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ANCHOR QEA

DNAPL Monitoring Semiannual Summary Report (July 1 through December 31, 2023)

Prepared for NW Natural

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CERTIFICATION STATEMENT

The material and data in this report were prepared under the supervision and direction of the undersigned.

Expires January 1, 2025

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Anchor QEA

April 1, 2024

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ABBREVIATIONS

CDR	*Revised Groundwater Source Control Construction Design Report*
DEQ	Oregon Department of Environmental Quality
DNAPL	dense nonaqueous phase liquid
HC&C	hydraulic control and containment
LNAPL	light nonaqueous phase liquid
NAPL	nonaqueous phase liquid
Siltronic	Siltronic Corporation
Site	NW Natural Gasco site
TarGOST	Tar-Specific Green Optical Screening Tool
TMA	TarGOST monitoring area
WBZ	water-bearing zone

1 Introduction

This report presents the results of the dense nonaqueous phase liquid (DNAPL) monitoring program implemented by Anchor QEA at the NW Natural Gasco site (Site) in Portland, Oregon. DNAPL monitoring has occurred prior to and during testing and subsequent full-time operation of the groundwater hydraulic control and containment (HC&C) system over 13 semiannual reporting periods since April 29, 2013.

As outlined in the *Revised Groundwater Source Control Construction Design Report* (CDR) (Anchor QEA 2012), the DNAPL monitoring program was implemented at the request of the Oregon Department of Environmental Quality (DEQ) to evaluate whether operation of the HC&C system at the Site could potentially mobilize DNAPL from the former effluent management areas on the NW Natural and Siltronic Corporation (Siltronic) properties. To address DEQ's request, Anchor QEA implemented a DNAPL monitoring program that has included the following four tasks:

- **Well Monitoring.** The presence or absence of DNAPL and, where applicable, the rates of DNAPL entry and removal are monitored at 75 wells located along the Site shoreline of the Willamette River.
- **Tar-Specific Green Optical Screening Tool (TarGOST) Borings near Pumping Wells.** TarGOST borings have been advanced on multiple occasions near six pumping wells selected by DEQ with known DNAPL presence in the subsurface to assess possible changes in DNAPL distribution.
- **TarGOST Monitoring Area (TMA) Borings.** TarGOST borings have been advanced on multiple occasions in three 10-foot-by-10-foot-square monitoring areas (TMAs) near the edges of known DNAPL boundaries to assess possible changes in DNAPL distribution in areas that have had no previous historical detections of DNAPL.
- **Oil-Water Separator Monitoring.** DNAPL pulled into pumping wells and recovered in oil-water separators is monitored, recorded, and removed.

In the current reporting period, Anchor QEA conducted the following monitoring activities:

- Monitoring for the presence or absence and, where applicable, the amount of DNAPL in the wells in the DNAPL monitoring program
- Calculating the rate of DNAPL entry into wells and the volume of DNAPL removed

The DNAPL monitoring program was initiated before startup of the HC&C system to characterize baseline conditions. Monitoring the rate of DNAPL entry into wells and the volume of DNAPL removed began on April 29, 2013, 6 months before interim operation of the HC&C system began and continues to the present. Interim operation and testing of the HC&C system began on September 23, 2013, and continued until May 14, 2015. Full-time, full-scale operation of the HC&C system began on May 14, 2015, and continues to the present.

Five TarGOST boring events have been completed on the following dates:

- Baseline TarGOST borings near the pumping wells were completed in April 2012 and August 2013. Baseline TarGOST borings at the three TMAs were completed in August 2013.
- Follow-up TarGOST events near the pumping wells and TMA TarGOST borings were completed in the following months:
  - June 2014
  - November 2015
  - June 2016
  - March 2022

The HC&C system objective is to prevent migration of contaminated groundwater from the uplands to the Willamette River in the Upper and Lower Alluvium water-bearing zones (WBZs) in a manner that minimizes DNAPL mobilization associated with system operations. The system was also designed to recover and manage any DNAPL captured during system operation. Performance monitoring completed to date indicates the system is meeting these objectives. DNAPL monitoring data collected since 2013 in accordance with the DEQ-approved DNAPL monitoring program presented in the CDR (Anchor QEA 2012) show that, incidental to its operation, the HC&C system has not caused DNAPL movement in the nearshore area except near pumping wells where DNAPL entry is occurring, and the HC&C system is capturing that DNAPL in the immediate vicinity of these pumping wells.

2 Well Monitoring

2.1 DNAPL Occurrence

The nearshore DNAPL monitoring program includes gauging and, where applicable, DNAPL removal at 75 wells and piezometers (hereafter collectively referred to as "wells"). See Table 1 for a list of the wells in the DNAPL monitoring program. The locations of the wells in the nearshore DNAPL monitoring program are shown in Figure 1.

In this report, "DNAPL zone" indicates stratigraphic intervals in which DNAPL was visually identified during well installation and the screened interval of wells where DNAPL was not observed during well installation but later entered the well. In the Alluvium WBZs, the term "DNAPL" refers only to fluid and does not include manufactured gas plant residuals described as tar, solid tar, and/or semisolid tar based on field observations. These terms are restricted to the Fill WBZ. The term "weathered DNAPL" is used for observations of tar-like material below the base of the Fill WBZ.

Table 1 lists wells in the DNAPL monitoring program that had DNAPL observations during well installation, wells that have had DNAPL entry through the well screen, and wells where DNAPL has been removed from the well sumps designed specifically for that intended purpose. DNAPL entry or removal at a given well listed in Table 1 applies to any point in the monitoring history of the well, not only the current reporting period.

DNAPL was observed during drilling and well installation activities at 55 of the 75 nearshore locations where wells are monitored as part of this program; measurable DNAPL has entered and accumulated in 20 of the 75 wells. These 20 wells are screened as follows:

- Sixteen are screened in the Upper Alluvium WBZ: DW-6U, DW-11U, DW-14U, MW-16-45, MW-26U, MW-27U, MW-30U, MW-37U, MW-38U, PW-1-80, PW-3-85, PW-6U, PW-11U, PW11Ub, PW-13U, and PW-14U.
- Three are screened in the Lower Alluvium WBZ: PW-2L, MW-PW2L, and MW-34L.
- One is screened in the Fill WBZ: MW-18-30.

Of the 20 wells with DNAPL entry, DNAPL was not observed within the screened interval (including filter pack) during drilling and well installation activities at six wells (MW-27U, MW-30U, PW-11U, PW-11Ub, PW-13U, and PW-14U). DNAPL began entering these wells after well installation.

Figure 2 shows the 20 nearshore wells where DNAPL has been detected and summarizes the calculated DNAPL entry rates in gallons per month for each of these wells for the current reporting period. Table 2 lists the DNAPL thickness and volume measurements and DNAPL entry and removal volumes during the current reporting period at the wells where DNAPL has been detected. A comprehensive electronic version of Table 2 including all data collected since the DNAPL monitoring

program began is included on the SharePoint site as Appendix A. Table 2 contains data points with pink shading, which indicate a "false positive" or "false negative" field measurement. These data points indicate anomalous manual field measurements, such as a decrease in the volume of DNAPL in a well sump without a corresponding DNAPL removal (a physical impossibility) or a measurement that indicated an anomalously large increase in DNAPL entry that was then shown to be anomalous from subsequent measurements. It should be noted that these anomalous measurements include decreases as small as 0.01 foot in DNAPL thicknesses between consecutive measurements. The pink shaded values are excluded from analysis and plots. The exclusion of these values does not affect the overall usability of the data.

Table 3 lists the total volume of DNAPL entry into or removed from each well and the average DNAPL entry rates for each reporting period. The depth intervals of DNAPL observations during drilling and well installation activities are shown in cross section in Figures 3a and 3b. Figures 3a and 3b also highlight the nearshore wells where DNAPL has been detected.

The 20 wells with detected DNAPL are monitored according to the schedule in Table 1 to measure the DNAPL thickness in each well. DNAPL has been removed via dedicated DNAPL pumps from 14 of the 20 wells at the frequency necessary to keep the DNAPL below the top of the well sump. DNAPL has been removed on a one-time basis from four wells (DW-6U, DW-11U, PW-3-85, and PW-11U) for DNAPL testing and characterization, but not because the volume of DNAPL in the well approached the well sump capacity. DNAPL has not been removed from one well, MW-37U, because the thickness of DNAPL through June 30, 2023, has not approached the capacity of the well sump.

2.2 DNAPL Entering Wells

2.2.1 DNAPL Entering Nearshore Wells

Table 3 lists the DNAPL entry rates for the 20 nearshore wells with measurable DNAPL entry in the DNAPL monitoring program. Table 3 also presents the changes over time in the total DNAPL entry rates and in the percentage of the total DNAPL entry that occurs into nearshore non-pumping wells and pumping wells. During the current reporting period, approximately 6% of all DNAPL entry was into non-pumping wells. The remaining approximately 94% of DNAPL entry was into pumping wells.

As shown in Table 3 and Figure 2, in the current reporting period, 10 of the 20 nearshore wells had DNAPL entry rates of less than 0.1 gallon per month, three wells had DNAPL entry rates between 0.1 and 0.5 gallon per month, and six wells had DNAPL entry rates between 0.5 and 5 gallons per month. One nearshore well, PW-2L, had a DNAPL entry rate greater than 5 gallons per month.

Figure 4a shows DNAPL entry rates in gallons per month as time-series plots for 10 of the 15 non-pumping wells that have had measurable DNAPL entry; wells DW-11U, MW-30U, MW-37U, PW-3-85, and PW11U are excluded because of near-zero (less than 0.05 gallon per month) or zero average

DNAPL entry. Figure 4b shows the average DNAPL entry rates in gallons per month as time-series plots for four pumping wells that have had measurable DNAPL entry. Operation of pumping well PW-11Ub began on March 4, 2022, and replaced PW-11U as an active pumping well; pumping was terminated at PW-11U on March 28, 2022. Since that time, PW-11U has been considered a non-pumping well.

Pumping well PW-2L is excluded from Figure 4b to provide greater resolution of the DNAPL entry rates at the remaining pumping wells. Moreover, DNAPL was continuously removed from the PW-2L well sump via automatic pumping from November 2017 through July 2020, and the entry rate could not be directly measured during that time. Therefore, the DNAPL removal rate and the groundwater pumping rate from PW-2L are shown separately in Figure 4c, with the assumption that the DNAPL entry and removal rates are approximately equal.

Figures 5a and 5b show the total combined DNAPL entry rates for the non-pumping wells and pumping wells (PW-2L excluded), respectively. Figures 6a and 6b show the total combined cumulative volume of DNAPL entry into the non-pumping wells and pumping wells (PW-2L excluded), respectively. Figures 7a and 7b show the total combined monthly DNAPL entry volume for the non-pumping and pumping wells (PW-2L excluded), respectively. Figure 7c shows the average monthly volume of DNAPL removed from pumping well PW-2L. PW-2L was excluded from Figures 5b, 6b, and 7b to improve the graphing resolution on these figures.

The DNAPL entry rates and monthly and cumulative volumes of DNAPL entry into each individual well since DNAPL monitoring began in April 2013, or since each well was installed, are presented in Appendices B and C.

Wells MW-38U, MW-PW2L, PW-1-80, and PW-2L have had time periods during the DNAPL monitoring program when DNAPL was either continuously removed via an automated removal system or DNAPL was manually removed without thickness measurements. During those time periods, it was not possible to directly measure the DNAPL entry rates into the wells, as explained in previous reports.

The data on the plots in Figures 4a and 5a and the plots in Appendices B and C show that the DNAPL entry and removal rates are approximately equal based on the long-term record of the majority of wells where entry and removal data have been detailed.

2.2.2 DNAPL Entry Rate Trend Analysis

As shown in Table 3, DNAPL entry rates generally increased after startup of the HC&C system and the beginning of monitoring. The reporting period with the highest average DNAPL entry rate for a given well, group of wells, or total value is highlighted in blue in Table 3. Most of the wells had the highest average DNAPL entry rate in 2018 or earlier. However, three wells (PW-11Ub, PW-13U, and

PW-14U) reached the highest DNAPL entry for a given reporting period in 2023. Additional details are provided as follows:

- The DNAPL entry rate into pumping well PW-11Ub is still equilibrating. This well was installed in early 2022 and first monitored for DNAPL in March 2022, and it has not been monitored for a sufficient time to allow for trend interpretation.
- The DNAPL entry rate into PW-13U has averaged more than 2 gallons per month since 2017 with frequent increases and decreases in the rate, ranging from 0.88 gallon per month to 3.37 gallons per month in the current reporting period. The entry rate in the current reporting period replaced the rate of 2.92 gallons per month in the first half of 2019 as the peak entry rate.
- The DNAPL entry rate into PW-14U spiked during spring 2023; however, its DNAPL entry rate subsequently decreased to within historical ranges after the spike subsided (Figure 4b).

The remaining wells listed in Table 3 had peak DNAPL entry rates in 2020 or earlier. For these remaining wells, after the peak DNAPL entry rate was observed, the DNAPL entry rates decreased or remained approximately stable.

After the highest DNAPL entry rate was observed at a given well, the DNAPL entry rates appear to have decreased in most wells or remained approximately stable. A Mann-Kendall trend analysis was performed following U.S. Environmental Protection Agency QA/G-9S (EPA 2006) statistical guidance to classify each well as having either a decreasing or stable DNAPL entry rate trend since its peak DNAPL entry rate through 2023 (Appendix D). Further trend analyses via Mann-Kendall will be repeated after the completion of each calendar year of data collection. The results through 2023 are summarized in the following text.

To help identify the approximate timing of the peak value given the observed short-term variations in the dataset, the peak DNAPL entry rate was estimated based on a 1-year (four-quarter) moving average of median quarterly DNAPL entry rate (see figures in Appendix D). The moving average is calculated using two preceding quarters and two trailing quarters, and the data are plotted at the end of the second of four quarters. This method was selected to provide a reasonable degree of data resolution for each well, while also smoothing short-term variations in DNAPL entry.

Aggregate (total combined) DNAPL entry rate datasets were also calculated using the DNAPL entry rates for all non-pumping wells and all pumping wells, and these were used to identify the timing of the peak DNAPL entry rate for both groups of wells (Appendix D, Figure D-1). These data were aggregated using the sum of the interpolated quarterly median DNAPL entry rate for all five pumping wells. The peak DNAPL entry rates for the aggregate group of non-pumping wells and pumping wells occurred in Fourth Quarter 2014 and First Quarter 2018, respectively. The visible data patterns for both datasets indicate a general decline in DNAPL entry rates after the peak. It should be noted that the plot of the DNAPL entry rate for all pumping wells combined in Appendix D, Figure D-1 and the same plot

for individual pumping well PW-2L in Appendix D, Figure D-4 are nearly identical. Nearly 80% of all DNAPL entry into pumping wells occurs at PW-2L, which accounts for the plot similarity.

DNAPL entry rate trends for individual wells for the period after the peak DNAPL entry rate (including the peak value) were evaluated with the Mann-Kendall test. Datasets with a significant (p-value less than or equal to 0.05) monotonic trend were classified as "decreasing," and those without a significant trend were classified as "stable." The trend analysis results for data through December 31, 2023, are summarized in Table 4. Three wells (PW-14U, MW-37U, and PW-11Ub) lacked sufficient data to complete the trend analysis, listed as follows:

- The peak moving average DNAPL entry rates into PW-14U and PW-11Ub occurred in Second Quarter 2023 and Fourth Quarter 2022, respectively. There have not been sufficient data since these peaks to establish a trend.
- A trend could not be established at MW-37U due to zero or near zero DNAPL entry.

For comparison, a DNAPL entry rate trend analysis was also completed via the Mann-Kendall test for the MW-6 and MW-13 combined location, although these locations are not part of the DNAPL monitoring program. Although DNAPL entry has occurred at the T-50 trench sump, the number of data are still insufficient to perform a Mann-Kendall trend analysis.

After the observed peak DNAPL entry rate through December 31, 2023, at all the wells that have sufficient data to calculate trends following the peak DNAPL entry rate, DNAPL entry rates have remained stable or have decreased at the nearshore non-pumping wells and pumping wells. Greater than half of the non-pumping wells (9 of 14) and pumping wells (2 of 3) with sufficient post-peak data for trend analysis have statistically significant decreasing DNAPL entry rate trends after the peak.

The next DNAPL entry rate trend analysis is scheduled to be completed in the DNAPL monitoring semiannual report covering the period from July 1 to December 31, 2024, and will include trend analysis of all data through December 31, 2024.

2.2.3 DNAPL Removal Rates from MW-6-32 and MW-13-30

Table 3 shows the approximate volume of DNAPL removed from wells MW-6-32 and MW-13-30. Wells MW-6-32 and MW-13-30 are not part of the DNAPL monitoring program, are not located near the river shoreline, and are screened in the Fill WBZ. MW-6-32 and MW-13-30 are plumbed together and routine in-well measurement of DNAPL is not possible, given the configuration of the DNAPL recovery system; DNAPL observations from these wells are based on the combined removal volumes measured in a 550-gallon storage tank. These are the only inland locations where measurable DNAPL had been recovered on a routine basis until installation of the nearby T-50 trench in 2020 as described in Section 2.2.4, and their DNAPL removal rates are provided for completeness and for comparison versus those observed at nearshore wells.

As shown in Table 3, based on the data collected in specific reporting periods, the lowest DNAPL entry rates for these two wells combined (5.2 gallons per month) occurred in this reporting period, immediately following the highest DNAPL entry rate in the previous reporting period (18.9 gallons per month). The DNAPL entry rate this reporting period is approximately 30% lower than the historical average of 14.0 gallons per month for these two wells. The lower than typical DNAPL entry rate during this period is attributable to the fact that the DNAPL recovery system at MW-6-32 and MW-13-30 was turned off for approximately 3 months (July through September) because the system's storage was at capacity.

The DNAPL removal rates from these two wells, which are located upland of the Willamette River shoreline, have been consistently greater than the DNAPL entry rates at all the nearshore wells of the HC&C system except for pumping well PW-2L.

2.2.4 DNAPL Removal Rates from Fill WBZ Interceptor Trenches

Two Fill WBZ interceptor trenches (T-50 and T-100) were installed in late 2020/early 2021 and began full-time operation on March 11, 2021. The trenches were installed to control Fill WBZ groundwater in the central part of the site near the LNG Basin. As required in the Fill WBZ Trench Design (Anchor QEA 2020), the sumps in the trenches were monitored for DNAPL entry weekly for the first month of operation and then moved to a monthly schedule.

DNAPL was first detected in the T-50 trench sump on August 3, 2022, and the monitoring of DNAPL entry into the sump was returned to a weekly monitoring schedule. The amount of DNAPL removed and the DNAPL entry rate for the current reporting period are shown in Figure 2 and presented in Table 3. During the current reporting period, the T-50 trench had a higher average DNAPL entry (or removal) rate (25.1 gallons per month) than any of the wells listed in Table 3 except for pumping well PW-2L.

As of December 31, 2023, no measurable DNAPL has been detected in the T-100 sump since operation of the trench began.

2.2.5 Normalized DNAPL Entry Rates

To evaluate the effect that groundwater pumping rates may have on DNAPL entry at a given shoreline area pumping well or non-pumping well, DNAPL entry rates were normalized to groundwater pumping rates on a well-by-well basis. The DNAPL entry rates were normalized by calculating the ratio of the DNAPL entry rate (gallons per month) to the nearby groundwater pumping rate at pumping wells (gallons per minute). For each pumping well, the groundwater pumping rate at that same well was used in calculating the normalized DNAPL entry rates. For each non-pumping well, the combined pumping rates of nearby pumping wells were used. The DNAPL

entry rates and groundwater pumping rates that were used for this evaluation are presented in Appendix B, and the normalized DNAPL entry rates are presented graphically in Appendix E.

A change in normalized DNAPL entry rate may indicate a commensurate change in DNAPL transmissivity in the formation connected to the screened interval of the well. DNAPL transmissivity depends on the DNAPL physical properties, the soil physical properties, the DNAPL saturation within the strata from which DNAPL enters a given well, and the thickness of those DNAPL-containing depth interval(s). DNAPL saturation is the fraction of soil pore space filled with DNAPL. The DNAPL and soil physical properties at a given depth and location are expected to be constant. Therefore, if the normalized DNAPL entry rate increases, that suggests the DNAPL saturation within those strata, and/or the thickness of the DNAPL-containing interval(s), has increased. Alternatively, if the normalized DNAPL entry rate decreases, that suggests the DNAPL saturation within those strata, and/or the thickness of the DNAPL-containing interval(s), has decreased.

2.2.5.1 Pumping Wells

Temporal trends in **normalized DNAPL entry rates** at pumping wells can be summarized as follows:

- General increase, then variable: PW-6U, PW-13U
- General decrease, then increase: PW-14U
- Variable (increases and decreases): PW-2L, PW-11Ub

For a given pumping well, the normalized DNAPL entry rate (and therefore the DNAPL transmissivity) may increase if nearby mobile DNAPL migrates toward the pumping well, as may occur due to the enhanced hydraulic gradient toward the pumping well caused by groundwater extraction. However, the converse may occur if DNAPL was already present at the pumping well location and the DNAPL was depleted over time due to entry into the pumping well. A combination of these factors may produce variable changes in normalized DNAPL entry rates over time. All three of these types of trends were observed in the pumping well datasets, as summarized in the previous bullet list. At well PW-14U, the normalized DNAPL entry rate reached a peak around 2017 to 2018 and then decreased.

2.2.5.2 Non-Pumping Wells

Temporal trends in **normalized DNAPL entry rates** at non-pumping wells can be summarized as follows:

- Relatively steady: DW-6U, DW-11U, DW-14U, MW-16-45, MW-18-30, MW-26U, MW-27U
- General decrease over time: MW-34L, PW-11U
- General decrease and then increase: MW-38U, MW-PW2L
- Variable (increases and decreases): MW-30U
- Negligible rate: MW-37U, PW-1-80, PW-3-85

At non-pumping wells, the hydraulic gradients related to groundwater pumping are not as strong as they are at the pumping wells, so little or no DNAPL movement may occur. Consistent with this interpretation, half of the non-pumping monitoring wells exhibited relatively steady normalized DNAPL entry rates, regardless of groundwater pumping rate changes. Where DNAPL was already present at a non-pumping monitoring well location, and it migrated toward a groundwater pumping well, then the normalized DNAPL entry rate at the non-pumping well may decrease; this type of trend was observed at three of the non-pumping monitoring wells (MW-34L, MW-38U, and MW-PW2L). At two of those wells (MW-38U and MW-PW2L), the normalized DNAPL entry rate later increased despite a decrease in the pumping rates of adjacent pumping wells. At the other non-pumping monitoring wells, the normalized DNAPL entry rates were variable or negligible (near zero).

Future DNAPL monitoring reports will present updated charts of normalized DNAPL entry rates so that additional changes can be assessed as specific well-by-well pumping rates change over time.

2.3 General Effects of HC&C System Operation on DNAPL Entry Rates

In addition to the detailed, non-normalized DNAPL entry rate trend analyses discussed previously, Table 5 summarizes the average DNAPL entry rates for three general time periods relative to HC&C system operations, as follows:

- Prior to HC&C system startup (April 29, 2013, to September 23, 2013)
- HC&C interim operation and testing period (September 23, 2013, to May 14, 2015)
- Full-time, full-scale operation of the HC&C system (May 14, 2015, to the present)

On average, as of December 31, 2023, approximately 92% of the DNAPL entry during full-time, full-scale operation of the HC&C system occurs at pumping wells, and approximately 77% of the total DNAPL entry into nearshore wells occurs at pumping well PW-2L (Table 5). Similarly, during the current reporting period, 94% of total DNAPL entry occurred in the pumping wells (Table 3).

Based on the data listed in Table 5, general differences between DNAPL entry rates between the period prior to system startup and the full-time, full-scale HC&C system operation can be summarized in the following general categories:

- **No Pre-Startup Data.** Four non-pumping wells (DW-6U, DW-11U, DW-14, and MW-PW2L) and one pumping well (PW-11Ub) were installed after startup of the HC&C system. Thus, the datasets for these wells cannot be used to evaluate changes in DNAPL entry between the period before system startup and during full-scale operation.
- **Consistent Near-Zero DNAPL Entry.** Non-pumping wells MW-30U, MW-37U, and PW-3-85 have had near-zero DNAPL entry (less than 0.1 gallon per month) throughout the entire historical monitoring period. PW-11U has had near-zero DNAPL entry since it was replaced

with PW-11Ub and pumping ceased. These wells are excluded from the subsequent listed categories.

- **Lower DNAPL Entry Rate During Full-Scale Operation.** This category includes four non-pumping wells (MW-16-45, MW-18-30, MW-34L, and PW-1-80).
- **Higher DNAPL Entry Rate During Full-Scale Operation.** This category includes four pumping wells (PW-6U, PW-13U, PW-14U, and PW-2L) and three non-pumping wells (MW-26U, MW-27U, and MW-38U).

It is important to note that these categories only compare average DNAPL entry rates for extended periods of time and do not indicate recent trends in DNAPL entry rates over a shorter duration. For example, within the last category (Higher DNAPL Entry Rate During Full-Scale Operation), three of the four pumping wells (PW-6U, PW-14U, and PW-2L) and two of the three non-pumping wells (MW-26U and MW-38U) have statistically significant decreasing DNAPL entry rate trends (according to the trend analysis conducted on data through 2022) following the peak DNAPL entry rate. Thus, although the average DNAPL entry rates have been higher during full-scale operation than prior to system startup, the DNAPL entry rates are decreasing at these wells. The other two wells in that category have stable trends following the peak DNAPL entry rate. In addition, as discussed in Section 2.2.2, all of the wells in the monitoring program are past the peak DNAPL entry rate, which occurred several years ago for most of the wells, except PW-11Ub, which lacks significant monitoring time for peak DNAPL entry rate assessment.

A generally decreasing DNAPL entry rate following an earlier increase to a peak entry rate is consistent with common observations during nonaqueous phase liquid (NAPL) recovery programs. Although the HC&C system was not designed primarily to recover DNAPL, DNAPL is being incidentally removed by the system's pumping wells and at nearby non-pumping wells during system operation. Following the peak DNAPL entry rate at a given well, DNAPL removal has continued. DNAPL removal causes the following parameters to decrease in the surrounding soil:

- DNAPL volume
- DNAPL saturation
- DNAPL relative permeability
- DNAPL transmissivity

Consequently, the DNAPL entry rate ultimately declines with time as DNAPL is removed. Based on the common observation of declining DNAPL or light nonaqueous phase liquid (LNAPL) recovery rates over time, multiple methods of "decline curve" analysis have been developed (API 2001; ITRC 2009a, 2009b; CH2MHill 2010; EPRI 2015; MassDEP 2016).

The observation of higher average DNAPL entry rates at four of five pumping wells during full-scale operation than prior to system startup, combined with the general decreasing or stable trend in "post-

peak" DNAPL entry rates (Section 2.2.2 and Appendix B), indicates that the pumping wells are capturing nearby mobile DNAPL. These data, along with the HC&C system monitoring data that show that the system has reversed the groundwater hydraulic gradient consistent with the design (i.e., producing a hydraulic gradient from the Willamette River toward the upland), indicate that DNAPL is being captured in the vicinity of the pumping wells in the shoreline upland area.

2.4 Shoreline Piezometers

Three clusters of piezometers (PZ6s, PZ7s, and PZ9s) located on the Willamette River shoreline downgradient of known upland DNAPL zones are included in the DNAPL monitoring program (Figure 1). Each piezometer cluster includes at least four piezometers, with at least one piezometer screened in each identified WBZ (Fill WBZ, Upper Alluvium WBZ, Lower Alluvium WBZ, and Deep Lower Alluvium WBZ). These piezometer clusters effectively act as "sentinel wells" to monitor for the presence of DNAPL at multiple depths along the Willamette River shoreline. The piezometers have been monitored for the presence of DNAPL since the DNAPL monitoring program began in April 2013 and are currently monitored semiannually. DNAPL has not been detected in any of the shoreline piezometers.

3 TarGOST Monitoring

The DNAPL TarGOST monitoring program has been completed. Refer to the *DNAPL Monitoring Semiannual Summary Report (July 1 through December 31, 2022)* (Anchor QEA 2023) for the most recent information regarding TarGOST monitoring.

4 Monitoring of Oil-Water Separators

As of December 7, 2023, monitoring of DNAPL entering oil-water separators has been suspended indefinitely because the type of filter media used since 2022 makes any estimate of the volume of DNAPL captured by the system difficult and unreliable. Refer to the *DNAPL Monitoring Semiannual Summary Report (January 1 through June 30, 2023)* (Anchor QEA 2023) for the most recent information regarding oil-water separator monitoring.

5 Summary of Findings

Most of the wells in the monitoring program are past their peak DNAPL entry rate, which occurred several years ago. However, peak DNAPL entry rates occurred during the current reporting period at pumping well PW-13U. In addition, peak DNAPL entry rates occurred at pumping wells PW-11Ub and PW-14U in the previous reporting period; however, DNAPL entry rates at both of these wells decreased to average historical levels during the current reporting period.

For the remaining locations, since their observed peak DNAPL entry rate, DNAPL entry rates have been low, remained stable, or decreased in most non-pumping nearshore monitoring wells and nearshore pumping wells. DNAPL entry rates normalized to groundwater pumping rates vary for the pumping wells but are steady or decreasing for most of the non-pumping wells.

The total combined DNAPL entry rate into the non-pumping wells has been lower during full-time, full-scale operation of the HC&C system than it was prior to system startup and interim operations and testing except at wells MW-26U, MW-27U, and MW-38U. In contrast, as expected, the DNAPL entry rates at the pumping wells increased after startup of the HC&C system.

DNAPL monitoring data collected since 2013 in accordance with the DEQ-approved DNAPL monitoring program presented in the CDR (Anchor QEA 2012) show that, incidental to its operation, the HC&C system is capturing DNAPL from the shoreline upland area in the immediate vicinity of the pumping wells. DNAPL has never been detected in any of the piezometers screened in multiple depth intervals along the Willamette River shoreline downgradient of known upland DNAPL zones, and active DNAPL migration from the uplands to the Willamette River has not been documented or visually observed. The findings of this report show that the HC&C system is operating successfully as designed, meeting the design objective of controlling contaminated groundwater in the Upper and Lower Alluvium WBZs from migrating to the Willamette River while minimizing DNAPL mobilization associated with system operations.

6 Reporting Schedule

DNAPL Monitoring Summary Reports will continue to be provided on a semiannual basis. The next report will cover the monitoring period from January 1 through June 30, 2024, and is due to DEQ on or before September 30, 2024.

7 References

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Tables

Table 1
DNAPL Monitoring Program

Well ID	Unit	DNAPL Monitoring Frequency				DNAPL Visibly Observed During Drilling Activities?	DNAPL in Well Screen Zone When Constructed (Including Filter Pack)?	DNAPL Entry into Well?[1]	DNAPL Removed from Well Sump?[1,2]
		Weekly	Monthly	Quarterly	Semi-Annually				
MW-3-26	Surficial Fill				X	Yes	No	No	
MW-3-56	Upper Alluvium				X	Yes	No	No	
MW-4-35	Fill/Upper Alluvium				X	No	No	No	
MW-4-57	Upper Alluvium				X	No	No	No	
MW-4-101	Lower Alluvium				X	No	No	No	
MW-5-32	Fill/Upper Alluvium				X	No	No	No	
MW-5-100	Upper Alluvium				X	No	No	No	
MW-5-175	Deep Alluvium				X	No	No	No	
MW-16-45	Upper Alluvium		X			Yes	Yes	Yes	Yes
MW-16-65	Upper Alluvium				X	Yes	No	No	
MW-18-30	Surficial Fill		X			Yes	Yes	Yes	Yes
MW-18-125	Lower Alluvium				X	Yes	No	No	
MW-18-180	Deep Alluvium				X	Yes	No	No	
MW-19-22	Surficial Fill				X	Yes	No	No	
MW-19-125	Lower Alluvium				X	Yes	No	No	
MW-19-180	Deep Alluvium				X	Yes	No	No	
MW-20-120	Lower Alluvium				X	Yes	No	No	
MW-24-70	Upper Alluvium				X	Yes	No	No	
MW-24-130	Lower Alluvium				X	Yes	No	No	
MW-26U	Upper Alluvium	X				Yes	Yes	Yes	Yes
MW-27L	Lower Alluvium				X	Yes	No	No	
MW-27U	Upper Alluvium		X			Yes	No	Yes	Yes
MW-28L	Lower Alluvium				X	Yes	No	No	
MW-28U	Upper Alluvium				X	Yes	No	No	
MW-29U	Upper Alluvium				X	No	No	No	
MW-30U	Upper Alluvium				X	Yes	No	Yes	Yes
MW-31L	Lower Alluvium				X	Yes	No	No	
MW-31U	Upper Alluvium				X	Yes	No	No	
MW-32U	Upper Alluvium				X	Yes	No	No	
MW-33U	Upper Alluvium				X	Yes	No	No	
MW-34L	Lower Alluvium			X		Yes	Yes	Yes	Yes
MW-34U	Upper Alluvium				X	Yes	No	No	
MW-35U	Upper Alluvium				X	No	No	No	
MW-36U	Upper Alluvium				X	No	No	No	
MW-37U	Upper Alluvium				X	Yes	Yes	Yes	No
MW-38U	Upper Alluvium	X				Yes	Yes	Yes	Yes
MW-42F	Surficial Fill				X	No	No	No	
MW-PW2L	Lower Alluvium		X			Yes	Yes	Yes	Yes
WS-21-112	Lower Alluvium				X	NA[3]	No	No	
WS-47-183	Lower Alluvium				X	Yes	No	No	
OW-2F	Surficial Fill				X	Yes	No	No	
OW-5F	Surficial Fill				X	Yes	No	No	
PW-1-80	Upper Alluvium				X	Yes	Yes	Yes	Yes
PW-2L	Lower Alluvium	X				Yes	Yes	Yes	Yes
PW-2U	Upper Alluvium				X	Yes	No	No	
PW-3-85	Upper Alluvium				X	NA[3]	NA[3]	Yes	Yes[4]
PW-3-118	Lower Alluvium				X	NA[3]	NA[3]	No	
PW-3U	Upper Alluvium				X	No	No	No	

Table 1
DNAPL Monitoring Program

Well ID	Unit	DNAPL Monitoring Frequency				DNAPL Visibly Observed During Drilling Activities?	DNAPL in Well Screen Zone When Constructed (Including Filter Pack)?	DNAPL Entry into Well?[1]	DNAPL Removed from Well Sump?[1,2]
		Weekly	Monthly	Quarterly	Semi-Annually				
PW-4L	Lower Alluvium				X	Yes	No	No	
PW-4U	Upper Alluvium				X	Yes	No	No	
PW-5L	Lower Alluvium				X	Yes	No	No	
PW-5U	Upper Alluvium				X	Yes	No	No	
PW-6L	Lower Alluvium				X	Yes	No	No	
PW-6U	Upper Alluvium		X			Yes	Yes	Yes	Yes
PW-11U	Upper Alluvium				X	Yes	No	Yes	Yes[4]
PW-11Ub	Upper Alluvium	X				Yes	No	Yes	Yes
PW-12U	Upper Alluvium				X	Yes	No	No	
PW-13U	Upper Alluvium		X			Yes	No	Yes	Yes
PW-14U	Upper Alluvium		X			Yes	No	Yes	Yes
DW-6U	Upper Alluvium				X	Yes	Yes	Yes	Yes[4]
DW-11U	Upper Alluvium				X	Yes	Yes	Yes	Yes[4]
DW-14U	Upper Alluvium			X		Yes	Yes	Yes	Yes
PZ6-5	Surficial Fill				X	No	No	No	
PZ6-50	Upper Alluvium				X	No	No	No	
PZ6-115	Lower Alluvium				X	No	No	No	
PZ6-150	Deep Alluvium				X	No	No	No	
PZ7-5	Surficial Fill				X	No	No	No	
PZ7-50	Upper Alluvium				X	Yes	No	No	
PZ7-100	Lower Alluvium				X	Yes	No	No	
PZ7-150	Deep Alluvium				X	Yes	No	No	
PZ9-5	Surficial Fill				X	No	No	No	
PZ9-50	Upper Alluvium				X	Yes	No	No	
PZ9-75	Deep Alluvium				X	Yes	No	No	
PZ9-110	Deep Alluvium				X	Yes	No	No	
PZ9-150	Deep Alluvium				X	Yes	No	No	
Totals		**4**	**7**	**2**	**62**	**55**	**13**	**20**	**19**
Locations Where DNAPL Presence Is Assessed but Are Not Part of DNAPL Monitoring Program									
MW-6-32 and MW-13-30	Surficial Fill	NA	NA	NA	NA	NA	NA	Yes	Yes
T-100[5]	Surficial Fill		X			NA	NA	No	
T-50[6]	Surficial Fill	X				NA	NA	Yes	Yes

Notes:
1. DNAPL entry and removal applies to any point during the monitoring history of the well, not only the current reporting period.
2. DNAPL removed on an as-needed basis when the level of DNAPL approaches the top of the well sump.
3. No data; no boring log exists.
4. DNAPL removed on a one-time basis for testing and characterization.
5. T-100 is the 100-foot primary Fill Water-Bearing Zone trench.
6. T-50 is the 50-foot secondary Fill Water-Bearing Zone trench.

DNAPL: dense nonaqueous phase liquid, specifically oil and/or semisolid tar
NA: not available or not applicable

Table 2
DNAPL Accumulation and Removal Volumes (July 1 through December 31, 2023)

Well ID	Date and Time	Sump Length (feet)	Sump Volume (gallons)	Depth to Bottom of Well (feet TOC)	Depth to Top of DNAPL (feet TOC)	DNAPL Thickness (feet)	Volume of DNAPL in Well Sump (gallons)	Volume of DNAPL Removed Between DNAPL Storage Container Measurement Events (gallons)	Cumulative Volume of DNAPL Entry into Well (gallons)	Cumulative Volume of DNAPL Removed (gallons)	Removal Activity
DW-6U	12/28/23 8:59	5.0	7.4	56.42	53.13	3.29	4.84	---	8.9	3.0	---
DW-11U	12/28/23 8:54	5.0	7.4	41.90	41.74	0.16	0.40	---	1.1	0.1	---
DW-14U	9/26/23 9:19	5.0	7.4	54.77	52.83	1.94	2.85	---	41.9	29.7	---
DW-14U	12/28/23 9:07	5.0	7.4	54.77	52.53	2.24	3.29	---	42.3	29.7	---
MW-16-45	7/31/23 9:50	2.5	0.4	50.60	50.23	0.37	0.06	---	13.4	11.2	---
MW-16-45	8/29/23 10:02	2.5	0.4	50.60	49.50	1.10	0.18	---	13.5	11.2	---
MW-16-45	9/26/23 11:32	2.5	0.4	50.60	49.33	1.27	0.21	---	13.6	11.2	---
MW-16-45	10/31/23 14:25	2.5	0.4	50.60	49.12	1.48	0.24	---	13.6	11.2	---
MW-16-45	11/1/23 11:31	2.5	0.4	50.60	49.11	1.49	0.24	0.09	13.6	11.2	All DNAPL removed
MW-16-45	12/28/23 13:14	2.5	0.4	50.60	49.76	0.84	0.14	---	13.7	11.2	---
MW-18-30	7/31/23 8:20	1.0	0.2	32.97	32.44	0.53	0.09	---	9.3	9.1	---
MW-18-30	8/1/23 11:15	1.0	0.2	32.97	NM	NM		0.13	9.3	9.2	All DNAPL removed
MW-18-30	8/29/23 11:23	1.0	0.2	32.97	32.59	0.38	0.06	---	9.4	9.2	---
MW-18-30	9/26/23 10:59	1.0	0.2	32.97	32.47	0.50	0.08	---	9.4	9.2	---
MW-18-30	10/30/23 13:25	1.0	0.2	32.97	32.12	0.85	0.14	---	9.4	9.2	---
MW-18-30	11/2/23 10:46	1.0	0.2	32.97	32.13	0.84	0.14	---	9.4	9.2	All DNAPL removed[1]
MW-18-30	11/27/23 14:05	1.0	0.2	32.97	32.65	0.32	0.05	---	9.5	9.2	---
MW-18-30	12/28/23 8:53	1.0	0.2	32.97	32.40	0.57	0.09	---	9.5	9.2	---
MW-18-30	12/29/23 11:39	1.0	0.2	32.97	NM	NM	NM	0.30	9.5	9.5	All DNAPL removed
MW-26U	7/5/23 10:35	3.0	0.5	54.65	52.48	2.17	0.35	---	84.4	67.5	All DNAPL removed[1]
MW-26U	7/10/23 14:44	3.0	0.5	54.65	53.37	1.28	0.21	---	84.4	67.5	---
MW-26U	7/17/23 8:52	3.0	0.5	54.65	53.00	1.65	0.27	---	84.7	67.5	All DNAPL removed[1]
MW-26U	7/24/23 11:27	3.0	0.5	54.65	53.51	1.14	0.19	---	84.8	67.5	---
MW-26U	7/31/23 9:02	3.0	0.5	54.65	52.94	1.71	0.28	11.57	84.9	79.1	All DNAPL removed
MW-26U	8/7/23 13:10	3.0	0.5	54.65	53.14	1.51	0.25	---	85.2	79.1	All DNAPL removed[1]
MW-26U	8/15/23 9:15	3.0	0.5	54.65	53.67	0.98	0.16	---	85.3	79.1	---
MW-26U	8/21/23 12:59	3.0	0.5	54.65	52.89	1.76	0.29	---	85.5	79.1	All DNAPL removed[1]
MW-26U	8/28/23 10:10	3.0	0.5	54.65	53.25	1.40	0.23	---	85.7	79.1	All DNAPL removed[1]
MW-26U	9/5/23 10:05	3.0	0.5	54.65	53.19	1.46	0.24	---	85.9	79.1	All DNAPL removed[1]
MW-26U	9/11/23 14:02	3.0	0.5	54.65	53.60	1.05	0.17	---	86.1	79.1	---
MW-26U	9/18/23 11:29	3.0	0.5	54.65	52.86	1.79	0.29	---	86.2	79.1	All DNAPL removed[1]
MW-26U	9/25/23 13:02	3.0	0.5	54.65	53.31	1.34	0.22	---	86.4	79.1	---
MW-26U	10/2/23 13:41	3.0	0.5	54.65	53.02	1.63	0.27	---	86.5	79.1	All DNAPL removed[1]
MW-26U	10/9/23 10:55	3.0	0.5	54.65	53.81	0.84	0.14	---	86.6	79.1	---
MW-26U	10/16/23 14:32	3.0	0.5	54.65	53.11	1.54	0.25	---	86.7	79.1	---
MW-26U	10/17/23 13:07	3.0	0.5	54.65	53.08	1.57	0.26	---	86.7	79.1	All DNAPL removed[1]
MW-26U	10/23/23 11:40	3.0	0.5	54.65	53.40	1.25	0.20	---	87.0	79.1	All DNAPL removed[1]
MW-26U	10/30/23 13:40	3.0	0.5	54.65	53.71	0.94	0.15	---	87.1	79.1	---

Table 2
DNAPL Accumulation and Removal Volumes (July 1 through December 31, 2023)

Well ID	Date and Time	Sump Length (feet)	Sump Volume (gallons)	Depth to Bottom of Well (feet TOC)	Depth to Top of DNAPL (feet TOC)	DNAPL Thickness (feet)	Volume of DNAPL in Well Sump (gallons)	Volume of DNAPL Removed Between DNAPL Storage Container Measurement Events (gallons)	Cumulative Volume of DNAPL Entry into Well (gallons)	Cumulative Volume of DNAPL Removed (gallons)	Removal Activity
MW-26U	11/6/23 13:55	3.0	0.5	54.65	53.09	1.56	0.25	---	87.2	79.1	All DNAPL removed[1]
MW-26U	11/13/23 10:17	3.0	0.5	54.65	53.69	0.96	0.16	---	87.4	79.1	---
MW-26U	11/20/23 12:35	3.0	0.5	54.65	52.78	1.87	0.30	---	87.5	79.1	All DNAPL removed[1]
MW-26U	11/27/23 13:36	3.0	0.5	54.65	54.17	0.48	0.08	---	87.6	79.1	---
MW-26U	12/4/23 13:55	3.0	0.5	54.65	53.07	1.58	0.26	---	87.8	79.1	All DNAPL removed[1]
MW-26U	12/11/23 13:00	3.0	0.5	54.65	53.71	0.94	0.15	---	87.9	79.1	---
MW-26U	12/18/23 13:05	3.0	0.5	54.65	53.02	1.63	0.27	1.24	88.0	80.4	All DNAPL removed
MW-26U	12/27/23 14:30	3.0	0.5	54.65	53.92	0.73	0.12	---	88.2	80.4	---
MW-27U	7/17/23 9:17	3.0	0.5	81.60	79.81	1.79	0.29	---	35.0	24.4	All DNAPL removed[1]
MW-27U	7/31/23 9:35	3.0	0.5	81.60	80.60	1.00	0.16	---	35.1	24.4	---
MW-27U	8/14/23 12:07	3.0	0.5	81.60	79.23	2.37	0.39	---	35.3	24.4	---
MW-27U	8/15/23 10:14	3.0	0.5	81.60	NM	NM	NM	---	35.3	24.4	All DNAPL removed[1]
MW-27U	8/29/23 9:48	3.0	0.5	81.60	80.66	0.94	0.15	---	35.5	24.4	---
MW-27U	9/11/23 13:48	3.0	0.5	81.60	79.78	1.82	0.30	---	35.6	24.4	All DNAPL removed[1]
MW-27U	9/26/23 9:08	3.0	0.5	81.60	79.30	2.30	0.37	---	36.0	24.4	All DNAPL removed[1]
MW-27U	10/16/23 14:47	3.0	0.5	81.60	80.66	0.94	0.15	---	36.2	24.4	---
MW-27U	10/30/23 13:55	3.0	0.5	81.60	79.40	2.20	0.36	---	36.4	24.4	All DNAPL removed[1]
MW-27U	11/13/23 10:31	3.0	0.5	81.60	80.70	0.90	0.15	---	36.5	24.4	---
MW-27U	11/27/23 10:45	3.0	0.5	81.60	79.36	2.24	0.37	---	36.7	24.4	All DNAPL removed[1]
MW-27U	11/28/23 13:34	3.0	0.5	81.60	NM	NM	NM	16.73	36.7	41.1	All DNAPL removed
MW-27U	12/11/23 11:35	3.0	0.5	81.60	80.92	0.68	0.11	---	36.9	41.1	---
MW-27U	12/28/23 9:21	3.0	0.5	81.60	79.79	1.81	0.30	---	37.0	41.1	---
MW-30U	7/17/23 13:37	3.0	0.5	55.98	53.29	2.69	0.44	---	2.5	1.0	---
MW-30U	7/19/23 13:25	3.0	0.5	55.98	55.34	0.64	0.10	0.22	2.5	1.2	Some DNAPL removed
MW-30U	9/28/23 10:56	3.0	0.5	55.98	55.03	0.95	0.15	---	2.5	1.2	---
MW-30U	12/28/23 13:25	3.0	0.5	55.98	54.84	1.14	0.19	---	2.6	1.2	---
MW-34L	9/28/23 11:34	3.0	0.5	115.45	112.99	2.46	0.40	---	10.8	5.7	---
MW-34L	12/28/23 12:47	3.0	0.5	115.45	111.64	3.81	0.62	---	11.0	5.7	---
MW-34L	12/29/23 9:15	3.0	0.5	115.45	NM	NM	NM	0.60	11.0	6.3	All DNAPL removed
MW-37U	12/28/23 9:55	3.0	0.5	55.80	55.38	0.42	0.07	---	0.1	0.0	---
MW-38U	7/5/23 11:03	3.0	0.5	66.15	64.90	1.25	0.20	---	105.4	100.4	---
MW-38U	7/10/23 14:35	3.0	0.5	66.15	65.27	0.88	0.14	---	105.4	100.4	---
MW-38U	7/17/23 13:51	3.0	0.5	66.15	63.87	2.28	0.37	---	105.8	100.4	All DNAPL removed[1]
MW-38U	7/24/23 11:10	3.0	0.5	66.15	65.27	0.88	0.14	---	105.9	100.4	---
MW-38U	7/31/23 13:05	3.0	0.5	66.15	64.31	1.84	0.30	---	106.1	100.4	All DNAPL removed[1]
MW-38U	8/7/23 11:05	3.0	0.5	66.15	65.17	0.98	0.16	---	106.2	100.4	---
MW-38U	8/14/23 11:22	3.0	0.5	66.15	64.37	1.78	0.29	---	106.4	100.4	All DNAPL removed[1]
MW-38U	8/21/23 13:50	3.0	0.5	66.15	65.33	0.82	0.13	---	106.5	100.4	---

Table 2
DNAPL Accumulation and Removal Volumes (July 1 through December 31, 2023)

Well ID	Date and Time	Sump Length (feet)	Sump Volume (gallons)	Depth to Bottom of Well (feet TOC)	Depth to Top of DNAPL (feet TOC)	DNAPL Thickness (feet)	Volume of DNAPL in Well Sump (gallons)	Volume of DNAPL Removed Between DNAPL Storage Container Measurement Events (gallons)	Cumulative Volume of DNAPL Entry into Well (gallons)	Cumulative Volume of DNAPL Removed (gallons)	Removal Activity
MW-38U	8/28/23 10:25	3.0	0.5	66.15	64.27	1.88	0.31	---	106.7	100.4	All DNAPL removed[1]
MW-38U	9/5/23 10:20	3.0	0.5	66.15	64.89	1.26	0.21	---	106.9	100.4	---
MW-38U	9/11/23 13:30	3.0	0.5	66.15	64.31	1.84	0.30	---	107.0	100.4	All DNAPL removed[1]
MW-38U	9/18/23 11:14	3.0	0.5	66.15	65.44	0.71	0.12	---	107.1	100.4	---
MW-38U	9/25/23 13:30	3.0	0.5	66.15	64.98	1.17	0.19	---	107.2	100.4	---
MW-38U	10/2/23 14:02	3.0	0.5	66.15	64.59	1.56	0.25	---	107.2	100.4	All DNAPL removed[1]
MW-38U	10/9/23 11:19	3.0	0.5	66.15	65.51	0.64	0.10	---	107.3	100.4	---
MW-38U	10/16/23 15:10	3.0	0.5	66.15	64.92	1.23	0.20	---	107.4	100.4	---
MW-38U	10/23/23 10:41	3.0	0.5	66.15	64.67	1.48	0.24	---	107.5	100.4	All DNAPL removed[1]
MW-38U	10/30/23 11:50	3.0	0.5	66.15	65.27	0.88	0.14	---	107.6	100.4	---
MW-38U	11/6/23 11:07	3.0	0.5	66.15	64.67	1.48	0.24	---	107.7	100.4	All DNAPL removed[1]
MW-38U	11/13/23 11:39	3.0	0.5	66.15	65.54	0.61	0.10	---	107.8	100.4	---
MW-38U	11/20/23 12:52	3.0	0.5	66.15	64.34	1.81	0.30	---	108.0	100.4	All DNAPL removed[1]
MW-38U	11/27/23 14:41	3.0	0.5	66.15	65.27	0.88	0.14	---	108.1	100.4	---
MW-38U	12/4/23 13:02	3.0	0.5	66.15	64.52	1.63	0.27	---	108.3	100.4	All DNAPL removed[1]
MW-38U	12/11/23 10:44	3.0	0.5	66.15	65.12	1.03	0.17	---	108.4	100.4	---
MW-38U	12/18/23 11:45	3.0	0.5	66.15	64.17	1.98	0.32	4.30	108.6	104.7	All DNAPL removed
MW-38U	12/27/23 14:41	3.0	0.5	66.15	64.88	1.27	0.21	---	108.8	104.7	---
MW-PW2L	7/28/23 10:02	5.0	0.9	147.45	144.64	2.81	0.46	---	120.2	101.1	All DNAPL removed[1]
MW-PW2L	8/30/23 8:35	5.0	0.9	147.45	144.48	2.97	0.48	---	120.7	101.1	---
MW-PW2L	9/25/23 10:21	5.0	0.9	147.45	145.07	2.38	0.39	---	120.7	101.1	---
MW-PW2L	10/30/23 9:40	5.0	0.9	147.45	143.41	4.04	0.66	---	120.9	101.1	All DNAPL removed[1]
MW-PW2L	11/27/23 9:28	5.0	0.9	147.45	145.58	1.87	0.30	---	121.2	101.1	---
MW-PW2L	12/29/23 13:44	5.0	0.9	147.45	143.05	4.40	0.72	4.10	121.6	105.2	All DNAPL removed
PW-1-80	12/29/23 14:50	2.5	3.7	84.95	NM	---	---	0.00	---	50.9	Liquids removed; oily water
PW-2L	7/5/23 8:35	5.0	7.4	147.80	144.75	3.05	4.48	23.13	---	3378.8	All DNAPL removed
PW-2L	7/10/23 9:25	5.0	7.4	147.80	144.54	3.26	4.79	---	---	3378.8	All DNAPL removed[1]
PW-2L	7/14/23 9:10	5.0	7.4	147.80	144.54	3.26	4.79	---	---	3378.8	All DNAPL removed[1]
PW-2L	7/17/23 11:04	5.0	7.4	147.80	145.62	2.18	3.20	---	---	3378.8	---
PW-2L	7/19/23 9:00	5.0	7.4	147.80	144.56	3.24	4.76	---	---	3378.8	All DNAPL removed[1]
PW-2L	7/21/23 8:30	5.0	7.4	147.80	146.69	1.11	1.63	---	---	3378.8	---
PW-2L	7/24/23 9:05	5.0	7.4	147.80	144.27	3.53	5.19	---	---	3378.8	All DNAPL removed[1]
PW-2L	7/28/23 9:40	5.0	7.4	147.80	144.54	3.26	4.79	---	---	3378.8	All DNAPL removed[1]
PW-2L	8/2/23 9:00	5.0	7.4	147.80	143.82	3.98	5.85	24.99	---	3403.8	All DNAPL removed
PW-2L	8/7/23 9:15	5.0	7.4	147.80	144.45	3.35	4.92	---	---	3403.8	All DNAPL removed[1]
PW-2L	8/9/23 10:10	5.0	7.4	147.80	145.40	2.40	3.53	---	---	3403.8	All DNAPL removed[1]
PW-2L	8/14/23 9:10	5.0	7.4	147.80	144.77	3.03	4.45	---	---	3403.8	Some DNAPL removed
PW-2L	8/16/23 9:04	5.0	7.4	147.80	145.82	1.98	2.91	---	---	3403.8	---
PW-2L	8/18/23 9:09	5.0	7.4	147.80	144.88	2.92	4.29	---	---	3403.8	Some DNAPL removed
PW-2L	8/21/23 9:55	5.0	7.4	147.80	145.87	1.93	2.84	---	---	3403.8	---

