HIGHWAY STUDY REPORT

WATER QUALITY STUDY

DUMBARTON BRIDGE REPLACEMENT

72-50

EPORT

March, 1972

STATE OF CALIFORNIA

BUSINESS AND TRANSPORTATION AGENCY

DEPARTMENT OF PUBLIC WORKS

DIVISION OF HIGHWAYS

MATERIALS AND RESEARCH DEPARTMEN

STUDY REPORT

NO. M & R 667099-1

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STATE OF CALIFORNIA—TRANSPORTATION AGENCY

RONALD REAGAN, Governor

DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS
MATERIALS AND RESEARCH DEPARTMENT
5900 FOLSOM BLVD., SACRAMENTO 95819

March, 1972
Final Report
No. M&R 667099-1

Mr. E. R. Foley
Division of Bay Toll Crossings
151 Fremont Street
San Francisco, CA 94105

Dear Sir:

Submitted herewith is a report titled:

Water Quality Study

Dumbarton Bridge Replacement

Included are the results of chemical analyses of bottom sediments and water from piezometers. Development of the sampling program and coordination of laboratory testing was performed by the Environmental Improvement Section under the general direction of John Skog. The report was prepared by Richard Howell and Mike Quint under the general supervision of Earl Shirley.

Very truly yours,

JOHN L. BEATON
Materials and Research Engineer

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REFERENCE: Quint, M. L.; Howell, R. B.; Shirley, E. C.; Water Quality Study on the Dumbarton Bridge Replacement, State of California, Department of Public Works, Division of Highways, Materials and Research Department, Report 667099-1, February 1972.

ABSTRACT: The Division of Bay Toll Crossings has developed plans for replacement of the existing Dumbarton Bridge, located in South San Francisco Bay, with construction tentatively scheduled for the spring of 1973. In October 1971, the Environmental Improvement Section of the Division of Highways was requested to perform a water quality analysis of bottom sediments and aquifers.

The San Francisco Bay Regional Water Quality Control Board, in conjunction with other agencies, formulated testing requirements for performing a water quality analysis. The tests included the following: A chemical analysis of the bottom sediments; toxicity and biostimulation (Nitrogen) potential tests on the bottom sediments; and a chemical analysis of the upper two aquifers.

The Nimbus Laboratory of the Department of Fish and Game performed the toxicity tests and the Bryte Laboratory of the Department of Water Resources performed the analyses on the bottom sediments and aquifers in accordance with the test methods of the Environmental Protection Agency and Standard Methods for Water and Wastewater.

The results of these analyses are presented in this report.

KEY WORDS: Dredging, toxicity potential, biostimulation, bottom sediments, aquifer.

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The assistance of the following individuals is greatly appreciated. Mr. Michael Knickelbein, of the Division of Bay Toll Crossings, collected the field samples. Mr. George Gaston of the Department of Water Resources Bryte Chemical Laboratory conducted the chemical analysis and "biostimulation" potential tests on the Bay sediment, and the chemical analysis of the two aquifers. Mr. Jack Beer, of the Department of Fish and Game, provided technical assistance and Messrs. Richard Hansen and Fred Kopperdahl of the Department's Nimbus Laboratory performed the toxicity potential tests. Dr. Teng-Chung Wu and Mr. Richard Wood, of the San Francisco Regional Water Quality Control Board, provided advice and guidance.

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INTRODUCTION

Project Scope

The Dumbarton Bridge project consists of replacing the existing low-level overwater bridge across the southern end of San Francisco Bay with a high-level structure. The new bridge, about 9,400 feet in length, will be parallel and about 90 feet north of the existing structure. It will provide two 12-foot lanes with 8-foot shoulders. The approach roads at both ends of the bridge will be constructed on an improved alignment which will pass through salt ponds. Construction of the new bridge is tentatively scheduled for the spring of 1973.

Looking West along the North side of the existing structure. The proposed bridge alignment will be at the right of the picture.

The Division of Bay Toll Crossings (BTC) is currently studying several alternative proposals for the construction of the new bridge. One of the plans, illustrated on the "Sample Location Plan" and the "Preliminary Generalized Soil Profile" in the Appendix, outlines the

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scope of the construction work pertaining to this study. This report studies the effects of the dredging and piling operations on the water quality of the Bay by analyzing the bottom sediments that will be dredged and the aquifers that may be pierced or disturbed by the piling operations. The Department of Fish and Game (DFG) is preparing a separate report on the ecological effects of the new alignment through the salt ponds.

The Materials and Research Department coordinated the sampling and testing programs for this study. Testing requirements were established by the San Francisco Bay Regional Water Quality Control Board, in conjunction with other agencies. The BTC collected the samples as directed from the proposed bridge site and delivered them to the laboratories. Chemical analyses on the bottom sediment and aquifers, and the "biostimulation" tests were performed by the Department of Water Resources, Bryte Laboratory. The Department of Fish and Game, Nimbus Laboratory performed the toxicity tests.

Objective

The purpose of this report is to study the chemical composition, "biostimulation" potential, and toxicity potential of the bottom sediments that will be dredged during construction, and the chemical composition of the water bearing aquifers that underlie the project location.

Analysis of Data

The chemical analysis and "biostimulation" potential tests on the bottom sediments provide information as to the chemical and biochemical characteristics of the overlying water mass and the immediate underlying sediment. The productivity of the surrounding Bay water is also reflected in the chemical composition of the bottom sediments.

The results of the bottom sediment tests and tentative criteria for some of these tests are summarized below.

