Harding Lawson Associates

A Report Prepared for

Blue Print Service Company
149 Second Street
San Francisco, California 94105

WORK PLAN
CITY BLUE PRODUCTION FACILITY SITE
17TH AND JEFFERSON STREETS
OAKLAND, CALIFORNIA

HLA Job No. 18106,004.04

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EXECUTIVE SUMMARY

Harding Lawson Associates (HLA) has performed soil and ground water characterization at the City Blue Production Facility site located at 1700 Jefferson Street in Oakland, California (Plate 1). The site is owned and under further development by Blue Print Service Company. In the above characterization, gasoline hydrocarbons (which appear to be relatively volatile) were detected in the soil and ground water. The source of gasoline appears to have been one or more of three underground storage tanks which were on the property but have subsequently been excavated and removed from the site. In this report HLA provides an interpretation of geological and hydrogeological conditions at the site, identifies and screens the potential remedial alternatives for soil and ground water, submits a work plan for remediation of soil and, finally, outlines a tentative schedule for implementation of the soil and ground water cleanup programs.

Because the extent of gasoline hydrocarbons in the soil and ground water has not been extensively characterized at this time, details of the work plan for remediation may need modification as additional characterization is done.

Geologic and Hydrogeologic Conditions at the Site

The site is generally characterized by three distinct predominantly sand units overlying a silty clay aquitard found at about 30 to 32 feet below the ground surface. These three units consist of approximately 3 to 5 feet of silty sand fill underlain by 15 to 18 feet of native silty or clayey sand which is further underlain by 10 to 15 feet of fine-grained sand.

Ground water is encountered approximately 25 to 26 feet below the ground surface. The ground water gradient or direction of movement, as determined by surveyed water-level readings, is in a north to northeast direction.

Soil Remediation Technologies

The following candidate technologies for remediation of soil are evaluated:

1. Off-site disposal
2. Enhanced biodegradation (land farming)
3. Chemical oxidation
4. Incineration
5. Soil aeration
6. In situ biodegradation
7. Soil venting (also known as Vapor Extraction Systems or VES)

These technologies are evaluated based on three technical screening criteria: demonstrated performance, implementability at the site, and institutional (regulatory) acceptability. For this site soil venting appears to meet all the screening criteria mentioned above and is recommended for implementation at the site. Soil venting is an effective, in-situ treatment technology for permeable soil containing elevated concentrations of gasoline hydrocarbons. Installation and operation of either a pilot-scale or full-scale soil venting system will not affect current or future building construction programs.

Work Plan: Implementation of Soil Venting

The implementation of a soil venting program will be accomplished in two separate phases.

I. **Pilot-Scale Soil Venting.** A pilot-scale soil venting test will be mobilized at the site and operated for a period of two weeks. The objectives of the pilot test are: 1) to assess the effectiveness of the soil venting system to reduce the level of hydrocarbon concentrations in the vadose zone; 2) to collect data needed to apply to the Bay Area Air Quality Management District (BAAQMD) to acquire an authority to construct and operate a full-scale system; and 3) to develop scale-up criteria for detailed design and implementation of a full-scale system. A process flow diagram of the pilot-scale soil venting system is shown in Plate 2.

II. **Full-Scale Soil Venting.** Based on the results of the pilot-scale soil venting system described above, a full-scale soil venting system will be designed and operated at the site.

<u>Treatment of Ground Water</u>

As documented in our Ground-Water Investigation report dated November 3, 1987, free gasoline product has been detected floating on the ground water in Monitoring Well MW-1 at the site. Following this report, additional wells (MW-1A and MW-4) were installed. These wells are shown on the Site Plan, Plate 1. Free gasoline product has subsequently been detected in both MW-1A and MW-4. In addition, ground-water samples collected at MW-1, MW-1A, MW-2 and MW-4 (Plate 1) have been found to contain elevated concentrations of dissolved TPH (total petroleum hydrocarbons), benzene, toluene, and xylene.

The first step in ground-water treatment will be to extract the subsurface fluid and in aboveground equipment physically separate any hydrocarbons from the water. The balance of water containing dissolved hydrocarbons will then be treated by one of the three potential alternatives. The Conceptual Flow Diagram for the above scheme is shown on Plate 3.

The proposed treatment process includes a single pump extraction system to pump ground water to an aboveground oil/water separator. The separator will remove free gasoline from ground water. The free gasoline will be recycled or disposed at an approved facility.

The effluent ground water from the oil/water separator will contain gasoline hydrocarbons as dissolved constituents. The following technologies are identified and screened for removal of dissolved gasoline hydrocarbons:

1. Air stripper
2. Liquid phase activated carbon treatment
3. Biological treatment (surface bioreactor)
4. Ultraviolet/Hydrogen Peroxide oxidation.

Table 2 summarizes the screening of ground-water treatment alternatives. Air-stripping, liquid phase activated carbon bed, and biological treatment appear to be suitable for implementation at the site. A technical and cost evaluation for these three alternatives is necessary and recommended as the next step.

Implementation Schedule

The proposed implementation schedule of the soil and ground-water remediation programs is shown on Plate 4.

The soil and ground water remediation programs will be implemented in four phases. Phase I involves detailed site characterization which includes (a) definition of the lateral and vertical distribution of gasoline hydrocarbons in soil, and (b) evaluation of the aquifer parameters. Phase II involves a detailed technical and cost evaluation of the soil and ground water remediation alternatives which have been selected in this report. For soil, soil venting and for ground water air stripping, liquid phase activated carbon bed and biological treatment have been recommended for further evaluations. Phase III involves implementation of a pilot scale and, based on the results of pilot scale, a full-scale soil venting system. Phase IV involves the design and implementation of the remedial alternative for ground-water remediation, which has been selected after detailed technical and cost evaluations described in Phase II. The time frames for the implementation of these four phases overlap with each other and proposed time period for implementation of Phases I-IV is approximately 3 years.

1.0 INTRODUCTION

In February 1987 Harding Lawson Associates (HLA) conducted a soils investigation and preliminary hazardous waste assessment at 1700 Jefferson Street, Oakland, California, prior to the proposed construction of the City Blue Production Facility by the property owner, Blue Print Service Company (Plate 1). A gasoline station was located on the northwestern corner of the property. At that time, five soil borings were installed, two of which (Borings 4 and 5) were located near three underground fuel tanks used by the gas station. Chemical analysis of soil and ground water from Borings 4 and 5 indicated that petroleum hydrocarbons were present in the subsurface in the area of the tanks. On the basis of our observations during subsequent tank removal and the analytical results from these borings, HLA concluded that one or more of the three tanks had released petroleum hydrocarbons. A leak report was subsequently filed in early April 1987*.

In June 1987, the gas station was demolished and the three underground tanks were excavated and inspected. Each of the tanks appeared to be a possible source for leakage. The soil beneath the tanks was excavated to a depth of approximately 9 feet, aerated at the surface, in accordance with Bay Area Air Quality Control Management District's Regulation 8, Rule 40, and used as backfill for the excavation. During June 1987, three monitoring wells (MW-1, MW-2, and MW-3) were installed on the property to evaluate the distribution of hydrocarbons in the subsurface and determine the direction of ground-water movement.

Gasoline was found floating on the ground water in Monitoring Well MW-1. Skimming of the floating gasoline has been taking place on a daily basis since early September 1987, with recovery of approximately 200-250 gallons of product. In January

* Copies of the leak report were sent to the property owner, the Alameda County Environmental Health Service, the California Regional Water Quality Control Board (San Francisco Bay Region), the State Water Resources Control Board and the California Toxic Substances Control Division.

1988 two additional monitoring wells (MW-1A and MW-4) were installed at the facility. Well MW-1A replaced MW-1 whose casing had failed due to prolonged contact with the floating product. Monitoring Well MW-1 and MW-1A are currently being used for product recovery. MW-1 will be sealed during the cleanup program.

1.1 Existing Facility

Construction of the reproduction facility building began in December 1987 and should be completed in July 1988. The building is located on the eastern two-thirds of the property, with a proposed asphalt-paved parking lot covering the land occupied by the former gas station and associated underground tanks.

1.2 Objectives

The objectives of this report are as follows:

1. Interpret existing geologic and hydrogeologic conditions at the facility.
2. Describe available technologies for remediation of soil and on-site ground water containing gasoline hydrocarbons.
3. Screen the technologies to assess which are suitable for further evaluation.
4. Identify additional studies needed to evaluate the selected technologies and their implementability at the site.
5. Identify the tasks involved and provide a tentative schedule to implement a successful remediation program for both soil and ground water.

2.0 GEOLOGY AND HYDROGEOLOGY

2.1 Lithology

The site is 180 feet by 70 feet in plan dimensions and is relatively level. Subsurface lithologic conditions encountered during installation of the borings and monitoring wells have been uniform over the site.

The site is covered by 3 to 5 feet of loose to medium-dense silty sand fill that occasionally contains gravels and/or brick fragments. The sand fill is underlain by a 15- to 18-foot-thick layer of native medium-dense to dense silty or clayey sand. In some of the borings, the fill-to-native-soil contact is nearly indistinguishable. The silty or clayey sand is underlain by approximately 10 to 15 feet of dense, fine-grained sand. This sand is underlain by a stiff to very stiff silty or sandy clay, which extends to the depths investigated (approximately 32 to 35 feet).

Hydrocarbon odors were noted where drilling Borings 4, 5, and 6, and Monitoring Wells MW-1, MW-1A, MW-2, and MW-4. Lithologic logs for these borings and monitoring wells are presented in Appendix A. The highest hydrocarbon concentrations detected in the soil using a Gastech Combustible Gas Indicator were typically within 5 to 10 feet of the water table. Ground water in the borings and monitoring wells was first encountered approximately 25 feet below ground surface.

2.2 Hydrogeology

Each monitoring well was surveyed after installation to determine location and elevation. Depth to ground water was measured using a steel tape, and a clear acrylic bailer was used to check for free product floating on the ground water. Free product has been found in Monitoring Wells MW-1A, MW-1, and MW-4. Ground-water measurements recorded indicate that ground water is moving in a northeasterly direction. Ground-water samples have been collected and analyzed in each monitoring well and indicate that benzene, toluene, and xylenes (BTX) are present. The analytical results of soil and ground-water samples taken during and after monitoring well installation are presented in Table 3.

3.0 SOIL REMEDIATION TECHNOLOGIES

Remedial technologies available for removing gasoline hydrocarbons from soil are listed below:

1. Off-site disposal
2. Enhanced biodegradation (landfarming)
3. Chemical oxidation
4. Incineration
5. Soil aeration
6. In situ biodegradation
7. Soil venting

3.1 Off-Site Disposal

Soil with elevated concentrations of gasoline hydrocarbons can be excavated and disposed at a Class I landfill. Off-site disposal is relatively expensive and could have potential long-term liabilities.

