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# **SUPERFUND TREATABILITY CLEARINGHOUSE**

## **Document Reference:**

Smith,, D.L. and I.H. Sabberwal. "On-site Remediation of Gasoline-Contaminated Soil."  
15 pp. Technical paper presented at the International Congress on Hazardous Materials  
Management, Chattanooga, TN, June 8-12, 1987.

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## SUPERFUND TREATABILITY CLEARINGHOUSE ABSTRACT

Treatment Process: Physical/Chemical - Reduction/Oxidation

Media: Soil/Generic

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Document type: Conference Paper

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Site Name: Soil Treatment Project, Southern California (Non-NPL)

Location of Test: Los Angeles, CA

**BACKGROUND:** This treatability study reports on the results of tests aimed at treating gasoline contaminated soils at seven different sites using hydrogen peroxide to oxidize gasoline constituents to  $\text{CO}_2$  and  $\text{H}_2\text{O}$  in the presence of a proprietary synthetic polysilicate catalyst.

**OPERATIONAL INFORMATION:** The author reviews the magnitude of the contamination problems associated with leaking underground storage tanks with emphasis on problems in California. The use of hydrogen peroxide to oxidize hydrocarbons is then discussed along with its attributes (no hazardous residue formation) and its drawbacks (slow reaction time oxidizing saturated hydrocarbons). A table showing the ability of  $\text{H}_2\text{O}_2$  to react with various classes of compounds is included in the document along with a table showing the various types of organic constituents present in gasoline. The authors discuss the mechanism whereby a patented synthetic polysilicate named "Landtreat" is used to enhance the  $\text{H}_2\text{O}_2$  oxidation of soils contaminated with gasoline. Basically the polysilicate acts as a catalyst to enhance the oxidation of the organic species. Through a high-temperature, high-vacuum process, Frankel defects are created in the matrix of the polysilicate. These defects become active sites which increase the absorptive capacity of the "Landtreat". UV light also enhances the reaction rate. Furthermore, the active sites on the "Landtreat" react with cations, specifically heavy metals, converting them to metal silicates which pass the EP toxicity test.

The soil to be treated is excavated, mixed with "Landtreat" and sprayed with a solution of  $\text{H}_2\text{O}_2$  in water. The soil is mixed with a backhoe, front-loader or similar earth mover to ensure adequate contact. QA/QC and Health

and Safety procedures are discussed in the document. Cost for treating the soil ranges from \$70-\$130 per cubic yard.

**PERFORMANCE:** The information presented in the report are from actual soil treatment projects performed in southern California. In general, between 300 and 1500 cubic yards of soil were treated. Dry sandy and sandy clay soils were reported. Project completion time took from 3 to 7 days work on site excluding excavation, lab analysis, and backfilling. Average treatment efficiencies for total petroleum hydrocarbons (TPH) ranged from 96% to in excess of 99% depending on the site characteristics. The results of a seven day test at one site and the amount of total petroleum hydrocarbons removed is shown in Table 1. The results indicate that the oxidation of hydrocarbon contaminated soils by  $H_2O_2$  in the presence of a synthetic catalyst is a technically viable soil remediation method.

#### **CONTAMINANTS:**

Analytical data is provided in the treatability study report. The breakdown of the contaminants by treatability group is:

<u>Treatability Group</u>	<u>CAS Number</u>	<u>Contaminants</u>
W01-Halogenated Nonpolar Aromatic Compounds	108-90-7	Chlorobenzene
W04-Halogenated Aliphatic Compounds	106-93-4	Ethylene dibromide
W07-Simple Nonpolar Aromatics and Heterocyclic	71-43-2	Benzene
	108-88-3	Toluene
	95-47-6	O&P-Xylene
	100-41-4	Ethylbenzene
	108-38-3	M-Xylene
W11-Volatile Metals	7439-92-1	Lead
W13-Other Organics	TOT-PETROL	Total Petroleum Hydro- carbons

TABLE 1

TOTAL PETROLEUM HYDROCARBON CONCENTRATIONS AT SITE 6  
BEFORE AND AFTER TREATMENT

<u>Untreated Soil (ppm)</u>	<u>Treated Soil* (ppm)</u>
6,700	6.9
4,300	<2.0
1,803	15.8
8,884	15.2
1,663	<2
40,302	6
71.7	4

\* There is no direct correlation between treated and untreated soil for the results shown above. Untreated soil samples were taken at various depths during excavation and the treated samples were taken from various parts of the treatment pile subsequent to mixing and treatment.

