4.182 There were oxygen reductions during the dredge/disposal operation. Oxygen reductions may be a function of one or a combination of factors. First, the resuspended material can exert a chemical and biochemical oxygen demand which consumes oxygen at varying rates and to varying degrees depending on conditions. Second, readings could have been an aberration; a function of electronic problems (i.e., due to dilution of the water mass by the suspended particulates giving an erroneous picture of the actual oxygen concentration of the water, or denaturing of the probe's membrane during operations resulting in a slow deterioration in the accuracy of the readings). Both of these factors will result in data indicating a reduction in dissolved oxygen.

4.183 It is unlikely the dredged Bar sand has an appreciable oxygen demand. The chemical oxygen demand (COD) of the dredged sediments averaged 31 mg/l. This is approximately the same level as found in the water column during the sampling operation on 10 February 1972. Samples taken outside of the area influenced by the turbidity plume had an average demand (COD) of 24.5 mg/l. Samples taken in the area of influence averaged 30.5 mg/l (203). In neither case did the water show a biochemical oxygen demand. Chemical oxygen demand analysis is performed by oxidating organic and oxidizable inorganic substances with a potassium dichromate solution in 50 percent sulfuric acid solution. This harsh, laboratory oxidation reaction does not occur in the real world. There is always a certain amount of oxidizable matter in solution as indicated by the background samples (outside of the area of influence); therefore, it is unlikely that the oxygen fluctuations recorded occurred as a result of oxygen consumption by the resuspended sediments.

4.184 During dredging two turbidity plumes were identified (1) a surface plume resulting from overboarding, and (2) a bottom plume resulting from perturbation by the dragheads and the dredge's screws. The surface plume is generated by the overflow of fines separated during the loading of the hoppers. The surface plume is the result of surcharging prior to opening the hopper gates. The surcharge is necessary to breakup the material and prevent arching in the bin. The turbidity plume in the lower water is generated from the actual release of the material (the hopper gates are approximately 15 to 20 feet below the surface), its movement down to the bottom and subsequent resuspension due to impact on the bottom. The bottom plume resulting from the disposal operation is discussed under Dredging and Sediment Disturbance of this section.

4.185 To obtain a qualitative estimate of the surface plume, aerial photographs were taken of operations on 14 June 1971 using Kodak Aerocolor Negative Film 2445 and GAF 1000 Blue Insensitive Color Film Type 2575 at scales of 1:6,000 and 1:9,000 during slack and flood currents. The photographs using the non-blue emulsion film, unfortunately, were overexposed and interpretation of the imagery was not possible. Color photographs showed discoloration greatest during the dredging in the channel. This corresponds with the observation made from the dredge disposal sites duirng operations.

4.186 The discolorations is a result of fine material being introduced into the water column from the overflow of the hoppers. The photographs showed that dispersion of fine material in suspension occurs rapidly. The concentration of the suspended material is diluted and the discoloration vanishes within a few minutes after the dredge passes. Photographs of the dredge in transit and other vessels in the area indicated slow settling rates for fine material. In both cases, the wash from the vessel's propellers re-agitated the fine material and again discolored the surface water.

4.187 Low altitude aerial photography on 8 Feburary 1972 used Kodak EF 8442 color positive film with a yellow filter. The combination of film, filter and exposure has been found to provide the greatest resolution of suspended sediments. However, the photographs showed no discoloration at the disposal site following the release of material. The lack of discoloration is probably due to the decrease of fines and increase in median grain size of the material being dredged with the new deepening.

4.188 Based on information gained from the aerial photographs, the turbidity readings obtained with the transmissometer during 1972 were probably reflecting the suspended particulate concentration in the water ebbing from the Bay rather than discoloration from the disposal operation.

4.189 (3) Material Dispersion. Three programs were developed to determine the material dispersion and deposition. They were: (1) aerial and surface observations, (2) bottom deposition evaluation using measurements and sampling at specified underwater stations, underwater photography and observations, and (3) current measurements including both current velocity-direction and current path. The programs were conducted during June 1971 and February 1972 except for current path studies which were conducted on four occasions.

4.190 A test disposal site was established about 3,000 feet south of the Main Ship Channel in 35 to 40 feet of water. Six marker buoys were placed to define a dredge release course 200 feet wide and 2,000 feet long. Delay in dredge arrival, high sea-state and adverse weather conditions prevented the various programs from being carried out simultaneously. The actual study was extended over 19 days from 8 June to 26 June, and the schedule was as follows:

8 June 1971	Current velocity-direction
10 June 1971	Test releases and diving operation
14 June 1971	Aerial photography
18 June 1971	Test releases and diving operation
25-26 June 1971	Current Path

Test releases and diving operation on 18 June were done only at one station.

4.191 The second program was conducted on 8-9 February 1972. Four underwater stations with 200-foot spacing established a test section. Test releases, diving operations and aerial photography were accomplished on 8 February with current velocity-direction measurements made on both days.

4.192 The current path studies, in addition to 25-26 June 1971, were conducted on 1-2 October 1971, 5-7 November 1971 and 1-2 February 1972.

