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PROPERTY DEVELOPMENT
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PROGRAMS

March 1, 1991

David S. Mowday
Deputy Assistant Regional Administrator
of Office and Policy Management
United States Environmental Protection Agency
Region 9
75 Hawthorne Street
San Francisco, CA 94105

Dear Mr. Mowday:

Enclosed you will find the final risk assessment report for the contamination identified at the Richmond Field Station. The risk assessment has been revised to incorporate the input received from your office.

I will be on vacation for the next three weeks. You can either contact the consultant (Mark Jonas, Jonas Associates, Tel. 676-8554) or my supervisor (Dorothy Walker, Associate Vice Chancellor--Property Development, Tel. 642-7376, FAX 642-6513) if you have any questions regarding the report.

We are looking forward to receiving a draft of the letter that will address what, if any, measures are needed to address contamination at the Field Station prior to the development of the EPA laboratory. If you could, please fax the letter to both Dorothy Walker, and Alan Waltner (FAX 465-6248). They will respond on behalf of the University.

Sincerely,

Kevin Hufferd
Research Center Project
Coordinator

Enclosure

cc: Terry Stumph, EPA, Region 9 (w/ Attachment)
Richard Robbins, Wareham Development (w/ Attachment)
Associate Vice Chancellor Barclay (w/ Attachment)
Assistant Vice Chancellor Walker (w/ Attachment)
Associate Dean Leitmann
Professor Blakely

JONAS & ASSOCIATES INC.
Environmental Consultants

PRELIMINARY RISK ASSESSMENT

UNIVERSITY OF CALIFORNIA
RICHMOND FIELD STATION

February 22, 1991

PRELIMINARY RISK ASSESSMENT

UNIVERSITY OF CALIFORNIA
RICHMOND FIELD STATION

February 22, 1991

Prepared for:

University of California
Richmond Field Station
47th Street and Hoffman Boulevard
Richmond, California 94808

Prepared by:

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EXECUTIVE SUMMARY

Background

The University of California at Berkeley's Richmond Field Station (UCB-RFS) is located in Richmond, California at 1301 South 46th Street. Explosives manufacturing was conducted from the 1840s to about 1945 in an area that included the southeastern portion of the site. A major part of the operations in this area involved the production of mercury fulminate.

Investigations of the UCB-RFS facility have been conducted by the California Department of Health Services (DHS), by CH2M Hill, and by Jonas and Associates Inc. These investigations indicate that mercury is present in the areas sampled at an average concentration of 25 mg/kg and a maximum concentration of 630 mg/kg. Other metals, including arsenic, copper, and lead were also detected at the site at somewhat elevated levels.

Current land uses adjacent to UCB-RFS are primarily industrial. The U.S. Environmental Protection Agency intends to construct a laboratory on the property and is concerned about the mercury detected at the site.

Risk Assessment Results

Based on the results of this preliminary risk assessment, use of the UCB-RFS is unlikely to pose health risks, but could pose risks under the following conservative exposure scenarios:

- Daily worker exposure for an extended period of time to soil contaminated with over 600 mg/kg of mercury alone or over 1000 mg/kg of lead alone. Health risks could also be posed by soils containing slightly lower levels of both metals in combination.

- Frequent accidental or intentional ingestion exposure to soil or off-site marsh sediments containing more than background levels of arsenic.

Based on the available information and on site characteristics, soil remediation levels of around 600 mg/kg of mercury and 1,000 mg/kg of lead would probably be sufficient to protect workers. Concurrent exposure to soils containing these levels of metals might be of some concern but based on the available data, elevated levels of mercury and lead do not occur in the same areas.

Under the exposure scenarios used in the preliminary risk assessment, even background levels of arsenic pose a risk above the one in one million cancer risk commonly used as a risk goal by regulatory agencies. However, based on the expected use of the facility and the cleanup levels established for other sites, a cleanup level for arsenic in the range of 100 - 200 mg/kg seems appropriate for the UCB-RFS. It also seems unlikely that the no action alternative would pose a substantial health risk given the presence of elevated levels of arsenic in only two isolated areas of the facility.

The cleanup levels that are provided above indicate the concentration of a material that would be unlikely to pose a health risk under the conditions of regular repeated contact for an extended period of time. If such frequent exposure is unlikely, concentrations exceeding these levels would also not pose a significant health risk. For example, only two on-site arsenic concentrations are above the 100 mg/kg value used in the risk calculations, and 34 of 37 surface soil samples analyzed were at expected background levels. Similarly, for mercury, only one on-site surface concentration exceeded 600 mg/kg and for lead only one value exceeded 1,000 mg/kg. Because frequent direct contact with these areas is unlikely, the presence of arsenic and lead at these levels is unlikely to pose a health risk.

Numerous factors influence the uptake of metals by aquatic organisms and consequently it is difficult to accurately quantify exposure via the consumption of fish or shellfish harvested from the marsh. However, elevated sediment concentrations of some of the metals were present in discrete areas in the marsh and it appears prudent to limit consumption of benthic organisms, including shellfish, from these areas. A factor mitigating the potential concern for this pathway is that arsenic is converted by aquatic organisms to an organic arsenical which is not metabolically active and is rapidly eliminated from the human body.

In order to ensure that the health of on-site and off-site workers and any nearby residents is adequately protected, conservative (health protective; unlikely to underestimate risk) assumptions were used in deriving both the exposure estimate and the toxicity values. Because of the use of these conservative (although not necessarily worst case) assumptions, it is unlikely that chemicals remaining at the site at these levels would pose an actual hazard. Any response action that would eliminate the ingestion exposure pathway for soils (such as capping, asphalting, fencing, other access restrictions, or use restrictions) would further limit the potential for exposure and protect public health and welfare.

PRELIMINARY RISK ASSESSMENT
UNIVERSITY OF CALIFORNIA
RICHMOND FIELD STATION

1.0 INTRODUCTION

The purpose of this preliminary risk assessment is to analyze the extent of the mercury and heavy metal contamination at the University of California at Berkeley's Richmond Field Station (UCB-RFS) and determine if this contamination could pose a risk to public health. The preliminary site-specific risk assessment can be used to determine whether or not risks to public health are posed by the no action alternative or by some minimal remedial action such as capping with clean fill.

Preparation of the risk assessment consists of combining the site-specific information with standard risk assessment assumptions and formulas to estimate potential exposure, and then combining the exposure estimate with toxicity information to estimate risks. A key part of this risk assessment process is an evaluation of the uncertainties associated with the assessment process and a review of past regulatory practices at other mercury- and metal-contaminated sites.

This risk assessment was conducted in compliance with the following documents:

California Department of Health Services (DHS) 1990. Book II - Scientific and Technical Standards for Hazardous Waste Sites (Draft). Toxic Substances Control Program, Program and Administrative Support Division, Technical Services Branch, DHS. August 1990. DHS Doc. No. 7540-958-1102-0

Environmental Protection Agency (EPA) 1988. Superfund Exposure Assessment Manual. Office of Remedial Response, USEPA, Washington, D.C. April 1988. EPA 540/1-88-001

Environmental Protection Agency (EPA) 1989. Exposure Factors Handbook. Office of Health and Environmental Assessment, Washington, D.C. July 1989. EPA 600/8-89/043

Environmental Protection Agency (EPA) 1989. Risk Assessment Guidance for Superfund: Human Health Evaluation Manual, Part A (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. July 1989. OSWER Directive 9285.701A

Environmental Protection Agency (EPA) 1989. Air/Superfund National Technical Guidance Study Series - Procedures for Conducting Air Pathway Analyses for Superfund Applications (Interim Final) Volumes I-IV. Office of Air Quality Planning and Standards, Research Triangle Park, NC EPA 450/1-89-001 - EPA 450/1-89-004

Environmental Protection Agency (EPA) 1990. Health Effects Assessment Summary Tables: Most recent update. Office of Health and Environmental Assessment, Cincinnati, Ohio, OERR 9200.6-303-(90)

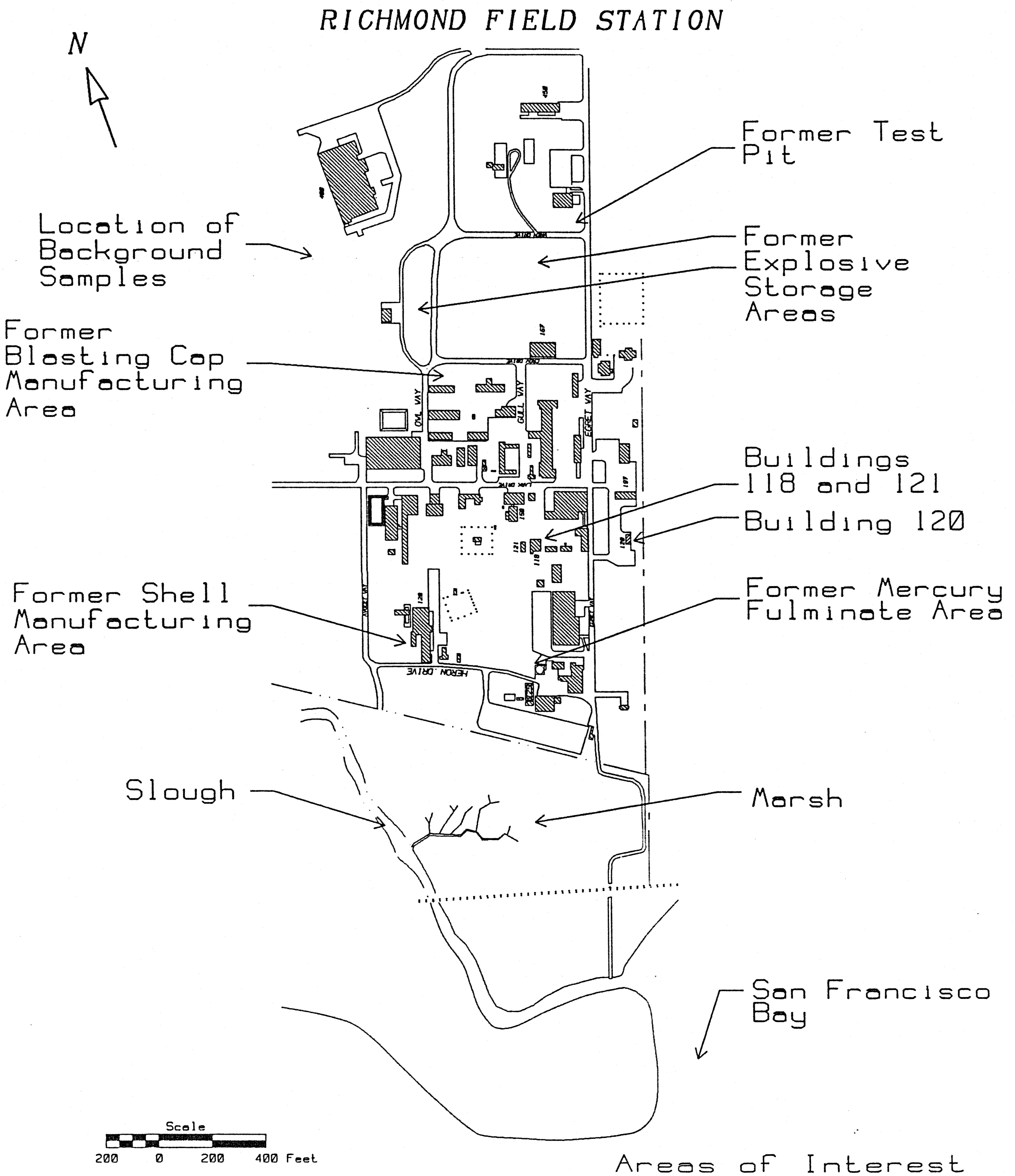
Environmental Protection Agency (EPA) 1990. Integrated Risk Information System (IRIS). Chemical-specific reference doses and cancer potency factors and EPA Toxicology Background Documents. Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, Ohio.

Section 2 of the risk assessment contains background information on the site and information on the nature and extent of contamination. In section 3, the environmental fate and transport of the key site contaminants and the key toxicological characteristics of these compounds are discussed. As part of the toxicological assessment section, health-based criteria, and other established criteria and guidance are identified. An exposure assessment, including a discussion of exposure pathways, a description of potential receptors, and a quantitative estimate of exposure, are presented in section 4. Section 5 contains the risk characterization, in which information on the toxicity of the metals (from section 3) is combined with the results of the exposure assessment (from section 4) to determine if the site poses a risk to public health or the environment. A discussion of the uncertainties in the risk assessment is also included in this section and site-specific soil remediation levels are developed. The conclusions of the risk assessment are presented in section 6.

2.0 SITE CHARACTERIZATION

2.1 Site Background

The University of California at Berkeley's Richmond Field Station (UCB-RFS) is located in Richmond, California at 1301 South 46th Street (Figure 2-1). Explosives manufacturing was conducted in an area that included the southeastern portion of the site from the 1840s to about 1945. A major part of the operations in this area involved the production of mercury fulminate. Mercury fulminate is very explosive when dry and is generally stored in water. Fumes and dusts of mercury fulminate may be emitted during manufacture. The University of California purchased the property in 1950.



Areas of Interest
on the
University of California
Richmond Field Station

Prepared by
JONAS & ASSOCIATES

Date: 12-20-1990 Scale as shown	Figure 2-1	Drawing Number	

Figure 2-1

Drawing Number

Checked by

Approved by

Drawn by AJ 12-20-1990

Between 1950 and 1953, parts of the site were cleared for construction by burning. Several explosions were noted during these burning operations, suggesting that at least some mercury fulminate had been deposited on site.

Current land uses adjacent to the UCB-RFS are primarily industrial. A Safeway Distribution Center lies to the north, the Price Club and Bio Rad Labs are located to the east, and ICI Americas (ICI) lies to the west of UCB-RFS. Prior to 1987, the ICI Americas property was owned by Stauffer Chemical Company. The Richmond Inner Harbor lies to the south of the facility, along the shoreline of the City of Richmond. The U.S. Environmental Protection Agency intends to construct a laboratory on the property and is concerned about the mercury detected at the site.

Under regulatory direction from the Regional Water Quality Control Board (RWQCB), ICI Americas completed a preliminary investigation of its property in December 1987. Under a Remedial Action Program designed and implemented by ICI, shallow groundwater under their facility was found to be contaminated with pesticides. The RWQCB requested that ICI Americas perform a hydrogeologic investigation of the closed cinder landfill and associated ponds also formerly operated by Stauffer.

The UCB-RFS site is located adjacent to the Richmond Inner Harbor of San Pablo Bay and consists of the fenced research facility and a marsh area immediately south of the facility. For purposes of this assessment, the terms "property" or "site" will be used to refer to the entire area (research station and marsh) while the terms "facility" or "research station" will refer only to the fenced area (i.e. will exclude the marshy section of the UCB property). San Pablo Bay (in the northern portion of San Francisco Bay) forms the major surface water body to the south of the property. The marsh drains south into San Pablo Bay through a single opening in a raised Santa Fe Railroad causeway.

No streams are present on the UCB-RFS 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 UCB-RFS a tidal slough collects water from urban storm drainage throughout the City of Richmond. This slough is used by local industrial dischargers and is hydraulically connected with the marsh at the border of San Pablo Bay.

2.2 Geologic and Hydrogeologic Setting

2.2.1 Geology

The Richmond Field Station is a 150-acre property located at the distal end of an alluvial plain that slopes in a southwesterly direction toward the San Pablo Bay. To the northeast lies the Hayward Fault Zone, which transects the upper alluvial plain approaching the Berkeley Hills. The southern portion of the Richmond Field Station comprises 50 acres of marsh, which drains south into the San Pablo Bay.

The alluvium is Quaternary in age and consists primarily of consolidated to unconsolidated clays, silts, sands, and gravels. The total thickness of these deposits varies across the alluvial plain, reaching a maximum estimated thickness of 300 feet. Mesozoic Franciscan Formation underlies the alluvium, consisting of a complex assemblage of serpentinite, greenstone, graywacke, chert, shale, sandstone, and schist.

Subsurface geology of the alluvium in the area of the Richmond Field Station has been characterized by numerous boring logs, some exceeding 100' in depth (Pouch, 1987; Jonas and Associates, 1990). These boreholes indicate the following generalized stratigraphy:

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

Pouch (1987) interprets these deposits to reflect intertonguing marine and alluvial deposits. He proposes that the lower sands and gravels are alluvial and were deposited unconformably above the Franciscan Formation during the initial Quaternary subsidence of the Bay. A later sea level rise (probably related to the Sangamon Interglacial highstand) resulted in the marine deposition of clays and sandy clays, which are intercalated with minor alluvial deposits. Alluvial sands and gravels increase in upper sections, corresponding to a drop in sea level or progradation of the shoreline. The uppermost clay may represent another period of marine transgression, or possibly just landfill.

2.2.2 Hydrogeology

The Richmond Field Station lies within the Alameda Bay Plain Groundwater Basin between the Berkeley Hills and the San Francisco Bay. Groundwater flow in the area is poorly known; the low permeability of the clays and limited thickness of transmissive units precludes use by local municipalities or for agricultural irrigation. On the basis of geologic correlations, groundwater is probably channeled into deposits of former river channels, distributaries and near shore marine sands and gravels. Groundwater flow paths are undoubtedly complicated and tortuous in the channel and bar finger deposits, with thick overlying clay. These deposits may represent confined aquifers.

Groundwater recharge in the area is believed to occur along the Wildcat and San Pablo stream beds, located approximately 1.5 miles northeast of the Richmond Field Station. Large paved areas and the occurrence of low permeability shallow clays greatly limit recharge of groundwater by rainfall infiltration.

Monitoring wells have been installed at the UCB-RFS and the adjacent ICI Americas properties (Jonas and Associates Inc., 1990). ICI monitoring wells indicate that shallow groundwater has a hydraulic gradient of approximately 0.004, with a hydraulic conductivity between 0.4 to 17 gal/day/ft^2 (Hall, 1988). Using an estimated effective porosity of 0.25, groundwater velocity is calculated to range between 0.3 to 13 feet/year.

Groundwater in the monitoring wells first appears between 5 to 10 feet below the surface. Due to thick surficial clays, shallow groundwater often occurs under confined to semiconfined conditions within lenses of sand and gravel. Deeper transmissive water-bearing conditions occur at a depth of 90 feet, where a sandy gravel unit occurs. At intermediated depths, perched groundwater is often encountered in sand and gravel above beds of low permeability clay.

Aquifer tests on the 90 foot wells on the RFS property were conducted in 1954 by the U.C. Sanitary Engineering Research Laboratory. They estimated the aquifer to be 3.5 feet thick and to have a hydraulic conductivity of 1,760 gal/day/ft^2 (235 ft/day).

2.3 Nature and Extent of Contamination

Investigations of the site have been conducted by the California Department of Health Services (DHS) in 1981 and 1982, by CH2M Hill in 1988, and by Jonas and Associates in 1989 and 1990. These investigations indicate that mercury is present within the fenced area of the property at levels exceeding the State of California Total Threshold Limit Concentrations (TTLC) of 20 mg/kg, with a maximum concentration of 630 mg/kg detected on site. Arsenic, copper, and lead were also detected on the facility grounds and in the marsh at levels above the expected background concentrations for these metals (see section 2.4). Information on past sampling and analysis at the site is described in the Environmental Sampling and Analysis Plan and in a Preliminary Remedial Investigation report prepared by Jonas and Associates Inc. (1990a,b). Sample results collected by Jonas and Associates from December 1989 to February 1990 and in November and December 1990 were used for the preliminary risk assessment. Sampling results pertinent to the Preliminary Risk Assessment are presented in Tables 2-1 and 2-2 and in Appendix A.

Extensive soil sampling was conducted by Jonas & Associates Inc. at the Richmond Field Station between December 1989 and February 1990. Soil samples composited from 0-3 foot depths were analyzed for the presence of mercury for sampling points across the facility. Figure 2-2 presents the locations of the soil samples collected during this time period. Soil samples were also taken from a limited number of locations for copper, zinc, nitrate, and sulfate. Copper and zinc were analyzed because they had been detected at elevated levels in earlier sampling. Sampling for nitrate was conducted because nitrate is an expected breakdown product of mercury fulminate degradation. Sampling for the presence of sulfate was conducted to determine if flooding from the ICI Americas Ponds had contaminated the site.

In addition to the 0-3 foot soil samples, 10 surface soil samples (0-3 inches) were collected and analyzed for mercury and the 0-3 foot composite with the highest mercury concentrations (B-18; 630 mg/kg) was reanalyzed at 1 foot intervals. A groundwater monitoring well was installed and composite soil samples from 0-0.5, 2.5-4.5, 4.5-6.0, 6.0-7.5, and 7.5-9.0 feet were analyzed to determine the vertical extent of the mercury in site soils.

A second round of sampling was conducted by Jonas & Associates Inc. in the fall of 1990 to evaluate mercury levels in areas not previously sampled, to determine the concentrations of other metals, total petroleum hydrocarbons, and pesticides at the site, and to better define the vertical extent of on-site mercury. Samples were collected from the explosive storage area, the blasting cap area, the slough, the pier, the west and east storm drains, and the marsh. These samples were analyzed for the EPA target list of 22 metals, including mercury, arsenic, copper, lead, selenium, and zinc.

The locations of the samples collected in the fall of 1990 by Jonas and Associates Inc. are presented in Figure 2-3 for the former Shell Manufacturing Area and Mercury Fulminate Facility. Figure 2-4 presents the locations of the samples collected in the fall of 1990 in the marsh. Average, 95% upper confidence limit values (UCL), and maximum concentrations detected at selected locations within the fenced facility and in the marsh are presented in Tables 2-1 and 2-2, respectively. Sampling data are provided in Appendix A of this report.

TABLE 2-1

CONCENTRATIONS OF METALS IN SURFACE SOIL AT THE UCB-RFS FACILITY

CHEMICAL	NO. OF DETECTIONS/ NO. OF SAMPLES	MEAN[a] (mg/kg)	UCL[b] of MEAN (mg/kg)	MAXIMUM CONC. (mg/kg)
Antimony	5/37	6	14	45.3
Arsenic	33/37	15	99	236
Barium	37/37	235	451	95
Beryllium	21/37	.47	.59	67
Cadmium	35/37	2	6	9.2
Chromium	37/37	31	56	71.2
Cobalt	37/37	19	37	51.5
Copper	37/37	222	788	1140
Lead	37/37	100	543	1140
Mercury	80/86	25	180	630
Molybdenum	0/37	3	4	ND
Nickel	37/37	34	62	79.7
Selenium	0/37	2	9	ND
Silver	2/37	2	2	2.1
Thallium	0/37	1	3	ND
Vanadium	37/37	27	39	40.1
Zinc	37/37	249	1056	1550

ND = Not Detected

[a] Values are arithmetic means or averages of samples collected from selected areas of the site.

[b] Values are upper 95% confidence limits of the arithmetic mean

TABLE 2-2

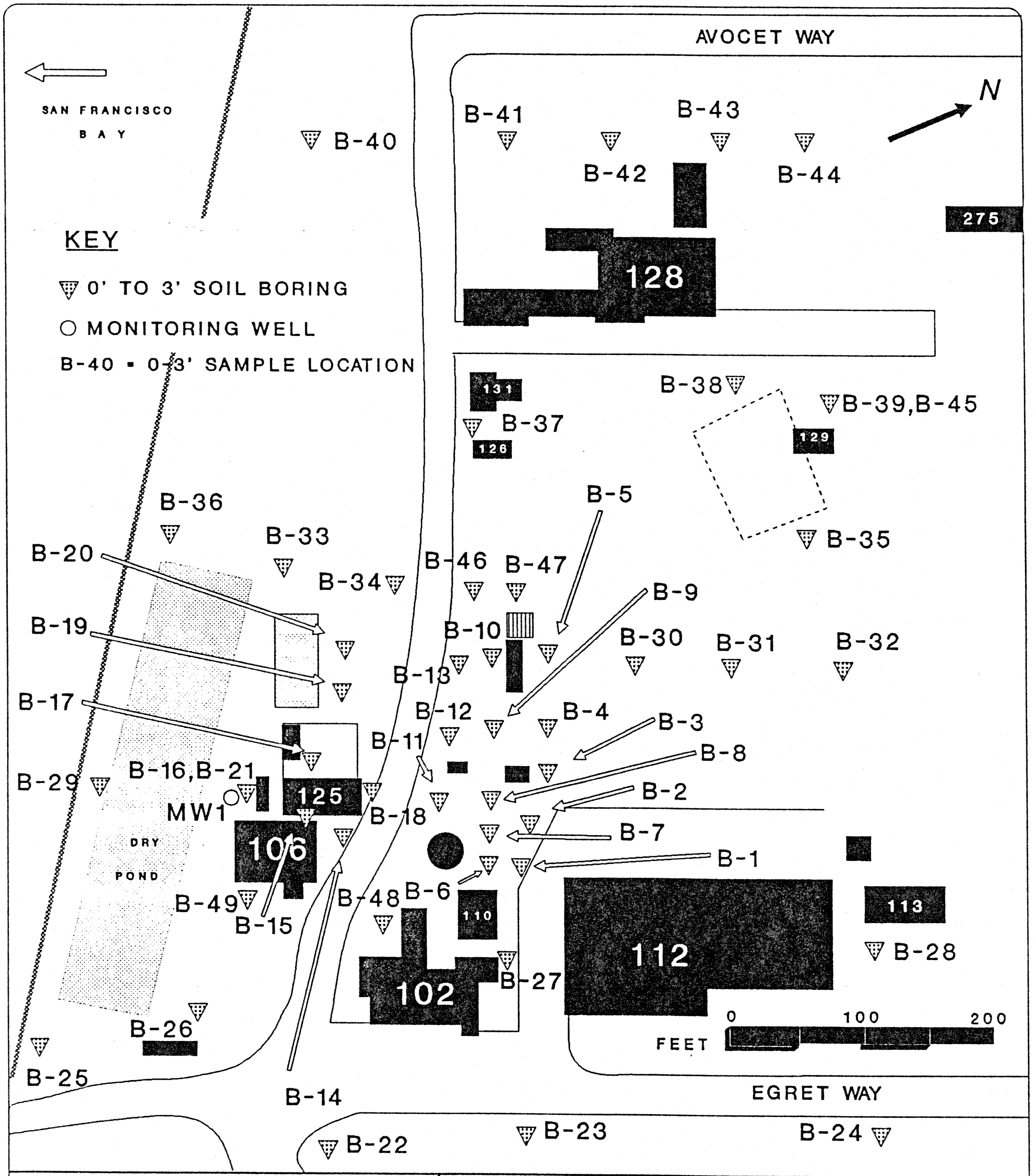
CONCENTRATIONS OF METALS IN MARSH SEDIMENTS AND SOIL AT THE UCB-RFS SITE

CHEMICAL	NO. OF DETECTIONS/ NO. OF SAMPLES	MEAN[a] (mg/kg)	UCL[b] of MEAN (mg/kg)	MAXIMUM CONC. (mg/kg)
Antimony	3/11	21	42	47.9
Arsenic	9/11	408	700	2210
Barium	11/11	107	210	195
Beryllium	2/11	1	2	1
Cadmium	11/11	3	12	12.3
Chromium	11/11	108	210	209
Cobalt	10/11	17	30	27
Copper	11/11	293	670	519
Lead	11/11	135	320	357
Mercury	10/11	10	33	36
Molybdenum	1/11	7	13	11
Nickel	10/11	65	120	111
Selenium	2/11	10	NA	11
Silver	0/11	3	6	ND
Thallium	0/11	7	14	ND
Vanadium	11/11	67	110	109
Zinc	11/11	705	1500	1470

