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MEMO

TO	Katie Daugherty, Oregon Department of Environmental Quality
FROM	Brendan Robinson, PE, Environmental Resources Management, Inc.
DATE	15 July 2024
REFERENCE	0732445 Phase 204
SUBJECT	May 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 May 2024 MPR summarizes the GW SCM performance monitoring data collected in May 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 (RWs), 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 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 approximately 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. RECOVERY WELL AND EXTRACTION WELL PERFORMANCE

The average system influent flow rate was 40.48 gallons per minute (gpm) for the entire month of May 2024, including non-operational periods. The average operational influent flow during operational periods was 51.52 gpm, roughly the same as in April 2024.

Extraction pumps become fouled with accumulated solids over time. A proactive pump removal and maintenance program is in place to address fouling and maximize flow rates. In late February 2024, a recordable injury occurred onsite during pump removal and maintenance activities. As a result, pump maintenance activities were paused while a root cause analysis was performed, and procedures updated to mitigate ergonomic and fall risks. An updated pump pulling and maintenance procedure was approved 30 April 2024, and implemented in May 2024. Additionally, Trench 1 was off during April 2024 through 20 May 2024 in preparation for chemical redevelopment to mitigate the impact of silt and biofouling at EW-01. Redevelopment was also completed at EW-07, EW-09, and EW-11 during May 2024. Conveyance and lateral lines maintenance is planned for June 2024 to mitigate back pressure impeding flow rates. Extraction rates and hydraulic gradient performance are expected to improve following resumption of pump maintenance activities, chemical redevelopment, and conveyance line maintenance in July 2024.

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.

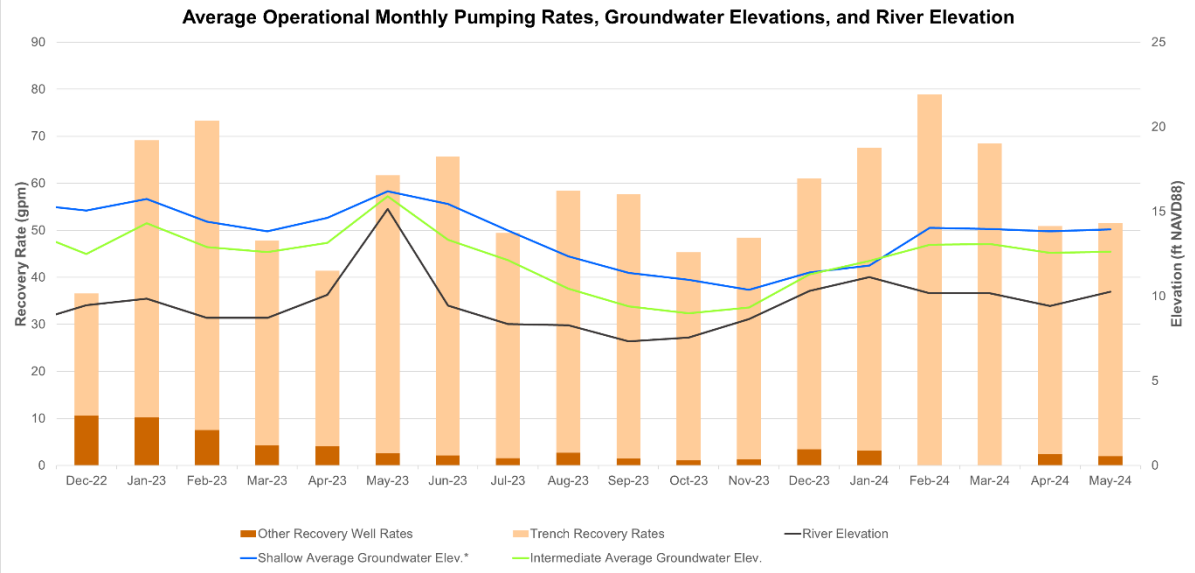
TABLE 1-1 RECOVERY WELL PUMPING RATES

Recovery Well	May 2024 Average Operational Pumping Rate (gpm)	May 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	2.00	1.61
EW-01	2.17	0.56

Recovery Well	May 2024 Average Operational Pumping Rate (gpm)	May 2024 Average Monthly Pumping Rate (gpm)
EW-02	1.41	0.36
EW-03	7.19	6.96
EW-04	3.21	3.10
EW-05	7.06	6.83
EW-06	2.81	2.72
EW-07	3.65	2.24
EW-08	3.62	1.87
EW-09	0.49	0.08
EW-10	4.41	4.27
EW-11	2.89	1.21
EW-12	1.72	1.16
EW-13	2.14	0.97
EW-14	6.74	6.53
Total	51.52	40.48

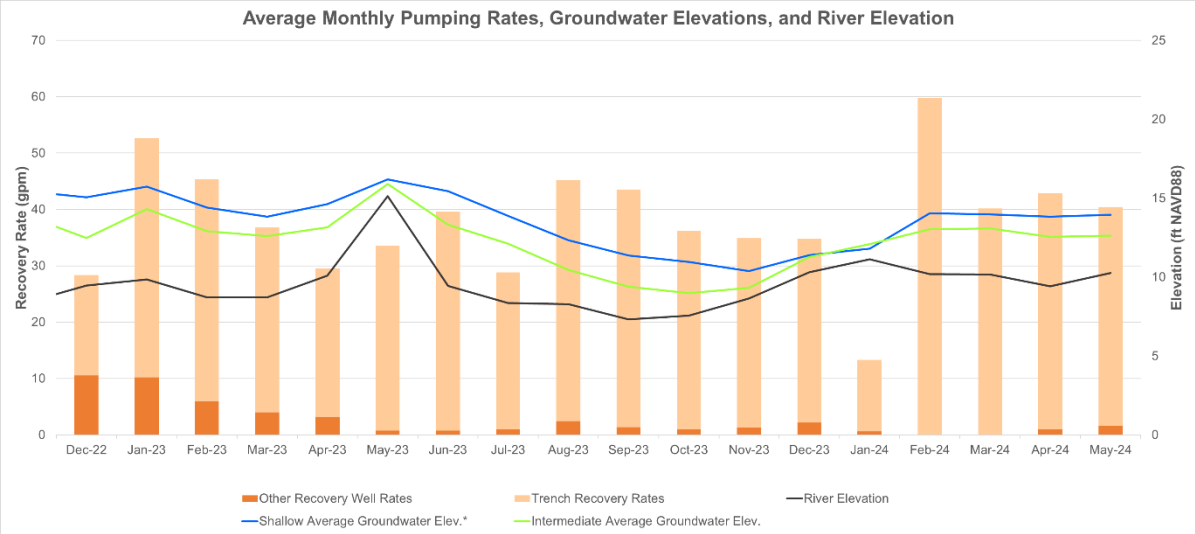
Notes:
* = Recovery well not in service during reporting period.
gpm = gallon per minute

FIGURE 1-1 OPERATIONAL 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

3.1 GWET SYSTEM PERFORMANCE

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

- 29 April 2024: The GWET system was shut down due to a carbon changeout on the lead carbon vessel. The ODEQ was notified, and discharge restarted 2 May 2024.
- 8 May 2024: The GWET system was shut down for one hour due to T-1 overflowing within the GWET plant. All water from tank T-1 was captured in the plant sump and processed.

4. 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.

4.1 GROUNDWATER ELEVATION MONITORING

Groundwater elevation monitoring was completed on 17 May 2024. Manual groundwater elevations were measured at wells that were experiencing transducer mechanical issues or that were offline during the groundwater elevation measurement event. 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 2024, the following transducers were:

Fully out of service pending repairs:

- MWA-58d
- MWA-19
- MWA-34i

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

- PA-06
- PA-07
- PA-26d

MWA-58d and MWA-19 were taken out of service due to the abandonment and replacement of MWA-34i but will be back online 12 June 2024. PA-06, PA-07 and PA-26d had faulted transducers that were replaced 1 May 2024. MWA-34i was abandoned and replaced with MWA-34iR on 30 May 2024.

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 May 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 19 April 2024 are shown below at each GCC (Table 1-2 and Table 1-3).

TABLE 1-2 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	27.53	PA-04	28.14	-0.006
	Intermediate	PA-17iR	13.26	PA-10i	14.27	-0.010
	Deep	PA-27d	12.17	PA-18d	12.07	0.001
GCC2	Shallow	MWA-2	10.56	PA-05	11.85	-0.019
	Intermediate	MWA-8i	10.90	PA-11i	11.94	-0.014
	Deep	PA-19d	9.62	PA-30d	10.91	-0.024
GCC3	Shallow	MWA-69	10.87	PA-06^{M}	12.92	-0.019
	Intermediate	MWA-66i	10.65	PA-12i	12.88	-0.020
	Deep	PA-21d	9.66	PA-20d	10.38	-0.006
GCC4	Shallow	MWA-19	10.66	PA-28	15.22	-0.045
	Intermediate	MWA-34i^{M}	10.87	PA-13i^{M}	12.53	-0.018
	Deep	MWA-58d	10.25	PA-22d	11.62	-0.015
GCC5	Shallow	MWA-47	10.77	PA-07^{M}	15.04	-0.041
	Intermediate	PA-29i	10.88	PA-14i	12.27	-0.026
	Deep	PA-24d^{M}	10.38	PA-23d	10.82	-0.008
GCC6	Shallow	PA-09	13.21	PA-08	13.74	-0.010
	Intermediate	PA-16i^{M}	11.65	PA-15i^{M}	11.92	-0.005
	Deep	PA-26d^{M}	12.42	PA-25d^{M}	11.92	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 1-3 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	28.14	PA-10i	14.27	1.40
		GCC2	PA-05	11.85	PA-11i	11.94	-0.01
		GCC3	PA-06^{M}	12.92	PA-12i	12.88	0.00
		GCC4	PA-28	15.22	PA-13i^{M}	12.53	0.42
		GCC5	PA-07^{M}	15.04	PA-14i	12.27	0.29
		GCC6	PA-08	13.74	PA-15i^{M}	11.92	0.14
	IZ-DZ	GCC1	PA-10i	14.27	PA-18d	12.07	0.29
		GCC2	PA-11i	11.94	PA-30d	10.91	0.15
		GCC3	PA-12i	12.88	PA-20d	10.38	0.13
		GCC4	PA-13i^{M}	12.53	PA-22d	11.62	0.05
		GCC5	PA-14i	12.27	PA-23d	10.82	0.04
		GCC6	PA-15i^{M}	11.92	PA-25d^{M}	11.92	0.00
Exterior	SZ-IZ	GCC1	PA-03	27.53	PA-17iR	13.26	0.91
		GCC2	MWA-2	10.56	MWA-8i	10.90	-0.02
		GCC3	MWA-69	10.87	MWA-66i	10.65	0.02
		GCC4	MWA-19	10.66	MWA-34i^{M}	10.87	-0.03
		GCC5	MWA-47	10.77	PA-29i	10.88	-0.01
		GCC6	PA-09	13.21	PA-16i^{M}	11.65	0.11
	IZ-DZ	GCC1	PA-17iR	13.26	PA-27d	12.17	0.17
		GCC2	MWA-8i	10.90	PA-19d	9.62	0.82
		GCC3	MWA-66i	10.65	PA-21d	9.66	0.08
		GCC4	MWA-34i^{M}	10.87	MWA-58d	10.25	0.03
		GCC5	PA-29i	10.88	PA-24d^{M}	10.38	0.01
		GCC6	PA-16i^{M}	11.65	PA-26d^{M}	12.42	-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