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Test	Results Low - High	Avg.	Tentative Criteria
Volatile Solids (Mg/Kg)	32000 - 60000	47000	60000
COD (Mg/Kg)	39000 - 140000	70000	50000
Oil & Grease (Mg/Kg)	1300 - 3200	1800	1500
Mercury (Mg/Kg)	0.09 - 0.59	0.43	1
Lead (Mg/Kg)	5 - 36	21	50
Zinc (Mg/Kg)	65 - 83	73	50
Cadmium (Mg/Kg)	1 - 2	1	
Copper (Mg/Kg)	13 - 31	24	
Total Phosphorus (Mg/Kg)	450 - 770	650	
pH	7.3 - 7.4	7.4	
Pesticides			
(a) Total indicated chlorinated hydrocarbons (TICH reported as DDT) (µg/Kg) or (ppb)	0 - 153	77	
(b) Polychlorinated biphenyl (PCB reported as Arclor 1254) (µg/Kg) or (ppb)	0 - 8	2	
"Biostimulation" Potential			
Nitrates (Mg/Kg)	1 - 2	1	
Nitrites (Mg/Kg)	0.1 - 0.8	0.2	
Ammonia (Mg/Kg)	150 - 400	270	
Organic Nitrogen (Mg/Kg)	1200 - 2000	1500	
Total Nitrogen (Kjeldahl) (Mg/Kg)	1450 - 2210	1730	1000

The total Nitrogen (Kjeldahl) is taken as a measure of the bio-stimulation potential of the bottom sediment. This concentration is substantially higher than the tentative standards. The chemical oxygen demand (COD) and zinc concentrations were higher than the tentative standards while the volatile solids, mercury, and lead concentrations were lower.

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The average pesticide concentration of 77 parts per billion of TICH and 2 parts per billion of PCB appears to be insignificant. Cadmium and copper concentrations in the bottom sediment are rather low whereas the phosphorus concentration is relatively high.

Toxicity tests on the bottom sediments provide information concerning impact on the biota by the sediments resuspended in the water during the dredging operation. These sediments could release toxic chemicals, if present, into the water and could also place an excessive drain on the dissolved oxygen available in the water.

Acute toxicants have been determined as one of the most significant pollutants discharged into the Bay (See reference 5). The results of this study indicate that the toxicity potential of the bottom sediments at the Dumbarton Bridge site is low (none of the test organisms died), but the dissolved oxygen demand is rather high. Chemical analyses show the chemical oxygen demand average is 70,000 Mg/Kg. Aeration was required on several of the toxicity tests to maintain oxygen levels at or above 3 Mg/L.

The toxicity tests were conducted for a 48-hour period using the three-spined stickleback (Gasterosteus aculeatus) as the test organism. These fish were approximately two inches long and were selected because of their availability and salinity tolerance. Although no mortalities occurred among the fish tested, it must be noted that these tests apply only to the short-term toxic nature of the sediments and not to the long term or chronic effects on the aquatic ecosystem of the South Bay.

The results of the chemical tests of water from the aquifers are summarized below. The shallow aquifer tests were performed on water from two wells located at the west and east bridgeheads varying in depth from 63 to 68 feet below sea level. The deep aquifer tests were performed on four wells located at the east and west bridgehead varying in depth from 200 to 320 feet below sea level.

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Test	Shallow Aquifer Low - High	Shallow Aquifer Avg.	Deep Aquifer Low - High	Deep Aquifer Avg.
Total Dissolved Solids	24200 - 40000	32100	330 - 532	395
Specific Conductance (Micromhos/cm)	33500 - 49500	41500	544 - 880	692
Chloride (Mg/L)	11000 - 22600	16800	31 - 100	54
Nitrate (Mg/L)	0.0 - 0.2	0.1	0.0 - 2.2	0.6
Sulphate (Mg/L)	1040 - 3930	2490	7 - 23	12
Phosphate (Mg/L)	0.02 - 0.02	0.02	0.15 - 1.30	0.57
Sodium (Mg/L)	6800 - 11000	8900	74 - 186	118
Potassium (Mg/L)	50 - 85	68	2 - 3	3
Calcium (Mg/L)	409 - 808	609	11 - 16	14
Magnesium (Mg/L)	835 - 1520	1180	8 - 14	10
Manganese (Mg/L)	0.00 - 0.00	0.00	0.06 - 0.14	0.11
Iron (Mg/L)	4.9 - 12.0	8.5	0.2 - 2.5	1.0
pH	6.8 - 7.0	6.9	7.7 - 8.4	8.0

These data clearly indicate the differences in the composition of the water sampled from the shallow and the deep aquifers. Water sampled from the shallow aquifer (elevation -65±) is significantly higher in total dissolved solids, specific conductance, chloride, sulphate, sodium, potassium, calcium, magnesium, and iron than water from the deep aquifer (elevation -200 to -320 ±). The pH, phosphate, nitrate, and manganese concentrations in the shallow aquifer are lower than the concentrations in the deep aquifer.

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TEST REQUIREMENTS

The San Francisco Bay Regional Water Quality Control Board, in conjunction with other Federal and State agencies, developed requirements for studying the environmental effects of the Dumbarton Bridge replacement on the water quality of the Bay. The tests required are grouped into three areas:

I. The tests required to satisfy dredging requirements consist of a total chemical analysis of the bottom sediment to determine concentrations of the following:

(a) Volatile solids
(b) Chemical Oxygen Demand (COD)
(c) Oil and grease
(d) Mercury
(e) Lead
(f) Zinc
(g) Cadmium
(h) Copper
(i) Total phosphates
(j) pH
(k) Pesticides

(1) Total indicated chlorinated hydrocarbons (TICH)

(2) PCB as Arclor 1254

II. The tests which are concerned with possible environmental effects due to construction and dredging operations cover two sub-areas:

(A) The determination of the toxicity potential of the sediment through tests on live organisms.

