A Report Prepared for

City of Oakland
Redevelopment Agency
One City Hall Plaza
Oakland, California 94612

REPORT OF WASTE DISCHARGE
PACIFIC RENAISSANCE PLAZA
CHINATOWN REDEVELOPMENT PROJECT AREA
OAKLAND, CALIFORNIA

HLA Job No. 09382,030.02

by

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1.0 INTRODUCTION

This report has been prepared by Harding Lawson Associates (HLA) for the City of Oakland Redevelopment Agency (Agency). It presents the plan for removing gasoline from soil and ground water at the Pacific Renaissance Plaza (PRP) site in the Chinatown Redevelopment Project Area of downtown Oakland, California (Plate 1).

The purpose of this report is to present information required to obtain a permit (Waste Discharge Requirements) from the California Regional Water Quality Control Board, San Francisco Bay Region (RWQCB) for reinjection of treated ground water. The report discusses: (1) site background, (2) the design basis and operation plan for the proposed soil treatment system, (3) the proposed method for treating ground water produced during the course of soil treatment, (4) monitoring of the system, (5) post-treatment verification of cleanup effectiveness, and (6) monitoring and handling of soil during construction excavation activities. The report also addresses the proposed method for treating ground water produced during dewatering of the site, because construction activities at the site will require dewatering during the planned soil excavation.

1.1 Background

The PRP site comprises the area bounded by 9th, Webster, and Franklin streets and the East Bay Municipal Utility District (EBMUD) property line north of 10th Street (Plate 2). The property is currently an at-grade, asphalt-surfaced parking lot. Construction of high-rise commercial, retail and residential buildings is scheduled to begin at the site in August 1989. The construction process will include dewatering of site soil and excavation and removal of soil to a depth of approximately 40 feet.

HLA's characterization of the site, reported in *Site Characterization, Pacific Renaissance Plaza* (*HLA, 1988n*), included: (1) a site history review, (2) completion of approximately 28 soil borings, (3) installation of three ground-water monitoring wells, and (4) collection and analysis of soil and ground-water samples. Results indicated the presence in soil of petroleum hydrocarbons identified as gasoline at concentrations up to 4800 parts per million (ppm) total petroleum hydrocarbons (TPH). The available data suggest that the gasoline is associated with a gasoline filling station formerly located at 925 Webster Street, within the area proposed for excavation. The volume of soil with TPH values exceeding 100 ppm is estimated to be 7000 cubic yards (yd^3). Contaminated soil is located primarily in the southern portion of the site between 15 and 30 feet below ground surface (Plate 2). The highest concentrations were measured in samples from approximately 25 feet below ground surface, at depths generally consistent with known ambient ground-water levels. Ground-water samples collected from on-site Monitoring Wells MW-9, MW-10, and MW-11 had elevated levels of TPH and of volatile organic compounds.

A description of the extent of soil and ground-water contamination at the site, including cross sections, plots of TPH in soil as a function of depth, and laboratory data for soil and ground-water sample analyses, is presented in the site characterization report (*HLA, 1988n*).

1.2 Regulatory Setting

This report is submitted in support of an application for waste discharge requirements to the RWQCB for permission to discharge treated ground water into an on-site infiltration gallery as part of in situ biological treatment.

1.3 Environmental Setting

The project site is in an urbanized area of Oakland (Plate 1). The nearest surface-water bodies are Lake Merritt, approximately 2,500 feet east of the site, and Oakland Inner Harbor, approximately 3,000 feet southwest of the site. Regional ground-water flow is estimated to be toward the Inner Harbor, in a generally southwesterly direction.

A variety of beneficial uses for water resources of the San Francisco Bay basin are described in the *Water Quality Control Plan, San Francisco Bay Basin (2)* (*RWQCB, 1982*). This plan indicates that the Oakland Inner Harbor is not a water body for which beneficial uses are specified. Designated beneficial uses of Lake Merritt include recreation, wildlife habitat, and estuarine habitat.

Ground water may also have beneficial uses. The basin plan does not indicate that the site lies in a designated ground-water basin. Files maintained by the Alameda County Public Works Department were also reviewed in the course of preparing this treatment system plan. The review indicated that no drinking water wells are present within 1/4 mile of the PRP site.

1.4 Previous Investigations

HLA has previously submitted a number of reports to the Agency that discuss subsurface geologic and hydrogeologic conditions at or near the site. *Initial Gasoline Leak Investigation, Chinatown Redevelopment Project Area (HLA, 1987)* discusses installation and sampling of Monitoring Well MW-1. *Ground-Water Investigation, Chinatown Redevelopment Project Area* (*HLA, 1988d*) discusses the installation and sampling of four ground-water monitoring wells (MW-2, MW-3, MW-4 and MW-5) and the results of aquifer testing conducted at the adjacent EBMUD site. *A-Aquifer*

Monitoring Report, Chinatown Redevelopment Project Area, (HLA, 1989), discusses the installation of four additional ground-water monitoring wells (MW-6, MW-7, MW-8 and MW-9) and the results of sampling and analysis of a network of seven wells in the vicinity of the EBMUD site. Wells MW-1 and MW-4 were destroyed during excavation at the EBMUD site. Two additional monitoring wells (MW-10 and MW-11) were installed as part of PRP site characterization. One additional well, designated DW-1 was installed as part of activities at the adjacent EBMUD site. Well DW-1 is completed in the next deeper aquifer zone. The current A-aquifer monitoring well network in the Chinatown Redevelopment Project Area comprises Wells MW-2, MW-3, and MW-5 through MW-11. This network includes four A-aquifer wells, designated MW-5, MW-9, MW-10, and MW-11 located within the PRP site boundary (Plate 2).

1.5 Site Geologic Setting and Aquifer Conditions

Logs of borings drilled by HLA (*HLA, 1987; 1988d; 1988n; 1989*) and by previous consultants indicate that the uppermost geologic unit at this site consists of approximately 35 to 45 feet of medium-sorted to poorly sorted sand with a small percentage of silt and clay and that a locally continuous clay unit underlies the sand.

Ground water occurs at depths of approximately 23 to 25 feet in the uppermost sand unit. For the purposes of this investigation, the sand unit is called the A-aquifer. Water-level data collected in March 1988 indicate that the hydraulic gradient in the A-aquifer, prior to activation of dewatering wells at the EBMUD site, was approximately 2.1 x 10^{-3} ft/ft toward the west (*HLA, 1989*). Recent water-level measurements in Wells MW-9, MW-10, and MW-11, give hydraulic gradients that are generally toward the north, in the direction of the EBMUD site. These water-level data are in agreement with data collected at other HLA wells in the area which indicate ground-water gradients toward the EBMUD excavation, most likely as a result of pumping of dewatering wells at that site (*HLA, 1989*).

Estimates of hydraulic conductivity calculated from previously performed aquifer tests at the site (*HLA, 1988d*) range from 2.2 to 6.3 ft/day.

2.0 SOIL TREATMENT SYSTEM DESIGN

2.1 Objective of the Treatment System

Soil at the PRP site contains elevated levels of petroleum hydrocarbons (identified as gasoline) and benzene, toluene, ethylbenzene and xylenes (BTEX). Guidance used by the RWQCB classifies soil with TPH values exceeding 1000 ppm as hazardous waste *(Leaking Underground Fuel Tank Task Force, 1987)* and soil with TPH values between 100 and 1000 ppm as designated waste. Soil at this site falls into both categories and would require disposal at a Class I or Class II landfill.

The Agency wishes to treat soils in place prior to excavation to reduce concentrations to levels acceptable for Class III disposal (i.e., less than 100 ppm TPH). In situ biological treatment using a system of injection and extraction wells is the treatment method proposed to accomplish this objective. Carbon adsorption, using the water treatment system currently in place at the site, is the proposed method to treat ground water produced in conjunction with soil treatment.

