CENWS-OD-ME-DMMO

MEMORANDUM FOR: RECORD September 19, 2013

SUBJECT: DETERMINATION REGARDING THE SUITABILITY OF PROPOSED DREDGED MATERIAL FROM THE DUWAMISH YACHT CLUB, SEATTLE, WA EVALUATED UNDER SECTION 404 OF THE CLEAN WATER ACT FOR UNCONFINED OPEN-WATER DISPOSAL AT THE ELLIOTT BAY NON-DISPERSIVE DISPOSAL SITE.

1. Introduction. This memorandum reflects the consensus determination of the Dredged Material Management Program (DMMP) agencies (U.S. Army Corps of Engineers, Washington State Department of Ecology, Washington State Department of Natural Resources, and the Environmental Protection Agency) regarding the suitability of up to 20,250 cubic yards (cy) of dredged material from the Duwamish Yacht Club for open-water disposal at the Elliott Bay non-dispersive site.

2. Background. The Duwamish Yacht Club is located along the Duwamish River, at approximately river mile 4.0 within the Lower Duwamish Superfund Site, see Figure 1. The Duwamish Yacht Club was constructed in 1977 and consists of a floating pier system with moorage slips for boats up to 50 feet in length. Due to rapid sedimentation in the marina, maintenance dredging has occurred periodically since 1977. The most recent dredging occurred in 1999 (DMMP, 1999). Build-up of sediment from the Hamm Creek stormwater culvert and from the Duwamish River since the last dredging cycle has reduced the operational depth of the marina to the point that maintenance dredging is necessary to restore full access to all the slips.

   Potential sources of contamination include the Hamm Creek culvert that discharges into the southwest portion of the marina, and historical contamination of the Duwamish River from past industrial uses.

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

Table 1. Project Summary

Project ranking	High
Proposed dredging volume	20,250 cy
Proposed dredging depth	-8 ft MLLW (no overdepth)
1st draft SAP received	October 12, 2012
Comments provided on 1st draft SAP	October 19, 2012
2nd draft SAP received	November 7, 2012
Comments provided on 2nd draft SAP	November 9, 2012
Final SAP received	November 12, 2012
SAP approved	November 13, 2012
Sampling dates	November 14 – 15, 2012

Draft data report received	May 24, 2013
Comments provided on draft report	May 31, 2013
Final data report received	August 27, 2013
EIM Study ID	DMMP-DUWYC-A-338-12
USACE Permit Application Number	not yet submitted
Recency Determination (high = 2 years)	November 2014

4. Project Ranking and Sampling Requirements. This project was ranked "high" by the DMMP agencies according to the guidelines set out in the User's Manual for areas of the Duwamish River downstream of station 254+00. In a high-ranked area the number of samples and analyses are calculated using the following guidelines (DMMP, 2013):
    - Maximum volume of sediment represented by each field sample = 4,000 cubic yards
    - Maximum volume of sediment represented by each analysis in the upper 4-feet of the dredging prism (surface sediment) = 4,000 cubic yards
    - Maximum volume of sediment represented by each analysis in the subsurface portion of the dredging prism = 12,000 cubic yards

    Due to shoaling greater than 4ft deep in the southern portion of the project area, this area was divided into one surface and two subsurface DMMUs (DMMUs 4, 5, and 6). The central and northern portions of the project area were divided into three surface DMMUs (DMMUS 1, 2, and 3), each represented by a composite of two sediment cores. See Figure 2 for surface DMMU layout and Figure 3 for subsurface DMMUs within the marina. The sampling coordinates and compositing information is presented in Table 2.

5. Sampling. Sampling took place November 14-15, 2012 with a Vibracore sampler. The approved SAP was followed to the extent possible, and all changes to core locations were made in consultation with the DMMO. All revised core locations remained within the boundaries of the DMMU. Core DC-6 was moved slightly to the north due the presence of several boats. A stiff sandy layer present at the sampling location for DC-8 prevented collection of material from the subsurface DMMU 6. Therefore, an additional core (DC-11) was collected with the boundaries of DMMU 6 in order to provide adequate horizontal representation. Z-samples were collected from each core and archived separately.

    One change to the SAP was made without coordination with the DMMO. Two cores were collected from location DC-10 and composited into DMMUs 4 and 6. The appropriate intervals of the cores were collected, but the additional material from the same core location slightly skewed the horizontal representativeness of the DMMUs. The DMMP agencies determined that this change was minor and did not affect the overall validity of the data.

6. Chemical Analysis. Analysis of conventionals and all standard DMMP COCs was conducted by Fremont Analytical. Dioxin analysis was conducted by Analytical Resources, Inc. The approved sampling and analysis plan (Kane Environmental, 2012) was followed, with the exceptions noted below, and quality control guidelines specified by the DMMP program were generally met.

The conventionals results showed that the material is predominantly sandy loam with some loam and sandy clay loam. Percent sand ranged from 49 – 79%, and fines from 21 – 51% . Total Organic Carbon (TOC) ranged from 1.64 – 2.65%.

Chemistry results showed exceedances of screening levels (SLs) in multiple DMMUs, see Table 3. Total Chlordane, dimethyl phthalate and butyl benzyl phthalate were above their respective screening levels in DMMU 4; and total chlordane and butyl benzyl phthalate were above the screening levels in DMMU 6. These are the two DMMUs closest to the Hamm Creek culvert, suggesting that the contamination originates from the Hamm Creek drainage. There were no SL exceedances of standard DMMP chemicals of concern in DMMUs 1, 2, 3, or 5.

Dioxin concentrations throughout the marina ranged from 4.1 to 20.94 parts per trillion (pptr) toxicity equivalents (TEQ, with U = ½ RL). Dioxin results and TEQ calculations are presented in Table 4. Stage IV validation was conducted for the 6 DMMUs, but not for the composited z-samples.

