Harding Lawson Associates
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LETTER OF TRANSMITTAL

DATE 8-5-96	JOB NO. 11295.012
ATTENTION Mr. Dale Klettke	
RE Feasibility Study	
1700 Jefferson Street	
Oakland, CA	

To Alameda County Health Care Services
Division of Hazardous Materials
1131 Harbor Bay Parkway, 2nd Floor
Alameda, California 94502-6577

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A Report Prepared for

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

AQUIFER TESTING AND GROUND-WATER TREATMENT COST FEASIBILITY STUDY
CITY BLUE PRODUCTION FACILITY
1700 JEFFERSON STREET
OAKLAND, CALIFORNIA

HLA Job. No. 18106,006.04

by

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February 2, 1990

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1.0 INTRODUCTION

This report presents the results of the aquifer testing and ground-water treatment cost feasibility study performed by Harding Lawson Associates (HLA) for Blue Print Services Company at the City Blue Production Facility at 1700 Jefferson Street in Oakland, California. Based on previous investigations by HLA, it is known that soil and ground water at the site contains concentrations of total petroleum hydrocarbons (TPH) and benzene, toluene, ethyl benzene and xylenes (BTEX) and free floating petroleum product resulting from leaking underground storage tanks which previously existed on site.

The purpose of the aquifer testing and feasibility study is 1) to determine the aquifer parameters that will govern the approach for removing floating product and remediating ground water containing concentrations of hydrocarbons, and 2) to determine the ground-water treatment technology most technically feasible and cost effective given the aquifer characteristics and applicable discharge restrictions for use of the local sewer system. The tasks included in this proposal were previously outlined in Section 6.0 of the work plan report submitted to Blue Print Services Company, dated May 25, 1988. The information obtained from this proposed aquifer testing and feasibility study, combined with information obtained from previous investigations, will enable a cost-effective product removal and ground-water remediation system to be designed and implemented at the City Blue site. The services were authorized by Blue Print Services Company on November 7, 1989 under HLA's Standard Service Agreement, dated August 9, 1989.

2.0 SCOPE OF WORK

The scope of services for this investigation, outlined in HLA's proposal dated October 22, 1989, consisted of the following:

2.1 Task 1 - Aquifer Testing and Data Analysis

HLA performed slug tests on two existing monitoring wells, on-site Monitoring Well MW-3 and off-site Monitoring Well MW-5, to evaluate expected short-term and long-term flow rates from extraction well(s). These aquifer testing data are required to properly design a cost-effective product removal and ground-water treatment system and to calculate ground-water extraction parameters, including the volume of ground water to be treated and effluent discharge rates.

2.2 Task 2 - Ground-Water Treatment Cost Feasibility Study

Upon completion of Task 1, the aquifer testing data, together with other site characteristics identified in previous studies, were evaluated to determine the most cost-effective approach to product removal and ground-water treatment. At the City Blue site, there are three feasible, cost-effective methods of ground-water treatment. The three approaches include carbon adsorption, air stripping, and biological treatment.

The technical evaluation for each ground-water treatment alternative was carried out based on the estimated ground-water flow rates, contaminant concentrations, site space limitations, air emission standards, and discharge standards for disposal to the East Bay Municipal Utilities District (EBMUD) sanitary sewer system. The cost evaluations included comparing the capital costs, the operation and maintenance costs and net present value for each process alternative. Using the detailed technical and cost evaluations, conceptual process and flow diagrams were developed for the best treatment technology.

2.3 Task 3 - Report Preparation

HLA prepared this written report which includes the results of Tasks 1 and 2.

3.0 BACKGROUND

3.1 Previous Work

During February 1987, five soil borings were drilled by HLA as part of a preliminary hazardous waste assessment at the City Blue property. Two of the five soil borings were drilled to a depth of 30 feet adjacent to the three underground storage tanks used by the service station formerly located on the northwestern portion of the property. Selected soil samples were analyzed for TPH using EPA Method 8015. TPH concentrations from the two borings ranged from 46 parts per million (ppm) to 3300 ppm. The highest concentration values were detected at depths from approximately 19 to 27 feet. The results of the soil chemical testing and the observations during the subsequent removal of the three tanks indicated that one or more of the tanks had released petroleum hydrocarbons.

In June 1987, during excavation of the three tanks, 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. Subsequently, three monitoring wells (MW-1, MW-2, and MW-3) were installed on site to evaluate the distribution of petroleum hydrocarbons in the soil and ground water and to determine the direction of ground-water flow (Plate 1).

Petroleum hydrocarbons, presumably gasoline or degraded gasoline, was found floating on the ground water in Monitoring Well MW-1. In January 1988, two additional monitoring wells (MW-1A and MW-4) were installed by HLA at the property. Floating product has been detected in both wells. Monitoring Well MW-1A was installed adjacent to Monitoring Well MW-1. Floating product has been removed on a daily basis since early September 1987 by City Blue personnel. Monitoring Wells MW-1, MW-1A, and MW-4 are currently being used for product recovery. Monitoring Well MW-2 was abandoned on November 11, 1987 to facilitate construction of the City Blue facility.

On May 25, 1988, HLA submitted a work plan to City Blue recommending that site aquifer parameters be assessed, that an additional off-site monitoring well be installed downgradient of the City Blue site to further assess plume characteristics, and that a technical and cost evaluation for remedial alternatives be performed.

One off-site monitoring well (MW-5) was installed by HLA in August 1988, approximately 170 feet north-northeast (downgradient) of the location of the former on-site underground tanks. Petroleum hydrocarbons were detected in Monitoring Well MW-5 during two episodes of ground-water sampling performed on August 17, 1988, and September 12, 1988.

HLA performed additional investigations and presented the results in a report dated October 4, 1989. A site history review and contacts with regulatory agencies performed as part of the investigation identified several potential hydrocarbon source areas upgradient of the City Blue site. An off-site soil-gas survey was attempted in the city streets surrounding the City Blue site. However, thick steel-reinforced concrete beneath the asphalt prevented penetration of the soil-gas probe. Ground-water samples for chemical testing were also obtained from each of the on- and off-site monitoring wells to determine if changes in product thickness or hydrocarbon concentrations in ground water had occurred over the previous year. Neither product thickness nor hydrocarbon concentrations had changed significantly.

3.2 Subsurface Conditions

The subsurface soil encountered during the drilling of on- and off-site monitoring wells consists of poorly graded silty sand and sand from the ground surface to a depth of approximately 31 feet. This sandy unit is underlain by lower permeable sandy silt and clay that extends to the maximum depth of the borings, which ranges from 32 feet to 41.5 feet. On July 12, 1989, the depth to ground water in the five existing on- and off-site wells ranged from 24.4 feet to 26.0 feet. The shallow aquifer is unconfined based on the absence of the confining layer overlying the saturated aquifer material. Floating product has been detected in four of the five existing wells: on-site Monitoring Wells MW-1, MW-1A, MW-4, and off-site Monitoring Well MW-5. The greatest product thicknesses have been measured in on-site Monitoring Wells MW-1, MW-1A, and MW-4.

4.0 AQUIFER TESTING AND DATA ANALYSIS

4.1 Slug Test Field Procedures

Slug tests were performed on on-site Monitoring Well MW-3 and off-site Monitoring Well MW-5. A large capacity funnel was used to inject a 2.5-gallon volume (slug) of water into each well under the force of gravity. A pressure transducer, placed near the bottom of each well, was used to measure the water level recovery following the slug injection. The output of the transducer was recorded by a data logger and subsequently plotted on a hydrograph, as shown in the Appendix.

4.2 Results and Data Analysis

4.2.1 Slug Test

The hydraulic conductivity of the shallow unconfined aquifer was estimated from the results of one on-site single well slug test performed on Monitoring Well MW-3. At the time of the slug test, the equilibrium water level in Monitoring Well MW-3 was 24.75 feet below the top of casing. A slug test performed on off-site Monitoring Well MW-5 yielded undecipherable results.

