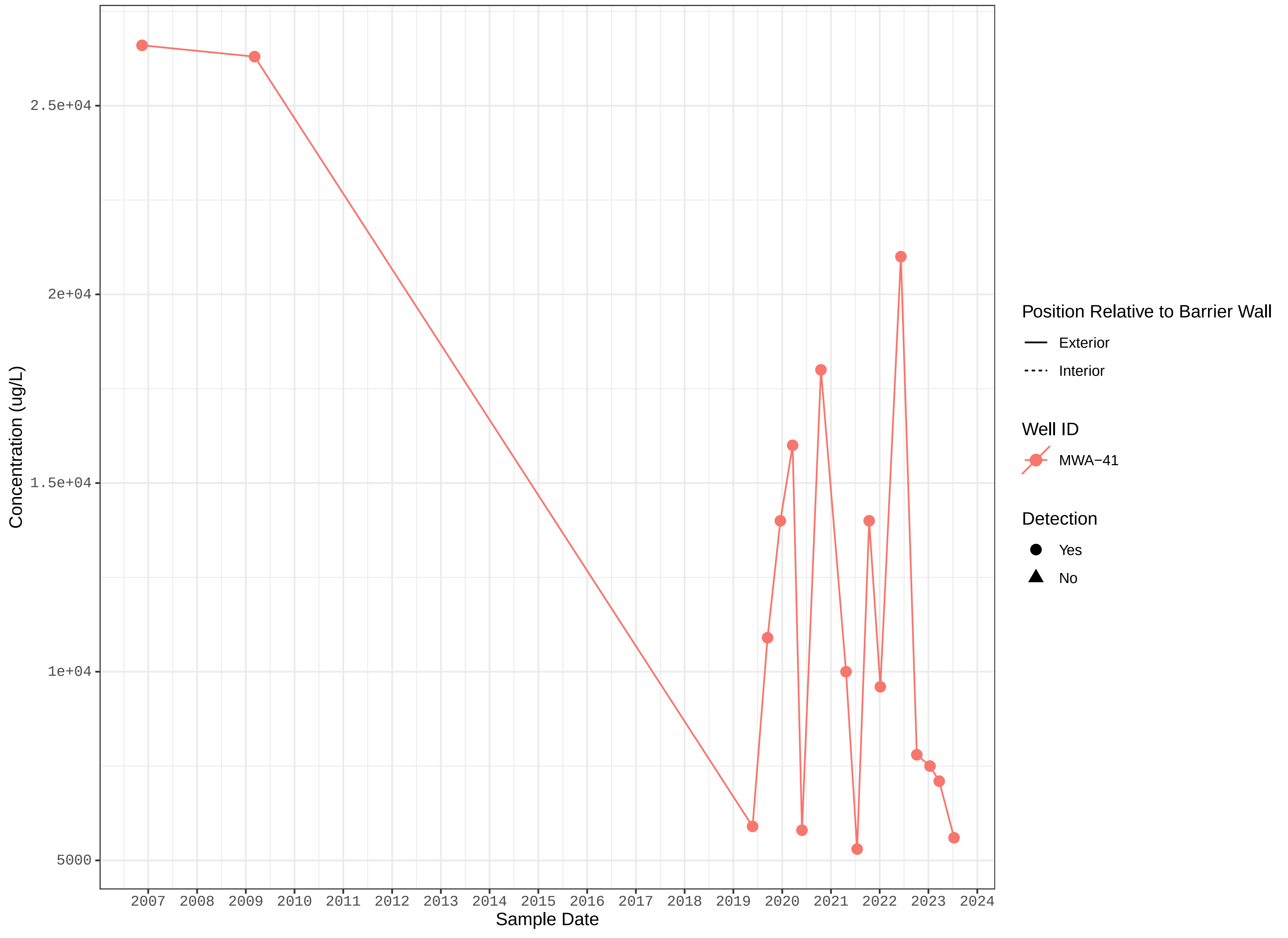
Study Period Trend − GCC5 & Proximal Wells − Chlorobenzene − Deep



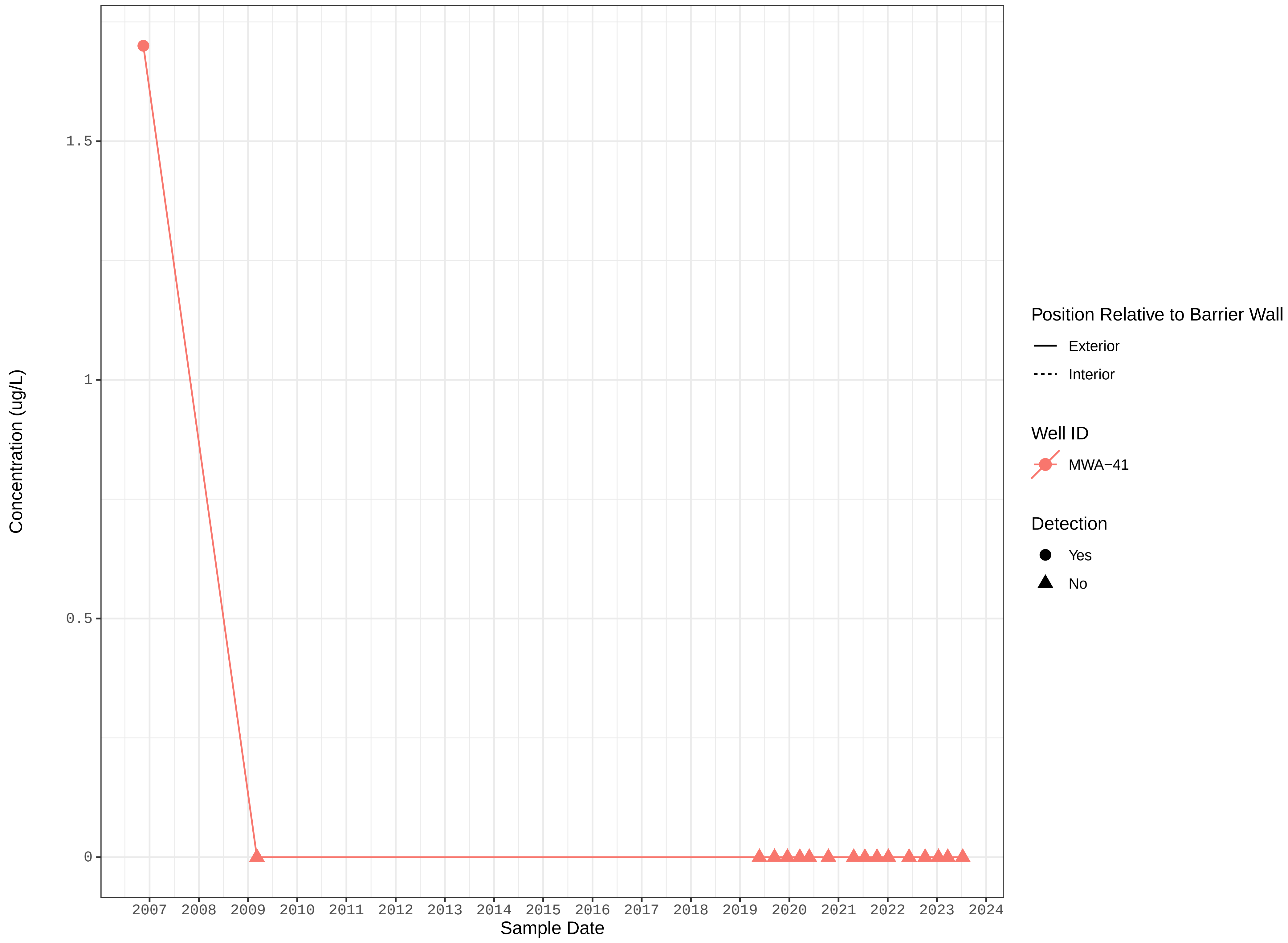
Study Period Trend − GCC5 & Proximal Wells − Perchlorate − Deep



