RSI REMEDIATION SERVICE, INT'L.

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Further Site Assessment and Remediation Work Plan
for
Desert Petroleum Station #796 (dba Arco)
2844 Mountain Boulevard
Oakland, California

prepared for
Desert Petroleum, Inc.
2060 Knoll Drive
Ventura, CA 93003

prepared by
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1.0 INTRODUCTION

This work plan details further site assessment and remediation at Desert Petroleum's station #796. This station operates under the Arco trade name and is located at 2844 Mountain Boulevard, Oakland, Alameda County, California (Figure 1). Soil and groundwater containing elevated levels of hydrocarbons were discovered during the earlier work onsite. Remediation Service, Int'l (RSI) has been retained to further delineate and remediate the gasoline contamination.

1.1 Site Description

The site is occupied by a retail gasoline outlet supplying regular, regular-unleaded and super-unleaded gasolines. The gasoline underground storage tanks have capacities of 3,000 gallons (super unleaded), 4,000 gallons (regular) and 10,000 gallons (regular unleaded). Surface improvements include a cashiers building, two pump islands and canopy (Figure 2).

1.2 Background Summary

Soil contamination was initially identified during replacement of the gasoline supply lines. Four soil samples were collected from beneath the previous supply lines, in the vicinity of the fuel pumps, under the direction of Alameda County Health Care Services personnel. Laboratory analysis of the samples showed total petroleum hydrocarbon (TPH) concentrations ranging from 8 to 87 parts per million (ppm). An additional sample taken near the edge of the super unleaded tank had a TPH concentration of 8,400 ppm.

The next phase of characterization was conducted by On-Site Technologies. Their excavation work was completed between July 7 and August 18, 1989. Soil was removed from the south end of the super unleaded tank, creating a hole approximately 9 feet in radius and 12 feet deep. All excavated dirt was stockpiled onsite in three separate locations. Soils uncovered by the excavation consisted of clays and gravelly clays. Groundwater flowed into the excavation and stabilized at 8.5 to 8.7 feet below grade.

Laboratory analyses of soil and water samples indicated a fairly confined plume of hydrocarbon contamination in the soil at the southern end of the super-unleaded tank. TPH concentrations for soil samples from the excavation ranged from 2 to 3,300 ppm. A groundwater sample obtained from the excavation contained a TPH concentration of 160 ppm.

On May 29 and 30, 1990 RSI advanced and sampled four (4) soil borings. Each boring was then completed as a 4-inch PVC-cased groundwater monitoring well. Samples showed low to moderate concentrations of hydrocarbons, 1 to 240 ppm, in the soil column. Groundwater occurs at very shallow depths beneath the site, 6 to 8.3 feet. Hydrocarbon analyses done on groundwater samples found elevated levels of contamination in all wells. TPH values ranged from 0.33 ppm (RS-3) to 23 ppm (RS-2).

2.0 FURTHER SITE ASSESSMENT

Under the supervision of an RSI geologist, one 12 hour pump test and four slug tests will be conducted. Data will be gathered to evaluate individual well and general "aquifer" characteristics. These test results will then be used to determine the adequacy of the existing wells to remediate the groundwater contamination. The details of the groundwater cleanup will be outlined in a groundwater assessment report.

3.0 REMEDIATION

Contaminated soil and groundwater at this site will be remediated using vapor extraction and spray aeration techniques. Vapor extraction is an effective and economical method to remediate gasoline contamination.

3.1 Remediation Equipment

RSI's S.A.V.E. System (shown in Appendix C) is proposed to remediate gasoline contaminated soils and groundwater at this site.

The S.A.V.E. System is a blending of three separate types of remediation which are more efficient than the three systems alone. These systems are as follows:

1. Vapor extraction from soil.

2. Spray aeration treatment of groundwater.

3. Thermal oxidation using an engine for combusting hydrocarbon-laden vapors and a catalytic converter to control emissions.

The soil vapor extraction system consists of a vacuum pump driven by an internal combustion engine. The engine powers a vacuum pump which is connected to one or more extraction wells. Placing a vacuum on the well, or wells, causes an air flow through the contaminated soil and into the well. The air flow causes the gasoline to be volatilized and entrained in the flow. The vapors are drawn through the well and into the engine where they are burned as fuel. Generally a secondary fuel supply, either propane or natural gas, is necessary. The exhaust is then passed through a catalytic converter to insure complete combustion. Emissions from the engine, even when running on 100% gasoline vapors, meets the air quality standards for motor vehicle engines.

not if well screens are covered as they are here!

Groundwater contamination is remediated by use of a spray aerator. Spray aeration works on the same principle as an air stripper. In an air stripper, air is moved quickly over the surface of hydrocarbon laden water in order to volatilize the hydrocarbons. In spray aeration, hydrocarbon laden water is sprayed through the air inside a tank causing the hydrocarbons to volatilize. However, in the spray aerator there is no packing to foul or replace. To ensure sufficient hydrocarbon removal, the water is recirculated through a second set of spray nozzles. In this part of the system, water-hydrocarbon separation is enhanced by both vacuum and heat. By lowering the air pressure, the temperature at which hydrocarbons vaporize drops. Increasing the temperature further increases the potential for hydrocarbons to vaporize. The RSI spray aerator takes advantage of both of these principles by spraying heated water in a vacuum. The engine provides the energy source for heating the water as well as powering the vacuum pump and downhole water pumps.