Note: This is a partial listing of data. Refer to the document for more information.

ON-SITE REMEDIATION OF GASOLINE-CONTAMINATED SOIL 980-TS1-RT-FWF2  
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## I. INTRODUCTION

Gasoline leaking from service station tanks threatens groundwater supplies in many areas of the nation. California and other states have underground storage tank monitoring programs, with mandatory replacement of leaking tanks. The scope of the problem nationwide is still unknown. However, discussions with the California Water Quality Control Board indicate that an unlined gasoline tank underground for five years has a 50% probability of leaking. The probability of leakage approximates 100% after a decade of service. A WQCB official estimated that there are about 500 sites in Los Angeles and Ventura counties where groundwater has been affected. Another 1500 sites have significant tank leaks which have not affected ground water.

The WQCB has found that inventory reconciliation by itself is insufficient to detect many leaks. Product delivery records and dipstick measurements are generally made in hundred-gallon increments. Fifty or sixty gallons of gasoline can be lost without showing up on daily inventories. At this rate of loss, 21,900 gallons of gasoline would enter the soil in a year from a single tank. Even in smaller stations using weekly inventories, fifteen gallons could be lost per day without discrepancies occurring. This is equivalent to spilling 5,475 gallons of gasoline per tank per year. A typical gas station has three or four underground tanks.

Substantial quantities of soil can be contaminated if the leakage is allowed to continue for years. At one site a gasoline station was demolished in the early sixties. (See Site A in site Histories, below). The storage tanks were removed, and the tank cavity backfilled. The tank removal report noted a pronounced gasoline odor at the bottom of the cavity, a depth of fifteen feet. No action was taken. In 1986, over twenty years later, while digging the foundation for a multistory office building on the site, the old tank cavity was reopened. The gasoline odor was still prevalent, and construction was halted. The area had to be excavated to a depth of thirty-two feet before background Total Petroleum Hydrocarbon (TPH) levels were reached. Eleven hundred cubic yards of soil had to be treated and backfilled before construction could resume.

## II. PAST USES OF HYDROGEN PEROXIDE

Hydrogen peroxide has long been known to oxidize many classes of noxious organic compounds. These compounds are shown in Table I.

Hydrogen peroxide has several advantages over other oxidants: it is readily available, inexpensive, and its liquid state makes it easy to use in field conditions. Peroxide cleaves aromatic ring structures, and oxidizes the resulting straight- or branched- chain alkenes. Oxidation proceeds through a series of progressively shorter hydrocarbon chains, eventually resulting in carbon dioxide and water. Peroxide's primary advantage, however, is that it leaves no hazardous residue itself. This compares favorably with oxidants such as chlorine, which can be acutely toxic. Chlorination can also produce toxic chlorinated hydrocarbons. Unreacted peroxide spontaneously decomposes to water and oxygen. The released oxygen enriches the soil, promoting aerobic bacterial activity. Aerobic bacteria destroys sulfides and other noxious odor-producing chemicals. Oxygen also inhibits anaerobic bacteria, which produce sulfides, and filamentous bacteria, which produce other foul-smelling byproducts.

Peroxide treatment by itself has several crippling disadvantages. Under normal conditions, hydrogen peroxide reacts very slowly with saturated alkanes, and the reactions do not go to completion. Saturated alkanes make up nearly two-thirds of a typical unleaded gasoline (see Table II). Direct peroxide addition to soil gives an uncontrolled, highly exothermic reaction. The heat evolved volatilizes most of the gasoline before it can be destroyed. The heat also drives off the intermediate decomposition products, which are more volatile due to their lower molecular weight. The intermediate breakdown products, especially mercaptans, can be more noxious than the original compounds. Both these factors constitute an air pollution problem which precludes peroxide treatment in the open air. Additionally, the heat of reaction facilitates hydrogen peroxide's autocatalytic decomposition to water and oxygen. Adding additional peroxide to compensate for decomposition losses gives a hotter reaction and faster peroxide loss.