4.193 Results showed that at no time during diving operations on the Bar did the accumulation of released material exceed two inches in depth during any one release. The maximum recorded accumulation during an entire operation was four inches. Prestudy predictions estimated the maximum and minimum accumulation after one release would be 2.5 inches and 0.25 inches, respectively. The horizontal displacement for the maximum and minimum accumulation conditions would be 100 feet and 1,700 feet, respectively. The maximum accumulation would occur when the line of release was parallel to the current direction and the minimum accumulation would occur when the line of release was perpendicular to the current direction. The above values were estimated using the following parameters: speed of the vessel during release-4 knots; the time required for discharge of the load-5 minutes; the total load discharged-3,000 cubic yards; the current velocity-1 knot over the entire water column; sediment size ranged from 0.22 millimeters to 0.84 millimeters using the 84th and 16th percentiles of the cumulative distribution curve; and the sediment accumulated was distributed evenly over the area. The maximum accumulation of two inches did fall within the predicted ranges of accumulation.

4.194 The horizontal movement of suspended dredge material and the subsequent dispersion of material after deposition can be described as the vector sum of the tidal currents, wind induced current, coastal currents and wave induced turbulence (surge). The observed velocity-direction measurements are the sum of the tidal, coastal, and wind induced currents. The wave induced motion near the bottom-water interface is primarily oscillatory in nature and, thus, is mainly a suspending force. The dispersion of the deposited dredge material will be in the direction of the bottom currents as observed during the current velocity-direction measurements.

4.195 The current velocity-direction measurements observed on 8 June 1971 are indicative of summer-fall current conditions on the Bar. Currents were fairly homogeneous at all depths and exhibited a definite southwestward predominance. During the winter season with its high freshwater outflows from the Bay, current reversals with depth are encountered on the Bar. A net water discharge occurs in the upper water column during these freshets, whereas in the lower column a net influx into the Bay of more saline water occurs. Even during the winter season the water circulation on the Bar exhibits

a southwestward predominance (See discussion of Oceanographic Conditions of the San Francisco Bar and Vicinity in Section II). It follows then that the dispersion of dredge material on the southern portion of the Bar would initially be directed in the direction of the tidal currents as observed from velocity-direction measurements. Thus, if dredge material release operations are conducted during ebb flows, the initial dispersion would be away from the Golden Gate in a southwestward direction. Conversely, the initial movement of released material during flood flows would be towards the Golden Gate.

4.196 The bottom deposition program has shown that accumulation of dredge material on the bottom does not exceed two inches during any one release and that after deposition the material is dispersed quickly as a result of the suspending wave induced turbulence and the transporting bottom currents. The current velocity-direction program indicated that the dredge material while in the water column and after deposition will have a net dispersion directed to the southwest.

4.197 During diving operations, four distinguishable sediment layers were observed in the water column. They were the upper water column extending from 25 to 35 feet below the sea surface, the turbid layer extending 3 to 15 feet above the bottom, the fluid sediment layer 3 to 6 inches deep on the bottom, and the underlying compacted sediment.

4.198 The turbid and fluid sediment layers were found to be the transport strata for material on the Bar. The turbid layer was composed of suspended sediment, moving horizontally along the water-bottom interface. It was observed before, during and after all test releases throughout the entire study. The depth and sediment concentration of the turbid layer was found to be a function of current velocities and sea state. As the currents and sea state increased, the depth of the layer and concentration of sediment in the layer increased. The maximum and minimum depth encountered during the study were 15 feet and 3 feet, respectively. The minimum conditions existed during calm seas with only slight bottom currents. Water samples in the turbid layer showed the presence of considerable suspended sand in the 200-275 micron range, the same range as that found in the fluid and compacted sediment layers. The fluid sediment layer was composed of uncompacted sand moving as bed load. It was observed to be absent during calm conditions with a more compacted layer of sediment existing in its place. As the sea state became more active the fluid layer again appeared.

4.199 The minimum condition of sediment transport that existed on the Bar during the study was in the more advanced stage of sediment motion as described by Shepard (170) from observations in a simple flume. Shepard's advanced stage of sediment

transport consists of both bed load and suspended load transport of sediment. The sediment that is transported by bedload is moved by siltation and is associated with the formation of ripple marks. The sediment transported by suspended load is put into suspension by turbulence over the bed and is associated with a high Reynolds' number which is a function of height above the bed, the flow over the bed and the viscosity of the water. Large Reynolds' numbers are always present in an environment such as San Franicsco Bar and mainly state and internal waves (surge). Although the Reynolds' number due to current flow is sufficient to maintain the suspended load in the turbid layer, the major component of turbulence is due to the activity of the surface waves and the existing surge. The major suspending force on the Bar is the wave induced turbulence. Tidal flows are responsible for net horizontal movement on and within the Bar. At all times during the study the wave induced turbulence was great enough to keep material in suspension. The turbid conditions precluded the actual observations of bedload transport of sediment; however, ripple marks with a wave height of 1½ inches and wave length of four inches indicated that such a transport was occurring.

4.200 The condition of greatest sediment transport during the study was observed during increased sea state and surge action. The presence of a thick turbid layer and a fluid sediment layer indicates the existence of Shepard's maximum condition of both a large suspended load and sheet flow. Due to the turbulence on the Bar, there is no threshold velocity associated with the sediment transport.

4.201 (4) Benthic Study. The objectives of the benthic study were (a) to develop a faunal list, (b) characterize those species found as to their susceptibility to smothering and (c) determine if there was a significant difference in the number of species and/or number of individuals before and after dredging and disposal operations. The program involved (1) a survey of the benthos using a bottom dredge, (2) diver observations of benthic fauna and (3) laboratory experiments investigating the phenomena of smothering.