The proposed in situ biological treatment system is subject to the following constraints:

- Completion of soil cleanup prior to start of excavation at the PRP site. Construction is currently scheduled to begin August 1989.
- Control of ground-water movement during soil treatment so that injected water is captured by the ground-water extraction wells.
- Maintenance of a ground-water elevation differential of less than 2 feet across the Bay Area Rapid Transit (BART) tunnel, which runs below 9th Street (Plate 2).

2.2 Treatment System Design

2.2.1 Treatability Study

The presence in site soils of an indigenous population of microorganisms that can utilize hydrocarbons for growth was established through a biodegradation evaluation conducted by HLA in conjunction with site characterization and reported in Appendix B of the site characterization report (*HLA, 1988n*). This evaluation indicated that gasoline-utilizing microorganisms exist in the subsurface at the site, and that normal growth of these microorganisms may be limited because insufficient nitrogen, phosphorus, and oxygen exist in the soil.

Further evaluation of the feasibility of the biological treatment approach was conducted using soil cores and ground water collected from the site. Results of the treatability study are presented in Appendix A of this report and form the basis for the treatment process design. The results of the treatability study indicate that adequate stimulation of microbial populations can be achieved through the addition of nitrogen, phosphorus and oxygen. The form and concentration of these additions are summarized as follows. Nitrogen will be added to injection water in the form of ammonium nitrate, at a total concentration of approximately 20 parts per million (ppm). This will supply approximately 40 ppm nitrogen (20 ppm ammonia and 20 ppm nitrate). Phosphorous will be added as potassium phosphate and sodium phosphate. Total phosphate concentrations in injected water are estimated to be from 35 to 50 ppm. Total nutrient concentrations are not expected to exceed 100 ppm. Oxygen will be added as hydrogen peroxide. Hydrogen peroxide concentrations will begin at 250 ppm and will be increased over a period of several months to 1000 ppm.

The treatability study results also indicate that the extent to which hydrocarbons in the soil are degraded is a function of the volume of water passed through the contaminated soil and of the number of microorganisms present in the injected water.

The highest concentrations of TPH measured in site soils during characterization approached 5000 ppm. A reduction of TPH values from 5000 ppm to less than 100 ppm is equivalent to a destruction efficiency of 98 percent. During the treatability study, passage of approximately 4.5 pore volumes of nutrient-enriched but biologically inert water through soil columns collected from the site resulted in reductions in TPH concentrations of approximately 80 percent. As discussed in Appendix A, reductions exceeding 90 percent would be expected if four pore volumes or more of microbially-enriched water were passed through the column. Recycling water that has passed through the column is a means of introducing microbially enriched water to the column. As discussed in Section 2.2.2, passage of four pore volumes through site soils within the desired time frame will require an engineered system to increase natural hydraulic gradients. Therefore, the biological treatability study results indicate that success of the treatment system in reducing hydrocarbon levels to levels acceptable for Class III disposal by August 1989 is dependent on: (1) increasing natural hydraulic gradients and (2) injecting water that is both nutrient- and microbe-enriched.

Recycling water treated by carbon adsorption is proposed as the means to introduce microbe-enriched water to the subsurface. Recycling treated ground water has the following operational and economic advantages:

- Recycled water, compared to using potable water (which is usually biologically inert), reduces treatment times because gasoline-utilizing microorganisms native to the site are introduced to the subsurface with the injected water.
- During the present period of water shortage, usage of potable water is minimized.

- Any nutrients remaining in extracted ground water are used during the recycling process.

- Compatibility of recycled water with formation water reduces the potential for operational problems (e.g., well clogging).

2.2.2 Hydraulic Control System

The proposed injection/extraction well system comprises 22 extraction wells and 11 injection wells screened from approximately 10 feet below ground surface to the clay aquitard below the aquifer, at approximately 35-45 feet below ground surface. The system is designed to move approximately four pore volumes of water through the contaminated soil zone in a six-month period, while preventing the migration of ground water away from the site. The well configuration was developed: (1) using the results of the site characterization study regarding locations and levels of contamination, (2) information on hydraulic properties and geologic conditions presented in previous HLA reports (*HLA, 1988d; 1988n; 1989*), and (3) a numerical model of ground-water flow developed for this site and based on the U.S. Geological Survey (USGS) computer code MODFLOW (*McDonald and Harbaugh, 1984*).

MODFLOW was used to quantitatively predict water-level responses to pumping and injection of ground-water from multiple wells for specified pumping periods. The model required numerical representation of the following input parameters:

- Model domain boundary conditions
- Initial water-level conditions
- Aquifer hydraulic conductivity
- Aquifer storativity
- Bottom of aquifer elevations
- Duration of the simulation

The model domain for the site (Plate 3) was divided into discrete units using a rectangular grid system containing 78 rows and 56 columns. The model contains 4368 nodes centered on each cell of the model grid. The dimensions of model cells in the area of the proposed treatment system were specified at 10 ft by 10 ft (100 ft^2). Dimensions of model cells away from the excavation and toward the model boundaries were specified at greater intervals, reaching a maximum of 400 ft by 400 ft (1,600 ft^2) at the corners of the model grid. The model covers about 112 acres (Plate 3) so that model boundaries are not within the influence of pumping or recharge by wells simulated in the model.

The presence of the new EBMUD building in the next block was included in the model as a no-flow area north of the PRP site. The BART tunnel along 9th Street is represented as an area of reduced transmissivity because the tunnel is completed across a portion of the A-aquifer.

Head-dependent flux nodes were used to simulate ground-water flow into the model domain under a regional hydraulic gradient. The head values (i.e., water levels) in these boundary nodes were specified by interpolating water-level elevations and calculated hydraulic gradients measured on March 9 and 10, 1988. Initial water-level conditions for a steady-state calibration simulation were specified using measured and interpolated water-level elevations.

On the basis of the calibration and the results of a slug test conducted by HLA on Well MW-3 (*HLA, 1988d*), a constant aquifer hydraulic conductivity of 6.3 ft/day was specified for the entire model domain. The aquifer storativity (specific yield) was specified at 0.15 on the basis of published values for similar geologic materials (*Morris and Johnson, 1967*) and the calibration run results.

The bottom elevation of the A-aquifer was specified at -1.0 feet MSL for the model domain. This elevation is an approximate average elevation at which the top of the aquitard (i.e., bottom of the aquifer) was encountered during the completion of soil borings and installation of monitoring wells at the site.

In the southern site area, injection wells were initially located in areas where highest TPH levels in soil were measured (Plate 2). Extraction wells in this area were located in an elliptical pattern around the injection wells. This pattern permits increased hydraulic gradients to be imposed on a well-defined area while maintaining overall control of migration of injected water. In the northern site area, one pair each of injection and extraction wells are arranged in a doublet pattern.

Two transient ground-water flow simulations were conducted to represent site dewatering conditions after 30-day and 180-day operation periods.

Well locations and pumping and injection rates were adjusted until results indicated: (1) overall containment of injected water, (2) minimal leakage of injected water between pairs of extraction wells, (3) average travel time of 45 days (equivalent to four pore volumes in six months) and (4) less than 2 feet of difference in water elevations across the BART tunnel. The locations providing most satisfactory results are shown on Plate 4. Results of transient simulations for this configuration after pumping periods of 30 days and 180 days are presented as potentiometric contours in Plates 5 and 6, respectively. Water injection rates for the simulation are set at 34.4 gallons per minute (gpm), and ground-water extraction rates are set at 34.6 gpm.

The capture area of the system, estimated using the results of the 180-day simulation, is presented on Plate 7. The capture area indicates overall containment of injected water. The potentiometric contour maps indicate that hydraulic gradients can be locally increased by injecting water and that injected water can be contained by a network of closely spaced extraction wells.

2.3 Process Description

The treatment process consists of circulating nutrient-enriched water through the contaminated soil to enhance the growth of preexisting microorganisms that utilize hydrocarbons as an energy source, producing carbon dioxide and water as by-products. This process reduces the concentration of petroleum hydrocarbons in the subsurface.