3.2 Enhanced Biodegradation (Landfarming)

Landfarming is an established technology for treating petroleum hydrocarbon-contaminated soils. Widely used in the petroleum industry, landfarming achieves destruction of hydrocarbon wastes by enhancing bacterial metabolism in the contaminated soils. Contaminated soils are excavated and hauled to a treatment area where nutrients are added to the soil to increase and sustain the indigenous microbial population. These microorganisms use hydrocarbons for growth, thus reducing the concentrations of hydrocarbons in the soil. The treatment area could be constructed on site and consist of a containment liner and leachate collection system. Water and electric lines and a security fence would be necessary.

3.3 Chemical Oxidation

Chemical oxidation involves adding hydrogen peroxide and a catalyst to hydrocarbon-bearing soils. The hydrogen peroxide oxidizes the hydrocarbons present in the soil to carbon dioxide and water. To achieve chemical oxidation, adequate contact between the hydrocarbons and the reagents is required. The contaminated soils must be excavated and processed in a designated treatment area or an aboveground reactor. This relatively new technology has been demonstrated in two separate sites and is currently being evaluated by the regulatory agencies. A feasibility study will be needed to demonstrate the effectiveness of this process. A permit for treatment will be required by the appropriate regulatory agencies.

3.4 Incineration

Incineration is an effective process for thermal destruction of soil containing hydrocarbons. The hydrocarbon-bearing soil requires excavation before incineration in a kiln having a typical oxidation temperature of 1,500°F. Hydrocarbons present in gasoline are oxidized to carbon dioxide and water. Permits from the appropriate regulatory agencies are required to operate an incinerator. However, it is difficult to get a permit to operate an incinerator in California.

3.5 Soil Aeration

Soil aeration requires excavating and moving the soil to a treatment area, where it is spread to a depth of 1 to 3 feet and periodically mixed by mechanical equipment, such as a large rototiller. The volatile hydrocarbons present in the soil are released to the atmosphere during the treatment period. The treated soil can then be backfilled in the excavated area. Volatilization rates can be calculated and treatment periods estimated based upon the average concentration of hydrocarbons present in the soil. The local air quality management district must be notified and approve the proposed aeration.

3.6 In Situ Biodegradation

In situ biodegradation involves enhancing the ability of indigenous bacteria to metabolize hydrocarbons in the soil by applying nutrient-enriched water to the subsurface by infiltration or injection. An aqueous solution containing inorganic nutrients and hydrogen peroxide or sparged oxygen is typically used. The water source could be the effluent from the site's ground-water treatment facility.

A laboratory treatability study and a DOHS permit or variance are usually required.

3.7 Soil Venting

Soil venting removes volatile hydrocarbons from soil by applying a vacuum below surface. Air that has been in contact with volatile compounds in the soil contains vapors in proportion to the saturation vapor pressure of the hydrocarbons present in gasoline. Applying a vacuum below ground surface extracts the hydrocarbon vapor, which is then passed through an emission control system to meet air emission criteria.

Soil venting has been successfully applied for the removal of volatile hydrocarbons from vadose zone soils. However, the soils must be permeable enough to permit air flow, and the vapor pressure of the individual compounds must be sufficiently high to promote volatilization from the soil.

3.8 Screening of Soil Remediation Technologies

The seven soil remediation technologies described in the previous section were screened based on the following three technical criteria:

1. Demonstrated performance: Technologies must have been applied successfully in full-scale systems.

2. Implementability: Technologies must be appropriate, simple, easy to fabricate and implementable at the site.

3. Institutional (Regulatory) Acceptance: Technologies must be appropriate for the remediation objectives and must comply with the Department of Health Services (DOHS), Bay Area Air Quality Management District (BAAQMD), Regional Water Quality Control Board (RWQCB), and local regulatory agency requirements. In addition, any disposal to landfills or discharge to city sewer must meet their local administrative requirements. Current soil cleanup regulations can be described as follows:

   The RWQCB generally allows treated soil with total petroleum hydrocarbon (TPH) as gasoline concentration up to 1000 mg/kg to remain in place. They sometimes permit higher concentrations under certain conditions. In general, soils with TPH concentration above 1000 mg/kg must be treated to reduce the hydrocarbon concentration or removed and treated or disposed to a Class I landfill. More stringent guidelines may be published prior to cleanup of the site and the final design and cost of the remediation system will depend on such designated cleanup levels.

Of the seven technologies described above, the first five alternatives, namely off-site disposal, enhanced biodegradation (landfarming), chemical oxidation, incineration, and soil aeration require excavation of the contaminated soil. Excavation at the site would require extensive shoring and is considered cost-prohibitive. Furthermore, excavation would have a serious negative impact on planned building utilization. Therefore, these five technologies do not meet the implementability criterion and were eliminated from further consideration.

An in situ biological degradation process requires a ground-water extraction system to provide hydraulic control of the treatment area for the required nutrient addition and to minimize migration of the contaminant plume. A concentrated aqueous nutrient solution would be added to the extracted ground water and the nutrient rich ground water is returned to the aquifer by injection wells or trenches. This remediation technique has been demonstrated to be effective in full-scale operations at sites with similar contaminant profiles. However, a treatability study would be required to determine site-specific process parameters before a full-scale system can be implemented. Because of the existing building structures, implementation of the required ground-water extraction system would be complicated and may be cost-prohibitive. Therefore, in situ biodegradation does not meet the implementability criterion and will not be considered for further evaluation.

Soil venting is an applicable remedial technology for permeable soil containing volatile hydrocarbons. The flow rate and hydrocarbon concentrations in the exhaust gas discharged from a soil venting system have to be monitored and analyzed in accordance with BAAQMD guidelines. Operation of a soil venting system also requires issuance of a permit by BAAQMD. Detailed design and costing of a soil venting system will require additional site-specific information, including the peak and asymptotic rates of volatilization of hydrocarbons from soil and the effective radius of influence of the induced vacuum in the subsurface. Soil venting meets all the screening criteria and should be considered for further technical and cost evaluations.

3.9 Recommendation

Table 1 summarizes the technical screening of remedial alternatives for soil. In summary, off-site disposal, landfarming, chemical oxidation, incineration, soil aeration, and in situ biodegradation do not meet the screening criteria and are not recommended for further evaluations. Soil venting does meet all the screening criteria and a work plan describing the implementation of the proposed soil venting technology is described in Section 4.0.

4.0 WORK PLAN - IMPLEMENTATION OF SOIL REMEDIATION TECHNOLOGY

In the previous section, the available soil remediation technologies have been evaluated based on a number of technical screening criteria. Soil venting is the only technology which meets all the criteria and was recommended for implementation at the site. The following is a work plan for implementation of the soil venting technology at the site.

4.1 Description of Soil Venting Technology

Soil venting utilizes in situ volatilization of subsurface volatile constituents and is particularly suited for vadose zone remediation. This process consists of applying a vacuum to a well or series of wells in the vadose zone containing hydrocarbons and inducing air flow in the subsurface soil through air inlet wells placed at or beyond the boundary of the hydrocarbon-bearing zone.

As air passes through the hydrocarbon-bearing soil, it displaces the soil gas (which is in vapor phase equilibrium with the hydrocarbons in solution in the pore water) and comes into contact with the gasoline adsorbed onto soil particles. The soil gas containing hydrocarbon vapors is drawn off and extracted by the vapor extraction well. The newly injected air in the soil matrix becomes recharged with additional vapor phase constituents as the hydrocarbons continue to volatilize. As this process continues, the volatile contaminant concentrations in both the soil and pore water are gradually drawn off into the vapor phase, where they are induced to migrate to a single collection point by an engineered, subsurface pressure gradient. The advantages and limitations of a soil venting system are discussed below:

Advantages

1. Soil venting is a simple, in situ remediation technology and does not require excavation of the contaminated soil in the vadose zone. The system can be operated effectively without affecting the present building construction program or future activities.

2. Soil venting is effective in remediating sites contaminated with gasoline and having permeable soil.

3. Soil venting has been successfully used by HLA and other consultants at sites with similar conditions.

Limitations

1. Soil venting leads to preferential volatilization of hydrocarbons which are more volatile than other hydrocarbons present in gasoline.

2. Soil venting may be susceptible to channeling effects that lead to air flow and volatilization of hydrocarbons in channels established in the subsurface. Therefore, some zones are treated more effectively than others.

4.2 Approach

The proposed implementation of the soil venting system will be carried out in two separate phases as follows:

I. A pilot scale study

II. Full-scale implementation

A detail description of these two phases is given below.

4.2.1 Pilot Scale Study

The objectives of the pilot scale study are as follows:

- To assess the effectiveness of soil venting at the site
- To gather data that would enable us to calculate design parameters for a full-scale system
- To gather data necessary to apply to the Bay Area Air Quality Management District (BAAQMD) for an authority to construct and permit to operate a full-scale system.

The scope of the pilot scale study can be defined as follows:

1. HLA will mobilize a portable vacuum extraction unit, vapor phase activated carbon system for off-gas treatment, and associated piping. Existing monitoring wells near the building (MW-1, MW-1A, and possibly MW-4) will be used as vapor recovery wells. A source of 230 or 460 volt power at the test locations will be required at the site. A schematic flow diagram of the pilot-scale vapor extraction system is shown on Plate 2.

2. The pilot test will consist of the following tasks:

   a) Each well will be tested individually (or "developed") for 4 to 24 hours. Development of each well will be discontinued when the flow rate becomes relatively stable. Wellhead VOC gas concentrations will be monitored during this period with an organic vapor analyzer (OVA). This will provide data from which the total VOC concentration and total VOC removal rate may be calculated. Gas flow rates will be measured with an in-line flow meter.

   b) The well having the highest VOC mass removal rate (based on data collected during Task a) will be tested more extensively.

      The test will comprise a 1 to 1-1/2 week test period during which we will extract soil gas and monitor wellhead concentrations of the selected extraction well. Any wells present at the site, but not undergoing extraction will be sealed at the surface and equipped with a manometer to measure the response to vacuum exerted at the extraction well. We will perform routine system maintenance.

   c) During the initial period of operation of the pilot test, VOC concentrations in the air samples collected at the wellheads will be monitored with an OVA at 15- to 30-minute intervals. Subsequent sampling intervals will be determined by changes in the rate of VOC extraction. To better define the compounds removed, samples will also be submitted to a laboratory for quantification of EPA Test Method 602 parameters. These data will be used to develop a calibration curve for the OVA. One or two samples per day on five different days will be submitted.

   d) Extracted VOCs will be adsorbed on activated vapor phase carbon consisting of at least a primary and a secondary carbon unit. The outlet of the carbon adsorption system will be monitored by the OVA for VOCs to determine when the carbon units should be replaced. The spent carbon will be transported in accordance with the appropriate regulations to a permitted thermal regenerator. Blue Print Service Company representatives will be responsible for preparing and signing transport manifests for the spent carbon.

