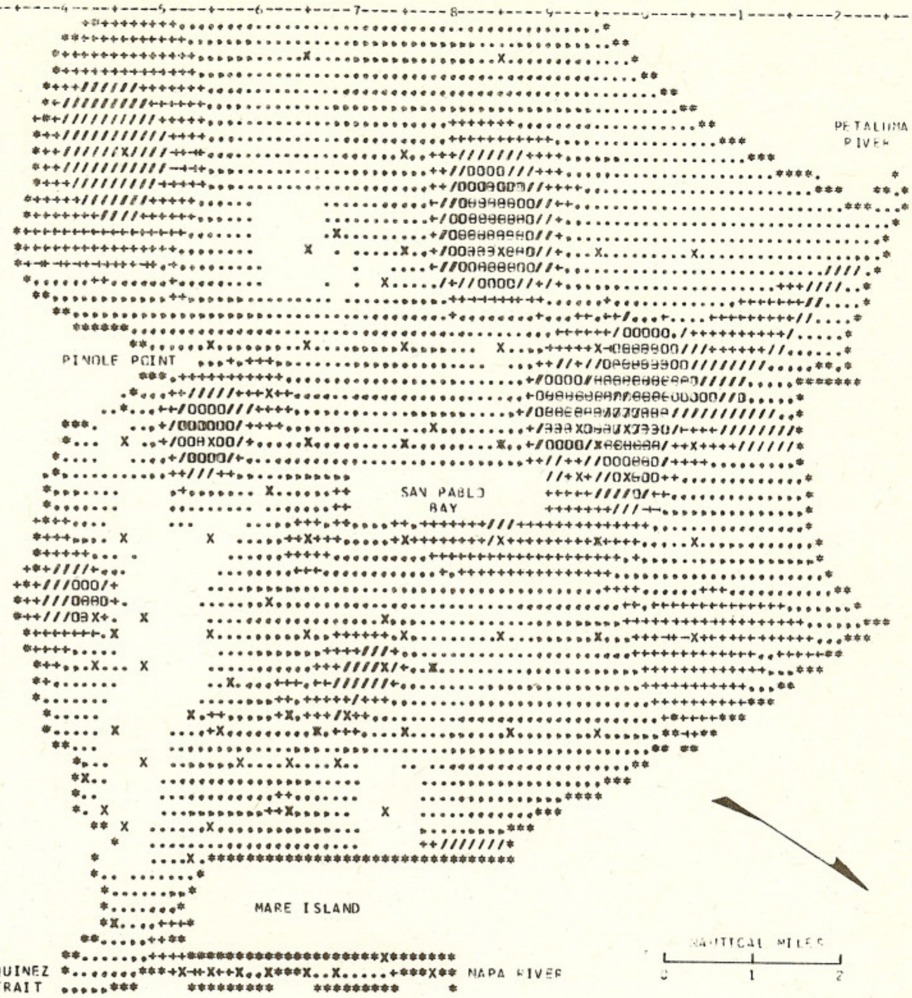
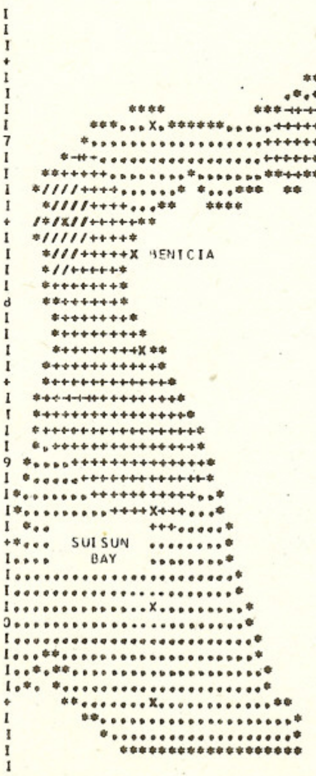
LEGEND

LEVEL NUMBER	SYMBOL	PERCENT VALUE RANGE
LOW	LLLLLLLL LLLLLLLL LLLLLLLL	0.000 0.000
1		0.000 .500
2	....	.500 2.000
3	******** ******** ********	2.000 4.000
4	++++++++ ++++++++ ++++++++	4.000 6.000
5	//////// //////// ////////	6.000 8.000
6	00000000 00000000 00000000	8.000 10.000
7	88888888 88888888 88888888	10.000 20.000
8	88888888 88888888 88888888	20.000 40.000
9	88888888 88888888 88888888	40.000 80.000
10	88888888 88888888 88888888	80.000 100.000
HIGH	HHHHHHHH HHHHHHHH HHHHHHHH	100.000 100.000





