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Memorandum

To: Mr. David South

Copies: Don Robbins, Port of Seattle

From: Jessi Massingale, PE; Megan McCullough, PE

Date: March 17, 2015

Project No: POS-LLA T.6110

Re: **Demonstration of Groundwater Protection of Surface Water Beneficial Uses**

INTRODUCTION

The purpose of this memorandum is to present the lines of evidence demonstrating that under existing and potential future site conditions at the Lora Lake Parcel (LL Parcel), hazardous substances are not likely to reach surface water and, therefore, applicable groundwater cleanup levels for the LL Parcel do not include protection of surface water beneficial uses. This memorandum focuses on dioxins/furans because for all other site contaminants of concern (COCs), surface water beneficial uses are not the most stringent applicable cleanup level, and, therefore, not including surface water protection does not change the cleanup level selection. This memorandum describes the factors (other than implementation of a cleanup action) used to make this demonstration in accordance with Washington Administrative Code (WAC) 173-340-720(4)(b)(ii).

CHEMICAL PROPERTIES OF DIOXINS/FURANS—LIMITED GROUNDWATER TRANSPORT

Dioxins and furans are two classes of similar chemicals that both contain two carbon benzene ring structures. All dioxins contain two oxygen atoms, while all furans contain one oxygen atom. They can be anthropogenically and naturally produced as trace impurities or incidental byproducts in chlorophenols, chlorinated herbicides, commercial Aroclor (polychlorinated biphenyl [PCB]) mixtures, and bleached paper production or combustion (ATSDR 1994 and 1998). Dioxins/furans are characterized by extremely low vapor pressures, high log octanol-water partition coefficients (K_{ow}), high soil organic carbon-water partitioning coefficients (K_{oc}), and extremely low water solubilities. These factors indicate a strong affinity for soil, particularly soil with high organic content. The strong adsorption to soil, low water solubilities, and high K_{oc} result in dioxins/furans being extremely immobile compounds in groundwater. Once sorbed to particulate matter or bound in the sediment organic phase, dioxins/furans exhibit little potential for leaching or volatilization. For example, an average soil organic carbon-water partitioning coefficient (K_{oc}) for the dioxin congener 2,3,7,8-tetrachloro-dibenzo-p-dioxin (2,3,7,8-TCDD)[1] is 12,500,000 liters per kilogram (L/kg; refer to peer-reviewed literature, Appendix J, Worksheet 1 of the Remedial Investigation/Feasibility Study [RI/FS; Floyd|Snider 2015a] for K_{oc} references) compared to the K_{oc} value for benzo(a)pyrene, a common hydrophobic compound, of 995,000 L/kg (refer to peer-reviewed literature, Appendix P, Table P.3 of the RI/FS [Floyd|Snider 2015a] for K_{oc} references). The 2,3,7,8-TCDD congener is the least chlorinated and, therefore, the most mobile dioxins/furans congener and would consequently have a lesser K_{oc} than the other more chlorinated congeners.

Dioxins/furans are relatively recalcitrant and retain the same distribution or concentrations of congeners once released to the environment, without many changes due to chemical or biological degradation. The only environmentally significant transformation process for these congeners is believed to be photodegradation of chemicals not bound to particles (e.g., in the gaseous phase or at the soil/air or water/air interface). Bacterial degradation of dioxins/furans is possible, but is a very slow process. For example, an aerobic half-life of 4,720 days was used in the RI/FS cap modeling (Floyd|Snider 2015a; Appendix P). For comparison purposes, conservatively, an aerobic half-life of 309 days was used for benzo(a)pyrene in the cap modeling.

APPLICABLE SITE CONDITIONS AND RI/FS GROUNDWATER CLEANUP LEVEL DEVELOPMENT

The Lora Lake Apartments Site (the Site) is the area where contamination associated with historical operations conducted on the Lora Lake Apartments Parcel (LL Apartments Parcel) have come to be located. The Site includes the LL Apartments Parcel, the LL Parcel, and the Dredged Material Containment Area (DMCA). Contamination associated with the Site is a result of barrel-washing operations that were conducted at the LL Apartments Parcel in the 1940s through the early 1950s. Since closure of the barrel-washing operation in the early 1950s, contamination was dispersed to other areas of the Site through regrading of soil at the LL Apartments Parcel, leaching of soil contaminants to groundwater, and, potentially, through releases to stormwater that resulted in transport of contamination from the LL Apartments Parcel to sediments in Lora Lake on the LL Parcel. Contamination in Lora Lake sediments was then transported to the DMCA during a lake dredging event in 1982 that stockpiled dredged sediments at the DMCA. Although stormwater sampling has confirmed that, under current conditions, contaminants are not being transported from the LL Apartments Parcel to Lora Lake, it cannot be confirmed that this contaminant migration did not historically occur, and hence, the LL Parcel and the DMCA are included in the Site.