4.202 The first step in investigating the effects of disturbing the benthic ecosystem was to reconnoiter the inhabitants of that environment, determining the composition of the population and their numbers. This examination was to proceed in a quantitative and a qualitative manner. The quantitative approach involved a benthic survey or collection program prior to and following each dredging operation. The qualitative program was based on diver observations.

4.203 The benthic sampling consistently recovered few species and individuals (see discussion of Benthos of San Francisco Bar and Vicinity, Section II). Even variations in sampling technique (Petersen dredge, Ponar dredge and diver collection) did not produce significant changes in the number of organisms retrieved (252). diver observations confirmed this impression of a general paucity of macro-biota which developed during the remote sampling. Fager (52) studied the subtidal invertebrate community inhabiting the sand plain between the submarine canyons in La Jolla Bight (San Diego). Albeit his principle concern was with epifaunal invertebrate species, the observations he made further illustrate the demography of a community residing in a churning, sand substrate. The sand plain environment he studied is very similar to the rigorous conditions found on the Bar. Long-period swell keep the top few millimeters of sand almost constantly in motion, moving it such that organisms living in this layer are usually in a "miniature sandstorm." The epifaunal community at the La Jolla Bight consisted of only nine species with densities typically less than one individual per square meter. The overall scarcity of species and individuals in this and the Bar environment is indicative of the instability and harshness of the habitats.

4.204 The ability of indigenous organisms to survive in this type of environment depends on their capacity to adjust to rapid changes in sand level (52). The one characteristic which was distinctive in all native species collected and observed during the Bar study was mobility. As previously mentioned, the Bar is a constantly shifting sand environment, influenced by storm-generated long-period swells, wind-generated waves, high velocity tidal currents and long-shore drift. The dynamics of the overlying waters have a profound impact on the shoal causing bedload movement, variable amounts of resuspension and deposition as well as deposition from external sources (i.e., the bay and coastline). This constant shifting was observed by the divers both as a turbid fluid layer which varied in depth above the compacted bottom and as sand ripples which are indicative of bed load movement. The ability of organisms to survive and proliferate in such an environment would predominantly depend on efficiency of movement on or through the substrate. Any sedentary organism requiring continuous contact with the overlying waters would soon be smothered. To avoid burial, the organisms must be mobile enough to escape the deposition and bed movements occurring during storm periods (primarily in winter).

4.205 Post-dredging sampling indicated that benthos recovery began in the Bar Channel within two to four months (203) The numbers of species and numbers of organisms both increased, which is a typical phenomena observed after dredging (128).

4.206 Post-disposal observations showed, in general, a decrease in numbers of individuals due to smothering but species numbers remained fairly stable. Since the material dispersion study indicated that disposal caused accumulation of slightly more than two inches, those bottom animals unable to either swim or move away from the disposal site would be quickly covered by the extraneous sand.

4.207 The sand dollar (Dendraster excentricus), because of its abundance on the bar and its slow mode of locomotion, would be one of the primary species covered by two inches of sand. Laboratory burial experiments were conducted on the sand dollar to determine the effect of this burial. Results indicate that rapid sand deposition of two inches had little effect on the ability of the sand dollar to exhume itself and survive (203). It is well known to marine biologists that sand dollars can, and do bury and exhume themselves periodically under natural conditions.

4.208 Kranz conducted laboratory and field studies on 25 species of bivalves to determine the effects of burial (92) He demonstrated that the exhuming ability of bivalves is closely related to their life habit. Borers, deep burrowing adult siphonate suspension feeders and suspension feeding epifaunal forms were generally unable to escape sediment coverings thicker than 1 cm (0.4 inches). However, shallow burrowing siphonate suspension feeders and young deep burrowers were usually able to escape from under 10 cm to 50 cm (4-20 inches) of their native sediment.

4.209 Characteristically the infauna of the Bar seem to possess the behavior and morphology of organisms which are typically found in unstable, sand environments. Exhuming behavior and morphological adaptions to burrowing would be necessary for organism survival during periods of rapid sand movement (such as, during winter storms, etc.)

4.210 With respect to other species, such as the Dungeness crab and various flatfish species (e.g., Dover sole, English sole and Petrole sole) known to be abundant around the bar (see Section II), no burial studies have been conducted. However, based on circumstantial evidence, the fact that the Dungeness crab and flatfish are relatively common in this area, even under annual maintenance dredging and disposal operations since 1922, indicates that these bottom animals are either not or only minimally affected by the maintenance activities. The dynamic oceanographic conditions at the Bar appear to effectively mask the "lesser", short-term perturbations of dredging and disposal.

4.211 c. Conclusions. Based on the studies conducted in 1971 and 1972 investigating the effects of dredging and disposal operations associated with the San Francisco Main Ship Channel, the following conclusions can be drawn:

4.212 (1) Chemical analyses of the sediment demonstrated that the material being dredged are not polluted by any of the presently recognized disposal criteria. The 96-hour toxicity bioassays using Three-spined stickleback fish indicate the sediments from the Main Ship Channel are non-toxic to the species. Comparisons of particle size distribution from the dredged and disposal areas indicate the two materials are compatible and thus would not change the fauna habitat.

4.213 (2) Both dredging and disposal operations cause limited fluctuations in the water quality conditions of the Bar environment. Effects are restricted to temporary increases in turbidity levels in the upper and lower water column and minor reductions in the dissolved oxygen concentration. Large changes in conductivity and pH did not occur during the disposal operation. The surface turbidity plume is rapidly dispersed by the turbulence and high current velocities of the area such that the suspended solids loadings are reduced to ambient conditions. The bottom turbidity plume is probably quickly assimilated into the incessant suspended and bed load movement. The dissolved oxygen level, when reduced, is not depleted below 5 mg/l.

