ENSCO ENVIRONMENTAL SERVICES, INC.

REMEDIAL ACTION PLAN

FOR

SHELL OIL COMPANY
DUBLIN, CALIFORNIA

Project No. 3427E
Revision 1
June 1989

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GW

ensco environmental services, inc.
a subsidiary of environmental system company

July 7, 1989

Alameda County Health Care Services
Department of Environmental Health
Hazardous Materials Division
800 Swan Way, Suite 200
Oakland, California 94621

Attention: Mr. Lowell Miller
Senior Hazardous Materials Specialist

Re: Remedial Action Plan (RAP), Rev. 1
Shell Oil Company
7194 Village Parkway, Dublin, CA
Project Number 3427E

Dear Mr. Miller:

Kindly receive enclosed, a copy of the above-referenced document for your information. Ensco Environmental Services, Inc. (EES) has revised the RAP due to the addition of a vapor-phase carbon system for air stripper effluent treatment. There is no effect on the groundwater extraction or wastewater effluent portions of the system.

Please call John Turney or me at EES if you have any questions.

Thank you.

Sincerely,

Reuben H. Chow
Manager, Program Management

Enclosure

cc: Ms. Diane Lundquist
Shell Oil Company

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REMEDIAL ACTION PLAN

FOR

SHELL OIL COMPANY
7194 AMADOR VALLEY BLVD
DUBLIN, CALIFORNIA

SECTION 1.0

SUMMARY

1.1 Introduction

The purpose of this report is to assess the extent of ground water and soil contamination and develop a technical approach for ground water remediation at the former Shell Oil Company (Shell) gasoline station site located at 7194 Village Parkway in Dublin, California (see Figure 1).

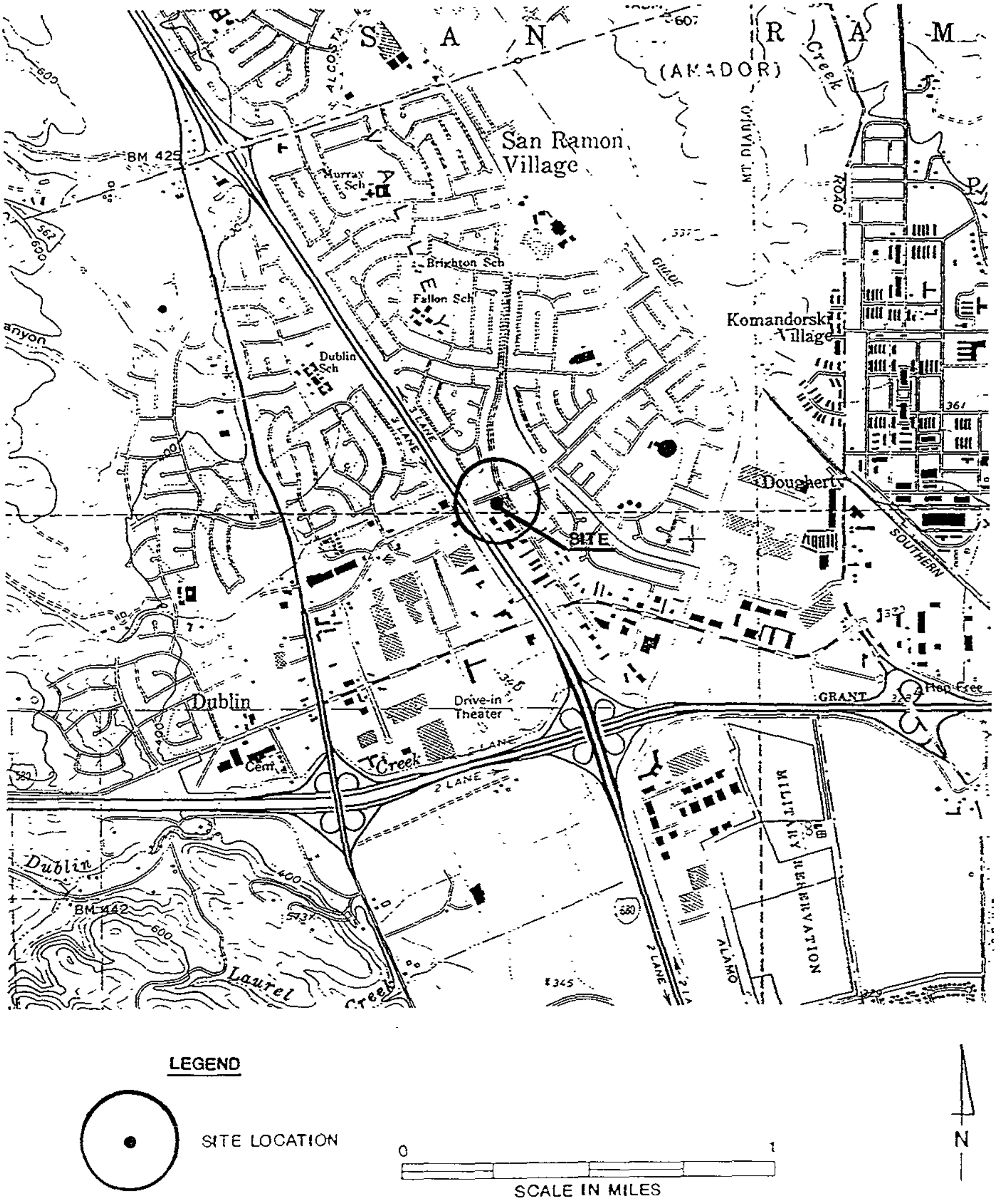
In preparation for a property transfer of the project site to Oil Changers, Shell removed the four underground storage tanks (see Figure 2). On August 3, 1987, three 10,000 gallon fiberglass tanks were removed from one excavation, and one 280 gallon steel waste oil tank was removed from a second excavation. Strong product odors were present in the tank excavations.

Soil samples collected from the excavations contained Total Petroleum Hydrocarbons (TPH) up to 1900 parts-per-million (ppm). A groundwater sample contained 85 ppm (mg/l) TPH. Approximately 4,600 cubic yards of contaminated soil were excavated and treated by aeration on site.

Shell contracted Ensco Environmental Services, Inc. (EES) to perform a site assessment to determine the extent of any remaining contamination. Because additional soil and groundwater contamination was found, Shell retained EES to determine the vertical and lateral extent of the contamination. The resulting reports (References 9.1 and 9.2) concluded:

- Groundwater was encountered at depths ranging from 10 to 15 feet, and flows to the southeast at a gradient of 0.0023 feet per foot.

- No floating product or sheen was evident in any of the monitoring wells.



SITE LOCATION MAP

FORMER SHELL STATION

7194 VILLAGE PARKWAY

DUBLIN, CALIFORNIA

ensco environmental services, Inc.

REVIEWED BY

APPROVED BY

JOB # 3427E

DRAWN BY SLS

DATE 12/01/88

DRAWING # A-3427E-4

FIG. 1

- Contamination of the soil and groundwater has spread beyond the property boundries.

- TPH contamination in soil samples varied up to 540 ppm.

- TPH contamination in ground water samples varied up to 200 ppm.

- Benzene concentrations in ground water exceeded the California Department of Health Services (DOHS) applied action level of 0.0007 mg/l, varying up to 4.4 ppm.

- The optimum extraction rate at recovery well RW-1 is estimated to be 1 to 2 gallons-per-minute (gpm).

- The pump test on RW-1 showed no effect on monitoring wells MW-5 and MW-7. As a result, one recovery well may not adequately capture all the migrating contamination. It is estimated that two or three additional recovery wells will be required to control the spread of contamination. The total extraction rate is estimated to be 6 to 8 gpm. Drilling of additional extraction wells is proposed after startup and operation of the above-ground treatment system.

Additional ground water samples were taken subsequent to the samples for references 9.1 and 9.2. The results of samples taken on October 5, 1988, indicate that maximum TPH has decreased to 17 ppm, and maximum benzene has increased to 6.7 ppm.

1.2 Proposed Treatment System

In comparing the soil and ground water contmaination levels to regulatory guidelines, EES recommends that ground water cleanup rather than soil cleanup, or both as the most appropriate remediation direction. Following an analysis of available ground water treatment alternatives, EES determined that the most technically feasable and cost-effective treatment system is ground water extraction and above ground treatment using air stripping. Air stripper liquid effluent would be discharged to the sanitary sewer without further treatment.

1.3 Approvals and Permits Required

Approval of the proposed treatment method is required from the Alameda County Health Agency (ACHA) and the Regional Water Quality Control Board (RWQCB), Region 2. Permits are required from the following agencies:

- Dublin San Ramon Services District (DSRSD) - Waste water discharge permit
- Bay Area Air Quality Management District (BAAQMD) - Air discharge permit
- City of Dublin - Building permit

REMEDIAL ACTION PLAN

FOR

SHELL OIL COMPANY
DUBLIN, CALIFORNIA

Project No. 3427E
Revision 1
June 1989

Prepared for:

Ms. Diane Lundquist
Shell Oil Company
P.O. Box
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Facilities Design Section

SECTION 2.0

INTRODUCTION

The purpose of this Remedial Action Plan is to provide the Alameda County Health Agency (ACHA), the Bay Area Air Quality Management District (BAAQMD), the Dublin San Ramon Services District (DSRSD), and the Regional Water Quality Control Board (RWQCB), Region 2 with definitive work tasks necessary to implement a site remediation program which complies with regulatory guidelines, at a former Shell gasoline station site in Dublin, California.

In preparation for transferring the project site to Oil Changers, four underground storage tanks were excavated and removed from the site on August 3, 1987. Three 10,000 gallon fiberglass gasoline tanks were removed from one excavation and one 280 gallon steel waste oil tank was removed from another excavation. Upon excavation and removal of the tanks, strong product odors were observed which indicated that a petroleum hydrocarbon release had possibly occured. Four soil samples from the gasoline tank excavation contained Total Petroleum Hydrocarbon (TPH) concentrations ranging from 270 parts-per-million (ppm) to 1900 ppm. A ground water sample from the same excavation contained a TPH concentration of 85 ppm. A soil sample from the waste oil tank excavation contained a TPH (as diesel) concentration of 45 ppm.

Subsequent to the initial tank excavation and sampling, approximately 4,600 cubic yards of soil were excavated and treated by aeration at the site from August 28, 1987 to February 2, 1988.

Shell then contracted EES to perform the following scope of work:

1. Perform a site assessment to determine the extent of any remaining contamination. This included the drilling and sampling of five montoring wells on the former service station site.

2. Perform additional investigation of the extent and degree of contamination, including investigations beyond the property boundries. This task included a soil gas survey, drilling eight exploratory borings, two of which were converted to monitoring wells, sampling, and the installation of a recovery well as shown on Figure 2.

3. Development of a Remedial Action Plan.
4. Obtain the approval and permits for construction of a site remediation system.
5. Design, procure, construct and install the approved site remediation system.
6. Provide startup supervision of the site remediation system.
7. Obtain system effluent samples to ensure permit limits are being met on startup.
8. Provide long term maintenance of the system.
9. Perform periodic sampling of the system influent and effluent, and the monitoring wells.

Tasks 1 and 2 have been completed and this report represents the development of Task 3.

The remainder of this report discusses the current status of the contamination and geological conditions at the project site (Section 3.0), the proposed ground water treatment system and why this system was selected (Section 4.0), the permits which must be obtained to construct and operate the system (Section 5.0), and the remaining tasks and their schedule to begin remediation of the site (Sections 6.0 and 7.0).

SECTION 3.0

SITE DESCRIPTION

Seven monitoring wells (MW-1 through MW-7), one recovery well (RW-1) and six soil borings (B-1 through B-6) have been drilled. The location of these wells and borings are shown on Figure 2. Trace contamination of benzene, toluene and xylene has been detected.

In addition to the wells and borings, soil gas sampling was performed both on the property and surrounding the property. This sampling indicated that contamination has spread off the property (Reference 9.2).

3.1 Ground Water Contamination

Table 1 lists only the most recent Benzene-Toluene-Xylene (BTX) ground water data. Water sample analyses revealed the presence of TPH and BTX in the ground water underlying the property and extending off-site. The maximum TPH concentration detected during the most recent sampling was 17 ppm. BTX were detected at concentrations up to 6.7 ppm for benzene, 0.36 ppm for toluene, and 0.73 ppm for xylenes. Action levels for BTX in water have been established by the California Department of Health Services (DOHS) (see Appendix D). These action levels are shown in Reference 9.5 and are: benzene, 0.0007 ppm; toluene, 0.1 ppm; and xylene, 0.62 ppm. All of the monitoring wells on the property have benzene concentrations above the DOHS action level. In addition, monitoring well MW-1 has a toluene concentration of 0.36 ppm and a xylene concentration of 0.73 ppm, both above the DOHS action level.

3.2 Soil Contamination

Results of the soil analyses are presented in Table 2. The analyses revealed the presence of TPH and BTX in some of the soil samples. The maximum TPH concentration reported was 540 ppm. The maximum BTX concentrations in the soils tested were 9.8 ppm for benzene, 6.4 ppm for toluene, and 42 ppm for xylenes.

TABLE 1

GROUND WATER RESULTS SUMMARY

Contaminants (ppm)

Sample	TPH	Benzene	Toluene	Xylene
MW-1	17	6.7	0.36	0.73
MW-2	0.2	0.02	0.0023	0.012
MW-3	0.26	0.1	0.0027	0.007
MW-4	0.45	0.11	0.0063	0.02
MW-5	7.5	2.7	ND	0.59
MW-6	2.7	0.13	0.038	0.22
MW-7	ND	ND	ND	ND
DOHS Action Levels (Ref 9.5)	None	0.0007	0.1	0.62

NOTES:

1. See Figure 2 for monitoring well locations.
2. ND: Not Detected using EPA standard laboratory procedure.
3. Ground water samples reported in this table were collected October 5, 1988.

TABLE 2

SOIL ANALYSIS RESULTS SUMMARY

Contaminants (ppm)

Sample Location	Approximate Depth (ft.)	TPH	Benzene	Toluene	Xylene
B-1	COMP	ND	NA	NA	NA
B-1	8	22	NA	NA	NA
B-2	COMP	ND	NA	NA	NA
B-3	COMP	ND	NA	NA	NA
B-4	COMP	ND	NA	NA	NA
B-5	COMP	ND	NA	NA	NA
B-5	8	420	9.8	1.8	36
B-5	10	43	NA	NA	NA
B-5	12	170	9.3	1.3	14
B-5	13	10	NA	NA	NA
B-6	COMP	ND	NA	NA	NA
B-6	7	66	4.8	5.6	1.8
B-6	9	540	3.9	6.4	42
B-6	10	130	ND	1.3	11
B-6	12	14	NA	NA	NA
B-6	13	ND	NA	NA	NA
MW-6	COMP	ND	NA	NA	NA
MW-6	10	11	NA	NA	NA
MW-6	12	75	NA	NA	NA
MW-7	COMP	ND	NA	NA	NA
RWQCB Priority Level (Ref. 9.3)		100	None	None	None
SWRCB Appraisal Limits (Ref. 9.4)		None	100	80	40

NOTES:

1. See Figure 2 for monitoring well and soil boring locations.
2. COMP: The sample analyzed was a composite of samples from several depths.
3. ND: Not detected using EPA standard laboratory procedure.
4. NA: The sample was not analyzed for that compound.