ND = Not Detected

[a] Values are arithmetic means or averages of samples collected from the marsh

[b] Values are upper 95% confidence limit of the arithmetic mean



Prepared for

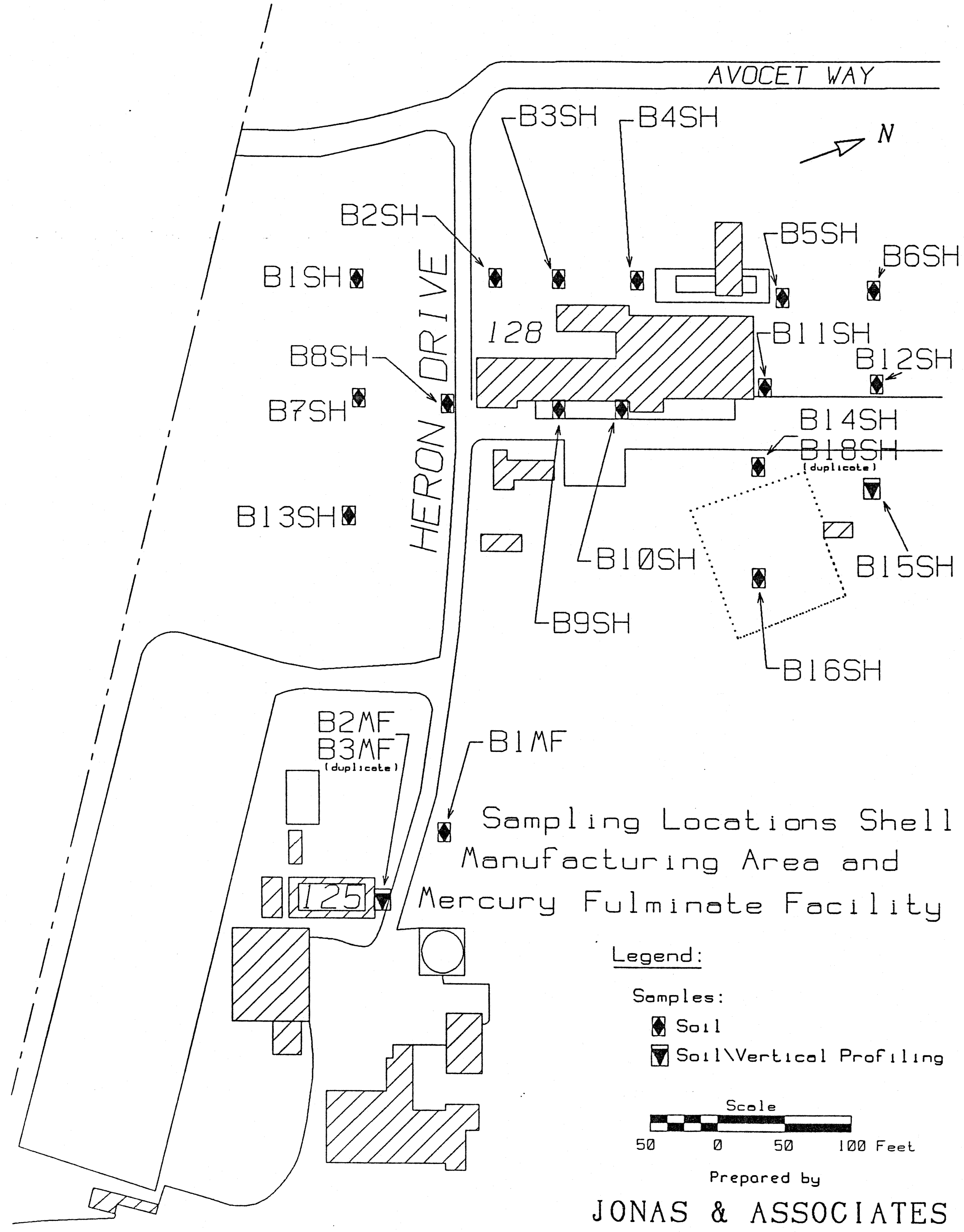
UNIVERSITY OF CALIFORNIA

Richmond Field Station

Prepared by

JONAS & ASSOCIATES

FIGURE 2-2
LOCATION OF SOIL SAMPLES AND MONITORING WELL
(J&A, 1989-90)



Sampling Locations Shell Manufacturing Area and Mercury Fulminate Facility

Prepared by

JONAS & ASSOCIATES

Date: 12-20-1990
Scale as shown

Figure 2-3

Drawing Number

Figure 2-3
Drawing Number
Checked by
Approved by
AJ
12-20-1990
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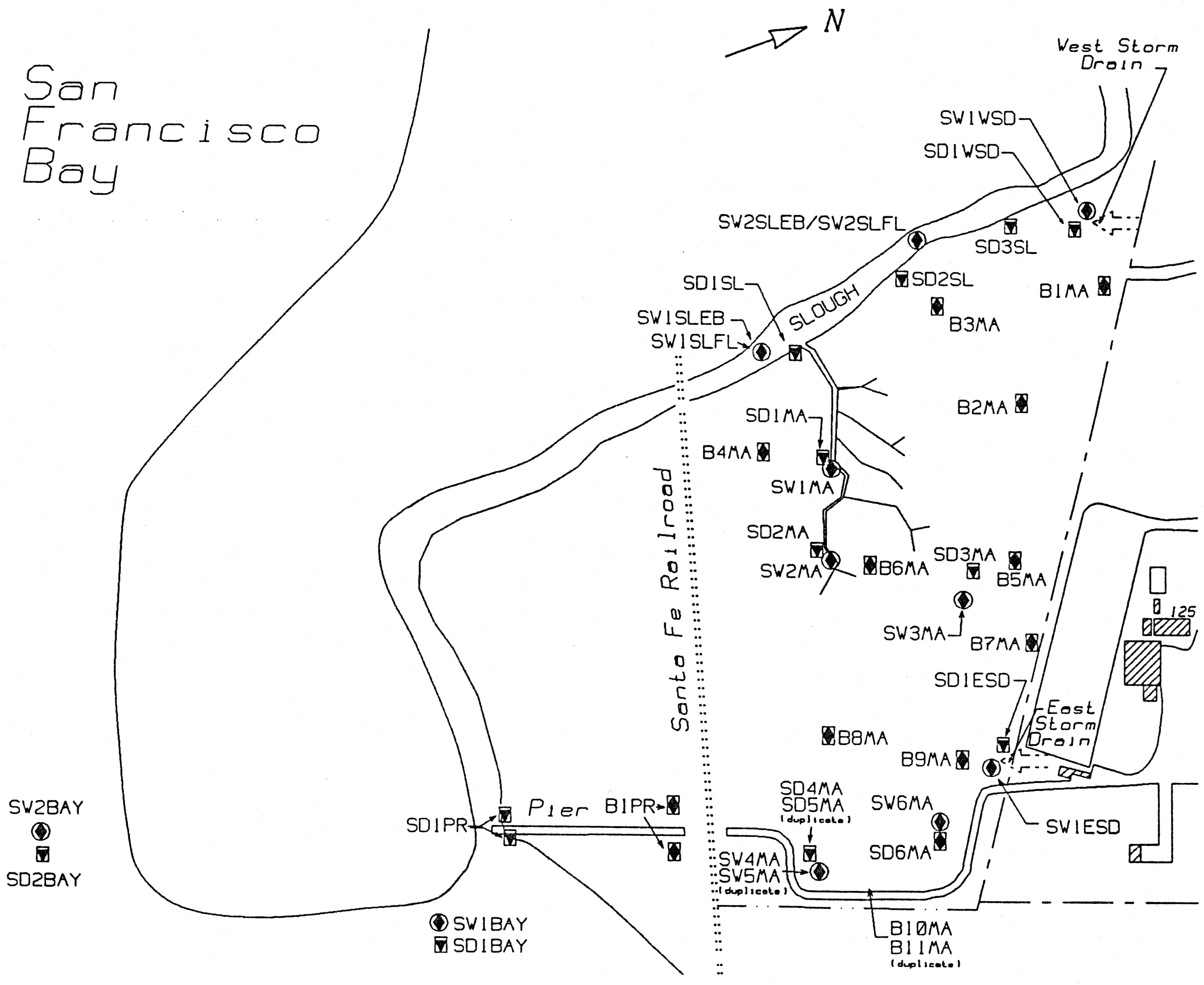


Legend:

Samples:

- ◆ Soil
- ▼ Submerged Sediment
- ◈ Surface Water

Scale

150 0 150 300 Feet

Sampling Locations Slough, East and West Storm Drains, Marsh and Bay

Prepared by

JONAS & ASSOCIATES

Date: 12-20-1990

Scale as shown

Figure 2-4

Drawing Number

Figure 2-4

Drawing Number

Checked by

Approved by

AJ

12-20-1990

Drawn by

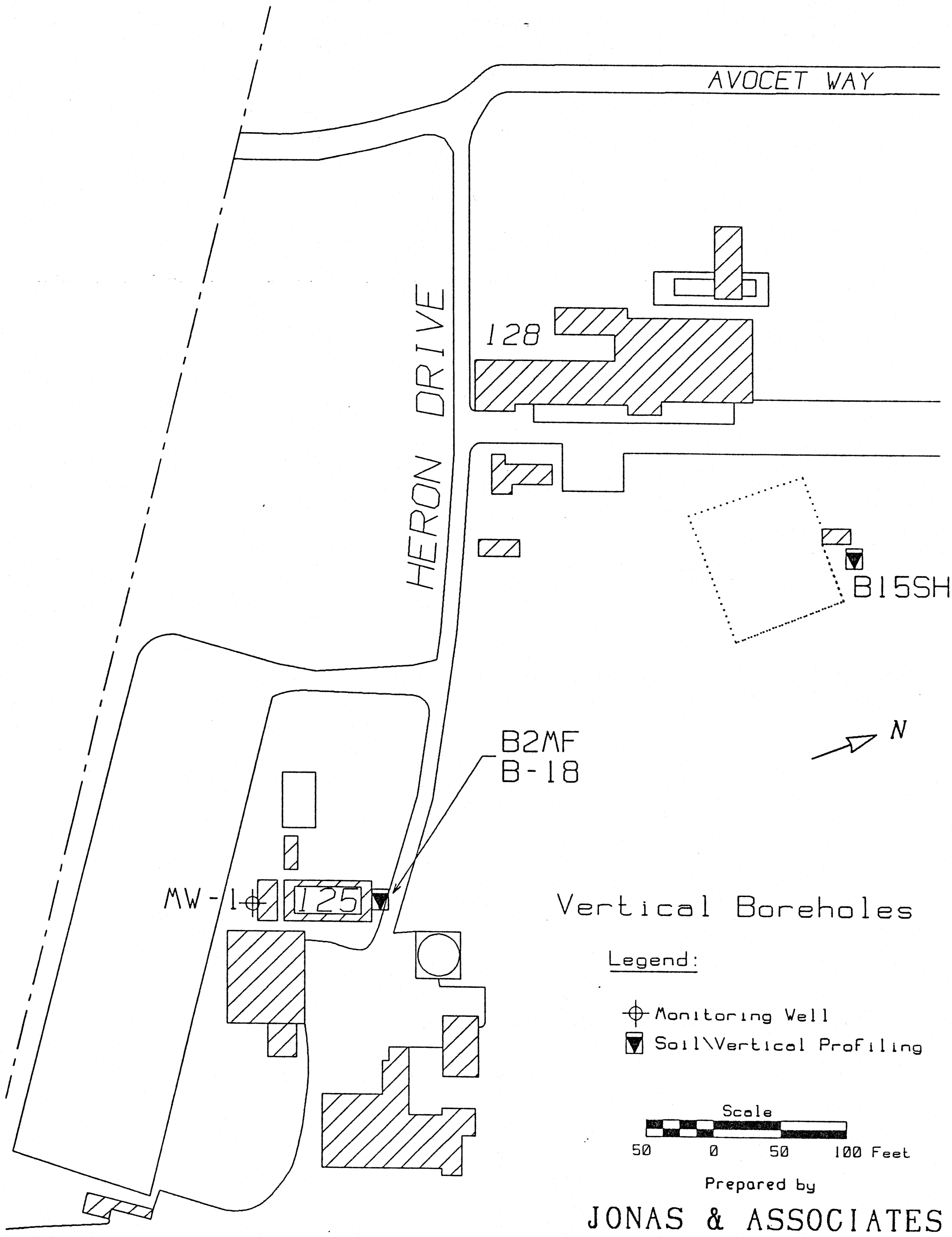
Jonas and Associates collected samples from areas of the site that past use suggested may have elevated concentrations of metals. Consequently, the average values reported in Tables 2-1 and 2-2 are not representative of the entire site, but rather only the areas sampled. The areas sampled include the former Mercury Fulminate Facility, former Shell Manufacturing Area, former Explosive Storage Area, and the Marsh.

Vertical samples were collected in the area of sampling point B-18, where the highest soil samples had been collected (Boring B2MF) and in an upgradient area near Building 129 (Boring B15SH). Figure 2-5 shows the locations of the vertical samples. Table 2-3 presents the concentrations of mercury detected at different depths. MW-1 was sampled at depths of 0-0.5, 2.5-4.5, 4.5-6.0, 6.0-7.5, and 7.5-9.0 feet. The sample at boring B-18 was sampled at 0-1, 1-2, and 2-3 feet. Six inch samples were collected in October 1990 from borings B2MF and B15SH at depths of 1.5, 4.0, 6.5, 9.0, 11.5, and 14.0 feet.

Data from boring MW-1 indicates that mercury was present on the south side of Building 125 from the surface to approximately 7.5 feet, at concentrations between 20 and 40 mg/kg. At approximately 7.5 feet below grade, the soil profile changes from silty clay to silty sand. The sample taken below this level showed a mercury concentration of 2.7 mg/kg. This data suggests that the silty clay has less of a tendency to bind the mercury than the organic-rich silty clay.

Levels reported for boring MW-1 were consistent with values detected elsewhere on the site. Higher levels were reported from the north side of Building 125, where an average of 630 mg/kg was detected in a 0-3 foot sample. Samples from 0-1, 1-2, and 2-3 foot depths in B-18 indicated that the mercury was uniformly distributed at approximately 500 mg/kg. (The slight discrepancy between the average of 500 mg/kg for the three samples and 630 mg/kg for the single composite is not inconsistent with common field sampling or laboratory error).

Samples B2MF and B15SH provide information on the vertical mercury migration. Data are slightly elevated from the 1.5 foot depth in both borings (4.4 mg/kg in B2MF and 6.4 mg/kg in B15SH) and at the 4 foot depth in B2MF (2.6 mg/kg). However, mercury concentrations below this depth are fairly uniform and appear to be close to expected background levels (0.1 - 2 mg/kg). Boring B2MF (4.4 mg/kg at 1.5 feet) was collected within one foot of B-18 (concentration of 470 mg/kg at 1-2 feet). These values differ by over two orders of magnitude (a factor of 100). Possible explanations for this difference are that the mercury contamination may be highly localized and the newer samples may have been collected from cleaner areas or that the heterogeneity of the sampling matrix may have significantly affected the sampling results.



Vertical Boreholes

Prepared by

JONAS & ASSOCIATES

Date: 12-20-1990 Scale as shown	Figure 2-5	Drawing Number

Figure 2-5

Drawing Number

Checked by

Approved by

AJ

12-20-1990

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TABLE 2-3

CONCENTRATION OF MERCURY AT VARYING DEPTHS

	Concentrations at Site Boring Locations (mg/kg)			
Depth (feet)[a]	MW-1	B-18	B2MF	B15SH
0 - 1.0	24	560	240[b]	5[c]
1.0 - 2.0	NA	470	4.39	6.42
2.0 - 3.0	NA	510	NA	NA
2.5 - 4.5	36		2.6	0.3
4.5 - 6.0	27		NA	NA
6.5 - 7.5	24		0.46	0.26
7.5 - 9.5	2.7		<0.12	0.11
11.5	NA		1.63	0.11
14.0	NA		2.03	0.25

[a] Samples were composited from different depths but are grouped here for purposes of comparison. For example, a 6 inch sample collected at approximately 4 feet in B15SH and B2MF is compared with the MW-1 composite for 2.5 - 4.5 feet.

[b] Value reported for a 0-3 inch surface soil sample (B-18) during previous sampling round (Jonas & Associates: December 1989 - January 1990). A concentration of 630 mg/kg mercury was reported for a 0 - 3 foot sample from the same area.

[c] Value is average of three 0-3 foot samples reported from approximately the same area (Borings B-35, B-39, and B-45).

2.4 Selection of Key Site Chemicals

When a number of chemicals is detected at a site, a subset of key site chemicals is often selected in order to focus the assessment on those contaminants that are most likely to pose risks at the site. The following criteria were used to select the chemicals of concern at the UCB-RFS site:

> Past use at the site. Mercury is a key constituent of the mercury fulminate that was produced at the facility. Consequently, it will be included as a key chemical in this assessment.
>
> Comparison with background concentrations. Concentrations of contaminants detected on the site were compared to concentrations detected in samples from off-site areas that were not contaminated by the site. For purposes of selecting the chemicals of concern, chemicals with upper confidence limit values not exceeding the expected background concentrations were considered not to be different from background.
>
> Concentration, toxicity, and physicochemical properties. The relative concentrations and toxicity of chemicals with similar physicochemical properties were compared. Chemicals clearly posing a hazard well below (one or more orders of magnitude) that of other contaminants were removed from further consideration.

Metals are natural constituents of all soils; in order to determine if levels of metals detected in surface soils at the UCB-RFS site were site-related, concentrations detected at potentially contaminated areas of the facility were compared to levels present in clean areas and in uncontaminated soils nationwide. Site-specific background samples were taken from adjacent to Building 400 (BG1 and BG2) in locations that were considered unlikely to be affected by the site. Background levels in the conterminous United States are available for most of the metals detected on the property (Shacklette and Boerngen 1984). Table 2-4 presents a comparison of samples from the facility (within the fenced portion of the site) with background levels. The values used for the national background data are the 95% upper confidence limit on the geometric means for these metals. Geometric means are used because Shacklette and Boerngen (1984) and other researchers note that environmental data tend to be log-normally distributed. Average values or arithmetic mean values are overly influenced by high concentration values and therefore will tend to be higher than geometric means. The maximum site-specific background value was also used for comparison purposes.

TABLE 2-4

COMPARISON OF SURFACE SOIL CONCENTRATIONS AT THE UCB-RFS SITE

	FACILITY SOIL		BACKGROUND SOIL	
CHEMICAL	UCL[a] OF MEAN (mg/kg)	MAXIMUM CONC. (mg/kg)	UCL[b] OF US DATA (mg/kg)	MAXIMUM ON-SITE (mg/kg)
Antimony	14	45.3	NA	ND
Arsenic	99	236	25	ND
Barium	451	95	1600	142
Beryllium	.59	67	3.4	0.65
Cadmium	6	9.2	NA	3.1
Chromium	56	71.2	220	45.1
Cobalt	37	51.5	40	9.5
Copper	788	1140	100	22.4
Lead	543	1140	58	10.7
Manganese	2290	4280	3700	360
Mercury	180	630	0.4	ND
Molybdenum	4	ND	4.9	ND
Nickel	62	79.7	75	38.7
Selenium	9	ND	1.7	ND
Silver	2	2.1	NA	ND
Thallium	3	ND	20	ND
Vanadium	39	40.1	290	25.8
Zinc	1056	1550	180	37.1

[a] Values are 95% upper confidence limit of the average soil concentration from selected areas within the fenced area of the UCB-RFS property.

[b] Value is the 95% upper confidence limit of the geometric mean of soil concentrations in the conterminous U.S. as reported by Shacklette and Boerngen (1984)

ND = Not Detected

Based on a comparison with background metals, antimony, arsenic, copper, lead, mercury, and zinc are present at elevated levels on the active portion of the site. Antimony was detected infrequently (5/37 samples) and compared with the other metals detected at the facility does not contribute substantially to health hazards. It is therefore not considered as a key site contaminant for the UCB-RFS. Arsenic, copper, lead, and mercury are all toxic and are selected as key site chemicals. Zinc is present on site at levels within the range of expected background levels for the western United States (<2,000 mg/kg; Shacklette and Boerngen 1984) and is not particularly toxic. It is unlikely to contribute substantially to health hazards, and consequently is not considered as a key site contaminant.

Low levels of alpha-BHC (hexachlorocyclohexane) and DDD, a breakdown product of DDT were also detected in the marsh. These compounds are persistent organochlorine pesticides that were in common use until the early 1970s. Because these compounds degrade slowly, they are commonly found in sediments as a result of non-point source releases from farming. The compounds were present at levels below the California TTLC for DDT of 1 mg/kg and 4 mg/kg for the gamma-BHC isomer (lindane). Because these compounds are not known to be site-related and may be present at area-wide background levels, they are not considered as key site contaminants at the UCB-RFS.

3.0 CHARACTERISTICS OF KEY CHEMICALS

3.1 Environmental Fate and Transport

The environmental behavior of chemicals is dependent on the physical and chemical properties of the compounds, the environmental transformation processes affecting them, and the characteristics of the media (soil, sediments, water) in which they are present and through which they may migrate. The principal environmental fate processes for metals is adsorption to soils, leaching into the underlying soils and groundwater and subsequently to off-site areas, or volatilization into the atmosphere. Because exposure of human and environmental receptors is highly dependent on the fate and transport of the chemicals of concern, these characteristics are discussed in detail as part of the risk assessment.

Most metals are not considered to be very mobile in the environment and are likely to remain bound to site soils. However, the behavior of individual metals is highly dependent on their form in the environment and infiltrating precipitation may leach the more soluble chemicals from soil and transport them into the groundwater. Soil parameters that must be considered are clay and metal oxide content, fraction of organic matter, Ph, and oxidation-reduction potential. Chemical partitioning between soil and water can be expressed by a soil-water distribution coefficient (K_d). The K_d values may underestimate migration potential because they are based on chemical adsorption and desorption reaching equilibrium. As a rough estimate of relative mobilities, K_ds for the inorganic chemicals of concern can be compared. For example, cadmium has a low K_d of 6.5 whereas lead, with a K_d of 900, is much less mobile. However, mobility can be enhanced by the presence of other chemicals such as naturally occurring humic materials.

Mercury

Mercury exists in the environment in several forms including elemental metal, inorganic salts, organic mercury complexes and alkyl mercury (EPA 1985). The specific form depends on such factors as Ph, redox potential, the anions present (particularly chloride and sulfate), and the presence of methylating bacteria.
Elemental mercury is a silver liquid with an atomic weight of 200.59, a boiling point of 356.6°C, a melting point of -38.9°C, and a specific gravity of 13.6 at 20°C. Elemental mercury is relatively insoluble in water, with a water solubility of 0.081 mg/liter at 30°C. Mercury has a vapor pressure of 0.0012 torr, and volatilizes fairly readily from surface soils.

Mercury and certain of its compounds, including several inorganic species and dimethyl mercury, can volatilize to the atmosphere from aquatic and terrestrial sources. Volatilization is reduced by conversion of metallic mercury to complexed species and by deposition of HgS in reducing sediments, but even so, atmospheric transport is the major environmental distribution pathway for mercury. Precipitation is the primary mechanism for removal of mercury from the atmosphere. Photolysis is important in the breakdown of airborne mercurials and may be important in some aquatic systems. Adsorption onto suspended and bed sediments is probably the most important process determining the fate of mercury in the aquatic environment. Adsorption is strongest onto organic materials. Mercury in soils is generally complexed to organic compounds.

In general, the mercuric salts (Hg^{+2}) are more soluble than the mercurous salts. In addition, virtually any mercury compound can be remobilized in aquatic systems 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 strongly bioaccumulated by numerous mechanisms. Methylmercury is the most readily accumulated and retained form of mercury in aquatic biota, and once it enters a biological system it is very difficult to eliminate.

3.2 Toxicity/Hazard Evaluation

Preparation of a toxicity/hazard assessment involves considering the types of adverse health effects associated with the chemicals of concern and identifying the amount (dose) of these chemicals required to produce these adverse effects. A brief description of the type of toxic effects associated with the chemicals of concern is presented in the assessment. This information was used as the basis for determining if the chemicals posed a substantial risk. The EPA (1989) hierarchy of approved sources of toxicity information was followed in selecting the most appropriate toxicity criteria for individual chemicals. Specifically, criteria that have been validated by an intra-agency EPA toxicology workgroup (the IRIS database) were used preferentially to other EPA values, with values that have not been reviewed by EPA used only if EPA-approved values were not available.

Mercury

Mercury can cause adverse neurological and renal effects in humans (EPA 1984). Inhalation of high concentrations of mercury vapor can cause pneumonitis, bronchitis, chest pains, dyspnea, coughing, stomatitis, gingivitis, salivation, and diarrhea. Soluble mercuric salts are highly poisonous by ingestion, with oral LD_{50} values of 20 to 60 mg/kg reported. Mercurous compounds are less toxic when administered orally. Acute exposure to mercury compounds at high concentrations causes a variety of gastrointestinal symptoms and severe anuria with uremia. Signs and symptoms associated with chronic exposure involve the central nervous system and include behavioral and neurological disturbances.

When administered by intraperitoneal injection, metallic mercury produces implantation site sarcomas in rats. No other studies were found connecting mercury exposure with carcinogenic effects in animals or humans but several mercury compounds exhibit a variety of genotoxic effects in eukaryotes. Although brain damage due to prenatal exposure to methylmercury has occurred in human populations, no conclusive evidence is available to suggest that mercury causes anatomical defects in humans. Embryotoxicity and teratogenicity of methylmercury has been reported for a variety of experimental animals and mercuric chloride is reported to be teratogenic in experimental animals. No conclusive results concerning the teratogenic effects of mercury vapor are available.

Organic mercury compounds can produce toxic effects on the heart, liver, and immune system in experimental animals. In humans, alkyl mercury compounds pass through the blood brain barrier and the placenta very rapidly, in contrast to inorganic mercury compounds. Methylmercury is particularly hazardous because of the difficulty of eliminating it from the body. Alkyl mercury compounds are generally considered to be more toxic than inorganic mercury; some conversion of inorganic to methylated mercury occurs in the body. EPA (1989) established an oral reference dose for alkyl and inorganic mercury of 3 x 10^{-4} (mg/kg/day) based on effects on the central nervous system. EPA (1989) has also determined a RfD for elemental mercury of 3 x 10^{-4} based on adverse effects on the kidneys. An inhalation reference concentration (RfC) of 3 x 10^{-4} mg/m^3 was recently determined by EPA based on an inhalation RfD of 8.6 x 10^{-5} mg/kg/day and assuming a breathing rate of 20 m^3/day for a 70 kg individual (Hiatt 1991).

The California Department of Health Services (DHS 1989) calculated an Applied Action Level (AAL) for mercury in drinking water of 0.07 mg/liter and an inhalation AAL of 0.07 ug/m^3. The EPA Office of Drinking Water (EPA 1989) proposed a Maximum Contaminant Level Goal (MCLG) and Maximum Contaminant Level (MCL) of 0.002 mg/liter for mercury (both inorganic and organic) in drinking water. The MCLG was based on the RfD of 3 x 10^{-4}, the assumption that the average adult weighs 70 kg and drinks 2 liters of water/day, and a source contribution factor of 20%. The Food and Drug Administration (FDA) has established a guideline for mercury in fish tissue of 0.5 mg/kg (NAS 1977) and an action level of 1 mg/kg (EPA 1983).