4.2 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 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 generalized groundwater movement to the extraction trenches in the Shallow, Intermediate, and Deep Zones due to GW SCM pumping, and cones of depression are apparent around each groundwater extraction trench. Inward gradient was observed in the Deep Zone at GCC1 and GCC6. Horizontal gradients at GCCs across the Site mostly improved and are trending toward inward gradients in all hydrogeological zones.

River elevations are shown over time on Figures 1-1 and 1-2 above, and in an inset on the potentiometric surface maps (Figures 2 through 4). The river elevation in May 2024 had an average elevation of 10.27 feet NAVD88 with a minimum elevation of 7.70 NAVD88 and a maximum elevation of 12.96 NAVD88, a small increase from April 2024. Compared to last May, the current river elevation is 30 percent lower, and has not changed materially since December 2023. Because the river did not experience a seasonal rise this year, groundwater elevations outside the GWBW did not increase, making hydraulic containment more difficult to achieve.

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 generally downward with exception to GCC2 being upward (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 upward and the rest downward as shown on Figure 5 and in Attachment B-2.

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 exception to GCC6 being upward, as shown on Figure 6 and Attachment B-3. While vertical groundwater gradients interior of the GWBW are generally downward, the magnitude of the gradients is getting smaller and approaching zero, indicating that mass flux of COCs is decreasing.

4.2.1 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.

5. 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	6/7/2024
2024 Quarter 2	6/10/2024–6/13/2024	9/13/2024*

* Dates are tentative.

6. SUMMARY AND CONCLUSIONS

This report presents a summary of the GW SCM operation, maintenance, and monitoring activities conducted at the Site in May 2024 and documents results from system monitoring. The following summarizes ERM's observations and conclusions drawn from collected data.

6.1 GROUNDWATER FLOW

- Horizontal groundwater gradients provided for the Deep Zone in Attachment B-2 show gradients were inward GCC1 and GCC6. Horizontal gradients at GCCs across the Site mostly improved and are trending toward inward gradients except for GCC6 in the Intermediate Zone. Additional improvements in gradients are anticipated as higher flow rates and uptime are achieved.
- Vertical groundwater gradients interior of the GWBW between the Shallow and Intermediate Zones were generally downward with exception to GCC2 being upward (Figure 5), and the magnitude of downward gradients continues to decrease. Exterior of the GWBW, vertical gradients between the Shallow and Intermediate Zones were mixed with GCC2, GCC4, 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 May 2024 was 10.27 feet NAVD88 with a minimum elevation of 7.70 feet NAVD88 and a maximum elevation of 12.96 feet NAVD88. A increase from river elevations observed in April 2024.

6.2 GROUNDWATER EXTRACTION

Based on May 2024 groundwater 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, 3, and 4 is largely gone, and the mound around Trenches 5, 6, and 7 is being reduced with increased extraction rates. Average monthly pumping rates in February to May 2023 were significantly lower than February to May 2024, resulting in improved horizontal and vertical gradients and increased COC containment.

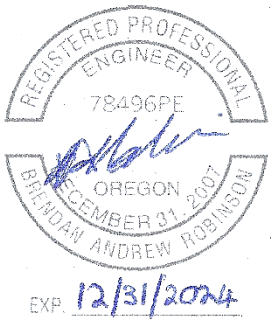
Within the Site alluvial sequence, potentiometric maps indicate the GW SCM is producing generalized hydraulic capture throughout the Target Capture Zone. More operational time at elevated extraction rates will be required to evaluate whether GWET objectives are being met system wide.

Due to work conducted throughout 2024 issues limited groundwater extraction rates including fouling of the pumps within the EW trenches, back pressure in the conveyance line, and a pause on pump maintenance, have all been addressed resulting in improved average pumping rates. As of May 2024, the main limitations to groundwater extraction are water levels, and the accumulation of silt within the EW trenches filter pack. Efforts to successfully redevelop the trenches and remove silt are ongoing.

6.3 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 June 2024 to mitigate turbidity and improve accuracy of Intermediate Zone groundwater contour maps. Conveyance line cleaning is planned for June 2024 to mitigate the observed backpressure in the conveyance lines. LSS will continue to optimize new EWs, including pump maintenance and upgrades. 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

7. 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.

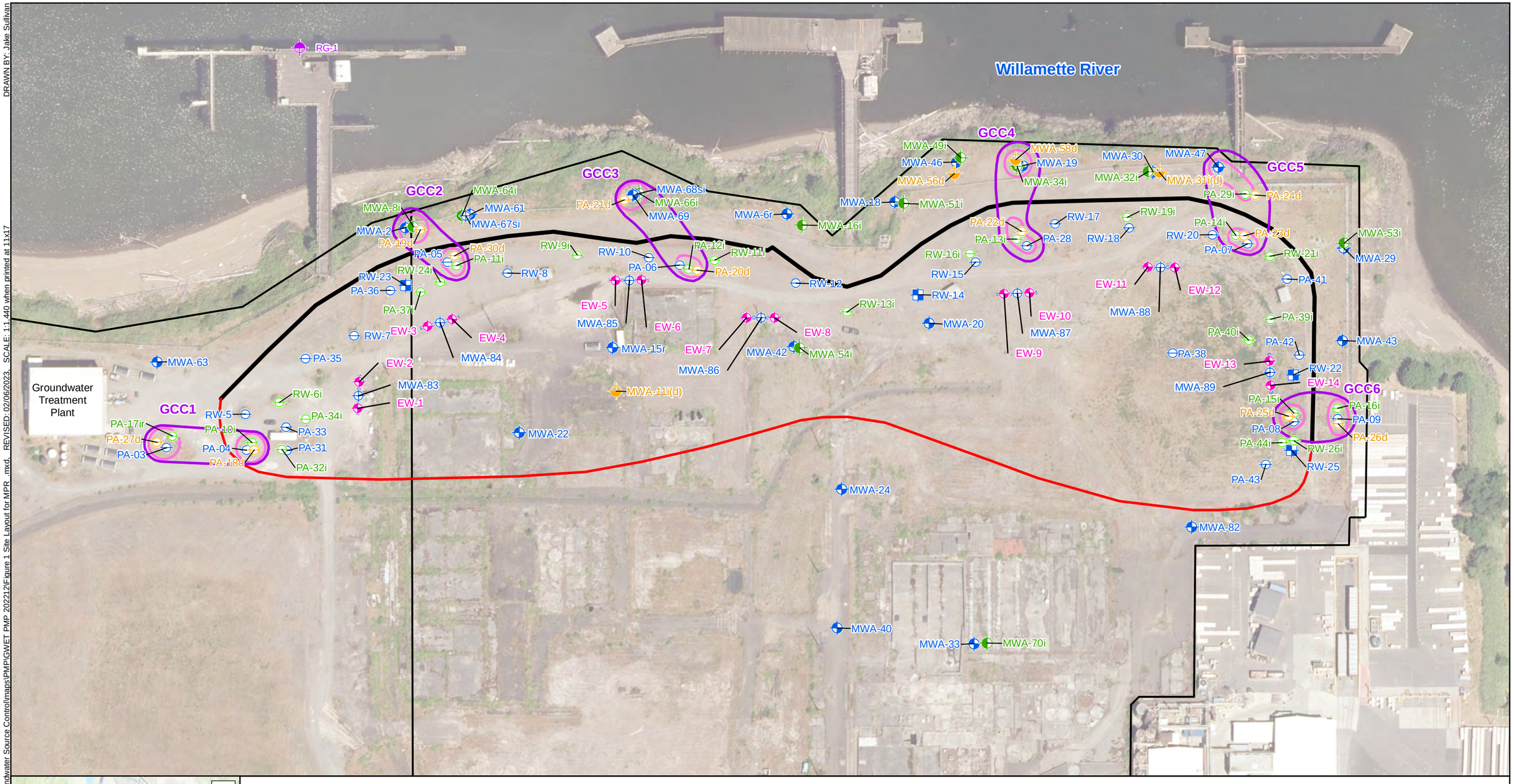
_____. 2018. *Draft GWET System Effectiveness Evaluation, Arkema Inc. Facility, Portland, Oregon*. September 2018.

