

Memorandum

March 20, 2020

To: Jing Liu, Project Manager
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Northwest Regional Office
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Bellevue, Washington 98008-5452

From: David Templeton, Julia Fitts, Dan Hennessy, and Cindy Fields
Anchor QEA, LLC

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

**Re: Duwamish Shipyard, Inc. Site – Remedial Investigation Addendum
Tributyltin Study Data Summary Memorandum
Ecology Agreed Order No. DE 6735**

Duwamish Shipyard, Inc. (DSI) and Anchor QEA, LLC (Anchor QEA) conducted supplemental remedial investigation (RI) activities to address tributyltin (TBT) data gaps to support completion of the RI for the DSI site. The work was performed at the site in accordance with Agreed Order No. DE 6735. This TBT Study Data Summary Memorandum documents the results of the sediment sampling and analyses performed in accordance with the Washington Department of Ecology (Ecology)-approved *RI Addendum: Tributyltin Bioaccumulation Study Work Plan* (TBT Study Work Plan; Anchor QEA 2019). This memorandum also documents the rationale, as determined in consultation with Ecology and the U.S. Environmental Protection Agency (EPA) in October and November 2019, for the decisions to not collect additional sediment information and to instead utilize the East Waterway Superfund Site TBT cleanup level (CUL) in the development of the Feasibility Study (FS) for the DSI site.

Background

Due to the absence of a full understanding of the sources of TBT in the Lower Duwamish Waterway (LDW) and the lack of a CUL in the Record of Decision (ROD; EPA 2014), Ecology directed DSI to perform a Tributyltin Bioaccumulation Study (TBT Study) to address the nature, extent, and potential ecological effects of TBT in sediments adjacent to DSI (Figure 1). The goal of the study was to develop a site-specific bioaccumulation factor (BAF) for use in developing a site-specific TBT CUL for sediment at the DSI site. The site includes the DSI uplands and portions of adjacent LDW sediments.

The LDW RI collected surface sediment data from throughout the 5-mile site, and TBT was detected in 94% of samples and ranged from 0.28 to 3,000 micrograms per kilogram ($\mu\text{g}/\text{kg}$) with a mean concentration of 90 $\mu\text{g}/\text{kg}$ (EPA 2014). LDW RI sampling locations with concentrations of TBT greater than the 95th percentile (250 $\mu\text{g}/\text{kg}$) were located adjacent to DSI, in Slip 1, and between river

mile 0.0 and river mile 0.5 near Kellogg Island. Historically, TBT was used as an antifouling compound and was a common constituent of vessel hull paint. Wood preservatives and resins historically used at lumber yards may have also contained TBT (EPA 2003). There are multiple historical and ongoing sources of TBT in the LDW. These include leaching from ship hulls, painting, and ship repair activities.

Historical sandblasting of ship bottoms at DSI likely resulted in a coarse-grained source material (sandblast grit and paint chips) that was transported to sediments by various mechanisms (e.g., spills) and then mixed into the sediment through physical and biological processes. At DSI, the highest TBT concentrations are localized near the shoreline adjacent to the former dry dock and within the marine railway and in subsurface sediment in proximity to those former shipyard features. The ROD issued for the LDW identified TBT as a contaminant of potential concern for the benthic invertebrate community (receptor of concern). However, it was not retained as an LDW site-wide chemical of concern (COC) as part of the ecological risk assessment and, therefore, no sediment CUL for the LDW was developed.

Although a sediment TBT CUL was not established for the LDW, a TBT CUL was developed for the East Waterway Superfund Site, located just over a mile downstream of the DSI site. The East Waterway TBT CUL is between 120 and 150 micrograms per kilogram ($\mu\text{g}/\text{kg}$; dry weight), based on the sediment organic carbon (OC) content used (Windward and Anchor QEA 2014). The OC normalized CUL concentration is 7.5 milligrams per kilogram (mg/kg)-OC. During the DSI RI, TBT was detected in bulk sediment at concentrations that could potentially pose a risk to ecological receptors (i.e., above the East Waterway TBT CUL) and thus Ecology required that it be evaluated as a site-specific COC. In the vicinity of DSI, bulk TBT concentrations detected in surface sediments (i.e., from 0 to 10 centimeters) have ranged from undetected ($3.6 \mu\text{g}/\text{kg}$ detection limit) to $4,200 \mu\text{g}/\text{kg}$, with the highest concentrations located in the vicinity of the former DSI marine railway and within approximately 75 feet of the shoreline. Similar to studies conducted as part of the East Waterway Supplemental RI (East Waterway SRI), collection of site-specific sediment samples and a laboratory bioaccumulation study were proposed to determine the bioaccumulation potential of TBT in surface sediments at the DSI site, and ultimately to develop a site-specific TBT CUL.