The slug test data obtained from Monitoring Well MW-3 were analyzed according to the method of Hvorslev (1951). The ratio of h_t/h_o was plotted on the logarithmic scale of semilogarithmic graph paper as a function of time since slug injection (see Appendix). In this instance, h_o is defined as the vertical distance between the water level in the well immediately after slug injection and the equilibrium water level (hydraulic head) in the tested well and h_t is defined as the vertical distance at some time after slug injection.

Hydraulic conductivity is calculated from:

$$K = \frac{r^2 \ln(L/R)}{2L\ T_o}$$

where r is the well casing radius, R is the well screen radius, L is the height of the portion of the well through which water enters, and T_0 is the basic time lag. The value for T_0 was measured directly from the water-level recovery hydrograph at $h_t/h_0 = 0.37$.

A conservative hydraulic conductivity estimate of the 1.48 feet/day was derived from the test on Monitoring Well MW-3. A conservative "best fit" interpretation was selected to account for the inherent inaccuracies of the slug test method. The hydraulic conductivity estimate corresponds to that of a moderately permeable silty sand. This evaluation correlates well with the lithologic classification of the aquifer material.

4.2.2 Simulation of Sustained Well Yields

EQUIPLOT (Data Services, McEdwards, and HLA, 1986) computer simulations were conducted to evaluate sustained well yields at various pumping rates for the proposed ground-water extraction system. EQUIPLOT uses estimates of aquifer hydraulic conductivity, storativity, and saturated thickness to calculate ground-water equipotentials, estimates of the configuration of the water table during ground-water pumping, using the Theis equation (Theis, 1935). Hence, the resulting simulated potentiometric surface of the aquifer is subject to the assumptions/limitations of the Theis equation. EQUIPLOT can be used to quantitatively predict water-level responses to the pumping of single or multiple well ground-water extraction systems in aquifer materials that do not exhibit extreme variability in hydraulic properties. Table 1 summarizes the input parameters required for EQUIPLOT and an additional computer model, CAPTURE, which is discussed in Section 4.2.3.

On the basis of aquifer hydraulic properties estimated from slug test data, EQUIPLOT simulations indicate that pumping rates from the proposed extraction wells will likely be less than 1 gallons per minute (gpm) per well. Pumping rates will likely decrease with time to less than 0.25 gpm per well. The results of the various simulations conducted are presented in Table 2.

Table 2. Well Yield Simulation Results

Simulation Time (days)	Pumping Rate (gpm)	Maximum Drawdown (feet)	Aquifer Storativity (unitless)
730	1.0	23.6	0.10
30	0.5	7.5	0.10
10	0.5	6.1	0.10
730	0.3	7.1	0.10
730	0.25	5.9	0.10
730	0.25	5.6	0.15
730	0.2	4.7	0.10
730	0.1	2.4	0.10

gpm - gallons per minute

4.2.3 Simulation of Capture Zone

CAPTURE (Data Services and McEdwards, 1985) computer simulations were conducted for the majority of the simulations listed in Table 2. Input parameters for CAPTURE were equivalent to those used in the EQUIPLOT simulation with the exception of aquifer storativity. CAPTURE requires an effective porosity value rather than aquifer storativity. Effective porosity was assumed to equal aquifer storativity (i.e., specific yield) for the CAPTURE simulations. Simulations periods are not used for CAPTURE simulations because the CAPTURE model assumes steady-state conditions.

On the basis of the CAPTURE simulations, it appears that pumping rates of 0.25 to 0.5 gpm from each of the two wells, MW-1A and MW-4, will effectively capture ground water in the vicinity of the former tank removal excavation. The lateral extent of free-product and dissolved phase gasoline in the shallow aquifer has not been fully evaluated at this time. Consequently, it is difficult to evaluate the potential effectiveness of the extraction system in reducing the volume of free product and lateral extent of dissolved phase gasoline.

4.2.4 Comparison of Estimated Well Yields to the Pacific Renaissance Plaza Site

HLA has conducted site investigation and ground-water extraction activities at the nearby Pacific Renaissance Plaza site located approximately 2000 feet from the City Blue site. Aquifer lithology and hydraulic properties at this site are similar to those of the City Blue site. Long-term ground-water extraction rates from the 23 extraction wells at the Pacific Renaissance site range from less than 0.20 gpm to slightly greater than 2.0 gpm. Saturated aquifer thickness at the Pacific Renaissance Plaza site is approximately 15 feet, more than twice that of the City Blue site. Consequently, it appears that an estimated sustained well yield for the City Blue site of 0.25 gpm per well is reasonable.

5.0 GROUND-WATER TREATMENT COST FEASIBILITY STUDY

In 1988, HLA had submitted a Work Plan (*HLA, 1988*) to Blue Print Service Company for soil and ground-water remediation at the City Blue site. A number of ground water remediation technologies were identified and evaluated in the Work Plan.

Three technologies, air stripping, liquid phase activated carbon filtration, and biodegradation, were identified as reliable, institutionally acceptable and feasible at the site and were recommended for detailed cost evaluations.

The objectives of the cost feasibility study are as follows:

- Develop design criteria for ground water treatment based on available site information, hydrogeology, chemical analyses data, target discharge criteria, and applicable regulations.
- Estimate capital costs, Operation and Maintenance (O&M) costs and Net Present Values (NPV) for each of the applicable technologies.
- Select a ground water remediation technology for implementation at the site based on its technical feasibility and cost effectiveness.
- Develop a conceptual design and process flow diagram for the selected treatment system.

5.1 Design Criteria for Ground-Water Treatment

The following design criteria for treatment of ground water at the site have been developed:

1. Treatment system design flow rate is 2 gpm. A design flow rate of 2 gpm, which is above the expected flow rates from Wells MW-1A and MW-4, is used in case additional wells are added to the system at a later date or if higher flow rates are obtained from Wells MW-1A and MW-4.
2. Average concentrations of dissolved gasoline hydrocarbons in the monitoring wells are given in Table 3.
3. Two existing monitoring wells, MW-1A and MW-4, will be used as extraction wells for ground-water treatment.
4. Expected average concentrations of petroleum hydrocarbons in ground water influent to the treatment system are shown in Table 3.
5. Ground water may contain free product.

6. Treated ground water is intended to be discharged to the sanitary sewer systems. The target clean-up levels for gasoline hydrocarbons set by EBMUD are shown in Table 3.

7. Ground water will not be treated for inorganic compounds, including heavy metals.

8. Treatment system will be designed for continuous operation.

9. Treatment system will be equipped with necessary instruments and controls for automatic and continuous operations.

10. Treatment system will be built in accordance with applicable local, state, and federal regulations.

5.2. Cost Evaluation

Estimated Capital and O&M costs for each treatment process alternative have been developed based on the design criteria discussed in Section 5.1, the conceptual process flow diagram for the treatment processes (Plate 2), available vendor information, and HLA's experience on similar sites. Capital costs for the ground-water collection system and the three treatment alternatives: liquid phase activated carbon beds, air stripper followed by polishing carbon beds, and bioreactor followed by polishing carbon beds are shown on Tables 4, 5, 6, and 7, respectively. Table 8 is a summary of the capital and O&M costs, and Net Present Values (NPV) for the ground-water collection system and for each of the treatment alternatives. NPVs are calculated based on an expected duration of the ground-water treatment project which for the purpose of financial planning is assumed to be either four or five years.

Total project cost of remediation (Capital + NPV) by air stripping and biodegradation are approximately the same ($165,000 for four years or $185,000 for five years). Total project cost for liquid phase carbon treatment is substantially higher than either air stripping or biodegradation (Table 8).

