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ANCHOR QEA

Memorandum

August 14, 2023

To: Bob Wyatt, NW Natural; Patty Dost, Pearl Legal Group PC; and Rob Ede, Hahn and Associates, Inc.

From: Raghav Narayanan and Deborah Chiavelli, PhD; Anchor QEA, LLC

cc: Ryan Barth, Anchor QEA, LLC

Re: Assessment of Dioxins/Furans on the Siltronic Property

Introduction

This memorandum addresses Maul Foster Alongi's (MFA)'s response on July 14, 2023, to the Oregon Department of Environmental Quality's (DEQ's) comments on the *Siltronic Operable Unit Remedial Investigation Data Summary Report* (MFA 2023, Attachment A). DEQ's June 1, 2023, comments advised Siltronic Corporation (Siltronic) that "DEQ does not consider dioxins/furans to be COIs associated with the Gasco Operable Unit. Likewise, DEQ does not consider dioxins/furans on the Siltronic OU to be associated with former MGP Wastes and Byproducts. DEQ notes that we do consider dioxins/furans to be COIs associated with other potential sources relevant to the Siltronic OU (e.g. Willamette River Dredge Spoils)" (DEQ 2023a). In its response, MFA incorrectly claims that available site data support manufactured gas plant (MGP) waste materials as a source of dioxins/furans (D/F) in the Siltronic Operable Unit (SOU).

MFA's attempts to show that D/F found in the SOU are sourced from Gasco MGP operations are inaccurate for the following reasons:

1. Reliance on one unsubstantiated literature source to provide support for the alleged production of D/F by MGP operations
2. No consideration of new literature showing that trichloroethylene (TCE) is a source of D/F
3. Failure to rule out pentachlorophenol (PCP) as a source of D/F in the SOU
4. Incorrect attribution of nonaqueous phase liquid (NAPL) in the southwest corner of the SOU to MGP waste

MGP Operations Are Not a Source of D/F

MGP operations have been extensively studied across the United States and are not a known source of D/F. MFA cites a 1997 study by Walker et al. to claim that MGP operations can be a source of D/F because the process involves combustion where carbon and chlorine are present (MFA 2023, Attachment A). This 1997 study was a theoretical exercise that provided no data of any type and no evidence that the coal-gasification process can generate D/F. More recent studies have concluded

that MGP operations are not a source of D/F (see, for example, the discussion in the recent remedial investigation [RI] report conducted for a different MGP in the Pacific Northwest, the South State Street Manufactured Gas Plant [SSSMGP] [Landau Associates 2018]). The production of manufactured gas is a pyrolysis process, which is not a combustion process due to the absence of oxygen. This distinction is very important because D/F formation is associated with combustion, as noted by MFA. Further, the feedstocks used in MGP processes are unlikely to contain more than 1% chlorine, which is a threshold for dioxin formation (Landau Associates 2018). The SSSMGP RI also conducted a survey of other MGP sites and a review of other bodies of work about MGP sites, and D/F were not listed as contaminants of concern at any of the sites reviewed (Landau Associates 2018).

Trichloroethylene Is a Source of D/F

MFA ignores TCE as a source of D/F. TCE is a chlorinated solvent that was extensively used by Siltronic and has been found in multiple site media, including soil, groundwater, and DNAPL (DEQ 2023b). Liu et al. (2023) found that the manufacture of TCE produces D/F. Excluding octachlorodibenzodioxin (OCDD) (which is >60% of the total D/F in TCE), the D/F fingerprint is dominated by 1,2,3,4,6,7,8-heptachlorodibenzo-*p*-dioxin (HpCDD), octachlorodibenzofuran (OCDF), and 1,2,3,4,6,7,8-heptachlorodibenzo-*p*-furan (HpCDF); as discussed in the next section, these are the same congeners that are also present at elevated concentrations in the Siltronic property NAPL samples.

MFA Ignores Documented PCP Presence on the Siltronic Property and Presents a Flawed Analysis to Rule Out PCP as a D/F Source

MFA presents a flawed analysis of D/F measured in four DNAPL samples collected at two locations on the Siltronic property.[1] The locations of these samples are shown in Figure 1.