As the water level rises in the spray aerator tank from influx of water from the wells, a float will trigger a discharge of an equal amount of remediated water. The level of contaminant reduction can be determined by sampling water influent and effluent. The treated water will then be passed through activated charcoal for final polishing before discharge. At an assumed recovery rate of 5 gpm, there will be an average of 20 cycles through the system before discharge. An 85% - 99% reduction in contaminants per cycle is the normal achieved rate, resulting in final removal rates approaching 100%.

Hydrocarbons extracted from the water in the spray aerator are combined with the vapors drawn out of the wells. The combined vapors are fed directly to the intake of the engine where they are combined with a secondary fuel (either propane or natural gas) and then burned in the engine. The exhaust is passed through a catalytic converter to insure complete combustion.

Exhaust discharge from the engine, even when running on 100% gasoline vapors, meets the air quality standards for motor vehicle engines.

Because the entire system is under vacuum until vapors enter the cylinders of the engine for combustion, any possible leaks of seals or connections are into the system, resulting in no loss of hydrocarbons to the atmosphere. Since the engine is the power source for all other equipment, all systems stop when the engine stops. In addition, to provide for safe and secure operation of this equipment, the following safety elements have been designed into the system:

1. The engine has automatic shutoff features which will shut the entire system down if the engine should overheat or engine oil pressure drops below normal range.
2. The vacuum type fuel pump is mechanically driven by the engine; this ensures that when the engine stops running no more fuel will be pumped.
3. The hoses connecting the extraction wells to the equipment will run underground, when possible, through conduit.
4. All equipment, including the fuel tank, will be enclosed in a fenced compound.

3.2 Work Plan

Vacuum extraction of vapors is generally considered to be most effective within a 10 to 50 foot radius (100 foot diameter) of an extraction well. The zone influenced by the vacuum is thought to extend laterally and above the screened portion of the well. The necessary vapor extraction wells to effectively remediate the gasoline contaminated soils beneath this site have already been installed (Figure 2). Groundwater remediation potential will be evaluated based on the slug test results. If more wells are necessary they will be recommended.

The S.A.V.E. equipment will be installed at the site and surrounded by a security enclosure. All four wells installed at the site will be connected to the S.A.V.E. equipment via underground pipes. RS-1 and -2 will be used to address the contaminated soils to the south and east of the tank pit. All four wells will be used to treat the hydrocarbon dissolved phase, with special emphasis on RS-2.

No phase of this project will commence until the necessary permits and approvals for that phase have been secured.

4.0 Monitoring

After equipment has been installed and the necessary permits and approvals have been received, the system will be put into operation. Remediation at this site is estimated to take from

between 9 and 18 months. However, the time necessary to reduce gasoline concentration in the soil to acceptable levels is site specific and dependent on a number of complex variables. Since some of these variables change throughout the remediation process the estimates are subject to modification based on field data.

In order to track the progress of remediation, vapor samples will be taken at the time the system is initially started up and then at regular intervals thereafter until remediation is complete. The vapor samples will consist of one sample each from selected wells and a combined sample from the intake of the S.A.V.E. equipment. Exhaust samples will be taken as necessary to comply with the conditions of the emissions permit. The samples will be analyzed for TPH and BTEX by a state certified laboratory. Other operating parameters which will be monitored and recorded include: hours of operation, engine rpm, vacuum level and air flow.

Vapor concentrations will tend to decrease rapidly at first because as a vacuum is induced on the wells, large volumes of soil vapors must continually pass through regions of lower pressure in order to enter the well bore. Therefore, many more per-volume exchanges occur near the well bore than away from it. The most obvious result is that the withdrawn soil vapors decrease the contaminant concentrations very quickly at first; the concentrations then level off towards a steady decline. All the vapors near the well are removed very quickly and those further away are removed more slowly.