Air stripping is a non-destructive technology where the hydrocarbons present in ground water are transferred from ground water to the atmosphere. Air stripping does

Table 3. INFLUENT GROUND-WATER QUALITY AND TARGET DISCHARGE CRITERIA
City Blue Production Facility, Oakland, California

	Average Concentrations of Petroleum Hydrocarbons in Ground Water (ppm) MW-1	MW-1A	MW-3	MW-4	MW-5	Average Concn. of Petroleum Hydrocarbons in The Influent Ground Water (ppm) (*2)	Mass of Organics (lbs/day) (*3)	Target Treated Water Discharge Criteria (*4)
Total petroleum hydrocarbons (TPH)(*1)	190.0	220	13	93	34	156.5	3.75	No limit
Benzene	1	1.2	0.004	0.46	0.007	0.03	0.02	0.003
Toluene	8.9	9.21	0.36	4.2	0.019	6.705	0.16	0.031
Ethyl benzene	2.9	3.1	0.21	1.2	0.21	2.15	0.05	0.005
Xylene	19	20	0.42	9.7	0.5	16.85	0.40	0.042

Note:
*1 - Total Petroleum Hydrocarbons in the gasoline range.
*2 - Average concentrations are calculated based on using MW-1A and MW-4 as extraction wells.
*3 - Mass loading is calculated based on average flow rate of 2 gallons per minute (gpm);
1 gpm from each extraction well, MW-1A and MW-4.
*4 - EBMUD Sanitary Sewer Discharge Guidelines.

Table 4. ESTIMATE OF BUDGETARY CAPITAL COST (+/-30%) FOR GROUND-WATER COLLECTION SYSTEM
City Blue Production Facility, Oakland, California

ITEM	DESCRIPTION	QTY	UNITS	COSTS MATERIAL UNIT	EXTENDED COST	LABOR UNIT	EXTENDED COST	TOTAL UNIT	TOTAL COST
1	Well installation				Not required, Existing wells MW-1A and MW-4 will be used				$0
2	Pumps	2	ea	$2,500	$5,000	$800	$1,600	$3,300	$6,600
5	Collection system piping	200	ft.	$15	$3,000	$5	$1,000	$20	$4,000

SUBTOTAL			$10,600
Instrumentation & electrical System	10	PERCENT	$1,060
SUBTOTAL W/O MARKUP & CONTINGENCY			$11,660
Contractor Overhead and Profit	12	PERCENT	$1,399
*** SUBTOTAL ***			$13,059
CONTINGENCY	30	PERCENT	$3,918
Subtotal W/O System Design			$16,977
System Design (Engineering)			$2,000
TOTAL			$18,977

Table 5. ESTIMATE OF BUDGETARY (+/- 30%) CAPITAL COST FOR LIQUID-PHASE CARBON ADSORPTION
City Blue Production Facility, Oakland, California

ITEM	DESCRIPTION	QTY	UNITS	COSTS MATERIAL UNIT	EXTENDED COST	LABOR UNIT	EXTENDED COST	TOTAL UNIT	TOTAL COST
1	Infl./Effl. holding tank	2	ea	$1,000	$2,000	$200	$400	$1,200	$2,400
2	Infl./Effl. pumps	2	ea	$500	$1,000	$200	$400	$700	$1,400
3	Filter (100 um)	1	ea	$500	$500	$100	$100	$600	$600
4	Polishing carbon beds	2	ea	$800	$1,600	$200	$400	$1,000	$2,000

SUBTOTAL			$6,400
Treatment system piping	5	PERCENT	$320
SUBTOTAL			$6,720
Instrumentation & Electrical System	10	PERCENT	$672
SUBTOTAL W/O MARKUP & CONTINGENCY			$7,392
Contractor Overhead and Profit	12	PERCENT	$887
*** SUBTOTAL ***			$8,279
CONTINGENCY	30	PERCENT	$2,484
Subtotal W/O System Design			$10,763
System Design (Engineering)			$8,000
TOTAL			$18,763

Table 6. ESTIMATE OF BUDGETARY CAPITAL COST (+/- 30%) FOR AIR STRIPPER
City Blue Production Facility, Oakland, California

ITEM	DESCRIPTION	QTY	UNITS	COSTS MATERIAL UNIT	EXTENDED COST	LABOR UNIT	EXTENDED COST	TOTAL UNIT	TOTAL COST
1	Infl./Effl. holding tank	2	ea	$1,000	$2,000	$200	$400	$1,200	$2,400
2	Infl./Effl. pumps	2	ea	$500	$1,000	$200	$400	$700	$1,400
3	Dual filter units(100 & 10 um)	2	ea	$400	$800	$100	$200	$500	$1,000
4	pH control system	1	ea	$1,000	$1,000	$200	$200	$1,200	$1,200
5	Air stripper,controls,accessories	1	ea	$9,000	$9,000	$2,000	$2,000	$11,000	$11,000
6	Polishing carbon beds	2	ea	$800	$1,600	$200	$400	$1,000	$2,000

SUBTOTAL			$19,000
Treatment system piping	10	PERCENT	$1,900
SUBTOTAL			$20,900
Instrumentation & Electrical Systems	10	PERCENT	$2,090
SUBTOTAL W/O MARKUP & CONTINGENCY			$22,990
Contractor Overhead & Profit	12	PERCENT	$2,759
*** SUBTOTAL ***			$25,749
CONTINGENCY	30	PERCENT	$7,725
Subtotal W/O System Design			$33,473
System Design (Engineering)			$8,000
TOTAL			$41,473

Table 7. ESTIMATE OF BUDGETARY CAPITAL COST (+/- 30%) FOR BIOLOGICAL TREATMENT
City Blue Production Facility, Oakland, California

ITEM	DESCRIPTION	QTY	UNITS	COSTS MATERIAL UNIT	EXTENDED COST	LABOR UNIT	EXTENDED COST	TOTAL UNIT	TOTAL COST
1	Bioreactor and Controls	1	ea	$12,000	$12,000	$3,000	$3,000	$15,000	$15,000
2	Influent/Effluent holding tank	2	ea	$1,000	$2,000	$200	$400	$1,200	$2,400
3	Influent/Effluent pumps	3	ea	$500	$1,500	$100	$300	$600	$1,800
4	Filter units	1	ea	$200	$200	$50	$50	$250	$250
5	Nutrient tanks	1	ea	$500	$500	$200	$200	$700	$700
6	Polishing carbon beds	2	ea	$800	$1,600	$200	$400	$1,000	$2,000

SUBTOTAL			$22,150
Treatment system piping	10	PERCENT	$2,215
SUBTOTAL			$24,365
Instrumentation & Electrical System	10	PERCENT	$2,437
SUBTOTAL W/O MARKUP & CONTINGENCY			$26,802
Contractor Overhead and Profit	12	PERCENT	$3,216
*** SUBTOTAL ***			$30,018
CONTINGENCY	30	PERCENT	$9,005
Subtotal W/O System Design			$39,023
System Desgin (Engineering)			$8,000
TOTAL			$47,023

Table 8. Summary of Budgetary Capital, O&M*, and Net Present Values for Process Alternatives
City Blue Production Facility, Oakland, California

Process	Ground-Water Treatment Alternatives: Ground-Water Collection System & Liquid-Phase Carbon Adsorption (Table-4 & 5)	Ground-Water Collection System & Air Stripper & Polishing Carbon beds (Table-4 & 6)	Ground-Water Collection System & Bioreactor & Polishing Carbon beds (Table-4 & 7)
Capital cost:			
Ground water collectn. system	$19,000	$19,000	$19,000
Ground water Remediation	$19,000	$42,000	$47,000
Total capital cost	$38,000	$61,000	$66,000
O&M cost/year:			
Carbon	$33,000	$500	$500
Chemical		$1,000	$1,000
Utilities	$500	$1,000	$500
Maintenance & Repairs	$5,000	$5,000	$5,000
Sampling and analytical	$17,000	$17,000	$17,000
Subtotal	$55,500	$24,500	$24,000
Contingencies (30%)	$16,650	$7,350	$7,200
Total O&M	$72,150	$31,850	$31,200
Expected duration of project	4-5 years	4-5 years	4-5 years
Net present value (N.P.V.) (4yr, 10%)of O&M	$228,708	$100,961	$98,901
Net present value (5yr, 10%)of O&M	$273,506	$120,737	$118,273
Capital+N.P.V.(4 yr)	$267,000	$162,000	$165,000
Capital+N.P.V.(5 yr)	$312,000	$182,000	$184,000

*O&M = Operation and Maintenance.

not result in chemical destruction or degradation of these hydrocarbons. Also, installation and operation of an air stripper requires a permit from Bay Area Air Quality Management District (BAAQMD).

