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STATE OF WASHINGTON

DEPARTMENT OF ECOLOGY

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MEMORANDUM
December 7, 1981

To: Rick Pierce

From: Marc Heffner

Subject: ASARCO Class II Survey - February 24 and 25, 1981

INTRODUCTION

On February 24 and 25, 1981 a Class II inspection was conducted at the American Smelting and Refining Company (ASARCO) facility in Tacoma, Washington. Personnel involved included Bill Yake and Marc Heffner (Washington Department of Ecology [WDOE], Water Quality Investigations Section), Rick Pierce and Darrel Anderson (WDOE, Southwest Regional Office), Ken Mosbaugh (Environmental Protection Agency [EPA]), and Kent Wise and Charlie Hochmuth (ASARCO).

The ASARCO plant includes copper smelting, arsenic roasting, and sulfuric acid and sulfur dioxide capture facilities. Also, the waste slag from the smelting process is cooled, crushed, and distributed by another company, Industrial Mineral Products, on site for use as, among other things, sandblasting material, ballast in log storage yards, and fill. Runoff (except from the arsenic roasting area) and non-contact cooling waters are discharged from three outfalls into Commencement Bay, while process wastes, laboratory wastes, and arsenic roasting area runoff are routed to holding tanks and evaporated. Sanitary wastes are handled in a separate system and sent to the City of Tacoma for treatment. Figures 1 and 2 show facility location and a simplified version of the facility layout.

LABORATORY AND SAMPLING PROCEDURES

ASARCO

Permanent composite samplers are located at each of the three outfalls (Figure 2) with samples taken approximately every 15 minutes. Grease and oil samples are taken at the discharge from the sampling tube. The pH and flow are continuously monitored at each outfall.

Some backup in the outfall lines occurs during high tides and flow measurement is adjusted with a tide cut system. This system maintains

the flow measurement at the flow rate recorded prior to tidal interference for the duration of the interference. Periods when the tide cut system is functioning can be identified by the color ink on the script chart.

Metals samples are run through an SES 604 course filter, acidified, and analysis run weekly. Metals are tested using an atomic absorption spectrophotometer with the exception of arsenic, which is tested using the silver diethyldithiocarbamate method.

WDOE

Acid-rinsed WDOE composite samplers were used at all three outfall monitoring stations (see Figure 2). Twenty-four-hour composite samples were collected. Both ASARCO and WDOE composite samples were split between ASARCO and WDOE laboratories (see Tables 1 and 2). In addition, grab samples were taken at the locations noted in Figure 2 (see Table 2). WDOE metals analyses were conducted using an atomic absorption spectrophotometer.

Instantaneous flows were measured at the north and middle outfalls and compared to ASARCO flow meter readings (Table 3). Free flow did not occur during the inspection at the south outfall, so flow was estimated based on the capacity of pumps providing most of the flow.

Fish Samples

Blue sea perch, copper rockfish, and edible mussels were collected by WDOE SCUBA divers near ASARCO's north outfall during the Class II inspection. Similar sampling had been conducted during the September 20, 1978 Class II inspection. The samples were brought to the WDOE laboratory in Tumwater where gills, fillets, gut contents, and livers were removed from the fish. When adequate sample was available, the sample was then split and all samples frozen. The following day, a partial set of frozen samples was delivered to ASARCO.

On March 3, 1981 blue sea perch, copper rockfish, and edible mussel samples were collected by WDOE SCUBA divers near Hartstene Island Bridge to serve as background samples. The fish were dissected and all samples frozen.

WDOE laboratory analysis involved first letting the samples thaw. Soft tissues were removed from the mussels. The individual samples were crushed and wet and dry weights measured. Samples were then digested using nitric acid and peroxide, an approved EPA procedure. The digested samples were than sent to the EPA Manchester laboratory for metals analysis. ASARCO laboratory analysis was performed by their Salt Lake City laboratory.

RESULTS

ASARCO's discharge is authorized by a letter of extension to extend the January 5, 1980 expiration date of their NPDES permit. Flow, temperature, pH, heavy metals, and total oil and grease are monitored. Flow, pH, and total oil and grease limits are described in Table 4.

Table 4. ASARCO NPDES effluent limitations (non-contact cooling water [marine and fresh], and storm water).

Parameter	Daily Maximum
Flow (marine cooling water only)	8,640,000 gallons
Oil and Grease	15 mg/L and no visible sheen
pH	$6.5 \leq pH \leq 8.5$

Data collected during the Class II inspection were generally in compliance with the effluent limitations shown in Table 4, although the south outfall pH measurements fell below the 6.5 limit on occasion (see Table 2). Temperature limitations are based on changes in conditions outside of a dilution zone and were not checked during the inspection. Heavy metal concentrations are monitored, but no limitations exist.

Because heavy metals were of primary interest, a general discussion of the observations made at each outfall is included. Metals data referred to in this discussion are found in Tables 1 and 5.