5.0 LIMITATIONS OF INVESTIGATIONS

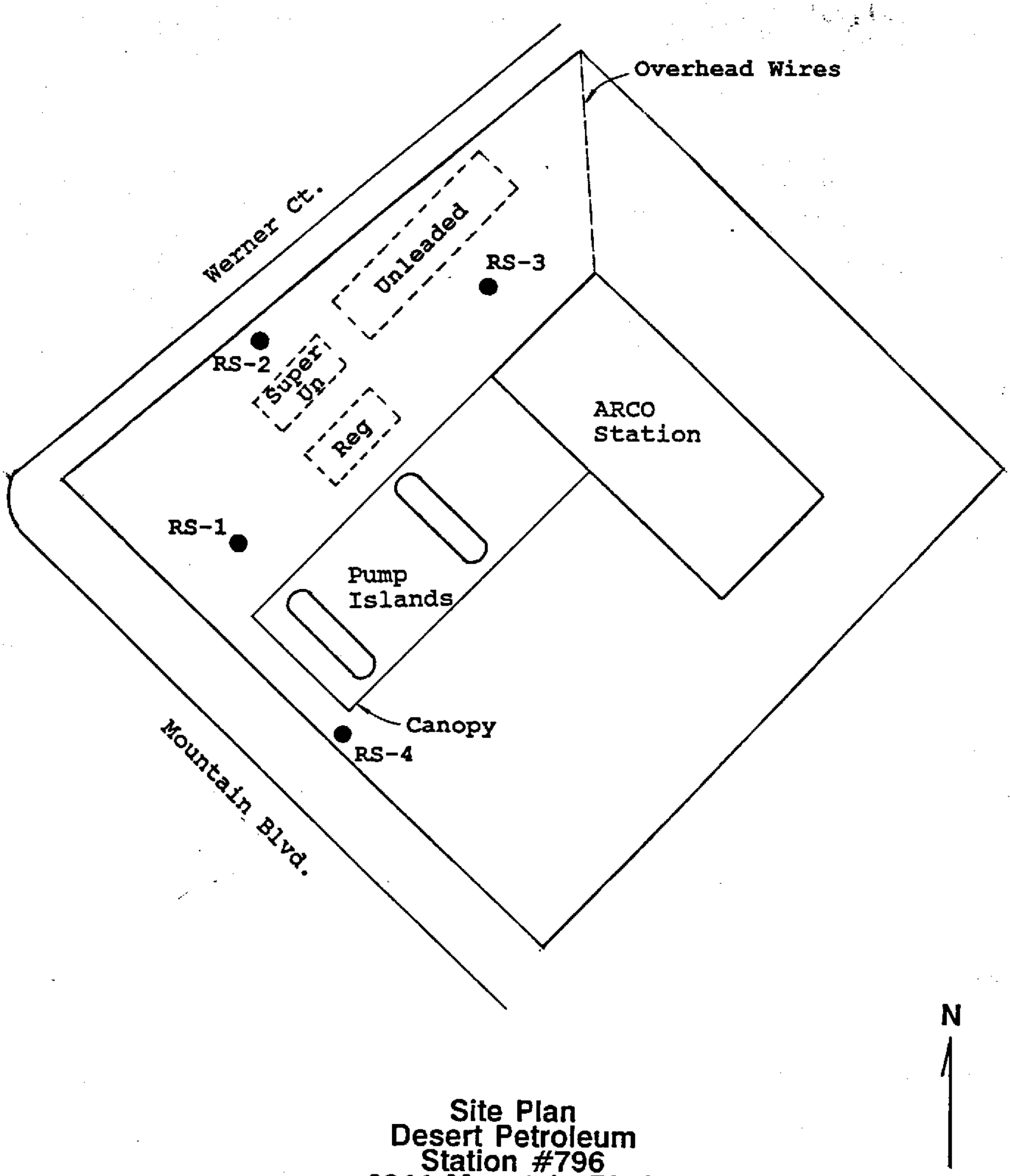
The discussion and recommendation presented in this report are based on the following:

1. The professional performance of the personnel who conducted the investigations.
2. The observations of the field personnel.
3. The results of laboratory analyses performed by a state certified laboratory.
4. Any referenced documents.
5. Our understanding of the regulations of the State of California; also, if applicable, other local regulations.

The services performed by Remediation Service Int'l have been conducted in a manner consistent with the level of care and skill ordinarily exercised by members of our profession currently practicing under similar conditions in the State of California. Please note that contamination of soil and/or groundwater must be reported to the appropriate agencies in a timely manner. No other warranty, expressed or implied, is made.

