Prepared by:
The Dredged Material Management Office
Seattle District, U.S. Army Corps of Engineers

MEMORANDUM FOR RECORD January 4, 2019

SUBJECT: PRELIMINARY SEDIMENT CHARACTERIZATION ASSOCIATED WITH POTENTIAL DREDGING OF UNION SLOUGH (EVERETT, WASHINGTON) BY SNOHOMISH COUNTY

1. Introduction. This memorandum reflects the consensus opinion of the Dredged Material Management Program (DMMP) agencies (U.S. Army Corps of Engineers, Washington Departments of Ecology and Natural Resources, and the Environmental Protection Agency) regarding preliminary sediment characterization results associated with potential future dredging of Union Slough and additional actions required of Snohomish County prior to dredging.

2. Background. The Snohomish River estuary includes the mainstem river and three primary interconnected distributary tidal channels: Union Slough, Steamboat Slough and Ebey Slough (Figure 1). Flows within Steamboat and Union sloughs are connected through the short navigational channel known informally as the Buse Cut, created between 1955 and 1965. Buse Timber transports logs from Puget Sound upstream in Steamboat Slough, through the Buse Cut, and downstream in Union Slough to the Buse Log Ramp, which is 300 feet west of I-5 (Figure 2). The proposed dredging would occur in the channel of Union Slough, between the Buse Cut and the Buse Log Ramp (Anchor, 2017).

   Prior to the arrival of Euro-Americans around the mid-19th century, the estuary downstream of the head of Ebey Slough contained approximately 10,000 acres of tidal marsh where freshwater from the Snohomish River mixed with saltwater from Puget Sound. After Euro-American settlement, the estuary area was progressively logged and cleared. A system of dikes, tide gates, and linear ditches were constructed to drain the marshlands and prevent tidal inundation and flooding. A diking district, which later became Diking Improvement District 5, was formed in 1931 to construct a diking system on Smith Island. A dike was constructed adjacent to Union Slough, likely in the early 1930s (Anchor, 2017).

   In 2018 Snohomish County breached the Smith Island dike in several places to restore the island to tidal marshland. The dike breaches allowed water from Union Slough to flow over Smith Island. With this flow came the potential for erosion of material from the marsh plain and newly excavated dike material into Union Slough. Breaches were also made in a dike on the west side of Mid-Spencer Island, increasing the tidal influence there and subjecting the newly excavated dike material to erosion.

   Prior to construction of the Smith Island restoration project, Buse Timber expressed concern that erosion from the island could result in accumulation of sediment in Union Slough to such an extent as to make the slough practicably impassable by raft tugs. Snohomish County agreed to dredge the slough should that happen. The county worked proactively with the DMMP agencies prior to construction to characterize upland material that could erode and necessitate dredging of the slough.

   Conservative estimates of potential post-construction erosion were made prior to breaching the dikes through the use of bed shear-stress modeling, (Anchor, 2017). Three areas with the highest erosion potential were identified. These included the East Tidal Channel, Mid-Spencer Island and East Smith Island. The South Tidal Channel had a lower shear-stress value, but was identified conservatively as a

fourth area with erosion potential due to plans to construct a new channel in that area. Construction plans called for breached dike material to be graded behind the breaches in the East Tidal Channel, Mid-Spencer Island and East Smith Island. This newly placed material had the highest likelihood of being mobilized by tidal floodwaters. The erosion potential of the marsh plain in the area of the East Tidal Channel was also high. A maximum total of 100,000 cy of sediment was projected to potentially wash downstream after the dikes were breached.

3. Project Summary. Table 1 includes project summary and tracking information.

Table 1. Project Summary

Project ranking	Moderate (homogeneous)
Characterized volume	100,000 cy
Characterized depth (feet)	Erosional areas: 2.5 ft Slough: 10 cm
Draft SAP received	September 7, 2017
Draft SAP returned for revisions	September 19, 2017
Revised SAP received	October 6, 2017
Revised SAP returned for revisions	October 19, 2017
Final SAP received	October 19, 2017
Final SAP approved	October 19, 2017
Sampling dates	January 2-4, 2018
Data report received	December 10, 2018
DMMO Tracking number	UNION-1-A-F-394
EIM Study ID	UNION18
USACE Permit Application Number	TBD
Recency Determination	January 2023 (moderate rank = 5 yrs)

4. Project Ranking and Sampling Requirements. The DMMP agencies ranked the potential erosional areas as 'moderate' for sediment characterization due to the project's location within the plume of the former ASARCO smelter in Everett. Previous soil sampling in the vicinity of the East Tidal Channel, Mid-Spencer Island and South Tidal Channel demonstrated that concentrations of COCs did not vary significantly with depth (Anchor, 2017). Therefore, the potential erosional areas were considered to have soil that was relatively homogeneous. The minimum numbers of field samples and dredged material management units (DMMUs) in the erosional areas were calculated using the following Puget Sound guidelines for homogeneous material in a moderate-ranked area (DMMP, 2016):

- Maximum volume of sediment represented by each field sample = 4,000 cubic yards
- Maximum volume of sediment represented by each DMMU = 20,000 cubic yards.

Based on these guidelines, five DMMUs with five field samples in each DMMU were nominally required. However, in a conference call with Anchor QEA on September 27, 2017, during which a preliminary sampling diagram was reviewed, the DMMP agencies agreed that four field samples per DMMU were sufficient to represent the four most compact DMMUs (DMMUs 1, 2, 3 and 5). For DMMU 4, which was

elongated, the agencies required five field samples to adequately represent the area (Figure 2).

For the purpose of conducting an antidegradation evaluation for the project, existing conditions within Union Slough needed to be assessed (DMMP, 2008; Ecology, 2013). The rationale for doing so was that dredging would presumably return the slough to conditions similar to those existing prior to construction. The DMMP agencies required collection of three individual surface grab samples from the slough for this assessment (sampling stations SG-01, SG-02 and SG-03 in Figure 2).

5. Sampling. Sampling took place January 2-4, 2018 using a hand auger for soil samples in the erosional areas and a power Van Veen grab sampler for the surface samples from Union Slough. Soil borings to a depth of 2.5 feet were deemed representative of the erodible material in the marsh plain and dikes. Grab samples from Union Slough were taken from the top 10 cm to assess existing conditions. Figure 2 shows the target and actual sampling locations. Tables 2 and 3 provide the sampling data for the soil borings and sediment grab samples respectively.

   In the East Tidal Channel area, both the marsh plain behind the dike, and dike material that was to be excavated and placed behind the breaches, were predicted to be subject to potential erosion. Two samples within each of the three DMMUs in this area were collected from the dike and the other two samples from each DMMU were collected from the marsh plain.