There are no published EPA limits nor DOHS action levels for hydrocarbons in the soil. The RWQCB, Region 2 has established a "priority level" for concentrations of TPH in the soil of 100 ppm (Reference 9.3). The analyzed concentrations in the soil which exceeded this level were from borings B-5 and B-6. The State Water Resources Control Board (SWRCB) has selected "general risk appraisal concentration limits" in soil of 100 ppm for benzene, 80 ppm for toluene, and 40 ppm for xylenes (Reference 9.4). Only one sample from one boring had a concentration level which exceeded these limits. This sample was from boring B-6 with a xylene concentration of 42 ppm.

It appears, therefore, that the ground water contamination is much more significant than the soil contamination. Consequently, only ground water remediation is recommended.

3.3 Geology

Borings were drilled to a depth of 10 to 25 feet. The soils observed during the drilling consisted primarily of silty to sandy clay interbedded with clayey sand to a depth of 6 to 9 feet. These overlie silty clays which extend beyond the maximum depth of the borings. The impermeable clay layers appeared to minimize the spread of gasoline contamination.

3.4 Hydrogeology

Ground water was encountered at depths from 10 to 15 feet, and flows to the southeast at a gradient of 0.0023 feet per foot.

During a 24 hour constant discharge test of RW-1 at 5 gpm, the well dewatered after a sharp increase in the drawdown rate at 12 hours. During this test, no influence on monitoring wells MW-5 and MW-7 was observed. Based on this test, an aquifer transmissivity of 547 gpd/ft and a storage coefficient of 0.0024 were calculated. The continuous recovery rate from RW-1 is estimated at 1 to 2 gpm.

The results of this test indicate that the long term operation of the one existing extraction well may not produce a capture zone capable of containing the contamination in the shallow ground water underlying the site. To achieve the required zone of capture, 2 to 3 additional extraction wells may be required. EES recommends the design and construction of an above ground treatment system capable of treating the effluent from four wells, estimated to be up to 8 gpm. Additional extraction wells, if any, will be drilled after startup of the treatment system and monitoring the results.

SECTION 4.0

TREATMENT SYSTEM DESCRIPTION

Based on the soil and ground water sample results discussed in Section 3.0 and regulatory guidelines, ground water contamination is more significant than soil contamination. As a result, ground water treatment is recommended as the most appropriate method to remediate the site.

4.1 Alternative Treatment Processes

There are several alternative treatment processes for removal of petroleum hydrocarbons dissolved in water:

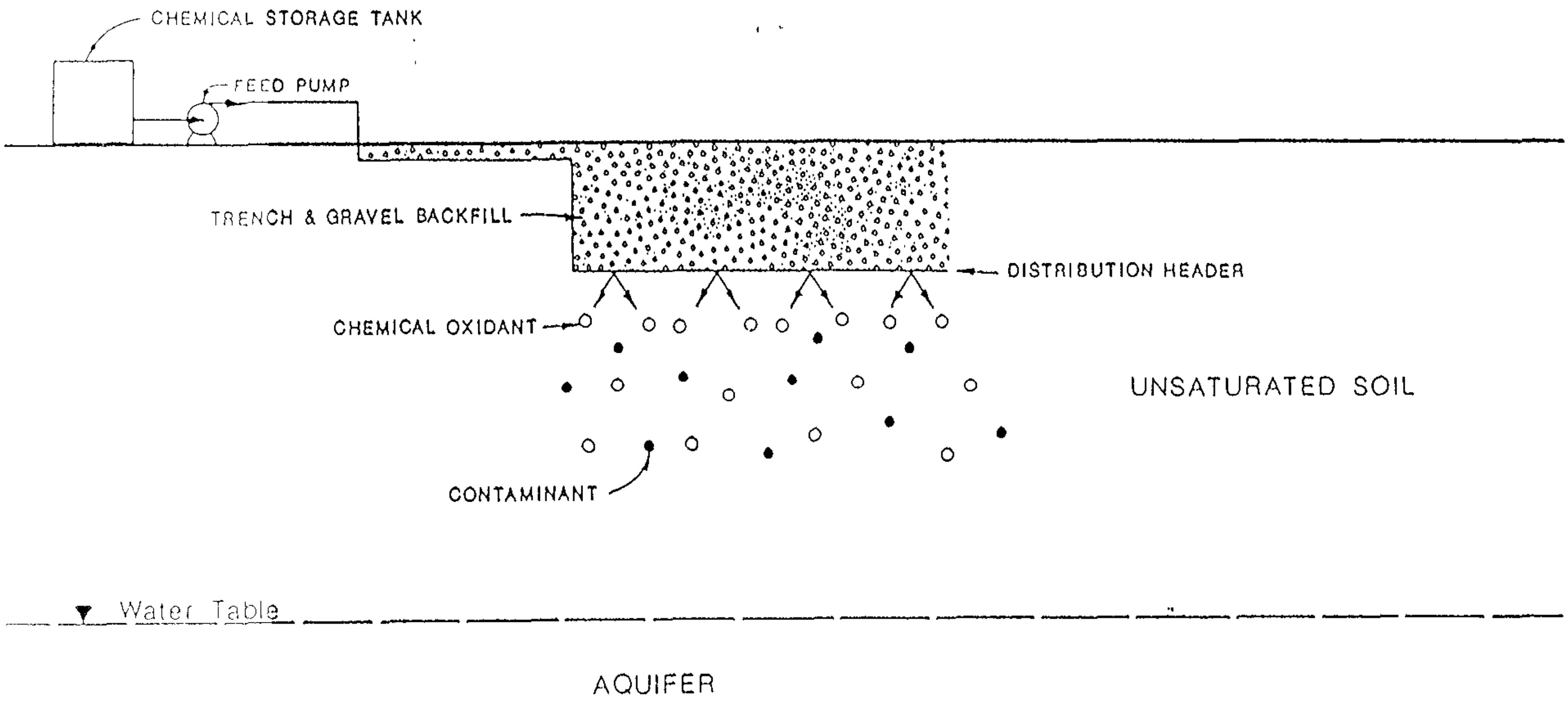
- Chemical Oxidation
- Incineration
- Liquid-Phase Carbon Adsorption
- Air Stripping

One of these alternatives will be used until the groundwater contamination falls consistently below 15 ppm, at which time it would be pumped to the sanitary sewer system without treatment. The cost study details for one to three years of operation are in Appendix E.

4.1.1 Chemical Oxidation

Three chemical oxidants have been widely used for industrial treatment: chlorine and ozone (Figure 3), and hydrogen peroxide with UV light (Figure 4).

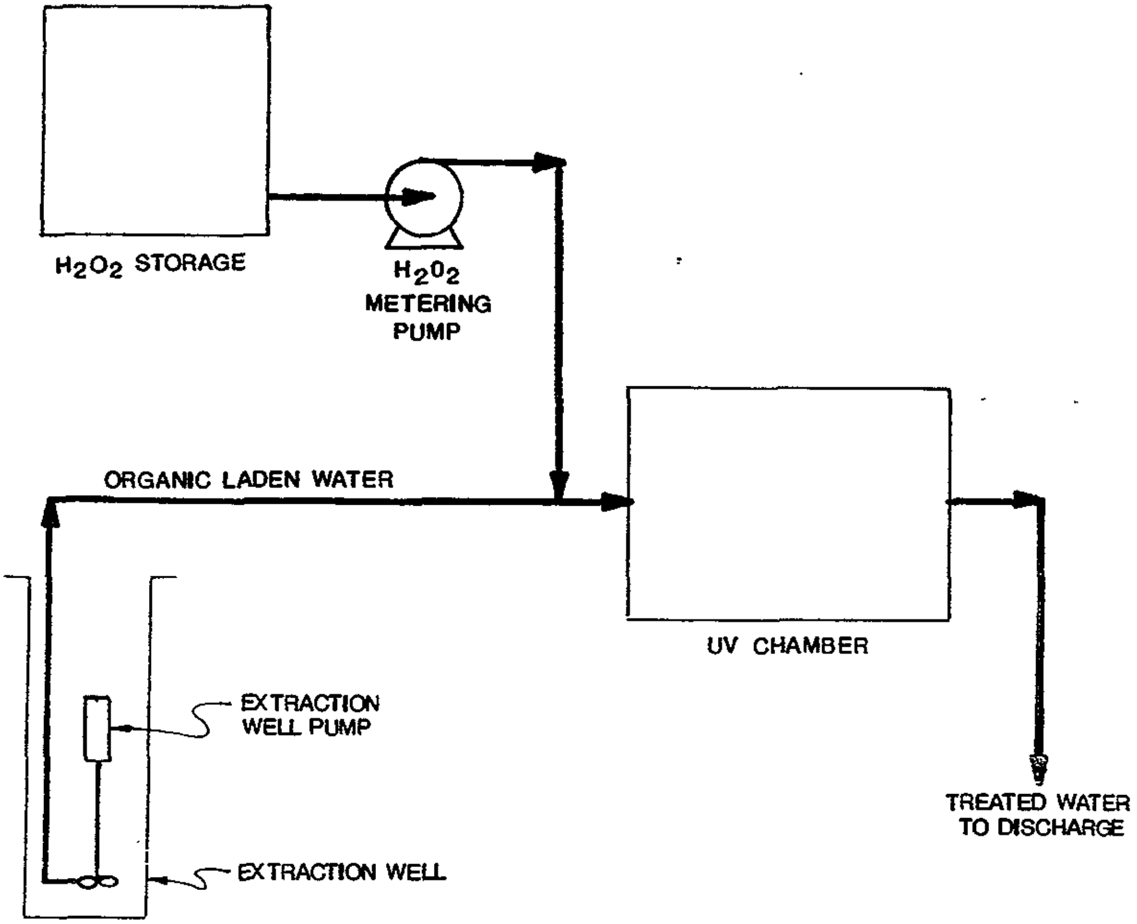
Chlorine oxidation produces chlorinated hydrocarbon by-products which themselves are considered contaminants. Therefore, chemical oxidation by chlorine is not considered a viable ground water treatment technology.



NOT TO SCALE

ensco environmental services, Inc.	**CHEMICAL OXIDATION TREATMENT PROCESS DIAGRAM**	REVIEWED BY	APPROVED BY
		JOB #: 3427E	DRAWN BY: J.C.
		DATE: 1-20-89	DRAWING #:

FIG. 3



HYDROGEN PEROXIDATION PROCESS DIAGRAM

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FIG. 4

Ozone is the strongest of the oxidizing agents. With sufficient time, ozone can eliminate any organic compound. However, because of high capital and operating costs, ozone is also not considered a viable option for this site cleanup.

Hydrogen peroxide is readily available and works very well on organic compounds with double and triple bonds. Ring compounds like benzene can be oxidized by peroxide.

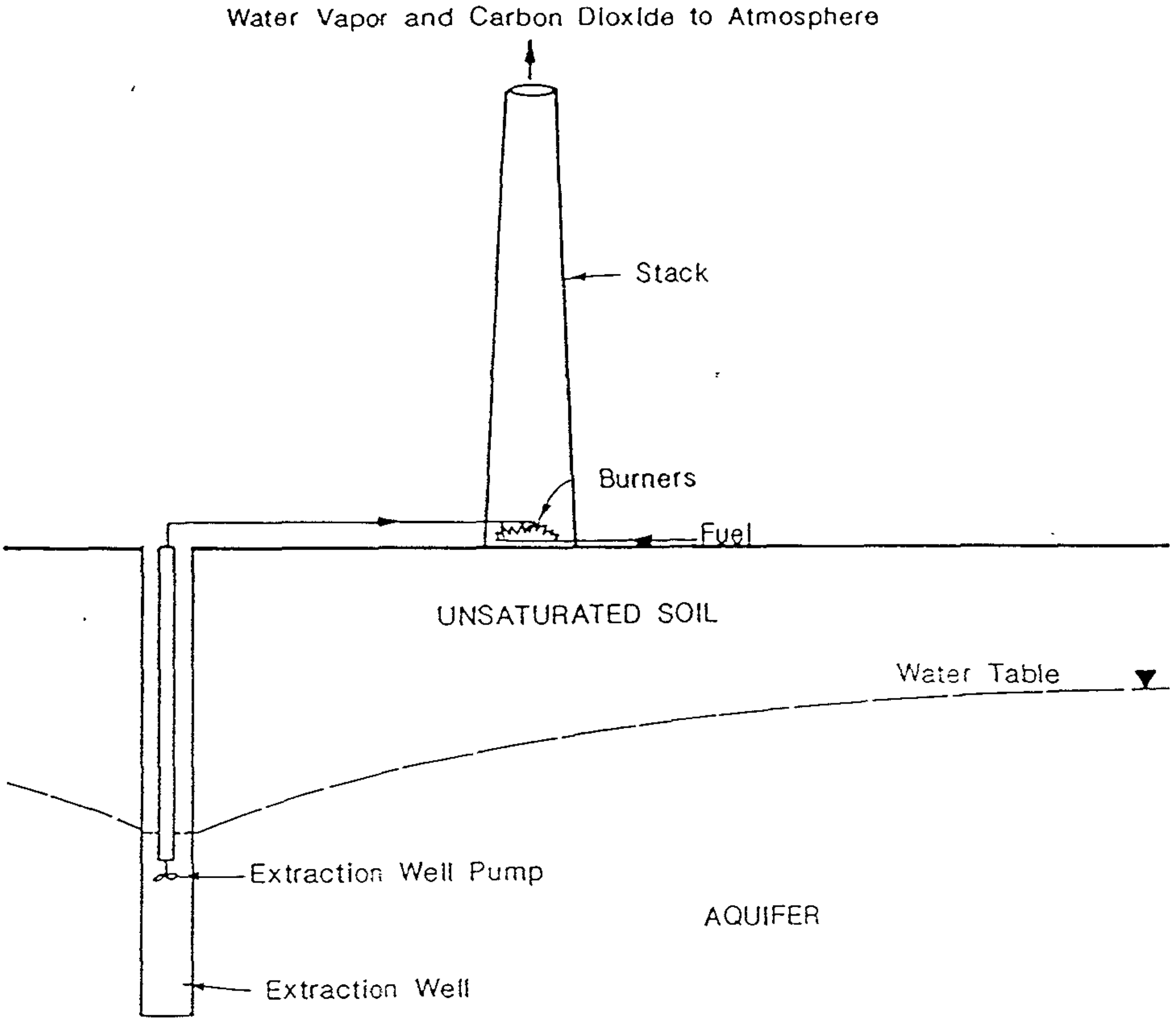
Ultraviolet light in conjunction with hydrogen peroxide catalyzes the chemical oxidation of organic contaminants in water by its combined effect upon the organic contaminant and its reaction with hydrogen peroxide. Many organic contaminants absorb UV light and may undergo a change in their chemical structure or simply become more reactive to chemical oxidants. More importantly, at less than 40 nm wave length, UV light reacts with hydrogen peroxide molecules to form hydroxyl radicals. These very powerful chemical oxidants then react with the organic contaminants in the water. If carried to completion, the end products of the process are carbon dioxide and water.

Like most other chemical oxidations, this process is dependent upon a number of reaction conditions which can affect both performance and cost. The more important variables include type and concentration of organic contaminant and the UV dosages.