(B) The determination of the "biostimulation" potential of the sediment as indicated by the presence of the following:

(1) Nitrate
(2) Nitrite
(3) Ammonia
(4) Total Nitrogen (Kjeldahl)

III. Tests to provide knowledge about the two upper aquifers that underlie the bridge site. Water samples from the piezometers located near the two bridgeheads and the KGO Well and Duck Club Well were tested for:

(1) Total Dissolved Solids (TDS)
(2) Specific Conductance
(3) Chloride

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(4) Nitrate
(5) Sulphate
(6) Phosphate
(7) Sodium
(8) Potassium
(9) Calcium
(10) Magnesium
(11) Manganese
(12) Iron

SAMPLING PROGRAM

A sampling program for the chemical analysis and "biostimulation" tests on the Bay mud was developed in conjunction with the Sa. Francisco Bay Regional Water Quality Control Board. The sampling program for the toxicity tests was developed in conjunction with the Department of Fish and Game. The locations of the samples are illustrated on the "Sample Location Plan" and the "Preliminary Generalized Soil Profile" in the Appendix.

A. Chemical Analysis and "Biostimulation" Tests:

A stratified sampling program was developed for these tests to determine the chemical composition of the sediment at various depths. At location numbers one and two, samples were taken from the top two feet, the bottom two feet and the middle two feet of the sediment to be dredged. These correspond to elevations -5, -18, and -12 feet, respectively. Location number one represents the 49,000 cubic yards of sediment to be dredged for the cofferdam piers on the west approach of the bridge. Location number two represents the 67,000 cubic yards of sediment to be dredged for the cofferdam piers on the east approach of the bridge. At location number three, which represents the 50,000 cubic yards of sediment to be dredged for the access channel, samples were taken from the top two feet and the bottom two feet; that is elevation -4 and -7 feet, respectively. The following table indicates the locations and quantities of the samples:

Loc. No.	Bridge Center-line Station	Sample Quantity: Top 2' layer of sediment	8' below the top of the sediment	(reference MSL) Elev. -18' to -20'
1	475	1 L.F. of 2"σ Core*	1 L.F. of 2"σ Core	1 L.F. of 2"σ Core
2	525	1 L.F. of 2"σ Core	1 L.F. of 2"σ Core	1 L.F. of 2"σ Core
3	512	1 L.F. of 2"σ Core	1 L.F. of 2"σ Core	--

* One lineal foot of two-inch diameter sediment core.

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B. Toxicity Potential Tests:

To determine the toxicity potential of the sediment in the planned dredging area, samples were taken from the top two feet and bottom area (average elevation -20 feet) within the dredging limits. At location numbers one, two, and three, samples were taken from the top two feet of the sediment. At location numbers one and two, samples were taken from the bottom area of the sediment to be dredged; that is, a composite sample composed of an approximate continuous core sample from two feet below the top of the sediment down to elevation -20 feet below mean sea level (MSL). The following table indicates the locations and quantities of the samples:

Location Number	Bridge Centerline Station	Sample	
		Top 2' layer of sediment	Composite of bottom area to be dredged
1	475	3 gallons	3 gallons
2	525	3 gallons	3 gallons
3	512	3 gallons	--

C. Chemical Analysis of the Aquifers:

Water samples were taken from the two piezometers and the Duck Club Well located near the west bridgehead and the two piezometers and the KGO radio well located near the east bridgehead. The piezometer and well locations are illustrated on the "Sample Location Plan" in the Appendix. The following table indicates the locations and elevations of the piezometer well points and of the water wells.

	Piezometer No.	Bridge Centerline Station	Approx. Elevation, feet (reference MSL)
West Approach	1	458	-206
	3	458	- 63
	Duck Club Well	458	-200
East Approach	2	534	-231
	4	534	- 68
	KGO Radio Well	534	-320

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SAMPLING PROCEDURES

Chemical Analysis and "Biostimulation" Tests of the Bottom Sediment

The sediment samples were extracted with an Osterberg Piston Sampler (two-inch diameter) mounted on a 17-foot fishing boat. A Wisconsin air-cooled engine powered the hydraulic pump for the sampler. Three men on the boat operated the equipment and kept the records. The samples were taken during periods of calm water and at high tide because a gentle flow of the water occurred at that time. Also, this minimized the chance of hitting some underwater obstruction with the boat. The samples were difficult to extract from the lower elevations because of the suction of the sediment on the core tube.

One pound sediment samples were found to be sufficient to run all of the required chemical tests. The samples were delivered to the Bryte Laboratory in Sacramento in lacquer-lined steel Shelby tubes. One lineal foot of the two-inch diameter sediment core provided the required one pound of sediment for testing. Each sample was sealed by wrapping both the ends of the tube with aluminum foil. The samples were packed in ice and delivered to the Bryte Laboratory within 24-hours. The 24-hour limit was set because the Chemical Oxygen Demand (COD) and "biostimulation" potential of the sediment are under continual change. The samples were each labeled with the location number, bridge centerline station, elevation of the sample below MSL, date, time, and the initials of the person taking the sample.

Toxocity Potential Tests

The sediment samples were extracted in the same manner as the samples for Chemical Analysis and Biostimulation Tests. Three-gallon samples were obtained by taking several core samples and extracting the sediment into a five-gallon can. The can had a lug crimp cover and molded gasket and was lined with a plastic bag. The plastic bag was sealed tightly against the sample to eliminate air voids prior to installing the cover on the can. The sample was packed in ice and delivered to the Nimbus Laboratory east of Sacramento within 24-hours. Each sample was identified with the location number, bridge centerline station, elevation of the sample below MSL, date, time and initials of the person taking the sample.