Location Map
Desert Petroleum
Station #796
2844 Mountain Blvd.
Oakland, CA

FIGURE 1

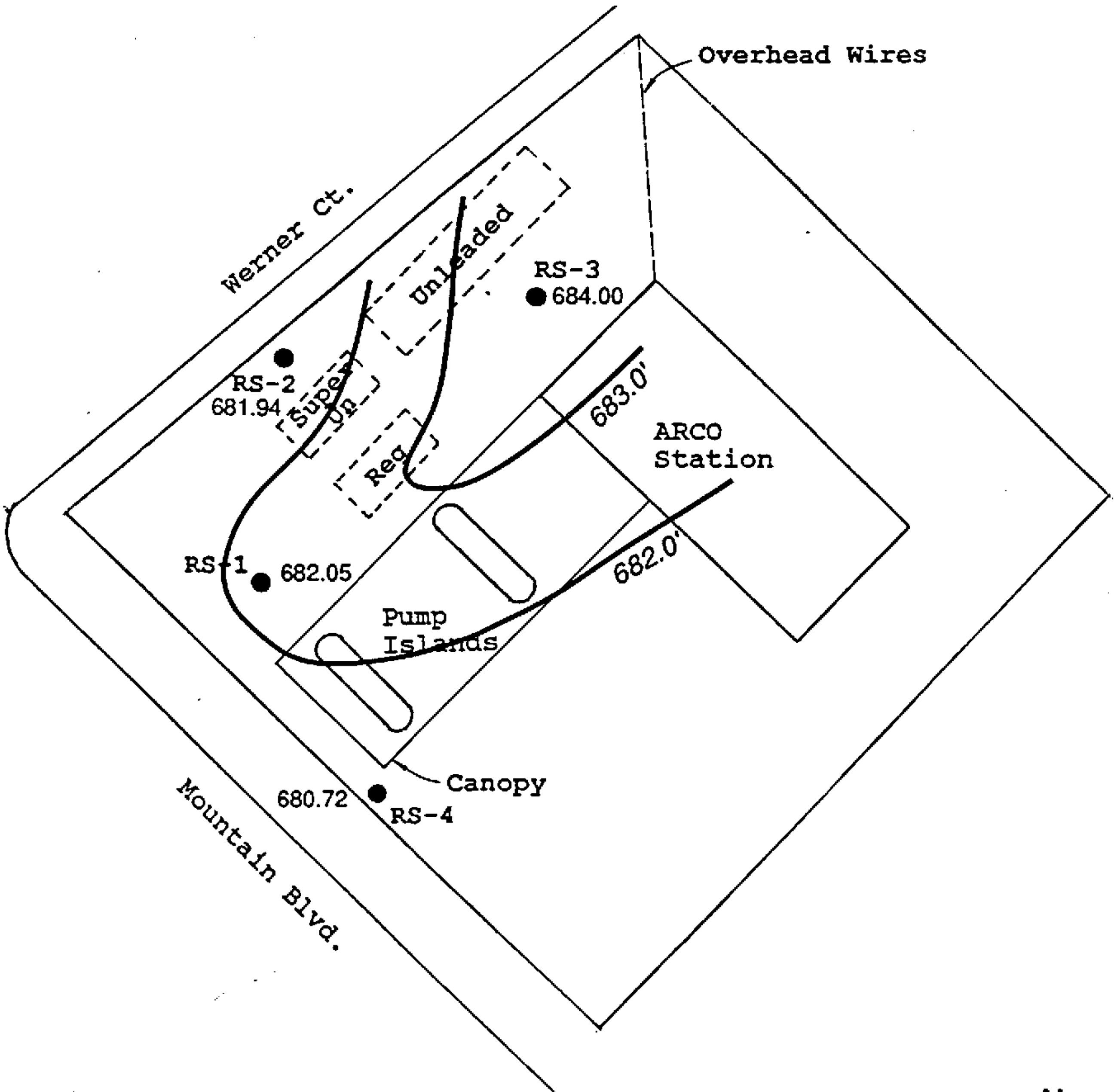


Site Plan
Desert Petroleum
Station #796
2844 Mountain Blvd.
Oakland, CA

● Monitoring Well Location

Approximate Scale: 1" = 25'

FIGURE 2



GROUNDWATER ELEVATION MAP

5/30/90

Desert Petroleum
Station #796
2844 Mountain Blvd.
Oakland, CA

● Monitoring Well Location

Approximate Scale: 1" = 25'

FIGURE 3

TABLE 1

Desert Petroleum Station #796

Summary of the Analytical Results for Soil (mg/kg)

Well I.D.	Depth (ft)	Benzene	Toluene	Xylenes	Ethyl Benzene	TPH
RS-1	5	0.59	0.53	0.76	0.085	9
RS-1	10	6.20	8.00	5.20	0.850	58
RS-1	28	0.004	0.003	ND	ND	ND <1
RS-2	5	1.10	0.85	2.50	0.26	22
RS-2	8	1.30	7.30	20.0	2.90	240
RS-2	25	0.059	0.08	0.068	ND	1
RS-3	5	0.084	0.014	0.030	0.004	ND <1
RS-3	25	0.004	0.009	0.020	ND	ND <1
RS-4	5	0.079	0.006	0.028	0.004	ND <1
RS-4	7	0.037	0.006	0.006	ND	ND <1
RS-4	25	0.006	0.007	0.006	ND	ND <1

TPH - Total Petroleum Hydrocarbons

ND not detected

TABLE 2

Desert Petroleum Station #796

Summary of Analytical Results for Groundwater (mg/l)

Well I.D.	Benzene	Toluene	Xylenes	Ethylbenzene	TPH
RS-1	0.37	0.42	0.32	0.04	2.7
RS-2	7.2	4.8	3.3	0.30	23.
RS-3	0.002	0.001	0.15	0.001	0.33
RS-4	0.009	0.011	0.049	0.009	0.44

SAMPLING PROCEDURES FOR GROUNDWATER MONITORING WELLS

1. Top of casing or wellhead is surveyed and referenced to datum point.

2. Equipment is decontaminated using a three bucket wash. This consists of: (1) washing the equipment in water with trisodiumphosphate detergent; (2) rinsing with tap water; and, (3) rinsing with deionized water.