In its report, MFA states the following:

> "MFA reviewed analytical data to determine if the dioxins/furans present in the MGP waste NAPL could be associated with an unknown historical source of PCP. No PCP is detected in any of the MGP waste NAPL samples, nor is PCP detected in soil or groundwater in the vicinity of the MGP waste NAPL samples. The complete absence of PCP present in or near the MGP waste NAPL samples is a compelling line of evidence that PCP is not the source of the observed dioxins/furans." (MFA 2023, Attachment A)

[1] Four DNAPL samples were collected, two each from monitoring wells WS-43-36 and WS-33-81 in March and September 2019 (MFA 2023, Attachment A).

MFA's suggestion that the absence of any PCP detected presently is evidence of the lack of PCP use or presence historically is incomplete and incorrect for the following reasons:

- PCP is readily biodegraded under aerobic and anaerobic conditions in soils and groundwater, whereas D/F are persistent (ATSDR 2022, 1998). The absence of measurable PCP in recent DNAPL data is not evidence that historical PCP use was not the source of the D/F.
- PCP has been measured in soil samples and in wastewater on the Siltronic property. A 1988 DEQ letter notes that 0.2 part per million (ppm) PCP was measured in Siltronic's wastewater (DEQ 1988a). The release of PCP on the Siltronic property was one of the factors used by DEQ to list the property on the State Confirmed Release List and Inventory (DEQ 1988b). Samples collected in 1985 contained PCP concentrations up to 6.9 ppm (DEQ 1999). For comparison, the Record of Decision for the McCormick & Baxter Creosoting Co. (McCormick & Baxter) site, which operated a wood-treating facility on the east bank of the Willamette River between 1944 and 1991 and released the wood preservatives PCP and creosote into the Willamette River, reported a maximum PCP concentration of 7.2 ppm (EPA 1996; DEQ 2023c).
- MFA does not address the fact that PCP could have been present in the fill materials of the Siltronic property. Dredge spoils from the McCormick & Baxter site could have been used as fill material on the west bank and could be a potential source of PCP.
- Starlink Logistics, Inc. (SLLI) characterized the D/F patterns in a 2006 NAPL sample PZ-03-40 collected in the southwest corner of the SOU as "consistent with wood treating waste and general anthropogenic background"(AMEC 2008). SLLI also stated, "It should be noted that the absence of pentachlorophenol is not necessarily a good indication that dioxins present in environmental media did not originate form wood treating wastes, as pentachlorophenol has been documented to form OCDD under both photolytic and enzymatic pathways" (AMEC 2008).

In Figure 2, we present the D/F fingerprints in the Siltronic NAPL samples (bottom four panels) and D/F fingerprints in PCP from EPA (2006; top panel).[2] The EPA PCP signature is dominated by 1,2,3,4,6,7,8-HpCDD, followed by OCDF and then 1,2,3,4,6,7,8-HpCDF. This is the characteristic PCP-associated D/F signature. NewFields et al. (2013) also identified 1,2,3,4,6,7,8-HpCDD as the diagnostic congener for PCP-associated D/F profiles and modestly elevated 1,2,3,4,6,7,8-HpCDF concentrations as a feature of PCP-associated D/F profiles. As observed in the bottom four panels of Figure 2, the Siltronic NAPL D/F signatures are similar to the characteristic PCP-associated D/F signature.

[2] The profile plots used for polychlorinated dibenzo-*p*-dioxin/furan (PCDD/F) fingerprinting analyses show concentrations of sixteen of the seventeen 2,3,7,8-substituted PCDD/F congeners, excluding OCDD. This is because OCDD concentrations can often be orders of magnitude greater than the other congeners, leading to an inability to distinguish the signatures of different sources of PCDD/F. Similar exclusions of OCDD have been performed in other fingerprinting analyses (Quadrini et al. 2015; Towey et al. 2012). The PCDD/F profiles shown here include results for the total PCDD/F concentration (17 congeners) and the total plotted PCDD/F concentration (16 congeners; labeled "Plotted Dioxins Furans"); the difference between these two numbers is the OCDD measured in the plotted sample.