The treatment system, designed to meet the soil treatment objective subject to the constraints discussed in Section 2.1, consists of:

- A 3000-gallon mixing tank and appurtenances for addition of nutrients and hydrogen peroxide to extracted, treated water to stimulate indigenous microorganisms capable of degrading petroleum hydrocarbons.
- Eleven injection wells, to introduce water to the contaminated zone, and 22 extraction wells to collect and hydraulically contain ground water after it passes through the contaminated zone.
- Associated piping and controls.
- The existing carbon treatment system, which will be used to treat extracted ground water to reduce petroleum hydrocarbons and other organic compounds to discharge limits specified in the Agency's existing NPDES permit. The treated ground water will either be pumped to the nutrient mixing tank to be used for reinjection or be discharged to the storm drain.

The treatment system layout at the site is shown on Plate C1. Typical construction details of injection and extraction wells are presented on Plate C2. A schematic flow diagram of the system is shown on Plate M1. Initially, potable water from an EBMUD hydrant at 10th and Webster streets will be fed to a 3,000-gallon mixing tank located south of 10th Street. A backflow preventer will be placed in the line from the hydrant to protect the potable water supply. After start-up, treated water from the carbon treatment system currently in place on 10th Street will be used as the source for injection water.

The nutrients and hydrogen peroxide will be stored in separate 300-gallon tanks adjacent to the mixing tank, and will be injected into the influent water stream as necessary to achieve target concentrations in injection water.

Water from the mixing tank will be pumped to the injection wells for introduction to the subsurface. Injected water will travel from the injection wells to the extraction wells through the soil. Extracted water will then be pumped to the first of five 21,000-gallon storage tanks in place at the site, filtered to remove fine sediments, and treated to reduce hydrocarbon concentrations to NPDES permit limits. The treated effluent will be used as influent to the nutrient mixing tank, with the goal of eliminating the use of potable water. The total extraction pumping rate will be maintained slightly greater than the total injection rate, as a means of maintaining hydraulic control and ensuring capture of injected water. After startup, it is anticipated that treated effluent will supply all influent water requirements, with any excess discharged to the storm drain in accordance with the existing NPDES permit.

2.4 Process Waste Streams

Drilling and development of the injection and extraction wells will generate soil cuttings and development water. Soil cuttings will be stockpiled on site and, if necessary, aerated in compliance with Regulation 8, Rule 40 of the Bay Area Air Quality Management District (BAAQMD). Development water will be collected and transferred to a storage tank for subsequent treatment by the carbon adsorption system.

During system operation, waste streams will be those associated with the existing carbon treatment system. No additional waste streams will be generated by the in situ biological treatment system. Carbon system waste streams are described in "*Dewatering Effluent Treatment System Plan, Chinatown Redevelopment Project Area*" (*HLA, 1988a*) and consist of treated water, spent carbon, and used filter elements. Operation and monitoring of the carbon treatment system have been documented in monthly reports submitted to the RWQCB (*HLA, 1988b; 1988c; 1988e; 1988f; 1988g; 1988h; 1988i; 1988j; 1988k; 1988l; 1988m*).

3.0 SOIL TREATMENT SYSTEM OPERATIONS AND MONITORING PLAN

3.1 Ground-Water System and Flow Monitoring

The locations of injection, extraction, and monitoring wells proposed as part of the treatment system monitoring plan are shown on Plate 4. The proposed frequency, types of measurements, and analyses of water samples at each location are presented in Table 1. Monitoring Wells MW-9, MW-11, MW-15, MW-16, and MW-17 are within the southern area's ellipse of extraction wells. These wells will be used primarily to monitor the progress of the treatment through collection of water-level and water chemistry data, including concentrations of nutrients and petroleum hydrocarbons.

Monitoring Wells MW-3, MW-5, MW-7, MW-10, MW-12, MW-13, MW-14, MW-18, and MW-19 and the extraction wells will be used to monitor for hydraulic containment of injected water. Nutrient and petroleum hydrocarbon concentrations in these wells will also be monitored. Key wells among these are MW-12, MW-13, and MW-14. Modeling results suggest that these wells are located close to but outside of extraction well capture zones. MW-13 and MW-14 are placed midway between extraction wells at locations most likely to show breakthrough in the event that hydraulic control is not maintained. Water levels, injection rates and water chemistry at injection wells will also be monitored.

The following criteria and methods will be used to evaluate the effectiveness of hydraulic control:

- Water levels. Water levels in injection, extraction and monitoring wells will be contoured to evaluate flow directions and capture zones. Contoured data indicating that ground-water flow is towards the extraction wells will be interpreted as evidence of hydraulic control of injected water.

- Ground-water flow modeling. The existing model for the site will be calibrated to water levels at the start of system operation and then updated with actual pumping rates from the extraction and injection wells. Model results will be compared to ground-water elevation measurements, contours, and capture areas developed from water-level measurements. Comparison of these results will be used to interpret the effectiveness of hydraulic control.

- Water chemistry. Results of analyses for nutrients, hydrogen peroxide, and petroleum hydrocarbons will be used to evaluate the effectiveness of hydraulic control. Nitrate and hydrogen peroxide levels will be primary data, because of the anticipated large differences in the concentrations of these constituents between ambient water and injected water. Any increases in nitrate and hydrogen peroxide levels in ground-water samples from wells outside the extraction well ellipse will be interpreted in light of ground-water flow directions estimated from water levels and predicted by modeling. Chemical data showing a trend of increases in indicator chemicals in a well interpreted from water-level data to be outside the capture area or upgradient will trigger a corrective response.

- Pumping rates. Flow meter data will be used to verify that total extraction rates are greater than total injection rates. These data will serve as a mass balance check on the more detailed information provided by water level contours and water chemistry data.

As shown in Table 1, ground water from injection, extraction, and monitoring wells will be analyzed monthly or quarterly for TPH using EPA Test Method 8015 and for purgeable organics using EPA Test Methods 8010 and 8020. Because of the presence of petroleum hydrocarbons in ground water at and in the vicinity of the site, and because of perturbations to ground-water flow directions resulting from ongoing dewatering operations at the adjacent EBMUD site, use of organic chemical data will serve at best as a supplementary means of assessing hydraulic control. These data will be used to check interpretations based on water levels, modeling, and nutrient chemistry data.

3.2 <u>Responses to Hydraulic Control Problems</u>

In the event that analysis of water-level data, pumping rates, modeling results, and water chemistry data indicates that hydraulic control is not being maintained, the following responses will be initiated:

- Extraction well and injection well flow rates will be adjusted to reestablish hydraulic control.
- If flow rates of existing wells cannot be adjusted to establish control, additional extraction wells will be installed in appropriate areas.

4.0 TREATMENT OF DEWATERING EFFLUENT

Construction of the PRP development will require excavation to a depth of approximately 40 feet. Because of BART concerns associated with water-level differences across the BART tunnels, it will be necessary for the PRP developers to install a shoring system around the site prior to the start of excavation so that dewatering of soil will not affect water levels at the tunnels. It is the intent of the Agency to coordinate with the PRP developers so that any water produced during dewatering of the site will be treated through the existing carbon adsorption system prior to discharge.

5.0 EXCAVATION MONITORING AND SOIL HANDLING

Before construction of the PRP buildings begins, all soil within the site boundaries will be excavated to a depth of approximately 40 feet and removed from the site. Available soil sampling results indicate that the maximum depth of soil contamination is approximately 30 feet below ground surface. Thus, all known areas of soil contamination within the property boundary will be removed during excavation. Prior to the start of excavation, soil borings will be drilled and soil samples collected and analyzed to assess the effectiveness of the biological treatment. Analytical results will also be used to guide soil handling and disposition during excavation.

During excavation, soil will be monitored if necessary for the presence of petroleum hydrocarbons using an organic vapor analyzer (OVA) and sensory cues (visual staining and odors) in conjunction with collection of soil samples for laboratory analysis.