7. Sediment Exposed by Dredging. The sediment to be exposed by dredging must either meet the State of Washington Sediment Quality Standards (SQS) (Ecology, 1995) or the State's antidegradation standard (DMMP, 2008).

DMMUs 4,5, & 6 - Due to the SL exceedances in surface DMMU 4 and subsurface DMMU 6, z-sample analysis of cores DC-10 and DC-11 were required by the DMMP agencies. Only those chemicals with SL exceedances were analyzed in the z-samples. Total chlordane was below the SL and lower than the surface DMMU concentrations in both cores. However, z-sample dimethyl phthalate was less than the surface, but still above the SL in DC-11, and concentrations of butyl benzyl phthalate in both DC-10 and DC-11 were higher than the surface DMMU and above the SL.

Due to the high level of dioxin found in DMMU 4, a composite z-sample from the four cores comprising DMMU 4 (DC 7, 8, 10, 11) was analyzed to determine whether the exposed surface was degraded relative to current surface conditions. The results of the z-sample analysis for dioxin are presented in Table 5. Although the result for the z-sample composite (13.66 pptr TEQ) was less than the surface DMMU (20.94 pptr TEQ), it is nevertheless greater than 10 pptr TEQ (the upper threshold of what is allowed for disposal at the DMMP disposal site).

In the absence of overriding data from bioassays and dioxin bioaccumulation testing, the area beneath DMMU 4 does not pass anti-degradation. The Duwamish Yacht Club chose not to pursue biological testing, thus the entire area beneath DMMU 4 will have to be overdredged and covered with a 12 inch layer of clean sand.

DMMU 1, 2 & 3 – Given that dioxin in the z-sample composite for DMMU 4 (13.66 pptr TEQ) was elevated relative to dioxin observed in the overlying subsurface DMMUs 5 & 6 (6.43 and 10.73 pptr TEQ, respectively), the DMMP agencies required that dioxin be analyzed in the remaining z-samples from the rest of the marina (Table 5).

A composite of z-samples DC-1 & 2 (DMMU 1) and a second composite of z-samples DC-3,4,5,& 6 (DMMU 2 & 3) were quantitated at 9.07 and 11.07 pptr TEQ, respectively. Given the bioaccumulative nature of dioxin, and the fact that the organisms exposed to dioxin live within an area larger than a single DMMU, the DMMP agencies determined that it was appropriate to average the dioxin concentration of the two z-sample composites to determine anti-degredation for the combined area of DMMUs 1, 2, and 3. The average dioxin concentration in the z-layer of DMMU 1, 2 & 3 (10.07 pptr TEQ) is slightly higher than the current average surface dioxin concentration (DMMU 1 to 4) 9.01 pptr TEQ and is similar to the upper bound concentration (11 pptr TEQ) associated with background dioxin concentrations in Puget Sound (DMMP, 2009).

Therefore, using best professional judgment, and in particular, considering that the differences in the current surface/post-dredge surface dioxin averages are within the range of analytical uncertainty, the DMMP agencies determined that the sediment surface to be exposed after dredging DMMUs 1, 2, and 3 passes anti-degradation.

8. Suitability Determination. This memorandum documents the evaluation of the suitability of sediment proposed for dredging from the Duwamish Yacht Club for open-water disposal at the Elliott Bay non-dispersive disposal site. The approved sampling and analysis plan was followed. The data gathered were deemed sufficient and acceptable for regulatory decision-making under the DMMP program.

With respect to the standard DMMP COCs, DMMUs 4 and 6 have SL exceedances that would require bioassay testing. However, the Duwamish Yacht Club chose not to pursue biological testing due to the presence of elevated dioxin concentrations in these same DMMUs. There for the material represented by DMMUs 4 and 6 are not suitable for open-water disposal.

Dioxin concentrations in the remaining DMMUs (1,2,3 and 5) were at or above 4 pptr TEQ, such that the volume-weighted-average was greater than maximum for open-water disposal. However, after reviewing the validated dioxin data for DMMUs 2 and 3, the DMMP agencies determined that these two DMMUs, with dioxin concentrations of 4.155 and 4.23 pptr TEQ (with U = 1.2 RL), were within the analytical uncertainty of 4 pptr TEQ, and therefore are eligible for open-water disposal (per Case-by-Case Determinations, DMMP, 2010). The remaining DMMUs, 5 and 1, are unsuitable for open-water disposal based on their dioxin concentrations (both exceeding 6 pptr TEQ).

In summary, based on the results of the previously described testing, the DMMP agencies conclude that 7,900 cy from DMMUs 2 and 3 are suitable for open-water disposal at the Elliott Bay non-dispersive site. The remaining 12,350 cy from DMMUs 1, 4, 5, and 6 are unsuitable for open-water disposal at the Elliott Bay non-dispersive site and must be disposed at an approved upland location.

This suitability determination does ***not*** constitute final agency approval of the project. During the public comment period that follows a public notice, the resource agencies will provide input on the overall project. A final decision will be made after full consideration of agency input, and after an alternatives analysis is done under section 404(b)(1) of the Clean Water Act.

A pre-dredge meeting with DNR, Ecology and the Corps of Engineers is required at least 7 days prior to dredging. A dredging quality control plan must be developed and submitted to the Regulatory Branch of the Seattle District Corps of Engineers at least 7 days prior to the pre-dredge meeting. A DNR site use authorization must also be acquired.

9. References.

DMMP, 2013. *Dredged Material Evaluation and Disposal Procedures (Users Manual)*. Prepared by the Seattle District Dredged Material Management Office for the Dredged Material Management Program, July 2013.

DMMP, 2010. *Dredged Material Management Program New Interim Guidelines for Dioxins*. December 6, 2010.

DMMP, 2009. OSV Bold Summer 2008 Survey: Final Data Report. Prepared by The Dredged Material Management Program, June 25, 2009.

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, 1999. *Determination on the suitability of proposed maintenance dredged material from the Duwamish Yacht Club dredging project (1998-2-02213) evaluated under Section 404 of the Clean Water Act (CWA) for open-water disposal at the Elliott Bay disposal site,* 18 May, 1999.