3. Data collected during this pilot study will be analyzed and presented in a report to include:

   a) Discussion of the system's operation, sampling, and analytical procedures

   b) Results of chemical analyses

   c) Graphs of the mass of VOCs extracted versus time

d) Estimate for the range of cleanup time of the site to a specified level of gasoline concentrations in soil.

e) Recommendations for design specifications for a full-scale treatment system.

4.2.2 Full-Scale Implementation

Full-scale implementation of a soil vapor extraction system will include the following steps:

1. Scope definition, design specification for a vapor extraction system
2. Work authorization from client
3. Preparation of BAAQMD air permit application
4. Detail design of vapor extraction system
5. Internal (HLA) and client review
6. BAAQMD permit review and authorization
7. Procurement
8. Construction
9. Construction inspection
10. Startup and troubleshooting
11. Operation

A tentative schedule for the implementation of soil vapor extraction system is given on Plate 4.

5.0 GROUND-WATER TREATMENT TECHNOLOGIES

Ground-water samples collected from Monitoring Wells MW-1 and MW-2 have been found to contain elevated concentrations of dissolved gasoline hydrocarbons (*HLA Report dated November 3, 1987*). Free gasoline product has also been observed in Monitoring Well MW-1 during the early phase of site investigation. Following installation of MW-1A and MW-4, additional chemical analyses and measurements of product thickness were performed and hydrocarbons were detected in MW-1A and MW-4. The observed product thicknesses in Monitoring Wells MW-1, MW-1A, and MW-4 are in the range of 12 to 24 inches.

Plate 4 shows a conceptual design of the proposed ground-water treatment system. Ground-water treatment will consist of two separate activities:

1. Ground-Water Extraction and Separation
   A single pump extraction system will pump ground water to an aboveground oil/water separator. The separator will remove the free gasoline from the influent ground water. The effluent ground water from the separator will contain gasoline hydrocarbons as dissolved constituents. The separated free gasoline must be disposed of properly.

2. Treatment of Separated Ground Water
   The effluent ground water from the separator needs to be treated further to remove dissolved hydrocarbons. The following alternatives are available.

   a. Air stripping

   b. Liquid phase activated carbon treatment

   c. Biological treatment (surface bioreactor)

   d. Ultraviolet/hydrogen peroxide oxidation.

In Sections 5.1 through 5.5 below, available ground-water remediation technologies are described and screened; Section 5.6 recommends further evaluation of three most promising technologies.

5.1 Air Stripping

Air stripping has successfully been applied in treatment systems at many sites to remove gasoline hydrocarbons from ground water. To remove or strip volatile compounds from ground water, the extracted water is introduced at the top of a tower filled with a high surface area plastic packing medium. Water is sprayed downward over the packing medium while air is blown upward from the bottom of the tower to transfer the hydrocarbons from an aqueous phase into a vapor phase. Hydrocarbons present in the influent ground water are removed by the air stripping process.

The BAAQMD requires permits to construct and operate an air stripper. BAAQMD also regulates the amount of gasoline vapors that may be discharged to the atmosphere.

Air pollution control devices may be required to remove the stripped hydrocarbons from the off-gas before it is discharged to atmosphere; if so, emissions from the air stripper typically would be passed through contactors containing granular activated carbon which would adsorb the gaseous volatiles. Activated carbon contactors saturated with the hydrocarbons would have to be treated or disposed of by off-site regeneration, on-site regeneration, or disposal at a Class I landfill.

5.2 Liquid Phase Activated Carbon Treatment

With a liquid phase activated carbon treatment system, extracted ground water is passed directly through granular activated carbon contactors for adsorption of hydrocarbons.

Monitoring of the treated effluent water will be necessary to determine breakthrough of the carbon beds. If the carbon contactors are operated in series, only the first contactor would need to be monitored. When breakthrough occurred in the first contactor, the second contactor would treat the full load until the carbon in the first contactor was replaced.

Spent carbon can be regenerated either on site or off site. On-site regeneration increases capital investment and operation and maintenance costs, and is usually economical only for sites with high carbon usage. For off-site regeneration, an outside vendor assumes responsibility for removing spent carbon, replacing it with fresh material, and reactivating the spent carbon.

5.3 Biological Treatment

Biological treatment removes organic contaminants from the ground water through enhancement of indigenous microorganisms to metabolize the organic contaminants. Biological enhancement involves the addition of limiting nutrients such as nitrogen, phosphorus, and oxygen to the contaminated ground water in a surface bioreactor. Addition of nutrients is required to accelerate the rate of biological degradation of the organic contaminants. If oxygen and inorganic nutrients are available, natural ground-water microorganisms have been shown to degrade organic compounds present in gasoline, including aromatic hydrocarbons such as benzene, toluene, and xylenes. Biodegradation of the organic contaminants usually results in the formation of carbon dioxide, water, and nonhazardous cellular constituents.

Extracted ground water is introduced into a bioreactor containing the microorganisms and supplemental nutrients. Following a specified retention time (usually 8 to 12 hours) for hydrocarbon removal, the ground water is passed through a sand filter to remove excess microorganisms and may be discharged. A treatability study to define site-specific treatment process parameters and a RWQCB permit or variance are required for implementing this technology.

5.4 Ultraviolet/Hydrogen Peroxide (UV/H_2O_2) Oxidation

UV/H_2O_2 oxidation is a process by which organic chemicals are converted to carbon dioxide and water. Although UV light alone can oxidize organics, it is generally used in conjunction with H_2O_2 or ozone to facilitate oxidation. When H_2O_2 is catalyzed by UV light, hydroxyl radicals are formed which react with the organic compounds present in gasoline to form carbon dioxide and water.

This process has been utilized successfully to treat ground water containing both aliphatic and aromatic organic chemicals. A pilot study to determine flow rate and final process design is usually necessary. A permit or variance from RWQCB would be required.

5.5 Screening of Ground-Water Treatment Technologies

On-site ground-water remediation alternatives were screened on the basis of demonstrated performance, implementability and institutional (regulatory) requirements. A detailed explanation of the screening criteria is given in Section 3.8. The regulatory requirements for cleanup of ground water will depend on a number of factors, including the concentration of dissolved hydrocarbons and a definition of the hydrocarbon plume in the ground water.

The first three remediation technologies, air stripping, liquid phase activated carbon adsorption, and biological treatment, have been successfully applied in the past to treat ground water containing gasoline under similar site conditions. Each of these three technologies meets the screening criteria, and merits further technical and cost evaluations.

UV/H_2O_2 oxidation is a developing technology that meets reliability and performance criteria based on pilot scale demonstrations. Usually the implementation of this technology is more capital intensive than that for the other alternatives. Also, implementation of this technology would require a pilot study for process control and design evaluation.

Design and operation data are available on air stripping and liquid phase activated carbon treatment of ground water containing gasoline. Therefore, application of either of these two technologies will not require a treatability study. In contrast, design and operation of a biological treatment system are site specific. Therefore, a treatability study is needed prior to a detail design of a biological treatment system. The treatability study will provide data as to the site-specific process parameters for the treatment system.

5.6 Recommendation

Table 2 summarizes the technical screening of ground-water remediation alternatives. Air stripping, liquid phase activated carbon filtration, and biodegradation were identified as reliable, institutionally acceptable, and implementable remediation technologies. Further technical and cost evaluation should be performed for each of these alternatives.

5.7 Disposal Options for Treated Ground Water

Three options are available for the disposal of treated ground water. They are:

1. Discharge to the storm drain
2. Discharge to the sanitary sewer
3. Injection to the subsurface.

To discharge to the storm drain an NPDES (National Pollutant Discharge and Elimination System) permit from the RWQCB is required. Discharge to the sanitary sewer would require issuance of a permit by the local sanitary district, in this case the East Bay Municipal Utilities District (EBMUD). Injection of treated ground water to the subsurface would be accomplished through injection well(s) and would require a permit from the RWQCB. Generally, injection is difficult to permit and has stringent monitoring requirements. Selection of the disposal alternative will depend on the field location of the ground-water treatment system, permitting requirements, and disposal cost. Disposal options will be evaluated during the final design of the treatment system.

6.0 RECOMMENDED FUTURE ACTION

6.1 Task I. Site Characterization

Task I involves characterization of the site. On the basis of the characterizations to date, the following steps will be required in Task I.

a) Assess Aquifer Parameters

HLA has conducted a hydrogeologic investigation approximately 2,000 feet south of the Blue Print Service Company facility which has similar lithologies. It is believed that the information obtained at the other location should be approximately representative of conditions at the Blue Print Service Company facility. To confirm this, a slug test will be performed on Monitoring Well MW-3 to evaluate the aquifer parameters.

b) Install MW-5

The five wells installed at the site are not sufficient to completely define the plume of gasoline contamination. A sixth well, MW-5, will be installed off site near the corner of 18th and Jefferson streets. The results of sampling and chemical analysis of soil and ground water from this well may affect the extent of remediation required.

6.2 Task II. Technical and Cost Evaluations for Remedial Alternatives

In Sections 3.0 and 5.0 of this report, possible soil and ground-water remediation technologies have been screened based on a number of technical criteria. The following selected remediation alternatives will require further technical and cost evaluations.

1. Vapor extraction system for soil
2. Air stripper for ground water
3. Liquid phase carbon filtration for ground water
4. Biological treatment for ground water

6.3 Task III. Implementation of Soil Remediation Technology

A work plan describing the implementation of a soil vapor extraction system has been discussed in detail in Section 4.0.

6.4 Task IV. Design and Implementation of Ground-Water Remediation Technology

Task IV will involve selecting the best available technology that is technically feasible and cost-effective, followed by design, implementation and operation of the selected technology at the site. The following steps are involved in this task:

1. Selection of remedial alternatives based on technical and cost evaluations.
2. Scope definition, design specification for ground-water treatment process.
3. Treatability Study, if needed.
4. Work authorization by client.
5. Permit requirements for discharge of treated water (NPDES).
6. Detail design of water treatment system.
7. Internal (HLA) review.
8. Receive NPDES permit.
9. Preparation of construction bid package, evaluation and contractor selection.
10. Installation of extraction wells (as required).
11. Construction of water treatment system.
12. Startup.
13. Operation.