TBT Study Approach

The TBT Study was designed to assess the bioavailability of TBT in site sediments. The TBT Study design was generally based on the approach used for the East Waterway SRI (Windward and Anchor QEA 2014) and included the following five elements:

1. Collect surface sediment at 10 locations outside of DSI's nearshore sediment area that are anticipated to represent a gradient of TBT concentrations ranging from less than $100 \mu\text{g}/\text{kg}$ to $400 \mu\text{g}/\text{kg}$.

2. Conduct expedited bulk chemistry testing for TBT and total organic carbon (TOC) and, in consultation with Ecology and EPA, determine which of the samples would be selected for bioaccumulation testing.
3. Perform 45-day bioaccumulation testing with an adult bivalve (*Macoma nasuta*) and an adult polychaete (*Nephtys caecoides*) on five samples selected to represent a range of TBT and TOC levels.
4. Evaluate the sediment and tissue data and calculate a BAF.
5. Calculate a CUL using the tissue-based toxicity reference value from Gibbs et al. (1988) divided by the BAF.

TBT Study Implementation

Sediment sampling and initial bulk chemistry testing, the first two elements of the TBT Study, were performed in accordance with the TBT Study Work Plan, as further described below. Sample collection for the TBT Study focused on surface sediment (0 to 10 centimeters) in areas where existing data showed a range of TBT concentrations from less than 100 µg/kg to 400 µg/kg and TOC concentrations from 1.4% to 3% in surface sediment. Following review of the analytical testing results and consultation with Ecology and EPA, the decision was made to cease further work (i.e., elements 3 through 5 of the TBT Study). Details regarding sample collection, analytical testing, sample results, and the consultations with Ecology and EPA are provided below, as well as the subsequent modifications to the TBT Study that were agreed upon by DSI, Ecology, and EPA.

Surface Sediment Sampling and Chemical Analysis

Surface sediment samples were collected at ten (10) sample locations adjacent to the DSI property from September 20, 2019, to September 21, 2019 (Figure 2). Surface sediment samples were collected using a pneumatic power grab sampler deployed from a vessel. Sample locations were identified and documented using an onboard differential geographic positioning system. Due to large volume requirements for bioaccumulation testing (8 gallons), multiple (typically three to four) casts of the grab sampler were performed at each station. All casts of the grab sampler were repeated within a 10-foot radius of the target sample location. Location BT-02 was moved approximately 20 feet off target due to a barge that blocked access to the target location. Sediment station coordinates, mudline elevations, recovery depths, and lithology observations are presented in Table 1.

Following sample retrieval, samples were evaluated for acceptability based on sample quality criteria detailed in Section 3.2 of the Sampling and Analysis Plan. At least three discrete grabs were included in each composite; four discrete grabs were included at locations BT-03 and BT-04 to provide extra sample volume for quality assurance/quality control (QA/QC) samples. Sediment from each accepted discrete sample grab was then homogenized using a 15-gallon stainless-steel kettle with a stainless-steel mixing paddle attached to an electric drill. The sampler and mixing containers and apparatus

were decontaminated between stations and rinsed with site water between casts. Sample containers were then filled with the composited material and prepared for transport to the chemistry laboratory. Bioaccumulation test samples were placed in plastic bags with zero headspace. Surface sediment collection logs are provided in Attachment A-1 and sampling photographs are provided in Attachment A-2.

Twelve samples, including one field duplicate and one equipment rinse blank, plus archived sediment for bioaccumulation testing from each station, were submitted to Analytical Resources, Inc. (ARI) in Tukwila, Washington. All surface sediment samples were analyzed for grain size, total solids, TOC, and bulk TBT. Bioaccumulation test samples were archived with zero headspace at 4°C, pending review of the analytical chemistry results and consultation with Ecology and EPA.

Data Quality Assessment

Testing was performed by ARI, an Ecology-accredited laboratory that is also accredited under the National Environmental Laboratory Accreditation Program. Laboratory data packages are provided in Attachment B-1. Data quality objectives and QA/QC procedures are provided in the Quality Assurance Project Plan appendix to the TBT Study Work Plan (Anchor QEA 2019). Data packages were validated by Laboratory Data Consultants in Carlsbad, California. Data validation reports are provided in Attachment B-2.

All data qualifiers applied to the data during final validation have been incorporated into the database for this project. Data qualifiers assigned during data validation include the following:

- "J" indicates the associated numerical value is an estimated concentration.
- "U" indicates a reporting limit below which the analyte was not detected.
- "UJ" indicates an approximate reporting limit below which the analyte was not detected.

The validation process did not result in any rejected values. All data were considered useable as reported or as qualified. Certain data were qualified as estimated values for a particular analysis based on a method or technical criterion, as stated in the national functional guidelines (EPA 2017a, 2017b).

Sample Results

Surface sediment samples were predominantly sandy silt, with an average of 44% silt, 36% sand, and 18% clay. Fines (combined silt and clay content) ranged from 35% to 74%, with a TOC content of 0.8% to 4.5% and total solids content of 49% to 65%. Gravel content ranged from 0.1% to 8.6%. Debris observed during sampling included trace angular rocks (0.5 to 4 inches long) and wood pieces. At two stations (BT-04 and BT-06), trace (less than 5%) black angular sand was observed on the surface of the grab. Biota observed on the surface or within the top 10 centimeters of the sediment samples included seaweed, small shrimp and crabs, shells and living clams and mussels, polychaetes, shell hash, leaves, and small sticks.