Chemical Analysis of the Aquifer

A compressor was used to flush the piezometers for approximately 30 minutes prior to extracting the water samples. This was done to eliminate obtaining a "stagnant" sample from the aquifer. To collect the sample, compressed air was blown into the piezometer through a plastic tube. One half gallon water samples were obtained in plastic bottles, packed in ice and delivered to the Bryte Laboratory within

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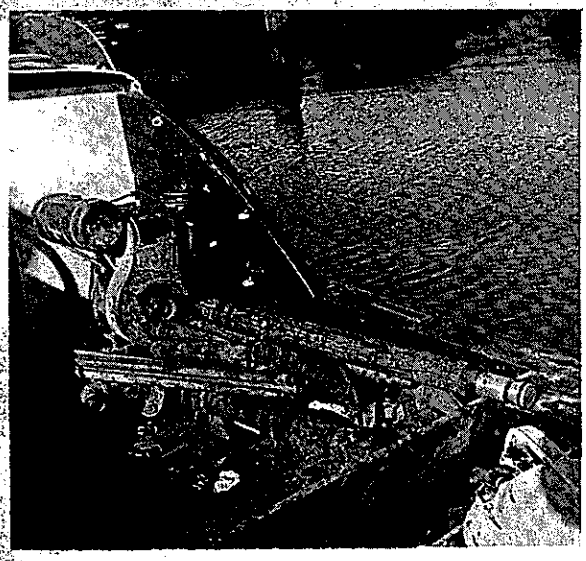
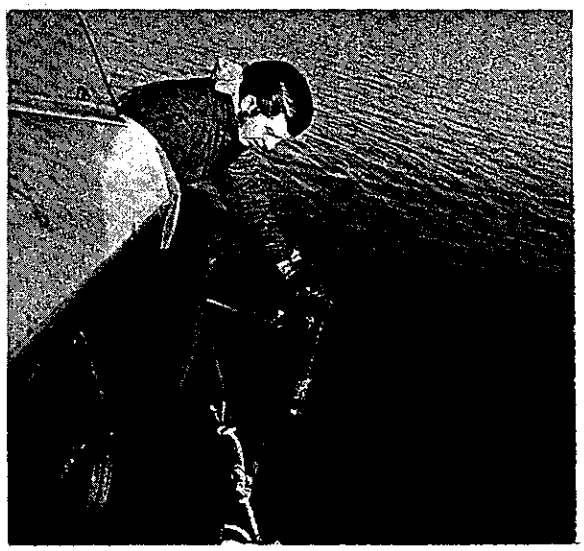
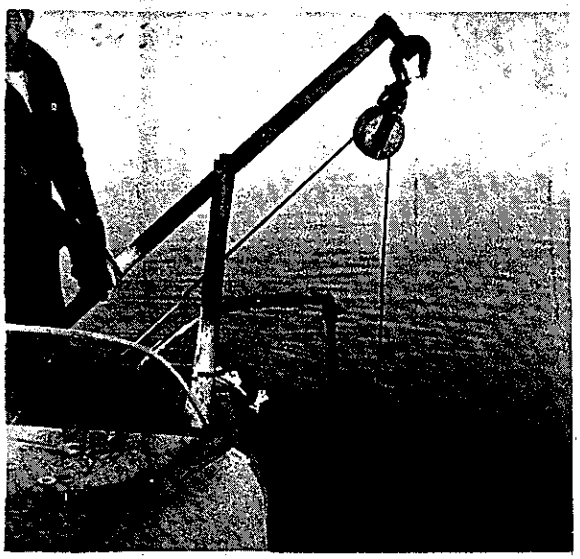


Two-inch diameter Osterberg Piston Sampler and pump in the back of the boat.



Preparing to take a sample with the Osterberg Piston Sampler. The piston is "shot" through the sediment by means of water pressure from the pump mounted on the boat.



Pulling the one-inch pipe out with a winch and frame. The Osterberg Sampler is attached to the bottom of the pipe.

Depositing the sediment sample into a five gallon container, lined with plastic, in preparation for shipment to the testing lab.

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24-hours. Each sample was identified with the piezometer number, bridge centerline station, elevation of sample below mean sea level, date, time, and initials of the person taking the sample.

TEST METHODS

The Nimbus Laboratory of the Department of Fish and Game and the Bryte Laboratory of the Department of Water Resources performed the tests in accordance with the methods outlined below.

Chemical Analysis and "Biostimulation" Tests on the Bottom Sediments

These tests were performed at the Department of Water Resources Chemical Laboratory in Bryte. The following methods and guidelines were used:

Test	Method	Reference Number*
Volatile Solids	Standard Methods (Heated one-hour at 600°C)	1, 2, 3
Chemical Oxygen Demand	Standard Methods	"
Oil and Grease	Standard Methods (Soxhlet Apparatus)	"
Lead	Atomic Absorption Detection	2, 3
Zinc	" " "	"
Cadmium	" " "	"
Copper	" " "	"
Total Phosphates	Dry ash method	"
pH	pH meter	"
Mercury	AOAC digestion with atomic absorption detection	6, 7

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Test	Method	Reference Number*
Pesticides		
Total indicated chlorinated hydrocarbons and PCB as Arclor 1254	Benzene-methanol extraction, acetonitrile partitioning, silicic acid column separation, microcoulometric gas chromatograph detection.	8, 9
Biostimulation		
(a) Nitrates	Modified Brucine	1, 2, 3
(b) Nitrites	Naphthylamine	"
(c) Ammonia	Distillation	"
(d) Organic Nitrogen	Kjeldahl Digestion	"

* Numbers refer to references on page 22.

Toxicity Potential Tests on Bottom Sediment

Toxocity tests were performed at the Department of Fish and Game Nimbus Laboratory, east of Sacramento.

Tests were performed in accordance with the method outlined in "A Guide on Physical Chemical, and Biological Analyses Required on Sediment Samples During Pre-Dredging Studies", Appendix B titled "Sediment Bioassay", Environmental Protection Agency (see reference 4).