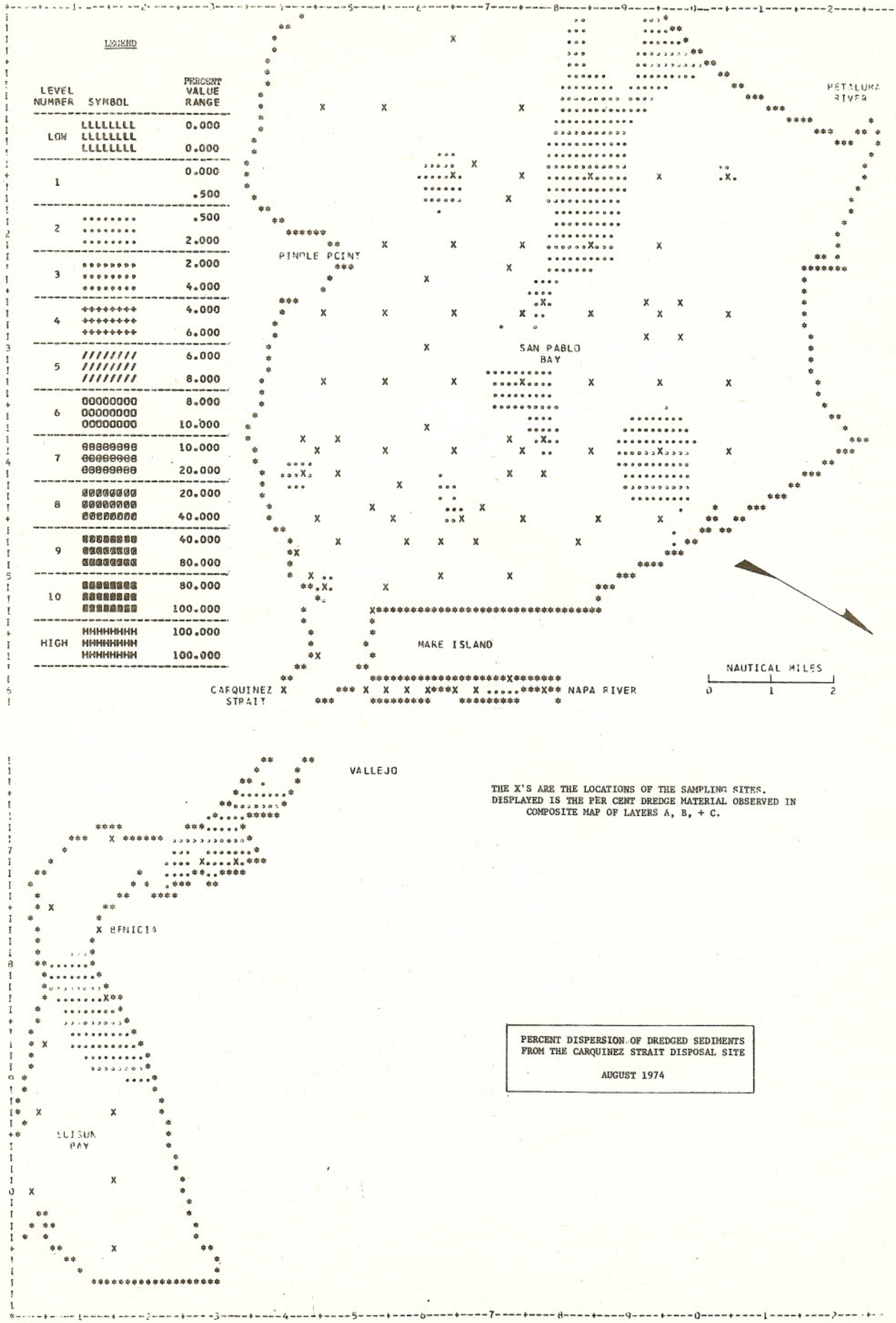
THE X'S ARE THE LOCATIONS OF THE SAMPLING SITES.
DISPLAYED IS THE PER CENT DREDGE MATERIAL OBSERVED IN
COMPOSITE MAP OF LAYERS A, B, + C.

PERCENT DISPERSION OF DREDGED SEDIMENTS
FROM THE CARQUINEZ STRAIT DISPOSAL SITE

APRIL 1974

AUTOMAP II

SOURCE: Dredge Disposal Study, Appendix E (in preparation)



LEGEND

LEVEL NUMBER	SYMBOL	PERCENT VALUE RANGE
LOW	LLLLLLLL	0.000 – 0.000
1		0.000 – .500
2	....	.500 – 2.000
3	••••••••	2.000 – 4.000
4	++++++++	4.000 – 6.000
5	////////	6.000 – 8.000
6	00000000	8.000 – 10.000
7	88888888	10.000 – 20.000
8	@@@@@@@@	20.000 – 40.000
9	@@@@@@@@	40.000 – 80.000
10	@@@@@@@@	80.000 – 100.000
HIGH	HHHHHHHH	100.000 – 100.000

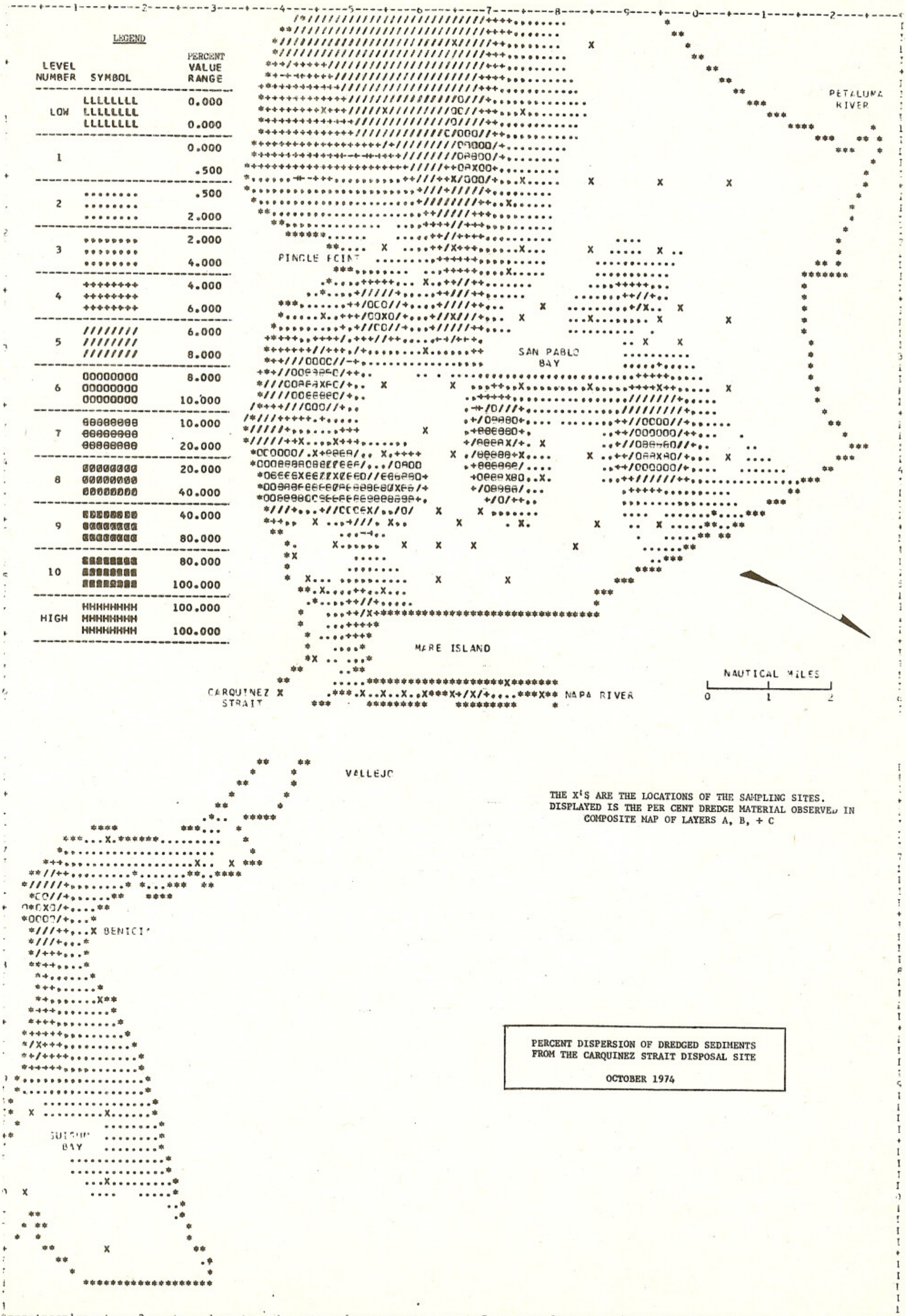
THE X'S ARE THE LOCATIONS OF THE SAMPLING SITES.
DISPLAYED IS THE PER CENT DREDGE MATERIAL OBSERVED IN
COMPOSITE MAP OF LAYERS A, B, + C.