All excavated soil will be handled in accordance with applicable guidelines. At the present time, soil with TPH values less than 100 ppm is proposed for disposal in a Class III landfill. Soil with TPH values exceeding 100 ppm will be disposed at appropriate Class I or Class II facilities or aerated in accordance with BAAQMD Regulation 8, Rule 40 to reduce TPH values to less than 100 ppm.

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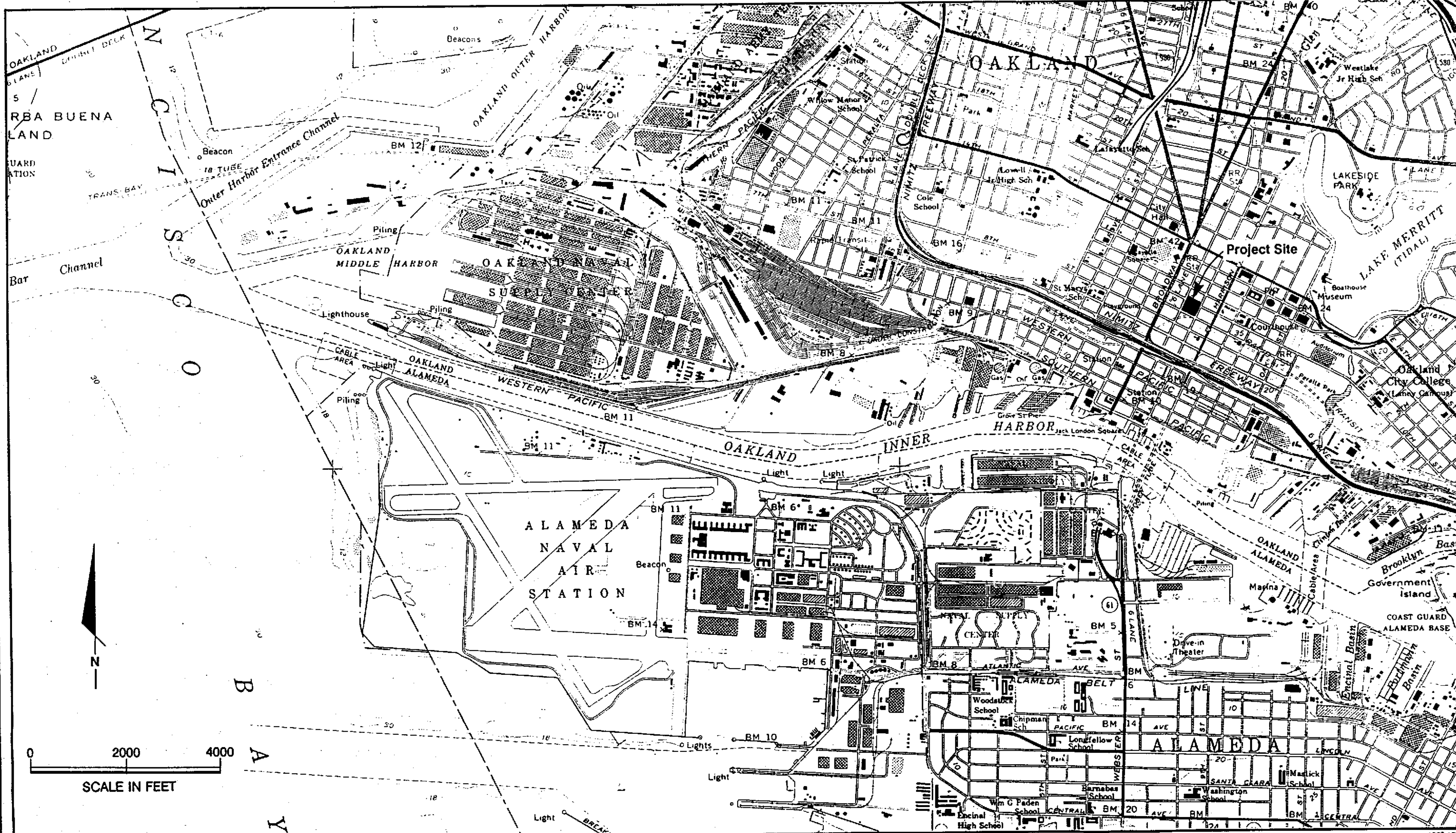
Table 1. Soil Treatment System Plan
Schedule for Sampling, Measurement, and Analysis

Sampling Station	Flow/Water Levels	Nitrate	Ammonia	Phosphate	Dissolved Oxygen	EPA 8010	EPA 8015	EPA 8020 (BTXE)
	Measurement/Analysis							
Extraction wells: composite	D/W	W	W	W	W	M	W/M	W/M
Injection wells: composite	D/W	W	W	W	W	M	W/M	W/M
Extraction wells: individual	D/W	W	W	W	W	---	---	---
Injection wells: individual	D/W	---	---	---	---	---	---	---
MW-3	M	---	---	---	---	Q	---	Q
MW-5	M	---	---	---	---	Q	---	Q
MW-7	M	M	---	---	M	Q	---	Q
MW-9	W	W/M	---	---	W/M	Q	M	M/Q
MW-10	W	W/M	---	---	M	Q	M	M/Q
MW-11	W	W/M	---	---	W/M	Q	M	M/Q
MW-12	W	W/M	---	---	M	Q	M	M/Q
MW-13	W	W/M	---	---	M	Q	M	M/Q
MW-14	W	W/M	---	---	M	Q	M	M/Q
MW-15	W	W/M	---	---	W/M	Q	M	M
MW-16	W	W/M	---	---	W/M	Q	M	M
MW-17	W	W/M	---	---	W/M	Q	M	M
MW-18	W	M	---	---	M	Q	M	M/Q
MW-19	M	M	---	---	M	Q	M	Q

Notes:
D/W = daily for first two weeks, weekly thereafter
W = at startup, weekly thereafter
W/M = at startup, weekly for the first month, and monthly thereafter
M = at startup and monthly thereafter
M/Q = at startup, monthly for three months, and quarterly thereafter
Q = quarterly
--- = no analysis proposed