TBT concentrations ranged from 33 to 119 µg/kg. The highest TBT concentration was detected at location BT-04. TOC was out of the range specified in the TBT Study Work Plan in sample BT-01. Sediment sample results are presented in Table 2 and Figure 3.

In accordance with the TBT Study Work Plan, the preliminary data were reviewed in consultation with Ecology and EPA. The TBT concentrations in surface sediment were notably lower than the historical data. The maximum TBT concentration (119 µg/kg at BT-04) was below the anticipated target range of 200 µg/kg to 400 µg/kg. That maximum TBT concentration is also lower than the TBT CUL used at the East Waterway site (120 µg/kg to 150 µg/kg).

As discussed in further detail below, the anticipated target range is important for the study because the site-specific CUL for TBT, which was intended to be developed based on the subsequent bioaccumulation testing, cannot be higher than the maximum test sample concentration. In addition, because the sole need for this sediment data is for use in developing a site-specific BAF, sediment concentrations need to be high enough to result in measurable tissue accumulation, and the bioaccumulation testing response needs to be demonstrated across a range of concentrations that encompass the ultimate CUL. With maximum test sample concentrations less than the anticipated target range, Anchor QEA and the agencies agreed to consult on whether to proceed with the remaining elements of the TBT Study.

Ecology and EPA Consultation

It appears that surface sediment TBT concentrations adjacent to DSI are decreasing over time (e.g., natural recovery of surface sediment through upstream source control and sediment deposition). The last round of RI activities and the LDW sampling events were conducted approximately 5 to 15 years ago. During discussions in October 2019, Ecology and EPA identified the following three options for DSI:

1. Conduct the TBT bioaccumulation testing as planned, using the current (i.e., "Round 1") samples to develop a site-specific TBT CUL;
2. Collect additional, "Round 2" grab samples in other areas of the site to try to obtain samples with higher (and more ideal) concentrations of TBT (i.e., within the recommended range of 200 µg/kg to 400 µg/kg) that could be used for the bioaccumulation testing and potential development of a site-specific TBT CUL; or
3. Cease further work on the TBT Study and use the existing East Waterway CUL for TBT, which ranges from about 120 to 150 µg/kg, depending on the OC content of the sediment, or 7.5 mg/kg-OC, in developing the FS for the DSI site.

These options were subsequently evaluated in terms of uncertainties, benefits, and potential costs to DSI. Considerations included: (a) the uncertainties of finding sediment samples within the desired range of TBT; (b) the potential that DSI would end up with a BAF that does not represent true

bioaccumulation potential at the site and therefore an uncertain CUL; and (c) the significant cost to conduct bioaccumulation testing and possibility that the resulting CUL would not differ significantly from the existing East Waterway TBT CUL.

Based on that analysis, the collective decision was made to cease further work on the bioaccumulation study and to use the TBT CUL from the East Waterway site to complete the RI and FS for the DSI site. This decision was confirmed in a follow-up discussion with Ecology on November 12, 2019.

Conclusions

The TBT Study was implemented in accordance with the Ecology-approved TBT Study Work Plan (Anchor QEA 2019) and sediment sampling and analysis were completed in September 2019. The preliminary data were reviewed with Ecology and EPA. Because the TBT sediment concentrations were notably lower than historical data and the maximum concentration was below the established TBT CUL for the nearby East Waterway site, the agencies requested DSI to evaluate other study options. These options included proceeding with the TBT bioaccumulation testing using the existing sampling data (with low concentrations of TBT), resampling to obtain higher TBT concentrations, or ceasing further work on the TBT Study and using the East Waterway TBT CUL at the DSI site.

Based on the risks of the uncertain outcomes from the first two options, the high costs of proceeding with bioaccumulation testing, and the clear benefits of using an existing TBT CUL from another site, the decision was made to cease further work on the TBT Study and apply the East Waterway TBT CUL at the DSI site.

The TBT Study sediment sample data will be provided electronically via Ecology's Environmental Information Management (EIM) system under the Study ID: DSI_TBT_2019.

References

- Anchor QEA (Anchor QEA LLC), 2019. *Remedial Investigation Addendum, Tributyltin Bioaccumulation Study Work Plan*. Prepared for Washington Department of Ecology on behalf of Duwamish Shipyard, Inc. Prepared by Anchor QEA, LLC, Seattle Washington. July 2019.
- EPA, 2003. Ambient Aquatic Life Water Quality Criteria for Tributyltin (TBT) – Final. EPA 822-R-03-031.
- EPA, 2014. Record of Decision, Lower Duwamish Waterway Superfund Site. November 2014.
- EPA, 2017a. USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Methods Data Review. U.S. Environmental Protection Agency, Office of Superfund Remediation and Technology Innovation. EPA-540-R-2017-001. January 2017.

