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WATER QUALITY REPORT

HYDRAULIC DREDGING AND THE EFFECT OF A METHOD OF SPOIL DISPOSAL ON WATER QUALITY AND JUVENILE SALMON SURVIVAL IN PORT GARDNER BAY, EVERETT, WASHINGTON

by

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ABSTRACT

The Washington State Department of Ecology instituted a study of the effects of hydraulic dredging on wate[illegible] the Port of Everett Hewitt Avenue Terminal project in October, [illegible]on to water quality parameters, toxicity to juvenile chinook salmon (O. tshawytscha) was investigated. The settling basin effluent weir contained a maximum of 0.21 ppb of mercury, a PBI of 41 mg/l, 18% volatile solids, and sulfides were not detected. The in-situ bioassay demonstrated no toxicity. Dissolved oxygen was depressed greater than 50% in the areas of dredging and supernatant return during sludge material removal.

SUMMARY

A study was conducted in Port Gardner Bay and Everett Harbor, Washington to evaluate a method of dredging and its impact on water quality. Approximately 260,000 cubic yards of sediment was to be removed by a cutter suction dredge and pumped into a 2-cell settling basin. The sediments were of two general types; coarse to fine sand and fine sludge-like material. Predredging conditions were determined and compared with receiving water conditions during actual dredging of the two sediment types. The physical parameters measured were conductivity, salinity, temperature, pH, dissolved oxygen, Pearl Benson Index, turbidity, sulfides, settleable solids, volatile solids, mercury, and transparency. Toxicity of the settling basin effluent to juvenile chinook salmon (O. tshawytscha) was also determined.

Dissolved oxygen levels during dredging fell below the State minimum water quality standards. Dissolved oxygen was reduced below predredge levels approximately 40% during coarse material dredging and 50% during the dredging of sludge-like materials. The area of maximum dissolved oxygen depression was in the immediate area of the dredge.

The dredging operation had a significant effect on the receiving waters. PBI values were lower during coarse material removal than during the predredge survey. PBI values increased 100 to 200% over predredging levels during the dredging of sludge-like material. Turbidity exceeded water quality criteria only in the area of the supernatant return from the settling

basins and within the immediate vicinity of the dredging operation. Secchi-disk measurements decreased by 50% in the same areas as turbidity. Mercury values during dredging were between 0.2 to 0.3 ppb. Total sulfides were not found in the receiving waters. Sulfide levels were as high as 8 mg/l at the spoil landing (Station 14) but decreased to 0 mg/l at the outlet weir (Station 12).

No significant mortalities to juvenile salmon were observed during the dredging activity. The juvenile salmon located closest to the spoil discharge demonstrated some distress when turbidity levels rose to 15 JTU's.

Conventional dredging and spoil disposal have been shown to have an adverse effect on water quality (1). However the effects can be significantly reduced if the spoil is disposed of on land in adequate settling basins with properly designed overflow weirs. The necessity of having a qualified and conscientious full-time resident engineer or inspector on such projects was also demonstrated.

INTRODUCTION

The objectives of the study described in this report were to determine the effects of a dredging project conducted by the Port Everett upon the water quality of Everett Harbor and Port Gardner Bay, and to provide background data in the development of guidelines for dredging and dredge spoil disposal.