The UV/peroxidation system requires little operator attention. The system does not produce air emissions.

4.1.2 Incineration

Destruction of organic contaminants by incineration requires raising the temperature of the ground water to between 1500 and 2000 degrees F (see Figure 5). The water boils away to steam and the organic contaminants are oxidized. When the contaminated water contains approximately 20% organics, the ground water will have a self-sustaining flame. At lower concentrations auxiliary fuel is required, as is the case here. The high capital and operating cost, together with the lengthy paperwork necessary to obtain environmental permits, make incineration impractical (See also Section 4.1.5.2).



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INCINERATION PROCESS DIAGRAM

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APPROVED BY

DRAWN BY J.C.

3427E

1-20-89

FIG. 5

4.1.3 Liquid-Phase Carbon Adsorption

Adsorption is a process in which molecules are attracted to and then held at the surface of a solid. Carbon has about 7,000,000 ft^2 of surface area per pound. Adsorption allows molecules of BTX to be held at the surface of carbon (see Figure 6).

Because the actual volume of contaminated ground water has not been determined, the length of operation of the remediation system is unknown. However, one to three years is typical.

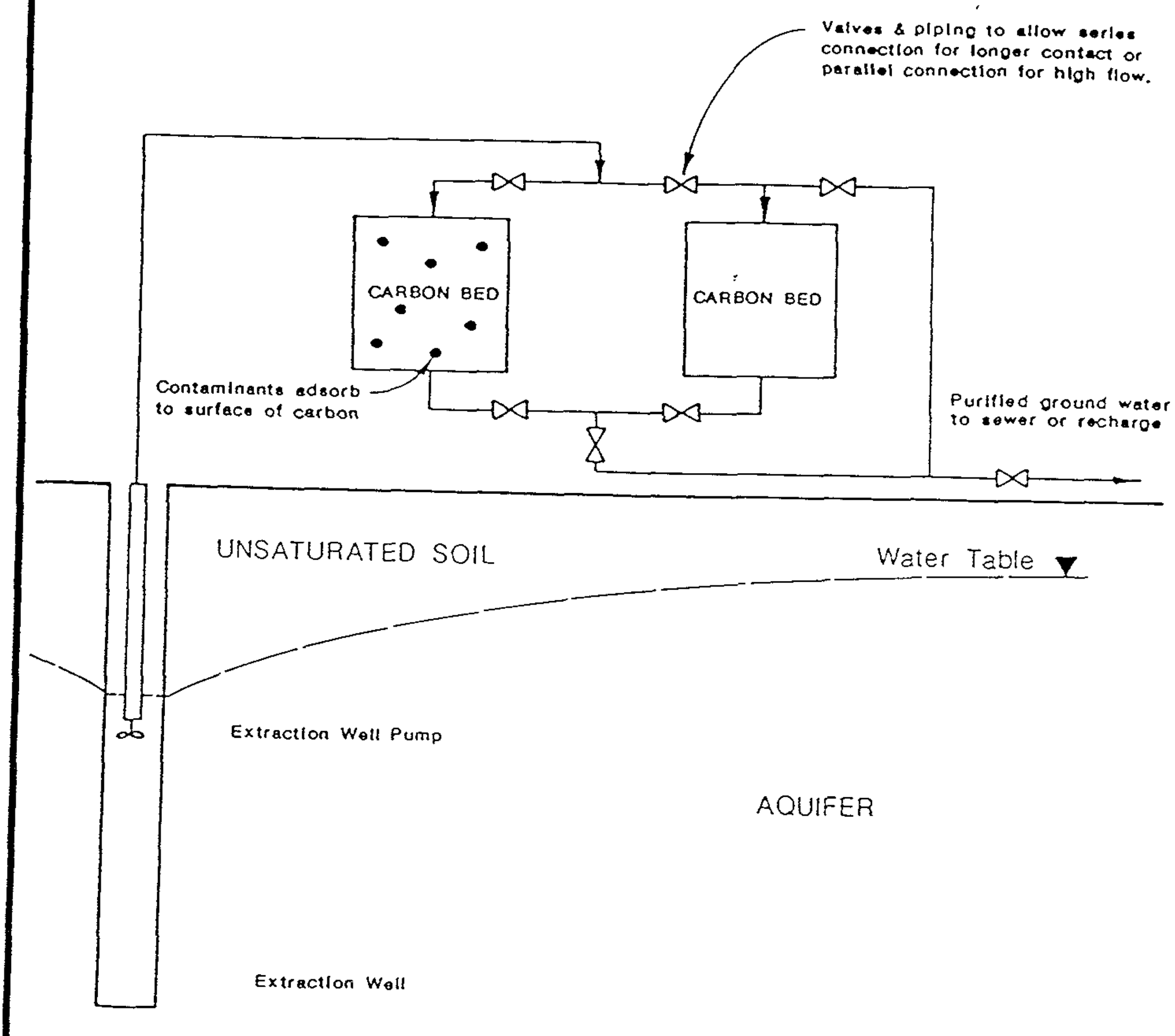
4.1.4 Air Stripping

Air stripping is an ideal process to remove volatile petroleum hydrocarbon compounds (like benzene, toluene and xylene) and halogenated solvents (like dichloroethane, dichloroethylene, trichloroethane, tetrachloroethane, trichloroethylene, and tetrachloroethlene) from ground water (see Figure 7). The basic concept behind any air-stripping facility is to bring the contaminated water into intimate contact with air, so that the volatile compounds are stripped from the water and discharged into the atmosphere.

Once the air stripper is installed, its operation is simple. The air is delivered by a blower and the water is supplied by a pump. Maintenance is minimal and periodic inspection of the bed is all that is required internally.

If air emission concentrations are sufficiently low, the volatile organics may be discharged directly to the atmosphere. Two factors mitigate the effect of the atmospheric discharge. The first is the dilution that takes place in the stripping tower before the vapors are emitted. The air-to-water volume ratio is on the order of 200 to 1. Therefore the pollutant is diluted by a similar factor when it exits the stripper and enters the atmosphere. Furthermore, there is natural dilution that occurs as soon as the air stream disperses into the atmosphere. If the total mass discharge to the atmosphere is too high, the exhaust gases can be minimized by an air polishing method as described in Section 4.1.5.

Why treat the ground water in an air stripper if there will still be a requirement to treat the dilute vapor ? If carbon bed air polishing is used, logic might dictate that the contaminated ground water should be treated directly in a carbon bed without using an air stripper. However, by



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environmental
services, Inc.

LIQUID PHASE CARBON TREATMENT

REVIEWED BY
RFernandez

APPROVED BY
TC

3427E

J.C.

1-20-89

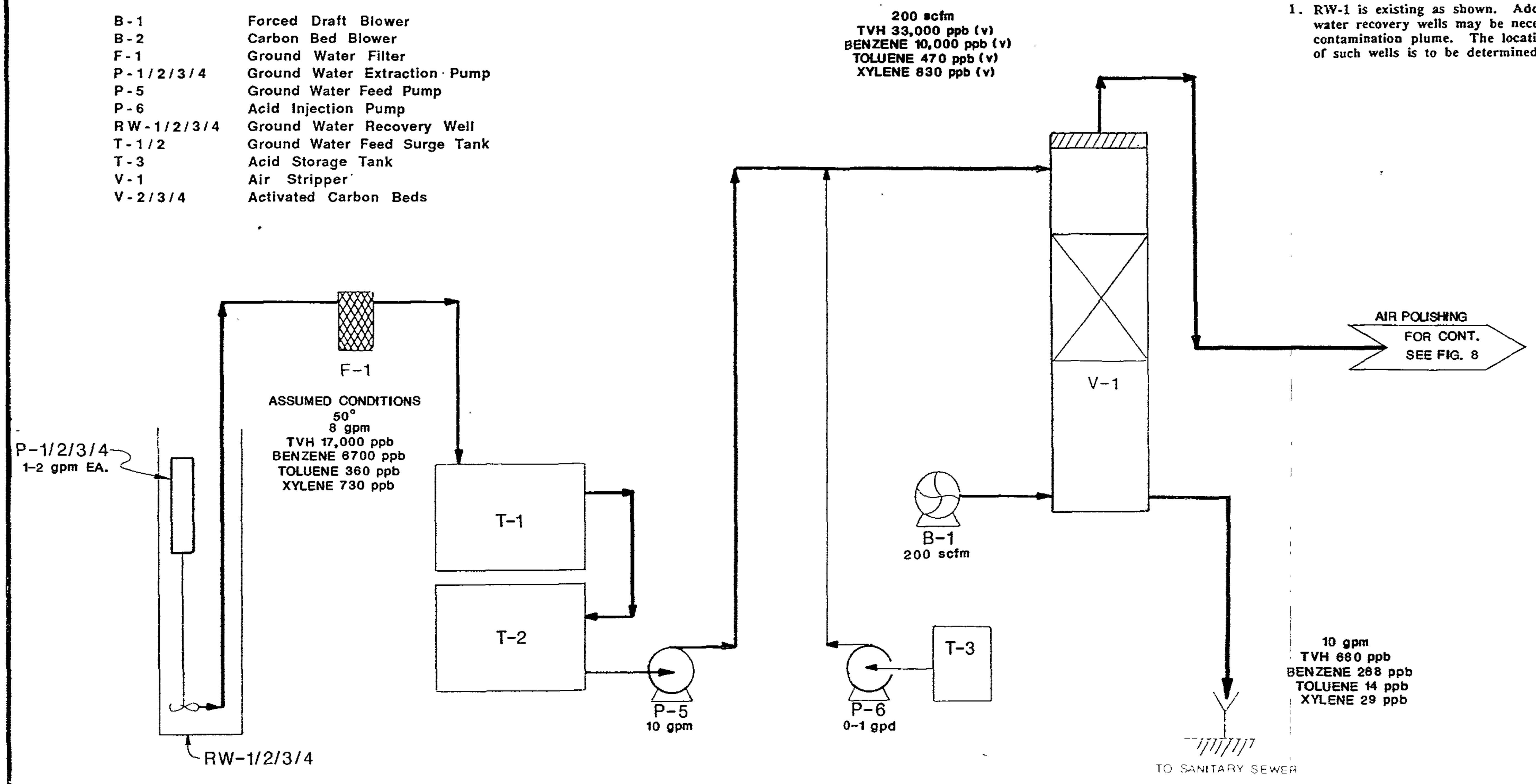
FIG. 6

EQUIPMENT LIST

B-1	Forced Draft Blower
B-2	Carbon Bed Blower
F-1	Ground Water Filter
P-1/2/3/4	Ground Water Extraction Pump
P-5	Ground Water Feed Pump
P-6	Acid Injection Pump
RW-1/2/3/4	Ground Water Recovery Well
T-1/2	Ground Water Feed Surge Tank
T-3	Acid Storage Tank
V-1	Air Stripper
V-2/3/4	Activated Carbon Beds

NOTE:

1. RW-1 is existing as shown. Additional ground water recovery wells may be necessary to capture contamination plume. The location and quantity of such wells is to be determined later.



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REV	DESCRIPTION	DATE	BY	APPD
1	ADD NOTE TO AIR POLISHING & T-2	6/19/89	SLS	

ensco environmental services, Inc.

PROCESS FLOW DIAGRAM

FORMER SHELL STATION
7194 VILLAGE PARKWAY
DUBLIN, CALIFORNIA

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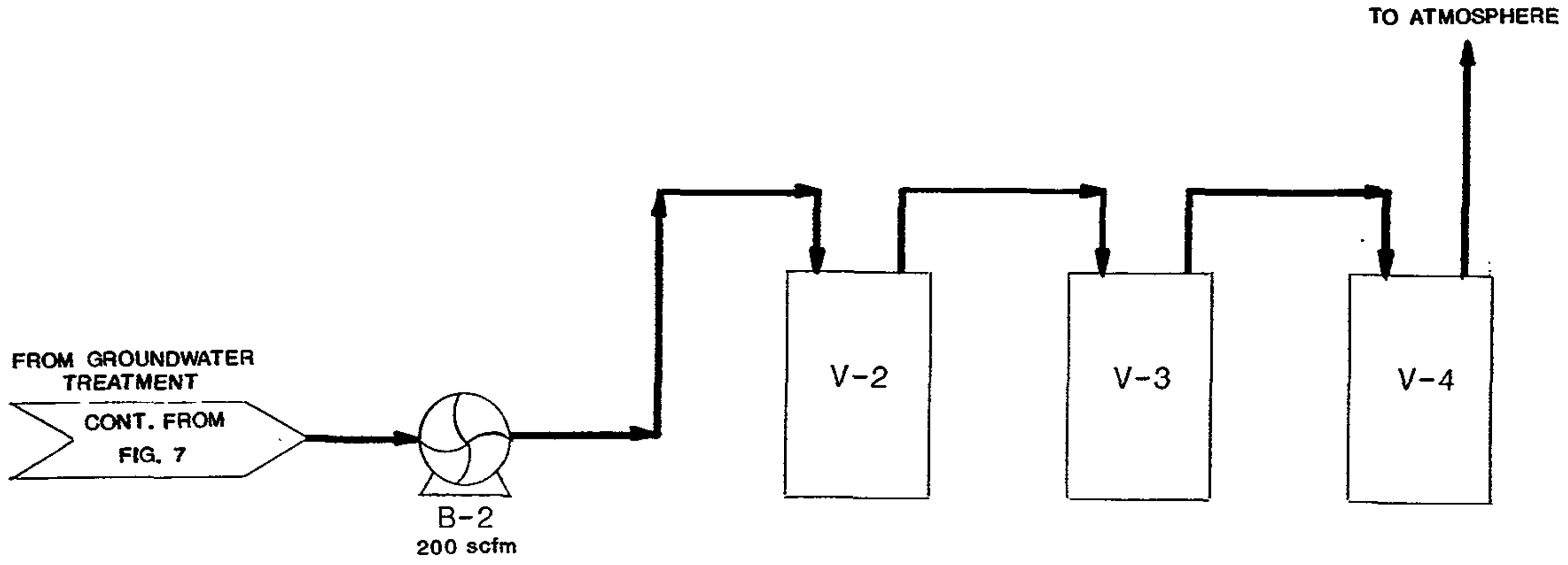
EDK	RA Katen P.E.
JOB # 3427E	DRAWN BY SLS
DATE 11-30-88	DRAWING # B-3427E-5

FIG 7



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REV	DESCRIPTION	DATE	BY	APPD

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PROCESS FLOW DIAGRAM CONT.

FORMER SHELL STATION
7194 VILLAGE PARKWAY
DUBLIN, CALIFORNIA

REVIEWED BY:	APPROVED BY:
DESIGNED BY:	DATE:
JOB #: 3427E	DRAWN BY: SLS
DATE: 6/26/89	DRAWING #: B-3427E-14

using an air stripper, there is considerable savings in carbon costs because vapor-phase carbon can often adsorb more targeted contaminants than can liquid-phase carbon. There will also be fewer chemicals in the vapor stream competing for the available pore space on the vapor-phase carbon, since many harmless compounds will remain in the ground water, not exhausting the available capacity in the vapor phase carbon.