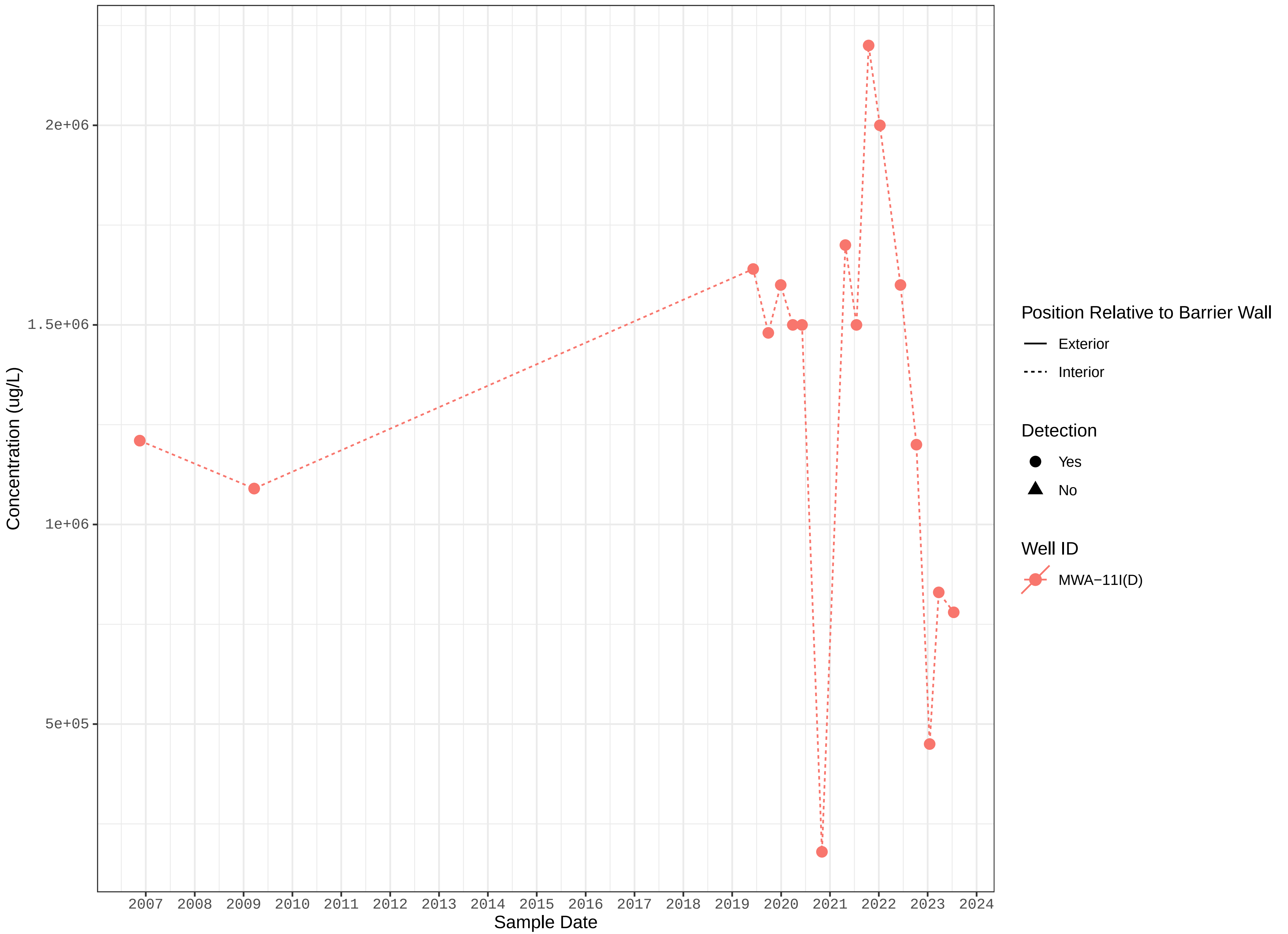
Study Period Trend − GCC6 & Proximal Wells − Chloride − Shallow



Study Period Trend − GCC6 & Proximal Wells − Perchlorate − Shallow

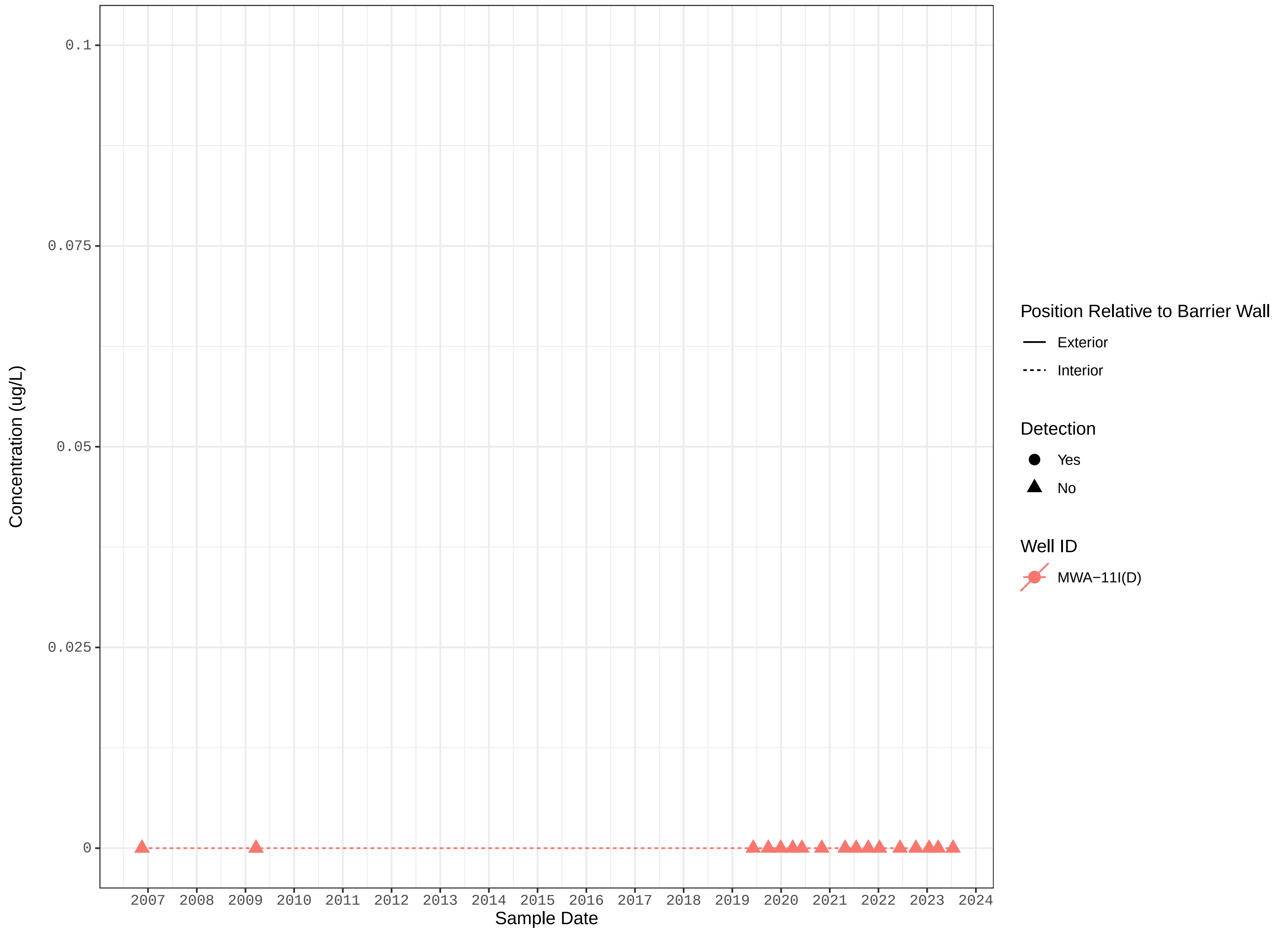


Study Period Trend − Well Distal from BW and GCCs − Chloride − Deep




Study Period Trend − Well Distal from BW and GCCs − Chlorobenzene − Deep
Concentration (ug/L)
0
2
4
6
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Sample Date
Position Relative to Barrier Wall
Exterior
Interior
Detection
Yes
No
Well ID
MWA−11I(D)