Ecology, 1995. *Sediment Management Standards – Chapter 173-204 WAC*. Washington State Department of Ecology, December 1995.

Kane Environmental, 2012. *Sampling and Analysis Plan: Duwamish Yacht Club, Duwamish River, Seattle, WA.* November 12, 2012.

10. Agency Signatures.

The signed document is on file in the Dredged Material Management Office.

Concur:

Date	Kelsey van der Elst - Seattle District Corps of Engineers
Date	Erika Hoffman - Environmental Protection Agency
Date	Laura Inouye, Ph.D. - Washington Department of Ecology
Date	Celia Barton - Washington Department of Natural Resources

Copies furnished:

DMMP signatories

Jacalen Printz, Corps Regulatory PM

Mike Canan, Duwamish Yacht Club

John Kane, Kane Environmental

Eric Nassau, Kane Environmental

Table 2. Sampling and Compositing.

		Coordinates (NAD 83)								
		Latitude	Longitude	DMMU 1	DMMU 2	DMMU 3	DMMU 4	DMMU 5	DMMU 6	Total
	SAP volume (CY):			3,900	4,000	3,900	3,450	2,325	2,675	20,250
Station	DC-1	47.52032	-122.30824	-5.3 to -8						
	DC-2	47.52003	-122.30776	-5.7 to -8						
	DC-3	47.51966	-122.30775		-4.8 to -8					
	DC-4	47.51923	-122.30745		-3.6 to -8					
	DC-5	47.51926	-122.30778			-5.2 to -8				
	DC-6	47.51954	-122.30839			-5.6 to -8				
	DC-7	47.51886	-122.30725				-3.4 to -6	-6 to -8		
	DC-8	47.51874	-122.30800				-1.5 to -6			
	DC-9	47.51913	-122.30725					-6 to -8		
	DC-10	47.51902	-122.30792				-5.6 to -6		-6 to -8	
	DC-10 rep	47.51902	-122.30792				-5.6 to -6		-6 to -8	
	DC-11	47.51879	-122.30768						-6 to -8	

Notes:

1) The design depth for DMMUs 1-3, 5,6 is -8 feet MLLW, with no overdepth.

2) The design depth for DMMU-4 is -6 feet MLLW; with no overdepth

Table 3. Chemical results compared to DMMP regulatory guidelines.

CHEMICAL	SL	BT	ML	DMMU 1		DMMU 2		DMMU 2 duplicate		DMMU 3		DMMU 4		DMMU 5		DMMU 6		z-sample DC-10		z-sample DC-11	
CONVENTIONALS				conc	LQ	conc	LQ	conc	LQ	conc	LQ	conc	LQ	conc	LQ	conc	LQ	conc	LQ	conc	LQ
Gravel, %				---		---		---		---		---		---		---					
Sand, %				62.1		48.9		43.7		56.3		79.2		60		69.5					
Silt, %				14.9		33.9		29.9		21		9		20.8		11.7					
Clay, %				23		17.2		26.4		22.7		11.8		19.2		18.8					
Fines (Silt + Clay), %				37.9		51.1		56.3		43.7		20.8		40		30.5					
Total Solids, %				43.6		46.3		46.6		40.2		61.2		50.2		41.4					
Volatile Soilids, %				7.5		8.76		9.92		5.44		7.56		8.4		9.18					
Total Organic Carbon, %				2.48		2.1		2.04		2.39		1.64		1.55		2.65					
Total Sulfides, mg/kg				1.11	U	3.35		1.1	U	1.18	U	0.87	U	1	U	1.22	U				
Total Ammonia, mg N/kg				164		147		158		153		74.8		138		161					
METALS (mg/kg dry)																					
Antimony	150	---	200	0.269	J	0.215	J	0.16	J	0.216	J	0.312	J	0.145	J	0.267	J				
Arsenic	57	507	700	13	J	13.4	J	12.1	J	14.3	J	9.27	J	11.3	J	15	J				
Cadmium	5.1	11.3	14.0	0.297	J	0.228	J	0.239	J	0.288	J	0.358		0.247	J	0.349					
Chromium	260	260	---	30.1		28.9		28.6		33		79.1		27.2		42.8					
Copper	390	1,027	1,300	49.8		43.2		43.5		56.4		49.8		40.7		62.5					
Lead	450	975	1,200	18		14.3		14.9		17.6		35.4		14.7		24.1					
Mercury	0.41	1.5	2.3	0.119	J	0.127	J	0.138	J	0.129	J	0.0677	J	0.0809	J	0.126	J				
Selenium	---	3	---	0.915		0.931		0.844		0.606	J	0.519	J	0.515	J	0.477	J				
Silver	6.1	6.1	8.4	0.144	J	0.119	J	0.121	J	0.136	J	0.0846	J	0.1	J	0.155	J				
Zinc	410	2,783	3,800	110		101		100		119		347		107		182					
ORGANOMETALLIC COMPOUNDS (ug/L interstitial water)																					
Tributyltin (ion)	0.15	0.15	---																		
PAHs (ug/kg dry)																					
Total LPAH	5,200	---	29,000	74.42	J	115.99		118.07		253.5		319.68		164.4	J	185.6	J				
Naphthalene	2,100	---	2,400	8.09	J	10.9	J	12	J	18	J	23.3	J	12.5	J	16.1	J				
Acenaphthylene	560	---	1,300	4.11	J	7.5	J	6.54	J	26.3	J	107		10.3	J	10.5	J				
Acenaphthene	500	---	2,000	5.14	J	6.59	J	8.63	J	29.6	J	9.98	J	10.3	J	13.2	J				
Fluorene	540	---	3,600	8.48	J	12.4	J	11.3	J	23.5	J	20.2	J	15	J	15.6	J				
Phenanthrene	1,500	---	21,000	35.7	J	59.2		55.2		84.2		113		84.3	J	93.6	J				
Anthracene	960	---	13,000	12.9	J	19.4	J	24.4	J	71.9		46.2		32	J	36.6	J				
2-Methylnaphthalene	670	---	1,900	6.96	J	10.7	J	11.5	J	12.9	J	10.8	J	11.9		13.2					
Total HPAH	12,000	---	69,000	453.44	J	598.22	J	652.92	J	1454.9	J	2036.7	J	989.4	J	1142.8	J				
Fluoranthene	1,700	4,600	30,000	100	J	136	J	156	J	403	J	471	J	228	J	219	J				
Pyrene	2,600	11,980	16,000	102	J	134	J	133	J	336	J	419	J	221	J	248	J				
Benzo(a)anthracene	1,300	---	5,100	25.7	J	33	J	40.5	J	107	J	132	J	59.3	J	67.5	J				
Chrysene	1,400	---	21,000	44.1	J	61.9	J	67.1	J	151	J	190	J	98.1	J	117	J				
Total benzofluoranthenes	3,200	---	9,900	92.5	J	112.2	J	125.2	J	252.2	J	398.4	J	189.7	J	243.2	J				
Benzo[a]pyrene	1,600	---	3,600	36.1	J	48	J	53.5	J	98.3	J	189	J	81.9	J	105	J				
Indeno(1,2,3-c,d)pyrene	600	---	4,400	19.7	J	27.8	J	30	J	42.2	J	92.7	J	43.1	J	55.3	J				
Dibenzo(a,h)anthracene	230	---	1,900	5.04	J	7.12	J	7.52	J	11.1	J	23.6	J	10.5	J	13.8	J				
Benzo(g,h,i)perylene	670	---	3,200	28.3	J	38.2	J	40.1	J	54.1	J	121	J	57.8	J	74	J				