EPA, 2017b. USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review. U.S. Environmental Protection Agency, Office of Superfund Remediation and Technology Innovation. EPA 540 R 2017-002. January 2017.

Gibbs, P.E., P.L. Pascoe, and G.R. Burt, 1988. "Sex Change in the Female Dog-Whelk, *Nucella Lapillus*, Induced by Tributyltin from Antifouling Paints." *Journal of the Marine Biological Association of the United Kingdom* 68:715–731.

Windward and Anchor QEA, 2014. *Final Supplemental Remedial Investigation Report, East Waterway Operable Unit*. 2014.

Attachments

Tables

Table 1	Surface Sediment Sample Collection Summary
Table 2	Sediment Sample Results

Figures

Figure 1	Vicinity Map
Figure 2	Sediment Sample Locations
Figure 3	Tributyltin in Surface Sediment ($\mu\text{g}/\text{kg}$), 0 to 10 cm

Attachment A

A-1	Field Logs
A-2	Photographs

Attachment B

B-1	Laboratory Reports
B-2	Data Validation Reports

Tables

Table 1
Surface Sediment Sample Collection Summary

Station ID	Date Collected	Actual Coordinates ^{1,2} (NAD83)		Water Depth ³ (feet)	Mudline Elevation	Sample ID	Grab Sample Recovery Depth (centimeters) ⁴	Lithology	Surface Sediment Testing
		Easting (X)	Northing (Y)						
DSISUP-BT-01	9/20/2019	1268197	204337.1	34.3	-25.2	DSISUP-BT-01	11.5	SILT (ML): soft, wet, olive gray, sand (30%), silt (70%), trace biota, trace shell hash	Grain size, TOC, TS, TBT
DSISUP-BT-02	9/21/2019	1268158.3	204593.6	39.1	-31.7	DSISUP-BT-02	12.3	SILT (ML): soft, wet, gray, sand (30%), silt (70%), trace biota (worms), trace shell hash, trace sheen	
DSISUP-BT-03	9/20/2019	1268077.7	204648.2	21.3	-12.1	DSISUP-BT-03	10.0	SILT (ML): soft, wet, olive gray, sand (30%), silt (70%), trace gravel (<1%), trace biota (worms), trace shell hash	
DSISUP-BT-04	9/20/2019	1268045	204676.3	23.4	-15.3	DSISUP-BT-04	10.8	SILT (ML): soft, wet, olive gray, sand (30%), silt (70%), trace gravel (<1%), trace biota (worms), trace shell hash	
DSISUP-BT-05	9/20/2019	1268007.6	204761.9	25.9	-18.5	DSISUP-BT-05	10.6	SILT (ML): soft, wet, olive gray, sand (30%), silt (70%), trace biota (worms), trace shell hash	
DSISUP-BT-06	9/20/2019	1268076.7	204765.1	32.7	-26.3	DSISUP-BT-06	13.0	SILT (ML): soft, wet, olive gray, sand (30%), silt (70%), trace gravel (<1%), trace biota (worms), trace shell hash, trace organic debris (sticks, leaves)	
DSISUP-BT-07	9/20/2019	1268043.5	204820.7	32.1	-26.1	DSISUP-BT-07	11.8	SILT (ML): soft, wet, olive gray, sand (30%), silt (70%), trace biota (worms), trace shell hash	
DSISUP-BT-08	9/21/2019	1267993.7	204833.4	28.8	-20.4	DSISUP-BT-08	10.8	SILT (ML): soft, wet, gray, sand (30%), silt (70%), trace biota (worms), trace shell hash	
DSISUP-BT-09	9/21/2019	1268051.4	204888.4	37.6	-28.5	DSISUP-BT-09	11.3	SILT (ML): soft, wet, olive gray, sand (30%), silt (70%), trace biota (worms), trace shell hash	
DSISUP-BT-10	9/21/2019	1267980.7	204940.1	36.2	-27.3	DSISUP-BT-10	11.0	SILT (ML): soft, wet, gray, sand (40%), silt (60%), trace shell hash, trace organic debris, trace biota (worms)	

Notes:

1. Actual differentially corrected coordinates for multiple locations per accepted surface sediment sample were averaged for use in this table.
2. Horizontal datum is NAD83 FIPS 4601, State Plane feet.
3. Water depth presented is at the time of sampling and measured by depth sounder located directly above the grab sampler.
4. Samples were collected from 0–10 centimeters.