   In the East Smith Island and Mid-Spencer Island areas, the material subject to the greatest erosion potential was predicted to be the dike material that was to be excavated and placed behind the breaches. Therefore, all five samples in DMMU 4 were collected along the dikes to be breached.

   In the South Tidal Channel area, excavated dike material was to be stockpiled upland in an area not subject to erosion. Therefore, the core samples in DMMU 5 were collected along the sides of the newly created channel, which was constructed behind the dike prior to breaching.

   Two grab samples were taken from each station in Union Slough to collect enough sediment for chemical and potential biological analysis. Sampling difficulties were encountered at stations SG-1 and SG-3, necessitating multiple attempts in order to collect two intact grab samples at these stations. Difficulties included winnowing of sediment within the grab sampler and objects such as sticks and cobbles keeping the jaws of the sampler from closing.

6. Grain Size, Sediment Conventional and Chemical Analysis. The grain-size, sediment conventional and chemical results are presented in Table 4. The grain-size data show that the physical characteristics of the erosional material varied considerably from one DMMU to another. For example, DMMU 1 contained 40% gravel and only 39% fines, while DMMUs 3 and 5 had very little gravel and a fines content of over 80%. DMMUs 2 and 4 had a more even distribution of grain sizes, with each containing 14% gravel, 25-30% sand and 56-61% fines. The grab samples taken from three stations in Union Slough were predominantly sand, with only one of them (SG-3) having a significant fines fraction.

   The total organic carbon content (TOC) also varied widely in the erosional material, ranging from 0.9% in DMMU 2 to 4.4% in DMMU 5. TOC in the grab samples was uniformly low, ranging from 0.1 to 0.4%. Total solids ranged from 55 to 75% in the erosional areas and 68 to 77% in the grab samples. Total volatile solids ranged from 4.5 to 11.2% in the erosional material and only 0.9 to 2.1% in the grab samples. Ammonia concentrations were low (or undetected) in all samples and sulfides were undetected throughout.

The DMMP marine guidelines were used to assess COC concentrations in the erosional material, because this material has the potential to be dredged and placed at the Port Gardner open-water disposal site. The three DMMUs in the East Tidal Channel erosional area (DMMUs 1, 2 and 3) all had one or more exceedances of SL for pesticides (Table 5). All three DMMUs exceeded the SL for dieldrin, with concentrations ranging from 8.4 to 23.3 ug/kg (SL = 1.9 ug/kg). DMMUs 2 and 3 also had SL exceedances for 4,4'-DDE and 4,4'-DDT. Concentrations of 4,4'-DDE for DMMUs 2 and 3 were 11.5 and 28.8 ug/kg respectively (SL = 9 ug/kg) and concentrations of 4,4'-DDT were18.6 and 49.9 ug/kg respectively (SL = 12 ug/kg). DMMU 3 also exceeded the BT (50 ug/kg) and maximum level (ML) (69 ug/kg) for Total DDT, with a concentration of 88.1 ug/kg. None of the other marine SLs were exceeded in the East Tidal Channel area. DMMUs 4 and 5 had no DMMP guideline exceedances.

There was no reason to believe that tributyltin or dioxins/furans would be present at elevated concentrations. Therefore, the DMMP agencies did not require these chemicals to be analyzed.

The State of Washington marine sediment quality standards (SQS) were used to assess COC concentrations in surface grab samples collected from Union Slough. The data provided in Table 4 show that there were no SQS exceedances for any of the three surface samples from the slough.

7. Biological Testing. The SL and BT exceedances would normally result in a requirement to run bioassays and bioaccumulation testing were the chemical results for actual dredged material. In this case, however, the tested material only has the potential to erode. Depending on the rate of erosion and the resulting mixing ratio with cleaner bed-load material, the concentration of pesticides in the material requiring dredging may or may not exceed DMMP guidelines (Anchor, 2018).

8. Antidegradation Evaluation. As discussed earlier, should dredging be required in the future, the post-dredge surface will likely be similar to the condition existing in Union Slough prior to breaching the dikes. This condition was represented by the three surface grab sample composites taken from the slough prior to construction. Concentrations of COCs in these samples were all below SQS. Therefore, assuming that dredging returns Union Slough to its pre-construction condition, the State of Washington antidegradation standard will be met.

9. Additional Actions Required Before Dredging. This memorandum documents the evaluation of data collected by Snohomish County from erosional areas in preparation for potential dredging of Union Slough. Should dredging be required, Snohomish County will collect surface grab samples of shoaled material in the slough in accordance with Anchor (2017) and at a level of intensity consistent with the DMMP guidelines. A SAP addendum consisting of the proposed dredge footprint, sampling locations, and compositing scheme will be provided to the DMMP agencies for approval prior to sampling.

   The preliminary data clearly showed that other than dieldrin and DDT, there is no reason to believe that concentrations of other COCs will exceed DMMP SLs or BTs. Therefore, only dieldrin and DDT constituents will need to be analyzed (along with TOC and grain size). Should concentrations exceed one or more SL or BT, the appropriate biological testing will need to be performed. A brief technical memorandum including the sampling data, sample location figure, and testing results will be provided to the DMMP agencies by Snohomish County. The data will also be provided in EIM format.

Once testing of the dredged material has been completed, the DMMP agencies will document the results in a suitability determination. This memorandum will be referenced and included as an attachment to the suitability determination.

10. References.

Anchor, 2017. *Final Sampling and Analysis Plan for Union Slough Sediment Characterization.* Prepared by Anchor QEA for Snohomish County Public Works, October 2017.

Anchor, 2018. *Sediment Characterization Report for Union Slough Sediment Characterization.* Prepared by Anchor QEA for Snohomish County Public Works, December 2018.

DMMP, 2008. *Quality of Post-Dredge Sediment Surfaces (Updated)*. A Clarification Paper Prepared by David Fox (USACE), Erika Hoffman (EPA) and Tom Gries (Ecology) for the Dredged Material Management Program, June 2008.

DMMP, 2016. *Dredged Material Evaluation and Disposal Procedures (User Manual)*. Dredged Material Management Program, August 2016.

Ecology, 2013. *Sediment Management Standards – Chapter 173-204 WAC*. Washington State Department of Ecology, Revised February 2013.

11. DMMO Signature. This memorandum was coordinated by the undersigned with Laura Inouye (Ecology), Justine Barton (EPA) and Celia Barton (DNR).

The signed copy is on file in the Dredged Material Managment Office.