Table 2
DNAPL Accumulation and Removal Volumes (July 1 through December 31, 2023)

Well ID	Date and Time	Sump Length (feet)	Sump Volume (gallons)	Depth to Bottom of Well (feet TOC)	Depth to Top of DNAPL (feet TOC)	DNAPL Thickness (feet)	Volume of DNAPL in Well Sump (gallons)	Volume of DNAPL Removed Between DNAPL Storage Container Measurement Events (gallons)	Cumulative Volume of DNAPL Entry into Well (gallons)	Cumulative Volume of DNAPL Removed (gallons)	Removal Activity
PW-2L	8/23/23 9:19	5.0	7.4	147.80	144.51	3.29	4.84	---	---	3403.8	All DNAPL removed[1]
PW-2L	8/25/23 9:15	5.0	7.4	147.80	145.84	1.96	2.88	---	---	3403.8	All DNAPL removed[1]
PW-2L	8/28/23 9:10	5.0	7.4	147.80	145.63	2.17	3.19	---	---	3403.8	Continuous DNAPL removal
PW-2L	8/30/23 8:48	5.0	7.4	147.80	145.65	2.15	3.16	---	---	3403.8	Continuous DNAPL removal
PW-2L	9/1/23 9:00	5.0	7.4	147.80	144.90	2.90	4.26	---	---	3403.8	Continuous DNAPL removal
PW-2L	9/3/23 16:00	5.0	7.4	147.80	146.98	0.82	1.21	---	---	3403.8	Continuous DNAPL removal
PW-2L	9/5/23 8:45	5.0	7.4	147.80	145.04	2.76	4.06	30.36	---	3434.2	---
PW-2L	9/6/23 10:28	5.0	7.4	147.80	144.27	3.53	5.19	---	---	3434.2	All DNAPL removed[1]
PW-2L	9/8/23 9:01	5.0	7.4	147.80	146.71	1.09	1.60	---	---	3434.2	All DNAPL removed[1]
PW-2L	9/11/23 9:17	5.0	7.4	147.80	144.29	3.51	5.16	---	---	3434.2	Continuous DNAPL removal
PW-2L	9/15/23 9:10	5.0	7.4	147.80	145.37	2.43	3.57	---	---	3434.2	Continuous DNAPL removal
PW-2L	9/18/23 9:25	5.0	7.4	147.80	146.23	1.57	2.31	---	---	3434.2	Continuous DNAPL removal
PW-2L	9/20/23 9:45	5.0	7.4	147.80	144.84	2.96	4.35	---	---	3434.2	Continuous DNAPL removal
PW-2L	9/22/23 0:00	5.0	7.4	147.80	145.97	1.83	2.69	---	---	3434.2	Continuous DNAPL removal
PW-2L	9/25/23 10:05	5.0	7.4	147.80	144.61	3.19	4.69	---	---	3434.2	Continuous DNAPL removal
PW-2L	9/27/23 9:39	5.0	7.4	147.80	144.95	2.85	4.19	---	---	3434.2	Continuous DNAPL removal
PW-2L	9/29/23 9:21	5.0	7.4	147.80	144.62	3.18	4.67	---	---	3434.2	Continuous DNAPL removal
PW-2L	10/2/23 11:52	5.0	7.4	147.80	145.18	2.62	3.85	---	---	3434.2	Continuous DNAPL removal
PW-2L	10/9/23 15:24	5.0	7.4	147.80	145.21	2.59	3.81	---	---	3434.2	Continuous DNAPL removal
PW-2L	10/11/23 10:03	5.0	7.4	147.80	145.97	1.83	2.69	---	---	3434.2	Continuous DNAPL removal
PW-2L	10/13/23 10:20	5.0	7.4	147.80	146.00	1.80	2.65	---	---	3434.2	Continuous DNAPL removal
PW-2L	10/16/23 9:50	5.0	7.4	147.80	146.79	1.01	1.48	---	---	3434.2	Continuous DNAPL removal
PW-2L	10/18/23 9:15	5.0	7.4	147.80	144.15	3.65	5.37	---	---	3434.2	Continuous DNAPL removal
PW-2L	10/23/23 9:05	5.0	7.4	147.80	144.24	3.56	5.23	---	---	3434.2	Continuous DNAPL removal
PW-2L	10/25/23 10:35	5.0	7.4	147.80	144.44	3.36	4.94	---	---	3434.2	Continuous DNAPL removal
PW-2L	10/27/23 10:35	5.0	7.4	147.80	143.70	4.10	6.03	---	---	3434.2	Continuous DNAPL removal
PW-2L	10/30/23 9:54	5.0	7.4	147.80	143.94	3.86	5.67	---	---	3434.2	Continuous DNAPL removal
PW-2L	11/1/23 10:25	5.0	7.4	147.80	143.91	3.89	5.72	---	---	3434.2	Continuous DNAPL removal
PW-2L	11/2/23 9:20	5.0	7.4	147.80	143.82	3.98	5.85	---	---	3434.2	Continuous DNAPL removal
PW-2L	11/2/23 10:00	5.0	7.4	147.80	NM	NM	NM	32.22	---	3466.4	Continuous DNAPL removal
PW-2L	11/6/23 9:55	5.0	7.4	147.80	143.87	3.93	5.78	---	---	3466.4	Continuous DNAPL removal
PW-2L	11/8/23 10:04	5.0	7.4	147.80	144.74	3.06	4.50	---	---	3466.4	Continuous DNAPL removal
PW-2L	11/10/23 10:37	5.0	7.4	147.80	144.20	3.60	5.29	---	---	3466.4	Continuous DNAPL removal
PW-2L	11/13/23 9:40	5.0	7.4	147.80	146.02	1.78	2.62	---	---	3466.4	Continuous DNAPL removal
PW-2L	11/15/23 9:43	5.0	7.4	147.80	144.54	3.26	4.79	---	---	3466.4	Continuous DNAPL removal
PW-2L	11/17/23 9:42	5.0	7.4	147.80	144.97	2.83	4.16	---	---	3466.4	Continuous DNAPL removal
PW-2L	11/20/23 9:28	5.0	7.4	147.80	146.05	1.75	2.57	---	---	3466.4	Continuous DNAPL removal
PW-2L	11/22/23 9:30	5.0	7.4	147.80	145.90	1.90	2.79	---	---	3466.4	Continuous DNAPL removal
PW-2L	11/27/23 9:40	5.0	7.4	147.80	145.97	1.83	2.69	---	---	3466.4	Continuous DNAPL removal
PW-2L	11/29/23 9:40	5.0	7.4	147.80	145.83	1.97	2.90	---	---	3466.4	Continuous DNAPL removal
PW-2L	12/1/23 10:10	5.0	7.4	147.80	145.68	2.12	3.12	---	---	3466.4	Continuous DNAPL removal
PW-2L	12/4/23 9:50	5.0	7.4	147.80	145.12	2.68	3.94	---	---	3466.4	Continuous DNAPL removal
PW-2L	12/6/23 10:10	5.0	7.4	147.80	145.24	2.56	3.76	---	---	3466.4	Continuous DNAPL removal

Table 2
DNAPL Accumulation and Removal Volumes (July 1 through December 31, 2023)

Well ID	Date and Time	Sump Length (feet)	Sump Volume (gallons)	Depth to Bottom of Well (feet TOC)	Depth to Top of DNAPL (feet TOC)	DNAPL Thickness (feet)	Volume of DNAPL in Well Sump (gallons)	Volume of DNAPL Removed Between DNAPL Storage Container Measurement Events (gallons)	Cumulative Volume of DNAPL Entry into Well (gallons)	Cumulative Volume of DNAPL Removed (gallons)	Removal Activity
PW-2L	12/11/23 9:27	5.0	7.4	147.80	145.58	2.22	3.26	---	---	3466.4	Continuous DNAPL removal
PW-2L	12/13/23 10:50	5.0	7.4	147.80	144.79	3.01	4.42	---	---	3466.4	Continuous DNAPL removal
PW-2L	12/15/23 10:30	5.0	7.4	147.80	144.52	3.28	4.82	---	---	3466.4	Continuous DNAPL removal
PW-2L	12/18/23 10:20	5.0	7.4	147.80	144.71	3.09	4.54	---	---	3466.4	Continuous DNAPL removal
PW-2L	12/20/23 9:45	5.0	7.4	147.80	NM	NM	NM	42.96	---	3509.4	Continuous DNAPL removal
PW-2L	12/20/23 10:55	5.0	7.4	147.80	144.94	2.86	4.20	---	---	3509.4	Continuous DNAPL removal
PW-2L	12/22/23 10:51	5.0	7.4	147.80	144.74	3.06	4.50	---	---	3509.4	Continuous DNAPL removal
PW-2L	12/27/23 13:25	5.0	7.4	147.80	144.48	3.32	4.88	7.23	---	3516.6	Continuous DNAPL removal
PW-3-85	12/28/23 9:28	10.0	26.1	92.50	89.79	2.71	3.98	---	4.0	0.65	---
PW-6U	7/31/23 10:03	5.0	7.4	72.13	69.87	2.26	3.32	---	256.3	189.0	---
PW-6U	8/29/23 10:08	5.0	7.4	72.13	68.93	3.20	4.70	---	257.7	189.0	---
PW-6U	9/26/23 11:37	5.0	7.4	72.13	67.68	4.45	6.54	---	259.5	189.0	Some DNAPL removed
PW-6U	10/2/23 10:35	5.0	7.4	72.13	68.10	4.03	5.92	---	259.5	189.0	---
PW-6U	10/2/23 16:00	5.0	7.4	72.13	68.93	3.20	4.70	---	259.5	189.0	Some DNAPL removed
PW-6U	10/10/23 9:09	5.0	7.4	72.13	68.23	3.90	5.73	---	259.5	189.0	Some DNAPL removed
PW-6U	10/12/23 10:05	5.0	7.4	72.13	69.34	2.79	4.10	---	259.5	189.0	Some DNAPL removed
PW-6U	10/12/23 14:40	5.0	7.4	72.13	71.27	0.86	1.26	---	259.5	189.0	Some DNAPL removed
PW-6U	10/31/23 14:35	5.0	7.4	72.13	70.07	2.06	3.03	---	261.3	189.0	---
PW-6U	11/27/23 14:32	5.0	7.4	72.13	69.18	2.95	4.34	---	262.6	189.0	---
PW-6U	12/1/23 15:15	5.0	7.4	72.13	NM	NM	NM	---	262.6	189.0	Some DNAPL removed
PW-6U	12/7/23 14:37	5.0	7.4	72.13	71.07	1.06	1.56	25.97	262.6	215.0	---
PW-6U	12/28/23 13:20	5.0	7.4	72.13	69.95	2.18	3.20	---	264.2	215.0	---
PW-11U	12/28/23 9:09	5.0	7.4	72.65	ND	0.00	0.00	---	2.8	1.0	---
PW-11Ub	7/5/23 11:35	5.0	7.4	73.67	73.67	0.00	0.00	---	12.8	25.8	---
PW-11Ub	7/10/23 13:50	5.0	7.4	73.67	73.18	0.49	0.72	---	13.6	25.8	---
PW-11Ub	7/17/23 13:20	5.0	7.4	73.67	73.67	0.00	0.00	---	13.6	25.8	---
PW-11Ub	7/24/23 10:55	5.0	7.4	73.67	73.67	0.00	0.00	---	13.6	25.8	---
PW-11Ub	7/31/23 13:30	5.0	7.4	73.67	73.31	0.36	0.53	---	13.6	25.8	---
PW-11Ub	8/7/23 12:45	5.0	7.4	73.67	72.97	0.70	1.03	---	13.6	25.8	---
PW-11Ub	8/14/23 11:02	5.0	7.4	73.67	72.57	1.10	1.62	---	13.6	25.8	---
PW-11Ub	8/21/23 13:30	5.0	7.4	73.67	72.81	0.86	1.26	---	14.1	25.8	---
PW-11Ub	8/28/23 10:35	5.0	7.4	73.67	72.59	1.08	1.59	---	14.4	25.8	---
PW-11Ub	9/5/23 10:30	5.0	7.4	73.67	72.47	1.20	1.76	---	14.6	25.8	---
PW-11Ub	9/11/23 13:17	5.0	7.4	73.67	72.34	1.33	1.96	---	14.8	25.8	---
PW-11Ub	9/18/23 10:58	5.0	7.4	73.67	72.25	1.42	2.09	---	14.9	25.8	---
PW-11Ub	9/25/23 14:20	5.0	7.4	73.67	72.18	1.49	2.19	---	15.0	25.8	---
PW-11Ub	10/2/23 14:27	5.0	7.4	73.67	72.10	1.57	2.31	---	15.1	25.8	---
PW-11Ub	10/9/23 11:35	5.0	7.4	73.67	72.02	1.65	2.43	---	15.3	25.8	---
PW-11Ub	10/16/23 13:29	5.0	7.4	73.67	71.93	1.74	2.56	---	15.4	25.8	---

Table 2
DNAPL Accumulation and Removal Volumes (July 1 through December 31, 2023)

Well ID	Date and Time	Sump Length (feet)	Sump Volume (gallons)	Depth to Bottom of Well (feet TOC)	Depth to Top of DNAPL (feet TOC)	DNAPL Thickness (feet)	Volume of DNAPL in Well Sump (gallons)	Volume of DNAPL Removed Between DNAPL Storage Container Measurement Events (gallons)	Cumulative Volume of DNAPL Entry into Well (gallons)	Cumulative Volume of DNAPL Removed (gallons)	Removal Activity
PW-11Ub	10/23/23 10:21	5.0	7.4	73.67	71.96	1.71	2.51	---	15.4	25.8	---
PW-11Ub	10/30/23 11:35	5.0	7.4	73.67	71.85	1.82	2.68	---	15.5	25.8	---
PW-11Ub	11/6/23 10:38	5.0	7.4	73.67	72.26	1.41	2.07	---	15.5	25.8	---
PW-11Ub	11/13/23 12:49	5.0	7.4	73.67	71.77	1.90	2.79	---	15.6	25.8	---
PW-11Ub	11/20/23 13:08	5.0	7.4	73.67	71.70	1.97	2.90	---	15.7	25.8	---
PW-11Ub	11/27/23 11:58	5.0	7.4	73.67	71.52	2.15	3.16	---	16.0	25.8	---
PW-11Ub	12/28/23 8:35	5.0	7.4	73.67	71.12	2.55	3.75	---	16.6	25.8	---
PW-13U	7/5/23 11:10	0.6	0.9	80.05	77.75	2.30	3.38	---	185.2	169.9	---
PW-13U	7/10/23 14:20	0.6	0.9	80.05	77.70	2.35	3.45	---	185.3	169.9	---
PW-13U	7/31/23 11:15	0.6	0.9	80.05	77.24	2.81	4.13	---	186.0	169.9	---
PW-13U	8/1/23 15:21	0.6	0.9	80.05	NM	NM	NM	---	186.0	169.9	All DNAPL removed[1]
PW-13U	8/29/23 10:30	0.6	0.9	80.05	77.07	2.98	4.38	---	190.3	169.9	---
PW-13U	9/28/23 10:25	0.6	0.9	80.05	76.40	3.65	5.37	---	191.3	169.9	All DNAPL removed[1]
PW-13U	10/31/23 12:50	0.6	0.9	80.05	77.09	2.96	4.35	0.83	195.7	170.7	All DNAPL removed
PW-13U	11/27/23 14:19	0.6	0.9	80.05	78.29	1.76	2.59	---	198.3	170.7	---
PW-13U	12/28/23 9:50	0.6	0.9	80.05	75.53	4.52	6.64	---	202.3	170.7	---
PW-14U	7/17/23 9:40	5.0	7.4	75.45	72.97	2.48	3.65	---	61.7	29.2	---
PW-14U	7/31/23 10:24	5.0	7.4	75.45	72.58	2.87	4.22	---	62.3	29.2	All DNAPL removed[1]
PW-14U	8/29/23 11:30	5.0	7.4	75.45	72.50	2.95	4.34	---	62.3	29.2	---
PW-14U	9/26/23 9:41	5.0	7.4	75.45	71.41	4.04	5.94	---	64.0	29.2	Some DNAPL removed
PW-14U	11/1/23 14:20	5.0	7.4	75.45	70.91	NM	NM	---	64.0	29.2	Some DNAPL removed
PW-14U	11/9/23 8:57	5.0	7.4	75.45	70.67	4.78	7.03	7.44	65.1	36.6	All DNAPL removed
PW-14U	11/13/23 11:04	5.0	7.4	75.45	75.05	0.40	0.59	---	65.7	36.6	---
PW-14U	11/27/23 11:32	5.0	7.4	75.45	74.47	0.98	1.44	---	66.6	36.6	---
PW-14U	12/28/23 9:40	5.0	7.4	75.45	73.56	1.89	2.78	---	67.9	36.6	---

Notes:

False positive or false negative reading; not included in volume calculations.

1. Removal volumes were not measured after each removal event. In order to obtain more accurate removal measurements, removed DNAPL was stored in a container and measured when a significant amount of DNAPL had accumulated.

2. Measurement of volume of DNAPL entry into well was not available.

---: not applicable

DNAPL: dense nonaqueous phase liquid, specifically oil and/or semisolid tar

ND: not detected

NM: not measured

TOC: top of casing

Table 3
DNAPL Entry and Removal Rates and Volumes

Well ID	Date of First DNAPL Detection	Total DNAPL Volume Entry into and/or Removed from Location (gallons) (as of 12/31/2023)	Average DNAPL Entry Rate and/or Removal Rate (gallons per month)															
			Reporting Period															
			Total	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
			Average During Entire Monitoring Period	Beginning of Monitoring to 12/31/2014	1/1/2015 to 6/30/2017	7/1/2017 to 12/31/2017	1/1/2018 to 6/30/2018	7/1/2018 to 12/31/2018	1/1/2019 to 6/30/2019	7/1/2019 to 12/31/2019	1/1/2020 to 6/30/2020	7/1/2020 to 12/31/2020	1/1/2021 to 6/30/2021	7/1/2021 to 12/31/2021	1/1/2022 to 6/30/2022	7/1/2022 to 12/31/2022	1/1/2023 to 6/30/2023	7/1/2023 to 12/31/2023
DNAPL Entry Rate Calculated from Measurements of Accumulation in Well																		
DW-6U	1/21/2014	8.9	0.07	0.11	0.09	0.17	0.11	0.05	0.09	0.05	0.03	0.08	0.05	0.07	0.02	0.02	0.06	0.00
DW-11U	1/21/2014	1.1	0.01	0.03	0.01	0.00	0.00	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.02	0.00	0.00	0.00
DW-14U	2/11/2014	42.3	0.35	0.28	0.51	0.48	0.39	0.45	0.38	0.21	0.40	0.26	0.10	0.35	0.28	0.22	0.30	0.12
MW-16-45	4/29/2013	13.7	0.11	0.12	0.10	0.16	0.12	0.14	0.08	0.10	0.06	0.06	0.06	0.08	0.11	0.07	0.08	0.06
MW-18-30	4/29/2013	9.5	0.07	0.11	0.08	0.04	0.09	0.05	0.09	0.05	0.07	0.04	0.07	0.05	0.10	0.06	0.08	0.04
MW-26U	5/6/2013	87.1	0.64	0.39	0.89	0.81	0.38	0.81	0.69	0.76	0.53	0.78	0.74	0.75	0.57	0.69	0.58	0.65
MW-27U	11/6/2013	37.0	0.28	0.10	0.33	0.39	0.32	0.29	0.21	0.45	0.22	0.31	0.22	0.25	0.34	0.38	0.40	0.36
MW-30U	8/3/2015	2.6	0.02	0.00	0.01	0.02	0.04	0.05	0.04	0.06	0.02	0.02	0.04	0.02	0.02	0.02	0.02	0.03
MW-34L	4/29/2013	11.0	0.08	0.11	0.09	0.08	0.10	0.09	0.08	0.08	0.07	0.07	0.07	0.07	0.06	0.07	0.05	0.05
MW-37U	11/3/2014	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PW-3-85	4/29/2013	2.4	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PW-6U[1]	10/14/2013	264.3	1.88	0.04	0.74	2.75	2.74	4.53	3.82	3.20	3.26	3.73	2.69	3.45	4.34	2.22	1.76	1.37
PW-11U	11/6/2013	2.8	0.02	0.06	0.04	0.11	0.00	0.00	0.00	0.01	0.16	0.00	0.00	0.00	0.00	0.00	0.05	0.00
PW11Ub[1]	4/27/2022	16.6	0.79	---	---	---	---	---	---	---	---	---	---	---	0.74	0.79	0.99	0.62
PW-13U[1]	5/4/2015	202.3	1.53	0.00	0.88	1.97	1.78	2.04	2.92	2.11	2.50	1.89	2.25	1.91	2.61	2.06	1.87	3.37
PW-14U[1]	7/7/2014	67.9	0.52	0.12	0.34	0.90	1.07	0.73	0.59	0.21	0.15	0.40	0.17	0.42	0.26	0.50	2.71	1.13
DNAPL Entry Rate Calculated from Combination of Accumulation in Well and Volume Removed from Well																		
MW-38U[2]	4/29/2013	108.1	0.81	1.81	1.12	0.78	1.25	0.30	0.16	0.22	0.13	0.30	0.21	0.56	0.60	0.66	0.59	0.56
MW-PW2L[3]	2/10/2014	121.6	1.02	3.38	1.85	0.63	0.55	0.50	0.42	0.34	0.19	0.29	0.14	0.19	0.28	0.39	0.38	0.30
DNAPL Entry Rate Calculated from Volume Removed from Well																		
PW-1-80[4]	4/29/2013	50.9	0.17	1.11	0.03	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PW-2L[1]	4/29/2013	3516.6	26.9	18.1	4.9	63.8	46.4	52.5	50.2	37.7	30.5	30.9	33.0	36.4	42.6	27.0	28.8	27.2
DNAPL Entry Rate of Locations not in DNAPL Monitoring Program																		
MW-6-32 and MW-13-30 Combined[5]	8/8/2000	3911	14.0	14.6	16.3	0.0	16.4	17.9	13.6	9.2	13.3	8.8	11.2	9.7	9.7	14.5	18.9	5.2
T-50 Trench Sump[6]	8/3/2022	414.8	24.3	---	---	---	---	---	---	---	---	---	---	---	---	14.8	33.2	25.1
Total		4567	35.3	25.9	12.1	73.1	55.4	62.6	59.8	45.6	38.3	39.1	39.8	44.6	52.9	35.2	38.7	35.9
Non-Pumping Wells Total		499	3.7	7.5	5.1	3.6	3.4	2.8	2.3	2.3	1.7	2.2	1.7	2.4	2.4	2.6	2.6	2.2
Pumping Wells Total		4068	31.6	18.3	6.9	69.5	52.0	59.8	57.5	43.2	36.6	36.9	38.1	42.2	50.5	32.6	36.1	33.7
Pumping Wells Percentage of Total		89.1	89.6	70.8	57.6	95.1	93.9	95.5	96.2	94.9	95.5	94.4	95.7	94.6	95.5	92.7	93.3	93.9
Non-Pumping Wells Percentage of Total		10.9	10.4	29.2	42.4	4.9	6.1	4.5	3.8	5.1	4.5	5.6	4.3	5.4	4.5	7.3	6.7	6.1

Notes:

1. Denotes pumping well.

2. DNAPL volume removed from well used in lieu of accumulation volume from March 10, 2014, to September 11, 2015, and January 22, 2016, to March 12, 2018.

3. DNAPL volume removed from well used in lieu of accumulation volume from March 15, 2014, to December 4, 2014.

4. DNAPL volume removed from well used in lieu of accumulation volume from March 2, 2015, to present.

5. DNAPL removal system offline for entire year of 2017. These two wells are not included in totals or percentages because they are not part of the DNAPL monitoring program.

6. DNAPL entry into trench is monitored but not included in totals or percentages because it is not part of the DNAPL monitoring program.

Blue shading indicates reporting period with highest average DNAPL entry rate for each well, group of wells, or total. This excludes MW-37U, which has had an average DNAPL entry rate of 0.00 gallon per month in each reporting period.

---: not applicable

DNAPL: dense nonaqueous phase liquid, specifically oil and/or semisolid tar

Table 4
DNAPL Entry Rate Trend Analysis Results Through December 31, 2023

Well Type	DNAPL Entry Rate Trend via Mann-Kendall	Well ID	DNAPL Entry Rate in Current Reporting Period (July 1 through December 31, 2023) (gallons per month)	Peak DNAPL Entry Rate Moving Average through December 31, 2023[1] (gallons per month)	Moving Average Peak DNAPL Entry Date
Non-Pumping	Decreasing	DW-14U	0.12	0.74	Second Quarter 2017
		MW-16-45	0.06	0.16	Fourth Quarter 2017
		MW-26U	0.65	1.08	Third Quarter 2015
		PW-11U	0.00	0.13	Second Quarter 2017
		MW-34L	0.05	0.13	Second Quarter 2013
		MW-38U	0.56	2.54	First Quarter 2015
		MW-PW2L	0.30	3.74	First Quarter 2014
		PW-1-80	0.00	2.74	Second Quarter 2013
		PW-3-85	0.00	0.06	Second Quarter 2014
	Stable	DW-11U	0.00	0.03	Third Quarter 2015
		MW-27U	0.36	0.41	Third Quarter 2022
		DW-6U	0.00	0.18	Fourth Quarter 2017
		MW-18-30	0.04	0.15	Second Quarter 2013
		MW-30U	0.03	0.05	Second Quarter 2018
	Insufficient data to perform analysis	MW-37U	0.00	0.03	Second Quarter 2014
Pumping	Decreasing	PW-2L	27.2	58.6	Fourth Quarter 2017
		PW-6U	1.37	3.64	Second Quarter 2020
	Stable	PW-13U	3.37	2.71	First Quarter 2019
	Insufficient data to perform analysis	PW-11Ub	0.62	0.86	Fourth Quarter 2022
		PW-14U	1.13	2.36	Second Quarter 2023
Other	Decreasing	MW-6-32 and MW-13-30 combined	6.35	35.0	Fourth Quarter 2010
	Insufficient data to perform analysis	T-50 Trench Sump	28.7	26.9	First Quarter 2023

Notes:

1. Moving average calculated as the average of the entry rate value and the two previous and two subsequent entry rate values for each date of data (5 total data points averaged).

DNAPL: dense nonaqueous phase liquid, specifically oil and/or semisolid tar

Table 5

DNAPL Entry Rates During Different Operational Periods of the HC&C System

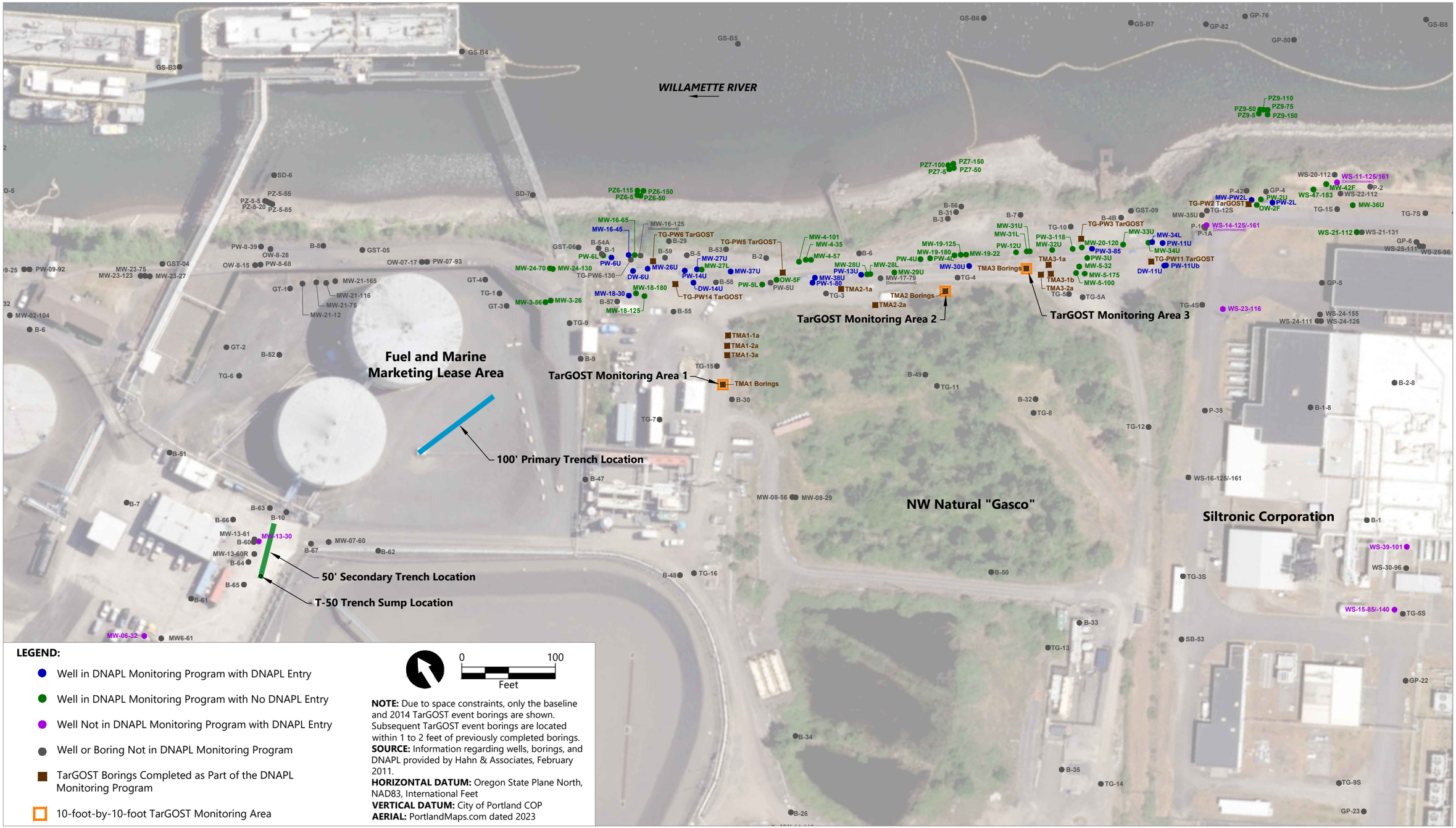
Well ID	HC&C System Operation Period		
	Prior to Startup (beginning of monitoring until 9/23/2013)	Interim Operation and Testing Period (9/23/2013 through 5/14/2015)	Full-Time, Full-Scale Operation (5/14/2015 through 12/31/2023)
	Average DNAPL Entry Rate (gallons per month)		
DNAPL Entry Rate Calculated from Measurements in Well			
DW-6U	NA	0.12	0.07
DW-11U	NA	0.03	0.01
DW-14U	NA	0.33	0.35
MW-16-45	0.18	0.10	0.09
MW-18-30	0.13	0.11	0.06
MW-26U	0.01	0.57	0.73
MW-27U	0.00	0.14	0.33
MW-30U	0.00	0.00	0.02
MW-34L	0.13	0.10	0.08
MW-37U	0.00	0.00	0.00
PW-3-85	0.03	0.00	0.00
PW-6U[1]	0.00	0.10	2.53
PW-11U	0.00	0.09	0.01
PW-11Ub[1]	NA	NA	0.79
PW-13U[1]	0.00	0.02	1.95
PW-14U[1]	0.00	0.22	0.62
DNAPL Entry Rate Calculated from Combination of Accumulation in Well and Volume Removed from Well			
MW-38U[2]	0.46	1.98	0.62
MW-PW2L[3]	NA	3.30	0.67
PW-1-80[4]	3.11	0.46	0.01
DNAPL Entry Rate Calculated from Volume Removed from Well			
PW-2L[1]	5.97	16.49	30.30
Total	10.01	24.17	39.23
Non-Pumping Wells Total	4.04	7.25	3.05
Pumping Wells Total	5.97	16.92	36.18
Pumping Wells Percentage of Total	59.6	70.0	92.2
Non-Pumping Wells Percentage of Total	40.4	30.0	7.8

Table 5
DNAPL Entry Rates During Different Operational Periods of the HC&C System

Notes:
1. Denotes pumping well.
2. DNAPL volume removed from well used in lieu of accumulation volume from March 10, 2014, to September 11, 2015, and January 22, 2016, to March 12, 2018.
3. DNAPL volume removed from well used in lieu of accumulation volume from March 15, 2014, to December 4, 2014.
4. DNAPL volume removed from well used in lieu of accumulation volume from March 2, 2015, to present.

DNAPL: dense nonaqueous phase liquid, specifically oil and/or semisolid tar
HC&C: hydraulic control and containment
NA: not available; well was not installed during testing period

Figures



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Filepath: K:\Projects\0029-NW Natural Gas Co\Gasco Source Control\DNAPL Monitoring Summary Report\2023 Jul 1 - Dec 31\0029-RP-001 (DNAPL Mon Locs).dwg Figure 1

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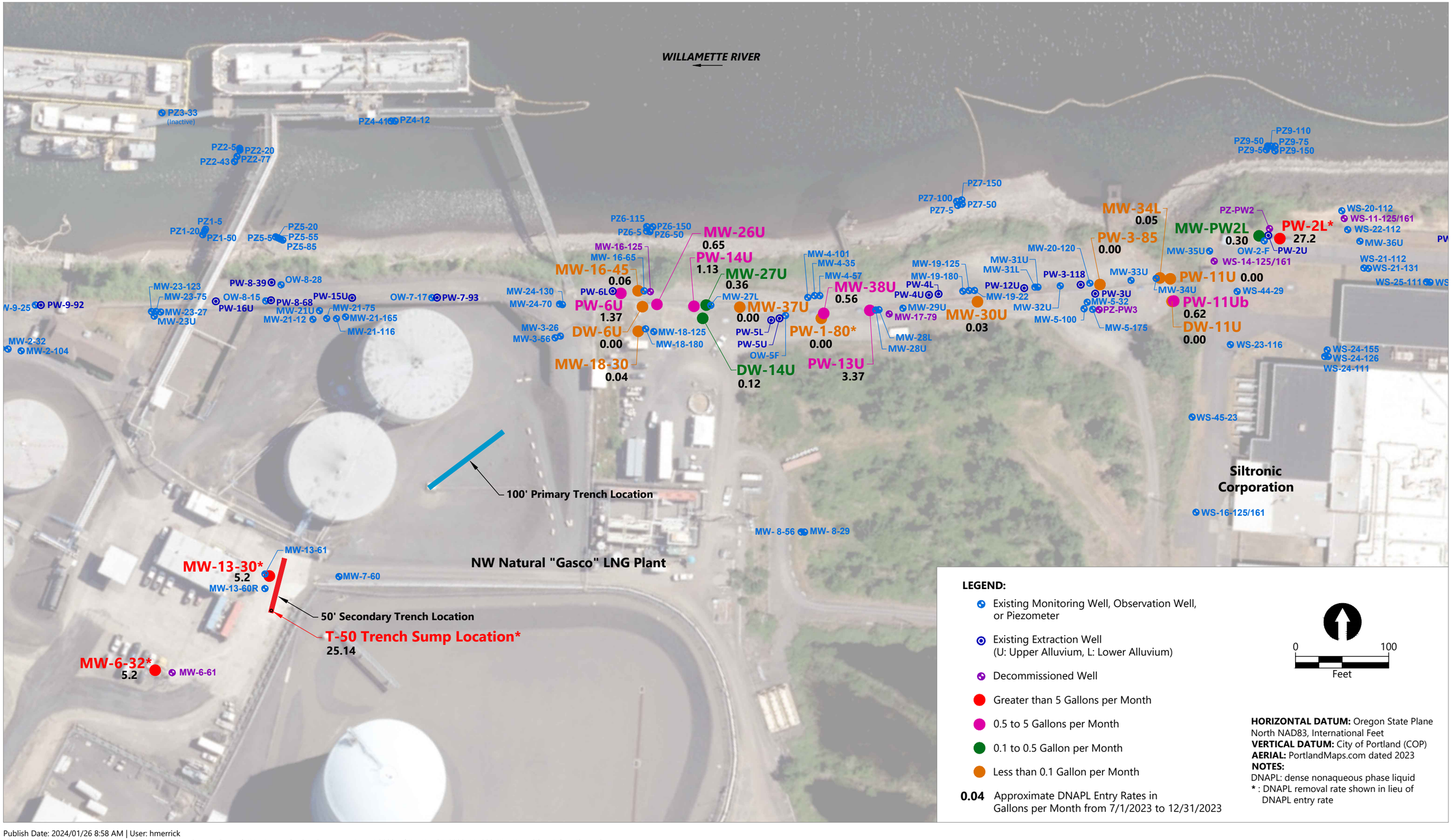
Figure 1
DNAPL Monitoring Locations

DNAPL Monitoring Semiannual Summary Report (July 1 through December 31, 2023)
NW Natural Gasco Site



LEGEND:

- Existing Monitoring Well, Observation Well, or Piezometer
- Existing Extraction Well (U: Upper Alluvium, L: Lower Alluvium)
- Decommissioned Well
- Greater than 5 Gallons per Month
- 0.5 to 5 Gallons per Month
- 0.1 to 0.5 Gallon per Month
- Less than 0.1 Gallon per Month
- **0.04** Approximate DNAPL Entry Rates in Gallons per Month from 7/1/2023 to 12/31/2023

0 100 Feet

HORIZONTAL DATUM: Oregon State Plane North NAD83, International Feet
VERTICAL DATUM: City of Portland (COP)
AERIAL: PortlandMaps.com dated 2023
NOTES:
DNAPL: dense nonaqueous phase liquid
* : DNAPL removal rate shown in lieu of DNAPL entry rate

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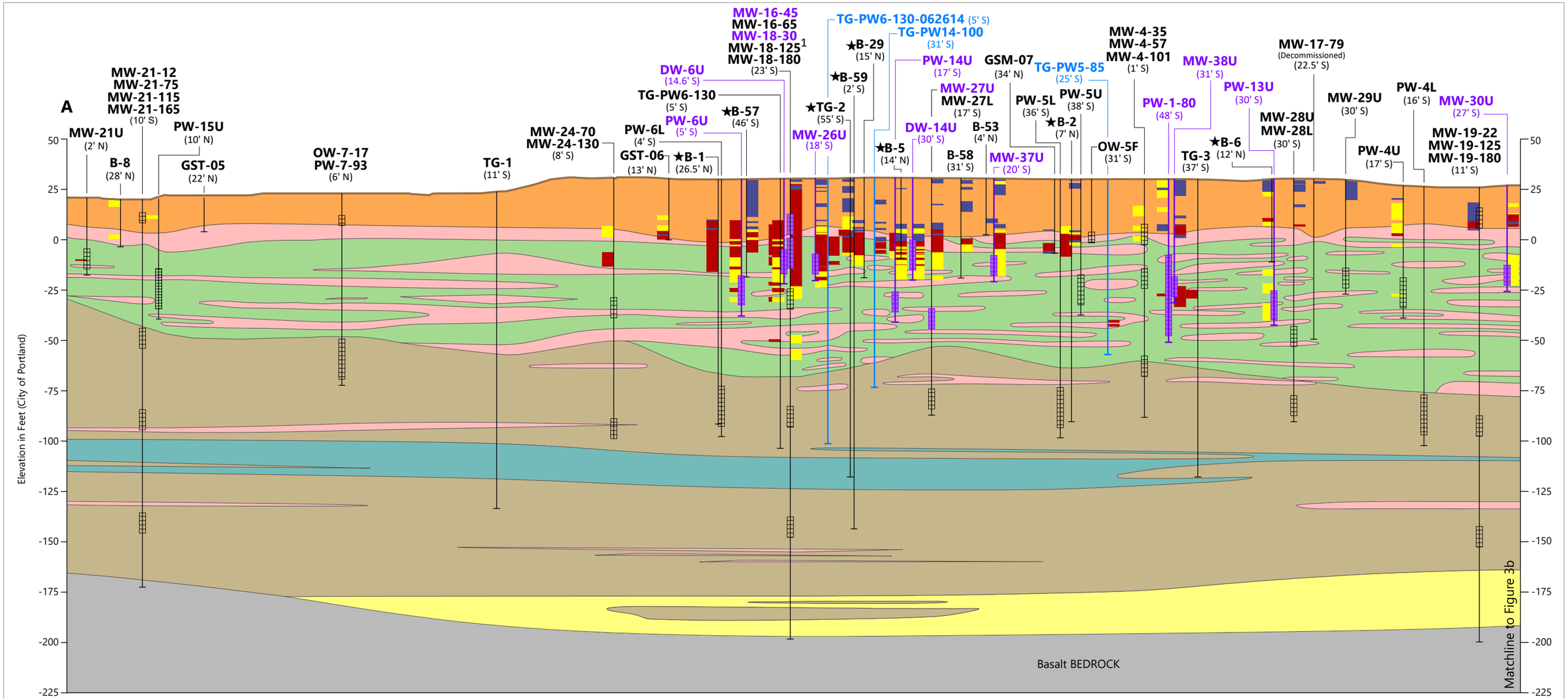
Figure 2
Average Monthly DNAPL Entry Rates

DNAPL Monitoring Semiannual Summary Report (July 1 through December 31, 2023)
NW Natural Gasco Site



LEGEND:

- **Fill WBZ** - Fill composed of Gravel, Silt, Sand, Metal, Brick, and Concrete Debris
- Primarily Silt and Sandy Silt Interbedded with Thin Sand and Silty Sand Layers
- **Upper Alluvium WBZ** - Primarily Fine to Medium Grained Sand and Silty Sand Interbedded with Thin Silt and Sandy Silt Layers
- **Lower Alluvium WBZ** - Primarily Medium Grained Sand with Generally Less than 5% Fines
- **Lower Silt Unit** - Primarily Silt and Sandy Silt with aquitard properties Interbedded with Thin Sand and Silty Sand Layers (Considered Boundary between Lower and Deep Lower WBZ)
- Alluvial Gravel, Sandy Gravel, Gravelly Sand, and Gravelly Silt
- Basalt Bedrock
- Existing Ground Surface
- Geologic Contact (dashed where inferred)

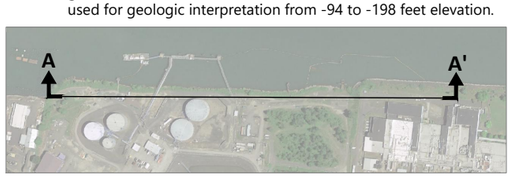
MW-21-16 (57' E) — Boring ID; Offset Distance in Feet

Well with DNAPL Entry; Extraction Well TarGOST Boring; Existing Well or Piezometer

- Tar Interval
- Oil or Mixed Oil and Tar Interval
- Sheen Interval
- Well Screen

0 50 Feet

NOTES:
Oil, tar, and sheen designations are based on information obtained during drilling and logging activities.
★ Not used for geologic interpretation.
1 Data from MW-18-125 used for geologic interpretation from ground surface to -94 feet elevation. Data from MW-18-180 used for geologic interpretation from -94 to -198 feet elevation.



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Filepath: K:\Projects\0029-NW Natural Gas Co\Gasco Source Control\DNAPL Monitoring Summary Report\2023 Jul 1 - Dec 31\0029-RP-003 (XSEC A).dwg Figure 3a

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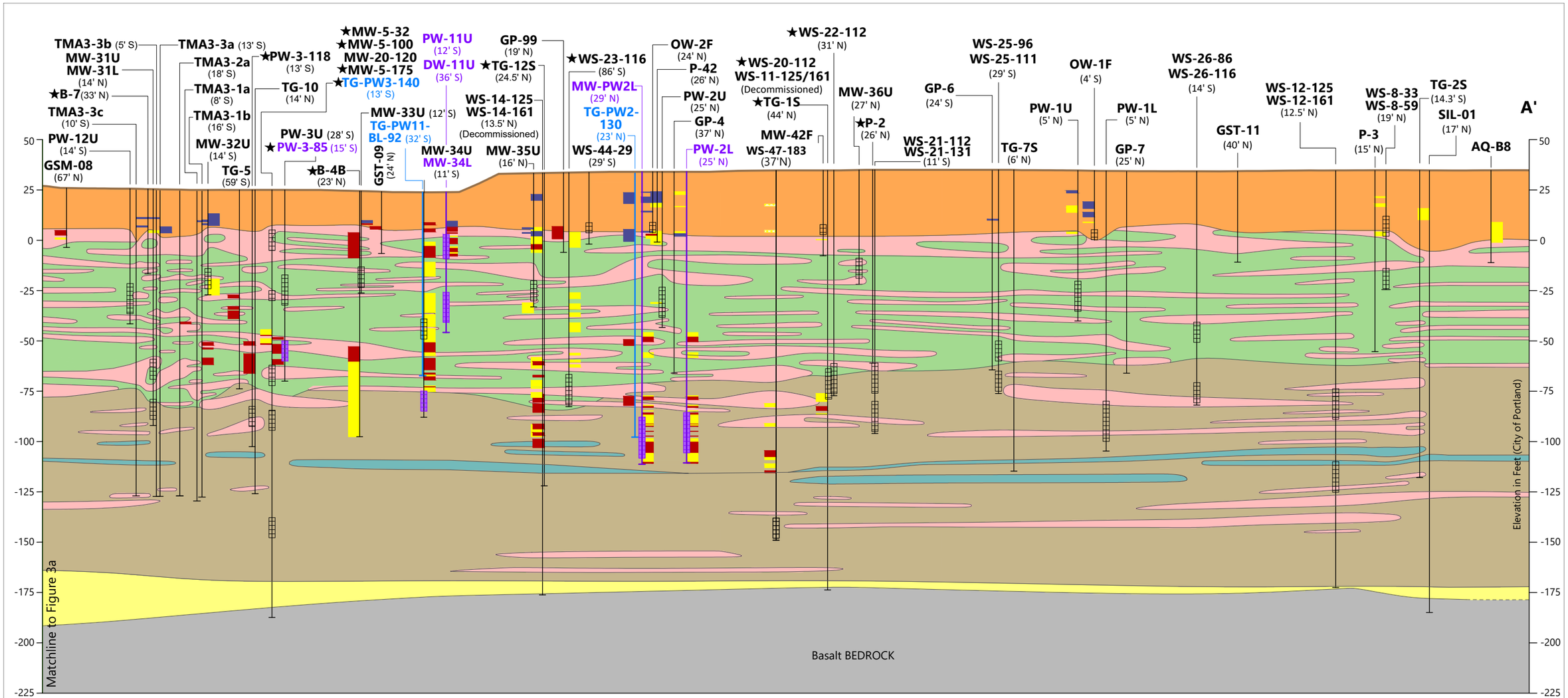
Figure 3a
Geologic Cross Section A-A'

DNAPL Monitoring Semiannual Summary Report (July 1 through December 31, 2023)
NW Natural Gasco Site



LEGEND:

- **Fill WBZ** - Fill composed of Gravel, Silt, Sand, Metal, Brick, and Concrete Debris
- Primarily Silt and Sandy Silt Interbedded with Thin Sand and Silty Sand Layers
- **Upper Alluvium WBZ** - Primarily Fine to Medium Grained Sand and Silty Sand Interbedded with Thin Silt and Sandy Silt Layers
- **Lower Alluvium WBZ** - Primarily Medium Grained Sand with Generally Less than 5% Fines
- **Lower Silt Unit** - Primarily Silt and Sandy Silt with aquitard properties Interbedded with Thin Sand and Silty Sand Layers (Considered Boundary between Lower and Deep Lower WBZ)
- Alluvial Gravel, Sandy Gravel, Gravelly Sand, and Gravelly Silt
- Basalt Bedrock
- Existing Ground Surface
- Geologic Contact (dashed where inferred)

MW-21-16 (57' E) — Boring ID; Offset Distance in Feet

Well with DNAPL Entry; Extraction Well TarGOST Boring; Existing Well or Piezometer

- Tar Interval
- Oil or Mixed Oil and Tar Interval
- Sheen Interval
- Well Screen

0 50 Feet

NOTES: Oil, tar, and sheen designations are based on information obtained during drilling and logging activities.
★ Not used for geologic interpretation.