South Outfall

Flow from the south outfall consists primarily of marine water used as non-contact cooling water in the sulfuric acid plant. The "south infall", a line carrying runoff from nearby hillsides, also makes a flow contribution. The total flow passes through the south outfall monitoring station into a dispersion pond dug into slag. Percolation from the pond into Commencement Bay is the designed method of discharge.

During the Class II inspection, percolation was insufficient for the flow being discharged, resulting in back-up at the monitoring station and discharges over the pond walls into the bay. Back-up at the monitoring station caused the flow-measuring system to operate in the tide-cut mode for the duration of the inspection. Because the weir was flooded, instantaneous WDOE flow measurements were impossible. A WDOE

flow estimate of 3,000 gpm (Table 3) was made based on ASARCO personnel estimates of 2,000 to 3,000 gpm from two 2,000 gpm pumps used in pumping sulfuric acid plant cooling water and 50 to 70 gpm flowing through the south infall (during the inspection, the south infall flow meter was not functional).

The south outfall monitoring station generally showed that the highest concentrations of metals were being discharged through this outfall. Based on the flow estimates in Table 3, this outfall is shown to have the highest gross metals loadings also (see Table 5). Unfortunately, metals concentrations into the cooling system are not known so the contribution made by ASARCO to the cooling water is unknown. Also, during the Class II inspection the sulfur dioxide plant was closed down for one week for yearly cleaning. Since the sulfur dioxide plant does not contribute directly to south outfall flows, the effects of this shutdown and cleanup on survey results is believed to be minimal.

Sampling also included a grab sample at the south infall (see Tables 1 and 2). Fairly high arsenic (7.2 mg/L), antimony (.26 mg/L), and copper (2.7 mg/L) levels in the infall samples suggest that runoff from the light rain that was falling picks up some metals from the area being drained.

The dispersion pond method of discharge appeared to have at most a minimal treatment effect on the metals being discharged. Grab samples were taken from the pond and from a seep coming out of the pond wall and going into the bay. Although As, Cd, Cu, and Zn concentrations in the dispersion pond samples were slightly lower than those in the outfall samples, this was probably due to flow equalization effects of the pond and possible dilution by seawater with tidal movement. The difference between the pond and seepage appears minimal and this, along with the flow monitoring problems discussed previously, make the merits of the dispersion pond system questionable.

Middle Outfall

Middle outfall data indicate a difference between the ASARCO compositor and WDOE compositor sampling results. ASARCO sample results were higher in each lab for metals than the corresponding WDOE samples. Discussion with ASARCO personnel has not revealed the source of this discrepancy.

During times of high runoff the middle infall pond (see Figure 2) may overflow and contribute to the flow from the middle outfall. A grab sample was taken from the pond which showed metals concentrations in the pond much lower than those in the middle outfall discharge. Thus, it does not appear that the effect of pond overflow would increase metals concentrations in the middle outfall discharge.

Memo to Rick Pierce
ASARCO Class II Survey - February 24 and 25, 1981

North Outfall

North outfall flows had the lowest concentrations of metals observed of the three outfalls. Also, this outfall has the lowest estimated flows as shown on Table 3.

METALS RESULTS

Metals Criteria

In order to evaluate the possible effects of the discharge on aquatic organisms, criteria included in the November 28, 1980 Federal Register, were utilized (Environmental Protection Agency, 1980). This document uses information from studies conducted to determine the toxicity of various pollutants to aquatic organisms and attempts to define concentrations at which acute or chronic toxicity occurs. Table 6 shows the concentrations of the metals tested for as part of the Class II survey. These criteria are not thought to include any synergystic effects brought about by several metals acting together.

Table 7 was set up to compare metals concentrations in the discharge to Federal Register criteria for the metals tested. The amount of uncontaminated water necessary to dilute the discharge to criteria concentrations was calculated by comparing the discharge concentration as measured by the WDOE laboratory from the WDOE compositors to the criteria. The "dilution required" values assume that the receiving water contains no metals.

The comparison indicates that in most cases of discharge to the receiving water, dilution is required before metals concentrations meet criteria concentrations. Copper discharges from the south outfall appear to present the greatest toxicity threat as the flow from that outfall is the largest and the "dilution required" (acute 286:1, chronic 1649:1) is also the largest.

Background information to estimate the effects of additional metals loadings was obtained from Dames and Moore (1981) (Table 8 and Figure 1). Most of this information was collected during October, 1980, a period during which ASARCO was on strike (ASARCO was on strike from July to November, 1980). Thus conditions in the absence of daily effluent discharges from ASARCO are described. These metals concentrations generally fell below federal toxicity criteria, although copper concentrations at stations 11 (.005 mg/L) and 19 (.003 mg/L) are similar to federal chronic toxicity criteria (.004 mg/L).

It appears, therefore, that copper concentrations in the receiving water approach chronic toxicity criteria levels even in the absence of ASARCO discharges. Additional metal loadings generated when ASARCO is operating probably aggravate this problem. Although only water-borne loadings have been quantified here, additional metals loads may be contributed by stack emissions and slag cooling operations.