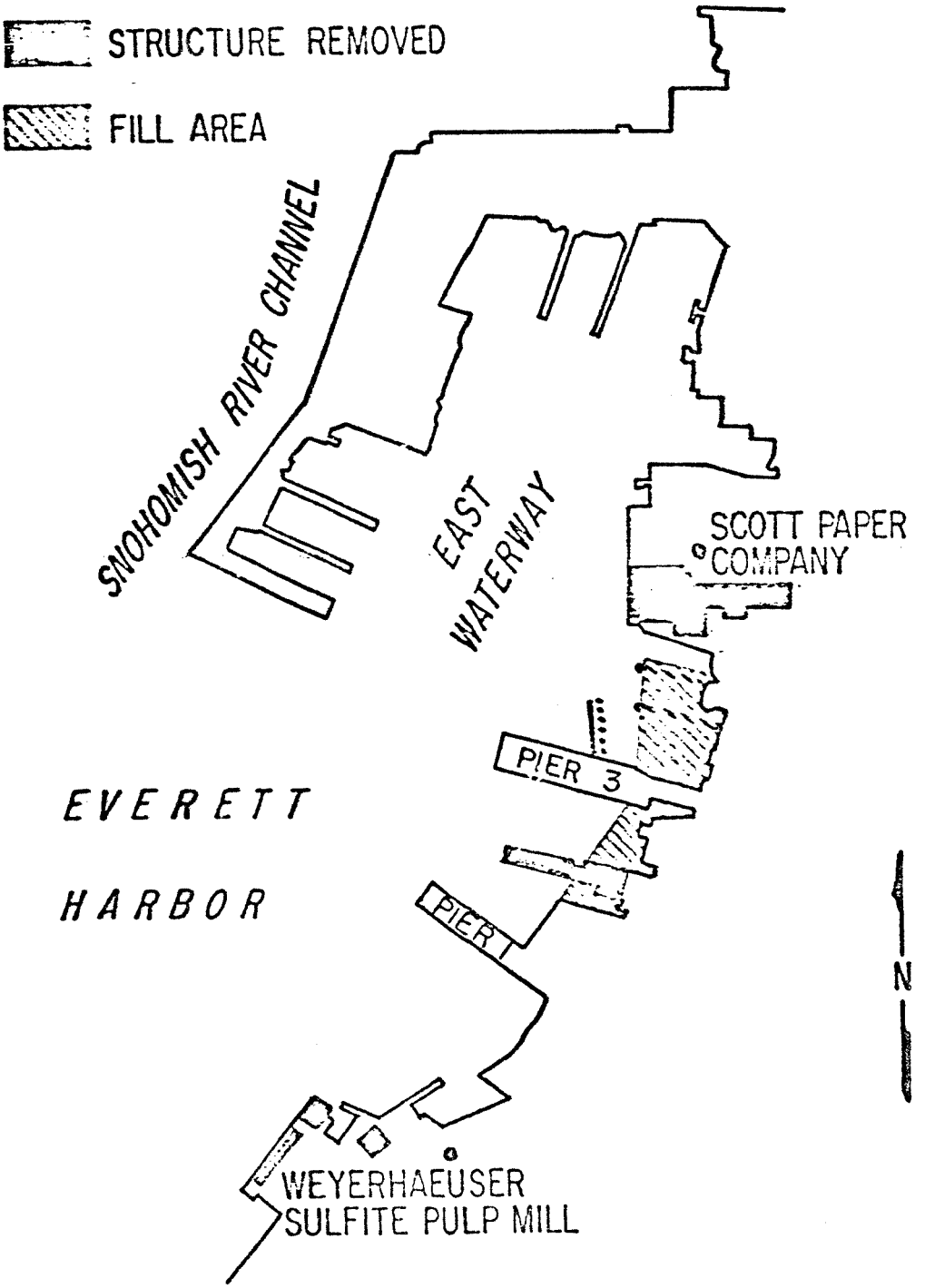

Figure 1. LOCATION OF PROJECT MODIFICATIONS TO HARBOR.

The purpose of the project was to expand the cargo handling and ship docking facilities at the Port of Everett's Hewitt Avenue Terminal (Figure 1, page 3). The project involved construction of settling basins on the north and south sides of Pier 3 (Figure 2, page 5) which would be filled with 260,000 cubic yards of dredge spoil to a maximum height of 20 feet above MLLW. Berthing areas on the north and south side of Pier 3 were dredged to 25 feet and 42 feet respectively below MLLW. The boundaries of the filled area will ultimately be faced with sheet piling to retard tidal errosion. Several existing piers and breakwaters were removed and a new, larger pier facility will be eventually constructed on the south side of Pier 3.

The dredging portion of the project was accomplished with a cutter suction type hydraulic dredge. The dredge had a pumping capability of 25,000 gallons per minute of water containing 15 to 18 percent solids. The dredge spoils were transported through a 24-inch floating pipeline to a two-cell settling basin with a 200-foot long effluent wier.

The U.S. Army Corps of Engineers Permit No. NPS-71-420, authorizing the Port of Everett to conduct the project, described the dredge material as consisting of sand, organic material and industrial waste.