8675



Source: U.S.G.S. 7 1/2 Minute Quadrangles: Oakland East and Oakland West

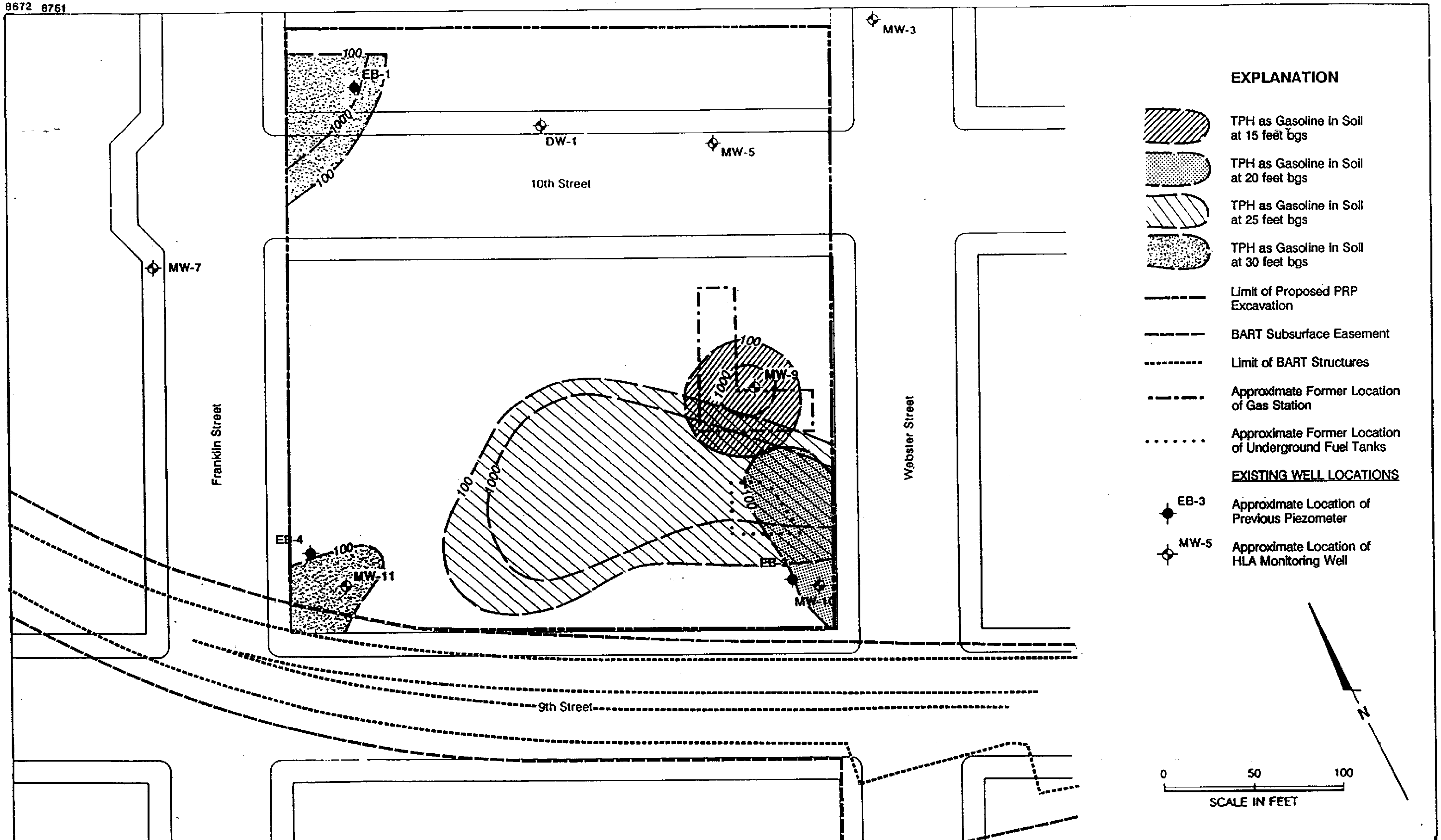
HLA **Harding Lawson Associates**
Engineers and Geoscientists

Site Location
Pacific Renaissance Plaza
Chinatown Redevelopment Project Area
Oakland, California

PLATE **1**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED
DM	9382,030.02	DFL	1/89	

109483



Source: BART As-Built Drawings, Pacific Renaissance Associates, City of Oakland, HLA

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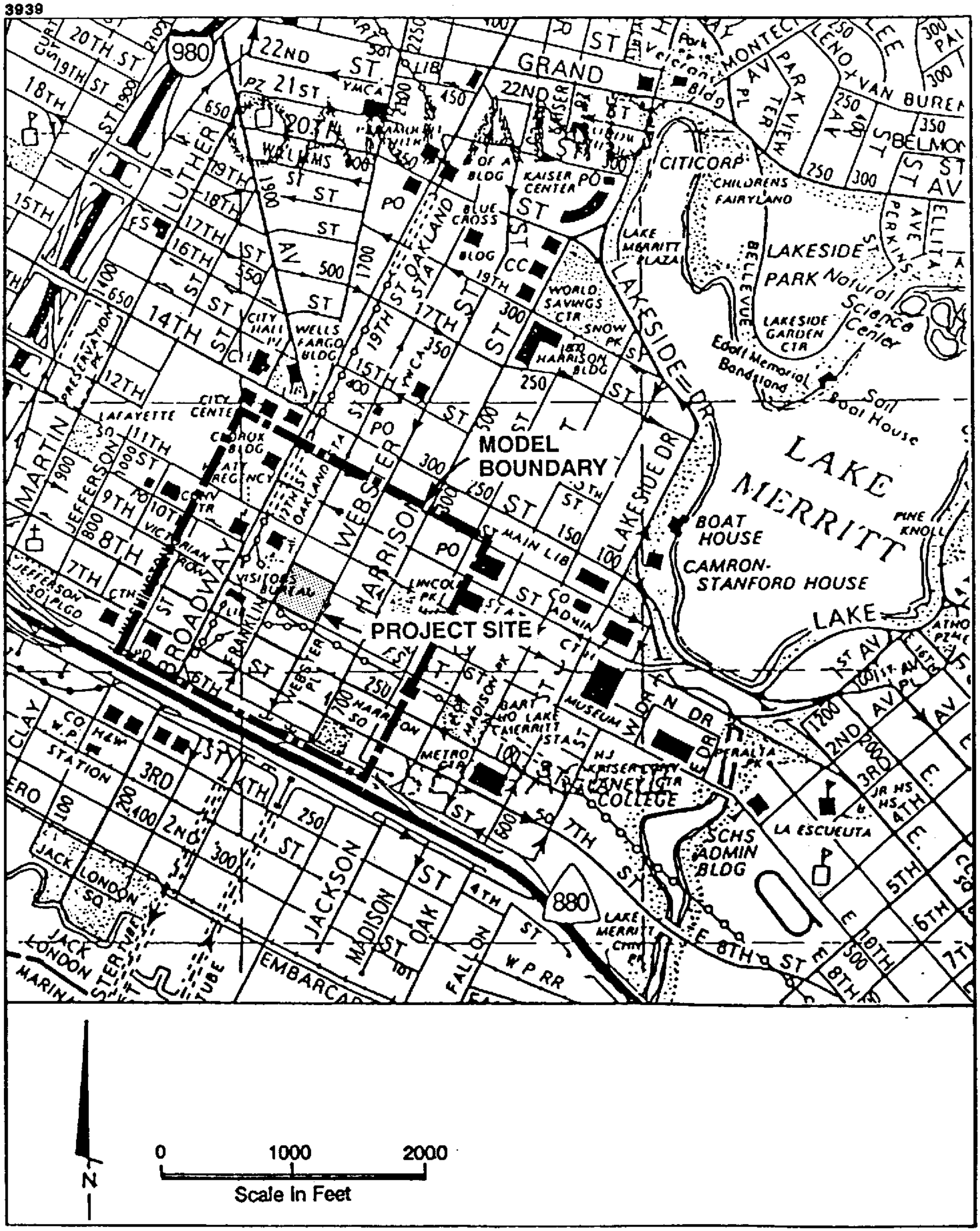
Engineers and Geoscientists

Site Plan and Vicinity
Pacific Renaissance Plaza
Chinatown Redevelopment Project Area
Oakland, California

PLATE **2**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
ML	9382,030.02	DFL	1/89		



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Ground-Water Flow Model Domain
Pacific Renaissance Plaza
Chinatown Redevelopment Project Area
Oakland, California