Initially, bioassays were conducted for a 48-hour period on concentrations of 3% sediment by volume. Additional concentrations of 0.3% and 1% were scheduled providing fish mortalities were encountered in the initial tests. Three-spined stickleback, (Gasterosteus aculeatus), acclimated to sea water, were selected as the test species due to their availability and salinity tolerance.

Dilution water used in these tests was Pacific Ocean water obtained from the Steinhart Aquarium in San Francisco. The tests were conducted at 15.5 degrees Centigrade for a period of 48-hours.

The test aquaria were modified by extending the return line from the recirculating pumps to within 5 inches of the bottom of the tank. This was done to afford better mixing of the sediments.

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Chemical Analysis of the Aquifers

The water samples were analyzed at the Department of Water Resources Chemical Laboratory located in Bryte in accordance with the test methods described in "Standard Methods for the Examination of Water and Wastewater" (see reference 1).

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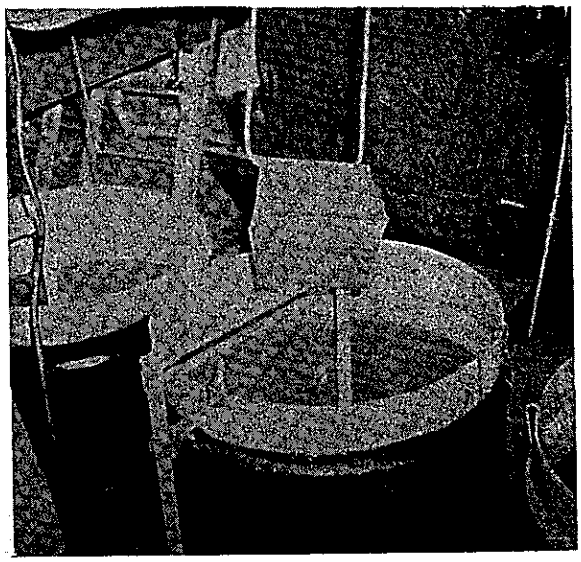
Toxicity testing tanks with recirculating pumps and return lines.



Three-Spined Stickleback retained in basket for periodic observation during the toxicity test.

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TEST RESULTS

The results of this study are discussed in Sections A, B and C below.

A. The results of the chemical analysis and "biostimulation" tests on the bottom sediments are listed in Table A. These results were calculated on a dry weight basis.

   Samples taken at the -18 foot elevation were lower in mercury, lead, zinc, oil and grease, and total phosphorus than the samples taken from the upper strata of the bottom sediment. The results of the other tests noted in Table A do not show any consistent trends between the sediment strata.

   The pesticides (TICH) results at location number three increase approximately proportionally with depth. Pesticide concentrations at location numbers one and three decreased with depth. There was no correlation between depth and pesticide concentration.

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TABLE A

CHEMICAL ANALYSIS AND BIOSTIMULATION POTENTIAL TEST RESULTS

TEST	Location #1 (Sta. 475) Elev. (Reference MSL)* -5	-12	-18	Location #2 (Sta. 525) Elev. (Reference MSL)* -5	-12	-18	Location #3 (Sta. 512) Elev. (Reference MSL)* -4	-7
1. Volatile Solids (mg/kg)	49,000	60,000	46,000	32,000	51,000	58,000	34,000	45,000
2. COD (mg/kg)	95,000	46,000	58,000	73,000	62,000	140,000	39,000	46,000
3. Oil & Grease (mg/kg)	3,200	1,900	1,400	2,500	1,300	1,300	1,300	1,700
4. Mercury (Hg) (mg/kg)	0.58	0.55	0.12	0.52	0.56	0.09	0.46	0.59
5. Lead (Pb) (mg/kg)	20	11	11	36	22	5	35	27
6. Zinc (Zn) (mg/kg)	73	83	65	82	67	66	68	77
7. Cadmium (Cd) (mg/kg)	1	1	1	2	1	1	1	1
8. Copper (Cu) (mg/kg)	30	29	24	17	13	21	27	31
9. Total Phosphorus (as P) (mg/kg)	640	620	450	770	880	500	690	670
10. pH	7.4	7.4	7.4	7.4	7.4	7.3	7.3	7.4

*feet

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TABLE A (continued)

CHEMICAL ANALYSIS AND BIOSTIMULATION POTENTIAL TEST RESULTS

TEST	Location #1(Sta.475) Elev.(Reference MSL)* -5	-12	-18	Location #2(Sta.525) Elev.(Reference MSL)* -5	-12	-18	Location #3(Sta.512) Elev.(Reference MSL)* -4	-7
11. Pesticides								
a.Total indicated Chlorinated Hydrocarbons reported as DDT (μg/kg)	80	1	0	38	85	118	153	140
b.Polychlorinated Biphenyl reported as Arclor 1254 (μg/kg)	0	4	8	0	0	0	0	0
12. "Biostimulation"								
a.Nitrates (as N) (mg/kg)	1	1	2	1	1	2	1	1
b.Nitrites (as N) (mg/kg)	0.1	0.1	0.1	0.0	0.1	0.2	0.1	0.8
c.Ammonia (as N) (mg/kg)	150	340	230	250	400	210	250	330
d.Organic Nitrogen (as N) (mg/kg)	1,600	1,400	1,300	1,400	1,500	2,000	1,200	1,300
e.Total Kjeldahl Nitrogen(mg/kg)	1,750	1,740	1,530	1,650	1,900	2,210	1,450	1,630

*feet

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B. The 48-hour toxicity potential tests resulted in no fish mortalities. However, the sediments exerted an extremely high oxygen demand. Aeration was required on several tests to maintain oxygen levels above the required minimum of 3 milligrams per liter.

The results of the toxicity tests are listed in Tables B-1 and B-2. Samples were obtained at locations 1, 2 and 3 at Stations 475, 525 and 512, respectively.

