

PRELIMINARY INVESTIGATION OF MERCURY IN SOIL AND GROUNDWATER  
AT FORMER MERCURY FULMINATE FACILITY

RICHMOND FIELD STATION

Richmond, California

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submitted to:

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## 1.0 INTRODUCTION

University of California (UC) has initiated a comprehensive investigation of potential mercury contamination at the former mercury fulminate facility in Richmond Field Station (RFS), Richmond, California. Earlier investigations had indicated the presence of mercury in soils. Jonas & Associates Inc. was retained in December 1989, under order O-200248-TR to continue this investigation.

The recent investigation by Jonas & Associates primarily focused on characterizing the horizontal extent of mercury in soil. In addition, it provided supporting information to evaluate potential, soil to groundwater and soil to air, pathways. The investigation of mercury in the soil concentrated in the general area of the former mercury fulminate facility, located in the southern section of the Richmond Field Station. Soil samples were collected from the surface, at zero to three inches, and from the upper three feet of soil. Most of the analysis of these samples were to determine the presence and concentration of mercury in soil around the former fulminate facility. Some of the soil samples were also analyzed for nitrate, sulfate, copper and zinc. In addition, a groundwater monitoring well was installed downgradient of the highest mercury concentrations found at the facility. After sufficient development of the monitoring well, a groundwater sample was collected and analyzed for mercury and total dissolved solids.

The overall objectives of this phase of the remedial investigation (RI), for evaluating the general area of the former mercury fulminate facility, are the following:

- o Collect the necessary data to verify and characterize the presence of contamination;
- o Assess the nature and extent of soil contamination at the RFS, using the data collected;
- o Determine if there is mercury in the groundwater;
- o Identify the appropriate cleanup criteria and provide a quantitative basis for selection of an effective remedial action;
- o Conduct field investigations to collect the site-specific data necessary to meet the overall RI objectives; and
- o Integrate the results of the RI, on a continuing basis, with those of the Clean-up.

Under this investigation, work performed by Jonas & Associates verified the presence of mercury in soil, around the former fulminate facility, and provided the necessary data to evaluate the lateral extent of significant concentrations of mercury in soil. Currently, 63 soil samples have been collected and analyzed for mercury. From these analysis and an evaluation of the data, it appears that significant concentrations of mercury are fairly localized underneath, and adjacent to the former mercury fulminate



production building. Mercury was also analyzed from a groundwater sample collected immediately downgradient of the former fulminate production area. No mercury was found the groundwater, even with a detection limit down to one part per billion (1 ppb).

This report presents the results of these investigations, along with a preliminary evaluation of potential transport pathways. In addition, the state and federal regulatory framework is reviewed.

This report, titled a Preliminary Analysis of Soil and Groundwater Contamination Former Mercury Fulminate Facility, is organized into eight major sections, which include:

- Section 1: Introduction
- Section 2: Previous Site Investigations
- Section 3: Current Soil Sampling Study Conducted by Jonas & Associates Inc.
- Section 4: Monitoring Well Drilling, Construction, Sampling and Analysis
- Section 5: Toxicology of Mercury and Migration Pathways
- Section 6: Regulatory Analysis of Remedial Standards
- Section 7: Preliminary Evaluation of Remedial Technologies.
- Section 8: Summary and Recommendations.

Section 1 provides the general objectives of the investigation, a site description, site status and a summary chronology of the facility in the area of the former fulminate facility.

Section 2 presents a summary of previous investigations performed by various consultants and the Department of Health Services.

Section 3 presents the recent soil sampling investigation conducted by Jonas & Associates Inc.

Section 4 includes ground water monitoring well drilling, construction details, development, sampling and analysis.

Section 5 is a preliminary analysis of toxicology and migration pathways.

Section 6 provides a regulatory analyses of remedial standards.

Section 7 is a Preliminary Evaluation of Remedial Technologies.

Section 8 provides a summary of results to date and recommendations.

The references section cites documents evaluated in preparation of this report.

## 1.1 SITE LOCATION

University of California (UC), Richmond Field Station (RFS) is located at 1301 South 46th Street, Richmond, California 94804. Figure 1-1 is a general map of the RFS property and adjacent areas. As identified in the figure, the 160 acres Richmond Field Station is located between Hoffman Boulevard and the Richmond Inner Harbor. Figure 1-2 is a site map of buildings and roads in the southern section of the RFS, in the general areas of the former mercury fulminate facility. Figure 1-3 is a composite of the current building locations, shown in black and the former structures, shown in hatched line. The former mercury fulminate area is shown as a circle. The approximate locations of the former buildings was retrieved from areal photographs provided by RFS.

## 1.2 SITE STATUS

This investigation's primary focus is to evaluate potential mercury contamination in soil in the areas of the fulminate facility. Originally, the mercury fulminate facility was owned and operated by the California Cap Company during 1920s. Recently, because the California Cap Company's primary activities was the manufacture of explosive fulminate of mercury, the Richmond Field Station was included on the Department of Health Service's (DHS) list of abandoned hazardous waste sites. DHS made their original determination in 1981. In addition, the Department of Fish and Game, the San Pablo Sanitary District, and Cal OSHA are aware that mercury may be currently present on the property.

To evaluate whether mercury was present at the site, DHS began an investigation of the RFS property in the general area of the mercury fulminate facility in 1981. DHS then conducted two additional investigations, in 1984 and 1987. The results of these preliminary investigations by DHS indicated the presence of metal contamination in soil. But, during the 1987 investigation, results from soil samples showed no mercury concentrations. From these results, DHS concluded that no further site investigation or EPA action were necessary. DHS is continuing to consider the facility as a "medium" priority, until sampling results in areas previously tested can be verified. DHS has indicated concern about the adequacy and quality assurance/quality control of previous DHS sampling and analysis. The RWQCB has also expressed concern about contamination from "various metals" (Singer, 1983).

Currently, RFS is not under any regulatory order from state or federal agencies to conduct any additional investigations of on-site mercury. But as part of a good faith effort on the part of the University, further studies were performed. Samples were collected of soil, groundwater and surface water, and analyzed for mercury. From these samples, mercury was detected in soil, with significant concentrations in the area of the former mercury fulminate facility. The results of current and previous investigations are presented in sections two, three, and four of this report.

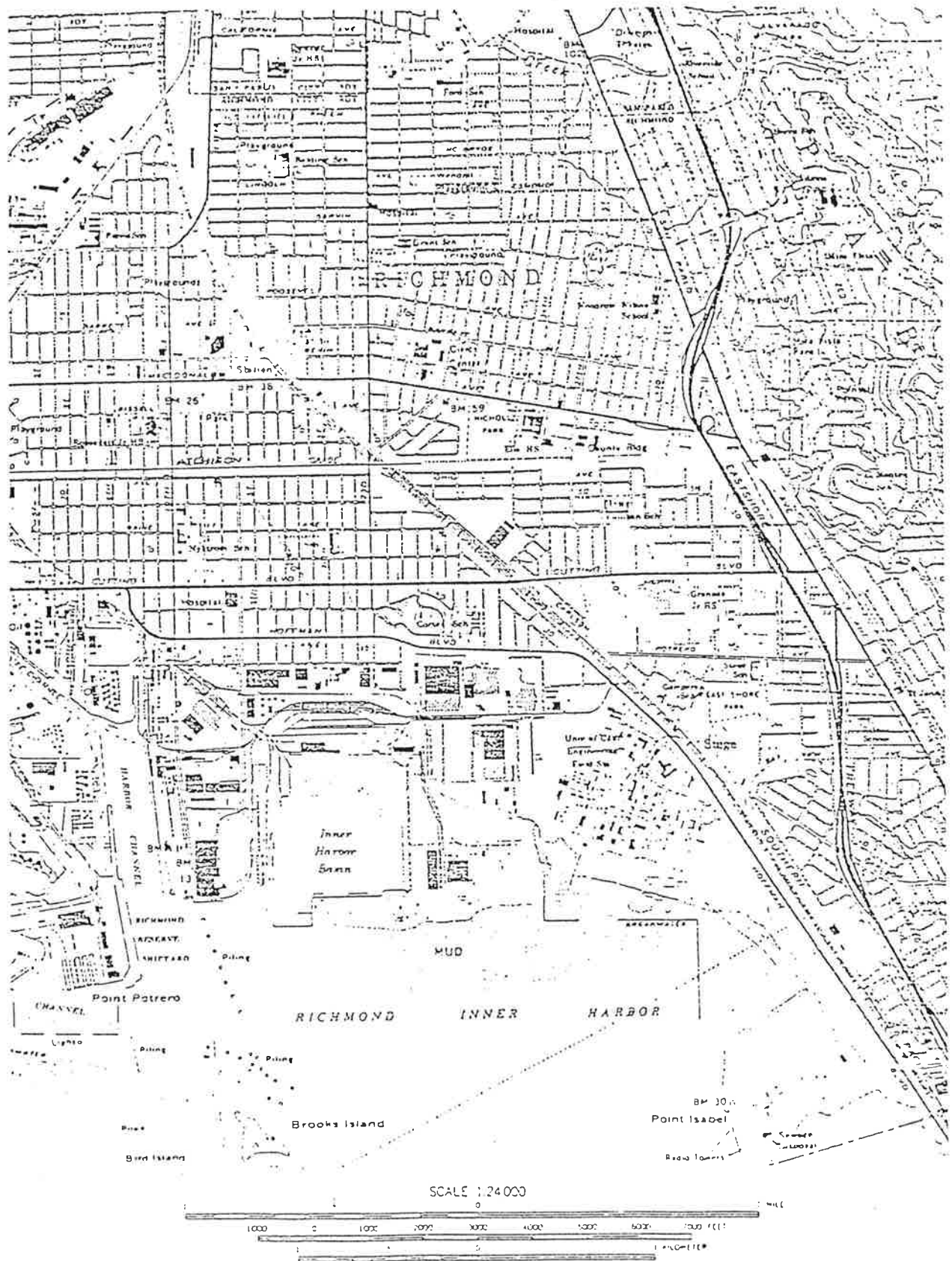
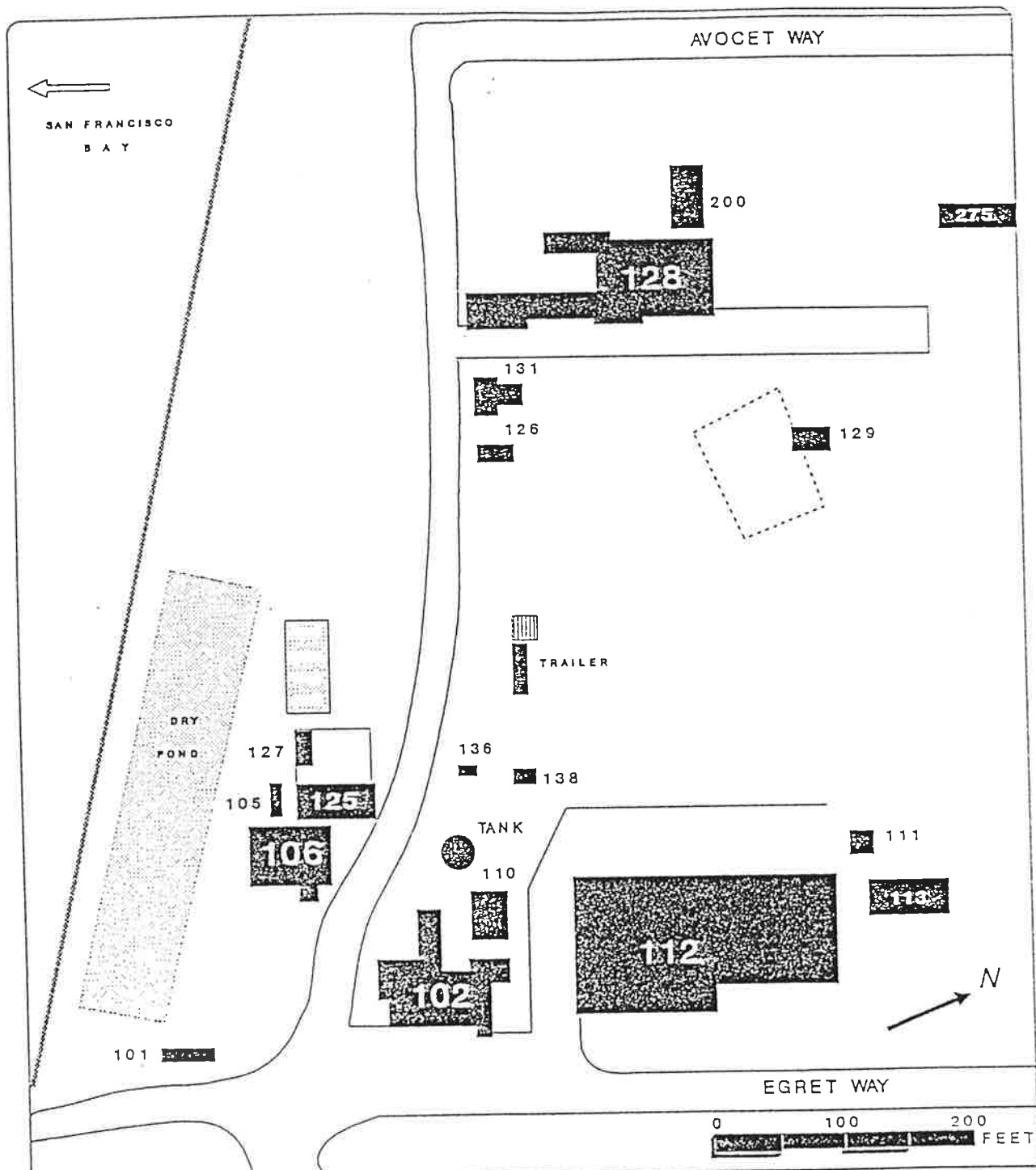
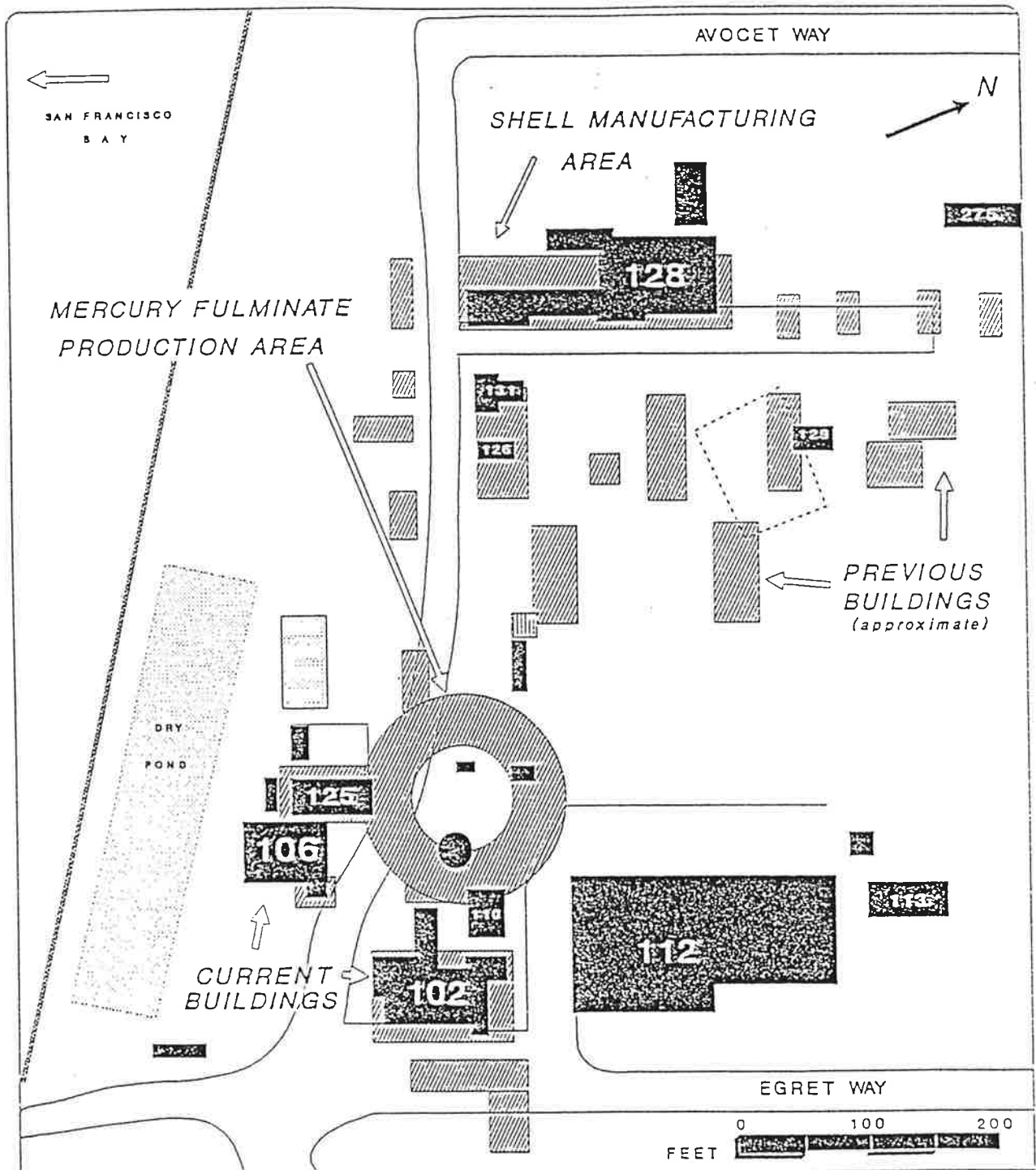


Figure 1-1



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FIGURE 1-2  
SITE MAP - GENERAL  
AREA OF INVESTIGATION



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FIGURE 1-3  
CURRENT and  
HISTORIC LAND USE

### 1.3 CHRONOLOGY OF EVENTS

This section summarizes the history of certain major activities which have occurred in the general area of the mercury fulminate facility from 1840 to 1990. A summary of regulatory agency actions is also presented.