Elevated concentrations of dioxins/furans are present in lake bottom sediments from the surface to depths of 56 centimeters (cm; approximately 1.8 feet) at concentrations up to 217 picograms per gram (pg/g) toxicity equivalent (TEQ). The site Conceptual Site Model (CSM) has determined the source of these dioxins/furans to be historical and ongoing stormwater discharges to Lora

[1] 2,3,7,8-TCDD is the only congener with multiple peer-reviewed and published K_{oc} values because it is the most toxic and well-studied dioxin congener (USEPA 2003).

Lake. The other potential mechanism for contaminant migration from the LL Apartments Parcel (groundwater transport) was evaluated in the RI/FS as part of the groundwater cleanup level development. To evaluate this potential migration pathway, an empirical data demonstration was conducted that compared soil and groundwater concentrations, and evaluated groundwater concentrations downgradient of the soil source area. A BioScreen-AT model was also used to evaluate the potential for contaminant transport in groundwater. This evaluation concluded that contamination at the LL Apartments Parcel was not likely to migrate in groundwater and discharge to surface water. Refer to Section 5.2.2.2 and Appendix L of the RI/FS for additional detail.

During sediment sampling activities at the LL Parcel, surface sediment samples were also collected from Miller Creek. These sediment samples did not contain elevated concentrations of dioxins/furans, and Miller Creek was, therefore, not identified as an area where contamination associated with the Site has come to be located, and is not included in the Site extent.

MODIFICATION OF THE EXISTING GROUNDWATER CLEANUP LEVEL EVALUATION FOR FUTURE CONDITIONS AT THE LL PARCEL

Because the groundwater cleanup level determination in the RI/FS did not include consideration of post-remedy conditions at the LL Parcel where existing lake sediments and lake surface water will be converted to soil and groundwater, an additional demonstration of these post-remedy conditions at the LL Parcel is necessary. This demonstration is needed to confirm that post-remedy, hazardous substances at the Site—including contaminants in current lake sediments that will, in the future, be soil—are not likely to migrate in groundwater and discharge to the surface water of Miller Creek, and the groundwater cleanup level selection conducted in the RI/FS is applicable to the LL Parcel. It is critical to note that per WAC 173-340-720(4)(b)(ii), this demonstration must be based on factors other than implementation of a cleanup action at the Site, as discussed in the following sections.

WAC Rationale for Demonstration of Groundwater Protection of Surface Water Beneficial Uses

Model Toxics Control Act (MTCA) groundwater cleanup standards determination is conducted through the process outlined in WAC 173-340-720. For future groundwater conditions at the LL Parcel, the following WAC rationale is proposed:

- According to WAC 173-340-700(5),

  "The first step in setting cleanup levels is to identify the nature of the contamination, the potentially contaminated media, the current and potential pathways of exposure, the current and potential receptors, and the current and potential land and resource uses. A conceptual site model may be developed as part of this scoping process. Cleanup levels may then be established for each media."

The CSM included in the RI/FS meets these requirements, and at the LL Parcel considers all potential pathways with the exception of sediment leaching to groundwater, followed by groundwater migration and discharge to surface water. This memorandum adds the evaluation of this potential pathway to the existing site CSM.

- Selection of sediment cleanup levels was conducted in a separate technical memorandum, and followed the revised SMS process. This evaluation considered human and ecological risk, and sediment protection of surface water, and identified human health criteria as the most stringent for dioxins/furans (Floyd|Snider 2015b).
- Groundwater cleanup levels for existing site conditions were evaluated in the RI/FS, and considered the highest beneficial uses. This evaluation determined potable drinking water standards were the most stringent, as hazardous substances in groundwater are not likely to discharge to surface water, as discussed above. However, for existing site conditions, the point of groundwater discharge to surface water was at the western edge of Lora Lake. Post-remedy, the point of groundwater discharge to surface water will be the bank of Miller Creek. This memorandum provides the demonstration needed to confirm that potential contaminants in groundwater located downgradient of Lora Lake are also not likely to discharge to surface water in Miller Creek.
- The groundwater cleanup level at the LL Parcel shall be based on highest beneficial use, and must be established at concentrations that do not directly or indirectly cause violations of surface water, sediments, soil, or air cleanup standards established under WAC 173-340-720 or other applicable state and federal laws (WAC 173-340-720(1)(c)).
    - Per WAC 173-340-720(1)(a), "Groundwater cleanup levels shall be based on estimates of the highest beneficial use and the reasonable maximum exposure expected to occur under both current and potential future site use conditions." And, unless determined that the site has a different beneficial use, the groundwater cleanup level shall be established using the exposure scenario of ingestion through drinking water and other domestic uses. Because the Site does not demonstrate non-potable conditions per WAC 173-340-720(2), groundwater cleanup levels at the LL Parcel should assume selection of cleanup levels for potable groundwater.
    - In accordance with WAC 173-340-720(4)(b), where groundwater cleanup levels are based on drinking water beneficial use, standard MTCA Method B cleanup levels shall be at least as stringent as applicable state and federal laws, protection of surface water beneficial uses, and human health protection.
    - Applicable state and federal laws and human health protection cleanup levels that would apply at the LL Parcel are consistent with those evaluated in the RI/FS for

existing site conditions. This memorandum now focuses on the applicability of protection of surface water beneficial uses.

- Per WAC 173-340-720(4)(b)(ii), cleanup levels shall be at least as stringent as: "Concentrations established in accordance with the methods specified in WAC 173-340-730 for protecting surface water beneficial uses, unless it can be demonstrated that the hazardous substances are not likely to reach surface water."
    - This demonstration must be based on factors other than implementation of a cleanup action at the Site.
    - MTCA does not specify how this demonstration must be conducted, nor does it provide a definition for "demonstration." This memorandum outlines the Port's evaluation that demonstrates that hazardous substances associated with contaminated sediments (that will be soil following remedy completion) under both current and future conditions are not likely to reach surface water, and, therefore, protection of surface water beneficial uses is not applicable in evaluation of groundwater cleanup levels.
    - Assuming this demonstration is sufficient, according to WAC 173-340-720(4)(b)(ii), the applicable cleanup level for groundwater at the LL Parcel would be the more stringent of the applicable state and federal laws, and human health protection.
    - The more stringent of applicable state and federal laws, and human health protection, is the MTCA Method B cleanup level for drinking water of 6.7 µg/L.

Applicability of Sediment Concentrations in Assessing the Protectiveness of the Groundwater to Surface Water Pathway

The contaminated sediments located within Lora Lake are the primary source of dioxins/furans that could potentially be transported to Miller Creek surface water via surface water exchange and/or lateral groundwater migration through the lake sediments under existing and potentially future conditions. The vertical migration of dioxins/furans from the sediment surface into overlying cap material and lake surface water was evaluated in Appendix P of the RI/FS (the Sediment Leaching and Numerical Cap Modeling appendix).

As described in Section 5.2.2.2 of the RI/FS, the groundwater dioxins/furans TEQ concentrations detected in the four monitoring wells located on the LL Parcel (MW-8 through MW-11; Figure 2.14) and in the three monitoring wells located in the DMCA range from approximately 2.5 picograms per liter (pg/L) to 3 pg/L. This concentration range is also within the range of the dioxins/furans TEQ reporting limit, or the calculated TEQ result when no congeners are detected in a groundwater sample, and within the range of the dioxins/furans analytical method blanks that represent the ideal water matrix, free of interferences from the analysis. Therefore, the range is representative of the lowest achievable dioxins/furans TEQs, or project-specific practical quantitation limit (PQL; 1 to 3 pg/L).

Because the dioxins/furans Clean Water Act Surface Water Quality Criterion applicable at Miller Creek (0.005 pg/L)[2] is significantly less than the dioxins/furans PQL, groundwater samples would not be able to confirm the protectiveness of groundwater discharge to surface water. Therefore, the evaluation of sediments to assess the protectiveness of the groundwater to surface water pathway provides a more empirical approach that includes the use of measureable dioxins/furans concentrations collected from site sediment samples as part of the LL Parcel RI.

Lora Lake Sediments to Miller Creek Surface Water Dioxins/Furans Empirical Data Demonstration

Because groundwater data are not available downgradient of the Lora Lake sediments, and, if collected, groundwater data would not be able to confirm if groundwater concentrations downgradient of the Lake were protective (i.e., below the applicable surface water criterion) of discharge to surface water in Miller Creek, an equilibrium partitioning evaluation was conducted using measured site sediment dioxins/furans and total organic carbon (TOC) concentrations. This evaluation asks: *If* the maximum Lora Lake sediment dioxins/furans TEQ concentration were partitioned to groundwater, and then partitioned to Miller Creek sediments and Miller Creek surface water,

> Would the calculated concentration in Miller Creek sediments be greater than what was empirically measured in Miller Creek surface sediments?

If the answer is yes, then no further analysis is needed and this evaluation demonstrates that the existing site conditions are protective of Miller Creek surface water. The equilibrium partitioning evaluation, including parameters and calculations, is provided in Attachment 1.

Conservative Demonstration Assumptions

This demonstration is conducted using multiple conservative assumptions to provide a "worst-case" scenario to determine the potential for contamination in Lora Lake sediments to impact groundwater, and, therefore, result in groundwater discharges to Miller Creek in excess of applicable surface water standards. The conservative assumptions made in this memorandum include the following:

- Attenuation does not occur during groundwater migration.
- Chemical properties for the most mobile dioxins/furans congener are used in the evaluation, even though the dioxins/furans congeners present are not the most mobile.

[2] The Federal Clean Water Act Surface Water Quality Criterion (0.005 pg/L) for dioxins/furans is for the most toxic and well-studied congener, 2,3,7,8-TCDD. Consistent with USEPA's National Recommended Water Quality Criteria: 2002 (USEPA 2002), the water quality criteria for 2,3,7,8-TCDD should be used in conjunction with the national/international convention of toxicity equivalence factors (TEFs) to account for the additive effects of other dioxin-like compounds.

- Groundwater flow paths between Lora Lake and Miller Creek currently and in the future, will include a route of lateral migration through contaminated lake sediment, followed by vertical migration up to and discharge into Miller Creek.

Equilibrium Partitioning Calculations

Equilibrium partitioning assumes instantaneous chemical equilibrium between the constituents in the groundwater and sediment or soil particles. Therefore, equilibrium partitioning calculations are inherently conservative and, because of this, are commonly used as a screening tool to assess the worst case potential of sediment cap recontamination or limits of sediment cap design. For this evaluation, the calculations are also conservative because the maximum measured dioxins/furans sediment concentration is used as a source concentration, which maximizes the amount of dioxins/furans that could potentially partition to groundwater. Sediment dioxins/furans concentrations used in the equilibrium partitioning calculations were obtained from the sediment data collected as part of the RI/FS (Floyd|Snider 2015a). The maximum dioxins/furans TEQ concentration was conservatively selected as the starting input value for the equation. The maximum concentration was paired with the average partitioning coefficient (K_{oc} value of 12,500,000 L/kg) as used for sediment cap modeling (refer to Appendix P, Table P.3 of the RI/FS [Floyd|Snider 2015a] for K_{oc} references). This combination of conservative inputs and empirical site data results in a very simple and conservative screening tool.

Equilibrium partitioning was calculated with the following equation:

$$C_{sed} = C_{gw} \times K_d$$

Where: C_{sed} = Equilibrium sediment concentration
C_{gw} = Groundwater concentration
K_d = Dioxins/furans partitioning coefficient

The individual K_d values for the various media (Lora Lake sediment, Miller Creek sediment) were calculated using the organic carbon content associated with the maximum dioxins/furans Lora Lake sediment sample (LL-SED2) and the average organic carbon content from the three Miller Creek sediment samples. The K_d values were calculated using the following equation:

$$K_d = K_{oc} \times f_{oc}$$

Where: K_d = Dioxins/furans partitioning coefficient
K_{oc} = Organic carbon partitioning coefficient
f_{oc} = Fraction of organic carbon in sediment sample

Following the equilibrium partitioning calculations, the resulting Miller Creek sediment concentration was compared to the measured Miller Creek surface sediment dioxins/furans concentrations, and the resulting Miller Creek surface water concentration was compared to the dioxins/furans surface water quality criterion.

The equilibrium partitioning evaluation, as shown in Attachment 1, consisted of three steps that are described in detail below.

Step 1: Partitioning of Lora Lake Sediment Dioxins/Furans to Groundwater

Conservatively, using the maximum dioxins/furans sediment concentration measured during the LL Parcel RI of 217 pg/g TEQ and the TOC measured in the associated sediment sample collected from LL-SED2, the maximum groundwater dioxins/furans TEQ concentration resulting from the sediments that could potentially migrate laterally in groundwater was calculated to be 0.164 pg/L.

Step 2: Partitioning of Calculated Groundwater Dioxins/Furans to Miller Creek Sediments

The groundwater dioxins/furans TEQ concentration calculated from Step 1 along with the average TOC measured in Miller Creek surface sediments of 0.35 percent were used to partition the groundwater dioxins/furans to Miller Creek sediments. This step is extremely conservative as it directly partitions the groundwater dioxins/furans resulting from the lake sediments to the creek sediments, and, therefore, assumes no attenuation of dioxins/furans occurs during transport of groundwater from the lake, through organics-rich wetland and berm soils, to the creek. The maximum dioxins/furans TEQ concentration in Miller Creek sediments from groundwater was calculated to be 7.17 pg/g TEQ. This means that if the contaminants in lake sediments were to leach to groundwater, and then that groundwater were to flow through the creek sediments to discharge into Miller Creek surface water, the concentration of dioxins/furans in the Miller Creek sediments would be 7.17 pg/g TEQ.

Using empirical site data for comparison, the calculated Miller Creek sediment dioxins/furans TEQ concentration resulting from lateral groundwater transport of 7.17 pg/g is approximately 16 times the concentrations measured in Miller Creek surface sediment samples that range from 0.327 to 0.442 pg/g. These measured creek concentrations would also include any inputs or partitioning to sediments from dioxins/furans in surface water. As dioxins/furans are a known ubiquitous urban contaminant, it is not likely that groundwater would be the only source of dioxins/furans to the Miller Creek system. Therefore, empirical site data support that, under existing conditions (and future conditions as the pathway to sediments will be removed in the future), if dioxins/furans are migrating laterally from lake sediments to the creek, substantial attenuation is occurring during transport. Additionally, dioxins/furans migrating laterally from the lake sediments to Miller Creek would also have to migrate through the existing berm and the surrounding organics-rich wetland soils that would provide additional attenuation that is not accounted for in this evaluation.

Additional Lines of Evidence

Comparison of Miller Creek Sediment and Lora Lake Sediment Dioxins/Furans

The dioxins/furans congeners detected in sediment samples collected from Lora Lake differ from those collected in Miller Creek surface sediment samples. In the four surface sediment samples collected from Lora Lake (LL-SED 1 through LL-SED4) and the subsurface sediment samples with detected dioxins/furans concentrations, all 17 dioxins/furans congeners were detected. However, in the three Miller Creek surface sediment samples, a total of four dioxins/furans congeners were detected: 1,2,3,4,6,7,8-heptachlorodibenzo-p-dioxin (HpCDD), octachlorodibenzo-p-dioxin (OCDD), octachlorodibenzofuran (OCDF) and 1,2,3,4,6,7,8-heptalchlorodibenzo-p-furan (HpCDF). Figure 2 shows the congener makeup of sediment samples collected in Lora Lake compared to samples collected in Miller Creek. Additionally, the four congeners detected in Miller Creek are the congeners with the most chlorine atoms and are, therefore, the least mobile and have the highest affinity for sorption to soils or sediments. The least chlorinated and most mobile congeners that were detected in Lora Lake sediments, such as 2,3,7,8-TCDD, 1,2,3,7,8-pentachlorodibenzo-p-dioxin, 1,2,3,7,8-pentochlorodibenzo-p-furan (PeCDF), and 2,3,4,7,8-PeCDF, were not detected in the Miller Creek sediment samples. If dioxins/furans present in Lora Lake sediments were leaching to groundwater that was migrating laterally to Miller Creek, and then being transported vertically through creek sediments and into surface water, it would be expected that these most mobile congeners would be present in the creek sediments because they would migrate the farthest away from the source sediment. Therefore, the sediment chemical data further support the demonstration that existing dioxins/furans present in Lora Lake sediments are not migrating to groundwater and on to creek sediments.

Post-Remediation Hydrogeology and Groundwater Flow

Conversion of Lora Lake to a scrub-shrub wetland will involve: placement of a sand cap with at least the retention capacity of an 18-inch sand cap with an organic carbon content of 0.1 percent, followed by placement of fill material, and finally the placement of surface soil suitable to support the wetland plantings. The design of the wetland, including the hydraulic conductivity and properties of both the cap and fill materials, will take into account the functional requirements for the constructed wetland stated in the Cleanup Action Plan. These requirements ensure that the remedial action does not result in modifications to the functionality of the existing Lora Lake system. This means that lake filling may not modify the hydroperiod of the existing system, or increase flood frequency or intensity in the downstream system. The wetland will be designed to mimic the existing vertical groundwater gradients, and fill material will have higher hydraulic conductivities than the surrounding native soil, which will result in upward groundwater gradients through the contaminated sediments and into the placed cap and wetland fill. This further supports that the hypothetical groundwater flow pathway evaluated in this memorandum of horizontal groundwater flow through contaminated sediment, followed by vertical groundwater flow up through native soil and discharge into Miller Creek, is not likely to occur. The actual flow pathway of groundwater moving vertically through contaminated sediment and up through the high conductivity sand cap was evaluated in the RI/FS, and is protective of surface water quality standards at the surface of the cap as previously mentioned.

Miller Creek Sediments Protective of Surface Water

As described in detail and presented in Appendix P (the Sediment Leaching and Numerical Cap Modeling appendix) of the RI/FS, equilibrium partitioning was used to predict the dioxins/furans pore water concentrations that would leach from the sediment surface in Miller Creek. The resulting pore water dioxins/furans concentration was then compared to Clean Water Act Surface Water Quality Criteria for human health consumption of organisms and water. The results of this evaluation indicate that the dioxins/furans concentration (0.00041 pg/L TEQ) that could potentially leach from Miller Creek surface sediments do not exceed the applicable human health criterion (0.005 pg/L) (Table P.5). Therefore, Miller Creek surface sediments are protective of the human health pathway, and this provides an additional line of evidence that dioxins/furans present in soils and sediments within Lora Lake are not migrating to groundwater and discharging to Miller Creek surface water at levels of concern. This can be assumed because, to reach surface water, the dioxins/furans migrating in groundwater would have to be transported through creek bed sediments, where, due to dioxins/furans' strong affinity for soil and sediments, it would be detected in sediments at a greater concentration than has been observed.

CONCLUSION

This memorandum presents how the existing Lora Lake sediment data and Miller Creek sediment data can be used to demonstrate that, per WAC 173-340-720(4)(b)(ii), groundwater cleanup levels for protection of surface water beneficial uses are not applicable because hazardous substances are not likely to reach surface water. Therefore, consistent with the evaluation of groundwater cleanup levels conducted in the RI/FS, the most stringent of applicable groundwater cleanup levels is protection of human consumption via drinking water (MTCA Method B value of 6.7 pg/L).

REFERENCES

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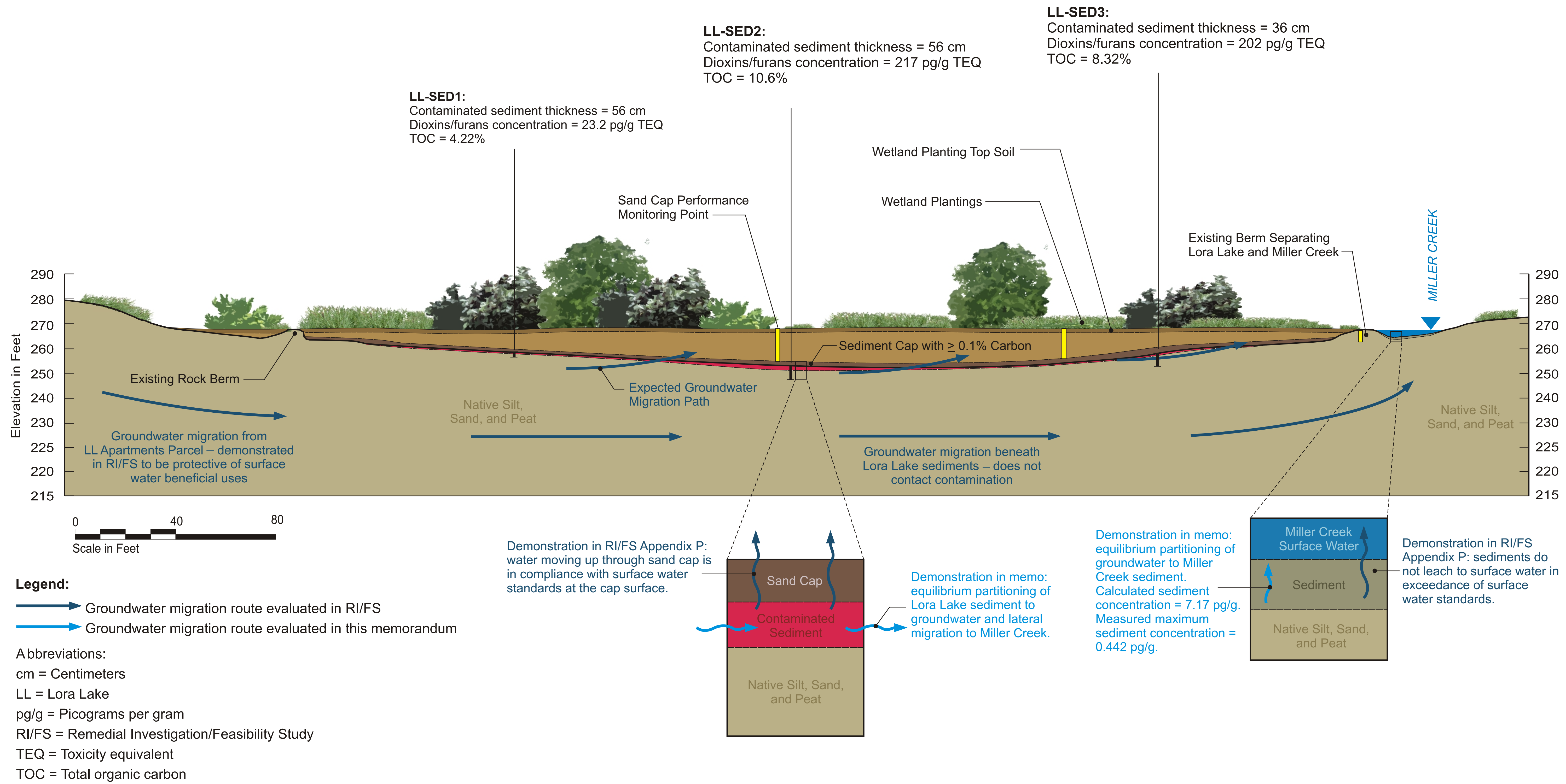
LIST OF FIGURES

LIST OF ATTACHMENTS

Figures



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Demonstration of Groundwater Protection of Surface Water Beneficial Uses
Lora Lake Apartments Site
Burien, Washington

Figure 1
Conceptual Remedy Cross Section
Equilibrium Partitioning

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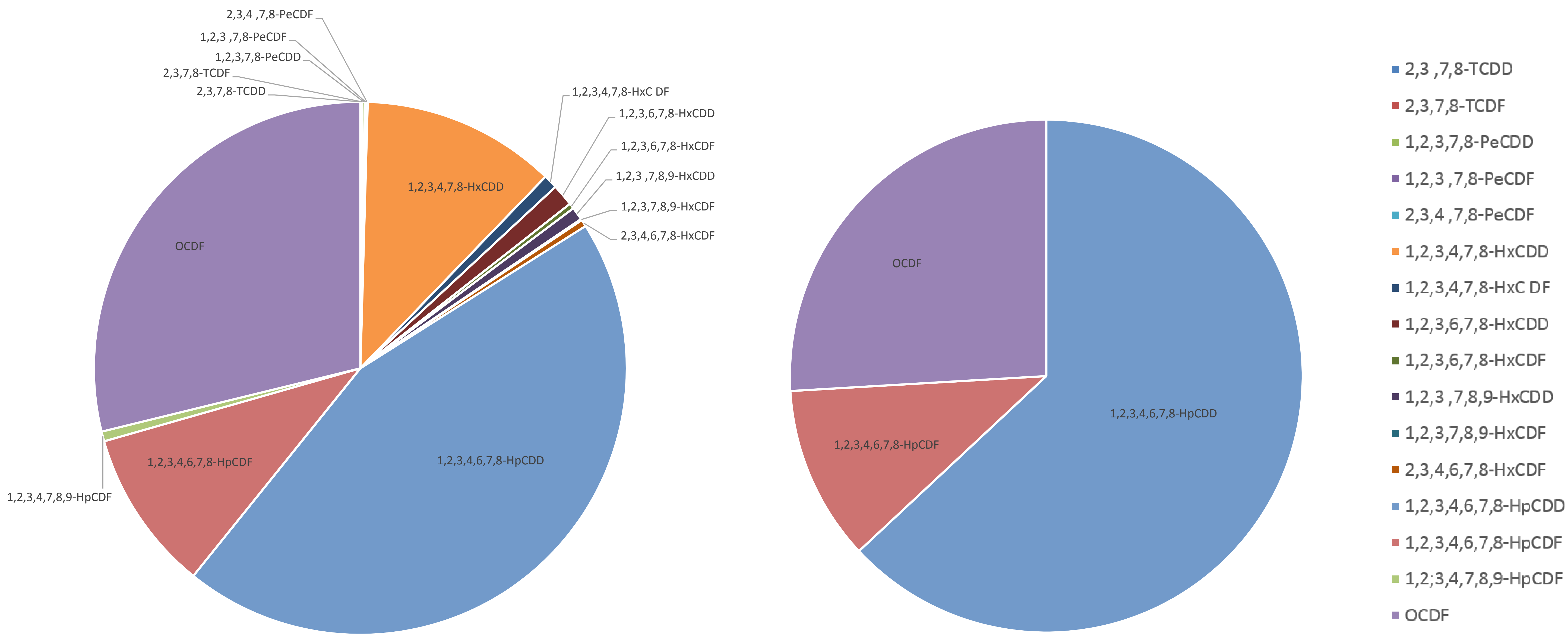

Detections in Lora Lake Sediment Samples
LL-SED1 through LL-SED5 - Excluding OCDD

Detections in Miller Creek Sediment Samples
MC-SED1 through MC-SED3 - Excluding OCDD

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Demonstration of Groundwater Protection of Surface Water Beneficial Uses
Lora Lake Apartments Site
Burien, Washington

Figure 2
Dioxins/Furans Congener Detections in Lora Lake and Miller Creek Sediment Samples

Attachment 1
Lora Lake Sediments to Miller Creek Surface Water
Equilibrium Partitioning Evaluation

Attachment 1
Lora Lake Sediments to Miller Creek Surface Water Equilibrium Partitioning Evaluation

Method: Equilibrium Partitioning Equations

$C_{gw} = C_{Sed} / K_d$ $K_d = K_{oc} * f_{oc}$

Dioxins/Furans K_{oc}[1]

12,500,000 L/kg

Step 1
Partitioning of Lora Lake Sediment Dioxins/Furans to Groundwater
Max measured dioxins/furans lake sediment concentrations 217 pg/g TEQ
T_{oc} measured in lake surface sediment sample (LLSED-2) with max dioxins/furans 10.6 %
K_d (Calculated using lake sediment T_{OC}) 1325000 L/kg
Calculated max dioxins/furans in groundwater from lake sediments 0.164 pg/L

Step 2
Partitioning of Calculated Groundwater Dioxins/Furans to Miller Creek Sediments
Calculated max dioxins/furans in groundwater from lake sediments (calculated in Step 1) 0.164 pg/L
Average T_{oc} measured in Miller Creek surface sediments 0.35 %
K_d (Calculated using Miller Creek sediment T_{OC}) 43750 L/kg
Calculated max dioxins/furans potentially in Miller Creek sediments from groundwater (assuming no attenuation during migration from lake to creek) 7.17 pg/g TEQ
For Comparison - Range of measured Dioxin/furan Miller Creek sediment concentrations *0.327–0.442 pg/g TEQ*
CONCLUSION: Measured range of dioxins/furans TEQ in Miller Creek sediments is approximately 1/16 the calculated max dioxins/furans assuming no attenuation occurs during transport. Empirical data support attenuation is occurring during groundwater migration.

Note:

1 Refer to RI Appendix P, Table P.3 for K_{oc} references.

Abbreviations:

C_{gw}	Groundwater concentration
C_{sed}	Sediment concentration
f_{oc}	Fraction organic carbon (= T_{oc}/100)
K_d	Partitioning coefficient
K_{oc}	Organic carbon paritioning coefficient
L/kg	Liters per kilogram
pg/g	Picograms per gram
pg/L	Picograms per liter
RI	Remedial Investigation
TEQ	Toxicity equivalent
T_{oc}	Total organic carbon