PERCENT DISPERSION OF DREDGED SEDIMENTS
FROM THE CARQUINEZ STRAIT DISPOSAL SITE

AUGUST 1974

AUTOMAP II

SOURCE: Dredge Disposal Study, Appendix E (in preparation)

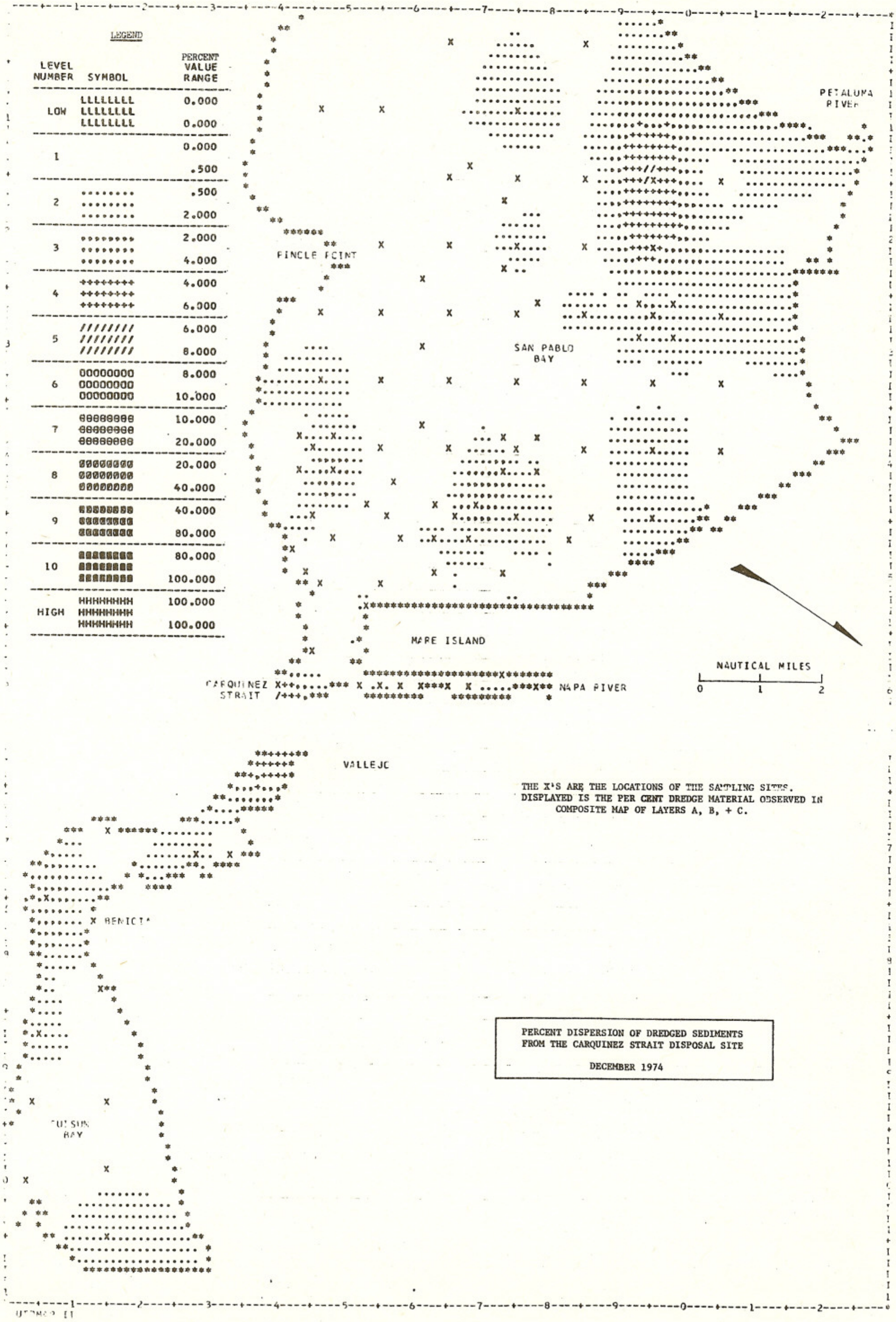


THE X'S ARE THE LOCATIONS OF THE SAMPLING SITES. DISPLAYED IS THE PER CENT DREDGE MATERIAL OBSERVED IN COMPOSITE MAP OF LAYERS A, B, + C