In contrast, the application of biodegradation technology leads to chemical degradation and ultimate destruction of the hydrocarbons present in ground water. Biodegradation is a proven technology and has been successfully implemented by HLA for remediation of ground water contaminated with gasoline hydrocarbons at a nearby site in downtown Oakland, California. Application or implementation of this technology is approved by regulatory agencies and does not require a permit from BAAQMD.

Therefore, based on technical feasibility, regulatory acceptance, implementability and cost effectiveness, biodegradation is recommended for application and implementation at the site. Details about the technology and a conceptual design of the treatment system are discussed in following sections.

5.3 Biological Treatment System

Biological treatment, followed by polishing carbon beds, has been identified as the most appropriate technology to implement at the site. Previous laboratory and field studies at nearby and other sites have shown that natural ground-water microorganisms have the metabolic capacity to effectively degrade gasoline hydrocarbons when the proper environment (adequate nutrients and oxygen) is provided. However, because of the variability associated with each contaminated ground-water situation, a bench scale bioreactor process study needs to be performed to evaluate and optimize the biodegradation rate.

The objectives of the bench scale bioreactor process study are:

- To determine nutrient requirements to optimize biological degradation.
- To determine efficiency of biological degradation of indicator compounds (BTEX) in ground water.

- To establish approximate retention times for sizing of the biological treatment reactor.
- To determine final effluent concentrations of indicator compounds in treated water.
- To determine organic loading rates for the post-treatment carbon adsorption module.

5.4. Conceptual Design of Ground-Water Treatment System

The remediation of ground water at the site consists of the following basic components:

- Ground-Water Extraction Wells
- Extraction Well Pumps
- Collection Piping System
- Ground-Water Treatment System
- Discharge of treated water to an EBMUD sanitary sewer.

A brief description of each of these components is given below.

5.4.1 Ground-Water Extraction Wells

Two existing monitoring wells, MW-1A and MW-4 will be used as ground water extraction wells. Projected long-term maximum flow rate from each well is estimated below 0.50 gpm. Locations of wells, Monitoring MW-1A and MW-4, are shown on Plate 1. The well construction details are given in Plates 3 and 4.

5.4.2 Extraction Well Pumps

The ground-water extraction wells should be equipped with bottom feeding positive displacement type extraction well pumps. Exact specification for the pumps will be developed during the detail design phase of the project. Pump controls will include high and low water level sensors, a run time indicator, a totalizing flowmeter, and an automatic shut-off to the treatment system.

5.4.3 Collection System and Ground-Water of Treatment System

The location and design of the treatment system and collection system piping will be finalized during the detailed design phase of this project. The collection piping will be aboveground PVC pipes without any double containment. A conceptual process flow diagram for the biological treatment system is shown in Plate 3. The design of the ground-water treatment system will contain the following modules:

A. Pretreatment Module: The pretreatment module consists of the following elements:

1. Equalization tank: a holding tank is used to equalize the fluctuating ground-water flow from the extraction wells. The holding tank serves the following purposes: a) provides a constant flow to the treatment unit, b) allows separation of free gasoline from the influent ground water, and c) allows settling of larger particulates coming from the extraction wells. Free gasoline will be skimmed off periodically from the top of the tank.

2. Filtration: A 100 micron strainer is used to remove particulates before ground water enters the treatment system.

B. Treatment Module: The proposed treatment system will include a bioreactor, a sand filter, and appurtenances required for the addition of required nutrients. The system will be designed for a 2 gpm flow from the collection system. The bioreactor design volume will depend on the microbial degradation kinetics determined from the bioreactor process study discussed in Section 5.3.

Contaminated ground water will be pumped into the bioreactor from the pretreatment module. The ground water will be supplemented with the required inorganic nutrients by an automated metering system and remain in the reactor for a specified residence time. The treated ground water will then flow through a sand filter to reduce the quantity of biomass.

C. Post Treatment Module: The post treatment module will consist of two liquid-phase polishing carbon beds in series which will be used to remove residual organics from the bioreactor effluent. The treated ground water will be stored in a holding tank before discharge to the nearby EBMUD sanitary sewer.

5.5 Overview of System Start-Up, Maintenance, and Operation

This section describes the technical approach for the start-up and operation procedures for the ground-water remediation system.

5.5.1 System Start-Up

Following construction of the ground-water treatment facility, the following activities will be performed:

- o Pump ground water from extraction wells through the collection system into the treatment unit and then into the discharge line.
- o Ensure proper performance of equipment.
- o Collect and analyze ground-water samples per EBMUD discharge guidelines.
- o Read and regulate flow rates as required to calibrate system.
- o Correct any operating deficiencies, if required.
- o Collect samples from ground-water remediation system including each well, inlet/outlet of the bioreactor, and inlet/outlet of polishing carbon units. Analyze samples for TPH and BTEX.

5.5.2 System Operation

After successful start-up, the treatment system will be considered operational. An Operations and Maintenance (O&M) Manual should be developed from the experience of the start-up period and should include vendor operating instructions, recommended maintenance procedures, manual start-up and shut-down procedures, troubleshooting advice, contingency plans for automatic shutdowns or accidental spills or equipment failure, and sampling procedures and laboratory protocols. The activities to be performed during this period should include:

- Continued monitoring of the bioreactor influent and effluent streams.
- Systematic inspection and recording at least weekly for proper performance of all components including flows, pressures, control settings, water levels.
- Collect and analyze samples from all extraction wells at six-month intervals.
- Provide a Monthly Operation report that summarizes O&M activities for the previous month.

6.0 CONCLUSIONS

1. A hydraulic conductivity estimate of 1.48 feet/day was derived from a slug test performed on Monitoring Well MW-3. Computer simulations indicate that pumping rates from the proposed extraction wells (MW-1A and MW-4) will likely be less than 1 gpm per well and that long-term pumping rates will likely decrease to less than 0.25 gpm per well. Additional computer simulations indicate that these pumping rates will effectively capture ground water in the vicinity of the former tank removal excavation.

2. Capital and operation and maintenance costs for the three treatment process alternatives (air stripping, liquid phase activated carbon filtration, and biodegradation) have been estimated. On the basis of technical feasibility, regulatory acceptance, implementability, and cost effectiveness, biodegradation as a means of ground-water treatment is recommended for this site.