1840	Several operating explosives manufacturing companies were located in the southern portion of current RFS property.
Beginning of 20th Century	The California Cap Company (CCC) bought land from the Hercules Powder Company.
1920	By 1920, CCC had purchased all of the other explosives companies in the area, thereby becoming the only explosives manufacturer on the property.
1945	CCC ceased operations at the end of World War II.
1950	University of California purchased the property. Under the terms of the sale, the California Cap Company was required to remove all hazardous material before the University would accept title. The company reportedly complied with this requirement, but the exact activities performed by CCC is currently not known.
1981	Because one of the California Cap Company's primary activities was the manufacture of the explosive fulminate of mercury, the Richmond Field Station was included on the DHS list of abandoned hazardous waste sites in 1981. The Department of Fish and Game, the San Pablo Sanitary District, and Cal OSHA agreed that fulminate of mercury might be present on the property, which presented a risk of explosion and soil contamination. DHS began investigation of the RFS property in 1981.
2/18/81	In 1981, soil samples were collected from five locations by DHS, although the exact types and quality control of the analyses performed are not known. Available data showed that elevated concentrations of mercury were found in two of these samples: Sample 2, near the former shell manufacturing area (in the general area of the current Building 128), contained 105 parts per million (ppm) of mercury, and Sample 6, taken from the marsh, contained 23 ppm of mercury. A DHS report (DHS, June 24, 1982) indicated that arsenic, copper, zinc, and lead were also present in the RFS soil samples, but didn't identify concentrations.
6/24/82	In 1982, DHS collected 17 soil samples from the RFS and analyzed them for 29 inorganic constituents. Mercury was not detected in any

of the samples. None of the other inorganic constituents analyzed for exceeded Total Threshold Limit Concentration (TTLC), set by DHS to identify a material as hazardous. At least two samples were analyzed for DDT; none was detected. DHS concluded that no mercury remained on the RFS property and recommended that it be removed from the list of abandoned hazardous waste sites. It should be noted that although none of the 1982 DHS samples exceeded the TTLC and no samples showed mercury contamination, several samples showed relatively high concentrations of some metals.

- 03/10/83 Letter from RWQCB stating that they had received copies of the DHS sampling results and consider that the elevated levels of various (non-mercury) metals may pose a threat to water quality.
- 02/23/84 RWQCB requested University of California to submit a proposal for further study of potential water quality threat problem.
- 03/23/84 University of California retained the EAL Corporation to analyze water samples from two existing wells and four surface water samples collected in the slough and marsh areas. The wells had been drilled previously for a research project and are completed approximately 90 feet below the ground surface.
- 04/05/84 EAL collected water samples in slough and marsh area as well as sampled the existing two wells.
- 05/07/84 Report from EAL summarizing the April 5, 1984 sampling results.
- 07/05/84 Letter from RWQCB requesting University of California to submit a water quality plan.
- 09/18/84 University of California submitted a memorandum to RWQCB concluding that based on the previous sampling results, surface runoff and infiltration from RFS were not adversely affecting groundwater.
- 11/06/87 DHS requested copies of the existing sampling data.
- 11/17/87 University of California sent the data and requested that the site be removed from any hazardous site list.
- 1987 In 1987, DHS conducted another preliminary assessment of the facility, under U.S. Environmental Protection Agency funding. The report concluded that no further EPA action or site investigation was necessary. DHS is continuing to consider the facility as a "medium" priority, until sampling results in areas previously tested can be verified. DHS has indicated concern about the adequacy and quality assurance/quality control on previous DHS testing, particularly the

results of mercury testing in 1982. The RWQCB has also expressed concern about contamination from "various metals" (Singer, 1983).

- 03/07/88 Aqua Science Engineers installed a groundwater monitoring well at the RFS. Groundwater samples were collected to test for the possible presence of non-halogenated hydrocarbons which may have resulted from an existing underground fuel storage tank (this tank was not located within the study area).
- 06/03/88 Aqua Science Engineers submitted a report summarizing the results of March 7, 1988 work. Chemical analyses indicated that non-halogenated hydrocarbon concentrations in the groundwater ranged from below instrument detection levels for benzene, ethylbenzene, and total petroleum hydrocarbons (TPH), to 0.6 ug/l (parts per billion) for xylene and 6.6 ug/l for toluene.
- 10/18/88-11/02/88 Between October 18, and November 2, 1988, CH2MHill conducted additional sampling at the RFS. The purpose of the investigation was to follow-up on previous sampling activities to supplement and/or clarify analytical results, as well as to investigate the western portion of the property to evaluate potential soils contamination and assess any possible limitations posed for the first phase of the planned redevelopment.
- Neither the California Department of Health Services nor the California Regional Water Quality Control Board had requested that additional investigations be conducted at the RFS. This sampling and analysis program was a good faith effort on the part of the University of California RFS.
- During this investigation six soil sampling areas were identified and sampled. The samples were analyzed for metals. In addition, five samples were analyzed for pesticides and PCBs. Elevated levels of mercury were detected in the area of the former mercury fulminate facility. In addition to mercury, elevated concentrations of zinc and copper (relative to the samples collected at other locations on the RFS) were found in the vicinity of the old mercury fulminate facility. However, these copper and zinc were well below TTLC for these metals.
- 12/89 to 3/90 Jonas & Associates Inc. initiated a more focused soil and ground water sampling investigation in the general area of the former mercury fulminate facility. This report, presented herein, summarizes the findings of this investigation.



## 2.0 INITIAL SITE EVALUATION

An objective of this report is to provide a summary of previous work performed and the results of the current sampling effort. This section of the report will provides a summary of the previous work performed in the general area of the former mercury fulminate and shell manufacturing areas.

### 2.1 SITE DESCRIPTION

#### 2.1.1 Property History and Adjacent Land Use

##### 2.1.1.1 Property History

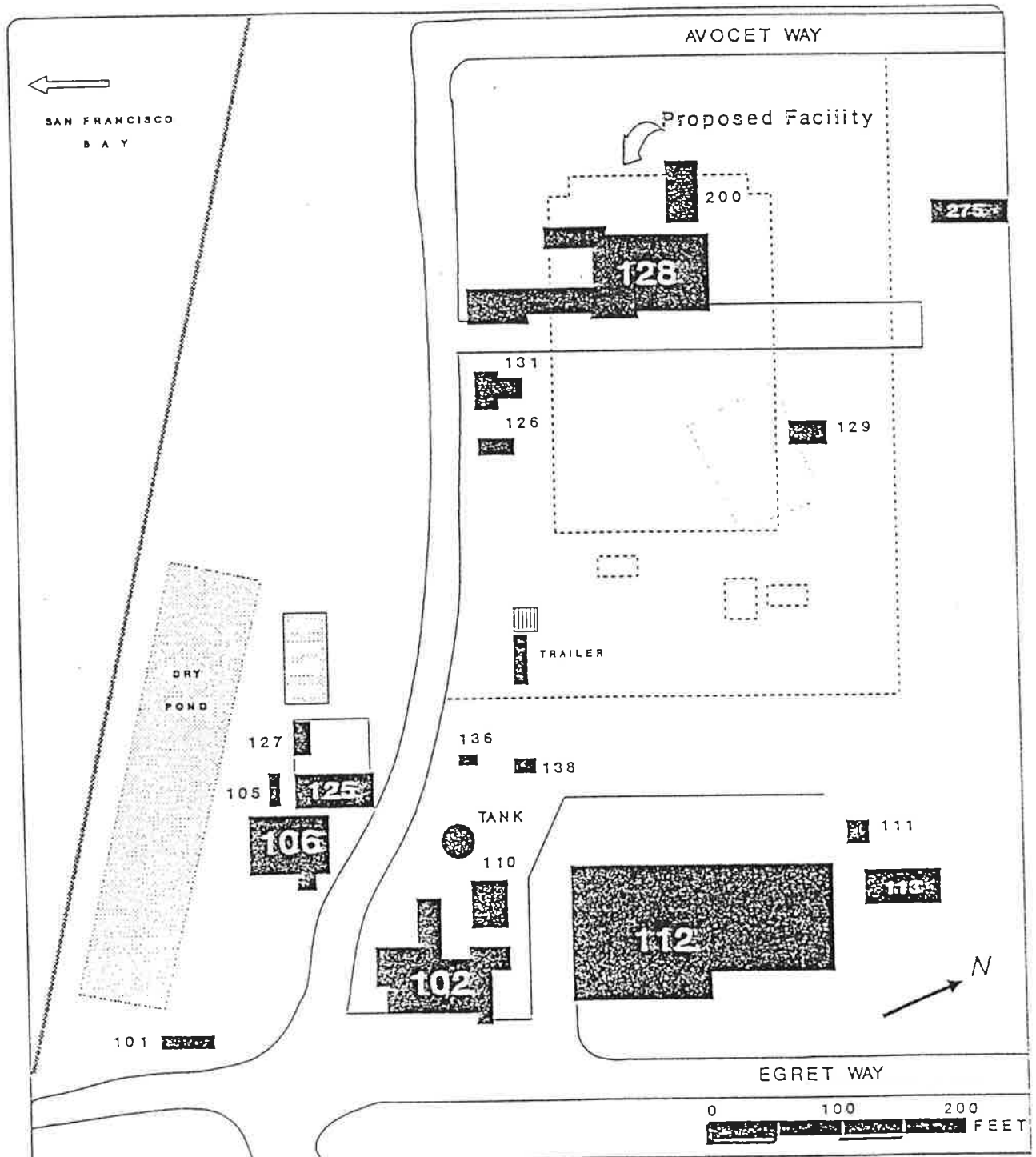
Beginning in the 1840s, several operating explosives manufacturing companies were located in an area that is now the south-eastern portion of the Richmond Field Station (RFS). At the beginning of the 1900s, the California Cap Company (CCC) bought land and an explosive manufacturing operation from the Hercules Powder Company. By 1920, CCC had purchased all of the other explosives manufacturing companies in the area, thereby becoming the only explosives manufacturer on the property.

CCC ceased operations at the end of World War II in 1945. The University of California purchased the property in 1950. Under the terms of the sale, the California Cap Company was required to remove all hazardous materials before the University would accept the title. It is currently unknown if any corrective actions took place at that time.

The property is currently owned and operated by the University of California, as its Richmond Field Station. In the future, the University of California plans to create a Research Campus within the Richmond Field Station. The Concept Plan for the facility includes large research facility, a regional library, recreational open space, and private sector development in the western portion of the property. Figure 2-1 presents a possible location for one of the proposed facilities.

##### 2.1.1.2 Adjacent Land Use

In areas adjacent to the RFS, current land uses are primarily industrial. A Safeway Distribution Center lies to the north, Price Club and Bio Rad Labs to the east, and ICI Americas to the west. The ICI Americas property was owned by Stauffer Chemical Company, until 1987. The Richmond Inner Harbor lies to the south of the facility, along the shoreline of Richmond.



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FIGURE 2-1  
PROPOSED FACILITY

Under regulatory direction by the Regional Water Quality Control Board - San Francisco Bay Region (Regional Board), Stauffer Chemical Company completed a preliminary investigation of its property in December 1987. Under a Remedial Action Program, designed and implemented by Stauffer, shallow groundwater contaminated with pesticides is currently being extracted and treated. Currently, the Regional Board requested that ICI Americas perform a hydrogeologic investigation of a closed cinder landfill and associated ponds.

Recently, the Richmond Inner Harbor has come under scrutiny by the U.S. Environmental Protection Agency (EPA), the California Department of Health Services (DHS) and the Regional Board, due to elevated concentrations of contaminants found in the water and biota of the harbor. At present, the Regional Board has identified twenty-four properties along the harbor shoreline for possible investigations of hazardous materials.

## 2.1.2 Environmental Setting

### 2.1.2.1 Regional Geology

The Richmond Field Station is located at the distal end of a gently alluvial plain, sloping in a southwesterly direction. To the northeast towards the Berkeley Hills, the alluvial plain is transected by the Hayward Fault Zone (Jennings & Burnett, 1961). To the south of the facilities lies San Pablo Bay.

The alluvial plain, upon which the Field Station is located, is Quaternary in age; representing relatively recent deposits. The lithology of the alluvial plain is primarily composed of consolidated to unconsolidated clays, silts, sands, and gravels. Bordering the San Pablo Bay, are organic-rich clays and silts. Total thickness of all these deposits range from zero feet, where the alluvium thins against the Berkeley Hill, to approximately 300 feet in depth. These deposits are underlain by bedrock of the Mesozoic Franciscan Formation. The Franciscan Formation is a complex assemblage of serpentinite, greenstone, graywacke, chert, shale, sandstone, and schist, and is found on many ridges and mountains of the San Francisco Bay region.

### 2.1.2.2 Local Geology

Subsurface geology of the upper 100 feet is characterized by two boring logs, drilled for wells installed on the Richmond Field Station property. Both of these logs indicated that approximately 8 feet of clay directly underlie the RFS. Beneath this clay layer are interbeds of poorly sorted gravels, sand, and clay, extending to a depth of approximately 40 feet below ground surface. Clay to gravelly clay occurs from approximately 40 to 90 feet below ground surface. Sandy gravel was encountered from approximately 90 feet to the bottom of the borings at approximately 102 feet below ground surface. These lithologic descriptions are summarized in Table 2-1:

Table 2-1

## Borehole Stratigraphy

<u>Depth Below Surface</u> (feet)	<u>Lithology</u>
0 - 8	Silty clay
8 - 40	Interbeds of poorly sorted gravels, sands, silts and clays
40 - 90	Clay to sandy gravelly clay
90 - 102	Sandy gravel

Adjacent to the eastern boundary of the Field Station, on the ICI Americas property, four borings were drilled to a depth of 60 feet below ground surface. The logs from these borings were not available, but the local subsurface conditions were described as predominantly fine-grained sands, silts, and clays with minor amounts of gravel, found in poorly graded deposits of sand, silts, and clays (Hall, 1988). The Hall (1988) report further states that discrete lithologies identified in these boreholes do not appear to be laterally or vertically extensive within the upper 60 feet.

#### 2.1.2.3 Surface Water

The Richmond Field Station is a 160-acre property located adjacent to the Richmond Inner Harbor of the San Pablo Bay. The San Pablo Bay (in the northern portion of the San Francisco Bay) forms the major surface water body to the south of the facility. Marshes border the San Pablo Bay. Marshes at the southern extent of the facility drains south into the Bay through a single opening in a raised Santa Fe Railroad causeway.

No streams are present on the Richmond Field Station property. Surface water runoff from the facility is collected and discharged through two storm drains, located at the southern extent of the property. These drains discharge into San Pablo Bay. To the west of the Field Station, is a tidal slough which collects water from an urbanized drainage through the City of Richmond. This slough also is hydraulically connected with the marsh at the border of San Pablo Bay and is used by local industrial dischargers.

#### 2.1.2.4 Regional Hydrogeology and Groundwater Quality

##### 2.1.2.4.1 Regional Hydrogeology

The Richmond Field Station lies within the Alameda Bay Plain (ABP) Groundwater Basin (DWR, 1980). This groundwater basin extends southward from Richmond to

Alvarado, between the Berkeley Hills and the San Francisco Bay. The basin's hydrogeologic conditions are not well characterized because groundwater is currently not being used by local municipalities or for agricultural irrigation, due to its low permeability and the limited thickness of transmissive units.

Most groundwater recharge to the ABP groundwater basin, in the Richmond area, is probably from drainage through the beds of the Wildcat and San Pablo Creeks. Recharge from the infiltration of rainfall is believed to be limited due to the low permeability shallow clays and by the large amount of paved areas overlying the basin (Caltrans, 1978). Shallow groundwater probably eventually discharges into San Francisco Bay.