4.214 (3) Disposed sand never accumulates more than two inches during any one release which is quickly dispersed.

4.215 (4) Studies of the benthic biology of the Bar environment lead to the recognition of two predominate characteristics. First, is the general paucity of macro-biota in this dynamic region. Sampling, even with different modes of collection (Ponor dredge, Petersen dredge, and diver collection), consistently brought up few species and numbers of individuals. The overall scarcity of the Bar biota cannot be solely attributed to dredging and/or disposal because low numbers of animals were relatively uniform from station to station (inside and outside the channel and disposal site) and from sampling period to sampling period during the study. This lack of abundants can be more easily attributed to the incessant motion of surface sand and water in the Bar environment, which apparently over-rides the effects of dredging and disposal in this area. This is not to say that dredging and disposal operations do not have an overall effect on the biota but that the effects are apparently masked by the overwhelming energy and motion of the Bar site on a long-term basis. The second characteristic is the mobile nature of all species collected. A constantly shifting sand environment dictates a mobile species if it is to successfully adapt to such a changing environment. It must be able to withstand a certain amount of burial as well as exposure, and to move if it finds itself in an unfavorable predicament. These abilities, which allow the animals to successfully tolerate or adapt to the drifting motion of the bar, seemingly, also allow the animals to tolerate, withstand - or even adapt - to the dredging and disposal operation at the Bar. The sand dollars, used in the burial experiments and which they successfully survived, epitomize the above abilities. Thus, it seems that the dynamic conditions of the Bar environment have a greater effect on the kinds and numbers of macro-biota living at the Bar than dredging and disposal.

4.216 4. Impact on Endangered and Rare Species. Except for the marine mammals, the California least tern and the California brown pelican, all other endangered and rare species inhabiting the Bay Area are associated with upland areas (salt marshes included). Since the majority of the dredging projects and disposal occur in the Bay, these particular species will not be directly threatened by most maintenance projects. However, for those projects anticipating land disposal, such as, Redwood City Harbor, San Rafael Creek, San Leandro Marina, Suisun (Slough) Channel and New York Slough, a more critical examination of the proposed areas is required. Proposed land disposal sites for Redwood City Harbor were described in Section II (see Terrestrial Environment) and four endangered and rare species are known to occur in this general vicinity. These are: the California least tern, the California brown pelican, the California clapper rail, and the Salt marsh harvest mouse. Land disposal may result in loss of vital habitat for these four species, as well as other species of wildlife which frequent the area. Considerable objections have already been raised by the U.S. Fish and Wildlife Service and California Fish and Game concerning Disposal Site No. 1. Alternative land sites are being considered as described in Section II.

4.217 The other four projects considering future land disposal, depending on the specific site, might also contain endangered an/or rare species at or near the proposed site. Since these land areas are still very tentative and have not been investigated, it would be premature at this point to discuss impacts on endangered and rare species. Should land disposal take place, the status of these threatened animals at the chosen sites will be determined, and a supplemental environmental statement describing the impacts will be issued before any action takes place.

4.218 Maintenance dredging is not expected to have an impact on the California least tern and the California brown pelican since maintenance dredging occurs in highly industrialized or developed areas where these two threatened species probably avoid for the most part. Disposal in the Bay is confined to four aquatic sites occurring in relatively deep water. Feeding by the least tern and brown pelican, in general, are closer inshore and thus will not be directly affected.

4.219 With respect to endangered whales, most occur too far offshore to be affected by localized and infrequent disposal at the 100-Fathom Disposal Site. The only exception is the endangered California gray whale, which ventures inside the 100-fathom depth contour, but it is highly doubtful that infrequent and localized ocean disposal would have any impact on them.

4.220 Although indirectly related, activities dependent upon maintenance dredging could have some impact on threatened species; such as impacts of inadvertent oil spillage.

4.221 Impact on Air Quality. Based on the emissions data in Section II, emmissions from Corps dredging operations have been estimated. Table IV-15 compares Corps of Engineers dredge emissions to total Bay Area emissions and total Bay Area emissions resulting from ships. A search of Bay Area Pollution Control District records dating back to 1960 was carried out (no earlier records were available) and revealed that no citations have been issued to Corps dredging operations.

TABLE IV-15

AIR POLLUTANT EMISSIONS

POLLUTANT	Bay Area Daily Total (Pounds)	Ships Daily Total (Pounds)	COE Dredges Daily Total (Pounds)*	Bay Area Annual Tot. (Tons)	Ships Anu. Total (Tons)	COE 1/ DREDGES ANUL. TOT. (Tons)
Sulfur dioxide	520,000**	28,000	612	94,900**	5,110	757
Nitrogen oxide	1,560,000	10,000	590	284,700	1,825	71
Particulate	320,000	2,000	745	58,400	365	99

* Dredge operation data are available for operations accounting for approximately 56 percent of the total cubic yards shown in Table I-I. Emissions for this 56 percent were calculated, and the total Corps dredge emissions figures represent an extrapolation of this known data.

** Sulfur oxides 1/ COE = Corps of Engineers

4.222 Considering the points of origin and the usual dispersal characteristics of air pollutants, the air quality impact of aquatic disposal is further diminished. The emissions would originate in the Bay where pollutant concentrations are generally low, with the primary exceptions being those areas in proximity to the major brides. There are no populated areas in the Bay except for Treasure and Yerba Buena Islands. Dispersal characteristics of air pollutants are such that by the time aquatic disposal-related pollutant concentrations reach onshore populated areas, the concentrations are significantly lower than at the points of origin.