_____ _____
Date David Fox, P.E. - Seattle District Corps of Engineers

Copies furnished:

DMMP agencies
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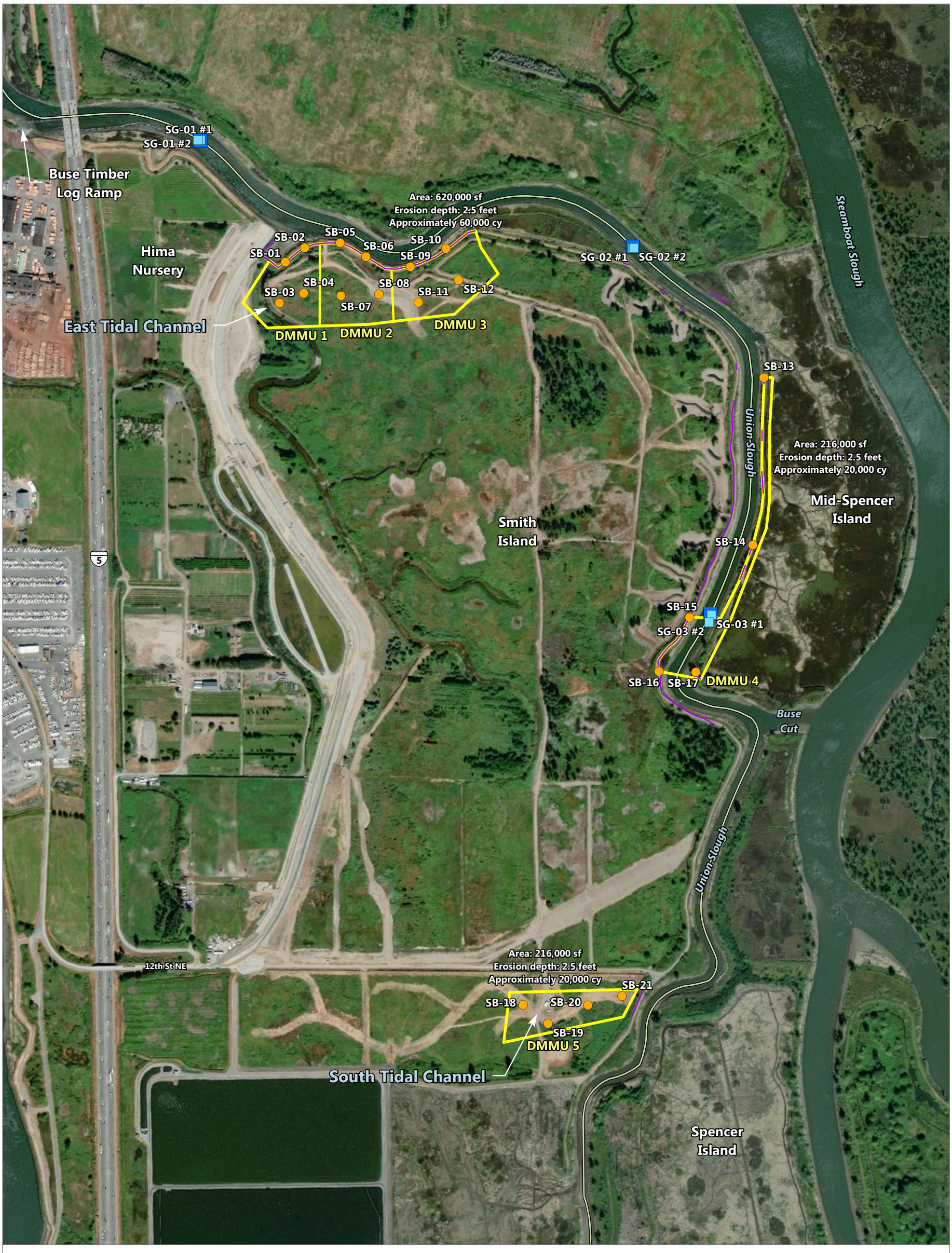
ANCHOR QEA

Figure 1
Vicinity Map
Sediment Characterization Report
Union Slough Sediment Characterization



LEGEND:

- Surface Grab (Actual)
- Surface Grab (Proposed)
- Soil Boring (Proposed and Actual)
- Predicted Erosion Area
- Breach Location
- Union Slough Center Line

NOTE(S):
cy: cubic yard
DMMU: dredge material management unit
sf: square feet

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Feet

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Figure 2
Proposed and Actual Sampling Locations
Sediment Characterization Report
Union Slough Sediment Characterization

Table 2
Soil Collection Data

DMMU	Station ID	Date	X Coordinate[1]	Y Coordinate[1]	Archive Sample ID[2]	Composite Sample ID	Sampling Interval	Surface Interval Composite Testing Parameters
DMMU1	SB-1	1/2/2018	1313428.92	375335.59	SB-1-180102	DU-1-180102	0 to 2.5 feet below ground surface (0 to 76 centimeters)	DMMP Testing Parameters,[3] Bioassay Archive
	SB-2		1313565.45	375434.89	SB-2-180102			
	SB-3		1313388.18	375046.30	SB-3-180102			
	SB-4		1313556.86	375115.74	SB-4-180102			
DMMU2	SB-5	1/2/2018	1313813.76	375469.14	SB-5-180102	DU-2-180102		
	SB-6		1313993.98	375373.27	SB-6-180102			
	SB-7		1313818.12	375098.88	SB-7-180102			
	SB-8		1314085.70	375109.52	SB-8-180102			
DMMU3	SB-9	1/4/2018	1314307.53	375303.60	SB-9-180104	DU-3-180104		
	SB-10		1314558.40	375430.41	SB-10-180104			
	SB-11		1314363.26	375052.01	SB-11-180104			
	SB-12		1314645.13	375209.17	SB-12-180104			
DMMU4	SB-13	1/4/2018	1316789.82	374524.17	SB-13-180104	DU-4-180104		
	SB-14		1316711.19	373348.48	SB-14-180104			
	SB-15		1316267.21	372839.02	SB-15-180104			
	SB-16		1316053.03	372459.79	SB-16-180104			
	SB-17		1316310.98	372454.75	SB-17-180104			
DMMU5	SB-18	1/4/2018	1315098.34	370118.52	SB-18-180104	DU-5-180104		
	SB-19		1315273.10	369986.11	SB-19-180104			
	SB-20		1315554.18	370116.60	SB-20-180104			
	SB-21		1315793.49	370179.11	SB-21-180104			