6.5 Tentative Schedule for Implementation of Tasks I - IV

A tentative schedule for the implementation of the four tasks described previously is shown on Plate 4.

Table 1. Summary of Technical Screening of Soil Remediation Alternatives

Alternative	Demonstrated Performance	Implementability	Institutional (Regulatory) Acceptability	Comment*
1. Off-Site Disposal	+	x	x	Do not recommend
2. Landfarming	+	x	+	Do not recommend
3. Chemical Oxidation	+	x	+	Do not recommend
4. Incineration	+	x	x	Do not recommend
5. Soil Aeration	+	x	+	Do not recommend
6. In-situ Biodegradation	+	x	+	Do not Recommend
7. Soil Venting	+	+	+	Recommend

\+ Meets the screening criterion.

x Does not meet the screening criterion.

* For details on demonstrated performance, implementability and institutional acceptability for each remedial alternative, please see Section 3.8.

Do not recommend: Do not recommend this alternative to be evaluated or considered any further.

Recommend: Recommend further technical and cost evaluations for this alternative.

Table 2. Summary of Technical Screening of Ground Water Remediation Alternatives

Alternative	Demonstrated Performance	Implementability	Institutional Regulatory Acceptability	Comment*
1. Air Stripping	+	+	+	Recommend
2. Liquid Phase Carbon Treatment	+	+	+	Recommend
3. Biological Treatment	+	+	+	Recommend
4. UV/H_2O_2 Oxidation	x	+	x	Do not recommend

\+ Meets the screening criterion.

x Does not meet the screening criterion.

* For details on reliability, demonstrated performance, implementability and institutional acceptability for each remedial alternative, please see Section 3.8.

Do not recommend: Do not recommend this alternative to be evaluated or considered any further.

Recommend: Recommend further technical and cost evaluations for this alternatives.ts

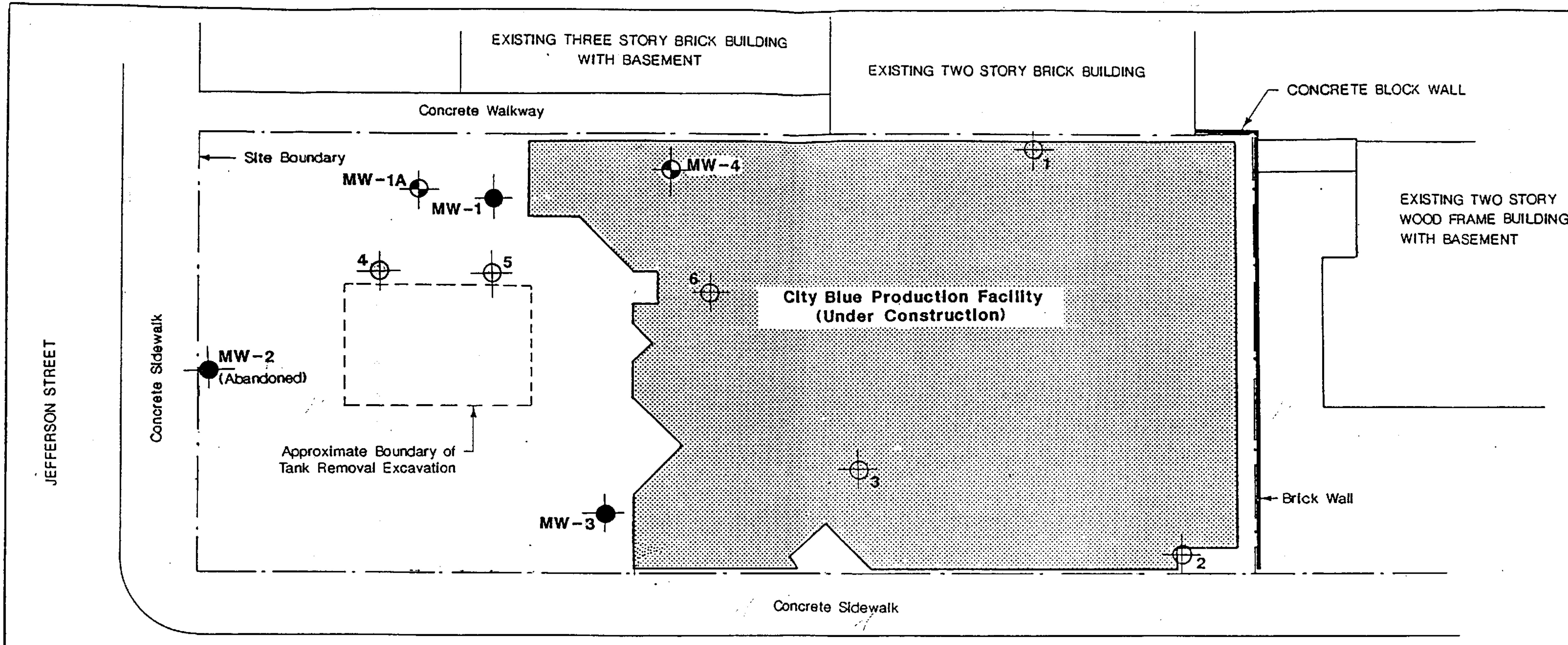
Table 3. Analytical Results

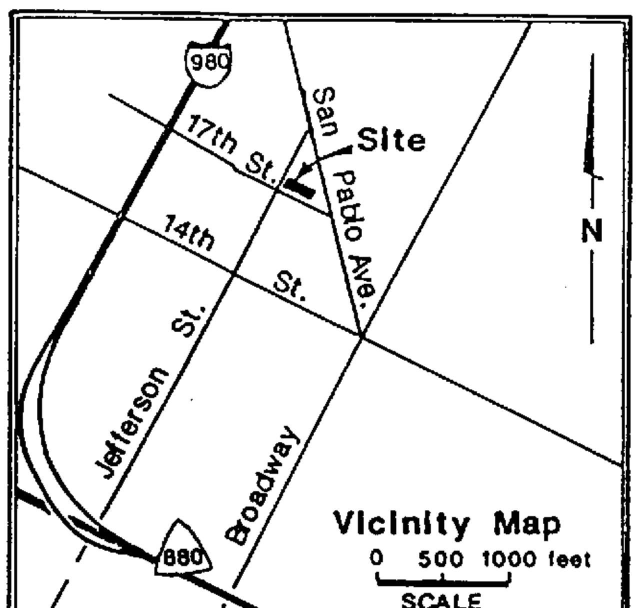
Monitoring Well	MW-1	MW-1A	MW-2	MW-3	MW-4
Soil Analyses					
Volatile Hydrocarbons pm (Modified EPA 8015)	4,500 ppm	--	ND	ND	270 p
Moisture Content (by weight)	13 %	--	11 %	11 %	--
Field Density	109 pcf	--	106 pcf	122 pcf	--
Ground-Water Analyses (ppm)					
Volatile Hydrocarbons (Modified EPA 8015)	190	40	8.2	6.2	12
Benzene	18	4.0	1.5	0.18	0.20
Toluene	26	7.0	0.35	0.50	<30
Xylene	3.7	7.0	0.087	0.17	2.00

mg/kg = Milligrams per kilogram

pcf = Pounds per cubic foot

ppm = Parts per million





EXPLANATION

MW-1 ● Approximate Monitoring Well Location and Number, previous investigation

1 ⊕ Approximate Boring Location and Number, previous investigation

MW-4 ◐ Approximate Monitoring Well Location and Number, this investigation

REFERENCES:

1. "Preliminary Site Plan, City Blue Production Facility, 1700 Jefferson Street, Oakland, California," by Garcia/Wagner and Associates, dated Feb. 17, 1987.
2. Untitled Survey (partial print), Seventeenth Street and Jefferson Street, Surveyor unknown.

N

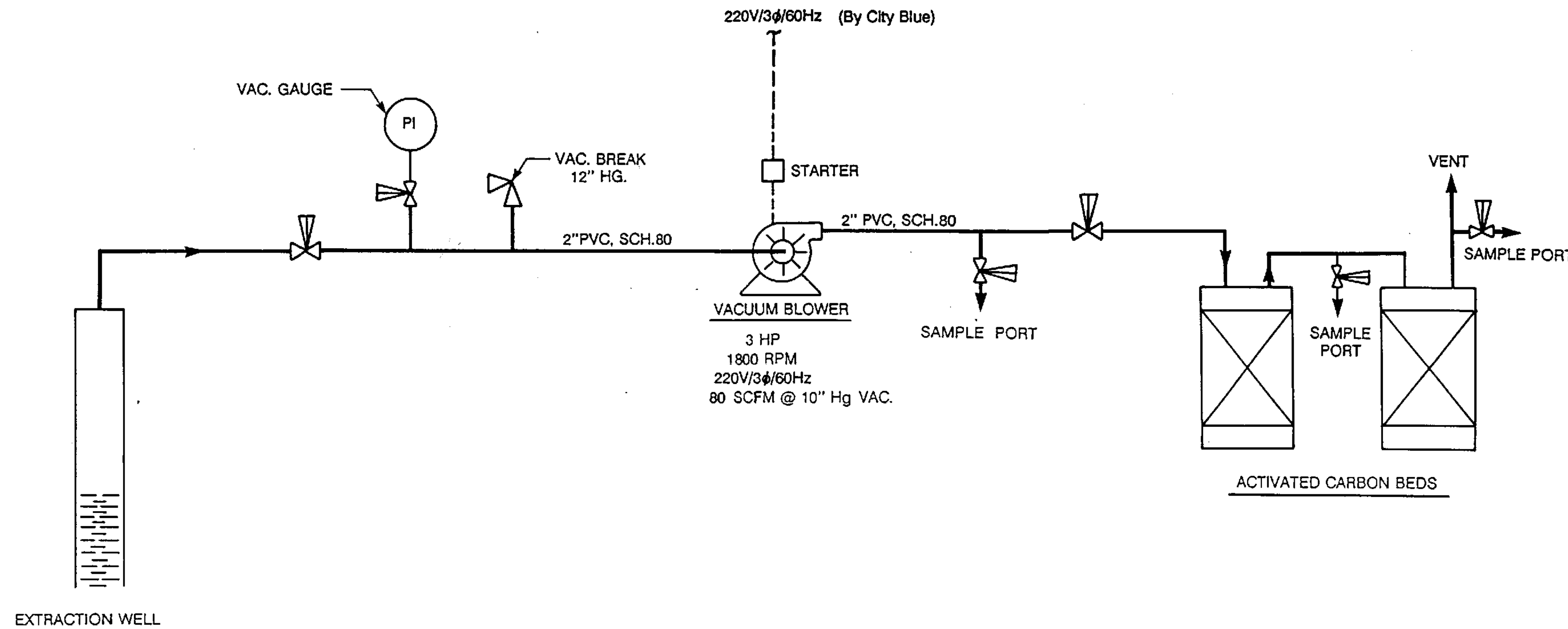
0 16
Scale in feet

Harding Lawson Associates
Engineers, Geologists & Geophysicists

Site Plan
Remedial Investigation
City Blue Production Facility
Oakland, California

