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10 December 1990

Mr. Howard Hatayama
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Toxic Substances Control Program
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Subject: Final Remedial Investigation Report
Liquid Gold Site, Richmond, CA
K/J/C 855018.07-G-96

Dear Mr. Hatayama:

Kennedy/Jenks/Chilton is pleased to submit the final Remedial Investigation Report for the Liquid Gold Site in Richmond, California on behalf of the Southern Pacific Transportation Company. This report has been prepared in accordance with the Department of Health Services' final Consent Order dated 13 January 1988.

If you have any questions regarding the final Remedial Investigation Report, please contact us or Mr. Greg Shepherd of SP Environmental Systems.

Very truly yours,

KENNEDY/JENKS/CHILTON

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Enclosure

Enclosure to Kennedy/Jenks/Chilton's
letter to Department of Health Services
dated 10 December 1990

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Document No. 16

FINAL REMEDIAL INVESTIGATION REPORT

LIQUID GOLD SITE, RICHMOND, CALIFORNIA

(K/J/C 855018.07)

Prepared For

Southern Pacific Transportation Company

By

Kennedy/Jenks/Chilton

December 1990

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EXECUTIVE SUMMARY

Kennedy/Jenks/Chilton (K/J/C) has prepared this Remedial Investigation Report (RI) for the Liquid Gold site on behalf of the Southern Pacific Transportation Company (SPT Co.) in accordance with a California Department of Health Services' (DHS) final Consent Order dated 13 January 1988. Incorporated into this report are the results of the final public health and environmental evaluation. This report was prepared in accordance with the U.S. Environmental Protection Agency (EPA) guidance document for conducting a Remedial Investigation/ Feasibility Study (RI/FS) (Draft Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, March 1988). Additional federal and state guidance documents specified in the DHS final Consent Order were also consulted.

The site under investigation, commonly referred to as the Liquid Gold site, consists of about 18 acres of an approximately 29-acre property currently owned by SPT Co. The site is located west of Interstate 580 (formerly Hoffman Boulevard) south of the Bayview Avenue overpass in Richmond, California, adjacent to the San Francisco Bay. The site was formerly the location of an asphalt manufacturing facility and later of an oil storage and transfer facility known as the Liquid Gold Oil Corporation. All operations ceased in 1982 and the site is presently inactive, with the exception of the operation of a firing range on a portion of the property.

The site was placed on the California State Superfund list in January 1983 and subsequently included by the Environmental Protection Agency (EPA) on the National Priority List (NPL) in September 1983. Soil and groundwater investigations were previously conducted at the site in response to Cleanup and Abatement Orders issued by the Regional Water Quality Control Board (RWQCB) as well as in response to concerns of the Department of Health Services (DHS) and the EPA. Interim remedial measures consisting of removal of tank fluids, tanks and drums,

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and excavation and disposal of contaminated soil were performed between 1982 and 1985.

The DHS issued a draft Consent Order to SPT Co., Southern Pacific Land Corporation, and Liquid Gold Oil Corporation in August 1987. The final Consent Order was issued in January 1988. In accordance with the draft Consent Order, K/J/C prepared three reports on behalf of SPT Co. These are the Scoping Document dated January 1988, the Preliminary Public Health and Environmental Evaluation (PPHEE) dated January 1988, and the Remedial Investigation/Feasibility Study (RI/FS) Workplan dated July 1988.

This report provides the results of the remedial investigation, which was conducted according to the RI/FS Workplan, incorporating changes agreed to with the agencies. The major components of the remedial investigation included a surface and subsurface soil investigation, a groundwater investigation, and an ecological study of the adjacent Hoffman Marsh. Data from these investigations were used to conduct human health and environmental evaluations of the site. Summaries of these investigations are provided below.

The soil sampling program was implemented in September 1988. Sampling was performed to further characterize areas previously investigated, particularly where past data indicated the presence of chemicals at levels potentially of concern, and to investigate areas of potential previous site activities which had not been investigated. Soil samples were analyzed for six metals of interest (chromium, copper, lead, mercury, nickel, and zinc), polychlorinated biphenyls (PCBs), base/neutral/acid extractable compounds (BNAs) (or polycyclic aromatic hydrocarbons (PAHs) and phenols), oil and grease, total petroleum hydrocarbons (TPH), and sulfur.

During the period from October 1988 to October 1989, groundwater elevation and chemistry were monitored in 18 onsite and nearsite wells. Samples were analyzed for the six metals of interest, oil and grease,

TPH, and routine water quality parameters. A monitoring test was also performed in winter 1989 to detect any tidal influence on shallow groundwater at the site.

An ecological investigation was conducted starting in October 1988 to provide information about marsh areas adjacent to the site. The objective of the ecological investigation was to evaluate if chemicals originating on the Liquid Gold site are impacting the marsh biota. The following tasks were conducted to provide information on the health of the marsh adjacent to the site relative to other areas of the marsh:

- Sediment chemistry analyses
- Benthos sampling and abundance calculations
- Animal tissue chemistry analyses
- Vegetation survey
- Plant tissue chemistry analyses
- Small mammal survey
- Bird survey

The original ecological study plan called for collection of field data during both dry and wet seasons. However, the collection of wet season data was considered inappropriate because of the continuation of a drought in northern California. Upon the suggestion of the agencies, it was agreed that bioassays of site soil elutriates would be used to provide some information relevant to potential impacts to the marsh during the wet season.

The results of the soil investigation, groundwater investigation, marsh ecological study, and bioassay study were used to finalize the preliminary public health and environmental evaluation. The human health baseline risk assessment followed the standard procedure of comparing estimates of potential exposure with information from a toxicity assessment in order to characterize risk. Both potential current and potential future exposure conditions were evaluated.

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The environmental evaluation proceeded in a different manner than the human health evaluation because the results of the ecological field study and bioassay study provided for a more direct measure of potential risk. In addition, the environmental evaluation also included considerations of calculated potential exposure and toxicity information.

The following is a summary of the results of the evaluation of chemicals in soil and groundwater.

SURFACE SOIL

There were large variations in metal concentrations in soil samples, which is often seen in soil investigations. In general, metal concentrations at the site were within typical ranges for soils. In limited areas of the site, surface soils contain chemicals possibly as a result of site activities. The southwest drainage path contained elevated levels of soluble lead. Some PAHs were found in surface soil composite samples at low levels. PCBs were found at low levels (not above 3 mg/Kg) in two isolated areas. One area (designated as Lot 4) contained elevated levels of lead and PAHs at 0 to 2 feet. In addition, asphaltic material is present at the surface to a limited extent in the former activity area.

SUBSURFACE SOIL

Variations in soil metal concentrations were also seen in subsurface soil samples. In general, metal concentrations were within typical ranges for soils, with some exceptions:

- Copper concentrations exceeded the common range in soil in about one third of the samples.

- A subsurface area (Area A) at a depth of about 5 to 6.5 feet was found to contain statistically significant higher concentrations

of lead than other areas of the site. Zinc concentrations may also be higher in this area. Again, there was substantial variation in sample results from this area.

Area A is a designation given to an area that includes the fill beneath the former activity areas, but also extends beyond the former activity areas. Because of the variation in lead concentrations in the subsurface samples, and the lack of high concentrations in samples from shallow depths in this area, a definitive source of the lead was not established. It is likely that the higher metal concentrations were present in the fill material originally placed in this area.

Subsurface soil also contains isolated samples with higher metal concentrations and other isolated samples containing PAHs. These areas are of limited extent. For instance, PAH distribution was primarily limited to one area (Lot 4) and at isolated other smaller areas in the former activity area. In addition, oil was observed in some subsurface samples. The presence of visible oil in isolated subsurface soil samples reinforces the conclusion at the end of the interim remedial action removal of visible oil that pockets of oil may still exist in the subsurface.

An evaluation of the fate and mobility of chemicals in soil concluded that only slow if any movement of metals, PCBs, PAHs, and oils can be expected at the site.

GROUNDWATER

The major conclusions regarding groundwater movement are:

- Tidal influence on shallow site groundwater, although detected, is considered insignificant.

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- Groundwater movement in the shallow zone is very slow, and significant movement is limited to winter months when sufficient rainfall occurs.

- Deeper zone groundwater discharges into San Francisco Bay at a location greater than one mile from the site.

The following are the major conclusions regarding the presence of chemicals in groundwater:

- Organic compounds of interest were not detected in shallow or deep groundwater, except for two oil and grease measurements in shallow groundwater slightly above detection limits.

- Concentrations of metals in both shallow and deeper zone groundwater monitoring wells fluctuated, but there were no apparent trends to the fluctuations.

- Groundwater beneath the site is not potable for reasons unrelated to site activities (e.g., conductivity, coliform), and water yields are observed to be low.

- Concentrations of metals in samples from both shallow and deeper zone groundwater monitoring wells were generally similar and relatively low.

- The only indication of a possible onsite source area for metals is elevated lead, nickel, and zinc concentrations in groundwater from monitoring well MW-4R. This monitoring well is located in the former activity area.

- Significant future changes in either groundwater movement or metal concentrations in groundwater are not expected.

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HUMAN HEALTH AND ENVIRONMENTAL EVALUATION CONCLUSIONS

The human health and environmental evaluations showed that there are no substantial current risks to humans or the environment as a result of chemicals found on or released from the Liquid Gold site. The major conclusions from the human health evaluation are the following:

- Potential risks due to ingestion and inhalation of chemicals in surface and subsurface soil were evaluated. Groundwater was not considered a potential human exposure route due to poor regional water quality and observed low yields onsite. Potential exposure scenarios evaluated included residential exposure to children and adults, office building exposure to adults, and exposure to trespassing children. Areas evaluated included a one acre lot (Lot 4), chosen to represent worst-case residential exposure, a subsurface area with identified elevated soil lead levels (Area A), and the entire site.

- A potential future risk from exposure to noncarcinogenic chemicals was identified for ingestion exposure to residential children. The areas of concern are Lot 4 at 0 to 2 feet and 5 to 6.5 feet, and Area A at 5 to 6.5 feet. Lead in soil provided the primary contribution to the hazard index exceeding 1. Hazard indices for the other exposure scenarios indicated that there were not significant risks from exposure to noncarcinogenic chemicals.

- Potential lifetime incremental cancer risks from exposure to soil were in the range of 10^{-4} to 10^{-6}. The highest calculated lifetime incremental cancer risks were associated with the ingestion of PAHs in surface and subsurface soil by adults residing on Lot 4. This potential risk may be considered unacceptable.

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The major conclusions from the environmental evaluation are the following:

- There is no indication that the Liquid Gold site and its past operations is a contributor of metals to Hoffman Marsh (Transects 1 to 4).

- No significant risk resulting from chemicals originating on the site to the biota in Hoffman Marsh (Transects 1 to 4) was identified. However, there are uncertainties present in the environmental evaluation process.

- Low benthos density was observed in the upper end of the Southwest Drainage Channel (Transect 6). The impacts may be the result of the higher elevation of this location and the exposure to freshwater runoff from the uplands, or the result of exposure to chemicals originating on the site, or a combination of effects. One of the latter two explanations is considered slightly more likely based on information presented in Appendix C. However, the source of the chemicals is unclear. Environmental effects could not be statistically linked to chemicals from the site, and the potentially affected area is likely of limited extent (approximately 1 to 2 m^2).

- There is no clear indication that PCBs are moving from the site to the wetlands via the drainage pathways.

- The operations of the Liquid Gold site have not caused elevated levels of PAHs or metals in the yellow shore crab, nor has the population of yellow shore crabs been depressed near the site.

- Given the lack of correlation between soil or sediment metal concentrations and plant or animal tissue metal concentrations, there is no indication that ingestion of pickleweed or yellow

shore crabs by shorebirds is a significant pathway into the food web for chemicals originating on the site.

- There is no indication that chemicals originating on the site are impacting water birds or small mammals through the food web.

- The results of the bioassay study of surface and subsurface soil elutriates show no clear indication of harm to test organisms due to chemicals from the site.

No further remedial investigation studies are recommended to characterize the site. Additional data obtained would be of only marginal benefit, and would not substantially alter the following conclusions.

Two areas of the site were identified as being of unacceptable potential future risk to humans:

- Surface and subsurface soil in Lot 4 (an area designated as a residential lot for the purposes of the risk assessment), primarily due to the presence of lead (of potential concern for residential exposure to children) and carcinogenic PAHs (of potential concern for residential exposure to adults).

- Subsurface soil (5 to 6.5 feet) in Area A (an area identified as having elevated soil lead levels) due to the presence of lead at levels potentially harmful to residential children.

The residential setting showing the potential for unacceptable risks from chemicals in soil is a hypothetical exposure scenario and does not currently exist. Also, the chemicals of primary concern are either present in subsurface soil or in surface soil (defined as 0 to 2 feet) generally beneath asphalt, so that potential exposure would be less likely. However, it is recommended that the surface and subsurface

soils in Lot 4 and the subsurface soils in Area A be considered for remediation in the feasibility study.

There are other isolated areas in subsurface soil that may be of potential concern from either a human health or environmental perspective were exposure to occur. In particular, there are areas with subsurface soil samples containing visible oil. Were oils to be exposed at the surface, there is the potential for adverse environmental impacts on the marsh should runoff occur. Again, these are hypothetical risks because exposure to subsurface soils does not currently exist. The location of oils in the subsurface is known only from isolated samples. The overall extent is not known, nor is there any indication where other isolated areas of oil in the subsurface exist. The conservative assumption is that exposure to subsurface soil anywhere in the site has the potential for providing contact with oils. It is recommended that further consideration be given to subsurface soils during the feasibility study.

Shallow groundwater may be impacted to a small extent (limited to the vicinity of monitoring well MW-4R) due to chemicals from site activities. Concentrations of metals in groundwater from the rest of the site do not appear elevated. This finding is consistent with the expected relative immobility of metals in groundwater, and supports the conclusion that the concentrations of metals in samples from monitoring well MW-4R are not considered of concern. Also, shallow groundwater movement at the site is very slow, when it occurs, and movement is limited to winter months with sufficient rainfall. Given the limited flow of groundwater, and the results of the ecological and bioassay studies, there are no apparent adverse environmental effects from metals in groundwater. In addition, because the groundwater is not potable, there are no human health concerns for exposure to chemicals of interest. However, it is recommended that groundwater that appears to be impacted in the vicinity of monitoring well MW-4R be considered in the feasibility study.

The quarterly groundwater monitoring rounds were implemented from October 1988 to July 1989 according to the RI/FS workplan. An additional sampling round was added in October 1989. At the request of the agencies, it is recommended that interim groundwater monitoring, separate from either the remedial investigation or feasibility study, be implemented beginning in October 1990.

Potential environmental risk as a result of chemicals in subsurface soil potentially reaching receptors through groundwater movement was not shown by the ecological study or soil elutriate bioassay study, nor would it be expected given groundwater flow characteristics and the calculated significant dilution or hypothetical dilution as groundwater enters surface water.

Harm to biota in most areas of the marsh as a result of chemicals from the site is considered unlikely based on the results of the environmental evaluation. However, the uncertainty inherent in the process of ecological assessment was acknowledged in Section 9. Given this uncertainty, and at the request of the reviewing agencies, it is recommended that the need for remediation to address potential risks to biota from chemicals in marsh sediments adjacent to the site (upper ends of Transects 1 and 6) be considered during the feasibility study.

SECTION 1

INTRODUCTION

1.1 OVERVIEW OF REPORT

This report was organized following EPA guidance (EPA 1988) and requirements of the Consent Order (1988). The initial sections of the report describe the history of the site and major site features. Sections 3 and 4 present the results of the soil and groundwater investigations, respectively. Section 5 addresses the extensive ecological investigation performed in Hoffman marsh adjacent to the site. The chemical data from Section 3 (soil), Section 4 (groundwater), and Section 5 (marsh) are evaluated in Section 6 along with data prior to 1988 to provide an indication of the extent of chemicals at or near the site.

The public health and environmental evaluation is incorporated into this report primarily as Sections 7, 8, and 9. The reason for combining these evaluations into the RI report was to provide for a comprehensive presentation of data and its interpretation. Conclusions related to the remedial investigation will necessarily incorporate the results of the public health and environmental evaluation. Section 7 presents information on chemical fate and mobility and interprets this with regard to chemicals present on the site. The public health evaluation is presented in Section 8. The environmental evaluation, extending the results of the ecological study (Section 5), is presented in Section 9.

Conclusions and recommendations are given in Section 10. A number of appendices are included in order to provide detailed information supporting sections in the main report.

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1.2 SITE BACKGROUND

1.2.1 Site Description

The site under investigation comprises about 18 acres of an approximately 29-acre property currently owned by SPT Co. (refer to Figures 1 and 2 for site location and boundaries). The site is located along Interstate 580 (formerly Hoffman Boulevard), southwest of the Bayview overpass in Richmond, California. The property, which is irregularly shaped, is bounded by Interstate 580 to the northeast, industries to the northwest, and open land consisting of fill areas and tidal marsh areas to the south and southwest. These areas lie adjacent to the San Francisco Bay located west of the site. The site under investigation is the portion of the property southeast of the drainage channel, referred to herein as the Stege Drainage Channel, running through the property (Figure 2).

The principal past features of the site, depicted in Figure 2, include: the firing range, the former asphalt facility, the depression at the former pond area, the concrete slab debris area, and the Stege, southeast, southwest and south drainage channels. The majority of the structures and debris were removed from the site in 1989.

Although SPT Co. has historically leased only two to three acres of the site to others, the entire site was generally accessible for use by former SPT Co. tenants. The Stege Drainage Channel is approximately 15 feet wide and physically separates the site from the portion of the property lying to the northwest. Therefore, activities of former tenants probably did not include the property northwest of Stege Drainage Channel.

1.2.2 Environmental Setting

The area in the vicinity of the site is geomorphologically a transition zone between an active alluvial fan deposition zone, and the tidal

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saltwater marsh estuarine environment, including Hoffman Marsh to the south (Helley, et al. 1979). The surface and shallow subsurface soils at the site are fill material deposited over an extended period of time as needed, varying in thickness across the site from 5 to 10 feet. The fill is underlain by the natural soil surface, which consists of the Bay Mud and Bay Clay typical of the San Francisco Bay margin. The Bay Mud varies in thickness from 7 to 19 feet. Below the Bay Mud and Bay Clay are older alluvial surficial deposits.

The water-bearing sediments overlying the Bay Mud in the vicinity of the site (from ground surface to a depth of approximately 35 feet) have been characterized by CalTrans as the Hoffman Aquifers (DOT 1978). CalTrans has referred to the alluvial materials immediately underlying the Bay Mud as the Richmond Aquifers (DOT 1978). The alluvial materials below the Richmond Aquifers have been called the San Pablo Aquifers (DOT 1978). It is unlikely that the shallow groundwater which occurs onsite is directly connected to the groundwater sampled by CalTrans.

The depth to saturated fill material is approximately 3 to 4 feet below ground surface. This fill is defined as the shallow aquifer zone at the site. The saturated alluvial materials immediately underlying the Bay Mud onsite are considered the deeper aquifer zone. Examination of boring logs indicate that the depth to this zone is approximately 20 to 30 feet below ground surface.

The occurrence of surface water on the site corresponds to rainfall events where the water either ponds onsite or discharges to the adjacent wetlands via drainage paths. Surface waters are present in areas such as Hoffman Marsh, Stege Drainage Channel, and the drainage channel along the western side of the site. Surface waters adjacent to the site are influenced by the tides.

The Liquid Gold site is located in a former marsh area which has been progressively filled since before 1949. Historical aerial photographs of the Liquid Gold site have been examined to assess the filling

activities which have taken place on the property. The progression of the fill boundary with time is shown on Figure 3.

In 1949, only the area bounding the asphalt plant and buildings west of the asphalt plant was filled. Between 1949 and 1959, filling activities took place mainly in the areas southwest and southeast of the asphalt plant. Extensive filling took place on the property between 1959 and 1969. Excluding a small area east of the asphalt plant, the site appears to have been filled by 1964 to the lateral extent that is found at the site today.

The origin of the fill material is unknown, but it has been reported that most of the fill along the eastern edge of the San Francisco Bay is dredged Merritt Sand and material from the Temescal formation (E&E 1984). In addition, a review of the aerial photographs and existing soil boring logs documents the use of rubble and wood for fill materials at the site.

1.2.3 Site History

SPT Co. leased approximately 3 acres of their property to Mr. Lee J. Immel from approximately 1947 to 1974. Mr. Immel operated an asphalt manufacturing plant at this location under the company name of San Pablo Oil until approximately 1965.

Historical aerial photographs indicate that several buildings, some tanks, and auxiliary equipment were present during operation of the facility. These areas are outlined on Figure 4. Based on a review of photographs, it appears that a large metal culvert (approximately 6 feet in diameter and 160 feet long) at the southern end of the asphalt facility area was originally used by the asphalt manufacturing plant. The asphalt manufacturing plant was not dismantled after San Pablo Oil ceased operations. The remaining equipment was later used by the Liquid Gold Oil Corporation, and the buildings were demolished and removed along with the wooden pallets and other debris in December 1989. The

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metal culvert was removed in 1985 during interim site cleanup activities.

Mr. Bryan Fabian subleased and then leased portions of the site from 1965 to 1982. Mr. Fabian operated an oil storage and transfer facility, ultimately named Liquid Gold Oil Corporation (Liquid Gold). Oils, solvents, and tank bottoms were stored onsite in storage tanks and subsequently sold. The facility, with two main tank farms (east and west), is indicated on Figure 2. Liquid Gold operations ceased in 1982, and all waste oil storage tanks were removed by the middle of 1983.

SPT Co. currently operates a firing range in the western portion of the site. The firing range was constructed in 1976 and is used by over 30 police and security departments in the area. CalTrans recently constructed an access road directly north and northeast of the firing range. Access to the site is restricted by a barbed wire cyclone fence which encircles the site.

1.2.4 Previous Investigations

The Liquid Gold facility was the focus of numerous inspections by the RWQCB and the DHS throughout the 1970s and early 1980s. Site investigations by several consultants have been performed since 1980. A brief summary of the inspections and investigations is provided below. The results of agency inspections and studies by consultants are addressed in greater detail in the Scoping Document (K/J/C 1988a).

The RWQCB first inspected the Liquid Gold facility on 10 October 1974 in response to an apparent complaint. Approximately 20 tanks storing used oil were present onsite at the time. An estimated 500 gallons of oil spilled as a result of a shut-off valve failure, were noted in one of the bermed tank storage areas. The owner of the Liquid Gold facility, Mr. Bryan Fabian, was requested to clean up the spilled oil and dispose of it at a Class I disposal site.

The RWQCB conducted several follow-up inspections in October and early November 1974. These inspections indicated that the oil pools were not completely removed, additional oil spillage was present, and a pool of chemical waste was present in the southeast drainage path, which had been bermed at its entrance to the marsh. Following their inspections, the RWQCB issued Cleanup and Abatement Order (CAO) No. 74-13 to Mr. Bryan Fabian, requiring cleanup and preventative containment of the storage facilities. The RWQCB rescinded the order on 4 February 1976, after follow-up inspections indicated that spilled oils, chemicals, and paint wastes had been removed from the areas cited and disposed of at the Richmond Class I disposal site.

The DHS first inspected the Liquid Gold facility on 7 May 1979 following an aerial surveillance which indicated a leaking storage tank. At this time, inspectors noted ponded oil, other liquid wastes, and oily sludge. Additional follow-up inspections were conducted by the DHS in May and June 1979.

Two former Liquid Gold employees, interviewed by the DHS on 24 August 1979, alleged that liquid wastes were routinely drained from storage tanks onto the ground and discharged from tank trucks into the open-ended metal culvert. The DHS conducted a series of inspections in October 1979 and collected samples of oil and liquid wastes from tanks, ponded areas, surface soil and gravel. In a letter to Mr. Fabian, the DHS identified lead, nickel, copper, chromium, zinc, polychlorinated biphenyls (PCBs), and oil as chemicals of concern on the basis of their October 1979 sampling results.

Liquid Gold was cited by the U.S. Coast Guard for illegal discharge of oil from the site via the southeast drainage ditch leading to the marsh areas adjacent to I-580 in early March 1980. Subsequently, several agency inspections were conducted in March and April 1980 by the RWQCB, the DHS, and California Department of Fish and Game (DFG). During these inspections, ponded oil was observed. Mr. Fabian was already in the process of cleaning up oil discharged in the southeast drainage path.

Samples of spilled waste and surface soil were collected from the site by the DHS and RWQCB. Sediment samples from the marsh around the concrete slab debris area and the southeast drainage ditch were also collected by the RWQCB and found to contain PCBs. Samples collected from a leaking horizontal tank in the east tank farm area were found to contain phenols. On the basis of these events, the RWQCB issued CAO No. 80-007 to Liquid Gold Oil Corporation, Mr. Bryan Fabian, and the Southern Pacific Land Corporation. The CAO requested removal and disposal of all leaking storage tanks and spilled wastes and development of a sampling and analysis plan to determine the extent of contamination at the facility and adjacent areas.

Mr. Fabian responded to CAO No. 80-007 by pumping out and disposing of liquid waste from the pond area at the south end of the metal culvert and removing oily soil and vegetation from the concrete slab debris area. This work was performed under the supervision of the RWQCB. In addition, Mr. Fabian hired Heath Consultants who subcontracted to JLV & Associates (JLV) to develop a sampling plan for site characterization.

JLV performed a soil investigation of the Liquid Gold site in July and August 1980 in accordance with a sampling plan dated June 1980. Surface and subsurface soil samples were collected from all the identified areas of concern, including: the tank storage areas, the old asphalt facility, directly east of the old asphalt facility, the pond-culvert area, the concrete slab debris area, and the southeast and southwest drainage paths. The results of this investigation were submitted to the DHS in October 1980.

The DHS collected samples of spilled waste, soil, and ponded surface water during inspections conducted in late 1980 and March 1981. According to the files reviewed, no significant activities occurred at the site for the next year. Liquid Gold apparently ceased its operations at this site sometime in 1982. In May 1982, PSC Associates, Inc. (PSC) conducted limited soil investigations at the site for Liquid

Gold. Their investigation consisted of 8 soil borings drilled to a depth of 6 feet.

The DHS prepared a site scoring package for the Liquid Gold site in March 1982 resulting in the site's placement on the California State Superfund list in January 1983. The EPA scored the site in August 1982, in accordance with the Hazard Ranking System (HRS). The site was subsequently included on the NPL in September 1983.

SPT Co. hired IT Corporation in October 1982 to conduct interim remedial actions at the site. In November 1982 and April 1983, IT Corporation removed all storage tanks and their contents from the site for disposal at Class I disposal sites.

Following these removal activities, SPT Co. retained Ecology and Environment, Inc. (E&E) in 1983 to conduct soil and groundwater investigations of the site in accordance with the RWQCB CAO No. 80-007. Preliminary soil borings were installed by E&E in September 1983. Following agency approval of a comprehensive sampling plan, E&E completed its field investigation in October and November 1983. This investigation consisted of drilling 57 borings (ranging in depth from 11 to 36.5 feet deep) for subsurface soil sampling, and installing and sampling 10 groundwater monitoring wells (MW-1 through MW-10). Surface soil sampling was also conducted. Samples were collected from all identified areas of site activity with the exception of the drainage paths.

On 22 January 1985, the RWQCB issued CAO No. 85-002 requiring additional soil and groundwater investigations and the development of a Remedial Action Plan (RAP). In response to CAO No. 85-002, a "Plan for Additional Field Work" dated 31 January 1985, was prepared by E&E and subsequently agreed upon by the interested regulatory agencies.

The additional field work was conducted by K/J/C (formerly Kennedy/Jenks Engineers), who was retained by SPT Co. in March 1985. This

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investigation consisted of resampling of the groundwater monitoring wells, additional surface soil sampling (including drainage paths), and digging and sampling 16 trenches to Bay Mud.

Following this investigation, SPT Co., K/J/C, and the concerned agencies held a meeting at which a three-phase plan was agreed upon. The phases were defined as: Phase I - removal of soil with visible oil; Phase II - capping the site; and Phase III - a plan for continued groundwater investigation. A Phase I Plan was prepared by K/J/C in September 1985 (K/J/C 1985a). After receiving agency approval for the Phase I Plan, visible oil and oily soil were removed from the site during November and December 1985. A Phase II Plan for site capping and grading was submitted in November 1985 (K/J/C 1985b). Phase II was not performed due to requests from the agencies for additional site characterization. As part of Phase III, K/J/C abandoned three existing monitoring wells and installed nine new monitoring wells (MW-4R, MW-7R, MW-11 through -13, and MW-15 through -18)) during July and August 1986.

SPT Co. and K/J/C met with the DHS, the RWQCB, the DFG, and the EPA on 16 October 1986 to discuss outstanding agency concerns regarding site soil characterization. Primary agency concerns were: (1) the presence of elevated levels of oil and grease in the southeast drainage path leading to adjacent marsh areas, and (2) the potential for the presence of chemicals in areas not previously sampled but where agency inspection records from the 1970s indicated discharge of wastes. At this meeting, it was agreed that K/J/C would collect samples to be submitted for detailed analysis for petroleum hydrocarbons from the southeast drainage path and the adjacent marsh area. In addition, it was agreed that a separate workplan for additional soil sampling to address outstanding concerns regarding areas which had not been previously sampled was to be prepared by K/J/C. This sampling workplan was submitted by K/J/C in December 1986 (K/J/C 1986a). Agency comments on the sampling workplan were never received; therefore, the additional sampling was not conducted.

The DHS issued a draft Consent Order to SPT Co., Southern Pacific Land Corporation, and Liquid Gold Oil Corporation on 4 August 1987. Subsequently, on 5 August 1987, the RWQCB filed a request in the Superior Court of Contra Costa County for a preliminary injunction (Case No. 304545) against the above-named parties. Following several meetings and court appearances, the proceeding was settled in late November 1987. Execution of the final Consent Order, issued by the DHS in coordination with the RWQCB, was completed on 13 January 1988.

1.2.5 Interim Remedial Measures

Interim Remedial Measures (IRMs) were discussed in detail in the Scoping Document (K/J/C 1988a). The major activities performed are summarized in this section.

Liquid Gold conducted some cleanup actions at the site during the years that the facility was in operation, but these are not well documented. However, soil removal activities conducted by Liquid Gold in fill and marsh areas adjacent to the facility are documented.

Liquid Gold was cited by the U.S. Coast Guard for illegal discharge of oil from the site via the southeast drainage path in March 1980. Subsequently, inspections by the other regulatory agencies revealed ponded oil and other liquid wastes in the tank storage areas, the southeast drainage path, and the concrete slab debris area. In April and May 1980, Liquid Gold removed liquid wastes, oily soil, and oily vegetation from the southeast drainage path and the concrete slab debris area. Excavated material was placed in 55-gallon drums which were locked in the warehouse onsite. SPT Co. had the drums and the layer of dirt on the floor of the warehouse removed and disposed of at a Class I facility in October 1984.

SPT Co. has implemented several IRMs during the ongoing remedial investigation of the site. These measures are summarized below.

1.2.5.1 Tank Removal Activities

SPT Co. retained IT Corporation in October 1982 to remove storage tanks remaining at the site. Four of the 25 tanks were removed in November 1982 and their contents disposed of at a Class I facility. A review of the hazardous waste manifests indicated that the material included approximately 58,000 lbs. of liquids and sludges containing PCBs, approximately 4,700 gallons of liquids and sludges containing PCBs, and 170 barrels of flammable liquids.

In April and May 1983, IT Corporation removed and disposed of the contents of the remaining 21 tanks. Approximately 150,000 gallons of hazardous waste from this removal activity were disposed of at a Class I disposal facility.

1.2.5.2 Soil Excavation Activities

Soil excavation activities conducted by American Environmental Management Corporation in November and December 1985 are documented in a report entitled "Phase I - Soil Remediation Activities" (K/J/C 1986b). A summary of the excavation activities is given below for the former east tank farm area, the old asphalt facility area, and the metal culvert. These areas are shown on Figure 5. All excavated materials were disposed of at a Class I disposal facility.

Soil was excavated from the former east tank farm area with a backhoe. During the excavation, seams of oil were occasionally observed along the sidewalls; therefore, the width of the excavation was expanded to remove the visible oil. Several sections of piping (1 to 2 inches in diameter) were encountered at approximately the 1-foot depth in the south end of this excavation area. The pipes contained residual oil and were excavated and disposed of as hazardous waste. The total volume of soil excavated and disposed of as hazardous waste from the former east tank farm area was about 130 cubic yards, resulting in an excavated area approximately 80 feet long, 20 feet wide, and 2.5 feet deep. A

composite soil sample was collected and analyzed (K/J/C 1986b, K/J/C 1988a).

Soil was excavated from several different sections of the former asphalt facility area, as shown on Figure 5. The total volume of oily soil excavated from this area was approximately 390 cubic yards. The remaining wooden building in this area was also removed, resulting in an additional 65 cubic yards of wood and metal debris which was also disposed of as hazardous waste. Post excavation samples were collected and analyzed from this area (K/J/C 1986b, K/J/C 1988a).

The metal culvert and oily materials contained therein were removed and disposed of as hazardous waste. Oily materials were not observed underneath the culvert; however, approximately 2 feet of oily black sand that was contained in the culvert was poured into the excavation trench during the removal activities. Upon removal of the metal culvert sections, the oily sand was excavated from the excavation trench. All visually oily material (approximately 105 cubic yards) was removed and disposed of at a Class I facility. Due to infiltration of shallow groundwater and subsequent rainfall, post excavation soil samples could not be collected. However, samples of the oily black sand were collected and analyzed (K/J/C 1986b, K/J/C 1988a).

Soil was also excavated from the former location of a trench east of the former asphalt facility area where flowable oil was encountered during the site investigation (refer to Figure 5). During this excavation, small pockets of flowable oil and oily groundwater were again encountered at a depth of 2 feet. The oily water was pumped into 55-gallon drums and the excavation was continued to follow traces of oil seeping in from the trench walls. Some sections of oily pipe were encountered and removed and may have been the source of flowing oil observed in this area. Soil excavation activities in this area were completed when it was agreed by the K/J/C field engineer and the DHS inspector that there was no more flowable oil and that occasional drops of oil observed along the sidewalls were apparently not related to a

specific source. The final excavation was approximately 6 feet deep and irregular in areal extent. The total volume of soil excavated from this area was approximately 135 cubic yards.

Spot removal of visually oily soil in two locations in the former west tank farm area resulted in the removal and disposal of approximately ten additional cubic yards of soil.

1.2.5.3 Miscellaneous Cleanup Activities

Removal of additional hazardous materials and general site cleanup was conducted in November and December 1989. A wooden building was sampled and demonstrated to contain lead in excess of the California Code of Regulations (CCR), Title 22, Total Threshold Limit Concentration of 2,000 ppm. This building was demolished and disposed in a Class 1 facility. Rolls of what appeared to be roofing material containing asbestos were removed from an area at the southern edge of the property. In addition, the soil in this area was excavated to a depth of 1 foot. Both the soil and the roofing material were placed in two bins lined with plastic and subsequently disposed according to State asbestos disposal guidelines.

Fragments of a material containing 20 percent chrysotile asbestos were observed scattered about a large area east of the former asphalt facility. This material was collected by hand and disposed according to guidelines. Also found in the area with the roofing material were 20 cans (approximately three gallons) containing lubricating grease. The cans were placed in 55-gallon drums and disposed at a hazardous waste facility.

Other nonhazardous debris such as wooden pallets and stacked lumber were removed. Additionally, the remaining buildings were demolished and removed.

1.3 REMEDIAL INVESTIGATIONS

In accordance with the draft Consent Order, Kennedy/Jenks/Chilton (K/J/C) prepared three reports on behalf of SPT Co. These are the Scoping Document dated January 1988 (K/J/C 1988a), the Preliminary Public Health and Environmental Evaluation (PPHEE) dated January 1988 (K/J/C 1988b), and the Remedial Investigation/Feasibility Study (RI/FS) Workplan dated July 1988 (K/J/C 1988c). The Scoping Document contains: a detailed history of past site operations and investigations; a presentation and evaluation of existing site characterization data; and identification of data needs and general investigative tasks for the Remedial Investigation (RI) and Feasibility Study (FS) according to the requirements of the National Contingency Plan (NCP). The PPHEE evaluates chemicals of concern with respect to environmental fate and transport mechanisms, potential migration and exposure pathways, potential populations exposed and the estimated extent of actual or potential exposure. Data needed to complete the final Public Health and Environmental Evaluation (PHEE) are also addressed. The RI/FS workplan presents detailed plans and procedures for activities necessary to complete the RI and FS in accordance with the data needs identified in the Scoping Document, the final Consent Order and applicable federal and state guidelines.

Agency comments were received on both the Scoping Document and PPHEE. Following a meeting on 28 March 1988 with the agencies, responses to these comments were presented in two separate addenda dated 21 April 1988. Both documents, based on the inclusion of these addenda, were approved by the DHS in a letter to SPT Co. dated 4 May 1988.

This report provides the results of the remedial investigation, which was conducted according to the RI/FS Workplan, and incorporating changes agreed to with the agencies. The major components of the remedial investigation included a surface and subsurface soil investigation, a groundwater investigation, and an ecological study of the adjacent Hoffman Marsh, which included a bioassay study on elutriates of site

soils in accordance with an approved workplan (K/J/C 1989b). Data from these investigations were used to conduct human health and environmental evaluations of the site.

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SECTION 2

SITE FEATURES

This section includes information regarding land use, demographics, natural resources, and climatology near the site. This information is relevant for the human health evaluation (Section 8) and the environmental evaluation (Section 9).

2.1 LAND USE AND DEMOGRAPHICS

The project site located on the eastern side of San Francisco Bay is surrounded by an area of mixed use. Located directly to the northwest of the site is an industrial zone. The area one mile to the northwest of the site is a development for multiple-family residences. To the northeast the site is bounded by Interstate 580. Located across the highway and less than a quarter of a mile from the site is primarily a single family residential area. A salt marsh and open areas consisting of fill material are located to the south and southwest of the site.

SPT Co currently operates a firing range in the western portion of the site. The firing range was constructed in 1976 and is used by over thirty police and security departments.

2.2 NATURAL RESOURCES

The project site is located on fill material adjacent to Hoffman Marsh. The marsh is relatively young, approximately 30 to 50 years old. The marsh was developed as a result of increased sedimentation and decreased tidal flushing brought about by construction of a levee along the railroad right-of-way. The plant community present in Hoffman Marsh is typical of that found in other salt marshes of comparable age and is dominated by pickleweed (*Salicornia subterminali* and *S. europa*). Marsh and upland areas are habitat for a variety of wildlife including birds,

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waterbirds, rodents, and benthic and aquatic organisms. The site is potential habitat for eight species of wildlife identified as endangered or of concern. Thus, the primary natural resource value of the site is habitat for wildlife.

2.3 CLIMATOLOGY

Climatic information for the site was obtained from the National Weather Service meteorological station located in Berkeley and Bay Area Air Quality Management District (BAAQMD) meteorological station located in Richmond. The summer weather is characterized by moderate temperatures, little or no precipitation and cyclical fog accompanied by southwesterly winds. The cool marine air serves to moderate the summer temperatures as the temperatures a short distance inland are considerably higher. The winter climate is characterized by mild temperatures and frequent rain. The warmest month is September with a mean temperature of 64°F. December is the coolest month with a mean temperature of 50°F. The average annual rainfall is 21 inches, with the majority of the precipitation falling between October and April. The summer weather patterns start in late April and persist through September. During this period it is common for fog to develop in the late afternoon and to burn-off by mid-morning of the following day. Accompanying the fog are southwesterly breezes. Average annual predominant wind speeds are approximately 11 mph.

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SECTION 3

GEOLOGIC INVESTIGATION

3.1 AREA GEOLOGY

The site is located within the Department of Water Resources'(DWR) San Francisco Bay Hydrologic Study Area and within the Alameda Bay Plain Groundwater Basin (DWR 1980). Water-bearing surficial deposits within the Alameda Bay Plain consist generally of alluvial materials (DWR 1980). At the site, these naturally placed water-bearing surficial deposits (aquifer materials) are overlain and interlayered by the fine-grained sediments (Bay Mud aquitard materials) deposited by the San Francisco Bay. The most recent of these Bay margin aquitard sediments are identified as Bay Mud (Schlocker 1974) and probably extend from the existing Bay margin at the site to about 4 miles into the Bay. The Bay Mud does not extend to the east of I-580, according to logs of monitoring wells MW-19 and MW-20 (see Section 4). Surficial deposits overlying the Bay Mud at the site are considered aquifer materials for purposes of this report. These deposits are primarily man-placed fill materials. The thickness of these deposits at the site are discussed below.

The bedrock at the site probably consists of Franciscan Formation rocks occurring at a depth of approximately 200 feet below ground surface (Department of Transportation (DOT) 1978). In general, Franciscan Formation rocks were eroded along faults and shear zones which characterize the San Francisco area tectonic environment to form the present Bay Basin (Schlocker 1974). Overlying the Franciscan Formation are quaternary surficial deposits (sediments) which correlate in age with the Colma Formation (Schlocker 1974). These deposits are in turn overlain in the area by the recent Bay Mud.

3.1.1 Area Soils and Subsurface Sediments

In general, the area in the vicinity of the site is geomorphologically a transition zone between an active alluvial fan deposition zone, which receives sediments from the bedrock uplands of El Cerrito to the east of the site, and the tidal salt-water Marsh estuarine environment characterized by the Hoffman Marsh to the south (Helley, et al. 1979). Thus, surficial deposits in the area grade from the quaternary Bay Mud which has frequently been overlain by fill for human activities at the intertidal zone, to contemporary active alluvial and landslide deposits which occur towards the uplands (Helley, et al. 1979). The uplands consist of the Franciscan Formation; sandstone, shale and siltstone, punctuated by volcanic rocks; and soils and landslide deposits derived from Franciscan parent materials (Schlocker 1974).

CalTrans, in preparation for improvement of Hoffman Boulevard and Interstate 580, characterized the water-bearing materials overlying the Bay Mud in the vicinity of the site (from ground surface to the depth of approximately 35 feet) as the Hoffman Aquifers (DOT 1978). CalTrans has referred to the alluvial materials immediately underlying the Bay Mud as the Richmond Aquifers (DOT 1978). The alluvial materials below the Richmond Aquifers have been called the San Pablo Aquifers (DOT 1978). The vicinity of the site is reportedly in the Contra Costa Groundwater Basin (DOT 1978), which is a further subdivision of the Alameda Bay Plain Basin, according to the Department of Water Resources (DWR 1980).

3.1.2 Site Surface Soils

The Bay Mud at the site is overlain by recent fill material. This fill was probably brought to the site from various sources over time as more of the site was used for industrial or other human activities. This progressive filling of the intertidal zone at the site can be seen chronologically in a sequence of historical aerial photographs obtained by K/J/C (Figure 3). E&E characterized the fill as consisting of dredged Merritt Formation sand, material from the Temescal Formation,

and miscellaneous refuse (e.g., broken concrete, etc.) (E&E 1984a). The U.S. Geological Survey reports that the Merritt and Temescal formations are contemporary with the Colma Formation (Schlocker 1974) and thus would likely be of similar age to the deposits which underlie the Bay Mud at the site. The fill at the site is of variable thickness, ranging from more than 10 feet thick near groundwater monitoring well MW-2 to 5 feet approximately near MW-3. That area onsite where the fill is saturated is considered the shallow aquifer zone. This zone is currently monitored by 9 shallow groundwater monitoring wells constructed for SPT Co. by K/J/C and E&E (refer to Section 4).

For the purposes of discussing soil chemical characteristics below in Sections 3.2 and 6.1, surface soil samples are defined as those collected without cores at 0 to 0.5 feet. The definition of surface soil samples used for the human health risk assessment (Section 8) includes soil core samples collected from 0 to 2 feet.

3.1.3 Site Subsurface Soils and Sediments

The fill at the site is underlain by the natural soil surface, which consists of the Bay Mud typical of the San Francisco Bay margin. The Bay Mud at the site is an unconsolidated or semi-consolidated, usually saturated, dark, plastic clay and silty clay which is rich in organic materials. As reported by the U.S. Geological Survey, the Bay Mud is underlain by older alluvial surficial deposits of the probable age of the Colma, Merritt, and Temescal Formations (Schlocker 1974). These surficial deposits probably extend under the Bay Mud westward about 4 miles from the site and eastward to the uplands of El Cerrito, approximately 1 mile from the site.

The saturated alluvial materials immediately underlying the Bay Mud onsite are considered the deeper aquifer zone and are currently monitored by 7 onsite groundwater monitoring wells (refer to Section 4). Two additional offsite deep aquifer monitoring wells were installed to monitor upgradient conditions. On the basis of available boring logs

prepared in conjunction with subsurface investigations conducted by K/J/C (1985a; 1986e), and E&E (1984a) three schematic cross sections showing the occurrence and depth of recent fill materials, Bay Mud (and Bay Clay), and older alluvial materials were prepared. The locations of the borings used to prepare the three cross sections are shown on Figure 6. The three cross sections are shown on Figure 7, Figure 8, and Figure 9.

3.2 RI SOIL INVESTIGATIONS

3.2.1 Summary of Pre-1988 Soil Investigations

As discussed in Section 1, soil chemical studies for the pre-1988 phase of site characterization were conducted from 1980 to 1986 by four consultants for SPT Co. and Liquid Gold. The database generated during this phase of the investigation was evaluated and presented in the Scoping Document (K/J/C 1988a). Included in the evaluation was an analysis of the validity or quality of the data. This was achieved by reviewing the results of quality control (QC) samples and making an assessment of the precision, accuracy and integrity of the data. In the case of the data generated by the Liquid Gold consultants (JLV and PSC), insufficient QC data or documentation was available to make an assessment of data quality. Therefore these data could not be validated and their use is limited to semi-quantitative interpretations. Most of the data generated by SPT Co. consultants (E&E and K/J/C) were judged to be valid and useable for all purposes. Deficiencies with data and quality assessments are presented in Section 6 of the Scoping Document (K/J/C 1988a).

3.2.1.1 Surface Soil Metal Analysis

A total of 37 discrete surface soil samples were collected during the earlier phase of the investigation. The 17 surface soil samples collected, during July and August 1980, by the Liquid Gold consultant (JLV) were analyzed for total lead and zinc. These data are presented

in the Scoping Document (K/J/C 1988a). The SPT Co. consultant (K/J/C) collected a total of 20 surface samples in May and September 1985, which were analyzed for total and soluble lead, nickel, copper, chromium, and zinc. In addition, two composite surface samples were collected at the southeast drainage and at the western edge of the marsh by E&E in November 1983. Results of the K/J/C data for total and soluble metals along with sampling locations are depicted in Figure 10.

3.2.1.2 Surface Soil Hydrocarbon Analysis

K/J/C analyzed 14 surface samples for aliphatic hydrocarbons by gas chromatography in May 1985. The results were discussed in the Scoping Document (K/J/C 1988a) and are presented in Figure 10. Six of the samples did not have detectable levels of aliphatic hydrocarbons. Seven samples had total aliphatic hydrocarbon levels less than 35 mg/kg. One sample contained hydrocarbons at more than 4,000 mg/kg. Most of the hydrocarbons found had even carbon number chains, and some samples contained pristane. These results are indicative of hydrocarbons from an anthropogenic source.

The sample with the highest petroleum hydrocarbons value (S-3) was also analyzed for BNAs. No priority pollutants were found, and the non-priority pollutant results confirmed the GC analysis. The area around this sample was excavated during the interim remedial measures.

As discussed in the Scoping Document, prior studies on hydrocarbons regarding surface soil did not yield validated results, and are therefore not discussed here.

3.2.1.3 Subsurface Soil Metals Analysis

A total of 246 discrete subsurface samples were collected from 86 borings located throughout the site. The soil samples were collected from depths ranging from 0.5 to 30 feet and consisted of the three types of substratum: fill material, Bay Mud, and alluvium. Subsurface grab

soil samples were also collected from areas of interim remedial measures following soil excavation activities.

A total of 25 borings were drilled by Liquid Gold contractors. Seventeen (17) of the borings were drilled by JLV in August 1980. Samples were taken at depths ranging between 0.5 to 7.5 feet and analyzed for total chromium, copper, lead, nickel, and zinc. Samples taken from the remaining 8 borings by PSC in May 1982 were taken at depths between 2 to 6 feet and analyzed for total lead and zinc. As stated previously, the Liquid Gold data could not be validated, and its use is limited for semi-quantitative interpretations. These data are presented in the Scoping Document (K/J/C 1988a).

Samples were taken by E&E from 57 borings and from 4 of the 10 monitoring wells drilled. Sampling locations are depicted on Figure 11. Additionally, ten composite subsurface soil samples were also collected. Three composite post-excavation samples were collected by K/J/C in December 1985. All samples collected by SPT Co. contractors were analyzed for total chromium, copper, lead, nickel and zinc. In addition, the ten composite subsamples were also analyzed for soluble metals.

Metal results for the 57 borings are presented in Figures 12 to 15 and Table 1. Results for ten composite subsamples for the post-excavation samples are presented in the Scoping Document (K/J/C 1988a) and elevated concentrations in Figure 16. Elevated concentrations are defined as concentrations which exceed the common range in soils as defined by Lindsay (1979) and/or concentrations which exceed the 95 percent distribution range of values for the site. This evaluation was performed for comparison purposes only in this section. The more important consideration is whether the levels of chemicals present in soil present a potential risk to human health or the environment. Potential risks are evaluated in Section 8 (human health evaluation) and Section 9 (environmental evaluation).

3.2.1.4 Subsurface Soil Hydrocarbon Analysis

As discussed in the Scoping Document (K/J/C 1988a), subsurface soil data collected in 1980 and 1982 were not considered valid.

The first major subsurface investigation at the site was by E&E in 1983. Following the results of a preliminary study in September, 1983, an extensive follow-up study was started one month later. In this study, over 150 soil samples collected from borings down to 36.5 feet were analyzed for oil and grease by Standard Method 503E. The quality of these data was poor (see Appendix A of the Scoping Document, K/J/C 1988a)), but they nevertheless provided some indication of potential areas of interest at the site. The concentrations of hydrocarbons in samples collected from depths of 0 to 1.5 feet, 5 to 15 feet, and 20 to 36 feet are summarized in Figures 17, 18, and 19, respectively.

An evaluation in the Scoping Document found that no correlation was found between oil and grease measurements and depth. The oil and grease values are not associated with the historical activity areas at the site shown on Figure 2 and Figure 4. In addition, visible oil in samples (indicated on Figures 17 through 19) was not associated with high oil and grease values. Samples which contained visible oil according to the boring logs often had oil and grease values much lower than those which did not. The most likely reason for the lack of any correlation is that the oil and grease test measures such a broad range of constituents, including natural materials, that it is not a useful indicator for problem areas at the site. As discussed in the Scoping Document, E&E provided preliminary GC/MS evidence that oil and grease values in the fill and Bay mud are the result of different constituents.

In March 1985, K/J/C analyzed over 20 samples of subsurface soil for petroleum hydrocarbons by GC. The locations of the 16 trenches from which samples were collected are shown in Figure 18. Trench locations were chosen on the basis of E&E's oil and grease results. All general areas where E&E's sampling had shown oil and grease at levels greater

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than 1,000 mg/kg in Bay mud or fill were trenched. Samples were collected from the fill/Bay mud interface or in the fill if the material looked oily. Petroleum hydrocarbons were found at low levels at only three locations. As discussed in the Scoping Document, these samples were further analyzed for BNAs by GC/MS, with small amounts of a few priority pollutants detected. Chemicals of high molecular weight (carbon number above about 24) would not be identified by GC/MS.

3.2.2 1988-1989 Soil Investigation

The Scoping Document (K/J/C 1988a) presented an evaluation of the database and identified additional data needs required to complete the RI/FS. Three general areas of additional data needs were identified in the Scoping Document:

- Additional soil sampling was needed to further characterize areas previously investigated and to investigate areas of potential previous site activities which had not been investigated.

- Additional soil sampling was necessary to further characterize areas where past data indicate the presence of chemicals at levels potentially of concern.

- Additional soil and sediment sampling was required to complete the Public Health and Environmental Evaluation.

The sampling objectives, sampling methodology, number of additional sampling locations, depth of sampling, analytes for each sampling area and quality assurance/quality control (QA/QC) procedures are discussed in detail in the RI/FS Workplan for Liquid Gold (K/J/C 1988c) and are outlined below.

The areas sampled have been referenced in this report by former site activity or distinguishing landmarks (i.e., former asphalt facility

area, concrete slab debris area). Some of the areas sampled are not easily referenced by former site activity or distinguishing landmarks and, as a result, have been assigned an area number (i.e., Area 1) for ease of reference (see Figure 11). The assigned area names and numbers are consistent with those used in the Scoping Document (K/J/C 1988a) and RI/FS Workplan (K/J/C 1988c). Sample locations are displayed in Figure 11.

3.2.2.1 Area 1

Area 1 is located near monitoring well MW-3 in the northeast area of the site. This was an area of chemical storage which had some chemical spillage (RWQCB 1975). The nature of the chemicals present was not specified. Spilled oils, chemicals, and paint wastes were removed from this area by February 1975, but soil analyses to document removal were not performed.

To investigate if chemicals remained in this area, two borings (borings 100 and 101) were drilled and sampled. Samples were collected at depths of 0 to 1.5 feet, 5 to 6.5 feet, 10 to 11.5 feet, and 15 to 16.5 feet.

Composite surface soil samples were also collected to estimate possible site contributions to surface runoff.

3.2.2.2 Area 2

Area 2 is located near the northern end of the marsh on the eastern edge of the site. Ponding of chemical waste in this area reported by the RWQCB. The chemical waste was reportedly removed and the area was filled in 1975. However, the cleanup was not documented by soil analysis. Additional samples were taken at three locations (borings 103 to 105) in this area to confirm that the cleanup was adequate. Due to the inaccessibility of the area to a drill rig, the samples were collected with a manual drive soil sampler. Three composite surface

samples were also collected to estimate possible site contributions to surface runoff.

3.2.2.3 Area 3

Area 3, located between Area 2 and the concrete slab debris area, is an area of suspected past activity based on a 1973 aerial photograph and may have involved chemical and/or oil spillage. Samples were taken at two locations (borings 106 and 107) in Area 3. Due to the inaccessibility of this area to a drill rig, samples were collected at the two locations using a manual drive soil sampler.

3.2.2.4 Area 4

This area is located east of Stege Drainage Channel adjacent to monitoring wells MW-2 and MW-12. Regulatory agencies have expressed concern over unidentified activity occurring in this area as indicated on aerial photographs. Three borings (borings 126 to 128) were drilled in this area. Also, three composite surface soil samples were collected.

3.2.2.5 Area 5

Area 5 is an area of suspected past site activities based on aerial photographs which demonstrate filling activity and vehicle tracks. Area 5 is located adjacent to MW-10, immediately north of the South Drainage Channel.

Due to the limited data for this area and at the request of regulatory agencies, further sampling was conducted. Three borings (borings 113 to 115) were drilled and sampled.

3.2.2.6 Area 6

According to a DHS Hazardous Waste Surveillance and Compliance Report dated November 21, 1979, rug pads, household trash, wood, bricks and concrete were disposed in an area located approximately 250 feet southwest of the former pond area adjacent to MW-9. This area has been designated as Area 6. Three borings (borings 110 to 112) were drilled in this area and sampled.

3.2.2.7 Concrete Slab Debris Area

This site, located between Areas 3 and 6, was reportedly cleaned up by removal of oily soil and vegetation. However, post cleanup soil samples were not collected. Samples were collected at two locations (borings 108 and 109) in the concrete slab debris area using a manual drive soil sampler.

3.2.2.8 Former Asphalt Facility Area

Two areas within the former asphalt facility were investigated. One area immediately north of the metal culvert had not been previously sampled. Agency inspection records document ponded oil from leaking storage tanks in this area. One boring (boring 122) was drilled in this area to the alluvium. The other area investigated was the location of a former building and area excavated to remove soil containing oil and lead. Three borings (borings 123 to 125) were drilled around the perimeter of the excavated area.

3.2.2.9 Former Pond Area

This area, located approximately 200 feet south of the former asphalt facility area, reportedly received oily material discharged into the metal culvert during Liquid Gold's operations. Although this area had been previously investigated, there was reason to believe that additional analytes not previously analyzed for may be present. Two

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borings (borings 118 and 119) were drilled and samples collected in this area.

3.2.2.10 Southeast Drainage Path

The southeast drainage path runs from the railroad tracks in the southern part of the site to the head of Hoffman Marsh adjacent to I-580. Although sediment samples had been collected in this area, they were not analyzed for polycyclic aromatic hydrocarbons (PAHs). Surface and shallow subsurface soil samples were collected at two locations in the drainage path. In addition, four composite surface soil samples were collected in the vicinity of the drainage path (Figure 11). Two composite surface samples were collected on the north side of the drainage path and two composite surface soil samples were collected on the south side of the drainage path.

3.2.2.11 Areas with Elevated Levels of Oil and Grease

Data collected by E&E indicated elevated levels of oil and grease in some soil samples collected in the alluvium below the Bay Mud. Considering former site activities, and given the presence of a Bay Mud layer approximately 7 to 19 feet thick across the site, it is unlikely that these values are attributable to petroleum products resulting from site contributions. However, additional subsurface investigations in selected areas where high oil and grease values were reported in Bay Mud and alluvium were undertaken to verify that petroleum products potentially containing priority pollutant base/neutral/acid extractable compounds (BNAs) are not present at these locations.

3.2.2.12 Hoffman Marsh

In addition to soil sampling, sediment samples were also collected in areas where oil and grease levels may be elevated. Sediment samples were collected from the two locations in Hoffman Marsh which were previously sampled and extensively characterized for hydrocarbons by

Western Research Institute (see Appendix B of the Scoping Document, K/J/C 1988a). Samples were collected from 0 to 6 inches and 1 to 2 feet using a hand auger in the same manner as before. The results were used to compare the information provided by all the analytical tests used for hydrocarbons.

3.2.2.13 Modifications to the RI/FS Workplan

The following modifications were made to the sampling and analysis plan in the RI/FS workplan based on field conditions and agency recommendations:

- Two additional soil samples were collected in a previously unidentified drainage path located between Area 3 and the Concrete Slab Debris Area. This location is indicated in Figure 11 as D1.

- Upon the recommendation of the regulatory agencies, selected borings (Table 2) were analyzed for 17 metals from the CCR Title 22, List of Inorganic Persistent and Bioaccumulative Toxic Substances (22 CCR 66699). Based on the results of these analyses, a reduced list of target metals for analysis of soil and sediment samples was derived. This list included mercury in addition to the five previous metals of interest: chromium, copper, lead, nickel, and zinc. In order to attempt to discriminate between anthropogenic and natural sources of oils and greases, total petroleum hydrocarbon (TPH) analysis was also included.

- Two borings were drilled, east of I-580, for the purpose of installing offsite monitoring wells (MW-19 and MW-20). In addition, soil samples were taken from these borings at the intervals indicated in Table 1. It was decided that soil results from these locations would not be indicative of

background levels given that fill material was placed on the site.

- The two deepest sampling intervals for boring 121, located in Area A (Figure 11) could not be collected because the material in the stratum penetrated could not be retained in the sampling device. The material was described as unconsolidated flowing sands.

Two of the areas where E&E data indicated elevated levels of oil and grease in the alluvium were resampled. These areas were resampled to characterize the priority pollutant organic constituents, if any, related to the elevated levels of oil and grease in E&E results.

In addition, subsurface soil samples were collected adjacent to three former boring locations to verify the concentrations of oil and grease in these areas and to determine if there is a correlation between oil and grease concentrations and depth. Such a correlation may be evidence for an anthropogenic source of the oil and grease.

The sampling depths selected for borings in each area were based on two criteria: (1) the accessibility of the area to a drill rig, and (2) the former activity in the area. For areas which were not accessible to a drill rig, the samples were collected with a manual soil sampler to a depth of approximately 3 feet. In areas which are known not to be high use areas, and as a result are not expected to contain elevated levels of chemicals, borings were not advanced through the Bay Mud and into the alluvium. Generally, these borings were 15 feet deep. In high use areas, the borings were sampled to a depth of approximately 30 feet or until a sample could be collected in the alluvium. The number of borings or sample locations proposed for each area were selected based on the general size of the area.

In selected areas, surface soil samples were collected to estimate the amount of chemicals potentially transported via surface runoff to the

wetlands. Samples were taken from study areas in which runoff occurs (Areas 1, 2, 4, and Southeast Drainage Path). Surface soil samples were collected by dividing the study area into roughly three sections. In each section three surface subsamples were collected and subsequently composited by the laboratory into one sample. Thus, three composite samples per study area where runoff occurs were collected except at the Southeast Drainage Path, where four composite surface samples were collected. Two composite samples were taken from each side of the drainage path (north and south).

The soil sampling program was implemented in September 1988. Table 2 summarizes the sampling program, including sample types, depth and analytical parameters. Samples taken from borings with the exception of those in the Southeast Drainage, Hoffman Marsh and the Drainage Path, were analyzed for the six target metals, PCBs, BNAs, oil and grease, TPH and sulfur. Boring samples from the Southeast Drainage, Hoffman Marsh and the Drainage Path were analyzed for all the above parameters except BNAs. In place of BNAs, samples were analyzed for PAHs and phenols. Likewise, the surface composite samples were analyzed for the six target metals, PCBs, PAH, phenols, oil and grease, TPH and sulfur. Analytical results were evaluated with respect to QC sample results and an assessment of data quality was made. Details regarding the validation process and results are presented in Appendix E of this document. Results of selected borings analyzed for the CCR Title 22, 17 metals are presented in Table 3. Results of the six target metals for all samples are presented in Table 1. Metal concentrations in surface composite samples are shown on Figure 20. Subsurface metal concentrations at the various sampling ranges are depicted in Figures 21, 22, 23, and 24. The highest levels are depicted in Figure 16. Results for PAH are presented in Table 4 and for BNA and phenols in Table 5. Positive results for PAHs and phenols are depicted in Figure 25. The remaining analytes, PCBs, oil and grease, TPH, and sulfur are depicted in Table 6. The highest oil and grease values are presented in Figure 25.

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Additional surface and subsurface soil samples (Figure 26) were collected as part of a biological study. The objective of the study was to evaluate potential acute effects of storm water runoff and wet season groundwater on aquatic organisms on the adjacent marsh. Elutriates of surface soils were used to estimate runoff water quality and elutriates of subsurface soils to estimate groundwater quality. Soil analytical results are presented here as it contributes to the soil chemical database. The bioassay sampling program is summarized in Section 5.6 and presented in detail in letters dated 31 July 1989 (K/J/C 1989a) and 24 August 1989 (K/J/C 1989b) to the Department of Health Services (included in Appendix D).

Surface soil sampling locations labeled as M1 or M6 are shown on Figure 26. Surface sampling locations were selected on the basis of surface drainage analysis (K/J/C 1988a) and the results of chemicals analysis of surface soil samples collected in September 1988. Surface soil samples were collected from three subsites located at the corners of a triangle with sides 10 feet long. The subsamples were subsequently composited to form one sample for each location. The three sample locations designated "M1" were chosen for potential drainage into Drainage Area 1. The three "M6" sample locations were chosen for potential drainage into Area VI. The drainage areas are also designated on Figure 26.

The subsurface soil sampling locations are labeled on Figure 26 with the M0 designation. The three locations were selected in the former activity area on the basis of past chemical analysis of subsurface soil samples (K/J/C 1988a), primarily elevated metal concentrations.

Surface and subsurface soil samples were analyzed for the six target metals, oil and grease, BNAs, and PCBs. Results are presented in Tables 7 and 8 and the elevated levels on Figure 25.

The final soil sampling effort was implemented in two phases in September and October 1990 (K/J/C 1990). During the first phase of soil

sampling in September 1990, three types of field activities were performed:

- Collection of samples from five borings near boring #111 to confirm the levels of chemicals in soil from an area chosen for attention in the human health risk assessment (discussed as Lot 4 in Section 8). The borings are labeled L4-1 to L4-5 in Figure 11. The plan was for soil samples to be collected from each boring at three depths: 0 to 1.5 feet, 5 to 6.5 feet, and 10 to 11.5 feet. Because of asphalt encountered in the shallow subsurface, four of the shallow soil samples were collected at a depth of approximately 2 feet. Soil samples were analyzed for BNAs, oil and grease, PCBs, chromium (total and hexavalent), copper, lead, mercury, nickel, and zinc.

- Collection of four surface soil samples in other areas of the site for chromium VI analysis.

- Logging of a boring near Monitoring Well MW-5 to confirm the lithology of this well.

The analytical results are summarized in Table 9 for metals and oil and grease, and Table 10 for BNAs. On the basis of the results from the first phase of soil sampling, it was agreed that a second phase would be conducted in October 1990. The analytes of interest during the second phase of soil sampling were limited to copper, lead, zinc, and PAHs.

During the second phase of soil sampling in October 1990, twenty shallow subsurface samples (0 to 1.5 feet) were collected by hand auger in the areas south and east of Lot 4. Nine soil sample locations (labeled L4-15 to L4-23) were chosen in the vicinity of the five soil borings from the first phase of soil sampling to investigate shallow subsurface soils in the area south of Lot 4. Nine other sample locations (labeled L4-6 to L4-14) were selected in the area east of Lot 4 according to a grid system to characterize soils in this area. Two additional sample

locations (L4-24 and L4-25) were added to the northern portion of the grid at the request of the EPA. The analytical results are summarized in Table 11 for metals and Table 12 for PAHs. A statistical summary of the second phase of data for metals is also included in Table 11.

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SECTION 4

HYDROGEOLOGIC INVESTIGATION

4.1 REGIONAL GROUNDWATER CHARACTERISTICS

CalTrans characterized groundwater near the site in a study (DOT 1978) for a proposed section of what is now the I-580 freeway. The eastern end of this section is approximately 0.5 miles northwest of the site. The groundwater aquifer zones in the west Richmond area are designated as the Hoffman Aquifers, the Richmond Aquifers, and the San Pablo Aquifers, in order of increasing depth (DOT 1978). As described in Section 3, the two aquifers identified at the site are the shallow aquifer and the deeper aquifer. The shallow aquifer is a fill zone, and therefore does not correspond to any of the regional aquifers quoted above. It is unclear to which of the three CalTrans aquifers the deeper aquifer zone corresponds.

CalTrans cites Webster (1972) in stating that in the vicinity of the site there exists a 95 percent chance that maximum well yields will range from 0.1 to 10 gallons per minute and thus that the area is only "... marginally adequate (as a groundwater supply) for a single-family home or for cattle." (DOT 1978). It is unclear which of the three CalTrans aquifers Webster refers to. CalTrans also cited the "Tricities Seismic Safety and Environmental Resources Study (1973), which characterized groundwater in the vicinity of the site as "not available" (DOT 1978). CalTrans further cites Nevin (1973) in characterizing the Contra Costa Groundwater Basin as a whole, as follows.

> "clay predominates in the Basin, making up as much as 90 percent or more of the alluvial section (surficial deposits as defined elsewhere by the U.S.G.S.) in most areas for which data are available. It (clay) occurs typically in large thicknesses and is virtually impermeable. Sand and gravel layers, deposited mainly by

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San Pablo and Wildcat Creeks, are sparse and highly variable in occurrence and cannot be individually traced for any distance. Generally, only a few feet in thickness, they are found mostly below depths of 100 feet or more. Such deeper pervious beds constitute the only productive aquifers within the area." (DOT 1978).

Approximately 20 private groundwater wells are located within one mile of the site (see Figure 27). No wells are located downgradient of the site. The quality of shallow groundwater (less than a depth of 50 feet) in the site vicinity is reportedly poor, indicating that drinking water is not a potential beneficial use of groundwater nearby (DOT 1978). CalTrans reports that the manganese content in all 9 shallow groundwater samples collected in its investigation exceeded the secondary drinking water standard of 0.05 mg/l (DOT 1978). The manganese concentrations reported for groundwater samples analyzed by CalTrans ranged from 0.11 mg/l to 1.9 mg/l (DOT 1978). CalTrans further reported that "serious bacterial contamination" was detected in groundwater samples collected from all 9 sampled wells (all shallow wells, less than 50 feet deep, between 0.75 and 2 miles from the site) (DOT 1978). The shallow groundwater sample collected nearest the site (CalTrans boring P-11, near the intersection of Meeker Avenue and Hoffman Boulevard) contained a coliform density of 9,200 MPN (most probable number) per 100 milliliters (DOT 1978). The California primary drinking water standard for total coliform bacteria density is 1.0 MPN per 100 milliliters.

Upgradient groundwater from below 90 feet in depth is reportedly used for industrial and domestic purposes (DOT 1978). Since the deepest screened interval in site monitoring wells is 35 feet, underlain by an unknown thickness of clay, it is unlikely that this deeper groundwater described by CalTrans is in hydraulic connection with site groundwater.

CalTrans concluded on the basis of water quality analyses of shallow groundwater samples collected from depths less than 50 feet that (DOT 1978):

1. Samples analyzed were "moderately to severely contaminated" with coliform bacteria

2. Manganese content did not meet secondary drinking water standards

3. Calcium, magnesium, and/or bicarbonate concentrations in all 9 analyzed groundwater samples were above levels recommended for fish and aquatic life.

It is unlikely that the shallow groundwater which occurs onsite is directly connected to the groundwater sampled by CalTrans or to groundwater which could possibly be used as drinking water. This is because site shallow groundwater occurs in imported fill material not present to the northeast of the site. Because of lithologic differences in onsite and offsite boring logs, it is also uncertain whether site deep groundwater is hydraulically connected to the sampled offsite groundwater. For this reason, groundwater samples for onsite and nearsite monitoring wells (both shallow and deep) were analyzed for coliform bacteria and manganese. Samples were also analyzed for total dissolved solids (TDS), for which a secondary drinking water standard of 1,500 mg/L (short-term maximum) has been established (22 CCR 64473). On the basis that coliform bacteria, manganese, and/or TDS results exceeded the cited standards in all site monitoring wells, site shallow and deep groundwater was found to be unsuitable for drinking water as well as other beneficial uses as described in Section 4.2.8

4.2 RI GROUNDWATER INVESTIGATION

There are presently 18 onsite and nearsite monitoring wells, numbered MW-1 through MW-20, excluding wells MW-10 and MW-14. Wells designated

with an R (e.g., MW-4R) are replacements for destroyed wells. Monitoring well locations are shown on Figure 28. Nine of these wells are screened in the fill zone, which extends from the surface to a depth between 5 and 11 feet. These wells are designated as shallow wells. The remaining nine deep wells are screened in the alluvial zone beneath the Bay Mud, at depths below about 20 feet. Well construction summaries are provided in Table 13. Well logs are provided in Appendix A.

E&E installed monitoring wells MW-1 through -10 in November 1983. The deep wells MW-1, -2, -3, -6, and -9 were intended to surround the former site activity areas and enable measurement of deep groundwater gradient under the site.

Wells MW-7, -8, and -10 were completed as shallow wells in central areas of former site activity. Monitoring wells MW-4 and MW-5 were described by E&E as being screened within the Bay Mud zone and not in the shallow or deep aquifers (E&E 1984a). MW-4 was later damaged and replaced by K/J/C with shallow well MW-4R, screened at a higher elevation than MW-4.

The groundwater elevations measured in Well MW-5 more closely resembled the behavior of shallow monitoring wells, and MW-5 was labeled by K/J/C as a shallow well. Because the E&E log was not clear in its subsurface materials descriptions, a test boring was drilled approximately ten feet from MW-5 (at surface soil location CR-4) in September 1990 to verify lithology. The boring was continuously cored to a depth of 20 feet to determine precise depths of contact. The log of this boring is provided in Appendix B. On the basis of these data it was determined that the source of groundwater is in fact within the Bay Mud zone. The coarse-grained alluvial (deep aquifer) layer appears to be absent in this area of the site, and the fine-grained alluvium at the base of the screened interval of MW-5 was dry and is not believed to contribute groundwater to the well. Hydraulically, the well behaves as a shallow well, and has therefore remained with that designation, even though it is not screened in the fill zone. In July-August 1986, K/J/C replaced MW-4 and MW-7 with MW-4R and MW-7R, respectively. MW-10 was destroyed and not

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replaced. In addition, K/J/C installed wells MW-11 and MW-17 as assumed up- and downgradient (respectively) shallow wells, well MW-12 to form a shallow/deep cluster with MW-2, and two additional shallow/deep clusters: MW-13/MW-18 and MW-15/MW-16.

Wells MW-12, MW-15, and MW-18 were damaged by separate events between 1987 and 1989 and were replaced by the corresponding "R" wells shortly after each event.

Wells MW-19 and MW-20 were installed by K/J/C in September 1988 in an attempt to monitor upgradient deep groundwater, as described below.

The work during October 1988 and October 1989 (described below) included water level monitoring, collection of quarterly groundwater samples, installation of new and replacement monitoring wells, and tidal influence monitoring for selected shallow wells. Discussion of groundwater sample analysis results is provided in Section 6.2.

4.2.1 Shallow Groundwater

Water levels in the nine shallow monitoring wells (MW-4R, -5, -7R, -8, -11, -12R, -13, -15R, and -17) were measured on a monthly basis to estimate groundwater flow direction and gradient magnitude, and to monitor any seasonal variations. Previous monitoring of the shallow zone yielded inconsistent hydraulic data that suggested a compartmented, non-continuous shallow groundwater distribution (K/J/C 1988a). This is typified by groundwater elevation data that do not show a consistent gradient when contoured. The apparently random elevation distribution suggests that groundwater monitored by each well is not hydraulically connected, and that the system is made up of limited groundwater zones or compartments.

Water elevations in shallow monitoring wells are listed in Table 14 and elevation contours for the wet season (January to May) are presented on Figures 29 to 35. Groundwater levels in shallow monitoring wells

generally increased from September/October through March/April, then decreased from April to September. A major exception was well MW-13, where a sharp drop between October 1988 and December 1988 was followed by increasing levels through June. Water levels in wells MW-11 and MW-17 both peaked in March, and did not show a consistent decline in subsequent months. Water level data were not obtained from MW-15 during January through March due to damage to the well. Data collection for the replacement well MW-15R began in April following destruction of MW-15.

Shallow groundwater elevations measured in October and December 1988 (Figure 29) were similar to previous data (August 1986, Figure 36). There did not appear to be a continuous and consistent gradient across the site for this period, supporting the interpretation that a compartmentalized groundwater system exists. However, data from January through April (Figures 30 through 33) indicated a southwest gradient direction (about 1 foot per 150 feet) and a more continuous system. This was likely a result of increased precipitation between January and April. Recharge to the shallow aquifer during this time may have raised water levels enough so that effects of localized heterogeneities of the fill material on the water table were reduced. An analogous situation may be that of tidal pools which are filled and overflowed during high tide. Site-wide continuous groundwater flow in the shallow aquifer may only exist for a limited time during the rainy season. The gradient magnitude decreased considerably in May 1989 (Figure 34), and by June 1989 the water level pattern had reverted to that described for October and December 1988 and previous dry season data. Between June and October 1989 the gradient remained small in magnitude (about 1 foot per 650 feet) and fluctuated in direction between southwest and northeast (e.g., see Figure 35).

Using previous estimates of porosity and measured hydraulic conductivity (K/J/C 1988a) along with measured 1988 to 1989 wet season gradients, the shallow groundwater velocity (v) during winter months is estimated to range from 2 to 80 m/yr in the southwest direction:

$$v = \frac{Ki}{n}$$

where K = hydraulic conductivity
i = gradient
n = porosity

K range = 5.5×10^{-4} to 6.1×10^{-3} cm/s (K/J/C 1988a)
i range = 6×10^{-3} to 1×10^{-2} (1/89 to 4/89 data)
n range = 0.25 to 0.50 (K/J/C 1988a)
v range = 7×10^{-6} to 2×10^{-4} cm/s
= 2 to 80 m/yr

This flow rate likely only exists for 3-4 months out of the year, while during the remainder of the year the flow direction is variable and the velocity much smaller.

Monitoring wells MW-12 and MW-15 were damaged during 1988 and were subsequently destroyed and replaced with MW-12R and MW-15R, respectively. Destruction was performed in accordance with state and federal regulations and consisted of overdrilling the well with a hollow stem auger, removing the PVC casing, and backfilling the hole with grout. Each replacement well was constructed identical to and installed within ten feet of the destroyed well. MW-12 was replaced in September 1988 and MW-15 in March 1989.

4.2.2 Deep Groundwater

Water levels in the nine deep groundwater monitoring wells (MW-1, -2, -3, -6, -9, -16, -18R, -19, and -20) were measured on a quarterly basis to monitor any seasonal variation in groundwater flow direction or gradient magnitude.

Monitoring well MW-18 was damaged during construction of the site access road. The well was properly destroyed and replaced with MW-18R in the same manner as shallow wells MW-12R and MW-15R (Section 4.2.1).

In accordance with the RI/FS Workplan (K/J/C 1988c), two upgradient monitoring wells, MW-19 and MW-20, were installed northeast of I-580. The wells were designed for monitoring upgradient water chemistry to provide background levels of chemicals of concern. The locations of MW-19 and MW-20 were further northeast than originally proposed in the RI/FS Workplan (K/J/C 1988c) due to access problems.

However, conditions encountered in this vicinity were different from those encountered onsite in the following ways:

- The blue-gray Bay Mud layer was not encountered during drilling. This layer was consistently found at the site between the fill (shallow) and alluvial (deep) aquifers. Instead, a tan clay resembling that encountered below the alluvial aquifer was dominant to as deep as 50 feet, with occasional thin sand layers. It is not clear whether these sand layers correlate with the alluvial aquifer described onsite.

- Measured groundwater elevations in wells MW-19 and MW-20 were below those measured in onsite deep upgradient wells MW-1 and MW-3 in October 1988, July 1989, and October 1989 sampling rounds. During the rainy season (sampling rounds in January and April 1989), the relationship was reversed, possibly indicating a perched groundwater zone at MW-19 and MW-20. These data suggest that the two aquifer zones are not hydraulically connected. The hydraulic relationship of the aquifer zone monitored by the offsite wells to those monitored by the onsite wells is not clear.

- Water quality parameters of nitrate and total dissolved solids (TDS) concentrations in samples from wells MW-19 and MW-20 were markedly different from those measured in samples from onsite wells. TDS ranged from 420-860 mg/L in samples from wells MW-19 and MW-20, while the measured onsite range is 1,200-56,000 mg/L. Nitrate concentrations, on the other hand, averaged 3.4 mg/L in samples from wells MW-19 and MW-20 while only two onsite samples contained over 1 mg/L. These elevated parameters appear to be indicative of regional groundwater quality issues and are not likely the result of or influenced by past site activity.

On the basis of these three observations, it was concluded that monitoring wells MW-19 and MW-20 may not be representative of upgradient groundwater conditions. The groundwater zone screened by these wells is probably not hydraulically connected to the onsite deep groundwater zone.

Quarterly groundwater elevation measurements are listed in Table 14, and contours are presented on Figures 37 through 41. Water levels in deep monitoring wells rose between October and April in response to increasing recharge from precipitation. The direction of apparent deep groundwater flow was consistently to the southwest throughout the monitoring period, consistent with that measured in previous studies (Figure 42). There is a southwest-trending bend in the contour lines for the 1988-1989 data that was absent in the August 1986 data. This is because the groundwater elevation in well MW-18R is consistently lower than that in MW-6 and is similar to that in MW-16. The destroyed Well MW-18 water level was higher than both of these wells, precipitating a different contour pattern. Though MW-18R was constructed identically to MW-18 and within 10 feet of the destroyed well, conditions may be slightly different. In either case, the deep groundwater gradient is to the southeast.

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It is also notable that during the rainy season monitoring events (January and April 1989, Figures 38 and 39) the deep groundwater contour lines may be extended northeast to include MW-19 and MW-20, apparently eliminating the groundwater divide that appears to exist in the dry season (October 1988, July and October 1989, Figures 37, 40, and 41). It is not known whether this condition actually exists or not. Because only two data points are present northeast of I-580, a gradient cannot be calculated independently for this area. The contours shown in Figures 37 through 41 are therefore hypothetical in the area in question. The magnitude of the gradient decreased in July and October 1989 in response to decreased precipitation in the area.

On the basis of previous hydraulic conductivity measurements and porosity estimates (K/J/C 1988a) and the observed 1988-1989 gradient magnitudes, the estimated deep groundwater velocity (v) range is 2 to 1,000 m/yr to the southwest:

$$v = \frac{Ki}{n}$$

K range = 1.4×10^{-3} to 1.2×10^{-1} cm/s (K/J/C 1988a)
i range = 2×10^{-3} to 8×10^{-3} (10/88 to 10/89)
n range = 0.25 to 0.50 (K/J/C 1988a)
v range = 6×10^{-6} to 4×10^{-3} cm/s
= 2 to 1,000 m/yr

4.2.3 Groundwater Sampling

The 18 groundwater monitoring wells described in Section 4.2 were sampled on a quarterly basis for five quarters from October 1988 to October 1989. The samples were analyzed for the following constituents.

- metals of concern (chromium, copper, lead, mercury, nickel, and zinc)

- organics (oil and grease, total petroleum hydrocarbons [TPH])

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- water quality parameters (manganese, nitrate, coliform bacteria, pH, conductivity, total dissolved solids [TDS])

Complete results of chemical analyses of groundwater samples are cited in Table 15 and metals concentrations are displayed on Figure 43 (for shallow groundwater results) and Figure 44 (for deep groundwater results).

Samples from three shallow wells (MW-12R, MW-13, and MW-17) and from two adjacent drainage channels (Stege and South) were analyzed for major ions (sodium, calcium, magnesium, chloride, alkalinity, and sulfate) in order to compare basic water chemistry. This comparison was made as a tool in evaluating tidal influence on shallow groundwater (refer to Section 4.2.4).

Sample collection, handling, and analysis procedures, along with quality assurance/quality control (QA/QC) procedures are described in the RI/FS Workplan (K/J/C 1988c). Procedures were carried out as planned with the exceptions noted in the quality assurance appendix (Appendix E).

4.2.4 Tidal Influence Monitoring

4.2.4.1 Field Activity

A monitoring test was performed in February/March 1989 to attempt to detect tidal influence on shallow groundwater at the Liquid Gold Site. Water levels in three shallow wells and two drainage channels were monitored using temporarily installed electronic pressure transducers (accurate to approximately 0.03 feet) and digital electronic data storage and retrieval devices (data loggers). Both drainage channels run adjacent to the site and are connected to San Francisco Bay. Locations of the transducers and data loggers are shown on Figure 45. On 24 February 1989, transducers were installed in monitoring wells MW-12R and MW-13 and in Stege Drainage Channel. The three transducers were linked to a data logger and the system was then calibrated so that

the relative elevation of water above each transducer at the start-up time was set to zero. Transducers in MW-17 and the South Drainage Channel were linked to a second data logger and calibration was completed in the same manner.

The test methodology was identical to that of the tidal influence test of August/September 1986 (K/J/C 1988a). In this case, only shallow monitoring wells adjacent to drainage channels were tested. A modification in the 1989 test was that stages in Stege and South Drainage Channels were directly monitored to obtain site tidal fluctuations. In 1986, tidal data were estimated on the basis of San Francisco Bay tide tables.

The data loggers were programmed to take readings every half-hour, beginning at 4:00 p.m. on 24 February 1989. In accordance with the RI/FS workplan, the test was to be run a minimum of five days. Because rain was forecast for 1 March, a decision was made to extend the monitoring period in order to examine effects of rainfall infiltration in the monitoring wells. Data were downloaded from the data loggers on 3 March and at the conclusion of the test on 10 March. On 3 March it was discovered that the transducer from MW-13 had been dislodged and had to be reset. As a result of this incident, data were lost for MW-13 between 27 February and 3 March. Otherwise, field activities went as planned and all other data were recovered.

The wells and drainage channels were sampled prior to commencement of monitoring, and the samples were later analyzed for major ions (sodium, calcium, magnesium, chloride, alkalinity, and sulfate). The wells and channels were sampled at this time to compare water chemistry concurrent with hydraulic monitoring. Major ion analyses were also performed on samples from these wells and drainage channels during the October 1988 and January, July, and October 1989 sampling rounds. A discussion of results of these analyses is presented in Section 4.2.3.3.

4.2.4.2 Discussion of Hydraulic Analysis Results

Data were plotted in the format of elevation versus time and are presented herein on Figures 46 through 50. Data from shallow wells MW-12 and MW-13 are shown individually on Figures 46 and 47, respectively, and together with Stege Drainage Channel data on Figure 48. Similarly, data from shallow well MW-17 are presented on Figure 49 and are combined with South Drainage Channel data on Figure 50.

Evaluation of data from individual well plots (Figures 46, 47, and 49) suggested a slight tidal influence, especially from data collected before the rain event on 1 March. Elevations appear to rise and fall in a periodic manner with similar frequency to tidal cycles in the drainage channels. However, it should be noted that the magnitude of these fluctuations is on the order of 0.2 feet. When these data are plotted on the same scale as that of the drainage channel data (Figures 48 and 50), the fluctuation pattern is shown to be less than one-tenth that of the drainage channels.

On the basis of the test data there appears to be a hydraulic connection between shallow groundwater and these drainage channels. The lateral extent of this connection is unknown. The absence of a connection in the August 1986 test and the seasonal variation of shallow groundwater head distribution suggest that this connection exists only during the rainy season.

Between 6:00 p.m., 1 March and 6:00 p.m., 2 March 1989, Richmond received 1.6 inches of precipitation (NOAA 1989). This caused a dramatic effect on water levels in shallow groundwater monitoring wells MW-12R and MW-17. Following this rainfall event, water levels in these wells were highly variable as additional precipitation and variable recharge was occurring. These responses further suggest that tidal influence on shallow groundwater is insignificant, especially compared

to precipitation. Because data were lost for MW-13 during this period, the response in this well to the rainfall event is unknown.

In summary, the results of the tidal influence monitoring test were similar to those of the previous (1986) test. There appears to be a negligibly small and inconsistent response of shallow groundwater to tidal fluctuations in drainage channels. A 0.1 feet tidal influence on the monitoring wells nearest to the channels (Figures 46 and 47) will not significantly influence the groundwater gradient of the shallow aquifer (Figure 32). A tidal influence of approximately 2 feet would be needed to influence the shallow groundwater gradient. Also, the tidal influence of 0.1 feet is insignificant compared with the rainfall influence of approximately 1.2 feet (Figure 46). The responses in the monitoring wells to the rainfall event supports the previous hypothesis that shallow groundwater recharge is dominated by precipitation.

4.2.4.3 Discussion of Chemical Analysis Results

As a tool in investigating tidal influence, general water chemistry of samples from Stege and South Drainage Channels was compared to that for samples from the adjacent shallow wells MW-12R, MW-13, and MW-17. Similar water chemistry between shallow groundwater and tidal drainage channels would support the possibility of a tidal influence on shallow groundwater quality. Samples from the drainage channels and the three wells were collected on a quarterly basis and analyzed for major constituents (sodium, calcium, magnesium, chloride, alkalinity, and sulfate). Samples were collected in late February 1989 rather than April in order for sampling to coincide with the tidal influence test. Insufficient yield prevented a sample from MW-12R from being collected in October 1989, and a sample was obtained from MW-13 only for the February 1989 sampling round.

Major ions data for groundwater monitoring wells and surface water are given in Table 16. To graphically illustrate the water chemistry comparison method, a Stiff chemical quality diagram was used (Figures 51

through 55). This is a plot of the major constituents and their concentrations in units of milliequivalents per liter (meq/L). These units are used to weigh the constituents by charge and atomic (or molecular) weight, so that the measure is of ion abundance and not simply milligrams per liter. This is the chemically more significant measure. The dominant ions are shown as the largest horizontal peaks in the diagram. Also, the size of the diagram is proportional to overall salinity. Therefore, Stiff diagrams may be used to illustrate differences in chemical makeup and in salinity.

As stated in Section 4.2.3.2, the results of the hydraulic tests indicated that there was detectable tidal influence on shallow groundwater, but that it has a negligible effect on groundwater gradient. Results of chemical analyses support these conclusions, but not definitively. Some correlations between shallow groundwater quality and seawater quality is detectable, but the chemistries of surface water and shallow groundwater are not identical.

South Drainage Channel water samples were similar to typical seawater composition (Hem 1988). There appears to be little influence of surface runoff on the water chemistry of the South Drainage Channel. Stege Drainage Channel water samples, on the other hand, appear to have been much more influenced by surface runoff from upstream freshwater sources. Samples collected in January, February, and July 1989 show a much lower salinity than that of South Drainage as well as the monitoring well samples. This may be explained by low tide and high surface runoff periods at the time of sample collection. Only in October 1989 was the sample from Stege similar to seawater composition.

The samples from the three monitoring wells have high salinities, but the chemical character of the waters is different from that of either South or Stege Drainage Channels. The seawater chemistry of South Drainage Channel is typified by a sulfate spike in the Stiff diagram (Figure 53). This configuration is not present for the monitoring well

samples, regardless of the salinity. There is, however, some parallel water chemistry behavior.

Though different from Stege Drainage Channel in both chemical character and salinity, samples from MW-12R showed a seasonal fluctuation in salinity correlated with that of Stege. This suggests the possibility of hydraulic connection between the two, but also the possible influence of other factors on MW-12R water chemistry, such as evaporation, soil chemistry, and separate recharge (there was a significant influence of precipitation on shallow groundwater). As in the hydraulic data discussion, there appears to be a minor surface drainage channel chemical correlation with shallow groundwater. This supports the conclusions reached on the basis of the hydraulic analysis (Section 4.2.3.2).

The only sample collected from MW-13 (February 1989) indicated the inconsistent nature of shallow groundwater chemistry. The sample from MW-13 was much more saline than the sample from MW-12R, which appears to support the hydraulic theory of a compartmentalized shallow groundwater system.

Just as MW-12R chemistry varied with that of Stege, the stability of MW-17 sample chemistry correlated with the chemical stability of South Drainage Channel samples. Again, MW-17 water had a different and more saline chemistry than South Drainage Channel. MW-17 also showed a more stable groundwater elevation during the sampling period (Table 14), and the consistent chemistry may be the result of a more steady recharge than, for example, MW-12R.

In summary, the chemical analyses of shallow groundwater and drainage channel samples provided the following conclusions:

- As in the hydraulic analysis, there appears to be a minor tidal influence (and hence surface water influence) on shallow

groundwater, though it is apparent that other criteria influence shallow groundwater chemistry.

- Shallow groundwater chemistry is variable at the site, supporting the compartmentalized hydraulic theory and indicating variable fill composition.

4.2.5 Hypothetical Shallow Groundwater Dilution

As concluded in Section 4.2.4, there is not believed to be a significant interaction between shallow groundwater and surface drainage channels at the site. However, for use in the environmental assessment (Section 9), a hypothetical influx to the South Drainage Channel was estimated on the basis of calculated shallow groundwater velocities. The dilution factor of shallow groundwater into the South Drainage Channel was then estimated. The assumptions for this estimate are as follows:

- Averaged over one year, shallow groundwater velocity ranges, from 0.7 to 30 m/yr (assuming a velocity range of 2 to 80 m/yr for 4 months out of the year, as calculated in Section 4.2.1, and no flow for the remainder of the year).

- The average width of South Drainage Channel is about 5 meters, as measured from aerial photographs.

- Shallow groundwater flows into a 1 m x 1 m area. The tidal fluctuation in South Drainage Channel appears to be about 1 m (see Figure 48) and a 1 m stretch of the channel was chosen for simplicity.

From these assumptions, the surface water volume replaced each tidal cycle (12 hours) is equal to 1 m x 1 m x 5 m = 5 m^3. Along the same 1 m stretch, the amount of shallow groundwater influx is:

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$$1\ m \times 1\ m \times 30\ m/yr \times 1\ yr/365\ d \times 1\ d/24\ hr \times 12\ hr = 0.04\ m^3$$

(maximum velocity)

This corresponds to a dilution factor of 0.04/5 = 0.8 % or 125 to 1. The maximum estimated groundwater velocity was used in this calculation. Other velocity estimates will yield larger dilutions.

Though this estimate is very approximate, it indicates that shallow groundwater will be substantially diluted by mixing with water of South Drainage Channel.

4.2.6 Hypothetical Deep Groundwater Dilution

Deep groundwater flows underneath South Drainage Channel and discharges at an unknown point in San Francisco Bay, on the basis of known surface and groundwater elevations. The depth to deep groundwater beneath the site is approximately 20 to 30 feet below mean sea level. The water in the Bay near Richmond is relatively shallow, with depths less than 5 feet approximately 1 mile from the site. Deep groundwater would therefore be expected to discharge to the bay at a location beyond this distance. Depths approaching 20 to 30 feet do not occur until about 2 to 4 miles from the site. The dilution of deep groundwater discharging to the bay is assumed to be greater than that calculated for shallow groundwater (125:1) in Section 4.2.5, because shallow groundwater discharges to a smaller surface water body (South Drainage Channel).

4.2.7 Surface Water

An analysis of past and present drainage pathways and areas was performed in the Scoping Document (K/J/C 1988a). The current drainage areas are shown on Figure 26. As discussed in the Scoping Document, only three of the drainage areas, I, VII, and VIII, have net runoff for hypothetical storm events. Area VIII has been modified slightly since

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these estimates were calculated by construction of the site access road. This is not believed to significantly affect the conclusions of the Scoping Document (K/J/C 1988a).

4.2.8 Beneficial Use

The following are considered to be potential beneficial uses of groundwater in the San Francisco Bay region (SWRCB/RWQCB 1986):

Municipal and Domestic Supply
Agricultural Supply
Industrial Process Supply
Industrial Service Supply

There is no known current beneficial use of groundwater at the site. During sampling, many of the monitoring wells are bailed dry before three well volumes are removed. It is therefore not anticipated that there is sufficient yield in either the deep or shallow aquifer to sustain a beneficial use.

In addition, some water quality parameters preclude several beneficial uses at the site. The beneficial use criteria for municipal groundwater supply are exceeded in the categories of total coliform (most wells), conductivity (all onsite wells), and manganese (all onsite wells), according to the Water Quality Control Plan for the San Francisco Bay Basin (SWRCB/RWQCB 1986). Agricultural use is precluded (SWRCB/RWQCB 1986) by manganese (some wells) and conductivity (all onsite wells). Site groundwater concentrations of dissolved solids and manganese exceed the recommended limiting concentrations for industrial process waters (Todd 1980).

Other potential beneficial uses for consideration are the beneficial uses of surface receiving waters. For the purpose of this evaluation, it is assumed that shallow groundwater enters surface waters of the marsh near the site and that deeper groundwater enters open bay surface

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waters farther from the site. Beneficial uses have been specified by the State of California and the RWQCB for significant marshes in the San Francisco Bay region. Hoffman Marsh is not included on this list (SWRCB/RWQCB 1986), however, in general the beneficial uses of marshes are identified by the State and RWQCB as the following:

- Water contact recreation
- Non-contact water recreation
- Ocean commercial and sport fishing
- Wildlife habitat
- Preservation of rare and endangered species
- Marine habitat
- Fish migration
- Fish spawning
- Estuarine habitat

Of these potential beneficial uses of surface water, the two major uses that appear to apply to the areas near Hoffman Marsh are wildlife habitat and marine habitat. An evaluation of potential impacts to these uses can be considered an integral part of the ecological evaluation presented in Section 9. Other potential uses are less likely to be relevant at the site, but would also be addressed by the environmental evaluation.

4.2.9 Summary

From the previous discussions of site groundwater and surface water conditions, we may conclude the following:

- The area surrounding the site has been documented to contain poor quality groundwater.

- Evaluation of shallow and deep groundwater leads to the conclusion that site groundwater is unsuitable for drinking

because of regional characteristics such as high salinity and coliform, and observed low yield.

- Shallow groundwater flow is slow, and site-wide continuous flow occurs only during the rainy season.

- There appears to be a minor tidal influence on shallow groundwater, but the influence on gradient is considered negligible. This conclusion is supported by general chemical data.

- The minimum hypothetical dilution factor of shallow groundwater as it flows into South Drainage Channel is 125:1. The dilution factor for deep groundwater entering San Francisco Bay is believed to be much greater.

SECTION 5

ECOLOGICAL INVESTIGATION

An ecological investigation was conducted to provide information about marsh areas adjacent to the site for the final Environmental Evaluation. The major objective of the ecological investigation was to evaluate if chemicals originating on the Liquid Gold site are impacting the wetlands biota. Uplands areas were also briefly surveyed. Specifically, the investigation was conducted to evaluate the ecological health of marsh areas adjacent to the Liquid Gold site in comparison with other areas of Hoffman Marsh. The study was designed so that differences between potential impacts due to past Liquid Gold operations and potential impacts due to offsite sources of chemicals would be apparent. The presence of rare, threatened, or endangered species, as well as potential risk to these species was investigated.

5.1 STUDY PLAN

To meet the above objectives, the study included several components. The following tasks were conducted to provide information on the health of the marsh adjacent to the site relative to other areas of the marsh:

- Sediment chemistry analyses
- Benthos sampling and abundance calculations
- Animal tissue chemistry analyses
- Vegetation survey
- Plant tissue chemistry analyses
- Small mammal survey
- Bird survey
- Bioassays of surface and subsurface soil elutriates

The sediment chemistry, benthos, and tissue investigations were conducted using a transect sampling approach. Samples were collected

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along transects across the marsh portions of the study area (Figures 56 and 57). Each transect location was chosen to provide data on potential sources of chemicals to the marsh. Transects 1 and 6 were located in areas of historical discharge from the Liquid Gold site to the marsh and results from these transects were intended to be compared with results from the other transects not likely to be affected by the site. Results from Transects 1 should be compared with results from the other transects in Hoffman Marsh (2, 3, and 4). Transects 2 and 3, as well as Transect 1, may be impacted by highway or urban runoff. Specific sources of chemicals to Transect 4 were not anticipated. Results from Transect 6 should be compared with results from Transect 5, and not with results from Transects 1 through 4. Transects 5 and 6 are not part of Hoffman Marsh and receive tidal flushing through a separate inflow channel.

Other tasks in the ecological investigation were conducted over the entire study area encompassing both onsite uplands and offsite marsh areas. Vegetation, bird, and mammal surveys were conducted with special effort toward identifying sensitive species. Only the bioassay sampling was confined to the onsite portion of the study area.

Each of the aspects of the ecological investigation are summarized below. Detailed discussions of the marsh and bioassay studies are presented in Appendices C and D.

5.2 SEDIMENT AND BENTHOS INVESTIGATIONS

Initially, both dry and wet season sampling of sediment and benthos were planned. It was agreed in a 27 February 1989 meeting with the agencies that wet season sampling would not be conducted because the salinity of Hoffman Marsh was not low enough to be typical of wet season conditions (see Attachment A of Appendix C). Therefore, the impact of seasonal variation on the benthos was not assessed during this study, resulting in some uncertainty in the interpretation of the study results. Dry season sampling of sediment and benthos was conducted during October 1988.

5.2.1 Sediment Sampling and Analyses

The objective of the sampling and analyses was to provide information on the concentrations of potentially bioavailable chemicals in sediment ycollected from various areas of the marsh. The sediment samples were collected along transects (Figures 56 and 57) in tidal channels using an Ekman dredge. Samples were collected from three vertical locations in the channel for Transects 1 through 4: from the bottom of the channel (A series), from the side of the channel (B series), and from the pickleweed marsh adjacent to the channel (C series). Only A series samples were collected in Transects 5 and 6. Sediment samples were analyzed for the following chemicals:

- inorganics: chromium, copper, lead, mercury, nickel, zinc, sulfur, sulfide, and chloride

- organics: oil and grease, base/neutral/acid extractables (BNAs, including PAHs), phenols, PCBs, and total organic carbon (TOC)

In addition to the chemical analyses, sediment grain size was measured using the phi value.

The results of the sediment chemistry analyses are summarized in Section 5.2.3. Detailed results of sediment chemical analyses and grain size measurements are presented in Tables 3, 4, 5, and 6 of Appendix C, as well as Attachment C of Appendix C. The star plots were prepared from the new chemistry results. The data were analyzed using cluster analysis.

5.2.2 Benthos Sampling and Analyses

Benthos sampling was conducted to provide information on the relative abundance and species composition of the benthic community in various areas of the marsh. The benthos samples were also collected using the Ekman dredge in the same sampling locations as the sediment sampling

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except no benthos samples were collected from the C series of the transects. The samples were analyzed by sorting the benthic organisms out of the sediment and detritus and identifying the organisms to the lowest taxon practical.

The general results of the benthos investigation are summarized in Section 5.2.3. Results of the benthos sampling are summarized in detail in Table 7 and Figures 5 and 6 of Appendix C. The raw results of the benthos investigation are presented in Attachment D of Appendix C. Cluster analyses and bar graphs were prepared using the raw benthos data.

5.2.3 Results and Conclusions of Sediment and Benthos Investigations

The results of the sediment and benthos investigations are summarized separately below. The combined results of these investigations as well as the conclusions drawn from these results are then summarized and presented.

In Transect 6 samples, a trend of decreasing concentrations of lead with increasing distance from the site was observed. Given that results for six metals were examined at four sampling locations in the transect, it would not be statistically unusual to find at least one trend. The average lead concentration in Transect 6 was also higher than that in Transect 5. However, as discussed in Section 7, lead is considered the least mobile of the metals and no surface soil source of lead was found in the area of the site draining to the Transect 6 area. Therefore, the connection between the Liquid Gold site and the lead in Transect 6 is unclear. No other trends were observed in heavy metal concentrations in Transect 6.

Of the samples collected in Transects 1 and 6, only one sample (T6-1A) contained a detectable level of PCBs (Table 4, Appendix C). PCBs were also detected at similar levels in Transect 3 and 5 locations. In addition, PCBs were found (at 1.2 mg/Kg) in only one onsite surface soil

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sample. Therefore, no trend of PCB input to the marsh from the site was found. PAHs (a subset of the BNA analysis) were detected in the upper ends (highest point of drainage) of both Transects 1 and 6, but also in Transects 2, 3, 4, and 5 (Table 5, Appendix C). One other BNA was detected (bis(2-ethylhexyl)phthalate) in one location in Transect 5 (T5-6A). Other BNAs, including phenols, were not detected in either Transect 1 or 6. No clear trend of increasing total PAHs with proximity to the Liquid Gold site was observed in Transect 1. A possible relationship between PAH concentrations in sediment and proximity to the site in Transect 6 was noted. However, because of the low number of samples and detected concentrations of PAHs, the relationship cannot be confirmed.

Oil and grease was detected at elevated levels relative to other sediment samples in sampling locations at the upper end of Transect 1 (T1-1A, T1-1B). These sample locations were in the bottom (A series) and side slope (B series) of the drainage channel, respectively. Out of channel (C series) samples from Transect 1 (C series) did not contain elevated levels of oil and grease when compared to other sediment samples collected from the out of channel locations. The highest concentrations of oil and grease in sediments collected from Transects 5 and 6 occurred at T6-1 and T6-2. Therefore, the highest levels of oil and grease in sediment analyzed during this study occurred at locations nearest the site in the upper ends of the drainage channels in Transects 1 and 6.

The results of the benthos investigation are summarized below. The results were interpreted based on a statistical analysis, which proceeded from a review of bar graphs to an evaluation by cluster analysis. All references to high or low numbers of particular taxa refer to a comparison of various sampling locations within this study.

The upper end of Transect 1 A series (T1-1A, T1-2A, T1-3A) was low in cumaceans as was the upper end of Transect 2 A series (T2-1A, T2-2A) (Table 15, Appendix C). No other Transect 1 A series locations were

unique when compared with other benthos sampling locations. The upper end of Transect 1 B series (T1-1B) was unique in the high numbers of polychaetes and oligochaetes and low numbers of amphipods found there. Again, a similar pattern was noted in the sample at the upper end of Transect 2 (T2-1).

Sampling locations in Transect 6 (A series only) were unique in the low numbers of nematodes present. However, nematodes were also present in low numbers in Transect 5 (Figure 6 of Appendix C).

In summary, the benthos composition in the upper ends of both Transects 1 and 2 is unique but total numbers of organisms are not depressed relative to other transects.

Results of benthos investigations were reviewed for possible relationships. Numerous line graphs were made in an attempt to identify relationships between chemical parameters and benthos community factors. Based on a review of the line graphs, several potential relationships were tested for statistical correlations. It was thought that the higher number of oligochaetes in the upper end of Transect 1 could be related to the oil and grease or PAHs present in the sediment. This potential relationship was not confirmed when statistically tested using non-parametric tests. A similar relationship was suspected between polychaete densities and oil and grease or PAH levels in sediment. Again, this relationship was not confirmed by the statistical analyses.

On the basis of the analyses presented in Appendix C, the following conclusions were drawn:

- Although influence of the Liquid Gold site on the upper end of Transect 1 was suggested after initial review of the data, the conclusion after statistical analysis was that chemicals are not significantly impacting benthic fauna in Hoffman Marsh (Transects 1 to 4). This conclusion is based on the lack of statistical correlation between sediment chemistry parameters and benthos

densities in Transect 1, and the similarities between benthos in Transect 1 locations and other transect locations.

- Environmental factors (such as dessication), chemicals, or a combination of these factors may be impacting benthos found in the marsh portion of the southwest drainage path (Transect 6). It was concluded that environmental factors alone are not likely to be the cause of the observed impact at site 1 of Transect 6.

5.3 VEGETATION STUDY

The vegetation study consisted of two main tasks; plant species identification and subsequent vegetation community mapping, and plant tissue analyses. The species identification and community mapping was conducted during October-November 1989. The plant tissue analyses were conducted during April-May 1989.

5.3.1 Vegetation Community Mapping

Vegetation community mapping was used to establish the terrestrial habitat characteristics and the characteristics of the marsh areas adjacent to the site. This task provided information that was useful for interpreting the results of the mammal trapping survey.

The community mapping was accomplished by walking the site, recording all identifiable vascular plants, and mapping vegetation types on an aerial photograph. During the field survey no state- or federally-listed rare, threatened, or endangered plant species were observed on the site. In addition, no candidate species for listing were observed. One species with limited distribution, the marsh gumplant, was observed along the marsh fringes. The pickleweed marsh is relatively new and the upland areas have been subject to ongoing disturbance. A detailed discussion of the marsh and upland plant communities is presented in Appendix C, Section 4.4.

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There are no apparent visual impacts on marsh vegetation due to the Liquid Gold site. The Hoffman marsh vegetation community does not significantly differ from other marsh areas of similar age and elevation. Additionally, the marsh vegetation nearest the site was not visibly different from other areas of the marsh. No visual signs of impact to marsh vegetation due to the past operations of the Liquid Gold site were observed. The upland areas have a plant community typical of areas that have been subjected to physical disturbance.