CHEMICAL	SL	BT	ML	DMMU 1	DMMU 2	DMMU 2 duplicate	DMMU 3	DMMU 4	DMMU 5	DMMU 6	z-sample DC-10	z-sample DC-11
CHLORINATED BENZENES (ug/kg dry)												
1,2-Dichlorobenzene	35	---	110	2.82 U	2.91 U	3.15 U	3.22 U	2.47 U	2.86 U	3.49 U		
1,4-Dichlorobenzene	110	---	120	2.94 U	3.03 U	3.28 U	3.36 U	2.57 U	2.97 U	3.64 U		
1,2,4-Trichlorobenzene	31	---	64	2.35 U	2.43 U	2.63 U	2.69 U	2.06 U	2.39 U	2.92 U		
Hexachlorobenzene	22	168	230	3.22 U	3.32 U	3.6 U	3.68 U	2.81 U	3.26 U	3.98 U		
PHTHALATE ESTERS (ug/kg dry)												
Dimethyl phthalate	71	---	1,400	14 J	10.1 J	10.7 J	27.3 J	237	45.5	33.9	55	173
Diethyl phthalate	200	---	1,200	15.2 J	26.2 J	50.7 J	48.5 J	24.5 J	39.3 J	42.1 J		
Di-n-butyl phthalate	1,400	---	5,100	19.9 J	27.5 J	54.3 J	46.6 J	35.7 J	44.1 J	45.5 J		
Butyl benzyl phthalate	63	---	970	18 J	28.7 J	32.7 J	41.9	74.5	37.6	211	183	389
Bis(2-ethylhexyl)phthalate	1,300	---	8,300	104	317	170	294	636	279	418		
Di-n-octyl phthalate	6,200	---	6,200	3.79 J	249	5.79 J	10.1 J	29.5 J	7.6 J	20.9 J		
PHENOLS (ug/kg dry)												
Phenol	420	---	1,200	36.8 J	46.4 J	68.7 J	64.5 J	51.9 J	59.4 J	69 J		
2 Methylphenol	63	---	77	3.83 J	4.19 J	6.16 J	31.9 J	21.9 J	5.36 J	10.4 J		
4 Methylphenol	670	---	3,600	11 J	26.9 J	32.9 J	30.9 J	24.9 J	29.4 J	31.3 J		
2,4-Dimethylphenol	29	---	210	4.57 U	4.72 U	5.11 U	5.23 U	4 U	4.64 U	5.67 U		
Pentachlorophenol	400	504	690	6.07 J	4.32 U	4.68 U	4.88 J	16.6 J	4.24 U	25.5 J		
MISCELLANEOUS EXTRACTABLES (ug/kg dry)												
Benzoic acid	650	---	760	168	243	315	285	262	220	239		
Benzyl alcohol	57	---	870	4.51 U	4.65 U	5.04 J	5.15 U	3.94 U	4.57 U	5.58 U		
Dibenzofuran	540	---	1,700	8.28 J	12 J	11.1 J	19 J	16.5 J	13.9 J	14.8 J		
Hexachlorobutadiene	11	---	270	4.74 U	4.89 U	5.3 U	5.42 U	4.15 U	4.81 U	5.88 U		
N-Nitrosodiphenylamine	28	---	130	3.45 U	3.56 U	3.86 U	3.94 U	3.02 U	3.5 U	4.27 U		
PESTICIDES (ug/kg dry)												
Aldrin	9.5	---	---	0.0208 U	0.0201 U	0.0201 U	0.0218 U	0.0157 U	0.0192 U	0.0244 U		
Total Chlordane	2.8	37	---	2.08	1.68	1.31	2.11	5.59	1.82	2.93	2.07 J	2.22 J
Dieldrin	1.9	---	---	0.0299 U	0.0288 U	0.0289 U	0.0313 U	0.0226 U	0.0275 U	0.035 U		
Heptachlor	1.5	---	---	0.156 U	0.151 U	0.151 U	0.164 U	0.118 U	0.144 U	0.183 U		
p,p'-DDE	9	---	---	5.02	4.82	4.51	5.61	7.74	5.17	8.83		
p,p'-DDD	16	---	---	0.0887 U	0.0854 U	0.0858 U	0.093 U	0.093 U	0.0816 U	0.106 U		
p,p'-DDT	5	---	---	0.0798 U	0.0768 U	0.0772 U	0.0837 U	0.0603 U	0.0734 U	0.0934 U		
Total DDT		50	69	5.02	4.82	4.51	5.61	7.74	5.17	8.83		
PCBs (ug/kg dry)												
Total PCBs	130	---	3,100	91	55	46	65	92	57	83		
Total PCBs (mg/kg OC)	---	38	---	3.66	2.63	2.23	2.74	5.61	3.66	3.12		
DMMP DETERMINATION												
DMMU volume				3900	4000		3900	3450	2325	2675		
Rank				high	high	high	high	high	high	high		
Mean sample depth												
Maximum sampling depth												
	SL	BT	ML	DMMU 1	DMMU 2	DMMU 2 duplicate	DMMU 3	DMMU 4	DMMU 5	DMMU 6	z-sample DC-10	z-sample DC-11

