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MEMO

TO	Katie Daugherty, Oregon Department of Environmental Quality
FROM	Brendan Robinson, PE, Environmental Resources Management, Inc.
DATE	19 April 2024
REFERENCE	0719595 Phase 106
SUBJECT	February 2024 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 February 2024 MPR summarizes the GW SCM performance monitoring data collected in February 2024. 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 23 February 2024. 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 February 2024, the following transducers were:

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

- PA-07
- PA-26d
- RW-13
- RW-25

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

- N/A

PA-07, PA-26d, RW-13, and RW-25 have faulted transducers, and are scheduled for repair in April 2024. RW-13 and RW-25 are not in the GCCs.

Some transducers onsite had the water elevations adjusted based on the recalibration event completed 13 March 2024. The February 2024 hydrographs shown in Attachment B-1 are the water elevations prior to adjusting for recalibration. Hydraulic gradients (Attachment B-2 and B-3) and groundwater elevation maps (Figures 2 through 4) account for the adjusted groundwater elevations measurements. The revisions in water table elevations are noted in Attachment B.

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 February 2024 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 23 February 2024 are shown below at each GCC (Table 1-1 and Table 1-2).

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	29.95	PA-04	30.22	-0.003
	Intermediate	PA-17iR	12.95	PA-10i	14.09	-0.011

Gradient Cluster	Well Pair Zone	Exterior Well	Water Elevation (ft NAVD88)	Interior Well	Water Elevation (ft NAVD88)	Horizontal Gradient (ft/ft)
	Deep	PA-27d	11.70	PA-18d	12.47	-0.006
GCC2	Shallow	MWA-2	10.15	PA-05	11.50	-0.020
	Intermediate	MWA-8i	10.45	PA-11i	11.29	-0.012
	Deep	PA-19d	8.85	PA-30d	10.51	-0.031
GCC3	Shallow	MWA-69	9.80	PA-06	13.03	-0.030
	Intermediate	MWA-66i[M]	9.68	PA-12i	12.93	-0.029
	Deep	PA-21d[M]	8.96	PA-20d	9.65	-0.005
GCC4	Shallow	MWA-19	10.66	PA-28	16.26	-0.056
	Intermediate	MWA-34i	*	PA-13i	12.28	**
	Deep	MWA-58d	9.57	PA-22d	11.09	-0.017
GCC5	Shallow	MWA-47	10.30	PA-07[M]	15.57	-0.051
	Intermediate	PA-29i	10.37	PA-14i	11.83	-0.027
	Deep	PA-24d	9.64	PA-23d	10.01	-0.007
GCC6	Shallow	PA-09	13.07	PA-08	14.13	-0.019
	Intermediate	PA-16i	11.44	PA-15i	11.21	0.004
	Deep	PA-26d[M]	11.83	PA-25d	10.83	0.016

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 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	30.22	PA-10i	14.09	1.63
		GCC2	PA-05	11.50	PA-11i	11.29	0.02
		GCC3	PA-06	13.03	PA-12i	12.93	0.01
		GCC4	PA-28	16.26	PA-13i	12.28	0.62
		GCC5	PA-07[M]	15.57	PA-14i	11.83	0.39

Region	Pair	Gradient Cluster	Upper Well	Water Elevation (ft NAVD88)	Lower Well	Water Elevation (ft NAVD88)	Vertical Gradient (ft/ft)
		GCC6	PA-08	14.13	PA-15i	11.21	0.217
	IZ-DZ	GCC1	PA-10i	14.09	PA-18d	12.47	0.22
		GCC2	PA-11i	11.29	PA-30d	10.51	0.11
		GCC3	PA-12i	12.93	PA-20d	9.65	0.17
		GCC4	PA-13i	12.28	PA-22d	11.09	0.06
		GCC5	PA-14i	11.83	PA-23d	10.01	0.05
		GCC6	PA-15i	11.21	PA-25d	10.83	0.01
Exterior	SZ-IZ	GCC1	PA-03	29.95	PA-17iR	12.95	1.08
		GCC2	MWA-2	10.15	MWA-8i	10.45	-0.02
		GCC3	MWA-69	9.80	MWA-66i[M]	9.68	0.01
		GCC4	MWA-19	10.66	MWA-34i	*	**
		GCC5	MWA-47	10.30	PA-29i	10.37	-0.01
		GCC6	PA-09	13.07	PA-16i	11.44	0.11
	IZ-DZ	GCC1	PA-17iR	12.95	PA-27d	11.70	0.19
		GCC2	MWA-8i	10.45	PA-19d	8.85	1.03
		GCC3	MWA-66i[M]	9.68	PA-21d[M]	8.96	0.06
		GCC4	MWA-34i	*	MWA-58d	9.57	**
		GCC5	PA-29i	10.37	PA-24d	9.64	0.02
		GCC6	PA-16i	11.44	PA-26d[M]	11.83	-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 23 February 2024 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. As shown in Attachment B-2, the Shallow, Intermediate, and Deep Zones horizontal gradients are outward during the month of February, except at GCC6 in the Intermediate and Deep Zones.

River elevations are shown over time on Figure 1-1 and 1-2 below, and in an inset on the potentiometric surface maps (Figures 2 through 4). The river elevation in February 2024 varied with an average of 10.18 feet NAVD88 with a minimum elevation of 7.95 feet NAVD88 and a maximum elevation of 13.83 feet NAVD88 observed toward the end of the month, a higher maximum than in February 2023 (11.75 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.

The difference between average interior Shallow Zone groundwater elevations and river level elevation were 5.70 ft and 3.86 ft in February 2023 and February 2024, respectively. The difference between river level and Shallow Zone groundwater elevations is anticipated to grow as water levels rise on the exterior of the wall and extraction capacity is maintained in the Target Capture Zone. A potentiometric separation is still noticeable exterior to the GWBW, indicating that 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 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 and GCC5 upward and the rest 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. After a camera inspection was completed at MWA-34i, a hole in the well casing was discovered. This well is scheduled for inspection by a licensed driller, and then repair or replacement.

Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were downward. The direction of vertical gradients exterior to the GWBW were primarily downward with GCC6 being upward, 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.

As discussed below in section 3.3.2, GWET pumping rates have been operating at lower levels since December 2023 through the end of February 2024 due system maintenance and upgrade activities. The water level measurements collected on 23 February 2024 were within in this period of reduced groundwater extraction. These lower rates of groundwater extraction have resulted in the inward gradients observed in December 2023 trending to outward gradients in February 2024. Extraction rates achieved after the maintenance and upgrades are higher than previously achieved in December 2023, and are anticipated to restore a trend toward inward gradients.

3.3.1 GWET SYSTEM PERFORMANCE

The GWET system operated within permit conditions during the reporting period. There was one shutdown:

16 February 2024: The GWET system was shut down for 10 hours due to a power outage, discharge restarted 17 February 2024.

During December 2023, jetting of the Shallow Zone trunk line was completed to address fouling of the conveyance piping. This maintenance reduced the back pressure and increased operational average flow rates from 33.13 gpm to 55.20 gpm. During January 2024, the GWET system was shut down for 23 days to reconfigure the conveyance lines to connect to Trenches 5, 6, and 7 to the previously unused Intermediate Zone conveyance line. This upgrade to mitigated back pressure effects on pumping rates. Operational average flow rates increased to 66.02 gpm after reconfiguration.

The EWs in Trenches 1, 4, 5, and 6 were redeveloped between 13 February and 29 February 2024 to address solids accumulation in the gravel backfill filter pack. The pumps from these EWs were removed during the redevelopment activities, however the remaining extraction trenches 2, 3, and 7 remained active. This resulted in lower overall groundwater extraction rates during this period. Following redevelopment extraction flows have increased from these trenches. Individual flow rates are discussed in the following section.

3.3.2 RECOVERY WELL AND EXTRACTION WELL PERFORMANCE

The average system influent flow rate was 59.80 gallons per minute (gpm) for the entire month of February 2024, including non-operational periods. The average influent flow during operational periods was 78.86 gpm. Redevelopment of Trenches 1, 4, and 6 was completed 29 February 2024 to mitigate biofouling and solids accumulation within the EWs and trench gravel backfill that were limiting flow rates. Prior to redevelopment the operational average flow rate was 2.43 gpm at Trench 4, and 1.93

gpm at Trench 6. After redevelopment the operational average flow rates increased to 7.45 gpm at Trench 4, and 2.54 gpm at Trench 6. Since redevelopment was completed 29 February, continued improvement in extraction rates and hydraulic gradient performance is expected during March 2024.

Despite the partial shutdown of the extraction system during February 2024, the average operational influent rate (78.86 gpm), and the overall average monthly extraction rate (59.8 gpm) were the highest sustained extraction rates ever achieved by the GW SCM, and achieved a monthly cumulative maximum extracted volume of 2,382,140 gallons.

LSS is continuing to optimize 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.

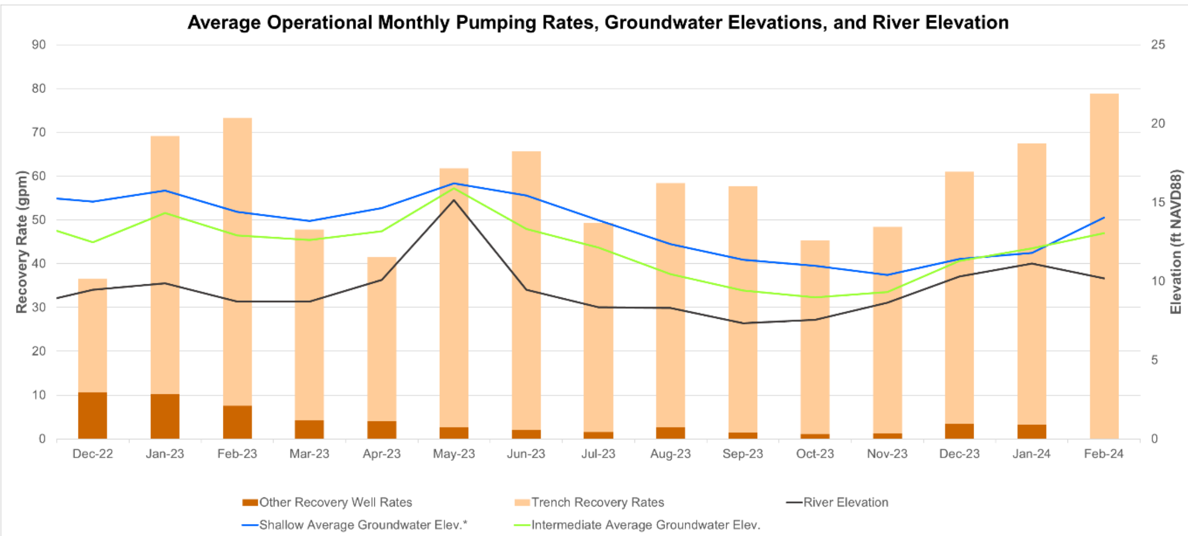
TABLE 1-3 RECOVERY WELL PUMPING RATES

Recovery Well	February 2024 Average Operational Pumping Rate (gpm)	February 2024 Average Monthly Pumping Rate (gpm)
RW-14*	0.00	0.00
RW-22*	0.00	0.00
RW-23*	0.00	0.00
RW-25*	0.00	0.00
EW-01*	0.00	0.00
EW-02	3.11	3.11
EW-03	7.09	2.93
EW-04	8.44	8.44
EW-05	13.28	13.28
EW-06	2.67	1.66
EW-07	3.99	2.20
EW-08	4.09	2.96
EW-09	3.55	0.49
EW-10	8.57	2.36
EW-11	1.85	0.83
EW-12	5.03	4.33
EW-13	7.41	7.41
EW-14	9.79	9.79