TABLE B-1

DISSOLVED OXYGEN DATA
(FIRST 12-HOUR PERIOD)

Location	Time	11:00 (start)	13:30	16:30	18:30	21:30
	Control	8.6	8.6	8.6	8.1	8.1
1	Surface	8.6	6.2	4.8	4.8	4.7
1	Composite	8.6	5.8	4.2	4.2	*3.8
2	Surface	8.6	5.8	4.0	*3.0	7.2
2	Composite	8.6	7.0	5.4	6.0	5.4
2	Composite (0.3%)	8.6	8.0	7.0	6.7	5.7
3	Surface	8.6	6.8	5.4	5.4	6.9

* Aeration began to maintain Dissolved Oxygen levels above 3.0 mg/l.

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TABLE B-2

SEDIMENT BIOASSAY TEST RESULTS

Initial Characteristics

Location	*Control	#1 Surface	#1 Composite	#2 Surface	#2 Composite	#2 Composite	#3 Surface
Conc. %	5%	3%	3%	3%	3%	0.3%	3%
No. Fish	10	10	10	10	10	10	10
pH Unit	7.1	7.7	7.7	7.7	7.5	7.1	7.7
D. O. mg/l	8.6	8.6	8.6	8.6	8.6	8.6	8.6
Turbidity JTU	220	260	290	310	450	132	290
T. Susp. Matter mg/l	3,512	100	654	1,196	942	28	950
Cl^- mg/l	15,600	15,600	15,600	15,600	15,600	15,600	15,600
Electrical Conductance micro mhos/cm	33,000	33,000	33,000	33,000	33,000	33,000	33,000
24-Hour							
D.O. mg/l	7.2	4.0	**5.7	**6.7	4.6	5.1	7.0
Mortality	0	0	0	0	0	0	0
48-Hour							
D.O. mg/l	6.6	2.1	5.8	6.6	2.9	4.8	6.3
Mortality	0	0	0	0	0	0	0

* Control - Simulated sediment using a mixture of sand and soil.

** Tests aerated to maintain D.O. levels above 3.0 mg/l.

C. The results of the chemical analysis of the aquifers are listed in Table C. These results clearly indicate differences in the contents of the water sampled from the shallow and the deep aquifers. Also there is a distinct variation in the contents of the water sampled from the east side and the west side of the Bay.

Water sampled from the shallow aquifer (elevation -65± feet) is significantly higher in total dissolved solids, specific conductance, chloride, sulphate, sodium, potassium, calcium, magnesium, and iron, than water from the deep aquifer (elevation -200 to -320 ± feet). The pH, phosphate, and manganese concentrations of the shallow aquifer are lower than those of the deep aquifer.

Water sampled from the shallow aquifer on the west side of the Bay is higher in total dissolved solids, specific conductance, chloride, nitrate, sodium, potassium, calcium, magnesium, and iron than the shallow aquifer water from the east side of the Bay.

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TABLE C

RESULTS OF CHEMICAL ANALYSIS OF AQUIFERS

TEST	West Bridgehead Piezometer Number 1 Elev.* -206	West Bridgehead Piezometer Number 3 Elev.* -63	West Bridgehead Duck Club Well Elev.* -200±	East Bridgehead Piezometer Number 2 Elev.* -231	East Bridgehead Piezometer Number 4 Elev.* -68	East Bridgehead KGO Radio Well Elev.* -320±
1. Total dissolved solids (TDS) (mg/L)	337	40,000	380	532	24,200	330
2. Specific Conductance (Micromhos/cm) (25°C)	544	49,500	801	880	33,500	544
3. Chloride (Cl) (mg/L)	31	22,600	53	100	11,000	32
4. Nitrate (NO_3) (mg/L)	0.0	0.2	2.2	0.0	0.0	0.0
5. Sulphate (SO_4) (mg/L)	7	1,040	10	23	3,930	8
6. Phosphate (P) (mg/L)	1.30	0.02	0.15	0.49	0.02	0.35
7. Sodium (Na) (mg/L)	100	11,000	113	186	6,800	74
8. Potassium (K) (mg/L)	2	85	3	3	50	2
9. Calcium (Ca) (mg/L)	16	808	16	11	409	11
10. Magnesium (Mg) (mg/L)	9	1,520	14	8	835	10
11. Manganese (Mn) (mg/L)	0.14	0.00	0.14	0.06	0.00	0.08
12. Iron (Fe) (mg/L)	2.5	12.0	0.8	0.2	4.9	0.5
13. pH	7.7	6.8	7.9	8.0	7.0	8.4

*Reference Mean Sea Level (feet)

