R0414

MF 25/26

Harding Lawson Associates

December 18, 1998

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Mr. Dale H. Klettke, CHMM
Port of Oakland
Environmental Health & Safety Compliance
530 Water Street, 2nd Floor
Oakland, California 94607

Work Plan for Installation of Oxygen-Releasing Compound (ORC)
United Airlines Hangar Area - Economy Parking Lot Site
Metropolitan Oakland International Airport
Oakland, California

Dear Mr. Klettke:

Harding Lawson Associates (HLA) is pleased to submit this work plan to the Port of Oakland (Port) to remediate groundwater at the United Airlines Hangar Area - Economy Parking Lot Site, Metropolitan Oakland International Airport (MOIA), Oakland, California (Plate 1). The objective of this project is to remediate soil and groundwater by providing an oxygen source to enhance the biodegradation of petroleum hydrocarbons. We plan batch applications of oxygen releasing compound (ORC) at the former underground storage tank (UST) battery and then monitoring of bioactivity by measuring the dissemination of dissolved oxygen (DO) in downgradient monitoring wells. A two-year groundwater monitoring program will be conducted to document remediation activities and groundwater conditions.

Background

In March 1992, two USTs MF-25 and MF-26 were removed. Approximately 700 cubic yards of impacted soil was removed and confirmation soil samples were collected following soil removal. The former UST excavation (80-feet by 80-feet) was reportedly backfilled with permeable material. The area is now paved and used for parking (Plate 2). Monitoring well MW-1 was installed in 1992 where total petroleum hydrocarbons as diesel (TPHd) and petroleum hydrocarbons as motor oil (TPHmo) were reported with elevated concentrations. Two additional monitoring wells, MW-2 and MW-3, were installed in 1995. Observations of free product in MW-2 and MW-3 were reported starting in 1996. Monitoring wells MW-4 though MW-8 were installed in 1998.

Approach

HLA plans an empirical approach to the application of ORC. Batches of ORC will be applied to the groundwater at the upgradient side of the former UST excavation. The DO will be utilized by existing microbial populations while they consume hydrocarbons. Each batch application of ORC is anticipated to disperse DO further than the previous batch as hydrocarbons are depleted by the microbes there-by reducing oxygen demand. As enhanced biodegradation proceeds, DO should be observed in downgradient monitoring

wells because oxygen demand is reduced as microbial populations decline from decreasing concentrations of available hydrocarbons.

We have considered batch ORC applications using two oxygen-delivery methods: liquid peroxide or time-release ORC. Although each batch delivery is more costly with time-release ORC, the effectiveness and long-term cost efficiency is anticipated to be much greater than could be achieved with hydrogen peroxide. High concentrations of peroxide allow for substantial quantities of oxygen to be introduced into the subsurface, but most of the DO is utilized inefficiently within hours as the peroxide oxidizes a wide variety of organic and inorganic compounds encountered in the soil matrix. Unless batch peroxide dosages occur several times per week, microbial populations can not expand because oxygen is not continually available. In addition, biodegradation would be inhibited near the injection point because the high concentrations of peroxide would be toxic to microbes. In order to provide sufficient peroxide in low concentrations a sophisticated delivery system would need to be constructed. The high cost of equipment or labor to achieve a sufficient source of oxygen through peroxide injections make this alternative more costly in the long term. Time-released ORC was selected for implementation at this site.

Batch treatments of time-released ORC will be applied to groundwater within the former UST excavation to provide a continuing source of oxygen that will sustain a substantial microbial population. Four injection points will be spaced at a 20-foot interval across the upgradient boundary of the former UST excavation area, providing for 10-foot radial dispersion of ORC at each location. Each batch delivery will disperse DO across the excavation width to be carried downgradient with groundwater movement.

Each batch will consist of a total of 1,000 pounds of time-release ORC mixed in about 300 gallons of water to treat the former UST excavation area, with an aerial extent of roughly 80-feet by 80-feet. This batch volume was calculated based on sensitivity analyses using two sets of groundwater conditions (calculation sheets attached). This dosage has been calculated to be sufficient for treating a dissolved hydrocarbon concentration of 4 mg/L across a 10-foot aquifer thickness which is representative of recent measured dissolved total petroleum hydrocarbon (TPH) concentrations in MW-4 across the its screened interval. A 1,000-pound ORC dosage would also treat a dissolved hydrocarbon concentration of 20 mg/L across the 1.5 foot smear zone, created by seasonal groundwater surface elevation fluctuations, where 20 mg/L represents approximately 10 to 20 percent of the saturation concentration.