METHODS

Water samples were collected at selected stations in the study area (Figure 2, page 5) prior to and during the dredging operation. Stations 1, 2, 3, 4,

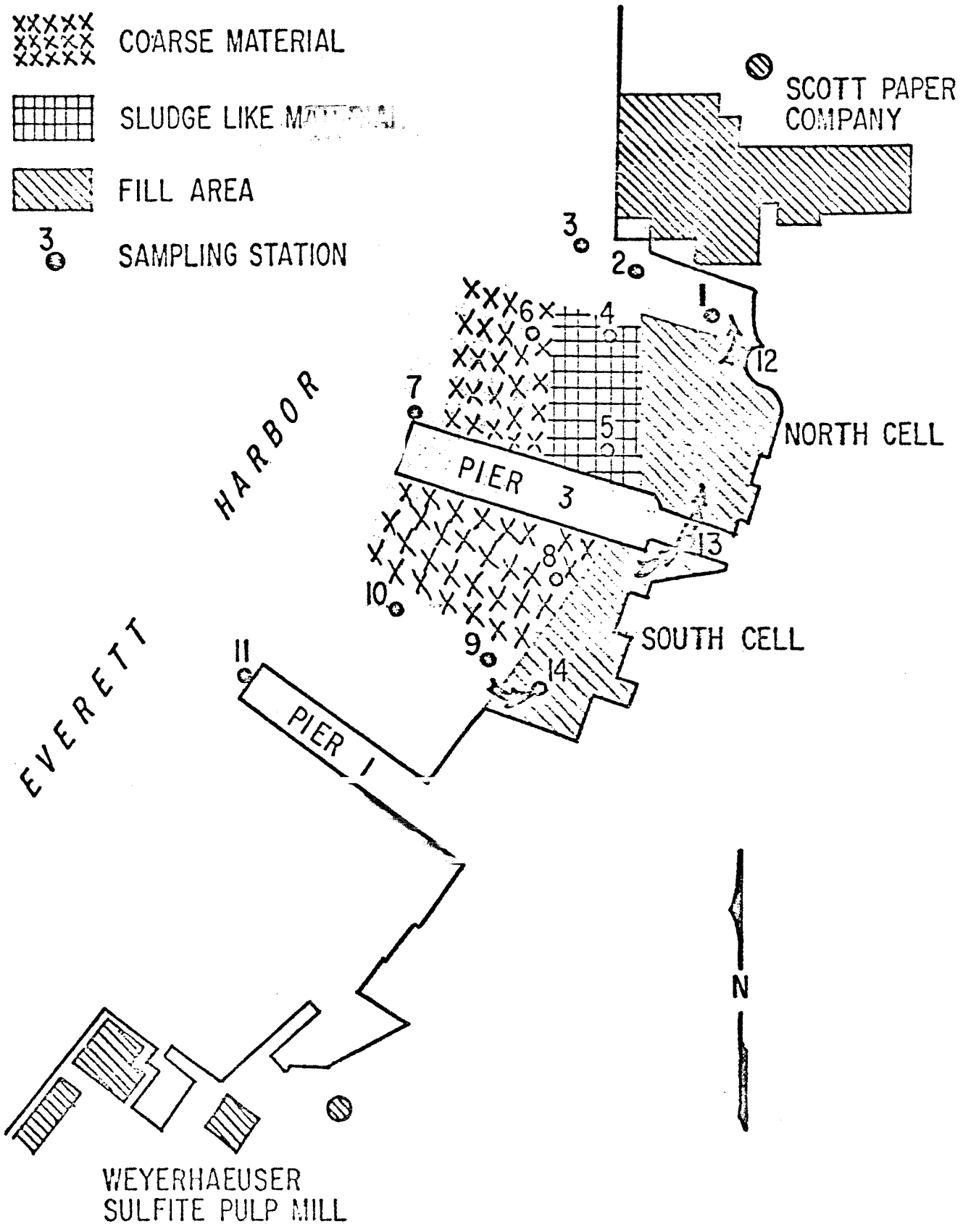

Figure 2. LOCATION OF STATIONS AND SEDIMENT TYPES

and 6 were located to provide information on the dilution of the supernatant discharged from the settling basin. Station 12, 13, and 14 provided information on the efficiency of the settling basin, and the remaining stations were used to determine the local effects of the dredges activity.

The receiving water stations were sampled at the 0.5 m (1.6 feet) and 4.0 m (13.1 feet) depths for conductivity, salinity, temperature, pH, dissolved oxygen, Pearl Benson Index (PBI) and turbidity. Samples were collected only at the 0.5m depth for total sulfides, settleable solids, percent volatile solids and mercury. Secchi-disk measurements for transparency were also taken. Samples collected in the settling basin were analysed for total sulfides, pH, settleable solids, percent volatile solids, turbidity, PBI and mercury.