TABLE I

WASTE CHEMICAL CLASSES ABILITY  
TO REACT WITH HYDROGEN PEROXIDE

Chemical Compound	Yes	No	Unknown
Aliphatic Hydrocarbons (1)	x	x	
Alkyl Halides			x
Ethers			x
Halogenated Ethers and Epoxides			x
Alcohols (2)	x		
Glycols, Expoxides	x		
Aldehydes, Ketones (3)	x		
Carboxylic Acids	x		
Amides	x		
Esters			x
Nitriles	x		
Amines	x		
Azo Compounds, Hydrazine Derivatives	x		
Nitrosamines	x		
Thiols (3)	x		
Sulfides, Disulfides (3)	x		
Sulfonic Acids, Sulfoxides			x
Benzene and Substituted Benzene (2)	x		
Halogenated Aromatic Compounds			x
Nitrophenolic Compounds	x		
Fused Polycyclic Hydrocarbons	x		
Fused Non-Alterant Polycyclic Hydrocarbon	x		
Heterocyclic Nitrogen Compounds	x		
Heterocyclic Oxygen Compounds	x		
Heterocyclic Sulfur Compounds			x
Organophosphorus Compounds			x

- (1) Saturated alkanes unreactive; unsaturated compounds form epoxides and poly-hydroxy compounds.  
 (2) Requires catalyst  
 (3) May require catalyst

SOURCE: Remedial Action of Waste Disposal Sites, (Revised) EPA/625/6-85/006, USEPA Office of Research and Development, Hazardous Waste Engineering Research Laboratory, Cincinnati, OH, October, 1985, p 9-55.

TABLE II

## LIQUID GASOLINE COMPONENTS IN UNLEADED GASOLINE

COMPOUNDS	VOLUME PERCENT
1. Butane	3.85
2. Butane, 2-methyl	9.26
3. Pentane	3.42
4. 2-Pentene (trans)	1.02
5. 2-Butene, 2-methyl	1.76
6. Butene, 2, 3-dimethyl	1.34
7. Pentane, 2-methyl	3.70
8. Pentane, 3-methyl	2.31
9. Hexane	2.37
10. Cyclopentane, methyl	1.88
11. Pentane, 2, 2-dimethyl	1.13
12. Benzene	1.57
13. Hexane, 2-methyl	2.20
14. Cyclopentane, 1, 1-dimethyl	1.61
15. Hexane, 3-methyl	1.80
16. Pentane, 2, 2, 4-trimethyl	4.00
17. Heptane	1.45
18. Toluene	7.20
19. Benzene, ethyl	1.18
20. Xylene, para and meta	3.50
21. Xylene, ortho	1.62
22. Toluene, para and meta ethyl	2.00
23. Benzene, 1, 3, 5-trimethyl	1.25
24. Benzene, 1, 2, 4-trimethyl	2.36
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TOTAL 63.78%	
Total branched-chain alkanes:	61.1%
Total branched-chain alkenes:	6.5%
Total substituted aromatics:	32.4%

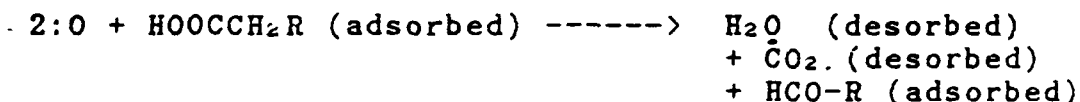
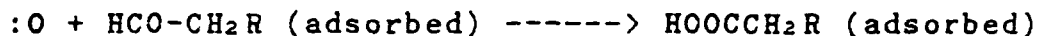
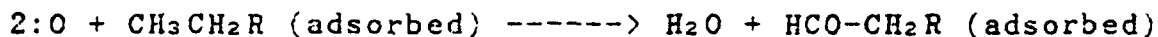
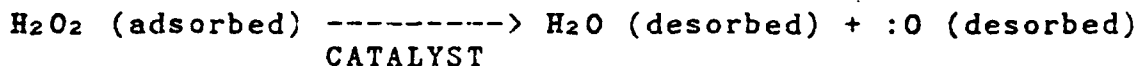
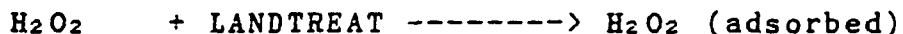
As analyzed by capillary gas chromatography. The remaining 36.22% consists of 116 minor components, each less than 1.00 % by volume. The same 2:1 approximate ratio of branched-chain aliphatic to substituted aromatic compounds is retained among the minor constituents. The gasoline used for this analysis was a typical unleaded gasoline. Percentages may vary depending on the crude source, blending composition and gasoline grade.