Work Plan

The scope of work includes checking for free product, providing batch treatments of ORC, and monitoring groundwater at surrounding wells. The scope of work for each task is discussed below.

Task 1 - Check for Free Product

HLA will visit the site and measure groundwater and free product elevations using a oil-water interface probe. If free product is encountered, HLA will propose a method to recover the free product prior to installing ORC. Free product removal would be needed because ORC is not cost efficient in applications where free product is present. For the reduction of petroleum hydrocarbons by bioremediation to be effective, it is necessary for the petroleum hydrocarbons to be in a dissolved state. Product can be removed in a more timely and cost efficient manner while in the free phase state by other methods.

Task 2 - Batch Treatment of ORC

The following activities will be conducted one week prior to each batch application:

- Conduct private utility clearance of push-rod locations.
- Measure water levels and DO concentrations in all accessible monitoring wells.

if the tooled cant (250#) if ORC slurry cannot be injected, will need more inj points.

A direct-push rig will be mobilized to inject ORC-grout along the upgradient edge of the former UST excavation at the four locations shown on Plate 3. A 2-inch diameter rod will be pushed at each location to a depth of 4 feet below ground surface. At each location approximately 250 pounds of time-release ORC will be mixed into 75 gallons of water providing a 30 percent blend with a consistency similar to white wash. The ORC solution will be pumped into the formation at low pressure. Based on the information provided by the Port, we have assumed that the near surface stratigraphy consists of sands and gravels that will accept the solution without resistance. Each push-point location will be completed with neat grout upon completion.

The need for additional ORC batch treatments will be determined after 6 months based on the results groundwater monitoring conditions. This frequency is based on manufacturer recommendations; ORC typically continues releasing DO for 6 to 12 months. Initially, DO concentrations are anticipated to remain relatively low at downgradient wells (MW-2 and MW-4) and cross-gradient wells (MW-1 and MW-3) because microbes will be utilizing the oxygen as they consume hydrocarbons. An increase of DO concentrations in nearby wells would indicate that the degradation process is nearing completion because microbes are no longer utilizing oxygen. Eventually, increased DO may be detected even farther downgradient at wells MW-5, MW-6, and MW-7.

Task 3 - Groundwater Monitoring

HLA will perform 8 quarters of quarterly monitoring and reporting as follows:

- Sample 8 monitoring wells, where accessible, in accordance with the standard procedures described in Attachment 1, once each quarter. Quality assurance and quality control (QA/QC) procedures will be implemented during each sampling event by submitting a blank field duplicate for chemical analyses.

- Conduct laboratory analyses of groundwater samples for the following analytes:
  - TPHg by modified EPA Method 8015
  - Benzene, Toluene, Ethylbenzene, total Xylenes (BTEX), and Methyl t-butyl ether (MTBE) by EPA Method 8020
  - TPHd, TPHj, and TPHmo by EPA Method 8015 with a silica gel cleanup procedure
  - Purgable halocarbons by EPA Method 8010
  - Ferrous/Ferric Iron, Nitrate, Sulfate, Orthophosphates, Redox/ORP
  - Total Organic Carbon (TOC) by EPA Method 415.2

- Monitor DO in the four wells within and adjacent to the former UST excavation (MW-1, MW-2, MW-3, and MW-4) following each batch ORC application. DO monitoring will be conducted on a weekly basis after each application for the first month and monthly thereafter for the following five months.
- Prepare quarterly reports that include tabulated groundwater level measurements, analytical data and DO concentration measurements from the wells (historical and current data), a site plan which presents the most recent groundwater elevation measurements with groundwater gradient and direction shown, a site plan which presents the last sample events results of chemical analyses of groundwater samples or observed conditions in the wells, and the laboratory reports.