The state of California has established a Total Threshold Limit Concentration (TTLC) for mercury of 20 mg/kg and a Soluble Threshold Limit Concentration (STLC) of 0.2 mg/liter. The maximum concentration for mercury in the EPA Toxicity Characteristic Leaching Potential (TCLP) test is also 0.2 mg/liter.

Arsenic

Arsenic is associated with an increased incidence of lung, liver, bladder, and skin cancer in individuals exposed via drinking water (Tseng et al. 1968; Chen et al. 1986). Arsenic has also been associated with an increased incidence of lung cancer in occupationally exposed workers (EPA 1988). EPA's Carcinogen Assessment Group (CAG) calculated a cancer potency factor for exposure to arsenic via ingestion of 1.5 $(mg/kg/day)^{-1}$ based on the skin tumors observed in the Tseng et al. 1968 study and calculated a unit risk for inhalation exposure of 4.3 x $10^{-3}(ug/m^3)^{-1}$ equal to an inhalation cancer potency factor of 50 $(mg/kg/day)^{-1}$ as an internal dose, assuming 30% of an inhaled dose is absorbed (EPA 1987; 1988). EPA has classified arsenic in Group A - Human Carcinogen, based on the weight of evidence for carcinogenicity.

Copper

Copper is not a potent toxic agent to humans (EPA 1980, 1984). The current EPA secondary drinking water standard (SMCL) is 1 mg/liter, based on the organoleptic properties (taste and odor) of copper rather than on its toxicity (EPA 1980). The EPA Office of Drinking Water has proposed a Maximum Contaminant Level Goal (MCLG) for copper of 1.3 mg/liter based on the occurrence of gastrointestinal effects in man (EPA 1985b, 1984a). EPA Region IX has determined an oral RfD for copper of 3.7 x 10^{-2} mg/kg/day, based on the MCLG (Hiatt 1991).

Lead

Lead, at relatively low exposure levels, has been shown to cause adverse neurological effects in humans, especially young children and fetuses. Of particular concern are the effects on learning ability that have been associated with very low (e.g., 10-20 ug/dl) blood lead levels (Bellinger et al. 1987). Oral ingestion of some lead salts has been associated with increased renal tumor frequencies in rats. EPA (1989) has classified lead as a Probable Human Carcinogen (Group B2) based on these results. EPA has also noted that the available data provide an insufficient basis on which to regulate carcinogenic lead salts and no quantitative estimate of the excess cancer risk has been provided. EPA has established an ambient air quality standard for lead of 1.5 ug/m^3 and a Maximum Contaminant Level (MCL) for drinking water of 50 ug/liter. Both of these standards are currently undergoing review by EPA. The EPA Office of Drinking Water has proposed an MCLG of zero and an MCL of 5 ug/liter for lead (EPA 1990). No reference dose has been established for lead, as most toxicity criteria are measured in terms of body burden, specifically blood lead levels. EPA is considering using 10 ug/deciliter of whole blood (ug/dl) as a blood lead level of concern for children. The potential risks associated with exposure to lead are evaluated using the Lead Biokinetic Model which allows the consideration of multiple sources of exposure. The Lead Biokinetic Model has not been formally adopted by EPA but is a useful tool in determining if observed soil concentrations may be of concern. The EPA Superfund program has also established an interim cleanup level range of 500 - 1,000 mg/kg in residential soils.

4.0 EXPOSURE ASSESSMENT

The objectives of the exposure assessment are to identify actual or potential exposure pathways, to characterize the potentially exposed populations, and to determine the extent of any exposure. An exposure route consists of four main elements: (1) a source and mechanism of chemical release to the environment; (2) an environmental transport medium for the released chemical; (3) a point of actual or potential contact by a receptor with the contaminated medium (referred to as the exposure point); and (4) a method of intake (e.g., ingestion, inhalation, dermal absorption) at the exposure point. If any one of these factors is absent, exposure cannot occur because the receptor will not be able to come in contact with the chemical. The potential for chemicals to get from the site soils to a receptor population is evaluated as the first section of an exposure assessment.

Potential receptor populations for the site include all people in the area of the site who may be exposed to chemicals either by direct contact on site or as a result of exposure to chemicals emanating from the site. However, the level of exposure experienced by different individuals is likely to vary considerably. It is standard practice in site-specific risk assessments to evaluate a reasonable maximum exposure to an individual rather than an average exposure to a population. Use of the reasonable maximum individual exposure ensures that most, if not all people in the area of a site receive actual exposures that are equal to or lower than the estimated reasonable maximum exposure levels. In many cases, actual exposure may be zero.

Once the exposure routes and potential receptors have been identified, the final step in an exposure assessment is a determination of the potential levels of exposure that are associated with the various possible exposure routes. Exposure quantification is presented in section 4.2.

4.1 Exposure Routes

The exposure assessment for the UCB-RFS needs to consider exposure both on the active facility (within the fenced areas of the property) and in areas outside of the fence, such as in the marsh. The assessment must also consider both current and potential future uses of the site. Exposure on the facility grounds is separated from exposure in areas outside the fence because of differences in the frequency of use and accessibility of the two areas. Current exposure assumes that the use of the facility does not change significantly in the future. If use of the facility changes substantially, potential exposure pathways may also change. The EPA is planning to construct a laboratory facility at the UCB-RFS site, but this use is unlikely to substantially change the potential for exposure except possibly to increase the frequency of use of the facility. Any potential increase in exposure associated with more frequent use will be somewhat balanced by a new concrete floor at be base of the building which will inhibit fugitive dust and vapor transport.

Development of a day care center for the children of workers using the site has been considered as a possible future use for a small portion of the property. Any potential health risks to children using a day care center would be highly dependent on its location, and possible locations of such a center has not been determined. Therefore, use of a portion of the property as a day care center was not evaluated in this assessment. Potential site-specific risks associated with use of a particular on-site area for such a center should be assessed prior to its development.

4.1.1 Possible Exposure Routes on the Active Facility

Possible routes of exposure inside the fenced area at the field station include direct contact with chemicals in soil and inhalation exposure to chemicals in air. Direct contact with soils may lead to exposure via dermal absorption of chemicals present in the soils or via ingestion (either inadvertent or intentional) of on-site soils. Exposure to airborne chemicals could include inhalation of mercury vapors released from facility soils or inhalation of metal-contaminated windborne particulate matter.

Routes of exposure that are often considered at sites similar to UCB-RFS include use of on-site groundwater as a source of potable water and the ingestion of vegetables grown on site. These routes are considered unlikely to occur at the UCB-RFS property and are not evaluated in detail in the assessment. Groundwater at the site is encountered at approximately 9 feet below the surface and this water appears to meet state of California criteria for water quality. However, continuous use of this water would almost certainly lead to saltwater intrusion rendering the water unusable for drinking or gardening. Consumption of homegrown vegetables from the site is considered unlikely to pose a substantial concern because the metals of concern for the site are not readily taken up from soils by plants. Lead and mercury are not readily translocated to plant foliage even when soil levels are very high, while arsenic and copper are phytotoxic to plants and this phytotoxicity will limit the potential for chronic exposure (Chaney 1984).

Direct Contact - Surface Soils

Direct contact with surface soils can lead to exposure to any contaminants in these soils through inadvertent or intentional soil ingestion or through dermal absorption. The potential ingestion of contaminated soils will be evaluated quantitatively in this assessment. Metals generally do not migrate through the skin to a substantial degree and, relative to ingestion, any exposure would almost certainly be minimal. Consequently, the potential exposure via dermal absorption will not be addressed in this assessment.

Air

Individuals on site may be exposed to mercury that volatilizes from site cover soils and to metals that are present in any dusts that are released into the air as a result of wind erosion of surface soils. Mercury can also be released into buildings constructed on contaminated soil, if cracks exist in their foundations. The potential for exposure via these pathways will be evaluated in this exposure assessment.

4.1.2 Possible Exposure Routes in Areas of Unrestricted Access

Possible routes of exposure in areas adjacent to the active research facility include direct contact with chemicals in the marsh (soils, sediments, and surface water), ingestion of fish or shellfish from this area, and inhalation exposure. Direct contact with marsh sediments or surface water can lead to exposure via dermal absorption of chemicals or via ingestion (either inadvertent or intentional). Fishermen catching fish or shellfish from the area as a source of food could be exposed to the chemicals taken up by these organisms. Finally, inhalation exposure to mercury vapors or to metals bound to windborne particulates being released from the site could occur.

Direct Contact - Marsh Sediments

Individuals wading or playing in the marsh may be exposed to surface water or sediment through dermal absorption or incidental ingestion. Local children, clam diggers, and fishermen are particularly likely to be exposed via these routes. Somewhat elevated concentrations of arsenic, copper, lead, and mercury were detected in sediments at several points in the marsh. These data are used in section 4.2 to estimate the potential exposure associated with the marsh.

Ingestion of Contaminated Fish or Shellfish

Fish or shellfish spending substantial portions of their life in a marsh area can take up chemicals present in the marsh water or in exposed sediments. Fishermen or their families who eat these fish or shellfish can then be exposed to these chemicals. The potential for exposure to metals in sediments and water in the marsh through the ingestion of contaminated fish or shellfish will be addressed qualitatively in section 4.2.2.

Air

Nearby residences could be exposed to mercury that volatilizes from cover soils from the active facility or to metals that are present in any dusts that are released into the air as a result of wind erosion of surface soils. The marsh is vegetated and marsh sediments tend to be moist, and for these reasons, fugitive dust release is unlikely to be a significant exposure pathway. The potential for exposure to airborne chemicals will be addressed for residents living off-site in the vicinity of the UCB-RFS property.

4.2 Quantitative Exposure Assessment

Individuals are exposed to materials released into the environment in varying quantities and proportions, via a wide variety of exposure routes. The actual amount of material an individual is exposed to depends on the individual's frequency, extent, and duration of exposure which in turn depends on many factors, including location of residence, age, body weight, sex, and activity patterns. Patterns of exposure are highly variable among individuals. For example, the amount of soil ingested by a child may vary from less than 10 mg for a child playing only on a grassy area or indoors in a very clean house, to relatively large amounts (1,000 mg or more) in children who are intentionally eating soil. This large potential variation in exposure to environmental contaminants implies that a certain amount of uncertainty is inherent in risk assessment. This exposure assessment uses standard approaches and assumptions to estimate exposure to the key site constituents: mercury, arsenic, and copper. A somewhat different approach, the Lead Biokinetic Model, is used by EPA to assess exposure to lead. In addition, the EPA Superfund office has developed interim cleanup criteria for lead in residential soils of 500 - 1,000 mg/kg. For this preliminary risk assessment, soil levels will be compared with the interim EPA guidance and a detailed evaluation of potential lead exposure will not be conducted.

The exposure assessment approaches and assumptions are designed to be health protective, that is, they are designed to produce estimates of exposure that overestimate rather than underestimate exposure and risk. A more detailed discussion of the uncertainty in the risk assessment is presented in section 5.3.

4.2.1 Exposure in the Area of the Active Facility

Soil Ingestion

Exposure via direct ingestion of soils is of greatest concern if the soils are in an area that is frequently used (as in a backyard) and if the soils are not covered by grass, pavement, or buildings. Workers engaged in digging, gardening, or earth moving activities are most likely to contact soils. The active portion of UCB-RFS is patrolled and is surrounded by a fence, which should serve to limit (although not prevent) access to site soils. In addition, the facility has at least some vegetative cover (primarily short grasses) and direct contact with soils will be decreased by this cover material.

In order to establish likely maximum exposure levels for workers, it is assumed that a worker is exposed every workday (250 days/365 days) to facility soils, works for 25 years, and ingests 50 mg/day of facility soil. It is further assumed that the worker weighs 70 kg and has an average lifespan of 70 years.

For noncarcinogens, exposure is averaged over the duration of exposure. For carcinogens, cancer potency factors are developed based on a full lifetime exposure and therefore the averaging time is also expressed in terms of a full lifetime of 70 years (EPA 1989). Using these assumptions, exposure can be estimated using the formula:

$$\mathrm{CDI} = \frac{\mathrm{CS \times IR \times CF \times FI \times EF \times ED}}{\mathrm{BW \times AT}}$$

where:

CDI = Average daily intake of the chemical (mg/kg/day),
CS = Chemical concentration in soil (mg/kg),
IR = Soil ingestion rate (50 mg/day),
CF = Conversion factor (10^{-6}kg/mg),
FI = Relative fraction absorbed from soil (100%),
EF = Frequency of site contact (250 days/365 days),
ED = Exposure duration (25 years),
BW = Body weight (70 kg), and
AT = Averaging time (25 or 70 years).

Using this equation and the 95% upper confidence limit on the average soil concentration for the active facility from Table 2-1, chronic daily intake levels can be calculated and are presented in Table 4-1.

Inhalation Exposure

Exposure to site-related chemicals may occur as a result of inhalation of fugitive dust or volatile emissions. Exposure can occur within the fenced area or chemicals may be transported by the wind or by diffusion to other locations outside of the active facility. Inhalation exposure could also occur as a result of volatilization of mercury upward through the vadose zone and into buildings on the facility through any cracks in their foundation.

No ambient or indoor air monitoring has been conducted at the facility and therefore, reconnaissance-level air modelling was used to estimate air concentrations. Exposure was calculated for three scenarios: exposure on the active facility from fugitive dust

TABLE 4-1

EXPOSURE FROM SOIL INGESTION AT THE UCB-RFS FACILITY IN RICHMOND, CALIFORNIA

	Soil Conc.	Chronic Daily Intake
Arsenic:	100 mg/kg	1.7×10^{-5}mg/kg/day
Copper:	790 mg/kg	3.9×10^{-4}mg/kg/day
Lead:	540 mg/kg	
Mercury:	180 mg/kg	8.8×10^{-5}mg/kg/day

emissions and volatilization of mercury, migration to areas outside of the fence and subsequent exposure through these same pathways, and migration of mercury through cracks in a building foundation.

Inhalation Exposure to Fugitive Dusts

Inhalation exposure to workers at the facility will depend on the amount of mercury and other metals that is present in the air and that is inhaled, and the amount of time the worker is exposed. No information is available on the amount of mercury or particulate matter actually airborne at the facility. In order to estimate potential maximum exposure levels, the concentration of particulates in air was assumed to be equal to the national ambient air quality standards for respirable particulate matter of 70 ug/m^3 or $7 \times 10^{-8} kg/m^3$. The average person weighs 70 kg, and EPA Region IX practice is to assume that a worker inhales at most 20 m^3 of air each day (assuming the worker is engaged in vigorous activity), and that workers are on the job 250 days each year (Hiatt 1991). Workers are unlikely to work at the UCB-RFS facility for their entire working life (45 years) and therefore a value of 25 years will be used for the duration of exposure. For noncarcinogens, exposure is averaged over the duration of exposure while for carcinogens, the averaging time is expressed in terms of a full lifetime of 70 years (EPA 1989). Using these assumptions, exposure can be estimated using the formula:

$$EXP = [SC \times PA \times BR \times EF \times ED]/[BW \times AT]$$

where:

EXP = Inhalation dose (mg/kg/day)
SC = Concentration of chemical in soil (mg/kg)
PA = Concentration of particulates in air ($7 \times 10^{-8} kg/m^3$)
BR = Breathing rate (20 m^3/day)
EF = Exposure frequency (250/365 days)
ED = Exposure duration (25 years)
BW = Body weight (70 kg) and
AT = Averaging time (25 or 70 years).

The soil concentrations used in the equation are the upper 95% confidence limit of the average soil values for the active facility. These values are presented in Table 2-1. The inhalation doses calculated using this equation are presented in Table 4-2.

TABLE 4-2

OUTDOOR EXPOSURE TO AIRBORNE CONTAMINANTS AT THE UCB-RFS IN RICHMOND, CALIFORNIA

COMPOUND	CHRONIC DAILY INTAKE
Arsenic:	4.9×10^{-7}mg/kg/day
Copper:	1.1×10^{-5}mg/kg/day
Mercury:	1.2×10^{-5}mg/kg/day[a]

[a] The chronic daily intake value for mercury is the sum of the estimated exposure from mercury-contaminated fugative dust (9×10^{-7} mg/kg/day) and volatile mercury (4.2×10^{-6} mg/kg/day).

Volatilization of Mercury

Contaminant release and reconnaissance-level air dispersion modelling was used to estimate exposure to mercury volatilizing from facility soils (EPA 1988; 1990). Emission from soils was estimated using an equation developed by Farmer et al (1978) as modified by Shen (1981). Dispersion and airborne concentrations were then estimated using a simple box model. Finally, inhalation doses were calculated using the estimated exposure point concentrations and standard exposure assumptions.

Farmer et al. (1978) developed an equation to estimate volatilization through landfill covers. This equation was modified by Shen (1981). The equation as modified is:

$$ER = (D \times SC \times A \times P^{4/3})\ W/L$$

where,

ER = Emission rate (g/sec),
D = Diffusivity of the chemical (cm^2/sec),
SC = Saturation vapor concentration (g/cm^3),
A = Exposed surface area (cm^2),
P = Soil porosity (unitless),
W = Weight fraction of the chemical (g/g), and
L = Effective depth of soil cover (cm).

The model assumes that migration through the soil is a steady state process and that soil concentrations remain constant over time.

Shen (1982; as cited in EPA 1988) determined the diffusivities for a large number of organic compounds. Values reported by Shen (1982) range from 0.05 to 1.2. A value of 0.05 was derived for mercury based on the similarity of its chemical properties and those of PCBs with a single chloride atom (mercury: MW = 200 and vapor pressure = 0.0012; PCBs: MW = 189 and vapor pressure = 0.001). Exposed surface area was assumed to be equal to 10 acres (4×10^8 cm^2) for outdoor exposure and 2×10^3 cm^2 (approximately equal to the area of a 0.5 -1 inch crack running the width of a 50 foot wide building) for the indoor air release scenario. Soil porosity was assumed to be 0.5 based on the assumption that the soil would be generally dry and somewhat compacted (EPA 1988). Finally, a minimum soil cover depth of 1 cm (worst case) was assumed.

Outdoor Exposure

The estimated emission rates calculated in the Farmer equation were used in a simple box model to estimate exposure at the active facility to mercury volatilizing from soils. The box model assumes steady and spatially uniform conditions of dispersion so that chemicals released into the air are uniformly distributed in a volume of air defined by mixing height and area. The equation for the box model is:

$$C = (ER)/(H/2 \times W \times U)$$

where,

C = Exposure point concentration (g/m^3),
ER = Emission rate (g/sec),
H = Mixing height (m),
W = Crosswind width of the source (m), and
U = Wind speed (m/sec).

Mixing height was estimated to be 2 meters, or the area encompassing the human breathing zone. The crosswind area of the source was assumed to be 200 meters, or the width of the area of emissions. Wind speed was assumed to be 2 m/sec (4 mph), corresponding to fairly low movement. Using these values and the estimated emission rate for mercury of 1.8×10^{-5}g/sec, an exposure point concentration for mercury of 4.5×10^{-8}g/m^3 or 4.5×10^{-5}mg/m^3 is estimated.

The same standard risk assessment assumptions described for exposure to fugitive dust are used to determine the exposure from volatile mercury releases. Specifically, it is assumed that the average person weighs 70 kg, breathes a maximum of 20 m^3 of air/workday, and works 250/365 days per year for 25 years (EPA 1989; Hiatt 1991). Using these assumptions, exposure can be estimated using the formula:

$$EXP = \frac{AC \times BR \times EF \times ED}{BW \times AT}$$

where:

EXP = Inhalation intake (mg/kg/day)
AC = Concentration of chemical in air (mg/m^3)
BR = Breathing rate (20 m^3/day)
EF = Exposure frequency (250 days/365 days)
ED = Exposure duration (25 years)
BW = Body weight (70 kg) and
AT = Averaging time (25 years).

Based on an estimated 95% UCL concentration of mercury of 180 mg/kg and the numerous conservative assumptions used in estimating airborne mercury levels, a chronic daily intake of 9×10^{-6}mg/kg/day is estimated.

Indoor Exposure

The estimated emission rates calculated in the Farmer equation were used in a simple box model to estimate exposure concentrations in a building located above soils contaminated with mercury. The box model assumes steady and spatially uniform conditions of dispersion, so that chemicals released into indoor air are uniformly distributed throughout the living space. The equation for the box model for indoor exposure is:

$$C = (ER)/(AV \times AE)$$

where,

C = Exposure point concentration (g/m^3),
ER = Emission rate (g/sec),
AV = Air volume of the building (m^3), and
AE = Air exchange rate (m^3/sec).

The air volume of an average house is 400 m^3 based on values presented by McKone (1987). This is approximately equal to the volume in a single story 50 ft x 50 ft home with 8 foot ceilings. Any on-site building is likely to be larger than this and will have greater dilution. The value for the house therefore provides an estimate of the likely maximum exposure. McKone (1987) also presented a value for the residence time of air in this space (120 minutes) and these two values can be used to determine an average air exchange rate (400m^3/120 min = 0.06 m^3/sec). Using these values, concentrations of mercury in the indoor air for a building on the UCB-RFS are calculated to be 4×10^{-9} mg/m^3.

The same assumptions used to evaluate intake of outdoor air are used to determine the exposure from indoor releases. Specifically, it is assumed that the average worker weighs 70 kg, breathes a maximum of 20 m^3 of air/workday, works 250/365 days per year for 25 years (EPA 1989). Using these assumptions, exposure can be estimated using the formula:

$$EXP = \frac{AC \times BR \times EF \times ED}{BW \times AT}$$

where:

EXP = Inhalation intake (mg/kg/day)
AC = Concentration of chemical in air (mg/m^3)
BR = Breathing rate (20 m^3/day)
EF = Exposure frequency (250 days/365 days)
ED = Exposure duration (25 years)
BW = Body weight (70 kg) and
AT = Averaging time (25 years).

Using this equation and the assumptions noted above, the estimated chronic daily intake level for indoor inhalation exposure to mercury is 8×10^{-10}mg/kg/day for workers.

4.2.2 Exposure in Areas with Unrestricted Access

Routes of exposure in areas adjacent to the active field station facility include inadvertent ingestion of metals in the marsh (soils, sediments, and surface water), ingestion of fish or shellfish that has become contaminated by metals in this area, and inhalation exposure to metal-contaminated fugitive dusts or mercury that is transported from the facility by the wind.

Sediment Ingestion

Fishermen and people harvesting shellfish from the area of the marsh are likely to get marsh sediments on their hands and may inadvertently ingest this material. In addition, contaminants present in these sediments may be absorbed through the skin. Metals are generally not absorbed to a great degree from the skin and direct dermal absorption is not considered quantitatively in this assessment. The amount of sediment that a individual using the marsh could ingest will vary with individual behavior, with frequency of use of the marsh, and with the person's activity. Children tend to ingest larger amounts of soil than adults, however, they are also less likely to be engaged on a regular basis in activities such as fishing or collecting shellfish. For purposes of this assessment, it is assumed that an adult or older child is the target population of concern but the exposure scenario should also be protective for a child using the site less frequently. Assuming that an individual uses the marsh 52 days/year for 30 years, ingests 50 mg/day of sediments, and weighs 70 kg, exposure can be estimated using the equation:

$$CDI = \frac{CS \times IR \times CF \times FI \times EF \times ED}{BW \times AT}$$

where:

CDI = Average daily intake of the chemical (mg/kg/day),
CS = Chemical concentration in sediment (mg/kg),
IR = Sediment ingestion rate (50 mg/day),
CF = Conversion factor (10^{-6}kg/mg),
FI = Relative fraction absorbed from sediment (100%),
EF = Frequency of site contact (52 days/365 days),
ED = Exposure duration (30 years),
BW = Body weight (70 kg), and
AT = Averaging time (30 or 70 years).

Chronic daily intake levels developed using this equation and the 95% upper confidence limit on the average sediment concentration are presented in Table 4-3.

Ingestion of Fish or Shellfish

Metals from the site may have entered the marsh as a result of past fill activities or as a result of transport by surface water runoff. Metals in marsh sediments can be taken up by benthic organisms living in the sediment, such as shellfish. In addition, if these metals enter the water or are taken up by benthic prey species they may ultimately be taken up by fish. People eating these fish or shellfish could be exposed to the metals. Frequent consumption of shellfish from areas of the marsh with elevated metal levels poses the greatest potential risk, as fish are more mobile and will feed in many locations, thereby diluting metal exposure. The uptake of metals by aquatic organisms varies considerably depending on a large number of factors including actual location of the organism relative to the contamination, amount of time the organism spends in the area, the depth in the sediment of the metals, form of the metals in the environment, size and age of the organism, and species difference in absorption. Similarly, the consumption of fish or shellfish from a particular area will vary considerably among individuals. Because of the difficulties in accurately quantifying exposure via this pathway, it will not be quantitatively evaluated in this assessment. The effects of dilution, depth to the actual contamination, and the relatively small amount of the area actually containing high levels of metals should serve to prevent significant exposure under most scenarios. However, it appears prudent to avoid frequent consumption of shellfish from areas of the marsh containing high metal levels.

TABLE 4-3

EXPOSURE FROM SEDIMENT INGESTION IN THE MARSH AT THE UCB-RFS IN RICHMOND, CALIFORNIA

Metal	Sediment Conc.	Chronic Daily Intake
Arsenic:	1700 mg/kg	7.4×10^{-5} mg/kg/day
Copper:	670 mg/kg	6.8×10^{-5}mg/kg/day
Lead:	320 mg/kg	
Mercury:	33 mg/kg	1.3×10^{-5}mg/kg/day

A general principle of exposure assessment is that conservative assumptions (i.e., assumptions that tend to overestimate exposure and therefore risk) are made at each step, so that the final estimates of exposure will be higher than (often much higher than) the upper end of the likely range of actual exposures. Estimates of exposure developed in this chapter are conservative, in this sense, in two independent ways. First, for each exposure scenario, the assessment is focused on the locations where exposure is expected to be greatest, and on the subpopulations likely to be most exposed (for example, on-site workers in the most contaminated areas of the facility). For this reason, the estimates of exposure are really only valid for the most highly exposed persons, referred to as the maximally exposed individual (MEI) and will overestimate exposure for most people. Second, exposure assessments for these persons incorporate health protective assumptions about many factors that influence exposure, including emission rates, deposition rates, environmental persistence, bio-uptake, bioavailability, and human activity. For this reason, the exposure estimates are intended to overestimate exposures even for the MEI.

5.0 RISK EVALUATION

In this section, information on the potential levels of exposure to contaminants (presented in Section 4) is combined with information on the toxicity of the contaminants (presented in Section 3) in order to determine the potential health risks to individuals living near the site under current conditions. The cancer risk is obtained by multiplying the chronic daily intake of the contaminant under consideration (from the exposure assessment) by its cancer potency factor or slope factor (from the toxicity section). EPA typically expresses cancer risk in terms of an upper-bound excess lifetime cancer risk level. EPA and DHS use an upper-bound excess lifetime cancer risk level of a one in one million (10^{-6}) as a risk level goal for carcinogens and EPA generally sets regulatory criteria within a risk range of between one in ten thousand and one in one million (10^{-4} and 10^{-6}).