#### 2.1.2.4.2 Local Hydrogeology

Local hydrogeology at the site is characterized by monitoring wells installed on Richmond Field Station property and the adjacent ICI Americas property. Two groundwater monitoring wells are present at the RFS facility. These wells are identified as MW-A and MW-1. MW-A is located adjacent to Building 167, in approximately the center of the Richmond Field Station. Monitoring well MW-1 is located behind Building 105, in the area of the former mercury fulminate facility.

On the Richmond Field Station, during the drilling of monitoring wells MW-A and MW-1, groundwater was first encountered at depths of 9.0 to 7.5 feet below ground surface, respectively. In the borehole for monitoring well MW-1, below a thick layer of clay, the first water-bearing unit composed of sand was located at a depth of 8 to 13 feet. This water-bearing unit was then screened. After monitoring well MW-1 was installed and allowed to equilibrate, the water levels rose to 4.25 feet below the surface, indicating confined conditions. Because of the presence of a thick clay layer below the surface, locally groundwater probably occurs under confined to semiconfined conditions. Boring logs for MW-A and MW-1 are shown as Figures 4-2 and 4-3 in Section 4.0 of this report.

Geologic logs from borehole drilled on Richmond Field Station indicate that a second transmissive water-bearing unit of sandy gravel exists below a depth of 90 feet below ground surface.

Groundwater in the vicinity of the Richmond Field Station is considered to flow from north-northeast to south-southwest, toward the Richmond Inner Harbor (Hall, 1988). Locally, hydraulic cone of depression has been created by a groundwater extraction system, currently operating at the adjacent ICI Americas facility. The center of this cone is located approximately 1,000 feet southeast of the border with Richmond Field Station. It was considered by Hall (1988) that the actual cone of depression for the extraction system does not extend to the Richmond Field Station.

Several aquifer tests have been previously performed on the Richmond Field Station property. These tests were performed by U.C. Sanitary Engineering Research Laboratory in 1954. For a 3.5 foot gravelly aquifer located at a depth of 90 feet below

the surface, the average transmissivity was calculated from several tests to be 5,775 gal/day/ft. Dividing the calculated transmissivity by the measured thickness of the aquifer (3.5 feet), an estimated hydraulic conductivity at 90 foot below the surface is 1,760 gal/day/ft-squared (235 ft/day). These values indicate a fairly transmissive zone of the gravelly aquifer located at a depth of 90 feet below the surface, but the shallower water-bearing zones are probably significantly less transmissive due to a greater presence of silts and clays in aquifer material. Currently, no aquifer tests have been performed in the shallow water-bearing zone (8 to 13 feet below the surface) at the Richmond Field Station.

At the ICI Americas property, located adjacent to the RFS, slug tests were conducted in monitoring wells for a hydrogeologic investigation (Hall, 1988). These slug test provided a rough estimate of hydraulic conductivity in a shallow permeable zones of the upper 60 feet under the ICI Americas facility. The well completion details were not available for review. The calculated hydraulic conductivity values ranged between 0.4 to 17 gal/day/ft (0.05 to 2.3 ft/day). These values are well within the expected range for fine sand, silt, and clay (Freeze and Cherry, 1979).

The horizontal hydraulic gradient of the shallow groundwater at the ICI America property has been calculated to be approximately 0.004 (Hall, 1988). This was based upon a potentiometric surface map prepared from water level measurements from monitoring wells less than 60 feet deep. Using an estimated effective porosity of 0.25 and the hydraulic gradient of 0.004, shallow groundwater velocity is calculated to range between 0.3 to 13 feet/year.

Any tidal effects on the hydraulics of the water-bearing units has not be previously evaluated.

#### 2.1.2.4.3 Groundwater Quality

On March 24, 1990 a groundwater monitoring well, identified as MW-1, was installed downgradient from the former mercury fulminate facility. This well was installed to determine if mercury was present in the first water-bearing zone. After purging of the well a groundwater sample was collected and analyzed for mercury and Total Dissolved Solids (TDS). No mercury was detected in the groundwater at the former mercury fulminate facility. Total Dissolved Solids were measured at 1,300 ppm.

In 1984, EAL Corporation also analyzed groundwater samples from two existing wells and four surface water samples collected in the slough and marsh areas. The wells had been drilled previously for a research project and are completed approximately 90 feet below the ground surface. Results are summarized in Table 2-2.

As is indicated by the results presented in this table, no concentrations in the water-bearing zone at 90 feet below the surface exceeded Safe Drinking Water Act standards.

Groundwater was also sampled at the ICI Americas site. The ICI Americas facility and property is reported to be associated with the use of the following compounds: fuels, pyrite cinders, sulfuric acid, ferric sulfate, pesticides, solvents, and alum (Hall, 1988).

TABLE 2-2

Results of Existing RFS Well Sample Analyses  
(EAL Corporation, 1984)

	Sample 5 Well 167 (mg/L)	Sample 6 Well 175 (mg/L)	Safe Drinking Water Act Maximum Contaminant Level (mg/L)
Mercury	<0.0005	<0.0005	0.002
Copper	0.01	<0.006	1.0 <sup>a</sup>
Zinc	0.083	0.067	5.0 <sup>a</sup>
Iron	0.04	<0.02	0.3 <sup>a</sup>
Lead	0.03	0.04	0.05

note: a Secondary MCL (aesthetic, not health-based)

Two rounds of samples were collected from wells completed less than 60 feet below ground surface in November, 1987. The results are presented in the following Table 2-3:

TABLE 2-3

Results of ICI Americas Well Sample Analyses

Constituent	Range in Concentration (mg/L)	Safe Drinking Water Act Water Standard (mg/L)
Copper	<0.02 - 38	1.00 <sup>a</sup>
Zinc	0.06 - 75	5.00 <sup>a</sup>
Arsenic	0.005 - 0.088	0.05
Iron	0.07 - 840	0.30 <sup>a</sup>
Cadmium	<0.02 - 0.15	0.01
Lead	all < 0.06	0.05
Aluminum	<0.3 - 44	- -

note: a Secondary MCL (aesthetic, not health-based)

As is indicated by the results of the groundwater analysis under the ICI Americas property, most of the metals tested significantly exceeded federal Safe Drinking Water Act standards.

Limited water quality data also exists in several Caltrans reports (1978, 1979), for local groundwater encountered in borings less than 50-feet deep. From borings sampled in the vicinity of the Richmond Field Station, shallow groundwater had total dissolved solids (TDS) ranging from 1,300 to 29,405 milligrams per liter (mg/l). In more recent Caltrans investigations (Caltrans 1987), groundwater samples were collected from a series of shallow wells to monitor the effects of a local freeway dewatering system. These wells were located to the north of the Richmond Field Station and further away from the influence of the San Pablo Bay. With an exception of one well located near the U.C. Richmond Field station with TDS >1,000 mg/l, all other water samples from 17 Caltrans wells contained TDS generally below 600 mg/l. In addition, the TDS concentrations in nine 50-foot-deep wells were generally less than the TDS concentrations in a 25-foot-deep wells, suggesting shallower permeable zones more prone to salt water intrusion from the bay.

The Regional Water Quality Control Board defines a "drinking water source" as containing less or equal to 3,000 ppm TDS. Groundwater will have a defined beneficial use as a drinking water source when: 1) the groundwater is less than or equal to 3,000 ppm TDS; 2) the aquifer produces a sufficient amount of water (approximately 150 gallons per day).

Based on the TDS requirements, the groundwater in the general region of the RFS area may be a drinking water source.

A description of well installation, sampling procedures and the results of the recently installed MW-1 monitoring well are presented in Section 4 of this report. From a groundwater sample collected from MW-1, in the area of the former mercury fulminate facility, no mercury was detected with a detection limit of 0.001 mg/L. An additional analysis of a groundwater sample from monitoring well MW-1, measured Total Dissolved Solids at 1,300 mg/L, from a 8 to 13 foot deep sand zone.

#### 2.1.2.4.4 Surface Water Quality

As discussed earlier, surface water drainage from the facility are discharged into storm drains. These storm drains are then eventually discharged into the San Pablo Bay. Results of a previous analysis of samples from the east and west storm drains and in the sloughs are presented in Table 2-4.

As shown in Table 2-4, with the exception of mercury the results of the 1984 sampling generally indicated that the concentrations of metals were higher in water from the sloughs than the storm drains that serve the RFS.



TABLE 2-4

Results of Slough and Storm Drain Sample Analyses  
(EAL Corporation, 1984)

	Sloughs (mg/L)		RFS Storm Drains (mg/L)		Surface Water Quality Criteria <sup>a</sup> (mg/L)
	Sample 3	Sample 1	Sample 4	Sample 2	
	South	North	East	West	
Mercury	<0.0005	0.0005	0.001	<0.0005	0.0002
Copper	0.11	0.086	0.024	0.01	0.003
Zinc	0.072	1.1	0.56	0.76	0.095
Iron	2.4	0.55	0.11	0.54	---
Lead	0.24	0.14	0.02	0.057	0.140

notes: a/ EPA National Ambient Water Quality Criteria to Protect Saltwater Aquatic Life, 1-hour average.

The data in Table 2-2 shows that water samples from the RFS wells 167 and 175 satisfy the U.S. EPA drinking water criteria for the five metals. No mercury contamination was found in the groundwater sample collected from the recently installed well at the location of the former mercury fulminate facility. Groundwater quality samples collected under the ICI Americas facility and presented in Table 2-3 indicate significant metal contamination. Surface water samples collected from sloughs and storm drains exceed some water quality standards for saltwater aquatic life, under the National Ambient Water Quality Criteria of the Clean Water Act.

#### 2.1.2.4.5 Water Uses

In the area of South Richmond, Caltrans (1978) conducted a door-to-door survey for wells. The results of this survey identified over 100 wells in the general area of the Richmond Field Station. It is important to note that all of these wells are upgradient from the Field Station.

## 2.2 SUMMARY OF THE PREVIOUS SOIL STUDIES (1981 - 1988)

### 2.2.1 Previous Investigations

The former mercury fulminate facility was owned and operated by the California Cap Company during 1920s. Because of the California Cap Company's activities of manufacturing of explosive fulminate of mercury, the Richmond Field Station was

included on the Department of Health Services (DHS) list of abandoned hazardous waste sites in 1981. DHS began an investigation of the RFS property in 1981. During the investigation DHS collected three rounds of sampling, between 1981 and 1984. Sampling locations are presented on Figures 2-2 and 2-3.

In 1981, DHS collected soil samples from five locations. The results from the analyses of these samples identified elevated concentrations of mercury at two locations: Sample 2, near the former shell manufacturing area and Sample 6 collected in the marsh adjacent to San Pablo Bay. Results of Samples 2 and 6 for mercury identified 105 and 23 mg/Kg, respectively.

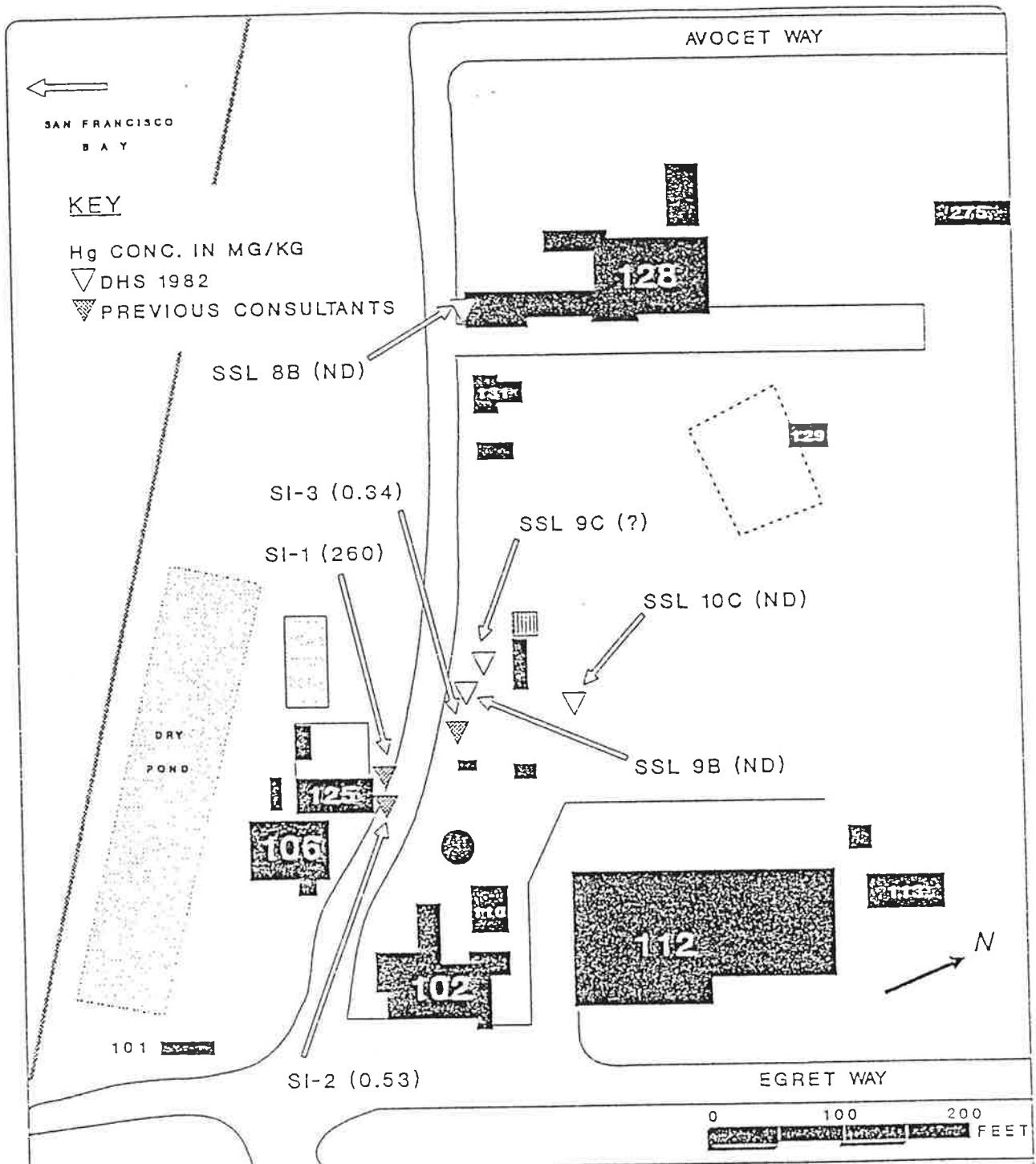
In 1982, DHS collected 17 additional soil samples from the RFS facility and analyzed them for a large suite of inorganic constituents. Mercury was not detected in any of the samples collected by DHS. Two of these samples were from the same locations as the earlier Samples 2 and 6, collected in 1981 by DHS. None of the inorganic constituents analyzed exceeded Total Threshold Limit Concentrations (TTLC), set by DHS to identify a material as hazardous. DHS concluded that no mercury remained on the RFS property and recommended that it should be removed from the list of abandoned hazardous waste sites. According to DHS records elevated levels of copper was identified in samples SSL-009A and SSL-010A, collected in the area of the former mercury fulminate facility. Samples SSL-009A and SSL-010A identified 359 and 577 mg/Kg of copper, respectively. The exact locations of these samples are unknown, but the results are well below the 2,500 mg/Kg TTLC for copper.

In 1988, a previous consultant (CH2MHILL) conducted additional samples at the RFS. The purpose of this investigation was to follow-up on previous sampling activities and to supplement and/or clarify analytical results. Neither, DHS nor the Regional Board had requested that additional investigations be conducted at the RFS. This program was a good faith effort on the part of the Richmond Field Station to become more knowledgeable of previous hazardous waste management practices on the facility.

During this investigation three soil samples were collected in the general area of the former California Cap Company mercury fulminate facility area. These samples are identified as SI-1, -2, and -3 on Figure 2-2 and Figure 2-3. To collect these samples, test pits were excavated down to approximately two feet. In each pit, samples were collected at various depth along the wall. These samples were then composited. After sampling effort, the pit was refilled with the excavated soils. Prior to sample collection, the air in the pit was tested for the presence of volatile organic using an HNu. No HNu measurements above zero were identified during sampling. All of the six composited soil samples were analyzed for metals. Five of the soil samples were also analyzed for pesticides and PCBs. The results of the soil samples with elevated concentrations are presented in Table 2-5.