Recovery Well	February 2024 Average Operational Pumping Rate (gpm)	February 2024 Average Monthly Pumping Rate (gpm)
Total	78.86	59.80

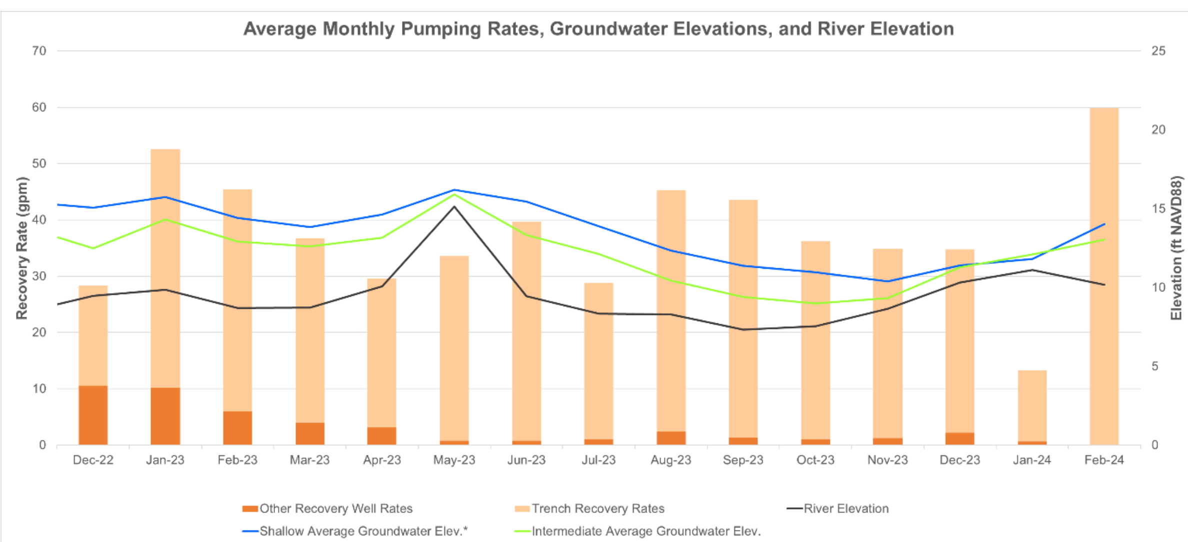
Notes:
* = Recovery well not in service during reporting period.
gpm = gallon per minute

FIGURE 1-1 OPERATIONAL MONTHLY PUMPING RATE



* = 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



* = 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 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 February 2024 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 were outward, except GCC6 in the Intermediate and

Deep Zones, likely due to reduced flows rates during development efforts and seasonal increases to groundwater flows upgradient.

- Vertical groundwater gradients interior of the GWBW between the Shallow and Intermediate Zones were generally downward (Figure 5). Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were mixed with GCC2 and GCC5 being upward and the rest downward.
- Interior of the GWBW vertical gradients between the Intermediate and Deep Zones were downward. The direction of vertical gradients exterior to the GWBW were generally downward with GCC6 being upward, as shown on Figure 6.
- The average river elevation in February 2024 was 10.18 feet NAVD88 with a minimum elevation of 7.95 feet NAVD88 and a maximum elevation of 13.83 feet NAVD88.

5.2 GROUNDWATER EXTRACTION

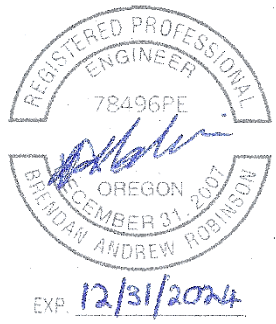
Based on February 2024 extraction and relevant hydrograph analysis, the trenches are achieving increased groundwater extraction rates compared to the legacy system. The groundwater mound around Trenches 1, 2, and 3 has diminished. Within the Site alluvial sequence, potentiometric maps indicate the GW SCM is producing localized areas of hydraulic capture throughout the Target Capture Zone. More time at elevated extraction rates will be required to evaluate whether GWET objectives are being met system wide.

The groundwater extraction flow rate has been limited by a combination of groundwater elevation, fouling of the EWs within the trenches, and back pressure in the conveyance line. In January, the wellfield was reconfigured to connect three of the trenches to the Intermediate Zone trunk line and this is anticipated to mitigate the impact of back pressure in the conveyance lines. In February EW Trenches 1, 4, and 6 were redeveloped to mitigate the impact of silt and biofouling on pumping rates. These efforts are anticipated to mitigate the limitations observed in Q4 2023 and Q1 2024.

5.3 RECOMMENDATIONS AND FUTURE WORK

Redevelopment of several Intermediate Zone groundwater elevation monitoring locations (RW-6i, RW-9i, RW-11i, RW-13i, RW-16i, RW-19i, RW-21i, RW-24i, RW-26i, and PA-12i) is planned for Q2 2024 to mitigate turbidity. LSS will continue to optimize new EWs, including pump maintenance/upgrades, redevelopment of the wells. 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

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.

_____. 2014. *Revised Final Performance Monitoring Plan – Groundwater Source Control Measure, Arkema Inc. Facility, Portland, Oregon*. July 2014.