To evaluate possible risk from exposure to noncarcinogenic contaminants other than lead, the chronic daily intake (CDI; the average daily exposure dose) is divided by the health criterion value [the reference dose (RfD), formerly referred to as the allowable daily intake (ADI)]. If the CDI:RfD ratio is less than one (i.e., if the daily intake is below the health criterion) the contaminant is considered unlikely to pose a health hazard to individuals exposed under the given scenario. As suggested in the EPA (1986) guidelines for Health Risk Assessment of Chemical Mixtures, the CDI:RfD ratios are summed to determine if combined exposure may pose a health concern (EPA 1986). It should be noted that the summed CDI/RfD ratio (termed the hazard index or HI) is used only as an indication of possible hazard, as summation is only valid if there are no synergistic or antagonistic interactions among the summed compounds and if they have the same mechanism and site of action.

Neither a cancer slope factor nor an RfD is currently available for lead. EPA assesses risk to this metal by assuming that 10 ug of lead/deciliter (ug/dl) of blood is a level of concern in children and uses the Lead Biokinetic Model to determine if potential exposure would be likely to produce blood lead levels exceeding 10 ug/dl in a significant portion of a potential exposed population. As an interim measure, the EPA Superfund office has adopted cleanup levels for lead in residential soils of 500 - 1,000 mg/kg, based on the CDC (1985) statement that these levels are unlikely to lead to an increase in blood lead levels in children. Adults absorb less lead from the gastrointestinal tract and also are less susceptible to the adverse effects of lead than children. Further considering that the population of concern for this assessment is workers and that exposure to lead-containing soils will likely be the lower than for children, the upper value of 1,000 mg/kg will be used as a point of comparison in this assessment.

In addition to summing the risks posed by different chemicals, individuals may be exposed to more than one media by more than one route. For example, a worker could receive exposure to metals in soils via ingestion and could also be exposed to any airborne contaminants.

A number of assumptions were used in deriving both the CDI and the RfD or slope factor. Therefore, there is some uncertainty in interpreting the implications that the cancer risk levels and noncarcinogen CDI:RfD ratios have for risk. However, in the estimation of these factors, conservative (health protective) assumptions were made so that it is improbable that the cancer risks would be higher or the CDI:RfD ratio would be less than one if there were any actual hazard at the site. A further discussion of the uncertainties in risk assessment is presented in Section 5.3.

5.1 Risks at the Active Facility

Risks associated with ingestion of chemicals present in soils within the fenced area of the UCB-RFS property are presented in Table 5-1. For worker exposure, the hazard index for the noncarcinogens was less than one, indicating that it is unlikely that exposure to chemicals via this scenario poses a risk of systemic toxicity. The cancer risk for arsenic exposure was 3 x 10^{-5}. This value is above the upper bound excess lifetime cancer risk of 1 x 10^{-6} commonly used as a target risk level by EPA and other regulatory agencies but is within the risk range of most EPA regulatory decisions of 10^{-4} to 10^{-6}.

TABLE 5-1

HEALTH RISK FROM SOIL INGESTION AT THE UCB-RFS, RICHMOND, CALIFORNIA

Metal	Chronic Daily Intake	Risk	CDI:RfD
Arsenic:	1.7×10^{-5}mg/kg/day	3×10^{-5}	
Copper:	3.9×10^{-4}mg/kg/day		0.01
Mercury:	8.8×10^{-5}mg/kg/day		0.3
		Hazard Index:	0.3

A reconnaissance- or screening-level analysis of the risks associated with inhalation exposure in outdoor locations at the facility either to fugitive dust emissions or to volatilizing mercury was conducted. Table 5-2 presents the results of this evaluation. The hazard index for the noncarcinogens was less than one, indicating that it is unlikely that exposure to chemicals via inhalation poses a risk of systemic toxicity. Under the conditions presented in the exposure assessment for inhalation exposure, an upper bound excess lifetime cancer risk for exposure to arsenic of 7×10^{-6} was estimated. Under the conditions presented in the exposure assessment for the scenario involving direct release of mercury into a building, a CDI:RfD ratio of <0.0001 was estimated. This CDI:RfD level is well below one, indicating that it is unlikely that a risk is posed by this pathway.

The major purpose of a screening-level exposure analysis is to determine the exposure pathways that may pose health risks. Accordingly, assumptions are designed to represent maximum exposure conditions. If no risk is associated with exposure under these conditions, it is improbable that exposure poses a risk and no further analysis is required. In this case, the CDI:RfD ratios were all less than one, indicating that the noncarcinogenic metals are unlikely to pose a health hazard at the facility. The cancer risk level associated with exposure to arsenic was equal to or slightly above the target risk level of 1×10^{-6}. However, considering the very conservative (health protective) assumptions that were used to derive the exposure estimates in the screening analysis, it is unlikely that actual risks exceed the 1×10^{-6} regulatory criterion level.

5.2 Risks in Areas with Unrestricted Access

Risks associated with ingestion of metals in the marsh area sediments are presented in Table 5-3. The hazard index for the noncarcinogens was less than one for the metals, indicating that it is unlikely that exposure poses a risk of systemic toxicity. The total risk of cancer was 1×10^{-4} for ingestion exposure based on potential exposure to arsenic. This value is above the upper bound excess cancer risk level of 1×10^{-6} used as a target risk level goal for this site. It is at the upper end of the risk range of 10^{-4} - 10^{-6} that EPA uses to set regulatory standards.

Inhalation at on-site locations did not pose a significant health risk. Considering the industrial nature of the area, it is likely that off-site exposure scenarios would be similar to on-site exposure (i.e., primarily worker exposure) but the concentrations of metals in the air would be lower as a result of dilution. Consequently, this pathway is unlikely to pose a substantial risk to nearby potentially exposed populations, even under the worst-case analysis used in this preliminary screening level risk assessment.

TABLE 5-2

HEALTH RISK FROM EXPOSURE TO AIRBORNE CONTAMINANTS AT THE UCB-RFS IN RICHMOND, CALIFORNIA

Metal	Chronic Daily Intake	Risk	CDI:RfD
Arsenic:	4.9 x 10^{-7}mg/kg/day	7 x 10^{-6}	
Copper:	1.1 x 10^{-5}mg/kg/day		<0.001
Mercury:	1.2 x 10^{-5}mg/kg/day		0.1
		Hazard Index	0.1

TABLE 5-3

HEALTH RISK FROM SEDIMENT INGESTION IN THE MARSH AT THE UCB-RFS IN RICHMOND, CALIFORNIA

Metal	Chronic Daily Intake	Risk	CDI:RfD
Arsenic:	7.4 x 10^{-5}mg/kg/day	1 x 10^{-4}	
Copper:	6.8 x 10^{-5}mg/kg/day		0.002
Mercury:	3.3 x 10^{-6}mg/kg/day		0.01
		Hazard Index	0.01

5.3 Uncertainties in the Risk Assessment

The procedures and inputs used to assess potential human health risks in this and most such evaluations are subject to a wide variety of uncertainties. In general, there are five main sources of uncertainty in the risk assessment of a reasonably well characterized site:

- -- Environmental chemistry sampling and analysis,
- -- Environmental parameter measurements,
- -- Fate and transport modeling,
- -- Toxicological data and dose-response extrapolations, and
- -- Errors through combinations of the above.

These sources of uncertainty as they pertain to this preliminary risk assessment are discussed below.

Environmental chemistry sampling and analysis error can stem from the error inherent in the procedures, from a failure to take an adequate number of samples to arrive at sufficient areal resolution, from mistakes on the part of the sampler, or from the heterogeneity of the matrix being sampled. Some small sampling and analytical error is almost certainly present, but overall, sampling and analysis error probably only increases the uncertainty in the assessment to a small degree. A possible exception is the potential that some elevated areas of mercury were missed because of the small sample analyzed under the CLP procedures. Some additional soil samples are being collected to further define the vertical extent of the key site contaminants.

Exposure estimation is another potentially large source of error in this risk assessment. The use of the 95% upper confidence limit of the average concentration of the metals at the active facility and in the marsh is likely to lead to overestimating the actual concentrations that individuals could contact. The site investigation focused on areas considered likely to have been impacted by past industrial activities and metal concentrations in soils at other areas of the site are likely to be lower than those used in this assessment. It is unlikely that points of exposure will always be the most contaminated areas. In addition, exposure estimates in many cases are highly dependent on the prediction of intake values, exposure frequency, exposure duration, and other exposure assumptions used in the assessment. The exposure parameters used in this exposure assessment such as a worker working outdoor at the site for 250 days/year and ingesting 50 mg/day of soils were selected to ensure that exposure was overestimated rather than underestimated. The extent of the overestimation will vary among individual workers and is unknown, but it is probably substantial.

The results of animal studies are often used to predict the potential health effects of a chemical in humans. Extrapolation of toxicological data from animal tests is probably one of the largest sources of uncertainty in any risk assessment. There may be important but unidentified differences in uptake, metabolism, and distribution in the body between the test species and man. Typically, the animals are administered high doses of a chemical in a standard diet while humans are generally exposed to much lower doses in a highly variable diet. Because of these differences, it is not surprising that extrapolation error is a large source of uncertainty in risk assessment. Even if studies in humans are available, uncertainties can be large because the diet, activity patterns, exposure duration and frequency, and individual susceptibility may not be the same in the study populations as in the individuals exposed at the site.

Uncertainties from different sources will be compounded in the risk assessment. For example, if a CDI for a contaminant measured in the environment is compared to an RfD to determine potential health hazard, the uncertainties in the concentration measurement, exposure assumptions and the toxicology are all expressed in the result. In order to ensure that human health is adequately protected, the public health assessment incorporates conservative (unlikely to underestimate risk) approaches and uncertainty factors. Therefore, the actual risk associated with the exposure routes considered in this assessment is unlikely to be larger, but may be lower than that predicted.

5.4 Cleanup Level Determination

5.4.1 Mercury

Mercury is present on the portion of the active facility that was sampled at an average concentration of 25 mg/kg, a maximum concentration of 630 mg/kg, and a 95% upper bound concentration of 180 mg/kg. The average concentration for these soils of 25 mg/kg is well above the range of expected background levels of this metal. Most of the mercury contamination was located in the area of the former Mercury Fulminate Facility. Expected background levels for the western United States are in the range of 0.1 mg/kg to 0.4 mg/kg but levels in the San Francisco Bay area may be somewhat higher, in the range of 1 mg/kg.

Direct ingestion of mercury within the fenced portion of the property was estimated to pose the greatest health hazard. However, even exposure to mercury levels of 180 mg/kg alone did not pose a substantial health hazard for workers. As outlined in the DHS manual on Scientific and Technical Standards for Hazardous Waste Sites (DHS 1990), allowable soil remediation levels can be back-calculated by setting the chronic daily intake value equal to an allowable intake level (the RfD), keeping all exposure assumptions constant, and solving for concentration. A mathematically equivalent approach is given by the equation:

$$\frac{\text{Concentration}_i}{\text{Concentration}_x} = \frac{\text{CDI:RfD}_i}{\text{CDI:RfD}_x}$$

where:

The concentration and CDI:RfD of i are the known values, the CDI:RfD_x is the allowable ratio of one (1) and concentration_x is the desired concentration.

Solving this equation, with a known mercury level of 180 mg/kg giving a CDI:RfD ratio of 0.3 for workers, an allowable concentration is 600 mg/kg. Only a single value on site (630 mg/kg) is even slightly above this level and it is highly unlikely that any individual would be exposed to this particular area for a sufficient length of time to be placed at risk by this concentration. Consequently, it is unlikely that the site would pose a health risk to workers as a result of the on-site mercury levels.

Both lead and mercury adversely affect the nervous system, and if these metals can act concurrently on nerve cells and if lead occurs in areas of high mercury concentrations, somewhat lower levels would be necessary to ensure that concurrent exposure does not pose a health risk. A review of the data for the UCB-RFS site indicates that elevated lead levels are generally not found in the same locations as elevated mercury levels. Therefore, based on the available information, a mercury level of around 600 mg/kg of mercury would appear to be sufficient to protect workers.

5.4.2 Arsenic

Arsenic is present in the sampled areas on site at an average concentration of 15 mg/kg and a 95% UCL concentration of 100 mg/kg. The average concentration of 15 mg/kg is in the range of expected background levels of this metalloid. Review of the data indicates that only 3 of 37 surface soil (0-1.5 feet) samples had arsenic levels above 25 mg/kg, the 95% confidence limit of the geometric mean and the upper end of the expected background range (Table 2-4). Based on these values, elevated levels of arsenic at the site appear to occur infrequently and in isolated areas.

Direct ingestion of arsenic was estimated to pose the greatest risk, with cancer risk levels in the range of 6×10^{-5}. As outlined in the DHS manual on Scientific and Technical Standards for Hazardous Waste Sites (DHS 1990), allowable soil remediation levels can be back-calculated by setting the chronic daily intake value equal to an allowable intake level, keeping all exposure assumptions constant, and solving for concentration. A mathematically equivalent approach for carcinogens is given by the equation:

$$\frac{\text{Concentration}_i}{\text{Concentration}_x} = \frac{\text{Risk}_i}{\text{Risk}_x}$$

where:

> The concentration and risk of i are the known values, the risk_x is the allowable risk level and concentration_x is the desired concentration, the concentration associated with the allowable risk level.

Solving this equation for arsenic with a known arsenic level of 100 mg/kg posing a risk of 6×10^{-5} and an allowable risk level of 1×10^{-6}, the EPA target risk level, an allowable concentration is 3 mg/kg, a level that is below expected background concentrations for this area. Because risk-based cleanup levels at arsenic sites are often below expected background levels, EPA has developed soil remediation levels for arsenic at other sites based on a consideration of both technical feasibility and less conservative health risk assessments. At the Whitewood Creek Superfund Site in South Dakota, EPA used a soil level of 100 mg/kg of arsenic as a soil remediation objective, with soil exceeding 100 mg/kg of arsenic in residential areas either being removed or covered with at least 12 inches of clean fill. At another site, the Silver Mountain Superfund Site in Okanogan County, Washington, EPA established a cleanup standard of 200 mg/kg for arsenic.

Based on the expected use of the facility and the cleanup levels established for other sites, a cleanup level for arsenic in the range of 100 - 200 mg/kg seems appropriate. It also seems unlikely that the no action alternative would pose a substantial health risk given the presence of elevated levels of arsenic only in isolated areas.

5.4.3 Copper

The levels of copper present at the facility or in the marsh do not pose a public health risk under any of the scenarios presented. Consequently, a risk-based cleanup level is not established for copper. The California TTLC for copper is 2,500 mg/kg. Based on calculations in this risk assessment, soil containing 2,500 mg/kg of copper would not pose a health risk at the UCB-RFS.

5.4.4 Lead

Lead is present within the fenced portion of the property at an average concentration of 100 mg/kg and a 95% UCL concentration of 540 mg/kg. The average concentration of 100 mg/kg is above the range of expected background levels of this metal presented in Shacklette and Boerngen (1984). However, lead was a very commonly used metal and is often present in urban or industrial areas or along roadways at concentrations well above 100 mg/kg (EPA 1989). Only 2 of 37 surface soil samples from the area of the active facility had lead levels above 500 mg/kg.

CDC (1985) noted that levels of lead in soil of from 500-1000 mg/kg may lead to increases in blood lead levels in children. These soil levels have been adopted by the EPA (1989) as an interim soil cleanup level for residential soils to protect children. EPA (1989) noted that site-specific factors should be considered in determining actual site cleanup levels. Because the UCB-RFS will not be used for residential purposes and because of the differences between adult workers and children regarding exposure potential, absorption, and susceptibility, a lead level of 1,000 mg/kg should be sufficient to protect workers. Only a single value (1140 mg/kg) on site slightly exceeded 1,000 mg/kg, and it is highly unlikely that any individual would frequently contact this area. Consequently, it is unlikely that the site would pose a health risk to workers as a result of the on-site lead.

As noted above, both lead and mercury adversely affect the nervous system, and if these metals can act concurrently on nerve cells and if lead occurs in areas of high mercury concentrations, somewhat lower levels would be necessary to ensure that concurrent exposure does not pose a health risk. Because elevated mercury levels are generally not found in the same locations as elevated lead levels, a lead level of around 1,000 mg/kg would appear to be sufficient to protect workers.

6.0 CONCLUSIONS

Based on the results of this preliminary risk assessment, use of the UCB-RFS is unlikely to pose a substantial health risk, but could pose risks under the following conservative exposure scenarios:

- Daily worker exposure for an extended period of time to soil contaminated with over 600 mg/kg of mercury alone or over 1000 mg/kg of lead alone. Health risks could also be posed by soils containing slightly lower levels of both metals in combination.
- Frequent accidental or intentional ingestion exposure to soil or off-site marsh sediments containing more than background levels of arsenic.

Based on the available information and on site characteristics, soil remediation levels of around 600 mg/kg of mercury and 1,000 mg/kg of lead would probably be sufficient to protect workers. Concurrent exposure to soils containing these levels of metals might be of some concern but based on the available data, elevated levels of mercury and lead do not occur in the same areas.

Under the exposure scenarios used in the preliminary risk assessment, even background levels of arsenic pose a risk above the one in one million cancer risk commonly used as a risk goal by regulatory agencies. However, based on the expected use of the facility and the cleanup levels established for other sites, a cleanup level for arsenic in the range of 100 - 200 mg/kg seems appropriate for the UCB-RFS. It also seems unlikely that the no action alternative would pose a substantial health risk given the presence of elevated levels of arsenic only in two isolated areas.

The cleanup levels that are developed indicate the concentration of a material that would be unlikely to pose a health risk under the conditions of regular repeated contact for an extended period of time. If such frequent exposure is unlikely, concentrations exceeding these levels would also not pose a significant health risk. For example, only two on-site arsenic concentrations are above the 100 mg/kg value used in the risk calculations and 34 of 37 surface soil samples were at expected background levels. Similarly, for lead, only one on-site surface concentrations exceeded 1,000 mg/kg, while for mercury only one sample exceeded 600 mg/kg. Because frequent direct contact with these areas is unlikely, the presence of these levels is unlikely to pose a health risk.

Numerous factors influence the uptake of metals by aquatic organisms and consequently it is difficult to accurately quantify exposure via the consumption of fish or shellfish harvested from the marsh. However, elevated concentrations of some of the metals were present in hotspots in the marsh sediments and it appears prudent to limit consumption of benthic organisms including shellfish from these areas. A factor mitigating the potential concern for this pathway is that arsenic is converted by aquatic organisms to an organic arsenical which is metabolically inactive and rapidly eliminated from the human body.

In order to ensure that the health of on-site and off-site workers and any nearby residents is adequately protected, conservative (unlikely to underestimate risk) assumptions were used in deriving both the exposure estimate and the toxicity values. Because of the use of these conservative (although not necessarily worst case) assumptions, it is unlikely that chemicals remaining at the site at these levels would pose an actual hazard. Any response action that would eliminate the ingestion exposure pathway for soils (such as capping, asphalting, fencing, other access restrictions, or use restrictions) would further limit the potential for exposure and protect public health and welfare.

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APPENDIX A

Graphics and Data Table

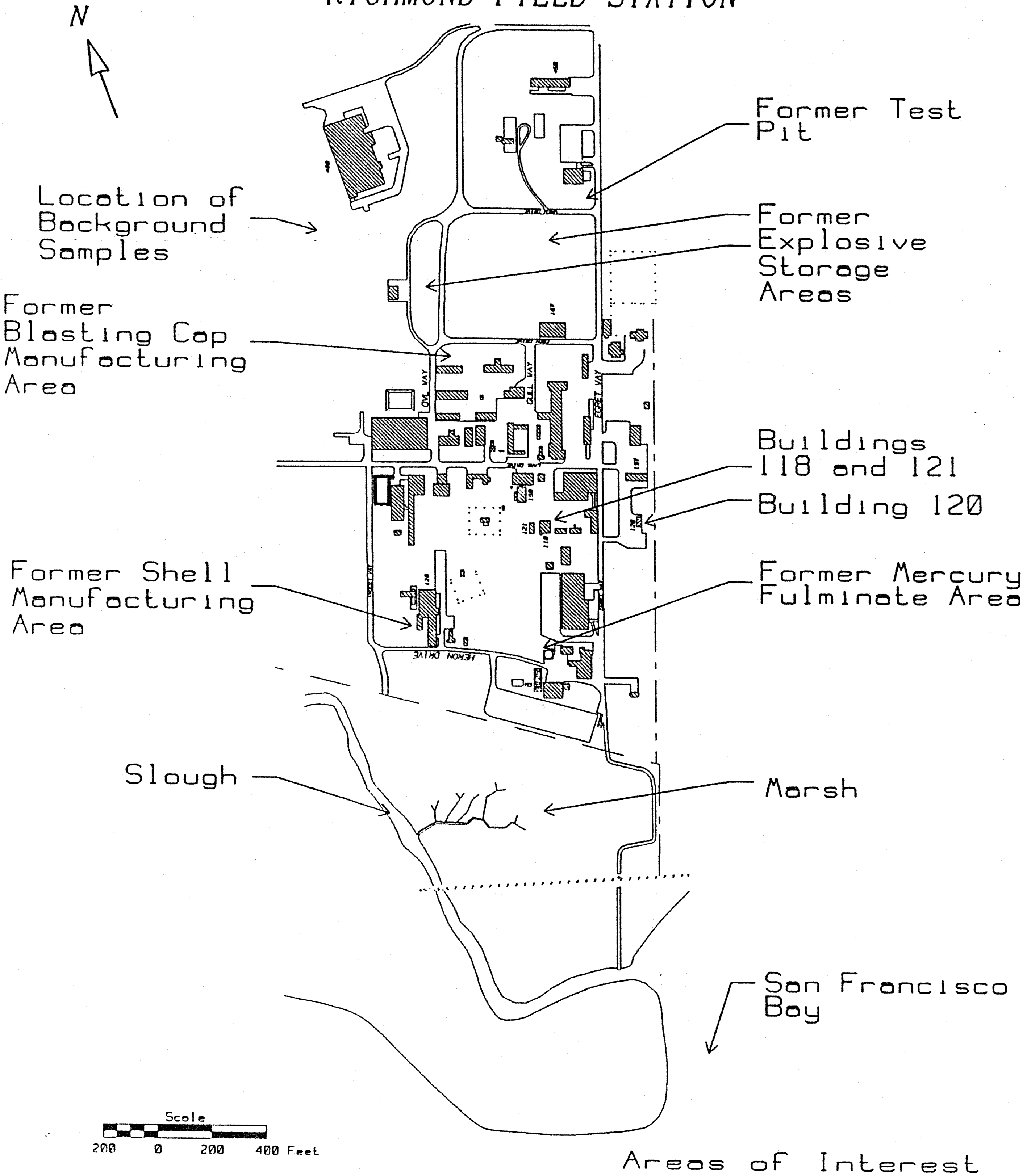
From

Sampling and Analysis Report

Richmond Field Station

December 24, 1990

RICHMOND FIELD STATION



Areas of Interest
on the
University of California
Richmond Field Station

Prepared by
JONAS & ASSOCIATES

Date: 12-20-1990 Scale as shown	Figure 2-1	Drawing Number

Figure 2-1

Drawing Number

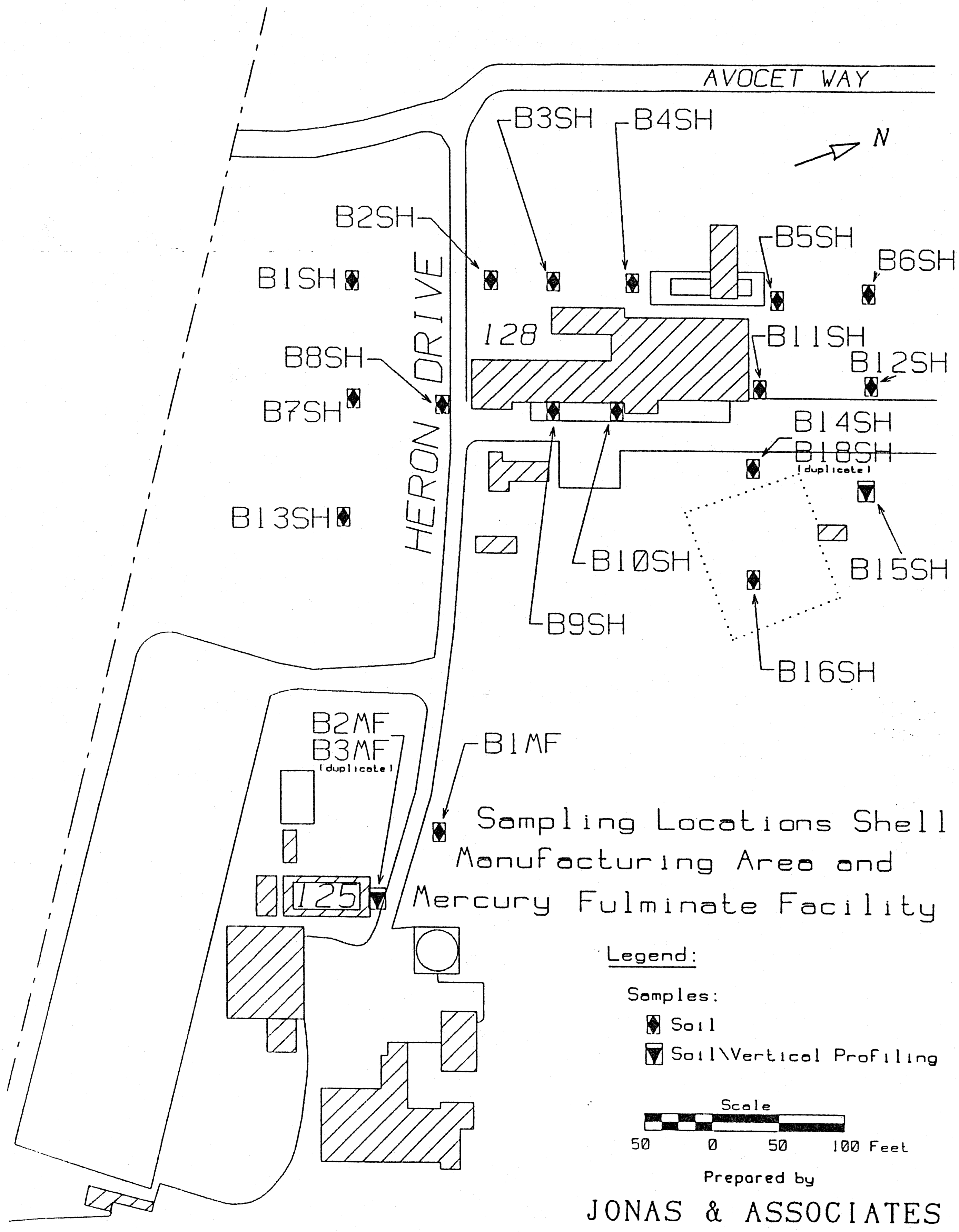
Checked by

Approved by

AJ

12-20-1990

Drawn by



Sampling Locations Shell Manufacturing Area and Mercury Fulminate Facility

Prepared by

JONAS & ASSOCIATES

Date: 12-20-1990
Scale as shown

Figure 2-2

Drawing Number

Figure 2-2
Drawing Number
Checked by
Approved by
AJ
12-20-1990
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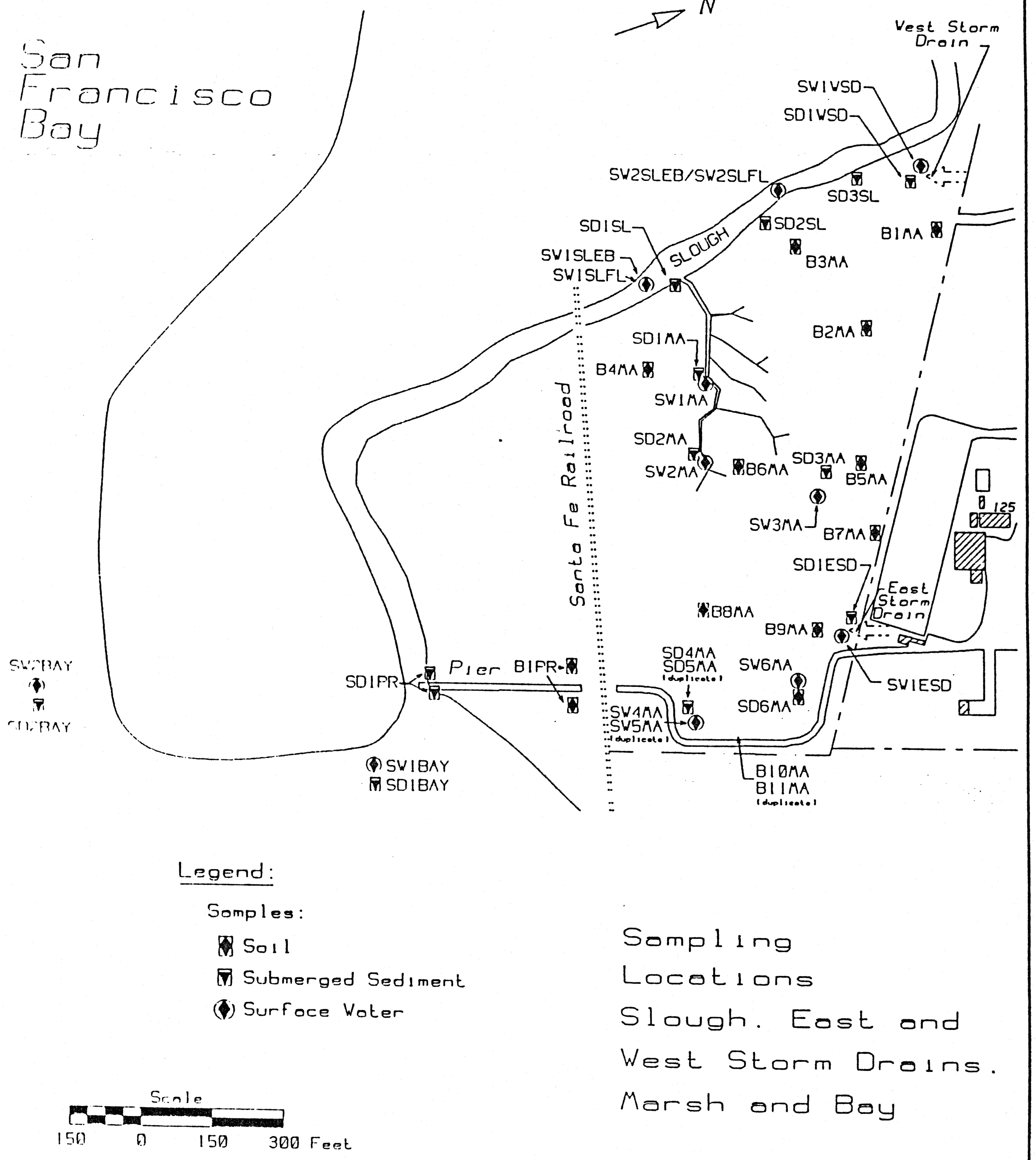