Results from soil sample SI-1 indicated the presence of 260 mg/Kg of mercury. This sample appears to have been collected in the middle of the former mercury fulminate facility. Sample SI-2 and SI-3 also identified mercury in soil in the area of the fulminate facility, but at much lower concentrations of 0.53 and 0.34 mg/Kg,

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FIGURE 2-3  
PREVIOUS SOIL SAMPLING  
LOCATIONS FOR MERCURY

TABLE 2-5

Results of 1988 Soil Samples  
Collected From the Former Mercury Fulminate Facility

	SI-1 (mg/Kg)	SI-2 (mg/Kg)	SI-3 (mg/Kg)	TTLc (mg/Kg)
Mercury	260	0.53	0.34	20
Copper	223	47	16	2,500
Zinc	436	100	24	5,000

respectively. Currently the Total Threshold Limit Concentration (TTLc) for mercury is 20 mg/Kg, specified by California Administrative Code Title 22 Section 66699.

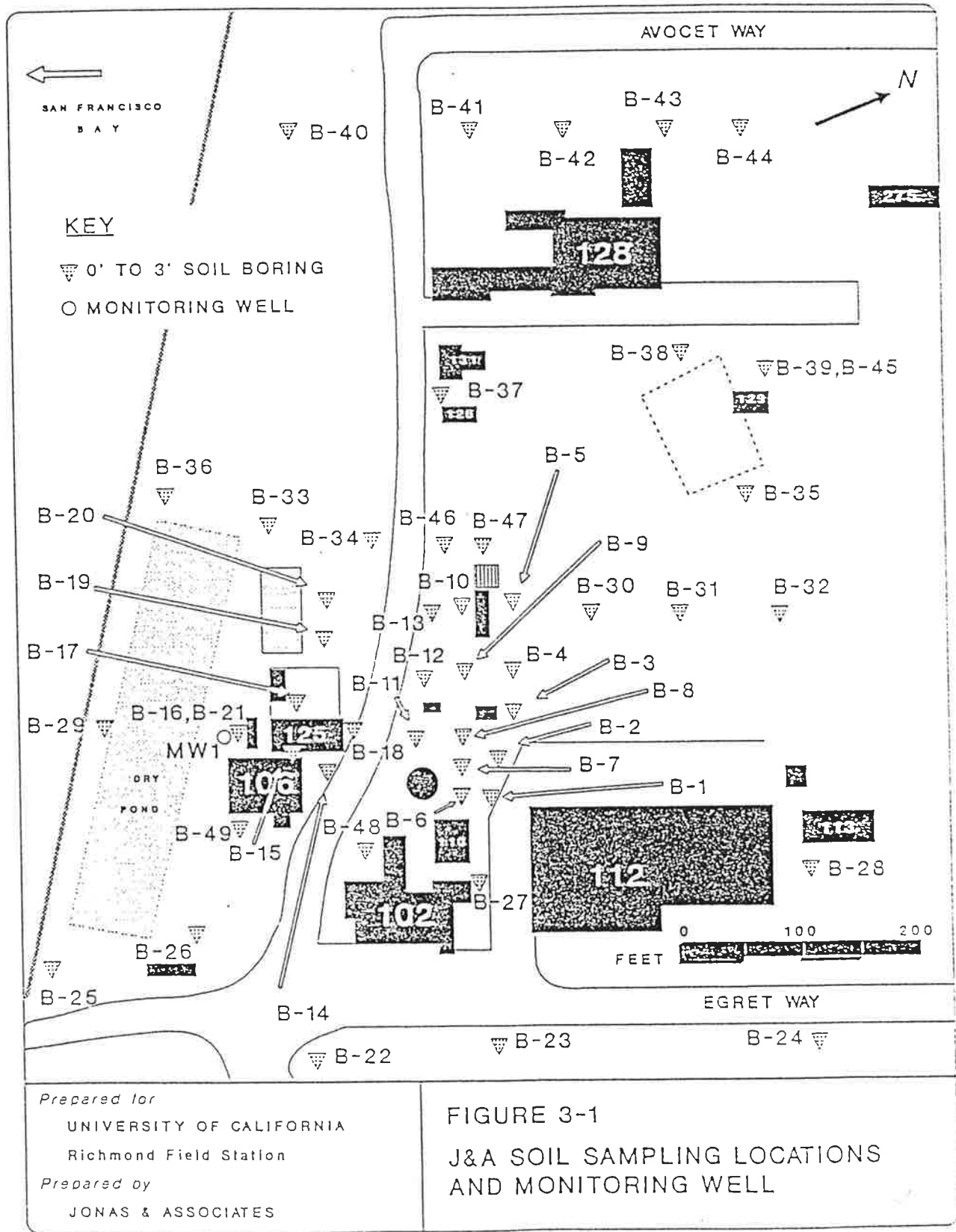
### 3.0 CURRENT SOIL SAMPLING CONDUCTED BY JONAS & ASSOCIATES

#### 3.1 SAMPLING METHODS AND PROCEDURES

##### 3.1.1 Sample Collection and Analysis

From December 1989 through February 1990, four rounds of soil samplings were performed by Jonas & Associates Inc. A total of 47 boreholes were sampled. At each borehole three discrete soil samples were collected: at 0 to 1 foot, 1 to 2 feet and 2 to 3 feet below surface. Figure 3-1 identifies the J&A sampling locations. In each borehole discrete samples were composited and then analyzed. Selected samples were analyzed for mercury, nitrate, sulfate, copper, zinc, STLc Wet Extraction, and EP Toxicity Extraction. Duplicate samples were collected from two of the boreholes (B-16/B-21 & B-39/B-45). From the J&A sampling efforts a total of 147 discrete samples were collected.

During the on-site field effort soil samples were obtained using a two-inch stainless steel hand auger. A sufficient amount of soil was collected for the selected laboratory analysis. The minimum sample volume required for laboratory analysis was 270 grams. Immediately after collection, samples were transferred to airtight, labeled sample container. Each container was sealed in an individual plastic bag. Samples were then placed into an insulated cooler for shipment to the laboratory, maintaining them at approximately 4° Celsius. Upon the receipt by the laboratory, one composite sample was prepared per each sample location. A total of forty-nine (49) composites were tested for mercury, using Method 7471. Samples from boring B-21 was also tested for EP Toxicity Extraction (EPA Method 3020/7470) in order to determine the leachability of mercury in soil under slightly acidic conditions. This sample location was selected because it had mercury concentration representative of the concentrations detected at the general mercury fulminate facility.



Composite samples from borings B-21, B-22, B-23 and B-24 were also analyzed for sulfate (EPA Method 300). The reason for this analysis was because in the past, this area was reported to have been flooded by aqueous sulfate solutions from the ICI Americas's ponds.

Because mercury fulminate is prepared by the reaction of mercury, ethyl alcohol and nitric acid, composite samples from borings B-21, B-37, B-39 and B-42 were also analyzed for nitrate (EPA Method 300). These sampling locations were selected because they are located in the immediate area proposed for future redevelopment. Sample from boring B-21 was also analyzed for nitrate and EP Toxicity and the composite sample from B-18 was tested for STLC (Waste Extraction Test, Wet). EP Toxicity and STLC was performed in order to determine if the soil is considered a hazardous waste.

Based on the previous sampling activities (discussed earlier in this report), relatively high concentrations of zinc and copper were reported at the facility. For confirmation of the previous sampling results, samples from borings B-18, B-12, B-38 and B-39 were also tested for copper and zinc.

In addition to the above samplings, ten surface soil samples were collected from 0 to 3 inches in depth identified with SS for "surface sample". These samples were collected at previous borehole sampling locations. The borehole sampling locations with their surface soil sample numbers are presented in Table 3-1. All of these surface samples were analyzed for mercury to determine if a potential fugitive dust pathway for mercury exists.

---

Table 3-1

Surface Samples and Borehole Locations

<u>Surface Samples</u>	<u>Borehole Locations</u>
SS1	B-6
SS2	B-3
SS3	B-12
SS4	B-18
SS5	B-16
SS6	B-20
SS7	B-10
SS8	B-37
SS9	B-39
SS10	B-43

---

### 3.1.4 Sample Identification Numbers

Each sample was assigned a unique identification number that will allow retrieval of information regarding the sample. The sample identification number consists of three main parts, which are separated by a hyphen. The first part is determined by the boring number, and is made up of the letter "B" and a one- to two-digit number representing the boring number. The second part represents the sampling depth. The third part, consists of a two-digit number representing the month, and a two-digit number representing the day and a two digit number representing the year.

Example: B1-1-011690

Represents: Boring # one, taken at the depth of one foot on January 16, 1990.

### 3.1.5 Field logbooks

A project field logbook was used to document the following:

- o Date and time of log entries;
- o Field conditions (weather, terrain, hazards, etc.);
- o Personnel present during field operations;
- o Decontamination procedures;
- o Waste disposal procedures, and a daily inventory of wastes present onsite;
- o Field measurements taken, instrumentation used, and frequency of instrument calibration;
- o Maintenance of instruments;
- o Information recorded on sample labels, as well as the site identification number and the sampling depth.
- o Any unusual sample characterization; and
- o Other specific considerations pertaining to sample acquisition.

### 3.1.6 Sample Labels

A pre-printed adhesive label was affixed to each sample (Figure 3-2). The information below was written on every sample label;

- o Project number;
- o Sample Identification Number;
- o Date of Sampling;
- o Name of Sample Collector; and
- o Type of Analysis.

Figure 3-2  
Sampling Label

Curtis & Topkins, Ltd.,  
2323 Fifth Street  
Berkeley, California 94710

SAMPLE NO. \_\_\_\_\_ DATE \_\_\_\_\_  
CUSTOMER \_\_\_\_\_  
SIGNATURE \_\_\_\_\_  
TYPE OF ANALYSIS \_\_\_\_\_



### 3.1.7 Chain-of-Custody Records

A Chain-of-Custody Record accompanied samples when they were shipped to the laboratory (Attachment A). The Chain-of-Custody Record documents transfer of samples from one party to another. Additional information that was noted on this form is as follows:

- o Project Number;
- o Sample Identification Number;
- o Date and Time of Sampling;
- o Type of Sample; and
- o Type of Analysis to be Performed.

### 3.1.8 Quality Control Samples

Duplicate soil samples were collected with a frequency of ten percent per sample type and analytical parameter. Location of the duplicate soil samples are presented in Figure 3-1 and identified as B-21 and B-45. The duplication of samples is a means of checking field and laboratory procedures. They are collected, numbered, and sealed in the same manner as the other samples. Field duplicates, which reflect the precision of sampling techniques, are collected from sampling points that are known or suspected to be contaminated, and are analyzed for the complete parameter suite. Since soil samples collected in an acceptable manner can have results which differ significantly, the use of soil duplicates to determine quality control need to consider natural variability of concentrations in soil.

### 3.1.9 Sample Shipment

The J&A Technical Manager notified the Sales Manager at Curtis & Tompkins, Ltd. (CTL) a week before each round of sampling was scheduled to begin, so that the laboratory can prepare and ship the necessary coolers and sample bottles to the field team in advance. This shipment of sampling supplies from CTL were accompanied by a cooler packing slip, which documents the number of coolers and the number and type of sample containers sent.

Samples were packaged for shipment in a cooler chilled with bags of ice. Sample jars were placed in sealed Zip lock bags. When possession of the samples was transferred, the individuals relinquishing and accepting custody wrote their names, the names of their organizations, and the time of custody transfer on the Chain-of-Custody Record.

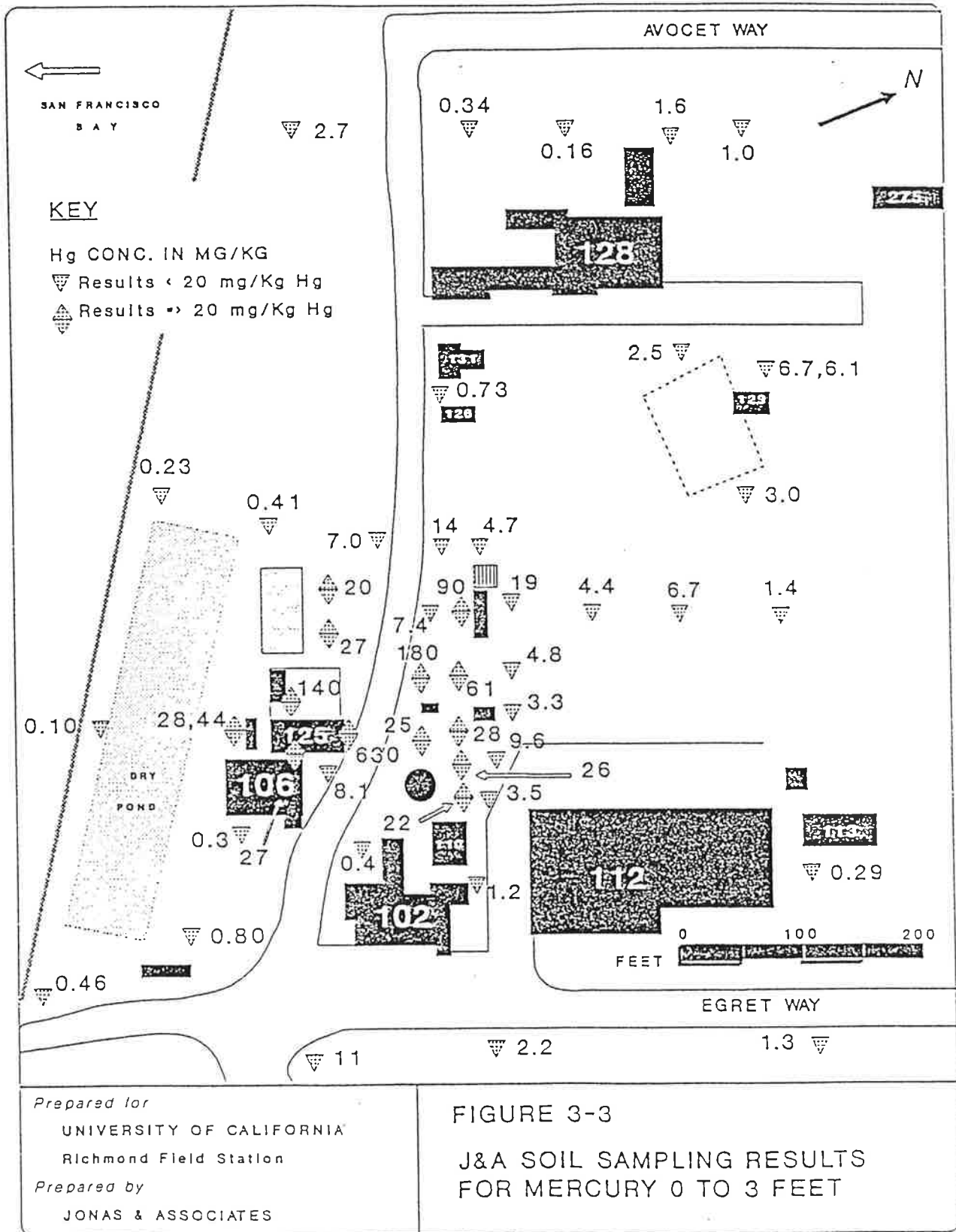
## 3.2.1 Results of Analyses for Mercury in Soil Samples