MFA argues that D/F in NAPL samples collected on the Siltronic property in 2019 do not originate from PCP because the dioxin concentrations do not show an order of magnitude increase with increasing chlorination when plotted on a logarithmic scale, a PCP fingerprint characteristic identified by Johnson (2017). However, this argument is incorrect. MFA's sole reliance on Johnson's study assumes that PCP is the only source of D/F to the Siltronic property, but as noted previously, TCE, which was widely used in the Siltronic property, is also a source of D/F on the property. The D/F signature resulting from the mixing of TCE and PCP will logically not follow the patterns resulting from PCP alone.

MFA also states, "OCDF accounts for approximately 10 percent of all congeners in PCP, but accounts for only approximately 1 percent in the MGP NAPL samples" (MFA 2023, Attachment A). This statement implies that the Siltronic NAPL samples are therefore not from a PCP source; however, this result appears to be incorrect. Our analysis finds that OCDF accounts for 5.6% of the total D/F in the EPA (2006) profile and 3% to 4% of the Siltronic NAPL profiles (i.e., these two sources are within the same range).[3] Further, as noted previously, a variation from a pure-PCP signature is expected due to the impact of D/F from TCE.

MFA Incorrectly Attributes NAPL in the Southwest Corner of the SOU to MGP Waste

MFA incorrectly states that NAPL in the southwest corner of the SOU contains polycyclic aromatic hydrocarbons (PAHs) consistent with the composition of MGP waste from Gasco, as follows:

> "The NAPL sample from PZ-03-40 was collected by RPAC in 2006 as part of their RI/SCE investigation activities and is located at the southwestern corner of the SOU. Although this sample was collected outside the footprint of known historical MGP waste disposal activities, the available data indicates that it is consistent with MGP waste NAPL. The sample is composed primarily of petroleum hydrocarbons and PAHs and is consistent with the composition of known MGP waste from the Gasco site (Table 1). Other chemicals typically detected in NAPL samples from the RPAC property, including chlorobenzenes and xylenes, are not present in this sample from PZ-03-40. Both RPAC and DEQ agree with the interpretation that this sample is consistent with MGP waste NAPL located on the Gasco site. (AMEC 2010; DEQ 2008)" (MFA 2023, Attachment A)

[3] OCDF-toxic equivalents (TEQ) account for <1% of the total TEQ of the four Siltronic NAPL samples, so perhaps MFA's calculations are on a TEQ basis. However, such calculations are inappropriate for fingerprinting purposes. TEQ-based calculations can be disproportionately impacted by trace amounts of the most toxic congeners, such as 1,2,3,7,8-pentachlorodibenzo-*p*-dioxin (PeCDD), which was discharged by Rhone-Poulenc (RPAC) and detected at very low concentrations in all four Siltronic NAPL samples.

MFA's attribution of this sample to MGP waste is incorrect. Neither Rhone-Poulenc (RPAC) nor DEQ performed any forensic analysis of this sample. However, the PZ-03-40 NAPL sample and other samples collected in the vicinity of North Doane Lake and the Northwest Drainage Pond contain PAH fingerprints consistent with coal tar creosote, not oil-gas MGP residuals. PAH profiles for the PZ-03-40 NAPL sample and three other samples with high total PAH collected in this region are shown in Figure 3[4] and described as follows; the sample locations are shown in Figure 4.

- **Sample ID NDL-104-S11/19/200316:407.5N; total PAH 1,286,420 micrograms per kilogram (µg/kg):** The maximum PAH concentration measured in a group of samples collected in 2003 in North Doane Lake; due to its characteristic creosote signature, the remaining samples are compared against it in Figure 3
- **Sample ID 5237-080415-017; total PAH 927,000 µg/kg:** A 2008 soil sample collected adjacent to the culvert that connects the Northwest Drainage Pond to Outfall 22C
- **Sample ID NDP-101-S11/24/200314:000.5N; Total PAH 256,000 µg/kg:** A Northwest Drainage Pond sediment sample collected during the same 2003 investigation that measured the first sample in this list
- **Sample ID 1055-01; Total PAH 435,250,000 µg/kg:** Dense nonaqueous phase liquid (DNAPL) recovered from the monitoring well PZ-03-40W at the Northwest Drainage Pond in 2006 by RPAC, which is also noted in the previously quoted MFA text

All PAH profiles contain the following characteristics that confirm they do not originate from Gasco (which solely manufactured gas from oil, never from coal):

1. All four samples have a fluoranthene (FL) to pyrene (PY) ratio greater than 1.0. FL/PY is <1 for pyrogenic tars produced by facilities using petroleum feedstocks (such as the oil gas process used by Gasco) and is >1 for coal tar-derived pyrogenic PAHs like creosote (EPRI 2000; Yunker et al. 2002; Stogiannidis and Laane 2015).
2. All four samples are also depleted in 5-ring and 6-ring PAHs compared to 4-ring and smaller PAHs. This pattern is specifically diagnostic of creosote (Stout et al. 2001; Stout and Graan 2010).