The total effect of these metals loadings needs to be more precisely defined. A receiving water study which defines plume dispersion characteristics, near-shore metals concentrations when ASARCO is operating, and distribution of marine organisms near the ASARCO site would help define the effect of ASARCO on marine organisms.

Fish Tissues

Results of the fish tissue analysis are shown in Tables 9, 10, and 11. Comparison of the ASARCO and WDOE laboratory results for the samples split with ASARCO revealed several discrepancies. Some of these discrepancies might be due to how the samples were split. As noted in the "laboratory and sampling procedures" section of this report, samples were split without first homogenizing the samples; thus there is no assurance that identical samples were provided to each laboratory.

Because of the variability between ASARCO and WDOE laboratory results, data interpretation focused on the differences existing between the WDOE analysis of the ASARCO and background samples. Table 12 was set up to aid in interpretation of relative differences between the samples collected near ASARCO and background samples. For each metal tested, the concentration present in the ASARCO area sample divided by the concentration present in the background sample was calculated using the dry weight data. These figures were then averaged for each metal and for each sample. This analysis indicated that the metals found in highest concentrations near ASARCO relative to the Hartstene Island background were copper (4.8 times), lead (3.2 times), and zinc (3.2 times), and the tissues which generally accumulated metals in the highest concentration were mussels (>3.9 times), perch tissue plugs (≈3.6 times), perch gut contents (>3.6 times), and rockfish gill sets (≈2.8 times). Two factors should be kept in mind when looking at this analysis:

1. The number of samples collected was limited; and

2. "Less than" values were taken at face value when being compared to a known greater value. Had the actual value been determined, it is assumed only minor changes in the ratios would occur.

CONCLUSIONS AND RECOMMENDATIONS

1. Metal concentrations in ASARCO's waste stream are such that dilution is required to bring concentrations below the toxicity criteria published in the Federal Register. By exceeding these criteria, organisms sensitive to a particular contaminant may be threatened. Table 7 suggests that copper may be of primary concern as it requires the greatest dilution factor to meet the federal criteria. Also, in the fish samples, copper was found in the highest ratio when compared to the background samples (4.8:1) (see Table 12).

2. The comparison of instantaneous flows as measured by ASARCO meters and by WDOE at the weir (Table 3) showed poor correlation for both the north and middle outfalls. The calibration of the flow monitoring devices should be checked.

   The monitoring at the south outfall was inadequate as the tide cut system functioned continuously during the inspection. This was thought to be a consequence of back-ups caused by inadequate percolation of the wastewater through the dispersion pond walls. It appears that the pond could be abandoned as it provides little if any treatment and compounds flow measurement problems. Since flows from this outfall are primarily the sulfuric acid facility cooling waters, provisions for neutralization of spills when necessary should be considered when a new permit is drafted.

3. Laboratory and sampling techniques were generally good. A change in the method of collection of oil and grease samples was recommended. A grab sample should be collected in a clean glass bottle as the discharge falls over the outfall weir. Passing the effluent through a sampling line could result in loss of oil and grease in the sampling tube.

   There was some discussion, on site, regarding filtering metal samples with a course filter prior to analysis. The ASARCO lab follows this practice whereas the WDOE lab does not. A comparison of results from the laboratories (Table 1) shows results to be in the same range. A procedure change does not seem warranted.

   Metals concentrations were noticeably higher in the samples collected by ASARCO than those collected by WDOE at the middle outfall site. While the source of this difference is unclear, a routine inspection, maintenance, and cleaning of all samplers should be initiated and may eliminate this type of discrepancy in future surveys.

4. Future receiving water studies should include the following considerations:

   a. Collect and analyze receiving waters for metals. This is especially needed because seawater is used for cooling and is later discharged through the south outfall. Metals concentrations in the seawater would have to be known before net ASARCO metals loadings could be determined.

   b. The fish tissue data presented suggest that differences may exist between the specimens collected near ASARCO and background samples. The small amount of data available and the variability between the previous Class II data, the present Class II data as measured by the WDOE lab, and the present Class II data as measured by the ASARCO lab make determination

of the significance of differences noted difficult. Additional fish tissue analysis might be done to help in determining the roles of variability between individuals at a particular site and differences in individuals from different sites in quantified terms applicable to defining human health hazards.

c. The comparison of discharge metals concentrations to federal toxicity criteria (Table 7) suggests that detrimental effects to the aquatic community may be occurring near the outfalls. An attempt to define the scope of effects to the aquatic community including both area and species affected, should be made.

d. The slag processing operation adjoining the smelter plant should be included in future survey work. Slag leachate and runoff could be affecting the marine ecosystem.

e. The temperature requirements in the NPDES permit were not checked during the Class II inspection since they are in terms of changes outside a dilution zone. Confirmation of compliance with this requirement should be made.