4.223 Corps maintenance dredging activities enable continued use of Bay Area port facilities and, therefore, on-land vehicle emissions resulting from ports' activities are an indirect result of dredging. Table II-3 (Section II) shows the concentrations resulting from existing vehicle traffic at the major port facilities. Corps dredging would allow for maintenance of existing operational levels and, therefore, if traffic volumes remain the same the on-land vehicle emissions should not increase.

C. IMPACTS ON THE REGIONAL ECONOMY

4.224 1. Introduction. San Francisco Bay and the Delta comprise one of the major waterways in the United States, facilitating transportation and commerce. In 1973, 56,146,583 short tons of waterborne commerce were reported to have utilized this waterway system. Significantly, over 22 million of these tons were foreign trade.

4.225 The purpose of this section is to describe qualitatively and quantitatively the economic effects generated by a dredging maintenance program for the Bay waterway system. The navigational channels required for present day operations are maintained by over 20 separate dredging operations in the Bay and Delta area. The dredging operations are directly tied to the economic impact of the Bay and Delta waterways. At this stage of what is envisioned as an ongoing economic study, no major effort was devoted toward isolating the impacts of individual dredging operations or any combination thereof. Rather, the attempt has been made to provide a framework for further study by describing the overall impact of deepwater navigation on the Bay-Delta area. Major facts and findings listed below indicate the extent of economic impact:

MAJOR FACTS AND FINDINGS

1973 WATERBORNE COMMERCE

1. 20,400 JOBS IN THE SAN FRANCISCO BAY-DELTA AREA ARE DIRECTLY RELATED TO THE WATERBORNE TRANSPORTATION INDUSTRY.

2. THE PAYROLL FOR THE JOBS DIRECTLY RELATED TO THE WATERBORNE TRANSPORTATION INDUSTRY IS $309 MILLION.

3. APPROXIMATELY 7,800 JOBS IN THE REGION HAVE BEEN IDENTIFIED IN EXPORT MANUFACTURING EMPLOYMENT.

4. TOTAL EMPLOYMENT IN THE REGION IS 2,375,300 FOR 1970.
TOTAL POPULATION IN THE REGION IS 5,641,687 FOR 1970.

5. THE TOTAL PORT INVESTMENT - MILITARY AND CIVILIAN IN THE BAY-DELTA AREA IS NEARLY $2 BILLION.

6. 4,781 VESSEL TRIPS WITH SHIPS OF GREATER THAN 25-FOOT DRAFT PASS THROUGH SAN FRANCISCO BAY.

7. OVER 56 MILLION TONS OF CARGO ARE HANDLED BY THE BAY-DELTA PORTS.

8. THE CURRENT MAINTENANCE DREDGING OPERATION CONDUCTED BY THE CORPS OF ENGINEERS FOR SAN FRANCISCO BAY AND DELTA COST APPROXIMATELY $.14 PER TON OF CARGO SHIPPED: ON AN AD VALOREM BASIS THE DREDGING COSTS APPROXIMATELY 15/100 OF ONE PERCENT OF VALUE OF CARGO.

4.226 2. Plant and Facilities. Commercial ports, private wharves, oil piers, and military installations have been established on the shoreline of San Francisco Bay and its tributaries during the past one hundred years from San Francisco to Sacramento and Stockton.

4.227 Commercial ports developed to accommodate the general waterborne commerce of the region. The book value of the investment in the major ports of the region is $206,400,000 and includes land, buildings and structures, and equipment less depreciation (Table IV-16).

4.228 Industrial concerns, which are located primarily in the upper bay, have private wharves built on land leased from the State of California. The investment in these private wharves is estimated from county assessor records and company officials at $7,150,000 (Table IV-17). Excluded from total investmant are shore-based facilities, such as storage bins, etc.

4.229 Refineries have been built on the shoreline of the inland waterways from Richmond in San Francisco Bay to Avon in Suisun Bay. Large oil piers are adjuncts to these refineries. Other concerns, such as Pacific Gas & Electric Company, also have oil piers. The land in the waterway on which the oil piers are built is leased from the State of California. The estimated replacement value of the oil piers is approximately $85,000,000 (Table IV-18). As with private wharves, shore-based facilities are excluded. An example of a shore-based facility is the holding tanks.

4.230 The protective features of a nearly land-locked bay has resulted in the locating of numerous military installations that use San Francisco Bay and its tributaries. These installations have a land, plant and facilities original investment of $477,179,000 and a replacement value of $1,636,382,000 (Table IV-19).

4.231 Cumulatively, the investment in land, plant and facilities, which are related to waterborne commerce and use of San Francisco Bay and its tributaries is estimated at $1,934,932,000, which is a value that is greater than the original investment but less than the replacement value.

TABLE IV-16

INVESTMENT IN COMMERCIAL PORTS 1/
1974

Item	Port of Oakland	Port of San Francisco	Port of Richmond	Port of Redwood City	Port of Benicia	Port of Sacramento	Port of Stockton	Total
Land	$9,000,000	$29,000,000	$9,500,000	$3,900,000	$7,000,000	$5,500,000	$2,100,000	
Buildings, Structures & Improvements	59,000,000	61,000,000	3,000,000	2,300,000	10,400,000	19,900,000	13,500,000	
Equipment	13,000,000	3,000,000		200,000		1,600,000	2,000,000	
Subtotal	81,000,000	93,000,000		6,400,000		27,000,000	17,600,000	
Less: Reserve for Depreciation	7,300,000	30,000,000		1,200,000		4,000,000	6,000,000	
Total	$73,700,000	$63,000,000	$12,500,000	$5,200,000	$17,400,000	$23,000,000	$11,600,000	$206,400,000

1/ Book Value

Source: Port Comptroller and Engineering Staff; Terminal Companies.