7.0 REFERENCES

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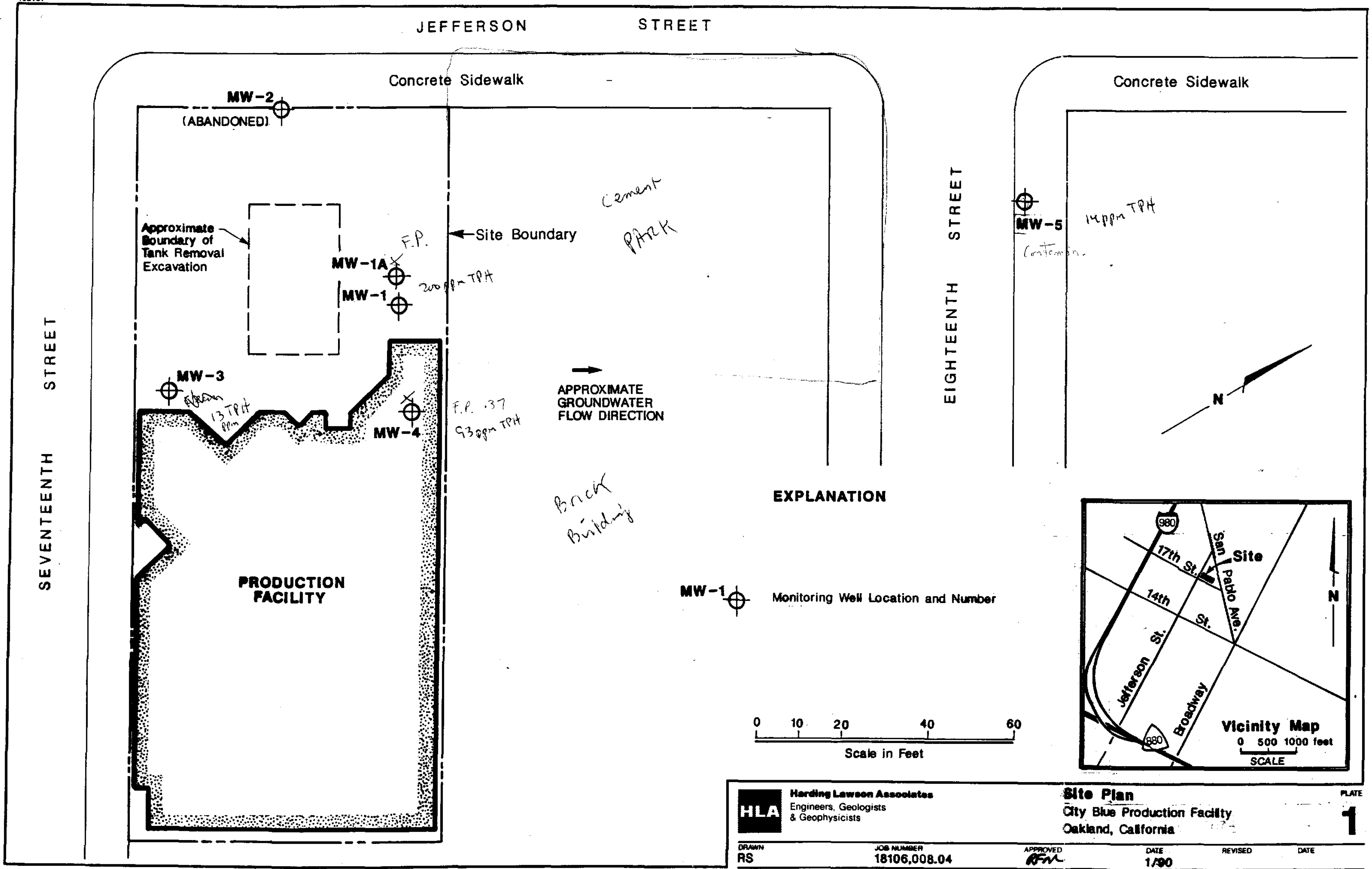
Theis, C. V., 1935. The Relation Between the Lowering of the Piezometric Surface and the Rate and Duration of Discharge of a Well Using Ground-Water Storage, Transactions, American Geophysical Union, Vol. 16.



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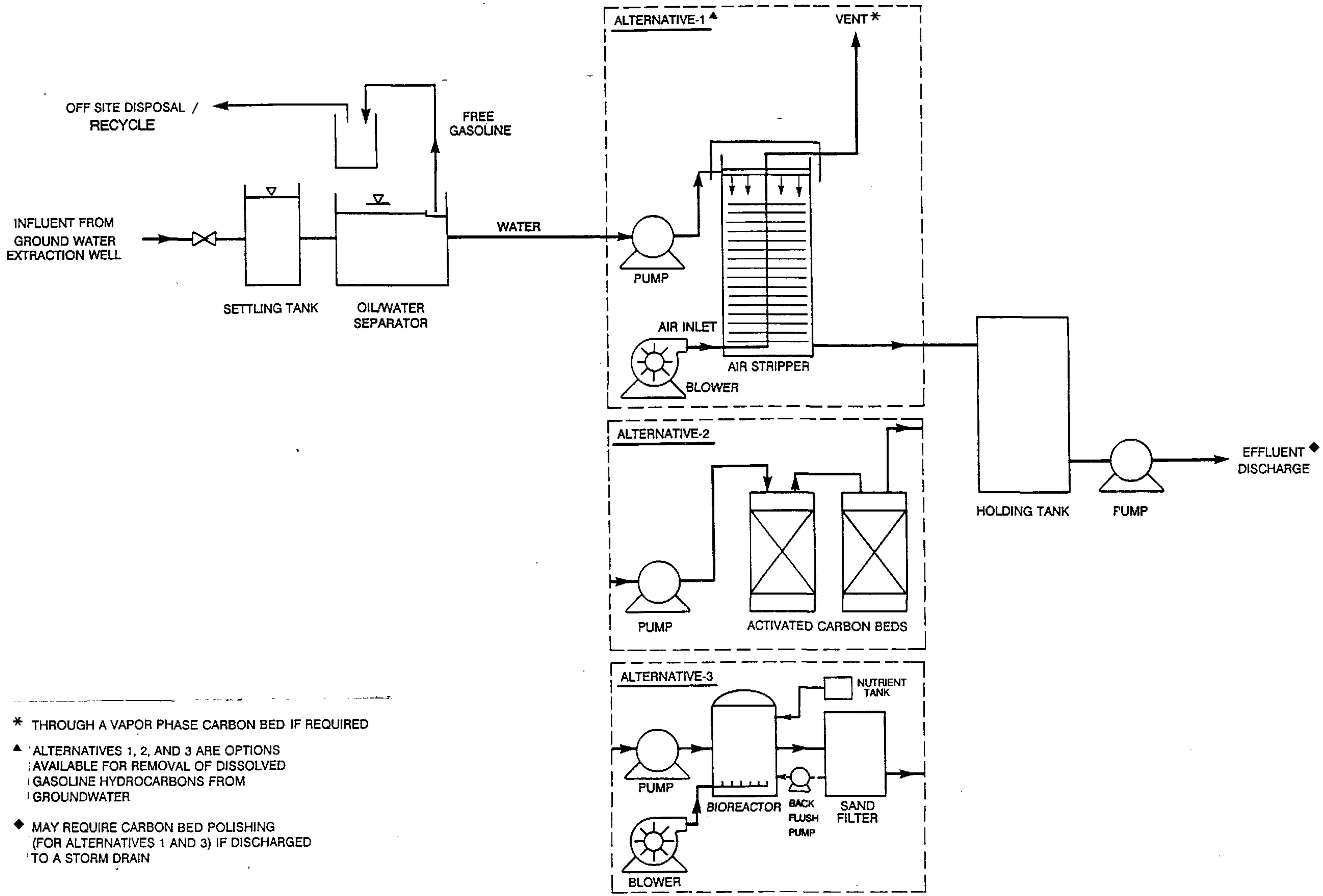
Site Plan
City Blue Production Facility
Oakland, California

PLATE 1

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
RS	18106,008.04	RFM	1/90		



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

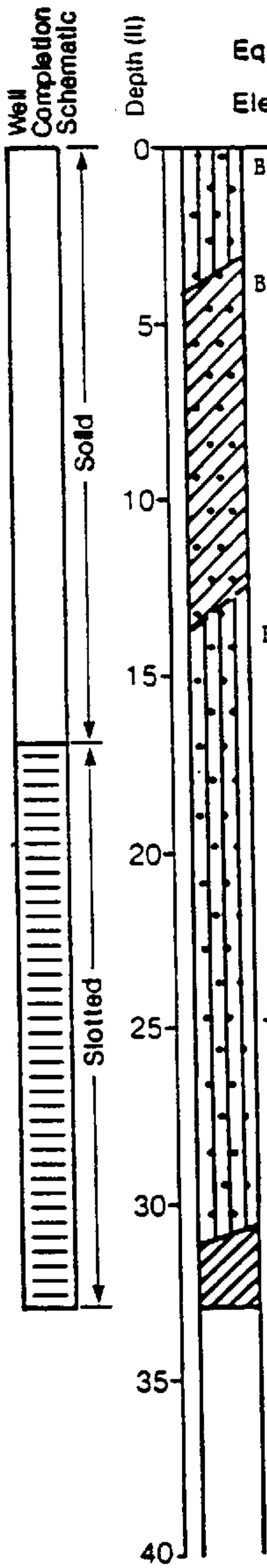
PLATE **2**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
AK	18106,008.04	RCB			

Equipment: 10.75-inch diameter Hollow Stem Auger

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

Laboratory Tests	Odor	Field Gastech Reading (ppm)
	none	ND**
	none	ND
	none	ND
	none	35
	weak	320
	strong	500+
	strong	500+