Study Period Trend − Well Distal from BW and GCCs − Perchlorate − Deep



ERM

APPENDIX D COMPLETE STATISTICAL DATA ANALYSIS

Table 1
Descriptive Statistics
ARKEMA-PORTLAND

chemical_name	sys_loc_code	date_range	cluster	barrier	aquifer	Units	N	Num Detects	Num ND	Percent Detects	Min RL	Max RL	Min Detect	Median	Mean	Max Detect	SD	CV	Distribution
Chloride	MWA-11I(D)	Current	Well Distal from BW and GCCs	Interior	Deep	ug/L	15	15	0	100.00%			180000	1500000	1344000	2200000	557900	41.51%	Normal
Chloride	MWA-11I(D)	Study Period Trend	Well Distal from BW and GCCs	Interior	Deep	ug/L	19	19	0	100.00%			180000	1480000	1303000	2200000	499500	38.33%	Normal
Chloride	MWA-11I(D)	Historic	Well Distal from BW and GCCs	Interior	Deep	ug/L	4	4	0	100.00%			1090000	1150000	1150000	1210000	69280	6.02%	NDD
Chloride	MWA-31I(D)	Current	GCC5 & Proximal Wells	Exterior	Deep	ug/L	15	15	0	100.00%			14000000	25900000	23770000	30000000	5096000	21.43%	Normal
Chloride	MWA-31I(D)	Study Period Trend	GCC5 & Proximal Wells	Exterior	Deep	ug/L	19	19	0	100.00%			14000000	27000000	30140000	54300000	13440000	44.58%	NDD
Chloride	MWA-31I(D)	Historic	GCC5 & Proximal Wells	Exterior	Deep	ug/L	4	4	0	100.00%			53700000	54000000	54000000	54300000	346400	0.64%	NDD
Chloride	MWA-41	Current	GCC6 & Proximal Wells	Exterior	Shallow	ug/L	15	15	0	100.00%			5300	9600	10570	21000	4961	46.95%	Normal
Chloride	MWA-41	Study Period Trend	GCC6 & Proximal Wells	Exterior	Shallow	ug/L	19	19	0	100.00%			5300	10900	13910	26600	7963	57.24%	Lognormal
Chloride	MWA-41	Historic	GCC6 & Proximal Wells	Exterior	Shallow	ug/L	4	4	0	100.00%			26300	26450	26450	26600	173.2	0.65%	NDD
Chloride	MWA-56D	Current	GCC4 & Proximal Wells	Exterior	Deep	ug/L	15	15	0	100.00%			14000000	19000000	19030000	26000000	3743000	19.67%	Normal
Chloride	MWA-56D	Study Period Trend	GCC4 & Proximal Wells	Exterior	Deep	ug/L	19	19	0	100.00%			14000000	21000000	20360000	27900000	4399000	21.61%	Normal
Chloride	MWA-56D	Historic	GCC4 & Proximal Wells	Exterior	Deep	ug/L	4	4	0	100.00%			22800000	25350000	25350000	27900000	2944000	11.62%	NDD
Chloride	MWA-58D	Current	GCC4 & Proximal Wells	Exterior	Deep	ug/L	15	15	0	100.00%			18900000	20000000	21470000	29000000	2954000	13.76%	NDD
Chloride	MWA-58D	Study Period Trend	GCC4 & Proximal Wells	Exterior	Deep	ug/L	19	19	0	100.00%			18900000	22000000	26130000	53600000	10720000	41.04%	NDD
Chloride	MWA-58D	Historic	GCC4 & Proximal Wells	Exterior	Deep	ug/L	4	4	0	100.00%			33600000	43600000	43600000	53600000	11550000	26.48%	NDD
Chloride	MWA-63	Current	GCC1 & Proximal Wells	Exterior	Shallow	ug/L	15	15	0	100.00%			4900	14000	24680	83000	25640	103.90%	Lognormal
Chloride	MWA-63	Study Period Trend	GCC1 & Proximal Wells	Exterior	Shallow	ug/L	19	19	0	100.00%			4900	17000	129800	690000	224400	172.92%	NDD
Chloride	MWA-63	Historic	GCC1 & Proximal Wells	Exterior	Shallow	ug/L	4	4	0	100.00%			358000	524000	524000	690000	191700	36.58%	NDD
Chloride	MWA-81I	Current	GCC6 & Proximal Wells	Exterior	Intermediate	ug/L	15	15	0	100.00%			14000	49800	100400	610000	148600	148.02%	Lognormal
Chloride	MWA-82	Current	GCC6 & Proximal Wells	Interior	Shallow	ug/L	15	15	0	100.00%			9000	11000	13470	34800	6229	46.23%	NDD
Chloride	PA-03	Current	GCC1 & Proximal Wells	Exterior	Shallow	ug/L	15	14	1	93.33%	9000	9000	4500	7300	7067	10000	2078	29.40%	Normal
Chloride	PA-04	Current	GCC1 & Proximal Wells	Interior	Shallow	ug/L	15	15	0	100.00%			4600	7900	9013	14300	3429	38.04%	Lognormal
Chloride	PA-08	Current	GCC6 & Proximal Wells	Interior	Shallow	ug/L	15	15	0	100.00%			29000	130000	208000	770000	182700	87.85%	Lognormal
Chloride	PA-09	Current	GCC6 & Proximal Wells	Exterior	Shallow	ug/L	15	15	0	100.00%			5600	23600	57060	199000	61930	108.53%	Lognormal
Chloride	PA-10I	Current	GCC1 & Proximal Wells	Interior	Intermediate	ug/L	15	15	0	100.00%			35000	76000	153500	1300000	318000	207.15%	NDD
Chloride	PA-15I	Current	GCC6 & Proximal Wells	Interior	Intermediate	ug/L	15	15	0	100.00%			4400	260000	273300	850000	189100	69.21%	NDD
Chloride	PA-16I	Current	GCC6 & Proximal Wells	Exterior	Intermediate	ug/L	15	15	0	100.00%			12000	110000	152700	530000	133000	87.08%	Lognormal
Chloride	PA-17IR	Current	GCC1 & Proximal Wells	Exterior	Intermediate	ug/L	15	15	0	100.00%			8800	30000	36650	73600	20980	57.24%	Normal
Chloride	PA-18D	Current	GCC1 & Proximal Wells	Interior	Deep	ug/L	4	4	0	100.00%			27000	52000	52750	80000	21720	41.17%	Normal
Chloride	PA-19D	Current	GCC2	Exterior	Deep	ug/L	15	15	0	100.00%			94000	320000	265700	360000	97640	36.75%	NDD
Chloride	PA-20D	Current	GCC3	Interior	Deep	ug/L	15	15	0	100.00%			570000	880000	931300	1200000	170300	18.28%	Normal
Chloride	PA-21D	Current	GCC3	Exterior	Deep	ug/L	15	15	0	100.00%			290000	350000	360700	463000	45180	12.53%	Normal
Chloride	PA-22D	Current	GCC4 & Proximal Wells	Interior	Deep	ug/L	15	15	0	100.00%			4800000	7400000	7546000	10200000	1733000	22.97%	Normal
Chloride	PA-23D	Current	GCC5 & Proximal Wells	Interior	Deep	ug/L	15	15	0	100.00%			12500	16000000	14870000	30000000	10160000	68.32%	Normal
Chloride	PA-24D	Current	GCC5 & Proximal Wells	Exterior	Deep	ug/L	15	15	0	100.00%			31000000	38000000	37790000	46000000	5299000	14.02%	Normal
Chloride	PA-25D	Current	GCC6 & Proximal Wells	Interior	Deep	ug/L	15	15	0	100.00%			1100	22100	19280	34000	7900	40.98%	Normal
Chloride	PA-26D	Current	GCC6 & Proximal Wells	Exterior	Deep	ug/L	15	15	0	100.00%			6500	52000	49260	74000	21630	43.90%	Normal
Chloride	PA-27D	Current	GCC1 & Proximal Wells	Exterior	Deep	ug/L	15	15	0	100.00%			450000	840000	836900	1150000	183000	21.87%	Normal