TABLE IV-17

INVESTMENT IN PRIVATE WHARVES
1974

Company	Location	Assessed Valuation
C & H Sugar Company	Crockett	$2,500,000
U.S. Steel Company	Pittsburg	1,500,000
Crown Zellerbach Corporation	Antioch	900,000
Diablo Service Corporation	Pittsburg	1,000,000
Dow Chemical Company	Pittsburg	700,000
Kaiser Cement and Gypsum Co.	Antioch	550,000
	Total	$7,150,000

SOURCE: Contra Costa County Assessor's Office and company officials.

TABLE IV-18

INVESTMENT IN OIL PIERS 1/
1975

Company	Location	Replacement Value
Standard Oil Company	Richmond	$65,000,000 2/
Union Oil Company	Oleum	4,900,000
Gulf Oil Company	Hercules	5,000,000
Phillips Petroleum Company	Martinez	2,700,000
Phillips Petroleum Company	Avon	3,200,000
Exxon U.S.A.	Benicia	3,200,000
Uco	Martinez	1,200,000
Pacific Gas & Electric Co.	Pittsburg	500,000
Holly Corporation	Ozol	500,000 3/
	Total	$85,000,000

1/ Includes wharf and facilities on wharf, such as pipe. Excludes onshore facilities, such as tanks.

2/ Richmond Refinery Long Wharf is the most intensively developed. Besides pipe and pump out system, there are various buildings, including a dormitory and cafeteria.

3/ Dock was burnt. Settlement being negotiated. Value is estimated, based on previously-assessed valuation.

SOURCE: Engineering staffs at the refineries. Company officials at other concerns other than refineries.

TABLE IV-19

INVESTMENT IN MILITARY INSTALLATIONS

Item	MOTBA-North 1/ Oakland Army Base	MOTBA-East 2/ Alameda Facility	Naval Supply Center - Oakland	Pt. Molate	Alameda Naval Air Station	Mare Island Naval Shipyard - Vallejo	Naval Weapons Station - Concord	Government Island - Oakland	Total
				ORIGINAL INVESTMENT ($)					
Land		3,800,000			6,800,000	1,168,000		168,000	
Improvements		2,240,000			99,100,000	110,000,000		7,393,000	
Total	36,000,000	6,040,000	(no land) 55,017,000	(no land) 8,493,000	105,900,000	111,168,000	147,000,000	7,561,000	477,179,000
				REPLACEMENT VALUE ($)					
Total	150,000,000	19,980,000	(no land) 269,136,000	(no land) 44,266,000	250,000,000	665,000,000	208,000,000	30,000,000	1,636,382,000

1/ Military Ocean Terminal, Bay Area

SOURCE: Financial, Real Estate and/or Engineering Staff for the installation.

3. Depths of Shipping Channels and Draft of Ships.

4.232 a. Channel Depths: Data including original depths, existing depths, and expected depths if maintenance dredging is discontinued are displayed in Table IV-20 and defined below:

4.233 (1) Original condition. The original condition is based on the depths of channels prior to dredging by the Federal government. Certain parts of the channels may have been dredged prior to government dredging.

4.234 (2) Existing depth. These are the controlling channel depths under existing maintenance dredging conditions.

4.235 (3) Depth if channel is not maintained. It is estimated that the channels will revert to these depths if maintenance dredging is discontinued. It should be noted that in some cases, these depths are different from the depths for the original condition. This is because these depths were estimated by examining the depths of the bay adjacent to the channels. For example, the depth of the bay adjacent to the channel in the Oakland Outer Harbor is between 12 and 14 feet.

b. Vessel Trips.

4.236 The number of vessels, 26 feet and greater, which needed a dredged channel for navigation in 1973 was 4,781. This represents the number of in/outbound dry cargo and passenger vessels, and tankers that enter and leave across the San Francisco Bar. Table IV-21 presents the number of in/out 26 feet and greater vessels by Bay and Delta harbors.