MH:cp

Attachments

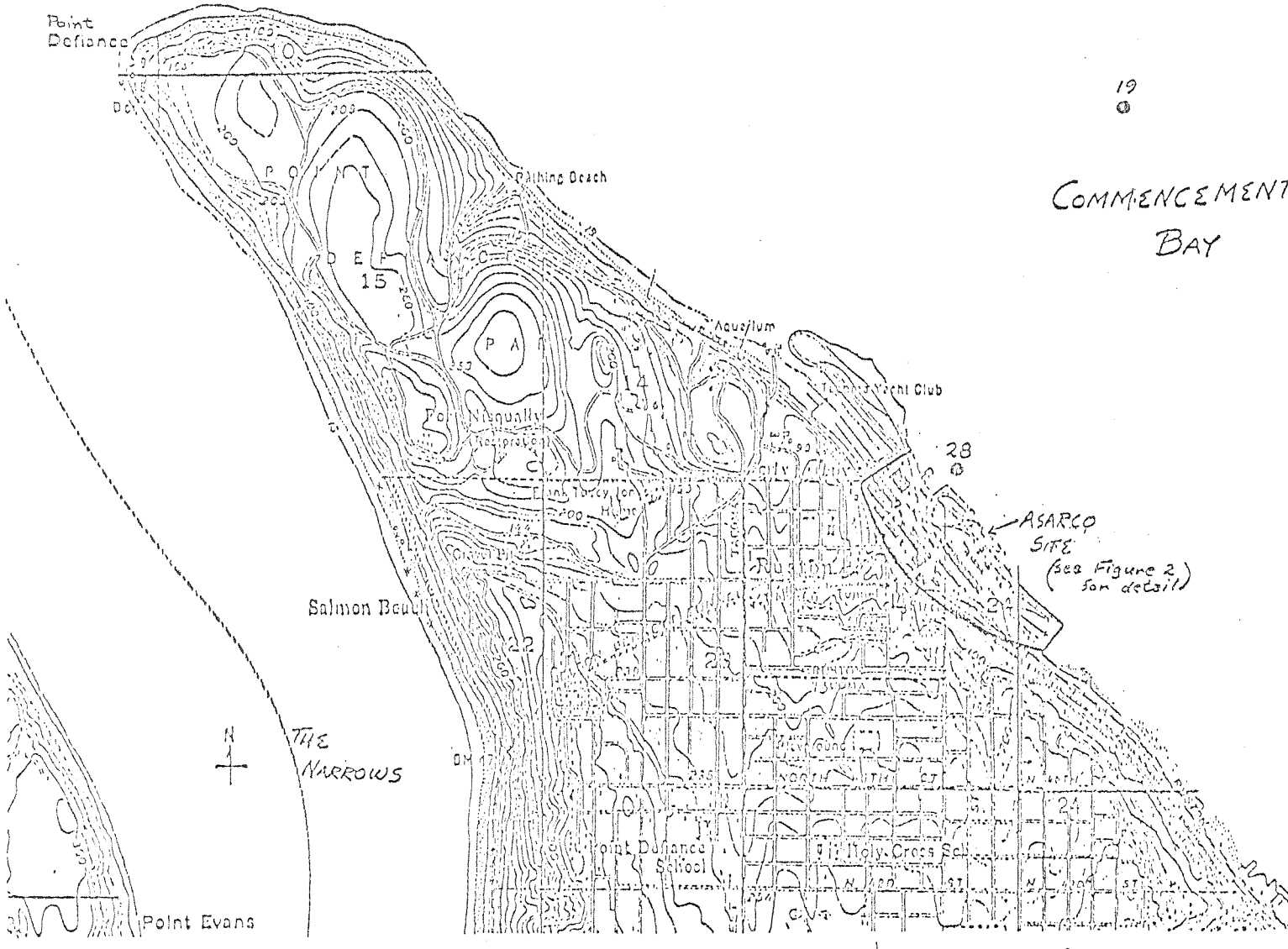
REFERENCES CITED

Cloud, G., 1979. *ASARCO Class II Survey*, Memorandum to Rick Pierce, Wash. Dept. of Ecology, April 19, 1979, 11 pp.

Dames and Moore, 1981. *Preliminary Draft Sediment Studies Technical Report for Commencement Bay Studies*, March 20, 1981, 42 pp.

Environmental Protection Agency, Federal Register, Part V, Vol. 45, No. 281, *"Water Quality Criteria Documents; Availability"*, November 28, 1980.