_____. 2017. *Revised Upland Feasibility Study Work Plan, Arkema Facility, Portland, Oregon*. November 2017.

_____. 2018. *Draft GWET System Effectiveness Evaluation, Arkema Inc. Facility, Portland, Oregon*. September 2018.

_____. 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: FEBRUARY 2024 SHALLOW ZONE GROUNDWATER CONTOURS

FIGURE 3: FEBRUARY 2024 INTERMEDIATE ZONE GROUNDWATER CONTOURS

FIGURE 4: FEBRUARY 2024 DEEP ZONE GROUNDWATER CONTOURS

FIGURE 5: FEBRUARY 2024 SHALLOW TO INTERMEDIATE ZONE VERTICAL HEAD DIFFERENCE

FIGURE 6: FEBRUARY 2024 INTERMEDIATE TO DEEP ZONE VERTICAL HEAD DIFFERENCE

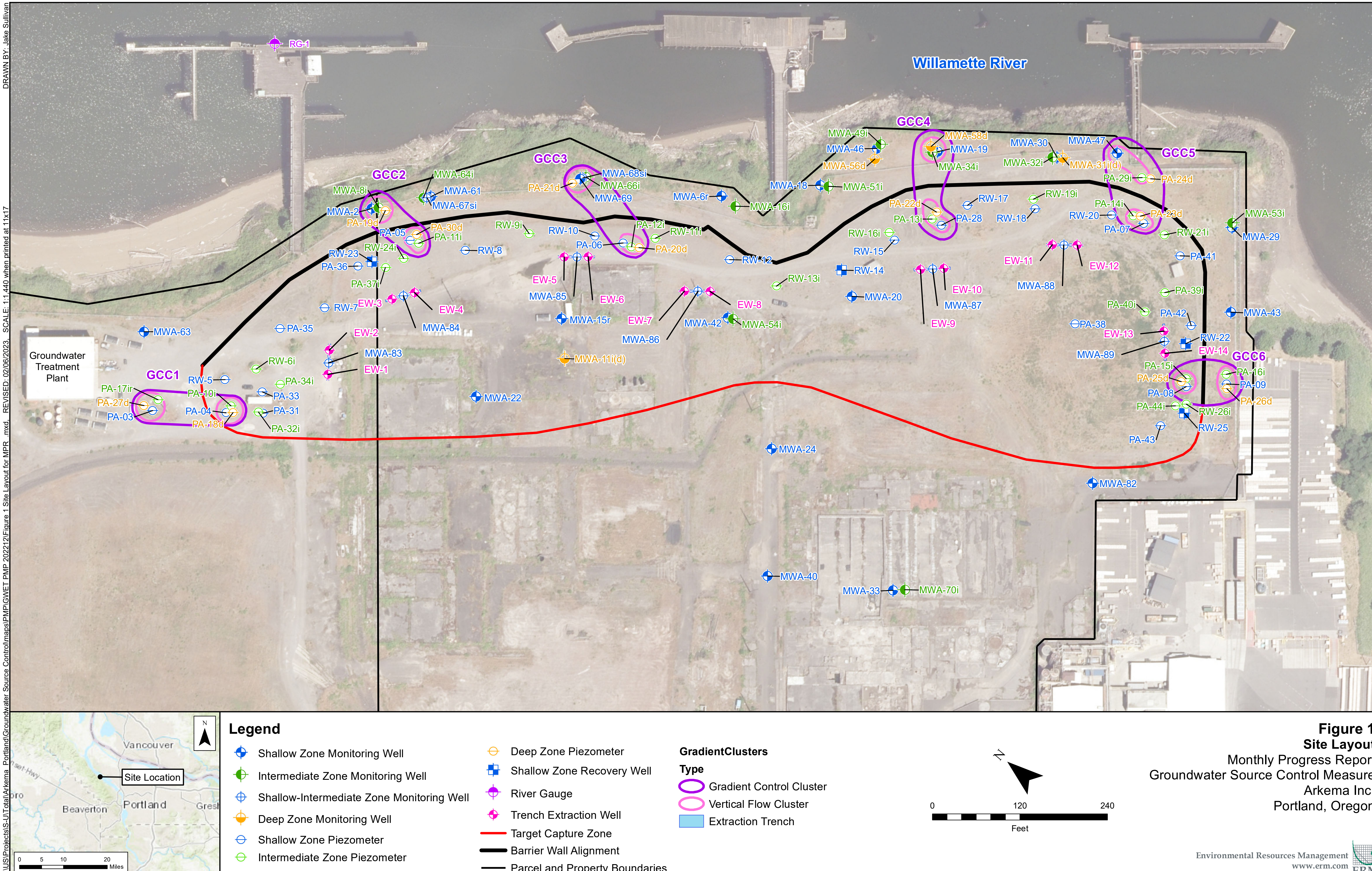
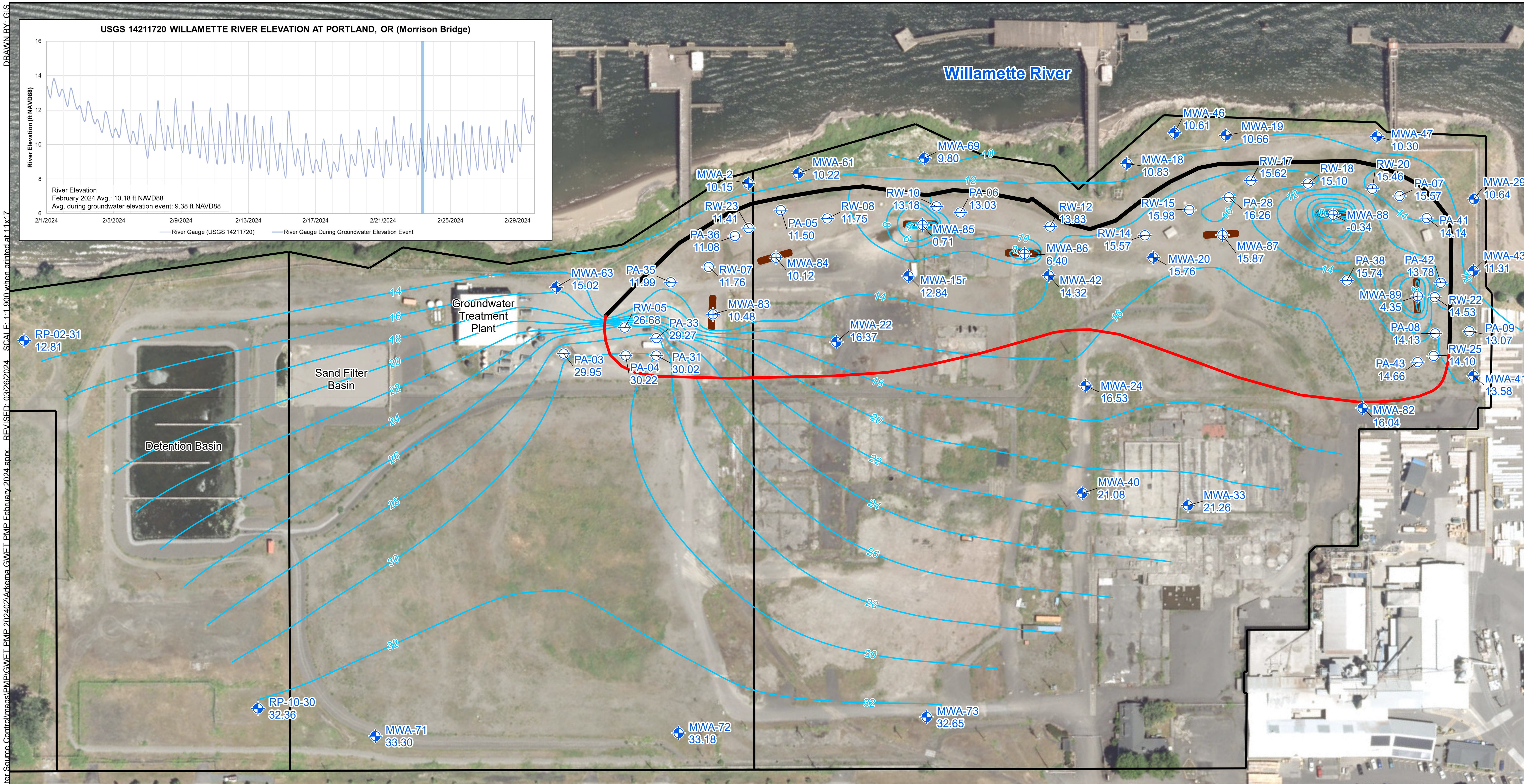


Figure 1
Site Layout
Monthly Progress Report
Groundwater Source Control Measure
Arkema Inc.
Portland, Oregon

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



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 February 23, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 2
February 2024 Shallow Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

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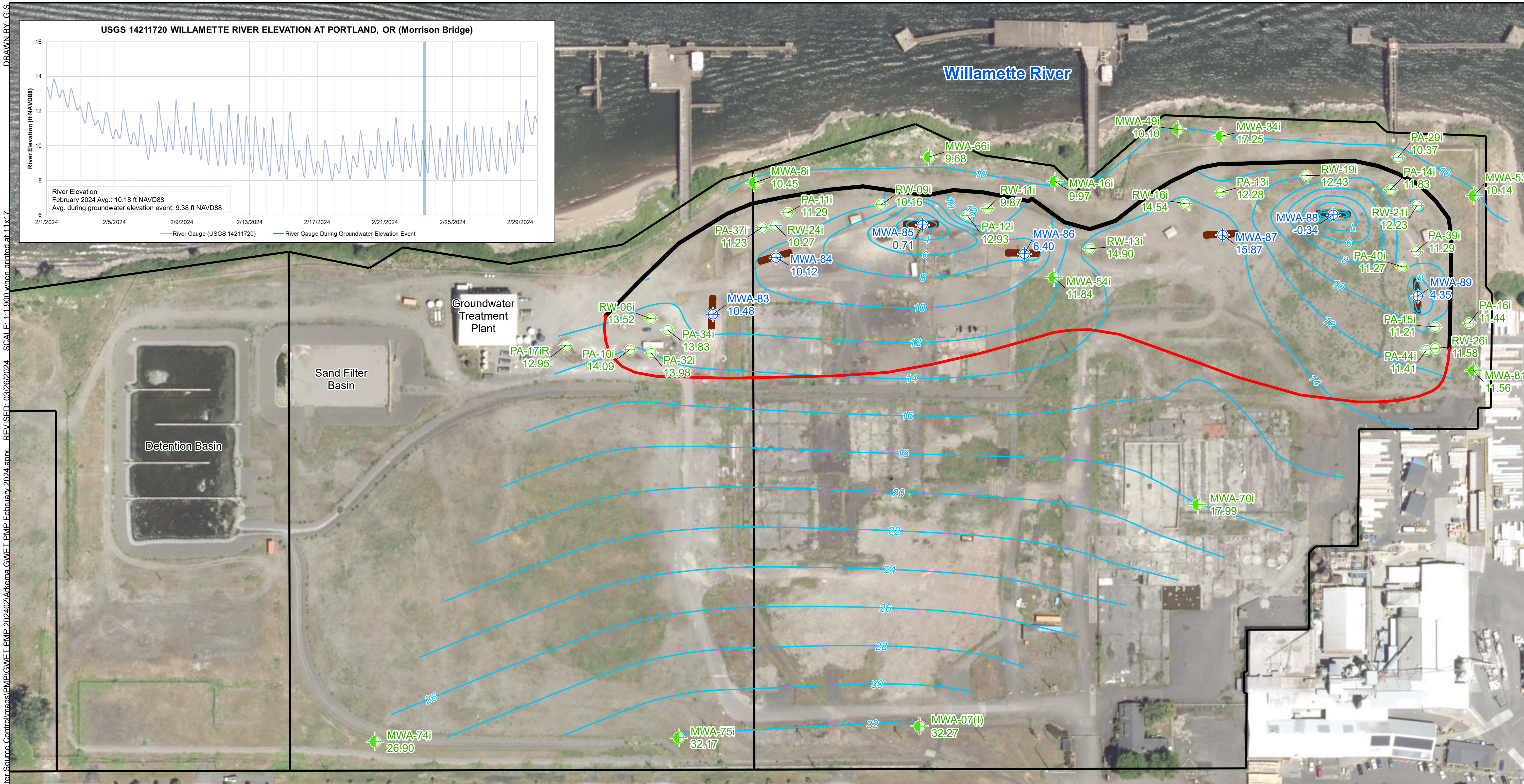
NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

DRAWN BY: GIS SCALE: 1:1,900 when printed at 11x17 REVISED: 03/26/2024 M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 2024\02\Arkema GWET PMP February 2024.aprx



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 February 23, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 3

February 2024 Intermediate Zone Groundwater Contours

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

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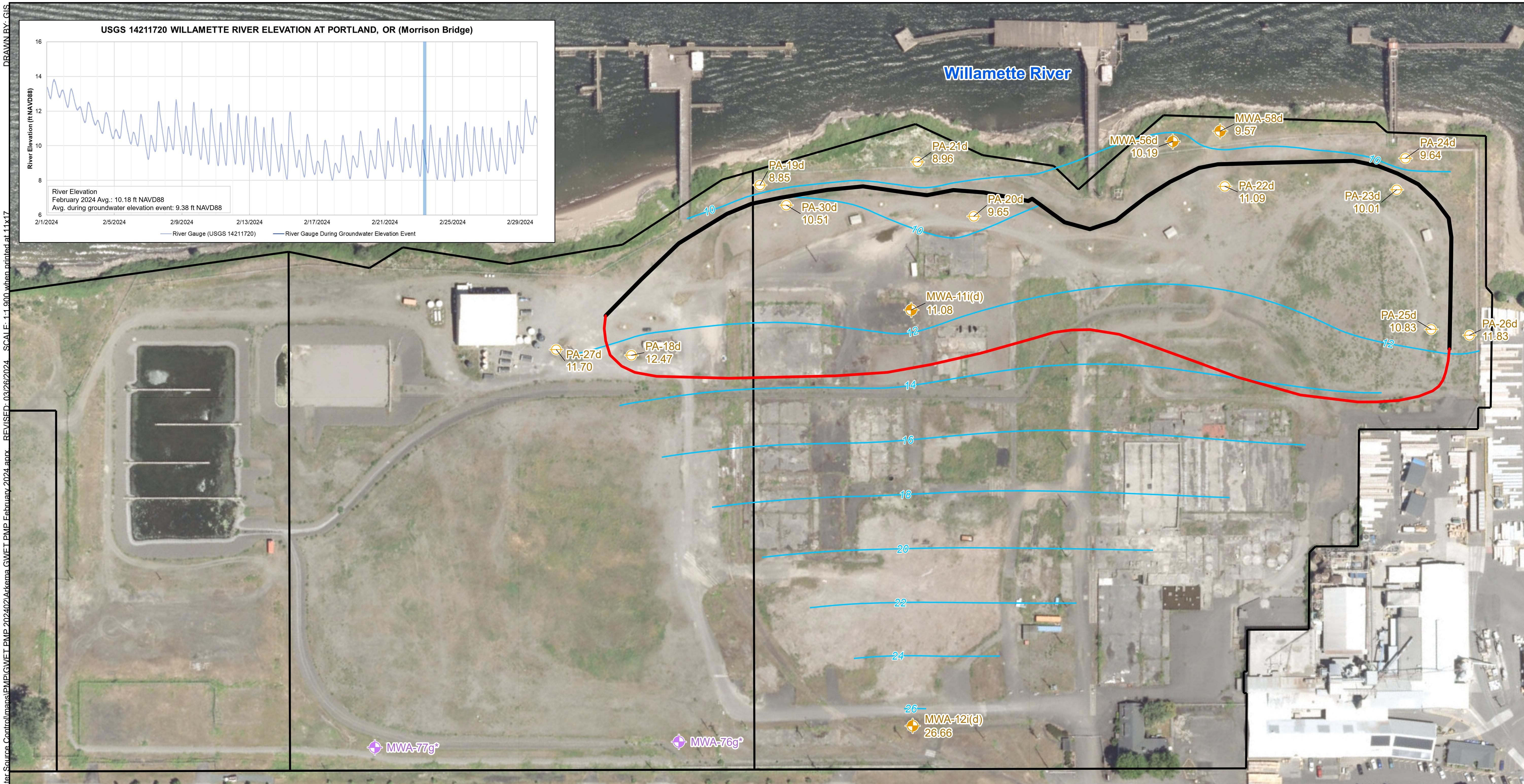
M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 2024\02\Arkema GWET PMP February 2024.aprx REVISED: 03/26/2024 SCALE: 1:1,900 when printed at 11x17 DRAWN BY: GIS