The fingerprints discussed here clearly demonstrate a creosote source area, including the PZ-03-40W NAPL, in the southwest corner of the SOU. Any statements attributing this creosote to the Gasco MGP operations are incorrect.

Conclusions

MFA is speculating on a theoretical exercise to establish a tenuous connection between MGP waste and D/F, a connection inconsistent with scientific consensus and with data analyzed at many

[4]Total PAH is calculated using the summation rules described in Appendix A of the *Portland Harbor RI/FS: Feasibility Study* (EPA 2016). These fingerprints exclude naphthalene because naphthalene is highly susceptible to weathering. PAHs in these profiles are arranged on the x-axis with increasing ring number and roughly increasing molecular weight. The list of PAHs and their abbreviations used in these plots can be found in Table 1.

well-characterized former MGP sites. MFA incorrectly attributes coal tar-derived creosote NAPL near North Doane Lake to MGP operations. MFA also downplays or completely ignores the well-documented associations between D/F and chemicals and chlorinated solvents that are known to have been used or placed on the Siltronic property historically: PCP and TCE. Any attribution of D/F to Gasco MGP operations is completely unsupported. The documented presence of PCP and TCE on the property, the presence of D/F sources such as PCP in fill materials, and the similarity of the D/F fingerprints associated with PCP and TCE and in the Siltronic property NAPL samples logically suggest that PCP and TCE are the potential sources of D/F to the property, with attribution to MGP wastes having no merit.

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Table

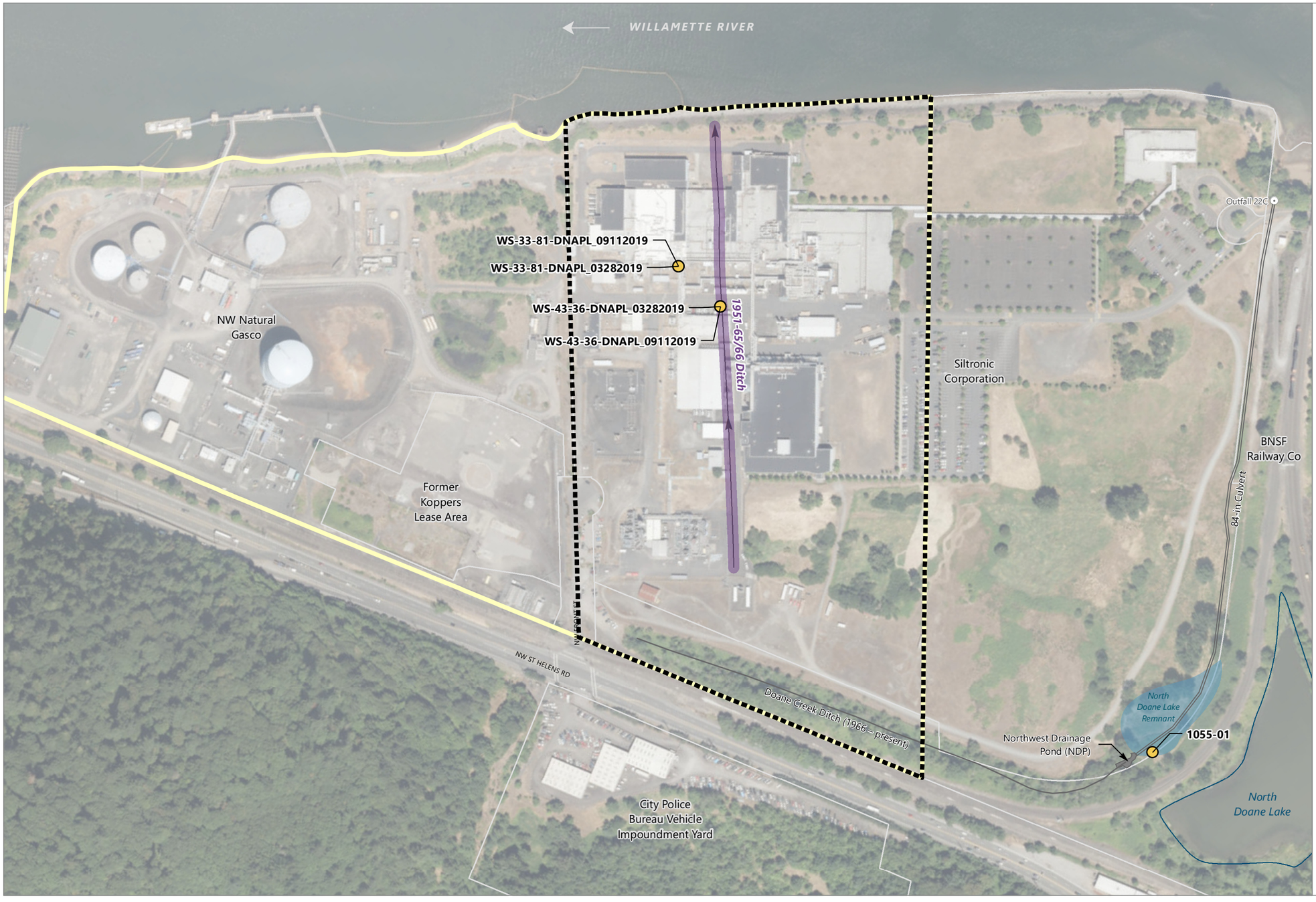
Table 1
List of Plotted Polycyclic Aromatic Hydrocarbons