PERCENT DISPERSION OF DREDGED SEDIMENTS FROM THE CARQUINEZ STRAIT DISPOSAL SITE

OCTOBER 1974

SOURCE: Dredge Disposal Study, Appendix E (in preparation)



THE X'S ARE THE LOCATIONS OF THE SAMPLING SITES.
DISPLAYED IS THE PER CENT DREDGE MATERIAL OBSERVED IN COMPOSITE MAP OF LAYERS A, B, + C.

PERCENT DISPERSION OF DREDGED SEDIMENTS FROM THE CARQUINEZ STRAIT DISPOSAL SITE

DECEMBER 1974

SOURCE: Dredge Disposal Study, Appendix E (in preparation)

the dredged channel. By the completion of dredging operations at Mare Island Strait in April 1974 dredge material was found dispersed over a 100 square mile area including San Pablo Bay, Carquinez Strait and Suisun Bay. Localized areas were found in San Pablo Bay that had higher percentages of dredge material. By August 1974, five months after dredging had been completed, very little evidence of dredge material was present in the first 9 inches of sediment over the 100 square mile area. After the second dredging cycle in Mare Island Strait channel in September-October 1974 dredge material quantities were found to increase throughout the study area. This increase is primarily attributed to redredging of previously tagged dredge material that had returned to the dredged channel. Preliminary estimates indicate that the quantity of dredge material returning to Mare Island Strait channel after disposal at the Carquinez disposal site at least during the winter dredging cycle is between 20 and 30 percent of the quantity dredged. A large portion of the dredge material in October was located in the natural channel leading to San Pablo Strait and Central Bay. By December 1974, two months after the second dredging cycle of Mare Island Strait, most of the dredge material had again disappeared fom the study area.

4.145 (b) Movement of Dredge Material from North Bay into Central and South Bays. As part of the tracer study five samples were taken in Central and South Bays each month beginning in September 1974 to determine the extent of movement of dredge material throughout the entire Bay system after disposal at the Carquinez disposal site. Plate IV-1 shows the locations of these samples. Table IV-13 shows the results of analysis for dredge material in the Central Bay and South Bay samples. In September 1974 dredge material was found in the Alameda Naval Air Station and in San Rafael channel. Traces of dredge material were found at Oakland Outer Harbor and San Bruno Shoal channel. No dredge material was found in the sample of Richmond Harbor. In October 1974 dredge material was found off Bay Farm Island and near Berkeley Pier. A trace of dredge material was found near Richmond Long Wharf and no dredge material was found in samples at Oakland Outer Harbor and Southampton Shoal. In November 1974 a trace of dredge material was found in Emeryville Flats. No dredge material was found in samples in Richardson Bay, San Bruno Shoal, Berkeley Flats and Southampton Shoal Channel. In December 1974 a trace of dredge material was found at Islais Creek but no dredge material was found in samples at Sausalito Base Yard, Richmond Inner Harbor, Berkeley Flats or Fisherman's Wharf.

4.146 (2) Alcatraz Disposal Site. No field studies have been conducted on dispersion and long-term movement of dredge material disposed of at the Alcatraz disposal site. However, model studies of the Alcatraz disposal site have been conducted

TABLE IV-13

TRACER STUDY
PERCENT DREDGE MATERIAL IN CENTRAL AND SOUTH BAYS

Hole No.	Location	0-1 Inch	1-5 Inches	5-9 Inches
			September 1974	
142	San Bruno Shoal Channel	0	0	0.670
143	Alameda Naval Air Station	3.517	1.717	0
144	Oakland Outer Harbor	0.381	0	0
145	Richmond Outer Harbor	0	0	0
146	San Rafael Channel	0.693	1.240	4.380
			October 1974	
147	Bay Farm Island	2.525	0.973	-
148	Oakland Inner Harbor	0	0	0
149	Berkeley Pier	1.097	0	0
150	Southampton Shoal	0	0	0
151	Richmond Long Wharf	0	0	0.371
			November 1974	
152	Richardson Bay	0	0	0
153	San Bruno Shoal	0	0	0
154	Emeryville Flats	0	0.057	2.411
155	Berkeley Flats	0	0	0
156	Southampton Shoal Channel	0	0	0
			December 1974	
157	Sausalito Base Yard	0	0	0
158	Richmond Inner Harbor	0	0	0
159	Berkeley Flats	0	0	0
160	Islais Creek	0.013	0	0.179
161	Fisherman's Wharf	0	0	0

Source: Dredge Disposal Study, Appendix E (In preparation).

at the San Francisco Bay hydraulic model in Sausalito, California. Dredge material disposal tests in the Bay model were run with the approximate mean tide of 21-22 September 1956 and a Delta fresh-water inflow of 16,000 cubic feet per second (215). Gilsonite was used to simulate dredge material and the simulated disposal operations took place over 5 tidal cycles. The movement of gilsonite was followed for an additional 15 tidal cycles (approximately 15 prototype days) after the simulated disposal operations were completed.

