the Bay during the winter from direct sediment inflow and in the spring-summer season from the greater volume of sediment resuspended in the shallow areas. The greater turbidity also results in a larger sediment outflow to the ocean.

2.112 Dredging the shoaled sediment in navigation channels and disposing at one of the disposal sites in the Bay has the effect of redistributing the sediment within the system. As discussed in the preceding paragraph, the origin of the shoaled sediment is from the direct inflow of sediment-laden river water, and resuspension and recirculation of sediment in the Bay's shallow areas. Disposal of dredged sediments in the Bay brings back into circulation material that would otherwise remain out of circulation (retained in the channel). Upon disposal, the dredged sediment will reenter the deposition-resuspension-redeposition cycle, eventually being permanetly placed in low energy areas or carried to the ocean. Since dredged channels are out of equilibrium, a portion of the disposed dredged material will likely reenter the same or other dredged channels. Although dredged sediment, after disposal in the Bay, will be temporarily stored in the shallow areas, wind-wave action in these areas will resuspend and currents will recirculate the sediment.

2.113 Sites for disposal of dredged material in San Francisco along the channel margins or in natural channels. No net accumulation of dredged sediments in any of the disposal sites has been detected dince disposal operations at the sites were initiated. Disposal of dredged sediment in these high current velocity areas and the present practice of using the closest disposal site towards the ocean from the dredging site has the effect of eliminating one or more steps of the resuspension-recirculation-redeposition cycle in the process of transporting sediments through the estuary to the ocean. Studies currently being conducted by the San Francisco District (225, 232) indicate that a large amount of dredged sediments after disposal will be transported towards the ocean as bedload or as a high solids content suspended load within the confines of the natural channel. The major transporting mechanism of the dredged sediments in the natural channels is by tidal currents and occurs at depths greater than the depth of effective wave action. Just as the water has a tendency to remain in the natural channels, as evidenced by the high current velocities, dredged sediments also have a tendency to remain within the confines of the natural channels for at least some period of time.

2.114 The natural channel network leading to the ocean in the Bay is not continuous, causing the dredged sediments, like the natural sediments, to leave the boundaries of the natural channels and move onto the shallows as part of the resuspension-recirculation-redeposition cycle. The dredged sediments moving onto the shallows are dispersed and do not inhibit the system's ability to resuspend and recirculate the material (225). In contrast, if "high wave energy" or "low wave energy-low current energy" disposal sites were used for deposition of dredged sediments in the Bay, the ability of the system to assimilate the dredged sediment or the ability of the dredged sediment to reenter the resuspension-recirculation cycle could be significantly reduced. For example, disposing in north San Pablo Bay shallows during the winter, when wind-wave resuspension is at a minimum, could, conceivably, cause a large enough accumulation of dredged sediments such that wind-wave resuspension in the subsequent spring-summer season would be insufficient to remove all the material. The result of such an action would decrease the water depths in the surrounding area, further decreasing the wave action and the ability to resuspend and circulate the sediment. This would disrupt the existing equilibrium, resulting in a net accumulation of sediments in the shallows.

(5) Chemical Constituents in Bay Sediments.

2.115 (a) Sources of chemical constituents. The San Francisco Bay megalopolis with its concommitant industrial and commercial activities and natural erosion are the main sources for a wide range of chemical constituents in the Bay system. Dissolved chemicals are sorbed onto particulate matter (sediments) both before and after entry into the estuary, and show behavior and distribtuion patterns similar to that of natural sediments. The physical geography of the Bay and estuarine processes are responsible for their movement and deposition. Chemically-laden sediments accumulate in certain deposition zones within the Bay system, and in some cases reach high enough concentrations within bottom sediments to be considered "polluted". Sediments with high chemical content are found in areas subject to both maintenance and new-work dredging by the Corps of Engineers.

2.116 Chemicals enter the Bay system directly via municipal sewage and industrial waste outfall (known as point sources), storm drains and surface runoff, aerial fallout, overboard discharge from vessel; and indirectly via catchment basin rivers conveying agricultural drainage, materials from upland erosion and leaching from waste disposal sites adjacent to Bay and tributary receiving waters. These various sources of chemical contaminants are briefly described.

2.117 <u>Municipal and industrial discharge</u>. One source of chemical contaminants injected into the Bay is municipal and industrial wastewater discharge. A study of water quality and waste discharge characteristics in San Francisco Bay by the University of California identified 203 municipal and industrial dischargers (189) of which 83 major ones are shown in Plate II-24. These do not include municipal and industrial discharges injecting wastewater into the Sacramento-San Joaquin River System. In general, there are 160 municipalities and sanitary districts and 6,000 manufacturing enterprises located within the San Francisco Bay and Sacramento-San Joaquin Delta Region contributing to the cumulative impact of sewage and wastewater disposal in the Bay estuary.

2.118 Almost 100 percent of municipal sewage 1/ discharged into the Bay and Delta received either primary (60 percent) or biological secondary (40 percent) treatment (87). The level of industrial wastewater treatment falls between municipal primary and secondary processes. Combined wastewater flow rates generated by municipal and industrial sources range between 600 and 700 million gallons per day (mgd), and of this, ten percent of the total originates directly from industrial sources (87). The predominant delivery mechanism for this wastewater is through submarine outfall pipes located in shallow nearshore regions within the Bay.

2.119 Understanding the impacts of dredging and disposing of municipal and industrial effluent-laden sediments in the Bay requires consideration of the contaminants found in municipal sewage and industrial wastewater. A primary constituent of municipal effluent is fecal waste. Plant nutrients (especially nitrogen and phosphorus) are also primary constituents of municipal and industrial discharge. Large amounts of nutrient substances stimulate excessive algal (especially plankton) growth. Alga are photosynthetic organisms using dissolved oxygen for metabolic processes during periods of low light intensity. A high BOD also occurs during decomposition of these organisms after the plankton bloom has died-off. These die-offs can be triggered by overpopulation coupled with changing environmental factors such as - temperature, salinity, light availability, and current circulation patterns or a reduction in nutrient supplies.

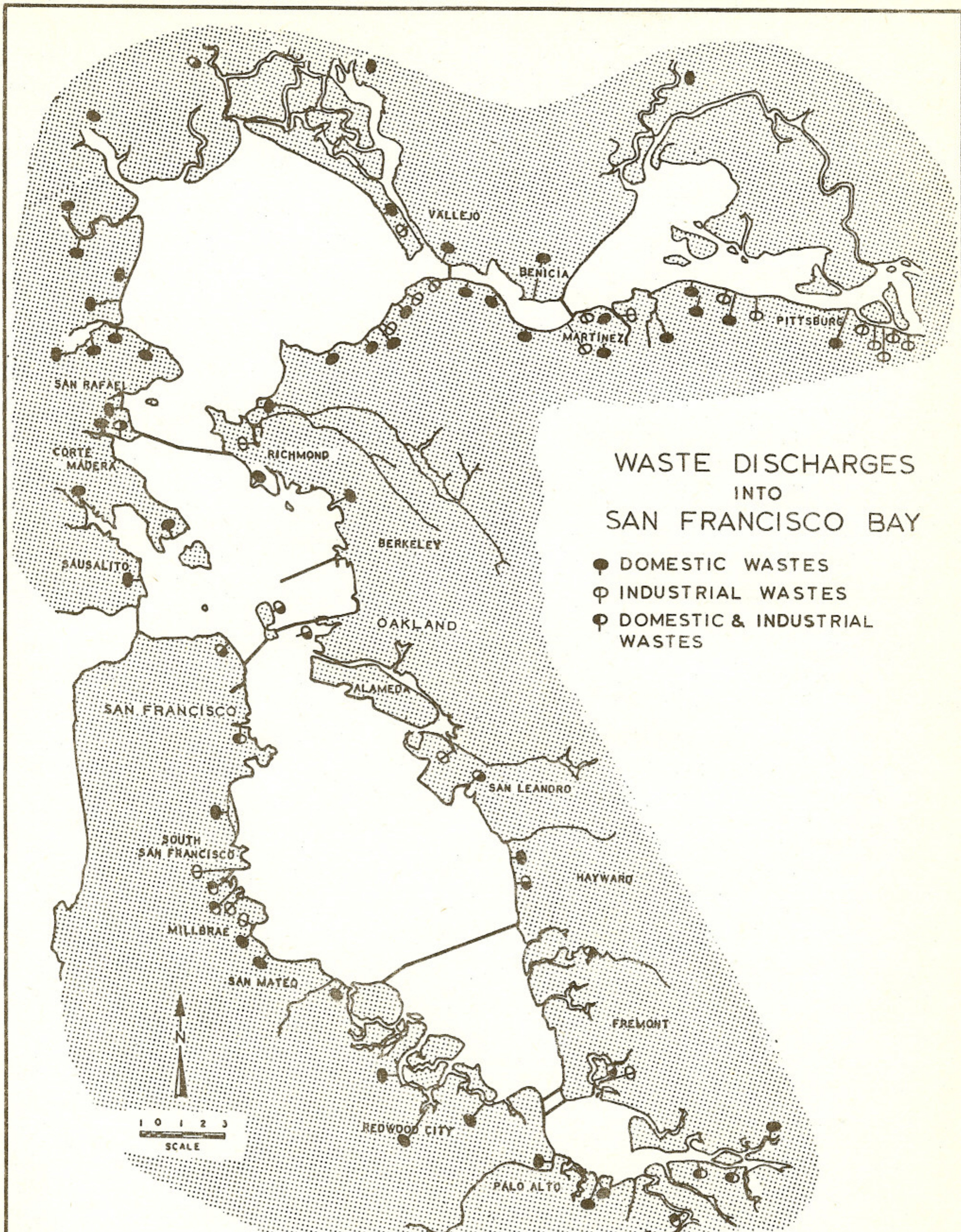
1/ The majority of industrial dischargers are connected to municipal treatment and sewage facilities.