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Filepath: K:\Projects\0029-NW Natural Gas Co\Gasco Source Control\DNAPL Monitoring Summary Report\2023 Jul 1 - Dec 31\0029-RP-003 (XSEC A).dwg Figure 3b

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Figure 3b
Geologic Cross Section A-A'

DNAPL Monitoring Semiannual Summary Report (July 1 through December 31, 2023)
NW Natural Gasco Site

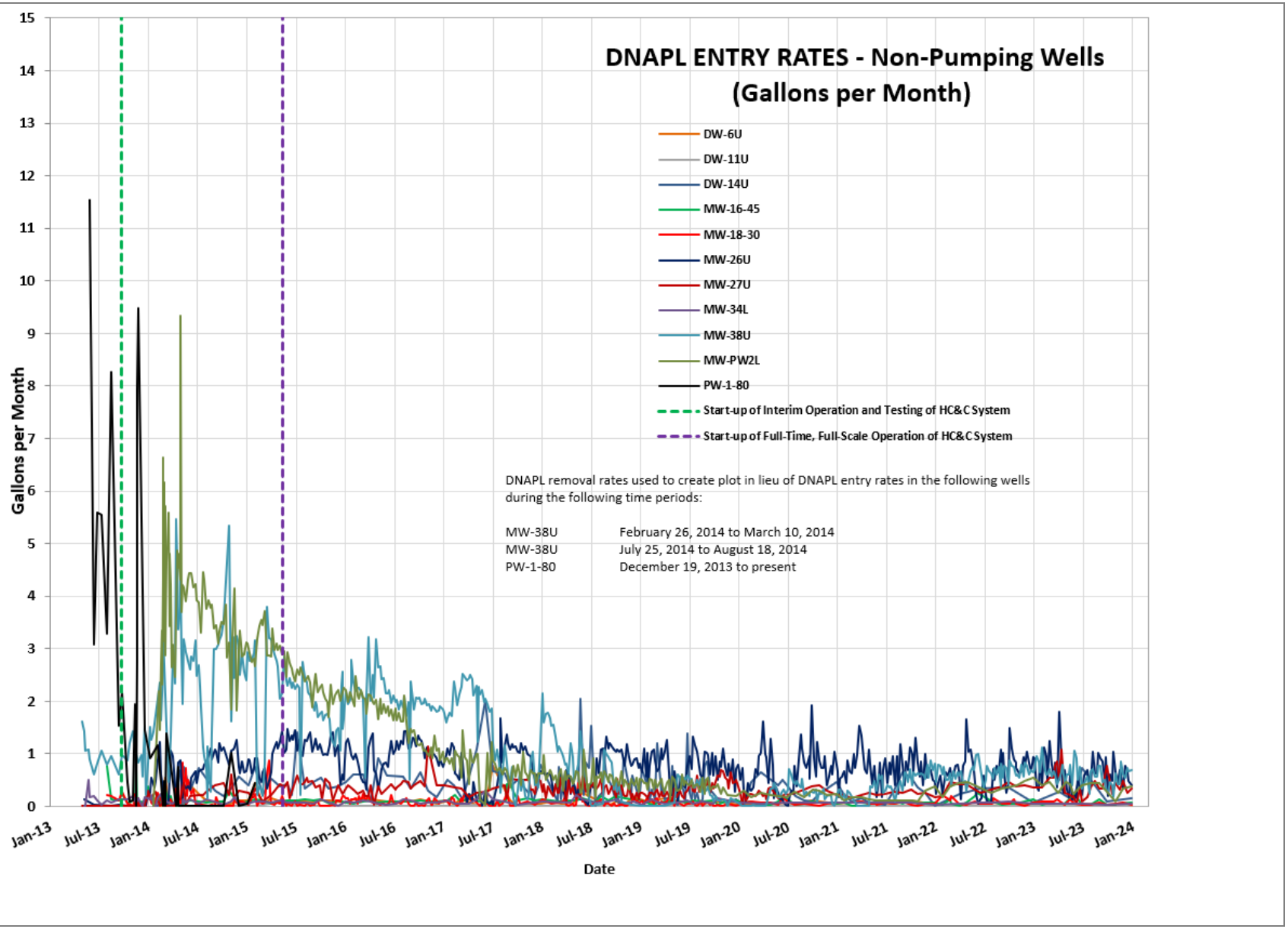

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Figure 4a
DNAPL Entry Rates – Non-Pumping Wells
DNAPL Monitoring Semiannual Summary Report (July 1 through December 31, 2023)
NW Natural Gasco Site

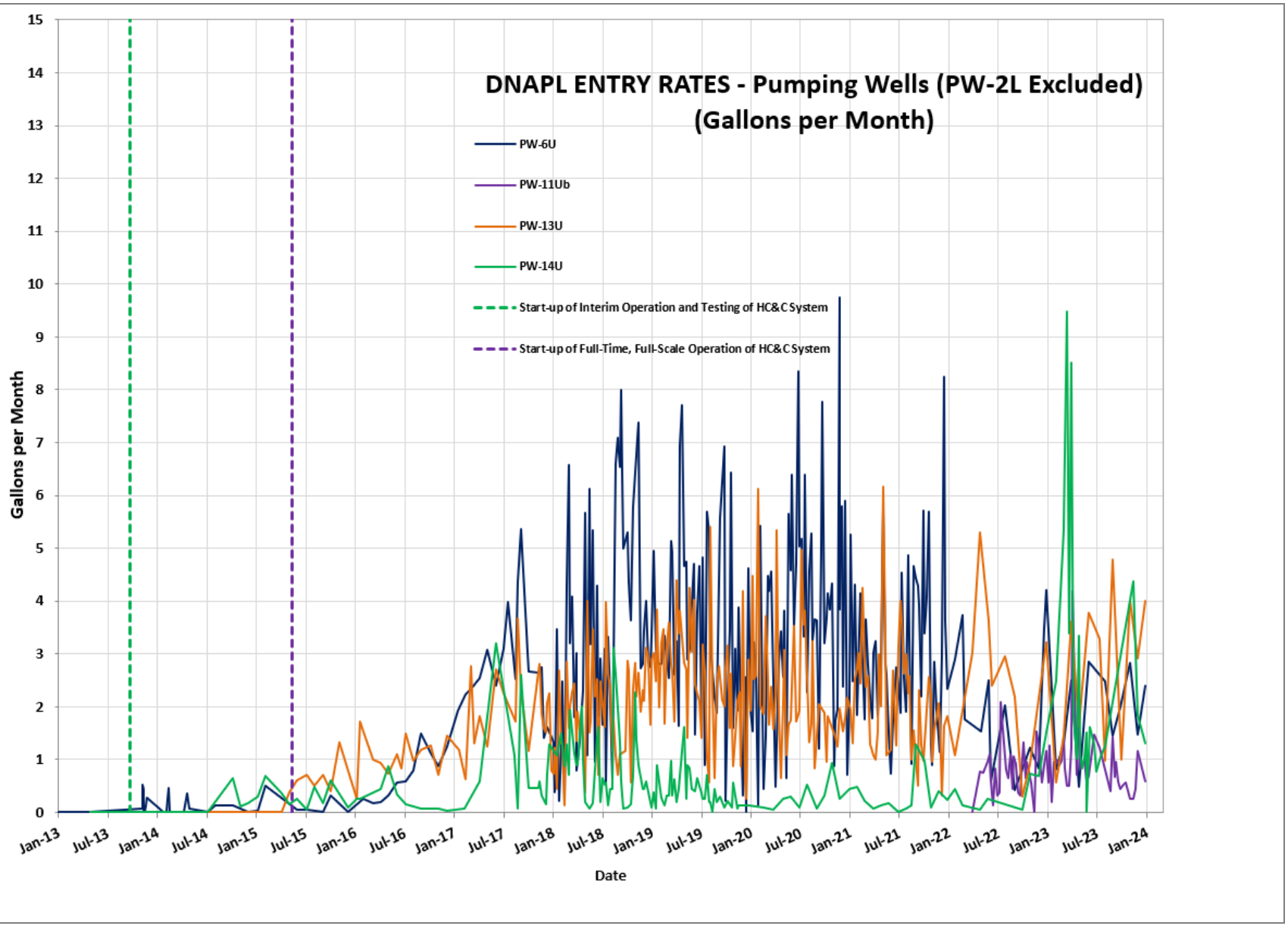

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Figure 4b

DNAPL Entry Rates – Pumping Wells (PW-2L Excluded)

DNAPL Monitoring Semiannual Summary Report (July 1 through December 31, 2023)
NW Natural Gasco Site

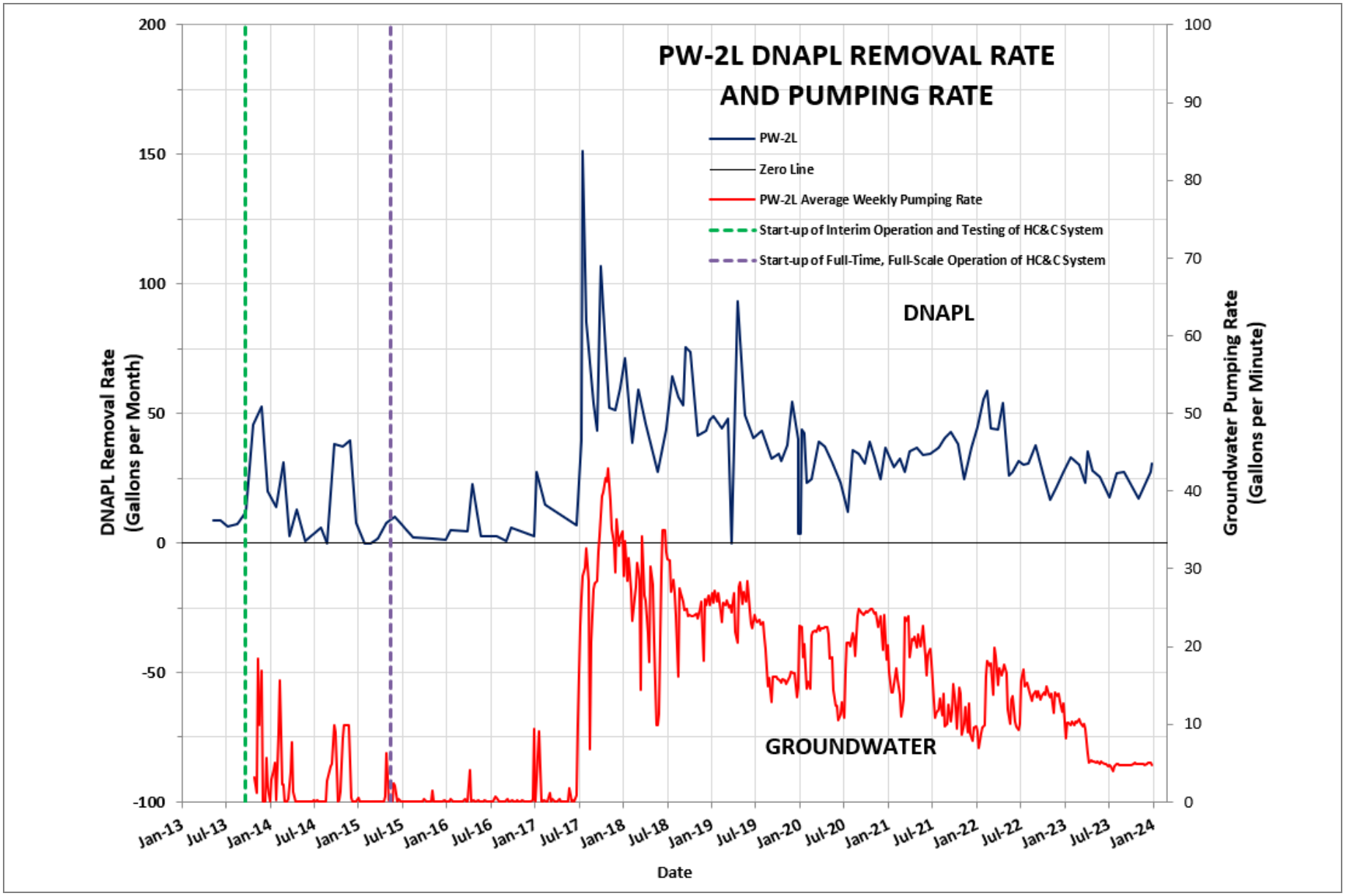

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Figure 4c
DNAPL Removal Rate – PW-2L
DNAPL Monitoring Semiannual Summary Report (July 1 through December 31, 2023)
NW Natural Gasco Site

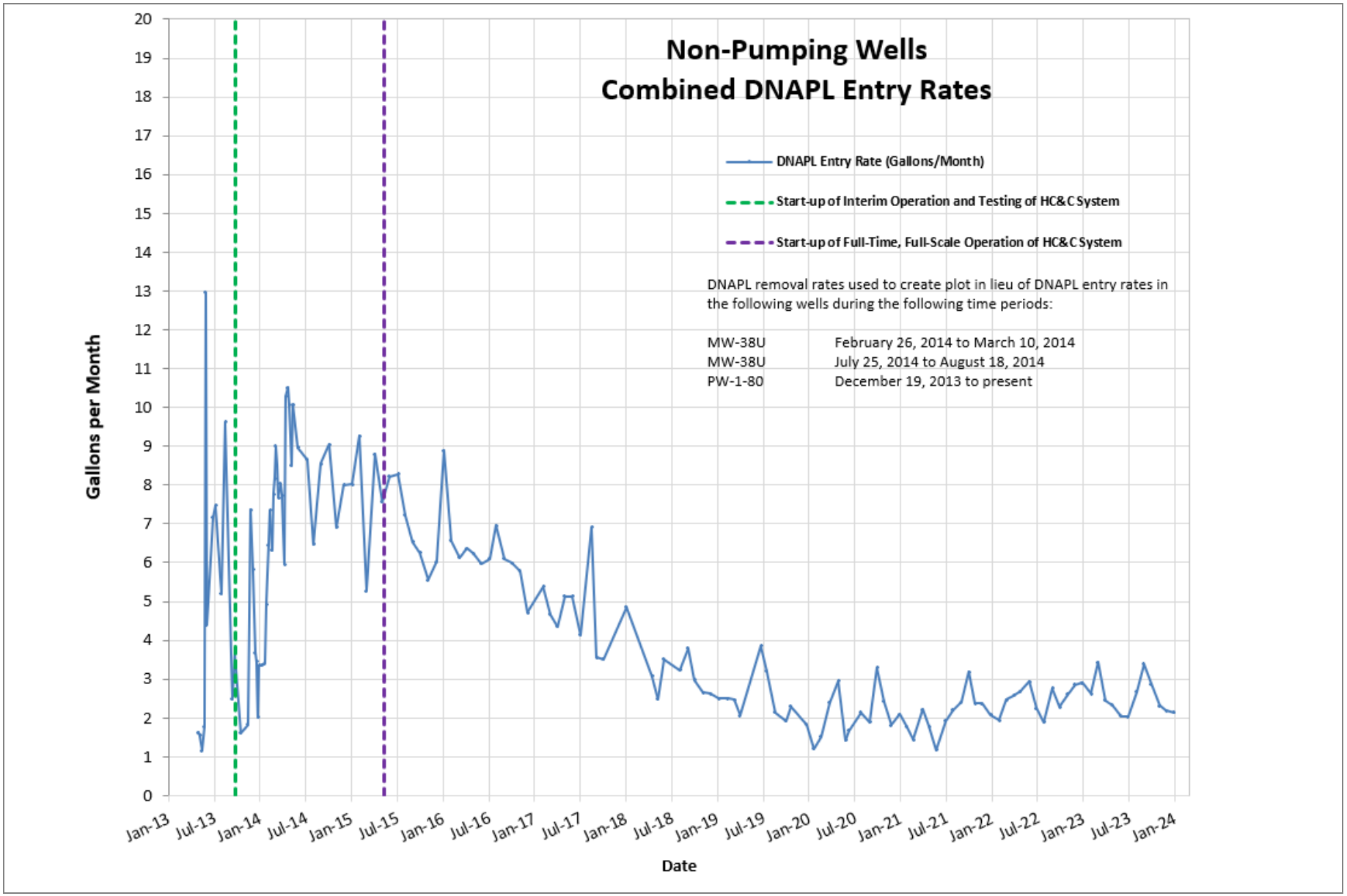

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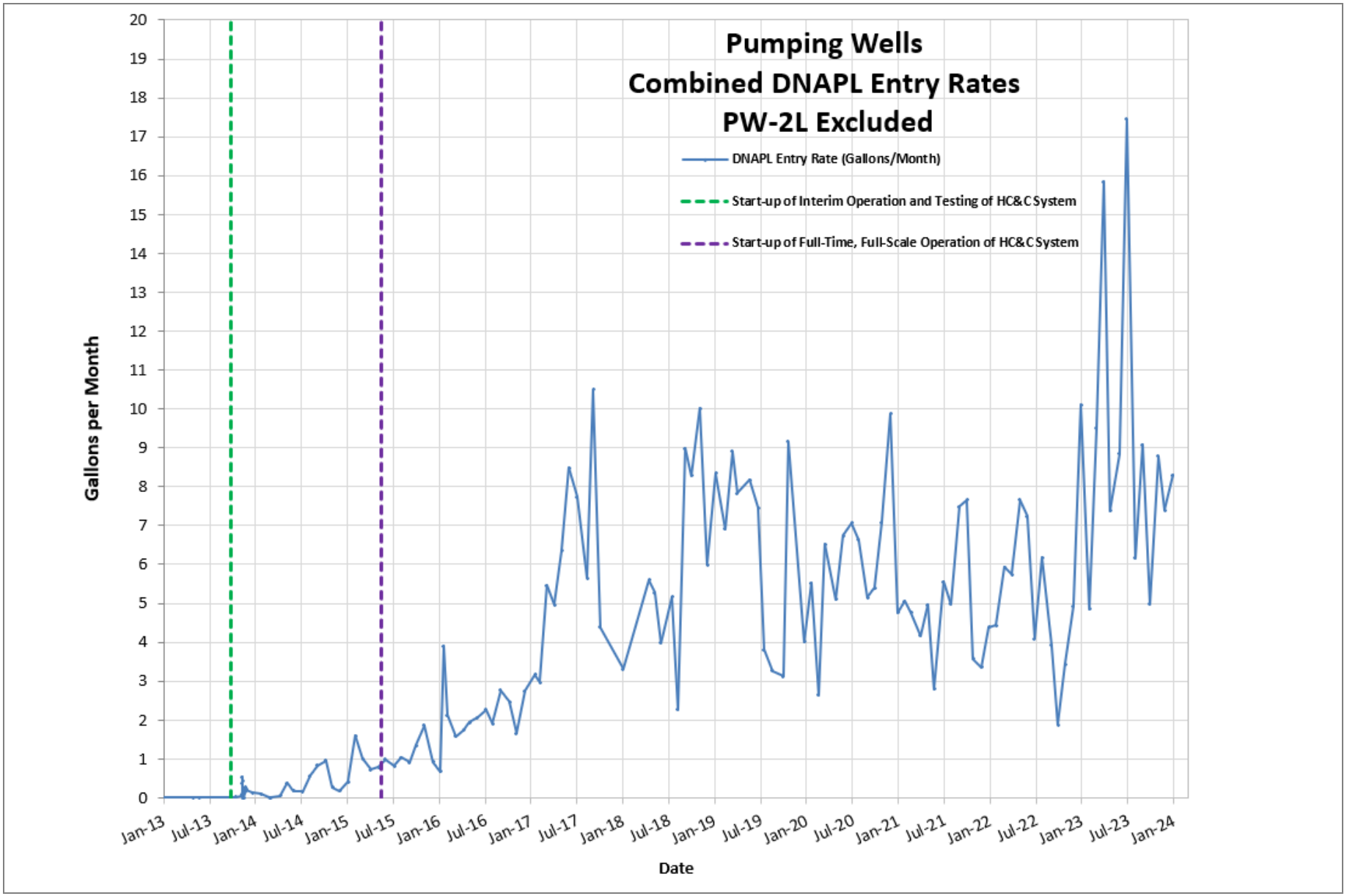
Figure 5a
Combined DNAPL Entry Rates – Non-Pumping Wells
DNAPL Monitoring Semiannual Summary Report (July 1 through December 31, 2023)
NW Natural Gasco Site



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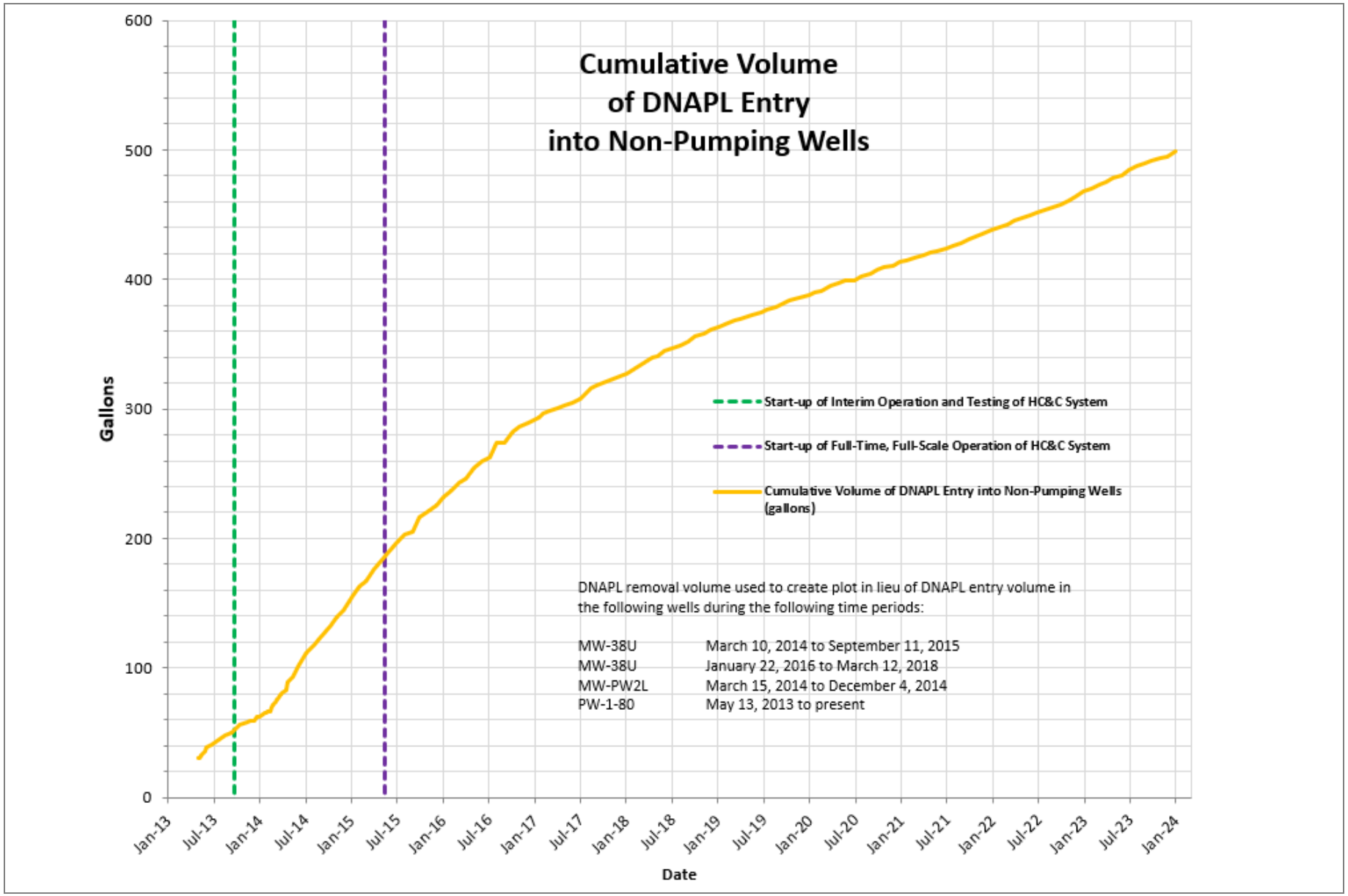
ANCHOR QEA

Figure 5b
Combined DNAPL Entry Rates – Pumping Wells (PW-2L Excluded)
DNAPL Monitoring Semiannual Summary Report (July 1 through December 31, 2023)
NW Natural Gasco Site



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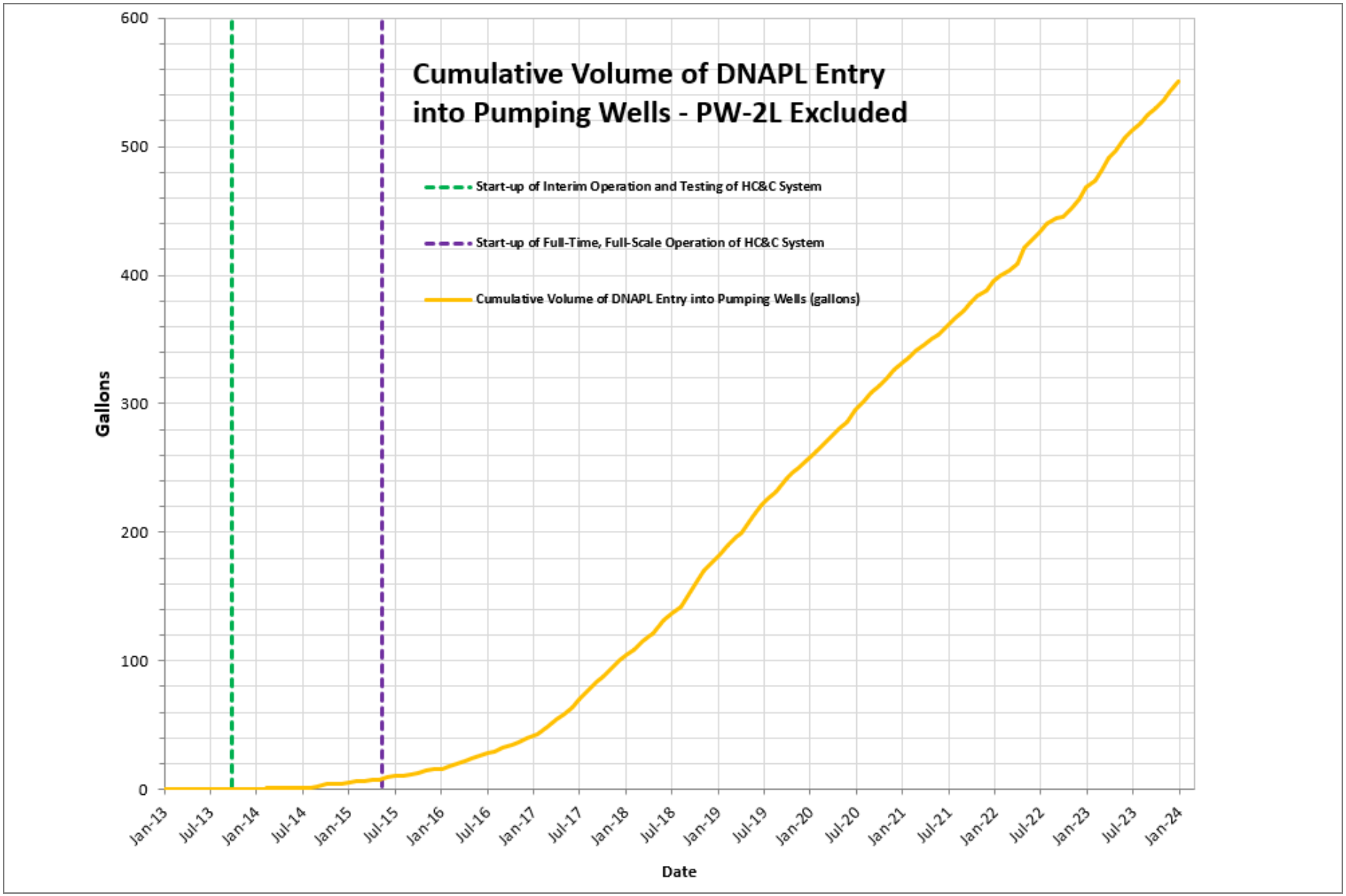
ANCHOR QEA

Figure 6a
Cumulative Volume of DNAPL Entry into Non-Pumping Wells
DNAPL Monitoring Semiannual Summary Report (July 1 through December 31, 2023)
NW Natural Gasco Site



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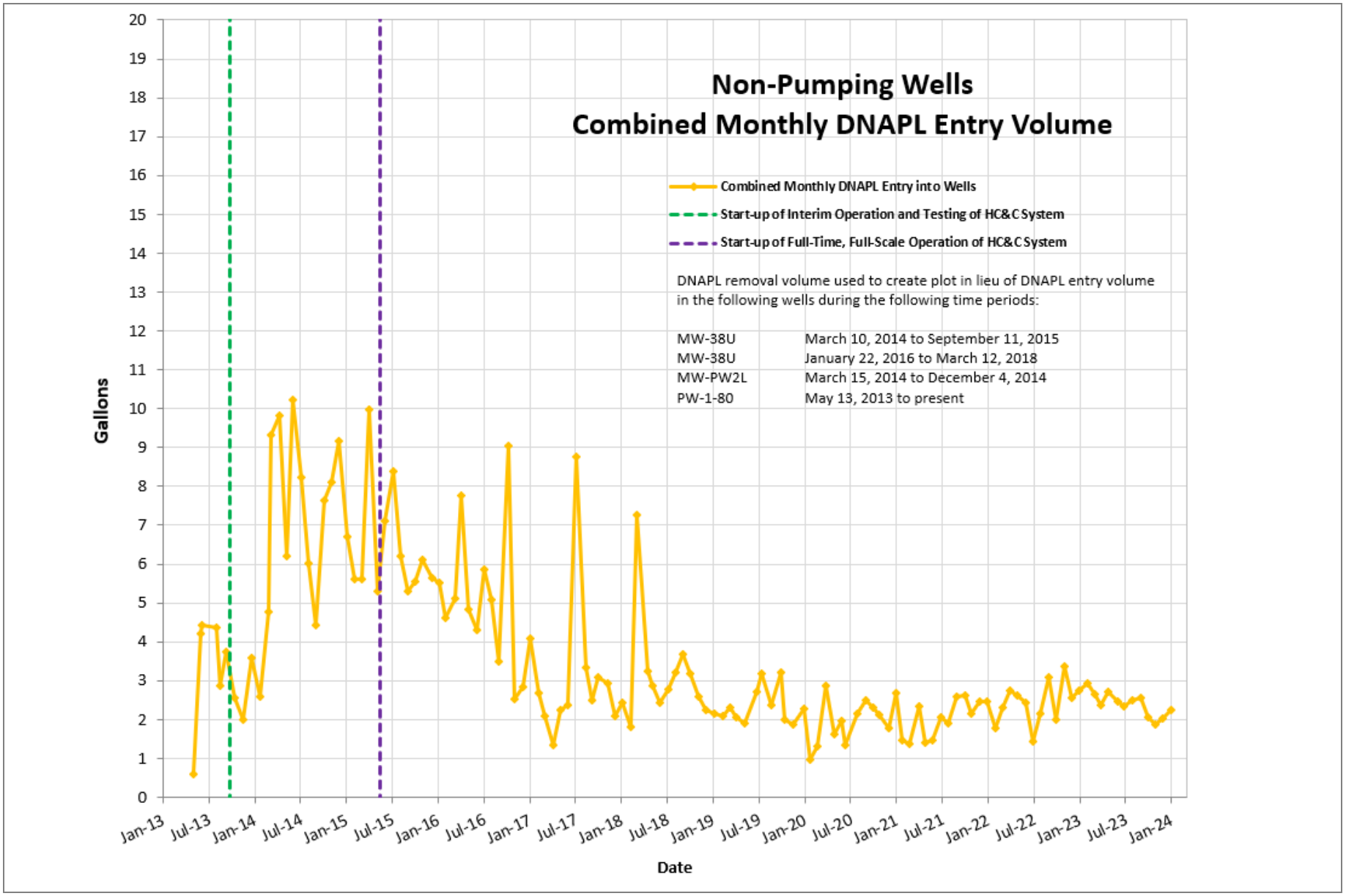
ANCHOR QEA

Figure 6b
Cumulative Volume of DNAPL Entry into Pumping Wells (PW-2L Excluded)
DNAPL Monitoring Semiannual Summary Report (July 1 through December 31, 2023)
NW Natural Gasco Site



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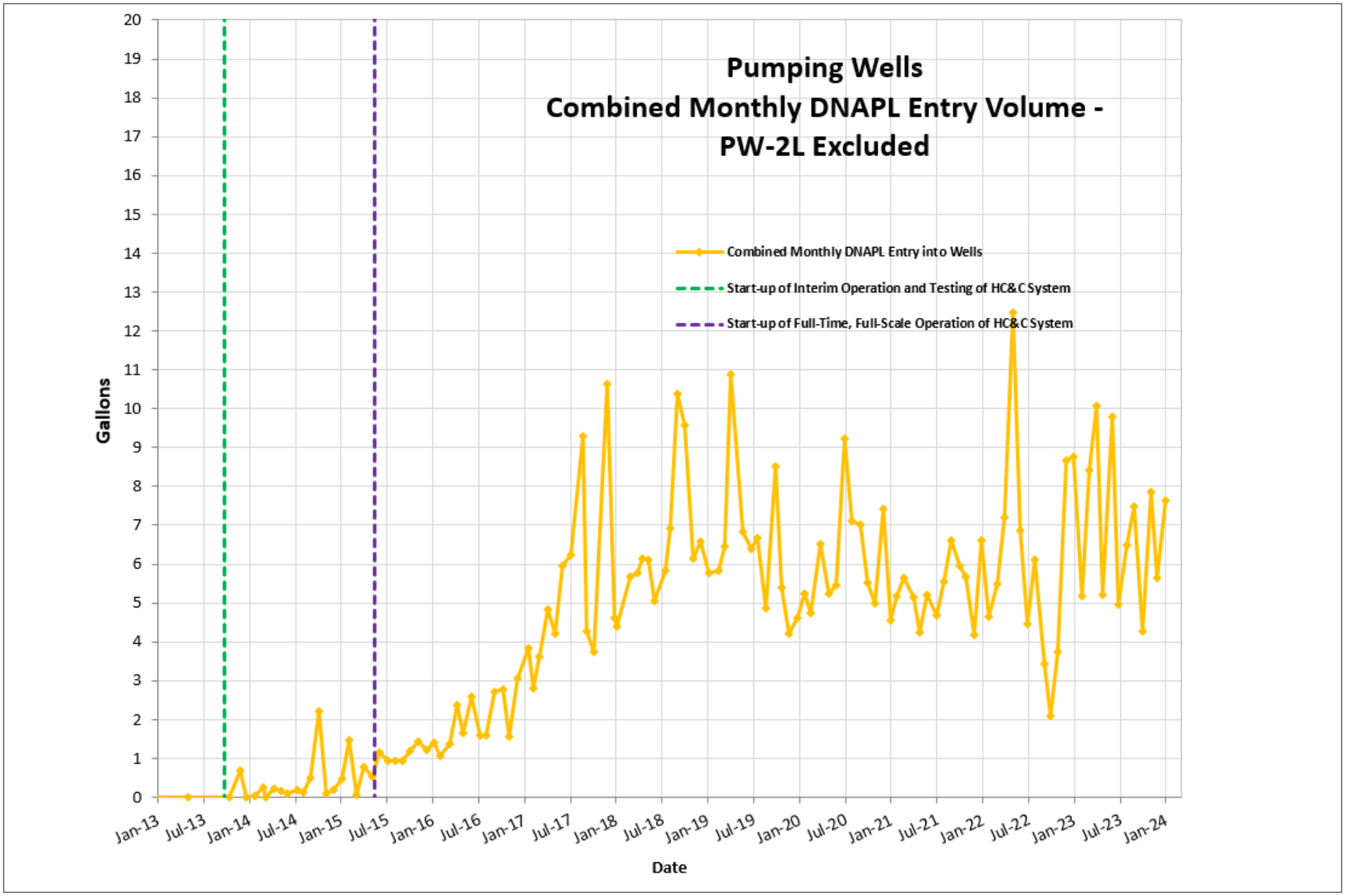
ANCHOR QEA

Figure 7a
Combined Monthly DNAPL Entry Volume – Non-Pumping Wells
DNAPL Monitoring Semiannual Summary Report (July 1 through December 31, 2023)
NW Natural Gasco Site



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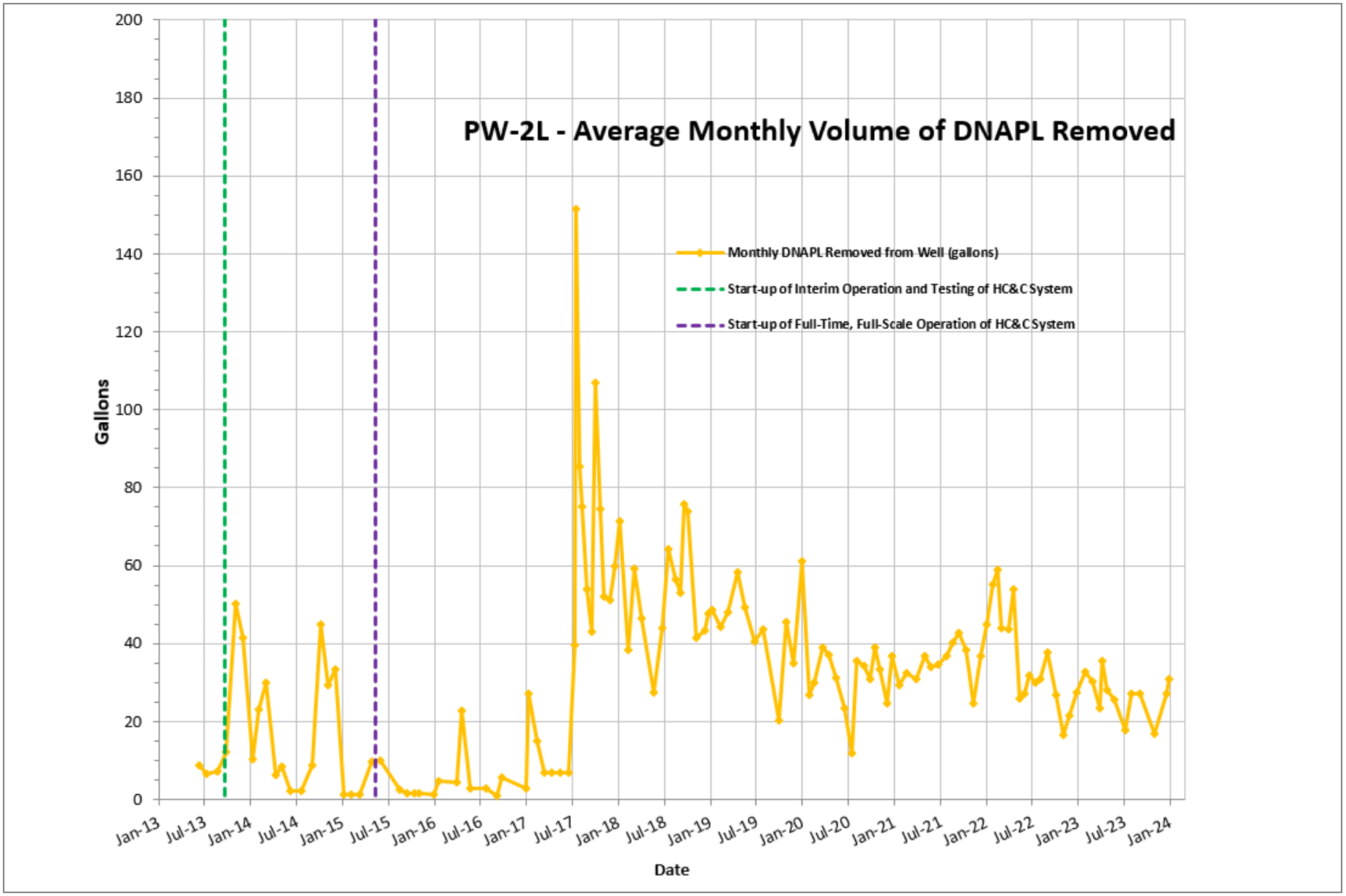
ANCHOR QEA

Figure 7b
Combined Monthly DNAPL Entry Volume – Pumping Wells (PW-2L Excluded)
DNAPL Monitoring Semiannual Summary Report (July 1 through December 31, 2023)
NW Natural Gasco Site



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ANCHOR QEA

Figure 7c

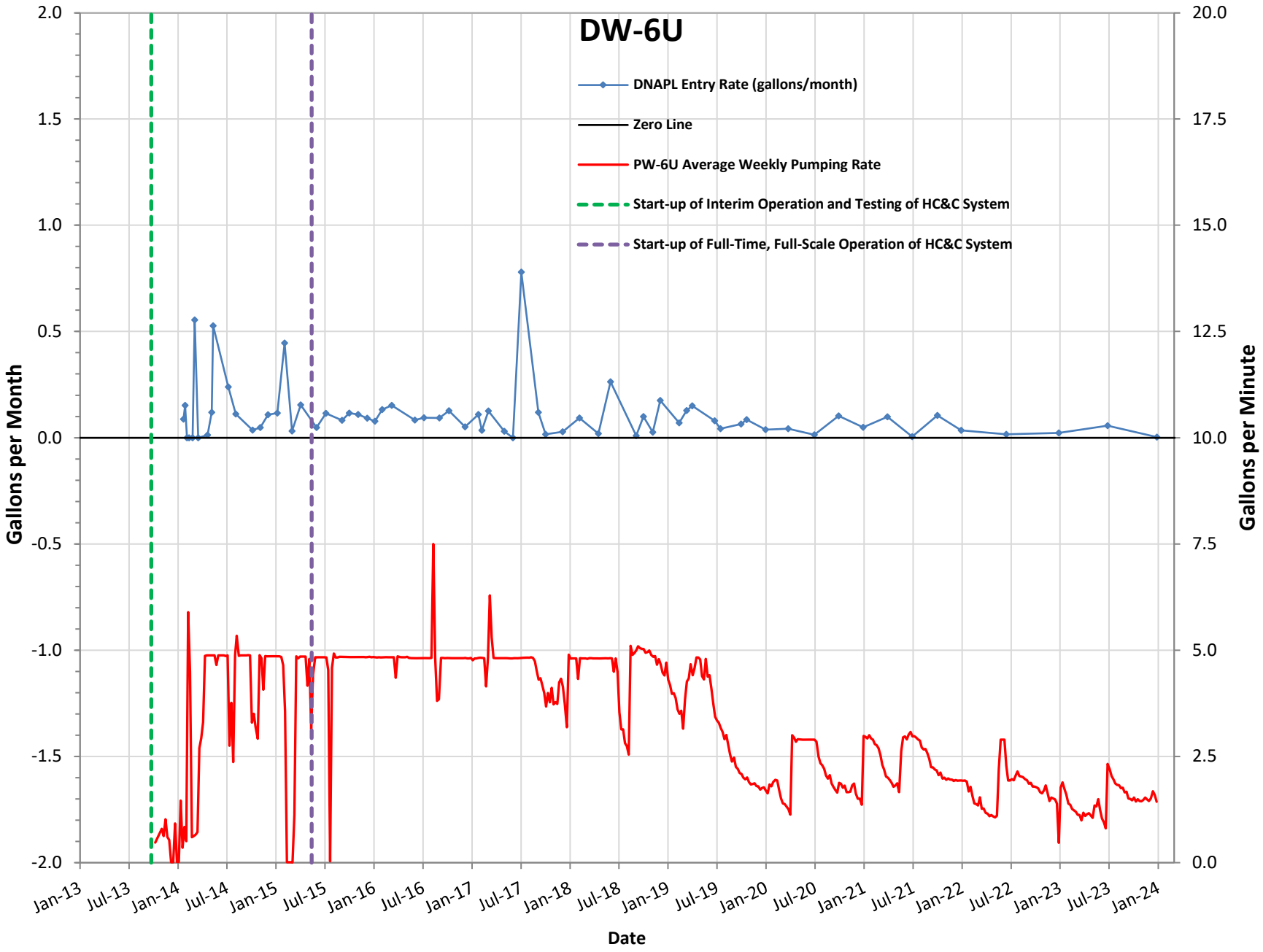
Average Monthly DNAPL Removal Volume – PW-2L

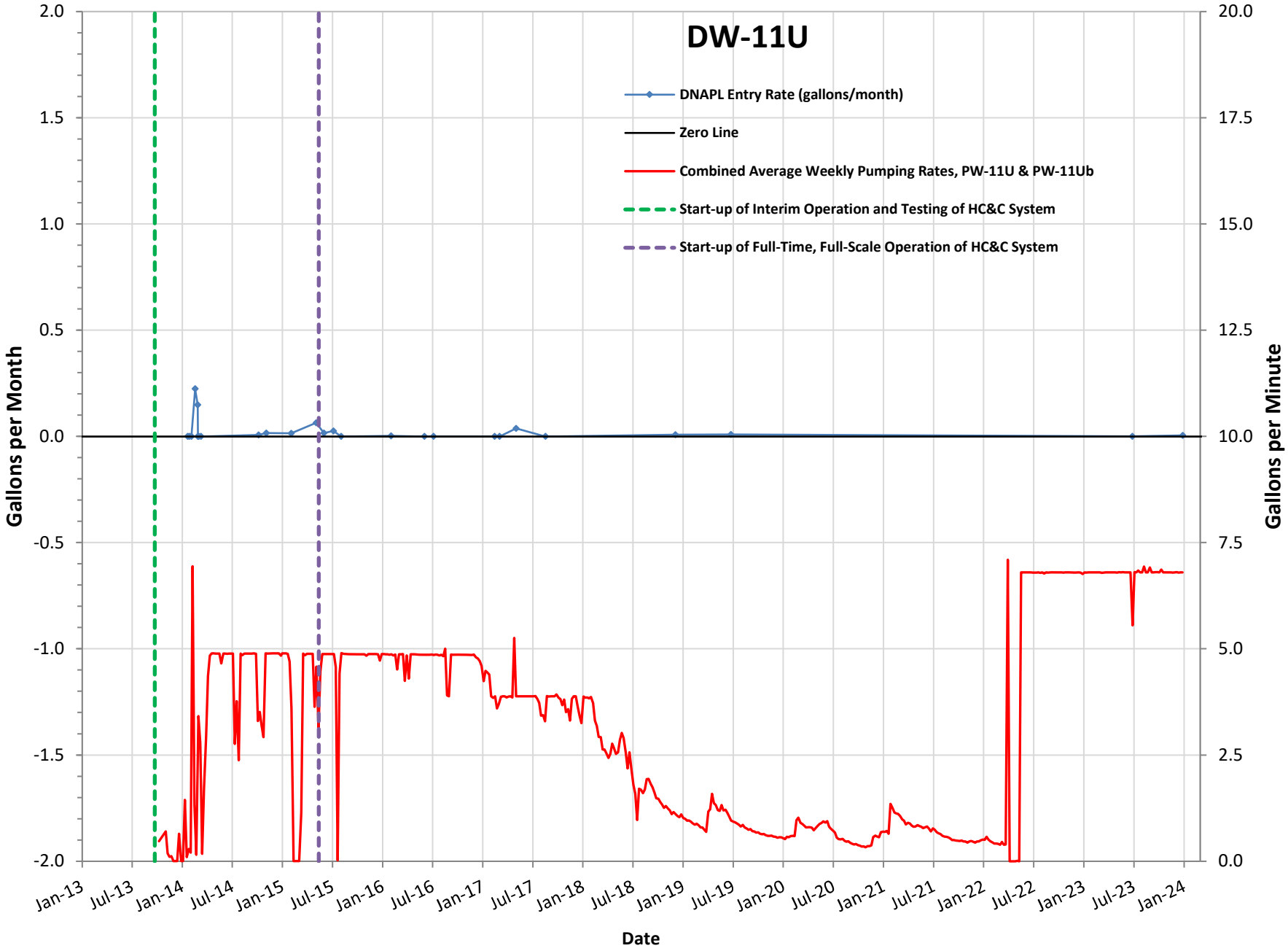
DNAPL Monitoring Semiannual Summary Report (July 1 through December 31, 2023)
NW Natural Gasco Site

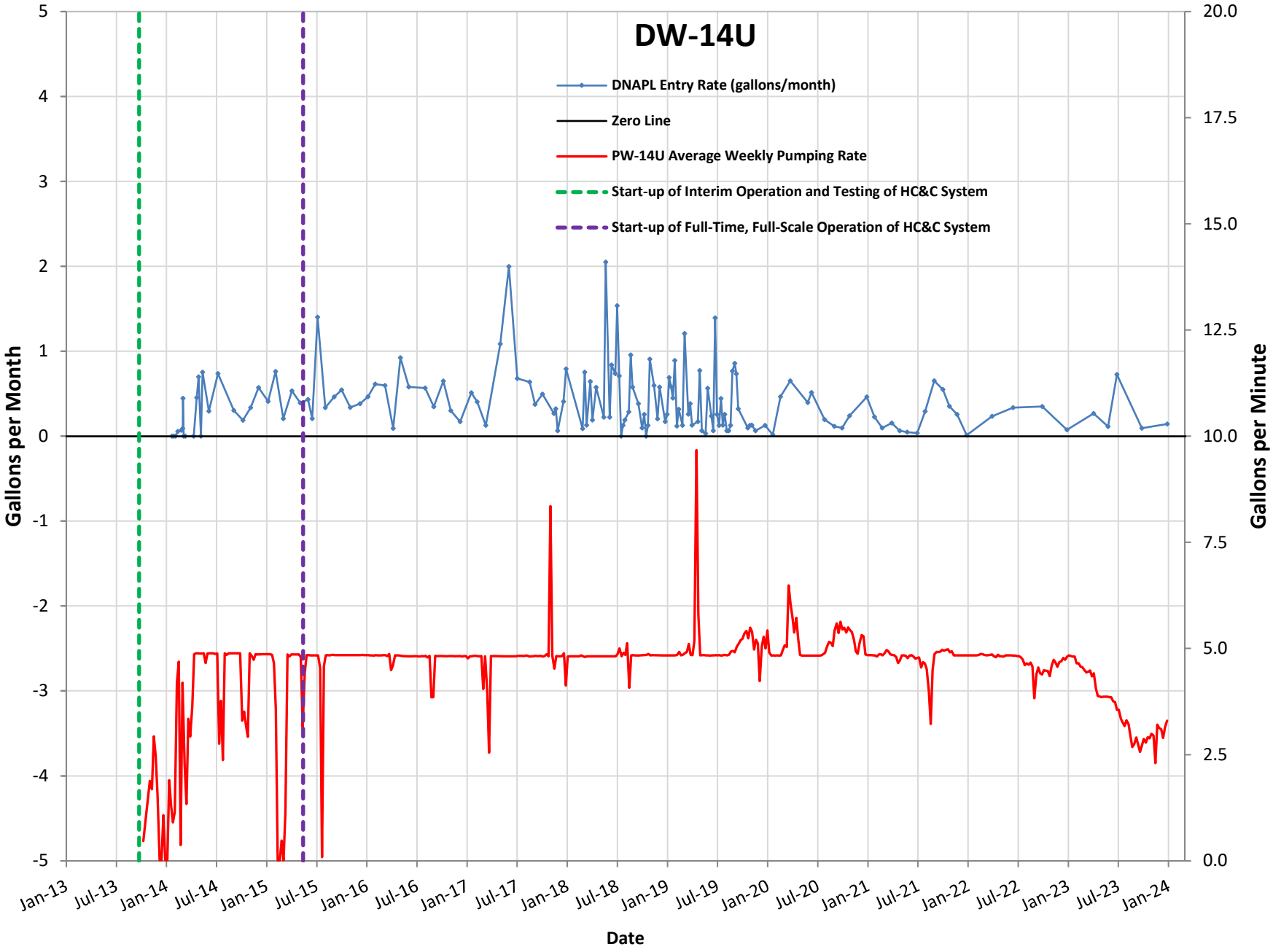
Appendix A
Comprehensive Table 2

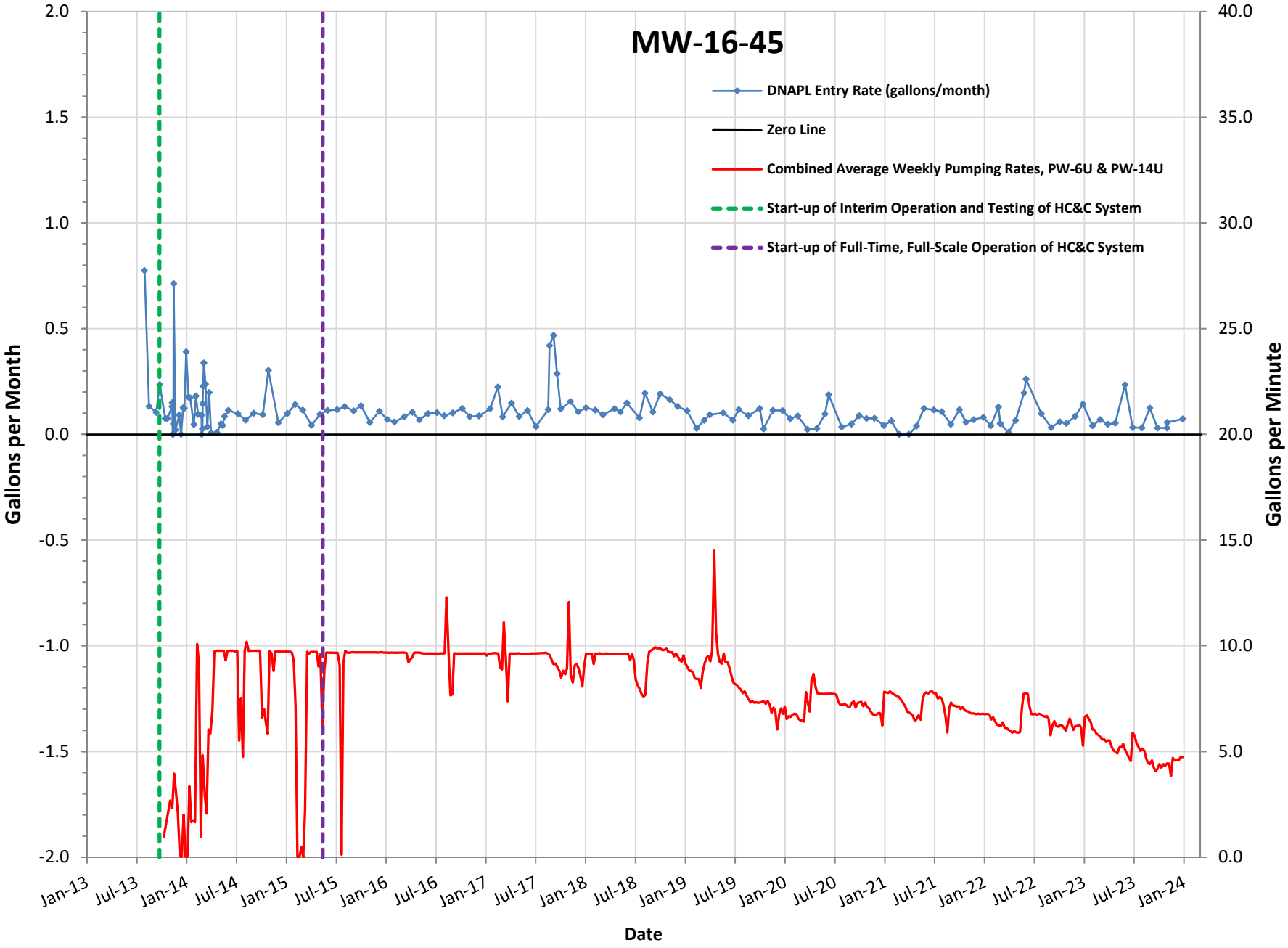
Included as an electronic file via SharePoint site upload.