4.147 Distribution of gilsonite in model studies of dredge material disposal is believed to be representative of intial prototype dispersion. The Bay model faithfully simulates the tides, tidal currents and the salinity regime of the Bay system, but it does not simulate wave action or currents that may be induced by winds. For this reason the Bay model cannot faithfully simulate the resuspension and circulation of dredge material after initial deposition. Much of the dredge material disposed of at the two major disposal sites (Carquinez Strait and Alcatraz), as shown by the prototype tracer study and model studies, is initially deposited in the shallow repository areas of the Bay; for example, San Pablo Bay shallows, Berkeley Flats and South Bay shallows. The results of the model studies, therefore, should be considered only as a temporary distribution, and that wind-wave action over the shallow expanses of the Bay will continue the process of re-suspension and recirculation of dredge material overtime. The effect of the continuing distributing processes not simulated in the Bay model is that in the prototype, lesser percentages of dredge material will be found in the shallow areas of the Bay than indicated by the model studies and greater percentages of dredge material will move out of the Bay system and back into dredged channels. As an example, model studies showed that after disposal at the Carquinez Strait the dredge material was retained in San Pablo Bay shallows and five to six percent returned to Mare Island Strait channel. On the other hand, the tracer study showed that after initial deposition in the shallows of the San Pablo Bay and Mare Island Strait channel similar to that found in the model studies the dredge material in the shallows was resuspended and moved out of the shallows into Central Bay and some back into Mare Island Strait channel.

4.148 (a) <u>Initial Dispersion of Dredge Material at Alcatraz Disposal Site.</u> Model studies indicated that there were a rapid dispersion and wide spread distribution of dredge material released at the Alcatraz disposal site. Very little dredge material settled through the fast currents and great depth of water at the disposal site to deposit on the bottom. After twenty tidal cycles (approximately 20 prototype days) the distribution of dredge material throughout the Bay system was as follows: 47 percent of the dredge material had left the Bay system via the Golden Gate; 1 percent had deposited in the extreme southern end of South Bay; 21 percent had deposited in South Bay between San Francisco International Airport and the San Francisco to Oakland Bay Bridge; 27 percent of the dredge material had deposited in Central Bay between Point San Pablo and the San Francisco to Oakland Bay Bridge; 3 percent had deposited in San Pablo Bay; 1 percent had deposited in Carquinez Strait; and no dredge material was found in Suisun Bay. Dredge material that remained in the Bay system (53 percent) was deposited principally in the shallow areas of the Bay. Model tests to verify prototype shoaling in navigation projects revealed that only about 10 percent of the simulated dredge material returned to the dredged channels. Model studies of disposal operations at the Alcatraz site during ebb current only indicated that as much as 80 percent of the dredge material would leave the Bay via the Golden Gate.

4.149 (b) Probable Long-Term Dispersion of Dredge Material at Alcatraz Disposal Site. As discussed previously, model studies of the Alcatraz disposal site simulated the short-term or initial distribution of released dredge material. Since the majority of the sediments remaining in the Bay are located in the shallow areas, the continuing process of wind-wave resuspension and recirculation by currents in the prototype will continue until the dredge material is moved out of the Bay system or deposited in areas not subject to wind-wave resuspension. The long-term result of the continuing resuspension and recirculation, as discussed in Section II (fate of dredge material disposal) is that more dredge material will leave the Bay system via the Golden Gate than was indicated by the model studies; also more dredge material will re-enter dredged channels.

4.150 g. Summary and Conclusions of Impacts on the Bay Estuarine Environment. The San Francisco Bay is a delightful estuarine environment. The preservation of the biological communities residing in this environment is paramount to retaining this pleasant nature of the area. Without the estuarine inhabitants of the Bay there would be no fishing or marine birds to brighten our lives. Man does influence this environment and the organisms associated with it, and dredging and disposal activities are only one of many operations which man uses to modify this estuarine environment. The degree and magnitude of impacts associated with this activity have been discussed earlier. To recapitulate, when dredging operations occur there is an initial disturbance of bottom sediments, a displacement and, ultimately, redeposition of those dredged sediments in an area outside of the project area. Potential adverse impacts can take place both in the water column and at the water sediment interface. Further, these impacts can be of a physical and/or chemical nature. The possibility of physical impacts is always present just because of the sediment disturbance characteristic of dredging and disposal operations. Chemical impacts are not necessarily an offshoot of operations, but are contingent on the degree and nature of pollutants associated with the sediments being moved.

4.151 Studies performed to date (both the Dredge Disposal Study and related studies across the country) evaluating the potential of either physical or chemical impacts in the upper water column seem to indicate that adverse impacts on biota are minimal. Increases in turbidity and the release of toxicants in this portion of the aqueous system are not of sufficient degree or duration to cause massive mortalities, or for that matter, to cause even a measurable effect on most pelagic adult species. Larval influences could be more severely affected but the actual significance has not been demonstrated. Impacts at the sediment-water interface are more pertinent and obvious. During dredging, organisms are removed from the channel area; during disposal operations, animals are buried. Just as some of the animals survive the excavation, some animals are able to exhibit exhuming behavior and survive the disposal. In any case, these surviving animals and others which migrate into the disturbed areas repopulate the substrate in a modicum of time. However, problems could result during the recovery period if a fluff zone or a high sediment density transport zone is created and remains in either the channel or disposal site for any duration. The significance of this phenomena to biological systems has not been quantified, but if it were severe and of long duration, project areas and disposal sites would be biological deserts which are not the case (224). Thus, the physical impacts at the bottom are initially harsh but the resilience of biological systems seems to compensate.

4.152 This does not mean that all species originally in either the project or disposal areas are able to re-establish themselves following the disturbance. Over the long-term, where there are frequent dredging and disposal at given sites, there is no doubt that these sites would be biologically different than other areas in the Bay, but the effects are localized and do not extend beyond the immediate areas of direct influence. It is conceivable that, after decades of routine maintenance dredging and/or disposal, after cessation of these operations complete re-establishment to the pre-dredged and pre-disposed state at the disturbed sites might never occur.