BROWN SILTY SAND (SM)
medium dense, moist

BROWN CLAYEY SAND (SC)
medium dense to dense, moist, with silt

BROWN GRAY SILTY SAND (SM)
dense, moist

decreased silt below 19 feet

▽ water level measured on 1/12/88

saturated below 26 feet

gray below 30 feet

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

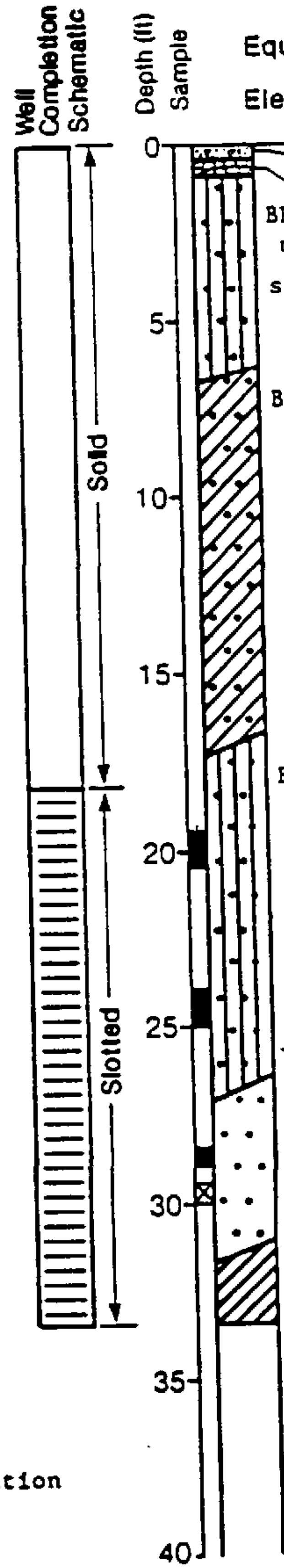
PLATE **3**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
RS	18106,008.04	DJ	1/90		

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



- 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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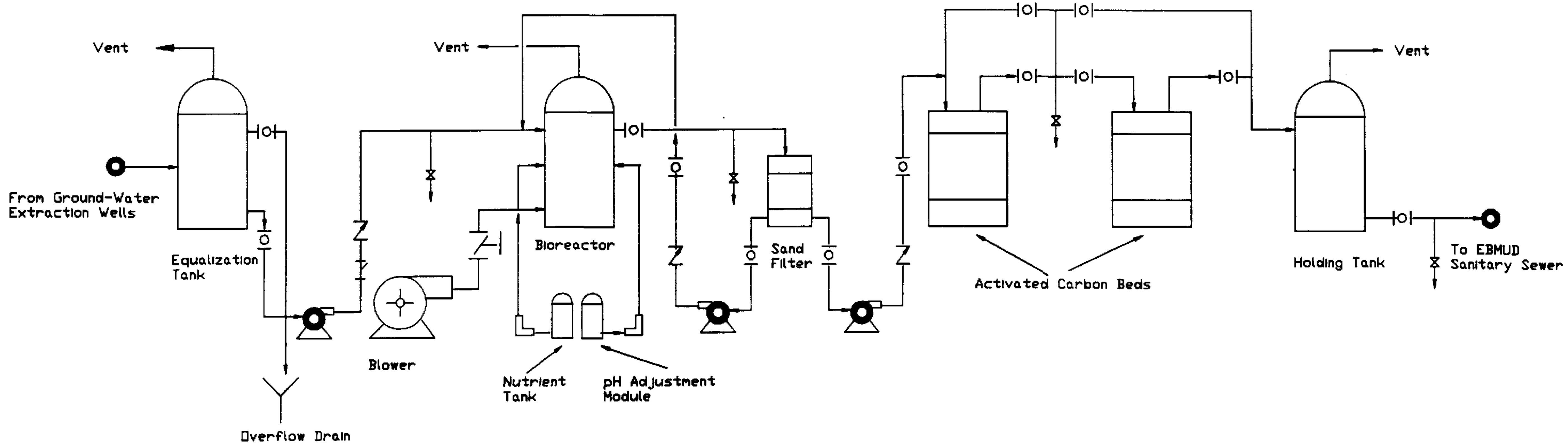
Log of Boring MW-4

City Blue Production Facility
Oakland, California

PLATE **4**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
RS	18106,008.04	DL	1/90		



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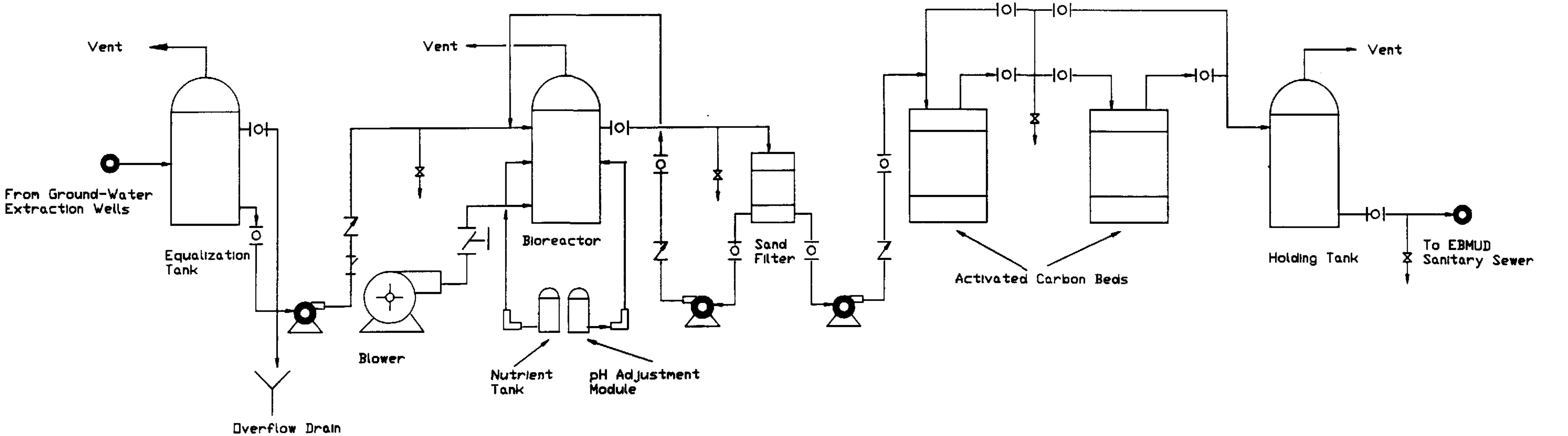
CONCEPTUAL PROCESS FLOW DIAGRAM
FOR BIOTREATMENT PROCESS UNIT
CITY BLUE PRODUCTION FACILITY
OAKLAND, CALIFORNIA

PLATE **5**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
S.B.C	18016,008.04	RGB	1-20-90		

109463



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CONCEPTUAL PROCESS FLOW DIAGRAM
FOR BIOTREATMENT PROCESS UNIT
CITY BLUE PRODUCTION FACILITY
OAKLAND, CALIFORNIA