4.1.5 Air Polishing

The Bay Area Air Quality Management District (BAAQMD) is now looking at the risk of cancer due to the release of carcinogens such as benzene as well as the release of Total Petroleum Hydrocarbons (TPH). The risk of cancer to someone at the property boundary, breathing the benzene-laden air for 70 years, cannot exceed an annual average value of 1×10^{-6} (one in a million). The carcinogenic risk factor for benzene is 5.3×10^{-5} risk per $\mu g/m^3$. The maximum benzene concentration at ground level from an air stripper alone predicted by the PTPLU-2.0 computer model as shown in Appendix C is 24.10 $\mu g/m^3$. The maximum carcinogenic risk value is 5.3×10^{-5} risk per $\mu g/m^3 \times 24.10\ \mu g/m^3 = 1.28 \times 10^{-3}$. BAAQMD uses 10% of this value for the annual average value, or 1.28×10^{-4}, which exceeds 1×10^{-6}. Therefore, air polishing is required. There are several alternative treatment processes for air emission polishing, including:

- Vapor-Phase Carbon Adsorption
- Catalytic Incineration

4.1.5.1 Vapor-Phase Carbon Adsorption

A forced-draft blower is provided to force 200 cfm of air from the air stripper discharge through three (3) carbon beds in series. Vapor-phase carbon bed effluent gas concentrations will be very low with a removal efficiency in excess of 99% for all compounds. The remediation process of air stripping and carbon adsorption will proceed until breakthrough occurs at the discharge of the second carbon bed. The carbon beds are then shut down and contents of the first bed are exchanged for reactivation. The second bed is placed in the first position and the newly-recharged bed is placed in the third position. This will allow fuller utilization of the carbon as compared to a two-bed system.

4.1.5.2 Catalytic Incineration

Catalytic incineration is an effective means of removing VOC's from a vapor stream. The unit can destroy in excess of 99 % of the VOC's present, converting them to carbon dioxide, water, heat and minor levels of NOx. The incinerator requires a natural gas source for the burner and a 115/230 volt, 10 amp electrical source for ignition. The unit will have a stack which will allow for adequate air dispersion while isolating the heat source from possible explosion hazards. Safety interlocks provide shutdown to the entire system in case of blower failure or loss of flame in the incinerator.

Compared to activated carbon, catalytic incineration becomes cost effective on relatively long term operations, and when high concentrations and/or flow rate require the use of extensive amounts of carbon.

4.1.6 Recommendation

The following table is a summary of the annual cost for the alternative remediation systems previously discussed (from Section E.1, Appendix E):

Annual Cost

Alternative	One Year	Two Years	Three Years
With Air Stripper:			
Vapor-Phase Carbon Adsorp.	$89,130	$53,850	$42,080
Gas Incinerator	151,310	91,810	71,670
Electric Incinerator	163,600	93,600	69,960
Without Air Stripper:			
Liquid-Phase Carbon Adsorp.	97,450	94,350	89,880
UV/Peroxidation	100,400	90,400	87,070

As a result of these design and cost considerations, the best apparent alternative to treat the ground water is air stripping combined with vapor-phase carbon adsorption air treatment.

4.2 Ground Water Extraction System

The ground water extraction system consists of the recovery wells, which collect the contaminated ground water, and the ground water feed surge tank. A process flow diagram is shown in Figure 7.

4.2.1 Ground Water Pumping

As discussed in Section 3.4, one recovery well capable of extracting 1 to 2 gpm has been drilled. A pump, sized to extract 2 gpm, is recommended for installation in this well. Because no floating product has been observed, only a single, electric motor-driven pump need be used. This pump would draw down the well, creating a cone of depression drawing the contaminated ground water to the recovery well.

The cone of depression created by this extraction pump may not be large enough to capture all of the contaminated ground water. Upon system start-up, the effects of the treatment system will be observed in the monitoring wells. Up to three additional recovery wells will be drilled, if required.

4.2.2 Ground Water Feed Surge Tank

The total ground water flow rate is unknown at this time, but may be between one and eight gallons per minute. Since the recommended air stripper would be designed for a single flow rate of 10 gpm, a feed surge tank is included in the system to balance this operation. The air stripper would operate intermittently, being started and stopped by high and low level switches in the feed surge tank. Should an air stripper system malfunction occur allowing the surge tank to fill, a high-high level switch should shutdown the ground water extraction pump. Two (2) 1000-gallon tanks are proposed. This size balances the requirements to minimize the size of the treatment system for aesthetic reasons and the desire to minimize startup and shutdown of the air stripper.

4.3 Air Stripping System

An EES model AS-11 air stripping system is recommended for treatment of ground water extracted from the recovery well(s). Figure 7 is a Process Flow Diagram (PFD) showing the proposed treatment system. For this application we have designed the system for a ground water recovery rate on the order of 6 to 8 gpm.

4.3.1 Air Stripper

The major process component of an air stripping system is the stripping tower. The tower shell is usually cylindrical, for strength, for ease of fabrication, and to avoid any corners that might induce channeling of the air or water. The tower must be built to withstand all applicable wind and earthquake loads for the area. In addition, it must be able to support the combined weight of the tower internals, the packing, and the water held up in the tower. EES designs the cylindrical tower with pad-eyes for guy wire tie-downs for wind and earthquake considerations.

A minimum thickness pad-type demister is recommended to reduce the likelihood of entrained water vapor from exiting the stripper and entering the carbon bed blower. It provides greater mist removal, especially at higher flow rates, than chevron-type demisters.

Water must be introduced into the tower in a manner to enhance even distribution across the surface of the packing, while allowing for smooth, unimpeded air flow upward. Methods for accomplishing this include: distribution trays, trough-and-weir arrangements, header-lateral piping, and spray nozzles. The header-lateral and trough-and-weir systems rely on dividing the flow into successively smaller streams. Weir systems have "blind" spots under the troughs where water does not fall. Header-lateral systems have unequal flow in different laterals, depending on their location. Distribution trays with bubble caps, valves, or orifices are designed to keep a standing head of water on them, thereby assuring an equal pressure, and hence equal flow distribution. While these trays are efficient, they are also relatively expensive. Less expensive but equally efficient are spray nozzles which immediately break up the water flow into droplets. EES proposes the use of a spray nozzle which has good flow distribution capabilities and minimizes the space required for flow distribution.

Below the spray nozzle lies the packing. The ideal tower packing will provide a large surface area for the air and water to interact, and it will also create turbulence in the water stream to constantly expose new untreated ground water surfaces to the air. The packing should have a large void area to minimize the pressure drop through the tower. Secondary considerations for packing include weight, corrosion resistance, ability to maintain a uniform liquid flow, and, of course, cost. Earlier technology packing, such as saddles and Raschig rings, were limited to fairly simple shapes by the nature of their production process, usually in metals or ceramics. EES recommends installation of a packing made of polypropylene, with a complex shape to assure a large void area to minimize pressure drop. It is chemically inert and will not degrade when exposed to ground water. It is less inexpensive (8 to 10 times less) than an equal volume of ceramic packing and is lightweight and strong, allowing greater packed bed depth without crushing the packing at the base of the tower. Based upon design requirements EES recommends installing 11 feet of 2 inch Tri-Packs^R in the AS-11 Air Stripper.

The packing is held up in the air stripper by a packing support plate. Typically, a fiberglass reinforced plastic (FRP) or other chemically inert thermoplastic grating is installed which provides an adequate open area to prevent flooding.

EES proposes that the treated water from the air stripper gravity drain to the sanitary sewer.

4.3.2 Air Stripper Sizing

When sizing an air stripper, the design engineer has five basic variables to define: a) tower height, b) tower diameter, c) air-to-water ratio, d) temperature, and e) reflux ratio. Reflux is not proposed for this installation. Although these variables are dependent upon each other (i.e., a change in air-to-water ratio may allow, or require, a change in packing height), the following basic relationships are helpful in preliminary sizing:

- Tower diameter is most strongly a function of liquid flow rate. The cross-sectional area of a tower is proportional to the flow rate. The AS-11 is designed for a maximum flow rate of 15 gpm.

- Tower height is most strongly a function of removal efficiency required. This relationship follows the law of diminishing returns: For each incremental foot of packing added a proportionately smaller amount of contaminant will be removed.

- Air-to-water ratio is a function of the contaminant being removed. The more volatile a substance, the less the amount of air that is required to strip it. Also, the more soluble a contaminant is in water, the more difficult it will be to strip.

- A fourth variable that controls the efficiency of the stripping process, temperature, may also be changed through the use of preheaters on the ground water or injection of steam directly into the tower. Stripping efficiency improves at elevated temperatures. However, high operating costs limit the practical use of heating ground water as a means of enhancing stripper performance. Even though the ambient air temperature may fluctuate between summer and winter, the ground water temperature stays at a near constant temperature year round. A ground water temperature of 50 degrees Fahrenheit (^{O}F) is assumed.

The design of the stripper starts with review of the basic mass transfer process. The rate of transfer of the petroleum hydrocarbons will be a function of the driving force (the concentration gradient between water and air) and the air-water interface surface area. Different compounds will be transferred at different rates, depending upon the Henry's law constant of the particular compound. The higher the Henry's law constant, the easier it is to strip that compound. Of the contaminants of concern, benzene has the lowest Henry's law constant and will be the most difficult to strip (see Table 3). Therefore design efficiency is based upon the ability to strip benzene. The efficiency of an EES Model AS-11 air stripper treating 8 gpm in this application has been calculated at 96% (see Appendix B).

TABLE 3

RELATIVE EASE OF STRIPPING*

Contaminant	Henry's Law Constant dimensionless
Benzene	0.23
Toluene	0.25
Xylene	0.27

*The lower the Henry's Law Constant, the harder to strip.

4.3.3 Acid Addition System

Experience has demonstrated the need for acid addition to increase the solubility of water hardness chemicals such as calcium carbonate and iron by controlling the pH of the feed to the air stripper. Without this, severe calcification on the packing can occur. When that occurs the column stripping efficiency falls drastically. An acid addition system should be installed to control the pH of the incoming water, thus preventing severe calcification.

4.3.4 Air Stripper Blower

A forced-draft blower is provided at the base of the air stripper. The blower is required to produce approximately 200 cfm at the static pressure rating of the 18 foot high air stripper. The blower injects air into the air stripper, and then carries all vapors out of the air stripper into the air polishing system described in Section 4.1.5.1. An air intake silencer/filter is installed on the blower to quiet the intake, remove air particulates, and provide for personnel protection. To ensure that no untreated ground water is discharged, numerous safety interlocks are installed including a system shutdown if the blower malfunctions.

4.3.5 Vapor-Phase Carbon Adsorption

Three vapor-phase carbon vessels will be installed in series from the air stripper air discharge line. Vapor-phase carbon bed effluent gas concentrations will be very low with a removal efficiency in excess of 99% for all compounds. The remediation process of air stripping and carbon adsorption will proceed until breakthrough occurs at the discharge of the second carbon bed. The carbon beds are then shut down and contents of the first bed are exchanged tor reactivation. The second bed is placed in the first position and the newly-recharged bed is placed in the third position. This will allow fuller utilization of the carbon as compared to a two-bed system.

A forced-draft blower is provided to force 200 cfm of air from the air stripper discharge through the 3 carbon beds in series. A safety interlock at the discharge of the second carbon bed will shut the blower down to prevent exceeding air discharge limits. This interlock will also shut the system down if an explosive concentration of vapors is detected.

4.3.6 Overall System Safety

To reduce the likelihood of an explosion from occurring, EES recommends installation of a hydrocarbon monitor to detect explosion hazards. For an explosion to occur the vapor concentration of hydrocarbons would have to be greater than 1.4% or 14,000 ppm. To prevent this, the system should be designed to shutdown at 0.7% of the lower explosion limit (LEL) or 100 ppm hydrocarbons (as gasoline). Assuming concentrations listed in Section 4.4.1, should all the hydrocarbons in the ground water be removed, an explosion could not occur, even if a flame was present. This represents a concentration of 0.25% of the LEL.

Safety interlocks should be provided to prevent:

- Untreated water from leaving the air stripping system due to well pump, or air blower malfunction;
- Untreated ground water from returning to the extraction well;
- Explosion hazard as a result of stripper vent gas concentration exceeding the Lower Explosive Limit (LEL) of gasoline; and
- Discharge air from leaving a saturated carbon bed.

4.4 Expected System Performance

4.4.1 Assumed Ground Water Conditions

The ground water conditions are assumed to be as listed below based on worse case monitoring well results (MW-1 in Table 1):

Total Petroleum Hydrocarbons	17,000 ppb
Benzene	6,700 ppb
Toluene	360 ppb
Xylene	730 ppb

4.4.2 Air Stripper Effluent Water Quality

Given these influent conditions, and the calculated 96% removal efficiency, the expected effluent concentrations are as follows:

Total Petroleum Hydrocarbons	680 ppb
Benzene	268 ppb
Toluene	14 ppb
Xylene	29 ppb

4.4.3 Air Stripper Vent Gas Quality

Expected mass discharge to the carbon beds from the air stripper is calculated in Appendix B and is as follows:

Total Petroleum Hydrocarbons	1.6 lbs/day
Benzene	0.62 lbs/day
Toluene	0.033 lbs/day
Xylene	0.067 lbs/day

On a volume basis, the concentrations of air emissions in the stripper vent gas to the carbon beds would be:

Total Petroleum Hydrocarbons	32 ppm (v)
Benzene	10 ppm (v)
Toluene	0.47 ppm (v)
Xylene	0.83 ppm (v)

4.4.4 Carbon Bed Vent Gas Quality

The concentration of air emissions from the carbon beds is expected to be non-detectable until the point of breakthrough.

SECTION 5.0

PERMIT REQUIREMENTS

The following permits are required for operation of the recommended air stripper system:

Waste Water Discharge Permit	- Dublin, San Ramon Services District (DSRSD)
Air Discharge Permit	- Bay Area Air Quality Management District (BAAQMD)
Building Permit	- City of Dublin

5.1 Waste Water Discharge Permit

A waste water discharge permit is required to discharge treated air stripper effluent to the sanitary district (DSRSD). In discussions with DSRSD, the only applicable discharge limit is 2 ppm TPH.

As shown in Section 4.4, the expected effluent water quality is 0.68 ppm TPH. Therefore, this limit can be met. A sewer connection was completed in August, 1988, and EES has been informed verbally that a permit should be issued.

5.2 Air Discharge Permit

From Section 4.1.5, the air stripper discharge air requires carbon bed treatment to meet BAAQMD risk limits. Air emissions from carbon bed systems are normally sufficiently low that the BAAQMD will issue an air discharge permit without further requirements.

Typically, BAAQMD requires approximately two months to review and approve a permit to construct. This review process can be accelerated by performing air dispersion modeling and submitting the results with the permit application. This modeling has been performed using the computer program PTPLU-2.0, the same program as used by BAAQMD. Benzene, being the compound of greatest concern, was modeled for the recommended system and the highest concentration without carbon treatment would be 24.1 micrograms per cubic meter at a distance of 135 feet away. The PTPLU-2.0 model was also used to determine at what feed concentration the carbon beds can be removed. See Appendix C.