5.3.2 Plant Tissue Analyses

Plant tissue analyses were conducted to provide information on the following:

- non-visual signs of impact to vegetation potentially due to the Liquid Gold site
- uptake of chemicals from sediment
- quantity of chemicals available to biota dependent on pickleweed as a food source

The plant tissue was collected from pickleweed tips during the spring of 1989. Only living portions of the plant were collected from a 1 meter radius of sixteen C series sampling locations. The samples were frozen then digested and analyzed for chromium, copper, lead, mercury, nickel and zinc.

Results of plant tissue analyses are summarized in Appendix C, Table 8. Chromium was not detected in plant tissue. Lead and copper were detected in some samples, but zinc was the only metal detected in all samples. Mercury and nickel were each detected in only one of the samples. Of the metals commonly detected, only copper appeared to be associated with the corresponding concentration in sediment. However, this correlation was not statistically significant. No evidence for

adverse impacts to marsh vegetation due to the Liquid Gold site was obtained as a result of the plant tissue analyses. Therefore, there is no indication that those animals using the pickleweed as a food source are being adversely impacted by the Liquid Gold site.

5.4 ANIMAL TISSUE SAMPLING AND ANALYSES

Animal tissue sampling was conducted to provide information on the uptake of chemicals compared with corresponding chemicals in sediment. Additionally, the data were gathered for use in evaluating the potential for movement of chemicals up the food chain.

The yellow shore crab (Hemigrapsus oregonensus) was used for the animal tissue analyses due to its abundance. The crabs were collected from the upper and lower ends of each transect using baited minnow traps. Two additional samples were collected from the middle of T1 and T5. The samples were homogenized, digested, and analyzed for chromium, copper, lead, mercury, nickel, zinc, and BNAs. The results of these analyses are presented in Table 10 of Appendix C.

Organic compounds were not detected in crab samples. Metals were detected in crab tissue, but only chromium in tissue was found to have a statistically significant positive correlation with the corresponding metal in sediment. The chemistry of the crab tissue collected from areas nearest the Liquid Gold site was not unique when compared with other areas of the marsh. Further, there is no indication that the yellow shore crab is a significant pathway for chemical movement in the food chain. There is no evidence that the yellow shore crab has been impacted by past operations of the Liquid Gold site.

5.5 WILDLIFE STUDY

The wildlife study was conducted to provide information on the species composition and use of the Liquid Gold site and adjacent marsh areas by wildlife. Wildlife use of the area was investigated to evaluate whether

the past operations of Liquid Gold site have impacted wildlife in the area. The wildlife investigation consisted of small mammal trapping and a bird survey. These tasks were focused to provide information on the salt marsh harvest mouse, the California clapper rail and the California black rail, each of which is an endangered or threatened species.

5.5.1 Mammal Trapping

The mammal trapping was conducted to survey the salt marsh harvest mouse and other small mammals using the site and adjacent areas as habitat. Two sizes of baited traps were used to provide a broader survey of existing populations. Traplines were set above the high water mark and individual traps were set onsite (see Figure 8 of Appendix C). Trapped animals were marked with non-toxic dye prior to releasing them so that individuals would not be counted more than once if re-trapped.

No sensitive species were captured or observed during the trapping survey. The house mouse and the Norway rat were the most abundant species observed (Table 11 of Appendix C). The absence of endemic species and the existing small mammal populations may be attributable to the age of the marsh, the physical disturbance of upland areas, proximity to urban development, historic toxic disturbance, and/or isolation from other marsh habitats.

5.5.2 Bird Survey

Specific surveys for the endangered California clapper rail and threatened California black rail were conducted. During these field surveys, incidental observations of other bird species were recorded. The rail surveys were conducted during the breeding season by using tape-recorded calls to evoke response calls from rails in the marsh.

Several common bird species were observed during the surveys and are listed in Attachment E of Appendix C. The most commonly observed species included the great egret, killdeer, marbled godwit, willet,

common snipe and marsh wren. Although the California clapper rail and the California black rail were not observed during these surveys, it is possible that these species are present in the vicinity of the site. The marsh provides suitable habitat, but the marsh transition zone provides little cover for these species. Four bird species of particular interest were observed during the survey. The salt marsh yellow throat (a candidate species for endangered species listing), the northern harrier, the short-eared owl (both species of special concern), and the black-shouldered kite (a fully protected species) were all observed in the study area.

Prey species, used by shorebirds, such as the yellow shore crab were present near the site and did not contain elevated levels of chemicals in tissue when compared with tissue collected from other areas of the marsh. Also, shorebird populations were consistent across the marsh. Therefore, there is no apparent impact on shorebird populations that is attributable to the past operations of the Liquid Gold site.

5.6 BIOASSAY STUDY

As previously mentioned, the ecological study was to include a sediment and benthos sampling event during the wet season as well as during the dry season. However, salinity in Hoffman Marsh was not sufficiently lowered during 1989 to be typical of wet season conditions. Therefore, at the suggestion of the agencies, a bioassay study was proposed to provide information on potential acute effects of surface water runoff on aquatic organisms in the adjacent marsh. The Bioassay Workplan was conditionally approved on 17 August 1989, and revised and resubmitted to the agencies on 24 August 1989 (K/J/C 1989b). The study was also conducted to provide information on the potential acute affects of groundwater discharge on these organisms.

5.6.1 Bioassay Workplan

The Bioassay Workplan and results are included as Appendix D of this report.

The purpose of the Bioassay Study was to provide information on potential acute effects to freshwater marsh biota through two pathways: surface water runoff and groundwater discharge.

Surface water runoff was simulated by producing elutriates from six surface soil samples (M1-1 through M1-3 and M6-1 through M6-3) collected from drainage Areas I and VII. Groundwater discharge was simulated by producing elutriates from five subsurface soil samples (MO-1 through MO-5) collected from former activity areas. Surface and subsurface soil sample locations are shown on Figure 26.

Two elutriates were prepared from each soil sample. One elutriate was prepared with deionized water (DI) acidified with sulfuric acid to an initial Ph of 5.7. (For the confirmation analysis described below, the elutriate Ph was initially 5.0.) The second elutriate was prepared using deionized water containing 10 percent mineral water (DMW). The purpose of preparing these two elutriates was to evaluate the effect that acidification would have on the bioassays.

Two test organisms were chosen for the bioassays: the crustacean, Ceriodaphnia dubia and the algae, Selenastrum capricornutum. These species were selected based on their sensitivity to the chemicals of interest, their Ph and salinity tolerance, and their applicability to the RI process. The Ceriodaphnia test was conducted in accordance with the modified ASTM protocol for Daphnia magna (ASTM 1984). The Selenastrum test was conducted in accordance with EPA protocol (EPA 1985). Further detail of the test protocols are provided in Appendix D.

The bioassay test results were reported as percent mortality in the Ceriodaphnia and as percent inhibition of growth in the Selenastrum.

5.6.2 Bioassay Results

Multiple factors were considered in evaluating the results of the bioassay test. In addition to chemical content, the response of the test organisms may be influenced by a combination of other factors including salinity, suspended particulates, Ph, dissolved oxygen, and competing organisms. Mortality of the test organism, therefore, may not be a direct indication of chemical toxicity. A summary of the bioassay test results and potentially influencing factors is presented in Table 17.

Significant Ceriodaphnia mortality (greater than 5 percent mortality) was observed in elutriates prepared from three samples (MO-1, M1-2, M6-2). The initial elutriates from samples M1-2 and M1-6 exhibited extremely high salinity levels. In accordance with the test protocol, a bioassay was not performed on these elutriates and second elutriates were prepared. Significant mortality was observed in the second elutriates. This was mainly attributed to a continued high salinity level. To verify this conclusion, third elutriates were prepared from these samples. No mortality (100 percent survival) was observed in 3 of the 4 third elutriates (M1-2 DI, M6-2 DI, M6-2 DMW). Significant mortality was again observed in sample M1-2 DMW. This sample also continued to exhibit high salinity.

Mortality was observed in both the DI and DMW elutriates from sample MO-1. Although above average metals concentrations were found in these elutriates, very high levels of suspended particulates were noted in these elutriates and probably contributed to the mortality of the Ceriodaphnia.

Growth inhibition in Selenastrum was observed in elutriates prepared from four samples (M1-1, M1-2, MO-1, MO-4). The elutriates from samples M1-1 and MO-1 both exhibited very high levels of suspended particulates and contained unidentified organisms. Suspended particulates are known to adversely affect Selenastrum growth. In addition, the presence of

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the organisms may inhibit algal growth, although this effect cannot be quantified because the organisms were not identified.

As in the Ceriodaphnia bioassay, the factor most likely contributing to Selenastrum growth inhibition in sample M1-2 is the high level of salinity.

There are no apparent reasons for the growth inhibition observed in the elutriate from sample MO-4. Although lead levels were above average, there are several factors which indicate that lead levels are not responsible for the observed inhibition. First, higher concentrations of lead were detected in sample MO-5 than in sample MO-4 (0.052 mg/Kg and 0.046 mg/Kg, respectively) yet no growth inhibition was observed in sample MO-5. Second, past studies have shown that Ceriodaphnia exhibit toxic effects at similar lead concentrations as do Selenastrum. Therefore, if the observed inhibition was a toxic response to lead, a similar effect should be observed in the Ceriodaphnia bioassay for sample MO-4. This redundant effect has not been observed.

Although mortality and growth inhibition were observed during the bioassays, it was unlikely that these effects resulted from chemical toxicity. In each series of bioassays, factors other than metals concentrations, most notably salinity, suspended solids, and the presence of organisms, most likely influenced results. However, because the initial bioassay results were not entirely conclusive, it was agreed following discussions with the agencies, that confirmation bioassays should be performed. The purpose of the confirmation testing was to verify that the mortality observed in the initial bioassays was due to factors other than elevated metals concentrations.

Confirmation soil samples were collected in February 1990 from sampling locations M1-2, M6-2, and MO-2. In order to minimize the effects of salinity and suspended particulate on the bioassays, several modifications were made to the test protocol with the approval of the regulatory agencies. The two major modifications were that elutriates

prepared from confirmation samples were filtered through a 0.45 μm filter to remove suspended particulates and that bioassays would only be performed on elutriates with a salinity of less than 2 parts per thousand (ppt) as measured by specific conductivity. If the specific conductivity were greater than 2 ppt, then a repeat (multiple) elutriate would be prepared. Other modifications were made to the protocol and are presented in Appendix D.

The initial elutriates prepared from the MO-1 and M6-2 confirmation samples exhibited salinities less than 2 ppt. Bioassays were subsequently performed on these elutriates. The salinity of the initial elutriates from confirmation sample M1-2 exceeds 2 ppt; so, second elutriates were prepared from this sample. The salinity of the second elutriate was less than 2 ppt. Bioassays were performed on the second elutriate.

No mortality or growth inhibition was observed in any of the confirmation bioassays. The results of these bioassays are presented in Table 17. Additionally, the metals concentrations measured in the confirmation elutriates were higher than in the corresponding original sample elutriates.

These results, higher survival rates in conjunction with higher metals concentrations, indicate that the observed mortality in the initial bioassays was not due to metals toxicity. The observed mortality was a result of other factors, particularly salinity and suspended particulate content.

SECTION 6

DISCUSSION OF RESULTS AND CHEMICAL DISTRIBUTION

6.1 SOIL

Discussion of soil results are divided into the pre-1988 and 1988-89 remedial investigations. The pre-1988 investigation results have been discussed in detail in the Scoping Document (K/J/C 1988a) and are summarized in this report. The 1988-89 investigation are the additional data gathered as a result of recommendations in the Remedial Investigation/Feasibility Study Workplan (K/J/C 1988b). Finally, all available valid data will be evaluated to draw conclusions regarding the distribution of chemicals at the site.

The interpretation of the soil chemical data is complicated by the lack of available guidelines and standards. The California Code of Regulations (CCR) Title 22 provides concentration limits of various analytes for the classification of materials as hazardous waste and was previously used in the Scoping Document as the primary interpretative guide for the evaluation of the pre-1988 data. However, these values are not based on public health considerations. Therefore, in addition to the CCR Title 22 hazardous waste limits, for the purpose of establishing concentration trends and identifying areas of potential concern, two interpretive guides were used: the 95 percent upper confidence limit on the arithmetic average of site metal concentrations and the common range of metal concentrations in soils as cited by Lindsay (1979) (Table 18). Metal concentrations which exceed the limits of the interpretative guide will be highlighted.

Both of the interpretive guides are relative measures, and are useful for comparisons. However, the more important consideration is whether the levels of metals found in soil present a potential risk to human health or the environment. The public health concerns associated with

metals in soil are discussed in Section 8 and the potential environmental effects are discussed in Section 9. Trace metals are ubiquitous in soils and values vary widely depending on the nature of the parent material. Thus, the presence of metals does not necessarily indicate contributions originating from site activities. Meaningful background metal concentrations could not be established for the site due to the multiple and unknown sources of fill placed on the site over an extended period of time (Figure 3).

For the organic parameters, PCBs and BNAs, values that exceed the reporting limits will be highlighted and used to identify areas of potential concern. Wherever possible, background values available in the literature will be compared to the levels at the site.

6.1.1 Pre-1988 Investigations

6.1.1.1 Surface Soils

Metals

Concentrations of trace metals vary widely in soils and are potentially influenced by factors other than site activity contributions; for example, dry or wet deposition of lead from automobile exhaust or runoff from offsite. Also elevated levels of metals may be inherent in the soil parent material. For example, soils derived from serpentinite have elevated levels of nickel and chromium.

Results of the pre-1988 investigation are discussed in detail in the Scoping Document (K/J/C 1988a) and will only be highlighted in this document. Generally, most metal analysis results were within the common ranges for soils reported by Lindsay (1979) and where available with values reported by the Agency for Toxic Substance and Disease Registry (ATSDR 1988, 1989a).

In the old asphalt plant area, lead and zinc concentrations for two samples exceeded the CCR Title 22, Total Threshold Limit Concentration (TTLC) and Soluble Threshold Limit Concentration (STLC) values. One sample contained 5,000 and 9,300 mg/Kg for total lead and zinc, respectively; and 280 and 510 mg/l for extractable lead and zinc, respectively. Another sample in this vicinity exceeded the STLC value for extractable lead (40 mg/l). Surface soils in this vicinity were removed and results of a post-excavation composite sample demonstrated metal concentrations below common ranges for soils, except for lead, which had a value of 270 mg/Kg.

Soluble lead results for five samples taken along the southwest drainage path exceeded the STLC values (Figure 10). Likewise, a composite sample taken in the warehouse also exceeded the STLC for soluble lead. As part of the interim remedial measures the 1- to 2-inch layer of soil on the surface of the asphalt floor of the warehouse was scraped and disposed. TTLC values were also exceeded for lead (1,920 mg/Kg) in a sample collected by JLV in the pond at the end of the metal culvert. A sample collected by K/J/C adjacent to the JLV sample failed to confirm the JLV result as the results for metals were low (lead 9 mg/Kg).

BNAs

The one surface sample collected from the former Asphalt Facility area did not contain BNA compounds above the detection limits.

PCBS

Surface soil samples were collected at 14 locations for PCB analysis. Detectable levels of PCBs was detected only at K/J/C surface sample S-9 at 1.2 ppm, slightly above the detection limit of 1 ppm. Additional sampling in the vicinity of this sample failed to demonstrate additional presence of PCBs. PCBs, as with other persistent organic compounds, are found throughout the environment. PCBs have been detected in sediments of remote high altitude lakes in Rocky Mountain National Park at levels

ranging from 0.098 to 0.54 ppm (Heit et al. 1984 as cited in ATSDR 1989b).

Phenols

Surface soil samples were collected at 14 locations by K/J/C for phenols. Levels of phenols below 1 ppm were detected in samples collected in the Southeast and Southwest Drainage Paths and on the west side of the former asphalt facility. Two samples (S-1 and S-3 shown on Figure 10) from the former Asphalt Facility contained phenols at 7 and 8 ppm, respectively. A composite sample from the warehouse floor contained 18 ppm. Soils from the warehouse were removed as part of interim remedial measures.

Oil and Grease and TPH

Oil and grease data generated throughout the investigation are not comparable because various methods were used to determine oil and grease, which yield data that are not comparable. Furthermore, the procedures do not discriminate between anthropogenic and natural sources. Elevated levels of oil and grease and hydrocarbons have been detected throughout the site and in all stratum (fill, Bay Mud and alluvium) as shown on Figures 17 to 19. High levels of oil and grease in the fill were attributed to anthropogenic sources by E&E, based on the low mobility of heavy petroleum products and proximity to sources (K/J/C 1988a). This was supported by the GC/MS analysis of a surface sample (fill) with high levels of oil and grease. The surface sample was found to contain aliphatic hydrocarbons (K/J/C 1988a). The presence of aliphatic hydrocarbons is indicative of anthropogenic sources. Analysis of 14 surface soil samples for TPH by K/J/C found only 8 samples to contain detectable levels of TPH. Seven of the samples had TPH levels less than 35 ppm, although one sample located in the former Asphalt Facility (S-3 on Figure 10) contained TPH at a concentration of 4,300 mg/Kg (K/J/C 1988a).

Cyanides

K/J/C collected 14 surface soil samples for cyanides. None of the samples contained cyanide above the detection level of 0.4 mg/Kg.

6.1.1.2 Subsurface Soils

Metals

Metal concentration were observed to vary with depth. These concentration distributions corresponded to the nature of the subsurface material (fill, Bay Mud or alluvium). Therefore, the discussion of subsurface concentrations will be according to substratum.

Fill. Average total metal concentrations in the fill material were higher than the concentrations reported in the Bay Mud or alluvium. Concentrations of metals in boring samples taken at depth ranges of 0 to 1.5 feet and 5 to 6.5 feet in the fill are shown in Figures 12 and 13. Generally, metal concentrations were within the common range cited in Lindsay, 1979, with a few exceptions. All nickel and chromium results are within the common range for soils (Lindsay 1979) (Table 18). The highest zinc concentrations were found at E&E boring 26 (Figure 12), which contained zinc at 5,200 ppm. Copper and lead were also found above the common range for soils in this boring. Levels of copper and lead were observed at 107 and 390 ppm, respectively. At the 0 to 1.5-foot depth, the highest concentration of copper and lead were reported up to 156 and 486 ppm, respectively. Lead concentrations at or near the upper range for soils (Lindsay 1979) were noted on the perimeter of the former West Tank Farm Area.

At the 5 to 6.5-foot depth copper, lead, and zinc were reported at concentrations up to 360 mg/Kg, 726 mg/Kg, and 4,764 mg/Kg, respectively. Concentrations of metals above the ranges cited in Lindsay, 1979, occurred most frequently at the 5 to 6.5-foot depths, and at that depth, the most elevated levels were observed to occur

consistently in a black sand fill based on correlation of boring logs with metal concentration (E&E 1984, K/J/C 1988a). Boring logs and cross sections from trenches excavated indicated that the black sand fill is discontinuous across the site. In areas where black sand fill is present, it occurs at approximately 1.5 to 2.5 feet below the ground surface and extends to 5.5 to 9 feet below the ground surface.

Borings which contained elevated concentrations of metals are apparently randomly distributed and do not indicate particular source areas other than the black sands. In addition, no relationship is apparent between the elevated levels of metals found at a depth of 5 to 6.5 feet and those found at 0 to 1.5 feet. Borings which had elevated metal levels in the 5 to 6.5-foot depth were not generally observed to have high metal levels at the 0 to 1.5-foot depth. This lack of vertical or lateral distribution trends indicating a lack of source of movement through the fill and the association of elevated metal concentrations with the black sand fill led E&E to conclude that elevated metal concentrations were inherent in the fill (E&E 1984).

The JLV data support the conclusions drawn above, in that samples with elevated metal concentrations were generally found at depths greater than 5.5 feet and corresponded to the description of dark gray to black sands as noted in the boring log (JLV 1980). Also, there does not appear to be a correlation between high metal concentration at deeper depths and shallower depths from the same boring. The JLV results were generally higher than the E&E and K/J/C results. This may be due to the reporting of results on a dry weight basis by JLV, whereas E&E and K/J/C reported their results in on a wet weight basis.

Ten composite subsurface samples were created from discrete boring samples and were analyzed for total and soluble metals by CCR Title 22 procedures. Five of the composites were created by compositing samples collected at the 0 to 1.5-foot depth and the other five composite from samples collected at the 5 to 6.5-foot depth. Only two samples were reported to contain extractable lead concentration above the STLC

values. One sample which was created from samples collected in the former Asphalt Facility area from depths of 5 to 6.5 feet contained 7.8 mg/L extractable lead (Figure 16, composite sample C4), and the other which was created from samples described as being collected south of the buildings (not specified) contained 27 mg/L extractable lead (Figure 16, composite sample C6).

Bay Mud. Subsurface metals data collected by the E&E and K/J/C consultant, indicate that the metals concentrations in the Bay Mud are low. Generally, the metals concentrations are within the following ranges: copper 13 to 43 mg/Kg, chromium 15 to 64 mg/Kg, lead 1 to 30 mg/Kg, nickel 6 to 61 mg/Kg, and zinc 16 to 374 mg/Kg.

The Bay Mud at the site begins at a depth of approximately 5 feet and ranges in thickness from approximately 7 to 20 feet. Metal concentrations were within the common range for soils (Lindsay 1979).

Alluvium. Like the Bay Mud, the alluvium was found to contain low concentrations of metals. The metal concentration ranges are similar to those found in the Bay Mud except for nickel, which is found at a somewhat higher average concentration in the alluvium (average concentrations for nickel in Bay Mud and alluvium are 34 mg/Kg, and 77 mg/Kg, respectively) (K/J/C 1988a).

All metal concentrations are within the common ranges for soils (Lindsay 1979).

BNA

Ten subsurface samples collected at the site were analyzed for base/neutral/acid extractable (BNA) organic compounds. Subsurface samples collected by K/J/C included three trench samples, three predisposal samples, and two samples from excavation areas. Two of the trench samples were collected where visible asphalt debris and flowing oil were noted. One of these samples, located east of the asphalt

plant, contained phthalates at 330 mg/Kg and fluorene at 150 mg/Kg. Visible oil in this area was later excavated during interim remedial measures. The third trench sample was collected from the Bay Mud. This sample along with the other trench sample contained some BNA compounds at levels less than 5 ppm. Two BNA compounds, pyrene and chrysene, were detected in two of the predisposal samples. The highest concentrations were 92 ppm for pyrene and 80 ppm for chrysene. BNA compounds were also detected in two of the post-excavation samples. One sample of oily black sand from the metal culvert contained 12 BNA compounds at levels not exceeding 5 ppm. The other sample, from beneath the former wooden building in the Asphalt Facility, contained phenanthrene at 3 ppm and chrysene at 1 ppm.

PCBs

Subsurface soil samples collected from 74 borings, 3 predisposal samples, and 2 post-excavation soil samples were analyzed for PCBs. Only three of the samples had detectable levels of PCBs (1 mg/Kg). Two predisposal grab samples of excavated material from the former east tank farm area contained PCBs at 5.5 and 1.9 ppm. A post-excavation composite soil sample, collected from the bottom of the former east tank farm excavation area contained PCBs at 1.3 ppm.

Phenols

Soil samples collected from 31 borings and two predisposal sites were analyzed for phenols by K/J/C. Levels of phenols below 1 ppm were detected in subsurface soil samples collected in the southeast and southwest drainage paths and on the west side of the Asphalt Facility. Two samples from the former Asphalt Facility contained phenols at 7.0 and 8.0 mg/Kg (Figure 25), respectively. A composite sample from the warehouse floor contained 18.0 ppm. Soil from the warehouse was removed as part of interim remedial measures. Prior sampling by JLV confirmed the K/J/C results as detectable levels of phenols were found around the former Asphalt Facility.

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Oil and Grease and TPH

As discussed previously, E&E concluded that oil and grease in the fill was most likely due to anthropogenic sources. In addition, the WRI characterization of sediment samples high in oil and grease also suggested anthropogenic origins.

The shortcomings with the oil and grease data were discussed previously in Section 6.1.1.1. Oil and grease values are shown on Figures 17 to 19. Oil and grease in the Bay mud was attributed by E&E to natural sources due to the unlikelihood of the migration of heavy petroleum hydrocarbons to the subsurface. This conclusion was supported by the GC/MS analysis of one sample from the Bay mud which was high in oil and grease and was found not be contain aliphatic hydrocarbons (K/J/C 1988a). The presence of aliphatic hydrocarbons are indicative of anthropogenic sources. The E&E conclusion regarding natural organic matter being the source of oil and grease in the Bay mud is further supported by the fact that fill material was placed over the former estuary which is rich in natural organic matter and thus could yield high oil and grease values.

Further studies were conducted in which more than 20 samples were collected and analyzed for TPH from 16 trench locations for which previous studies had demonstrated oil and grease levels greater than 1,000 mg/Kg. TPH was detected at low levels (500 to 1,600 mg/Kg) in only three of the samples (Figure 18). The TPH analysis is specific for petroleum derived compounds with 6-22 carbon atoms. Petroleum products in this range are gasoline, diesel, jet fuel, and kerosene.

Organic Lead

Subsurface soil samples collected from 17 boring locations by JLV were analyzed for organic lead. The JLV data could not be validated, and therefore, is considered semiquantitative. Organic lead was found at three locations scattered throughout the site, the highest (15.5 mg/Kg)

being at a location northwest of Stege Drainage Channel. A possible source of organic lead may be automobile exhaust from the combustion of leaded gasoline.

6.1.2 1988-1990 Remedial Investigations

The same criterion used to evaluate the pre-1988 data was used to evaluate the post-1988 data. Post-1988 data were collected under a quality assurance plan (included in the RI/FS Workplan, K/J/C 1988c), which included provisions for evaluation of data validity and quality. This review is presented in Appendix E.

6.1.2.1 Surface Soils

Composite surface soil samples were collected at Areas 1, 2, 4, and the southeast drainage (Figure 11). Additionally, samples were collected at the 0 to 0.5-foot depth interval of borings collected from the Southeast Drainage, Hoffman Marsh and the Drainage Path (between Area 3 and the Concrete Slab Area). Six composite surface samples were collected for bioassay study and were chemically characterized (Figure 26).

Metals

A statistical summary of the soil composite data for metals is provided in Table 19. Metal concentrations for the surface samples were generally within the common ranges cited for soils (Lindsay, 1979). Only two values were observed to be outside of the common range. This was observed for copper (200 mg/Kg) in surface composite sample A2 and for mercury (1.1 mg/Kg) in a surface composite sample A1 (Figure 20).

PAHs

Surface samples from the Southeast Drainage Path and the Drainage Path were analyzed for PAHs by EPA Test Method 8270 (GC/MS) and EPA Test Method 8100 (GC). The GC procedure yields lower detection limits (0.13

to 0.20 ppm) than GC/MS procedure (0.33 to 1.6 ppm). However, the list of analytes is not as comprehensive. The Hoffman Marsh samples were only analyzed by Method 8100.

PAHs in surface samples were detected in two Hoffman Marsh surface samples. The total PAH concentration was measured at 1.6 ppm and 0.58 ppm for samples NS-19 and NS-20, respectively. Benzo[b]fluoranthene was detected at 3.1 ppm in a surface composite sample collected from Area 4 (Table 4). Minor quantities of total PAHs were also observed onsite in bioassay surface samples M6-1 (1.6 ppm).

The concentration of PAHs on the surface soils of the site and Hoffman Marsh are not significant in relation to other areas adjacent to highways and are probably due to contributions from automobile exhaust rather than site activities. In a study of PAH levels in a mountain valley (Blumer et al. 1979), found high levels of PAHs (85-300 ppm) in soils adjacent to a highway, whereas concentrations away from the highway in an alpine meadow were measured at 4 ppm. Based on evaluation of other PAH values in remote areas, the authors concluded that a value of 5 ppm may represent a worldwide PAH background level. The authors also found that unsubstituted forms of PAHs were the most prominent forms detected and hypothesized that these forms originated from pyrolitic processes such as automobile combustion of petroleum products and natural fires, whereas, PAHs expected to originate from asphalt material are of the alkyl-substituted forms. The characterization of the PAHs at the site were limited to those in the Target Compound List, which are of the unsubstituted form. However, the presence of unsubstituted PAHs and the proximity of the site to the highway suggests that automobile exhaust is the source of PAHs in surface soils at the site and in Hoffman Marsh.

Phenols

Phenols were not detected in any of the surface samples collected at the detection limits ranging from 0.005 to 0.33 ppm.

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BNAs

Minor quantities of bis(2-ethylhexyl) phthalate were observed in bioassay surface composite soil samples M1-2 (0.6 ppm) and M6-1 (0.36 ppm); detection limit is 0.33 ppm. Phthalates are common artifacts of the sampling and analysis process and are generally observed at these levels. No additional BNA compounds were detected in the surface samples.

PCBs

A PCB identified as Aroclor 1260 was identified in a shallow subsurface (0 to 0.5 feet) soil sample located in Area 6 at 3 ppm. No other PCBs were detected.

Oil and Grease, TPH, and Sulfur

Previous investigations have demonstrated relatively high levels of oil and grease in selected samples. However, the presence of high oil and grease does not necessarily indicate an environmental problem as the analytical method does not discriminate between anthropogenic and natural sources. For example, plant or animal material, as well as oil or gasoline, may yield high levels of oil and grease. Thus, oil and grease analysis must be used in conjunction with other analysis to further characterize the nature of the material. For this phase of the RI, TPH as gasoline and diesel were used in conjunction with the oil and grease analysis. TPH is more specific for petroleum-derived organics and covers the range of C6 to C22 hydrocarbons. In addition to the above analysis, samples were also analyzed for total sulfur, as previous reports discussed the possible interference of sulfur with the determination of oil and grease (K/J/C 1988a). A regression analysis of the sulfur results versus the oil and grease data yielded a linear regression coefficient (R^2) of 0.10 (Figure 58). This indicates a lack of correlation between the two sets of data. Therefore, it is concluded

that the interference in the oil and grease determination by sulfur in this set of soil samples is not important.

Elevated levels of oil and grease were detected in two surface soil samples. One sample (Boring 129) from the southeast drainage contained 5,000 ppm and the other from the Hoffman Marsh (NS-18) contained 4,000 ppm. TPH levels were found to be below the detection level of 1 to 2 ppm for all surface samples. Thus, it can be concluded that the source of the oil and grease present is not due to gasoline or a middle distillate fuel (e.g., diesel, kerosene, jet fuel). This result is not unexpected given the expected heavy nature of hydrocarbons from the site (see Section 7.2).

6.1.2.2 Subsurface Soils

As previously mentioned, the substratum is comprised of fill, Bay Mud and alluvium. The fill material is very complex in that it has been placed over an extended period of time from a variety of uncertain sources. Thus metal concentrations are expected to vary according to the nature of the fill material.

Metals

Statistical summaries of the 1988 soil data by study area for each of the six metals are provided in Tables 20 through 25. Chromium and nickel concentrations were all well within the common range cited for soils by Lindsay, 1979. Thus, their distribution will not be analyzed.

Copper was the most frequent metal to exceed the common range cited for soils of 2 to 200 mg/Kg (Lindsay, 1979). Thirty-five (35) percent of the concentration values exceeded the upper limit of this range. The mean value of all of the validated copper data collected at the site (both pre- and post-1988 data) was calculated at 97 ppm. The upper limit for which 95 percent of the values lie within was calculated to be 500 ppm (Table 19).

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Statistical summaries were computed for each study area (Table 19). The statistical parameters computed include study area means and 95 percent confidence interval of the mean. Conclusions regarding mean differences between study areas could not be drawn due to large variances, thus resulting in overlap of confidence intervals. However, the areas of apparent higher levels of copper are Areas 4, 5, 6 and the former Asphalt Facility. The highest levels of copper and the highest mean values were observed for these areas.

The highest values of copper were observed in Area 4, boring 127, at 5 feet (2,600 ppm); Area 6, boring 11, at 5 feet (1,100 ppm); drainage path boring at 1.5 feet (1,000 ppm); Area 5, boring 114, at 15 feet (910 ppm); and the former Asphalt Facility boring 123 at 11 feet (570 ppm).

Lead concentrations exceeding the 95 percent distribution range of 1,100 ppm were observed in seven samples. These were located at Area 6, boring 111, at a depth of 5 feet (5,200 mg/Kg); boring 112, at a depth of 5.5 feet (1,100 mg/Kg); boring 116, at a depth of 2 feet (1,800 mg/Kg); the former Asphalt Facility, boring 122, at the depths of 2 and 5.5 feet (4,200 and 3,100 mg/Kg, respectively); boring 123, at a depth of 5.5 feet (1,200 mg/Kg); and the Pond Area, boring 119, at a depth of 5 feet (3,600 mg/Kg).

Six of the seven locations noted above were located at the 5 to 6.5-foot depth. This is consistent with the findings of the previous investigations which concluded that the higher lead concentrations were most frequently found at this depth.

In order to evaluate the possible spatial distribution of lead, an area which was observed to have the highest level of lead was identified as Area A. The original area was established prior to collection of additional samples during September and October 1990 in the southeast portion of the site (labeled L4 in Figure 20), and was somewhat larger than the Area A shown on Figure 20. To test hypotheses regarding

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spatial lead distributions, the original Area A and the area outside of Area A were subdivided into 5 classes according to depth. Summary statistics were computed for each class and a nonparametric statistical test was used to analyze the means of the various classes. The test demonstrated a significant difference (at the 99 percent confidence level) between (1) lead concentrations within the original Area A at 5 to 6.5-foot depth versus the lead concentration for all borings outside Area A at 5 to 6.5-foot depth, and (2) lead concentration for borings within Area A at depths other than 5 to 6.5 versus lead concentrations for borings within Area A at depths of 5 to 6.5 feet.

Because of the high lead concentration at boring 111, the original southern edge of Area A, additional soil samples were collected in the southeast portion of the site. The additional soil sample locations are labeled with L4 prefixes on Figure 20. On the basis of the new data, and the results of the public health risk evaluation regarding an acceptable level of lead in soil (Section 8), Area A was redefined as shown on Figure 20.

Summary statistics were again computed for each of the classes of data given in Table 26. The Mann-Whitney-U statistical test, a nonparametric procedure, was used to analyze the means of the various classes. As before, the test demonstrated a significant difference at the 1 percent significance level (1) between lead concentration within Area A at 5 to 6.5-foot depth versus the lead concentration for all borings outside Area A at 5 to 6.5-foot depth, and (2) between lead concentrations for borings within Area A at depths of 5 to 6.5 feet and borings within Area A at depths other than 5 to 6.5 feet.

The statistical evaluation demonstrates that the lead concentrations are higher in the Area A at 5 to 6.5-foot depth as compared to the same depth interval outside of Area A. This confirms the observation that Area A is an area of higher lead concentrations. Also, the analysis demonstrates that the lead concentrations within Area A are highest at

the 5 to 6.5-foot depth. This confirms observations made in previous investigations regarding the lateral distribution of lead.

Numerous values of mercury exceeded the common range of 0.01 to 0.3 ppm cited for soils (Lindsay, 1979). Among the highest values observed are at boring 116 at a depth of 5.5 feet (4.8 mg/Kg) and boring 120 at a depth of 6 feet (2.0 mg/Kg). Other areas with soil mercury values exceeding the common range were Area 6 boring 111 at a depth of 10 feet (1.4 mg/Kg), the concrete debris area boring 108 at 2.5 feet (1.8 mg/Kg), and the southeast drainage area boring 130 at 1.5 feet (1.4 mg/Kg).

Means and 95 percent confidence intervals for each study area were computed (Table 23). However, due to the high variability of the data, the 95 percent confidence intervals of the mean are too wide to be able to draw conclusions regarding the spatial distribution of mercury.

With the exception of two values, all zinc concentrations were within the common range of 60 to 2,000 mg/Kg cited for soils (Lindsay, 1979). The highest values observed were located in the former Asphalt Facility, boring 122 at 2 feet (4,900 mg/Kg) and Area 6, boring 11 at 5 feet (2,200 mg/Kg). Other values exceeding the 95 percent distribution were observed at Asphalt Facility boring 123 at 5.5 feet (1,600 mg/Kg) and at boring 116 at 5.5 feet (1,300 mg/Kg). As with the other metal data, conclusions regarding area concentration differences or spatial distributions could not be established.

PAHs

A statistical summary of the soil data for organic compounds is provided in Table 27.

The detection of PAHs was generally confined to a few of the study areas and were not widely distributed throughout the site. A wide range of PAHs were detected in samples collected from all three borings drilled

in Area 6. At boring 111, at a depth of 0.5 foot, the following PAH compounds were detected: pyrene at 8.6 mg/Kg; benzo(b)fluoranthene at 2.0 mg/Kg; benzo-(g,h,i)perylene at 1.2 mg/Kg; and benzo(a)pyrene at 1.1 mg/Kg. Other PAHs were also detected at lesser quantities with a total PAH concentration of 15.1 mg/Kg for this sample. For boring 112, at a depth of 1.5 feet, the major PAHs detected were the following: benzo(b)fluoranthene at 2.7 mg/Kg; indeno(1,2,3-c,d) pyrene at 1.6 mg/Kg; benzo(g,h,i)perylene at 1.6 mg/Kg; benzo(a)pyrene at 1.5 mg/Kg; and chrysene at 1.2 mg/Kg. Other lesser quantities of PAHs were also detected in this sample with a total PAH concentration of 11.5 mg/Kg. For boring 110, at a depth of 6.5 feet, a wide range of PAHs were detected at minor concentrations (one to three times the detection limit) and a total PAH concentration of 4.6 mg/Kg was computed for this sample.

At the former Asphalt Facility, 2-methylnapthalene was detected at boring 123 at depths of 3 and 6 feet at 13 and 12 mg/Kg. No other PAHs were detected in these samples. A wide range of PAHs were detected in the former pond area at boring 118 at a depth of 5.5 feet and in the boring 116 at depth of 5 feet, at low concentrations. Minor quantities of PAHs were also detected in samples from the Hoffman Marsh and the drainage path area (boring D1). Total PAH concentrations ranged from 0.13 to 1.6 mg/Kg (Table 4).

PAHs were also detected in three of the subsurface composite samples from the bioassay study (Table 8). Samples MO-2 and MO-3 (Figure 21), contained a total PAH concentration of 10.2 and 13.9 mg/Kg, respectively. The principal PAHs detected in sample MO-3 included pyrene at 1.9 mg/Kg, benzo[k]fluoranthene at 2.1 mg/Kg, indeno[1,2,3,-c,d]pyrene at 2.0 mg/Kg, and benzo[g,h,i]perylene at 3.3 mg/Kg. The major PAHs detected in sample MO-2 included benzo[k]fluoranthene at 2.0 mg/Kg, benzo[g,h,i]perylene at 1.6 mg/Kg, and pyrene at 1.5 mg/Kg.

PAHs were detected in four of the twenty-five samples (labeled L4 in Figure 11) collected during the expanded 1990 study in the southeast

portion of the site (Tables 10 and 12). At sample location L4-2, eight PAHs were found at up to 7.8 mg/Kg at 5 - 6.5 feet, and up to 11 mg/Kg at 10 - 11.5 feet. Various PAHs were also found at depths of 0 - 2 feet at three other locations: L4-3 (concentrations up to 1.5 mg/Kg), L4-16 (concentrations up to 2 mg/Kg), and L4-21 (concentrations up to 0.18 mg/Kg).

Phenols

Generally, the samples were found to be free of phenolic compounds with the exception of two borings located in the former Asphalt Facility. 4-Methylphenol and 2,4-dimethylphenol were detected in boring 123 at the 3-foot depth at 41 and 50 mg/Kg, respectively. 2,4-dimethylphenol was also detected in boring 123 at the 6-foot depth at 55.0 mg/Kg. Minor quantities of phenol were detected in boring 125 at a depth of 10.5 (0.43 mg/Kg) and 4-methylphenol was detected at 7.4 mg/Kg.

Low levels of phenols were detected in bioassay sample MO-3. 4-Methylphenol was detected at 3.5 mg/Kg and phenol and 2,4-dimethylphenol were detected at trace levels.

BNAs

The only remaining BNA compounds not previously discussed are the phthalates. Minor quantities (up to two times the detection limit) of di-n-butylphthalate was detected in nine borings. However, this compound along with bis(2-ethylhexyl)phthalate are considered by the EPA to be common sampling and analysis artifacts. Therefore, the presence of these compounds cannot necessarily be attributed to site conditions.

Oil and Grease, TPH, and Sulfur

There does not appear to be any apparent distribution pattern to the oil and grease levels. Relatively high levels of oil and grease were found throughout the various study areas. The highest levels (Table 28) were observed in the former asphalt area, boring 125 at 1.5 feet (27,000 mg/Kg), and boring 124 at 5.5 feet (12,000 mg/Kg). Other elevated levels observed included: boring 102 at 4 feet (12,000 mg/Kg); Area 5, boring 115, at 10 feet (11;000 mg/Kg), bioassay sample MO-3 (6,200 mg/Kg); Area 4, boring 127, at 0.5 feet (5,400 mg/Kg); and offsite monitoring well MW-20 at 2.5 feet (8,900 mg/Kg). The ten highest levels were also found from depths varying from the surface to 10 feet deep, so there also does not appear to be any vertical distribution pattern. Also, high levels at a particular boring depth were generally not associated with adjacent samples; for example, sample boring 125 at 1.5 feet contained 27,000 mg/Kg while the following sample at 5.5 feet contained 200 mg/Kg oil and grease.

TPH levels were found to be below the detection level of 1 to 2 mg/Kg for most of the samples analyzed or when detected, it was found at low levels. Thus, it can be concluded that the source of oil and grease present is not due to gasoline or a middle distillate fuel (e.g., diesel, kerosene, jet fuel).

As discussed previously, there was a lack of correlation between sulfur and oil and grease data and will not be discussed further here.

6.1.3 Chemical Distributions

6.1.3.1 Metals

Elevated (exceeding the common range in soils as cited in Lindsay, 1979) levels of metals are found throughout the site. However, the highest frequency of occurrence is within the area defined as Area A (Figure 11).

All four consultants involved in the investigation of the site observed that elevated metal concentrations occurred primarily in the fill material, specifically at the 5 to 6.5-foot depth.

A correlation between the nature of the fill material and elevated metal concentrations was previously observed. The elevated levels appeared to correspond to a material described as black sands in the boring logs. Boring logs and cross sections from trenches indicate that the black sands do not occur continuously across the site. In areas where the black sand fill is present, it occurs at approximately 1.5 to 2.5 feet below the ground surface and extends to 5.5 to 9 feet below ground surface. While elevated metal concentration appears to be associated with the presence of black sand fill, the converse is not necessarily true. That is, the presence of black sand does not necessarily indicate elevated metal concentrations.

Although elevated concentrations of metals are generally concentrated with the area of primary activity, there does not appear to be any spatial correlation either vertically or horizontally between metal concentrations. For example, a boring with high concentrations of metals may be located adjacent to another boring with low concentrations. Likewise, there does not appear to be a relationship between the elevated concentrations of metals found at a depth of 5 to 6.5 feet and those found in the same boring at 0 to 1.5 feet.

This observation indicates that elevated concentrations of metals in the fill may be inherent to the fill itself and not as a result of site activities. This conclusion is based on the lack of vertical or lateral distribution trends, indicating a lack of source from which migration occurs, and the frequent association of elevated concentrations with the black sand fill. Furthermore, Area A where the elevated levels of lead were observed, lies within the fill-line boundary for fill placed prior to 1949 (Figure 3). This area is presumably of similar fill material.

Within the area of elevated metals, highest frequency of elevated metals occur at the former Asphalt Facility, the former pond area, the area to the east of the former pond area and Area 6 (Figure 16).

Statistical summaries of the metal data (Tables 20 to 25) failed to demonstrate differences between areas due to large data variability and the small sample size used for some study areas. Evaluation of the September 1988 soil data demonstrated elevated levels of copper throughout all the areas sampled and at all depths (Table 21 and Figure 16). Chromium and nickel concentrations were all within the common range for soils (Lindsay 1979) and are not of concern.

Similar to copper, there did not appear to be a pattern to the distribution of elevated mercury concentrations in the soil.

Analysis of lead data confirmed the observations made in previous investigations regarding the distribution of lead in the fill, specifically at 5 to 6.5 feet. Additionally, an area defined as Area A was demonstrated to contain elevated lead concentrations in relation to the area outside of Area A (Table 26).

A similar analysis was not undertaken for zinc as was for lead. However, a ranking of the highest zinc concentration (Table 29) revealed that elevated levels of zinc were associated with elevated lead levels. Furthermore, the highest six zinc levels are all found in the fill and predominantly at 5 to 6.5-foot depth. Therefore, there does not appear to be any relationship between the other chemicals present at the site.

In summary, it appears that elevated lead and zinc values are inherent in a certain layer of fill and not as a result of site contribution.

Copper and mercury were randomly distributed and did not appear to have a source area. These metal concentrations were not related to other chemical distributions found at the site.

6.1.3.2 PAHs

PAHs were detected in five surface samples. Two samples are located in Hoffman Marsh, two were samples collected for the bioassay study and the fifth is a composite sample from Area 4. The levels observed were, with one exception, within the ranges generally observed in the environment (Butler et al. 1984). The presence of these chemicals onsite cannot be attributed solely to site contributions as there is potential for offsite contributions through runoff and dry/wet deposition especially considering the proximity of the site to a major highway.

PAHs in the subsurface were primarily confined to Area 6, the former Asphalt Facility and the former pond area. Levels of total PAHs varied from 0.4 to 14 mg/Kg. A wide range of PAHs were detected in Area 6 and the Pond Area. At the former Asphalt Facility, however, 2-methylnapthalene was the only PAH detected. Elevated levels of PAHs were previously detected in some locations with visible oil, however, these soils were excavated.

Previous site operations of asphalt manufacturing and temporary storage of petroleum products presents a potential source for the introduction of PAHs to the environment. PAH levels vary widely in petroleum products. Levels are highest in coal oils and liquids and lower and nearly absent in lubricating oils and unrefined petroleum products.

Oil and grease values if due to anthropogenic sources may contain PAHs, depending on the nature of the petroleum products. Comparison of the PAH levels with the corresponding oil and grease values for the samples with the highest PAH levels (Table 29) did not demonstrate a corresponding elevated oil and grease concentration. Likewise, comparison of the highest levels of oil and grease with the corresponding PAH value revealed that none of the samples had detectable levels of PAHs (Table 29).

6.1.3.3 Phenols

The presence of phenols at the site are confined to the former Asphalt Facility. The substituted phenols, 4-methylphenol and 2,4-dimethylphenol were observed in the subsurface.

6.1.3.4 BNAs

In addition to the phenols and PAHs, the only other BNA compounds detected were phthalates. Phthalates are used as plasticizers and are common artifacts in the sampling and analysis process. Therefore, the low level detection in a few samples are considered to be artifacts.

6.1.3.5 PCBs

PCBs were detected in two surface locations. In the southwest drainage, PCBs were detected at 1.2 mg/Kg. Additional sampling in the vicinity of this sample to determine the extent of PCBs in this area failed to demonstrate the presence of additional PCBs. A PCB identified as Aroclor 1260 was also observed at 0 to 0.5 feet in Area 6 at 3 mg/Kg. PCBs were also detected in a post-excavation sample in the former east tank farm area at 1.3 mg/Kg.

The distribution of PCBs are not widespread and the levels are generally low.

6.1.3.6 Oil and Grease, TPH, and Sulfur

Soil samples were analyzed for oil and grease as an indicator of the amount of petroleum products in the soil. A large variety of petroleum products have been used at the site through the years of operation of the asphalt manufacturing facility and as a storage of petroleum products for later re-sale. Thus, there exists a potential for the release of a large variety of petroleum products. Oil and grease methods measure petroleum products by extracting a portion of fractions

of the petroleum which is subsequently analyzed by gravimetric, infrared or gas chromatographic procedures. The amount and type of hydrocarbons measured are dependent on the nature of the extracting solvent and measurement method. The oil and grease data generated throughout the site investigation are not comparable because a variety of methods were used. Furthermore, the procedures do not discriminate between anthropogenic and natural sources. Decomposing plant and animal matter, waxes, lipids, etc., contribute to the determination of oil and grease. Therefore, the oil and grease determination alone cannot be used as the indicator of petroleum products but must be used in conjunction with another procedure which further characterizes the petroleum product. In the later investigations, TPH determination was used in conjunction with oil and grease measurement. TPH determines the volatile and middle distillate fraction (C_6-C_{22} hydrocarbon) of petroleum products such as gasoline, diesel, and kerosene. TPH values in samples from the site were generally low or not detected. This is not surprising considering that heavy oils and asphalt were the primary petroleum products handled at the site.

Sulfur was analyzed as it was identified in an earlier study as possible interferences with the oil and grease determination. However, there was no correlation between oil and grease levels and sulfur content.

Elevated levels of oil and grease appear to be randomly distributed throughout the site and occurs in isolated pockets. Apparent sources do not appear to exist as borings drilled adjacent to high oil and grease boring were found to be low in oil and grease. Also, there is no apparent vertical correlation as oil and grease levels at one depth within a boring were unrelated to oil and grease levels in the same boring at the adjacent sampling intervals. In addition, there does not appear to be a relationship between elevated oil and grease levels and activity areas as high levels were found both in activity areas and non-activity areas.

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In attempt to obtain more information on the nature of the oil and grease, one study focused on samples from Hoffman Marsh. The results of this study are discussed in detail in Appendix B of the Scoping Document (K/J/C 1988a). The samples were subject to extraction followed by simulated distillation, fractionation, and high resolution mass spectroscopy. The following conclusions were reached based on the analysis performed:

- The boiling point range of the extractable material was found to be in excess of 1,000°F indicating a heavy molecular weight mixture and eliminating the source as being gasoline or a middle distillate.

- The amount type and distribution of the detected nitrogen compounds is not consistent with the material being a natural soil material or a refined petroleum product.

- The types and distribution of compounds present are consistent with the extractable material being a highly weathered crude oil and/or a weathered, unrefined distillation tower bottom from a refinery.

As noted earlier, it does not appear to be a relationship between elevated oil and grease levels and total PAHs concentrations. Furthermore, it was observed that samples with visible oil did not yield elevated levels of oil and grease. The oily material was observed to be a heavy dark semi-solid. Thus, in conclusion, the material is a heavy oil with low extractability of hydrocarbons. The expected mobility of this type of material is discussed in Section 7.

6.2 GROUNDWATER

6.2.1 General Discussion

Ecology and Environment (E&E 1984a) collected groundwater samples from monitoring wells MW-1 through MW-10 in November 1983 and analyzed the samples for lead, nickel, copper, chromium, zinc, phenols, petroleum hydrocarbons, PCBs, and purgeable halocarbons. Results of metals analysis are provided in Table 30. Concentrations of organic compounds in groundwater were not believed to be of concern (K/J/C 1988a). Kennedy/Jenks/Chilton subsequently sampled the wells for total metals (same five metals as above) in March and May 1985. Dissolved concentrations of the metals in groundwater samples were measured in May 1985, January 1986, and August 1986. The August 1986 samples also included the new wells MW-4R, MW-7R, MW-12, MW-13, MW-15, MW-16, MW-17, and MW-18. Wells MW-4, MW-7, and MW-10 were destroyed in 1986. Results of these analyses are provided in Table 30.

Although K/J/C also analyzed groundwater samples for oil and grease, volatile organic compounds, BNAs, and TPH, concentrations were either below detection limit or not of concern (K/J/C 1988a). K/J/C conducted quarterly sampling of the 18 monitoring wells between October 1988 and October 1989 in accordance with the RI/FS Workplan (K/J/C 1988c).

Complete results of chemical analyses of these groundwater samples are listed in Table 15 and summarized in Table 31. Metals concentrations are displayed on Figure 43 for shallow groundwater results and Figure 44 for deep groundwater results. The data for each metal varied considerably throughout the site, similar to that observed previously (K/J/C 1988a). Despite the variation of data, the average concentrations of metals in shallow groundwater and deep groundwater are essentially equivalent (Table 31). Two factors that may effect the distribution of chemicals at the site are variation of both fill composition and direction of shallow groundwater flow.

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The fill was placed over a long period of time from several different sources (K/J/C 1988a). The contents of most of the fill material is unknown. Elevated chemical concentrations in some areas may be the result of metal-rich fill leaching rather than past site activities.

As discussed in Section 4.2.1, the shallow groundwater zone water levels appear to vary seasonally. The direction of groundwater flow during the dry season is variable and difficult to predict. Chemicals may be transported intermittently with fluctuations in flow direction, resulting in a complex distribution.

Despite the complex distribution, concentrations of metals in shallow and deep groundwater were within the ranges listed in previous reports (K/J/C 1988a), with the exception of chromium in two October 1988 samples from MW-1 and MW-12R. The reported concentrations of 0.024 and 0.020 mg/L, respectively, exceeded the previous high chromium value of 0.019 mg/L. However, average concentrations of metals for the five sampling quarters were considerably less than those observed in 1985 and 1986 (Table 25). Mercury was not analyzed in previous studies.

6.2.2 Shallow Groundwater Zone

An examination of the data from shallow groundwater monitoring wells prompted a statistical T-test analysis (Davis 1973) for the data from Well MW-4R. The results showed that average concentrations of lead (0.026 mg/L), nickel (0.088 mg/L), and zinc (0.12 mg/L) in Well MW-4R were elevated compared to the other wells at the 95 percent confidence level. Average concentrations of lead, nickel and zinc in the remaining shallow wells were 0.007, 0.016, and 0.020 mg/L, respectively, assuming one-half detection limit for non-detects. The results of the statistical analysis are provided in Table 32. Other well samples suspected of being outliers were also tested, but no such significance was demonstrated. The source of these metals in samples from MW-4R is not precisely known, but the well is located adjacent to areas of former site activity such as the metal culvert and the former Asphalt Facility

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area. The screened interval of this well is within Area A, the soil zone in which statistically significant higher levels of lead were found (see Section 6.1.2.2). MW-4R is located at the edge of a previously excavated area (K/J/C 1986b), so the majority of the source has likely been removed. Well MW-7R is also screened in Area A, but samples from this well did not exhibit elevated metals concentrations (average concentrations: lead = below detection limit, nickel = 0.017 mg/L, zinc = 0.012 mg/L).

Though the shallow groundwater gradient is intermittent (Section 4), Well MW-5 appears to be immediately downgradient of Well MW-4R during periods of significant groundwater flow (Figure 32). Average concentrations of lead (below detection limit), nickel (0.042 mg/L), and zinc (0.037 mg/L) in this well are noticeably lower than in MW-4R. Wells further downgradient contain still lower concentrations of metals, commonly at or below detection limit.

Total petroleum hydrocarbons were not detected in any shallow wells. Oil and Grease was detected in MW-17 (2.1 mg/L) in October 1988 and in MW-15 (2.8 mg/L) in January 1989. Oil and Grease was not detected in the remainder of the shallow wells.

6.2.3 Deep Groundwater Zone

The distribution of dissolved metal concentrations in the deep groundwater zone showed no apparent consistency. Elevated concentrations usually occurred as isolated anomalies. For example, the concentration of dissolved copper in Well MW-1 was 0.048 mg/L in October 1989, but was at or below the detection limit of 0.005 or 0.006 mg/L in all other quarters.

One exception to this trend was Well MW-2, which showed an average dissolved mercury concentration of 0.00096 mg/L (assuming one-half detection limit for concentrations below detection limit). Samples from all other deep wells contained mercury at or below the detection limit

of 0.0002 mg/L. In addition, no shallow well sample showed a dissolved mercury concentration of greater than 0.0006 mg/L (average concentrations were 0.058 mg/L and 0.068 mg/L, respectively).

Also, concentrations of dissolved nickel in Wells MW-2 and MW-18R were consistently elevated above detection limit (average concentrations were 0.058 mg/L and 0.068 mg/L, respectively).

No TPH or Oil and Grease were detected in deep groundwater samples.

6.2.4 Drinking Water Criteria

Several parameters associated with drinking water standards were measured to estimate potability of site groundwater. In a report by Caltrans (DOT 1978), groundwater to the north of the site was found to exceed drinking water standards for bacteria, nitrate, manganese, and total dissolved solids (TDS). Samples from the site were analyzed for these constituents to correlate with findings of the report. These constituents are likely unrelated to past site activities.

Both shallow and deep groundwater at the site are not considered to be suitable as a drinking water source on the basis of chemical criteria described below. There is therefore no anticipated exposure of humans to groundwater in the form of drinking water supply.

Total dissolved solids (TDS) ranged from 420 to 56,000 mg/L. The Secondary Drinking Water Standard for TDS is 500 mg/L, and only Well MW-19 (offsite) passed this standard. Many samples had salinities approaching or exceeding that of sea water.

Concentrations of manganese ranged from below detection limit to 38 mg/L. The Secondary Drinking Water Standard for manganese is 0.05 mg/L, a value exceeded in all wells except MW-19.

Coliform bacteria counts varied widely, from less than 2 to 160,000 MPN/100 ml (most probable number per 100 ml). Wells with the highest counts were MW-15, MW-7R, and MW-16, though most varied a great deal between sampling rounds. Waters with detectable bacteria counts are considered unsuitable for drinking. All wells except MW-5 and MW-6 contained detectable coliform bacteria.

Like manganese and coliform bacteria, nitrate concentrations were highly variable, but all concentrations were below the Primary Drinking Water Standard of 45 mg/L.

6.2.5 Mobility

The concentration of any one of the metals in groundwater is dependent on a variety of chemical criteria, including pH, redox potential, salinity, soil type and composition, and concentrations of potential complexing agents. These criteria play a role in solubility and subsequent transport of metals in groundwater.

Physical properties of the groundwater system also play an important role in transport. Spatial variations in hydraulic conductivity and variations of gradient with time result in complex transport mechanisms and make prediction of future movement of chemicals difficult. In addition, adsorption of metal cations and metal anion complexes is a commonly dominant mechanism for slowing the movement of metals in groundwater.

It is probably the combination of these criteria that contribute to the observed variation of metals concentrations. On the basis of the observed groundwater and soils data, there may be a source area for nickel, lead, and zinc in the vicinity of Well MW-4R. Concentrations of these metals in other wells are generally much lower, indicating a low mobility in the site groundwater system. Changes in system properties influencing mobility, discussed above, are not expected to change significantly in the future.

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6.3 SURFACE WATER AND MARSH SEDIMENT

Surface water was sampled in November 1985 in two drainage channels adjacent to the site, the South Drainage Channel and Stege Drainage channel, as part of a preliminary surface water and sediment investigation. The results are discussed in the Scoping Document (K/J/C 1988a). Sample locations and metal concentrations are presented on Figure 59.

As discussed in the Scoping Document, generalizations regarding the quality of surface water adjacent to the site should not be made because the data are for one point in time, and therefore do not take into account tidal or seasonal fluctuations. Even if the data had been collected on several occasions and were, therefore, more representative of actual conditions, the meal concentrations cannot necessarily be attributed to the Liquid Gold site. The concentrations of the metals detected in surface water are probably influenced by background levels in the Bay or other nearby sources.

Sediment samples (surface to a depth of approximately 6 inches) were collected in November 1985 at the same locations as the surface water samples. The analytical results for metals are given on Figure 59. Sediment samples were collected from other areas adjacent to the site (Hoffman Marsh and the Southeast Drainage Channel) in October 1986. Samples were collected at two depths: 0 to 3 inches and 1 to 2 feet. The analytical results for metals are also shown on Figure 59.

No major conclusions were drawn in the Scoping Document on the basis of these sediment data. The results are considered superseded by the extensive sediment and benthos investigation discussed above in Section 5.2.

6.4 AIR

Measurements of chemicals in air were not performed at the site, primarily because the chemicals of interest are not considered volatile. A conclusion of the preliminary PHEE (K/J/C 1988b) was that exposure to metals via inhalation of dusts under current site conditions is not expected to be significant. A similar conclusion was reached in the final public health evaluation (Section 8) for both metals and organics, supporting the decision that air measurements are not necessary at the site.

SECTION 7

CHEMICAL FATE AND MOBILITY

This section discusses the fate and transport processes, which will be important in the final assessment of health and environmental risks from the chemicals reported at the site. The discussion is divided into a general discussion of fate and transport followed by a discussion of the dominant processes governing the fate and transport of site chemicals. The concluding section is a projection of the probable fate and migration pathways of the chemicals of potential concern at the Liquid Gold site.

7.1 GENERAL FATE AND TRANSPORT CONSIDERATIONS

The chemicals of interest at the Liquid Gold site include PAHs, phenols, PCBs, metals (specifically copper, lead, mercury and zinc), and other chemicals of a general petroleum class.

Chemical, physical, and biological processes all can affect the fate and transport of chemicals in water, soil, and air. Chemical processes include hydrolysis, oxidation, and photolysis. Physical processes include advective transport, volatilization, and sorption to soils (soils also include sediments). Biological processes include biotransformation and bioconcentration. The degree to which each of these processes occurs is dependent on the physical and chemical properties of each compound, the physical and chemical properties of the soil, and environmental factors such as temperature, humidity, and the volume and rate of water movement.

These processes can result in a decrease of chemical concentrations in water, soil, and air. The half-life, or $T_{1/2}$, is the time required for the concentration of a specific chemical to be decreased by one-half as

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a result of all processes that remove that chemical. These general processes are briefly discussed in the following sections.

7.1.1 Chemical Processes

Chemical reactions that can affect organic compounds in water are hydrolysis, oxidation/reduction, and photolysis. Hydrolysis involves the reaction of a water molecule (or its components, hydrogen ion, or hydroxide ion) with a chemical to yield substitution or elimination products. Oxidation/reduction involves a transfer of electrons between two molecules. Oxidation/reduction of compounds can occur by chemical means as well as biological means. Oxidation often results in functional groups containing oxygen being introduced into organic chemicals, resulting in more polar compounds (e.g., carboxylic acids and alcohols). A third process, photolysis, involves the absorption of energy (light) by a chemical and its subsequent transformation into other chemical products. Many chemicals are oxidized or photodegraded following their volatilization into the atmosphere. The susceptibility of chemicals to undergo these processes is a function of chemical structure. Evaluation of chemical processes is also complicated by incomplete knowledge of mechanisms by which these processes occur in the environment.

7.1.2 Physical Processes

Physical processes include advective transport, volatilization, and sorption to soil and sediments. Advective transport of dissolved chemicals in groundwater is a major physical process that transports these chemicals to potential receptor points. Advection is the bulk movement of a fluid in response to pressure gradients within that fluid.

A chemical's tendency to move from the liquid phase to the soil or atmosphere is directly proportional to its vapor pressure and inversely proportional to its water solubility. The Henry's Law Constant, which is an index of a chemical's volatility from a water system, is the ratio

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of the chemical's vapor pressure to its water solubility. Thus, chemicals with low vapor pressure and low water solubility may be volatile.

Values for Henry's constant (Hc) for each compound also provide valuable information on the volatilization of chemicals from water. Compounds with Henry's constant less than 3×10^{-7} atm-m^3 mol^{-1} are classified as having low volatility, those between 3×10^{-7} and 10^{-3} as intermediate volatility, and those greater than 10^{-3} as high volatility (Lyman 1982).

Compounds with high water solubilities (greater than 100 mg/L) and low organic carbon partition coefficients (K_{oc}) will tend to remain in solution and move at velocities similar to groundwater flow rates. This coefficient is the ratio of the concentration of chemical adsorbed to soil (normalized for organic carbon in the soil) to the concentration of the chemical in solution at equilibrium. Mobilities of compounds have been divided into five mobility classes based on organic carbon partition coefficients (Dragun 1988). Compounds with K_{oc} values in excess of 2,000 are classified as immobile, those between 500 and 2,000 as having low mobility, those between 150 and 500 as having intermediate mobility, those between 50 and 150 as mobile, and those with less than 50 as very mobile. These generalizations regarding mobility apply to soil-water systems for low concentrations of the organic compound, and in the absence of facilitative transport.

Facilitative transport is any process that enhances the mobility of a chemical in a soil-water system beyond that expected by Darcian flow and equilibrium sorptive interactions with the immobile soil phase. Facilitative transport processes include co-solvent effect, interaction of chemical with mobile organic or inorganic colloids, and hydrodynamic dispersion. Facilitative transport mechanisms are apt to be important to some extent in certain situations.

Cosolvent effect involves the movement of chemicals in a water-organic solvent system. Another process is the movement of a chemical with an

organic solvent in a multi-phase system (water/soil/solvent). Other processes by which facilitative transport occurs is the movement of chemicals sorbed to colloids or organic matter that may be mobile in groundwater.

7.1.3 Biological Processes

Aquatic organisms may take up chemical substances present in the water. The biocentration factor (BCF) is a measure of a chemical's tendency to be stored in an aquatic organism. The BCF is defined as the ratio of the concentration of chemical in the organism to the concentration of the chemical in the water. The BCF can be estimated from the octanol/water partition coefficient (K_{ow}), which is defined as the ratio of the concentration of chemical in a reference octanol phase (i.e., lipid-like material) to its concentration in the aqueous phase of a two-phase octanol/water system. The K_{ow} is also indirectly related to water solubility and directly related to soil adsorption coefficients and BCFs for aquatic life. Chemicals with values less than 10 (log K_{ow} less than 1) generally have high water solubilities, low soil/sediment adsorption coefficients, and low BCFs.

Organic compounds found in soil/water systems are subject to a variety of biotransformation reactions. Oxidative biotransformations utilize oxygen under aerobic conditions and nitrate, sulfate, and carbon dioxide under anaerobic conditions. Hydrocarbons, including aromatics (e.g., benzene and toluene) are subject to oxidative microbial transformation. This oxidative degradation results in cresols and catechols by hydroxylation of the aromatic ring (Callahan 1979).

7.1.4 Environmental Factors

While the interaction of the above mentioned chemical, physical, and biological processes govern the fate and mobility of chemicals at the site, certain environmental factors govern the degree to which these processes are manifested and to a large degree the rates of these

processes. The degree to which advection (mass flow) is a significant transport process is dependent on the quantity and intensity of rainfall. It is also dependent on the infiltration rate of water through the soil, which in turn is a function of particle size distribution and soil structure.

The oxidation/reduction environment of a soil system is governed by soil geochemistry and microbial activity in the soil. Water-logged soils are generally under reduced conditions because of slow oxygen diffusion in such soils. Drained soils are under oxidizing conditions because oxygen resupply occurs more readily. Water status of soil is determined by rainfall, infiltration rate, soil profile features and clay content of the soil. In a water system reducing conditions are created when oxygen is depleted in the process of microbial consumption of organic substrate. Thus, the degree of the reducing conditions is dependent on the microbial population and the amount and biodegradability of the organic substrate.

The rate and extent of volatilization of chemicals from soils and aquatic systems is determined by temperature, water diffusion coefficient, and concentration gradient, which in turn is a function of air turbulence. Thus, maximum volatilization will occur under high temperatures and wind speeds.

Air dispersal of aerosols and particulates containing sorbed chemicals is a function of the erosion character of the soil, which is determined by moisture, soil structure, particle size, and other factors. The degree of vegetative cover and frequency in which threshold wind velocities are exceeded are also important.

Adsorption of organic and inorganic species occur by two processes; nonspecific and specific adsorption. Nonspecific adsorption are all adsorption processes involving electrostatic interactions of adsorbent and adsorbate. An example of this type of interaction is the electrostatic interaction of an ion with an oppositely charged colloid.

Specific adsorption involve all interactions which are non-electrostatic in nature and are also termed chemisorption. The extent of these processes is dependent on the amount and type of clays, the amount of organic matter, the soil pH and the amount of sorbate and competing species.

The rate of biotransformation of a chemical is a complex function of environmental variables that include organism types and populations. These variables are, in turn, functions of nutrients and conditions related to utilization of the chemical by the organisms. The reaction a chemical will undergo also depends on this particular reactivity toward the metabolic agents that perform the various hydrolysis, oxidation, and reduction processes.

Some chemicals are more reactive in aerobic (oxygen-containing) systems, while others are more reactive in anaerobic (oxygen-deficient) systems. Biotransformation of hydrocarbons is an aerobic process.

Thus, the fate and transport of chemicals are governed by a complex interaction of chemical, physical and biological processes. The extent to which these process are expressed and the rates are determined by several environmental factors, among which the most important are temperature, moisture, wind speed, organic matter content clay content and microbial activity.

7.2 FATE AND TRANSPORT ANALYSIS OF SITE CHEMICALS

7.2.1 Hydrocarbons

The history of the Liquid Gold site includes the processing and storage of petroleum products. The Liquid Gold facility has handled a variety of petroleum products and were documented as (K/J/C 1988a):

1. Used motor oil
2. Solvents (Stoddard and paint thinner)

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3. Bunker oil
4. Diesel fuel and other light oils
5. Oil-water mixtures and emulsions

Information regarding chemical usage by the Asphalt facility is not available in agency or SPT Co. files. However, based on the nature of the operations, it is probable that among the materials used are the residual products (tank bottoms) of crude oil refining. These are high molecular weight aromatic or aliphatic hydrocarbons.

A detailed characterization of the oil and grease fraction of three samples from Hoffman Marsh was performed by Western Research Institute (WRI), which has extensive experience characterizing petroleum products. The results were presented in Appendix B of the Scoping Document (K/J/C 1988a). The characterization included extraction, determination of oil and grease and sulfur, distillation, fractionation and z-series analysis. The simulated distillation analysis demonstrated the majority (55 to 86 percent) of the oil and grease components had a boiling point range in excess of 1,000°F, indicating a "heavy" petroleum mixture. As a reference, the normal paraffin n-tetradecane ($C_{14}H_{30}$) boils at about 490°F, and n-dotetracontane ($C_{42}H_{86}$) at about 1,000°F. The boiling point range indicates that the oil and grease is not gasoline or middle distillate product such as diesel or jet fuel. The sulfur content varied from 16 to 80 percent of the oil and grease fraction and thus, constitute a significant amount of the oil and grease fraction.

The z-series analysis demonstrated that the carbon number of the hydrocarbons ranged from C_{14} to C_{35}. According to WRI, the amount of nitrogen-containing compounds found would not be expected from motor oils, and are more likely associated with heavy or crude oil.

WRI concluded that the boiling point range of the material eliminated the source of the hydrocarbons as gasoline or middle distillate full; the amount, type, and distribution of detected nitrogen compounds is not consistent with the material being a natural product or refined

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petroleum product; and the types and distributions of compounds present are consistent with the extractable material being a highly weathered crude oil and/or weathered, unrefined distillation tower bottoms from a refinery. These conclusions are consistent with the heavier petroleum fractions handled at the site and observations of a dark semi-solid, asphalt-like materials seen east of the former asphalt facility. The composition of asphalt is complex and dependent on the nature of the source (paraffinic or aromatic) as well as the nature of and proportions of the asphaltines and resins. Also, the asphalt may have undergone weathering over time.

The samples analyzed by WRI are few and limited to a small area. The oil and grease measurements from samples collected in this area are assumed to contain hydrocarbons of the type described above, however, it cannot be concluded that this is the nature of hydrocarbons in samples containing oil and grease from other areas of the site. As discussed in Section 6.1.1.1, oil and grease are defined by the method used for the measurement, and can include hydrocarbons of anthropogenic or natural sources. An earlier GC/MS study by Ecology and Environment (1984) showed that two site soil samples with high oil and grease values showed different results: the surface soil sample contained aliphatic hydrocarbons similar to those observed commonly in petroleum products; the subsurface soil sample did not contain aliphatic hydrocarbons, and it is therefore more likely that natural materials are contributing to oil and grease values. Therefore it is not known if soil samples with high oil and grease values -- other than those from the sediment samples collected for the WRI study -- contain anthropogenic hydrocarbons.

The WRI conclusion that the material is not gasoline or a middle distillate product was further supported by the results of the TPH-gasoline and TPH-diesel analysis of soil samples, which were generally low (less than 35 mg/kg) or absent. Thus, there does not appear to be widespread presence of the chemicals used by Liquid Gold as evidenced by the absence of light and middle distillate fractions. The absence of these fractions from the soil may be due to lack of release

of these materials to the environment or the removal of these materials from the environment through volatilization or degradation.

The following is a discussion of the fate processes of hydrocarbon compounds:

Volatilization is not an important fate process currently operating at the site given the high boiling point range of the oil and grease fraction. However, if the lighter components were previously present, volatilization would have been an important mechanism for the removal from the site.

Smith et al. (1981) investigated the volatilization of various jet fuel hydrocarbons from water and concluded that all of the hydrocarbons studied (including n-decane, cyclohexane, benzene, toluene, and xylene) except naphthalene were highly volatile. Leinonen and Mackay (1975) also reported the rapid volatilization of several hydrocarbons except naphthalene. They derived an equation for predicting the half-life of a hydrocarbon in an aqueous environment and estimated volatilization half-lives of about five to six hours for benzene, toluene, o-xylene, n-octane, and 2,2,4-trimethylpentane in water at a depth of one meter.

The volatilization of the lighter organics from past discharges at the Liquid Gold site has probably already occurred, as evidenced by the lack of detection of low molecular weight components. Also given the current conditions at the site, and the time since the last known chemical release, it is unlikely that volatilization of organics is currently occurring at significant rates.

Another important fate process of hydrocarbons is biotransformation. Biotransformation of hydrocarbons is most efficient in aerobic environments. Petroleum wastes from refineries are commonly degraded by land farming. Microbial degradation is limited by the availability of oxygen and other

nutrients such as nitrogen and phosphorus and the concentration of the substrate. Large concentrations of substrates may be toxic to the micro-organisms and limit degradation rates. Although there is no information to evaluate the importance of biotransformations occurring at the site, the presence of weathered hydrocarbons in marsh sediments indicates that biotransformation processes may be one of the mechanisms transforming the hydrocarbon materials.

Some components of petroleum products are photoactive and are expected to be photodegraded. Smith et al. (1981) concluded that for naphthalene and the substituted naphthalenes, photolysis may be a major removal process. Other major components are resistant to photodegradation, as evidenced by the photolytic half-lives for alkyl benzenes, which under experimental conditions were predicted to be at least several years (Smith et al. 1981). Nevertheless, photolysis is limited to surface soils and surface waters, and thus expected to be an unimportant fate process.

Photolysis may have been a more important removal mechanism in the past, but current conditions at the site make it unlikely that photolysis is still having a significant impact on chemical concentrations.

7.2.2 PAHs

The occurrence of PAHs is usually found as a PAH mixture, and their presence is due to the mechanism (pyrolysis or combustion) by which PAHs are formed. High temperature pyrolysis will produce unsubstituted PAHs, whereas unrefined petroleum products will contain alkyl-substituted PAHs. Such mixtures were generally observed in the samples in which PAHs were detected. An exception was two samples from a boring in the former asphalt facility in which only 2-methylnaphthalene was detected.

Due to the similarity of the structure of priority pollutant PAHs (3-rings or more), the environmental behavior of these PAHs is expected to be similar. Therefore, physical properties of selected PAHs

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(Table 33) will be used to make generalizations regarding the environmental fate and transport of the PAHs of interest at the site.

Adsorption of PAHs to soils, sediments, and particulates is expected to be the main fate process as the K_{oc} values are well in excess of immobile value of 2,000 (Table 33). Due to the immobility of these compounds, PAHs are expected to be concentrated in surface soils. However, PAHs were observed in the subsurface at the site. The process by which PAHs have been transported to the subsurface are unknown. As mentioned previously, immobile organic compounds can be transported to the subsurface through facilitative transport process; for example, bulk flow of oils or solvents containing PAHs. Owing to the strong adsorption of PAHs, the main transport process is through erosion and runoff of sediments containing PAHs.

Volatilization of PAHs is expected to be insignificant given the strong adsorption low vapor pressures and corresponding Henry's Law constants values (Table 33). An exception may be 2-methylnaphthalene, which although a Henry's Law constant value was not available, volatility is similar to naphthalene due to similarities in structure. Naphthalene has a Henry's Law constant value of 1.15×10^{-3} atm-m^3 mol^{-1} which classifies it as highly volatile. However, volatilization is limited by the strong adsorption of this compound.

The K_{ow} for the available PAHs suggest that PAHs are bioaccumulated. However, bioaccumulation in aquatic organisms appears to be a short-term process as many organisms have the capability of metabolizing PAHs to products which are subsequently excreted. Leversee et al. (1981) report that bluegill sunfish were able to excrete 89 percent of the benzo[a]pyrene introduced in a four-hour period. Elimination of PAHs from mammals requires metabolism. Biotransformation of PAHs, although considered an important fate process, is a slow process as evidenced by available half lives (Table 33).

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Photodegradation may be a significant process for PAHs on surface soils because PAHs strongly absorb light above 300 nm. However, the effects of sorption of PAHs to particulates on photolysis has not been resolved, and sorption may retard or prevent photolysis.

7.2.3 PCBs

PCBs, or as commonly referred to by the trade name Aroclors, are mixtures of chlorinated biphenyls and have been found in sporadic samples. The various Aroclors are identified by the degree of chlorination. As is known from the widespread presence of PCBs in the environment, a major source of environmental exposure is environmental cycling of PCBs previously introduced into the environment.

The cycling process involves volatilization from ground surfaces into the atmosphere with subsequent removal from the atmosphere via wet/dry deposition and then revolatilization.

The identification of PCBs at the site have been limited to a few isolated samples and at low concentrations (less than 3 mg/kg). There does not appear to be any particular source areas and the affected areas are small. Thus, they are not of major concern at the site. Aroclor 1260 is the principal PCB detected at the site.

Adsorption to soils and sediments is one of the principal fate processes. An average K_{oc} value of 6.7×10^6 has been reported for the Aroclor 1260 mixture (Mabey et al. 1982). Consequently, in the absence of facilitative transport, the PCBs are expected to be concentrated in the surface soils. Transport of sediments containing PCBs through runoff to drainage channels is a possible transport mechanism.

PCBs are expected to readily volatilize from water as Henry's Law constant values in the range of 2×10^{-3} to 5×10^{-4} atm-m^3 mol^{-1} are reported for the various congeners (ASTDR 1989b). Volatilization from

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soils probably does not occur to the same extent, as the strong adsorption to soils limits volatilization.

Degradation of PCBs by chemical processes (oxidation and hydrolysis) is not significant. Photolysis may occur to some extent in water; however, insufficient data exist to assess its relative importance. Biotransformation is the only likely process for removal of PCBs from the environment, and experience has found this process to be slow.

Biotransformation of PCBs is influenced by the degree of chlorination. Persistence toward oxidative processes increases with increasing chlorination. Higher chlorinated PCBs are reductively dechlorinated to form lower chlorinated forms which can be subsequently aerobically biodegraded.

7.2.4 Phenols

Phenolic compounds were detected in soil samples at 6 and 10.5 feet depths in only two borings from the former asphalt facility. Elevated levels of 2,4-dimethylphenol and 4-methylphenol (cresol) were identified. Environmental fate data for these compounds suggests that these compounds are mobile. K_{oc} values of 47 and 96 are reported for 4-methylphenol and 2,4-dimethylphenol, respectively and a water solubility of 1,840 mg/L for 4-methylphenol (Neely and Blau 1987). However, these compounds are likely associated with the oily substances found in the borings, and their rate of release into water will be slow and controlled by diffusion from the oil phase. It should also be noted that naturally occurring phenolic compounds are expected to be present in the marsh.

Volatilization of these compounds also appears to be an important fate process. Henry's constant values of 1.7×10^{-5} and 6.8×10^{-6} atm-m^3 mol^{-1} for 2,4-dimethylphenol and 4-methylphenol (EPA 1982), respectively, indicate that the compounds have intermediate volatility.

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7.2.5 Metals

The metals of interest at the site include chromium, copper, lead, mercury, nickel and zinc. Four metals exceeded the common range for soils as cited in Lindsay (1979) in some soil samples. Soil concentrations of nickel and chromium were within the common range for soils (Lindsay 1979) and are therefore not of concern. The fate and transport of metals in soils and aquatic environments is dependent on the pH, redox potential, organic matter content, soil mineralogy, ionic strength, and cation exchange capacity (CEC) of the soil.

The metals copper (Cu), lead (Pb), and zinc (Zn), generally exhibit similar behavior in the environment. The solubility of the metals increases with decreasing pH. At neutral to alkaline pHs in natural waters, the metals form strong complexes with hydroxides and carbonates, which form relatively insoluble compounds. The metals will also form soluble chloride complexes when chloride is present in high concentrations. The metals will also complex with organic materials (as ligands) in soil and water. The presence of metal oxides and hydroxides are generally the principal species controlling the concentration of metals in soil solutions, because the metals are adsorbed to the surface of the metal oxides. In turn, the presence of metal oxides and hydroxides in soils is largely dependent on the redox potential and pH of the soil.

In general, the concentration of metals in waters at the site will be dependent on pH and the presence of chloride. If surface waters have high concentrations of chloride, metals are expected to have enhanced mobility. If the pH of the waters is neutral to alkaline, the trace metals are expected to have low mobilities.

Waterlogging of soils resulting from high rainfall may result in formation of reducing conditions. The subsequent decrease in the redox potential will result in solubilization of metal oxides with a corresponding increase concentration in solution of copper, lead and

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zinc. However, the reducing conditions will result in the reduction of sulfates to sulfides which will form insoluble precipitates with the metals of interest. Thus, there may be no increase in the concentration of metals.

In soils there are many naturally occurring organic materials. The most commonly recognized of these consists of a group known as humic materials. Humic materials may be fractionated into humic acid, fulvic acid, and humin. These coiled polymer chained materials have a large number of functional groups with a great affinity to complex metal ions. Humic materials containing complexed metals, also tend to sorb onto clay and oxide particles in soil and suspended sediments which reduces the mobility of metals. Kabata-Pendias (1984) describe complex interactions between humic substances and metals as attributable to various processes including ion exchange, surface sorption, chelation, coagulation, and peptization. It is thought by some that chelation is a much more important process. Since a chelating agent is an organic ligand that has more than one atom that bonds to the metal, it is likely to have more stability than singly bonded complexes.

As an example of the impact of organic matter on metal mobility, Dowdy et al. (1981) in their review of the transport of heavy metals in soils treated with sewage sludge found that the heavy metals copper, lead and zinc were generally immobile in soils. These metals were not transported greater than 15 to 50 cm from the point of application even under conditions conducive to mobilization; for example sandy soils, low pH, low organic matter content and high leaching fractions. Zinc was found to be the most mobile of the three metals. The conditions in the marsh may not be all that different from soils amended with sewage sludge as marsh soils are rich in organic matter.

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7.2.5.1 Copper

Copper exhibits several naturally occurring oxidation states. In the range of conditions encountered in the environment, the divalent (+2) state is the most prevalent form.

Copper ions complex and form a series of hydroxy complexes in dilute aqueous solutions. In freshwaters at pHs greater than 7, $Cu(OH)_3^-$ is probably the most important complex (Hem 1985). Carbonate and hydroxy-carbonate complexes are slightly soluble and maintain copper concentrations in the less than 10 ug/L range in freshwaters (Hem 1985). Organic copper complexes may also be locally important, particularly in an organic-rich vadose zone and estuarine systems. It has been estimated that about 80 percent of the soluble forms of organic copper in soil solutions are present as organic chelates (Hodgson et al. 1966).

In oxygen rich soils with an abundance of calcium carbonate the principal inorganic form of copper is as copper carbonate. The solubility of copper carbonate is not pH dependent but is related to partial pressure of carbon dioxide.

In soils copper not removed by precipitation processes is subject to adsorption by clays and organic materials. Hydrated copper and soluble cationic complexes of copper is non-specifically adsorbed primarily by the layer silicates and organic matter. Specific adsorption of copper is primarily by oxide and hydroxide amorphorous minerals and organic matter.

In a review of priority pollutants Callahan et al. (1979) concluded that bioconcentration was an important process in determining the fate of As, Cd, Cr, Cu, Pb, Hg, and Zn, but not Sb and Ni.

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7.2.5.2 Lead

In soils, particularly contaminated soils, lead is commonly found concentrated in the surface (top 6 inches). While this can be in part attributed to the low solubility of inorganic lead complexes, it may also be attributed to organic-lead complexation as shown by the high stability constants shown for lead-humic complexes (Kabata-Pendias and Pendias 1984). The stability of lead complexes with humic materials has been shown to be directly correlated with increased pH in the range from 3 to 7 (Hildebrand and Blume, 1974). As with copper, lead shows the same preference for humic over fulvic materials which tends to make it less mobile.

Lead has several oxidation states and occurs mainly in the divalent (+2) oxidation state, although the quadravalent (+4) state is also found in very oxidizing environments (Kabata-Pendias and Pendias 1984).

Studies performed by Hahne and Kroontje (1973) show that lead-hydroxy species become important above a pH of 5, and that in the pH range between 6 and 10 that the single hydroxy species ($PbOH^+$) predominates. They also showed that complexation with chloride becomes more important and competitive with other species in waters with higher chloride concentrations. The solubility of the chloride complexes renders lead more mobile than the hydroxy species. Low solubility lead phosphate and lead carbonate minerals may also be important in regulating the solubility and speciation of lead in water and in soils in areas where phosphates and carbonates are important anions.

In general, lead is considered the least mobile of the heavy metals. Dissolved lead is usually found as the free ion Pb^{+2}, as hydroxide complexes and probably as carbonate and sulfate ion pairs (Hem 1985). Lead phosphate compounds are probably an additional important sink in areas where phosphate is found in high concentrations (Adriano 1986).

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7.2.5.3 Mercury

Mercury has three oxidation states. The form found in soils and waters is a function of pH and oxidation/reduction environment. The elemental form of mercury (Hg°) is a liquid at ambient temperature and highly volatile. The elemental form is the principal species in the atmosphere. In soils and surface waters mercurous (+1) and mercuric (+2) ions form complexes of varying solubilities. In surface waters the dominant form is mercuric, which chelates with organic and inorganic ligands. Mercury also forms stable complexes with organic matter. In soils mercury forms complexes with chloride and hydroxides, with the specific complex formed is dependent on pH, ionic strength and the composition of the soil.

Mercury can be methylated through biotic processes to form monoalkyl and dialkyl mercury compounds. Monoalkyl mercury compounds (e.g., methyl mercuric chloride) are relatively soluble and thus mobile, whereas dialkyl mercury compounds (e.g., dimethyl mercury) are relatively insoluble. Methyl mercury compounds are accumulated in the aquatic food chain by a factor of 10,000 to 100,000 of the concentration in the water.

Other than transformations, the dominant fate process in soils is adsorption. The adsorption process is related to the organic matter content of the soil. Inorganic mercury adsorbed to the soil is not readily desorbed and thus leaching from soils is insignificant. Soluble forms of mercury can be chemically or microbially reduced to elemental form which are subsequently released to the atmosphere. In some soil/water systems, mercury can be methylated, with the methyl mercury subsequently accumulated in aquatic organisms.

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7.2.5.4 Zinc

As for the other elements previously discussed, zinc has more than one oxidation state. However, in the natural aqueous environment zinc occurs exclusively in the divalent (+2) oxidation state.

Minimal hydrolysis occurs under acidic conditions while higher pHs near neutral induce precipitation of insoluble hydroxides. Below a pH of 7.7 in soil solutions the predominant Zn species is Zn^{+2} (Lindsay 1979). In basic solutions mono and polynuclear hydrolysis species predominate, such as $Zn(OH)_2$ and Zn_2OH^{+3}. Above a pH of 9.1, $Zn(OH)_2$ is the primary species (Adriano 1986). In air-saturated water a zinc hydroxy-carbonate species is known to be the stable phase, whereas zinc oxide predominates at very low carbon dioxide partial pressures (Schindler et al. 1969). Zinc chloride complexes are weak and important only at very high chloride concentrations. Zinc also forms complexes with phosphate, nitrate, and sulfate but they are not expected to be quantitatively important in most environments (Lindsay 1979).

Zinc retention by soil has been correlated to its organic content, and in particular soil humic content (Randhawa and Broadbent 1965). As shown previously for the other metals, studies show that zinc has a greater affinity for humic acids than it does for fulvic acids. A strong zinc retention in soils as a function of pH has been correlated with the nucleation of zinc hydroxide on clay surfaces (McBride and Blasiak 1979). In soil solutions with pHs less than 7, zinc is susceptible to mobilization by leaching because of ligand exchange with competing cations such as calcium.

7.3 EVALUATION OF FATE AND MOBILITY

7.3.1 Potential Source Areas

Agency inspection in the 1970s and early 1980s reported releases of oils and chemicals to the soils in areas around the east and west tank farms,

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the former pond and the southeast drainage ditch. Subsequent interim remedial measures undertaken at the site prior to 1983 have likely removed some of these potential source areas. However, removal activities and confirmation sampling (if any) during this period are not well documented.

The major remedial investigation can be considered to start with the Ecology and Environment soil and groundwater study in 1983 followed by studies by Kennedy/Jenks/Chilton until 1990. Review of the RI chemical data revealed some areas of elevated metal concentrations and areas containing organic chemicals. The distribution of chemicals have been discussed in detail in Section 6. Briefly, the areas of elevated metal concentrations were identified as:

1. Area A, located along areas of former site activity and corresponding approximately to the area of fill placement prior to 1949. This area was demonstrated to have elevated levels of lead in relation to the remainder of the site and also possibly zinc. The elevated lead levels are found primarily in the subsurface (5 to 6.5 feet) and are believed to be associated with the fill material.

2. The southwest drainage path which was observed to contain elevated levels of soluble lead.

3. Isolated regions of elevated metal concentrations such as borings 127 for copper, and 26 and 51 for zinc.

Potential sources of organics are located primarily in areas of prior site activity and are identified as:

1. The former asphalt facility where elevated levels of oil and grease, PAHs and phenols were observed.

2. Area 6 where PAHs and PCBs were identified.

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3. Isolated localized regions such as: sample locations MO-2, MO-3, 116, and 118 which contained PAHs; the area east of the former asphalt facility where visible asphalt material has been observed; and localized pockets of oil in the subsurface which still may exist.

Evaluation of chemical distributions at the site and their potential impact to areas adjacent to the site is complicated by potential contribution from offsite sources, including the following:

- Runoff from the highway bordering the site (I-580).
- Urban stormwater runoff from the watershed that drains toward the Stege Drainage Channel adjacent to the site.
- Dry and wet deposition from nearby industries and automobile exhaust.
- The San Francisco Bay, through tidal waters in the marshes.

Interstate-580, located adjacent to the site, is potentially a significant contributor of chemicals to the site due to the proximity of the highway and the heavy volume of traffic. PAHs from the highway and resulting from incomplete combustion of automobile fuels, and lead from the combustion of leaded gasoline are the principal chemicals potentially introduced to the site through runoff and wet and dry deposition.

Urban stormwater runoff from the watershed north and northeast of the site to the Stege Drainage Channel and to drainage channels entering the Hoffman Marsh may be transporting chemicals to the site and Hoffman Marsh. Studies in the San Francisco Bay Area including Richmond have focused on oil and grease transport from commercial parking areas and streets (ABAG 1982, 1985). One conclusion of these studies is that there are significant effects of low levels of oil and grease pollution

and that continuous low level pollution of the type found in urban storm water can change the ecology of a marine environment (ABAG 1982). Metals and other chemicals can also be transported by stormwater runoff.

The Liquid Gold site is bounded by the Stauffer Chemical facility to the north and Point Isabel to the south. Both of these sites are of interest because chemicals were used and/or disposed of on them. The concern at Stauffer Chemical has been mainly with pesticides. It is unlikely that the area of the Liquid Gold site under investigation has been affected by conditions at Stauffer Chemical. At Point Isabel, the focus of the site cleanup activities was on the presence of elevated levels of lead and zinc in soils and Bay sediments. The influence, if any, of those chemicals at the Liquid Gold site was not investigated. However, the Hoffman Channel, from which sediment has been excavated as a remedial action, is the drainage channel for Hoffman Marsh, which extends to the Liquid Gold site. The potential therefore exists for transport of chemicals between sites by tidal action.

The San Francisco Bay can also possibly serve as a source of chemicals to the marshes. For example, point and non-point source discharges around the Bay and accidental spills from oil tankers likely contribute to hydrocarbon levels in Bay waters. Oils and other chemicals, including metals, may be carried by tidal action and deposited in marsh areas, such as those adjacent to the site. Deposits from such offsite sources complicate an evaluation of chemicals present as a result of past releases from the site.

7.3.2 Assessment of Fate and Transport of Site Chemicals

This section presents an analysis of potential chemical fate and migration pathways of the chemicals present at the Liquid Gold site. The Liquid Gold site has several distinct environments present, and each which has unique conditions which affect the fate and transport of chemicals. The approach for the analysis first describes the environment, then identifies the important pathways in the environment,

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and finally evaluates chemical movement in the pathways. This approach requires some reasonable assumptions as to the character and proportions of the specific environments.

There are three principal environments in which source areas are located; surface soils, subsurface soils, and estuarine. Surface soils are characterized as nonhomogeneous fill material placed at different times, and thus the surface soils have a varied mineralogy. The soil surface is generally expected to be the zone containing the greatest amount of organic matter because vegetation and other soil biota grow and accumulate in this zone. Surface soils are expected to be aerobic, except when temporary ponding occurs in localized regions such as in topographic depression during periods of high rainfall. The pH of the soil is expected to be in the neutral range (pH - 6 to 7.5). This is the typical range of pHs for soils in this region, which is characterized by a temperate climate and moderate rainfall.

Source areas located in the subsurface are in fill material. Similarly to surface soils, the mineralogy is varied as demonstrated by the boring log descriptions which note materials ranging from gravels to clays. The organic matter content of the subsurface soil is expected to be low unless inherent in the fill material or unless fill was placed on existing organic material. The redox environment is generally expected to be aerobic. However, water logging of soil or the rising of the water table during the rainy season may create anaerobic conditions due to reduced oxygen diffusion rates. The pH of the soil is also expected to be in the neutral range for the reasons given previously.

The marsh areas (Hoffman Marsh and South drainage channel) presents environmental conditions very different from the two previous environments. Due to the hydrologic connection of the marsh with the Bay, the marsh water has high ionic strength, and in particular a high chloride content. This salinity has a bearing in the fate of chemicals, primarily metals. The organic matter content of the soils in the marsh are expected to be high because of biological growth and deposition of

organic matter from tidal action. The redox environment is expected to be generally reducing in the marsh soils and channel bottom. However, in the uplands where soils are better drained and throughout most of the water column, the redox environment is oxidizing. The mineralogy is expected to be high in clays as it is a major component of the Bay mud and clays. The pH is expected to be neutral to slightly alkaline.

7.3.2.1 Metals

The primary source areas for metals is in the subsurface in Area A, and the Southwest Drainage. The four metals of concern (copper, lead, mercury, and zinc) are expected to be immobile in the subsurface due to the formation of low solubility precipitates of hydroxides and carbonates, and to adsorption to surfaces of metal oxides and hydroxides amorphous minerals. The mobility of copper and zinc is expected to be low in reducing environments due to the formation of low solubility sulfides, and the solubility of lead is expected to remain unchanged (Hermann and Neumann-Mahlkau 1985).

In the saline marsh waters the solubility of these metals may be enhanced, compared to fresh water, by the formation of chloride complexes. However, in the organic rich environment the metals are expected to be strongly complexed with soil humic material. Thus, metals of concern are expected to be immobile because of formation of precipitates of low solubility and/or stable complexes with humic material.

Due to their low mobility, the metals in surface soil are not expected to move with infiltrating water into the soil profile. The elevated metal concentrations in the subsurface in Area A and the lack of vertical gradient in metal concentration suggest a lack of vertical migration and is further evidence of the fill material being the source of the elevated metal concentrations.

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No major sources of surface soils containing mercury have been identified at the site. Locations where mercury were detected at elevated levels were sporadic, few in number, and in the subsurface. Due to the strong adsorption of mercury to soil organic matter, the most probable mechanism of transport is through surface runoff of particulates containing mercury to the drainage channels. The site is probably not the source of mercury in the drainage channels since surface sources at the site were not identified and sediment transport is over short distances. Thus, it is even less probable that mercury in Transect 2 which is located at a remote distance from the site originated from the site. A more probable source of elevated metals in the drainage channels is from non-point runoff from the urban areas and the highway and from tidal action depositing sediments containing metals which are subsequently bioconcentrated. This scenario is supported by the elevated concentrations of metals present in Transect 2 (Figure 56) of which the most probable source is runoff from the highway due to its proximity to the drainage channel.

7.3.2.2 PAHs

PAHs have been identified at the Former Asphalt Facility, Area 6, Biological Study Transects 1 and 6, composite borings MO-2 and MO-3, and at various other locations showing low PAH levels (less than 2 ppm total PAH concentration). Although PAHs have generally been detected in shallow borings, some subsurface locations have been found to contain PAHs. PAHs are expected to be strongly adsorbed to the organic fraction of soils and therefore, concentrated in the surface and do not readily migrate to the subsurface. The process by which PAHs have come to reside in the subsurface is unknown. Immobile compounds such as PAHs may be transported to the subsurface by facilitative processes or by direct placement.

Surface runoff transport of sediments containing PAHs from the site is a possible mechanism for the introduction of PAHs to Transects 1 and 6.

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However, because sediment transport occurs over short distances, the site is probably not the source of PAHs in Transects 2, 3, 4, and 5.

In addition to adsorption and surface runoff transport, another important fate process is biotransformation. Biotransformation processes are most efficient in aerobic environments and thus degradation in channel bottoms is expected to be slow.

PAHs may also be transported offsite through wind dispersal of surface soils containing PAHs. The degree of dispersal is dependent on such factors as wind speed, surface characteristics (e.g., vegetative cover, presence of a crust), and soil surface disturbances such as vehicle traffic.

7.3.2.3 PCBs

PCBs are not widely present at the site as they have only been detected at two locations, the highest concentration being 3 ppm. Therefore, the site is not expected to be a significant source of PCBs for offsite migration. However, PCBs have been detected widely in Hoffman Marsh in Transects 3, 5 and 6 at concentrations below 1 ppm. The most probable source is environmental cycling via air deposition or from organic matter deposition by tidal action; as has been noted previously, PCBs appear to be ubiquitous in the general environment.

The dominant processes governing the fate of PCBs are adsorption, volatilization, and biotransformation. Due to the strong adsorption, PCBs are not transported into the subsurface soils. Biotransformation rates are slow and reducing conditions are important for the reductive dechlorination of the higher chlorinated congeners.

7.3.2.4 Phenols

The distribution of phenols is limited to two borings at the former Asphalt Facility. The main process governing the fate of the phenolic

compounds is solubilization in water and subsequent transport to groundwater.

7.3.2.5 Summary

In summary, the metals of interest are relatively immobile and are not expected to migrate. PAHs are strongly adsorbed to soils and the most probable mechanism for transport is through erosion and sediment transport. This is a possible mechanism for the introduction of PAHs into Transects 1 and 6 of Hoffman Marsh. However, due to the distance of Transects 2, 3, 4, and 5 from the site, the site is not the probable source of PAHs. The distribution of PCBs at the site are not widespread and at low levels. Therefore, PCB levels offsite are probably not due to site contributions. Phenols are readily mobile in the environment. However, the distribution at the site is limited to a small area.

SECTION 8

PUBLIC HEALTH EVALUATION

This chapter provides an evaluation of the potential human health risks associated with chemicals at or from the Liquid Gold site. The analysis is based on information provided in the previous chapters and is an extension of the public health sections of the previously submitted preliminary public health and environmental evaluation (PHEE) (K/J/C 1988b), which is summarized first.

8.1 SUMMARY OF THE PRELIMINARY PUBLIC HEALTH EVALUATION

The preliminary public health and environmental evaluation (PHEE) was submitted on 15 January 1988 (K/J/C 1988b). The document was reissued in June 1988 with an addendum that included agency comments on the original report, responses to the comments, and a summary of agreements reached at a meeting with the agencies held on 28 March 1988. Objectives of the preliminary PHEE included initial identification and characterization of the following based on available data:

a. Hazardous substances and/or hazardous wastes present in all relevant media (air, groundwater, surface water, soil, sediment, and biota).

b. Environmental fate and transport mechanisms within each environmental medium.

c. Intrinsic toxicological properties, human health standards, and criteria of the identified hazardous substances or hazardous wastes.

d. Potential exposure pathways and extent of expected potential exposure.

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e. Populations potentially at risk.

f. Magnitude of potential health hazards and the likelihood of adverse health effects occurring.

Data gaps and information needs were also identified for further consideration prior to completion of this final public health and environmental evaluation.

The following conclusions were drawn in the preliminary PHEE regarding the Liquid Gold site's possible impact on public health:

- Preliminary calculations indicate that on the basis of observed highest indicator chemical concentrations, potential worker exposure from inhalation of surface soils (as fugitive dust) is below the occupational limits for the indicator chemicals. It is unlikely that even under worst-case conditions onsite that the nearest residence, located one-quarter mile southeast of the site, will be exposed to significant quantities of fugitive dusts from the site.

- Calculated soil ingestion values for the indicator chemicals are below applicable criteria for acceptable daily intake levels. Therefore, ingestion is not a route of exposure warranting further public health evaluation.

- A possible route of exposure of public health concern is ingestion of groundwater from the deeper groundwater zone, if it can be developed as a future beneficial source of drinking water. However, preliminary information indicates that this may not be possible. Average concentrations of lead and chromium in unfiltered groundwater samples from the deeper groundwater zone exceed Federal and State drinking water standards. Average metals concentrations in filtered water samples were below Federal and State drinking water standards, although maximum

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concentrations in a few samples did exceed standards. The filtered water samples would be representative of groundwater quality for domestic use.

- General rubble and abandoned buildings and trailers on the Liquid Gold site constitute a public welfare concern. Such areas should be completely fenced and secured to prevent access to the site by unauthorized persons.

The following recommendations were presented in the preliminary PHEE. The chemicals found in groundwater would not be a public health concern if the groundwater is found not to be useful as a drinking water source. Reported data on groundwater in the vicinity of the site indicate that drinking water standards for at least coliform and manganese are exceeded. An analysis for these and other water quality parameters of groundwater samples from monitoring wells at the site was recommended to determine the suitability of the groundwater as a drinking water source.

8.2 APPROACH

The Consent Order specified that the Superfund Public Health Evaluation Manual (SPHEM) should be used as guidance in preparing the final PHEE. Consequently, a structure similar to that used in the preliminary PHEE will be used here. However, certain aspects of new EPA guidance on risk assessments will be incorporated. For instance, public health evaluations are now described as human health evaluations. The basic parts of a human health evaluation are:

- Baseline risk assessment
- Development of preliminary remediation goals
- Remedial alternative risk evaluation

This section presents the baseline risk assessment. The other two parts are included in the feasibility study (FS) process. Preliminary applicable or relevant and appropriate requirements (ARARs) were

presented in a letter to the agencies dated 14 April 1989. Final remediation goals, to be presented in the FS report, will be based on information provided in this baseline risk assessment and ARARs. The FS report will also include a risk evaluation of remedial alternatives.

The preliminary PHEE was conducted using indicator chemicals to limit the analysis, following EPA guidance in the SPHEM. Current EPA guidance is that indicator chemicals should only be used in special cases. For completeness, this human health evaluation will not be limited to indicator chemicals.

The primary components of the baseline risk assessment are:

- Exposure Assessment - which estimates the magnitude of potential human exposures, the frequency and duration of these exposures, and the potential exposure pathways.

- Toxicity Assessment - which considers the types of adverse health effects associated with chemical exposures, the relationship between magnitude of exposure and adverse effects, and related uncertainties.

- Risk Characterization - which combines information from both the exposure assessment and the toxicity assessment to characterize potential baseline risks, both quantitatively and qualitatively.

These components are presented in the following three sections.

8.3 EXPOSURE ASSESSMENT

The routes of potential exposure discussed in the preliminary PHEE were:

- Inhalation of airborne dusts
- Ingestion of groundwater and surface water

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- Direct contact with groundwater, surface water, soils, or sediments
- Ingestion of soils and sediments
- Consumption of shellfish from near the site

The three routes chosen in the preliminary PHEE as major routes for evaluation were inhalation of dusts, ingestion of groundwater and ingestion of soil. These routes are further evaluated here with regard to new data collected during the final phase of the remedial investigation.

Exposure Scenarios

The following three exposure scenarios were evaluated:

1. Children and adults in a residential setting
2. Adults in an office building setting
3. Children trespassing on an undeveloped site

Residential exposure was evaluated as the most conservative future scenario. The office building scenario was evaluated as a more realistic future exposure scenario. In addition to future development exposure scenarios, a current exposure scenario was evaluated. Because of sporadic and expected low potential current exposure, the current exposure scenario was a trespass scenario assuming no development of the site.

Exposure assumptions specific to the various media are provided below for each exposure route. A lifetime (70 years) of exposure was assumed for residential exposure. Office exposure assumed a working life of potential exposure. Potential exposure to trespassing children will be intermittent. The specific exposure values used are provided in the sections below for the calculation of inhalation or ingestion intakes.

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For potential exposure to soil (inhalation of dust or ingestion of soil), the following soil areas were considered for evaluation in the risk assessment:

- overall site (at depths of 0-1.5, 5-6.5, and 10-11.5 feet)
- Area A (found to contain the highest concentrations of lead at 5-6.5 feet)
- Specific areas representing possible 0.5 to 1 acre residential lots (at depths of 0-1.5, 5-6.5, and 10-11.5 feet)

The areas representing the possible residential lots are shown on Figure 60. Chemical data for the lots are summarized in Tables 34 and 35. For the purpose of the risk assessment, soil samples from cores collected at 0 to 2 feet were considered surface soil samples. This definition differs from that used in other sections describing chemical distribution in soil. In Sections 3 and 6, surface soil samples are defined as soil samples collected in the top few inches of surface soil.

Given that soil samples were collected primarily from fill material, appropriate background soil metal concentrations could not be determined. Therefore, total soil metal concentrations (Table 34) were used in this risk assessment rather than incremental (above background) concentrations commonly used in risk assessments. This approach for evaluating potential risks is conservative.

After consideration of the September 1988 soil data primarily for lead and the carcinogenic PAHs, and on the recommendation of the DHS and EPA, Lot 4 was chosen as the specific area to be evaluated further in the risk assessment. Lot 4 was also further characterized in September and October 1990 as discussed in Section 3.2. On the basis of the 1990 soil data, Lot 4 was expanded to include the area shown in Figure 60.

Samples added to delineate Lot 4 (L4-1 to L4-5), and some additional surface samples (Cr1 to Cr4), were analyzed for chromium VI. Given the low levels of chromium VI found, it was agreed that additional

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collection and analysis of soil samples for chromium VI was not necessary. It is unlikely that the levels of chromium VI present at the site were contributed by activities at the Liquid Gold facility. However, for completeness, the assessment presented here includes an evaluation of potential exposure to chromium VI in Lot 4, essentially as part of an assessment of fill material. Given the limited data, an evaluation of chromium VI levels across the rest of the site was not made.