PLATE **1**

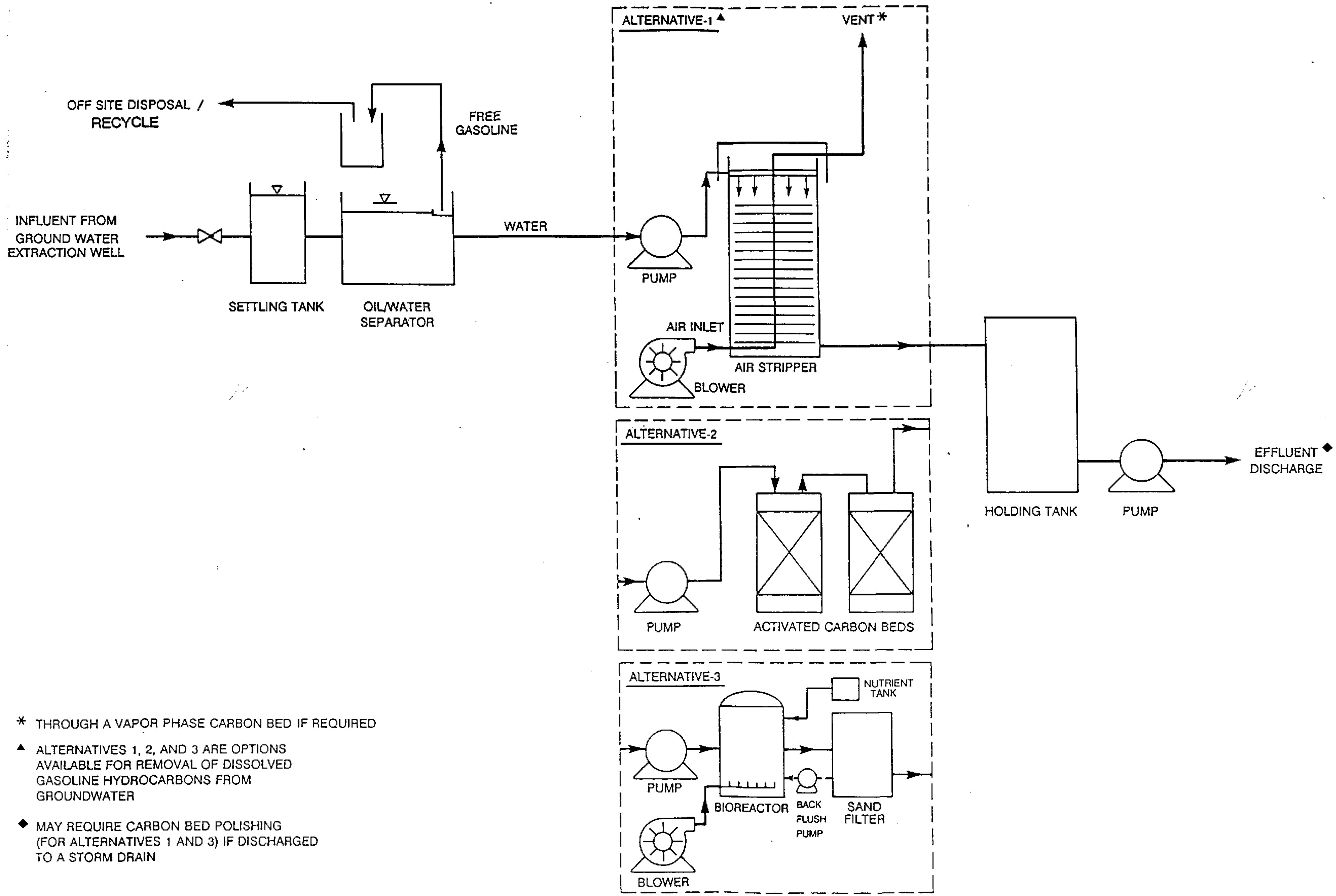
DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
AG	18106,004.04	DL	5/88		



HLA **Harding Lawson Associates** Engineers and Geoscientists	**Pilot Vapor Extraction System** City Blue Production Facility Oakland, California	PLATE **2**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
AK	18106,004.04	DL	4/88		

109463



* THROUGH A VAPOR PHASE CARBON BED IF REQUIRED

▲ ALTERNATIVES 1, 2, AND 3 ARE OPTIONS AVAILABLE FOR REMOVAL OF DISSOLVED GASOLINE HYDROCARBONS FROM GROUNDWATER

◆ MAY REQUIRE CARBON BED POLISHING (FOR ALTERNATIVES 1 AND 3) IF DISCHARGED TO A STORM DRAIN

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Conceptual Process Flow Diagram of the Proposed Ground Water Treatment System
City Blue Production Facility
Oakland, California

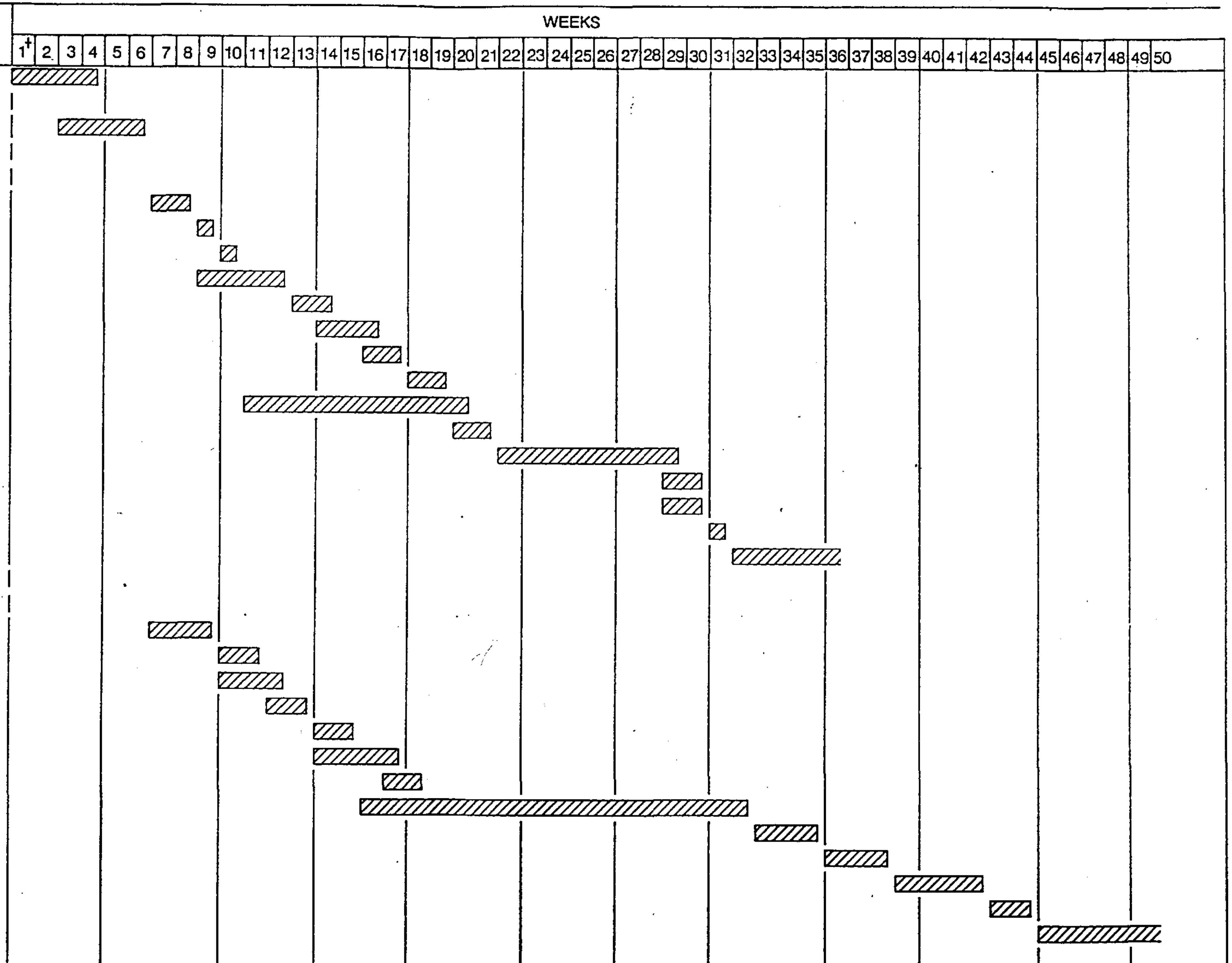
PLATE **3**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
AK	18106,004.04	DL	4/88		

109463

TASK NAME	DUR● DAYS
Phase I: Site Characterization	20
Phase II: Technical and Cost Eval. of Remedial Alternatives	20
Phase III: Design & Implement. Vapor Extract. System for Soil	
1. Scope. Design Spec.	10
2. Work Authorization	5
3. Prepare BAAQMD Permit	5
4. Pilot Plant Study	20
5. Data Review	10
6. Detail Design of VES	15
7. Internal (HLA) Review	10
8. Client Review	10
9. BAAQMD Permit/Review Author	50
10. Client Author to Construct	10
11. Procurement	40
12. Construction	10
13. Comstruction Supervision	10
14. Start-up/Troubleshoot	5
15. Operation *	
Phase IV: Design & Implement of Ground Water Remedial Technoly	
1. Selection of Remedial Alt.	15
2. Scope. Design Spec	10
3. Treatability Study, if need	15
4. Work Authorizatn by Client	10
5. Prep NPDES Permit Applicatn	10
6. Detail Design	20
7. Internal (HLA) Review	10
8. RWQCB Permit Approval	85
9. Client Design Review/Wk Aut	15
10. Bid Pkg/Bid Eval/Procuremt	15
11. Construction	20
12. Startup/Troubleshoot	10
13. Operation *	

WEEKS



† APPROVAL OF WORK PLAN

* ONGOING TASK

● ACTUAL WORK DAYS

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HLA

Implementation Schedule for Phases I-IV
City Blue Production Facility
Oakland, California