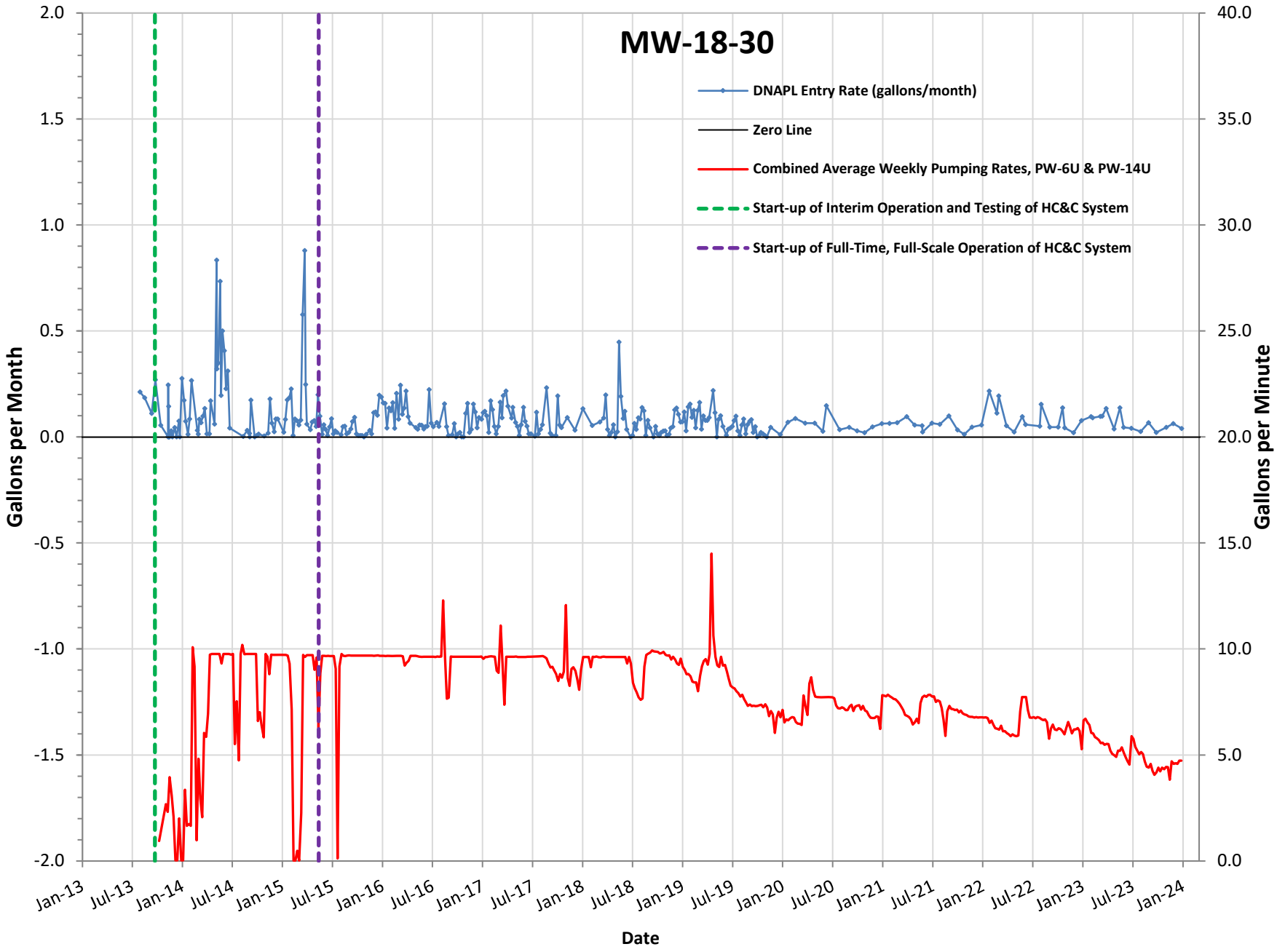
Appendix B
Time-Series Plots – DNAPL Entry Rates

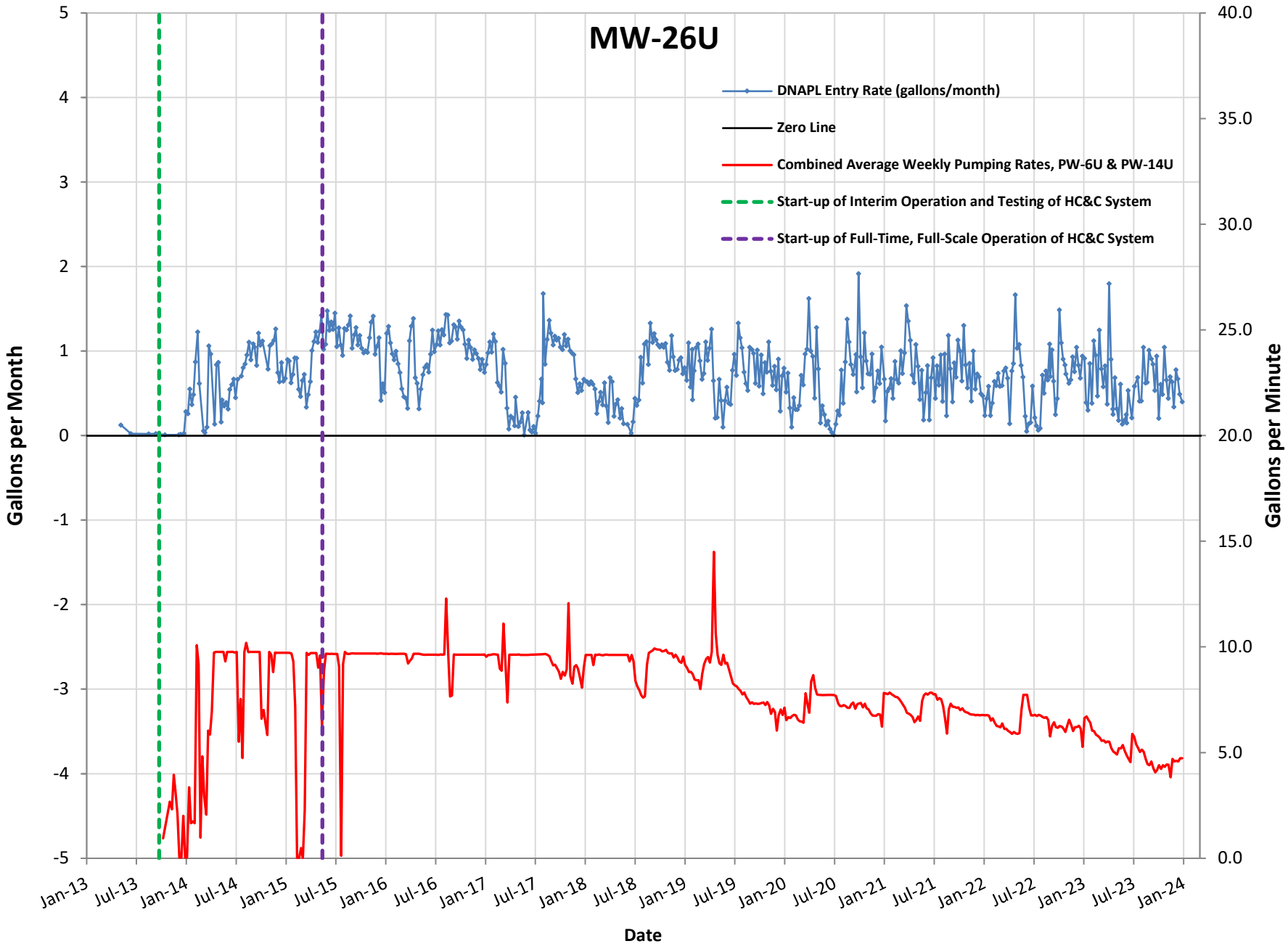

DW-6U
DNAPL Entry Rate (gallons/month)
Zero Line
PW-6U Average Weekly Pumping Rate
Start-up of Interim Operation and Testing of HC&C System
Start-up of Full-Time, Full-Scale Operation of HC&C System
Gallons per Month
Gallons per Minute
Date
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Jul-19
Jan-20
Jul-20
Jan-21
Jul-21
Jan-22
Jul-22
Jan-23
Jul-23
Jan-24

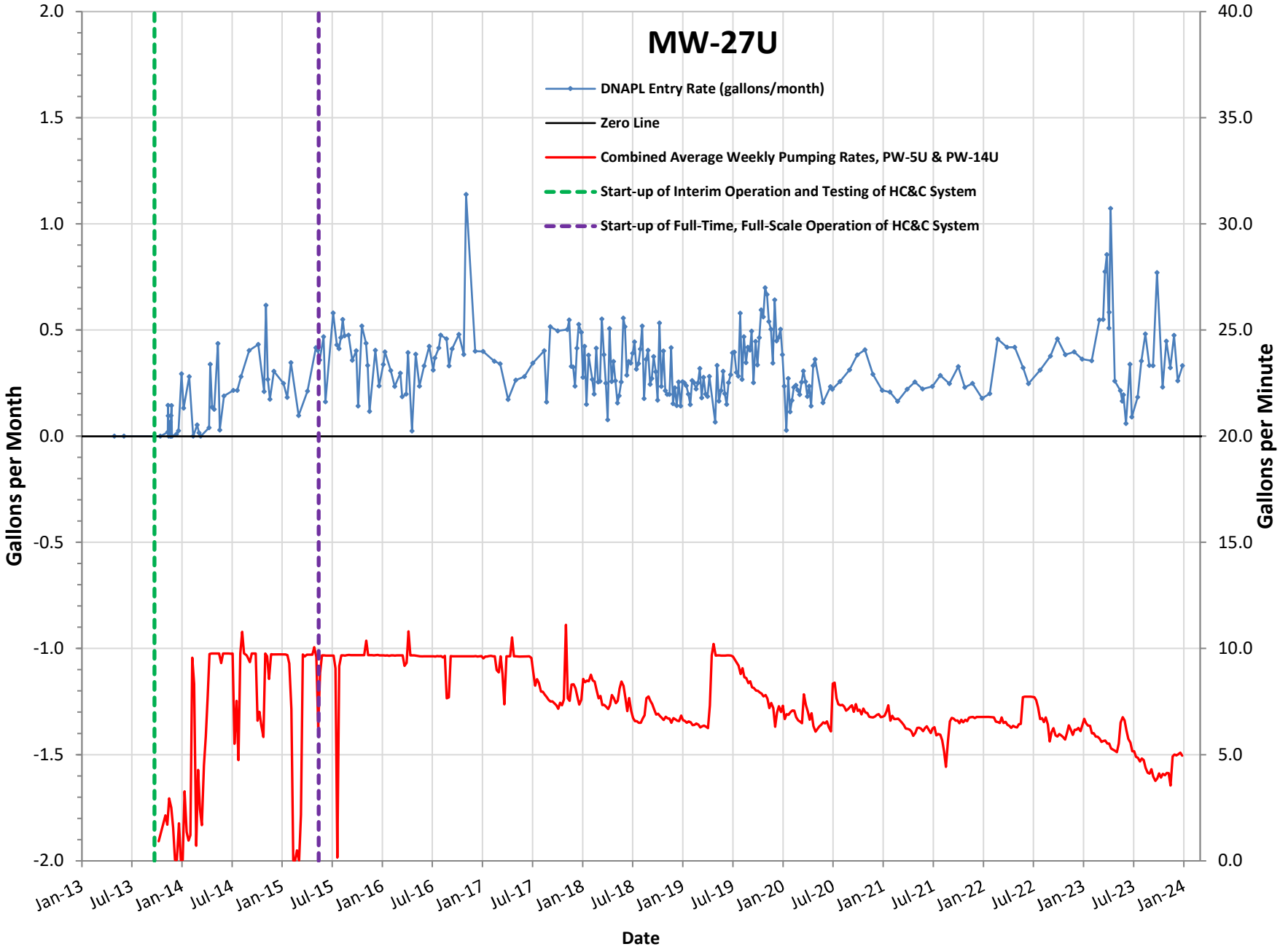

DW-11U
DNAPL Entry Rate (gallons/month)
Zero Line
Combined Average Weekly Pumping Rates, PW-11U & PW-11Ub
Start-up of Interim Operation and Testing of HC&C System
Start-up of Full-Time, Full-Scale Operation of HC&C System
Gallons per Month
Gallons per Minute
Date
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Jul-19
Jan-20
Jul-20
Jan-21
Jul-21
Jan-22
Jul-22
Jan-23
Jul-23
Jan-24

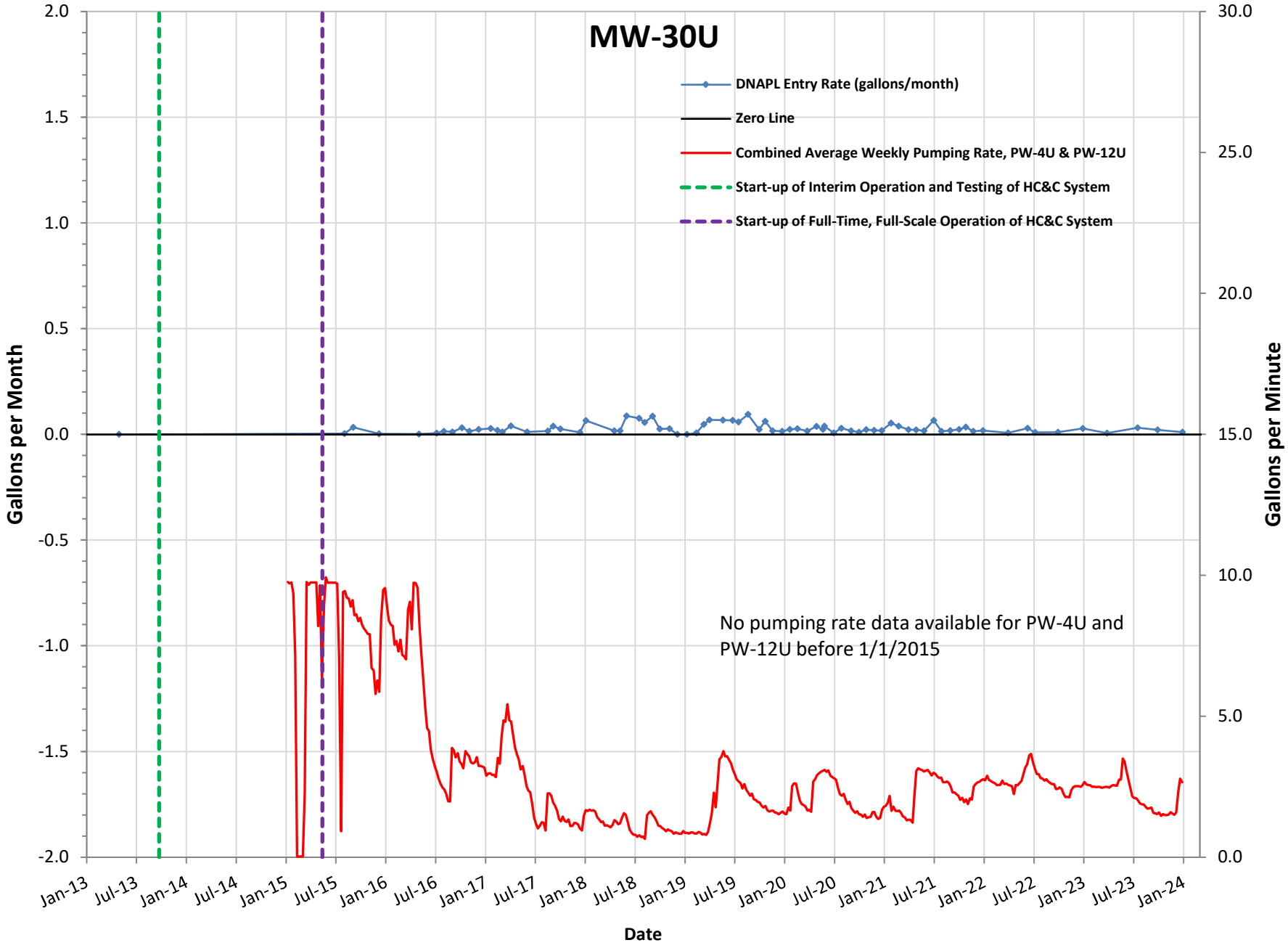

DW-14U
DNAPL Entry Rate (gallons/month)
Zero Line
PW-14U Average Weekly Pumping Rate
Start-up of Interim Operation and Testing of HC&C System
Start-up of Full-Time, Full-Scale Operation of HC&C System
Gallons per Month
Gallons per Minute
Date
5
4
3
2
1
0
-1
-2
-3
-4
-5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Jul-19
Jan-20
Jul-20
Jan-21
Jul-21
Jan-22
Jul-22
Jan-23
Jul-23
Jan-24

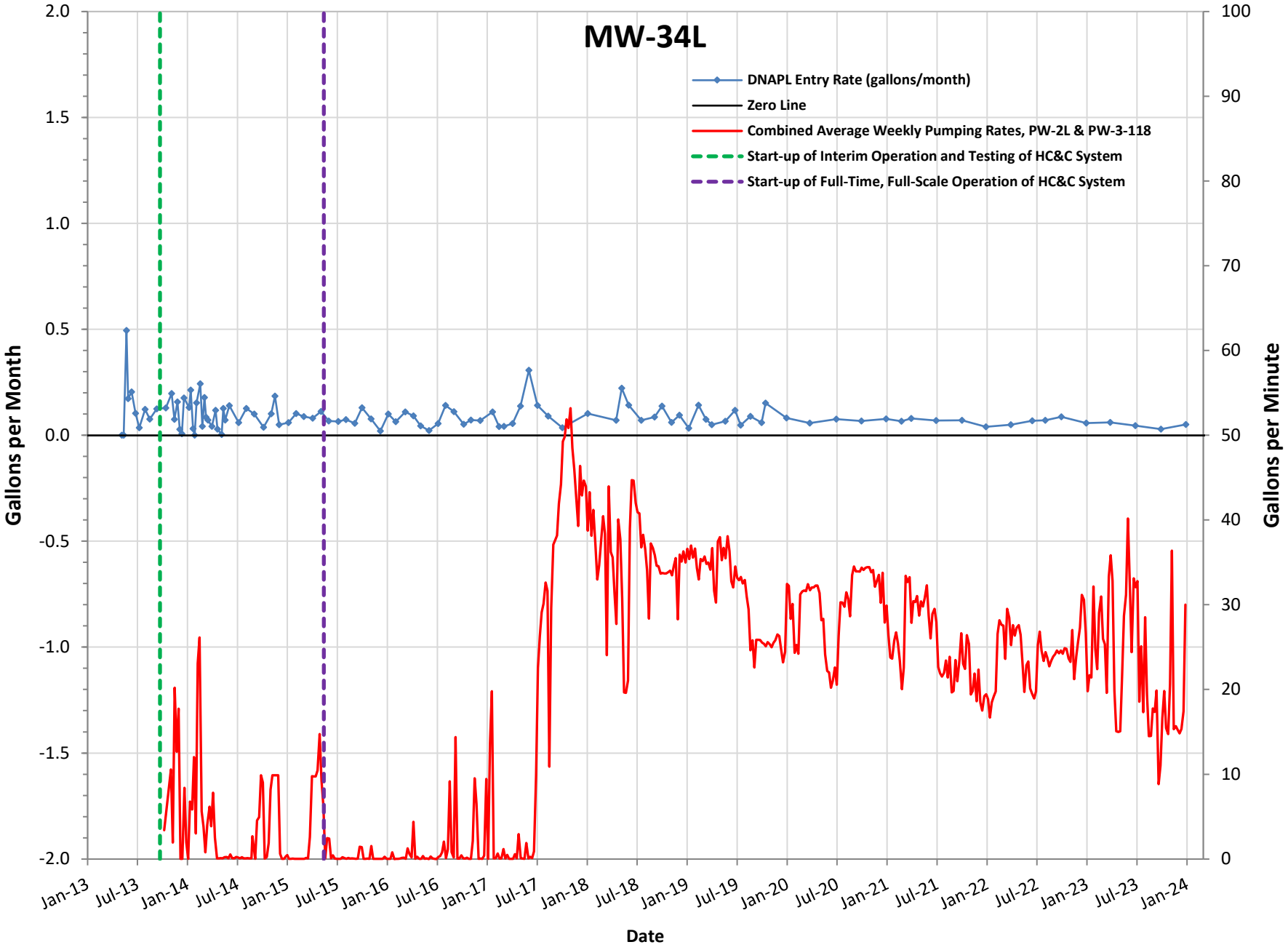

MW-16-45
DNAPL Entry Rate (gallons/month)
Zero Line
Combined Average Weekly Pumping Rates, PW-6U & PW-14U
Start-up of Interim Operation and Testing of HC&C System
Start-up of Full-Time, Full-Scale Operation of HC&C System
Gallons per Month
Gallons per Minute
Date
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Jul-19
Jan-20
Jul-20
Jan-21
Jul-21
Jan-22
Jul-22
Jan-23
Jul-23
Jan-24

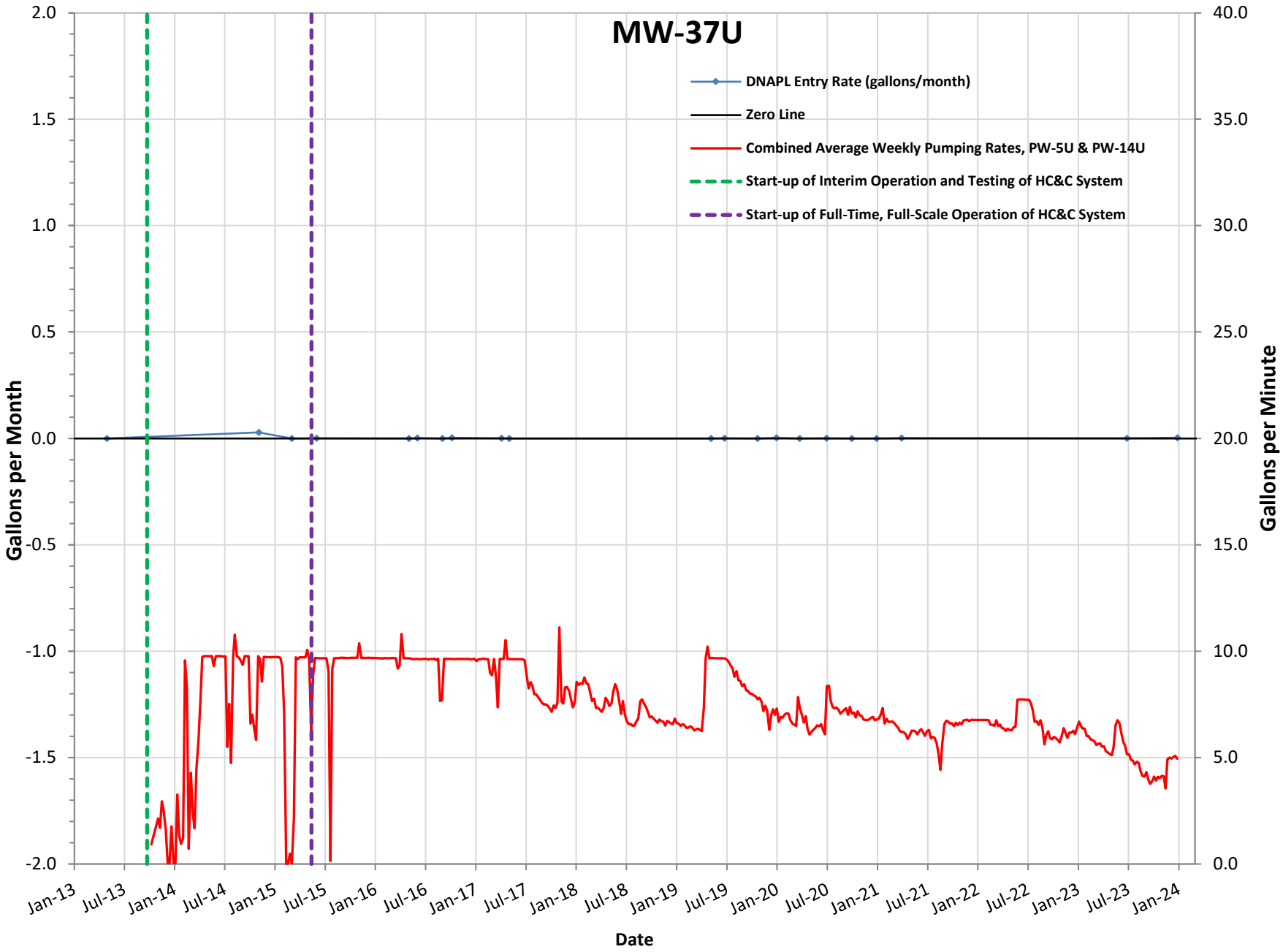

MW-18-30
DNAPL Entry Rate (gallons/month)
Zero Line
Combined Average Weekly Pumping Rates, PW-6U & PW-14U
Start-up of Interim Operation and Testing of HC&C System
Start-up of Full-Time, Full-Scale Operation of HC&C System
Gallons per Month
Gallons per Minute
Date
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Jul-19
Jan-20
Jul-20
Jan-21
Jul-21
Jan-22
Jul-22
Jan-23
Jul-23
Jan-24

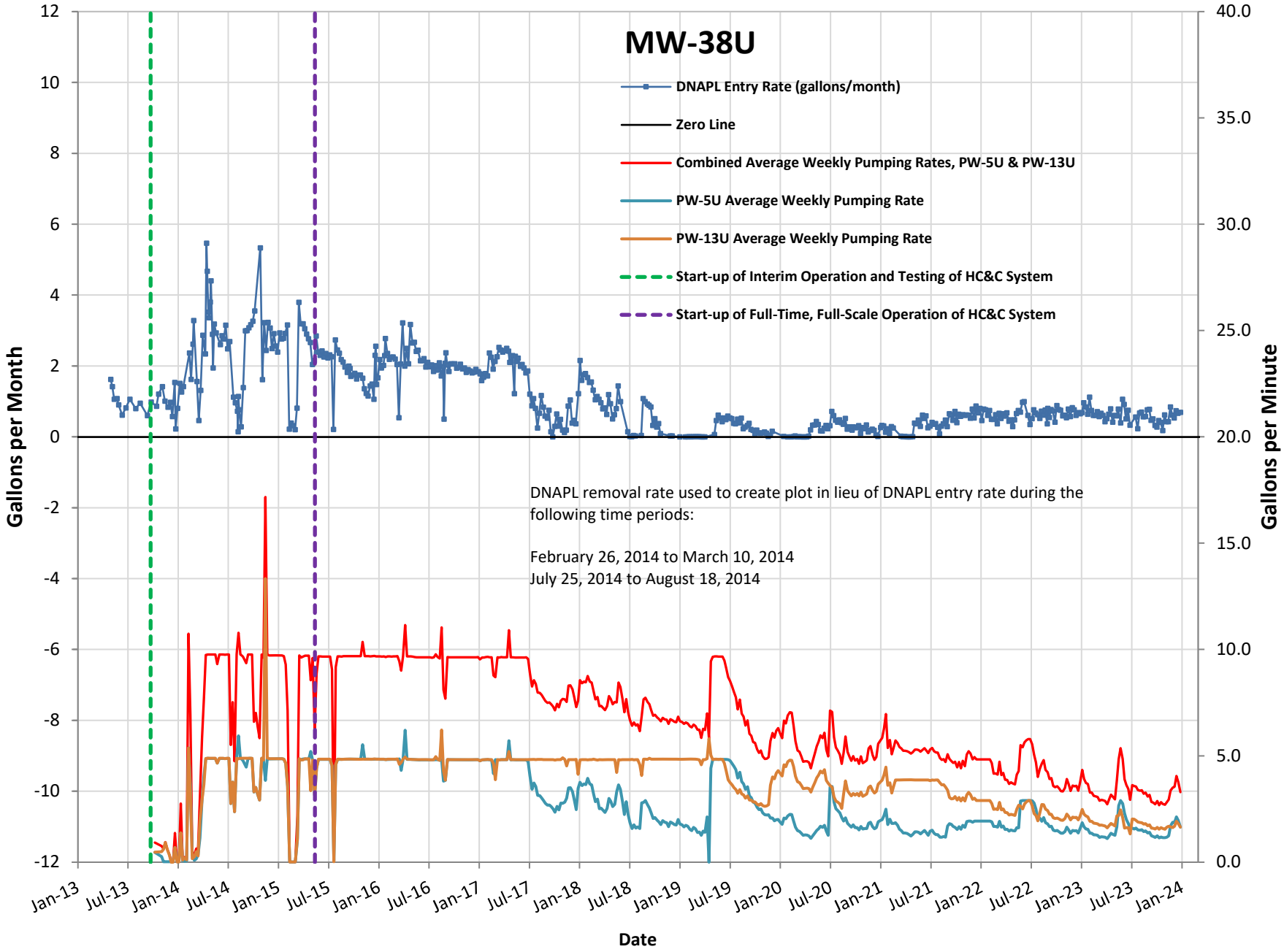

MW-26U
DNAPL Entry Rate (gallons/month)
Zero Line
Combined Average Weekly Pumping Rates, PW-6U & PW-14U
Start-up of Interim Operation and Testing of HC&C System
Start-up of Full-Time, Full-Scale Operation of HC&C System
Gallons per Month
Gallons per Minute
Date
5
4
3
2
1
0
-1
-2
-3
-4
-5
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Jul-19
Jan-20
Jul-20
Jan-21
Jul-21
Jan-22
Jul-22
Jan-23
Jul-23
Jan-24

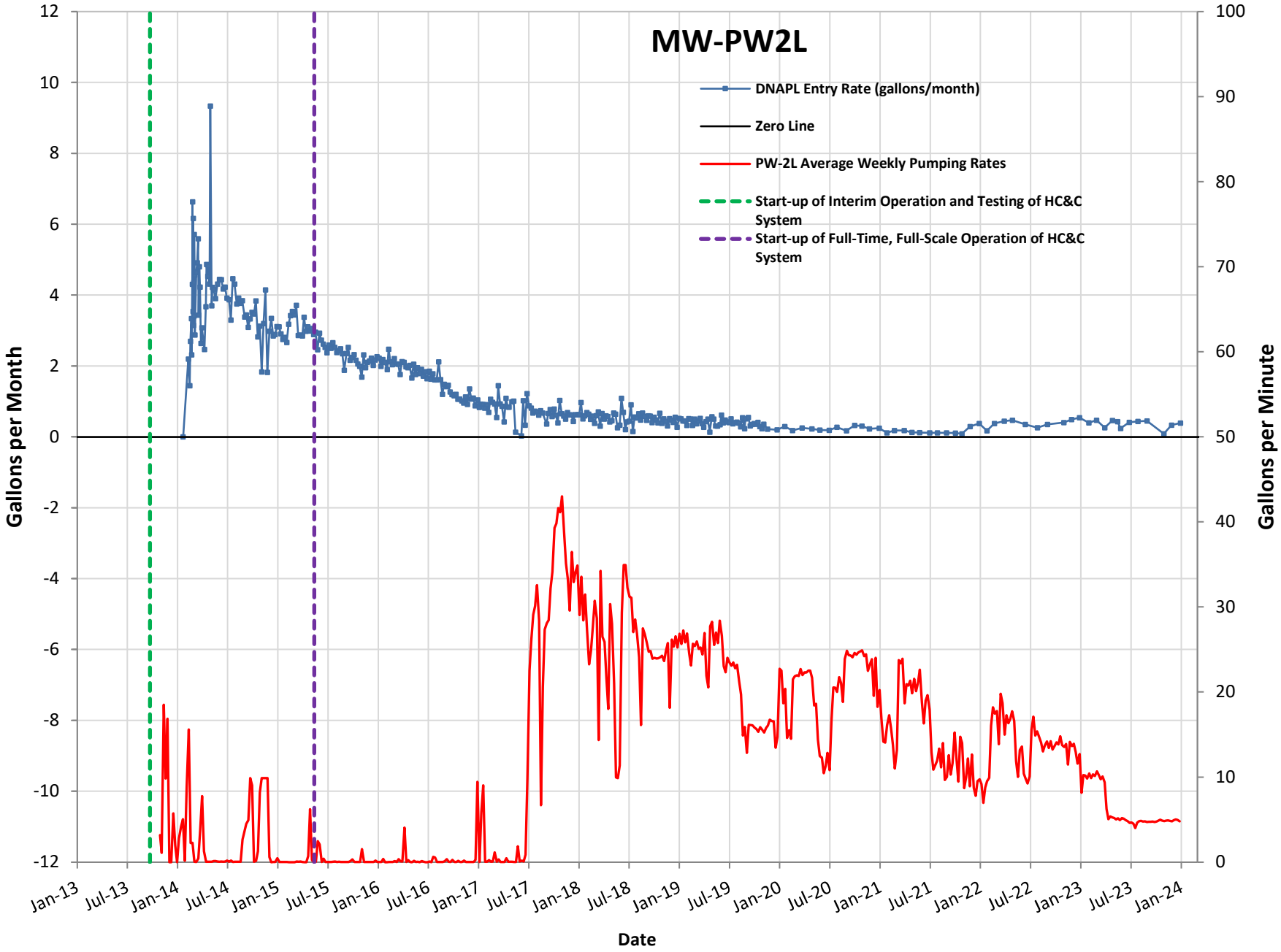

MW-27U
DNAPL Entry Rate (gallons/month)
Zero Line
Combined Average Weekly Pumping Rates, PW-5U & PW-14U
Start-up of Interim Operation and Testing of HC&C System
Start-up of Full-Time, Full-Scale Operation of HC&C System
Gallons per Month
Gallons per Minute
Date
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Jul-19
Jan-20
Jul-20
Jan-21
Jul-21
Jan-22
Jul-22
Jan-23
Jul-23
Jan-24


MW-30U
DNAPL Entry Rate (gallons/month)
Zero Line
Combined Average Weekly Pumping Rate, PW-4U & PW-12U
Start-up of Interim Operation and Testing of HC&C System
Start-up of Full-Time, Full-Scale Operation of HC&C System
No pumping rate data available for PW-4U and PW-12U before 1/1/2015
Gallons per Month
Gallons per Minute
Date
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Jul-19
Jan-20
Jul-20
Jan-21
Jul-21
Jan-22
Jul-22
Jan-23
Jul-23
Jan-24


MW-34L
DNAPL Entry Rate (gallons/month)
Zero Line
Combined Average Weekly Pumping Rates, PW-2L & PW-3-118
Start-up of Interim Operation and Testing of HC&C System
Start-up of Full-Time, Full-Scale Operation of HC&C System
Gallons per Month
Gallons per Minute
Date
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
100
90
80
70
60
50
40
30
20
10
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Jul-19
Jan-20
Jul-20
Jan-21
Jul-21
Jan-22
Jul-22
Jan-23
Jul-23
Jan-24


MW-37U
DNAPL Entry Rate (gallons/month)
Zero Line
Combined Average Weekly Pumping Rates, PW-5U & PW-14U
Start-up of Interim Operation and Testing of HC&C System
Start-up of Full-Time, Full-Scale Operation of HC&C System
Gallons per Month
Gallons per Minute
Date
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Jul-19
Jan-20
Jul-20
Jan-21
Jul-21
Jan-22
Jul-22
Jan-23
Jul-23
Jan-24


MW-38U
DNAPL Entry Rate (gallons/month)
Zero Line
Combined Average Weekly Pumping Rates, PW-5U & PW-13U
PW-5U Average Weekly Pumping Rate
PW-13U Average Weekly Pumping Rate
Start-up of Interim Operation and Testing of HC&C System
Start-up of Full-Time, Full-Scale Operation of HC&C System
DNAPL removal rate used to create plot in lieu of DNAPL entry rate during the following time periods:
February 26, 2014 to March 10, 2014
July 25, 2014 to August 18, 2014
Gallons per Month
Gallons per Minute
Date
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Jul-19
Jan-20
Jul-20
Jan-21
Jul-21
Jan-22
Jul-22
Jan-23
Jul-23
Jan-24


MW-PW2L
DNAPL Entry Rate (gallons/month)
Zero Line
PW-2L Average Weekly Pumping Rates
Start-up of Interim Operation and Testing of HC&C System
Start-up of Full-Time, Full-Scale Operation of HC&C System
Gallons per Month
Gallons per Minute
Date
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
100
90
80
70
60
50
40
30
20
10
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Jul-19
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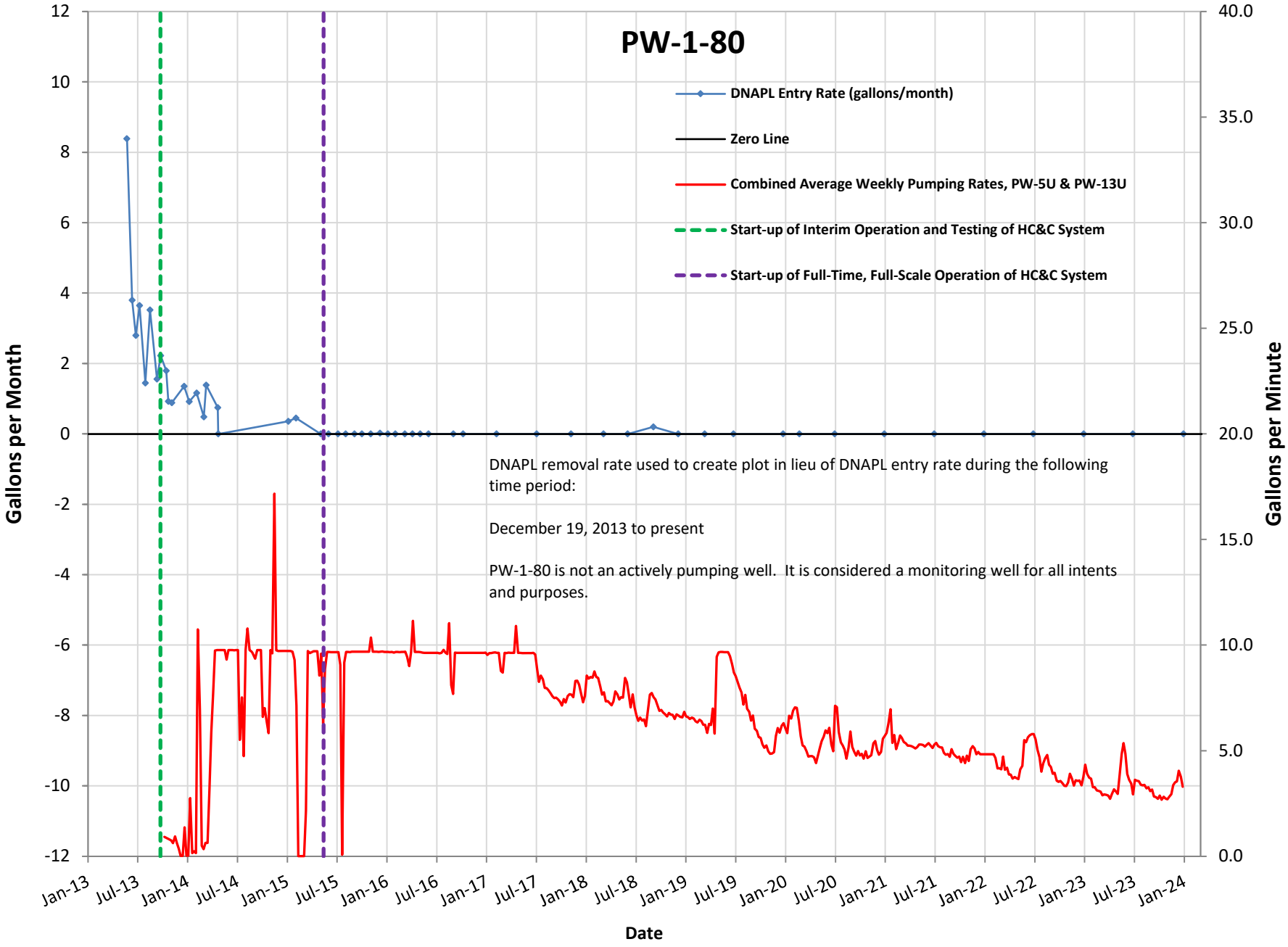
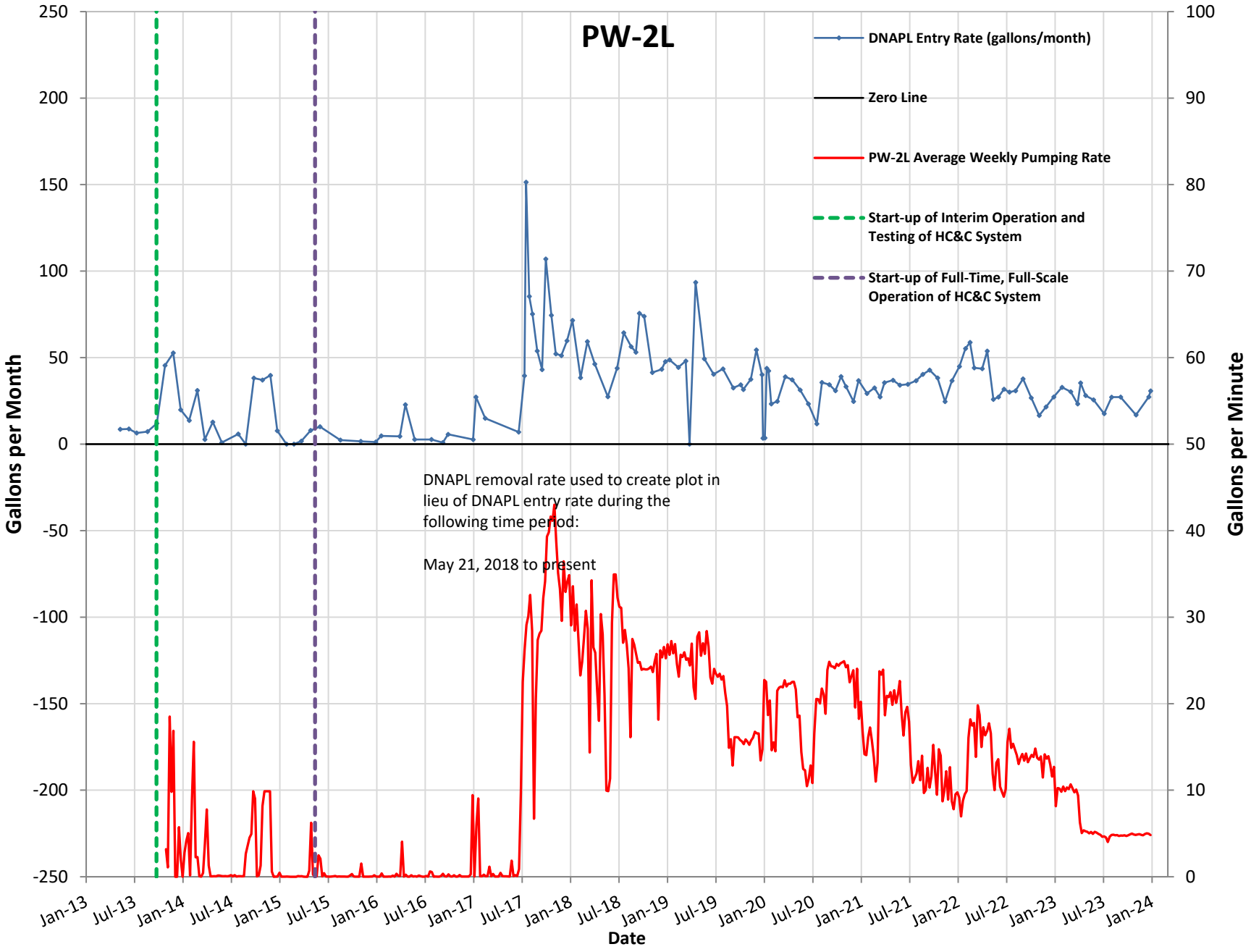
Jul-20
Jan-21
Jul-21
Jan-22
Jul-22
Jan-23
Jul-23
Jan-24


PW-1-80
DNAPL Entry Rate (gallons/month)
Zero Line
Combined Average Weekly Pumping Rates, PW-5U & PW-13U
Start-up of Interim Operation and Testing of HC&C System
Start-up of Full-Time, Full-Scale Operation of HC&C System
DNAPL removal rate used to create plot in lieu of DNAPL entry rate during the following time period:
December 19, 2013 to present
PW-1-80 is not an actively pumping well. It is considered a monitoring well for all intents and purposes.
Gallons per Month
Gallons per Minute
Date
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Jul-19
Jan-20
Jul-20
Jan-21
Jul-21
Jan-22
Jul-22
Jan-23
Jul-23
Jan-24


PW-2L
DNAPL Entry Rate (gallons/month)
Zero Line
PW-2L Average Weekly Pumping Rate
Start-up of Interim Operation and Testing of HC&C System
Start-up of Full-Time, Full-Scale Operation of HC&C System
DNAPL removal rate used to create plot in lieu of DNAPL entry rate during the following time period:
May 21, 2018 to present
Gallons per Month
Gallons per Minute
Date
250
200
150
100
50
0
-50
-100
-150
-200
-250
100
90
80
70
60
50
40
30
20
10
0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Jul-19
Jan-20
Jul-20
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Jul-21
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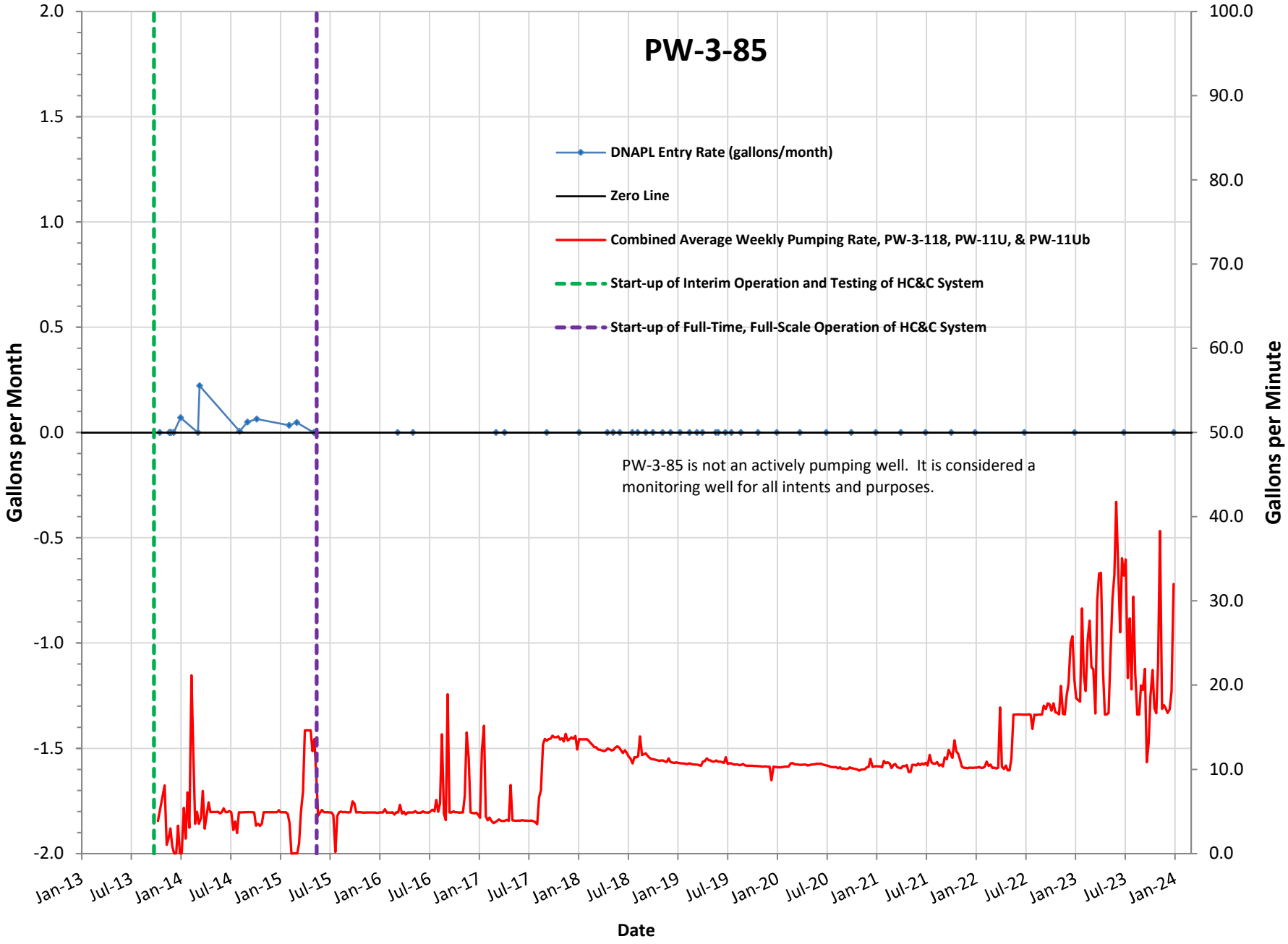
Jul-22
Jan-23
Jul-23
Jan-24