Chloride	PA-30D	Current	GCC2	Interior	Deep	ug/L	15	15	0	100.00%			56000	320000	331500	540000	133000	40.13%	Normal
Chloride	PA-31	Current	GCC1 & Proximal Wells	Interior	Shallow	ug/L	15	15	0	100.00%			2500	6400	6767	10500	2320	34.29%	Normal
Chloride	PA-32I	Current	GCC1 & Proximal Wells	Interior	Intermediate	ug/L	15	15	0	100.00%			31000	93000	106800	170000	47290	44.28%	Normal
Chloride	PA-44I	Current	GCC6 & Proximal Wells	Interior	Intermediate	ug/L	15	15	0	100.00%			1900	51000	80470	370000	98240	122.07%	Lognormal
Chlorobenzene	MWA-11I(D)	Current	Well Distal from BW and GCCs	Interior	Deep	ug/L	15	8	7	53.33%	0.03	0.7	0.039	0.06	0.8028	7	1.83	227.99%	Lognormal
Chlorobenzene	MWA-11I(D)	Study Period Trend	Well Distal from BW and GCCs	Interior	Deep	ug/L	19	10	9	52.63%	0.03	0.78	0.039	0.22	0.8769	7	1.661	189.35%	Lognormal
Chlorobenzene	MWA-11I(D)	Historic	Well Distal from BW and GCCs	Interior	Deep	ug/L	4	2	2	50.00%	0.78	0.78	1.92	1.155	1.155	1.92	0.8833	76.48%	NDD
Chlorobenzene	MWA-31I(D)	Current	GCC5 & Proximal Wells	Exterior	Deep	ug/L	15	6	9	40.00%	0.44	1	0.32	0.22	0.3587	0.58	0.1649	45.97%	NDD
Chlorobenzene	MWA-31I(D)	Study Period Trend	GCC5 & Proximal Wells	Exterior	Deep	ug/L	19	8	11	42.11%	0.44	2.5	0.32	0.5	0.4821	0.64	0.3196	66.29%	NDD
Chlorobenzene	MWA-31I(D)	Historic	GCC5 & Proximal Wells	Exterior	Deep	ug/L	4	2	2	50.00%	2.5	2.5	0.64	0.945	0.945	0.64	0.3522	37.27%	NDD
Chlorobenzene	MWA-41	Current	GCC6 & Proximal Wells	Exterior	Shallow	ug/L	15	1	14	6.67%	0.03	0.44	0.16	0.03	0.049	0.16	0.06229	127.12%	NDD
Chlorobenzene	MWA-56D	Current	GCC4 & Proximal Wells	Exterior	Deep	ug/L	15	0	15	0.00%	0.3	4.4		0.22	0.7953		0.8996	113.11%	NDD
Chlorobenzene	MWA-56D	Study Period Trend	GCC4 & Proximal Wells	Exterior	Deep	ug/L	19	0	19	0.00%	0.3	5		0.22	1.023		0.9596	93.83%	NDD
Chlorobenzene	MWA-56D	Historic	GCC4 & Proximal Wells	Exterior	Deep	ug/L	4	0	4	0.00%	2.5	5		1.875	1.875		0.7217	38.49%	NDD
Chlorobenzene	MWA-58D	Current	GCC4 & Proximal Wells	Exterior	Deep	ug/L	15	0	15	0.00%	0.3	4.4		0.22	0.714		0.7212	101.01%	NDD
Chlorobenzene	MWA-58D	Study Period Trend	GCC4 & Proximal Wells	Exterior	Deep	ug/L	19	2	17	10.53%	0.3	4.4	2	1.1	0.9058	2	0.7625	84.18%	NDD
Chlorobenzene	MWA-58D	Historic	GCC4 & Proximal Wells	Exterior	Deep	ug/L	4	2	2	50.00%	2.5	2.5	2	1.625	1.625	2	0.433	26.65%	NDD
Chlorobenzene	MWA-63	Current	GCC1 & Proximal Wells	Exterior	Shallow	ug/L	15	1	14	6.67%	0.3	44	5.6	0.22	2.158	5.6	5.675	262.98%	NDD
Chlorobenzene	MWA-63	Study Period Trend	GCC1 & Proximal Wells	Exterior	Shallow	ug/L	19	3	16	15.79%	0.3	100	0.18	0.22	6.986	5.6	15.97	228.68%	NDD
Chlorobenzene	MWA-63	Historic	GCC1 & Proximal Wells	Exterior	Shallow	ug/L	4	2	2	50.00%	100	100	0.18	25.09	25.09	0.18	28.76	114.64%	NDD
Chlorobenzene	MWA-81I	Current	GCC6 & Proximal Wells	Exterior	Intermediate	ug/L	15	1	14	6.67%	0.03	0.44	0.26	0.03	0.05567	0.26	0.07831	140.68%	NDD
Chlorobenzene	MWA-82	Current	GCC6 & Proximal Wells	Interior	Shallow	ug/L	15	2	13	13.33%	0.03	0.44	0.03	0.03	0.06133	0.24	0.07392	120.52%	NDD
Chlorobenzene	PA-03	Current	GCC1 & Proximal Wells	Exterior	Shallow	ug/L	15	1	14	6.67%	0.03	0.44	0.29	0.03	0.05333	0.29	0.08341	156.39%	NDD
Chlorobenzene	PA-04	Current	GCC1 & Proximal Wells	Interior	Shallow	ug/L	15	1	14	6.67%	0.03	2	0.14	0.03	0.1047	0.14	0.2525	241.19%	NDD
Chlorobenzene	PA-08	Current	GCC6 & Proximal Wells	Interior	Shallow	ug/L	15	5	10	33.33%	0.03	0.6	0.084	0.084	0.1251	0.53	0.144	115.14%	Lognormal
Chlorobenzene	PA-09	Current	GCC6 & Proximal Wells	Exterior	Shallow	ug/L	16	2	14	12.50%	0.03	0.44	0.16	0.03	0.09734	0.39	0.1065	109.36%	Lognormal
Chlorobenzene	PA-10I	Current	GCC1 & Proximal Wells	Interior	Intermediate	ug/L	15	12	3	80.00%	0.06	0.44	0.37	0.65	0.9653	5.7	1.366	141.46%	Lognormal
Chlorobenzene	PA-15I	Current	GCC6 & Proximal Wells	Interior	Intermediate	ug/L	15	2	13	13.33%	0.03	2.5	0.073	0.03	0.1674	0.29	0.3161	188.89%	Lognormal
Chlorobenzene	PA-16I	Current	GCC6 & Proximal Wells	Exterior	Intermediate	ug/L	16	5	11	31.25%	0.03	0.44	0.073	0.1125	0.12	0.31	0.09306	77.53%	Normal
Chlorobenzene	PA-17IR	Current	GCC1 & Proximal Wells	Exterior	Intermediate	ug/L	15	6	9	40.00%	0.03	0.7	0.072	0.1	1.732	24	6.162	355.90%	NDD
Chlorobenzene	PA-18D	Current	GCC1 & Proximal Wells	Interior	Deep	ug/L	4	0	4	0.00%	0.44	0.44		0.22	0.22		0	0.00%	NDD
Chlorobenzene	PA-19D	Current	GCC2	Exterior	Deep	ug/L	14	14	0	100.00%			2500	6850	6293	12000	3000	47.67%	Normal
Chlorobenzene	PA-20D	Current	GCC3	Interior	Deep	ug/L	15	15	0	100.00%			9.3	23	24.15	41	10.88	45.07%	Normal
Chlorobenzene	PA-21D	Current	GCC3	Exterior	Deep	ug/L	15	15	0	100.00%			11000	30000	31530	49000	12310	39.04%	Normal
Chlorobenzene	PA-22D	Current	GCC4 & Proximal Wells	Interior	Deep	ug/L	15	0	15	0.00%	0.3	0.44		0.22	0.2153		0.01807	8.39%	NDD
Chlorobenzene	PA-23D	Current	GCC5 & Proximal Wells	Interior	Deep	ug/L	15	2	13	13.33%	0.3	0.44	1.3	0.22	0.4593	2.8	0.7055	153.60%	NDD
Chlorobenzene	PA-24D	Current	GCC5 & Proximal Wells	Exterior	Deep	ug/L	15	0	15	0.00%	0.3	0.44		0.22	0.2153		0.01807	8.39%	NDD
Chlorobenzene	PA-25D	Current	GCC6 & Proximal Wells	Interior	Deep	ug/L	15	0	15	0.00%	0.03	0.44		0.03	0.04033		0.05427	134.56%	NDD
Chlorobenzene	PA-26D	Current	GCC6 & Proximal Wells	Exterior	Deep	ug/L	16	1	15	6.25%	0.03	0.44	0.71	0.03	0.08969	0.71	0.1788	199.34%	NDD
Chlorobenzene	PA-27D	Current	GCC1 & Proximal Wells	Exterior	Deep	ug/L	15	3	12	20.00%	0.3	0.44	0.52	0.22	0.4953	3.5	0.8494	171.48%	NDD
Chlorobenzene	PA-30D	Current	GCC2	Interior	Deep	ug/L	14	14	0	100.00%			3500	5800	11240	26000	8658	77.06%	NDD
Chlorobenzene	PA-31	Current	GCC1 & Proximal Wells	Interior	Shallow	ug/L	15	1	14	6.67%	0.03	0.44	0.15	0.03	0.044	0.15	0.05942	135.03%	NDD