Notes:
1. Coordinates are in North American Datum of 1983 Washington State Plane, North Zone, U.S. feet.
2. Archives of individual intervals kept.
3. DMMP testing parameters include semivolatile organic compounds, polycyclic aromatic hydrocarbons, pesticides, polychlorinated biphenyls, metals, sulfide, ammonia, total organic carbon, grain size, total volatile solids, and total solids.
DMMP: Dredged Material Management Program
DMMU: Dredged Material Management Unit

Table 3
Sediment Collection Data – Z-Samples

Station ID	Date	Accepted Attempt	X Coordinate[1]	Y Coordinate[1]	Water Depth (feet)	Water Level (feet NAVD88)[2,3]	Mudline Depth (feet NAVD88)[3]	Sample ID	Sampling Interval Below Mudline	Z-Sample Testing Parameters
SG-1	1/3/2018	5	1312833.00	376191.08	10.8	4.04	-6.8	SG-1-180103	0 to 10 centimeters (0 to 4 inches)	DMMP Testing Parameters,[4] Bioassay Archive
		8	1312814.20	376192.59	11.0	4.04	-7.0			
SG-2	1/3/2018	1	1315867.41	375431.71	12.6	4.36	-8.2	SG-2-180103		
		2	1315876.56	375434.26	12.4	4.36	-8.0			
SG-3	1/3/2018	4	1316421.33	372855.82	13.4	6.59	-6.8	SG-3-180103		
		8	1316404.31	372803.77	11.6	5.10	-6.5			

Notes:

1. Coordinates are in North American Datum of 1983 Washington State Plane, North Zone, U.S. feet.
2. Water levels at time of sampling were surveyed using a real time kinematic global positioning system connected to the Washington State Reference Network.
3. Add 2 feet to NAVD88 to obtain mean lower low water elevation.
4. DMMP testing parameters include semivolatile organic compounds, polycyclic aromatic hydrocarbons, pesticides, polychlorinated biphenyls, metals, sulfide, ammonia, total organic carbon, grain size, total volatile solids, and total solids.