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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 February 23, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 4
February 2024 Deep Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

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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 February 23, 2024.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 5
February 2024 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

M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 2024\02\Arkema GWET PMP February 2024.aprx REVISED: 03/26/2024 SCALE: 1:1,560 when printed at 11x17 DRAWN BY: GIS

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 February 23, 2024.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 6
February 2024 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

M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 2024\02\Arkema GWET PMP February 2024.aprx REVISED: 03/26/2024 SCALE: 1:1,560 when printed at 11x17 DRAWN BY: GIS

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ATTACHMENT A-1 TRANSDUCER FLAGS

Attachment A-1. Transducer Flags

Table A-1
Transducer Malfunction Log: February 2024
Arkema Inc. Facility
Portland, Oregon

Gradient Cluster	Transducer	Interval	Date Range		Issue and Repairs Performed
GCC3	PA-26d	Deep	1/29/2024	Present	Transducer faulted, replacement ordered.
N/A	RW-13	Intermediate	1/29/2024	Present	Transducer faulted, replacement ordered.
N/A	RW-25	Shallow	1/29/2024	Present	Transducer faulted, replacement ordered.
GCC5	PA-07	Shallow	1/29/2024	Present	Transducer faulted, replacement ordered.

Notes:

I/O = input/output

LOTO = lockout/tagout

VFD = variable frequency drive

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ATTACHMENT A-2 RECOVERY WELL STATUS

Attachment A-2. Recovery Well Status

Table A-2
Recovery Well Status: February 2024
Arkema Inc. Facility
Portland, Oregon

Recovery Well ID	Status as of 2/29/2023 (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	Inactive	None	N/A	N/A	Good	Good	0.00	OFF*	Off due to low water levels
RW-22	Inactive	Ground Fault	Replace cable leads	N/A	Good	Good	0.00	OFF*	Off due to ground fault
RW-23	Inactive	None	N/A	N/A	Good	Good	0.00	OFF*	Off due to low water levels
RW-25	Inactive	Transducer Malfuction	New transducer ordered	N/A	Not Working	Good	0.00	OFF*	Off due to Transducer malfunction
EW-01	Inactive	Plumbing	Repair	3/5/2024	Good	Good	0.00	OFF*	Off for plumbing repairs and redevelopment
EW-02	Active	None	N/A	N/A	Good	Good	3.11	G	Off for part of the month due to redevelopment
EW-03	Active	Plumbing	N/A	2/12/2024	Good	Good	7.09	G	Off for part of the month due to plumbing repairs
EW-04	Active	None	N/A	N/A	Good	Good	8.44	G	
EW-05	Active	None	N/A	N/A	Good	Good	13.28	G	
EW-06	Active	None	N/A	N/A	Good	Good	2.67	M	Off for part of the month due to low water levels
EW-07	Active	Plumbing	Repair	2/12/2024	Good	Good	3.99	G	Off for part of the month due to plumbing repairs and redevelopment
EW-08	Active	None	N/A	N/A	Good	Good	4.09	G	Off for part of the month due to redevelopment
EW-09	Active	None	N/A	N/A	Good	Good	3.55	G	Off for part of the month due to redevelopment
EW-10	Active	None	N/A	N/A	Good	Good	8.57	G	Off for part of the month due to redevelopment
EW-11	Active	None	N/A	N/A	Good	Good	1.85	M	Off for part of the month due to redevelopment
EW-12	Active	None	N/A	N/A	Good	Good	5.03	G	Off for part of the month due to redevelopment
EW-13	Active	None	N/A	N/A	Good	Good	7.41	G	
EW-14	Active	None	N/A	N/A	Good	Good	9.79	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

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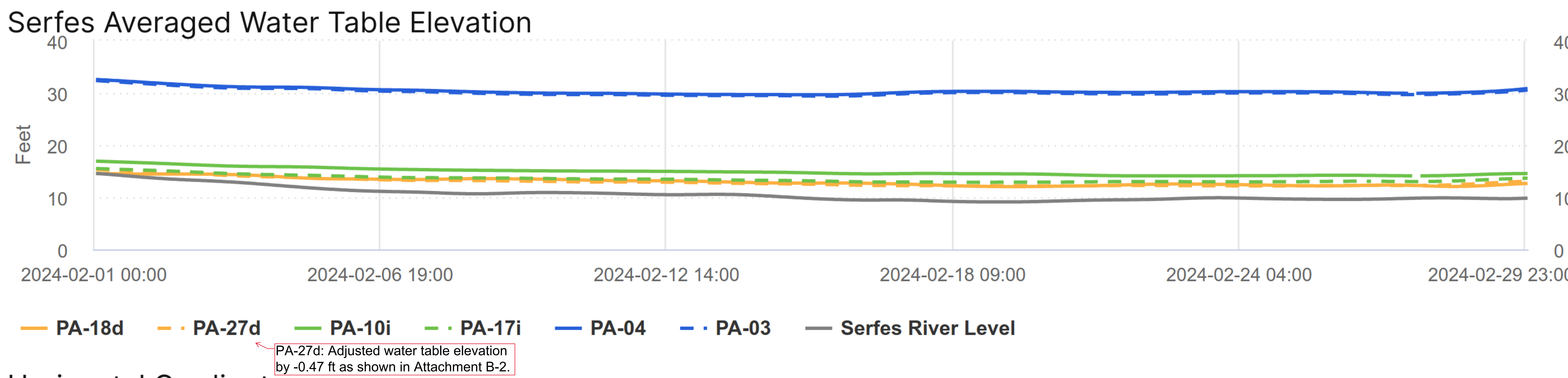
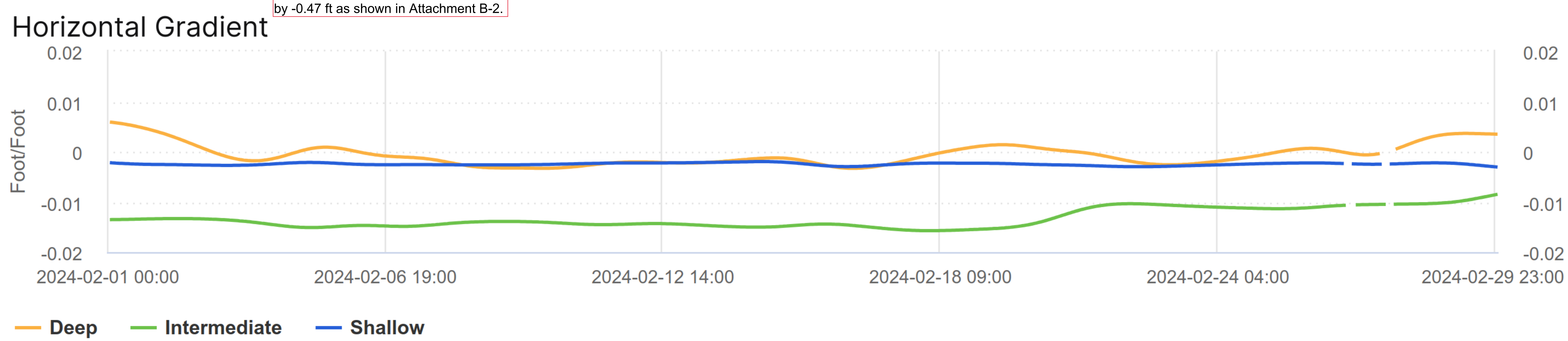
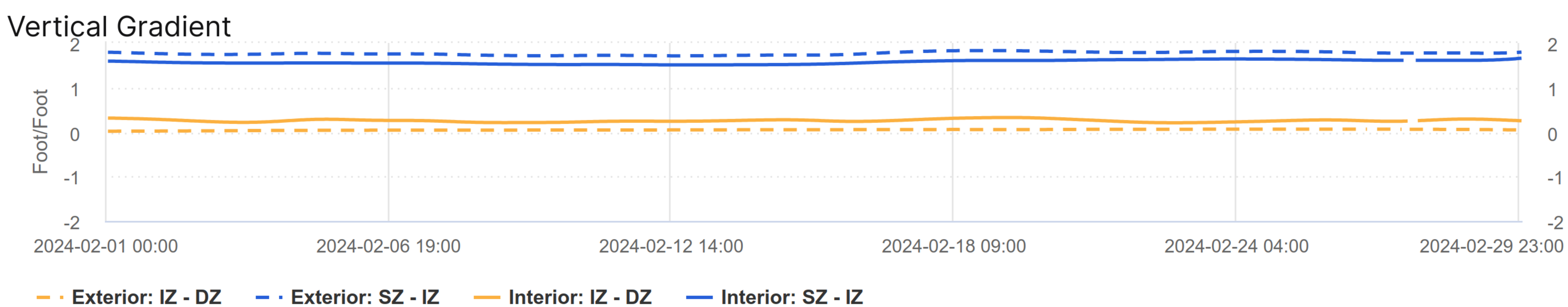
ATTACHMENT B-1 GRADIENT HYDROGRAPHS