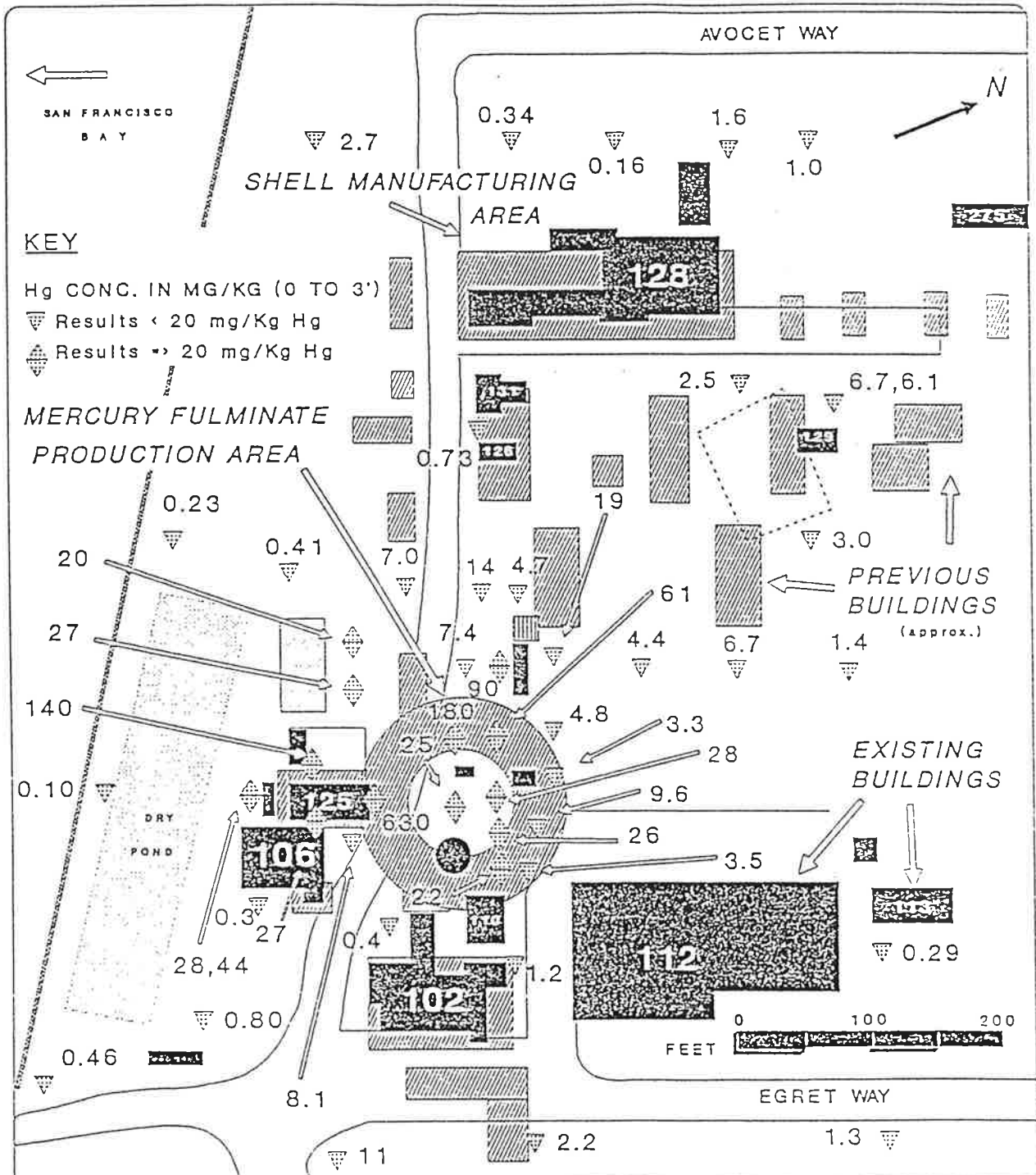
The results of the Jonas & Associates December 1989 and January 1990 sampling efforts are presented in Figures 3-3, 3-4, 3-5 and 3-6. Figure 3-3, 3-4, and 3-5 present mercury concentration from composite samples collected from the upper three feet of soil. Figure 3-6 presents sulfate and nitrate results from selected boreholes. Table 3-2 lists the borehole and mercury concentration of soils collected from 0 to 3 feet. Table 3-3 lists mercury results of soil samples collected from 0 to 3 inches of the surface soil.

Table 3 - 2

MERCURY IN 0 TO 3 FEET OF SOIL  
RICHMOND FIELD STATION  
12/89 & 1/90

BORING	MERCURY mg/Kg	BORING	MERCURY mg/Kg
B1	3.5	B2	41.3
B2	9.6	B25	0.46
B3	3.3	B26	0.80
B4	4.8	B27	1.2
B5	19	B28	0.29
B6	22	B29	0.10
B7	26	B30	4.4
B8	28	B31	6.7
B9	61	B32	1.4
B10	90	B33	0.41
B11	25	B34	7.0
B12	180	B35	3.0
B13	7.4	B36	0.23
B14	8.1	B37	0.73
B15	27	B38	2.5
B16	28	B39	6.7
B17	140	B40	2.7
B18	630	B41	0.34
B19	27	B42	0.16
B20	20	B43	1.6
B21	44	B44	1.0
B22	11	B45	6.1
B23	2.2	B46	14
B47	4.7	B48	0.41
B49	0.32		

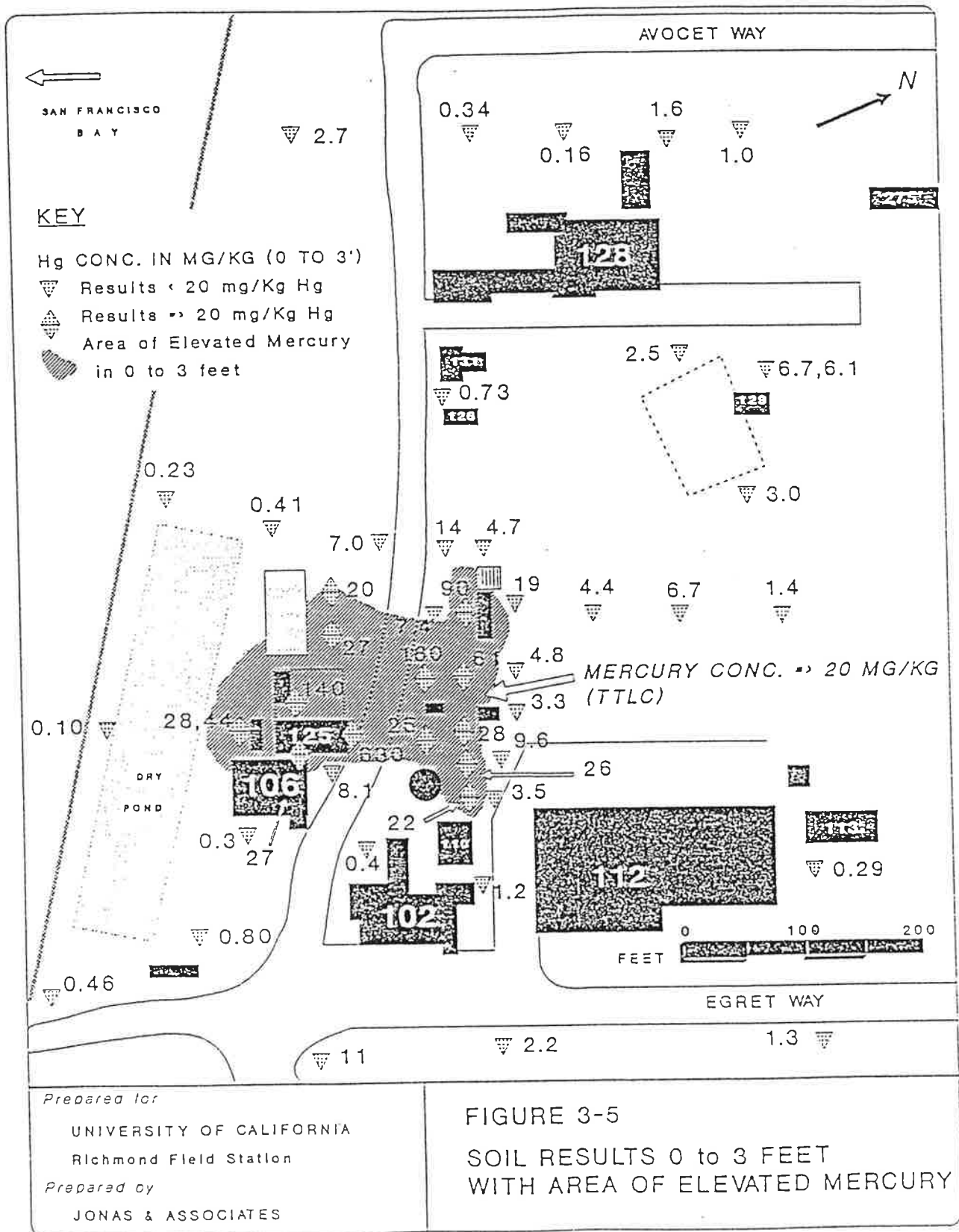


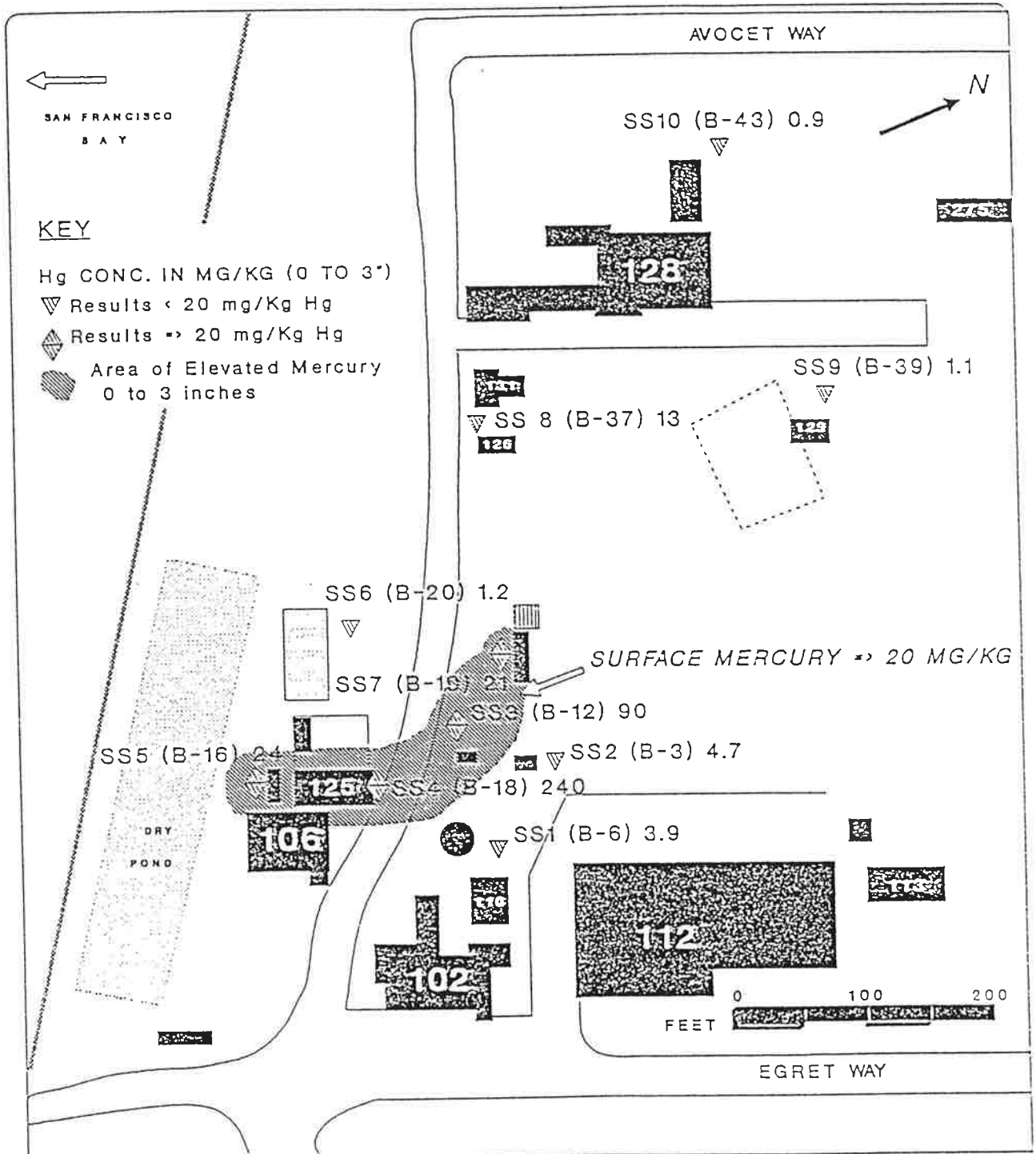


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FIGURE 3-4

PREVIOUS & EXISTING STRUCTURES  
WITH SOIL SAMPLING RESULTS





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FIGURE 3-6  
SURFACE SOIL RESULTS  
0 TO 3 INCHES  
WITH AREA OF ELEVATED MERCURY

Table 3 - 3

MERCURY IN 0 TO 3 INCHES OF SOIL  
RICHMOND FIELD STATION  
2/90

BORING	MERCURY mg/Kg	BORING	MERCURY mg/Kg
SS1/B3	4.7	SS1/B6	3.9
SS1/B10	21	SS1/B12	90
SS1/B16	24	SS1/B18	240
SS1/B20	1.2	SS1/B37	13
SS1/B39	1.1	SS10/B43	0.92

As seen in Figure 3-3, mercury concentrations range from 0.1 mg/Kg to 630 mg/Kg. Highest concentrations were located in the general area of Building 125 and Building 110. Lowest concentrations were in the area of the south-southwestern fence line and at Building 128. Three samples collected along the fence line ranged from 0.10 mg/Kg to 0.46 mg/Kg, with an average concentration of 0.26 mg/Kg mercury. The seven borehole samples collected around Building 128 ranged from 0.16 mg/Kg to 6.7 mg/Kg, with an average concentration of 1.86 mg/Kg mercury. Four samples defined the northern extent of sampling for mercury in soil. Results from these samples ranged from 0.29 mg/Kg to 6.7 mg/Kg.

Figure 3-4 presents the soil mercury results superimposed on the former mercury fulminate production area. As seen in this figure, high concentrations of mercury are located in this previous production area. Outside of this mercury production area, twenty borehole composite samples ranged in concentrations from 0.1 mg/Kg to 6.7 mg/Kg, with an average concentration of 2.3 mg/Kg mercury. From this analysis it appears that there is a good correlation between previous activities in the mercury fulminate production area and concentrations of mercury in shallow soil. Figure 3-5 shows that the main body of mercury in soil is localized in the area of the former mercury fulminate facility.

Duplicate samples were collected and analyzed. Samples B-16 and B-21 were collected from the same borehole. Mercury in each of these samples were 28 mg/Kg and 44 mg/Kg, respectively. Samples B-39 and B-45 were also collected from the same borehole. Mercury in each of these samples were 6.7 mg/Kg and 6.1 mg/Kg, respectively. These differences of results from each borehole are probably due to the natural variation of mercury adsorption in the soil.

Results from sampling of the surface soil are presented in Table 3-3 and on Figure 3-6. As presented in the Figure, the concentrations above the 20 mg/Kg TTLC level is

fairly localized in the area of the former mercury fulminate facility. The potential for this to act as a source for fugitive dust is currently undefined. This analysis will be done as part of the risk assessment study. If there is a potential for fugitive dust transport of mercury in soil, it can be easily corrected by capping with asphalt or another appropriate material.

During drilling of the monitoring well MW-1, 18 soil samples were collected from 2.5 to 11.5 feet and 14 to 15 feet depths. Four composite samples (2.5 - 9 feet) were analyzed for mercury. Mercury was detected in all four samples at a concentration range of 2.7 to 36 mg/kg. Figure 4-2 contains graphical presentation of these mercury results in soil.

### 3.2.2 Results of Analyses for Sulfate and Nitrate in Soil Samples

As Table 3-4 indicate, four composite soil samples 0 to 3 feet were analyzed for sulfate and nitrate. The location and concentration of these samples are shown in Figure 3-7. Concentrations of sulfate ( $\text{SO}_4^{2-}$ ) sampled east of Egret Way ranged from 170 mg/Kg to 300 mg/Kg and were collected from three boreholes. Another sample was collected in the rear of Building 125 and showed 5.9 mg/Kg sulfate. The higher concentrations found adjacent to Egret Way are above what would be considered as ambient and could be the results of previous ICI Americas discharges.