Sampling Locations Slough, East and West Storm Drains, Marsh and Bay

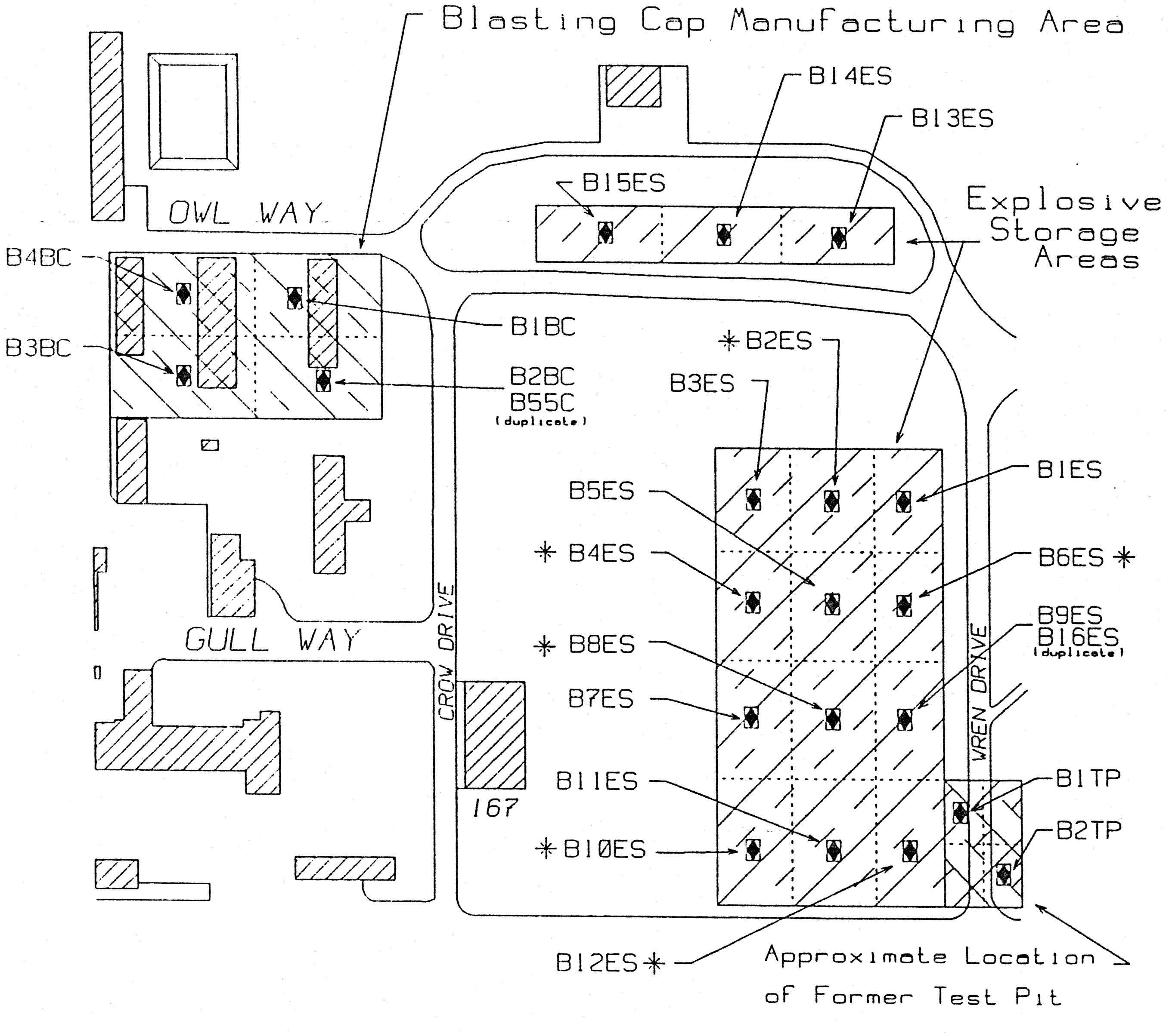
Prepared by
JONAS & ASSOCIATES

Date: 12-20-1990
Scale as shown

Figure 2-3

Drawing Number

Figure 2-3
Drawing Number
Checked by
Approved by
AJ
12-20-1990
Drawn by

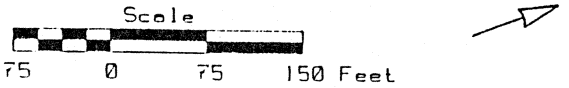


Legend:

Samples:

▨ Soil

✱ These samples will be analyzed only if other concentrations in the area are significant



Sampling Locations - Former Explosive Storage and Blasting Cap Areas and Test Pit

Prepared by
JONAS & ASSOCIATES

Date: 12-20-1990 Scale as shown	Figure 2-4	Drawing Number	

Figure 2-4

Drawing Number

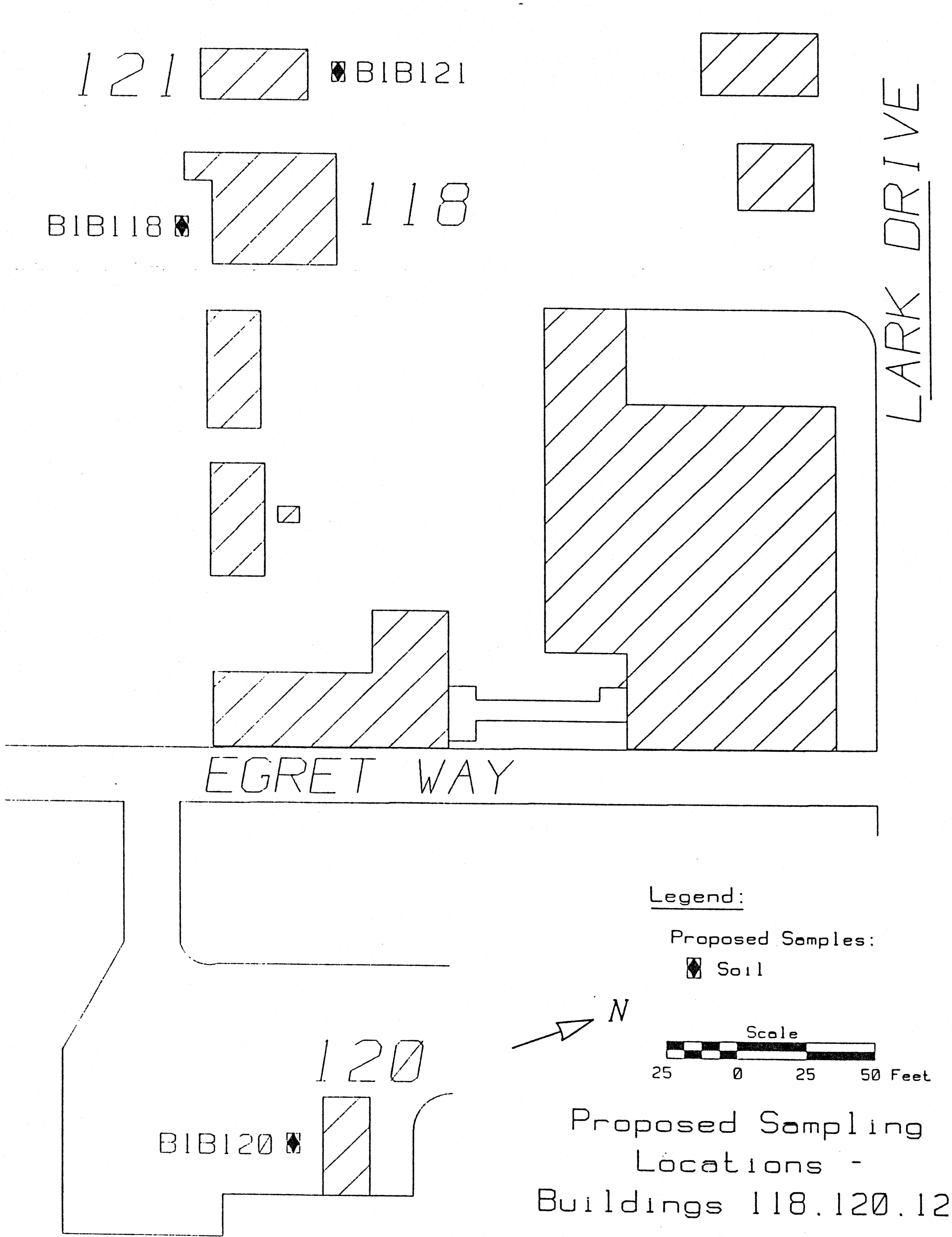
Checked by

Approved by

AJ

12-20-1990

Drawn by



Proposed Sampling Locations - Buildings 118.120.121

Prepared by
JONAS & ASSOCIATES

Date: 9-30-1990 Scale as shown	Figure 2-5	Drawing Number 90-101-S4424

Figure 2-5

Drawing Number 90-101-S4424

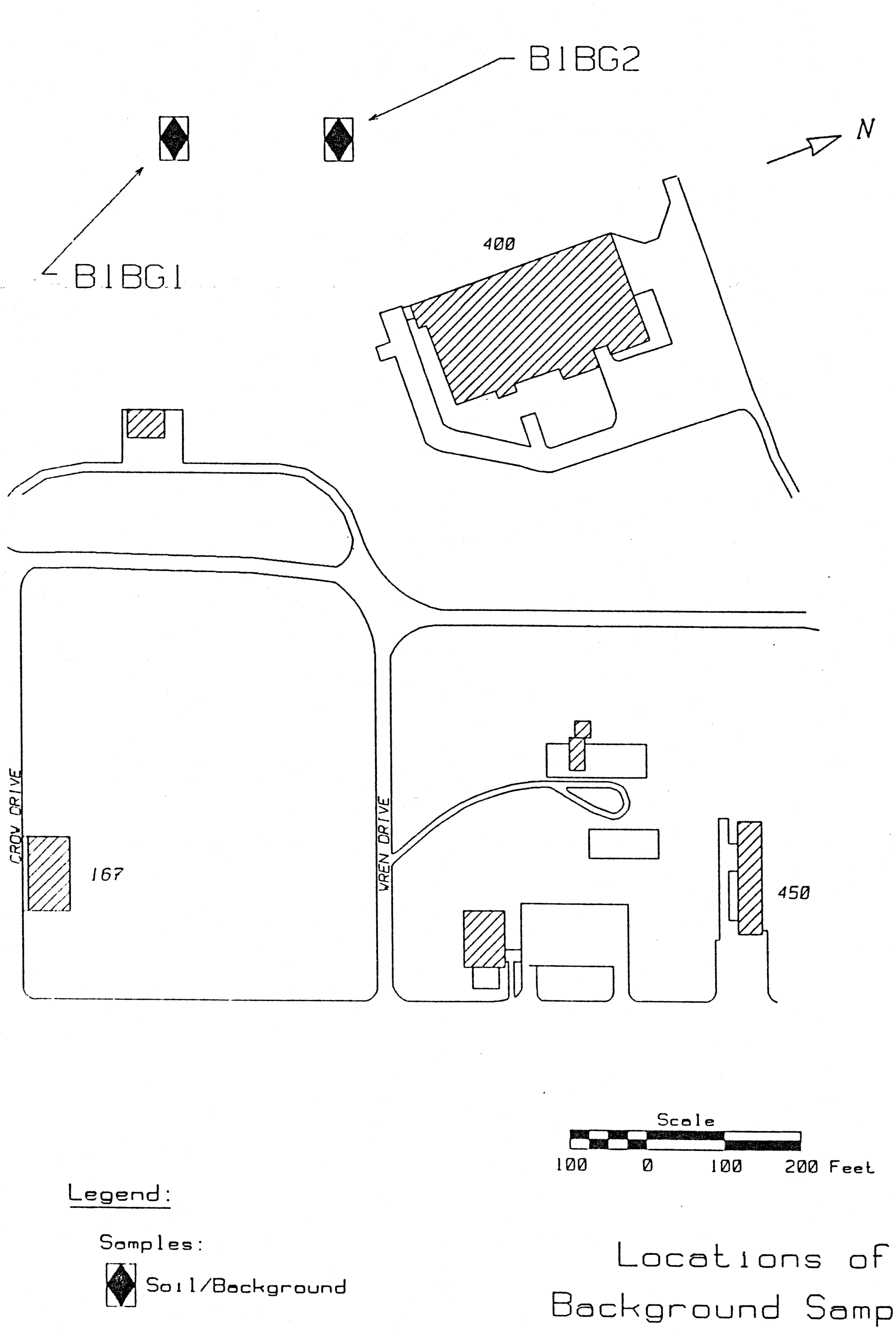
Checked by

Approved by

AJ

9-30-1990

Drawn by



Locations of Background Samples

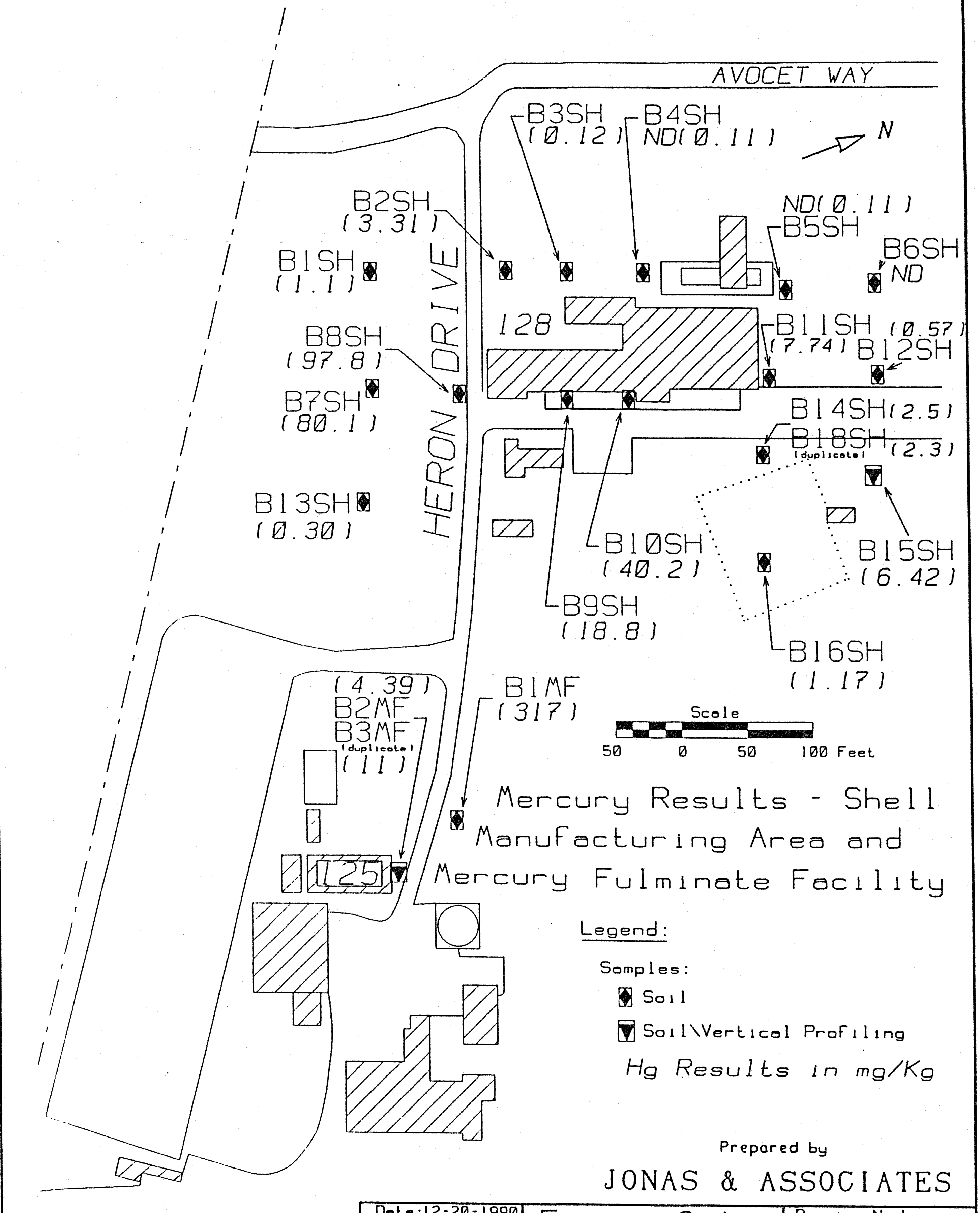
Prepared by
JONAS & ASSOCIATES

Date: 12-20-1990
Scale as shown

Figure 2-6

Drawing Number

Figure 2-6
Drawing Number
Checked by
Approved by
AJ
12-20-1990
Drawn by



Mercury Results - Shell Manufacturing Area and Mercury Fulminate Facility

Legend:

Samples:

- ◆ Soil
- ▼ Soil\Vertical Profiling

Hg Results in mg/Kg

Prepared by

JONAS & ASSOCIATES

Date:12-20-1990 Scale as shown	Figure 3-1	Drawing Number

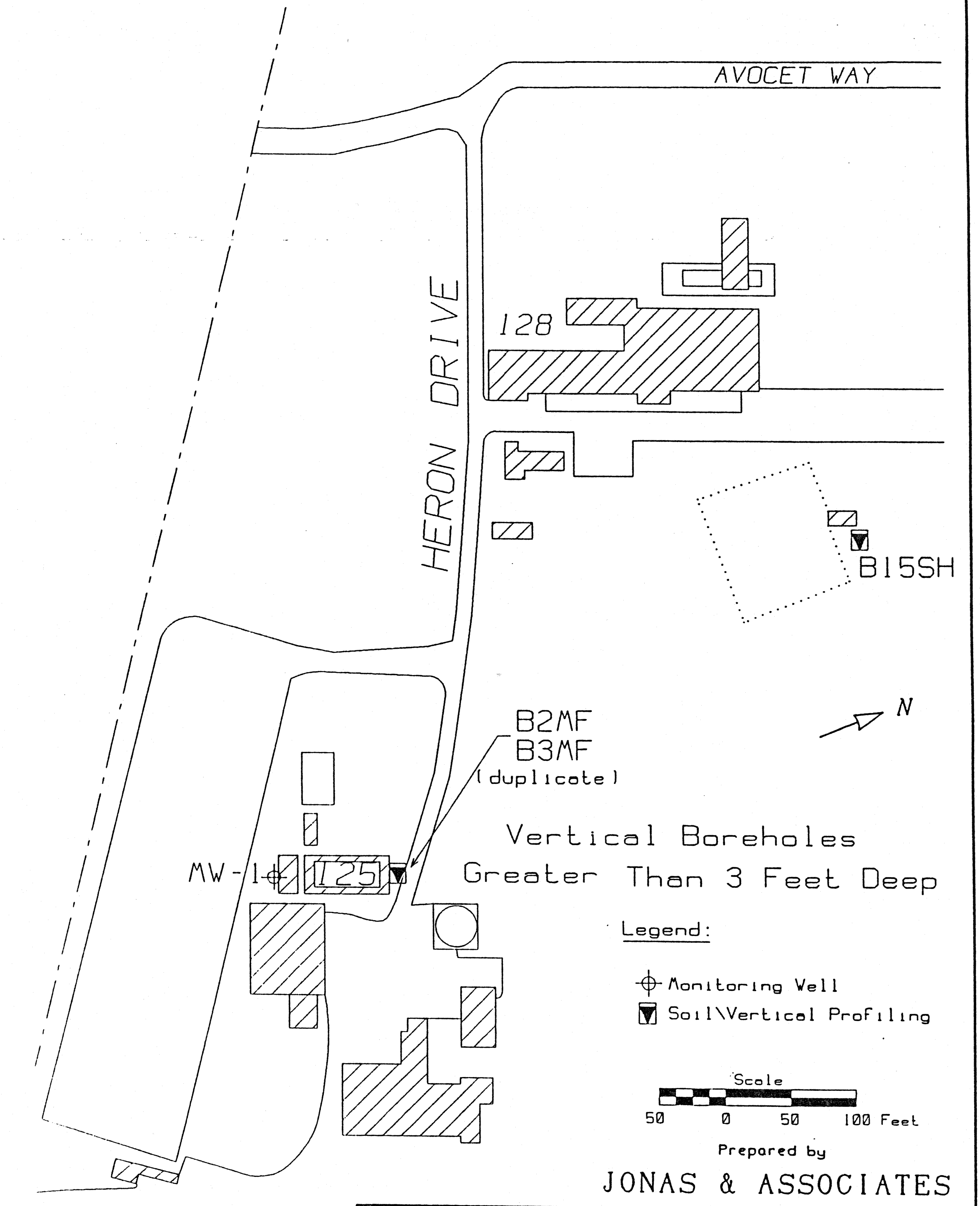
Figure 3-1

Drawing Number

Checked by

Approved by

Drawn by AJ 12-20-1990



Vertical Boreholes Greater Than 3 Feet Deep

Prepared by

JONAS & ASSOCIATES

Date: 12-20-1990
Scale as shown

Figure 3-2

Drawing Number

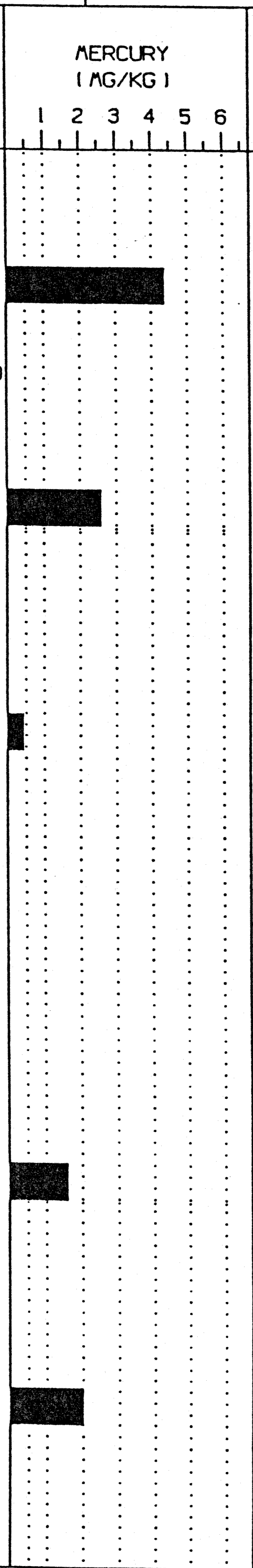
Figure 3-2
Drawing Number
Checked by
Approved by
Drawn by
AJ
12-20-1990

STRATIGRAPHIC COLUMN

PROJECT Richmond Field Station		JOB NO. UCRFS	SHEET NO. 1 OF 1	COLUMN NO. B2MF
BEGAN / COMPLETED 10-24-1990 & 12-1-1990	COORDINATES N/A	GROUND ELEV. N/A	TOTAL DEPTH 14 Feet	LOGGED BY MARTA WILLIAMS

DEPTH (FEET)	LITHOLOGIC DESCRIPTION	SAMPLE NUMBER	CONCENTRATION (MG/KG)
1.5	SILTY CLAY - Dark brown, organic-rich, silty clay with very fine sand.	B2MF1.5-120190	4.39
		B3MF-120190 (duplicate)	11.0
4.0	SILTY CLAY - Gray, silty clay with fine sand.	B2MF4-120190	2.60
6.5	SILTY CLAY - Tan, silty plastic clay.	B2MF6.5 102490	0.46
9.0	SANDY SILTY CLAY - Grey to tan, sandy silty clay. Moist to saturated.	B2MF9-102490	(ND)0.12
11.5	GRAVEL-BEARING SILTY CLAY - Brown silty clay with subangular gravel and very fine sand. Saturated.	B2MF11.5-102490	1.63
14.0	SILTY CLAYEY SAND - Multi-colored sand with brown silty clay. Saturated.	B2MF14-102490	2.03

Base of borehole at 14'.