Proposed Schedule

The following proposed schedule may be modified depending on site conditions; ORC applications will be discontinued when DO is detected in downgradient wells:

Date	Activities
December 1998	• Groundwater sampling • Check for free product
January 1999	• Install ORC, if no free product is present
February 1999	• Quarterly sampling, weekly DO monitoring
March & April 1999	• Monthly DO monitoring
May 1999	• Quarterly sampling, monthly DO monitoring
June 1999	• ORC Data evaluation/analysis • Install 2nd batch of ORC if no DO observed in downgradient wells • Weekly DO monitoring
July 1999	• Monthly DO monitoring
August 1999	• Quarterly sampling, monthly DO monitoring
September & October 1999	• Monthly DO monitoring
November 1999	• Quarterly sampling, monthly DO monitoring
January 2000	• ORC Data evaluation/analysis • Install 3rd batch of ORC if no DO observed in downgradient wells • Weekly DO monitoring

if conc of DO not sign. greater than BG (MW-8)

February 2000	• Quarterly sampling, monthly DO monitoring
March & April 2000	• Monthly DO monitoring
May 2000	• Quarterly sampling, monthly DO monitoring
June 2000	• ORC Data evaluation/analysis • Install 4th batch of ORC if no DO observed in downgradient wells • Weekly DO monitoring
July 1999	• Monthly DO monitoring
August 2000	• Quarterly sampling, monthly DO monitoring
September, October, & November 2000	• Monthly DO monitoring

If you have any questions or need additional information, please contact the undersigned at (510) 451-1001.

Sincerely,

HARDING LAWSON ASSOCIATES

Michael A. Sides, PE
Senior Engineer

James McCarty
Project Engineer

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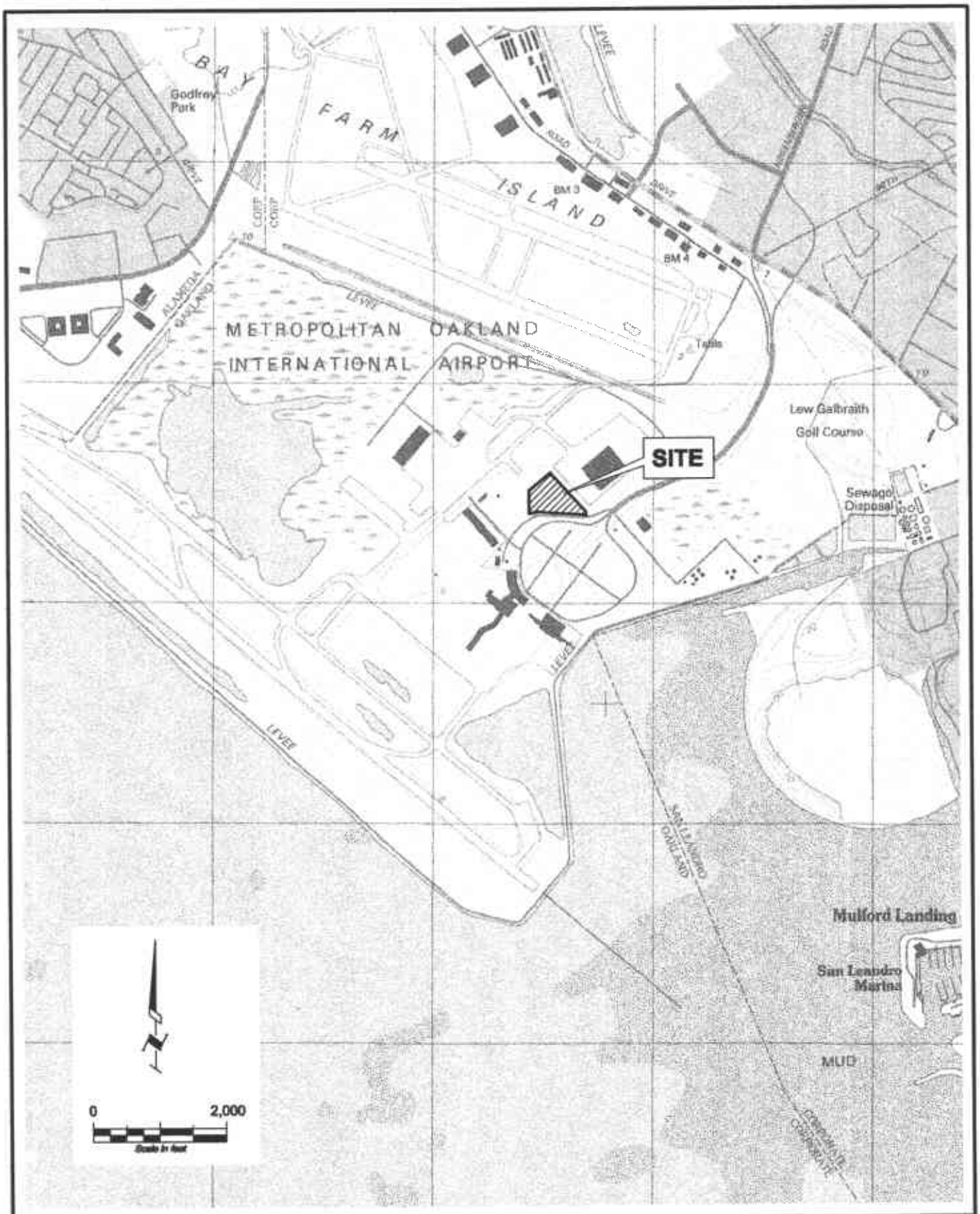
Attachments: Plate 1 - Site Location Map
Plate 2 - Site Plan
Plate 3 - ORC Injection Plan
Attachment 1 - Well Purging and Sampling Procedures