3. Depth to water, depth to free product (if present) and total depth of well is measured.

4. The well is bailed or pumped either until dry, or until 4 to 5 casing volumes of water have been removed. The water is discharged into a DOT hazardous waste drum which is labeled and left on site pending laboratory analysis of water sample.

5. After the well has recovered, a sample is taken using a teflon bailer and placed in a VOA vial such that no headspace is present. The vial is sealed, labeled, and cooled.

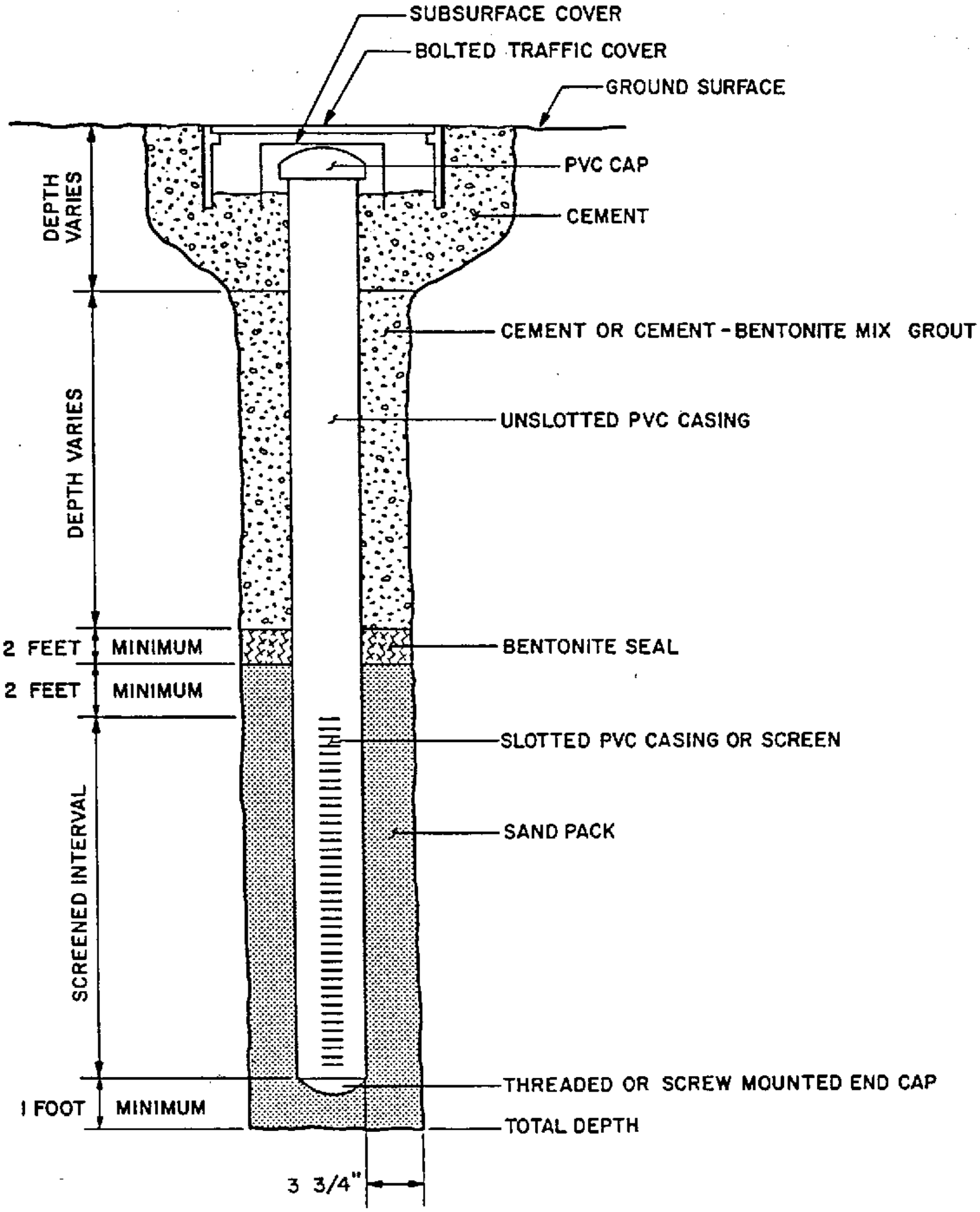
6. The field data sheet is completed with all pertinent information.

7. All the equipment is decontaminated using the 3-bucket wash.

8. The samples are transported to the laboratory as soon as possible following chain of custody procedures.

9. Wells are sampled from the cleanest to the most contaminated.

10. Site conditions are noted which may potentially contaminate the sample . . . any smoke, vapors from running engines, etc.