PLATE **4**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
DC	18106,004.04	DL	4/88		

Equipment Hollow Stem Auger

Elevation 33.5 feet * Date 2-20-87

Laboratory Tests	Blows/foot **	Moisture Content (%)	Dry Density (pcf)	Depth (ft)	Description
				0	2 inches asphalt pavement
					DARK BROWN SILTY SAND (SM), loose to medium dense, moist with some clay and debris/brick fragments (FILL)
	7				
				5	debris at 4 feet
					MOTTLED GRAY AND BROWN CLAYEY SAND (SC), medium dense to dense, moist, fine-grained, with some silt
	26	16	110		
				10	
					increased silt at 14 feet
	41				
				15	
	46	10	134		brown with decreased clay at 19 feet
				20	
TxUU 4390 (2500)	45	18	105		
				25	▽ water level measured on 2-20-87
					MOTTLED BROWN AND GRAY SAND (SP), dense, moist, fine-grained, with some silt
	45				
				30	
	31	29	94		GRAY SILTY CLAY (CH) stiff to very stiff, saturated, trace sand
				35	
					increased sand at 38 feet
	13	27	95		No petroluem odors were detected in any samples.
				40	

* City of Oakland Datum

** Equivalent Standard Penetration Test (SPT) Resistance Values

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Log of Boring 1

City Blue Production Facility
Oakland, California

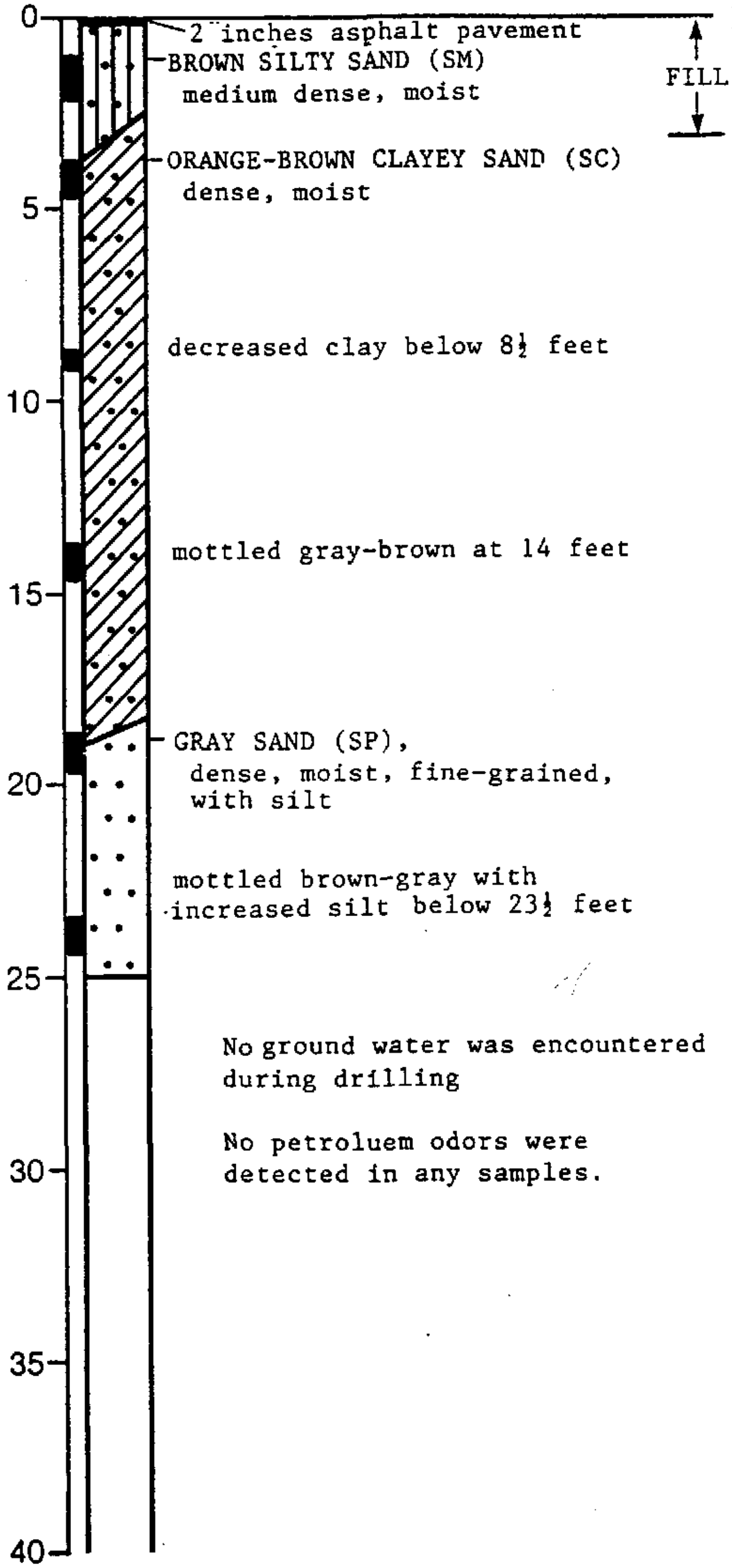
PLATE A1

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
Shields	18106,004.04	DL	5/88		

Equipment: Hollow Stem Auger

Elevation: 32.0 feet Date: 2-20-87

Laboratory Tests	Blows/foot	Moisture Content (%)	Dry Density (pcf)
25% passing #200 sieve	22	10	111
	39		
TxUU 1370 (950)	33	14	108
17% passing #200 sieve	36	18	113
	33		
12% passing #200 sieve	35	14	96



2 inches asphalt pavement

BROWN SILTY SAND (SM)
medium dense, moist

ORANGE-BROWN CLAYEY SAND (SC)
dense, moist

decreased clay below 8½ feet

mottled gray-brown at 14 feet

GRAY SAND (SP),
dense, moist, fine-grained,
with silt

mottled brown-gray with
increased silt below 23½ feet

No ground water was encountered during drilling

No petroluem odors were detected in any samples.

Harding Lawson Associates
Engineers, Geologists
& Geophysicists

Log of Boring 2

City Blue Production Facility
Oakland, California

PLATE **A2**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
Shields	18106,004.04	DL	5/88		

Laboratory Tests	Blows/foot	Moisture Content (%)	Dry Density (pcf)	Depth (ft)	Description
				0	2 inches asphalt pavement
	23				DARK BROWN SILTY SAND (SM) medium dense, moist, with some clay and debris (FILL)
TxUU 1000 (350)	34	16	107		MOTTLED BROWN AND DARK GRAY CLAYEY SAND (SC) dense, moist
				5	
				10	
				15	
				20	
				25	
				30	
				35	
				40	

Equipment: Hollow Stem Auger

Elevation: 31.6 feet Date: 2-20-87

No ground water was encountered

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Log of Boring 3

City Blue Production Facility
Oakland, California

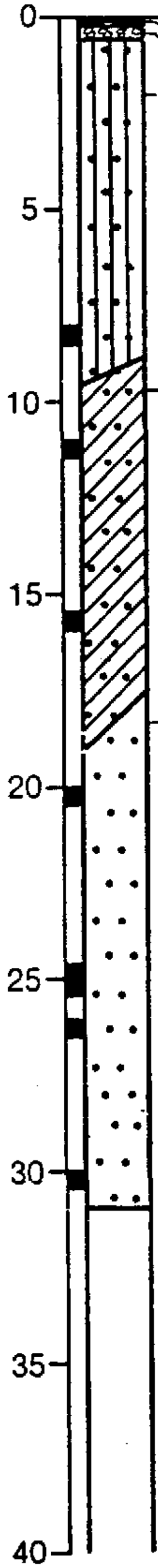
PLATE **A3**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
Shields	18106,004.04	DL	5/88		

Equipment: Hollow Stem Auger

Elevation: 31.5 feet * Date: 2-19-87

Laboratory Tests	Blows/foot ***	Moisture Content (%)	Dry Density (pcf)
TPH = Total Petroleum Hydrocarbons			
ppm = parts per million			
	21		
TPH = 64 ppm	31		
TPH = 310 ppm	49		
TPH = 2100 ppm	33/6"		
	33/5½"		
TPH = 1700 ppm	49/6"		
TPH = 46 ppm	40		



2 inches Asphalt pavement

6 inches Gravel road base

DARK BROWN SILTY SAND (SM) medium dense, moist, no petroluem odor detected

some clay below 4 feet

mottled green-gray and brown with increased clay below 6 feet

no petroluem odor detected at 7 feet

FILL

MOTTLED GRAY AND BROWN CLAYEY SAND (SC) medium dense to dense, moist, with very slight petroluem odor

dense, with slight petroluem odor below 14½ feet

BROWNISH-GRAY SAND (SP) dense to very dense, moist, very fine grained, uniform, trace silt with petroluem odor

strong petroluem odor at 25 feet

** water level measured on 2-20-87, no product visible on surface, strong petroluem odor detected

greenish-gray with silt below 28 feet

* City of Oakland datum

** Water sample TPH = 58 ppm

*** Equivalent Standard Penetration test (SPT) resistance values

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Log of Boring 4

City Blue Production Facility
Oakland, California

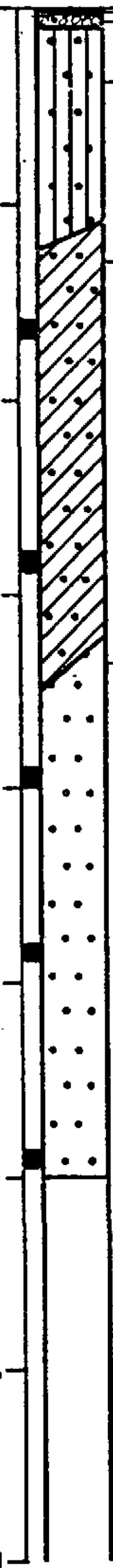
PLATE **A4**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
Shields	18106,004.04	DL	5/88		

Equipment: Hollow Stem Auger

Elevation: 31.5 feet   Date: 2-20-87

Laboratory Tests	Blows/foot	Moisture Content (%)	Dry Density (pcf)	Depth (ft)	Sample	Description
				0		2 inches Asphalt pavement; 6 inches Gravel road base
						GREENISH GRAY SILTY SAND (SM) medium dense, moist, trace clay (FILL)
				5		increased clay at 5 feet (FILL)
						MOTTLED BROWN AND GREENISH GRAY CLAYEY SAND (SC) medium dense, moist, with silt, no petroluem odor detected
	17				■	
				10		increased clay below 9 feet
						decreased clay, slight petroluem odor below 13½ feet
TPH = 150 ppm	12				■	
				15		
						GRAY-BROWN SAND (SP) medium dense, moist, uniform, fine-grained, with strong petroluem odor
TPH = 900 ppm	27			20	■	
						dense with some silt, strong to very strong petroluem odor at 24 feet
TPH = 3300 ppm	49				■	
				25		▽* water level measured on 2-20-87, product was visible on surface, strong petroluem odor detected
	33				■	greenish gray, saturated, with slightly less petroluem odor below 28½ feet.
				30		
				35		
				40		