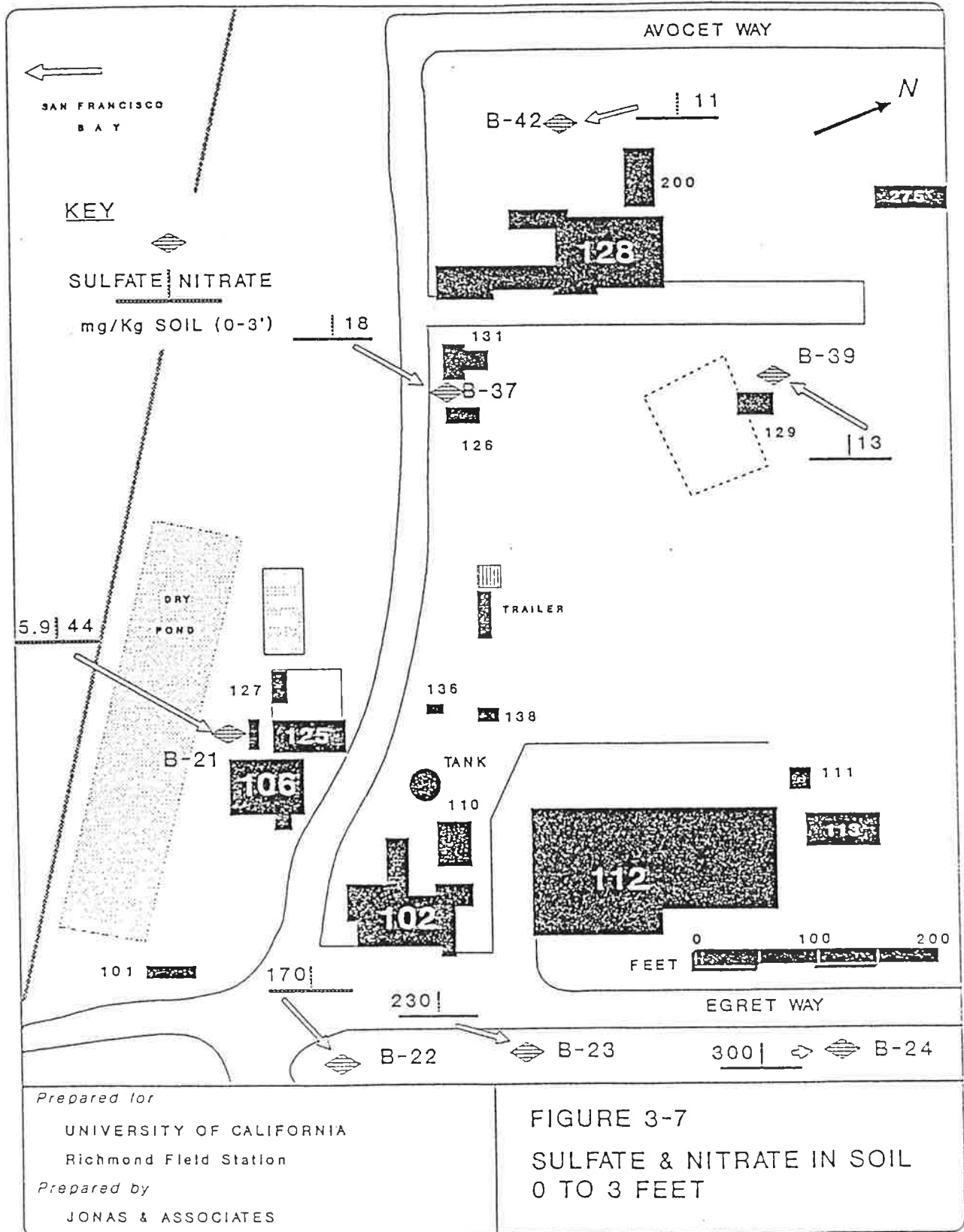
From three samples collected near Building 128, nitrate ( $\text{NO}_3^-$ ) ranged in concentration from 11 to 18 mg/Kg. These concentration levels are probably above ambient, but the relationships with previous facility activities is unknown. Samples were collected adjacent to a previous sewage treatment pond and also within a 150 feet of the previous Shell Manufacturing Area, as seen in Figure 3-6. Currently, it is unknown whether the nitrate found represents a free radical of nitroglycerin ( $\text{C}_3\text{H}_5(\text{ONO}_2)_3$ ), mercury fulminate ( $\text{C}_2\text{N}_2\text{O}_2\text{Hg}$ ) or is from another anthropogenic source (garden fertilizer or previous sewage activity).

Table 3 - 4

SULFATE & NITRATE IN 0 TO 3 FEET OF SOIL  
RICHMOND FIELD STATION  
1/90

BORING	SULFATE mg/Kg	BORING	NITRATE mg/Kg
B21	5.9	B21	44
B22	170	E37	18
B23	230	B39	13
B24	300	B42	11





### 3.2.3 Results of Analyses for Copper and Zinc in Soil Samples

Table 3-5 and Figures 3-8 and 3-9 presents the sample locations and results of copper and zinc concentrations in borings B-12, B-18, B-38 and B-39. In addition, two samples 0 to 3 inches were collected from B-18 and B-39. All samples were below the TTLC level of 2,500 ppm for copper.

Zinc concentrations in all borings tested were below the TTLC of 5,000 ppm for zinc.

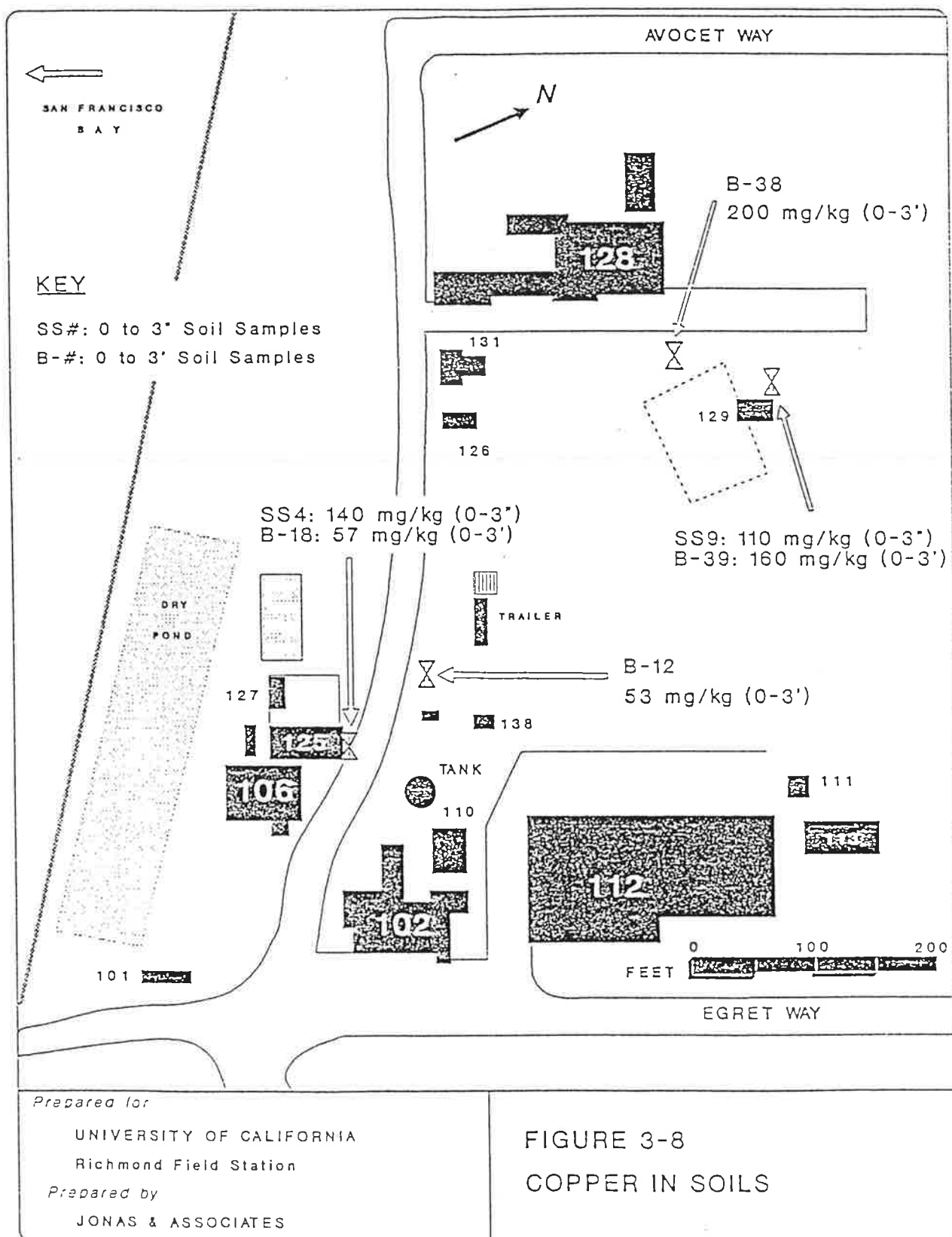
Table 3 - 5

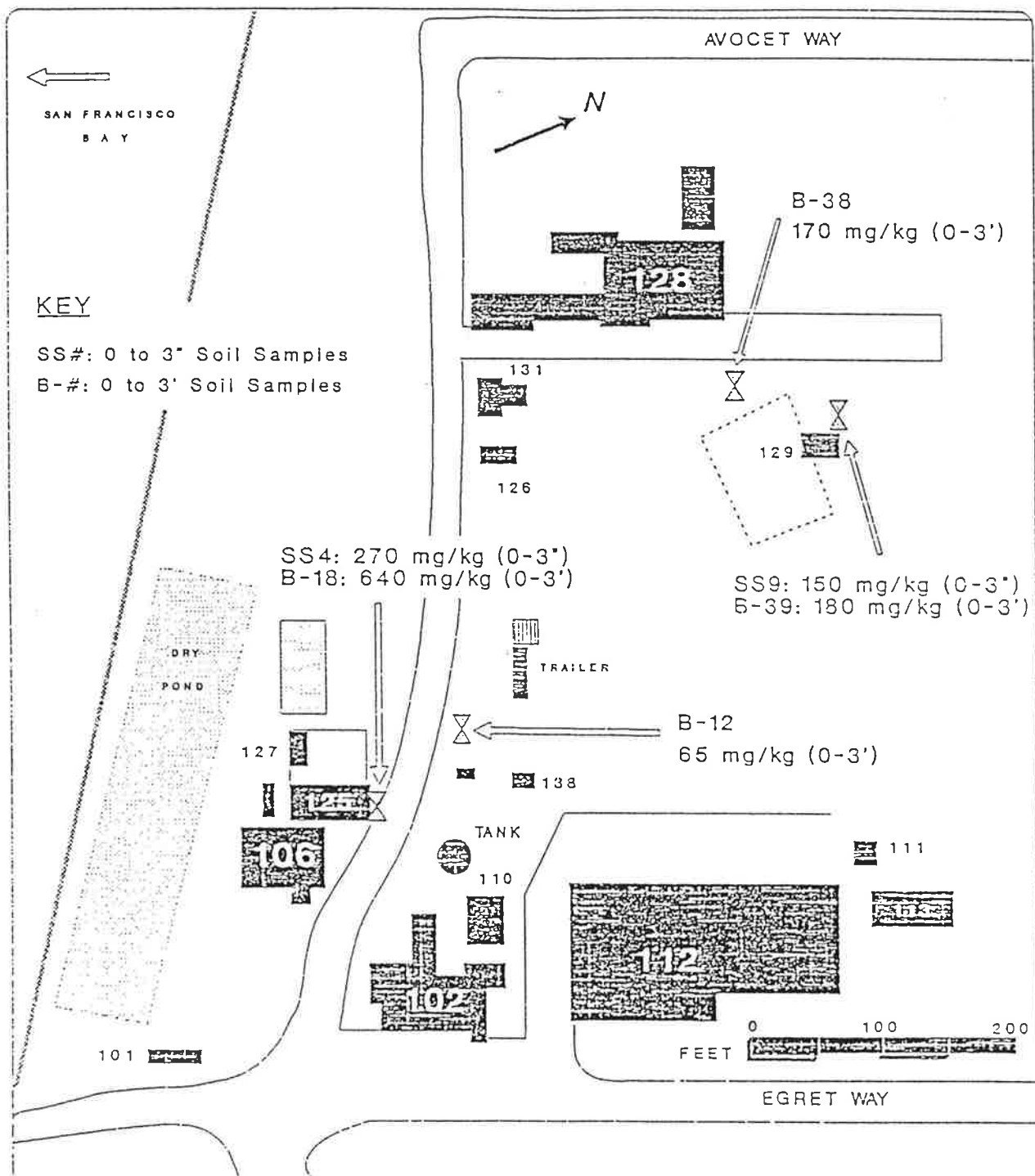
COPPER AND ZINC IN 0 TO 3 FEET AND 0 TO 3 INCHES OF SOIL  
RICHMOND FIELD STATION  
1 AND 2/90

BORING	COPPER mg/Kg	BORING	ZINC mg/Kg
B12	53	B12	65
B18	57	B18	640
B38	200	B38	170
B39	160	B39	180
SS4(B18)	140	SS4(B18)	270
SS9(B39)	110	SS9(B39)	150

### 3.2.4 Results of Analyses for STLC and EP Toxicity in Soil Samples

To determine leachability under slightly acidic conditions, an EP Toxicity Extraction (EPA 3020/7470) was performed on borehole sample B-21. The sample had shown 44 mg/Kg of mercury in soil. Results from the laboratory analysis determined that mercury in leachate was not present above the detection limit of 0.01 mg/L. In addition to this analysis, composite samples from borehole B-18 was tested for Waste Extraction Test (WET). Mercury concentration of 1.3 mg/L was detected in the waste extracted. The STLC for mercury is set at 0.2 mg/L. Even though the results from the EP Toxicity test is relatively encouraging, the results of the WET test for STLC does indicate that the mercury at concentrations found are a definable hazardous waste.





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FIGURE 3-9  
ZINC IN SOILS

#### 4.0 GROUNDWATER MONITORING WELL DRILLING, CONSTRUCTION, DEVELOPMENT AND SAMPLING

To characterize the vertical stratigraphy, water table and determination of presence or absence of mercury in groundwater at the RFS, an additional groundwater monitoring well (MW-1) was installed downgradient from the former mercury fulminate facility. The well was installed by Aqua Science Engineers Inc., a California licensed well-drilling contractor. Figure 4-1 presents the well construction details of the monitoring well MW-1. Figure 4-2 identifies the general lithologies encountered at the location of MW-1 and the results from the soil samples.

On March 7, 1988 an earlier groundwater monitoring well was installed by Aqua Science Engineers as part of an underground fuel storage tank investigation. The location of this well is shown in Figure 2-2. Since this well is located upgradient from the former mercury fulminate facility, in the future investigations, it will be considered as an upgradient well and in this report as well as future reports it will be referred to as MW-A. The well log description of MW-A is shown as Figure 4-3 of this report.

The methods and procedures for drilling, construction, development, and sampling of monitoring well MW-1 are described in this section. Details regarding sample analysis requests, techniques, and reporting are also included.

##### 4.1 DRILLING METHODS

Soil borings for the monitoring well was drilled utilizing a hollow-stem auger. Hollow-stem auger drilling is accomplished utilizing a hollow central shaft to which is attached a spiral scroll. Each section of auger is aligned so that a continuous scroll is formed. A bit is attached at the bottom of the first auger flight. Cuttings created by the bit are removed by the scroll as the auger stem is turned. This method is suitable for relatively shallow drilling in unconsolidated formations. A soil boring 13 feet deep was drilled with an auger rig utilizing eight-inch outside diameter (OD) hollow-stem auger. This boring was completed as a monitoring well. The spoil was collected in drums and set aside for appropriate disposal.

Soil samples for lithologic description and chemical analysis were collected every foot, utilizing a split-barrel drive sampler. A total of 18 soil samples were collected. Four composite samples were analyzed for mercury. Details on sample collection and analysis are provided in Section 3 of this report.

##### 4.2 WELL CONSTRUCTION

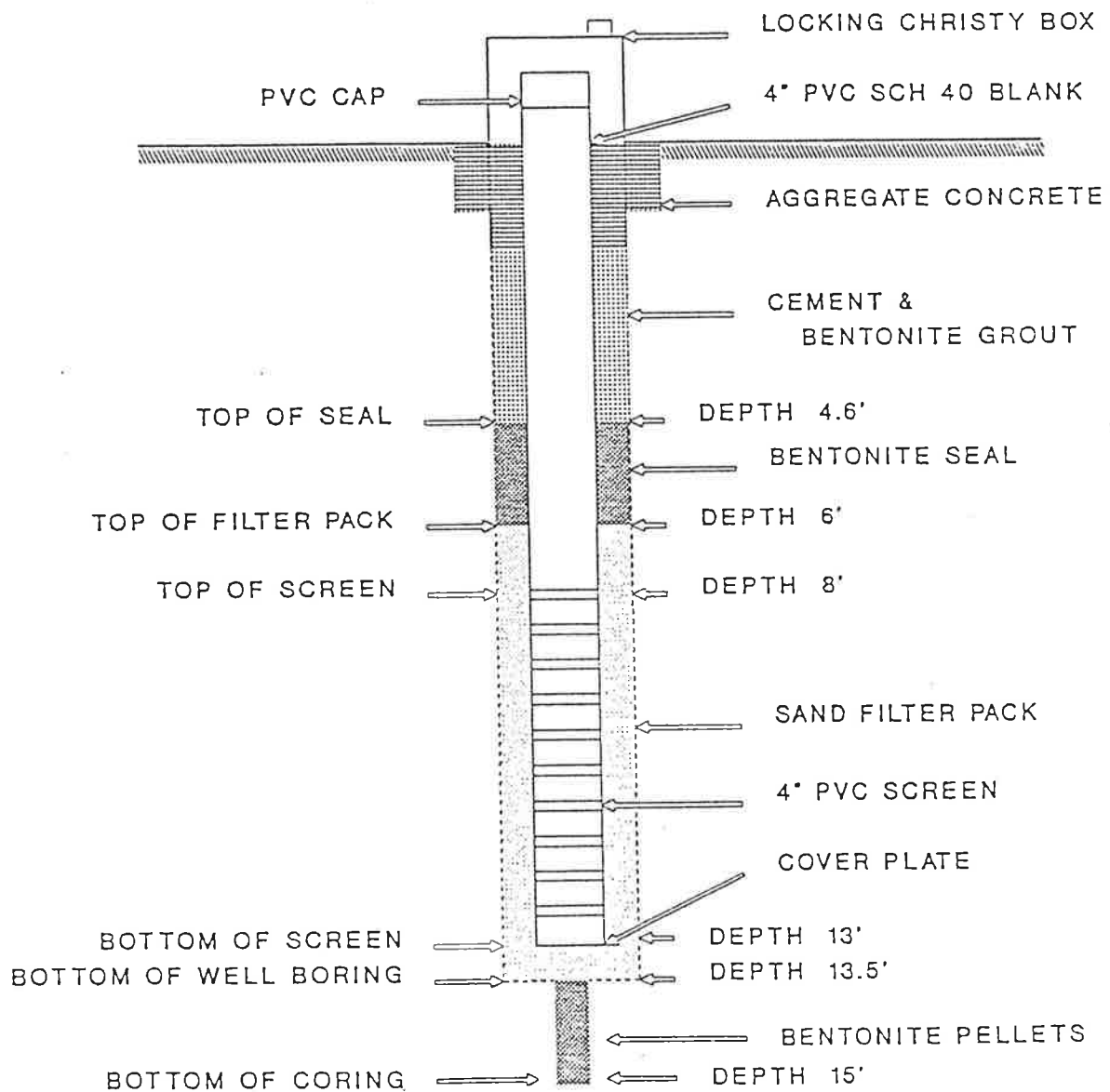
The groundwater monitoring well MW-1 was completed with a 5-foot long PVC screen, with a 0.01-inch slot size. The screen was connected to a 10-foot long PVC riser pipe. All joints are flush threaded and no solvents or cements were used on the PVC. Pipe and screen were steam-cleaned before use. The screen penetrates the complete thickness of the aquifer.

## JONAS AND ASSOCIATES INC.

WELL No.: MW1  
PROJECT No.: UCRFS-101

Figure 4-1 Well Details

PROJECT NAME: UNIVERSITY OF CALIFORNIA RICHMOND FIELD STATION  
BORING LOCATION: Behind Building 105      DATE: 2-25-90      BY: RJ



NOT TO SCALE

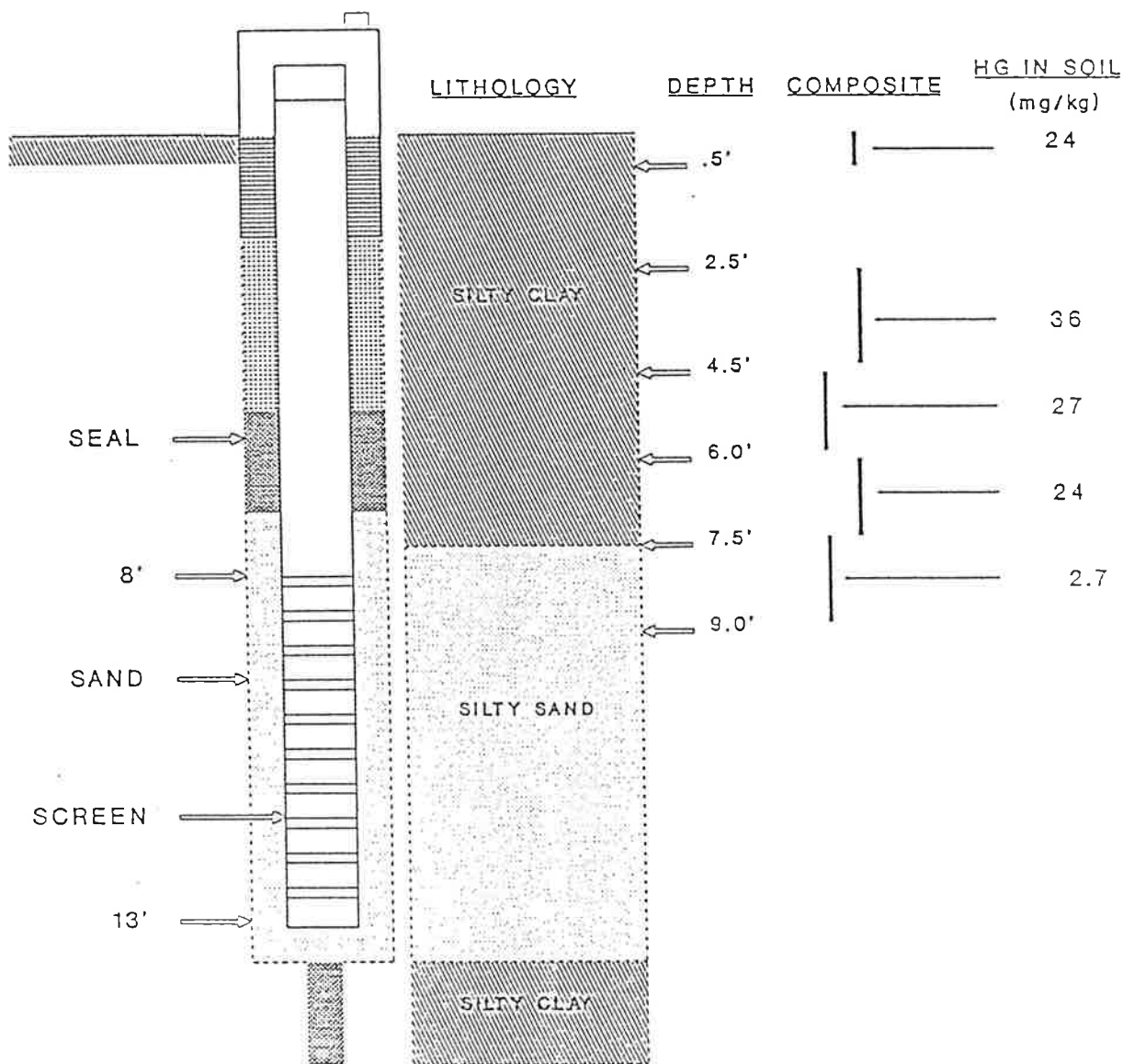
## JONAS AND ASSOCIATES INC.

WELL No.: MW1

PROJECT No.: UCRFS-101

Figure 4-2 MW1 STRATIGRAPHY AND SOIL RESULTS

PROJECT NAME: UNIVERSITY OF CALIFORNIA RICHMOND FIELD STATION  
 BORING LOCATION: Behind Building 105 DATE: 2-25-90 BY: RJ



NOT TO SCALE

Project: University of California, Richmond Field Station, 1301 S. 46th St.		Log of Monitoring Well		
depth (ft.)	SOIL DESCRIPTION	Monitoring Well Details	Hammer Blow Count	REMARKS
0	Brown, gravel and dirt backfill material, dry (GM)	<p>4.5 ft. bent cement locking cap and box</p> <p>1 ft. bentonite pellets</p> <p>slotted 2" PVC (0.01") to 7.5 ft</p> <p>no. 3 sand to 6 ft</p>		First water at approximately 9 feet.
2				
4				
6				
8	Light gray/yellow, silty clay, slightly moist, medium plasticity. (CL)			
10	Pebble-size gravel and coarse sand layer, approximately 10-12.5 ft (saturated)			
12				
14	Light gray/brown/yellow silty clay, slightly moist, medium plasticity, (bay mud) mixed with gravel to approximately 17.5 ft.			
16				
18				
20	Below 17.5 feet clay is saturated and mixed with fine gravel/coarse sand.			
22		<p>4.5 ft. bent cement locking cap and box</p> <p>1 ft. bentonite pellets</p> <p>slotted 2" PVC (0.01") to 7.5 ft</p> <p>no. 3 sand to 6 ft</p>		$\begin{array}{r} 14 \\ 22 \\ \hline 19 \end{array}$
24				
26				
28	B. O. H.			
30				
32				
Logged by BB on 3-7-88		Aqua Science Engineers		Figure 4-3



A filter pack consisting of 3-inch silica sand was placed in the annular space at the well screen and carried two feet above the top of the screen. A bentonite seal, one-half foot thick and composed of one-half inch pellets, was placed above the sand pack and the remaining annular space was filled with a neat cement-bentonite grout. Frequent measurements with a steel tape were made during placement of materials to ensure that proper amounts of material were placed and that seals were properly located to avoid cross-contamination. The grout used to finish the well consisted of neat Portland cement modified with sodium bentonite to reduce shrinkage. The ratio of cement to bentonite was approximately 20:1 on a weight basis. First water was added to the Portland cement, then bentonite was added.

The well head was completed approximately 1 foot above the grade. A three feet protective metal casing that extends 1.7 feet below grade and 1.3 feet above grade was placed over the 1-foot riser. The metal casing includes a hinged steel lid with provision for a padlock.

When constructing the well, the maximum effort was made to avoid contamination of the well construction materials. The PVC construction materials was procured clean from the fabricators. The following procedures were followed to insure quality control:

- o All screen and casings were steam-cleaned before installation;
- o All filter-pack material was placed directly from the bag (spilled material was not to be taken from the ground and placed in the boring); and
- o The steel tape used to sound for depth during installation was steam-cleaned between borings.

Additional quality control factors implemented during well construction include:

- o Ensuring that no foreign material entered the well casing during construction;
- o Made frequent soundings when placing the filter pack, bentonite, and ground into the annular space; and
- o The total casing length in the borehole, the stickup, and the casing cutoff was noted when the well construction was completed so that the total depth can be accurately calculated (i.e.:  $\{(\text{total casing length}) - (\text{stickup} + \text{cutoff})\} = \text{depth}$ );
- o Recording all final measurements, problems, and comments in the field log book.

#### 4.3 WELL DEVELOPMENT

When well construction was complete and the grout column was cured for a minimum of 24 hours, well development was performed with a submersible pump. Developing was initiated by lowering a submersible pump into the well. The pump was connected directed to an outlet in one of the buildings nearest to the monitoring well. The pump was placed one foot above the bottom of the well. Approximately five well volumes was removed during development. Well volume was calculated using the formula:

$$V = \pi(h/4) \{D_c^2(1-n) + nD_p^2\}$$

where V = volume of standing water in well, ft<sup>3</sup>  
 $\pi$  = 3.14  
 $D_p$  = diameter of filter pack, ft  
 $D_c$  = diameter of well casing, ft  
 n = porosity of the filter pack, decimal fraction  
 h = height of standing water in well, ft

The variable h was determined by subtracting the depth to water from the total well depth. The value n was 0.3. to convert the well volume to gallons, V was multiplied by 7.48. Water level and well depth was measured with an electric sounding device.

The monitoring well was pumped until the discharge was clear, colorless, free of particulates. Water discharged during equipment steam-cleaning and development were stored in 55-gallon drums.

#### 4.4 SAMPLE COLLECTION PROCEDURES AND ANALYSIS

Upon the completion of well development, a teflon bailer was used to collect the sample. Initially teflon bailer was rinsed 5-times with the well water. Then sample was directly poured from the bailer into a one liter plastic sample bottles provided by Curtis & Tompkins laboratory. Bailer was decontaminated prior and after sample collection. Sample bottles were sealed, labeled and kept at 4°C in an ice chest until they were transferred to the laboratory. Samples were filtered and preserved by the laboratory upon receipt. Groundwater sample was analyzed for mercury and total dissolved solids.

#### 4.5 RESULTS OF ANALYSES FOR MERCURY AND TDS IN WATER SAMPLE

Mercury was not detected in the water sample. Total dissolved Solids (TDS) level in the groundwater was 1,300 ppm.

As presented in Figure 4-2, mercury was encountered in the soil down to a depth of nine feet below the surface. The transmissive zone of silty sand, which was eventually screened for monitoring well MW-1, showed a mercury concentration in soil of 2.7 mg/Kg. Concentrations above that zone were generally an order of magnitude higher.

The results of the groundwater sample indicates that the mercury in the soil could be effectively bound and not release into groundwater. From a water quality perspective this is very encouraging.

Figure 4-4 presents the location of monitoring well MW-1 with the location of the area of mercury contamination in the areas of the former mercury fulminate facility. MW-1 was located downgradient of the highest mercury concentrations measured in soil (630 mg/Kg in B-18).

## 5.0 MERCURY TOXICOLOGY, CHEMISTRY AND MIGRATION PATHWAYS

### 5.1 TOXICOLOGY OF MERCURY

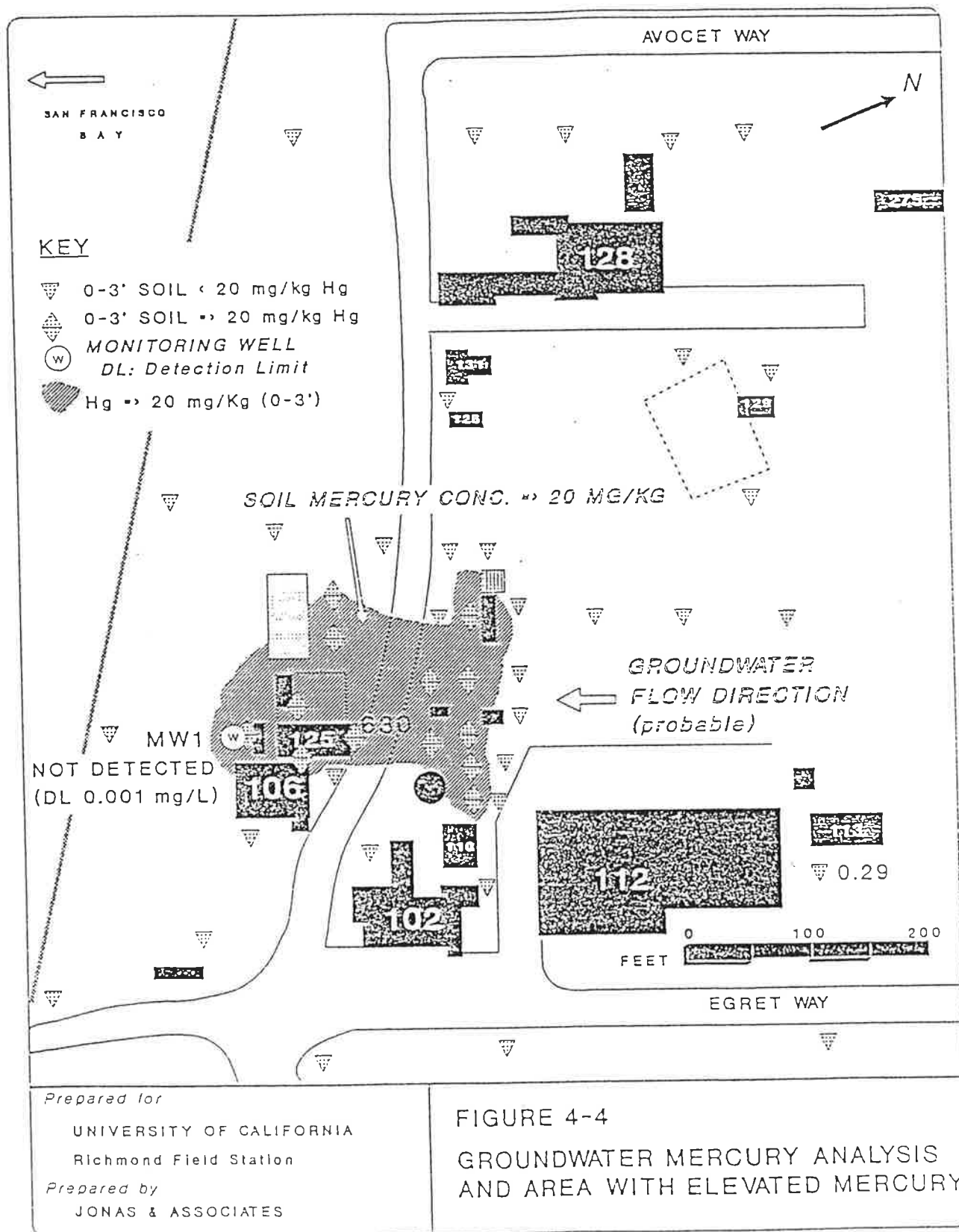
Mercury occurs as elemental mercury, and as inorganic and organic compounds (mercury vapor, mercury liquid, mercury salts, short-chain alkylmercury compounds, alkoxyalkylmercury compounds and phenylmercury compounds). All having different toxicological properties.

Mercury can be analyzed in water, air and biological material by atomic absorption methods and by neutron activation analysis, and can be detected down to concentrations of a tenth of a nanogram per gram in biological material. Methylmercury can be detected in biological material at levels of a few nanograms by extraction with benzene after strong acidification with hydrochloric acid, followed by gas chromatographic analysis of methylmercury chloride.