Conductivity, salinity and temperature were determined in the field with a Beckman Model RF5-3 salinometer. A Leeds and Northrop Model 4866-60 field meter and a LaMotte Model 4630 field kit was used to measure pH and total sulfide respectively. An 8-inch secchi-disk was used to determine water transparency, and settleable solids were measured with standard Imhoff cones. Dissolved oxygen levels were determined using the Azide modification of the Winkler method. All other analyses were made at the Olympia or Redmond laboratories of the Department of Ecology.

In-situ bioassay measurements were made at Stations 1 thru 11 to determine the possible toxic effects of the dredging operation. The test organisms

were juvenile chinook salmon obtained from Dom-Sea Farms near Manchester, Washington. The test fish had an average weight of 16 grams and a mean length of 110 mm. The fish were transported by truck to the Everett Yacht Basin in 20-gallon nontoxic plastic containers filled with iced seawater. They were then transferred to a large holding pen after first being acclimated to ambient water temperatures. The fish were held for a minimum of 18 hours before being used for the bioassay tests.

Test fish were transferred to liveboxes made from sections of fiberglass pipe, 31 cm (12 inches) in diameter and 46 cm (18 inches) long (2). The open ends were covered with small mesh nylon netting held in place by bands of innertube. The boxes were equipped with two brass eye-bolts and snaps and were secured to boom logs or attached to anchored floats. Five fish were used at each bioassay station.

RESULTS

Predredging Study

The predredging study was conducted on the 15th and 16th of August, 1972. Tidal range during this period was 9.9 feet to 1.6 feet above MLLW. Dissolved oxygen was below 7 mg/l and above 6 mg/l while the PBI values ranged from 18 to 240 mg/l at Stations 1 thru 6 (Table 1, page 8). Stations (7, 8, 10, and 11) had an average DO above 7.0 mg/l and a PBI below 70 mg/l. Secchi-disk readings for all stations averaged 1.5 m (5 feet), while turbidity averaged 1 JTU. Total sulfides at all

Table 1. WATER QUALITY DATA OBSERVED PRIOR TO DREDGING

STA	DEPTH METERS	DISSOLVED OXYGEN mg/l	PBI mg/l	TURB JTU	SECCHI DISK METERS	VOLATILE SOLIDS (%)	Hg ppb	TOTAL SULFIDES mg/l
1	0.5	7.4	18	1	1.2	13	3.0	N.D.
		7.3	90	1	1.4	13		N.D.
		6.1	118	1	1.4	10		N.D.
		6.4	90	2	1.5	15		
		6.3	104	1	1.3	15		N.D.
			240	1	1.3	15	4.9	
2	0.5		63	1	1.5	12	1.4	
		6.9	95	1	1.8	14		N.D.
		6.9	95	1	1.5	17	1.6	N.D.
3	0.5		113	1	1.4		3.5	N.D.
		6.9	86	1	1.4	20		
		6.8	45	1	1.5	13		N.D.
			203	1	1.8	12	2.7	N.D.
4	0.5			1	1.5	14	2.1	N.D.
		6.4		2	1.4	16		N.D.
					1.5		2.1	
5	0.5		72		1.5		3.0	
		6.3	63	1	1.5	16		N.D.
		6.8	90	2	1.4	11	2.3	N.D.
				2	1.5	11		
6	0.5		68	1	1.5	13		
		6.3	59	1	1.5	16	4.3	N.D.
		6.5	99	1	1.5	17	5.1	N.D.
			68	1	1.5	16		
7	0.5		68	1	1.8			
		8.7	41	1	1.6	16	5.4	N.D.
		7.7	36	1	2.3	19	2.9	N.D.
					1.7	16		
8	0.5		41		1.8			
		8.1	41		1.8	11	4.5	N.D.
		7.1	90		1.2	13	2.9	N.D.
					1.7	13		
10	0.5		63	3		17		
		8.2	27	1	1.2	18	2.6	N.D.
		7.5	81	2	1.3	17	3.0	N.D.
					1.8			
11	0.5				1.8			
		7.1	59	1	2.1	19	2.4	N.D.
			72		2.1		3.5	