PW-3-85
DNAPL Entry Rate (gallons/month)
Zero Line
Combined Average Weekly Pumping Rate, PW-3-118, PW-11U, & PW-11Ub
Start-up of Interim Operation and Testing of HC&C System
Start-up of Full-Time, Full-Scale Operation of HC&C System
PW-3-85 is not an actively pumping well. It is considered a monitoring well for all intents and purposes.
Gallons per Month
Gallons per Minute
Date
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
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Jul-20
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Jul-21
Jan-22
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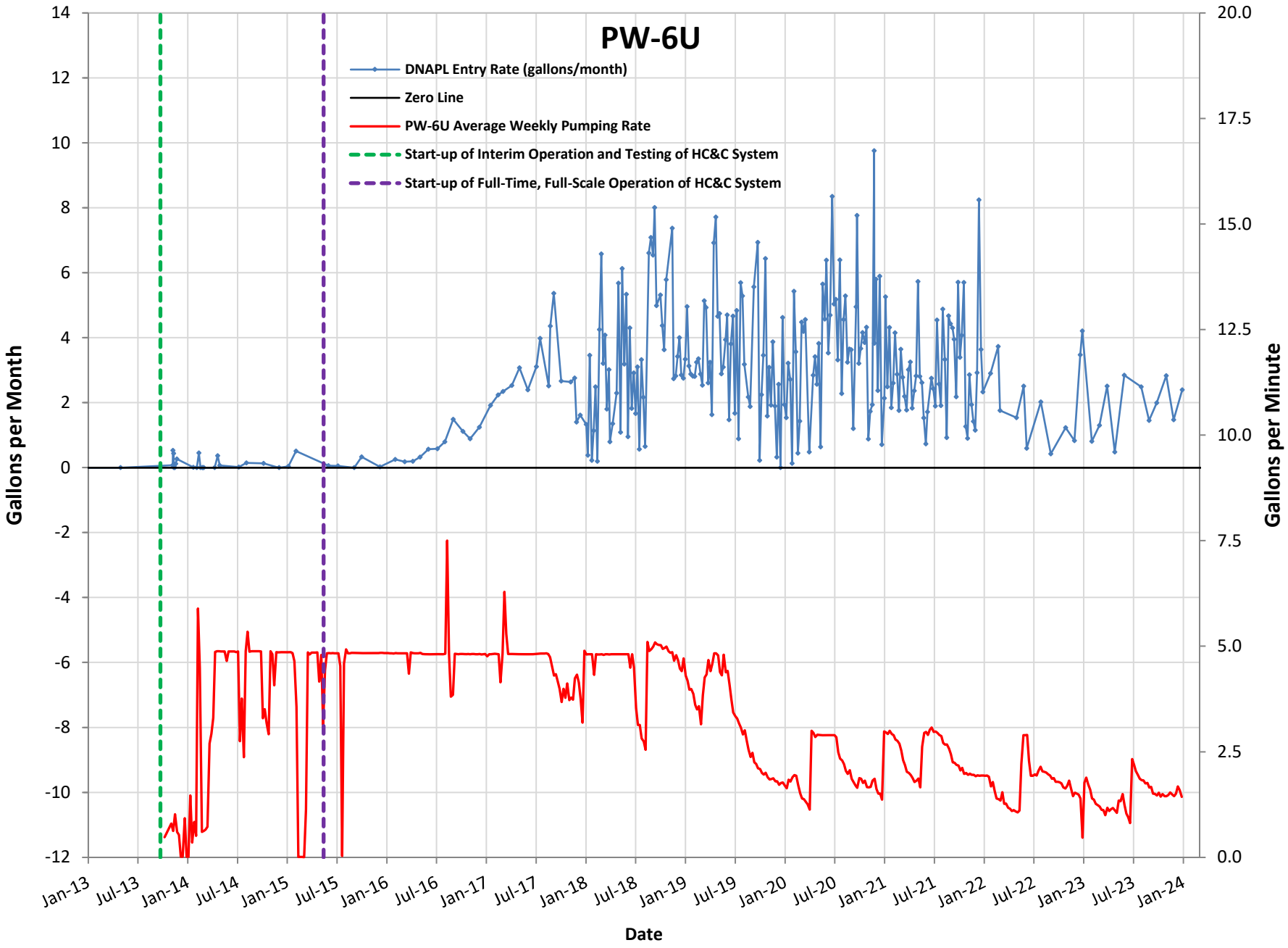
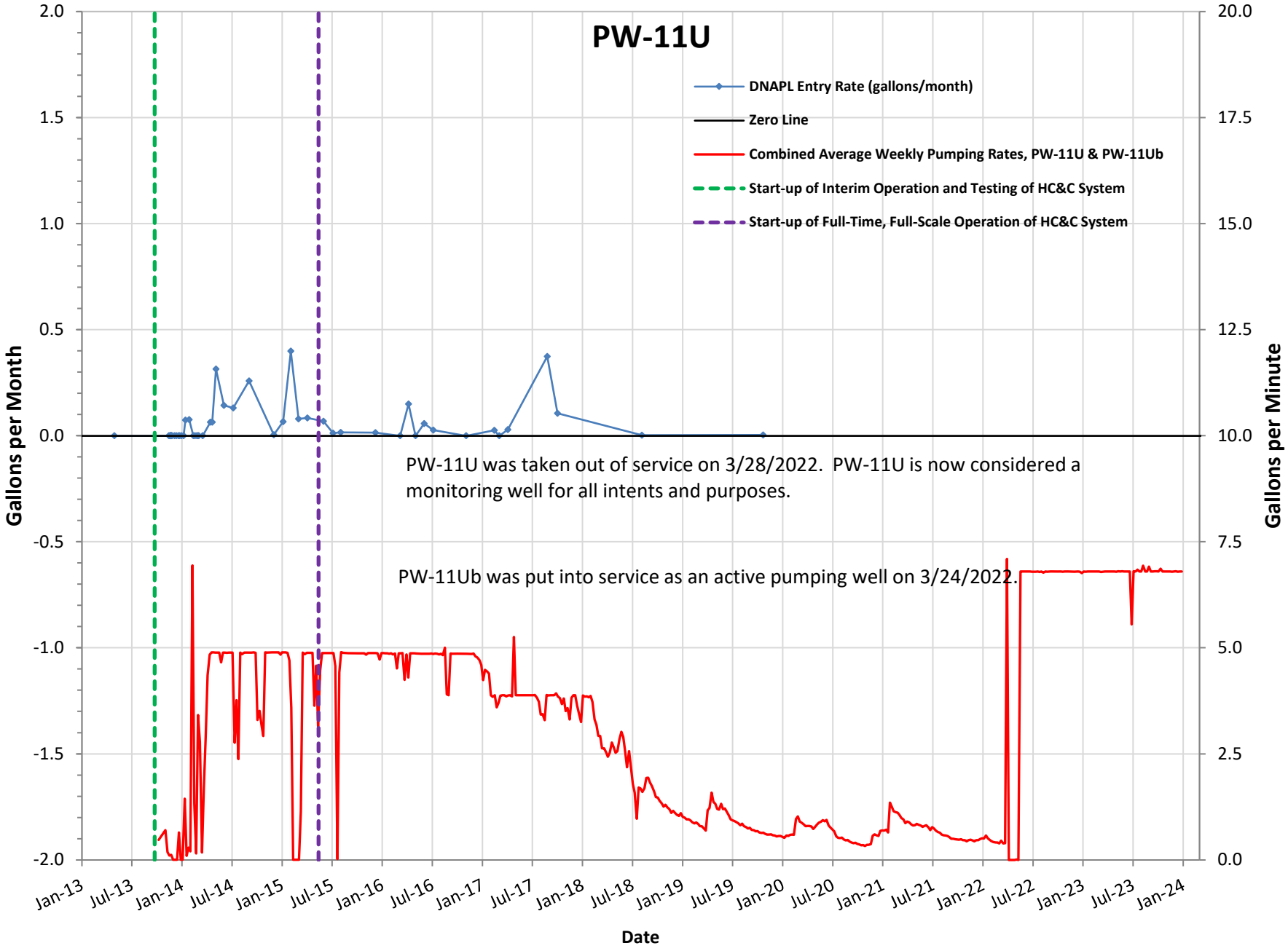
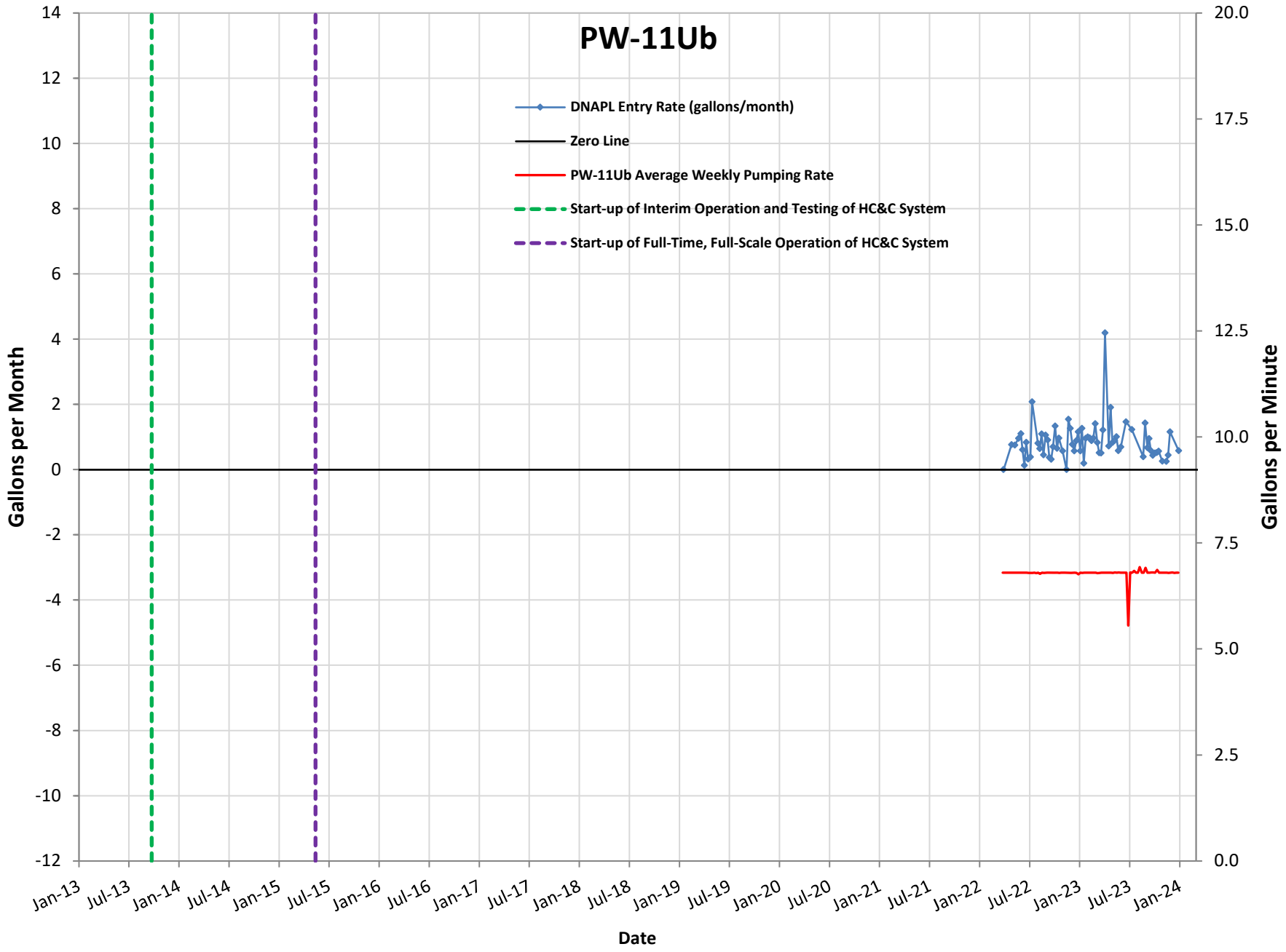
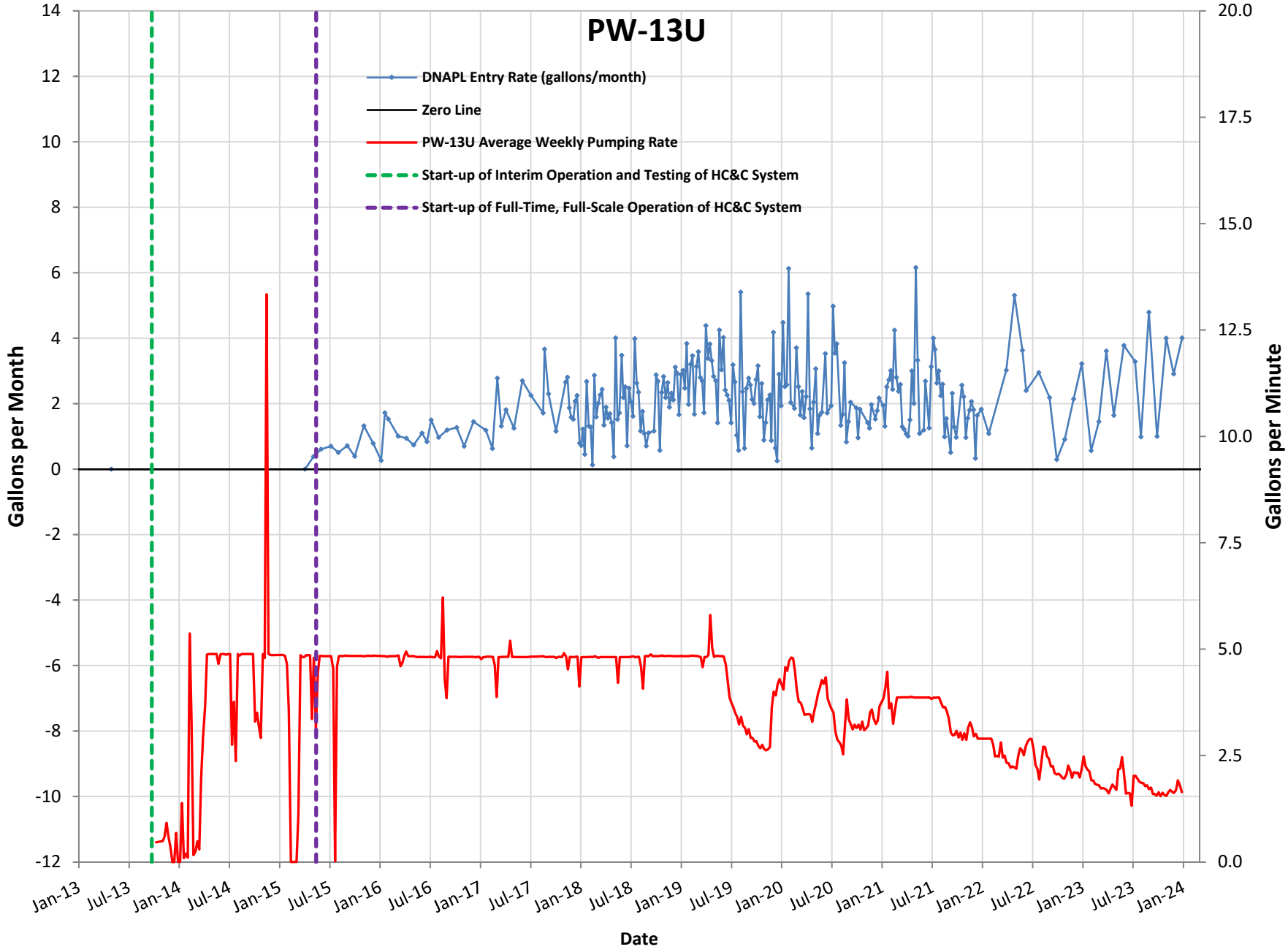
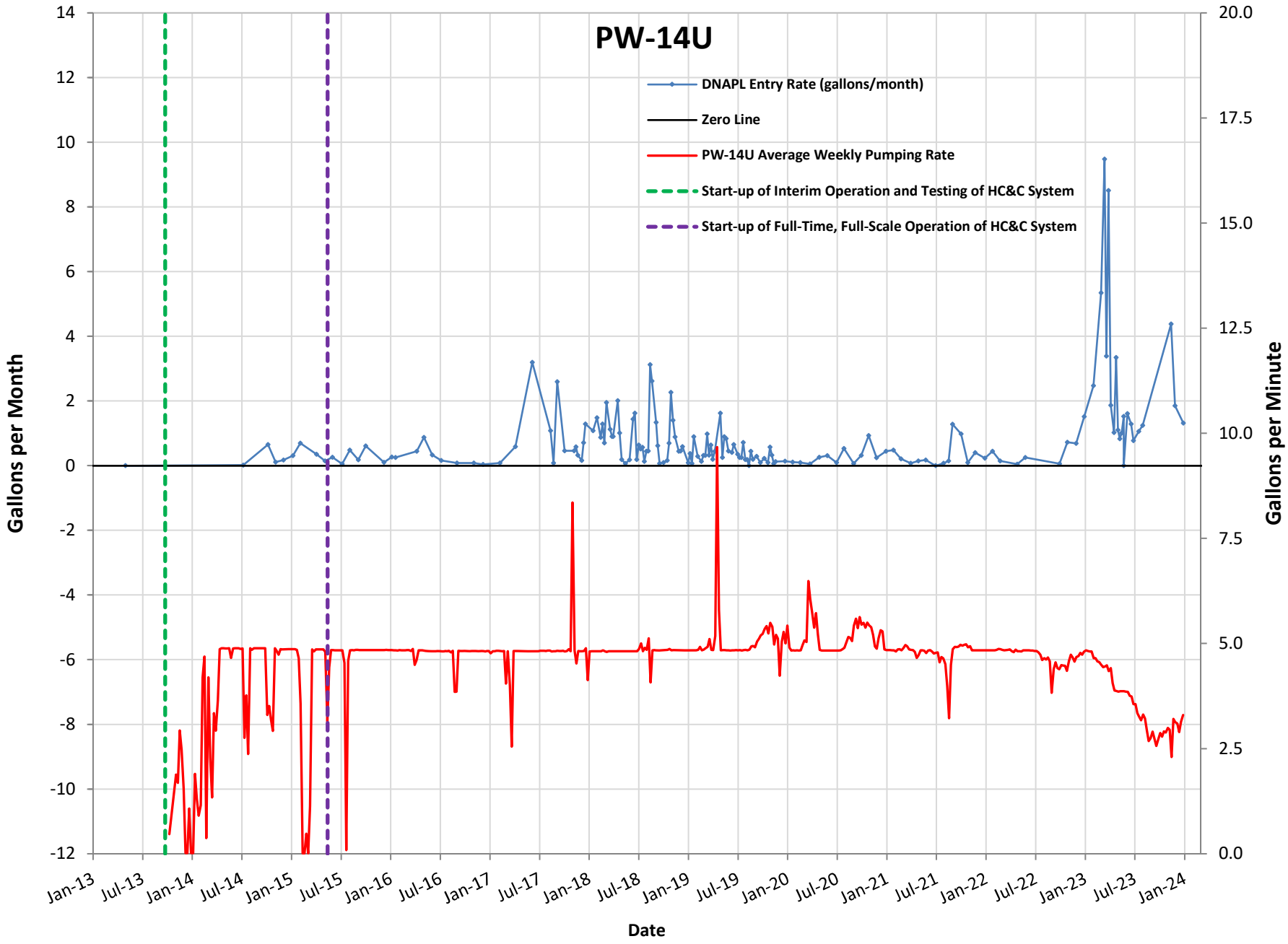
Jan-23
Jul-23
Jan-24

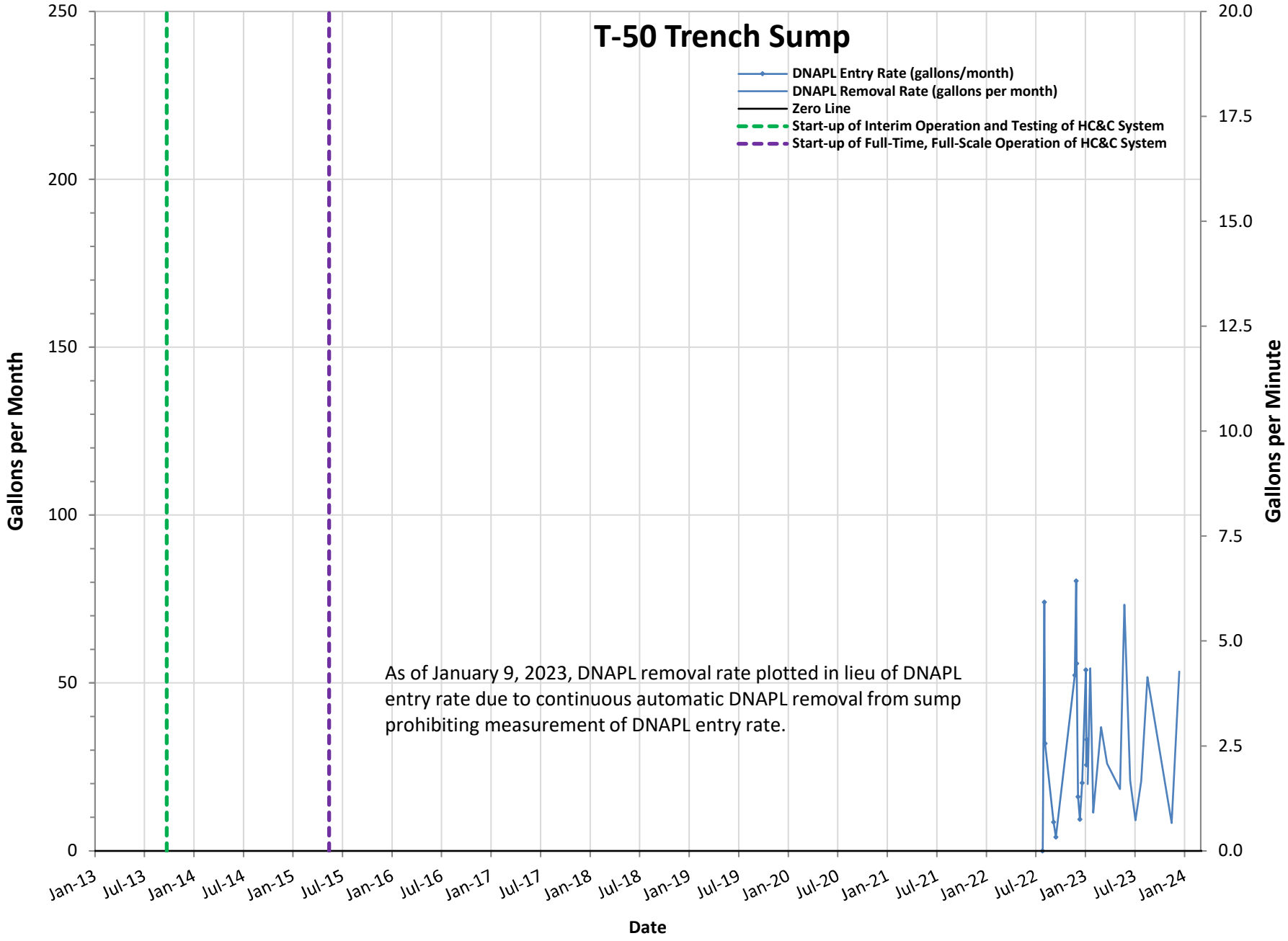

PW-6U
DNAPL Entry Rate (gallons/month)
Zero Line
PW-6U Average Weekly Pumping Rate
Start-up of Interim Operation and Testing of HC&C System
Start-up of Full-Time, Full-Scale Operation of HC&C System
Gallons per Month
Gallons per Minute
Date
14
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Jul-19
Jan-20
Jul-20
Jan-21
Jul-21
Jan-22
Jul-22
Jan-23
Jul-23
Jan-24

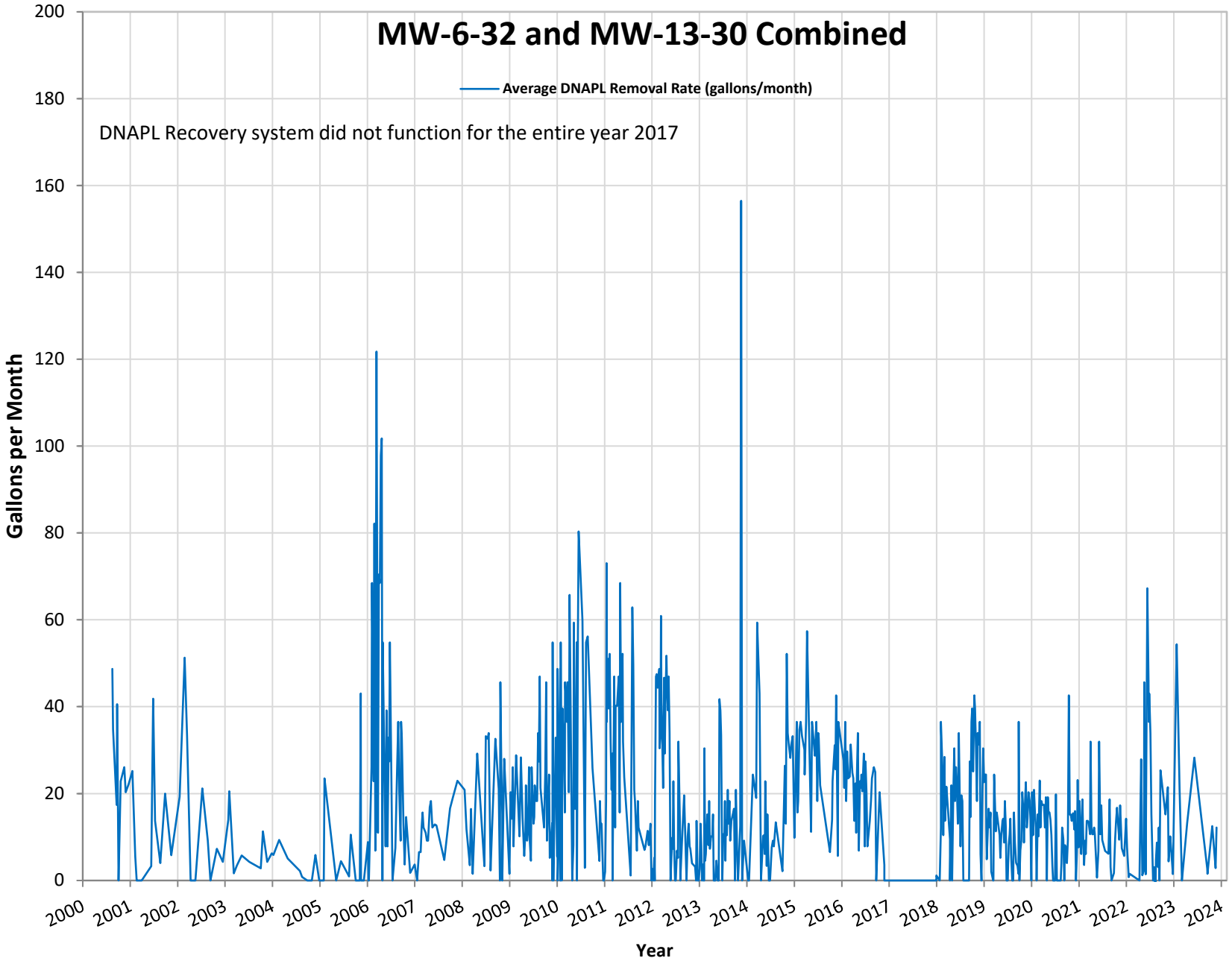

PW-11U
DNAPL Entry Rate (gallons/month)
Zero Line
Combined Average Weekly Pumping Rates, PW-11U & PW-11Ub
Start-up of Interim Operation and Testing of HC&C System
Start-up of Full-Time, Full-Scale Operation of HC&C System
PW-11U was taken out of service on 3/28/2022. PW-11U is now considered a monitoring well for all intents and purposes.
PW-11Ub was put into service as an active pumping well on 3/24/2022.
Gallons per Month
Gallons per Minute
Date
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Jul-19
Jan-20
Jul-20
Jan-21
Jul-21
Jan-22
Jul-22
Jan-23
Jul-23
Jan-24


PW-11Ub
DNAPL Entry Rate (gallons/month)
Zero Line
PW-11Ub Average Weekly Pumping Rate
Start-up of Interim Operation and Testing of HC&C System
Start-up of Full-Time, Full-Scale Operation of HC&C System
Gallons per Month
Gallons per Minute
Date
14
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Jul-19
Jan-20
Jul-20
Jan-21
Jul-21
Jan-22
Jul-22
Jan-23
Jul-23
Jan-24

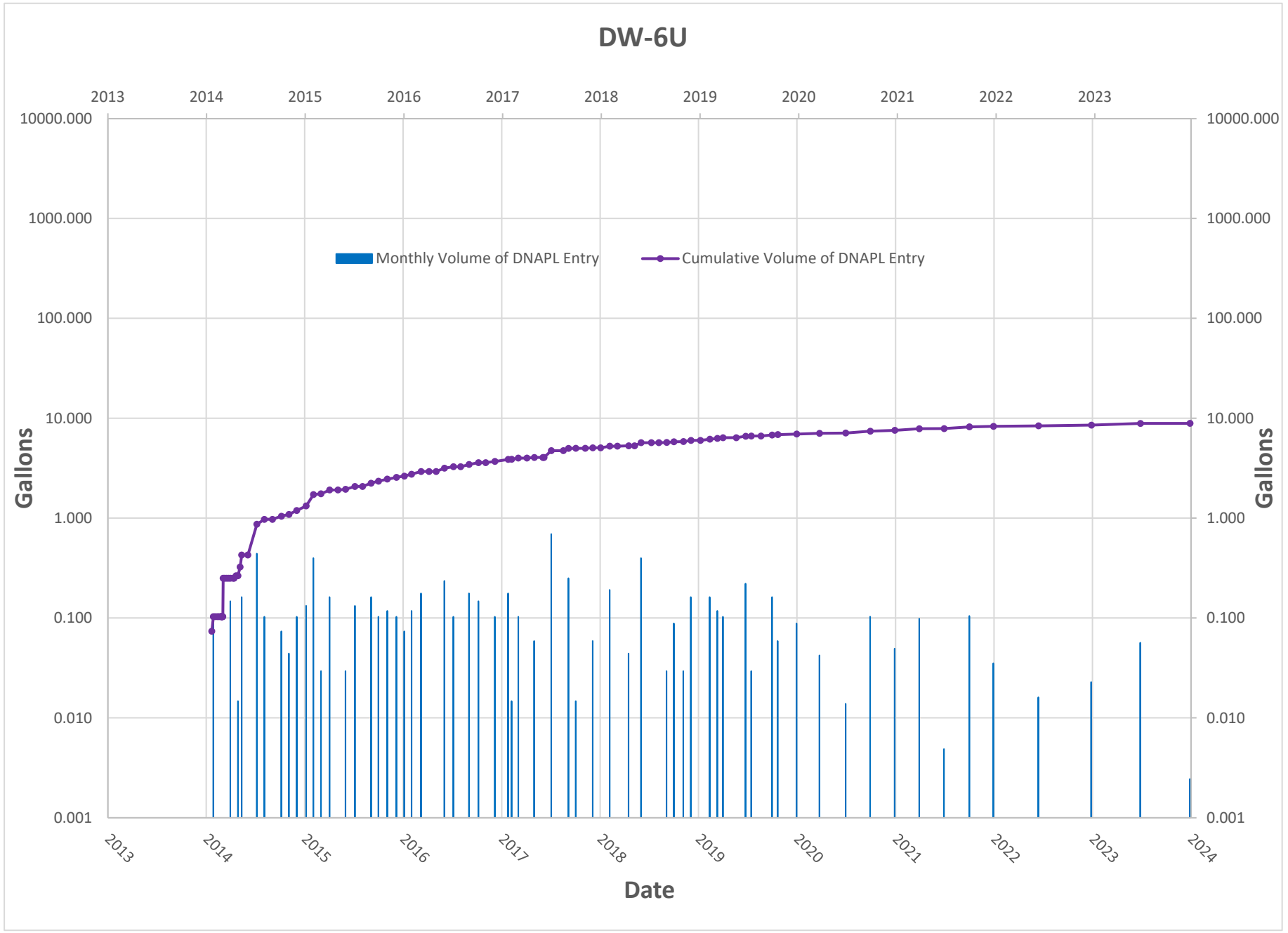

PW-13U
DNAPL Entry Rate (gallons/month)
Zero Line
PW-13U Average Weekly Pumping Rate
Start-up of Interim Operation and Testing of HC&C System
Start-up of Full-Time, Full-Scale Operation of HC&C System
Gallons per Month
Gallons per Minute
Date
14
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Jul-19
Jan-20
Jul-20
Jan-21
Jul-21
Jan-22
Jul-22
Jan-23
Jul-23
Jan-24

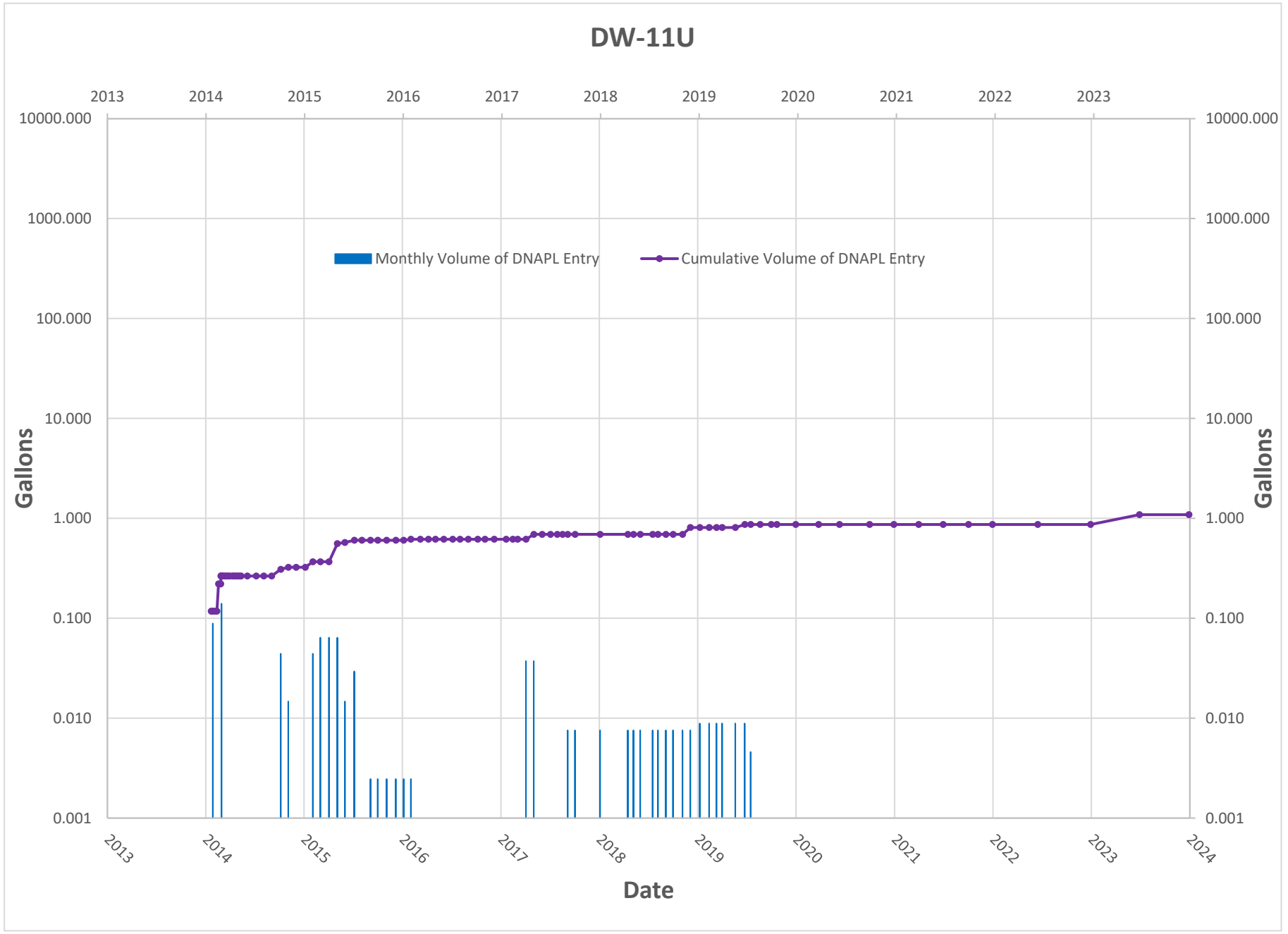

PW-14U
DNAPL Entry Rate (gallons/month)
Zero Line
PW-14U Average Weekly Pumping Rate
Start-up of Interim Operation and Testing of HC&C System
Start-up of Full-Time, Full-Scale Operation of HC&C System
Gallons per Month
Gallons per Minute
Date
14
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Jul-19
Jan-20
Jul-20
Jan-21
Jul-21
Jan-22
Jul-22
Jan-23
Jul-23
Jan-24

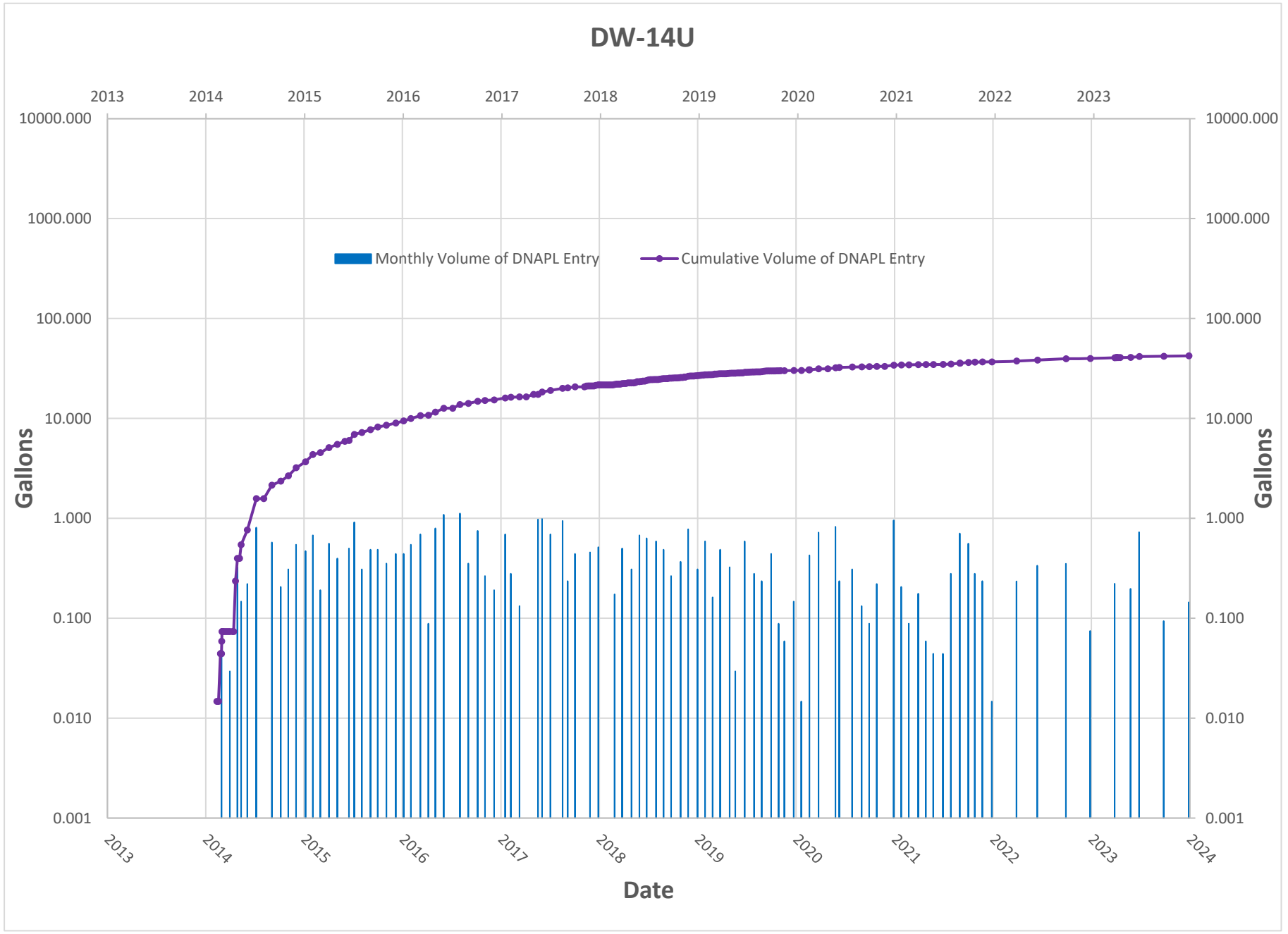

T-50 Trench Sump
DNAPL Entry Rate (gallons/month)
DNAPL Removal Rate (gallons per month)
Zero Line
Start-up of Interim Operation and Testing of HC&C System
Start-up of Full-Time, Full-Scale Operation of HC&C System
As of January 9, 2023, DNAPL removal rate plotted in lieu of DNAPL entry rate due to continuous automatic DNAPL removal from sump prohibiting measurement of DNAPL entry rate.
Gallons per Month
Gallons per Minute
Date
250
200
150
100
50
0
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Jul-19
Jan-20
Jul-20
Jan-21
Jul-21
Jan-22
Jul-22
Jan-23
Jul-23
Jan-24

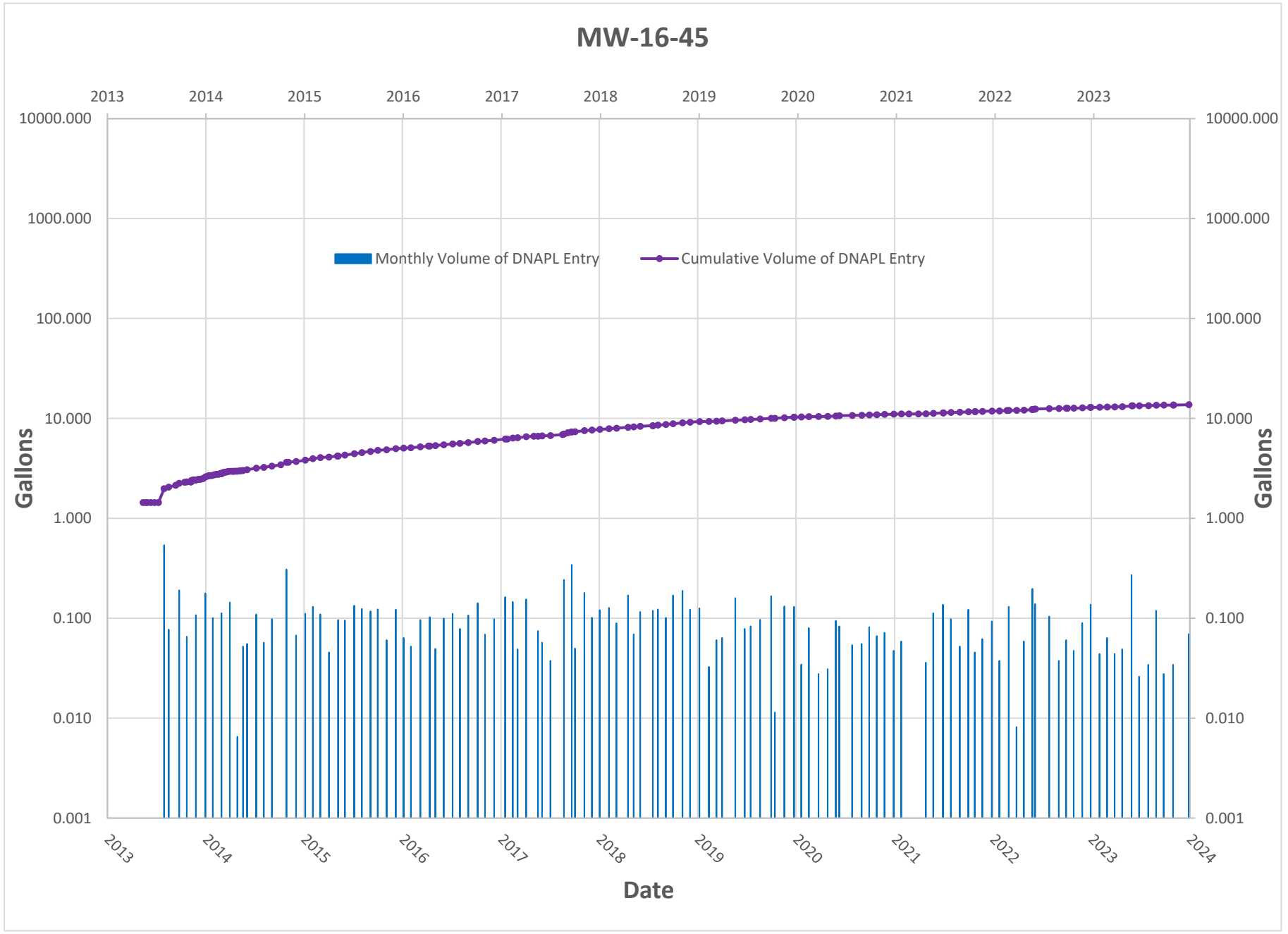

MW-6-32 and MW-13-30 Combined
Average DNAPL Removal Rate (gallons/month)
DNAPL Recovery system did not function for the entire year 2017
Gallons per Month
Year
0
20
40
60
80
100
120
140
160
180
200
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

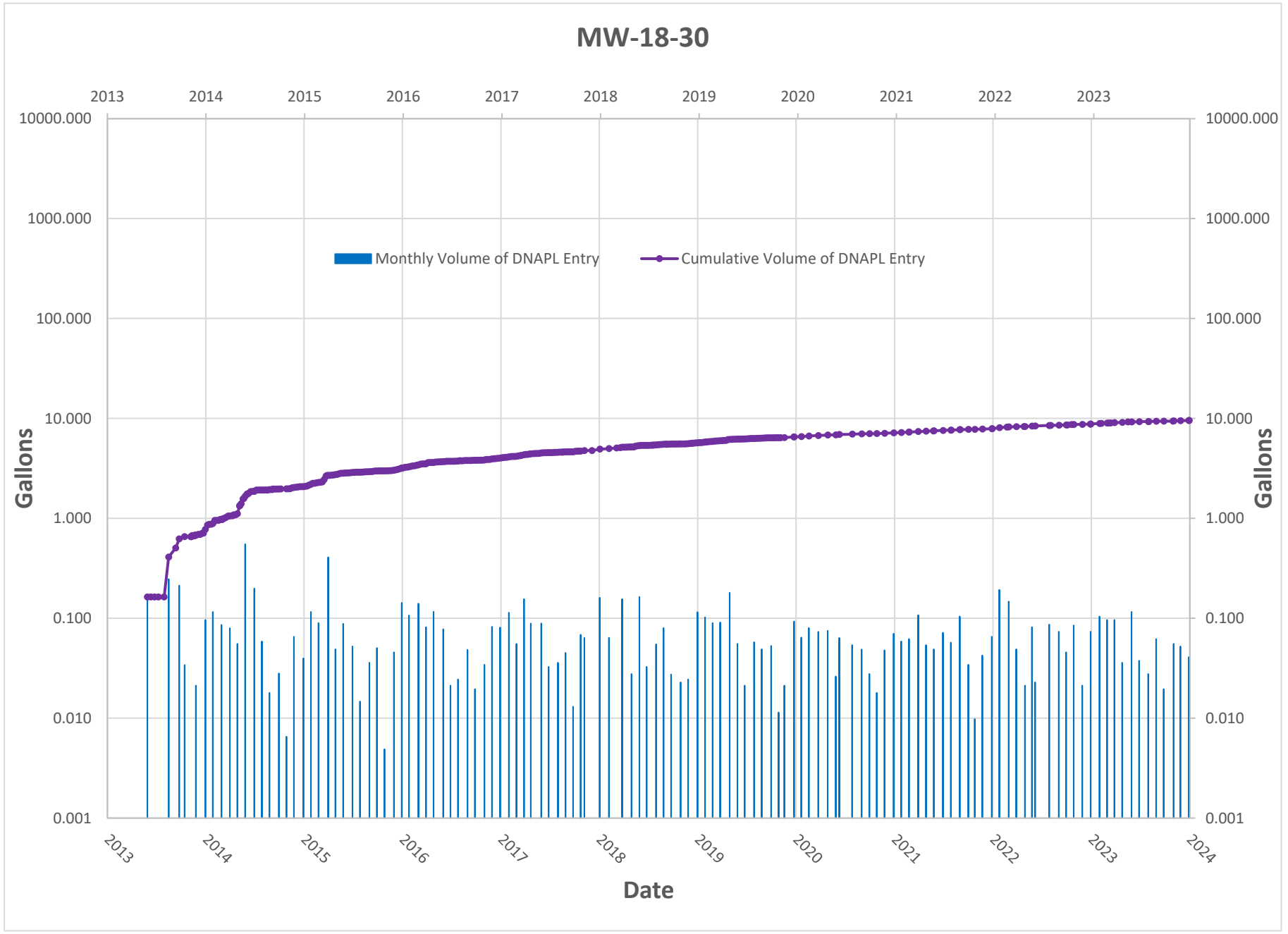
Appendix C
Time-Series Plots – Monthly and Cumulative Volume of DNAPL Entry into Wells

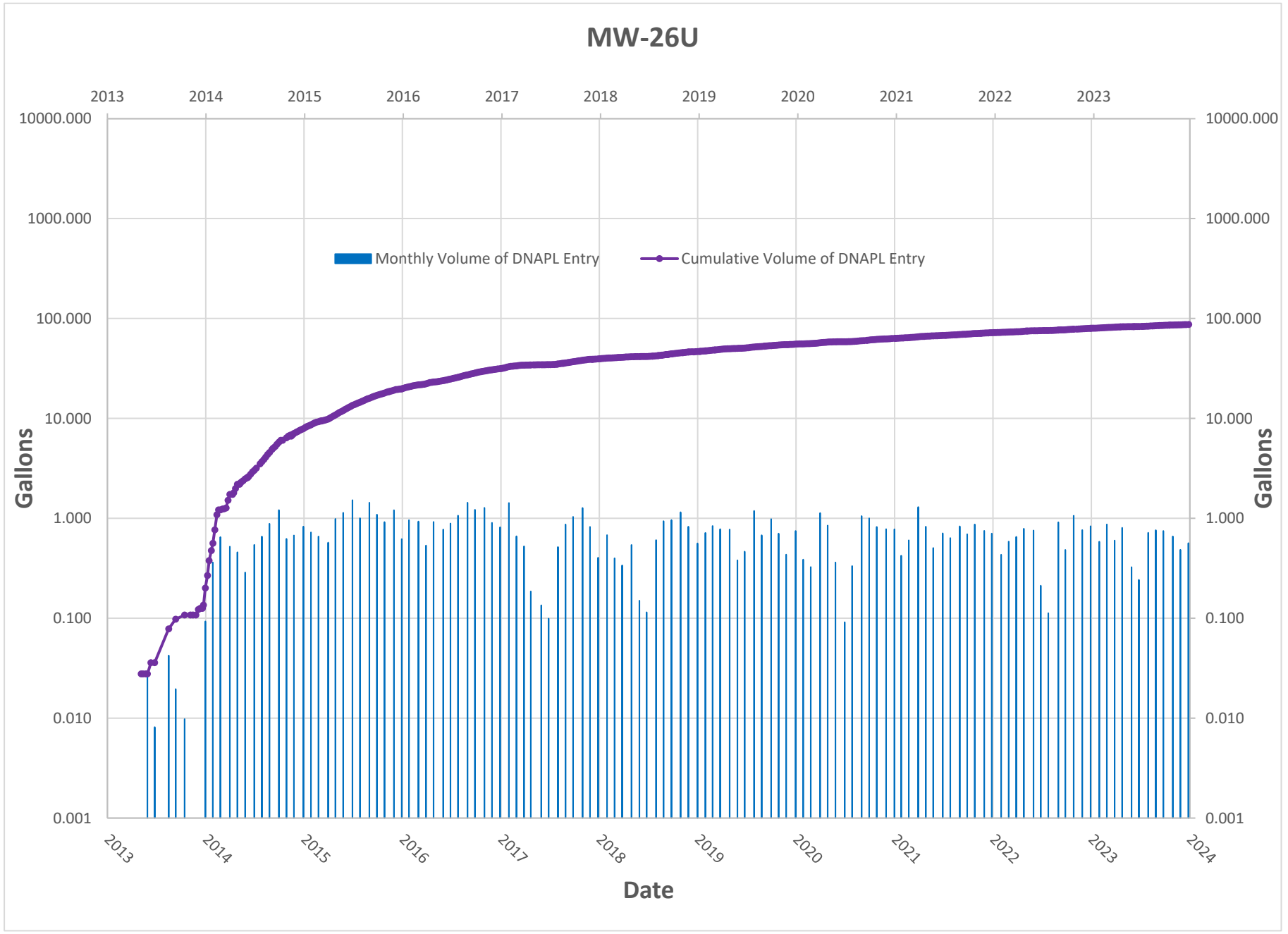

DW-6U
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
10000.000
1000.000
100.000
10.000
1.000
0.100
0.010
0.001
Monthly Volume of DNAPL Entry
Cumulative Volume of DNAPL Entry
Gallons
Gallons
Date
2024

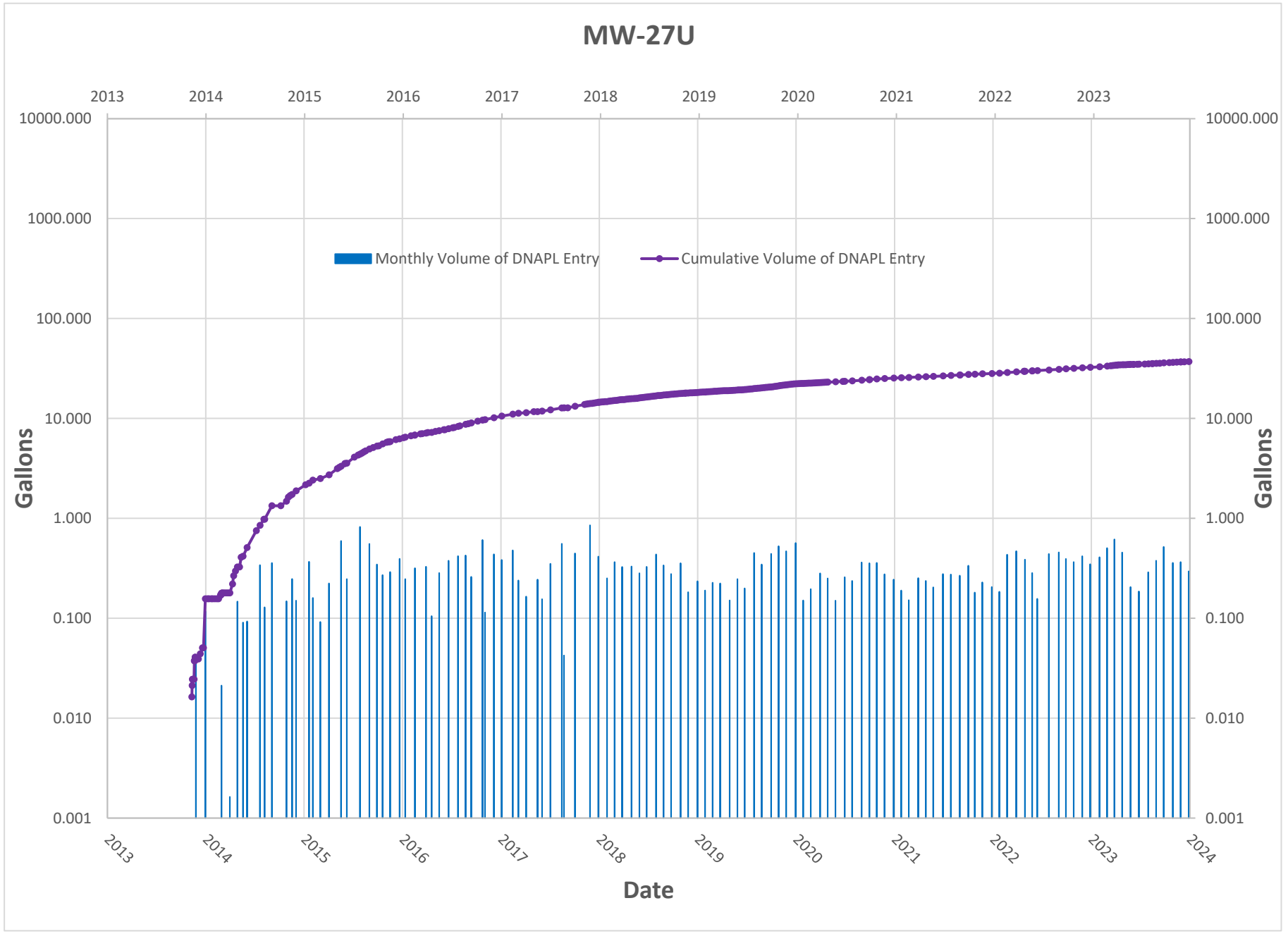

DW-11U
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
10000.000
1000.000
100.000
10.000
1.000
0.100
0.010
0.001
Monthly Volume of DNAPL Entry
Cumulative Volume of DNAPL Entry
Gallons
Gallons
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Date

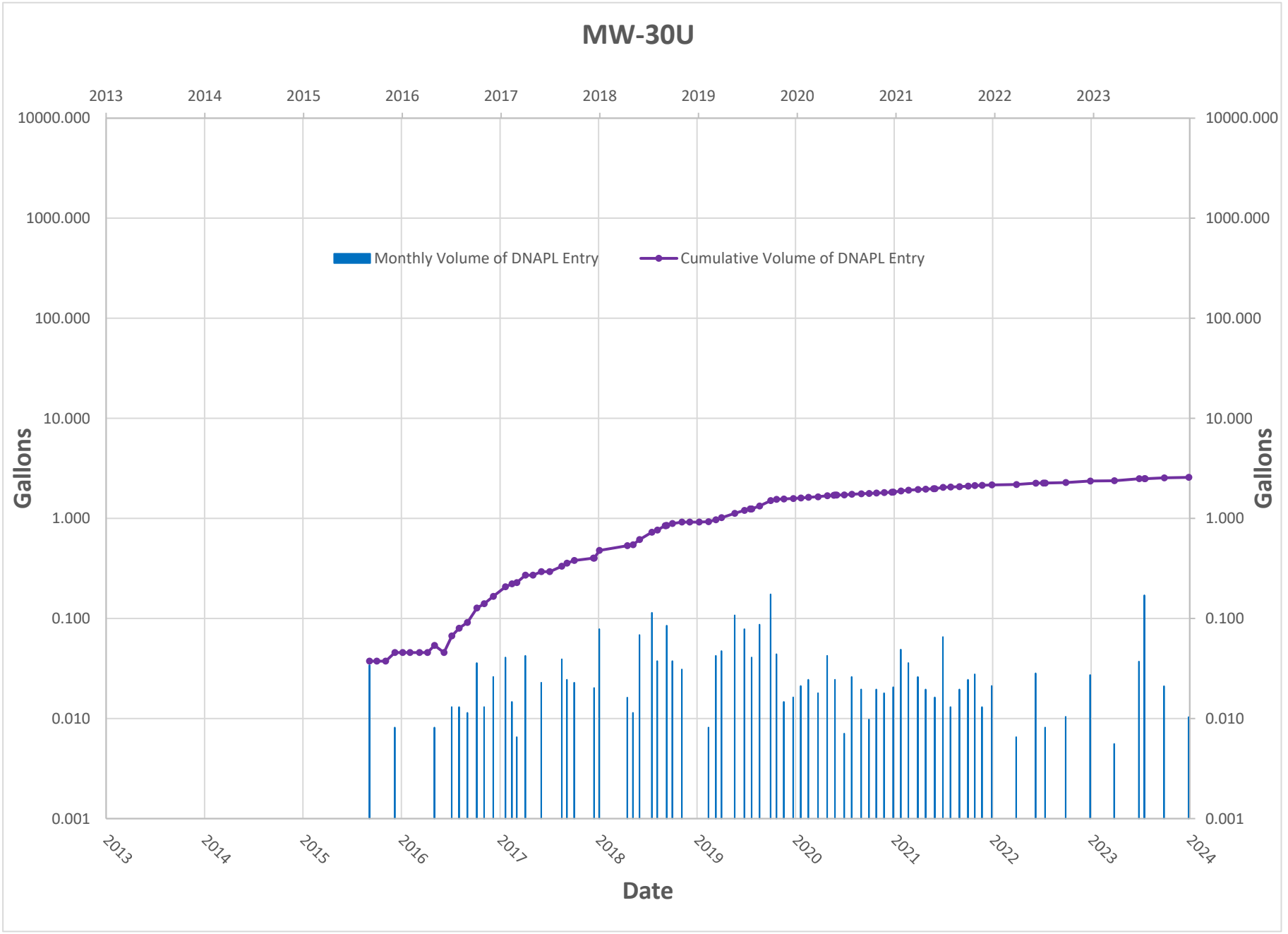

DW-14U
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
10000.000
1000.000
100.000
10.000
1.000
0.100
0.010
0.001
Monthly Volume of DNAPL Entry
Cumulative Volume of DNAPL Entry
Gallons
Gallons
Date
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

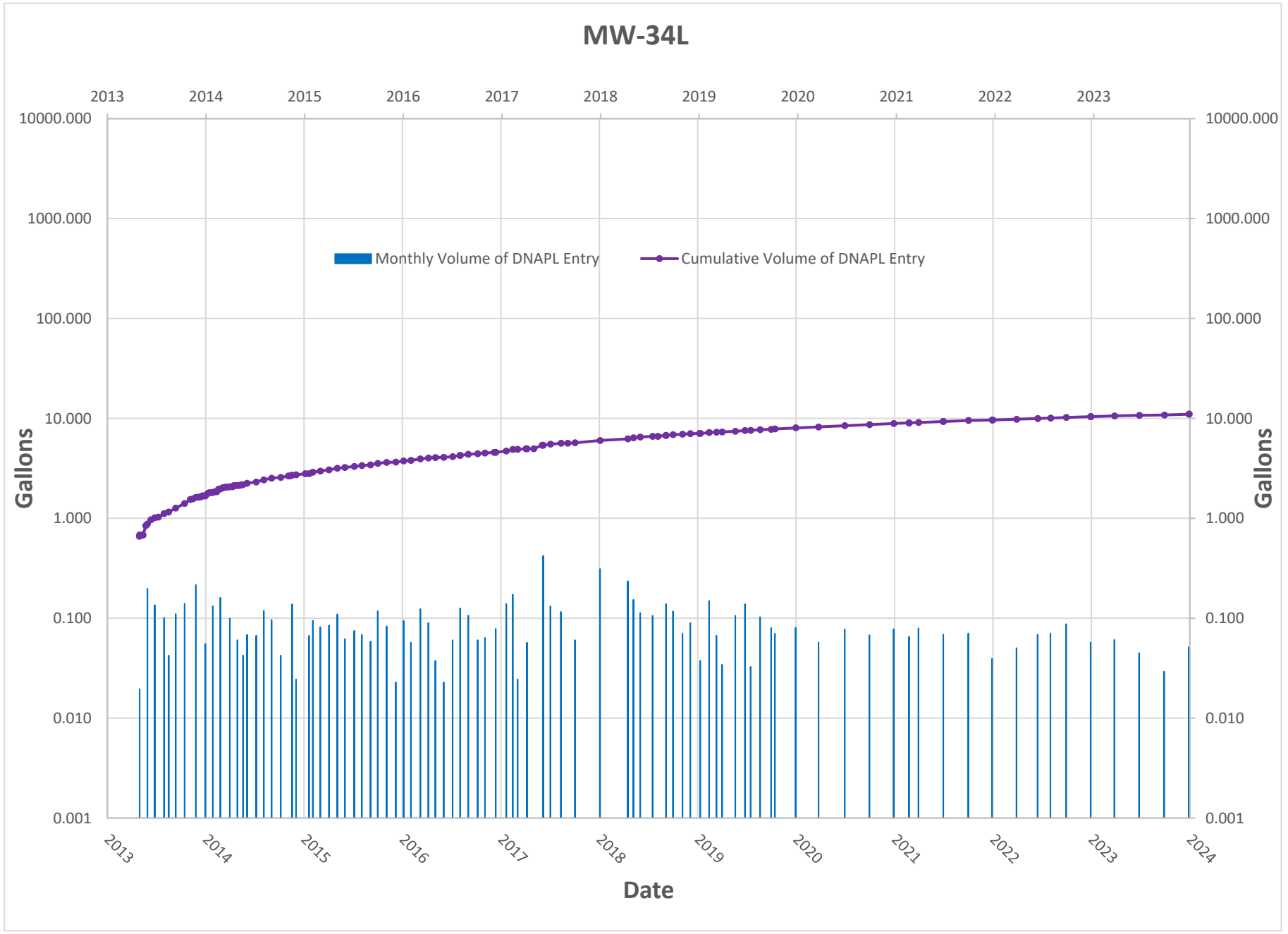

MW-16-45
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
10000.000
1000.000
100.000
10.000
1.000
0.100
0.010
0.001
Monthly Volume of DNAPL Entry
Cumulative Volume of DNAPL Entry
Gallons
Gallons
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Date