Chemical Name	Plot Code	Number of Benzene Rings
Acenaphthylene	AY	3
Acenaphthene	AE	3
Fluorene	F0	3
Anthracene	A0	3
Phenanthrene	P0	3
Fluoranthene	FL0	4
Pyrene	PY0	4
Benz[a]anthracene	BA0	4
Chrysene/Triphenylene	C0	4
Total Benzofluoranthenes[1]	BF-Tot	5
Benzo(a)pyrene	BAP	5
Dibenz(a,h)anthracene/Dibenz(a,c)anthracene	DA	5
Indeno(1,2,3-cd)pyrene	IND	6
Benzo(g,h,i)perylene	GHI	6

Notes:

1. Sum of benzo(b, j, and k)fluoranthenes

Figures



LEGEND:

- Site Boundary (Siltronic GSA)
- Approximate Gasco OU Boundary
- Tax Lot Boundary
- 1951-65/66 Ditch
- North Doane Lake Remnant
- Doane Creek Ditch
- Culvert, Active
- Northwest Drainage Pond

NOTES:

1. Arrow indicates direction of flow of river.
2. Horizontal datum is NAD83 (HARN 91) Oregon State Plane North, International Feet.
3. Aerial imagery from City of Portland 2018.
4. North Doane Lake Drainage Ditch depictions are from GSI, 2015 using 1948 and 1960 aerial photograph estimations.