DMMP: Dredged Material Management Program

NAVD88: North American Vertical Datum of 1988

Table 4

						Location ID	DU-1-180102	DU-2-180102	DU-3-180104	DU-4-180104	DU-5-180104	SG-1-180103	SG-2-180103	SG-3-180103
						Sample ID	DU-1-180102	DU-2-180102	DU-3-180104	DU-4-180104	DU-5-180104	SG-1-180103	SG-2-180103	SG-3-180103
						DMMU	DMMU1	DMMU2	DMMU3	DMMU4	DMMU5	--	--	--
						Sample Date	1/2/2018	1/2/2018	1/4/2018	1/4/2018	1/4/2018	1/3/2018	1/3/2018	1/3/2018
						Depth	0 - 2.5 feet	0 - 2.5 feet	0 - 2.5 feet	0 - 2.5 feet	0 - 2.5 feet	0 - 10 cm	0 - 10 cm	0 - 10 cm
						Matrix	SO	SO	SO	SO	SO	SE	SE	SE
	Method	DMMP SL	DMMP BT	DMMP ML	SMS Marine SCO SCUM II	SMS Marine CSL SCUM II								
Conventional Parameters (mg/kg)														
Ammonia as nitrogen	SM4500NH3H						**1.62 J**	**1.03 J**	**2.41**	**2.2**	**6.59**	0.51 U	0.55 U	**1.12**
Sulfide	SM4500S2D						1.22 U	1.29 U	1.41 U	1.42 U	1.69 U	1.33 U	1.36 U	1.47 U
Conventional Parameters (pct)														
Total organic carbon	SW9060AM						**1.29 J**	**0.93 J**	**1.62**	**3.4**	**4.35**	**0.11 J**	**0.13 J**	**0.41 J**
Total solids	SM2540G						**74.61**	**73.57**	**71.29**	**70.89**	**55.22**	**76.74**	**70.71**	**68.48**
Total volatile solids	PSEP						**5.13**	**4.53**	**6.37**	**8.21**	**11.2**	**0.887**	**0.98**	**2.13**
Grain Size (pct)														
Gravel	PSEP						**40.2**	**13.6**	**0.2**	**13.7**	**1.1**	**0.1**	**0.3**	**0**
Sand, very coarse	PSEP						**3.3**	**5.1**	**0.9**	**1.9**	**2**	**0.9**	**0.5**	**0.3**
Sand, coarse	PSEP						**2.9**	**6.6**	**1.2**	**5**	**2.9**	**18.6**	**2.9**	**2.8**
Sand, medium	PSEP						**3.2**	**9.1**	**1.2**	**6.6**	**3.2**	**71.4**	**53.9**	**27**
Sand, fine	PSEP						**4.2**	**6.5**	**3.6**	**5.1**	**3.2**	**7.6**	**40.1**	**32.3**
Sand, very fine	PSEP						**6.9**	**3.1**	**12.3**	**6.9**	**2.3**	**0.3**	**1.5**	**14.2**
Total Sand	PSEP						**20.5**	**30.4**	**19.2**	**25.5**	**13.6**	**98.8**	**98.9**	**76.6**
Silt, coarse	PSEP						**5.8**	**6.8**	**14.5**	**12.6**	**5.5**	1 U	0.8 U	**8.9**
Silt, medium	PSEP						**8.3**	**10.2**	**17.6**	**13.1**	**14.3**	1 U	0.8 U	**4.7**
Silt, fine	PSEP						**7.6**	**11.2**	**15**	**11.2**	**19.3**	1 U	0.8 U	**3.4**
Silt, very fine	PSEP						**5.6**	**9.4**	**12.1**	**8.8**	**16.2**	1 U	0.8 U	**2.2**
Clay, coarse	PSEP						**4.3**	**6.8**	**8.2**	**5.4**	**10.7**	1 U	0.8 U	**1.7**
Clay, medium	PSEP						**2.7**	**4.1**	**5.1**	**3.6**	**6.5**	1 U	0.8 U	**1**
Clay, fine	PSEP						**5**	**7.6**	**8.3**	**6**	**12.7**	1 U	0.8 U	**1.3**
Total Fines (Silt + Clay)							**39.3**	**56.1**	**80.8**	**60.7**	**85.2**	1 U	0.8 U	**23.2**
Metals (mg/kg)														
Antimony	SW6020A	150		200			**-- R**	**-- R**	**-- R**	**-- R**	**0.04 J**	**-- R**	**-- R**	**-- R**
Arsenic	SW6020A	57	507.1	700	57	93	**14.3**	**13.8**	**18.4**	**13.8**	**27.2**	**5.83**	**5.58**	**7.82**
Cadmium	SW6020A	5.1	11.3	14	5.1	6.7	**0.13 J**	**0.1 J**	**0.16**	**0.11 J**	**0.27**	**0.04 J**	**0.04 J**	**0.07 J**
Chromium	SW6020A	260	260		260	270	**59.9 J**	**65.6 J**	**57.3 J**	**51.2 J**	**65.4**	**21.5 J**	**27.4 J**	**38.1 J**
Copper	SW6020A	390	1027	1300	390	390	**40**	**34.5**	**45.3**	**39.8**	**52.6**	**13.6**	**16.1**	**26**
Lead	SW6020A	450	975	1200	450	530	**13**	**11.4**	**14.2**	**14.6**	**30.5**	**4.09**	**4.07**	**5.62**
Mercury	SW7471B	0.41	1.5	2.3	0.41	0.59	**0.0831**	**0.0686**	**0.0796**	**0.0889**	**0.0966**	0.0296 U	0.0316 U	**0.0321**
Selenium	SW6020A		3				**1.13**	**1.17**	**1.39**	**0.97**	**1.62**	**0.49 J**	0.7 U	**0.77**
Silver	SW6020A	6.1	6.1	8.4	6.1	6.1	**0.11 J**	**0.08 J**	**0.13 J**	**0.12 J**	**1.2**	**0.02 J**	**0.03 J**	**0.07 J**
Zinc	SW6020A	410	2783	3800	410	960	**63**	**67.4**	**71.1**	**58.5**	**77**	**39.4**	**43.4**	**55.2**
Semivolatile Organics (mg/kg-OC)														
1,2,4-Trichlorobenzene	SW8270DSIM				0.81	1.8	0.3721 U	0.5054 U	0.3086 U	0.1441 U	0.1103 U	*4.4545 U*	*3.8462 U*	*1.1707 U*
1,2-Dichlorobenzene	SW8270DSIM				2.3	2.3	0.3721 U	0.5054 U	0.3086 U	0.1441 U	0.1103 U	*4.4545 U*	*3.8462 U*	1.1707 U
1,4-Dichlorobenzene	SW8270DSIM				3.1	9	0.3721 U	0.5054 U	0.3086 U	0.1441 U	0.1103 U	*4.4545 U*	*3.8462 U*	1.1707 U
2,4-Dimethylphenol	SW8270DSIM						1.876 UJ	2.5269 UJ	1.5309 UJ	0.7265 UJ	0.554 UJ	22.4545 UJ	19.2308 UJ	5.8293 UJ
2-Methylphenol (o-Cresol)	SW8270DSIM						**0.2326 J**	0.5054 U	0.3086 U	**0.1382 J**	**0.0828 J**	4.4545 U	3.8462 U	1.1707 U
4-Methylphenol (p-Cresol)	SW8270DSIM						0.3721 U	0.5054 U	0.3086 U	**0.0882 J**	**0.3655**	4.4545 U	3.8462 U	**1.0488 J**
Benzoic acid	SW8270DSIM						**8.837**	**7.5484**	**6.667**	**4.912**	**6.345**	44.8182 U	38.3846 U	**4.1707 J**
Benzyl alcohol	SW8270DSIM						1.5039 U	2.0215 U	1.2284 U	0.5794 U	0.4437 U	17.9091 U	15.3846 U	4.6585 U
bis(2-Ethylhexyl)phthalate	SW8270D				47	78	3.7597 U	5.0538 U	3.0679 U	1.4529 U	**0.7839 J**	44.8182 U	**27.6154 J**	11.6341 U
Butylbenzyl phthalate	SW8270D				4.9	64	1.5039 U	2.0215 U	1.2284 U	0.5794 U	0.4437 U	*17.9091 U*	*15.3846 U*	4.6585 U
Diethyl phthalate	SW8270DSIM				61	110	1.5039 U	2.0215 U	1.2284 U	0.5794 U	0.4437 U	17.9091 U	15.385 U	4.6585 U
Dimethyl phthalate	SW8270DSIM				53	53	0.3721 U	2.151 U	0.3086 U	0.1441 U	0.1103 U	4.4545 U	3.8462 U	1.1707 U
Di-n-butyl phthalate	SW8270D				220	1700	1.5039 U	2.1398 U	1.2284 U	0.5794 U	0.4437 U	17.9091 U	15.3846 U	4.6585 U
Di-n-octyl phthalate	SW8270D				58	4500	1.5039 U	2.1183 U	1.2284 U	0.5794 U	0.4437 U	17.9091 U	15.3846 U	4.6585 U
Hexachlorobenzene	SW8270DSIM				0.38	2.3	0.3721 U	*0.5054 U*	0.3086 U	0.1441 U	0.1103 U	*4.4545 U*	*3.8462 U*	*1.1707 U*
Hexachlorobutadiene (Hexachloro-1,3-butadiene)	SW8270DSIM				3.9	6.2	0.3721 U	0.5054 U	0.3086 U	0.1441 U	0.1103 U	*4.4545 U*	3.8462 U	1.1707 U
n-Nitrosodiphenylamine	SW8270DSIM				11	11	0.3721 U	0.5054 U	0.3086 U	0.1441 U	0.1103 U	4.4545 U	3.8462 U	1.1707 U
Pentachlorophenol	SW8270DSIM						**0.1938 J**	2.0215 U	1.2284 U	0.5794 U	0.4437 U	17.9091 U	15.3846 U	4.6585 U
Phenol	SW8270DSIM						**0.7907**	**0.6989**	**0.4877**	**0.3794**	**0.3678**	**5.8182**	**5.2308**	**2.6585**
Semivolatile Organics (µg/kg)														
1,2,4-Trichlorobenzene	SW8270DSIM	31		64			4.8 U	4.7 U	5 U	4.9 U	4.8 U	4.9 U	5 U	4.8 U
1,2-Dichlorobenzene	SW8270DSIM	35		110			4.8 U	4.7 U	5 U	4.9 U	4.8 U	4.9 U	5 U	4.8 U
1,4-Dichlorobenzene	SW8270DSIM	110		120			4.8 U	4.7 U	5 U	4.9 U	4.8 U	4.9 U	5 U	4.8 U
2,4-Dimethylphenol	SW8270DSIM	29		210	29	29	24.2 UJ	23.5 UJ	24.8 UJ	24.7 UJ	24.1 UJ	24.7 UJ	25 UJ	23.9 UJ
2-Methylphenol (o-Cresol)	SW8270DSIM	63		77	63	63	**3 J**	4.7 U	5 U	**4.7 J**	**3.6 J**	4.9 U	5 U	4.8 U