### III. THE LANDTREAT PROCESS

LANDTREAT is a patented synthetic polysilicate. (U. S. Patent Nos. 4,440,867 and 4,530,765.) It is used in a finely divided, high-surface-area powder. The silicate matrix has been expanded by a high-temperature, high-vacuum process, creating Frankel defects. These defects become active sites where hydrogen peroxide and gasoline components can be adsorbed. The active sites facilitate peroxide decomposition to singlet oxygen, a highly reactive species. Singlet oxygen attacks saturated alkanes as well as unsaturated and aromatic species. LANDTREAT resorbs the intermediate decomposition products. These partially broken down species are attacked again, and the process continues until essentially complete decomposition to carbon dioxide and water is achieved. Reaction rates are further enhanced by the ultraviolet light in sunlight.

The general reaction sequence can be written as follows:



R is alkyl, branched or straight-chained. The process is also being applied to other fuels, including kerosine and diesel; and to a variety of industrial solvents, including ketones, aldehydes, and alcohols.

The stoichiometry and kinetics of the reaction sequence are still under investigation. Field experience indicates that TPH reductions of up to 90% can be obtained within hours of peroxide addition in threefold excess of assumed stoichiometric amounts.

As a side reaction, the active sites on the LANDTREAT also react with cations, specifically heavy metals. The metals are converted into metal silicates. The silicates pass the USEPA's E.P. Toxicity test, as well as California's CAM test, a similar but more stringent procedure. Metal contamination from leaded gasoline, waste motor oil, or other sources is therefore treated at the same time.

Ensotech has developed a different fixation process where extensive heavy metal contamination exists at elevated levels. An extended discussion of this process is outside the scope of the present paper, however.

#### IV. TREATMENT PROTOCOL

The treatment protocol is quite simple. The Site Supervisor surveys the area and marks off the treatment area, decontamination area, and treated and untreated soil storage areas. These areas are then roped off and placarded appropriately. Appropriate precautions are taken in the treatment area to protect the paving, if any, and the underlying soil. An earthen berm is created around the treatment area to prevent runoff. The minimum berm height is six inches, with proportionate thickness. The decontamination area is located with the berm. The only decontamination residues are unreacted peroxide and water, which are allowed to mix into the treated soil. Splash barriers and windbreaks are erected to guard against windborne aerosol formation if site conditions dictate.

The soil may have been stockpiled in advance, or may be excavated at the time of treatment. The soil is treated sectionally. Each section is spread over the treatment area to form a layer of uniform thickness. Layer thickness is not critical. LANDTREAT is mixed into the soil. The soil is manipulated with a backhoe, frontloader, or similar type of earthmover.

The soil-LANDTREAT mixture is sprayed with a solution of hydrogen peroxide in water. Peroxide is diluted in a premix tank on board the spray unit. The unit is entirely self-contained on a small trailer which includes the premix tank, gasoline-powered compressor, and 100' to 300' of hose. The unit is operated from the spray gun via an electric control circuit.

Quality control during the treatment is maintained by on-site testing. Successive peroxide applications continue until on-site results are satisfactory. On-site testing consists of exposing standardized soil samples to a TLV sniffer or photoionization detector. Calibration curves have been developed using soil samples spiked with predetermined levels of gasoline. Different curves are required for different soil types, but all show good reproductibility when sniffer readings are made according to the standard handling procedure. The sniffer is also used to monitor ambient air quality around the treatment site.

#### V. SAFETY PRECAUTIONS

Site safety procedures are in accordance with normal industry practice for peroxide use. All personnel handling the peroxide solution are equipped with Level II protection: protective rubber clothing, including gloves and boots, as well as a face shield and respiratory protection. Lesser levels of protection are sufficient for supervisory personnel or bystanders not in the treatment area.

A portable eyewash kit, a first aid kit, and a fire extinguisher are kept on-hand in a site safety cart. A water hose from the nearest city water connection is kept near the treatment area at all times to serve as an emergency safety shower, if needed. The hose is also used to decontaminate all protective clothing at the end of the day, using the predesignated decontamination area.

Personal tools (shovels, etc.) are decontaminated at the end of each working day, and removed from the jobsite. Major treatment equipment is left in the treatment area overnight until the project is completed, and is then decontaminated at the end of the job.