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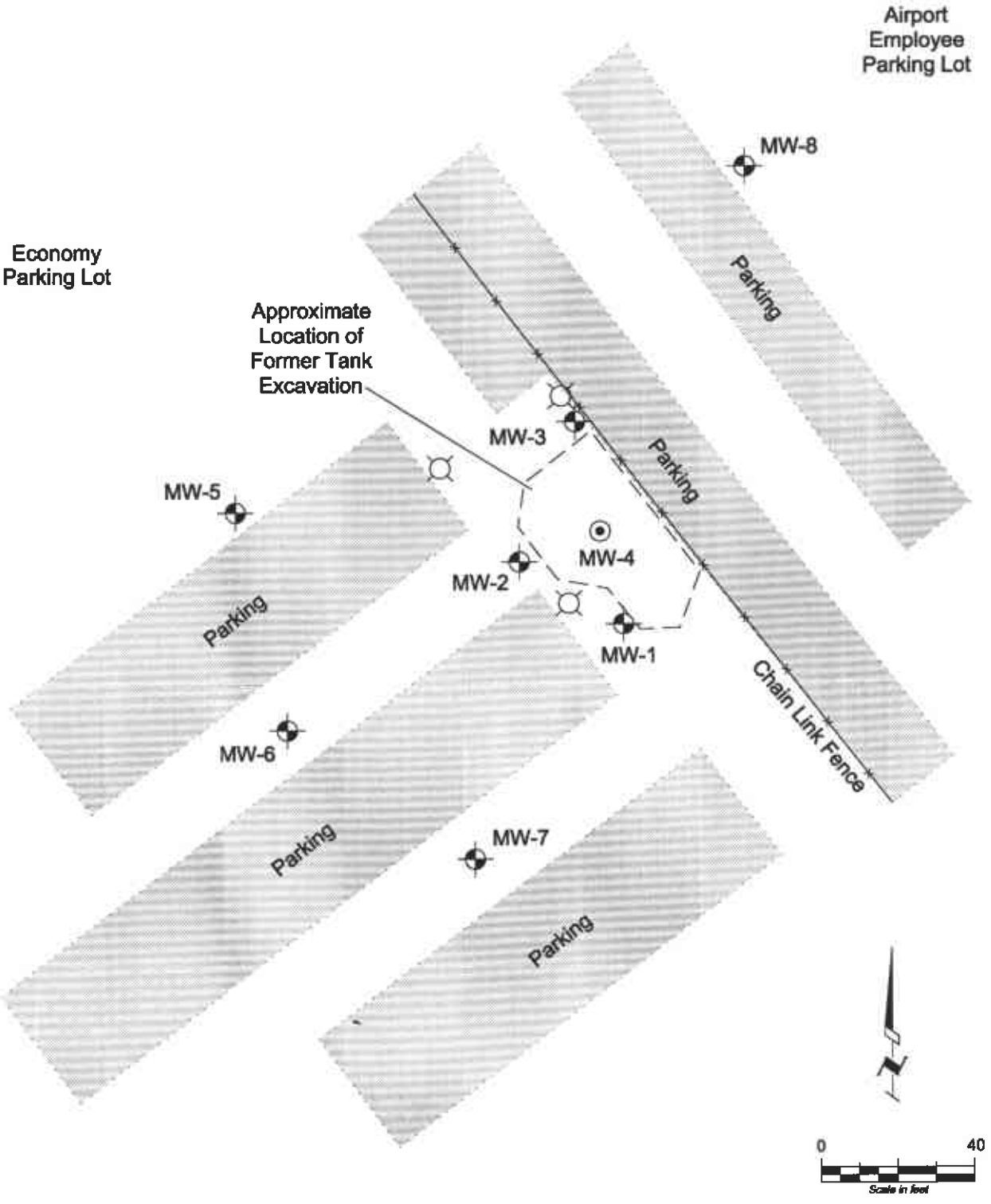
Engineering and Environmental Services

Site Location Map

Economy Parking Lot - United Airlines Hanger Site
Oakland International Airport
1100 Airport Drive, Oakland, California

PLATE **1**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
AJW	43145.2	MS	12/16/98	---



Reference:
Map based on a figure prepared by
Innovative Technologies Solutions, Inc.