TABLE 5. PER CENT MORTALITY OF IN SITU BIOASSAYS FOR 24 HOURS EXPOSURE UNLESS OTHERWISE NOTED

STATION	PREDREDGE	COARSE MATERIAL	SLUDGE MATERIAL
1	0	0 (5 HOURS)	0
2	0 (7 HOURS)	60%	20
3	0 (7 HOURS)	100	0
4	0	0	0
5	0	0	0
6	0	20	0 (5 HOURS)
7	0	20	20
8	0	0 (4 HOURS)	
9		0	
10	0 (7 HOURS)	0	0
11	0	0 (4 HOURS)	0

stations were below detectable limits. Salinity values averaged 23 ppt; pH was approximately 7.6 units, and settleable solids were trace or less. Volatile solids averaged 14%.

The field bioassays were conducted from 1030 hours, August 15th to 1300 hours, August 16th or approximately 26 hours. No mortalities were observed at any stations (Table 5, page 9). The fish at three stations (Stations 2, 3, and 10) were lost between the last observation on August 15th to the first observation the next morning. The missing fish were replaced.

Coarse Material Dredging

The dredge was operating to the south of Pier 3 during this phase of the study. The soil engineering reports characterized the bottom sediments in this area to be medium to fine organic sand and medium to coarse sandy materials. Secchi-disk measurements increased slightly or remained similar to the predredge study results. Volatile solids averaged 13%. Dissolved oxygen was 2 to 3 mg/l lower than values observed during the predredge study (Table 2, page 11). The greatest impact on dissolved oxygen depression occurred at stations located in the vicinity of the dredge. PBI values for receiving water stations ranged from 41 to 9 mg/l and averaged 18 mg/l. Turbidity averaged 2 JTU's at all receiving water stations.

Stations 12, 13, and 14 were established to measure the effectiveness of the settling basins (Figure 2, page 5). Total sulfides were only detectable

Table 2. WATER QUALITY DATA OBSERVED DURING DREDGING OF COARSE MATERIAL

STA	DEPTH METERS	DISSOLVED OXYGEN mg/l	PBI mg/l	TURBIDITY	SECCHI DISK METERS	VOLATILE SOLIDS (%)	Hg ppb	TOTAL SULFIDES mg/l
1	0.5	4.8	9			13.5	0.14	N.D.
		5.0	14			15.0	0.80	
	4	4.2	14			13.5		
		4.7	18	4		15.7		
2	0.5	5.1	18	3	1.5	14.1	0.25	N.D.
		5.6	14	2	1.5	12.6		
	4	4.7	9	2		15.0		
		4.7	23	3		12.5		
3	0.5	5.5	14	1	1.5	13.2		
	4	4.1	41	2		11.9		
4	0.5	5.4	14	1	1.8	13.5	0.21	N.D.
	4	4.0	14	2		11.5		
5	0.5	5.7	14	1	2.1	11.8	0.33	N.D.
		4.5	18	2	1.4	11.3		
	4	4.3	14	2		11.8		
		3.7	23	3		11.7		
6	0.5	5.5	9		1.8	11.8	0.21	N.D.
		4.6	18	1	1.8	10.8		
	4	4.1	14	2		13.1		
		3.9	18	2		11.2		
7	0.5	5.8	14	2	1.8	11.8	0.11	N.D.
		5.6	23	2	2.1	16.3		
	4	4.2	18	1		12.6		
		5.0	18	2		11.7		
9	0.5	6.1	9	1	2.0	13.6	0.21	
		4.5	27	2	1.4	12.4		
	4	4.0	14	1		11.4		
		3.4	23	3		13.2		
10	0.5	6.0	18	2	2.4		0.33	N.D.
		5.0	23	2	1.5			
	4	4.2	14	2		16.2		
		3.8	18	1		10.4		
11	0.5	5.6	23	2	1.8	10.4		
	4	4.3	23	1		10.7		

N.D. = None Detected

TABLE 4. SETTLING BASIN WATER QUALITY PARAMETERS

STATION	TOTAL SULFIDES MG/L	SETTLEABLE SOLIDS ML	VOLATILE SOLIDS (%)	TURB JTU	PBI MG/L	Hg PPB
		COARSE MATERIAL STUDY				
12	N.D.	TRACE	10.9	50	9	0.21
	N.D.	TRACE	10.8	26	9	0.29
						0.17
13	N.D.	37	11.1	40	5	0.27
	N.D.	25	11.9	35	9	0.25
14	4.0	150	11.0	750	9	0.17
	1.5	TRACE	9.0	750	5	0.21
		SLUDGE MATERIAL STUDY				
12	N.D.	2.5	18	180	23	0.21
	N.D.	0.5		70	41	
13	0.5	250		2000	570	
	N.D.	200		2000	41	
14	8.0	50		2000	23	0.11
	N.D.	125		1000	5	