JONAS AND ASSOCIATES

PLATE 1
BORING B2MF WITH MERCURY RESULTS

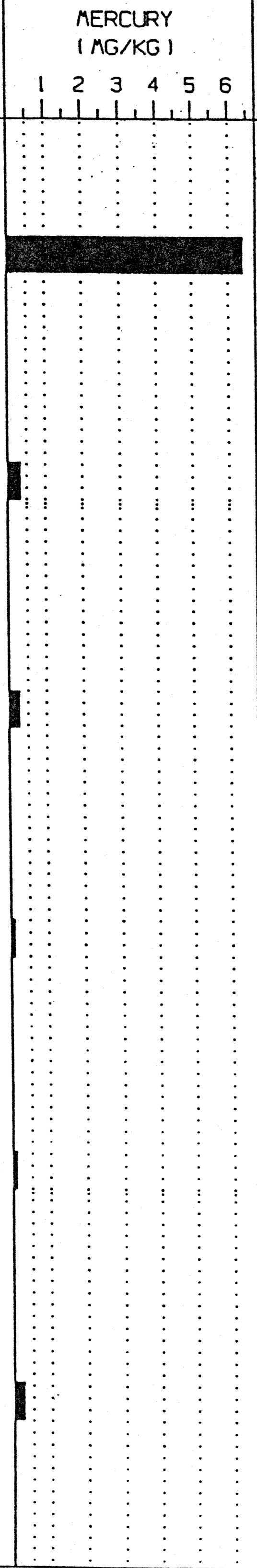
COLUMN NO.
B2MF

STRATIGRAPHIC COLUMN	PROJECT	JOB NO.	SHEET NO.	COLUMN NO.
	Richmond Field Station	UCRFS	1 OF 1	B15SH

BEGAN / COMPLETED	COORDINATES	GROUND ELEV.	TOTAL DEPTH	LOGGED BY
10-24-90 & 12-1-1990	N/A	N/A	14 Feet	MARTA WILLIAMS

DEPTH (FEET)	DEPTH (FEET)	LITHOLOGIC DESCRIPTION	SAMPLE NUMBER	CONCEN-TRATION (MG/KG)
1.5	1.5	SILTY CLAY - Dark brown, organic-rich, silty clay with very fine sand.	B15SH1.5-120190	6.42
4.0	4	GRAVEL-BEARING SILTY CLAY -Tan, subangular gravel in silty clay.	B15SH4-102490	0.30
6.5	6.5	SILTY CLAY - Dark brown, silty clay. Organic matter present, prossibly roots.	B15SH6.5-102490	0.26
9.0	9	GRAVEL-BEARING SILTY CLAY -Tan, subangular gravel in silty clay. Moist.	B15SH9-102490	0.11
11.5	11.5	SANDY SILTY CLAY - Dark brown, sandy silty clay. Moist.	B15SH11.5-102490	0.11
14.0	14	SANDY SILTY CLAY - Tan, sandy, gravel-bearing silty clay. Moist to saturated.	B15SH14-102490	0.25

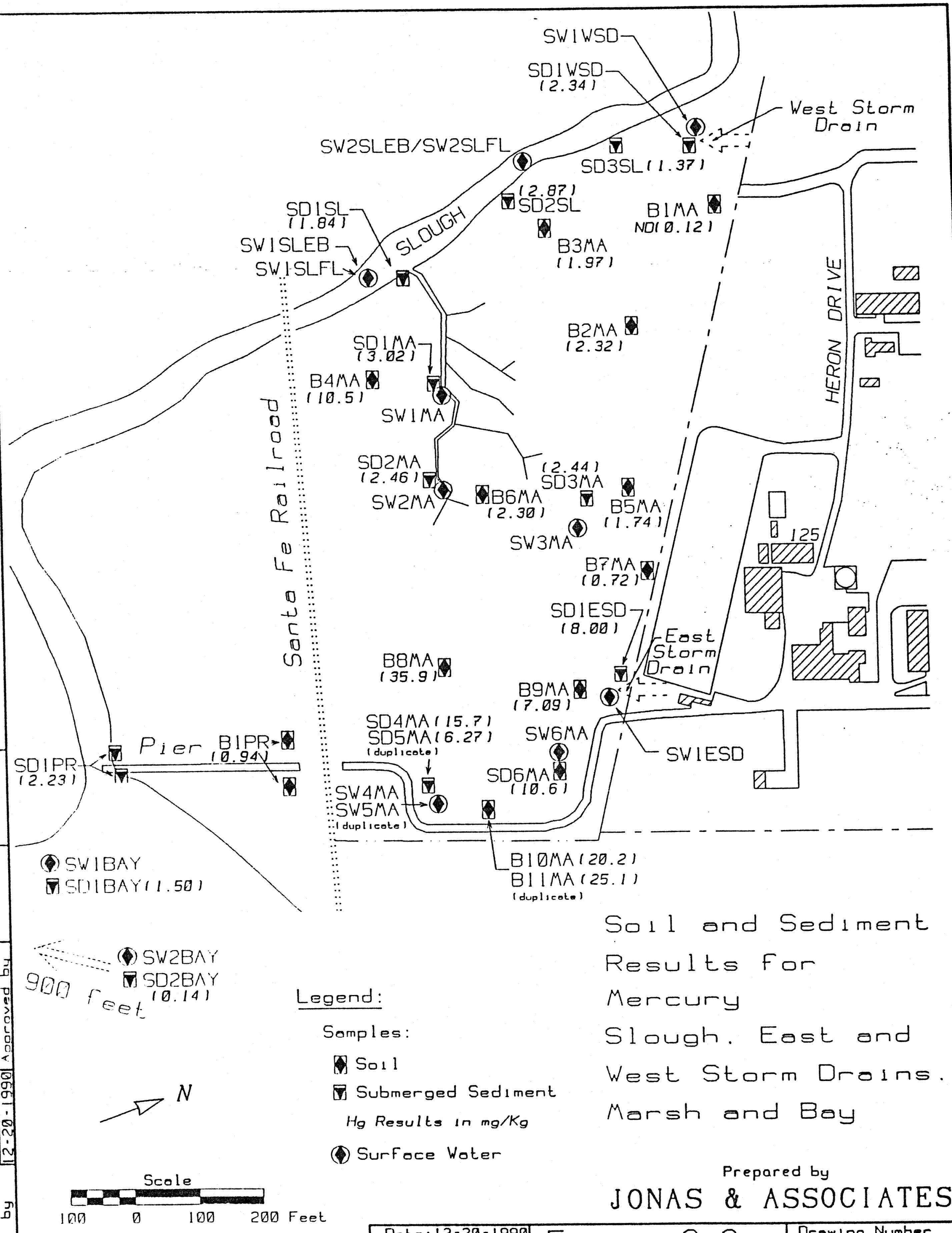
Base of borehole at 14'.



JONAS AND ASSOCIATES

PLATE 2
BORING B15SH WITH MERCURY RESULTS

COLUMN NO.
B15SH



Soil and Sediment Results for Mercury Slough, East and West Storm Drains, Marsh and Bay

Prepared by
JONAS & ASSOCIATES

Date: 12-20-1990
Scale as shown

Figure 3-3

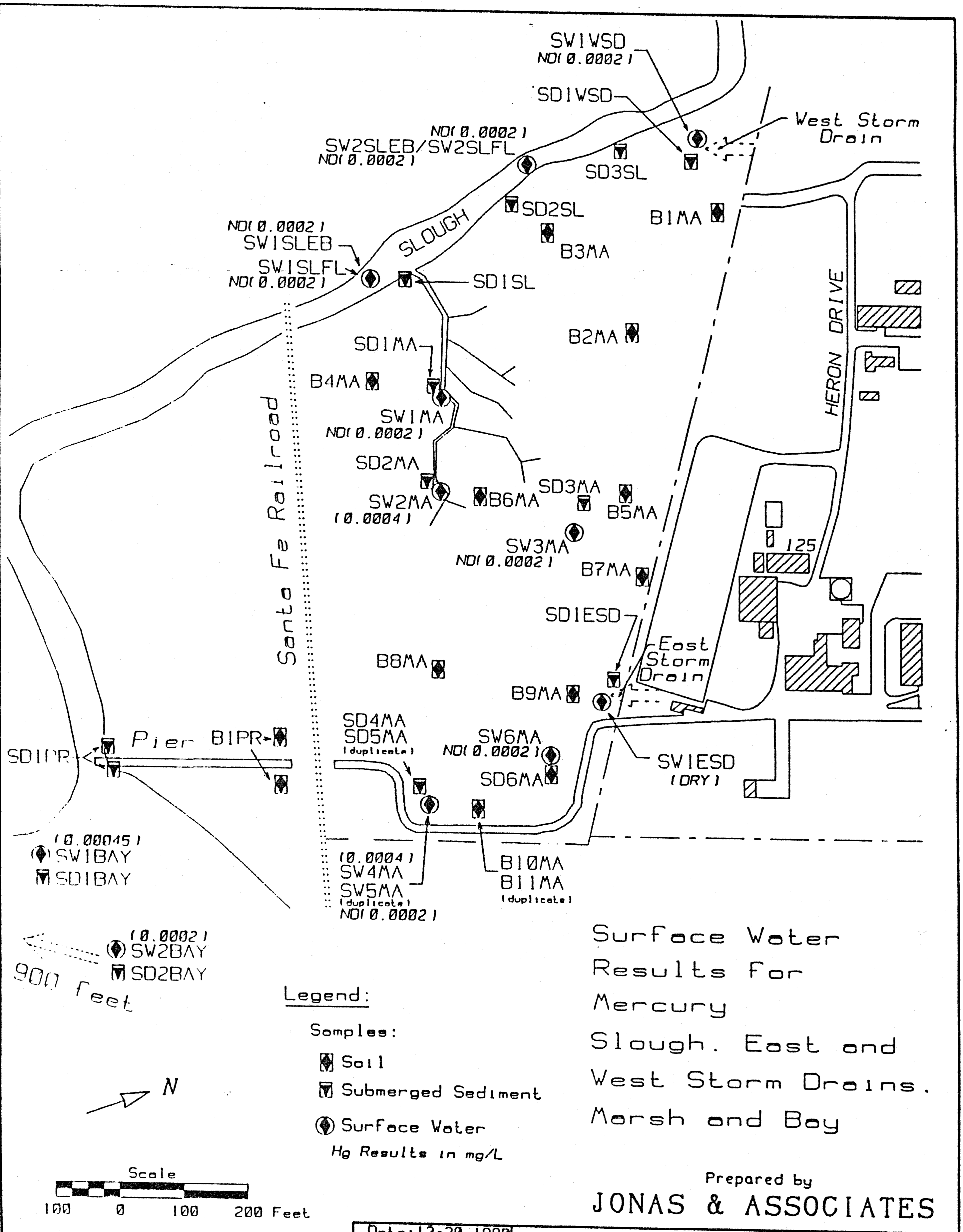
Drawing Number

Figure 3-3

Drawing Number

Checked by AJ
Approved by 12-20-1990

Drawn by



Surface Water Results For Mercury Slough, East and West Storm Drains, Marsh and Bay

Prepared by
JONAS & ASSOCIATES

Date: 12-20-1990
Scale as shown

Figure 3-4

Drawing Number

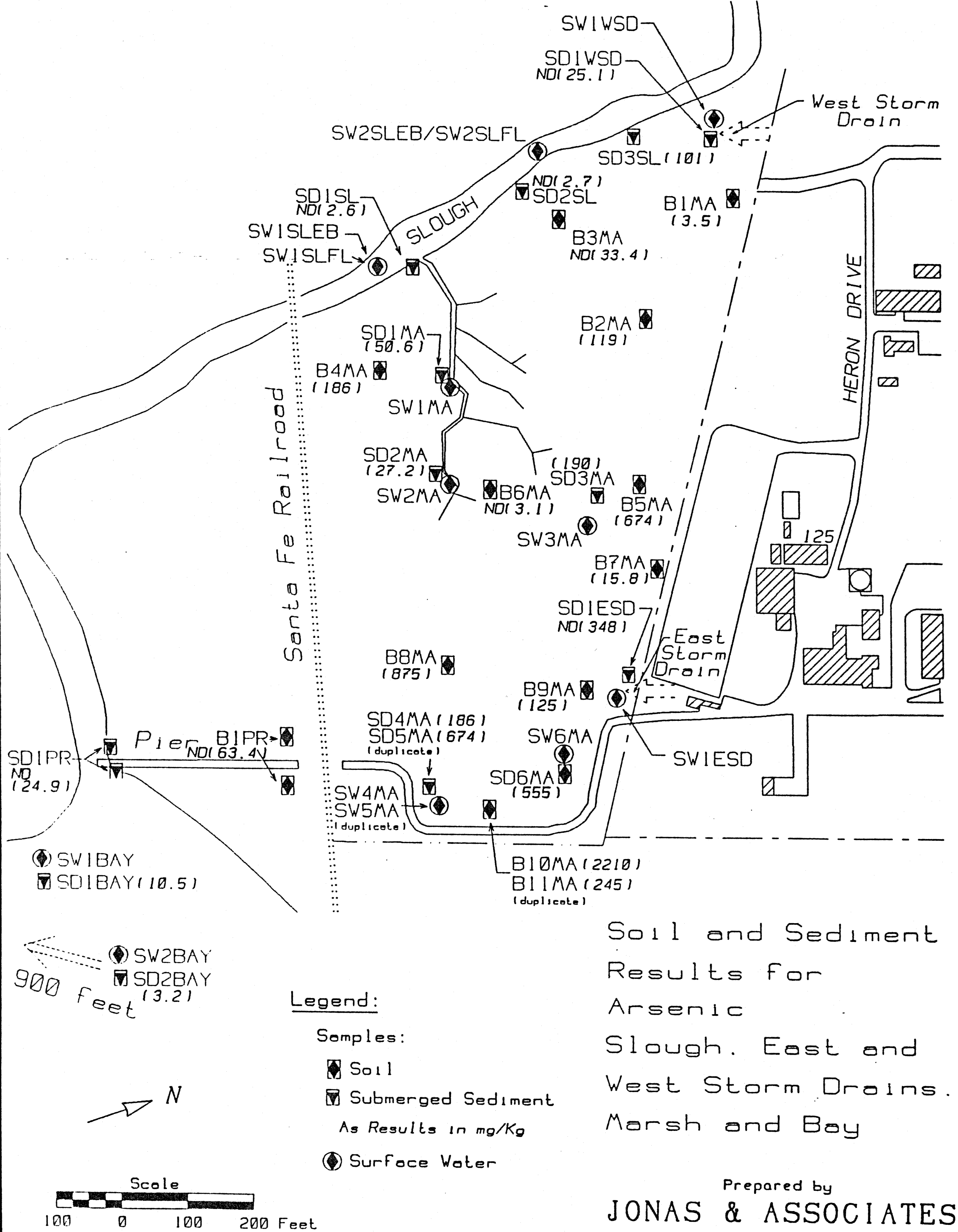
Figure 3-4

Drawing Number

Checked by
Approved by

AJ
12-20-1990

Drawn by



Soil and Sediment Results for Arsenic Slough, East and West Storm Drains, Marsh and Bay

Prepared by
JONAS & ASSOCIATES

Date: 12-20-1990
Scale as shown

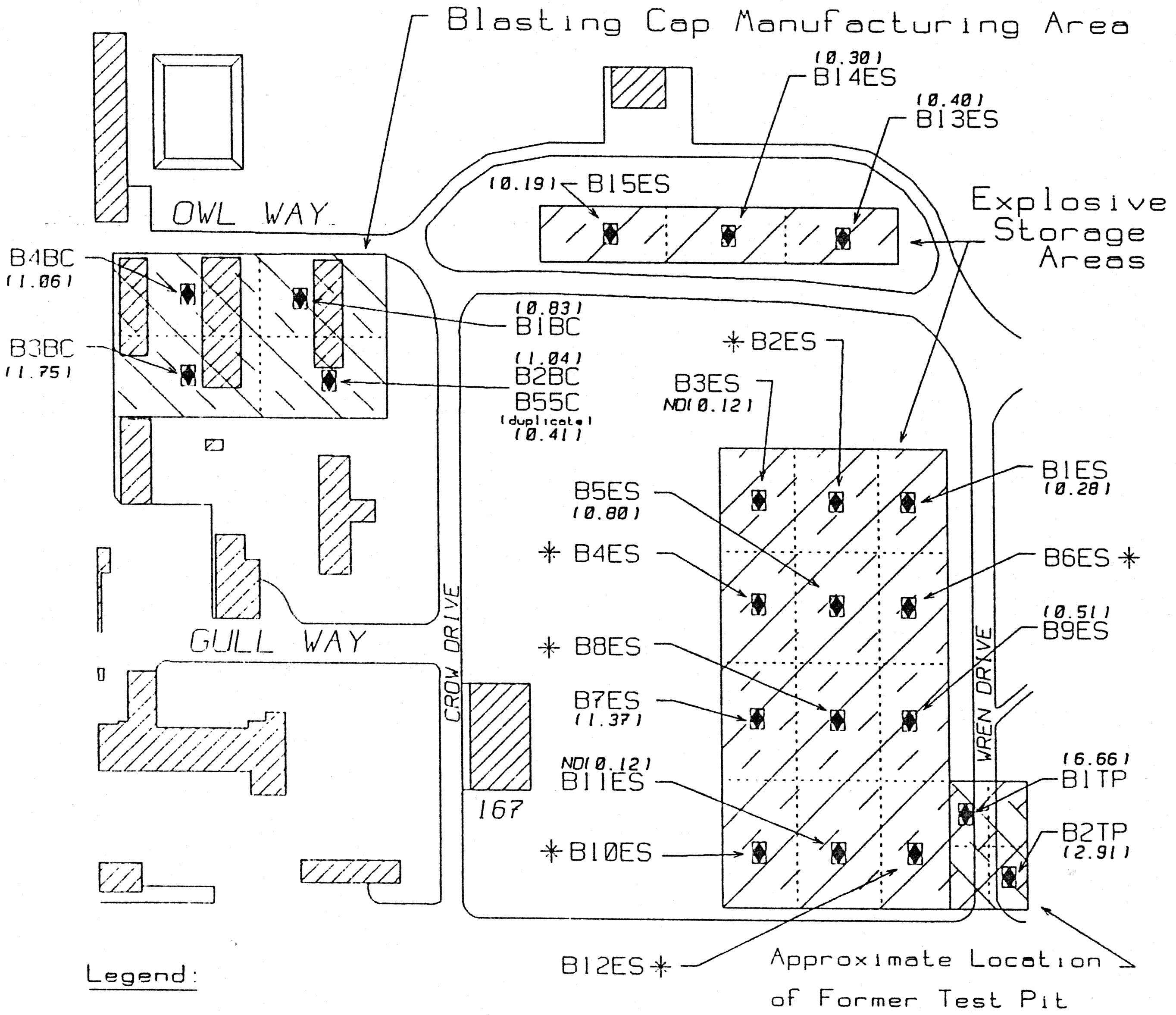
Figure 3-5

Drawing Number

Figure 3-5
Drawing Number
Checked by
Approved by
AJ
12-20-1990
Drawn by

Figure 3-6

Drawing Number



Legend:

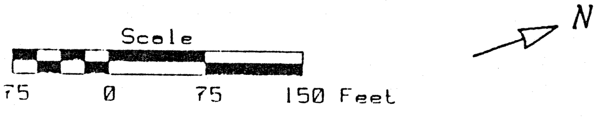
Samples:

▣ Soil

Hg Results in mg/Kg

Mercury Sampling Results - Former Explosive Storage and Blasting Cap Areas and Test Pit

* These samples will be analyzed only if other concentrations in the area are significant.



Prepared by
JONAS & ASSOCIATES

Checked by	Approved by	Drawn by	
AJ	12-20-1990		

Date:12-20-1990 Scale as shown	Figure 3-6	Drawing Number

SOIL SAMPLE RESULTS
TARGET ANALYTE LIST OF 22 METALS
UNIVERSITY OF CALIFORNIA
RICHMOND FIELD STATION

SAMPLE NUMBER	SAMPLE LOCATION	SAMPLE DATE	SAMPLE DEPTH (FEET)	ALUMINUM (mg/kg)	ANTIMONY (mg/kg)	ARSENIC (mg/kg)	BARIUM (mg/kg)	BERYLLIUM (mg/kg)	CADMIUM (mg/kg)	CALCIUM (mg/kg)	CHROMIUM (mg/kg)
B01SH120190	SHELL MANUFACTURING	10/18&12/01-90	1.3	15500	ND(8.5)	ND(0.90)	178	0.6	2.3	8520	64.1
B02SH101890	SHELL MANUFACTURING	10/18/90	1.3	7920	ND(8.2)	3.4	208	0.43	1.2	29200	27.7
B03SH101890	SHELL MANUFACTURING	10/18/90	1.3	3920	8.9	3	695	0.45	1.6	2220	19.2
B04SH101890	SHELL MANUFACTURING	10/18/90	1.3	2990	ND(7.9)	2.4	203	0.44	0.86	1680	16.1
B05SH101890	SHELL MANUFACTURING	10/18/90	1.3	7060	ND(8.5)	9.7	57.2	0.49	1.4	7780	25.1
B06SH101890	SHELL MANUFACTURING	10/18/90	1.3	6990	ND(8.4)	7.1	62.3	ND(0.44)	1.6	7760	24.6
B07SH120190	SHELL MANUFACTURING	10/18&12/01-90	1.3	4010	ND(8.3)	3	261	ND(0.44)	ND(0.76)	3960	17.8
B08SH120190	SHELL MANUFACTURING	10/18&12/01-90	1.3	4490	ND(8.3)	6.5	248	0.43	1.6	3720	20.7
B09SH120190	SHELL MANUFACTURING	10/18&12/01-90	1.3	4420	ND(7.9)	6.3	190	ND(0.42)	1.9	3510	14.8
B10SH120190	SHELL MANUFACTURING	10/18&12/01-90	1.3	4080	ND(8.2)	7.4	214	0.45	2.2	3450	20.9
B11SH120190	SHELL MANUFACTURING	10/18&12/01-90	1.3	7220	ND(8.3)	ND(8.7)	169	ND(0.44)	3	2190	28.9
B12SH101890	SHELL MANUFACTURING	10/18/90	1.3	3580	ND(8.3)	3.2	145	0.46	ND(0.77)	17770	34.2
B13SH101890	SHELL MANUFACTURING	10/18/90	1.3	7960	ND(8.5)	2.8	162	0.47	0.87	37300	28
B14SH101890	SHELL MANUFACTURING	10/18/90	1.3	3940	ND(8.1)	3.2	258	0.45	0.87	1170	22.5
B16SH101890	SHELL MANUFACTURING	10/18/90	1.3	5060	9.2	3.6	223	0.48	0.88	579	22.4
B18SH101890	SHELL MANUFACTURING	10/18/90	1.3	5690	ND(8.3)	2.8	223	ND(0.44)	0.96	1420	33.2
B15SH1.5-120190	SHELL MANUFACTURING	10/24&12/01-90	1.5	7340	8.8	126	238	ND(0.43)	4.2	2880	25.9
B15SH04-102490	SHELL MANUFACTURING	10/24/90	4	21200	ND(8.7)	1.9	200	0.55	5.1	2520	71.2
B15SH6.5-102490	SHELL MANUFACTURING	10/24/90	6.5	15900	ND(8.8)	2.7	580	ND(0.47)	2.9	3510	58
B15SH09-102490	SHELL MANUFACTURING	10/24/90	9	14600	ND(8.2)	ND(8.8)	132	ND(0.56)	2.5	3320	69.8
B15SH11.5-10249	SHELL MANUFACTURING	10/24/90	11.5	15900	ND(8.7)	3.2	198	0.57	1.7	4840	63.3
B15SH14-102490	SHELL MANUFACTURING	10/24/90	14	12600	ND(9.0)	1.7	183	ND(0.47)	1.9	4130	43.3
B1MF-120190	MERCURY FULMINATE	10/24&12/01-90	1.3	10800	ND(8.3)	9.3	291	ND(0.44)	0.98	4680	32.9
B2MF1.5-120190	MERCURY FULMINATE	10/24&12/01-90	1.5	11700	12	33.7	420	0.59	4.7	6300	52.4
B2MF04-120190	MERCURY FULMINATE	10/24&12/01-90	4	11900	45.3	46.8	362	0.49	5.3	4370	36.5
B2MF6.5-102490	MERCURY FULMINATE	10/24/90	6.5	15000	ND(9.4)	3.2	143	0.67	1.6	4340	51
B2MF09-102490	MERCURY FULMINATE	10/24/90	9	11100	ND(9.3)	1.1	147	ND(0.49)	2	3970	53.7

ND(8.3) = Not Detected (Detection Limit); NA = Not Analyzed; * = Exceeded Holding time for Mercury

SOIL SAMPLE RESULTS
TARGET ANALYTE LIST OF 22 METALS
UNIVERSITY OF CALIFORNIA
RICHMOND FIELD STATION

SAMPLE NUMBER	SAMPLE LOCATION	SAMPLE DATE	SAMPLE DEPTH (FEET)	ALUMINUM (mg/kg)	ANTIMONY (mg/kg)	ARSENIC (mg/kg)	BARIUM (mg/kg)	BERYLLIUM (mg/kg)	CADMIUM (mg/kg)	CALCIUM (mg/kg)	CHROMIUM (mg/kg)
B2MF11.5-102490	MERCURY FULMINATE	10/24/90	11.5	8350	ND(8.7)	1.3	42.5	ND(0.46)	0.82	3560	45.8
B2MF14-102490	MERCURY FULMINATE	10/24/90	14	7890	ND(8.5)	2.3	48.3	ND(0.45)	2.5	3770	35
B3MF-120190	MERCURY FULMINATE	10/24&12/01-90	1.3	10300	ND(8.5)	236	432	ND(0.45)	9.2	4940	46.5
B01BC101690	BLASTING CAP	10/16/90	0.5 - 1.5	8470	ND(1.4)	5.5	148	ND(0.45)	2.2	3620	27.1
B02BC101690	BLASTING CAP	10/16/90	0.5 - 1.5	3630	ND(1.4)	3.5	299	ND(0.47)	2.5	960	15.8
B03BC101690	BLASTING CAP	10/16/90	0.5 - 1.5	4940	ND(1.4)	1.2	207	0.48	2	2030	24.3
B04BC101690	BLASTING CAP	10/16/90	0.5 - 1.5	4670	ND(1.3)	ND(0.89)	287	0.47	2.2	1730	18.7
B05BC101690	BLASTING CAP	10/16/90	0.5 - 1.5	4050	ND(1.4)	1.1	183	ND(0.47)	2.2	946	22.2
B01ES101790	EXPLOSIVE STORAGE	10/17/90	0.5 - 1.5	5550	ND(1.3)	1.3	243	ND(0.43)	3.3	2120	31.7
B03ES101790	EXPLOSIVE STORAGE	10/17/90	0.5 - 1.5	7710	ND(1.4)	0.96	169	0.46	1.4	2230	28.3
B05ES101790	EXPLOSIVE STORAGE	10/17/90	0.5 - 1.5	5040	ND(1.3)	2.8	214	0.42	1.3	4400	24.7
B07ES101790	EXPLOSIVE STORAGE	10/17/90	0.5 - 1.5	11100	ND(1.3)	10.2	225	ND(0.43)	4.6	3860	44.4
B09ES120190	EXPLOSIVE STORAGE	10/20&12/01-90	0.5 - 1.5	16100	ND(8.1)	3.6	185	0.68	3.4	18200	56.8
B11ES120190	EXPLOSIVE STORAGE	10/20&12/01-90	0.5 - 1.5	11800	ND(8.3)	ND(8.7)	236	0.5	0.81	2570	42.2
B13ES120190	EXPLOSIVE STORAGE	10/17&12/01-90	0.5 - 1.5	4450	ND(1.3)	2.8	187	ND(0.42)	1.4	1810	30.5
B14ES101790	EXPLOSIVE STORAGE	10/17/90	0.5 - 1.5	5060	ND(1.3)	2.8	198	0.44	1.7	2270	29.7
B15ES101790	EXPLOSIVE STORAGE	10/17/90	0.5 - 1.5	4800	ND(1.3)	2.8	184	0.43	1.6	1520	27.7
B16ES120190	EXPLOSIVE STORAGE	10/20&12/01-90	0.5 - 1.5	17700	ND(8.1)	2.4	205	0.66	4.1	12400	65.1
B1TP120190	TEST PIT	10/20&12/01-90	0.5 - 1.5	11100	15.6	21.2	247	ND(0.44)	9.9	2790	36.1
B2TP120190	TEST PIT	10/20&12/01-90	0.5 - 1.5	9000	ND(8.7)	4.3	390	ND(0.46)	2.8	2130	34
B1BG1120190	BACKGROUND	10/20&12/01-90	1.3	14300	ND(8.8)	ND(0.92)	122	0.48	1.2	3930	39.7
B1BG2120190	BACKGROUND	10/20&12/01-90	1.3	16900	ND(9.1)	ND(0.95)	142	0.65	3.1	4460	45.1
B1MA120190	MARSH	10/24&12/01-90	1	21000	ND(9.1)	3.5	195	0.74	2.2	6890	59.6
B2MA102490	MARSH	10/24/90	1	21700	ND(25.9)	119	54.9	ND(1.4)	9.8	4910	85.2