PLATE
3

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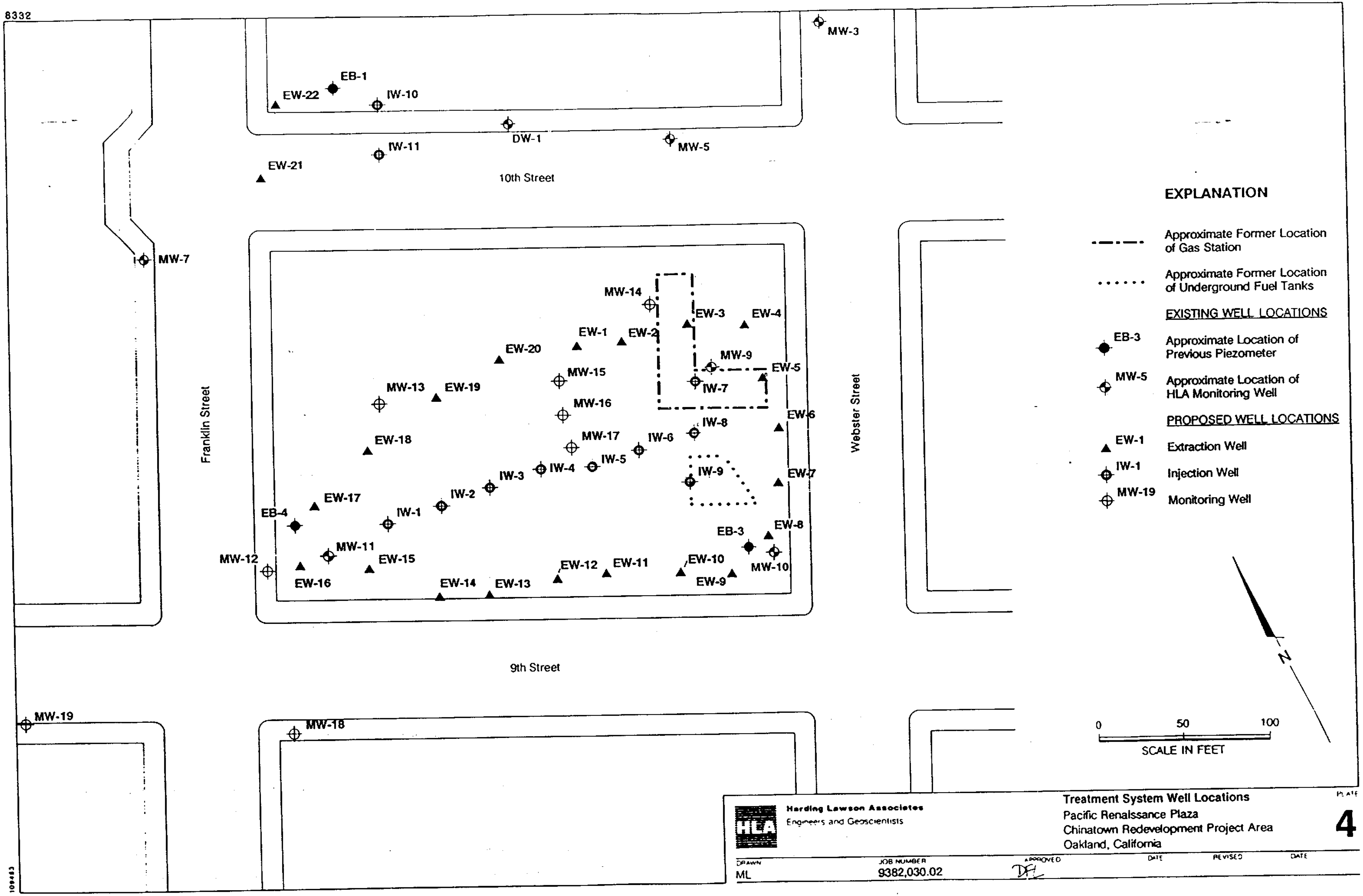

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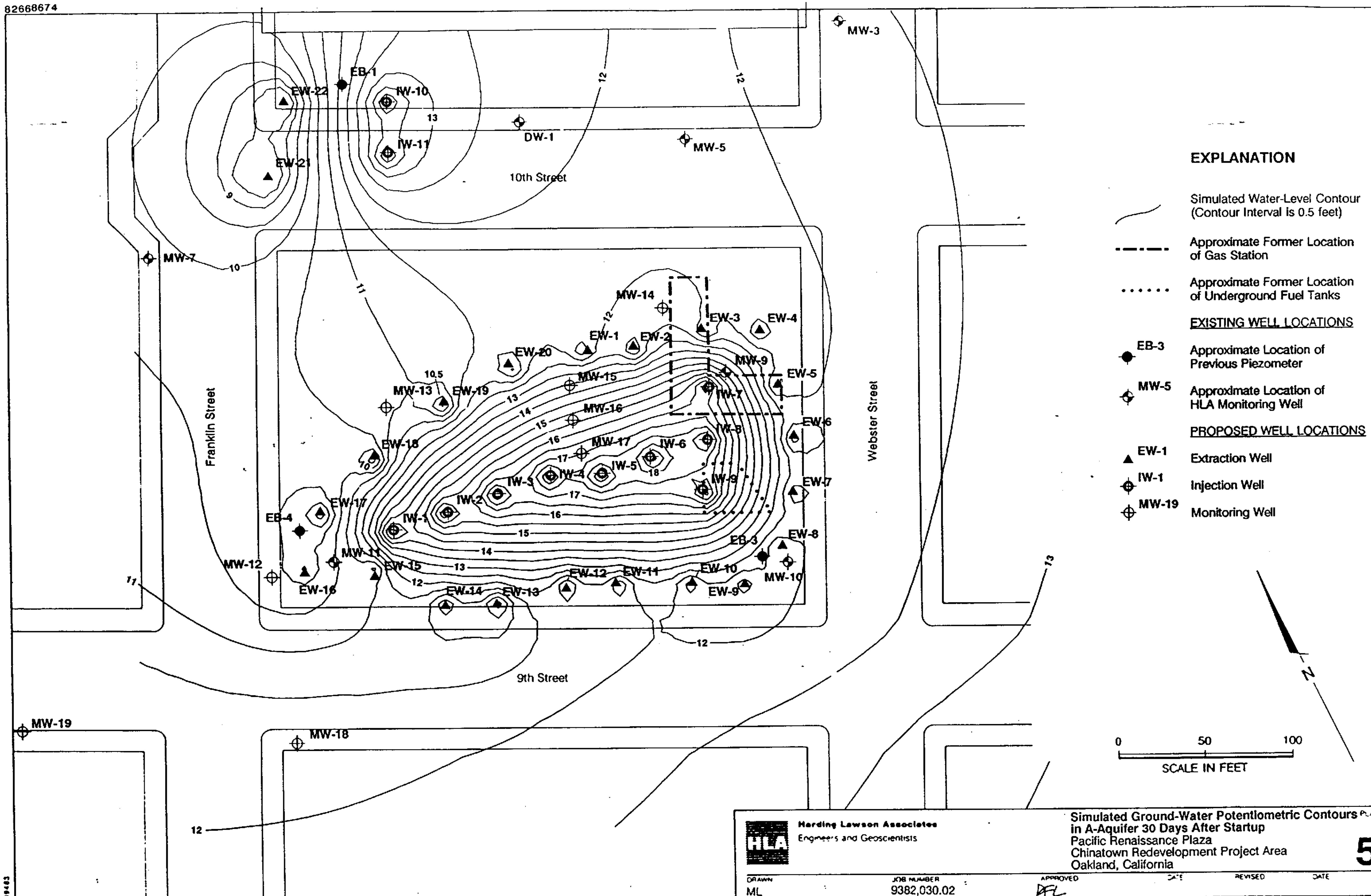
Treatment System Well Locations
Pacific Renaissance Plaza
Chinatown Redevelopment Project Area
Oakland, California

PLATE **4**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
ML	9382,030.02	DH			



Harding Lawson Associates
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Simulated Ground-Water Potentiometric Contours in A-Aquifer 30 Days After Startup
Pacific Renaissance Plaza
Chinatown Redevelopment Project Area
Oakland, California