_____. 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



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

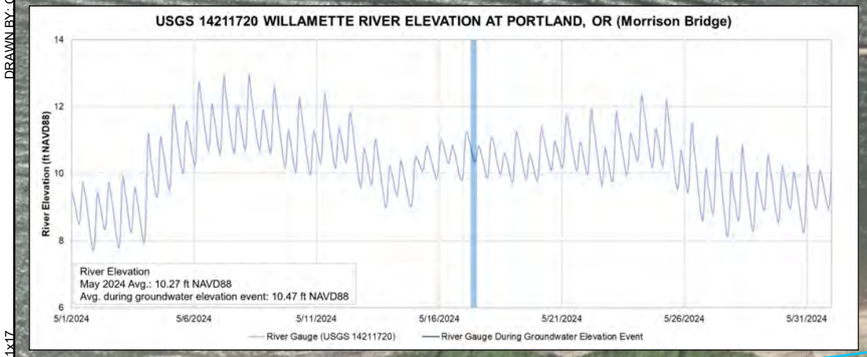
Figure 1
Site Layout
Monthly Progress Report
Groundwater Source Control Measure
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com

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

DRAWN BY: Jake Sullivan

M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 2022\2Figure 1 Site Layout for MPR_mxd_ REVISED 02/06/2023 SCALE: 1:1,440 when printed at 11x17



Willamette River

Groundwater Treatment Plant

Sand Filter Basin

Detention Basin

RP-02-31 12.72
RP-10-30 30.82
MWA-2 10.56
MWA-19 10.66
MWA-20 14.83
MWA-22 16.33
MWA-24 16.46
MWA-33 21.68
MWA-40 20.40
MWA-41 13.43
MWA-42 14.00
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MWA-89 4.40
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RW-12 13.93
RW-14 14.88
RW-15 14.89
RW-15r 12.77
RW-17 15.11
RW-18 14.67
RW-20 14.89
RW-22 14.26
RW-23 11.70
RW-25* 14.28

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 17, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

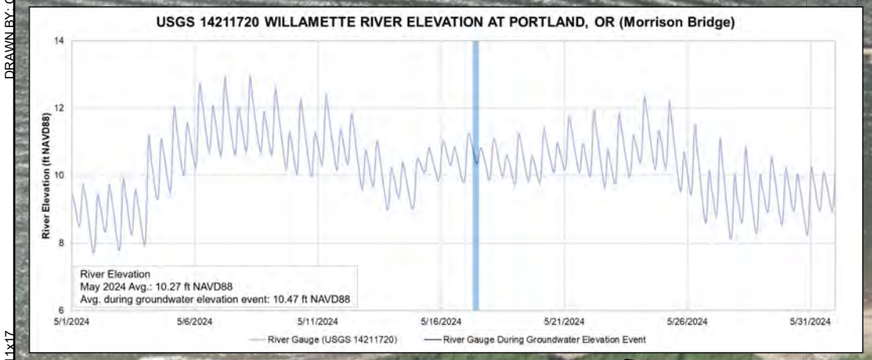
Figure 2
May 2024 Shallow Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

M:\US\Projects\US\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 20240614\Arkema_GWET PMP_May 2024.aprx REVISED: 06/28/2024 SCALE: 1:1,900 when printed at 11x17

DRAWN BY: GIS



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 May 17, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

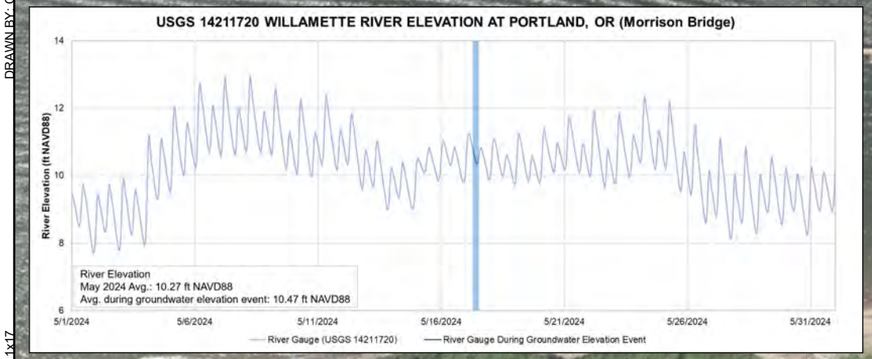
Figure 3
May 2024 Intermediate Zone Groundwater Contours
Monthly Progress Report
Groundwater Source Control Measures
Arkema Inc.
Portland, Oregon

Environmental Resources Management
www.erm.com
ERM

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

M:\US\Projects\SLU\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 20240614\Arkema_GWET PMP_May 2024.aprx REVISED: 06/28/2024 SCALE: 1:1,900 when printed at 11x17

DRAWN BY: GIS



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 17, 2024.
ft NAVD88: feet North American Vertical Datum of 1988.
Aerial Photo: City of Portland, Summer 2017.

N

0 160 320
Feet

Figure 4
May 2024 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\US-LUT\all\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 20240618\Arkema GWET PMP May 2024.aprx REVISED: 06/28/2024 SCALE: 1:1,900 when printed at 11x17

DRAWN BY: GIS

Willamette River

-0.02
0.02
-0.03
-0.01
0.42
0.29
0.00
-0.01
0.91
1.40
0.14
0.11

GCC1
GCC2
GCC3
GCC4
GCC5
GCC6

MWA-8i
MWA-2
MWA-64i
MWA-61
MWA-67si
MWA-69
MWA-66i
MWA-68si
MWA-6r
MWA-16i
MWA-18
MWA-49i
MWA-46
MWA-51i
MWA-19
MWA-34i
MWA-30
MWA-32i
MWA-47
PA-29i
PA-05
PA-11i
RW-24i
RW-23
PA-36
PA-37i
RW-8
RW-9i
RW-10
PA-06
PA-12i
RW-11i
RW-12
RW-13i
RW-14
RW-15
RW-16i
PA-13i
PA-28
RW-17
RW-18
RW-19i
RW-20
PA-14i
PA-07
RW-21i
MWA-53i
MWA-29
PA-41
PA-39i
PA-40i
PA-42
MWA-43
RW-22
PA-38
MWA-20
MWA-15r
MWA-42
MWA-54i
RW-7
PA-35
MWA-63
RW-5
RW-6i
PA-34i
PA-33
PA-31
PA-32i
PA-17ir
PA-10i
PA-03
PA-04
MWA-22
MWA-24
MWA-82
MWA-40
MWA-33
MWA-70i
PA-15i
PA-16i
PA-08
PA-09
PA-44i
RW-26i
RW-25
PA-43

Groundwater Treatment Plant

Sand Filter Basin

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 17, 2024.
Aerial Photo: City of Portland, Summer 2017.

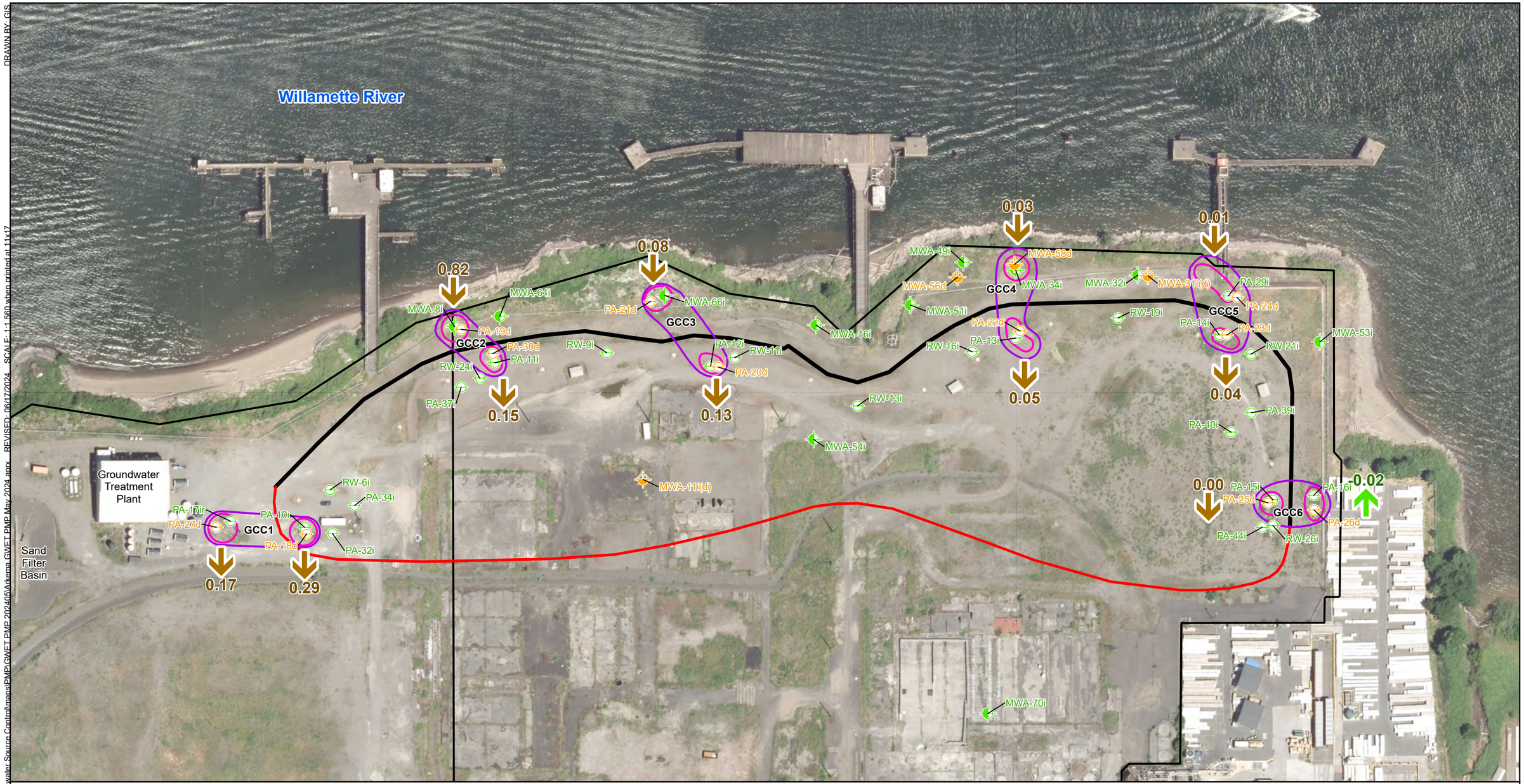
N

0 130 260
Feet

NAD 1983 StatePlane Oregon North FIPS 3601 Feet Intl

Figure 5
May 2024 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



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 17, 2024.
Aerial Photo: City of Portland, Summer 2017.