J = estimated concentration
U = undetected
OC = organic carbon
SL = screening level
BT = bioaccumulation trigger
ML = maximum level

Table 4. Dioxin results

CHEMICAL	TEF	DMMU 1				DMMU 2				DMMU 2 duplicate				DMMU 3			
DIOXINS/FURANS		conc	VQ	TEQ (U = 0)	TEQ (U = 1/2 RL)	conc	VQ	TEQ (U = 0)	TEQ (U = 1/2 RL)	conc	VQ	TEQ (U = 0)	TEQ (U = 1/2 RL)	conc	VQ	TEQ (U = 0)	TEQ (U = 1/2 RL)
1,2,3,4,6,7,8-HpCDD	0.01	128		1.28	1.28	86.3		0.863	0.863	83.7		0.837	0.837	89.2		0.892	0.892
1,2,3,4,6,7,8-HpCDF	0.01	21.2		0.212	0.212	13.7		0.137	0.137	15.8		0.158	0.158	14		0.14	0.14
1,2,3,4,7,8,9-HpCDF	0.01	1.71	J	0.0171	0.0171	1	JEMPC	0	0.005	1.32	J	0.0132	0.0132	1.12	JEMPC	0	0.0056
1,2,3,4,7,8-HxCDD	0.1	1.67	J	0.167	0.167	1.25	J	0.125	0.125	1.12	J	0.112	0.112	1.23	J	0.123	0.123
1,2,3,4,7,8-HxCDF	0.1	2.44		0.244	0.244	1.45	J	0.145	0.145	1.51	J	0.151	0.151	1.62	J	0.162	0.162
1,2,3,6,7,8-HxCDD	0.1	5.7		0.57	0.57	3.91		0.391	0.391	3.84		0.384	0.384	3.78		0.378	0.378
1,2,3,6,7,8-HxCDF	0.1	1.29	J	0.129	0.129	0.8	J	0.08	0.08	0.732	JEMPC	0	0.0366	0.913	J	0.0913	0.0913
1,2,3,7,8,9-HxCDD	0.1	4.93		0.493	0.493	3.04		0.304	0.304	2.8		0.28	0.28	2.84		0.284	0.284
1,2,3,7,8,9-HxCDF	0.1	0.659	J	0.0659	0.0659	0.416	J	0.0416	0.0416	0.396	J	0.0396	0.0396	0.387	JEMPC	0	0.01935
1,2,3,7,8-PeCDD	1	2.12		2.12	2.12	1.26		1.26	1.26	1.35		1.35	1.35	1.3		1.3	1.3
1,2,3,7,8-PeCDF	0.03	0.563	BJX	0.01689	0.01689	0.406	BJX	0.01218	0.01218	0.378	BJ	0.01134	0.01134	0.402	BJ	0.01206	0.01206
2,3,4,6,7,8-HxCDF	0.1	1.83	J	0.183	0.183	1.22	JEMPC	0	0.061	1.14	J	0.114	0.114	1.13	J	0.113	0.113
2,3,4,7,8-PeCDF	0.3	0.866	J	0.2598	0.2598	0.585	J	0.1755	0.1755	0.49	JEMPC	0	0.0735	0.561	JEMPC	0	0.08415
2,3,7,8-TCDD	1	1.08	BEMPC	0	0.54	0.557	BJEMPC	0	0.2785	0.565	BJEMPC	0	0.2825	0.67	BJEMPC	0	0.335
2,3,7,8-TCDF	0.1	0.798	J	0.0798	0.0798	0.432	J	0.0432	0.0432	0.432	J	0.0432	0.0432	0.493	J	0.0493	0.0493
OCDD	0.0003	1090		0.327	0.327	739		0.2217	0.2217	654		0.1962	0.1962	746		0.2238	0.2238
OCDF	0.0003	66		0.0198	0.0198	37.4		0.01122	0.01122	62.8		0.01884	0.01884	42.9		0.01287	0.01287
TOTAL TEQ				6.18	6.72			3.810	4.155			3.708	4.101			3.78	4.23