TABLE IV-20

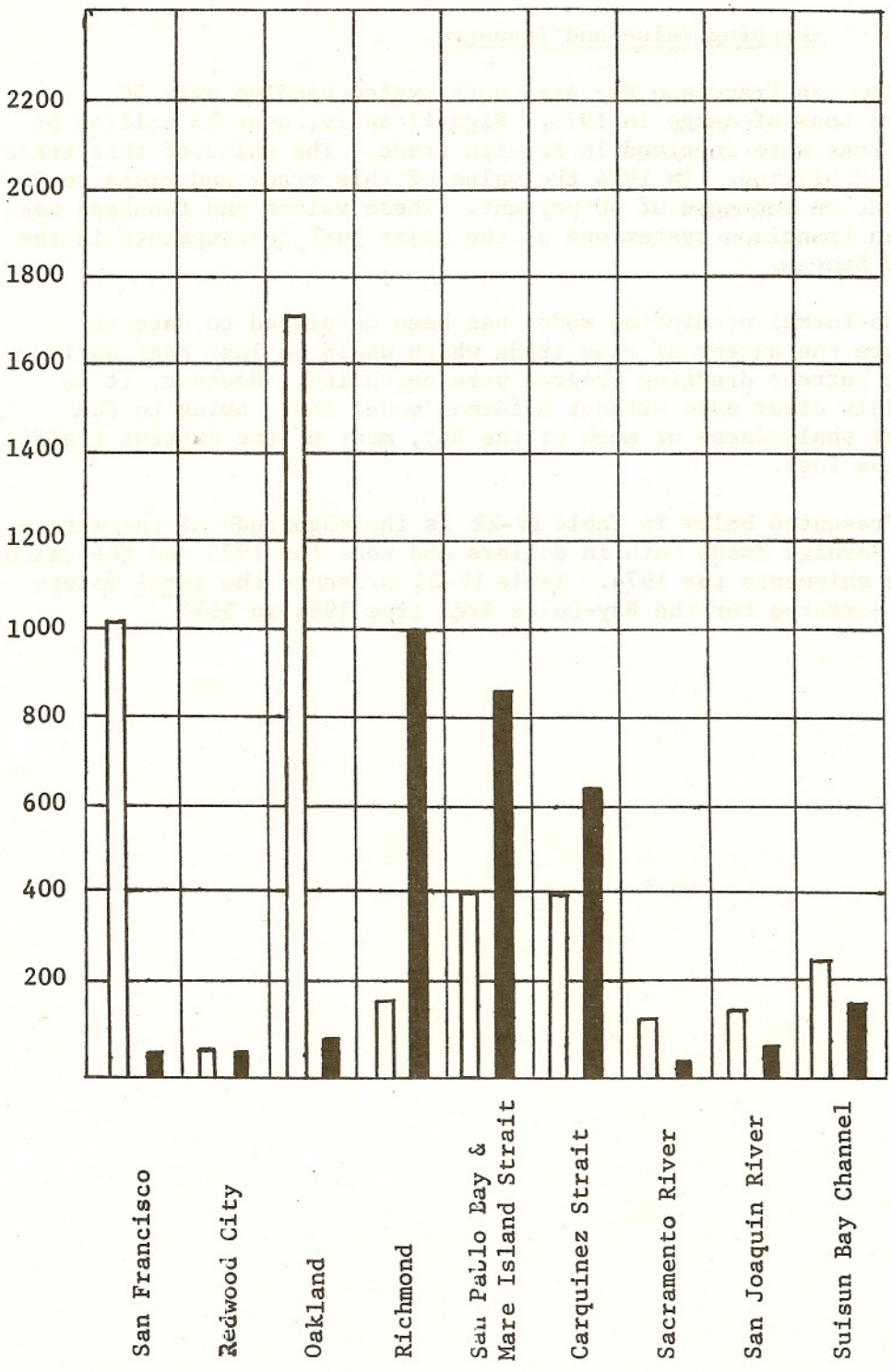
CHANNEL DEPTHS IF NOT DREDGED
(feet)

	San Francisco Harbor		Oakland Outer Harbor		Richmond Harbor		San Pablo-Mare Island-Straights		San Rafael Creek	Petaluma River (mouth)	San Leandro Marina	Redwood City Harbor	Stockton Channel	Suisun Bay Channel		Sacramento River	San Joaquin River
	Main Ship Channel	Islais Creek Entrance	Outer Harbor	Inner Harbor	Outer	Inner	Pinole Shoal Channel	Mare Island Channel						Lower	Upper		
Original Condition 1/	34	23	6-12	10	6	Dry	19	27	Dry	2	Marshland	2-7	6	16-19	9	4	6
Existing Depth 2/	55	35	35	35	35	35	35	32	6	8	4.7	28	30	30	30	30	30
Depth if Channel is not Maintained 3/	28-34	23	12-14	16	20	14-16	26-30	24-26	Dry	2	1	2-7	6	16-19	9	4	6

1/ Source: Annual Reports, War Department, fiscal year ended June 30, 1915, 1928, 1930, "Report of Chief of Engineers, U.S. Army", Part 1.
2/ Refers to mean lower low water.
3/ These depths are estimates based on the existing depths of the Bay adjacent to the channels.

TABLE IV-21

SAN FRANCISCO BAY VESSEL TRIPS 1973
(26 feet and greater)



Source: U.S. Army Corps of Engineers. Waterborne Commerce of the United States, Calendar Year 1973, Part 4.

4. Shipping Value and Tonnages.

4.237 The San Francisco Bay Area port system handled over 56 million tons of cargo in 1973. Significantly, over 23 million of these tons were involved in foreign trade. The value of this trade was $4.2 billion. In 1974 the value of this trade had risen to $6.0 billion, an increase of 40 percent. These values and tonnages make the San Francisco system one of the major port developments in the United States.

4.238 No formal prediction model has been developed to date to estimate the extent of this trade which would be lost regionally if the current dredging program were curtailed. However, it is certainly clear even without a formal model that, owing to the natural shallowness of much of the Bay, most of the current traffic would be lost.

4.239 Presented below in Table IV-22 is the magnitude of the waterborne Foreign Trade both in dollars and tons for 1973 and the value of the shipments for 1974. Table IV-23 presents the total waterborne commerce for the Bay-Delta Area from 1964 to 1973.