N

0 130 260
Feet

Figure 6
May 2024 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

DRAWN BY: GIS
REVISED: 06/17/2024 SCALE: 1:1,560 when printed at 11x17
M:\US\Projects\S-U\Total\Arkema_Portland\Groundwater Source Control\maps\PMP\GWET PMP 20240605\Arkema GWET PMP May 2024.aprx

ATTACHMENT A-1 TRANSDUCER FLAGS

Attachment A-1. Transducer Flags

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

Gradient Cluster	Transducer	Interval	Date Range		Issue and Repairs Performed
GCC3	PA-26d	Deep	1/29/2024	5/1/2024	Transducer faulted and replaced.
GCC5	PA-07	Shallow	1/29/2024	5/1/2024	Transducer faulted and replaced.
GCC4	MWA-34i	Intermediate	5/28/2024	6/12/2024	Transducer taken out of service for MWA-34i abandonment and replacement.
GCC4	MWA-58d	Deep	5/28/2024	6/12/2024	Transducer taken out of service for MWA-34i abandonment and replacement.
GCC4	MWA-19	Shallow	5/28/2024	6/12/2024	Transducer taken out of service for MWA-34i abandonment and replacement.
GCC3	PA-06	Shallow	5/22/2024	5/31/2024	Transducer faulted and 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: May 2024
Arkema Inc. Facility
Portland, Oregon

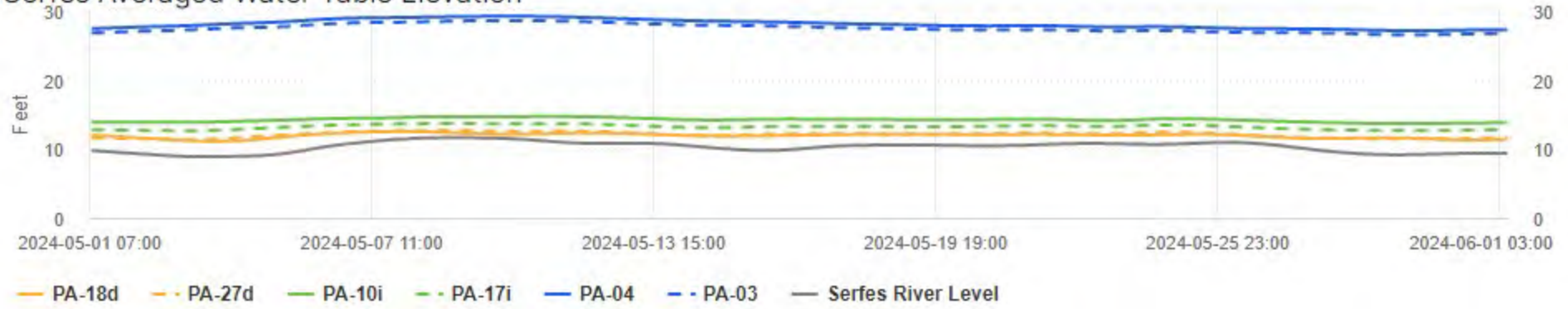
Recovery Well ID	Status as of 5/31/2024 (active or inactive)	Issue	Actions to get online	Expected date back online	Transducer Status	Totalizer Status	Average Operational Flow Rate (gpm)	Overall Extraction Rate	Notes
RW-14	Inactive	None	N/A	N/A	Good	Good	0.00	OFF*	Not turned on
RW-22	Inactive	Ground Fault	Replace cable leads	N/A	Good	Good	0.00	OFF*	Cable leads need to be replaced
RW-23	Inactive	None	Redeploy clean pump	6/19/2024	Good	Good	0.00	OFF*	
RW-25	Active	None	N/A	N/A	Good	Good	2.00	M**	
EW-01	Inactive	Low pH	Adjust pH	7/1/2024	Good	Good	2.17	M**	Transfer Trench 1 water to Frac tank to adjust pH
EW-02	Inactive	Low pH	Adjust pH	7/1/2024	Good	Good	1.41	M**	Transfer Trench 1 water to Frac tank to adjust pH
EW-03	Active	None	N/A	N/A	Good	Good	7.19	G	½-Hp pump swapped out for a 1-Hp pump
EW-04	Active	None	N/A	N/A	Good	Good	3.21	G	Operating but Motor Overload Fault at higher frequency
EW-05	Active	None	N/A	N/A	Good	Good	7.06	G	
EW-06	Active	None	N/A	N/A	Good	Good	2.81	M**	Operating but Motor Overload Fault at higher frequency
EW-07	Inactive	Load Fault	Clean conveyance line	6/1/2024	Good	Good	3.65	G**	Pulled for Hydropuls redevelopment and conveyance line cleaning
EW-08	Active	Motor Overload Fault	N/A	N/A	Good	Good	3.62	G**	Motor overload at higher frequency, possibly change motor
EW-09	Active	None	Clean conveyance line	6/5/2024	Good	Good	0.49	P**	Pulled for Hydropuls redevelopment and conveyance line cleaning
EW-10	Active	None	N/A	N/A	Good	Good	4.41	G**	
EW-11	Active	None	Clean conveyance line	6/5/2024	Good	Good	2.89	M**	Pulled for Hydropuls redevelopment and conveyance line cleaning
EW-12	Active	None	N/A	N/A	Good	Good	1.72	M**	
EW-13	Active	None	Repair pumbing	6/5/2024	Good	Good	2.14	M**	Check valve leaking
EW-14	Active	None	N/A	NA	Good	Good	6.74	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