8.3.1 Soil Inhalation

Available data on prevailing wind direction, wind speed, and geographical features affecting wind patterns (CARB 1984) indicate that dusts from the site could be transported offsite. The annual average predominant wind speed at the two monitoring stations closest to the site is approximately 11 mph from the west and southwest, indicating moderate winds from the Bay. The nearest potentially exposed residential population offsite is located approximately one-quarter mile southeast of the site. Airborne dusts potentially containing metals or organics are expected to be greatest near the site and decrease with increasing distance from the site.

The extent of exposure to metals via inhalation of dusts under present site conditions is not expected to be significant. Intermittent human exposure to dusts possibly containing metals may occur during periods of high winds or unusually dusty conditions resulting from construction activities. Data on airborne dusts and metals concentrations are not available; however, calculated potential exposures are discussed below.

To evaluate the potential extent of exposure to airborne dusts containing chemicals, a dust concentration of 0.03 mg/m^3 was assumed. This value is the annual average, California ambient air quality standard for suspended particulate matter (PM_{10}). It is also the average PM_{10} concentration for Richmond in 1989 (BAAQMD 1990). Concentrations of chemicals in air were then calculated by using

95 percent upper confidence intervals on metal and organic concentrations in site surface soils. The results of the calculations are shown in Table 36. The average concentrations of chemicals used here are approximately the same as past data used previously in the preliminary PHEE. Potential chemical intake by inhalation was calculated using the following formula:

$$\text{Intake (mg/Kg•day)} = \frac{CA \times IR \times EF \times ED}{BW \times AT}$$

where: CA = Calculated chemical concentration in air (mg/m^3) from Table 36

IR = Inhalation Rate
20 m^3/day for residential child and adult
10 m^3/day for office adult
4 m^3/day for trespassing child

EF = Exposure Frequency
365 days/year for residential child and adult
250 days/year for office adult
12 days/year for trespassing child

ED = Exposure Duration
70 years for residential child and adult
46 years for office adult
6 years for trespassing child

BW = Body Weight
70 Kg for adult
16 Kg for child

AT = Averaging Time
70 years x 365 days/year for carcinogenic effects
ED x 365 days/year for noncarcinogenic effects

Potential intake values are shown in Table 36.

8.3.2 Groundwater

The shallow aquifer underlying the site is not used as a drinking water source. There is no identifiable human population that is considered to be at risk of exposure to groundwater from the shallow aquifer at the site. The average measured specific conductivity of approximately

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18,000 micromhos/cm for groundwater from the shallow aquifer onsite suggests a high concentration of total dissolved solids (TDS). This specific conductivity exceeds the DHS upper maximum contaminated level of 1,600 micromhos/cm for domestic water (CCR 1987). It is highly unlikely that the shallow groundwater zone will have potential beneficial use as drinking water due to low expected yields. The shallow groundwater zone probably consists of relatively closed-basin compartments during the dry season.

Presently, there are no known beneficial uses associated with the deeper groundwater aquifer zone underlying the site. Groundwater from below 90 feet is reportedly used for industrial and domestic purposes upgradient of the site (DOT 1978). The greatest depth screened by Liquid Gold monitoring wells lies at 35 feet below ground surface, under which lies a low-permeability clay of unknown thickness. Because of the presence of this clay, it is unlikely that groundwater monitored at the site is connected to any deeper aquifer. Due to the difference in depth (35 versus 90 feet), along with the observed poor water quality and low yield, it is unlikely the deeper groundwater zone onsite is the same zone described in the DOT report. If it is in fact the same zone, there is still no beneficial use for this groundwater due to both quality and quantity criteria. Well locations in the vicinity of the site are shown on Figure 27.

Therefore, exposure to chemicals which may be present in either groundwater aquifer zone is not likely and is not considered a public health concern under current conditions.

8.3.3 Soil Ingestion

Intentional ingestion of soil from the site is not likely except as a behavior displayed by children. Indirect ingestion of soil by adults may occur, for example, through accumulation of soil on skin and subsequent ingestion of foods which have contacted the soils from unwashed hands.

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For residential exposure, the extent of exposure to chemicals in soil was estimated using an average daily soil ingestion estimate of 0.1 g of soil over a 75-year lifetime (EPA 1989a). This value is the upper end of values suggested by EPA for adult ingestion rates (0.001 g/day to 0.1 g/day). Ingestion rates for children may be higher (average 0.2 g/day).

Chemical ingestion rates were calculated by depth for the entire site, Area A, and Lot 4. For surface soils (0 to 2 feet), 95 percent upper confidence limits on the mean for metal and organic concentrations were used, as discussed above for inhalation exposure. For subsurface soils, similar calculations were performed.

Potential chemical intake by ingestion was calculated using the following formula:

$$\text{Intake (mg/Kg day)} = \frac{CS \times IR \times FI \times EF \times ED}{BW \times AT}$$

where: CS = Chemical concentration in soil (mg/Kg) from Table 37

IR = Ingestion Rate
0.0001 Kg/day for adult
0.0002 Kg/day for child

FI = Fraction ingested from soil
Conservatively set at 1

EF = Exposure Frequency
365 days/year for residential child and adult
250 days/year for office adult
12 days/year for trespassing child

ED = Exposure Duration
70 years for residential child and adult
46 years for office adult
6 years for trespassing child

BW = Body Weight
70 Kg for adult
16 Kg for child

AT = Averaging Time
70 years x 365 days/year for carcinogenic effects
ED x 365 days/year for noncarcinogenic effects

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Calculated potential chemical intakes from surface and subsurface soil ingestion are shown in Table 37.

8.4 TOXICITY ASSESSMENT

The toxicity of chemicals was evaluated primarily on the basis of derived acceptable daily intakes for noncarcinogenic effects, and potency slope factors for potential carcinogenic effects. Available health based criteria were also addressed. Explanations of the toxicity information are presented below, first for noncarcinogenic effects, and then for potential carcinogenic effects.

8.4.1 Noncarcinogenic Toxic Effects

The numeric indicators of toxicity used in the evaluation are Reference Dose (RfD) values cited in the literature. Reference Doses for chronic exposure are the maximum daily concentrations (expressed as milligrams per kilogram of body weight per day) which would be allowable without observed health effects (EPA 1989a). Subchronic and chronic values are derived from quantitative information available from animal studies or observations made in human epidemiological studies relating intake and noncarcinogenic effects. The highest subchronic or chronic exposure level not causing adverse effects or the no-observed-adverse-effect-level (NOAEL) is determined from available studies reported in the literature. The no-observed-adverse-effect-level is then divided by appropriate uncertainty factors (typically 100 to 1,000) to yield the RfD. RfDs are designed to be protective of sensitive populations.

Critical toxicity values for the oral and inhalation routes of human exposure are shown in Table 38. These values are given in the U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) and Health Effects Assessment Summary Tables (EPA 1989d). For some chemicals, the EPA does not have recently established RfDs.

Although these chemicals do not appear to be critical to an evaluation of the site, the absence of RfDs prohibits the completion of a risk evaluation with a consistent set of toxicity values. As an alternative approach to confirm that potential chemicals of concern are not being overlooked because of lack of RfD toxicity data, Acceptable Intake values for chronic exposure (AICs) were used for comparison. AICs were given in Appendix A of the old Superfund Public Health Evaluation Manual (EPA 1986), and are the maximum daily concentrations which would be allowable without observed health effects. AICs were expressed as milligram per kilogram of body weight per day, and were often derived from RfDs. The preliminary PHEE included a toxicity evaluation based on AICs.

8.4.2 Lead

An RfD has not been established by the EPA for lead, although efforts are currently underway at the EPA to develop factors. Prior to finalizing the toxicity values, the EPA has set forth interim guidance on establishing soil lead cleanup levels at Superfund sites (EPA 1989c). The cleanup level is set at 500 mg/Kg to 1000 mg/Kg, which the EPA considers protective for contact at residential settings.

The EPA guidance values will not be used, however, because it was agreed with the EPA and DHS that a DHS procedure for evaluating potential toxic responses to lead intake would be followed. The correlation used by DHS is 0.16 ug/dL increase in blood lead per 1 ug/day ingested lead (DHS 1990). This value was derived from data on infants, but is also used by the DHS for older children. Also, because there may be pregnant women in an adult population potentially exposed to lead, the correlation is also used by the DHS to evaluate exposure to adults.

The DHS uses 15 ug/dL as an acceptable level of lead in blood (ASTDR 1989). Using the correlation between ingested lead and blood lead levels, an acceptable daily intake from sources other than diet was calculated as follows:

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$$\frac{15 \text{ ug/dL acceptable blood lead}}{0.16 \text{ ug/dL per ug/day}} = 94 \text{ ug/day acceptable lead intake (total)}$$

The DHS considers 20 ug/day as the normal dietary intake of lead. Subtracting this value from the total acceptable lead intake gives an acceptable lead intake from sources other than diet:

94 ug/day acceptable lead intake (total)	-	20 ug/day dietary lead intake	=	74 ug/day (0.074 mg/day) acceptable lead intake

This value was used to derive the acceptable intake value shown in Table 38 assuming an average child weight of 16 Kg:

$$\frac{0.074 \text{ mg/day}}{16 \text{ Kg}} = 4.6 \times 10^{-3} \text{ mg/Kg}\bullet\text{day acceptable lead intake}$$

Because lead was the only chemical found to be consistently higher in one area (Area A), the following calculation was performed to find the levels in soil corresponding to acceptable lead intakes. For a child consuming 0.2 g/day (0.0002 Kg/day) of soil, the acceptable soil lead concentration was calculated to be:

$$\frac{0.074 \text{ mg lead/day}}{0.0002 \text{ Kg soil/day}} = 370 \text{ mg/Kg of lead in soil for children}$$

An acceptable soil lead concentration for adults could be calculated by factoring in the greater body weight of an adult and the lower rate of daily soil consumption. The result would be an acceptable soil level almost an order of magnitude greater than that for children. Because it is not clear if such a calculation would be an appropriate extension of the original data derived from children, an acceptable soil lead concentration for adults is not offered. Given that the risk assessment is focused on children as the primary receptors for chemicals with noncarcinogenic effects, and that decisions would be made on this basis, it was not a priority to pursue the issue of an acceptable soil lead level for adults. However, for the purpose of this assessment, the

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acceptable intake for lead given in Table 38 will be applied in a manner consistent with that of the RfDs.

8.4.3 Potential Carcinogenic Effects

Derivation of acceptable intakes for carcinogens, using the same approach as noncarcinogens, is not possible given the EPA's assumption that carcinogens do not have threshold levels. Instead, potential adverse effects are evaluated based on the probability of contracting cancer. Slope Factors (SF), previously called Carcinogenic Potency Factors, are derived by the EPA for chemicals with possible carcinogenic effects. The SF is expressed as the excess lifetime risk of cancer, per milligram of chemical intake, per kilogram of body weight, per day. Slope factors for the potentially carcinogenic chemicals are shown in Table 39. The carcinogenic potency of the PAHs is currently under review by EPA. Until this evaluation is completed, EPA policy is to use the slope factor for benzo[a]pyrene for all of the carcinogenic PAHs. This information is included in Table 39. The EPA derives carcinogenic potency factors using a linearized multistage model that estimates a plausible upper bound on risk. The approach likely overstates the risk of cancer.

8.5 RISK CHARACTERIZATION

8.5.1 Noncarcinogenic Characterization

The human health evaluation is completed separately for carcinogenic and noncarcinogenic chemicals. For noncarcinogens, potential exposures (expressed as mg/Kg•day) for the relevant pathways are directly compared with reference doses (also in mg/Kg•day), or acceptable intakes if RfDs are not available. The ratio of the potential exposure to the RfD is called the hazard quotient. A potential health concern is indicated if the calculated potential exposure is greater than the RfD (hazard quotient greater than 1).

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To assess the overall potential for noncarcinogenic effects posed by more than one chemical, a hazard index (HI) was calculated. The HI is the sum of the hazard quotients for the various chemicals for a specific exposure scenario and pathway:

$$HI = \frac{E_1}{RfD_1} + \frac{E_2}{RfD_2} + \ldots + \frac{E_i}{RfD_i}$$

where: E = Exposure intake for i^{th} chemical (mg/Kg•day)
RfD = Reference dose for i^{th} chemical (mg/Kg•day)

Hazard quotients and hazard indices are given on Table 40 for the residential child exposure scenario, Table 41 for the residential adult exposure scenario, Table 42 for the office adult exposure scenario, and Table 43 for the trespassing child scenario. A potential health concern is indicated if the hazard index is greater than 1.

Of the different exposure scenarios, a hazard index of 1 was exceeded only for residential child ingestion exposure. This occurred at the following locations:

- Lot 4 (0 to 2 feet and 5 to 6.5 feet)
- Area A (5 to 6.5 feet)
- Entire Site (5 to 6.5 feet)

In all cases, lead in soil provided the primary contribution to the hazard index. The presence of lead in soil in Area A and Lot 4 is the reason why the hazard index for the entire site at 5 to 6.5 feet exceeds 1 for residential exposure of soil ingested by children. Lead concentrations at the 5 to 6.5-foot depth outside of Area A are considerably lower than those within Area A (Table 26). The associated hazard quotient for residential exposure of children to lead in soil at 5 to 6.5 feet outside of Area A is 0.2. Therefore, Lot 4 (at 0 to 2 feet and 5 to 6.5 feet) and Area A (at 5 to 6.5 feet) are considered the areas of concern due to potential exposure of children to lead in

soil in a residential setting. Residential exposure is a potential future exposure scenario. There is currently no exposure of this magnitude occurring, and an evaluation of potential current exposure to trespassing children did not show a potential health risk.

8.5.2 Carcinogenic Characterization

For carcinogens, a different method of evaluation is used. Calculated potential exposure rates were multiplied by slope factors to arrive at a lifetime incremental cancer risk:

$$\text{Risk} = \text{CDI} \times \text{SF}$$

where:

Risk = incremental probability of an individual developing cancer from a lifetime of exposure

CDI = chronic daily intake averaged over a lifetime (mg/Kg•day)

SF = slope factor $(\text{mg/Kg}\bullet\text{day})^{-1}$

Table 44 provides the calculated lifetime incremental cancer risks for the two long-term exposure scenarios. Also shown are the aggregate lifetime incremental cancer risks calculated by summing the potential risks associated with the individual chemicals.

The highest calculated lifetime incremental cancer risks were for potential ingestion of soil by adults residing in Lot 4. The calculated lifetime incremental cancer risks were approximately 1×10^{-4}, varying slightly with depth depending primarily on the presence of PAHs. At the 10 to 11.5-foot depth in Lot 4, the calculated risk was entirely due to PAHs in one of the eight borings.

Calculated lifetime incremental cancer risks to adult office workers in Lot 4 (in the range of 2×10^{-5} to 3×10^{-5}) were a factor of 4 less than calculated risks to residential adults. Calculated lifetime incremental

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cancer risks to both office and residential adults in Area A and the entire site were the lowest (in the range of 10^{-6} to 10^{-5}).

Although the choice of an acceptable level is a risk management decision, the maximum calculated lifetime incremental cancer risks are at the upper end of the range of 10^{-4} to 10^{-6} that the EPA uses for Superfund site remediation goals. The calculated risks are hypothetical risks only, and were calculated to evaluate potential long-term future exposure. The following factors should be considered when interpreting the results:

- Long-term human exposure (e.g. continual exposure for 70 years) is not currently occurring on the site. Potential exposure is limited to intermittent and brief visits by adult workers involved with the site investigation.

- Exposure to subsurface soils does not currently occur.

- Potential cancer risks are due to chemicals from a small number of sample locations.

- Slope factors for carcinogens are based on 95 percent upper confidence intervals.

For the above reasons, the results of the baseline human health risk evaluation should not be taken as a characterization of absolute risk. The primary goal is to highlight potential sources of risk from chemicals at the site so that they can be addressed, if necessary, later in the remedial process.

Given the information presented above, it appears that the calculated lifetime incremental cancer risks associated with potential exposure to surface and subsurface soils in Lot 4 may be considered unacceptable.

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There are two potential exposures at the site that could not be characterized due to lack of toxicological information: potential exposure to apparent asphalt on surface soil in the area of the old asphalt facility; and possible future exposure to oil at various subsurface locations. Potential exposure to small quantities of surface asphalt does not appear to be of major concern due to its apparent similarity to asphalt in widespread use in society. The potential risks due to exposure to oil were evaluated on the basis of specific toxic components of oils, primarily PAHs.

SECTION 9

ENVIRONMENTAL EVALUATION

During the final Environmental Evaluation, exposure, toxicity, and potential risks to the environment were assessed and conclusions and recommendations for remediation were developed. Previously submitted documents are referenced in Section 9.1 as background information. The methods used and the results of the final Environmental Evaluation are presented in subsequent sections.

9.1 BACKGROUND

A preliminary environmental evaluation was conducted by Kennedy/Jenks/Chilton and WESCO Inc. in 1987. The methods and results of that evaluation were presented in the Preliminary Public Health and Environmental Evaluation (PHEE) report submitted in 1988 (K/J/C 1988b). On the basis of conclusions presented in the preliminary PHEE, an ecological analysis of areas adjacent to the Liquid Gold site was recommended. A workplan for the ecological study with specific sampling tasks focused toward defining potential impacts to natural resources from Liquid Gold site activities was included in the RI/FS workplan (K/J/C 1988b). The results of the ecological study were incorporated in the Final Environmental Evaluation presented in the sections below.

9.2 FINAL ENVIRONMENTAL EVALUATION OBJECTIVES

The general objective of the Final Environmental Evaluation was to evaluate potential adverse environmental impact due to the past activities at the Liquid Gold site. A major component of the environmental evaluation is the ecological study. Specific objectives of the ecological study are presented in Section 5 of this report.

9.3 APPROACH AND SCOPE OF FINAL ENVIRONMENTAL EVALUATION

The approach used in the environmental evaluation will generally be similar to the human health evaluation. The major elements of the assessment are:

Exposure Assessment (Section 9.5) - which considers the magnitude of potential environmental exposure, pathways, and receptors.

Toxicity Assessment (Section 9.6) - which considers the types of adverse environmental effects associated with chemical exposure, and the relationship between magnitude of exposure and adverse effects.

Risk Characterization (Section 9.7) - which combines information from both the exposure assessment and the toxicity assessment to characterize (both quantitatively and qualitatively) potential risks to the environment. Appropriate environmental criteria were also applied in the risk characterization. In addition, results of field and laboratory studies that directly evaluate potential harm are incorporated into the risk characterization.

A major difference between the human health evaluation and the environmental evaluation is the availability of biological field data that can be used to directly characterize risk to the environment near the site. The final Environmental Evaluation is therefore based on both chemical and biological data. Chemical data were collected over a five year period from surface and subsurface soil, groundwater, sediment, and surface water. The extent of chemicals detected in these media is summarized in Section 6 of this report. The extent of sampling on the site for chemical analysis is shown on Figures 10 through 26. Biological data were collected from both onsite and offsite areas (Figures 56 and 57) (Appendix C) in an effort to assess current adverse effects due to the site.

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The scope of the biological sampling and analysis is covered in Section 5 and in greater detail in Appendices C and D. Review of the appendices is critical for an understanding of the final Environmental Evaluation. Biological data generally consisted of information on endemic and introduced flora and fauna from various habitats, as well as bioassay results. Organisms were investigated at a variety of trophic levels in a short term study. The biological parameters measured are summarized in Table 45.

9.4 STUDY AREA LOCATION AND BACKGROUND

The Liquid Gold site location and history is described in detail in Section 1 of this report. The study area included in the final Environmental Evaluation extends well beyond the limits of the Liquid Gold site as shown on Figure 2. General descriptions of onsite and offsite areas are presented below.

The general area in the vicinity of the site is urban and is characterized by the presence of industries such as a chemical plant, Stauffer Chemical, and a remediated hazardous waste site at Point Isabel. The Hoffman Channel, the main inflow channel to Hoffman Marsh, was dredged as part of the remediation of Point Isabel. A major highway, Hoffman Blvd (Highway 580), is located adjacent to the study area (Figure 1) and the study area is subject to highway runoff likely to contain metals and petroleum hydrocarbons. Residential areas are also located within one mile of the site.

The site, located in a former marsh area, is now an upland area consisting of fill material that has been disturbed repeatedly by construction and vehicle traffic. As a result, the vegetation is comprised mainly of weed species (Appendix C). Some landscaping was conducted and eucalyptus and pine trees have been planted onsite. The topography of the site including surface drainage is shown on Figure 26. Adjacent offsite areas consist mainly of pickleweed salt marsh and salt marsh transition areas delineated during the preliminary Public Health

and Environmental Evaluation (K/J/C 1988b) using the Army Corps of Engineers procedure. Impact to wetland areas adjacent to the site is of special interest because this habitat is regularly lost to filling. Gosselink and Baumann (1980) noted that wetlands are lost at a rate of about 3 percent per year in California. Wetlands serve as important nursery grounds for a variety of aquatic organisms, as well as essential habitat for shorebirds and some species of mammals. Hoffman Marsh is of particular value since it is designated an "unprotected and essential habitat" that is to be secured and managed (USFWS 1984). This status was designated as part of the recovery plan for two endangered species, the salt marsh harvest mouse and the California clapper rail, although neither species was observed in the study area during the remedial investigation (Appendix C).

Flora and resident and transient fauna are discussed in detail in Appendix C and lists of species observed in the study area are included. Several bird species and one plant species are of special interest in the study area. The salt marsh yellowthroat is a rare resident species, classified as a category 2 federal candidate species for listing on the U.S. Fish and Wildlife Service, (USFWS, DOI) endangered or threatened species list. At this time there is insufficient information to support a proposed rule on this species. One fully protected resident species, the black-shouldered kite, was observed in the study area. The "fully protected" status is designated by California Department of Fish and Game (CDFG). Two California species of special concern, the northern harrier and the short-eared owl, were observed in the study area. The northern harrier is a common migrant and winter resident and the short-eared owl is also likely to be observed in the winter months. These birds are not legally protected but are designated by CDFG as species of special concern due to declining breeding populations. The marsh gum plant, Grindelia humilis, is on the California Native Plant Society's Inventory of Rare and Endangered Vascular Plants of California watch list of plants with limited distributions. These listed plants are not legally protected. Additional information on these species is presented in Appendix C.

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No readily observed adverse impacts potentially attributable to the Liquid Gold Site have been noted. These types of observable impacts include stressed vegetation, fish kills, or visually obvious changes in species composition or distribution within a habitat.

9.5 EXPOSURE ASSESSMENT

In the exposure assessment, the sources of chemicals of interest, pathways by which plants and animals may be exposed to these chemicals, and plant and animal species that are potential receptors of exposure were evaluated. The exposure assessment is an initial step in prioritization of risks to the environment that may be associated with the site.

9.5.1 Source Media

Chemicals of interest with respect to the site were considered in the final Environmental Evaluation. Source media of chemicals of interest and pathways by which plant and animal populations may be exposed are presented in Table 46. As discussed in Section 6, chemicals are currently present to some extent in surface and subsurface soil, marsh sediment, and to a lesser extent in shallow groundwater underlying the site. Therefore, these media are sources of chemicals of interest for potential exposure of plant and animal populations. The chemicals of interest and other chemicals measured in various media are summarized in Table 47. Representative concentrations of chemicals of interest in source media are presented in Tables 31 and 48. Concentrations of chemicals in marsh sediment are shown on Figures 61 through 76.

The extent of oil in subsurface soils cannot be quantified. The empirical studies such as the marsh ecological field study and the site soil elutriate bioassay should identify adverse environmental effects associated with current conditions. However, it is difficult to predict the effects of potential future exposure to oil, such as through contact following excavation of subsurface soil.

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9.5.2 Pathways

The potential pathways for exposure were ranked and presented in Table 46. The ranking process for the exposure pathways is discussed below. The pathways, or release media, selected for further consideration were uptake of chemically affected marsh sediment, surface runoff to the marsh, ingestion of chemically affected surface soil, bioaccumulation of chemicals from marsh sediment, and discharge of chemically affected groundwater to the marsh. The EPA provides general guidance for evaluating exposure pathways (EPA 1988b). Principles presented in the guidance were used as a general means of ranking exposure pathways. According to the EPA guidance, the pathway should first be complete. The EPA defines a pathway as complete if there is (1) a source or chemical release from a source, (2) an exposure point where contact can occur, and (3) an exposure route by which contact can occur. Justification for omitting a complete pathway from a detailed evaluation include the following:

- The exposure resulting from the pathway is much less than that from another pathway involving the same medium at the same exposure point.

- The potential magnitude of exposure from a pathway is low.

- The probability of the exposure occurring is very low and risks associated with the occurrence are not high.

The above general guidance was used in ranking the exposure pathways. The following additional criteria were also evaluated during the ranking of the exposure pathways:

- concentrations of all chemicals of interest in source media during the remedial investigation

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- the presence or absence of rare, threatened, or endangered species in potential receptor habitats

- the sensitivity or uniqueness of receptor habitats

- the presence or absence of game species

- the likelihood or frequency of exposure via each pathway

Each of the above criteria were given equal weight during the evaluation and a summary of the evaluation of each of these criteria is presented below.

Concentrations of chemicals of interest in onsite source media are summarized in Tables 31 and 48. Average concentrations in source media were evaluated in selecting the pathways of interest. Source media considered include shallow groundwater, surface and subsurface soil, and marsh sediment.

Marsh sediment was considered separately because use of average concentrations was not appropriate for this medium as discussed in the study design (Section 5). On the basis of summary data presented in Tables 31 and 48, subsurface soil exposed by erosion or bioturbation was selected as a pathway of interest. A closer review of individual chemical concentrations in marsh sediment was conducted and potential trends in chemical concentrations with proximity to the site were reviewed (Figures 61 through 76). The evaluation of marsh sediment as a potential source is discussed below.

Offsite marsh sediments were analyzed for chemicals of interest and trends in concentrations were evaluated. Sediment sample analytical results are presented in Appendix C. The sediment and benthos study using transects is discussed in Section 5 and Appendix C. Transect 1 and Transect 6 sediment sampling locations were selected to measure chemical concentrations along the exposure pathways of direct

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availability of marsh sediment, past surface runoff from the site, and shallow groundwater discharge (Figure 56). These chemical concentrations were used to select pathways of potential concern. The relationship between each Transect 1 sample location and the chemical concentration in the sediment is shown for each chemical of interest on Figures 61 through 68. The NS samples included on these figures were collected in September 1988 and the other samples were collected in October 1988. Percent moisture was not measured in the NS samples, so a conservative assumed moisture content of 75 percent was used to convert to dry weight results for comparison with other sediment analytical results. On Figure 61, an apparent decreasing trend in oil and grease concentrations with greater distance from sampling point NS-18 was observed. NS-18 was collected near the marsh end of the southeast drainage channel (Figure 56), an area of historical discharge to the marsh. The total polycyclic aromatic hydrocarbon (PAH) data, graphed on Figure 62, do not follow this trend. The total PAHs in onsite soil also did not correlate with oil and grease data (Table 29). Total PAHs were summed from the detected base/neutral/acid extractable compounds (BNAs) summarized in Table 5 of Appendix C. The total PAH concentrations may reflect the influence of another source of chemicals (Section 7).

Results of heavy metal analyses of sediments in Transect 1 are shown on Figures 63 through 68. In Transect 1, no apparent trend was observed in metals concentrations with increasing distance from the site. PCBs were not detected in sediment samples from Transect 1.

For each chemical of interest, the relationship between the Transect 6 sample location and the chemical concentration in the sediment is shown on Figures 69 through 76. On Figure 69, an apparent decreasing trend in oil and grease concentrations with greater distance from the site along Transect 6 was observed. A similar decreasing trend was observed in total PAH concentrations (Figure 70), however, PAHs were detected in only two samples along Transect 6. This similarity is not consistent with the analytical results from Transect 1 locations or onsite soil samples discussed above. PCBs were detected in the sample location

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nearest the site in Transect 6. PCBs were not detected in other locations along this transect.

Results of heavy metal analyses of sediments in Transect 6 are shown on Figures 71 through 76. With the exception of lead concentrations shown on Figure 73, no apparent trend was observed in metals concentrations with increasing distance from the site. The observed trend in lead concentrations may be attributable to sediment transport of lead in surface runoff from fill (Section 7). Lead results from surface soil samples collected in 1985 in the southwest drainage channel are shown on Figure 10. These onsite lead levels were somewhat elevated with respect to ranges of lead concentrations typically found in soil (Table 18). The average lead concentration of the samples collected in the southwest drainage channel was 180 mg/Kg and the typical range for lead in surface soil was 2-200 mg/Kg. Therefore, on the basis of the fate and transport analysis in Section 7, lead in sediment in Transect 6 is not likely to be related to the past operations of the Liquid Gold site.

On the basis of chemical concentrations in sediments, direct availability of sediments to marsh biota was chosen as an exposure pathway potentially of concern. Concentrations of oil and grease in both Transects 1 and 6, and concentrations of lead in Transect 6 were of particular interest because there is an apparent decreasing trend in the chemical concentrations with increasing distance from the site or from historical discharge points.

In ranking the exposure pathways potentially of concern, the presence or absence of rare, threatened, or endangered species was considered. No state-or Federally-listed threatened or endangered species were observed in the study area. It is possible but unlikely that the endangered California clapper rail and the threatened California black rail are present in the marsh portions of the study area. Because there have been no recorded sightings of the black rail in the study area, it is considered unlikely to be present. Use of this area by the rails may be affected because there is little cover for the birds seeking refuge

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during high tide events, and substantial noise from vehicle traffic on Highway 580. The four bird species discussed in Section 9.4, the black-shouldered kite, the northern harrier, the short-eared owl, and the salt marsh yellowthroat, are of special interest to CDFG or USFWS and were observed in the study area. Because these sensitive species are known to be present in the marsh portions of the study area, exposure pathways to the marsh were selected for further evaluation. Direct availability of marsh sediment, bioaccumulation and subsequent exposure through the foodweb, surface water runoff to the marsh, and groundwater discharge to the marsh were selected as pathways for further consideration. These pathways were also selected on the basis of the ecological importance of salt marsh wetlands. The value of wetlands and Hoffman Marsh in particular was discussed in Section 9.4.

The presence of game species onsite was considered in ranking the pathways for further evaluation. Two species of dove, the rock dove and the mourning dove, have been observed onsite. On the basis of the presence of game species onsite, exposure of upland species to surface soil was selected as a pathway of interest.

On the basis of the likelihood or frequency of exposure via each exposure pathway, two pathways were selected for further evaluation. Direct availability of chemically affected marsh sediment results in a potentially ongoing exposure of benthic invertebrates and other marsh organisms to chemicals of interest. Direct availability of chemically affected surface soil could result in chronic exposure of upland species to chemicals of interest. Frequent exposure via other pathways was less likely because a release mechanism was necessary to result in exposure. Some pathways such as ingestion of subsurface soil were given a lower ranking because current site conditions are such that the source is not exposed.

In summary, direct exposure of marsh biota to potentially chemically affected sediment was chosen as the pathway of greatest concern. Other pathways that were considered for the final Environmental Evaluation

were chemically affected surface runoff to the marsh, ingestion of or direct contact with chemically affected surface soil, bioaccumulation of chemicals in marsh sediment and subsequent exposure via the foodweb, and discharge of chemically affected shallow groundwater to marsh areas. The complete ranking of exposure pathways is presented in Table 46.

9.5.3 Receptors

Potential receptor populations can be divided into two main groups on the basis of habitat use. The groups defined for this analysis are marsh biota primarily using the salt marsh habitat, and upland species primarily using onsite terrestrial habitat. Species observed in the study area are listed in Appendix C. Potential receptor populations, for exposure to chemicals of interest via the most likely exposure pathways, are considered below.

Marsh biota may be exposed via direct contact or ingestion of sediments, surface runoff to the marsh, groundwater discharge to the marsh, or bioaccumulation. These species include benthic infauna and epifauna, shorebirds mammals, and wetlands vegetation, all investigated as part of the ecological study summarized in Section 5. The four sensitive species of shorebirds and one sensitive plant species previously discussed in Section 9.4 are included in this group. This group also includes fishes and free-swimming invertebrates that were not studied due to the mobility of these species and the related difficulty in assessing the causes of any observed impacts.

Upland biota may be exposed via ingestion or contact with exposed surface soil. These species include small animals such as the house mouse, Norway rat, Western fence lizard, California ground squirrel, Bottae pocket gopher, and California vole. Larger mammals such as the red fox or striped skunk, birds, and ruderal vegetation may also be exposed to chemically affected surface soil.

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No state- or federally-listed threatened or endangered species were observed in either group in the study area. Additional information on sensitive species and distributions of receptor populations is presented in Appendix C.

9.6 TOXICITY EVALUATION

The toxicity of source media was evaluated using the results of bioassay testing (Appendix D), benthos density, and invertebrate and plant tissue analysis. These results were used to evaluate toxicity of source media to marsh biota. Potential toxicity of surface soil to upland biota was evaluated using available toxicity data developed using terrestrial test species (Table 49).

9.6.1 Marsh Biota

The primary pathways with respect to exposure of marsh biota to chemicals originating on the Liquid Gold site were summarized in Table 46. A discussion of toxicity associated with each pathway is presented below.

Potential toxic effects to the benthic community resulting from ingestion of, or direct contact with chemically affected marsh sediment was investigated by collecting and analyzing benthos samples from transects adjacent to the site and comparing the results with results from several other transects in the study area. This approach accounted primarily for direct exposure to chemically affected sediments, but would also include the secondary combined potential toxic effects of shallow groundwater discharge and surface runoff. Shallow groundwater is considered a secondary pathway of exposure because of the small quantity of water discharged and subsequent dilution, and because the discharge of shallow groundwater is likely to be limited to the south drainage channel (Figure 32). Groundwater flow in the shallow zone is discussed in detail in Section 4. The surface runoff pathway is also considered a secondary exposure pathway because of the small amount of

surface runoff from a few areas of the site (Section 4) and the low mobility of the chemicals of interest (Section 7). Surface drainage from the site is discussed in detail in Section 4. The benthos investigation was conducted to provide information on potential toxic effects from exposure via these pathways, and the results of the investigation are summarized below.

In general, the benthos community was similar between transects. However, Transect 1 sample location T1-1B (Figure 56) collected from the side-slope of the drainage channel was unique in the large numbers of oligochaetes and polychaetes and the low number of amphipods found there. Polychaetes and oligochaetes are considered less sensitive to chemical pollutants than other taxa identified in this study (Appendix C). The sampling locations along bottom of upper Transect 1 (T1-1A, T1-2A. T1-3A) were unique in the low numbers of cumaceans found in these locations. A similar pattern was noted in the upper end of Transect 2 (Table 15, Appendix C). However, chemical concentrations in these sample locations in Transects 1 and 2 did not follow a pattern that could be used to explain the benthos results. One notable exception was the chloride concentrations which were high in the upper end of both Transects (Tables 13 and 14, Appendix C). For Transects 1 through 4, the benthos community results were correlated with chloride content in the sediment and not correlated with concentrations of chemicals related to the operation of the Liquid Gold site (Appendix C). Therefore, although a gradient of oil and grease concentrations was observed in Transect 1, no toxic effects to the benthos community in Hoffman Marsh related to the past operation of the site could be identified during this study.

Benthos community data collected near the southwest drainage channel (Transect 6) were also evaluated for potential toxic effects. The data from Transect 6 were compared with data from Transect 5. Sample locations at the upper end of Transect 6 (T6-1A, T6-2A) were unique in the small number of cumaceans present in the samples. These same locations had high levels of oil and grease, total PAHs, and lead

relative to other sites in Transect 6 (see Figures 69, 70, and 73). Because the drainage channel at Transect 6 is very short, only a limited amount of data could be collected from this transect. Chemical concentrations could not be statistically correlated with benthos results from this transect. Factors other than chemical concentrations in this transect may explain the benthos results. Transect 6, especially T6-1, is subject to greater desiccation (Appendix C). However, environmental factors alone may not account for the impact observed at T6-1 (Appendix C). It is slightly more likely that the impact is a result of a combination of environmental factors and chemical concentrations, or chemical concentrations alone. The source of the observed chemical concentrations is unclear, and as discussed in Section 7, may not be the Liquid Gold site.

Potential toxic effects resulting from exposure of marsh biota via the surface runoff pathway was also investigated using surface soil elutriate bioassays. No detrimental effects attributable to chemical toxicity were observed in bioassays performed on one invertebrate test species, Ceriodaphnia dubia, and one species of alga, Selenastrum capricornutum (Appendix D).

Slow moving chemically-affected shallow groundwater may discharge to the marsh area of the south drainage channel during the wet season (Figure 32). Because wet season conditions did not exist during the scheduled time for wet season sediment and benthos sampling, subsurface soil elutriate bioassays with Ceriodaphnia and Selenastrum were used as one indication of the potential toxicity of wet season groundwater. No toxicity was observed during the subsurface soil elutriate bioassay testing that was attributable to chemicals of interest (Appendix D). Therefore, there is no indication from the bioassay study that shallow groundwater is a significant source of toxicity to marsh biota. Subsurface soil elutriates were believed to be conservative and therefore suitable to provide an indication of potential toxicity of shallow groundwater. The elutriate approach was conservative because several metal concentrations observed in the subsurface soil elutriates

from one or both elutriation methods (acidified deionized water or dilute mineral water) were greater than average metal concentrations in shallow groundwater for lead, nickel, copper, and mercury (Table 31 and Appendix D), the most toxic of the metals of interest in aquatic systems (EPA 1986).

Potential toxic effects due to bioaccumulation of chemicals of interest and subsequent exposure via the foodweb were investigated. Pickleweed, Salicornia sp., tissue was collected along the study area transects and analyzed for only metals of interest because petroleum hydrocarbons do not bioaccumulate in this plant (Appendix C). No relationship was observed between metals concentrations in pickleweed and proximity of the sampling location to the site. Additionally, there is a general lack of correlation between metals concentrations in pickleweed and sediment from the same location. Therefore, toxic effects due to bioaccumulation of chemicals, originating on the Liquid Gold site, in marsh plants are unlikely.

Potential bioaccumulation and subsequent exposure of shorebirds was also investigated by collecting yellow shore crabs, Hemigrapsus oregonensus, and analyzing the crab tissue for chemicals of interest. The mobility of yellow shore crabs is expected to be limited, so that there should be little overlap of populations between sampling locations, which were chosen at opposite ends of each transect. There is far less likelihood of overlap between populations in different transects, and differences between transects near the site and those farther away was the main focus of the ecological study. Organic chemicals were not detected in crab tissue and heavy metal concentrations in crab tissue were not correlated with heavy metal concentrations in the sediment. Additionally, the sediment sample collected nearest the site did not contain significantly elevated concentrations of heavy metals relative to other sampling locations (Appendix C). Therefore, toxic effects due to bioaccumulation of chemicals of interest in crab tissue, and subsequent ingestion of the crabs by predators, are not anticipated.

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Benthic infauna more commonly used for tissue analyses were observed in low numbers throughout the marsh regardless of proximity to the site. Collection of sufficient biomass of infauna for tissue analyses would have resulted in substantial habitat disruption. Therefore, infauna were not collected and the scope of the benthic tissue investigation was limited to analysis of epifauna tissue using the yellow shore crab.

In summary, it was concluded that there was no measurable adverse impact to the benthos in Hoffman Marsh (Transects 1 to 4) that could be attributed to the presence of chemicals from the Liquid Gold site. The impact observed in the upper end of the southwest drainage path (T6-1) may be at least partially attributable to the presence of chemicals in sediment, but the source of the chemicals is unclear. The benthos and sediment chemistry investigations are summarized in Section 5 and presented in detail in Appendix C.

9.6.2 Upland Biota

The primary exposure pathway of concern for upland species was ingestion of chemically affected surface soil (Table 46). To evaluate potential toxic effects due to this pathway, available toxicity data and calculated soil ingestion rates were combined and reviewed. Toxicity data were available for mammalian terrestrial species only (Table 49). Toxicity of surface soil to reptiles, birds, and upland plants could not be evaluated due to the limited amount of toxicological data for these groups. However, a qualitative toxicity evaluation based on field observations by experienced terrestrial biologists is included.

Available mammalian toxicity data are summarized in Table 49. Toxicity data were summarized only for metals of interest. Potential toxic effects of ingestion of organic chemicals in surface soil were not evaluated because most organic compounds were either not detected or detected in only one sample out of 19 surface soil samples collected (Table 48).

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Potential toxic effects of incidental surface soil ingestion by upland mammals were calculated using data from the Registry of Toxic Effects of Chemical Substances (RTECS)(NIOSH 1988) (Table 49). Because toxicity data in RTECS are listed by metal compound (i.e., salt) rather than by element, the RTECS value was first corrected for the weight fraction of metal present in the metal salt. To reflect the metal toxicity, only data for salts with low toxicity anions were used (i.e., acetate salts, chloride, sulfate, etc.).

This approach was based on the reasonable assumption that metals at the site have undergone weathering processes and exist in the following oxidation states: Cr(+3), Cu(+2), Pb(+2), Hg(+2), Ni(+2), and Zn(+2). It was assumed that the metals are in the form of simple salts of low toxicity anions, or oxides such that on uptake by organisms, the metal will hydrolyze in physiological systems and have dose/response effects similar to those measured in toxicity tests. This approach is conservative; metal toxicity may be overestimated because actual dissolution of metal compounds may be slower, or because complexation with humic materials in soil may reduce the bioavailability of the metal and consequently reduce metal toxicity.

Toxicity calculations were used to rank the potential toxic effects risk associated with each of the metals of interest in surface soil. Because RTECS data using the rat as a subject species were most consistently available, these data were used. The toxic dose data in Table 49 were converted from mg/Kg(bodyweight)/day to mg/day by assuming that a rat weights 200 g (NIOSH 1988). The soil ingestion rate required for toxicity was then calculated using average metal concentrations in surface soil (Table 50).

Based on information presented in RTECS, a 200 gram rat consumes approximately 20 grams of food daily. Although incidental soil consumption rates for small mammals in situ were not found, it was conservatively assumed that soil ingestion rates are less than 20 percent of food intake rates, equivalent to 4 g/day. If the

calculated soil ingestion rate required to induce toxic effects is greater than 4 g/day for the rat, then the metal in surface soil is considered to pose insignificant risks in upland mammals. All of the calculated soil ingestion rates were much greater than 4 g/day (Table 50). These results show that mammals would be required to consume very large quantities of soil (far greater than would be expected) in order to reach daily metal intakes that may produce toxic effects. It was concluded that metals in surface soil do not pose significant risks to upland mammals.

9.7 RISK CHARACTERIZATION

Several methods were used to characterize risks to ecological receptors in the study area. Concentrations in source media were compared with environmental criteria if possible. In addition to comparison of site data with appropriate criteria, the toxicity and/or exposure assessments were used to evaluate the likelihood of occurrence and potential magnitude of each risk or impact.

9.7.1 Environmental Criteria Evaluation

Although site-specific data were available to measure potential adverse impacts to the ecosystem from chemicals of interest, a comparison of chemical concentrations in source media with environmental criteria is still valuable. Environmental criteria are generally conservative and developed with the goal of protecting the entire ecosystem. Site specific biological data were collected to evaluate potential impacts to bioindicators, such as benthic organisms, in an effort to identify actual impacts, if any. Both approaches are valuable and can be used to complement each other and provide a broader view of a potential risks due to the site.

Environmental criteria considered during the final environmental evaluation were the marine chronic criteria for water (MCC), and multimedia environmental goals (MEGs). Apparent effects thresholds for

sediment (AETs) were considered in the preliminary evaluation, but were not considered further in the final evaluation. The applicability of each of the criteria including the AETs is discussed below.

MCC belong to a larger group of water quality criteria established by the EPA which includes marine and freshwater criteria for both short-term and long-term exposures. MCC are criteria, or guidelines, not enforceable standards. In general, water quality criteria denote concentrations of chemicals that, if not exceeded, are protective of aquatic ecosystems.

Comparison of source concentrations with the MCC was used in an approach that focused on the incremental contribution of chemicals to the wetlands. A hypothetical dilution of 1 to 125 (groundwater:surface water), or 0.008, was calculated for groundwater potentially discharging to surface water in South Drainage Channel (Section 4.2.5). Average dissolved metal concentrations in groundwater were multiplied by the 0.008 dilution factor and compared with MCC (Table 51). The MCC were not exceeded by the diluted metal concentrations in groundwater.

Although a hypothetical dilution factor calculated for the site was 1 to 125 (0.008), lower dilutions were used to check the sensitivity of the comparison with the MCC. As shown on Table 51, the incremental contribution of metals from groundwater potentially discharging to the South Drainage Channel did not exceed the MCC at the much lower dilution of 1 to 8 (0.125). At dilutions of less than 1 to 8, the calculated incremental contribution of mercury exceeded the MCC (0.07 ug/l vs. 0.025 ug/l MCC). It should be noted that the detection limit for mercury in groundwater (0.02 ug/l) was high relative to the MCC, and one-half the detection limit was conservatively used to calculate the average concentration of mercury in groundwater. Dilutions of much less than 1 to 8 may not result in an exceeded MCC for mercury. Given the difference between the calculated dilution (1 to 125) and the dilution at which mercury in groundwater poses a potential risk to aquatic biota

(1 to 8), the magnitude and likelihood of risk to biota via this exposure route is expected to be small.

The EPA has formulated Multimedia Environmental Goals (MEGs) to provide criteria for environmental assessments. They are not regulations. MEGs are defined as levels of chemicals in environmental media that "(1) are predicted not to produce negative effects in the surrounding populations or ecosystems, or (2) present control limits achievable through technology." MEGs were developed to assist in ranking chemicals in terms of potential impacts to the environment. Application of the MEGs should only be made with the awareness that MEG values are frequently based on limited data, or data of unknown reliability (EPA 1980b).

The available MEGs were only for organic compounds, and are presented in Table 52 along with detected concentrations of the chemicals in surface and subsurface soil for comparison. In surface soil, only the PCB concentration exceeded the MEG, and this occurred at only one location. Because the MEG is exceeded, there is the potential for harm to the environment. However, because of the limited extent of PCBs at the site, the potential magnitude and likelihood of harm to the environment is expected to be small. In subsurface soil, MEGs for PCBs, 4-methylphenol, and 2,4-dimethylphenol were exceeded at a small number of locations (3 out of 146 samples). Given that subsurface soil is not a current exposure route except for two species of burrowing mammals: the bottae pocket gopher and the California ground squirrel, and given the limited extent of these chemicals in subsurface soil, the potential magnitude and likelihood of harm to the environment is expected to be small.

In the absence of national or regional sediment quality criteria, AETs were initially considered for comparison with sediment chemistry data collected during the ecological study. AETs were developed for Puget Sound by Tetra Tech (1987) for several chemicals of interest in that estuary. Each AET represents the concentration of chemical in sediment "above which adverse effects are always expected to occur" (Tetra Tech

1987). In calculating AETs, sediment samples collected from subtidal areas were analyzed for a given chemical, then sediment bioassays were conducted. Organisms used in the bioassay tests were amphipods, oyster larvae, and bioluminescent bacteria. The structure and health of the benthic community sampled in the sediment was also examined by identifying and counting infauna. Amphipod, oyster, benthic, and microtox (luminescent bacteria) AETs have been established for some chemicals.

Because the sediment samples were collected from subtidal areas for AET formulation, and sediment samples collected for the ecological study conducted by Western Ecological Services Company, Inc. (WESCO) were collected from intertidal salt marsh, the AETs were not considered relevant criteria. Other factors were considered that resulted in eliminating the comparison with AETs. The AETs were developed for Puget Sound which differed significantly from San Francisco Bay in both biotic and abiotic factors. The empirical sediment quality and benthos community data collected during the ecological study are more indicative of potential adverse impacts than is a comparison of sediment chemistry with the AETs. The evaluation of potential risk based on data developed during the ecological study is presented in Section 9.7.2.

In summary, two potential risks were characterized as a result of comparison of data from source media with environmental criteria. First, potential risks were identified on the basis of comparison of calculated incremental concentrations of metals in groundwater with MCC. However, at dilutions significantly lower than those calculated, the incremental contribution of mercury in groundwater poses a potential risk. Second, potential risk to two species of burrowing mammals was identified. This risk was identified on the basis of comparison of chemical data from subsurface soil with MEGs. The MEGs for PCBs, 4-methylphenol, and 2,4-dimethylphenol were exceeded in a small number of samples (3 of 146). For both of the risks identified, the potential magnitude and likelihood of harm to the environment is expected to be small.

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9.7.2 Application of Ecological Study Data

Risks of detectable community level adverse impacts were evaluated empirically during the ecological study. A detailed discussion of the study is presented in Appendix C. The study is summarized in Section 5.

As a result of the exposure assessment (Section 9.5), adverse impacts from exposure of marsh biota to oil and grease in both marsh areas adjacent to the site, and PAHs and lead in the southwest drainage area (Transect 6) were considered further. The primary pathway by which this exposure could occur was through chemically affected marsh sediments, although exposure via surface runoff was not omitted from further consideration. Exposure to oil and grease via discharged groundwater was eliminated from further consideration on the basis of the low concentrations detected (Table 15), infrequency of detection, and limitations on the usefulness of oil and grease data for evaluating toxicity. Exposure to lead via discharged groundwater was eliminated from further consideration. This decision was made based on a comparison of calculated values with MCC (Table 51). The incremental contribution of lead in groundwater discharging to the South Drainage Channel was calculated based on the average concentrations of lead in groundwater (Table 31) and the hypothetical dilution factor calculated in Section 4.25. The incremental contribution was then compared with the MCC and did not exceed the MCC. Although the hypothetical dilution factor calculated for the site was 1 to 125 (on 0.008), lower dilution factors were used to check the sensitivity of the comparison with the MCC. The incremental contribution of lead in groundwater discharging to the South Drainage Channel did not exceed the MCC even at a dilution of 1 to 3 or 0.33 (Table 51). A 1 to 3 dilution factor is far lower than the 1 to 125 dilution calculated for the site.

Potential toxic effects to marsh biota include growth effects, reproductive effects, and mortality. Potential toxic effects on individuals were not measured. During the toxicity evaluation (Section 9.6.1), potential toxic effects on marsh biota were evaluated

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based on community level benthos data presented in Appendix C. No community level toxic effects were observed that were clearly attributable to chemicals originating on the Liquid Gold site, so risk to marsh biota is considered low. However, some risk to biota in the upper end of the southwest drainage path (Transect 6) may exist, and be at least partially attributable to chemicals in sediment.

Although there are indications of differences in biota from the upper end of Transect 1, there were no conclusive findings of harm to biota due to the presence of chemicals in sediment. However, there are uncertainties present in the ecological study, particularly given the absence of wet season benthos sampling data.

In addition to the benthos investigation, other biota were surveyed for observable impacts. No evidence of risk to marsh biota via uptake of chemicals in the foodweb was observed (Section 9.6.1), and no obvious impacts to shorebird populations or wildlife populations were observed. Therefore, risk to higher trophic level organisms in marsh areas is considered insignificant.

Impacts on upland mammal populations attributable to chemicals on the Liquid Gold site were not observed during the mammal trapping survey or other onsite work. In addition, the potential risk of toxic effects on upland mammals resulting from ingestion of metals in surface soil was found to be insignificant in the toxicity evaluation (Section 9.6.2).

9.7.3 Results of Bioassay Study

The potential risks to marsh biota exposed to surface runoff were further evaluated using surface soil elutriate bioassays (Section 9.6.1, Appendix D). No significant toxicity attributable to site chemicals was observed in surface soil elutriates collected in areas that discharge surface runoff to the adjacent wetlands. Therefore, the risk to biota potentially exposed via this pathway is considered insignificant.

The potential risk to marsh biota exposed to groundwater was evaluated based on the hydrogeologic investigation (Section 4) and chemical fate and mobility (Section 6.2). The risk was further evaluated using subsurface soil elutriates. No toxicity was observed during the subsurface soil elutriate testing that was clearly attributable to chemicals of interest. Therefore, on the basis of information presented in Sections 4 and 6.2, and the results of bioassay testing, the risk to biota potentially exposed via this pathway is considered insignificant.

9.8 SUMMARY AND CONCLUSIONS

The final environmental evaluation was based on assessment of three main factors: exposure, toxicity, and risk. The assessment and results are summarized below for each part of the evaluation.

The exposure assessment (Section 9.5) consisted of an analysis of chemical concentrations in source media, pathways by which biota may be exposed to chemicals, and potential receptors of chemical exposure. As a result of the exposure assessment, combinations of sources, pathways, and receptors were qualitatively ranked (Table 46). The five highest ranked exposure pathways combinations were chosen for consideration in the final Environmental Evaluation.

As a result of the process summarized above, the following pathways were chosen for further consideration during the toxicity assessment and risk characterization:

- Exposure of marsh biota to chemically affected sediment, particularly oil and grease, PAHs, and lead in Transect 6 sediment.

- Exposure of marsh biota to chemically affected surface runoff.

- Exposure of upland biota, particularly ground dwelling mammals, to chemically affected surface soil via ingestion.

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- Exposure of upland and marsh biota to bioconcentrated chemicals via the foodweb.

- Exposure of marsh biota to chemically affected groundwater.

Other pathways were omitted from further consideration during the final Environmental Evaluation. It was assumed that adverse environmental impacts, if any, would be greatest from the exposure pathways outlined above.

The toxicity assessment (Section 9.6) consisted of a separate assessment for marsh biota and upland biota. The marsh biota toxicity assessment was based via a review of biological data collected during the ecological study. The data were reviewed to identify evidence of community level impacts, if any, due to exposure via marsh sediment, surface runoff from the site, or shallow groundwater discharge pathways. It was assumed that observable impacts would serve as indicators of toxicity provided the impacts could be correlated with chemical concentrations.

No community level impacts were observed that could be statistically correlated with the chemicals of interest in sediment. However, data collected in the marsh area of the southwest drainage path (Transect 6) were not conclusive. An impact observed at T6-1 may be at least partially attributable to chemicals in sediment, although the source of the chemicals is unclear.

Potential toxic effects impacting the marsh biota foodweb were investigated using pickleweed and yellow shore crab tissue analyses. Toxic effects on upper trophic levels due to bioaccumulation of chemicals of interest are not anticipated. No correlations between chemicals originating on the Liquid Gold site and concentrations of chemicals in tissue were observed.

The upland biota toxicity assessment was based on a review of mammalian toxicity data and calculations of soil ingestion rates below which toxic effects are considered insignificant. As a result of these calculations, ingestion of metals in surface soil by ground dwelling mammals was considered an insignificant potential risk.

The risk characterization (Section 9.7) consisted of an evaluation and application of environmental criteria, and an evaluation of the likelihood and magnitude of environmental risks based on the biological data collected during the remedial investigation. The results of the risk characterization are summarized below:

- Two potential risks were characterized as a result of comparison of data from source media with environmental criteria. The first potential risk was associated with potential discharge of groundwater containing mercury. The second potential risk was associated with the limited presence of PCBs, 4-methylphenol, and 2,4-dimethylphenol in subsurface soil (MEGs exceeded in 4 of 165 samples). As discussed in Section 9.7.1, the potential magnitude and likelihood of harm to the environment is expected to be small.

- There are indications of differences in biota from the upper end of Transect 1 in Hoffman Marsh, although there were no conclusive findings of harm to biota due to the presence of chemicals in sediment. However, there are uncertainties present in the ecological study, particularly given the absence of wet season benthos sampling data.

- Definitive conclusions could not be reached regarding the potential risks to marsh biota in the southwest drainage area (Transect 6). However, low benthos observed in the upper end of Transect 6 may be at least partially attributable to chemicals in sediment.

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Based on the detailed evaluation of the first five pathways ranked during the exposure assessment, the following conclusions were drawn from the final environmental evaluation:

- No significant risk resulting from chemicals originating on the Liquid Gold site to the biota in Hoffman Marsh (Transects 1 to 4) was identified. However, uncertainties present in the process of environmental evaluations are acknowledged.

- Low benthos density was observed in the upper end of the Southwest Drainage channel (Transect 6). The impacts may be the result of the higher elevation of this location and the exposure to freshwater runoff from the uplands, or the result of exposure to chemicals, or a combination of effects. The impact is considered to be slightly more likely due to one of the latter two explanations. However, the source of the chemicals is unclear. Environmental effects could not be statistically linked to chemicals from the site, and the potentially affected area is likely of limited extent (approximately 1 to 2 m^2).

- No significant risk was found to upland mammals from exposure to chemicals at the site.

As noted in EPA's Risk Assessment Guidance for Superfund Environmental Evaluation Manual, "the process of assessing ecological effects is one of estimation under conditions of uncertainty (EPA 1989a)." Throughout the preceding evaluation, sources of uncertainty were identified. Sources of uncertainty included variation in significance of statistical results, assumptions underlying the approaches used in addressing various environmental media, and sampling anomalies.

SECTION 10

SUMMARY AND CONCLUSIONS

10.1 SUMMARY

10.1.1 Summary of Site Conditions and Extent of Chemicals

The following is a summary of the results of the evaluation of chemicals in soil and groundwater.

10.1.1.1 Surface Soil

There were large variations in metal concentrations in soil samples, which is often seen in soil investigations. In general, metal concentrations at the site were within typical ranges for soils. The more important issue of the potential impacts of metal concentrations found in soil is addressed in the public health and environmental evaluations (Sections 8 and 9). In limited areas of the site, surface soils contain chemicals possibly as a result of site activities. The southwest drainage path contained elevated levels of soluble lead. Some PAHs were found in surface soil composite samples at low levels. PCBs were found at low levels (not above 3 mg/Kg) in two isolated areas. One area (designated as Lot 4) contained elevated levels of lead and PAHs at 0 to 2 feet. In addition, asphaltic material is present at the surface to a limited extent in the former activity area.

10.1.1.2 Subsurface Soil

Variations in soil metal concentrations were also seen in subsurface soil samples. In general, metal concentrations were within typical ranges for soils, with some exceptions:

- Copper concentrations exceeded the common range in soil in about one third of the samples.

- A subsurface area (Area A) at a depth of about 5 to 6.5 feet was found to contain statistically significant higher concentrations of lead than other areas of the site. Zinc concentrations may also be higher in this area. Again, there was substantial variation in sample results from this area.

Area A is a designation given to an area that includes the fill beneath the former activity areas, but also extends beyond the former activity areas. Because of the variation in lead concentrations, and the lack of high concentrations in samples from shallow depths in this area, a definitive source of the lead was not established. It is likely that the higher metal concentrations were present in the fill material originally placed in this area.

Subsurface soil also contains isolated samples with higher metal concentrations and other isolated samples containing PAHs. These areas are of limited extent. For instance, PAH distribution was primarily limited to Area 6 (Lot 4) and at isolated areas in the former activity area. In addition, oil was observed in some subsurface samples. The presence of visible oil in isolated subsurface soil samples reinforces the conclusion at the end of the interim remedial action removal of visible oil (K/J/C 1986b) that pockets of oil may still exist in the subsurface. The areas with the presence of oil in the subsurface cannot be predicted on the basis of available data.

An evaluation of the fate and mobility of chemicals in soil concluded that only slow if any movement of metals, PCBs, PAHs, and oils can be expected at the site.

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10.1.1.3 Groundwater

The major conclusions regarding groundwater movement are:

- Tidal influence on shallow site groundwater, although detected, is considered insignificant with respect to influencing the groundwater gradient.

- Groundwater movement in the shallow zone is very slow, and significant movement is limited to winter months when sufficient rainfall occurs.

- Deeper zone groundwater discharges into San Francisco Bay at a location greater than one mile from the site.

The following are the major conclusions regarding the presence of chemicals in groundwater:

- Organic compounds of interest were not detected in shallow or deep groundwater, except for two oil and grease measurements in shallow groundwater slightly above detection limits.

- Concentrations of metals in both shallow and deeper zone groundwater monitoring wells fluctuated, but there were no apparent trends to the fluctuations.

- Groundwater beneath the site is not potable for reasons unrelated to site activities (e.g., conductivity, coliform), and water yields are observed to be low.

- Concentrations of metals in samples from both shallow and deeper zone groundwater monitoring wells were generally similar and relatively low.

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- The only indication of a possible onsite source area for metals is elevated lead, nickel, and zinc concentrations in groundwater from monitoring well MW-4R. This monitoring well is located in the former activity area.

- Significant future changes in either groundwater movement or metal concentrations in groundwater are not expected.

10.1.2 Summary of Public Health and Environmental Evaluations

The human health and environmental evaluations showed that there are no substantial current risks to humans or the environment as a result of chemicals found on or released from the Liquid Gold site. The major conclusions from the human health evaluation are the following:

- Potential risks due to ingestion and inhalation of chemicals in surface and subsurface soil were evaluated. Groundwater was not considered a potential human exposure route due to poor regional water quality and observed low yields onsite. Potential exposure scenarios evaluated included residential exposure to children and adults, office building exposure to adults, and exposure to trespassing children. Areas evaluated included a one acre lot (Lot 4), chosen to represent worst-case residential exposure, a subsurface area with identified elevated soil lead levels (Area A), and the entire site.

- A potential future risk from exposure to noncarcinogenic chemicals was identified for ingestion exposure to residential children. The areas of concern are Lot 4 at 0 to 2 feet and 5 to 6.5 feet, and Area A at 5 to 6.5 feet. Lead in soil provided the primary contribution to the hazard index exceeding 1. Hazard indices for the other exposure scenarios indicated that there were not significant risks from exposure to noncarcinogenic chemicals.

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- Potential lifetime incremental cancer risks from exposure to soil were in the range of 10^{-4} to 10^{-6}. The highest calculated lifetime incremental cancer risks were associated with the ingestion of PAHs in surface and subsurface soil by adults residing on Lot 4. This potential risk may be considered unacceptable.

The major conclusions from the environmental evaluation are the following:

- There is no indication that the Liquid Gold site and its past operations is a contributor of metals to Hoffman Marsh (Transects 1 to 4).

- No significant risk resulting from chemicals originating on the site to the biota in Hoffman Marsh (Transects 1 to 4) was identified. However, there are uncertainties present in the environmental evaluation process.

- Low benthos density was observed in the upper end of the Southwest Drainage Channel (Transect 6). The impacts may be the result of the higher elevation of this location and the exposure to freshwater runoff from the uplands, or the result of exposure to chemicals originating on the site, or a combination of effects. One of the latter two explanations is considered slightly more likely based on information presented in Appendix C. However, the source of the chemicals is unclear. Environmental effects could not be statistically linked to chemicals from the site, and the potentially affected area is likely of limited extent (approximately 1 to 2 m^2).

- There is no clear indication that PCBs are moving from the site to the wetlands via the drainage pathways.

- The operations of the Liquid Gold site have not caused elevated levels of PAHs or metals in the yellow shore crab, nor has the population of yellow shore crabs been depressed near the site.

- Given the lack of correlation between soil or sediment metal concentrations and plant or animal tissue metal concentrations, there is no indication that ingestion of pickleweed or yellow shore crabs by shorebirds is a significant pathway into the food web for chemicals originating on the site.

- There is no indication that chemicals originating on the site are impacting water birds or small mammals through the food web.

- The results of the bioassay study of surface and subsurface soil elutriates show no clear indication of harm to test organisms due to chemicals from the site.

10.2 CONCLUSIONS AND RECOMMENDATIONS

No further remedial investigation studies are recommended to characterize the site. Additional data obtained would be of only marginal benefit, and would not substantially alter the following conclusions.

Two areas of the site were identified as being of unacceptable potential future risk to humans:

- Surface and subsurface soil in Lot 4 (an area designated as a residential lot for the purposes of the risk assessment), primarily due to the presence of lead (of potential concern for residential exposure to children) and carcinogenic PAHs (of potential concern for residential exposure to adults).

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- Subsurface soil (5 to 6.5 feet) in Area A (an area identified as having elevated soil lead levels) due to the presence of lead at levels potentially harmful to residential children.

The residential setting showing the potential for unacceptable risks from chemicals in soil is a hypothetical exposure scenario and does not currently exist. Also, the chemicals of primary concern are either present in subsurface soil or in surface soil (defined as 0 to 2 feet) generally beneath asphalt, so that potential exposure would be less likely. However, it is recommended that the surface and subsurface soils in Lot 4 and the subsurface soils in Area A be considered for remediation in the feasibility study.

There are other isolated areas in subsurface soil that may be of potential concern from either a human health or environmental perspective were exposure to occur. In particular, there are areas with subsurface soil samples containing visible oil. Were oils to be exposed at the surface, there is the potential for adverse environmental impacts on the marsh should runoff occur. Again, these are hypothetical risks because exposure to subsurface soils does not currently exist. The location of oils in the subsurface is known only from isolated samples. The overall extent is not known, nor is there any indication where other isolated areas of oil in the subsurface exist. The conservative assumption is that exposure to subsurface soil anywhere in the site has the potential for providing contact with oils. It is recommended that further consideration be given to subsurface soils during the feasibility study.

Shallow groundwater may be impacted to a small extent (limited to the vicinity of monitoring well MW-4R) due to chemicals from site activities. Concentrations of metals in groundwater from the rest of the site do not appear elevated. This finding is consistent with the expected relative immobility of metals in groundwater, and supports the conclusion that the concentrations of metals in samples from monitoring well MW-4R are not considered of concern. Also, shallow groundwater

movement at the site is very slow, when it occurs, and movement is limited to winter months with sufficient rainfall. Given the limited flow of groundwater, and the results of the ecological and bioassay studies, there are no apparent adverse environmental effects from metals in groundwater. In addition, because the groundwater is not potable, there are no human health concerns for exposure to chemicals of interest. However, it is recommended that groundwater that appears to be impacted in the vicinity of monitoring well MW-4R be considered in the feasibility study.

The quarterly groundwater monitoring rounds were implemented from October 1988 to July 1989 according to the RI/FS workplan. An additional sampling round was added in October 1989. At the request of the agencies, it is recommended that interim groundwater monitoring, separate from either the remedial investigation or feasibility study, be implemented beginning in October 1990.

Potential environmental risk as a result of chemicals in subsurface soil potentially reaching receptors through groundwater movement was not shown by the ecological study or soil elutriate bioassay study, nor would it be expected given groundwater flow characteristics and the calculated significant dilution or hypothetical dilution as groundwater enters surface water.

Harm to biota in most areas of the marsh as a result of chemicals from the site is considered unlikely based on the results of the environmental evaluation. However, the uncertainty inherent in the process of ecological assessment was acknowledged in Section 9. Given this uncertainty, and at the request of the reviewing agencies, it is recommended that the need for remediation to address potential risks to biota from chemicals in marsh sediments adjacent to the site (upper ends of Transects 1 and 6) be considered during the feasibility study.

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TABLES

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TABLE 1

TOTAL METAL CONCENTRATIONS (MG/KG) OF SUBSURFACE SOIL SAMPLES
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

BORING	AREA	STRATA	SAMPID	DEPTH (FT)	DATE	CHROMIUM	COPPER	LEAD	MERCURY	NICKEL	ZINC
100-A	AREA1	Mud	886879	0.5	20-Sep-88	34	43	46	0.32	66	56
100-B	AREA1	Mud	886880	5.5	20-Sep-88	29	31	1	5.4	0.06	42
100-C	AREA1	Mud	88688	10	20-Sep-88	24	110	5.9	<0.05	33	62
100-D	AREA1	Mud	886882	15	20-Sep-88	24	140	6	<0.05	28	76
101-A	AREA1	Fill	886883	1.5	20-Sep-88	50	53	27	0.06	69	52
101-B	AREA1	Fill	886884	6.5	20-Sep-88	60	23	39	<0.05	82	55
101-C	AREA1	Mud	886885	10	20-Sep-88	32	19	<5	<0.05	37	35
101-D	AREA1	Mud	886886	15	20-Sep-88	27	180	<5	<0.05	29	130
102-A	OILGRS	Fill	886364	1	07-Sep-88	51	130	450	0.74	38	200
102-B	OILGRS	Mud	886366	4	07-Sep-88	16	82	260	0.15	23	140
102-C	OILGRS	Mud	886368	8.5	07-Sep-88	21	250	<5	<0.05	21	100
102-D	OILGRS	Mud	886370	14	07-Sep-88	19	68	<5	<0.05	21	62
102-E	OILGRS	Mud	886372	19	07-Sep-88	33	120	<5	0.07	50	50
102-F	OILGRS	Mud	886374	23.5	07-Sep-88	22	22	<5	0.07	39	33
102-G	OILGRS	Mud	886376	28.5	07-Sep-88	30	25	<5	0.14	49	50
103-A	AREA2	Fill	887084	0.5	28-Sep-88	35	220	<5	0.12	40	110
104-A	AREA2	Fill	887122	0.5	29-Sep-88	22	120	37	<0.05	24	72
104-B	AREA2	Fill	887123	2.5	29-Sep-88	30	300	<5	0.06	25	190
105-A	AREA2	Fill	887124	0.5	29-Sep-88	62	380	92	1.2	71	350
105-B	AREA2	Fill	887125	2.5	29-Sep-88	38	340	<5	0.07	40	260
106-A	AREA3	Fill	887086	0.5	28-Sep-88	46	40	13	0.13	59	48
106-B	AREA3	Fill	887087	2.5	28-Sep-88	62	25	12	0.1	88	36
107-A	AREA3	Fill	887126	0.5	29-Sep-88	32	34	30	0.12	39	63
107-B	AREA3	Fill	887127	2.5	29-Sep-88	27	17	21	0.07	26	37
108-A	CONCRETE	Fill	887089	0.5	28-Sep-88	23	39	66	0.1	22	82
108-B	CONCRETE	Fill	887090	2.5	28-Sep-88	34	400	120	1.8	30	270
109-A	CONCRETE	Fill	887088	0.5	28-Sep-88	24	49	82	0.13	25	77
109-A	CONCRETE	Fill	887093	1.5	28-Sep-88	24	140	14	0.05	27	80
110-A	AREA6	Fill	886841	1.0	19-Sep-88	22	42	200	0.36	15	130
110-B	AREA6	Mud	886842	6.0	19-Sep-88	23	24	21	0.1	29	31
110-C	AREA6	Mud	886843	10.0	19-Sep-88	29	75	8.3	<0.05	29	52
110-D	AREA6	Mud	886844	15.0	19-Sep-88	26	140	7.6	<0.05	28	170
111-A	AREA6	Fill	886887	0.0	20-Sep-88	44	220	800	0.27	43	640
111-B	AREA6	Fill	886888	5.0	20-Sep-88	47	1100	5200	0.3	77	2200
111-C	AREA6	Mud	886889	10.0	20-Sep-88	20	220	340	1.4	20	550
111-D	AREA6	Mud	886890	15.0	20-Sep-88	25	250	6	<0.05	27	130
112-A	AREA6	Fill	886817	1.0	16-Sep-88	150	40	5.9	<0.05	210	55
112-B	AREA6	Fill	886818	5.5	16-Sep-88	16	130	1100	0.06	25	250
112-C	AREA6	Mud	886819	10.5	16-Sep-88	26	160	<5	<0.05	22	75
112-D	AREA6	Mud	886820	15.0	16-Sep-88	29	190	<5	0.05	29	120
113-A	AREA5	Fill	886805	0.5	16-Sep-88	32	53	50	0.11	43	58
113-B	AREA5	Fill	886806	5.5	16-Sep-88	28	22	28	0.1	40	53
113-C	AREA5	Mud	886807	11.5	16-Sep-88	30	140	<5	<0.05	28	81
113-D	AREA5	Mud	886808	15.0	16-Sep-88	25	490	5.8	<0.05	25	270
114-A	AREA5	Fill	886813	2.0	16-Sep-88	5.4	17	18	0.05	9.2	16
114-B	AREA5	Fill	886814	5.0	16-Sep-88	23	34	350	0.22	32	70
114-C	AREA5	Mud	886815	11.5	16-Sep-88	65	540	114	1.6	53	570
114-D	AREA5	Mud	886816	15.0	16-Sep-88	27	910	7.6	0.06	27	450
115-A	AREA5	Gravel	886809	1.5	16-Sep-88	20	27	12	<0.05	27	40
115-B	AREA5	Gravel	886810	5.0	16-Sep-88	17	83	16	<0.05	23	67
115-C	AREA5	Gravel	886811	10.0	16-Sep-88	25	160	7.9	<0.05	25	85
115-D	AREA5	Mud	886812	15.5	16-Sep-88	29	280	5.7	<0.05	29	240
116-A	OILGRS	Fill	886532	2.0	08-Sep-88	16	26	100	0.11	21	64
116-B	OILGRS	Fill	886533	5.5	08-Sep-88	28	400	1800	4.8	18	1300
116-C	OILGRS	Mud	886534	10.5	08-Sep-88	21	400	40	0.13	23	250
116-D	OILGRS	Mud	886535	16.0	08-Sep-88	23	90	<5	<0.05	23	50
116-E	OILGRS	Mud	886536	20.5	08-Sep-88	42	14	<5	0.1	32	17
116-F	OILGRS	Mud	886537	25.0	08-Sep-88	23	66	5	0.07	32	45
116-G	OILGRS	Mud	886538	30.0	08-Sep-88	25	50	<5	0.07	30	49
117-A	OILGRS	Fill	886452	2.5	07-Sep-88	21	34	45	0.06	32	57
117-B	OILGRS	Fill	886453	5.5	07-Sep-88	16	190	87	0.07	21	220
117-C	OILGRS	Fill	886454	10.0	07-Sep-88	24	140	<5	<0.05	25	91
117-D	OILGRS	Mud	886455	15.5	07-Sep-88	26	150	<5	<0.05	31	82
117-E	OILGRS	Mud	886456	20.5	07-Sep-88	29	120	5	<0.05	31	80
117-F	OILGRS	Mud	886457	25.5	07-Sep-88	46	31	5	0.09	68	26
117-G	OILGRS	Mud	886458	31.0	07-Sep-88	26	66	<5	0.06	47	51
118-A	POND	Fill	886922	0.5	21-Sep-88	12	29	5	<0.05	13	39

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TABLE 1

TOTAL METAL CONCENTRATIONS (MG/KG) OF SUBSURFACE SOIL SAMPLES
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

BORING	AREA	STRATA	SAMPID	DEPTH (FT)	DATE	CHROMIUM	COPPER	LEAD	MERCURY	NICKEL	ZINC
118-B	POND	Mud	886923	5.0	21-Sep-88	19	250	290	<0.05	25	390
118-C	POND	Mud	886924	10.0	21-Sep-88	55	490	230	0.82	66	310
118-D	POND	Mud	886925	15.5	21-Sep-88	27	25	<5	<0.05	31	36
118-E	POND	Mud	886926	20.0	21-Sep-88	32	450	<5	<0.05	31	260
118-F	POND	Mud	886927	25.0	21-Sep-88	25	39	<5	0.09	60	43
118-G	POND	Mud	886928	30.0	21-Sep-88	19	21	<5	<0.05	58	31
119-A	POND	Fill	886929	0.5	21-Sep-88	230	37	11	0.07	280	52
119-B	POND	Fill	886930	5.0	21-Sep-88	47	450	3600	0.39	43	290
119-C	POND	Mud	886931	10.0	21-Sep-88	27	19	<5	<0.05	27	34
119-D	POND	Mud	886932	15.0	21-Sep-88	33	170	<5	<0.05	31	120
119-E	POND	Mud	886933	20.0	21-Sep-88	51	55	<5	0.11	56	33
119-F	POND	Mud	886934	25.5	21-Sep-88	20	84	<5	0.05	39	50
119-G	POND	Mud	886935	30.0	21-Sep-88	35	21	<5	<0.05	49	35
120-A	OILGRS	Fill	886464	2.0	07-Sep-88	25	32	11	<0.05	34	47
120-B	OILGRS	Mud	886465	6.0	07-Sep-88	36	100	62	2.0	45	170
120-C	OILGRS	Mud	886466	10.5	07-Sep-88	25	28	<5	0.07	29	41
120-D	OILGRS	Mud	886459	16.0	07-Sep-88	22	120	<5	<0.05	25	81
120-E	OILGRS	Mud	886460	20.5	07-Sep-88	50	27	<5	0.08	88	29
120-F	OILGRS	Gravel	886460	20	07-Sep-88	38	40	<5	<0.05	68	34
120-G	OILGRS	Gravel	886462	30.5	07-Sep-88	32	17	<5	0.076	52	20
121-A	OILGRS	Fill	886378	2.5	07-Sep-88	20	22	7.8	<0.05	25	53
121-B	OILGRS	Mud	886380	6.0	07-Sep-88	21	220	<5	<0.05	17	67
121-C	OILGRS	Mud	886382	11.0	07-Sep-88	20	41	<5	<0.05	19	33
121-D	OILGRS	Mud	886384	15.5	07-Sep-88	22	81	<5	<0.05	23	47
121-E	OILGRS	Mud	886463	20.5	07-Sep-88	35	27	<5	<0.05	65	21
122-A	ASPHALT	Fill	886707	2.0	15-Sep-88	140	420	4200	0.11	51	4900
122-B	ASPHALT	Fill	886708	5.5	15-Sep-88	16	260	3100	0.07	32	630
122-C	ASPHALT	Mud	886709	10.5	15-Sep-88	26	170	62	<0.05	26	90
122-D	ASPHALT	Mud	886710	15.5	15-Sep-88	14	78	<5	<0.05	16	45
122-E	ASPHALT	Mud	886711	20.5	15-Sep-88	37	130	<5	0.09	88	55
122-F	ASPHALT	Mud	886712	25.0	15-Sep-88	20	34	7.6	0.08	34	36
122-G	ASPHALT	Mud	886713	30.0	15-Sep-88	29	55	5.9	<0.05	39	46
123-A	ASPHALT	Fill	886695	2.5	15-Sep-88	22	44	280	<0.05	23	160
123-B	ASPHALT	Fill	886696	5.5	15-Sep-88	34	160	1200	0.21	39	1600
123-C	ASPHALT	Mud	886697	11.0	15-Sep-88	25	570	41	<0.05	26	340
123-D	ASPHALT	Mud	886698	15.5	15-Sep-88	23	67	<5	<0.05	24	82
124-A	ASPHALT	Fill	886699	1.0	15-Sep-88	110	22	6.7	<0.05	190	40
124-B	ASPHALT	Sand	886700	5.5	15-Sep-88	15	85	290	0.16	13	170
124-C	ASPHALT	Mud	886701	10.0	15-Sep-88	24	140	<5	<0.05	28	79
124-D	ASPHALT	Mud	886702	15.0	15-Sep-88	24	350	<5	0.05	26	190
125-A	ASPHALT	Fill	886703	1.5	15-Sep-88	19	16	22	<0.05	23	34
125-B	ASPHALT	Fill	886704	5.5	15-Sep-88	22	32	140	0.11	33	120
125-C	ASPHALT	Fill	886705	10.0	15-Sep-88	26	31	51	<0.05	27	61
125-D	ASPHALT	Mud	886706	15.0	15-Sep-88	23	300	<5	<0.05	26	260
126-A	AREA4	Fill	886891	1.0	20-Sep-88	23	17	14	<0.05	29	37
126-B	AREA4	Fill	886892	5.0	20-Sep-88	19	30	45	<0.05	22	46
126-C	AREA4	Mud	886893	10.0	20-Sep-88	25	160	<5	<0.05	25	72
126-D	AREA4	Mud	886894	15.0	20-Sep-88	40	56	6.9	0.06	46	230
127-A	AREA4	Fill	886895	0.5	20-Sep-88	27	36	42	0.1	36	64
127-B	AREA4	Fill	886896	5.0	20-Sep-88	20	2600	110	0.05	20	65
127-C	AREA4	Mud	886897	10.0	20-Sep-88	25	370	6.8	<0.05	29	190
127-D	AREA4	Mud	886898	15.5	20-Sep-88	51	38	<5	0.10	56	28
128-A	AREA4	Fill	886899	1.5	20-Sep-88	38	37	98	1.3	42	75
128-B	AREA4	Fill	886900	5.5	20-Sep-88	21	80	8.7	<0.05	18	340
128-C	AREA4	Mud	886901	10.0	20-Sep-88	24	300	<5	<0.05	34	150
128-D	AREA4	Mud	886902	15.5	20-Sep-88	27	43	<5	<0.05	28	42
129-A	SEDRAIN	Sediment	887130	0.0	29-Sep-88	31	82	37	0.18	32	230
129-B	SEDRAIN	Sediment	887131	1.5	29-Sep-88	41	370	12	0.18	34	220
130-A	SEDRAIN	Sediment	887983	0.0	31-Oct-88	31	22	21	0.06	32	42
130-B	SEDRAIN	Sediment	887984	1.5	31-Oct-88	32	43	32	1.40	33	78
D1-A	DRAINAGE	Sediment	887091	0.0	28-Sep-88	28	29	14	<0.05	21	42
D1-B	DRAINAGE	Sediment	887092	1.5	28-Sep-88	48	1000	55	0.32	48	660
MW-19A	GW	Gravel	886601	1.0	09-Sep-88	35	22	<5	0.07	71	38
MW-19B	GW	Mud	886602	6.0	09-Sep-88	26	20	<5	0.07	48	42
MW-19C	GW	Mud	886603	11.0	09-Sep-88	29	18	<5	0.05	34	38
MW-19D	GW	Mud	886604	15.5	09-Sep-88	18	14	<5	<0.05	28	33
MW-19E	GW	Mud	886605	20.5	09-Sep-88	19	17	<5	<0.05	39	31

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TABLE 1

TOTAL METAL CONCENTRATIONS (MG/KG) OF SUBSURFACE SOIL SAMPLES
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

BORING	AREA	STRATA	SAMPID	DEPTH (FT)	DATE	CHROMIUM	COPPER	LEAD	MERCURY	NICKEL	ZINC
MW-19F	GW	Mud	886606	26.0	09-Sep-88	20	14	<5	0.05	33	33
MW-19G	GW	Mud	886607	30.0	09-Sep-88	34	20	<5	<0.05	64	39
MW-20A	GW	Fill	886539	2.5	08-Sep-88	24	120	45	0.07	33	91
MW-20B	GW	Mud	886540	5.5	08-Sep-88	20	64	<5	0.07	26	45
MW-20C	GW	Mud	886541	10.5	08-Sep-88	26	64	<5	0.07	27	42
MW-20D	GW	Mud	886542	15.5	08-Sep-88	23	33	5.9	0.08	53	44
MW-20E	GW	Mud	886543	20.5	08-Sep-88	26	16	5.9	0.06	33	37
MW-20F	GW	Mud	886544	25.5	08-Sep-88	27	19	<5	0.07	37	51
MW-20G	GW	Mud	886545	30.5	08-Sep-88	30	16	<5	<0.05	43	35
MW-20H	GW	Mud	886546	35.5	08-Sep-88	24	19	<5	<0.05	45	37
MW-20I	GW	Mud	886547	41.0	08-Sep-88	20	15	<5	0.14	32	29
MW-20J	GW	Mud	886548	45.5	08-Sep-88	19	10	<5	<0.05	18	22
MW-20K	GW	Mud	886549	50.5	08-Sep-88	18	8.5	<5	0.06	20	20
NS-18A	MARSH	Sediment	887170	0.0	30-Sep-88	8.2	10	58	0.05	7	18
NS-18B	MARSH	Sediment	887172	1.0	30-Sep-88	40	19	32	0.35	44	51
NS-19A	MARSH	Sediment	887174	0.0	30-Sep-88	5.1	9.9	42	0.10	7.2	45
NS-19B	MARSH	Sediment	887176	1.0	30-Sep-88	9.6	22	47	0.21	34	210
NS-20A	MARSH	Sediment	887166	0.0	30-Sep-88	5.3	6.7	19	<0.04	5.6	27
NS-20B	MARSH	Sediment	887168	1.0	30-Sep-88	12	12	36	0.08	14	88
EELG-1	NPA	Fill		0	20-Sep-83	NM	NM	186	NM	NM	NM
EELG-1	NPA	Mud		5	20-Sep-83	NM	NM	98.1	NM	NM	NM
EELG-1	NPA	Mud		10	20-Sep-83	NM	NM	<16	NM	NM	NM
EELG-1	NPA	Mud		15	20-Sep-83	NM	NM	<19	NM	NM	NM
EELG-2	NPA	Fill		0	20-Sep-83	NM	NM	82.1	NM	NM	NM
EELG-2	NPA	Mud		5	20-Sep-83	NM	NM	71.3	NM	NM	NM
EELG-2	NPA	Mud		10	20-Sep-83	NM	NM	<20	NM	NM	NM
EELG-2	NPA	Mud		15	20-Sep-83	NM	NM	<20	NM	NM	NM
EELG-3	NPA	Fill		0	20-Sep-83	NM	NM	48.4	NM	NM	NM
EELG-3	NPA	Mud		5	20-Sep-83	NM	NM	30.4	NM	NM	NM
EELG-3	NPA	Mud		10	20-Sep-83	NM	NM	<20	NM	NM	NM
EELG-3	NPA	Mud		15	20-Sep-83	NM	NM	<20	NM	NM	NM
EELG-4	NPA	Fill		0	20-Sep-83	NM	NM	34.2	NM	NM	NM
EELG-4	NPA	Mud		5	20-Sep-83	NM	NM	60.2	NM	NM	NM
EELG-4	NPA	Mud		10	20-Sep-83	NM	NM	<20	NM	NM	NM
EELG-4	NPA	Mud		15	20-Sep-83	NM	NM	<16	NM	NM	NM
EELG-5	NPA	Fill		0	20-Sep-83	NM	NM	68.3	NM	NM	NM
EELG-5	NPA	Fill		5	20-Sep-83	NM	NM	32.8	NM	NM	NM
EELG-5	NPA	Mud		10	20-Sep-83	NM	NM	114	NM	NM	NM
EELG-5	NPA	Mud		15	20-Sep-83	NM	NM	23	NM	NM	NM
EELG-6	NPA	Fill		0	20-Sep-83	NM	NM	<18	NM	NM	NM
EELG-6	NPA	Mud		5	20-Sep-83	NM	NM	44.7	NM	NM	NM
EELG-6	NPA	Mud		10	20-Sep-83	NM	NM	<15	NM	NM	NM
EELG-6	NPA	Mud		15	20-Sep-83	NM	NM	<19	NM	NM	NM
EELG-7	NPA	Fill		0	20-Sep-83	NM	NM	<18	NM	NM	NM
EELG-7	NPA	Mud		5	20-Sep-83	NM	NM	149	NM	NM	NM
EELG-7	NPA	Mud		10	20-Sep-83	NM	NM	18	NM	NM	NM
EELG-7	NPA	Mud		15	20-Sep-83	NM	NM	<18	NM	NM	NM
EELG-8	NPA	Fill		0	20-Sep-83	NM	NM	<18	NM	NM	NM
EELG-8	NPA	Mud		5	20-Sep-83	NM	NM	726	NM	NM	NM
EELG-8	NPA	Mud		10	20-Sep-83	NM	NM	<19	NM	NM	NM
EELG-8	NPA	Mud		15	20-Sep-83	NM	NM	<17	NM	NM	NM
EELG-9	NPA	Fill	834308	0.7	08-Nov-83	26	25	39	NA	29	81
EELG-9	NPA	Fill	834309	5.7	08-Nov-83	23	7	3	NA	18	56
EELG-9	NPA	Mud	834310	10.7	08-Nov-83	29	14	3	NA	50	32
EELG-10	AREA4	Mud	834082	20.7	01-Nov-83	NA	NA	4	NA	69	77
EELG-11	NPA	Fill	834113	0.7	01-Nov-83	18	26	3	NA	124	24
EELG-11	NPA	Fill	834114	5.7	01-Nov-83	105	22	37	NA	NA	77
EELG-11	NPA	Mud	834115	10.7	01-Nov-83	33	13	6	NA	25	39
EELG-12	NPA	Fill	834085	0.7	01-Nov-83	31	26	9	NA	38	521
EELG-12	NPA	Fill	834086	5.7	01-Nov-83	26	18	5	NA	28	41
EELG-12	NPA	Mud	834087	10.7	01-Nov-83	19	17	2	NA	39	44
EELG-13	NPA	Fill	834110	3.2	31-Oct-83	21	156	110	NA	37	1900
EELG-13	NPA	Fill	834111	5.7	31-Oct-83	19	15	74	NA	18	70
EELG-13	NPA	Mud	834112	10.7	31-Oct-83	19	16	2	NA	28	45
EELG-14	NPA	Fill	834088	0.7	01-Nov-83	41	24	28	NA	29	74
EELG-14	NPA	Fill	834089	5.2	01-Nov-83	24	9	3	NA	24	36
EELG-14	NPA	Mud	834090	10.3	01-Nov-83	31	20	3	NA	26	43

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TABLE 1

TOTAL METAL CONCENTRATIONS (MG/KG) OF SUBSURFACE SOIL SAMPLES
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

BORING	AREA	STRATA	SAMPID	DEPTH (FT)	DATE	CHROMIUM	COPPER	LEAD	MERCURY	NICKEL	ZINC
EELG-15	NPA	Fill	834233	0.7	07-Nov-83	18	28	86	NA	34	86
EELG-15	NPA	Fill	834234	5.7	07-Nov-83	21	30	7	NA	94	86
EELG-15	NPA	Mud	834235	10.7	07-Nov-83	37	16	2	NA	38	58
EELG-16	NPA	Alluvium	834119	20.7	01-Nov-83	NA	NA	3	NA	68	89
EELG-17	NPA	Fill	834107	0.7	31-Oct-83	49	30	12	NA	14	298
EELG-17	NPA	Fill	834108	5.7	31-Oct-83	27	14	3	NA	25	86
EELG-17	NPA	Mud	834109	10.7	31-Oct-83	28	15	3	NA	55	48
EELG-18	NPA	Fill	834101	0.7	31-Oct-83	31	34	17	NA	46	1
EELG-18	NPA	Fill	834102	5.7	31-Oct-83	40	150	150	NA	30	940
EELG-18	NPA	Mud	834103	10.7	31-Oct-83	27	18	1	NA	18	45
EELG-19	NPA	Alluvium	834095	20.7	31-Oct-83	NA	NA	4	NA	91	45
EELG-20	NPA	Fill	834091	0.7	01-Nov-83	33	59	18	NA	44	250
EELG-20	NPA	Fill	834092	5.7	01-Nov-83	30	19	10	NA	34	57
EELG-20	NPA	Fill	834093	10.7	01-Nov-83	11	16	2	NA	24	39
EELG-21	NPA	Fill	834158	0.7	01-Nov-83	30	33	52	NA	51	65
EELG-21	NPA	Fill	834159	5.7	01-Nov-83	17	16	4	NA	104	60
EELG-21	NPA	Mud	834160	10.7	01-Nov-83	44	20	2	NA	42	63
EELG-22	NPA	Fill	834104	0.7	31-Oct-83	28	27	6	NA	55	110
EELG-22	NPA	Mud	834105	5.7	31-Oct-83	52	22	3	NA	31	94
EELG-22	NPA	Mud	834106	10.7	31-Oct-83	19	20	27	NA	29	89
EELG-23	NPA	Fill	834122	0.7	01-Nov-83	34	24	48	NA	45	92
EELG-23	NPA	Fill	834123	5.7	01-Nov-83	55	206	58	NA	66	675
EELG-23	NPA	Mud	834124	10.7	01-Nov-83	19	19	2	NA	25	41
EELG-24	NPA	Alluvium	834116	20.7	01-Nov-83	NA	NA	4	NA	133	59
EELG-25	NPA	Fill	834098	0.7	31-Oct-83	23	31	208	NA	27	97
EELG-25	NPA	Fill/Mud	834099	5.7	31-Oct-83	12	13	6	NA	18	46
EELG-25	NPA	Mud	834100	10.7	31-Oct-83	20	18	3	NA	23	43
EELG-26	NPA	Fill	834128	0.7	01-Nov-83	38	107	390	NA	46	5200
EELG-26	NPA	Fill/Mud	834129	5.7	01-Nov-83	19	17	30	NA	29	62
EELG-26	NPA	Mud	834130	10.7	01-Nov-83	19	16	30	NA	20	41
EELG-27	NPA	Fill	834152	0.7	02-Nov-83	31	24	51	NA	18	56
EELG-27	NPA	Fill	834153	5.7	02-Nov-83	43	24	41	NA	62	179
EELG-27	NPA	Mud	834154	10.7	02-Nov-83	27	19	3	NA	41	69
EELG-28	NPA	Fill	834184	0.7	03-Nov-83	17	30	65	NA	27	83
EELG-28	NPA	Fill/Mud	834185	5.7	03-Nov-83	16	15	7	NA	18	37
EELG-28	NPA	Mud	834186	10.7	03-Nov-83	19	18	30	NA	33	42
EELG-29	NPA	Fill	834146	0.7	02-Nov-83	42	49	27	NA	43	20
EELG-29	NPA	Fill	834147	5.7	02-Nov-83	28	15	28	NA	37	48
EELG-29	NPA	Mud	834148	10.7	02-Nov-83	28	18	1	NA	23	52
EELG-30	NPA	Fill	834149	0.7	02-Nov-83	31	23	86	NA	15	81
EELG-30	NPA	Fill/Mud	834150	5.7	02-Nov-83	29	95	570	NA	31	510
EELG-30	NPA	Mud	834151	10.7	02-Nov-83	26	43	2	NA	38	41
EELG-31	NPA	Fill	834155	0.7	02-Nov-83	49	27	56	NA	51	132
EELG-31	NPA	Fill/Mud	834156	5.7	02-Nov-83	30	14	6	NA	18	54
EELG-31	NPA	Mud	834157	10.7	02-Nov-83	58	18	3	NA	48	47
EELG-32	NPA	Fill	834316	0.7	07-Nov-83	33	17	81	NA	23	20
EELG-32	NPA	Fill	834317	5.7	07-Nov-83	76	20	19	NA	79	59
EELG-32	NPA	Mud	834318	10.7	07-Nov-83	64	18	4	NA	46	16
EELG-33	NPA	Fill	834131	0.7	02-Nov-83	20	16	11	NA	32	199
EELG-33	NPA	Mud	834132	5.7	02-Nov-83	15	14	2	NA	6	64
EELG-33	NPA	Mud	834133	10.7	02-Nov-83	19	27	5	NA	39	61
EELG-34	NPA	Fill	834134	0.7	02-Nov-83	13	57	52	NA	80	1700
EELG-34	NPA	Fill/Mud	834135	5.7	02-Nov-83	12	20	4	NA	36	54
EELG-34	NPA	Mud	834136	10.7	02-Nov-83	16	19	3	NA	13	42
EELG-35	NPA	Fill	834143	0.7	02-Nov-83	20	81	68	NA	22	87
EELG-35	NPA	Fill	834144	5.7	02-Nov-83	32	213	420	NA	223	1000
EELG-35	NPA	Mud	834145	10.7	02-Nov-83	22	19	2	NA	50	85
EELG-36	NPA	Fill	834140	0.7	02-Nov-83	21	22	64	NA	8	63
EELG-36	NPA	Mud	834141	5.7	02-Nov-83	20	34	10	NA	21	76
EELG-36	NPA	Mud	834142	10.7	02-Nov-83	15	19	3	NA	35	83
EELG-37	NPA	Fill	834236	0.7	07-Nov-83	19	24	349	NA	30	92
EELG-37	NPA	Fill/Mud	834237	5.7	07-Nov-83	21	18	4	NA	37	87
EELG-37	NPA	Mud	834238	10.7	07-Nov-83	18	21	4	NA	42	374
EELG-38	NPA	Fill	834137	0.7	02-Nov-83	38	37	1	NA	92	75
EELG-38	NPA	Fill	834138	5.7	02-Nov-83	30	18	3	NA	46	18
EELG-38	NPA	Mud	834139	10.7	02-Nov-83	19	18	2	NA	24	44
EELG-39	NPA	Fill	834164	1.7	02-Nov-83	25	20	62	NA	21	62

TABLE 1

TOTAL METAL CONCENTRATIONS (MG/KG) OF SUBSURFACE SOIL SAMPLES
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

BORING	AREA	STRATA	SAMPID	DEPTH (FT)	DATE	CHROMIUM	COPPER	LEAD	MERCURY	NICKEL	ZINC
EELG-39	NPA	Fill	834165	5.7	02-Nov-83	18	80	79	NA	41	197
EELG-39	NPA	Mud	834166	10.7	02-Nov-83	29	18	3	NA	36	200
EELG-40	NPA	Mud	834180	20.7	02-Nov-83	28	23	2	NA	49	84
EELG-40	NPA	Alluvium	834181	25.7	02-Nov-83	16	18	8	NA	65	43
EELG-40	NPA	Alluvium	834182	30.7	02-Nov-83	14	12	4	NA	52	23
EELG-40	NPA	Alluvium	834183	35.7	02-Nov-83	40	19	3	NA	62	46
EELG-41	NPA	Alluvium	834161	20.7	02-Nov-83	14	NA	4	NA	69	29
EELG-42	NPA	Fill	834187	0.7	03-Nov-83	20	25	3	NA	32	79
EELG-42	NPA	Fill/Mud	834188	5.7	03-Nov-83	28	25	5	NA	32	80
EELG-42	NPA	Mud	834189	10.7	03-Nov-83	29	20	2	NA	61	62
EELG-43	NPA	Fill	834190	0.7	03-Nov-83	17	26	5	NA	19	91
EELG-43	NPA	Fill/Mud	834191	5.7	03-Nov-83	39	16	3	NA	30	54
EELG-43	NPA	Fill/Mud	834192	10.7	03-Nov-83	30	16	2	NA	21	51
EELG-44	NPA	Fill	834193	0.7	03-Nov-83	77	26	3	NA	53	128
EELG-44	NPA	Fill/Mud	834194	5.7	03-Nov-83	20	20	50	NA	29	100
EELG-44	NPA	Mud	834195	10.7	03-Nov-83	30	23	2	NA	61	49
EELG-45	NPA	Alluvium	834196	25.7	03-Nov-83	NA	15	8	NA	NA	NA
EELG-46	NPA	Alluvium	834199	20.7	03-Nov-83	NA	14	2	NA	NA	NA
EELG-47	POND	Fill	834243	0.7	07-Nov-83	16	33	9	NA	30	46
EELG-47	POND	Fill	834244	5.7	07-Nov-83	22	360	190	NA	21	1700
EELG-47	POND	Mud	834245	10.7	07-Nov-83	30	25	2	NA	45	60
EELG-48	NPA	Fill	834253	0.7	03-Nov-83	24	21	9	NA	33	61
EELG-48	NPA	Fill	834254	5.7	03-Nov-83	91	93	186	NA	46	25
EELG-48	NPA	Mud	834255	10.7	03-Nov-83	35	21	5	NA	44	58
EELG-49	NPA	Mud	834202	20.7	04-Nov-83	NA	16	2	NA	NA	36
EELG-50	NPA	Fill	834259	0.7	04-Nov-83	32	26	4	NA	49	63
EELG-50	NPA	Fill	834260	5.7	04-Nov-83	20	44	130	NA	6	91
EELG-50	NPA	Fill/Mud	834261	10.7	04-Nov-83	28	3	3	NA	28	58
EELG-51	NPA	Fill	834250	5.7	04-Nov-83	30	124	330	NA	18	4764
EELG-51	NPA	Mud	834251	10.7	04-Nov-83	32	18	2	NA	29	47
EELG-51	NPA	Mud	834252	15.7	04-Nov-83	20	19	2	NA	25	61
EELG-52	NPA	Mud	834205	20.7	03-Nov-83	NA	26	2	NA	NA	58
EELG-53	NPA	Fill	834240	5.7	07-Nov-83	20	93	27	NA	1	250
EELG-53	NPA	Mud	834241	10.7	07-Nov-83	15	19	2	NA	28	62
EELG-53	NPA	Mud	834242	15.7	07-Nov-83	35	19	4	NA	44	52
EELG-54	NPA	Fill	834256	0.7	04-Nov-83	31	23	18	NA	36	51
EELG-54	NPA	Fill	834257	5.7	04-Nov-83	15	173	333	NA	1	190
EELG-54	NPA	Fill/Mud	834258	10.7	04-Nov-83	37	74	82	NA	21	140
EELG-55	NPA	Fill	834208	0.7	03-Nov-83	25	10	3	NA	50	32
EELG-55	NPA	Fill/Mud	834209	10.7	03-Nov-83	21	16	1	NA	25	41
EELG-56	NPA	Fill	834246	0.7	14-Nov-83	29	60	31	NA	51	160
EELG-56	NPA	Fill	834247	5.7	14-Nov-83	15	24	6	NA	37	53
EELG-56	NPA	Mud	834248	10.7	14-Nov-83	36	20	2	NA	41	51
EELG-57	NPA	Mud	834210	20.7	03-Nov-83	NA	22	2	NA	NA	63

Notes:

1. Borings 100-130, MW and NS samples were collected by K/J/C in 1988.
2. Borings EELG-9 through 57 samples were collected by E&E in 1985.
3. NA = Not Analyzed.