Gradient Control Cluster 1

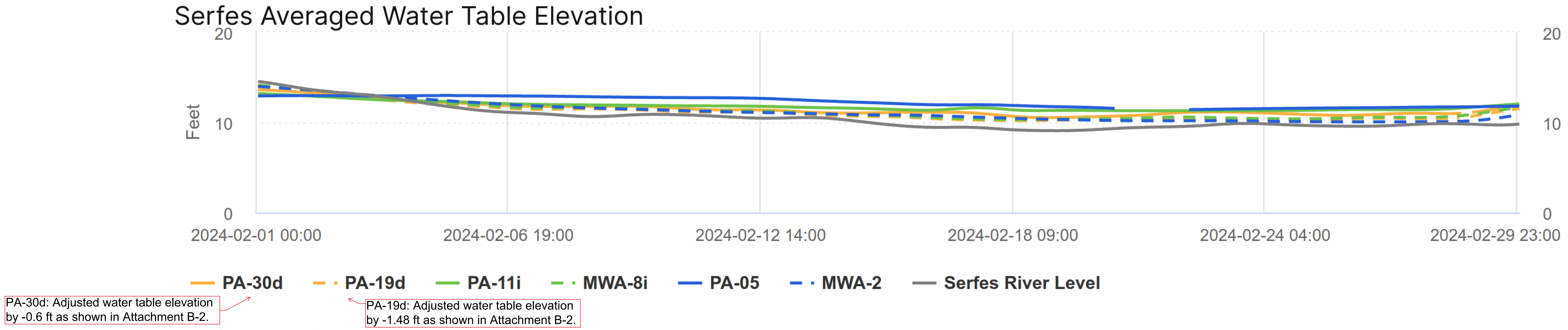


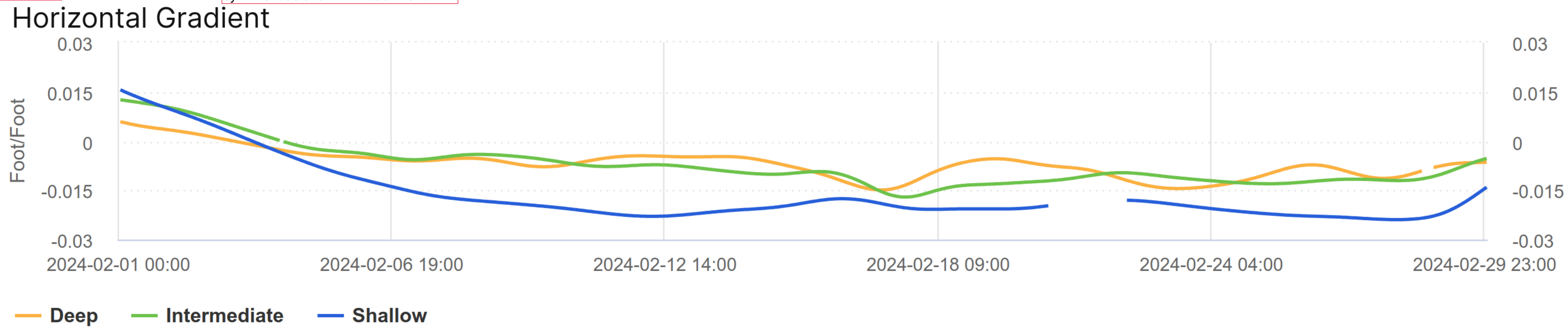


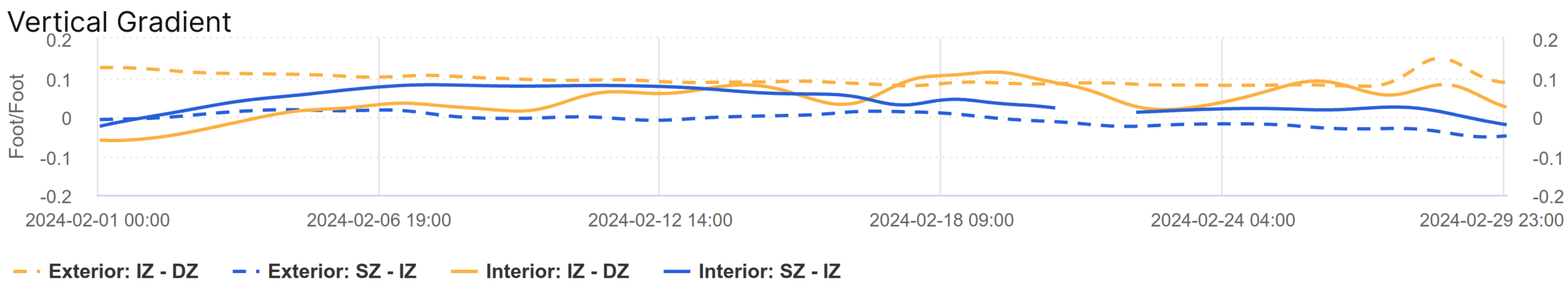


Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside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

Gradient Control Cluster 2



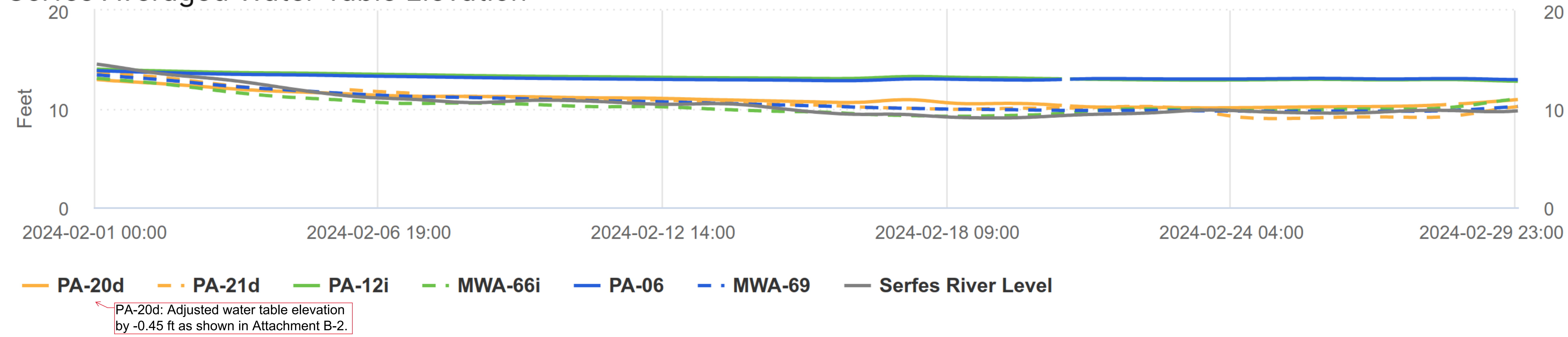




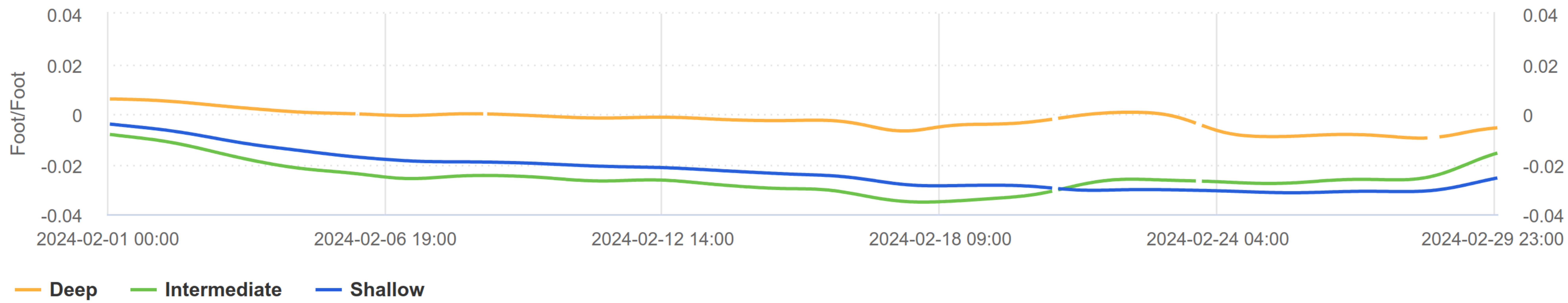
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside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