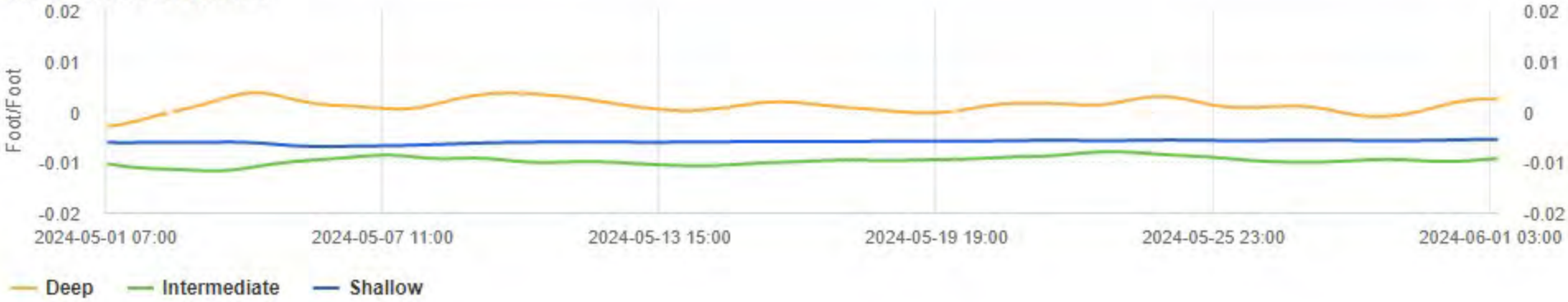
ATTACHMENT B-1 GRADIENT HYDROGRAPHS

Gradient Control Cluster 1

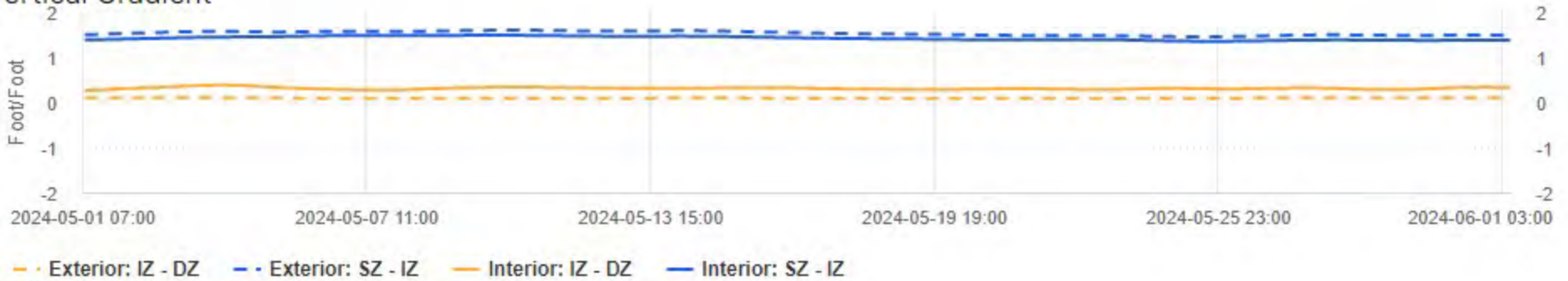
Serfes Averaged Water Table Elevation



Horizontal Gradient



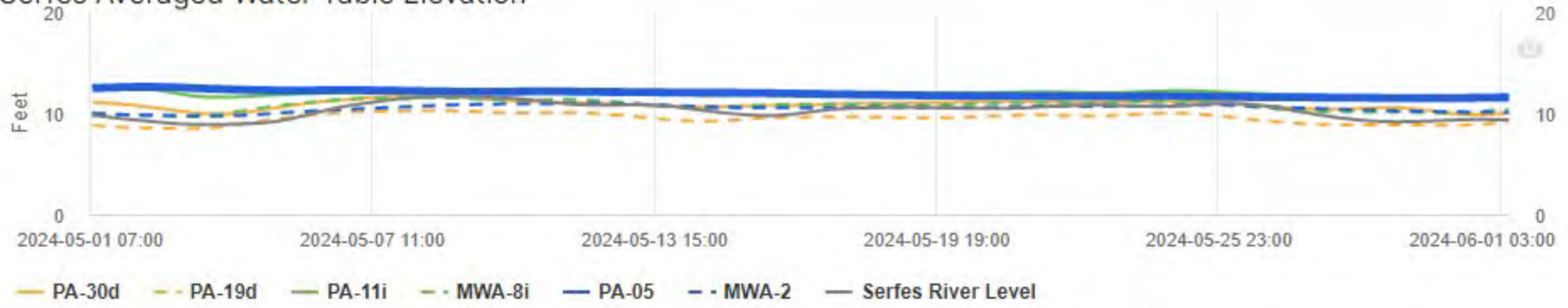
Vertical Gradient



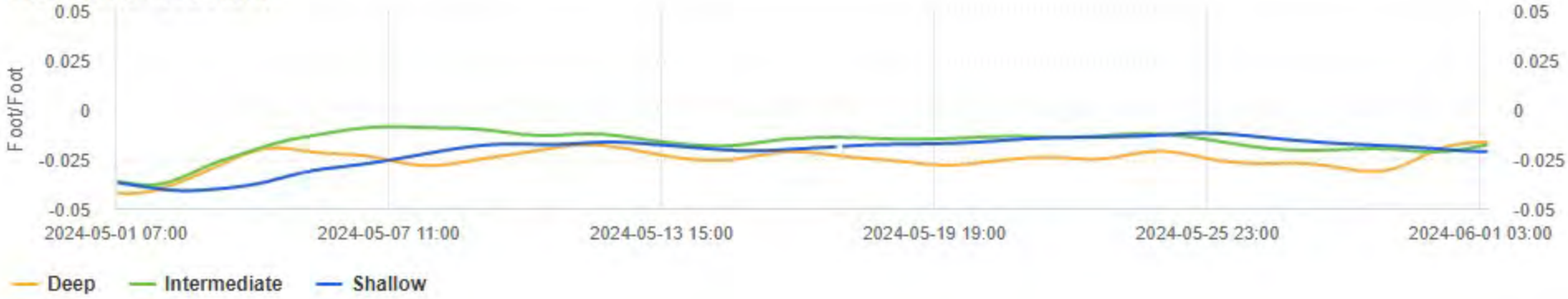
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside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

Gradient Control Cluster 2

Serfes Averaged Water Table Elevation



Horizontal Gradient

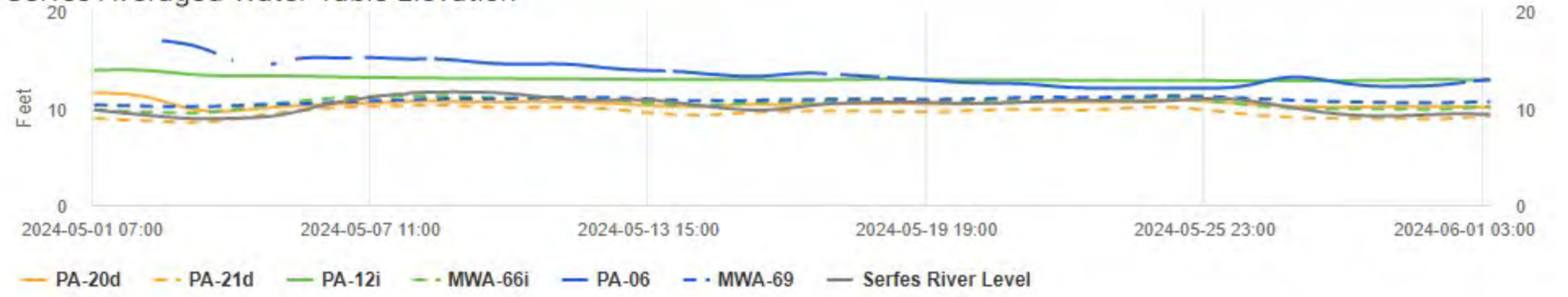


Vertical Gradient

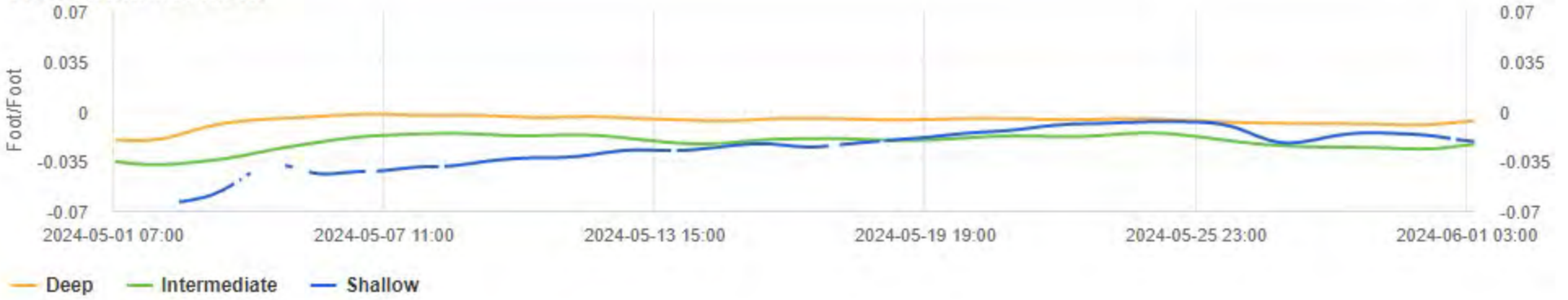
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside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

Gradient Control Cluster 3

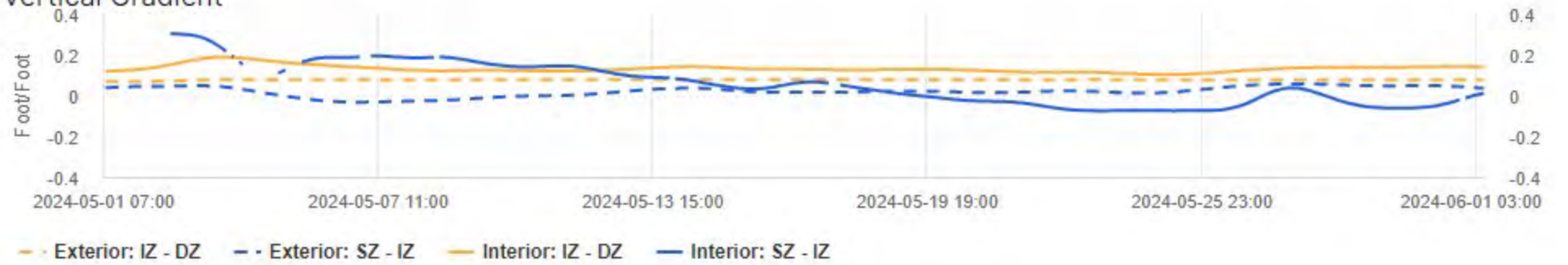
Serfes Averaged Water Table Elevation



Horizontal Gradient



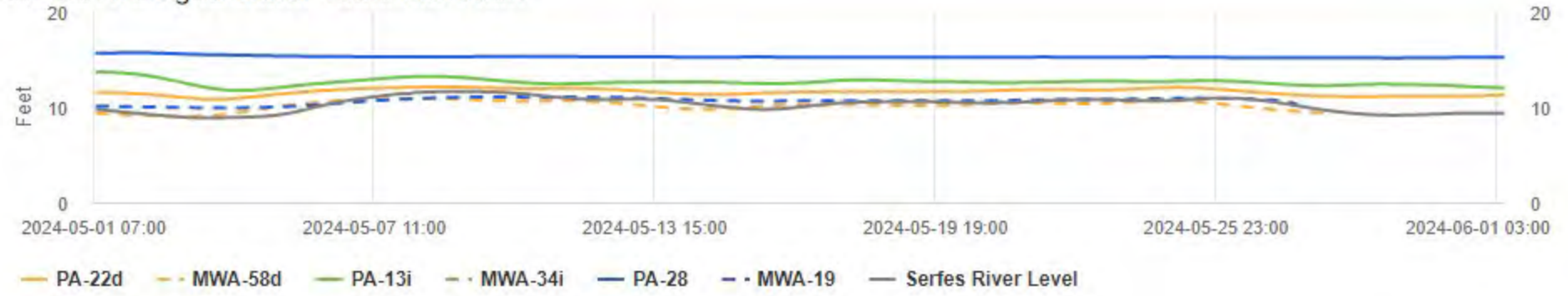
Vertical Gradient



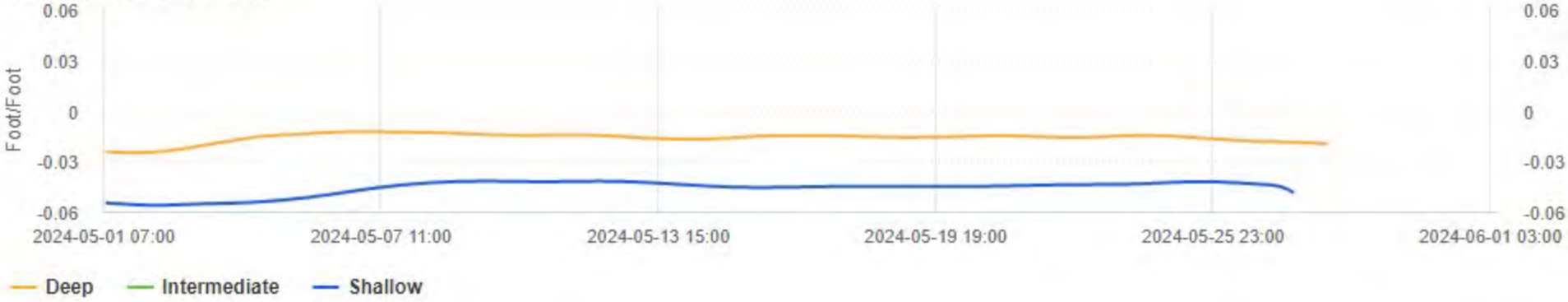
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside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