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APPENDIX

1. Location Map
2. Sample Location Plan
3. Preliminary Generalized Soil Profile

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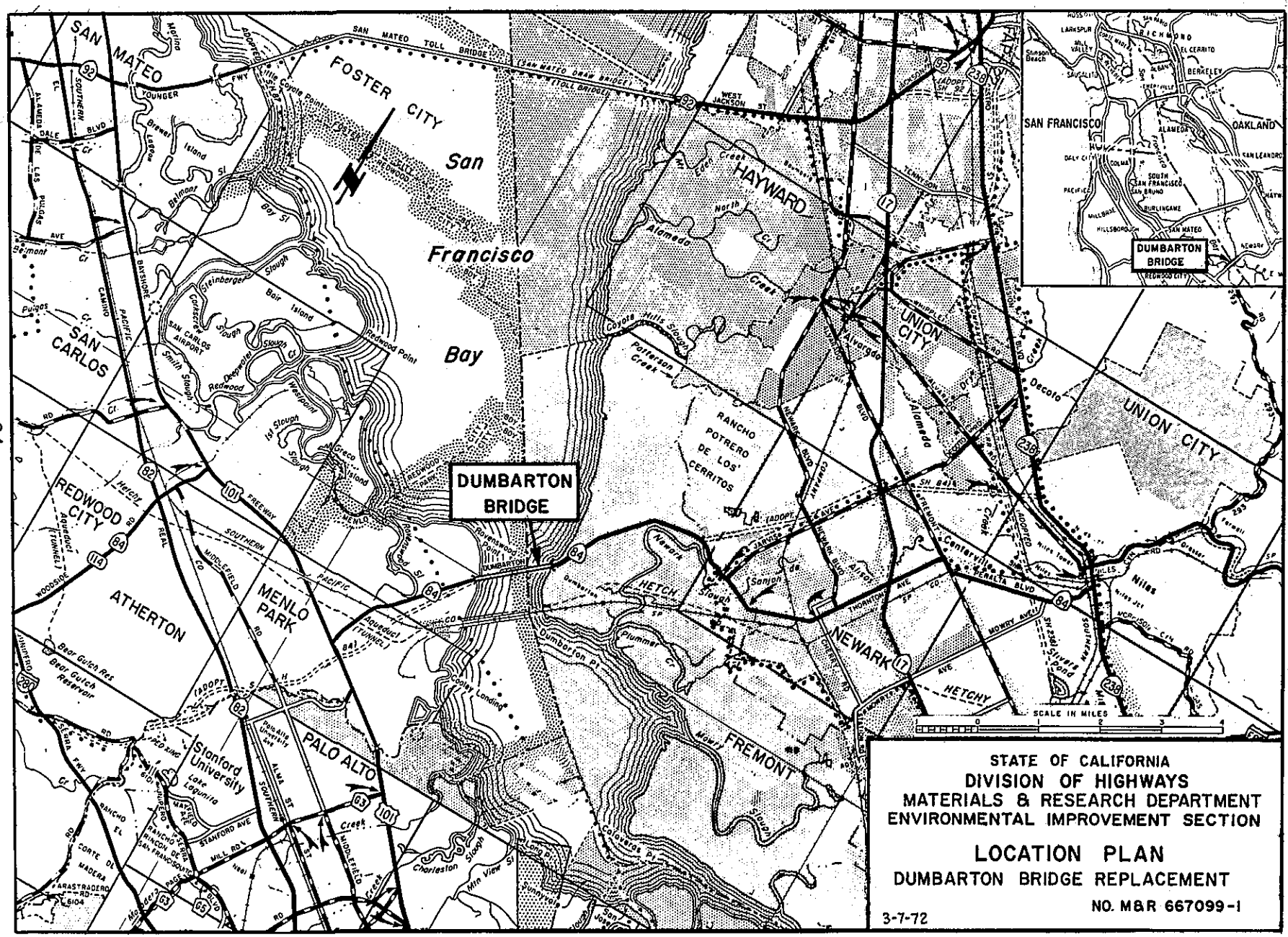

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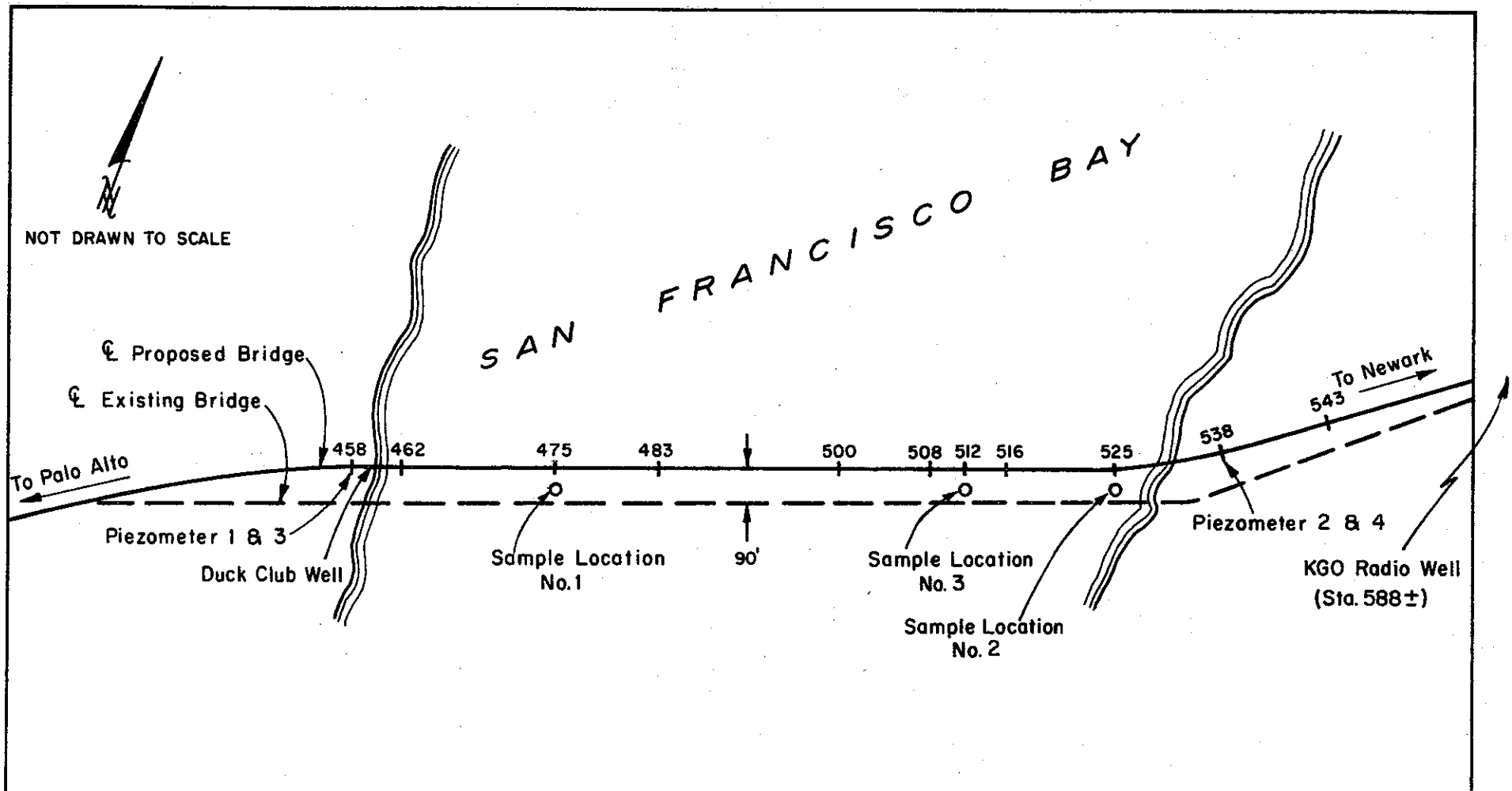