Gradient Control Cluster 3

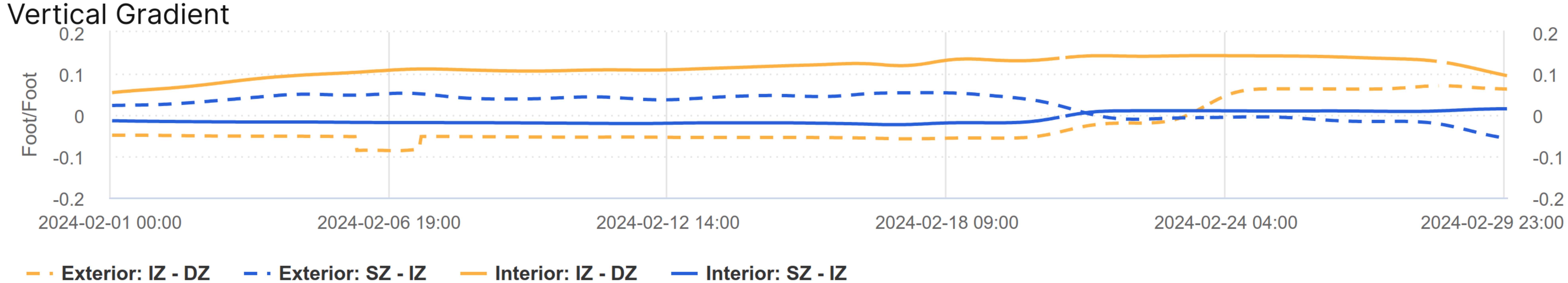
Serfes Averaged Water Table Elevation



Horizontal Gradient



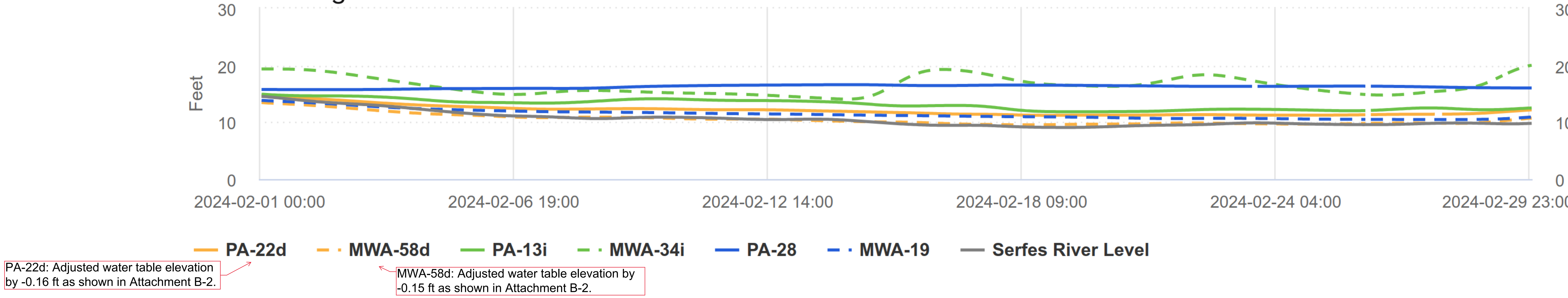
Vertical Gradient



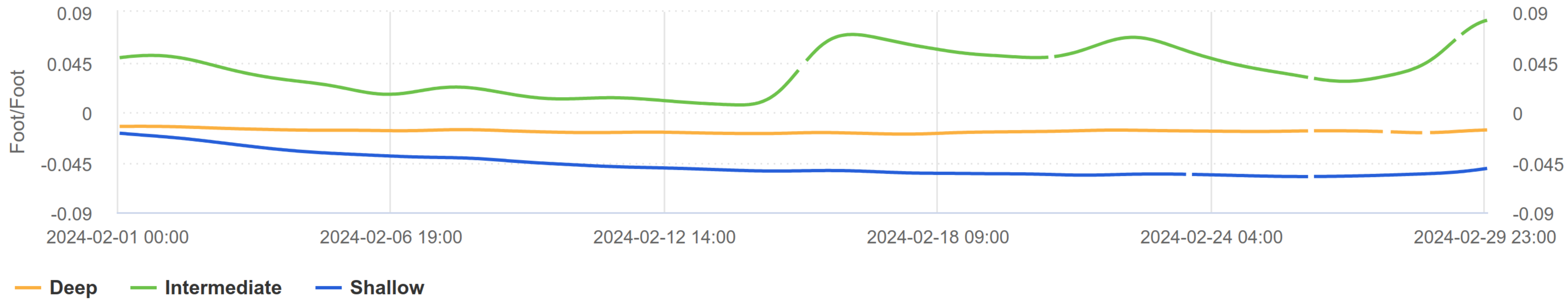
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside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

Gradient Control Cluster 4

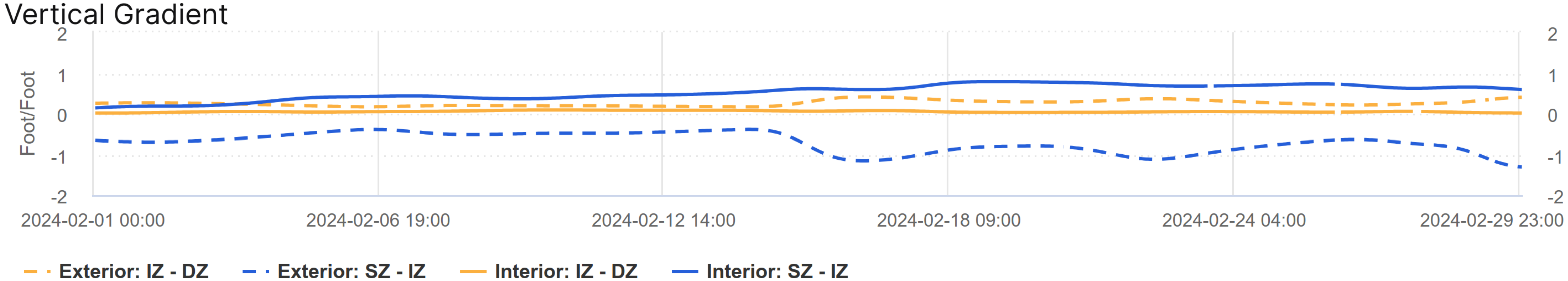
Serfes Averaged Water Table Elevation



Horizontal Gradient



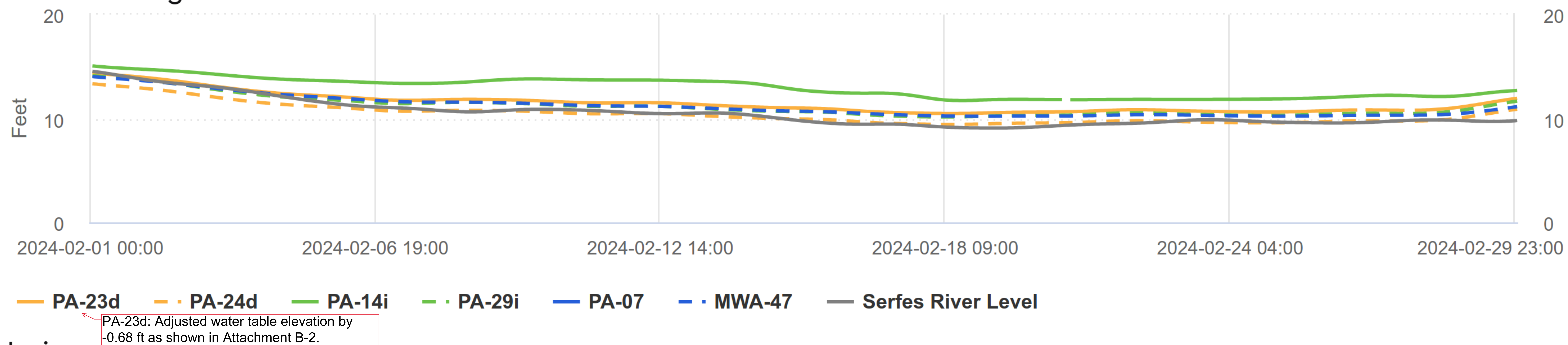
Vertical Gradient



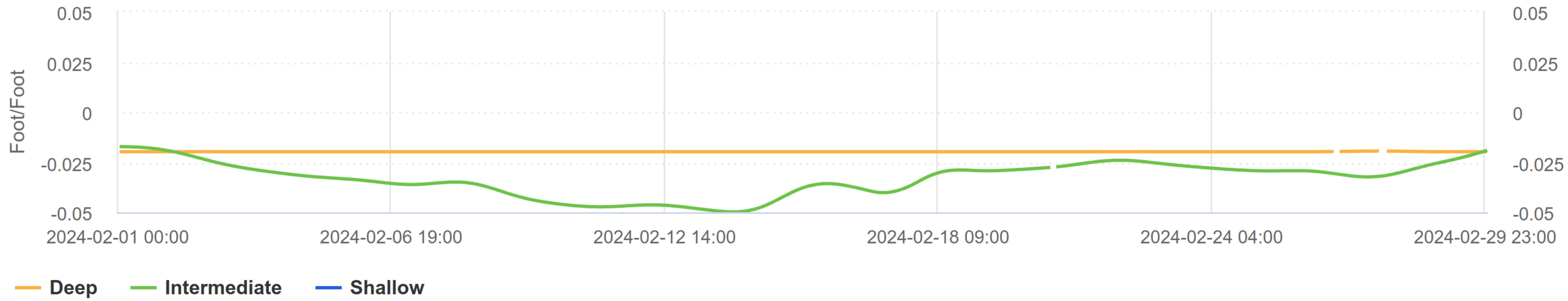
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside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