Gradient Control Cluster 4

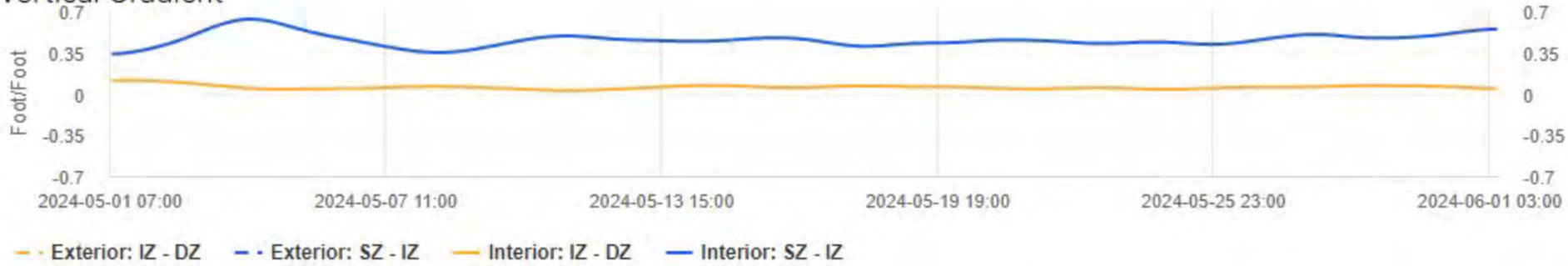
Serfes Averaged Water Table Elevation



Horizontal Gradient



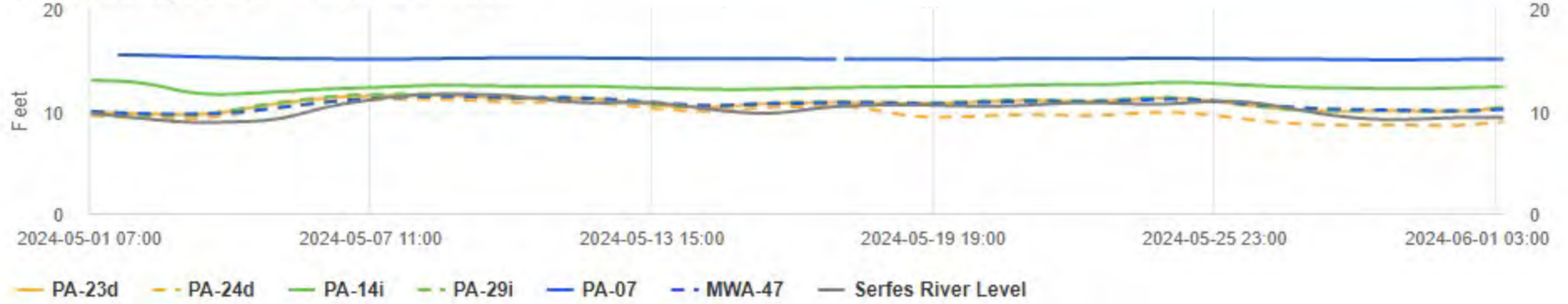
Vertical Gradient



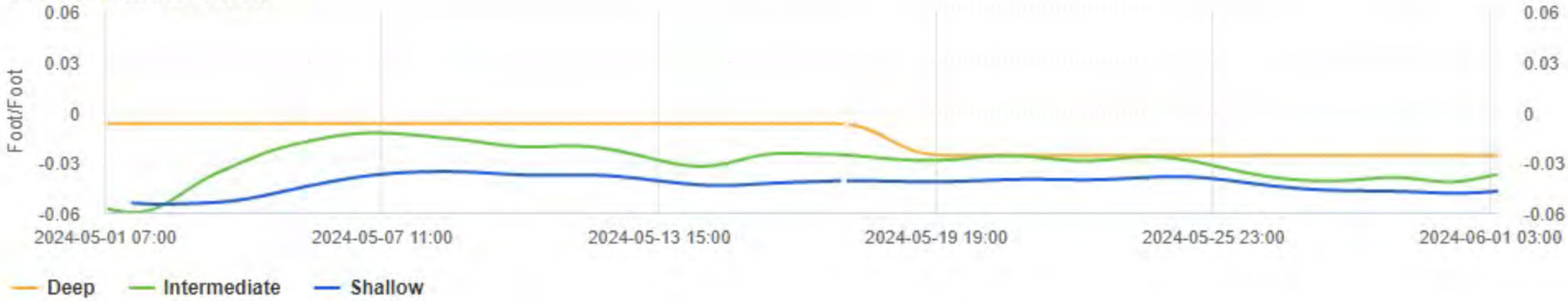
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside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

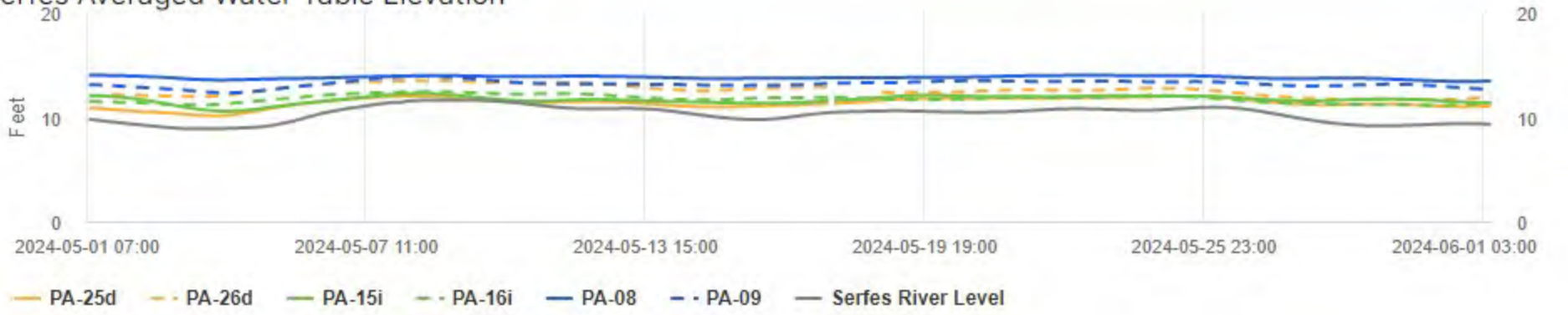
Notes:

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

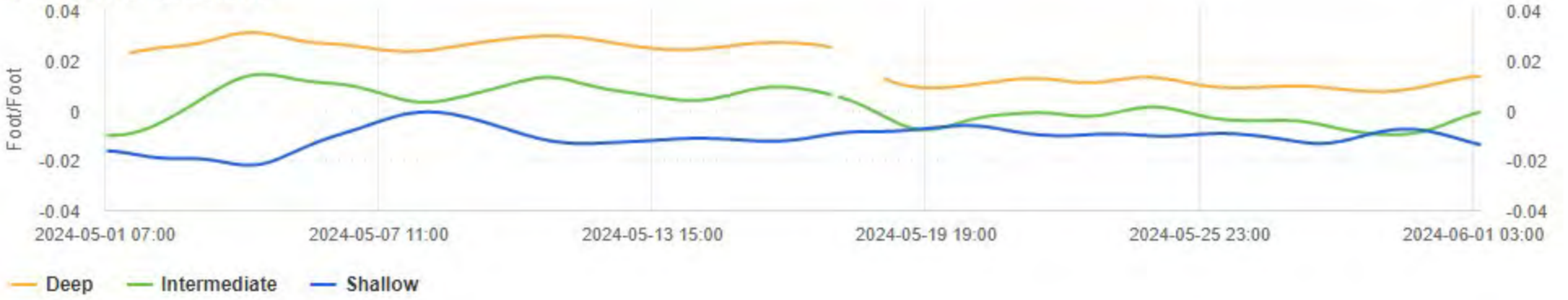
SZ = Shallow Zone
IZ = Intermediate Zone
DZ = Deep Zone