Table 4

						Location ID	DU-1-180102	DU-2-180102	DU-3-180104	DU-4-180104	DU-5-180104	SG-1-180103	SG-2-180103	SG-3-180103
						Sample ID	DU-1-180102	DU-2-180102	DU-3-180104	DU-4-180104	DU-5-180104	SG-1-180103	SG-2-180103	SG-3-180103
						DMMU	DMMU1	DMMU2	DMMU3	DMMU4	DMMU5	--	--	--
						Sample Date	1/2/2018	1/2/2018	1/4/2018	1/4/2018	1/4/2018	1/3/2018	1/3/2018	1/3/2018
						Depth	0 - 2.5 feet	0 - 2.5 feet	0 - 2.5 feet	0 - 2.5 feet	0 - 2.5 feet	0 - 10 cm	0 - 10 cm	0 - 10 cm
						Matrix	SO	SO	SO	SO	SO	SE	SE	SE
	Method	DMMP SL	DMMP BT	DMMP ML	SMS Marine SCO SCUM II	SMS Marine CSL SCUM II								
4-Methylphenol (p-Cresol)	SW8270DSIM	670		3600	670	670	4.8 U	4.7 U	5 U	**3 J**	**15.9**	4.9 U	5 U	**4.3 J**
Benzoic acid	SW8270DSIM	650		760	650	650	**114**	**70.2**	**108**	**167**	**276**	49.3 U	49.9 U	**17.1 J**
Benzyl alcohol	SW8270DSIM	57		870	57	73	19.4 U	18.8 U	19.9 U	19.7 U	19.3 U	19.7 U	20 U	19.1 U
bis(2-Ethylhexyl)phthalate	SW8270D	1300		8300			48.5 U	47 U	49.7 U	49.4 U	**34.1 J**	49.3 U	**35.9 J**	47.7 U
Butylbenzyl phthalate	SW8270D	63		970			19.4 U	18.8 U	19.9 U	19.7 U	19.3 U	19.7 U	20 U	19.1 U
Diethyl phthalate	SW8270DSIM	200		1200			19.4 U	18.8 U	19.9 U	19.7 U	19.3 U	19.7 U	20 U	19.1 U
Dimethyl phthalate	SW8270DSIM	71		1400			4.8 U	20 U	5 U	4.9 U	4.8 U	4.9 U	5 U	4.8 U
Di-n-butyl phthalate	SW8270D	1400		5100			19.4 U	19.9 U	19.9 U	19.7 U	19.3 U	19.7 U	20 U	19.1 U
Di-n-octyl phthalate	SW8270D	6200		6200			19.4 U	19.7 U	19.9 U	19.7 U	19.3 U	19.7 U	20 U	19.1 U
Hexachlorobenzene	SW8270DSIM	22	168	230			4.8 U	4.7 U	5 U	4.9 U	4.8 U	4.9 U	5 U	4.8 U
Hexachlorobutadiene (Hexachloro-1,3-butadiene)	SW8270DSIM	11		270			4.8 U	4.7 U	5 U	4.9 U	4.8 U	4.9 U	5 U	4.8 U
n-Nitrosodiphenylamine	SW8270DSIM	28		130			4.8 U	4.7 U	5 U	4.9 U	4.8 U	4.9 U	5 U	4.8 U
Pentachlorophenol	SW8270DSIM	400	504	690	360	690	**2.5 J**	18.8 U	19.9 U	19.7 U	19.3 U	19.7 U	20 U	19.1 U
Phenol	SW8270DSIM	420		1200	420	1200	**10.2**	**6.5**	**7.9**	**12.9**	**16**	**6.4**	**6.8**	**10.9**
Polycyclic Aromatic Hydrocarbons (mg/kg-OC)														
2-Methylnaphthalene	SW8270D				38	64	1.5039 U	2.0215 U	1.2284 U	0.5794 U	0.4437 U	17.9091 U	15.3846 U	4.6585 U
Acenaphthene	SW8270D				16	57	1.5039 U	2.0215 U	1.2284 U	0.5794 U	0.4437 U	*17.9091 U*	15.3846 U	4.6585 U
Acenaphthylene	SW8270D				66	66	1.5039 U	2.0215 U	1.2284 U	0.5794 U	0.4437 U	17.9091 U	15.3846 U	4.6585 U
Anthracene	SW8270D				220	1200	1.5039 U	2.0215 U	1.2284 U	0.5794 U	0.4437 U	17.9091 U	15.3846 U	4.6585 U
Benzo(a)anthracene	SW8270D				110	270	1.5039 U	2.0215 U	1.2284 U	0.5794 U	0.4437 U	17.9091 U	15.3846 U	4.6585 U
Benzo(a)pyrene	SW8270D				99	210	1.5039 U	2.0215 U	1.2284 U	**0.1971 J**	0.4437 U	17.9091 U	15.3846 U	4.6585 U
Benzo(b,j,k)fluoranthenes	SW8270D						**1.2248 J**	4.043 U	**0.6296 J**	**0.4676 J**	**0.577 J**	35.9091 U	30.7692 U	9.3171 U
Benzo(g,h,i)perylene	SW8270D				31	78	1.5039 U	2.0215 U	1.2284 U	0.5794 U	**0.1885 J**	17.9091 U	15.3846 U	4.6585 U
Chrysene	SW8270D				110	460	**0.4186 J**	2.0215 U	**0.4259 J**	0.5794 U	**0.223 J**	17.9091 U	15.3846 U	**1.2439 J**
Dibenzo(a,h)anthracene	SW8270DSIM				12	33	0.3721 U	0.5054 U	0.3086 U	0.1441 U	0.1103 U	4.4545 U	3.8462 U	1.1707 U
Dibenzofuran	SW8270D				15	58	1.5039 U	2.0215 U	1.2284 U	0.5794 U	0.4437 U	*17.9091 U*	*15.3846 U*	4.6585 U
Fluoranthene	SW8270D				160	1200	**0.4109 J**	2.0753 U	**0.4691 J**	**0.3118 J**	**0.3034 J**	**15.0909 J**	15.3846 U	**1.439 J**