4.153 The effects of chemical toxicants are potentially more adverse. These substances have the potential for killing the organisms, impairing their reproductive capacities (thus adversely affecting future generations, and poisoning their tissues such that their meat is toxic to other species, including man. Transfer of toxicants from sediments to organisms can occur either by ingestion or absorption. Interstitial waters of the sediments are often enriched with certain heavy metals and thus are available for passive uptake by burrowing organisms. The deposit feeders or mud-eaters can take up heavy metals as well as other toxicants, such as pesticides or polychlorinated biphenyls, by ingesting these materials in association with mineral or organic particles. Toxic substances can be sequestered by organisms from certain organic and inorganic sinks. The degree of availability seems to be dependent on the strength of the metal-sediment binding (279). Organisms also are able to obtain these substances directly from solution. Disposal and dredging operations have the potential for elevating the ambient levels of trace constituent concentrations in the water column (229, 294). Following initial desorption reactions these constituents will become reassociated with particulates (minerals, detritus, algae and other plankters) or form soluble complexes. The degree of biological availability will depend on the strength of the new bond formation.

4.154 The actual significance of dredging and disposal operations to the biota of San Francisco Bay is contingent on how "significance" is defined. If the definition is predicated on the total absence of any impacts, then operations in the Bay cause some significant impacts. The most severe impacts are associated with the physical actions of excavation and deposition. Organisms are removed or disturbed during the dredging operation and buried during the disposal operations. During both operations, the water column has a higher suspended solids concentrations than typical ambient levels. The hindered settling phenomenon results in the creation of fluff zones in the dredged areas. In addition, density flows (bottom transport zones) can occur at disposal areas as a function of mounding of fluid muds at the disposal sites. These are the most obvious effects. More indirect effects including the redistribution of sediments, release of toxic substances, etc., also occur and are more difficult to quantify. Such effects operate on a chronic basis rather than acute. The long-term influence of the redistribution of contaminated sediments out of industrialized harbors and on to the productive tidal flat areas (depending on the residence time) could contribute to the body burdens of indigenous species. Desorption or ingestion followed by uptake of contaminants could lead to elevation of the tissue levels such that the organisms dies or the contaminant level reaches a higher concentration than is found in the same organisms from cleaner environments. San Francisco Bay organisms have higher body burdens of both trace elements and pesticies than organisms from outside the Bay (228).

4.155 The environmental impact of dredging and disposal operations can be described in the context of other extraneous influences impacting the system. But when such effects are reviewed in the context of the total San Francisco Bay system, the severity of their significance to biota is questionable. Sediment transport by natural processes are approximately seventeen times greater than annual dredging associated transport. Total bulk toxicant loading by municipal and industrial discharges, agricultural drainage and particularly, urban runoff seemingly dwarf out the worst potential bulk loading which could be attributed to dredging and disposal operations (131,162). The transport of these trace constituents by a single day of all dredging activity in San Francisco Bay is approximately one one-hundredth of the daily transport of these materials in naturally settling particulates (229). Thus the significance of dredging and disposal operations in San Francisco Bay is predicated on the definition of the word significance.

4.156 This section (Impacts on Bay Estuarine Environment) addressed the short-term, direct, lethal effects of dredging and disposal operations. Within these constraints, operations only seem to cause limited adverse biological reactions. However, if long-term, indirect, sub-lethal phenomena are investigated (which are being addressed in a limited extent in San Francisco Bay), problems of a greater magnitude may be discovered resulting from dredging and disposal activities.

4.157 2. Impact on Terrestrial Environment. This discussion is based largely on information on the terrestrial environment provided in the Environmental Setting. At this time, only the potential impacts of land disposal in the Redwood City Harbor area will be discussed. Land disposal at other sites will be discussed in a supplement to the Composite Statement, to be publicly issued at a later date.

4.158 Four Redwood City Harbor sites have been described in the Environmental Setting. These sites are shown on Plate I-15. Environmental impacts of land disposal involve geologic and hydrologic effects (including subsidence, settlement, and seismic hazards), aesthetics, and effects on vegetation and wildlife. Long-range effects involve possible use of the filled sites for open space, recreation, or port development.

4.159 Hydrologic effects are expected to be minimal. Bay mud is generally fine-grained and relatively impermeable to leaching of dredged material; furthermore, the characteristics of the dredged material itself tend to preclude infiltration of water associated with dredged material into topsoil layers (204). Land disposal of dredged material will have little or no effect on groundwater quality.

4.160 Local long-term consolidation of the surrounding area should be considered. There are two conditions which contribute to the lowering of the ground surface in the vicinity of Redwood City: subsidence and settlement.

4.161 Subsidence is generally a lowering of the ground surface because of reductions in fluid pressures as in cases of oil, gas, and ground water withdrawl. This phenomenon has occurred throughout the Santa Clara Valley to the southeast for decades mainly due to the removal of ground water for domestic, agricultural and industrial purposes.

4.162 Subsidence has been occurring in the Port of Redwood City since the mid-1920's. This has created a bowl which is centered over the ground water well field of the Ideal Cement plant located south across Redwood Creek from Site 1. Studies over the years in this area show that the area has settled from 1.5 to 2 feet since the mid-1920's. The 1972 rate of subsidence in the bowl was about 1½ inches in its center. This translates to approximately 3/4 to 1 inch at the four potential disposal sites. The removal of ground water in the area has been almost completely stopped within the vicinity of the cement plant; therefore, the rate of subsidence should progressively decrease to almost zero in a few years.