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TABLE 2

SUMMARY OF 1988 SOIL SAMPLING AND ANALYSIS PROGRAM
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

AREA	NUMBER OF BORINGS (Locations)	TOTAL DEPTH (Ft)	SAMPLE INTERVAL (Feet)	TOTAL NUMBER OF SAMPLES	ANALYSES[1]
Area 1 Composite surface samples	2	15-16.5	0-1.5, 5-6.5, 10-11.5, 15-16.5	8	Pb, Ni, Cu, Cr, Zn, Hg, PCB, BNA, OG, TPH, S
	3	0.25	0-0.25	3	Pb, Ni, Cu, Cr, Zn, PCB, PAH, phenol, OG, S, TPH
Area 2 Composite surface samples	3	3	0.5-1, 2.5-3	6	Pb, Ni, Cu, Cr, Zn, Hg, PCB, BNA, OG, TPH, S
	3	0.25	0-0.25	3	Pb, Ni, Cu, Cr, Zn, PCB, PAH, phenol, OG, S, TPH
Area 3	2	3	0.5-1, 2.5-3	4	Pb, Ni, Cu, Cr, Zn, Hg, PCB, BNA, OG, TPH, S
Area 4 Composite surface samples	3	15-16.5	0-1.5, 5-6.5, 10-11.5, 15-16.5	12	Pb, Ni, Cu, Cr, Zn, Hg, PCB, BNA, OG, TPH, S
	3	0.25	0-0.25	3	Pb, Ni, Cu, Cr, Zn, PCB, PAH, phenol, OG, S, TPH
Area 5	3	16.5	0-1.5, 5-6.5, 10-11.5, 15-16.5	12	Pb, Ni, Cu, Cr, Zn, Hg, PCB, BNA, OG, S, TPH
Area 6	3	15-16.5	0-1.5, 5-6.5, 10-11.5, 15-16.5	12	Pb, Ni, Cu, Cr, Zn, Hg, PCB, BNA, OG, S, TPH
Concrete Slab Area	2	3	0.5-1, 2.5-3	4	Pb, Ni, Cu, Cr, Zn, Hg, PCB, BNA, OG, S, TPH
Former Asphalt Facility Area	1	30	0-1.5, 5-6.5, 10-11.5, 15-16.5, 20-21.5, 25-26.5, 30-31.5	7	Pb, Ni, Cu, Cr, Zn, Hg, PCB, BNA, OG, S, TPH
	3	15-16.5	0-1.5, 5-6.5, 10-11.5, 15-16.5	12	Pb, Ni, Cu, Cr, Zn, Hg, PCB, BNA, OG, S, TPH
Former Pond Area	2	30	0-1.5, 5-6.5, 10-11.5, 15-16.5, 20-21.5, 25-26.5, 30-31.5	14	Pb, Ni, Cu, Cr, Zn, Hg, PCB, BNA, OG, S, TPH

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TABLE 2

SUMMARY OF 1988 SOIL SAMPLING AND ANALYSIS PROGRAM
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

AREA	NUMBER OF BORINGS (Locations)	TOTAL DEPTH (Ft)	SAMPLE INTERVAL (Feet)	TOTAL NUMBER OF SAMPLES	ANALYSES[1]
Southeast Drainage Path, Composite surface samples	2	2	0-0.5, 1.5-2	4	Pb, Ni, Cu, Cr, Zn, Hg, PCB, PAH, phenol, OG, S, TPH
	4	0.25	0-0.25	4	Pb, Ni, Cu, Cr, Zn, Hg, PCB, PAH, phenol, OG, S, TPH
Subsurface soil	4	30	0-1.5, 5-6.5, 10-11.5, 15-16.5, 20-21.5, 25-26.5, 30-31.5	28	Pb, Ni, Cu, Cr, Zn, Hg, PCB, BNA, phenol, OG, S, TPH
	1	20	0-1.5, 5-6.5, 10-11.5, 15-16.5, 20-21.5	5	Pb, Ni, Cu, Zn, Hg, PCB, BNA, OG, S, TPH
Hoffman Marsh	3	2	0-0.5, 1-2	6	Pb, Ni, Cu, Zn, Hg, PCB, PAH, phenol, OG, S, TPH
Drainage Path	1	2	0-0.5, 1.5-2	2	Pb, Ni, Cu, Cr, Zn, Hg, PCB, PAH, phenol, OG, S, TPH
Monitoring Wells	1	30	1-1.5, 6-6.5, 11-11.5, 15.5-16, 20.5-21, 26-26.5, 30-30.5	7	Pb, Ni, Cu, Cr, Zn, Hg, PCB, BNA, OG, S, TPH
	1	51	2.5-3, 5.5-6, 10.5-11, 15.5-16, 20.5-21, 25.5-26, 30.5-31, 35.5-36, 41-41.5, 45.5-46, 50.5-51	11	Pb, Ni, Cu, Cr, Zn, Hg, PCB, BNA, OG, S, TPH

NOTES:

1. Pb = lead, Ni = Nickel, Cu = copper, Cr = chromium, Zn = zinc, PCB = polychlorinated biphenyls, BNA = base/neutral/acid extractable compounds, OG = oil and grease, PAH = polycyclic aromatic hydrocarbons, S = sulfur

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TABLE 3

CONCENTRATION OF METALS FOR SELECTED SUBSURFACE SOIL SAMPLES
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

LOCATION	DEPTH (Ft)	TOTAL METAL CONCENTRATION IN SOIL (mg/Kg)[1]																
		Sb	As	Cd	Cr	Co	Cu	Pb	Hg	Mo	Ni	Se	Ag	Tl	V	Zn	Bi	Ti
Soil Boring																		
102-A	1-1.5	0.37	6.8	0.26	51	8.2	130	450	0.74	<0.2	38	0.1	0.42	<0.1	13	200	9.7	14
102-B	4-4.5	<0.3	6	0.81	16	6.8	82	260	0.15	<0.2	23	<0.1	0.19	<0.1	12	140	7.6	13
102-C	8.5-9	<0.3	7.3	<0.05	21	4	250	<5	<0.05	<0.2	21	<0.1	<0.1	<0.1	11	100	12	17
102-D	14-14.5	<0.3	7.6	<0.05	19	3.8	68	<5	<0.05	<0.2	21	<0.1	<0.1	<0.1	10	62	6.6	14
102-E	19-19.5	<0.3	7.2	<0.05	33	6.4	120	<5	0.07	<0.2	50	<0.1	<0.1	<0.1	16	50	8.1	14
102-F	23.5-24	<0.3	12	<0.05	22	6.9	22	<5	0.07	<0.2	39	<0.1	<0.1	<0.1	13	33	5	3.1
102-G	28.5-29	<0.3	9.5	<0.05	30	8.4	25	<5	0.14	<0.2	49	<0.1	<0.1	<0.1	11	50	6.9	2.9
Soil Boring																		
116-A	2-2.5	0.42	15	<0.05	16	5.4	26	100	0.11	<0.2	21	<0.1	0.49	<0.1	12	64	9.5	14
116-B	5.5-6	11	14	0.8	28	3.2	400	1800	4.8	<0.2	18	<0.1	0.99	0.1	11	1300	25	80
116-C	10.5-11	0.49	6.6	<0.05	21	6.3	400	40	0.13	<0.2	23	<0.1	0.44	<0.1	15	250	16	44
116-D	16-16.5	<0.3	7.3	<0.05	23	4.3	90	<5	<0.05	<0.2	23	<0.1	0.29	<0.1	18	50	8	31
116-E	20.5-21	<0.3	6.4	<0.05	42	6.6	14	<5	0.1	<0.2	32	<0.1	0.2	<0.1	16	17	3.5	51
116-F	25-25.5	<0.3	8.4	<0.05	23	8.7	66	5	0.07	<0.2	32	<0.1	0.2	<0.1	14	45	6	6
116-G	30-30.5	<0.3	8.7	<0.05	25	5.3	50	<5	0.07	<0.2	30	<0.1	0.19	<0.1	13	49	7.7	4.6
Soil Boring																		
117-A	2.5-3	<0.3	11	<0.05	21	6	34	45	0.06	<0.2	32	<0.1	0.59	<0.1	15	57	9.6	140
117-B	5.5-6	<0.3	5.8	<0.05	16	4.6	190	87	0.07	<0.2	21	<0.1	0.39	0.1	15	220	17	83
117-C	10-10.5	<0.3	8.4	<0.05	24	4.6	140	<5	<0.05	<0.2	25	<0.1	0.39	<0.1	15	91	10	74
117-D	15.5-16	<0.3	10	<0.05	26	5.5	150	<5	<0.05	<0.2	31	0.39	0.29	<0.1	16	82	10	53
117-E	20.5-21	<0.3	13	<0.05	29	5.2	120	5	<0.05	<0.2	31	0.49	0.39	<0.1	18	80	11	57
117-F	25.5-26	<0.3	7.8	<0.05	46	11	31	5	0.09	<0.2	68	<0.1	0.39	<0.1	11	26	3.8	7.4
117-G	31-31.5	<0.3	9.8	<0.05	26	12	66	<5	0.06	<0.2	47	<0.1	0.28	<0.1	14	51	8.1	7.3
Soil Boring																		
120-A	2-2.5	<0.3	13	<0.05	25	8.7	32	11	<0.05	<0.2	34	<0.1	0.49	<0.1	18	47	6	12
120-B	6-6.5	<0.3	16	<0.05	36	9.7	100	62	2	<0.2	45	<0.1	0.38	<0.1	14	170	18	15
1200-C	10.5-11	<0.3	11	<0.05	25	6	28	<5	0.07	<0.2	29	0.29	0.19	<0.1	16	41	6.8	15
120-D	16-16.5	<0.3	8.1	<0.05	22	4.2	120	<5	<0.05	<0.2	25	0.28	0.19	<0.1	14	81	8.5	21
120-E	20.5-21	<0.3	7.3	<0.05	50	11	27	<5	0.08	<0.2	88	<0.1	0.19	<0.1	11	29	6.2	20
120-F	26-26.5	<0.3	5.4	<0.05	38	12	40	<5	<0.05	<0.2	68	<0.1	<0.1	0.1	12	34	5.6	33
120-G	30.5-31	<0.3	6.1	<0.05	32	11	17	<5	0.076	<0.2	52	<0.1	<0.1	<0.1	14	20	5.2	176

TABLE 3

CONCENTRATION OF METALS FOR SELECTED SUBSURFACE SOIL SAMPLES
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

LOCATION	DEPTH (Ft)	TOTAL METAL CONCENTRATION IN SOIL (mg/Kg)[1]																
		Sb	As	Cd	Cr	Co	Cu	Pb	Hg	Mo	Ni	Se	Ag	Tl	V	Zn	Bi	Ti
Soil Boring																		
121-A	2.5-3	<0.3	15	<0.05	20	8.7	22	7.8	<0.05	<0.2	25	<0.1	0.22	<0.1	17	53	7.4	59
121-B	6-6.5	<0.3	7.9	<0.05	21	3.1	220	<5	<0.05	<0.2	17	<0.1	<0.1	<0.1	12	67	10	11
121-C	11-11.5	<0.3	8.4	<0.05	20	3.8	41	<5	<0.05	<0.2	19	<0.1	<0.1	<0.1	11	33	5.7	18
121-D	15.5-16	<0.3	10	<0.05	22	4.3	81	<5	<0.05	<0.2	23	0.2	<0.1	<0.1	12	47	5.4	12
121-E	20.5-21	<0.3	5	<0.05	35	26	27	<5	<0.05	<0.2	65	<0.1	0.3	<0.1	16	21	2.3	52
Monitoring Well																		
19-A	1-1.5	1.4	12	<0.05	35	14	22	<5	0.07	<0.2	71	<0.1	0.29	<0.1	25	38	13	230
19-B	6-6.5	0.42	12	<0.05	26	9.5	20	<5	0.07	<0.2	48	0.2	0.3	<0.1	8.5	42	9.4	7.4
19-C	11-11.5	0.38	12	<0.05	29	5.9	18	<5	0.05	<0.2	34	0.1	0.2	<0.1	7.6	38	6.6	7.1
19-D	15.5-16	0.66	7.8	<0.05	18	7.6	14	<5	<0.05	<0.2	28	<0.1	0.39	<0.1	9.4	33	6.9	3.5
19-E	20.5-21	0.58	10	<0.05	19	8.9	17	<5	<0.05	<0.2	39	<0.1	0.29	<0.1	9.3	31	6.9	4.2
19-F	26-26.5	0.48	7.2	<0.05	20	11	14	<5	0.05	<0.2	33	<0.1	0.15	<0.1	10	33	5.9	7.3
19-G	30-30.5	0.74	16	<0.05	34	10	20	<5	<0.05	<0.2	64	<0.1	0.4	<0.1	10	39	9.4	2.8
Monitoring Well																		
20-A	2.5-3	<0.3	7.2	<0.05	24	5.7	120	45	0.07	<0.2	33	<0.1	0.2	<0.1	15	91	7.6	27
20-B	5.5-6	<0.3	5.9	<0.05	20	6.2	64	<5	0.07	<0.2	26	<0.1	0.2	<0.1	11	45	6.5	9.3
20-C	10.5-11	<0.3	6.8	<0.05	26	6	64	<5	0.07	<0.2	27	<0.1	0.2	<0.1	12	42	5.7	28
20-D	15.5-16	<0.3	9.3	<0.05	23	8.3	33	5.9	0.08	<0.2	53	0.2	0.3	<0.1	11	44	7.3	3.5
20-E	20.5-21	<0.3	7.9	<0.04	26	8.5	16	5.9	0.06	<0.2	33	<0.1	0.3	<0.1	10	37	5.6	7.5
20-F	25.5-26	<0.3	7.6	<0.05	27	10	19	<5	0.07	<0.2	37	<0.1	0.3	<0.1	9.9	51	6	6.9
20-G	30.5-31	<0.3	8.9	<0.05	30	7.9	16	<5	<0.05	<0.2	43	0.1	0.3	<0.1	9.6	35	4.7	4
20-H	35.5-36	<0.3	13	<0.05	24	7.8	19	<5	<0.05	<0.2	45	0.1	0.49	<0.1	19	37	8.8	3.6
20-I	41-41.5	<0.3	9.4	<0.05	20	6.6	15	<5	0.14	<0.2	32	0.1	0.3	<0.1	21	29	6.5	2.2
20-J	45.5-46	<0.3	5.8	<0.05	19	3.4	10	<5	<0.05	<0.2	18	<0.1	0.29	<0.1	4.6	22	4.3	10
20-K	50.5-51	<0.3	4.4	<0.05	18	4	8.5	<5	0.06	<0.2	20	<0.1	<0.1	<0.1	6.6	20	3.4	12

NOTES:

1. Sb = Antimony
   As = Arsenic
   Cd = Cadmium
   Cr - Total Chromium
   Co = Cobalt
   Cu = Copper
   Pb = Lead
   Hg = Mercury
   Mo = Molybdenum
   Ni = Nickel
   Se = Selenium
   Ag = Silver
   Tl = Thallium
   V = Vanadium
   Zn = Zinc
   Bi = Bismuth
   Ti = Titanium

2. Samples were collected September 1988.

LG006267

TABLE 4
PAH CONCENTRATION (μg/Kg) OF SUBSURFACE SOIL SAMPLES COLLECTED IN SEPTEMBER 1988
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

Location:	AREA 1			AREA 2			HOFFMAN MARSH				
Sample No.:	100	101	102*	103	104	105	NS18	NS19A	NS19B	NS20A	NS20B
Depth (ft):	0-15	0-15	0-28.5	0.5	0.5-2.5	0.5-2.5	0-1	0	1	0	1
ANALYTE											
Napthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Methyl-Napthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	140
Benzo[a]-anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chrysene	ND	ND	ND	ND	ND	ND	ND	700	130	580	150
Benzo[b]-fluoranthene	ND	ND	ND	ND	ND	ND	ND	280	ND	ND	ND
Benzo[a]-pyrene	ND	ND	ND	ND	ND	ND	ND	620	ND	ND	ND
Ideno-[1,2,3-c,d]-pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenzo-[a,h]-anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo-[g,h,i]-perylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Poly Aromatic Hydrocarbons	ND	ND	ND	ND	ND	ND	ND	1600	130	580	290

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TABLE 4
PAH CONCENTRATION (µg/Kg) OF SUBSURFACE SOIL SAMPLES COLLECTED IN SEPTEMBER 1988
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

Location:	AREA 3		DRAINAGE AREA	CONCRETE SLAB DEBRIS AREA		AREA 6			AREA 5		
Sample No.:	106A	107	D1B	108	109	110B	111A	112A	113	114	115
Depth (ft):	0.5	0.5-2.5	1.5	0.5-2.5	0.5-1.5	6	0	1	0.5-2.5	2-15	1.5-15.5
ANALYTE											
Napthalene	390	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Methyl-Napthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenan-threne	ND	ND	200	ND	ND	360	ND	ND	ND	ND	ND
Fluor-anthene	ND	ND	ND	ND	ND	590	590	570	ND	ND	ND
Pyrene	ND	ND	400	ND	ND	920	8600	830	ND	ND	ND
Benzo[a]-anthracene	ND	ND	ND	ND	ND	330	630	800	ND	ND	ND
Chrysene	ND	ND	600	ND	ND	400		1200	ND	ND	ND
Benzo[b]-fluor-anthene	ND	ND	ND	ND	ND	630	2000	2700	ND	ND	ND
Benzo[a]-pyrene	ND	ND	ND	ND	ND	530	1100	1500	ND	ND	ND
Ideno-[1,2,3-c,d]-pyrene	ND	ND	ND	ND	ND	330	890	1600	ND	ND	ND
Dibenzo-[a,h]-anthracene	ND	ND	ND	ND	ND	ND	ND	670	ND	ND	ND
Benzo-[g,h,i]-perylene	ND	ND	ND	ND	ND	500	1200	1600	ND	ND	ND
Total Poly Aromatic Hydro-carbons	390	ND	1200	ND	ND	4590	15010	11470	ND	ND	ND

LG006269

TABLE 4
PAH CONCENTRATION (μg/Kg) OF SUBSURFACE SOIL SAMPLES COLLECTED IN SEPTEMBER 1988
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

Location:			FORMER POND AREA				FORMER ASPHALT FACILITY AREA				
Sample No.:	116B*	117*	118B	119	120*	121*	122	123A	123B	124	125
Depth (ft):	5.5	2.5-31	5	0.5-30	2-30.5	2.5-20.5	2-30	2.5	5.5	1-15	1.5-15
ANALYTE											
Napthalene	ND	ND	360	ND	ND	ND	ND	ND	ND	ND	ND
2-Methyl-Napthalene	ND	ND	ND	ND	ND	ND	ND	13000	1200	ND	ND
Phenanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	460	ND	330	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene	530	ND	630	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[a]-anthracene	370	ND		ND	ND	ND	ND	ND	ND	ND	ND
Chrysene	550	ND	660	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[b]-fluoranthene	1500	ND		ND	ND	ND	ND	ND	ND	ND	ND
Benzo[a]-pyrene	570	ND	460	ND	ND	ND	ND	ND	ND	ND	ND
Ideno-[1,2,3-c,d]-pyrene	ND	ND	400	ND	ND	ND	ND	ND	ND	ND	ND
Dibenzo-[a,h]-anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo-[g,h,i]-perylene	ND	ND	460	ND	ND	ND	ND	ND	ND	ND	ND
Total Poly Aromatic Hydrocarbons	3980	ND	3300	ND	ND	ND	ND	13000	1200	ND	ND

LG006270

TABLE 4
PAH CONCENTRATION (μg/Kg) OF SUBSURFACE SOIL SAMPLES COLLECTED IN SEPTEMBER 1988
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

Location:	AREA 4			SOUTHEAST DRAINAGE	
Sample No.:	126	127	128	129	130
Depth (ft):	1-15	0.5-15.5	1.5-15.5	0-1.5	0-1.5
ANALYTE					
Napthalene	ND	ND	ND	ND	ND
2-Methyl-Napthalene	ND	ND	ND	ND	ND
Phenan-threne	ND	ND	ND	ND	ND
Fluor-anthene	ND	ND	ND	ND	ND
Pyrene	ND	ND	ND	ND	ND
Benzo[a]-anthracene	ND	ND			
Chrysene	ND	ND	ND	ND	ND
Benzo[b]-fluor-anthene	ND	ND			
Benzo[a]-pyrene	ND	ND	ND	ND	ND
Ideno-[1,2,3-c,d]-pyrene	ND	ND	ND	ND	ND
Dibenzo-[a,h]-anthracene	ND	ND	ND	ND	ND
Benzo-[g,h,i]-perylene	ND	ND	ND	ND	ND
Total Poly Aromatic Hydro-carbons	ND	ND	ND	ND	ND

* Sampling site of former E&E sampling location where oil and grease was detected at high levels.
ND = Not Detected; detection limits generally at 330 μg/Kg. Selected samples due to matrix inteference had raised detetion limits of 3,300 μg/Kg.
Data originally presented in K/J/C 1988d.

TABLE 5

BNA COMPOUND CONCENTRATIONS (µg/Kg)
SUBSURFACE SOIL SAMPLES (excluding PAHs)
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

SAMPLE NAME	DEPTH (ft)	PHENOL	2-METHYL-PHENOL	4-METHYL-PHENOL	2,4-DIMETHYL-PHENOL	DI-N-BUTYL-PHTHALATE	BIS-2-ETHYLHEXYL) PHTHALATE	DI-N-OCTYL-PHTHALATE
100-A	1.0	<330	<330	<330	<330	<330	<330	<330
100-B	6.0	<330	<330	<330	<330	<330	<330	<330
100-C	10.5	<330	<330	<330	<330	<330	<330	<330
100-D	15.5	<330	<330	<330	<330	<300	<330	<330
101-A	2.0	<330	<330	<330	<330	<330	<330	<330
101-C	10.5	<330	<330	<330	<330	<330	<330	<330
101-D	15.5	<330	<330	<330	<330	<330	<330	<330
102-B	3.5	<3300	<3300	<3300	<3300	<3300	<3300	<3300
102-C	8.0	<330	<330	<330	<330	<330	400	<330
102-D	13.5	<330	<330	<330	<330	<330	<330	<330
102-E	18.5	<330	<330	<330	<330	<330	<330	<330
102-F	23.0	<330	<330	<330	<330	<330	<330	<330
102-G	28.0	<330	<330	<330	<330	<330	<330	<330
103-A	1.0	<330	<330	<330	<330	<330	<330	<330
103-B	3.0	<330	<330	<330	<330	<330	<330	<330
104-A	1.0	<330	<330	<330	<330	<330	<330	<330
104-B	3.0	<330	<330	<330	<330	<330	<330	<330
105-A	1.3	<330	<330	<330	<330	<330	<330	<330
105-B	3.0	<330	<330	<330	<330	<330	<330	<330
106-A	1.0	<330	<330	<330	<330	<330	<330	<330
106-B	3.0	<330	<330	<330	<330	<330	<330	<330
107-A	1.0	<330	<330	<330	<330	<330	<330	<330
107-B	3.0	<330	<330	<330	<330	<330	<330	<330
108-A	1.0	<330	<330	<330	<330	<330	<330	<330
108-B	3.0	<330	<330	<330	<330	<330	<330	<330
109-A	1.0	<330	<330	<330	<330	<330	<330	<330
110-A	1.5	<330	<330	<330	<330	<330	<330	<330
110-B	6.5	<330	<330	<330	<330	590	<330	<330
110-C	10.5	<330	<330	<330	<330	<330	<330	660
110-D	15.5	<330	<330	<330	<330	<330	<330	<330
111-A	0.5	<330	<330	<330	<330	<330	<330	<330
111-B	5.5	<330	<330	<330	<330	610	<330	<330
111-C	10.5	<330	<330	<330	<330	<330	<330	<330
111-D	15.5	<330	<330	<330	<330	<330	<330	<330
112-A	1.5	<330	<330	<330	<330	<330	<330	<330
112-B	6.0	<330	<330	<330	<330	550	<330	<330
112-C	10.5	<330	<330	<330	<330	<330	<330	<330
112-D	11.5	<330	<330	<330	<330	<330	<330	<330
113-A	0.0	<3300	<3300	<3300	<3300	<3300	<3300	<3300
113-B	6.0	<330	<330	<330	<330	690	<330	<330
113-C	12.0	<330	<330	<330	<330	<330	<330	<330
113-D	15.5	<330	<330	<330	<330	<330	<330	<330
114-A	1.5	<330	<330	<330	<330	<330	<330	<330
114-B	5.5	<330	<330	<330	<330	<3300	<3300	<330
114-C	12.0	<330	<330	<330	<330	<330	<330	<330
114-D	15.5	<330	<330	<330	<330	370	<330	<330
115-A	2.0	<3300	<3300	<3300	<3300	<3300	<3300	<3300
115-B	5.5	<3300	<3300	<3300	<3300	<3300	<3300	<3300
115-C	10.5	<330	<330	<330	<330	<330	<330	<330
115-D	16.0	<330	<330	<330	<330	<330	<330	<330
116-A	2.5	<330	<330	<330	<330	<330	<330	<330
116-B	5.0	<330	<330	<330	<330	590	<330	<330
116-C	11.0	<330	<330	<330	<330	<330	<330	<330
116-D	15.5	<330	<330	<330	<330	<330	<330	<330
116-E	20.0	<330	<330	<330	<330	<330	<330	<330
116-F	25.5	<330	<330	<330	<330	470	<330	<330
116-G	30.5	<330	<330	<330	<330	<330	<330	<330
117-B	6.0	<330	<330	<330	<330	<330	<330	<330
117-C	10.5	<330	<330	<330	<330	<330	<330	<330
117-D	15.0	<330	<330	<330	<330	<330	<330	<330
117-E	20.0	<330	<330	<330	<330	<330	<330	<330

TABLE 5

BNA COMPOUND CONCENTRATIONS (µg/Kg)
SUBSURFACE SOIL SAMPLES (excluding PAHs)
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

SAMPLE NAME	DEPTH (ft)	PHENOL	2-METHYL-PHENOL	4-METHYL-PHENOL	2,4-DIMETHYL-PHENOL	DI-N-BUTYL-PHTHALATE	BIS-2-ETHYLHEXYL) PHTHALATE	DI-N-OCTYL-PHTHALATE
117-F	26.0	<330	<330	<330	<330	<330	<330	<330
117-G	30.5	<330	<330	<330	<330	<330	<330	<330
118-A	1.0	<330	<330	<330	<330	<330	<330	<330
118-B	5.5	<330	<330	<330	<330	<330	<330	<330
118-C	10.5	<330	<330	<330	<330	<330	<330	<330
118-D	16.0	<330	<330	<330	<330	<330	<330	<330
118-E	20.5	<330	<330	<330	<330	<330	<330	<330
118-F	25.5	<330	<330	<330	<330	<330	<330	<330
118-G	30.5	<330	<330	<330	<330	<330	<330	<330
119-A	1.0	<330	<330	<330	<330	<330	<330	<330
119-B	5.5	<330	<330	<330	<330	<330	<330	<330
119-C	10.5	<330	<330	<330	<330	<330	<330	<330
119-D	15.5	<330	<330	<330	<330	<330	<330	<330
119-E	20.5	<330	<330	<330	<330	<330	<330	<330
119-F	26.0	<330	<330	<330	<330	<330	<330	<330
119-G	30.5	<330	<330	<330	<330	<330	<330	<330
120-A	2.5	<330	<330	<330	<330	<330	<330	<330
120-B	5.5	<330	<330	<330	<330	370	<330	<330
120-C	11.0	<330	<330	<330	<330	400	330	<330
120-D	15.5	<330	<330	<330	<330	<330	<330	<330
120-E	20.0	<330	<330	<330	<330	<330	<330	<330
120-F	26.5	<330	<330	<330	<330	<330	<330	<330
120-G	30.0	<330	<330	<330	<330	<330	<330	<330
121-A	2.0	<3300	<3300	<3300	<3300	<3300	<3300	<3300
121-B	5.5	<330	<330	<330	<330	<330	<330	<330
121-C	10.5	<330	<330	<330	<330	470	<330	<330
121-D	15.0	<330	<330	<330	<330	590	<330	<330
121-E	20.0	<330	<330	<330	<330	<330	<330	<330
122-A	1.5	<3300	<3300	<3300	<3300	<3300	<3300	<3300
122-B	6.0	<330	<330	<330	<330	<330	<330	<330
122-C	11.0	<330	<330	<330	<330	<330	<330	<330
122-D	16.0	<330	<330	<330	<330	<330	<330	<330
122-E	21.0	<330	<330	<330	<330	<330	<330	<330
122-F	25.5	<330	<330	<330	<330	<330	<330	<330
122-G	30.5	<330	<330	<330	<330	<330	<330	<330
123-A	3.0	<3300	<3300	41000	50000	<3300	<3300	<3300
123-B	6.0	<3300	<3300	<3300	55000	<3300	<3300	<3300
123-C	10.5	<330	<330	<330	<330	<330	<330	<330
123-D	16.0	<330	<330	<330	<330	<330	<330	<330
124-A	1.5	<330	<330	<330	<330	<330	<330	<330
124-B	6.0	<330	<330	<3300	<3300	<3300	<3300	<3300
124-C	10.5	<330	1000	<330	<330	<330	<330	<330
124-D	15.5	<330	<330	<330	<330	<330	<330	<330
125-A	2.0	<3300	<3300	<3300	<3300	<3300	<3300	<3300
125-B	5.0	<3300	<3300	<3300	<3300	<3300	<3300	<3300
125-C	10.5	430	<330	7400	<330	<330	<330	<330
125-D	15.5	<330	<330	<330	<330	<330	<330	<330
126-A	1.5	<330	<330	<330	<330	<330	<330	<330
126-B	5.5	<330	<330	<330	<330	<330	<330	<330
126-C	10.5	<330	<330	<330	<330	<330	<330	<330
126-D	15.5	<330	<330	<330	<330	<330	<330	<330
127-A	1.0	<330	<330	<330	<330	<330	<330	<330
127-B	5.5	<330	<330	<330	<330	<330	<330	<330
127-C	10.5	<330	<330	<330	<330	<330	<330	<330
127-D	15.0	<330	<330	<330	<330	<330	<330	<330
128-A	2.0	<330	<330	<330	<330	<330	<330	<330
128-B	6.0	<330	<330	<330	<330	560	<330	<330
128-C	10.5	<330	<330	<330	<330	<330	<330	<330
128-D	16.0	<330	<330	<330	<330	<330	<330	<330
129-A	0.0	<500	NA	NA	<500	NA	NA	NA
129-A	0.5	<330	<330	<330	<330	<330	<330	<330

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TABLE 5

BNA COMPOUND CONCENTRATIONS (µg/Kg)
SUBSURFACE SOIL SAMPLES (excluding PAHs)
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

SAMPLE NAME	DEPTH (ft)	PHENOL	2-METHYL-PHENOL	4-METHYL-PHENOL	2,4-DIMETHYL-PHENOL	DI-N-BUTYL-PHTHALATE	BIS-2-ETHYLHEXYL) PHTHALATE	DI-N-OCTYL-PHTHALATE
129-B	1.5	<500	NA	NA	<500	NA	NA	NA
129-B	2.0	<330	<330	<330	<330	<330	<330	<330
130-A	0.0	<500	NA	NA	<500	NA	NA	NA
130-A	0.5	<330	<330	<330	<330	<330	<330	<330
130-B	1.5	<500	NA	NA	<500	NA	NA	NA
130-B	2.0	<330	<330	<330	<330	<330	<330	<330
D1-A	0.0	<500	NA	NA	<500	NA	NA	NA
D1-A	0.5	<330	<330	<330	<330	<330	<330	<330
D1-B	1.5	<500	NA	NA	<500	NA	NA	NA
D1-B	2.0	<330	<330	<330	<330	<330	<330	<330
MW-19A	0.5	<330	<330	<330	<330	<330	<330	<330
MW-19B	5.5	<330	<330	<330	<330	<330	<330	<330
MW-19C	10.5	<330	<330	<330	<330	<330	<330	<330
MW-19D	15.0	<330	<330	<330	<330	<330	<330	<330
MW-19E	20.0	<330	<330	<330	<330	<330	<330	<330
MW-20A	2.0	<330	<330	<330	<330	<330	<330	<330
MW-20B	5.0	<330	<330	<330	<330	<330	<330	<330
MW-20C	11.0	<330	<330	<330	<330	<330	<330	<330
MW-20D	15.0	<330	<330	<330	<330	<330	<330	<330
MW-20E	20.0	<330	<330	<330	<330	<330	<330	<330
MW-20F	25.0	<330	<330	<330	<330	<330	<330	<330
MW-20G	30.0	<330	<330	<330	<330	<330	<330	<330
NS-18A	0.0	<0.05	NA	NA	<0.05	NA	NA	NA
NS-18B	1.0	<0.05	NA	NA	<0.05	NA	NA	NA
NS-19A	0.0	<0.05	NA	NA	<0.05	NA	NA	NA
NS-19B	1.0	<0.05	NA	NA	<0.05	NA	NA	NA
NS-20A	0.0	<0.05	NA	NA	<0.05	NA	NA	NA
NS-20B	1.0	<0.05	NA	NA	<0.05	NA	NA	NA

NOTES:

1. Sample depth shown in table is the top of a 6-inch core (i.e., depth 0 indicates sample collected from 0 to 6 inches).

2. Polycyclic aromatic hydrocarbon results are given in Table 4. Only base/neutral/acid extractable compounds detected in at least one sample are shown in the table.

3. Samples 129A, 129B, 130A, 130B, D1-A, and D1-B were analyzed for phenols by GC, and base/neutral/acid extractable compounds by GC/MS. Results of the GC analyses for these samples are given first in the table, followed by the GC/MS results.

4. Samples NS-18A, NS-18B, NS-19A, NS-19B, NS-20A, and NS-20B were analyzed for phenols by GC.

5. NA = Not Analyzed.

6. Samples were collected September 1988.

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TABLE 6

PCB, OIL AND GREASE, TPH, AND TOTAL SULFUR CONCENTRATIONS (mg/Kg)
IN SUBSURFACE SOIL SAMPLES
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

SAMPLE NAME	DEPTH (ft)	PCBs	OIL AND GREASE	TOTAL PETROLEUM HYDROCARBONS (AS GASOLINE)	TOTAL PETROLEUM HYDROCARBONS (AS DIESEL)	TOTAL SULFUR
100-A	0.5	<1	710	<1	<1	<25
100-B	5.5	<1	170	<1	<1	112
100-C	10.0	<1	120	<1	<1	<29
100-D	15.0	<1	88	<1	<1	<29
101-A	1.5	<1	800	<1	<1	<26
101-B	6.5	<1	1,700	<1	<1	<26
101-C	10.0	<1	200	<1	<1	<23
101-D	15.0	<1	190	<1	<1	<28
102-A	1.0	<1	1,200	<1	<1	<18
102-B	4.0	<1	12,000	<1	<1	143
102-C	8.5	<1	130	<1	<1	23
102-D	14.0	<1	260	<1	<1	<20
102-E	19.0	<1	<40	<1	<1	NA
102-F	23.5	<1	<40	<1	<1	NA
102-G	28.5	<1	<40	<1	<1	NA
103-A	0.5	<1	79	<1	<1	<28
103-B	2.5	<1	130	<1	<1	<24
104-A	0.5	<1	2,100	<1	<1	57
104-B	2.5	<1	220	<1	<1	110
105-A	0.5	<1	500	<1	<1	<29
105-B	2.5	<1	240	<1	<1	<25
106-A	0.5	<1	2,100	<1	<1	<22
106-B	2.5	<1	370	<1	<1	<28
107-A	0.5	<1	120	<1	<1	<31
107-B	2.5	<1	420	<1	<1	<31
108-A	0.5	<1	300	<1	<1	<30
108-B	2.5	<1	760	<1	<1	420
109-A	0.5	<1	4,300	<1	<1	<31
109-A	1.5	<1	120	<1	<1	<32
110-A	1.0	<1	46	<1	<1	<31
110-B	6.0	<1	<40	<1	<1	<31
110-C	10.0	<1	<40	<1	<1	<32
110-D	15.0	<1	110	<1	<1	33
111-A	0.0	3	800	<1	<1	<28
111-B	5.0	<1	<40	<1	<1	71
111-C	10.0	<1	1,100	<1	<1	239
111-D	15.0	<1	<40	<1	<1	<32
112-A	1.0	<1	270	<1	<1	<30
112-B	5.5	<1	50	<1	<1	<31

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TABLE 6

PCB, OIL AND GREASE, TPH, AND TOTAL SULFUR CONCENTRATIONS (mg/Kg)
IN SUBSURFACE SOIL SAMPLES
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

SAMPLE NAME	DEPTH (ft)	PCBs	OIL AND GREASE	TOTAL PETROLEUM HYDROCARBONS (AS GASOLINE)	TOTAL PETROLEUM HYDROCARBONS (AS DIESEL)	TOTAL SULFUR
112-C	10.5	<1	85	<1	<1	<24
112-D	11.0	<1	52	<1	<1	<27
113-A	0.5	<1	2,400	<1	<2	<24
113-B	5.5	<1	2,100	<1	<2	<30
113-C	11.5	<1	240	<1	<2	<29
113-D	15.0	<1	87	<1	<2	NA
114-A	2.0	<1	2,000	<1	<2	<28
114-B	5.0	<1	4,200	<1	<2	95
114-C	11.5	<1	390	<1	<1	56
114-D	15.0	<1	1,300	<1	<1	<32
115-A	1.5	<1	1,500	<1	<2	<29
115-B	5.0	<1	710	<1	<2	<30
115-C	10.0	<1	11,000	<1	<2	30
115-D	15.5	<1	190	<1	<2	<31
116-A	2.0	<1	2,800	<1	<1	<35
116-B	5.5	<1	75	<1	<1	<35
116-C	10.5	<1	200	<1	<1	<35
116-D	16.0	<1	400	<1	<1	66
116-E	20.5	<1	<40	<1	<1	28
116-F	25.0	<1	86	<1	<1	<23
116-G	30.0	<1	62	<1	<1	<22
117-A	2.5	<1	69	<1	<1	<22
117-B	5.5	<1	800	<1	<1	54
117-C	10.0	<1	84	<1	<1	<21
117-D	15.5	<1	<40	<1	<1	NA
117-E	20.5	<1	58	<1	<1	<18
117-F	25.5	<1	<40	<1	<1	NA
117-G	31.0	<1	<40	<1	<1	NA
118-A	0.5	<1	740	<1	<1	<29
118-B	5.0	<1	130	<1	<1	<32
118-C	10.0	<1	190	<1	<1	<28
118-D	15.5	<1	<40	<1	<1	<33
118-E	20.0	<1	81	<1	<1	<26
118-F	25.0	<1	<40	<1	<1	NA
118-G	30.0	<1	50	<1	<1	<27
119-A	0.5	<1	110	<1	<1	NA
119-B	5.0	<1	620	<1	<1	<24
119-C	10.0	<1	150	<1	<1	<27
119-D	15.0	<1	160	<1	<1	<32

TABLE 6

PCB, OIL AND GREASE, TPH, AND TOTAL SULFUR CONCENTRATIONS (mg/Kg)
IN SUBSURFACE SOIL SAMPLES
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

SAMPLE NAME	DEPTH (ft)	PCBs	OIL AND GREASE	TOTAL PETROLEUM HYDROCARBONS (AS GASOLINE)	TOTAL PETROLEUM HYDROCARBONS (AS DIESEL)	TOTAL SULFUR
119-E	20.0	<1	59	<1	<1	<31
119-F	25.5	<1	67	<1	<1	<29
119-G	30.0	<1	100	<1	<1	<29
120-A	2.0	<1	<40	<1	<2	<35
120-B	6.0	<1	535	<1	<2	220
120-C	10.5	<1	63	<1	<2	22
120-D	16.0	<1	118	<1	<2	<22
120-E	20.5	<1	<40	<1	<2	<35
120-F	26.0	<1	<40	<1	<2	<35
120-G	30.5	<1	<40	<1	<2	<35
121-A	2.5	<1	70	<1	<1	<16
121-B	6.0	<1	77	<1	<1	<17
121-C	11.0	<1	36	<1	<1	NA
121-D	15.5	<1	48	<1	<1	<21
121-E	20.5	<1	<40	<1	<2	<35
122-A	2.0	<1	1,400	2	16	NA
122-B	5.5	<1	1,700	<1	<2	295
122-C	10.5	<1	<40	<1	<2	47
122-D	15.5	<1	<40	<1	<2	<31
122-E	20.5	<1	46	<1	<2	<22
122-F	25.0	<1	220	<1	<2	<31
122-G	30.0	<1	<40	<1	<2	<26
123-A	2.5	<1	1,300	<1	17	121
123-B	5.5	<1	48	<1	<1	<19
123-C	11.0	<1	370	<1	4	45
123-D	15.5	<1	<40	<1	<1	NA
124-A	1.0	<1	96	<1	<1	<21
124-B	5.5	<1	12,000	<1	2	505
124-C	10.0	<1	79	<1	<1	<29
124-D	15.0	<1	110	<1	<1	22
125-A	1.5	<1	27,000	<1	<1	NA
125-B	5.5	<1	200	<1	3	na
125-C	10.0	<1	470	<1	<2	na
125-D	15.0	<1	310	<1	<2	na
126-A	1.0	<1	<40	<1	<2	<21
126-B	5.0	<1	120	<1	<2	<26
126-C	10.0	<1	84	<1	<2	<30
126-D	15.0	<1	<40	<1	<2	NA
127-A	0.5	<1	5,400	<1	<2	59

TABLE 6

PCB, OIL AND GREASE, TPH, AND TOTAL SULFUR CONCENTRATIONS (mg/Kg)
IN SUBSURFACE SOIL SAMPLES
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

SAMPLE NAME	DEPTH (ft)	PCBs	OIL AND GREASE	TOTAL PETROLEUM HYDROCARBONS (AS GASOLINE)	TOTAL PETROLEUM HYDROCARBONS (AS DIESEL)	TOTAL SULFUR
127-B	5.0	<1	810	<1	<2	<29
127-C	10.0	<1	100	<1	<2	<29
127-D	15.5	<1	<40	<1	<2	<24
128-A	1.5	<1	500	<1	<2	<28
127-D	5.5	<1	<40	<1	<2	NA
128-C	10.0	<1	<40	<1	<1	<30
128-D	15.5	<1	91	<1	<1	<23
129-A	0.0	<1	5,000	<1	<1	44
129-B	1.5	<1	840	<1	<1	210
130-A	0.0	NA	1,700	<1	<1	<28
130-A	0.0	<1	NA	NA	NA	NA
130-B	1.5	<1	NA	NA	NA	NA
130-B	1.5	NA	140	<1	<1	<29
D1-A	0.0	<1	NA	<1	<1	<27
D1-B	1.5	<1	NA	<1	<1	210
MW-19A	1.0	<1	<40	<1	<2	<21
MW-19B	6.0	<1	<40	<1	<2	<20
MW-19C	11.0	<1	<40	<1	<2	<20
MW-19D	15.5	<1	<40	<1	<2	<20
MW-19E	20.5	<1	<40	<1	<2	<21
MW-19F	26.0	<1	<40	<1	<2	<21
MW-19G	30.0	<1	<40	<1	<2	<20
MW-20A	2.5	<1	8,900	<1	<1	391
MW-20B	5.5	<1	<40	<1	<1	<24
MW-20C	10.5	<1	<40	<1	<1	NA
MW-20D	15.5	<1	44	<1	<1	NA
MW-20E	20.5	<1	<40	<1	<1	NA
MW-20F	25.5	<1	<40	<1	<1	NA
MW-20G	30.5	<1	<40	<1	<1	NA
MW-20H	35.5	<1	55	<1	<1	NA
MW-20I	41.0	<1	<40	<1	<1	NA
MW-20J	45.5	<1	<40	<1	<1	NA
MW-20K	50.5	<1	<40	<1	<1	NA
NS-18A	0.0	<1	4,000	<1	<1	<35
NS-18B	1.0	<1	300	<1	<1	220
NS-19A	0.0	<1	1,400	<1	<1	520
NS-19B	1.0	<1	390	<1	<1	230
NS-20A	0.0	<1	1,000	<1	<1	300
NS-20B	1.0	<1	3,100	<1	<1	1,500

LGC06278

TABLE 6

PCB, OIL AND GREASE, TPH, AND TOTAL SULFUR CONCENTRATIONS (mg/Kg)
IN SUBSURFACE SOIL SAMPLES
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

NOTES:

1. Sample depth shown in table is the top of a 6-inch core (i.e., depth 0 indicates sample collected from 0 to 6 inches.

2. The total sulfur analysis was performed on the extract used for the oil and grease analysis. If oil and grease were not detected, the total sulfur analysis was not performed.

3. Sample results for Sample 109A are given for two depths, 0 - 5 feet and 1.5 - 2.0 feet. Because a sample could not be collected for Sample 109B (2.5 - 3.0 feet), the deepset sample from 109A was retained and analyzed.

4. Samples 130A and 130B were collected on two dates (11 October and 31 October 1988) because insufficient sample was initially obtained for analysis. Two sets of sample results which correspond to the dates of collection are given in the table.

5. NA = Not Analyzed.

6. Samples were collected September 1988.

TABLE 7

METAL CONCENTRATIONS IN SOIL SAMPLES COLLECTED FOR BIOASSAY STUDY
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.05-G-01)

	METAL CONCENTRATION IN mg/Kg[1]										
	SUBSURFACE (0-6.5 FT)					SURFACE (0-1 IN)					
METAL	M0-1	M0-2	M0-3	M0-4	M0-5	M1-1	M1-2	M1-3	M6-1	M6-2	M6-3
Chromium (Total)	24/34[2]	19	30	31	26	30	22/20	21	29	32/26	24
Copper	35/28	210	120	18	76	27	18/11	30	32	66/40	57
Lead	54/70	370	280	10	61	83	62/28	56	96	150/77	94
Mercury	0.07/ 0.12	0.38	0.06	0.07	0.18	0.57	0.09/ <0.05	0.22	0.37	0.21/ 0.19	0.24
Nickel	26/42	31	28	34	26	36	30/22	25	29	34/31	29
Zinc	54/53	200	200	29	260	140	77/37	55	70	140/77	79

NOTES:

1. Initial samples were collected August and September 1989. Confirmation samples for M0-1, M1-2 and M6-2 were collected January 1990. Soil samples were composited in the laboratory, with part of the composite sample used for chemical analyses and another part of the sample used for the soil elutriate.

2. Initial sample result/confirmation sample result.

L0006280

TABLE 8

ORGANIC COMPOUND CONCENTRATIONS IN SOIL SAMPLES COLLECTED FOR BIOASSAY
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

	CHEMICAL CONCENTRATION IN mg/Kg[1]										
	SUBSURFACE (0-6.5 FT)					SURFACE (0-1 IN)					
CHEMICAL	MO-1	MO-2	MO-3	MO-4	MO-5	M1-1	M1-2	M1-3	M6-1	M6-2	M6-3
Base/Neutral/Acid Extractable											
Phenol	ND[2]/ND[3]	ND	0.78	ND	ND	ND	ND/ND	ND	ND	ND/ND	ND
2,4-Dimethylphenol	ND/ND	ND	0.35	ND	ND	ND	ND/ND	ND	ND	ND/ND	ND
Pyrene	ND/ND	1.5	1.9	ND	ND	ND	ND/ND	ND	0.78	ND/ND	ND
Benz[a]anthracene	ND/ND	0.92	0.77	ND	ND	ND	ND/ND	ND	ND	ND/ND	ND
Bis(2-ethylhexyl)phthalate	0.75/ND	0.46	1.5	ND	0.49	ND	0.59/ND	ND	0.36	ND/ND	ND
Chrysene	ND/ND	1.0	1.3	ND	ND	ND	ND/ND	ND	0.33	ND/ND	ND
Benzo[k]fluoranthene	ND/ND	2.0	2.1	ND	ND	ND	ND/ND	ND	0.47	ND/ND	ND
Benzo[a]pyrene	ND/ND	0.93	0.96	ND	ND	ND	ND/ND	ND	ND	ND/ND	ND
Indeno[1,2,3-cd]pyrene	ND/ND	1.1	2.0	ND	ND	ND	ND/ND	ND	ND	ND/ND	ND
Dibenz[a,h]anthracene	ND/ND	0.48	0.96	ND	ND	ND	ND/ND	ND	ND	ND/ND	ND
Benzo[g,h,i]perylene	ND/ND	1.6	3.3	ND	ND	ND	ND/ND	ND	ND	ND/ND	ND
4-Methylphenol	ND/ND	ND	3.5	ND	ND	ND	ND/ND	ND	ND	ND/ND	ND
2-Methylnaphthalene	ND/ND	ND	0.61	ND	ND	ND	ND/ND	ND	ND	ND/ND	ND
Fluoranthene	ND/ND	0.62	ND	ND	ND	ND	ND/ND	ND	ND	ND/ND	ND
Oil and Grease	2200/ 5900	1600	6200	920	390	670	520/240	740	900	930/ 1200	150
PCB	<1/<1	<1	<1	<1	<1	<1	<1	<1/<1	<1	<1/<1	<1

NOTES:

1. Initial samples were collected August and September 1989. Confirmation samples for MO-1, M1-2, and M6-2 were collected January 1990. Soil samples were composited in the laboratory, with part of the composite sample used for chemical analyses and another part of the sample used for the soil elutriate.
2. ND = Not Detected. Detection limit = 0.33 mg/Kg, except for sample MO-4, which had detection limits of 10 mg/Kg due to interferences from aliphatic hydrocarbons and the confirmation sample of MO-1, which had detection limits of 3.3 mg/Kg.
3. Initial sample result/confirmation sample result.

TABLE 9

SOIL SAMPLING RESULTS - SEPTEMBER 1990
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
K/J/C 855018.11

LOCATION	DEPTH (FEET)	CONCENTRATION (MG/KG)[1]							
		Cr (TOTAL)	Cr (VI)	Cu	Pb	Hg	Ni	Zn	OIL AND GREASE
L4-1	0-1.5	47	1.1	2,200	1,600	0.45	54	1,500	4,400
	5-6.5	29	<0.05	90	430	0.52	27	350	18,000
L4-2	0-1.5	19	<0.05	13	<14	0.08	34	55	190
	5-6.5	6.3	<0.05	46	150	<0.05	5	140	550
	10-11.5	16	<0.05	21	250	0.06	17	200	290
L4-3	0-1.5	26	0.08	160	790	<0.05	26	86	110
	5-6.5	16	<0.05	31	32	0.15	37	120	14,000
	10-11.5	27	0.06	14	6.1	<0.05	37	55	61
L4-4	0-1.5	16	<0.05	130	360	0.09	62	2,700	440
	5-6.5	9.2	<0.05	85	710	0.09	10	660	440
	10-11.5	27	<0.05	13	13	<0.05	26	43	<30
L4-5	0-1.5	19	<0.05	220	920	0.41	17	780	350
	5-6.5	7.2	<0.05	32	14	0.17	11	570	270
	10-11.5	23	<0.05	38	150	0.05	23	63	<30
CR-1	surface	32	<0.05	NM[2]	NM	NM	NM	NM	NM
CR-2	surface	17	<0.05	NM	NM	NM	NM	NM	NM
CR-3	surface	48	<0.05	NM	NM	NM	NM	NM	NM
CR-4	surface	22	1	NM	NM	NM	NM	NM	NM

Notes:

1 Samples were collected 13 September 1990. See Figure 11 for sample locations.
2 NM = Not measured.

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TABLE 10

SOIL SAMPLING RESULTS FOR BNAs - SEPTEMBER 1990
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
K/J/C 855018.11

CONCENTRATION (UG/KG)[1]

	L4-1		L4-2			L4-3			L4-4			L4-5		
CHEMICAL[2]	(0-2 FT)	(5-6.5 FT)	(0-2 FT)	(5-6.5 FT)	(10-11.5 FT)	(0-1.5 FT)	(5-6.5 FT)	(10-11.5 FT)	(0-2 FT)	(5-6.5 FT)	(10-11.5 FT)	(0-2 FT)	(5-6.5 FT)	(10-11.5 FT)
2,4-dimethylphenol	<1,300	<6,700	<1,300	1,300	5,200	<1,000	<6,700	<660	<6,700	<6,700	<660	<6,700	<1,000	<1,000
fluoranthene	<1,300	<6,700	<1,300	2,300	3,400	1,000	<6,700	<660	<6,700	<6,700	<660	<6,700	<1,000	<1,000
pyrene	<1,300	<6,700	<1,300	3,100	4,700	1,000	<6,700	<660	<6,700	<6,700	<660	<6,700	<1,000	<1,000
benz[a]anthracene	<1,300	<6,700	<1,300	3,500	4,500	1,200	<6,700	<660	<6,700	<6,700	<660	<6,700	<1,000	<1,000
chrysene	<1,300	<6,700	<1,300	4,000	6,500	1,400	<6,700	<660	<6,700	<6,700	<660	<6,700	<1,000	<1,000
benzo[b]fluroanthene	<1,300	<6,700	<1,300	<1,000	<2,700	1,300	<6,700	<660	<6,700	<6,700	<660	<6,700	<1,000	<1,000
benzo[k]fluroanthene	<1,300	<6,700	<1,300	7,800	<2,700	1,500	<6,700	<660	<6,700	<6,700	<660	<6,700	<1,000	<1,000
benzo[a]pyrene	<1,300	<6,700	<1,300	3,400	11,000	<1,000	<6,700	<660	<6,700	<6,700	<660	<6,700	<1,000	<1,000
indeno[1,2,3-cd]pyrene	<1,300	<6,700	<1,300	1,600	<2,700	<1,000	<6,700	<660	<6,700	<6,700	<660	<6,700	<1,000	<1,000
benzo[g,h,i]perylene	<1,300	<6,700	<1,300	1,600	<2,700	<1,000	<6,700	<660	<6,700	<6,700	<660	<6,700	<1,000	<1,000

Notes:

1. Samples were collected 13 September 1990. See Figure 11 for sample locations.
2. Only detected base/neutral/acid extractable compounds are shown.

LG006283

TABLE 11

SOIL SAMPLING RESULTS FOR METALS - OCTOBER 1990
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
K/J/C 855018.11

LOCATION[1]	Metal Concentration (mg/Kg) Cu	Pb	Zn
First Phase[2]			
L4-1	2,200	1,600	1,500
L4-2	13	<14	55
L4-3	160	790	86
L4-4	130	360	2,700
L4-5	220	920	780
Arithmetic Mean	540	740	1,000
Second Phase[3]			
L4-6	20	14	40
L4-7	18	6.2	20
L4-8	13	7.9	22
L4-9	25	8.9	33
L4-10	33	15	38
L4-11	17	5.6	25
L4-12	20	19	47
L4-13	20	26	43
L4-14	14	22	25
L4-15	24	53	36
L4-16	35	54	72
L4-17	14	15	40
L4-18	34	170	150
L4-19	19	14	25
L4-20	12	11	32
L4-21	49	8.1	24
L4-22	35	100	90
L4-23	16	8.6	19
L4-24	32	320	190
L4-25	13	12	28
Arithmetic Mean	23	45	50

Notes:

1. See Figure 11 for sample locations.
2. Samples L4-1 to L4-5 were collected from 0-2 feet on 13 September 1990; see also Table 1.
3. Samples L4-6 to L4-25 were collected from 0-1.5 feet on 16-17 October 1990.

LG006284

TABLE 12

SOIL SAMPLING RESULTS FOR PAHs -- OCTOBER 1990
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
K/J/C 855018.11

Concentration of Polycyclic Aromatic Hydrocarbons[1] (ug/Kg)

CHEMICAL[2]	L4-6	L4-7	L4-8	L4-9	L4-10	L4-11	L4-12	L4-13	L4-14	L4-15	L4-16	L4-17	L4-18	L4-19	L4-20	L4-21	L4-22	L4-23	L4-24	L4-25
naphthalene	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<125	<1,250	<1,250	<1,250	<125	<1,250	<1,250	<1,250	<1,250
acenaphthylene	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	1,300	<125	<1,250	<1,250	<1,250	140	<1,250	<1,250	<1,250	<1,250
acenaphthene	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<125	<1,250	<1,250	<1,250	160	<1,250	<1,250	<1,250	<1,250
fluorene	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	1,500	<125	<1,250	<1,250	<1,250	180	<1,250	<1,250	<1,250	<1,250
phenanthrene	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	2,000	<125	<1,250	<1,250	<1,250	<125	<1,250	<1,250	<1,250	<1,250
anthracene	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<125	<1,250	<1,250	<1,250	<125	<1,250	<1,250	<1,250	<1,250
fluoranthene	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	2,100	<125	<1,250	<1,250	<1,250	<125	<1,250	<1,250	<1,250	<1,250
pyrene	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	1,500	<125	<1,250	<1,250	<1,250	<125	<1,250	<1,250	<1,250	<1,250
chrysene	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<125	<1,250	<1,250	<1,250	<125	<1,250	<1,250	<1,250	<1,250
benz[a]anthracene	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<125	<1,250	<1,250	<1,250	<125	<1,250	<1,250	<1,250	<1,250
benzo[k]fluoranthene	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<125	<1,250	<1,250	<1,250	<125	<1,250	<1,250	<1,250	<1,250
benzo[b]fluoranthene	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	1,300	<125	<1,250	<1,250	<1,250	<125	<1,250	<1,250	<1,250	<1,250
benzo[a]pyrene	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<1,250	<125	<1,250	<1,250	<1,250	<125	<1,250	<1,250	<1,250	<1,250
indeno[1,2,3-cd]pyrene	<1,750	<1,750	<1,750	<1,750	<1,750	<1,750	<1,750	<1,750	<1,750	<1,750	<1,750	<175	<1,750	<1,750	<1,750	<175	<1,750	<1,750	<1,750	<1,750
dibenz[a,h]anthracene	<2,000	<2,000	<2,000	<2,000	<2,000	<2,000	<2,000	<2,000	<2,000	<2,000	<2,000	<200	<2,000	<2,000	<2,000	<200	<2,000	<2,000	<2,000	<2,000
dibenzo[ghi]perylene	<1,750	<1,750	<1,750	<1,750	<1,750	<1,750	<1,750	<1,750	<1,750	<1,750	<1,750	<175	<1,750	<1,750	<1,750	<175	<1,750	<1,750	<1,750	<1,750

Notes:

1. See Figure 11 for sample locations. Samples were collected 16-17 October 1990 from 0 to 1.5 feet. Analysis was by EPA Method 8100.
2. Only detected PAH compounds are shown.

LG00285

TABLE 13

MONITORING WELL CONSTRUCTION SUMMARY
LIQUID GOLD SITE, RICHMOND, CA
K/J/C 855018.07

WELL[1]	TOTAL DEPTH (FT)	TOC ELEVATION (FT ABOVE MEAN SEA LEVEL)	SCREENED INTERVAL (DEPTH BELOW GROUND SURFACE, FT)	TARGET GROUNDWATER ZONE
MW-1	30	9.17	23-28.5	Deep
MW-2	25	7.64	20-25	Deep
MW-3	35	7.72	30-35	Deep
MW-4	15	7.95	10-15	Bay Mud
MW-4R	10	8.30	3-7.5	Shallow
MW-5	20	6.31	15-20	Shallow[1]
MW-6	30	6.43	25-30	Deep
MW-7	10	5.43	5-10	Shallow
MW-7R	10.5	8.13	3-9	Shallow
MW-8	10	5.87	5-10	Shallow
MW-9	35	6.05	29-34	Deep
MW-10	25	7.43	5-10	Shallow
MW-11	8.5	11.33	3-8	Shallow
MW-12	8.5	7.92	3-7	Shallow
MW-12R	8	6.87	3-8	Shallow
MW-13	5.5	7.15	2.5-5.5	Shallow
MW-15	11.5	7.58	3-10	Shallow
MW-15R	10	6.61	3-10	Shallow
MW-16	32	7.56	22-32	Deep
MW-17	10.5	6.63	3-8.5	Shallow
MW-18	26.5	7.34	16.5-26.5	Deep
MW-18R	26.5	6.65	16.5-26.5	Deep
MW-19	31.5	10.00	12-22	Deep
MW-20	51.5	9.68	20-30	Deep

Notes:

1. Wells MW-4, -7, -10, -12, -15, and -18 were destroyed. "R" designation indicates a replacement well.

LG006286

WATER LEVEL ELEVATIONS
LIQUID GOLD SITE, RICHMOND, CA
K/J/C 855018.07

WATER LEVEL ELEVATIONS BY MONITORING WELL AND DATE[1]

WELL:	MW-1	MW-2	MW-3	MW-4R	MW-5	MW-6	MW-7R	MW-8	MW-9	MW-11	MW-12R	MW-13	MW-15R[3]	MW-16	MW-17	MW-18R	MW-19	MW-20
DEPTH:[2]	D	D	D	S	S	D	S	S	D	S	S	S	S	D	S	D	D	D
DATE																		
13-Oct-88	3.87	2.94	3.49	1.90	2.51	2.83	1.98	1.94	2.78	2.21	1.89	2.87	1.98	2.69	2.78	2.45	1.85	2.33
	(5.30)	(4.70)	(4.23)	(6.40)	(3.80)	(3.60)	(6.15)	(3.93)	(3.27)	(9.12)	(4.98)	(4.28)	(5.60)	(4.87)	(3.85)	(4.20)	(8.15)	(7.35)
16-Dec-88	4.02	2.74	4.80	2.43	2.61	3.11	2.55	2.67	3.03	2.33	3.39	1.90	2.21	2.76	2.95	2.63	3.06	3.20
	(5.15)	(4.90)	(2.92)	(5.87)	(3.70)	(3.32)	(5.58)	(3.20)	(3.02)	(9.00)	(3.48)	(5.25)	(5.37)	(4.80)	(3.68)	(4.02)	(6.94)	(6.48)
05-Jan-89	4.67	3.18	4.23	3.88	2.96	3.43	4.05	4.10	3.10	4.41	4.35	2.01	NM	3.18	3.19	3.00	4.78	4.37
	(4.50)	(4.46)	(3.49)	(4.42)	(3.35)	(3.00)	(4.08)	(1.77)	(2.95)	(6.92)	(2.52)	(5.14)	NM	(4.38)	(3.44)	(3.65)	(5.22)	(5.31)
10-Feb-89	NM[4]	NM	NM	4.14	2.97	NM	4.03	4.14	NM	4.21	4.37	2.06	NM	NM	3.05	NM	NM	NM
	NM	NM	NM	(4.16)	(3.34)	NM	(4.10)	(1.73)	NM	(7.12)	(2.50)	(5.09)	NM	NM	(3.58)	NM	NM	NM
10-Mar-89	4.83	3.33	4.44	5.15	3.24	3.70	4.74	4.81	3.63	4.59	4.62	2.30	NM	3.28	3.15	3.31	NM	NM
	(4.34)	(4.31)	(3.28)	(3.15)	(3.07)	(2.73)	(3.39)	(1.06)	(2.42)	(6.74)	(2.25)	(4.85)	NM	(4.28)	(3.48)	(3.34)	NM	NM
05-Apr-89	5.09	3.50	4.72	4.96	3.57	3.80	4.61	4.62	3.80	4.36	3.81	3.18	3.81	3.34	2.98	3.55	5.22	4.74
	(4.08)	(4.14)	(3.00)	(3.34)	(2.74)	(2.63)	(3.52)	(1.25)	(2.25)	(6.97)	(3.06)	(3.97)	(2.80)	(4.22)	(3.65)	(3.10)	(4.78)	(4.94)
05-May-89	NM	NM	NM	4.00	NM	NM	3.75	3.72	NM	3.66	3.51	NM	3.25	NM	3.03	NM	NM	NM
	NM	NM	NM	(4.30)	NM	NM	(4.38)	(2.15)	NM	(7.67)	(3.36)	NM	(3.36)	NM	(3.60)	NM	NM	NM
06-Jun-89	NM	NM	NM	3.36	3.26	NM	3.16	3.14	NM	1.19	3.20	3.96	2.94	NM	3.08	NM	NM	NM
	NM	NM	NM	(4.94)	(3.05)	NM	(4.97)	(2.73)	NM	(10.14)	(3.67)	(3.19)	(3.67)	NM	(3.55)	NM	NM	NM
10-Jul-89	4.27	3.00	3.84	2.82	3.08	3.15	2.74	2.75	3.23	2.81	3.08	3.89	2.64	2.93	2.84	2.86	2.78	3.18
	(4.90)	(4.64)	(3.88)	(5.48)	(3.23)	(3.28)	(5.39)	(3.12)	(2.82)	(8.52)	(3.79)	(3.26)	(3.97)	(4.63)	(3.79)	(3.79)	(7.22)	(6.50)
07-Aug-89	NM	NM	NM	2.56	2.96	NM	2.46	2.44	NM	1.81	3.10	2.28	2.48	NM	2.90	NM	NM	NM
	NM	NM	NM	(5.74)	(3.35)	NM	(5.67)	(3.43)	NM	(9.52)	(3.77)	(4.87)	(4.13)	NM	(3.73)	NM	NM	NM
12-Sep-89	NM	NM	NM	2.21	2.73	NM	2.15	2.11	NM	2.01	2.75	NM	2.24	NM	2.91	NM	NM	NM
	NM	NM	NM	(6.09)	(3.58)	NM	(5.98)	(3.76)	NM	(9.32)	(4.12)	NM	(4.37)	NM	(3.72)	NM	NM	NM
09-Oct-89	4.25	2.82	3.77	2.30	2.82	3.11	2.39	2.42	3.11	2.88	2.96	2.62	2.28	2.86	2.93	2.69	2.94	3.21
	(4.92)	(4.82)	(3.95)	(6.00)	(3.49)	(3.32)	(5.74)	(3.45)	(2.94)	(8.45)	(3.91)	(4.53)	(4.33)	(4.70)	(3.70)	(3.96)	(7.06)	(6.47)

NOTES:

1. Water elevations in feet above mean sea level; depth to water in parentheses.

2. D = deep well; S = shallow well

3. Well MW-15 was damaged between December 1988 and January 1989 and as a result data was not obtained for January-March 1989. Well MW-15R was measured for April 1989 onward.

4. NM = not measured. Deep wells were measured quarterly and shallow wells monthly. Some wells were not measured due to field error.

TABLE 15

GROUNDWATER MONITORING WELL DATA
OCTOBER 1988 - OCTOBER 1989
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

WELL[1]	WELL DEPTH[2]	DATE	DISSOLVED METAL CONCENTRATION[3] (mg/L) TOTAL Cr	Cu	Pb	Mn	Hg	Ni	Zn	TDS[4] (mg/L)	NITRATE (mg/L)	OIL & GREASE (mg/L)	pH	SPECIFIC CONDUCTIVITY (umhos/cm)	TOTAL COLIFORM[5] (mpn/100 ml)	TPH[6] (GASOLINE) (mg/L)	TPH[6] (DIESEL) (mg/L)
MW-1	D	11/11/88[7]	0.025	0.006	<.010	9.400	<0.0002	0.03	0.003	12,000	<0.03	<2.0	7.6	33,000	<5.0	<0.05	<0.05
		01/09/89	<0.001	<0.005	<.010	10.000	<0.0002	<0.01	0.005	11,000	<0.03	<2.0	6.9	15,000	17	<0.05	<0.05
		04/06/89	<0.001	<0.005	<.010	10.000	<0.0002	<0.01	<0.020	12,000	0.07	<2.0	7.0	27,000	300	<0.05	<0.05
		07/10/89[7]	NV	<0.006	<.009	8.400	<0.0002	<0.01	0.020	12,000	0.09	<5.0	7.0	20,000	<2.0	<0.05	<0.05
		10/09/89	<0.001	0.048	<.010	9.600	<0.0002	0.03	<0.020	13,000	0.04	<5.0	7.0	17,000	170	<0.05	<0.05
MW-2	D	10/11/88	<0.001	0.030	<.010	34.000	<0.0002	0.05	0.220	54,000	0.41	<2.0	6.6	96,000	<2.2	<0.05	<0.05
		01/05/89	<0.001	0.007	<.010	31.000	<0.0002	0.06	0.012	53,000	<0.15	<2.0	6.5	50,000	4.0	<0.05	<0.05
		04/05/89	0.004	0.008	<.010	34.000	0.0006	0.05	0.035	54,000	0.65	<2.0	6.7	38,000	<2.0	<0.05	<0.05
		07/10/89	NV	<0.006	<.009	25.000	0.0018	0.02	<0.020	55,000	0.15	<5.0	6.7	67,000	<2.0	<0.05	<0.05
		10/09/89	<0.001	0.009	<.010	3.200	0.0022	0.11	0.030	56,000	<0.02	<5.0	6.6	55,000	<2.0	<0.05	<0.05
MW-3	D	10/12/88	<0.001	<0.010	<.010	13.000	<0.0002	<0.01	0.080	12,000	0.20	<2.0	6.8	37,000	17.0	<0.05	<0.05
		01/06/89	0.001	<0.005	<.010	26.000	<0.0002	0.03	0.055	11,000	0.05	<2.0	6.5	15,000	4.0	<0.05	<0.05
		04/05/89	<0.001	<0.005	<.010	15.000	<0.0002	0.01	0.025	11,000	0.20	<2.0	6.8	21,000	<2.0	<0.05	<0.05
		07/11/89	NV	0.008	<.009	13.000	<0.0002	0.02	0.040	12,000	0.10	<5.0	6.9	20,000	<2.0	<0.05	<0.05
		10/10/89	<0.001	0.008	0.020	13.000	<0.0002	0.06	0.030	12,000	0.15	<5.0	6.8	16,000	<2.0	<0.05	<0.05
MW-4R	S	01/06/89	<0.001	<0.005	0.050	4.600	<0.0002	0.12	0.350	6,600	0.35	<2.0	6.6	7,500	13,000	<0.05	<0.05
		04/05/89	<0.001	0.007	0.020	2.900	0.0002	0.09	0.037	4,400	0.25	<2.0	6.9	7,500	900	<0.05	<0.05
		07/10/89	NV	<0.006	0.012	2.000	<0.0002	0.07	0.020	5,400	0.35	<5.0	7.2	9,900	30	<0.05	<0.05
		10/10/89	0.001	<0.006	0.020	1.300	<0.0002	0.07	0.080	NA	0.30	NA	6.5	7,000	NA	<0.05	<0.05
MW-5	S	10/10/88[7]	<0.001	<0.005	<.010	12.500	0.0002	0.04	0.090	52,500	0.53	<2.0	7.3	76,000	<2.0	<0.05	<0.05
		01/06/89	0.003	0.007	<.010	13.500	0.0002	0.06	0.024	51,500	0.14	<2.0	6.5	50,000	<2.0	<0.05	<0.05
		04/05/89	0.001	<0.005	<.010	13.000	0.0002	0.05	0.020	52,000	0.26	<2.0	6.8	39,000	<2.0	<0.05	<0.05
		07/11/89	NV	0.061	<.009	11.000	0.0006	0.03	0.050	52,000	2.40	<5.0	6.8	66,000	<2.0	<0.05	<0.05
		10/12/89[7]	0.007	<0.006	<.010	9.250	<0.0002	0.03	<0.020	53,000	0.18	<5.0	7.2	58,500	<2.0	<0.05	<0.05
MW-6	D	10/10/88	0.001	<0.005	<.010	15.000	<0.0002	<0.01	0.020	10,000	0.50	<2.0	6.8	15,000	<2.0	<0.05	<0.05
		01/06/89	0.002	0.015	<.010	13.000	<0.0002	<0.01	<0.005	8,600	0.06	<2.0	6.7	11,000	<2.0	<0.05	<0.05
		04/06/89	0.002	<0.005	<.010	16.000	<0.0002	<0.01	0.054	9,600	0.34	<2.0	6.9	23,000	<2.0	<0.05	<0.05
		07/12/89	NV	<0.006	<.009	14.000	0.0002	<0.01	0.060	10,000	<0.02	<5.0	6.9	18,000	<2.0	<0.05	<0.05
		10/12/89	0.003	<0.006	<.010	17.000	<0.0002	<0.01	<0.020	13,000	0.18	<5.0	6.9	17,000	<2.0	<0.05	<0.05
MW-7R	S	10/10/88	<0.001	<0.005	<.010	0.750	0.0002	<0.01	0.010	5,900	0.10	<2.0	7.2	9,200	240	<0.05	<0.05
		01/06/89	<0.001	<0.005	<.010	0.650	<0.0002	0.02	<0.005	3,200	0.13	<2.0	6.9	2,400	9,000	<0.05	<0.05
		04/06/89	<0.001	<0.005	<.010	2.200	0.0002	0.01	0.027	3,000	0.21	<2.0	7.0	8,600	50,000	<0.05	<0.05
		07/11/89[7]	NV	<0.006	<.009	0.755	<0.0002	0.01	<0.020	4,250	<0.02	<5.0	7.2	7,350	26,000	<0.05	<0.05
		10/10/89	<0.001	0.010	<.010	1.100	<0.0002	0.04	<0.020	4,600	<0.02	<5.0	7.1	6,400	30,000	<0.05	<0.05

TABLE 15

GROUNDWATER MONITORING WELL DATA
OCTOBER 1988 - OCTOBER 1989
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

WELL[1]	WELL DEPTH[2]	DATE	DISSOLVED METAL CONCENTRATION[3] (mg/L) TOTAL Cr	Cu	Pb	Mn	Hg	Ni	Zn	TDS[4] (mg/L)	NITRATE (mg/L)	OIL & GREASE (mg/L)	pH	SPECIFIC CONDUCTIVITY (umhos/cm)	TOTAL COLIFORM[5] (mpn/100 ml)	TPH[6] (GASOLINE) (mg/L)	TPH[6] (DIESEL) (mg/L)
MW-8	S	10/10/88	0.003	<0.005	0.010	12.000	<0.0002	<0.01	0.040	17,000	0.30	<2.0	7.0	36,000	17	<0.05	<0.05
		01/06/89	0.001	<0.005	<.010	16.000	<0.0002	<0.01	<0.005	10,000	0.65	<2.0	6.7	11,000	2.0	<0.05	<0.05
		04/06/89	<0.001	<0.005	<.010	17.000	<0.0002	<0.01	<0.020	9,500	0.19	<2.0	6.8	20,000	<2.0	<0.05	<0.05
		07/13/89	NV	<0.006	<.009	12.000	<0.0002	<0.01	<0.020	15,000	<0.02	<5.0	7.0	23,000	4.0	<0.05	<0.05
		10/10/89	0.004	<0.006	<.010	12.000	<0.0002	0.01	<0.020	15,000	0.17	<5.0	7.0	18,000	<2.0	<0.05	<0.05
MW-9	D	10/12/88[7]	<0.001	<0.005	<.010	8.500	<0.0002	0.02	0.020	15,500	0.34	<2.0	6.9	45,000	2.5	<0.05	<0.05
		01/09/89	0.002	<0.005	<.010	9.300	<0.0002	<0.01	0.035	15,000	0.30	<2.0	6.9	19,000	300	<0.05	<0.05
		04/06/89[7]	0.001	<0.005	<.010	10.000	<0.0002	<0.01	<0.020	15,000	0.16	<2.0	6.9	27,000	<2.0	<0.05	<0.05
		07/13/89[7]	NV	<0.006	<.009	9.100	<0.0002	<0.01	<0.020	15,000	0.03	<5.0	6.9	24,000	<2.0	<0.05	<0.05
		10/10/89[7]	<0.001	0.006	<.010	8.200	<0.0002	0.05	<0.020	15,000	0.27	<5.0	6.9	19,000	<2.0	<0.05	<0.05
MW-11	S	01/09/89	<0.001	<0.005	<.010	2.200	<0.0002	<0.01	0.010	1,800	4.80	<2.0	6.4	6,000	30	<0.05	<0.05
		04/05/89	<0.001	<0.005	<.010	1.700	<0.0002	0.01	<0.020	1,200	0.80	<2.0	7.8	2,400	50	<0.05	<0.05
		07/11/89	NV	<0.006	0.054	5.500	<0.0002	0.02	<0.020	NA	NA	NA	6.5	NA	500	NA	NA
		10/12/89	0.003	0.015	<.010	1.600	<0.0002	0.04	<0.020	NA	<0.02	NA	7.0	NA	8,0000	NA	NA
MW-12R	S	10/12/88	0.020	<0.010	<.010	1.400	<0.0002	0.02	0.020	NA	<0.10	<2.0	7.2	95,000	<2.0	<0.05	<0.05
		01/05/89	0.002	<0.005	<.010	2.400	<0.0002	<0.01	<0.005	12,000	<0.03	<2.0	6.8	17,000	800	<0.05	<0.05
		04/05/89	0.002	<0.005	<.010	3.000	<0.0002	0.01	0.028	11,000	0.12	<2.0	7.5	18,000	4.0	<0.05	<0.05
		07/10/89	NV	<0.006	<.009	2.300	<0.0002	0.01	<0.020	44,000	0.00	<5.0	6.8	57,000	<5.0	<0.05	<0.05
		10/09/89	0.011	<0.006	<.010	2.800	<0.0002	<0.01	<0.020	45,000	<0.02	<5.0	7.0	NA	11,000	<0.05	<0.05
MW-13	S	07/12/89	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6.7	NA	<2.0	NA	NA
		10/12/89	0.004	<0.060	<.030	0.060	<0.0020	<0.10	<0.200	NA	0.09	NA	6.9	NA	<2.0	NA	NA
MW-15	S	10/10/88	0.001	<0.005	<.010	4.100	<0.0002	<0.01	0.010	9,300	0.40	<2.0	6.9	13,000	9,000	<0.05	<0.05
		01/09/89[7,8]	0.001	<0.005	<.010	3.600	<0.0002	<0.01	0.006	5,250	0.26	2.8	6.5	5,500	160,000	<0.05	<0.05
MW-15R	S	04/06/89	0.001	<0.005	<.010	3.000	<0.0002	<0.01	<0.020	4,000	0.33	<2.0	6.8	11,000	8,000	<0.05	<0.05
		07/12/89	NV	<0.006	<.009	4.100	<0.0002	<0.01	0.030	9,500	0.80	<5.0	6.7	16,000	40	<0.05	<0.05
		10/11/89	0.004	<0.006	<.010	3.800	<0.0002	<0.01	<0.020	10,000	<0.02	<5.0	6.8	15,000	28,000	<0.05	<0.05
MW-16	D	10/10/88	<0.001	0.010	<.010	9.000	<0.0002	<0.01	0.040	11,000	0.11	<2.0	7.0	14,000	140,000	<0.05	<0.05
		01/09/89[7]	0.001	<0.005	<.010	8.200	0.0002	<0.01	0.014	11,000	<0.03	<2.0	6.9	13,500	300	<0.05	<0.05
		04/06/89	<0.001	<0.005	<.010	8.500	<0.0002	<0.01	0.026	10,500	0.28	<2.0	6.9	21,000	<2.0	<0.05	<0.05
		07/12/89	NV	<0.006	<.009	7.900	<0.0002	<0.01	<0.020	15,000	0.72	<5.0	6.9	18,000	<2.0	<0.05	<0.05
		10/11/89	0.001	<0.006	<.010	7.400	<0.0002	<0.01	<0.020	11,000	0.12	<5.0	7.2	15,000	2.0	<0.05	<0.05

TABLE 15

GROUNDWATER MONITORING WELL DATA
OCTOBER 1988 - OCTOBER 1989
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

WELL[1]	WELL DEPTH[2]	DATE	DISSOLVED METAL CONCENTRATION[3] (mg/L) TOTAL Cr	Cu	Pb	Mn	Hg	Ni	Zn	TDS[4] (mg/L)	NITRATE (mg/L)	OIL & GREASE (mg/L)	pH	SPECIFIC CONDUCTIVITY (umhos/cm)	TOTAL COLIFORM[5] (mpn/100 ml)	TPH[6] (GASOLINE) (mg/L)	TPH[6] (DIESEL) (mg/L)
MW-17	S	10/10/88	0.002	<0.005	<.010	1.800	<0.0002	<0.01	0.070	16,000	<0.15	2.1	7.0	36,000	240	<0.05	<0.05
		01/09/89	0.002	<0.005	<.010	2.000	<0.0002	<0.01	<0.005	14,000	0.07	<2.0	6.8	15,000	5,000	<0.05	<0.05
		04/06/89	0.002	<0.005	<.010	1.900	0.0002	<0.01	<0.020	7,600	0.15	<2.0	7.0	12,000	240	<0.05	<0.05
		07/12/89	NV	<0.006	<.009	2.300	<0.0002	<0.01	<0.020	9,400	<0.02	<5.0	6.9	16,000	30	<0.05	<0.05
		10/11/89	0.003	<0.006	<.010	1.300	<0.0002	<0.01	<0.020	8,400	<0.02	<5.0	7.3	22,000	4.0	<0.05	<0.05
MW-18R	D	10/12/88	<0.001	<0.010	<.010	38.000	<0.0002	0.02	0.016	42,000	0.20	<2.0	6.9	83,000	30	<0.05	<0.05
		01/05/89[7]	<0.001	0.014	<.010	32.500	<0.0002	0.09	0.016	44,000	<0.03	<2.0	6.6	44,000	<2.0	<0.05	<0.05
		04/05/89[7]	<0.001	<0.005	<.010	37.000	<0.0002	0.09	0.055	43,500	0.73	<2.0	6.6	47,000	18	<0.05	<0.05
		07/11/89	NV	0.016	<.009	30.000	0.0002	0.05	<0.020	44,000	0.09	<5.0	6.7	57,000	<2.0	<0.05	<0.05
		10/09/89	<0.001	<0.006	<.010	37.000	0.0002	0.09	<0.020	45,000	0.40	<5.0	6.8	51,000	80	<0.05	<0.05
MW-19	D	10/11/88	<0.001	0.008	<.010	<0.010	<0.0002	<0.01	0.009	420	9.20	<2.0	7.4	740	100	<0.05	<0.05
		01/06/89	0.003	<0.005	<.010	0.010	<0.0002	<0.01	<0.005	420	7.70	<2.0	7.8	600	4.0	<0.05	<0.05
		04/07/89[7]	0.003	<0.005	<.010	<0.010	<0.0002	0.01	0.012	435	2.65	<2.0	7.1	755	8.5	<0.05	<0.05
		07/13/89	NV	<0.006	0.018	0.026	0.0002	<0.01	<0.020	420	0.61	<5.0	7.2	570	<2.0	<0.05	<0.05
		10/11/89	<0.002	<0.006	<.010	1.200	<0.0002	<0.01	<0.020	480	6.80	<5.0	7.6	670	<2.0	<0.05	<0.05
MW-20	D	10/11/88[7]	<0.001	<0.005	<.010	0.490	<0.0002	<0.01	0.012	705	0.18	<2.0	7.6	1,400	12.5	<0.05	<0.05
		01/06/89	<0.001	<0.005	<.010	0.530	<0.0002	<0.01	<0.005	860	<0.03	<2.0	7.4	1,300	1,700	<0.05	<0.05
		04/07/89	<0.001	<0.005	<.010	0.480	<0.0002	<0.01	0.014	840	0.04	<2.0	7.4	1,800	<2.0	<0.05	<0.05
		07/13/89	NV	<0.006	<.009	0.470	<0.0002	<0.01	<0.020	640	7.20	<5.0	7.5	850	<2.0	<0.05	<0.05
		10/11/89	<0.001	<0.006	<.010	0.440	<0.0002	<0.01	<0.020	NA	0.05	<5.0	7.9	2,000	<2.0	<0.05	<0.05

NOTES:

(1) R = Replacement Well.
(2) D = Well screened in deeper groundwater zone.
S = Well screened in shallow groundwater zone.
(3) Samples were filtered through a 0.4 micron filter in the laboratory the same day that they were collected.
(4) TDS = Total Dissolved Solids.
(5) Total Coliform in Most Probable Number per 100 ml.
(6) TPH = Total Petroleum Hydrocarbons (with indicated standard).
(7) Reported as arithmetic average between duplicate samples.
(8) MW-15 was damaged at time of sampling. Analytical results may not be representative.
(9) NA = Not Analyzed; indicates insufficient sample was yielded for analysis.
(10) NV = Not Valid. See text for discussion of quality control concerns.

TABLE 16

MAJOR IONS DATA FOR GROUNDWATER MONITORING WELLS AND SURFACE WATER
OCTOBER 1988 - OCTOBER 1989
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

GROUNDWATER MONITORING WELL	DATE	TOTAL ION CONCENTRATIONS					
		TOTAL ALKALINITY (as $CaCO_3$)(mg/L)	CALCIUM (mg/L)	CHLORIDE (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	SULFATE (mg/L)
MW-12R	10/12/88	4,500	880	35,000	2,200	17,000	1,400
	01/09/89	1,200	180	7,800	330	3,800	2900
	02/24/89	1,300	210	7,800	390	4,300	84
	07/12/89	3,110	900	27,000	1,500	13,000	940
	10/09/89	NA	NA	NA	NA	9,600	NA
MW-13	10/12/88	NA	NA	NA	NA	NA	NA
	01/09/89	NA	NA	NA	NA	NA	NA
	02/24/89	2,300	650	26,000	1,300	12,000	140
	07/12/89	NA	NA	NA	NA	NA	NA
	10/09/89	NA	NA	NA	NA	NA	NA
MW-17	10/10/88	1,700	530	9,200	630	4,600	18
	01/09/89	1,500	490	8,000	540	3,900	60
	02/24/89	1,700	880	9,000	310	3,900	22
	07/12/89	1,390	400	4,700	350	2,800	<0
	10/11/89	1,700	560	10,000	700	5,400	29

TABLE 16

MAJOR IONS DATA FOR GROUNDWATER MONITORING WELLS AND SURFACE WATER
OCTOBER 1988 - OCTOBER 1989
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

SURFACE WATER SAMPLES[1]	DATE	TOTAL ION CONCENTRATIONS					
		TOTAL ALKALINITY (as $CaCO_3$)(mg/L)	CALCIUM (mg/L)	CHLORIDE (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	SULFATE (mg/L)
Drainage Channel	10/12/88	140	490	18,000	1,300	9,600	2,400
	01/09/89	170	220	11,000	580	5,200	1,400
	02/24/89	130	350	16,000	950	8,300	2,500
	07/12/89	172	560	14,000	760	7,800	2,000
	10/11/89	180	800	15,000		8,300	2,200
Drainage Channel	10/10/88	230	570	5,100	340	2,800	810
	01/09/89	140	36	120	29	80	57
	02/24/89	250	60	400	62	240	110
	07/12/89	262	78	800	80	530	140
	10/12/89	150	920	14,000	540	7,600	2,000

NOTES:

1. Stege Drainage Channel sample collected midway between Monitoring Wells MW-12R and MW-13. South Drainage Channel sample collected adjacent to Monitoring Well MW-17.

2. NA = Not analyzed due to sufficient sample volume.

TABLE 17

SUMMARY OF FACTORS INFLUENCING THE POTENTIAL TOXICITY OF SOIL ELUTRIATES
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

SAMPLE[1]	ELUTRIATE	% SURVIVAL CERIODAPHNIA	% GROWTH[2] SELENASTRUM	SUSPENDED PARTICULATES	RELATIVELY ELEVATED METAL CONC.[3]	SALINITY[4] (ppt)	EQUIVALENT[5] SALINITY (ppt)	OTHER FACTORS	(Yes/No) TOXICITY ATTRIBUTED TO CHEMICALS (JUSTIFICATION)[9]
M1-1	DI[6]	100	-49	very high	Cu, Ni, Zn, Hg	0(0)	1.0	debris, motile orgs.	No[a,b]
	DWM[7]	100	--[8]	--	Cu, nI	1	0.8		No[a,c]
M1-2	DI								
	First	--	--	high	--	18-20	--	debris, irreg. cells	No[d]
	Second	90	-52	--	--	2-4(1)	--	filtered	
	Third	100	+108	medium	none	0(0)	0.8		
	DMW								
	First	--	--	--	--	>10	--	low D.O. in second	No[a,e,f]
	Second	13	--	--	--	2	--	elutriate	
	Third	47	--	medium	Pb, Ni	<1	2.15		
M1-2	DI								
	First	--		clear[8]			>2		No[g]
	Second	100	+335	clear[8]			<1		
confirmation									
	DMW								
	First	--		clear[8]			>2		No[g]
	Second	100	--	clear[8]			<1		
M1-3	DI	100	+64	high	Pb, Ni, Zn	1-2(1)	1.25	debris, irreg. cells	No[g]
	DMW	100	--	--	Ni	1	0.5		No[c]
M6-1	DI	100	+96	clear	none	1-2	0.7	other algae, irreg. cells	No[g]
	DMW	100	--	--	Pb	1	0.75		No[c]

TABLE 17

SUMMARY OF FACTORS INFLUENCING THE POTENTIAL TOXICITY OF SOIL ELUTRIATES
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

SAMPLE[1]	ELUTRIATE	% SURVIVAL CERIODAPHNIA	% GROWTH[2] SELENASTRUM	SUSPENDED PARTICULATES	RELATIVELY ELEVATED METAL CONC.[3]	SALINITY[4] (ppt)	EQUIVALENT[5] SALINITY (ppt)	OTHER FACTORS	(Yes/No) TOXICITY ATTRIBUTED TO CHEMICALS (JUSTIFICATION)[9]
M6-2	DI				--	36	--		No[d]
	First	--	--	extremely high					
	Second	0	+68	--	--	5	--	motile orgs. Paramecium filtered	
	Third	100	+236	low	Cu	1(1)	1.8		
	DMW								
	First	--	--	--	--	>10	--		No[c]
	Second	0	--	--	--	9	--		
	Third	100	--	low	Cu, Ni	2	1.2		
Confirmation									
	DI	100	+699	clear[8]			<2		No[g]
	DMW	100	--	clear[8]			<2		No[g]
M6-3	DI	100	+102	clear	Cu, Ni	1	0.55	motile orgs.	No[g]
	DMW	100	--	--	Cu	1	0.75		No[c]
M01	DI	93	-36	very high	Cu, Hg, Ni	<1	1.1	Unknown orgs., silt, irreg. cells	No[a,b]
	DMW	53	--	very high	Cu, Hg	0	1.25		No[a,f]
Confirmation									
	DI	100	+371	clear[8]			<1		No[g]
	DMW	100	-	clear[8]			<1		No[g]
M02	DI	97	+56	low	Cu, Hg	<1	1.0	debris, motile orgs. irreg. cells	No[g]
	DMW	97	--	--	Cu, Hg	0	1.05		No[c]
M03	DI	100	+86	low	Cu, Pb, Ni	<1	0.3	debris, motile orgs.	No[g]
	DMW	100	--	--	Cu, Ni, Zn	0	0.35		No[c]

TABLE 17

SUMMARY OF FACTORS INFLUENCING THE POTENTIAL TOXICITY OF SOIL ELUTRIATES
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

SAMPLE[1]	ELUTRIATE	% SURVIVAL CERIODAPHNIA	% GROWTH[2] SELENASTRUM	SUSPENDED PARTICULATES	RELATIVELY ELEVATED METAL CONC.[3]	SALINITY[4] (ppt)	EQUIVALENT[5] SALINITY (ppt)	OTHER FACTORS	(Yes/No) TOXICITY ATTRIBUTED TO CHEMICALS (JUSTIFICATION)[9]
M04	DI	100	-66	low	Pb	<1	0.6	debris, irreg. cells	No[a,b]
	DMW	100	--	--	none	0	0.59		No[c]
M05	DI	100	+29	low	Pb, Hg, Zn	<1	--	debris, motile orgs.	No[g]
	DMW	100	--	--	Hg	0	1.3		No[c]

NOTES:

1. Initial samples collected August and September 1989. Confirmation samples collected January 1990.
2. Minus sign indicates growth inhibition, plus sign indicates growth stimulation.
3. Metals with concentrations greater than the midpoint of range concentration found in all samples. Comparison was not made for confirmation samples.
4. Salinity measured by refractometer. Numbers in parentheses show multiple values of salinity when measured in more than one bioassay test. Refractometer measurements not performed on confirmation samples.
5. Equivalent salinities were determined by extrapolation from conductivity versus salinity calibration graph.
6. DI = deionized water elutriates.
7. DMW = dilute mineral water elutriates.
8. Blanks in table indicate where data were not taken or not available.
9. Justification for not attributing toxicity to chemicals:

   a. No consistent pattern of elevated metal concentration was associated with observed toxic response.
   b. Toxicity not seen in both Ceriodaphnia and Selanastrum toxicity tests.
   c. Ceriodaphnia test shows no toxicity.
   d. Toxicity effects associated with particulates; toxicity removed by filtering.
   e. Elevated salinity associated with toxicity effects.
   f. Toxicity effects associated with particulates; Ceriodaphnia exhibits toxicity due to physical factors associated with particulates.
   g. Both bioassays showed positive results: no toxic effects.

DO = Dissolved oxygen

TABLE 18

TYPICAL METAL CONCENTRATIONS IN SOIL AND HAZARDOUS LIMITS
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

REFERENCES		CONCENTRATION (mg/Kg)					
		Lead	Nickel	Copper	Chromium	Zinc	Mercury
Bohn, H. L., B. L. McNeal, and G.A. O'Connor. 1979. Soil Chemistry. New York, N.Y. Wiley - Interscience	Typical	2-200	10-1000	2-100	5-1000	10-3000	.02-0.2
Rose, A. W., H. E. Hawkes and J. S. Webb. 1979. Geochmistry in Mineral Exploration. Academic Press	Median Concentration in Soils	17	17	15	43	36	
Lindsay, W. L. 1979. Chemical Equilibria in Soils. New York, N.Y. Wiley - Interscience	Common Range for Soils	2-200	5-500	2-100	1-1000	60-2000	0.01-0.3
	Selected Average[1]	10	40	30	100	300	0.03
Agency for Toxic Substance and Disease Registry - Toxicological Profiles	Typical Range in Soil	NA	5-500	NA	5-1500	NA	NA
California Administrative Code, Title 22, Division 4, Chapter 30, Article 11, Section 66699	Total Threshold Limit Concentration (TTLC)	1000	2000	2500	2500	5000	20
	Soluble Threshold Limit Concentration (mg/L) (STLC)	5	20	25	560	250	0.2
Mean Value for Site and the Upper 95 Percent Limit Range		113 1134	40 99	95 511	29 72	136 834	.19 1.2

NOTES:

1. Selected Average is a concentration selected by the author as an arbitrary reference level for soils.

TABLE 19

SUMMARY STATISTICS FOR ANALYSIS OF METALS IN
COMPOSITE SURFACE SOIL SAMPLES
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

	METAL CONCENTRATION (mg/Kg)			
METAL	AVERAGE	MINIMUM	MAXIMUM	UPPER 95% C.I.
Chromium	35	21	54	39
Copper	37	14	200	53
Lead	76	27	170	92
Mercury	0.3	0.09	1.1	0.4
Nickel	44	25	120	53
Zinc	95	37	240	120

NOTE:

Composite soil samples collected September 1988 (Figure 20) and October 1989 (Figure 26).

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TABLE 20

STATISTICAL SUMMARY OF SOIL CHROMIUM CONCENTRATIONS BY AREA
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

		CHROMIUM CONCENTRATION (mg/Kg)			
SAMPLE AREA[1]	SAMPLE SIZE	AVERAGE	MINIMUM	MAXIMUM	UPPER 95% CI.I.
Area 1	8	35	24	60	45
Area 2	5	37	22	62	54
Area 3	4	42	27	62	63
Area 4	12	28	19	51	34
Area 5	12	27	5	65	36
Area 6	12	38	16	150	60
Asphalt	19	34	14	140	50
Concrete	4	26	23	34	33
Drainage	2	38	28	48	130
Pond	17	41	12	230	66
GW	18	24	18	35	27
Marsh	6	13	5	40	26
OilGrs	33	27	16	51	31
SE Drain	4	34	31	41	40
Other	115	29	11	105	32
Entire Site	270	30	5	230	33

Notes:

1. Sample areas shown on Figure 11. Sample data from Table 1.

   Abbreviations:

   Asphalt = Former Asphalt Facility Area
   Concrete = Concrete Slab Debris Area
   Drainage = Drainage Area Between Asphalt and Concrete Areas
   Pond = Former Pond Area
   GW = Groundwater Monitoring Wells
   Marsh = Upper End of Hoffman Marsh
   Oilgrs = Samples From Locations With Past Elevated Oil and Grease Levels
   SE Drain = Southeast Drainage
   Other = Areas Not Included In Above Designations

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TABLE 21

STATISTICAL SUMMARY OF SOIL COPPER CONCENTRATIONS BY AREA
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

		COPPER CONCENTRATION (mg/Kg)			
SAMPLE AREA[1]	SAMPLE SIZE	AVERAGE	MINIMUM	MAXIMUM	UPPER 95% C.I.
Area 1	8	75	19	180	120
Area 2	5	272	120	380	390
Area 3	4	29	17	40	43
Area 4	12	314	17	2,600	757
Area 5	12	230	17	910	400
Area 6	12	216	24	1,100	390
Asphalt	19	156	16	570	230
Concrete	4	157	39	400	390
Drainage	2	515	29	1,000	4,900
Pond	17	150	19	490	240
GW	18	28	9	120	42
Marsh	6	13	7	22	19
OilGrs	33	98	14	400	130
SE Drain	4	129	22	370	350
Other	119	33	3	213	40
Entire Site	274	97	3	2,600	120

Notes:

1. Sample areas shown on Figure 11. Sample data from Table 1.

   Abbreviations:

   Asphalt = Former Asphalt Facility Area
   Concrete = Concrete Slab Debris Area
   Drainage = Drainage Area Between Asphalt and Concrete Areas
   Pond = Former Pond Area
   GW = Groundwater Monitoring Wells
   Marsh = Upper End of Hoffman Marsh
   Oilgrs = Samples From Locations With Past Elevated Oil and Grease Levels
   SE Drain = Southeast Drainage
   Other = Areas Not Included In Above Designations

LG006299

TABLE 22

STATISTICAL SUMMARY OF SOIL LEAD CONCENTRATIONS BY AREA
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

		LEAD CONCENTRATION (mg/Kg)			
SAMPLE AREA[1]	SAMPLE SIZE	AVERAGE	MINIMUM	MAXIMUM	UPPER 95% C.I.
Area 1	8	17	5	46	31
Area 2	5	29	5	92	71
Area 3	4	19	12	30	31
Area 4	12	29	5	110	52
Area 5	12	52	5	350	110
Area 6	12	642	5	5,200	1,500
Asphalt	19	497	5	4,200	1,000
Concrete	4	71	14	120	130
Drainage	2	35	14	55	220
Pond	17	258	2	3,600	690
GW	18	7	5	45	12
Marsh	6	39	19	58	52
OilGrs	33	90	5	1,800	200
SE Drain	4	26	12	37	41
Other	123	41	1	570	57
Entire Site	279	114	1	5,200	170

Notes:

1. Sample areas shown on Figure 11. Sample data from Table 1.

   Abbreviations:

   Asphalt = Former Asphalt Facility Area
   Concrete = Concrete Slab Debris Area
   Drainage = Drainage Area Between Asphalt and Concrete Areas
   Pond = Former Pond Area
   GW = Groundwater Monitoring Wells
   Marsh = Upper End of Hoffman Marsh
   Oilgrs = Samples From Locations With Past Elevated Oil and Grease Levels
   SE Drain = Southeast Drainage
   Other = Areas Not Included In Above Designations

LG006300

TABLE 23

STATISTICAL SUMMARY OF SOIL MERCURY CONCENTRATIONS BY AREA
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

		MERCURY CONCENTRATION (mg/Kg)			
SAMPLE AREA[1]	SAMPLE SIZE	AVERAGE	MINIMUM	MAXIMUM	UPPER 95% C.I.
Area 1	8	0.1	0.05	0.3	0.2
Area 2	5	0.3	0.05	1.2	0.9
Area 3	4	0.1	0.07	0.1	0.1
Area 4	12	0.2	0.05	1.3	0.4
Area 5	12	0.2	0.05	1.6	0.5
Area 6	12	0.2	0.05	1.4	0.5
Asphalt	19	0.1	0.05	0.2	0.1
Concrete	4	0.5	0.05	1.8	1.7
Drainage	2	0.2	0.05	0.3	1.4
Pond	14	0.1	0.05	0.8	0.3
GW	18	0.1	0.05	0.1	0.1
Marsh	6	0.1	0.04	0.4	0.3
OilGrs	33	0.3	0.05	4.8	0.6
SE Drain	4	0.5	0.06	1.4	1.3
Other	0	NA	NA	NA	NA
Entire Site	152	0.2	0.04	4.8	0.3

Notes:

1. Sample areas shown on Figure 11. Sample data from Table 1.

   Abbreviations:

   Asphalt = Former Asphalt Facility Area
   Concrete = Concrete Slab Debris Area
   Drainage = Drainage Area Between Asphalt and Concrete Areas
   Pond = Former Pond Area
   GW = Groundwater Monitoring Wells
   Marsh = Upper End of Hoffman Marsh
   Oilgrs = Samples From Locations With Past Elevated Oil and Grease Levels
   SE Drain = Southeast Drainage
   Other = Areas Not Included In Above Designations

LG006301

TABLE 24

STATISTICAL SUMMARY OF SOIL NICKEL CONCENTRATIONS BY AREA
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

		NICKEL CONCENTRATION (mg/Kg)			
SAMPLE AREA[1]	SAMPLE SIZE	AVERAGE	MINIMUM	MAXIMUM	UPPER 95% C.I.
Area 1	8	47	28	82	64
Area 2	5	40	24	71	61
Area 3	4	53	26	88	90
Area 4	12	32	18	56	39
Area 5	12	30	9	53	37
Area 6	12	46	15	210	79
Asphalt	19	40	13	190	59
Concrete	4	26	22	30	31
Drainage	2	35	21	48	160
Pond	17	53	13	280	83
GW	18	38	18	71	45
Marsh	6	19	6	44	34
Oilgrs	33	35	17	88	41
SE Drain	4	33	32	34	34
Other	117	40	1	223	45
Entire Site	273	39	1	280	43

Notes:

1. Sample areas shown on Figure 11. Sample data from Table 1.

Abbreviations:

Asphalt = Former Asphalt Facility Area
Concrete = Concrete Slab Debris Area
Drainage = Drainage Area Between Asphalt and Concrete Areas
Pond = Former Pond Area
GW = Groundwater Monitoring Wells
Marsh = Upper End of Hoffman Marsh
Oilgrs = Samples From Locations With Past Elevated Oil and Grease Levels
SE Drain = Southeast Drainage
Other = Areas Not Included In Above Designations

LG006302

TABLE 25

STATISTICAL SUMMARY OF SOIL ZINC CONCENTRATIONS BY AREA
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

		ZINC CONCENTRATION (mg/Kg)			
SAMPLE AREA[1]	SAMPLE SIZE	AVERAGE	MINIMUM	MAXIMUM	UPPER 95% C.I.
Area 1	8	64	35	130	87
Area 2	5	196	72	350	320
Area 3	4	46	36	63	63
Area 4	12	112	28	340	170
Area 5	12	167	16	570	280
Area 6	12	367	31	2,200	740
Asphalt	19	470	34	4,900	1,000
Concrete	4	127	77	270	260
Drainage	2	351	42	660	3,100
Pond	17	108	1	390	170
GW	18	39	20	91	47
Marsh	6	73	18	210	140
OilGrs	33	111	17	1,300	190
SE Drain	4	143	42	230	280
Other	121	92	1	940	110
Entire Site	277	140	1	4,900	180

Notes:

1. Sample areas shown on Figure 11. Sample data from Table 1.

   Abbreviations:

   Asphalt = Former Asphalt Facility Area
   Concrete = Concrete Slab Debris Area
   Drainage = Drainage Area Between Asphalt and Concrete Areas
   Pond = Former Pond Area
   GW = Groundwater Monitoring Wells
   Marsh = Upper End of Hoffman Marsh
   Oilgrs = Samples From Locations With Past Elevated Oil and Grease Levels
   SE Drain = Southeast Drainage
   Other = Areas Not Included In Above Designations

LG006303

TABLE 26

SUMMARY STATISTICS FOR SOIL LEAD CONCENTRATIONS WITHIN SELECTED PORTIONS OF THE SITE
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

	BORINGS FROM AREA A[1]			BORINGS FROM OUTSIDE OF AREA A	
	All Depths (excluding 5-6.5 feet)	0 - 5 ft.	5 - 6.5 ft.	All Depths	5 - 6.5 ft.
Sample Size	70	19	20	260	56
Minimum (mg/Kg)	2	5	27	1	2
Maximum (mg/Kg)	4,200	4,200	5,200	920	350
Average (mg/Kg)	130	400	1,000	42	51
Upper 95% C.I. (mg/Kg)	230	790	1,500	53	69

Notes:

1. Area A shown on Figure 11.

LG006304

TABLE 27

SUMMARY STATISTICS FOR ANALYSIS OF ORGANIC COMPOUNDS IN SOIL BORING SAMPLES
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

COMPOUND	# SAMPLES ANALYZED	# SAMPLES DETECTED	RANGE OF DETECTED VALUES MIN-MAX (mg/Kg)	AVERAGE OF DETECTED RANGE VALUES (mg/Kg)	RANGE OF DETECTION LIMITS MIN-MAX (mg/Kg)
Total Petroleum Hydrocarbon (Gas)	159	1	0.002 - 0.002	0.002	0.001 - 0.001
Total Petroleum Hydrocarbon (Diesel)	159	5	0.002 - 0.017	0.008	0.001 - 0.002
Total Sulfur	131	37	0.022 - 1.5	0.185	0.016 - 0.035
PCBs	158	1	3 - 3	3	0.001 - 0.001
Phenol	149	2	0.43 - 0.78	0.61	0.33 - 3.3
2-Methylphenol	143	2	0.61 - 1	0.81	0.33 - 3.3
4-Methylphenol	143	3	3.5 - 41	17	0.33 - 3.3
2,4-Dimethylphenol	149	3	0.35 - 55	35	0.33 - 3.3
Naphthalene	180	2	0.36 - 0.39	0.38	0.13 - 3.3
2-Methylnaphthalene	143	3	0.61 - 13	8.5	0.33 - 3.3
Phenanthrene	180	3	0.2 - 2	0.85	0.13 - 3.3
Di-n-butyl-phthalate	143	12	0.37 - 0.69	0.52	0.33 - 3.3
Fluoroanthene	194	10	0.33 - 3.4	1.1	0.13 - 6.7
Pyrene	194	13	0.14 - 8.6	1.9	0.13 - 6.7
Benzo(a)anthracene	194	9	0.33 - 4.5	1.4	0.13 - 6.7
Bis-(2-ethylhexyl)-phthalate	143	6	0.33 - 1.5	0.66	0.33 - 3.3
Chrysene	194	14	0.13 - 6.5	1.4	0.13 - 6.7
Di-n-octyl-phthalate	143	1	0.66 - 0.66	0.66	0.33 - 3.3
Benzo-(b)-fluoranthene	194	7	0.28 - 2.7	1.4	0.033 - 6.7
Benzo-(a)-pyrene	194	11	0.18 - 11	1.9	0.13 - 6.7
Indeno-(1,2,3-c,d)-pyrene	177	7	0.33 - 2.0	1.1	0.33 - 6.7
Dibenzo-(a,h)-anthracene	180	3	0.67 - 0.96	0.70	0.2 - 3.3
Benzo-(g,h,i)-perylene	180	6	0.46 - 3.3	1.4	0.18 - 3.3
Benzo(k)fluoranthene	177	4	2.0 - 7.8	3.4	0.33 - 6.7

NOTE:

1. Data from Tables 4, 5, 6, 8, 10 and 12.

TABLE 28

STATISTICAL SUMMARY OF SOIL OIL AND GREASE CONCENTRATIONS BY AREA
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

		OIL AND GREASE CONCENTRATION (mg/Kg)			
SAMPLE AREA[1]	SAMPLE SIZE	AVERAGE	MINIMUM	MAXIMUM	UPPER 95% C.I.
Area 1	7	467	88	1,700	980
Area 2	6	545	79	2,100	1,300
Area 3	4	753	120	2,100	2,000
Area 4	14	542	40	5,400	1,300
Area 5	12	2,176	87	11,000	4,000
Area 6	12	223	40	1,100	440
Asphalt	19	2,400	40	27,000	5,500
Concrete	4	1,370	120	4,300	4,100
Drainage	0	NA	NA	NA	NA
Pond	17	203	6	740	320
GW	18	533	40	8,900	1,500
Marsh	11	1,159	24	4,000	2,000
OilGrs	33	595	36	12,000	1,300
SE Drain	4	1,920	140	5,000	4,900
Other	150	250	1	990	290
Entire Site	311	600	1	27,000	830

Notes:

1. Sample areas shown on Figure 11. Data from Table 6.

Abbreviations:

Asphalt = Former Asphalt Facility Area
Concrete = Concrete Slab Debris Area
Drainage = Drainage Area Between Asphalt and Concrete Areas
Pond = Former Pond Area
GW = Groundwater Monitoring Wells
Marsh = Upper End of Hoffman Marsh
Oilgrs = Samples From Locations With Past Elevated Oil and Grease Levels
SE Drain = Southeast Drainage
Other = Areas Not Included In Above Designations

LG006306

TABLE 29

RANKING OF ELEVATED CHEMICAL CONCENTRATIONS
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

BORING	DEPTH (Ft)	CHEMICAL CONCENTRATION (mg/Kg) Copper	Lead	Mercury	Zinc	T-PAHs	O&G	Sulfur
Copper								
127	5	2600	110	0.05	65	ND	810	<29
111	5	1100	5200	0.30	2200	ND	<40	71
D1	1.5	1000	55	0.32	660	1.2	NA	210
114	15	910	7.6	0.06	450	ND	1300	<32
123	11	570	41	<0.05	340	ND	370	45
114	11.5	540	114	1.6	570	ND	390	56
113	15	490	5.8	<0.05	270	ND	87	NA
118	10	490	230	0.82	310	ND	190	<28
Lead								
111	5	1100	5200	0.30	2200	15	<40	71
122	2	420	4200	0.11	4900	ND	1400	NA
119	5	450	3600	0.39	290	ND	620	<24
122	5	260	3100	0.07	630	ND	1700	295
116	5	400	1800	4.8	1300	4	75	<35
123	5	160	1200	0.21	1600	12	48	<19
112	5	130	1100	0.06	250	ND	50	<31
111	1	220	800	0.27	640	15	800	<28
102	1	130	450	0.74	200	ND	1200	<18

TABLE 29

RANKING OF ELEVATED CHEMICAL CONCENTRATIONS
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

BORING	DEPTH (Ft)	CHEMICAL CONCENTRATION (mg/Kg) Copper	Lead	Mercury	Zinc	T-PAHs	O&G	Sulfur
Mercury								
116	5	400	1800	4.8	1300	4	75	<35
120	5	100	62	2.0	170	ND	535	220
108	2.5	400	120	1.8	270	ND	760	420
114	11.5	540	114	1.6	570	ND	390	56
111	10	220	340	1.4	550	ND	1100	239
130	1.5	43	32	1.4	78	ND	NA	NA
128	1.5	37	98	1.3	75	ND	500	<28
105	0.5	380	92	1.2	350	ND	500	<29
Zinc								
122	2	420	4200	0.11	4900	ND	1400	NA
111	5	1100	5200	0.30	2200	ND	<40	71
123	5.5	160	1200	0.21	1600	12	48	<19
116	5.5	400	1800	4.80	1300	4	75	<35
D1	1.5	1000	55	0.32	660	1.2	NA	210
122	5.5	260	3100	0.07	630	ND	1700	295

LG006308

TABLE 29

RANKING OF ELEVATED CHEMICAL CONCENTRATIONS
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

BORING	DEPTH (Ft)	CHEMICAL CONCENTRATION (mg/Kg) Copper	Lead	Mercury	Zinc	T-PAHs	O&G	Sulfur
T-PAHs								
111	0.5	220	800	0.27	640	15	800	<28
123	3	44	280	<0.05	160	13	1300	121
123	6	160	1200	0.21	1600	12	48	<19
112	1.5	40	5.9	<0.05	55	11.5	270	<30
110	6.5	24	21	0.10	31	4.6	<40	<31
116	5	400	1800	4.8	1300	4.0	75	<35
Oil & Grease								
125	1.5	16	22	<0.05	34	ND	27000	NA
124	5.5	85	290	0.16	170	ND	12000	505
102	4	82	260	0.15	140	ND	12000	143
115	10	160	7.9	<0.05	85	ND	11000	<30
MW-20	2.5	120	45	0.07	91	ND	8900	391
127	0.5	36	42	0.10	64	ND	5400	59
129	0	82	37	0.18	230	ND	5000	44
109	0.5	49	82	0.13	77	ND	4300	<31
114	5	34	350	0.22	70	ND	4200	95

Note:

1. Data from samples collected September 1988 (Tables 1 and 6).

L600639

TABLE 30

SUMMARY OF ANALYSIS RESULTS IN GROUNDWATER SAMPLES (1983-1986)
LIQUID GOLD SITE (K/J/C 855018.07)

TOTAL AND DISSOLVED METAL CONCENTRATIONS (mg/L)

MONITORING	Lead						Nickel						Copper						Chromium						Zinc					
	Total			Dissolved			Total			Dissolved			Total			Dissolved			Total			Dissolved			Total			Dissolved		
WELL	11/83	3/85	5/85	5/85	1/86	8/86	11/83	3/85	5/85	5/85	1/86	8/86	11/83	3/85	5/85	5/85	1/86	8/86	11/83	3/85	5/85	5/85	1/86	8/86	11/83	3/85	5/85	5/85	1/86	8/86
Shallow Zone																														
MW-4	0.32	0.23	0.35	0.05	-	-	<0.10	0.20	0.12	<0.01	-	-	0.10	0.36	0.26	0.05	-	-	0.30	0.28	0.17	0.014	-	-	<0.05	0.53	0.51	<0.01	-	-
MW-5	0.06	0.06	0.04	0.01	<0.01	0.10	<0.10	0.35	0.30	0.04	0.03	0.10	0.07	0.23	0.21	0.08	<0.005	0.08	<0.10	0.057	0.18	0.004	NV	0.007	<0.05	0.20	0.25	0.12	0.07	0.05
MW-7	0.01	4.7	16	0.01	<0.01	-	<0.10	0.32	1.3	0.01	<0.01	-	0.02	1.1	4.2	0.02	<0.005	-	<0.10	0.28	1.2	0.002	NV	-	<0.05	5.3	24	0.01	<0.005	-
MW-8	0.01	2.6	1.9	0.01	<0.01	0.02	<0.10	0.44	0.40	<0.01	<0.01	0.06	0.04	1.1	0.87	0.03	<0.005	0.03	0.15	0.52	0.53	0.003	NV	0.005	<0.05	2.4	2.2	<0.01	<0.005	0.02
MW-10	0.04	0.01	0.08	<0.01	<0.01	-	<0.10	0.12	0.17	<0.01	<0.01	-	0.01	0.09	0.21	0.03	<0.005	-	0.10	0.038	0.25	0.007	NV	-	<0.05	0.14	0.56	0.12	0.01	-
MW-4R	-	-	-	-	-	0.02	-	-	-	-	-	0.04	-	-	-	-	-	<0.01	-	-	-	-	-	0.003	-	-	-	-	-	<0.01
MW-7R	-	-	-	-	-	0.01	-	-	-	-	-	0.02	-	-	-	-	-	0.02	-	-	-	-	-	0.002	-	-	-	-	-	0.01
MW-12	-	-	-	-	-	0.08	-	-	-	-	-	0.20	-	-	-	-	-	0.06	-	-	-	-	-	0.019	-	-	-	-	-	0.15
MW-13	-	-	-	-	-	0.04	-	-	-	-	-	0.13	-	-	-	-	-	0.06	-	-	-	-	-	0.012	-	-	-	-	-	0.24
MW-15	-	-	-	-	-	0.01	-	-	-	-	-	<0.01	-	-	-	-	-	0.02	-	-	-	-	-	0.003	-	-	-	-	-	0.02
MW-17	-	-	-	-	-	0.01	-	-	-	-	-	<0.01	-	-	-	-	-	0.03	-	-	-	-	-	0.002	-	-	-	-	-	<0.01
Deeper Zone																														
MW-1	0.01	0.01	0.01	<0.01	<0.01	0.02	<0.10	0.32	0.35	<0.01	<0.01	<0.01	0.05	0.18	0.11	0.02	<0.005	0.02	<0.10	0.28	0.38	0.001	NV	0.001	<0.05	0.27	0.15	0.09	0.01	0.01
MW-2	1.1	0.06	0.03	0.06	<0.01	0.10	0.89	0.32	0.28	0.04	0.03	0.25	0.10	0.42	0.23	0.12	<0.005	0.10	<0.10	0.12	0.25	0.014	NV	0.013	<0.05	0.27	0.21	0.05	0.08	0.06
MW-3	0.06	0.03	0.05	0.01	<0.01	0.01	<0.10	1.6	0.35	0.02	<0.01	<0.01	0.05	0.64	0.17	0.03	<0.005	0.02	0.30	2.4	0.48	0.003	NV	0.001	<0.05	1.0	0.27	0.03	0.05	0.05
MW-6	0.27	0.06	0.15	<0.01	<0.01	0.01	0.49	0.72	0.25	0.15	<0.01	0.01	0.10	0.79	1.03	0.02	<0.005	0.03	<0.10	0.60	1.05	0.09	NV	0.002	<0.06	0.55	0.74	0.02	<0.005	0.01
MW-9	0.23	0.01	0.07	0.01	<0.01	0.02	<0.10	1.4	0.70	<0.01	<0.01	0.04	0.05	0.39	0.23	0.04	<0.005	0.02	<0.10	1.5	1.00	0.004	NV	0.002	<0.05	0.68	0.44	0.01	<0.005	<0.01
MW-16	-	-	-	-	-	0.01	-	-	-	-	-	<0.01	-	-	-	-	-	0.03	-	-	-	-	-	0.001	-	-	-	-	-	0.01
MW-18	-	-	-	-	-	0.07	-	-	-	-	-	0.43	-	-	-	-	-	0.07	-	-	-	-	-	0.003	-	-	-	-	-	0.08

Notes:

References: 11/83 - Ecology and Environment (E&E) 1984a.
3/85 and 8/86 - K/J/C 1988a.
NV = Not valid due to QA/QC problem (K/J/C 1988a).