5.3 Building Permit

Discussions have been held with the City of Dublin Planning Department. A construction permit was obtained for the underground water, sewer and electrical conduit which was installed in August. The Planning Department raised the following concerns:

- The concrete slab must be sufficient to support the remediation system;
- The treatment equipment must be visually screened;
- Any treatment equipment higher than the screens should be painted a dark color;
- The structural anchors for wind and earthquake loads must be adequate; and
- The noise levels from pumps and blowers should be unobtrusive.

A concrete slab was installed for a treatment system by Oil Changers. Once the treatment system is approved, the concrete slab will be evaluated to determine its adequacy.

A six foot high concrete block wall is proposed for screening three sides of the treatment system. The fourth side would be screened by a vinyl-clad chain link gate with redwood slats.

The height of the Oil Changers building is 18 feet. The system would, therefore, be partially screened from the street by the building. It would also be painted dark grey to match the Oil Changers building trim.

If the proposed system is approved, the structural supports and guy wire anchors will be analyzed for wind and earthquake loads per the Uniform Building Code (UBC).

The proposed ground water feed pump would be a 3/4 HP centrifugal pump. The noise level from this size pump is normally about the same as from normal conversation. The air intake to the two blowers will be equipped with a silencer to limit noise as well as provide personnel protection.

The City of Dublin normally requires a Site Development Review for a project of this size. However, considering its temporary nature, they have indicated that a waiver may be requested if their concerns are addressed. We recommend a waiver be requested.

SECTION 6.0

REMEDIATION TASK ELEMENTS

6.1 Completed Tasks

The following tasks have been completed:

1. Excavation and removal of product storage tanks.
2. Excavation of contaminated soil and treatment by aeration.
3. Performance of a site assessment.
4. Determination of the extent of contamination that has moved outside the property limits.
5. Drilling of seven monitoring wells.
6. Drilling of a ground water recovery well and determination of hydrogeologic parameters.
7. Installation of underground piping and conduit.
8. Upgrading of PG&E service transformer.
9. Connection to sanitary sewer.

6.2 Remaining Tasks

6.2.1 Permit Applications (Task 1.0)

Applications for air and water permits to construct will be filed with BAAQMD, and DSRSD. Permit approval is anticipated within two months. A waiver of Site Development Review will be requested from the City of Dublin.

6.2.2 Detailed Design (Task 2.0)

Upon approval of the Remedial Action Plan, production of the detailed design drawings and specifications will begin. The final drawing package would contain the following documents:

- Piping and Instrumentation Diagram
- Skid Piping Layout Drawing

- Air Stripper Construction Detail
- Air Polishing System Layout Drawing
- Electrical Logic Diagram
- Electrical Elementary Diagram
- Panel Construction Detail
- Equipment Anchor Details

6.2.3 Equipment Procurement (Task 3.0)

After the remediation system is approved and equipment specified, individual components will be purchased. Some items will be readily available, others may require up to two months of lead time for delivery.

6.2.4 System Construction and Startup (Task 4.0)

As the equipment arrives, the treatment systems will be shop assembled unit as much as practical. The equipment should be mounted on skids and be modular. Once the skid mounted unit is fully assembled, it would be delivered to the former Shell gasoline station in Dublin. The carbon beds, groundwater feed surge tank, and groundwater filter will be assembled at the site. After equipment installation at the site is complete, the regulatory agencies will be notified and the system will be started.

6.2.5 Phase I Operation (Task 5.0)

EES proposes to provide startup supervision to fine tune the treatment system.

6.2.6 Source Testing (Task 6.0)

Once reliable, continuous operations are established, discharged water and air will be sampled as directed, to ensure compliance with environmental regulatory requirements.

6.2.7 System Modifications (if required) (Task 7.0)

Although modifications to the remediation system are not expected, based upon laboratory analysis of discharged water and air samples, the remediation equipment will be adjusted, if required, to meet permit limits.

6.2.8 Phase II Long Term Operation (Task 8.0)

EES can be contracted to provide supervision and coverage for a two week period to assure continued efficient operation of the system. EES offers monthly maintenance of the remediation equipment to meet regulatory requirements until the site is remediated to the satisfaction of RWQCB. An annual shutdown of the system is recommended to clean and calibrate all instrumentation.

Once the concentrations of contaminants from the air stripper gas discharge are low enough to meet BAAQMD requirements, the vapor-phase carbon bed system may be removed. An occasional vapor sample will identify when remediation no longer requires air polishing. Vapor samples will be taken and analyzed on a time and material basis.

Each of the three carbon bed units will be saturated after approximately 90 days. EES can provide changeout and reactivation of the spent carbon every 90 days.

6.2.9 Periodic Water Testing (Task 9.0)

Periodic sampling of effluent will be conducted at the frequency directed by the RWQCB and the DSRSD.

6.2.10 System Removal

Once the site has been declared 'clean' by the RWQCB, the system should be removed and the parking spaces for Oil Changers restored.

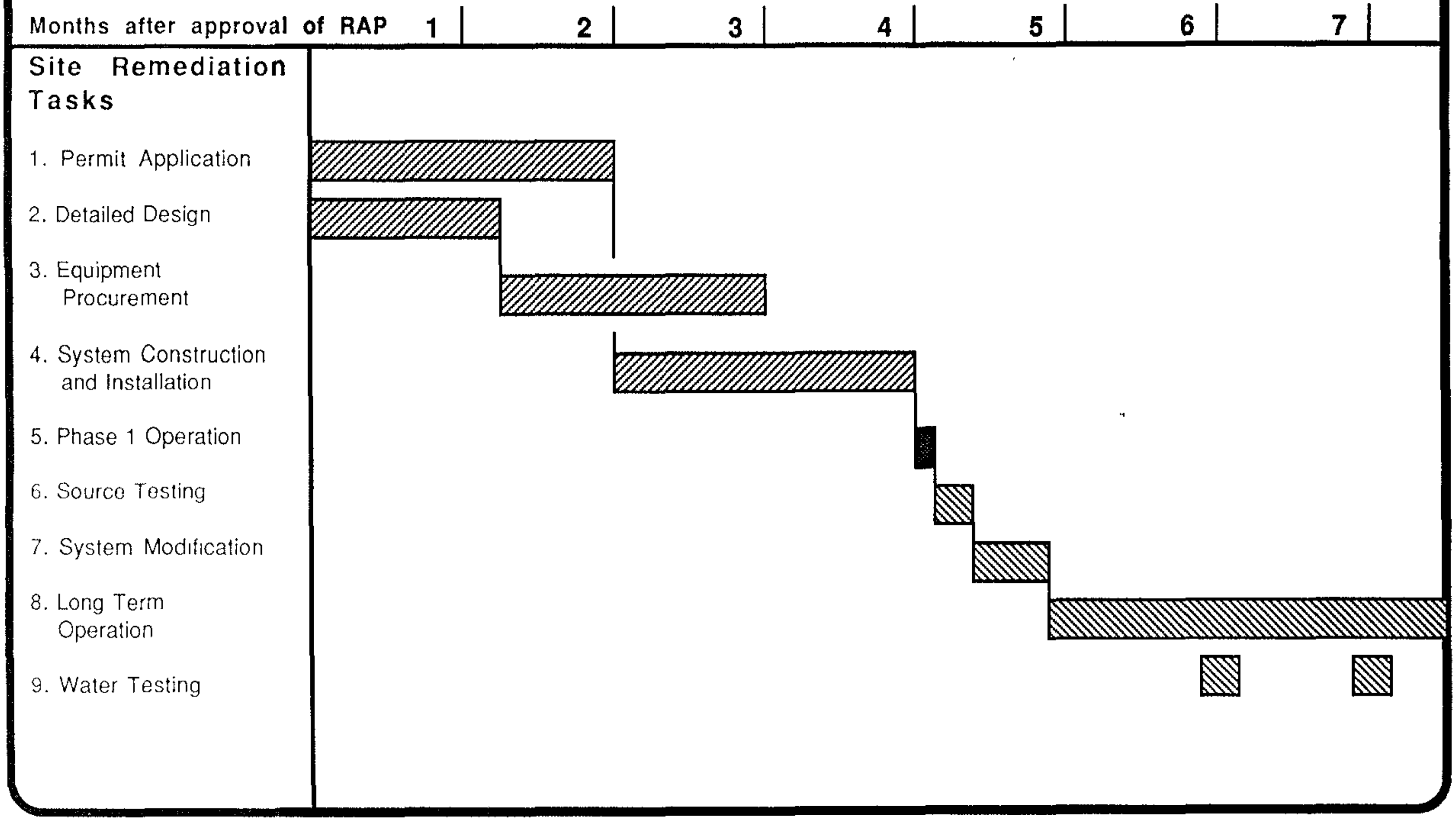
SECTION 7.0

SCHEDULE

A time-line schedule showing work task elements, as described previously in Section 5.0, is presented in Figure 9. No task element work will commence until receiving required approval from the RWQCB, DSRSD, and the BAAQMD.

ensco
environmental
services, inc.

Figure 9
REMEDIATION TASK SCHEDULE
SHELL OIL COMPANY - DUBLIN, CALIFORNIA



SECTION 8.0

COSTS

Estimated costs for performing each task are given below:

TASK		ESTIMATED COST	FREQUENCY
1.0	Permit Application	$ 3,300	one time
2.0	Detailed Design	$ 8,000	one time
3.0	Equipment Procurement	(included in Task 4.0)	one time
4.0	System Construction & Startup (less installation)	$52,000-57,000	one time
5.0	Phase I Operation	$4,000	one time
6.0	Source Testing (One Time)	$1,000	one time
7.0	System Modifications	---	one time
8.0	Phase II Long Term Operation (carbon bed changeout pro-rated monthly)	$ 2,200	monthly
9.0	Periodic Water Testing	$ 1,000	monthly

SECTION 9.0

REFERENCES

9.1 Ensco Environmental Services, Inc., "Soil and Ground Water Investigation for Shell Oil Company 7194 Amador Valley Blvd, Dublin, California," Ensco Project 1826G, May, 1988.

9.2 Ensco Environmental Services, Inc., "Supplemental Soil and Ground Water Investigation for Shell Oil Company 7194 Amador Valley Blvd, Dublin, California," Ensco Project 1826G, November, 1988.

9.3 North Coast, San Francisco Bay and Central Valley RWQCB, "Regional Board Staff Recommendations for Initial Evaluation and Investigation at Underground Tanks," June, 1988.

9.4 SWRCB, Leaking Underground Fuel Tank (LUFT) Field Manual, May, 1988.

9.5 Dr. David J. Leu, Memorandum, "Available Criteria For Toxic Substances", March 17, 1986 (Attached in Appendix D)

9.6 Peroxidation Systems, Inc., "Groundwater Treatment with Zero Air Emissions."

APPENDIX "A"

Service Station Mitigation System Form

SERVICE STATION MITIGATION SYSTEM

Service Station Address: 7194 Village Parkway, Dublin, CA
Cross Streets: Amador Valley Road, Village Parkway
WIC No: 204227701 EXP Code: Est. Cost:
Engineer: Diane Lundquist District: San Fransisco SSN:

DESIGN CRITERIA

Predominant Soil Type: Silty to Sandy Clay
Depth to Water Table: 9 to 11 ft. Gradient: 0.0023

		Transmissivity	Storage Coefficient
Well Number:	RW-1	547 gpd/ft	0.0024

SYSTEM HYDRCARBON CONCENTRATIONS

INFLUENT (ppb)					EFFLUENT (ppb)				
Benzene	Toluene	Xylene	TPH	Lead	Benzene	Toluene	Xylene	TPH	Lead
6,700	360	730	17,000	-	268	14	29	680	-

Separate Phase Yes: No: x Thickness: N/A

PERMIT AUTHORITIES ALLOW AIR STRIPPER

Yes: x No: Cat. Oxidizer Required: Yes: No: x
Controlling Authorities: Bay Area Air Quality Management District (BAAQMD)

INFLUENT - RECOVERY WELLS

Number: 4 (Design), 1 (Existing) Total Flow Rate: 8 gpm

EFFLUENT - DISCHARGE

Discharge 8 gpm direct to sewer.

DISCHARGE REQUIREMENTS

NPDES Permit Yes: No: x In-hand Yes: No: x Applied for: N/A
Discharge Limitations Yes: No: x Explain below:

POTW Permit Yes: x No: In-hand Yes: No: x* Applied for: Aug 10, 1988
Discharge Limitations Yes: x No: Explain below: (*Draft received Jan 12,1989)
<15 mg/l TPH

SERVICE STATION MITIGATION SYSTEM

Service Station Address: 7194 Village Parkway, Dublin, CA

SYSTEM DESIGN CRITERIA

Flow: 1 - 8 gpm Concentration: 17,000 ppb TPH

EQUIPMENT	Yes	No	Make and Model Number
Pumping Equipment	x		
Feed Tank	x		Two (2) 1,000 gal, Poly-Cal Plastics Model SP128
Separator		x	
Clarifier		x	
Coalescer		x	
Water Filter	x		Rosedale Model 6-18 or equal
Bio-Reactor		x	
Air Stripper	x		Ensco Environmental Services, Inc. Model AS-11
Cat. Oxidizer		x	
Carbon Adsorber	x		Westates Carbon Vent Scrub VSC-1200
Product Tank		x	

Electrical: New Service Yes: x No: Existing Yes: No: Separate Meter Yes: x No:

Applied for: Available:

Natural Gas: Yes: No: x Available Yes: No:

Applied for: N/A Installed:

Submitted by: Date:

Attachments: Remedial Action Plan
Containing:
Site Plan,
Process Flow Diagram,
System Description

Contractor: Ensco Environmental Services Inc.
41647 Christy Street
Fremont, CA 94538-3114

(415) 659-0404

Approved by: Date:

Approved by: Date:

APPENDIX "B"

Equipment Sizing Calculations

APPENDIX "B"

EQUIPMENT SIZING CALCULATIONS

B.1 Liquid-Phase Carbon Adsorption

Data on liquid-phase carbon consumption were obtained from four (4) different carbon bed manufacturers:

- Carbtrol Corporation: 40 lbs/day
- Calgon Carbon: 43 lbs/day
- Tigg Corporation: 8 lbs/day
- Westates Carbon: 59 lbs/day

From the above data, only Tigg Corporation's estimate deviated excessively from the range given by the other three (3) vendors. Therefore, Tigg Corporation's estimate will not be used. The average estimate

$$= (40 + 43 + 59) / 3$$
$$= 47.3 \text{ lbs/day}$$

In addition to adsorption of contaminants, the carbon will adsorb naturally occurring inorganics, organics, bacteria, etc. To account for this, the carbon usage is multiplied by a factor of 1.75 to yield a value of 83 lbs/day.

B.2 Air Stripper Size

Assumptions:

1. Liquid Flow Rate: 8 gpm
2. Air FLow Rate: 200 scfm
3. Tower Diameter: 1.0 ft
4. Column Height: 18 ft
5. Packing Height: 11 ft
6. Packing Type: 2" Jaeger Tri-Packs®
7. Influent TPH conc: 17,000 ppb or 17 ppm
8. Required Effluent conc: 15 mg/l ≈ 15 ppm
9. HTU for BTX given by Jaeger (Ref 1) is 39.2 in. for 2" Tri-Packs®

Methodology:

The method outlined in Kavanaugh and Trussell (Ref 2) is used to calculate the number of transfer units (NTU). The height of a transfer unit is taken from Jaeger Product Bulletin 600 (Ref 2) after its applicability is verified. The number of transfer units is found from the equation for the packing height, Z = (NTU) (HTU). The packing height is 11 ft for an EES model AS-11 air stripper. From the NTU the efficiency can be found.