## VI. SITE CLOSURE AND REGULATORY CONSIDERATIONS

Closure requirements are minimal. Once laboratory analysis confirms complete treatment (usually defined as TPH < 100 mg/kg and total Benzene-Toluene-Xylene-Ethyl Benzene (BTXE) < 10 mg/kg), the soil can be backfilled on-site, sent to a Class III (sanitary) landfill, or used as clean fill for landscaping. The gas station resumes operation.

Final samples are generally split with the lead regulatory agency for independent verification. Analyses commonly performed include USEPA methods 7420 (lead), 8010 (Ethylene Dibromide [EDB], an antiknock additive commonly found in unleaded gasoline), 8015 (TPH), and 8020 (BTXE). Some agencies also require method 9040, pH. To date, no treated soil has been rejected by a regulatory agency or by a sanitary landfill. Groundwater monitoring wells are not generally required unless groundwater contamination already exists. A separate groundwater treatment system may be required in some cases. Even without treatment, groundwater quality will gradually improve with time after the contamination source is removed.

Permitting requirements vary with the lead agency, which in turn varies with the geographical area and the presence or potential of groundwater contamination. In general a variance must be obtained to perform on-site treatment at each specific site. At this writing, the process has been used under the jurisdiction of the California Department of Health Services, the Los Angeles County Department of Health Services, the Los Angeles City

Department of Public Works, the Los Angeles Regional Water Quality Control Board, the Santa Ana Regional Water Quality Control Board, the Orange County Health Care Agency, and the Riverside County Health Department.

Because the process is virtually emission-free, no air pollution permits are required. In the case of an operating gas station, ambient gasoline vapors at the pump islands are orders of magnitude higher than at the periphery of the treatment area.

## VI. SITE HISTORIES

The data presented below comes from actual soil treatment projects performed in Southern California. In general, between 300 to 1500 cubic yards of soil were treated at each site. Treatment costs ranged from \$70.00 to \$130.00 per cubic yard. This compares favorably with the total disposal cost at a Class I dumpsite. Transport and disposal of the untreated soil would cost approximately \$250.00 to \$330.00 per cubic yard. Treatment cost is site-specific, varying with the volume of soil, extent of contamination, and other factors.

Each project took approximately three to seven days of work on-site. This does not include permitting, excavation, backfilling, or the laboratory analyses required to certify complete treatment.

Note on sample reporting: the site characterizations from which these data were derived were performed under varying circumstances in conjunction with any of several different agencies. Sample location and numbering schemes therefore vary from site to site as do the quantity and type analyses performed. In some cases, specific analytical data gathered by other firms was not approved for publication, so general TPH and BTXE ranges have been given instead.

# SITE A

Gas station abandoned and tanks removed in early 1960's. Original depth of tank cavity: 15'. Depth excavated to reach background: 32'. Depth to groundwater: 200'+. Dry sandy clay soil. Approximately 1100 cubic yards treated in four working days. Treated soil was backfilled.

## UNTREATED SOIL AS EXCAVATED

Sample	Depth/loc	Pb	TPH	EDB
V-399-1	30 ft	9.3	20	NA
V-399-2	22 ft	9.3	196	NA
V-399-3	18 ft	20.00	425	NA
V-399-4	15 ft	20.00	798	0.17
V-399-5	untreated excavated soil	9.3	211	NA
V-399-6	Background soil	20.00	35	<0.1

## TREATED SOIL AS BACKFILLED

Sample	Depth/loc	Pb	TPH	EDB
V-465-1	24-32 ft	9.3	31	<0.1
V-465-2	16-23 ft	9.3	25	<0.1
V-465-3	9-22 ft	15.00	45	<0.1
V-465-4	0-8 ft	15.00	43	<0.1

Note: The following abbreviations are used throughout the site histories:

TPH	=	Total Petroleum Hydrocarbon
B	=	Benzene
T	=	Toluene
m-X	=	meta-Xylene
o&p-X	=	ortho- and para-Xylene
EB	=	Ethylbenzene
CB	=	Chlorobenzene
EDB	=	Ethylene Dibromide
Pb	=	Lead
NA	=	Not Analyzed

All results are reported in milligrams per kilogram of soil unless otherwise noted.

# SITE B

Gas station demolished and tanks removed. Treatment performed immediately after demolition. Depth of excavation: 12-14'. Groundwater perched and variable, with highest recorded level at 15'. Monitoring well installed during site characterization found no perch water contamination. Monitoring well removed upon conclusion of treatment. Moist, fine silty clay and sand. 1215 cubic yards of soil excavated and treated in ten working days. Treated soil was backfilled.