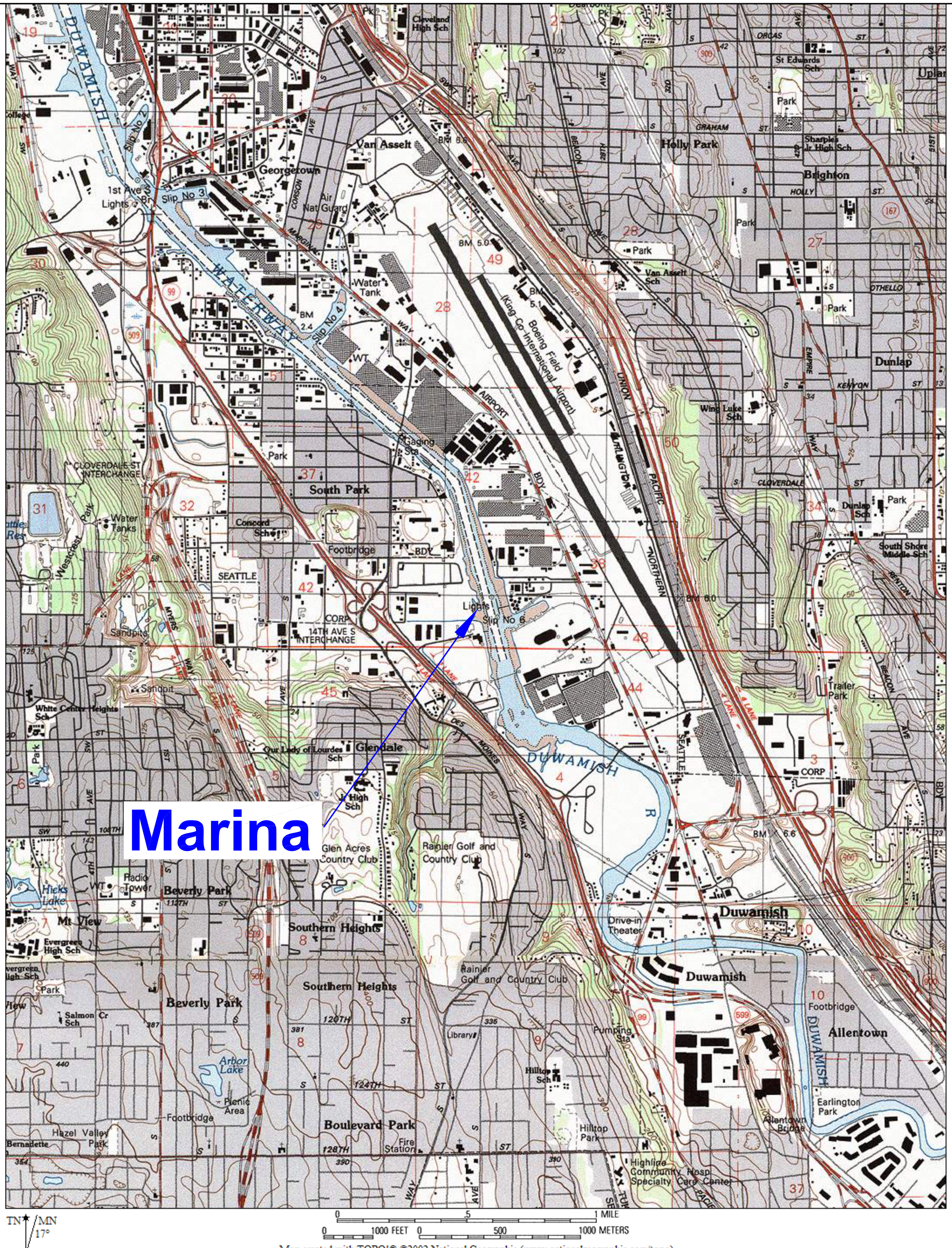
CHEMICAL	TEF	DMMU 4				DMMU 5				DMMU 6			
DIOXINS/FURANS		conc	VQ	TEQ (U = 0)	TEQ (U = 1/2 RL)	conc	VQ	TEQ (U = 0)	TEQ (U = 1/2 RL)	conc	VQ	TEQ (U = 0)	TEQ (U = 1/2 RL)
1,2,3,4,6,7,8-HpCDD	0.01	215		2.15	2.15	102		1.02	1.02	174		1.74	1.74
1,2,3,4,6,7,8-HpCDF	0.01	24		0.24	0.24	17		0.17	0.17	24.9		0.249	0.249
1,2,3,4,7,8,9-HpCDF	0.01	1.91	J	0.0191	0.0191	1.38	J	0.0138	0.0138	1.99	J	0.0199	0.0199
1,2,3,4,7,8-HxCDD	0.1	3.77		0.377	0.377	1.47	J	0.147	0.147	2.47		0.247	0.247
1,2,3,4,7,8-HxCDF	0.1	2.91		0.291	0.291	1.88	J	0.188	0.188	2.86		0.286	0.286
1,2,3,6,7,8-HxCDD	0.1	14.1		1.41	1.41	5.1		0.51	0.51	8.56		0.856	0.856
1,2,3,6,7,8-HxCDF	0.1	1.67	J	0.167	0.167	0.936	J	0.0936	0.0936	1.46	J	0.146	0.146
1,2,3,7,8,9-HxCDD	0.1	14.1		1.41	1.41	4.34		0.434	0.434	7.76		0.776	0.776
1,2,3,7,8,9-HxCDF	0.1	1.11	J	0.111	0.111	0.553	J	0.0553	0.0553	0.766	J	0.0766	0.0766
1,2,3,7,8-PeCDD	1	9.02		9.02	9.02	2.28		2.28	2.28	3.71		3.71	3.71
1,2,3,7,8-PeCDF	0.03	0.921	JX	0.02763	0.02763	0.456	BJ	0.01368	0.01368	0.684	JEMPC	0	0.01026
2,3,4,6,7,8-HxCDF	0.1	2.46		0.246	0.246	1.35	J	0.135	0.135	2.13		0.213	0.213
2,3,4,7,8-PeCDF	0.3	1.1		0.33	0.33	0.602	J	0.1806	0.1806	0.984	J	0.2952	0.2952
2,3,7,8-TCDD	1	4.57		4.57	4.57	0.895	BJ	0.895	0.895	1.57		1.57	1.57
2,3,7,8-TCDF	0.1	0.903	J	0.0903	0.0903	0.47	J	0.047	0.047	0.744	J	0.0744	0.0744
OCDD	0.0003	1550		0.465	0.465	769		0.2307	0.2307	1500		0.45	0.45
OCDF	0.0003	50.7		0.01521	0.01521	48.4		0.01452	0.01452	73		0.0219	0.0219
TOTAL TEQ				20.94	20.94			6.43	6.43			10.73	10.74