Gradient Control Cluster 5

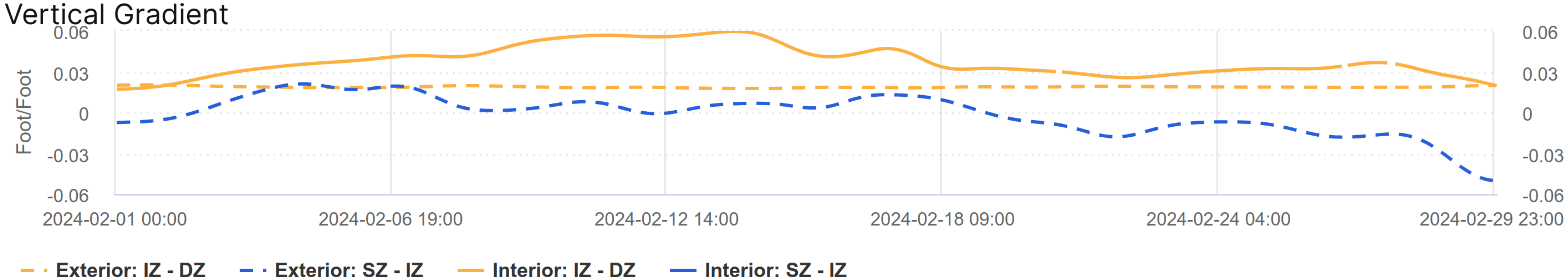
Serfes Averaged Water Table Elevation



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

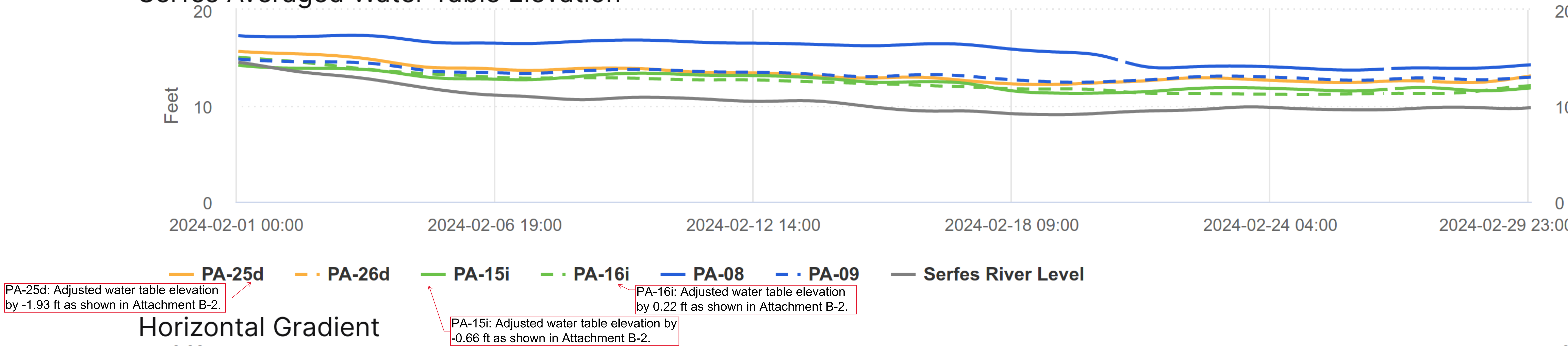
SZ = Shallow Zone

IZ = Intermediate Zone

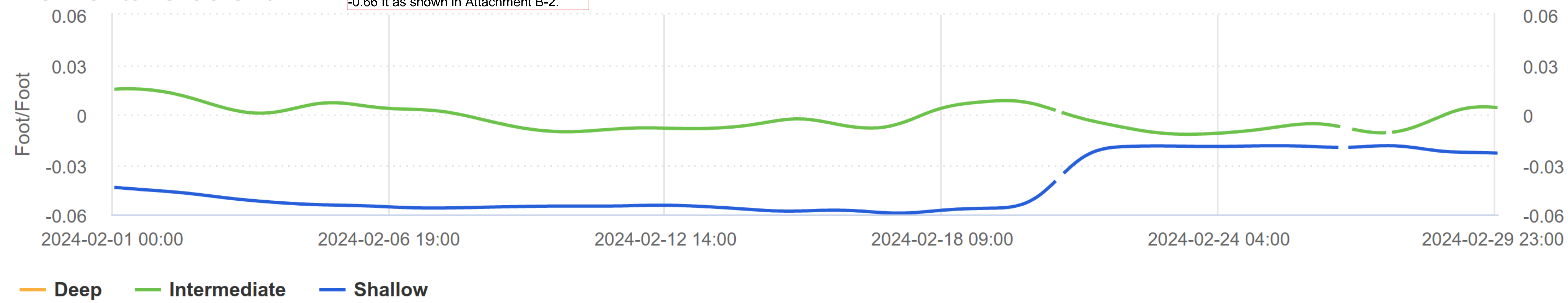
DZ = Deep Zone

Gradient Control Cluster 6

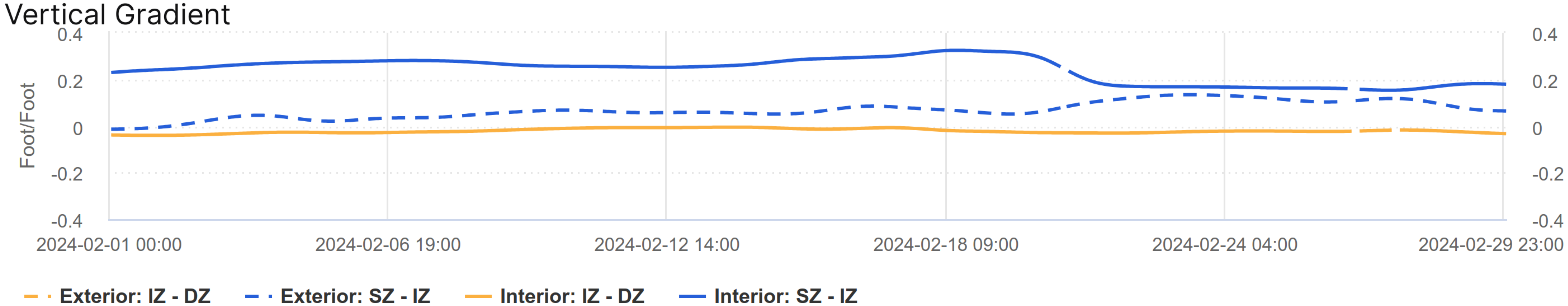
Serfes Averaged Water Table Elevation



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

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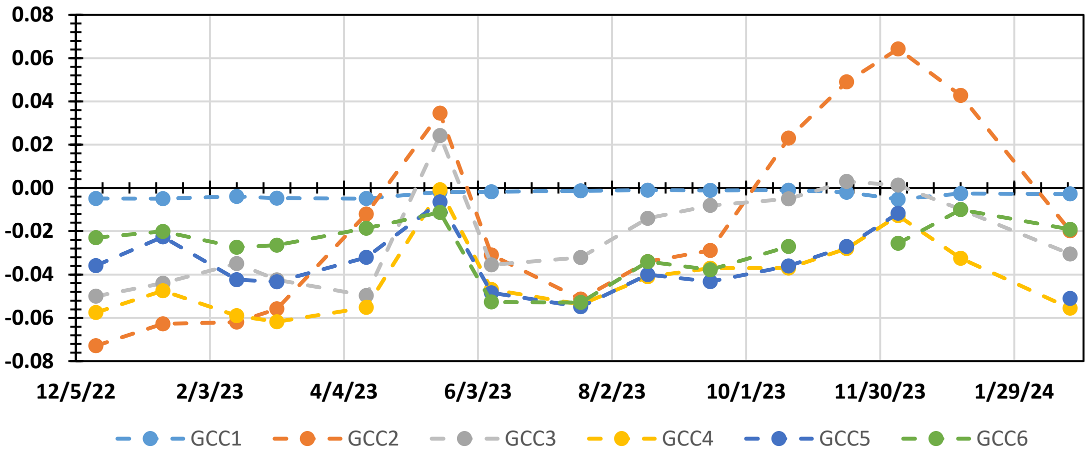
ATTACHMENT B-2 HORIZONTAL GRADIENTS

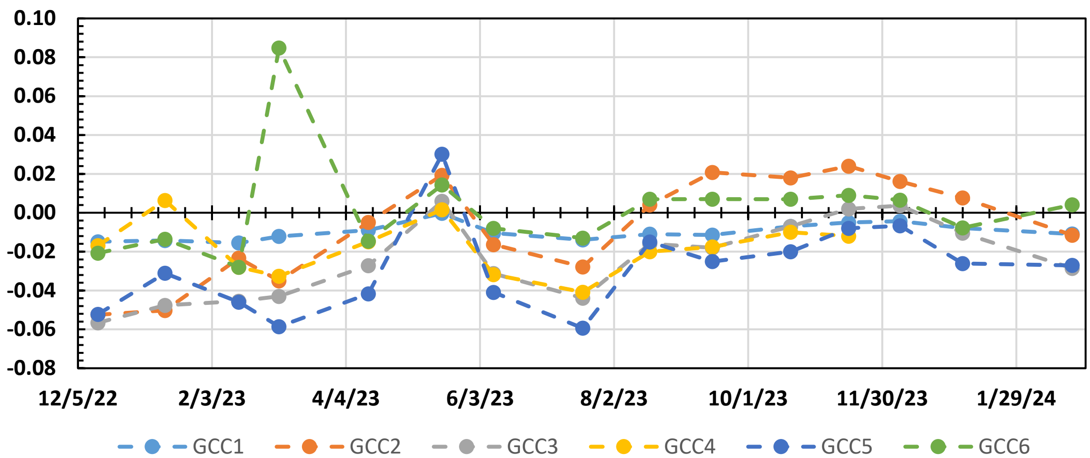
Attachment B-2

Horizontal Gradients Summary: February 2024
Arkema Inc. Facility
Portland, Oregon