Definition of Variables:

L = Liquid Flow Rate in lb/hr-ft^2 or kmol/m^2-sec

G = Air Flow Rate in lb/hr-ft^2 or kmol/m^2-sec

P = Air Stripper Operating Pressure in atmospheres

V = Air Stripper Air Flow Rate in ft^3/min

r = Ideal Gas Constant: $1.314 \ \frac{\text{atm-ft}^3}{\text{lb mol-°K}}$

T = Absolute Temperature in °K

H_{ATM} = Henry's Law Constant in atmospheres

H = Henry's Law Constant (dimensionless)

R = Stripping Ratio

X_{in} = Solute Concentration into the Stripper

X_{out} = Solute Concentration in Stripper Effluent

Calculation:

$$L = 8 \text{ gpm} / 3.14\,(0.5 \text{ ft})^2 \times 8.34 \text{ lb/gal} \times 60 \text{ min/hr}$$

$$= 5.1\text{E}{+}3 \text{ lb/hr-ft}^{2\,*} \qquad (* \ 5.1\text{E}{+}3 = 5.1 \times 10^3)$$

$$= \frac{8 \text{ gpm } (1 \text{ min}/60 \text{ sec})\,(3.785\text{E-}3 \text{ m}^3/\text{gal})\,(55.6 \text{ kmol/m}^3)}{3.14\,(0.5 \text{ ft})^2\,(9.290\text{E-}2 \text{ m}^2/\text{ft}^2)}$$

$$= 0.38 \text{ kmol/m}^2\text{sec}$$

$$PV = NrT$$

$$N = \frac{PV}{rT}$$

$$= \frac{1 \text{ atm } (200 \text{ ft}^3/\text{min})}{(1.314 \text{ atm-ft}^3/\text{lb mol-K}^\circ)\ (283^\circ\text{K})}$$

$$= 0.54 \text{ lb mol/min}$$

$$G = \frac{0.54 \text{ lb mol/min } (1 \text{ min}/60 \text{ sec})\ (0.454 \text{ kgr/lb})}{3.14\ (0.5 \text{ ft})^2\ (9.290\text{E-}2 \text{ m}^2/\text{ft}^2)}$$

$$= 5.60\text{E-}2 \text{ kmol/m}^2\text{.sec}$$

$$= \frac{200 \text{ ft}^3/\text{min } (60 \text{ min/hr})\ (1 \text{ lb}/13 \text{ ft}^3)}{3.14\ (0.5 \text{ ft})^2}$$

$$= 1.2\text{E+}3 \text{ lb/hr-ft}^2$$

$$G/L = (\text{lb/lb}) = \frac{1.2\text{E+}3}{5.1\text{E+}3} = 0.23$$

$$G/L = (\text{mol/mol}) = \frac{5.60\text{E-}2}{0.38} = 0.15$$

$$H = H_{ATM} \frac{(0.2194)}{T(^\circ\text{K})}$$

$$H_{ATM}(\text{Benzene}, 50^\circ\text{F}) = \frac{0.23\ (273+10)}{0.2194}$$

$$= 2.97\text{E+}2 \text{ atm}$$

$$R = (H_{ATM}/P)\ (G/L)$$ (Ref 2)

$$= (2.97\text{E+}2 \text{ atm}/1 \text{ atm})(0.15)$$

$$= 44.5$$

$$NTU = Z/HTU$$

$$= 11 \text{ ft } (12 \text{ in/ft})/39.2 \text{ in} = 3.37$$

$$NTU = (R/R\text{-}1) \ln \left[\frac{X \text{ in}/X \text{ out } (R\text{-}1) + 1}{R}\right]$$ (Ref 2)

$$X_{in}/X_{out} = \frac{R \exp [NTU\ (R\text{-}1)/R] - 1}{R\text{-}1}$$

$$= \frac{44.5 \exp [3.37\ (43.5)/44.5] - 1}{43.5}$$

$$= 27.5$$

$$X_{out}/X_{in} = 3.64\text{ E-}2$$

$$\text{Efficiency} = (1.0 - X_{out}/X_{in})\ 100\% = 96.4\%$$

Use 96% for all further calculations.

B.3 Expected Atmospheric Releases

For each ppb of hydrocarbon in 8 gpm of ground water feed, the daily discharge to the atmosphere will be

$$= (8 \text{ gpm}) \cdot (8.34 \text{ lb/gal}) \cdot (1440 \text{ min/day}) \cdot (1.0\text{E-}9 \text{ lb/ppb}) \cdot 0.96$$
$$= 9.22\text{E-}5 \text{ (lb/day)/(ppb)}$$

TPH:	17,000 ppb x 9.22E-5	=	1.57 lb/day
Benzene:	6,700 ppb x 9.22E-5	=	0.62 lb/day
Toluene:	360 ppb x 9.22E-5	=	0.033 lb/day
Xylene:	730 ppb x 9.22E-5	=	0.067 lb/day

The concentration of contaminants in the vent gas will be

$$= \frac{(379.5 \text{ ft}^3\text{/mol}) \cdot (1 \times 10^6 \text{ ppm})}{(\text{MW, lb/mol}) \cdot (200 \text{ ft}^3\text{/min}) \cdot (1440 \text{ min/day})}$$

$$= \frac{1.32\text{E+3}}{\text{MW}} \text{ ppm/(lb/day)}$$

Contaminant	MW	Concentration
TPH:	64 lb/mole	32 ppm (volume)
Benzene:	78 lb/mole	10 ppm (v)
Toluene:	92 lb/mole	0.47 ppm (v)
Xylene:	106 lb/mole	0.83 ppm (v)

References:

1. Jaeger Products, Inc. Product Bulletin 600

2. Michael C. Kavanaugh & R. Rhodes Trussell, "Design of Areation Towers to Strip Volatile Contaminants from Drinking Water," Journal AWWA, p. 684, December 1980.

APPENDIX "C"

Air Dispersion Modeling

APPENDIX "C"

AIR DISPERSION MODELING

C.1 Reason For Modeling

Air emissions are limited by BAAQMD. To determine the concentrations of vent gases exiting the air stripper, in the area around the site, computer air dispersion modeling was necessary. See Section 4.1.5 for the calculation of the annual average risk value.

C.2 Description Of Model Utilized

The User's Network for Applied Modeling of Air Pollution (UNAMAP) version 6 contains 31 air quality simulation models or processors. EES utilized PTPLU-2.0, an adapted and improved version of PTMAX which quickly determines, for a single point source, the approximate location of maximum concentration and the meteorological conditions causing it. Concentrations based on wind speed, both adjusted and unadjusted, for stack height are displayed.

Most air quality studies will start by analyzing a representative sample of stacks with this program to guide the receptor placement in more extensive modeling. PTPLU-2.0 determines maximum concentrations through a process in iteration. In this process, concentrations are calculated for gradually increasing downwind distances until the peak is passed, then the program decreases the downwind distance until a peak is passed again. After several reversals, the maximum is found. Stack-tip downwash, buoyancy-induced dispersion and partial plume rise can be considered in the calculations.

In order to run a dispersion model, two distinct tasks must be performed:

- A source data file must be constructed. This file will contain a physical description of the source or sources to be modeled (i.e. stack height, stack diameter, emission rate, etc.).
- The model options must be specified. These are the options required by the model for each run (i.e. rural or urban dispersion coefficients, gradual or final plume rise, receptor locations, meteorological data, etc.).

The UNAMAP6 version of the PTPLU-2.0 contains a "regulatory default switch". The regulatory default switch sets the following model options according to EPA guidelines:

OPTIONS	EPA GUIDELINE
Use Gradual Plume Rise	No
Use Stack Tip Downwash	Yes
Use Buoyancy Induced Dispersion	Yes
Wind Profile Exponents	As listed

In this modeling session, EES utilized the EPA guidelines.

C.3 Air Dispersion Modeling Predictions

Table C-1 is the output from an air stripper exit benzene discharge of 0.64 lb/day. Calculations using the maximum benzene concentration from Table C-1 resulted in an annual average impact greater than 1 x 10^{-6}. A second modeling was done to determine a benzene discharge that would result in an annual average impact value of less than the allowable 1 x 10^{-6}, resulting in the output Table C-2.

The tables provide data for six stability cases. The stability cases are a function of wind speed and direction, as well as solar radiation. Of the six stability cases analyzed, case number 1 is the least stable and 6 is the most stable.

Two sets of data are presented in the tables. The column on the left assumes that wind speed remains constant with height. The column on the right extrapolates wind speed based on altitude. Winds tend to move slower near the ground surface due to friction. EES specified 10 meters as the annemetric height for wind calculations at the top of the air stripper vent gas stack. The computer makes "stack top wind' calculations.

In each of the two columns just described is a list of data at each of the 6 stability cases, including: wind speed, maximum plume concentration (micrograms per cubic meter) at various distances (kilometers) from the source, and plume height (meters).

TABLE C-1

Benzene @ 0.64 Lb/Day

```
        PTPLU-2.0  (DATED 86196)
        AN AIR QUALITY DISPERSION MODEL IN
        SECTION 3. NON-GUIDELINE MODELS.
        IN UNAMAP (VERSION 6) JUL 86
        SOURCE: FILE 21 ON UNAMAP MAGNETIC TAPE FROM NTIS.

        IBM-PC VERSION 1.00
(C) COPYRIGHT 1986, TRINITY CONSULTANTS, INC.
SERIAL NUMBER 5323 SOLD TO ENSCO
RUN BEGAN ON 06-14-89 AT 15:40:49

                                     >>>INPUT PARAMETERS<<<
 *** TITLE***  Shell-Dublin (Benzene at 0.64  lb/day)

 ***OPTIONS***                      ***METEOROLOGY***                                 ***SOURCE***
 IF = 1, USE OPTION                 AMBIENT AIR TEMPERATURE =   283.00 (K)            EMISSION RATE =      .00 (G/SEC)
 IF = 0, IGNORE OPTION              MIXING HEIGHT           =  5000.00 (M)            STACK HEIGHT  =     5.49 (M)
 IOPT(1) = 0 (GRAD PLUME RISE)      ANEMOMETER HEIGHT       =    10.00 (M)            EXIT TEMP.    =   288.71 (K)
 IOPT(2) = 1 (STACK DOWNWASH)       WIND PROFILE EXPONENTS  = A: .15, B: .15, C: .20  EXIT VELOCITY =     1.29 (M/SEC)
 IOPT(3) = 1 (BUOY. INDUCED DISP.)                            D: .25, E: .30, F: .30  STACK DIAM.   =      .30 (M)
 IDFLT   = 1 (1 = USE DEFAULT, 0 = NOT USE DEFAULT)
 MUOR    = 1 (1 = URBAN, 2 = RURAL)
***RECEPTOR HEIGHT*** =      .00 (M)

                                    >>>CALCULATED PARAMETERS<<<
 VOLUMETRIC FLOW =      .09 (M**3/SEC)          BUOYANCY FLUX PARAMETER =      .01 (M**4/SEC**3)


 Shell-Dublin (Benzene at 0.64  lb/day)
                   ****WINDS CONSTANT WITH HEIGHT****        ****STACK TOP WINDS (EXTRAPOLATED FROM  10.0 METERS)****
 STABILITY   WIND SPEED   MAX CONC   DIST OF MAX   PLUME HT      WIND SPEED   MAX CONC   DIST OF MAX    PLUME HT
              (M/SEC)    (UG/CU M)      (KM)          (M)          (M/SEC)   (UG/CU M)      (KM)          (M)
     1           .50        19.81        .023         7.8            .46        20.53        .023         8.0
     1           .80        15.64        .020         6.9            .73        16.46        .021         7.1
     1          1.00        14.14        .019         6.5            .91        14.64        .020         6.7
     1          1.50        11.59        .017         5.9           1.37        12.16        .018         6.0
     1          2.00         9.72        .016         5.6           1.83        10.28        .017         5.6
     1          2.50         8.34        .016         5.4           2.28         8.89        .016         5.4
     1          3.00         7.29        .015         5.2           2.74         7.79        .016         5.3
                   ****WINDS CONSTANT WITH HEIGHT****        ****STACK TOP WINDS (EXTRAPOLATED FROM  10.0 METERS)****
 STABILITY   WIND SPEED   MAX CONC   DIST OF MAX   PLUME HT      WIND SPEED   MAX CONC   DIST OF MAX    PLUME HT
              (M/SEC)    (UG/CU M)      (KM)          (M)          (M/SEC)   (UG/CU M)      (KM)          (M)
     2           .50        19.81        .023         7.8            .46        20.53        .023         8.0
     2           .80        15.64        .020         6.9            .73        16.46        .021         7.1
     2          1.00        14.14        .019         6.5            .91        14.64        .020         6.7
     2          1.50        11.59        .017         5.9           1.37        12.16        .018         6.0
     2          2.00         9.72        .016         5.6           1.83        10.28        .017         5.6
     2          2.50         8.34        .016         5.4           2.28         8.89        .016         5.4
     2          3.00         7.29        .015         5.2           2.74         7.79        .016         5.3
     2          4.00         5.82        .015         5.1           3.66         6.26        .015         5.1
     2          5.00         4.83        .015         5.0           4.57         5.22        .015         5.0
                   ****WINDS CONSTANT WITH HEIGHT****        ****STACK TOP WINDS (EXTRAPOLATED FROM  10.0 METERS)****
 STABILITY   WIND SPEED   MAX CONC   DIST OF MAX   PLUME HT      WIND SPEED   MAX CONC   DIST OF MAX    PLUME HT
              (M/SEC)    (UG/CU M)      (KM)          (M)          (M/SEC)   (UG/CU M)      (KM)          (M)
     3          2.00        11.69        .020         5.6           1.77        12.62        .020         5.7
     3          2.50        10.04        .019         5.4           2.22        10.91        .019         5.5
     3          3.00         8.77        .019         5.2           2.66         9.60        .019         5.3
     3          4.00         7.01        .018         5.1           3.55         7.72        .018         5.1
     3          5.00         5.82        .018         5.0           4.43         6.44        .018         5.0
     3          7.00         4.35        .017         4.9           6.21         4.84        .017         4.9
```

TABLE C-1 Cont'd.