TABLE 30

SUMMARY OF ANALYSIS RESULTS IN GROUNDWATER SAMPLES (1983-1986)
LIQUID GOLD SITE (K/J/C 855018.07)

WATER QUALITY PARAMETERS

MONITORING WELL	pH				TOC (mg/L)				Conductivity (umho/cm)			
	3/85	5/85	1/86	8/86	3/85	5/85	1/86	8/86	3/85	5/85	1/86	8/86
Shallow Zone												
MW-4 (1)	7.1	6.9	--	--	NM (4)	38	--	--	43,000	32,000	--	--
MW-4R (2)	--	--	--	--	--	--	--	--	--	--	--	--
MW-5	7.0	6.7	5.8	6.2	NM	21	15	14	47,500	35,000	45,000	44,000
MW-7 (3)	8.0	8.0	7.9	--	NM	116	67	--	12,000	11,000	10,000	--
MW-7R (2)	--	--	--	7.5	--	--	--	52	--	--	--	7,500
MW-8	6.9	6.8	6.1	6.7	NM	67	31	32	15,000	13,000	10,500	21,000
MW-10 (3)	7.1	7.1	6.0	--	NM	28	36	--	20,000	7,000	14,000	--
MW-11 (2)	--	--	--	NM	--	--	--	NM	--	--	--	NM
MW-12 (2)	--	--	--	6.6	--	--	--	130	--	--	--	43,000
MW-13 (2)	--	--	--	6.6	--	--	--	130	--	--	--	33,000
MW-15 (2)	--	--	--	6.7	--	--	--	65	--	--	--	11,000
MW-17 (2)	--	--	--	6.7	--	--	--	55	--	--	--	8,500
Deeper Zone												
MW-1	6.8	6.9	6.1	6.4	NM	13	18	3.8	17,000	13,000	14,500	14,000
MW-2	6.4	6.5	6.1	6.7	NM	8.9	20	6.8	>50,000	41,000	>50,000	44,000
MW-3	6.9	6.9	5.9	6.5	NM	14	9.2	4.9	14,000	13,000	14,000	12,000
MW-6	6.7	6.6	6.0	6.9	NM	163	3.5	<1	11,000	11,000	11,000	12,000
MW-9	6.9	6.9	5.8	6.6	NM	44	31	10	19,000	16,000	18,000	15,000
MW-16 (2)	--	--	--	7.2	--	--	--	8.4	--	--	--	11,000
MW-18 (2)	--	--	--	6.7	--	--	--	8.8	--	--	--	40,000

REFERENCES: 3/85 and 5/85 - Kennedy/Jenks Engineers, Final Report, Soil and Groundwater Investigation, Liquid Gold Site, Richmond, California, July 1985.

1/86 - Kennedy/Jenks/Chilton letter to RWQCB dated 21 March 1986.

NOTES:

(1) MW-4 was accidentally destroyed during interim remedial activities in November 1985. It was abandoned in August 1986.
(2) Well installed during August 1986.
(3) Well abandoned during August 1986.
(4) NM indicates Not Measured.

LG006311

TABLE 31

SUMMARY OF DISSOLVED METAL CONCENTRATIONS
IN GROUNDWATER SAMPLES, OCTOBER 1988-OCTOBER 1989
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
K/J/C 855018.07

	DISSOLVED METAL CONCENTRATION (µg/L)							
	SHALLOW ZONE				DEEPER ZONE			
	1988-1989		1985-1986		1988-1989		1985-1986	
METAL	RANGE[1]	AVERAGE	RANGE	AVERAGE[2]	RANGE[1]	AVERAGE	RANGE	AVERAGE[2]
Lead	<9-54	9	<10-100	20	<9-20	6	<10-100	20
Nickel	<10-1	20	<10-200	40	<10-110	20	<10-430	60
Copper	<5-61	6	<5-80	30	<5-48	6	<5-120	30
Chromium	<1-20	3	2-19	6	<1-25	2	1-90	20
Zinc	<5-350	30	<5-240	50	<5-220	25	<5-90	30
Mercury	<0.2-0.6	0.2	NA	NA	<0.2-2.2	0.2	NA	NA

Notes:

1. Data presented in Table 15 and on Figures 43 and 44.
2. Data presented in Table 30.

General Notes:

1. NA = Not analyzed. Concentrations below detection limit were assigned values of one-half detection limit for computation of averages.

LG006312

TABLE 32

STATISTICAL SUMMARY OF GROUNDWATER METALS DATA
LIQUID GOLD SITE, RICHMOND, CA
(K/J/C 855018.07)

ALL WELLS

October 1988 - October 1989

	CHROMIUM	COPPER	LEAD	MERCURY	NICKEL	ZINC
MEAN CONCENTRATION (µg/L)	2.1	6.0	7.0	0.18	23	27
STANDARD DEVIATION (µg/L)	4.0	9.1	7.8	0.31	28	46
NUMBER OF SAMPLES	67	84	84	84	84	84

WELL MW-4R

October 1988 - October 1989

MEAN CONCENTRATION (µg/L)	0.67	3.9	26	0.13	88	120
STANDARD DEVIATION (µg/L)	0.24	1.8	15	0.043	20	130
NUMBER OF SAMPLES	3	4	4	4	4	4
T-TEST SIGNIFICANCE AT 95% CONFIDENCE INTERVAL?	No	No	Yes	No	Yes	Yes

General Notes:

1. For each metal, the T-test compared the concentration population of MW-4R samples with the concentration population of samples from all other wells. If a statistically significant difference in between the populations was determined, a "Yes" appears in the bottom row of the table.

LG006313

TABLE 33

PHYSICAL CONSTANTS FOR PAHs
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

COMPOUND	MOLECULAR WEIGHT	SOLUBILITY (ug/L)	Kow[1]	Koc[2]	Hc[3] (atm-m^3 mol^{-1})	$T_{1/2}$[4] (days)
Chrysene	228.3	1.5-2.2	4.1×10^5	2×10^5	2.5×10^{-8}	1000
Benz[a]anthracene	228.3	9-14	4.1×10^5	2×10^5	2.4×10^{-8}	290
Benzo[b]fluoranthene	252.3	14	1.15×10^6	5.5×10^5	2.9×10^{-9}	
Benzo[a]pyrene	252.3	3.8	1.15×10^6	5.5×10^5	4.9×10^{-7}	290
Dibenzo[a,h]anthracene	278.4	0.5	6.9×10^6	3.3×10^6	1.7×10^{-9}	

Notes:

1. Kow = Octanol/Water Partition Coefficient (unitless)
2. Koc = Sediment Partition Coefficient, Normalized for Organic Carbon Fraction (unitless)
3. Hc = Henry's Constant
4. $T_{1/2}$ = Half Life

LG006314

TABLE 34

METAL CONCENTRATIONS IN SOIL SAMPLES BY DEPTH AND LOT NUMBER
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

Metal	Depth (feet)	Mean Soil Concentration (mg/kg) Lot Number 1	2	3	4	5	6	7	8	9	10	11	12
Chromium	0-1.5	40	40	48	72	23	25	33	35	39	33	36	32
	5-6.5	27	27	31	27	21	22	25	20	65	38	NA	NA
	10-11.5	25	27	29	27	27	26	21	25	30	33	NA	NA
Copper	0-1.5	32	24	25	100	36	34	40	30	30	44	160	190
	5-6.5	90	87	230	320	42	37	16	900	25	73	NA	NA
	10-11.5	85	25	120	130	91	20	18	280	47	51	NA	NA
Lead	0-1.5	74	20	14	340	23	22	110	85	37	160	46	39
	5-6.5	400	40	680	1600	100	59	24	55	27	50	NA	NA
	10-11.5	21	3	33	71	5	7	9	4	5	2	NA	NA
Mercury	0-1.5	ND	NA	0.05	0.22	0.1	NA	NA	0.3	0.4	ND	0.4	0.1
	5-6.5	0.14	1	1.3	0.15	0.1	NA	NA	0.03	0.04	NA	NA	NA
	10-11.5	ND	0.05	0.25	0.38	ND	NA	NA	ND	ND	ND	NA	NA
Nickel	0-1.5	45	31	62	89	32	47	37	45	79	40	40	34
	5-6.5	50	32	20	35	25	26	26	20	57	65	NA	NA
	10-11.5	32	33	33	27	33	38	30	29	32	31	NA	NA
Zinc	0.1.5	200	94	50	280	44	120	750	94	77	77	120	150
	5-6.5	400	120	500	640	68	840	59	150	58	320	NA	NA
	10-11.5	100	75	110	170	82	51	49	140	45	53	NA	NA

Notes: Lots shown on Figure 60. Arithmetic mean calculated using data for original Lot 4.
ND = Not Detected
NA = Not Analyzed

LG006315

TABLE 35

ORGANIC CHEMICAL CONCENTRATIONS IN SOIL SAMPLES BY DEPTH AND LOT NUMBER
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

Chemical	Depth (feet)	Mean Soil Concentration (mg/kg) Lot Number 1	2	3	4	5	6	7	8	9	10	11	12
PCB (mg/kg)	0-1.5	ND	ND	ND	1	ND	ND	ND	ND	ND	ND	ND	ND
	5-6.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
	10-11.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA
Oil and Grease (mg/kg)	0-1.5	8800	5700	4200	370	1600	8000	4600	2100	770	11000	460	1100
	5-6.5	5100	6500	6000	30	1800	1800	1300	320	680	6000	NA	NA
	10-11.5	2600	8100	6800	340	5800	1800	3600	70	120	5200	NA	NA
TPH (Gas) (mg/kg)	0-1.5	ND	ND	ND	ND	ND	NA	NA	ND	ND	ND	ND	ND
	5-6.5	ND	ND	ND	ND	ND	NA	NA	ND	ND	ND	NA	NA
	10-11.5	ND	ND	ND	ND	ND	NA	NA	ND	ND	ND	NA	NA
TPH (Diesel) (mg/kg)	0-1.5	8	ND	ND	ND	ND	NA	NA	ND	ND	ND	ND	ND
	5-6.5	1	ND	ND	ND	ND	NA	NA	ND	ND	ND	NA	NA
	10-11.5	2	ND	ND	ND	ND	NA	NA	ND	ND	ND	NA	NA
Carcinogenic PAH (ug/kg)	0-1.5	ND	ND	ND	4400	ND	NA	NA	0.5	ND	NA	ND	60
	5-6.5	ND	ND	260	740	ND	NA	NA	ND	ND	ND	NA	NA
	10-11.5	ND	170	ND	ND	ND	NA	NA	ND	ND	ND	NA	NA
Total Other BNA (ug/kg)	0-1.5	30000	ND	ND	4600	ND	NA	NA	ND	ND	NA	ND	60
	5-6.5	14000	190	1700	1300	230	NA	NA	190	ND	ND	NA	NA
	10-11.5	2100	440	ND	170	ND	NA	NA	ND	ND	ND	NA	NA

Notes: Lots shown on Figure 60. Arithmetic mean calculated using data for original Lot 4.
ND = Not Detected
NA = Not Analyzed

LG00316

TABLE 36

CALCULATED HYPOTHETICAL CHEMICAL CONCENTRATIONS IN AIRBORNE DUST
AND CALCULATED INTAKE RATES
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
K/J/C 855018.07

Chemical and Area	Depth (feet)	Conc. in Soil[1]	Calc. Conc. in Air[2] (mg/m3)	Calculated Inhalation Intake[3] (mg/Kg.day) Residential Child	Residential Adult	Office Adult	Trespass Child
Chromium (total)							
Lot 4	0-1.5	71	$2.1x10^{-6}$	$2.7x10^{-6}$	$6.1x10^{-7}$	$1.4x10^{-7}$	$1.8x10^{-8}$
	5-6.5	28	$8.4x10^{-7}$	$1.1x10^{-6}$	$2.4x10^{-7}$	$5.4x10^{-8}$	$6.9x10^{-9}$
	10-11.5	28	$8.4x10^{-7}$	$1.1x10^{-6}$	$2.4x10^{-7}$	$5.4x10^{-8}$	$6.9x10^{-9}$
Area A	5-6.5	30	$9.0x10^{-7}$	$1.1x10^{-6}$	$2.6x10^{-7}$	$5.8x10^{-8}$	$7.4x10^{-9}$
Entire Site	0-1.5	40	$1.2x10^{-6}$	$1.5x10^{-6}$	$3.4x10^{-7}$	$7.7x10^{-8}$	$9.9x10^{-9}$
	5-6.5	31	$9.3x10^{-7}$	$1.2x10^{-6}$	$2.7x10^{-7}$	$6.0x10^{-8}$	$7.6x10^{-9}$
	10-11.5	29	$8.7x10^{-7}$	$1.1x10^{-6}$	$2.5x10^{-7}$	$5.6x10^{-8}$	$7.2x10^{-9}$
Chromium (VI)							
Lot 4	0-1.5	0.66	$2.0x10^{-8}$	$2.5x10^{-8}$	$5.7x10^{-9}$	$1.3x10^{-9}$	$1.6x10^{-10}$
	5-6.5	0.025	$7.5x10^{-10}$	$9.4x10^{-10}$	$2.1x10^{-10}$	$4.8x10^{-11}$	$6.2x10^{-12}$
	10-11.5	0.052	$1.6x10^{-9}$	$2.0x10^{-9}$	$4.5x10^{-10}$	$1.0x10^{-10}$	$1.3x10^{-11}$
Copper							
Lot 4	0-1.5	750	$2.3x10^{-5}$	$2.8x10^{-5}$	$6.4x10^{-6}$	$1.4x10^{-6}$	$1.8x10^{-7}$
	5-6.5	420	$1.3x10^{-5}$	$1.6x10^{-5}$	$3.6x10^{-6}$	$8.1x10^{-7}$	$1.0x10^{-7}$
	10-11.5	150	$4.5x10^{-6}$	$5.6x10^{-6}$	$1.3x10^{-6}$	$2.9x10^{-7}$	$3.7x10^{-8}$
Area A	5-6.5	360	$1.1x10^{-5}$	$1.4x10^{-5}$	$3.1x10^{-6}$	$6.9x10^{-7}$	$8.9x10^{-8}$
Entire Site	0-1.5	120	$3.6x10^{-6}$	$4.5x10^{-6}$	$1.0x10^{-6}$	$2.3x10^{-7}$	$3.0x10^{-8}$
	5-6.5	200	$6.0x10^{-6}$	$7.5x10^{-6}$	$1.7x10^{-6}$	$3.9x10^{-7}$	$4.9x10^{-8}$
	10-11.5	110	$3.3x10^{-6}$	$4.1x10^{-6}$	$9.4x10^{-7}$	$2.1x10^{-7}$	$2.7x10^{-8}$
Lead							
Lot 4	0-1.5	840	$2.5x10^{-5}$	$3.2x10^{-5}$	$7.2x10^{-6}$	$1.6x10^{-6}$	$2.1x10^{-7}$
	5-6.5	2100	$6.3x10^{-5}$	$7.9x10^{-5}$	$1.8x10^{-5}$	$4.1x10^{-6}$	$5.2x10^{-7}$
	10-11.5	180	$5.4x10^{-6}$	$6.8x10^{-6}$	$1.5x10^{-6}$	$3.5x10^{-7}$	$4.4x10^{-8}$
Area A	5-6.5	1500	$4.5x10^{-5}$	$5.6x10^{-5}$	$1.3x10^{-5}$	$2.9x10^{-6}$	$3.7x10^{-7}$
Entire Site	0-1.5	210	$6.3x10^{-6}$	$7.9x10^{-6}$	$1.8x10^{-6}$	$4.1x10^{-7}$	$5.2x10^{-8}$
	5-6.5	490	$1.5x10^{-5}$	$1.8x10^{-5}$	$4.2x10^{-6}$	$9.5x10^{-7}$	$1.2x10^{-7}$
	10-11.5	36	$1.1x10^{-6}$	$1.4x10^{-6}$	$3.1x10^{-7}$	$6.9x10^{-8}$	$8.9x10^{-9}$

LG006317

TABLE 36

CALCULATED HYPOTHETICAL CHEMICAL CONCENTRATIONS IN AIRBORNE DUST
AND CALCULATED INTAKE RATES
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
K/J/C 855018.07

Chemical and Area	Depth (feet)	Conc. in Soil[1]	Calc. Conc. in Air[2] (mg/m3)	Calculated Inhalation Intake[3] (mg/Kg.day) Residential Child	Residential Adult	Office Adult	Trespass Child
Mercury							
Lot 4	0-1.5	0.33	9.9×10^{-9}	1.2×10^{-8}	2.8×10^{-9}	6.4×10^{-10}	8.1×10^{-11}
	5-6.5	0.28	8.4×10^{-9}	1.1×10^{-8}	2.4×10^{-9}	5.4×10^{-10}	6.9×10^{-11}
	10-11.5	0.53	1.6×10^{-8}	2.0×10^{-8}	4.5×10^{-9}	1.0×10^{-9}	1.3×10^{-10}
Area A	5-6.5	0.92	2.8×10^{-8}	3.5×10^{-8}	7.9×10^{-9}	1.8×10^{-9}	2.3×10^{-10}
Entire Site	0-1.5	0.3	9.0×10^{-9}	1.1×10^{-8}	2.6×10^{-9}	5.8×10^{-10}	7.4×10^{-11}
	5-6.5	0.63	1.9×10^{-8}	2.4×10^{-8}	5.4×10^{-9}	1.2×10^{-9}	1.6×10^{-10}
	10-11.5	0.3	9.0×10^{-9}	1.1×10^{-8}	2.6×10^{-9}	5.8×10^{-10}	7.4×10^{-11}
Nickel							
Lot 4	0-1.5	98	2.9×10^{-6}	3.7×10^{-6}	8.4×10^{-7}	1.9×10^{-7}	2.4×10^{-8}
	5-6.5	42	1.3×10^{-6}	1.6×10^{-6}	3.6×10^{-7}	8.1×10^{-8}	1.0×10^{-8}
	10-11.5	29	8.7×10^{-7}	1.1×10^{-6}	2.5×10^{-7}	5.6×10^{-8}	7.2×10^{-9}
Area A	5-6.5	62	1.9×10^{-6}	2.3×10^{-6}	5.3×10^{-7}	1.2×10^{-7}	1.5×10^{-8}
Entire Site	0-1.5	52	1.6×10^{-6}	2.0×10^{-6}	4.5×10^{-7}	1.0×10^{-7}	1.3×10^{-8}
	5-6.5	41	1.2×10^{-6}	1.5×10^{-6}	3.5×10^{-7}	7.9×10^{-8}	1.0×10^{-8}
	10-11.5	35	1.1×10^{-6}	1.3×10^{-6}	3.0×10^{-7}	6.8×10^{-8}	8.6×10^{-9}
Zinc							
Lot 4	0-1.5	1200	3.6×10^{-5}	4.5×10^{-5}	1.0×10^{-5}	2.3×10^{-6}	3.0×10^{-7}
	5-6.5	980	2.9×10^{-5}	3.7×10^{-5}	8.4×10^{-6}	1.9×10^{-6}	2.4×10^{-7}
	10-11.5	260	7.8×10^{-6}	9.8×10^{-6}	2.2×10^{-6}	5.0×10^{-7}	6.4×10^{-8}
Area A	5-6.5	1000	3.0×10^{-5}	3.8×10^{-5}	8.6×10^{-6}	1.9×10^{-6}	2.5×10^{-7}
Entire Site	0-1.5	380	1.1×10^{-5}	1.4×10^{-5}	3.3×10^{-6}	7.3×10^{-7}	9.4×10^{-8}
	5-6.5	470	1.4×10^{-5}	1.8×10^{-5}	4.0×10^{-6}	9.1×10^{-7}	1.2×10^{-7}
	10-11.5	120	3.6×10^{-6}	4.5×10^{-6}	1.0×10^{-6}	2.3×10^{-7}	3.0×10^{-8}
Carcinogenic PAHs							
Lot 4	0-1.5	4100	1.2×10^{-7}	1.5×10^{-7}	3.5×10^{-8}	7.9×10^{-9}	1.0×10^{-9}
	5-6.5	7300	2.2×10^{-7}	2.7×10^{-7}	6.3×10^{-8}	1.4×10^{-8}	1.8×10^{-9}
	10-11.5	9000	2.7×10^{-7}	3.4×10^{-7}	7.7×10^{-8}	1.7×10^{-8}	2.2×10^{-9}
Area A	5-6.5	840	2.5×10^{-8}	3.2×10^{-8}	7.2×10^{-9}	1.6×10^{-9}	2.1×10^{-10}

TABLE 36

CALCULATED HYPOTHETICAL CHEMICAL CONCENTRATIONS IN AIRBORNE DUST
AND CALCULATED INTAKE RATES
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
K/J/C 855018.07

Chemical and Area	Depth (feet)	Conc. in Soil[1]	Calc. Conc. in Air[2] (mg/m3)	Calculated Inhalation Intake[3] (mg/Kg.day) Residential Child	Residential Adult	Office Adult	Trespass Child
Entire Site	0-1.5	660	$2.0x10^{-8}$	$2.5x10^{-8}$	$5.7x10^{-9}$	$1.3x10^{-9}$	$1.6x10^{-10}$
	5-6.5	390	$1.2x10^{-8}$	$1.5x10^{-8}$	$3.3x10^{-9}$	$7.5x10^{-10}$	$9.6x10^{-11}$
	10-11.5	ND[5]	NA[6]	NA	NA	NA	NA
PCB							
Lot 4	0-1.5	3000	$9.0x10^{-8}$	$1.1x10^{-7}$	$2.6x10^{-8}$	$5.8x10^{-9}$	$7.4x10^{-10}$
	5-6.5	ND	NA	NA	NA	NA	NA
	10-11.5	ND	NA	NA	NA	NA	NA
Area A	5-6.5	ND	NA	NA	NA	NA	NA
Entire Site	0-1.5	190	$5.7x10^{-9}$	$7.1x10^{-9}$	$1.6x10^{-9}$	$3.7x10^{-10}$	$4.7x10^{-11}$
	5-6.5	ND	NA	NA	NA	NA	NA
	10-11.5	ND	NA	NA	NA	NA	NA
2-Methylphenol							
Lot 4	0-1.5	ND	NA	NA	NA	NA	NA
	5-6.5	ND	NA	NA	NA	NA	NA
	10-11.5	ND	NA	NA	NA	NA	NA
Area A	5-6.5	ND	NA	NA	NA	NA	NA
Entire Site	0-1.5	ND	NA	NA	NA	NA	NA
	5-6.5	ND	NA	NA	NA	NA	NA
	10-11.5	120	$3.6x10^{-9}$	$4.5x10^{-9}$	$1.0x10^{-9}$	$2.3x10^{-10}$	$3.0x10^{-11}$
4-Methylphenol							
Lot 4	0-1.5	ND	NA	NA	NA	NA	NA
	5-6.5	ND	NA	NA	NA	NA	NA
	10-11.5	ND	NA	NA	NA	NA	NA
Area A	5-6.5	ND	NA	NA	NA	NA	NA
Entire Site	0-1.5	ND	NA	NA	NA	NA	NA
	5-6.5	ND	NA	NA	NA	NA	NA
	10-11.5	900	$2.7x10^{-8}$	$3.4x10^{-8}$	$7.7x10^{-9}$	$1.7x10^{-9}$	$2.2x10^{-10}$

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TABLE 36

CALCULATED HYPOTHETICAL CHEMICAL CONCENTRATIONS IN AIRBORNE DUST
AND CALCULATED INTAKE RATES
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
K/J/C 855018.07

Chemical and Area	Depth (feet)	Conc. in Soil[1]	Calc. Conc. in Air[2] (mg/m3)	Calculated Inhalation Intake[3] (mg/Kg.day) Residential Child	Residential Adult	Office Adult	Trespass Child
Fluoranthene							
Lot 4	0-1.5	890	$2.7x10^{-8}$	$3.3x10^{-8}$	$7.6x10^{-9}$	$1.7x10^{-9}$	$2.2x10^{-10}$
	5-6.5	870	$2.6x10^{-8}$	$3.3x10^{-8}$	$7.5x10^{-9}$	$1.7x10^{-9}$	$2.1x10^{-10}$
	10-11.5	930	$2.8x10^{-8}$	$3.5x10^{-8}$	$8.0x10^{-9}$	$1.8x10^{-9}$	$2.3x10^{-10}$
Area A	5-6.5	140	$4.2x10^{-9}$	$5.3x10^{-9}$	$1.2x10^{-9}$	$2.7x10^{-10}$	$3.5x10^{-11}$
Entire Site	0-1.5	110	$3.3x10^{-9}$	$4.1x10^{-9}$	$9.4x10^{-10}$	$2.1x10^{-10}$	$2.7x10^{-11}$
	5-6.5	280	$8.4x10^{-9}$	$1.1x10^{-8}$	$2.4x10^{-9}$	$5.4x10^{-10}$	$6.9x10^{-11}$
	10-11.5	350	$1.1x10^{-8}$	$1.3x10^{-8}$	$3.0x10^{-9}$	$6.8x10^{-10}$	$8.6x10^{-11}$
Naphthalene							
Lot 4	0-1.5	ND	NA	NA	NA	NA	NA
	5-6.5	ND	NA	NA	NA	NA	NA
	10-11.5	ND	NA	NA	NA	NA	NA
Area A	5-6.5	99	$3.0x10^{-9}$	$3.7x10^{-9}$	$8.5x10^{-10}$	$1.9x10^{-10}$	$2.4x10^{-11}$
Entire Site	0-1.5	15	$4.5x10^{-10}$	$5.6x10^{-10}$	$1.3x10^{-10}$	$2.9x10^{-11}$	$3.7x10^{-12}$
	5-6.5	44	$1.3x10^{-9}$	$1.7x10^{-9}$	$3.8x10^{-10}$	$8.5x10^{-11}$	$1.1x10^{-11}$
	10-11.5	ND	NA	NA	NA	NA	NA
Phenol							
Lot 4	0-1.5	ND	NA	NA	NA	NA	NA
	5-6.5	ND	NA	NA	NA	NA	NA
	10-11.5	ND	NA	NA	NA	NA	NA
Area A	5-6.5	ND	NA	NA	NA	NA	NA
Entire Site	0-1.5	ND	NA	NA	NA	NA	NA
	5-6.5	ND	NA	NA	NA	NA	NA
	10-11.5	52	$1.6x10^{-9}$	$2.0x10^{-9}$	$4.5x10^{-10}$	$1.0x10^{-10}$	$1.3x10^{-11}$
Pyrene							
Lot 4	0-1.5	3000	$9.0x10^{-8}$	$1.1x10^{-7}$	$2.6x10^{-8}$	$5.8x10^{-9}$	$7.4x10^{-10}$
	5-6.5	1200	$3.6x10^{-8}$	$4.5x10^{-8}$	$1.0x10^{-8}$	$2.3x10^{-9}$	$3.0x10^{-10}$
	10-11.5	1300	$3.9x10^{-8}$	$4.9x10^{-8}$	$1.1x10^{-8}$	$2.5x10^{-9}$	$3.2x10^{-10}$
Area A	5-6.5	210	$6.3x10^{-9}$	$7.9x10^{-9}$	$1.8x10^{-9}$	$4.1x10^{-10}$	$5.2x10^{-11}$

LG006320

TABLE 36

CALCULATED HYPOTHETICAL CHEMICAL CONCENTRATIONS IN AIRBORNE DUST
AND CALCULATED INTAKE RATES
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
K/J/C 855018.07

Chemical and Area	Depth (feet)	Conc. in Soil[1]	Calc. Conc. in Air[2] (mg/m3)	Calculated Inhalation Intake[3] (mg/Kg.day)			
				Residential		Office	Trespass
				Child	Adult	Adult	Child
Entire Site	0-1.5	370	1.1×10^{-8}	1.4×10^{-8}	3.2×10^{-9}	7.1×10^{-10}	9.1×10^{-11}
	5-6.5	390	1.2×10^{-8}	1.5×10^{-8}	3.3×10^{-9}	7.5×10^{-10}	9.6×10^{-11}
	10-11.5	480	1.4×10^{-8}	1.8×10^{-8}	4.1×10^{-9}	9.3×10^{-10}	1.2×10^{-10}

Notes:

1. Metal concentrations in mg/Kg, organic chemical concentrations in ug/Kg. Values are 95% upper confidence limits on the mean.

2. Calculated Concentration in air = (Metal Concentration in Soil) * (0.03 mg/m3) / (1,000,000 mg/Kg).

   Calculated Concentration in air = (Org. Concentration in Soil) * (0.03 mg/m3) / (1,000,000,000 ug/Kg)

3. Residential Intake (child) = (air concentration mg/m3) * (20 m3/day) / (16 Kg)

   Residential Intake (adult) = (air concentration mg/m3) * (20 m3/day) / (70 Kg)

   Office Intake = (air concentration mg/m3) * (10 m3/day) / (70 Kg) * (250 day/365 day) * (46 yr/70 yr)

4. Trespass Intake = (air concentration mg/m3) * (4 m3/day) / (16 Kg) * (12 day/365 day)

5. ND = Not detected

6. NA = Not applicable

LG006321

TABLE 37

CALCULATED CHEMICAL INGESTION RATES DUE TO
POTENTIAL EXPOSURE TO SOILS
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
K/J/C 855018.07

Chemical and Area	Depth (feet)	Conc. in Soil[1]	Calculated Ingestion Intake[2] (mg/Kg.day) Residential Child	Residential Adult	Office Adult	Trespass Child
Chromium (total)						
Lot 4	0-1.5	71	$8.9x10^{-4}$	$1.0x10^{-4}$	$2.3x10^{-5}$	$2.9x10^{-5}$
	5-6.5	28	$3.5x10^{-4}$	$4.0x10^{-5}$	$9.0x10^{-6}$	$1.2x10^{-5}$
	10-11.5	28	$3.5x10^{-4}$	$4.0x10^{-5}$	$9.0x10^{-6}$	$1.2x10^{-5}$
Area A	5-6.5	30	$3.8x10^{-4}$	$4.3x10^{-5}$	$9.6x10^{-6}$	$1.2x10^{-5}$
Entire Site	0-1.5	40	$5.0x10^{-4}$	$5.7x10^{-5}$	$1.3x10^{-5}$	$1.6x10^{-5}$
	5-6.5	31	$3.9x10^{-4}$	$4.4x10^{-5}$	$1.0x10^{-5}$	$1.3x10^{-5}$
	10-11.5	29	$3.6x10^{-4}$	$4.1x10^{-5}$	$9.3x10^{-6}$	$1.2x10^{-5}$
Chromium (VI)						
Lot 4	0-1.5	0.66	$8.3x10^{-6}$	$9.4x10^{-7}$	$2.1x10^{-7}$	$2.7x10^{-7}$
	5-6.5	0.025	$3.1x10^{-7}$	$3.6x10^{-8}$	$8.0x10^{-9}$	$1.0x10^{-8}$
	10-11.5	0.052	$6.5x10^{-7}$	$7.4x10^{-8}$	$1.7x10^{-8}$	$2.1x10^{-8}$
Copper						
Lot 4	0-1.5	750	$9.4x10^{-3}$	$1.1x10^{-3}$	$2.4x10^{-4}$	$3.1x10^{-4}$
	5-6.5	420	$5.3x10^{-3}$	$6.0x10^{-4}$	$1.4x10^{-4}$	$1.7x10^{-4}$
	10-11.5	150	$1.9x10^{-3}$	$2.1x10^{-4}$	$4.8x10^{-5}$	$6.2x10^{-5}$
Area A	5-6.5	360	$4.5x10^{-3}$	$5.1x10^{-4}$	$1.2x10^{-4}$	$1.5x10^{-4}$
Entire Site	0-1.5	120	$1.5x10^{-3}$	$1.7x10^{-4}$	$3.9x10^{-5}$	$4.9x10^{-5}$
	5-6.5	200	$2.5x10^{-3}$	$2.9x10^{-4}$	$6.4x10^{-5}$	$8.2x10^{-5}$
	10-11.5	110	$1.4x10^{-3}$	$1.6x10^{-4}$	$3.5x10^{-5}$	$4.5x10^{-5}$
Lead						
Lot 4	0-1.5	840	$1.1x10^{-2}$	$1.2x10^{-3}$	$2.7x10^{-4}$	$3.5x10^{-4}$
	5-6.5	2100	$2.6x10^{-2}$	$3.0x10^{-3}$	$6.8x10^{-4}$	$8.6x10^{-4}$
	10-11.5	180	$2.3x10^{-3}$	$2.6x10^{-4}$	$5.8x10^{-5}$	$7.4x10^{-5}$
Area A	5-6.5	1500	$1.9x10^{-2}$	$2.1x10^{-3}$	$4.8x10^{-4}$	$6.4x10^{-4}$
Entire Site	0-1.5	210	$2.6x10^{-3}$	$3.0x10^{-4}$	$6.8x10^{-5}$	$8.6x10^{-5}$
	5-6.5	490	$6.1x10^{-3}$	$7.0x10^{-4}$	$1.6x10^{-4}$	$2.0x10^{-4}$
	10-11.5	36	$4.5x10^{-4}$	$5.1x10^{-5}$	$1.2x10^{-5}$	$1.5x10^{-5}$

LG006322

TABLE 37

CALCULATED CHEMICAL INGESTION RATES DUE TO
POTENTIAL EXPOSURE TO SOILS
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
K/J/C 855018.07

Chemical and Area	Depth (feet)	Conc. in Soil[1]	Calculated Ingestion Intake[2] (mg/Kg.day) Residential Child	Residential Adult	Office Adult	Trespass Child
Mercury						
Lot 4	0-1.5	0.33	$4.1x10^{-6}$	$4.7x10^{-7}$	$1.1x10^{-7}$	$1.4x10^{-7}$
	5-6.5	0.28	$3.5x10^{-6}$	$4.0x10^{-7}$	$9.0x10^{-8}$	$1.2x10^{-7}$
	10-11.5	0.53	$6.6x10^{-6}$	$7.6x10^{-7}$	$1.7x10^{-7}$	$2.2x10^{-7}$
Area A	5-6.5	0.92	$1.2x10^{-5}$	$1.3x10^{-6}$	$3.0x10^{-7}$	$3.8x10^{-7}$
Entire Site	0-1.5	0.3	$3.8x10^{-6}$	$4.3x10^{-7}$	$9.6x10^{-8}$	$1.2x10^{-7}$
	5-6.5	0.63	$7.9x10^{-6}$	$9.0x10^{-7}$	$2.0x10^{-7}$	$2.6x10^{-7}$
	10-11.5	0.3	$3.8x10^{-6}$	$4.3x10^{-7}$	$9.6x10^{-8}$	$1.2x10^{-7}$
Nickel						
Lot 4	0-1.5	98	$1.2x10^{-3}$	$1.4x10^{-4}$	$3.2x10^{-5}$	$4.0x10^{-5}$
	5-6.5	42	$5.3x10^{-4}$	$6.0x10^{-5}$	$1.4x10^{-5}$	$1.7x10^{-5}$
	10-11.5	29	$3.6x10^{-4}$	$4.1x10^{-5}$	$9.3x10^{-6}$	$1.2x10^{-5}$
Area A	5-6.5	62	$7.8x10^{-4}$	$8.9x10^{-5}$	$2.0x10^{-5}$	$2.5x10^{-5}$
Entire Site	0-1.5	52	$6.5x10^{-4}$	$7.4x10^{-5}$	$1.7x10^{-5}$	$2.1x10^{-5}$
	5-6.5	41	$5.1x10^{-4}$	$5.9x10^{-5}$	$1.3x10^{-5}$	$1.7x10^{-5}$
	10-11.5	35	$4.4x10^{-4}$	$5.0x10^{-5}$	$1.1x10^{-5}$	$1.4x10^{-5}$
Zinc						
Lot 4	0-1.5	1200	$1.5x10^{-2}$	$1.7x10^{-3}$	$3.9x10^{-4}$	$4.9x10^{-4}$
	5-6.5	980	$1.2x10^{-2}$	$1.4x10^{-3}$	$3.2x10^{-4}$	$4.0x10^{-4}$
	10-11.5	260	$3.3x10^{-3}$	$3.7x10^{-4}$	$8.4x10^{-5}$	$1.1x10^{-4}$
Area A	5-6.5	1000	$1.3x10^{-2}$	$1.4x10^{-3}$	$3.2x10^{-4}$	$4.1x10^{-4}$
Entire Site	0-1.5	380	$4.8x10^{-3}$	$5.4x10^{-4}$	$1.2x10^{-4}$	$1.6x10^{-4}$
	5-6.5	470	$5.9x10^{-3}$	$6.7x10^{-4}$	$1.5x10^{-4}$	$1.9x10^{-4}$
	10-11.5	120	$1.5x10^{-3}$	$1.7x10^{-4}$	$3.9x10^{-5}$	$4.9x10^{-5}$
Carcinogenic PAHs						
Lot 4	0-1.5	4100	$5.1x10^{-5}$	$5.9x10^{-6}$	$1.3x10^{-6}$	$1.7x10^{-6}$
	5-6.5	7300	$9.1x10^{-5}$	$1.0x10^{-5}$	$2.3x10^{-6}$	$3.0x10^{-6}$
	10-11.5	9000	$1.1x10^{-4}$	$1.3x10^{-5}$	$2.9x10^{-6}$	$3.7x10^{-6}$

LG006323

TABLE 37

CALCULATED CHEMICAL INGESTION RATES DUE TO
POTENTIAL EXPOSURE TO SOILS
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
K/J/C 855018.07

Chemical and Area	Depth (feet)	Conc. in Soil[1]	Calculated Ingestion Intake[2] (mg/Kg.day) Residential Child	Residential Adult	Office Adult	Trespass Child
Area A	5-6.5	840	$1.1x10^{-5}$	$1.2x10^{-6}$	$2.7x10^{-7}$	$3.5x10^{-7}$
Entire Site	0-1.5	660	$8.3x10^{-6}$	$9.4x10^{-7}$	$2.1x10^{-7}$	$2.7x10^{-7}$
	5-6.5	390	$4.9x10^{-6}$	$5.6x10^{-7}$	$1.3x10^{-7}$	$1.6x10^{-7}$
	10-11.5	ND[3]	NA[4]	NA	NA	NA
PCB						
Lot 4	0-1.5	3000	$3.8x10^{-5}$	$4.3x10^{-6}$	$9.6x10^{-7}$	$1.2x10^{-6}$
	5-6.5	ND	NA	NA	NA	NA
	10-11.5	ND	NA	NA	NA	NA
Area A	5-6.5	ND	NA	NA	NA	NA
Entire Site	0-1.5	190	$2.4x10^{-6}$	$2.7x10^{-7}$	$6.1x10^{-8}$	$7.8x10^{-8}$
	5-6.5	ND	NA	NA	NA	NA
	10-11.5	ND	NA	NA	NA	NA
2-Methylphenol						
Lot 4	0-1.5	ND	NA	NA	NA	NA
	5-6.5	ND	NA	NA	NA	NA
	10-11.5	ND	NA	NA	NA	NA
Area A	5-6.5	ND	NA	NA	NA	NA
Entire Site	0-1.5	ND	NA	NA	NA	NA
	5-6.5	ND	NA	NA	NA	NA
	10-11.5	120	$1.5x10^{-6}$	$1.7x10^{-7}$	$3.9x10^{-8}$	$4.9x10^{-8}$
4-Methylphenol						
Lot 4	0-1.5	ND	NA	NA	NA	NA
	5-6.5	ND	NA	NA	NA	NA
	10-11.5	ND	NA	NA	NA	NA
Area A	5-6.5	ND	NA	NA	NA	NA
Entire Site	0-1.5	ND	NA	NA	NA	NA
	5-6.5	ND	NA	NA	NA	NA
	10-11.5	900	$1.1x10^{-5}$	$1.3x10^{-6}$	$2.9x10^{-7}$	$3.7x10^{-7}$

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TABLE 37

CALCULATED CHEMICAL INGESTION RATES DUE TO
POTENTIAL EXPOSURE TO SOILS
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
K/J/C 855018.07

Chemical and Area	Depth (feet)	Conc. in Soil[1]	Calculated Ingestion Intake[2] (mg/Kg.day) Residential Child	Residential Adult	Office Adult	Trespass Child
Fluoranthene						
Lot 4	0-1.5	890	$1.1x10^{-5}$	$1.3x10^{-6}$	$2.9x10^{-7}$	$3.7x10^{-7}$
	5-6.5	870	$1.1x10^{-5}$	$1.2x10^{-6}$	$2.8x10^{-7}$	$3.6x10^{-7}$
	10-11.5	930	$1.2x10^{-5}$	$1.3x10^{-6}$	$3.0x10^{-7}$	$3.8x10^{-7}$
Area A	5-6.5	140	$1.8x10^{-6}$	$2.0x10^{-7}$	$4.5x10^{-8}$	$5.8x10^{-8}$
Entire Site	0-1.5	110	$1.4x10^{-6}$	$1.6x10^{-7}$	$3.5x10^{-8}$	$4.5x10^{-8}$
	5-6.5	280	$3.5x10^{-6}$	$4.0x10^{-7}$	$9.0x10^{-8}$	$1.2x10^{-7}$
	10-11.5	350	$4.4x10^{-6}$	$5.0x10^{-7}$	$1.1x10^{-7}$	$1.4x10^{-7}$
Naphthalene						
Lot 4	0-1.5	ND	NA	NA	NA	NA
	5-6.5	ND	NA	NA	NA	NA
	10-11.5	ND	NA	NA	NA	NA
Area A	5-6.5	99	$1.2x10^{-6}$	$1.4x10^{-7}$	$3.2x10^{-8}$	$4.1x10^{-8}$
Entire Site	0-1.5	15	$1.9x10^{-7}$	$2.1x10^{-8}$	$4.8x10^{-9}$	$6.2x10^{-9}$
	5-6.5	44	$5.5x10^{-7}$	$6.3x10^{-8}$	$1.4x10^{-8}$	$1.8x10^{-8}$
	10-11.5	ND	NA	NA	NA	NA
Phenol						
Lot 4	0-1.5	ND	NA	NA	NA	NA
	5-6.5	ND	NA	NA	NA	NA
	10-11.5	ND	NA	NA	NA	NA
Area A	5-6.5	ND	NA	NA	NA	NA
Entire Site	0-1.5	ND	NA	NA	NA	NA
	5-6.5	ND	NA	NA	NA	NA
	10-11.5	52	$6.5x10^{-7}$	$7.4x10^{-8}$	$1.7x10^{-8}$	$2.1x10^{-8}$
Pyrene						
Lot 4	0-1.5	3000	$3.8x10^{-5}$	$4.3x10^{-6}$	$9.6x10^{-7}$	$1.2x10^{-6}$
	5-6.5	1200	$1.5x10^{-5}$	$1.7x10^{-6}$	$3.9x10^{-7}$	$4.9x10^{-7}$
	10-11.5	1300	$1.6x10^{-5}$	$1.9x10^{-6}$	$4.2x10^{-7}$	$5.3x10^{-7}$
Area A	5-6.5	210	$2.6x10^{-6}$	$3.0x10^{-7}$	$6.8x10^{-8}$	$8.6x10^{-8}$

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TABLE 37

CALCULATED CHEMICAL INGESTION RATES DUE TO
POTENTIAL EXPOSURE TO SOILS
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
K/J/C 855018.07

Chemical and Area	Depth (feet)	Conc. in Soil[1]	Calculated Ingestion Intake[2] (mg/Kg.day) Residential Child	Residential Adult	Office Adult	Trespass Child
Entire Site	0-1.5	370	4.6×10^{-6}	5.3×10^{-7}	1.2×10^{-7}	1.5×10^{-7}
	5-6.5	390	4.9×10^{-6}	5.6×10^{-7}	1.3×10^{-7}	1.6×10^{-7}
	10-11.5	480	6.0×10^{-6}	6.9×10^{-7}	1.5×10^{-7}	2.0×10^{-7}

NOTES:

1) Metal concentrations in mg/Kg, organic chemical concentrations in ug/Kg. Values are 95% upper confidence limits on the mean.

2) Resid. Intake (child) = (conc. mg/Kg) * (0.0002 Kg/day) / (16 Kg)

   Resid. Intake (adult) = (conc. mg/Kg) * (0.0001 Kg/day) / (70 Kg)

   Office Intake = (conc. mg/kg) * (0.00005 Kg/day) / (70 Kg)
   * (250 day/365 day) * (46 yr/70 yr)

   Trespass Intake = (conc. mg/Kg) * (0.0002 Kg/day) / (16 Kg) * (12 day/365 day)

   For organic chemicals, an additional factor of (mg/1000 ug) is needed for all equations.

3) ND = Not detected

4) NA = Not applicable

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TABLE 38

TOXICITY VALUES FOR NONCARCINOGENIC EFFECTS
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

Chemical	Oral RfD[1] (mg/Kg•day)	AIC[2] (mg/Kg•day) Oral	AIC[2] (mg/Kg•day) Inhalation
Chromium III	1	-	-
Chromium VI	$5x10^{-3}$	-	-
Copper	$3.7x10^{-2}$	$3.7x10^{-2}$	$1x10^{-2}$
Lead	$4.6x10^{-3}$(3)	-	-
Mercury	-	$2x10^{-3}$	$5.1x10^{-5}$
Nickel	$2x10^{-2}$	-	-
Zinc	-	$2.1x10^{-1}$	$1x10^{-2}$
Cresols			
2-methylphenol	$5x10^{-2}$	$5x10^{-2}$	$1x10^{-1}$
4-methylphenol	$5x10^{-2}$	$5x10^{-2}$	$1x10^{-1}$
Phenol	$6x10^{-1}$	-	-
Naphthalene	$4x10^{-3}$	-	-
Fluoranthene	$4x10^{-2}$(4)	-	-
Pyrene	$3x10^{-2}$(4)	-	-

Notes:

1. Source of Reference Doses: EPA's Integrated Risk Information System and Health Effects Assessment Summary Tables (EPA 1989d).
2. Source of Acceptable Intakes - Chronic: Superfund Public Health Evaluation Manual (EPA 540/1-86-060, October 1986).
3. Lead RfD derived from factors provided by DHS. See text.
4. Interim values from EPA Environmental Criteria and Assessment Office.

TABLE 39

SLOPE FACTORS FOR POTENTIAL CHEMICAL CARCINOGENS
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

CHEMICAL	EPA WEIGH-OF-EVIDENCE CLASSIFICATION[1]	INGESTION SLOPE FACTOR[2] $(mg/Kg \cdot day)^{-1}$	INHALATION SLOPE FACTOR[2] $(mg/Kg \cdot day)^{-1}$
Chromium VI	A	NA[3]	41
PCB	B	7.7	NA
Carcinogenic PAHs[4]		11.5	6.1
Benz[a]anthracene	B2		
Benzo[b]fluoranthene	B2		
Benzo[a]pyrene	B2		
Chrysene	B2		
Dibenz[a,h]anthracene	B2		
Indeno[1,2,3]pyrene	B2		

Notes:

1. Group A = Sufficient evidence of carcinogenicity in humans.
   Group B1 = Limited evidence of carcinogenicity in humans.
   Group B2 = Inadequate evidence of carcinogenicity in humans; sufficient evidence of carcinogenicity in animals.
2. Source: EPA's Integrated Risk Information System (IRIS).
3. Not applicable by this exposure route.
4. Slope factors for PAHs are currently under review by EPA. EPA policy is to use the prior benzo[a]pyrene slope factors for all carcinogenic PAHs.

TABLE 40
HAZARD INDICES FOR NONCARCINOGENIC EFFECTS
RESIDENTIAL CHILD EXPOSURE
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
K/J/C 855018.07

HAZARD INDEX[1] - ORAL

	Lot 4			Area A	Entire Site		
Chemical	0'-1.5'	5'-6.5'	10'-11.5'	5'-6.5'	0'-1.5'	5'-6.5'	10'-11.5'
Chromium	$8.9x10^{-4}$	$3.5x10^{-4}$	$3.5x10^{-4}$	$3.8x10^{-4}$	$5.0x10^{-4}$	$3.9x10^{-4}$	$3.6x10^{-4}$
Copper	$2.5x10^{-1}$	$1.4x10^{-1}$	$5.1x10^{-2}$	$1.2x10^{-1}$	$4.1x10^{-2}$	$6.8x10^{-2}$	$3.7x10^{-2}$
Lead	$2.2x10^{0}$	$5.6x10^{0}$	$4.8x10^{-1}$	$4.0x10^{0}$	$5.6x10^{-1}$	$1.3x10^{0}$	$9.6x10^{-2}$
Mercury	$2.1x10^{-3}$	$1.8x10^{-3}$	$3.3x10^{-3}$	$5.8x10^{-3}$	$1.9x10^{-3}$	$3.9x10^{-3}$	$1.9x10^{-3}$
Nickel	$6.1x10^{-2}$	$2.6x10^{-2}$	$1.8x10^{-2}$	$3.9x10^{-2}$	$3.3x10^{-2}$	$2.6x10^{-2}$	$2.2x10^{-2}$
Zinc	$7.1x10^{-2}$	$5.8x10^{-2}$	$1.5x10^{-2}$	$6.0x10^{-2}$	$2.3x10^{-2}$	$2.8x10^{-2}$	$7.1x10^{-3}$
2-Methylphenol	NA[2]	NA	NA	NA	NA	NA	$3.0x10^{-5}$
4-Methyphenol	NA	NA	NA	NA	NA	NA	NA
Fluoran-thene	$2.8x10^{-4}$	$2.7x10^{-4}$	$2.9x10^{-4}$	$4.4x10^{-5}$	$3.4x10^{-5}$	$8.8x10^{-5}$	$1.1x10^{-4}$
Naphthalene	NA	NA	NA	$3.1x10^{-4}$	$4.7x10^{-5}$	$1.4x10^{-4}$	NA
Phenol	NA	NA	NA	NA	NA	NA	$1.1x10^{-6}$
Pyrene	$1.3x10^{-3}$	$5.0x10^{-4}$	$5.4x10^{-4}$	$8.8x10^{-5}$	$1.5x10^{-4}$	$1.6x10^{-4}$	$2.0x10^{-4}$
TOTAL	$2.6x10^{0}$	$5.8x10^{0}$	$5.7x10^{-1}$	$4.2x10^{0}$	$6.6x10^{-1}$	$1.4x10^{0}$	$1.6x10^{-1}$

HAZARD INDEX[1] - INHALATION

	Lot 4			Area A	Entire Site		
Chemical	0'-1.5'	5'-6.5'	10'-11.5'	5'-6.5'	0'-1.5'	5'-6.5'	10'-11.5'
Chromium	$2.7x10^{-6}$	$1.1x10^{-6}$	$1.1x10^{-6}$	$1.1x10^{-6}$	$1.5x10^{-6}$	$1.2x10^{-6}$	$1.1x10^{-6}$
Copper	$7.6x10^{-4}$	$4.3x10^{-4}$	$1.5x10^{-4}$	$3.6x10^{-4}$	$1.2x10^{-4}$	$2.0x10^{-4}$	$1.1x10^{-4}$
Lead	$6.7x10^{-3}$	$1.7x10^{-2}$	$1.4x10^{-3}$	$1.2x10^{-2}$	$1.7x10^{-3}$	$3.9x10^{-3}$	$2.9x10^{-4}$
Mercury	$2.5x10^{-4}$	$2.1x10^{-4}$	$4.0x10^{-4}$	$6.9x10^{-4}$	$2.3x10^{-4}$	$4.7x10^{-4}$	$2.3x10^{-4}$
Nickel	$1.8x10^{-4}$	$7.9x10^{-5}$	$5.4x10^{-5}$	$1.2x10^{-4}$	$9.8x10^{-5}$	$7.7x10^{-5}$	$6.6x10^{-5}$
Zinc	$4.5x10^{-3}$	$3.7x10^{-3}$	$9.8x10^{-4}$	$3.8x10^{-3}$	$1.4x10^{-3}$	$1.8x10^{-3}$	$4.5x10^{-4}$
2-Methylphenol	NA	NA	NA	NA	NA	NA	$9.0x10^{-8}$
4-Methyphenol	NA	NA	NA	NA	NA	NA	$6.8x10^{-7}$
Fluoran-thene	$8.3x10^{-7}$	$8.2x10^{-7}$	$8.7x10^{-7}$	$1.3x10^{-7}$	$1.0x10^{-7}$	$2.6x10^{-7}$	$3.3x10^{-7}$
Naphthalene	NA	NA	NA	$9.3x10^{-7}$	$1.4x10^{-7}$	$4.1x10^{-7}$	NA
Phenol	NA	NA	NA	NA	NA	NA	$3.3x10^{-9}$
Pyrene	$3.8x10^{-6}$	$1.5x10^{-6}$	$1.6x10^{-6}$	$2.6x10^{-7}$	$4.6x10^{-7}$	$4.9x10^{-7}$	$6.0x10^{-7}$
TOTAL	$1.2x10^{-2}$	$2.1x10^{-2}$	$3.0x10^{-3}$	$1.7x10^{-2}$	$3.5x10^{-3}$	$6.4x10^{-3}$	$1.1x10^{-3}$

NOTES:
1) Hazard Index = (Calc. Intake mg/Kg.day) / (RfD mg/Kg.day)
Calculated intakes taken from Table 37 for oral and Table 36 for inhalation.
RFD values taken from Table 38.

2) NA = Not Applicable

TABLE 41
HAZARD INDICES FOR NONCARCINOGENIC EFFECTS
RESIDENTIAL ADULT EXPOSURE
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
K/J/C 855018.07

HAZARD INDEX[1] - ORAL

	Lot 4			Area A	Entire Site		
Chemical	0'-1.5'	5'-6.5'	10'-11.5'	5'-6.5'	0'-1.5'	5'-6.5'	10'-11.5'
Chromium	$1.0x10^{-4}$	$4.0x10^{-5}$	$4.0x10^{-5}$	$4.3x10^{-5}$	$5.7x10^{-5}$	$4.4x10^{-5}$	$4.1x10^{-5}$
Copper	$2.9x10^{-2}$	$1.6x10^{-2}$	$5.8x10^{-3}$	$1.4x10^{-2}$	$4.6x10^{-3}$	$7.7x10^{-3}$	$4.2x10^{-3}$
Lead	$2.6x10^{-1}$	$6.4x10^{-1}$	$5.5x10^{-2}$	$4.6x10^{-1}$	$6.4x10^{-2}$	$1.5x10^{-1}$	$1.1x10^{-2}$
Mercury	$2.4x10^{-4}$	$2.0x10^{-4}$	$3.8x10^{-4}$	$6.6x10^{-4}$	$2.1x10^{-4}$	$4.5x10^{-4}$	$2.1x10^{-4}$
Nickel	$7.0x10^{-3}$	$3.0x10^{-3}$	$2.1x10^{-3}$	$4.4x10^{-3}$	$3.7x10^{-3}$	$2.9x10^{-3}$	$2.5x10^{-3}$
Zinc	$8.2x10^{-3}$	$6.7x10^{-3}$	$1.8x10^{-3}$	$6.8x10^{-3}$	$2.6x10^{-3}$	$3.2x10^{-3}$	$8.2x10^{-8}$
2-Methylphenol	NA[2]	NA	NA	NA	NA	NA	$3.4x10^{-6}$
4-Methyphenol	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	$3.2x10^{-5}$	$3.1x10^{-5}$	$3.3x10^{-5}$	$5.0x10^{-6}$	$3.9x10^{-6}$	$1.0x10^{-5}$	$1.3x10^{-5}$
Naphthalene	NA	NA	NA	$3.5x10^{-5}$	$5.4x10^{-6}$	$1.6x10^{-5}$	NA
Phenol	NA	NA	NA	NA	NA	NA	$1.2x10^{-7}$
Pyrene	$1.4x10^{-4}$	$5.7x10^{-5}$	$6.2x10^{-5}$	$1.0x10^{-5}$	$1.8x10^{-5}$	$1.9x10^{-5}$	$2.3x10^{-5}$
TOTAL	$3.0x10^{-1}$	$6.6x10^{-1}$	$6.5x10^{-2}$	$4.8x10^{-1}$	$7.5x10^{-2}$	$1.6x10^{-1}$	$1.9x10^{-2}$

HAZARD INDEX[1] - INHALATION

	Lot 4			Area A	Entire Site		
Chemical	0'-1.5'	5'-6.5'	10'-11.5'	5'-6.5'	0'-1.5'	5'-6.5'	10'-11.5'
Chromium	$6.1x10^{-7}$	$2.4x10^{-7}$	$2.4x10^{-7}$	$2.6x10^{-7}$	$3.4x10^{-7}$	$2.7x10^{-7}$	$2.5x10^{-7}$
Copper	$1.7x10^{-4}$	$9.7x10^{-5}$	$3.5x10^{-5}$	$8.3x10^{-5}$	$2.8x10^{-5}$	$4.6x10^{-5}$	$2.5x10^{-5}$
Lead	$1.5x10^{-3}$	$3.8x10^{-3}$	$3.3x10^{-4}$	$2.7x10^{-3}$	$3.8x10^{-4}$	$8.9x10^{-4}$	$6.6x10^{-5}$
Mercury	$5.7x10^{-5}$	$4.8x10^{-5}$	$9.1x10^{-5}$	$1.6x10^{-4}$	$5.1x10^{-5}$	$1.1x10^{-4}$	$5.1x10^{-5}$
Nickel	$4.2x10^{-5}$	$1.8x10^{-5}$	$1.2x10^{-5}$	$2.7x10^{-5}$	$2.2x10^{-5}$	$1.8x10^{-5}$	$1.5x10^{-5}$
Zinc	$1.0x10^{-3}$	$8.4x10^{-4}$	$2.2x10^{-4}$	$8.6x10^{-4}$	$3.3x10^{-4}$	$4.0x10^{-4}$	$1.0x10^{-4}$
2-Methylphenol	NA	NA	NA	NA	NA	NA	$2.1x10^{-8}$
4-Methyphenol	NA	NA	NA	NA	NA	NA	$1.5x10^{-7}$
Fluoranthene	$1.9x10^{-7}$	$1.9x10^{-7}$	$2.0x10^{-7}$	$3.0x10^{-8}$	$2.4x10^{-8}$	$6.0x10^{-8}$	$7.5x10^{-8}$
Naphthalene	NA	NA	NA	$2.1x10^{-7}$	$3.2x10^{-8}$	$9.4x10^{-8}$	NA
Phenol	NA	NA	NA	NA	NA	NA	$7.4x10^{-10}$
Pyrene	$8.6x10^{-7}$	$3.4x10^{-7}$	$3.7x10^{-7}$	$6.0x10^{-8}$	$1.1x10^{-7}$	$1.1x10^{-7}$	$1.4x10^{-7}$
TOTAL	$2.8x10^{-3}$	$4.8x10^{-3}$	$6.9x10^{-4}$	$3.9x10^{-3}$	$8.1x10^{-4}$	$1.5x10^{-3}$	$2.6x10^{-4}$

NOTES:
1) Hazard Index = (Calc. Intake mg/Kg.day) / (RfD mg/Kg.day)
Calculated intakes taken from Table 37 for oral and Table 36 for inhalation.
RFD value taken from Table 38.

2) NA = Not Applicable.

TABLE 42
HAZARD INDICES FOR NONCARCINOGENIC EFFECTS
OFFICE BUILDING ADULT EXPOSURE
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
K/J/C 855018.07

HAZARD INDEX[1] - ORAL

	Lot 4			Area A	Entire Site		
Chemical	0'-1.5'	5'-6.5'	10'-11.5'	5'-6.5'	0'-1.5'	5'-6.5'	10'-11.5'
Chromium	$3.5x10^{-5}$	$1.4x10^{-5}$	$1.4x10^{-5}$	$1.5x10^{-5}$	$2.0x10^{-5}$	$1.5x10^{-5}$	$1.4x10^{-5}$
Copper	$9.9x10^{-3}$	$5.5x10^{-3}$	$2.0x10^{-3}$	$4.7x10^{-3}$	$1.5x10^{-3}$	$2.6x10^{-3}$	$1.5x10^{-3}$
Lead	$8.7x10^{-2}$	$2.1x10^{-1}$	$1.8x10^{-2}$	$1.5x10^{-1}$	$2.1x10^{-2}$	$5.3x10^{-2}$	$3.8x10^{-3}$
Mercury	$8.1x10^{-5}$	$6.8x10^{-5}$	$1.3x10^{-4}$	$2.3x10^{-4}$	$7.3x10^{-5}$	$1.5x10^{-4}$	$7.3x10^{-5}$
Nickel	$2.4x10^{-3}$	$1.0x10^{-3}$	$7.2x10^{-4}$	$1.5x10^{-3}$	$1.3x10^{-3}$	$1.0x10^{-3}$	$8.5x10^{-4}$
Zinc	$2.7x10^{-3}$	$2.3x10^{-3}$	$6.1x10^{-4}$	$2.3x10^{-3}$	$8.8x10^{-4}$	$1.1x10^{-3}$	$2.7x10^{-4}$
2-Methylphenol	NA[2]	NA	NA	NA	NA	NA	$1.2x10^{-6}$
4-Methyphenol	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	$1.1x10^{-5}$	$1.1x10^{-5}$	$1.1x10^{-5}$	$1.7x10^{-6}$	$1.3x10^{-6}$	$3.5x10^{-6}$	$4.3x10^{-6}$
Naphthalene	NA	NA	NA	$1.2x10^{-5}$	$1.8x10^{-6}$	$5.3x10^{-6}$	NA
Phenol	NA	NA	NA	NA	NA	NA	$4.3x10^{-8}$
Pyrene	$4.9x10^{-5}$	$2.0x10^{-5}$	$2.1x10^{-5}$	$3.5x10^{-6}$	$6.1x10^{-6}$	$6.4x10^{-6}$	$7.8x10^{-6}$
TOTAL	$1.0x10^{-1}$	$2.2x10^{-1}$	$2.3x10^{-2}$	$1.7x10^{-1}$	$2.3x10^{-2}$	$5.6x10^{-2}$	$6.4x10^{-3}$

HAZARD INDEX[1] - INHALATION

	Lot 4			Area A	Entire Site		
Chemical	0'-1.5'	5'-6.5'	10'-11.5'	5'-6.5'	0'-1.5'	5'-6.5'	10'-11.5'
Chromium	$2.1x10^{-7}$	$8.2x10^{-8}$	$8.2x10^{-8}$	$8.8x10^{-8}$	$1.2x10^{-7}$	$9.1x10^{-8}$	$8.5x10^{-8}$
Copper	$5.9x10^{-5}$	$3.3x10^{-5}$	$1.2x10^{-5}$	$2.9x10^{-5}$	$9.6x10^{-6}$	$1.5x10^{-5}$	$8.7x10^{-6}$
Lead	$5.2x10^{-4}$	$1.3x10^{-3}$	$1.1x10^{-4}$	$9.4x10^{-4}$	$1.3x10^{-4}$	$3.0x10^{-4}$	$2.3x10^{-5}$
Mercury	$2.0x10^{-5}$	$1.7x10^{-5}$	$3.0x10^{-5}$	$5.3x10^{-5}$	$1.8x10^{-5}$	$3.7x10^{-5}$	$1.8x10^{-5}$
Nickel	$1.4x10^{-5}$	$6.2x10^{-6}$	$4.3x10^{-6}$	$9.1x10^{-6}$	$7.6x10^{-6}$	$6.1x10^{-6}$	$5.2x10^{-6}$
Zinc	$3.5x10^{-4}$	$2.9x10^{-4}$	$7.6x10^{-5}$	$2.9x10^{-4}$	$1.1x10^{-4}$	$1.4x10^{-4}$	$3.5x10^{-5}$
2-Methylphenol	NA	NA	NA	NA	NA	NA	$7.0x10^{-9}$
4-Methyphenol	NA	NA	NA	NA	NA	NA	$5.3x10^{-8}$
Fluoranthene	$6.5x10^{-8}$	$6.4x10^{-8}$	$6.8x10^{-8}$	$1.0x10^{-8}$	$8.1x10^{-9}$	$2.1x10^{-8}$	$2.6x10^{-8}$
Naphthalene	NA	NA	NA	$7.3x10^{-8}$	$1.1x10^{-8}$	$3.2x10^{-8}$	NA
Phenol	NA	NA	NA	NA	NA	NA	$2.6x10^{-10}$
Pyrene	$2.9x10^{-7}$	$1.2x10^{-7}$	$1.3x10^{-7}$	$2.1x10^{-8}$	$3.7x10^{-8}$	$3.8x10^{-8}$	$4.7x10^{-8}$
TOTAL	$9.7x10^{-4}$	$1.7x10^{-3}$	$2.4x10^{-4}$	$1.3x10^{-3}$	$2.7x10^{-4}$	$5.0x10^{-4}$	$9.0x10^{-5}$

NOTES:
1) Hazard Index = (Calc. Intake mg/Kg.day) / (RfD mg/Kg.day) Calculated intakes taken from Table 37 for oral and Table 36 for inhalation without including exposure duration factor (46 years/70 years). RfD values taken from Table 38.

2) NA = Not Applicable.

TABLE 43
HAZARD INDICES FOR NONCARCINOGENIC EFFECTS
TRESPASSING CHILD EXPOSURE
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
K/J/C 855018.07

HAZARD INDEX[1] - ORAL

	Lot 4			Area A	Entire Site		
Chemical	0'-1.5'	5'-6.5'	10'-11.5'	5'-6.5'	0'-1.5'	5'-6.5'	10'-11.5'
Chromium	$2.9x10^{-5}$	$1.2x10^{-5}$	$1.2x10^{-5}$	$1.2x10^{-5}$	$1.6x10^{-5}$	$1.3x10^{-5}$	$1.2x10^{-5}$
Copper	$8.3x10^{-3}$	$4.7x10^{-3}$	$1.7x10^{-3}$	$4.0x10^{-3}$	$1.3x10^{-3}$	$2.2x10^{-3}$	$1.2x10^{-3}$
Lead	$7.3x10^{-2}$	$1.8x10^{-1}$	$1.6x10^{-2}$	$1.3x10^{-1}$	$1.8x10^{-2}$	$4.3x10^{-2}$	$3.1x10^{-3}$
Mercury	$6.8x10^{-5}$	$5.8x10^{-5}$	$1.1x10^{-4}$	$1.9x10^{-4}$	$6.2x10^{-5}$	$1.3x10^{-4}$	$6.2x10^{-5}$
Nickel	$2.0x10^{-3}$	$8.6x10^{-4}$	$6.0x10^{-4}$	$1.3x10^{-3}$	$1.1x10^{-3}$	$8.4x10^{-4}$	$7.2x10^{-4}$
Zinc	$2.3x10^{-3}$	$1.9x10^{-3}$	$5.1x10^{-4}$	$2.0x10^{-3}$	$7.4x10^{-4}$	$9.2x10^{-4}$	$2.3x10^{-4}$
2-Methylphenol	NA[2]	NA	NA	NA	NA	NA	$9.9x10^{-7}$
4-Methyphenol	NA	NA	NA	NA	NA	NA	NA
Fluoran-thene	$9.1x10^{-6}$	$8.9x10^{-6}$	$9.6x10^{-6}$	$1.4x10^{-6}$	$1.1x10^{-6}$	$2.9x10^{-6}$	$3.6x10^{-6}$
Naphthalene	NA	NA	NA	$1.0x10^{-5}$	$1.5x10^{-6}$	$4.5x10^{-6}$	NA
Phenol	NA	NA	NA	NA	NA	NA	$3.6x10^{-8}$
Pyrene	$4.1x10^{-5}$	$1.6x10^{-5}$	$1.8x10^{-5}$	$2.9x10^{-6}$	$5.1x10^{-6}$	$5.3x10^{-6}$	$6.6x10^{-6}$
TOTAL	$8.6x10^{-2}$	$1.9x10^{-1}$	$1.9x10^{-2}$	$1.4x10^{-1}$	$2.2x10^{-2}$	$4.7x10^{-2}$	$5.4x10^{-3}$

HAZARD INDEX[1] - INHALATION

	Lot 4			Area A	Entire Site		
Chemical	0'-1.5'	5'-6.5'	10'-11.5'	5'-6.5'	0'-1.5'	5'-6.5'	10'-11.5'
Chromium	$1.8x10^{-8}$	$6.9x10^{-9}$	$6.9x10^{-9}$	$7.4x10^{-9}$	$9.9x10^{-9}$	$7.6x10^{-9}$	$7.2x10^{-9}$
Copper	$5.0x10^{-6}$	$2.8x10^{-6}$	$1.0x10^{-6}$	$2.4x10^{-6}$	$8.0x10^{-7}$	$1.3x10^{-6}$	$7.3x10^{-7}$
Lead	$4.4x10^{-5}$	$1.1x10^{-4}$	$9.4x10^{-6}$	$7.9x10^{-5}$	$1.1x10^{-5}$	$2.6x10^{-5}$	$1.9x10^{-6}$
Mercury	$1.6x10^{-6}$	$1.4x10^{-6}$	$2.6x10^{-6}$	$4.5x10^{-6}$	$1.5x10^{-6}$	$3.1x10^{-6}$	$1.5x10^{-6}$
Nickel	$1.2x10^{-6}$	$5.2x10^{-7}$	$3.6x10^{-7}$	$7.6x10^{-7}$	$6.4x10^{-7}$	$5.1x10^{-7}$	$4.3x10^{-7}$
Zinc	$3.0x10^{-5}$	$2.4x10^{-5}$	$6.4x10^{-6}$	$2.5x10^{-5}$	$9.4x10^{-6}$	$1.2x10^{-5}$	$3.0x10^{-6}$
2-Methylphenol	NA	NA	NA	NA	NA	NA	$5.9x10^{-10}$
4-Methyphenol	NA	NA	NA	NA	NA	NA	$4.4x10^{-9}$
Fluoran-thene	$5.5x10^{-9}$	$5.4x10^{-9}$	$5.7x10^{-9}$	$8.6x10^{-10}$	$6.8x10^{-10}$	$1.7x10^{-9}$	$2.2x10^{-9}$
Naphthalene	NA	NA	NA	$6.1x10^{-9}$	$9.2x10^{-10}$	$2.7x10^{-9}$	NA
Phenol	NA	NA	NA	NA	NA	NA	$2.1x10^{-11}$
Pyrene	$2.5x10^{-8}$	$9.9x10^{-9}$	$1.1x10^{-8}$	$1.7x10^{-9}$	$3.0x10^{-9}$	$3.2x10^{-9}$	$3.9x10^{-9}$
TOTAL	$8.2x10^{-5}$	$1.4x10^{-4}$	$2.0x10^{-5}$	$1.1x10^{-4}$	$2.3x10^{-5}$	$4.2x10^{-5}$	$7.5x10^{-6}$

NOTES:
1) Hazard Index = (Calc. Intake mg/Kg.day) / (RfD mg/Kg.day)
Calculated intakes taken from Table 37 for oral and Table 36 for inhalation.
RFD value taken from Table 38.

LG006332

2) NA = Not Applicable.

TABLE 44
CALCULATED LIFETIME INCREMENTAL RISK OF CANCER
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
K/J/C 855018.07

		CALCULATED LIFETIME INCREMENTAL RISK OF CANCER[1]						
		Lot 4			Area A	Entire Site		
	Exposure	Depth in Feet			Depth in Feet	Depth in Feet		
Chemical	Scenario	0-1.5	5-6.5	10-11.5	5-6.5	0-1.5	5-6.5	10-11.5
Residential - adult								
Inhalation								
PAHs		$2x10^{-7}$	$4x10^{-7}$	$5x10^{-7}$	$4x10^{-8}$	$3x10^{-8}$	$2x10^{-8}$	NA
PCBs		NA[2]	NA	NA	NA	NA	NA	NA
Cr(VI)		$2x10^{-7}$	$9x10^{-9}$	$2x10^{-8}$	NA	NA	NA	NA
Total		$4x10^{-7}$	$4x10^{-7}$	$5x10^{-7}$	$4x10^{-8}$	$3x10^{-8}$	$2x10^{-8}$	NA
Ingestion								
PAHs		$7x10^{-5}$	$1x10^{-4}$	$1x10^{-4}$	$1x10^{-5}$	$1x10^{-5}$	$6x10^{-6}$	NA
PCBs		$3x10^{-5}$	NA	NA	NA	$2x10^{-6}$	NA	NA
Cr(VI)		NA	NA	NA	NA	NA	NA	NA
Total		$1x10^{-4}$	$1x10^{-4}$	$1x10^{-4}$	$1x10^{-5}$	$1x10^{-5}$	$6x10^{-6}$	NA
Residential TOTAL		$1x10^{-4}$	$1x10^{-4}$	$1x10^{-4}$	$1x10^{-5}$	$1x10^{-5}$	$6x10^{-6}$	NA
Office - adult								
Inhalation								
PAHs		$5x10^{-8}$	$9x10^{-8}$	$1x10^{-7}$	$1x10^{-8}$	$8x10^{-9}$	$5x10^{-9}$	NA
PCBs		NA	NA	NA	NA	NA	NA	NA
Cr(VI)		$5x10^{-8}$	$2x10^{-9}$	$4x10^{-9}$	NA	NA	NA	NA
Total		$1x10^{-7}$	$9x10^{-8}$	$1x10^{-7}$	$1x10^{-8}$	$8x10^{-9}$	$5x10^{-9}$	NA
Ingestion								
PAHs		$2x10^{-5}$	$3x10^{-5}$	$3x10^{-5}$	$3x10^{-6}$	$2x10^{-6}$	$1x10^{-6}$	NA
PCBs		$7x10^{-6}$	NA	NA	NA	$5x10^{-7}$	NA	NA
Cr(VI)		NA	NA	NA	NA	NA	NA	NA
Total		$2x10^{-5}$	$3x10^{-5}$	$3x10^{-5}$	$3x10^{-6}$	$3x10^{-6}$	$1x10^{-6}$	NA
Office TOTAL		$2x10^{-5}$	$3x10^{-5}$	$3x10^{-5}$	$3x10^{-6}$	$3x10^{-6}$	$1x10^{-6}$	NA

NOTES:

1) Lifetime Incremental Cancer Risk = Calc. Intake (mg/Kg.day) * Slope Factor $(mg/Kg.day)^{-1}$
Calculated intakes taken from Table 37 for oral and Table 36 for inhalation. Slope factors taken from Table 39.
2) NA = not applicable

TABLE 45

SUMMARY OF BIOLOGICAL PARAMETERS MEASURED
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

PARAMETER	SOURCE/RECEPTOR	TIME	LOCATION
density/gross diversity	benthic invertebrates	October 1988	offsite marsh
bioaccumulation	benthic invertebrate[1]	October 1988	offsite marsh
presence of sensitive species/densities	small mammals	November 1988	onsite and offsite marsh transition areas
presence of sensitive species/densities	larger mammals	November 1988	onsite uplands and marsh transition areas
presence of sensitive species/densities	shorebirds	December 1988, January 1989, March-April 1989	offsite marsh
presence of sensitive species/species distribution	vegetation	November 1988	study area (onsite and offsite)
bioaccumulation	vegetation	April-May 1989	offsite marsh
toxicity to alga and invertebrate[2]	surface soil elutriate	August 1989	onsite uplands[3]
toxicity to alga and invertebrate	subsurface soil elutriate	August 1989	onsite uplands (subsurface)

Notes:

1. Yellow shore crab (*Hemigrapsus oregonensus*) was used for tissue analysis.
2. *Selenastrum* and *Ceriodaphnia* were the test organisms.
3. Sampling locations are shown on Figure 26.

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TABLE 46

ECOLOGICAL EXPOSURE ANALYSIS
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

RANKING	RELEASE SOURCE	PATHWAY		TIME FRAME	POTENTIAL RECEPTOR POPULATIONS[2]
		RELEASE MEDIUM	RELEASE MECHANSIM		
1	marsh sediment	marsh sediment	direct availability	longterm	marsh biota especially benthic invertebrates
2	surface soil	surface water	surface runoff	episodic	marsh biota including: benthic invertebrates demersal fishes shorebirds California clapper rail California black rail Black-shouldered kite Northern Harrier Short-eared owl Saltmarsh yellowthroat
3	surface soil	surface soil	direct availability	longterm	upland species including: mammals birds
4	surface and subsurface soil, marsh sediment	foodweb	bioaccumulation	potentially longterm	potential exposure of terrestrial, avian, and estuarine species
5	subsurface soil	groundwater	leaching of chemicals soil to groundwater and subsequent discharge of groundwater	episodic	marsh biota
6	subsurface soil (0.5' - 6.5')[3]	subsurface soil	bioturbation	longterm	upland burrowing species
7	subsurface soil	surface water	erosion of surface soil followed by surface runoff	potentially episodic	marsh biota
8	subsurface soil	newly exposed surface soil	erosion of surface soil followed by direct availability	potentially longterm	onsite species
9	surface soil	air	airborne dust	longterm	upland species

Notes:

1. Each source-pathway-receptor combination is presented in order of decreasing importance based on sensitivity of receptors and habitats, chemical concentrations in source media, and frequency of exposure.
2. Only sensitive species observed or potentially present in the vicinity of the site are listed herein. Other potential receptor populations are presented in general groups. Specific information on potential receptor populations is presented in Appendix D.
3. For the Environmental Evaluation, subsurface soil was evaluated as a pathway at depths from 0.5' to 6.5'. Although exposure of burrowing deeper than 2' to 3' is unlikely, worst-case concentrations were considered when the depth was extended to 6.5'.

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TABLE 47

SUMMARY OF CHEMICAL PARAMETERS MEASURED DURING THE REMEDIAL INVESTIGATION
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

MEDIA	PARAMETERS	REFERENCE
Surface soil	Cr, Cu, Pb, Hg, Ni, Zn, oil and grease, total sulfur, TPH as gasoline, TPH as diesel, PAHs, phenols, PCBs	Tables 14, 22, 37 Figures 5 and 12
Surface soil (for elutriate preparation)	Cr, Cu, Pb, Hg, Ni, Zn, oil and grease, BNAs, PCBs	Tables 7 and 8
Subsurface soil	Cr, Cu, Pb, Hg, Ni, Zn, oil and grease, total sulfur, BNAs, PCBs	Tables 15 to 22, 24, and 37 Figures 7 to 11, 13 to 17
Groundwater	Cr, Cu, Pb, Hg, Ni, Zn, oil and grease, TDS, nitrate, coliforms	Table 25 Figures 24 and 25
	sodium[2], calcium[2], magnesium[2], chloride[2], bicarbonate[2], sulfate[2]	Table 25 Figures 32 to 36
Surface water	sodium, calcium, magnesium, chloride, bicarbonate, sulfate	
Sediment	Cr, Cu, Pb, Hg, Ni, Zn, oil and grease, total sulfur, BNAs, PCBs, chloride, sulfide, TOC, PHI	Appendix C

Notes:

1. Abbreviations: Cr = Chromium, Cu = Copper, Pb = Lead, Hg = Mercury, Ni = Nickel, Zn = Zinc, TPH = Total Petroleum Hydrocarbons, PAHs = Polycyclic Aromatic Hydrocarbons, PCBs = Polychlorinated Biphenyls, BNAs = Base/Neutral/Acid extractable compounds, TDS = Total Dissolved Solids, TOX = Total Organic Carbon, PHI = Sediment particle size.
2. Parameters measured in water samples from MW-12, MW-13, and MW-17 only.

TABLE 48

SUMMARY OF STATISTICS FOR ANALYSIS OF CHEMICALS
IN SURFACE AND SUBSURFACE SAMPLES
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

CHEMICAL	COMPOSITE SURFACE SOIL SAMPLES		SHALLOW SUBSURFACE SOIL CORES (0 to 2 feet)		DEEPER SUBSURFACE SOIL CORES (2.5 to 6.5 feet)	
	NUMBER OF DETECTIONS/ NUMBER OF SAMPLES	MEAN CONCENTRATION[1] (mg/Kg)	NUMBER OF DETECTIONS/ NUMBER OF SAMPLES	MEAN CONCENTRATION[1] (mg/Kg)	NUMBER OF DETECTIONS/ NUMBER OF SAMPLES	MEAN CONCENTRATION[1] (mg/Kg)
Chromium	19/19	35	83/83	34	79/79	27
Copper	19/19	37	103/103	81	79/79	130
Lead	19/19	76	109/111	130	82/87	290
Mercury	19/19	76	34/45	0.22	31/40	0.31
Nickel	19/19	0.3	83/83	45	78/78	34
Zinc	19/19	95	103/103	250	79/79	320
TPH (Gasoline)	0/19	-	0/45	-	1/39	2
TPH (Diesel)	0/19	-	0/45	-	5/39	8
PCB	1/19	1.2	1/48	3	0/46	-
Phenol	0/19	-	0/45	-	1/45	0.43
2-Methylphenol	0/19	-	0/45	-	1/45	1
4-Methylphenol	0/19	-	0/45	-	2/45	24
2,4-Dimethylphenol	0/19	-	0/45	-	2/45	53
Naphthalene	0/19	-	1/74	0.39	1/42	0.36
2-Methylnaphthalene	0/19	-	0/74	-	2/42	13
Phenanthrene	0/19	-	2/74	1.1	1/42	0.36
Fluoranthene	0/19	-	4/74	1.1	3/42	1.1
Pyrene	1/19	0.78	6/74	2.1	4/42	1.3
Benz[a]anthracene	0/19	-	3/74	0.89	3/42	1.4
Chrysene	1/19	0.33	7/74	0.68	4/42	1.4
Benzo[b]fluoranthene	1/19	3	5/74	1.5	2/42	1.1
Benzo[a]pyrene	0/19	-	4/74	0.85	4/42	1.2
Indeno[1,2,3-c,d]pyrene	0/19	-	2/74	1.2	3/42	.78
Dibenzo[a,h]anthracene	0/19	-	1/74	0.67	0/42	-
Benzo[g,h,i]perylene	0/19	-	2/74	1.4	3/42	0.85
Benzo[k]fluoranthene	1/19	0.47	1/74	1.5	1/42	7.8

Notes:

1. A metal not detected in a sample was assumed to be present at one-half the detection limit for the calculation of the mean. Mean concentrations for organics are for detected values only.

2. Includes MO samples collected for bioassay study.

3. Oil and grease was omitted from the list of chemicals because there is a lack of environmental criteria and toxicity data for oil and grease. Oil and grease was considered in depth during the ecological study (Appendix C).

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TABLE 49

SUMMARY OF TOXICITY DATA FOR RAT
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

METAL COMPOUND	TOXIC DOSE FOR RAT[1] (mg/Kg-bodyweight/day) METAL SALT	METAL[2]
Chromium (3+) chloride	1870	610
Copper (2+) acetate	595	210
Lead (2+) acetate	900[3]	570
Mercury (2+) acetate	23.9	15
Nickel (2+) acetate	350	120
Zinc (2+) acetate	2510	890

Notes:

1. Oral LD_{50} for metal salt, except as noted.
2. Toxic dose value corrected for the weight fraction of metal present in the metal salt.
3. TD_{LO} for tumorigenic effects.

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TABLE 50

CALCULATION OF TOXIC SOIL INGESTION RATES
FOR SMALL MAMMAL TOXICITY EVALUATION
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

METAL	AVERAGE SURFACE SOIL CONCENTRATION[1] (mg/Kg)	TOXIC DOSE[2] (mg/Kg(bw)/day)	CALCULATED CHEMICAL INGESTION RATE REQUIRED FOR TOXICITY[3] (mg/Kg(bw))	CALCULATED SOIL INGESTION RATE REQUIRED FOR TOXICITY[4] (g/day)
Chromium	35	610	120	3,500
Copper	37	210	41	1,100
Lead	76	570	110	1,500
Mercury	0.3	15	3	10,000
Nickel	44	120	23	530
Zinc	95	890	180	1,900

Notes:

1. From Table 48.
2. LD_{50} values from Table 49 (TD_{LO} tumorigenic value used for lead). Values corrected for weight fraction of metal.
3. Calculated as Toxic Dose (mg/Kg(bw)) x 0.2 kg(bw).
4. Calculated as Chemical Ingestion Rate (mg/day) ÷ Average Soil Concentration (mg/Kg). Daily maximum consumption of soil by a 200 g rat is estimated at 4 g/day.

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TABLE 51

ANALYTICAL RESULTS OF GROUNDWATER SAMPLES AND REFERENCE CRITERIA
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

METAL	AVERAGE CONCENTRATION IN GROUNDWATER SAMPLES (µg/L)[1]	CALCULATED INCREMENTAL CONTRIBUTION OF METALS VIA GROUNDWATER (µg/L)			MARINE CHRONIC CRITERIA (µg/L)
		0.33 DILUTION FACTOR[2]	0.125 DILUTION FACTOR[3]	0.008 DILUTION FACTOR[4]	
Chromium	3	1	0.4	0.02	50
Copper	6	2	0.8	0.05	2.9
Lead	9	3	1	0.07	5.6
Mercury	0.2	0.07	0.025	0.002	0.025
Nickel	20	7	3	0.2	8.3
Zinc	30	10	4	0.2	86

Notes:

1. Concentrations are average concentrations of dissolved metals in groundwater samples collected from October 1988 to October 1989. Ranges of concentrations are presented in Table 31.
2. Concentrations were calculated by applying a 0.33 dilution factor to average concentrations in groundwater. This hypothetical dilution factor corresponds to a 1 to 3 dilution of groundwater into surface water.
3. Concentrations were calculated by applying a 0.125 dilution factor to average concentrations in groundwater. This hypothetical dilution factor corresponds to a 1 to 8 dilution of groundwater into surface water.
4. Concentrations were calculated by applying a 0.008 dilution factor to average concentrations in groundwater. This dilution factor corresponds to a 1 to 125 dilution of groundwater into surface water as calculated for the site in Section 4.2.5.
5. Reference: EPA 1986.

LG006340

TABLE 52

COMPARISON OF CHEMICAL CONCENTRATIONS IN SOIL WITH AVAILABLE AMBIENT LEVEL GOALS
LIQUID GOLD SITE, RICHMOND, CALIFORNIA
(K/J/C 855018.07)

CHEMICAL	COMPOSITE SURFACE SOIL SAMPLES		SUBSURFACE SOIL SAMPLES (0.5 to 6.5 Feet)		EPA AMBIENT LEVEL GOAL[3] (mg/Kg)
	NO. OF DETECTIONS[1]	AVG. CONC. OF DETECTIONS (mg/Kg)	NO. OF DETECTIONS[2]	AVG. CONC. OF DETECTIONS (mg/Kg)	
PCB	1	1.2	1	3	0.0002
Phenol	0	-	1	0.43	20
Cresol	0	-			10
2-Methylphenol			1	1	
4-Methylphenol			2	24	
2,4-Dimethylphenol	0	-	4	28	20
Naphthalene	0	-	2	0.38	10

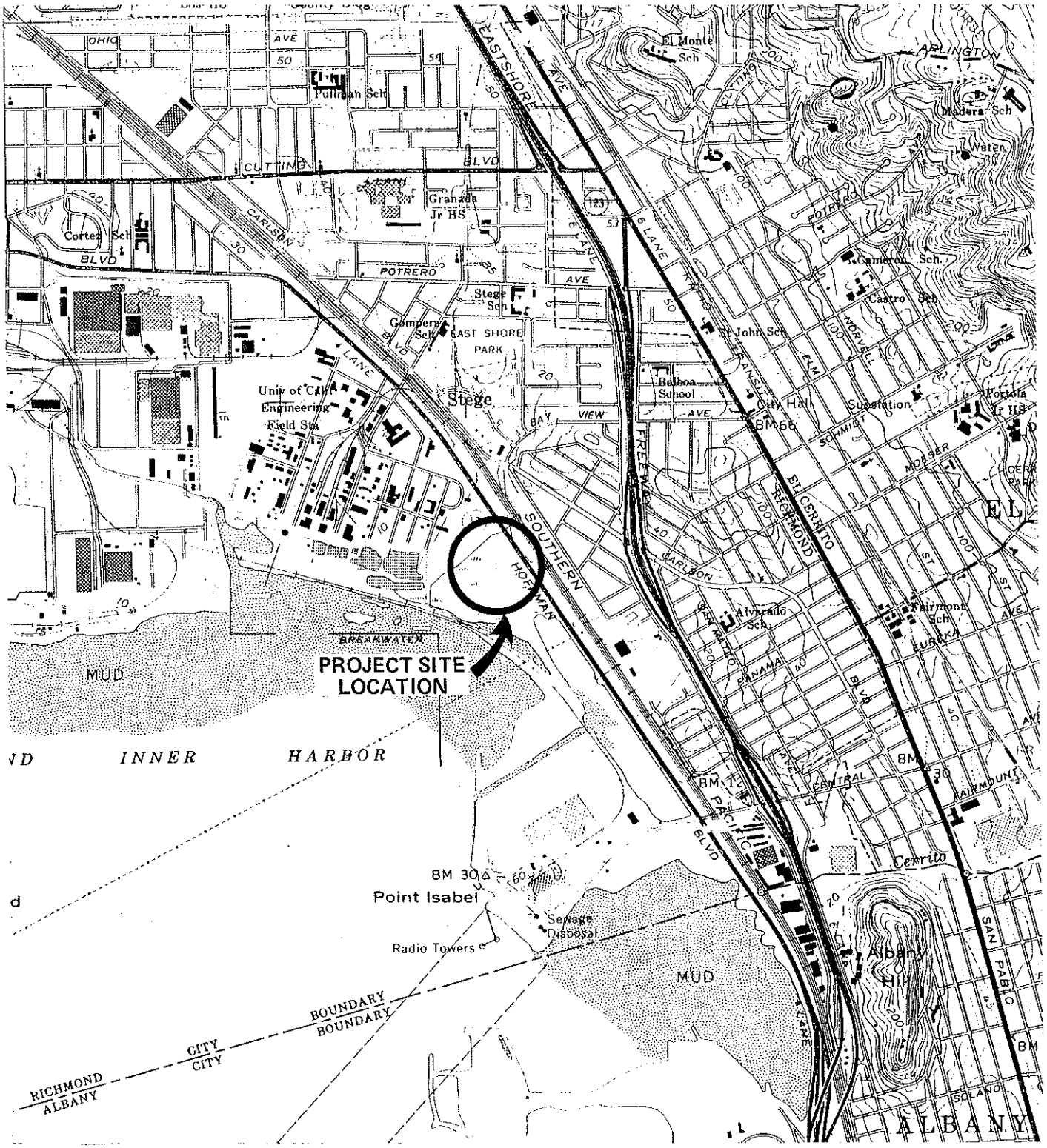
Notes:

1. Total of 19 composite surface samples collected.
2. Total of 146 subsurface samples collected.
3. Toxicity-based estimated permissible concentration based on ecological effects (EPA 1979).

LG006341

FIGURES

LG006342



Basemap Reference: USGS Topographic Map
Richmond Quadrangle 7.5 Minute Series
Photorevised 1980
Sources: DOT (1978), DWR (1990)

N

0 2000 4000

Approximate Scale in Feet

Kennedy/Jenks/Chilton

Southern Pacific Transportation Company
Liquid Gold Site

Site Location Map

K/J/C 855018.07
December 1990

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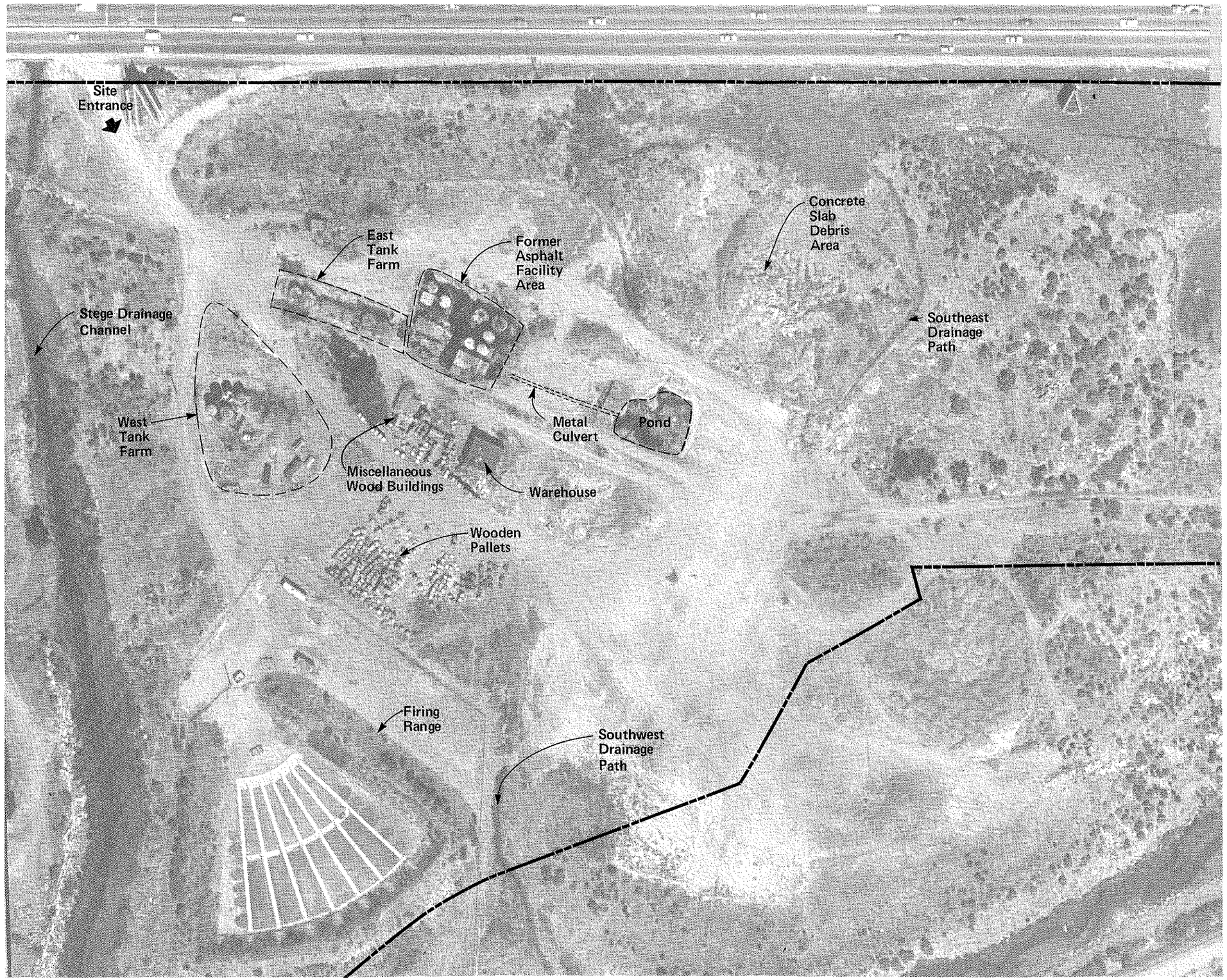
Figure 1



N

0 100 200

Scale in Feet
(Approx)

Basemap Reference

Pacific Aerial Survey.
Job number AV1750-07-10.
Flown 06 September 1979.
Airphoto negative scale 1 inch = 1000 feet.

Legend:

Southern Pacific Property Line (Approximate)

Kennedy/Jenks/Chilton

Southern Pacific Transportation Company
Liquid Gold Site

Liquid Gold Facility and Property Boundary

K/J/C 855018.07
December 1990

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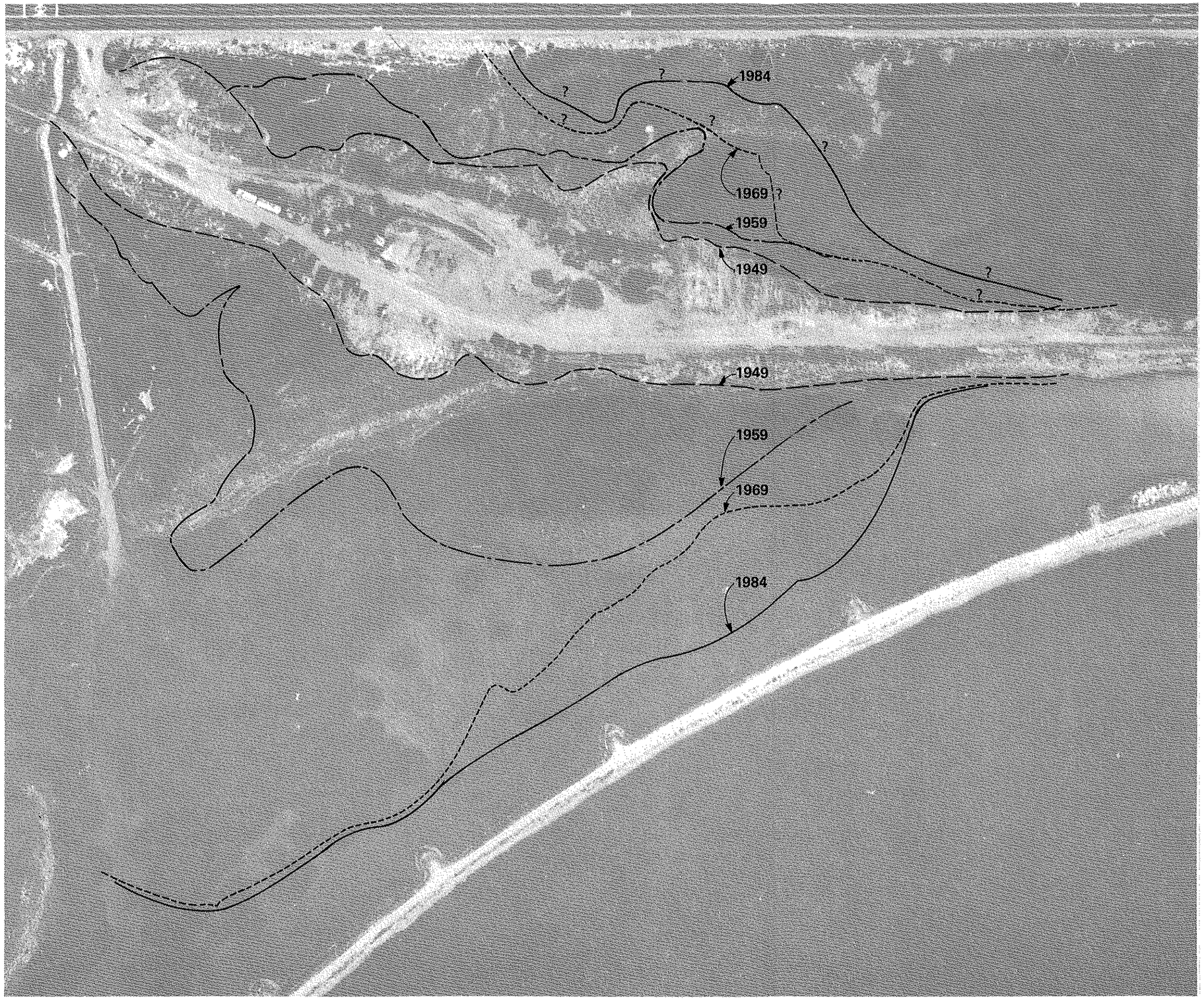
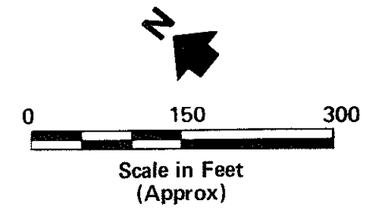
Figure 2





Basemap Reference

Pacific Aerial Survey.
Job number AV-28-09-22.
Flown 06 September 1949.
Airphoto negative scale 1 inch = 600 feet.

Note

1. **All fill boundaries shown are approximate.**

Kennedy/Jenks/Chilton

Southern Pacific Transportation Company
Liquid Gold Site

Fill History

K/J/C 855018.07
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Figure 3

N

0 100 200

Scale in Feet (Approx.)

Basemap Reference

Pacific Aerial Survey.
Job number AV337-08-12. Flown 07 July 1959.
Airphoto negative scale 1 inch = 800 feet.