NO SCALE
TYPICAL ONLY

TYPICAL MONITORING WELL
CONSTRUCTION

RSI

RSI S.A.V.E. SYSTEM
Equipment Operation and Process Description

Soil and Water Remediation

The RSI S.A.V.E. (Spray Aeration Vacuum Extraction) System has been designed to solve the problem of gasoline contamination in soil and ground water. The system utilizes several remediation technologies that remove petroleum hydrocarbons from the contaminated subsurface, and uses the reclaimed gasoline as fuel for the remediation process. The process includes a four cylinder internal combustion engine which operates on the gasoline vapors and an auxiliary fuel, either natural gas or propane.

The system combines three remediation technologies. Each will be discussed in this process description. The technologies are:

- Vacuum extraction to remove gasoline vapors from the soil
- Spray aeration to separate the gasoline from the water
- Combustion in the internal combustion engine and catalytic converter to destroy the gasoline vapors.

Vacuum Extraction

Vacuum extraction is used primarily to extract the gasoline vapors from the soil. A recovery well or similar structure is installed in the contaminated area. A vacuum powered by a vacuum pump is placed on the recovery well, which causes the gasoline hydrocarbons to volatilize and flow with the air into the engine, where combustion occurs.

Spray Aeration

The contaminated water is pumped into the spray aerator water tank at a maximum rate of 10 gpm, where it is sprayed through one pair of nozzles into the tank chamber. This process promotes vaporization of the gasoline. Volatilization of the gasoline occurs; then the water falls to the bottom of the tank and the gasoline vapors travel to the engine where they are burned. Water is recirculated at a rate of 130 gpm. First this water is heated, then reintroduced into the tank through an additional pair of spray nozzles. Contamination reduction is 80% to 90% per cycle.

As the water level rises from the influx of well water, a float triggers the discharge of the treated water. To determine the level of reduction of the contaminates, the water is sampled prior to treatment and at the system discharge point. Treated water is passed through activated granular carbon before final discharge.

Combustion

Gasoline vapors from the soil and treated ground water enter the internal combustion engine, where they are burned during combustion. They represent a portion of the fuel required to operate the engine. An auxiliary fuel source is required, either natural gas or propane, to make up the difference between the engine fuel requirements and the available gasoline vapors from the remediation process. A three-way automotive catalytic converter is used to complete combustion and control hydrocarbon emissions to the atmosphere.

Safety

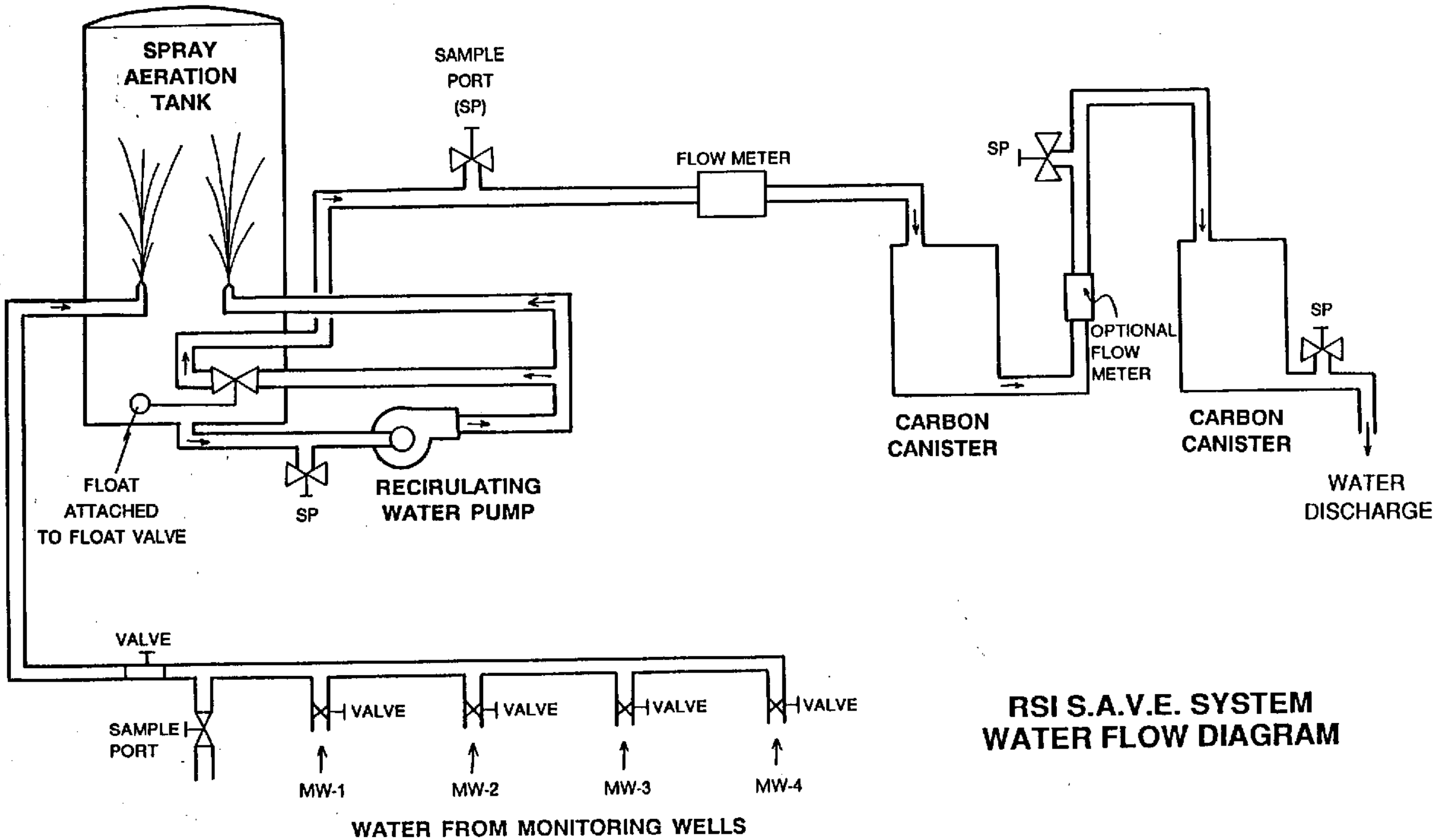
The following safety elements have been designed into the system:

Leaks: The entire system operates under a vacuum until the gasoline vapors enter the cylinders of the engine for combustion. As a result of this arrangement, any leaks of seals or connections are into the system. No hydrocarbons escape to the atmosphere.

Automatic Shut Off: The engine provides the power for all other system equipment, the entire system will stop if the engine stops, thus preventing any uncontrolled releases. In addition, the engine has shut off devices which are triggered by low oil pressure, loss of vacuum or engine overheating.

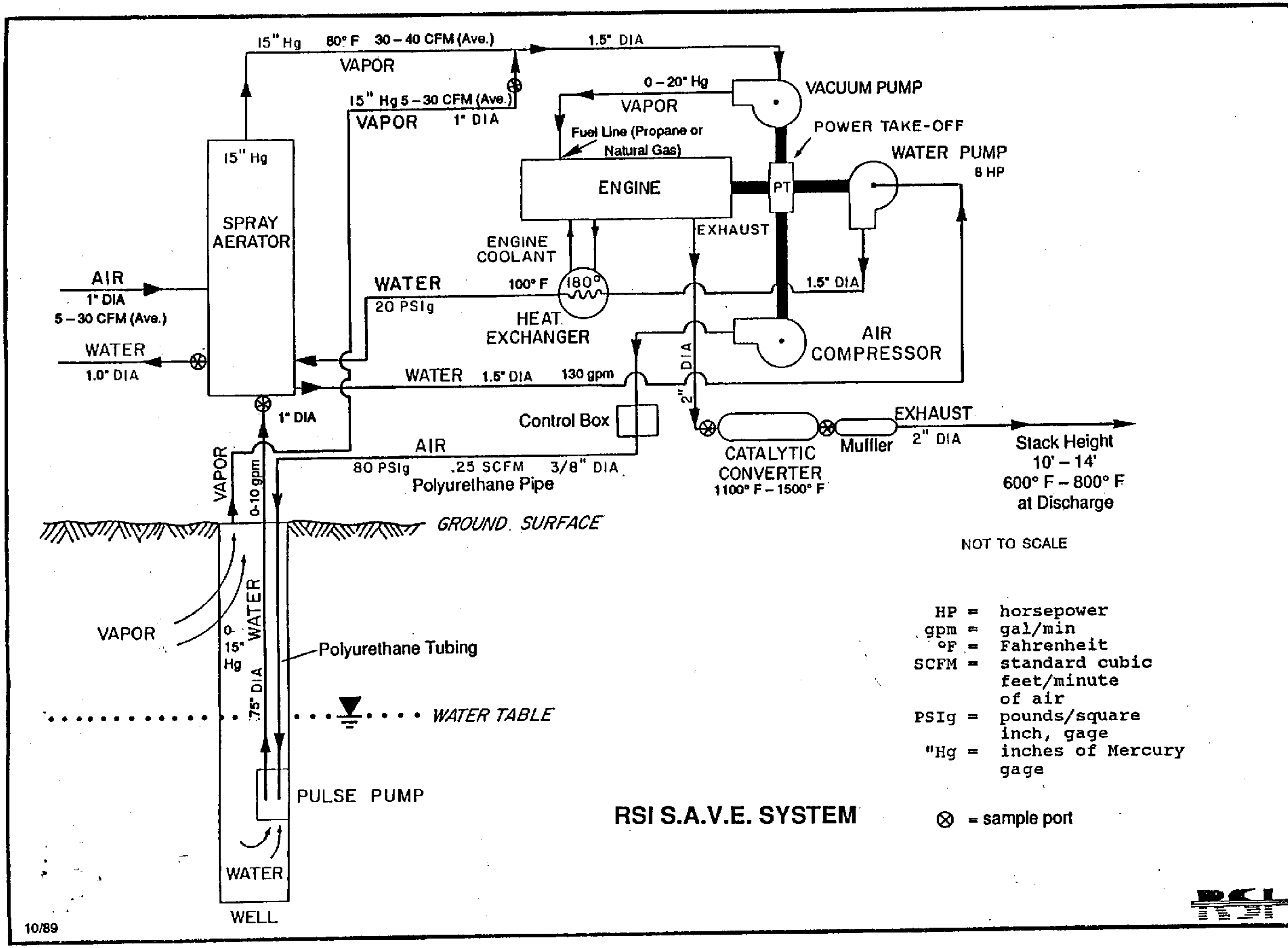
Well connections: The hoses connecting the wells to the equipment are installed within underground conduit.