ND(8.3) = Not Detected (Detection Limit); NA = Not Analyzed; * = Exceeded Holding time for Mercury

SOIL SAMPLE RESULTS
TARGET ANALYTE LIST OF 22 METALS
UNIVERSITY OF CALIFORNIA
RICHMOND FIELD STATION

SAMPLE NUMBER	SAMPLE LOCATION	SAMPLE DATE	SAMPLE DEPTH (FEET)	ALUMINUM (mg/kg)	ANTIMONY (mg/kg)	ARSENIC (mg/kg)	BARIUM (mg/kg)	BERYLLIUM (mg/kg)	CADMIUM (mg/kg)	CALCIUM (mg/kg)	CHROMIUM (mg/kg)
B3MA102490	MARSH	10/24/90	1	26700	ND(20.4)	ND(33.4)	61.2	ND(1.1)	3.8	3980	102
B4MA120190	MARSH	10/24&12/01-90	1	24700	ND(13.4)	186	96.1	ND(0.70)	5	3180	100
B5MA120190	MARSH	10/24&12/01-90	1	27400	ND(33.9)	674	61	ND(1.8)	8.2	4600	110
B6MA102490	MARSH	10/24/90	1	29800	ND(19.0)	ND(3.1)	62.9	ND(1.0)	5.3	3870	115
B7MA120190	MARSH	10/24&12/01-90	1	17400	13.6	15.8	189	0.99	6.9	17700	35.7
B8MA112690	MARSH	10/24&11/26-90	1	30000	ND(18.9)	875	86.9	ND(1.0)	7.7	4160	209
B9MA112690	MARSH	10/24&11/26-90	1	11600	ND(15.8)	125	164	ND(0.67)	8.7	1730	39.5
B10MA112690	MARSH	10/24&11/26-90	1	21900	47.9	2210	108	ND(0.92)	12.3	4300	185
B11MA112690	MARSH	10/24&11/26-90	1	21500	16.5	245	100	ND(0.86)	7.6	3690	143
SD1BAY102490	BAY	10/24/90	1	21000	ND(14.3)	10.5	71	ND(0.75)	3.2	5040	73.2
SD2BAY102490	BAY	10/24/90	1	6840	ND(10.3)	3.2	70.7	ND(0.54)	2	3200	26.9
SD1SL102490	SLOUGH	10/24/90	1	24800	ND(15.4)	ND(2.6)	74.2	0.89	4.8	3430	95.6
SD2SL102490	SLOUGH	10/24/90	1	23400	ND(16.3)	ND(2.7)	69.2	ND(0.86)	2	3810	89.7
SD3SL102490	SLOUGH	10/24/90	1	24200	ND(16.8)	101	105	1.1	10.8	3630	138
B1PR102490	PIER	10/24/90	1.3	7580	ND(9.9)	ND(63.4)	39.2	ND(0.52)	1.8	18400	36.8
SD1PR102490	PIER	10/24/90	1	19700	ND(14.6)	ND(24.9)	77.3	ND(0.77)	5.6	3400	83.5
SD1WSD102490	WEST STORM DRAIN	10/24/90	1	25400	ND(14.9)	ND(25.1)	73.1	0.86	5.7	3500	115
SD1ESD102490	EAST STORM DRAIN	10/24/90	1	8160	41.8	ND(348)	178	ND(1.1)	31	1890	37.6
SD1MA102490	MARSH	10/24/90	1	28400	ND(16.1)	50.6	77.2	ND(0.85)	5.9	4180	105
SD2MA102490	MARSH	10/24/90	1	31000	ND(16.1)	27.2	75.6	ND(0.85)	2.8	4110	105
SD3MA102490	MARSH	10/24/90	1	32700	ND(24.2)	190	57	1.5	5	4400	116
SD4MA120190	MARSH	10/24/90	1	9440	26	161	112	ND(0.54)	9.7	2310	32.9
SD5MA120190	MARSH	10/24/90	1	8710	30.4	167	97.1	ND(0.60)	11	2740	35.8
SD6MA120390	MARSH	10/24/90	1	13800	79	555	207	ND(0.84)	33.7	1690	33.8

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SOIL SAMPLE RESULTS
TARGET ANALYTE LIST OF 22 METALS
UNIVERSITY OF CALIFORNIA
RICHMOND FIELD STATION

SAMPLE NUMBER	SAMPLE LOCATION	SAMPLE DATE	SAMPLE DEPTH (FEET)	COBALT (mg/kg)	COPPER (mg/kg)	CYANIDE (mg/kg)	IRON (mg/kg)	LEAD (mg/kg)	MAGNESIUM (mg/kg)	MANGANESE (mg/kg)	MERCURY (mg/kg)
B01SH120190	SHELL MANUFACTURING	10/18&12/01-90	1.3	21.7	187	0.15	19500	81.3	4310	605	1.1
B02SH101890	SHELL MANUFACTURING	10/18/90	1.3	13.3	34	NA	10800	37.1	5100	518	3.31
B03SH101890	SHELL MANUFACTURING	10/18/90	1.3	51.5	12.6	NA	10300	7.4	1370	4280	0.12
B04SH101890	SHELL MANUFACTURING	10/18/90	1.3	13.2	10.5	NA	5970	6.4	1070	898	ND(0.11)
B05SH101890	SHELL MANUFACTURING	10/18/90	1.3	14.6	18.1	NA	17300	6.3	6550	353	ND(0.11)
B06SH101890	SHELL MANUFACTURING	10/18/90	1.3	15	17	NA	13200	5.4	6340	380	ND(0.11)
B07SH120190	SHELL MANUFACTURING	10/18&12/01-90	1.3	27.2	38.9	NA	7520	20.6	1250	1290	80.1
B08SH120190	SHELL MANUFACTURING	10/18&12/01-90	1.3	27.1	181	NA	11800	121	1960	1220	97.8
B09SH120190	SHELL MANUFACTURING	10/18&12/01-90	1.3	10.8	70.5	NA	9750	187	2000	489	18.8
B10SH120190	SHELL MANUFACTURING	10/18&12/01-90	1.3	16.5	188	NA	10000	87.4	1650	986	40.2
B11SH120190	SHELL MANUFACTURING	10/18&12/01-90	1.3	5.5	291	NA	9460	313	1440	345	7.74
B12SH101890	SHELL MANUFACTURING	10/18/90	1.3	11.3	24.3	NA	7390	8.9	1590	508	0.57
B13SH101890	SHELL MANUFACTURING	10/18/90	1.3	11.5	24.8	NA	9960	9.2	5610	497	0.3
B14SH101890	SHELL MANUFACTURING	10/18/90	1.3	23.7	22.5	0.13	7510	12.9	1620	1100	2.48
B16SH101890	SHELL MANUFACTURING	10/18/90	1.3	16.2	804	NA	7470	9.3	1350	491	1.17
B18SH101890	SHELL MANUFACTURING	10/18/90	1.3	22.2	29.8	0.13	11000	40.1	2010	1000	2.27
B15SH1.5-120190	SHELL MANUFACTURING	10/24&12/01-90	1.5	15.4	408	ND(0.1)	45100	741	1500	579	6.42
B15SH04-102490	SHELL MANUFACTURING	10/24/90	4	19	32.3	NA	25500	6.5	5170	713	0.3
B15SH6.5-102490	SHELL MANUFACTURING	10/24/90	6.5	5.9	54.3	NA	22000	9.7	7140	130	0.26
B15SH09-102490	SHELL MANUFACTURING	10/24/90	9	14.7	25.3	NA	24900	4.2	6670	537	0.11
B15SH11.5-10249	SHELL MANUFACTURING	10/24/90	11.5	18.8	62.7	NA	31000	4.2	7330	875	0.11
B15SH14-102490	SHELL MANUFACTURING	10/24/90	14	19.6	25.5	NA	18800	3.2	6090	538	0.25
B1MF-120190	MERCURY FULMINATE	10/24&12/01-90	1.3	11.8	102	0.19	16600	91.5	2760	403	317
B2MF1.5-120190	MERCURY FULMINATE	10/24&12/01-90	1.5	16.6	209	ND(0.1)	36700	388	3990	319	4.39
B2MF04-120190	MERCURY FULMINATE	10/24&12/01-90	4	15	159	NA	29200	697	3200	487	2.6
B2MF6.5-102490	MERCURY FULMINATE	10/24/90	6.5	8	44	NA	23400	7.4	9500	208	0.46
B2MF09-102490	MERCURY FULMINATE	10/24/90	9	7.9	29.2	NA	20600	5	6250	130	ND(0.12)

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SOIL SAMPLE RESULTS
TARGET ANALYTE LIST OF 22 METALS
UNIVERSITY OF CALIFORNIA
RICHMOND FIELD STATION

SAMPLE NUMBER	SAMPLE LOCATION	SAMPLE DATE	SAMPLE DEPTH (FEET)	COBALT (mg/kg)	COPPER (mg/kg)	CYANIDE (mg/kg)	IRON (mg/kg)	LEAD (mg/kg)	MAGNESIUM (mg/kg)	MANGANESE (mg/kg)	MERCURY (mg/kg)
B2MF11.5-102490	MERCURY FULMINATE	10/24/90	11.5	9.1	22.7	NA	15500	4.3	6380	184	1.63
B2MF14-102490	MERCURY FULMINATE	10/24/90	14	8.9	34.7	NA	14800	5.6	5330	209	2.03
B3MF-120190	MERCURY FULMINATE	10/24&12/01-90	1.3	13.7	451	ND(0.1)	42600	1140	2640	261	11
B01BC101690	BLASTING CAP	10/16/90	0.5 - 1.5	14.2	207	NA	16600	19.1	3660	666	0.83
B02BC101690	BLASTING CAP	10/16/90	0.5 - 1.5	27.2	232	NA	8660	19.8	832	1360	1.04
B03BC101690	BLASTING CAP	10/16/90	0.5 - 1.5	16	70.8	NA	9830	69.5	1500	923	1.75
B04BC101690	BLASTING CAP	10/16/90	0.5 - 1.5	24.6	149	NA	8520	17.1	1300	1460	1.06
B05BC101690	BLASTING CAP	10/16/90	0.5 - 1.5	13.7	201	NA	11200	14.2	905	705	0.41
B01ES101790	EXPLOSIVE STORAGE	10/17/90	0.5 - 1.5	43.1	654	NA	12800	8.5	1640	2340	0.28
B03ES101790	EXPLOSIVE STORAGE	10/17/90	0.5 - 1.5	10.5	736	NA	9460	5	2160	356	ND(0.12)
B05ES101790	EXPLOSIVE STORAGE	10/17/90	0.5 - 1.5	12.2	44.1	NA	10000	10.5	1640	816	0.8
B07ES101790	EXPLOSIVE STORAGE	10/17/90	0.5 - 1.5	19.1	516	NA	25900	24.3	3550	702	1.37
B09ES120190	EXPLOSIVE STORAGE	10/20&12/01-90	0.5 - 1.5	15.6	77.8	NA	19800	18	6930	553	0.51
B11ES120190	EXPLOSIVE STORAGE	10/20&12/01-90	0.5 - 1.5	18.1	21.2	NA	15000	6.9	2780	879	ND(0.12)
B13ES120190	EXPLOSIVE STORAGE	10/17&12/01-90	0.5 - 1.5	13	29.5	NA	9480	12	1400	689	0.4
B14ES101790	EXPLOSIVE STORAGE	10/17/90	0.5 - 1.5	13.4	29.3	NA	9500	15.1	1590	715	0.3
B15ES101790	EXPLOSIVE STORAGE	10/17/90	0.5 - 1.5	9.2	22.6	NA	9490	17.4	1500	364	0.19
B16ES120190	EXPLOSIVE STORAGE	10/20&12/01-90	0.5 - 1.5	22.2	70.7	NA	23100	15	8140	639	0.84*
B1TP120190	TEST PIT	10/20&12/01-90	0.5 - 1.5	32.8	899	NA	70000	49.2	3150	842	6.66
B2TP120190	TEST PIT	10/20&12/01-90	0.5 - 1.5	30.6	1140	NA	27800	46.4	1560	1630	2.91
B1BG1120190	BACKGROUND	10/20&12/01-90	1.3	4.2	17.9	ND(0.1)	12600	7.3	2930	167	ND(0.11)
B1BG2120190	BACKGROUND	10/20&12/01-90	1.3	9.5	22.4	0.25	15600	10.7	3300	360	ND(0.12)
B1MA120190	MARSH	10/24&12/01-90	1	24.9	44.4	NA	26000	7.5	5260	1030	ND(0.12)
B2MA102490	MARSH	10/24/90	1	21.6	112	NA	45700	125	13300	222	2.32

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RICHMOND FIELD STATION

SAMPLE NUMBER	SAMPLE LOCATION	SAMPLE DATE	SAMPLE DEPTH (FEET)	COBALT (mg/kg)	COPPER (mg/kg)	CYANIDE (mg/kg)	IRON (mg/kg)	LEAD (mg/kg)	MAGNESIUM (mg/kg)	MANGANESE (mg/kg)	MERCURY (mg/kg)
B3MA102490	MARSH	10/24/90	1	9.5	88.6	NA	37600	83.7	14100	217	1.97
B4MA120190	MARSH	10/24&12/01-90	1	15.1	514	NA	37900	122	10900	169	10.5
B5MA120190	MARSH	10/24&12/01-90	1	24.4	494	NA	67700	221	15200	238	1.74
B6MA102490	MARSH	10/24/90	1	15.9	122	NA	37200	99.6	14900	233	2.3
B7MA120190	MARSH	10/24&12/01-90	1	27	121	NA	48100	72.2	6430	586	0.72
B8MA112690	MARSH	10/24&11/26-90	1	13.6	415	NA	60900	235	13600	170	35.9
B9MA112690	MARSH	10/24&11/26-90	1	13.1	519	NA	65200	91.3	2550	31.3	7.09
B10MA112690	MARSH	10/24&11/26-90	1	17.8	495	NA	92800	357	8530	99.5	20.2
B11MA112690	MARSH	10/24&11/26-90	1	ND(6.5)	294	NA	47300	74.6	9180	120	25.1
SD1BAY102490	BAY	10/24/90	1	16.1	255	NA	32000	58.3	10700	257	1.5
SD2BAY102490	BAY	10/24/90	1	9.5	183	NA	11100	10.8	3890	126	0.14
SD1SL102490	SLOUGH	10/24/90	1	21.5	178	NA	48400	143	12500	234	1.84
SD2SL102490	SLOUGH	10/24/90	1	13.7	106	NA	33000	108	12400	198	2.87
SD3SL102490	SLOUGH	10/24/90	1	19	692	NA	42100	485	11500	249	1.37
B1PR102490	PIER	10/24/90	1.3	12	108	NA	21400	129	4980	125	0.94
SD1PR102490	PIER	10/24/90	1	10.8	85.7	NA	32600	122	11000	188	2.23
SD1WSD102490	WEST STORM DRAIN	10/24/90	1	12.5	152	NA	38900	188	12800	228	2.34
SD1ESD102490	EAST STORM DRAIN	10/24/90	1	16.8	813	NA	235000	172	3650	89.8	8
SD1MA102490	MARSH	10/24/90	1	18.1	154	NA	45200	123	13300	279	3.02
SD2MA102490	MARSH	10/24/90	1	21.5	127	NA	42500	95.4	14500	283	2.46
SD3MA102490	MARSH	10/24/90	1	12.4	145	NA	50400	153	15600	232	2.44
SD4MA120190	MARSH	10/24/90	1	16.7	262	NA	83500	293	4330	99.5	15.7
SD5MA120190	MARSH	10/24/90	1	17.5	400	NA	80600	275	3950	91.7	6.27
SD6MA120390	MARSH	10/24/90	1	30.9	823	NA	199000	814	3610	81.3	10.6

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SOIL SAMPLE RESULTS
TARGET ANALYTE LIST OF 22 METALS
UNIVERSITY OF CALIFORNIA
RICHMOND FIELD STATION

SAMPLE NUMBER	SAMPLE LOCATION	SAMPLE DATE	SAMPLE DEPTH (FEET)	MOLYBDENUM (mg/kg)	NICKEL (mg/kg)	POTASSIUM (mg/kg)	SELENIUM (mg/kg)	SILVER (mg/kg)	SODIUM (mg/kg)	THALLIUM (mg/kg)	VANADIUM (mg/kg)
B01SH120190	SHELL MANUFACTURING	10/18&12/01-90	1.3	ND(3.3)	53.4	1600	ND(9.0)	ND(1.6)	427	ND(0.90)	36.2
B02SH101890	SHELL MANUFACTURING	10/18/90	1.3	ND(3.2)	48.7	373	ND(3.6)	ND(1.5)	334	ND(3.4)	25.7
B03SH101890	SHELL MANUFACTURING	10/18/90	1.3	ND(3.2)	46.7	179	ND(0.70)	ND(1.5)	378	ND(0.34)	38.5
B04SH101890	SHELL MANUFACTURING	10/18/90	1.3	ND(3.1)	20.9	199	ND(0.70)	ND(1.5)	315	ND(0.34)	21.6
B05SH101890	SHELL MANUFACTURING	10/18/90	1.3	ND(3.4)	41.2	471	ND(0.74)	ND(1.6)	413	ND(0.36)	17.4
B06SH101890	SHELL MANUFACTURING	10/18/90	1.3	ND(3.3)	35.9	565	ND(0.73)	ND(1.5)	534	ND(3.6)	16.2
B07SH120190	SHELL MANUFACTURING	10/18&12/01-90	1.3	ND(3.3)	31.8	296	ND(0.73)	ND(1.5)	298	ND(0.35)	24.2
B08SH120190	SHELL MANUFACTURING	10/18&12/01-90	1.3	ND(3.3)	34.4	365	ND(0.70)	ND(1.5)	356	ND(0.34)	27.9
B09SH120190	SHELL MANUFACTURING	10/18&12/01-90	1.3	ND(3.1)	20.5	798	ND(0.70)	ND(1.5)	283	ND(3.4)	16.3
B10SH120190	SHELL MANUFACTURING	10/18&12/01-90	1.3	ND(3.2)	34	620	ND(0.72)	ND(1.5)	258	ND(3.5)	21.7
B11SH120190	SHELL MANUFACTURING	10/18&12/01-90	1.3	ND(3.3)	20.2	586	ND(8.7)	ND(1.5)	322	ND(0.87)	25.7
B12SH101890	SHELL MANUFACTURING	10/18/90	1.3	ND(3.3)	29.6	456	ND(0.72)	ND(1.5)	641	ND(0.35)	21.1
B13SH101890	SHELL MANUFACTURING	10/18/90	1.3	ND(3.3)	45.3	553	ND(0.76)	ND(1.6)	332	ND(1.8)	21.6
B14SH101890	SHELL MANUFACTURING	10/18/90	1.3	ND(3.2)	32.6	603	ND(0.71)	ND(1.5)	1440	ND(0.69)	22.3
B16SH101890	SHELL MANUFACTURING	10/18/90	1.3	ND(3.4)	12.6	474	ND(0.76)	ND(1.6)	787	ND(0.37)	20.8
B18SH101890	SHELL MANUFACTURING	10/18/90	1.3	ND(3.3)	36.1	826	ND(0.71)	ND(1.5)	1370	ND(3.4)	28.7
B15SH1.5-120190	SHELL MANUFACTURING	10/24&12/01-90	1.5	ND(3.2)	39.8	1460	ND(8.6)	ND(1.5)	544	ND(0.86)	34.1
B15SH04-102490	SHELL MANUFACTURING	10/24/90	4	ND(3.4)	60.9	592	ND(9.30	ND(1.6)	857	ND(0.93)	40.8
B15SH6.5-102490	SHELL MANUFACTURING	10/24/90	6.5	ND(3.5)	57.4	397	ND(9.2)	ND(1.6)	1020	ND(9.2)	27.6
B15SH09-102490	SHELL MANUFACTURING	10/24/90	9	ND(3.2)	53.7	739	ND(8.8)	ND(1.5)	849	ND(8.8)	37.2
B15SH11.5-10249	SHELL MANUFACTURING	10/24/90	11.5	ND(3.4)	74.4	839	ND(9.0)	ND(1.6)	867	ND(0.90)	46.3
B15SH14-102490	SHELL MANUFACTURING	10/24/90	14	ND(3.6)	49.5	779	ND(9.5)	ND(1.7)	774	ND(0.95)	35.1
B1MF-120190	MERCURY FULMINATE	10/24&12/01-90	1.3	ND(3.3)	33	1310	ND(0.88)	ND(1.5)	1120	ND(0.88)	27.7
B2MF1.5-120190	MERCURY FULMINATE	10/24&12/01-90	1.5	ND(3.3)	34.6	1340	ND(8.9)	ND(1.5)	507	ND(0.89)	33.8
B2MF04-120190	MERCURY FULMINATE	10/24&12/01-90	4	ND(3.7)	34.7	738	ND(9.9)	ND(1.7)	587	ND(0.99)	30
B2MF6.5-102490	MERCURY FULMINATE	10/24/90	6.5	ND(3.7)	63.3	352	ND(10.0)	ND(1.7)	740	ND(1.00)	31.8
B2MF09-102490	MERCURY FULMINATE	10/24/90	9	ND(3.7)	50.4	437	ND(0.96)	ND(1.7)	605	ND(0.96)	43

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SAMPLE NUMBER	SAMPLE LOCATION	SAMPLE DATE	SAMPLE DEPTH (FEET)	MOLYBDENUM (mg/kg)	NICKEL (mg/kg)	POTASSIUM (mg/kg)	SELENIUM (mg/kg)	SILVER (mg/kg)	SODIUM (mg/kg)	THALLIUM (mg/kg)	VANADIUM (mg/kg)
B2MF11.5-102490	MERCURY FULMINATE	10/24/90	11.5	ND(3.4)	40.2	327	ND(8.9)	ND(1.6)	465	ND(0.89)	23.7
B2MF14-102490	MERCURY FULMINATE	10/24/90	14	ND(3.3)	41.9	512	ND(0.88)	ND(1.6)	561	ND(0.88)	26.5
B3MF-120190	MERCURY FULMINATE	10/24&12/01-90	1.3	ND(3.4)	45.7	1180	ND(0.90)	ND(1.6)	516	ND(0.90)	25.9
B01BC101690	BLASTING CAP	10/16/90	0.5 - 1.5	ND(3.4)	40	831	ND(0.92)	ND(1.6)	2680	ND(0.92)	29.8
B02BC101690	BLASTING CAP	10/16/90	0.5 - 1.5	ND(3.6)	13.1	369	ND(0.96)	ND(1.7)	315	ND(0.96)	24
B03BC101690	BLASTING CAP	10/16/90	0.5 - 1.5	ND(3.4)	23.4	444	ND(0.91)	2.1	343	ND(0.91)	24.5
B04BC101690	BLASTING CAP	10/16/90	0.5 - 1.5	ND(3.3)	26.5	424	ND(0.89)	ND(1.6)	293	ND(0.89)	25.5
B05BC101690	BLASTING CAP	10/16/90	0.5 - 1.5	ND(3.5)	13.2	460	ND(0.94)	ND(1.7)	306	ND(0.94)	28.1
B01ES101790	EXPLOSIVE STORAGE	10/17/90	0.5 - 1.5	ND(3.2)	47.8	481	ND(0.87)	ND(1.5)	291	ND(0.87)	34.5
B03ES101790	EXPLOSIVE STORAGE	10/17/90	0.5 - 1.5	ND(3.5)	19.4	359	ND(0.90)	ND(1.6)	290	ND(0.90)	27.2
B05ES101790	EXPLOSIVE STORAGE	10/17/90	0.5 - 1.5	ND(3.1)	29.8	458	ND(0.84)	ND(1.5)	251	ND(0.84)	25
B07ES101790	EXPLOSIVE STORAGE	10/17/90	0.5 - 1.5	ND(3.3)	35.9	758	ND(0.87)	1.9	401	ND(0.87)	27.9
B09ES120190	EXPLOSIVE STORAGE	10/20&12/01-90	0.5 - 1.5	ND(3.2)	65.4	1220	ND(3.5)	ND(1.5)	427	ND(1.7)	32.9
B11ES120190	EXPLOSIVE STORAGE	10/20&12/01-90	0.5 - 1.5	ND(3.3)	30.9	436	ND(8.7)	ND(1.5)	423	ND(0.87)	33.4
B13ES120190	EXPLOSIVE STORAGE	10/17&12/01-90	0.5 - 1.5	ND(3.2)	26.8	668	ND(0.85)	ND(1.5)	348	ND(0.85)	29.9
B14ES101790	EXPLOSIVE STORAGE	10/17/90	0.5 - 1.5	ND(3.3)	32.3	755	ND(0.86)	ND(1.5)	363	ND(0.86)	30.3
B15ES101790	EXPLOSIVE STORAGE	10/17/90	0.5 - 1.5	ND(3.2)	27.2	760	ND(0.86)	ND(1.5)	338	ND(0.86)	27.8
B16ES120190	EXPLOSIVE STORAGE	10/20&12/01-90	0.5 - 1.5	ND(3.2)	79.7	1310	ND(7.2)	ND(1.5)	464	ND(1.7)	40.1
B1TP120190	TEST PIT	10/20&12/01-90	0.5 - 1.5	ND(3.3)	27.1	1010	ND(0.72)	ND(1.5)	454	ND(3.5)	29.3
B2TP120190	TEST PIT	10/20&12/01-90	0.5 - 1.5	ND(3.4)	33.7	551	ND(9.1)	ND(1.6)	384	ND(0.91)	36.8
B1BG1120190	BACKGROUND	10/20&12/01-90	1.3	ND(3.5)	36.8	289	ND(9.2)	ND(1.6)	607	ND(0.92)	21.6
B1BG2120190	BACKGROUND	10/20&12/01-90	1.3	ND(3.6)	38.7	342	ND(9.2)	ND(1.7)	757	ND(0.95)	25.8
B1MA120190	MARSH	10/24&12/01-90	1	ND(3.6)	61	899	ND(7.9)	ND(1.7)	507	ND(0.38)	40.8
B2MA102490	MARSH	10/24/90	1	11.2	111	5690	ND(22.2)	ND(4.8)	29700	ND(10.8)	59.8