ML: Lean Silt (<https://www.ncagr.gov/SWC/tech/documents/Soil-USCSTexturalTriangle.pdf>)

NAD83: North American Datum of 1983

TBT: tributyltin

TOC: total organic content

TS: total solids

Table 2
Sediment Sample Results

Location ID	BT-01	BT-02	BT-03	BT-04	BT-04	BT-05
Sample ID	DSISUP-BT-01	DSISUP-BT-02	DSISUP-BT-03	DSISUP-BT-04	DSISUP-BT-54	DSISUP-BT-05
Sample Date	9/20/2019	9/21/2019	9/20/2019	9/20/2019	9/20/2019	9/20/2019
Depth	0–10 cm	0–10 cm	0–10 cm	0–10 cm	0–10 cm	0–10 cm
Sample Type	Normal	Normal	Normal	Normal	Field Duplicate	Normal
Matrix	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
Easting (X)	1268197.00	1268158.30	1268077.70	1268045.00	1268045.00	1268007.60
Northing (Y)	204337.10	204593.60	204648.20	204676.30	204676.30	204761.90
Conventional Parameters (percent)						
Total organic carbon	4.53 J	2.36 J	2.06 J	1.7 J	1.8 J	2.66 J
Total solids	49.17	50.17	53.58	57.14	56.18	51.98
Grain Size (percent)						
Gravel	0.16	0.19	1.68	3.25	2.57	0.1
Sand, very coarse	0.5	0.41	1.85	4.3	4.32	0.23
Sand, coarse	3.16	2.27	3.25	8.18	7.33	2.06
Sand, medium	4.54	4.84	6.85	12.6	10.7	6.19
Sand, fine	6.67	9.94	10.2	12.3	11.7	9.09
Sand, very fine	10.9	10.9	10.0	7.89	7.84	8.13
Total sand	25.74	28.31	32.156	45.21	41.85	25.7
Silt, coarse	11.28	13.2	13.01	9.49	8.41	12.0
Silt, medium	17.81	15.94	15.09	9.95	11.23	19.3
Silt, fine	13.87	13.01	11.75	9.16	10.93	13.5
Silt, very fine	10.49	8.72	6.33	6.64	7.16	12.5
Total silt	53.45	50.87	46.18	35.24	37.73	57.32
Clay, coarse	5.25	6.47	7.18	5.39	5.8	2.1
Clay, medium	1.14	4.86	0.98	0.71	1.08	4.49
Clay, fine	14.24	9.35	11.76	10.22	10.97	10.3
Total clay	20.63	20.68	19.92	16.32	17.85	16.89
Total fines	74.1	71.6	66.1	51.6	55.6	74.2
Organometallic Compounds (µg/kg)						
Butyltin (ion)	6.77	8.21	12.1	10.1	12.6	9.46
Dibutyltin (ion)	12.6	18.6	36.3	41.3	26.2	21
Tetrabutyltin	4.9 U	4.93 U	4.93 U	4.85 U	4.94 U	4.95 U
Tributyltin (ion)	33.1	41.3	57.7	119	126	43.9

Notes:

Bold: Detected result

µg/kg: micrograms per kilogram

cm: centimeter

J: Estimated value

U: Compound analyzed, but not detected

above detection limit

Table 2
Sediment Sample Results

Location ID	BT-06	BT-07	BT-08	BT-09	BT-10
Sample ID	DSISUP-BT-06	DSISUP-BT-07	DSISUP-BT-08	DSISUP-BT-09	DSISUP-BT-10
Sample Date	9/20/2019	9/20/2019	9/21/2019	9/21/2019	9/21/2019
Depth	0–10 cm	0–10 cm	0–10 cm	0–10 cm	0–10 cm
Sample Type	Normal	Normal	Normal	Normal	Normal
Matrix	Sediment	Sediment	Sediment	Sediment	Sediment
Easting (X)	1268076.70	1268043.50	1267993.70	1268051.40	1267980.70
Northing (Y)	204765.10	204820.70	204833.40	204888.40	204940.10
Conventional Parameters (percent)					
Total organic carbon	3.59 J	2.39 J	2.24 J	2.33 J	0.81 J
Total solids	50.5	52.8	52.93	56.18	64.77
Grain Size (percent)					
Gravel	0.34	0.28	0.46	0.13	8.64
Sand, very coarse	0.41	0.44	0.52	0.54	3.07
Sand, coarse	3.25	2.83	3.8	3.35	8.55
Sand, medium	6.92	9.89	11	14.43	24.5
Sand, fine	9.98	13.7	15.5	15.5	15.2
Sand, very fine	8.89	8.84	8.65	7.47	5.03
Total sand	29.5	35.7	39.5	41.3	56.4
Silt, coarse	12.0	14.7	8.8	9.11	5.94
Silt, medium	15.2	11.5	13.2	12.9	6.77
Silt, fine	11.4	11.5	10.9	10.6	6.69
Silt, very fine	11.1	8.6	7.92	7.97	4.69
Total silt	49.69	46.32	40.78	40.61	24.09
Clay, coarse	4.11	6.71	6.13	5.39	3.49
Clay, medium	4.19	1.02	1.63	0.99	0.74
Clay, fine	12.2	9.97	11.5	11.9	6.95
Total clay	20.5	17.7	19.3	18.3	11.18
Total fines	70.2	64.0	60.1	58.9	35.3
Organometallic Compounds (µg/kg)					
Butyltin (ion)	12.7	8.71	9.81 J	14.5	6.42
Dibutyltin (ion)	21.1	12.5	14 J	15.2	10.9
Tetrabutyltin	4.89 U	4.86 U	4.95 U	4.85 U	4.86 U
Tributyltin (ion)	93.7	37.2	42 J	79	34.6