2.120 Large amounts of halogenated organic compounds (e.g. PCB, DDT, etc.) enter the estuary via urban sewage (90). Industrial effluent containing a broad range of synthetic organic chemicals (mainly synthesized from petroleum compounds) is regularly pumped into the Bay. Industrial waste dischargers inject a number of potentially toxic trace metals (e.g., lead mercury, and cadmium) into the estuary. Many of these metals in low concentrations are required for biological growth in certain marine organisms (known as trace metals), but become toxic in high concentrations.

2.121 Agricultural drainage. A second category of contaminant sources is agricultural drainage, which is an important source because California agricultural productivity is the highest in the nation. Most of this agriculture is dependent on irrigation, fertilizers and pesticides. Presently, there are over six million acres of irrigated agricultural land within the Central Valley. Irrigation water not lost by evapotranspiration drains from the fields into local aquifers or into the Sacramento-San Joaquin River System. These agricultural wastewaters transport large quantities of pesticide, fertilizer residues, animal wastes, and nutrients and minerals leached from the soil into the river system which ultimately drain into the Bay. Chlorinated hydrocarbon pesticides are the most serious contaminants reaching the Bay as a result of agricultural activity and, like heavy metals, are concentrated and stored in bottom sediments.

2.122 Agricultural drainage is also a primary source of nitrogen and phosphorous compounds. Nitrogen waste loads delivered to the Bay-Delta system constitute four percent of the total nitrogen fertilizers applied to Central Valley agricultural lands (87). There is a seasonal regimen associated with the delivery of these pollutants to the Bay which is concentrated in the irrigation season during the summer.

2.123 Storm runoff. Many contaminants are washed into the Bay by surface water runoff during winter and spring rainstorms (October through May). Runoff occurs on both urban and non-urban (agricultural and undeveloped) land. Non-urban runoff has similar waste load and delivery characteristics as agricultural drainage.



Source: Scott, M. 1963. <u>The Future of San Francisco Bay</u>. Inst. Govt'al Studies, U.C. Berkeley.

2.124 Urban (street) runoff takes place in settlements with large, contiguous areas of impervious ground surface (e.g. paved streets, parking lots, and other paved and developed areas). Older urban areas, such as San Francisco, Sacramento, and Vallejo, have combined stormwater and wastewater sewage systems which means that during high intensity and long duration rainstorms, treatment facilities exceed maximum capacity. Flows exceeding this capacity are untreated, and raw sewage is diverted directly into the receiving waters of the Bay and its tributaries.

2.125 Potential pollutants are also deposited and accumulated on city streets between rainstorms. Major contributors of these contaminants (especially oil and grease) are auto spillage/leakage, gas and service stations, vehicle maintenance centers (especially during washdown operations) and shipyards.

2.126 Contaminated substances conveyed to the Bay by storm runoff are not delivered at a constant rate or concentration. Both flows and loads are determined by lag time between succeeding storms, as well as intensity and duration of individual storms. The first major storm of the rainy season washes more contaminants into the estuary and its tributaries than succeeding storms and the largest amount of these substances is washed off impervious surfaces during the first two hours of a storm (196). The predominant contaminant introduced into the Bay system by urban runoff is oil and grease.

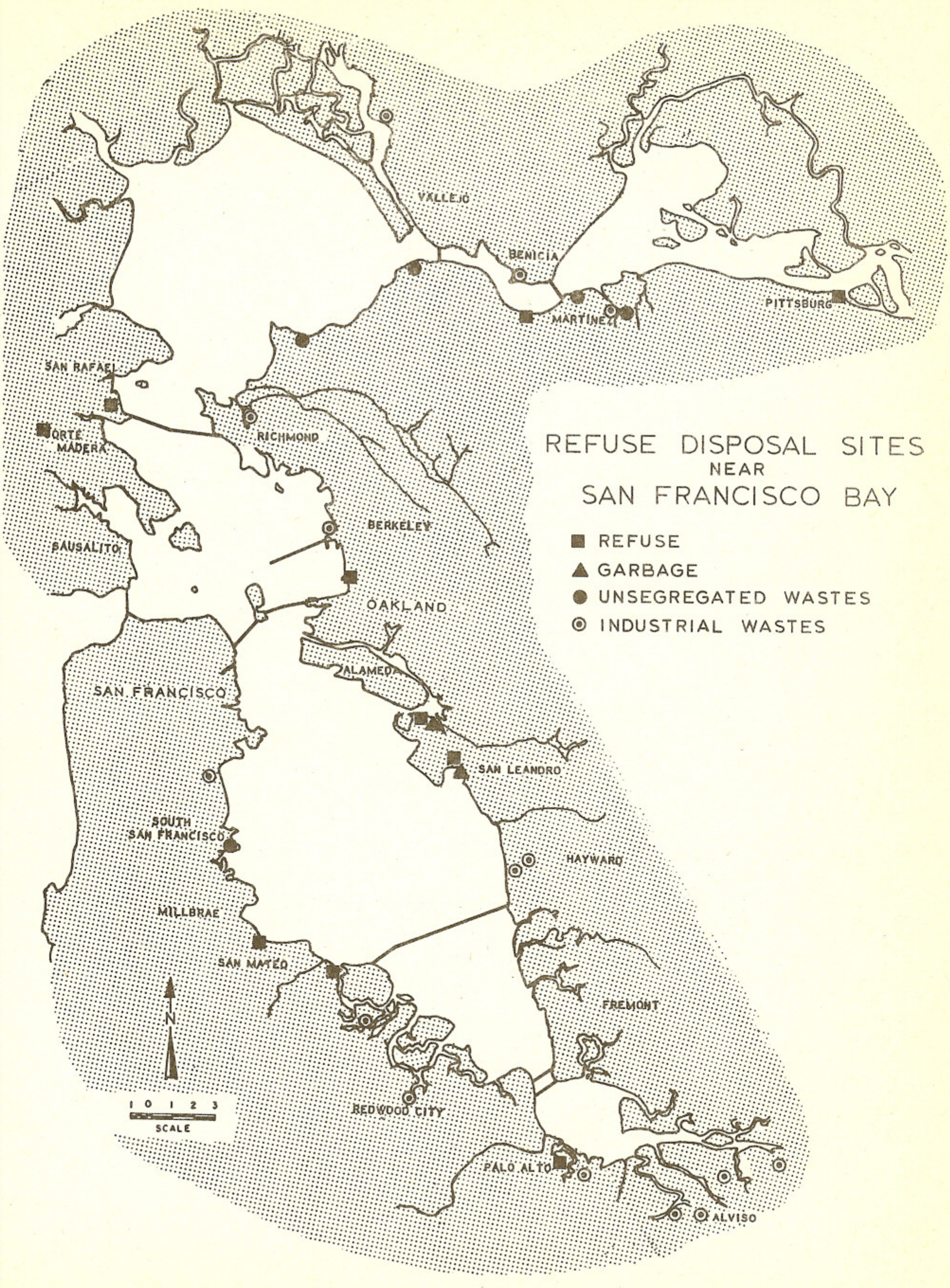
2.127 Aerial fallout. Aerial fallout delivers various types of airborne contaminants into the Bay system and includes residues from motor vehicle and aircraft exhausts (lead and hydrocarbons) particulate matter from industrial and domestic smokestacks and chimneys, and remnants of pesticides and fertilizers sprayed on crops.

2.128 Vessel discharge. Recreational (including houseboats), commercial and naval vessels (both underway and moored) are various sources whereby contaminants are introduced into the Bay estuary. Trash and garbage may be thrown overboard. Raw sewage use to be pumped directly into the receiving waters. It has been estimated that approximately 2,000 pounds of BOD (biochemical oxygen remand) per day is injected into the Bay from watercraft (87). A serious form of contamination is caused by petroleum residues conveyed into the Bay from ships (especially oil tankers) pumping bilge water, discharging ballast tanks and cleaning oil tanks.

2.129 Accidental oil spills from vessels occur as a result of collisions with other watercraft and shore structures. Anti-fouling paints exude a range of chemical constituents including copper, mercury, zinc, lead, chromium, arsenic and PCBs and thus surface sediments in harbors may contain large reservoirs of anti-fouling paint residues. Watercraft using sacrificial zinc anodes to control galvanic corrosion are sources of zinc contamination. Vessels consuming leaded-gasoline as fuel release lead residues into Bay waters.

2.130 Solid waste disposal sites. Solid waste disposal sites are additional sources of contaminants which consist of refuse, garbage and sewage sludge. In 1967, 13.5 million tons of solid waste was produced within the Bay-Delta region and disposed at 49 major sites located adjacent to the Bay and tributary wasters (Plate II-25). Contaminants are transported into contiguous estuarine and riverine waters by direct dumping, ebbtide flow (especially during tropic tidal and storm surge conditions), and seepage (resulting from soil saturation caused by rainfall, poor drainage and excessive applied water) through containment levees and dikes.

2.131 Upland erosion of parent formations. Trace elements (metals) in sediments of San Francisco Bay are derived in part from natural erosion of parent formations and conveyed to the Bay via the Bay's extensive drainage system. Many of these trace elements (such as, mercury, zinc, lead, cadmium, copper) are considered to be contaminants when deposited in the Bay system. The trace elements derived in this manner and deposited in the Bay are associated with sediments by being bound within the chemical structure of individual clay particles, attached to the surfaces of particles, and/or trapped within the latticework of conglomerated particles. No direct estimates have been made of the input of contaminants from upland erosion of parent formations. However, since this is the only true non-human associated source of contaminants in the Bay, quantitative estimates of the input from this source have been attempted from analysis of deep core samples in the Bay and adjacent land areas. D. H. Peterson, et al. of the U.S. Geological Survey in 1972 reported mercury, lead and copper concentrations from a deep bore-hole in South San Francisco Bay and associated these concentrations with sediments uncontaminated by man's activity (134). Table II-6 is a reproduction of their values. When making background determinations of trace metals (or other contaminants for that matter) extreme care must be taken to insure that samples are representative of the environment of deposition. Trace metals show an affinity for certain sediment



Source: Scott, M. 1963.

types which in turn exhibit selective deposition properties. This results in preferred accumulation types of sediments in different areas that could result in faulty background concentrations. In addition, vertical migration of trace elements due to changes in oxidation-reduction potentials and disturbances by organisms (bioturbidation) during deposition could play an important role in the vertical distribution of trace elements.

TABLE II-6

CONCENTRATIONS OF LEAD, COPPER AND MERCURY IN DEEP BAY SEDIMENTS

Depth Below Bay Bottom (feet)	Sediment Type	Element Concentration (ppm) Lead	Copper	Mercury
205	Mud	15	50	0.36
216	Sand	trace	15	0.15
245	Silt	trace	20	0.32
350	Mud	10	trace	0.28
405	Sand	none	15	0.06

Source: Peterson et al, 1972.

2.132 (b) Chemical contaminants in project sediments. The above discussion was centered on sources of contaminants in Bay sediments. The discussion that follows presents actual chemical concentrations in sediments from various dredging projects. Sediment samples have been obtained by the Corps of Engineers for all active maintenance dredging projects since 1970. In addition, pollution samples have been and are taken for all proposed navigation projects during feasibility studies. To characterize the chemicals in the Bay sediments, bulk sediment data on the parameters of lead, zinc, mercury, cadimum, copper and oil and grease are presented in Table II-7. Table II-7 includes a summary of the mean, standard deviation and range of contaminant concentrations in Corps dredged channel of Suisun Bay, San Pablo Bay, Central and South San Francisco Bay and San Francisco Bar (Main Ship Channel). The values represent four years of accumulated data and are based on hundreds of samples.

2.133 Generally, dredged channels in Central San Francisco Bay have lower mean concentrations of lead, zinc, cadmium, copper and oil and grease, than do channels in Suisun, San Pablo and South Bays. The mean concentration of each of the six parameters for all dredged channels from all sub-bays are as follows:

Parameter	Number of Samples	Mean Conc. (ppm)
Lead	869	35.6
Zinc	869	108.10
Mercury	872	0.55
Cadmium	567	1.59
Copper	380	41.6
Oil & Grease	727	800.0

2.134 Lead. The mean lead concentrations for the channels of Suisun-San Pablo Bays, Central Bay, South Bay and the San Francisco Bar are respectively, 38.8 ppm, 23.6 ppm, 47.9 ppm, and 10.9 ppm. The highest mean lead concentrations in dredged channels occur at Mare Island Strait (58.8 ppm) in San Pablo Bay, and Oakland Inner Harbor (58.3 ppm) and Redwood City Harbor (65.2 ppm) in South San Francisco Bay. Other areas with high mean lead concentrations are: Petaluma River (41.2 ppm) in San Pablo Bay, and Oakland Outer Harbor (49.3 ppm) and Alameda Naval Air Station (49.3 ppm) in South Bay. The largest ranges of lead concentrations in dredged channels are also found in these areas. For instance, in Redwood City Harbor, lead concentrations in bottom sediments range from 5 ppm to 286 ppm. Central San Francisco Bay channel sediments on the whole, have the lowest mean lead concentration in the Bay. Pinole Shoal (20.4 ppm) in San Pablo Bay and Southampton Shoal (15.7 ppm) in Central Bay have the lowest mean lead concentrations.

2.135 Zinc. The mean zinc concentrations for Suisun-San Pablo Bays, Central Bay, South Bay and the Main Ship Channel are respectively, 126.1 ppm, 87.4 ppm, 120.8 ppm, and 41.4 ppm. The highest zinc concentrations occur in the same dredged channels as do high mean lead concentrations; i.e., Mare Island Strait (193.3 ppm), Oakland Inner Harbor (141.3 ppm) and Redwood City Harbor (138.0 ppm). Other areas with high mean zinc concentrations are: Oakland Outer Harbor (136.1 ppm) and Alameda Naval Air Station (131.7 ppm). As with mean lead concentrations, Central San Francisco Bay navigation channels have the lowest mean zinc concentrations in the Bay. Other areas with low mean zinc concentrations are: Pinole Shoal Channel (76.2 ppm) in San Pablo Bay and Southampton Shoal (54.5 ppm) in Central Bay, and Islais Creek (62.9 ppm) in South Bay.

2.136 <u>Mercury</u>. The mean mercury concentrations in navigation channels of Suisun-San Pablo Bays, Central Bay, South Bay, and the San Francisco Bar, Main Ship Channel are respectively 0.41 ppm, 0.47 ppm, 0.78 ppm, and 0.02 ppm. The highest mean mercury concentrations are found in South Bay; namely, at Alameda Naval Air Station (1.10 ppm) and Oakland Inner Harbor (1.05 ppm). Some channels such as Sausalito in Central Bay and Islais Creek in South Bay have isolated cases of exceedingly high values of mercury. The lowest mercury concentrations are found in Carquinez Strait and Suisun Bay (0.21 ppm), Pinole Shoal Channel (0.20 ppm), Southhampton Shoal (0.38 ppm), and San Leandro Marina (0.18 ppm) in South Bay.

2.137 <u>Cadmium</u>. The mean cadmium concentrations in navigation channels of Suisun-San Pablo Bays, Central Bay, and South Bay are respectively 2.54 ppm, 1.04 ppm, and 1.84 ppm. No cadmium analysis has been performed on bottom sediments from the Main Ship Channel. The highest mean cadmium concentrations in dredged channels are found at Mare Island Strait (2.69 ppm), Islais Creek (2.30 ppm) and Redwood City Harbor (2.71 ppm). Other navigation channels with high mean cadmium concentrations are: Petaluma River (1.69 ppm), Richmond Inner Harbor (1.69 ppm). Oakland Inner Harbor (1.62 ppm) and Alameda Naval Air Station (1.82 ppm). In a few cases, individual sediment samples showed extremely high cadmium values. Two such examples are: Mare Island Strait sample with a concentration of 8.3 ppm, and one sample from Oakland Outer Harbor with a concentration of 15.6 ppm. On the whole, the lowest mean cadmium concentrations are found in Central San Francisco Bay channels. Southampton Shoal (0.86 ppm) has the lowest mean cadmium concentrations of the maintained navigation channels in the Bay.

2.138 <u>Copper</u>. The mean copper concentrations in Mare Island Strait, Central San Francisco Bay, and South Bay are respectively 85.02 ppm, 34.37 ppm, and 38.52 ppm. Mare Island Strait, the only navigation channel in San Pablo Bay having copper analysis, has the largest mean copper concentrations of all samples. Other channels with high mean copper concentrations are Richmond Outer Harbor (48.58 ppm), Richmond Long Wharf and Point Molate (50.02 ppm), Richmond Inner Harbor (49.67 ppm), and Alameda Naval Air Station (52.97 ppm). The channel with the lowest mean copper concentrations is Islais Creek (19.33 ppm).

2.139 <u>Oil and grease</u>. The mean oil and grease (O-G) concentrations in Suisun-San Pablo Bays, Central Bay, South Bay, and the San Francisco Bar are respectively 700 ppm, 520 ppm, 1,100 ppm, and 700 ppm. The highest mean O-G concentrations occur in Oakland Outer Harbor (1400 ppm) and Alameda Naval Air Station (1350 ppm). Large concentrations from individual samples have been encountered in Richmond Outer Harbor (6000 ppm) and Oakland Outer Harbor (8400 ppm). The lowest mean O-G concentrations occur at Southampton Shoal (200 ppm) in Central San Francisco Bay.

2.140 <u>Summary</u>. As one can see, the distribution of the above six parameters varies greatly within dredged channels of the San Francisco Bay System. The mean concentrations of parameters listed in Table II-7 indicate that the channels of Central Bay, including the Richmond Harbor complex, have lower mean concentrations for most parameters than do channels of Suisun-San Pablo Bays and South San Francisco Bay. Open-water channels such as Pinole Shoal Channel and Southampton Shoal Channel have lower mean concentrations than do the partially enclosed channels of active harbors; such as, Redwood City Harbor and Islais Creek and Mare Island Strait channel which have higher mean concentrations for most of the six parameters than do other channels in the bay.

2.141 Many of the mean concentrations listed in Table II-7 exhibit large standard deviations. These large values indicate a high degree of spread of measured values around the mean concentration. Three factors immediately become apparent as reasons for the large standard deviations. First, the samples used to arrive at the mean concentrations in Table II-7 are a result of four years of data collections in dredged channels representing large annual concentration variations in individual channels. Second, a large majority of samples represent only surface samples; these surface samples with few exceptions have substantially larger concentrations for all six parameters than do deeper sediments. Generally, surface sediment concentrations exceed those of deeper samples by 30 to 50 percent. In some cases the deeper sediment concentrations may be exceeded by the surface sediments by as much as 150 percent. Third, the spatial variation of contaminant concentrations vary greatly within individual channels.

TABLE II-7

MEAN CONCENTRATION OF CONTAMINANTS IN BAY CHANNELS
1970-1974

Description	Number of Samples	Mean ppm	Standard Deviation ppm	Range ppm
LEAD				
Suisun and San Pablo Bays	229	38.8		3-124
Pinole Shoal	54	20.4	8.8	7-43
Napa River	22	21.6	17.4	3-77
Sonoma Creek	9	30.4	22.0	10-81
Petaluma River	21	41.2	14.1	12-80
Point Davis 1/	7	33.7	12.0	17-46
Mare Island St.	88	58.8	20.4	26-124
Carquinez St. & Suisun Bay	28	26.7	16.6	9-66
Central San Francisco Bay	347	23.6		3-153
West Richmond Channel 1/	30	16.7	4.1	9-28
Southampton Shoal	34	15.7	4.9	10-30
Richmond Outer Harbor	76	28.3	24.8	60-150
Richmond Long Wharf	103	29.9	18.2	7-80
Sausalito 2/	75	16.8	16.1	3-89
South San Francisco Bay	285	47.9		4-286
Oakland Outer Harbor	71	49.3	49.7	5-234
Oakland Inner Harbor	33	58.3	38.3	12-144
Alameda N.A.S.	94	49.3	29.7	5-150
Islais Creek	45	30.9	29.1	5-50
San Leandro	5	67.2	13.1	52-80
San Bruno Shoal 3/	10	11.7	15.1	4-54
Redwood City	27	65.2	64.0	5-286
Main Ship Channel	8	11.0	7.9	1-27
All Channels	832	35.4	33.1	1-286

TABLE II- 7 (Cont'd)

Description	Number of Samples	Mean ppm	Standard Deviation ppm	Range ppm
ZINC				
Suisun and San Pablo Bays	229	126.1		31-624
Pinole Shoal	54	76.2	24.0	35-123
Napa River	22	86.3	36.2	32-175
Sonoma Creek	9	95.8	43.8	37-172
Petaluma River	21	112.0	41.4	31-188
Point Davis 1/	7	87.9	21.2	65-115
Mare Island St.	88	193.3	69.0	84-624
Carquinez St. & Suisun Bay	28	72.7	34.5	45-174
Central San Francisco Bay	347	87.4		20-549
West Richmond Channel 1/	30	55.3	8.9	39-73
Southampton Shoal	34	54.5	9.0	40-78
Richmond Outer Harbor	76	98.0	79.9	46-549
Richmond Long Wharf	103	104.3	28.7	38-218
Richmond Inner Harbor	29	90.9	55.8	20-240
Sausalito 2/	75	80.0	37.4	32-218
South San Francisco Bay	285	120.0		10-405
Oakland Outer Harbor	71	136.1	95.1	10-405
Oakland Inner Harbor	33	141.3	86.5	23-310
Alameda N.A.S.	94	131.7	57.3	16-380
Islais Creek	45	62.9	15.9	23-103
San Leandro	5	147.8	14.5	132-161
San Bruno Shoal 3/	10	41.6	12.0	22-63
Redwood City	27	138.0	79.0	41-343
Main Ship Channel	8	41.4	19.2	18-79
All Channels	869	108.1	68.1	1-624

TABLE II-7 (Cont'd)

Description	Number of Samples	Mean ppm	Standard Deviation ppm	Range ppm
MERCURY				
Suisun and San Pablo Bays	232	0.41		.01-4.0
Pinole Shoal	54	0.29	0.54	.05-4.0
Napa River	22	0.33	0.17	.01-.46
Sonoma Creek	9	0.40	0.23	.11-.81
Petaluma River	21	0.57	0.24	.20-.90
Point Davis 1/	7	0.28	0.19	.06-.38
Mare Island St.	88	0.56	0.43	.02-1.6
Carquinez St. & Suisun Bay	31	0.21	0.22	.01-.80
Central San Francisco Bay	347	0.41		.03-10.5
West Richmond Channel 1/	30	0.31	0.21	.03-1.1
Southampton Shoal	34	0.38	0.13	.10-.60
Richmond Outer Harbor	76	0.46	0.33	.10-1.9
Richmond Long Wharf	103	0.53	0.27	.10-1.7
Richmond Inner Harbor	29	0.40	0.29	.03-1.0
Sausalito 2/	75	0.55	1.22	.13-10.5
South San Francisco Bay	285	0.78		.01-10
Oakland Outer Harbor	71	0.46	0.29	.01-1.3
Oakland Inner Harbor	33	1.05	1.20	.008-4.9
Alameda N.A.S.	94	1.10	2.14	.08-10.0
Islais Creek	45	0.84	0.94	.12-5.6
San Leandro	5	0.18	0.03	.14-.2
San Bruno Shoal 3/	10	0.15	0.15	.17-.60
Redwood City	27	0.42	0.27	.11-1.2
Main Ship Channel	8	0.02	0.03	.002-.08
All Channels	872	0.55	0.92	.002-10.0

TABLE II-7 (Cont'd)

Description	Number of Samples	Mean ppm	Standard Deviation ppm	Range ppm
CADMIUM				
Suisun and San Pablo Bays	103	2.54		.07-8.3
Pinole Shoal	-	-	-	-
Napa River	-	-	-	-
Sonoma Creek	-	-	-	-
Petaluma River	15	1.69	0.24	1.2-2.0
Point Davis 1/	-	-	-	-
Mare Island St.	98	2.69	1.54	.70-8.3
Carquinez St. & Suisun Bay	-	-	-	-
Central San Francisco Bay	266	1.04		.3-3.4
West Richmond Channel 1/	17	0.56	0.14	.3-.80
Southampton Shoal	26	0.86	0.21	.50-1.3
Richmond Outer Harbor	57	1.24	0.50	.50-2.1
Richmond Long Wharf	79	1.01	0.48	.40-2.2
Richmond Inner Harbor	12	1.69	0.79	.79-3.4
Sausalito 2/	75	0.98	0.35	.33-2.4
South San Francisco Bay	198	1.84		.05-15.6
Oakland Outer Harbor	61	1.45	2.43	.05-15.6
Oakland Inner Harbor	12	1.62	0.68	.80-3.24
Alameda N.A.S.	52	1.82	1.05	.48-4.6
Islais Creek	40	2.30	1.30	.11-3.8
San Leandro	-	-	-	-
San Bruno Shoal 3/	10	0.65	0.51	.28-2.0
Redwood City	23	2.71	1.56	.35-4.8
Main Ship Channel	-	-	-	-
All Channels	567	1.59	1.37	.05-15.6

TABLE II-7 (Cont'd)

Description	Number of Samples	Mean ppm	Standard Deviation ppm	Range ppm
COPPER				
Suisun and San Pablo Bays	45	85.0		53-117
Pinole Shoal	-	-	-	-
Napa River	-	-	-	-
Sonoma Creek	-	-	-	-
Petaluma River	-	-	-	-
Point Davis 1/	-	-	-	-
Mare Island St.	45	85.0	19.5	53-117
Carquinez St. & Suisun Bay	-	-	-	-
Central San Francisco Bay	226	34.4		4-104
West Richmond Channel 1/	17	20.2	3.5	14-27
Southampton Shoal	26	25.3	6.4	13-43
Richmond Outer Harbor	50	48.5		20-104
Richmond Long Wharf	49	50.5	8.5	32-68
Richmond Inner Harbor	9	49.7	23.5	21-84
Sausalito 2/	75	19.2	9.3	4-37
South San Francisco Bay	109	38.5		6-85
Oakland Outer Harbor	35	35.7	25.2	7-85
Oakland Inner Harbor	-	-	-	-
Alameda N.A.S.	29	53.0	12.9	22-67
Islais Creek	12	19.3	10.3	6-38
San Leandro	-	-	-	-
San Bruno Shoal 3/	10	22.9	-	12-60
Redwood City	23	41.5	16.5	19-76
Main Ship Channel	-	-	-	-
All Channels	380	41.6	25.5	4-117

TABLE II-7 (Cont'd)

Description	Number of Samples	Mean ppm	Standard Deviation ppm	Range ppm
OIL - GREASE				
Suisun and San Pablo Bays	223	700	200	60-3100
Pinole Shoal	54	400	200	100-1100
Napa River	22	700	400	100-1900
Sonoma Creek	9	1000	1000	
Petaluma River	21	900	400	200-1800
Point Davis 1/	7	300	200	60-530
Mare Island St.	79	800	600	100-3100
Carquinez St. & Suisun Bay	31	500	400	100-1600
Central San Francisco Bay	271	520		10-6000
West Richmond Channel 1/	30	100	100	30-200
Southampton Shoal	34	200	100	30-700
Richmond Outer Harbor	76	600	900	10-6000
Richmond Long Wharf	102	700	400	80-1800
Richmond Inner Harbor	29	500	700	50-2200
Sausalito 2/	-	-	-	-
South San Francisco Bay	226	1100		20-8400
Oakland Outer Harbor	71	1400	1500	20-8400
Oakland Inner Harbor	16	650	420	90-1600
Alameda N.A.S.	78	1350	900	100-3000
Islais Creek	35	500	300	100-1500
San Leandro	5	1200	600	500-1900
San Bruno Shoal 3/	3	100	0	100-100
Redwood City	18	800	600	200-1600
Main Ship Channel	7	700	400	100-1000
All Channels	727	800	800	10-8400

1/ Point Davis and West Richmond Channel have not been dredged; they are part of the anticipated John F. Baldwin project.

2/ Sausalito Canal is an authorized project but has never been dredged (considered an inactive project).

3/ San Bruno Shoal Channel, which was authorized under the Redwood City Harbor project, is considered inactive and no longer maintained.

Since 1/, 2/ and 3/ are not maintenance dredging projects. They are not discussed in the text but are only included in the table for comparsion only.

Source: Dredge Disposal Study, Appendix B (in preparation).

2.142 (c) Elutriate analysis as dredge disposal criteria. On 5 September 1975, the interim final guidelines for the discharge of dredged or fill material in navigable waters were published in the Federal Register. These guidelines have resulted from comments on the 6 May 1975 proposed guidelines and provide immediate guidance for implementing the permit program under Section 404 of the Federal Water Pollution Control Act Amendments of 1972, Public Law 92-500, (See Section III, E., Compatibility of Aquatic Disposal and Water Use Controls, for brief discussion of disposal criteria development). These criteria allow consultation of the Regional Administrator of the Environmental Protection Agency on the interpretation of the interim final guidelines, but do not set any limiting concentrations to define polluted materials.

2.143 The discharge of dredge material into the territorial sea is governed by the Marine Protection, Research and Sanctuaries Act of 1972 (P.L. 92-532), commonly referred to as the Ocean Dumping Regulation. This regulation defines disposal material as polluted if the elutriate test indicates that the concentration of contaminants from the dredge site exceeds 1.5 times the concentration of the same contaminants in the water of the disposal site.

2.144 Under the interim final guidelines for navigable waters, the elutriate test may be used in order to predict the effect on water quality due to the release of contaminants from the sediment to the water column. Other tests to evaluate the effects of proposed discharges of dredged or fill material may be used as appropriate, since no single test can be applied to determine the array of effects in all cases.

2.145 The elutriate analyses that follow were conducted using the Ocean Dumping regulations. This data are presented only as a comparison for existing conditions and to preview heavy metal concentrations resulting from elutriate tests performed to date. Due to the similarity in testing procedures between the Ocean Dumping regulations and the proposed criteria of 6 May 1975 (Ref. Sec. III E), elutriate results are evaluated under both guidelines - based on one assumption. The assumption is that the disposal site water (in the Bay - although the Ocean Dumping Regulation concerns territorial waters) and the dredge site water (in the Bay) are similar enough so that both guidelines can be applied. Table II-8 presents the available results of tests conducted for some project areas using the 10-fold dilution factor of the 6 May 1975 proposed guidelines. Table II-8 should not be used to determine whether the material from a given project site is polluted or not, since the 5 September 1975 interim final guidelines do not specify pollution concentrations. Also, the elutriate test is only an indicator of the concentration of constituents given up to the water column, and has no bearing on the availability of these constituents to the biota. Retesting, where necessary, will be conducted based on consultation with the Regional Administrator of EPA.

2.146 In Table II-8, the terms "Disposal Site Water" and "Bay Water" are synonymous and refer to background levels of constituents before deposition of material. These background levels reveal wide variations for any given constituent (mercury, copper, etc.) and are governed by numerous factors, (many of which are unknown). Some factors affecting background levels of constituents in Bay waters are: tidal stage, mixing of fresh water with salt water, weather, effluent discharge rate and volume, runoff and season. Levels reported in Table II-8 can also be influenced by methods of analysis.

(6) Bay Water Quality Conditions.

2.147 (a) Introduction. The San Francisco Bay system is composed of essentially two physical regimes: sediment and water. The two regimes, although each discrete in itself, are interrelated and closely associated as to their chemical and physical properties. Sediment quality has been previously discussed and includes elucidation of the Bay's physical estuarine processes as they relate to pollutant sources. That information should be reviewed to enable development of a holistic impression of the physical system of the Bay.

2.148 Water, albeit a common substance, is the most important natural resource found in the San Francisco Bay area. Without this prime ingredient the region would lack its moderate climate, innate serenity and probably much of its large human population. However, to maintain an acceptable quality of life for the inhabitants of the region care must be taken to guard this resource.

2.149 The quality of the estuarine waters in the region has deteriorated since the period when the shores were bordered by lush vegetation and Indian camps. With approximately five million people presently surrounding the estuary, the probability of the waters returning to near pristine conditions is slight. However, the establishment of suitable criteria to protect the various beneficial uses of these waters will allow both man and the aquatic environment to survive and prosper.

TABLE II- 8

STANDARD ELUTRIATE ANALYSES

PROJECT	DATE SAMPLES TAKEN	SAMPLE NO.	SAMPLE DEPTH(FT)	AUTHORIZED DEPTH(FT)	MERCURY (PPM)	COPPER (PPM)	CADMIUM (PPM)	LEAD (PPM)	ZINC (PPM)	OIL & GREASE (PPM)	ORGANO-HALOGENS (PPB)		
San Francisco Bar (Main Ship Channel)	No analysis required because of sand substrate.												
Islais Creek	15 Jul 75	2F-16	35.0-44.0	35.0	—	—	—	—	—	—	0.03		
		2F-17	34.0-43.0	35.0	—	—	—	—	—	—	0.04		
		2F-18	27.0-38.5	35.0	—	—	—	—	—	—	0.02		
Range											0.02-0.04		
Mean											0.03		
Disposal Site Water											<0.01		
	6 Dec 73[1/]	1	36.0-38.0	35.0	0.0004	—	0.001	0.022	0.03	—	—		
Bay Water					0.0003	—	0.001	0.002	<0.01	—	—		
San Rafael Creek	10 Dec 73[1/]	7	5.0-7.0	8.0	0.0006	—	<0.001	0.012	0.02	—	—		
Bay Water					0.0003	—	0.001	0.002	<0.01	—	—		
Petaluma Creek - Phase I	28 Nov 73	2D-164	7.0-9.5	8.0	—	—	—	—	—	—	4.7(PCB)	—	0.011(DDT)
		2D-165	7.0-9.5	8.0	—	—	—	—	—	—	3.9(PCB)	—	0.008(DDT)
		2D-166	6.0-8.5	8.0	—	—	—	—	—	—	3.7(PCB)	0.15(BHC)	0.011(DDT)
		2D-167	7.0-9.5	8.0	—	—	—	—	—	—	6.0(PCB)	0.21(BHC)	—
		2D-168	7.0-9.5	8.0	—	—	—	—	—	—	4.2(PCB)	—	0.001(DDT)
		2D-169	7.0-9.5	8.0	—	—	—	—	—	—	4.0(PCB)	—	0.003(DDT)
Range											3.7-6.0		0.001-0.011
Mean											4.4	0.18	0.007
Disposal Site Water					—	—	—	—	—	—	4.1(PCB)	0.21(BHC)	0.005(DDT)
	17 Dec 73[1/]	12	12.0-15.0	8.0	0.0019	—	<0.001	0.012	8.00*	—	—		
Bay Water					0.0003	—	0.001	0.002	<0.01	—	—		
Mare Island Strait	6-7 Feb 75	2D-126(A)	22.0-27.2	26.0	—	0.02	0.008	0.02	0.13	—	—		
		2D-127(B)	26.0-30.9	30.0	—	0.07	0.014	0.07	0.03	22.2	—		
		2D-128(C)	26.0-30.4	30.0	—	0.02	0.012	0.02	0.06	—	—		
		2D-129(D)	28.0-31.0	30.0	—	0.01	0.008	0.01	0.04	—	—		
		2D-130(E)	21.0-31.0	30.0	—	0.02	0.013	0.02	0.10	—	—		
		2D-131(F)	28.0-31.0	30.0	—	0.03	0.013	0.03	0.14	24.2	—		
		2D-132(H)	29.0-32.0	30.0	—	0.04	0.013	0.04	0.27	12.6	—		
		2D-133(G)	29.0-32.0	30.0	—	0.03	0.028	0.03	0.06	34.8	—		
		2D-134(I)	29.0-32.0	30.0	—	0.03	0.028	0.03	0.07	25.8	—		
		2D-135(J)	28.0-31.0	30.0	—	0.03	0.017	0.03	0.06	20.8	—		
		2D-136(K)	28.0-31.0	30.0	—	0.03	0.033	0.03	0.08	11.7	—		
		2D-137(L)	27.0-31.5	30.0	—	0.02	0.024	0.02	0.10	—	—		
Range						0.01-0.07	0.008-0.033	0.01-0.07	0.03-0.27	11.7-34.8	—		
Mean						0.03	0.018	0.03	0.10	21.73	—		
Disposal Site Water					—	0.03	0.003	0.02	0.10	11.2	—		
Pinole Shoal	26-27 Feb 75	2D-164	34.5-37.0	35.0	—	0.03	0.01	0.01	0.07	—	—		
		2D-165	34.0-37.0	35.0	—	0.04	0.01	0.02	0.05	—	—		
		2D-166	34.0-37.0	35.0	—	0.03	0.01	0.01	0.06	—	—		
		2D-167	34.0-37.0	35.0	—	0.04	0.01	0.05	0.08	—	—		
		2D-168	34.0-37.0	35.0	—	0.03	0.01	0.06	0.05	—	—		
Range						0.03-0.04	0.01	0.01-0.06	0.05-0.08	—	—		
Mean						0.03	0.01	0.03	0.06	—	—		
Disposal Site Water					—	0.10	0.02	0.06	0.25	—	—		
Richmond Harbor Inner Harbor	24-25 Feb 75	2D-125	32.0-37.5	35.0	—	0.05	0.02	0.06	0.06	—	—		
		2D-126	34.0-37.0	35.0	—	0.04	0.02	0.09	0.15	15.2	—		
		2D-127	34.0-37.0	35.0	—	0.06	0.02	0.06	0.02	21.6	—		
		2D-128	34.0-37.0	35.0	—	0.02	0.02	0.04	0.15	—	—		
		2D-129	34.0-37.0	35.0	—	0.03	0.02	0.05	0.07	11.5	—		
		2D-130	34.0-37.0	35.0	—	0.02	0.02	0.08	0.10	—	—		
		2D-131	34.0-37.0	35.0	—	0.07	0.02	0.09	0.06	21.6	—		
		2D-132	34.0-36.8	35.0	—	0.06	0.02	0.09	0.06	—	—		
		2D-133	35.0-37.5	35.0	—	0.06	0.02	0.08	0.05	21.0	—		
Range						0.02-0.07	—	0.04-0.09	0.02-0.15	11.5-21.6	—		
Mean						0.05	0.02	0.07	0.09	18.2	—		
Disposal Site Water					—	0.10	0.02	0.06	0.25	17.2	—		

TABLE II -8 (Cont.)

STANDARD ELUTRIATE ANALYSES

PROJECT	DATE SAMPLES TAKEN	SAMPLE NO.	SAMPLE DEPTH (FT)	AUTHORIZED DEPTH (FT)	MERCURY (PPM)	COPPER (PPM)	CADMIUM (PPM)	LEAD (PPM)	ZINC (PPM)	OIL & GREASE (PPM)	ORGANO-HALOGENS (PPB)		
Richmond Harbor (cont.)		2D-134	36.0-46.0	45.0	—	0.06	0.02	0.09	0.06	—	—		
Outer Harbor		2D-135	39.0-46.5	45.0	—	0.05	0.02	0.08	0.06	22.5	—		
		2D-136	43.0-48.0	45.0	—	0.07	0.02	0.09	0.08	—	—		
Range						0.05-0.07	—	0.08-0.09	0.06-0.08	—	—		
Mean						0.06	0.02	0.09	0.07	22.5	—		
Disposal Site Water					—	0.10	0.02	0.06	0.25	17.2	—		
Oakland Harbor													
Inner Harbor	9 Feb 74	2D-179	33.0-38.0	35.0	—	—	—	—	—	—	0.04		
		2D-180	33.0-38.0	35.0	—	—	—	—	—	—	0.03		
		2D-181	33.0-38.0	35.0	—	—	—	—	—	—	0.04		
		2D-182	33.0-38.0	35.0	—	—	—	—	—	—	0.12		
Range											0.03-0.12		
Mean											0.06		
Disposal Site Water					—	—	—	—	—	—	<0.01		
	26 Sep 73	2D-13	33.0-35.5	35.0	0.0007	0.026	0.001	0.016	—	228	—		
		2D-14	33.0-35.5	35.0	0.0004	0.048	0.002	0.036	—	245	—		
		2D-15	34.0-36.5	35.0	0.0004	0.016	0.001	0.019	—	217	—		
		2D-17	33.0-35.5	35.0	0.0004	0.024	0.001	0.014	—	192	—		
		2D-21	33.0-35.5	35.0	0.0005	0.024	0.002	0.016	—	176	—		
		2D-25	34.0-36.5	35.0	0.0025	0.028	0.002	0.014	—	293	—		
Range					0.0004-0.0025	0.016-0.048	0.001-0.002	0.014-0.036		176-293			
Mean					0.0008	0.028	0.001	0.019		225			
Disposal Site Water					0.0006	0.024	0.001	0.014	—	166	—		
Outer Harbor	26 Sep 73	2D-134	37.0-39.5	35.0	0.0012	0.033	0.001	0.088	—	41	—		
		2D-135	38.0-40.5	35.0	—	—	—	—	—	—	—		
		2D-136	33.0-35.5	35.0	0.0008	0.015	0.001	0.017	—	166	—		
		2D-137	36.0-38.5	35.0	0.0012	0.019	0.001	0.014	—	159	—		
		2D-138	35.0-37.5	35.0	0.0006	0.034	0.001	0.017	—	126	—		
		2D-139	37.0-39.5	35.0	0.0004	0.020	0.001	0.017	—	127	—		
Range					0.0004-0.0012	0.015-0.034	—	0.014-0.088		41-166			
Mean					0.0008	0.024	0.001	0.031		123			
Disposal Site Water					0.0007	0.021	0.001	0.014	—	246	—		
San Leandro Marina	No elutriate data because project was dredged only once in 1973.												
Redwood City Harbor	7 Dec 73[1/]	2(1)	23.0-25.0	30.0	0.0011	—	0.001	0.010	<0.01	—	—		
		2(2)	23.0-25.0	30.0	0.0133*	—	<0.001	0.012	0.02	—	—		
Mean					0.0072		0.001	0.011	0.01				
Bay Water					0.0003	—	0.001	0.002	<0.01	—	—		
Sausalito Operations	6-7 Mar 75	2D-8(E)	19.0-26.0	23.0	0.0006	—	0.01	0.19	0.04	12.5	—		
Base Yard		2D-9(G)	24.0-26.0	23.0	0.0002	—	0.01	0.22	0.03	11.7	—		
		2D-10(F)	18.0-26.0	23.0	0.0002	—	0.01	0.21	0.04	12.3	—		
Range					0.0002-0.0006		—	0.19-0.22	0.03-0.04	11.7-12.5			
Mean					0.0003		0.01	0.21	0.04	12.2			
Disposal Site Water					0.0011	—	0.02	0.06	0.25	17.2	—		
Suisun Bay Channel	2-3 May 74	2D-1	30.0-32.5	30.0	—	—	—	—	—	—	1.2(PCB)	0.22(BHC)	—
		2D-2	29.0-34.0	30.0	—	—	—	—	—	—	0.5(PCB)	0.19(BHC)	0.009(DDT)
		2D-3	30.0-34.0	30.0	—	—	—	—	—	—	0.5(PCB)	—	0.008(DDT)
		2D-4	23.0-33.0	30.0	—	—	—	—	—	—	0.6(PCB)	0.23(BHC)	0.003(DDT)
		2D-5	29.0-31.5	30.0	—	—	—	—	—	—	0.6(PCB)	—	0.003(DDT)
		2D-6	26.0-33.5	30.0	—	—	—	—	—	—	0.5(PCB)	0.14(BHC)	0.003(DDT)
		2D-7	28.0-33.0	30.0	—	—	—	—	—	—	0.2(PCB)	0.11(BHC)	—
		2D-8	28.0-33.0	30.0	—	—	—	—	—	—	0.4(PCB)	—	—
		2D-9	29.0-31.5	30.0	—	—	—	—	—	—	0.4(PCB)	—	—
		2D-10	30.0-32.5	30.0	—	—	—	—	—	—	0.4(PCB)	—	—
		2D-11	31.0-33.5	30.0	—	—	—	—	—	—	0.5(PCB)	—	—
Range											0.2-1.2	0.11-0.23	0.003-0.009
Mean											0.5	0.18	0.005
Disposal Site Water					—	—	—	—	—	—	0.4(PCB)	—	—
	12 Dec 73[1/]	10	26.0-28.0		0.0008	—	<0.001	0.002	0.05	—	—	—	—
Bay Water					0.0003	—	0.001	0.002	<0.01	—	—	—	—

TABLE II - 8 (Cont.)

STANDARD ELUTRIATE ANALYSES

PROJECT	DATE SAMPLES TAKEN	SAMPLE NO.	SAMPLE DEPTH(FT)	AUTHORIZED DEPTH(FT)	MERCURY (PPM)	COPPER (PPM)	CADMIUM (PPM)	LEAD (PPM)	ZINC (PPM)	OIL & GREASE (PPM)	ORGANO-HALOGENS (PPB)
Suisun (Slough) Channel	No elutriate data. Channel last dredged in 1970.										
New York Slough Channel	No elutriate data. Probably dredged last in late -60's.										
Concord Naval Weapons Center	No elutriate data.										
Alameda NAS	19 Sep 74	2D-1A	32.0-42.0	42.0	0.0016	—	0.01	0.07	0.04	8.0	—
		2D-2A	38.0-43.0	42.0	0.0004	—	0.02	0.10	0.07	9.2	—
		2D-9A	35.0-42.5	42.0	0.0015	—	0.01	0.04	0.06	19.1	—
Range					0.0004-0.0016		0.01-0.02	0.04-0.10	0.04-0.07	8.0-19.1	
Mean					0.0012		0.01	0.07	0.6	12.1	
Disposal Site Water					0.0003	—	0.01	0.05	0.03	3.3	—
NOTRA - North	No elutriate data. Last dredged in 1967.										
Naval Supply Center - Oakland	No elutriate data. Last dredged in 1970.										
NOTRA - East	No elutriate data. Last dredged in 1970.										
Point Molate	13 Jul 74	2D-1	30.0-37.5	35.0	—	—	—	—	—	—	0.02
		2D-3	13.0-23.0	20.0	—	—	—	—	—	—	0.04
		2D-4	24.5-37.0	35.0	—	—	—	—	—	—	0.03
		2D-5	27.0-37.0	35.0	—	—	—	—	—	—	0.04
		2D-6	20.0-37.5	35.0	—	—	—	—	—	—	0.03
		2D-7	27.0-37.0	35.0	—	—	—	—	—	—	0.02
Range											0.02-0.04
Mean											0.03
Disposal Site Water					---	---	---	---	---	---	---?
Government Island	No elutriate data. Last dredged in 1967.										
Horseshoe Cove	No elutriate data. Last dredged in 1971, which consisted mostly of sand.										

1/ Data from Dredge Disposal Study, App. J.

* Exceeds proposed elutruate criteria of site water (1.5 limit) after 10-fold dilution factor applied to parameter (Ref. EPA [40 CFR Part 230]. "Navigable Waters, Discharge of Dredged or Fill Material." Federal Register, Vol. 40(88): 19794-19798, May 6, 1975.)

2.150 This section describes the present water quality condition of the Bay system and disucsses the extraneous influences which could modify this condition on either a long or short term basis. The characterization of present water quality conditions provides a baseline from which evaluation of human activities can be assessed.

2.151 The San Francisco Bay system, unlike many estuaries, is not a single well-defined body of water. Instead it is a series of four significantly different sub-bays which were briefly described earlier. These sub-bays vary in their water characteristics from one another because of many diverse factors including tidal influence, current paths, fresh water input and human activity. The boundaries of each, however, are not delineated by the water mass contained but by geographic features which separate them. The locations of these four sub-bays are shown on Plate II-11.

2.152 Because of the uniqueness of each of these areas the following discussion of water conditions in the San Francisco Bay system will be separated into discrete treatments of these four sub-bays. Where possible the discussion of extraneous influences will also follow this pattern.

2.153 (b) Water Quality Parameters. The quality of a water mass whether contained in a drinking glass or a drowned river valley can only be evaluated in terms of its intended uses. In the case of San Francisco Bay the California Water Resources Control Board has identified various beneficial uses and water quality objectives (186). Determination of the acceptability of a water mass necessitates measurement of selected parameters, and comparison of these measurements with criteria established according to the projected water use. The selection of parameters is dictated by the nature of the water body and the water characteristics of interest. Standard estuarine water quality parameters include salinity, temperature, pH, dissolved oxygen, turbidity and suspended solids. In addition to these basic characteristics, there are a large number of other analytical examinations that may be performed on a water sample depending on the intended use (240). A brief description of each of the basic six characteristics follows.

2.154 Salinity. The salinity of the water is important in maintaining the proper osmotic relationship between the organism and the water; thus, variations in salinity act mainly in determining the composition or types of species that inhabit a region rather than in determining the fertility of the region.

2.155 The formal definition of salinity and the technique established for its determination were developed by an International Commission in 1901 (36). Their definition is "the total amount of solid material in grams contained in one kilogram of sea water when all the carbonate has been converted to oxide, the bromine and iodine replaced by chlorine, and all organic matter completely oxidized". In general, salinity is a measure of the "saltiness" of a body of water. Units are either in parts per thousand, grams per kilogram, or parts per mille and are often abbreviated as ppt or ‰.

2.156 Temperature. Temperature is a factor of prime importance in the aquatic environment because of its effect on the physiological processes of animals and plants, especially upon rate of metabolism, growth and reproduction. For example, temperature strongly influences the rate at which calcium carbonate can be precipitated by molluscs and sponges in the formation of skeletal parts, shells and spicules. Equally important is temperature's close association with and influence on water characteristics such as the partial pressure of oxygen and other gases, viscosity and density distributions. The temperature reading is typically expressed to the nearest degree centigrade.

2.157 pH Value. The pH is a measure of the hydrogen ion concentration, or more correctly, the hydrogen ion activity. Pure distilled water dissociates into hydrogen and hydroxyl ions:

$$H_2O = H^+ + OH^-$$

For expressing the hydrogen ion concentration a logarithmic scale is used where pH is the logarithum of the reciprocal of the ion concentration in moles per liter. The practical pH scale extends from 0 (very acidic) to 14 (very alkaline). The middle of the scale (pH 7) corresponds to neutrality at 25 degrees centigrade (=77°F), and for most natural waters is between 4 and 9 with the majority of waters being slightly (greater than 7) because of the presence of carbonate and bicarbonate. The pH value is generally reported to the nearest 0.1 pH unit.

2.158 All bodies of water have a pH value, whether it be the Bay or the water inside a living cell. The pH affects the rate of chemical reactions and thus the importance of maintaining the proper pH value is often vitally important to life. For most chemical reactions to occur optimally, a pH range of 4 to 9 is usually required.

2.159 <u>Dissolved Oxygen</u>. Oxygen is indispensable to the life processes of all organisms. Normally, it is only available for metabolic activities when it is in solution in a free state. Very few organisms, mainly anaerobic bacteria, are able to utilize oxygen complexed with organic molecules. Thus, to continue respiration most organisms must have a source of free oxygen. In salt water the reservoir contains only about 9 mg/l whereas the atmospheric reservoir contains over 200 mg/l. Obviously, reduction in the oxygen level of the environment by introduction of oxygen consuming materials is a much more critical problem to aquatic organisms than air-breathing life. Therefore maintenance of sufficient oxygen concentrations for aquatic respiration is essential and measurement of dissolved oxygen is a primary parameter in water quality monitoring.

2.160 <u>Turbidity/Suspended Solids</u>. Turbidity is a poorly quantifiable parameter giving a relative indication of the amount of suspended matter in water. The parameter is defined by the degree of attenuation of light intensity passing through water. The light decrease is the result of not only blockage by particulates (including minerals, finely divided organic and inorganic matter, and plankton) but by dissolved solids and color. Any correlation between turbidity and the weight concentration of suspended matter is fortuitous. The shape, size and refractive index of particulate minerals are of great importance optically but are only indirectly related to the concentration and specific gravity of the suspended solids. Determination of actual suspended solids concentration requires filtering, drying and weighing. Measurement of light scattering by optical instruments is a less expensive and more convenient method to provide a relative basis for comparing the cloudiness of water. The standard optical instrument used is the Jackson candle turbidimeter. There are other transmissometers and nephelometers which have come into common usage. However, owing to the fundamental differences in the optical systems, the results obtained from these different systems will frequently not correlate even though the instruments are all precalibrated against the candle turbidimeter. Additionally, the different instruments report their measurements in one of several unit systems. Jackson turbidity units (JTU), Formazine turbidity units (FTU), nephelometric units (NU), and percent transmission are the principal unit categories. However, results reported in one system are not necessarily comparable to results reported in another system. Thus, comparison of readings and the estimates of suspended matter concentration derived from optical readings are of little value when quantitative investigations are required. When