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Engineering and
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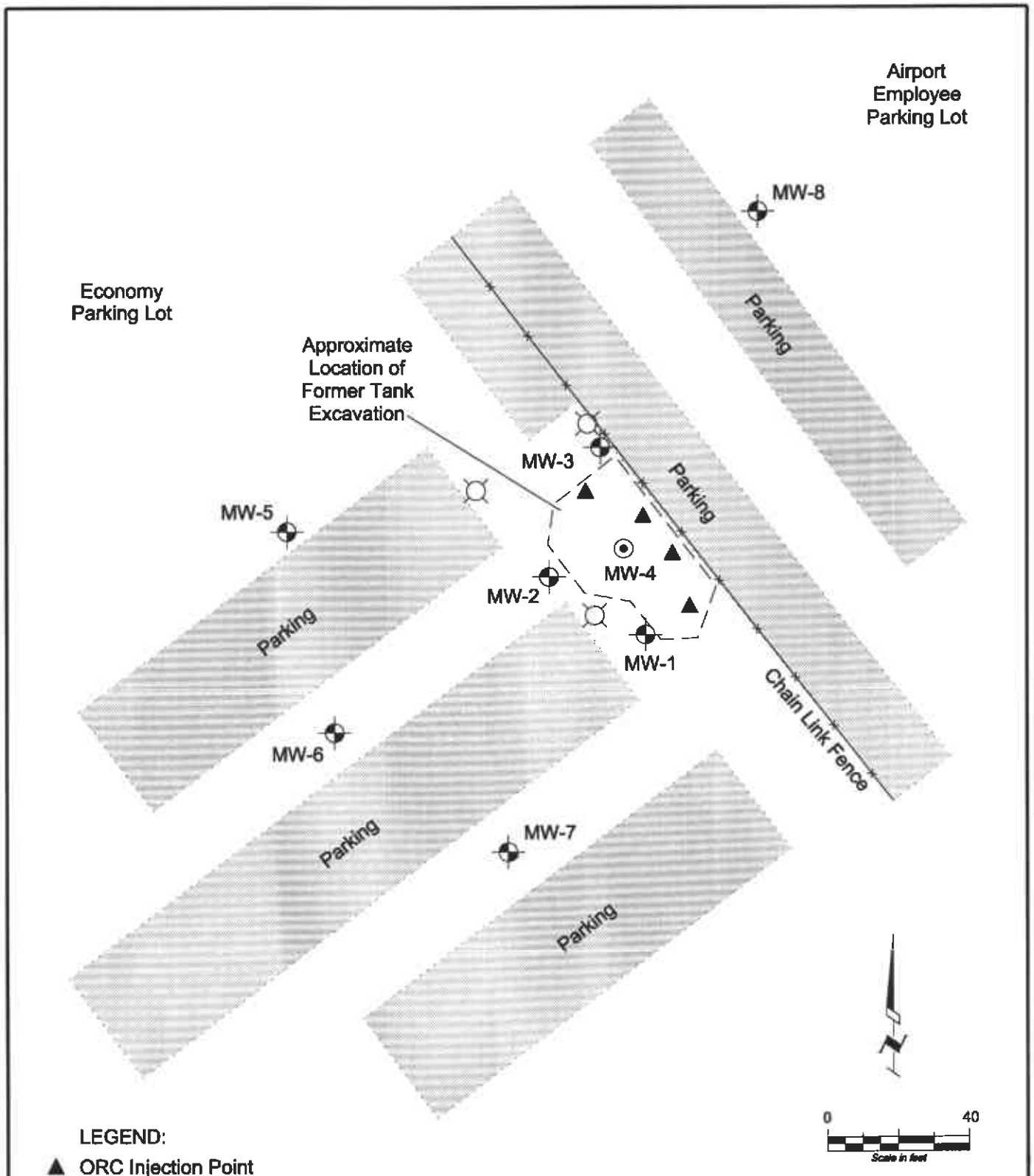
Site Plan
Economy Parking Lot - United Airlines Hanger Site
Oakland International Airport
1100 Airport Drive, Oakland, California

PLATE
2

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
AJW	43145.2	MS	12/16/98	...