4.163 Settlement, or the downward movement of the ground surface, is caused by compression or consolidation of the underlying soils under the weight of fills and/or structures placed on the ground. The rate and total amount of settlement are dependent upon the depth of the fill (dredged material) placed at any one time and over a period of years, the thickness of the underlying mud, and the amount of consolidation the subsurface soils have already undergone. Emplacement of hydraulic fill over bay mud impacts an unnatural loading condition. The underlying and adjacent material is then free to respond plastically. This response is known as mud wave formation or heave. If large areas are hydraulically filled at slow uniform rates, this phenomena can be restricted or prevented. Where filling is sporadic, occasionally heavy, or confined to restricted cells, outward lateral flows of plastic mud can occur.

4.164 Because subsurface (i.e., consolidation) data are not available for the Redwood City area, precise estimates of the amount of settlement are impossible. However, based on engineering judgment and experience relating to areas of similar conditions, it is estimated that about three or four feet of settlement can be expected at Sites 2, 3, or 4 with approximately eight feet of dredged material. Most of Site 3 is presently underneath a large salt pile and so is not expected to undergo further consolidation. Future plans for development would have to consider settlement. Although settlement with one year's dredge material would be less than a foot, continued disposal would result in continued settlement.

4.165 The Redwood City Harbor area lies in a highly active seismic region of the San Andreas (6 miles west), Hayward (12 miles east), and Calaveras (20 miles east) fault system. There is come inconclusive evidence that an old and inactive (Palo Alto) fault might be buried in bedrock near the south end of the harbor. Earthquakes of high magnitude will occur more frequently. A local, outstanding earthquake could cause ground failure, the severity and extent of which would depend on many factors at the time.

4.166 Tsunamis, or waves generated by seismic activity, come from areas distant from San Francisco Bay. Tide gauge records show that tsunamis arriving at the entrance to San Francisco Bay are reduced as they extend around the Bay. The amplitude or height is reduced at least 75 percent by the time it reaches Redwood City. If one considers that a tsunami of 20 feet can occur every 100 years, then this would produce a wave height of approximately 5 feet at Redwood City. With mean higher high water at +7.8 feet (MLLW datum) and a +5 foot tsunami, the levees would be slightly overtopped. However, the greatest tsunami recorded at the Golden Gate was only 3 feet high, or a wave at Redwood City of approximately 9 inches. Therefore, it is considered that dike elevations would be adequate to protect the disposal sites against tsunamis.

4.167 Impact on vegetation would be most severe at Sites 1 and 2. Continued dredge disposal over many years would result in chronic loss of upland vegetation, and permanent loss of marsh vegetation (pickleweed and cordgrass) which constitutes 30 to 40 acres for each site. Disposal at Site 4 would eliminate the possibility of restoring the salt pond to marsh, representing the loss of 90 acres of potential marsh habitat. The sparse vegetation at Site 3 would be eliminated if dredged material is disposed upon on this site.

4.168 Until recently, marshlands were considered "waste lands." Only recently has there been widespread recognition of the critical value of wetlands as feeding and nursery areas for fish and fowl. As mentioned in the Environmental Setting, there are four endangered species and numerous other species of wildlife in the vicinity. Marshlands are the primary habitat of these species. Diking and disposal at either of Sites 1 or 2 would result in the loss of 30 to 40 acres of valuable marsh habitat and thus a corresponding loss of wildlife. Disposal at Site 4 would eliminate the possibility of wildlife enhancement. Furthermore, the shifting of existing habitats and the disturbances during dike repair and disposal operations may have an indirect adverse effect on adjoining areas and their inhabitants.

4.169 Long-range effects are closely linked to both port development and to the plans of the U.S. Fish and Wildlife Service to establish a national wildlife refuge. The port already owns Site 1 and plans to reconstruct the surrounding dikes in order to use the site for disposal operations in the immediate future. A draft environmental statement on dike reconstruction was issued by the Corps in August 1975. As mitigation, the port proposes to reopen Deepwater Slough to Redwood Creek, which would allow tidal inundation into new areas. Eventual port development on Site 1 would require an access road extending across Site 2 to the mainland, which could result in further adverse environmental effects. A development plan prepared for the port by Williams-Kuebelbeck and Associates proposes no development on Sites 1 or 2 in the next several years (259). The port plans to develop Site 3 (where the salt pile is located) as a bulk cargo terminal. Site 4 (the salt pond) is suggested by Williams-Kuebelbeck and Associates for eventual port industrial use.

4.170 The U.S. Fish and Wildlife Service and the State Department of Fish and Game have other plans for Site 1. Both agencies would like to preserve the site in its present condition. The Fish and Wildlife Service considers the site a valuable buffer area adjacent to the authorized San Francisco Bay national Wildlife Refuge (Plate I-13). The Refuge would encompass most of Bair and Greco Islands, which are important feeding and resting areas for a great variety of waterfowl, including several endangered species mentioned above. The entire Bair Island complex is one of the most ecologically important and sensitive areas in the Bay. The Fish and Wildlife Service would prefer use of Site 3 for disposal and restoration of free tidal action to Deepwater Slough (244). The State Department of Fish and Game suggests use of Sites 3 or 4 for disposal (57).

4.171 A long-range effect of disposal in any one area would be the periodic destruction of vegetation. Pickleweed and coyote bush require several years to become re-established. If dredging at Redwood City Harbor continues on a biennial basis, the effect would be to maintain the disposal site as bare land, which would eliminate vegetative cover for all types of wildlife and would result in an adverse aesthetic effect. However, continued disposal would also preserve an area as open space for eventual use as a park or recreation area.

3. Impact on San Francisco Bar Environment.

4.172 a. Introduction. Between December 1970 and April 1972, the San Francisco District conducted a study at the San Francisco Bar or Main Ship Channel to assess the effects of deepening the channel from 50 to 55 feet and of disposing of the dredged sand on the Bar adjacent to the channel. This study was designed primarily to study the effects of the deepening but since the bar environment is rather unique (a shifting sand environment), the results give valuable insight to the effects of annual maintenance dredging and disposal at this environment of constant motion. The following is a summary of Appendix A of the Dredge Disposal Study which discusses the study in detail (203).