Gradient Control Cluster 6

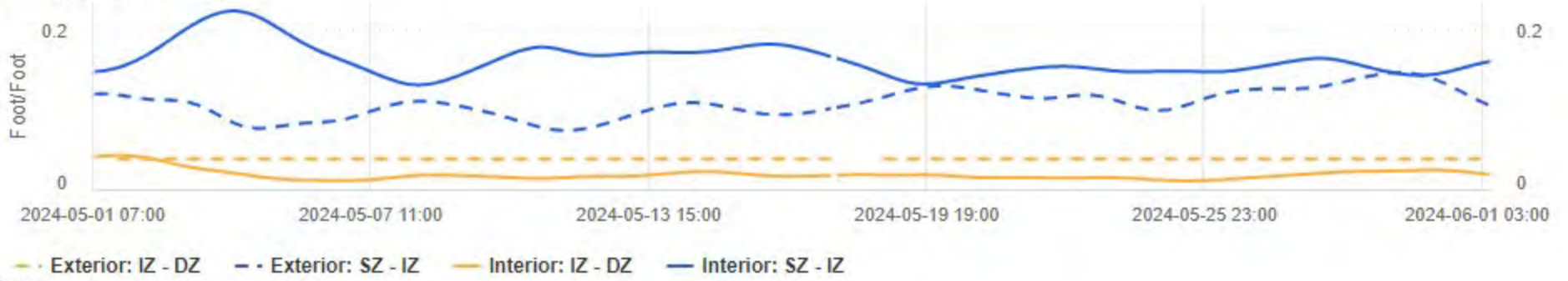
Serfes Averaged Water Table Elevation



Horizontal Gradient



Vertical Gradient

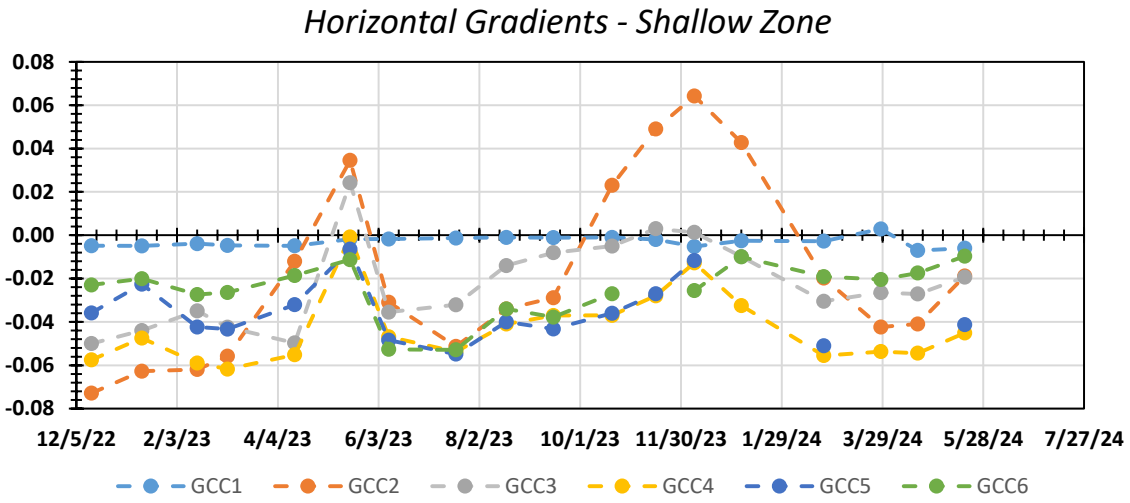


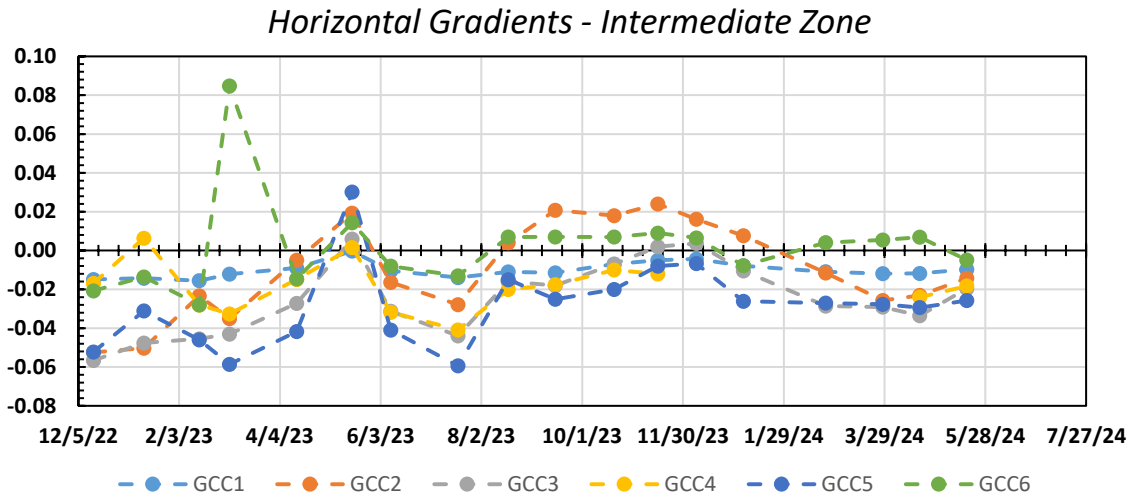
Notes:
Positive gradient indicates inward horizontal gradient and downward vertical gradient
Vertical Gradient calculated using (WTE_upper - WTE_lower)/(Bottom of Screen_upper - Top of Screen_lower)
Horizontal gradient calculated as Exterior – Interior. Interior: Upland of the GWBW, Exterior: Riverside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

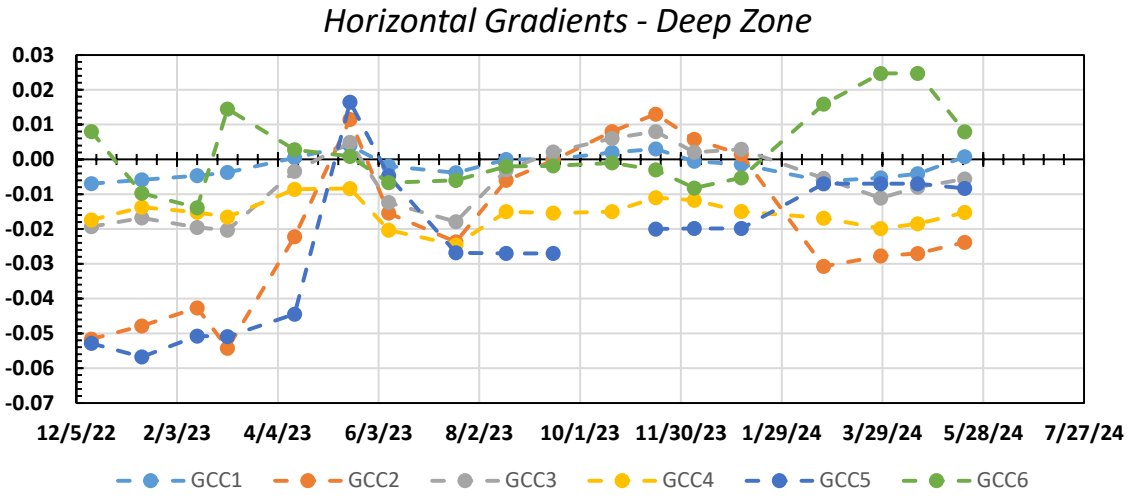
ATTACHMENT B-2 HORIZONTAL GRADIENTS

Attachment B-2

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







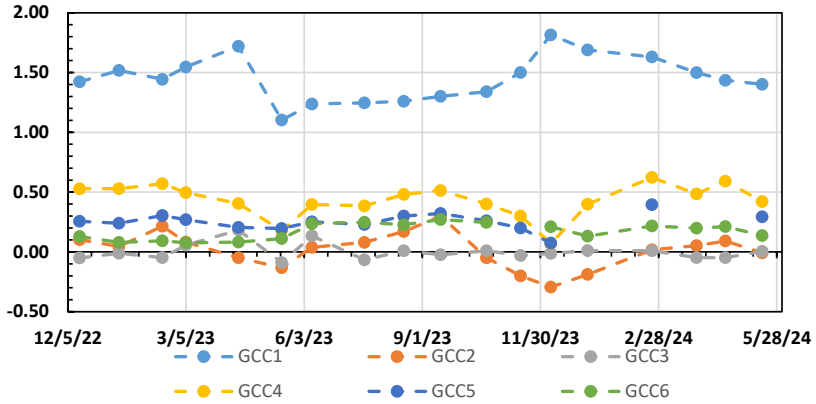
Positive horizontal gradient indicates an inward hydraulic gradient across the GWBW.