FIGURE 1 - ASARCO AREA MAP



COMMENCEMENT BAY

FIGURE 2 - ASARCO SITE MAP

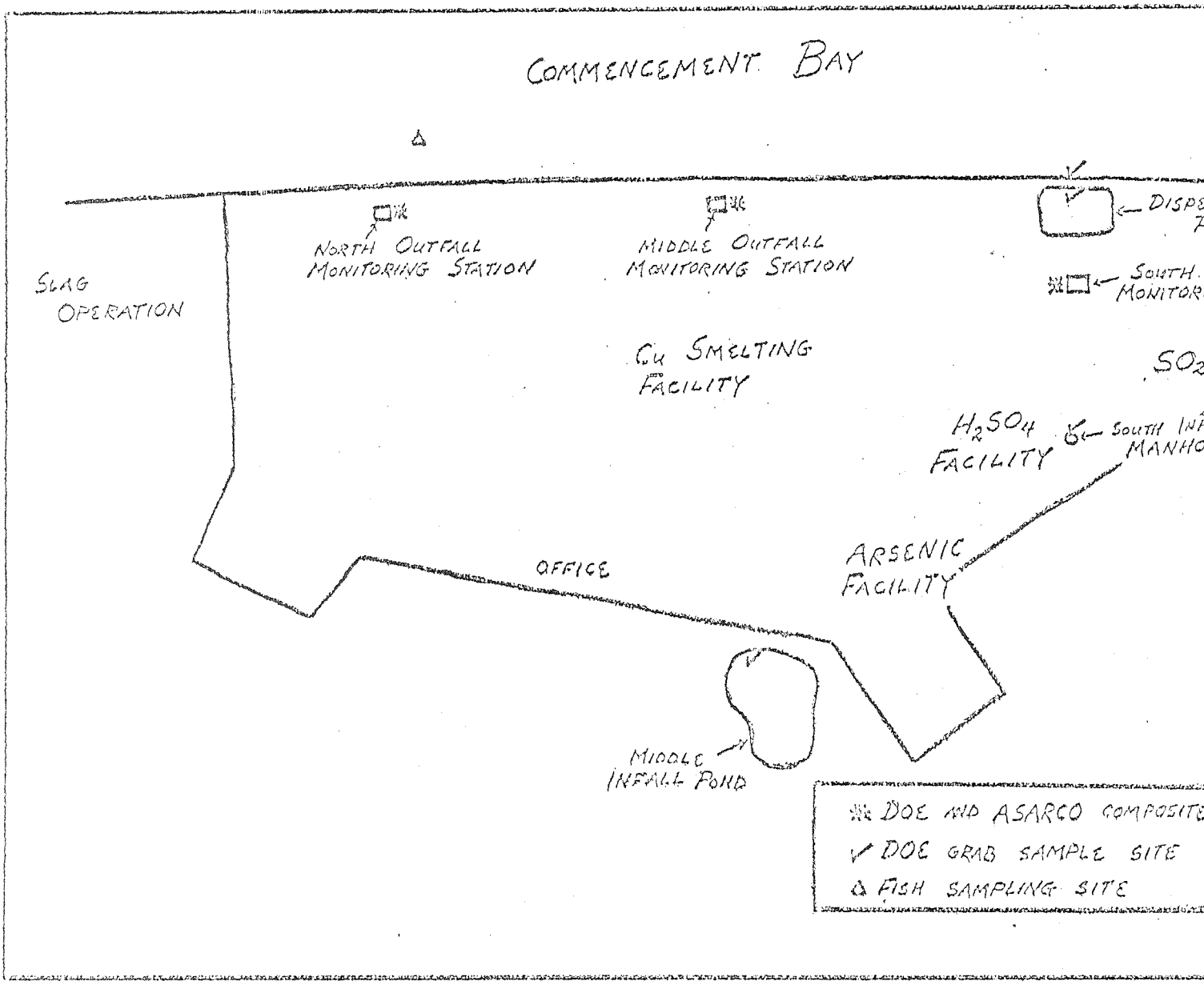


Table 1. Metals data (concentration in mg/L).

Location	Sampler	Laboratory	Date	Time	As*	Sb*	Cd	Cu	Pb*	
South Outfall	WDOE	WDOE	2/24-25/81	Comp.	8.9	.20	.25	6.6	.14	3
	WDOE	ASARCO	2/24-25/81	Comp.	6.3	.40	.24	6.7	.48	3
	ASARCO	WDOE	2/24-25/81	Comp.	8.8	.16	.3	6.4	.07	2
	ASARCO	ASARCO	2/24-25/81	Comp.	7.4	.40	.24	6.8	.58	3
Dispersion Pond	WDOE	WDOE	2/24/81	1145	6.7	.20	.1	4.8	.11	2
Dispersion Pond (seepage)	WDOE	WDOE	2/24/81	1155	6.1	.21	.15	4.5	.07	2
South Infall	WDOE	WDOE	2/24/81	1445	7.2	.26	.05	2.7	.60	1
Middle Outfall	WDOE	WDOE	2/24-25/81	Comp.	5.5	.062	.07	3.6	.27	2
	WDOE	ASARCO	2/24-25/81	Comp.	4.0	.25	.08	4.28	.30	1
	ASARCO	WDOE	2/24-25/81	Comp.	7.1	.140	.11	6.7	.76	2
	ASARCO	ASARCO	2/24-25/81	Comp.	6.8	.55	.11	8.68	.88	2
Middle Infall Pond	WDOE	WDOE	2/24/81	1325	.430	.028	<.005	.16	.029	
North Outfall	WDOE	WDOE	2/24-25/81	Comp.	.150	.027	<.005	.70	.08	
	WDOE	ASARCO	2/24-25/81	Comp.	.1	.10	.01	.70	.12	
	ASARCO	WDOE	2/24-25/81	Comp.	.130	.022	<.005	.52	.061	
	ASARCO	ASARCO	2/24-25/81	Comp.	.1	.09	.01	.53	.13	

*WDOE analysis run with graphite furnace.