PLATE **5**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
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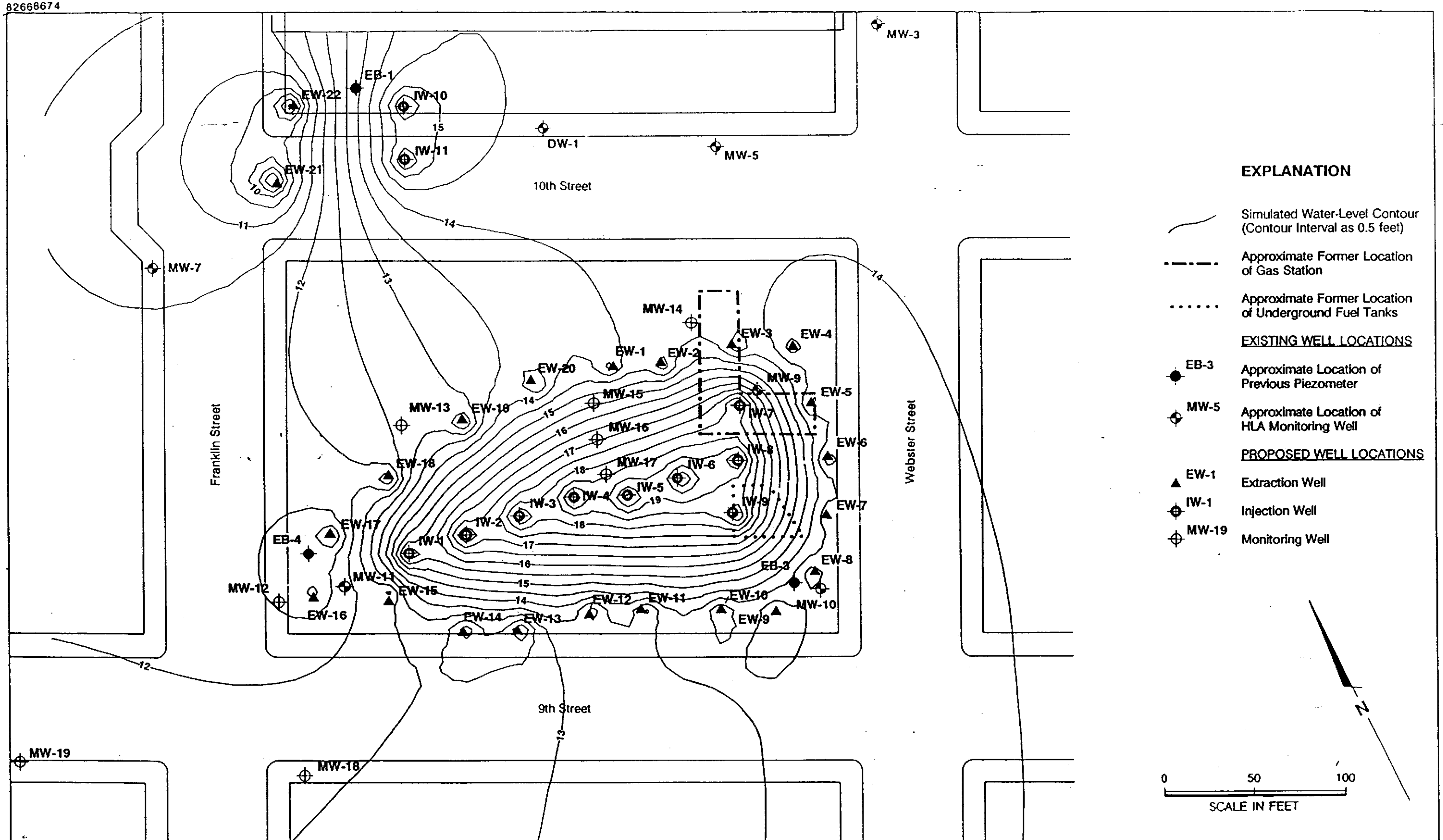

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Simulated Ground-Water Potentiometric Contours in A-Aquifer 180 Days After Startup
Pacific Renaissance Plaza
Chinatown Redevelopment Project Area
Oakland, California

PLATE **6**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
ML	9382,030.02	DRL			

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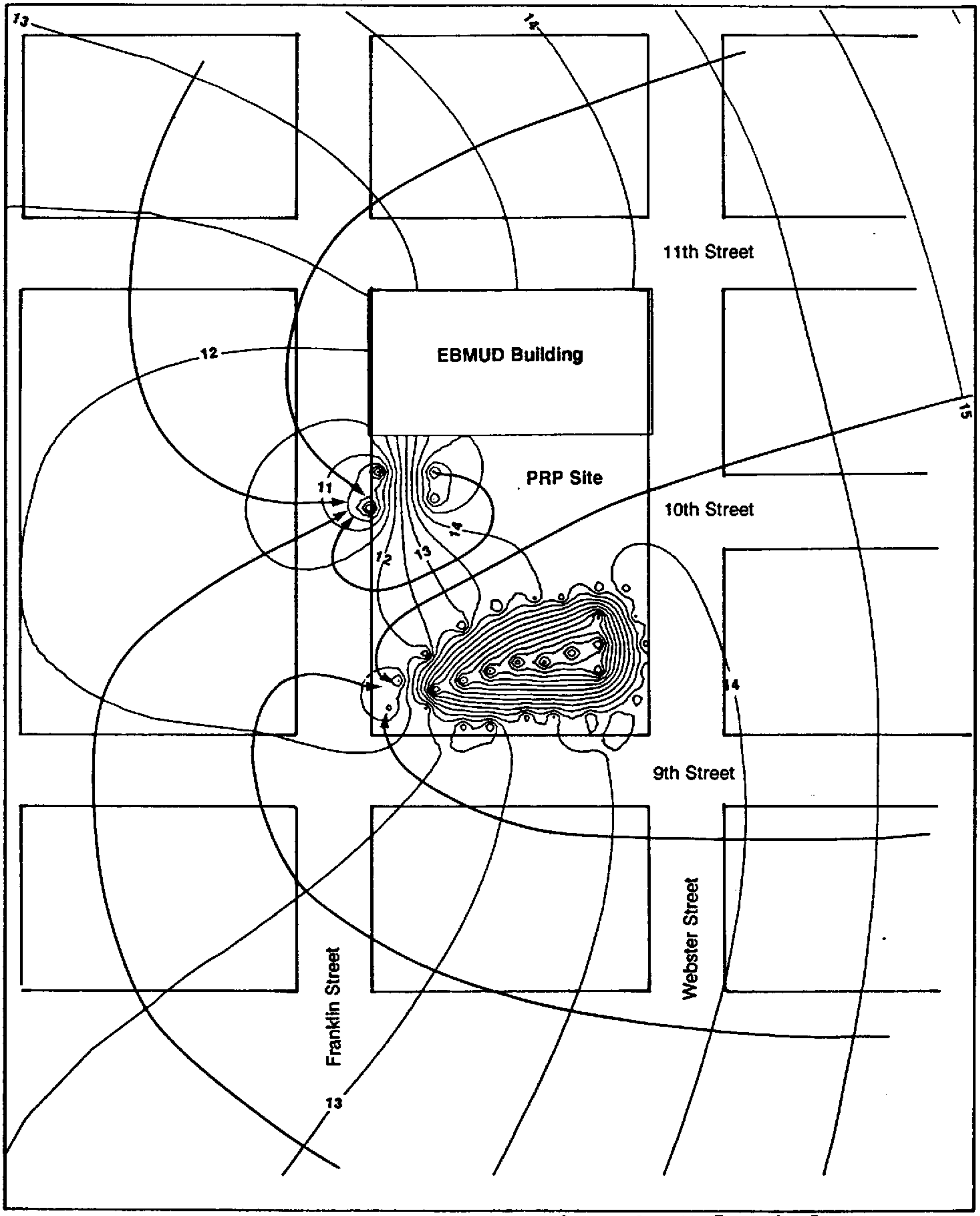

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Well System Capture Area 180 Days after Startup
Pacific Renaissance Plaza
Chinatown Redevelopment Project Area
Oakland, California

PLATE
7

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
	9382,030.02	DFL			

LARGE MAP REMOVED

APPENDIX A

BIODEGRADATION TREATABILITY STUDY

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1.0 INTRODUCTION

This report presents the results of Harding Lawson Associates' (HLA) laboratory study to evaluate the effectiveness of using in situ bioremediation techniques to clean up soil containing petroleum hydrocarbons (gasoline) on property in Oakland's Chinatown Redevelopment Project Area. The site comprises the area bounded by 9th, Webster, and Franklin Streets and the East Bay Municipal District (EBMUD) property line between 10th and 11th Streets.

Previous investigation (*Site Characterization, Pacific Renaissance Plaza, HLA, December 22, 1988*) has revealed the presence of petroleum hydrocarbons characteristic of gasoline at concentration levels up to 4,800 milligrams/kilogram (mg/kg, equivalent to parts per million [ppm]), of total petroleum hydrocarbons (TPH), in subsurface soils. The volume of soil containing petroleum hydrocarbons in excess of 100 ppm TPH is estimated to be about 7,000 cubic yards.