Fluorene	SW8270D				23	79	1.5039 U	2.0215 U	1.2284 U	0.5794 U	0.4437 U	17.9091 U	15.3846 U	4.6585 U
Indeno(1,2,3-c,d)pyrene	SW8270D				34	88	1.5039 U	2.0215 U	1.2284 U	0.5794 U	0.4437 U	17.9091 U	15.3846 U	4.6585 U
Naphthalene	SW8270D				99	170	**0.5736 J**	2.0215 U	**0.7407 J**	**0.4324 J**	**0.3816 J**	17.9091 U	15.3846 U	**1.3171 J**
Phenanthrene	SW8270D				100	480	**0.6047 J**	2.0215 U	**0.6667 J**	**0.3824 J**	**0.3586 J**	**20.3636**	15.3846 U	**1.5122 J**
Pyrene	SW8270D				1000	1400	**0.4574 J**	2.0215 U	1.2284 U	**0.2529 J**	**0.2184 J**	**14 J**	15.3846 U	**1.3659 J**
Total Benzofluoranthenes (b,j,k) (U = 0)					230	450	**1.2248 J**	4.043 U	**0.6296 J**	**0.4676 J**	**0.577 J**	35.9091 U	30.7692 U	9.3171 U
Total HPAH (SMS) (U = 0)					960	5300	**2.5116 J**	4.043 U	**1.5247 J**	**1.2294 J**	**1.5103 J**	**29.0909 J**	30.7692 U	**4.0488 J**
Total LPAH (SMS) (U = 0)					370	780	**1.1783 J**	2.0215 U	**1.4074 J**	**0.8147 J**	**0.7402 J**	**20.3636**	15.3846 U	**2.8293 J**
Polycyclic Aromatic Hydrocarbons (µg/kg)														
2-Methylnaphthalene	SW8270D	670		1900			19.4 U	18.8 U	19.9 U	19.7 U	19.3 U	19.7 U	20 U	19.1 U
Acenaphthene	SW8270D	500		2000			19.4 U	18.8 U	19.9 U	19.7 U	19.3 U	19.7 U	20 U	19.1 U
Acenaphthylene	SW8270D	560		1300			19.4 U	18.8 U	19.9 U	19.7 U	19.3 U	19.7 U	20 U	19.1 U
Anthracene	SW8270D	960		13000			19.4 U	18.8 U	19.9 U	19.7 U	19.3 U	19.7 U	20 U	19.1 U
Benzo(a)anthracene	SW8270D	1300		5100			19.4 U	18.8 U	19.9 U	19.7 U	19.3 U	19.7 U	20 U	19.1 U
Benzo(a)pyrene	SW8270D	1600		3600			19.4 U	18.8 U	19.9 U	**6.7 J**	19.3 U	19.7 U	20 U	19.1 U
Benzo(b,j,k)fluoranthenes	SW8270D						**15.8 J**	37.6 U	**10.2 J**	**15.9 J**	**25.1 J**	39.5 U	40 U	38.2 U
Benzo(g,h,i)perylene	SW8270D	670		3200			19.4 U	18.8 U	19.9 U	19.7 U	**8.2 J**	19.7 U	20 U	19.1 U
Chrysene	SW8270D	1400		21000			**5.4 J**	18.8 U	**6.9 J**	19.7 U	**9.7 J**	19.7 U	20 U	**5.1 J**
Dibenzo(a,h)anthracene	SW8270DSIM	230		1900			4.8 U	4.7 U	5 U	4.9 U	4.8 U	4.9 U	5 U	4.8 U
Dibenzofuran	SW8270D	540		1700			19.4 U	18.8 U	19.9 U	19.7 U	19.3 U	19.7 U	20 U	19.1 U
Fluoranthene	SW8270D	1700	4600	30000			**5.3 J**	19.3 U	**7.6 J**	**10.6 J**	**13.2 J**	**16.6 J**	20 U	**5.9 J**
Fluorene	SW8270D	540		3600			19.4 U	18.8 U	19.9 U	19.7 U	19.3 U	19.7 U	20 U	19.1 U
Indeno(1,2,3-c,d)pyrene	SW8270D	600		4400			19.4 U	18.8 U	19.9 U	19.7 U	19.3 U	19.7 U	20 U	19.1 U
Naphthalene	SW8270D	2100		2400			**7.4 J**	18.8 U	**12 J**	**14.7 J**	**16.6 J**	19.7 U	20 U	**5.4 J**
Phenanthrene	SW8270D	1500		21000			**7.8 J**	18.8 U	**10.8 J**	**13 J**	**15.6 J**	**22.4**	20 U	**6.2 J**
Pyrene	SW8270D	2600	11980	16000			**5.9 J**	18.8 U	19.9 U	**8.6 J**	**9.5 J**	**15.4 J**	20 U	**5.6 J**
Total Benzofluoranthenes (b,j,k) (U = 0)		3200		9900			**15.8 J**	37.6 U	**10.2 J**	**15.9 J**	**25.1 J**	39.5 U	40 U	38.2 U
Total HPAH (DMMP) (U = 0)		12000		69000			**32.4 J**	37.6 U	**24.7 J**	**41.8 J**	**65.7 J**	**32 J**	40 U	**16.6 J**
Total LPAH (DMMP) (U = 0)		5200		29000			**15.2 J**	18.8 U	**22.8 J**	**27.7 J**	**32.2 J**	**22.4**	20 U	**11.6 J**
Pesticides (µg/kg)														
4,4'-DDD (p,p'-DDD)	SW8081B	16					**1.42**	**2.44**	**9.4**	0.97 U	0.99 U	0.99 U	0.95 U	0.99 U
4,4'-DDE (p,p'-DDE)	SW8081B	9					**7.91**	**11.5**	**28.8**	0.97 U	0.99 U	0.99 U	0.95 U	0.99 U
4,4'-DDT (p,p'-DDT)	SW8081B	12					**9.17**	**18.6**	**49.9**	0.97 U	0.99 U	0.99 U	0.95 U	0.99 U
Aldrin	SW8081B	9.5					0.49 U	0.49 U	0.49 U	0.49 U	0.5 U	0.5 U	0.48 U	0.5 U