Safety enclosure: All equipment will be enclosed in a fenced, covered compound, to prevent tampering with the equipment.



RSI S.A.V.E. SYSTEM
WATER FLOW DIAGRAM

10/89



RSI S.A.V.E. SYSTEM

S.A.V.E. SYSTEM PERFORMANCE DATA

TABLE I

PROJECT LOCATION:

MONTH			SEP 90					
GROUNDWATER	SPRAY AERATOR WATER IN	GALLONS						
		TPH-PPM*						
	SPRAY AERATOR WATER OUT	GALLONS						
		TPH-PPM*						
VAPOR	RECOVERED VAPORS FROM WELLS	SCFM*						
		TPH-PPM*						
	TOTAL VAPORS TO ENGINE	SCF						
		TPH-PPM*						
AIR	TO SPRAY AERATOR	SCFM						
	TO ENGINE	SCFM						
FREE PRODUCT	RECOVERED FROM WELLS	GALLONS						
ENGINE	EXHAUST	TPH-PPM*						
		CO-PPM*						
	OPERATION	HOURS						
	SPEED	RPM						
TOTAL CONTAMINANT REMOVED	FROM THE PROJECT LOCATION	GALLONS						

* DENOTES AVERAGE CONCENTRATIONS.

S.A.V.E. SYSTEM
SUMMARY OF LABORATORY RESULTS FOR SEP 90
TABLE II

PROJECT LOCATION:

DATE	EXTRACTED H2O TO AERATOR (mg/l)	DISCHARGED H2O FROM AERATOR (mg/l)	EXTRACTED VAPOR FROM WELLS (ppmv)	ENGINE EXHAUST (ppmv)
	time: by: TPH. B. T. EB. X.	time: by: TPH. B. T. EB. X.	time: by: TPH. B. T. EB. X.	time: by: TPH. B. T. EB. X.
	time: by: TPH. B. T. EB. X.	time: by: TPH. B. T. EB. X.	time: by: TPH. B. T. EB. X.	time: by: TPH. B. T. EB. X.
	time: by: TPH. B. T. EB. X.	time: by: TPH. B. T. EB. X.	time: by: TPH. B. T. EB. X.	time: by: TPH. B. T. EB. X.

NOTES:

S.A.V.E. SYSTEM
MONITORING DATA LOG FOR SEP 90
TABLE III

PROJECT LOCATION:

	DATE	TIME	ENGINE OPERATION DATA		PRESSURE READINGS AT				
			RUNNING TIME (HOURS)	SPEED (RPM)	EXTRACTION MANIFOLD (INCH H2O)	EXTRACTION WELL (INCH H2O)	EXTRACTION WELL (INCH H2O)	SPRAY AERATOR (INCH Hg)	RECIRC WATER (PSI)
BEGIN	2	2:00	2.0						
	4	4:00	4.0						
	6	6:00	6.0						
	8	8:00	8.0						
	9	9:00	9.0						
	10	10:00	10.0						
	11	11:00	11.0						
	12	12:00	12.0						
	13	13:00	13.0						
	14	14:00	14.0						
	15	15:00	15.0						
	16	16:00	16.0						
	17	17:00	17.0						
	18	18:00	18.0						
	19	19:00	19.0						
	20	20:00	20.0						
	21	21:00	21.0						
	22	22:00	22.0						
END	09/22/90	22:00	22.0						

NOTES:

S.A.V.E. SYSTEM
MONITORING DATA LOG FOR SEP 90
TABLE IV

PROJECT LOCATION:

DATE	TEMPERATURE READINGS AT					FLOW READING AT			
	AMBIENT AIR (F)	EXTRACTED VAPOR (F)	ENGINE OUTLET (F)	CATALYST OUTLET (F)	RECIRC WATER (F)	AIR TO SPRAY TANK (CFM)	EXTRACTED VAPORS (CFM)	AUXILIARY FUEL (CFH)	DISCHARGE WATER (GALS)
2									
4									
6									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									

NOTES:

S.A.V.E. SYSTEM
MONITORING DATA LOG FOR SEP 90
TABLE V

PROJECT LOCATION:

DATE	EXHAUST GAS COMPONENTS				
	H-C	CO	CO2	O2	NOx
2					
4					
6					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					

NOTES: