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ANCHOR QEA

Memorandum

May 18, 2021

To: Rick Thomas and Jing Liu, Washington Department of Ecology
Elly Hale and Erika Hoffman, U.S. Environmental Protection Agency

From: Greg Brunkhorst, Julia Fitts, LG, and David Templeton, Anchor QEA, LLC

cc: Kyle McCleary, Duwamish Shipyard, Inc.
Kim Maree Johannessen, Johannessen & Associates, P.S.

Re: DSI Sediment Data Summary Figures

This memorandum presents updated figures (Figures 1 to 12), summarizes the data sources and handling procedures used to develop the figures, and provides additional summary information in tabular format for reference. These data provide available information for the horizontal and vertical extent of chemicals of concern (COCs) listed in the Record of Decision (ROD) and for tributyltin (TBT). This information is expected to inform discussion regarding the proposed approach for the DSI Site (Agreed Order No. DE6735) that integrates the Model Toxics Control Act (MTCA) cleanup process and Lower Duwamish Waterway (LDW) cleanup process as outlined in ROD.

Figure Development

Data Sources

The primary source of data used in Figures 1 to 12 was the Lower Duwamish Waterway Group (LDWG) Amendment 3 Access Database from https://ldwg.org/project-library/. This database, which was last updated on July 7, 2020, contained all DSI Site sediment data (i.e., sediment chemical data from the Draft Remedial Investigation Report [RI; Anchor QEA 2019]) with the exception of 10 surface sediment samples collected by Anchor QEA and analyzed for TBT in 2019 as part of the *Remedial Investigation Addendum Tributyltin Study Data Summary Memorandum* (Anchor QEA 2020). These 10 samples ("BT" series data) were merged with the LDWG dataset to provide a complete dataset for mapping purposes. Data collected after the year 2000 was retained on the figures; sediment data collected prior to 2000 was omitted due to age and uncertainty in data quality.[1]

Figures 1 through 9: Summary of COCs in Sediment at Depth Horizons

Figures 1 through 9 depict the sediment concentrations compared to remedial action levels (RALs) for three sets of chemicals (TBT, polychlorinated biphenyls [PCBs], and all other ROD COCs combined) at three depth horizons (0 to 10 centimeters [cm], 0 to 2 feet, and any depth of

[1] Note that March 24 meeting figures included pre-2000 data; however, these data were removed from the updated figure set due to potential quality and recency issues.

subsurface sediment).[2] Concentrations for each sample location are shown for a Thiessen polygon surrounding the sample location. The purpose of these figures is to show the approximate relative spatial extent of COCs at the three depth horizons as established in the ROD decision framework.

The data handling procedures were as follows:

- Exceedance Factors (All Figures): The figures present exceedance factors for chemicals, which equal the detected concentration divided by the RAL (or site-specific cleanup level [CUL], for TBT).
- Surface Sediment (Figures 1, 4, and 7): The exceedance factor of sampled material in the upper 10 cm of surface grab samples. Duplicates were averaged.
- Shallow Subsurface Sediment (Figures 2, 5, and 8): The exceedance factor in the 0- to 2-foot depth interval is based on the depth-weighted average concentration of subsurface samples in the upper 0 to 2 feet (as established in the ROD decision framework).
  - For example, if two samples in a core were collected from 0 to 0.5 foot and 1 to 2 feet, then the weighted-average exceedance factor would be one-third times the first sample exceedance factor plus two-third times the second sample exceedance factor.
- Subsurface Sediment (Figures 3, 6, and 9): The maximum concentration in subsurface sediment from any depth sample was presented, compared to the most restrictive RAL.
  - The maximum concentration in subsurface sediment at depth is not a criterion in the ROD that triggers active remediation.
- TBT (Figures 1 through 3): TBT data were organic carbon (OC)-normalized and compared to a RAL of 7.5 milligrams per kilogram (mg/kg)-OC.
  - OC normalized data were compared to the preliminary TBT CUL in all cases; data were not compared to a dry-weight criterion for particularly low or high OC values.
- PCBs (Figures 4 through 6): Total PCB concentrations were compared to the lowest of the ROD RALs of 12 mg/kg-OC for total organic carbon (TOC) between 0.5% and 3.5% and 130 micrograms per kilogram (µg/kg) dry weight for TOC less than 0.5% or greater than 3.5% based on the ROD.
  - PCBs were compared to the lowest of the ROD RALs. Because Thiessen polygons cut across different Recovery Category areas, tidal zones, and navigation areas, the comparison to the RALs was not modified based on location.
    - This approach was used in order to simplify the analysis and to provide a consistent comparison across areas. However, a complete ROD remediation area analysis would need to include other location factors (e.g., Recovery Categories) to accurately define remediation areas. The complete remediation area analysis is anticipated as part of the final DSI FS.

[2] Figures 1 through 9 are identical to the figures presented in the March 24 meeting, but with the year 2000 data cutoff applied.

    - For PCBs, the 0- to 2-foot (shallow subsurface sediment) figure should not be used to delineate specific remediation areas (e.g., because 0- to 2-foot depth horizon triggers remediation in Recovery Category 1 areas but not Recovery Category 2 and 3 areas).
- Other COCs (Figures 7 through 9): Other COCs includes all ROD COCs other than PCBs (and TBT).
    - Each Theissen polygon shows the maximum exceedance factor for any detected COC.
    - Like PCBs, relevant organic compounds were compared to the OC-normalized values for TOC between 0.5% and 3.5% and dry-weight-based values for TOC less than 0.5% or greater than 3.5% based on the ROD.
    - Like PCBs, other COCs were compared to the lowest of the ROD RALs. The notes associated with the first PCBs subbullet also apply to other COCs.

Figures 10 and 11: Summary of COC Exceedances in Surface and Shallow Subsurface Sediment[3]

Figures 10 and 11 depict surface sediment (0 to 10 cm) and shallow subsurface sediment (0 to 2 feet) COC and TBT concentrations compared to RALs (or the CUL, for TBT). The purpose of the figures is to compare potential future remediation areas for TBT and ROD COCs and assess co-location. Figures 10 and 11 were developed using the same general methodology as Figures 1 through 9; however, because Figures 10 and 11 depict points rather than Thiessen polygon areas, the point locations were coded based on additional ROD RAL rules (e.g., consideration of Recovery Category areas), as described in the following bullets:

- Methodology for exceedance factors, surface sediment, and shallow subsurface sediment are the same as for Figures 1 through 9, discussed previously.
- Total PCBs are combined with other ROD COCs for this analysis to simplify color coding.
- The areas west of the navigation channel, adjacent to DSI, are in Recovery Category 1 (e.g., see ROD Figure 12):
    - Use of the lowest RAL is applicable.
    - The 0 to 10 cm and the 0- to 2-foot depths are both applicable.
    - The small underpier area west of the navigation channel and adjacent to the DSI Property (between river mile 1.2 and 1.4) is designated as Recovery Category 3 in the LDW ROD (ROD Figure 12). For the purposes of this analysis, this small area was treated as a Recovery Category 1.
- The areas within and east of the navigation channel, and the Glacier Bay area south of DSI, are in Recovery Category 2 or 3:

[3] Figures 10 and 11 replace *Figure X Summary of COC Exceedances in Surface and Shallow Subsurface Sediment* presented in the March 24 meeting. The data handling was the same except that surface sediment and shallow subsurface sediment were split into separate figures for clarity, the year 2000 recency cut-off was applied, and a GIS layering issue was fixed.

  - The 0- to 10-cm depth is applicable; the 0- to 2-foot depth is not applicable (data not shown in Figure 11).
  - For human-health risk drivers (PCBs, arsenic, carcinogenic polycyclic aromatic hydrocarbons [cPAHs], and dioxins/furans), the lowest of the RALs is applicable.
  - For benthic risk drivers that are not human-health risk drivers, 2 times benthic sediment cleanup objective (SCO) is the RAL.
  - For TBT, the RAL was not adjusted within Recovery Category 2 or 3 (concentrations were compared to 7.5 mg/kg OC).
  - No shoaling areas were identified within the navigation channel, therefore subsurface sediment was not compared to RALs.
- Applicable samples were compared to applicable RALs to calculate exceedance factors and were coded as follows:
  - Green: no exceedance
  - Yellow: exceedance for ROD COCs but not TBT (or not analyzed for TBT)
  - Orange: exceedance for ROD COCs and TBT
  - Pink (no locations were identified): exceedance for TBT and not analyzed for ROD COCs, or not exceeding for ROD COCs

Figure 12 Tributyltin, OC-Normalized in Subsurface Sediment

Figure 12 depicts TBT exceedances in subsurface sediment at RI core locations. The figure was developed by updating Figure 7-3v from the RI (Anchor QEA 2019) to compare to the TBT RAL of 7.5 mg/kg OC.

Tabular Data

Following the March 24 meeting, a summary table was developed to further support DSI Site discussions. Table 1 presents a TBT co-location analysis by summarizing the information on Figures 10 and 11, for the areas adjacent to the DSI and AML properties (DSI-West, DSI-Nav, AML-West, and AML-Nav on the figures).

Table 1a shows the total exceedance count for these four areas. Table 1b breaks that information out by TBT exceedance counts compared to other COCs, and Table 1c provides summary statistics related to the TBT co-location analysis.

For reference, the raw data are provided in two excel files, “LDW_AOC3_RM0_9-1_5_2021-02-19.xlsx” and “DSI_BT_Samples_2021-04-21.xlsx.”

Discussion

Several observations can be drawn from the figures and tables:

1. **Large active remediation area.** Under the LDW ROD, much of the sediment area adjacent to the DSI Property would be actively remediated, based on existing data and the ROD decision process. Areas within and on either side of the navigation channel have exceedances of RALs (e.g., see yellow and orange dots in Figures 10 and 11 or light blue, yellow, or red areas in Figure 7). Within the areas adjacent to DSI and AML properties (outside of the navigation channel), 74% of samples exceeded one or more ROD RALs (Table 1a).
2. **ROD COCs are inclusive to elevated TBT concentrations.** The ROD remedy footprint offshore of the DSI Property is based entirely on RAL exceedances by ROD COCs. The ROD RAL exceedance footprint is significantly larger than and encompasses the TBT exceedance footprint (e.g., compare the yellow and orange dots in Figures 10 and 11, or compare Figure 1 to Figure 4 and 7). There were no locations that exceeded for TBT alone (i.e., TBT and not other ROD COCs) out of 72 samples with TBT data in the area. All but four samples included in the mapping analysis were analyzed for TBT (Tables 1a and 1b).
3. **TBT RAL exceedances are horizontally bounded.** The extent of the draft TBT CUL exceedances adjacent to DSI are bounded in surface sediment and shallow subsurface sediment (Figures 1 and 2), apart from shallow subsurface data to the north of the DSI sampling area. There is a high density of TBT sample locations throughout the area, particularly for an FS-level analysis.
4. **TBT appears to be isolated at depth.** Concentrations at depth are significantly higher than concentrations in surface sediment and shallow subsurface sediment for TBT and other chemicals (e.g., compare Figures 1, 2, and 3, or 7, 8, and 9), indicating a historical source and natural recovery.

These observations are consistent with the conceptual site model for DSI sediments, which can be summarized as follows:

- Historical contaminant releases of TBT along with co-located COCs, such as copper and arsenic, in the vicinity of DSI are due to historical shipyard activities.
- Site-related contaminant releases have since been comingled with LDW contaminants such as PCBs.
- The subsequent deposition and burial of contaminants by cleaner sediments is evident.
- Buried chemicals are relatively immobile, based on steep vertical concentration gradients for TBT; this is likely due to the nature of the TBT source (i.e., matrix-bound paint chips).

Table 1
DSI and AML Sediment and Adjacent Federal Navigation Channel Summary Statistics

a. RAL Exceedance Summary

Area[a]	Depth[b]	Total Samples[c]	Pass[d]	Exceed[e]	Percent Exceed
DSI-West	Surface Sediment (0-10 cm)	14	2	12	86%
	Shallow Subsurface Sediment (0-2 ft)	14	1	13	93%
AML-West	Surface Sediment (0-10 cm)	21	11	10	48%
	Shallow Subsurface Sediment (0-2 ft)	7	0	7	100%
DSI-Nav	Surface Sediment (0-10 cm)	12	6	6	50%
AML-Nav		7	1	6	86%
All	Both Depths	75	21	54	72%

b. TBT Co-location Analysis Counts

		Pass[d]			Exceed[e]			
Area[a]	Depth[b]	TBT and Other Chemicals Analyzed	TBT Not Analyzed	Other Chemicals Not Analyzed	Pass for TBT (Exceeds Other Chemicals)	Pass for Other Chemicals (Exceeds TBT)	TBT Not Analyzed	Exceeds (Both TBT and Other Chemicals)
DSI-West	Surface Sediment (0-10 cm)	1	0	1	5	0	2	5
	Shallow Subsurface Sediment (0-2 ft)	1	0	0	9	0	0	4
AML-West	Surface Sediment (0-10 cm)	2	1	8	5	0	0	5
	Shallow Subsurface Sediment (0-2 ft)	0	0	0	2	0	0	5
DSI-Nav	Surface Sediment (0-10 cm)	4	1	1	6	0	0	0
AML-Nav		1	0	0	6	0	0	0
All	Both Depths	9	2	10	33	0	2	19

c. TBT Co-location Analysis Percentages

Area[a]	Depth[b]	Percent Samples Analyzed for TBT	Percent of Samples with TBT Exceedances that also Exceed for Other Chemicals	Percent of Samples with Other Chemical Exceedances that also Exceed for TBT
DSI-West	Surface Sediment (0-10 cm)	86%	100%	42%
	Shallow Subsurface Sediment (0-2 ft)	100%	100%	31%
AML-West	Surface Sediment (0-10 cm)	95%	100%	50%
	Shallow Subsurface Sediment (0-2 ft)	100%	100%	71%
DSI-Nav	Surface Sediment (0-10 cm)	92%	100%	0%
AML-Nav		100%	100%	0%
All	Both Depths	95%	100%	35%

Table 1
DSI and AML Sediment and Adjacent Federal Navigation Channel Summary Statistics

Notes:

a. Areas are shown on Figure 10. The areas are shown strictly for this data summary and are not intended to represent Site areas for the FS evaluation. DSI-West is the area adjacent to the DSI Property and west of the federal navigation channel. AML-West is the area adjacent to the AML property and west of the federal navigation channel. DSI-nav is the area within the federal navigation channel adjacent to the DSI property. And AML-nav is the area within the federal navigation channel adjacent to the AML property.

b. Depths are based on the LDW ROD RAL depths of 0 to 10 cm and 0 to 2 feet with Recovery Category 1 (west of the federal navigation channel in these areas), and 0 to 10 cm only in Recovery Category 2 and 3 areas (within the federal navigation channel in these areas).

c. Sample data is from the LDW AOC3 Database plus the DSI TBT study data ("BT" series locations). Samples from prior to the year 2000 have been excluded.

d. Pass indicates no detected exceedances for any chemicals. Other COCs are compared to the ROD RALs based on the ROD proceedures. TBT is compared to 7.5 mg/kg OC.

e. Exceed indicates one or more detected exceedances for any chemical. Other COCs are compared to the ROD RALs based on the ROD proceedures. TBT is compared to 7.5 mg/kg OC.

cm: centimeter

COC: chemical of concern

FS: Feasibility Study

ft: feet

LDW: Lower Duwamish Waterway

mg/kg: milligrams per kilogram

OC: organic carbon

RAL: remedial action level

ROD: Record of Decision

TBT: tributyltin

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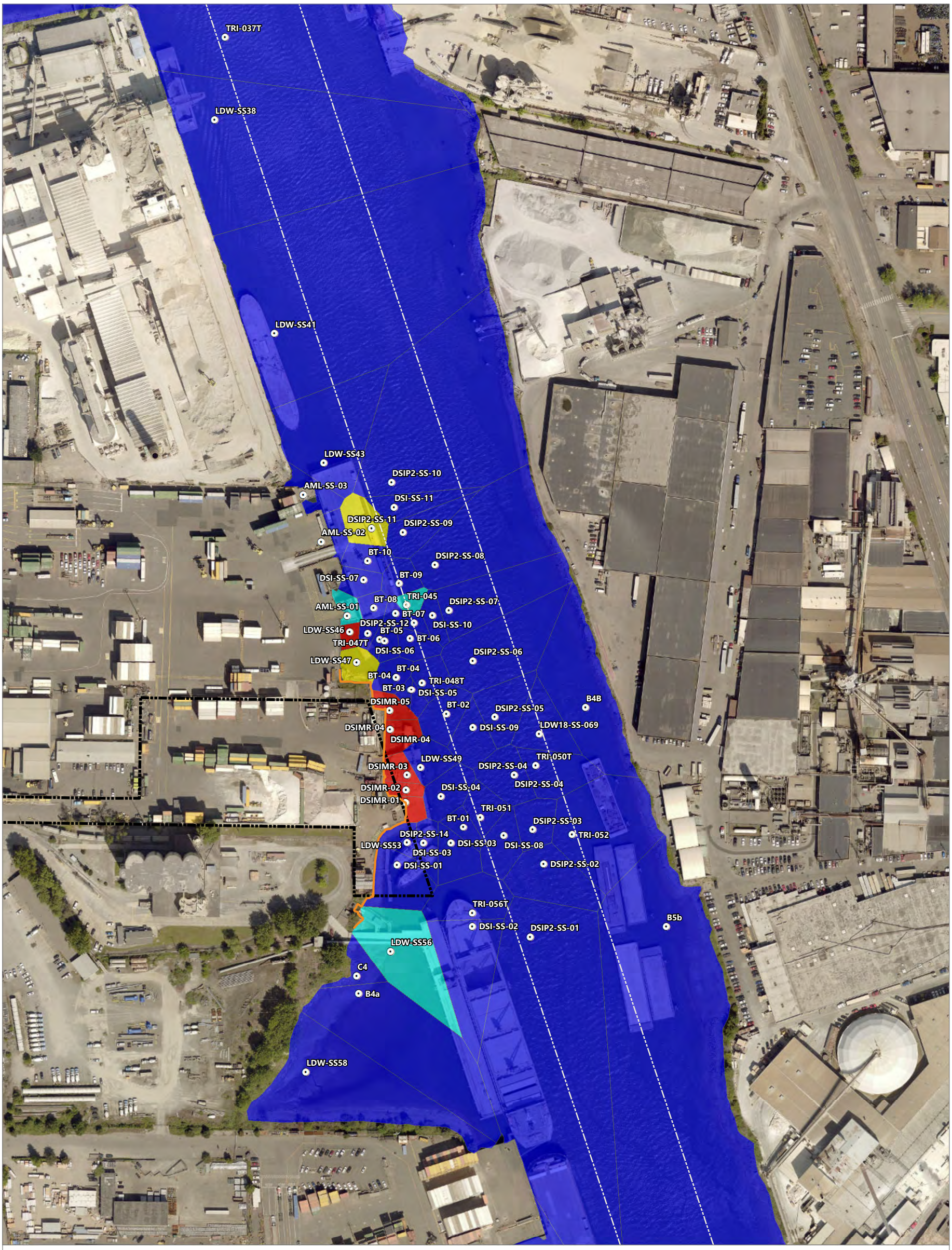

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Figure 1
Surface Sediment Tributyltin
Duwamish Shipyard Inc.

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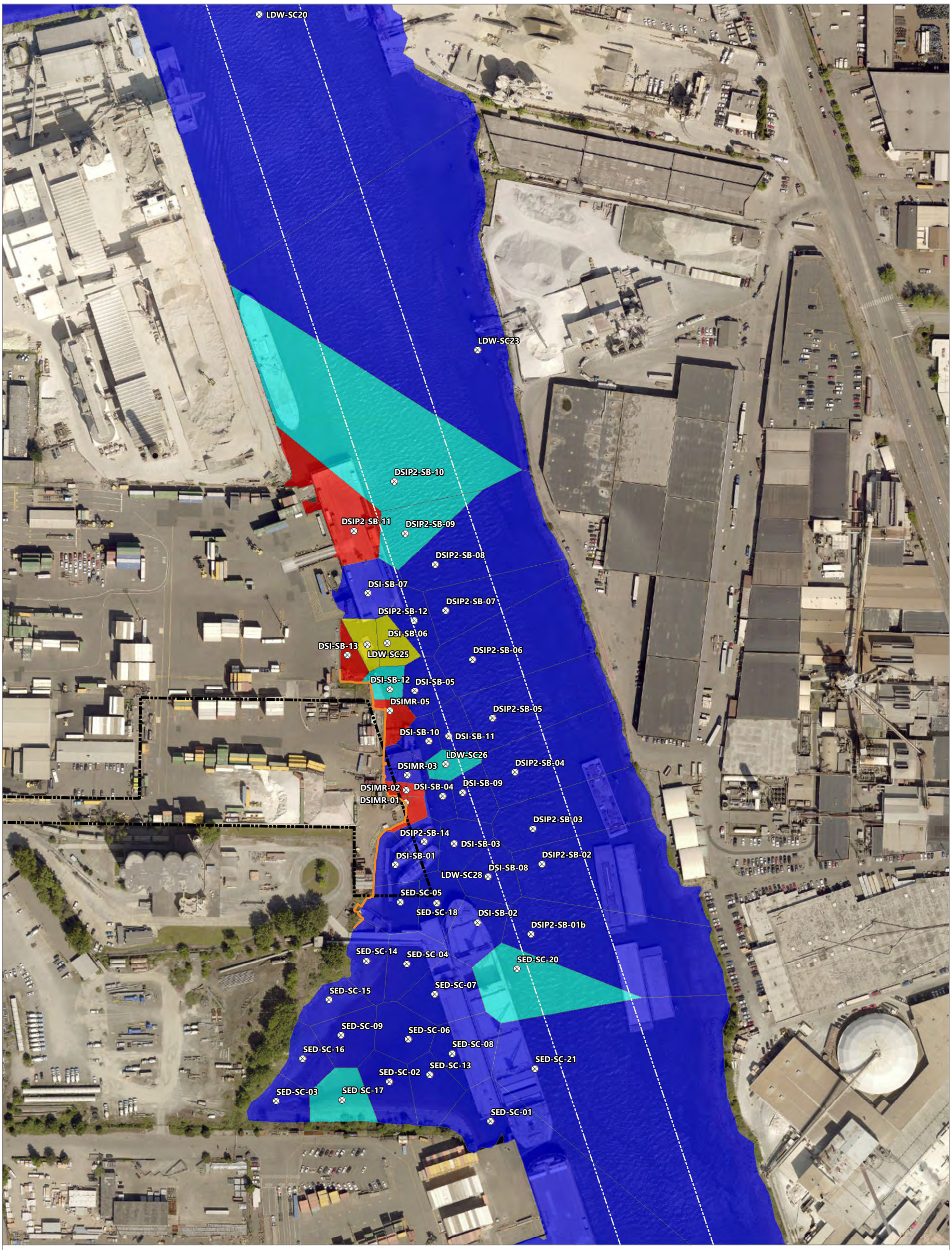

LEGEND:

- Shallow Subsurface Sediment Sample Location (0-2ft)
- Federal Navigation Channel
- Top of Bank
- Duwamish Shipyard Inc. Property Boundary

Tributyltin

CUL Exceedance Factor (7.5 mg/kg-OC)

- 0.0 - 1.0
- 1.1 - 2.0
- 2.1 - 3.0
- >3

0 200

Feet

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Figure 2
Shallow Subsurface Sediment Tributyltin
Duwamish Shipyard Inc.

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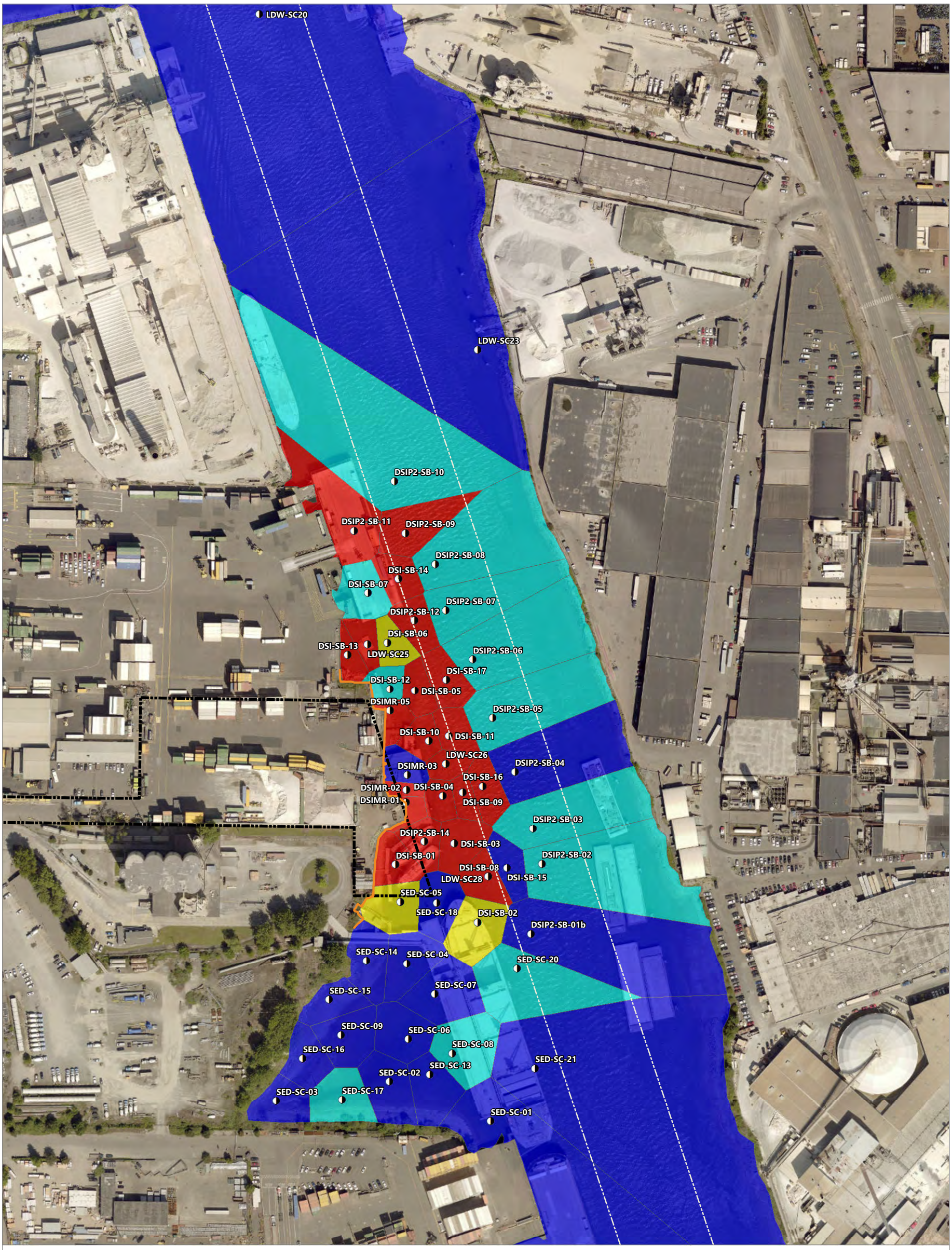

LEGEND:

- Subsurface Sediment Sample Location (Any Depth)
- Federal Navigation Channel
- Top of Bank
- Duwamish Shipyard Inc. Property Boundary

Tributyltin

CUL Exceedance Factor (7.5 mg/kg-OC)

- 0.0 - 1.0
- 1.1 - 2.0
- 2.1 - 3.0
- >3

0 200

Feet

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Figure 3
Subsurface Sediment Tributyltin
Duwamish Shipyard Inc.

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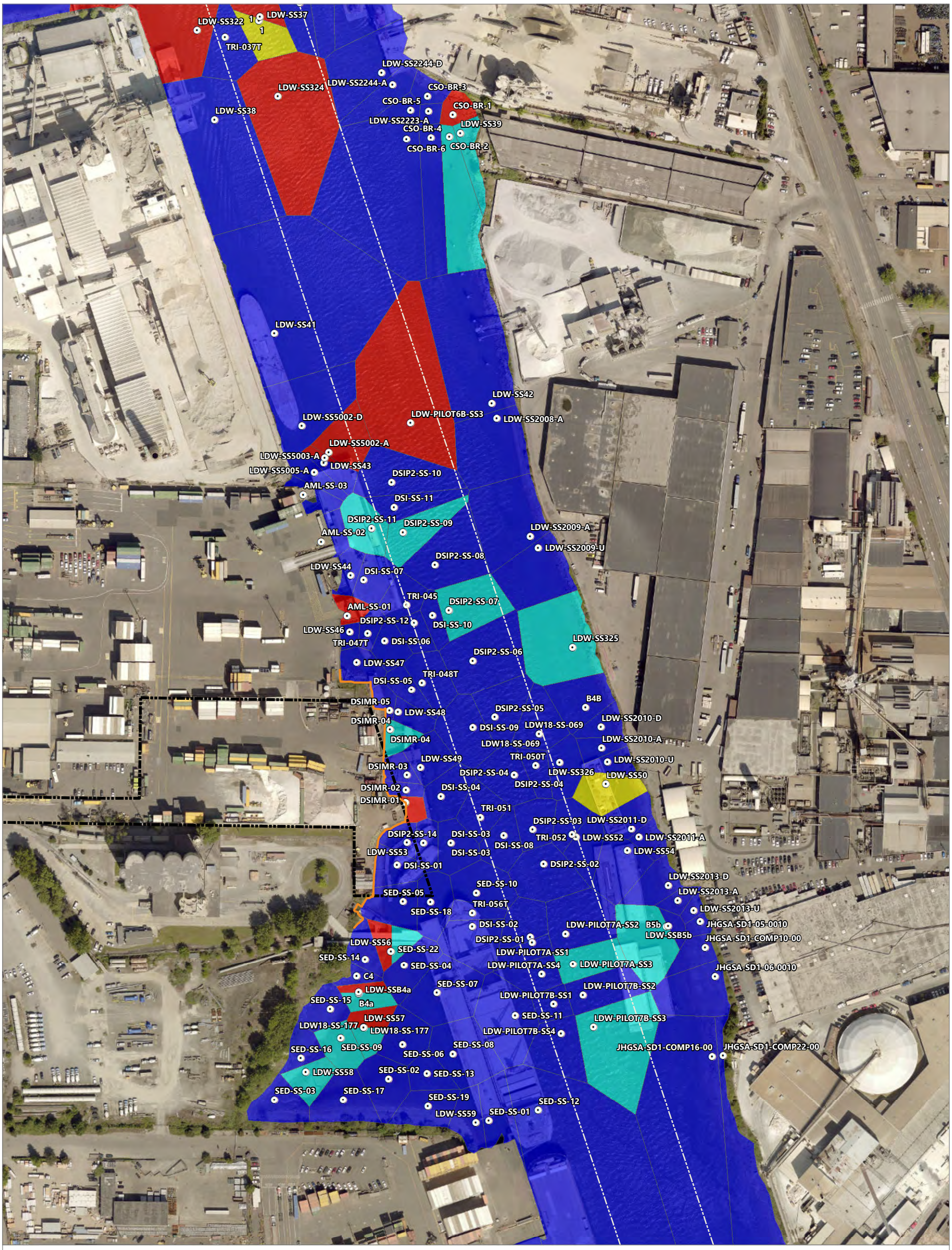

LEGEND:

- Surface Sediment Sample Location (0-10 cm)
- Federal Navigation Channel
- Top of Bank
- Duwamish Shipyard Inc. Property Boundary

Total PCB

RAL Exceedance Factor

- 0.0 - 1.0
- 1.1 - 2.0
- 2.1 - 3.0
- >3

0 200

Feet

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Figure 4
Surface Sediment Total PCBs
Duwamish Shipyard Inc.

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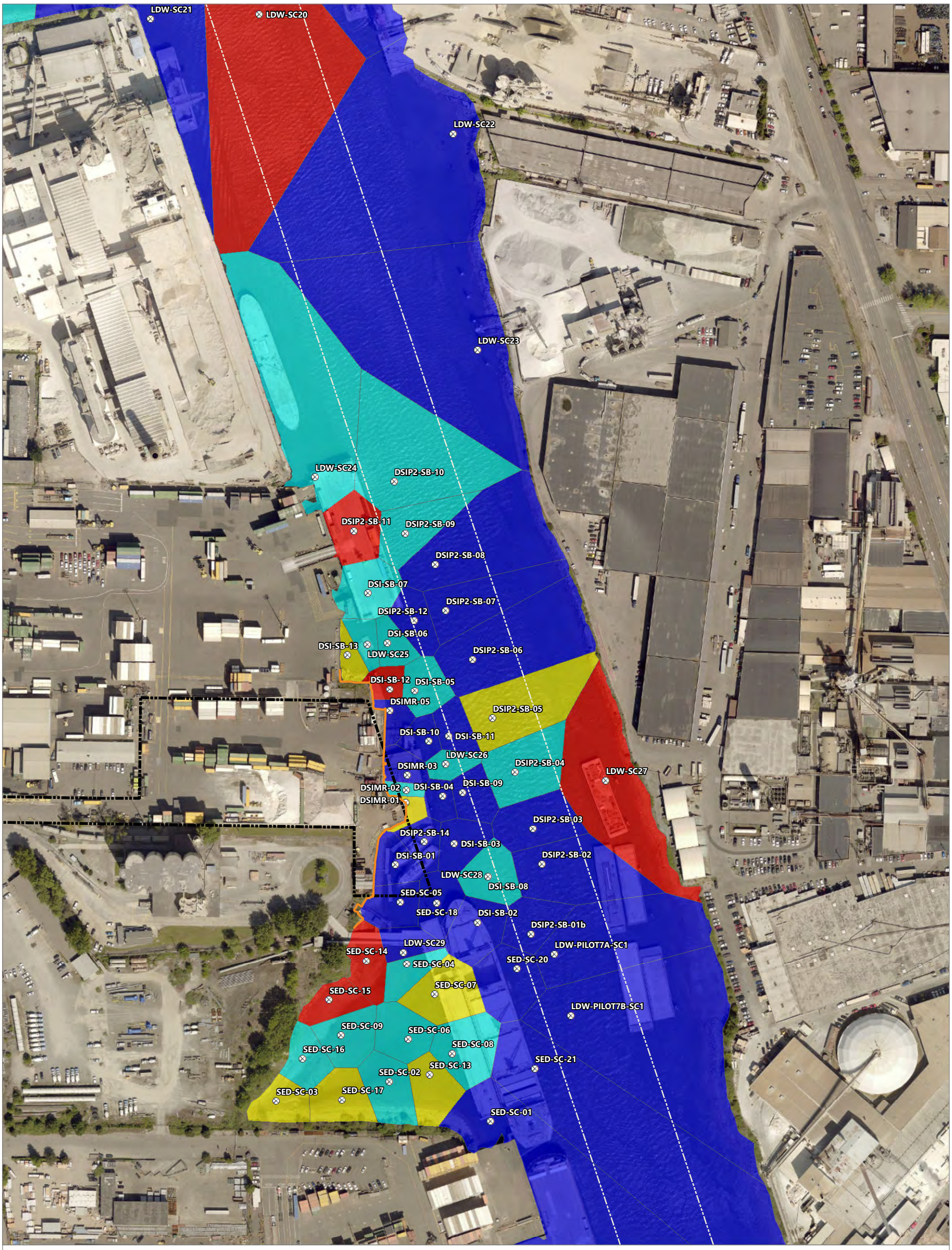

LEGEND:

- Shallow Subsurface Sediment Sample Location (0-2ft)
- Federal Navigation Channel
- Top of Bank
- Duwamish Shipyard Inc. Property Boundary

Total PCB

RAL Exceedance Factor

- 0.1 - 1.0
- 1.1 - 2.0
- 2.1 - 3.0
- >3

0 200

Feet

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Figure 5
Shallow Subsurface Sediment Total PCBs
Duwamish Shipyard Inc.

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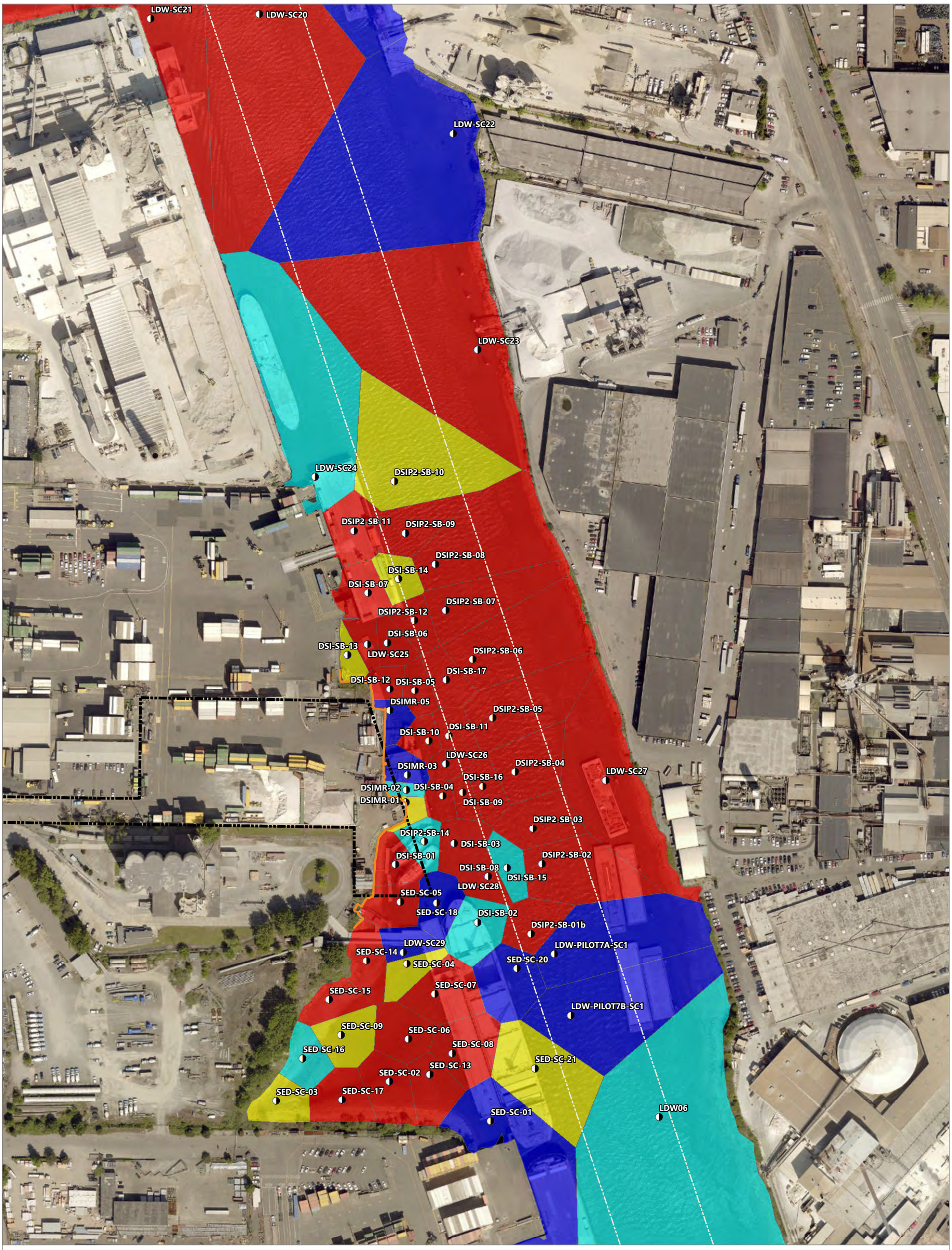

LEGEND:

- Subsurface Sediment Sample Location (Any Depth)
- Federal Navigation Channel
- Top of Bank
- Duwamish Shipyard Inc. Property Boundary

Total PCB

RAL Exceedance Factor

- 0.2 - 1.0
- 1.1 - 2.0
- 2.1 - 3.0
- >3

0 200

Feet

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Figure 6
Subsurface Sediment Total PCBs
Duwamish Shipyard Inc.

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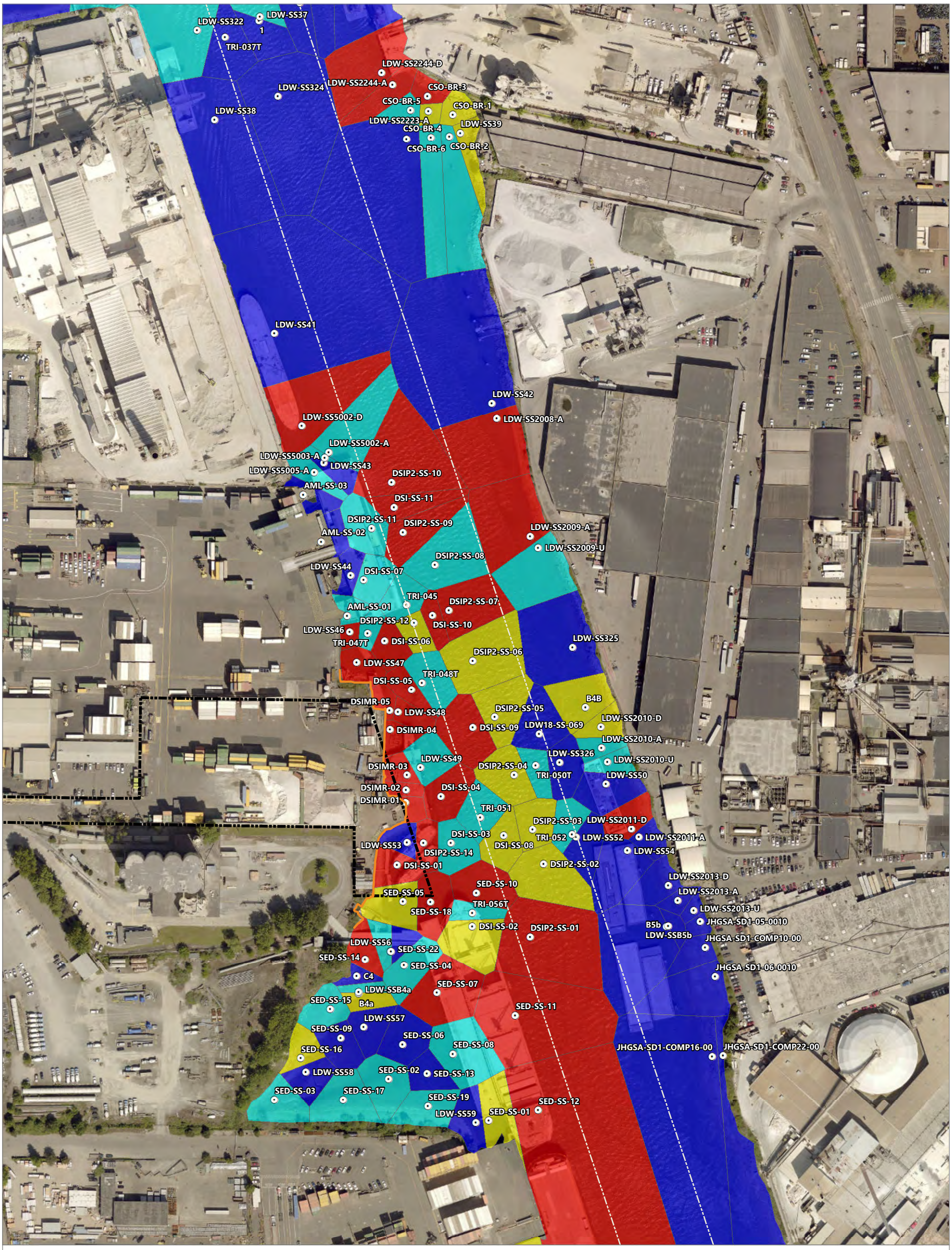

LEGEND:

- Suface Sediment Sample Location (0-10 cm)
- Federal Navigation Channel
- Top of Bank
- Duwamish Shipyard Inc. Property Boundary

Combined Other COC's (LDW COCs Excepting PCBs and TBT)

Maximum Exceedance Factor (of Lowest RAL for Each Chemical [i.e., Category 1 RALs])

- 0.0 - 1.0
- 1.1 - 2.0
- 2.1 - 3.0
- >3

0 200

Feet

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Figure 7
Surface Sediment Combined Other COCs
Duwamish Shipyard Inc.

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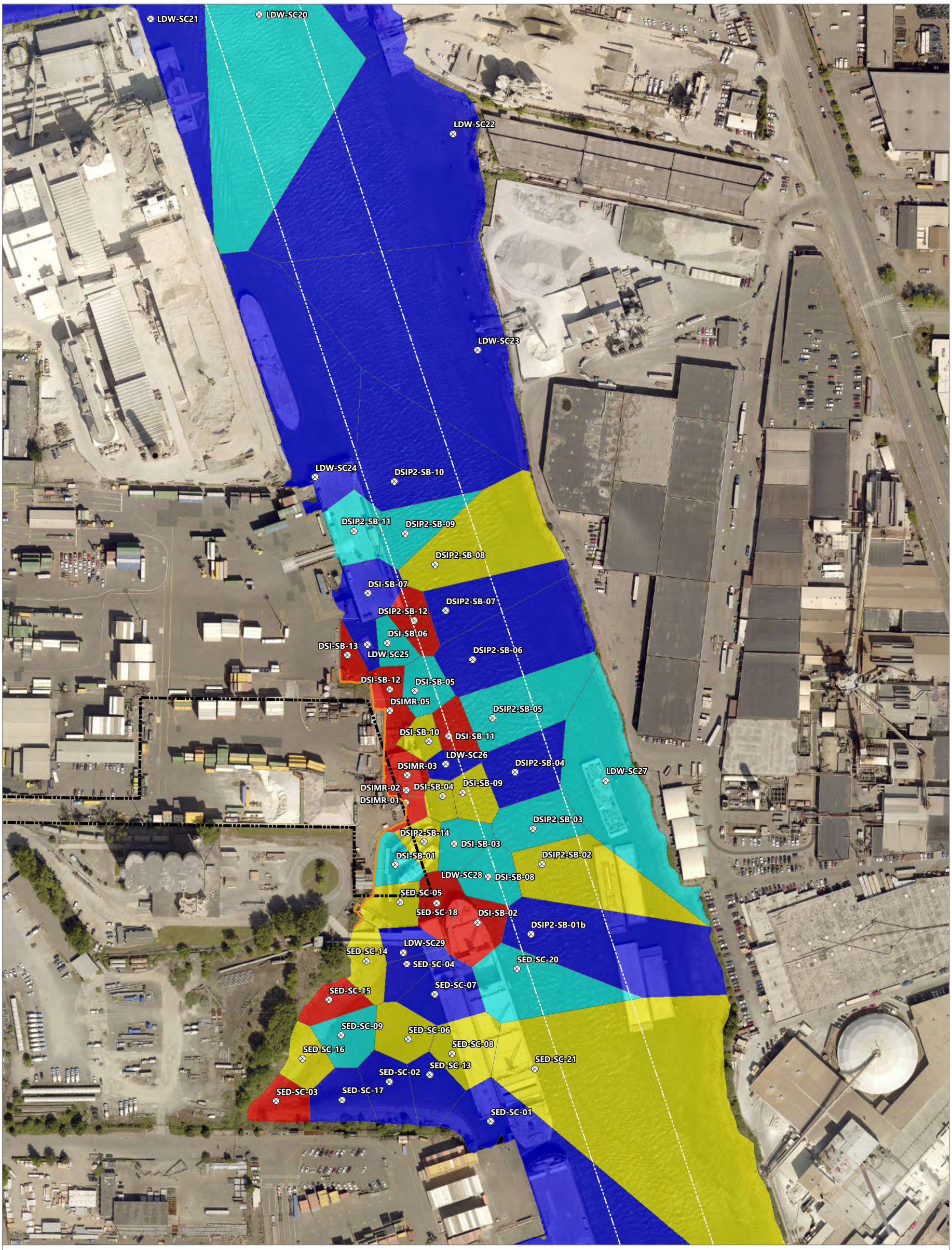

LEGEND:

- ⊗ Shallow Subsurface Sediment Sample Location (0-2ft)
- Federal Navigation Channel
- Top of Bank
- Duwamish Shipyard Inc. Property Boundary

Combined Other COC's (LDW COCs Excepting PCBs and TBT)

Maximum Exceedance Factor (of Lowest RAL for Each Chemical [i.e., Category 1 RALs])

- 0.3 - 1.0
- 1.1 - 2.0
- 2.1 - 3.0
- >3

0 200

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Figure 8
Shallow Subsurface Sediment Combined Other COCs
Duwamish Shipyard Inc.

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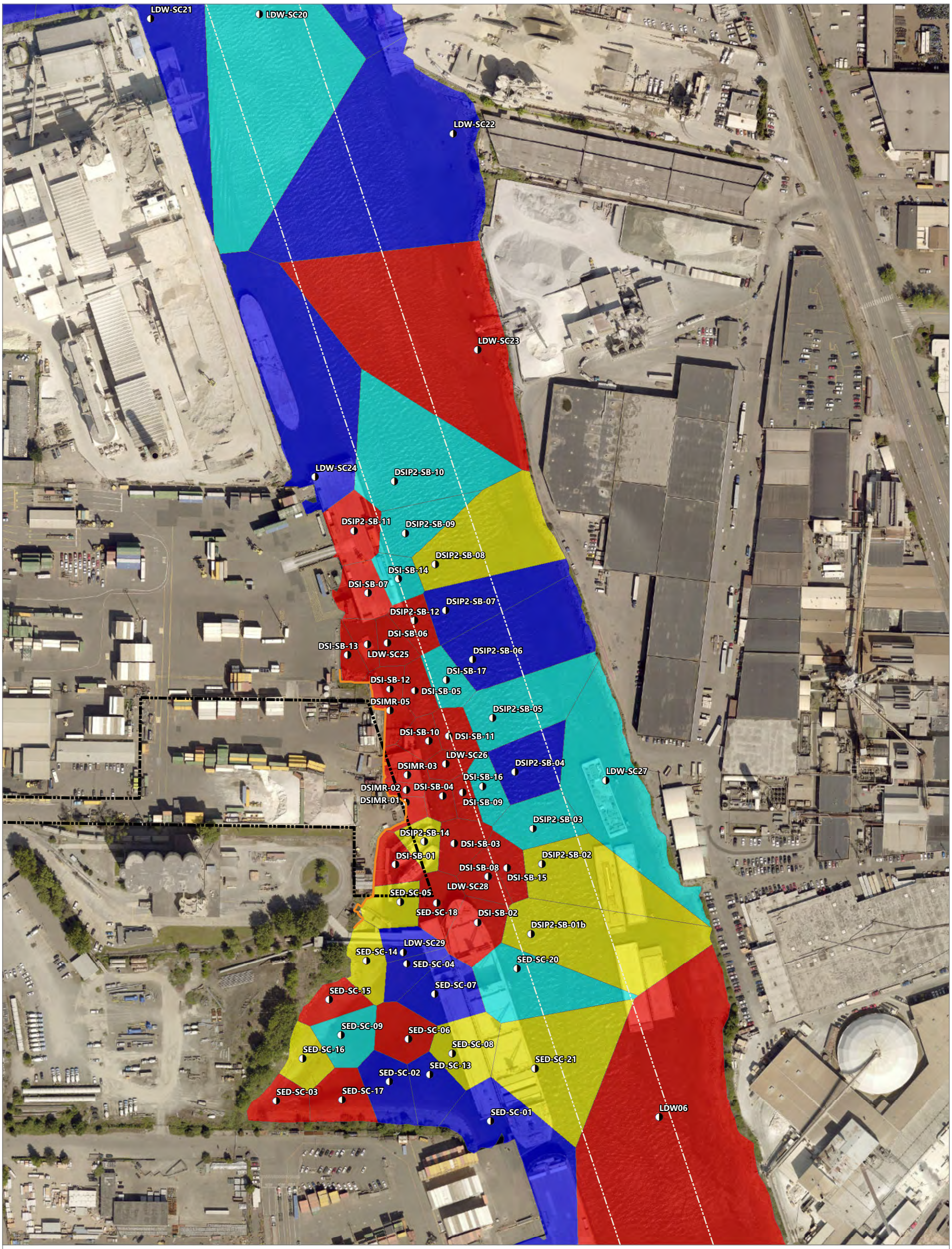

LEGEND:

- SubSurf_Other
- Federal Navigation Channel
- Top of Bank
- Duwamish Shipyard Inc. Property Boundary

Combined Other COC's (LDW COCs Excepting PCBs and TBT)

Maximum Exceedance Factor (of Lowest RAL for Each Chemical [i.e., Category 1 RALs])

- 0.5 - 1.0
- 1.1 - 2.0
- 2.1 - 3.0
- >3

0 200

Feet

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Figure 9
Subsurface Sediment Combined Other COCs
Duwamish Shipyard Inc.

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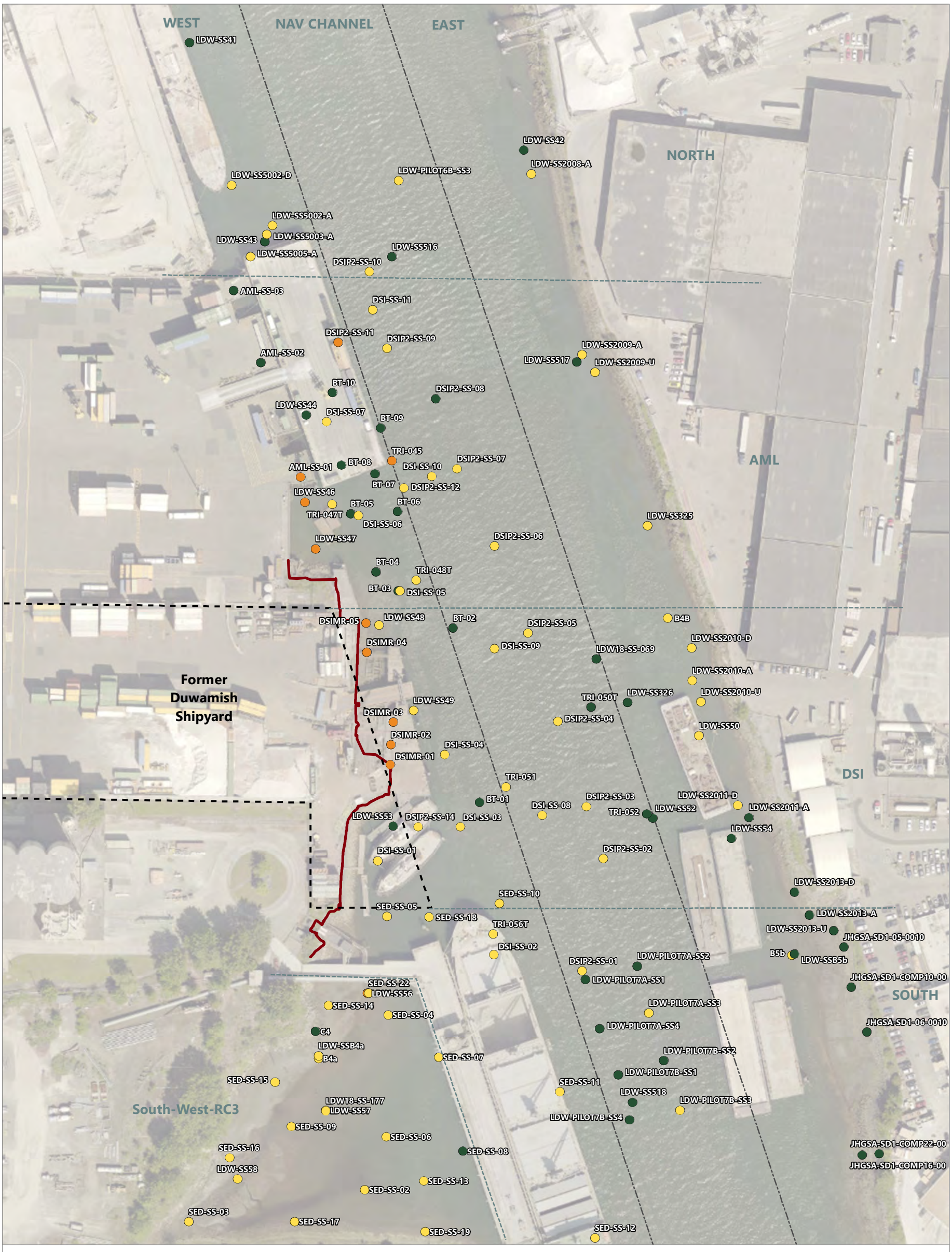

LEGEND:

- No Exceedances
- Exceeds for Other Chemicals
- Exceeds for TBT and Other Chemicals
- Top of Bank (Approximate)
- DSI Property Boundary
- Federal Navigation Channel

NOTES:

1. The dotted lines delineate gridded areas in the east-west direction (West, Navigation Channel, and East) and in the north-south direction (North, AML, DSI, South) for the purpose of summarizing sediment data only. These are not remediation areas or site areas.
2. Exceedances are compared to the ROD RALs or 7.5 mg/kg OC for TBT.
3. Surface sediment data are compared to RALs based on Recovery Category designation consistent with the ROD. Non-human-health risk drivers are compared to 2x benthic SCO outside of Recovery Category 1 areas. All areas west of the navigation channel are designated as Recovery Category 1 with the exception of the area labeled as South-West-RC3.
4. All TBT exceedances were co-located with an exceedance of one or more other COCs. There were not exceedances of TBT only.

0 150
Feet

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Figure 10
Summary of COC Exceedances in Surface Sediment
Duwamish Shipyard, Inc.

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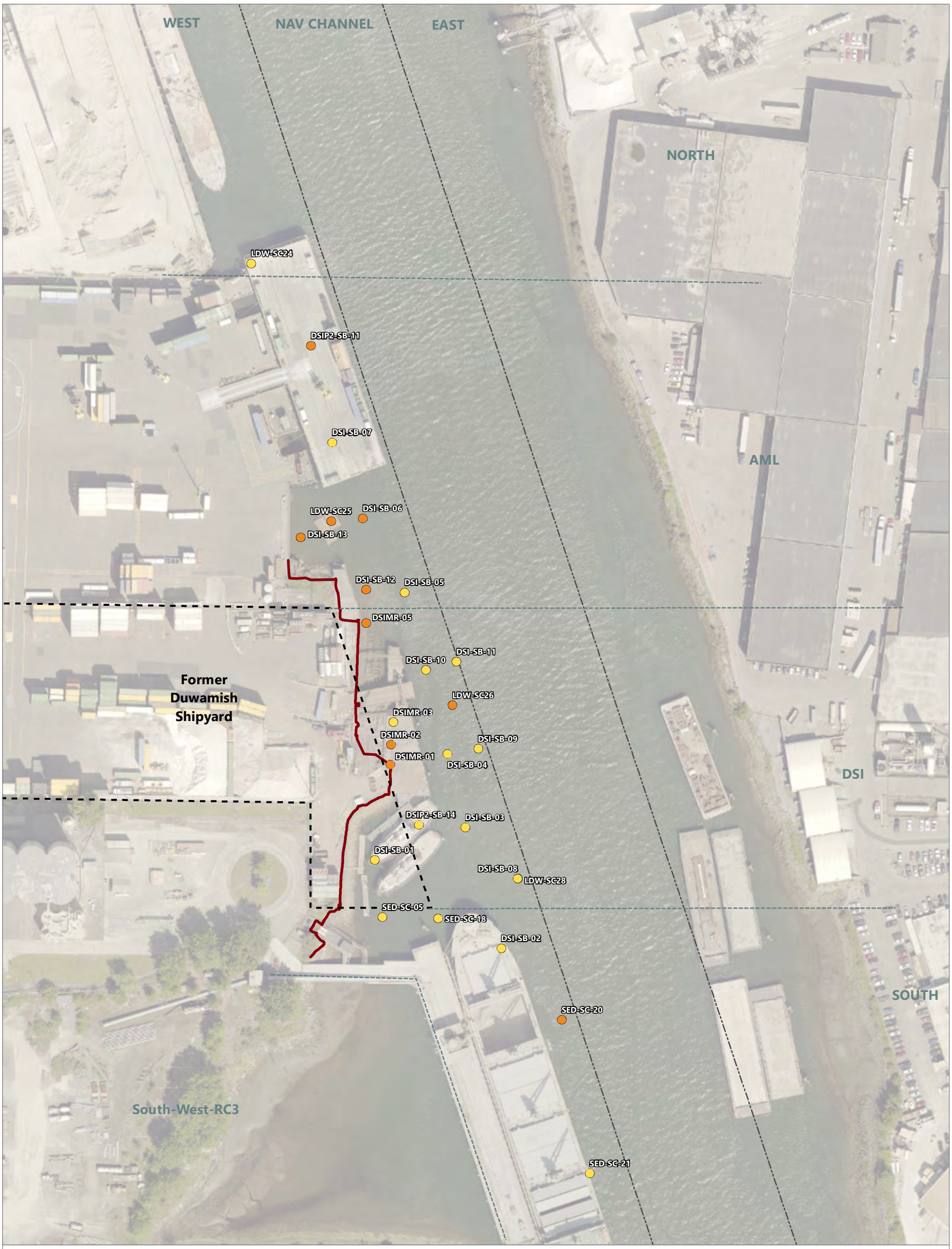

LEGEND:

- No Exceedances
- Exceeds for Other Chemicals
- Exceeds for TBT and Other Chemicals
- Top of Bank (Approximate)
- DSI Property Boundary
- Federal Navigation Channel

NOTES:

1. The dotted lines delineate gridded areas in the east-west direction (West, Navigation Channel, and East) and in the north-south direction (North, AML, DSI, South) for the purpose of summarizing sediment data only. These are not remediation areas or site areas.
2. Exceedances are compared to the ROD RALs or 7.5 mg/kg OC for TBT.
3. Shallow subsurface data shown in Recovery Category 1 areas only. All areas west of the navigation channel are designated as Recovery Category 1 with the exception of the area labeled as South-West-RC3.
4. All TBT exceedances were co-located with an exceedance of one or more other COCs. There were not exceedances of TBT only.

0 150
Feet

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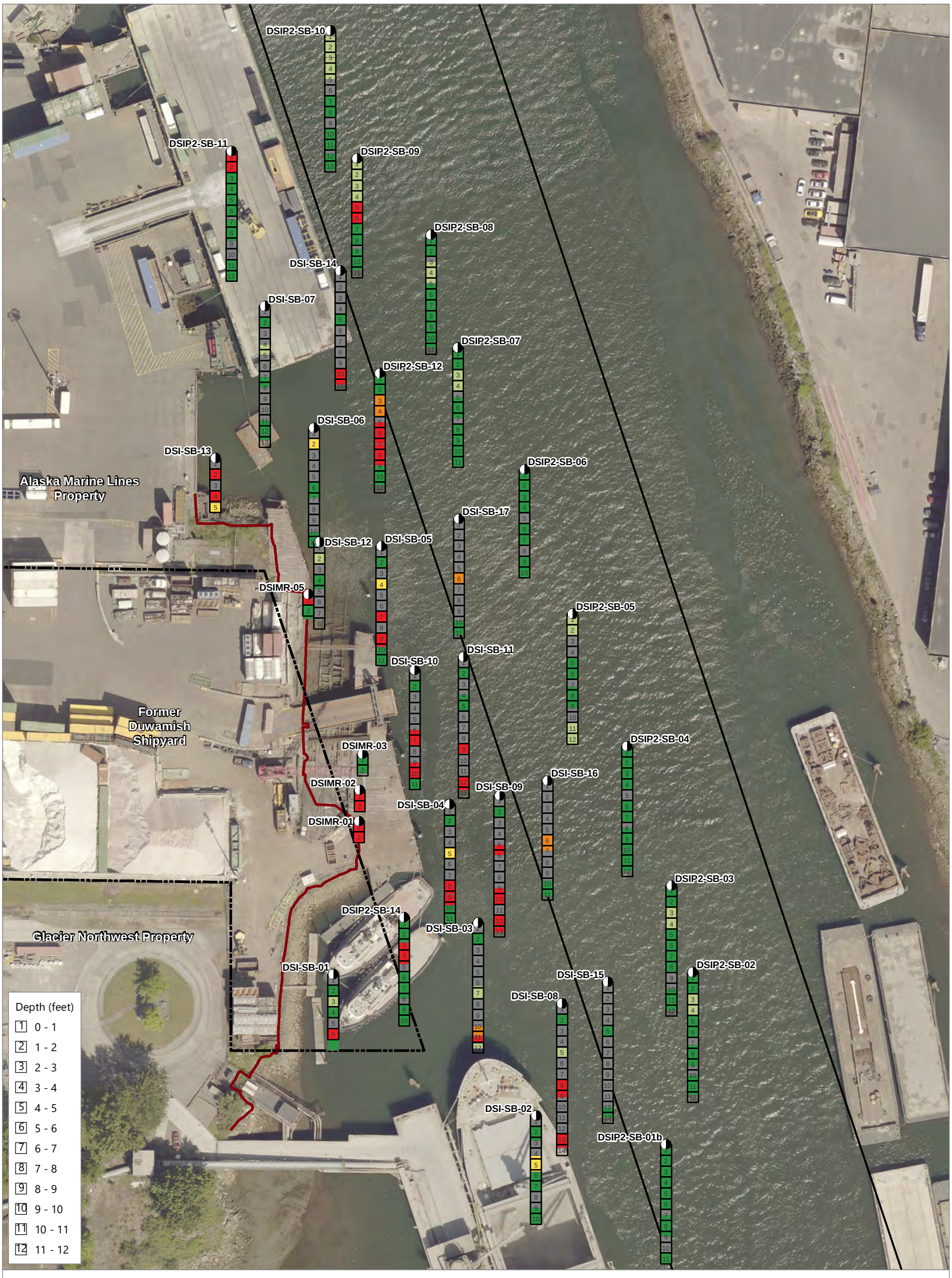
Figure 11
Summary of COC Exceedances in Shallow Subsurface Sediment
Duwamish Shipyard, Inc.

DRAFT



LEGEND:

- Sediment Sampling Location
- Tributyltin (mg/kg-OC)
- Exceedance Factor of TBT CUL (7.5 mg/kg-OC)
  - <1
  - 1 - 2
  - 2 - 3
  - 3 - 4
  - >4
  - No Data
- Top of Bank (Approximate)
- DSI Property Boundary
- Federal Navigation Channel

NOTES:
1. The full reporting limit for non-detects was used for data screening purposes.
2. Figure shows cores from the DSI RI.

0 100 Feet

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Figure 12
Tributyltin, OC-Normalized in Subsurface Sediment (DSI RI Cores)
Duwamish Shipyard, Inc.