ND(8.3) = Not Detected (Detection Limit); NA = Not Analyzed; * = Exceeded Holding time for Mercury

SOIL SAMPLE RESULTS
TARGET ANALYTE LIST OF 22 METALS
UNIVERSITY OF CALIFORNIA
RICHMOND FIELD STATION

SAMPLE NUMBER	SAMPLE LOCATION	SAMPLE DATE	SAMPLE DEPTH (FEET)	ZINC (mg/kg)
B01SH120190	SHELL MANUFACTURING	10/18&12/01-90	1.3	125
B02SH101890	SHELL MANUFACTURING	10/18/90	1.3	40.8
B03SH101890	SHELL MANUFACTURING	10/18/90	1.3	10.9
B04SH101890	SHELL MANUFACTURING	10/18/90	1.3	10.2
B05SH101890	SHELL MANUFACTURING	10/18/90	1.3	43.8
B06SH101890	SHELL MANUFACTURING	10/18/90	1.3	42.6
B07SH120190	SHELL MANUFACTURING	10/18&12/01-90	1.3	47.6
B08SH120190	SHELL MANUFACTURING	10/18&12/01-90	1.3	114
B09SH120190	SHELL MANUFACTURING	10/18&12/01-90	1.3	132
B10SH120190	SHELL MANUFACTURING	10/18&12/01-90	1.3	260
B11SH120190	SHELL MANUFACTURING	10/18&12/01-90	1.3	437
B12SH101890	SHELL MANUFACTURING	10/18/90	1.3	35.7
B13SH101890	SHELL MANUFACTURING	10/18/90	1.3	43.2
B14SH101890	SHELL MANUFACTURING	10/18/90	1.3	54.7
B16SH101890	SHELL MANUFACTURING	10/18/90	1.3	71.4
B18SH101890	SHELL MANUFACTURING	10/18/90	1.3	66.7
B15SH1.5-120190	SHELL MANUFACTURING	10/24&12/01-90	1.5	366
B15SH04-102490	SHELL MANUFACTURING	10/24/90	4	48.4
B15SH6.5-102490	SHELL MANUFACTURING	10/24/90	6.5	65.7
B15SH09-102490	SHELL MANUFACTURING	10/24/90	9	58.7
B15SH11.5-10249	SHELL MANUFACTURING	10/24/90	11.5	89.3
B15SH14-102490	SHELL MANUFACTURING	10/24/90	14	48.5
B1MF-120190	MERCURY FULMINATE	10/24&12/01-90	1.3	214
B2MF1.5-120190	MERCURY FULMINATE	10/24&12/01-90	1.5	2150
B2MF04-120190	MERCURY FULMINATE	10/24&12/01-90	4	676
B2MF6.5-102490	MERCURY FULMINATE	10/24/90	6.5	68.8
B2MF09-102490	MERCURY FULMINATE	10/24/90	9	57.4

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SOIL SAMPLE RESULTS
TARGET ANALYTE LIST OF 22 METALS
UNIVERSITY OF CALIFORNIA
RICHMOND FIELD STATION

SAMPLE NUMBER	SAMPLE LOCATION	SAMPLE DATE	SAMPLE DEPTH (FEET)	ZINC (mg/kg)
B2MF11.5-102490	MERCURY FULMINATE	10/24/90	11.5	63.9
B2MF14-102490	MERCURY FULMINATE	10/24/90	14	53.2
B3MF-120190	MERCURY FULMINATE	10/24&12/01-90	1.3	1550
B01BC101690	BLASTING CAP	10/16/90	0.5 - 1.5	135
B02BC101690	BLASTING CAP	10/16/90	0.5 - 1.5	171
B03BC101690	BLASTING CAP	10/16/90	0.5 - 1.5	392
B04BC101690	BLASTING CAP	10/16/90	0.5 - 1.5	223
B05BC101690	BLASTING CAP	10/16/90	0.5 - 1.5	267
B01ES101790	EXPLOSIVE STORAGE	10/17/90	0.5 - 1.5	260
B03ES101790	EXPLOSIVE STORAGE	10/17/90	0.5 - 1.5	266
B05ES101790	EXPLOSIVE STORAGE	10/17/90	0.5 - 1.5	177
B07ES101790	EXPLOSIVE STORAGE	10/17/90	0.5 - 1.5	138
B09ES120190	EXPLOSIVE STORAGE	10/20&12/01-90	0.5 - 1.5	222
B11ES120190	EXPLOSIVE STORAGE	10/20&12/01-90	0.5 - 1.5	24.4
B13ES120190	EXPLOSIVE STORAGE	10/17&12/01-90	0.5 - 1.5	154
B14ES101790	EXPLOSIVE STORAGE	10/17/90	0.5 - 1.5	161
B15ES101790	EXPLOSIVE STORAGE	10/17/90	0.5 - 1.5	270
B16ES120190	EXPLOSIVE STORAGE	10/20&12/01-90	0.5 - 1.5	178
B1TP120190	TEST PIT	10/20&12/01-90	0.5 - 1.5	227
B2TP120190	TEST PIT	10/20&12/01-90	0.5 - 1.5	142
B1BG1120190	BACKGROUND	10/20&12/01-90	1.3	27.6
B1BG2120190	BACKGROUND	10/20&12/01-90	1.3	37.1
B1MA120190	MARSH	10/24&12/01-90	1	95.9
B2MA102490	MARSH	10/24/90	1	622

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SOIL SAMPLE RESULTS
TARGET ANALYTE LIST OF 22 METALS
UNIVERSITY OF CALIFORNIA
RICHMOND FIELD STATION

SAMPLE NUMBER	SAMPLE LOCATION	SAMPLE DATE	SAMPLE DEPTH (FEET)	ZINC (mg/kg)
B3MA102490	MARSH	10/24/90	1	325
B4MA120190	MARSH	10/24&12/01-90	1	906
B5MA120190	MARSH	10/24&12/01-90	1	1470
B6MA102490	MARSH	10/24/90	1	446
B7MA120190	MARSH	10/24&12/01-90	1	930
B8MA112690	MARSH	10/24&11/26-90	1	517
B9MA112690	MARSH	10/24&11/26-90	1	1270
B10MA112690	MARSH	10/24&11/26-90	1	694
B11MA112690	MARSH	10/24&11/26-90	1	489
SD1BAY102490	BAY	10/24/90	1	283
SD2BAY102490	BAY	10/24/90	1	134
SD1SL102490	SLOUGH	10/24/90	1	661
SD2SL102490	SLOUGH	10/24/90	1	317
SD3SL102490	SLOUGH	10/24/90	1	1060
B1PR102490	PIER	10/24/90	1.3	353
SD1PR102490	PIER	10/24/90	1	259
SD1WSD102490	WEST STORM DRAIN	10/24/90	1	612
SD1ESD102490	EAST STORM DRAIN	10/24/90	1	305
SD1MA102490	MARSH	10/24/90	1	356
SD2MA102490	MARSH	10/24/90	1	343
SD3MA102490	MARSH	10/24/90	1	501
SD4MA120190	MARSH	10/24/90	1	697
SD5MA120190	MARSH	10/24/90	1	752
SD6MA120390	MARSH	10/24/90	1	2840

ND(8.3) = Not Detected (Detection Limit); NA = Not Analyzed; * = Exceeded Holding time for Mercury

SOIL SAMPLE RESULTS
PESTICIDES AND PCBs
UNIVERSITY OF CALIFORNIA
RICHMOND FIELD STATION

SAMPLE NUMBER	SAMPLE LOCATION	SAMPLE DATE	SAMPLE DEPTH (FEET)	alpha-BHC (mg/kg)	beta-BHC (mg/kg)	delta-BHC (mg/kg)	gamma-BHC (mg/kg)	Heptachlor (mg/kg)	Aldrin (mg/kg)	Heptachlor Epoxide (mg/kg)	Endosulfan I (mg/kg)	Dieldrin (mg/kg)
B8MA112690	MARSH	11/26/90	1	ND(0.041)	ND(0.041)	ND(0.041)	ND(0.041)	ND(0.041)	ND(0.041)	ND(0.041)	ND(0.041)	ND(0.082)
B9MA112690	MARSH	11/26/90	1	0.0418	ND(0.041)	ND(0.041)	ND(0.041)	ND(0.041)	ND(0.041)	ND(0.041)	ND(0.041)	ND(0.082)
B10MA11269	MARSH	11/26/90	1	ND(0.052)	ND(0.052)	ND(0.052)	ND(0.052)	ND(0.052)	ND(0.052)	ND(0.052)	ND(0.052)	ND(0.103)
B11MA11269	MARSH	11/26/90	1	ND(0.042)	ND(0.042)	ND(0.042)	ND(0.042)	ND(0.042)	ND(0.042)	ND(0.042)	ND(0.042)	ND(0.084)

SAMPLE NUMBER	SAMPLE LOCATION	SAMPLE DATE	SAMPLE DEPTH (FEET)	4,4'-DDE (mg/kg)	Endrin (mg/kg)	Endosulfan II (mg/kg)	4,4'-DDD (mg/kg)	Endosulfan Sulfate (mg/kg)	4,4'-DDT (mg/kg)	Methoxylchlor (mg/kg)	Endrin Ketone (mg/kg)	Chlordane (mg/kg)
B8MA112690	MARSH	11/26/90	1	ND(0.082)	ND(0.082)	ND(0.082)	0.178	ND(0.082)	ND(0.082)	ND(0.410)	ND(0.082)	ND(0.410)
B9MA112690	MARSH	11/26/90	1	ND(0.082)	ND(0.082)	ND(0.082)	ND(0.082)	ND(0.082)	ND(0.082)	ND(0.410)	ND(0.082)	ND(0.410)
B10MA11269	MARSH	11/26/90	1	ND(0.103)	ND(0.103)	ND(0.103)	0.336	ND(0.103)	0.129	ND(0.516)	ND(0.103)	ND(0.516)
B11MA11269	MARSH	11/26/90	1	ND(0.084)	ND(0.084)	ND(0.084)	0.282	ND(0.084)	ND(0.084)	ND(0.421)	ND(0.084)	ND(0.421)

SAMPLE NUMBER	SAMPLE LOCATION	SAMPLE DATE	SAMPLE DEPTH (FEET)	Toxaphene (mg/kg)	Aroclor 1016 (mg/kg)	Aroclor 1221 (mg/kg)	Aroclor 1232 (mg/kg)	Aroclor 1242 (mg/kg)	Aroclor 1248 (mg/kg)	Aroclor 1254 (mg/kg)	Aroclor 1260 (mg/kg)
B8MA112690	MARSH	11/26/90	1	ND(0.820)	ND(0.410)	ND(0.410)	ND(0.410)	ND(0.410)	ND(0.410)	ND(0.820)	ND(0.820)
B9MA112690	MARSH	11/26/90	1	ND(0.820)	ND(0.410)	ND(0.410)	ND(0.410)	ND(0.410)	ND(0.410)	ND(0.820)	ND(0.820)
B10MA11269	MARSH	11/26/90	1	ND(1.032)	ND(0.516)	ND(0.516)	ND(0.516)	ND(0.516)	ND(0.516)	ND(1.032)	ND(1.032)
B11MA11269	MARSH	11/26/90	1	ND(0.842)	ND(0.421)	ND(0.421)	ND(0.421)	ND(0.421)	ND(0.421)	ND(0.842)	ND(0.842)

SOIL SAMPLE RESULTS
TOTAL VOLATILE HYDROCARBONS WITH BTX&E (EPA METHOD 50 /8020)
EXTRACTABLE PETOLEUM HYDROCARBONS IN SOILS, CALIFORNI DOHS METHOD, LUFT MANUAL OCTOBER 1989
UNIVERSITY OF CALIFORNIA
RICHMOND FIELD STATION

SAMPLE NUMBER	SAMPLE LOCATION	SAMPLE DATE	SAMPLE DEPTH (INCHES)	TVH AS GASOLINE (mg/kg)	BENZENE (mg/kg)	TOLUENE (mg/kg)	ETHYL BENZENE (mg/kg)	TOTAL XYLENES (mg/kg)	KEROSEN RANGE (mg/kg)	DIESEL RANGE (mg/kg)
B1B118102090	BUILDING 118	10/20/90	0 - 6	6.8	ND (0.005)	ND (0.005)	ND (0.005)	0.039	ND (100)	1550
B1B120102090	BUILDING 120	10/20/90	0 - 6	ND (1.0)	ND (0.005)	0.012	0.008	0.044	ND (10)	187
B1B121102090	BUILDING 121	10/20/90	0 - 6	ND (1.0)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.015)	ND (10)	105

SURFACE WATER SAMPLE RESULTS
TARGET ANALYTE LIST OF 22 METALS
UNIVERSITY OF CALIFORNIA
RICHMOND FIELD STATION

SAMPLE NUMBER	SAMPLE LOCATION	SAMPLE DATE	ALUMINUM (ug/L)	ANTIMONY (ug/L)	ARSENIC (ug/L)	BARIUM (ug/L)	BERYLLIUM (ug/L)	CADMIUM (ug/L)	CALCIUM (ug/L)	CHROMIUM (ug/L)	COBALT (ug/L)	COPPER (ug/L)
SW1MA102490	MARSH	10/24/90	2060	ND(38.0)	ND(2560)	19.6	ND(2.0)	ND(3.5)	398000	ND(7.0)	ND(15.0)	44.5
SW2MA102490	MARSH	10/24/90	2090	ND(38.0)	ND(2560)	23.3	ND(2.0)	ND(3.5)	394000	7.7	ND(15.0)	44.6
SW3MA102490	MARSH	10/24/90	1560	ND(38.0)	ND(2560)	28	ND(2.0)	ND(3.5)	377000	ND(7.0)	ND(15.0)	50.6
SW4MA102490	MARSH	10/24/90	895	ND(38.0)	ND(2560)	49	ND(2.0)	ND(3.5)	624000	ND(7.0)	ND(15.0)	92.3
SW5MA102490	MARSH	10/24/90	930	ND(38.0)	ND(640)	22.9	ND(2.0)	ND(3.5)	638000	ND(7.0)	ND(15.0)	96.1
SW6MA102490	MARSH	10/24/90	126000	87.2	1570	147	ND(2.0)	53.8	575000	132	61.6	2360
SW1WSD102490	WEST STORM DRAIN	10/24/90	1250	ND(38.0)	ND(640)	30.8	ND(2.0)	ND(3.5)	341000	ND(7.0)	ND(15.0)	36.7
							ND	ND				
SW1BAY102490	BAY	10/24/90	1830	ND(38.0)	ND(640)	18.7	ND(2.0)	ND(3.5)	409000	7.7	ND(15.0)	41.2
SW2BAY102490	BAY	10/24/90	1080	ND(38.0)	ND(640)	14.9	ND(2.0)	ND(3.5)	401000	ND(7.0)	ND(15.0)	41.9
SW1SLEB102490	SLOUGH EBB	10/24/90	2520	ND(38.0)	ND(640)	60.7	ND(2.0)	ND(3.5)	371000	8.9	ND(15.0)	46.6
SW2SLEB102490	SLOUGH EBB	10/24/90	1490	ND(38.0)	ND(2560)	36.4	ND(2.0)	ND(3.5)	343000	ND(7.0)	ND(15.0)	37.7
SW1SLFL102490	SLOUGH FLOOD	10/24/90	1650	39.5	ND(640)	17.3	ND(2.0)	ND(3.5)	405000	7.4	ND(15.0)	42
SW2SLFL102490	SLOUGH FLOOD	10/24/90	1610	ND(38.0)	ND(640)	18.2	ND(2.0)	ND(3.5)	392000	ND(7.0)	ND(15.0)	41
SW1FB102490	FIELD BLANK	10/24/90	42.5	ND(38.0)	ND(6.4)	ND(1.0)	ND(2.0)	ND(3.5)	987	ND(7.0)	ND(15.0)	10.4

SURFACE WATER SAMPLE RESULTS
TARGET ANALYTE LIST OF 22 METALS
UNIVERSITY OF CALIFORNIA
RICHMOND FIELD STATION

SAMPLE NUMBER	SAMPLE LOCATION	SAMPLE DATE	CYANIDE (ug/L)	IRON (ug/L)	LEAD (ug/L)	MAGNESIUM (ug/L)	MANGANESE (ug/L)	MERCURY (ug/L)	MOLYBDENUM (ug/L)	NICKEL (ug/L)	POTASSIUM (ug/L)
SW1MA102490	MARSH	10/24/90	NA	1610	ND(120)	1200000	39.9	ND(0.20)	ND(15.0)	ND(27.0)	333000
SW2MA102490	MARSH	10/24/90	NA	1740	ND(120)	1200000	65.5	0.4	ND(15.0)	ND(27.0)	323000
SW3MA102490	MARSH	10/24/90	NA	1980	ND(120)	1130000	157	ND(0.20)	ND(15.0)	44.5	313000
SW4MA102490	MARSH	10/24/90	NA	580	ND(120)	1870000	233	0.4	ND(15.0)	50.4	515000
SW5MA102490	MARSH	10/24/90	NA	1120	ND(120)	1920000	234	ND(0.20)	ND(15.0)	ND(27.0)	517000
SW6MA102490	MARSH	10/24/90	NA	333000	ND(120)	1720000	306	ND(0.20)	ND(15.0)	ND(27.0)	477000
SW1WSD102490	WEST STORM DRAIN	10/24/90	NA	759	ND(120)	1010000	88.2	ND(0.20)	ND(15.0)	41.2	271000
SW1BAY102490	BAY	10/24/90	NA	1330	ND(120)	1250000	35.7	0.45	ND(15.0)	32	344000
SW2BAY102490	BAY	10/24/90	NA	460	ND(120)	1220000	19.7	0.2	ND(15.0)	ND(27.0)	337000
SW1SLEB102490	SLOUGH EBB	10/24/90	NA	2190	ND(120)	1100000	92.9	ND(0.20)	ND(15.0)	30.8	296000
SW2SLEB102490	SLOUGH EBB	10/24/90	NA	1020	ND(120)	1000000	79.2	ND(0.20)	ND(15.0)	ND(27.0)	261000
SW1SLFL102490	SLOUGH FLOOD	10/24/90	NA	1160	ND(120)	1240000	38.3	ND(0.20)	17.3	ND(27.0)	343000
SW2SLFL102490	SLOUGH FLOOD	10/24/90	NA	1070	ND(120)	1200000	54.2	ND(0.20)	ND(15.0)	ND(27.0)	325000
SW1FB102490	FIELD BLANK	10/24/90	NA	69.8	1.5	109	3	ND(0.20)	ND(15.0)	ND(27.0)	ND(442)

SURFACE WATER SAMPLE RESULTS
TARGET ANALYTE LIST OF 22 METALS
UNIVERSITY OF CALIFORNIA
RICHMOND FIELD STATION

SAMPLE NUMBER	SAMPLE LOCATION	SAMPLE DATE	SELENIUM (ug/L)	SILVER (ug/L)	SODIUM (ug/L)	THALLIUM (ug/L)	VANADIUM (ug/L)	ZINC (ug/L)
SW1MA102490	MARSH	10/24/90	ND(33.0)	ND(7.0)	9050000	ND(160)	ND(9.0)	30.7
SW2MA102490	MARSH	10/24/90	ND(33.0)	ND(7.0)	9140000	ND(160)	ND(9.0)	30.6
SW3MA102490	MARSH	10/24/90	ND(33.0)	ND(7.0)	8550000	ND(160)	ND(9.0)	94.3
SW4MA102490	MARSH	10/24/90	ND(33.0)	ND(7.0)	14700000	ND(160)	ND(9.0)	854
SW5MA102490	MARSH	10/24/90	ND(33.0)	ND(7.0)	14900000	ND(800)	ND(9.0)	877
SW6MA102490	MARSH	10/24/90	ND(33.0)	7.5	12700000	ND(800)	74.8	7900
SW1WSD102490	WEST STORM DRAIN	10/24/90	ND(33.0)	ND(7.0)	7630000	ND(160)	ND(9.0)	50.1
SW1BAY102490	BAY	10/24/90	ND(33.0)	ND(7.0)	9530000	ND(800)	ND(9.0)	73.2
SW2BAY102490	BAY	10/24/90	ND(33.0)	ND(7.0)	9290000	1210	ND(9.0)	11.5
SW1SLEB102490	SLOUGH EBB	10/24/90	ND(3.3)	ND(7.0)	8240000	ND(800)	ND(9.0)	116
SW2SLEB102490	SLOUGH EBB	10/24/90	ND(3.3)	ND(7.0)	7580000	ND(160)	ND(9.0)	38.5
SW1SLFL102490	SLOUGH FLOOD	10/24/90	ND(33.0)	ND(7.0)	9450000	ND(160)	ND(9.0)	23.1
SW2SLFL102490	SLOUGH FLOOD	10/24/90	ND(33.0)	ND(7.0)	8940000	ND(800)	ND(9.0)	30.8
SW1FB102490	FIELD BLANK	10/24/90	ND(3.3)	ND(7.0)	2640	1.9	ND(9.0)	38.6

SURFACE WATER SAMPLE RESULTS
PESTICIDES AND PCBs
UNIVERSITY OF CALIFORNIA
RICHMOND FIELD STATION

SAMPLE NUMBER	SAMPLE LOCATION	SAMPLE DATE	alpha-BHC (ug/L)	beta-BHC (ug/L)	gamma-BHC (ug/L)	delta-BHC (ug/L)	Heptachlor (ug/L)	Aldrin (ug/L)	Heptachlor Epoxide (ug/L)	Endosulfan I (ug/L)	Dieldrin (ug/L)
SW6MA11269	MARSH	11/26/90	0.09	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.10)

SAMPLE NUMBER	SAMPLE LOCATION	SAMPLE DATE	4,4'-DDE (ug/L)	Endrin (ug/L)	Endosulfan II (ug/L)	Endosulfan Sulfate (ug/L)	4,4'-DDD (ug/L)	4,4'-DDT (ug/L)	Methoxylchlor (ug/L)	Endrin Ketone (ug/L)	Chlordane (ug/L)
SW6MA11269	MARSH	11/26/90	ND(0.10)	ND(0.10)	ND(0.10)	ND(0.10)	ND(0.10)	ND(0.10)	ND(0.5)	ND(0.10)	ND(0.5)

SAMPLE NUMBER	SAMPLE LOCATION	SAMPLE DATE	Toxaphene (ug/L)	Aroclor 1016 (ug/L)	Aroclor 1221 (ug/L)	Aroclor 1232 (ug/L)	Aroclor 1242 (ug/L)	Aroclor 1248 (ug/L)	Aroclor 1254 (ug/L)	Aroclor 1260 (ug/L)
SW6MA11269	MARSH	11/26/90	ND(1.0)	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.5)	ND(1.0)	ND(1.0)

SOIL SAMPLE RESULTS
TARGET ANALYTE LIST OF 22 METALS
UNIVERSITY OF CALIFORNIA
RICHMOND FIELD STATION

SAMPLE NUMBER	SAMPLE LOCATION	SAMPLE DATE	SAMPLE DEPTH (FEET)	MOLYBDENUM (mg/kg)	NICKEL (mg/kg)	POTASSIUM (mg/kg)	SELENIUM (mg/kg)	SILVER (mg/kg)	SODIUM (mg/kg)	THALLIUM (mg/kg)	VANADIUM (mg/kg)
B3MA102490	MARSH	10/24/90	1	ND(8.1)	86.4	5680	ND(17.2)	ND(3.8)	22100	ND(8.3)	66.8
B4MA120190	MARSH	10/24&12/01-90	1	ND(5.3)	85.1	4490	ND(1.1)	ND(2.5)	13300	ND(5.5)	62.4
B5MA120190	MARSH	10/24&12/01-90	1	ND(13.4)	70.1	6510	ND(28.9)	ND(6.3)	43000	ND(14)	80.7
B6MA102490	MARSH	10/24/90	1	ND(7.5)	96.4	6410	ND(16.2)	ND(3.5)	19300	ND(7.8)	79
B7MA120190	MARSH	10/24&12/01-90	1	ND(3.1)	38	2690	ND(6.9)	ND(1.5)	527	ND(3.4)	36.1
B8MA112690	MARSH	10/24&11/26-90	1	ND(7.5)	77.3	5260	ND(1.6)	ND(3.5)	24500	ND(7.8)	92
B9MA112690	MARSH	10/24&11/26-90	1	ND(5.0)	ND(9.1)	5340	ND(11.1)	ND(2.3)	9730	ND(5.4)	31.2
B10MA112690	MARSH	10/24&11/26-90	1	ND(6.9)	32.3	3840	11	ND(3.2)	23000	ND(7.3)	109
B11MA112690	MARSH	10/24&11/26-90	1	ND(6.5)	46.9	3780	8.2	ND(3.0)	19700	ND(6.8)	74.9
SD1BAY102490	BAY	10/24/90	1	ND(5.6)	56.5	3890	ND(12.5)	ND(2.6)	10500	ND(6.1)	49.7
SD2BAY102490	BAY	10/24/90	1	ND(4.1)	21.9	1520	ND(0.89)	ND(1.9)	4830	ND(0.43)	19.2
SD1SL102490	SLOUGH	10/24/90	1	ND(6.1)	83.3	4580	ND(13.5)	ND(2.8)	14300	ND(6.6)	66.3
SD2SL102490	SLOUGH	10/24/90	1	ND(6.4)	84.6	4630	ND(14.0)	ND(3.0)	15000	ND(6.8)	63
SD3SL102490	SLOUGH	10/24/90	1	ND(6.6)	141	4320	ND(14.3)	ND(3.1)	12900	ND(4.3)	59.7
B1PR102490	PIER	10/24/90	1.3	ND(3.9)	40.1	1670	ND(8.6)	ND(1.8)	5250	ND(4.2)	25.3
SD1PR102490	PIER	10/24/90	1	ND(5.8)	69.6	4020	ND(12.8)	ND(2.7)	12600	ND(0.62)	51.9
SD1WSD102490	WEST STORM DRAIN	10/24/90	1	ND(5.9)	94	4890	ND(12.9)	9.3	12400	ND(6.3)	62.1
SD1ESD102490	EAST STORM DRAIN	10/24/90	1	ND(7.9)	ND(14.2)	7550	ND(17.9)	ND(3.7)	9320	ND(86.9)	24.7
SD1MA102490	MARSH	10/24/90	1	ND(6.3)	84.1	5020	ND(13.7)	ND(3.0)	14500	ND(6.6)	74.7
SD2MA102490	MARSH	10/24/90	1	ND(6.4)	89.1	5200	ND(13.9)	ND(3.0)	14200	ND(6.7)	75.5
SD3MA102490	MARSH	10/24/90	1	ND(9.6)	103	6930	ND(13.9)	ND(4.5)	27000	ND(10.2)	87.2
SD4MA120190	MARSH	10/24/90	1	ND(4.0)	15.3	1830	ND(4.5)	ND(1.9)	8120	ND(4.3)	29.1
SD5MA120190	MARSH	10/24/90	1	ND(4.5)	14.4	1880	4	ND(2.1)	10200	ND(4.3)	29.6
SD6MA120390	MARSH	10/24/90	1	ND(6.3)	ND(11.3)	2220	8.7	12.4	16800	ND(4.3)	32.6

ND(8.3) = Not Detected (Detection Limit); NA = Not Analyzed; * = Exceeded Holding time for Mercury