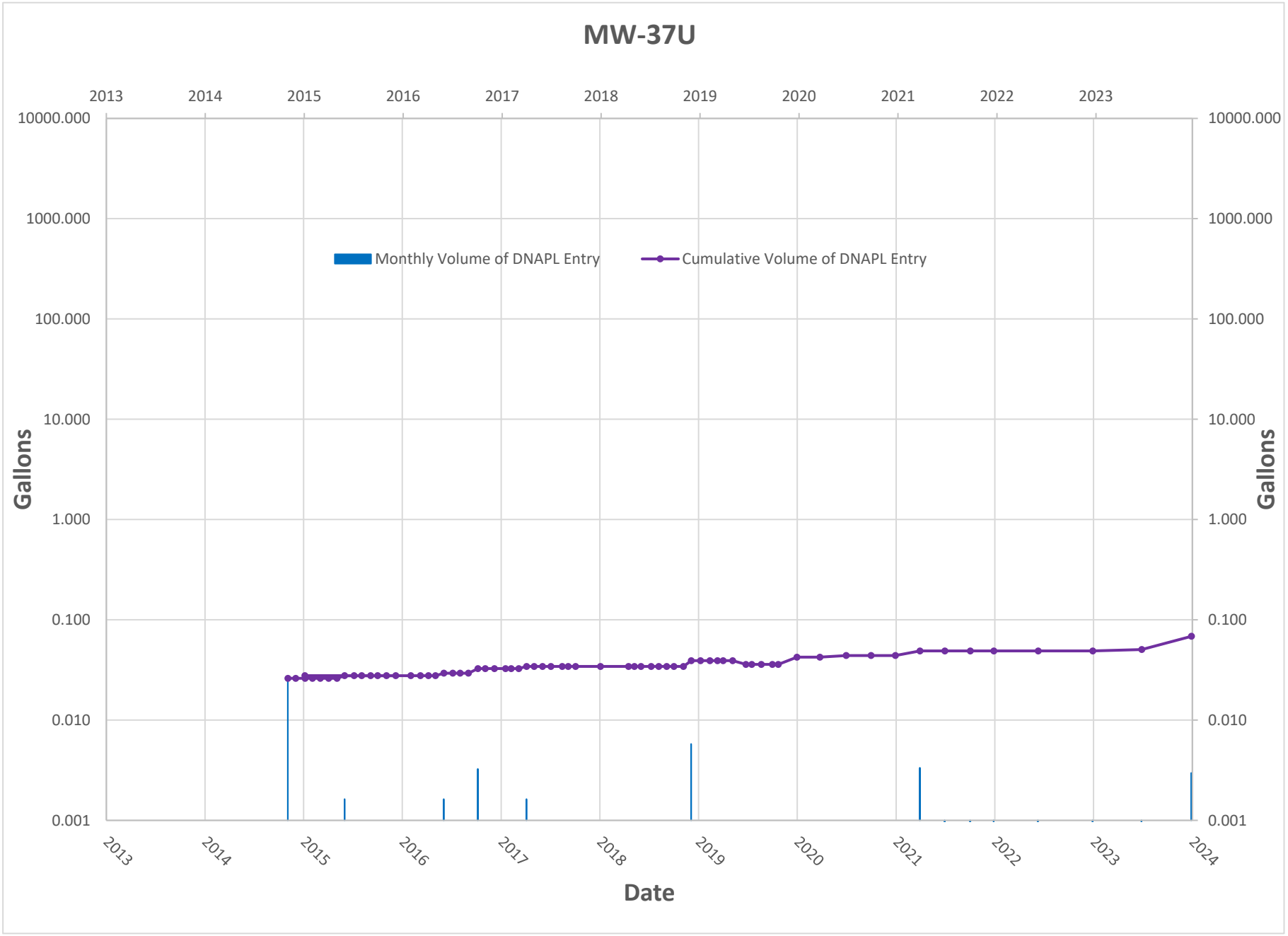

MW-18-30
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
10000.000
1000.000
100.000
10.000
1.000
0.100
0.010
0.001
Monthly Volume of DNAPL Entry
Cumulative Volume of DNAPL Entry
Gallons
Gallons
Date
2024

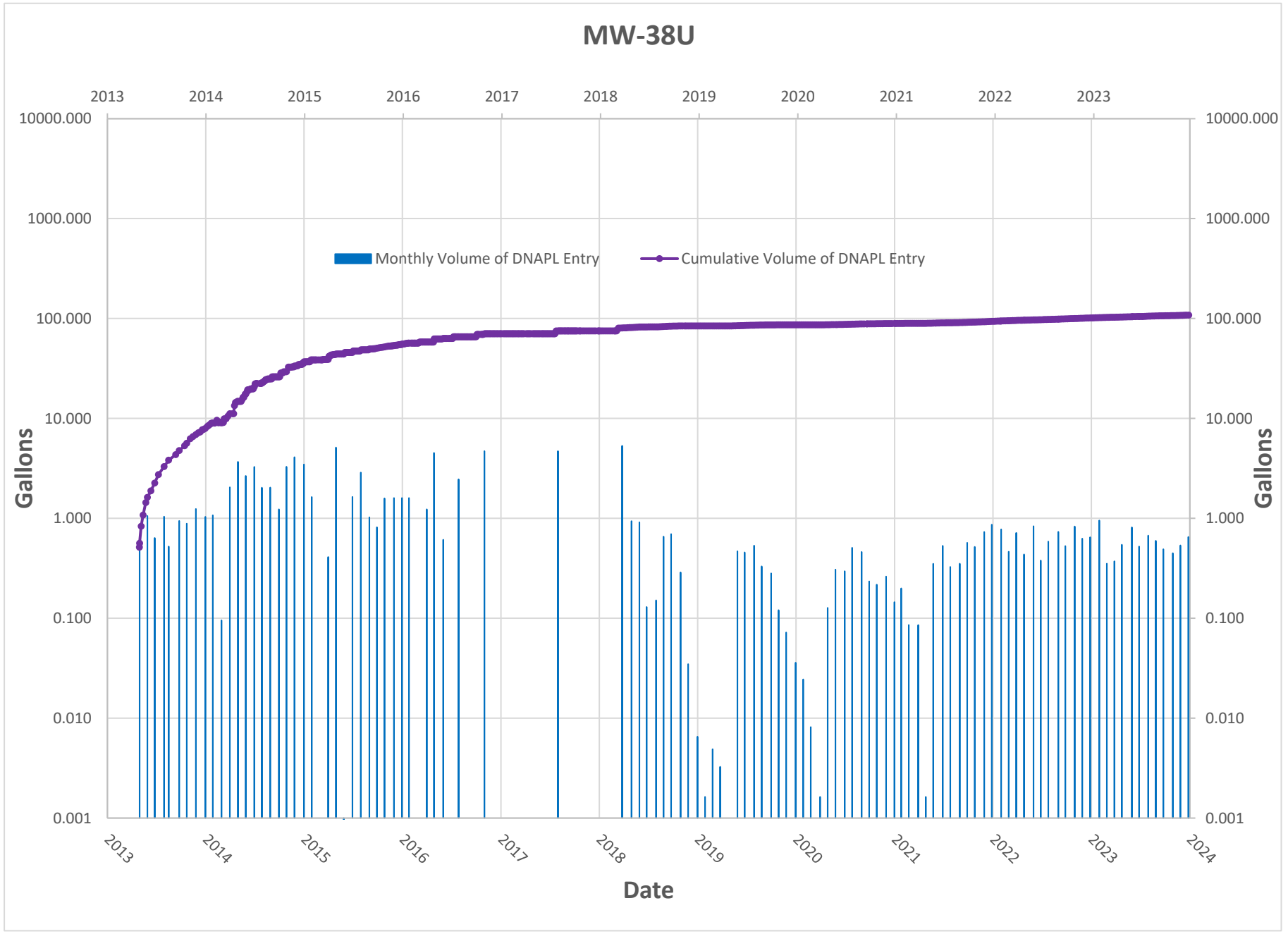

MW-26U
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
10000.000
1000.000
100.000
10.000
1.000
0.100
0.010
0.001
Monthly Volume of DNAPL Entry
Cumulative Volume of DNAPL Entry
Gallons
Gallons
Date

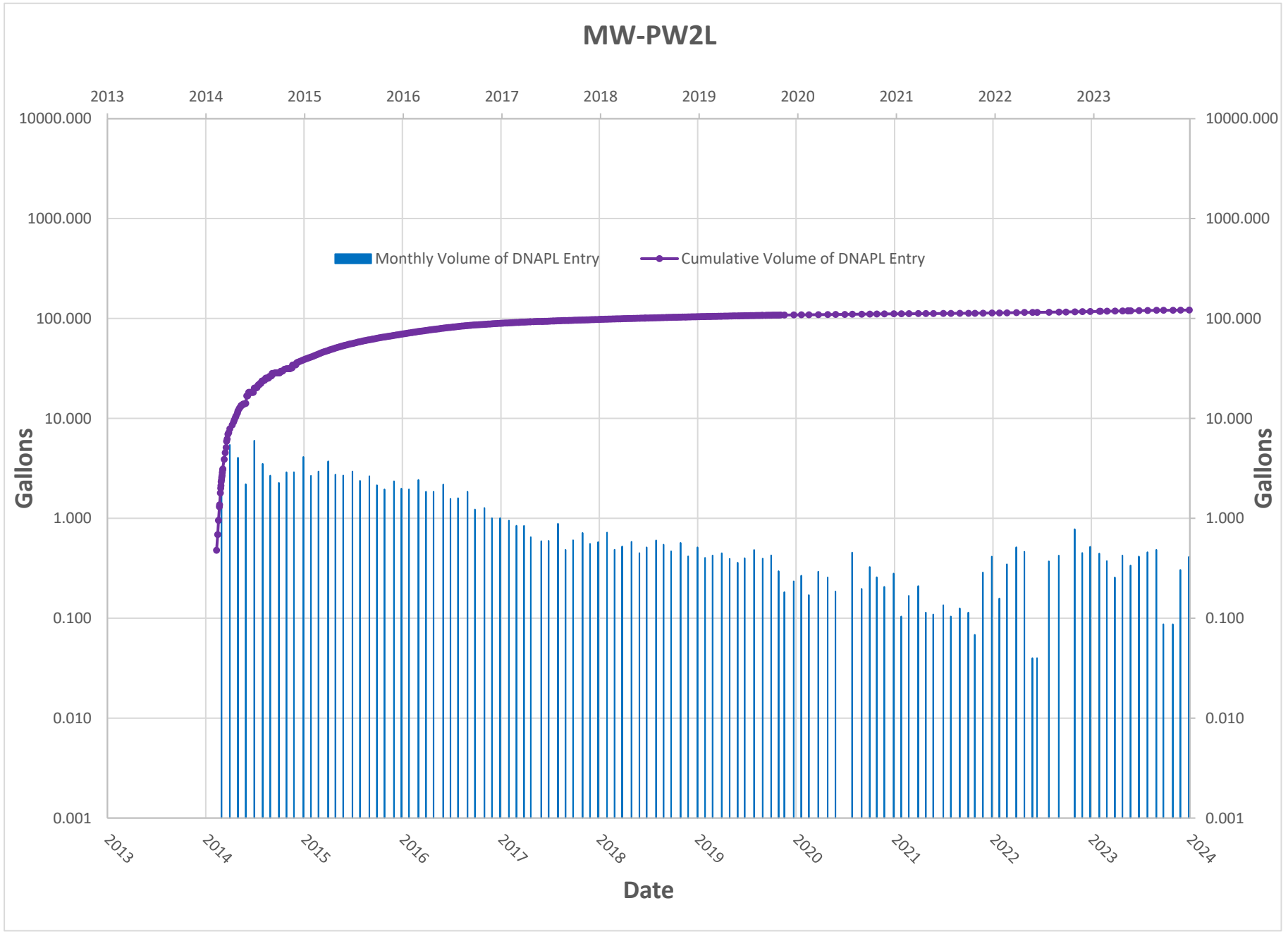

MW-27U
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
10000.000
1000.000
100.000
10.000
1.000
0.100
0.010
0.001
Monthly Volume of DNAPL Entry
Cumulative Volume of DNAPL Entry
Gallons
Gallons
Date
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

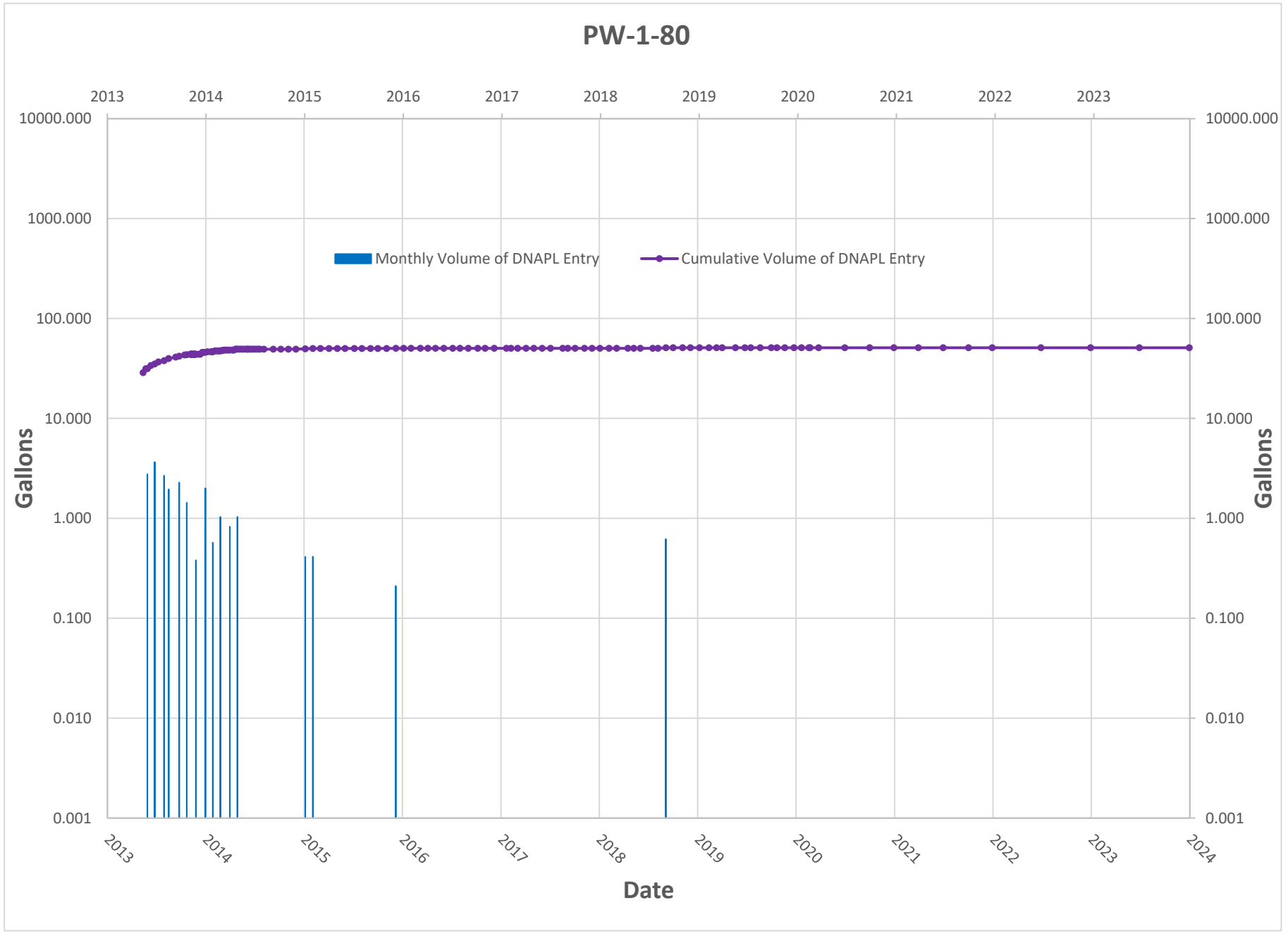

MW-30U
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
10000.000
1000.000
100.000
10.000
1.000
0.100
0.010
0.001
Monthly Volume of DNAPL Entry
Cumulative Volume of DNAPL Entry
Gallons
Gallons
Date
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

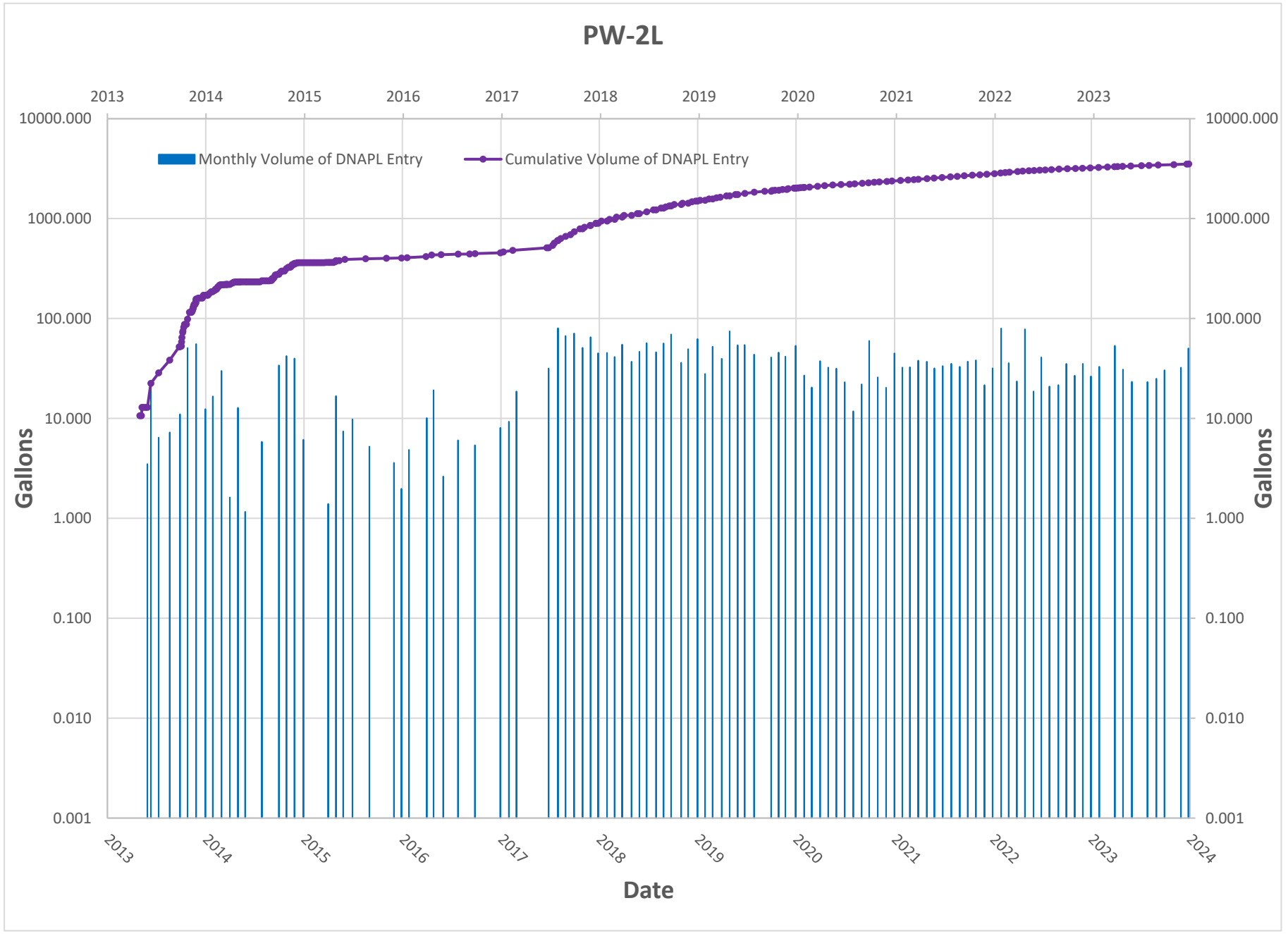

MW-34L
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
10000.000
1000.000
100.000
10.000
1.000
0.100
0.010
0.001
Monthly Volume of DNAPL Entry
Cumulative Volume of DNAPL Entry
Gallons
Gallons
Date
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

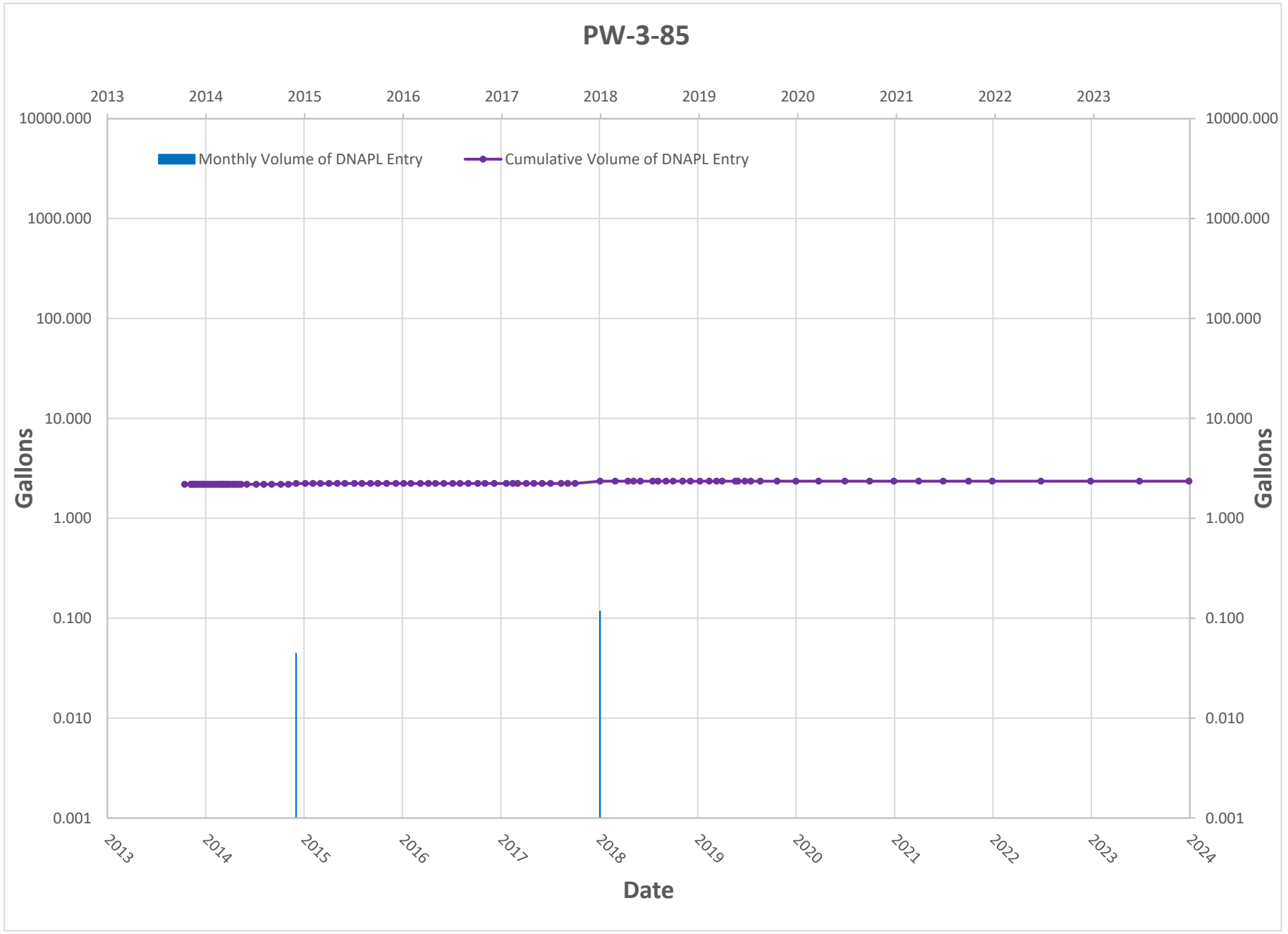

MW-37U
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
10000.000
1000.000
100.000
10.000
1.000
0.100
0.010
0.001
Monthly Volume of DNAPL Entry
Cumulative Volume of DNAPL Entry
Gallons
Gallons
Date
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

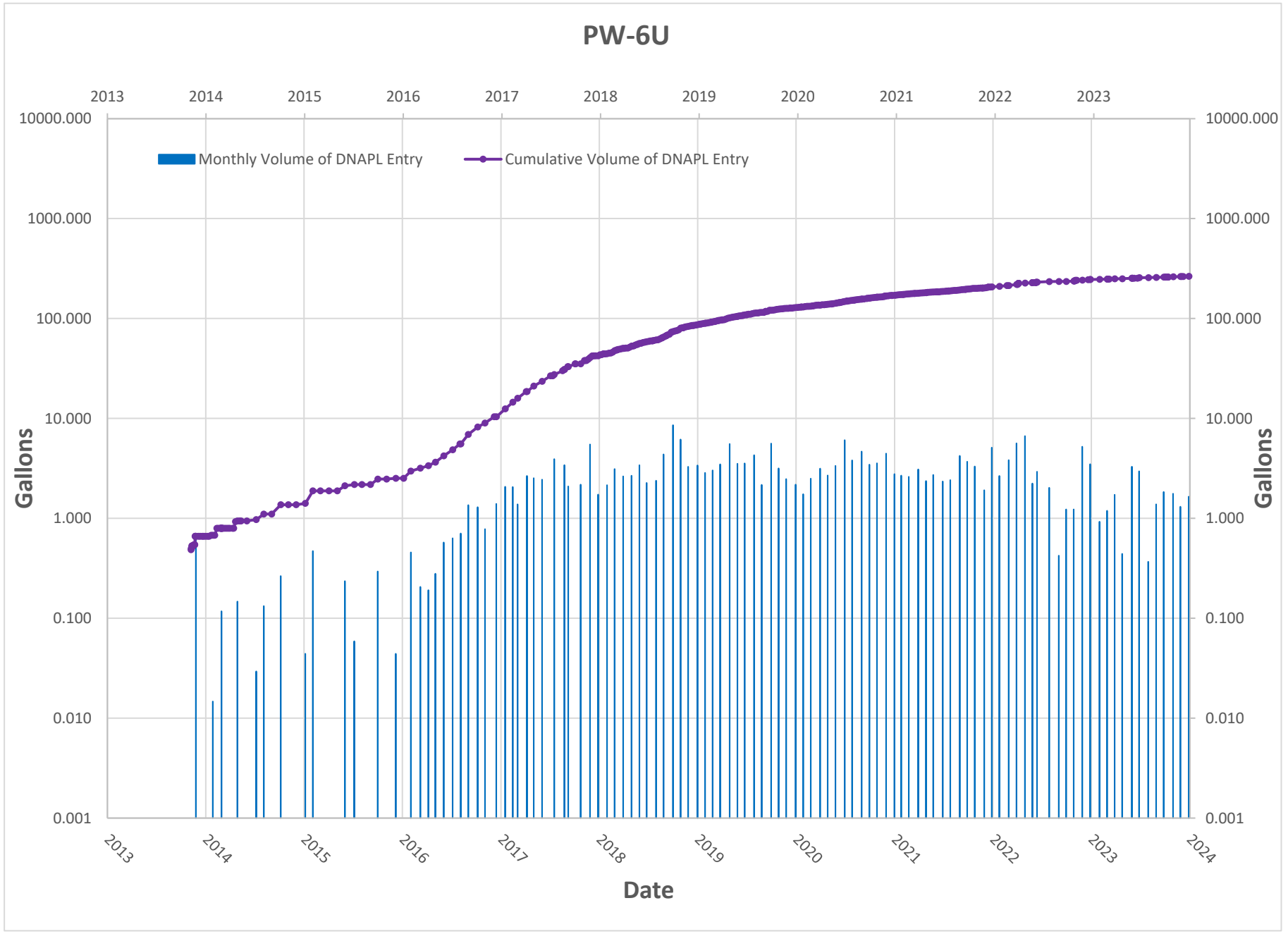

MW-38U
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
10000.000
1000.000
100.000
10.000
1.000
0.100
0.010
0.001
Monthly Volume of DNAPL Entry
Cumulative Volume of DNAPL Entry
Gallons
Gallons
Date
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

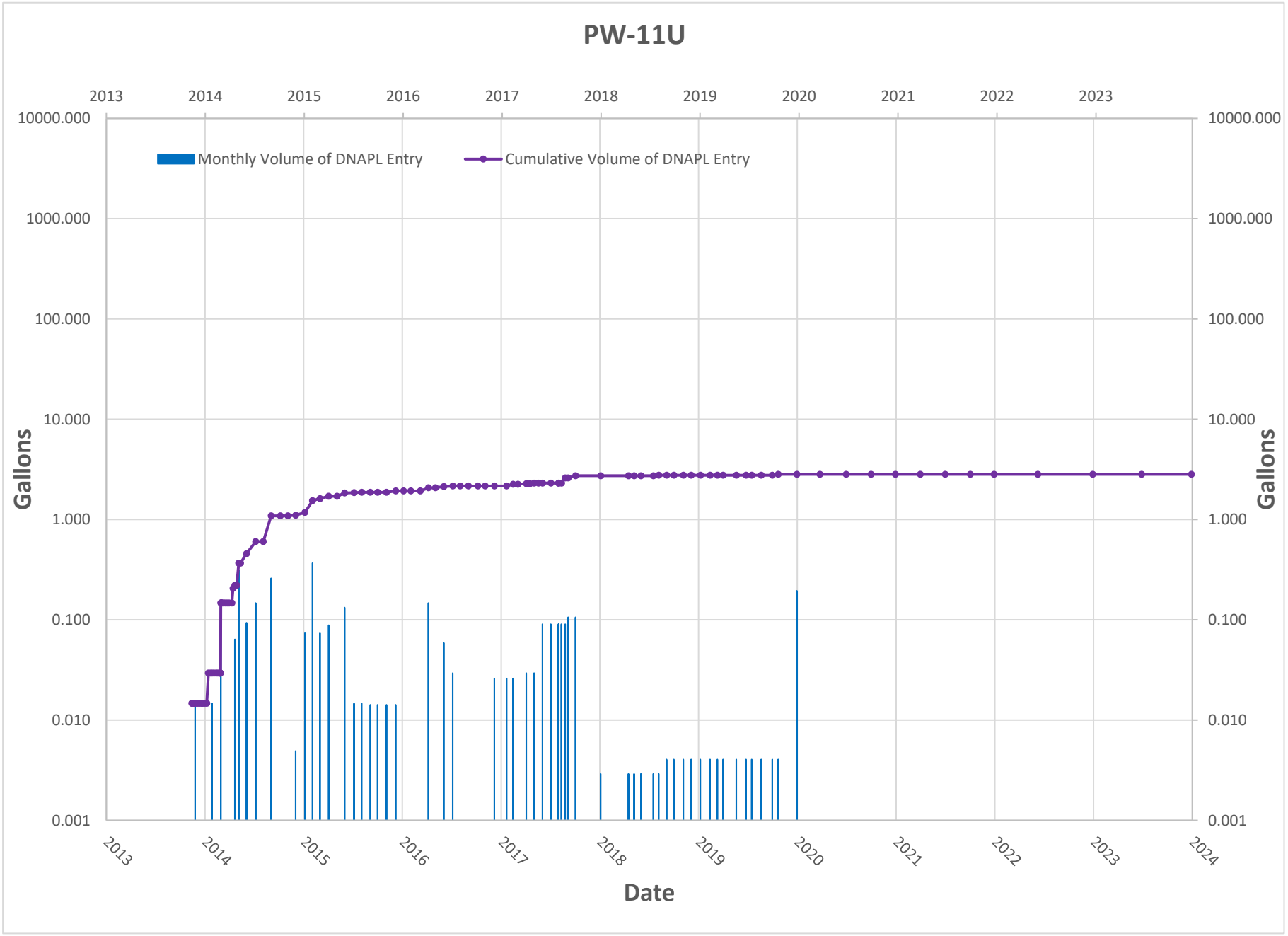

MW-PW2L
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
10000.000
1000.000
100.000
10.000
1.000
0.100
0.010
0.001
Monthly Volume of DNAPL Entry
Cumulative Volume of DNAPL Entry
Gallons
Gallons
Date
2024

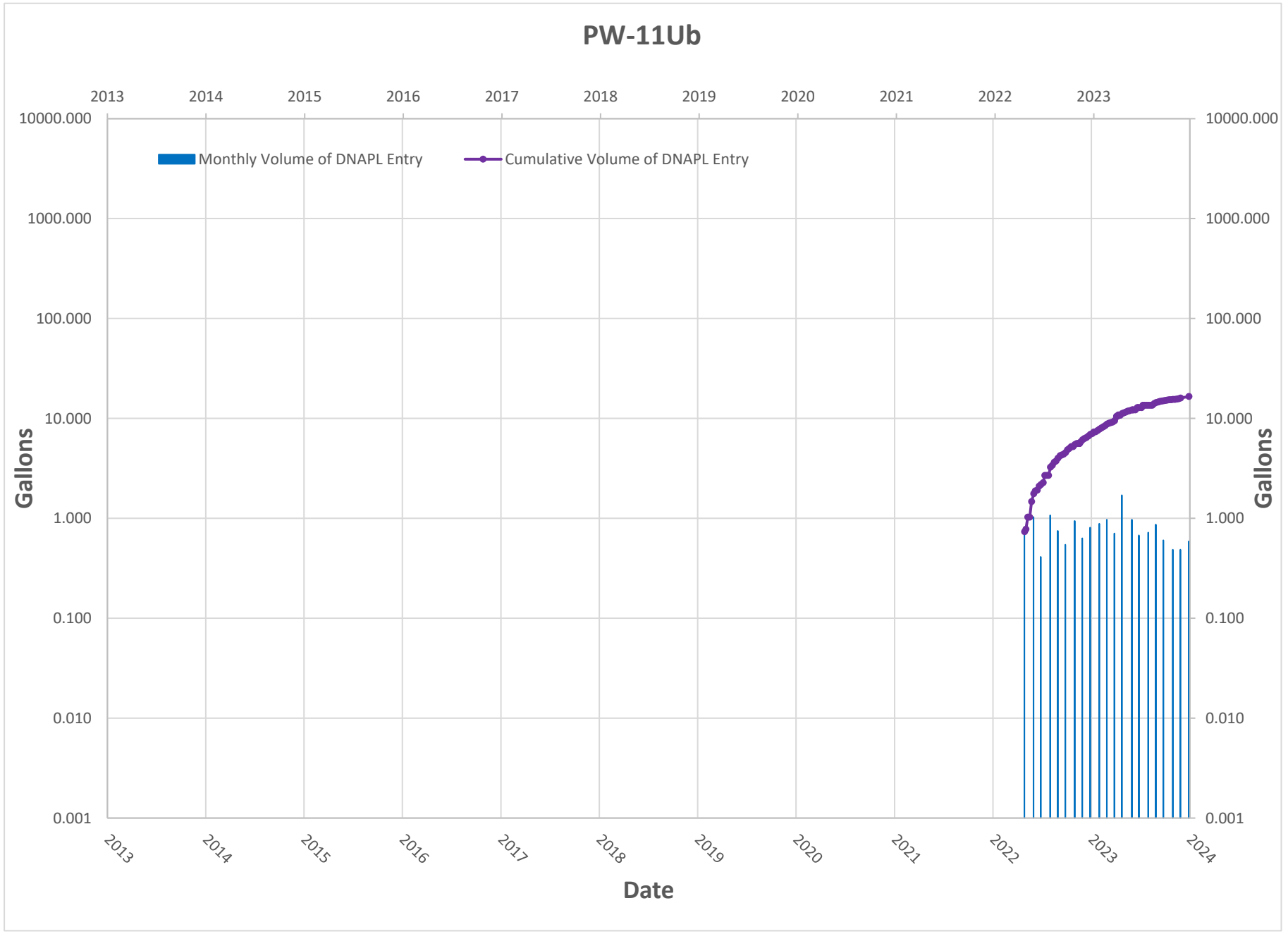

PW-1-80
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
10000.000
1000.000
100.000
10.000
1.000
0.100
0.010
0.001
Monthly Volume of DNAPL Entry
Cumulative Volume of DNAPL Entry
Gallons
Gallons
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Date

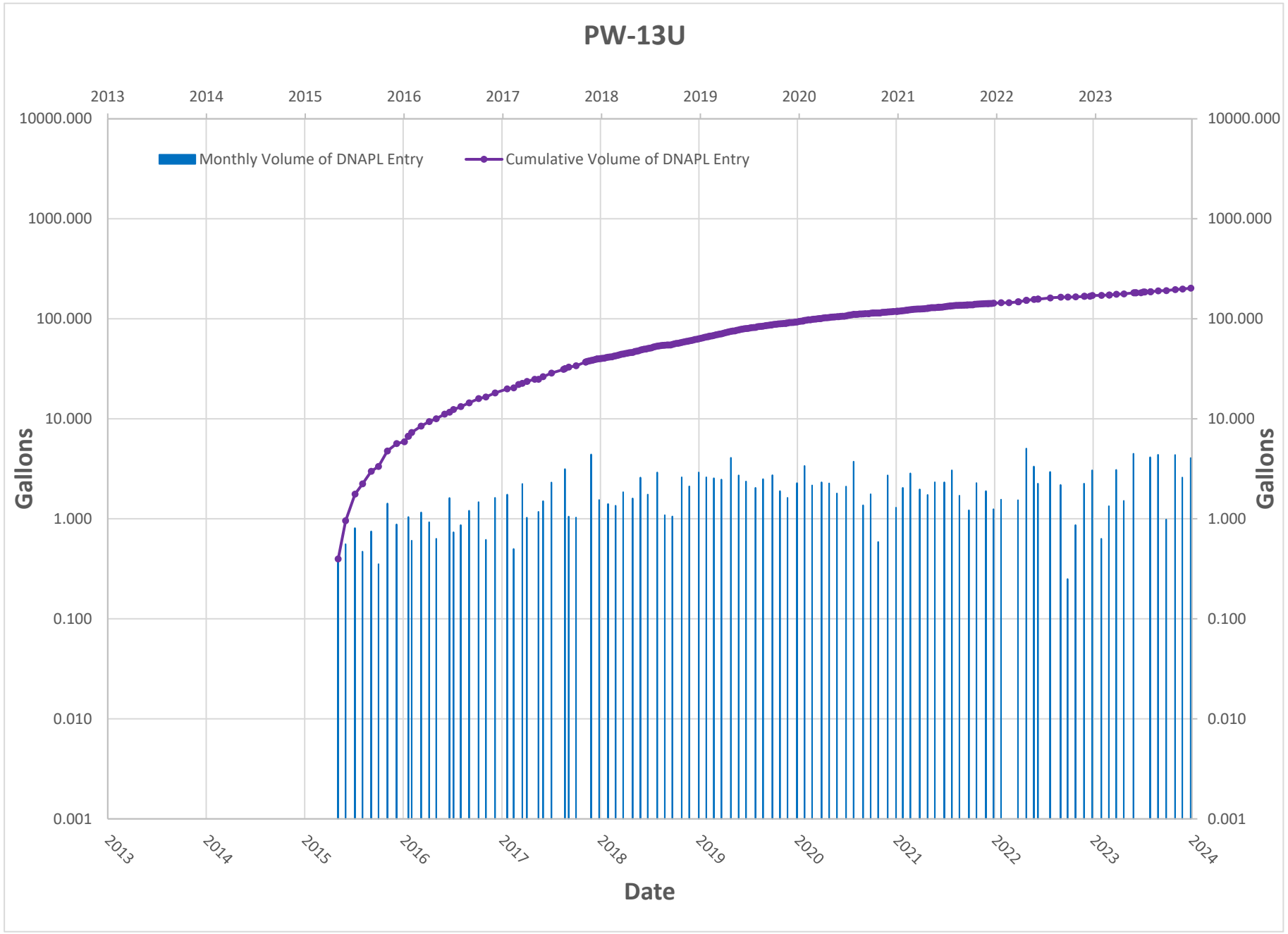

PW-2L
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
10000.000
1000.000
100.000
10.000
1.000
0.100
0.010
0.001
Monthly Volume of DNAPL Entry
Cumulative Volume of DNAPL Entry
Gallons
Gallons
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Date

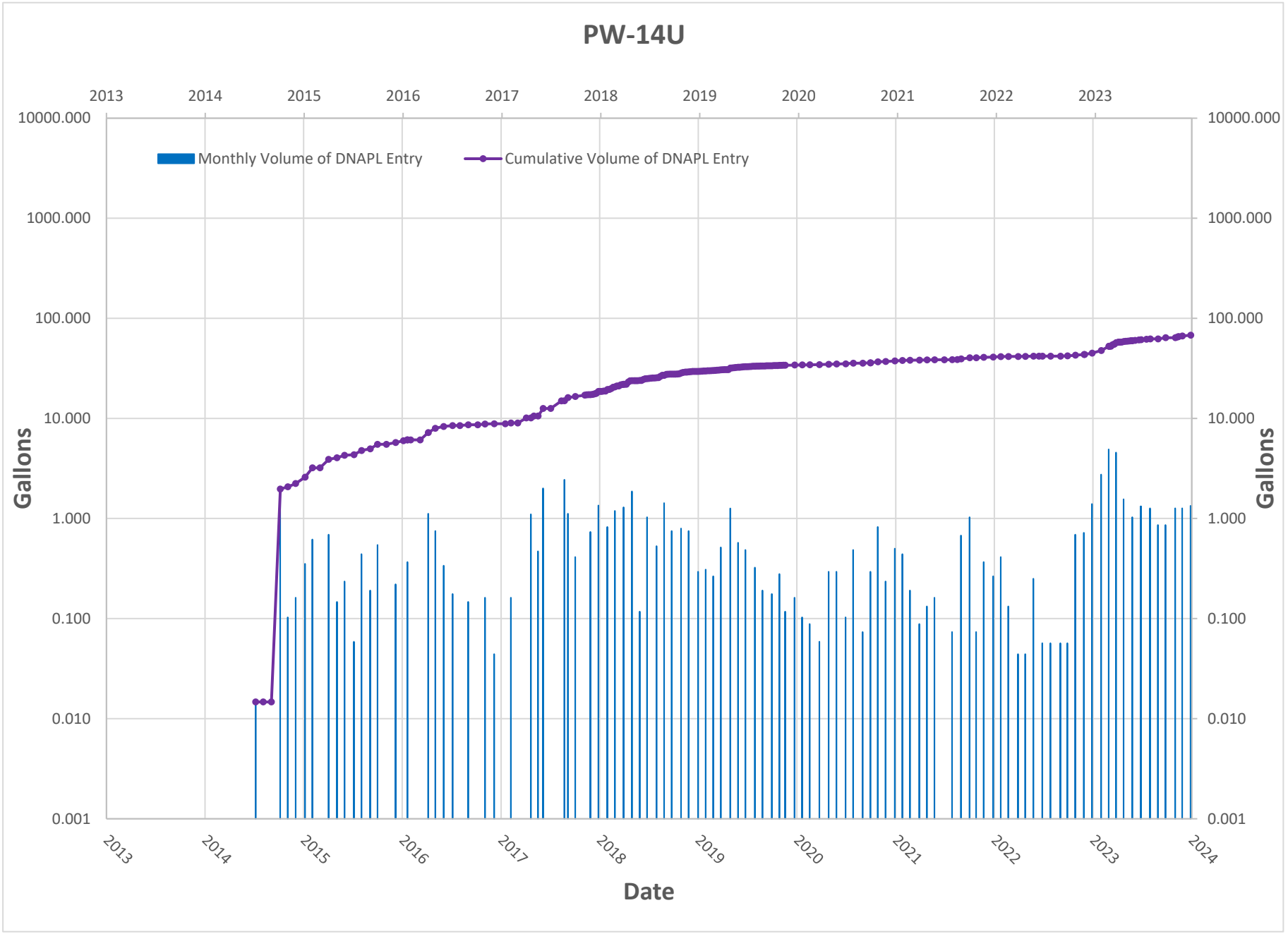

PW-3-85
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
10000.000
1000.000
100.000
10.000
1.000
0.100
0.010
0.001
Monthly Volume of DNAPL Entry
Cumulative Volume of DNAPL Entry
Gallons
Gallons
Date
2024

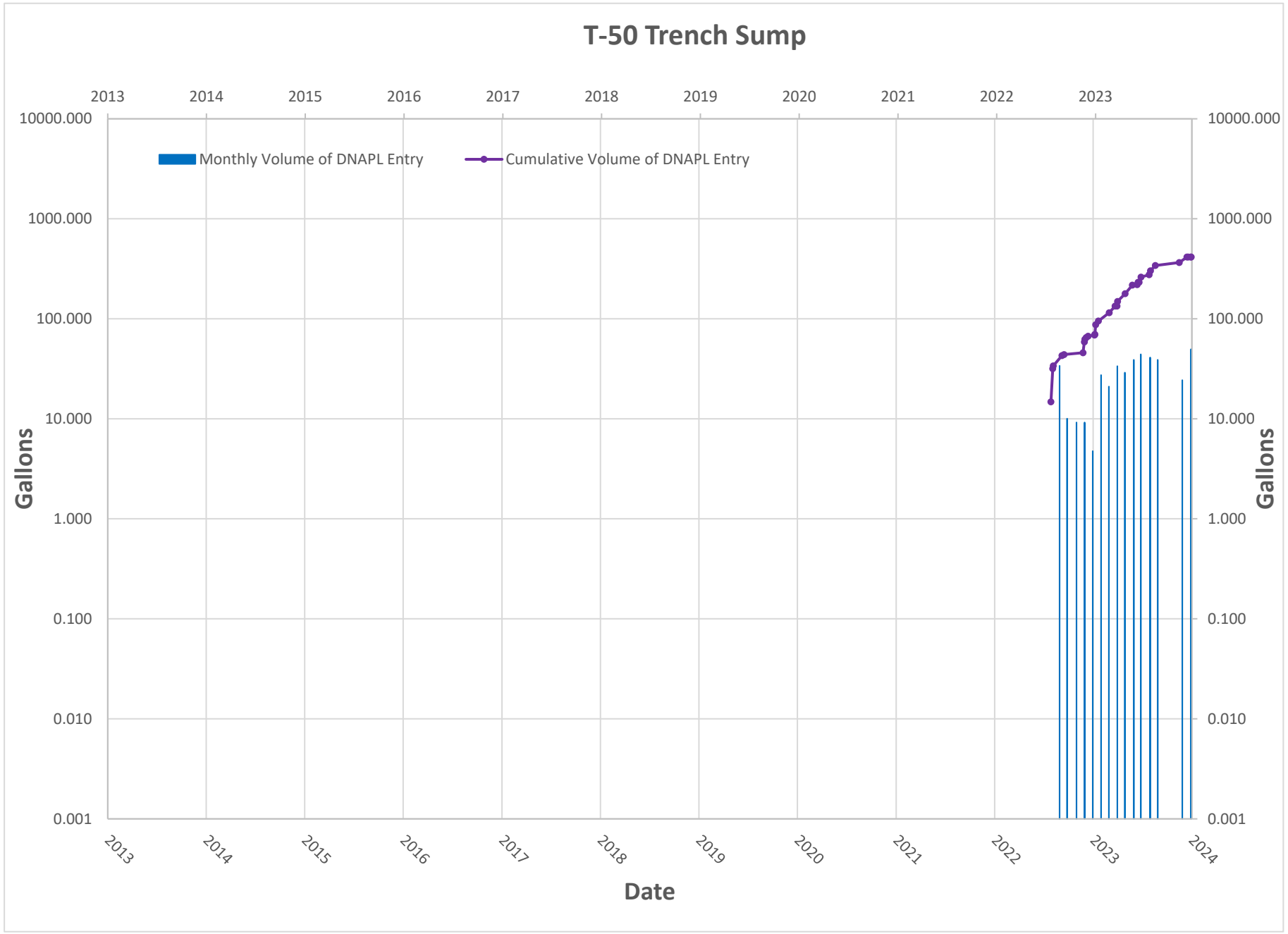

PW-6U
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
10000.000
1000.000
100.000
10.000
1.000
0.100
0.010
0.001
Monthly Volume of DNAPL Entry
Cumulative Volume of DNAPL Entry
Gallons
Gallons
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Date

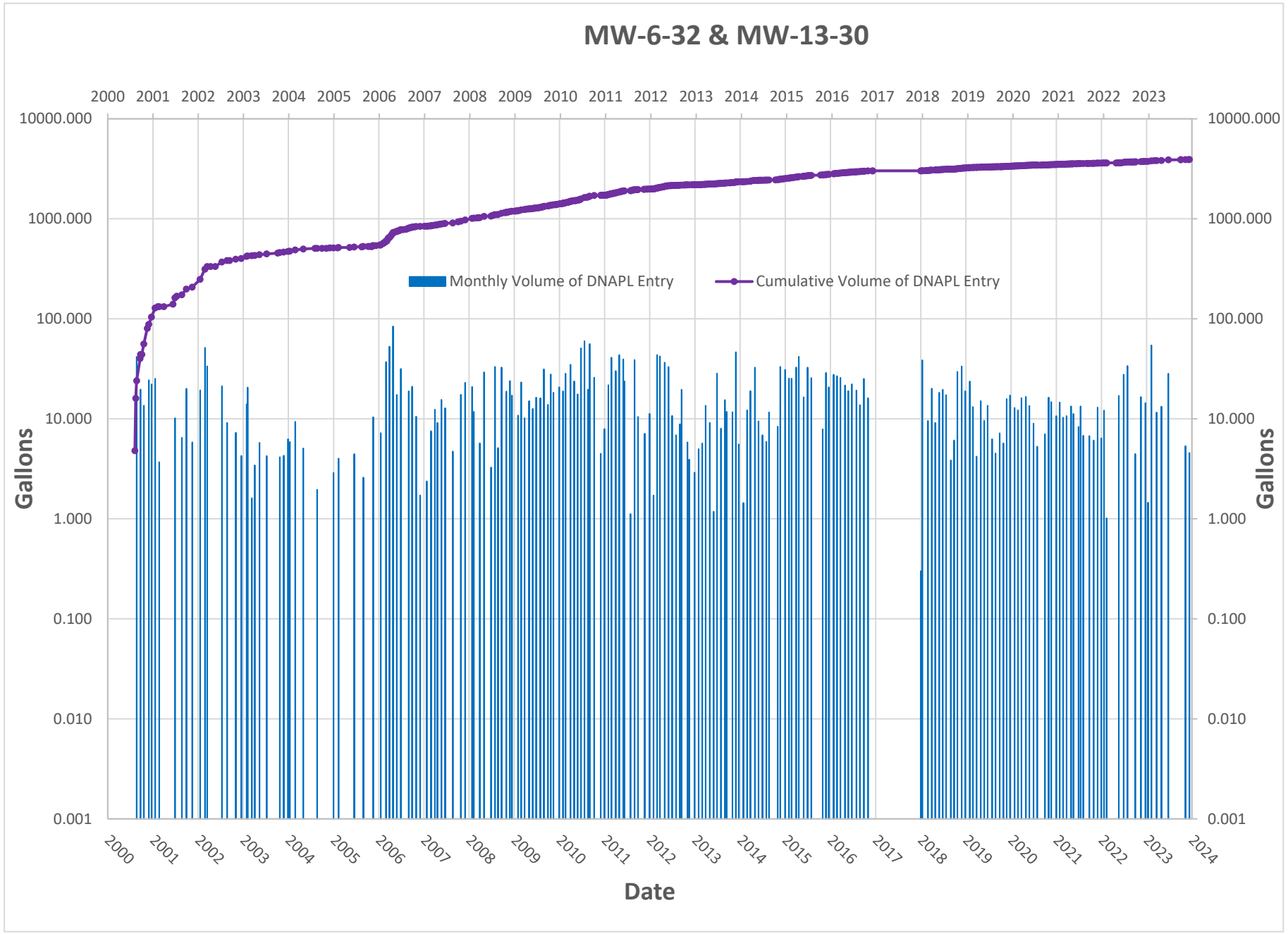

PW-11U
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
10000.000
1000.000
100.000
10.000
1.000
0.100
0.010
0.001
Monthly Volume of DNAPL Entry
Cumulative Volume of DNAPL Entry
Gallons
Gallons
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Date


PW-11Ub
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
10000.000
1000.000
100.000
10.000
1.000
0.100
0.010
0.001
Monthly Volume of DNAPL Entry
Cumulative Volume of DNAPL Entry
Gallons
Gallons
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Date

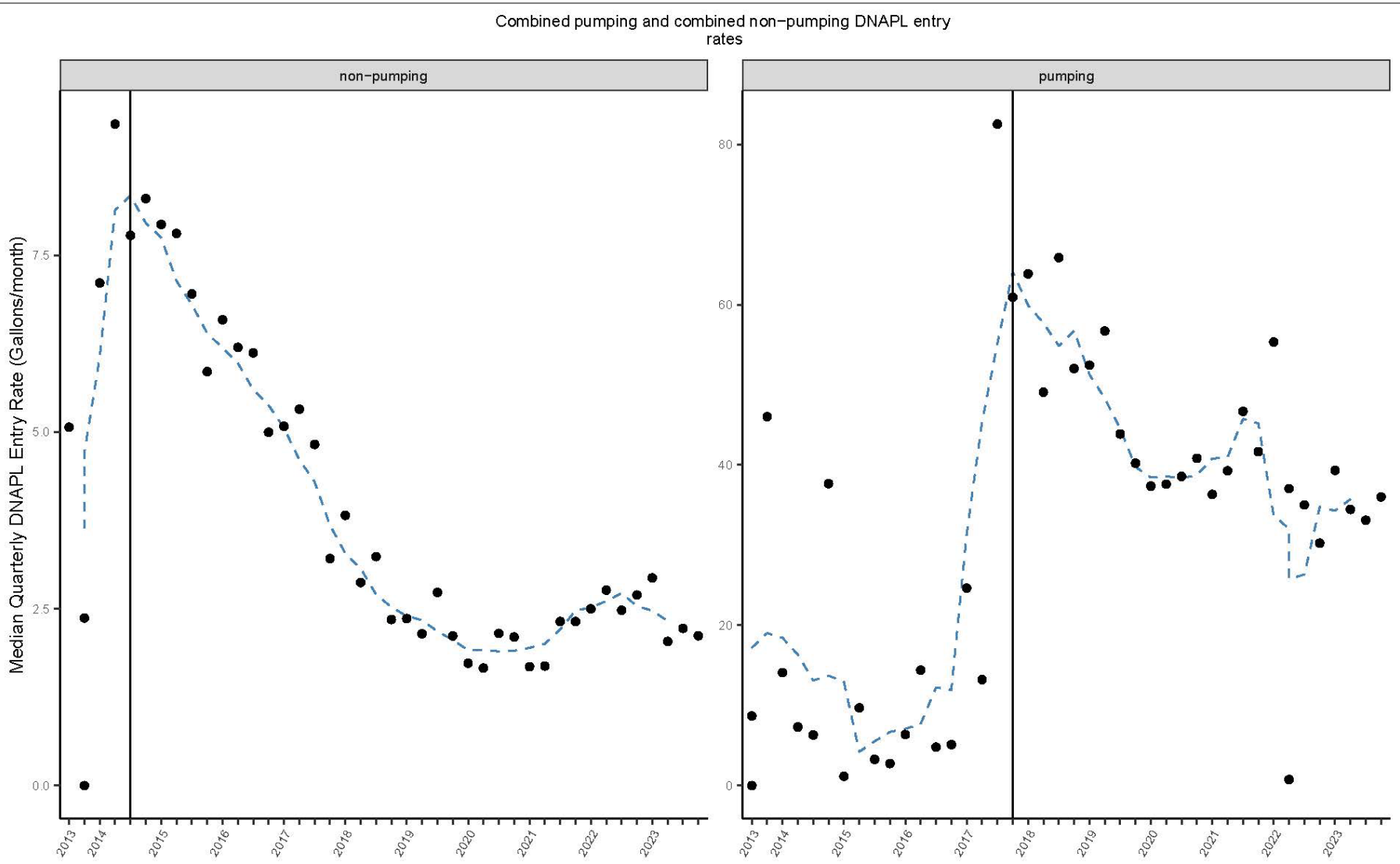

PW-13U
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
10000.000
1000.000
100.000
10.000
1.000
0.100
0.010
0.001
Monthly Volume of DNAPL Entry
Cumulative Volume of DNAPL Entry
Gallons
Gallons
Date


PW-14U
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
10000.000
1000.000
100.000
10.000
1.000
0.100
0.010
0.001
Monthly Volume of DNAPL Entry
Cumulative Volume of DNAPL Entry
Gallons
Gallons
Date
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024


T-50 Trench Sump
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
10000.000
1000.000
100.000
10.000
1.000
0.100
0.010
0.001
Monthly Volume of DNAPL Entry
Cumulative Volume of DNAPL Entry
Gallons
Gallons
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Date


MW-6-32 & MW-13-30
Monthly Volume of DNAPL Entry
Cumulative Volume of DNAPL Entry
Gallons
Gallons
Date
10000.000
1000.000
100.000
10.000
1.000
0.100
0.010
0.001
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

Appendix D
DNAPL Entry Rate Trend Analysis Results



Note: DNAPL entry rate is represented as the sum of quarterly median entry rate for each well type with a 1-year moving average. Peak DNAPL entry rate is represented as vertical black line based on the 1-year moving average.