Kennedy/Jenks/Chilton

Southern Pacific Transportation Company
Liquid Gold Site

Asphalt Facility Operations

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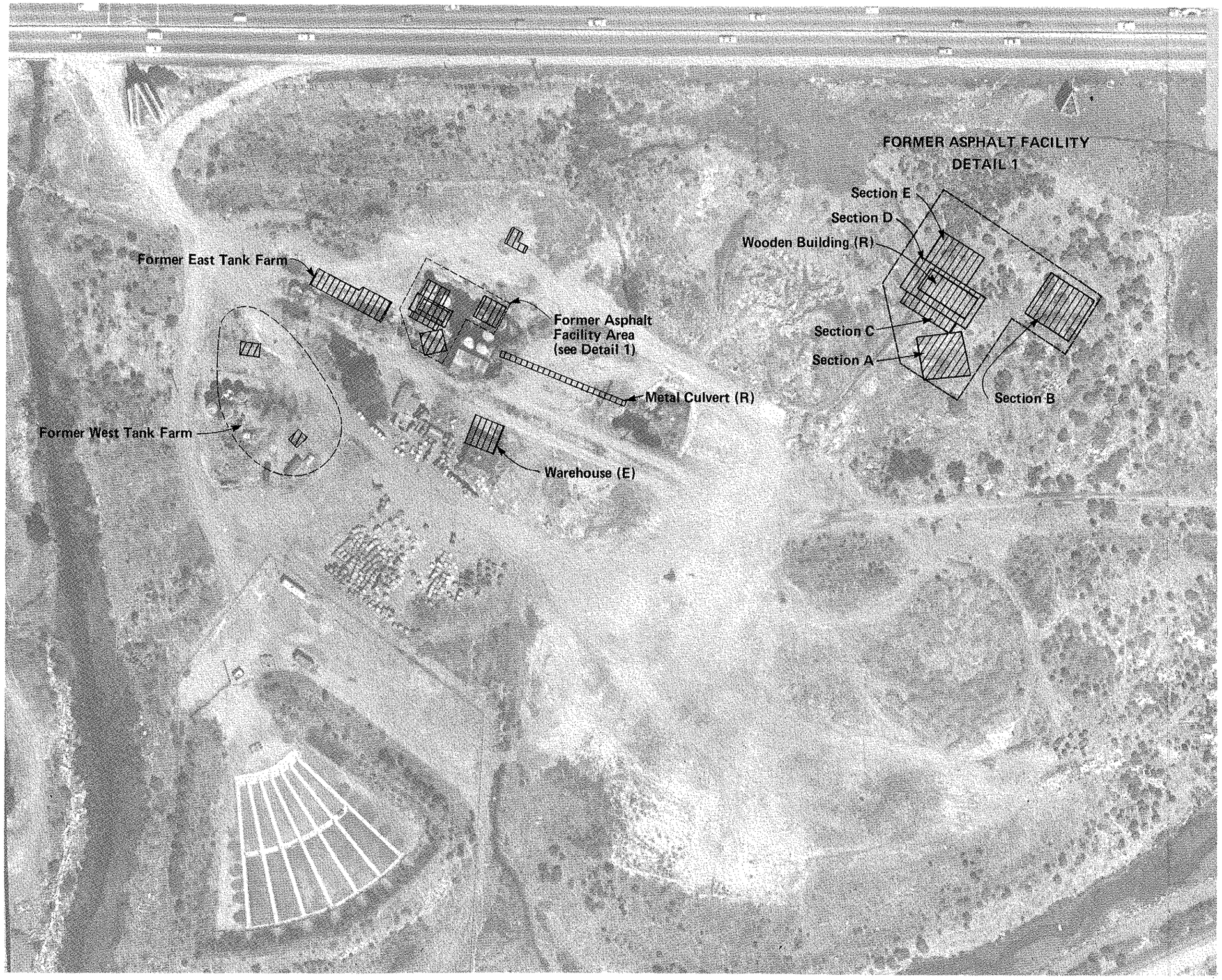
K/J/C 855018 07
December 1990

Figure 4



N

0 100 200

Scale in Feet
(Approx)

Basemap Reference

Pacific Aerial Survey.
Job number AV1750-07-10.
Flown 06 September 1979.
Airphoto negative scale 1 Inch = 1000 feet.

Legend

////// Approximate bounds of excavation

(E) Existing

(R) Removed

Notes

1. All excavation boundaries shown are approximate.
2. References:
   Kennedy/Jenks/Chilton. "Phase I-Soil Remediation Activities Report." May 1986.

Kennedy/Jenks/Chilton

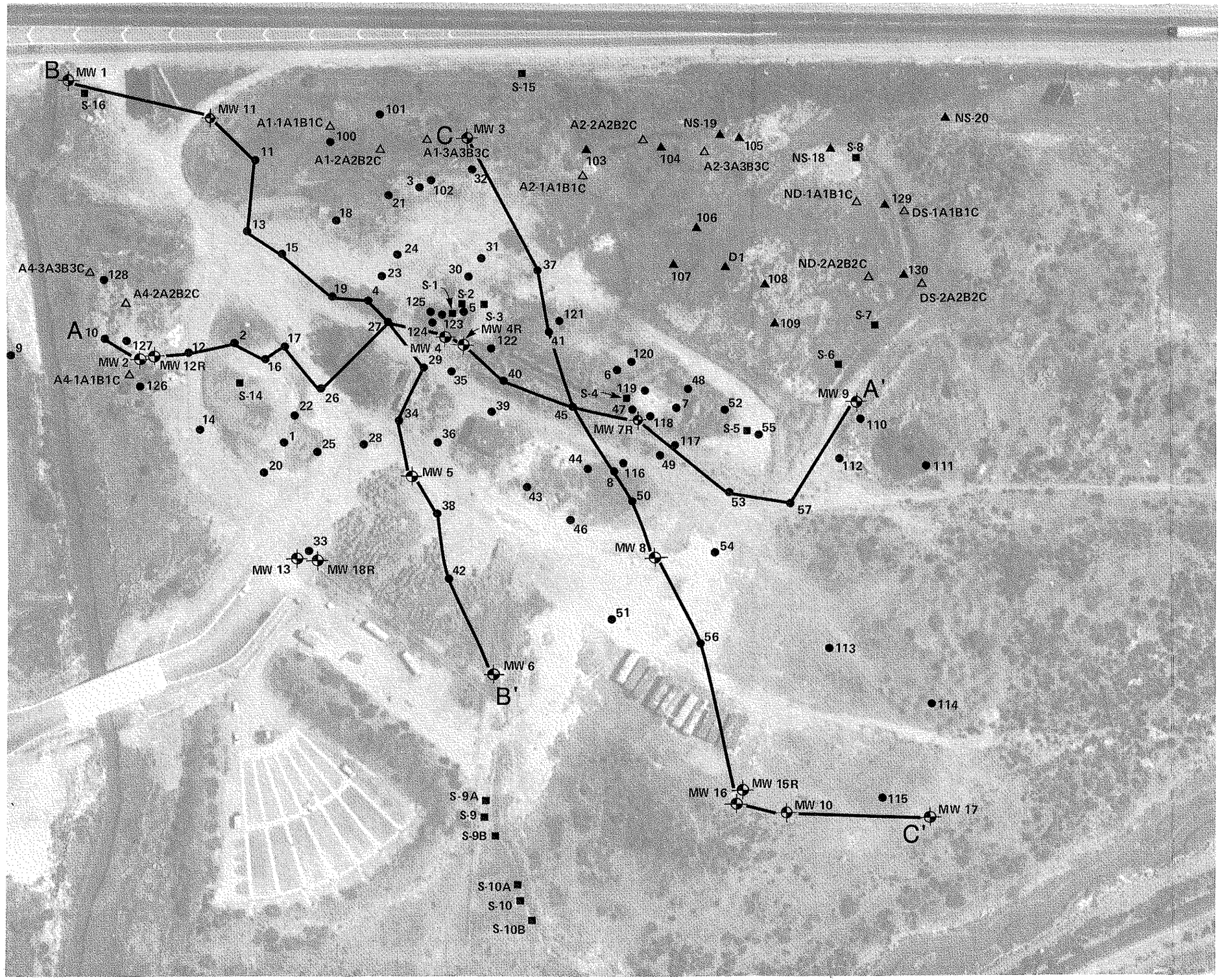
Southern Pacific Transportation Company
Liquid Gold Site

Approximate Excavation Areas

K/J/C 855018 07
December 1990

LG006347

Figure 5



0 100 200

Approximate Scale in Feet

Basemap Reference

Pacific Aerial Survey.
Job number AV3268-7-10. Flown 30 March 1988.
Airphoto negative scale: 1 inch = 1000 feet.

Legend:

●1	Boring location and number
▲	Boring sampled to 3 feet
○	Boring sampled to 2 feet
△	Composite surface sample location
■ S-1	Surface sample location and number
⊕ MW1	Monitoring well location and number
A–A'	Cross Sections

Notes

1. Locations are approximate.
2. Borings 1-57. Ecology and Environment, Inc.
3. All other samples collected by K/J/C.

Kennedy/Jenks/Chilton

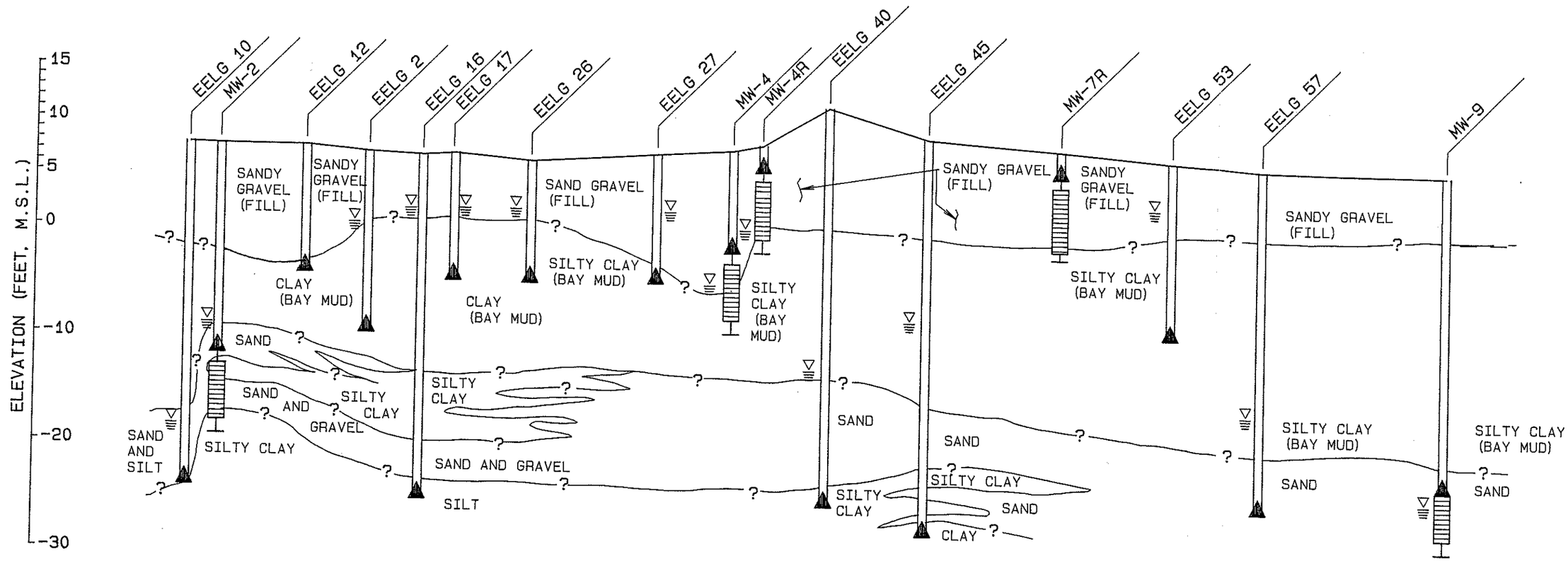
Southern Pacific Transportation Company
Liquid Gold Site

Location Map of Geologic Cross Sections

K/J/C 855018.07
December 1990

LG006348

Figure 6



Legend:

Depth of Water Encountered During Drilling

Backfilled Hole

Well Casing

Well Seal

Well Screen

Bottom of Bore Hole

10 — 0 — 80

Vertical Exaggeration = 8

—?——?— Undefined Lithologic Contact

Kennedy/Jenks/Chilton

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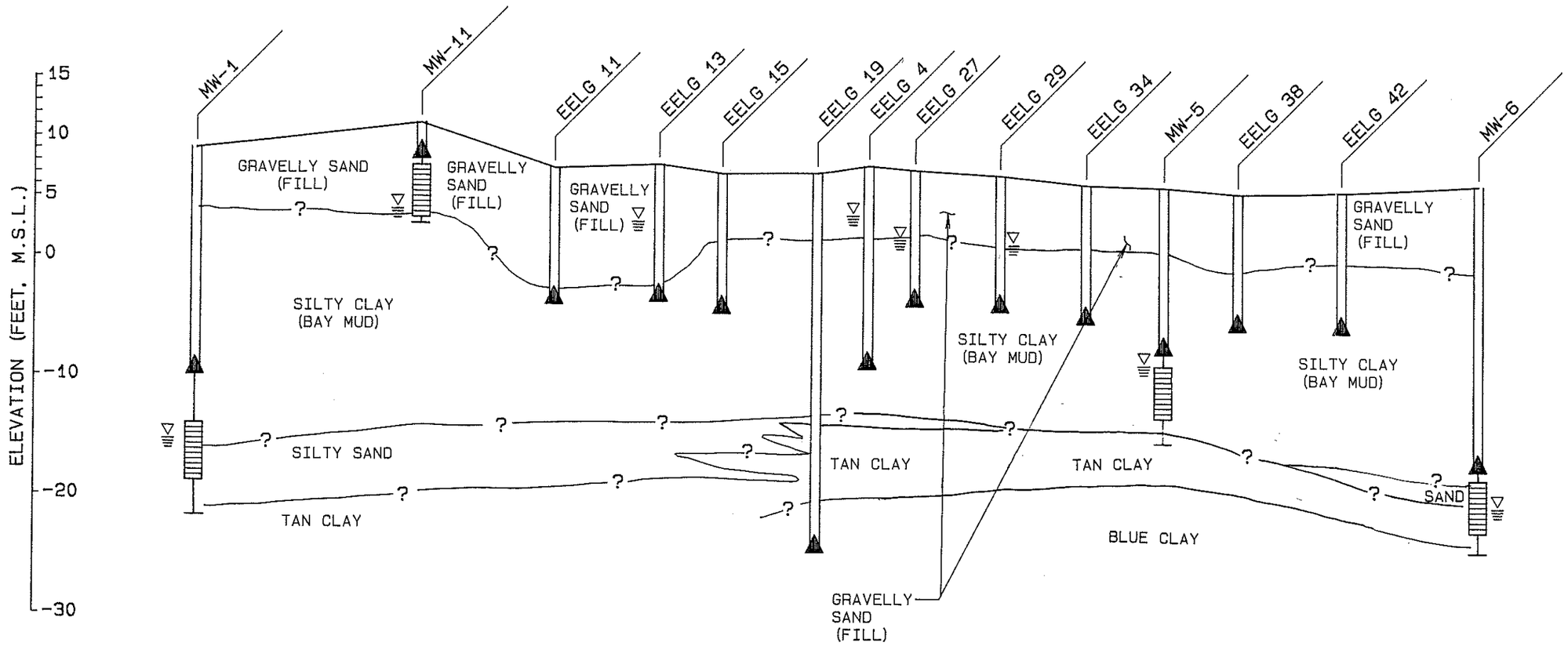
Liquid Gold Site

Geologic Cross Section A – A'

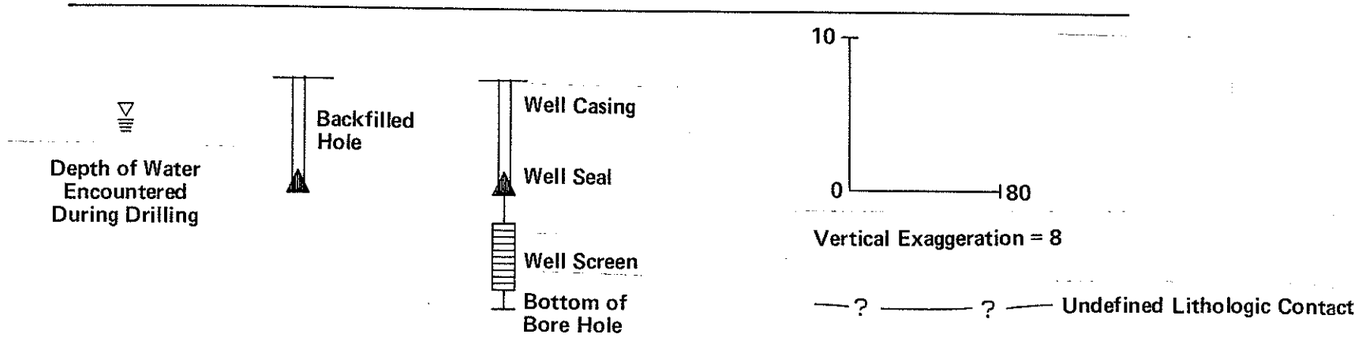
K/J/C 855018.07
December 1990

LG006349

Figure 7



Legend:



Kennedy/Jenks/Chilton

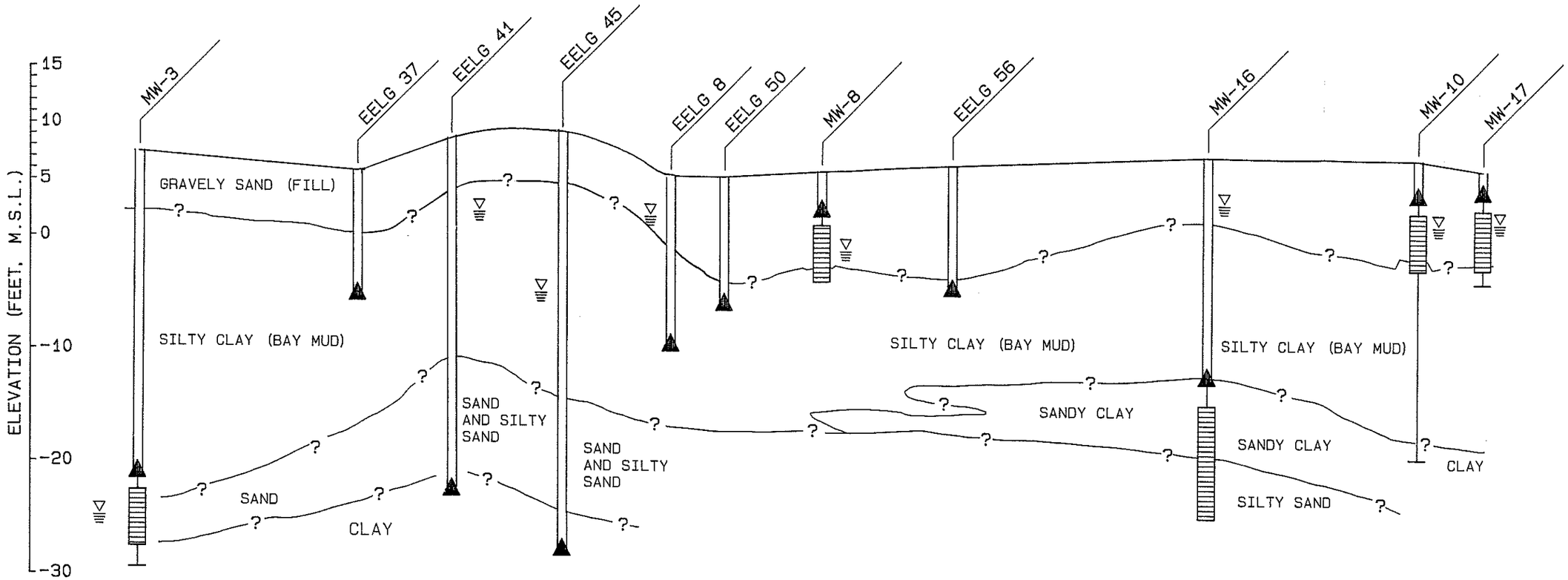
Southern Pacific Transportation Company
Liquid Gold Site

Geologic Cross Section B – B′

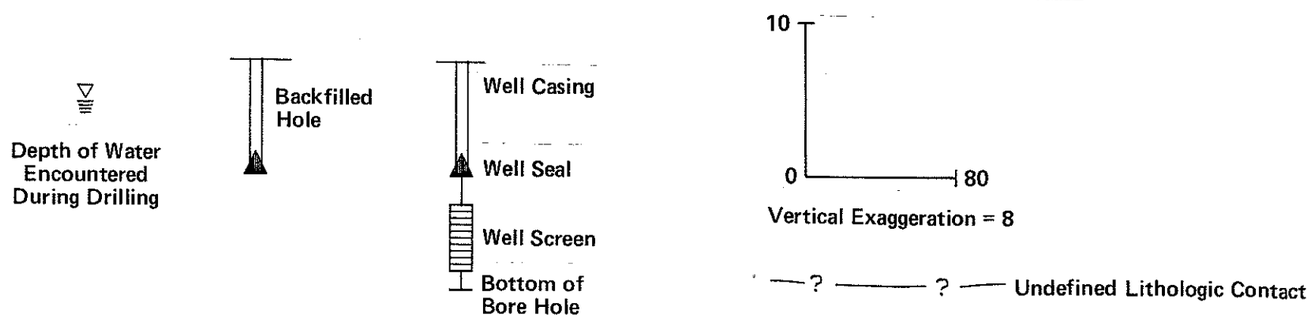
K/J/C 855018.07
December 1990

LG006350

Figure 8



Legend:



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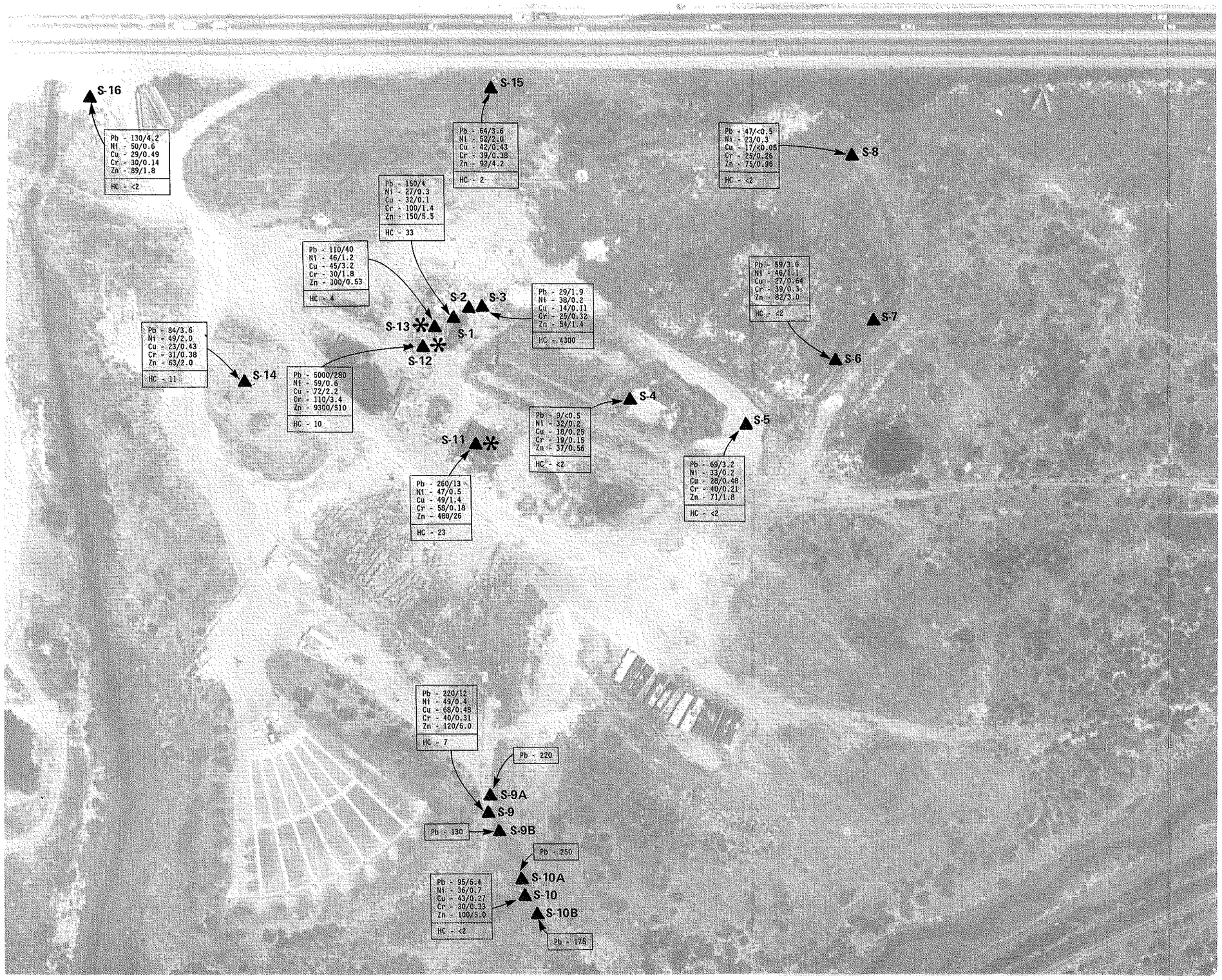
Liquid Gold Site

Geologic Cross Section C – C′

K/J/C 855018.07
December 1990

LG006351

Figure 9



N

0 100 200

Scale in Feet
(Approx.)

Basemap Reference

Pacific Aerial Survey.
Job number AV2640-7-10. Flown 15 May 1985.
Airphoto negative scale 1 inch = 1000 feet.

Legend

▲ S-2	Surface sample number and location
Pb - 130/4.2 Ni - 50/0.6 Cu - 29/0.49 Cr - 30/0.14 Zn - 89/1.8	First value is total concentration of metal in mg/kg. Second value is soluable concentration in mg/L. Pb-lead, Ni-nickel, Cu-copper, Cr-chromium and Zn-zinc
HC - <2	Total aliphatic hydrocarbon concentration ($C9$-C_{22} including pristane) in mg/kg.
*	Soil in this area was excavated and removed in 1985.

Notes

1. All sample locations are approximate.
2. Samples collected at locations S-2 and S-7 were not analyzed.
3. Sample data references.
   a) Surface soil samples S-1 through S-16. Kennedy/Jenks Engineers. "Soil and Groundwater Investigation Liquid Gold Site." July 1985
   b) Surface soil samples S-9A, S-9B, S-10A, and S-10B were collected by K/J/C on September 11, 1985. "Scoping Document" June 1988.

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Southern Pacific Transportation Company
Liquid Gold Site

Chemical Concentrations in Surface Soil Samples Collected in 1985

LG006352

K/J/C 855018.07
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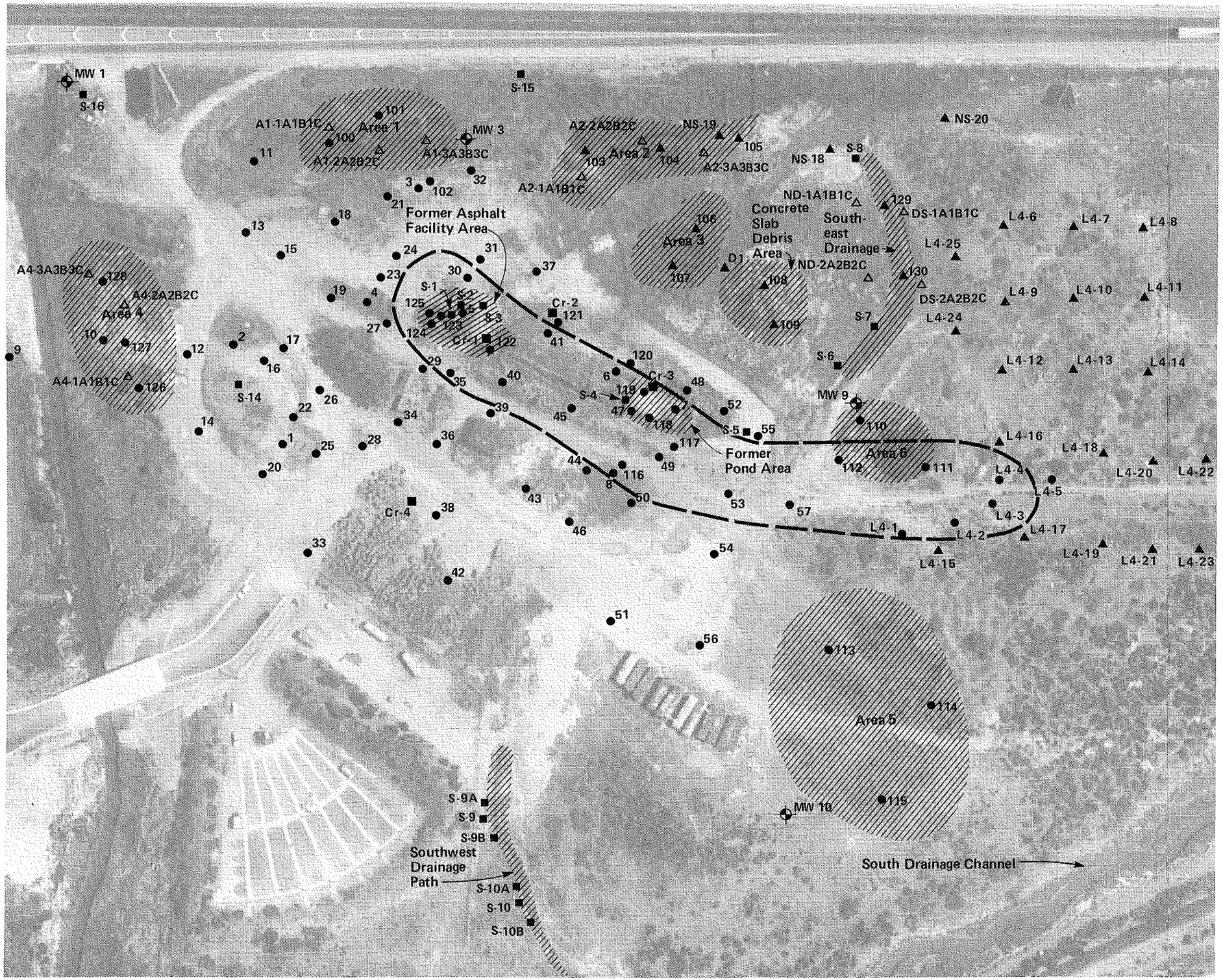
Figure 10



N

0 100 200

Approximate Scale in Feet

Basemap Reference

Pacific Aerial Survey.
Job number AV3268-7-10. Flown 30 March 1988.
Airphoto negative scale: 1 inch = 1000 feet.

Legend

- General areas of additional investigation
- ●18 Boring location and number
- ▲ Boring sampled to 2 or 3 feet
- △ Composite surface sample location
- ■ S-1 Surface sample location and number
- MW1 Monitoring well location and number
- Boundary of Area A

Notes

1. Locations are approximate.
2. Borings 1-57. Ecology and Environment, Inc.
3. All other samples collected by K/J/C.

Kennedy/Jenks/Chilton

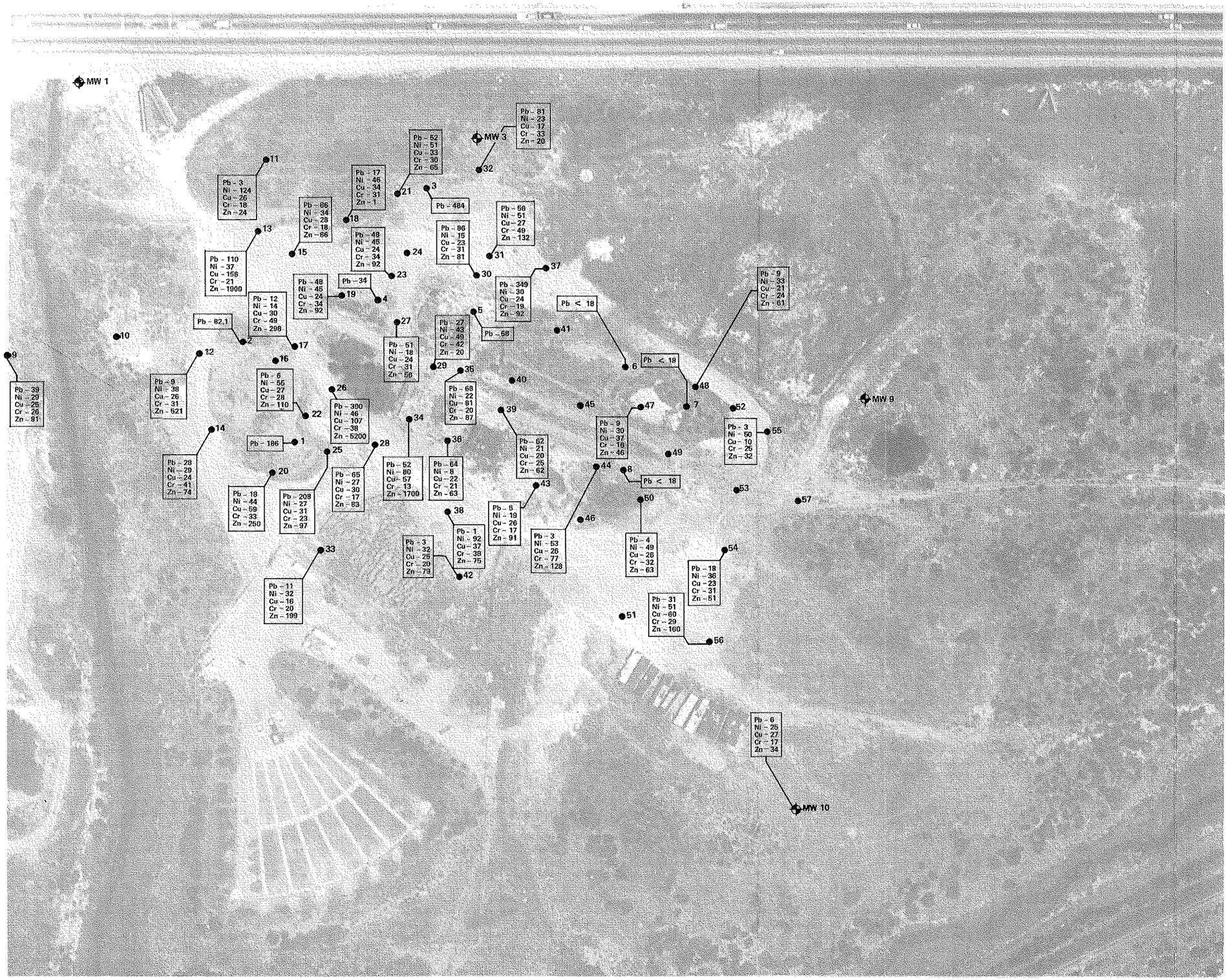
Southern Pacific Transportation Company
Liquid Gold Site

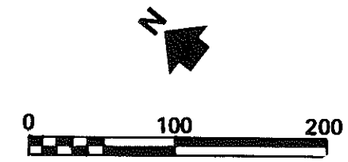
Soil Sampling Locations and Area A

K/J/C 855018.07
December 1990

LG006353

Figure 11





Basemap Reference

Pacific Aerial Survey.
Job number AV2640-7-10. Flown 15 May 1985.
Airphoto negative scale 1 inch = 1000 feet.

Legend

• 15	Boring location and number
⊕ MW 1	Monitoring well location and number
Pb - 17 Ni - 17 Cu - 15 Cr - 13 Zn - 36	Concentrations of total lead (Pb), nickel (Ni), copper (Cu), chromium (Cr), and zinc (Zn), reported at sampled locations in parts per million (ppm).

Notes

1. Soil samples were only collected from borings for monitoring wells 1,3,9 and 10.
2. All soil boring and monitoring well locations are approximate.
3. Actual location of boring 9 is approximately 38 feet northwest of location shown.
4. Sample data references:
   a) Borings 1-8. Ecology and Environment, Inc. "Plan for Soil and Groundwater Investigation." October 5, 1983.
   b) Borings 9-57 and monitoring wells 1,3,9 and 10. Ecology and Environment, Inc. "Site Investigation of the Southern Pacific Stege Lease/Liquid Gold Site." February 28, 1984.

Kennedy/Jenks/Chilton

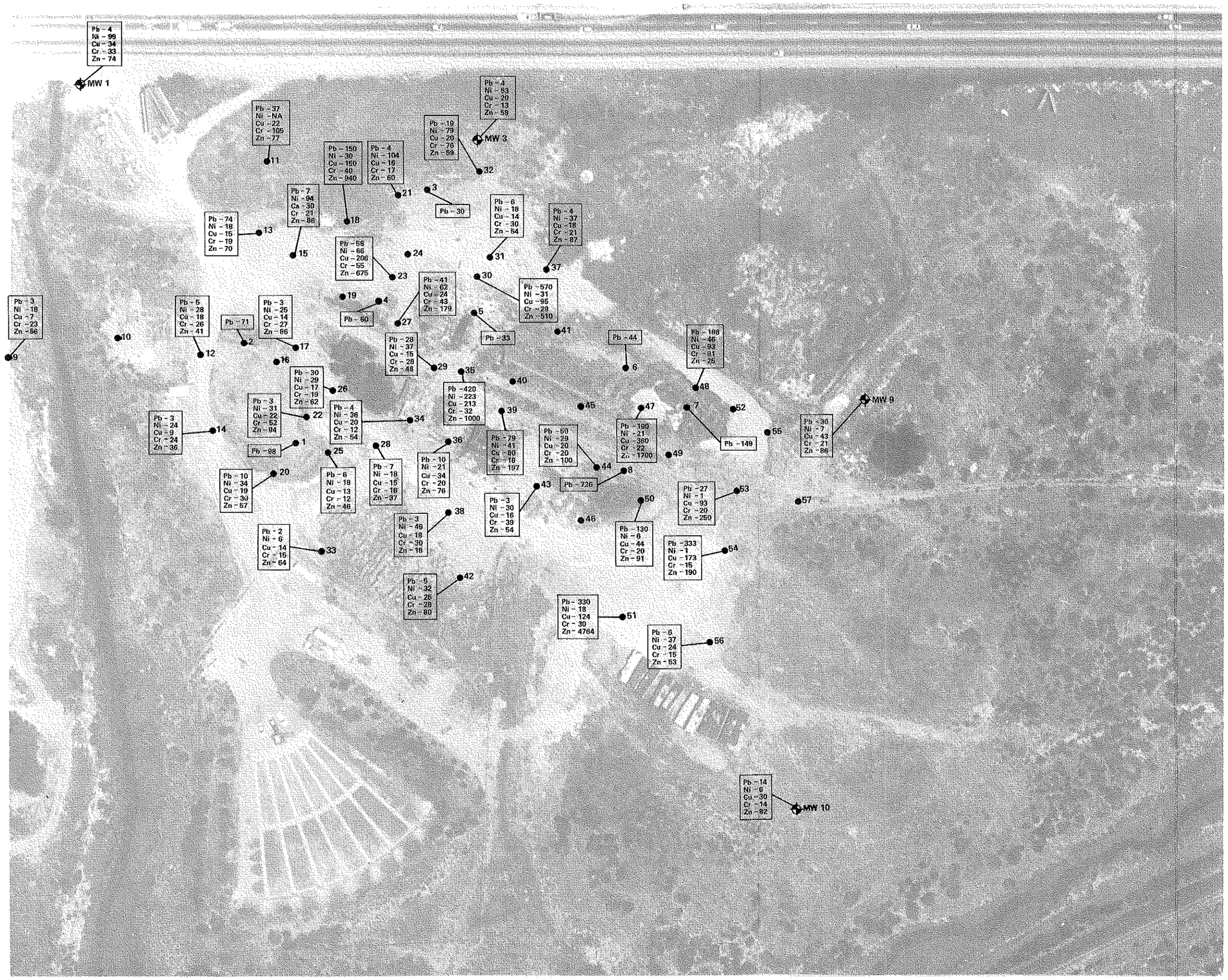
Southern Pacific Transportation Company
Liquid Gold Site

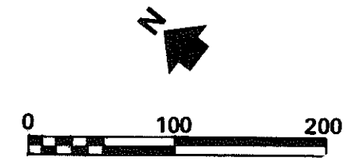
Concentrations of Metals at Depth of 0 to 1.5 Feet - 1983

LG006354

K/J/C 855018.07
December 1990

Figure 12





Basemap Reference

Pacific Aerial Survey.
Job number AV2640-7-10. Flown 15 May 1985.
Airphoto negative scale 1 inch = 1000 feet.

Legend

• 15	Boring location and number
⊕ MW 1	Monitoring well location and number
Pb - 17 Ni - 17 Cu - 15 Cr - 13 Zn - 36	Concentrations of total lead (Pb), nickel (Ni), copper (Cu), chromium (Cr), and zinc (Zn), reported at sampled locations in parts per million (ppm).

Notes

1. Soil samples were only collected from borings for monitoring wells 1,3,9 and 10.
2. All soil boring and monitoring well locations are approximate.
3. Actual location of boring 9 is approximately 38 feet northwest of location shown.
4. Sample data references:
   a) Borings 1-8. Ecology and Environment, Inc. "Plan for Soil and Groundwater Investigation." October 5, 1983.
   b) Borings 9-57 and monitoring wells 1,3,9 and 10. Ecology and Environment, Inc. "Site Investigation of the Southern Pacific Stege Lease/Liquid Gold Site." February 28, 1984.

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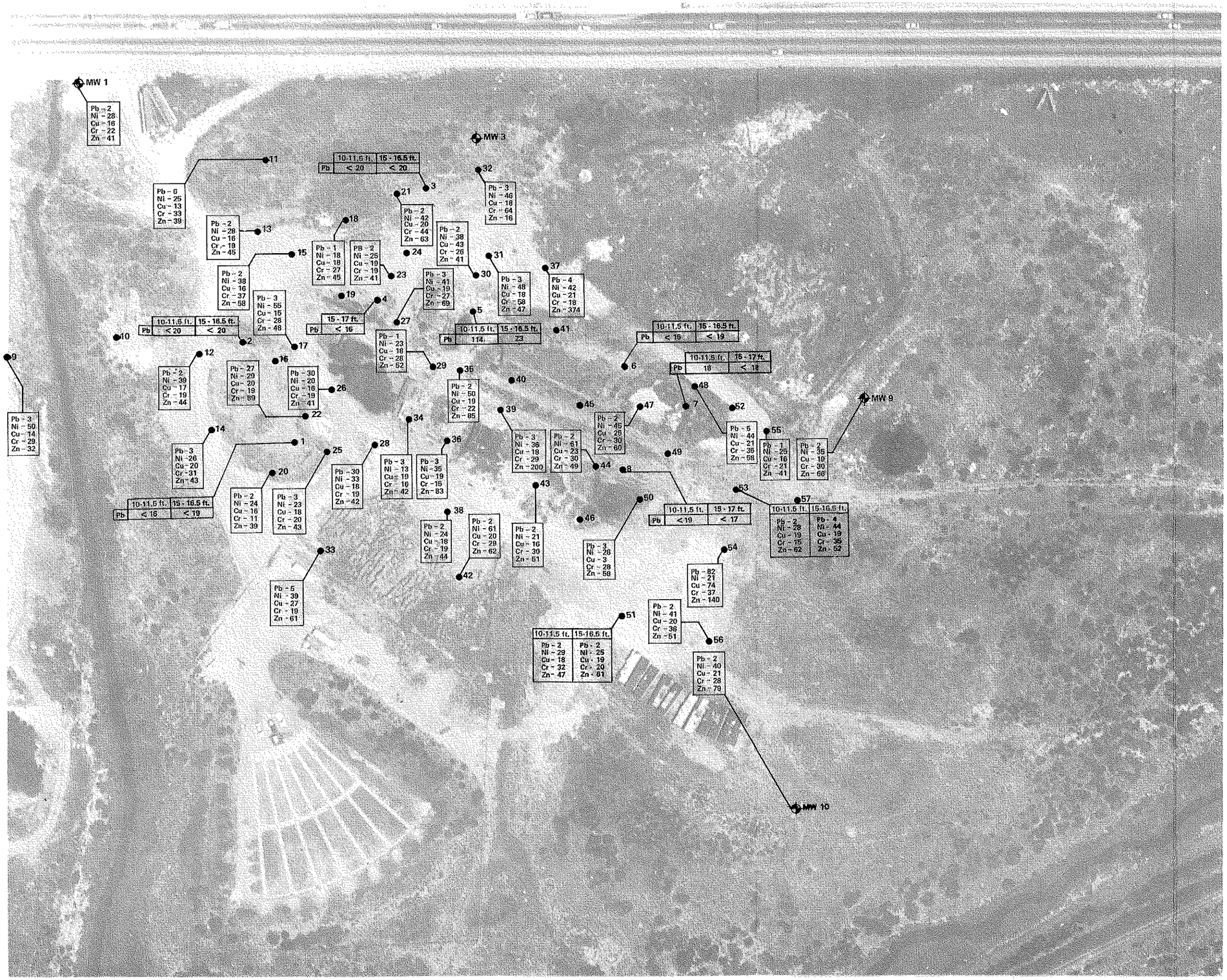
Southern Pacific Transportation Company
Liquid Gold Site

Concentrations of Metals at Depth of 5 to 6.5 Feet - 1983

LG006355

K/J/C 855018.07
December 1990

Figure 13



0 100 200

Scale in Feet (Approx.)

Basemap Reference

Pacific Aerial Survey.
Job number AV2640-7-10. Flown 15 May 1985.
Airphoto negative scale 1 inch = 1000 feet.

Legend

• 15	Boring location and number
⊕ MW 1	Monitoring well location and number
Pb - 17 Ni - 17 Cu - 15 Cr - 13 Zn - 36	Concentrations of lead (Pb), nickel (Ni), copper (Cu), chromium (Cr), and zinc (Zn) reported at depth of 10-11.5 feet in parts per million (ppm).

	10-11.5 ft.	15-16.5 ft.
Pb	4	5

Concentrations of metals at indicated depth

Notes

1. Soil samples were only collected from borings for monitoring wells 1,3,9 and 10.
2. All soil boring and monitoring well locations are approximate.
3. Actual location of boring 9 is approximately 38 feet northwest of location shown.
4. Sample data references:
   a) Borings 1-8. Ecology and Environment, Inc. "Plan for Soil and Groundwater Investigation." October 5, 1983.
   b) Borings 9-57 and monitoring wells 1,3,9 and 10. Ecology and Environment, Inc. "Site Investigation of the Southern Pacific Stege Lease/Liquid Gold Site." February 28, 1984.

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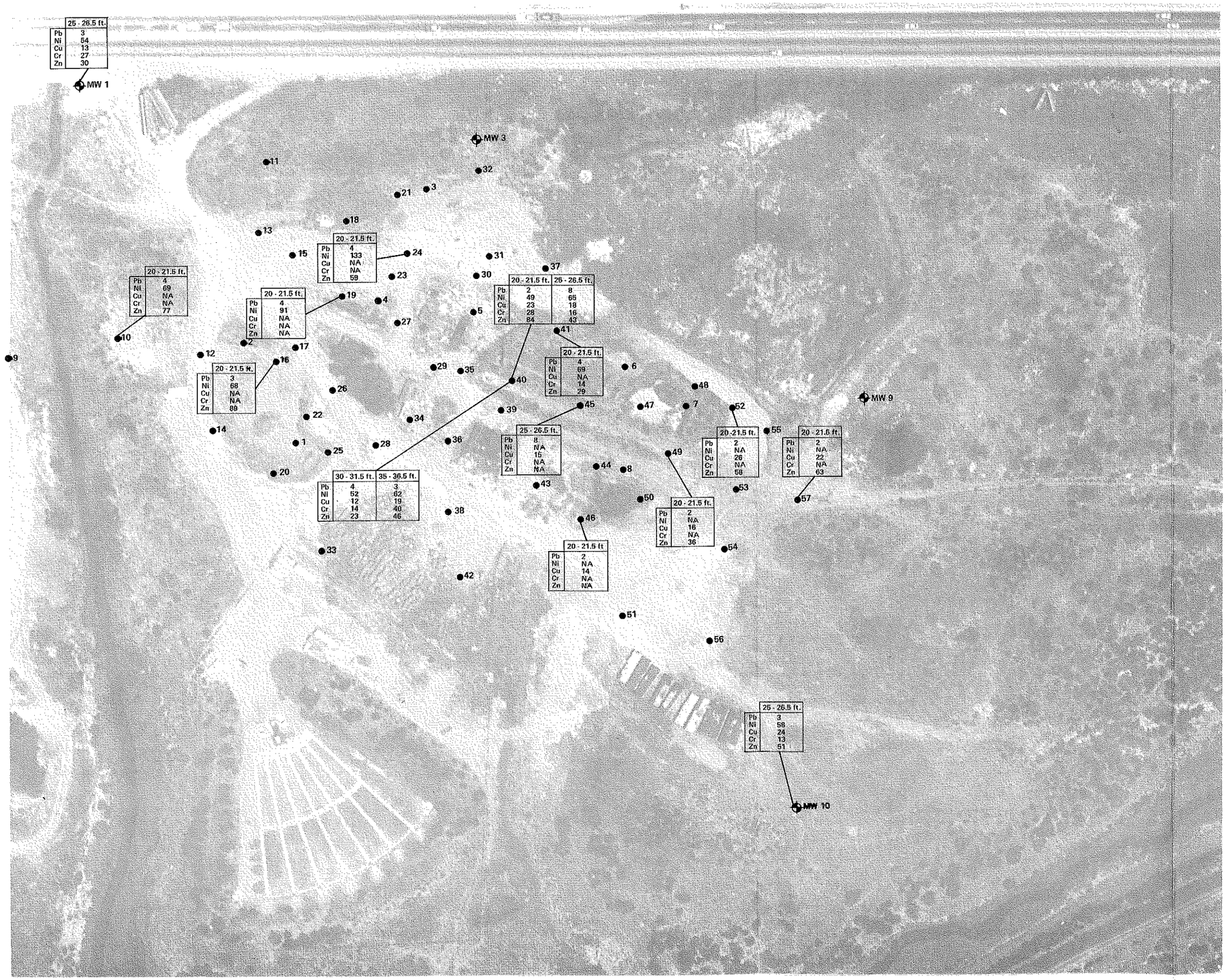
Southern Pacific Transportation Company
Liquid Gold Site

Concentrations of Metals at Depth of 10 to 16.5 Feet - 1983

LG006356

K/J/C 855018.07
December 1990

Figure 14



0 100 200

Scale in Feet (Approx.)

Basemap Reference

Pacific Aerial Survey.
Job number AV2640-7-10. Flown 15 May 1985.
Airphoto negative scale 1 inch = 1000 feet.

Legend

• 15 — Boring location and number

MW 1 — Monitoring well location and number

	20-21 ft.	25-26.5 ft.
Pb	2	2
Ni	49	44
Cu	16	22
Cr	28	35
Zn	36	63

Concentrations of lead (Pb), nickel (Ni), copper (Cu), chromium (Cr), and zinc (Zn) reported in parts per million (ppm) at indicated depth.

NA — Not analyzed

Notes

1. Soil samples were only collected in monitoring wells 1,3,9 and 10.
2. All soil boring and monitoring well locations are approximate.
3. Actual location of boring 9 is approximately 38 feet northwest of location shown.
4. Sample data references:
   a) Borings 1-8. Ecology and Environment, Inc. "Plan for Soil and Groundwater Investigation." October 5, 1983
   b) Borings 9-57 and monitoring wells 1,3,9 and 10. Ecology and Environment, Inc. "Site investigation of the Southern Pacific Stege Lease/Liquid Gold Site." February 28, 1984.

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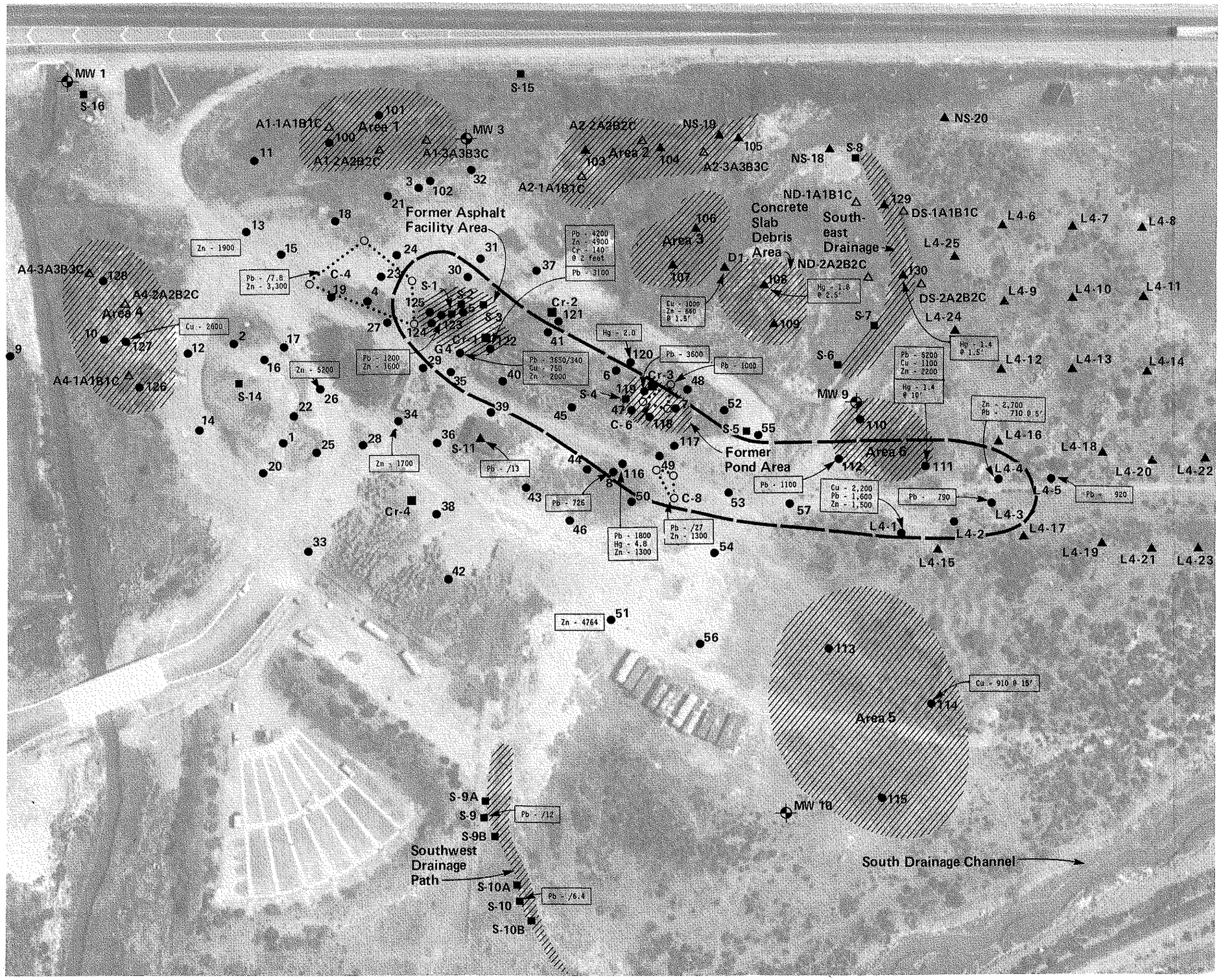
Southern Pacific Transportation Company
Liquid Gold Site

Concentrations of Metals at Depths Greater Than 20 Feet - 1983

LG006357

K/J/C 855018.07
December 1990

Figure 15



0 100 200

Approximate Scale in Feet

Basemap Reference

Pacific Aerial Survey.
Job number AV3268-7-10. Flown 30 March 1988.
Airphoto negative scale: 1 inch = 1000 feet.

Legend

- General Areas of additional investigation
- ● Subsurface boring location at 5-6.5 feet, unless otherwise stated
- ▲ Boring sampled to 2 or 3 feet
- ■ Surface soil sampling location number
- △ Composite surface sample location
- Composite subsurface (5-6.5 feet) boring locations
- Boundary of Area A
- Pb - 3650/340, Cu - 750, Zn - 2000: First value is total concentration of metal in mg/kg. Second value is soluble concentration in mg/l. Pb-lead, Cu-copper, Zn-zinc, Hg-mercury, Cr-chromium

Notes

1. Locations are approximate.
2. Borings 1-57 collected by Ecology & Environment. All other samples collected by K/J/C. Sample G4 is a post excavation sample.
3. Soluble metals determined as per WET, (22 CCR 66700).

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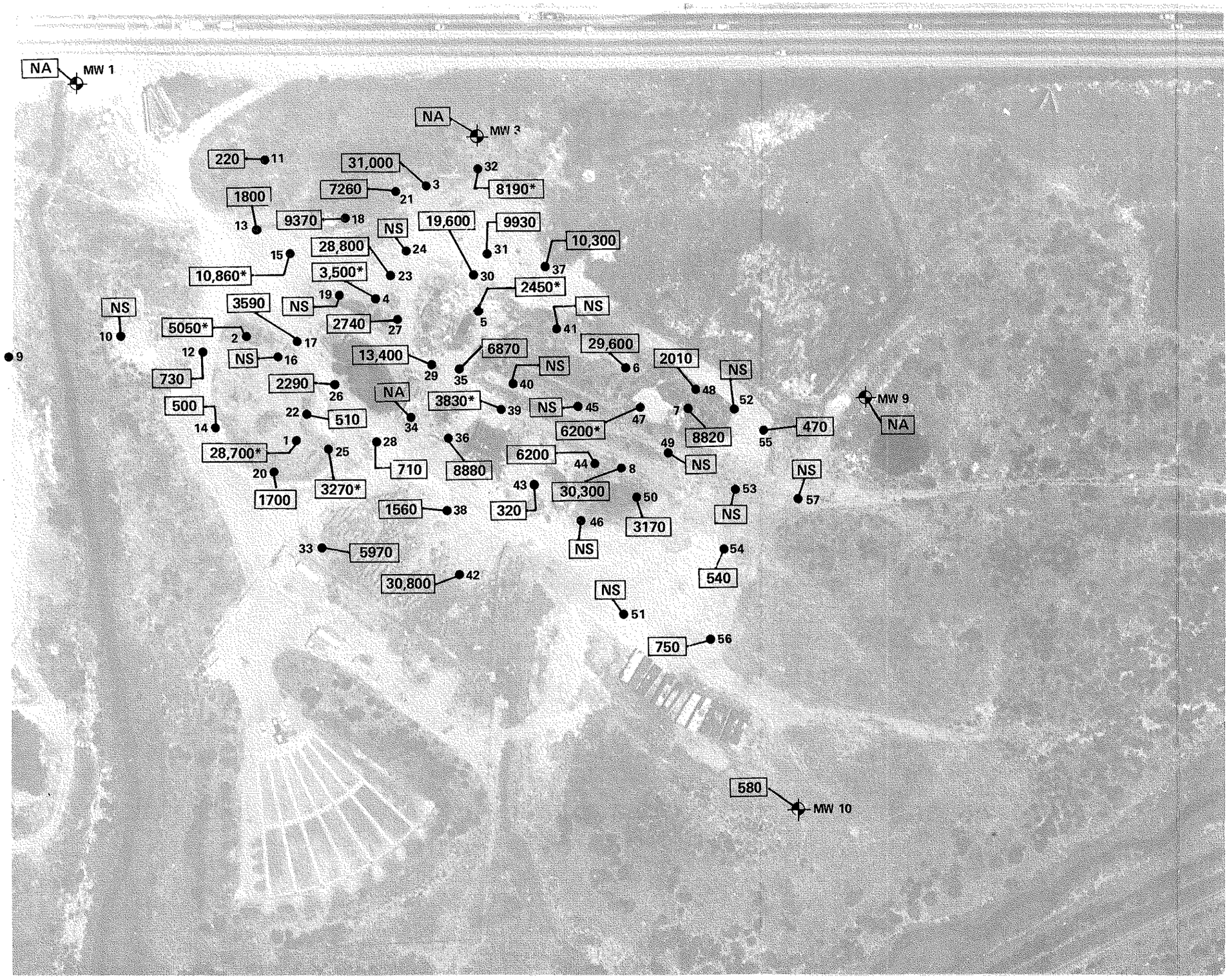
Southern Pacific Transportation Company
Liquid Gold Site

Elevated Metal Concentrations in Soil Samples

LG006358

K/J/C 855018.07
December 1990

Figure 16



0 100 200

Scale in Feet (Approx.)

Basemap Reference

Pacific Aerial Survey.
Job number AV2640-7-10. Flown 15 May 1985.
Airphoto negative scale 1 inch = 1000 feet.

Legend

● 15	Boring location and number
⊕ MW 1	Monitoring well location and number
470	Concentration of hydrocarbons in mg/kg (as determined by standard method 503D)
470*	Sample oily or oil stained
NS	Not sampled
NA	Not analyzed

Notes

1. Soil samples were collected at some depths in monitoring wells 1,3,9 and 10.
2. All soil boring and monitoring well locations are approximate.
3. Actual location of boring 9 is approximately 38 feet northwest of location shown.
4. Data useful only for qualitative comparisons due to high variability.
5. Sample data reference:
   a) Borings 1-57 and monitoring wells 1,3,9 and 10. Ecology and Environment, Inc. "Site Investigation of the Southern Pacific Stege Lease/Liquid Gold Site." February 28, 1984

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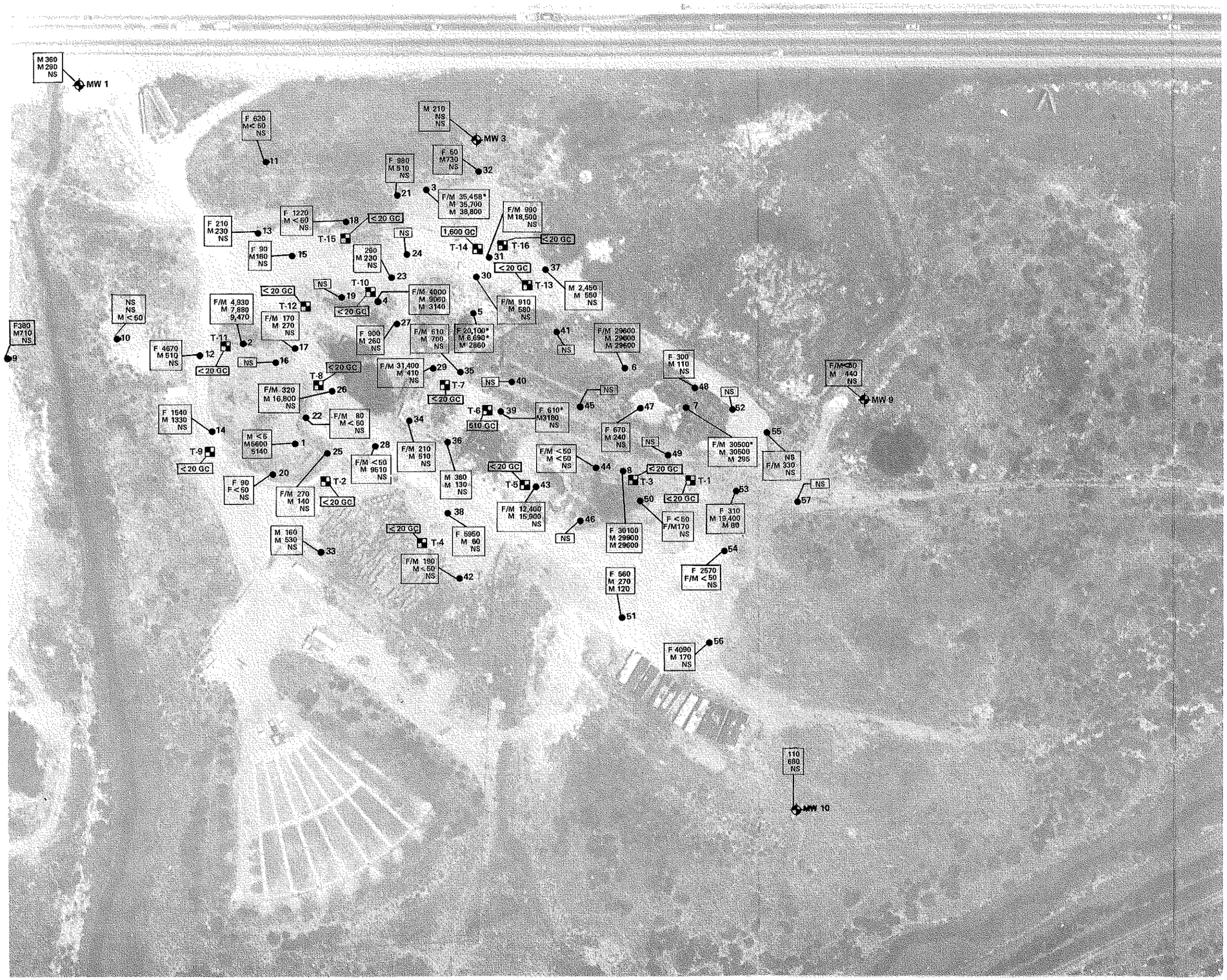
Southern Pacific Transportation Company
Liquid Gold Site

Concentrations of Hydrocarbons at Depths of 0 to 1.5 Feet - 1983

LG006359

K/J/C 855018.07
December 1990

Figure 17



Scale in Feet
(Approx)

Basemap Reference

Pacific Aerial Surveys.
Job number AV2640-7-10 Flown 15 May 1985.
Airphoto negative scale: 1 inch = 1000 feet

Legend

● 15	Boring location and number
MW 1	Monitoring well location and number
T-1	Trench location and number
210 / 90 / 170	Concentrations of hydrocarbons in mg/kg for 5 to 6.5 ft., 10 to 11.5 ft., and 15 to 16.5 ft. (as determined by Standard Method 503D)
200 GC	Total aliphatic hydrocarbon concentrations (C_9 - C_{22} including pristane) in mg/kg from 2 to 8.5 ft.
*	Sample oily or oil stained
F	Sample collected from fill
F/M	Sample collected from fill/Bay Mud Interface
M	Sample collected from Bay Mud
NS	Not Sampled

Notes

1. All soil boring and monitoring well locations are approximate.
2. Location of boring 9 is approximately 38 feet northwest of location shown.
3. Data useful only for qualitative comparisons due to high variability.
4. Sample data references:
   a) Borings 1-8. Ecology and Environment, Inc. "Plan for Soil and Groundwater Investigation." October 5, 1983.
   b) Borings 9-57 and monitoring wells 1,3,9 and 10. Ecology and Environment, Inc. "Site Investigation of the Southern Pacific Stege Lease/Liquid Gold Site." February 28, 1984.
   c) Trench samples. Kennedy/Jenks Engineers. "Soil and Groundwater Investigation Liquid Gold Site." July 1985.
   d) K/J/C. "Status Report Regarding Phase III Technical Activities." November 10, 1986.

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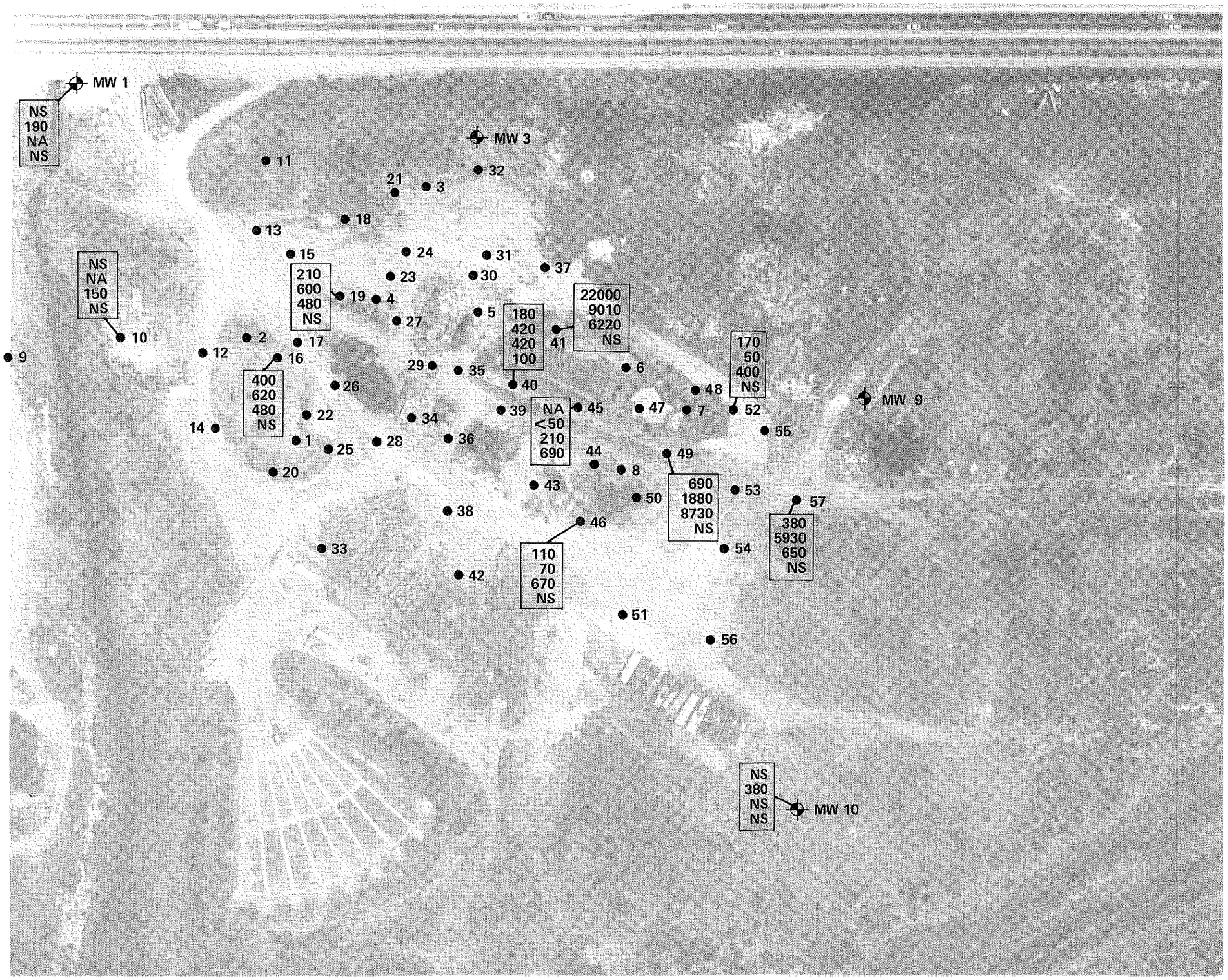
Southern Pacific Transportation Company
Liquid Gold Site

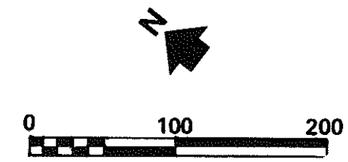
Concentrations of Hydrocarbons at Depths of 5 to 16.5 Feet - 1983

LG006360

K/J/C 855018.07
December 1990

Figure 18





Basemap Reference

Pacific Aerial Survey.
Job number AV2640-7-10. Flown 15 May 1985.
Airphoto negative scale 1 inch = 1000 feet.

Legend

● 15	Boring location and number
⊕ MW 1	Monitoring well location and number
170 210 130 220	Concentration of hydrocarbon at the following depths: 20 to 20.5 feet, 25 to 26.5 feet, 30 to 31.5 feet and 35 to 36.5 feet (as determined by standard method 503D).
NS	Not sampled
NA	Not analyzed

Notes

1. Soil samples were collected at some depths in monitoring wells 1,3,9 and 10 only.
2. Soil boring for which data are not shown were only 15 feet deep.
3. All soil boring and monitoring well locations are approximate.
4. Location of boring 9 is approximately 38 feet northwest of location shown.
5. Data useful only for qualitative comparisons due to high variability.
6. Sample data reference:
   a) Borings 1-57 and monitoring wells 1,3,9, and 10. Ecology and Environment, Inc. "Site Investigation of the Southern Pacific Stege Lease/Liquid Gold Site." February 28, 1984.

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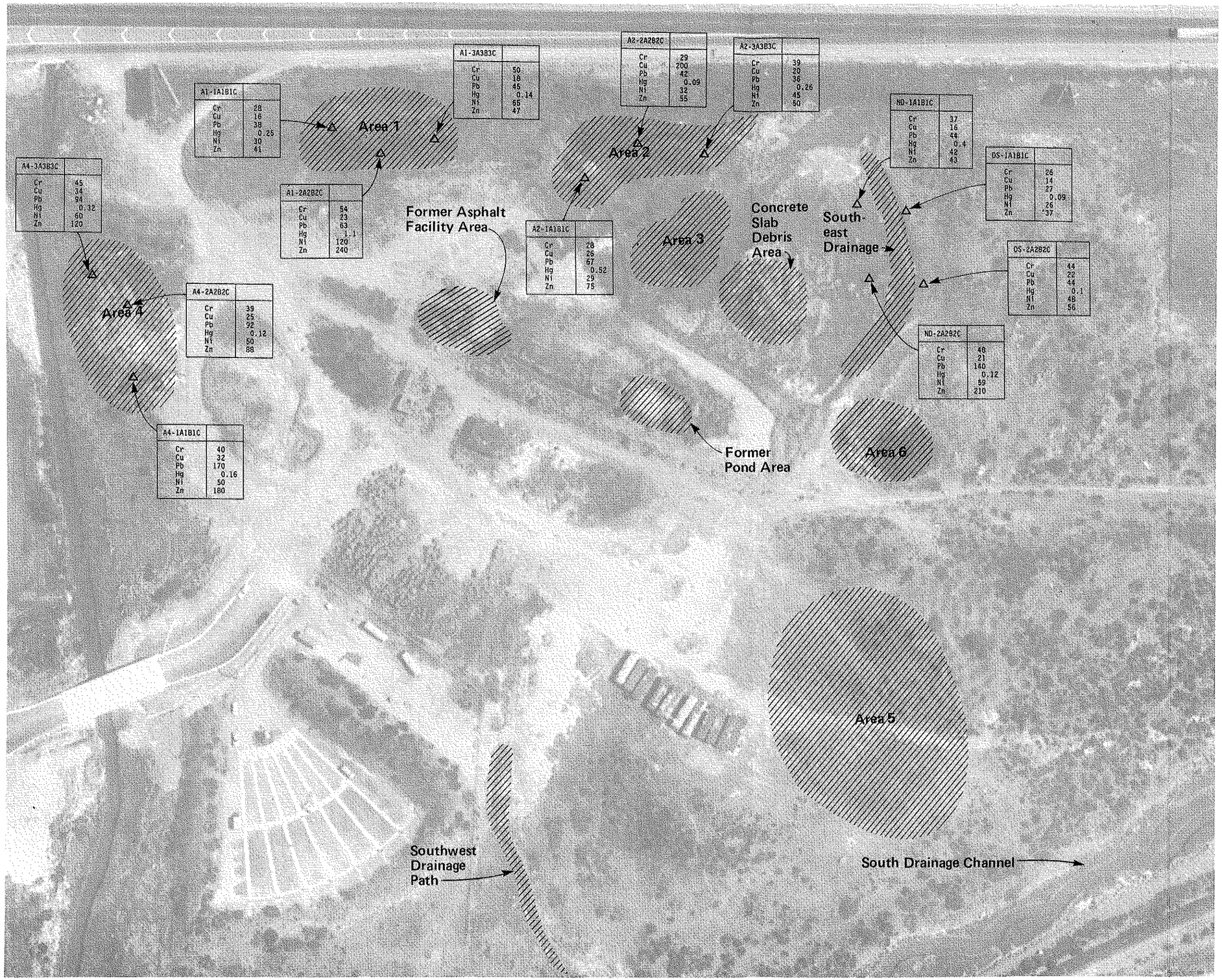
Southern Pacific Transportation Company
Liquid Gold Site

Concentrations of Hydrocarbons at Depths of 20 to 36.5 Feet - 1983

K/J/C 855018.07
December 1990

LG006361

Figure 19



0 100 200

Approximate Scale in Feet

Basemap Reference

Pacific Aerial Survey.
Job number AV3268-7-10. Flown 30 March 1988.
Airphoto negative scale: 1 inch = 1000 feet.

Legend

General Areas of additional investigation

△ Composite sample location. Three samples taken from the corners of a 17 foot equilateral triangle

ND-2A2B2C	
Cr	48
Cu	21
Pb	140
Hg	0.12
Ni	59
Zn	210

Concentration of total metal in mg/kg at the indicated sampling location. Ch-chromium, Cu-copper, Pb-lead, Hg-mercury, Ni-nickel and Zn-zinc

Notes

1. Locations are approximate
2. Subsamples collected at 0-3 inches.

Kennedy/Jenks/Chilton

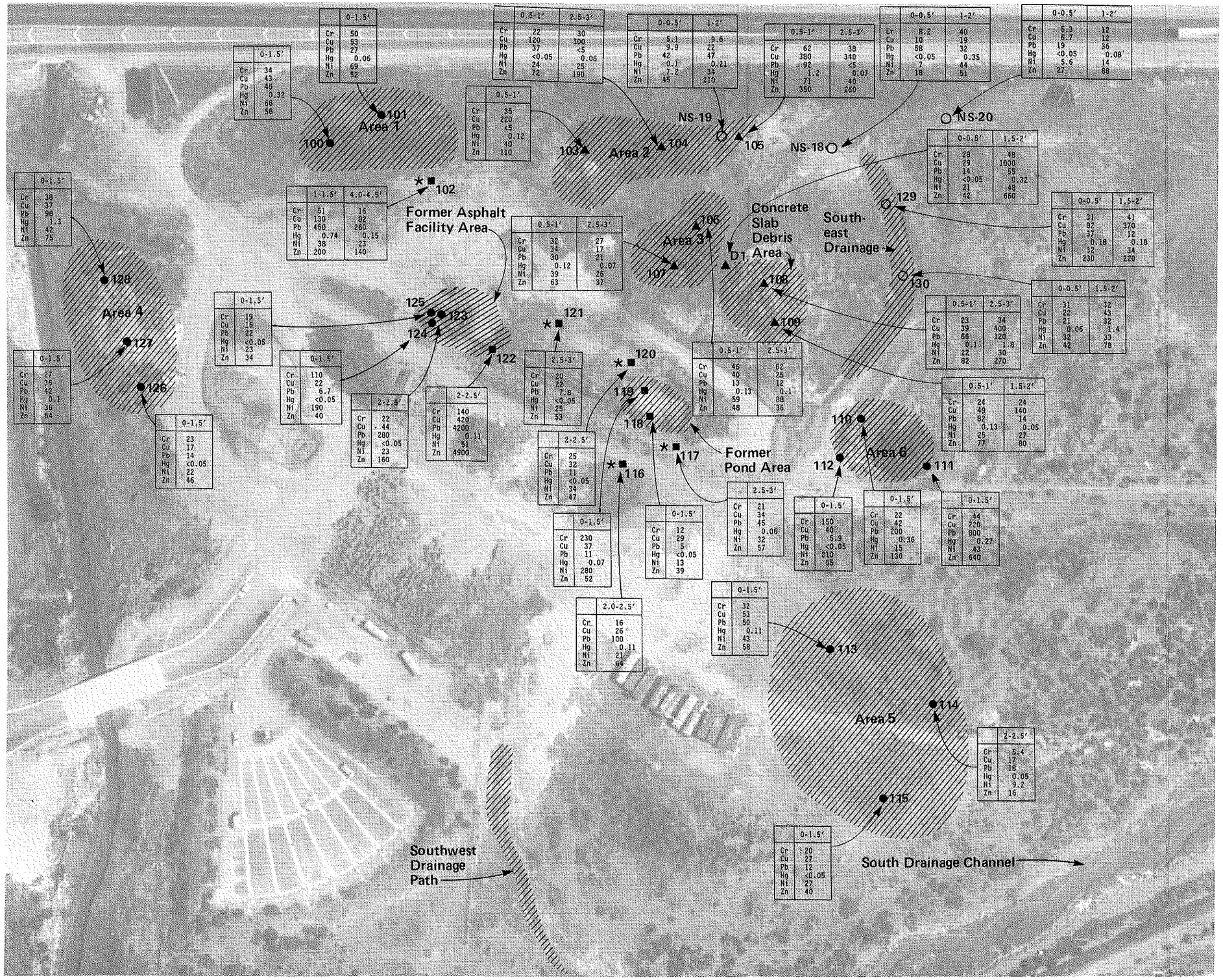
Southern Pacific Transportation Company
Liquid Gold Site

Concentration of Metals in Surface Soils Composite Samples September 1988 Sampling

LG006362

K/J/C 855018.07
December 1990

Figure 20



0 100 200

Approximate Scale in Feet

Basemap Reference

Pacific Aerial Survey.
Job number AV3268-7-10. Flown 30 March 1988.
Airphoto negative scale: 1 inch = 1000 feet.

Legend

- General Areas of additional investigation
- ● Boring sampled to 15 feet
- ■ Boring sampled to 30 feet
- ▲ Boring sampled to 3 feet
- ○ Boring sampled to 2 feet
- ★ Elevated levels of oil and grease indicated by E & E data
- Concentration of total metal in mg/kg at indicated depth. Cr-chromium, Cu-copper, Pb-lead, Hg-mercury, Ni-nickel, Zn-zinc

Notes

1. Locations are approximate.
2. Shallow boring samples were collected at depths of 0 to 6 inches and 1.5 to 2.0 feet except for NS-18, NS-19, and NS-20, which were sampled at 0 to 3 inches and 1 to 2 feet.

Kennedy/Jenks/Chilton

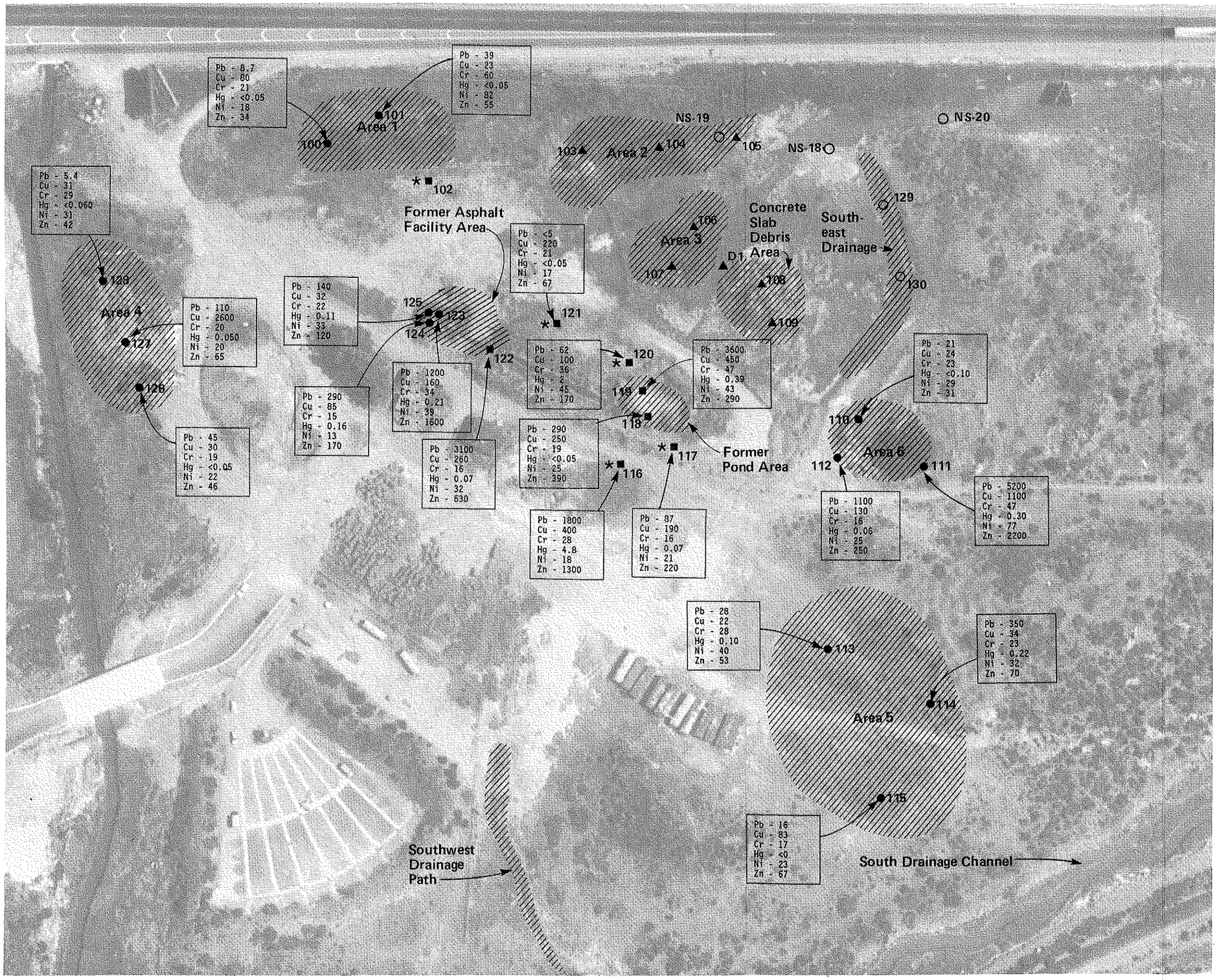
Southern Pacific Transportation Company
Liquid Gold Site

Concentration of Metals at 0 to 4 Feet
September 1988 Sampling

LG006363

K/J/C 855018.07
December 1990

Figure 21



N

0 100 200

Approximate Scale in Feet

Basemap Reference

Pacific Aerial Survey.
Job number AV3268-7-10. Flown 30 March 1988.
Airphoto negative scale: 1 inch = 1000 feet.

Legend

- General areas of additional investigation
- ● Boring sampled to 15 feet
- ■ Boring sampled to 30 feet
- ▲ Boring sampled to 3 feet
- ○ Surface soil samples
- ★ Elevated levels of oil and grease indicated by E & E data

Pb - 21 Cu - 24 Hg - <0.1 Hg - 0.210 Zn - 31

Concentration of total lead (Pb), copper (Cu), mercury (Hg), nickel (Ni), and zinc (Zn) in mg/kg

Note

1. Locations are approximate.
2. Surface soil samples were collected at depths of 0 to 6 inches and 1.5 to 2.0 feet except for NS-18, NS-19, and NS-20, which were sampled at 0 to 3 inches and 1 to 2 feet.

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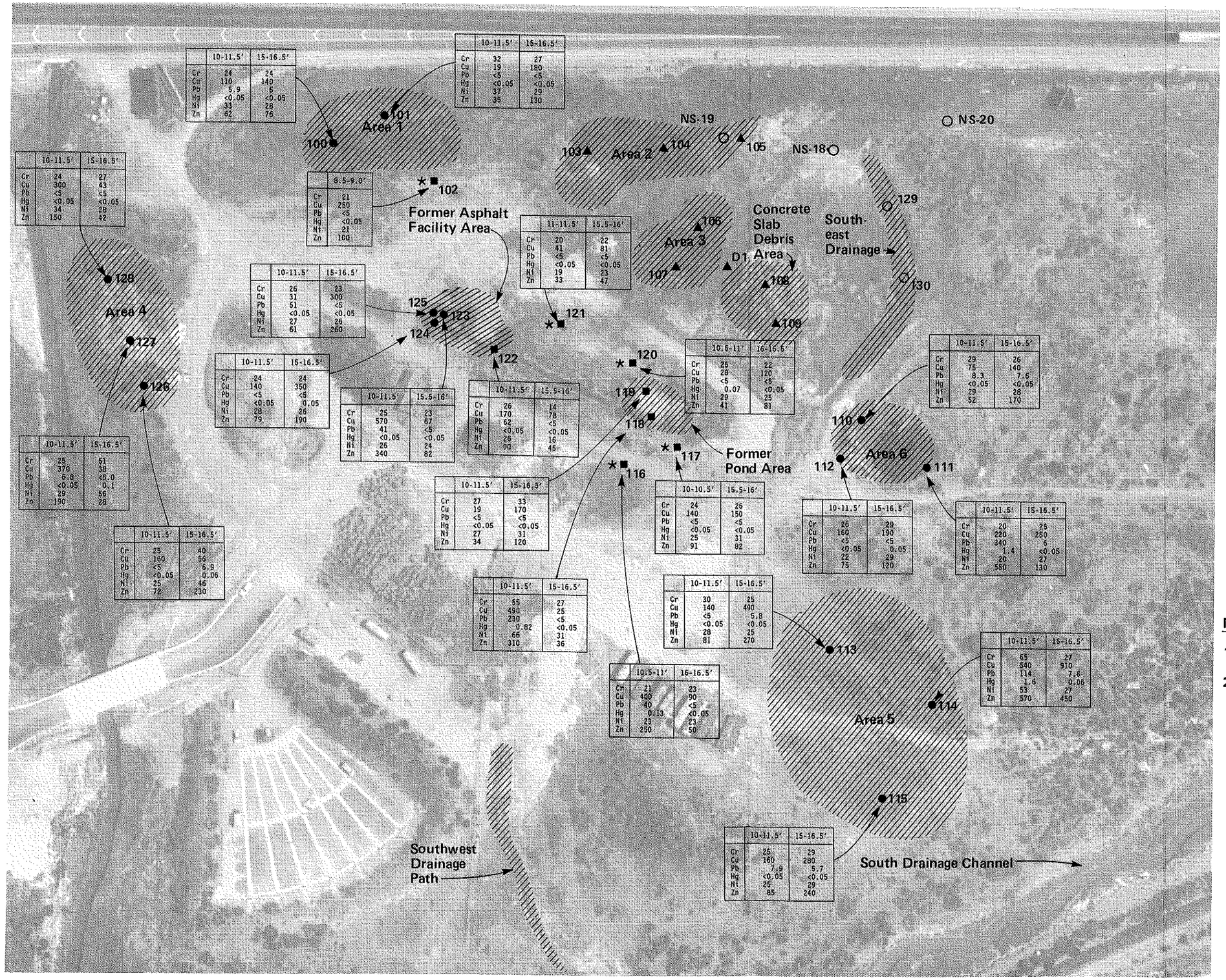
Southern Pacific Transportation Company
Liquid Gold Site

Concemtrations of Metals at Depth 5 to 6.5 Feet September 1988 Sampling

LG006364

K/J/C 855018.07
December 1990

Figure 22



	10-11.5'	15-16.5'
Cr	24	24
Cu	110	140
Pb	5.9	5
Hg	<0.05	<0.05
Ni	33	28
Zn	62	76

	10-11.5'	15-16.5'
Cr	32	27
Cu	19	180
Pb	<5	<5
Hg	<0.05	<0.05
Ni	37	29
Zn	35	130

	10-11.5'	15-16.5'
Cr	24	27
Cu	300	43
Pb	<5	<5
Hg	<0.05	<0.05
Ni	34	28
Zn	150	42

	8.5-9.0'
Cr	21
Cu	250
Pb	<5
Hg	<0.05
Ni	21
Zn	100

	11-11.5'	15.5-16'
Cr	20	22
Cu	41	81
Pb	<5	<5
Hg	<0.05	<0.05
Ni	19	23
Zn	33	47

	10-11.5'	15-16.5'
Cr	26	33
Cu	31	300
Pb	51	<5
Hg	<0.05	<0.05
Ni	27	26
Zn	61	260

	10-11.5'	15-16.5'
Cr	24	24
Cu	140	350
Pb	<5	<5
Hg	<0.05	0.05
Ni	28	26
Zn	79	190

	10-11.5'	15.5-16'
Cr	25	23
Cu	570	67
Pb	41	<5
Hg	<0.05	<0.05
Ni	26	24
Zn	340	82

	10-11.5'	15.5-16'
Cr	26	14
Cu	170	78
Pb	62	<5
Hg	<0.05	<0.05
Ni	28	16
Zn	90	45

	10.5-11'	16-16.5'
Cr	25	22
Cu	28	120
Pb	<5	<5
Hg	0.07	<0.05
Ni	29	25
Zn	41	81

	10-11.5'	15-16.5'
Cr	29	26
Cu	75	140
Pb	8.3	7.6
Hg	<0.05	<0.05
Ni	29	28
Zn	52	170

	10-11.5'	15-16.5'
Cr	25	51
Cu	370	38
Pb	6.8	<5.0
Hg	<0.05	0.1
Ni	29	56
Zn	190	28

	10-11.5'	15-16.5'
Cr	25	40
Cu	160	66
Pb	<5	6.9
Hg	<0.05	0.06
Ni	25	46
Zn	72	230

	10-11.5'	15-16.5'
Cr	27	33
Cu	19	170
Pb	<5	<5
Hg	<0.05	<0.05
Ni	27	31
Zn	34	120

	10-10.5'	15.5-16'
Cr	24	26
Cu	140	150
Pb	<5	<5
Hg	<0.05	<0.05
Ni	25	31
Zn	91	82

	10-11.5'	15-16.5'
Cr	28	28
Cu	160	190
Pb	<5	<5
Hg	<0.05	0.05
Ni	22	29
Zn	75	120

	10-11.5'	15-16.5'
Cr	20	25
Cu	220	250
Pb	340	6
Hg	1.4	<0.05
Ni	20	27
Zn	550	130

	10-11.5'	15-16.5'
Cr	55	27
Cu	490	25
Pb	230	<5
Hg	0.82	<0.05
Ni	66	31
Zn	310	36

	10-11.5'	15-16.5'
Cr	30	25
Cu	140	490
Pb	<5	5.8
Hg	<0.05	<0.05
Ni	28	25
Zn	81	270

	10.5-11'	16-16.5'
Cr	21	23
Cu	400	90
Pb	40	<5
Hg	0.13	<0.05
Ni	23	23
Zn	250	50

	10-11.5'	15-16.5'
Cr	65	27
Cu	540	910
Pb	114	7.6
Hg	1.6	0.06
Ni	53	27
Zn	570	450

	10-11.5'	15-16.5'
Cr	25	29
Cu	160	280
Pb	7.9	5.7
Hg	<0.05	<0.05
Ni	26	29
Zn	85	240

0 100 200

Approximate Scale in Feet

Basemap Reference

Pacific Aerial Survey.
Job number AV3268-7-10. Flown 30 March 1988.
Airphoto negative scale: 1 inch = 1000 feet.

Legend

- General Areas of additional investigation
- ● Boring sampled to 15 feet
- ■ Boring sampled to 30 feet
- ▲ Boring sampled to 3 feet
- ○ Boring sampled to 2 feet
- ★ Elevated levels of oil and grease indicated by E & E data

	10-11.5'
Cr	25
Cu	160
Pb	<5
Hg	<0.05
Ni	25
Zn	72

Concentration of total metal in mg/kg at indicated depth. Cr-chromium, Cu-copper, Pb-lead, Hg-mercury, Ni-nickel, Zn-zinc

Notes

1. Locations are approximate.
2. Shallow boring samples were collected at depths of 0 to 6 inches and 1.5 to 2.0 feet except for NS-18, NS-19, and NS-20, which were sampled at 0 to 3 inches and 1 to 2 feet.

Kennedy/Jenks/Chilton

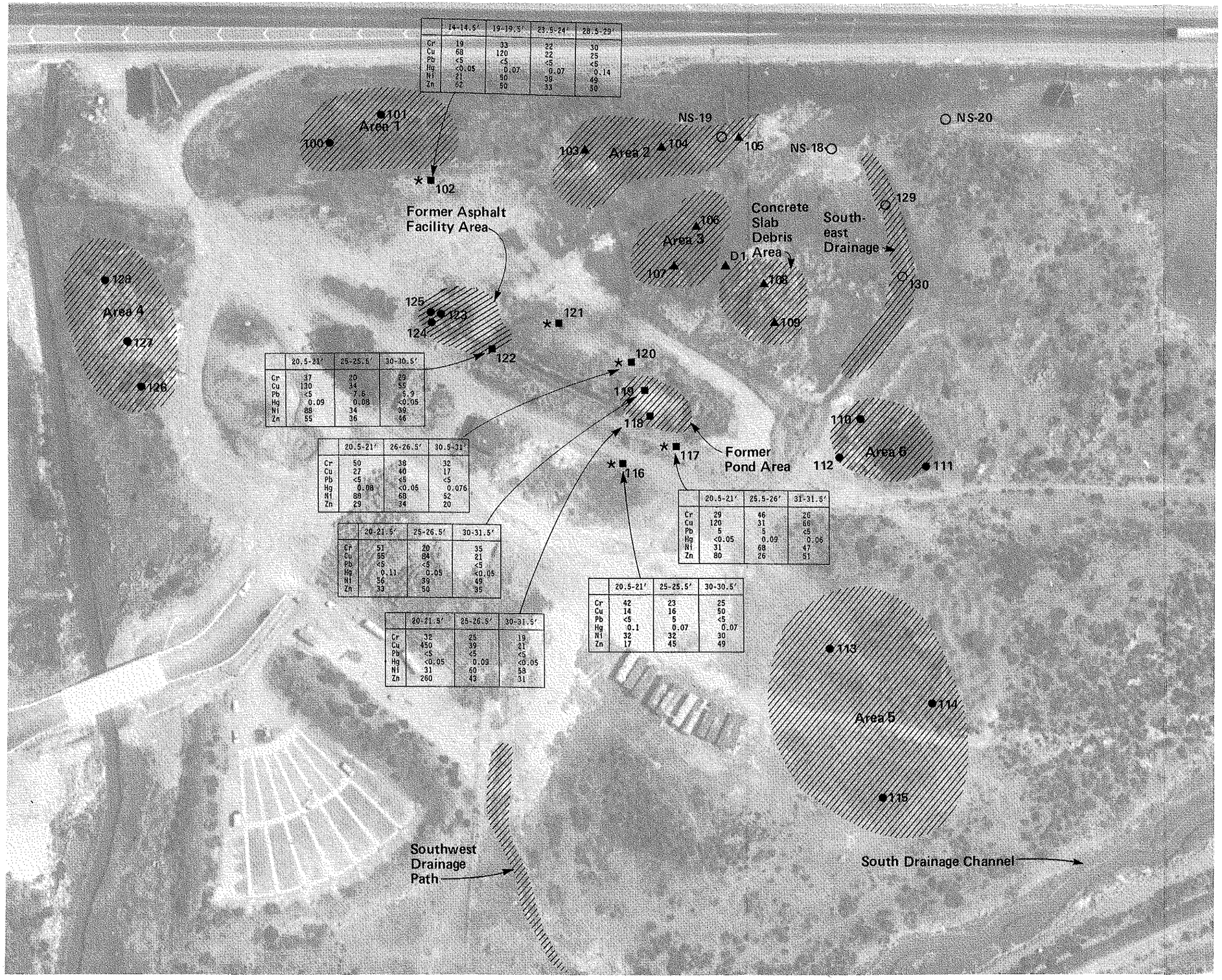
Southern Pacific Transportation Company
Liquid Gold Site

Concentration of Metals at 10 to 16.5 feet
September 1988 Sampling

LG006365

K/J/C 855018.07
December 1990

Figure 23



	14-14.5'	19-19.5'	23.5-24'	28.5-29'
Cr	19	33	22	30
Cu	68	120	22	25
Pb	<5	<5	<5	<5
Hg	<0.05	0.07	0.07	0.14
Ni	21	50	39	49
Zn	52	50	33	50

	20.5-21'	25-25.5'	30-30.5'
Cr	37	20	29
Cu	130	34	55
Pb	<5	7.6	5.9
Hg	0.09	0.08	<0.05
Ni	88	34	39
Zn	55	36	46

	20.5-21'	26-26.5'	30.5-31'
Cr	50	38	32
Cu	27	40	17
Pb	<5	<5	<5
Hg	0.08	<0.05	0.076
Ni	80	68	52
Zn	29	34	20

	20-21.5'	25-26.5'	30-31.5'
Cr	51	20	35
Cu	95	84	21
Pb	<5	<5	<5
Hg	0.11	<0.05	<0.05
Ni	56	39	49
Zn	33	50	35

	20-21.5'	25-26.5'	30-31.5'
Cr	32	25	19
Cu	450	39	21
Pb	<5	<5	<5
Hg	<0.05	0.09	<0.05
Ni	31	60	58
Zn	260	43	31

	20.5-21'	25.5-26'	31-31.5'
Cr	29	46	26
Cu	120	31	66
Pb	5	5	<5
Hg	<0.05	0.09	0.06
Ni	31	68	47
Zn	80	26	51

	20.5-21'	25-25.5'	30-30.5'
Cr	42	23	25
Cu	14	16	50
Pb	<5	5	<5
Hg	0.1	0.07	0.07
Ni	32	32	30
Zn	17	45	49

N

0 100 200

Approximate Scale in Feet

Basemap Reference

Pacific Aerial Survey.
Job number AV3268-7-10. Flown 30 March 1988.
Airphoto negative scale: 1 inch = 1000 feet.

Legend

- General Areas of additional investigation
- ● Boring sampled to 15 feet
- ■ Boring sampled to 30 feet
- ▲ Boring sampled to 3 feet
- ○ Boring sampled to 2 feet
- ★ Elevated levels of oil and grease indicated by E & E data

	23.5-24'
Cr	22
Cu	22
Pb	<5
Hg	0.07
Ni	39
Zn	33

Concentration of total metal in mg/kg at indicated depth. Cr-chromium, Cu-copper, Pb-lead, Hg-mercury, Ni-nickel, Zn-zinc

Notes

1. Locations are approximate.
2. Shallow boring samples were collected at depths of 0 to 6 inches and 1.5 to 2.0 feet except for NS-18, NS-19, and NS-20, which were sampled at 0 to 3 inches and 1 to 2 feet.

Kennedy/Jenks/Chilton

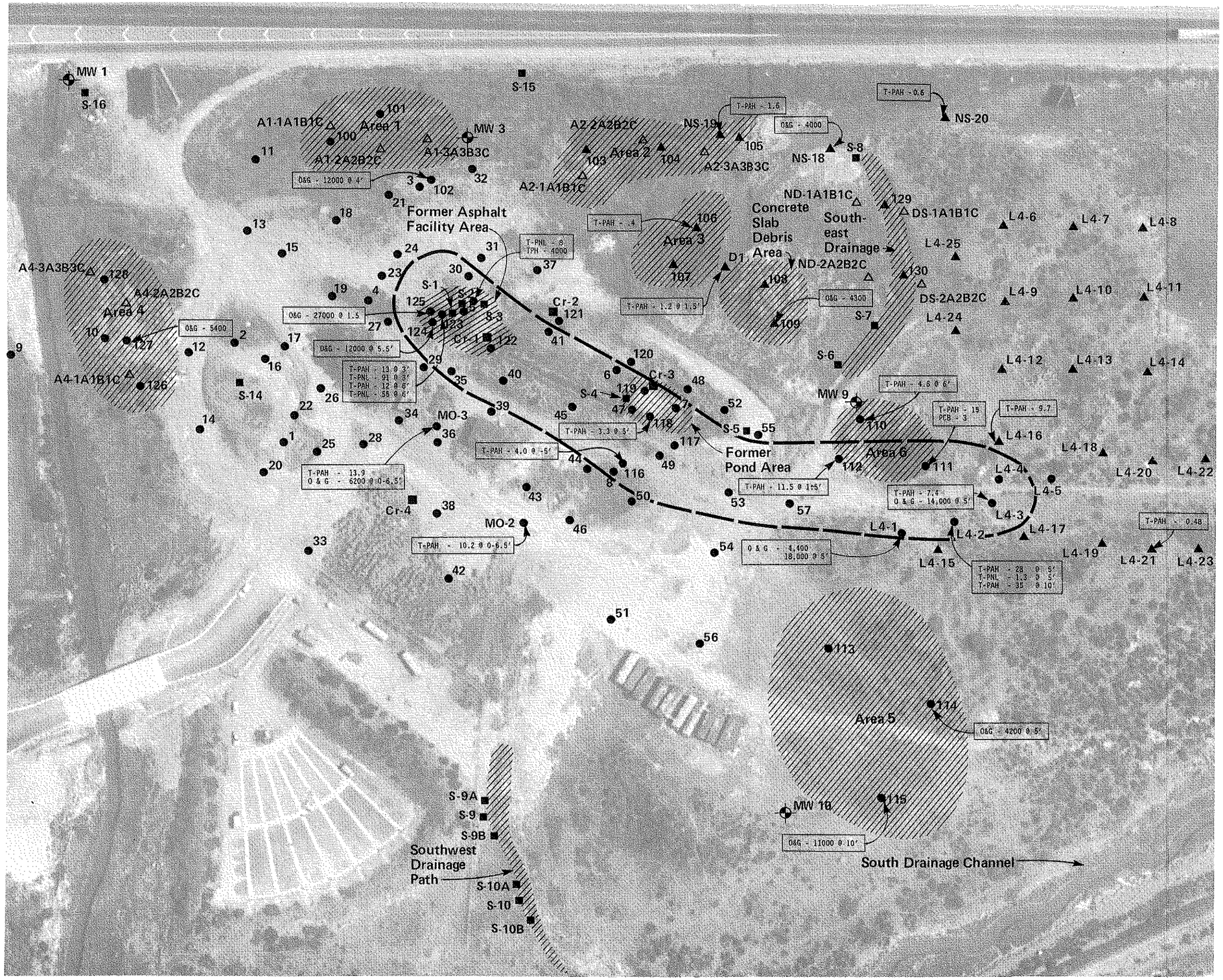
Southern Pacific Transportation Company
Liquid Gold Site

Concentration of Metals at 20 to 31.5 Feet
September 1988 Sampling

LG006366

K/J/C 855018.07
December 1990

Figure 24



N

0 100 200

Approximate Scale in Feet

Basemap Reference

Pacific Aerial Survey.
Job number AV3268-7-10. Flown 30 March 1988.
Airphoto negative scale: 1 inch = 1000 feet.

Legend

▨	General areas of additional investigation
●127	Subsurface boring location and number
▲	Boring sampled to 2 or 3 feet
■	Surface soil sampling location
△	Composite surface sampling location
T-PAH	total polycyclic aromatic hydrocarbons
T-PNL	total phenolic compounds
O & G	oil and grease (top 11 values)
PCB	total polychlorinated biphenyls
TPH	total petroleum hydrocarbons
MO-2	soil elutriate boring location number 0-6.5' composite

Notes

1. Locations are approximate.
2. Results are mg/kg.
3. Sample depths range from 0-1 foot unless otherwise stated.

Kennedy/Jenks/Chilton

Southern Pacific Transportation Company
Liquid Gold Site

Organic Chemical Concentrations in Soil Samples - 1988

K/J/C 855018.07
December 1990

LG006367

Figure 25

N

0 125 250

Scale in Feet
(Approx)

Basemap Reference

Hammon, Jensen, Wallen & Associates.
Job number 5841. Flown 26 November 1984.
Airphoto negative scale 1 inch = 300 feet.

Legend

- Drainage area boundary
- IX Drainage area designated number
- Area of ponding
- M1-1 Surface soil sample location
- M0-1 Subsurface soil sample location
- Road and bridge

Notes:

1. All boundaries shown are approximate. Boundaries are based on features shown on topographic map and on field observation by K/J/C in November 1987.

2. The road and bridge were constructed after the survey. Thus, contours in the vicinity of the road have been altered slightly. However, major surface drainage regions have not been affected.