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Feet

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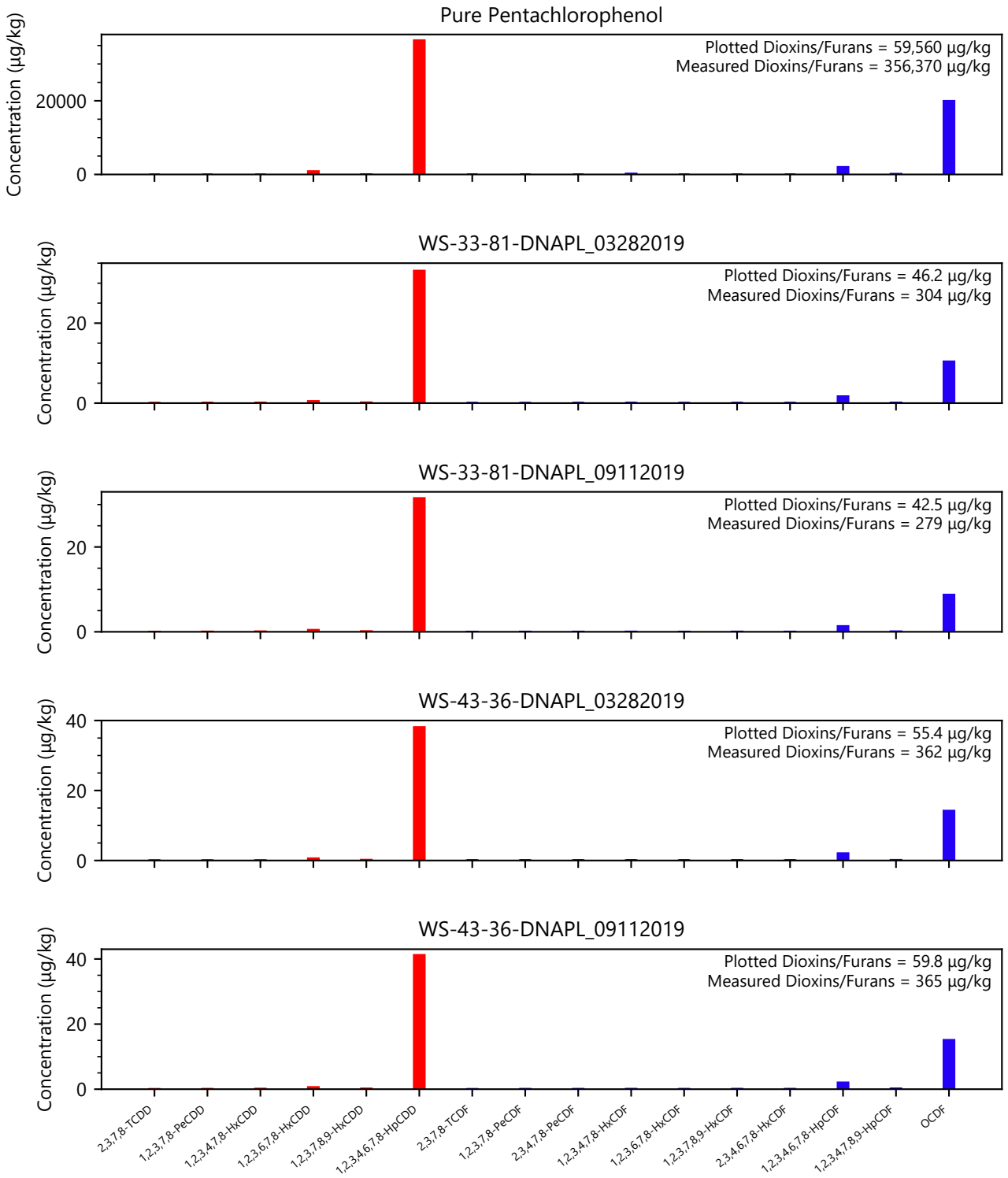
Figure 1
Siltronic DNAPL Sample Locations
Assessment of Dioxins/Furans on the Siltronic Property
NW Natural Gasco Site



The plotted PCDD/F concentration excludes OCDD. The difference between the measured and plotted PCDD/F values is the OCDD concentration.
See Figure 1 for sample locations.
Pure Pentachlorophenol is from EPA 2006.