Notes:

Bold: Detected result

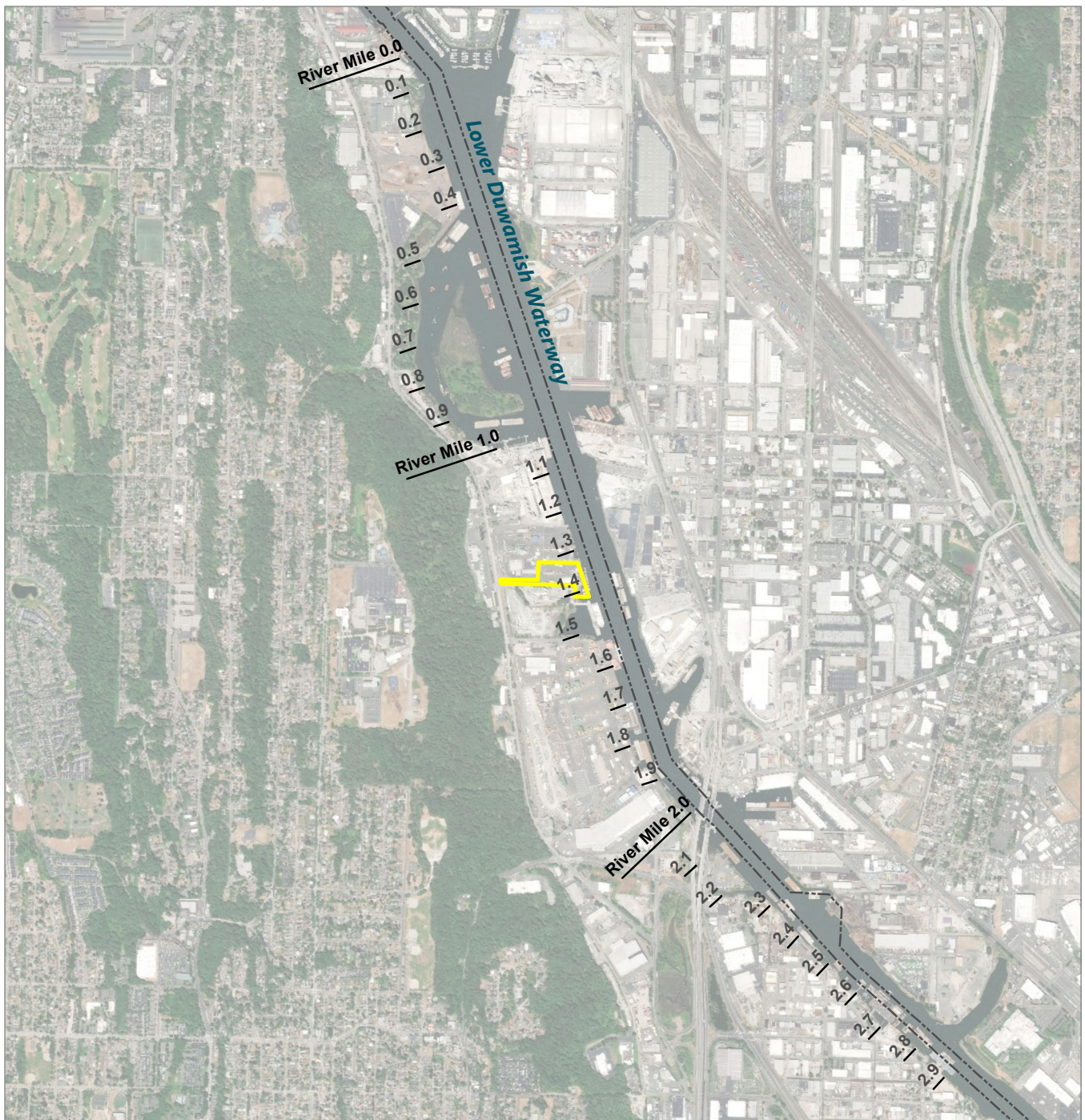
µg/kg: micrograms per kilogram

cm: centimeter

J: Estimated value

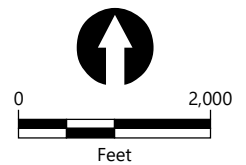
U: Compound analyzed, but not detected
above detection limit

Figures



LEGEND:

- Duwamish Shipyard, Inc. Property Boundary
- Federal Navigation Channel

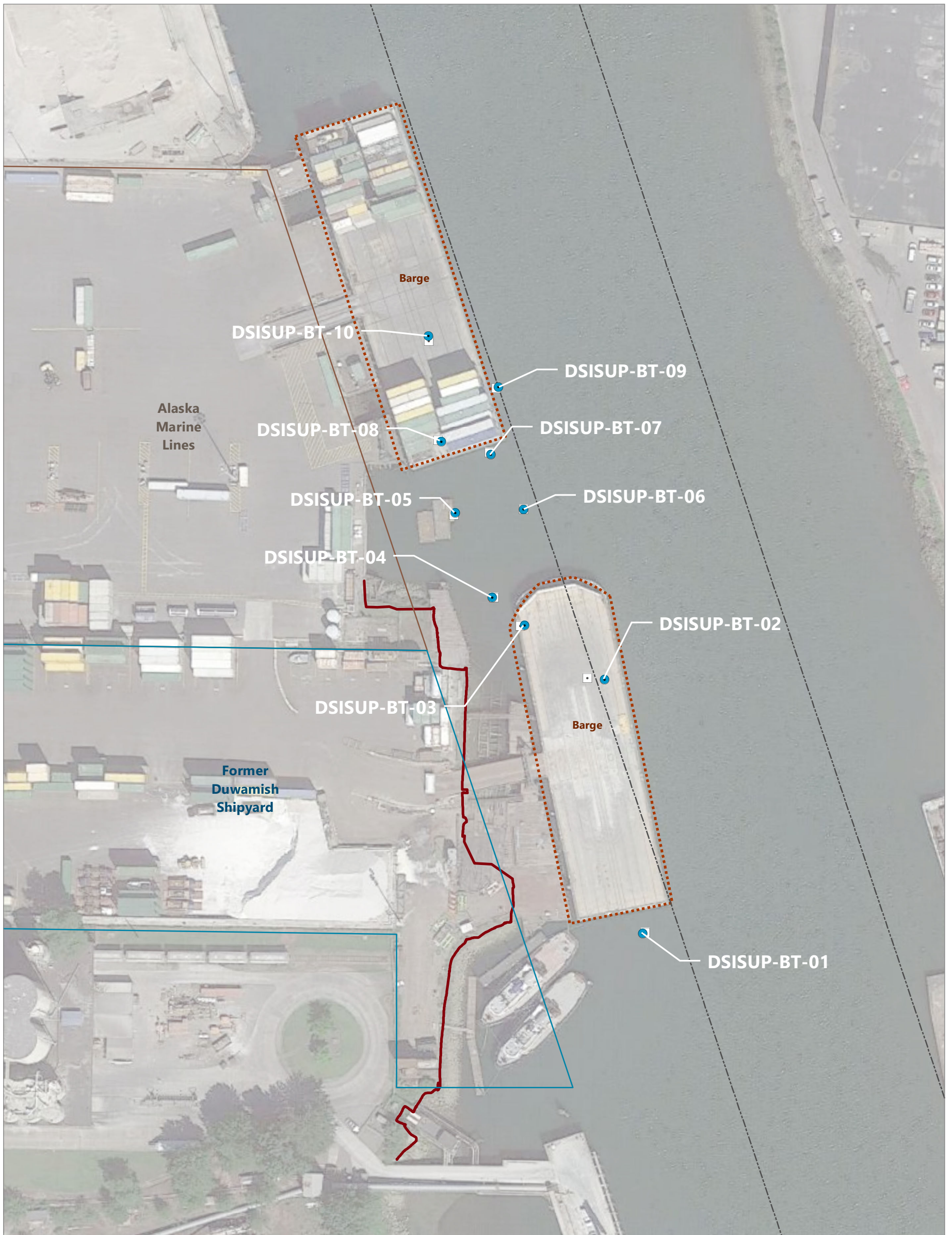


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**Figure 1
Vicinity Map**

Remedial Investigation Addendum Tributyltin Study Memorandum
 Duwamish Shipyard, Inc. Tributyltin Bioaccumulation Study

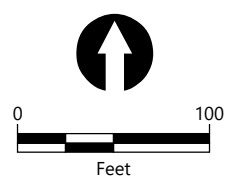


LEGEND:

- Actual Bioaccumulation Test Sample Location (Mean Centers)
- Proposed Bioaccumulation Test Sample Location
- Top of Bank (Approximate)
- DSI Property Boundary
- AML Property Boundary
- Barge
- Federal Navigation Channel

NOTES:

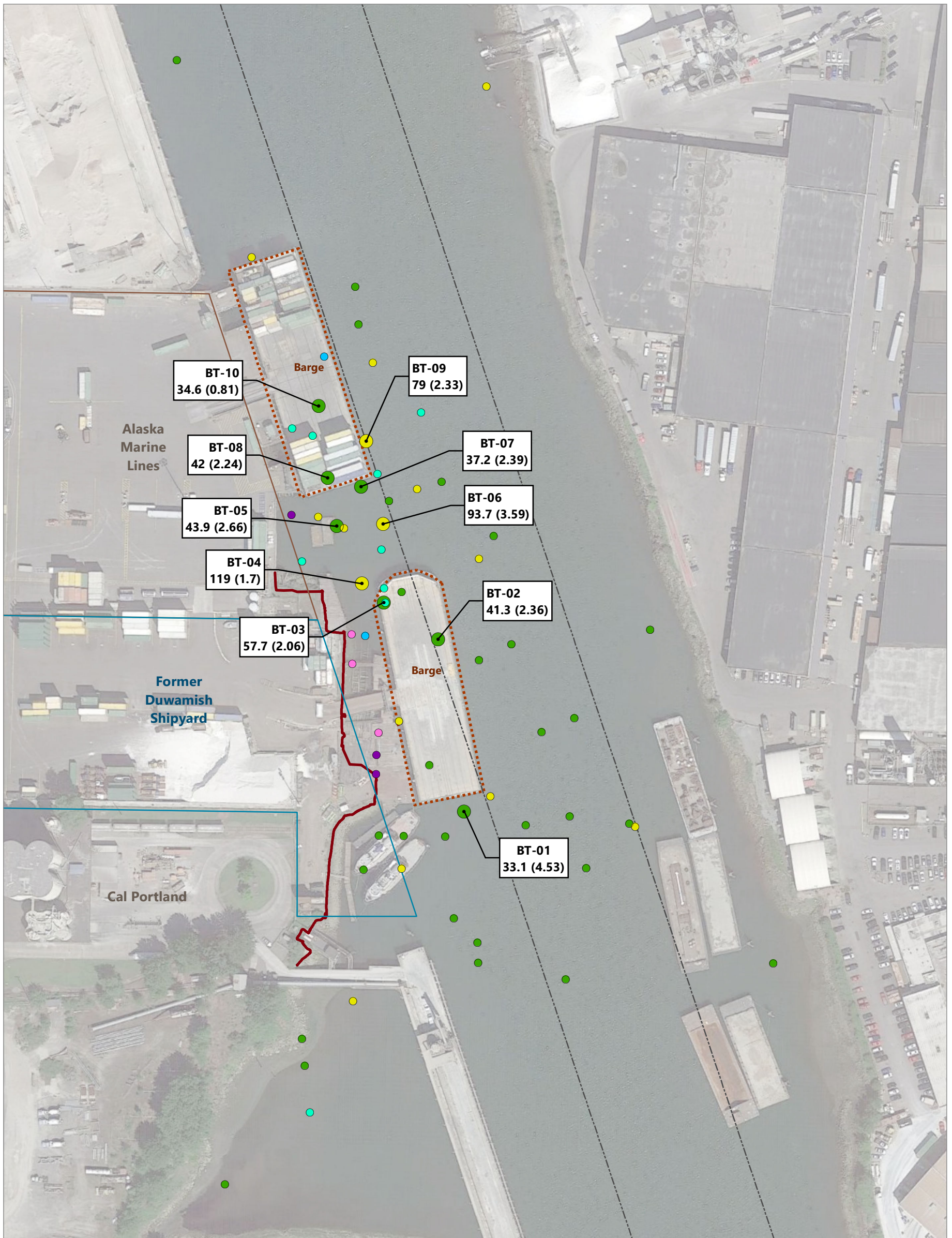
AML: Alaska Marine Lines
 DSI: Duwamish Shipyard, Inc.



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Figure 2
Sediment Sample Locations
 Remedial Investigation Addendum Tributyltin Study Memorandum
 Duwamish Shipyard, Inc. Tributyltin Bioaccumulation Study



LEGEND:

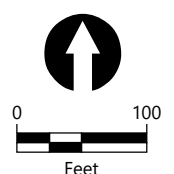
- Actual Bioaccumulation Test Sample Location (Mean Centers)
Sample ID
TBT Concentration $\mu\text{g}/\text{kg}$ (TOC %)
- Historical Sample Location
- Top of Bank (Approximate)
- DSI Property Boundary
- AML Property Boundary
- ▭ Barge
- - - Federal Navigation Channel

Tributyltin in Surface Sediment ($\mu\text{g}/\text{kg}$), 0 to 10 cm

- <73
- 73 to 150
- 150 to 365
- 365 to 730
- 730 to 1,825
- >1,825

NOTES:

AML: Alaska Marine Lines
 DSI: Duwamish Shipyard, Inc.
 $\mu\text{g}/\text{kg}$: Micrograms per Kilogram
 TBT: Tributyltin
 TOC: Total Organic Carbon



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 Filepath: \\orcas\GIS\Jobs\DuwamishShipyard\0111\DSI_Ecology_RI\Maps\FS\TBT_Bioaccum_Memo\AQ_DSI_TBT_Bioaccum_SedimentResults.mxd



Figure 3
Tributyltin in Surface Sediment ($\mu\text{g}/\text{kg}$), 0 to 10 cm
 Remedial Investigation Addendum Tributyltin Study Memorandum
 Duwamish Shipyard, Inc. Tributyltin Bioaccumulation Study

Attachment A-1

Field Logs

Attachment A-2

Photographs

Attachment B-1
Laboratory Reports

Attachment B-2

Data Validation Reports