Benzene @ 0.64 Lb/Day

```
   3         10.00       3.16       .017       4.8            8.87       3.52       .017       4.8
   3         12.00       2.66       .017       4.8           10.64       2.98       .017       4.8
   3         15.00       2.16       .017       4.7           13.30       2.42       .017       4.7

                 ****WINDS CONSTANT WITH HEIGHT****       ****STACK TOP WINDS (EXTRAPOLATED FROM  10.0 METERS)****
STABILITY  WIND SPEED  MAX CONC  DIST OF MAX   PLUME HT      WIND SPEED  MAX CONC  DIST OF MAX   PLUME HT
            (M/SEC)   (UG/CU M)     (KM)         (M)          (M/SEC)   (UG/CU M)     (KM)         (M)
   4           .50      22.77       .039       7.8             .43      24.10       .041       8.2
   4           .80      18.01       .035       6.9             .69      19.58       .036       7.2
   4          1.00      16.30       .033       6.5             .86      17.24       .035       6.8
   4          1.50      13.38       .030       5.9            1.29      14.50       .031       6.1
   4          2.00      11.23       .028       5.6            1.72      12.34       .029       5.7
   4          2.50       9.64       .027       5.4            2.15      10.70       .028       5.5
   4          3.00       8.43       .027       5.2            2.58       9.42       .027       5.3
   4          4.00       6.73       .026       5.1            3.44       7.59       .026       5.2
   4          5.00       5.60       .025       5.0            4.30       6.34       .026       5.0
   4          7.00       4.18       .025       4.9            6.03       4.77       .025       4.9
   4         10.00       3.03       .024       4.8            8.61       3.47       .024       4.8
   4         12.00       2.56       .024       4.8           10.33       2.94       .024       4.8
   4         15.00       2.08       .024       4.7           12.91       2.39       .024       4.7
   4         20.00       1.58       .024       4.7           17.22       1.82       .024       4.7
                 ****WINDS CONSTANT WITH HEIGHT****       ****STACK TOP WINDS (EXTRAPOLATED FROM  10.0 METERS)****
STABILITY  WIND SPEED  MAX CONC  DIST OF MAX   PLUME HT      WIND SPEED  MAX CONC  DIST OF MAX   PLUME HT
            (M/SEC)   (UG/CU M)     (KM)         (M)          (M/SEC)   (UG/CU M)     (KM)         (M)
   5          2.00       3.32       .084       9.1            1.67       3.70       .087       9.5
   5          2.50       2.89       .081       8.8            2.09       3.24       .083       9.0
   5          3.00       2.57       .078       8.5            2.51       2.89       .081       8.7
   5          4.00       2.13       .074       8.1            3.34       2.40       .077       8.3
   5          5.00       1.82       .072       7.8            4.18       2.06       .074       8.0
                 ****WINDS CONSTANT WITH HEIGHT****       ****STACK TOP WINDS (EXTRAPOLATED FROM  10.0 METERS)****
STABILITY  WIND SPEED  MAX CONC  DIST OF MAX   PLUME HT      WIND SPEED  MAX CONC  DIST OF MAX   PLUME HT
            (M/SEC)   (UG/CU M)     (KM)         (M)          (M/SEC)   (UG/CU M)     (KM)         (M)
   6          2.00       3.92       .077       8.4            1.67       4.39       .080       8.7
   6          2.50       3.39       .074       8.1            2.09       3.81       .077       8.4
   6          3.00       3.00       .072       7.9            2.51       3.38       .074       8.1
   6          4.00       2.46       .069       7.5            3.34       2.79       .071       7.7
   6          5.00       2.10       .067       7.3            4.18       2.39       .069       7.5
(1) THE DISTANCE TO THE POINT OF MAXIMUM CONCENTRATION IS SO GREAT THAT THE SAME STABILITY IS NOT LIKELY
        TO PERSIST LONG ENOUGH FOR THE PLUME TO TRAVEL THIS FAR.
(2) THE PLUME IS CALCULATED TO BE AT A HEIGHT WHERE CARE SHOULD BE USED IN INTERPRETING THE COMPUTATION.
(3) NO COMPUTATION WAS ATTEMPTED FOR THIS HEIGHT AS THE POINT OF MAXIMUM CONCENTRATION IS GREATER THAN 100 KILOMETERS
        FROM THE SOURCE.
RUN ENDED ON 06-14-89 AT 15:41:00
^Z
```

TABLE C-2

Benzene @ 0.005 Lb/Day

```
PTPLU-2.0  (DATED 86196)
AN AIR QUALITY DISPERSION MODEL IN
SECTION 3. NON-GUIDELINE MODELS.
IN UNAMAP (VERSION 6) JUL 86
SOURCE: FILE 21 ON UNAMAP MAGNETIC TAPE FROM NTIS.

IBM-PC VERSION 1.00
(C) COPYRIGHT 1986, TRINITY CONSULTANTS, INC.
SERIAL NUMBER 5323 SOLD TO ENSCO
RUN BEGAN ON 06-14-89 AT 15:39:16

                                        >>>INPUT PARAMETERS<<<
 *** TITLE***  Shell-Dublin (Benzene at 0.005  lb/day)

 ***OPTIONS***                     ***METEOROLOGY***                                ***SOURCE***
 IF = 1, USE OPTION                AMBIENT AIR TEMPERATURE =   283.00 (K)           EMISSION RATE =      .00 (G/SEC)
 IF = 0, IGNORE OPTION             MIXING HEIGHT           =  5000.00 (M)           STACK HEIGHT  =     5.49 (M)
 IOPT(1) = 0 (GRAD PLUME RISE)     ANEMOMETER HEIGHT       =    10.00 (M)           EXIT TEMP.    =   288.71 (K)
 IOPT(2) = 1 (STACK DOWNWASH)      WIND PROFILE EXPONENTS  = A: .15, B: .15, C: .20  EXIT VELOCITY =     1.29 (M/SEC)
 IOPT(3) = 1 (BUOY. INDUCED DISP.)                            D: .25, E: .30, F: .30  STACK DIAM.   =      .30 (M)
 IDFLT   = 1 (1 = USE DEFAULT, 0 = NOT USE DEFAULT)
 MUOR    = 1 (1 = URBAN, 2 = RURAL)
***RECEPTOR HEIGHT*** =       .00 (M)

                                      >>>CALCULATED PARAMETERS<<<
 VOLUMETRIC FLOW =       .09 (M**3/SEC)          BUOYANCY FLUX PARAMETER =       .01 (M**4/SEC**3)


 Shell-Dublin (Benzene at 0.005  lb/day)
                    ****WINDS CONSTANT WITH HEIGHT****          ****STACK TOP WINDS (EXTRAPOLATED FROM  10.0 METERS)****
 STABILITY   WIND SPEED   MAX CONC   DIST OF MAX     PLUME HT       WIND SPEED   MAX CONC   DIST OF MAX    PLUME HT
              (M/SEC)    (UG/CU M)      (KM)           (M)           (M/SEC)    (UG/CU M)      (KM)           (M)
     1          .50         .16         .023           7.8             .46         .16         .023          8.0
     1          .80         .12         .020           6.9             .73         .13         .021          7.1
     1         1.00         .11         .019           6.5             .91         .12         .020          6.7
     1         1.50         .09         .017           5.9            1.37         .10         .018          6.0
     1         2.00         .08         .016           5.6            1.83         .08         .017          5.6
     1         2.50         .07         .016           5.4            2.28         .07         .016          5.4
     1         3.00         .06         .015           5.2            2.74         .06         .016          5.3
                    ****WINDS CONSTANT WITH HEIGHT****          ****STACK TOP WINDS (EXTRAPOLATED FROM  10.0 METERS)****
 STABILITY   WIND SPEED   MAX CONC   DIST OF MAX     PLUME HT       WIND SPEED   MAX CONC   DIST OF MAX    PLUME HT
              (M/SEC)    (UG/CU M)      (KM)           (M)           (M/SEC)    (UG/CU M)      (KM)           (M)
     2          .50         .16         .023           7.8             .46         .16         .023          8.0
     2          .80         .12         .020           6.9             .73         .13         .021          7.1
     2         1.00         .11         .019           6.5             .91         .12         .020          6.7
     2         1.50         .09         .017           5.9            1.37         .10         .018          6.0
     2         2.00         .08         .016           5.6            1.83         .08         .017          5.6
     2         2.50         .07         .016           5.4            2.28         .07         .016          5.4
     2         3.00         .06         .015           5.2            2.74         .06         .016          5.3
     2         4.00         .05         .015           5.1            3.66         .05         .015          5.1
     2         5.00         .04         .015           5.0            4.57         .04         .015          5.0
                    ****WINDS CONSTANT WITH HEIGHT****          ****STACK TOP WINDS (EXTRAPOLATED FROM  10.0 METERS)****
 STABILITY   WIND SPEED   MAX CONC   DIST OF MAX     PLUME HT       WIND SPEED   MAX CONC   DIST OF MAX    PLUME HT
              (M/SEC)    (UG/CU M)      (KM)           (M)           (M/SEC)    (UG/CU M)      (KM)           (M)
     3         2.00         .09         .020           5.6            1.77         .10         .020          5.7
     3         2.50         .08         .019           5.4            2.22         .09         .019          5.5
     3         3.00         .07         .019           5.2            2.66         .08         .019          5.3
     3         4.00         .06         .018           5.1            3.55         .06         .018          5.1
     3         5.00         .05         .018           5.0            4.43         .05         .018          5.0
     3         7.00         .03         .017           4.9            6.21         .04         .017          4.9
```

TABLE C-2 Cont'd.

Benzene @ 0.005 Lb/Day

```
     3          10.00         .02        .017       4.8            8.87        .03       .017        4.8
     3          12.00         .02        .017       4.8           10.64        .02       .017        4.8
     3          15.00         .02        .017       4.7           13.30        .02       .017        4.7

                   ****WINDS CONSTANT WITH HEIGHT****          ****STACK TOP WINDS (EXTRAPOLATED FROM  10.0 METERS)****
 STABILITY   WIND SPEED   MAX CONC   DIST OF MAX   PLUME HT       WIND SPEED   MAX CONC   DIST OF MAX   PLUME HT
               (M/SEC)   (UG/CU M)      (KM)         (M)            (M/SEC)   (UG/CU M)      (KM)         (M)
     4            .50         .18        .039       7.8             .43        .19       .041        8.2
     4            .80         .14        .035       6.9             .69        .15       .036        7.2
     4           1.00         .13        .033       6.5             .86        .14       .035        6.8
     4           1.50         .11        .030       5.9            1.29        .11       .031        6.1
     4           2.00         .09        .028       5.6            1.72        .10       .029        5.7
     4           2.50         .08        .027       5.4            2.15        .08       .028        5.5
     4           3.00         .07        .027       5.2            2.58        .07       .027        5.3
     4           4.00         .05        .026       5.1            3.44        .06       .026        5.2
     4           5.00         .04        .025       5.0            4.30        .05       .026        5.0
     4           7.00         .03        .025       4.9            6.03        .04       .025        4.9
     4          10.00         .02        .024       4.8            8.61        .03       .024        4.8
     4          12.00         .02        .024       4.8           10.33        .02       .024        4.8
     4          15.00         .02        .024       4.7           12.91        .02       .024        4.7
     4          20.00         .01        .024       4.7           17.22        .01       .024        4.7
                   ****WINDS CONSTANT WITH HEIGHT****          ****STACK TOP WINDS (EXTRAPOLATED FROM  10.0 METERS)****
 STABILITY   WIND SPEED   MAX CONC   DIST OF MAX   PLUME HT       WIND SPEED   MAX CONC   DIST OF MAX   PLUME HT
               (M/SEC)   (UG/CU M)      (KM)         (M)            (M/SEC)   (UG/CU M)      (KM)         (M)
     5           2.00         .03        .084       9.1            1.67        .03       .087        9.5
     5           2.50         .02        .081       8.8            2.09        .03       .083        9.0
     5           3.00         .02        .078       8.5            2.51        .02       .081        8.7
     5           4.00         .02        .074       8.1            3.34        .02       .077        8.3
     5           5.00         .01        .072       7.8            4.18        .02       .074        8.0
                   ****WINDS CONSTANT WITH HEIGHT****          ****STACK TOP WINDS (EXTRAPOLATED FROM  10.0 METERS)****
 STABILITY   WIND SPEED   MAX CONC   DIST OF MAX   PLUME HT       WIND SPEED   MAX CONC   DIST OF MAX   PLUME HT
               (M/SEC)   (UG/CU M)      (KM)         (M)            (M/SEC)   (UG/CU M)      (KM)         (M)
     6           2.00         .03        .077       8.4            1.67        .03       .080        8.7
     6           2.50         .03        .074       8.1            2.09        .03       .077        8.4
     6           3.00         .02        .072       7.9            2.51        .03       .074        8.1
     6           4.00         .02        .069       7.5            3.34        .02       .071        7.7
     6           5.00         .02        .067       7.3            4.18        .02       .069        7.5
(1) THE DISTANCE TO THE POINT OF MAXIMUM CONCENTRATION IS SO GREAT THAT THE SAME STABILITY IS NOT LIKELY
     TO PERSIST LONG ENOUGH FOR THE PLUME TO TRAVEL THIS FAR.
(2) THE PLUME IS CALCULATED TO BE AT A HEIGHT WHERE CARE SHOULD BE USED IN INTERPRETING THE COMPUTATION.
(3) NO COMPUTATION WAS ATTEMPTED FOR THIS HEIGHT AS THE POINT OF MAXIMUM CONCENTRATION IS GREATER THAN 100 KILOMETERS
     FROM THE SOURCE.
RUN ENDED ON 06-14-89 AT 15:39:27
```

APPENDIX "D"

Available Criteria For Toxic Substances

Department of Health Services

California

Memorandum

To : All Section Chiefs
Toxic Substances Control Division

Date : March 17, 1986

Subject: Available Criteria for Toxic Substances

From : David J. Leu, Ph.D., Chief David J. Leu
Alternative Technology and Policy
Development Section
Toxic Substances Control Division
324-1807

3-990
MAR 18 1986
CALIFORNIA
DEPARTMENT OF HEALTH
SERVICES
RECEIVED

A list of applied Action Levels (AALs) and similar criteria for toxic substances is attached. Criteria which are AALs are indicated in the table by reference to Reference 4. This list can be employed in conjunction with the Decision Tree to evaluate a waste site. These criteria are specific for air or water and should be employed only in Test One in the Risk Appraisal and Risk Determination process (Decision Tree, p. 7-3). ATPDS takes full responsibility for defending the bases of the AALs in the list. Responsibility for other criteria, which are not AALs, rests with the promulgating agency(s).

At present, no governmental agency appears to have developed criteria for direct contact with soil. ATPDS is addressing this problem and plans to be the first agency to develop criteria for soil.

Note: units for air values are given ug/m^3.

To convert to ppm or ppb values use the following equations.

1) $$ppm = \frac{ug/m^3 x 24.5}{10^3 x MW}$$

2) $$ppb = \frac{ug/m^3 x 24.5}{MW}$$

where MW is molecular weight of the substance at standard temperature and pressure (i.e. 25 C and 1 atmosphere of pressure).

While AALs undergo continued development these criteria on the attached list can be employed within the Decision Tree process. This temporary measure has been the practice for addressing waste sites to date and should continue while new AAL's are established.

DJL:JW:ej

Attachment

(see cc next page)

cc: Jim Jenkins, Chief
Toxic Substances Control Division

C. David Willis, DHS
Deputy Director

Alex Cunningham, DHS
Chief Deputy Director

Alexander Kelter, M.D., Chief
Epidemiology & Toxicology Branch
714 P Street, Room 450

bcc: All Decision Tree Staff

REFERENCES

Draft Health Advisories. Office of Drinking Water.
US Environmental Protection Agency. Washington, DC September 30, 1985.

2. Ambient Water Quality Criteria Documents.
Office of Water Regulations and Standards.
US Environmental Protection Agency. Washington, DC.
October, 1980. (values adjusted for drinking water)

3. Draft Health Effects Assessment Documents.
Office of Emergency and Remedial Response.
Office of Environmental Criteria and Assessment.
US Environmental Protection Agency
Cinncinnati, OH. September 1984.