Chlorobenzene	PA-32I	Current	GCC1 & Proximal Wells	Interior	Intermediate	ug/L	15	9	6	60.00%	0.03	0.7	0.13	0.28	0.2273	0.5	0.1468	64.56%	Normal
Chlorobenzene	PA-44I	Current	GCC6 & Proximal Wells	Interior	Intermediate	ug/L	15	1	14	6.67%	0.03	0.44	0.18	0.03	0.05367	0.18	0.06889	128.36%	NDD
Perchlorate	MWA-11I(D)	Current	Well Distal from BW and GCCs	Interior	Deep	ug/L	15	0	15	0.00%	0.95	48		5	8.14		6.606	81.15%	NDD
Perchlorate	MWA-11I(D)	Study Period Trend	Well Distal from BW and GCCs	Interior	Deep	ug/L	19	0	19	0.00%	0.95	48		5	7.058		6.229	88.25%	Lognormal
Perchlorate	MWA-11I(D)	Historic	Well Distal from BW and GCCs	Interior	Deep	ug/L	4	0	4	0.00%	4	8		3	3		1.155	38.49%	NDD
Perchlorate	MWA-31I(D)	Current	GCC5 & Proximal Wells	Exterior	Deep	ug/L	15	15	0	100.00%			28000	97000	90330	100000	17840	19.75%	NDD
Perchlorate	MWA-31I(D)	Study Period Trend	GCC5 & Proximal Wells	Exterior	Deep	ug/L	19	19	0	100.00%			1840	91000	72110	100000	39530	54.81%	NDD
Perchlorate	MWA-31I(D)	Historic	GCC5 & Proximal Wells	Exterior	Deep	ug/L	4	4	0	100.00%			1840	3785	3785	5730	2246	59.34%	NDD
Perchlorate	MWA-41	Current	GCC6 & Proximal Wells	Exterior	Shallow	ug/L	15	0	15	0.00%	0.95	2		1	0.825		0.2562	31.05%	NDD
Perchlorate	MWA-41	Study Period Trend	GCC6 & Proximal Wells	Exterior	Shallow	ug/L	19	2	17	10.53%	0.95	4	1.7	1	1.041	1.7	0.4903	47.11%	NDD
Perchlorate	MWA-41	Historic	GCC6 & Proximal Wells	Exterior	Shallow	ug/L	4	2	2	50.00%	4	4	1.7	1.85	1.85	1.7	0.1732	9.36%	NDD
Perchlorate	MWA-56D	Current	GCC4 & Proximal Wells	Exterior	Deep	ug/L	15	15	0	100.00%			3300	8400	9147	15000	3837	41.95%	Normal
Perchlorate	MWA-56D	Study Period Trend	GCC4 & Proximal Wells	Exterior	Deep	ug/L	19	19	0	100.00%			2140	7100	7702	15000	4440	57.65%	Normal
Perchlorate	MWA-56D	Historic	GCC4 & Proximal Wells	Exterior	Deep	ug/L	4	4	0	100.00%			2140	2285	2285	2430	167.4	7.33%	NDD
Perchlorate	MWA-58D	Current	GCC4 & Proximal Wells	Exterior	Deep	ug/L	15	15	0	100.00%			38000	47000	47200	61000	5144	10.90%	Normal
Perchlorate	MWA-58D	Study Period Trend	GCC4 & Proximal Wells	Exterior	Deep	ug/L	19	19	0	100.00%			38000	49000	57010	128000	25720	45.11%	NDD
Perchlorate	MWA-58D	Historic	GCC4 & Proximal Wells	Exterior	Deep	ug/L	4	4	0	100.00%			59600	93800	93800	128000	39490	42.10%	NDD
Perchlorate	MWA-63	Current	GCC1 & Proximal Wells	Exterior	Shallow	ug/L	15	1	14	6.67%	0.95	10	13	1	2.02	13	3.245	160.66%	NDD
Perchlorate	MWA-63	Study Period Trend	GCC1 & Proximal Wells	Exterior	Shallow	ug/L	19	1	18	5.26%	0.95	10	13	1	2.226	13	2.93	131.59%	NDD
Perchlorate	MWA-63	Historic	GCC1 & Proximal Wells	Exterior	Shallow	ug/L	4	0	4	0.00%	4	8		3	3		1.155	38.49%	NDD
Perchlorate	MWA-81I	Current	GCC6 & Proximal Wells	Exterior	Intermediate	ug/L	15	0	15	0.00%	0.95	10		1	1.158		1.134	97.90%	NDD
Perchlorate	MWA-82	Current	GCC6 & Proximal Wells	Interior	Shallow	ug/L	15	13	2	86.67%	10	48	52	150	165	530	139.7	84.68%	Normal
Perchlorate	PA-03	Current	GCC1 & Proximal Wells	Exterior	Shallow	ug/L	15	0	15	0.00%	2	95		9.5	10.49		12.74	121.37%	Lognormal
Perchlorate	PA-04	Current	GCC1 & Proximal Wells	Interior	Shallow	ug/L	15	0	15	0.00%	2	48		2.4	5.513		6.057	109.86%	Lognormal
Perchlorate	PA-08	Current	GCC6 & Proximal Wells	Interior	Shallow	ug/L	15	2	13	13.33%	4	48	11	10	12.07	17	7.012	58.11%	NDD
Perchlorate	PA-09	Current	GCC6 & Proximal Wells	Exterior	Shallow	ug/L	15	5	10	33.33%	0.95	48	6.2	9.5	19.64	120	30.39	154.72%	Lognormal
Perchlorate	PA-10I	Current	GCC1 & Proximal Wells	Interior	Intermediate	ug/L	15	0	15	0.00%	2	95		10	11.02		12.41	112.64%	Lognormal
Perchlorate	PA-15I	Current	GCC6 & Proximal Wells	Interior	Intermediate	ug/L	15	0	15	0.00%	4	48		10	11.36		8.358	73.58%	Lognormal
Perchlorate	PA-16I	Current	GCC6 & Proximal Wells	Exterior	Intermediate	ug/L	15	0	15	0.00%	4	48		10	10.43		9.044	86.74%	NDD
Perchlorate	PA-17IR	Current	GCC1 & Proximal Wells	Exterior	Intermediate	ug/L	15	0	15	0.00%	2	190		10	16.86		24.87	147.51%	Lognormal
Perchlorate	PA-18D	Current	GCC1 & Proximal Wells	Interior	Deep	ug/L	4	0	4	0.00%	10	40		7.5	10		7.071	70.71%	Normal
Perchlorate	PA-19D	Current	GCC2	Exterior	Deep	ug/L	15	0	15	0.00%	10	200		10	22.23		24.19	108.82%	Lognormal
Perchlorate	PA-20D	Current	GCC3	Interior	Deep	ug/L	15	8	7	53.33%	10	100	46	50	45.93	140	39.74	86.51%	NDD
Perchlorate	PA-21D	Current	GCC3	Exterior	Deep	ug/L	15	9	6	60.00%	10	100	110	1100	792.3	2400	791.2	99.85%	NDD
Perchlorate	PA-22D	Current	GCC4 & Proximal Wells	Interior	Deep	ug/L	15	15	0	100.00%			13000	24000	27330	54000	12130	44.39%	Normal
Perchlorate	PA-23D	Current	GCC5 & Proximal Wells	Interior	Deep	ug/L	15	0	15	0.00%	0.95	1000		50	92.15		133.8	145.24%	NDD
Perchlorate	PA-24D	Current	GCC5 & Proximal Wells	Exterior	Deep	ug/L	15	0	15	0.00%	4.8	400		100	95.59		74.28	77.71%	NDD
Perchlorate	PA-25D	Current	GCC6 & Proximal Wells	Interior	Deep	ug/L	15	0	15	0.00%	0.95	9.5		1	1.11		1.035	93.20%	NDD
Perchlorate	PA-26D	Current	GCC6 & Proximal Wells	Exterior	Deep	ug/L	15	1	14	6.67%	0.95	9.5	1.1	1	1.218	1.1	1.041	85.48%	NDD
Perchlorate	PA-27D	Current	GCC1 & Proximal Wells	Exterior	Deep	ug/L	15	0	15	0.00%	4.8	95		10	12.83		11.37	88.68%	Lognormal
Perchlorate	PA-30D	Current	GCC2	Interior	Deep	ug/L	15	0	15	0.00%	10	200		20	29.97		30.55	101.94%	Lognormal
Perchlorate	PA-31	Current	GCC1 & Proximal Wells	Interior	Shallow	ug/L	15	0	15	0.00%	2	100		4.75	9.777		13.03	133.24%	Lognormal
Perchlorate	PA-32I	Current	GCC1 & Proximal Wells	Interior	Intermediate	ug/L	15	0	15	0.00%	4	190		10	21.1		23.2	109.95%	NDD
Perchlorate	PA-44I	Current	GCC6 & Proximal Wells	Interior	Intermediate	ug/L	15	5	10	33.33%	2	95	7.1	7.1	64.89	390	115.4	177.90%	Lognormal