Kennedy/Jenks/Chilton

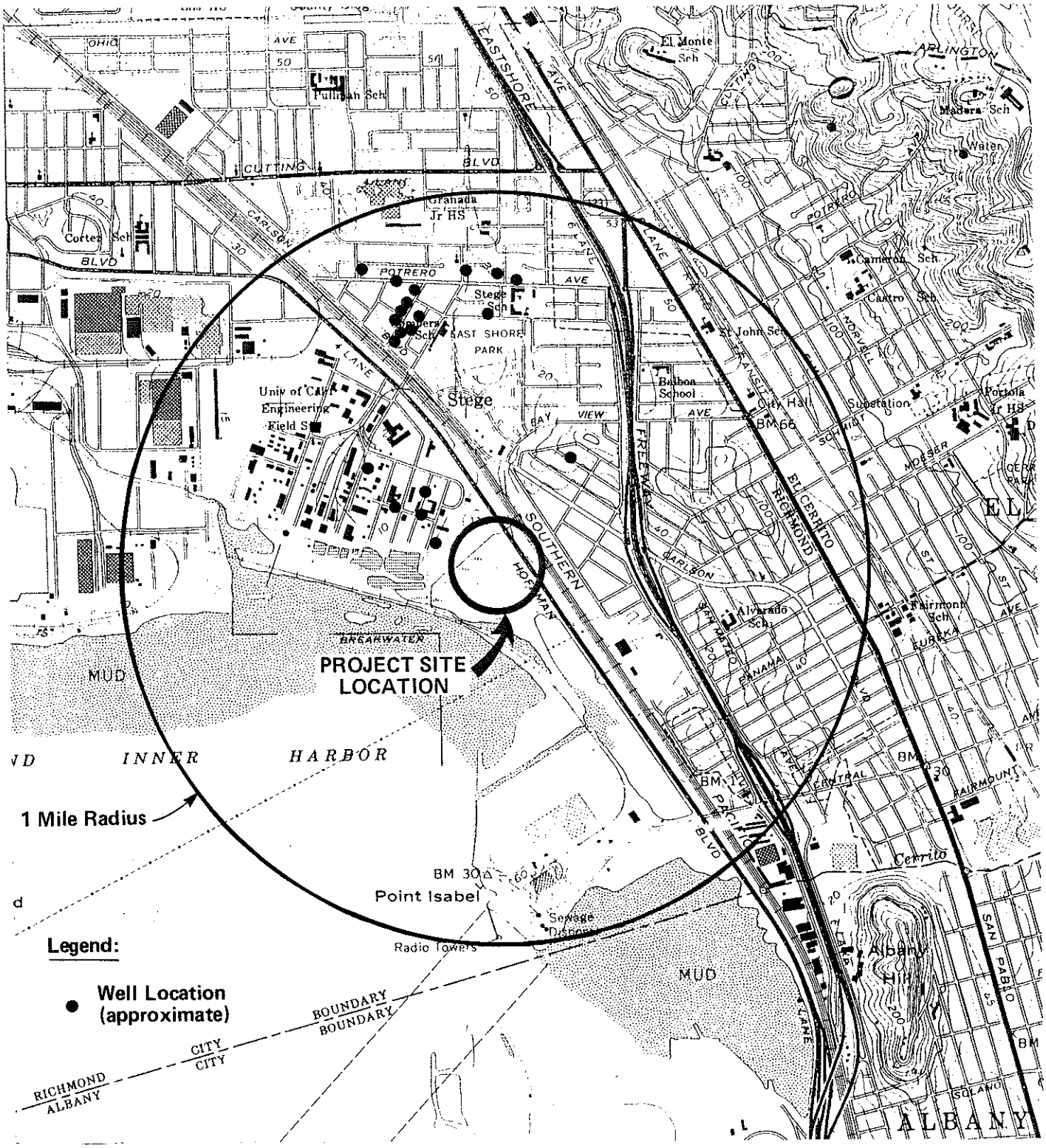
Southern Pacific Transportation Company
Liquid Gold Site

Bioassay Soil Sampling Locations and Site Drainage Boundaries

LG006368

K/J/C 855018.07
December 1990

Figure 26



Basemap Reference: USGS Topographic Map
Richmond Quadrangle 7.5 Minute Series
Photorevised 1980
Sources: DOT (1978), DWR (1990)

N

0 2000 4000

Approximate Scale in Feet

Kennedy/Jenks/Chilton

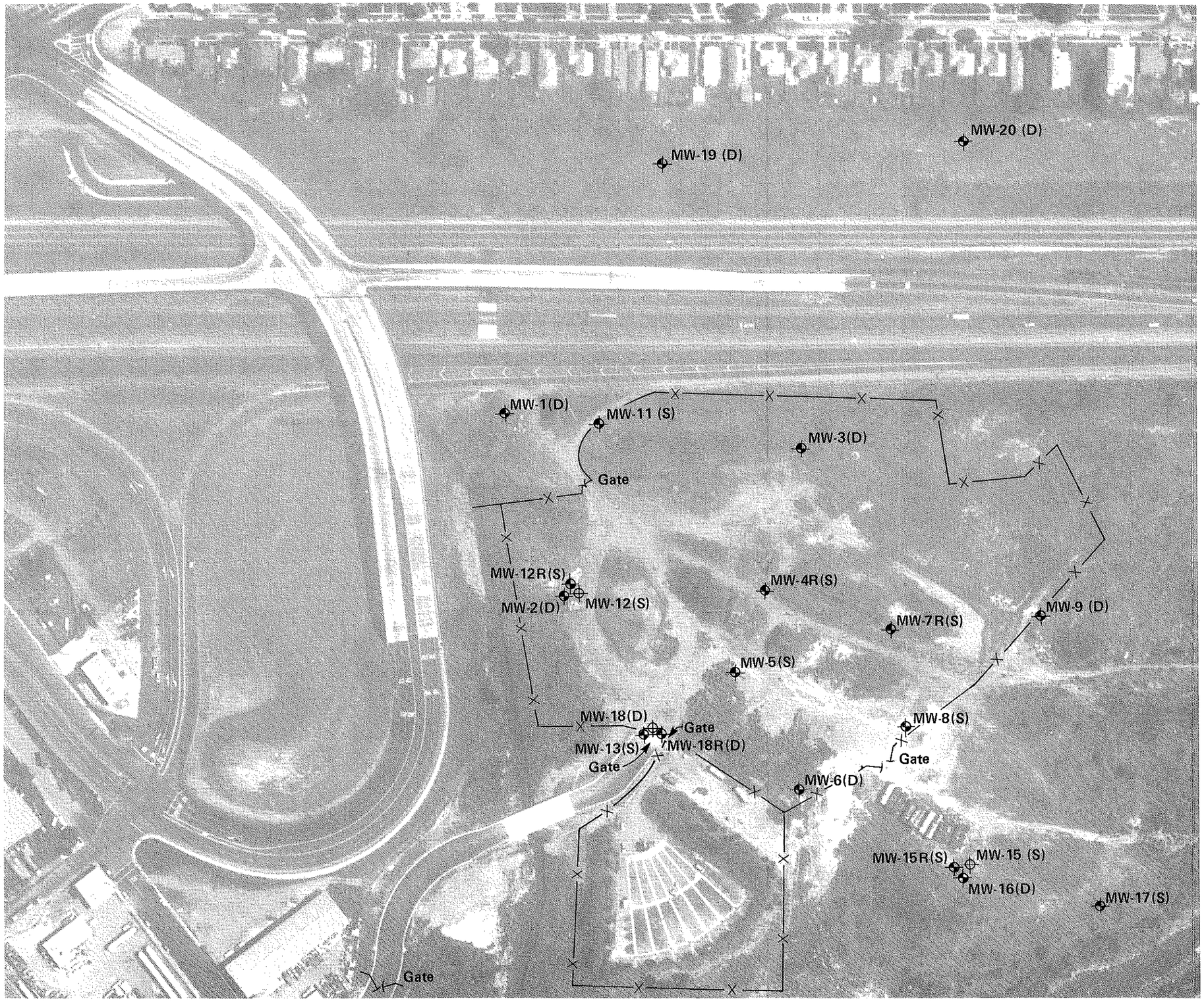
Southern Pacific Transportation Company
Liquid Gold Site

Location of Private Wells in Vicinity of Site

LG006369

K/J/C 855018.07
December 1990

Figure 27



N

0 150 300

Approximate Scale in Feet

Basemap Reference

Pacific Aerial Survey.
Job number AV3268-7-10. Flown 30 March 1988.
Airphoto negative scale. 1 inch = 1000 feet.

Legend:

MW-3	Monitoring Well Location and Number
MW-12	Destroyed Monitoring Well Location and Number
(S)	Shallow Well
(D)	Deep Well
—X—	Fence

Kennedy/Jenks/Chilton

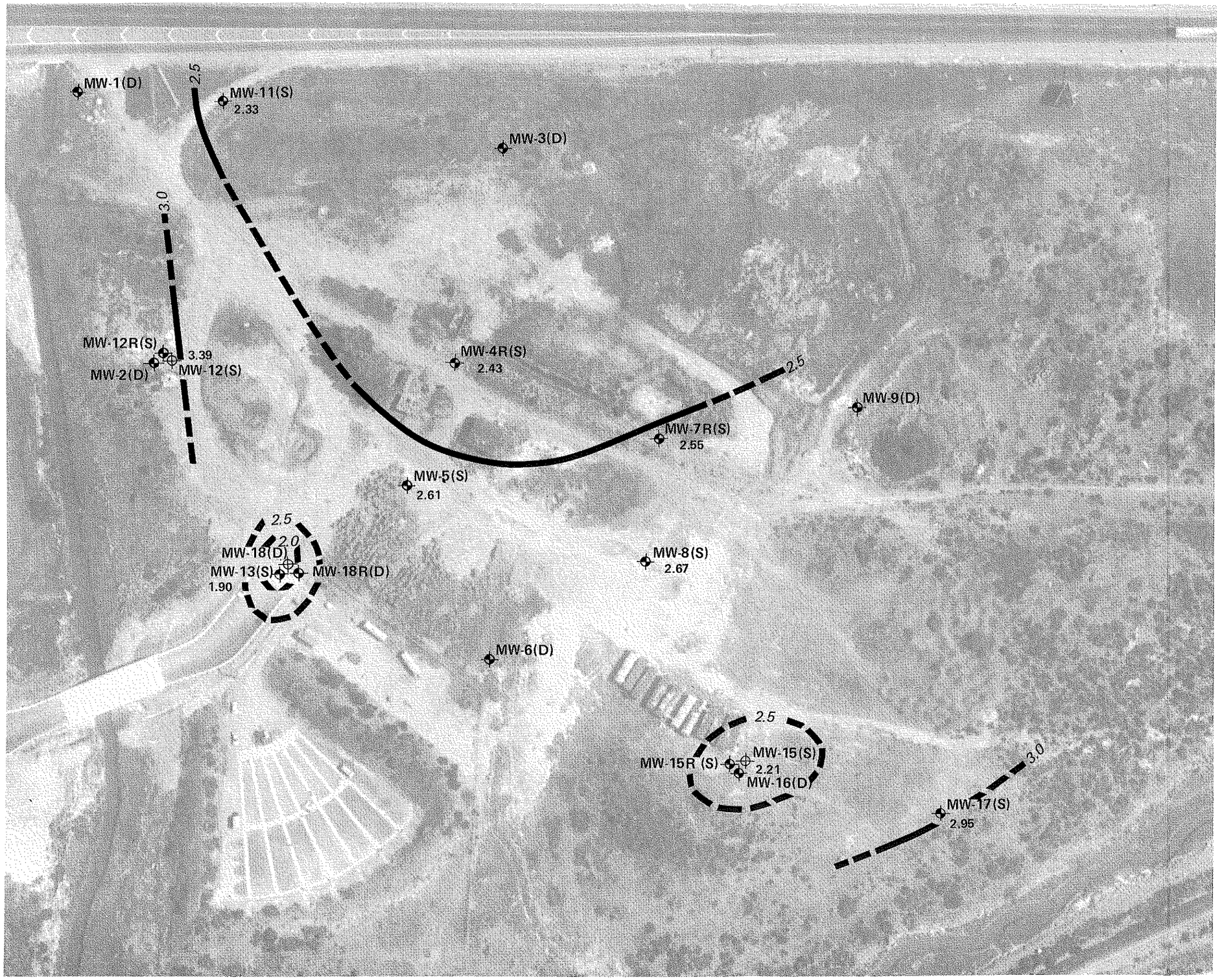
Southern Pacific Transportation Company
Liquid Gold Site

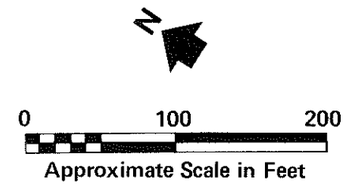
Locations of Monitoring Wells

LG006370

K/J/C 855018.07
December 1990

Figure 28





Basemap Reference

Pacific Aerial Survey.
Job number AV3268-7-10. Flown 30 March 1988.
Airphoto negative scale: 1 inch = 1000 feet.

Legend:

MW-9	Monitoring Well Location and Number
MW-12	Destroyed Monitoring Well Location and Number
(S)	Shallow Well
(D)	Deep Well
3.0	Contour of Equal Ground–Water Elevation (dashed where inferred)
2.43	Groundwater Elevation Measurement (Feet Above Mean Sea Level)

Notes:

1. All locations are approximate.

Kennedy/Jenks/Chilton

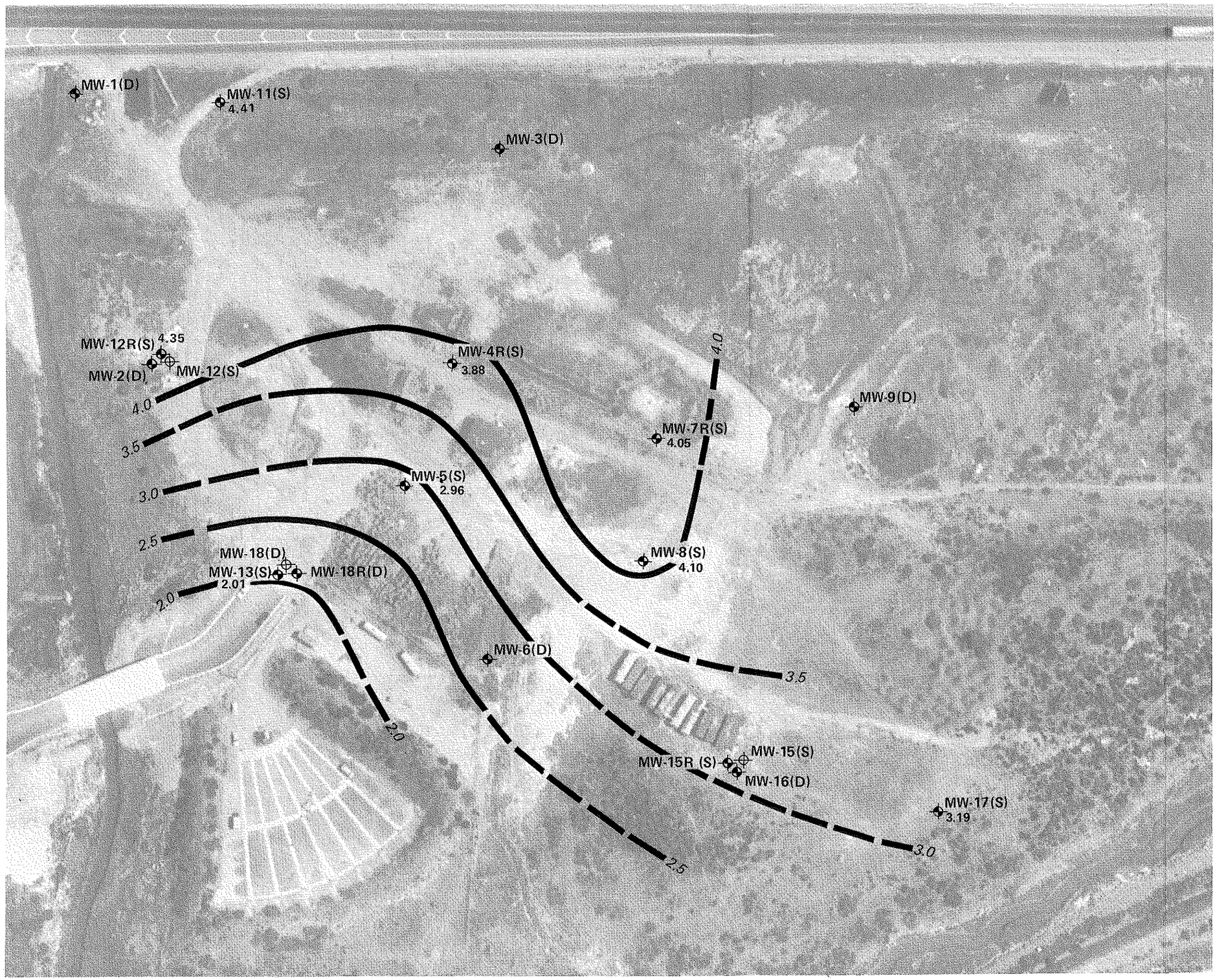
Southern Pacific Transportation Company
Liquid Gold Site

Approximate Groundwater Elevation Contours - Shallow Zone: 16 December 1988

LG006371

K/J/C 855018.07
December 1990

Figure 29



N

0 100 200

Approximate Scale in Feet

Basemap Reference

Pacific Aerial Survey.
Job number AV3268-7-10. Flown 30 March 1988.
Airphoto negative scale: 1 inch = 1000 feet.

Legend:

MW-9	Monitoring Well Location and Number
MW-12	Destroyed Monitoring Well Location and Number
(S)	Shallow Well
(D)	Deep Well
3.0	Contour of Equal Ground–Water Elevation (dashed where inferred)
2.43	Groundwater Elevation Measurement (Feet Above Mean Sea Level)

Notes:

1. All locations are approximate.
2. Well MW-15 was damaged and not measured.

Kennedy/Jenks/ Chilton

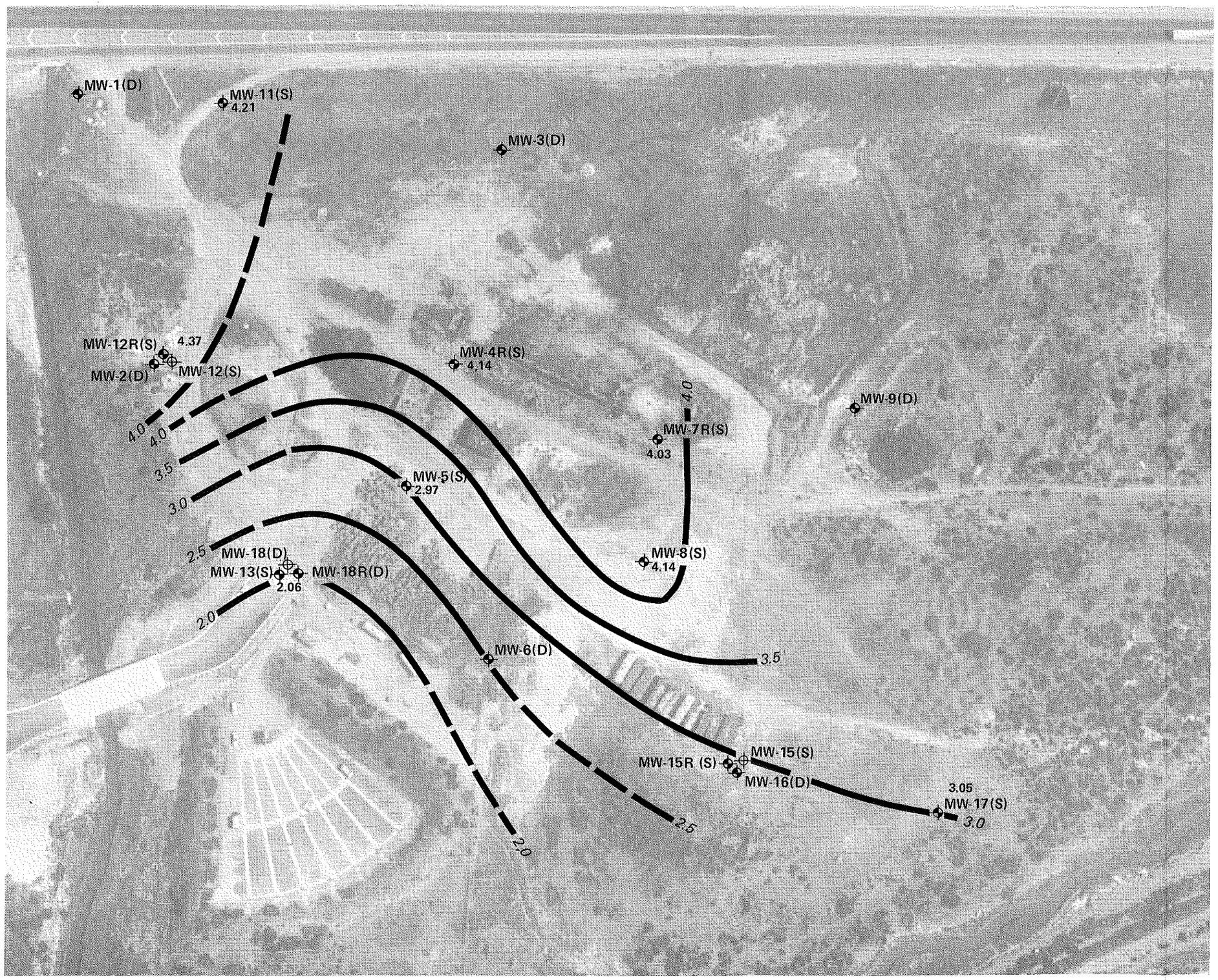
Southern Pacific Transportation Company
Liquid Gold Site

Approximate Groundwater Elevation Contours - Shallow Zone: 5 January 1989

LG006372

K/J/C 855018.07
December 1990

Figure 30



N

0 100 200

Approximate Scale in Feet

Basemap Reference

Pacific Aerial Survey.
Job number AV3268-7-10. Flown 30 March 1988.
Airphoto negative scale: 1 inch = 1000 feet.

Legend:

MW-9	Monitoring Well Location and Number
MW-12	Destroyed Monitoring Well Location and Number
(S)	Shallow Well
(D)	Deep Well
3.0	Contour of Equal Ground–Water Elevation (dashed where inferred)
2.43	Groundwater Elevation Measurement (Feet Above Mean Sea Level)

Notes:

1. All locations are approximate.
2. Well MW-15 was damaged and not measured.

Kennedy/Jenks/Chilton

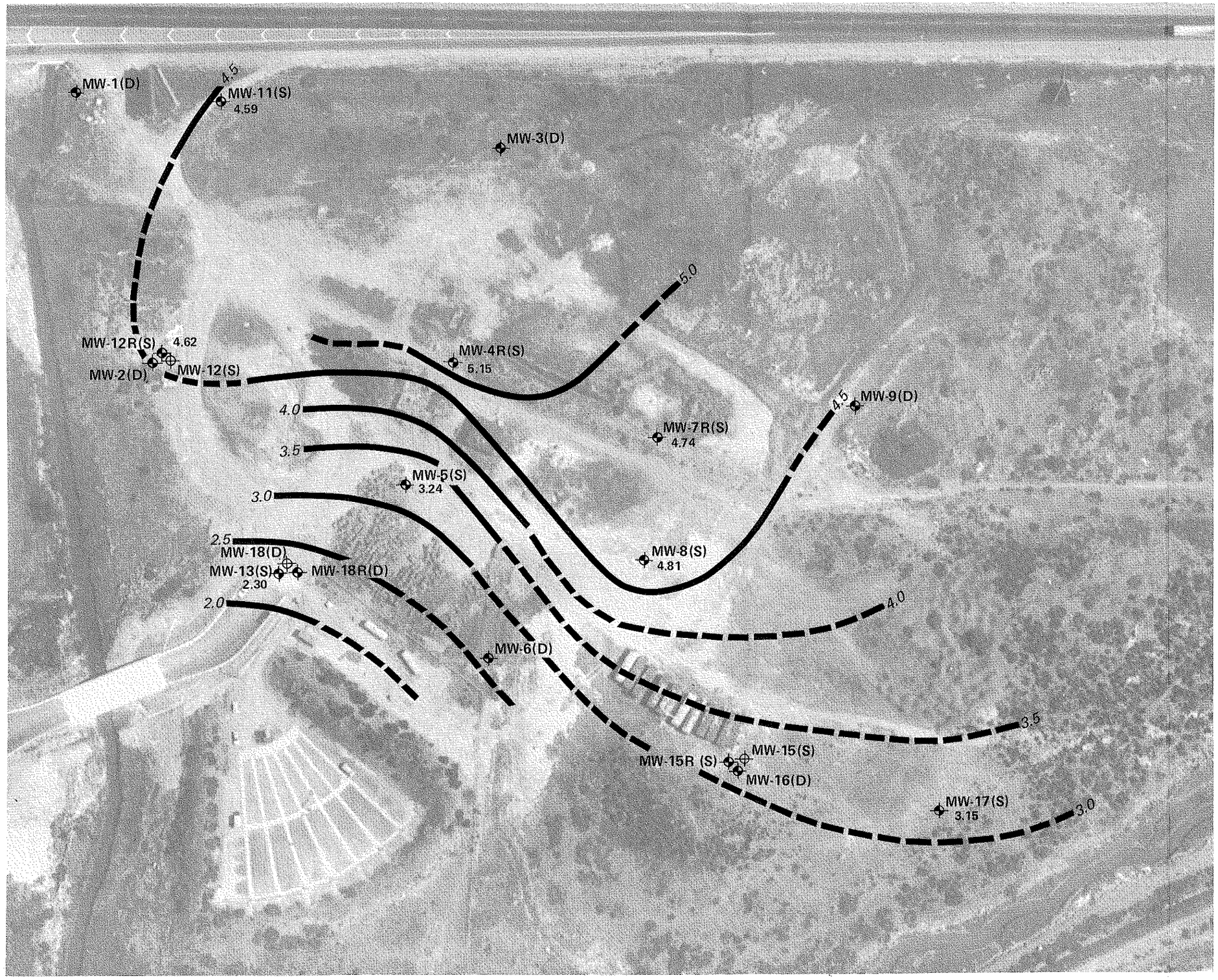
Southern Pacific Transportation Company
Liquid Gold Site

Approximate Groundwater Elevation Contours - Shallow Zone: 10 February 1989

K/J/C 855018.07
December 1990

LG006373

Figure 31



N

0 100 200

Approximate Scale in Feet

Basemap Reference

Pacific Aerial Survey.
Job number AV3268-7-10. Flown 30 March 1988.
Airphoto negative scale: 1 inch = 1000 feet.

Legend:

MW-9	Monitoring Well Location and Number
MW-12	Destroyed Monitoring Well Location and Number
(S)	Shallow Well
(D)	Deep Well
3.0	Contour of Equal Ground–Water Elevation (dashed where inferred)
2.43	Groundwater Elevation Measurement (Feet Above Mean Sea Level)

Notes:

1. All locations are approximate.
2. Well MW-15 Was Damaged And Not Measured.

Kennedy/Jenks/Chilton

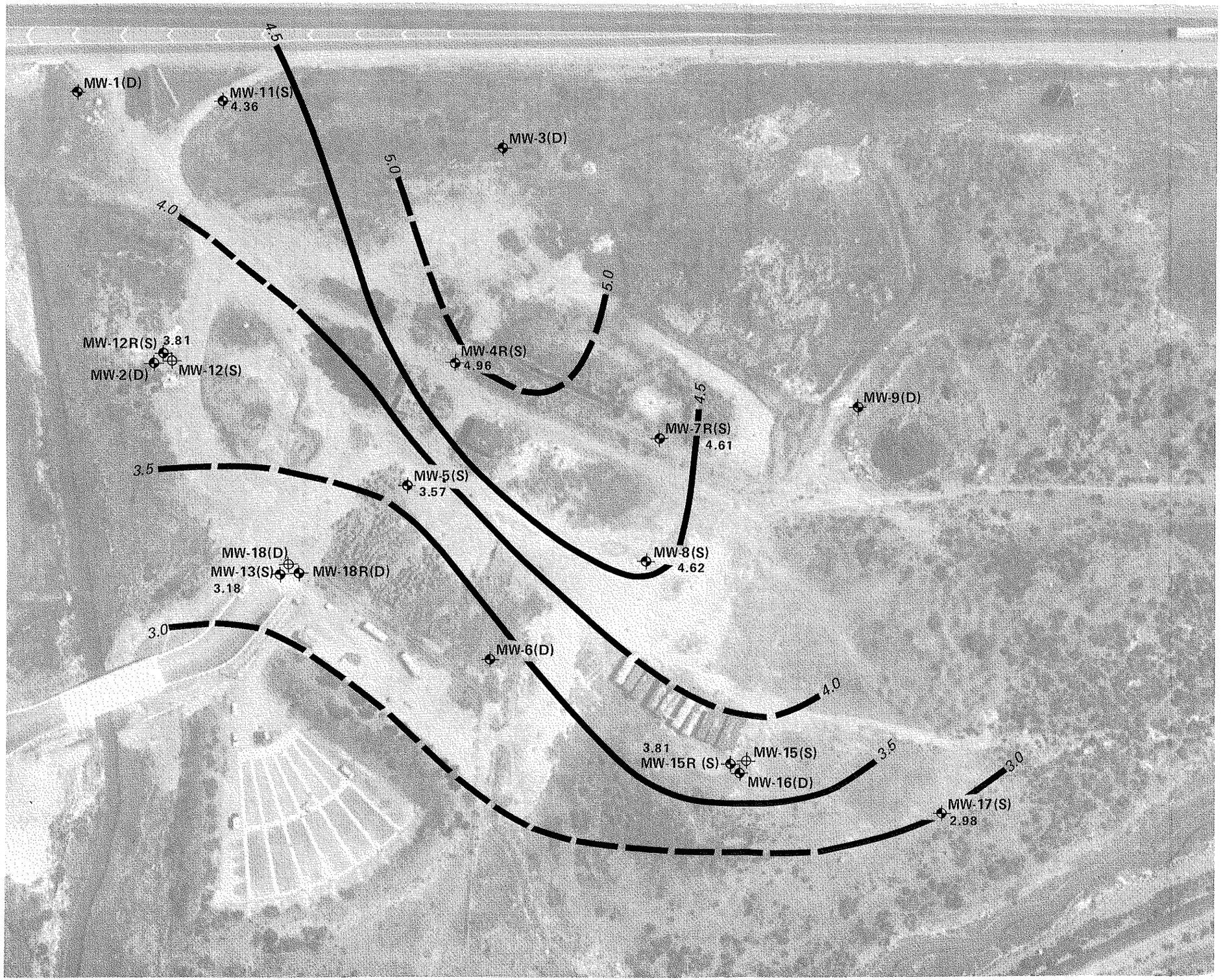
Southern Pacific Transportation Company
Liquid Gold Site

Approximate Groundwater Elevation Contours - Shallow Zone: 10 March 1989

K/J/C 855018.07
December 1990

LG006374

Figure 32



N

0 100 200

Approximate Scale in Feet

Basemap Reference

Pacific Aerial Survey.
Job number AV3268-7-10. Flown 30 March 1988.
Airphoto negative scale: 1 inch = 1000 feet.

Legend:

MW-9	Monitoring Well Location and Number
MW-12	Destroyed Monitoring Well Location and Number
(S)	Shallow Well
(D)	Deep Well
3.0	Contour of Equal Ground–Water Elevation (dashed where inferred)
2.43	Groundwater Elevation Measurement (Feet Above Mean Sea Level)

Notes:

1. All locations are approximate.

Kennedy/Jenks/Chilton

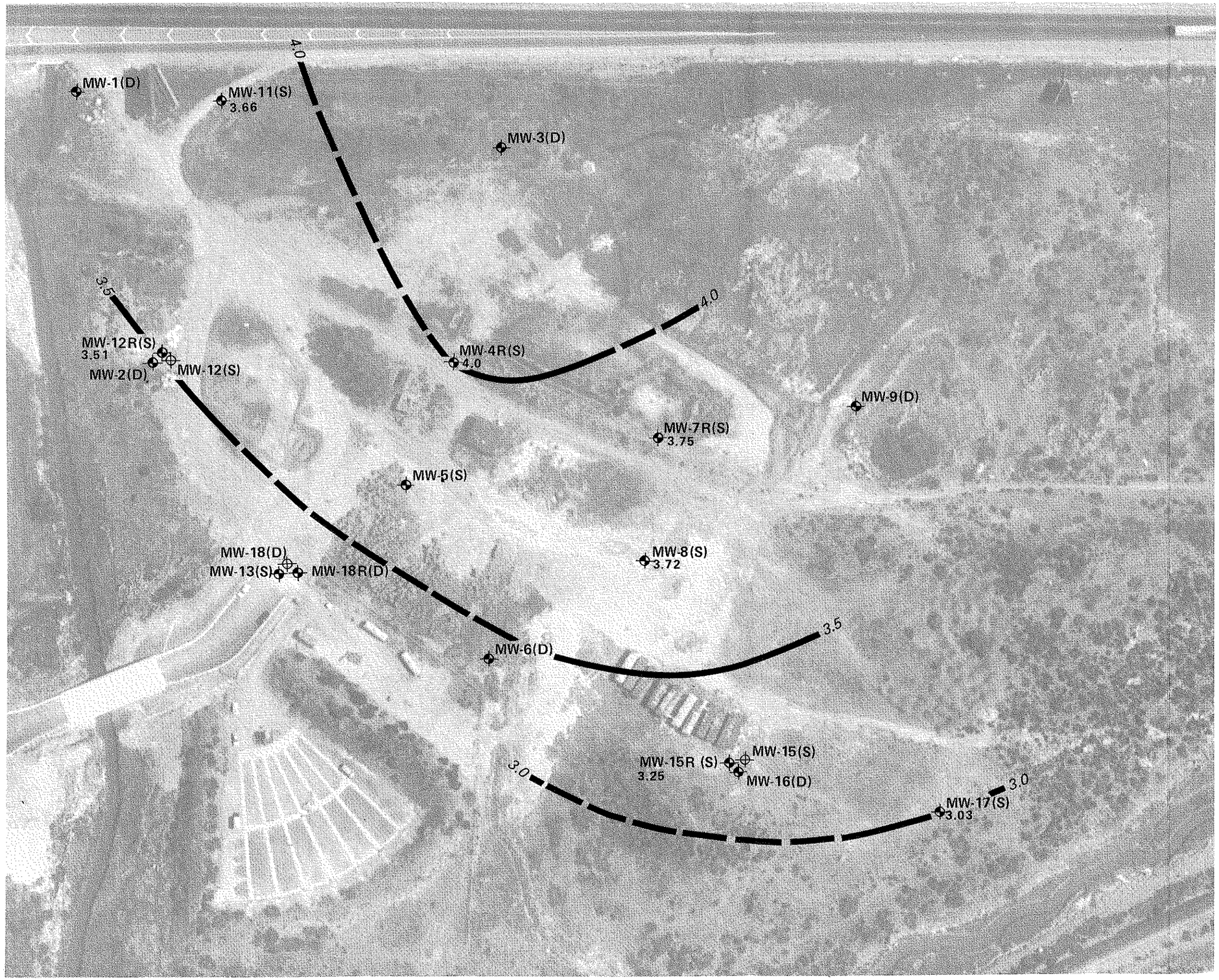
Southern Pacific Transportation Company
Liquid Gold Site

Approximate Groundwater Elevation Contours - Shallow Zone: 5 April 1989

LG006375

K/J/C 855018.07
December 1990

Figure 33



N

0 100 200

Approximate Scale in Feet

Basemap Reference

Pacific Aerial Survey.
Job number AV3268-7-10. Flown 30 March 1988.
Airphoto negative scale: 1 inch = 1000 feet.

Legend:

MW-9	Monitoring Well Location and Number
MW-12	Destroyed Monitoring Well Location and Number
(S)	Shallow Well
(D)	Deep Well
3.0	Contour of Equal Ground–Water Elevation (dashed where inferred)
2.43	Groundwater Elevation Measurement (Feet Above Mean Sea Level)

Notes:

1. All locations are approximate.

Kennedy/Jenks/Chilton

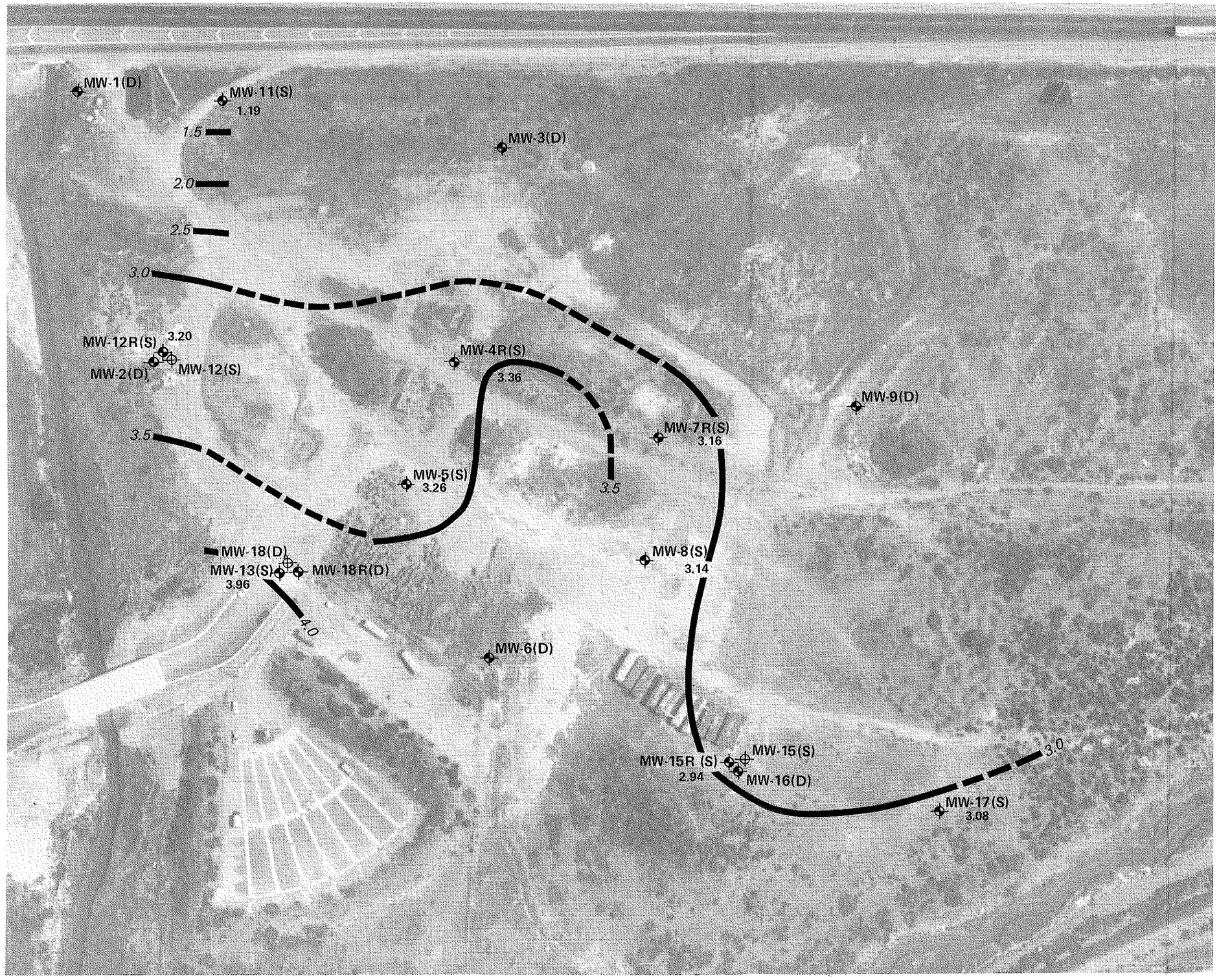
Southern Pacific Transportation Company
Liquid Gold Site

Approximate Groundwater Elevation Contours - Shallow Zone. 5 May 1989

LG006376

K/J/C 855018.07
December 1990

Figure 34



0 100 200

Approximate Scale in Feet

Basemap Reference

Pacific Aerial Survey.
Job number AV3268-7-10. Flown 30 March 1988.
Airphoto negative scale: 1 inch = 1000 feet.

Legend:

MW-9	Monitoring Well Location and Number
MW-12	Destroyed Monitoring Well Location and Number
(S)	Shallow Well
(D)	Deep Well
3.0	Contour of Equal Ground–Water Elevation (dashed where inferred)
2.43	Groundwater Elevation Measurement (Feet Above Mean Sea Level)

Notes:

1. All locations are approximate.

Kennedy/Jenks/Chilton

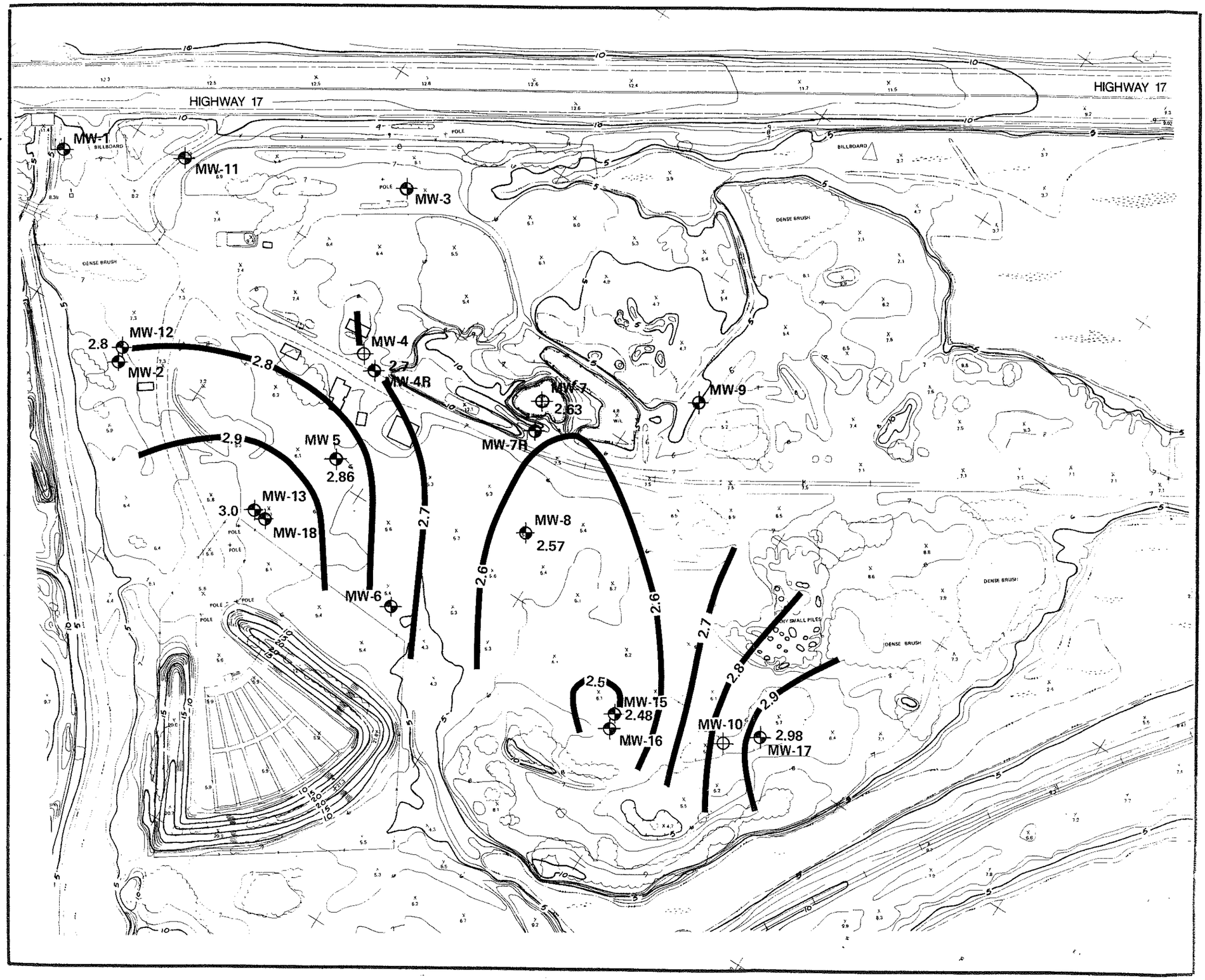
Southern Pacific Transportation Company
Liquid Gold Site

Approximate Groundwater Elevation Contours - Shallow Zone: 6 June 1989

K/J/C 855018.07
December 1990

LG006377

Figure 35



Basemap Reference

Hammon, Jensen, Wallen & Associates.
Job Number 5841. Flown 26 November 1984.
Airphoto Negative Scale 1 inch = 300 feet.

Legend

MW 9	Monitoring well number and location
MW 4	Abandoned monitoring well number and location
2.8	Groundwater elevation contour (feet msl)

Notes

1. Contour interval is 0.1 foot.
2. Boring and monitoring well locations are approximate.
3. References:
   a) Monitoring wells 1-10. Ecology and Environment, Inc. "Site Investigation of the Southern Pacific Stege Lease/ Liquid Gold Site." February 28, 1984.
   b) Monitoring wells 4R, 7R, 11-13, 15-18. Kennedy/Jenks/Chilton, "Status Report Regarding Phase III Technical Activities." November 10, 1986.

Kennedy/Jenks/Chilton

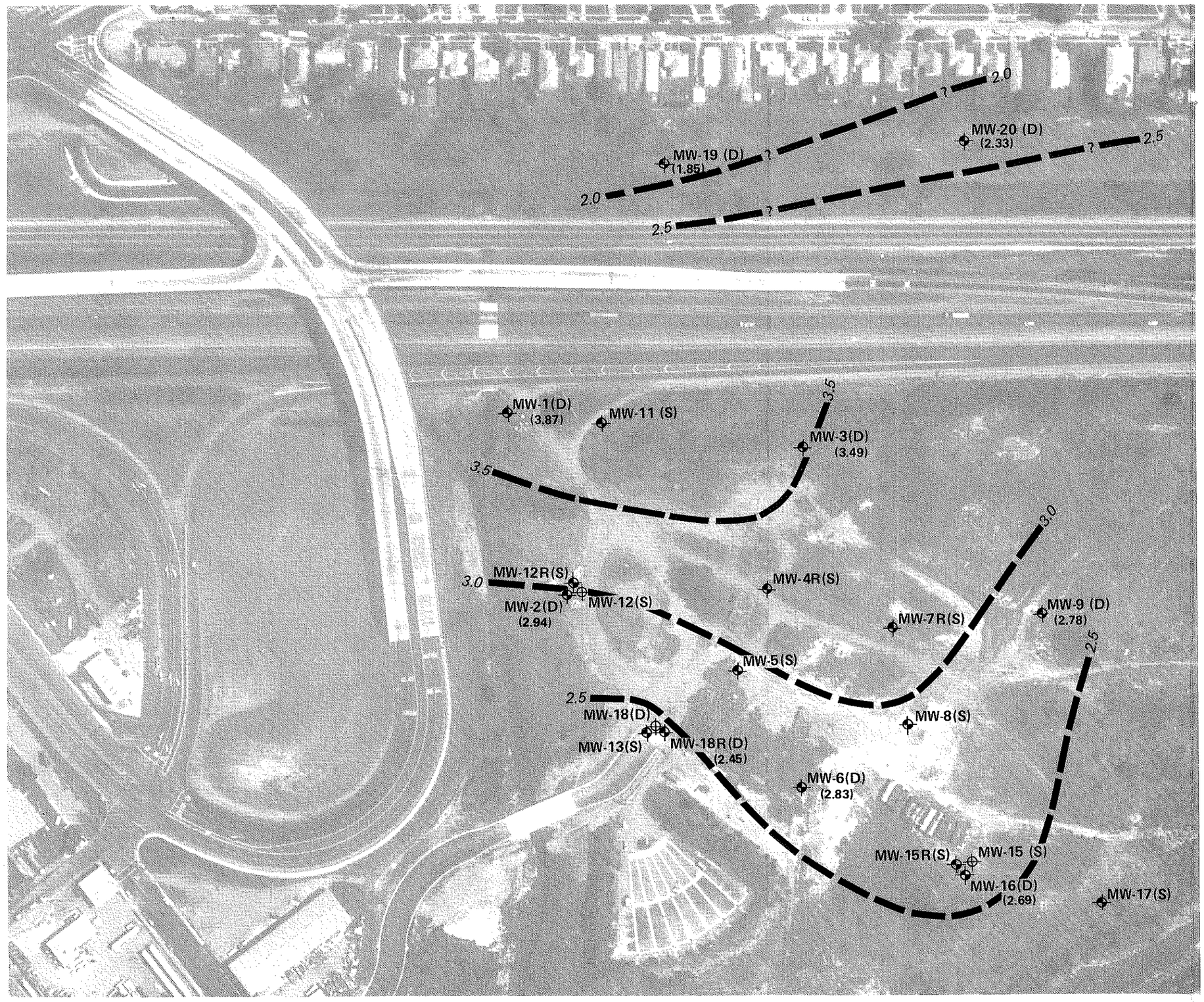
Southern Pacific Transportation Company
Liquid Gold Site

Approximate Groundwater Elevation Contours - Shallow Zone
11 August 1986

LG006378

K/J/C 855018.07
December 1990

Figure 36



N

0 150 300

Approximate Scale in Feet

Basemap Reference

Pacific Aerial Survey.
Job number AV3268-7-10. Flown 30 March 1988.
Airphoto negative scale: 1 inch = 1000 feet.

Legend:

MW-3	Monitoring Well Location and Number
MW-12	Destroyed Monitoring Well Location and Number
(S)	Shallow Well
(D)	Deep Well
3.0	Contour Line of Equal Groundwater Elevation (dashed where inferred)

Kennedy/Jenks/Chilton

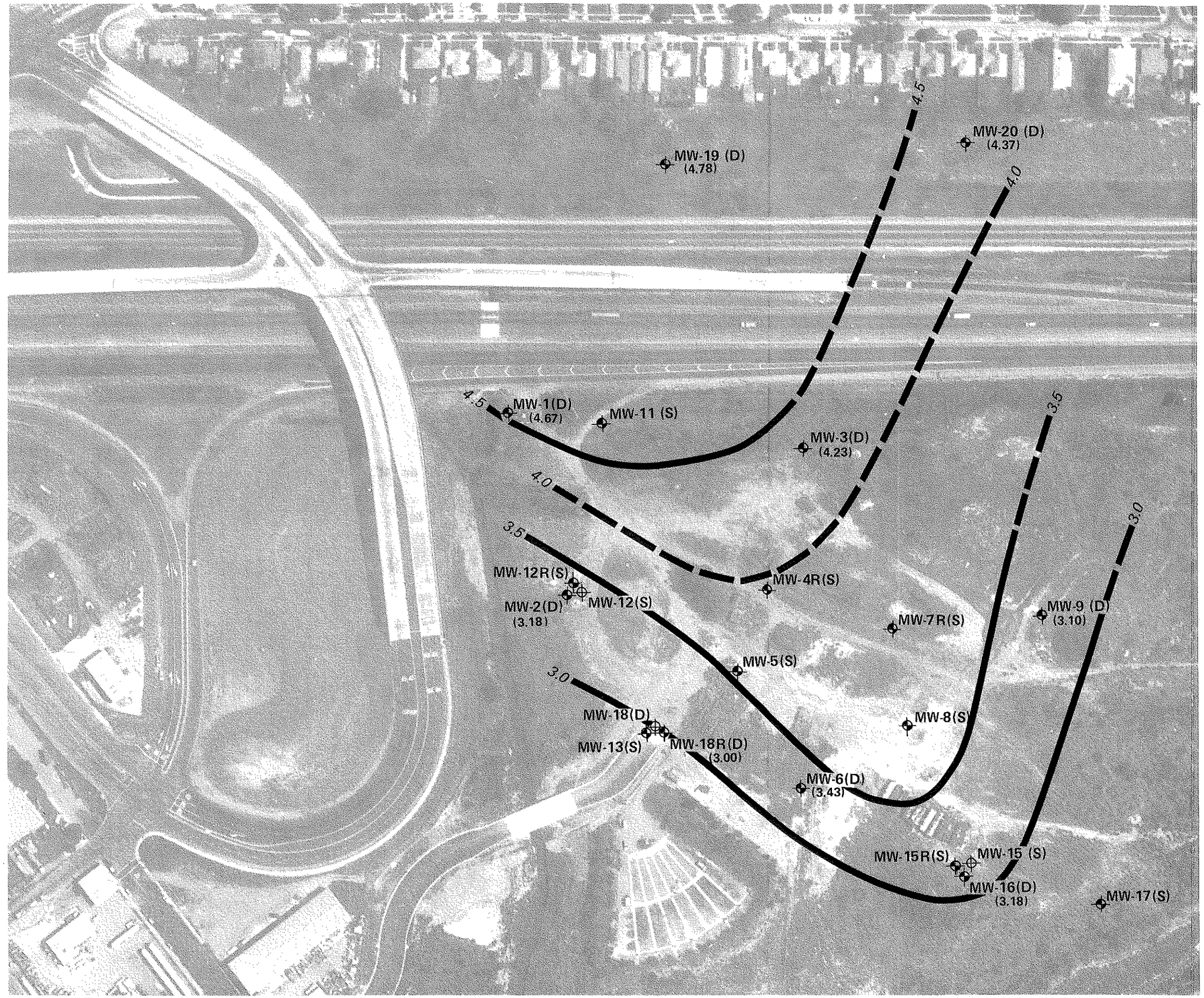
Southern Pacific Transportation Company
Liquid Gold Site

Approximate Groundwater Elevation Contours - Deep Zone: 10 October 1988

LG006379

K/J/C 855018.07
December 1990

Figure 37



N

0 150 300

Approximate Scale in Feet

Basemap Reference

Pacific Aerial Survey.
Job number AV3268-7-10. Flown 30 March 1988.
Airphoto negative scale. 1 inch = 1000 feet.

Legend:

MW-3	Monitoring Well Location and Number
MW-12	Destroyed Monitoring Well Location and Number
(S)	Shallow Well
(D)	Deep Well
3.0	Contour Line of Equal Groundwater Elevation (dashed where inferred)

Kennedy/Jenks/Chilton

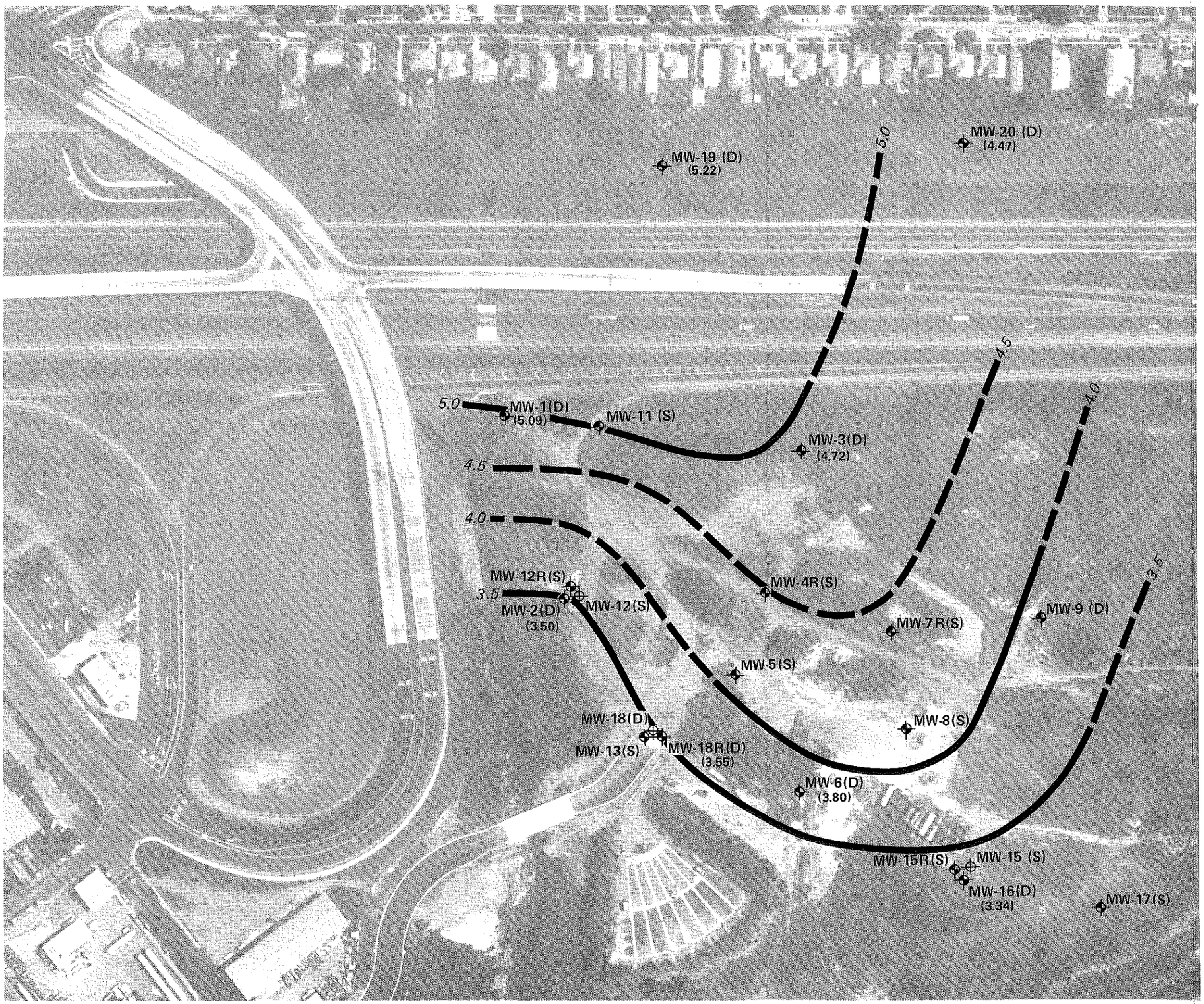
Southern Pacific Transportation Company
Liquid Gold Site

Approximate Groundwater Elevation Contours - Deep Zone: 5 January 1989

K/J/C 855018.07
December 1990

LG006380

Figure 38



N

0 150 300

Approximate Scale in Feet

Basemap Reference

Pacific Aerial Survey.
Job number AV3268-7-10. Flown 30 March 1988.
Airphoto negative scale. 1 inch = 1000 feet.

Legend:

MW-3	Monitoring Well Location and Number
MW-12	Destroyed Monitoring Well Location and Number
(S)	Shallow Well
(D)	Deep Well
3.5	Contour Line of Equal Groundwater Elevation (dashed where inferred)

Kennedy/Jenks/Chilton

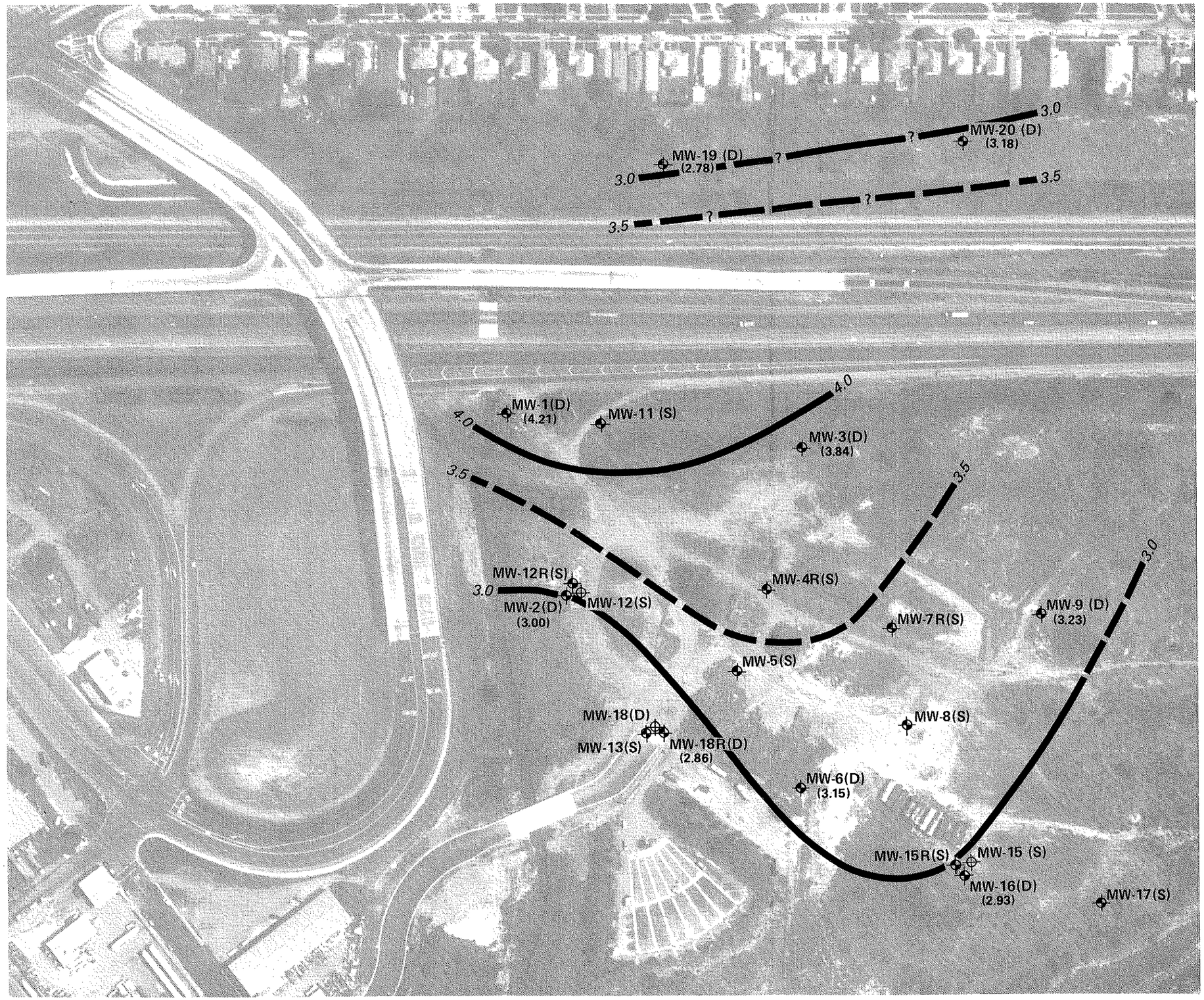
Southern Pacific Transportation Company
Liquid Gold Site

Approximate Groundwater Elevation Contours - Deep Zone: 5 April 1989

K/J/C 855018.07
December 1990

LG006381

Figure 39



N

0 150 300

Approximate Scale in Feet

Basemap Reference

Pacific Aerial Survey.
Job number AV3268-7-10. Flown 30 March 1988.
Airphoto negative scale. 1 inch = 1000 feet.

Legend:

MW-3	Monitoring Well Location and Number
MW-12	Destroyed Monitoring Well Location and Number
(S)	Shallow Well
(D)	Deep Well
3.0	Contour Line of Equal Groundwater Elevation (dashed where inferred)

Kennedy/Jenks/Chilton

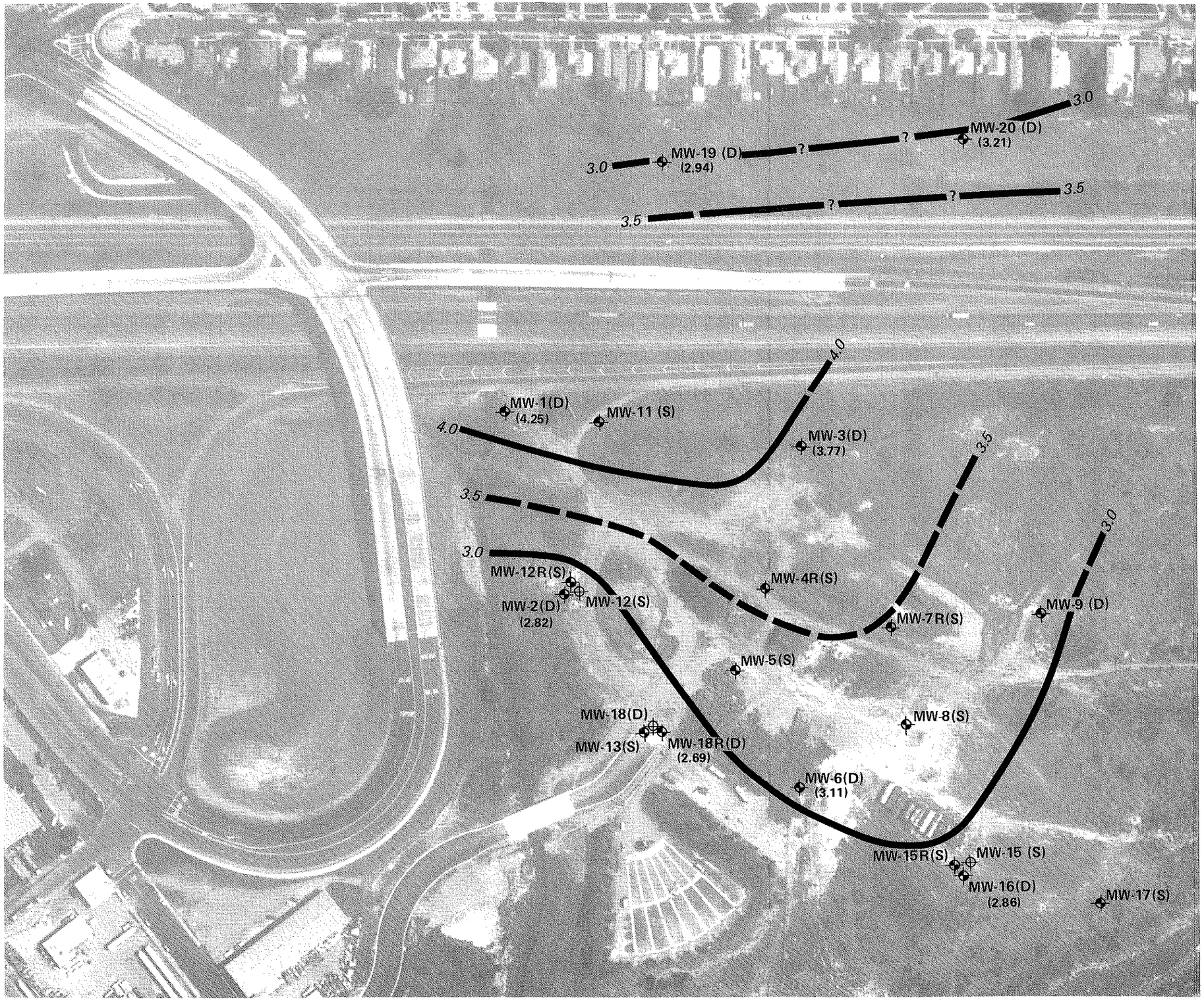
Southern Pacific Transportation Company
Liquid Gold Site

Approximate Groundwater Elevation Contours - Deep Zone. 10 July 1989

K/J/C 855018.07
December 1990

LG006382

Figure 40



N

0 150 300

Approximate Scale in Feet

Basemap Reference

Pacific Aerial Survey.
Job number AV3268-1-10. Flown 30 March 1988.
Airphoto negative scale. 1 inch = 1000 feet.

Legend:

MW-3	Monitoring Well Location and Number
MW-12	Destroyed Monitoring Well Location and Number
(S)	Shallow Well
(D)	Deep Well
3.0	Contour Line of Equal Groundwater Elevation (dashed where inferred)

Kennedy/Jenks/Chilton

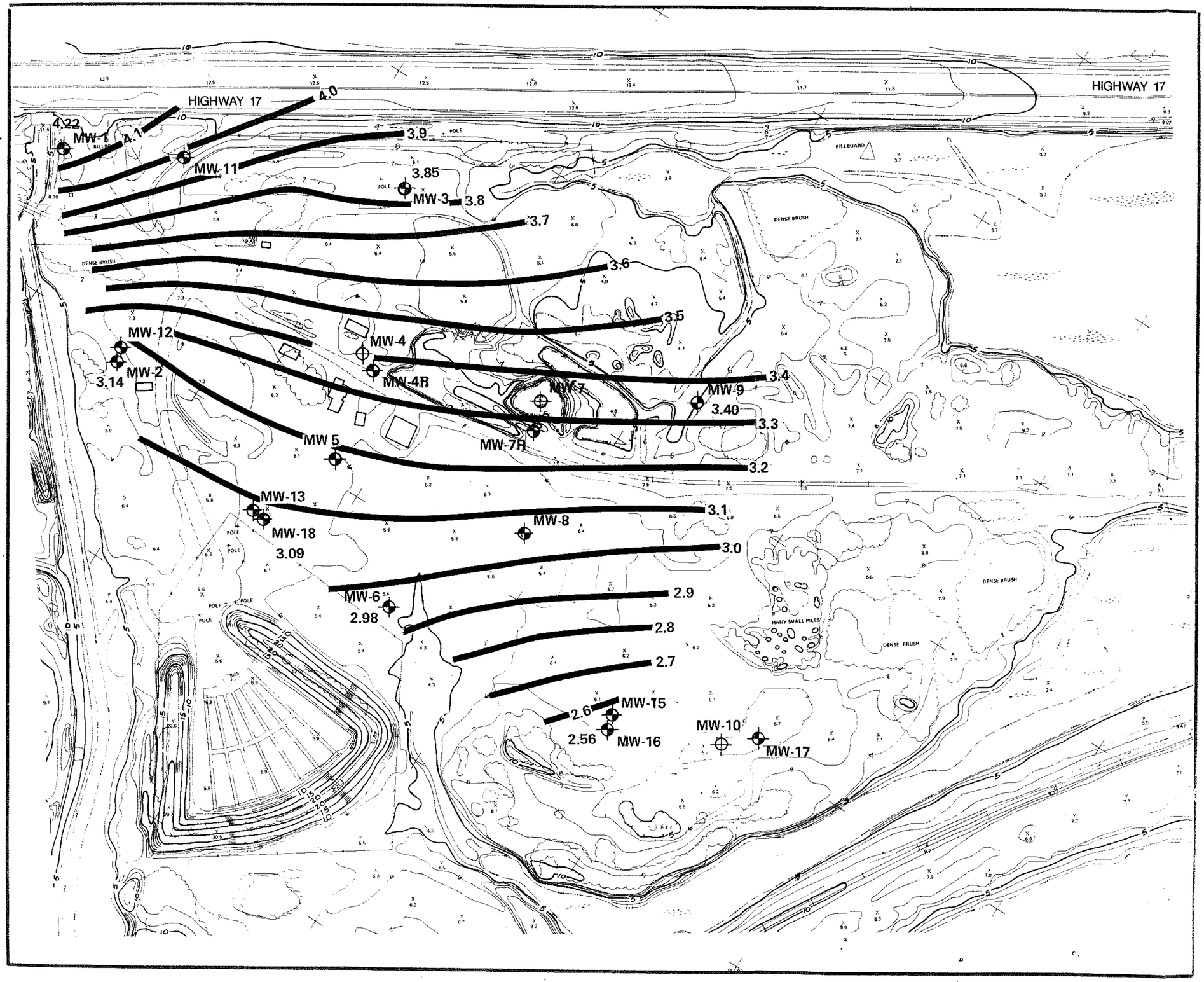
Southern Pacific Transportation Company
Liquid Gold Site

Approximate Groundwater Elevation Contours - Deep Zone: 9 October 1989

K/J/C 855018.07
December 1990

LG006383

Figure 41



N

0 125 250

Scale in Feet
(Approx.)

Basemap Reference

Hammon, Jensen, Wallen & Associates.
Job Number 5841. Flown 26 November 1984.
Airphoto negative scale 1 inch = 300 feet.

Legend

MW-1	Monitoring well number and location
MW-4	Abandoned monitoring well number and location
3.3	Groundwater elevation contour (feet, msl)

Notes

1. Contour interval is 0.1 foot.
2. References:
   (a) Monitoring wells 1-10. Ecology and Environment, Inc. "Site Investigation of the Southern Pacific Stege Lease/ Liquid Gold Site." February 28, 1984.
   (b) Monitoring wells 4R, 7R, 11-13. 15-18. Kennedy/Jenks/Chilton, "Status Report Regarding Phase III Technical Activities." November 10, 1986.

Kennedy/Jenks/Chilton

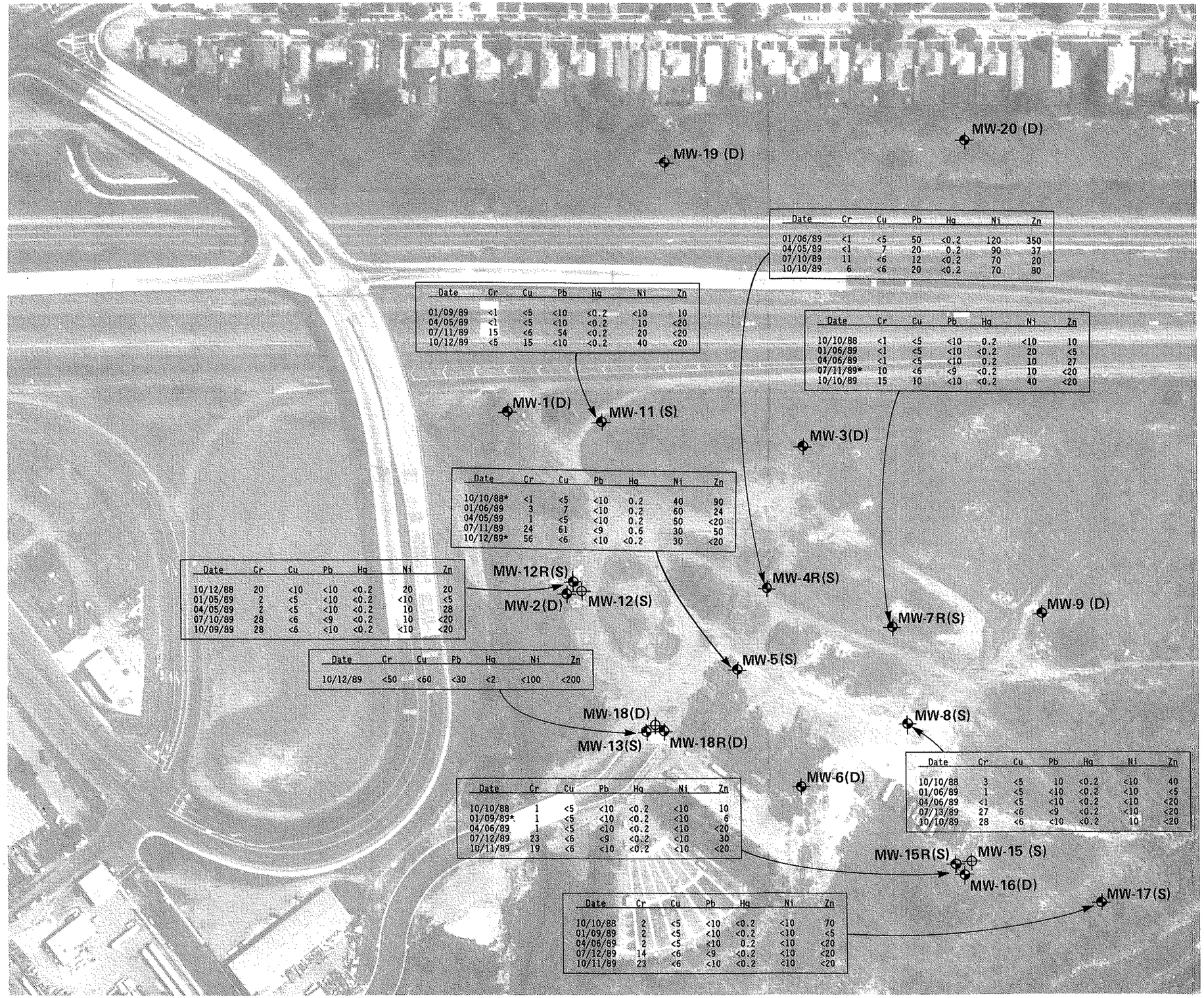
Southern Pacific Transportation Company
Liquid Gold Site

Approximate Groundwater Elevation Contours - Deep Zone
11 August 1986

LG006384

K/J/C 855018.07
December 1990

Figure 42



Date	Cr	Cu	Pb	Hg	Ni	Zn
01/06/89	<1	<5	50	<0.2	120	350
04/05/89	<1	7	20	0.2	90	37
07/10/89	11	<6	12	<0.2	70	20
10/10/89	6	<6	20	<0.2	70	80

Date	Cr	Cu	Pb	Hg	Ni	Zn
01/09/89	<1	<5	<10	<0.2	<10	10
04/05/89	<1	<5	<10	<0.2	10	<20
07/11/89	15	<6	54	<0.2	20	<20
10/12/89	<5	15	<10	<0.2	40	<20

Date	Cr	Cu	Pb	Hg	Ni	Zn
10/10/88	<1	<5	<10	0.2	<10	10
01/06/89	<1	<5	<10	<0.2	20	<5
04/06/89	<1	<5	<10	0.2	10	27
07/11/89*	10	<6	<9	<0.2	10	<20
10/10/89	15	10	<10	<0.2	40	<20

Date	Cr	Cu	Pb	Hg	Ni	Zn
10/10/88*	<1	<5	<10	0.2	40	90
01/06/89	3	7	<10	0.2	60	24
04/05/89	1	<5	<10	0.2	50	<20
07/11/89	24	61	<9	0.6	30	50
10/12/89*	56	<6	<10	<0.2	30	<20

Date	Cr	Cu	Pb	Hg	Ni	Zn
10/12/88	20	<10	<10	<0.2	20	20
01/05/89	2	<5	<10	<0.2	<10	<5
04/05/89	2	<5	<10	<0.2	10	28
07/10/89	28	<6	<9	<0.2	10	<20
10/09/89	28	<6	<10	<0.2	<10	<20

Date	Cr	Cu	Pb	Hg	Ni	Zn
10/12/89	<50	<60	<30	<2	<100	<200

Date	Cr	Cu	Pb	Hg	Ni	Zn
10/10/88	1	<5	<10	<0.2	<10	10
01/09/89*	1	<5	<10	<0.2	<10	6
04/06/89	1	<5	<10	<0.2	<10	<20
07/12/89	23	<6	<9	<0.2	<10	30
10/11/89	19	<6	<10	<0.2	<10	<20

Date	Cr	Cu	Pb	Hg	Ni	Zn
10/10/88	3	<5	10	<0.2	<10	40
01/06/89	1	<5	<10	<0.2	<10	<5
04/06/89	<1	<5	<10	<0.2	<10	<20
07/13/89	27	<6	<9	<0.2	<10	<20
10/10/89	28	<6	<10	<0.2	10	<20

Date	Cr	Cu	Pb	Hg	Ni	Zn
10/10/88	2	<5	<10	<0.2	<10	70
01/09/89	2	<5	<10	<0.2	<10	<5
04/06/89	2	<5	<10	0.2	<10	<20
07/12/89	14	<6	<9	<0.2	<10	<20
10/11/89	23	<6	<10	<0.2	<10	<20

N

0 150 300

Approximate Scale in Feet

Basemap Reference

Pacific Aerial Survey.
Job number AV3268-7-10. Flown 30 March 1988.
Airphoto negative scale. 1 inch = 1000 feet.

Legend:

MW-3	Monitoring Well Location and Number
MW-12	Destroyed Monitoring Well Location and Number
(S)	Shallow Well
(D)	Deep Well

Notes

1. All locations are approximate.
2. Concentrations in micrograms per liter (ug/L). A (*) indicates the values represent the arithmetic average of duplicate samples.
3. Well MW-15 was damaged for the January 1989 sampling round. Well MW-15R was constructed and sampled from April 1989 onward.

Kennedy/Jenks/Chilton

Southern Pacific Transportation Company
Liquid Gold Site

Dissolved Metals Concentrations-Shallow Zone

LG006385

K/J/C 855018.07
December 1990

Figure 43

Date	Cr	Cu	Pb	Hg	Ni	Zn
10/11/88*	<1	<5	<10	<0.2	<10	12
01/06/89	<1	<5	<10	<0.2	<10	<5
04/07/89	<1	<5	<10	<0.2	<10	14
07/13/89	8	<6	<9	<0.2	<10	<20
10/11/89	10	<6	<10	<0.2	<10	<20

Date	Cr	Cu	Pb	Hg	Ni	Zn
10/11/88	<1	8	<10	<0.2	<10	9
01/06/89	3	<5	<10	<0.2	<10	<5
04/07/89*	3	<5	<10	<0.2	10	12
07/13/89	<5	<6	18	0.2	<10	<20
10/11/89	<5	<6	<10	<0.2	<10	<20

Date	Cr	Cu	Pb	Hg	Ni	Zn
10/12/88	<1	<10	<10	<0.2	<10	80
01/06/89	1	<5	<10	<0.2	30	55
04/05/89	<1	<5	<10	<0.2	10	25
07/11/89	24	8	<9	<0.2	20	40
10/10/89	24	8	20	<0.2	60	30

Date	Cr	Cu	Pb	Hg	Ni	Zn
11/11/88*	25	6	<10	<0.2	30	3
01/09/89	<1	<5	<10	<0.2	<10	5
04/06/89	<1	<5	<10	<0.2	<10	<20
07/10/89*	22	<6	<9	<0.2	<10	20
10/09/89	31	48	<10	<0.2	30	<20

Date	Cr	Cu	Pb	Hg	Ni	Zn
10/12/88*	<1	<5	<10	<0.2	20	20
01/09/89	2	<5	<10	<0.2	<10	35
04/06/89	1	<5	<10	<0.2	<10	<20
07/13/89*	27	<6	<9	<0.2	<10	<20
10/10/89*	42	6	<10	<0.2	50	<20

Date	Cr	Cu	Pb	Hg	Ni	Zn
10/11/88	<1	30	<10	<0.2	50	220
01/15/89	<1	7	<10	<0.2	60	12
04/05/89	4	8	<10	0.6	50	35
07/10/89	38	<6	<9	1.8	20	<20
10/09/89	48	9	<10	2.2	110	30

Date	Cr	Cu	Pb	Hg	Ni	Zn
10/12/88	<1	<10	<10	<0.2	20	16
01/05/89*	<1	14	<10	<0.2	90	16
04/05/89*	<1	<5	<10	<0.2	90	55
07/11/89	29	16	<9	0.2	50	<20
10/09/89	29	<6	<10	0.2	90	<20

Date	Cr	Cu	Pb	Hg	Ni	Zn
10/10/88	1	<5	<10	<0.2	<10	20
01/06/89	2	15	<10	<0.2	<10	<5
04/06/89	2	<5	<10	<0.2	<10	54
07/12/89	30	<6	<9	0.2	<10	60
10/12/89	34	<6	<10	<0.2	<10	<20

Date	Cr	Cu	Pb	Hg	Ni	Zn
10/10/88	<1	10	<10	<0.2	<10	40
01/09/89	1	<5	<10	0.2	<10	14
04/06/89*	<1	<5	<10	<0.2	<10	26
07/12/89	24	<6	<9	<0.2	<10	<20
10/11/89	20	<6	<10	<0.2	<10	<20

N

0 150 300

Approximate Scale in Feet

Basemap Reference

Pacific Aerial Survey.
Job number AV3268-7-10. Flown 30 March 1988.
Airphoto negative scale. 1 inch = 1000 feet.

Legend:

MW-3	Monitoring Well Location and Number
MW-12	Destroyed Monitoring Well Location and Number
(S)	Shallow Well
(D)	Deep Well

Notes

1. All locations are approximate.
2. Concenterations in micrograms per liter (ug/L). A (*) indicates the values represent the arithmetic average of duplicate samples.
3. The groundwater zone monitored by Wells MW-19 and MW-20 is not hydraulically connected to site groundwater (see text).

Kennedy/Jenks/Chilton

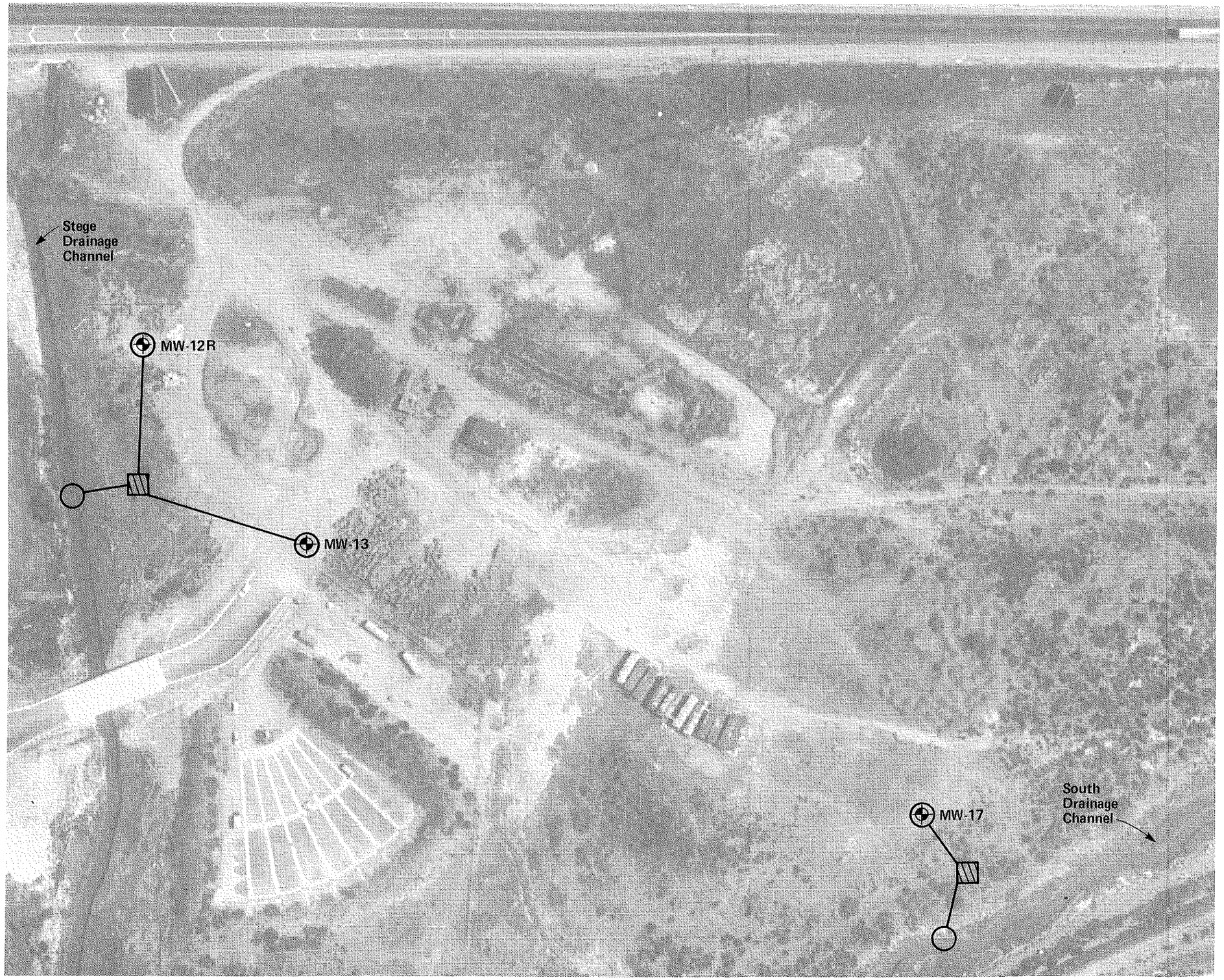
Southern Pacific Transportation Company
Liquid Gold Site

Dissolved Metals Concentrations-Deep Zone

LG006386

K/J/C 855018.07
December 1990

Figure 44



N

0 100 200

Approximate Scale in Feet

Basemap Reference

Pacific Aerial Survey.
Job number AV3268-7-10. Flown 30 March 1988.
Airphoto negative scale: 1 inch = 1000 feet.

Legend

- Monitoring well location and number
- Transducer measuring water elevation
- Datalogger recording elevation measurements

Kennedy/Jenks/Chilton

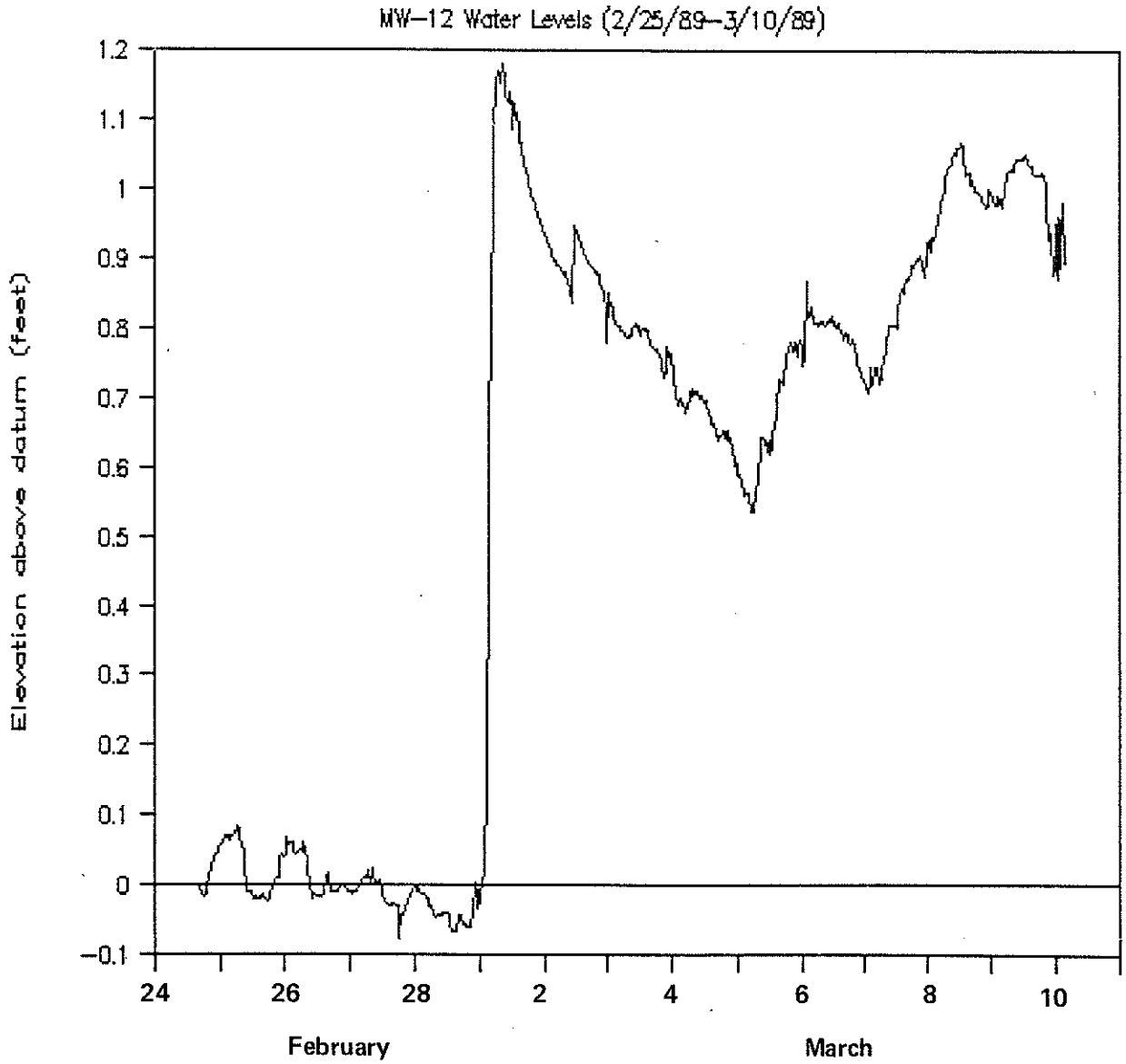
Southern Pacific Transportation Company
Liquid Gold Site

Groundwater Monitoring Wells and Tidal Influence Study

LG006387

K/J/C 855018.07
December 1990

Figure 45



Notes:

1. Elevations measured above arbitrary datum.
2. Increase in elevation on 1 March was due to a rain event.

Kennedy/Jenks/Chilton

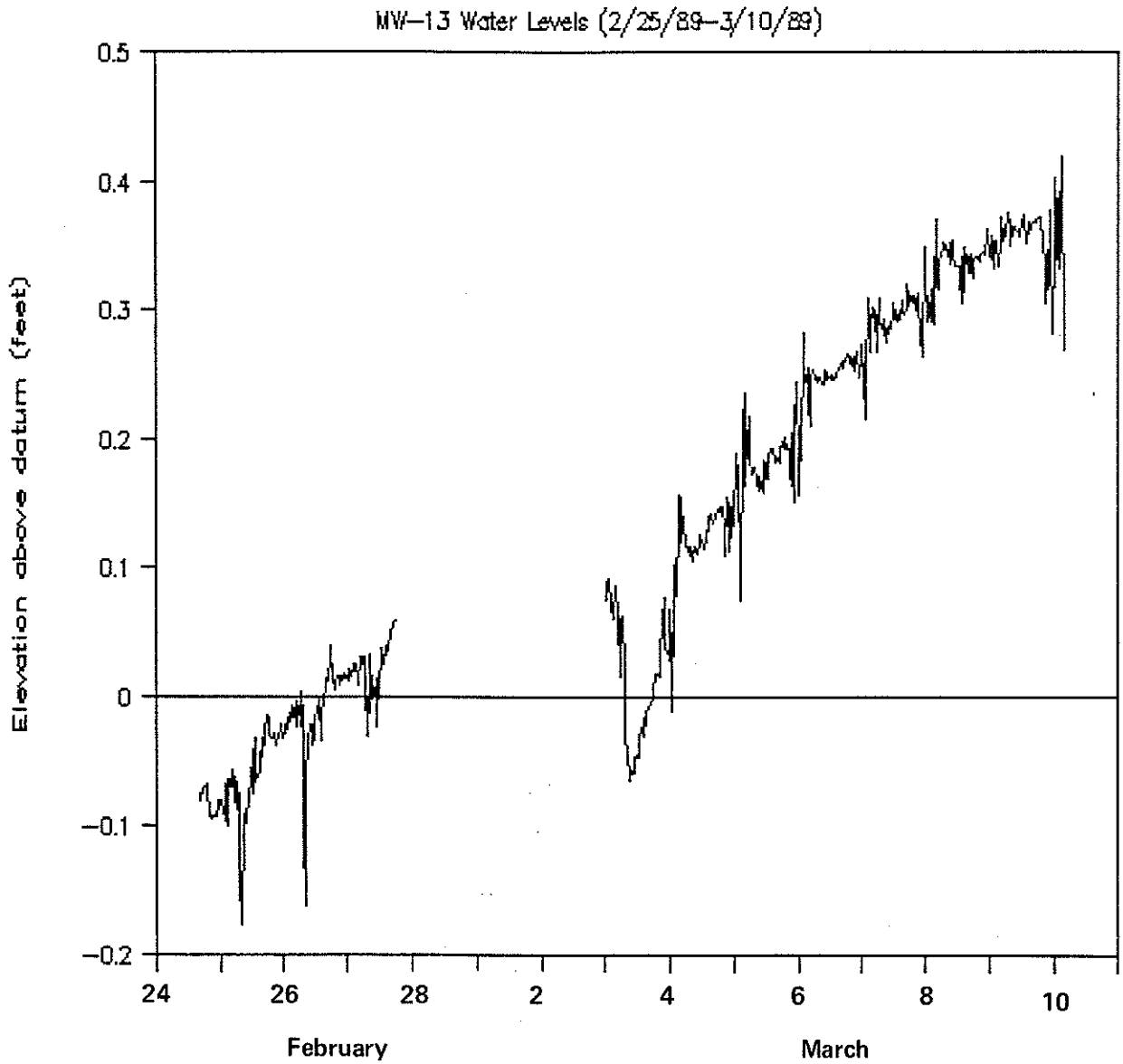
Southern Pacific Liquid Gold Site
Richmond, CA

Tidal Influence Study
Water Level Measurements: MW-12R

K/J/C 855018.07
December 1990

LG006388

Figure 46



Notes:

1. Elevations measured above arbitrary datum.
2. The transducer was disturbed and the data lost between 27 February and 3 March.