* Water sample
TPH = 51 ppm

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Log of Boring 5

City Blue Production Facility
Oakland, California

PLATE **A5**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
Shields	18106,00404	DJ	5/88		

Equipment 6-inch Diameter Solid Auger

Elevation 31.4 feet   Date 8/12/87

Laboratory Tests	Blows/foot	Moisture Content (%)	Dry Density (pcf)	Depth (ft)	Description
				0	BROWN SILTY SAND (SM) medium dense, moist, with some clay
					BROWN AND GRAYISH BROWN CLAYEY SAND (SC) medium dense to dense, moist, with silt
				5	
				10	dense below 11 feet
Laboratory Permeability = 9.9×10^{-6} cm/sec	38/9"	16	110		
				15	
	41				BROWNISH GRAY SAND (SP) dense, moist, very fine-grained, uniform, with silt
				20	
	47				
Laboratory Permeability = 3.1×10^{-4} cm/sec	40/10"	16	100		
				25	▽ water level observed 8/12/87; saturated below 26 feet
				30	
					BROWNISH GRAY SILTY CLAY (CH) stiff to very stiff, saturated, trace sand
				35	
				40	

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Log of Boring 6

City Blue Production Facility
Oakland, California

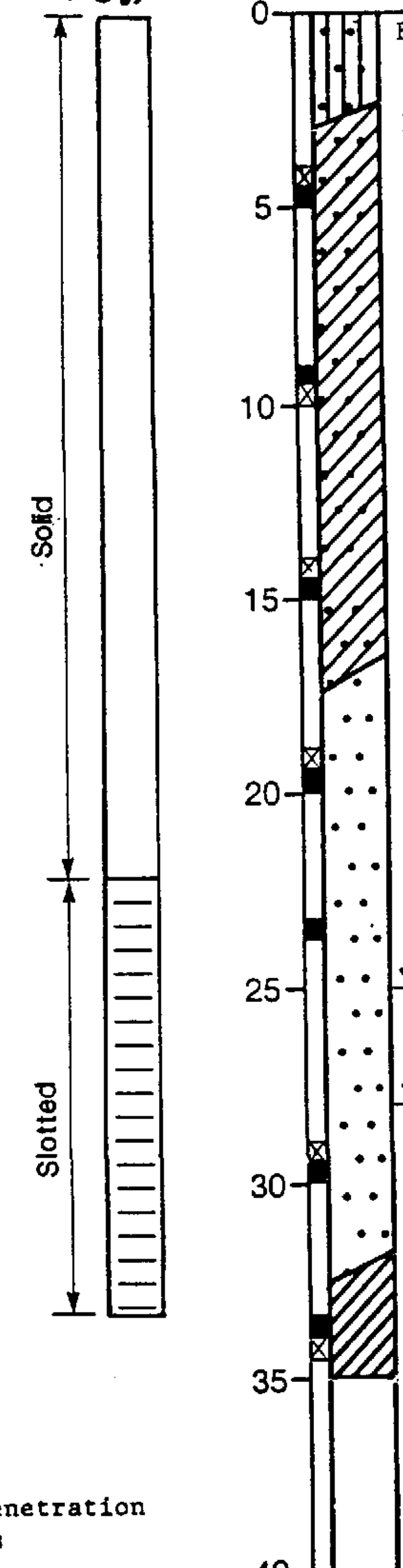
PLATE **A6**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
Shields	18106,004.04	DL			

Equipment: 10-inch Diameter Hollow Stem Auger

Elevation: 31.6 feet* Date: 6/24/87

Field and Laboratory Tests	Blows/foot	Depth (ft)	Description
		0	BROWN AND GRAY SILTY SAND (SM) medium dense, moist, some clay
			BROWN CLAYEY SAND (SC) dense, moist, with silt
Field GasTech (GT) reading = 30 ppm	42	5	
			mottled brown and gray with interbedded silty sand below 7 feet
GT = 90 ppm	20		medium dense below 9 feet
		10	
			decreased clay and silt with slight orange-brown discoloration below 12 feet
GT = 225 ppm	22	15	
			GRAY SAND (SP) dense, moist, uniform, fine-grained sand
GT = 500+ ppm	56	20	
GT = 500+ ppm Lab Moisure Content = 13% Lab Dry Density = 109 pcf Lab Volatile Hydrocarbons (TVH) = 4500 ppm	33/6"		
		25	water level measured on 6/25/87
			water level measured during drilling, 6/24/87
GT = 500+ ppm	47	30	
			GRAY SILTY CLAY (CH) very stiff, saturated, with trace sand
GT = 100 ppm	38	35	
		40	Note: Strong petroleum hydrocarbon odors encountered between 18-30 feet



*City of Oakland datum.

**Equivalent Standard Penetration Test (SPT) blow counts

Harding Lawson Associates
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Log of Boring MW-1
Underground Tank Investigation
City Blue Production Facility
Oakland, California

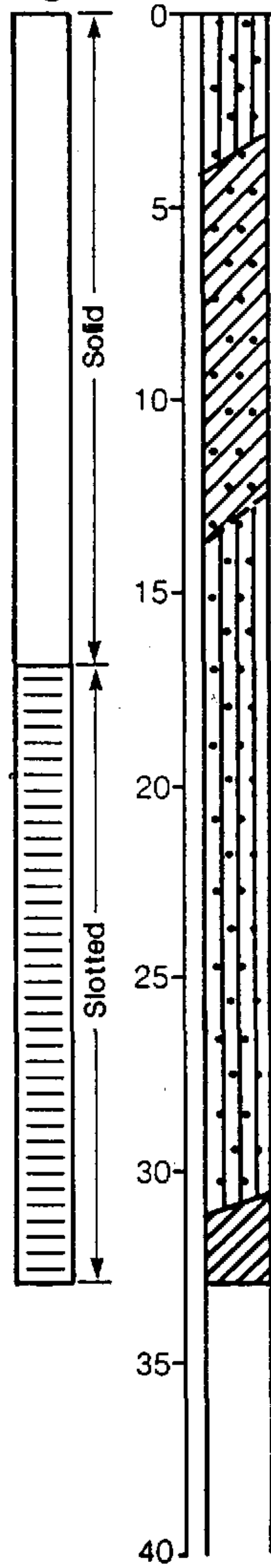
PLATE **A7**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
AG	18106,004.04	DL	5/88		

Equipment: 10.75-inch diameter Hollow Stem Auger

Elevation: 31.5 feet* Date: 1/6/88

Laboratory Tests	Odor	Field Gastech Reading (ppm)	Depth (ft)	Description
	none	ND**	0–3	BROWN SILTY SAND (SM) medium dense, moist
	none	ND	3–13	BROWN CLAYEY SAND (SC) medium dense to dense, moist, with silt
	none	ND		
	none	35	13	BROWN GRAY SILTY SAND (SM) dense, moist
	weak	320	19	decreased silt below 19 feet
	strong	500+	25	▽ water level measured on 1/12/88
			26	saturated below 26 feet
	strong	500+	30	gray below 30 feet
			31	GRAY SILTY CLAY (CH) very stiff, satruated



*City of Oakland datum

**ND = not detected

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Log of Boring MW-1A

City Blue Production Facility
Oakland, California

PLATE **A8**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
RS	18106,004.04	DI	5/88		

Equipment: 10-inch Diameter Hollow Stem Auger

Elevation: 30.7 feet Date: 6/25/87

Field and Laboratory Tests	Blows/foot	Well Completion Schematic	Depth (ft)	Description
		Solid	0	MOTTLED BROWN AND GRAY SILTY SAND (SM) dense, moist, with clay
GT = 25 ppm	43		5	
GT = 50 ppm	15		10	medium dense, very moist below 9 feet
GT = 25 ppm	22		15	
				BROWN SAND (SP) dense to very dense, moist to wet, fine-grained sand
GT = 150 ppm	33/6"		20	
				brown-gray, silty below 22 feet
GT = 280 ppm Lab Moisture Content = 11% Lab Dry Density = 106 pcf Lab TVH < 1 ppm	33/6"	Slotted	25	
				▽ water level measured during drilling, 6/25/87
				saturated with increased silt below 27 feet
GT = 60 ppm	33/6"			
			30	GRAY SILTY CLAY (CH) stiff to very stiff, saturated, occasional thin lenses of mottled brown-gray silty sand
GT = 25 ppm	25			
			35	
			40	

Note: Petroleum hydrocarbon odors encountered between 19-27 feet

Harding Lawson Associates
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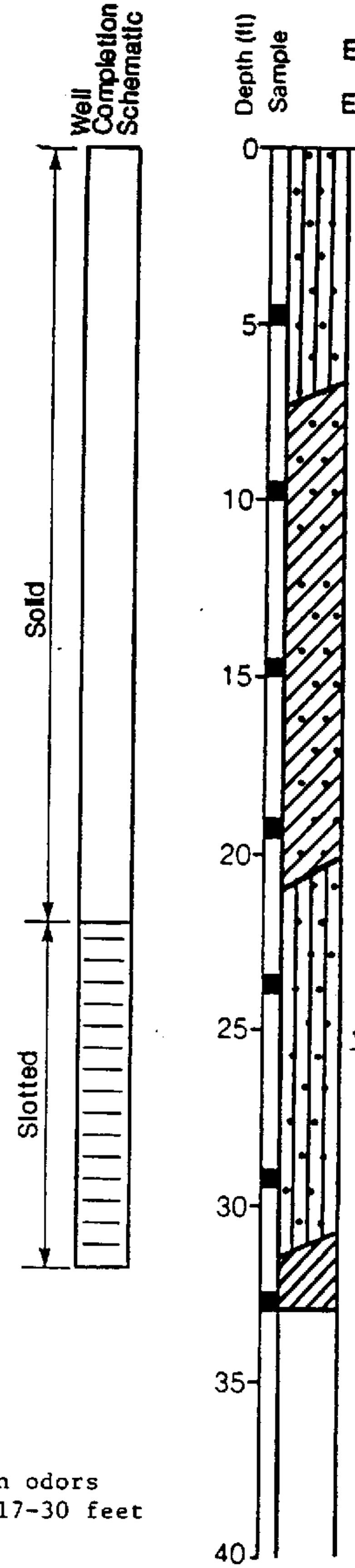
Log of Boring MW-2
Underground Tank Investigation
City Blue Production Facility
Oakland, California