Notes:
date_range: Historic includes dates from 2007 - 2010
date_range: Study Period Trend includes dates from 2007 - Q4 2023
date_range: Current includes dates from Q4 2019 - Q4 2023

Non-detects were substituted with a value of half the reporting limit for calculations
N: number of data points
Num ND: number of non-detected data points
Min RL: The minimum reporting limit value
Max RL: The maximum reporting limit value
SD: Standard Deviation
CV: Coefficient of Variation (standard deviation divided by the mean)
Normal: the data fit a normal distribution
Lognormal: the data fit a lognormal distribution
NDD: No discernible distribution
GammaHW or GammaWH: the data fit one of the particular gamma distributions

Table 2
Mann-Kendall Test for Trends
ARKEMA-PORTLAND

chemical_name	sys_loc_code	date_range	cluster	barrier	aquifer	N	Num Detects	Percent Detects	Meet Data Reqs	p-value	tau2	tau	Trend
Chloride	MWA-11I(D)	Current	Well Distal from BW and GCCs	Interior	Deep	15	15	1	Yes	0.213	0.0589	-0.243	NS
Chloride	MWA-11I(D)	Historic	Well Distal from BW and GCCs	Interior	Deep	4	4	1	Insufficient samples				
Chloride	MWA-11I(D)	Historic Trend	Well Distal from BW and GCCs	Interior	Deep	19	19	1	Yes	0.86	0.0009	-0.0299	NS
Chloride	MWA-31I(D)	Current	GCC5 & Proximal Wells	Exterior	Deep	15	15	1	Yes	0.0735	0.121	-0.348	NS
Chloride	MWA-31I(D)	Historic	GCC5 & Proximal Wells	Exterior	Deep	4	4	1	Insufficient samples				
Chloride	MWA-31I(D)	Historic Trend	GCC5 & Proximal Wells	Exterior	Deep	19	19	1	Yes	0.00122	0.302	-0.549	Significant
Chloride	MWA-41	Current	GCC6 & Proximal Wells	Exterior	Shallow	15	15	1	Yes	0.276	0.0443	-0.211	NS
Chloride	MWA-41	Historic	GCC6 & Proximal Wells	Exterior	Shallow	4	4	1	Insufficient samples				
Chloride	MWA-41	Historic Trend	GCC6 & Proximal Wells	Exterior	Shallow	19	19	1	Yes	0.00254	0.26	-0.51	Significant
Chloride	MWA-56D	Current	GCC4 & Proximal Wells	Exterior	Deep	15	15	1	Yes	<0.001	0.475	-0.689	Significant
Chloride	MWA-56D	Historic	GCC4 & Proximal Wells	Exterior	Deep	4	4	1	Insufficient samples				
Chloride	MWA-56D	Historic Trend	GCC4 & Proximal Wells	Exterior	Deep	19	19	1	Yes	<0.001	0.578	-0.761	Significant
Chloride	MWA-58D	Current	GCC4 & Proximal Wells	Exterior	Deep	15	15	1	Yes	0.96	0.0001	-0.0101	NS
Chloride	MWA-58D	Historic	GCC4 & Proximal Wells	Exterior	Deep	4	4	1	Insufficient samples				
Chloride	MWA-58D	Historic Trend	GCC4 & Proximal Wells	Exterior	Deep	19	19	1	Yes	0.0213	0.159	-0.399	Significant
Chloride	MWA-63	Current	GCC1 & Proximal Wells	Exterior	Shallow	15	15	1	Yes	0.234	0.0527	-0.23	NS
Chloride	MWA-63	Historic	GCC1 & Proximal Wells	Exterior	Shallow	4	4	1	Insufficient samples				
Chloride	MWA-63	Historic Trend	GCC1 & Proximal Wells	Exterior	Shallow	19	19	1	Yes	0.00499	0.225	-0.475	Significant
Chloride	MWA-81I	Current	GCC6 & Proximal Wells	Exterior	Intermediate	15	15	1	Yes	0.276	0.0443	-0.211	NS
Chloride	MWA-82	Current	GCC6 & Proximal Wells	Interior	Shallow	15	15	1	Yes	0.0159	0.229	-0.478	Significant
Chloride	PA-03	Current	GCC1 & Proximal Wells	Exterior	Shallow	15	14	0.933333	Yes	0.00148	0.382	-0.618	Significant
Chloride	PA-04	Current	GCC1 & Proximal Wells	Interior	Shallow	15	15	1	Yes	<0.001	0.52	-0.721	Significant
Chloride	PA-08	Current	GCC6 & Proximal Wells	Interior	Shallow	15	15	1	Yes	0.728	0.00462	-0.068	NS
Chloride	PA-09	Current	GCC6 & Proximal Wells	Exterior	Shallow	15	15	1	Yes	0.399	0.0267	-0.163	NS
Chloride	PA-10I	Current	GCC1 & Proximal Wells	Interior	Intermediate	15	15	1	Yes	0.00746	0.267	-0.517	Significant
Chloride	PA-15I	Current	GCC6 & Proximal Wells	Interior	Intermediate	15	15	1	Yes	0.655	0.00749	0.0865	NS
Chloride	PA-16I	Current	GCC6 & Proximal Wells	Exterior	Intermediate	15	15	1	Yes	0.18	0.0674	-0.26	NS
Chloride	PA-17IR	Current	GCC1 & Proximal Wells	Exterior	Intermediate	15	15	1	Yes	<0.001	0.718	-0.848	Significant
Chloride	PA-18D	Current	GCC1 & Proximal Wells	Interior	Deep	4	4	1	Insufficient samples				
Chloride	PA-19D	Current	GCC2	Exterior	Deep	15	15	1	Yes	0.00322	0.335	0.579	Significant
Chloride	PA-20D	Current	GCC3	Interior	Deep	15	15	1	Yes	0.208	0.0627	0.25	NS
Chloride	PA-21D	Current	GCC3	Exterior	Deep	15	15	1	Yes	0.0168	0.219	-0.468	Significant
Chloride	PA-22D	Current	GCC4 & Proximal Wells	Interior	Deep	15	15	1	Yes	<0.001	0.775	-0.88	Significant
Chloride	PA-23D	Current	GCC5 & Proximal Wells	Interior	Deep	15	15	1	Yes	0.0292	0.177	0.421	Significant
Chloride	PA-24D	Current	GCC5 & Proximal Wells	Exterior	Deep	15	15	1	Yes	<0.001	0.522	-0.722	Significant
Chloride	PA-25D	Current	GCC6 & Proximal Wells	Interior	Deep	15	15	1	Yes	0.92	0.00039	-0.0197	NS
Chloride	PA-26D	Current	GCC6 & Proximal Wells	Exterior	Deep	15	15	1	Yes	0.0292	0.177	0.421	Significant
Chloride	PA-27D	Current	GCC1 & Proximal Wells	Exterior	Deep	15	15	1	Yes	0.0359	0.168	-0.41	Significant
Chloride	PA-30D	Current	GCC2	Interior	Deep	15	15	1	Yes	0.252	0.0499	0.223	NS
Chloride	PA-31	Current	GCC1 & Proximal Wells	Interior	Shallow	15	15	1	Yes	0.00129	0.36	-0.6	Significant
Chloride	PA-32I	Current	GCC1 & Proximal Wells	Interior	Intermediate	15	15	1	Yes	<0.001	0.742	-0.861	Significant
Chloride	PA-44I	Current	GCC6 & Proximal Wells	Interior	Intermediate	15	15	1	Yes	0.0275	0.184	-0.429	Significant
Chlorobenzene	MWA-11I(D)	Current	Well Distal from BW and GCCs	Interior	Deep	15	8	0.533333	Yes	0.6	0.0113	-0.106	NS
Chlorobenzene	MWA-11I(D)	Historic	Well Distal from BW and GCCs	Interior	Deep	4	2	0.5	Insufficient samples				
Chlorobenzene	MWA-11I(D)	Historic Trend	Well Distal from BW and GCCs	Interior	Deep	19	10	0.526316	Yes	0.457	0.0177	-0.133	NS
Chlorobenzene	MWA-31I(D)	Current	GCC5 & Proximal Wells	Exterior	Deep	15	6	0.4	Insufficient detects				
Chlorobenzene	MWA-31I(D)	Historic	GCC5 & Proximal Wells	Exterior	Deep	4	2	0.5	Insufficient samples				
Chlorobenzene	MWA-31I(D)	Historic Trend	GCC5 & Proximal Wells	Exterior	Deep	19	8	0.421053	Insufficient FOD				
Chlorobenzene	MWA-41	Current	GCC6 & Proximal Wells	Exterior	Shallow	15	1	0.066667	Insufficient detects				
Chlorobenzene	MWA-56D	Current	GCC4 & Proximal Wells	Exterior	Deep	15	0	0	Insufficient detects				
Chlorobenzene	MWA-56D	Historic	GCC4 & Proximal Wells	Exterior	Deep	4	0	0	Insufficient samples				
Chlorobenzene	MWA-56D	Historic Trend	GCC4 & Proximal Wells	Exterior	Deep	19	0	0	Insufficient detects				
Chlorobenzene	MWA-58D	Current	GCC4 & Proximal Wells	Exterior	Deep	15	0	0	Insufficient detects				
Chlorobenzene	MWA-58D	Historic	GCC4 & Proximal Wells	Exterior	Deep	4	2	0.5	Insufficient samples				
Chlorobenzene	MWA-58D	Historic Trend	GCC4 & Proximal Wells	Exterior	Deep	19	2	0.105263	Insufficient detects				
Chlorobenzene	MWA-63	Current	GCC1 & Proximal Wells	Exterior	Shallow	15	1	0.066667	Insufficient detects				
Chlorobenzene	MWA-63	Historic	GCC1 & Proximal Wells	Exterior	Shallow	4	2	0.5	Insufficient samples				