N.D. = NONE DETECTED

at Station 14 which ranged from 1.5 to 4.0 ppm (Table 4, page 12). Setteable solids averaged respectively trace, 31 ml, and 75 mls. PBI values ranged from 5 to 9 mg/l. Turbidity measurements at Station 12, 13, and 14 averaged 38, 38, and 750 JTU's respectively. Maximum and minimum mercury values for the settling basin stations were 0.29 and 0.17 ppb. Volatile solids averaged 11%. The efficiency of the settling basins based on turbidity and setteable solids was good.

The in-situ bioassay duration was 24 hours. Cylindrical fiberglass liveboxes were used at all stations except Station 1 where a livebox enabling continuous observation was utilized (Table 5, page 9). The fish at Station 1 were observed continuously for seven hours and demonstrated no abnormal reactions. The remaining stations were reviewed at this time (1500 hours) and only at Stations 3 and 6 was a mortality noted. The liveboxes at Stations 8 and 11 were missing at the end of 24 hours, while Stations 4, 5, 9, and 10 had no mortalities. Mortalities of 20% (Station 6 and 7), 60% (Station 2), and 100% at Station 3 were observed.

Sludge and Fine Material Dredging

This phase of the study took place on October 18 and 19, 1973. Secchi-disk measurements ranged between 0.3 m and 2m. Turbidity at Stations 1, 2, and 6 exceeded Department of Ecology water quality criteria by 10 JTU, while the control station (Station 11) exhibited no change (Table 3, page 14).

Table 3. WATER QUALITY DATA OBSERVED DURING DREDGING OF SLUDGE MATERIAL

STA	DEPTH METERS	DISSOLVED OXYGEN mg/l	PBI mg/l	TURB JTU	SECCHI DISK METERS	VOLATILE SOLIDS (%)	Hg ppb	TOTAL SULFIDES mg/l
1	0.5	3.0	360	25	0.9	15.3		N.D.
		3.2	325	30		16.0		
	4	3.1	330	26				N.D.
		3.6	115	6		15.4		
2	0.5	3.1	465	15	0.3	15.9		
		4.0	85	4	1.1	18.2	0.11	
	4	3.6	370	15		52.5		
		3.4	75	1		18.2		
3	0.5	2.6	610	2	1.1	25.9		
		4.5	70	1	1.5	18.7	0.25	
	4	4.1	500	2		36.4		
			105	5		19.1		
4	0.5	3.0	500	3	0.9	39.3		
		3.9	90	1	1.5	18.6	0.08	
	4	3.2	340	6		51.7		
		3.4	70	5		19.9		
5	0.5	3.6	435	3	1.2	45.8		
		4.7	75	1	1.5	19.9	0.11	
	4	3.2	315	6		49.6		
		2.9	80	8		16.9		
6	0.5	2.9	565	3	1.1	31.9		
		3.7	85	1	1.5	17.5	0.10	
	4	3.4	465	5		89.6		
		2.6	60	35		19.2		
7	0.5	3.5	435	1	1.1	60.8		
		4.8	70	0	1.5	21.7	0.11	
	4	3.4	330	3		39.1		
		4.0	100	2		23.1		
10	0.5	3.5	320	1	1.5	57.8		
		5.1	70	1	2.0	10.9	0.11	
	4	2.9	295	3		18.1		
		3.5	60	1		11.6		
11	0.5	4.0	345	1	2.1	17.7		
		3.7	65	1	2.1	11.3	0.08	
	4	3.6	60	2		16.5		
		4.0	45	1		5.5		

N.D. = None Detected

PBI values averaged 275 ppm. Mercury values were very similar to those observed during coarse material dredging. Volatile solids averaged 28% for receiving water stations. The pH ranged from 6.8 to 7.7 for both receiving water and overflow weir stations. pH values below Department of Ecology water quality criteria occurred at all stations except Station 14. Total sulfides were not detected at the receiving water stations. Dissolved oxygen values below the water quality criteria of 4.0 mg/l were recorded at all receiving water stations. Stations in the area of dredging and supernate return suffered the greatest depression. The lowest dissolved oxygen value measured was 2.6 mg/l at Station 6.