TENTATIVE CONSTRUCTION PLANS

Sta 462 to 483 Dredge 49,000 C.Y. for cofferdam piers to elev. −20'. Drive 24"□ concrete piles to elev. −60' to −115'

Sta 483 to 508 – Drive 54" diameter concrete pile piers to elev. −120'

Sta 508 to 543 – Dredge 67,000 C.Y. for cofferdam piers to elev. −20'. Drive 24"□ concrete piles to elev. −55' to −110'

Sta. 508 to 516 – Dredge 50,000 C.Y. for 200' wide access channel to elev. −10'.

STATE OF CALIFORNIA
DIVISION OF HIGHWAYS
MATERIALS & RESEARCH DEPARTMENT
ENVIRONMENTAL IMPROVEMENT SECTION

SAMPLE LOCATION PLAN
DUMBARTON BRIDGE REPLACEMENT

12-6-71 M.Q. NO. M & R 667099-1

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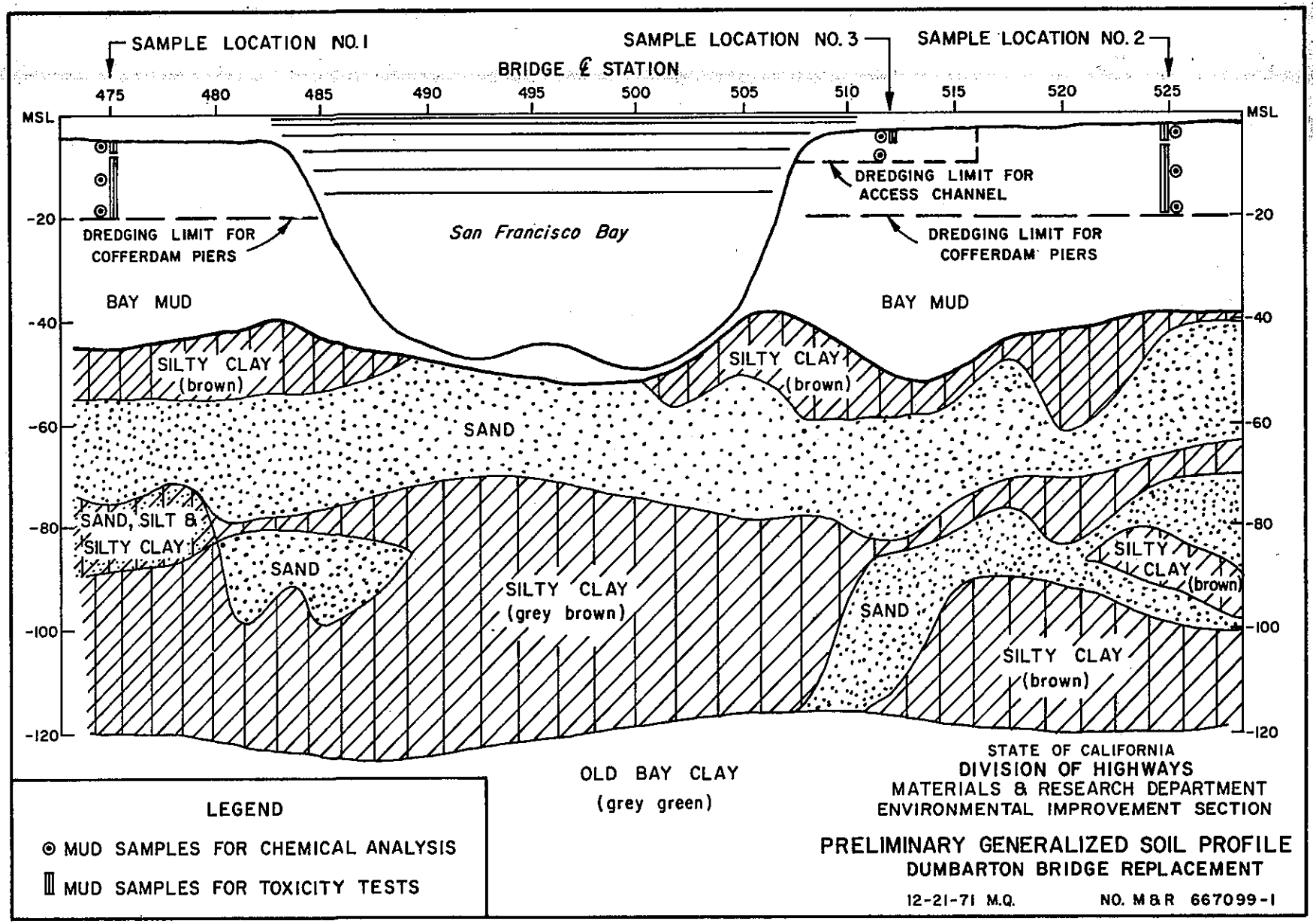

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