PLATE 5

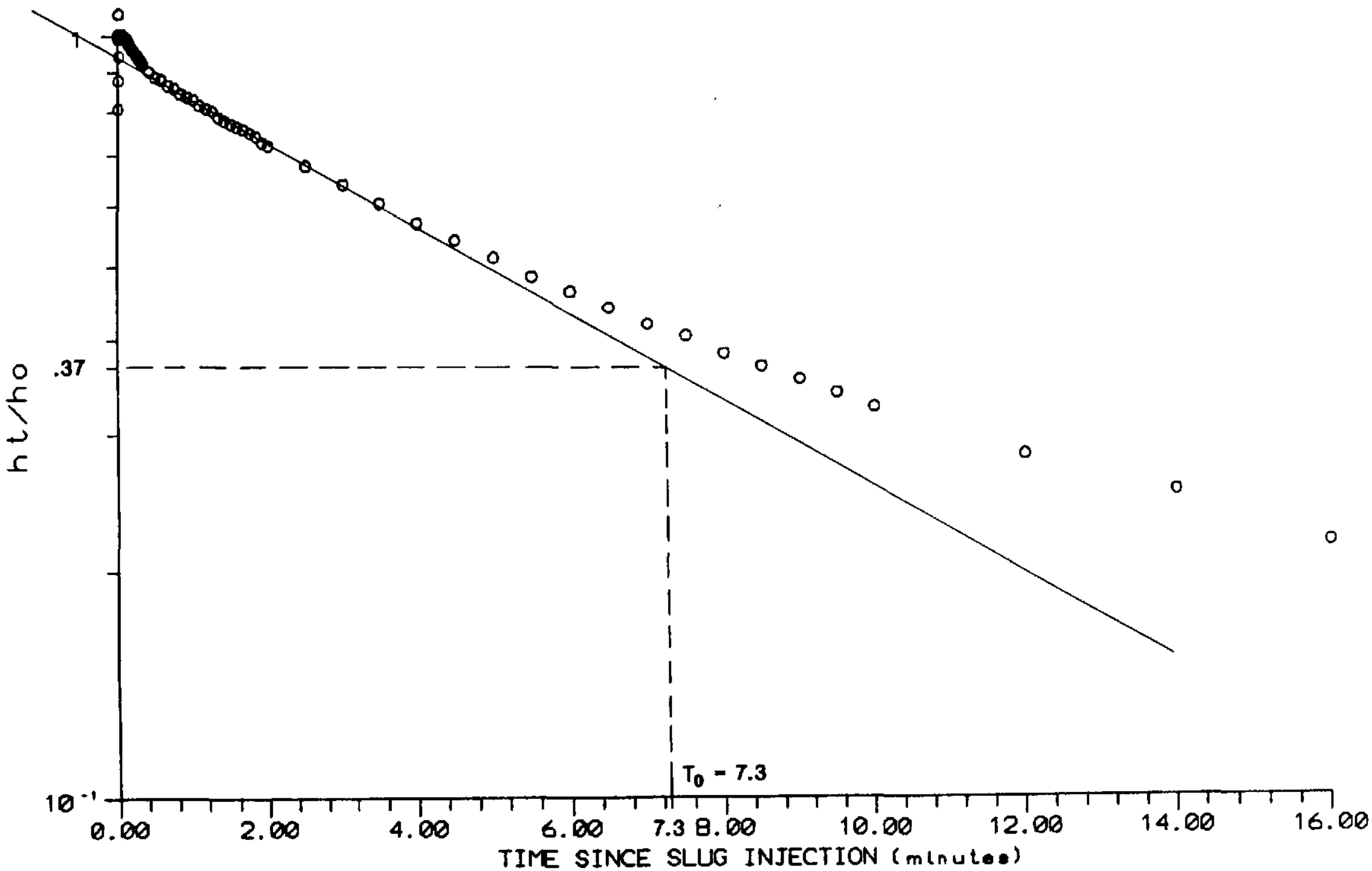
DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
S.B.C	18016,008.04	RDB	1-20-90		

