TABLE IV-28

SUMMARY OF IMPACTS

POTENTIAL IMPACTS (Section discussed)	Class	DREDGING			AQUATIC DISPOSAL			LAND DISPOSAL			Cum	Sig
		Type	Term	Rating	Type	Term	Rating	Type	Term	Rating		
WATER QUALITY								(effluent discharge)				✓
1. Increase in turbidity (IVB.1b)	P	1°	short	0 to -1	1°	short	0 to -1	1°	short	0		
a. Decrease in phytoplankton productivity	B	1°	short	0 to -1	1°	short	0 to -1	1°	short	0		
b. Impairment of predator visual acuity	B	1°	short	0 to -1	1°	short	0 to -1					
c. Impairment of filter feeding invertebrates and resultant population change	B	1°	short	-1	1°	short	-1					
2. Reduction in dissolved O_2 (IVB.1b)	B							2°	short	0		
a. Effect on distribution and abundance of invertebrates	B	1°	short	0 to -1	1°	short	0 to -1					
b. Effect on populations of plankton and fish	B	1°	short	0 to -2	1°	short	0 to -2					
3. Creation of a high density zone at the sediment-water interface (IVB. 1b)	B	1°	short	0 to -2	1°	short	0 to -2				X	
4. Suspension of toxicants (IVB.1d)	P	1°	short	-1	1°	short	-1	2°	short	0 to -1		
a. Effects of heavy metals on benthos	B	2°	long	U(-)	2°	long	U(-)	2°	long	U -	X	
b. Effects of heavy metals on plankton and fish	B	2°	long	U(-)	2°	long	U(-)	2°	long	U -	X	

TABLE IV-28 (Cont'd)

POTENTIAL IMPACTS (Section discussed)	Class	DREDGING Type	DREDGING Term	DREDGING Rating	AQUATIC DISPOSAL Type	AQUATIC DISPOSAL Term	AQUATIC DISPOSAL Rating	LAND DISPOSAL Type	LAND DISPOSAL Term	LAND DISPOSAL Rating	Cum	Sig
REMOVAL OF SUBTIDAL BENTHIC COMMUNITY (IVB.1c)												✓
1. Loss of habitat for invertebrates	B	1^{o} 1^{o}	short long	0 to -1 0 to -2	1^{o} 1^{o}	long long	0 to -1 0 to -2				X	
2. Loss of food source for free swimming organisms	B	2^{o} 2^{o}	short long	0 to -1 0 to -2	1^{o} 2^{o}	short long	0 to -1 0 to -2				X	
DISPOSAL ON SALT MARSHES (IVB.2)	B							1^{o}	long	-1 to -3	X	✓
1. Loss of primary productivity	B							1^{o} 2^{o}	long long	U- U-	X X	
2. Loss of estuarine animal habitat: birds, fish, mammals, invertebrates	B							1^{o}	long	-1 to -3	X	
3. Endangerment of rare and endangered species (IVB.4)	B							1^{o}	long	0 to -3	X	
4. Loss of plant and animal biomass	B							2^{o}	long	U-	X	
5. Loss of sink (trap) for pollutants	B S							2^{o} 2^{o}	long long	U- U	X X	

TABLE IV-28 (Cont'd)

POTENTIAL IMPACTS (Section discussed)	Class	DREDGING Type	DREDGING Term	DREDGING Rating	AQUATIC DISPOSAL Type	AQUATIC DISPOSAL Term	AQUATIC DISPOSAL Rating	LAND DISPOSAL Type	LAND DISPOSAL Term	LAND DISPOSAL Rating	Cum	Sig
INTERRUPTION OF HABITAT CONTINUITY												✓
1. Terrestrial (marsh and upland areas) (IVB.2)	B							1°	long	0 to -3	X	
2. Aquatic												
a. Bay (IVB.1c)	B	1°	long	0 to -1	1°	long	0 to -1				X	
b. Ocean (VID.1)	B				1°	long	0 to -2				X	
REMOVAL OF UPLAND VEGETATION (IVB.2)												✓
1. Loss of productivity and biomass	B							1°	short	0 to -2	X	
								1°	long	0 to -2		
								2°	long	0 to -2		
2. Loss of habitat or shelter	B							1°	long	0 to -2	X	
								2°	long	0 to -2		
3. Endangerment of rare and endangered species (IVB.4)	B							1°	long	0 to -3	X	
								2°	long	0 to -3		
CREATION OF NEW WILDLIFE HABITAT (VID.3,4)												✓
1. Terrestrial (marsh and upland areas)	B							1°	long	+1 to +3	X	
	S							2°	long	+1 to +3		
2. Aquatic ("Spoil islands")	B				2°	long	U+					
	S				2°	long	+1 to +3					
a. Effects on water circulation	P				1°	long	U					
b. Effects on sedimentation	P				1°	long	U					

TABLE IV-28 (Cont'd)

POTENTIAL IMPACTS (Section discussed)	Class	DREDGING			AQUATIC DISPOSAL			LAND DISPOSAL			Cum	Sig
		Type	Term	Rating	Type	Term	Rating	Type	Term	Rating		
TOPOGRAPHY AND BATHYMETRY												✓
1. Settlement (IVB.2)	P							2°	short	0 to -1		
2. Development of "mud waves" (IVB.2)	P							2°	long	U		
	B							2°	long	U		
3. Increase shoaling rate (IVB.1f)	P	1°	long	0 to -3							X	
		2°	long	0 to -3								
	B	2°	long	U								
4. Increase scouring rate (IVB.1f)	P	2°	long	0 to +3							X	
	B	1°	long	-1 to -3							X	
AIR QUALITY (IVB.5)												
1. Air pollution from dredge engine exhaust	P	2°	long	0 to -1	2°	long	0 to -1					
2. Odor	S							1°	short	0 to -1		

TABLE IV-28 (Cont'd)

POTENTIAL IMPACTS (Section discussed)	Class	DREDGING Type	DREDGING Term	DREDGING Rating	AQUATIC DISPOSAL Type	AQUATIC DISPOSAL Term	AQUATIC DISPOSAL Rating	LAND DISPOSAL Type	LAND DISPOSAL Term	LAND DISPOSAL Rating	Cum	Sig
ECONOMY (IVC)												✓
1. Maintains Port facilities and navigation commerce	S	1°	long	+3								
2. Helps sustain land values	S	2°	long	+3				2°	long	U	X	
3. Maintains public revenues	S	2°	long	+3				2°	long	U	X	
4. Maintains need for community services	S	2°	long	+2							X	
SOCIAL COMMUNITY (IVD)												
1. Helps sustain community life-style and integration	S	2°	long	+1							X	
2. Helps maintain governmental and transportation structure	S	2°	long	+1							X	
RECREATION (IVD.5)												✓
1. Maintains facilities for recreational boating	S	1°	long	+3							X	
HISTORICAL AND ARCHAEOLOGICAL RESOURCES (IVD.1)												✓
1. Terrestrial	S							1°	long	0 to -3		
2. Aquatic	S	1°	long	0	1°	long	0					

TABLE IV-28 (Cont'd)

POTENTIAL IMPACTS (Section discussed)	Class	DREDGING Type	DREDGING Term	DREDGING Rating	AQUATIC DISPOSAL Type	AQUATIC DISPOSAL Term	AQUATIC DISPOSAL Rating	LAND DISPOSAL Type	LAND DISPOSAL Term	LAND DISPOSAL Rating	Cum	Sig
<u>AESTHETIC</u> <u>ATTRIBUTES</u> (IVD.6)												✓
1. Interruption of visual integrity	S	1°	short	-1	1°	short	-1	1°	long	-1 to -3	X	
2. Loss of natural environment	S	1°	long	0 to -3	1°	long	0 to -3	1°	long	+2 to -3	X	
3. Scenic viewing	S	1°	short	-1	2°	long	-1	1°	short	-1 to -2		
4. Odor from land disposal								1°	short	-1 to -2		
5. Air pollution	S	2°	short	-1	2°	short	-1					

Adverse Environmental Effects Which Cannot Be Avoided V

SECTION V

ADVERSE ENVIRONMENTAL EFFECTS
WHICH CANNOT BE AVOIDED

A. ADVERSE EFFECTS ON WATER QUALITY

5.001 Sediment disturbance from routine maintenance dredging and disposal is unavoidable, and because of the fine material in the Bay turbidity plumes are created. The spatial and temporal extent of the plumes depend on the type of dredge used and on environmental factors (currents, wind, etc.). Clamshell dredges resuspend sediments throughout the water column; hoppers create turbidity primarily by running the dragheads through the shoal material and by overflow, and to a lesser degree by prop-wash; and the hydraulic cutterhead dredges disturb the bottom by rotating the cutterhead. For a more detailed discussion on turbidities created by various dredges, see Dredging and Sediment Disturbance in Section IV. Duration of the turbidity plume resulting from dredging in the Bay is typically less than 15 minutes but may last up to an hour during the winter and early spring when salinities are diluted (223).

5.002 During aquatic disposal, release of the material from the hopper bins or scows causes turbidity in the water column (extent depends on cohesiveness of material during descent) and on impact on the bottom. Bay aquatic disposal sites are high energy areas and the material is quickly dispersed and diluted within minutes.

5.003 At the San Francisco Bar, since the material is sand, very little turbidity is created during dredging and disposal.

5.004 In the Bay as well as at the Bar, a fluff similar to that occurring during storm conditions or periods of high sediment transport is generated during dredging and disposal at the sediment-water interface, which can remain in the channel or disposal site for several weeks.

5.005 Extraneous increases in turbidity over ambient levels could, among other effects, decrease phytoplankton productivity, impair predator visual acuity and impair filter feeder organisms but any such effects would normally be, very temporary and localized as explained in Section IV. The term normally is used because the fluff created at the sediment-water interface, especially in the deeper channel areas, could have greater adverse effects than turbidity created in the water column, simply because it tends to last longer.

5.006 Associated with sediment disturbance are certain temporary chemical changes in the water column. Bay mud is typically in a reduced state (oxygen deficient) and when resuspended, there is a demand on the oxygen in the water column. Severe oxygen depletion in the water can detrimentally affect all life in the water column. However, oxygen depressions in the upper water column are negligible during both dredging and disposal operations. Depressions do occur and continue in the high sediment concentration near the sediment-water interface during dredging operations as a result of sediment disturbance. During disposal operations temporary oxygen depressions (a few minutes) occur in the sediment transport zone at the bottom of the water column.

5.007 During oxidation of the disturbed sediments, certain elements, particulary those that are loosely bound to the clay, silt and organic particles, can be released from the sediments. On the other hand, dissolved elements are often scavenged by the suspended material. For the most part, most elements are tightly bound to the sediment particles and those that are released are usually in the sub-parts per billion concentration, which are diluted even further by dispersal. Dissolved chemicals and those chemicals bound to organic particles are the most probable pathways for biological uptake. Studies to date indicate that the actual amount of chemicals made available as a result of disturbing and re-distributing sediments is so small and of such short duration that the chemical's actual availability for biological uptake is very limited. The short-term effect has thus far been unmeasurable (229).

5.008 In addition to the primary impacts on water quality from dredge/disposal operations, there are potential secondary impacts. Maintenance dredging provides safe navigation and encourages full use of the channels and turning basins. Such navigation activity could potentially result in the deterioration of the water quality from cumulative, and invertent oil, gas and waste discharge. In order to prevent these discharges, strict adherence to pertinent local, State and Federal water pollution laws and regulations is essential. Other secondary or indirect impacts result from port, marina and oil company operations that are served by the navigation projects, and include air pollution and runoff to name only two.

B. <u>ADVERSE EFFECTS ON AQUATIC BIOTA</u>

5.009 During dredging, bottom organisms are excavated and displaced; during disposal they are buried. These impacts are unavoidable. In a frequently maintained channel or basin the biota would obviously be different from the surrounding area because the sediments are repeatedly disturbed and the biota assaulted. This does not mean, however, that frequently dredged areas are pauperate of species or numbers of individuals. Data from Mare Island Strait clearly show that the channel contains numerous organisms even though the channel is dredged biannually (see Table IV-7). Oakland Inner Harbor is dredged annually and yet it contains the most densely populated numbers of organisms and one of the richest varieties of organisms sampled from our various project sites in the Bay (224). The San Francisco Bay Channel is also dredged annually but this area is still biologically productive and very similar in species composition to the rest (undredged portions) of the Bar. Projects that are less frequently dredged, say once every 10 years or less, probably have a climax community similar to its surroundings.

5.010 The five aquatic disposal sites (four in the Bay and one at the Bar) are high energy areas characterized by high currents and scowering of the bottom. Animals residing in these areas will experience very little burial during disposal because the material is usually quickly dispersed. Nevertheless, there is some temporary accumulation on the bottom and those animals unable to exhume themselves would die. Those would be the sessile or non-motile bottom forms which are not typically found in high energy areas or where there is movement of the bottom substrate. Except for those organisms in the direct path of disposal, organisms in the water column (plankton and fish) will not be adversely affected.

5.011 Biological uptake of released elements from disturbed sediments has already been mentioned and because of the extremely low concentrations, adverse impacts attributable to dredging disposal are not expected.

5.012 Unavoidable adverse effects of disposing at the 100-Fathom disposal site are discussed in Section VI.

C. ADVERSE EFFECTS ON THE TERRESTRIAL ENVIRONMENT

5.013 Of the five projects anticipating land disposal, only one project land site has been investigated in detail. If Site No. 1 (see Plate I-15) for Redwood City Harbor is used, anticipated development by the Port of Redwood City, once the site is filled, would preclude any other uses. All impacts related to the permanent change of biological conditions of the site are considered adverse. Of particular concern is the elimination of potential habitat for some endangered and rare species known to inhabit the general vicinity. Formation of a mud wave is conceivable resulting from hydraulic disposal but if the site is filled at a slow and uniform rate, this pehnomenon can be restricted or prevented.

5.014 During land disposal, ridding excess water mixed with the sediments is necessary. Excess water overflowing from the weirs could temporarily increase the turbidity of the receiving water and reduce water quality. The Regional Water Quality Control Board has in the past required that the turbidity level be controlled to 1 ml/1 per hour or less. This has been complied with where required. When the new dredge disposal criteria for navigable waters become established, then the Corps will comply with the new regulations governing effluent discharge quality from upland disposal sites. Any odor emanating from the dredged material might be unavoidable.

5.015 Secondary and long-term adverse impacts would depend on the development and uses of the filled sites. If Site No. 1 is filled and developed according to the Port of Redwood City's plans, the added social and economic changes in the immediate area could affect the water quality and place additional stress on the remaining undeveloped tidal lands surrounding the Port. Extent of development would be limited, however, since the San Francisco Bay National Wildlife Refuge encompasses the mouth of Redwood Creek and vicinity.

D. OTHER ADVERSE EFFECTS

5.016 The dredging operation results in a minimal addition of hydrocarbons and carbon monoxide to the atmosphere. For some of the smaller projects, such as San Rafael Creek, San Leandro Marina and Redwood City Harbor, there might be some unavoidable interference with navigation during dredging.

Alternatives VI

SECTION VI

ALTERNATIVES

A. INTRODUCTION

6.001 Actually, there is only one alternative to maintenance dredging and that is no maintenance. Potential impacts of such an action are discussed below, and together with the discussion of economic impacts in Section IV, should give a reasonably clear picture as to the importance of maintenance dredging of the existing navigation projects in the Bay Area.

6.002 Although maintenance dredging is regarded as essential to the economic well-being of the Bay Area, this does not mean that alternative methods of dredging and disposal to reduce environmental impacts should not be sought. Alternative methods of dredging are being studied at the Corps Waterways Experimental Station in Mississippi which are briefly mentioned in the Alternative Method of Dredging discussion. Ideas to reduce environmental impacts by modifying the dredging and disposal techniques are discussed under Dredging Technology.

6.003 Alternative disposal sites and associated potential impacts are also discussed in this section. Ocean disposal is discussed in reference to the EPA-designated 100-Fathom Disposal Site. Under Land Disposal alternative, dredged material is treated as a potentially useful resource as opposed to it being defined as "spoil" material to be simply disposed of. Two potential uses of dredged material are mentioned: island reclamation is briefly described, and saltmarsh creation is discussed in detail.

6.004 Since average annual maintenance dredging in the Bay is over 10 million cubic yards, a brief discussion of the San Francisco District's study and conclusion on reducing the shoaling rate at a few of the major projects is included.

B. NO MAINTENANCE

6.005 As mentioned previously, the only true alternative to maintenance dredging is no maintenance of the federal navigation projects in San Francisco Bay. Although it does not appear likely that such a drastic action would be required, it is discussed below in order to consider all possibilities.

6.006 1. Complete Moratorium. The effects of no maintenance may be categorized into environmental and socio-economic effects, both short range and long range. The short range environmental effects would be rapid shoaling of the deepwater channels and unimpeded recolonization of benthic organisms. Recolonization would be a positive effect. Over the long range the rate of shoaling would decrease asymptotically as the channel depth reaches the equilibrium of its pre-dredged state. The equilibrium or pre-dredged depth of each of the channels in San Francisco Bay is roughly estimated in Table IV-20. Similarly, recolonization by benthic organisms would eventually reach a climax community similar to the pre-dredged state (assuming no deterioration in sediment and water quality from other sources).

6.007 No maintenance may, however, cause increased pollutant concentrations in local areas, particularly in harbors near industrial and municipal sewage outfalls. As channels shoal up to equilibrium depth, pollutants in the surface sediments formerly removed by dredging may tend to build up. This effect would be reinforced by reduced flushing action due to shallower depths, and may be particularly significant in Mare Island Strait where bulk sediment analyses have consistently shown high concentrations of pollutants. On the other hand, no maintenance will force closure of ports and marinas, and closure of any direct sewage outfalls into the Bay from any of these areas will correspondingly reduce the amount of pollutants entering the Bay.

6.008 The socio-economic effects of no maintenance are extremely complicated and nearly impossible to quantify accurately. Table IV-20 indicates that a complete moratorium on dredging would reduce channel depths to such an extent that deep-draft shipping to the ports of Oakland, Richmond, Petaluma, Redwood City, Stockton and Sacramento would be virtually eliminated. The entire Bay region would be dramatically affected since its social and economic health depend to a great extent on continued waterborne commerce. The extent of this commitment is graphically illustrated in the list of major facts and findings in Section IV D of this report. However, deepwater shipping is only one determinant of economic health interacting with many other determinants such as finance, manufacturing, government, agriculture, labor force, construction, land use, national and international economic trends and relationships, and land and air transportation systems.

6.009 Nevertheless, the major facts and findings indicate that over 20,000 jobs may be lost if all maintenance dredging was to cease. This should be considered an indirect long-range impact. Other economic impacts may be a loss in payrolls of up to $309 million, an additional 7,800 jobs lost in export manufacturing, a prodigious loss of nearly $2 billion in port investment, and a multitude of indirect effects, such as loss of up to 20,000 more jobs in the local business sectors (the "multiplier effect") and widening waves of economic depression throughout the Bay region as a whole. Certain business sectors may benefit, particularly railroads, trucking firms, air freight lines, and ports elsewhere on the West Coast, which would absorb a portion of the cargo volume. These benefits, however, would most likely be small compared to the losses incurred due to a cessation or drastic decline in Bay shipping. Prices of many commodities would rise rapidly due to more expensive modes of transportation and delivery.

6.010 In terms of demography, one might expect to see a certain population exodus from the major port areas due to the decline in employment, resulting in a cornucopia of tertiary effects: loss of tax revenue, loss of operating capital for banks and other institutions, housing decline, loss of community cohesion and cultural opportunities, and last but not necessarily least important, changes in community attitudes and expectations.

6.011 2. Partial Moratorium. A variation of no maintenance dredging would be a partial moratorium as opposed to the complete moratorium discussed above. A partial moratorium may involve elimination of dredging at one particular harbor or channel where pollutant concentrations are highest and transferring the waterborne commerce to other harbors, or involve limited dredging at several harbors, thereby reducing the authorized depths.

6.012 The sets of economic effects generated by a partial moratorium would not be based on an absolute loss of Bay Area waterborne commerce (as in the case of a complete moratorium), but rather on a reorganization of existing modes of transportation. For example, if dredging was to cease only in Oakland Harbor, other ports would attempt to absorb the cargo volume. The Port of San Francisco might absorb nearly all berths north of the Bay Bridge, and a portion of the containerized cargo at Pier 96 and future Pier 98.

The Port of Richmond might also proceed with construction of its planned Inner Harbor container terminal. Still, the economic benefits to other ports would most likely be small compared to the loss of $74 million of facilities at the Port of Oakland (Table IV-16) and the indirect economic impact on local businesses and industries in the City of Oakland.

6.013 The other variation - limited dredging of several channels - would most likely result in increased lightering at mid-Bay. Depending on the commodity being shipped, lightering may or may not be feasible. Petroleum is easily transferred from ship to barge by flexible pipeline; in fact, this process is already common in the Bay. However, transferring of containerized or general cargo from a deep-draft vessel to a barge or other shallow-draft vessel would be extremely difficult and is not known to be feasible at this time. Furthermore, extensive lightering would cause congestion problems at mid-Bay. Regardless of the place or the means, increased lightering would inevitably result in the increased price of the finished product for the consumer.

6.014 Limited or no dredging at military installations, however, must be considered separately. Although there would be economic impacts, such as loss of jobs, income and local business, the primary consideration would tend to be one of national defense security. MOTBA North, MOTBA East, the Naval Supply Center-Oakland, Government Island, Point Molate, Alameda Naval Air Station, Concord Naval Weapons Station, and Mare Island Naval Shipyard all service units of the Navy's Pacific Fleet, the U.S. Sixth Army, the Coast Guard, and other West Coast and Far East based military units. The costs of relocation would be absorbed through the national military budget and hence would not be losses specific to the Bay Area, but would be a major loss to the nation as a whole. Table IV-19 indicates that the total replacement cost for these eight military installations would be more than $1.6 billion. Similarly, closure or relocation of these bases may be construed as a hindrance to national security. San Francisco Bay is a militarily strategic location as a protected harbor in an urban area with access to many other modes of transportation and a skilled labor force. In terms of military logistics, closure and/or relocation of these bases outside the Bay would present an enormous security problem.

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6.015 Partial or no dredging would also hinder recreational boating. Over 1,000 boats are berthed along San Rafael Creek and 475 in San Leandro Marina. A moratorium on dredging would cause these channels to silt in to such an extent that recreational boating would be virtually eliminated. In addition, Table IV-20 indicates Petaluma River and Redwood Creek would silt into a similar extent, eliminating most boating along these channels as well. Redwood Creek presently berths 590 boats and some of the marinas are planning to expand because of the ever increasing demand for berths. Petaluma River presently supports nominal recreational boating; but, because of the demand for more berths, a 440 berth marina is being planned for construction.

6.016 In general, a partial or complete moratorium on federal maintenance dredging should therefore be considered an extreme measure which would have both positive and negative environmental effects, but with severe socio-economic impacts of widespread ramifications throughout the Bay region and the nation as a whole.

C. ALTERNATIVE METHODS OF DREDGING

6.017 There are basically only three methods of dredging and all three are being used in San Francisco Bay. These are the hydyraulic cutterhead pipeline, hopper and clamshell dredges, and the particular method used generally depends on the disposal site and cost. There is one other dredge that is used on the East and Gulf Coasts but not on the West Coast. This fourth dredge is a modified hydraulic dredge called the sidecaster. Instead of the material being pumped through a pipeline onto land or a barge, the material dredged by a sidecaster shoots the material out into open water. This type of dredge is normally used in a shallow, open water, sandy environment where little turbidity would be created. Use of the sidecaster would thus, not be practical in San Francisco Bay because extensive turbidity would be created and there is not enough open water to allow for "sidecasting" the material except at Pinole Shoal Channel, Suisun Bay Channel, New York Slough Channel and the San Francisco Bar Channel. It would probably be quite economical to sidecast dredge the open channels in Suisun Bay (a predominantly sand bottom in the channels) on a cost per project basis but it would not be economical in the long run for the government to purchase a sidecaster just to dredge two projects in the Bay. Sidecast dredging at the San Francisco Bar is impractical because the treacherous conditions at the bar would easily overturn the shallow draft sidecaster. Also, the drag arm of the sidecast dredge is too short to dredge the 55-foot authorized depth although alterations could probably be made with corresponding loss in dredging efficiency.

6.018 Modification of the three basic types of dredges used in the Bay in light of reducing potential impacts on the aquatic environment without sacrificing dredging efficiency is currently under study by the Corps' Waterways Experiment Station (WES) in Vicksburg, Mississippi. The discussion under Dredging Technology reveals some of the ideas under consideration.

D. ALTERNATIVE DISPOSAL SITES

1. Ocean Disposal.

6.019 a. Introduction. If for some reason(s), the various regulatory agencies feel that ocean disposal (outside the Golden Gate) is the only viable alternative to ridding Bay dredged material, then the EPA - designated 100-Fathom Disposal Site would be the logical location for deposition which is approximately 30 miles southwest of the Golden Gate (see Plate I-2).

6.020 It was pointed out in Section II under Oceanographic Conditions Outside the Golden Gate, that the continental shelf off the central California coast, which includes the Gulf of Farallones, is a highly productive area where virtually all depths of the shelf are utilized for feeding, spawnings and nursing. Plates II-51 and II-52 reflect the high productivity of this region and it appears that the greatest productivity for most commercially important fish is centered in the Gulf of the Farallones and south of the Farallon Islands at depths greater than 50 fathoms.

6.021 b. Ocean Disposal Study. A study by the San Francisco District and the U.S. Navy was conducted to assess the impact of ocean disposal at a 100-fathom site west of the Farallones in September 1974. Details of the study will be published in Appendix L of the Dredge Disposal Study (231).

6.022 A test disposal site was established along a 100-fathom contour line at 37°, 41'N and 123° 07.5'W. The site is approximately 35 nautical miles west of San Francisco and five nautical miles west of the Farallon Islands (Plate VI-1). Originally a site located 20 miles northwest of the study area was selected, but this site was found to have a sloping bottom, making it unsuitable for conducting the planned survey; therefore, the 100-fathom contour line was followed until a flat area was found. The study area was a 500-foot by 1,000-foot rectangle with a northwest to southeast orientation. The site was marked at each corner with a sonar reflector placed six feet from the bottom and at the center of the northwest end with a surface buoy (Plate VI-2).

6.023 Approximately 4,000 cubic yards of dredged material loaded in two barges towed in tandem were released over the study area. Sediment and benthic samples were collected prior to release and photographic surveys were made both before and after the dump.

6.024 The primary vehicle used for the survey was the Naval Undersea Center's (NUC) Cable-Control Underwater Recovery Vehicle, CURV III. This vehicle is tethered, unmanned and remotely controlled. The vehicle was used to place sonar reflectors on the bottom, to mark a grid pattern on the bottom at the study area and to take photographs. The support vessel for CURV III during this study was the M/V GEAR.

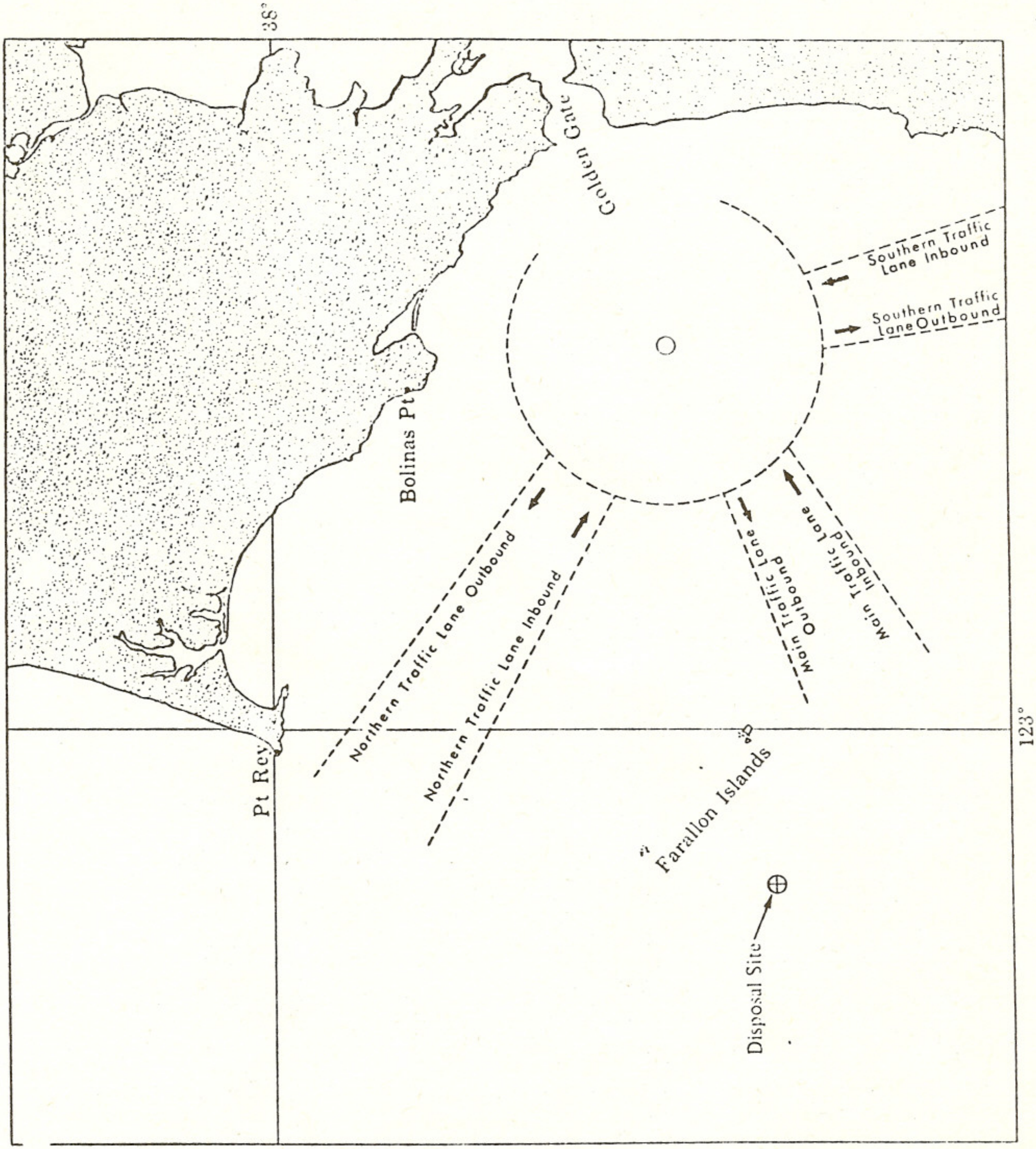
6.025 (1) Marine Sediment Analysis. Sediment samples were collected prior to the release of dredge material at five sites located at 200-foot intervals, along a 1000-foot transverse of the disposal study area (Plate VI-2). Each sediment sample was analyzed for copper, lead, zinc, cadmium and mercury. The sediment samples were also analyzed for chemical oxygen demand, volatile solids and grain size distribution.

6.026 Copper ranged from 4.97 - 7.81 ppm at four stations and was 21.1 ppm at a fifth station, cadmium levels ranged from 0.084-1.03 ppm, lead from 5.53-9.05 ppm, zinc from 30.9-61.5 ppm, and mercury from 51-87 ppb at three stations with two stations having values of 267 ppb and 376 ppb. COD ranged from 12.85-20.34 mg/g and volatile solids ranged from 1.6 percent to 2.9 percent.

6.027 Dispersed grain size distributions were as follows:

Station No.	Median Diameter (mm)	Mean Diameter (mm)	Composition (%) gravel	sand	silt	clay
1	0.0337	0.0190	0	24	56.6	19.5
2	0.0728	0.0661	0	58	40.0	2.0
3	0.0661	0.0791	0	72.2	21.3	6.5
4	0.1111	0.1073	0	85.5	12.5	2.0
5	0.1051	0.1022	0	88.5	9.5	2.0

6.028 (2) Benthic and Demersal Fauna. Speciation and enumeration of epibenthic macrofauna were obtained from photographs taken prior to dumping by CURV III (see description of ocean benthos in Section II). Animal densities were calculated from numerical totals obtained from the photographic survey. The mean area covered per slide was estimated to be $2.25m^2$; and the total area covered by the photographs was 1316 m^2. Animals on each slide were enumerated by group and the total for each group was divided by the total estimated area to obtain density. Species were also identified from the slides.



LOCATION OF THE OPEN OCEAN DREDGE MATERIAL DISPOSAL
SITE WEST OF THE FARALLON ISLANDS

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

PLATE VI-1

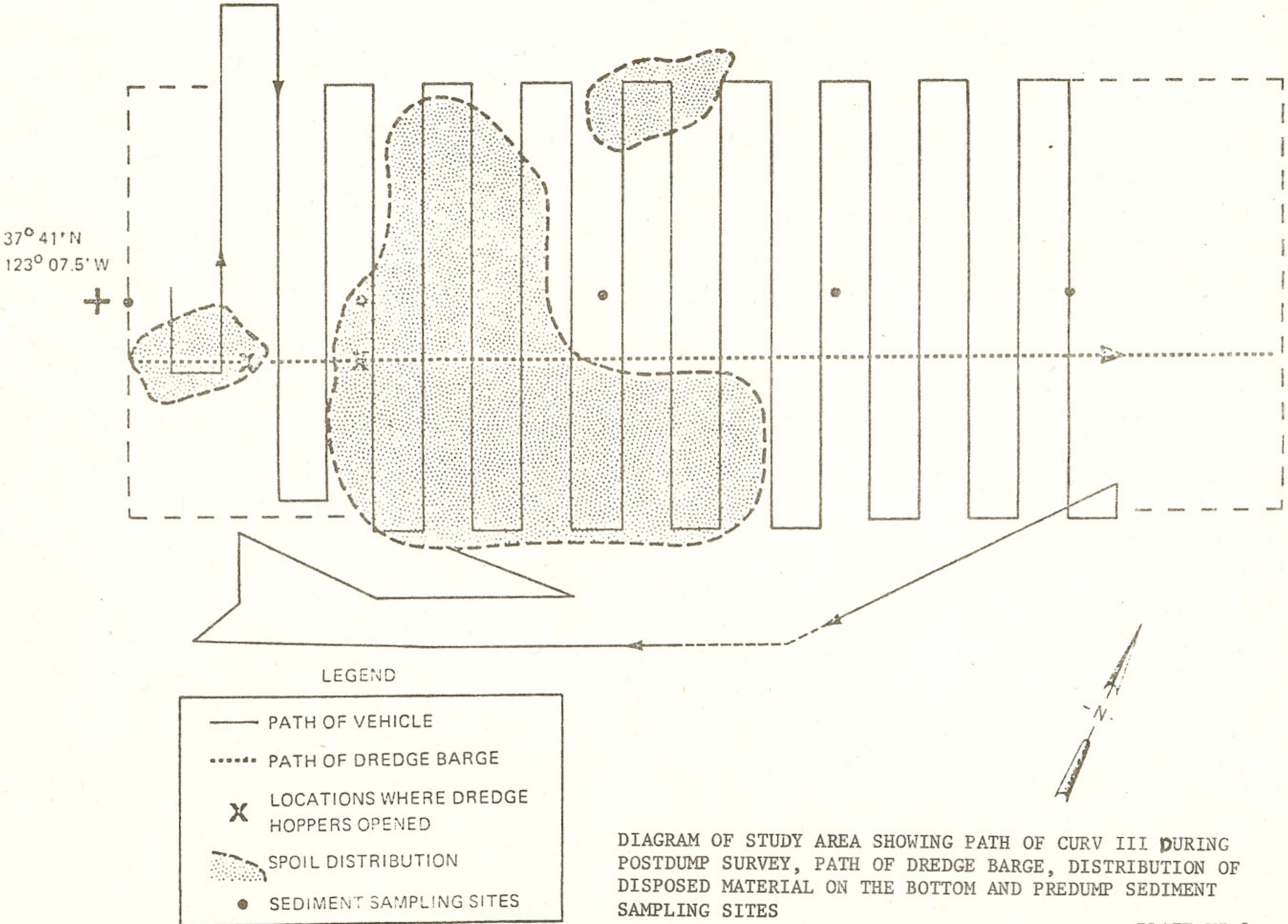


DIAGRAM OF STUDY AREA SHOWING PATH OF CURV III DURING POSTDUMP SURVEY, PATH OF DREDGE BARGE, DISTRIBUTION OF DISPOSED MATERIAL ON THE BOTTOM AND PREDUMP SEDIMENT SAMPLING SITES

PLATE VI-2

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

6.029 Three species of macrofauna were collected for analysis with a grasping backet assembly fitted to the CURV vehicle. A Pisaster sea star, a small Pacific hake fish, Merluccius productus, and a Heart urchin, Echinocardium, were collected. Each species was analyzed for mercury, copper, cadmium, lead, chromium, and zinc.

6.030 The epibenthic macrofauna of the study area was relatively abundant. Based on the photographs, the dominant group was the arthropod which made up about 70 percent of all bottom animals. In order of decreasing abundance the remainder were molluscs (13%), bony fishes (10%), and echinoderms (7%). The density of total animals was relatively high (1801 animals over 1316 m^2 or 1.4 animals/m^2), but the species diversity was relatively low. For a more detailed description of the bottom of this area, see Section II.

6.031 In three epibenthic species, copper ranged from 1.74-5.87 ppm, cadmium from 0.128-1.66 ppm, lead from 2.06-7.27 ppm, and chromium from 16.7-103.3 ppm. Mercury concentrations on replicate samples of the sea star were 259 ppb and 204 ppb.

6.032 (3) Dredge Material Release. To determine the dispersal of the dredged material a grid pattern was first marked on the bottom of the study area. This was accomplished with CURV III during the predump photographic survey using the skids of the vehicle. The predump markings consisted of 1,000-foot-long parallel lines at 25-foot intervals.

6.033 The dredged material was then released from two hoppers containing 2,000 cubic yards each. The hoppers were towed by a dredge barge starting from a position adjacent to the surface buoy and proceeding through the study area at a speed of 1-2 knots (Plate VI-2). The hoppers were opened 150 feet and 200 feet southeast of the buoy and the material was released as the vessel proceeded on course. Hoppers were emptied by the time they reached 500 feet into the study area.

6.034 Approximately 12-hours after the release of dredged material a second photographic survey was made. The vehicle followed a track perpendicular to the predump markings (Plate VI-2). As each 35-mm frame was exposed a sequential number was exposed on that frame. This number was related to a number tally in the CURV III control van on board the M/V GEAR. The position of the dredged material on the bottom was determined by cross referencing the frame number with the number and position log maintained in the control van.

6.035 Photographs indicate that the dredged material was deposited unevenly over the disposal site. Most of the material fell directly below the path of the barge, and at impact, some of the material spread laterally to the edge of the study area. Some of the material was deposited in large clumps while the rest was finer and more widely dispersed.

6.036 The photographic survey indicated that the average depth of deposited material was approximately one foot. Based on the area of deposition, this indicates a sediment total of 5,000 cubic yards of material which is in reasonable agreement with the 4,000 cubic yards actually dumped.

6.037 (4) Impacts. The potential physical and chemical impacts of disposal operations in aquatic areas are discussed in Section IV under Impacts on the Natural Environment. In general, the release of sediments near the waters surface may subject local organisms (such as plankton) to elevated levels of turbidity, various chemical pollutants and reductions in dissolved oxygen. Table VI-I compares water quality conditions observed in two Bay disposal areas (Carquinez Strait and Alcatraz) with those conditions measured near the 100-fathom contour in the Gulf of the Farallones.

TABLE VI-1

COMPARISON OF WATER QUALITY IN
BAY AND OCEAN DISPOSAL AREAS

WATER QUALITY PARAMETERS	DISPOSAL AREAS		
	Carquinez	Alcatraz	100-fathom
Salinity			
Surface	9.5	35.8	33.5
10 meters	12.9	26.6	33.5
Temperature			
Surface	13.8	14.5	13.5
10 meters	13.6	13.2	13.5
pH			
Surface	7.4	7.9	-*
10 meters	7.5	7.6	-*
Dissolved Oxygen			
Surface	9.1	8.6	10.4
10 meters	9.0	9.2	10.5
Turbidity (% transmission)			
Surface	27.9	95.7	91.6
10 meters	19.9	99.0	89.5
Turbidity (FTU)			
Surface	91.5	6.3	0.0
10 meters	132.5	13.0	1.0
Current Velocities (Maximum)	8-9	6-7	0-1

*Probe malfunction

In general, natural turbidity in the Gulf is low and dissolved oxygen is near saturation. Current velocities at the 100-fathom area are very low in comparison to the high energy Bay disposal areas.

6.038 The ocean disposal study indicated that nearly all of the dredge material fell directly below the path of two bottom dump barges with very little lateral mixing. The long haul (approximately 40 miles) and constant vibration caused consolidation of the material in transit and when released, fell in-mass. Under these conditions, it is doubtful that there was any significant degradation of the water column during disposal since little mixing between the dredged material and the water column occurred.

6.039 The physical and chemical properties of sediments dredged within San Francisco Bay differ greatly from those sediments found near the 100-fathom contour. Table VI-2 compares the physical properties of Bay sediments collected in three major dredged channels within San Francisco Bay with sediments sampled during the ocean disposal study.

TABLE VI-2

PHYSICAL PROPERTIES OF BAY AND OCEAN (100-FATHOM) SEDIMENTS

Dispersed Grain Size	Mare Island Strait 1/	Oakland Outer Harbor	Oakland Inner Harbor	100-fathom 2/
% sand	12	5	15	66
% silt	46	39	37	28
% clay	42	56	48	6

1/ San Francisco Bay and Estuary, Dredge Disposal Study Appendix F, Crystalline Matrix, 1975

2/ DDS Appendix L, Ocean Disposal (in preparation).

In general, Bay sediments are composed of predominantly fine silts and clays. The silt-clay fraction of Bay sediments ranges from 85-95 percent. The sediments collected in the Ocean Disposal study area were comprised of up to 89 percent fine sand although the average was 66 percent.

6.040 Ocean sediments were also found to be much lower in contaminant concentrations than Bay sediments. Table VI-3 compares the chemical properties of ocean and Bay sediments.

TABLE VI-3

COMPARISON OF CONTAMINANT LEVELS IN OCEAN AND BAY SEDIMENTS

Parameter	Dredged Channels S.F. Bay Mean Concentration ppm 1/	100-fathom Mean Mean Concentration ppm 2/
Lead	35.6	7.0
Zinc	108.1	40.5
Mercury	0.55	0.17
Cadmium	1.59	0.41
Copper	41.6	9.6
Volatile Solids	6.3×10^4	2.01×10^4
Chemical Oxygen Demand	4.12×10^4	1.51×10^4

1/ Dredge Disposal Study, Appendix B (in preparation).
2/ Dredge Disposal Study, Appendix L (in preparation).

In essence, the disposal of Bay sediment on the Gulf of the Farallones constitutes the introduction of an exotic substrate. Change in substrate texture in the disposal area will alter the composition of the benthic community. Local benthic populations will also be exposed to elevated levels of contaminants.

6.041 The potential for smothering of marine organisms during disposal operations is discussed in Section IV. In general, the deposition of more than 10 cm (four inches) of sediments over a short period will smother a large percentage of the benthic community. Kranz noted that a radical change from the native sediment type could be highly lethal (92). He observed for bivalves that often burial in only one centimeter (0.4 inches) of an exotic sediment was fatal.

6.042 Monitoring after disposal operations at the 100-fathom line indicated that the average depth of deposition within the disposal area was approximately 30 centimeters (12 inches). The material was spread over approximately a three acre area (231).

6.043 It is probable that this disposal operation of 4,000 c.y. caused high mortality in the three acre impact area. Because of the change in substrate texture, recovery of the disposal area may require an extended period of time.

6.044 (5) Conclusions. Sediment analyses showed that the 100-fathom disposal site does not contain high levels of heavy metals, volatile solids or chemical oxygen demand compared to San Francisco Bay sediments. The sediment in the ocean study area consisted of a large amount of fine material; most of which is fine sand.

6.045 Photographic survey of the bottom prior to the dump showed that the area is biologically active. Density of macrofauna was estimated to be 1.4 animals/m^2. However, species diversity was relatively low. Benthic grab samples which are currently being analyzed, might reveal a greater diversity of bottom life not detected from the photographs. Animals examined were not considered to be contaminated with heavy metals.

6.046 The material release study demonstrated that most material fell directly below the path of the hoppers, while some had spread laterally to the edge of the study area. Some of the material fell in clumps, probably because of compaction during transit to the disposal site. Many of the bottom animals, no doubt, were smothered and because of differences in substrate, recovery would probably be limited. Recovery would depend on the adaptive ability of the bottom fauna and on whether the Bay dredge material will stay intact on the disposal site bottom. If sub-surface currents disperse the material, then recovery would be enhanced. If the material is not dispersed from the ocean bottom, the disposal site would eventually become barren of life. If the disposal site per chance is a strategic spawning, nursing and/or feeding area (the Gulf of the Farallones seems to be an important area for these activities as described in Section II), long-term impacts of routine disposal could significantly reduce biological productivity at the site.

6.047 Should bay sediments be disposed of in the ocean, it would seem, based on our present knowledge, that dispersal would be the most effective method of reducing any physical impacts. It is difficult to say what effect this will have on the plankton but because of their astronomical numbers over a wide expanse of the ocean and dilution, any physical detriments of dispersion of Bay sediments would be subdued or minimized. At this time it is difficult to say what effect the chemicals associated with the sediments would have on the local plankton if the material was dispersed. Dispersion would allow for a greater opportunity for leaching of metals from the sediments because there is a greater chance for sediment oxidation. Dilution would play an important role in keeping the concentration of the leached contaminants to a minimum.

6.048 In addition to impacts on the ocean environment, there is an adverse impact on energy conservation resulting from barge and hopper transport of Bay sediments. Present fuel usage of total Federal maintenance dredging and disposal operations in the Bay is 3.4 million gallons per year. If Bay sediments were transported to the 100 fathom disposal site by hopper and/or barge, the total annual fuel needed would be about 12.8 million gallons, an increase of 9.4 million gallons over present usage.

6.049 c. Pipeline Transport for Ocean Disposal. The previous discussion about ocean disposal was based on existing operating procedures of transporting dredged material to ocean disposal sites. Transport by hopper and tugscow are the methods usually employed to remove material from the project site to the ocean disposal site. To address other methods of transporting dredged material to the ocean disposal site, an idea, originally generated by the Philadelphia District Corps of Engineers, was adapted to the San Francisco Bay maintenance dredging program in our Land Disposal Study. This concept involves the transport of dredge material from a temporary holding site to the ocean disposal site via a pipeline system with pumping stations set along the length of the pipeline at regular intervals (Plate VI-3). This pipeline system was looked at in the overall ocean disposal scheme in contrast directly to existing transport procedures. The Land Disposal Study discusses two types of pipeline fixtures for this extensive pipeline transport scheme: temporary and fixed. A temporary pipeline is defined as one used only for the duration of a dredging project and is then removed, whereas a fixed one is a permanent installation (detailed discussion may be found in the Land Disposal Study, Pipelines, Appendix J). Temporary pipelines lead from the dredge to the holding sites or to the water side terminus of a fixed pipeline system. In general, it was assumed that temporary pipelines leading from hydraulic dredges would be limited to about three miles in length. Variations or modified pipeline systems were not studied due to the cursory nature of the Land Disposal Study. Although not discussed in this report, modified schemes incorporating shortened pipeline systems and ocean barging can evolve into possible sub-alternatives. However, in this report the discussion is limited to the extensive fixed pipeline system.

6.050 Using the concept as derived from the Philadelphia District, an extensive fixed pipeline system was developed to demonstrate the overall capability of a self-contained disposal unit extending from the Bay to the ocean disposal site. This extensive pipeline system, as detailed in our Land Disposal Study, includes "holding sites" for the dredged material. It was assumed that these holding areas would facilitate collection from all O & M projects in the Bay and eventual transport to the ocean site within the extensive pipeline system in the most efficient, economical and convenient way possible. Within the scope of the Land Disposal Study, three holding sites or transfer points were determined due to the central location to all Bay maintenance dredging projects: one aquatic site in San Pablo Bay and two land sites, Petaluma River Area and Sherman Island (only 5 percent of total material dredged comes from the South Bay). Overall selection of the land sites was based on a lengthy process of elimination conducted in the Land Disposal Study and briefly discussed in this report under Land Disposal.

6.051 The transfer point in San Pablo Bay selected for study is adjacent to Pinole Shoal Channel, about six miles offshore from the Petaluma site (Plate VI-3). This point was chosen as being close to the center of dredging activity in the Bay and also accessible by hopper or scow. The transfer point could either be an enclosed dump basin, which would require a second dredge (hydraulic pipeline) to retransport the material from the basin into the pipeline system, or a pipeline terminus surrounded by breasting and mooring dolphins which would handle direct pumpout from the hopper or scow.