Table 2. Field results.

Location	Date	Time[1]	pH DOE Field	pH DOE Lab	pH ASARCO Meter	pH ASARCO Recorder	Conductivity Field	Conductivity Lab	Temp. (°C) WDOE	Temp. (°C) ASARCO	Salinity (ppt)	D.O. (mg/L)	Grease & Oils (ppm)
South Outfall	2/24	0945	6.7		6.65	6.5	>10,000		16.5			7.1	7
	2/25	0945	6.7		6.5	6.5	>1,000		16.3				
	*		6.9	6.6			>1,000	32,100	3.1		24.2		
	**			6.4				33,400			24.4		
Dispersion Pond													
Pond	2/24	1145		6.4			>10,000	33,100	15.0		24.9	9.2	
seepage	2/24	1155		6.4				32,900			25.0		
South Infall	2/24	1445	7.2	7.2			240	249	8.4				
Middle Outfall	2/24	1020	7.0		6.5	6.8	231		13.1			8.1	
	2/24	1410											<1
	2/25	1010	7.4		7.3	7.8	220		14.0	14.4			
	*		7.4	7.1			158	165	3.5				
Middle Infall (pond)	2/24	1325	7.5	7.3			257		8.5				
North Outfall	2/24	1050	7.1		7.2	7.1	52		25.7			6.3	
	2/24												<1
	2/25	1035	7.3		7.2	7.1	57		29.7				
	*		7.5	7.3			92	96	5.6				
	**			7.0				86					

[1]Time for grab samples. Comp = composite samples.

[2]TS = Total Solids.

[3]TNVS = Total Non-volatile Solids.

[4]TSS = Total Suspended Solids.

[5]TNVSS = Total Non-volatile Suspended Solids.

* = DOE Composite

** = ASARCO Composite

Table 3. Flow data (MGD).

Location	Instantaneous WDOE	Instantaneous ASARCO	ASARCO Totalizer
South Outfall	4.32*	2.5**	6.2
Middle Outfall	1.02	1.8	1.74
North Outfall	.32	.11	.168

*WDOE estimate based on service pumps contribution to flow. Pumps rated by ASARCO personnel at approximately 3000 gpm.

**ASARCO meter was operating in tide-cut mode. This mode freezes reading until tide goes down and flow over the weir is not obstructed. Meter operated in this mode for duration of Class II investigation.

Table 5. Gross metals loadings*.

Metal	South Outfall Flow** (MGD)	South Outfall Concentration*** (mg/L)	South Outfall Loading (lb/d)	Middle Outfall Flow** (MGD)	Middle Outfall Concentration*** (mg/L)	Middle Outfall Loading (lb/d)	North Ou Flow** (MGD)	North Ou Concentrati (mg/L)
As	4.32	8.9	320.7	1.02	5.5	46.8	.32	.150
Sb		.20	7.2		.062	.5		.027
Cd		.25	9.0		.07	.6		<.005
Cu		6.6	237.8		3.6	30.6		.70
Pb		.14	5.0		.27	2.3		.08
Zn		3.5	126.1		2.0	17.0		.075
Cr		<.02	<.7		<.01	<.1		.021
Ni		.17	6.1		<.05	<.4		<.05
Ag		≈.02	≈.7		<.02	<.2		<.02

*Metals concentrations for incoming flows are unknown, so net loadings cannot be calculated.
**WDOE measured flows from Table 3.
***WDOE sampling and laboratory analysis concentrations from Table 1.

Table 6. Federal Register criteria (Environmental Protection Agency, 1980).

Toxicity	Concentration in saltwater (ug/L)								
	As	Sb	Cd	Cu	Pb	Zn	Cr*	Ni	Ag
Acute	508	--	59	23	668	170	1260	140	2.3
Chronic**	--	--	4.5	4	25	58	18	7.1	--

-- = Data not available.
*Total recoverable hexavalent chromium.
**24-hour average concentration.

Table 7. Dilution required* (liters uncontaminated water:liter discharge).

Outfall	Toxicity	As	Sb	Cd	Cu	Pb	Zn	Cr	Ni	Ag
South	Acute	16.5:1	--	3.2:1	286:1	**	19.6:1	**	.2:1	7.7:1
	Chronic	--	--	54.6:1	1649:1	4.6:1	59.3:1	<.1:1	22.9:1	--
Middle	Acute	9.8:1	--	.2:1	155.5:1	**	10.8:1	**	**	<7.7:1
	Chronic	--	--	14.6:1	899:1	9.8:1	33.5:1	**	<6.0:1	--
North	Acute	**	--	**	29.4:1	**	**	**	**	<7.7:1
	Chronic	--	--	**	174:1	2.2:1	.3:1	.2:1	<6.0:1	--

*WDOE compositor and laboratory results used (Table 1).
**No dilution required
--No criteria available

Table 9. Fish collection.