## UNTREATED SOIL

Sample	Depth/ Loc	TPH	B	T	m-X	o&p-X	EB	CB
W-453	14ft	1010	4.75	33.90	47.90	7.31	2.16	1.94
W-462	14ft	193	1.88	5.44	6.38	9.95	5.01	0.50
W-463	15ft	174	0.73	3.22	6.18	7.42	2.67	0.29

## TREATED SOIL

Sample	TPH	B	T	m-X	o&p-X	EB	pH*	CB
W-491	8.4	0.16	<0.08	<0.08	<0.08	<0.08	9.0	<0.08
W-492	<2	0.40	<0.08	<0.08	<0.08	<0.08	8.4	<0.08
W-493	9.9	<0.08	<0.08	<0.08	<0.08	<0.08	8.6	0.23

\* Of a 10% solution

# SITE C

Depth of excavation approximately 20'. No groundwater in vicinity of site. Dry, sandy soil. Nine hundred cubic yards treated in three working days. Limited space available, due to large soil stockpiles, so treatment area located between pump islands. Treated soil was sent to a Class III landfill.

Before treatment, soil samples showed average TPH 191 to 1,350 mg/kg, with some values as high as 8,900 mg/kg. The highest total BTXE (Benzene-Toluene-Xylene-Ethylbenzene) recorded was 782 mg/kg.

## TREATED SOIL

Sample	TPH	B	T	m-X	o&p-X	EB	EDB	Pb
1	<2	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<2.5
2	<2	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<2.5
3	<2	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<2.5
4	<2	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<2.5
5	<2	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<2.5
6	<2	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<2.5
7	<2	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<2.5

# SITE D

Excavation in excess of thirty feet. Depth to groundwater: 140'. Soil was sandy, - unconsolidated alluvium. Treatment proceeded while new tanks were being installed. Approximately 480 cubic yards treated in four working days. Treated soil was used for landscaping on-site.

## UNTREATED TANK CAVITY SOIL

Sample	Depth (ft)	TPH	B	T	X	EB	Pb
1	14-G	4	<0.02	<0.02	<0.02	<0.02	3.0
2	18-G	10	<0.02	<0.02	<0.02	<0.02	7.1
3	14-G	40	<0.02	<0.02	<0.02	<0.02	25
4	18-G	6	<0.02	<0.02	<0.02	<0.02	3.7
5	8-W	1,820	<0.02	0.04	0.33	0.05	45
6	12-W	15	<0.02	<0.02	<0.02	<0.02	5.8

Sample	Depth (ft)	TPH	B	T	X	EB	Pb
1-A1	20-G	2,530	<0.01	7.3	920	57	<0.01
2-A2	24-G	1,960	<0.01	9.6	820	60	<0.01
3-D	10-W	2	<0.01	<0.01	0.01	<0.01	<0.1
U-DU	14-W	880	<0.01	0.02	2.7	0.05	1.5

Sample	Depth (ft)	TPH	Pb
7	32-G	4,980	0.1
8	25-G	<10	<0.1
9	12-W	98	<0.1
SP-1	NA-G	1,390	NA
SP-2	NA-G	97	NA

## TREATED SOIL

Sample	TPH	B*	T*	m-X*	o&p-X*	EB*	Pb
V-950-1	<8	<10	<10	<10	<20	<10	7.6
V-950-2	<8	<10	<10	<10	<20	<10	<2
V-950-3	<8	<10	<10	<10	<20	<10	<2

\* Values given are micrograms per kilogram of soil



# SITE E

Excavated to 22'. No groundwater in vicinity. Clayey silt alluvial deposits to 50'. Six hundred cubic yards treated in three working days. Treated soil was sent to Class III landfill.

## UNTREATED SOIL

Sample	Depth into pile	TPH
SE	8"	76
SM	8"	148
SW	8"	105
CE	5'	1040
CM	5'	1250
CW	5'	980
NE	8"	35
NM	8"	29
NW	8"	48

Composite of nine samples of untreated soil from spoil pile.