109463

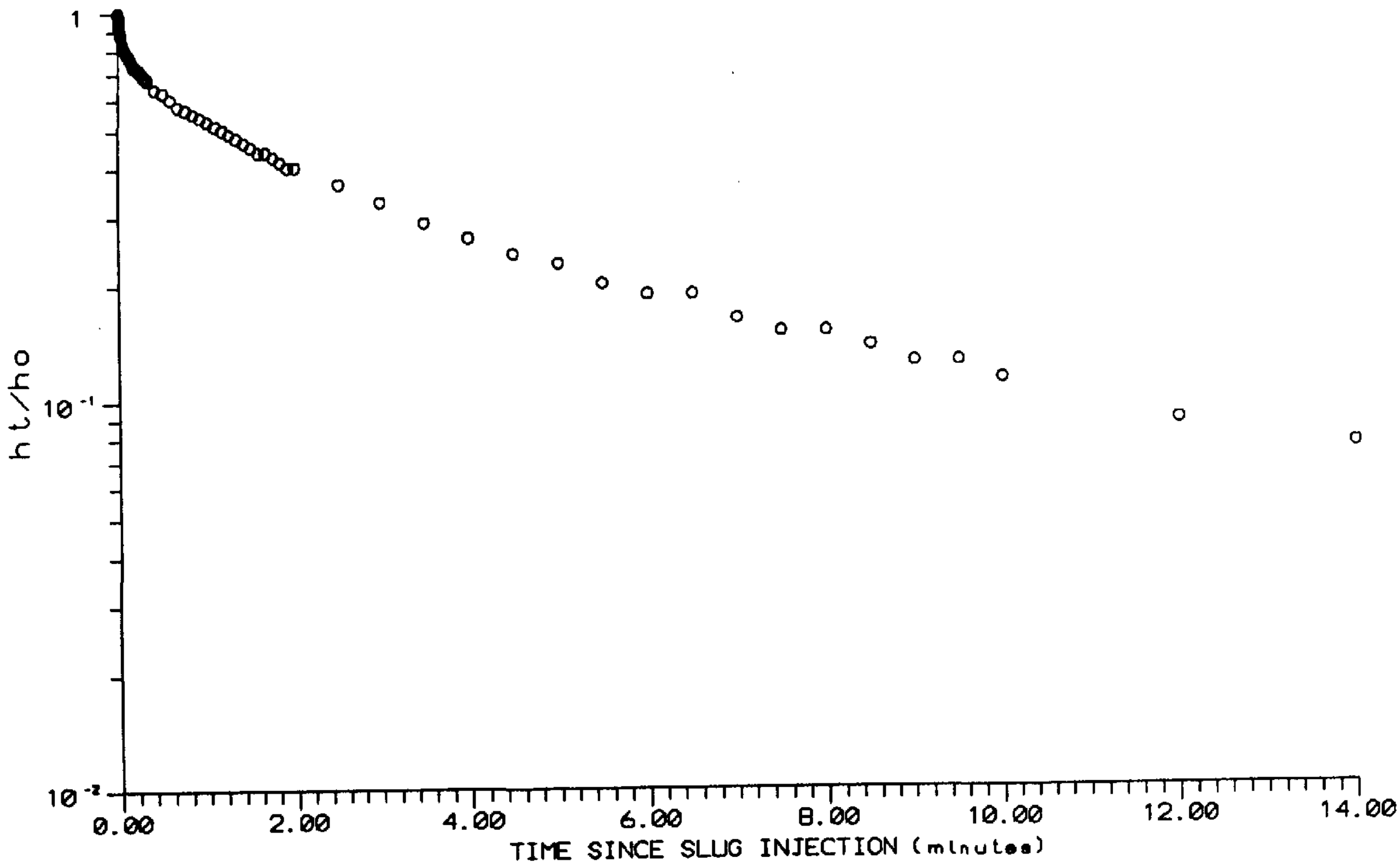
Appendix

SLUG TEST RESULTS

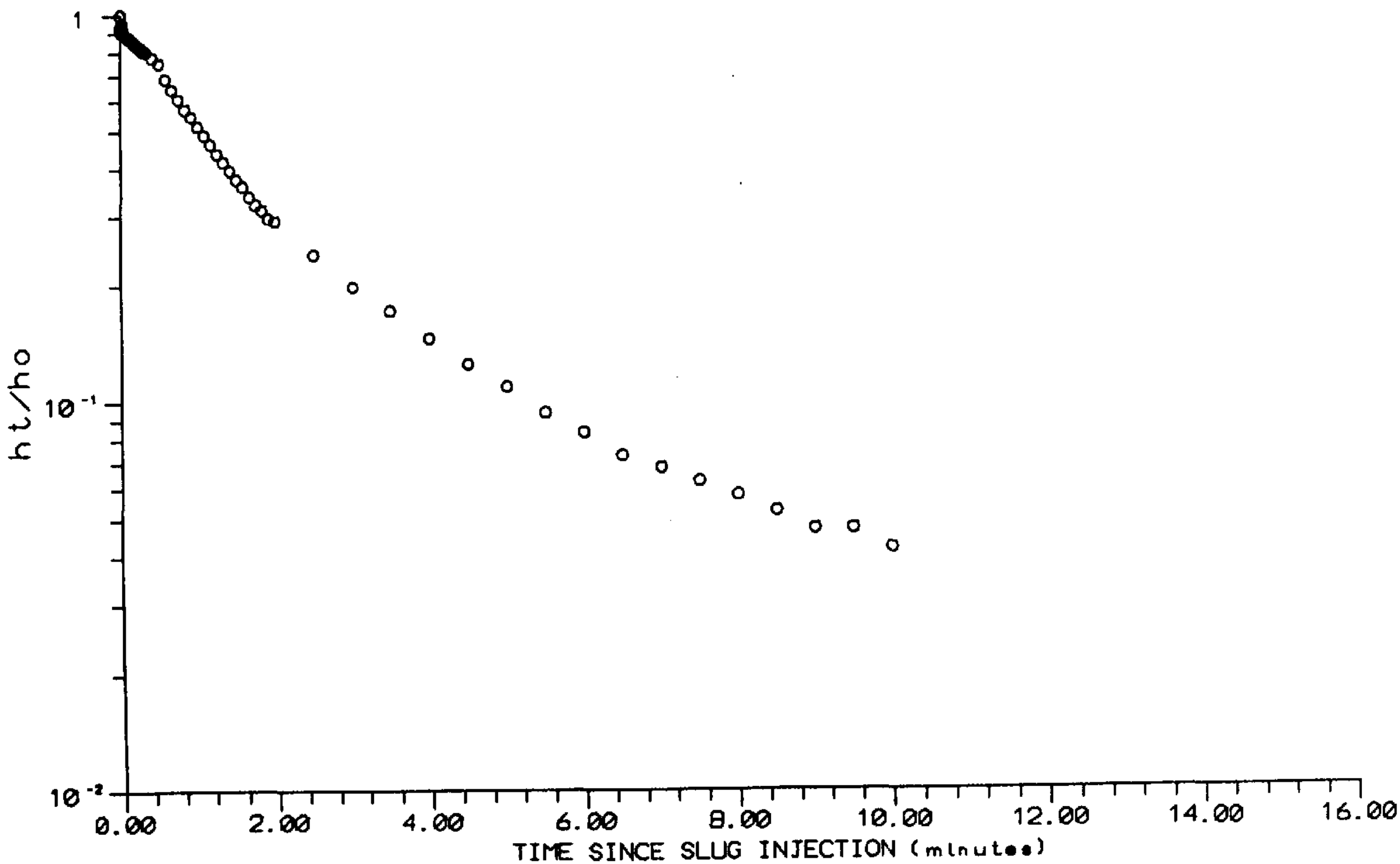
SLUG INJECTION DATA FOR MONITORING WELL #MW-3 CITY BLUE, OAKLAND, CALIFRONIA (NOTE: INJECTION OF 2.5 GALLON SLUG)



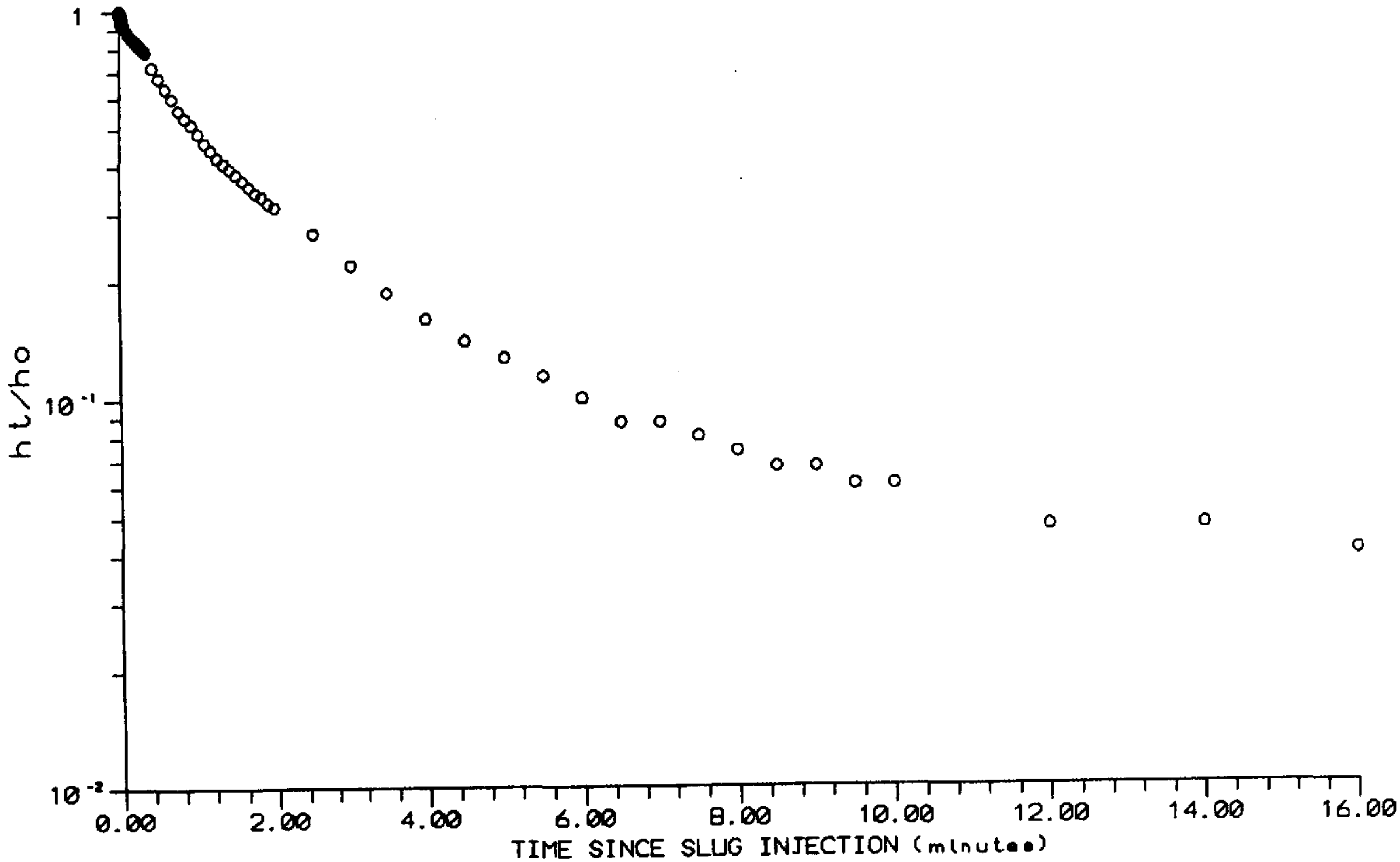
SLUG INJECTION DATA FOR MONITORING WELL #MW-3 CITY BLUE, OAKLAND, CALIFRONIA (NOTE:WITHDRAWAL OF .5 GALLON SLUG)



SLUG INJECTION DATA FOR MONITORING WELL #MW-5 CITY BLUE, OAKLAND, CALIFRONIA (NOTE: INJECTION OF 2.5 GALLON SLUG)



SLUG INJECTION DATA FOR MONITORING WELL #MW-5 CITY BLUE, OAKLAND, CALIFRONIA (NOTE: INJECTION OF 2.5 GALLON SLUG)



CALCULATIONS

$$K = \frac{r^2 \ln (L/R)}{2L\ T_0}$$

$$K = \frac{(0.16)^2 \ln (6.25/0.16)}{(2)(6.25)(7.3)}$$

$$K = \frac{(0.0256)\ (3.66)}{91.25} = 1.03 \times 10^{-3} \text{ ft/min}$$

$$K = 1.48 \text{ ft/day}$$

T_0 = 7.3 Min
r = Well casing radius
L = Height of portion of well through which water enters
T_0 = Basic lag time

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