ATTACHMENT B-3 VERTICAL GRADIENTS

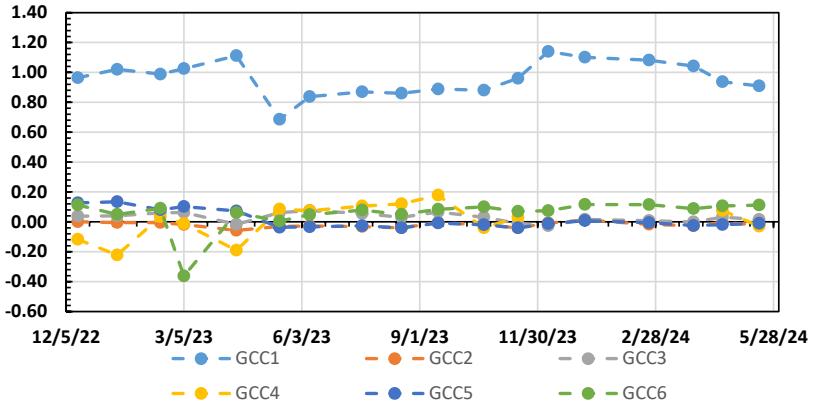
Attachment B-3

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

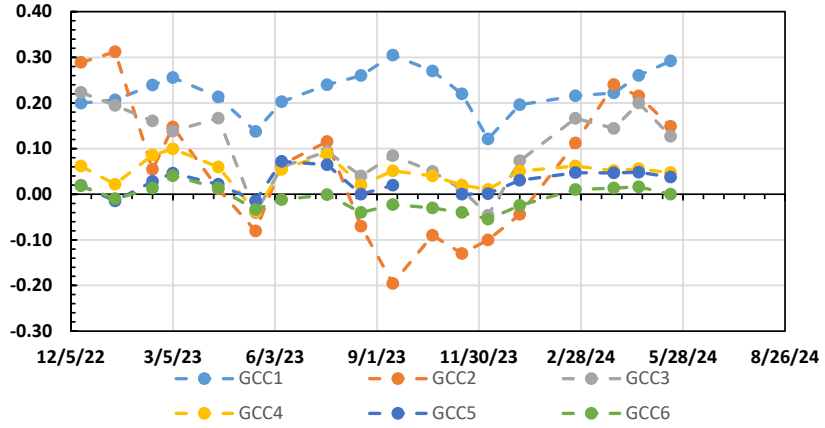
Vertical Gradients - Interior SZ-IZ



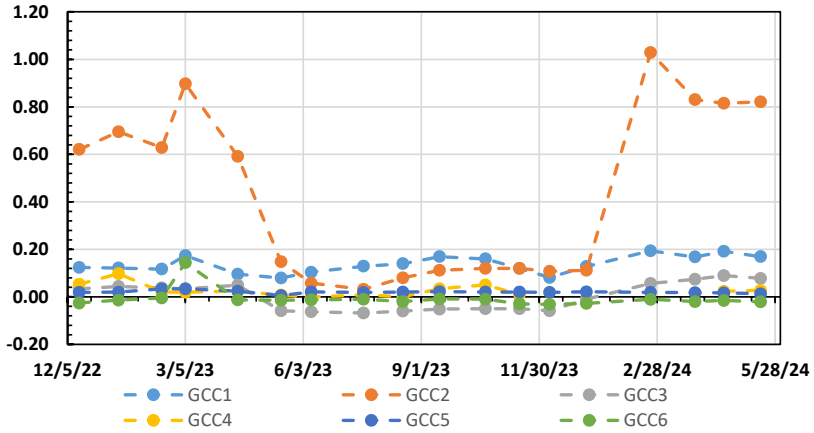
Vertical Gradients - Exterior SZ-IZ



Vertical Gradients - Interior IZ-DZ

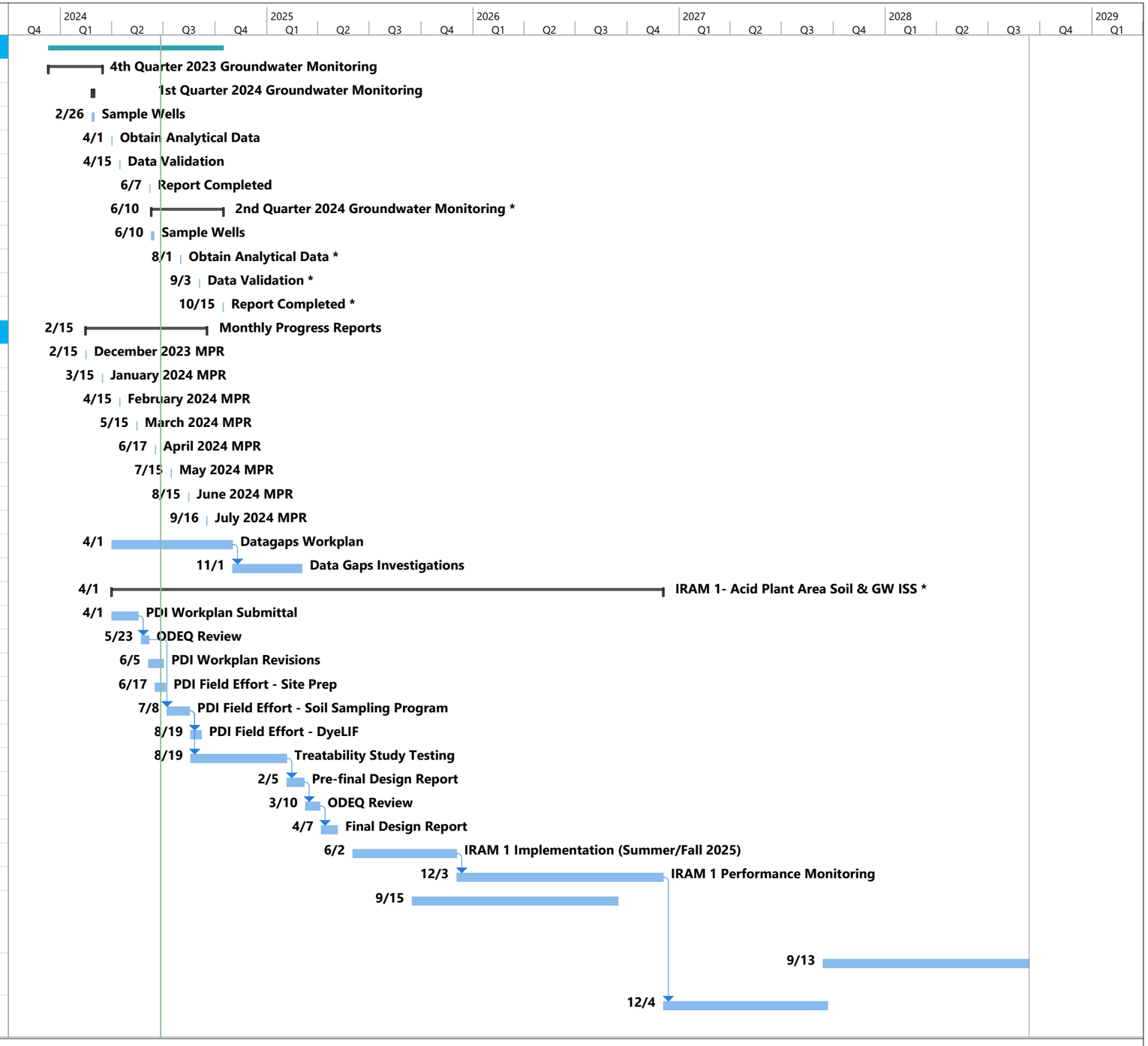


Vertical Gradients - Exterior IZ-DZ



ATTACHMENT C PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**Quarterly GW Monitoring**			
2	4th Quarter 2023 Groundwater Monitoring	70 days	Mon 12/11/23	Fri 3/15/24
7	**1st Quarter 2024 Groundwater Monitoring**	**4 days**	**Mon 2/26/24**	**Thu 2/29/24**
8	*Sample Wells*	*4 days*	*Mon 2/26/24*	*Thu 2/29/24*
9	*Obtain Analytical Data*	*1 day*	*Mon 4/1/24*	*Mon 4/1/24*
10	*Data Validation*	*1 day*	*Mon 4/15/24*	*Mon 4/15/24*
11	*Report Completed*	*1 day*	*Fri 6/7/24*	*Fri 6/7/24*
12	**2nd Quarter 2024 Groundwater Monitoring ***	**92 days**	**Mon 6/10/24**	**Tue 10/15/24**
13	*Sample Wells*	*5 days*	*Mon 6/10/24*	*Fri 6/14/24*
14	Obtain Analytical Data *	1 day	Thu 8/1/24	Thu 8/1/24
15	Data Validation *	1 day	Tue 9/3/24	Tue 9/3/24
16	Report Completed *	1 day	Tue 10/15/24	Tue 10/15/24
17	**Monthly Progress Reports**	**154 days**	**Thu 2/15/24**	**Mon 9/16/24**
18	*December 2023 MPR*	*1 day*	*Thu 2/15/24*	*Thu 2/15/24*
19	*January 2024 MPR*	*1 day*	*Fri 3/15/24*	*Fri 3/15/24*
20	*February 2024 MPR*	*1 day*	*Mon 4/15/24*	*Mon 4/15/24*
21	*March 2024 MPR*	*1 day*	*Wed 5/15/24*	*Wed 5/15/24*
22	*April 2024 MPR*	*1 day*	*Mon 6/17/24*	*Mon 6/17/24*
23	May 2024 MPR	1 day	Mon 7/15/24	Mon 7/15/24
24	June 2024 MPR	1 day	Thu 8/15/24	Thu 8/15/24
25	July 2024 MPR	1 day	Mon 9/16/24	Mon 9/16/24
26	**Datagaps Workplan**	154 days	Mon 4/1/24	Thu 10/31/24
27	**Data Gaps Investigations**	87 days	Fri 11/1/24	Mon 3/3/25
28	**IRAM 1- Acid Plant Area Soil & GW ISS ***	**699 days**	**Mon 4/1/24**	**Thu 12/3/26**
29	*PDI Workplan Submittal*	*35 days*	*Mon 4/1/24*	*Fri 5/17/24*
30	*ODEQ Review*	*10 days*	*Thu 5/23/24*	*Wed 6/5/24*
31	PDI Workplan Revisions	19 days	Wed 6/5/24	Mon 7/1/24
32	PDI Field Effort - Site Prep	15 days	Mon 6/17/24	Fri 7/5/24
33	PDI Field Effort - Soil Sampling Program	30 days	Mon 7/8/24	Fri 8/16/24
34	PDI Field Effort - DyeLIF	15 days	Mon 8/19/24	Fri 9/6/24
35	Treatability Study Testing	122 days	Mon 8/19/24	Tue 2/4/25
36	Pre-final Design Report	23 days	Wed 2/5/25	Fri 3/7/25
37	ODEQ Review	20 days	Mon 3/10/25	Fri 4/4/25
38	Final Design Report	21 days	Mon 4/7/25	Mon 5/5/25
39	IRAM 1 Implementation (Summer/Fall 2025)	132 days	Mon 6/2/25	Tue 12/2/25
40	IRAM 1 Performance Monitoring	262 days	Wed 12/3/25	Thu 12/3/26
41	**IRAM 2-Enhanced ISCR Perchlorate & CrVI In Chlorate Plant Area, if needed (Summer 2026 implementation)**	261 days	Mon 9/15/25	Mon 9/14/26
42	**IRAM 3-Remove Human Health Direct Contact Hot Spots, if needed (Summer 2028 implementation)**	261 days	Mon 9/13/27	Mon 9/11/28
43	**IRAM 4-Enhanced ISCR of Acid Plant Vicinity, if needed (Summer 2027 implementation)**	207 days	Fri 12/4/26	Mon 9/20/27



Arkema Portland
Monthly Progress Report
Attachment C

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