A preliminary screening of soil cleanup alternatives revealed that in situ biodegradation would meet performance and regulatory criteria, but was marginally acceptable with respect to implementability, primarily because of concerns related to the current construction schedule under which construction would begin in August 1989. A microbial evaluation study was conducted as part of preliminary screening activities. This study, reported in Appendix A of the site characterization report, indicates that an indigenous microbial population exists at the site that is capable of degrading petroleum hydrocarbons (gasoline). This gasoline utilizing population represents 0.01 to 0.04 percent of the total microbial population at the site. Also, soil and ground-water chemistry results indicate that the existing concentrations of inorganic nutrients such as nitrogen and phosphate may be limiting the potential for microbial degradation of hydrocarbons in the soil and ground-water environment.

To further evaluate the treatability of petroleum hydrocarbons in soils at the site, HLA conducted a treatability study to evaluate the technical feasibility of in situ bioremediation of the petroleum hydrocarbon bearing soil.

The scope of services and the results of the study are summarized below. The approach, procedure, observations, and conclusions are presented in detail in a separate report (*In Situ Biodegradation Treatability Study, HLA, in preparation*).

2.0 SCOPE OF SERVICES

The primary objective of the treatability study was to determine if in situ biodegradation is a technically and economically feasible technology for removing petroleum hydrocarbon in soils.

To accomplish the objective, the following scope of work was performed:

1. Evaluate the supplemental nutrients (inorganic) needed to increase the rate of biological degradation

2. Evaluate the site-specific conversion rate of hydrogen peroxide to increase the rate of biological degradation

3. Conduct a bench-scale simulation of the in situ bioremediation process.

The results of each task are discussed in the following sections.

3.0 MACRO- AND MICRO-NUTRIENT EVALUATION

Stimulation of the indigenous microbial populations to degrade the site contaminants requires the presence of optimum nutrient conditions for growth in the subsurface environment. Three nutrient formulations and oxygen sources were evaluated to determine the effect of each formulation on the rate of degradation of hydrocarbon (gasoline).

Soil composites were prepared from several boring locations and slurried with a composite sample of site ground water. In each test, 100 grams of soil was placed in a vial along with 20 milliliters (ml) of ground water that had been amended with the appropriate nutrient formulation and an initial hydrogen peroxide concentration of 500 ppm. After all additions were completed, headspace was minimized (less than 0.5 ml) and the vials capped with teflon-faced silicon septa. Periodically, hydrogen peroxide was injected through the septa to provide an estimated 10 ppm of dissolved oxygen. The results of this evaluation are summarized in Table A-1. The results indicate that each nutrient formulation stimulated the microbial degradation of hydrocarbons which resulted in approximately 99 percent removal of petroleum hydrocarbons as TPH in a 14-day incubation period. The control group which received no nutrient or oxygen additions but was exposed to the same laboratory conditions revealed no change in TPH concentration during the incubation period. Because there appears to be no significant advantage in TPH removal by increasing the nutrient formulation, the 100 ppm nutrient formulation was selected for the in situ simulation for ease of preparation and to minimize secondary reactions that may occur during introduction of the nutrients to the subsurface environment.

4.0 HYDROGEN PEROXIDE STABILITY

The ability to add oxygen at high concentrations to the subsurface environment will be crucial to the success of the bioremediation project. The most effective way to introduce large amounts of oxygen to the subsurface environment is through a stabilized hydrogen peroxide solution. Hydrogen peroxide is converted to oxygen and water as it diffuses through the soil. The rate of conversion of hydrogen peroxide is site-dependent and must be evaluated for each site.

Soil composites were prepared from several boring locations and slurried with a composite of the site ground water. In each test, 100 grams of soil were placed in a flask with 200 milliliters of site ground water and supplemented with 100 ppm of the nutrient formulation and an initial hydrogen peroxide concentration of 500 ppm. Periodically, aliquots were removed and analyzed for hydrogen peroxide by a potassium permanganate titration method. The results of the evaluation are summarized in Table A-2, and indicate that hydrogen peroxide stability is generally constant across the site. The percentage of hydrogen peroxide remaining after 24 hours ranged from 25 to 55 percent. In all cases, the loss of hydrogen peroxide was accompanied by the release of oxygen. The conversion rate of hydrogen peroxide for all samples was within a range acceptable for biological degradation.

5.0 BENCH-SCALE SIMULATION OF IN SITU BIOREMEDIATION

Two intact soil samples in lexan acrylic cores (approximately 3 inches in diameter and 18 inches in length) were obtained from the site and utilized in the bench-scale simulation. The soil cores were fitted at each end with machined permeameter heads and sealed. Prior to the start of the simulations, three soil samples were removed from the column via sampling ports spaced approximately four to five inches apart along the length of the column. The soil samples were analyzed for the primary contaminants and for microbial populations. The water passed through the column was similar to hydrant water available at the site. This water was supplemented with the 100 ppm nutrient formulation and hydrogen peroxide and continuously passed through the column at a flow rate of approximately 20 ml/hr. At this flow rate, a pore volume of water was estimated to be replaced every four to five days. Each pore volume of water was analyzed for selected organic contaminants, selected inorganic constituents, and microbial populations. The simulation was continued until approximately 4.5 pore volumes of water had been passed through the column. At the conclusion of the simulation, the soil within the column was sampled at three-inch intervals along the length of the column. The samples were analyzed for selected organic contaminants and microbial populations. The results of the bench-scale simulation are summarized in Table A-3. These results indicate that the addition of the selected nutrient formulation and oxygen resulted in an average decrease in TPH concentration of 79 percent throughout the column. The lower percentage removal of TPH in the column simulation (79%) compared to the percentage removal of TPH in the nutrient evaluation study (99%) probably occurred because microbially enriched water was not recirculated through the column. In general, column studies of similar design and using similar soil materials have resulted in TPH removal rates in the 90 to 99 percent range when four or more pore volumes of recycled water are passed through the column. Two advantages of recycling water are that: (1) the standing microbial populations within the soil profile can reach a higher population level within a shorter timeframe, thus resulting in an increase in the amount of biological degradation, and (2) surface active products produced by the microorganisms to aid metabolism of the hydrocarbons are in higher concentration which would also increase biological degradation.

The bench-scale simulation study indicates that in situ bioremediation is technically feasible for full-scale remediation of petroleum-hydrocarbon-bearing soil. The rate of TPH removal could potentially be increased by recycling water that has passed through the subsurface environment.

Table A-1. Macro- and Micro-Nutrient Evaluation

Group	Total Petroleum Hydrocarbons (ppm) Day 0	Day 7	Day 14	Percent Removal
1 100 ppm Nutrient solution	580	14	5.2	99.1
2 200 ppm Nutrient solution	580	16	5.8	99.0
3 500 ppm Nutrient solution	700	11	4.9	99.3
Control	240	270	260	0

Table A-2. Hydrogen Peroxide Stability Results

Soil Sample	Hydrogen Peroxide Concentration[1] Initial	8 hours	24 hours
1	500	375	274
2	500	320	188
3	500	352	154
4	500	304	126

1 Tests were conducted using a slurry of 1 part soil in 2 parts water. Hydrogen peroxide concentrations were determined by potassium permanganate titration method.

Table A-3. Bench Scale Simulation Results

Group	Total Petroleum Hydrocarbons		
	Day 0	Day 18	Removal (percent)
Test	720*	151**	79
Control	353*	468**	0

* Average concentration based on 3 sampling points.

** Average concentration based on 6 sampling points.

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DISTRIBUTION

REPORT OF WASTE DISCHARGE
PACIFIC RENAISSANCE PLAZA
CHINATOWN REDEVELOPMENT PROJECT AREA
OAKLAND, CALIFORNIA
February 3, 1989

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