Site	Date	Species	Number Collected
ASARCO near North Outfall	2/24/81	Blue Sea Perch *(Taeniotoca lateralis)*	3 adults
		Copper Rockfish *(Sebastes caurinus)*	5 adults
		Edible Mussels *(Mytilus edilus)*	Numerous
Near Hartstene Island Bridge	3/04/81	Blue Sea Perch	3 adults
		Copper Rockfish	1 adult
		Edible Mussels	Numerous

Table 8. Metals in Commencement Bay water samples* (results in mg/L).

Date	Station Number	As	Cu	Cd	Cr	Pb	Zn
10/2/80	11	<.02	.005	<.001	<.008	<.01	.013
10/2/80	19	<.02	.003	<.001	<.008	<.01	.004
10/2/80	28	<.02	<.005	<.001	<.008	<.01	.012
12/16/80	28	<.02	<.003	<.001	<.005	<.02	.008

*Samples were equal volume composites from surface, middle, and bottom samples. For sample locations, see Figure 1 (Dames and Moore, 1981).

Table 10. Metals in fish samples (ug/gm dry wt basis [ppm]).

Organism	Sample	Sample Site	Laboratory Analysis	Dry Wt. / Wet Wt.	As	Sb	Pb	Cd	Cr	Ni	Cu
Perch	Gill Set	ASARCO	WDOE	.393	<.08	.23	2.80	.12	.74	6.7	17
		Hart. Is.	WDOE	.272	<.10	.11	2.36	.13	.89	4.3	7
		ASARCO	ASARCO	.362	4.9	<10.9	10.9	1.1	10.9	<10.9	12.
	Tissue Plug	ASARCO	WDOE	.201	<.12	<.14	7.40	.12	.60	1.2	11
		Hart. Is.	WDOE	.207	<.07	<.08	1.87	.08	.22	<.14	2
		ASARCO	ASARCO	.201	1.2	<1.3	3.8	.13	2.5	<1.3	1.
	Gut Contents	ASARCO	WDOE	.183	3.76	1.64	12.5	14.2	1.6	1.8	241
		Hart. Is.	WDOE	.147	12.3	<.22	1.83	.59	7.6	38	40
	Liver	ASARCO	WDOE	.459	1.29	<.06	1.80	15.9	.19	1.6	96
		Hart. Is.	WDOE	.248	5.64	<.10	1.21	4.95	.40	.35	65
Rock-fish***	Gill Set	ASARCO	WDOE	.303	<.04	.43	2.70	.06	.27	.11	17
		Hart. Is.	WDOE	.303	<.07	<.08	.69	.07	.42	.29	2
		ASARCO	ASARCO	.273	18.2	7.2	20.6	.17	3.4	<1.7	48.
	Tissue Plug	ASARCO	WDOE	.243	<.09	<.10	2.01	.09	.33	<.18	2
		Hart. Is.	WDOE	.237	<.08	<.09	.97	.04	.27	.30	.
		ASARCO	ASARCO	.257	1.1	<1.3	1.3	<.13	1.3	<1.3	1.
	Liver	ASARCO	WDOE	.447	.11	<.03	3.58	1.04	.12	<.05	13
		Hart. Is.	WDOE	.369	<.04	<.04	.67	2.63	.16	<.07	30
		ASARCO	ASARCO	.437	2.4	<3.5	6.9	.69	3.5	<3.5	20.
Mussels	Soft Tissues	ASARCO	WDOE	.141	16.2	.25	.89	2.95	1.7	1.4	135
		Hart. Is.	WDOE	.101	1.70	<.14	1.01	5.00	1.5	2.7	11
		ASARCO	ASARCO	.134	10.7	<4.7	51.9	8.9	9.4	<4.7	278
		HCB-002*	WDOE	.177	2.61	<.11	1.36	17.0	2.1	4.0	18
		HCB-002**	WDOE	.209	1.04	<.09	1.77	10.5	.99	1.3	12
		SUZ-001**	WDOE	.232	.98	<.08	1.86	3.57	.86	1.4	6
		CRR-001**	WDOE	.271	.77	<.07	1.33	5.92	.82	.78	7
		CSE-001**	WDOE	.239	1.65	<.07	1.23	6.34	.72	1.1	7

* - 1979 sample
** - 1980 sample
*** - Void of gut contents.

NOTE: WDOE laboratory analysis involves digestion of samples at the WDOE laboratory and sample analysis at the

Table 11. Metals in fish samples (ppm on wet weight basis).