4. Toxicology Unit. Alternative Technology and Policy Development Section.
Toxic Substances Control Division.
California Department of Health Services.
Sacramento, CA 1985. March 1986.

5. Sanitary Engineering Branch
California Department of Health Services. Berkeley, CA 1985.

6. National Primary Drinking Water Regulations.
40 CFR Parts 141 and 142. Federal Register
49 (114): 24330 - 24355, June 12, 1984 and
50 (219): 46880 - 47025, November 13, 1985.

Table Criteria

TABLE D-1
AVAILABLE CRITERIA
FOR TOXIC SUBSTANCES

Compound	Air (ug/m3)	Ref	Water (ug/L)	Ref	Soil Contact (ug/L)
Acenapthene	1.9	4	19	4	NA
Acenaphthylene	1.9	4	19	4	NA
Acetone	20,000	3	NA		NA
Acrolein	NA		320	2	NA
Acrylamide	NA		1E-2 [a]	1	NA
Acrylonitrile	NA		6E-2	2	NA
Alachlor	NA		1.5E-1	1	NA
Aldicarb	NA		10	5	NA
Aldrin	NA		5E-2 (LOQ)	5	NA
Antimony	NA		145	2	NA
Arsenic	7E-5	3	2E-3	2	NA
Barium	5E-1	3	10	3	NA
Baygon	NA		90	5	NA
Benzene	1.3E-1	3	7E-1	1,5	NA
Benzo(a)pyrene	5.7E-4	3	2.9E-3	3	NA
Benzidine	NA		1.5E-4	2	NA
Beryllium	NA		3.9E-3	2	NA
Bolero *	NA		1	5	NA
Cadmium	4.5E-4	3	10	6	NA
Captan	NA		350	5	NA
Carbofuran	NA		36	1	NA
Carbon tetrachloride	NA		5	5	NA
Chlordane	NA		5E-2	5	NA
Chlorobenzene	20	3	490	3	NA
Chloroform	NA		5E-1	3	NA
Chlorophenol *	NA		1E-1	2	NA
Chromium III	18	3	51,000	3	NA
Chromium VI	8.5E-5	3	170	3	NA
CIPC	NA		350	5	NA
Copper	35	3	1300	3	NA
Cyanide	NA		750	1	NA
2,4-D	NA		70	1	NA
1,2-Dibromo-3-chloropane (DBCP)	NA		2.5E-2	1	NA
1,2-Dichlorobenzene *	NA		10	5	NA
1,3-Dichlorobenzene *	NA		20	5	NA
1,4-Dichlorobenzene *	NA		3E-1	5	NA
Dichlorobenzidine	NA		2E-2	2	NA
1,1-Dichloroethane	480	3	4,000	3	NA
1,2-Dichloroethane	NA		5.1E-1	3	NA
1,1-Dichloroethylene	2.3E-2	5	0.1-0.4(LOQ)	5	NA
1,2-cis -Dichloroethylene	NA		70	1	NA
1,2-trans -Dichloroethylene	NA		70	1	NA
Dichloromethane	NA		10	5	NA
1,2-Dichloropropane	NA		10	5	NA
2,4-Dichlorophenol *	NA		3E-1	2	NA

Table D-1 cont'd.

Compound	Air (ug/m3)	Ref	Water (ug/L)	Ref	Soil Contact (ug/L)
DDT	NA		4.2E-3 [a]	3	NA
Dieldrin	NA		5E-2 (LCQ)	5	NA
Diazinon	NA		14	5	NA
Dimethoate	NA		140	5	NA
2,4-Dimethylphenol *	NA		400	5	NA
Dinitrotoluene	NA		1.1E-1	2	NA
p -Dioxane	NA		568	1	NA
p -Dioxin	NA		2.2E-7	1	NA
Diphenamide	NA		40	5	NA
Diphenylhydrazine	NA		4.5E-2	2	NA
Endosulfan	NA		140	2	NA
Endrin	NA		2E-1	6	NA
Epichlorohydrin	NA		3.5	1	NA
Ethion	NA		35	5	NA
Ethylbenzene	NA		680	1	NA
Ethylene dibromide (EDB)	NA		5E-2 (LCQ)	5	NA
Ethylene glycol	NA		5500	1	NA
Fluoranthene	NA		42	2	NA
Formaldehyde	NA		30	5	NA
Glyphosate	NA		500	5	NA
Heptachlor	NA		1E-2	1	NA
Heptachlor epoxide	NA		6E-4	1	NA
Hexachlorobenzene	NA		2E-2	1,3	NA
Hexachlorobutadiene	NA		4.5E-1	3	NA
Hexachlorocyclohexane	NA		4E-3	6	NA
Hexachlorocyclopentadiene *	2.3E-1	3	1	2	NA
n -Hexane	NA		4000	1	NA
Iron	NA		30	3	NA
Isophorone	NA		5200	2	NA
Lead	1.5	3	10	1	NA
Malathion			160	5	NA
Manganese	1	3	7700	3	NA
Mercury (all forms)	1.8E-1	3	2	6	NA
Methoxychlor	NA		100	6	NA
Methyl Ethyl Ketone	NA		172	1	NA
Methyl parathion	NA		30	5	NA
Naphthalene	1.8	4	18	4	NA
Nickel	2.9E-3	3	150	1	NA
Nitrobenzene *	NA		30	2	NA
Ordram	NA		20	5	NA
Oxamyl	NA		160	1	NA
Parathion (ethyl parathion)	NA		30	5	NA
Polychlorinated biphenyls (PCB's)	NA		8.1E-3	3	NA
Pentachlorophenol	NA		30	5	NA
Phenanthrene	1.9	4	19	4	NA
Phenol *	70	3	1	5	NA
Pyrene	1.9	4	19	4	NA
Selenium	3.5	3	10	6	NA
Silver	NA		50	6	NA
Styrene	NA		1.4E-2	1	NA

Table D-1 cont'd.

Compound	Air (ug/m3)	Ref	Water (ug/L)	Ref	Soil Contact (ug/L)
2,4,5-TP (Silvex)	NA		10	6	NA
Terrachlor	NA		9E-1 [a]	5	NA
1,1,2,2-Tetrachloroethane (PCA)	NA		1.7E-1	3	NA
Tetrachloroethylene (PCE)	NA		8.7E-1	3	NA
Toluene	200	4	100	5	NA
Toxaphene	NA		35	2	NA
1,1,1-Trichloroethane	310	4	200	5	NA
1,1,2-Trichloroethane	NA		6.1E-1	3	NA
Trichloroethylene	5.8E-1	3	1.8	3	NA
2,4,5-Trichlorophenol	NA		3500	3	NA
2,4,6-Trichlorophenol	NA		1.7	3	NA
Trithion	NA		7	5	NA
Vinyl chloride	1.4E-1	3	1.5E-2	3	NA
Xylene	100	4	620	5	NA
Zinc	35	3	7400	3	NA

[a] Notation such as 1E-2, 4.2E-3, 9E-1 means 1×10^{-2}, 4.2×10^{-3}, 9×10^{-1}, respectively

- Not Available

- Limit of Quantification

Based on oder or taste threshold

APPENDIX "E"

Cost Analysis

Alternative Remediation Techniques

APPENDIX E

Cost Analysis
Alternative Remediation Techniques

E.1 Summary

Based on the results of computer air dispersion modeling in the area around the site, the air stripper discharge air requires polishing to meet BAAQMD's requirements.

Five (5) alternative groundwater treatment methods were considered:

- Air Stripper / Vapor-Phase Carbon Adsorption
- Air Stripper / Gas-Fueled Catalytic Incineration
- Air Stripper / Electric-Powered Catalytic Incineration
- UV / Peroxidation
- Liquid-Phase Carbon Adsorption

The last two (2) methods involve no air stripper, and therefore do not require any air polishing. All of these groundwater remediation methods have similar removal efficiencies. Therefore, any recommendation on which alternative should be selected will be based primarily on the capital and operating costs of each.

Since the influent groundwater BTX concentrations are low, one to three years operation is expected. The following table shows the cost analysis summary:

ANNUAL COST

Alternative	One Year	Two Years	Three Years
With Air Stripper:			
Vapor-Phase Carbon	$ 89,130	$53,850	$42,080
Gas Incinerator	151,310	91,810	71,670
Elec. Incinerator	163,600	93,600	69,960

Without Air Stripper:			
Liquid-Phase Carbon	97,450	94,350	89,880
UV/Peroxidation	100,400	90,400	87,070

E.2 Calculations

E.2.1 Air Stripper / Carbon Adsorption

Air Stripper Installed Cost = $46,000
Carbon Bed Cost Basis: Westates Carbon data and quotes

Assume: 3 units in series, 1000 lbs/unit
carbon usage = 11 lbs/day
life of one unit = 90 days; reactivated after 90 days
cost/unit = $8190
cost of reactivation/unit = $3280

For Two-Year Operation:

- Air Stripper Capital Cost = $46,000/2 = $23,000/Yr
- Air Stripper Maintenance = 4,800/Yr
- Cost of 3 new units = $8190 x 3 = $24,570
  Cost of 3 new units/yr = $24,570/2 = 12,290/Yr
- Cost of reactivation = $3280 x 4 = 13,120/Yr
- Cost of carbon change labor/year
  = 4 hrs x 4 timers/yr x $40/hr = 640/Yr

TOTAL = $53,850/YR

For Three-Year Operation:

- Air Stripper Capital Cost = $46,000/3 = $15,330/Yr
- Air Stripper Maintenance = 4,800/Yr
- Cost of 3 new units = $24,570/3 = 8,190/Yr

- Cost of reactivation = $3280 x 4 = 13,120/Yr
- Cost of carbon change labor/year = 640/Yr

TOTAL = $42,080/YR

E.2.2 GAS INCINERATION

Based on EES Incinerator Model No. CI-101 Specifications.
Capital Cost = $73,000

Fuel Consumption: 500,000 Btu/hr
Assume: Contribution by soil vent gas negligible.

Gas cost = $0.50/therm (1 them = 100,000 Btu/hr)
(Per telecon with PG & E)

$$\text{Gas Cost} = \frac{500{,}000 \text{ Btu/hr}}{100{,}000 \text{ Btu/hr per therm}} \times \$0.50 / \text{therm} = \$2.50 / \text{hr}$$

or $21,900/yr

Periodic System Evaluation:

Weeks 1 - 4 : Technician = 20 hrs • $40/hr = $ 800
Staff Engineer = 8 hrs • $55/hr = 440
Months 2 - 3 : Technician = 5 hrs • $40/hr = 200
Staff Engineer = 2 hrs • $55/hr = 110
Months 4 -12 : Technician = 15 hrs • $40/hr = 600
Staff Engineer = 6 hrs • $55/hr = 330
First-Year Total = $2,480
15% Contingency = 370
FIRST-YEAR TOTAL= $2,850

Second Year and Thereafter
= 1.15(600 + 330) = $1,070

Maintenance Cost:

Assume 5% of capital investment cost

For Two-Year Operation:

• Air Stripper Capital Cost		= $23,000/Yr
• Air Stripper Maintenance		= 4,800/Yr
• Capital Cost / Yr = $73,000/2		= 36,500/Yr
• Fuel Cost = $3280 x 4		= 21,900/Yr
• System Evaluation = (2,850 + 1,070) / 2		= 1,960/Yr
• Maintenance = 0.05 • 73,000		= 3,650/Yr
	TOTAL	**= $91,810/YR**

For Three-Year Operation:

• Air Stripper Capital Cost		= $15,330/Yr
• Air Stripper Maintenance		= 4,800/Yr
• Capital Cost / Yr = $73,000/3		= 24,330/Yr
• Fuel Cost		= 21,900/Yr
• System Evaluation = (2,850 + 2•1,070) / 3		= 1,660/Yr
• Maintenance		= 3,650/Yr
	TOTAL	**= $71,670/YR**

E.2.3 ELECTRIC INCINERATION

Based on ORS Catalytic Scavenger Specifications.

Capital Cost = $64,000

Installation Cost = $30,000

Power Consumption = 0.21 kwhr/min • 60 • 24 • 365 • $0.11/kwhr

= $12,140/yr

System Evaluation Cost: assumed the same as the cost for the gas incinerator

For Two-Year Operation:

- Air Stripper Capital Cost = $23,000/Yr
- Air Stripper Maintenance = 4,800/Yr
- Capital Cost = $94,000/2 = 47,000/Yr
- Fuel Cost = 12,140/Yr
- System Evaluation = 1,960/Yr
- Maintenance = 0.05 • 94,000 = 4,700/Yr

TOTAL = $93,600/YR

For Three-Year Operation:

- Air Stripper Capital Cost = $15,330/Yr
- Air Stripper Maintenance = 4,800/Yr
- Capital Cost / Yr = $94,000/3 = 31,330/Yr
- Fuel Cost = 12,140/Yr
- System Evaluation Cost = 1,660/Yr
- Maintenance Cost = 4,700/Yr

TOTAL = $69,960/YR

E.2.4 UV/PEROXIDATION

Costs based on *"Groundwater with Zero Air Emissions"* by Peroxidation Systems Systems, Inc. (Case Study 1, Table 5).

Full Service Agreement Annual Fee (includes H_2O_2, equipment, maintenance, emergency service, monthly operating report) = $54,400

Installation Cost = $20,000
Maintenance Cost : included in service agreement
Electric Power/Yr = $26,000

For Two-Year Operation:

- Annual Service Agreement = $54,400/Yr
- Annual Installation Charge = $20,000/2 = 10,000/Yr
- Annual Electric Power = 26,000/Yr

TOTAL = $90,400/YR

For Three-Year Operation:

- Annual Service Agreement = $54,400/Yr
- Annual Installation Charge = $20,000/3 = 6,670/Yr
- Annual Electric Power = 26,000/Yr

TOTAL = $87,070/YR

This unit requires 480 VAC, 3-phase power, which is not available on this site.

E.2.5 LIQUID-PHASE CARBON ADSORPTION

From Section B.1, Appendix B, the estimated carbon usage is 83 lbs/day. For a 2000-lb unit,

changeout = 2000 lbs/(83 lbs/day)
= 24 days
annual no. of changeouts = 365/24
= 15

changeout cost/unit = $5,150 (based on regeneration by Westates Carbon)
annual changeout cost = $5,150 • 15
= $77,250

capital cost/unit = $11,400
capital cost for 2 units = $22,800

Other mechanical/electrical equipment = $4,000

Total first-year capital cost = $26,800

Assume annual O & M = 5% of capital cost = $26,800 • 0.05
= $1,300

Cost of carbon change labor/yr = 4 hrs • 15 times/yr • $40/hr
= $2,400

For Two-Year Operation:

- Capital Cost = $26,800/2 = $13,400/Yr
- Cost of reactivation = 77,250/Yr
- Maintenance cost = 1,300/Yr
- Cost of carbon change labor/yr = 2,400/Yr

TOTAL = $94,350/YR

For Three-Year Operation:

- Capital Cost = $26,800/3 = $ 8,930/Yr
- Cost of reactivation = 77,250/Yr
- Maintenance cost = 1,300/Yr
- Cost of carbon change labor/yr = 2,400/Yr

TOTAL = $89,880/YR