4.173 b. Studies Conducted and Results. Studies were conducted by the Corps to determine the toxicity of Bay sediments, degree of water column degradation by dredging, area influenced by material dispersion, and impact of physical removal and deposition of sediments on the benthic community. The studies were conducted prior to and after dredging and disposal operations in the Main Ship Channel and Bar area. The studies can be divided into four categories: Sediment Analysis, Water Quality, Material Dispersion and Benthic Study.

4.174 (1) Sediment Analysis. Four sets of sediment samples were collected from the Main Ship Channel for determination of the sediment's pollutional status. The first and third sets were taken from the intake pipe of the hopper dredge BIDDLE on 28 December 1970 and on 8 June 1971. The only *in situ* samples were taken on 5 April 1971, using a modified Ponar bottom grab. On 18 January 1972, the fourth set was taken from the dredge as it worked the channel; however, these samples were obtained from the ship's hoppers instead of the intake pipe.

4.175 The first set of samples was analyzed by Corps of Engineers South Pacific Division Laboratory, Sausalito, and the remaining sets by the Environmental Protection Agency Laboratory, Alameda. All the samples were analyzed for the seven parameters of the Environmental Protection Agency's 1971 dredge disposal "criteria" (COD, volatile solids, grease-oil kjeldahl nitrogen, lead, mercury, and zinc).

The 1971 regulation is entitled "Criteria for Determining Acceptability of Dredge Spoil Disposal to the Nation's Waters." Analyses were performed in accordance with EPA procedures.

4.176 The bottom sediments at the San Francisco Bar are comprised of fine sand with low percentages of fines (grain size smaller than sand particles). Table IV-14 shows the bulk sediment data for the four periods of sampling. When this data is compared with the EPA's 1971 criteria, all measurements were within the stated limits; thus, San Francisco Bar Channel sediments are considered not polluted. Since then, the 1971 criteria has been superseded by the Ocean Dumping regulation of 1973 which governs disposal in the territorial sea (see discussion in Section III). According to the 1973 regulations, if the sediment is mostly sand, then it is not considered polluted, and San Francisco Bar material falls under this category.

TABLE IV-14

BULK SEDIMENT DATA
COMPARISON OF PARAMETER MEANS BETWEEN LOCATIONS

Parameter (percent of dry wt)	5 Apr 71 in-situ	28 Dec 70 & 8 Jun 71 Intake	18 Jan 72 Hopper	EPA's 1971 criteria
Chem. Oxy. Demand	0.59	0.169	0.286	5.0
Oil-grease	0.1	0.037	0.026	0.15
T. Kjeldahl Nit.	0.017	0.012	0.01	0.10
Volatile Solids	1.75	1.19	1.2	6.0
Lead (ppm)	13.2	13.0	5.4	50.0
Mercury (ppm)	0.02	0.03	0.005	1.0
Zinc (ppm)	41.5	46.4	25.3	50.0

Source: Mod. from App. A, Dredge Disposal Study, 1974.

4.177 If the 5 April 1971 data can be considered representative of the Bar's sediment composition, then Table IV-14 reveals an interesting facet to the mechanics of hopper dredging. The chemical oxygen demand (COD), which is a measure of the amount of oxygen required to oxidize both organic and inorganic matter by a chemical oxidizing agent, is between one and 1½ times less in the intake and hopper samples than in the in-situ samples. Similarly, values are less for oil-grease, volatile solids and most heavy metals in the intake and hopper samples than the in-situ, bottom samples. A plausible explanation for these reductions, if they are, in fact, true reductions, is that the lower pollutant levels is reduced principally by elutriation (suspension and dilution) of the sediments during the hydraulic pumping (which mixes the sediments with 80 percent water by volume) and overflow (ridding excess water from the hoppers) (251). During pumping and overflow, oil-grease and low density organic and inorganic particles are washed from the dredged sand.

4.178 Another method of examining the pollution status of sediments is the toxicity bioassay. The EPA used some of the 5 April in-situ sediments in a 96-hour static bioassay on the Three-spined stickleback fish (*Gasterosteus aculeatus*). Because of the low pollution level of Bar material, it was not surprising to find that the bioassay did not elicit any acute responses from the sticklebacks. Tolerance limits were not established because of the high survival rate (203).

4.179 Grain size of sediments in the channel are very similar to the grain size of sediments in the disposal area. Compatibility of sediments implies no substrate alteration at the disposal site and thus no alteration in biological habitat.

4.180 (2) Water Quality. The water quality monitoring program was initiated to determine the effects of the dredging and disposal operations on the water column. This program included measurement of temperature, salinity, conductivity, pH, dissolved oxygen and turbidity before, during and after operations in 1971 and 1972. Background readings of these parameters were obtained in the Main Ship Channel on 5 April 1971, and in the disposal sites on 8 June 1971 and 9 February 1972. On 10 and 18 June 1971, and on 8 and 10 February 1972, monitoring was conducted to measure parameter fluctuations during material releases in the disposal areas (it should be noted that the 1971 disposal area was 3,000 feet south of the channel and the 1972 area was 6,000 feet south.) On 10 February during sediment disposal three transects were run in and adjacent to the dredge's overflow plume. At this time water samples were taken at the end and midpoint of each transect for analysis of BOD and COD levels. The post-dredging monitoring was conducted on 30 June 1971.

4.181 Neither the dredging nor disposal operation had any measurable or expected effect on the conductivity or the temperature of the water mass (203) Hydrogen ion concentration (pH) is another parameter which did not change during dredging or disposal operations. The sample obtained on 28 December 1970 from the area of Buoy 7 had a pH of 7.6. The neutral sediment does not affect the hydrogen ion concentration of the water mass, which itself is buffered. Water column readings were always between pH 7.7 and 8.1, well within the pH range of seawater.