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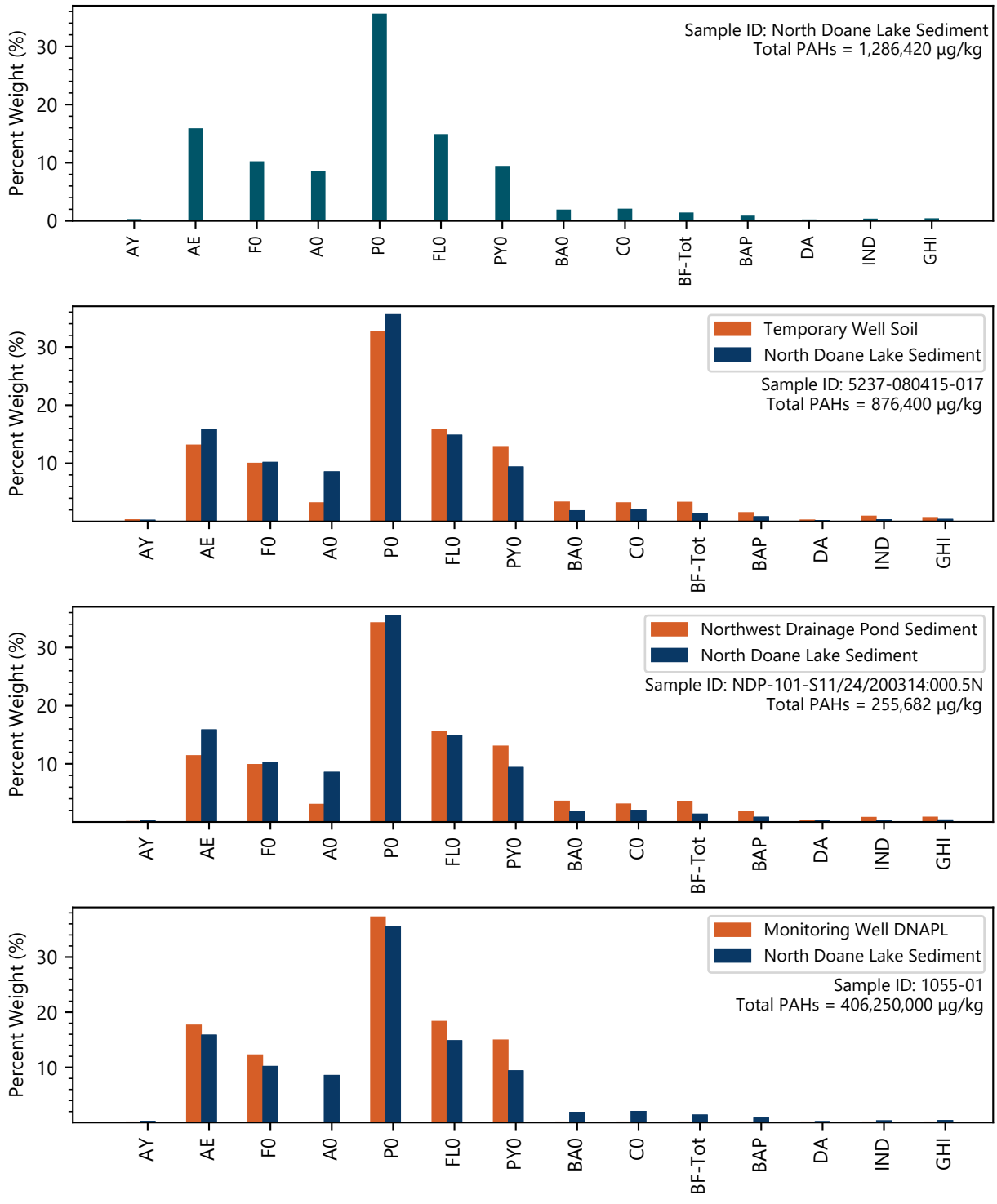
Figure 2
PCDD/F Fingerprints in Siltronic NAPL Samples and in Pentachlorophenol Reference
Assessment of Dioxins/Furans on the Siltronic Property
NW Natural Gasco Site



See Table 1 for x-axis PAH abbreviation definitions.
See Figure 4 for sample locations.