J = estimate concentration
B = blank contamination
EMPC = estimate maximum possible conc.
X = PBDE interference
Dioxin 4 - 10 pptr TEQ
Dioxin > 10 pptr TEQ

Table 5. Dioxin z-sample results

CHEMICAL	TEF	Z-Sample Composite 1,2				Z-Sample Composite 3,4,5,6				Z-Sample Composite 7,9,10,11			
DIOXINS/FURANS		conc	LQ	TEQ (U = 0)	TEQ (U = 1/2 RL)	conc	LQ	TEQ (U = 0)	TEQ (U = 1/2 RL)	conc	VQ	TEQ (U = 0)	TEQ (U = 1/2 RL)
1,2,3,4,6,7,8-HpCDD	0.01	178		1.78	1.78	220		2.2	2.2	225		2.25	2.25
1,2,3,4,6,7,8-HpCDF	0.01	25.8		0.258	0.258	28		0.28	0.28	42.4		0.424	0.424
1,2,3,4,7,8,9-HpCDF	0.01	2.48		0.0248	0.0248	2.37		0.0237	0.0237	2.9		0.029	0.029
1,2,3,4,7,8-HxCDD	0.1	2.42		0.242	0.242	2.59		0.259	0.259	2.85		0.285	0.285
1,2,3,4,7,8-HxCDF	0.1	3.58		0.358	0.358	3.55		0.355	0.355	3.75		0.375	0.375
1,2,3,6,7,8-HxCDD	0.1	7.85		0.785	0.785	9.62		0.962	0.962	10.7		1.07	1.07
1,2,3,6,7,8-HxCDF	0.1	1.71	EMPC	0	0.0855	1.81		0.181	0.181	1.97		0.197	0.197
1,2,3,7,8,9-HxCDD	0.1	5.84		0.584	0.584	7.81		0.781	0.781	9.86		0.986	0.986
1,2,3,7,8,9-HxCDF	0.1	1.03		0.103	0.103	0.859	J	0.0859	0.0859	0.966	JEMPC	0	0.0483
1,2,3,7,8-PeCDD	1	2.58		2.58	2.58	3.28		3.28	3.28	4.8		4.8	4.8
1,2,3,7,8-PeCDF	0.03	0.803	J	0.02409	0.02409	0.805	JX	0.02415	0.02415	0.894	JX	0.02682	0.02682
2,3,4,6,7,8-HxCDF	0.1	1.14		0.114	0.114	1.38	EMPC	0	0.069	1.74		0.174	0.174
2,3,4,7,8-PeCDF	0.3	1.23		0.369	0.369	1.25		0.375	0.375	1.24		0.372	0.372
2,3,7,8-TCDD	1	1.22	B	1.22	1.22	1.49	B	1.49	1.49	1.93		1.93	1.93
2,3,7,8-TCDF	0.1	1.04		0.104	0.104	1.07		0.107	0.107	1.09		0.109	0.109
OCDD	0.0003	1380		0.414	0.414	1900		0.57	0.57	1790		0.537	0.537
OCDF	0.0003	77		0.0231	0.0231	78.2		0.02346	0.02346	145		0.0435	0.0435
TOTAL TEQ				8.98	9.07			11.00	11.07			13.61	13.66

J = estimate concentration
B = blank contamination
EMPC = estimate maximum possible concentration
X = PBDE interference
Dioxin 4 - 10 pptr TEQ
Dioxin > 10 pptr TEQ



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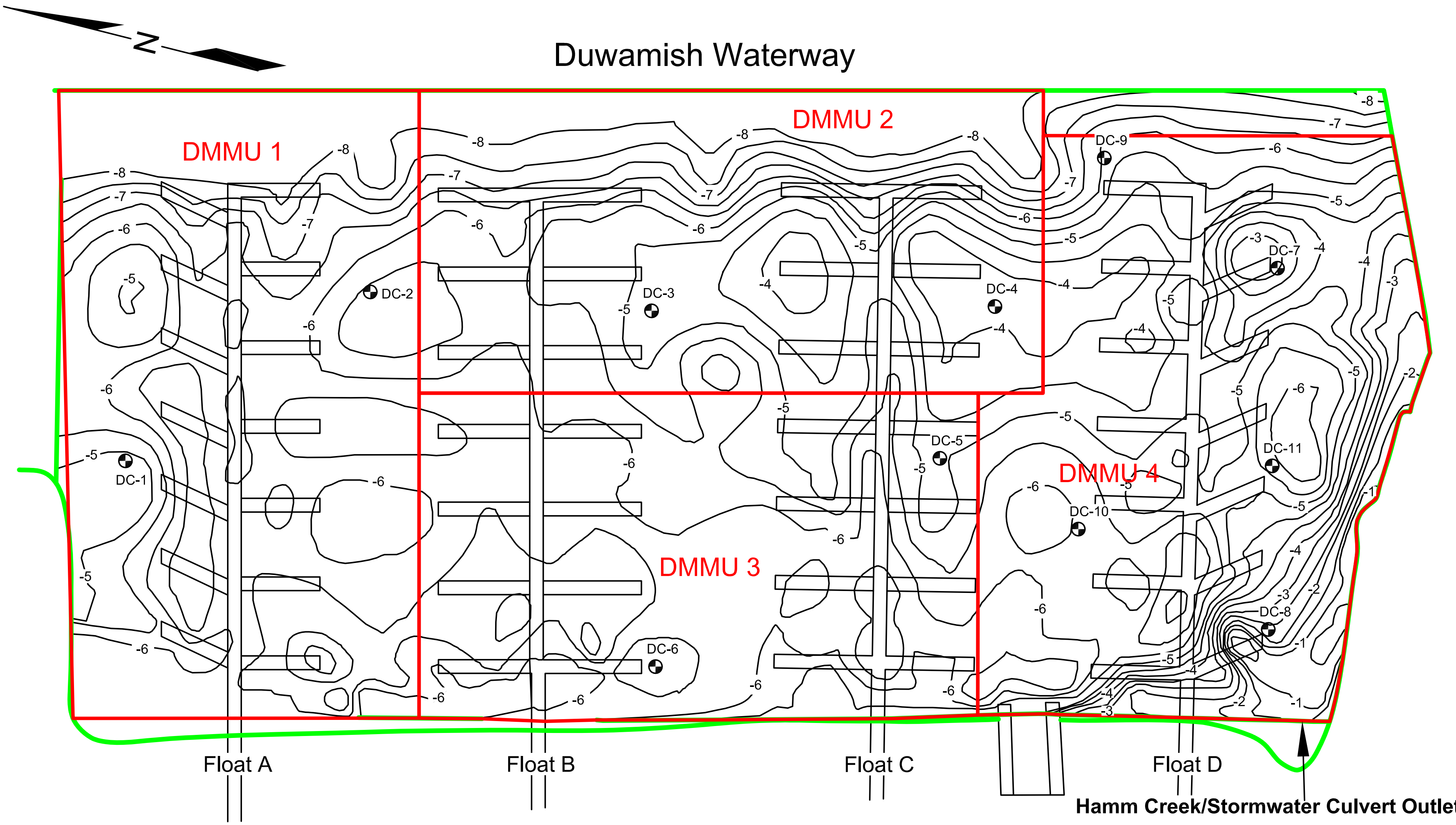
Sediment Characterization
Duwamish Yacht Club
Seattle, Washington