Kennedy/Jenks/Chilton

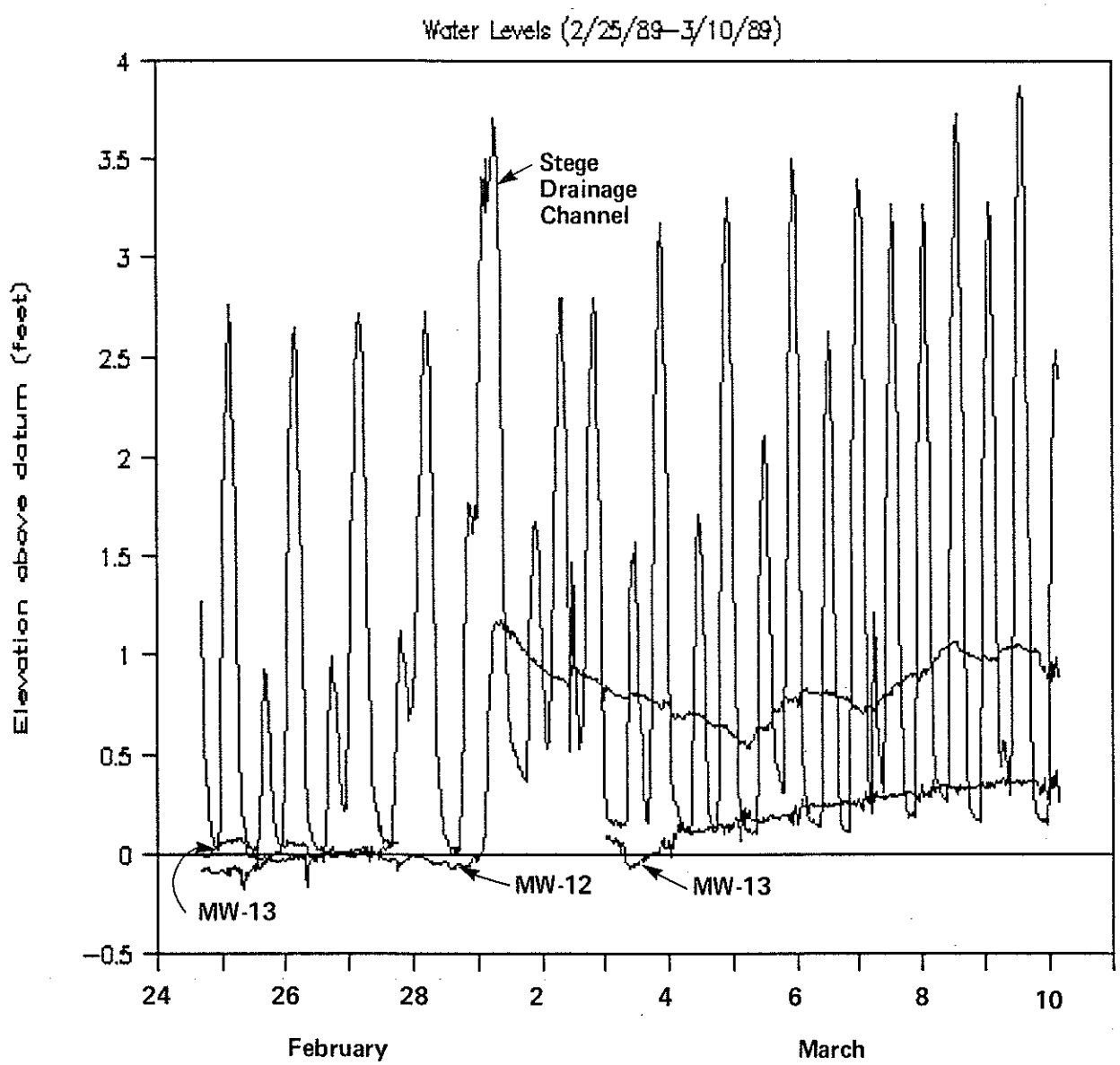
Southern Pacific Liquid Gold Site
Richmond, CA

Tidal Influence Study
Water Level Measurements: MW-13

LG006389

K/J/C 855018.07
December 1990

Figure 47



Notes:

1. Datum was established at an arbitrary elevation for each measurement location.

2. The transducer at MW-13 was disturbed between 27 February and 3 March.

3. Increased elevation on 1 March was due to a rain event.

Kennedy/Jenks/Chilton

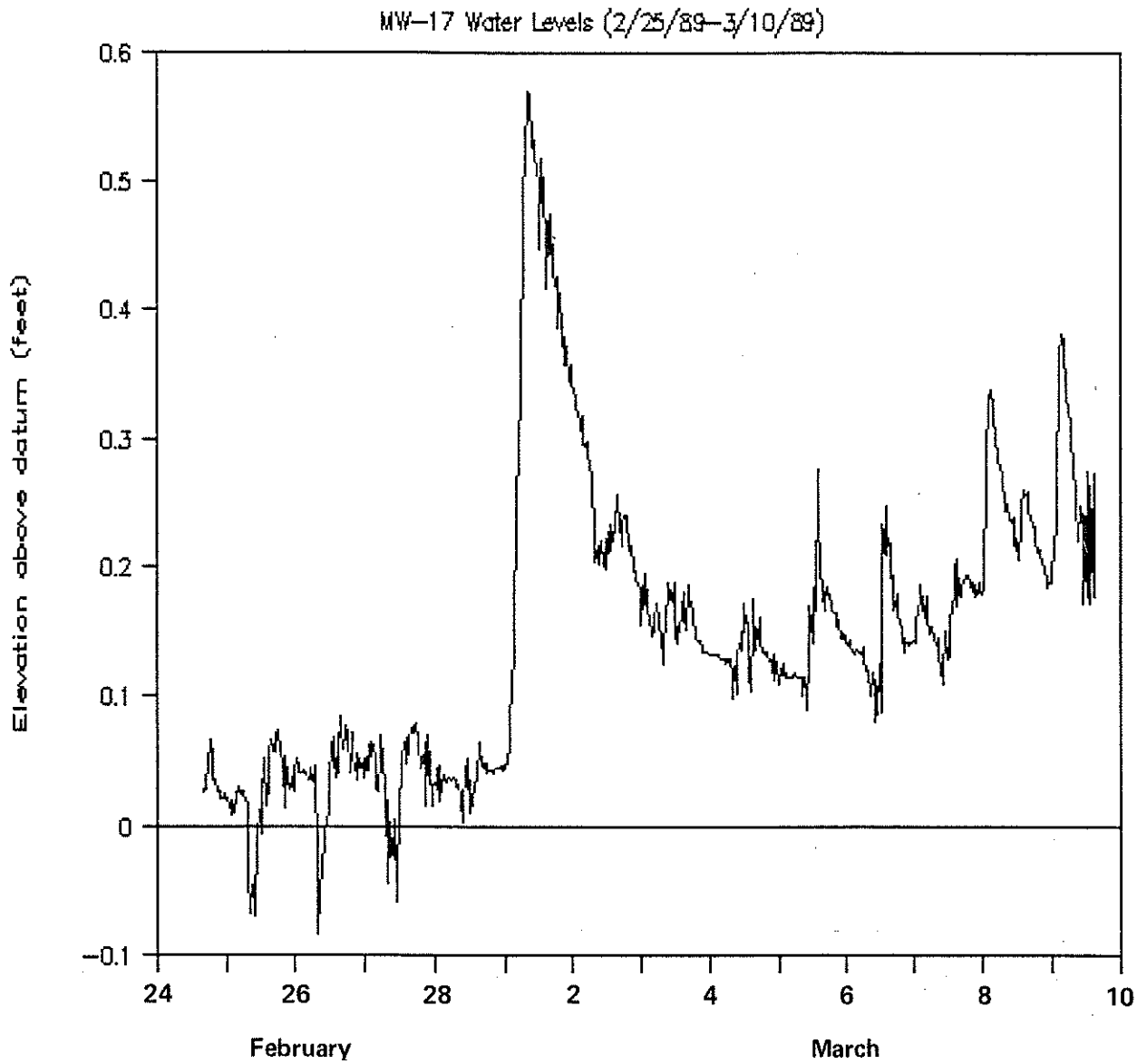
Southern Pacific Liquid Gold Site
Richmond, CA

Tidal Influence Study
Water Level Measurements: Stege Drainage Channel, MW-12R, and MW-13

LG006390

K/J/C 855018.07
December 1990

Figure 48



Notes:

1. Elevations measured above arbitrary datum.
2. Increase in elevation on 1 March was due to a rain event.

Kennedy/Jenks/Chilton

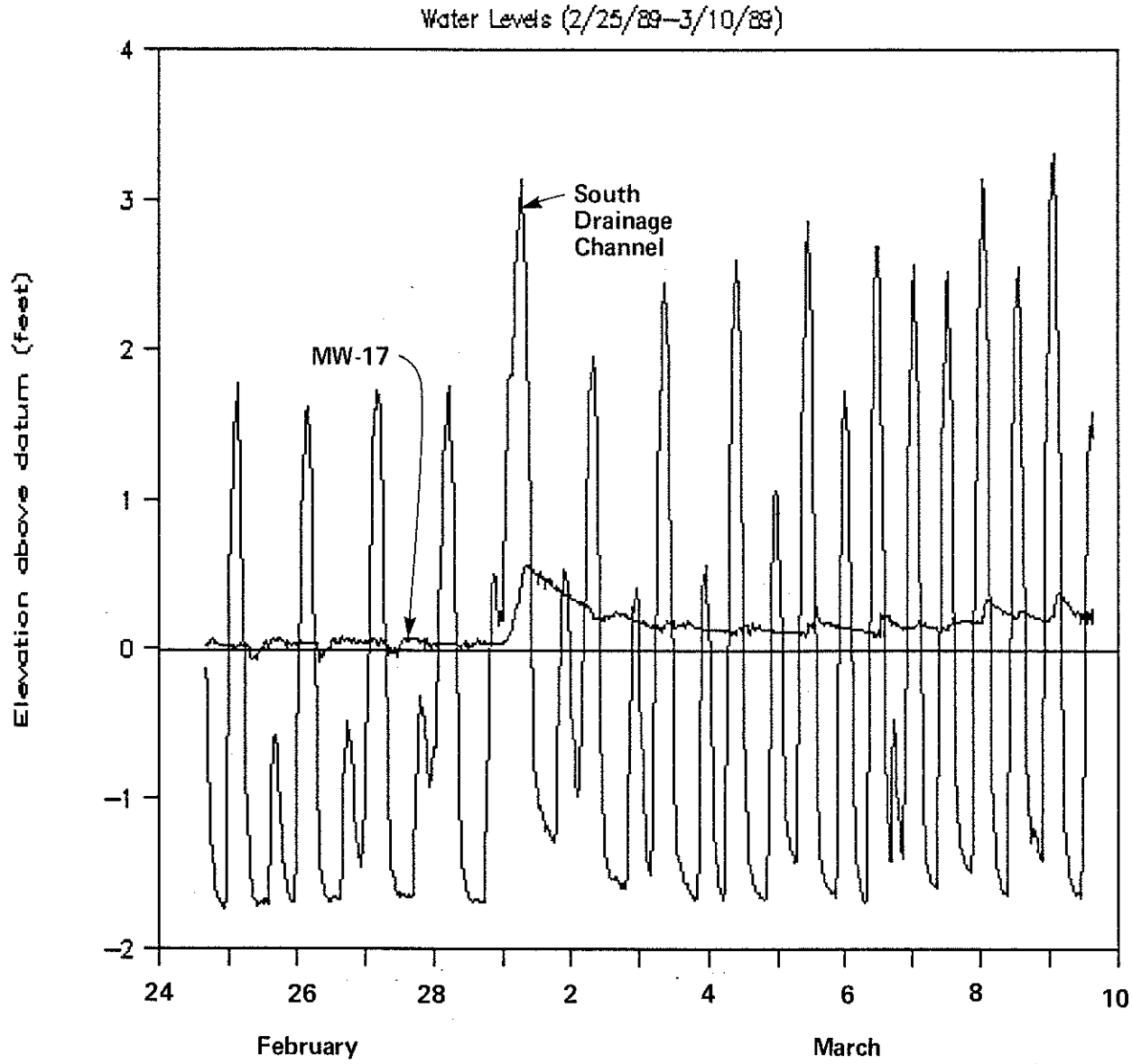
Southern Pacific Liquid Gold Site
Richmond, CA

Tidal Influence Study
Water Level Measurements: MW-17

LG006391

K/J/C 855018.07
December 1990

Figure 49



Notes:

1. Datum was established at an arbitrary elevation for each measurement location.

2. Increase in elevation on 1 March was due to a rain event.

Kennedy/Jenks/Chilton

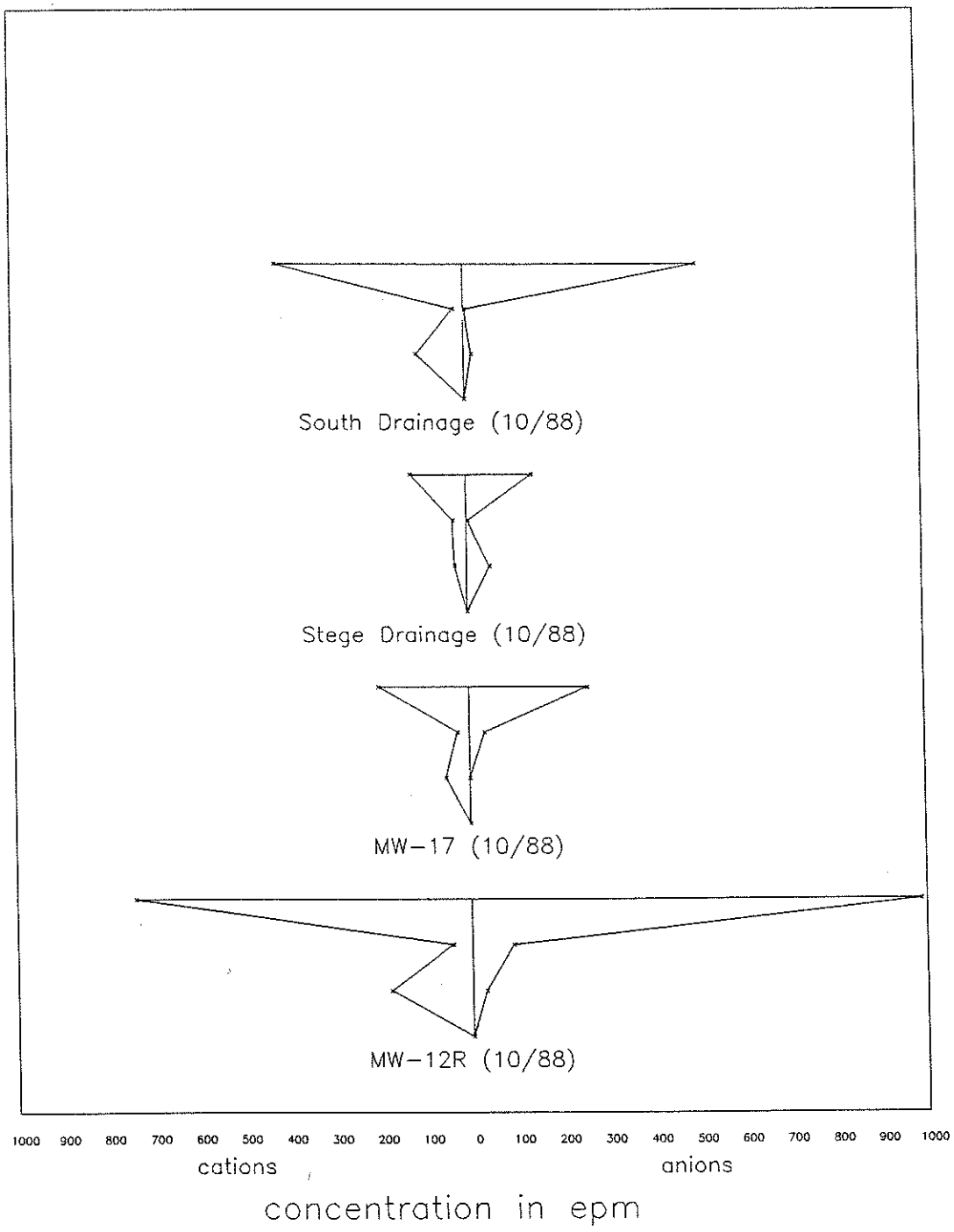
Southern Pacific Liquid Gold Site
Richmond, CA

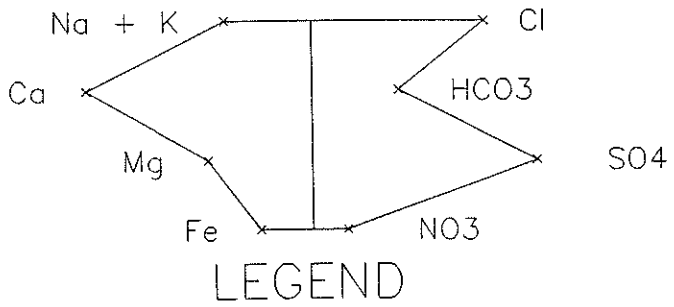
Tidal Influence Study
Water Level Measurements:
South Drainage Channel and MW-17

K/J/C 855018.07
December 1990

LG006392

Figure 50





Kennedy/Jenks/Chilton

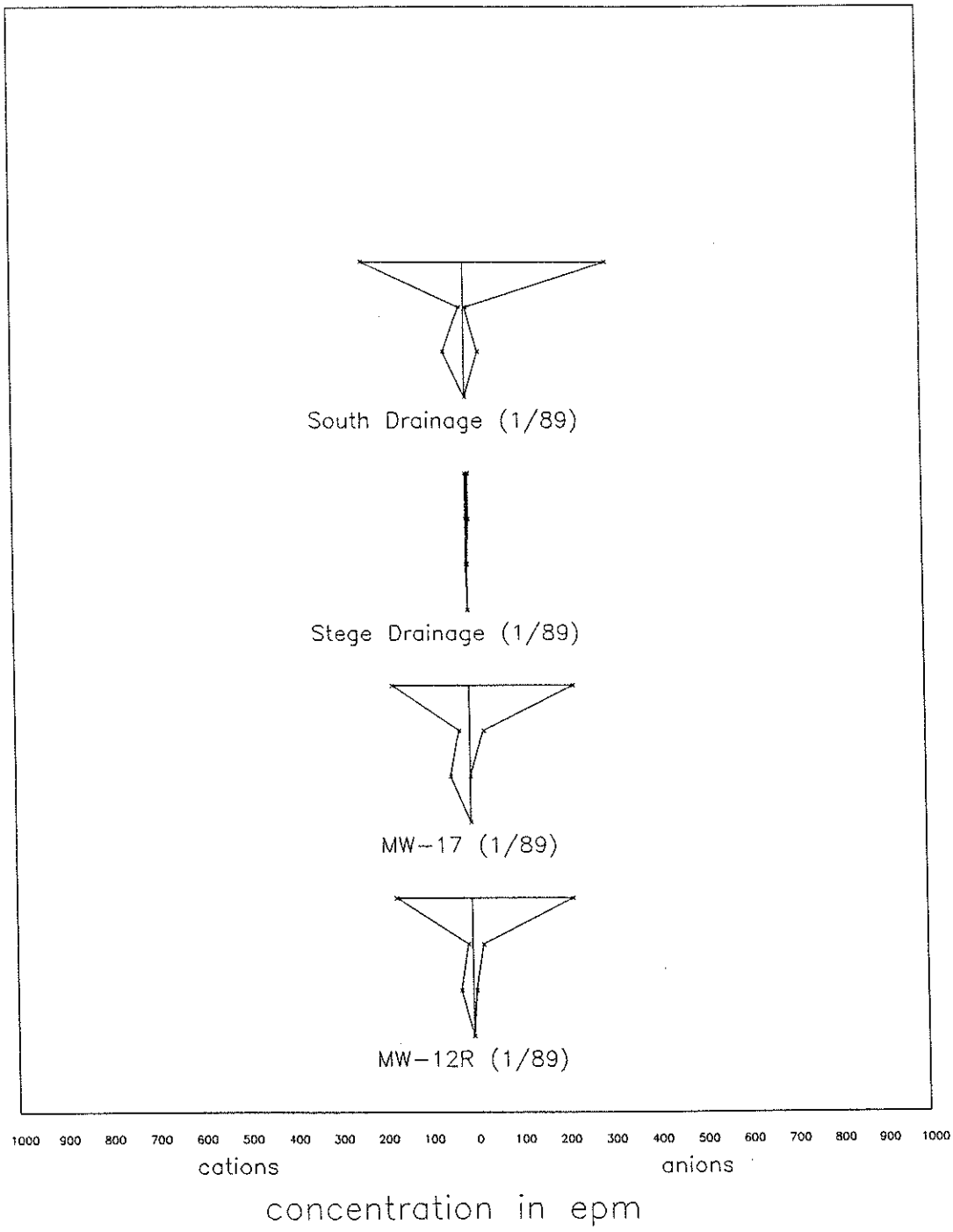
Southern Pacific Transportation Company
Liquid Gold Site

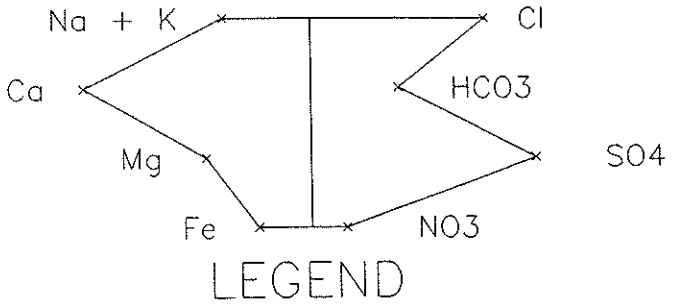
Stiff Chemical Diagrams for Selected Water Samples- October 1988

K/J/C 855018.07
December 1990

LG006393

Figure 51





Kennedy/Jenks/Chilton

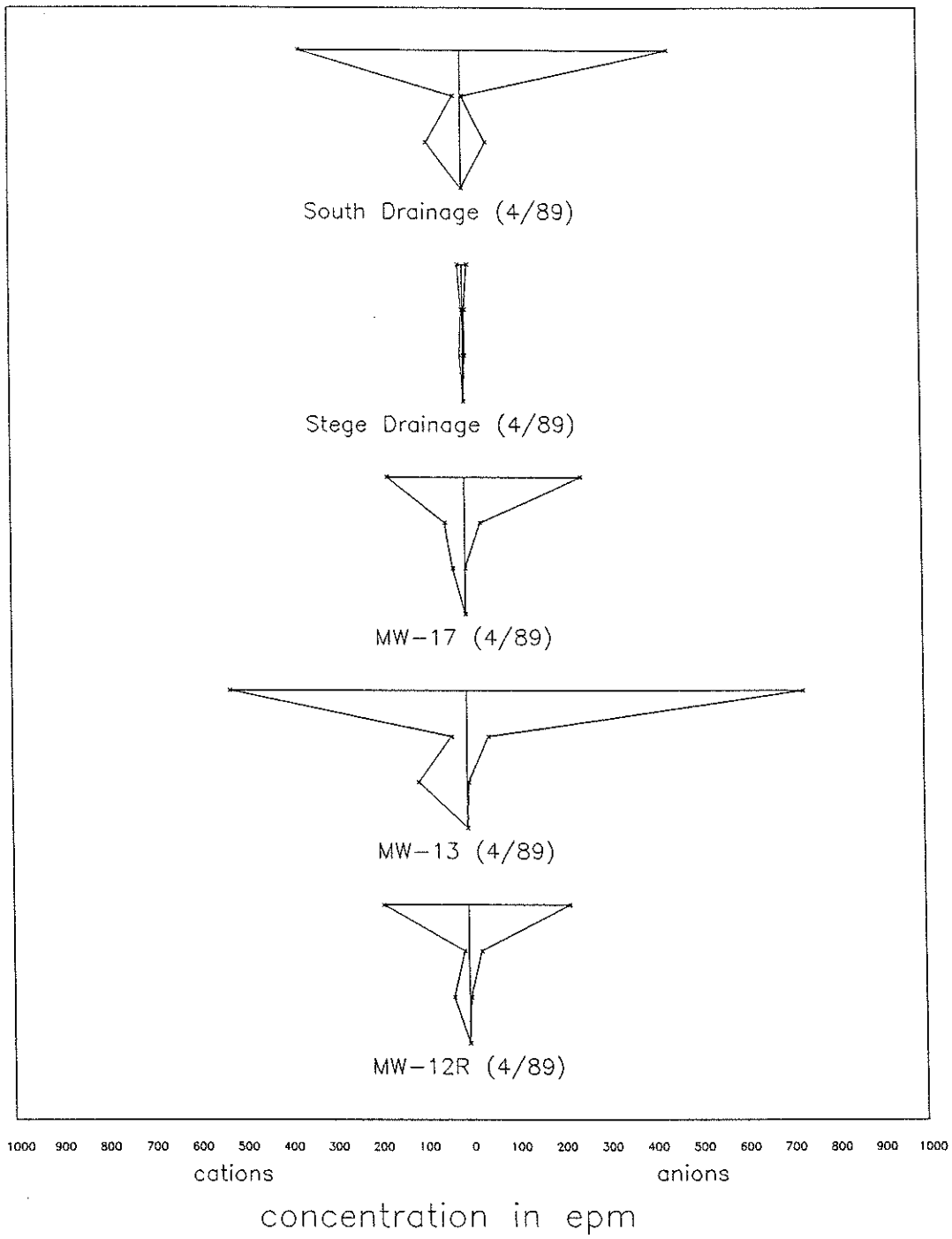
Southern Pacific Transportation Company
Liquid Gold Site

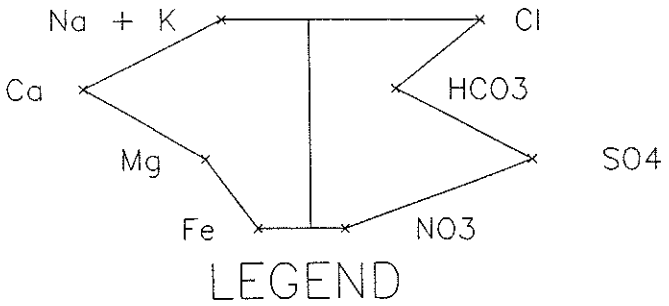
Stiff Chemical Diagrams for Selected Water Samples- January 1989

K/J/C 855018.07
December 1990

LG006394

Figure 52





Kennedy/Jenks/Chilton

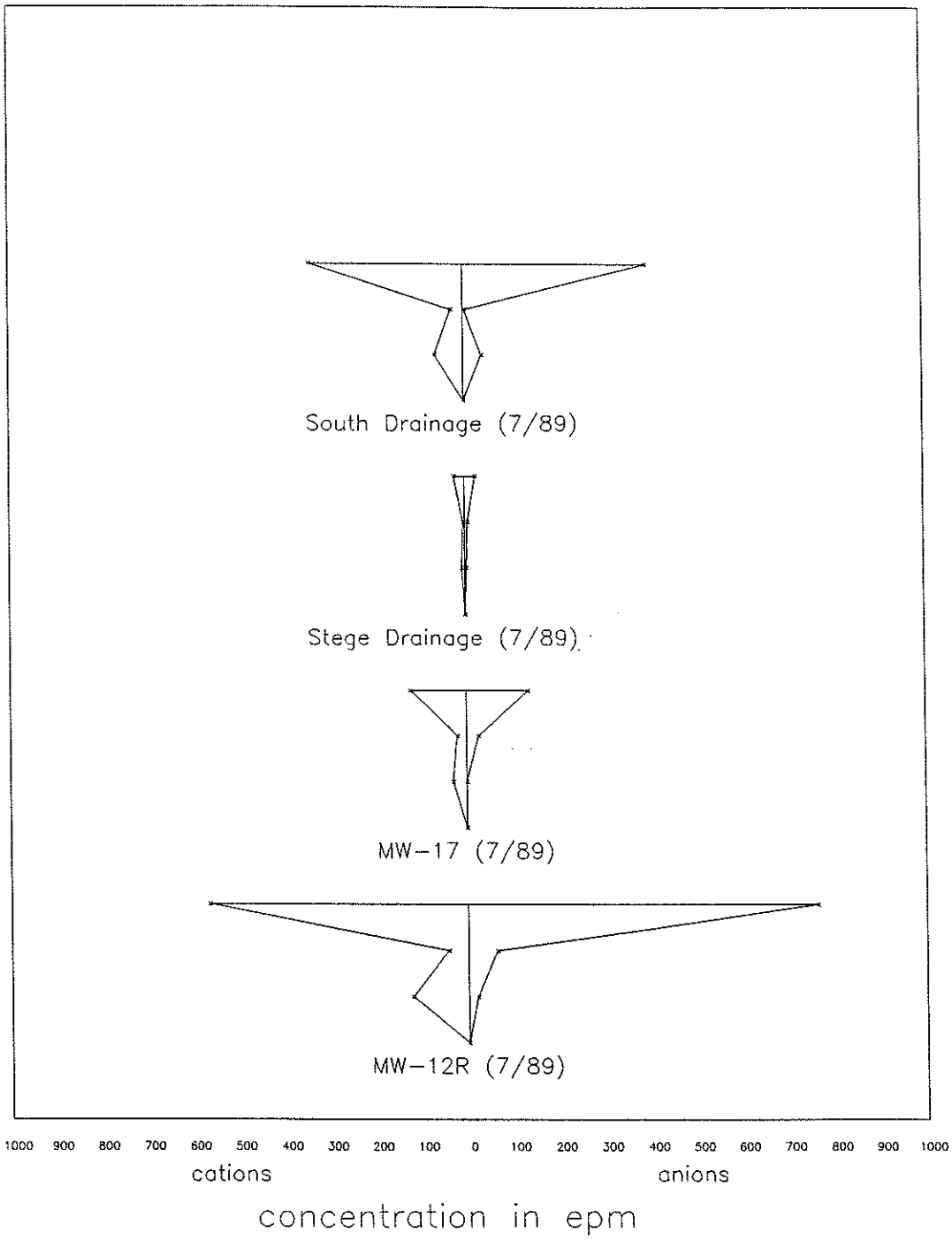
Southern Pacific Transportation Company
Liquid Gold Site

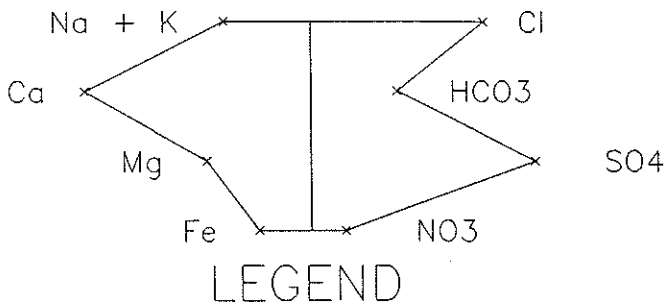
Stiff Chemical Diagrams for Selected Water Samples- April 1989

K/J/C 855018.07
December 1990

LG006395

Figure 53





Kennedy/Jenks/Chilton

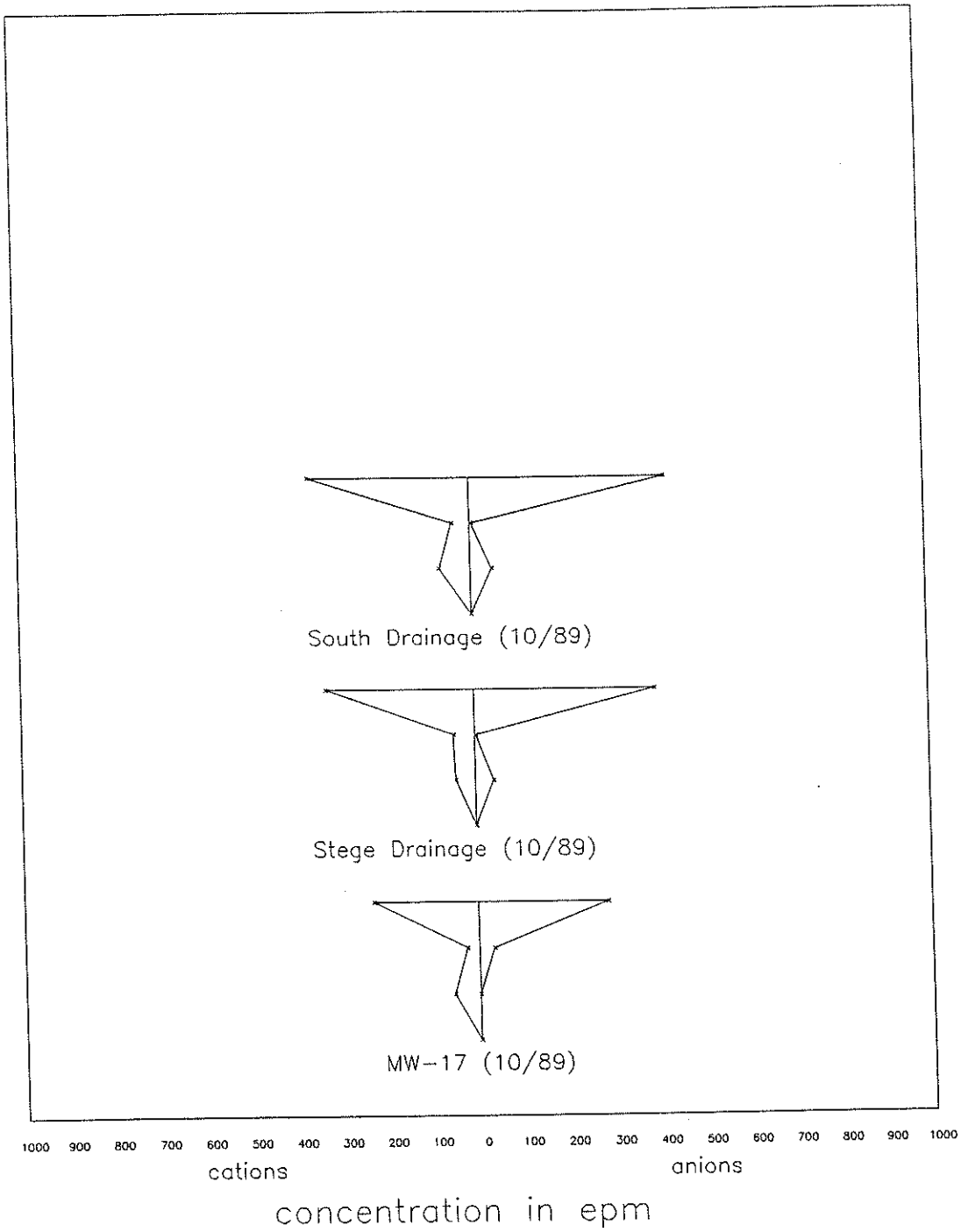
Southern Pacific Transportation Company
Liquid Gold Site

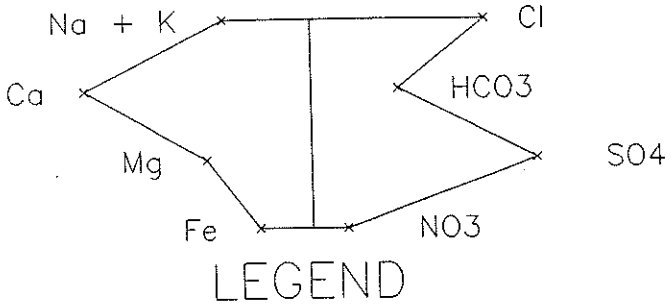
Stiff Chemical Diagrams for Selected Water Samples- July 1989

LG006396

K/J/C 855018.07
December 1990

Figure 54





Kennedy/Jenks/Chilton

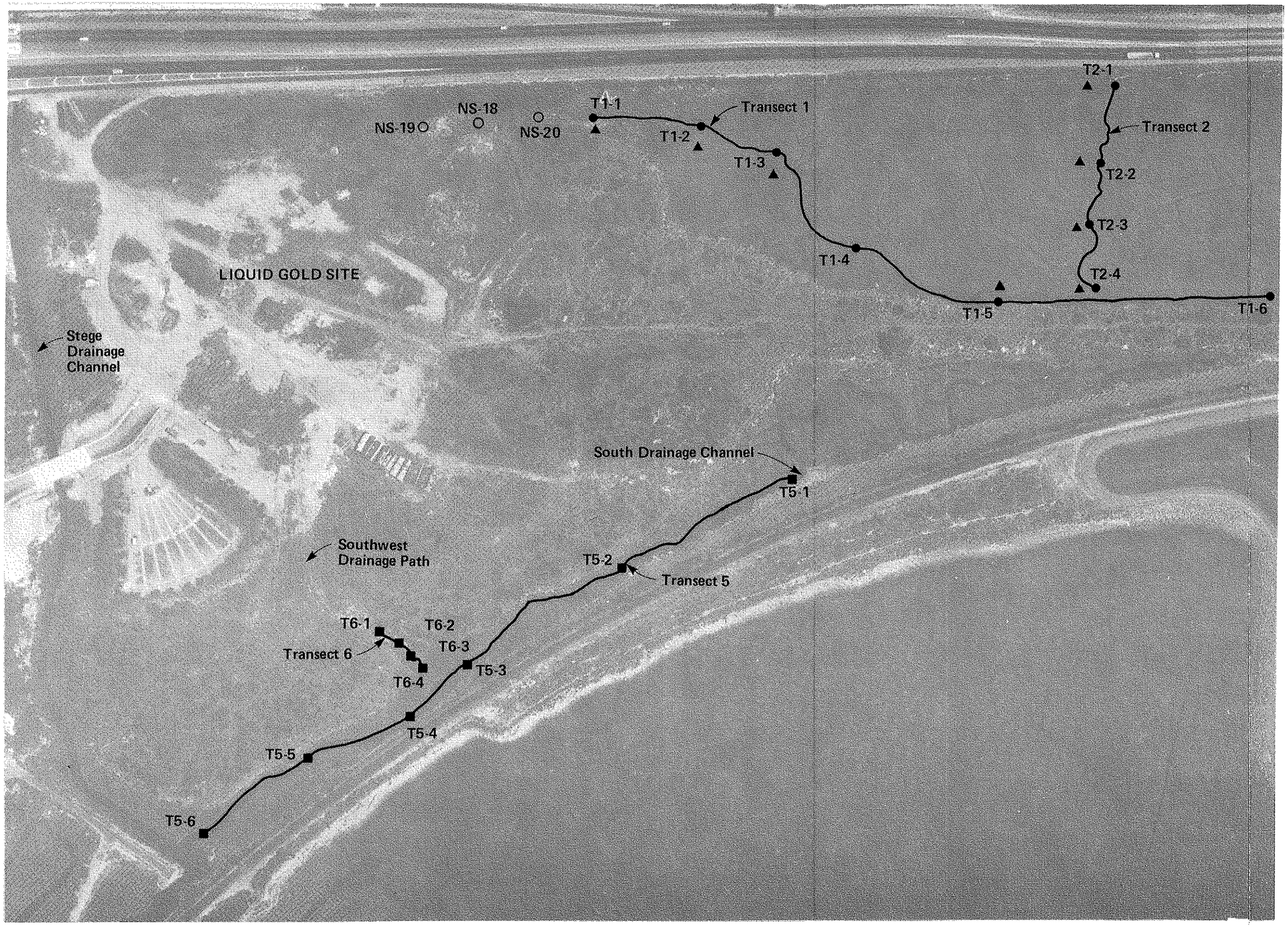
Southern Pacific Transportation Company
Liquid Gold Site

Stiff Chemical Diagrams for Selected Water Samples- October 1989

K/J/C 855018.07
December 1990

LG006397

Figure 55



N

0 175 350

Scale in Feet (Approx.)

Basemap Reference

Pacific Aerial Survey
Job number AV3268-7-11
Airphoto negative scale 1 inch = 1000 feet

Legend

T1-1 ● In-channel and side-slope sampling location and number

T1-2 ▲ Out-of-channel sampling location and number

NS-18 ○ Additional sediment sampling location and number

T5-1 ■ In-channel sampling location only and number

Kennedy/Jenks/Chilton

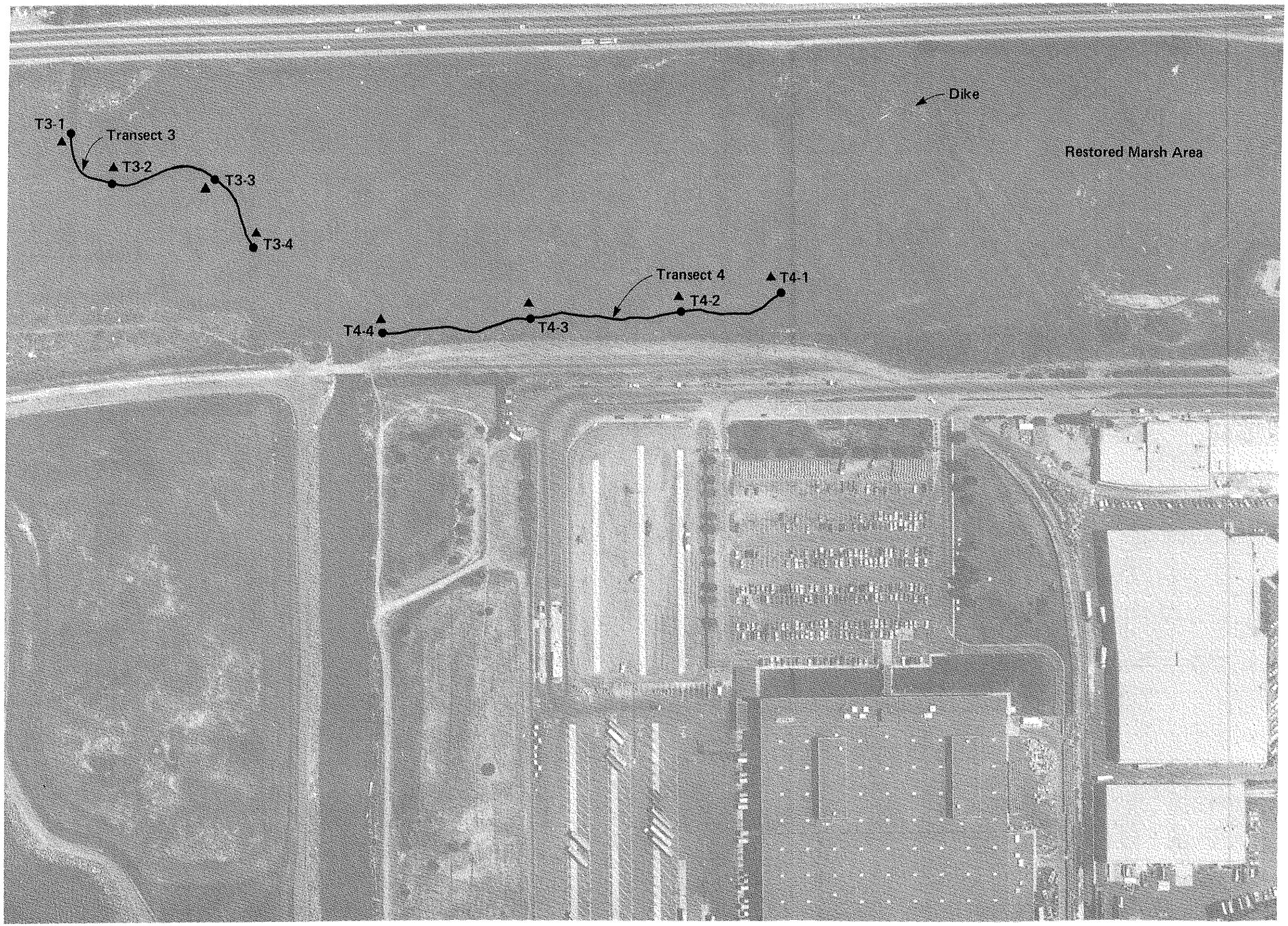
Southern Pacific Transportation Company
Liquid Gold Site

Sampling Locations for Biological Investigation North Study Area

LG006398

K/J/C 855018.07
December 1990

Figure 56



N

0 175 350

Scale in Feet
(Approx.)

Basemap Reference

Pacific Aerial Survey
Job number AV3268-7-11
Airphoto negative scale 1 inch = 1000 feet

Legend

T3-1 ● In-channel and side-slope sampling location and number

T3-1 ▲ Out-of-channel sampling location and number

Kennedy/Jenks/Chilton

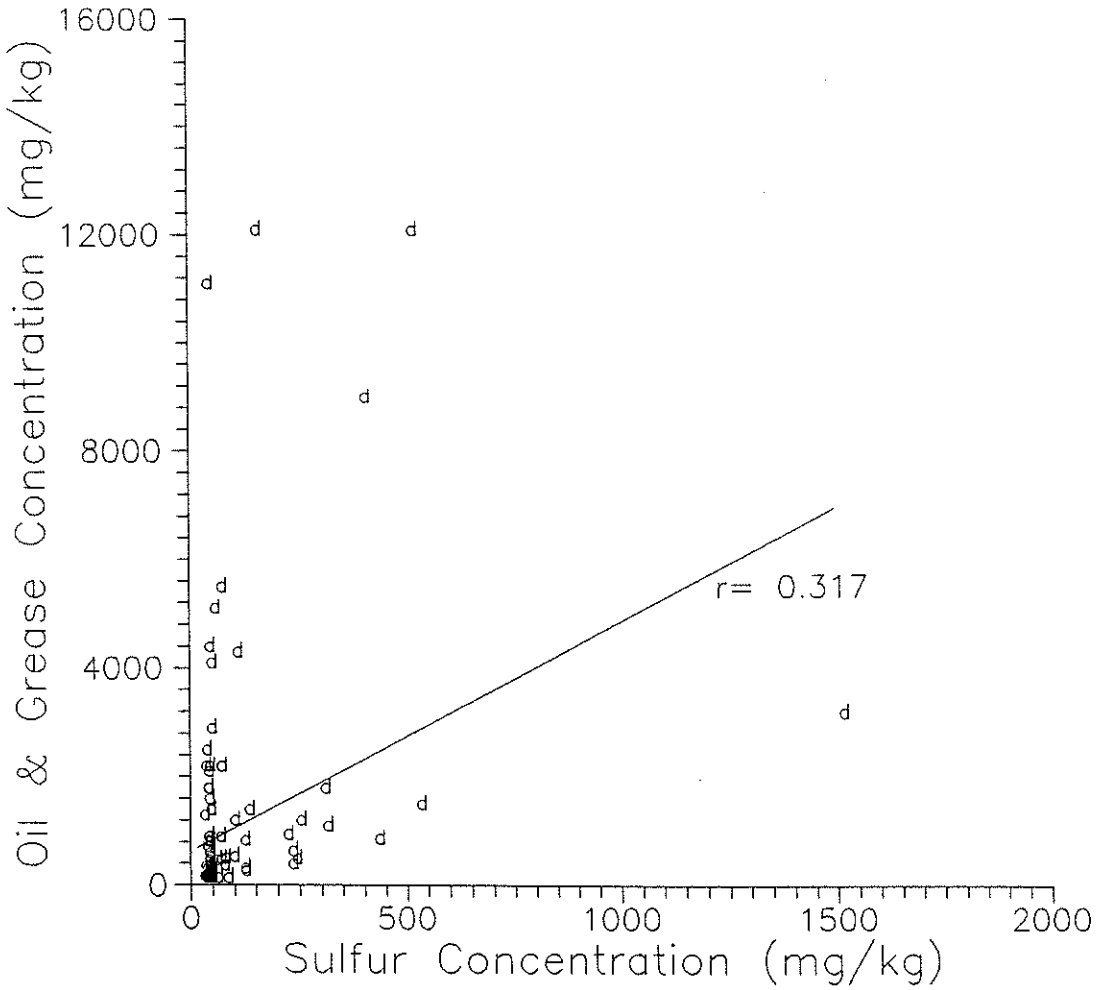
Southern Pacific Transportation Company
Liquid Gold Site

Sampling Locations for Biological Investigation South Study Area

LG006399

K/J/C 855018.07
December 1990

Figure 57



Kennedy/Jenks/Chilton

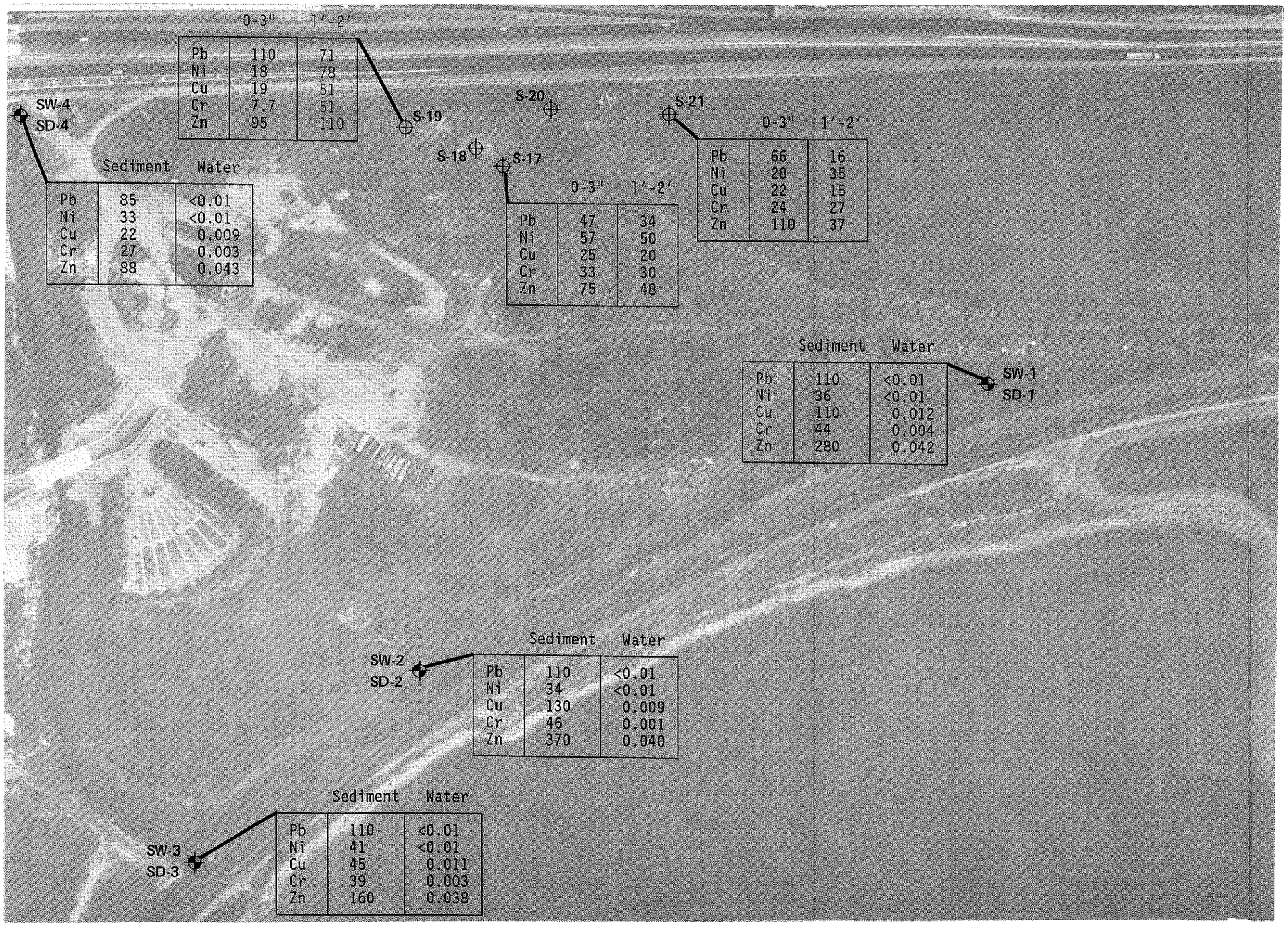
Southern Pacific Transportation Company
Liquid Gold Site

Regression Analysis of Oil and Grease Concentrations Versus Total Sulfur Concentrations

K/J/C 855018.07
December 1990

LG006400

Figure 58



N

0 175 350

Scale in Feet
(Approx.)

Basemap Reference

Pacific Aerial Survey
Job number AV3268-7-11
Airphoto negative scale 1 inch = 1000 feet

Legend

SW-1 SD-1 — Sample location and number for surface water (SW) and sediment (SD) samples collected by Kennedy/Jenks/Chilton on 21 November 1987.

S-19 — Sample location and number for sediment samples collected by Kennedy/Jenks/Chilton on 28 October 1986.

	Sediment	Water
Pb	110	< 0.01
Ni	36	< 0.01
Cu	110	0.012
Cr	44	0.004
Zn	280	0.042

Concentration of lead (Pb), nickel (Ni), copper (Cu), chromium (Cr), and zinc (Zn) reported in sediment samples in mg/kg and in surface water samples in mg/l.

	0-3"	1'-2'
Pb	47	34
Ni	57	50
Cu	25	20
Cr	33	30
Zn	75	48

Concentrations of metals in mg/kg at depth of 0 to 3 inches and 1 to 2 feet in sediment.

Notes

1. Sample data references:
   a) K/J/C 10 November 1986. "Status Report Regarding Phase III Technical Activities."
   b) K/J/C June 1988. Scoping Document, Liquid Gold Site.

Kennedy/Jenks/Chilton

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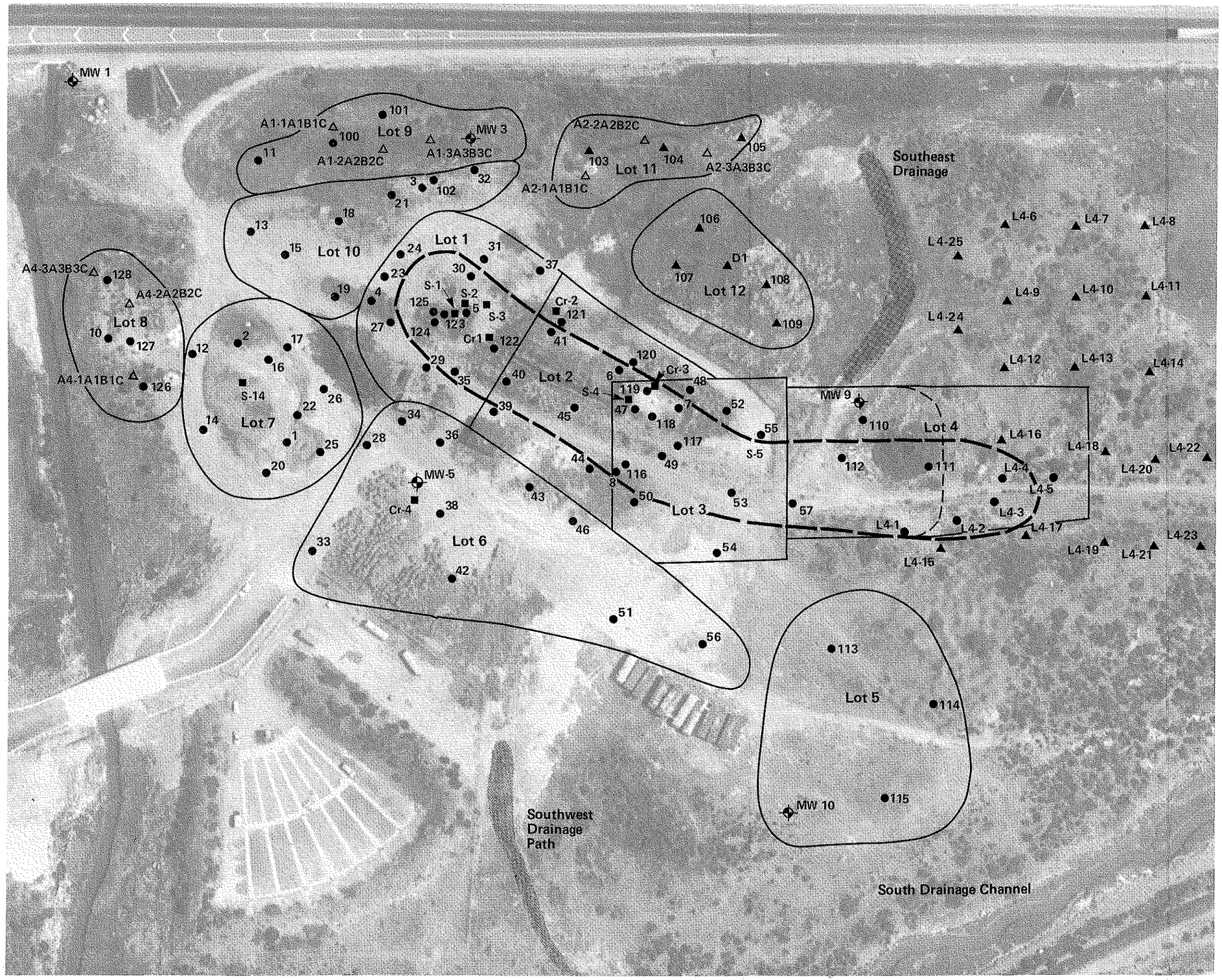
Liquid Gold Site

Metal Concentrations in Sediment and Surface Water Samples

K/J/C 855018.07
December 1990

LG006401

Figure 59



0 100 200

Approximate Scale in Feet

Basemap Reference

Pacific Aerial Survey.
Job number AV3268-7-10. Flown 30 March 1988.
Airphoto negative scale: 1 inch = 1000 feet.

Legend:

Prior Sample Locations

- ● 110 — Boring Location and Number
- ▲ — Boring Sampled to 2 or 3 Feet
- △ — Composite Surface Sample Location
- ■ S-1 — Surface Sample Location and Number
- MW-1 — Monitoring Well Location and Number
- ——— Boundary of Lots for Risk Assessment
- — — — Original Extent of Lot 4
- ═══ Boundary of Area A

Notes:

1. Locations are approximate.
2. Boring 1-57. Ecology and Environment, Inc.
3. All other samples collected by K/J/C.

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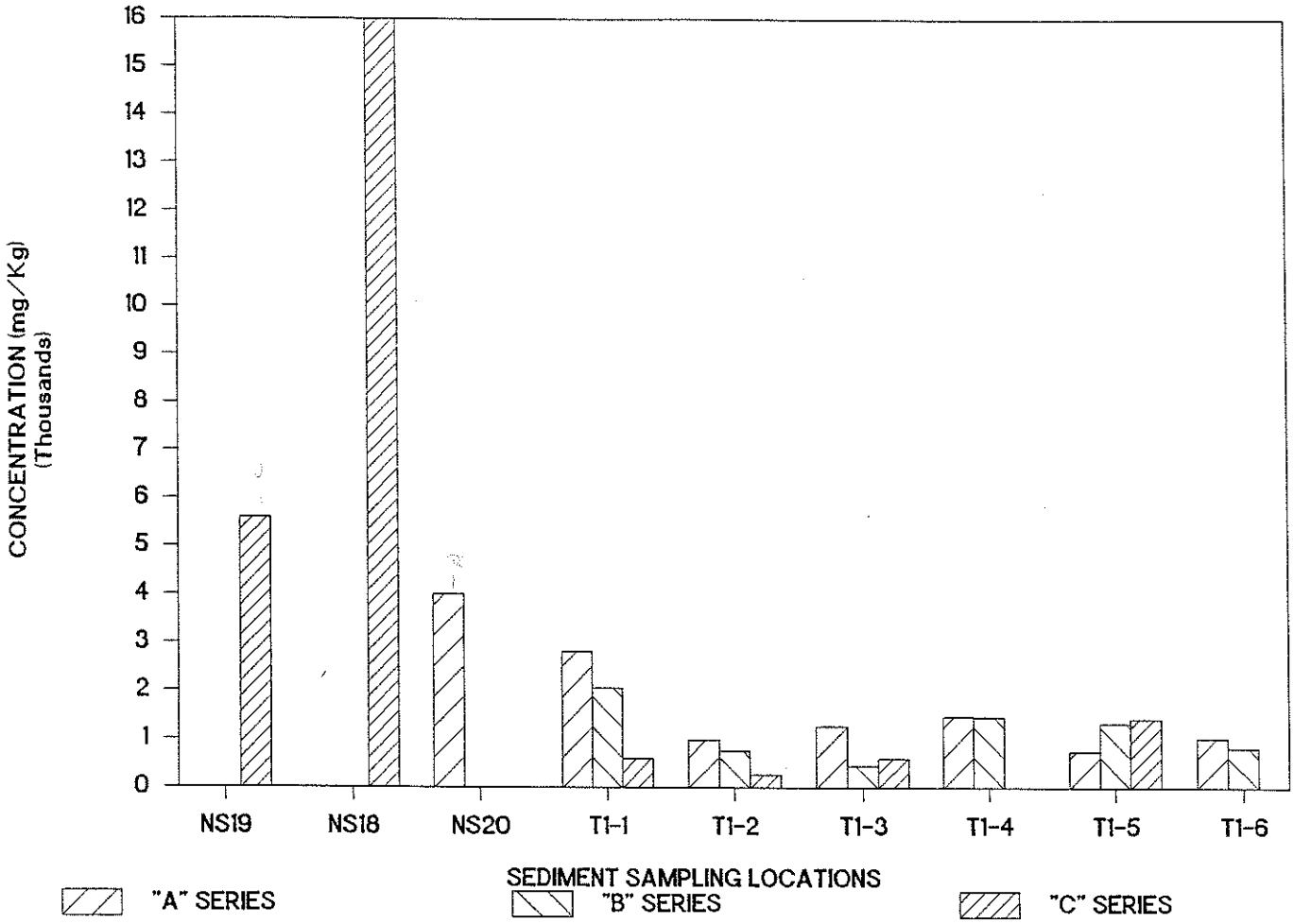
Liquid Gold Site

Location of Lots Evaluated for Risk Assessment

LG006402

K/J/C 855018.07
December 1990

Figure 60



Note:

1. All concentrations reported as dry weight.
   Percent moisture was available for T1 samples.
   NS samples were converted assuming 75% moisture.

Kennedy/Jenks/Chilton

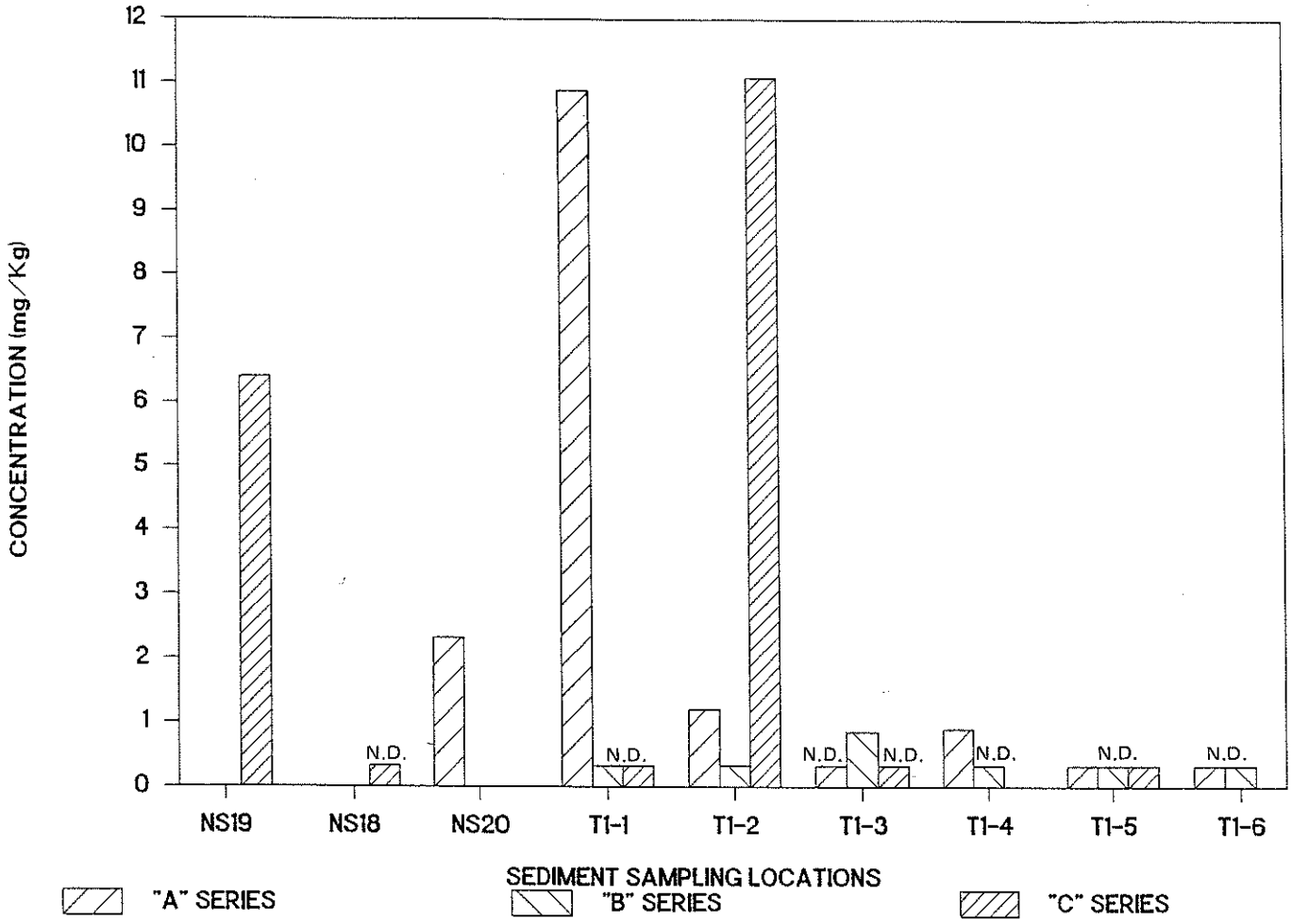
Southern Pacific Transportation Company
Liquid Gold Site

Oil and Grease in Sediment Samples
Transect T1

K/J/C 855018.07
December 1990

LG006403

Figure 61



Notes:

1. All concentrations reported as dry weight. Percent moisture was available for T1 samples. NS samples were converted assuming 75% moisture.

2. N.D. indicates not detected at the detection limit indicated.

Kennedy/Jenks/Chilton

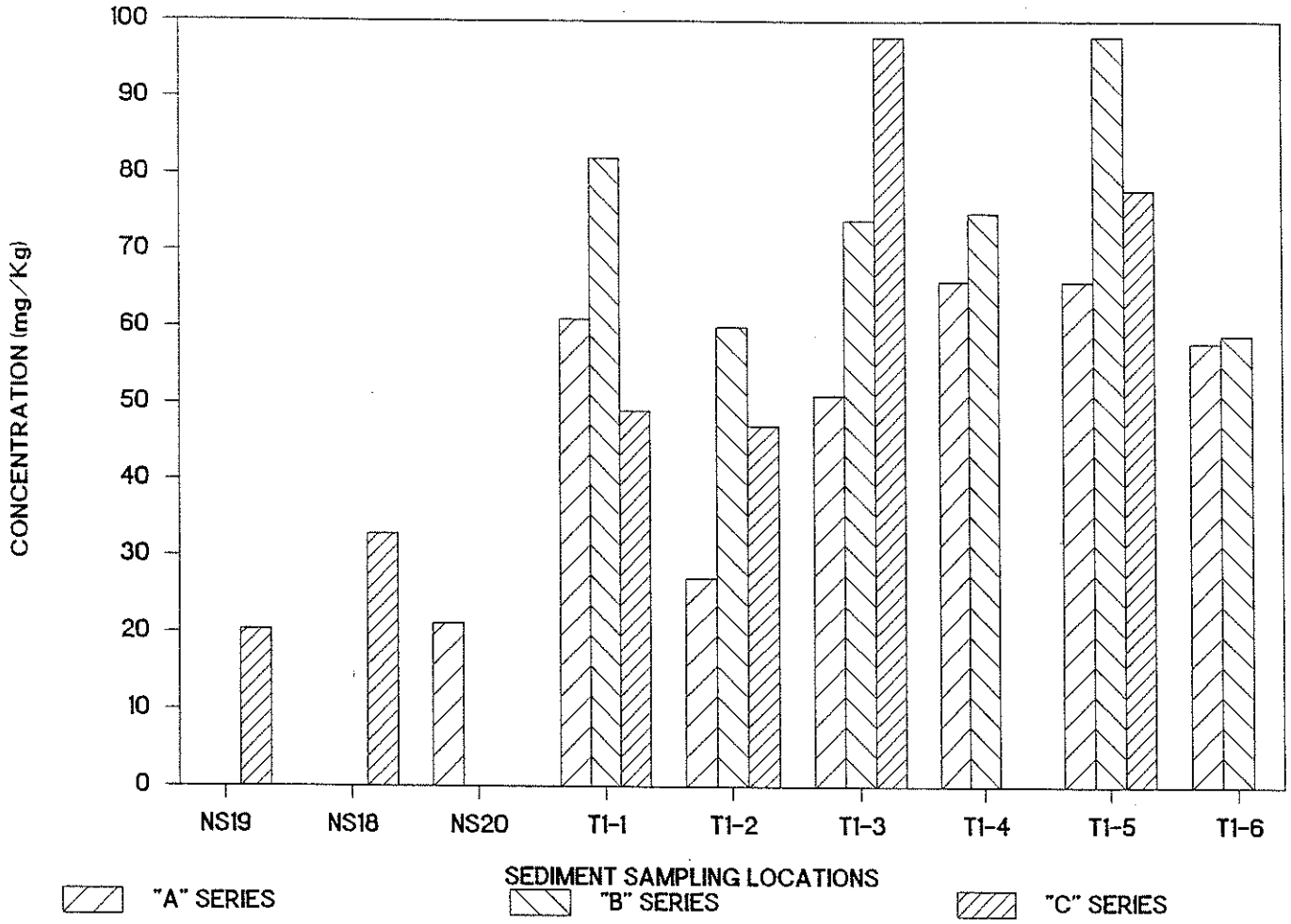
Southern Pacific Transportation Company
Liquid Gold Site

Total PAHs in Sediment Samples
Transect T1

LG006404

K/J/C 855018.07
December 1990

Figure 62



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Southern Pacific Transportation Company
Liquid Gold Site

Total Chromium in Sediment Samples
Transect T1

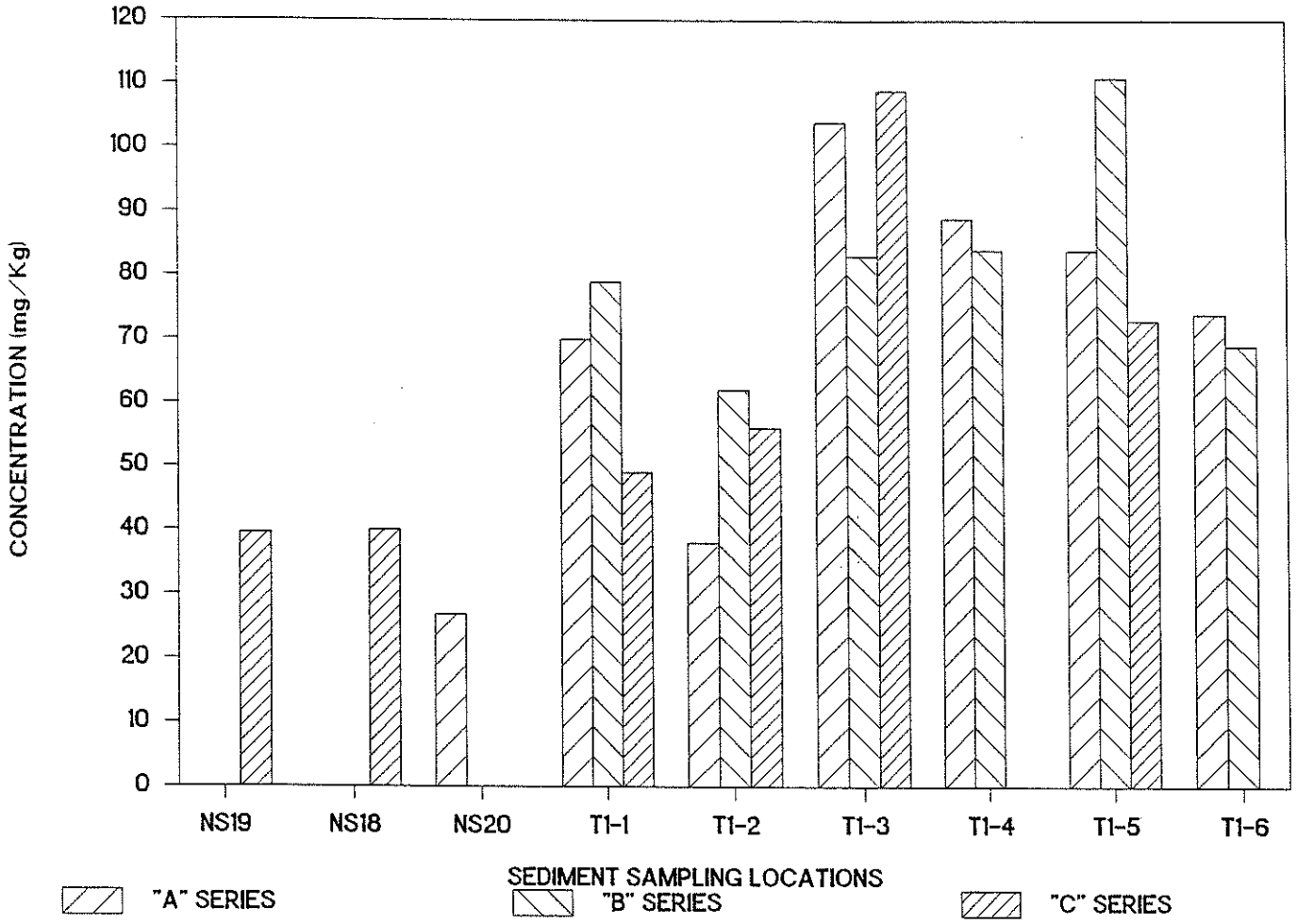
K/J/C 855018.07
December 1990

LG006405

Figure 63

Note:

1. **All concentrations reported as dry weight.**
   Percent moisture was available for T1msamples.
   NS samples were converted assuming 75% moisture.



Kennedy/Jenks/Chilton

Southern Pacific Transportation Company
Liquid Gold Site

Total Copper in Sediment Samples
Transect T1

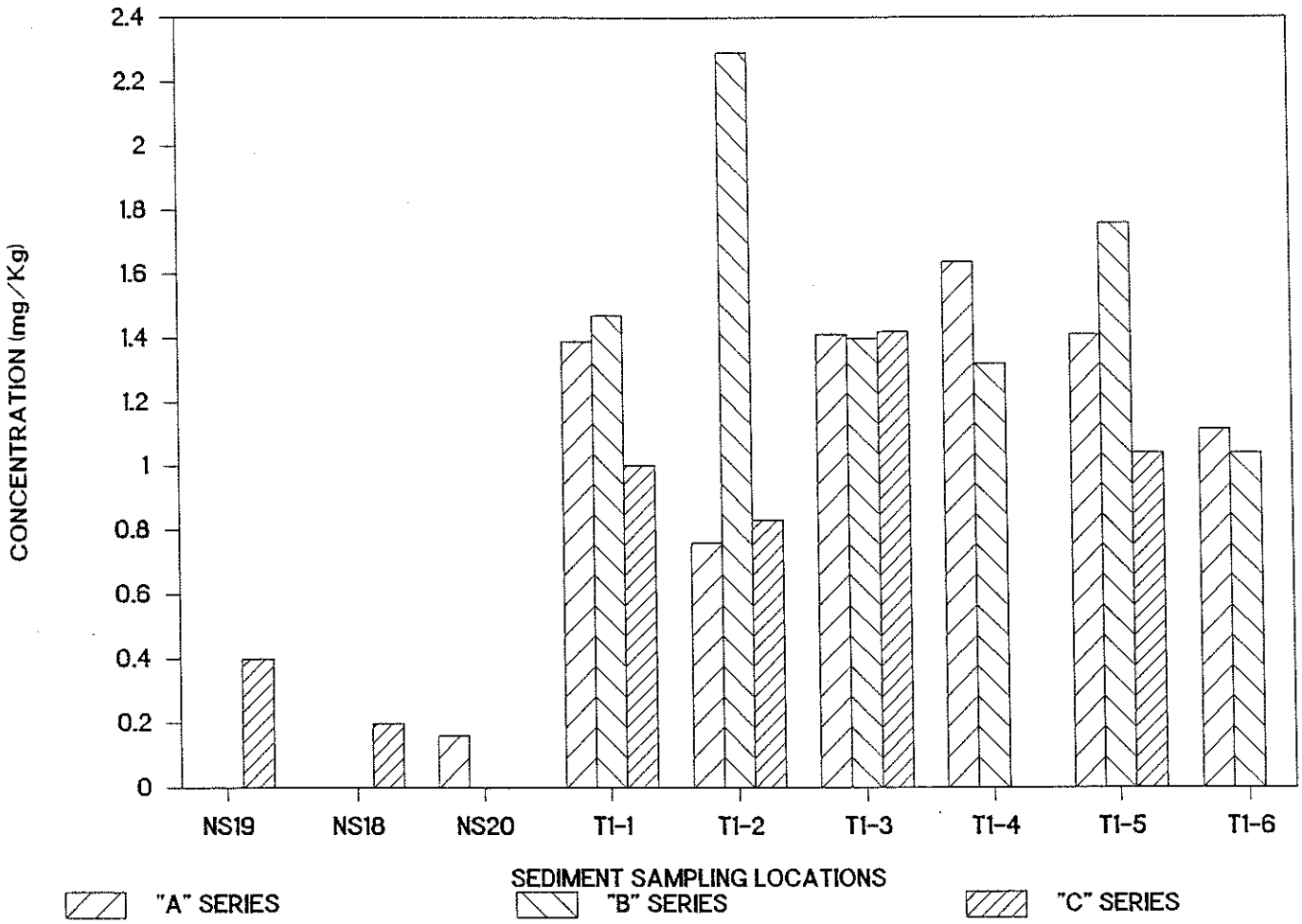
K/J/C 855018.07
December 1990

LG006406

Figure 64

Note:

1. **All concentrations reported as dry weight.**
   Percent moisture was available for T1 samples.
   NS samples were converted assuming 75% moisture.



Kennedy/Jenks/Chilton

Southern Pacific Transportation Company
Liquid Gold Site

Total Mercury in Sediment Samples
Transect T1

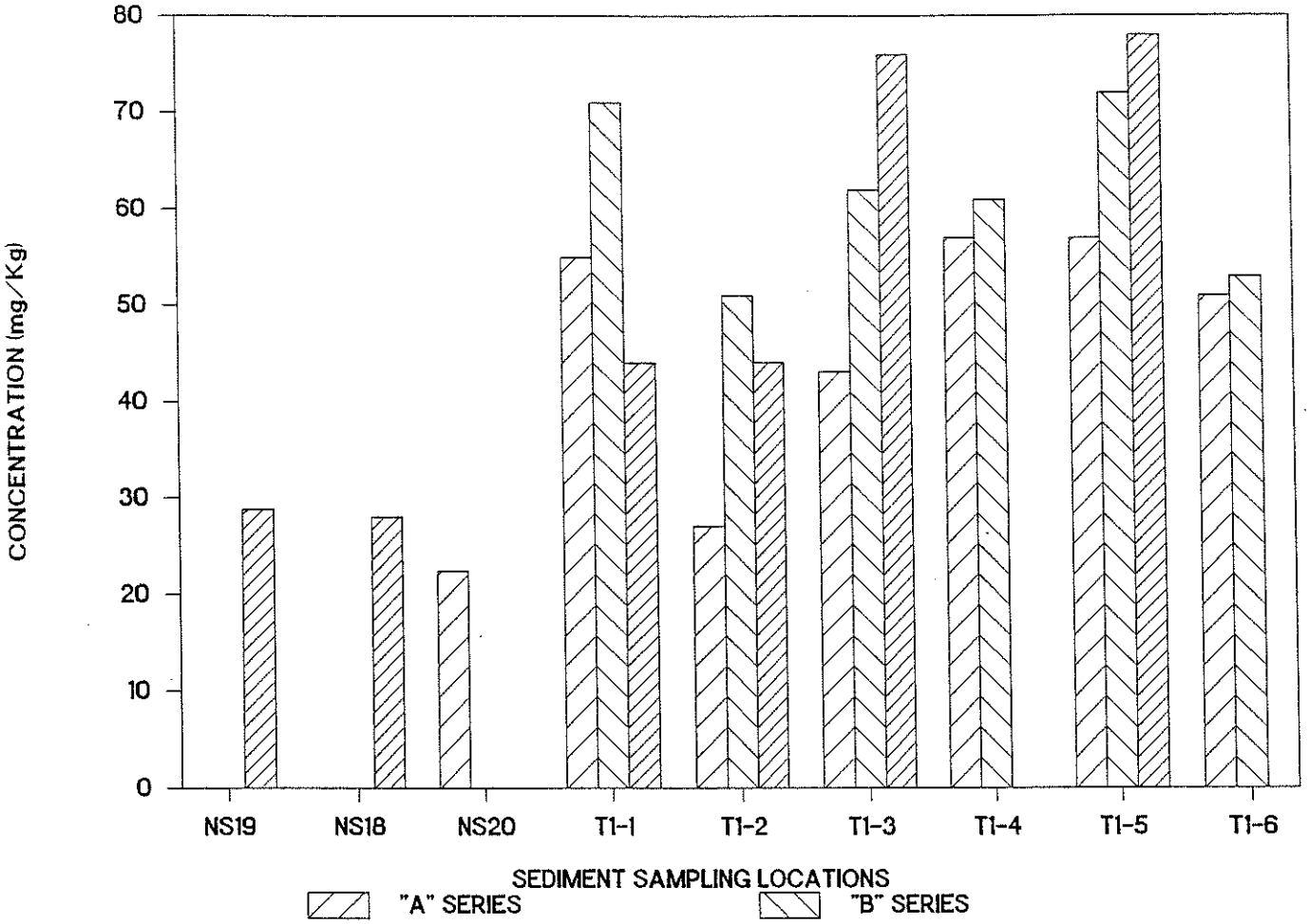
K/J/C 855018.07
December 1990

LG006408

Figure 66

Note:

1. All concentrations reported as dry weight.
   Percent moisture was available for T1 samples.
   NS samples were converted assuming 75% moisture.



Kennedy/Jenks/Chilton

Southern Pacific Transportation Company
Liquid Gold Site

Total Nickel in Sediment Samples
Transect T1

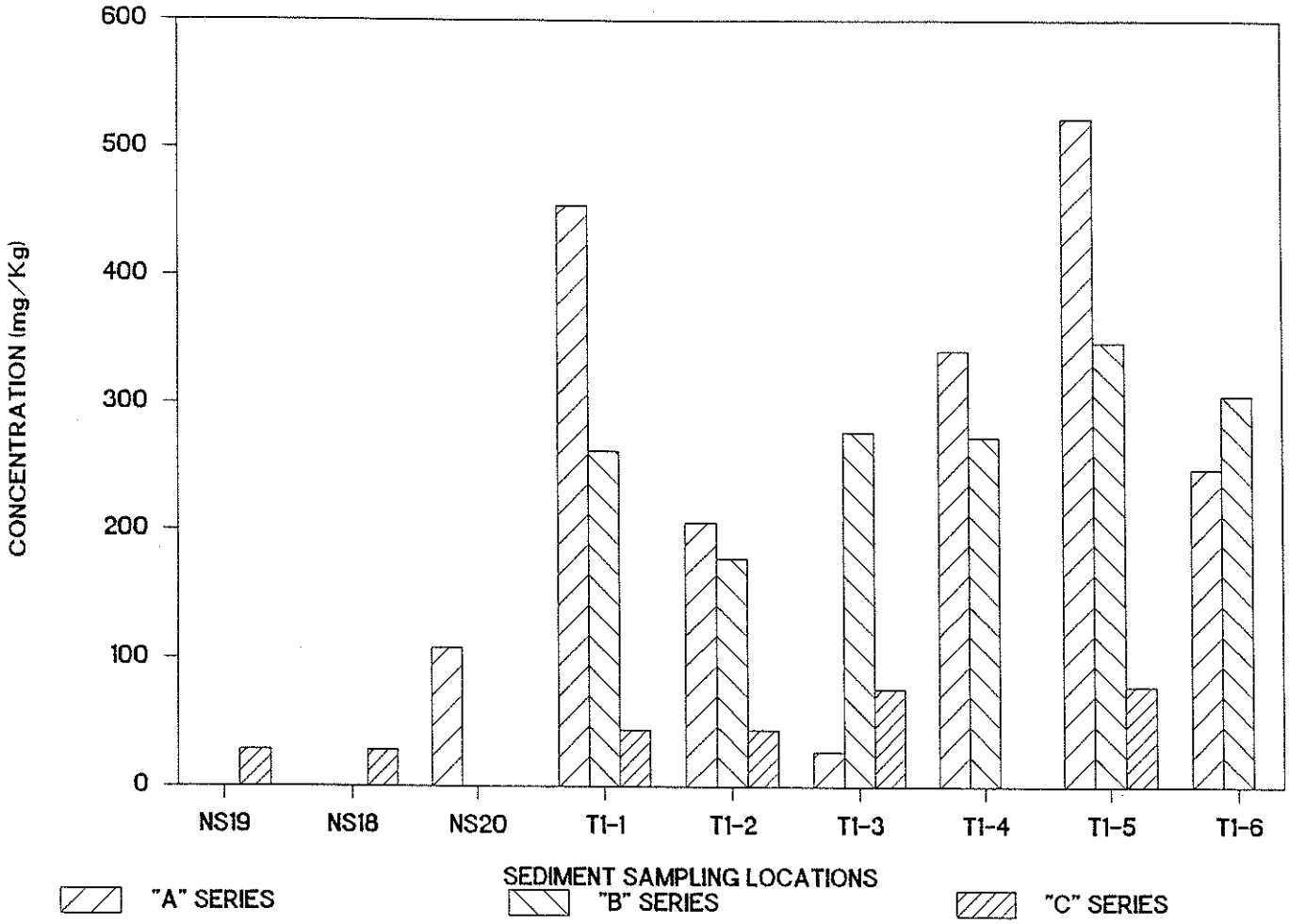
K/J/C 855018.07
December 1990

LG006409

Figure 67

Note:

1. **All concentrations reported as dry weight.**
   Percent moisture was available for T1 samples.
   NS samples were converted assuming 75% moisture.



Note:

1. All concentrations reported as dry weight.
   Percent moisture was available for T1 samples.
   NS samples were converted assuming 75% moisture.

Kennedy/Jenks/Chilton

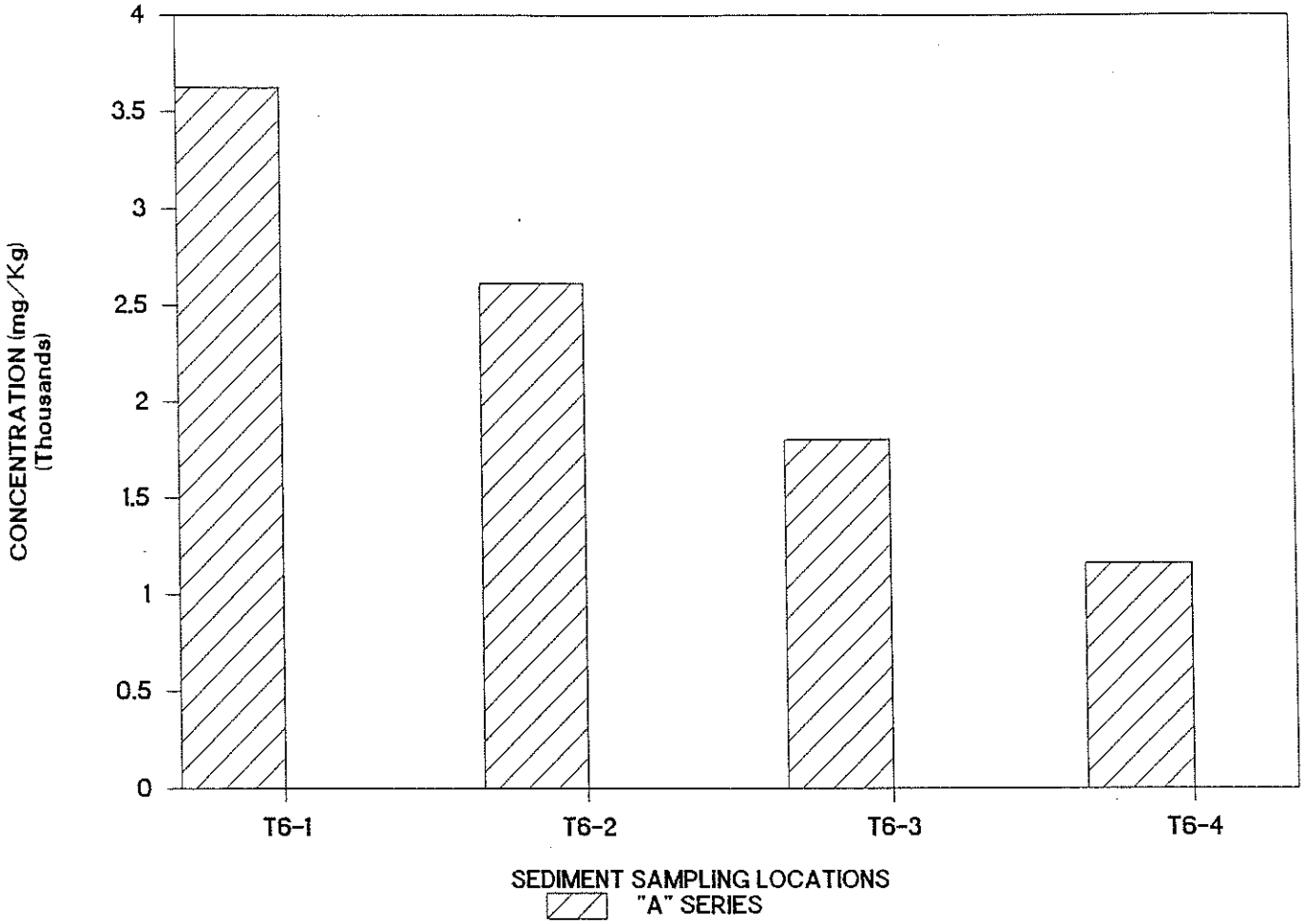
Southern Pacific Transportation Company
Liquid Gold Site

Total Zinc in Sediment Samples
Transect T1

LG006410

K/J/C 855018.07
December 1990

Figure 68



Kennedy/Jenks/Chilton

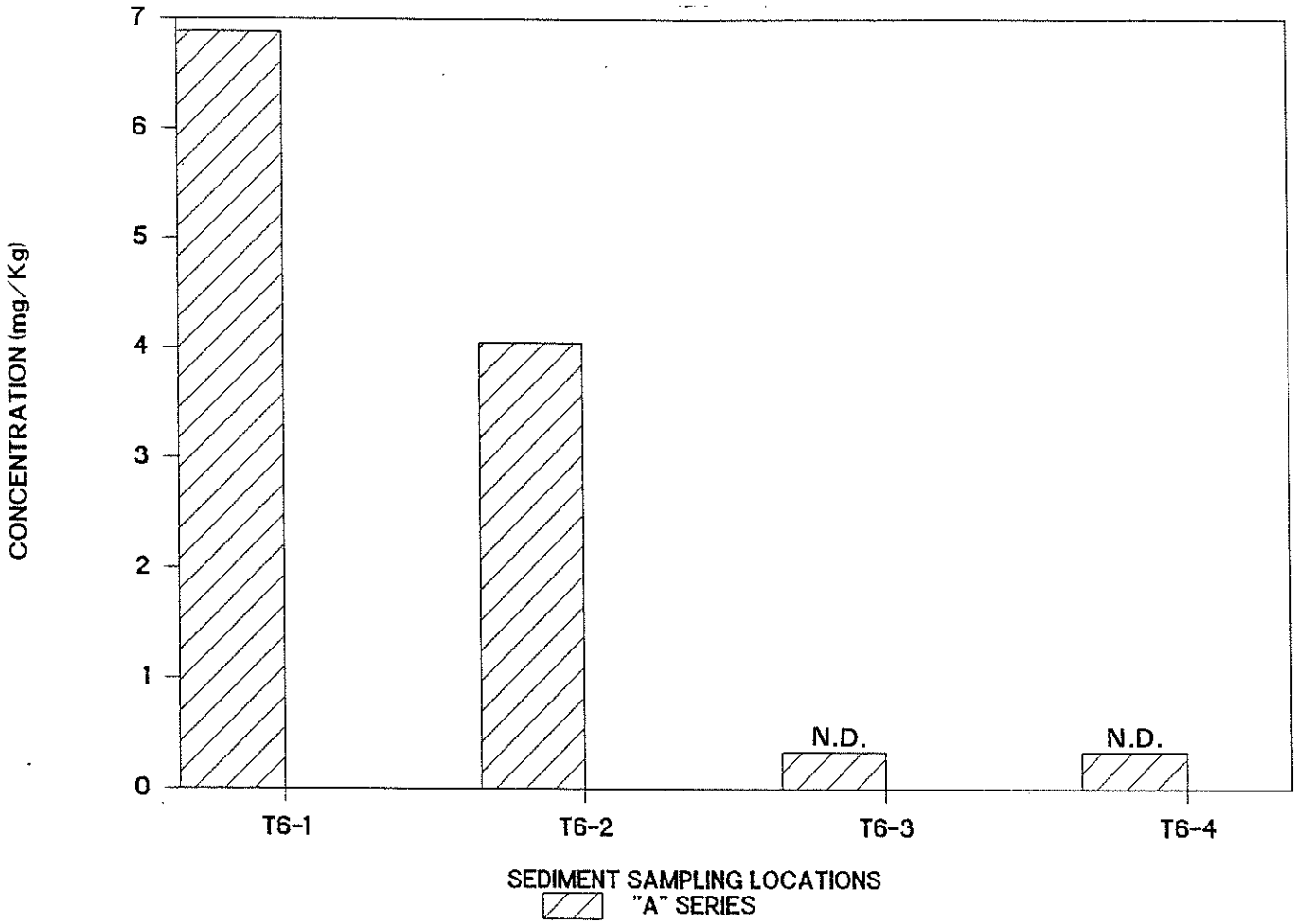
Southern Pacific Transportation Company
Liquid Gold Site

Oil and Grease in Sediment Samples
Transect T6

LG006411

K/J/C 855018.07
December 1990

Figure 69



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Southern Pacific Transportation Company
Liquid Gold Site

Total PAHs in Sediment Samples
Transect T6

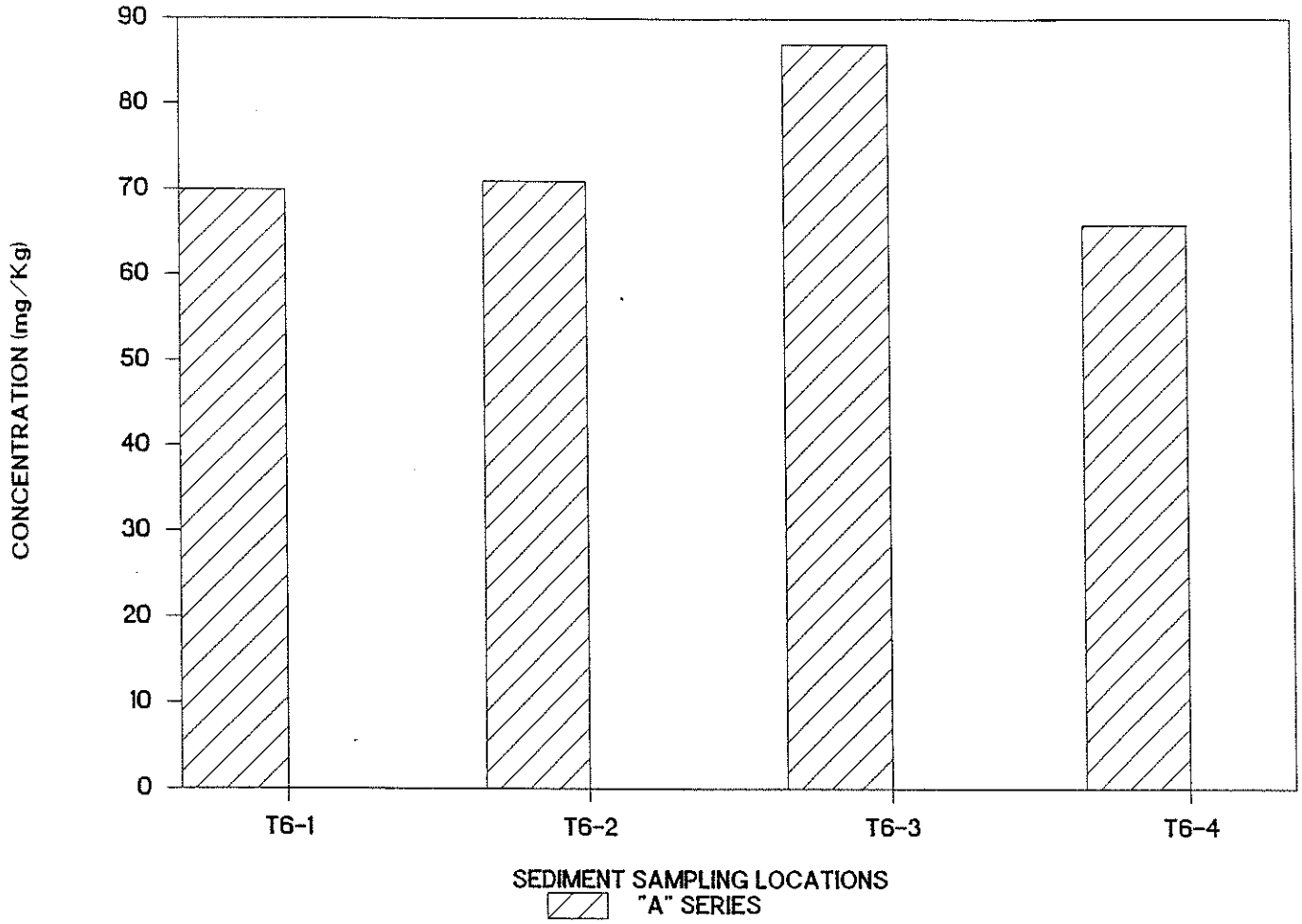
LG006412

K/J/C 855018.07
December 1990

Figure 70

Note:

N.D. indicates not detected at the detection limit indicated.



Kennedy/Jenks/Chilton

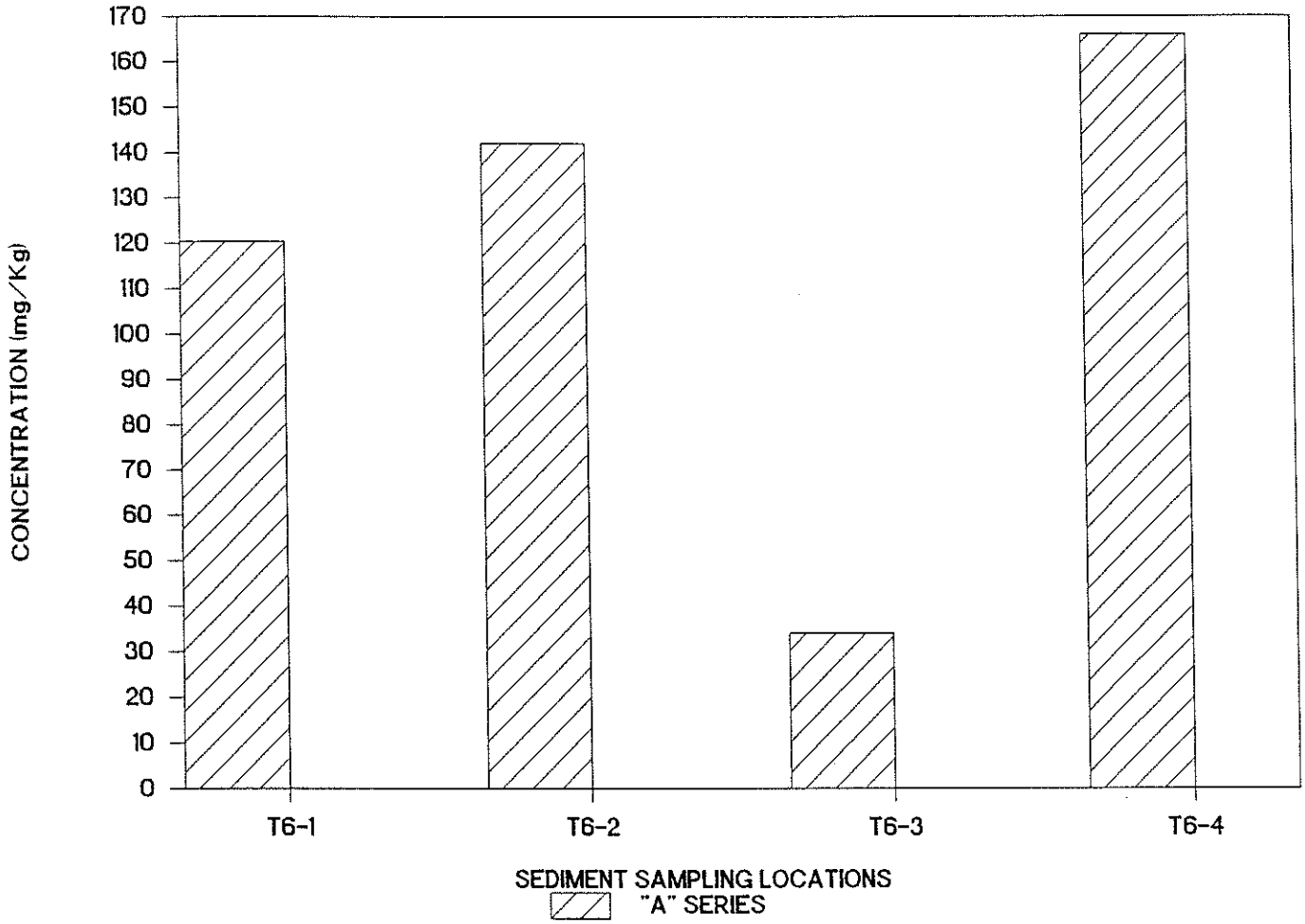
Southern Pacific Transportation Company
Liquid Gold Site

Total Chromium in Sediment Samples
Transect T6

LG006413

K/J/C 855018.07
December 1990

Figure 71



Kennedy/Jenks/Chilton

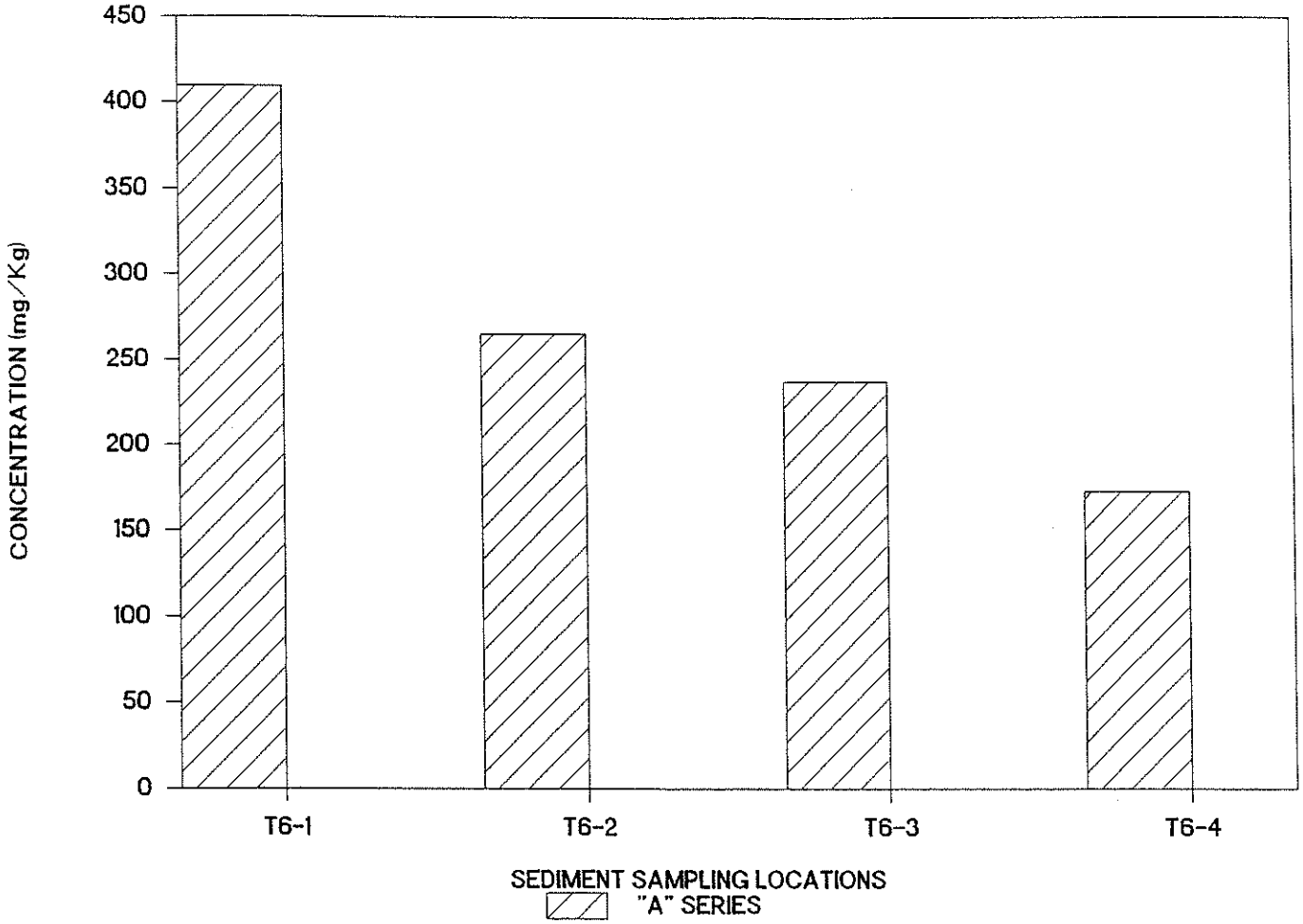
Southern Pacific Transportation Company
Liquid Gold Site

Total Copper in Sediment Samples
Transect T6

LG006414

K/J/C 855018.07
December 1990

Figure 72



Kennedy/Jenks/Chilton

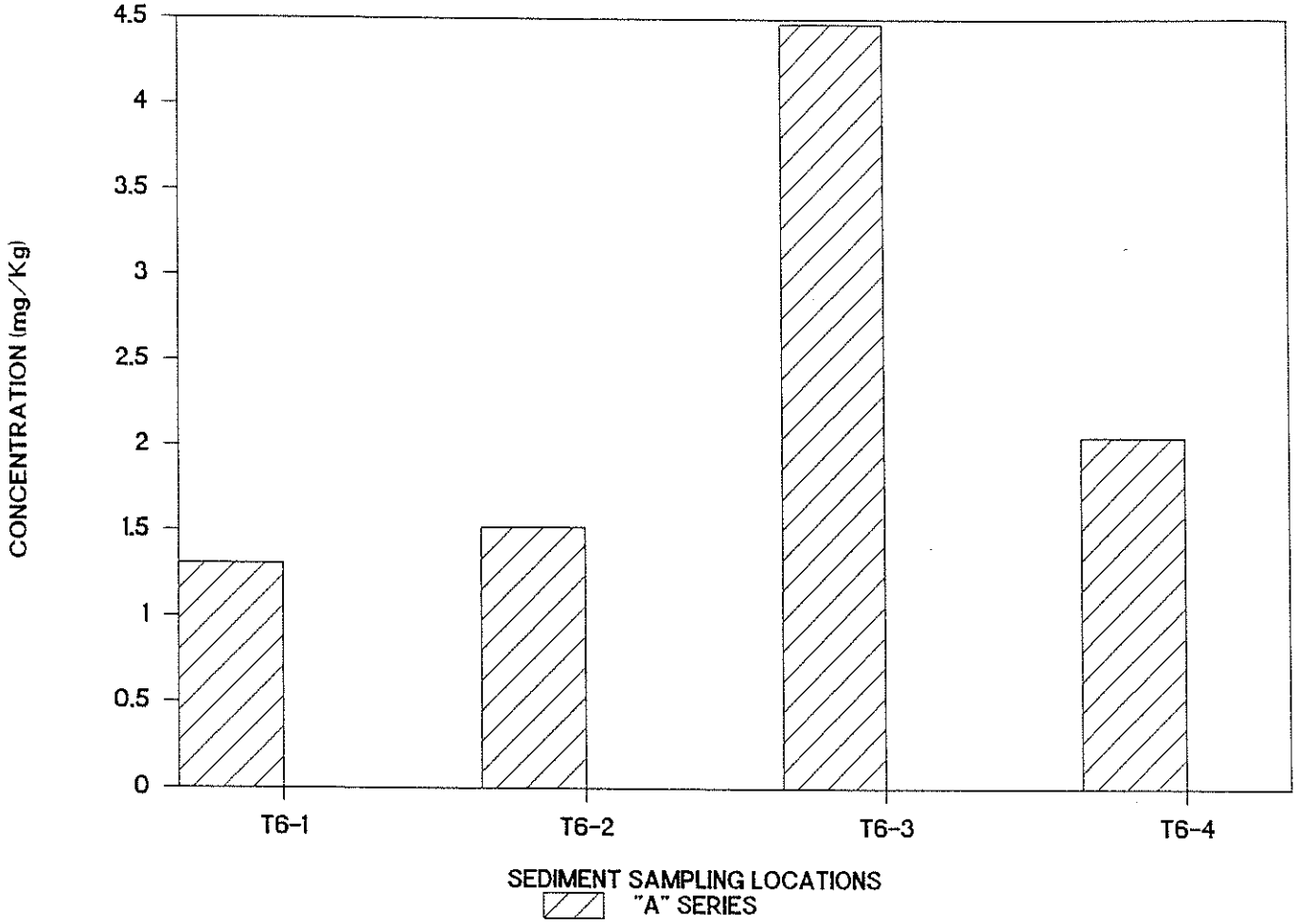
Southern Pacific Transportation Company
Liquid Gold Site

Total Lead in Sediment Samples
Transect T6

K/J/C 855018.07
December 1990

LG006415

Figure 73



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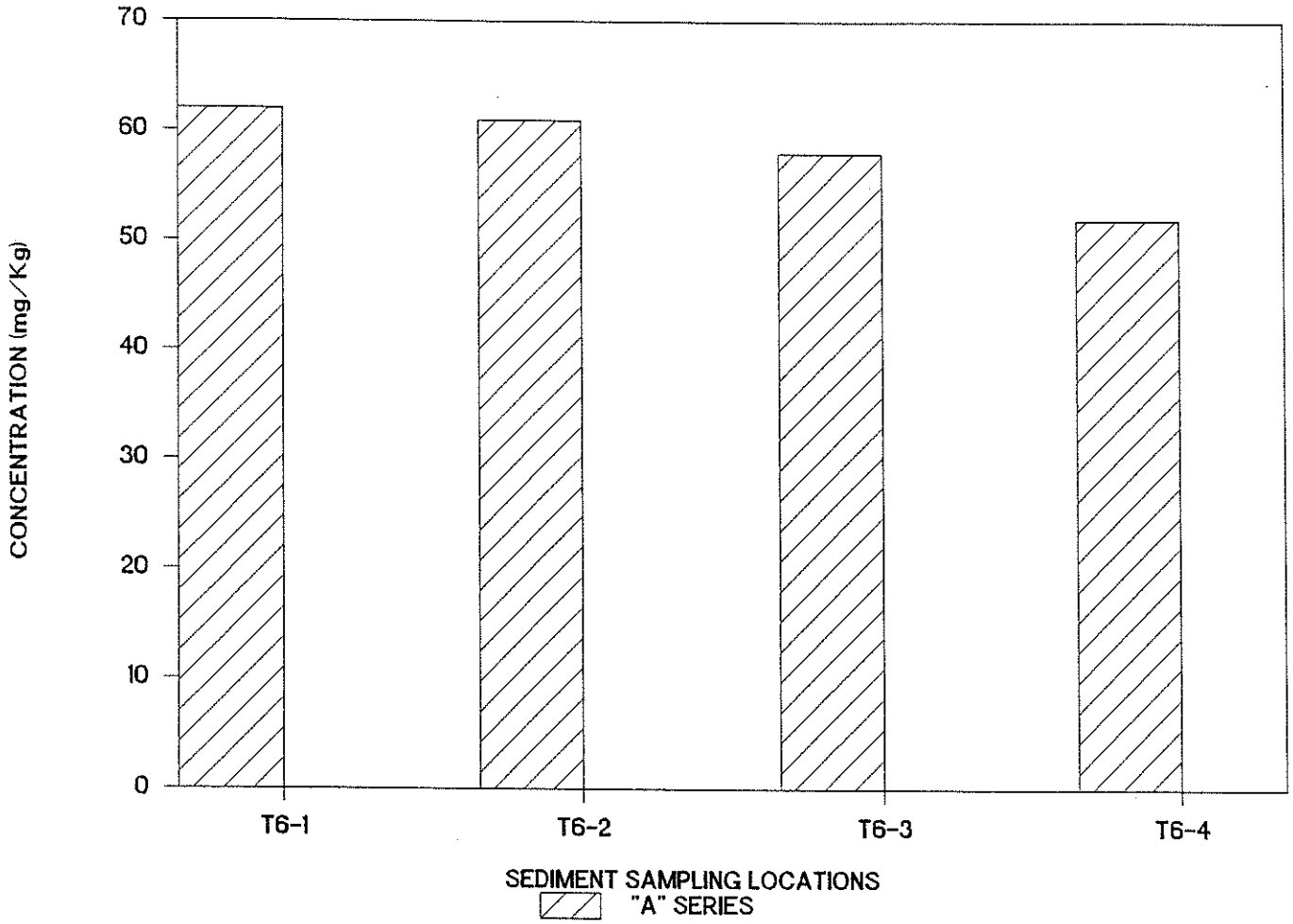
Southern Pacific Transportation Company
Liquid Gold Site

Total Mercury in Sediment Samples
Transect T6

LG006416

K/J/C 855018.07
December 1990

Figure 74



Kennedy/Jenks/Chilton

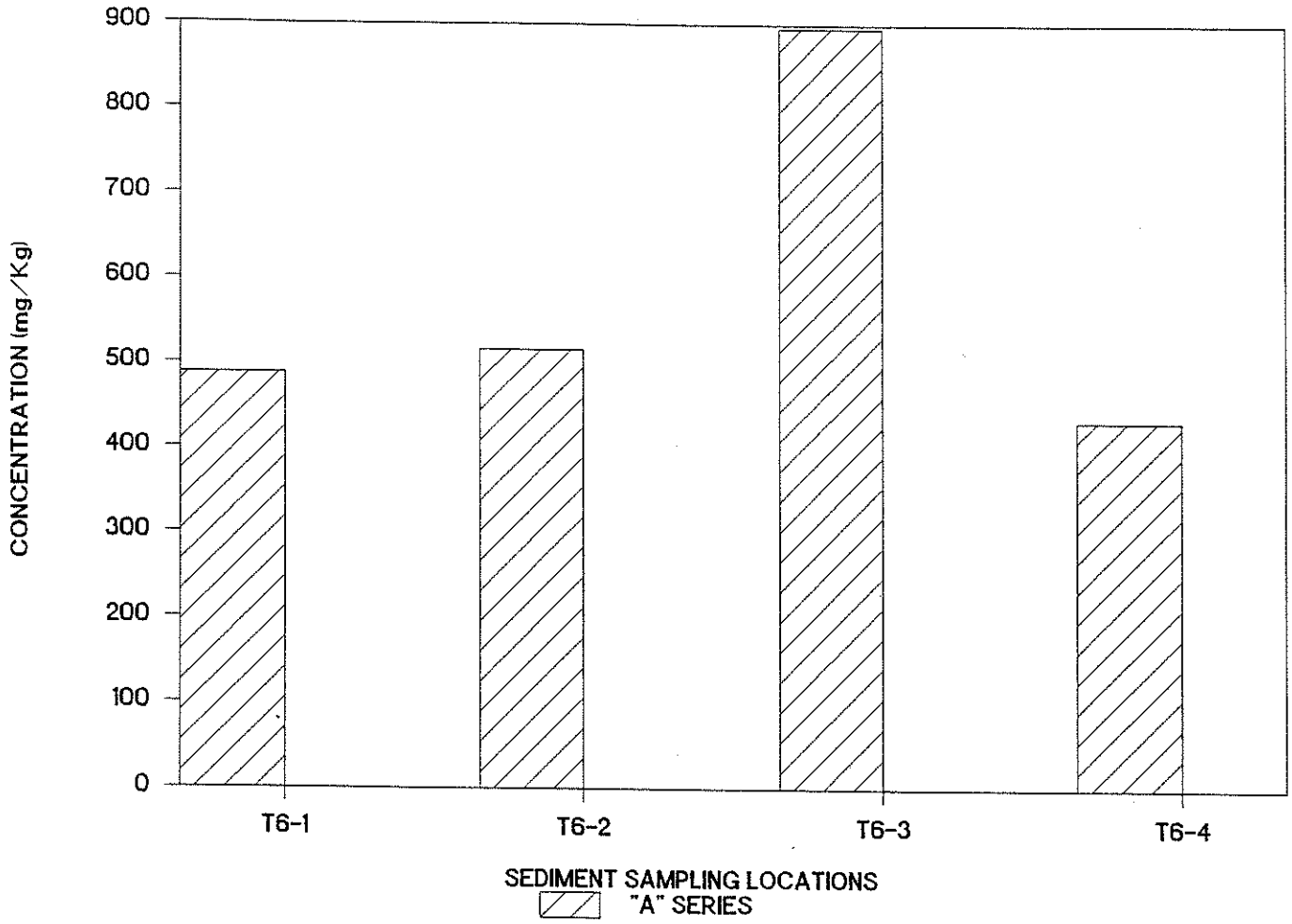
Southern Pacific Transportation Company
Liquid Gold Site

Total Nickel in Sediment Samples
Transect T6

LG006417

K/J/C 855018.07
December 1990

Figure 75



Kennedy/Jenks/Chilton

Southern Pacific Transportation Company
Liquid Gold Site

Total Zinc in Sediment Samples
Transect T6

LG006418

K/J/C 855018.07
December 1990

Figure 76