Ninety percent of the south settling basin was filled when the dredge started removing sludge material. The reduced settling time and dredging of fine material increased the turbidity levels at the effluent weir (Station 12) from 50 to 180 JTU's (Table 4, page 12). Settleable solids at this station ranged from 0.5 to 2.5 milliliters. Volatile solids for Station 12 was 18%. Total sulfide levels of 8 mg/l were observed at Station 12; however, sulfides were not detected at the effluent weir. The increases in turbidity, settleable solids, and PBI at Station 12 are the result of loss of retension time by the filling of the lagoons and the dredging of a lighter material which would require more retention time to provide the same quality effluent as we observed during the coarse material study phase.

The in-situ bioassays were accomplished in the same manner as the two previous studies. Station 6 was the only station where the fish were lost.

A 20% mortality was measured at Stations 2 and 7. No mortality was recorded at the remaining stations (Table 5, page 9).

CONCLUSIONS AND RECOMMENDATIONS

Dredging is a necessity in Washington State. The Port of Everett Hewitt Avenue project illustrates the type of advancements made in environmental degradation prevention when developmental groups and environmentalists work together to accomplish the goals of both groups.

Settling basins with significant retention times and long skimming weirs are of extreme importance when the dredging involves very fine or highly organic material. The project utilized two interconnected settling basins and a 200-foot long effluent weir.

Efficiency of the settling basins was excellent during the coarse material dredging. Efficiency decreased during the sludge material dredging; however, retention time had decreased by about one half. The number of instances where turbidity exceeded Department of Ecology water quality standards would have been reduced if the fine sludge material had been dredged first while maximum retention time in the settling basins was available.

Maximum dissolved oxygen depression occurred near the dredge and spoil supernatant discharge. Dissolved oxygen was reduced below predredge values

by 40% during coarse material removal and 50% during sludge material removal. Four stations (5, 6, 9, and 10) were below Department of Ecology water quality criteria for dissolved oxygen (4.0 mg/l) during dredging of coarse material. All stations demonstrated values below 4.0 mg/l dissolved oxygen during [illegible] ing. It appears that the dissolved oxygen depression observed was due to the dredging activity. More drastic depressions have been noted in other dredging projects where the dissolved oxygen was depressed into the lethal range (3). When a dredging project is being reviewed for permit issuance, the amount of dissolved oxygen necessary for chemical oxygen demand of the spoils should be exceeded by the amount of dissolved oxygen required for the local ecosystem.

PBI values were noticeably lower during coarse material dredging than the predredging study. The waste loading and possible bypassing of waste by local mills was investigated but no operational changes had occurred. A decrease in wet log loading in the immediate vicinity due to dredging activity was noted.

Total sulfide levels of 0.3 mg/l have been shown to correlate positively with fish distress and mortality (2). The sulfide level at the spoil landing was as high as 8.0 mg/l. The middle weir (Station 13) was measured at 0.5 mg/l while sulfides at Station 12 were nondetectable. The settling basins retention enabled the oxidation of the HS or H_2S to the less toxic sulfate radicle.

Mercury values during dredging averaged 0.2 to 0.3 ppb while samples taken before dredging were 2.0 to 3.0 ppb. Additional samples were collected several months later and measured between 2.3 ppb and 0.3 ppb. The source of mercury is not known at this time. The dredging activity did not cause significant mortalities to in-situ bioassayed juvenile chinook salmon, except at Stations 2 and 3 during coarse material dredging. If this mortality was the result of the discharging of spoil supernate to the receiving waters then we would expect the station closer to the discharge to have the higher mortality. However, the reverse is true suggesting the possibility of another toxic source. Station 3 was much closer to the scott Paper Company dockside diffuser than to the spoil discharge point.

The dredge's cutter encountered a large number of broken off pilings and shredded these into sizes varying from chips to 10-foot chunks. Previous arrangements enabled the resident engineer to have the area rapidly enclosed and the debris collected and removed to a sanitary landfill. Another similar problem arose when the dredge started discharging a heavy oil into the settling basins. Previously placed booms at the overflow weirs contained the oil to the settling basin where it was collected with an absorbent and disposed of in an approved manner. Planning and prompt action prevented these minor situations from becoming large problems.

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