Figure 1
Vicinity Map



LEGEND

DMMU Extents

Location of Sediment Sample

Approximate Extents of Marina

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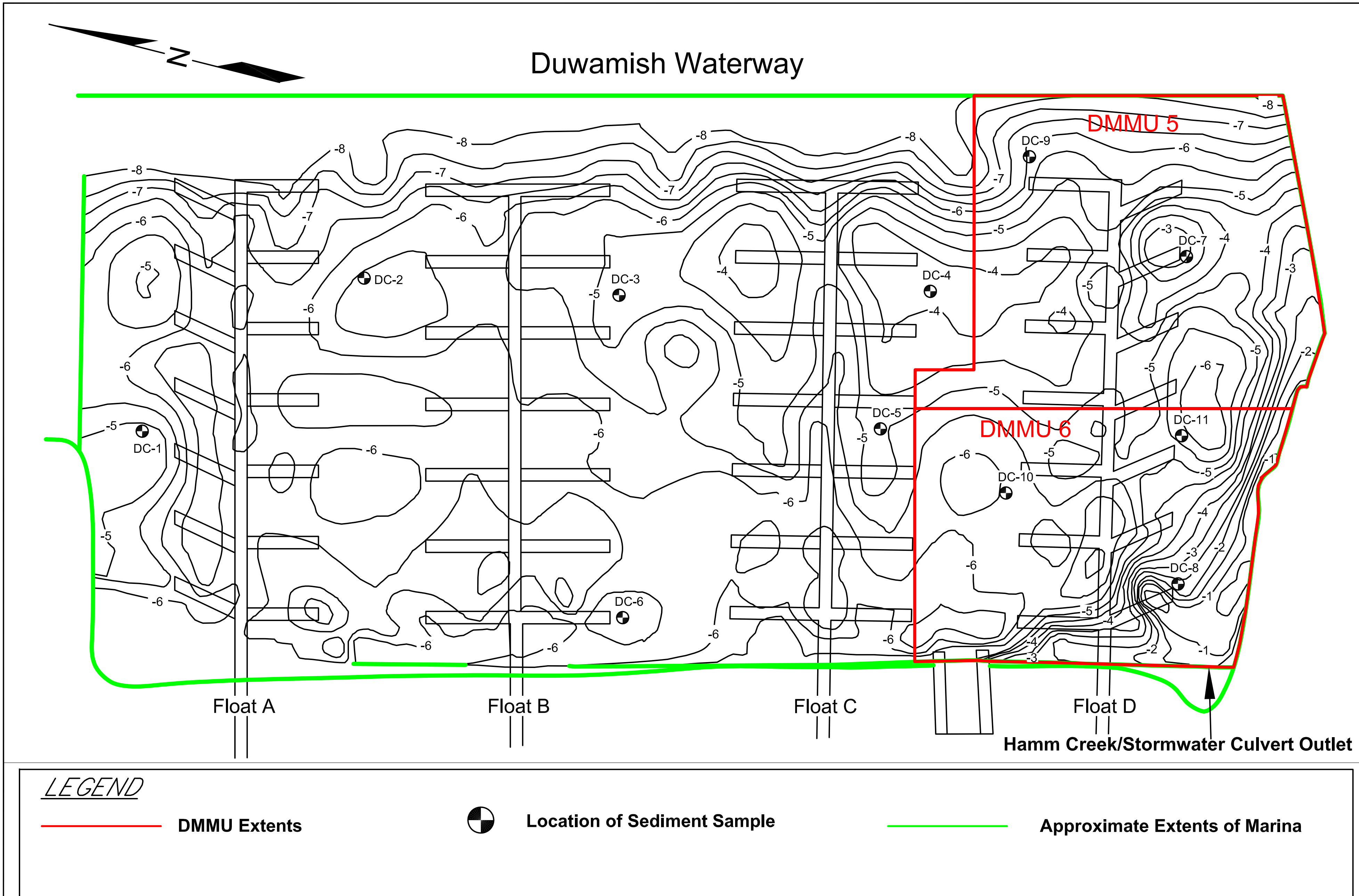
Sediment Characterization
Duwamish Yacht Club
Seattle, Washington

Figure 2
Surface Sediment DMMU's and
Sample Locations



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Duwamish Yacht Club
Seattle, Washington

Figure 3
Subsurface Sediment DMMU's and
Sample Locations