Sample	TPH	B	T	m-X	o&p-X
V-737-1 through V-737-9	860	2.1	24	35	37

## TREATED SOIL

Sample	TPH	B*	T*	m-X*	o&p-X*	EDB*	Pb
1A	<1	<5	<5	<5	<10	<10	<2
2A	<1	<5	<5	<5	<10	<10	<2
3A	<1	<5	<5	<5	<10	<10	<2
4A	<1	<5	<5	<5	<10	<10	<2
5A	<1	<5	<5	<5	<10	<10	<2

\* Values given are micrograms per kilogram of soil.

# SITE F

No groundwater in vicinity. Very confined site and thick, intractable clay slowed treatment. 1945 cubic yards of soil treated in ten working days. Some treated soil was used for on-site grading and some sent to a Class III landfill.

## UNTREATED SOIL

	Sample	TPH	B	T	m-X	o&p-X	EB	CB	Pb	
D	W-380	7.6	0.24	0.46	0.53	0.17	0.60	<0.08	<5	<u>log(TPH)</u> 0.881
	W-381	295	0.31	5.49	13.5	2.59	3.21	8.89	<5	2.470
	W-384	675	0.46	23.5	50.4	7.62	18.3	0.16	<5	2.829
	W-385	305	0.22	4.48	15.0	1.17	3.03	1.02	<5	2.484
	W-444	42	0.31	1.56	1.04	0.27	0.57	1.05	NA	1.623
S	W-445	16.8	0.17	0.35	0.15	0.31	<0.08	<0.08	NA	1.225
	W-446	236	0.08	10.1	<0.08	<0.08	2.52	5.53	NA	2.373

mean 1.984  
S.D. 0.739  
N<sub>S</sub> = 7

## TREATED SOIL

	Sample	TPH	B	T	m-X	o&p-X	EB	CB	pH
	W-421	22.0	0.18	0.42	0.97	<0.08	0.25	NA	7.8
	W-422	26.4	0.24	0.65	1.00	<0.08	0.30	NA	8.0
	W-423	20.5	0.24	0.72	0.62	<0.08	0.59	NA	8.1
	W-424	8.5	0.18	0.30	0.40	<0.08	<0.08	NA	8.2
	W-425	8.5	0.15	0.20	0.45	<0.08	<0.08	NA	8.0
	W-447	3.0	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	NA
	W-448	3.2	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	NA
	W-442	12.9	0.25	2.16	2.04	2.37	1.68	<0.08	NA
	W-443	9.1	0.24	0.62	1.31	1.67	0.27	<0.08	NA

# SITE G

Extensive gasoline and waste oil contamination. Site excavated to practical limit of 25'. Groundwater depth: 32'. Significant groundwater contamination being treated by other means. Moist, sandy clay to 7', followed by dense, damp, bedded, well-sorted, uncemented sandstone. Very confined site required some soil to be backfilled before the job completion in order to have room to treat remaining soil. Approximately 726 cubic yards of soil treated in seven working days. Remainder of treated soil sent to Class III landfill.

## UNTREATED SOIL

The laboratory results, in parts per million (ppm), are as follows:

### Tank Cavity Soils

### Spoils Pile

Sample	Depth (ft)	TPH	Sample	Tank	TPH
1A	8-W	3.83 6,700	5	W	3.47 2,970
1B	15-W	3.63 4,300	6	G	2.13 135
2A	14-G	3.26 1,803	7	G	1.72 52
2B	14-G	3.95 8,884	8	G	3.54 3,500
3A	14-G	3.22 1,663			
3B	14-G	4.61 40,302			
4A	14-G	0.00 <1.0			
4B	14-G	1.86 71.7			

mean 2.94  
S.D. 1.27  
t 1.356  
n = 9

G = Gasoline tank area  
W = Waste oil tank area

## TREATED SOIL

Sample	TPH	B	T	mX	o&p-X	EB
W-596	6.9 84	0.22	<0.08	<0.08	<0.08	<0.08
W-597	<2 0.30	0.08	<0.08	<0.08	<0.08	<0.08
W-598	15.8 1.20	0.08	<0.08	<0.08	<0.08	<0.08
W-599	15.2 1.18	0.09	<0.08	<0.08	<0.08	<0.08
W-600	<2 0.30	0.19	<0.08	<0.08	<0.08	<0.08
W-601	6.7 0.83	0.32	<0.08	<0.08	<0.08	<0.08
W-602	4.6 0.66	0.17	<0.08	<0.08	<0.08	<0.08

mean 0.76  
S.D. 0.37  
n = 12

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