Table 4

						Location ID	DU-1-180102	DU-2-180102	DU-3-180104	DU-4-180104	DU-5-180104	SG-1-180103	SG-2-180103	SG-3-180103
						Sample ID	DU-1-180102	DU-2-180102	DU-3-180104	DU-4-180104	DU-5-180104	SG-1-180103	SG-2-180103	SG-3-180103
						DMMU	DMMU1	DMMU2	DMMU3	DMMU4	DMMU5	--	--	--
						Sample Date	1/2/2018	1/2/2018	1/4/2018	1/4/2018	1/4/2018	1/3/2018	1/3/2018	1/3/2018
						Depth	0 - 2.5 feet	0 - 2.5 feet	0 - 2.5 feet	0 - 2.5 feet	0 - 2.5 feet	0 - 10 cm	0 - 10 cm	0 - 10 cm
						Matrix	SO	SO	SO	SO	SO	SE	SE	SE
	Method	DMMP SL	DMMP BT	DMMP ML	SMS Marine SCO SCUM II	SMS Marine CSL SCUM II								
Chlordane, alpha- (Chlordane, cis-)	SW8081B						0.49 U	0.49 U	0.49 U	0.49 U	0.5 U	0.5 U	0.48 U	0.5 U
Chlordane, beta- (Chlordane, trans-)	SW8081B						0.49 U	0.49 U	0.49 U	0.49 U	0.5 U	0.5 U	0.48 U	0.5 U
Dieldrin	SW8081B	1.9		1700			**8.4**	**9.93**	**23.3**	0.97 U	0.99 U	0.99 U	0.95 U	0.99 U
Heptachlor	SW8081B	1.5		270			0.49 U	0.49 U	0.49 U	0.49 U	0.5 U	0.5 U	0.48 U	0.5 U
Nonachlor, cis-	SW8081B						0.99 U	0.98 U	0.97 U	0.97 U	0.99 U	0.99 U	0.95 U	0.99 U
Nonachlor, trans-	SW8081B						0.99 U	0.98 U	**1.4**	0.97 U	0.99 U	0.99 U	0.95 U	0.99 U
Oxychlordane	SW8081B						0.99 U	0.98 U	0.97 U	0.97 U	0.99 U	0.99 U	0.95 U	0.99 U
Sum 4,4 DDT, DDE, DDD (U = 0)			50	69			**18.5**	**32.54**	**88.1**	0.97 U	0.99 U	0.99 U	0.95 U	0.99 U
Total DMMP Chlordane (U = 0)		2.8	37				0.99 U	0.98 U	**1.4**	0.97 U	0.99 U	0.99 U	0.95 U	0.99 U
PCB Aroclors (mg/kg-OC)														
Total DMMP PCB Aroclors (U = 0)			38		12	65	0.3023 U	0.4194 U	0.2407 U	0.1147 U	0.092 U	3.6364 U	2.9231 U	0.9756 U
PCB Aroclors (µg/kg)														
Aroclor 1016	SW8082A						3.9 U	3.9 U	3.9 U	3.9 U	4 U	4 U	3.8 U	4 U
Aroclor 1221	SW8082A						3.9 U	3.9 U	3.9 U	3.9 U	4 U	4 U	3.8 U	4 U
Aroclor 1232	SW8082A						3.9 U	3.9 U	3.9 U	3.9 U	4 U	4 U	3.8 U	4 U
Aroclor 1242	SW8082A						3.9 U	3.9 U	3.9 U	3.9 U	4 U	4 U	3.8 U	4 U
Aroclor 1248	SW8082A						3.9 U	3.9 U	3.9 U	3.9 U	4 U	4 U	3.8 U	4 U
Aroclor 1254	SW8082A						3.9 U	3.9 U	3.9 U	3.9 U	4 U	4 U	3.8 U	4 U
Aroclor 1260	SW8082A						3.9 U	3.9 U	3.9 U	3.9 U	4 U	4 U	3.8 U	4 U
Aroclor 1262	SW8082A						3.9 U	3.9 U	3.9 U	3.9 U	4 U	4 U	3.8 U	4 U
Aroclor 1268	SW8082A						3.9 U	3.9 U	3.9 U	3.9 U	4 U	4 U	3.8 U	4 U
Total DMMP PCB Aroclors (U = 0)		130		3100			3.9 U	3.9 U	3.9 U	3.9 U	4 U	4 U	3.8 U	4 U

Notes:
indicates detected concentration is greater than DMMP SL
Detected concentration is greater than DMMP BT
indicates detected concentration is greater than DMMP ML
Detected concentration is greater than SMS Marine SCO SCUM II screening level
Detected concentration is greater than SMS Marine CSL SCUM II screening level
Italicized indicates non-detected concentration is above one or more identified screening levels
Bold indicates detected result
µg/kg: microgram per kilogram
BT: bioaccumulation trigger
cm: centimeter
CSL: cleanup screening level
DMMP: Dredged Material Management Program
DMMU: Dredged Material Management Unit
ft: feet
HPAH: high-molecular-weight polycyclic aromatic hydrocarbon
J: estimated value
LPAH: low-molecular-weight polycyclic aromatic hydrocarbon
mg/kg: milligram per kilogram
mg/kg-OC: milligram per kilogram total organic carbon normalized
ML: maximum level
N: normal environmental sample
PCB: polychlorinated biphenyl
pct: percent
R: rejected
SCO: sediment cleanup objective
SCUM II: Sediment Cleanup Users Manual II
SE: sediment
SL: screening level
SMS: Sediment Management Standards
SO: soil
U: compound analyzed, but not detected above detection limit
UJ: compound analyzed, but not detected above estimated detection limit

Table 5
Pesticides Exceedance Summary

Compound	DMMP Criteria (µg/kg)			Sample Results (µg/kg)			Average of DMMU1, DMMU2, DMMU3 (µg/kg)			
	SL	ML	BT	DMMU1	DMMU2	DMMU3	AVG	AVG/2	AVG/4	AVG/10
Dieldrin	1.9	1,700	-	8.4	9.9	23.3	13.9	6.9	1.7	0.2
4,4-DDE	9	-	-	7.91	11.5	28.8	16.1	8	2	0.2
4,4-DDD	16	-	-	1.42	2.44	9.4	4.4	2.2	0.6	0.1
4,4-DDT	12	-	-	9.17	18.6	49.9	25.9	12.9	3.2	0.3
Total 4,4-DDX	-	69	50	18.5	32.54	88.1	46.4	23.2	5.8	0.6
TOC	-	-	-	1.29 J	0.93 J	1.62	-	-	-	-
Gravel	-	-	-	40.2	13.6	0.2	-	-	-	-
Sand	-	-	-	20.5	30.4	19.2	-	-	-	-
Fines	-	-	-	39.3	56.1	80.8	-	-	-	-

Notes:

indicates concentration is greater than DMMP screening level

indicates concentration is greater than DMMP maximum level or bioaccumulation trigger.

µg/kg: microgram per kilogram

AVG: the average of the three composite samples from the East Tidal Channel area.

AVG/X: a dilution factor representative of settled erosional material that has mixed with other sediments (other erosional areas from upstream)

BT: bioaccumulation trigger

DMMP: Dredged Material Management Program

DMMU: Dredged Material Management Unit

ML: maximum level

SL: screening level

TOC: total organic compound