TABLE IV-22

FOREIGN TRADE, SAN FRANCISCO BAY-DELTA, 1973 and 1974

	SHIPPING WEIGHT - 1973 (100's of Tons)					VALUE OF SHIPMENTS - 1973 (millions of dollars)					VALUE OF SHIPMENTS 1974 (millions of dollars)
		EXPORTS		IMPORTS			EXPORTS		IMPORTS		
	TOTAL	Dry	Tanker	Dry	Tanker	TOTAL	Dry	Tanker	Dry	Tanker	
San Francisco, Port	2,937	1,098	92	962	785	1,490	728	8	737	17	2,086
Stockton	980	862	-	28	90	80	74	-	-	6	112
Oakland	2,453	1,590	-	854	9	1,773	922	-	851	-	2,482
Richmond	5,865	363	253	269	4,980	159	38	19	-	102	223
Sacramento	1,303	1,227	-	76	-	106	100	-	6	-	148
Redwood City		156		18	49						
San Joaquin	539	261	43	235	-						
San Pablo Bay	1,235	-	-	-	1,235	21				21	29
Carquinez Strait	2,659	294	4	48	2,313	99	-	-	58	41	139
Suisun Bay	329		245		84						
Other S.F. Ports	4,680	987	313	283	3,097	527	137	9	307	74	737
SAN FRANCISCO BAY & DELTA	23,206	6,838	953	2,773	12,642	4,255	1,999	36	1,959	261	5,957

Sources: Dept. of Commerce Publication: FT985, Sept. 1974 (1973 Data).
Update to 1974 based on factor of 1.4 (increase in value of S.F. Custom Dist.)

TABLE IV- 23

SAN FRANCISCO BAY AND DELTA

WATERBORNE TRADE
(Tons)

	Domestic	Foreign	Total
1964	29,481,668	12,953,553	42,435,221
1965	32,229,039	12,909,894	45,138,933
1966	32,701,070	11,946,781	44,647,851
1967	30,492,587	12,155,690	42,648,277
1968	33,060,925	12,014,345	45,075,270
1969	40,978,933	13,231,013	54,209,946
1970	38,416,251	12,841,351	51,257,602
1971	35,176,300	14,553,417	49,719,717
1972	33,672,722	16,602,759	50,275,481
1973	34,087,256	22,059,227	56,146,483

SOURCE: U.S. Army Corps of Engineers. Waterborne Commerce of the United States, Part 4, 1964 - 1973.

5. Employment.

4.240 Within the San Francisco Bay-Delta Area this study has identified approximately 57,000 jobs to be directly dependent at least partially on the existence of the Waterborne Transportation System. In addition to these jobs there are many other jobs which for various reasons have not been quantified by this study to date. This section provides both a presentation of the quantifiable employment and a discussion of those aspects which were not quantified.

4.241 Data for direct water-related employment (non-governmental) and payrolls were collected from several sources.

4.242 a. Close-To-The-Water Jobs. These are classified under Standard Industrial Classification Code 44 as Water Transportation. These jobs include stevedoring, shipping companies, towing and tugboat services, ship building and repair, and miscellaneous marine-related services. Data for these jobs was collected on a county basis from records kept by the California State Employment Development Department. These jobs are described below, and data are presented in Tables IV-24 and IV-25.

(1) Port administration and marine terminal companies.

4.243 Port administration and marine terminal services include all workers engaged directly in moving cargo into or out of a port. These include office and clerical workers employed by a port plus firms engaged in stevedoring or marine cargo handling. These firms load and unload vessels while in port and arrange for the disposition of cargo once it is off the ship. Marine terminal companies locate at or near major ports.

(2) Shipping companies (companies involved in waterborne commerce).

4.244 These companies operate vessels for transporting freight or passengers. Employment from such companies is located in or around major ports and in the center of major cities. The latter location includes office workers, who arrange the companies' operations.

(3) Marine-related services.

4.245 This sub-category includes directly water-related services such as towing and tugboat companies, ship cleaning and steamship leasing, and ship building and repair. Towing and tugboat companies furnish marine towing and tugboat services in the performance of auxiliary or terminal services in harbor areas. Such vessels do not carry cargo or passengers and are located near major ports.

TABLE IV-24

EMPLOYMENT IN DIRECT WATERBORNE COMMERCE AND RELATED SERVICES FOR 1973

Port & Vicinity	Port Administration and Marine Terminal Facilities	Shipping Companies	Marine Related Services 1/	Customs Brokers and Export Management Firms	Surface Transportation Truck	Surface Transportation Rail 3/	Miscellaneous Services 2/	Total 4/
San Francisco	2,260	6,021	1,558	874	443		466	11,622
Oakland	2,201	927	849	46	573		161	4,757
Redwood City	13	4	43	120	137		60	377
Stockton	294	-	272	-	102		-	668
Sacramento	176	-	80	-	89		-	345
Contra Costa	204	911	708	-	304		58	2,185
TOTAL	5,148	7,863	3,510	1,040	1,648	573 3/	745	20,427

SOURCES: California State Employment Development Department, jobs covered by California State Unemployment Insurance. Interviews with officials of the ports of San Francisco, Oakland, Redwood City, Richmond, Sacramento and Stockton. "Export Services Guide," California Department of Commerce, Division of International Trade. Telephone interviews with a sampling of Bay Area businesses.

1/ Includes towing and tugboat companies, ship cleaning and steamship leasing, ship building and repair.
2/ Includes freight forwarding, public warehousing, inspection and weighing, packing and crating.
3/ Rail transportation not allocated to county or port.
4/ This column does not total to 20,427 because the data for rail employment is not allocated to each county or port.