Filepath: \\fuji\Anchor\Projects\NW Natural\Gasco\GASCO from Stumptown1\Groundwater Source Control\DNAPL Monitoring\Reporting\2023 Reports\2nd Half 2023\Appendices\Appendix D - Trend Analysis\Figure D-1.docx

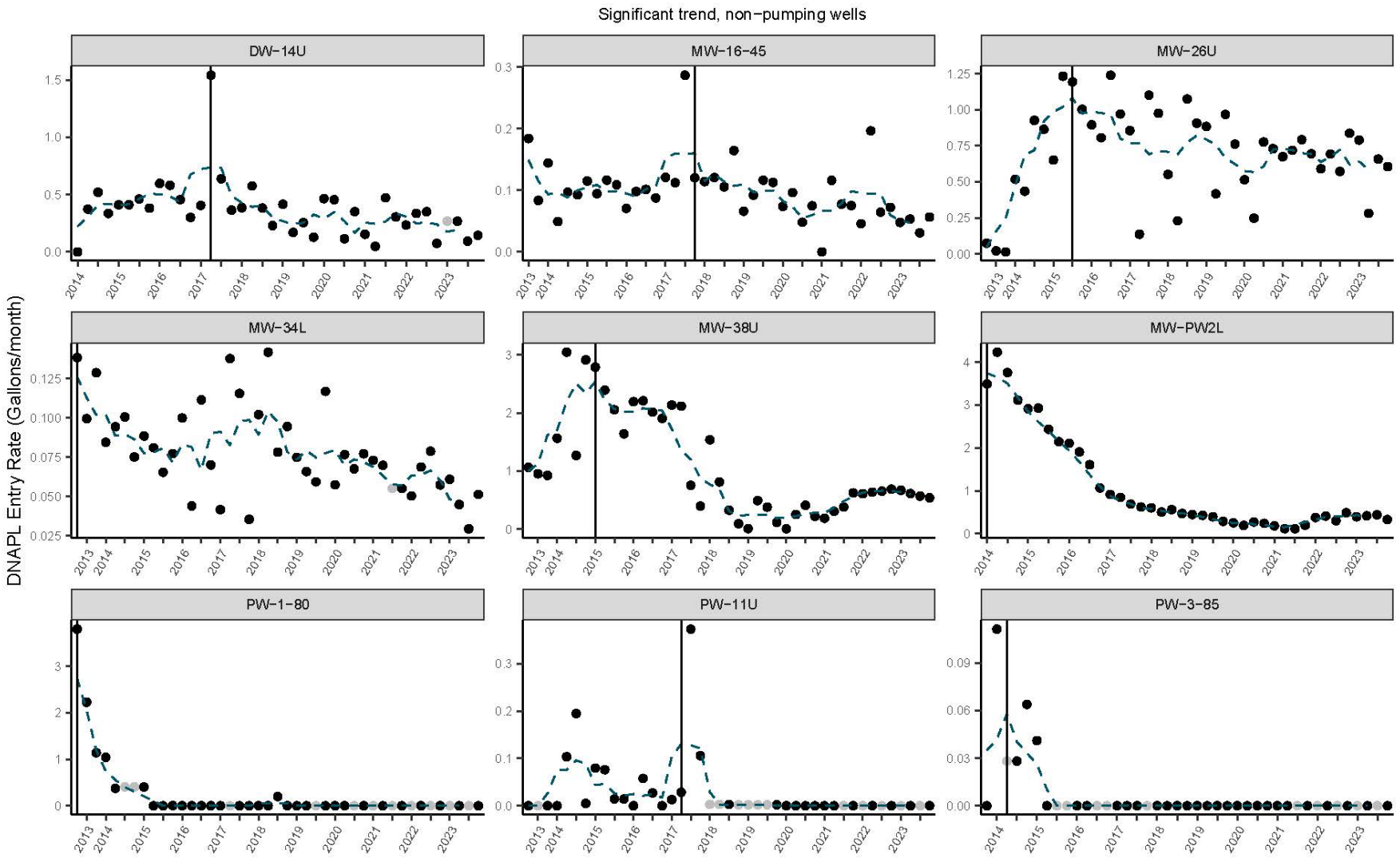
ANCHOR QEA

Figure D-1

DNAPL Entry Rates – Totals for Pumping and Non-Pumping Wells

DNAPL Monitoring Semiannual Summary Report (July 1 through December 31, 2023)

NW Natural Gasco Site



Note: DNAPL is represented as quarterly median entry rate with a 1-year moving average. Interpolated quarterly data, used to calculate the moving average, are displayed as gray dots. Peak DNAPL is represented with a vertical black line based on the 1-year moving average. Decreasing trend is based on a significant Mann-Kendall Test result for quarterly data on and after peak DNAPL entry rate. Interpolated data are not used in the trend test.

Filepath: \\fuji\Anchor\Projects\NW Natural\Gasco\GASCO from Stumptown1\Groundwater Source Control\DNAPL Monitoring\Reporting\2023 Reports\2nd Half 2023\Appendices\Appendix D - Trend Analysis\Figure D-2.docx

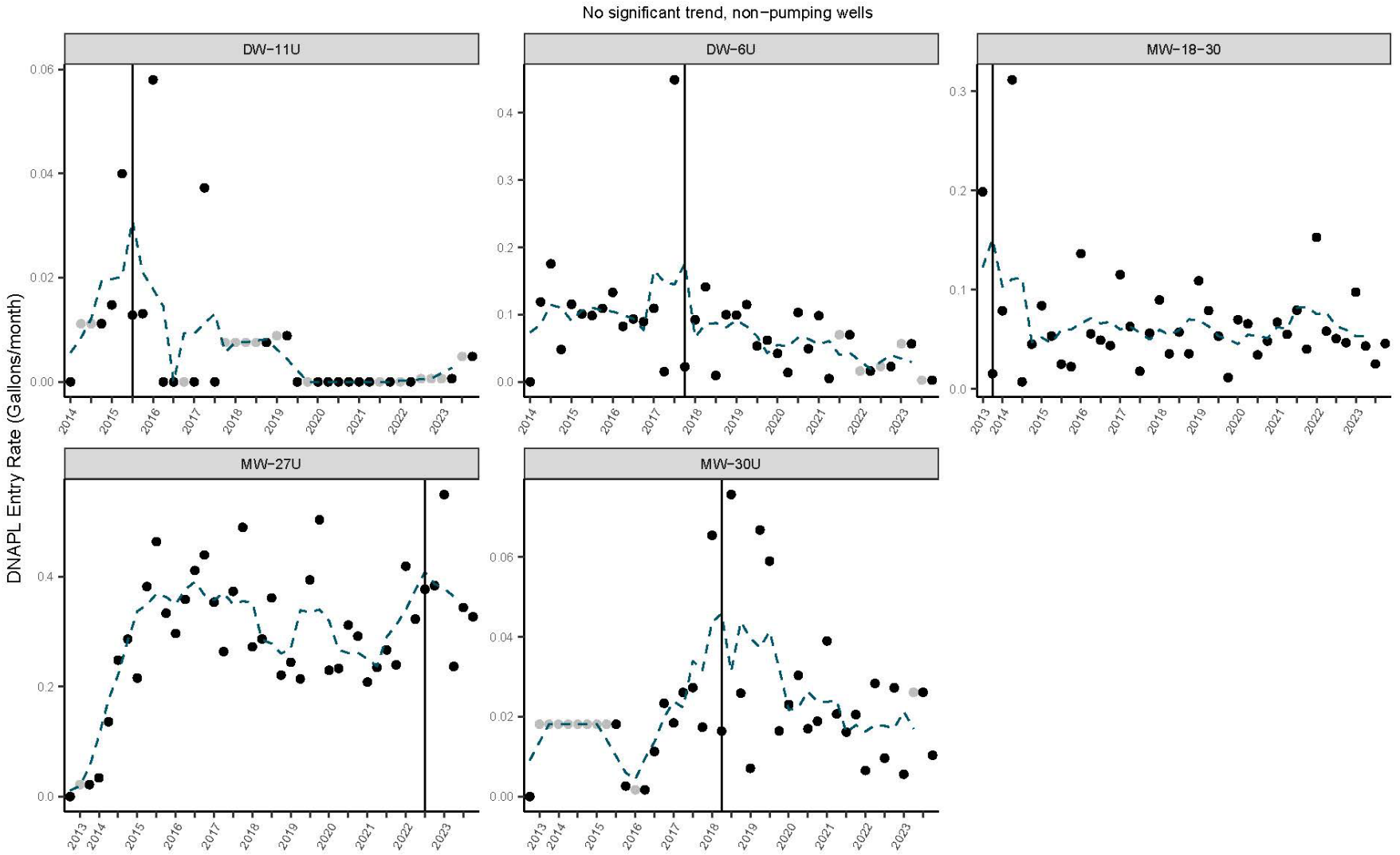
ANCHOR QEA

Figure D-2

DNAPL Entry Rates – Non-Pumping Wells with Significant Decreasing Trend

DNAPL Monitoring Semiannual Summary Report (July 1 through December 31, 2023)

NW Natural Gasco Site



Note: DNAPL is represented as quarterly median entry rate with a 1-year moving average. Interpolated quarterly data, used to calculate the moving average, are displayed as gray dots. Peak DNAPL is represented with a vertical black line based on the 1-year moving average. Stable trend is based on no significance in a Mann-Kendall Test result for quarterly data on and after peak DNAPL entry rate. Interpolated data are not used in the trend test.

Filepath: \\fuji\Anchor\Projects\NW Natural\Gasco\GASCO from Stumptown1\Groundwater Source Control\DNAPL Monitoring\Reporting\2023 Reports\2nd Half 2023\Appendices\Appendix D - Trend Analysis\Figure D-3.docx

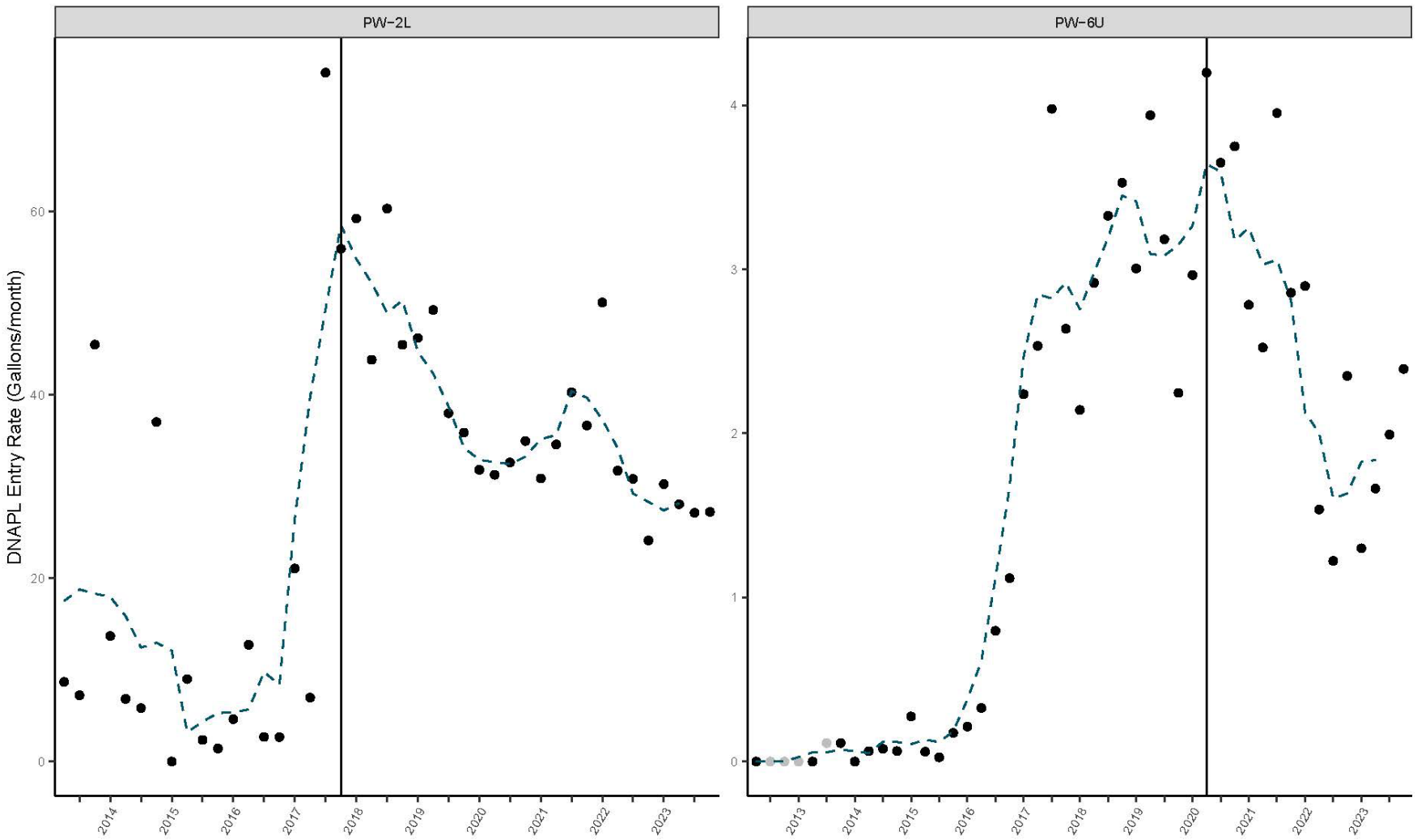
ANCHOR QEA

Figure D-3

DNAPL Entry Rates – Non-Pumping Wells with Stable Trend

DNAPL Monitoring Semiannual Summary Report (July 1 through December 31, 2023)

NW Natural Gasco Site



Note: DNAPL is represented as quarterly median entry rate with a 1-year moving average. Interpolated quarterly data, used to calculate the moving average, are displayed as gray dots. Peak DNAPL is represented with a vertical black line based on the 1-year moving average. Decreasing trend is based on a significant Mann-Kendall Test result for quarterly data on and after peak DNAPL entry rate. Interpolated data are not used in the trend test.

Filepath: \\fuji\Anchor\Projects\NW Natural\Gasco\GASCO from Stumptown1\Groundwater Source Control\DNAPL Monitoring\Reporting\2023 Reports\2nd Half 2023\Appendices\Appendix D - Trend Analysis\Figure D-4.docx

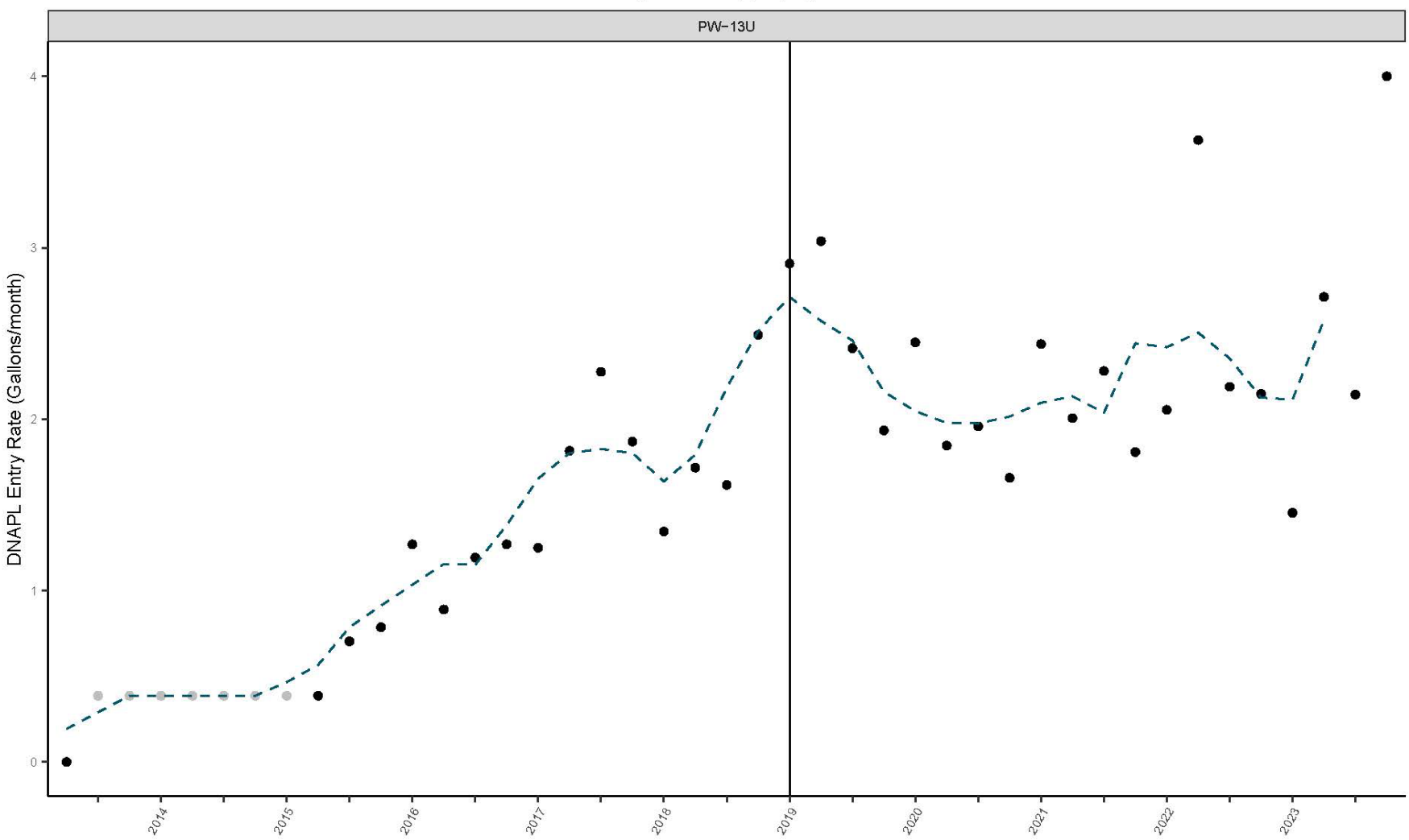
ANCHOR QEA

Figure D-4

DNAPL Entry Rates – Pumping Wells with Significant Decreasing Trend

DNAPL Monitoring Semiannual Summary Report (July 1 through December 31, 2023)

NW Natural Gasco Site



Note: DNAPL is represented as quarterly median entry rate with a 1-year moving average. Interpolated quarterly data, used to calculate the moving average, are displayed as gray dots. Peak DNAPL is represented with a vertical black line based on the 1-year moving average. Stable trend is based on no significance in a Mann-Kendall Test result for quarterly data on and after peak DNAPL entry rate. Interpolated data are not used in the trend test.

Filepath: \\fuji\Anchor\Projects\NW Natural\Gasco\GASCO from Stumptown1\Groundwater Source Control\DNAPL Monitoring\Reporting\2023 Reports\2nd Half 2023\Appendices\Appendix D - Trend Analysis\Figure D-5.docx

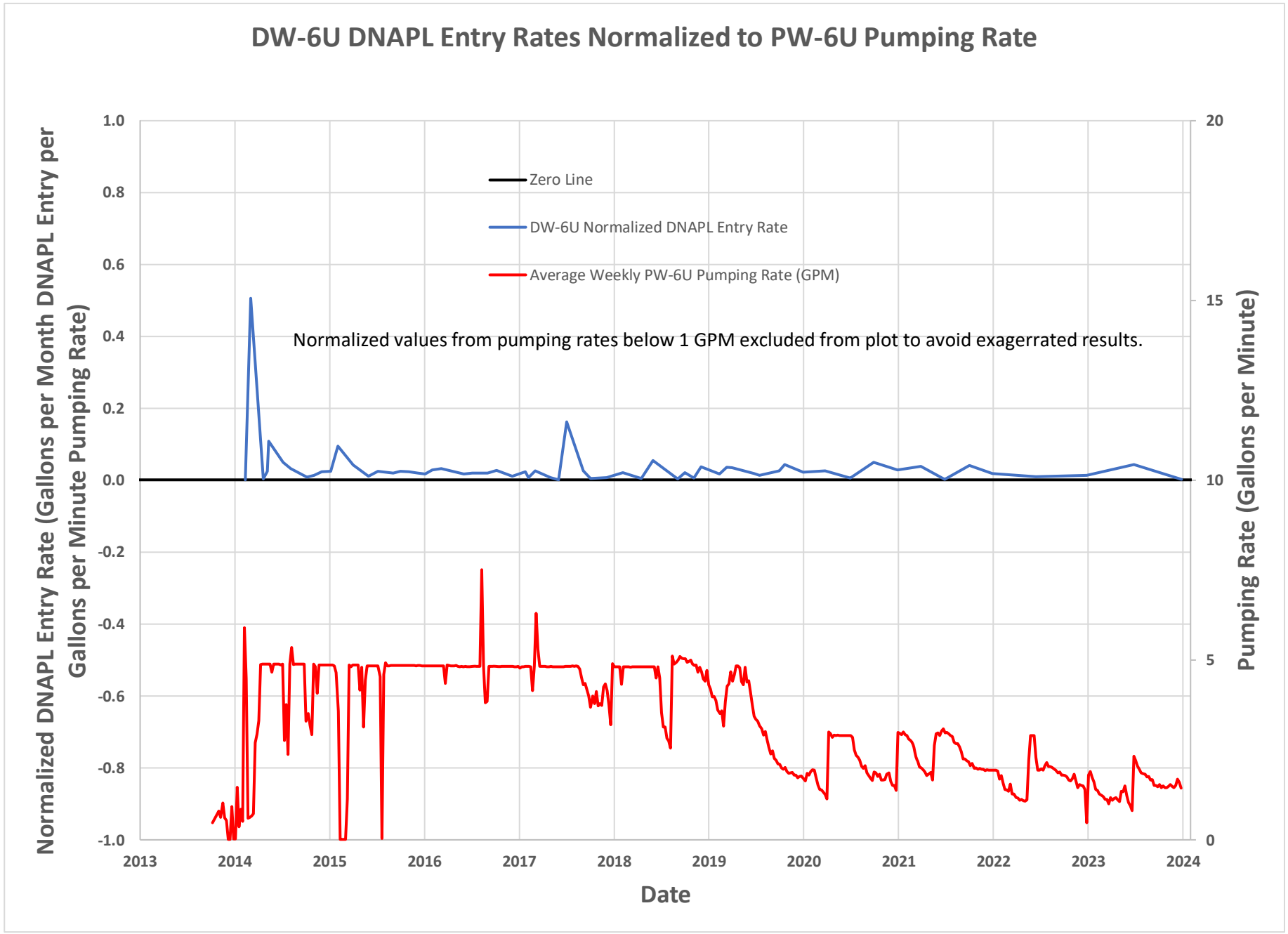
ANCHOR QEA

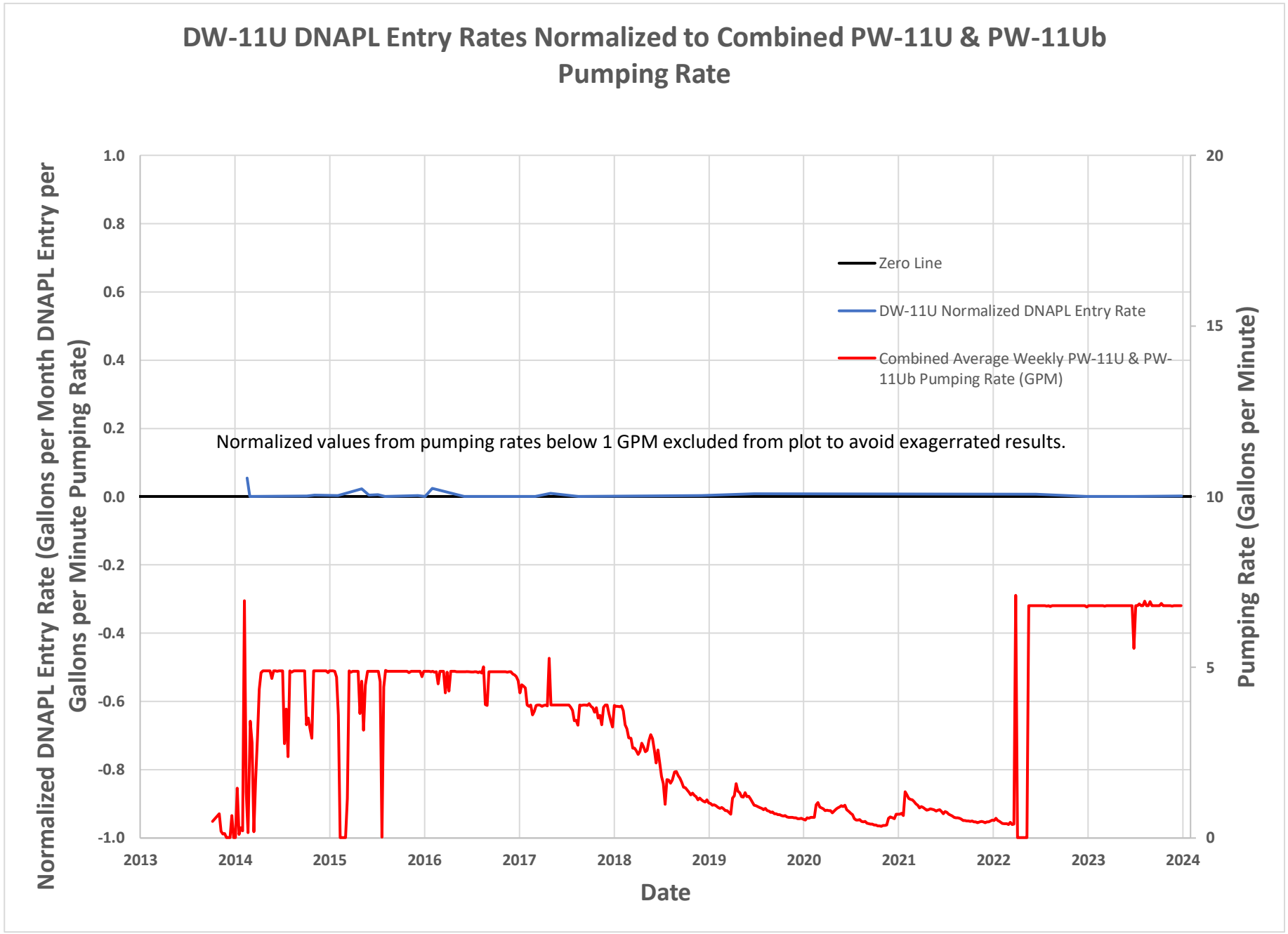
Figure D-5

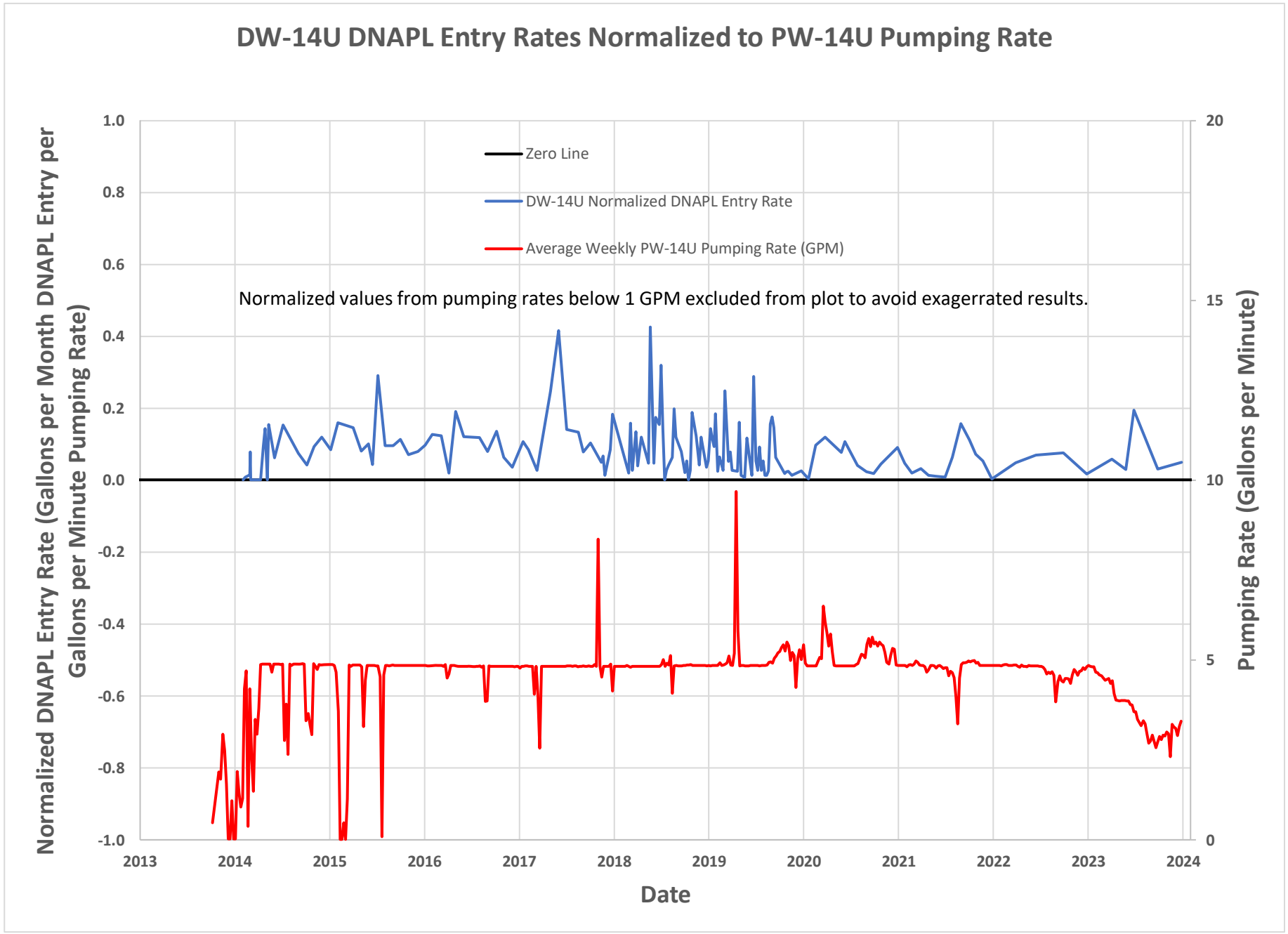
DNAPL Entry Rates – Pumping Wells with Stable Trend

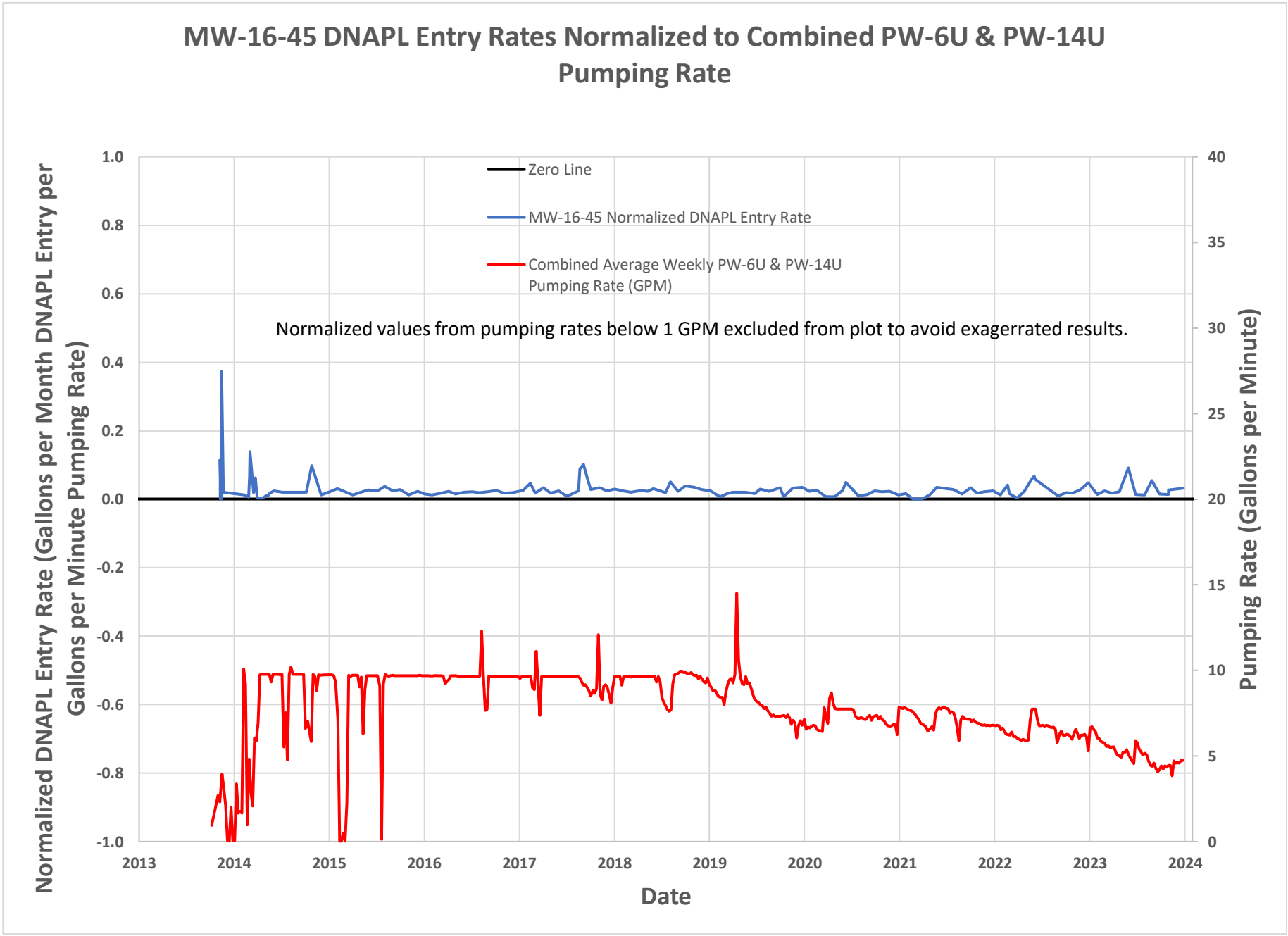
DNAPL Monitoring Semiannual Summary Report (July 1 through December 31, 2023)
NW Natural Gasco Site

Appendix E
Time-Series Plots – Normalized DNAPL Entry Rates

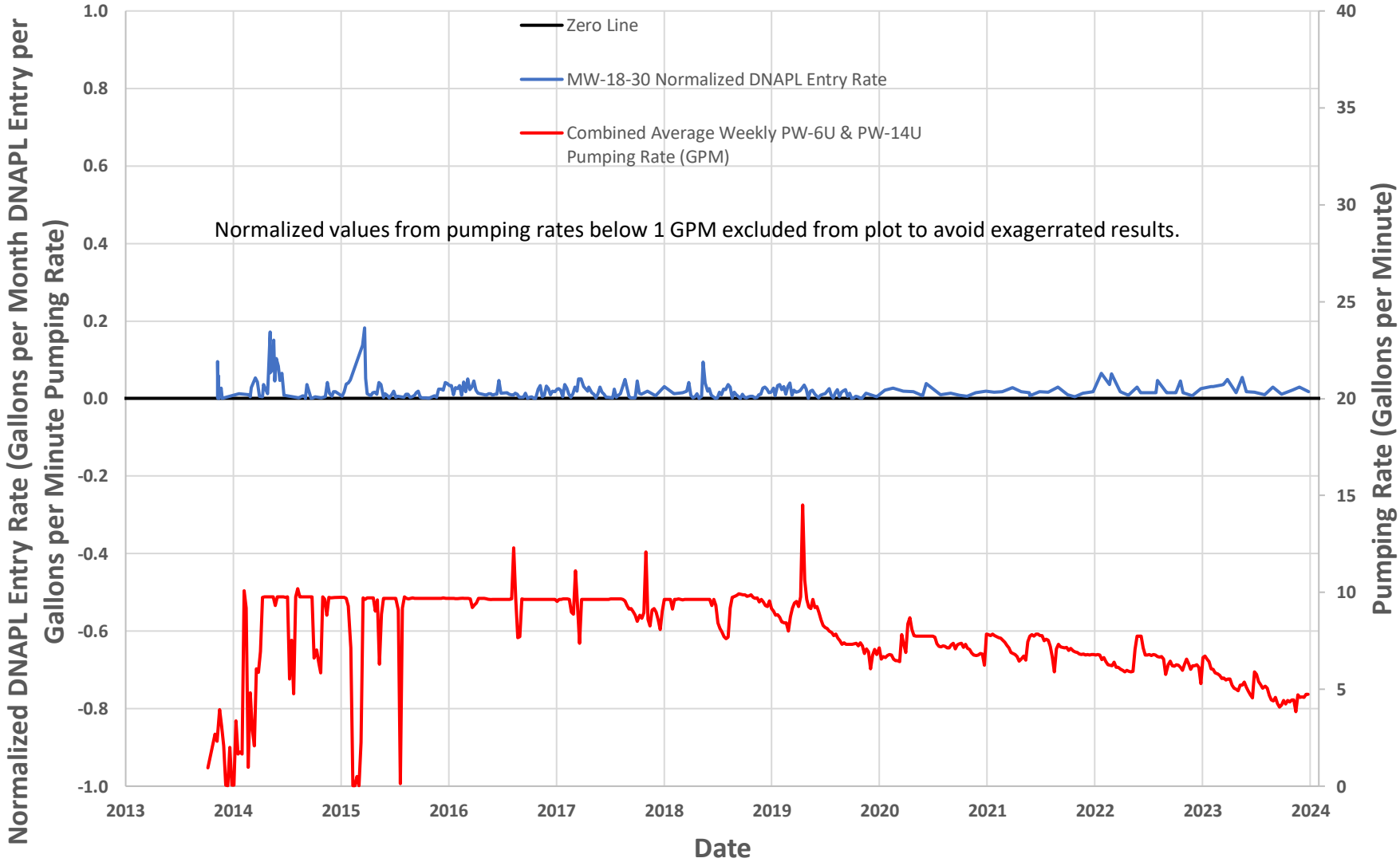

DW-6U DNAPL Entry Rates Normalized to PW-6U Pumping Rate
Normalized DNAPL Entry Rate (Gallons per Month DNAPL Entry per Gallons per Minute Pumping Rate)
Pumping Rate (Gallons per Minute)
Date
Zero Line
DW-6U Normalized DNAPL Entry Rate
Average Weekly PW-6U Pumping Rate (GPM)
Normalized values from pumping rates below 1 GPM excluded from plot to avoid exagerrated results.
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

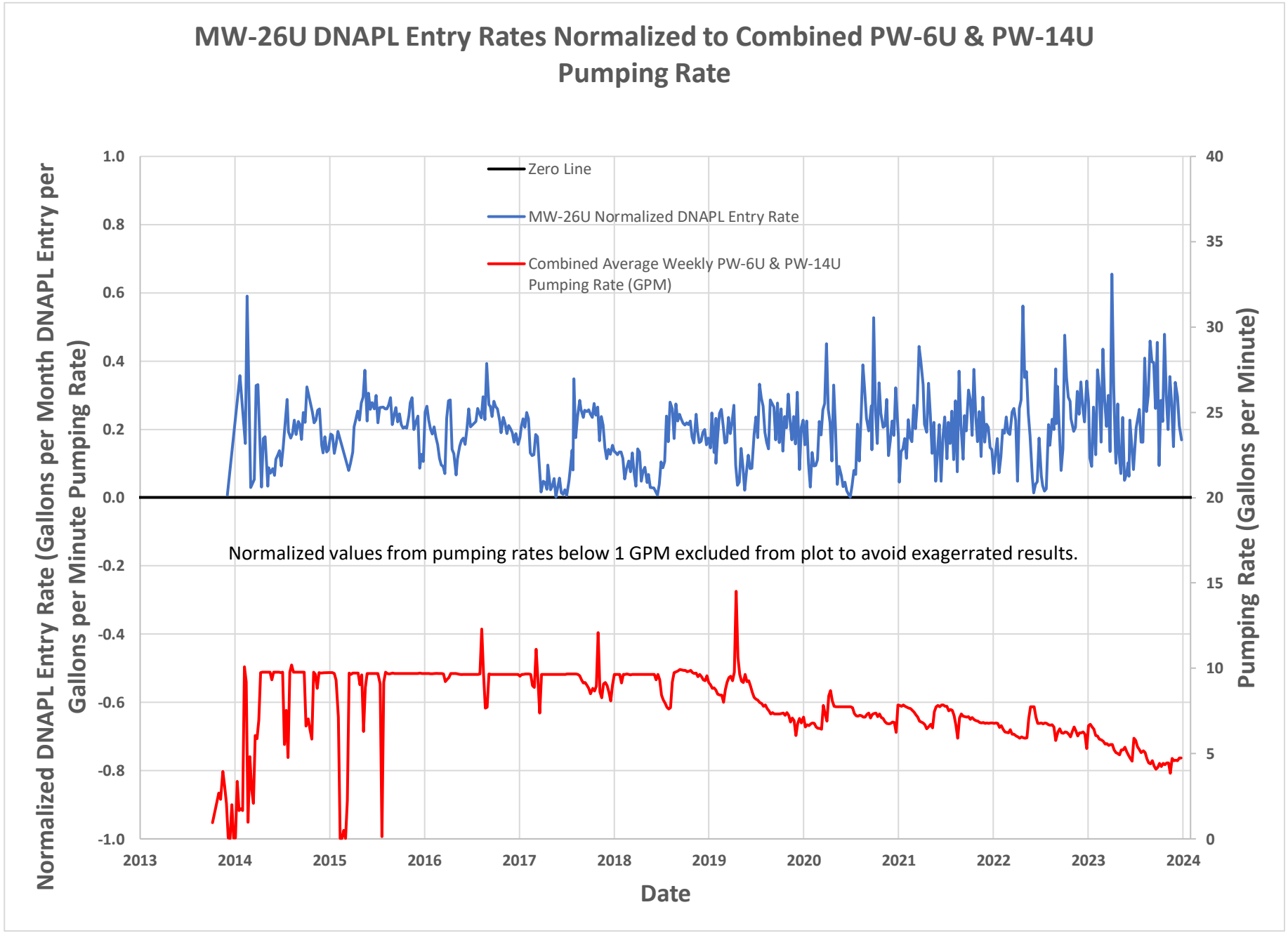

DW-11U DNAPL Entry Rates Normalized to Combined PW-11U & PW-11Ub Pumping Rate
Normalized DNAPL Entry Rate (Gallons per Month DNAPL Entry per Gallons per Minute Pumping Rate)
Pumping Rate (Gallons per Minute)
Date
Zero Line
DW-11U Normalized DNAPL Entry Rate
Combined Average Weekly PW-11U & PW-11Ub Pumping Rate (GPM)
Normalized values from pumping rates below 1 GPM excluded from plot to avoid exagerrated results.
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

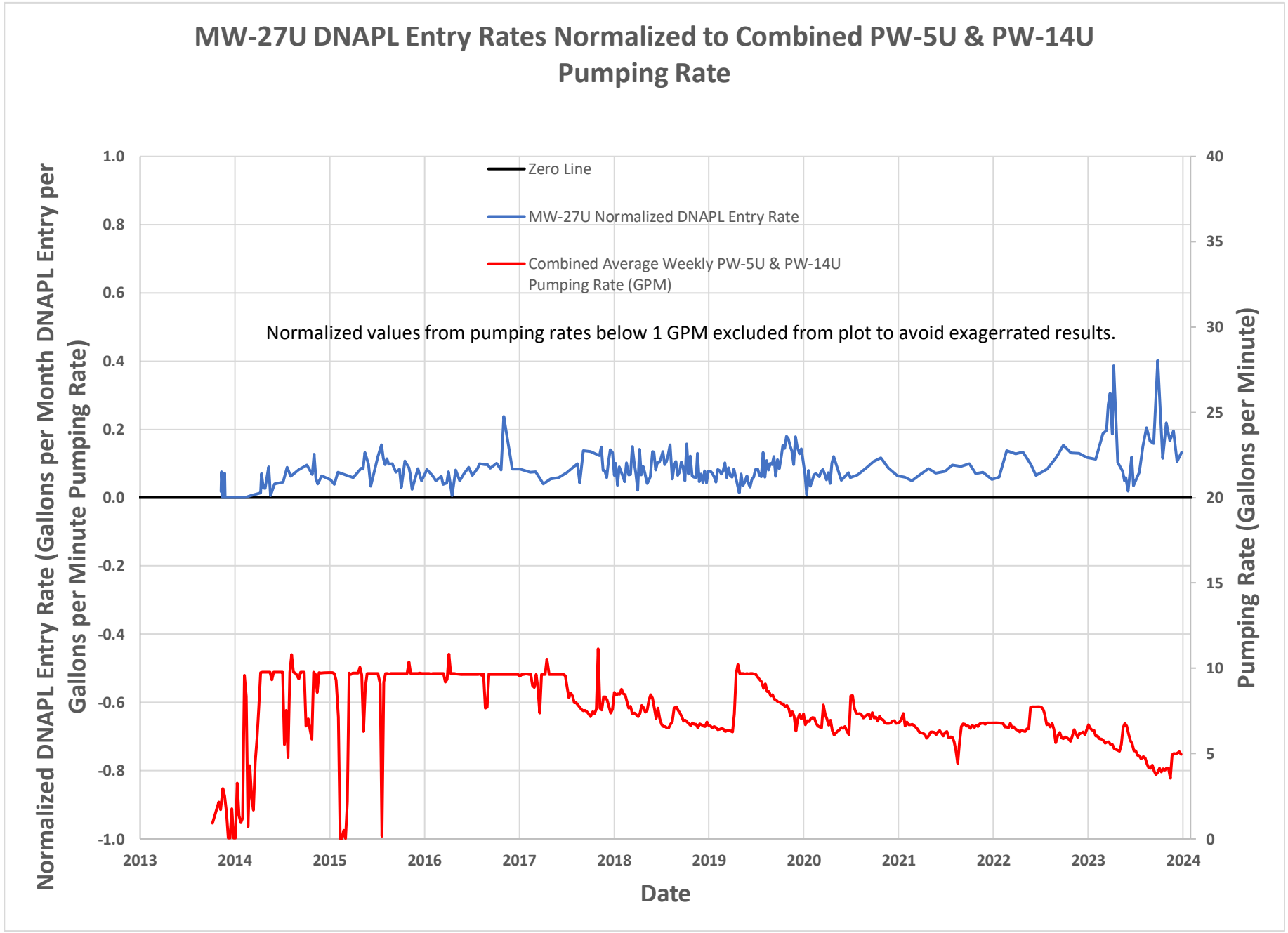

DW-14U DNAPL Entry Rates Normalized to PW-14U Pumping Rate
Zero Line
DW-14U Normalized DNAPL Entry Rate
Average Weekly PW-14U Pumping Rate (GPM)
Normalized values from pumping rates below 1 GPM excluded from plot to avoid exagerrated results.
Normalized DNAPL Entry Rate (Gallons per Month DNAPL Entry per Gallons per Minute Pumping Rate)
Pumping Rate (Gallons per Minute)
Date
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

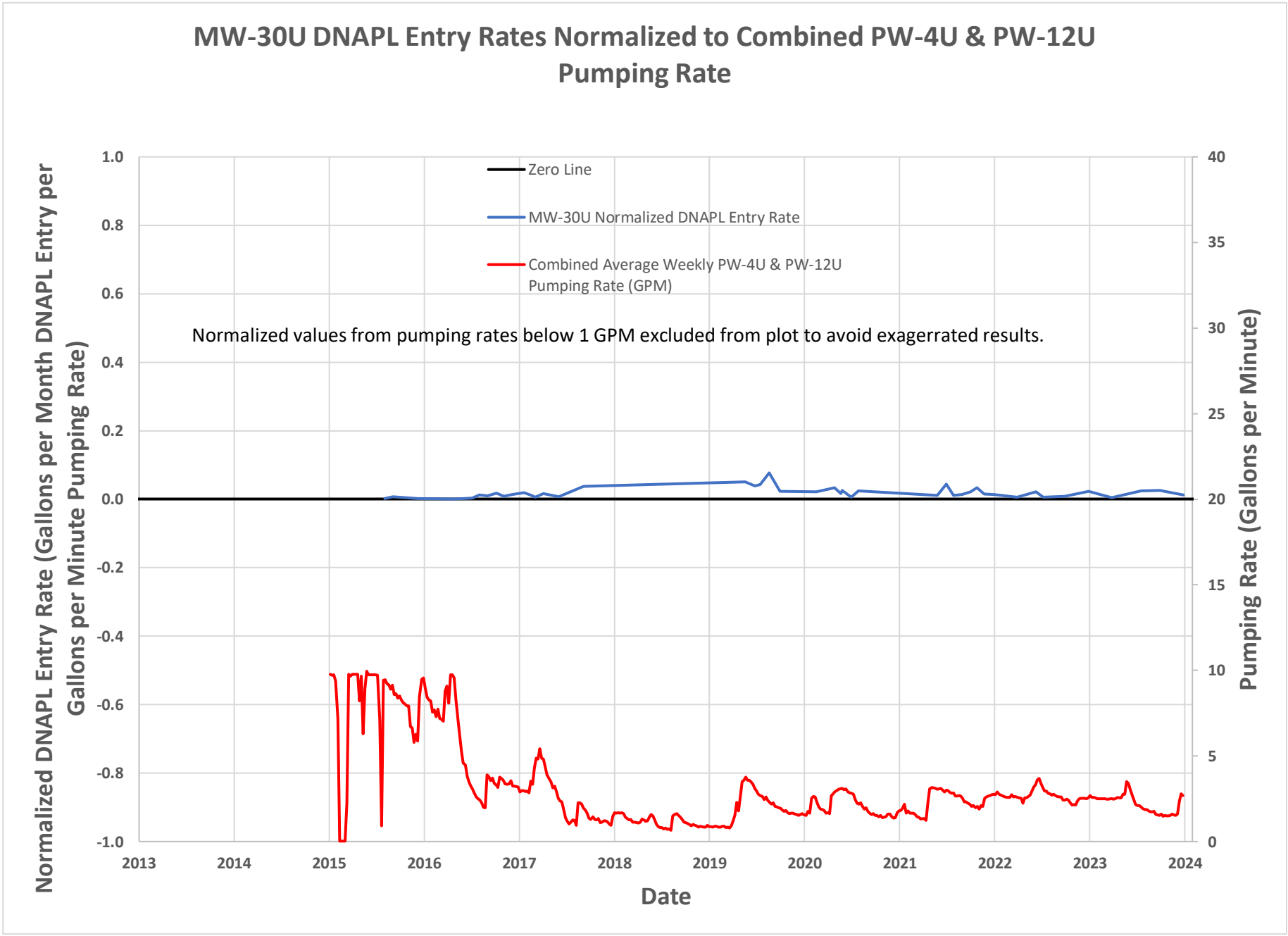

MW-16-45 DNAPL Entry Rates Normalized to Combined PW-6U & PW-14U Pumping Rate
Zero Line
MW-16-45 Normalized DNAPL Entry Rate
Combined Average Weekly PW-6U & PW-14U Pumping Rate (GPM)
Normalized values from pumping rates below 1 GPM excluded from plot to avoid exagerrated results.
Normalized DNAPL Entry Rate (Gallons per Month DNAPL Entry per Gallons per Minute Pumping Rate)
Pumping Rate (Gallons per Minute)
Date
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
40
35
30
25
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