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ORC Injection Plan
Economy Parking Lot - United Airlines Hanger Site
Oakland International Airport
1100 Airport Drive, Oakland, California

PLATE
3

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
AJW	43145.2	MS	12/16/98	...

ATTACHMENT 1

WELL PURGING AND SAMPLING PROCEDURES

Prior to the purging or sampling of the monitoring wells, the distance from the top of the well casing to groundwater in the well will be measured with an electric water level indicator to the nearest one-hundredth of a foot. MW-2, MW-3, and MW-4 will be checked for free-floating petroleum product with an oil-water interface probe and dissolved oxygen will be measured in all accessible wells.

Monitoring wells will be purged by removing a minimum of three well casing volumes of groundwater with a submersible pump or PVC bailer. Before each use, the pump or bailer will be decontaminated in a non-phosphate cleaning solution and rinsed first in tap water, then in distilled water. During purging; pH, conductivity, and temperature of the extracted groundwater will be monitored. Sampling will not take place until the aforementioned groundwater parameter measurements have stabilized to within 10 percent. Purged groundwater from the monitoring wells will be stored onsite in 55-gallon drums for subsequent disposal by the Port of Oakland.

Water samples will be collected using a disposable Teflon bailer and placed in laboratory supplied sample containers and stored in a cooler with ice packs for transport. The samples will be submitted to a California certified analytical laboratory for chemical analysis under chain of custody procedures.

ORC SLURRY INJECTION

Dissolved Hydrocarbon Level (ppm)	4
(For gasoline sites use BTEX measurements)	
Treatment Zone Width (ft)	80
Treatment Zone Length (ft)	80
Thickness of Saturated Treatment Zone (ft)	10
Porosity	0.3
(sand = 0.3, silt = 0.35, clay = 0.4)	
Total Treatment Zone Volume (cu. ft)	64,000
Dissolved Phase Hydrocarbon Mass (lbs)	4.8
Additional Demand Factor	8
(REGENESIS recommends a factor of about 8)	
Loaded Hydrocarbon Mass (lbs)	38.4
Oxygen Required (lbs)	115.2
ORC Required (lbs)	1,152.0
ORC Unit Cost	$ 10.00
Total Cost of ORC	$ 11,520.00

FOR SOLUTE TRANSPORT MODEL ENTER VALUES BELOW

GW Velocity (ft / day)	0.11
Compliance Pt. (ft)	40
Ratio of O2 provided : O2 required (percent)	75%
HC Level at compliance point after selected ratio of oxygen in ppm	0.188

Solids Content (%)	30%
Hole Spacing (ft)	40
Number of Holes in Grid	4
ORC per Hole (lbs)	288.0
Water needed per Hole for Slurry (gal)	80.6

APPLICATION COMMENTS

* ORC per hole is above lower limit of 1 pound per linear foot.

ORC SLURRY INJECTION

Dissolved Hydrocarbon Level (ppm)	20
(For gasoline sites use BTEX measurements)	
Treatment Zone Width (ft)	80
Treatment Zone Length (ft)	80
Thickness of Saturated Treatment Zone (ft)	1.5
Porosity	0.3
(sand = 0.3, silt = 0.35, clay = 0.4)	
Total Treatment Zone Volume (cu. ft)	9,600
Dissolved Phase Hydrocarbon Mass (lbs)	3.6
Additional Demand Factor	8
(REGENESIS recommends a factor of about 8)	
Loaded Hydrocarbon Mass (lbs)	28.8
Oxygen Required (lbs)	86.4
ORC Required (lbs)	864.0
ORC Unit Cost	$ 10.00
Total Cost of ORC	$ 8,640.00

FOR SOLUTE TRANSPORT MODEL ENTER VALUES BELOW

GW Velocity (ft / day)	0.11
Compliance Pt. (ft)	40
Ratio of O2 provided : O2 required (percent)	75%
HC Level at compliance point after selected ratio of oxygen in ppm	0.939

Solids Content (%)	30%
Hole Spacing (ft)	40
Number of Holes in Grid	4
ORC per Hole (lbs)	216.0
Water needed per Hole for Slurry (gal)	60.4

APPLICATION COMMENTS

* ORC per hole is above lower limit of 1 pound per linear foot.