Organism	Sample	Sample Site	Laboratory Analysis	As	Sb	Pb	Cd	Cr	Ni
Perch***	Gill Set	ASARCO	WDOE*	<.03	.09	1.10	.05	.29	2.64
		ASARCO**	WDOE	1.8	--	4.5	.08	<1.0	<5.0
		Hart. Is.	WDOE*	<.03	.03	.64	.04	.24	1.17
		ASARCO	ASARCO	1.8	<3.9	3.9	.40	3.9	<3.9
	Tissue Plug	ASARCO	WDOE*	<.02	<.03	1.49	.02	.12	.24
		ASARCO**	WDOE	.81	--	<2.0	0.1	<1.0	<5.0
		Hart. Is.	WDOE*	<.01	<.02	.39	.02	.05	<.03
		ASARCO	ASARCO	.24	<.26	.76	.03	.50	<.26
	Gut Content	ASARCO	WDOE*	.69	.30	2.29	2.60	.29	.33
		ASARCO**	WDOE	1.1	--	5.8	1.3	<1.0	<5.0
		Hart. Is.	WDOE*	1.81	<.03	.27	.09	1.12	5.60
	Liver	ASARCO	WDOE*	.59	<.03	.82	7.3	.09	.74
		ASARCO**	WDOE	0.55	--	3.8	1.4	<1.0	<5.0
		Hart. Is.	WDOE*	1.40	<.03	.30	1.23	.10	.09
Rock-fish****	Gill Set	ASARCO	WDOE*	<.01	.13	.82	.02	.08	.03
		ASARCO**	WDOE	1.2	--	6.6	0.4	<1.0	<5.0
		Hart. Is.	WDOE*	<.02	<.02	.21	.02	.13	.09
		ASARCO	ASARCO	4.97	1.97	5.62	.05	.93	<.46
	Tissue Plug	ASARCO	WDOE*	<.02	<.02	.49	.02	.08	<.04
		ASARCO**	WDOE	1.1	--	2.5	.08	<1.0	<5.0
		Hart. Is.	WDOE*	<.02	<.02	.23	.01	.06	.07
		ASARCO	ASARCO	.28	<.3	.33	<.03	.33	<.3
	Liver	ASARCO	WDOE*	.05	<.01	1.60	.46	.05	<.02
		ASARCO**	WDOE	.43	--	<2.5	0.5	<1.0	<5.0
		Hart. Is.	WDOE*	<.01	<.01	.25	.97	.06	<.03
		ASARCO	ASARCO	1.05	<1.5	3.02	.30	1.53	<1.53
Mussels	Soft Tissues	ASARCO	WDOE*	2.28	.04	.13	.42	.24	.20
		ASARCO**	WDOE	0.76	--	5.8	1.3	<1.0	<5.0
		Hart. Is.	WDOE*	.17	<.01	.10	.51	.15	.27
		ASARCO	ASARCO	1.43	<.63	6.95	1.19	1.26	<.63

*Laboratory work involves digestion of samples at the WDOE laboratory and sample analysis at the E
**Data collected during the September 20, 1978 Class II at ASARCO (Cloud, 1979).
***Perch collected during September 20, 1978 Class II were pile perch (*Rhacochilus vacca*). Perch co
25, 1981 Class II were blue sea perch (*Taeniotoca lateralis*).
****Rockfish collected as part of the 1981 Class II were void of gut contents.

Table 12. Metals ratios in fish samples*.

Sample	As	Sb	Pb	Cd	Cr	Ni	Cu	Ag	Zn	Avg.
Perch										
Gill Set	≈1:1	2.1:1	1.2:1	.92:1	.83:1	1.6:1	2.4:1	1.7:1	.86:1	≈1.4:1
Tissue Plugs	≈1:1	≈1:1	4.0:1	1.5:1	2.7:1	>8.6:1	5.5:1	≈1:1	6.8:1	≈3.6:1
Gut Content	.31:1	>7.4:1	6.8:1	24.1:1**	.21:1	.05:1	6.0:1	1.8:1	6.4:1	>3.6:1
Liver	.23:1	≈1:1	1.5:1	3.2:1	.48:1	4.6:1	1.5:1	.09:1	.42:1	≈1.4:1
Rockfish										
Gill Set	≈1:1	>5.4:1	3.9:1	.86:1	.64:1	.38:1	8.5:1	>4:1	.83:1	≈2.8:1
Tissue Plug	≈1:1	≈1:1	2.1:1	2.3:1	1.2:1	<.60:1	2.2:1	≈1:1	6:1	≈1.9:1
Liver	>2.7:1	≈1:1	5.3:1	.39:1	.75:1	≈1:1	.43:1	.10:1	.70:1	≈1.4:1
Mussels	9.5:1	>1.8:1	.88:1	.59:1	1.1:1	.52:1	12.3:1	5.5:1	3.3:1	>3.9:1
Average	≈2.1:1	≈2.6:1	3.2:1	1.4:1	1:1	≈2.2:1	4.8:1	≈1.9:1	3.2:1	

*Calculations made using WDOE analysis dry weight data (ASARCO dry wt.: Hart. Is. dry wt.).
**Data point appears aberrant and was excluded from average calculations.