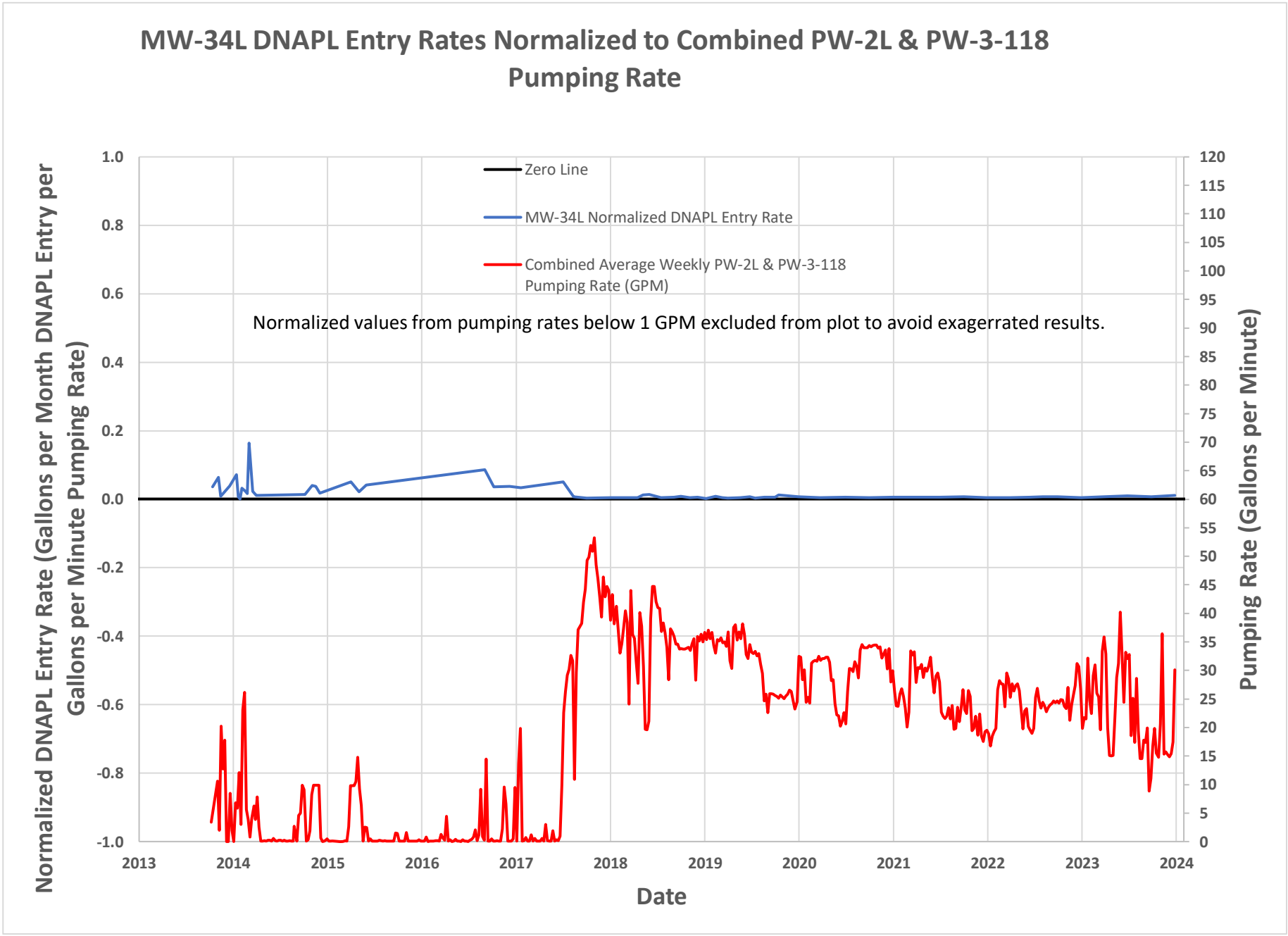
MW-18-30 DNAPL Entry Rates Normalized to Combined PW-6U & PW-14U Pumping Rate

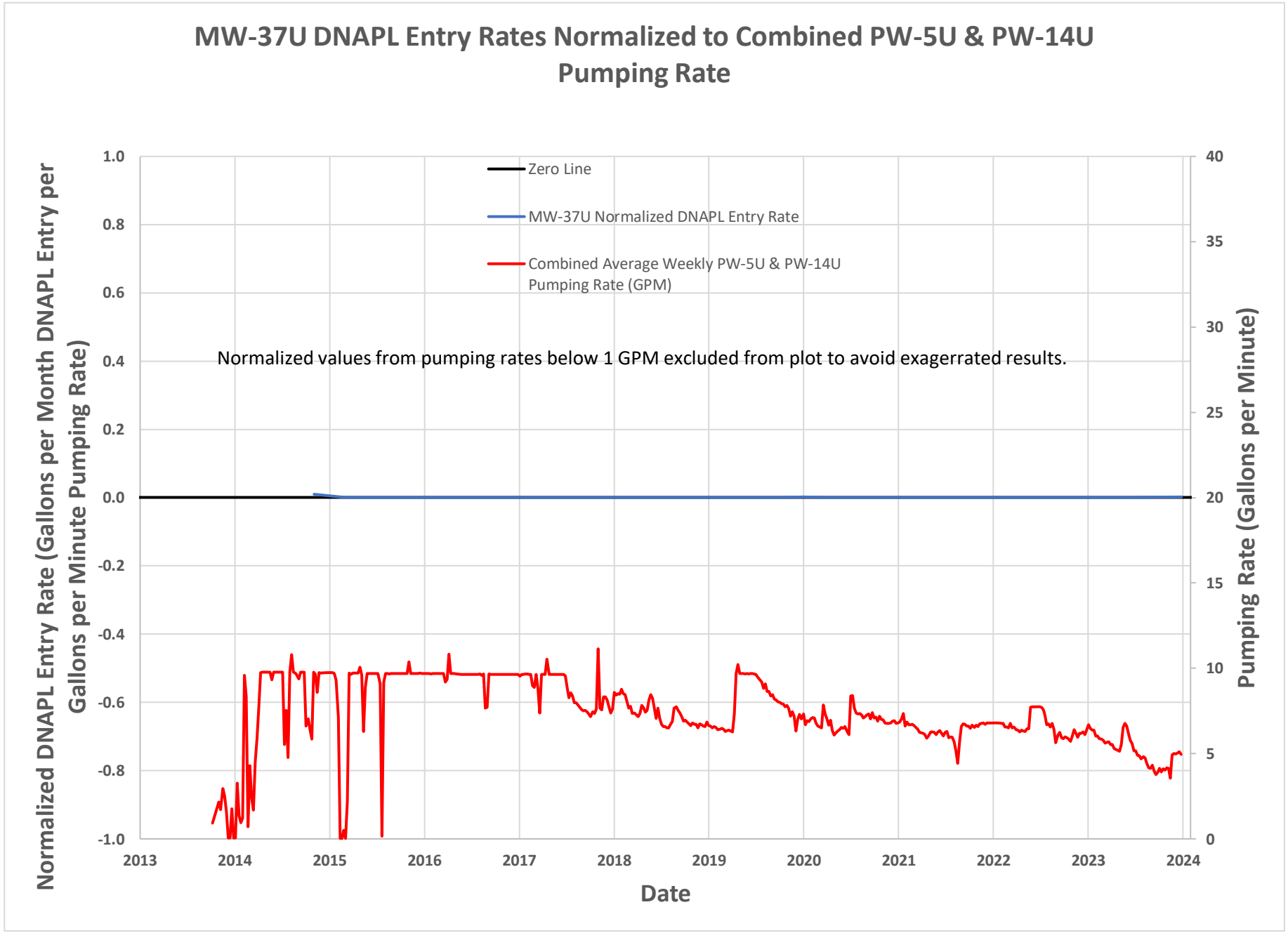


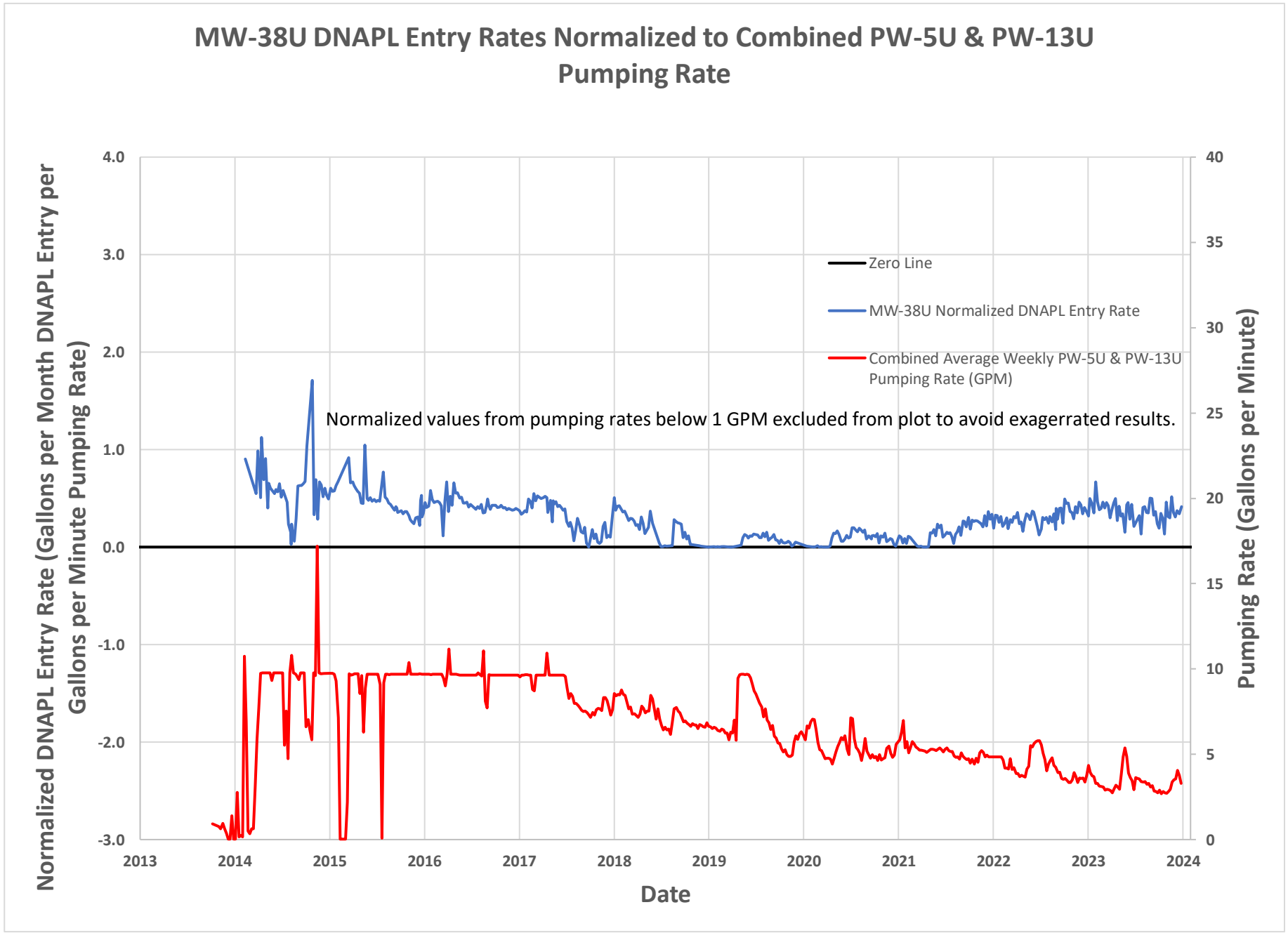

MW-26U DNAPL Entry Rates Normalized to Combined PW-6U & PW-14U Pumping Rate
Zero Line
MW-26U Normalized DNAPL Entry Rate
Combined Average Weekly PW-6U & PW-14U Pumping Rate (GPM)
Normalized values from pumping rates below 1 GPM excluded from plot to avoid exagerrated results.
Normalized DNAPL Entry Rate (Gallons per Month DNAPL Entry per Gallons per Minute Pumping Rate)
Pumping Rate (Gallons per Minute)
Date
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
40
35
30
25
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

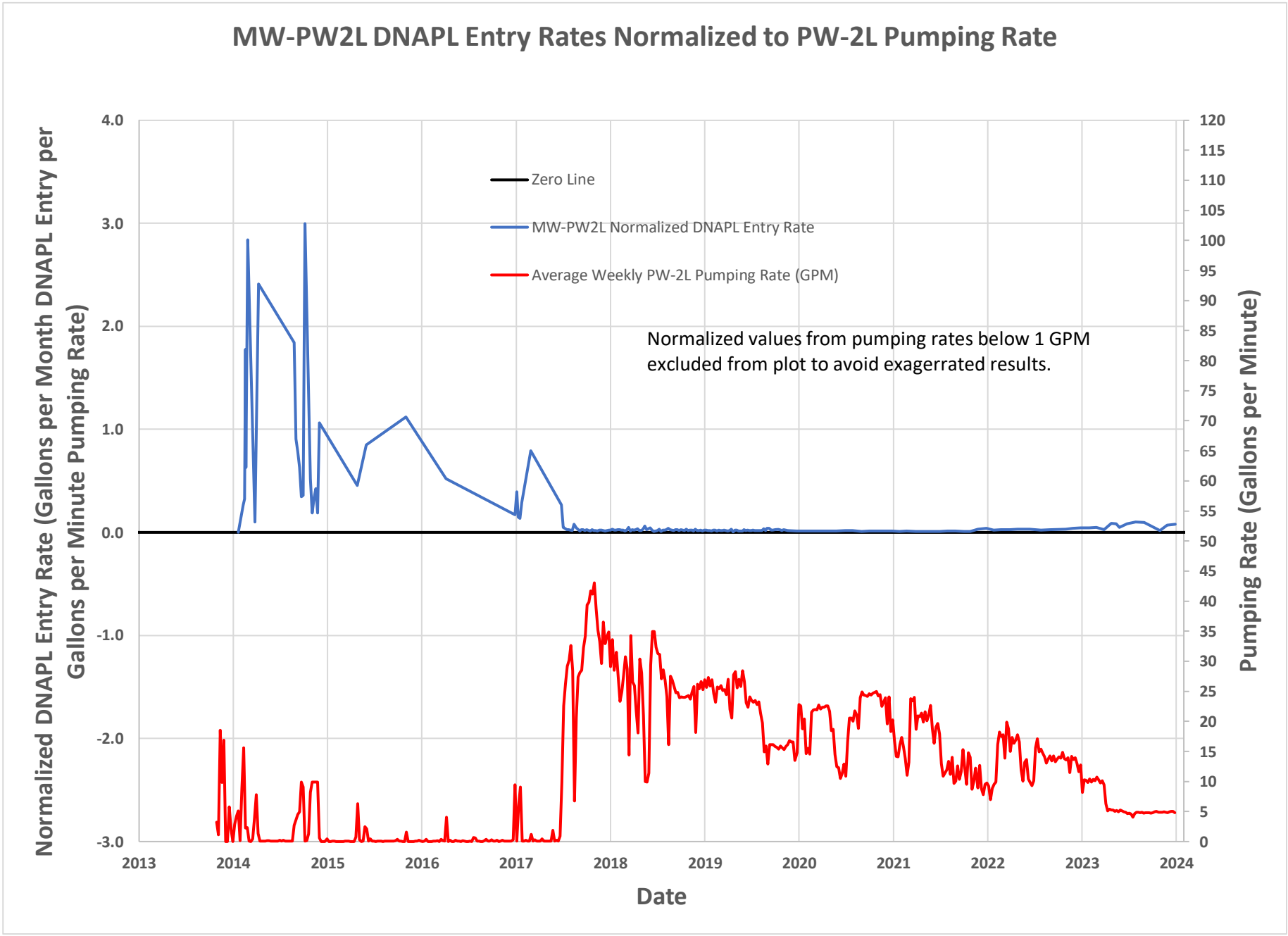

MW-27U DNAPL Entry Rates Normalized to Combined PW-5U & PW-14U Pumping Rate
Zero Line
MW-27U Normalized DNAPL Entry Rate
Combined Average Weekly PW-5U & PW-14U Pumping Rate (GPM)
Normalized values from pumping rates below 1 GPM excluded from plot to avoid exagerrated results.
Normalized DNAPL Entry Rate (Gallons per Month DNAPL Entry per Gallons per Minute Pumping Rate)
Pumping Rate (Gallons per Minute)
Date
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
40
35
30
25
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

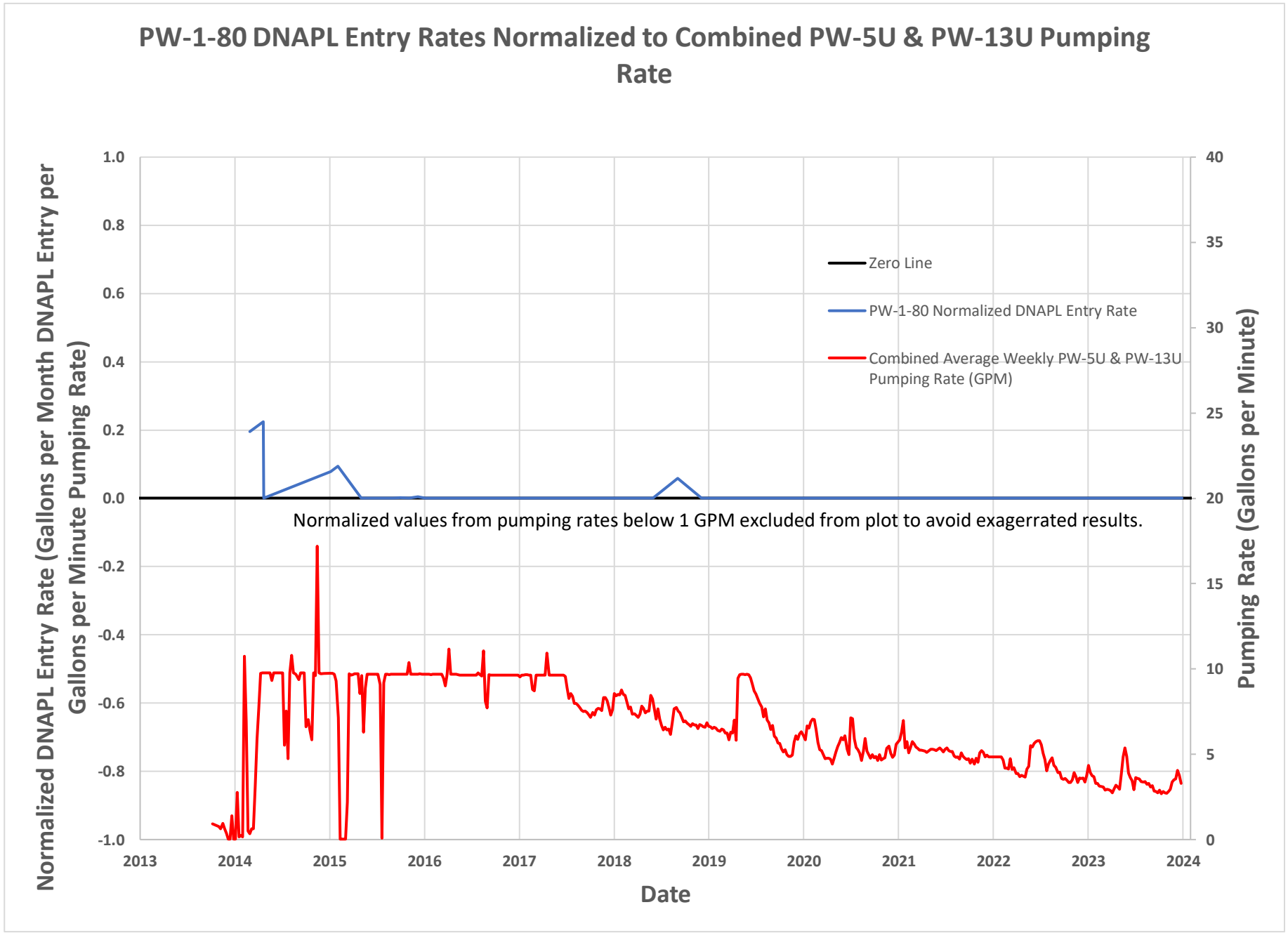

MW-30U DNAPL Entry Rates Normalized to Combined PW-4U & PW-12U Pumping Rate
Zero Line
MW-30U Normalized DNAPL Entry Rate
Combined Average Weekly PW-4U & PW-12U Pumping Rate (GPM)
Normalized values from pumping rates below 1 GPM excluded from plot to avoid exagerrated results.
Normalized DNAPL Entry Rate (Gallons per Month DNAPL Entry per Gallons per Minute Pumping Rate)
Pumping Rate (Gallons per Minute)
Date
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
40
35
30
25
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

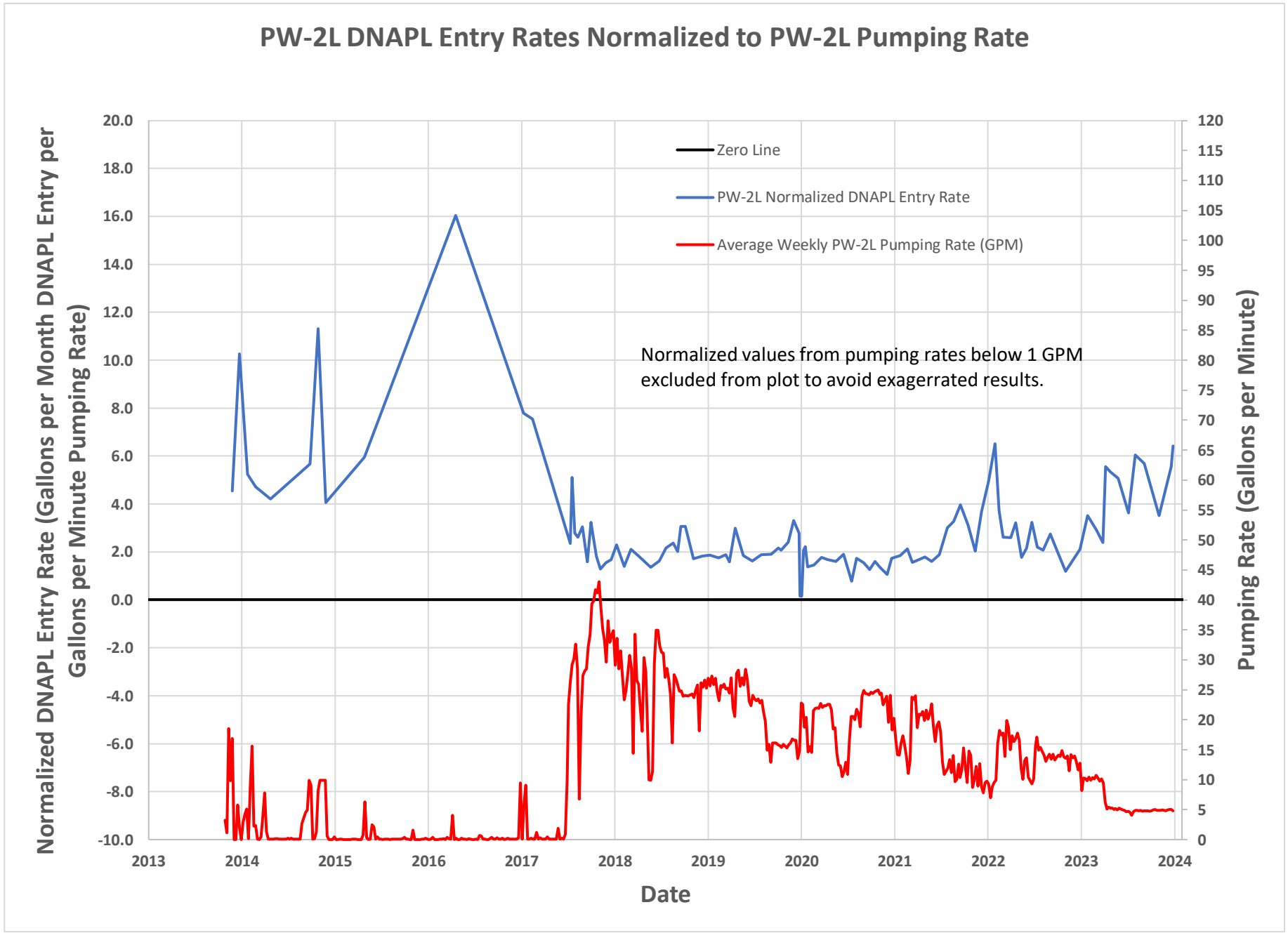

MW-34L DNAPL Entry Rates Normalized to Combined PW-2L & PW-3-118 Pumping Rate
Zero Line
MW-34L Normalized DNAPL Entry Rate
Combined Average Weekly PW-2L & PW-3-118 Pumping Rate (GPM)
Normalized values from pumping rates below 1 GPM excluded from plot to avoid exagerrated results.
Normalized DNAPL Entry Rate (Gallons per Month DNAPL Entry per Gallons per Minute Pumping Rate)
Pumping Rate (Gallons per Minute)
Date
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

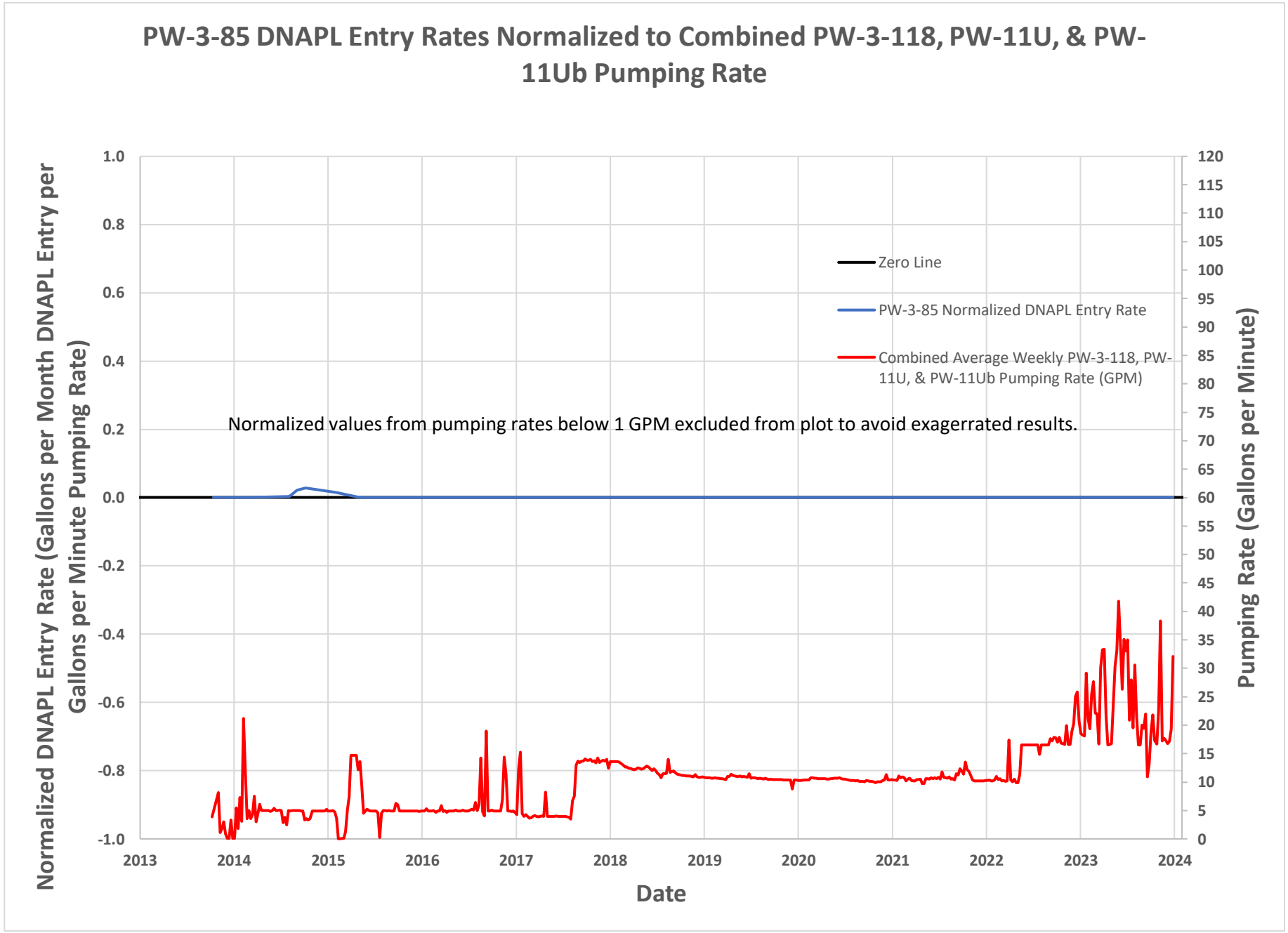

MW-37U DNAPL Entry Rates Normalized to Combined PW-5U & PW-14U Pumping Rate
Zero Line
MW-37U Normalized DNAPL Entry Rate
Combined Average Weekly PW-5U & PW-14U Pumping Rate (GPM)
Normalized values from pumping rates below 1 GPM excluded from plot to avoid exagerrated results.
Normalized DNAPL Entry Rate (Gallons per Month DNAPL Entry per Gallons per Minute Pumping Rate)
Pumping Rate (Gallons per Minute)
Date
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
40
35
30
25
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

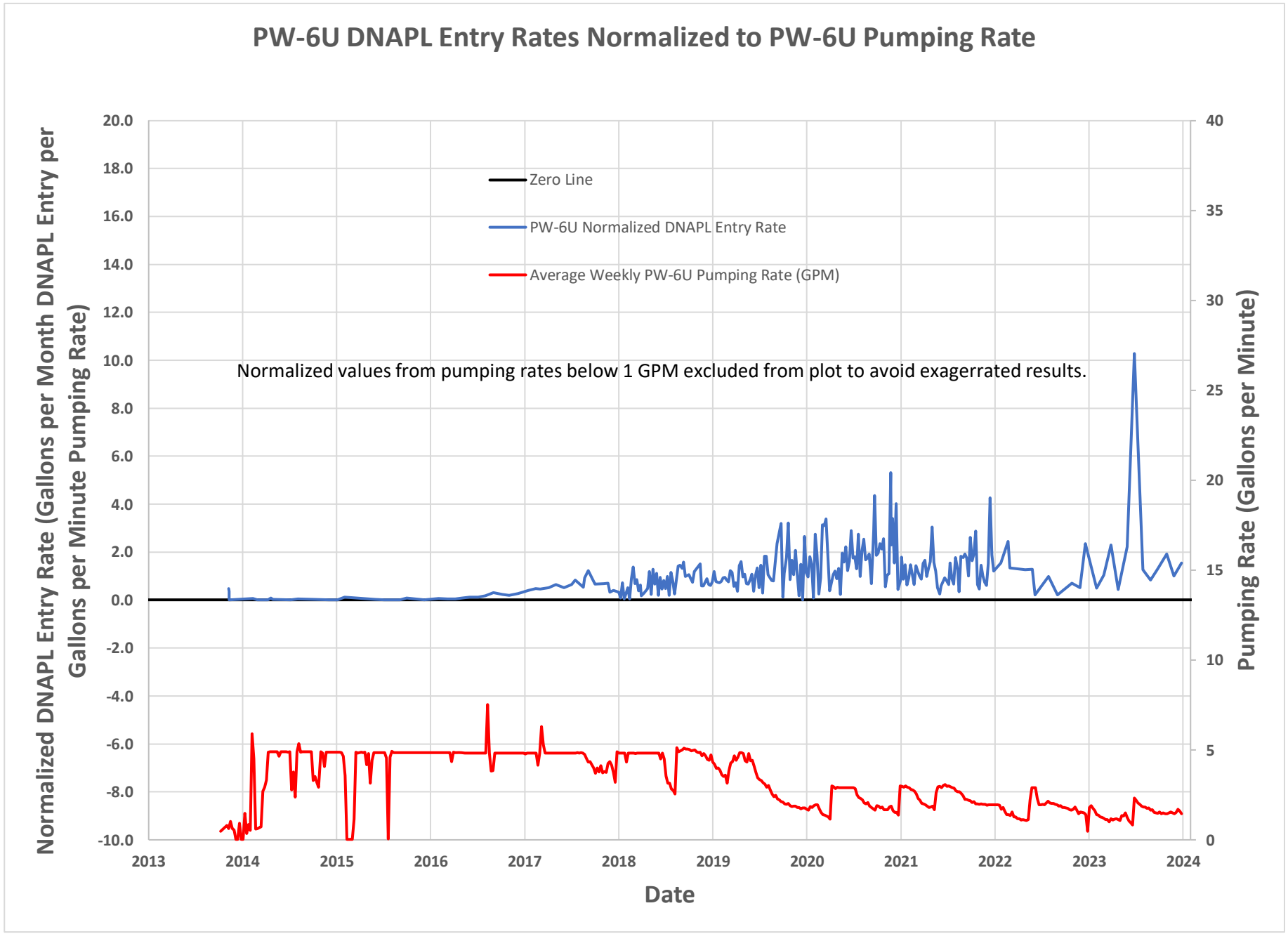

MW-38U DNAPL Entry Rates Normalized to Combined PW-5U & PW-13U Pumping Rate
Normalized DNAPL Entry Rate (Gallons per Month DNAPL Entry per Gallons per Minute Pumping Rate)
Pumping Rate (Gallons per Minute)
Date
Zero Line
MW-38U Normalized DNAPL Entry Rate
Combined Average Weekly PW-5U & PW-13U Pumping Rate (GPM)
Normalized values from pumping rates below 1 GPM excluded from plot to avoid exagerrated results.
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
40
35
30
25
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

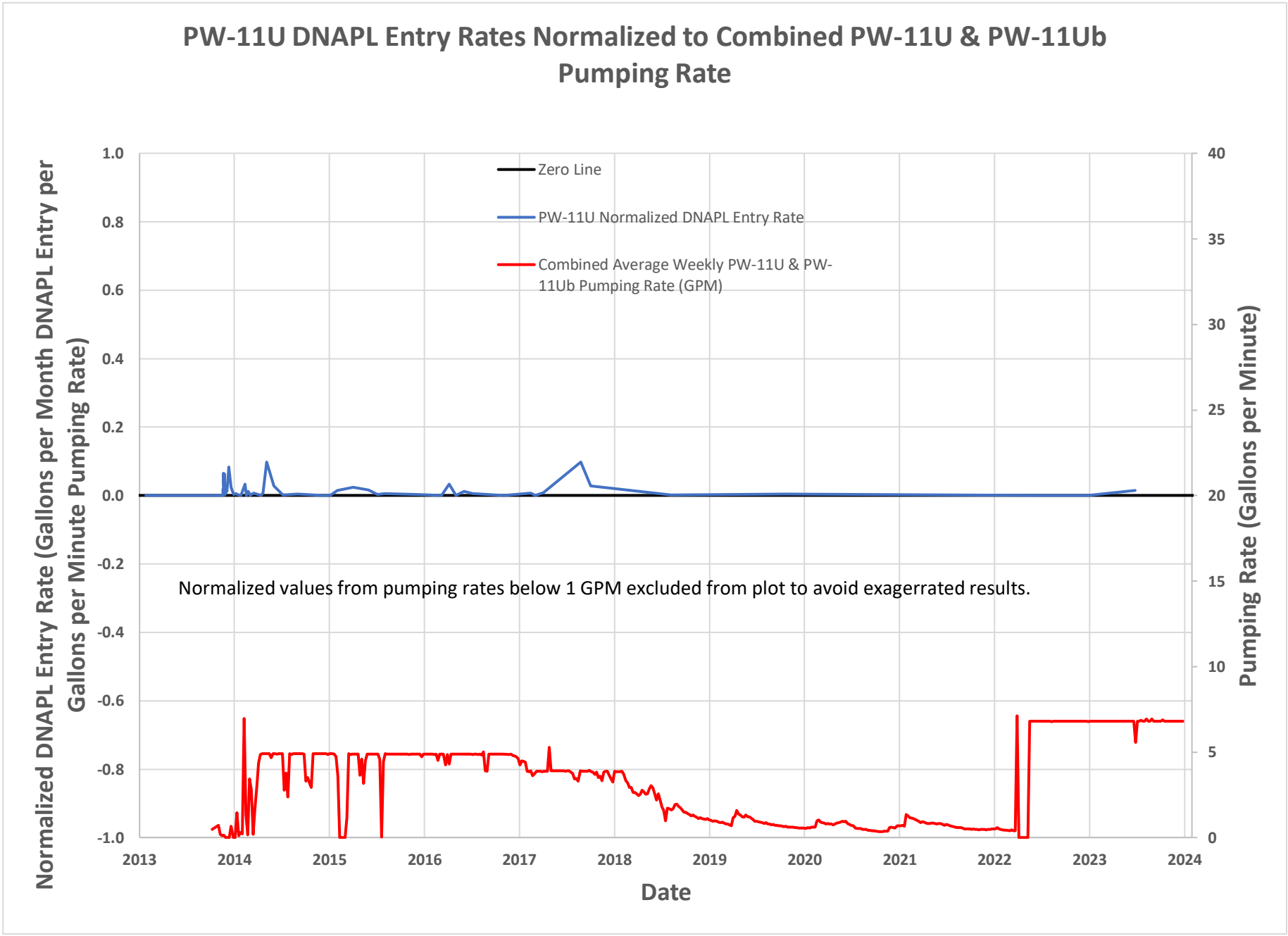

MW-PW2L DNAPL Entry Rates Normalized to PW-2L Pumping Rate
Normalized DNAPL Entry Rate (Gallons per Month DNAPL Entry per Gallons per Minute Pumping Rate)
Pumping Rate (Gallons per Minute)
Date
Zero Line
MW-PW2L Normalized DNAPL Entry Rate
Average Weekly PW-2L Pumping Rate (GPM)
Normalized values from pumping rates below 1 GPM excluded from plot to avoid exagerrated results.
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024


PW-1-80 DNAPL Entry Rates Normalized to Combined PW-5U & PW-13U Pumping Rate
Normalized DNAPL Entry Rate (Gallons per Month DNAPL Entry per Gallons per Minute Pumping Rate)
Pumping Rate (Gallons per Minute)
Date
Zero Line
PW-1-80 Normalized DNAPL Entry Rate
Combined Average Weekly PW-5U & PW-13U Pumping Rate (GPM)
Normalized values from pumping rates below 1 GPM excluded from plot to avoid exagerrated results.
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
40
35
30
25
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

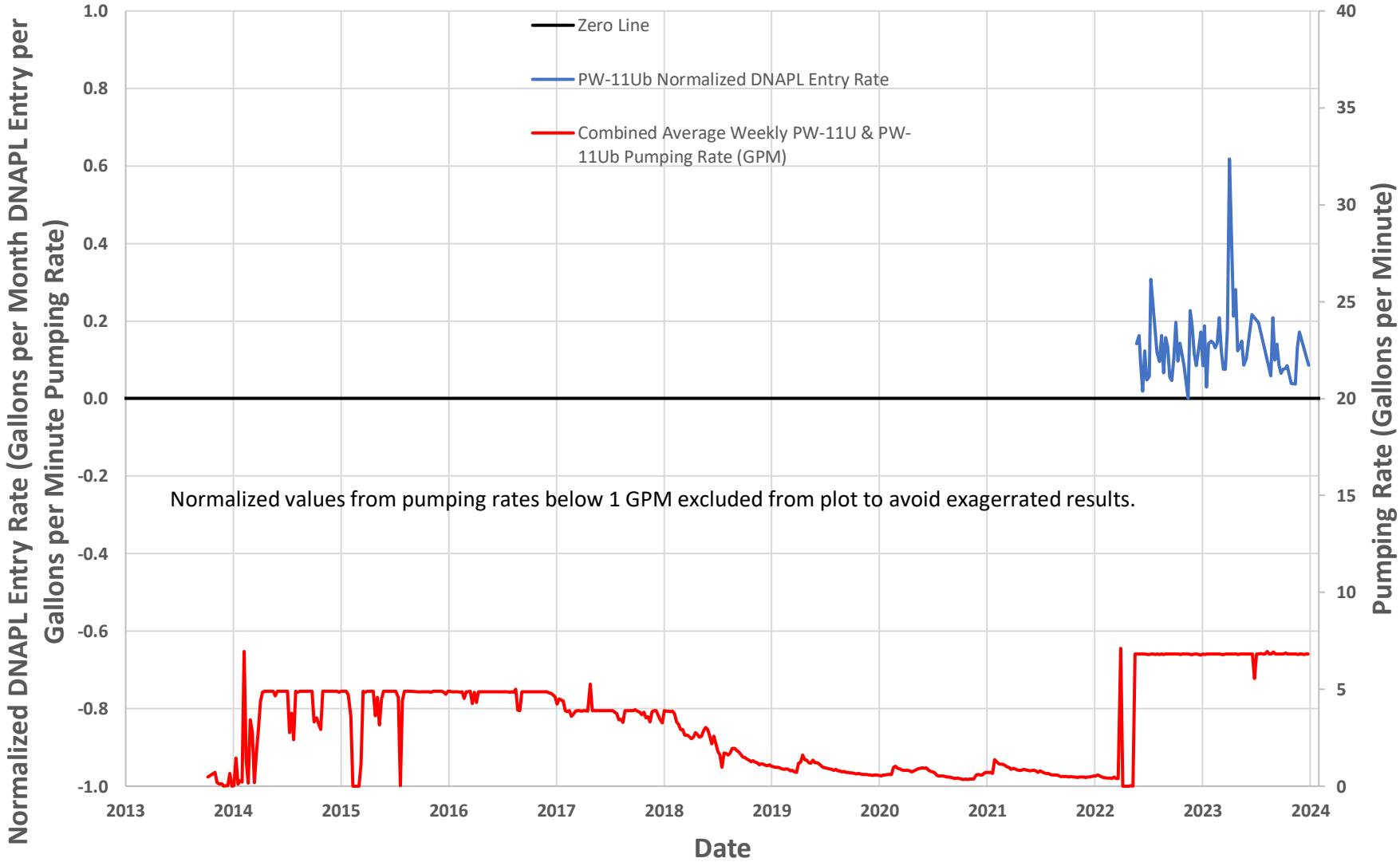

PW-2L DNAPL Entry Rates Normalized to PW-2L Pumping Rate
Normalized DNAPL Entry Rate (Gallons per Month DNAPL Entry per Gallons per Minute Pumping Rate)
Pumping Rate (Gallons per Minute)
Date
Zero Line
PW-2L Normalized DNAPL Entry Rate
Average Weekly PW-2L Pumping Rate (GPM)
Normalized values from pumping rates below 1 GPM excluded from plot to avoid exagerrated results.
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
-8.0
-10.0
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

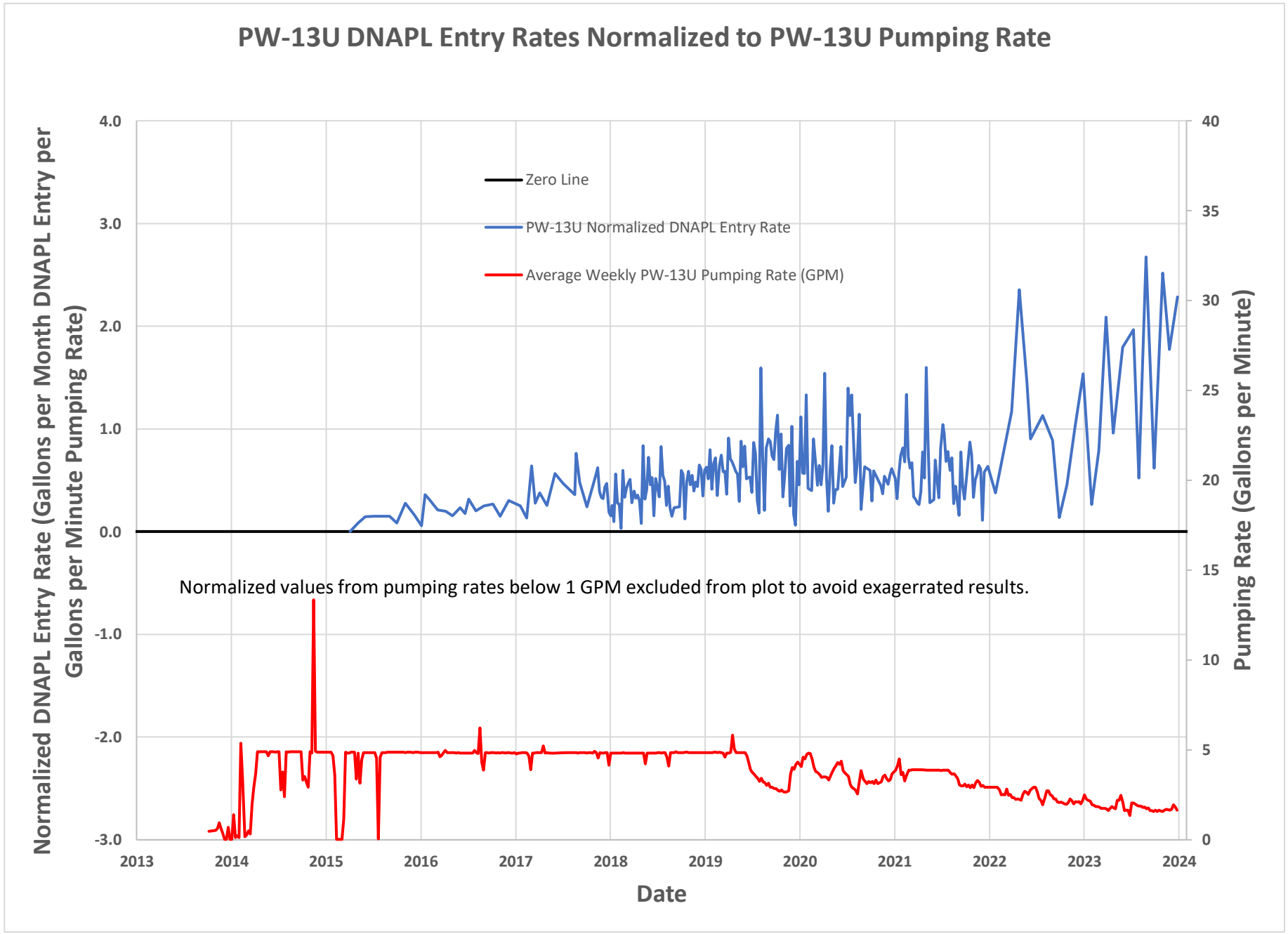

PW-3-85 DNAPL Entry Rates Normalized to Combined PW-3-118, PW-11U, & PW-11Ub Pumping Rate
Normalized DNAPL Entry Rate (Gallons per Month DNAPL Entry per Gallons per Minute Pumping Rate)
Pumping Rate (Gallons per Minute)
Date
Zero Line
PW-3-85 Normalized DNAPL Entry Rate
Combined Average Weekly PW-3-118, PW-11U, & PW-11Ub Pumping Rate (GPM)
Normalized values from pumping rates below 1 GPM excluded from plot to avoid exagerrated results.
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

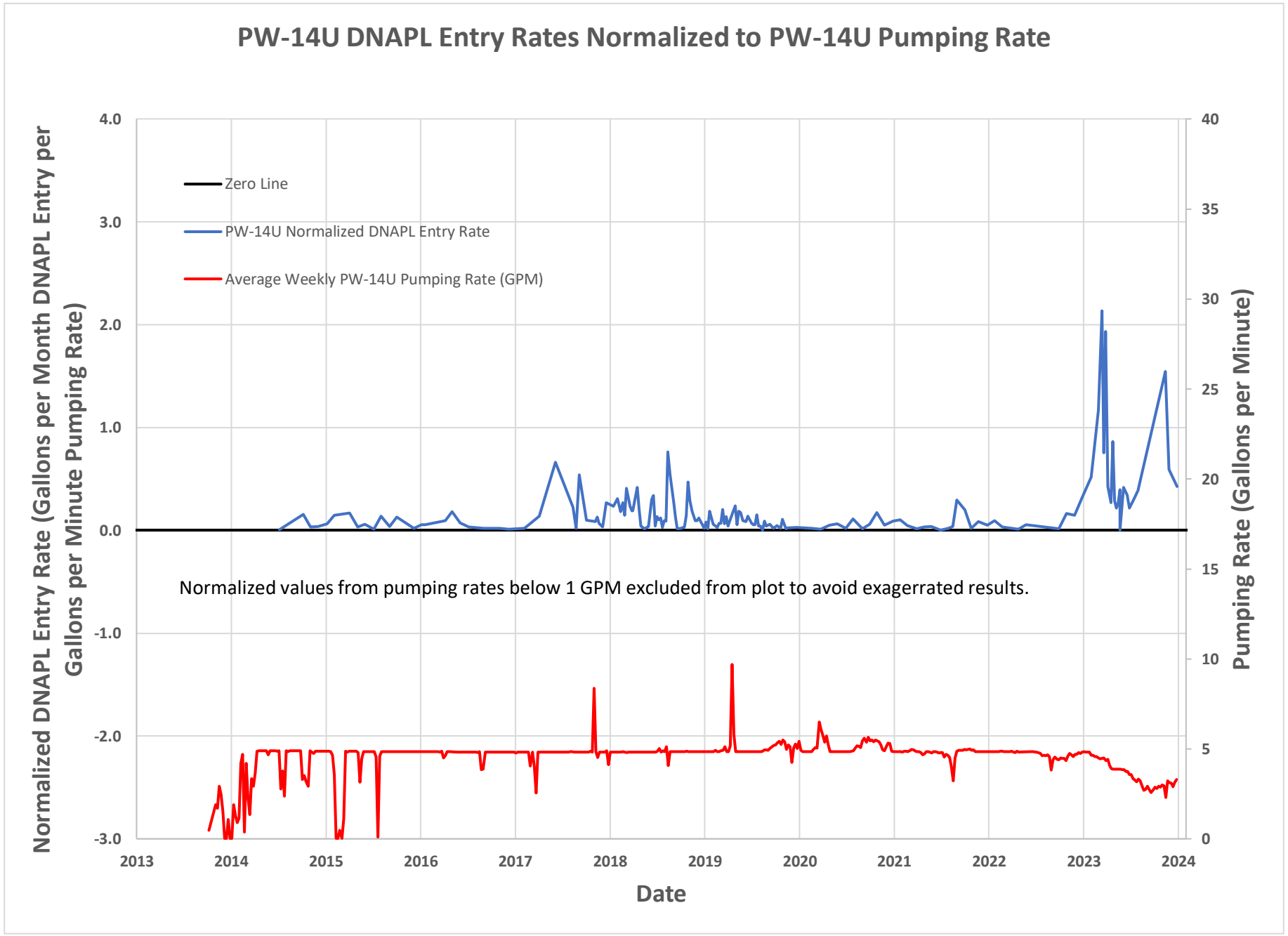

PW-6U DNAPL Entry Rates Normalized to PW-6U Pumping Rate
Normalized DNAPL Entry Rate (Gallons per Month DNAPL Entry per Gallons per Minute Pumping Rate)
Pumping Rate (Gallons per Minute)
Date
Zero Line
PW-6U Normalized DNAPL Entry Rate
Average Weekly PW-6U Pumping Rate (GPM)
Normalized values from pumping rates below 1 GPM excluded from plot to avoid exagerrated results.
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
-8.0
-10.0
40
35
30
25
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024


PW-11U DNAPL Entry Rates Normalized to Combined PW-11U & PW-11Ub Pumping Rate
Zero Line
PW-11U Normalized DNAPL Entry Rate
Combined Average Weekly PW-11U & PW-11Ub Pumping Rate (GPM)
Normalized values from pumping rates below 1 GPM excluded from plot to avoid exagerrated results.
Normalized DNAPL Entry Rate (Gallons per Month DNAPL Entry per Gallons per Minute Pumping Rate)
Pumping Rate (Gallons per Minute)
Date
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
40
35
30
25
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

PW-11Ub DNAPL Entry Rates Normalized to Combined PW-11U & PW-11Ub Pumping Rate




PW-13U DNAPL Entry Rates Normalized to PW-13U Pumping Rate
Zero Line
PW-13U Normalized DNAPL Entry Rate
Average Weekly PW-13U Pumping Rate (GPM)
Normalized values from pumping rates below 1 GPM excluded from plot to avoid exagerrated results.
Normalized DNAPL Entry Rate (Gallons per Month DNAPL Entry per Gallons per Minute Pumping Rate)
Pumping Rate (Gallons per Minute)
Date
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
40
35
30
25
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024


PW-14U DNAPL Entry Rates Normalized to PW-14U Pumping Rate
Zero Line
PW-14U Normalized DNAPL Entry Rate
Average Weekly PW-14U Pumping Rate (GPM)
Normalized values from pumping rates below 1 GPM excluded from plot to avoid exagerrated results.
Normalized DNAPL Entry Rate (Gallons per Month DNAPL Entry per Gallons per Minute Pumping Rate)
Pumping Rate (Gallons per Minute)
Date
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
40
35
30
25
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024