PLATE **A9**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
AG	18106,004.04	DL	5/88		

Field and Laboratory Tests	Blows/foot
GT = 50 ppm	25/6"
GT = 30 ppm	20
GT = 75 ppm	20
GT = 200 ppm	33/6"
Labor Moisture Content = 11% Lab Dry Density = 122 pcf GT = 500 ppm Lab TVH < 0.8 ppm	32/6"
GT = 150 ppm	34/6"
GT = 100 ppm	



Equipment 10-inch Diameter Hollow Stem Auger

Elevation 31.2 feet Date 6/24/87

BROWN SILTY SAND (SM)
dense, moist, with interbedded clayey sand layers

MOTTLED BROWN AND GRAY CLAYEY SAND (SC)
medium dense, moist, with silt

increased silt, moist to wet below 12 feet

dense below 19 feet

GRAY SILTY SAND (SM)
dense, moist

∇ water level measured on 6/25/87

saturated below 29 feet

BROWNISH GRAY SILTY CLAY (CH)
stiff to very stiff, moist, trace sand

Note: Petroleum hydrocarbon odors encountered between 17-30 feet

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Log of Boring MW-3

Underground Tank Investigation
City Blue Production Facility
Oakland, California

PLATE **A10**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
AG	18106,004.04	DI	5/88		

Equipment: 10.75-inch diameter Hollow Stem Auger

Elevation: 32 feet   Date: 1/6/88

Laboratory Tests	Blows/foot*	Odor	Field Gastech Reading (ppm)
		none	ND
		none	ND
		none	ND
		none	ND
	54	weak	180
	48	strong	500+
	43/6"	strong	—
		none	ND

Well Completion Schematic: Solid (0 to ~18 ft); Slotted (~18 to ~33.5 ft)

Depth (ft): 0, 5, 10, 15, 20, 25, 30, 35, 40

Sample

- 6-inch concrete slab
- 6-inch crushed rock
- BROWN SILTY SAND (SM)
  medium dense, moist
  some clay below 4 feet
- BROWN CLAYEY SAND (SC)
  medium dense to dense, moist, with some silt
- BROWN SILTY SAND (SM)
  dense, moist
  grayish brown below 24 feet
  ▽ water level measured on 1/12/88
- GRAY SAND (SP)
  dense, saturated, with silt
- BROWNISH GRAY SILTY CLAY (CH)
  stiff to very stiff, saturated

*Equivalent Standard Penetration test (SPT) blow counts

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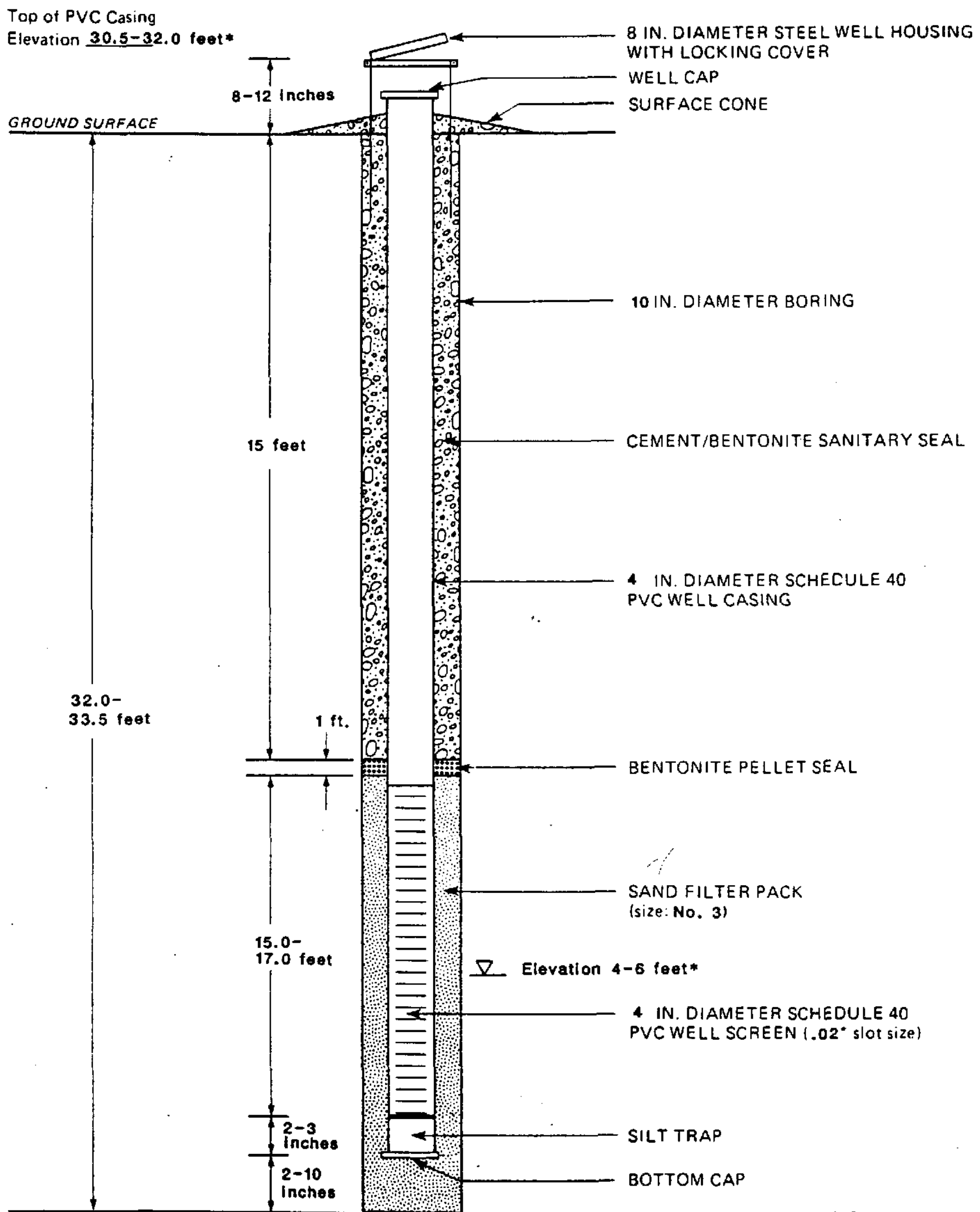
Log of Boring MW-4

City Blue Production Facility
Oakland, California

PLATE **A11**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
RS	18106,004.04	DL	5/88		



* City of Oakland datum

NOT TO SCALE

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Typical Well Completion Detail

City Blue Production Facility
Oakland, California

PLATE **A12**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
AG	18106,004.04	DL	5/88		

FORM GW1

MAJOR DIVISIONS					TYPICAL NAMES
COARSE–GRAINED SOILS MORE THAN HALF IS COARSER THAN NO. 200 SIEVE	GRAVELS MORE THAN HALF COARSE FRACTION IS LARGER THAN No. 4 SIEVE SIZE	CLEAN GRAVELS WITH LITTLE OR NO FINES	GW		WELL GRADED GRAVELS WITH OR WITHOUT SAND, LITTLE OR NO FINES
			GP		POORLY GRADED GRAVELS WITH OR WITHOUT SAND, LITTLE OR NO FINES
		GRAVELS WITH OVER 12% FINES	GM		SILTY GRAVELS, SILTY GRAVELS WITH SAND
			GC		CLAYEY GRAVELS, CLAYEY GRAVELS WITH SAND
	SANDS MORE THAN HALF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE SIZE	CLEAN SANDS WITH LITTLE OR NO FINES	SW		WELL GRADED SANDS WITH OR WITHOUT GRAVEL, LITTLE OR NO FINES
			SP		POORLY GRADED SANDS WITH OR WITHOUT GRAVEL, LITTLE OR NO FINES
		SANDS WITH OVER 12% FINES	SM		SILTY SANDS WITH OR WITHOUT GRAVEL
			SC		CLAYEY SANDS WITH OR WITHOUT GRAVEL
FINE–GRAINED SOILS MORE THAN HALF IS FINER THAN NO. 200 SIEVE	SILTS AND CLAYS LIQUID LIMIT 50% OR LESS		ML		INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTS WITH SANDS AND GRAVELS
			CL		INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, CLAYS WITH SANDS AND GRAVELS, LEAN CLAYS
			OL		ORGANIC SILTS OR CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50%		MH		INORGANIC SILTS, MICACEOUS OR DIATOMACIOUS, FINE SANDY OR SILTY SOILS, ELASTIC SILTS
			CH		INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			OH		ORGANIC SILTS OR CLAYS OF MEDIUM TO HIGH PLASTICITY
HIGHLY ORGANIC SOILS			Pt		PEAT AND OTHER HIGHLY ORGANIC SOILS

UNIFIED SOIL CLASSIFICATION – ASTM D2487-85

Perm	—	Permeability
Consol	—	Consolidation
LL	—	Liquid Limit (%)
PI	—	Plastic Index (%)
G_s	—	Specific Gravity
MA	—	Particle Size Analysis
■	—	"Undisturbed" Sample
⊠	—	Bulk or Classification Sample

Test	Shear Strength (psf)	Confining Pressure		
TxUU (FM) or (S)	3200	(2600)	—	Unconsolidated Undrained Triaxial Shear (field moisture or saturated)
TxCU (P)	3200	(2600)	—	Consolidated Undrained Triaxial Shear (with or without pore pressure measurement)
TxCD	3200	(2600)	—	Consolidated Drained Triaxial Shear
SSCU (P)	3200	(2600)	—	Simple Shear Consolidated Undrained (with or without pore pressure measurement)
SSCD	3200	(2600)	—	Simple Shear Consolidated Drained
DSCD	2700	(2000)	—	Consolidated Drained Direct Shear
UC	470		—	Unconfined Compression
LVS	700		—	Laboratory Vane Shear

KEY TO TEST DATA

Harding Lawson Associates
Engineers and Geoscientists

Soil Classification Chart and Key to Test Data
City Blue Production Facility
Oakland, California

PLATE **A13**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
RS	18106,004.04		1/88		

DISTRIBUTION

WORK PLAN
CITY BLUE PRODUCTION FACILITY SITE
17TH AND JEFFERSON STREETS
OAKLAND, CALIFORNIA

May 13, 1988

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QUALITY CONTROL REVIEWER

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