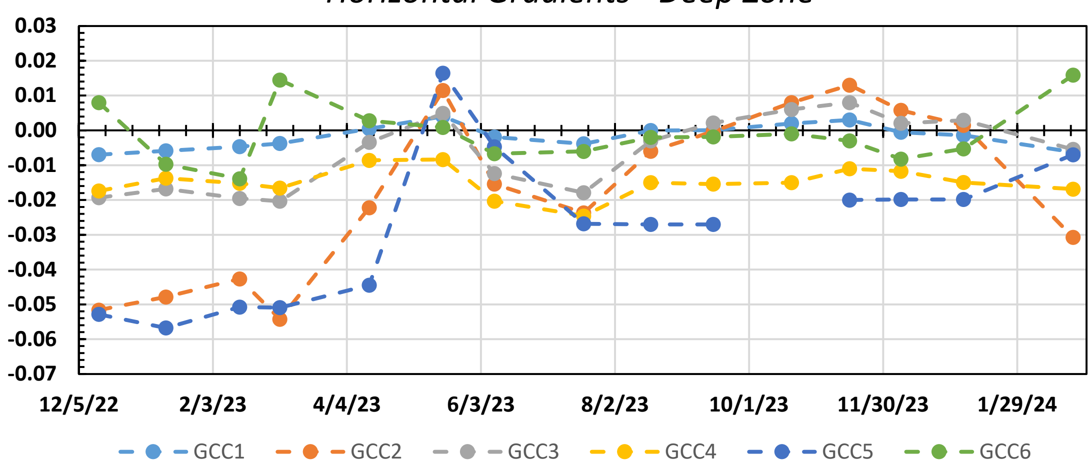
Horizontal Gradients - Shallow Zone



Horizontal Gradients - Intermediate Zone



Horizontal Gradients - Deep Zone



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

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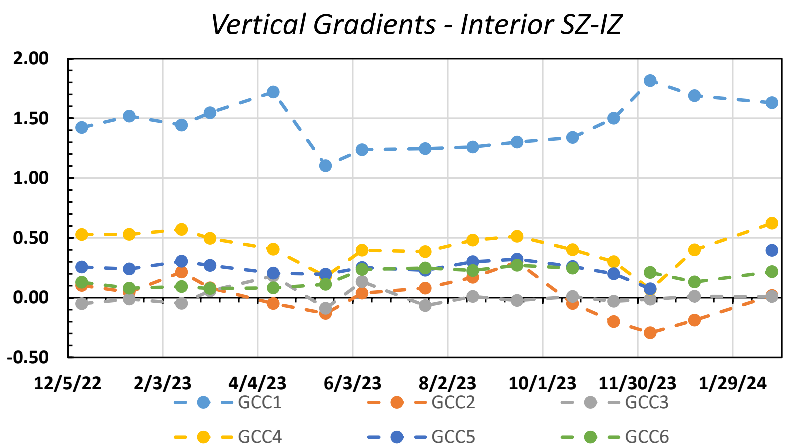
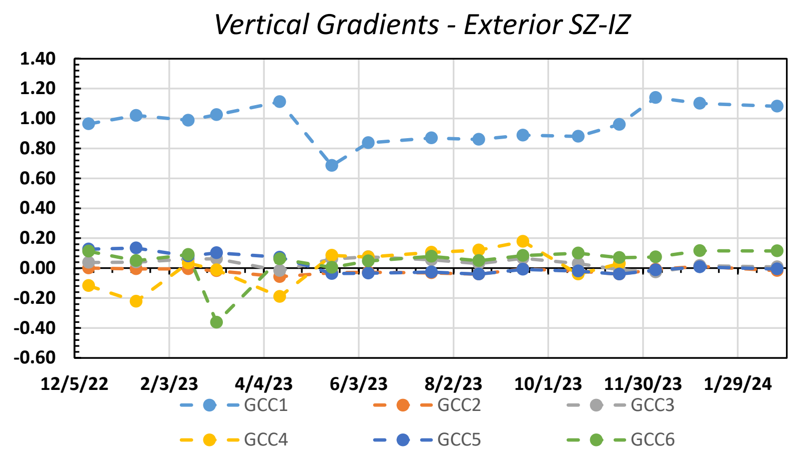
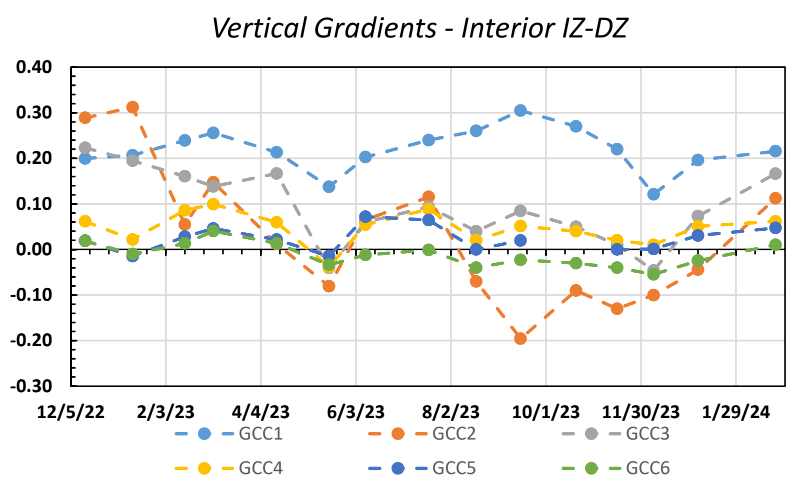
ATTACHMENT B-3 VERTICAL GRADIENTS

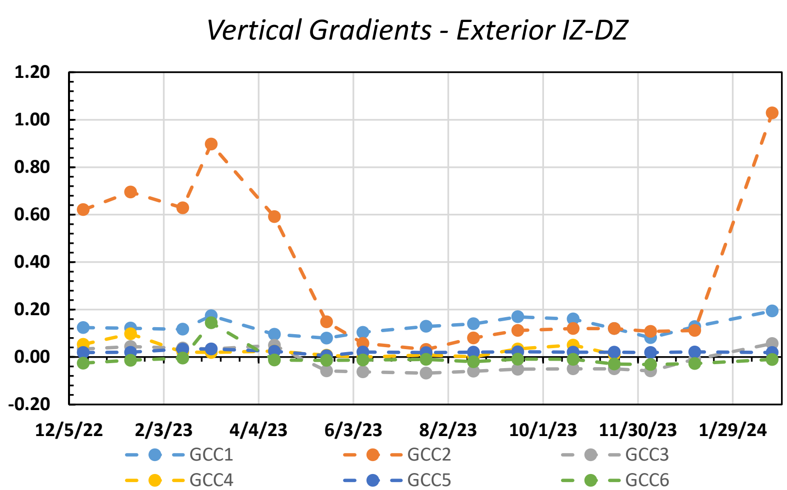
Attachment B-3

Vertical Gradients Summary: February 2024
Arkema Inc. Facility
Portland, Oregon









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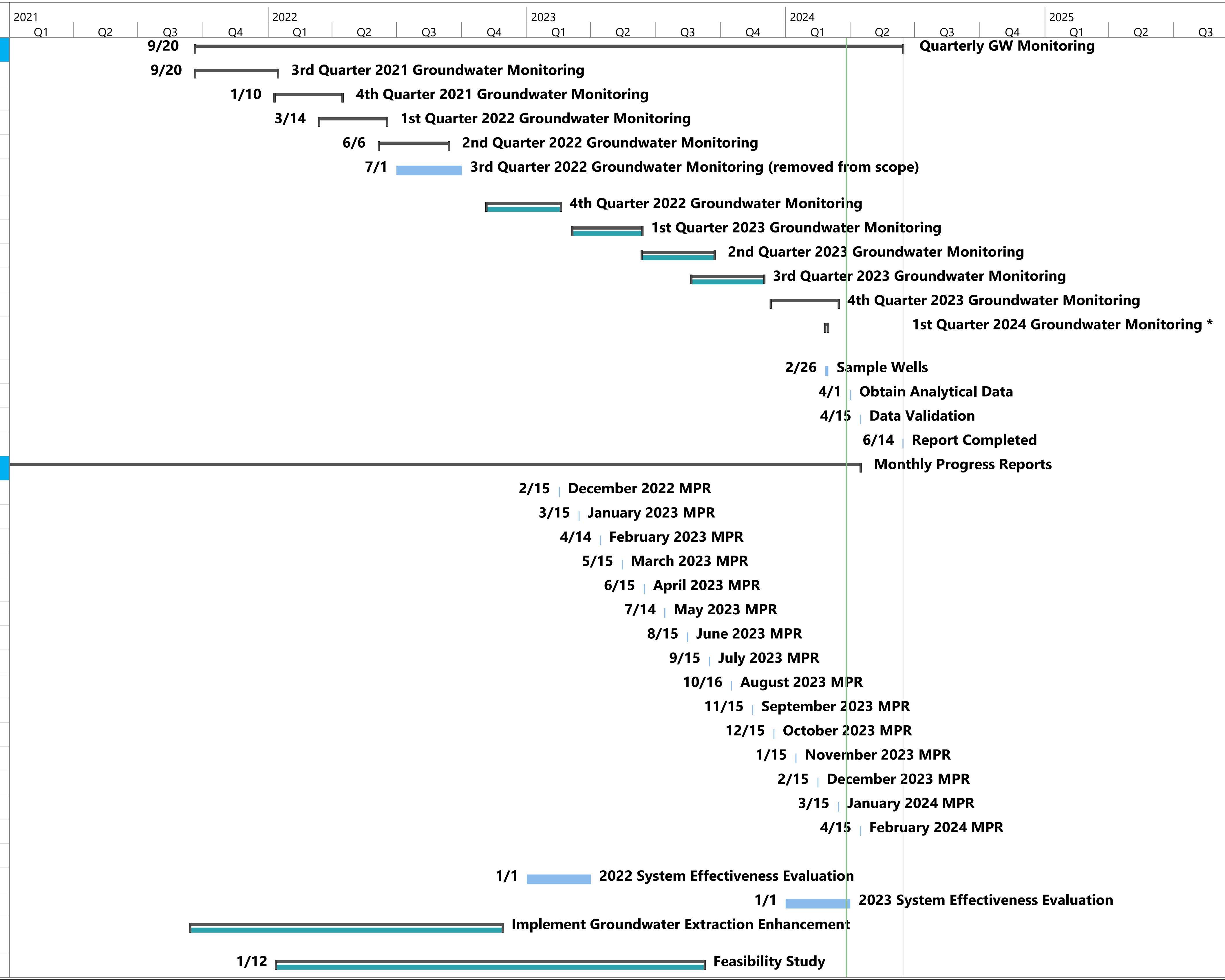
ATTACHMENT C PROJECT SCHEDULE

ID	Task Name	Duration	Start
1	**Quarterly GW Monitoring**	**719 days**	**Mon 9/20/21**
2	*3rd Quarter 2021 Groundwater Monitoring*	*85 days*	*Mon 9/20/21*
7	*4th Quarter 2021 Groundwater Monitoring*	*70 days*	*Mon 1/10/22*
11	*1st Quarter 2022 Groundwater Monitoring*	*70 days*	*Mon 3/14/22*
16	*2nd Quarter 2022 Groundwater Monitoring*	*71 days*	*Mon 6/6/22*
21	*3rd Quarter 2022 Groundwater Monitoring (removed from scope)*	*66 days*	*Fri 7/1/22*
22	*4th Quarter 2022 Groundwater Monitoring*	*78 days*	*Sat 11/5/22*
27	*1st Quarter 2023 Groundwater Monitoring*	*71 days*	*Mon 3/6/23*
32	*2nd Quarter 2023 Groundwater Monitoring*	*75 days*	*Mon 6/12/23*
37	*3rd Quarter 2023 Groundwater Monitoring*	*75 days*	*Mon 8/21/23*
42	4th Quarter 2023 Groundwater Monitoring	70 days	Mon 12/11/23
47	**1st Quarter 2024 Groundwater Monitoring ***	**4 days**	**Mon 2/26/24**
48	*Sample Wells*	*4 days*	*Mon 2/26/24*
49	*Obtain Analytical Data*	*1 day*	*Mon 4/1/24*
50	Data Validation	1 day	Mon 4/15/24
51	Report Completed	1 day	Fri 6/14/24
52	**Monthly Progress Reports**	**1217 days**	**Thu 8/22/19**
53	*December 2022 MPR*	*1 day*	*Wed 2/15/23*
54	*January 2023 MPR*	*1 day*	*Wed 3/15/23*
55	*February 2023 MPR*	*1 day*	*Fri 4/14/23*
56	*March 2023 MPR*	*1 day*	*Mon 5/15/23*
57	*April 2023 MPR*	*1 day*	*Thu 6/15/23*
58	*May 2023 MPR*	*1 day*	*Fri 7/14/23*
59	*June 2023 MPR*	*1 day*	*Tue 8/15/23*
60	*July 2023 MPR*	*1 day*	*Fri 9/15/23*
61	*August 2023 MPR*	*1 day*	*Mon 10/16/23*
62	*September 2023 MPR*	*1 day*	*Wed 11/15/23*
63	*October 2023 MPR*	*1 day*	*Fri 12/15/23*
64	*November 2023 MPR*	*1 day*	*Mon 1/15/24*
65	*December 2023 MPR*	*1 day*	*Thu 2/15/24*
66	*January 2024 MPR*	*1 day*	*Fri 3/15/24*
67	February 2024 MPR	1 day	Mon 4/15/24
68	March 2024 MPR	1 day	Thu 8/22/19
69	***2022 System Effectiveness Evaluation***	***66 days***	***Sun 1/1/23***
70	***2023 System Effectiveness Evaluation***	***66 days***	***Mon 1/1/24***
71	***Implement Groundwater Extraction Enhancement***	***317 days***	***Mon 9/13/21***
79	***Feasibility Study***	***436 days***	***Wed 1/12/22***



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	