Chlorobenzene	MWA-63	Historic Trend	GCC1 & Proximal Wells	Exterior	Shallow	19	3	0.157895	Insufficient detects				
Chlorobenzene	MWA-81I	Current	GCC6 & Proximal Wells	Exterior	Intermediate	15	1	0.066667	Insufficient detects				
Chlorobenzene	MWA-82	Current	GCC6 & Proximal Wells	Interior	Shallow	15	2	0.133333	Insufficient detects				
Chlorobenzene	PA-03	Current	GCC1 & Proximal Wells	Exterior	Shallow	15	1	0.066667	Insufficient detects				
Chlorobenzene	PA-04	Current	GCC1 & Proximal Wells	Interior	Shallow	15	1	0.066667	Insufficient detects				
Chlorobenzene	PA-08	Current	GCC6 & Proximal Wells	Interior	Shallow	15	5	0.333333	Insufficient detects				
Chlorobenzene	PA-09	Current	GCC6 & Proximal Wells	Exterior	Shallow	16	2	0.125	Insufficient detects				
Chlorobenzene	PA-10I	Current	GCC1 & Proximal Wells	Interior	Intermediate	15	12	0.8	Yes	0.0363	0.168	0.41	Significant
Chlorobenzene	PA-15I	Current	GCC6 & Proximal Wells	Interior	Intermediate	15	2	0.133333	Insufficient detects				
Chlorobenzene	PA-16I	Current	GCC6 & Proximal Wells	Exterior	Intermediate	16	5	0.3125	Insufficient detects				
Chlorobenzene	PA-17IR	Current	GCC1 & Proximal Wells	Exterior	Intermediate	15	6	0.4	Insufficient detects				
Chlorobenzene	PA-18D	Current	GCC1 & Proximal Wells	Interior	Deep	4	0	0	Insufficient samples				
Chlorobenzene	PA-19D	Current	GCC2	Exterior	Deep	14	14	1	Yes	0.388	0.0349	-0.187	NS
Chlorobenzene	PA-20D	Current	GCC3	Interior	Deep	15	15	1	Yes	<0.001	0.415	-0.644	Significant
Chlorobenzene	PA-21D	Current	GCC3	Exterior	Deep	15	15	1	Yes	0.0329	0.171	-0.413	Significant
Chlorobenzene	PA-22D	Current	GCC4 & Proximal Wells	Interior	Deep	15	0	0	Insufficient detects				
Chlorobenzene	PA-23D	Current	GCC5 & Proximal Wells	Interior	Deep	15	2	0.133333	Insufficient detects				
Chlorobenzene	PA-24D	Current	GCC5 & Proximal Wells	Exterior	Deep	15	0	0	Insufficient detects				
Chlorobenzene	PA-25D	Current	GCC6 & Proximal Wells	Interior	Deep	15	0	0	Insufficient detects				
Chlorobenzene	PA-26D	Current	GCC6 & Proximal Wells	Exterior	Deep	16	1	0.0625	Insufficient detects				
Chlorobenzene	PA-27D	Current	GCC1 & Proximal Wells	Exterior	Deep	15	3	0.2	Insufficient detects				
Chlorobenzene	PA-30D	Current	GCC2	Interior	Deep	14	14	1	Yes	0.0422	0.169	0.411	Significant
Chlorobenzene	PA-31	Current	GCC1 & Proximal Wells	Interior	Shallow	15	1	0.066667	Insufficient detects				
Chlorobenzene	PA-32I	Current	GCC1 & Proximal Wells	Interior	Intermediate	15	9	0.6	Yes	0.236	0.0579	-0.241	NS
Chlorobenzene	PA-44I	Current	GCC6 & Proximal Wells	Interior	Intermediate	15	1	0.066667	Insufficient detects				
Perchlorate	MWA-11I(D)	Current	Well Distal from BW and GCCs	Interior	Deep	15	0	0	Insufficient detects				
Perchlorate	MWA-11I(D)	Historic	Well Distal from BW and GCCs	Interior	Deep	4	0	0	Insufficient samples				
Perchlorate	MWA-11I(D)	Historic Trend	Well Distal from BW and GCCs	Interior	Deep	19	0	0	Insufficient detects				
Perchlorate	MWA-31I(D)	Current	GCC5 & Proximal Wells	Exterior	Deep	15	15	1	Yes	0.512	0.0173	-0.132	NS
Perchlorate	MWA-31I(D)	Historic	GCC5 & Proximal Wells	Exterior	Deep	4	4	1	Insufficient samples				
Perchlorate	MWA-31I(D)	Historic Trend	GCC5 & Proximal Wells	Exterior	Deep	19	19	1	Yes	0.128	0.0697	0.264	NS
Perchlorate	MWA-41	Current	GCC6 & Proximal Wells	Exterior	Shallow	15	0	0	Insufficient detects				
Perchlorate	MWA-41	Historic	GCC6 & Proximal Wells	Exterior	Shallow	4	2	0.5	Insufficient samples				
Perchlorate	MWA-41	Historic Trend	GCC6 & Proximal Wells	Exterior	Shallow	19	2	0.105263	Insufficient detects				
Perchlorate	MWA-56D	Current	GCC4 & Proximal Wells	Exterior	Deep	15	15	1	Yes	<0.001	0.844	0.919	Significant
Perchlorate	MWA-56D	Historic	GCC4 & Proximal Wells	Exterior	Deep	4	4	1	Insufficient samples				
Perchlorate	MWA-56D	Historic Trend	GCC4 & Proximal Wells	Exterior	Deep	19	19	1	Yes	<0.001	0.814	0.902	Significant
Perchlorate	MWA-58D	Current	GCC4 & Proximal Wells	Exterior	Deep	15	15	1	Yes	0.293	0.0433	0.208	NS
Perchlorate	MWA-58D	Historic	GCC4 & Proximal Wells	Exterior	Deep	4	4	1	Insufficient samples				
Perchlorate	MWA-58D	Historic Trend	GCC4 & Proximal Wells	Exterior	Deep	19	19	1	Yes	0.274	0.0353	-0.188	NS
Perchlorate	MWA-63	Current	GCC1 & Proximal Wells	Exterior	Shallow	15	1	0.066667	Insufficient detects				
Perchlorate	MWA-63	Historic	GCC1 & Proximal Wells	Exterior	Shallow	4	0	0	Insufficient samples				
Perchlorate	MWA-63	Historic Trend	GCC1 & Proximal Wells	Exterior	Shallow	19	1	0.052632	Insufficient detects				
Perchlorate	MWA-81I	Current	GCC6 & Proximal Wells	Exterior	Intermediate	15	0	0	Insufficient detects				
Perchlorate	MWA-82	Current	GCC6 & Proximal Wells	Interior	Shallow	15	13	0.866667	Yes	0.921	0.00037	0.0193	NS
Perchlorate	PA-03	Current	GCC1 & Proximal Wells	Exterior	Shallow	15	0	0	Insufficient detects				
Perchlorate	PA-04	Current	GCC1 & Proximal Wells	Interior	Shallow	15	0	0	Insufficient detects				
Perchlorate	PA-08	Current	GCC6 & Proximal Wells	Interior	Shallow	15	2	0.133333	Insufficient detects				
Perchlorate	PA-09	Current	GCC6 & Proximal Wells	Exterior	Shallow	15	5	0.333333	Insufficient detects				
Perchlorate	PA-10I	Current	GCC1 & Proximal Wells	Interior	Intermediate	15	0	0	Insufficient detects				
Perchlorate	PA-15I	Current	GCC6 & Proximal Wells	Interior	Intermediate	15	0	0	Insufficient detects				
Perchlorate	PA-16I	Current	GCC6 & Proximal Wells	Exterior	Intermediate	15	0	0	Insufficient detects				
Perchlorate	PA-17IR	Current	GCC1 & Proximal Wells	Exterior	Intermediate	15	0	0	Insufficient detects				
Perchlorate	PA-18D	Current	GCC1 & Proximal Wells	Interior	Deep	4	0	0	Insufficient samples				
Perchlorate	PA-19D	Current	GCC2	Exterior	Deep	15	0	0	Insufficient detects				
Perchlorate	PA-20D	Current	GCC3	Interior	Deep	15	8	0.533333	Yes	0.104	0.11	-0.332	NS
Perchlorate	PA-21D	Current	GCC3	Exterior	Deep	15	9	0.6	Yes	0.00137	0.426	-0.652	Significant
Perchlorate	PA-22D	Current	GCC4 & Proximal Wells	Interior	Deep	15	15	1	Yes	<0.001	0.934	-0.966	Significant
Perchlorate	PA-23D	Current	GCC5 & Proximal Wells	Interior	Deep	15	0	0	Insufficient detects				
Perchlorate	PA-24D	Current	GCC5 & Proximal Wells	Exterior	Deep	15	0	0	Insufficient detects				
Perchlorate	PA-25D	Current	GCC6 & Proximal Wells	Interior	Deep	15	0	0	Insufficient detects				
Perchlorate	PA-26D	Current	GCC6 & Proximal Wells	Exterior	Deep	15	1	0.066667	Insufficient detects				
Perchlorate	PA-27D	Current	GCC1 & Proximal Wells	Exterior	Deep	15	0	0	Insufficient detects				
Perchlorate	PA-30D	Current	GCC2	Interior	Deep	15	0	0	Insufficient detects				
Perchlorate	PA-31	Current	GCC1 & Proximal Wells	Interior	Shallow	15	0	0	Insufficient detects				
Perchlorate	PA-32I	Current	GCC1 & Proximal Wells	Interior	Intermediate	15	0	0	Insufficient detects				
Perchlorate	PA-44I	Current	GCC6 & Proximal Wells	Interior	Intermediate	15	5	0.333333	Insufficient detects				