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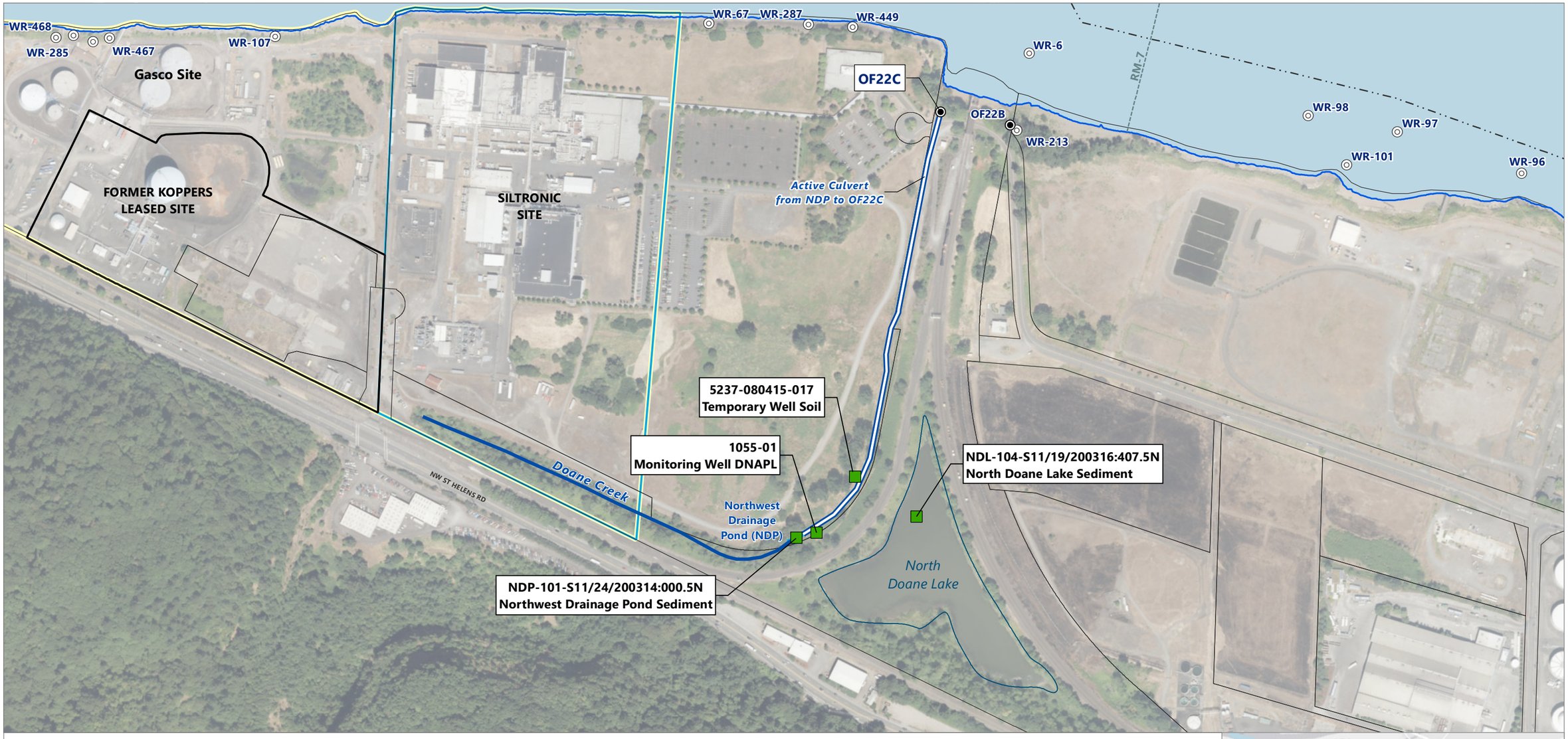
Figure 3
PAH Fingerprints of Northwest Drainage Pond Samples
Assessment of Dioxins/Furans on the Siltronic Property
NW Natural Gasco Site



- City of Portland Outfalls
- Non-City Outfalls
- River Miles
- Navigation Channel
- Portland Harbor Superfund Site
- Tax Lots
- Northwest Drainage Pond
- Doane Creek Ditch
- Active Culvert from NDP to OF22C
- Former Koppers Leased Site
- Siltronic Site
- Approximate Gasco OU Boundary

NOTES:
1. Horizontal datum is NAD83 Oregon State Plane North, International Feet.
2. Aerial imagery from City of Portland 2018.

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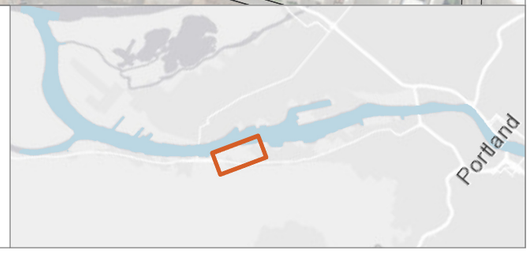

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Figure 4
Locations of Northwest Drainage Pond Samples
Assessment of Dioxins/Furans on the Siltronic Property
NW Natural Gasco Site