Mercury is circulated naturally in the biosphere, 30,000 - 150,000 tons being released into the atmosphere by degassing from the earth's crust and the oceans. In addition, 20,000 tons of mercury are released into the environment each year by human activities such as combustion of fossil fuels and other industrial release. Yearly, 10,000 tons of mercury are produced for industrial use, a small part of which is used for synthesizing organic mercury compounds.

In nature, methylmercury is produced from inorganic mercury as a consequence of microbial activity. In fish, the major amount of mercury is methylmercury. Factors determining the methylmercury concentration in fish are: mercury content in water and bottom sediment, pH and redox potential of water, species, age and size of fish.

The toxic properties of mercury vapor are due to mercury accumulation in the brain causing neurological signs, involving an unspecific psychoasthenic and vegetative syndrome (micromercurialism). At high exposure levels mercurial tremor is seen, accompanied by severe behavioral and personality changes, increased excitability, loss of memory and insomnia. On a group basis, exposure levels are likely to be reflected in mercury concentrations in blood and urine. Occupational exposure to mercury concentrations in air above  $0.1 \text{ mg/m}^3$  may produce mercurialism. Micromercurialism has not been reported at concentrations below  $0.01 \text{ mg/m}^3$ .



The acute and long-term action of mercuric salts, phenylmercury compounds and alkoxyalkylmercury compounds is likely to be gastrointestinal disturbance and renal damage - appearing as a tubular dysfunction with tubular necrosis in severe cases. The lethal dose in man is about 1 g of mercuric salt. The mercury load on the kidney is best determined by analysis of renal biopsy. Mercury concentrations in the kidney between 10 and 70 mg/kg have been reported in poison cases with renal injury. Levels below 3 mg/kg may be found in normal cases. Occasionally, mercuric compounds may cause idiosyncratic skin symptoms which may develop into severe exfoliative dermatitis or may cause glomerular nephritis. A specific form of idiosyncrasy, called acrodynia or pink disease, is seen in children. Most cases are associated with mercury exposure showing increased levels of mercury in urine.

The hazards involved in long-term intake of food containing methylmercury and in occupational exposure to methylmercury are due to the efficient absorption (90%) of methylmercury in man and the long retention-time (half-time 70 days) with accumulation of methylmercury in the brain. Chronic poisoning results in degeneration and atrophy of the sensory cerebral cortex, paresthesia, ataxia, hearing and visual impairment. Prenatal exposure causes cerebral palsy and in less severe cases, psychomotor retardation. Methylmercury concentration in blood and hair reflects the body burden and the concentration in brain of methylmercury. Intake resulting in body burdens of less than 0.5 mg/kg body weight is not likely to give rise to detectable neurological signs in adults. This intake corresponds to blood values of less than 200 ug/l and mercury level in hair less than 50 mg/kg. However, this level of methylmercury exposure in pregnant females may result in inhibited brain development of fetus with psychomotor retardation of the child as a consequence. The highest level of methylmercury load in pregnant women, not associated with inhibition of fetal brain development, is not known.

The history of mercury toxicology has been reviewed by Goldwater (1964), the pharmacology and toxicology by Clarkson et al. (1972), the chemistry of mercury in biological systems by Carty and Malone (1979), the toxicology of methylmercury by a Swedish Expert Group (1971), and the toxicology and epidemiology by Friberg and Vostal (1972), by the Task Group on Metal Accumulation (1973), the Task Group on Metal Toxicity (1976) and by the WHO (1976,1980).

## 5.2 CHEMISTRY OF MERCURY AND MERCURY FULMINATE

### 5.2.1 Chemistry of Mercury

Mercury has an atomic weight of 200.59. At 20°C , its specific gravity is 13.546 and its vapor pressure is 0.0012 torr. The solubility of metallic mercury in pure water has been determined by Sanemasa (1975) to be 0.019 mg/L and 0.081 mg/L at 5°C and 30°C, respectively.

Under the usual conditions of temperature and pressure that occur in the environment, mercury can be present in any one of three different oxidations states. The most reduced form is the metal, which is a liquid at ordinary temperatures and which has a tendency to vaporize. The other two forms are the mercurous ion,  $\text{Hg}^{+1}$ , and the

mercuric ion  $\text{Hg}^{+2}$ . Mercury can build many species. Some complex ions have considerable aqueous solubility, while others are relatively insoluble. Mercury also forms many stable organic complexes. Within a moderately oxidizing environment above pH 5, the predominant mercury species will be elemental mercury. Mildly reducing conditions can cause mercury to precipitate as a sulfate, cinnabar, which has an extremely low aqueous solubility. In aquatic environments that are high in chloride, the solubility of mercury in oxygenated solutions may be greatly increased by the formation of mercuric chloride complexes (Garvis and Ferguson, 1972).

Equally important are the processes which produce the organic complexes of mercury. Two types of alkylated mercury compounds are formed in the environment:

- o Compounds with a single carbon-mercury bond, acting as a substituted salt and is reasonably water-soluble.
  - An example is methyl mercuric chloride ( $\text{CH}_3\text{HgCl}$ ), which becomes  $\text{CH}_3\text{Hg}^+$  ion and  $\text{Cl}^-$  in solution.
- o The second type of alkylated mercury compound has two carbon atoms to the mercury. These covalent mercury compounds are generally quite insoluble.
  - An example is dimethyl mercury ( $\text{CH}_3\text{HgCH}_3$ ) which is volatile and is undisassociated in solution. Inorganic forms of mercury can be converted to organic forms by microbial action.

#### 5.2.2 Mercury Fulminate

Mercury fulminate  $\{\text{Hg}(\text{ONC})_2$  or  $\text{C}_2\text{N}_2\text{O}_2\text{Hg}\}$  has a molecular weight of 284.6 and a density of  $4.42 \text{ g/cm}^3$ . Its percentage of nitrogen is 9.84%. It form in standard temperature is a crystal. It heat of explosion is 355 kcal/kg or 1486 kj/kg. Mercury fulminates deflagration point is  $165^\circ\text{C}$  or  $330^\circ\text{F}$  and impact sensitivity is 0.1-0.2 kp m or 1-2 N m.

Mercury fulminate is practically insoluble in water. When dry, it is highly sensitive to shock, impact, and friction, and is easily detonated by sparks and flames.

Mercury fulminate is prepared by dissolving mercury in nitric acid, after which the solution is poured into 95% ethanol. After a short while, a vigorous gas evolution takes place and crystals are formed. When the reaction has ended, the crystals are filtered by suction and washed until neutral. The mercury fulminate product is obtained as small, brown-to grey pyramis-shaped crystals; the color is caused by the presence of colloidal mercury. Mercury fulminate is stored under water.

If small amounts of copper and of hydrochloric acid are added to the reaction mixture, a white product is obtained. It is dried at  $40^\circ\text{C}$  ( $104^\circ\text{F}$ ) shortly before use. Owing to its excellent priming power, its high brisance, and to the fact that it can easily be detonated, mercury fulminate was the initial explosive most frequently used prior to the appearance of lead azide. It is used in compressed form in the manufacture of blasting caps and percussion caps.

### 5.3 FATE AND TRANSPORT OF MERCURY

Mercury and certain of its compounds can volatilize to the atmosphere from aquatic and terrestrial sources. In the atmosphere complex species of mercury commonly forms. Precipitation is the primary mechanism for removal of mercury from the atmosphere. But photolysis can also breakdown airborne mercurials. Adsorption onto suspended and bottom sediments is commonly the fate of mercury in the aquatic environment. Sorption is strongest on organic materials. Mercury in soils generally complexes to organic compounds.

Virtually all mercury compounds can be remobilized by microbial conversion to methyl and dimethyl forms. Conditions reported to enhance biomethylation include large amounts of available mercury, large numbers of bacteria, the absence of strong complexing agents, near neutral pH, high temperatures, and moderately aerobic environments. Mercury is also strongly bioaccumulated by numerous mechanisms. Methylmercury is the most readily accumulated form of mercury in aquatic biota.

#### 5.3.1 Volatilization

Metallic mercury has a relatively high vapor pressure relative to other metals and commonly enters the atmosphere as several different gaseous compounds. The rate of vaporization of mercury and certain of its inorganic compounds decreases in the sequence  $\text{Hg} > \text{Hg}_2\text{Cl}_2 > \text{HgCl}_2 > \text{HgS} > \text{HgO}$ , according to Koksay and Bradshaw (1969). The microbial methylation of mercury also enhances evaporation of mercury.

#### 5.3.2 Sorption

Mercury has an affinity for many surfaces. In water samples a major portion of the total mercury is found associated with particulate (Hinkle and Learned, 1969). Ramamoorthy and Rust (1976) found that sorption rates are highest in organic-rich soils, with sediment binding capacity closely related to organic content. They also found that desorption rates are low: less than one percent Hg leached from sediments after 70 hours of agitation in distilled water.

#### 5.3.3 Biotransformation

Mercury does take part in biological reactions which alter its mobility and toxicity. Bisogni and Lawrence (1975) evaluated the influences of inorganic mercury concentrations and speciation, pH, microbial activity and redox potential, on mercury methylation rates. They found that at a neutral pH the primary product of mercury methylation is methyl mercury. Methylation can occur under both aerobic and anaerobic conditions. More mercury methylation occurs when more bacteria are present. Therefore, highly organic sediments which favor bacterial growth have a higher methylation potential than inorganic sediments. Upon entering an aqueous system mercurial compounds will tend to convert to methyl mercury through microbial chemical transformation.

## 6.0 REGULATORY ANALYSIS OF REMEDIAL STANDARDS

The Regional Water Quality Control Board and the Department of Health Services are the two primary state regulatory agencies responsible for overseeing any remediation. Regulatory mandates and general responsibilities of these agencies are discussed with respect to the determination of acceptable soil concentrations.

### 6.1 REGIONAL WATER QUALITY CONTROL BOARD

Within California the primary authority for water pollution control is the Regional Water Quality Control Board (Regional Board). The Regional Board has extensive powers. Their responsibilities include 1/ prescribing water discharge requirements, 2/ issuing cease-and-desist orders to compel curtailment and cleanup of hazardous water releases, and 3/ approve closure of waste disposal sites. The Regional Board's regulatory and remedial powers overlap with the responsibilities of the California Department of Health Services (DHS).

To regain and maintain beneficial uses of the waters, the Regional Board can issue waste discharge requirements (WDRs) and cease-and-desist orders. WDRs set discharge standards of a facility. Discharge requirements must implement the current basin plan with its water quality objectives and take into consideration the original beneficial use of the waters involved. Through WDRs and cease-and-desist orders, the Regional Board will typically require that a remediation achieves the original beneficial uses of the water (drinking, recreation,...). The Regional Board cannot "specify the design, location, (and) type of construction". If waters are not, or will not be, impacted by current or previous activities at a facility, commonly than the Regional Board is out of its area of jurisdictional responsibility.

With respect to regulating discharges of waste to land, the State Water Resources Control Board has adopted a substantial body of regulations. These regulations establish waste and site classification and waste management requirements for waste treatment, storage, or disposal in landfills, surface impoundments, waste piles and land treatment facilities. The waste classification system categorizes waste as "hazardous", "designated", "nonhazardous solid" or "inert". *Inert wastes* are wastes that do not contain hazardous wastes or soluble pollutants at concentrations in excess of applicable water quality objectives or decomposable wastes in significant quantities. *Nonhazardous solid wastes* are those solid, semisolid and liquid wastes which contain neither hazardous nor designated wastes. *Designated wastes* tend to be wastes with concentrations below "hazardous" but which could release at concentrations above water quality objectives or which could degrade water quality. This waste classification system provides the basis for determining which wastes may be discharged at what class of waste management unit.

### 6.2 DEPARTMENT OF HEALTH SERVICES

The Department of Health Services (DHS) is generally responsible for the regulation and control of hazardous materials, including hazardous wastes. Among its



responsibilities are 1/ enforcing a program for the manifesting of hazardous waste shipments, 2/ remediating actual or threatened hazardous waste releases, and 3/ designating property as either a "hazardous waste property" or a "border zone property" resulting in use restrictions and deed disclosure.

DHS can classify wastes as "hazardous", "restricted hazardous" or "nonhazardous" and sets site remedial criteria on direct threat to public health. The remedial criteria is to prevent toxicologic impacts on humans and other potential "biological receptors of concern". A methodology was presented by the DHS, titled The California Site Mitigation Decision Tree, to determine acceptable cleanup level using this criteria. But acceptable levels to DHS may differ from the Regional Board. This is due to the Regional Board's mandate to protect all beneficial uses of waters, whereas DHS concentrates on public health.

### 6.3 DETERMINATION OF ACCEPTABLE SOIL CONCENTRATIONS

The four factors for the determination of acceptable soil concentrations are:

- 1/ Test the groundwater for the constituent. If none is present, the soil is probably not contributing contaminants to the groundwater,
- 2/ If the groundwater has concentrations above acceptable limits, back calculate an acceptable soil concentration using water quality standards for a defined beneficial use.
- 3/ Evaluate the air transport pathway by sampling the upper three inches of soil. If chemicals are not present then the fugitive dust transport pathway does not need to be evaluated further.
- 4/ Determine whether gaseous transfer is occurring from the soil into the atmosphere.

Acceptable levels of chemicals in soils are commonly evaluated with respect to potential risk and applicable standards. The evaluation of the no-action alternative, or the Risk Assessment, is appropriate if acceptable regulatory standards are not available for the chemicals of concern. Overall, soil lacks direct regulatory standards. From water quality standards, acceptable concentrations in soil can be calculated. Table 5-1 presents a list of some potential water quality standards and criteria.

Table 6 - 1

MERCURY WATER QUALITY STANDARDS AND CRITERIA

Primary Drinking Water Standard: 0.002 mg/liter

EPA Health Advisories: 0.0011 mg/liter

EPA National Ambient Water Quality Criteria:

- o To protect public health: 0.000144 mg/liter

- o To protect freshwater aquatic life

- One-hour average: 0.0024 mg/liter

- Four-day average: 0.000012 mg/liter

- o To protect saltwater aquatic life

- One-hour average: 0.0021 mg/liter

- Four-day average: 0.000025 mg/liter

California Ocean Plan Limiting Concentrations

- o Instantaneous maximum: 0.0014 mg/liter

- o Daily maximum: 0.00056 mg/liter

- o Six-month medium: 0.00014 mg/liter

Soluble Threshold Limit Concentrations: 0.200 mg/liter

Total Threshold Limit Concentrations (for soil): 20.0 mg/Kg

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Based upon the current results, the groundwater does not appear to have been impacted by mercury. But, elevated concentration of mercury are present in shallow (0 to 3 inches) soil samples. In addition, some of the results from the borehole samples are above the TTLC level for mercury of 20 mg/Kg.

If after further investigation it is determined that the concentrations in the soil are not acceptable, then a remedial technology will need to be selected. Following is a table of possible remedial alternatives for contaminated soil:

#### Excavation and Removal of Soil

- o Backhoe
- o Cranes and attachments
- o Front end loaders
- o Scrapers
- o Pumps
- o Industrial vacuums

#### Air Pollution & Fugitive Dust Controls

- o Capping
  - Synthetic membrane
  - Clay
  - Asphalt
  - Multimedia cap
  - Concrete
  - Chemical sealants/stabilizers
- o Dust control polymers

#### In Situ Treatment

- o Oxidation
- o Reduction
- o Polymerization
- o Bioreclamation

#### Direct Waste Treatment

- o Mercury extraction by kiln with vapor collection
- o Chemical treatment
- o Solidification, stabilization, or fixation

#### Land Disposal Options

- o Landfills
- o Temporary storage

## 8.0 SUMMARY AND RECOMMENDATIONS

### 8.1 SUMMARY OF RESULTS

A summary of the current findings to date indicate that:

- 1/ Mercury is present in the soil above TTLC values, indicating that it is at concentrations that define a hazardous waste by the Department of Health Services.
- 2/ Mercury is present in soils at the surface and possibly could contribute to fugitive dust.
- 3/ Copper and zinc are present in soil samples, but at concentrations well below the TTLC value defining a hazardous waste.
- 4/ Nitrate and sulfate are also present in the soil, but at significantly low concentrations.
- 5/ Mercury was not identified in groundwater, probably due to the mercury effectively binding to the organic fraction of the silts and clays.

### 8.2 RECOMMENDATIONS

Following are a set of recommendations for managing the mercury contamination found in the general area of the former mercury fulminate facility.

- 1/ Submit the current information collected at the facility to the appropriate regulatory agency (probably DHS, since no groundwater contamination is present).
- 2/ Determine the potential risk associated with the presence of mercury in significant concentrations in surface soils by performing a risk assessment study.
- 3/ If a determination is made that a significant risk is associated with the fugitive dust transport of mercury, that capping with asphalt, or another form of capping be considered to mitigate the risk.
- 4/ Survey the soil sampling points, and the monitoring well location.

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