Notes:
date_range: Study Period Trend includes dates from 2007 - Q4 2023
date_range: Current includes dates from Q4 2019 - Q4 2023

Non-detects were substituted with a value of zero for trend analysis
N: number of data points
Meet Data Reqs: trend tests were performed only if the dataset had >=5 detected values and >=0.5 percent detects.
tau2: tau^2, measure of linear model fit
tau: Kendall's tau statistic
p-value: A two-sided p-value describing the probability of the H0 being true (a=0.99)

Table 3
Historical Barrier Wall Comparison Table
ARKEMA-PORTLAND

Analyte	Region	Aquifer Zone	Location	Unit	Historic N	Historic 2 N	Current N	Historic Max Conc	Current Max Conc	Order of Magnitude Change	Detect Status Change	Historic 2 Trend	Current Trend
Chloride	GCC1 & Proximal Wells	Deep	PA-18D	ug/L	0	0	4		80000	N/A	N/A	N/A	Insufficient samples
Chloride	GCC1 & Proximal Wells	Deep	PA-27D	ug/L	0	0	15		1150000	N/A	N/A	N/A	Decreasing
Chloride	GCC1 & Proximal Wells	Intermediate	PA-10I	ug/L	0	0	15		1300000	N/A	N/A	N/A	Decreasing
Chloride	GCC1 & Proximal Wells	Intermediate	PA-17IR	ug/L	0	0	15		73600	N/A	N/A	N/A	Decreasing
Chloride	GCC1 & Proximal Wells	Intermediate	PA-32I	ug/L	0	0	15		170000	N/A	N/A	N/A	Decreasing
Chloride	GCC1 & Proximal Wells	Shallow	MWA-63	ug/L	4	19	15	690000	83000	Decrease	None	Decreasing	Stable
Chloride	GCC1 & Proximal Wells	Shallow	PA-03	ug/L	0	0	15		10000	N/A	N/A	N/A	Decreasing
Chloride	GCC1 & Proximal Wells	Shallow	PA-04	ug/L	0	0	15		14300	N/A	N/A	N/A	Decreasing
Chloride	GCC1 & Proximal Wells	Shallow	PA-31	ug/L	0	0	15		10500	N/A	N/A	N/A	Decreasing
Chloride	GCC2	Deep	PA-19D	ug/L	0	0	15		360000	N/A	N/A	N/A	Increasing
Chloride	GCC2	Deep	PA-30D	ug/L	0	0	15		540000	N/A	N/A	N/A	Stable
Chloride	GCC3	Deep	PA-20D	ug/L	0	0	15		1200000	N/A	N/A	N/A	Stable
Chloride	GCC3	Deep	PA-21D	ug/L	0	0	15		463000	N/A	N/A	N/A	Decreasing
Chloride	GCC4 & Proximal Wells	Deep	MWA-56D	ug/L	4	19	15	27900000	26000000	None	None	Decreasing	Decreasing
Chloride	GCC4 & Proximal Wells	Deep	MWA-58D	ug/L	4	19	15	53600000	29000000	None	None	Decreasing	Stable
Chloride	GCC4 & Proximal Wells	Deep	PA-22D	ug/L	0	0	15		10200000	N/A	N/A	N/A	Decreasing
Chloride	GCC5 & Proximal Wells	Deep	MWA-31I(D)	ug/L	4	19	15	54300000	30000000	None	None	Decreasing	Stable
Chloride	GCC5 & Proximal Wells	Deep	PA-23D	ug/L	0	0	15		30000000	N/A	N/A	N/A	Increasing
Chloride	GCC5 & Proximal Wells	Deep	PA-24D	ug/L	0	0	15		46000000	N/A	N/A	N/A	Decreasing
Chloride	GCC6 & Proximal Wells	Deep	PA-25D	ug/L	0	0	15		34000	N/A	N/A	N/A	Stable
Chloride	GCC6 & Proximal Wells	Deep	PA-26D	ug/L	0	0	15		74000	N/A	N/A	N/A	Increasing
Chloride	GCC6 & Proximal Wells	Intermediate	MWA-81I	ug/L	0	0	15		610000	N/A	N/A	N/A	Stable
Chloride	GCC6 & Proximal Wells	Intermediate	PA-15I	ug/L	0	0	15		850000	N/A	N/A	N/A	Stable
Chloride	GCC6 & Proximal Wells	Intermediate	PA-16I	ug/L	0	0	15		530000	N/A	N/A	N/A	Stable
Chloride	GCC6 & Proximal Wells	Intermediate	PA-44I	ug/L	0	0	15		370000	N/A	N/A	N/A	Decreasing
Chloride	GCC6 & Proximal Wells	Shallow	MWA-41	ug/L	4	19	15	26600	21000	None	None	Decreasing	Stable
Chloride	GCC6 & Proximal Wells	Shallow	MWA-82	ug/L	0	0	15		34800	N/A	N/A	N/A	Decreasing
Chloride	GCC6 & Proximal Wells	Shallow	PA-08	ug/L	0	0	15		770000	N/A	N/A	N/A	Stable
Chloride	GCC6 & Proximal Wells	Shallow	PA-09	ug/L	0	0	15		199000	N/A	N/A	N/A	Stable
Chloride	Well Distal from BW and GCCs	Deep	MWA-11I(D)	ug/L	4	19	15	1210000	2200000	None	None	Stable	Stable
Chlorobenzene	GCC1 & Proximal Wells	Deep	PA-18D	ug/L	0	0	4		<0.44	N/A	N/A	N/A	Insufficient samples
Chlorobenzene	GCC1 & Proximal Wells	Deep	PA-27D	ug/L	0	0	15		3.5	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	GCC1 & Proximal Wells	Intermediate	PA-10I	ug/L	0	0	15		5.7	N/A	N/A	N/A	Increasing
Chlorobenzene	GCC1 & Proximal Wells	Intermediate	PA-17IR	ug/L	0	0	15		24	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	GCC1 & Proximal Wells	Intermediate	PA-32I	ug/L	0	0	15		<0.7	N/A	N/A	N/A	Stable
Chlorobenzene	GCC1 & Proximal Wells	Shallow	MWA-63	ug/L	4	19	15	<100	<44	N/A	None	Insufficient	Insufficient detects
Chlorobenzene	GCC1 & Proximal Wells	Shallow	PA-03	ug/L	0	0	15		<0.44	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	GCC1 & Proximal Wells	Shallow	PA-04	ug/L	0	0	15		<2	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	GCC1 & Proximal Wells	Shallow	PA-31	ug/L	0	0	15		<0.44	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	GCC2	Deep	PA-19D	ug/L	0	0	14		12000	N/A	N/A	N/A	Stable
Chlorobenzene	GCC2	Deep	PA-30D	ug/L	0	0	14		26000	N/A	N/A	N/A	Increasing
Chlorobenzene	GCC3	Deep	PA-20D	ug/L	0	0	15		41	N/A	N/A	N/A	Decreasing
Chlorobenzene	GCC3	Deep	PA-21D	ug/L	0	0	15		49000	N/A	N/A	N/A	Decreasing
Chlorobenzene	GCC4 & Proximal Wells	Deep	MWA-56D	ug/L	4	19	15	<5	<4.4	N/A	None	Insufficient	Insufficient detects
Chlorobenzene	GCC4 & Proximal Wells	Deep	MWA-58D	ug/L	4	19	15	<2.5	<4.4	N/A	None	Insufficient	Insufficient detects
Chlorobenzene	GCC4 & Proximal Wells	Deep	PA-22D	ug/L	0	0	15		<0.44	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	GCC5 & Proximal Wells	Deep	MWA-31I(D)	ug/L	4	19	15	<2.5	<1	N/A	None	Insufficier	Insufficient detects
Chlorobenzene	GCC5 & Proximal Wells	Deep	PA-23D	ug/L	0	0	15		2.8	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	GCC5 & Proximal Wells	Deep	PA-24D	ug/L	0	0	15		<0.44	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Deep	PA-25D	ug/L	0	0	15		<0.44	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Deep	PA-26D	ug/L	0	0	16		0.71	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Intermediate	MWA-81I	ug/L	0	0	15		<0.44	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Intermediate	PA-15I	ug/L	0	0	15		<2.5	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Intermediate	PA-16I	ug/L	0	0	16		<0.44	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Intermediate	PA-44I	ug/L	0	0	15		<0.44	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Shallow	MWA-41	ug/L	0	0	15		<0.44	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Shallow	MWA-82	ug/L	0	0	15		<0.44	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Shallow	PA-08	ug/L	0	0	15		<0.6	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	GCC6 & Proximal Wells	Shallow	PA-09	ug/L	0	0	16		<0.44	N/A	N/A	N/A	Insufficient detects
Chlorobenzene	Well Distal from BW and GCCs	Deep	MWA-11I(D)	ug/L	4	19	15	1.92	7	None	None	Stable	Stable
Perchlorate	GCC1 & Proximal Wells	Deep	PA-18D	ug/L	0	0	4		<40	N/A	N/A	N/A	Insufficient samples
Perchlorate	GCC1 & Proximal Wells	Deep	PA-27D	ug/L	0	0	15		<95	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Intermediate	PA-10I	ug/L	0	0	15		<95	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Intermediate	PA-17IR	ug/L	0	0	15		<190	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Intermediate	PA-32I	ug/L	0	0	15		<190	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Shallow	MWA-63	ug/L	4	19	15	<8	13	N/A	ND to Detec	Insufficient	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Shallow	PA-03	ug/L	0	0	15		<95	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Shallow	PA-04	ug/L	0	0	15		<48	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC1 & Proximal Wells	Shallow	PA-31	ug/L	0	0	15		<100	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC2	Deep	PA-19D	ug/L	0	0	15		<200	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC2	Deep	PA-30D	ug/L	0	0	15		<200	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC3	Deep	PA-20D	ug/L	0	0	15		140	N/A	N/A	N/A	Stable
Perchlorate	GCC3	Deep	PA-21D	ug/L	0	0	15		2400	N/A	N/A	N/A	Decreasing
Perchlorate	GCC4 & Proximal Wells	Deep	MWA-56D	ug/L	4	19	15	2430	15000	Increase	None	Increasing	Increasing
Perchlorate	GCC4 & Proximal Wells	Deep	MWA-58D	ug/L	4	19	15	128000	61000	Decrease	None	Stable	Stable
Perchlorate	GCC4 & Proximal Wells	Deep	PA-22D	ug/L	0	0	15		54000	N/A	N/A	N/A	Decreasing
Perchlorate	GCC5 & Proximal Wells	Deep	MWA-31I(D)	ug/L	4	19	15	5730	100000	Increase	None	Stable	Stable
Perchlorate	GCC5 & Proximal Wells	Deep	PA-23D	ug/L	0	0	15		<1000	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC5 & Proximal Wells	Deep	PA-24D	ug/L	0	0	15		<400	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Deep	PA-25D	ug/L	0	0	15		<9.5	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Deep	PA-26D	ug/L	0	0	15		<9.5	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Intermediate	MWA-81I	ug/L	0	0	15		<10	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Intermediate	PA-15I	ug/L	0	0	15		<48	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Intermediate	PA-16I	ug/L	0	0	15		<48	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Intermediate	PA-44I	ug/L	0	0	15		390	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Shallow	MWA-41	ug/L	4	19	15	<4	<2	N/A	None	Insufficient	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Shallow	MWA-82	ug/L	0	0	15		530	N/A	N/A	N/A	Stable
Perchlorate	GCC6 & Proximal Wells	Shallow	PA-08	ug/L	0	0	15		<48	N/A	N/A	N/A	Insufficient detects
Perchlorate	GCC6 & Proximal Wells	Shallow	PA-09	ug/L	0	0	15		120	N/A	N/A	N/A	Insufficient detects
Perchlorate	Well Distal from BW and GCCs	Deep	MWA-11I(D)	ug/L	4	19	15	<8	<48	N/A	None	Insufficient	Insufficient detects

Notes:
date_range: Historic includes dates from 2007 - 2010
date_range: Historic2 includes dates from 2007 - Q4 2023
date_range: Current includes dates from Q4 2019 - Q4 2023

Historic Max Conc: maximum concentration from the Historic date range
Current Max Conc: maximum concentration from the Current date range
Order of Magnitude Change: concentration change from Historic date range to Current date range
- Increase - Current concentration is a magnitude larger than Historic
- Decrease - Current concentration is a magnitude smaller than Historic
- None - Current concentration is not a magnitude larger or smaller than Historic
- N/A - detection status is different between the Historic and Current concentration, or both are NDs, or one of Historic and Current concentrations not sampled

Detect Status Change: detect status change from Historic date range to Current date range
- Detect to ND - Historic detect with Current ND
- Detect to ND, high Current DL - Historic detect with Current ND, but Current DL greater than Historic detect
- ND to Detect - Historic ND with Current detect
- ND to Detect, high Historic DL - Historic ND with Current detect, but Historic DL greater than Current detect
- None - same detection status between Historic and Current
- N/A - one of Historic and Current concentrations not sampled

Historic2 Trend: provides summary of trend results for Historic2 date range
- Stable, Increasing, or Decreasing: trend criteria met and calculated
- Insufficient detects, Insufficient samples: trend criteria not met and not calculated
- N/A - no Historic samples available

Current Trend: provides summary of trend results for Current date range
- Stable, Increasing, or Decreasing: trend criteria met and calculated
- Insufficient detects, Insufficient samples: trend criteria not met and not calculated
- N/A - no samples collected at all

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